Biological Inventory and Local Planner Outreach for Conservation in the Northern Lake Michigan Coastal Zone, Schoolcraft County

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Executive Summary

In 1999, Michigan Natural Features Inventory (MNFI) initiated a project to conduct systematic surveys of natural features along Lake Michigan's northern coastal zone in Schoolcraft County. Surveys were conducted for high quality natural communities and rare species. The study was also initiated as a pilot project to expand MNFI's coastal zone survey work to include landowner contact and local planner outreach. The study area was chosen deliberately to include a high proportion of private lands, coincident with high development pressure and significant survey gaps. Local planning units were queried and the extent to which threatened and endangered species concerns are integrated into local planning processes was informally assessed. Planners were also queried to determine if they would like the results of this study and in what form they would be most useful.

Landowner Contact: Two hundred and seventy six landowners were contacted, of which 86 returned positive responses, and 52 parcels were surveyed. Landowner contact complicated survey work due to the time and effort required to write and mail survey requests, track responses, and coordinate survey times and access. Properties where permission to survey was not granted also fragmented the survey effort, making it difficult to survey large areas of contiguous shoreline efficiently. However, landowner contact provided access to significant natural features and an opportunity for landowner education. To increase the positive response rate it is recommended that follow-up contacts be made with non-responders.

Animal Surveys: Bird point counts were conducted at 30 sites encompassing eight natural community types. One hundred and sixteen bird species were observed, including 98 during spring migration and 93 during the summer breeding season. Bird abundance and species richness were similar in May and June. An informal assessment of habitat use showed that bird abundance was greater at shoreline sites than interior sites and on the Garden Peninsula compared to non-peninsula sites during migration. During the breeding season, birds were observed more frequently at interior sites, however, no noticeable difference was observed between peninsula and non-peninsula sites. Individuals of seven listed species were seen in the study area, including osprey, bald eagle, red-shouldered hawk, Caspian tern, common loon, northern harrier, and northern goshawk.

Surveys for the Great Lakes endemic, Lake Huron locust, resulted in the identification of three new populations and the reconfirmation of six previously known populations, four of which were expanded in extent. Additional suitable habitat for this species was also identified. Most of the documented populations were ranked with fair to good viability. Additional surveys are needed to determine their complete distribution and extent, overall status, and long-term viability. The continued presence of the Lake Huron locust in the region indicates the persistence of high quality dunes. As development pressures continue in the region, deliberate efforts to minimize impacts to the dunes is essential for conservation of this species. Monitoring and research on the ecological requirements of the locust are also needed to help determine the best strategies to minimize impacts from development.

Five special concern land snails were previously documented in the study area. Limited project funding and time-consuming survey methods precluded conducting additional surveys during the current study. A brief discussion of the five species and a list of other sites with suitable habitat in the project area are provided.

Plant Surveys: Twenty nine new and 10 updated rare plant occurrences were documented during this study, and an additional 21 previously documented occurrences are considered likely extant. These 60 occurrences encompass 13 different species, including 30 occurrences of 3 state and federal listed Great Lakes endemics; dwarf-lake iris, Pitcher's thistle, and Houghton's goldenrod. Their protection will require the maintenance of tracts of land large enough that natural shoreline processes can function unimpeded. The minimum acreage required and the level of disturbance that can be tolerated is not fully understood. An encouraging sign is that some rare plant populations persist on residential properties where houses are located behind the open dunes, well back from the water's edge.

Further research and landowner education are critical if these and other occurrences are to be sustained. It is possible that one or more sites within the study area can be established as benchmark monitoring sites to assess long-term impacts in residential areas, and potentially serving as models for good stewardship.

Natural Community Surveys: Two occurrences each of wooded dune and swale and lakeshore pavement were confirmed in the current study, and two potential northern fen occurrences were identified. Confirmation of the latter two will require further landowner contact to secure permission to survey and access. In addition, a state- designated critical dune area comprises much of the study area to the east of Manistique. Disturbance of the wooded dune and swale occurrences was noted particularly along US-2, where residential and commercial development activities have occurred. Further development in this area is imminent. Although not afforded legal protection, it would be useful to educate planners, township administrators, developers, landowners, and others about the significance of these coastal communities. The provision of stewardship guidance and recommendations will increase the chances of their long-term sustainability.

Aquatic Community Characterization: The nearshore Lake Michigan fish, benthic invertebrate and plankton communities were sampled along three transects near Manistique. The habitat was primarily large boulder substrate, supporting a strong assemblage of native benthic and forage fish, as well as many native snail and aquatic invertebrate species. While no listed species were found, relatively undisturbed nearshore communities with a predominance of native species are rapidly vanishing elsewhere in the Great Lakes due to shoreline modification and exotic species invasion. This unique aquatic assemblage should be further studied to provide information not only for the protection of Northern Lake Michigan nearshore zones, but also for shoreline conservation and planning efforts throughout the Great Lakes.

Local Planner Outreach: Local planning processes and zoning ordinances do not systematically address threatened or endangered species concerns, nor is there systematic coordination with state or federal agencies regarding such concerns. Most local planners do not have an easily accessible geographic information system (GIS) platform for receipt and use of natural features data in digital format. However, all contacted planners were interested in learning about the coastal zone natural features and requested the results of this study in hard copy format.

Summary and Recommendations: The high number of natural features in the study area highlights the importance of this coastal zone region. The beauty and ruggedness imparted by these features provides a large part of the draw that brings people to the region. Yet, these features are currently threatened by development activities that are not systematically reviewed for impacts to threatened or endangered species or ecological integrity. When they are addressed, natural features concerns are handled on a case by case basis, resulting in cumulative impacts that are not easily detected. Maintenance of the ecological integrity of the coastal zone will ultimately require the institutionalization of protection measures into the planning process at all levels. This requires 1) good legislation at local, state, and federal levels; 2) high-quality and comprehensive data; and 3) education and outreach. The establishment of a long-term presence in the form of a coordinator or team to coordinate a landscape level conservation planning effort in the region is recommended. This effort should include representation from all levels of government and private sector groups.

List of Acronyms

The following acronyms are used in the body of this report.

Acronym	Full Name
BCD	Biological Conservation Database
CIWPIS	Coastal and Inland Waters Permit Information System
CRMI	Conservation Resource Management Initiative
CUPAD	Coalition of Upper Peninsula
DEQ	Department of Environmental Equality
FMD	Forest Management Division
GIS	Geographic Information System
GPS	Global Positioning System
LWMD	Land and Water Management Division
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resouces
MNFI	Michigan Natural Features Inventory
MSU	Michigan State University
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Services
WD	Wildlife Division

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Introduction

A landscape rich with significant natural communities and associated species, the Great Lakes coastal zone has long been a target for survey by Michigan Natural Features Inventory (MNFI) and others. The largest freshwater dune complexes in the world are found in this coastal zone, featuring impressive open dunes, interdunal wetlands, forested dunes, and extensive dune and swale communities. A rich assortment of other communities such as boreal forests, cedar swamps, northern fens, cobble beaches, limestone cliffs, Great Lakes marshes, lakeplain prairies, Great Lakes barrens, and alvar comprise much of the remainder of these lakeshores. A number of these communities are rare globally, found only in the Great Lakes basin, and some are also rare in Michigan. Interdunal wetlands, for example, are ranked G2 and S2 by The Nature Conservancy (TNC 1999), indicating they are imperiled due to rarity or vulnerable to extinction both globally and statewide. Michigan alvars, or limestone bedrock grassland communities are ranked G2 and S1, the latter rank reserved for the rarest elements in the state, which are considered critically imperiled.

The various coastal zone communities are home to numerous rare plant species including four Great Lakes endemics; Pitcher's thistle (*Cirsium pitcheri*), Houghton's goldenrod (*Solidago houghtonii*), dwarf lake iris (*Iris lacustris*), and Michigan monkey-flower (*Mimulus glabratus* var. *michiganensis*.) The former three state and federal threatened species are known only from the Great Lakes, while the latter, a state and federal endangered species, is Michigan's only true endemic plant species, known nowhere else except Michigan. Seven of the only fourteen known occurrences of Michigan monkey flower occur on Lake Michigan shores. Although not a true endemic, state threatened Lake Huron tansy (*Tanacetum huronense)* is also found here, as are several additional rare plant species. Rare species, particularly the endemics, are rapidly gaining notoriety, as evidenced by the recent designation of dwarf lake iris as Michigan's state wildflower.

Viable coastal communities are critical for numerous animal species as well. Northern Michigan's Great Lakes shores are the only known nesting area in the Great Lakes basin for the federal and state endangered piping plover (*Charadrius melodus*) (Wemmer et al. 1997.) The Lake Huron locust (*Trimerotropis huroniana*), a Great Lakes endemic, is known only from high quality, sparsely vegetated coastal sand dunes of Michigan, Wisconsin, and Ontario. It is currently listed as state threatened, and has been recommended to the U. S. Fish and Wildlife Service for consideration as a federal listed species. One of the most endangered odonates in the country, Hine's emerald dragonfly (*Somatochlora hineana*), was recently discovered along Lake Michigan in the eastern Upper Peninsula, and a number of globally rare land snails were also recently found in a variety of habitats along the Upper Peninsula shoreline. These shores also serve as important migration corridors for large concentrations of migrant landbirds (Beebe 1933, Perkins 1964, and Hussel et al. 1992) and provide critical stopover habitat for Neotropical migratory birds (Ewert and Hamas unpubl. data 1993.) Several other rare and/or declining animal species are known to be associated with coastal habitats, and it is plausible that others will be found.

Systematic shoreline surveys by MNFI continue to yield additional occurrences of high quality natural communities and rare species (Reese et al, 1986, Albert et al 1988, 1989, 1994, 1995; 1997; Lee et al 1998; Penskar et al 1993, 1997, 1999, 2000.) They have also made very clear the unusually high degree of threat facing these natural features. Recreational and residential development of Great Lakes shoreline communities is occurring at an alarming rate. These development pressures are increasingly in conflict with the conservation of viable coastal communities and their component species. Recent investigation of cumulative impacts to shoreline natural features indicates that significant impacts are indeed occurring but are not easily detected by a case-by-case permitting process (Olson & Soule 1998.) Another finding of the cumulative impact investigation was that most shoreline development activity involved only local permits. Unlike state and federal

permitting processes, local permitting offices do not typically consider natural features. It also appears from our considerable experience in the coastal zone, that local, state, and federal rules and regulations regarding shoreline development are not always working in concert with one another, nor are they always consistently applied and enforced. A proactive approach is urgently needed to minimize the cumulative impact to shoreline communities by individual development activities. This requires not only the availability of current, accurate data on the location and status of significant shoreline features, but also getting that information into the hands of planners and others involved with critical land-use decisions at local, state, and federal levels.

This study was initiated as a pilot project to expand MNFI's mainland coastal zone survey work to include landowner contact and local planner outreach. The survey focus was also expanded to include targeted animal surveys in addition to natural community and plant surveys, similar to those that are being conducted on Great Lakes Island (Penskar et al. 1999.) MNFI has not previously conducted systematic animal surveys along large areas of mainland shoreline. A preliminary characterization of near-shore aquatic communities was also conducted using separate funds. The study area was chosen to encompass a region where there were evident survey gaps, significant private ownership, and particularly high development pressure based on a review of recent permitting activity. Landowner contact to request permission to access property was a prerequisite to all surveys. Data gathered during the study were processed into the statewide Biological Conservation Database (BCD) and mapped in the GIS-based database (Biotics) currently under development by The Nature Conservancy (TNC) and MNFI. Local planners were identified to receive these data in a format useful to them. A summary article about these data and their significance to landscape level planning was prepared for local newspapers.

The study was designed with the following goals:

- to survey and document shoreline occurrences of rare species and high quality natural communities
- to investigate how threatened and endangered species concerns are addressed at the local, state, & federal level in the study area
- to inform local landowners and planners of these significant shoreline features

It is hoped that this study will promote a more pro-active approach to conservation of the Great Lakes shoreline communities and component species.

Organization of Report

This report is organized according to the six major components of the project. **Landowner contact** was accomplished prior to survey of any land parcel. Follow-up occurred if requested both during the survey time and by distributing survey results at the project conclusion. **Animal surveys** emphasized migratory and breeding birds, and rare invertebrates. Surveys were conducted in three phases, two early and one late season. **Plant surveys** focused on Great Lakes shoreline endemics and were conducted in early and late season phases to best capture the array of targeted elements. **Natural community surveys** were accomplished while conducting the other survey components and focused on the relocation and status assessment of previously known occurrences, and the identification of additional high quality natural communities. **Aquatic surveys** focused on near shoreline (within 0.4 km/0.25 mi offshore) aquatic ecosystems. They were intended to characterize the aquatic communities as well as document any rare or declining aquatic organisms. **Local planner outreach** was accomplished both during the field survey period and at the project conclusion. Methods, results, and discussion are provided separately for each of the six components, followed by a section entitled **Summary and Recommendations**.

Since the study area was relatively small, it was possible, for the most part, to sample representative points along the entire shoreline region. Using these sample points in conjunction

with aerial photo interpretation and information on the natural feature occurrences documented during the study, site summaries were developed. In areas where access was limited, site characteristics were determined by aerial photo interpretation alone.

Site summaries are provided in the final section. The report is appended by various pertinent items referenced in the text, including several page abstracts for the major species and natural communities targeted during the study.

The Study Area

The study area for this pilot project was located in Schoolcraft County and included approximately 56 km (35 mi) of shoreline extending from Seul Choix Point, approximately 29 kms (18 mi) east of Manistique, to Point O'Keefe, approximately 27 kms (17 mi) south along the Garden Peninsula (Figure 1.) Several additional sites on the Garden Peninsula were targeted for breeding and migratory bird surveys. All survey sites are shown in Figures 2-4, and explained in the methods sections for each component of the report. The focus for animal, plant, and coastal communities, was from the water's edge to approximately 0.4 km (0.25 mi) inland. However, significant natural features that extended further inland were considered. Near shore aquatic communities were sampled in transects within 0.4 km of the shore. The majority of this area is in private ownership, except for an approximately 1.6 km (1 mi) section of the Lake Superior State Forest, a small township park, the cities of Manistique and Thompson, several roadside parks, and 3.2 km (2 mi) stretch of Department of Transportation right-of-way between Stony Point and the village of Thompson.

Methods for Landowner Contact

The Schoolcraft County Equalization Department in Manistique, provided names and addresses of landowners within 0.4 kilometer (0.25 mile) of the shoreline in the study area. These addresses were transferred to an Excel spreadsheet for use with Word Mailmerge. A landowner contact letter describing the project and requesting permission to survey was developed (Appendix A), and mailed to landowners during May 2000. Small plats in sub-divisions were excluded from the initial mailing due to the amount of time required to process them. Responses were coded according to response type and recorded on plat and topographic quad maps utilized during field surveys. Response types included yes, no, request to be present during survey, request to know when survey will occur, and/or request survey results. The responses were collated and retained with the quad maps for reference during surveys, if needed. Additionally, they were recorded and tallied in the Excel table. Due to the relatively low initial response rate and the identification of survey gaps in high priority areas where small plats were located, a second mailing was conducted in July to capture additional landowners. Landowner contact was also conducted occasionally in high priority sites during late season surveys by knocking on doors, talking with landowners face-to-face and requesting permission to survey. Interactions with landowners were also used as an opportunity to educate them about the significance of the shoreline and specific stewardship activities that could be implemented. At the project conclusion, a letter documenting the survey results was sent to all landowners that requested them.

Results of Landowner Contact

Of the 273 letters that were sent out to landowners, 93 responses were received, 85 positive and 8 negative. This corresponds to a 34% total return rate, 91% of which were positive. Of the landowners that responded positively, 35% requested to be notified and/or present during the survey of their property and 25% requested a copy of the survey results (Table 1.) Direct contact was

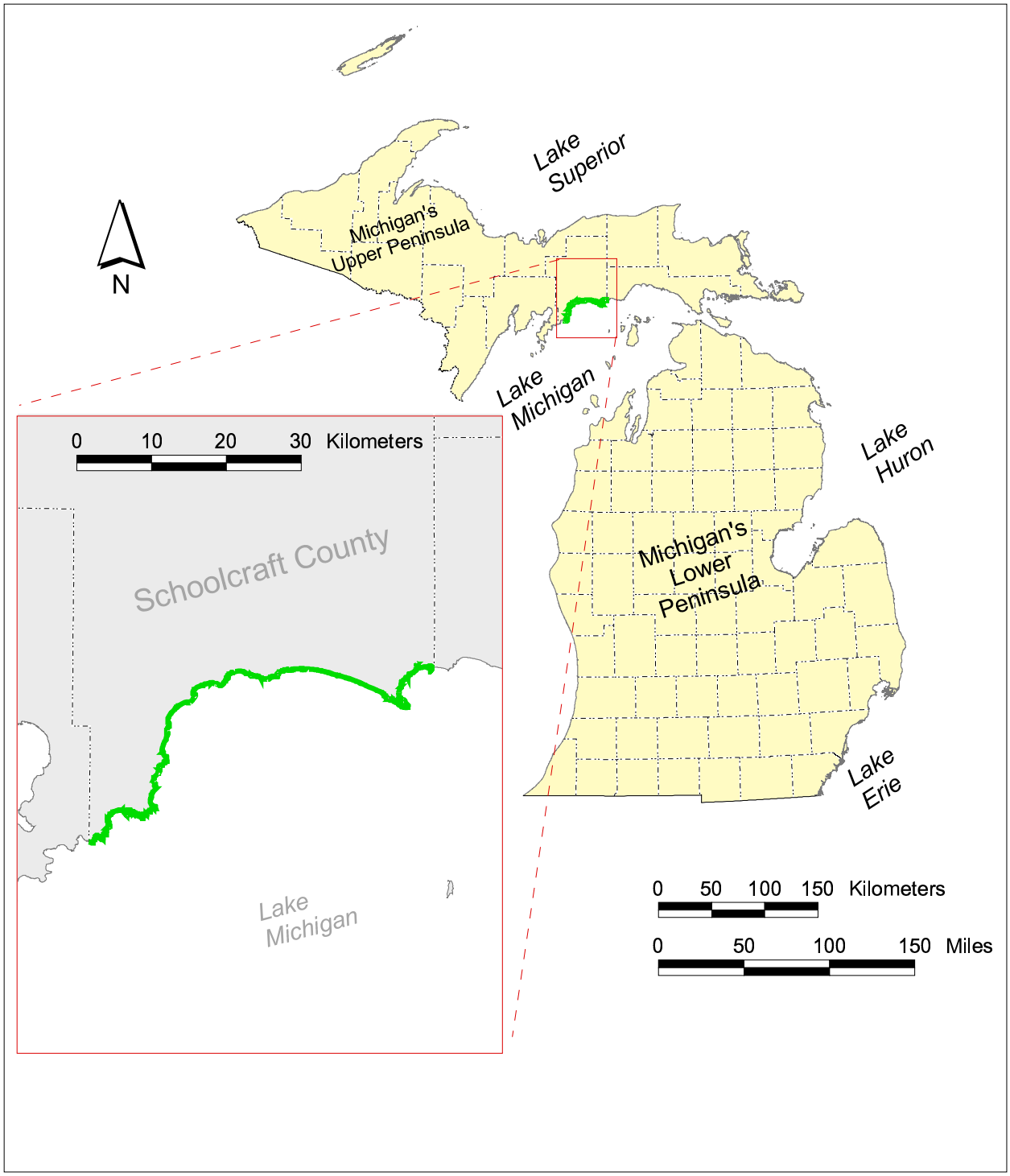

Figure 1. Location of study area.

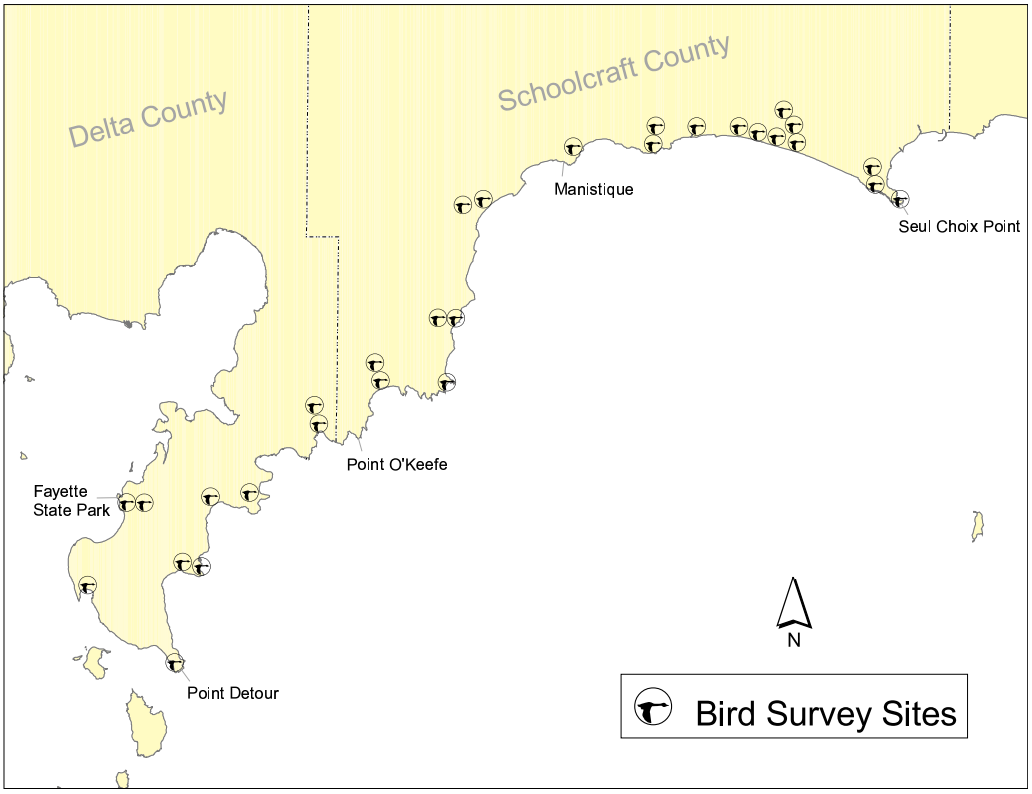

Figure 2. Breeding and migratory bird point count sites.

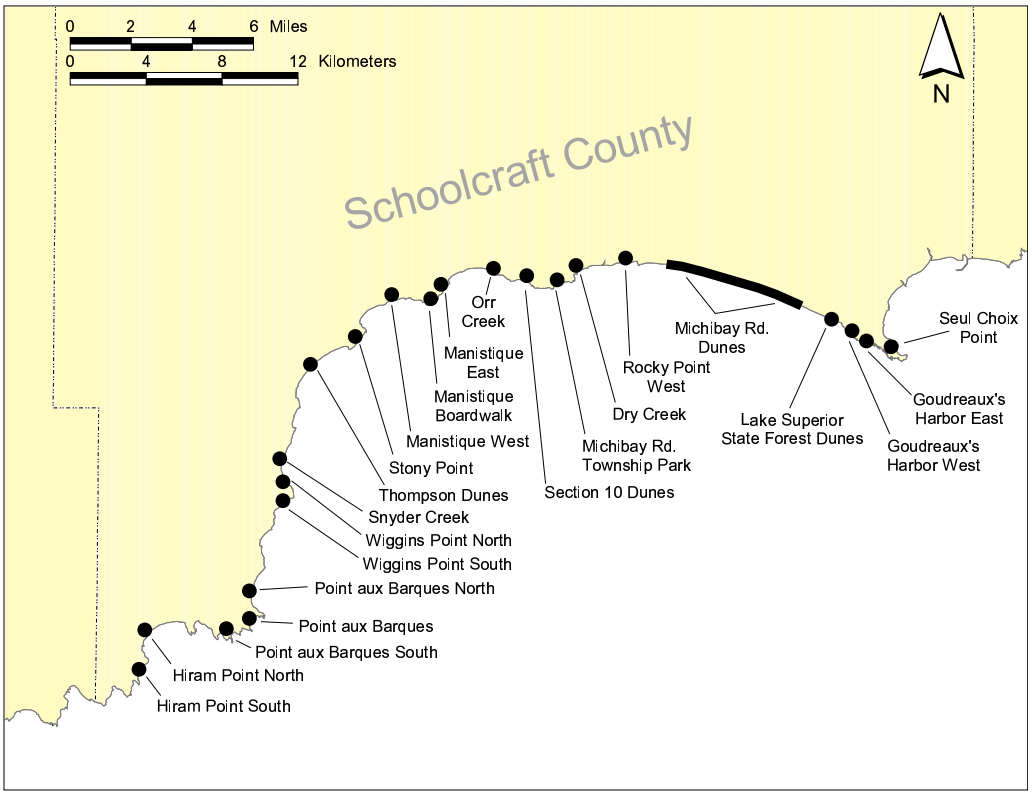

Figure 3. Survey sites for plant and animal surveys.

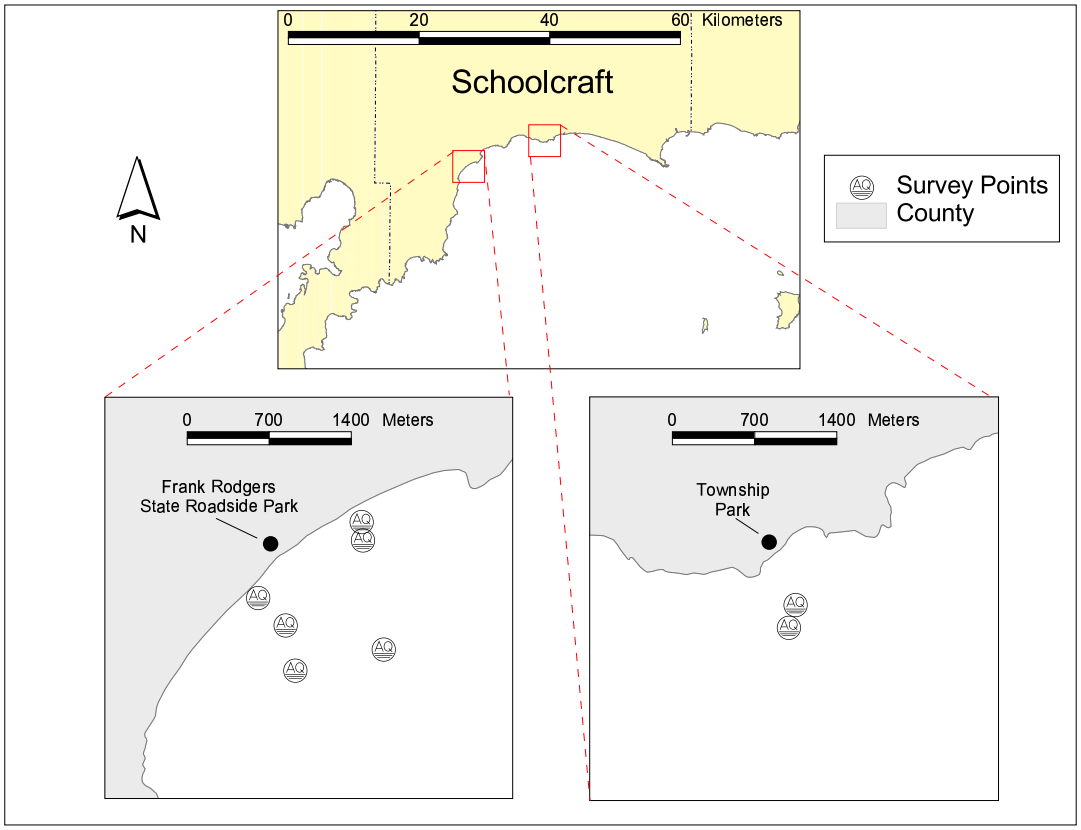

Figure 4. Transect locations for Aquatic Community Characterization.

made with several additional landowners that had not responded to either mailing, all of whom granted permission to survey. A fourth individual was contacted but did not own the land and was unable to grant permission. A total of 55 (62%) shoreline properties with permission to access were surveyed. A comparison of land ownership shown on plat maps downloaded from the internet with the landowner list provided by The Equalization Department shows that land ownership has changed considerably. In addition to changes from one landowner to another, many new parcels of land had been sold, and many more were put on the market during the course of this study.

Table 1. Summary of Landowner Responses.

Response	Total responses	Requested to be notified or present during survey	Requested survey results	Number of properties surveyed
Mail				
Positive	85	30	21	52
Negative	8	*na	na	0
Face-to-face				
Positive	3	na	0	3
Negative	**1			

*not applicable

**person contacted unable to grant permission because not owner of property

Discussion of Landowner Contact

As is apparent from the number of landowners contacted, the response rate, and the variety of responses, landowner contact complicates survey efforts. It requires a considerable amount of time to identify and develop a current database of landowners, to write and mail letters and results, and to track responses. While three days were budgeted for this component of the project, the actual time spent on these tasks was at least double that. Additional time was also required to re-contact landowners to notify them of survey dates, if requested, and to determine their availability if they wanted to be present during the survey. The limited response rate also complicated the survey process by restricting access, thus making it very difficult to survey large areas of contiguous shoreline in an efficient manner. Instead, the surveys were accomplished primarily property-by-property, and in many cases only when landowners were available.

The percentage of actual properties surveyed reflects similar complications. Scheduling of surveys to accommodate landowners was difficult and sometimes impossible due to the fact that many landowners visited their property infrequently, and not necessarily during the optimal survey windows for targeted elements. Accessing individual properties that were spaced far apart was more time consuming than simply walking a designated stretch of shoreline. This limited the number of properties that could be surveyed during the allotted survey time. An additional unanticipated factor encountered primarily on the Garden Peninsula, was the number of locked gates at common entrance roads, accompanied by "no trespassing" signs. Because the houses were often far inland from the entrance road, and many landowners were absent, it was difficult to find anyone who could unlock the gates. Access was therefore limited in several stretches of shoreline along the Garden Peninsula.

Despite these shortcomings, landowner contact is essential to ensure the long-term success of this type of outreach. Not only is it necessary to get permission to access properties, it provides an opportunity for landowner education about significant natural features. Without knowledge and understanding of natural features, appropriate stewardship practices are not likely to be implemented.

Although the overall response rate (34%) was low, this does not necessarily mean there was a lack of interest. On more than one occasion, individuals who did not respond by mail, allowed access when approached directly. To improve the positive response rate, a combined outreach strategy involving initial mailings followed by telephone and/or face-to-face contact for landowners who do not respond, is recommended. Several other MNFI projects have utilized this combination approach with considerable success. This approach requires more time. However, if funding is limited, landowner contact could be targeted to the highest priority areas, while ensuring some coverage over the entire study area.

Most landowners that were communicated with directly during the study were interested in the natural features on their property and concerned about maintaining them. Some were quite knowledgeable of the features on their property and were glad to have stewardship ideas reinforced. Because education of all those who use the coastal zone is critical to the long-term sustainability of Michigan's shoreline features, it is recommended that several public meetings be held. Participants would be informed of what is significant and why, and what they can do to help. It would also be useful to supply landowners with polished booklets for each shoreline rarity and natural community, providing practical stewardship advice.

The establishment of a network of natural resource professionals and stakeholders to maintain a local, long-term presence is also recommended. Their purpose would be to initiate a dialogue focusing attention on protection of Michigan's shoreline communities is also recommended. This group should be comprised of individuals from all levels of government and the private sector. This would help ensure the integration of natural features concerns into the planning process and bridge the gaps resulting from changes in land ownership. This recommendation is discussed further in the Local Planner Outreach component of this report.

Methods for Animal Inventory

Neotropical migratory and breeding birds and rare invertebrates endemic or largely associated with the Great Lakes region were the primary targets of animal surveys for this study. The Natural Heritage Biological and Conservation Database (BCD) was consulted for known occurrences of rare animal species within the study area and throughout the Garden Peninsula. Information on species was gathered by consulting expert zoologists and wildlife biologists, pertinent unpublished reports, and a variety of published sources. Survey sites for each target species or group were selected based upon historical occurrence records, air photo interpretation, land cover maps, and consultation with individuals knowledgeable about this section of shoreline. MNFI ecologists and botanists also identified potential survey sites.

A field schedule was developed based on prior Michigan observation and collection dates for each animal group or species and the extent of suitable habitat within the study area. Survey techniques varied according to species groups and are described in the following sections. Incidental observations of listed species, which have been designated under the federal Endangered Species Act and/or state endangered species legislation as endangered, threatened, or special concern status, were noted by all project staff when they occurred. Data from all sightings of listed animal species were recorded on MNFI field forms, including numbers of individuals observed and the extent and quality of occupied habitat. These data were then entered into the statewide BCD and digitized in Biotics, a GIS-based mapping program.

Birds

Bird counts were conducted using a point count method outlined by Ralph et al. (1993, 1995) at 30 sites located at least 250 m apart along the northern Lake Michigan shoreline (Figure 2.) All birds observed or heard within a 50-meter (164 feet) radius were tallied for 5 minutes during spring migration and for 10 minutes during the breeding season. Birds observed or heard outside the 50-meter radius circle were noted, but not included in species richness and abundance analyses. Spring migration bird counts were conducted between sunrise and 1200 hr on 20-21 May 2000. Breeding bird counts were conducted between sunrise and 1100 hr on 19-20 June 2000. All counts were conducted when there was no precipitation and minimal or no wind. Standard field forms for point counts were used.

Survey sites were chosen to capture a variety of shoreline and interior habitats after examining aerial photos, topographic maps, plat maps, and consulting with biologists who had conducted surveys in the area. Nineteen rocky, sandy, developed, and non-developed shoreline sites within 0.4 km (0.25 mi) of the high water mark and 11 inland sites bordering lakes, wetlands, and streams between 0.4 km and 1.6 km (1.0) of the high water mark were sampled. Overall mean abundance and species richness was calculated and compared for the migratory and breeding bird sample periods. The mean number of observations of each species was identified for each sample period by totaling the number of observations and dividing by the number of stations sampled, for each species. Species with a mean number of 10 or more were identified as dominant species.

An informal assessment of habitat use by migratory and breeding birds was also conducted by comparing mean bird abundance and species richness of shoreline versus interior sites. The sample sites were classified by community type and listed in the results, however, the study was not designed to analyze these data further. To assess the importance of the Garden Peninsula as a stopover site for migratory and breeding birds, 10 sites located on the Garden Peninsula but outside of the formally designated study area, were included as sample points. These sites were located from Point O'Keefe south to the tip of the peninsula and then north to Fayette State Park on the west side (Figure 2.) Of the total sample sites, these ten plus five within the study area were located on the Garden Peninsula. The remaining

15 were located on the mainland, east of the peninsula. Mean abundance and species richness was compared for peninsula and non-peninsula sites.

