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

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MICHIGAN STATE UNIVERSITY EXTENSION

Michigan Natural Features Inventory

Cover Photo Identification:
Open dune looking west from Hughes Point
by: Phyllis J. Higman

Executive Summary

Michigan Natural Features Inventory (MNFI) conducted systematic surveys for high quality natural communities and targeted rare species along Lake Michigan's northern coastal zone, from St. Ignace to Seul Choix Point. The study also included landowner contact and local planner and citizen outreach. Landowners were contacted for permission to survey their property and were invited to a public information meeting held in cooperation with the County Extension Office, Conservation Resource Management Initiative (CRMI). Participants at the meeting were informed about the project and significant natural features of the coastal zone through PowerPoint presentations, discussion, and a field trip. Local planners 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 could use the results of this study and in what form they would be most useful.

Landowner Contact: One hundred and ten private landowners responded to our request to survey, of which 62 (56%) gave positive responses. Twenty-four private parcels were surveyed and rare natural features were documented on 16 of these. Access was minimal for several large areas of shoreline in private ownership, because landowners either did not respond or responded negatively. Several landowners that did not respond favorably to our initial request to survey changed their mind after attending our public information meeting. Because private landowners represent a large segment of potential land stewards as well as advocates for protection of public lands, it is recommended that outreach to landowners be continued.

Animal Surveys: Bird point counts were conducted at 36 sites encompassing seven natural community types. One hundred ten bird species were observed, including 90 during spring migration and 99 during the summer breeding season. Bird abundance and species richness were higher during the breeding season compared to migration. The percentage of long distant migrants, short distant migrants, and resident birds recorded during the migration and breeding season was similar. Two new occurrences for listed birds were documented within the study area, including a nesting pair of northern harriers and three pairs of nesting piping plovers recorded on Hiawatha National Forest property. Seven additional listed species were seen in the study area including osprey, merlin, Caspian tern, common tern, common loon, red-shouldered hawk, and bald eagle. Several of these species are largely or solely dependent on shoreline and island habitats for nesting. Identification and preservation of these habitats has become urgent in the face of increasing development and recreation pressures.

Surveys for the Great Lakes endemic, Lake Huron locust, resulted in the identification of eight new populations and the reconfirmation of six previously known populations, two of which were expanded in extent. Additional suitable habitat for this species also was identified. Most of the documented populations were ranked with good to fair viability, with one population ranked as having excellent 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 ecologically intact dune systems. As recreational and development pressures continue in the region, deliberate efforts to minimize impacts to the dunes are essential for conservation of this species. Monitoring and research on the ecological requirements of the locust are also needed to help determine the level of disturbance that can be tolerated and the best strategies to minimize impacts from recreational use and development.

Surveys for the federal and state endangered Hine's emerald dragonfly and the state special concern incurvate emerald dragonfly failed to document any new populations. Surveyed habitat was considered marginal for the Hine's emerald dragonfly, but had good potential for the incurvate emerald dragonfly. Additional surveys, particularly for the incurvate emerald dragonfly, are warranted to further ascertain whether these species occur in the study area and to help determine their statewide distribution. In addition to the targeted species, there is potential for other rare invertebrates to

occur in the study area, including the state special concern dune cutworm moth (*Euxoa aurulenta*) and rare land snails.

Plant Surveys: Twenty-one new and 40 updated rare plant occurrences were documented during this study, and an additional 17 previously documented occurrences are considered likely extant, while 3 are believed extirpated. The 78 extant occurrences encompass 11 different species, including 35 occurrences of 3 state and federal listed Great Lakes endemics, dwarf-lake iris, Pitcher's thistle, and Houghton's goldenrod. Also included are five occurrences of the state and federal threatened Michigan monkey-flower, a species known only from Michigan. These five occurrences represent 30% of the total known localities of this species in the world. Protection of these rare plant populations will require the maintenance of tracts of land where natural shoreline processes can function unimpeded. However, further study is needed to determine the minimum acreage required and the level of disturbance that can be tolerated. An encouraging sign is that many rare plant populations currently persist on residential properties. Further research and continued landowner education are critical if these and other occurrences are to be sustained.

Natural Community Surveys: Twenty-one occurrences of eight different natural communities have been documented in the study area. These included six high quality occurrences of the globally significant wooded dune and swale community, four Great Lakes marshes, three interdunal wetlands, two open dunes, two dry-mesic northern forests, two cobble beaches, one mesic northern forest and one sand/gravel beach. Several areas that are likely to encompass additional natural communities were identified, but permission to access these areas was not obtained. It is recommended that additional efforts to secure access permission be made. The study area also encompasses very large regions of largely undeveloped lands, including both public and private holdings. As human demand for residential and recreational access to shoreline communities continue to increase, these lands become increasingly vulnerable to ecological degradation. A deliberate and proactive approach to their protection is urgently needed. Dedication of Mackinac state forest lands from Norton-Ogleby Limestone Company to Big Knob Campground, as a State Natural Area is encouraged. These lands span over fifteen miles of shoreline and encompass multiple natural community and rare species occurrences.

Local Planner and Citizen 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. Additionally, several local planners and landowners have been frustrated by what they perceive as inconsistent and unequal application of environmental regulations. 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 and the results of this study will be provided to the townships in hard copy. Mackinac County is currently in the process of establishing a county planning commission to help guide future development of the county. They may assist townships in the development or refinement of master plans. Hard copy results of this study will also be provided to the commission. Nineteen landowners attended a public information meeting that featured PowerPoint presentations on shoreline ecology, rare and declining plant and animal species, and endangered species legislation. Workshop participants were also led on a field trip to observe an open dune and associated rare species. The workshop was enthusiastically received and was rated highly by all participants. Effective protection of the coastal zone is most likely when it is integrated into the value systems of those who use the land. Additional information meetings that target planners, township administrators, developers, realtors, and landowners, are recommended.

Summary and Recommendations: The high number of natural features in the study area highlights the importance of the 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 also recommended. Ideally, this effort should include representation from all levels of government and private sector groups.

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List of Acronyms Used in Report

Acronym	Full Name
BCD	Biological Conservation Database – MNFI's statewide database on significant natural features
Biotics	MNFI's GIS-based mapping database
CIR	Color Infrared
CIWPIS	Coastal and Inland Waters Permit Information System
CRMI	Conservation Resource Management Initiative
CWPOA	Carnegie Woods Property Owners Association
CUPAD	Coalition of Upper Peninsula
DEQ	Department of Environmental Equality
FMD	Forest Management Division
GIS	Geographic Information System
GPS	Global Positioning System
G1, G2, G3, G4, G5	TNC global ranks where G1 is most imperiled and G5 is least imperiled
LWMD	Land and Water Management Division
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
MNFI	Michigan Natural Features Inventory
MSU	Michigan State University
ORV	Off-road vehicles
TNC	The Nature Conservancy
USDA	United States Department of Agriculture
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Services
USGS	United States Geographic System
WD	Wildlife Division

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. As described in detail in previous reports (e.g., Higman et al 2000), many of these natural features are rare globally, found only in the Great Lakes basin, and some are also rare in Michigan. Many of them are listed as state and/or federal threatened or endangered, and are thus protected by law. Systematic shoreline surveys by MNFI continue to yield additional occurrences of high quality natural communities and rare species while at the same time confirming the high degree of threat facing them (Higman et al 2000; Penskar et al 2000.) Recreational and residential development of Great Lakes shoreline continues at an alarming rate while many direct impacts and more difficult-to-detect cumulative impacts to shoreline ecology continue to occur unimpeded (Olson & Soule 1998).

Interviews with local planners in Schoolcraft County in 2001 (Higman et al 2000) showed that many shoreline development activities involve only local permits, which, unlike state and federal permitting processes, do not specifically consider natural features. A proactive approach is urgently needed to make local planners aware of the significance of shoreline features as well as their legal obligation to protect those that are listed as state or federal threatened or endangered. 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, including concerned citizens.

This study was a continuation of our systematic shoreline surveys along northern Lake Michigan including the landowner contact and local planner outreach components that were initiated in 2000. Surveys were conducted for high quality natural communities, rare plants, and targeted rare or declining animals. Landowner contact to request permission to access property was a prerequisite to all surveys on private lands. 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 meeting for the general public and local planners was convened to provide information on the study, laws pertaining to threatened and endangered species, shoreline ecology and ecosystems, and the biology and ecology of the natural communities and species sought. Finally, 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, and federal level in the study area
- to inform local landowners and planners of these significant shoreline features

It is hoped that this effort will help promote a more pro-active approach to conservation of coastal zone communities and their component species.

Organization of the Report

This report is organized according to the five major components of the project. **Landowner Contact** was accomplished prior to survey of any land parcel and follow-up occurred if requested both during surveys 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, mid, 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 general status assessment of previously known occurrences, and the identification of additional high quality natural communities. **Local Planner and Citizen Outreach** included *local planner interviews* to determine the level of awareness of natural features, and a *public information meeting* to inform local residents and planners about the project, endangered species legislation, and significant natural features of the Lake Michigan shoreline. Methods, results, and discussion are provided separately for each of the five components, followed by a **Summary and Recommendations** section.

Although we were not able to access all properties in the study area, we were able, 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 and are provided in the final section. The report is appended by various pertinent items referenced in the text, including **species and natural community abstracts** that describe the species and communities targeted during the study (Appendix F).

Study Area

The study area for this project was located in Schoolcraft and Mackinac counties extending approximately 117 km (73 mi) along the Lake Michigan shoreline from the eastern side of Seul Choix Point to Straights State Park, just east of the Mackinac Bridge (Figure 1). Lake Superior State Forest comprises the largest land holding in the study area with approximately 25 miles (40 km) of shoreline, while Hiawatha National Forest covers approximately 6 miles (9.6 km) of shoreline. There are several additional large holdings that are under single private ownership including Hiawatha Sportsman's Club (3.7 km/2.3 mi), Norton Ogleby Limestone Company (4.8 km/3 mi), and Sand Products Company (4.8 km/3 mi). The remaining shoreline area consists mostly of smaller private parcels and subdivisions. The focus for animal, plant, and natural community surveys was on the near-shore coastal communities, from the water's edge to approximately 0.4 km (0.25 mi) inland, although significant natural features that extended further inland were considered. All survey sites are shown in Figures 2-3, and are referenced in the methods sections for each component of the report.

Landowner Contact

Methods for Landowner Contact

The Mackinac County Equalization Department in St. Ignace was visited to obtain names and addresses of landowners within or near 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 Mail merge. A landowner contact letter describing the project and requesting permission to survey was written (Appendix A) and mailed in April of 2001 to a subset of landowners owning land where early migrating and breeding bird counts were to be conducted in early May. A larger mailing to the remaining landowners followed this in May of 2001. Most small plats in sub-divisions were excluded from the mailing due to the amount of time required to process them. However, some sub-division residents were contacted in high priority sites based upon either known occurrences of natural features or high likelihood of finding targeted elements.

Landowner responses were coded according to response type and recorded on plat maps and topographic quad maps utilized during field surveys. Response types included: 1) yes or no for permission to survey, 2) request to know when survey will occur and/or be present during survey, and 3) 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

used for the mailings. 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, either when requesting permission or surveying, were also used as an opportunity to educate them about the significance of the shoreline and of 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.

Landowner contact was also achieved through an informational meeting held on July 21, 2001. This component of the project is covered separately in the Local Planner and Citizen Outreach section of this report.

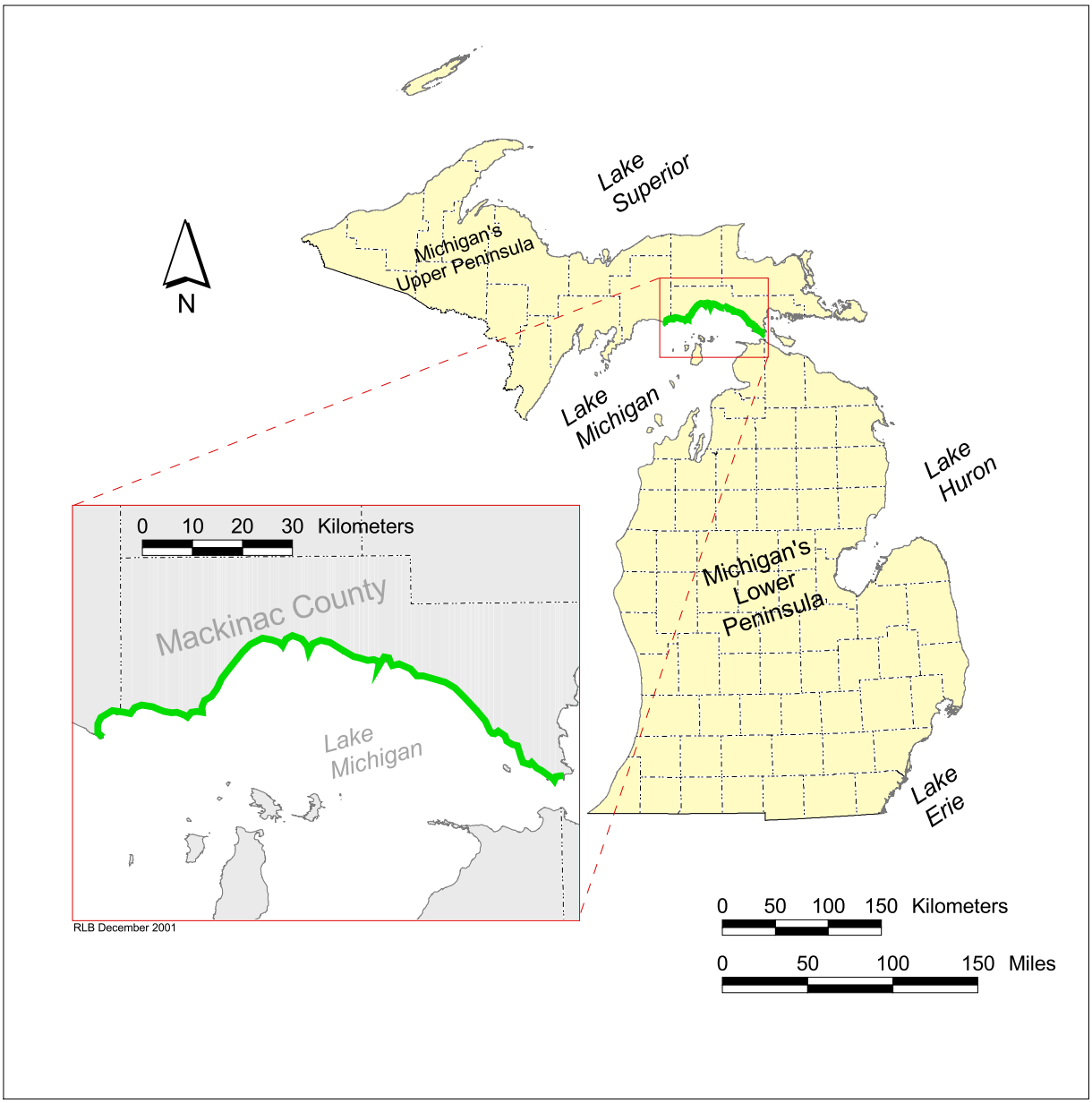

Figure 1. Location of the Study Area.

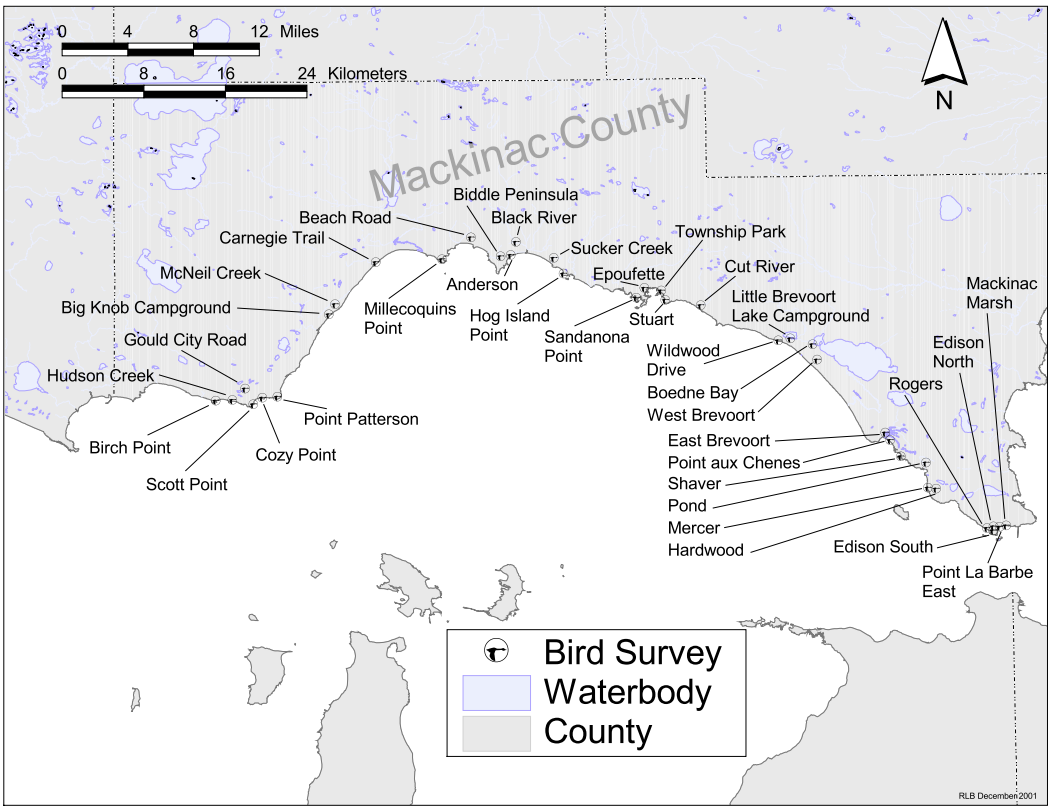

Figure 2. Breeding and migratory bird point count sites.

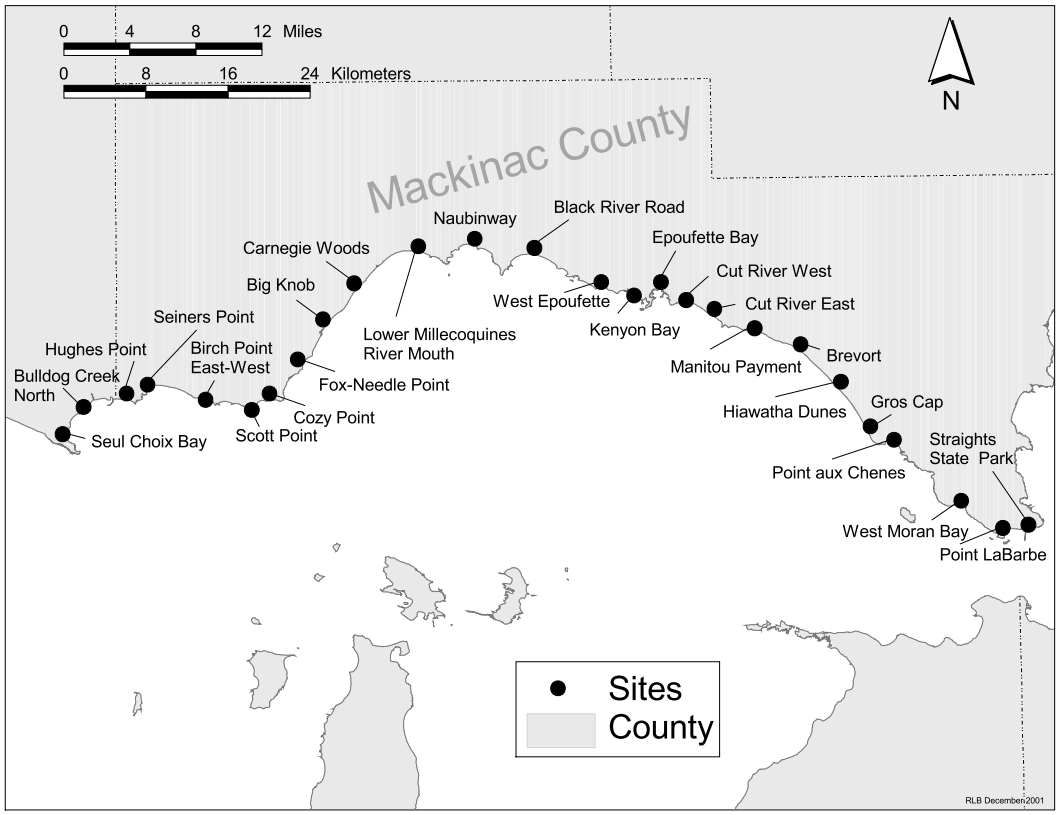

Figure 3. Survey sites for plant and animal surveys.

Results of Landowner Contact

One hundred and ten landowners responded to our request to survey their property. Permission to survey was granted by 56% (62) of the landowners who responded, 34% (22) of which requested the results of the study and 33% (21) of which requested to be present during the survey. Three additional landowners that attended the informational meeting held in July, but had not responded to the mailing, changed their mind and gave us verbal permission to survey their properties. Of the 65 properties where permission to survey had been granted, 40 were identified as high priority sites for survey based on likelihood of occurrence of natural features. Twenty-four of these sites were visited and rare natural features were documented on 16 of them. The remaining high priority sites were not accessed because survey times could not be coordinated with the landowner within the survey window, or due to lack of time and lower priority. Forty two percent (48) of the respondents did not want their property accessed. Some respondents indicated that they absolutely did not want any 'government' involvement on their land and several landowners indicated that they were sensitive about restrictions that might be placed upon them. Others simply said no, without explanation. The remaining landowners that received letters did not respond. Table 1 summarizes these findings.

Table 1. Summary of landowner responses for permission to survey shorelne properties.

Response	Total responses	Requested to be notified or present during survey	Requested survey results	Number of properties surveyed	Number of properties with rare plants
Positive	65* (56%)	21 (32%)	22 (34%)	24 (37%)	16 (67%)
Negative	48 (42%)				

*includes additional responses received during public information meeting

Discussion of Landowner Contact

The percentage of positive responses was lower this year (58%) compared to a similar outreach effort conducted west of the study area in 2000 (91%). The study was not designed to assess response rate or landowner attitudes, however, we speculate that the overall low response rate could reflect attitudes developed from recent threatened and endangered permitting issues in the study area. For some landowners, it was clear that their concern arose from a recent permitting issue involving the presence of the state and federal endangered Michigan monkey flower (*Mimulus glabratus* var. *Michiganensis*) in the vicinity. Resolution of the issue had resulted in some restrictions on road improvement that were perceived by some residents as negative. Many landowners welcomed survey of their land and many were interested in learning more about 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 appropriate stewardship activities reinforced.

As noted in year shoreline surveys (Higman et al 2001), landowner contact complicates survey efforts significantly by the considerable time required to identify and contact landowners, limiting access where there are denials, and by the difficult scheduling required to meet landowners that are only infrequently at their property. It was particularly time consuming this year because landowner addresses were not easily correlated with plat maps and it required considerable manipulation to generate an electronic file of addresses associated with property identifiers. Despite these difficulties, 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. The fact that 67% of private properties visited had rare natural features on them underscores the importance of this aspect of conservation efforts. Without knowledge and understanding of natural features by individual landowners, appropriate stewardship practices are not likely to be implemented.

Landowner attitudes can be changed by positive interactions regarding the natural features in their region of the state. As recommended in our year 2000 pilot landowner and outreach study, a public informational meeting was held to complement the landowner-contact letters. This meeting, described later in this report, was very successful and resulted in a change of attitude by some landowners as well as permission to survey additional properties. We believe that a combined approach of letter writing followed by one or more informational meetings will ultimately be a more efficient and effective way to influence landowner attitudes and concern for natural features. We suggest that the initial contact letter inform the landowners about informational meetings to be held at several different times and at various locations throughout the study area, making it easier for landowners to attend. Also discussed in the latter section of this report, is the need for a systematic and proactive process for addressing endangered species concerns at local, state and federal levels. This would help minimize misunderstandings between landowners, developers, planners, and regulators, helping to offset negative attitudes that can result from not being properly and fully informed.

Animal Inventory

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. 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 BCD and digitized into Biotics.

Birds

Survey sites were chosen after examining aerial photos, topographic maps, plat maps, obtaining permission from private landowners, and consulting with biologists who had conducted surveys in the area. An effort was made to include a variety of shoreline habitats including rocky, sandy, developed, and non-developed sites, as well as inland terrestrial sites and inland wetland sites which bordered lakes, wetlands, and streams. Twenty shoreline sites within 0.4 km (0.25 mi) of the high water mark, 11 inland terrestrial sites and four inland wetland sites between 0.4 km (0.25 mi) and 3.2 km (2.0 mi) of the high water mark were sampled. Overall mean abundance and species richness was calculated separately for migratory and breeding bird sample periods. The top three species most frequently recorded during the migration and breeding season were identified as dominant species. The percentages of long distance migrants, short distance migrants and resident birds recorded during the migration and breeding season were computed.

Bird counts were conducted using a point count method outlined by Ralph et al. (1993, 1995) at 36 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. Each survey station was visited twice in May and twice in June. Spring migration bird counts were conducted between sunrise and 1200 hr on 22-26 May 2001. Breeding bird counts were conducted between sunrise and 1100 hr on 20-23 June 2001. All counts were conducted when there was no precipitation and minimal or no wind. Standard field forms for point counts were used.