Suitable habitat was inventoried and surveyed for active nests of several state and/or federal listed species in June. State and federal endangered piping plover *(Charadrius melodus)*, and state threatened common tern *(Sterna hirundo)* and Caspian tern *(Sterna caspia)* were targeted along the shoreline in bare, gravelly, sandy sites. State special concern Forster's tern *(Sterna foresteri)*, American bittern *(Botaurus lentiginosus)*, and black tern *(Chlidonias niger* were targeted in interior marshes.

Invertebrates

Surveys for rare invertebrates focused on the Lake Huron locust due to the predominance of appropriate habitat within the project area. Rare land snails have been documented recently in the study area (Nekola 1998), however, due to limited project funding and time-consuming survey methods (e.g., most are <3.0 mm long), they were not inventoried during this study. The previous survey for land snails was reviewed and documented occurrences and preferred habitats are summarized by species in the results section. Appropriate habitat for land snails was noted during field surveys and also summarized in the results. The state special concern dune cutworm moth (*Papaipema aweme*) has been documented at one location along the northern Lake Michigan shoreline, but was not surveyed due to limited project funding and inadequate understanding of this species' ecology and habitat needs. Suitable habitat for other rare invertebrates, such as the Hine's emerald dragonfly, did not appear to be present within the study area.

Locust surveys focused on the reconfirmation and determination of extent of known populations, and identification of new populations. Six occurrences of the locust had been previously documented within the study area (Scholtens and Holland 1997), however these surveys focused mainly on sites with public access. Surveys in the current study were conducted on both public and private lands at or near known sites, in suitable habitat between known sites, and in other areas of suitable habitat not previously surveyed. Thirty-five parcels were surveyed, ranging in length of shoreline from about 60 meters (200 ft) to 1.6 km (1 mi), and separated by up to 4 km (2.5 mi.) Only properties where permission had been granted were surveyed.

The locust surveys were conducted from 27-31 August 2000 by walking through areas of suitable habitat and searching for adults in flight or perched on open sand. The number of adults observed, search time, general weather conditions and habitat conditions were noted. At new locations, voucher specimens were collected with an aerial net. Photographs were taken of each survey site and adjacent habitat.

Element occurrence specifications developed by TNC were used to determine whether observations of the Lake Huron locust were updates of known populations, or whether they constituted new populations. Observations of this species within a contiguous habitat and not separated by a major habitat discontinuity[1] or 1 km (0.6 mi) of apparently unoccupied habitat constitute a single element occurrence or population of this species (Whittaker 1994.) New occurrences were evaluated and ranked for population viability, ranging from excellent or good, to fair or poor viability, or not viable. These ranks are based on relative abundance, quantity and quality of available habitat, and degree of threat at a given site. Appendix B provides details of rank definitions. Previously known populations were updated and re-ranked if necessary.

[1] >0.2 kilometer (0.10 mi.) of rock pavement or outcrop, forested shoreline, wet sand, northern fen or wetland with no dunes nearby.

Results of Animal Inventory

Birds

One hundred sixteen different bird species were observed during the study (Table 2) including 98 species during spring migration, and 93 during the summer breeding season. Forty-eight species are classified as long distance migrants that winter south and breed north of the Tropic of Cancer. Forty-seven species are considered short distance migrants that winter in the southern U.S. and northern Mexico and breed in the U.S. and Canada. Twenty-one species are considered resident birds that winter and breed in the same region.

Table 2. Bird species recorded during migration and breeding season (2000), along the northern Lake Michigan shoreline, from Seul Choix Point (Schoolcraft County) to Fayette State Park (Delta County.) State listed species are in bold type.

Common Name	Scientific Name	Migration	Breeding
Long Distance Migrants			
Blue-winged teal	Anas discors	X	
Osprey (T)	**Pandion haliaetus**	**X**	**X**
Broad-winged hawk	Buteo platypterus	X	X
Black-bellied plover	Pluvialis squatarola	X	
Spotted sandpiper	Actitis macularia	X	
Caspian tern (T)	**Sterna caspia**	**X**	**X**
Yellow-billed cuckoo	Coccyzus americanus		X
Whip-poor-will	Caprimulgus vociferus	X	
Chimney swift	Chaetura pelagica		X
Ruby-throated hummingbird	Archilochus colubrus	X	
Eastern wood-pewee	Contopus virens	X	X
Yellow-bellied flycatcher	Empidonax flaviventris		X
Alder flycatcher	Empidonax alnorum		X
Least flycatcher	Empiodonax minimus	X	X
Great crested flycatcher	Myiarchus crinitus	X	X
Eastern kingbird	Tyrannus tyrannus	X	X
Northern rough-winged swallow	Stelgidopteryx serripennis		X
Bank swallow	Riparia riparia	X	X
Barn swallow	Hirundo rustica	X	
House wren	Troglodytes aedon		X
Veery	Catharus fuscescens		X
Swainson's thrush	Catharus ustulatus		X
Wood thrush	Hylocichla mustelina	X	
Gray catbird	Dumatella carolinensis	X	X
Blue-headed vireo	Vireo solitarius	X	X
Warbling vireo	Vireo gilvus	X	
Red-eyed vireo	Vireo olivaceus	X	X
Tennessee warbler	Vermivora peregrina	X	
Nashville warbler	Vermivora ruficapilla	X	X
Northern parula	Parula americana	X	X
Yellow warbler	Dendroica petechia	X	
Chestnut-sided warbler	Dendroica pensylvanica		X
Magnolia warbler	Dendroica magnolia	X	X
Black-throated green warbler	Dendroica virens	X	X
Blackburnian warbler	Dendroica fusca	X	X
Bay breasted warbler	Dendroica castanea		X

Table continues

Common Name	Scientific Name	Migration	Breeding
Black-and-white warbler	Mniotilta varia	X	X
American redstart	Setophaga ruticilla	X	X
Ovenbird	Seiurus aurocapillus	X	X
Northern waterthrush	Seiurus novaboracensis	X	X
Mourning warbler	Oporornis philadelphia		X
Common yellowthroat	Geothylpis trichas	X	X
Canada warbler	Wilsonia canadensis	X	X
Scarlet tanager	Piranga olivacea	X	X
Rose-breasted grosbeak	Pheuticus ludovicianus	X	
Indigo bunting	Passerina cyanea	X	X
Chipping sparrow	Spizella passerina	X	X
Bobolink	Dolichonyx oryzivorus	X	X
Short Distance Migrants			
Common loon (T)	**Gavia immer**	**X**	**X**
Double-crested cormorant	Phalacrocorax auritus	X	X
Great blue heron	Ardea herodias	X	X
Canada goose	Branta canadensis	X	X
Common merganser	Mergus merganser	X	X
Red-breasted merganser	Mergus serrator		X
Turkey vulture	Cathartes aura	X	
Northern harrier (SC)	**Circus cyaneus**	**X**	**X**
Red-shouldered hawk (T)	**Buteo lineatus**	**X**	
American kestrel	Falco sparverius	X	X
Sandhill crane	Grus canadensis	X	X
Killdeer	Charadrius vociferus	X	X
Dunlin	Calidris alpina	X	
Mourning dove	Zenaida macroura	X	X
Belted kingfisher	Ceryle alcyon	X	X
Red-bellied woodpecker	Melanerpes carolinus	X	
Yellow-bellied sapsucker	Sphyrapicus varius	X	
Northern flicker	Colaptes auruatus	X	X
Eastern phoebe	Sayornis phoebe	X	X
Tree swallow	Tachycineta bicolor	X	X
Brown creeper	Certhia americana	X	X
Winter wren	Troglodytes troglodytes	X	X
Ruby-crowned kinglet	Regulus calendula	X	X
Eastern bluebird	Sialia sialis	X	X
Hermit thrush	Catharus guttatus	X	X
American robin	Turdus migratorius	X	X
Northern mockingbird	Mimus polyglottos	X	
Brown thrasher	Toxostoma rufum	X	
Cedar waxwing	Bombycilla cedrorum		X
Myrtle warbler	Dendroica coronata	X	X
Pine warbler	Dendroica pinus	X	
Eastern towhee	Pipilo erythrophthalmus		X
Vesper sparrow	Pooecetes gramineus	X	
Savannah sparrow	Passerculus sandwichensis	X	X
Le Conte's sparrow	Ammodramus leconteii		X
Fox sparrow	Passerella iliaca		X

Table continues

Common Name	Scientific Name	Migration	Breeding
Common grackle	*Quiscalus quiscula*	X	X
Brown-headed cowbird	*Moluthrus ater*	X	X
Pine siskin	*Cardeulis pinus*	X	
American goldfinch	*Carduelis tristis*	X	X
Evening grosbeak	*Coccothraustes vespertinus*		X
Residents			
Mallard	*Anas platyrynchos*	X	X
Bald eagle (T)	***Haliaeetus leucocephalus***	**X**	**X**
Sharp-shinned hawk	*Accipiter striatus*	X	X
Northern goshawk (SC)	***Accipiter gentilis***	**X**	
Ruffed grouse	*Bonasa umbellus*	X	
Wild turkey	*Meleagris gallopavo*	X	X
Ring-billed gull	*Larus delawarensis*	X	X
Herring gull	*Larus argentatus*	X	X
Rock dove	*Columba livia*	X	X
Downy woodpecker	*Picoides pubescens*	X	X
Hairy woodpecker	*Picoides villosus*		X
Pileated woodpecker	*Drycopus pileatus*	X	X
Blue jay	*Cyanocitta cristata*	X	X
American crow	*Corvus brachyrhncos*	X	X
Common raven	*Corvus corax*	X	X
Black-capped chickadee	*Parus atricappilus*	X	X
Red-breasted nuthatch	*Sitta canadensis*	X	X
White-breasted nuthatch	*Sitta carolinensis*	X	X
Golden-crowned kinglet	*Regulus satrapa*	X	X
Eurasian starling	*Sturnus vulgaris*	X	X
Purple finch	*Carpodacus purpueus*	X	X
(T) State Threatened		**5**	**4**
(SC) Special Concern		**2**	**1**
TOTAL		98	93

Mean bird abundance during spring migration was 8.73 ± 1.16 birds (95% confidence level) and mean species richness was 6.00 ± 0.62 species (95% confidence level) (Table 3.) During this sample period, the American redstart, black-throated green warbler, American robin, ovenbird, myrtle warbler, chipping sparrow, and northern parula were identified as dominant species.

Mean bird abundance during the summer breeding season was the same as during migration at 8.73 ± 1.06. The confidence level varied only slightly. Mean species richness was 6.30 ± 0.69 species (95% confidence level) (Table 4.) The American redstart, black-throated green warbler, ovenbird, red-eyed vireo, myrtle warbler, American robin, and golden crowned kinglet were identified as dominant species.

Table 3. Mean bird abundance, species richness, and dominant species recorded during the 2000 spring migration along the northern Lake Michigan shoreline.

	95% Confidence Level	Dominant Species (listed in order of most to least dominant)
Mean Bird Abundance	8.73 ± 1.16	American Redstart Black-throated Green Warbler
Mean Species Richness	6.00 ± 0.62	American Robin Ovenbird Myrtle Warbler Chipping Sparrow Northern Parula

Table 4. Mean bird abundance, species richness, and dominant species recorded during the 2000 breeding season along the northern Lake Michigan shoreline.

	95% Confidence Level	Dominant Species (listed in order of most to least dominant)
Mean Bird Abundance	8.73 ± 1.06	American Redstart Black-throated Green Warbler
Mean Species Richness	6.30 ± 0.69	Ovenbird Red-eyed Vireo Myrtle Warbler American Robin Golden-crowned Kinglet

Mean bird abundance in May at Garden Peninsula sites was 8.9 ± 1.6 compared to 8.6 ± 1.8 at non-peninsula sites (Table 5.) Mean bird abundance in June at Garden Peninsula sites was 9.3 ± 1.8 versus 8.1 ± 1.3 at non-peninsula sites. Mean species richness during May for birds at Garden Peninsula sites was 6.3 ± 0.9. This was higher than non-peninsula sites during the same time, which was 5.7 ± 1.0. Mean species richness for both Garden Peninsula sites and non-peninsula sites was the same in June at 6.3 ± 1.1 and 6.3 ± 1.0 respectively.

Table 5. Mean bird abundance and species richness recorded for all birds observed at Garden Peninsula point count sites versus non-peninsula sites.

	Garden Peninsula sites (95% Confidence Level)	Non-peninsula sites (95% Confidence Level)
Mean Bird Abundance	8.9 ± 1.6 (May)	8.6 ± 1.8 (May)
	9.3 ± 1.8 (June)	8.1 ± 1.3 (June)
Mean Species Richness	6.3 ± 0.9 (May)	5.7 ± 1.0 (May)
	6.3 ± 1.1 (June)	6.3 ± 1.0 (June)

For an indication of site preference by short and long distance migrants, mean bird abundance and mean species richness at Garden Peninsula and non-peninsula sites was calculated for migrants only (no resident birds included.) Mean bird abundance in May at Garden Peninsula sites was 7.7 ± 1.7 compared to 7.6 ± 1.6 at non-peninsula sites (Table 6.) Mean bird abundance in June was higher on Garden Peninsula sites versus non-peninsula sites, at 8.4 ± 1.8 compared to 7.2 ± 1.2. Mean species richness was slightly higher in May and June at Garden Peninsula sites.

Table 6. Mean bird abundance and species richness recorded for migrants (no resident birds) observed at Garden Peninsula point count sites versus non-peninsula sites.

	Garden Peninsula sites (95% Confidence Level)	Non-peninsula sites (95% Confidence Level)
Mean Bird Abundance	7.7 ± 1.7 (May)	7.6 ± 1.6 (May)
	8.4 ± 1.8 (June)	7.2 ± 1.2 (June)
Mean Species Richness	5.3 ± 0.8 (May)	4.9 ± 0.7 (May)
	5.7 ± 1.1 (June)	5.5 ± 0.9 (June)

During migration, bird abundance was greater at shoreline sites compared to interior sites (Figure 5.) Species richness was also slightly higher (Figure 6.) In contrast, during breeding season, bird abundance and species richness was greater at interior sites (Figure 5 and 6.) Shoreline habitats included boreal forest, wooded dune and swale complex, mesic northern forest, poor conifer swamp (black spruce, tamarack, and/or balsam fir dominated), rich conifer swamp (cedar dominated), or northern fen. Over half of the 19 shoreline sites were either in boreal forest or wooded dune and swale complexes. Interior habitats included: mesic northern forest, wooded dune and swale complex, boreal forest, northern shrub thicket, alvar opening, poor conifer swamp, or rich conifer swamp. Mesic northern forest was most commonly encountered at interior sites, followed by boreal forest and wooded dune and swale complexes. A summary of the different community types sampled, and the number of each is provided in Table 7.

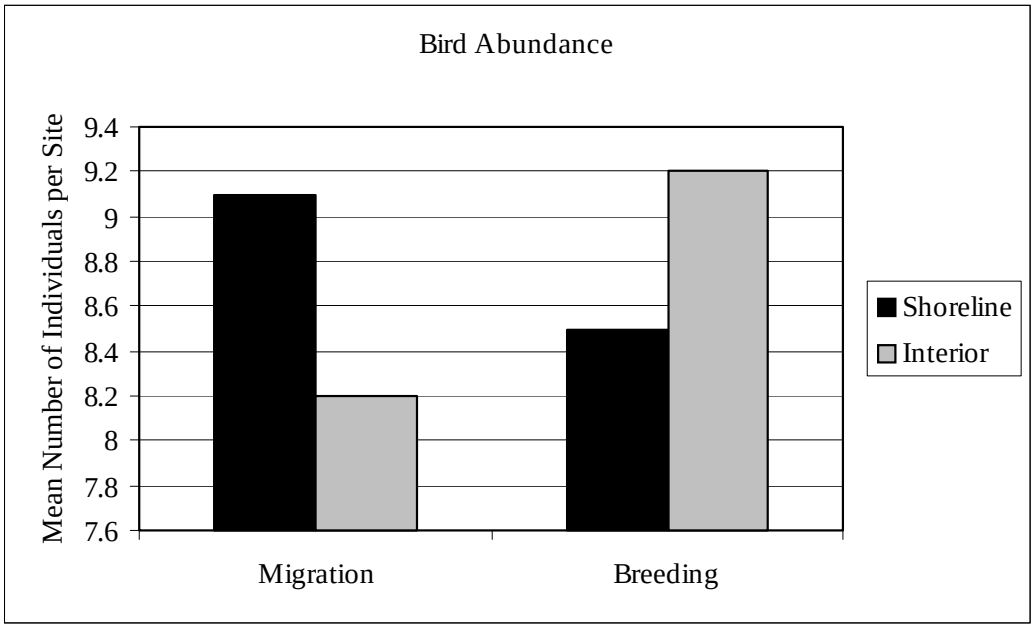

Figure 5. Comparison of mean breeding abundance at shoreline and interior sites.

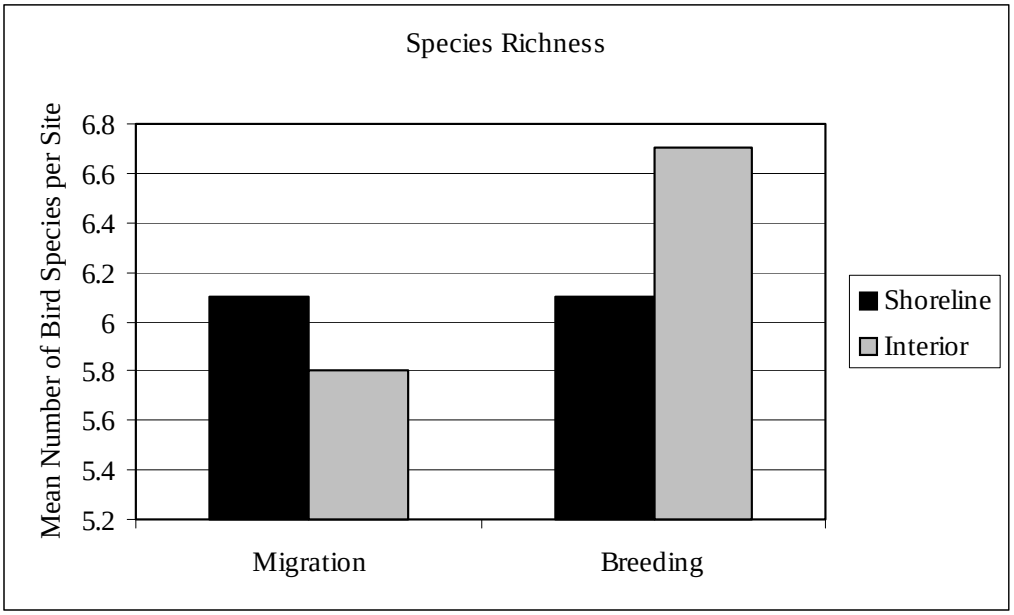

Figure 6. Comparison of mean species richness at shoreline and interior sites.

Table 7. Natural communities sampled for migratory and breeding birds.

Natural community	Number of sites surveyed
Boreal forest	10
Wooded dune and swale	8
Mesic northern forest	5
Poor conifer swamp	2
Rich conifer swamp	2
Northern shrub thicket	1
Northern fen	1
Alvar opening	1
Total	30 sites

No rare birds were observed during the nest surveys, however individuals of seven listed species were observed in the study area. Observations at the point count stations during migration included an osprey flying overhead, several Caspian terns foraging along the shoreline, and three common loons in Lake Michigan. Species observed outside of point count sites (e.g. while driving to sites in the evening) during migration included bald eagles, a red-shouldered hawk, northern harrier, and northern goshawk. Observations during the breeding season included an adult osprey in a nest on top of a utility pole and several Caspian terns foraging along the shoreline. Other listed species observed outside of point count sites include common loons, bald eagles, and a northern harrier.

One occurrence of piping plover had been known to occur west of Seul Choix Point, within an 8 km (5 mi) stretch of beach from the point, but was not observed during this study. Surveys for listed inland marsh birds were not productive. The interdunal wetlands dominating the interior portions of the study area where access was granted were generally smaller than is typically preferred by these species.

Invertebrates

Lake Huron locust

The Lake Huron locust was found at 26 of the 35 properties surveyed for this species. These observations resulted in the identification of three new populations and confirmation of the six previously known populations, four of which were expanded. Table 8 lists the nine occurrences of the Lake Huron locust delineated during this study.

Table 8. Occurrences of the Lake Huron locust along the Lake Michigan shoreline in Schoolcraft County from Seul Choix Point to Point O'Keefe.

Site Name	Status of EO	Population Viability Rank*
Lake Superior State Forest Dunes	*New*	*BC*
Michibay Rd. Dunes	*Update*	*BC*
Rocky Point West	*New*	*C*
Michibay Township Park	*Update*	*BC*
Section 10 Dunes	*New*	*C*
Manistique East	*Update*	*D*
Stony Point South	*Update*	*CD*
Wiggins Point	*Update*	*C*
Wiggins Point South	*Update*	*D*

Mapped representations of the nine occurrences of Lake Huron locust, as projected through Biotics, are shown in Figure 7. Since a global positioning system (GPS) unit was not utilized to precisely locate these populations, these polygons should be viewed as representations of the approximate location and currently known extent of populations. They should not be construed as definitive documentation of the occurrence of this species on specific properties. Properties containing the Lake Huron locust that were separated by approximately 0.2 km (0.10 mi) or less of contiguous suitable habitat and considered part of the same element occurrence were mapped within the same polygon, thereby including adjacent properties that were not specifically surveyed. Properties containing the locust that were separated by larger distances of contiguous, suitable habitat and still considered part of the same element occurrence were mapped as separate polygons. The polygon representations include a buffer indicating the level of locational uncertainty. Polygons that represent updates of known occurrences incorporate information from previous surveys and may not represent areas that were surveyed as part of the current study. The resulting Lake Huron locust sites ranged in known extent from approximately 0.24 to 2.0 km (0.15 to 1.25 mi.)

Based upon information from the current and previous studies (Scholtens and Holland 1997), and viability ranking specifications across the species' range, most of the Lake Huron locust populations were assessed as having fair, or good to fair viability (see Appendix B for rank definitions.) The number of individuals observed per site ranged from about 1 to 16 individuals per hour. The amount of available habitat per site, based on habitat surveyed, was estimated to range from less than 405 square meters (0.10 acre) to about 0.16 square km (40 acres.) Some sites contained additional habitat that was not surveyed and not included in these estimates. Habitat quality at most of the sites was good to excellent. Six of the nine populations (i.e., Michibay Road Dunes, Rocky Point West, Manistique East, Stony Point South, Wiggins Point North and Wiggins Point South) were evaluated as experiencing some level of threat primarily due to

residential development. The other three populations (i.e., Lake Superior State Forest Dunes, Michibay Road Township Park, and Section 10 Dunes) were located in areas that are currently subject to minimal threat and show little habitat degradation. The Lake Superior State Forest Dunes, Michibay Road Dunes and Michibay Road Township Park populations ranked highest in population viability, followed by Rocky Point West, Section 10 Dunes and Wiggins Point North. All of these sites except for Wiggins Point North occur east of Manistique.

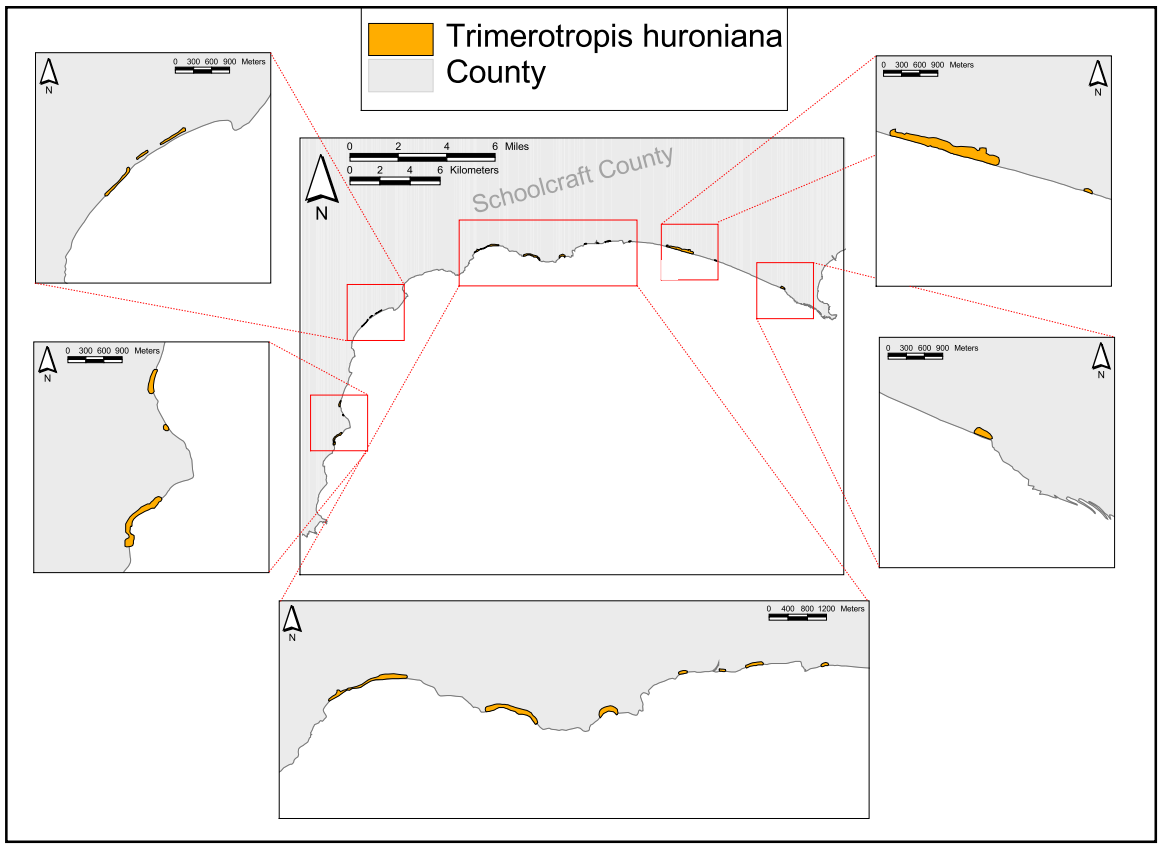

Figure 7. Biotics representation of Lake Huron locust occurrences.

Most of the surveyed parcels where locusts were not observed did not contain suitable open dune habitat. These properties were generally characterized by flat sand beach, wet sand or rock, and were located at Wiggins Point, north of Thompson and south of Point aux Barques along the Garden Peninsula. Manistique West contained the only surveyed property where suitable habitat was present, but the locust was not observed. This site was located between Stony Point and Manistique.

Land Snails

Surveys conducted in 1998 documented 25 species of rare land snails at two sites just west of Seul Choix Point in Schoolcraft County, and an additional 11 species along the east side of the Garden Peninsula in Delta County (Nekola 1998.) The former species were documented within the current study area. Five of these were recently listed as state special concern, including *Euconulus*

alderi, *Vertigo elatior*, *Planogyra asteriscus*, *Vertigo hubrichti* and *Vertigo paradoxa*. The first two species were found within a cobble beach community and the latter three in an adjacent upland cedar forest over shallow limestone. Appendix C provides a crosswalk between community names used by Nekola and those of MNFI's natural community classification.

Euconulus alderi was first discovered in North America in 1986, and is known from only 10 sites in Michigan's Upper Peninsula along the Lake Michigan-Lake Huron shoreline and the tip of the Keewenaw Peninsula (Nekola 1998.) This species is most frequently encountered in tamarack-sedge communities, although it also has been found in fens, cobble beaches, and white cedar wetlands along the shoreline. *Vertigo elatior* appears to be restricted to high quality calcareous wetlands underlain with limestone including fens, cobble beaches, alvars, and tamarack-sedge and white cedar wetlands. *Planogyra asteriscus* is most frequently found in white cedar wetlands but also has been documented from fens, lakeshore limestone/dolomite ledges, lakeshore alluvial banks, and rocky woodlands. *Vertigo hubrichti* was first discovered in Michigan in 1998. This glacial relict inhabits limestone/dolomite cliffs, lakeshore limestone/dolomite ledges, alvars, and rocky woodlands, characteristic of the Garden Peninsula, and is known from only 14 sites in Michigan. Finally, *Vertigo paradoxa* is generally limited to limestone/dolomite rock outcrop communities including limestone/dolomite cliffs, igneous rock outcrops, lakeshore limestone/dolomite ledges, rocky woodlands, tamarack-sedge wetlands and igneous bedrock shorelines. This species has a fairly limited range within the U.S., and more populations have been found in Michigan's Upper Peninsula than in any other state (Nekola 1998.)

Some researchers have recommended federal protection for *Vertigo hubrichti* and *Vertigo paradoxa* due to their rarity and fragility of their habitats (Frest 1991, Frest and Johannes 1991.) Eleven survey sites were identified in the study area that contain potential habitat for these special concern species (Table 9.) Additional microhabitats likely occur within the boreal forest that spans much of the inland study area.

Table 9. Sites with potential habitat for land snails.

Site Name	Description
Seul Choix Point	limestone pavement lakeshore
Goudreaux's Harbor East	limestone pavement lakeshore
Goudreaux's Harbor West	limestone pavement lakeshore
Rocky Point West	limestone pavement lakeshore
Dry Creek	limestone pavement lakeshore
Section 10 Dunes	limestone pavement lakeshore
Stony Point	limestone pavement lakeshore
Point aux Barques	limestone pavement lakeshore
Point aux Barques South	limestone pavement lakeshore, northern fen
Hiram Point	limestone pavement lakeshore, northern fen
Hiram Point South	limestone pavement lakeshore, northern fen

Discussion of Animal Inventory

Birds

The first year of bird work along the northern Lake Michigan shoreline resulted in the documentation of 98 migratory species, and 93 breeding species, showing that the area provides important stopover and nesting habitat. When and where a migrant makes a stopover, and the length of time spent at a particular site, depends on several factors, including condition of the bird (especially the amount of fat reserves), weather, wind direction, availability of a suitable place to land, and habitat quality. Birds must arrive at breeding grounds with sufficient fat reserves in order to establish a breeding territory, attract a mate, raise young, and stay alert to predators. Without

adequate food, water, and shelter along the way, birds can suffer lower reproductive success (Deinlein, no date.) The difference between whether the birds stay or quickly move on, and whether those that stay gain weight or not, is due primarily to the quality of the habitat, which in turn, is affected by the level of disturbance. Observations during this study confirm a rapid pace of development in the coastal zone, resulting in increased loss and degradation of coastal habitats. It is essential that viable coastal communities be maintained in order to sustain the variety and abundance of migratory and breeding birds that currently inhabit northern Lake Michigan's lakeshores.

In their 1993 research (unpubl.), Ewert and Hamas note that spring migrants often arrive in Michigan before the leaves on trees have fully emerged. Consequently, lepidopteran larvae, which are a primary source of food for migrants in areas south of Michigan, are not yet abundant. Migratory birds instead take advantage of the swarms of emerging aquatic insects, such as chironomid midges (Family: *Chironomidae*), that are concentrated along Great Lakes shorelines. Trees and shrubs in close proximity to the shoreline provide an excellent foraging substrate for migratory birds feeding on these insects in May. Mean bird abundance during migration in this study was higher at shoreline points compared to interior sites (9.1 and 8.2, respectively), as was mean species richness, although not as pronounced (6.1 and 5.8.) These initial results support the theory that emerging aquatic insects along the shoreline are important and concentrate birds during migration until leaves emerge and foliage insects are available.

Not surprisingly, interior sites had higher bird abundance per site and higher species richness during the breeding season. This would be expected as temperatures warm, leaves emerge, foliage insects appear, and variety of prey increases inland. Comparison of sites further inland than the 0.4 km to 1.6 km range sampled in this study may provide further insights, and studies that control for habitat types may show even stronger correlations.

The Nature Conservancy identified the Garden Peninsula as an important migratory stopover site for land birds and raptors, using criteria adopted or modified from the Important Bird Area Project of the American Bird Conservancy and the National Audubon Society. Important stopover sites are believed to consistently support a minimum of 20,000 birds per site per migration season for landbirds and shorebirds and 10,000 birds per site per migration season for raptors and waterfowl (Ewert 1999.) Scharf (1979) identified the Garden Peninsula as one of several sites that acts as a funnel for large numbers of birds during the spring or fall migration due to its unique physical and vegetational features and geographic location. In some cases peninsulas are the first piece of land birds may see when crossing ecological barriers such as large water bodies, possibly at least partially accounting for their significance. It was expected that bird abundance and species richness would be greater on the Garden Peninsula than on non-peninsula sites, especially during migration.

Mean abundance for short and long distance migrants (no resident birds) during May at Garden Peninsula sites was very similar to non-peninsula sites at 7.7 compared to 7.6, while mean species richness was higher at 5.3 compared to 4.9. While these data do not show the Garden Peninsula to stand out markedly from the mainland sites sampled in this study, migration was described as sporadic this year due to changing weather patterns. The spring was warm, but several thunderstorms moved through the study area during the month of May. Peak migration time was not easily defined and is better described as consistent throughout migration rather than peaking in any one time period. This could have resulted in the movement of migrants from the peninsula to interior sites over an extended time period, effectively masking any preference for peninsula sites. Additional work in the Garden Peninsula and at other non-peninsula sites along the shoreline may elucidate a clearer pattern, especially during a year when peak migration is more easily discernible.

Several species of conservation significance observed during this study include wood thrush, bobolink, black-throated green warbler, and northern parula. The wood thrush is one of 105 species currently on the National Audubon Society WatchList Website (Muehter 1998), which identifies North American bird species that are

faced with population decline, limited geographic range, and/or threats such as habitat loss on their breeding and wintering grounds. The Watchlist is compiled by Partners in Flight, a coalition of state, federal, and private sector conservationists working together to protect the birds of the western hemisphere. The wood thrush has a Conservation Priority Score of 20 (Partners In Flight Bird Prioritization Technical Committee 1998.) Scores begin at 18 with moderate priority and end at 30, with the highest priority. Criteria used to score species include relative abundance, breeding distribution, winter distribution, threats to breeding range, threats to non-breeding range, and population trend. Major threats identified by the technical committee for the wood thrush include:

- loss and fragmentation of forest habitat on breeding grounds leading to high rates of nest predation and nest parasitism by brown-headed cowbirds
- loss of old growth forests on tropical wintering grounds
- collisions with windows and towers during migration, especially in southeast U.S.