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

The primary targets for rare invertebrate surveys were the federal and state endangered Hine's emerald dragonfly (*Somatochlora hineana*) and the state threatened Lake Huron locust *(Trimerotropis huroniana*). The incurvate emerald dragonfly (*Somatochlora incurvata*), a special concern species in Michigan, occurs in similar habitats and flies at the same time as the Hine's emerald dragonfly and thus was surveyed for concurrently.

Hine's Emerald Dragonfly

The extremely rare Hine's emerald dragonfly was listed as federally endangered in January 1995 (DOI 1995). It is currently known from northern Michigan, northeastern Illinois, Door County in northeastern Wisconsin, and one site in the Missouri Ozarks (Cuthrell 1999a). Historically, the species was also known from Ohio and Indiana, and one specimen had also been collected in Alabama. It is believed extirpated from these states. First documented in Michigan in 1997, currently three distinct populations comprised of nine different sites in Michigan have been documented in the Upper Peninsula, the northeastern Lower Peninsula, and Bois Blanc Island in northern Lake Huron (Penskar et al. 2000). It has not been systematically surveyed in Michigan, and it is likely to be found in additional locations where suitable habitat is available. Prior to this study, it was known from five sites in Mackinac County adjacent to the study area. One of these sites is found along the shoreline east of the study area and the remainder are located approximately one to four miles inland.

This species is thought to be restricted to wetland habitats characterized by thin soils over dolomite bedrock (U.S. Fish and Wildlife Service 1999). Important habitat characteristics include graminoid, or grass dominated wetlands that contain cool seeps or shallow, slow-moving water flowing through vegetation and open areas in close proximity to the forest edge (Zercher 1999). The cool, shallow, flowing water provides important larval habitat, and the open areas provide adult foraging and roosting habitat (Cuthrell 1999a). Crayfish burrows also appear to provide important larval habitat (Soluk 1998). Sites in Michigan have been classified as calcareous wetlands or northern fens overlaying shallow dolomite, with one site described as thinly treed, alkaline peatlands (Penskar and Albert 1988, Cuthrell 1999a). Northern fens typically contain flowing groundwater rich in calcium and magnesium carbonates and marly areas. Dominant vegetation in northern fens includes sedges (*Carex aquatilis*, *C. lasiocarpa, C. limosa*, etc.), shrubby cinquefoil (*Potentilla fruticosa*), bulrushes (*Scirpus* spp.), rushes (*Eleocharis* spp.), and twig-rush (*Cladium mariscoides*).

Surveys focused on investigating potential habitat within wetland communities along or near the shoreline in an attempt to find new sites for this species. Surveys were conducted at seven sites including two wetland complexes northeast of the Pointe aux Chenes River approximately 0.4 km (0.25 mi) south of Round Lake Road and 0.8 km (0.5 mi) south of Castle Rock Road, interdunal wetlands between Pointe aux Chenes Bay and US-

2, the wooded dune and swale complex north of Pointe aux Chenes Bay and US-2 east of Brevort Lake Road and along the Pointe aux Chenes River, and wooded dunes and swales and interdunal wetlands at Big Knob Campground in the Lake Superior State Forest. All survey sites are located approximately 5-7 km (3- 4 mi) south of previously known Hine's emerald and incurvate emerald dragonfly sites, and all sites except Big Knob Campground are located within the Hiawatha National Forest.

Meander surveys for adult Hine's emerald dragonfly were conducted by walking through suitable habitat during the appropriate time of year in the study area from 17 to 20 July 2001. Adult dragonflies in the genus *Somatochlora* (emerald dragonflies) were caught with an aerial net, identified, and then released. In addition, close-focusing binoculars were used to observe dragonflies that were perched higher up in the trees and those that were flying over the open water.

Incurvate Emerald Dragonfly

The incurvate emerald dragonfly is one of the rarest dragonflies in North America, known only from Maine, Pennsylvania, Wisconsin and northern Michigan in the United States, and Ontario and Nova Scotia in Canada (Schiffer 1985). It was first documented in Michigan (and in the country) in the early to mid-1900's, and was only recently re-discovered in the state in 1992 (Walker 1925, MNFI 2002). This species is currently known from only six sites in five counties in the Upper Peninsula (MNFI 2002), including only one site in Mackinac County adjacent to the study area. However, similar to the Hine's emerald dragonfly, the incurvate emerald dragonfly has not been systematically surveyed in the state, and additional occurrences could be documented where suitable habitat is available.

Little is known about the ecology and life history of the incurvate emerald dragonfly. It is typically associated with spring-fed sphagnum bogs with small pools or depressions of slow moving spring water (Schiffer 1985). In Michigan, it has also been found in patterned peatlands and northern fens. Surveys were conducted in the same sites and in the same manner as described above for the Hine's emerald dragonfly.

Lake Huron Locust

The Lake Huron locust is a Great Lakes endemic known only from Michigan, Wisconsin and Ontario. Most of the known occurrences of this species are found in Michigan, along the northern shores of Lake Michigan and Lake Huron and along the Lake Superior shoreline. The Lake Huron locust has been recommended to the U. S. Fish and Wildlife Service for consideration as a federally listed species. It prefers dry, loose sand substrates characteristic of high-quality, sparsely vegetated coastal sand dunes (Scholtens and Holland 1997), and adults lay their eggs in soft sand where they overwinter. This grasshopper feeds on a number of dune grasses and several dune forbs, including the federally protected Pitcher's thistle (*Cirsium pitcheri*). Three plant species common to all Lake Huron locust sites include dune grass (*Calamovilfa longifolia*), beach grass (*Ammophila breviligulata*) and wild wormwood (*Artemisia campestris*).

This study focused on reconfirming the presence of known populations, surveying suitable habitat between known sites to determine the extent of these populations, and surveying additional suitable habitat to identify new populations. Prior to this study, the Lake Huron locust was known from seven sites within the study area, including sand dunes west of Cozy Point, at Fox Point, near Naubinway, west of Hog Island Point, east of Davenport Creek, along US-2 south of Brevort Lake and west of Pointe aux Chenes, and along Pointe aux Chenes Bay. Nineteen sites, including six of the seven previously known sites, were surveyed. The Naubinway site was not surveyed due to lack of landowner permission to access shoreline properties. Of the sites surveyed, twelve were located on Lake Superior State Forest property, two on State of Michigan Department of Transportation property, two on Hiawatha National Forest property, and three on private property.

Meander surveys for adult Lake Huron locusts were conducted from 20 to 24 August 2001 by walking through areas of suitable habitat and visually observing adults in flight or perched on open sand. The number of adults observed, the approximate length of habitat surveyed and survey duration were recorded to generate a measure of relative abundance at each site. A hand-held Global

Positioning System (GPS) was used at a subset of survey sites to more accurately determine the location and extent of survey routes and element occurrences. General weather conditions, habitat conditions and threats were also noted. At new locations, voucher specimens were collected with an aerial net. Photographs were taken of each survey site.

After field surveys were completed, all survey forms, data and photographs were compiled and reviewed. Element occurrence specifications developed by The Nature Conservancy were used to determine whether observations represented new populations (element occurrences), or updates, including possible expansions of known populations. Observations of the Lake Huron locust within a contiguous habitat and not separated by a major habitat discontinuity or 1 km (0.6 mi) of apparently unoccupied habitat constitute a single element occurrence or population of this species (Whittaker 1994). We defined major habitat discontinuity as an area greater than 0.16 km (0.10 mi) of rock pavement or outcrop, forested shoreline, wet sand, northern fen or other wetland with no dunes nearby. Element occurrence specifications for the Hine's emerald dragonfly currently do not stipulate a minimum distance or habitat conditions by which to separate element occurrences, and element occurrence specifications for the incurvate emerald dragonfly have not yet been developed. New element occurrences were identified, transcribed and entered into MNFI's statewide database. New status information was added to previously known occurrences. All element occurrences were evaluated and ranked for predicted population viability, ranging from excellent to poor viability or not viable. These ranks are based on specifications that take into account relative abundance, quantity and quality of available habitat, and degree of threat at a given site. Appendix B provides descriptions of viability ranks.

Results of Animal Inventory

Birds

Seven natural community types were sampled during the migration and breeding season including boreal forest, mesic northern forest, dry-mesic northern forest, shrub swamp, rich conifer swamp, northern fen, and emergent marsh. The number of each community type and their location are shown in Table 2. The total number of species observed at all of these sites combined was 110, including 90 species during spring migration and 99 species during the summer breeding season (Table 3). Forty-five species are classified as long distance migrants that winter south and breed north of the Tropic of Cancer. Forty-seven species are short distance migrants that winter in the southern U.S. and northern Mexico and breed in the northern U.S. and Canada. Eighteen species are considered resident birds that winter and breed in the same region.

Mean bird abundance per station visit during spring migration was 8.4 ± 0.6 birds (95% confidence level) and mean species richness per station visit during spring migration was 4.7 ± 0.4 species (95% confidence level) (Table 4). During this same period, the American redstart *(Setophaga ruticilla)*, black-throated green warbler *(Dendroica virens)* and red-eyed vireo *(Vireo olivaceus)* were identified as dominant species. Mean bird abundance per station visit during the breeding season was 11.3 ± 0.9 birds (95% confidence level) and mean species richness per station visit during the breeding season was 5.3 ± 0.4 species (95% confidence level) (Table 5). The same species dominant during the breeding season were also dominant during migration.

The percentage of long distant migrants, short distant migrants and resident birds recorded during the migration and breeding season was similar. During migration, short distant migrants were slightly more numerous than long distant migrants, followed by resident birds (Figure 4). During the breeding season, long distant migrants slightly outnumbered short distant migrants, followed by resident birds (Figure 5).

Rare birds were documented at two locations on Hiawatha National Forest property. The first was a nesting occurrence of the state special

concern northern harrier *(Circus cyaneus*), which was documented approximately two miles inland from Point Aux Chenes Bay, during a survey for the Hine's emerald dragonfly *(Somatochlora hineana)*. The second was at Point Aux Chenes Bay where three pairs of federal and state endangered piping plovers *(Charadrius melodus)* were recorded nesting by the U.S. Forest Service. Six plover chicks successfully fledged from this site.

Several old occurrence records for the state threatened common tern *(Sterna hirundo)* exist along the Mackinac County shoreline at Epoufette Island (unable to access), Point Aux Chenes Bay (no nesting terns), and Sand Products Harbor (unable to access). None of the nesting records were reconfirmed but several individuals were observed foraging for prey in Lake Michigan. A 1996 occurrence for the state threatened Caspian tern *(Sterna caspia)* was not reconfirmed west of Naubinway as there were no nesting individuals in the area. However, this species was observed during breeding season point counts. We were unable to access Green Island (just west of Mackinac Bridge) to reconfirm a nesting occurrence for the special concern black-crowned night-heron *(Nycticorax nycticorax)*.

Other rare species that were observed but were not confirmed nesting include: common loon *(Gavia immer)*, red-shouldered hawk *(Buteo lineatus)*, bald eagle *(Haliaeetus leucocephalus)*, osprey *(Pandion haliaetus)*, and merlin *(Falco columbarius)*.

Table 2. Natural communities sampled for migratory and breeding birds and their location in the study area.

Natural community	Number of sites surveyed	Shoreline	Inland Terrestrial	Inland Wetland
Boreal forest	21	12	8	1
Mesic northern forest	5	1	2	2
Dry-mesic northern forest	3	1	2	
Shrub swamp	3	3		
Rich conifer swamp	2	1		1
Northern fen	1	1		
Emergent marsh	1	1		
Total	36	20	12	4

Table 3. Bird species recorded during the migration and breeding season (2001) at selected sites along the Mackinac County shoreline. State listed species are in bold type.