The wood thrush prefers deciduous and mixed deciduous coniferous forests and riparian woodlands. Physical factors, especially moisture, may be more important than floristic composition in habitat selection, though large trees are required (Bertin 1977.) A wood thrush was heard at the Thompson Fish Hatchery on May 20, 2000. The site is best described as a rich conifer swamp with streams along both sides of the dirt road. There are many additional areas of suitable habitat for this species in the study area.

With a Conservation Priority Score of 19, the bobolink is also identified as a species of concern on the Watchlist (Muehter 1998.) Identified threats to this species include:

- habitat loss due to changing land-use practices, especially the decline of meadows and prairies, and the cutting of hayfields during peak nesting periods.
- predation on eggs and nest exposure to flooding.
- nest parasitism by brown-headed cowbirds.

The presence of bobolinks at several inland locations in the Garden Peninsula, is likely due to agricultural practices on privately owned lands. Due to the moderating effect of Lake Michigan, the climate and soils allow private landowners to raise crops and livestock on inland properties. State owned land is not used for this purpose, and shoreline areas, where boreal forest and mesic northern forest predominate, are not suitable. The agricultural fields and pastures structurally resemble meadows and prairies, the natural habitat for bobolink, and thus attract them. The Garden Peninsula may represent a population source or sink for the bobolink depending upon current land-use practices in the area. Breeding bird surveys which attempt to estimate the population of nesting bobolinks, and assess the importance of the Garden Peninsula for this species, would be useful in guiding future conservation efforts. Educational efforts to inform landowners of the optimal time to cut hayfields so as to minimize mowing-induced mortality, could have positive effects on the reproductive success of this species.

The Nature Conservancy (Ewert 1999) identified the Garden Peninsula as an important migratory stop-over site for the black-throated green warbler, during a Great Lakes Ecoregional Planning meeting convened in 1999. This species was heard at 14 of the 15 point count sites on the peninsula, supporting this finding. Black-throated green warblers most commonly inhabit extensive tracts of mature, mesic mixed forests containing hemlock, white pine, or fir, and secondarily in mesic deciduous and pure coniferous forests (Doepker and Ozoga 1991.) Much of the forested area of the Garden Peninsula shoreline meets this condition.

Although not on the WatchList, the northern parula is considered a habitat specialist on its breeding grounds. In Michigan, this warbler is found primarily in northern coniferous forest, particularly areas with hanging *Usnea* lichen (also known as “old man’s beard”.) This lichen is a crucial component for supporting its pendant nest, though occasionally clumps of debris and other vegetation are used (Petrides 1942.) Humid areas in mature eastern hemlock or balsam fir forests are optimal habitats for *Usnea* and the northern parula. Northern hardwood forests, northern white cedar

swamps, mesic mixed forests, and wet coniferous areas with black spruce and tamarack are also used (Evers 1991.) The northern parula was observed at seven point count including four Garden Peninsula sites and three mainland sites. These sites included boreal forest, dune and swale, poor conifer swamp, or rich conifer swamp. It will be important to maintain habitat that supports *Usnea* to sustain the nest-building activities of this warbler.

This informal analysis of the abundance and distribution of migrating and breeding birds along the northern Lake Michigan shoreline provides a good foundation for future work. These bird counts provide a valuable snapshot of bird use in the study area and suggests the relative importance of shoreline habitat to migrating and breeding birds.

Invertebrates

Lake Huron Locust

The Lake Huron locust is more prevalent along this stretch of shoreline than previously documented. It was found on every surveyed property with suitable habitat except the Manistique West site (Figure 3), establishing three new occurrences and expanding the known extent of four of six previously documented occurrences. Several areas of suitable habitat remain to be surveyed suggesting that additional occurrences will be documented in the future. High priority areas for survey include properties north and south of Wiggins Point, just west of Stony Point, and along Michibay Road from the Michibay Township Park to the Lake Superior State Forest Dunes.

The largest, apparently most stable locust populations are associated with extensive, wide dunes (Scholtens and Holland 1997, Rabe 1999). Those that are one mile or more in length with at least two sets of dune ridges and including dune blowout areas are ideal (Rabe 1999.) Almost all of the shoreline in the study area has undergone or is currently undergoing some level of residential, commercial, or recreational development. That the Lake Huron locust continues to persist in the region, despite the level of development, is the most significant finding of the study. The prevalence of the locust indicates that many of the dunes retain a reasonable level of ecological integrity. This species has been found to persist in other areas with low to moderate levels of disturbance, where the ecology of the dune system is kept intact (Rabe 1999.) Many of the housing developments in the study area, particularly along Michibay Road, have been effectively placed behind the open dunes, minimizing impacts to the active zone, thus maintaining suitable habitat. Elevated walkways or boardwalks over the dunes at several residences also help to minimize impacts to open dunes.

Protection of the remaining functional dune ecosystems in the study area is imperative for conservation of the Lake Huron locust. Protected dune sites should be large enough to allow natural processes to maintain and create habitat, particularly regions of bare sand where the locust lays its eggs and overwinters. Construction activities and frequent use of recreational areas in the active dune zone can significantly impair these reproductive activities. This is of particular concern in the dune complexes west of Manistique and on the Garden Peninsula where the dune system is fairly narrow. Also, human-related disturbances, often introduce invasive plant and animal species that can quickly increase in abundance and displace native species. The natural shifting of sands becomes impaired, and Lake Huron locust habitat and numbers can decline significantly. The use of exotic plants for residential landscaping and the application of lawn or garden chemicals in or near the dunes should be avoided and special measure to control exotic species will be necessary in some locations. Landowners should be informed of these stewardship needs.

Optimal habitat for the locust occurs primarily east of Manistique along Michibay Road. These dunes are subject to southwestern prevailing winds more so than are the dunes west of Manistique and those on the east side of the Garden Peninsula. The increase in shifting sands, is a stronger force keeping the eastern dunes open, and providing extensive, contiguous habitat for the locust. The

region from Rocky Point to Lake Superior State Forest Dunes is particularly notable as it provides at least eight km (5 mi) of quality habitat consisting of several open dunes with some vertical structure (i.e., ~6-9 meters high), dune blowouts and wide sand beaches. Sites with two dune ridges also occur west of Rocky Point and west of Manistique, particularly south of Wiggins Point, providing additional high quality habitat for the locust.

Both this study and surveys conducted in 1997 failed to document the Lake Huron locust from the dune complex at Manistique West (Figure 3), despite the availability of apparently suitable habitat and presence of near-by occurrences (approximately 1.5-2.5 mi to the west and east.) One possible explanation that warrants further investigation is a potential ecological association with Pitcher's thistle, a federal and state protected plant species also restricted to dunes. The locust feeds primarily on dune grasses, but Pitcher's thistle is one of several acceptable dune forbs included in its diet (Scholtens 1996.) It occurs at all known locust sites within the study area, but was absent from the West Manistique site. Other data suggest, however, that the locust feeds randomly on available host plants, and host plant specialization is currently not thought to be a factor limiting this species' distribution (Scholtens and Holland 1997.) Also, there are locust sites elsewhere within the species' range that do not contain Pitcher's thistle. The absence of these two dune-restricted species at this site may indicate a common cause, perhaps a lack of dunes or a severe disturbance at this site historically. Finally, Stony Point, which contains a 1.2 km (0.75 mi) segment of limestone bedrock pavement, and the City of Manistique may function as barriers preventing the dispersal or movement of these species from adjacent populations to this site.

The Lake Huron locust generally occurs in large numbers in quality sites, and quickly diminishes or disappears when dunes become heavily vegetated or disturbed (Ballard pers. comm.) Relatively low numbers of individuals of the Lake Huron locust were observed during this study, compared with results from previous surveys conducted in the study area (Scholtens and Holland 1997.) Hundreds of individuals were seen at the Michibay Road Dunes site in 1997, whereas only about 20 individuals were observed over a two-hour period on five different parcels during this study. This study focused primarily on documenting presence/absence and distribution of the locust and limited time was spent at each parcel or site (e.g., 15-30 minutes). This, in conjunction with limited landowner permission and small lot sizes in some areas, may have resulted in low numbers of individuals observed. Survey conditions may also have been less than optimal for some of the sites. Some parcels were surveyed under fairly windy and/or overcast weather conditions when the locust tends to seek shelter under heavy dune grass cover (Rabe 1999.) A few were surveyed in early evening (i.e., 1700 – 1900 hr) when individuals may have been less active and less likely to occur on the open sand. Also, 1997 surveys were conducted earlier in August than surveys in 2000. More intensive surveys using comparable or standard methodologies are needed to generate more precise population size estimates and to monitor population status, trends and viability.

The dynamic nature of shoreline dunes and the inherent, although limited, mobility of the Lake Huron locust, indicate high potential for this species to occur in all suitable habitat throughout the study area. . It is recommended that all properties with suitable habitat be surveyed prior to disturbance so that necessary precautions are taken and appropriate management activities implemented. Additional data will help determine the degree to which occupied sites are interconnected and whether various locations should be considered one site, population, or metapopulation. Since it is uncertain how long locust populations can persist in developed areas and small isolated pockets, more intensive surveys to monitor population size over time are also needed. This will help identify specific impacts to the locust. Additional research on the ecological requirements of this species is also warranted These data are essential for developing effective, long-term management and conservation strategies. Finally, it is important that landowners be armed with accurate information so they can practice appropriate stewardship, if the locust is to persist in remnant dunes located in the midst of development.

Land Snails

Results from 1998 surveys indicate how significant and, at the same time, poorly documented is Michigan's snail fauna, particularly the smaller snails. Surveying only 75 sites across 11 habitat types in 8 counties in the Upper Peninsula added 12 new species to the Michigan snail fauna and 17 species to the Upper Peninsula fauna (Nekola 1998.) Additional inventory is warranted to fully document this group of animals, of which many are considered locally, nationally and/or globally rare. Although Schoolcraft County is not considered one of the counties richest in land snails, considerable potential habitat was documented during this study (Table 9.) Suitable shoreline habitat includes limestone/dolomite pavements and cobble beach primarily, while cedar dominated pockets of wetlands likely occur inland. Additional inventory should also be conducted at the two known sites west of Seul Choix Point to provide additional status information.

Unfortunately, land snail communities can be very sensitive to disturbance (Frest and Johannes 1995), thus careful protection of suitable habitat will be required to sustain them. Investigation of specific ecological requirements and impacts of various management practices and other disturbance activities are needed. Surveys to document the presence or absence of rare land snails prior to disturbance and landowner education should be conducted to avoid negative impacts. These measures will help ensure that appropriate management strategies and precautions are implemented.

Methods for Plant Inventory

Copies of all known plant occurrence records in or near the study area were compiled and reviewed, and the location points for each occurrence were transcribed onto USGS 7.5 minute topographic quadrangles for reference during field inventories. Occurrences which were very dated, or for which locations were vague or data were minimal, were highlighted to indicate higher priority for survey. Using these maps in conjunction with MDNR 1978 color infrared (CIR) (1:24,000) aerial photos a 'gap analysis' was performed to identify survey gaps that were likely to reveal additional plant occurrences, based upon the presence of appropriate habitat. Landowner contact responses were recorded on plat maps and correlated to specific locations on the topographic maps. Survey sites where permission to survey was granted were then prioritized based upon the gap analysis, making sure to capture some sites across the entire study area.

Early and late season field surveys were conducted from 06-23 June and 07-11 August 2000. The June surveys targeted early flowering species such as beauty sedge (*Carex concinna*), Richardson's sedge (*C. richardsonii*), bulrush sedge *C. scirpoides*, calypso orchid (*Calypso bulbosa*), and ram's head orchid (*Cypripedium arietinum*.) New shoots and sometimes last year's stalks of Pitcher's thistle, Lake Huron tansy, and dwarf lake iris were also detectable at this time. Any habitats that appeared appropriate for later blooming species, such as Houghton's goldenrod, were also noted and highlighted for late season surveys. Other late season targets included state threatened pine drops (*Pterospora andromeda*) and state special concern starwort (*Stellaria longipes*) as well as Pitcher's thistle, Lake Huron tansy, and dwarf lake iris. Late season surveys were coordinated with late season animal surveys, so zoologists could survey additional territory for rare plants in high priority areas. During all surveys, surveyors were watchful for other rare plant species known from the vicinity. Survey sites are shown in Figure 3.

General species lists were taken during each survey, and each site was characterized by community type, and extent and types of disturbance. High quality natural communities were and documented as described in the natural community section of this report. When rare species were encountered, standard MNFI field forms were completed with information concerning associated species, threats, population extent and status, and extent of appropriate habitat. The

extent of all areas surveyed and the specific locations of rare plant population were marked on the field topographic maps. Where appropriate and when conditions allowed, photographs were taken of representative areas, and occasional plant specimens were collected for determination, if unknown. Voss (1972, 1985, 1996) and Holmgren (1992) with its companion Gleason & Cronquist guide (1998) were used as the primary sources for identification, taxonomy, and nomenclature.

At the termination of the field surveys, all survey forms, data, and photographs were compiled and reviewed. New plant element occurrences were identified and ranked based upon element occurrence specifications developed by The Nature Conservancy, and then transcribed and entered into the statewide database (BCD.) New status information was added to previously known occurrences, and these were also ranked or re-ranked, and processed into the database. All occurrences were then digitized into Biotics, and maps showing their spatial representation were produced.

Results of Plant Inventory

Table 10 below summarizes all occurrences of rare plants that have been documented and/or updated in the study area during or prior to the current inventory. A total of 29 new occurrences, including two beauty sedge, four dwarf lake iris, four Houghton's goldenrod, nine Pitcher's thistle, and 10 Lake Huron tansy were documented during this study. An additional nine previously documented occurrences were relocated and updated, while 21 were not observed. The latter may no longer persist, may have been overlooked for various reasons, or permission to survey where they occurred may not have been granted.

Table 10. Rare plant occurrences in study area from Seul Choix Point to Point O'keefe.

Site Name	New Occurrences	Previously Documented Occurrences
Seul Choix Point	*Solidago houghtonii* *Carex concinna*	*Iris lacustris (updated)* *Tanacetum huronense*
Goudreaux's Harbor East	*Iris lacustris*	
Goudreaux's Harbor West		*Asplenium viride* *Danthonia intermedia* *Solidago houghtonii* *Thalictrum venulosum* var. *confine*
Lake Superior State Forest Dunes	*Cirsium pitcheri* *Tanacetum huronense*	*Stellaria longipes*
Michibay Rd. Dunes	*Cirsium pitcheri* *Tanacetum huronense*	*Pterospora andromeda*
Rocky Point West	*Cirsium pitcheri* *Tanacetum huronense*	
Dry Creek	*Solidago houghtonii*	*Iris lacustris update* *Tanacetum huronense (updated)*
Michibay Township Park	*Cirsium pitcheri* *Iris lacustris* *Solidago houghtonii* *Tanacetum huronense*	
Section 10 dunes	*Cirsium pitcheri* *Solidago houghtonii* *Tanacetum huronense*	
Orr Creek	*Cirsium pitcheri* *Tanacetum huronense*	

Table continues

Site Name	New Occurrences	Previously Documented Occurrences
Manistique East		*Lycopodium selago* *Senecio indecorus* *Solidago houghtonii* *Stellaria longipes* *Thalictrum venulosum* var. *confine*
Manistique Boardwalk	*Cirsium pitcheri* *Tanacetum huronense*	
Manistique West	*Tanacetum huronense*	*Iris lacustris* *Solidago houghtonii*
Stony Point		*Iris lacustris*
Thompson Dunes		*Cirsium pitcheri (updated)* *Iris lacustris (updatde)* *Stellaria longipes (updated)* *Tanacetum huronense (updated)*
Snyder Creek	*Cirsium pitcheri* *Tanacetum huronense*	*Iris lacustris (updated)*
Wiggins Point	*Cirsium pitcheri* *Tanacetum huronense*	
Point aux Barques		*Cirsium pitcheri* *Iris lacustris* *Tanacetum huronense*
Point aux Barques South	*Iris lacustris*	
Hiram Point North		*Calypso bulbosa* *Carex concinna (updated)* *Iris lacustris (updated)* *Tanacetum huronense (updated)*
Hiram Point South	*Iris lacustris* *Carex concinna*	*Calypso bulbosa*

The mapped representation of all plant element occurrences in the study area, as projected through Biotics, is shown in Figure 8. Presence of polygons on specific properties should not be construed as definitive. GPS Units were not utilized during this study and element occurrence representations were approximated using a buffer zone representing the level of uncertainty of the precise location, or by using polygons that circumscribe the known habitat boundaries within which the occurrence is known. If appropriate habitat for a given element occurred on properties adjacent to that surveyed, and it was within the minimal distance identified in the TNC element specifications, the adjacent property was also included in the polygon, even if it was not specifically surveyed. Additionally, some polygons reflect information that was gathered prior to the current inventory and may not represent areas that were surveyed in 2000.

Discussion of Plant Inventory

It is clear from the high number of new and updated occurrences documented during this study, that this shoreline region is critically important for coastal zone plant rarities. Specific locations of 30 occurrences of the three Great Lakes endemic species, Pitcher's thistle, Houghton's goldenrod, and dwarf lake iris have been documented, as have 30 occurrences of other state listed species such as Lake Huron tansy and calypso orchid, or the lesser known pine-drops or stitchwort. Due to limited access, the inherent rarity of some species making them difficult to find, and overlapping survey windows (which render coverage of the entire survey area at optimal survey periods impossible,) it is likely that more occurrences of these species will be revealed. This is particularly true along the

Garden Peninsula where access was most restricted. Much of the unaccessed portion of the peninsula appears to have suitable habitat for dwarf lake iris and beauty sedge, and several locations of open dune were identified that could harbor Pitcher's thistle and/or Lake Huron tansy. These latter species should be particularly sought south of Bursaw Creek. The vast dune and swale complexes that extend over a mile inland both east and west of Manistique, are likely to harbor additional rarities as well.

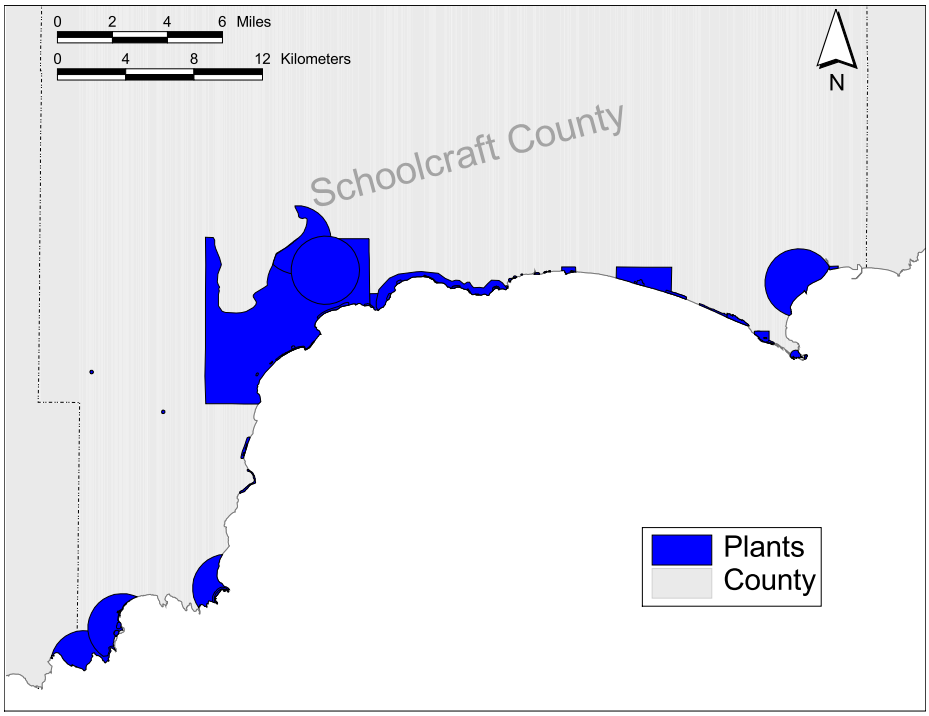

Figure 8. Biotics representation of rare plant occurrences.

In order to maintain viable populations of these species, it is critical that viable coastal communities be maintained as functional ecosystems complete with ecological processes that drive them. Shoreline communities are dynamic systems subject to continual varying intensity disturbances brought about primarily by wind and wave action. One landowner during this study bemoaned the fact that her property that was predominantly sand beach the year before, was now dominated by large chunks of cobble, while her neighbor's good fortune was to have gained sand beach. These changes had apparently occurred over one season of storms and are indicative of the natural disturbance regime that accompanies life along the shoreline. Given this scenario, many of the species of concern along the shoreline, such as Pitcher's thistle, do not persist in one exact location year after year. If they did, the frequent large-scale disturbances to their habitat would likely spell their demise. As a particular habitat is altered in one location, additional habitat is almost certainly being created elsewhere.

After flowering and producing seed, the propagules of these species must find suitable places to germinate. Pitcher's thistle, for example, requires a substrate of 70% bare sand for successful germination (Bowles et al 1993.) It is through various seed dispersal mechanisms such as wind or animals, even ants, in the case of dwarf lake iris, that propagules may disperse to appropriate germination sites, and thus "migrate" about the landscape in response to the changing environment. If last year Pitcher's thistle had been on the landowner's property described above, it is likely that it would not occur there again this year, but has a good chance of appearing on the neighbor's property. Because of the frequently

large scale and severe disturbances that occur along the Great Lakes shoreline, it is both logical and imperative that fairly large tracts of functional habitat, subject to natural disturbances must be maintained in order to sustain viable plant populations. The minimal size required is not known, but it is clear that these natural processes must proceed.

Considering the above discussion, it seemingly renders dots on maps showing locations of particular populations moot. This is true in the sense that a particular location may not be fixed over time, however a species' presence indicates that there is a seed source and that suitable habitat occurs and will likely be present somewhere in the vicinity for some time to come. In this study, the number and distribution of rare plant occurrences accentuates the significance of the study area as a whole. Virtually the entire shoreline has potential to harbor one or more listed plant species. A process to systematically address these rare species concerns should be implemented, perhaps requiring all shoreline properties to be surveyed prior to any development activity. Ideally, such surveys should not only determine if listed species are present, but also determine compatible stewardship and land use activities, thus helping to maintain the natural dynamics of the shoreline landscape.

An encouraging sign is that many of the documented populations appear to be persisting compatibly with landowners who occupy the property either intermittently or long-term. In these cases, houses are typically set well back from the water's edge and the open shoreline zone is left to function naturally. However, this is clearly not the case everywhere, and populations in many locations have been disturbed or threats to their viability are evident. Along the boardwalk in Manistique, where there has been human disturbance over many years, exotic species are common and if left alone, will continue to invade, eventually displacing native populations. There is also evidence of off-road vehicle use in the midst of a Pitcher's thistle population near the boardwalk. Extensive populations of spotted knapweed were observed in many other sites, particularly along US-2. Along portions of the Garden Peninsula, where residential development is occurring rapidly, evidence of the use of fill dirt containing seeds of exotic species is common and many properties have an abundance of weedy species advancing steadily from access roads and construction sites to shoreline habitats. In other areas, quality habitat is being fragmented by platting and putting up numerous lots for residential sales, without apparent recognition of the potential presence of rare species or their ecological requirements.

Despite the threats facing coastal zone features, the prognosis for sustaining high quality occurrences of rare shoreline species in the study area is good, if a proactive approach is taken now. Rare shoreline species have been observed persisting compatibly with landowners in other parts of the state as well (Penskar et al. 1997.) Long-term studies and monitoring in these areas are needed in order to assess their tolerance to various levels of disturbance over time. Acceptable stewardship practices can then be identified and provided to landowners. These efforts must be encouraged and facilitated in order to minimize cumulative impacts to the native coastal zone flora, including rare species. Additional recommendations are discussed in the summary section of this report.

Methods for Natural Community Surveys

Survey for exemplary occurrences of terrestrial natural communities was conducted during the animal and botanical surveys. This component of the project focused on assessing the status of previously known occurrences of high quality natural communities, identifying new occurrences in areas of survey gaps, and characterizing the shoreline within the study area. A preliminary survey and characterization of aquatic communities was conducted as a separate component of the study and is reported separately, following the natural community discussion.

Records for all known community occurrences within the study area were compiled and reviewed.

Occurrence locations and other pertinent data were transferred to USGS topographic quadrangles for reference during surveys. 1978 color infrared (CIR) photos were interpreted and potential high quality areas were identified and highlighted on the topographic maps. Potential high quality sites were visited that coincided with other survey priorities and where landowner permission had been granted. All sites surveyed during animal and plant inventories (Figure 3) were assessed for presence of high quality natural communities.

Data were collected in standardized format to update any existing natural community occurrences and for newly identified potential occurrences, and locations were outlined on the quad maps. Program ecologists were consulted to assess whether potential new occurrences met criteria for element occurrence status. Data were transcribed and entered into the statewide database and community boundaries were digitized into Biotics.

Results of Natural Community Surveys

All previously documented natural community occurrences that were visited during this survey had been well documented originally and did not require refinement of boundaries. These include two wooded dune and swale complexes (Gulliver Lake and Thompson Dunes) and two occurrences of limestone pavement lakeshore. The Thompson Dune wooded dune and swale lies partly within a State designated critical dune area. Some actions within critical dune areas are subject to permitting requirements. No new natural community occurrences were uncovered during this study, however several potential occurrences where access was limited were identified. These include a northern fen at Cole Point and a northern fen on the unnamed point between Hiram Point and Point O'Keefe. Access should be sought in the future by contacting landowners in order to determine if these sites merit status as element occurrences. All currently documented occurrences are summarized and ranked in Table 11 below and their spatial representations are shown in Figure 9.

Table 11. Natural community occurrences and survey site names in study area from Seul Choix Point to Point O'keefe.

Natural Community Occurrence	Natural Community Type	Survey Site Name (Fig. 3)	Rank
Goudreaux's Harbor	limestone pavement lakeshore	Seul Choix Point, Goudreaux's Harbor East and West	A
Gulliver Lake	wooded dune and swale	Lake Superior State Forest Dunes, Michibay Road Dunes, Rocky Point West	AB
Stony Point	limestone pavement lakeshore	Stony Point	B
Thompson Dunes	wooded dune and swale	Manistique West, Thompson Dunes	AB

Discussion of Natural Community Surveys

The most prominent natural community represented in the study area is that of wooded dune and swale. This community type was formed along embayments of the Great Lakes where progressively dropping lake levels and post-glacial uplifting resulted in the formation of a series of sandy beach ridges (Comer & Albert 1993.) Surface and ground water flow through the ridges resulted in the formation of wet swales in the troughs. These alternating ridges and swales appear as a series of arcs parallel to the shoreline, and are readily discernible on aerial photos. In some cases, including the Gulliver Lake complex and to a lesser extent the Thompson Dunes

complex in this study, the open dunes along the shoreline have been built-up and re-sorted by the wind, to form high irregular dune ridges. Although not globally imperiled, dune and swale complexes are considered globally rare, and in North America, are found only in the Great Lakes region (Comer & Albert 1993.) Of the approximately 95 occurrences known in the region, 70 such complexes once occurred in Michigan, only 41 of which are currently considered of high enough quality today to be included in the Michigan Natural Features statewide database. Others have been variously destroyed or degraded. See Comer et al, 1993 for a summary of dune and swale complexes in Michigan.

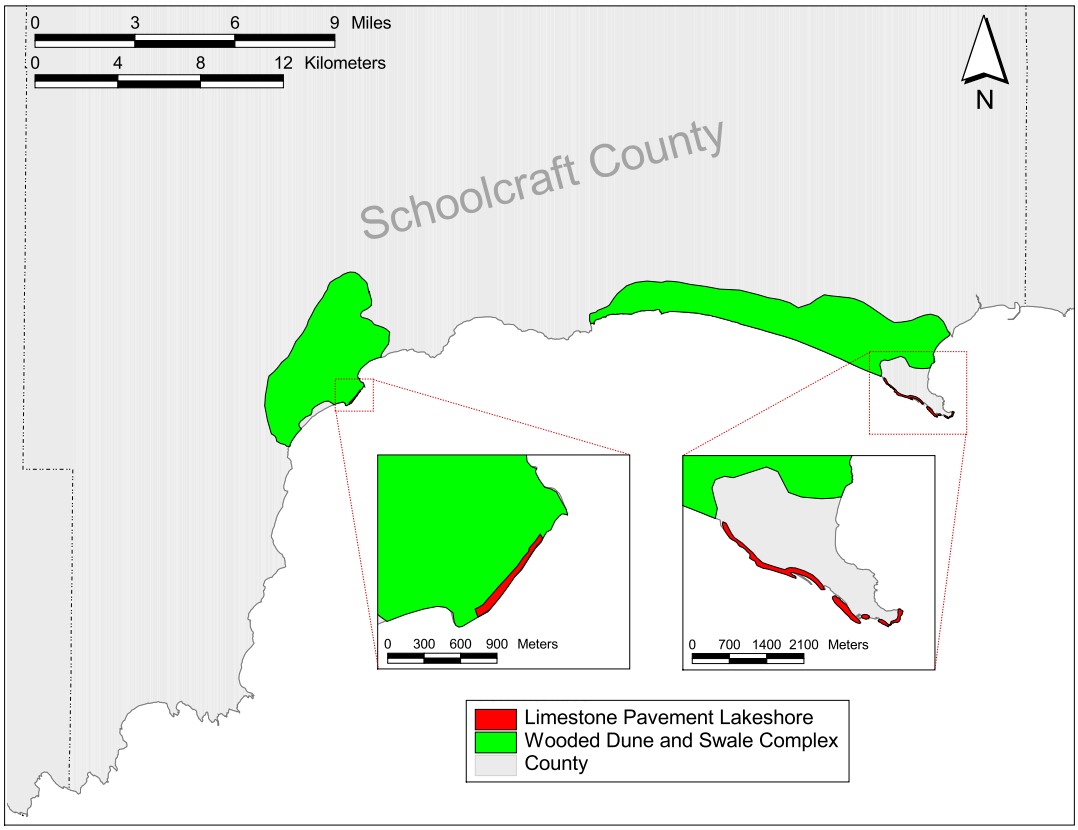

Figure 9. Biotics representation of natural community occurrences.

The Thompson Dunes complex on the Garden Peninsula, covering 9500 acres, is the largest of the high quality wooded dune and swale complexes in Michigan that have been inventoried to date. Both The Thompson Dunes and Gulliver Lake wooded dune and swale complexes were ranked AB by MNFI in 1993. This marks them as fifth in quality out of nineteen for the Northern lakes Huron/ Michigan Low Dune sub-type, and fifth out of seven for the Northern Like Michigan High Dune sub-type respectively (Comer & Albert 1993.) Gulliver Lake dune and swale lies within a formally designated critical dune area, further emphasizing the significance of this AB ranked complex. The ranks were not changed during this study, however, both complexes are experiencing increased disturbance, primarily where highway US-2 traverses them, bringing both people and development along its path. Of particular concern is the development of the shoreline dune ridge north of US-2 just west of Manistique. In several cases, the native dune ecosystem has been severely

altered where houses and other structures have been constructed and landscaped. Further development of this region is in process without a systematic approach to address rare species and natural community concerns. If these cumulative impacts are allowed to continue case by case, these unique and functional ecosystems will become irrevocably degraded.

Examples of apparently compatible development in the open dune segments of the dune and swales occur along Michibay Road. Here many of the houses have been built well back from the open dune, maintaining the natural ecosystem and allowing natural processes to continue. Rare species currently persist here, however studies of the long-term impacts of development activities should be implemented to assess ecosystem sustainability over time.

Occurrences of limestone pavement lakeshore have also been documented in the study area, from Seul Choix Point to Goudreaux's Harbor West and at Stony Point, representing two of only 14 known occurrences in the State (Comer et al 1997.) This community type is characterized by exposed flat bedrock pavement associated with the Niagaran Escarpment, the prominent feature of the Niagaran Cuesta, a gently sloping bedrock plain that extends along the Great Lakes from Rochester, New York to Milwaukee Wisconsin (Lee et al 1998.) The limestone and dolomite bedrock was formed from marine reefs that were common in the shallow seas covering the Michigan Basin about 400 to 500 million years ago, and hence is rich in calcium carbonates. Vegetation is typically sparse, finding a foothold in the cracks and crevices of the pavement. The Stony Point occurrence is relatively small (approximately 1.2 km/.75 miles long), with a low cobble ridge at the inland edge behind which lies an interdunal swale and boreal forest. The Seul Choix-Goudreaux's Harbor pavement community is one of the most extensive and scenic occurrences in the state, extending for over 3.2 kilometers (2 miles) of shoreline. Seven rare plant species have been documented in this community (see rare plant inventory results), piping plovers have nested here in the past, and a new state record for the rare land snail, *Vertigo hubrichtii*, and four other rare snails were recorded here in 1998.

Most of the shoreline, east of Manistique in the study area is part of either the limestone pavement or the open dune portion of Gulliver Lake dune and swale complex. The open dune narrows towards Manistique becoming mostly wet sand or exposed rock beach backed up by a narrow foredune and pockets of interdunal swales. To the west of Manistique lies the open dune portion of the Thompson dune and swale complex. Much of the remaining Garden Peninsula shoreline is rocky or wet sand beach, with occasional foredunes, backed primarily by dense boreal or mesic forest. Towards the southern end of the study area, there are several large areas of northern fen. Permission to access these sites was limited in 2000, and new attempts to contact landowners should be made. Summaries of specific survey sites are provided in the last section of the report.

Methods for Aquatic Community Characterization

Nearshore ecological properties were surveyed along the northern Lake Michigan shoreline (Schoolcraft Co., MI) on 18-19 October 2000. Physical habitat attributes and aquatic communities were sampled to provide a preliminary characterization of the nearshore ecosystems in the vicinity of Manistique, MI. Three transects were established perpendicular to and within 0.4 km (0.25 mile) of the shoreline, with sampling stations at one, three, and six meter water depths along each transect (Figure 4.) Transects were established southwest of Manistique off Frank Rogers Roadside Park (T1) and one kilometer north of the park near Stony Point (T2.) These were low bluff/dune shorelines with sandy shores, and large boulders over clay offshore. A third transect was established off Michibay Road Township Park (T3) east of Manistique. This was a low bluff/dune shoreline, with a sandy to rocky shore, and large boulders over bedrock offshore. Three animal community types were sampled, including benthic (bottom-dwelling) invertebrates, planktonic (water-column dwelling) invertebrates, and shallow-water fish.

Nearshore substrate characteristics at each sampling station were determined based on Ponar

grab samples and SCUBA reconnaissance. A Ponar grab was deployed from the boat to provide an initial characterization of local substrates. High-volume samples indicated that soft substrates (e.g., sand) were prevalent at the sampling station, while sparse grab samples suggested the presence of hard substrates and/or clay. Divers then assessed soft substrate stations to determine the local substrate composition.

Three samples were collected at each sampling station to characterize the benthic community. Benthic samples were collected using the Ponar at stations with soft, sandy substrate. In rocky, hard substrate areas, SCUBA divers used a custom-made vacuum device to remove biota from a 0.063-m template area. Stations with both hard and soft substrates were sampled proportionately using both methods to reflect the relative abundance of each habitat type at the sampling station. Benthic samples were preserved in 95% ethanol (EtOH) in the field and later identified in the laboratory. A summary of samples collected and methods used to collect benthic samples at each sampling station are provided in Table 12.

The planktonic invertebrate community was sampled using three vertical tows of a 0.5 m-diameter, 80µm-mesh plankton net at each sampling station. For each sample, the plankton net was deployed from the boat and allowed to sink to the lake bottom. It was then towed vertically through the water column, effectively sampling a volume zof water from the lake bottom to the surface. Plankton samples were preserved in 95% EtOH and later identified in the laboratory.

Three replicate beach seine hauls were used to characterize the shallow water fish communities at T1 and T3. A 10-m, 6.4-mm mesh seine was hauled for a 30-m distance parallel to the shore at water depths up to one meter after dusk for each replicate. All fish obtained in the beach seine hauls were identified to species, counted and released unharmed.

A calibrated YSI Model 55 digital temperature/oxygen meter was used to measure vertical temperature (°C) and dissolved oxygen (mg O_2 /l) profiles at each sampling station. A probe was deployed from the boat and temperature/dissolved oxygen measurements were taken at the water surface and at one-meter depth intervals from the water surface to the lake bottom.

Table 12. Benthic and planktonic invertebrate and fish samples collected on 18/19 October 2000 along Schoolcraft County shoreline from Lake Michigan. X = sampling completed; P = Benthic Ponar grab sample; V = Benthic Vacuum sample.

	T1 Rogers Roadside Park			T2 North of Roadside Park			T3 Township Park		
	1m	3m	6m	1m	3m	6m	1m	3m	6m
Benthic Invertebrates	P	P	P	P	P	V	---	V	V
Planktonic invertebrates	X	X	X	X	X	X		X	X
Nearshore fish		X			X			X	

Results of Aquatic Community Characterization

Sand dune beaches characterize the Lake Michigan shoreline near the city of Manistique. The nearshore substrate Southwest of Manistique (Site T1), is primarily comprised of sand. Substrates at Site T2 are primarily comprised of sand at one and three-meter water depths, changing to boulder over clay substrates near 6-m water depth. East of Manistique (Site T3), sand dune beaches with frequent cobble and boulder outcrops characterize the shoreline. Nearshore substrates at Site T3 are principally large cobble and boulders over bedrock with occasional patches of gravel.

During the survey, filamentous algal mats were present over sand substrates out to a one-meter water depth. Hard substrates were covered with zebra mussels (*Dreissena polymorpha*), with small patches of algae and freshwater sponges. Water clarity varied greatly, due mainly to storm and industry influences. When the lake was calm, visibility was at least six meters. However, when wave action increased, the water was darkly stained and cloudy, presumably with sawdust from the lumber industry in Manistique. Water temperatures varied from 11.4 to 12.4° C and dissolved oxygen levels ranged from 11.09 to 11.85 mg/L.

The sand substrate supported a wide diversity of native invertebrates, including two snails and several insect species (Table 13.) Cobbles were covered with zebra mussels, but also supported at least four native snail species. Many insect and other arthropod species were also found on and under cobble substrates (e.g. mayflies, caddisflies, and crayfish.) The zooplankton community observed in water column samples was characterized by a variety of cladocerans and copepods (Table 14.) Only one exotic zooplankter was present, the spiny water flea (*Bythotrephes cederstroemi*), and was rarely encountered.

Table 13. Occurrences of benthic invertebrates collected from Lake Michigan at sites near Manistique, MI. P indicates occurrences in a Ponar sample, collected from soft substrate (sand.) V indicates occurrences in a vacuum sample, collected from hard substrate (boulders.) * indicates an exotic species.

Common Name	Family	Genus	T1	T2	T3
Fingernail Clams	Sphaeriidae		P	P	
Zebra Mussels*	Dreisseniidae	*Dreissena polymorpha**		V	V
Snails	Physidae	*Physella*		V	V
	Pleuroceridae	*Goniobasis*		V	V
	Lymnaeidae	*Fossaria*	P	V	V
	Valvatidae	*Valvatata*	P	V	
True Flies	Chironomidae		P	P V	V
Caddisflies	Phryganeidae	*Banksiola*			V
	Mystacides			P	V
	Leptoceridae	*Oecetis*	P		
True Bugs	Corixidae	*Graptocorixa*			V
Mayflies	Ephemeridae	*Ephemera*	P	V	V
Water Mites				V	V
Crayfish	Cambaridae	*Orconectus*		V	
Amphipods	Gammaridae	*Gammarus*	P	P	V
Isopods	Asellidae	*Caecidotae*		V	V
Leeches	Hirudinea		P		
Worms	Oligachaeta			P	
Incidental zooplank.			P	P	

Table 14. Occurrences of planktonic invertebrates from Lake Michigan sites collected near Manistique, MI. * indicates an exotic species.

Order	Family	Genus	T1	T2	T3
Cladocera	Leptodoridae	***Leptodora***	X	X	
	Polyphemidae	*Polyphemus*	X		
	Daphnidae	*Daphnia*	X	X	X
	Bosmnidae	*Bosmina*	X	X	X
		Eubosmina			X
	Chydoridae	***Chydorus***	X	X	X
Copepoda	Centropagidae	*Limnocalanus*	X	X	X
	Cyclopidae	*Cyclops*	X	X	X
Diplostraca*	Cercopagidae	*Bythotrephes cederstroemi*		X	

Seven native fish species were present in the nearshore community (Table 15.) Rocky areas supported native benthic fish, such as mottle sculpins and johnny darters, while sandy areas supported mid-water forage fish (e.g., spottail and emerald shiners.) No exotic fish species were observed at either site at which beach seine samples were collected.

Table 15. Occurrences of nearshore fish species from Lake Michigan sites near Manistique, MI. BS indicates occurrence in a beach seine haul, SC indicates occurrence observed by SCUBA divers.

Common Name	Genus species	T1	T3
Longnose Dace	*Rhinichthys cataractae*	BS	BS
Emerald Shiner	*Notropis atherinoides*	BS	BS
Spottail Shiner	*Notropis hudsonius*	BS	BS
Threespine Stickleback	*Gasterosteus aculeatus*	BS	
Ninespine Stickleback	*Pungitius pungitius*		BS
Johnny Darter	*Etheostoma nigrum*	SC	
Mottled Sculpin	*Cottus bairdi*	SC	SC

Discussion of Aquatic Community Characterization

The sand and boulder nearshore habitats of northern Lake Michigan in Schoolcraft County support a wide variety of aquatic species comprising communities that are likely unique within the Great Lakes Basin and on a global scale. Although hard substrates were heavily encrusted with zebra mussels, several species of native snails, as well as a wide variety of aquatic insects, were present. Increased biomass and diversity of some native benthic communities has been documented in areas that have been colonized by zebra mussels, possibly in response to the increased habitat complexity and algal growth that is often associated with zebra mussel colonies (Stewart et al. 1998, Haynes et al. 1999.) However, additional exotic species invasions may further alter the community and decrease the ecological integrity of these areas. The round goby (*Neogobius melanostomus*), an exotic benthic fish, is now abundant in many rocky areas of the Great Lakes (see Charlebois et al. 1997, for a review.) In areas of the Great Lakes where the round goby is abundant, numbers of native mollusks and benthic insects have been drastically reduced. The dominance of rocky substrates in these northern Lake Michigan nearshore areas makes them especially vulnerable to round goby invasion, suggesting that the benthic communities and overall ecological integrity of these shoreline areas is highly threatened.

The nearshore zooplankton community contains a variety of predatory and filter-feeding taxa. Typical nearshore, cool, clear water taxa (Balcer et al. 1984), such as *Polyphemus* and *Chydorus*, were present. Only one exotic zooplankton, the spiny water flea (*Bythotrephes cederstroemi*), was present, and only in low numbers. The spiny water flea is of concern, because it can compete with planktivorous fish, such as young-of-the-year yellow perch, for food resources, and alter the zooplankton community, particularly in offshore waters (Lehman and Caceres 1993.)

The shallow-water (i.e., less than one meter water depth) fish community observed during this study appears to be stable and diverse. University of Michigan Museum of Zoology records (1941) indicate that the shallow-water fish community was historically comprised of spottail shiners, longnose dace, mottled sculpins, emerald shiners, yellow perch (*Perca flavescens*), lake chubs (*Couesius plumbeus*), sand shiners (*Notropis stramineus*), and small-mouth bass (*Micropterus dolomieu*.) A similar shallow-water fish community was observed during our surveys, suggesting that the community has not changed greatly in the past 50

years. While no listed fish species were found, the native assemblage is unique. Mottled sculpins, johnny darters, and longnose dace are non-game taxa characteristic of nearshore rocky areas of the Great Lakes. These fish have been decreasing in abundance in recent years, largely due to the round goby invasion (Jude, et al. 1995, Dubs and Corkum 1996, Jude and DeBoe 1996.) In addition, the diversity of forage fish present in the area (e.g., minnows and sticklebacks) provides a strong link to higher trophic levels. Unfortunately, due to time and weather constraints, survey of the nearshore large fish community was not conducted. Thus, the current status of this portion of the nearshore community is not discussed here. However, this data would contribute greatly to a more complete characterization and status evaluation of Great Lakes nearshore communities.

Compared to other nearshore areas of the Great Lakes that have been recently sampled by MNFI staff (St. Joseph, MI, Three Rivers and Port Washington WI), this site is unique. The habitat is home to several native species that have decreased drastically in abundance in the Great Lakes in recent history. The unimproved habitat (no artificial shoreline armoring) provides a glimpse of what the nearshore area of Lake Michigan was and should be. Habitat usage and community interactions and composition in these areas is poorly understood, and should be further investigated. The data provided by this and future studies will help to provide baseline information describing the largely native communities associated with Great Lakes nearshore areas. These areas should be monitored to detect changes in community structure and ecological integrity in response to shoreline impacts and exotic species invasions. The availability of pre-invasion/ environmental degradation community data will likely play a substantial role in future conservation efforts. Such data will also provide leverage for developing nearshore classification frameworks that may eventually identify specific shoreline areas as significant elements of biodiversity. These unique resources could then be listed and given protection to enhance their long-term viability and sustainability.

Methods for Local Planner Outreach

This portion of the study evaluated how local planning agencies address issues pertaining to natural features and especially threatened and endangered species during development of Great Lakes shoreline properties. The investigation was initiated by contacting the Resource Professional, sponsored by the Cooperative Resource Management Initiative (CRMI), for Schoolcraft, Luce, and west Mackinac counties, who provided a list of Schoolcraft County township agencies and staff. Also contacted were professionals from MNFI, MDEQ, MDNR, MSU-Extension, United States Fish and Wildlife Service (USFWS), Central Upper Peninsula Planning and Development (CUPAD), and The Nature Conservancy (TNC.) Meetings were held with township personnel to discuss local planning and development processes and procedures as they relate to threatened and endangered species. A detailed review of township ordinances and other planning documents was beyond the scope of this study. State and federal regulations and procedures that are designed to protect threatened and endangered species were also reviewed with appropriate agencies to determine when and how they are invoked, and if there is any coordination between local, state, and federal agencies on threatened and endangered species issues. These interactions were intended to accomplish the following:

- inform contacts about the project
- determine whether local units of government have local planning agencies or any regulatory authority pertaining to planning and development
- determine whether threatened and endangered species are considered in local or county planning and permitting processes
- determine whether threatened and endangered species concerns are systematically identified and referred or linked to other authorities to be addressed
- determine if local planning agencies inform groups involved with development of the

potential occurrence of threatened or endangered species

- determine if contacted individuals would be interested in receiving the results of the study and in what form the results would be most useful

Notes from these discussions were reviewed at the end of the project and the relationships of local planning processes and threatened and endangered species protection were summarized. Follow-up contacts were made with federal, state, and local agencies to clarify any uncertainties. Results of the inventory were sent to all individuals contacted during this process. In addition, a summary article highlighting the findings of this study was prepared for local newspapers (Appendix D.) Finally, these preliminary outreach efforts were informally evaluated and recommendations for future outreach efforts were made.

Results for Local Planner Outreach

Township zoning ordinances dealing with shoreline development in Schoolcraft County are applicable county-wide with the exception of the City of Manistique, which has its own set. None of these ordinances specifically address the protection of threatened or endangered species, or the integrity of natural communities. County and city ordinances require a setback of 50 or 75 feet from the high water zone of Lake Michigan, for most buildings. These set-backs, although perhaps inadvertently beneficial to some occurrences of shoreline rarities, were not designed for that purpose.

On private lands, threatened or endangered species concerns are addressed systematically by the state only when a developer applies for a permit through the Department of Environmental Quality-Land and Water Management Division (DEQ-LWMD.) DEQ uses the MNFI database within the context of a screening system, Coastal and Inland Waters Permit Information System (CIWPIS), to review applications. All natural features included in the MNFI database within one section of the section in which a project is planned (i.e., a nine section unit) are flagged. If there are one or more 'hits' the project is sent to MDNR to undergo their environmental review process. If MDNR determines that threatened and endangered species may be impacted, the project is further reviewed by MNFI biologists. MNFI staff provide comments regarding the likelihood of negative impacts, and recommendations for alternative actions or avoiding impacts, if appropriate. They may also request further information, if needed to adequately evaluate potential impacts. Based on these evaluations, MDNR makes the determination whether an endangered species permit is required, whether to issue a permit, and whether any permit conditions should be developed or negotiated.

State regulatory agencies may be involved in high profile, large-zzscale private land projects, where a more comprehensive review of environmental impacts is being conducted, but this does not necessarily invoke a review of potential impacts to threatened or endangered species by MDNR. However, in some cases, for various reasons, a survey and/or review of impacts may be conducted. This may be driven by public pressure, for example, or at the advice of environmental consultants associated with the project. There does not appear to be any conscious attempt to ensure threatened and endangered species protection required by law, through a coordinated review process conducted by state and local officials. Nor is there any established procedure to routinely inform developers of potential rare species concerns. In some cases where local agencies are aware of the need for permits for which they have no authority, developers are referred to the appropriate authority.

Actions on state lands, such as trail routing or land acquisition, go through the environmental review process described above, invoking MNFI review of natural features if MDNR-Wildlife Division (MDNR-WD) determines there are potential concerns. MDNR-Forest Management Division (MDNR-FMD) prescriptions for state forest lands are systematically reviewed by MNFI for natural features, and comments are passed directly to MDNR-FMD. When federal action

(i.e., any activities authorized, funded or carried out by Federal agencies) on federal land is planned, federal involvement is required, in the form of an initial informal consultation or conference. This would occur, for example when a U.S. Corps of Engineer permit is required for a project involving navigable waters. If it is determined, through the informal consult, that federal listed species will be impacted according to legal specifications of the endangered species act, a formal consultation is required prior to moving forward with the project. State listed species are not considered in this process. The formal consultation may or may not result in the protection of federal listed species within the project area.

All individuals contacted during this component of the study were interested in receiving the results in hard copy format. Ready access to a computerized network for electronic transfer of the information or receipt of digital information was not readily available to local planning units. The majority of individuals contacted expressed concern about the additional complication and expense that would be required by planners, developers, and landowners to address rare species protection.

Discussion of Local Planner Outreach

The results of this study indicate that impacts to rare species and the integrity of natural communities are not systematically addressed at the local level, nor is there a consistent, coordinated framework to address such concerns. In addition, local agencies in the study area currently do not have any authority to address these concerns directly. When invoked, state and federal laws provide some measure of protection in some cases, however, they do not address these concerns consistently for all shoreline projects. Therefore, consideration of impacts to coastal zone natural features by development activities is variable, as are subsequent protection measures. Enforcement is also highly variable.

The unique natural features of the Great Lakes shoreline are an asset that sets them apart from anywhere else in the world. The beauty and ruggedness of contiguous native coastal communities may be the true draw for many individuals who seek their refuge, either for quiet solitude and renewal or permanent residence. Lacking consistent recognition and protection, as well as appropriate stewardship, viable coastal communities and their component species will continue to be degraded or destroyed. It is likely that property values will decline as degradation continues. Data from several development projects elsewhere in the state show increased property values (in some cases as much as 20%) where natural features are kept intact and highlighted as an attribute of the development (Nancy Strohl pers. com.) Northern Lake Michigan developers could capitalize on the unique coastal zone features as a selling point while at the same time creating innovative projects that maintain and enhance natural features.

Education of developers, township administrators, planners, and landowners may provide a significant interim measure of protection, until more effective regulations or long-term, landscape-level conservation strategies are developed and implemented. The natural features data from this study provide the foundation upon which additional educational strategies can be built. The final report for this study will be provided to all identified local planner contacts within the study area, and made available on MNFI's web site. A summary article will also be included in one or more local newspapers or newsletters. In addition, it is recommended that prior to next year's work, an informational meeting be held for any interested landowners to inform them of the planned field work and to summarize last year's work. This could also be used as a forum for initiating discussion of long-term strategies to address concerns for the integrity of the coastal zone ecosystems and their component natural features.

Summary and Recommendations

The results of this inventory show the study area to be rich in natural features. Thirty-nine occurrences of rare plants were either newly found or confirmed during this study and an additional 21 previously documented occurrences are considered likely extant. Nine occurrences of the Lake Huron locust, 3 of which were newly documented, are now known from the area, and 5 species of rare land snails have been previously documented. The area also provides stop-over and breeding sites for at least 116 bird species, and 7 listed bird species were observed in the study area in 2000. Additionally, 4 high quality natural communities have been identified and the near-shore coastal communities that were sampled contain a diversity of predominantly native species. This study was not a comprehensive survey for all rare species, yet suitable habitat and the presence of appropriate communities suggest that additional occurrences will be found.

Development pressure in coastal areas is high. Coastal habitats are increasingly popular areas for home construction, recreation, and business development. Half of the total United States population now lives within 50 miles of its coasts (Deinlein, no date.) Projections for 2010 predict this number will increase by 60 percent. Although similar data is lacking for the northern Lake Michigan coastal zone, 25 properties were sold within the study area in 2000 (Schoolcraft County Equalization Office, pers. com.) and more than a dozen properties were put up for sale just during the course of year 2000 field surveys, suggesting a similar trend. The rapid pace of coastal development is expected to continue.

In the mean time, impacts to natural features by development activities are not being systematically and consistently addressed. Without a framework to assess and address impacts, cumulative impacts will increase and natural features of the shoreline will continue to be degraded or lost. The economic importance of shoreline properties stems in part from the underlying value inherent in the natural features of the landscape – the views, landforms, dunes, vegetation, and other features that make this area unique. As natural features of the landscape are degraded, the economic value of properties is affected as well. In at least several cases in the state, property values have been shown to increase when natural features are preserved.

Knowing the distribution and abundance of natural features in the coastal zone and their ecological requirements is essential if we are to prevent degradation of their inherent value. This study provides baseline data on the distribution of natural features in the area, while some data describing their ecological requirements are available in the literature. Most shoreline rarities are adapted to a dynamic environment that experiences continual change and new creation of suitable habitat by storm, wind, and wave action. These species 'move' about the landscape as their seeds successfully germinate in appropriate new micro-sites. Protection of tracts of land, large enough to allow these ecological processes to operate unimpeded, is necessary to sustain these species. However, the minimum area required, as well as the level of disturbance that can be tolerated by different species is not fully understood, and little data addressing these questions exist. There are few scientific studies that address the long-term viability of rare shoreline species in sites where humans live. In addition, simply knowing where these elements occur and what their ecological requirements are does not ensure their protection. It will require a comprehensive integration of stewardship principles into all levels of planning, from federal, state, and local government administrators, planners, and others, to individual landowners themselves, who must be willing to conduct appropriate stewardship.

Balancing the needs of residential and economic growth with the protection and management of shoreline natural features presents many challenges, yet there are reasons to be optimistic. Evidence from this study and others indicates that many of the rarities of concern can withstand and even require some disturbance. Additionally, many people who are educated about the economic and ecological importance of these features are willing to protect them. It is fully expected that given adequate protection measures

and knowledgeable stewardship, significant natural communities and rare species can coexist with human use of the landscape. However, with the rapid pace of development, the lack of complete ecological data or a framework to systematically address natural features concerns, the need to take deliberate action is urgent.

Ultimately, protection measures must become institutionalized into the planning process and become a part of the working culture and mindset of those who use them. This requires good legislation, high-quality, comprehensive data, and education and outreach. The establishment of a coordinator or team that focuses on the integration of these three intertwined factors can provide an effective means to enhance protection and economic value of shoreline habitats and ecosystems. This group could also coordinate a landscape level conservation planning effort for the region. The following recommendations should be considered:

Important Legislation:

- provide local authority for development and regulation of shoreline natural features and procedures for coordination with state and federal agencies
- develop consistent standards and enforcement of laws relating to natural features and threatened and endangered species
- consider a landscape approach to permitting rather than a case by case system that masks cumulative impacts
- consider the development of ordinances that prohibit activities detrimental to shoreline ecosystems, such as requiring raised boardwalks in dunes or restricting activities in the active shoreline zone

High-quality, Comprehensive Data:

- make information on unique natural features available in an easily accessible and interpretable format to local planners and other land-use agencies and groups
- support systematic surveys and research in the Great Lakes coastal zone
- conduct current surveys for natural features in appropriate habitats prior to any shoreline development activity
- facilitate the development of GIS based planning tools that can incorporate natural features data
- develop monitoring protocols and projects to assess management strategies and impacts over time

Education and Outreach:

- develop attractive, user-friendly guides with specific recommendations for stewardship of particular shoreline species or communities
- provide educational workshops to planners, local government officials, landowners, and others using shoreline ecosystems
- promote public awareness of the significance of coastal zone features
- identify models of good stewardship that illustrate examples of success
- encourage alternative uses of shoreline properties with compatible economic benefits such as ecotourism

Landscape Level Conservation Planning:

- establish a long-term presence of a coordinator or team in the region, focusing on land-owner education and development of landscape-level conservation strategies
- identify high priority conservation areas where no development activities are allowed, to serve as benchmarks of ecosystem function and population dynamics
- develop innovative conservation plans
- dedicate natural areas on state lands where

Site Summaries

This section provides an overview for each of the identified survey sites for the animal, plant, and natural community components of the study. Occurrences of natural features that were identified during or prior to this study and are still thought to be extant are highlighted in bold text.

Seul Choix Point

Seul Choix Point is characterized by a rocky cobble substrate, with significant segments of **limestone pavement**, comprising a natural community element occurrence that extends westward to Goudreaux's Harbor West. In some areas, large boulders project above the predominant elevation. On the north side of the point, thousands of zebra mussel shells blanket the shore in terraces, forming a sterile substrate of its own in places. Vegetation grows in cracks and crevices; consisting of such common species as grass-leaved goldenrod (*Euthamia graminifolia*), Ohio goldenrod (*Solidago ohioiensis*), smooth aster (*Aster laevis*), baltic rush (*Juncus balticus*), sedge (*Carex viridula*), hair grass (*Deschampsia cespitosa*), silverweed (*Potentilla anserina*), and low calamint (*Calamintha arkansana*.) Local clusters of **Houghton's goldenrod** were found in this rocky zone, however a previously documented occurrence of Lake Huron tansy was not found. Just Inland are pockets of fairly densely vegetated northern fen comprised of the aforementioned species and others such as twigrush (*Cladium mariscoides*), lesser fringed gentian (*Gentianopsis procera*), Kalm's lobelia (*Lobelia kalmii*), shrubby cinquefoil (*Potentilla anserina*), and red-osier dogwood (*Cornus stolonifera*.) The immediate vicinity of the lighthouse is planted to grass. A number of exotic species are common at the Point as a result of the development of the lighthouse visitor area. Among the common exotics are purple loosestrife (*Lythrum salicaria*), ox-eye daisy (*Chrysanthemum leucanthemum*), strawberry (*Fragaria virginiana*), self-heal (*Prunella vulgaris*), and yarrow (*Achillea millefolium*.) The road leading into the Point, transects dense boreal forest dominated by northern white cedar (*Thuja occidentalis*), spruce (*Picea* spp.), and balsam fir (*Abies balsamea.*) **Dwarf lake iris** was observed growing at the ecotone of road and forest and the ecotone of limestone pavement and forest. In the latter ecotone, beauty sedge (*Carex concinna*) was found in several pockets growing with the iris. Appropriate habitat for the piping plover occurs in the rocky portions of the shoreline, however, much of the site is too frequently disturbed by visitors to expect a high likelihood of nesting success. Five rare land snails also occur at this site, and suitable habitat for additional species is present.

Goudreaux's Harbor East

This site is a continuation of the limestone pavement community that extends in broken segments from Seul Choix Point westward to Goudreaux's Harbor West. In several areas large boulders form spits projecting parallel to the shoreline and forming islands of pavement in high water years. Segments of sand beach with dune grass (*Ammophila brevililgulata*) also occur between Seul Choix Point and Goudreaux's Harbor. Vegetation is sparsely distributed in the cracks and crevices of the limestone incuding such species as little blue-stem (*Schizachyrium scoparium*), death camus (Zygadenus glauca), goldenrod (*Solidago spathulata*), ninebark (*Physocarpus opulifolius*), shrubby cinquefoil (*Potentilla fruticosa*), and shrubby northern white cedar (*Thuja occidentalis*.) A localized patch of **dwarf lake iris** was found here, extending from the ecotonal edge of the boreal forest onto the pavement. Pockets of appropriate habitat for piping plover are found between this site and Seul Choix Point to the east, however, none were observed during this study. Suitable habitat for rare land snails also occurs at this site. Numerous houses occur along this site and others are under construction.

Goudreaux's Harbor West

The limestone pavement continues at this site from Seul Choix Point and Goudreaux's Harbor East, but was not surveyed during this study, due to lack of response or permission to survey. Occurrences of state threatened **rayless mountain ragwort** (*Senecio indecorus*)and **green spleenwort** (*Asplenium trichomanes-ramosum*), state special

concern veiny meadow-rue (***Thalictrum venulosum* var. *confine***), and **wild oat grass** (*Danthonia intermedia*), and state and federal threatened **Houghton's goldenrod** were documented here during previous survey work and there is no reason to doubt their persistence. A narrow sand beach occurs along the southern portion of the site. An occurrence of piping plover documented in the area in 1985, was not observed during this study, however appropriate habitat likely still persists. Suitable habitat for rare land snails also occurs at this site. Numerous houses occur at this site and more are currently under construction.

Lake Superior State Forest Dunes

This site forms the southeastern corner of a previously identified large **wooded dune and swale** complex (Gulliver Lake Dunes; Comer & Albert 1993) that extends over 2300 acres. It is also part of a DEQ-designated critical dune area. US-2 and County Road P432 bound the entire complex to the north, and it extends westward to Dutch John's Point. Strong prevailing winds have re-sorted the sands forming 3-4 m. irregular dune ridges with a series of parabolic dunes at the northeastern corner, south of McDonald Lake. The abundant swales in the complex vary considerably in size, organic content, and saturation. They are predominantly emergent marshes and intermittent wetlands containing such species as aquatic bulrush (*Scirpus subterminalis*), blue joint grass (*Calamagrostis canadensis*), common marsh spikerush (*Eleocharis smallii*), speckled alder (*Alnus rugosa*), small bur reed (*Sparganium minimum*), thin grass (*Agrostis perennans*), and swamp thistle (*Cirsium muticum*) (Comer & Albert, 1993.) The ridges, once dominated by white pine (*Pinus strobus*), paper birch (*Betula papyrifera*), and eastern hemlock (*Tsuga canadensis*), are currently dominated by red pine (*Pinus resinosa*), white pine, red oak (*Quercus rubra*), paper birch (*Betula papyrifera*), and red maple (*Acer rubrum*.)

The near-shore portion of the wooded dune and swale is part of Lake Superior State Forest and it contains the most well developed open dune complex in the study area. It also comprises the majority of the only remaining shoreline that lacks a significant near-shore road, and that has not seen considerable existing or imminent residential development. It has a complex topography of beach, foredune and blowout pockets extending inland to forested dunes. The dunes appear to be little disturbed and retain a healthy, diverse and predominantly native dune flora including such species as dune grasses (*Ammophila breviligulata*, *Calamovilfa longifolius*), wheat grass (*Agropyron dasystachum*), Canada wild-rye (*Elymus canadensis*), wormwood (*Artemisia campestre*), death camus (*Zygadenus glauca*), hoary puccoon (*Lithospermum canescens*), sand cherry (*Prunus pumila*), common juniper (*Juniperus communis*), bear-berry (*Arctostaphylos uva-ursi*) and red-osier dogwood (*Cornus stolonifera*.) Thriving populations of **Pitcher's thistle** and **Lake Huron tansy** were found scattered throughout the open portions of the complex and a population of the **Lake Huron locust** was also found here. Previously, an occurrence of state special concern **stitchwort** (*Stellaria longipes*) was documented and though not observed during this study, it is likely to persist in this relatively undisturbed complex.

Michibay Road Dunes

This site, spanning approximately five miles, merges with Lake Superior State forest dunes to the east and is also contained within the large **wooded dune and swale** complex discussed above. It is also contained within a DEQ-designated critical dune area. It can be characterized as sand beach with a series of foredunes, varying in extent along the length of the site. The open dunes at this site are generally less developed than those of Lake Superior State Forest to the east, but there are some pockets with significant topography, particularly south of Gulliver Lake. Several small creeks meander through wetlands and emerge at the beach. **Pitcher's thistle, Lake Huron tansy,** and **Lake Huron locust** were seen at every property that was visited throughout the length of this site, and it is likely that these three species occur throughout the entire site, as there doesn't appear to be any discontinuity in appropriate habitat. For this reason, this large area was considered one site.

Pine-drops (*Pterospora andromedea*) was previously noted inland from the shoreline, and although not seen during this survey, very likely persists. This species is quite difficult to find, not always appearing above ground each year and sometimes occurring in very small numbers. Lacking chlorophyll, it forms a mycorrhizal (fungal) relationship with the root of a tree, typically a conifer, to obtain nutrients. The upland ridges of the dune and swale complex, containing hemlock, spruce, balsam fir, or white cedar, provide many acres of appropriate habitat for this species. Michibay Road parallels the shoreline within ¼ mile of the lake. There are numerous houses already dotting the landscape in this region, with many future houses in process. Many of the existing dwellings are well set back from the dunes and seem not disrupt the natural shoreline processes, but it will be important to educate landowners, especially newcomers to the area, about the natural features that occur here. If carefully stewarded and monitored, this site could perhaps be developed into an exemplary occurrence of successful coexistence of humans and rare species, and serve as a model to emulate in other areas.

Rocky Point West

Separated from Michibay Road Dunes by a segment of rocky cobble shoreline at Rocky Point, this site is a relatively narrow sand beach with small foredunes dominated by common dune species such as dune grasses, wormwood, Canada wild-rye, Ohio goldenrod (*Solidago Ohioensis*), and ninebark. It forms the western edge of the wooded dune and swale complex described in the Lake Superior State Forest Dunes site above. Sparse populations of **Pitcher's thistle** and **Lake Huron tansy** were found here, as was the **Lake Huron locust,** however, it is not clear whether there is gene flow from this site to populations east of Rocky Point, hence separate occurrences of these species were recorded. Michibay continues to parallel the shoreline and houses in this area, are also set back behind the foredunes. Some have elevated walkways to the beach. They currently appear to have little effect on the dune species, however, it will be important to educate landowners and monitor the long-term success of populations. Suitable habitat for rare land snails was also identified at this site.

Dry Creek

The non-wooded shoreline continues to narrow from the open dunes to the east, and here is composed primarily of sparsely vegetated wet sand and rocky cobble beach with very little foredune development. Common species include dune grass (*Ammophila breviligulata*), wormwood, Canada wild-rye, Baltic rush, silverweed, sandbar willow (Salix exigua), bear-berry, and northern white cedar. Houses here are closer to the lake and exotic species such as purple loosestrife (*Lythrum salicaria*) and yarrow (*Achillea millefoliuim*) are more common than further eastward. Recent storm activity has remolded the shoreline substrate substantially, according to landowners. Local clusters of **Lake Huron tansy** were found here, updating a previously known occurrence, and several clusters of **Houghton's goldenrod** were also identified, representing a new occurrence of this species. A previously documented **dwarf lake iris** occurrence was not observed due to lack of permission to survey, however, there is no reason to suspect it does not persist. Suitable habitat for rare land snails was also identified at this site.

Michibay Township Park

Thriving populations of **Pitcher's thistle**, **Lake Huron tansy** were documented in this open dune complex, as was a previously known occurrence of **Lake Huron locust**. Localized patches of **dwarf lake iris** were discovered inland and two clusters of **Houghton's goldenrod** were also newly documented. The open dune retains a good diversity of native dune flora, including dune grasses, wheat grass, Canada wild-rye, hoary puccoon, wormwood, starry false soloman-seal, lyre-leaved rock-cress, creeping juniper, common juniper, bear-berry, sand cherry, and northern white cedar. Behind the dune is a boreal forest with a diverse flora including northern white cedar, white spruce, balsam fir, sarsaparilla (*Aralia nudicaulis*), gaywings (*Polygala paucifolia*), Canada mayflower (*Maianthemum canadensis*), starry false soloman-seal, bluebead lily (*Clintonia borealis*), twin flower (*Linnaea borealis*), starflower

important to educate the public of the significance of these natural features, and monitor impacts due to visitor use.

Section 10 Dunes

This site contains small to medium foredunes with regions of rocky, broken cobble shoreline dissected by several small creeks. Dense boreal forest occurs inland. **Pitchers' thistle, Lake Huron tansy,** and **Lake Huron locust** were found at all properties visited where sandy substrate was dominant, while several clusters of **Houghton's goldenrod** were documented on a property that was predominantly rocky. Suitable habitat for rare land snails was also identified here. Houses are mostly set well back from the open dune and appear to be coexisting peacefully with rarities causing little disturbance. Significant as-of-yet undeveloped regions harbor rarities, and landowners should be informed of these features and educated about ways to protect them.