Common Name	Scientific Name	Migration (May)	Breeding (June)
Long Distance Migrants			
Blue-winged Teal	*Anas discors*	X	X
Osprey (T)	***Pandion haliaetus***	X	X
Broad-winged Hawk	*Buteo platypterus*	X	X
Merlin (T)	***Falco columbarius***	X	X
Caspian Tern (T)	***Sterna caspia***		X
Common Tern (T)	***Sterna hirundo***		X
Black-billed Cuckoo	*Coccyzus erythropthalmus*		X
Ruby-throated Hummingbird	*Archilochus colubrus*	X	X
Eastern Wood-pewee	*Contopus virens*	X	X
Alder Flycatcher	*Empidonax alnorum*	X	X
Willow Flycatcher	*Empidonax trailii*		X
Least Flycatcher	*Empiodonax minimus*	X	X

Table 3 continued

Common Name	Scientific Name	Migration (May)	Breeding (June)
Long Distance Migrants			
Great Crested Flycatcher	*Myiarchus crinitus*	X	X
Eastern Kingbird	*Tyrannus tyrannus*		X
Barn Swallow	*Hirundo rustica*	X	X
Veery	*Catharus fuscescens*	X	X
Wood Thrush	*Hylocichla mustelina*	X	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	X
Chestnut-sided Warbler	*Dendroica pensylvanica*	X	X
Magnolia Warbler	*Dendroica magnolia*	X	X
Cape May Warbler	*Dendroica tigrina*	X	
Black-throated Blue Warbler	*Dendroica caerulescens*	X	X
Black-throated Green Warbler	*Dendroica virens*	X	X
Blackburnian Warbler	*Dendroica fusca*	X	X
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
Wilson s Warbler	*Wilsonia pusilla*	X	
Canada Warbler	*Wilsonia canadensis*	X	X
Scarlet Tanager	*Piranga olivacea*	X	X
Rose-breasted Grosbeak	*Pheuticus ludovicianus*	X	X
Indigo Bunting	*Passerina cyanea*	X	X
Chipping Sparrow	*Spizella passerina*	X	X
Bobolink	*Dolichonyx oryzivorus*		X
Baltimore Oriole	*Icterus galbula*		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
Wood Duck	*Aix sponsa*		X
Hooded Merganser	*Lophodytes cucullatus*	X	
Common Merganser	*Mergus merganser*	X	X
Red-breasted Merganser	*Mergus serrator*	X	X
Turkey Vulture	*Cathartes aura*	X	X
Cooper s Hawk	*Accipiter cooperii*	X	
Red-shouldered Hawk (T)	***Buteo lineatus***	X	X
Red-tailed Hawk	*Buteo jamaicensis*	X	
American Kestrel	*Falco sparverius*	X	X
Sandhill Crane	*Grus canadensis*	X	X
Piping Plover (E)	***Charadrius melodus***	X	X
Killdeer	*Charadrius vociferus*	X	X
Dunlin	*Calidris alpina*		X

Table 3 continued

Common Name	Scientific Name	Migration (May)	Breeding (June)
Mourning Dove	*Zenaida macroura*	X	X
Belted Kingfisher	*Ceryle alcyon*	X	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	
Winter Wren	*Troglodytes troglodytes*	X	X
Sedge Wren	*Cistothorus platensis*	X	X
Ruby-crowned Kinglet	*Regulus calendula*	X	
Eastern Bluebird	*Sialia sialis*		X
Hermit Thrush	*Catharus guttatus*	X	X
American Robin	*Turdus migratorius*	X	X
Brown Thrasher	*Toxostoma rufum*		X
Cedar Waxwing	*Bombycilla cedrorum*	X	X
Myrtle Warbler	*Dendroica coronata*	X	X
Pine Warbler	*Dendroica pinus*	X	X
Eastern Towhee	*Pipilo erythrophthalmus*	X	
Field Sparrow	*Spizella pusilla*		X
Savannah Sparrow	*Passerculus sandwichensis*	X	X
Le Conte s Sparrow	*Ammodramus leconteii*	X	
Song Sparrow	*Melospiza melodia*	X	X
Swamp Sparrow	*Melospiza georgiana*	X	X
White-throated Sparrow	*Zonotrichia albicolis*	X	X
Red-winged Blackbird	*Abelaius phoeniceus*	X	X
Brewer s Blackbird	*Euphagus cyanocephalus*		X
Common Grackle	*Quiscalus quiscula*	X	X
Brown-headed Cowbird	*Moluthrus ater*		X
American Goldfinch	*Carduelis tristis*	X	X
Evening Grosbeak	*Coccothraustes vespertinus*		X
Residents			
Mute Swan	*Cygnus olor*	X	X
Mallard	*Anas platyrynchos*	X	X
Bald Eagle (T)	***Haliaeetus leucocephalus***	X	X
Ruffed Grouse	*Bonasa umbellus*	X	X
Ring-billed Gull	*Larus delawarensis*	X	X
Herring Gull	*Larus argentatus*	X	X
Downy Woodpecker	*Picoides pubescens*		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
Golden-crowned Kinglet	*Regulus satrapa*	X	X
Eurasian Starling	*Sturnus vulgaris*	X	X
Dark-eyed Junco	*Junco hyemalis*		X
Purple Finch	*Carpodacus purpueus*	X	X
(E) Endangered		**1**	**1**
(T) State Threatened		**5**	**7**
TOTAL		90	99
TOTAL # Species recorded during Migration and Breeding		110	

Table 4. Mean bird abundance, species richness, and dominant species recorded during the 2001 spring migration at selected sites along the Mackinac County shoreline.

	95% Confidence Level	Dominant Species (top three)
Mean Bird Abundance	8.4 ± 0.6	American Redstart Black-throated Green Warbler
Mean Species Richness	4.7 ± 0.4	Red-eyed Vireo

Table 5. Mean bird abundance, species richness, and dominant species recorded during the 2001 breeding season at selected sites along the Mackinac County shoreline.

	95% Confidence Level	Dominant Species (top three)
Mean Bird Abundance	11.3 ± 0.9	American Redstart Black-throated Green Warbler
Mean Species Richness	5.3 ± 0.4	Red-eyed Vireo

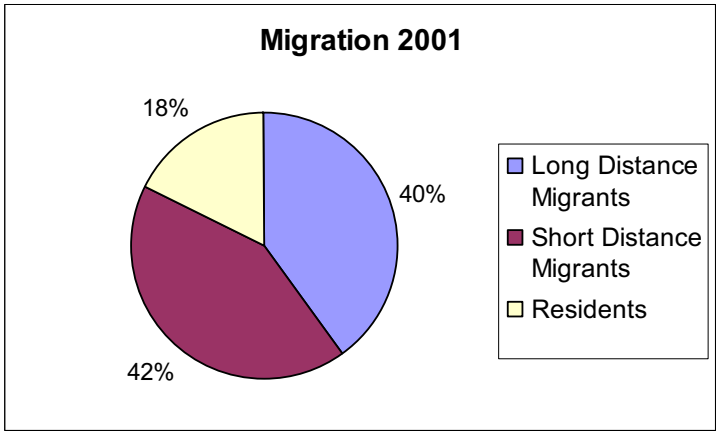

Figure 4. Percentage of long distance migrants, short distance migrants and resident birds recorded during migration.

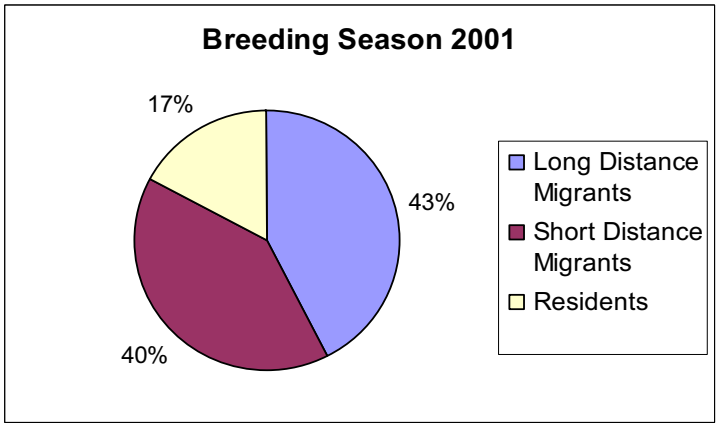

Figure 5. Percentage of long distance migrants, short distance migrants and resident birds recorded during the breeding season.

Invertebrates

Hine's Emerald and Incurvate Dragonflies

Surveys for the Hine's emerald and incurvate dragonflies in selected wetlands near the shoreline in Mackinac County failed to document any new populations of these two species. Several species of dragonflies were observed at most survey sites, but this included only one individual in the *Somatochlora* genus. This individual was seen in the wooded dune and swale complex along the Pointe aux Chenes River, however, we were unable to net the individual and identify it to species.

Habitat at most of the survey sites was considered marginal for the Hine's emerald dragonfly, but more suitable for the incurvate emerald dragonfly. The substrates at all sites consisted of sand or peat and no marl was observed. Also, few crayfish burrows were observed. Sedges dominated the vegetation, and shrubby cinquefoil, scattered conifers, pitcher plant (*Sarracenia purpurea*), leather leaf (*Chamaedaphne calyculata*), shrubby St. John's-wort (*Hypericum kalmianum*), and boneset (*Eupatorium perfoliatum*) were common associates. An open, flat wetland, about four to five acres in size, north of Pointe aux Chenes Bay, had the greatest potential for harboring Hine's emerald dragonflies. This site lies at the western end of the wooded dune and swale complex, just north of US-2 and east of Brevort Lake Road.

Lake Huron Locust

The Lake Huron locust was found at 14 of the 19 sites surveyed. Based on element occurrence specifications for this species, these observations resulted in the identification of eight new populations and reconfirmation of six previously known populations, two of which were expanded in extent. Table 6 summarizes all element occurrences of the Lake Huron locust that have been documented in the study area.

Mapped representations of the element occurrences of Lake Huron locust in the study area, as projected through Biotics, are shown in Figure 6. These polygons should be viewed as representations of the approximate location and currently known extent of populations. At the Hiawatha National Forest Dunes-Brevort Lake South site, Lake Huron locusts were observed every 0.3 km (0.2 mi) along the 6.1-km (3.8-mi) contiguous stretch of habitat. Observations at this site were mapped as a single, continuous polygon to represent the extent of this

Table 6. Element occurrences of the Lake Huron locust documented along the Lake Michigan shoreline in Schoolcraft and Mackinac counties from the eastern side of Seul Choix Point to Straits State Park, during 20-24 August 2001.

Site Name	Status of EO	Last documented prior to 2001	Population viability rank*
Bulldog Creek North	new		C
Hughes Point	new		B
Birch Point East-West	new		B
Birch Point East-West - Scott Point West	new		BC
Scott Point	new		C
Cozy Point	update	1997	CD
Needle Point to Fox Point	update	1997	BC
Big Knob Campground	new		C
Naubinway	did not survey	1921	H
Black River Road - Hog Island Point West	update	1997	D
West Epoufette - Davenport Creek	new		BC
West Epoufette	update	1997	D
West Epoufette - Paquin Creek West	new		C
Hiawatha Nat. Forest Dunes - Brevort Lake South	update	1997	A
Pointe aux Chenes-Pointe aux Chenes Bay	update	1991	B

* See Appendix B for definitions of population viability ranks.

population. However, observations of the Lake Huron locust at the West Epoufette site and the Needle Point-Fox Point site were separated by ≥0.4 km (0.25 mi) of contiguous suitable habitat that was not surveyed. These observations were mapped as separate polygons but were considered part of a single element occurrence at each of these two sites. The resulting Lake Huron locust sites within the study area range in known extent from approximately 0.4 to 6.1 km (0.25 to 3.8 mi). Only a portion of the suitable habitat at Birch Point East-West, Scott Point, Needle Point-Fox Point, and West Epoufette sites were surveyed and populations at these sites are likely greater in extent than was documented here.

Based on information from the current and previous studies (Scholtens and Holland 1997), most of the Lake Huron locust populations within the study area are predicted to have good to fair population viability, while the Brevort Lake South population is predicted to have excellent viability (Table 6). The number of individuals observed per site ranged from 8 individuals in a 1-hour search to about 250 individuals in a 15-minute search. The estimated amount of available habitat per site, based on habitat surveyed, ranged from about 9,726 square meters (2.4 acres) to 0.57 square km (140 acres). The Brevort Lake South site had the highest relative abundance of Lake Huron locusts observed and the largest amount of available habitat among the sites within the study area. Some sites qualified for higher predicted viability ranks based on the number of individuals observed but were given lower ranks because they did not meet the available habitat criteria.

Habitat quality ranged from good to marginal. Some sites, such as Brevort Lake South, Hughes Point, Needle Point to Fox Point and West Epoufette-Davenport Creek, had multiple foredunes with some vertical structure, and extensive areas of open sand. Other sites, such as Bulldog Creek North, Big Knob Campground and Black River Road-Hog Island Point West, had a narrow, sand beach with only a single, low foredune. All sites have experienced some level of habitat degradation or disturbance. Eleven sites are located on state forest land (Table 6), and are threatened primarily by recreational use and invasion of exotic plants. This is particularly true of Cozy Point, Big Knob Campground, and Hog Island Point West, which are located in or near public parks, or campgrounds. Six of the sites (i.e., West Epoufette, Paquin Creek West, Scott Point, Scott Point West, Birch Point East-West and Hughes Point) have no easy road access, and appear to be subject to less habitat disturbance. A portion of the Hughes Point West site and the Bulldog Creek North site are located on property owned by a limestone quarry, and have experienced some habitat disturbance due to adjacent industrial operations. The two easternmost Lake Huron locust sites in the study area, Brevort Lake South and Pointe aux Chenes, are located on national forest land along U.S. Highway 2. Due to easy access from the highway, these sites are subject to intense recreational pressure from pedestrian traffic, although this is primarily concentrated in the sand beach south or west of the highway. The invasion of exotic plants is particularly notable, however, these two sites still provide extensive suitable habitat for the locust.

The five sites at which Lake Huron locusts were not observed contained marginal or no suitable habitat, generally consisting of flat sand beaches with little or no foredune development. These sites were located along the shoreline south of the Rock River, a roadside park north and west of Mattix Creek, west of the Black River, south of Borgstrom Road, and west of Sucker Creek. Significant portions of the study area also contained little or no suitable habitat for the Lake Huron locust, such as the Manitou Payment Highbanks area between Epoufette and Brevort and the stretch of shoreline south of Pointe aux Chenes Bay east to Point La Barbe. These areas were not surveyed during this study.