Orr Creek

Similar to Section 10 dunes above, this site is comprised of a, narrow wet sand beach, sparsely vegetated with species such as Baltic rush, dune grass, and silverweed, and backed up to boreal forest. **Pitcher's thistle** and **Lake Huron tansy** were found on all parcels that were visited within this site. As development proceeds, landowners should be made aware of the natural features occurring here and educated about ways to protect them.

Manistique East

This site is comprised primarily of wet sand beach with a low foredune dominated by dune grasses. Other species noted include wormwood, beach pea (*Lathyrus japonicus*), Canada wild-rye, and sand cherry (*Prunus pumila*.) Sparse clusters of **Lake Huron tansy** were observed here and a specimen of **Lake Huron locust** was captured on one property at this site. Permission to survey in this region of the shoreline was limited and it is not clear if these populations extend onto adjacent properties or adjacent sites. Because there appears to be some discontinuity of optimal habitat, this occurrence was documented separately. Previously documented occurrences of **rayless mountain ragwort**, state special concern **fir clubmoss** (*Huperzia selago*), **chickweed** (*Stellaria longipes*), **veiny meadow rue,** and **Houghton's goldenrod** were not observed, but due to restricted access, their persistence here could not be ascertained. Appropriate habitat appears to persist, hence they are considered here as extant occurrences. Many properties along this shoreline stretch are maintained for visitors staying at motels north of the highway. Typically, they are mowed up to the very edge of the foredune, paving the way for the abundant exotic species that occur in abundance along the roadside edge. It does not appear that the majority of landowners are aware of the rare species that may occur on their properties, nor their ecological requirements. If these occurrences are to persist, landowner education is essential.

Manistique Boardwalk

This site extends along the lake shore in the City of Manistique east of the Manistique River. The boardwalk winds through an assortment of communities including, wet sand and rocky beach, shrub swamp, emergent marsh, pockets of northern fen, open dune, and boreal forest with nice informative signs for pedestrians. Due to the low water year, broad expanses of limestone pavement and broken rock were exposed on the lakeward edge. What little vegetation there was in this zone was confined primarily to cracks and crevices. Several clusters of **Lake Huron tansy** were located in a sandy zone inland from the limestone pavement, up against the boardwalk. Towards the Manistique river mouth, a small remnant population of **Pitcher's thistle** was located in an isolated pocket of open dune. Although retaining some diversity, including such species as dune grass, wormwood, and common milkweed, this pocket is relatively sheltered from the natural shoreline processes and appears to have suffered disturbance by ORV's. It remains to be seen how viable this dune remnant is over the long-term. The several pockets of northern fen were quite diverse containing native species such as twig-rush, Ohio goldenrod, Kalm's lobelia, purple gerardia (*Agalinis purpurea*), Indian paintbrush (*Castilleja coccinea*),

fringed gentian, low calamint (*Calamintha arkansana*), and shrubby cinquefoil (*Potentilla fruticosa*.) Exotic species were numerous along the entire boardwalk including purple loosestrife, yarrow, wild carrot, hawkweeds, bladder campion, sweet white clover, spotted knapweed, Canada bluegrass (*Poa compressa*.) It would be useful to add more information about the rare natural features that occur here and elsewhere in the Manistique region, to the informative signing along the boardwalk

Manistique West

West of the Manistique River mouth, the immediate shoreline consists of a narrow sand beach with a low foredune dominated by dune grass. **Lake Huron tansy** was found scattered throughout in low numbers, while a previously documented occurrence of **Houghton's goldenrod** was not relocated. During the course of this study, this site was platted up for sale. Developers and buyers should be informed of the occurrence of tansy here. This site also marks the northeast corner of a previously documented 9500 acre **wooded dune and swale** complex (Thompson Dunes, Comer & Albert, 1993) that extends all the way to Indian Lake on the northwest and to the village of Thompson on the southwest. This vast dune and swale complex, one of the largest known in the state, is bisected by US-2 and County Road P442 as well as the railroad tracks. High beach ridges occur near the shore north of US-2, while further inland they are smaller, ranging from 0.5 to 2 m high. Growing on the low ridges are cedar, hemlock, white pine, red pine, big-tooth aspen, black spruce, and red maple predominantly. The swales vary widely in size and amount of organic matter and are vegetated primarily with cedar, paper birch, black ash, balsam fir, sweet gale (*Myrica gale*), Michigan holly (*Ilex verticillata*), leatherleaf (*Chamaedaphne calyculata*), and sphagnum mosses (*Sphagnum spp*..) Calypso orchid and greenish-white sedge (*Carex albolutescens*) have been previously documented deep with in this complex north of the lake, however surveys conducted during the current study, focused on the near shoreline region.

Stony Point

Stony Point projects into Lake Michigan as a short rectangular peninsula with the long edge paralleling the shoreline. Documented previously, the exposed bedrock at the water's edge comprises a community occurrence of sparsely vegetated **limestone pavement,** which, in high water years, would be completely inundated. Just behind the pavement is a low cobble ridge, behind which lies an interdunal wetland that backs up to boreal forest dominated by white spruce, tamarack, balsam fir, and northern white cedar (Lee et al 1998.) A previously documented record for **dwarf lake iris** could not be confirmed due to restricted access during this study, however the inland habitat appears promising and it likely persists in the vicinity. Suitable habitat for rare land snails also occurs here. This site lies within the **wooded dune and swale** complex described in the Manistique West site above.

Thompson Dunes

This site lies between Stony Point and the Village of Thompson consisting of a narrow sand beach with small foredune features south of the highway and high dune ridges backed up by the wooded dune and swale complex north of the highway (described above.) There are several roadside turnouts and a developed roadside park with a paved parking lot, providing easy access by the public. The nearshore dunes harbor a relatively high diversity of plant species, but exotic species, such as spotted knapweed, yarrow, and hawkweeds (*Hieracium* spp.) are locally abundant. **Pitcher's thistle, Lake Huron tansy,** and **Lake Huron locust** occur in the northern shoreline portions of the site, but fade out southward towards Thompson where shoreline dune features are minimal. A significant population of **dwarf lake iris** was documented north of the highway in 1991 and was not resurveyed during this study. Of particular concern at this site is the on-going development occurring within the dune and swale complex north of the highway, with apparent disregard for rare species or the integrity of the community itself.

Thompson South

No access was granted to properties for approximately two miles from Thompson south. Aerial photo review indicates a narrow, somewhat rocky shoreline backed closely by mesic northern forest, along much of the shoreline, with several pockets of open dune. Access should be sought to conduct future surveys.

Snyder Creek

The site here consists of narrow, mostly wet sand and rock beach to the south, and a narrow sandy foredune ridge backed up by mesic-boreal forest and dune and swale features to the north. The previously documented **dwarf lake iris** was observed along the access road that transects the boreal forest, as well as on the several individual properties that were visited. **Lake Huron tansy** was observed in small fragmented clusters in the sandy foredune and wet sand beach of the visited properties, as was **Lake Huron locust,** while **Pitcher's thistle** was observed on one property only. Evidence of weedy fill dirt was present and numerous exotic species such as strawberry, hawkweeds, and poverty grass, were observed, particularly on the inland portions of the visited properties.

Wiggins Point

At the southern side of the Point, two low foredunes form a small open dune complex with a good complement of native dune species, in which populations of **Pitcher's thistle**, **Lake Huron tansy**, and **Lake Huron locust** were all documented. A slight swale with Baltic rush, Kalm's lobelia, and water horehound, occurs between the foredunes, forming the beginning of a larger dune and swale feature that continues inland. Northern white cedar and hemlock dominate the upland ridges. Northward the beach narrows to wet sand with little foredune development. Residential development here has been quite invasive, with clearing occurring to the beach bluff in places, and weedy fill dirt deposited with its numerous exotic species, such as yarrow, strawberry, and hawkweeds. Scattered clusters of **Lake Huron tansy** occur along the entire Point, and **Pitcher's thistle** was found at the northern edge of the site. **Lake Huron locust** was also documented here, the population continuing onto the Snyder Creek site above.

Wiggins Point South

No access to this region of the study area was gained during this study. Aerial photos indicate a segment of open dunes south of Gierke creek to approximately ½ mile south of Bursaw Creek, narrowing to a somewhat rocky beach rising to a forested bluff, south past Bourassas Point. The open dunes here are a high priority survey site for Pitcher's thistle, Lake Huron tansy, and Lake Huron locust, while the ecotonal areas provide potential habitat for dwarf lake iris, beauty sedge, and calypso orchid. Attempts to access properties in this region should be attempted in future years.

North Point aux Barques

A steep bluff rising from a very narrow rocky shoreline characterizes this site. Mesic northern forest predominates on the bluff and no rarities were observed on the few sites where access was gained. However, it is possible that species such as dwarf lake iris, beauty sedge, or calypso orchid, could be found on other properties in the vicinity. The point itself has experienced considerable disturbance, with significant areas that have been completely cleared of native vegetation.

Point aux Barques

The properties that were accessed in this site where characterized by sparsely vegetated rocky cobble with pockets of marly northern fen, backed up by a narrow band of wet sand and then forest. Surveys focused on the Lake Huron locust, which was not found on the few properties where access was gained. Previously documented occurrences of **dwarf lake iris**, **Lake Huron tansy**, and **Pitcher's thistle** were not observed, however appropriate habitat appears to be present south of the point, and it is likely that survey of additional properties would uncover them. Suitable habitat was also identified for rare land snails.

Point aux Barques South

This site is characterized by flat rocky substrate with little sand beach and thick boreal forest inland dominated primarily by cedar, spruce, balsam fir, and paper birch. Vegetation on the beach is sparse including species such as Baltic rush, sedge (*Carex viridula)*, low calamint, Kalm's lobelia, and silverweed. Pockets of calcareous northern fen occurred at the ecotone between forest and beach, with associated species such as Pitcher plant (*Sarracenia purpurea*), sundew (*Drosera rotundifolia*), Indian paintbrush (*Castilleja coccinnea*), ragwort (*Senecio paupercula*) and grass-of-Parnassus (*Parnassia glauca*.) **Dwarf lake iris** was observed in several locations, and is likely more widespread in the forest openings, however further access will be required to confirm this. Houghton's goldenrod should also be sought here in future surveys. Suitable habitat was also identified for rare land snails.

Hiram Point North

North of Hiram point lies a sparsely vegetated wet sand beach abutting a ridge of dense boreal forest that increases to a steep, high bluff along north Parent Bay. At Hiram Point the beach becomes a rocky substrate with segments of limestone pavement, and pockets of northern fen. A previous occurrence of **Lake Huron tansy** was located on a small dune ridge just south of Birch creek. **Dwarf lake iris** was relocated in the boreal forest ecotone extending from approximately one quarter mile north of Birch Creek to one half mile south of the Creek, and in several isolated pockets southward. Several pockets of **beauty sedge** were found scattered with the iris. A previously documented occurrence of **calypso orchid** was not observed, however, likely still persists somewhere in the numerous acres of boreal forest that occur here. Suitable habitat was also identified for rare land snails. In addition, aerial photos reveal several pockets of northern fen on Cole Point and access should be sought to assess these for element occurrence status.

Hiram Point South

South of Hiram Point, the shoreline is predominantly rocky with pockets of northern fen, inland at the boreal forest-beach ecotone, and backed up by boreal forest. Several clusters of **dwarf lake iris** and **beauty sedge** were documented on accessed properties. Although much of the remaining portions of site where access was limited, appears somewhat wet for dwarf lake iris, it is possible that this species could be found further south towards Point O'Keefe, and other species such as Houghton's goldenrod, and Calypso orchid should be sought here as well. Suitable habitat was also identified for rare land snails. The extent of northern fen should also be surveyed and considered for element occurrence status.

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Appendices

Appendix A.

Landowner Contact Letter

May 3, 2000

«First_name» «Last_name»
«address»
«city», «state» «zip»

Dear «First_name» «Last_name»:

The Michigan Natural Features Inventory (MNFI) was started as a partnership between The Nature Conservancy, a private, non-profit conservation organization, and the Wildlife Division of the Michigan Department of Natural Resources. We are in our twentieth year of conducting surveys for Michigan's unusual natural features. These features include rare plants and animals, unique geological features, and representative examples of Michigan's native forests, grasslands, and wetlands.

The Great Lakes shoreline is one of Michigan's most valuable and unique assets. This coastal zone encompasses a landscape rich with significant natural features unlike anywhere else in the world. It is home to many rare and/or declining species, including pitcher's thistle, Houghton's goldenrod, dwarf lake iris, piping plover, and Hine's emerald dragonfly. Parts of the shoreline also serve as important stopover sites for migrating birds.

In an effort to better understand the occurrence of these natural features along Michigan's shoreline, Michigan Natural Features Inventory has conducted systematic surveys along most of the entire Lower Peninsula shoreline and a significant number of Great Lakes islands. We are now expanding our systematic survey to the Upper Peninsula shores, and would like to include your property in our survey. Would you be willing to allow us to visit your property to collect information for our study?

We plan to conduct surveys between mid-May and late August. One or two people would visit your property up to three times, and take notes on the vegetation, animals and natural characteristics of the property. With your permission, we may also collect plant and insect specimens to verify their identities. If you wish, we would be happy to notify you of the day we plan to visit. You would be exempt from liability, should anything happen to us during our visit.

We would greatly appreciate your participation in this study. Please use the second page of this letter to indicate your willingness to assist in our efforts and return it in the enclosed envelope. If you have any questions, you may include them with your response, or you may call either Phyllis Higman at (517) 373-6983 or Yu Man Lee at (517) 373-3751.

Sincerely,

Phyllis J. Higman, Yu Man Lee

**Please make corrections below if necessary:

Name:	«First_name» «Last_name»
Address:	«address»
City, State zip:	«city», «state» «zip»
Phone:	_____
Location:	«location»

**Please check with an X if you agree to one or both of the following:

____Yes, you may visit my property to conduct a survey

____Yes, you may collect plant and insect specimens for identification purposes

The Nature Conservancy agrees to indemnify and hold the Landowner harmless from liability for any personal injury or property damage claims made by others in connection with the Conservancy's activities on the Landowner's property.

**Please indicate below if you have any concerns or wish to make additional comments.

_____

_____

_____

Appendix B.

Definitions of viability ranks for Lake Huron locust populations along the Lake Michigan shoreline in Schoolcraft County from Seul Choix Point to Point O'Keefe.

A* = Excellent viability – a persistent population estimated to be of >150 individuals after one hour survey in >1,000 acres of required habitat; threats are manageable.

B = Good viability – a persistent population estimated to be 50-150 individuals after one hour survey in 100-1,000 acres with no habitat degradation.

C = Fair Viability – a persistent population estimated to be 10-50 individuals after one hour survey in <100 acres of habitat; threats are more serious.

D = Poor viability/Not viable – a non-persistent population or an apparently persistent population estimated to be <10 individuals after one hour survey in habitat strip <10 m wide even if long (>1 km); threats are greater and more difficult to control.

Appendix C.

Crosswalk of Nekola and MNFI community types and habitats that support land snails found in Michigan's Upper Peninsula, taken from Nekola (1998) and MNFI (1989.)

Nekola Habitat Type	Definition	MNFI Natural Community Type
Carbonate cliff	2-20 meter tall, wooded limestone or dolomite outcrops	Non-acid cliff
Igneous outcrop	Wooded, 2-20 meter tall basal, rhyolite, or basalt-derived conglomerate outcrops, mostly found in northwestern Upper Peninsula	Non-acid cliff Acid cliff
Rocky woodland	Upland forest with talus or rocky slopes, exposed bedrock (≤1 meter tall) or boulders.	Limestone glade Grantic glade
White cedar wetland	Forested peatlands dominated by white cedar *(Thuja occidentalis*.) Soils can range from acidic, with abundant Sphagnum moss, to neutral, with little or no Sphagnum. Tamarack (*Larix laricina*) and speckled alder (*Alnus rugosa*) also common.	Rich conifer swamp
Cobble beach	Grassland habitats with exposed carbonate bedrock kept constantly moist by Lake Michigan or Lake Huron. Mostly restricted to Drummond Island and the Garden Peninsula.	Cobble beach Limestone pavement lakeshore
Fen	Peatlands associated with areas of groundwater discharge, and characterized by higher soil moistures and cooler soil temperatures.	Northern fen
Alvar	Grasslands on flat limestone or dolomite pavement with little or no soil development.	Alvar grassland
Igneous bedrock shoreline	Treeless areas with limited soil development that occur along the Lake Superior shoreline in the Keewanaw Peninsula where basalt or basalt-derived conglomerates are exposed. These areas support a number of western and arctic disjunct vascular plants.	Bedrock beach Balsatic bedrock lakeshore Volcanic conglomerate bedrock lakeshore
Tamarack-sedge wetland	Almost pure stands of tamarack which are open and support a thick sedge (*Carex* spp.) ground layer.	Poor conifer swamp
Lakeshore carbonate ledge	Less than 3 meter tall, forested limestone or dolomite outcrops which occur within 1 km of the Lake Michigan or Lake Huron shoreline	Limestone pavement lakeshore
Lakeshore alluvial bank	Steep forests along the Lake Michigan or Lake Huron shoreline which have developed into lacustrine material.	Forested dune

Appendix D.

Summary Article for Press Release

Michigan's extensive Great Lakes shoreline contains some of the most ecologically significant and unique natural features in the state and region. The largest freshwater dune complexes in the world are found in this coastal zone. A rich assortment of natural communities including boreal forests, cedar swamps, Great Lakes marshes, limestone cliffs, and a globally rare bedrock grassland community known as alvar comprises much of the remainder of these lakeshores. Michigan's coastal zone also is home to numerous rare plants and animals, some of which only occur along the Great Lakes shoreline. These include state and federal threatened or endangered plants such as Pitcher's thistle, Houghton's goldenrod, dwarf lake iris (Michigan's state wildflower) and Michigan monkey-flower. The federal and state endangered piping plover is only known to nest in the Great Lakes along northern Michigan's shoreline. The state threatened Lake Huron locust is known only from high quality, coastal sand dunes of Michigan, Wisconsin, and Ontario. One of the most endangered dragonflies in the country, the Hine's emerald dragonfly, was recently discovered along Lake Michigan in the eastern Upper Peninsula, and a number of globally rare land snails also were recently found along the Upper Peninsula shoreline. Great Lakes shores also serve as important migration corridors for large concentrations of landbirds and provide critical stopover habitat for neotropical migratory birds.

Michigan Natural Features Inventory conducted a project last year to survey and document shoreline occurrences of rare plants and animals and high quality natural communities in the northern Lake Michigan coastal zone in Schoolcraft County in the Upper Peninsula. A preliminary characterization of near-shore aquatic communities also was conducted. Thirty-nine occurrences of rare plants and nine populations of the state threatened Lake Huron locust were documented during the study. A total of 116 bird species were observed during migratory and breeding bird surveys. Five species of state-listed and globally rare land snails and four high quality natural communities were previously documented in the area. Additionally, the near-shore aquatic communities that were sampled contained a diversity of predominantly native species, which is increasingly rare in the Great Lakes due to shoreline modification and exotic species invasion.

The coastal zone in Schoolcraft County is predominantly privately owned and has experienced significant residential, recreational and commercial development in recent years. The results from this study indicate that many of the rare shoreline species can withstand some level of human disturbance. However, the long-term sustainability of shoreline communities and species will require appropriate stewardship by landowners and land use planning that balances the needs of economic growth with those of natural features. Recommendations for efforts that could help achieve long-term sustainability include the following: 1) landowner education on appropriate stewardship of coastal zone features, 2) continued surveys and monitoring to obtain current and accurate information on the distribution and status of natural features and long-term impacts of management, 3) development of an effective framework for planners and others involved with critical land-use decisions at local, state and federal levels to adequately address natural features concerns, and 4) development of a landscape-level approach to land use and conservation planning.

Michigan Natural Features Inventory (MNFI) is a program with Michigan State University Extension. MNFI is responsible for inventorying and tracking Michigan's endangered, threatened, or special concern plants and animals, natural communities, and other significant natural features. MNFI will be continuing surveys along the northern Lake Michigan shoreline in Mackinac County in 2001. This project is funded through a grant provided by the Michigan Department of Environmental Quality through the Coastal Zone Management Program. For more information, contact Phyllis Higman at Michigan Natural Features Inventory, P.O. Box 30444, Lansing, MI 48909-7944 or at www.dnr.state.mi.us/wildlife/heritage/mnfi.

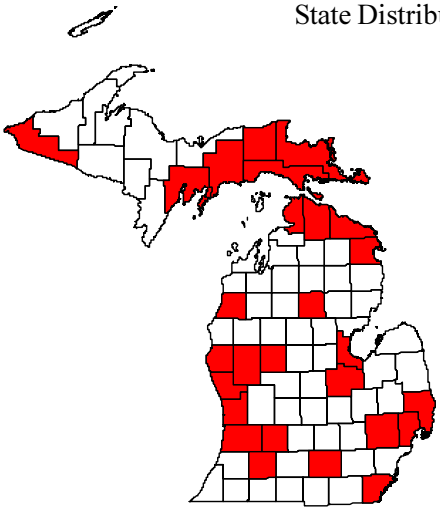
Appendix E.

Species Abstracts

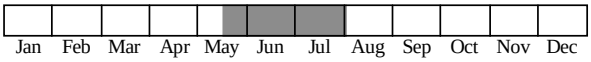
Chlidonias niger Linneaus — black tern

Photo by Barbara Simpson

State Distribution



Best Survey Period



Status: State special concern

Global and state rank: G4/S3

Family: Laridae (gull and terns)

Total range: Two subspecies are recognized, *C. niger surinamensis* found in North America, and *C. niger niger*, the Eurasian counterpart. In North America, black terns occur across most of southern Canada and the northern United States. They breed in all provinces of Canada except Prince Edward Island and Newfoundland. However, they are most common from central British Columbia across the prairie provinces to central Ontario and southern Quebec (Novak 1991). In the northern United States, black terns breed south to central California, northern Utah, Wyoming, Kansas, Iowa, Illinois, Indiana and Ohio to central and northern New York and northern New England. In Michigan, this species occurs mainly along the Great Lakes shorelines, but are also found at some inland locations (Chou 1994). Black terns usually migrate along the Atlantic coastline and mainly winter in marine and coastal areas south of the Gulf Coast through Central America to northern South America.

State distribution: Nesting black terns have been recorded in 27 Michigan counties (Brewer et al 1991; Natural Heritage Biological and Conservation Datasystem 2000). About half of all breeding records occur along the shores of the Great Lakes. In the southern Lower Peninsula they are well established at inland marshes and lakes. They occur primarily along Lake Michigan and Lake Huron as well as at several of the larger inland lakes in the northern Lower Peninsula. In the Upper Peninsula, black terns are also present along the shores of Lake Michigan and Lake Huron. However, they are absent from the Lake Superior shoreline west of Chippewa county and are almost absent in the western Upper Peninsula (Brewer et al. 1991).

Recognition: The **distinctive black head and underbody** with **gray wings, back, and tail** easily distinguishes this species from any other tern species in the state. Their size is also a key to recognition. With an **average length of only 9.75 inches (25 cm)** and a **wingspan average of 2 feet**, black terns are the smallest tern species to occur in Michigan. In North America, only the least tern is smaller averaging 9 inches (23 cm). **Under-tail coverlets are white**, while **eyes and beak are dark**. **Legs are reddish-black**, but this can be a difficult characteristic to identify. **In flight, the tail is short and slightly forked** and the species is highly acrobatic, often swooping and diving low over land or water. Juveniles and wintering adults are white or patchy black-and-white below with a gray tail. Wintering black terns can be easily confused with the Eurasian white-winged tern. However, a dark ear patch extending down from a black crown is a distinguishing characteristic of the black tern. Vocalizations include a harsh metallic *kik*, often produced when alarmed. Another softer common call is the *kyew* or *kyew-dik*.

Best survey time: The best survey time for black terns in Michigan begins during mid-May and

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continues through mid-August. Survey time for breeding birds is best between mid-May and late July. However, they can be seen in the state as early as mid-April in the Lower Peninsula and early May in the Upper Peninsula. Early October is the latest they have been found in Michigan (Chou 1994).

Habitat: Black tern colonies occur in freshwater marshes and wetlands with emergent vegetation found along lake margins and occasionally in rivers (Dunn and Argo 1995). Vegetation can vary greatly, but cattails (*Typha* sp.) or bulrushes (*Scirpus* sp.) are characteristically dominant in black tern colonies (Dunn 1979, Cuthbert 1954). Vegetative cover varies between dense and sparse but nests are usually protected from direct open water to avoid dangers such as wind and wave action. Overall, black terns tend to nest at sites with a 50:50 vegetation cover:open water ratio (Hickey and Malecki 1997). However, suitable marsh habitat of 5 ha or more is thought to be necessary. Nests are largely composed of the previous seasons' vegetation, found near the building site. In many instances nests are depressions in floating matted vegetation, found on logs or boards, and occupying abandoned muskrat lodges. Nesting occurs in water depths ranging from 0.5 m to 1.2 m (Dunn 1979, Mazzocchi et al. 1997). Spatial separation between nests can vary between 3 m to 30 m (Cuthbert 1954; Dunn 1979). This semi-social distribution is unusual for tern species and black terns are often labeled as a loosely colonial breeding bird (Brewer et al. 1991).

Biology: Black terns are a neotropical migratory species. Most reach the southern areas of the breeding range in early to mid-May. By mid to late August they are returning to their wintering locations in Central and South America. Pair mating occurs prior to arrival on the breeding grounds, and a short period of communal feeding and courtship behavior occurs before nest building begins (Dunn and Argo 1995). Both parents are involved in creating the nest and egg laying begins soon after nest completion. In Michigan's northern Lower Peninsula, egg laying starts in late May to early June (Cuthbert 1954), while in the southern part of the state, mid to late May is quite possible. Egg laying can continue into late July. Black terns generally lay 3 eggs per clutch, but numbers ranging from 1 to 5 are possible. Although black terns are considered a single-brooding species, nest failure does occur and they will re-nest if the first attempt fails. Both parents assist with the incubation process, which lasts 20-23 days (Bergman et al. 1970). Young black terns fledge 18-21 days after hatching. After fledging, parents continue to assist in feeding the young with food items consisting largely of small fish and insects (Dunn and Argo 1995). By late July or early August large numbers of black terns concentrate along Michigan's southern Great Lakes shores in preparation for fall migration. The southern migration begins soon after and few remain in Michigan by late September. Juvenile terns will not return to the breeding grounds until their second summer after fledging. They remain further south along the Gulf Coast. The maximum age recorded for the North American subspecies (*C. n. surinamensis*) is just less than 8.5 years.

Conservation/management: Black tern populations have decreased markedly since the mid 1960s. From 1966-1996, population declines throughout the North American breeding range were 3.1% annually. In Michigan, the decline was as high as 8.8% annually for the same time frame (Peterjohn and Sauer 1997). The drop in black tern populations in Michigan has been most evident in the southern tier of counties as well as the southeastern portion of the state. Many limiting factors exist as the cause or causes for such drastic declines including habitat loss, contaminants, and human disturbance.

An estimated 50% of Michigan's original wetlands have been drained, filled or altered and 70% of coastal wetlands have been lost throughout Michigan since European settlement (Cwikiel 1996). Similar situations have occurred in Canada. Compounding the problem, very little information concerning black tern winter ecology or the limiting factors on the wintering grounds is available. In addition to outright habitat loss are the corollary problems of habitat degradation, water and food quality and successional change. If pollutants, disturbance, or exotic invasion has changed the character of a wetland, it may become unsuitable for nesting black terns. Many wetlands exist today, which simply do not sustain colonies (Novak 1990). Toxic chemicals or contaminants including organochlorides (PCBs, DDT) and metals have been found in black tern eggs (Weseloh et al. 1997). Although studies have not determined biological effects on the birds, evidence indicates accumulation of these contaminants may lower reproductive success (Faber and Nosek 1985). The effects of human disturbance on black terns are poorly studied. However, activities other than habitat destruction include fishing, swimming, boating and prolonged human presence. Boat wakes can wash out black tern nests thereby submerging eggs or drowning chicks. Repeated and prolonged human presence in black tern colonies will prevent adults from incubating eggs or feeding offspring. When the adults are not present at the nest, exposure to weather or predation is more likely (Novak 1991).

Conservation and management options for the black tern, necessary to ensure a population stabilization or increase, include habitat preservation through land acquisition and conservation easements. Active management techniques involving artificial wetland production and management as well as artificial nest platform implementation are also viable options.

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Finally, a standardized methodology for surveying and sampling black tern populations in the state is essential (Hands et al 1989).

Research needs: Additional study is required to properly assess black tern numbers and trends in Michigan. Productivity measurements, foraging, diet and nutrition studies will assist in conservation efforts. Also, comparative studies across habitats and regions are necessary for insight into behavior and ecology. Finally, metapopulation dynamics and demography investigations are both essential components to understanding black tern population ecology (Nisbet 1997).

Related abstracts: common tern (*Sterna hirundo*), Caspian tern (*Sterna caspia*)

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Novak, P.G. 1991. Status of the black tern in the northeastern United States. The Nature Conservancy - Lower Hudson Chapter, Katonah, NY.

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Weseloh, D.V.C., J. Rodrigue, H. Blokpoel, and P.J. Ewins. 1997. Contaminant concentrations in eggs of black terns (*Chlidonias niger*) from southern Ontario and southern Quebec, 1989-1996. Colonial Waterbirds 20(3):604-616.

Abstract citation:

Currier, C.L. 2000. Special animal abstract for *Chlidonias niger* (black tern). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Funding for abstract provided by Michigan Department of Natural Resources - Parks and Recreation Division and Wildlife Division.

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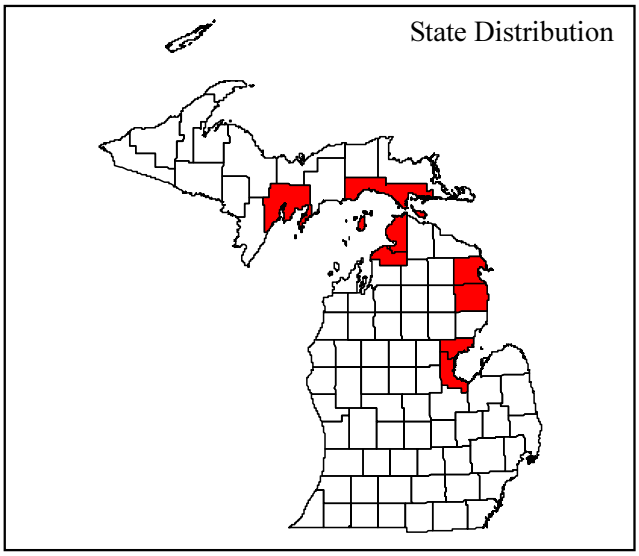
Sterna caspia *Pallas* — Caspian tern

Photo by O.S. Pettingill, Cornell Laboratory of Ornithology.



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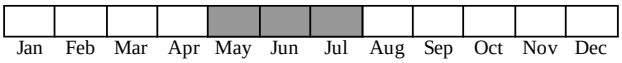

Status: State threatened

Global and state rank: G5/S2

Family: Laridae (gull and tern family)

Total range: The Caspian Tern is found throughout the world. In North America, six distinct populations breed on coastal and inland waters. On the Pacific coast, the species breeds locally in Washington and California, and south to Baja California. On the Atlantic coast, breeding occurs locally in Newfoundland and Quebec, and from Virginia to northern Florida. Nesting colonies also occur from Florida to Mexico along the Gulf coast. Inland populations reside in the Great Lakes northwest to central Manitoba, and locally in the Great Salt Lake region (Spendelow and Patton 1988). Wintering grounds include the southern coast of the United States, the West Indies, and northern South America (Ludwig 1942; Ludwig 1965).

State distribution: Caspian terns currently nest in eight counties within the State. Colonies are recorded from islands and coastal areas in Alpena, Alcona, Arenac, Bay, Charlevoix, Delta, Emmet, and Mackinac counties. Some of these nesting sites have been established since the early 1980s, including one on an artificial disposal dike in Saginaw Bay. Nesting is possible but not confirmed in Antrim, Cheboygan, Chippewa, Huron, Leelanau, Manistee, Presque Isle, and Tuscola Counties.

Recognition: The Caspian tern is the largest of the terns, with a **wingspan averaging 4.5 feet**. Its size, **stout red bill**, and **lack of a deeply forked tail** distinguishes it from other white terns found in the state. Its **black cap, large red bill**, and tern-like habit of flying slowly with its bill pointed downward separates it from the gulls. The **low harsh call** of the Caspian tern sounds similar to *karrr* or *kraa-ah* and is given frequently while in flight. The orange feet of immature birds distinguish them from fall-plumaged adults which have black feet (Evers 1994).

Best survey time: Although Caspian terns can be seen in Michigan from mid-April through September, the optimal time to survey for Caspian terns is during May, June and July.

Habitat: Nesting habitat of the Caspian tern is open sandy or pebble beaches, usually on islands in large bodies of water. The nest consists of a shallow depression near the water line. Water levels, competition from other species in the Laridae family, and vegetative succession are factors that influence the selection of sites for a nesting colony. Artificial nesting sites, such as the disposal dike in the Saginaw Bay, have proven to be acceptable nesting habitat (Scharf and Shugart 1983). A problem identified with this, and similar artificial sites is the possibility of toxins entering the surrounding ecosystem and negatively impacting the population. Foraging habitat can consist of almost any large body of water where their prey of alewife (*Alosa pseudoharengus*), American smelt (*Osmerus mordax*), or yellow perch (*Perca flavescens*) is common (Ludwig 1991).

Biology: Caspian terns are a migratory species. They arrive at their breeding grounds from mid-April to mid-May. Almost all individuals return to the same general breeding area for more than one season (Cuthbert 1988). Caspian terns nest in colonies, often within several feet of

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each other and other species of the Laridae family. (Ludwig 1965). Clutches with an average of two or three eggs each appear from mid-May to mid-July. Both males and females incubate the eggs for approximately 26 days until hatching in July and August. The young fledge 36-56 days after hatching. After migrating to their wintering grounds, first year birds remain through the first summer, and don't return to their breeding grounds until the second summer after their fledging (Ludwig 1968, Cuthbert 1988)

The rapid expansion of the alewife into the upper Great Lakes in the 1950s provided Caspian terns with a plentiful food source. The population size in Michigan grew in response, from approximately 525 nesting pairs in 1962 (Ludwig 1962), to an average of 1,800 nesting pairs between 1975 and 1982 (Evers 1994).

Conservation/management: Offspring tend to return to the region of their natal colony to breed and adults tend to return to the same colony to breed if nesting the previous year was successful. (Ludwig 1968, Cuthbert 1988). Combined with the geographic separation of colonies, this suggests there is little mixing between populations of different regions. This being the case, the Great Lakes population maintains itself primarily through reproduction with little immigration of individuals from other regions. Therefore, local perturbations could cause a dramatic decline in a region's population (Shugart et al. 1978). The Caspian tern is listed as threatened in Michigan because of the possibility of a local decline under these circumstances. The Caspian tern has never been common or widespread in the Great Lakes region. Current factors believed to be negatively affecting the population are interspecific competition, human disturbance, environmental contaminants, and a lack of isolated island habitat (Evers 1994). Washouts caused by high waves can destroy entire nesting colonies. Studies in the region attributed over half of nest failures in Caspian tern colonies to washouts (Shugart et al. 1978, Cuthbert 1988). Although nest counts for the species have been relatively high in recent times, there is still concern for the viability of the Great Lakes population. The mean fledging rate of 1.46 chicks per nest in the 1962-1967 period (Ludwig 1965, Ludwig 1968) declined to .61 in the 1986-1989 period (Ludwig et al. 1990). Evidence has been presented that PCB's have put Great Lakes populations under severe stress. High levels of this toxin in eggs correlate with rising rates of deformities, embryonic abnormalities, and depressed hatching rates (Ludwig and Kurita 1988, Tillit et al. 1988). Conservation efforts should concentrate on the protection of nest sites from human disturbance. Terns using contaminated sites for nesting should be provided with alternative breeding sites with uncontaminated substrate. Colonies should be monitored on a regular basis to document changes in numbers of breeding pairs, reproductive success, and impacts of toxins (Evers 1994).

Research needs: A better understanding of the effects of toxins on the Caspian Tern and related species is needed. In particular, how floods, dredging, and other physical events can mobilize toxicants from contaminated sediments into the aquatic food web needs to be researched.

Related abstracts: common tern (*Sterna hirundo*)

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Abstract citation

Hyde, D.A. 1996. Special animal abstract for *Sterna caspia* (Caspian tern). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

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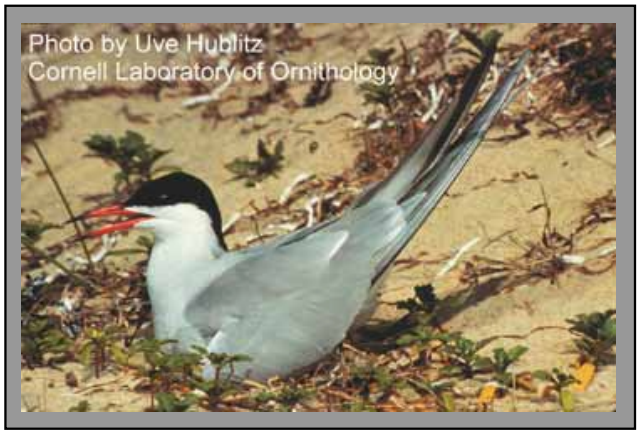
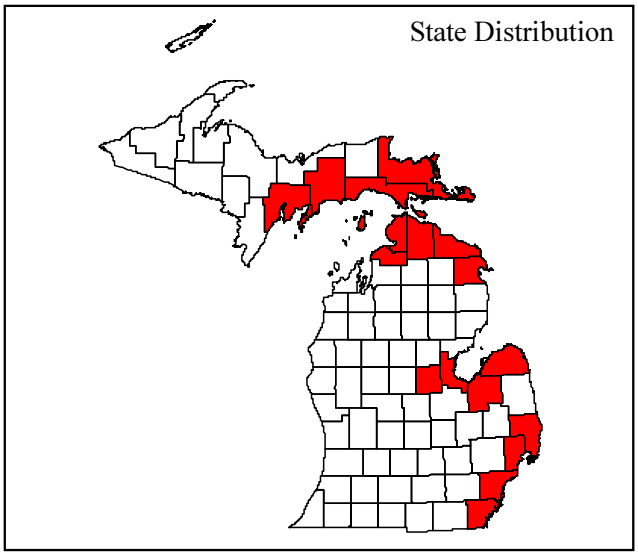
Sterna hirundo Linneaus — common tern





Best Survey Period

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
				■	■	■					

Status: State threatened

Global and state rank: G5/S2

Family: Laridae (gull and tern family)

Total range: The common tern breeds throughout much of the temperate zone of the Northern Hemisphere. Its primary breeding range in North America is from the south central Northwest Territories to southern Quebec and Newfoundland, the Atlantic Coast (from Nova Scotia to North Carolina), the Great Lakes region and the northern Great Plains. Great Lakes common terns migrate along the Atlantic coast and winter primarily along the north and west coasts of South America, in the Caribbean, and less frequently along the U.S. Gulf coast and the southern Atlantic coast (Austin 1953, Haymes and Blokpoel 1978).

State distribution: Common tern nesting sites have been recorded for seventeen counties in Michigan. These are Alpena, Bay, Charlevoix, Cheboygan, Chippewa, Delta, Emmet, Huron, Mackinac, Macomb, Midland, Monroe, Presque Isle, St. Clair, Schoolcraft, Tuscola, and Wayne counties. No recent nest sites have been recorded from either the northern coast of the Upper Peninsula or the western coast of the Lower Peninsula, although the species was once abundant on all the Great Lakes (Barrows 1912).

Recognition: The **slender body**, **long pointed wings** and **deeply forked tail** are key characteristics of the common tern. Their typical call is a drawled *kee-arr*. Their 31 inch average wingspan distinguishes them from the Caspian tern whose wingspan averages 54 inches. Wintering adults and immature birds have a black nape and dark bill. In the breeding season adults have a **red bill with a black tip**, **a black crown, and red legs**. Although it is easily confused with the Forster's tern, the common tern has darker wing tips, a higher pitched call, and a redder bill.

Best survey time: Common terns can be seen in Michigan from mid-April though October, although the best time to survey for them is in May, June and July.

Habitat: Common tern colonies occur on sparsely vegetated sand and gravel beaches of islands and peninsulas. Artificially created islands currently provide the most favorable nesting habitat. Colonies utilize sites formed from dredged material in Chippewa, Saginaw, and Monroe Counties. They also have been known to use abandoned wooden piers (Harris and Matteson 1975). Ocean shoreline habitats are used for roosting and foraging during the winter.

Biology: Common terns return to their Michigan breeding grounds beginning in mid-April and depart to their wintering grounds from late August through October. Nesting begins the second week of May in southern counties and in late May in northern counties. Both adults incubate a clutch, averaging two or three eggs, for a 22 to 25-day period. Initial nest loss is common and is often compensated by a second nesting. Although typically single-brooded, common tern pairs occasionally attempt to raise a second brood (Hay 1984). Both adults share in feeding the young (Wagner and Safina 1989) which begin flying four weeks after hatching. Reproductive maturity is reached at three years of age.

Common terns prefer to nest in relatively large colonies

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where they cooperate to defend against competitors and predators. The pair cooperates in building a nest that can be as simple as excavating a slight hollow in the sand and gravel, to construction of a slightly raised mound with a lining of fine grass and other material. Nests are usually associated with low, herbaceous vegetation and driftwood (Blokpoel et al. 1987). Common terns are opportunistic feeders, foraging on the small fish species that are most available (Courtney and Blokpeol 1980). They feed primarily on fish that are between 1 to 3 inches long by hovering over the water and then diving and capturing them with their bill. Insects are also caught while flying and can play a significant role in the common tern's diet in certain locales (Vermeer 1973).

Conservation/management: Common terns were once the most abundant tern in Michigan waters, frequenting the shores and islands of the Great Lakes as well as all the principal streams and interior lakes (Barrows 1912). The market for plumes and feathers nearly caused their extinction until they were given protection under the Migratory Bird Treaty of 1916. During the mid 1970's through 1984, an average of 1,800 nesting pairs were recorded in the state. Recent reductions in the Michigan population to 1,500 pairs in 1985 have been attributed to the declining quality of their nesting habitat.

A combination of natural and human-related factors are severely impacting common tern populations. Regularly fluctuating water levels of the Great Lakes, vegetation succession, and erosion continually reduce or eliminate suitable nesting sites. Competition and predation from increasing populations of ring-billed gulls (*Larus delawarensis*) and herring gulls (*L. argentatus*), are a significant limiting factor, especially due to competition for limited suitable nesting sites. (Scharf 1981). Other predators which impact reproductive success include: Norway rats, red fox, garter snakes, great horned owls, black-crowned night herons, and Canada geese (Cuthbert 1980, Evers 1994).

Human factors that limit common tern populations include island and beach development, use of off-road vehicles on beaches, and the release of chemical contaminants into the environment. Recent evidence suggests that PCB's have put Great Lakes populations under severe stress. High levels of this toxin in eggs correlate with rising rates of deformities, embryonic abnormalities, and depressed hatching rates (Ludwig and Kurita 1988).

Using fire to expose the ground surface, in areas succeeding to closed vegetation, has been demonstrated to be very helpful to common terns (Sharf 1986). Control of competitors and predators may be crucial in maintaining common tern populations, although restricting one competitor or predator is usually not adequate to increase fledgling success. Intensive programs to control all predators impacting a population as well as reducing disturbances by humans may be needed (Cuthbert 1980).

Research needs: More research is needed to understand the population dynamics of common terns and to insure the long-term preservation of nesting colonies in Michigan. Habitat availability, relationships with gulls and other competitors, and food requirements are key areas that need further study. Immediate measures such as habitat manipulations are needed to insure that populations in the Great Lakes ecosystem are maintained at healthy levels (Evers 1994).

Related abstracts: Caspian tern (*Sterna caspia),* sand/gravel beach.

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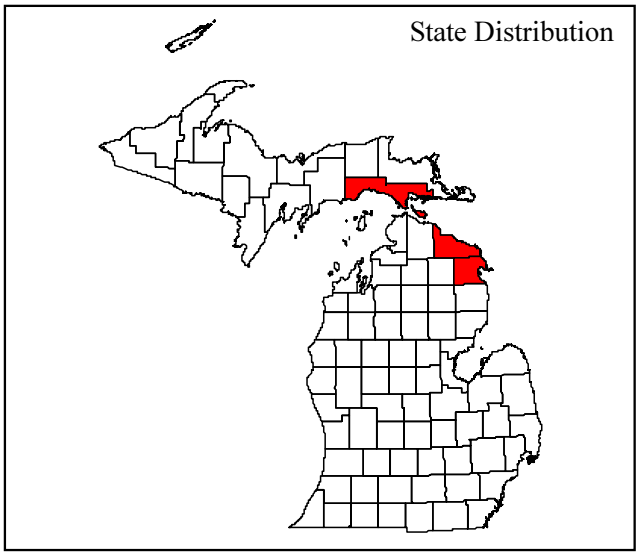
Somatochlora hineana Williamson — Hine's emerald dragonfly


Photo by William A. Smith.



Best Survey Period

Status: Federal and State endangered

Global and state rank: G1/S1

Family: Corduliidae (emerald dragonfly family)

Range: The Hine's emerald is currently known from northern Michigan, northeastern Illinois, Door County, Wisconsin, and one site in the Missouri Ozarks. Historically the species was known to occur in three areas of Ohio, and at one site in Indiana. In addition, one specimen had been collected in northern Alabama. Since 1961, Hine's emerald has not been seen in Ohio or Indiana, and it is believed to be extirpated from these states.

State distribution: The Hine's emerald is currently known from nine sites in Michigan. Seven sites are in Mackinac County in the eastern upper peninsula, with one site each in Alpena and Presque Isle counties in the northern lower peninsula. Although not confirmed from Michigan until 1997 a specimen was housed in the Michigan State University insect collection and remained undiscovered until 1998. This adult male specimen had been misidentified as *Somatochlora tenebrosa* (O'Brien 1997).

Recognition: Hine's emerald adults, like other members of its family, have **brilliant green eyes**. *Somatochlora hineana* can be distinguished from all other species of *Somatochlora* by a combination of its **dark metallic green thorax with two distinct creamy-yellow lateral lines** and its **distinctively shaped terminal appendages** or genitalia (Williamson 1931). Adults have a body length of 2.3-2.5 inches (60-65 mm) and a wingspan of 3.5-3.7 inches (90-95 mm) (Zercher 1999). Other species of *Somatochlora* in Michigan which may be confused with Hine's emerald include *Somatochlora elongata*, *S. forcipata*, *S. francklini*, *S. incurvata*, *S. kennedyi*, *S. minor*, *S. walshi*, and *S. williamsoni*. Distinctively shaped male terminal appendages, and female ovipositors separate adults of *S. hineana* from all others. For positive identification adult specimens need to be netted and verified by an expert. No one character will easily or reliably differentiate larvae of Hine's emerald from the species listed above (Zercher 1999). Researchers are currently working on devising keys to differentiate *Somatochlora* larvae.

Best survey time: Adult flight records in Michigan range from late-June through mid-August and adults are best sampled during this period. Larvae can be sampled for at any time during the growing season but seem to be less active during the cooler water temperatures of late fall and early spring (Soluk et al. 1998).

Habitat: Important habitat characteristics of Hine's emerald sites include graminoid dominated wetlands which contain seeps, or slow moving rivulets; cool, shallow water slowly flowing through vegetation; and open areas in close proximity to forest edge (Zercher 1999). The shallow, flowing, cool water provides important larval habitat and the open areas with adjacent woodland edge provide adult hunting and roosting habitat. Michigan Hine's emerald dragonfly sites could be classified as calcareous wetlands or northern fens with an underlining layer of shallow dolomite. One site in Mackinac County has been described as thinly treed, alkaline peatlands (Penskar and Albert 1988). Dominant

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vegetation in northern fens include sedges (*Carex aquatilis*, *C. lasiocarpa*, *C. limosa*, etc.), shrubby cinquefoil (*Potentilla fruticosa*), bulrushes (*Scirpus* spp.), rushes (*Eleocharis* spp.), and twig-rush (*Cladium mariscoide*). White cedar (*Thuja occidentalis*) commonly surrounds and invades northern fens. Other communities in and around Hine's emerald observation locations include: rich conifer swamps, marl fens, coastal fens with seeps, marl pools, hummocks, shallow pools, and small creeks.

Biology: The Hine's emerald exhibits a typical dragonfly life cycle with an aquatic egg, aquatic larva, and a terrestrial/aerial adult (Zercher 1999). The larval stage may last from between 2 to 4 years as they continue to forage and grow within small streamlets (Soluk et al 1998). Hine's emerald larvae are assumed to be a sit-and-wait predator. Analysis of larval behavior in the lab indicates that the larvae are more active at night than during the day (Pintor and Soluk, INHS, unpublished data). Other workers (Mierzwa et al. 1998) have also reported larval movement during the night in the field. It is very likely that the larvae are opportunistic predators feeding on a wide range of invertebrates including but not limited to mayfly, caddisfly, oligochaete larvae, isopods, smaller larvae of other dragonflies, mosquito larvae, worms, and snails (Zercher 1999). An interesting and possible important aspect of larval ecology is the ability to withstand low water or even drought conditions. Hine's emerald larvae have been found beneath discarded railroad timbers in a dried stream channel in Illinois and from crayfish burrows in Illinois and Wisconsin (Soluk 1998). The presumed larval habitat at sites in Michigan has been completely dried up during certain times of the year. Little is currently know on how the larvae survive these conditions in Michigan.

When the larva matures it climbs upon a cattail, rush, or other vertical structure and sheds its exoskeleton (skin) and transforms into a winged adult. This emergence takes place in Michigan from late June through July with adults on the wing until mid-August in most years. As an adult it feeds, establishes a territory, mates, and females lay eggs. Most adult dragonflies are general predators feeding primarily on insects in which they snare while flying (Corbet 1962).

Conservation/management: The most significant threats to the existence of this species have been identified as habitat destruction or alteration, and contamination. Types of direct habitat loss include commercial and residential development, quarrying, creating landfills, constructing pipelines, and filling of wetlands (Zercher 1999). Alteration of habitats include changing the hydrology of sites. This may include building roads, railways, pipelines, and ditches; flooding areas; pulling surface water from nearby areas for irrigation purposes; or pumping groundwater, which could lower groundwater levels (Zercher 1999). Roads and railroads which bisect suitable habitat are especially problematic. Wetland hydrology and quality should also be mantained by preventing improper off-road vehicle use and controlling invasive weeds in these areas. Contamination is a concern due to chemicals and their slow movement through these habitats and the long aquatic stage of this dragonfly (2-4 years). Chemicals in muck sediments can persist and remain toxic for long periods of time and may be difficult if not impossible to treat. Other concerns identified by researchers include environmental extremes, road kills, disease or predation, and fragmentation of habitat leading to genetic stochasticity (Zercher 1999). Further research is needed before more specific management guidelines can be developed. Education and outreach, as well as landowner contact, are important tools for Hine's emerald recovery in Michigan.

Research needs: Additional surveys are needed throughout its range to locate new Hine's emerald populations. In Michigan, larval habitats within occupied wetland complexes need to be identified and protected. Surveys to determine population sizes need to be undertaken at all Michigan sites. Research should focus on the ecological requirements of both adults and larvae.

Related abstracts: northern fen, incurvate emerald dragonfly

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Abstract citation

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Trimerotropis huroniana (Walker) Lake Huron locust

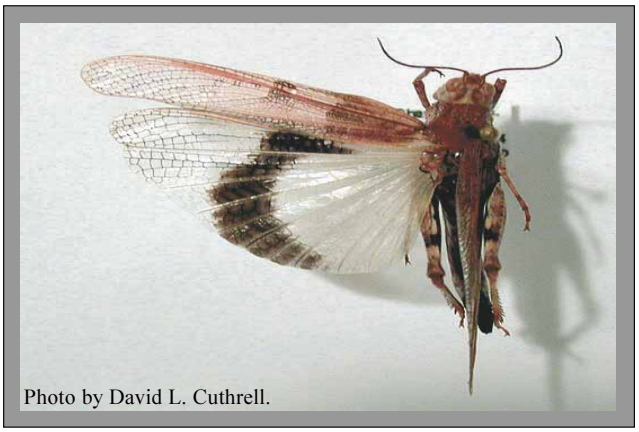
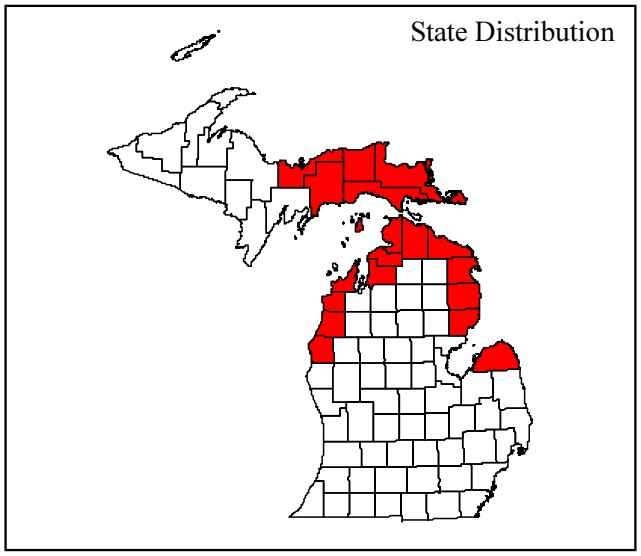


Photo by David L. Cuthrell.



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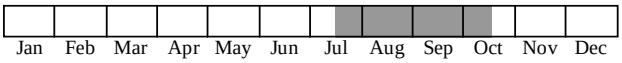

Status: State threatened

Global and state rank: G2G3/S2S3

Family: Acrididae (short-horned grasshopper)

Range: The Lake Huron locust is restricted to Great Lakes sand dunes in northeastern Wisconsin (Ballard 1989), the eastern Upper Peninsula and northern Lower Peninsula of Michigan, and the central Lake Huron shoreline of Ontario (Otte 1984).

State distribution: The Lake Huron locust occurs along the Lake Michigan shoreline, including the offshore islands, from Mason to Emmet and Mackinac to Schoolcraft counties; the Lake Huron shoreline from Iosco to Cheyboygan and Mackinac to Chippewa counties; and the Lake Superior shoreline from Chippewa to Alger County. Altogether, it is known from 18 counties, although it has not been observed in Huron County since the 1960s.

Recognition: The Lake Huron locust is a **small** band-winged grasshopper. The length to end of its folded forewings for males is 1-1.24 inches (24-30 mm), and for females is 1.1-1.6 inches (29-40 mm). The **body** is usually **silvery to ash gray, with darker brown and white markings**. Brick red, burnt orange, and ocher color morphs occur occasionally, especially among females. The tegmina (toughened **forewings)** of the adults **have darker bands that may be weakly or strongly expressed**. The **hindwings** are **light yellow near the body with a smoky patch near the tip**. Sexes can be easily distinguished by the males' stronger mottling, their noisy (crepitating) flight, and, as in other Orthoptera, their significantly smaller size. The Lake Huron locust is one of four species in the Great Lakes Region with the pronotum **(the saddlelike structure behind the head) cut across by two well-defined grooves** called sulci. The other three species occur predominately along shorelines farther south than the Lake Huron locust. The range of one of these, the similar-looking seaside locust (*Trimerotropis maritima*), overlaps with the Lake Huron locust along the Lake Michigan shoreline. It can be distinguished from the Lake Huron locust by the two narrow, blackish bands on the inner surface of the hind femora near the distal end. The Lake Huron locust has a **broad band covering half of the inner surface of the hind femora near the body and a narrow band near the distal end**. Other grasshoppers that occur with the Lake Huron locust have one or no sulcus cutting across the pronotum.

Best survey time: Nymphs can be found before mid-July. Adults are present from early to mid-July into October until the time of frequent heavy frosts and snow. Individuals become active between 9:30 and 10:00 a.m., after the sun had risen far enough to warm the foredune shoreline.

Habitat: In Michigan, the Lake Huron locust is restricted to sparsely vegetated, high-quality coastal sand dunes. A similar habitat affinity has been reported from Wisconsin (Ballard 1989). In these areas, it typically occurs in high numbers and is usually the dominant species. Where the open dunes grade into heavily vegetated or disturbed areas, their numbers quickly decline.

Biology: The seaside locust, *Trimerotropis maritima*, apparently replaces the Lake Huron locust as an ecological equivalent along the southern shores of Lake Huron and

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Lake Michigan (Hubbell 1929). On the west side of the state the northward range of the seaside locust, extends at least as far as Manistee, Manistee County, while the southward range of the Lake Huron locust extends at least as far as Ludington State Park, Mason County (Scholtens 1996). Currently, it is not known whether a similar overlap occurs along the Lake Huron shoreline. Scholtens (1996) also documented a third very similar sand-colored, yellow-banded Oedipodinae grasshopper, *Spharagemon collare*, as far north as Presque Isle County along the Lake Huron shoreline. Although it occurred in habitats that are typical for *T. huroniana*, only one of the sites he surveyed contained both species. *Spharagemon collare* was not found on any shoreline sites in good to excellent condition. All localities where it occurred were heavily disturbed with high numbers of invasive weeds.

Little on the life history of the Lake Huron locust has been published. Its courtship behaviors are thought to be similar to that of the pallid-winged locust, *T. pallidipennis* (Otte 1970). Egg masses for the single generation per year are laid in the soft soil where they overwinter. Nymphs hatch in late spring and mature by mid-July. Adults may be found in large numbers through the fall, most likely succumbing to the first hard frosts.

Adults communicate through visual and auditory signals (Otte 1970). Only males crepitate in flight by flashing and snapping their wings, making a cracking noise with each snap. Crepitation occurs during a hovering courtship flight in which the males snap their wings two or three times while hovering; this display typically occurs on sunny days when temperatures reach 80°F. Crepitation also occurs during flight elicited by a disturbance. On the ground, courting males stridulate by rubbing the femora against the forewings, producing a trill in busts of two to three pulses (Otte 1970). Females are cryptically colored against the light sand of the back dunes, whereas the males are virtually invisible on the gravel-dominated upper beaches of the foredunes.

The Lake Huron locust is strictly ground dwelling, essentially never climbing on foliage or other supports (Ballard 1989). On sunny, windless days, locusts are most common on sparsely vegetated sands, where they are evenly distributed with territories of several feet in diameter. In windy, overcast weather, individuals are densely distributed within the heavy dune grass cover, apparently seeking shelter.

Host plant use in the Lake Huron locust is not restricted to grasses, although these probably make up a large portion of the diet. Scholtens (1996) reports that abundant dune grasses are among the most preferred species, but several dune forbs apparently are included in the diet. Three plant species were common to all sites with Lake Huron locusts, dune grass (*Calamovilfa longifolia*), beach grass (*Ammophila breviligulata*) and wild wormwood (*Artemisia campestris*). Other plant species may be important to the locust if it employs diet mixing as a nutritional strategy as do many other locusts (Mulkern et al. 1969). Scholtens (1997) analyzed frass (fecal) pellets to confirm that Lake Huron locust nymphs were feeding on four vascular plant species, including beach grass, wild wormwood, dune grass, and wheatgrass (*Agropyron dasystachyum*). Significant among the acceptable forbs is Pitcher's thistle (*Cirsium pitcheri*), a federally protected species restricted to the dunes. Unacceptable species were generally woody species, but also included the state-threatened Lake Huron tansy (*Tanacetum huronense*). Limited observations in the field indicate that locusts feed by clipping off vegetation near the base of plants. Parts of insect exoskeletons were found in 28% and 44% of pellet samples from two sites (Scholtens 1997). It is thought that locust nymphs scavenge dead insects to supplement the nitrogen intake in their diet. Nitrogen is widely recognized as the most common limiting nutrient for herbivorous insects (Mattson 1980). Scholtens (1997) concluded that the locust appear to be fairly randomly distributed in dune habitat with respect to plant species and seemed to eat most acceptable host plants, virtually at random, although some preference was shown for beach grass. Host plant specialization is not thought to be a factor limiting this species to shoreline dune habitats at this time.

Lake Huron locusts do show significant preference for dry, loose sand substrates characteristic of shoreline dune habitats and not stabilized, wooded dunes or most inland habitats (Scholtens 1997). The biological reason for this preference is not known. The largest, apparently most stable populations of the locust are associated with areas of extensive, wide dunes. Shorelines that are one mile or more in length with at least two sets of dunes containing blowout areas are ideal.

Explaining the presence or absence of the locust from particular dune systems requires evaluation of a variety of factors including geological processes, biological interactions, and human influence. Interactions between changes in lake levels, availability of suitable habitat, and the locust' ability to colonize and recolonize could have significant influence on the species' distribution patterns at any one point in time.

Conservation/management: Unfortunately, significant parts of the locust's high-quality dune habitat have been degraded or destroyed by shoreline home and recreational development throughout the Great Lakes Region. Protection of the remaining habitat is the most significant action that could be taken for the conservation of this species in Michigan. Although a dune-obligate species, the Lake Huron locust apparently can persist with low to medium levels of human-related disturbance. The extent of the dunes protected at a site should be large enough to allow natural processes to locally change the character of the dunes through blowouts, which create more habitat, or stabilization by plants, which reduces habitat. When disturbance changes the character of the habitat away from a typical dune system to one with a large number of invasive weeds, or lack of sand movement, the Lake Huron

locust seems to drop significantly in numbers. Healthy locust populations have been maintained on private lands in several places on Lake Michigan and Lake Huron, as long as the basic dune system is kept intact. The housing developments most destructive to the locust seem to be those older developments along Lake Huron, where the dune system was quite narrow and construction of houses and swimming beaches has essentially removed the dune and its vegetation. Severe destruction of dunes on public lands has had the same effect where the dunes have been essentially denuded of native vegetation and mechanically flattened to create swimming and volleyball areas.

Scholtens (1996, 1997) identified several major shoreline areas with significant populations of the locust:

1. the northwestern segment of Emmet County along Lake Michigan at Sturgeon Bay, an area of at least 10 miles;
2. the Sleeping Bear Dunes National Lakeshore in Benzie and Leelanau counties;
3. the Ludington State Park area in Mason County which includes at least six miles of good beach front;
4. the Pt. Aux Chenes dunes in Mackinac County with at least two to three miles of dunes;
5. much of the Lake Superior shoreline, where long stretches of high dunes exist from Whitefish Point to the Grand Marais area in Chippewa County; and
6. the Lake Michigan islands.

Research needs: Additional surveys should be conducted to verify the current ranges of the Lake Huron locust, the seaside locust and *S. collare*. Examination of the ecological relationships between these species would be helpful. Additional information on the ecology and life history of the Lake Huron locust also is needed to provide a stronger basis for management planning and conservation activities. The exact microhabitat requirements of the locust over the course of its lifespan should be determined. Long-term monitoring of populations spanning a geographic range of disturbance types and levels would provide crucial information necessary to make recommendations about best management practices for this species. Information about normal movement and dispersal patterns, as well as about the locusts' recolonization capabilities, also would be useful.

Related abstracts: Pitcher's thistle, Houghton's goldenrod, Lake Huron tansy, piping plover, prairie warbler, dune cutworm, open dunes

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Abstract citation

Rabe, M.L. 1999. Special animal abstract for *Trimerotropis huroniana* (Lake Huron locust). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Funding for abstract provided by Michigan Department of Environmental Quality - Land and Water Management Division, Coastal Zone Management Program and Michigan Department of Natural Resources - Parks and Recreation Division and Wildlife Division, Non-Game Program.

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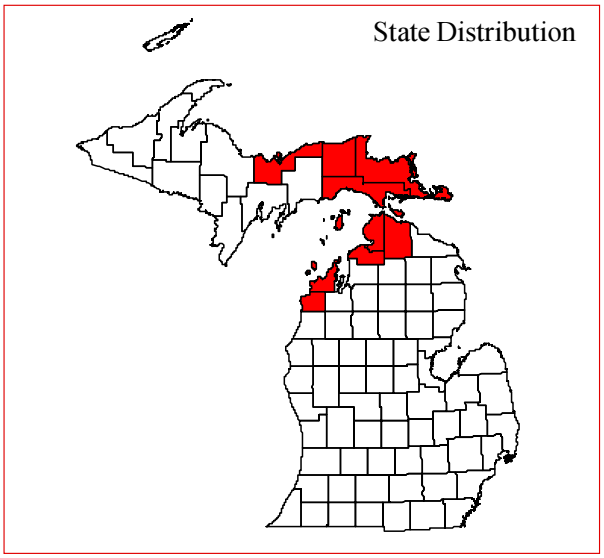
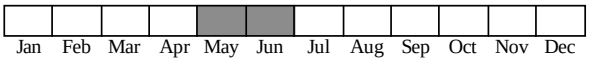
Charadrius melodus Ord — piping plover

Photo by Michigan Natural Features Inventory.



Best Survey Period



Status: Federal and State endangered

Global and state rank: G3/S1

Family: Charadriidae (plovers)

Total range: There are three geographic regions where piping plovers breed in North America including the beaches of the Atlantic coast from North Carolina to southern Canada, the shorelines of the Great Lakes, and along rivers and wetlands of the northern Great Plains from Nebraska to the southern Prairie Provinces. The winter ranges of the three breeding populations of piping plover overlap and extend from southern North Carolina to Florida on the Atlantic Coast and from the Florida Gulf Coast west to Texas and into Mexico, the West Indies and the Bahamas (Haig 1992).

State distribution: Historically plovers nested in 20 counties in Michigan along Lake Superior, Lake Michigan, Lake Huron, and Lake Erie (Weise 1991). Since the piping plover was listed as endangered in 1986, nests have been recorded at 30 breeding sites in nine counties in Michigan including Alger, Benzie, Charlevoix, Cheboygen, Chippewa, Emmet, Leelanau, Luce, and Mackinac counties (Wemmer 1999).

Recognition: The piping plover is a small compact robin-sized shorebird approximately 7¼" (18 cm) in length with a wing span measuring about 15" (38 cm) and a weight ranging from 1.5-2.2 oz (43-63 grams). It has a **very short and stout bill,** and **very pale upper-parts (the color of dry sand)**. The plover's sand colored plumage provides an effective camouflage in its preferred beach habitat. During the breeding season the **single narrow black band across the upper chest** (sometimes incomplete), **smaller black band across the forehead, orange-yellow legs and orange bill with a black tip** are distinctive. Its **white rump** is conspicuous in flight. Piping plovers can also be recognized by their distinctive **two-noted, "peep-lo", melodious whistle** (Bent 1929). The killdeer (*Charadrius vociferus*) is larger (approximately 10½") and darker overall, has two black breastbands and a bright reddish-orange rump, and has a distinctive loud "kill-dee" call (National Geographic Society 1983).

Best survey time: Although piping plovers can be seen in Michigan from late April through August, the optimal time to survey for piping plovers is during May and June.

Habitat: In Michigan, piping plovers prefer fairly wide, sandy, open beaches along the Great Lakes with sparse vegetation and scattered cobble for nesting (Lambert and Ratcliffe 1981, Powell and Cuthbert 1992). Nesting may occur on the open beach near the edge of the foredune or in the cobble pan behind the primary dune. Territories often include rivers, lagoons, channels, or interdunal wetlands that provide additional food sources for chicks. Nests consist of a shallow scrape in the sand that are sometimes lined or surrounded with fragments of shells, driftwood or small pebbles (Haig 1992). During the breeding season, the plover's home range is generally confined to the vicinity of the nest. Various Michigan studies describing nest site characteristics report mean beach widths >30 m

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(98.4'), mean distance from nest to treeline from 35 to >600m (115-1968'), and vegetative cover around the nest from 0-50% (Lambert and Ratcliffe 1981, Powell and Cuthbert 1992). On the wintering grounds plovers forage and roost along barrier and mainland beaches, mudflats, sandflats, algal flats, washover passes, salt marshes and coastal lagoons (Haig 1992, Wemmer 1999).

Biology: Plovers begin departing the wintering grounds in late February with the peak migration occurring in March. The breeding season in Michigan begins when the adults reach their nesting grounds in late April or early May. After females arrive, males initiate courtship behaviors that include aerial displays and calls, digging of several nest scrapes, tilt displays and a ritualized stone tossing display (Haig 1992). Nests are initiated by mid to late May and are usually spaced 200 feet or more apart (Wilcox 1959). Clutches consist of three to four eggs that both parents incubate for approximately 28 days (Haig 1992).

Chicks are precocial and within hours of hatching are able to walk a short distance from the nest before running back to their parents to be brooded. Chicks forage near the brooding parent and immediately use the "peck and run" foraging behavior of adults (Haig 1992). Field observations reveal that piping plovers feed primarily on exposed beach substrates by pecking for invertebrates at, or just below, the surface (Wemmer 1999). Analyses of gizzards from dead plovers have identified insects (particularly fly larvae and beetles), crustaceans, and mollusks as key components of their diet (Bent 1929, Haig 1992). Adults and chicks rely on their cryptic coloration to avoid predators. When approached, chicks will crouch on the ground and hold this posture until they are almost touched, at which point they run away very rapidly. Adults use distraction displays to lure predators away from their territories. Chicks breed the first spring after hatching (Haig 1992).