Discussion of Animal Inventory

Birds

The observation of 90 migratory species, and 99 breeding species during 2001 was similar to year 2000 surveys west of the current study area and supports other studies that show the Great Lakes shoreline to be an important stopover and breeding area (Ewert 1999). Where a migrant makes a stop,

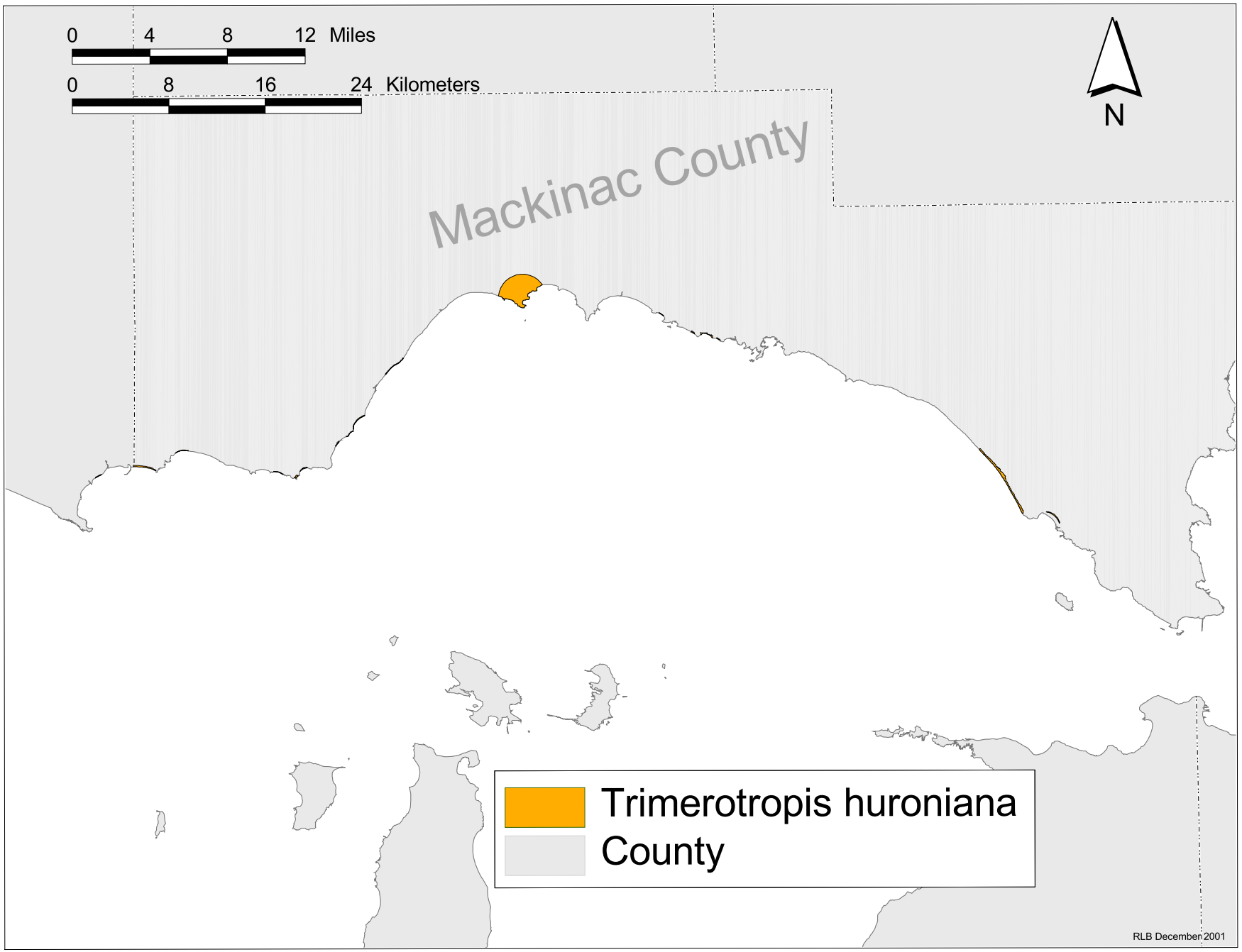

Figure. 6. Biotics representaion of Lake Huron locust occurrences (large occurrence in center represents locational uncertainty).

and the length of time spent at a particular site, depends on several factors, including the condition of the bird (especially the amount of fat reserves), weather, wind direction, availability of suitable habitat and prey abundance. Birds need to arrive at the breeding grounds with sufficient fat reserves to establish a breeding territory, attract a mate, raise young, and stay alert to predators. Without adequate food, water, and shelter along the way, or at the breeding grounds, birds can suffer lower reproductive success (Deinlein no date).

Great Lakes shoreline communities are attractive to migrants because many arrive here after a long night flight over Lake Michigan and these communities provide the nearest suitable area to land, rest, and refuel. The continuity of vegetation cover may be an important cue given that some forest birds may be hesitant to cross open areas after arriving at a stopover site (Desrochers et al. unpubl.). In addition, Ewert and Hamas (1993 unpubl.) 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. Spiders are also proving to be important food for migrating birds (Smith pers. comm.). Trees and shrubs in close proximity to the shoreline and interior riparian and wetland areas provide an excellent foraging substrate, along with shelter, for migratory and breeding birds feeding on these insects.

One might expect bird abundance and species richness to be higher during migration when both breeders and migrants are likely to be present. The fact that our results don't show this may be due to the short survey window (5 days) in which we conducted our surveys. Migration occurs over several weeks and birds often migrate in large groups and arrive at stopover sites in waves. Weather patterns also affect the timing and arrival of many species. Major waves of migrants usually move through after the passage of a warm front and stop when they encounter a cold front (Richardson 1966). Heavy clouds or rain also usually reduce the volume of migrants. Analysis of weather conditions during our migration surveys indicates that 75% of the station visits were conducted when it was cloudy or mostly cloudy. Migration surveys that are conducted over an extended period of time may reveal higher abundance and species richness during migration.

An informal comparison of bird abundance and species richness during the migration season and the breeding season showed some similarities. During migration, when data from both sample visits were combined, 6 survey stations had greater than 20 individual birds recorded, 11 stations had greater than 10 different species recorded, and 4 sites had both high numbers of individuals (>20) and species (>10). During the breeding season 5 stations had greater than 25 birds recorded, eleven sites had greater than 11 species recorded, and 4 stations had both high numbers of individuals and species. Only four sites had more than 10 species recorded during both migrating and breeding seasons. None of the sites had high bird numbers (>20 birds) during both the migration and breeding season. The variety of habitats and distance between sites suggests that several areas along the Mackinac County shoreline could be particularly important for migrating and breeding birds, although it should be noted that inferences are based on only one year of data. Additional bird surveys should be conducted to support or reveal a more significant pattern of bird use.

The percentage of long distance migrants, short distance migrants, and resident birds was similar between the migration and breeding seasons. The migrant groups combined represent over 80% of the bird diversity during spring and summer, but also reflects the significant loss of diversity that occurs during the fall and winter when the migrants leave. The arrival of long and short distance migrants greatly enhances the diversity of birds along the shoreline.

Important Bird Areas

The Great Lakes and Michigan offices of The Nature Conservancy initiated an ecoregional planning process for birds (Ewert 1999). Information from field ornithologists, including representatives of private and public organizations that work in the Great Lakes region, contributed to the identification of primary focus bird species, important breeding sites for primary focus species, and important stopover and wintering sites in the Great Lakes ecoregion. Avian species of primary focus have a global Partners in Flight (PIF) score[1] of 20 or more, or a Nature Conservancy global rank of G1-G4[2]. Species with small ranges, low abundance, fluctuating populations, and long-term, relatively large population declines are those of highest priority. Where identifiable, the working group also noted 10 sites with 25 or more breeding pairs for each primary focus species, and important stopover and wintering sites for land birds, raptors, shorebirds, and water birds in the Great Lakes ecoregion.

Point La Barbe, a peninsula just west of the Mackinac Bridge along the Mackinac County shoreline, was identified as an important stopover site for land birds during migration. Such a site meets the criterion of 20,000 birds/site/migration season (Ewert 1999). The physical shape and geographic location of Point La Barbe, a peninsula jutting south into Lake Michigan towards the Lower Peninsula, makes it an ideal landmark for birds funneling up the Lower Peninsula shoreline. The shortest distance between the Lower Peninsula and Upper Peninsula is between McGulpin Point (Lower Peninsula) and Point La Barbe (Upper Peninsula). Besides being an important stopover site for land birds, Point La Barbe has been identified as providing breeding habitat for a primary focus species, the black tern *(Chlidonias niger)*. Estimates from Ewert indicate that 15-25 breeding pairs of black terns use the marsh surrounding Point La Barbe. Our bird surveys did not document the presence of black terns at Point La Barbe but the marsh is extensive and access to the marsh from the water was not available and it is likely that they are still using this marsh.

Ewert also identified Point Aux Chenes Bay as providing breeding habitat for another primary focus species, the piping plover. Three pairs of piping plovers were reported nesting there in 2001 by the U.S. Forest Service (Dingledine 2001). With help from two plover monitors, the Forest Service surveyed over 30 miles of shoreline and six chicks were documented to fledge from the Point aux Chenes area. This is a great success for a bird that teeters near extinction in the Great Lakes region and for which only 32 breeding pairs total were confirmed nesting in 2001. Piping plovers nest on wide, flat, open, sandy beaches with sparse vegetation and scattered cobble (Weise 1991). The birds depend primarily on the cryptic coloration of their eggs and plumage along with behavior traits, such as the "broken-wing act," to protect their nests and young. Human disturbance and recreational use of these highly valued beaches continues to pose a conservation challenge to resource managers trying to protect this species. The continued existence and recovery of the piping plover will require the cooperation of public agencies, private landowners, and the general public who use the beaches. Education will continue to be of critical importance.

Identification of "important" breeding and migratory stopover habitat is not easy. Birds may use different sites within and among years depending upon weather conditions, Great Lakes water levels, and habitat characteristics. Even sites that are used infrequently may be essential to several or many species during some years. "Important" sites may be defined to mean that if the site were eliminated, it would affect the overall abundance of one or many species.

[1] Conservation Priority Scores begin at 18 with moderate priority and end at 30, with the highest priority.

[2] Global Ranks: G1 = critically imperiled globally, G2 = imperiled globally because of rarity, G3 = either very rare and local throughout its range or found locally in a restricted range, G4 = secure globally, though it may be quite rare in parts of its range.

In addition to the piping plover discussed above, eight other listed species have been documented in the study area (Table 3). One of these, the special concern northern harrier, was observed in a sedge-dominated wetland on Hiawatha National Forest property, exchanging food with a female harrier on the 17th of July. The female harrier subsequently flew to the northwest edge of the wetland and dropped down out of sight. Presumably, she returned to feed young in the nest. Habitat conditions, the time of year, and behavior of both adults, provided enough evidence to document this sighting as a breeding occurrence. The other listed species were observed during bird counts, and may or may not use the study area for nesting. Several of the others including common, Caspian, and Forester's terns are largely or solely dependent on shoreline and island habitats for nesting. The remaining listed species, although not dependant solely upon shoreline communities, are none-the-less significant. Their presence indicates that suitable habitat for these rare species persists in this coastal region for these rare species.

Three additional species of conservation significance were recorded during this study including the wood thrush *(Hylocichla mustelina)*, black-throated blue warbler *(Dendroica caerulescens)*, and northern parula *(Parula Americana)*. The wood thrush was recorded during both migration and breeding bird surveys and was also recorded during migration surveys in 2000 along the Schoolcraft County shoreline. It is on the National Audubon Society WatchList (Muehter 1998). The WatchList identifies North American bird species that are faced with population declines, 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). 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 to the wood thrush identified by the technical committee 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 recorded at a boreal forest site during migration. The species was also recorded during the breeding season at three sites; two characterized as dry-mesic northern forest and one as mesic northern forest.

With a Conservation Priority Score of 20, the black-throated blue warbler is also identified as a species of concern on the WatchList (Muehter 1998). Identified threats to this species include:

- habitat loss and degradation on breeding grounds.
- loss of habitat in wintering region may pose a greater threat as the region undergoes more human development.
- blue jays and an assortment of mammals, such as red squirrels and eastern chipmunks, destroy eggs and nestlings.
- long term climatic changes such as those suspected by global warming may cause decreases in breeding productivity.

The black-throated blue warbler breeds most commonly in mesic deciduous forest and mixed deciduous-coniferous forests. This warbler prefers the interior of mature forests where shade from the canopy is strong and the shrub cover is easily negotiable (Binford 1991). Black-throated

blue warblers were recorded at three sites during migration. Two of the sites are characterized as mesic northern forest and one a boreal forest. During the breeding season this warbler was recorded at a mesic northern forest site and a dry-mesic northern forest site.