Longevity records indicate that only 13% of females and 28% of males live to be five years of age or older, while eleven years of age it thought to be the maximum age attained (Wilcox 1959). Recent data from piping plovers banded in Michigan suggest adult survival is about 70% and fledgling survival is approximately 30%, similar to that reported for populations in other regions (Wemmer and Cuthbert 1998). Adults return to beaches where they previously nested approximately 65% of the time, thought to be a reflection of previous nesting success. Yet most young birds return to nest at sites far from their natal areas (Wemmer 1999). Only moderate mate retention has been observed in piping plovers (less than 50%), when compared to other shorebirds with similar mating systems (Wiens and Cuthbert 1988).

Plovers depart their breeding areas in the Great Lakes from mid July to early September (Wemmer 1999). It is thought that since few plovers are sighted at inland migration stopover sites, that inland birds may fly non-stop to and from Gulf Coast sites (Haig and Plissner 1993). However, spring and fall observations of transient plovers in Michigan suggest historical breeding sites may function as foraging sites for migrating plovers. Piping plovers banded in Michigan have been sighted in both Atlantic and Gulf Coast states, which may indicate a strong eastward component to migration and dispersal through the winter range (Wemmer 1999). While substantial progress has been made on understanding winter distribution, Haig and Plissner (1993) only accounted for 63% of the 1991 breeding population on the wintering grounds, suggesting that some wintering habitat remains unidentified.

Conservation/management: The Great Lakes population of the piping plover was listed as endangered under provisions of the U. S. Endangered Species Act on January 10, 1986. The population declined from a historical population of several hundred breeding pairs to 17 breeding pairs in 1986. The initial decline of piping plovers was primarily due to hunting in the late 19th century and early 20th century until the Migratory Bird Treaty Act of 1918 stopped this activity. Although populations began to recover, they started to decline again in the 1950s due to increasing habitat loss, recreational pressure, predation and contaminants. In the late 1970s to mid 1980s, high Great Lakes water levels temporarily reduced available nesting areas by flooding beaches (Weise 1991). Since listing in 1986, the population has fluctuated between 12 and 25 breeding pairs with breeding areas largely confined to Michigan. The current small size of the Great Lakes piping plover population renders it extremely vulnerable to chance demographic or environmental events which could potentially eradicate this species from the region (Wemmer 1999). Michigan has a State piping plover recovery plan and recovery team, whose members meet annually to direct monitoring and management activities. In addition, coordination meetings take place regularly to organize seasonal field-based conservation efforts. Annual breeding site surveys are conducted in Michigan, and all located nests are monitored throughout the breeding season. Historical breeding areas are surveyed at least once every five years during the International Piping Plover Census.

Habitat destruction, habitat alteration and human development of shorelines has resulted in the extirpation of piping plovers from most formerly occupied Great Lakes states. Marina construction, inlet dredging, and artificial structures such as breakwalls, can eliminate breeding areas and disrupt natural processes that maintain shoreline habitats. Local planning and zoning boards can address this problem by incorporating shoreline protection and piping plover habitat needs into land use plans and permitting processes. It is very

important to protect current and historical nesting habitat, as well as potential breeding sites to allow population growth and to support the population in the future (Wemmer 1999).

In Michigan, predation has been identified as the cause of nest failure for approximately 9% of clutches, and is suspected in the majority of disappearances of unfledged chicks. Michigan studies have identified actual and potential predators to include the ring-billed gull, herring gull, American crow, merlin, peregrine falcon, great horned owl, snowy owl, common raven, red fox, coyote, raccoon, thirteen-lined ground squirrel, striped skunk, domestic cat and dog. Predator exclosures have been used consistently around plover nests since 1988 to protect plover eggs from predation and have increased hatching success significantly. Captive rearing of orphaned piping plover chicks and abandoned eggs has been implemented since 1992 and resulted in the successful release of fledglings that otherwise would not have survived. Loss of chicks continues to be a major source of mortality that is very difficult to predict and control. (Wemmer 1999).

Although plovers do sometimes nest on Michigan beaches where residential development has occurred, reproductive success is generally lower due to disturbance by humans and pets (Wemmer 1999). Increased use of the shoreline by recreationists often causes parent birds to be frightened away from nests during critical periods of incubation, and the camouflaged eggs or young are easily trampled. A program was initiated in 1994 to organize volunteers to patrol and protect plover nesting areas over holiday weekends since Memorial Day and the Fourth of July coincide with peak egg laying and hatching of piping plovers (Weise 1991). The use of motorized vehicles on the beach, beach walking, bike riding, kite flying, fireworks, bonfires, horseback riding, and camping have been observed to disturb piping plovers and disrupt normal behavior patterns (Wemmer 1999). Pedestrians accompanied by their pets result in an even greater disturbance to breeding plovers as dogs frequently chase adults and chicks (Lambert and Ratcliff 1979). Landowners can assist plovers by keeping their dogs leashed in areas where plovers are nesting. Psychological fencing, which consists of bailing twine and “Unlawful to Enter” and/or “Closed Area” signs, and the use of predator exclosures have been successful in limiting human activity in the vicinity of plover nests and have increased hatching success from 37% to 70%.

Research needs: The amount and quality of existing habitat should be carefully quantified to assess the number of plover pairs that the region is capable of supporting and to determine whether additional land should be acquired, protected and/or restored to promote recovery of the population. The level and effect of disturbance on chicks at nesting sites should be closely monitored to better understand the causes of chick mortality (Stucker et al. 1998). Important resting and foraging habitat for migrating plovers should be identified. A better understanding of wintering ecology and distribution is warranted so that wintering sites can be protected. An analysis should be conducted to elucidate the level, source, and effects of contaminants in piping plovers and evaluate the sub-lethal impact on reproductive success (Wemmer 1999).

Related abstracts: Caspian tern, common tern, dune cutworm, Houghton’s goldenrod, Lake Huron locust, Lake Huron tansy, open dunes

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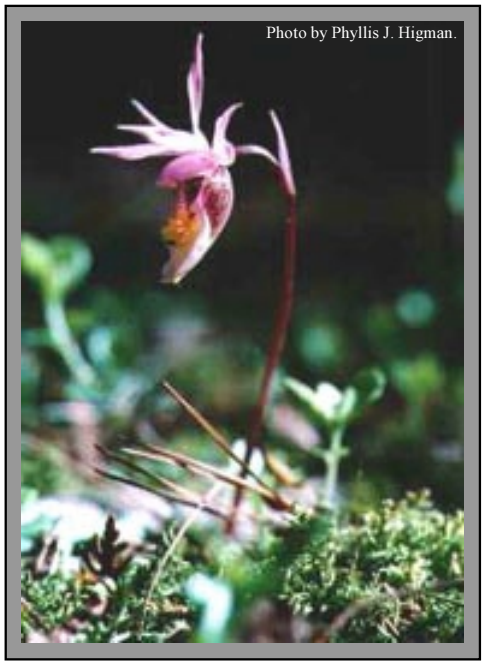
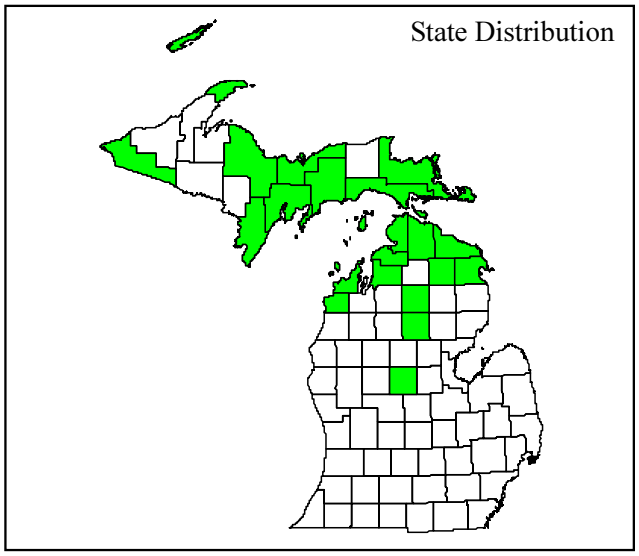
Abstract citation:

Hyde, D.A. 1999. Special animal abstract for *Charadrius melodus* (piping plover). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Funding for abstract provided by Michigan Department of Environmental Quality - Land and Water Management Division, Coastal Zone Management Program and Michigan Department of Natural Resources - Parks and Recreation Division and Wildlife Division, Non-Game Program.

Calypso bulbosa (L.) Oakes — calypso orchid





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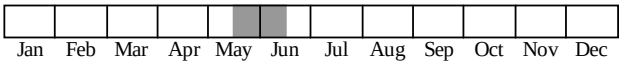

Status: state threatened

Global and state rank: G5/S2

Other common names: fairy slipper, deer's head orchid

Family: Orchidaceae

Synonyms: *Cytherea bulbosa* House, *Calypso borealis* Salisb.

Taxonomy: This is the only species in the genus *Calypso*. North American plants are sometimes considered var. *americana* (R. Brown) Luer and at least one form, occurring in the Pacific Northwest, differs in proportions, markings, and physiology (Case 1987).

Total range: This widespread species nearly circles the globe in the northern hemisphere, ranging throughout North America, Europe, and Asia. In North America, calypso is found from Labrador to Alaska, south to New England, Minnesota, the Great Plains, Arizona, and along the west coast to California. It is considered rare in Maine (S2 rank), Vermont (S2), and Wisconsin (S2-3), South Dakota (S3), and in New Hampshire and New York where it is known only from historical records.

State distribution: Calypso is widely distributed in the northern Lower Peninsula and the Upper Peninsula of Michigan, with 85 locational records from 23 counties. At least eight counties have records dating since 1980. Most mainland - especially more southerly - colonies consist of few plants, but large colonies with hundreds of plants occur occasionally to the north, especially on Isle Royale.

Recognition: At flowering time the visible portion of this plant consists of a **single pleated oval, basal leaf**, and a leafless stalk 1-2 dm tall, topped by a **tiny solitary flower**. The nodding blossom has **five purple to magenta petals** (1-2 cm long) and a **sac-like lip about 2 cm long**. The **back of the lip** is translucent white and **spotted with purple**, while **the front** is crested with **three rows of yellow hairs**. The lowermost saccate portion is whitish with red-brown to purple markings within and has two conspicuous horns at the base. The seldom seen capsule is erect, elliptical, and about 2.5 cm in length.

Best survey time/phenology: Due to its rarity and extremely small size, calypso orchid is notoriously difficult to find. Although its tiny, basal evergreen leaf could potentially be recognized and found with extremely diligent searching, this would be highly ineffective survey strategy. In all practicality one is limited to surveying when the showy flower is present. This survey window varies depending upon the location and specific weather conditions, but in Michigan is usually from late May through early June, varying according to locality and latitude.

Habitat: Calypso is an inhabitant of moist coniferous forests with cool soils. In Michigan, it is found in spruce-balsam-cedar swamps, and also in drier cedar-fir thickets along the shores of the upper Great Lakes, especially on calcareous substrates. When found in boggy areas, it inhabits drier hummocks or the bases of old trees or stumps. It is nearly always in the shade (Case 1964). Caljouw (1981) found it under canopy covers of no less than 60% and in soils no warmer than 15° C. Common

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associates include *Trientalis borealis* (twinflower), *Goodyera repens* (lesser rattlesnake plantain), and *Corallorhiza striata* (striped coral-root) (Case 1964).

Biology: In Michigan, Calypso plants flower from May to July depending on location, but are always among the first plants to bloom (Case 1964). After flowering, the single leaf fades and the corm produces a new bud on one side. From this bud a new leaf emerges in late summer, surviving the winter until the next flowering season. The corm is globose or ellipsoid and may have a coralloid rhizome attached (Mousley 1924; Correll 1950). Bumblebees of several species pollinate the flowers, but receive no reward since nectar is not produced. Plants are self-compatible, but require the mechanical action of a bumblebee to effect pollination (Mosquin 1970). Fruiting capsules develop in June and July, though they are rarely found, as are seedlings (Case 1964). Mousely (1924) reported rhizomatous roots at the base of the tuber to be a major means of reproduction. Dormancy, commonly of one to two years, has also been reported (Vickery 1984). The whole plant is frequently attacked by rodents, slugs, and fungi, particularly in the eastern U.S. (Correll 1950). Our plants tend to grow in scattered, sparse populations and have not been successfully cultured. The western form seems to be more "aggressive," growing in denser colonies, and has been successfully cultivated for one to two years when carefully tended (Case 1964).

Conservation/management: Calypso is protected in at least three Michigan Nature Association sanctuaries, three Nature Conservancy preserves, three state natural areas, two national parks, and in the Sylvania Recreation Area. At any site with considerable public recreation use, this species is vulnerable to trampling by wildflower enthusiasts. Corms are dug in western states for commercial export (Wiley 1968). In the East, logging and drainage of its habitat contribute to calypso's increasing rarity. In Maine, studies suggest that spruce budworm infestations may have damaged calypso populations by reducing shade (Vickery 1984). Publicizing the location of calypso colonies, especially readily accessible ones, should be avoided. Conservation of nearby bee populations could promote fertilization and seed-set.

Comments: This species has nutritional, as well as aesthetic value, as the mucilagenous corms were eaten by native Americans in British Columbia (Correll 1950). The name "calypso" comes from Homer's sea-nymph in the Odyssey who kept Odysseus concealed seven years on her island. Both the beauty and rarity of calypso, as well as the seclusion of its habitats, make this a fitting name (Correll 1950).

Research needs: Relatively little is known of the natural history of this diminutive orchid, and thus virtually any life history study would aid greatly in management and conservation. Of primary interest would be investigations of this species' breeding system, especially pollination biology and studies leading to a better understanding of the requirements for germination and establishment. Demographic monitoring would also enhance our knowledge of the population dynamics of this species.

Key words: rich conifer swamp, ram's head orchid

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Abstract citation

Michigan Natural Features Inventory. 1996. Special plant abstract for *Calypso bulbosa* (calypso orchid). Lansing, MI. 2 pp.

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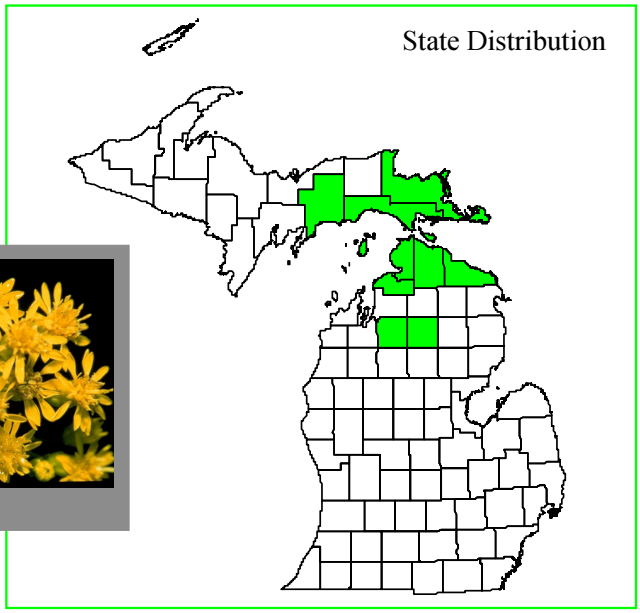
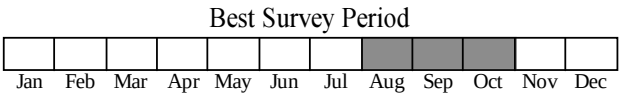
Solidago houghtonii A. Gray — Houghton's goldenrod

Large photo by Phyllis J. Higman

Photo by Doug Moore





Status: State threatened**,** federal threatened

Global and state rank: G3/S2S3

Family: Asteraceae (Aster family)

Taxonomy: Although *Solidago houghtonii* is widely accepted as a distinctive species, its origin and affinities are disputed. Morton (1979) theorizes that a hybrid of *S. ptarmicoides* (Nees) Boivin (long known as *Aster ptarmicoides* (Nees) T. & G.) and *S. ohioensis* Riddell backcrossed with *S. ohioensis* to form a sterile triploid (three sets of chromosomes); a subsequent doubling of chromosomes resulted in the fertile hexaploid (6x = 54) known as *S. houghtonii*. Semple & Ringius (1983), among others, disagree, concluding that *S. riddellii* Frank, not *S. ptarmicoides*, is the second parent. Most anomalous in the *S. houghtonii* "complex" is a population identified in Crawford County within Camp Grayling. These plants are reportedly octoploids, apparently the only such ploidy level known for a *Solidago* species, and differ somewhat from shoreline populations, thus possibly representing a different taxon. A reported disjunct station in Genesee County, New York (Bergen Swamp), is now believed to represent hybrids between *S. ptarmicoides* and *S. uliginosa.*

Total range: Houghton's goldenrod occurs primarily along the northernmost shores of Lakes Michigan and Huron, ranging east to the Bruce Peninsula in Ontario. Isolated inland stations of what some authors believe to be this species occur in Crawford and Kalkaska counties, Michigan, more than 100 km south of the Mackinac Straits region. A second disjunct station of what is currently considered to be this species occurs in western New York.

State distribution: The greatest concentrations of *S. houghtonii* lie in Chippewa, western Mackinac, northern Emmet, Cheboygan, and northern Presque Isle counties. Each of these areas has large populations extending over at least a mile of shoreline, as well as several scattered smaller populations. About 60 occurrences are known overall.

Recognition: Houghton's goldenrod has smooth, slender, often somewhat reddish stems that reach 3-6 dm in height. The well-scattered, pointed **leaves are long (to 1.3 dm), narrow (less than 1 cm), and often folded along the midrib** (conduplicate), **tapering to a slightly clasping base**. Terminating the stem is a more or less **flat-topped, branched inflorescence consisting of relatively few, showy, large flower-heads** that may number from 5-30 and not uncommonly more (standard manuals, basing their description on the wrong nomenclatural type, incorrectly state the number of flower-heads to be only 5-15). **The branches and pedicels** (flower stalks) of the inflorescence are **finely hairy**, at least sparsely so, with **fine upcurving hairs**, and the achenes are smooth and ribbed.

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This species is most likely to be confused with the widespread *Euthamia graminifolia* (grass-leaved goldenrod) and *S. ohioensis* (Ohio goldenrod*). Euthamia graminifolia* can be distinguished by its more leafy stem lacking basal leaves when in flower. It also has narrower 3-5 nerved leaves, and an inflorescence composed of distinctly smaller flower heads with short ray flowers and hairy achenes. *Solidago ohioensis*, the goldenrod most similar to *S. houghtonii* in northern Michigan, is a more robust species with leafier stems. It usually has broader, more flattened, ovate-lanceolate leaves and a dense, many-headed inflorescence. Other features include **smooth branches and pedicels, smaller ray flowers,** and smooth, unribbed achenes.

Best survey time/phenology: *Solidago houghtonii* is best identifed during peak flowering, when it is most easily distinguished from the extremely similar *Solidago ohioensis*. Flowering occurs from about early August through early September, with plants often blooming into October.

Habitat: *Solidago houghtonii* occurs primarily along the northern shores of Lakes Huron and Michigan, restricted to calcareous beach sands, rocky and cobbly shores, beach flats, and most commonly the shallow, trough-like interdunal wetlands that parallel shoreline areas. This species also occurs on seasonally wet limestone pavement, its more typical habitat in the eastern portion of its range, primarily in Ontario (Morton 1979; Semple and Ringius 1983). Common plant associates include *Parnassia glauca* (grass-of-Parnassus), *Lobelia kalmii* (Kalm's lobelia), *Calamintha arkansana* (Arkansas mint), *Tofieldia glutinosa* (false asphodel), *Potentilla fruticosa* (shrubby cinquefoil), *Gentiana procera* (fringed gentian), *Carex crawei* (sedge), *C. garberi* (sedge), *Eleocharis pauciflora* (spikerush), *Euthamia graminifolia* (grass-leaved goldenrod), *Solidago ohioensis* (Ohio goldenrod), and *Myrica gale* (sweet gale). In the Crawford and Kalkaska county localities, Houghton's goldenrod occurs in an unusual northern wet prairie habitat within the jack pine barrens. There it occupies seasonally indundated areas and old interdunal depressions in a sandy glacial outwash landscape, where it occurs with such species as *Pinus banksiana* (jack pine), *Andropogon gerardii* (big bluestem), *Lobelia spicata* (lobelia), *Castilleja coccinea* (Indian paintbrush), *Eleocharis elliptica* (spikerush), *Potentilla fruticosa*, *Carex conoidea* and *C. flava* (sedges), and several other rare plant species, including *Juncus vaseyi* (Vasey's rush), *Scirpus clintonii* (Clinton's bulrush), and *Viola novae-angliae* (New England violet).

Biology: Houghton's goldenrod is a perennial, frequently forming small clumps (clones) produced vegetatively by means of relatively short rhizomes (underground stem). Flowering occurs primarily in August and early September, but some plants may flower well until October.

Conservation/management: The shoreline habitat of *S. houghtonii* is strongly threatened by residential development and heavy recreational use. Recreational vehicles pose an ever present and increasing threat, as do heavy foot traffic and wetland alterations during the course of shoreline development. Four populations thought to be the largest in existence are currently under protective ownership, one on a Nature Conservancy preserve and three on state land. About fifteen other substantial populations lie on State Forest, National Forest, and State Park lands, receiving some form of protection. Several populations occur partly within Michigan Department of Transportation rights-of-way, in designated and signed protected areas.

Comments: This species is named in honor of Douglass Houghton, Michigan's first State Geologist, whose survey team discovered this Great Lakes endemic on the north shore of Lake Michigan during an 1839 expedition.

Research needs: Investigation of nearly all aspects of the biology and ecology of *Solidago houghtonii* is desirable to determine the smallest colony necessary to maintain a viable population. This includes research on demography, reproductive biology, genetic variability, and basic life-history strategies. Biosystematic and genetic research is also needed to determine the true origin of this taxon and its closest affinities. An understanding of colonization requirements and population dynamics is vital to the conservation of this rare Great Lakes endemic.

Related abstracts: cobblebeach, interdunal wetland, limestone pavement, open dunes, pine barrens, English sundew, Pitcher's thistle, Pumpelly's brome grass, zig-zag bladderwort, Caspian tern, dune cutworm, eastern massasauga, Hine's emerald dragonfly, Lake Huron locust, piping plover.

Selected references:

Argus, G.W. and D.J. White (eds.). 1983. Atlas of the Rare Vascular Plants of Ontario: Part 2. Nat. Mus. Nat. Sci., Ottawa. 191 pp. + maps.

Guire, K.E. and E.G. Voss. 1963. "Distributions of distinctive shoreline plants in the Great Lakes region." Mich. Bot. 2:99-114.

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Morton, J.K. 1979. "Observation's on Houghton's goldenrod (*Solidago houghtonii*)." Mich. Bot. 18:31-36.

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Semple, J.C. and G.S. Ringius. 1983. The goldenrods of Ontario: Solidago L. and Euthamia Nutt. Univ. Waterloo Biol. Ser. #26. 82 pp.

Abstract citation:

Michigan Natural Features Inventory. 1996. Special plant abstract for *Solidago houghtonii* (Houghton's goldenrod). Lansing, MI. 2 pp.

Updated September 2000.

Funding for abstract provided by Michigan Department of Natural Resources-Forest Management Division and Wildlife Division.

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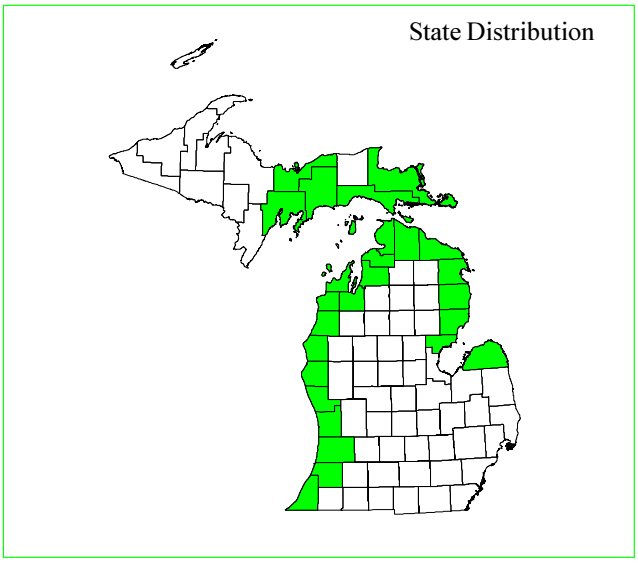
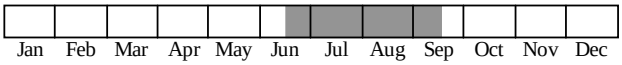
Cirsium pitcheri (Torrey and Gray) Pitcher's thistle

Photos by Sue Crispin



Best Survey Period



Status: State threatened, Federal threatened

Global and state rank: G3/S3

Other common names: Dune thistle

Family: Asteraceae (aster family)

Total range: The range of this Great Lakes endemic falls primarily within Michigan's borders, occuring along the entire shoreline of Lake Michigan, with localities along the more limited dunes of Lake Huron and a few sites along the extensive Grand Sable dunes of the Lake Superior shore. In Canada this species occurs in northern Lake Huron and at least one site on the north shore of Lake Superior. Several scattered sites occur along Lake Michigan in Wisconsin, and populations remain extant in Indiana within Indiana Dunes National Lakeshore. Historically, Pitcher's thistle was known from several localities in Illinois, where it was subsequently extirpated, but is now being reintroduced as part of the Federal Recovery Plan for the species.

State distribution: *Cirsium pitcheri* is most common in Michigan along the extensive dune systems on the northern and northeastern shores of Lake Michigan. It is scattered along the perimeters of southeastern Lake Michigan and northern Lake Huron. One major population and several relatively small occurrences are known along the southeastern shore of Lake Superior. The bulk of the occurrences, and those with the largest populations, are concentrated in the major dune landscapes in the northern Lake Michigan basin, especially in the Lower Peninsula counties of Emmet, Charlevoix, Leelanau, Benzie, Manistee, Mason, and Oceana.

Recognition: This stout, prickly, dune species may grow to ca. 1 m or more in height, though stunted individuals as small as 10 cm may flower. **The leaves and entire plant are blue-green in color and densely covered with white-woolly hairs.** The mature leaves are deeply divided into narrow, spine-tipped segments. **The prickly, spine-tipped flower heads are relatively large and strikingly cream-colored, though they may occasionally have a slightly pinkish tint,** yielding seeds with feathery bristles. Pitcher's thistle is unlikely to be easily confused with any other thistle species in Michigan, including both native and non-native species, all of which can be distinguished by their deep pink flower heads (with the rare exception of occasional albino flowers in other species). Although other thistles, particularly non-native ones, may inhabitat disturbed areas in dunes, they are unlikely to co-occur with Pitcher's thistle or persist in good quality, open dunes habitat. Vegetatively, all other thistles in Michigan lack the deep blue-green color of Pitcher's thistle and its usually dense covering of white woolly hairs.

Best survey time/phenology: *Cirsium pitcheri* is fairly easy to recognize as a seedling, but becomes more easily recognizable as it matures. Until one becomes familiar with the plant at all stages, it is best to survey for it during the principal flowering and fruiting period from late-June to early September.

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Habitat: Pitcher's thistle typically grows on open sand dunes and occasionally on lag gravel associated with shoreline dunes. All of its habitats are along the Great Lakes shores, or in very close proximity. Associated plants include such common dune species as *Ammophila breviligulata* (beach grass), *Andropogon scoparius* (little bluestem), *Elymus canadensis* (wild rye), *Arabis lyrata* (lyre-leaved sand cress), *Arctostaphylos uva-ursi* (bearberry), *Calamovilfa longifolia* (sand reed grass), *Agropyron dasystachyum* (dune wheat grass), *Asclepias syriaca* (common milkweed), *Salix cordata* and *S. myricoides* (dune willows), *Hudsonia tomentosa* (beach heath; false heather), *Lithospermum caroliniense* (hairy puccoon), and many other characteristic species of the open dunes, including other rare taxa such as *Stellaria longipes* (stitchwort), *Orobanche fasciculata* (fascicled broomrape), and *Botrychium campestre* (prairie moonwort). Pitcher's thistle often occurs in association with the Great Lakes endemic *Solidago houghtonii* (Houghton's goldenrod) when interdunal wetlands are present within the dunes landscape.

Biology: This monocarpic (once-flowering) plant produces a vigorous rosette that may mature for ca. 5-8 years or more before it flowers. Pitcher's thistle blooms from approximately late June to early September and is protandrous (the pollen maturing before stigmas are receptive on individual flowers), and at least partially self-compatible. Insect pollinators are relatively diverse, including halictid bees, bumblebees, megachilid bees, anthophorid bees, and skippers and butterflies (*Vanessa cardui, Daneus peleyippus*). Moths may well be nocturnal pollinators (Loveless 1984). Microlepidopteran larvae, especially the artichoke plume moth (*Platyptilia carduidactyla*), are responsible for varying amounts of seed predation by eating developing ovules. Loveless (1984) found that seed set declines throughout the flowering season. Seeds are dispersed individually by wind or as entire flower heads blown across the sand, or possibly transported by water.

American goldfinches were observed by Loveless (1984) to consume as much as 50% of the seeds in a flower head. Thirteen-lined ground squirrels also prey upon undispersed seed, and other birds, especially sparrows, forage on unburied dispersed seeds. The fundamental dispersal unit is often the entire head of mature achenes, which remains attached to the withered stem of the mother plant. Seeds germinate in June, and most seedlings appear within 1-3 meters of parent plants (Loveless 1984; Keddy & Keddy 1984). Spittlebugs contribute to mortality of adult plants by ovipositing on the apical meristem and deforming embryonic leaves. The taproot of this thistle, which can reach up to 2 m in length, enhances its ability to survive the dessicating conditions of the dune habitat (Loveless 1984; Johnson and Iltis 1963). High rates of sand movement probably stresses plants through erosion and burial of growing stems, though sand movement is absolutely essential for maintaining the open dune habitat of this species. Extreme drought can also be a major stress, especially for seedlings and juvenile plants with poorly developed, shallow tap roots.

Conservation/management: Though Pitcher's thistle can be locally extirpated by destruction or major disturbance of its habitat (e.g. by shoreline development or intensive recreation), it is somewhat tolerant of disturbance from pedestrians and limited ORV traffic. This is especially true in the heart of its range where it is more abundant and seed sources are present to assist in replenishment. However, vehicular traffic and regular foot traffic tend to unduly destabilize dune sands by mechanically destroying vegetation; this increases erosion and stresses Pitcher's thistle plants, which also are often severely affected by direct impacts. An indirect effect of artificial disturbance is that it enables non-native species such as the invasive spotted knapweed (*Centaurea maculosa*) to invade dune habitats and displace native vegetation, resulting in further habitat degradation.

Because of the extreme development pressure along the Great Lakes shoreline, the potential cumulative impacts to Pitcher's thistle populations is high. Efforts should be made to create active dune zones where development is limited.

Two of the world's largest populations of *Cirsium pitcheri* lie within Sleeping Bear National Lakeshore and Ludington State Park/Manistee National Forest (Nordhouse Dunes). The species also occurs in at least two Michigan Nature Association Sanctuaries, several Nature Conservancy preserves, five state natural areas, and in Pictured Rocks National Lakeshore, as well as in severally informally protected public and private tracts.

Comments: Loveless (1984) found *Cirsium pitcheri* to be very low in genetic diversity. She also discovered that populations around the Straits of Mackinac differed genetically from more northern and southern populations, suggesting that the former may have been genetically isolated at some point and have had gene flow primarily among themselves. Due to the genetic similarity between *C. pitcheri* and the Great Plains species *C. canescens*, Loveless postulates that they descended from a common parent in the west, which migrated east to the Great Lakes shores during the abrupt warming occurring during the hypsithermal period (ca. 11,000-8000 years B.P.) by colonizing local, transient dune systems created by glacial outwash and proglacial lakes. The genetically depleted and homogeneous founder population which reached and colonized the dunes along the Great Lakes was then isolated from its western counterpart by climatic changes, resulting in postglacial reforestation and the extinction of possible linking populations.

Research needs: The response of this species to disturbance would provide useful management information, as Pitcher's thistle occurs in many areas heavily used by recreationists.

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Related abstracts: houghton's goldenrod, Lake Huron tansy, open dunes.

Selected References:

Johnson, M.E. and H.H. Iltis. 1963. "Preliminary reports on the flora of Wisconsin No. 48. Compositae Family I." Wisc. Acad. Sci. Arts & Lett. 52:255-342.

Keddy, C.J. and P.A. Keddy. 1984. "Reproductive biology and habitat of *Cirsium pitcheri*." Mich. Bot. 23(2):57-67.

Loveless, M.D. 1980. Spatial Pattern and Population Structure in *Cirsium pitcheri*. Unpublished Natl. Sciences Foundation Grant Proposal.

Olson, J.A. and J.D. Soule. 1998. Cumulative Impact of Great Lakes Shoreline Development on Natural Features. Report to the Michigan Dept. of Environmental Quality, Land and Water Mgmt. Division, Michigan Coastal Management Program 47 pp + appendices.

Wisconsin Endangered and Nongame Species Handbook. Wisconsin DNR.

Abstract citation:

Higman, P.J. and M.R. Penskar. 1999. Special plant abstract for *Cirsium pitcheri*. Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Updated September 2000.

Funding for abstract provided by Michigan Department of Natural Resources-Forest Management Division and Wildlife Division.

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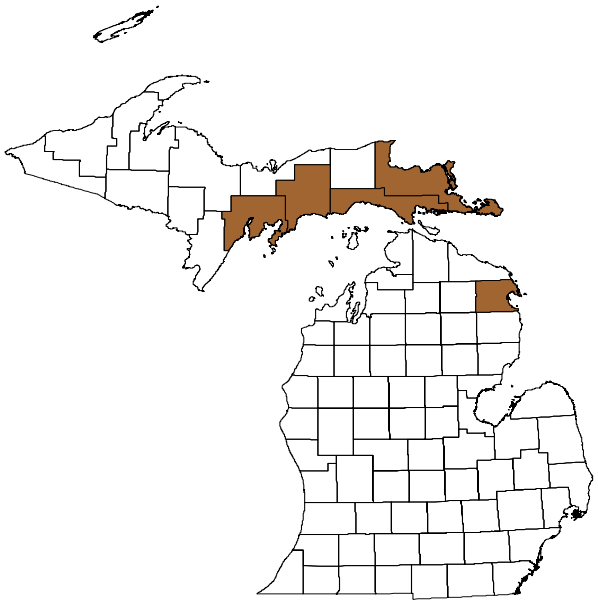
Limestone pavement lakeshore — Community Abstract

Photo by Patrick J. Comer

State Distribution



Global and state rank: G3G4/S2

Rank justification: This community has a restricted distribution but the status and ranking of sparsely and unvegetated communities has not been entirely resolved.

Range: Limestone/dolostone pavement lakeshores are found along the Great Lakes shorelines of Wisconsin, Michigan, Ontario, and New York. Fourteen occurrences are known from Michigan along the northern Lake Michigan and Lake Huron shorelines. Similar communities are found along Lake Champlain and on lakeshores throughout the Adirondack region.

Landscape context: In Michigan, these plant communities are commonly found along northern Great Lakes shores where flat bedrock pavement associated with the Niagaran Escarpement is exposed. The bedrock of the Niagaran Series is Silurian-age limestone and dolostone formed from marine reefs that were common in shallow portions of the Michigan Basin (Ehlers 1973). Ordovician-age limestone and dolostone also support these plant communities on northern Drummond Island. Being formed from marine organisms, these rocks are rich in calcium carbonates. Resistance to erosion is variable; limestone and dolostone are readily dissolved by rain water, producing solution cracks that often connect to the underlying groundwater system. In contrast, limestone rich in sand, silt, or clay sized particles originating from terrestrial sources (argillaceous limestone) is much more resistant to solution and typically contains few broad cracks. These lakeshores are located within sub-subsections VII.6.3, VIII.1.1, and VIII.1.3 of the Regional Landscape Ecosystems as delineated by Albert (1995). The proximity of the Great Lakes results in moderated climate and high precipitation in these sub-subsections, relative to adjacent portions of the upper Great Lakes region. The pavement of this community forms a gentle slope (averaging 1%) dipping into the lake. Immediately inland of the exposed pavement is often a ridge of limestone or dolostone cobble (typically 1-2 m high) deposited from ice scours and major storm events in years when lake levels were higher. From this point inland, more continuous soil development is common. Typically, beginning with the cobble ridge, there are dense forests of northern-white cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), balsam fir (*Abies balsamea*), and paper birch (*Betula papyrifera*). Given their location along Great Lakes shorelines, these forests tend to experience frequent windthrow, but typically have 80% forest canopy. Occasionally, the exposed pavement is bordered along the inland edge by open northern-white cedar glades, dense herbaceous and shrub vegetation.

Natural processes: Composition and diversity of plant species is largely determined by distance from the waters edge and the width of bedrock cracks. Soil accumulation begins in the cracks forming the first sites for vegetative colonization. A distinctive vegetative zonation results from the ice scrape and wave wash dynamics of the lakeshore. The lower zone of this community, averaging 10 m wide, is continually washed by waves and is very sparsely vegetated. Ice buildup and wave wash from severe storm events may also scour the pavement surface, depositing cobbles in a

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narrow ridge. This zonation varies with fluctuations in Great Lakes water levels. Pools of water typically occupy about 10% of the surface of this zone. Above the wave wash/scrape zone, a more densely vegetated zone extends to the inland forest edge. The width of this zone in Michigan varies from 5-70 m wide, averaging 23 m. Pools of water typically occupy about 1% of the surface of this zone. The soils and substrate are neutral to slightly alkaline (pH 6.7-8.0). All communities along these shorelines experience frequent high winds and storm events.

Vegetation description: Limestone pavement lakeshores are sparsely vegetated communities. The wave-washed and ice-scoured zone immediately adjacent to the lake on average contains 2% vegetative cover, with *Juncus balticus* (rush), *Potentilla anserina* (silverweed), and *Populus balsamifera* (Balm-of-Gilead) being most frequent. Mosses typically occupy 1% of the surface of this zone. The more densely vegetated zone, with patches of herbs, and occasional shrubs, typically has about 20% vegetative cover. Characteristic plant species include *Calamintha arkansana* (Arkansas mint), *Potentilla fruticosa* (shrubby cinquefoil), *P. anserina*, *Panicum lindheimeri* (panic grass), *Thuja occidentalis* (Northern white cedar), and *Deschampsia cespitosa* (hair grass). Mosses in this zone comprise 5% areal coverage. Occasionally, a glade zone occurs in the upper portion of the shoreline, dominated by stunted conifers, low evergreen shrubs, and dense herbaceous plants and mosses. These areas have, on average, 23% coverage of shrubs, 78% coverage of herbaceous plants, and 10% coverage of mosses. Characteristic plant species include: *Thuja occidentalis*, *Potentilla fruticosa*, *Arctostaphylos uva-ursi* (bearberry), *Deschampsia cespitosa*, S*enecio pauperculus* (ragwort), *Juniperus communis* (common juniper), and *Picea glauca* (white spruce).

Other plant species commonly associated with limestone pavement lakeshores in Michigan include: *Deschampsia flexuosa* (hair grass), *Hypericum kalmianum* (Kalm's St. John's-wort), *Aster laevis* (smooth aster), *Solidago ohioense* (Ohio goldenrod), *Campanula rotundifolia* (harebell), *Lycopus americanus* (water horehound), *Viola nephrophylla* (bog violet), *Euthamea graminifolia* (grass-leaved goldenrod), *Eleocharis elliptica* (spikerush), *Primula mistassinica* (bird's eye primrose), *Carex viridula* (sedge), *C. eburnea* (ebony sedge), and *Zigadenus glaucus* (white camass). Rare plants may include such species as *Carex richardsonii* (Richardson's sedge), *C. concinna* (beauty sedge), and *C. scirpoidea* (bulrush sedge). A total of 147 vascular plant species have been recorded along limestone pavement lakeshores in Michigan. On any given stretch of pavement lakeshore one would, on average, encounter 24 vascular plant species.

Strata	**Most abundant**
Tree canopy	*Thuja occidentalis*
Short shrub	*Potentilla fruticosa*, *Populus balsamifera*, *Thuja occidentalis*
Herbaceous	*Calamintha arkansana*, *Potentilla anserina*, *Juncus balticus*, *Deschampsia cespitosa*, *Panicum lindheimeri*

Michigan indicator species: *Primula mistassinica*, *Carex richardsonii.*

Other noteworthy species: *Solidago houghtonii*, *Carex scirpoidea*, *C. richardsonii*, *C. concinna*, *Iris lacustris*, *Cirsium hillii.*

Special animals: Special animal species that associate with the limestone pavement lakeshores in Michigan include several land snails and one uncommon butterfly. *Vertigo hubrichti* is a periglacial relict snail known from less than 30 sites worldwide and from two sites in Michigan. One of these is from a shaded, damp to dry low ledge in the shrub zone of limestone pavement shoreline.

A number of butterflies have been recorded from the limestone lakeshores including the tawny crescentspot (*Phyciodes batesii*). In addition to lakeshore pavements, this species can be found in alvar glades and wet meadows of northern Michigan where its larvae feed on a variety of aster species.

The shorelines also provide stopover and feeding corridors important to neotropical migratory birds including many warbler species.

Conservation/management: Principle threats to these areas are related to trampling of vegetation and the introduction of invasive, non-native plant species. Residential subdivision of adjacent uplands frequently causes degradation to this community through trampling, off-road vehicle use, water pollution, and non-native plant introduction. Protection of adjacent vegetation and limited shoreline access are needed surrounding each lakeshore occurrence.

Research needs: Range-wide perspective of the relative rarity and biological variation of these systems is needed to further clarify conservation priorities. Additional characterization of non-vascular plants and insects in Michigan shorelines is needed as well as research into the effects of residential development on the function of these communities.

Similar communities: alvar pavement, alvar grassland, limestone/dolostone glade, spruce-fir forest.

Other classifications:

Michigan Natural Features Inventory (MNFI) Presettlement Vegetation (MNFI): 74, exposed bedrock.

Michigan Department of Natural Resources (MDNR): K, rock

Michigan Resource Information Systems (MIRIS): 74, exposed rock.

National Wetland Inventory (NWI): none.

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The Nature Conservancy National Vegetation Classification:

ALLIANCE: Sparsely vegetated pavement.
ASSOCIATION: Great Lakes alkaline rock shore.

Related abstracts: Dwarf lake iris, Houghton's goldenrod, Hill's thistle, prarie smoke.

Selected references:

Albert, D.A., P.J. Comer, D.L. Cuthrell, M.R. Penskar, D. Hyde, W.A. Mackinnon & M.L. Rabe. 1997. Great Lakes Bedrock Lakeshore in Michigan. Report to Michigan Department of Environmental Quality, Land and Water Management Division. 210 pp.

Albert, D. A. 1995. Region Landscape Ecosystems of Michigan, Minnesota, and Wisconsin: a Working Map and Classification. North Central Forest Experiment Station. Forest Service - U.S. Department of Agriculture. 250 pp. + map. 1992 Folwell Ave. St. Paul, Minnesota 55108. 250 pp.

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Reschke, C. 1990. Ecological Communities of New York. New York Natural Heritage Program, New York State Department of Environmental Conservation, Latham, NY. 96 pp.

The Nature Conservancy (TNC). 1994. Rare Plant Communities of the Coterminous United States: Midwestern Region. D. Ambrose, J. Drake, & D. Faber-Langendoen (eds). Midwest Regional Office. Minneapolis, MN. pp.211-304.

Abstract citation:

Comer, P.J., D.L. Cuthrell, D.A. Albert, and M.R. Penskar. 1997. Natural community abstract for limestone/ dolostone pavement lakeshore. Michigan Natural Features Inventory, Lansing, MI. 3 pp.

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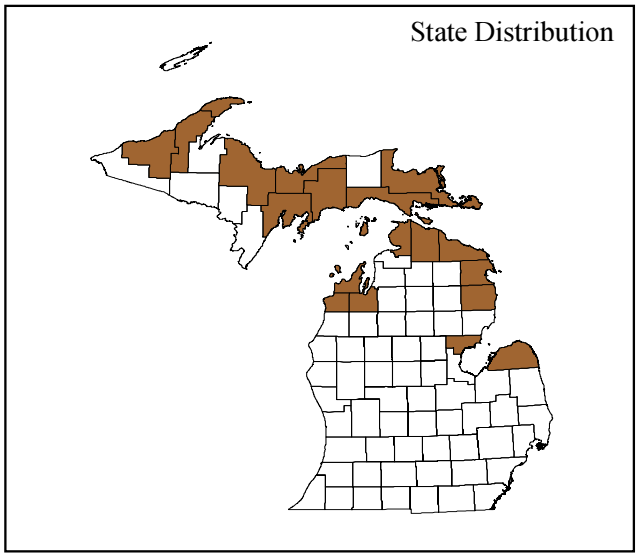
Wooded dune and swale complex — Community Abstract


Photo by Dennis A. Albert.



Global and state rank: G3/S3

Common name: Great Lakes wooded dune and swale

Range: This complex of wetland swales and upland beach ridges (dunes) is found in embayments and on large sand spits along the shoreline of all of the Great Lakes. These complexes are documented from Minnesota, Wisconsin, Michigan, Illinois, Indiana, Pennsylvania, Ohio, and the province of Ontario.

Rank justification: Wooded dune and swale complexes are restricted to the Great Lakes shoreline (Comer and Albert 1991, 1993, Homoya et al. 1985), although there are features of similar geological origin along the shorelines of most oceans and seas as well, the biota of the marine systems is distinctly different (Wiedemann 1984). Residential and recreational development has resulted in disrupted hydrological conditions and wetland destruction. Currently, about 95 dune and swale complexes have been identified in the Great Lakes, with 70 located in Michigan. Michigan's 40 highest quality dune and swale complexes total about 70,926 acres (28,370 hectares) in area.

Landscape context: Many complexes began forming when the Great Lakes were at glacial Lake Algonquin levels, approximately 12,000 years ago (Comer and Albert 1993, Dorr and Eschman 1970), but in the southern Great Lakes, some of the large complexes are younger, approximately 6,000 years old (Thompson 1992, Chrzastowski and Thompson 1992). Receding lake levels deposited a series of sandy beach ridges ranging from 0.5 m to 4.0 m high. From the air, these ridges appear as a series of arcs generally parallel to the shoreline, and often extending up to two miles inland (see photo, page 2). The dune ridges can be quite numerous, with 150 ridges forming over 6,000 years near Gary, Indiana (Thompson 1992) and 108 ridges forming over 3,500 years in northern Lower Michigan (Lichter 1998).

Natural processes: These complexes are best developed where streams provide a dependable sand source. The combination of along-shore currents, waves, and wind form foredunes along the shoreline. With gradual long-term drops in water level, combined with post-glacial uplifting of the earth's crust, these low dunes gradually rise above the direct influence of the lakes, and new foredunes replace them. Over several thousand years, a series of ridges and swales is created. For most complexes, the flow of surface streams and groundwater maintain the wet conditions in the swales. Along the Lake Superior shoreline, where post-glacial uplift is greatest, many of the complexes consist primarily of dry, forested swales (Comer and Albert 1993). The number and size of the dune ridges and swales differs depending on fetch and the amount of sediment available.

Vegetation description: Because they contain a unique assemblage of physiographic, soil, and vegetative components, and provide a high quality habitat for numerous shoreline animal species, the Wooded Dune and Swale Complex is considered a distinct natural community in Michigan (MNFI 1990). Classic ecological studies have identified distinctive successional zones within the sand dune portion of the complexes, determined on the basis of several factors, including distance from the lake, amount of soil development, and available light (Olson 1958, Cowles 1899). Lichter's (1998) recent study of dune and swale complexes at Wilderness State Park in northern Lower Michigan has identified similar successional trends. He found that, at the Lake Michigan shoreline, young dunes had 1) stronger winds, 2) more sand burial and erosion, 3) higher levels of sunlight, 4) higher rates of evaporation, and 5) lower available nitrogen and phosphorus than older beach ridges farther inland, resulting in an

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open herbaceous-dominated plant community along the shore. Farther inland, with greater protection from sun and wind and with greater soil development, there was succession from open dune, first to grassland, then to shrubs, and finally to forests, with mesic northern hardwoods increasing in dominance on beach ridges farther from the shoreline.

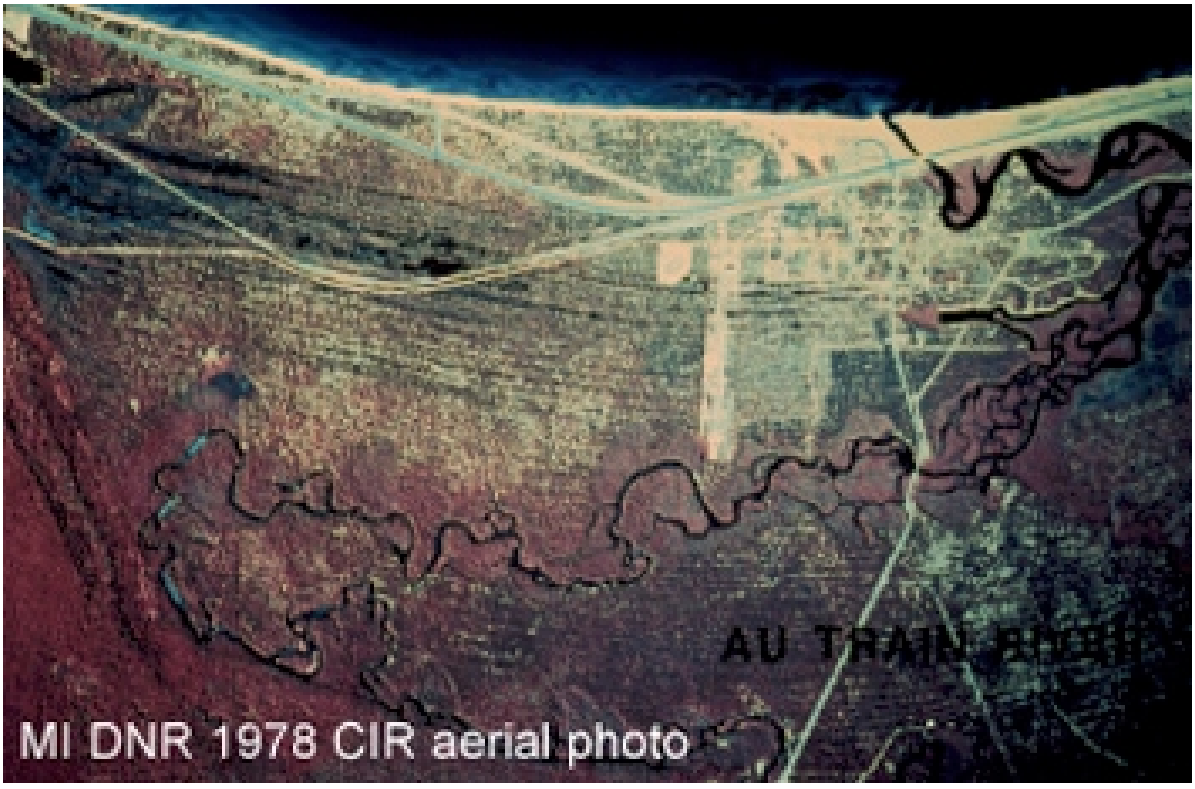
Both swales and upland dune ridges were studied by MNFI (Comer and Albert 1991, 1993). Of the 17 sites where elevations were measured from the shoreline inland, only 3 sites contained swales where the sandy bottoms of all or most of the swales lay below the current Great Lakes water levels. This suggests that, except for a few examples, the influence of Great Lakes water-level fluctuations is probably limited to the first few swales inland from the shoreline. For most of the complexes, the water occupying the swales comes from streams flowing from the adjacent uplands or from groundwater seepage.

The foredunes of most dune and swale complexes are commonly 1-2 meters high, with beach grass (*Ammophila breviligulata*), dune grass (*Calamovilfa longifolia*), autumn willow (*Salix serissima*), dune willow (*S. cordata)*, and balsam poplar (*Populus balsamifera*) most common. Within their ranges, federally-threatened Pitcher's thistle (*Cirsium pitcheri*) and state-threatened Lake Huron tansy (*Tanacetum huronense*) are also found on the foredunes.

Immediately behind the foredune, where lake-influenced, calcareous sands are most common, a shallow swale often contains twig-rush (*Cladium mariscoides)*, sweet gale (*Myrica gale*), shrubby cinquefoil (*Potentilla fruticosa*), blue joint grass (*Calamagrostis canadensis*), Kalm's lobelia (*Lobelia kalmii*), false asphodel (*Tofieldia glutinosa*), and grass-of-Parnassus (*Parnassia glauca*). Less commonly, in the Straits of Mackinac area, federally-threatened Houghton's goldenrod (*Solidago houghtonii*) is found in the swales behind the foredune.

The swale immediately behind the foredune is influenced by short-term variation in lake levels and can be partially or occasionally completely filled by dune sands following major storm events. Species common to this first swale include the rushes (*Juncus balticus*, *J. pelocarpus*, *J. nodosus*), spike rush, (*Eleocharis acicularis*), and threesquare (*Scirpus americanus*).

A low dune field with more advanced plant succession often follows the first open dunes and swales. Jack pine *(Pinus banksiana)*, white pine (*P. strobus)*, and red pine (*P. resinosa*) often form a scattered overstory canopy, while ground juniper (*Juniperus communis*), creeping juniper (*J. horizontalis*), bear berry (*Arctostaphylos uva-ursi*), beach grass, and June grass (*Koeleria macrantha*) form a scattered ground layer.



Aerial photo of dune and swale complex.

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Following the dune-field zone, both dunes and swales are typically forested. Moist swales are often forested and soil organic material has often begun to accumulate. Northern white cedar (*Thuja occidentalis*), speckled alder (*Alnus rugosa*), willows (*Salix spp.*), and red maple (*Acer rubrum*) dominate the partial overstory canopy and understory. In northern Lake Michigan and Lake Huron, where these swales are better drained, and northern white cedar forms the overstory, federally-threatened dwarf lake iris (*Iris lacustris*) may be found in large non-flowering populations.

In contrast to the dry or moist swales, in those swales where standing water is present through most of the year, sedges (*Carex aquatilis*) and (*C. stricta*), twigrush, marsh marigold (*Caltha palustris*), swamp candles (*Lysimachia terrestris*), and swamp cinquefoil (*Potentilla palustris*) commonly dominate the ground layer.

Forested beach ridges, with soils of medium to course sand, tend to be dominated by species common to dry-mesic and mesic northern forest (MNFI 1990). Soil moisture conditions appear to change dramatically with slight elevational changes and are reflected in the development of soil organic material and changing plant species. On higher, drier ridges, soils often have less than 3 cm of organic material. Red pine, white pine, and red oak (*Quercus rubra*) are often co-dominant, while paper birch (*Betula papyrifera*), bigtooth aspen (*Populus grandidentata*), balsam fir (*Abies balsamea*), and red maple are sub-dominant or understory species. Bracken fern (*Pteridium aquilinum*), black huckleberry (*Gaylussacia baccata*), blueberry (*Vaccinium myrtilloides*), bunchberry (*Cornus canadensis*), and wintergreen (*Gaultheria procumbens*) occur in the shrub and ground layers.

On lower ridges, where soils are moister, soil organic material accumulation is greater (4-25 cm). White pine may still dominate the overstory, but often white spruce, black spruce, red maple, balsam fir, northern white cedar, and occasionally tamarack (*Larix laricina*) are co-dominant. Canada honeysuckle (*Lonicera canadensis*), mountain holly (*Nemopanthus mucronatus*), twinflower (*Linnaea borealis*), dwarf blackberry (*Rubus pubescens*), Canada mayflower (*Maianthemum canadensis*), and starflower (*Trientalis borealis*) are common in the shrub and ground layers.

Complexes located in embayments protected from prevailing winds tend to be formed entirely of low, water-lain beach ridges. As a result, even the beach ridges within these complexes support wetland vegetation. An example is Ogontz Bay, in the eastern Upper Peninsula of Michigan. Here swales ranged from 1-30 m wide and 0.5-3.0 m deep. Narrow, shallow swales are forested with northern white cedar, black spruce, and red maple, with speckled alder and willows in the understory and shrub layers, and sedges (*Carex disperma*), (*C. trisperma*), (*C. leptalea*), (*C. interior*), (*C. cryptolepis*), (*C. flava*), (*C. intumescens*), blue joint grass, fowl manna grass (*Glyceria striata*), water horehound (*Lycopus uniflorus*), and Sphagnum mosses (*Sphagnum spp.*) in the ground layer.

Wider, deeper swales are more often unforested, with chokeberry (*Aronia prunifolia*), red osier dogwood (*Cornus stolonifera*), bog birch (*Betula pumila*), and speckled alder forming a shrubby ecotone, while sedges (*Carex lasiocarpa*), (*C. oligosperma*), (*C. aquatilis*), (*C. stricta*), and woolgrass (*Scirpus cyperinus*) form a mat within which marsh fern (*Thelypteris palustris*) and horned bladderwort (*Utricularia cornuta*) also occur. Where a sedge mat is not well developed, bur-reed (*Sparganium minimum*), pond-lily (*Nuphar variegata*), and pondweeds (*Potamogeton berchtoldii* and *P. natans*) are commonly found.

Organic material gradually accumulates in the swales over time; organic material in swales reaches a depth of 30-75 cm within 300 meters of the lake's edge. Vegetation in swales reflects the more acid conditions of the older thickets as peat accumulations. Leatherleaf (*Chamaedaphne calyculata*), bog rosemary (*Andromeda glaucophylla*), Labrador tea (*Ledum groenlandicum*), bog laurel (*Kalmia polifolia*), large cranberry (*Vaccinium macrocarpon*), cottongrass (*Eriophorum virginicum*), pitcher-plant (*Sarracenia purpurea*), Sphagnum mosses (*Sphagnum centrale*, *S. wulfianum*, *S. warnstorfii*, *S. magellanicum*, and *S. squarrosum*) are commonly found in the thick peat soils of the swale behind the shoreline.

An even stronger pattern of increased organic matter accumulation occurs farther north along Lake Superior. For example, at Grand Traverse Bay in Keweenaw County, very low beach ridges and swales have thick accumulation of acid organic matter, with bog-like vegetation in the first swale of the shoreline.

A PRELIMINARY CLASSIFICATION OF MICHIGAN WOODED DUNE AND SWALE COMPLEXES

North-south patterns in plant distributions are clear in both the uplands and wetlands of Michigan's wooded dune and swale complexes. Extremes are seen between the complexes along Saginaw Bay, with southern species, and those of the Keweenaw Peninsula, with more northern or boreal species (Comer and Albert 1993). Along this north-south gradient, complexes were broken into five sub-types based on a combination of geographic location and processes of beach ridge formation, which have resulted in significantly different assemblages of plant species. The five sub-types identified include the Southern Lake Huron, the Northern Lake Huron/Lake Michigan-Low Dune, the Northern Lake Michigan-High Dune, the Lake Superior-High Dune, and the Lake Superior-Low Dune sub-types.

Even within complexes of each sub-type, there are relatively low percentages of similar species. This reflects the highly variable nature of these complexes. There are, however, major floristic differences between the northern

and southern sub-types; for example, while 50% of the species are shared by two northern complexes, as little as 19% of plant species are shared by physically similar northern and southern complexes.

The Southern Lake Huron complexes can not be divided into distinctive landform sub-types, primarily because few intact examples remain. This sub-type is best distinguished by its southern species, including cottonwood (*Populus deltoides*), black walnut (*Juglans nigra*), and buttonbush (*Cephalanthus occidentalis*).

Complexes within the Northern Lake Huron/Lake Michigan-Low Dune sub-type are commonly found in embayments with little exposure to prevailing westerly winds. As a result, the low beach ridges (0.5-1m) of these complexes are almost entirely water-lain. They generally support wetland vegetation, both in the swales and on many of the ridges. All complexes along the Northern Lake Huron shoreline fall into this category. Along the Northern Lake Michigan shoreline, complexes of this sub-type are found in portions of Mackinac, Schoolcraft, and Delta counties, where embayments are protected from westerly winds. Because the sandy soils along these shorelines are partly derived from limestones and dolomites of the underlying Niagaran Escarpment, plant species associated with moist, calcareous conditions, including Great Lakes endemics such as Houghton's goldenrod and dwarf lake iris, are commonly found close to the shoreline.

The Northern Lake Michigan-High Dune sub-type is distinguished by high, often irregular dune ridges formed by prevailing westerly winds. Clear distinctions can be made between the upland vegetation of the high dune ridges (2-5 m) and the wetland vegetation of the swales. Dune ridges are dominated by white pine, red pine, red oak, and paper birch, while the swales contain the widest variety of plant communities of any sub-type. Wetland plant communities include emergent marsh, intermittent wetland, bog, northern wet meadow, speckled alder swamp and northern white cedar swamp. This sub-type is most common in Benzie, Leelanau, Emmet, Mackinac, and Schoolcraft counties; Sturgeon Bay is a typical example (see Appendix IV in Comer and Albert (1993)).

The Lake Superior sub-type is dominated by plant species of distinctly northern character. This sub-type, represented by relatively few examples concentrated in Marquette and Luce counties, typically contains few swales with wetland vegetation. This is due to well-drained conditions resulting from high, wind-sorted dune ridges (1-3 m), and by adjacent rivers that effectively drain much of the complex. An example is at the mouth of the Iron River in Marquette County, where the first swale lies below current Lake Superior water levels, but all other swales are above the lake and well drained. These complexes are characterized by dry northern forest with jack pine and red pine.

Complexes of the Lake Superior-Low Dune sub-type are typically found where embayments are not directly exposed to prevailing westerly winds. The resulting low, water-lain beach ridges often support swamp forests of white and black spruce, tamarack, and balsam fir. The wet swales contain vegetation characteristic of acid peatlands and bogs. A good example of this type is Grand Traverse Bay, in Houghton and Keweenaw counties.

Characteristic vegetation of open foredune

Strata	Most abundant
Tree canopy	*Populus balsamifera* (balsam poplar)
Short shrub	*Salix serissima* (autumn willow), *S. cordata* (dune willow), *Juniperus communis* (ground juniper), *J. horizontalis* (creeping juniper), *Arctostaphylos uva-ursi* (bear berry)
Herbaceous	*Ammophila breviligulata* (beach grass) *Calamovilfa longifolia* (dune grass)

Characteristic vegetation of open swale

Strata	Most abundant
Tree canopy	
Short shrub	*Myrica gale* (sweet gale), *Potentilla fruticosa* (shrubby cinquefoil), *Betula pumila* (bog birch), *Aronia prunifolia* (Chokeberry), *Cornus stolonifera* (red osier dogwood)
Herbaceous	*Carex stricta, C. aquatilis, C. lasiocarpa*, *C. oligosperma* (sedges), *Eleocharis rostellata, E. acicularis* (spike-rushes) *Cladium mariscoides* (twig-rush), *Scirpus acutus, S. americanus* (bulrushes), *Calamagrostis canadensis* (blue joint grass), *Juncus balticus*, *J. pelocarpus*, *J. nodosus* (rushes), *Scirpus cyperinus* (woolgrass), *Thelypteris palustris* (marsh fern), and *Utricularia cornuta* (horned bladderwort)

Characteristic vegetation of forested dune

Strata	Most abundant
Tree canopy	*Pinus banksiana* (jack pine), *P. strobus* (white pine), *P. resinosa* (red pine), *Quercus rubra* (red oak), *Betula papyrifera* (paper birch), *Populus grandidentata* (bigtooth aspen), *Acer rubrum* (red maple), *Abies balsamea* (balsam fir)
Short shrub	*Gaylussacia baccata* (black huckleberry), *Vaccinium myrtilloides* (blueberry)
Herbaceous	*Pteridium aquilinum* (bracken fern), *Cornus canadensis* (bunchberry), *Gaultheria procumbens* (wintergreen)

Characteristic vegetation of forested swale

Strata	Most Abundant
Tree canopy	*Thuja occidentalis* (northern white cedar), *Picea mariana* (black spruce), *Acer rubrum* (red maple)
Short shrub	*Alnus rugosa* (speckled alder), *Salix* spp. (willows)
Herbaceous	*Carex disperma*, *C. trisperma*, *C. leptalea*, *C. interior*, *C. cryptolepis*, *C. flava*, *C. intumescens* (sedges), *Calamagrostis canadensis* (blue joint grass), *Glyceria striata* (fowl manna grass), *Lycopus uniflorus* (water horehound), and *Sphagnum spp.* (Sphagnum mosses)

Michigan indicator species: The community is too widespread to identify a small group of representative species.

Other noteworthy species: Rare animals associated with wooded dune and swale complexes include *Haliaeetus leucocephalus* (bald eagle), *Charadrius melodus* (piping plover), *Pandion haliaetus* (osprey), *Martes americana* (American martin).

Rare plant associates include *Cirsium pitcheri* (Pitcher's thistle), *Solidago houghtonii* (Houghton's goldenrod), *Stellaria longipes* (starwort), *Iris lacustris* (dwarf lake iris), *Calypso bulbosa* (calypso), *Pterospora andromedea* (pine drops), *Tanacetum huronense* (Lake Huron tansy), *Cypripedium arietinum* (ram's head lady's-slipper), *Orobanche fasciculata* (clustered broom rape), *Carex albolutescens* (greenish-white sedge), *Ranunculus laponicus* (Lapland buttercup), *Armoracia lacustris* (lake cress), *Elymus mollis* (American dune wild-rye), *Salix pellita* (satiny willow), and *Crataegus douglasii* (Douglas' hawthorn).

Invasive, non-native species such as *Lythrum salicaria* (purple loosestrife), *Phalaris arundinacea* (reed canary grass), and *Phragmites australis* (giant bulrush) can also invade the wet swales.

Conservation/management: Protecting hydrology is important in the maintenance of vegetative structure in wooded dune and swale complexes. Road development across the swales, even with culverts, typically modifies the hydrology. Marinas, typically requiring dredging and other major modification of the wetlands, have been constructed in some complexes. Golf courses have also been built on complexes and unsuccessfully proposed for others. Intensive use as deer yards has greatly altered the wetlands in the Upper Peninsula, where regeneration of northern white cedar has been eliminated or greatly reduced. In some deer yarding areas, conversion of the ridges to aspen has also been proposed. Residential development has resulted in major alteration of several dune and swale complexes, due to several factors, including road and driveway construction, wetland filling, and septic leakage. Nutrient addition from leaking septic tanks and drain fields is suspected of contributing to the dominance of invasives such as *Typha angustifolia* (narrow-leaved cat-tail), giant bulrush, and purple loosestrife.

Research needs:

Similar communities: The dune and swale complexes contain several plant communities, including Great Lakes marsh, emergent marsh, intermittent wetlands, northern wet meadow, southern wet meadow, shrub carr, northern fen, poor fen, interdunal wetland, rich conifer swamp, poor conifer swamp, bog, dry northern forest, and open dune.

Other classifications:

Michigan Natural Features Inventory Presettlement Vegetation (MNFI): includes upland forest types: red pine/white pine, hemlock, red pine, white pine, oak/pine barrens, black oak, jack pine, aspen, beech/sugar maple, red pine/jack pine; swamp forest types: black ash, American elm, northern white cedar, tamarack, lowland conifer, balsam fir, black spruce, red maple, white birch, balsam poplar, trembling aspen, speckled alder, shrub swamp; herbaceous: Great Lakes marsh, open dune, emergent marsh, and lake.

Michigan Department of Natural Resources (MDNR): Several DNR cover types occur within the dune and swale complexes, including lowland brush, marsh, tamarack, paper birch, aspen, cedar, swamp hardwoods, spruce-fir, hemlock, jack pine, marsh, balsam poplar and swamp aspen and swamp white birch, mixed swamp conifer, oak, red pine, black spruce swamp, tamarack, white pine, sand dune, and water.

Michigan Resource Information Systems (MIRIS): The following MIRIS cover types occur within dune and swale complexes: aspen-birch, upland hardwoods, lowland hardwoods, upland conifer, lowland conifer, shrub, emergent, aquatic bed, and open water.

National Wetland Inventory (NWI): Several wetland types would be mapped within the wooded dune and swale complex, including: *palustrine system*: aquatic beds, emergent, scrub shrub, and forest classes; *lacustrine system*: unconsolidated shore, emergent, and open water classes.

The Nature Conservancy National Classification:

Code: CECX002000: Great Lakes dune-swale complex vegetation.

Alliance: This complex contains over 40 different alliances in different parts of its Great Lakes range.

Related abstracts: open dune, dwarf lake iris, pitcher's thistle, lapland buttercup, piping plover, and prairie warbler.

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