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 recorded during migrating and breeding bird surveys along the shoreline in 2000 and 2001. In 2001, the northern parula was encountered frequently and in a wide variety of habitats. It was documented at 17 sites during migration including 13 boreal forest sites, two mesic northern forest sites, one cedar swamp, and one dry-mesic northern forest site. During the breeding season the northern parula was recorded at 15 sites. Nine of the sites are characterized as boreal forest, three as mesic northern forest, two as shrub swamp, and one as dry-mesic northern forest. The high numbers of northern parula in the study area suggest the area provides abundant suitable habitat and the bird is doing relatively well. It will be important to maintain habitat that supports *Usnea* to sustain the nest-building activities of this warbler.

Summary

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. It is important to understand that these data are not the result of a highly controlled research study and conclusions should not be casually inferred. These bird counts provide a valuable snapshot of bird use in the study area and suggest the relative importance of the shoreline to migrating and breeding birds.

As noted above, a number of birds on Michigan's endangered, threatened, and special concern lists are associated with Great Lakes shorelines, islands and coastal wetlands and some are largely or solely dependent on shoreline and island habitats for nesting. Identification and preservation of these habitats has become urgent in the face of increasing development and recreation pressures. Preservation of important breeding and migratory stopover sites can take several forms including purchase, easements, and support of local land trusts. Sites should be managed for diverse vegetation cover and structure, diverse species composition and availability of fresh water. Some exotics may be tolerable if they are not invasive and do not displace other plant species with high food or shelter value. Multi-site strategies should include education efforts directed towards landowners to maintain and minimize impacts to wetland habitats, as well as canopy, subcanopy, and understory habitats which provide structure for migratory and breeding birds. Ideally, as discussed in the Summary and Conclusions section of this report, landscape level planning that considers functional ecosystems, should be implemented.

Invertebrates

Hine's and Incurvate Emerald Dragonflies

Although the Hine's and incurvate emerald dragonflies have been documented to the north and east of the study area, surveys during the current study failed to document either species within the study area. The shoreline wetland communities surveyed, contain less marl than the known Hine's emerald sites to the north, which may be a limiting factor for this species. This is likely due to the lesser amount of topographic relief, resulting in fewer seepage areas, and consequently, less marl. The wetlands in the study area are influenced much

more by lake levels than the sites to the north, which are located along old beach ridges.

Additional surveys for both species should be considered. Only a small number of priority sites were inspected and surveying for invertebrates, especially high-flying aerialists such as dragonflies, is generally difficult. Often, multiple visits to a site are needed to document the presence of rare species. The cloudy conditions during surveys may not have been ideal either. Also, given an incomplete understanding of the ecological requirements of the Hine's emerald dragonfly in Michigan, it may utilize a wider range of habitats than previously thought. Future surveys for this species should include revisits to the western end of the wooded dune and swale complex north of Pointe aux Chenes Bay just north of US-2 and east of Brevort Lake Road. Given the usage of peatlands in Michigan by the incurvate emerald dragonfly and the presence of peat at most of the survey sites, there appears to be a fair amount of suitable habitat. Although adult incurvate emerald dragonflies have been observed in mid-July, and as early as 29 June (Schiffer 1985), surveys conducted during this study may have been early in the adult flight season. Later surveys (e.g., in early August) may increase the likelihood of detecting this species.

Lake Huron locust

Surveys for the Lake Huron locust produced results similar to those generated by last year's inventory in Schoolcraft County (Higman et al. 2000). The locust is much more prevalent in the study area than previously documented. It was found at every survey site with suitable habitat, establishing eight new occurrences and reconfirming and expanding the extent of six previously documented occurrences. These results greatly expand the species' known distribution within the study area. 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. Several suitable areas remain to be surveyed, suggesting additional occurrences or expansions of known occurrences will likely be documented in the future. High priority areas for survey include properties south of Bulldog Creek, east of Seiners Point between Swan Creek and Birch Point, east of Birch Point, south of Crow River, west of Naubinway between the Lower Millecoquins and Rock rivers, east of Naubinway near East and West Mile creeks, and west of Epoufette between Davenport and Paquin creeks.

The largest, apparently most stable populations of Lake Huron locusts are associated with extensive, wide dunes (Rabe 1999). Those that are 1.6 km (1 mi) or more in length with at least two sets of dune ridges and including dune blowout areas are considered ideal (Rabe 1999). The Hiawatha National Forest Dunes-Brevort Lake South site has such habitat, with over 5 km (3 mi) of large, wide dunes with many blowouts. This site is the only A-rank site in the study area, and one of only six in the state (out of 80 total) currently assigned an "A" rank. Previous surveys (Scholtens 1996, Scholtens and Holland 1997) also identified a significant Lake Huron locust population along this area of shoreline. Other sites notable for the relative abundance of the locust and amount of available habitat include Hughes Point, Birch Point East-West and Needle Point-Fox Point.

While large populations are often associated with extensive, high-quality dunes, Lake Huron locusts can also inhabit small dune complexes. Many of the sites identified this year contained only a single, narrow, low foredune with no blowout areas. Individuals were even found in a strip of bare sand only 1-2 m wide, in an interdunal wetland connecting two dune complexes within the Needle Point-Fox Point site. The Lake Huron locust appears to be able to inhabit a site as long as loose, open sand and some dune structure are present. Scholtens and Holland (1997) also found that dimensions of the dune system (height, depth, length, and number of dunes) seem to have no consistent effect on the presence or absence of the locust, although there may be a small tendency for low or narrow dunes to lack locust populations. However, populations associated with small dune complexes may be more variable and vulnerable than those associated with large dunes since fluctuating lake levels and other natural shoreline processes can significantly affect the amount of available habitat at small sites. Also, the locust's

ability to colonize or utilize small dunes may be influenced by their proximity to larger dune sites.

This study provides further evidence that the Lake Huron locust can persist in areas with low to moderate levels of disturbance. All of the Lake Huron locust sites in the study area have experienced some level of habitat degradation. Other studies have also found that Lake Huron locust populations can persist in areas with low to moderate levels of disturbance (Scholtens 1996, Higman et al. 2000), and that healthy populations can be maintained as long as the ecology of the dune system is kept intact (Rabe 1999). Scholtens and Holland (1997) found that the level of disturbance required to extirpate the locust seems to be very high, almost requiring the destruction of the dune system. They suggest that some intermediate level of disturbance may, in fact, support the largest locust populations. However, the species also exists in areas with low apparent disturbance (Scholtens and Holland 1997). Continued monitoring and additional research are needed to further elucidate the short and long-term effects of habitat disturbance on Lake Huron locust populations.

Although the dune complexes surveyed during this study were generally not as extensive as those surveyed in Schoolcraft County in 1999 (i.e., narrower, less vertical structure, and less dune blowouts), greater relative abundances of Lake Huron locusts were observed during this year's study. Differences in sampling methodology, survey conditions, annual population variation, and/or site differences may have contributed to the greater numbers of locusts. Surveys were conducted one week earlier than last year and almost all sites surveyed were on public land, allowing longer contiguous stretches and greater amounts of habitat to be surveyed. Survey sites last year consisted primarily of small, disjunct private parcels, which may account for the smaller numbers of individuals observed. Finally, although greater densities of Lake Huron locusts are generally associated with larger habitat complexes, factors such as habitat condition, disturbance history and current threats to the site also influence local abundance. Most of the Lake Huron locust sites surveyed this year are located on public land and in areas that appear to be experiencing minimal threat from residential and commercial development. Sites in last year's study area are predominantly on private property and in areas that have experienced or are currently experiencing substantial development pressure. More intensive surveys using standard methodologies are needed to accurately compare relative densities of Lake Huron locusts between the two study areas.

Protection of the remaining functional dune ecosystems in the study area is essential for conservation of the Lake Huron locust along this stretch of shoreline. Protected dune sites need to remain dynamic in nature, retaining natural processes that maintain and create habitat, particularly areas of bare sand where the locust lays its eggs. Frequent use of the active dune zone can significantly impact Lake Huron locust habitat and reproductive success. Activities that lead to destruction of the dune system, such as decimation of dune vegetation or flattening of dunes to create swimming beaches or volleyball areas, can cause extirpation of local populations. Recreational use, particularly off-road vehicle use, should be monitored and evaluated for impacts to the active dune zone, and controlled or limited if necessary. Other human-related disturbances, such as industrial use, roads, and residential development, introduce invasive plant and animal species that can quickly increase in abundance and displace native species. Lake Huron locust numbers can decline significantly when disturbance changes the character of a typical dune system to one dominated and stabilized by invasive plants (Rabe 1999). The introduction and spread of invasive plants at locust sites should be monitored, and measures to control invasive plants may be necessary in some locations.

Dune reconstruction projects also represent a major disturbance for the locust, presumably because they follow other major disturbances, and the locust does not seem to colonize reconstructed and apparently ideal habitat easily (Scholtens and Holland 1997). These types of projects should be avoided or closely monitored if located at or near locust sites. Finally, residential development can significantly impact Lake Huron locust habitat and populations. The locust sites currently identified in the study area are located primarily on public land and are subject to minimal development pressure.

However, there is high potential for additional populations to occur along privately owned sections of the shoreline (not surveyed this year due to lack of landowner permission) in which residential development is more prevalent. Higman et al. (2000) observed that housing developments placed behind the open dunes can minimize impacts to the active dune zone, thus maintaining suitable habitat. Elevated walkways or boardwalks over the dunes at shoreline residences also help minimize impacts to open dunes. The use of non-native plants for residential landscaping and the application of lawn or garden chemicals in or near dunes should be avoided.

Given high potential for this species to occur in suitable habitat throughout the study area, it is recommended that all properties with suitable habitat be surveyed prior to disturbance, so that necessary precautions can be taken and appropriate management activities can be implemented. Additional survey data will help determine the degree to which occupied sites are interconnected and whether various locations should be considered one population or separate populations. Since it is uncertain how long locust populations can persist in highly degraded sites and small pockets of habitat, intensive surveys to estimate and monitor population sizes over time are needed to help determine the status and long-term viability of these populations. Monitoring population sizes and trends over time also will help identify specific impacts of various threats on the locust. Additional research on the ecological requirements of this species also is warranted. This information is essential for developing effective, long-term management and conservation strategies. Finally, it is important that resource managers and landowners are provided with accurate information about the Lake Huron locust so that they can practice appropriate stewardship, critical to this species' conservation.

Other Rare Invertebrates

In addition to the species surveyed for this study, there is potential for other rare invertebrates to occur in the study area. The state special concern dune cutworm moth (*Euxoa aurulenta*) is associated with sparsely vegetated, high quality coastal dune habitats, and has potential to occur in the same areas as the Lake Huron locust. This species was not surveyed due to limitations of project funding. The dune cutworm moth has been documented in disjunct populations in sandy areas throughout North America (11 states and 4 Canadian provinces). In Michigan, this species is known from only nine sites along the Lake Michigan shoreline in Berrien, Charlevoix, Chippewa, Muskegon, Oceana, and Ottawa counties. However, systematic surveys for this species have not been conducted in the state, and it may occur in additional counties with suitable habitat. The best survey period for this species is May through July, and the best way to survey for this species is by black lighting (Cuthrell 1999b).

Rare land snails have been documented near the study area (Nekola 1998), and have potential to occur within itz. These include the eastern flat-whorl (*Planogyra asteriscus)*, *Vertigo cristata*, *Euconulus alderi*, *Pupilla muscorum*, *Vertigo elatior* and possibly *Vertigo morsei* and *Catinella exile*. These land snails are all currently listed as state special concern and are associated with a range of habitats from steep talus slopes and bedrock outcrops to calcareous wetlands such as fens and white cedar wetlands (Nekola 1998, see Appendix C for definitions of snail habitats). Suitable habitats within the study area primarily consist of limestone/dolomite pavement along the shoreline and cedar dominated wetland pockets further inland. Sites within the study area that have potential for housing rare land snails include the limestone pavement at Bulldog Creek North and wooded dune and swale complexes along Seul Choix Bay, between Seiners Point and Scott Point, between Point Patterson and the mouth of McNeil Creek, south of Brevort Lake and north of Pointe aux Chenes Bay. The cobble shoreline area at West Harbor-Kenyon Bay also may have potential habitat. Since many of these rare land snails are extremely small (i.e., <5.0 mm long), the best way to survey for them is by collecting litter samples in the field, drying them in the laboratory, and examining and identifying shells and shell fragments in the dried samples.

Plant Inventory

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 (see Landowner Contact section) were then prioritized based upon the gap analysis, making sure to capture some sites across the entire study area. Survey sites are shown in Figure 3.

Field surveys were conducted on June 4-8, June 18-21, July 6-11, and August 10-24, 2001. The early 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*), ram's head orchid (*Cypripedium arietinum*), and butterwort (*Pinguicula vulgaris*.) 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. The later June and July surveys targeted Pitcher's thistle, Lake Huron tansy, state threatened pine drops (*Pterospora andromedea*), and state special concern stitchwort (*Stellaria longipes.*) Any sites that appeared appropriate for the later blooming Houghton's goldenrod were also noted and highlighted for late season surveys in August. Late season targets included many of the earlier targets as well, such as pine drops, Pitcher's thistle, Lake Huron tansy, and dwarf lake iris. Late season plant 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.

General species lists were taken during each survey and each site was characterized by community type, and extent and types of disturbance. 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 plant specimens were collected for determination, if unknown. Voss (1972, 1985, 1996) and Holmgren (1992), with its companion Gleason & Cronquist guide (1991), 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 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 a map showing their spatial representation was produced.

Results of Plant Inventory

A total of 64 rare plant occurrences were visited during this study including 21 that were newly documented, 40 that were updated, and 3 that could not be found and are considered extirpated. An additional 17 were not visited due to lack of permission to access the sites or time constraints. Most of the latter have been well documented fairly recently and are believed to persist. This represents

a total of 78 occurrences of 11 rare species. Table 7 summarizes these data by species and Table 8 presents documented occurrences by survey site.

The mapped representation of all plant element occurrences in the study area, as projected through Biotics, is shown in Figure 7. Presence of polygons on specific properties should not be construed as definitive for various reasons. Each element occurrence representation was approximated by 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 obviously appropriate habitat for a given element occurred on properties adjacent to that surveyed, 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 2001.

Table 7. Number of occurrences by species of rare plants documented in the study area during May-August, 2001.

Scientific Name	Common Name	State/Fed Status	New	Updated	Believed Extirpated	No Visit
Calypso bulbosa	calypso orchid	T				1
Cirsium pitcheri	Pitcher's thistle	T/LT	2	9	1	1
Cypripedium arietinum	ram's head orchid	SC				2
Huperzia selago	northern fir-moss	SC				1
Iris lacustris	dwarf-lake iris	T/LT	2	7		1
Mimulus glabratus var. Michiganensis	Michigan monkey-flower	E/E	1	2		2
Pinguicula vulgaris	butterwort	SC	1	2		2
Pterospora andromedea	pine drops	T				1
Solidago houghtonii	Houghton's goldenrod	T/LT	3	7		3
Stellaria longipes	stitchwort	T	6	3	1	
Tanacetum huronense	Lake Huron tansy	T	6	10	1	3
		Total:	21	40	3	17

Discussion of Plant Inventory

As has been shown in other Great Lakes coastal zone surveys, the current study area is rich with rare plants, including numerous populations of the Great Lakes endemic species, Pitcher's thistle, dwarf lake iris, Houghton's goldenrod, and Michigan monkey-flower. The latter, known only from Michigan is of particular significance, in that the five occurrences documented in the study area comprise 30% of the total known localities of this species in the world. Among them is the largest and most exemplary occurrence of the species, which virtually carpets the rocky shoreline just east of Epoufette Bay. Here it flourishes in the many scattered seeps and pools. Other species occurring in the study area include Lake Huron tansy, calypso orchid, ram's-head orchid, butterwort, and the less commonly known pine-drops, stitchwort, and northern fir-moss. Due to limited access to private lands and the inherent rarity and cryptic nature of some species, it is likely that more occurrences of these rarities will be discovered over time. This is particularly true for private lands between Mattix (Biddle) Point to Big Knob State Campground, where permission to access lands was minimal. Additional private properties between west Moran Bay and Point aux Chenes are also likely to harbor rarities as well. High quality occurrences of Houghton's goldenrod, butterwort, Lake Huron tansy, and Pitcher's thistle were documented on some properties in this region during this study and in previous years.

Table 8. List of rare plant occurrences in the study area by site.

Site Name	Occurrences	Status
Seul Choix Bay	*Cirsium pitcheri*	new
	Stellaria longipes	new
	Tanacetum huronense	update
Bulldog Creek North	*Solidago houghtonii*	new
	Tanacetum huronense	update
Hughes Point	*Cirsium pitcheri*	update
	Iris lacustris	new
	Stellaria longipes	new
	Tanacetum huronense	update
Seiner's Point	*Cobble beach*	update
	Solidato houghtonii	update
Birch Point East-West	*Cirsium pitcheri*	update
	Iris lacustris	update
	Stellaria longipes	new
	Tanacetum huronense	update
Scott Point	*Cirsium pitcheri*	update
	Iris lacustris	update
	Pinguicula vulgaris	new
	Tanacetum huronense	update
Cozy Point	*Cirsium pitcheri*	update
	Iris lacustris	update
	Pinguicula vulgaris	update
	Solidago houghtonii	new
	*Stellaria longipes**	new
	Stellaria longipes	new
	Tanacetum huronense	update
Point Patterson	*Tanacetum huronense*	new
Fox-Needle Point	*Cirsium pitcheri*	udpate
	Iris lacustris	new
	Solidago houghtonii	new
	Tanacetum huronense	update
Big Knob	*Cirsium pitcheri*	update
	Cirsium pitcheri	update
	Iris lacustris	update
	Solidago houghtonii	update
	Tanacetum huronense	update
Carnegie Woods	*Tanacetum huronense*	new
Lower Millecoquins River mouth	*Tanacetum huronense*	not visited
	Solidago houghtonii	not visited
Naubinway East	*Solidago houghtonii*	update
	Cirsium pitcheri	update
	Iris lacustris	update
	Iris lacustris	new
	Pinguicula vulgaris	not visited
	Solidago houghtonii	not visited
	Tanacetum huronense	update
Black River Road	*Cirsium pitcheri*	new
	Iris lacustris	update
	Solidago houghtonii	update
	Tanacetum huronense	update

Table 8 continued

	Tanacetum huronense	new
West Epoufette	*Cirsium pitcheri*	update
	Stellaria longipes	new
	Stellaria longipes	new
	Tanacetum huronense	update
Epoufette Bay	*Mimulus glabratus var Michiganensis*	update
Cut River West	*Mimulus glabratus var. Michiganensis*	udpate
	Tanacetum huronense	update
Cut River East	*Mimulus glabratus var Michiganensis*	new
	Stellaria longipes	Not found??
	Tanacetum huronense	new
Manitou Payment	*Cirsium pitcheri*	not visited
	Mimulus glabratus var Michiganensis	not visited
Brevort	*Mimulus glabratus var Michiganensis*	not visited
	Tanacetum huronense	not visited
Hiawatha Dunes	*Calypso bulbosa*	not visited
	Cirsium pitcheri	update
	Cypripedium arietinum	not visited
	Stellaria longipes	update
	Stellaria longipes	update
	Tanacetum huronense	update
Pte aux Chenes	*Cirsium pitcheri*	not visited
	Cypripedium arietinum	not visited
	Huperzia selago	not visited
	Iris lacustris	update
	Pinquicula vulgaris	not visited
	Pterospora andromedea	not visited
	Solidago houghtonii	update
	Stellaria longipes	not visited
Gros Cap	*Cirsium pitcheri*	update
	Iris lacustris	update
	Pinguicula vulgaris	update
	Solidago houghtonii	update
	Tanacetum huronense	update
West Morin Bay	*Adlumia fungosa*	not visited
	Iris lacustris	update
	Solidago houghtonii	update
	Tanacetum huronense	new
Point La Barbe	*Cirsium pitcheri*	not found
	Iris lacustris	update
	Solidago houghtonii	update
	Tanacetum huronense	not found
Straights State Park	*none*	

* Duplicate species names within the same site indicate separate occurrences.

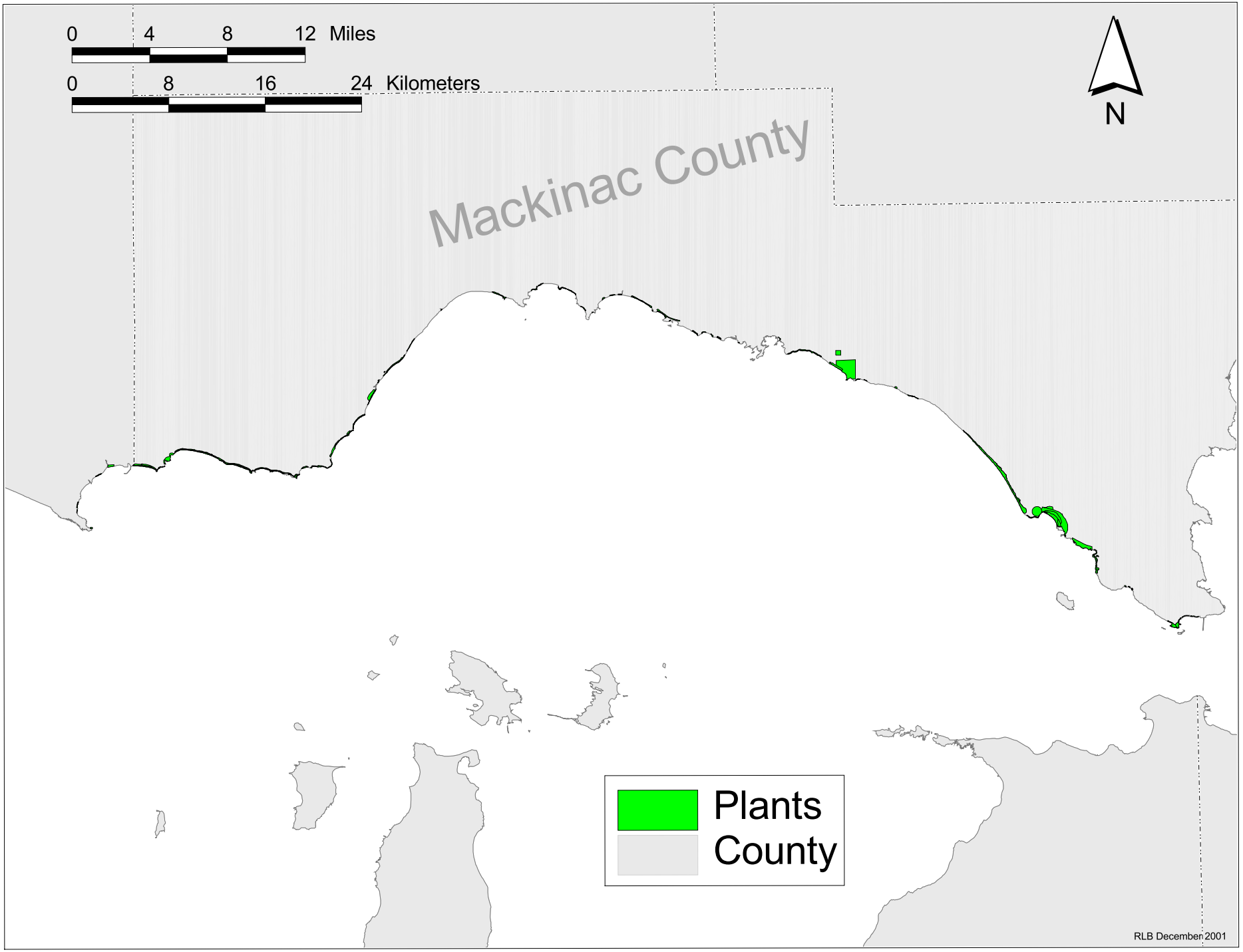

Figure 7. Biotics representation of rare plant occurrences.

Several occurrences of plant rarities that had been documented prior to this study were not found, despite thorough surveys. These sites were primarily in areas of heavy tourist activity, and it is possible that excessive use of the sites resulted in their demise, either directly or by degradation of their habitat. Many persisting occurrences suffer from increased invasion of non-native (exotic) species such as spotted knapweed, bladder campion, and various hawkweeds. This is true wherever there is easy access by people and especially where there are a lot of in-roads. Much of the study area, particularly the eastern half abuts US-2 or other major highways. The Nature Conservancy has ranked the invasion of aggressive exotic species the number two threat to high quality ecological communities, second only to habitat desctruction (NCPI 1999). It is recognized as a significant threat by most of the environmental community. Invasive species change the composition of ecological communities, ultimately displacing native species and in some cases altering natural ecological processes. ORV usage is also a problem in some areas, causing soil disturbances, uprooting plants, and transporting seeds of non-native species.

In spite of the threats noted above, numerous plant rarities persist in regions of human activity and the prognosis for their perpetuation is good as long as their existence and ecological needs are recognized. To maintain viable populations of these species, viable coastal communities must be maintained. Coastal communities are dynamic systems subject to continual varying intensity disturbances brought about primarily by wind and wave action. These disturbances can cause huge changes in shoreline habitats; a once sandy beach can be transformed into rocky cobble over one season, or as one landowner indicated with great satisfaction, "I've been watching this sand dune form in front of my property for over twenty years." As a particular habitat is altered in one location, additional habitat is almost certainly being created elsewhere. In this fashion, many coastal rarities move about the changing landscape, some even requiring disturbance to perpetuate themselves. It is important to retain large regions of shoreline where natural processes are allowed to proceed unencumbered and the landscape is not altered significantly. Education of all those involved with shoreline properties is urgently needed.

Natural Community Surveys

Methods for Natural Community Surveys

High quality natural communities were assessed informally as a component of the animal and botanical surveys. This component of the project focused on assessing the status of those portions of previously known occurrences within the study area (i.e. within ¼ mile of the lake), identifying new occurrences in areas of survey gaps, and generally characterizing the shoreline. 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

Most of this public land along this segment of shoreline has been well surveyed for natural communities and known occurrences are well documented. These include 21 occurrences of eight different natural community types as shown in Table 9. No new occurrences were documented,

however, several areas in private ownership with potential for natural community occurrences were noted. Permission to access these lands was not obtained during the time of study. These include multiple private properties at the mouth of the Lower Millecoquins River west to Rock River, and east of Mattix (Biddle) Point. Both of these areas have high potential for wooded dune and swale occurrences as well as interdunal wetlands.

Although non-native species and human usage has increased at most of the known natural community sites, none of the known occurrences were re-ranked based upon the informal assessment conducted during this study. All currently documented occurrences and their assigned ranks are summarized in Table 10 below and their spatial representations are shown in Figure 8.

Table 9. Number of occurrences by natural community type.

Natural Community Type	Number
wooded dune and swale	6
Great Lakes marsh	4
interdunal wetland	3
open dune	2
dry-mesic northern forest	2
cobble beach	2
mesic northern forest	1
sand/gravel beach	1
Total	21

Discussion of Natural Community Surveys

The most common 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.) 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 to be included in the Michigan Natural Features statewide database as element occurrences. Others have been variously destroyed or degraded. The six wooded dune and swales documented during this study, all of which are ranked B or above, thus are highly significant.

Interdunal wetlands have been identified separately within three of the wooded dune and swale complexes because of their size, complexity, and relative lack of disturbance**.** As is typical for these wetlands they occur in long troughs in between dune ridges and are sedge and shrub dominated. State and federal threatened Houghton's goldenrod is often associated with them and this is true for the three occurrences noted here. Open dune occurrences are also recognized separately within two of the dune and swale complexes. They do not reach the size and complexity of many open dune systems elsewhere in the state, however, they retain many native species, are fairly undisturbed, and harbor quality occurrences of plant and animal rarities. The lakeward edge of the remaining wooded dune and swales do not have open dunes large enough to warrant status as natural community occurrences. However, most of them have one or more small foredunes that support plant and/or animal rarities.

Of the four Great Lakes Marsh communities in the study area, the Point aux Chenes marsh, is of the greatest significance. This A-ranked occurrence

is very large and diverse, and represents one of the best occurrences in Michigan. The marsh is only one of several significant natural communities that comprise the Point aux Chenes complex. Also found here are an interdunal wetland, an open dune, a cobble beach and a sand/gravel beach. The latter two community types have not been well surveyed in the state and that these are among the few that have been documented to date, highlights their importance.

A striking feature of the mid-portion of the study area is the steep bluff known as the Manitou Payment Highbanks, spanning over eight miles from Brevort to Epoufette Bay. Although not a natural community occurrence, there are many rivulets and seepages at the base of this bluff that support the federal and state endangered Michigan monkey-flower. The Cut River bisects the Highbanks at about its' midpoint, forming a steep gorge as it makes its way to the lake. Surrounding the gorge is a B-ranked mesic northern forest, a rich forest dominated by beech (*Fagus grandifolia*) and hemlock (*Tsuga canadensis*), with a diverse understory and ground cover. An occurrence of state special concern northern fir-moss has been previously documented here.

With the exception of a few well know areas, most of the Upper Peninsula forests have been heavily cut and often burned. Reflective of this, only two additional forested community occurrences have been identified in the study area. These include two dry-mesic northern forest occurrences within the Hiawatha National Forest dunes site that spans much of the eastern portion of the study area. These forests were not surveyed during this study, but original surveyors described them as mature forests that exhibit good regeneration.

The known community occurrences summarized here provide a strong representation of ecologically intact natural communties. A notable aspect of this region is the large amount of land that lacks intensive development or is quite remote. This includes lands of the Hiawatha National Forest, Point aux Chenes, Hiawatha Sportsman's Club, Mackinac State Forest, and several regions of private holdings that have not yet been developed extensively. Some, such as the Pointe aux Chenes, complex encompass multiple natural community occurrences, and all of them encompass multiple rare species. Many of these lands are in public ownership and are thus afforded some protection, however as human demand for residential and recreational access to shoreline communities increases, these lands will become more vulnerable. Two regions of the Mackinac State Forest have been previously nominated for dedication as State Natural Areas. Recent state acquisition of lands joining these two sites, has resulted in an over 15 mile stretch of undeveloped shoreline in state ownership. An effort is currently underway to designate the entire region from just east of Norton-Ogleby Limestone Company to the northeastern edge of Big Knob as a single State Natural Area. Such a designation would provide stronger protection measures for these lands. Combined with education and strong enforcement, this proactive approach will help maintain their functional quality. Many of the private lands surveyed contain rarities and it is fully expected that more will be found on those that were not surveyed. Continued education of private land users is strongly encouraged. It is particularly important in this region because of the many areas that retain highly functional and ecologically intact shoreline ecosystems.

Local Planner and Citizen Outreach

Methods for Local Planner Outreach

Local Planner Interviews

This portion of the study evaluated how local planning agencies address issues pertaining to natural features during development of Great Lakes shoreline properties. Various officials of Mackinac County townships that contain Lake Michigan coastal zone lands were contacted to discuss local planning and development processes and procedures as they relate to threatened and endangered species. State and federal regulations and procedures that are designed to protect

threatened and endangered species were 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 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.)

Table 10. Natural community occurrences and their ranks, listed by survey site.

Survey Site Name	Natural Community Type	Rank
Seul Choix Bay	wooded dune and swale	B
Hughes Point	interdunal wetland	B
	open dune	B
Seiner's Point	cobble beach	U
Birch Point East-West	wooded dune and swale*	AB
	wooded dune and swale	AB
Fox-Needle Point	wooded dune and swale	A
Big Knob	interdunal wetland	AB
	wooded dune & swale	AB
West Epoufette	wooded dune and swale	A
Kenyon Bay & West	Great Lakes marsh	B
Epoufette Bay	Great Lakes marsh	B
Cut River East	mesic northern forest	B
Hiawatha Dunes	dry-mesic northern forest	BC
	dry-mesic northern forest	C
Pte aux Chenes	cobble beach	B
	interdunal wetland	B
	open dune	BC
	sand/gravel beach	B
	Great Lakes marsh	A
Point La Barbe	Great Lakes marsh	B

***Duplicate communities within one survey site represent separate occurrences.**

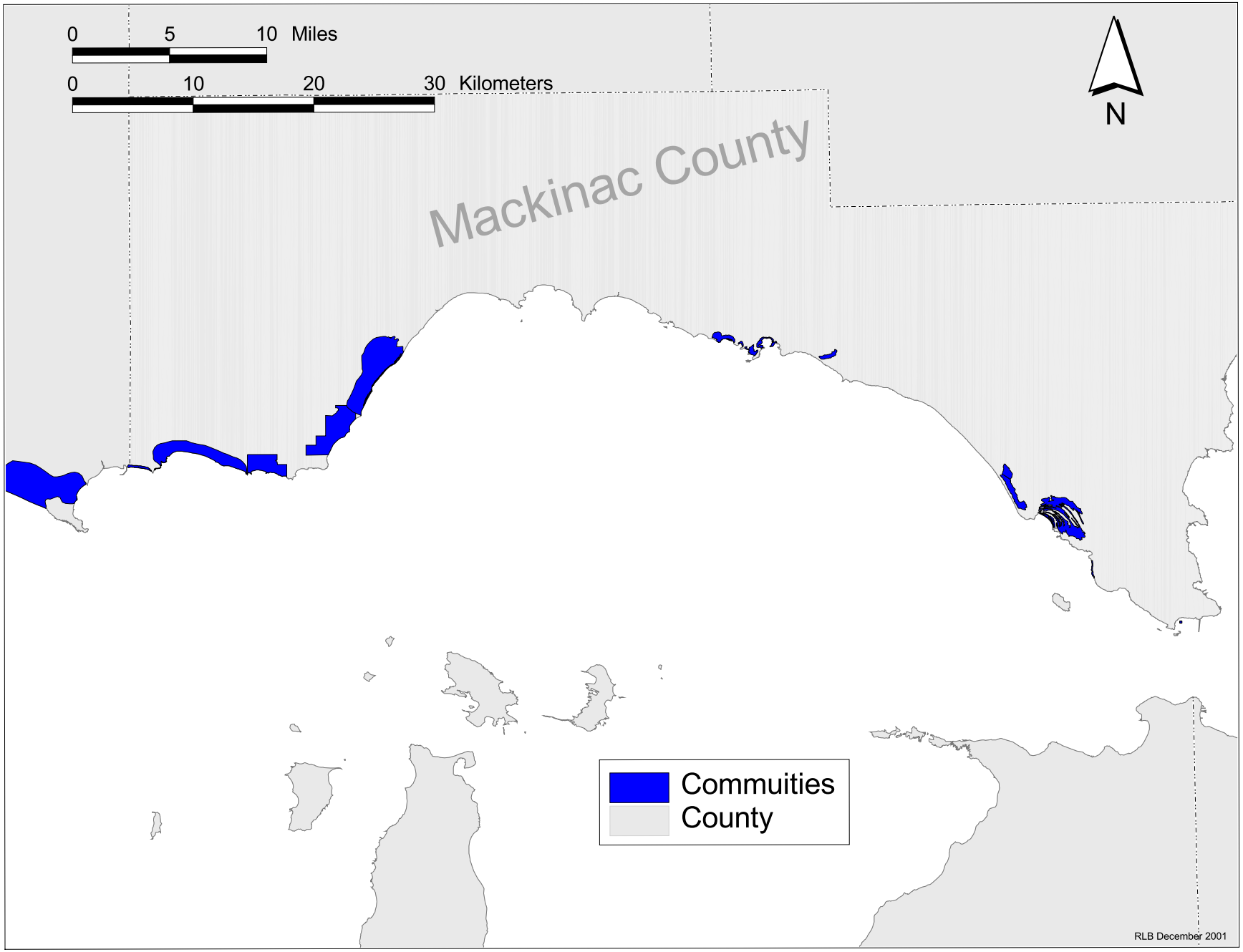

Figure 8. Biotics representation of significant natural community occurrences.

Public Information Meeting

A public information meeting was coordinated with the County Extension Office, Conservation Resource Management Initiative (CRMI), and held on July 21, 2001 in the city of Manistique. The meeting was intended to provide information on state and federal endangered species legislation and significant natural features of the shoreline to landowners and other interested individuals. It was also intended to provide a forum for discussion where participants could interact with experts and each other to increase understanding and awareness of these features. PowerPoint presentations were developed and presented over a two- hour time span, followed by an open discussion session. The presentations included: 1) an overview of the project, 2) shoreline ecology-101, 3) rare shoreline plants, 4) rare shoreline animals, and 5) threatened and endangered species legislation. Numerous handouts were made available to participants. Following the indoor session, the group participated in a field trip to a local township park to observe first-hand several of the species featured in the presentations. The agenda for the meeting is provided in Appendix E.

Results for Local Planner and Citizen Outreach

Local Planner Interviews

Township/County

Township zoning ordinances relating to shoreline development vary among townships and may or may not require specific set-backs from the high water mark of the lake. Any required setbacks, although perhaps inadvertently beneficial to some occurrences of shoreline rarities, were not designed for that purpose. No county or township ordinances were identified that specifically address the protection of threatened or endangered species, or the integrity of natural communities. Mackinac County is in the process of setting-up a countywide planning commission to help guide future development of the county. They may assist townships in the development or refinement of master plans. When asked whether or how this commission would address threatened and endangered species, it was clear that this concern was not yet on their radar screen. Several individuals indicated that with the formation of the county planning commission, they thought township level influence would decline.

Although there is no systematic review of threatened or endangered species at the township or county level, several township supervisors reported negative interactions with conservation groups and/or regulatory agencies that involved lands with such species. Two indicated that they felt environmental regulations are inconsistently and unequally applied and enforced throughout the State. Two examples of development activities were cited where the presence of a rare species became an issue late in the process, well after it should have been addressed. This caused considerable delay and additional expense to the individuals involved.

Most of the individuals interviewed indicated that they already knew the natural features that were in their township but, if necessary, they could access these data from the county if it was provided to them. Most also indicated that they would share these data with landowners, but would be reluctant to infringe upon private property owners by imposing specific regulations. One individual indicated he wouldn't use these data if received and another indicated he wouldn't know how to use them. All interviewees indicated that if these data were provided, they would like a hard copy or disk version. None of them had an easily accessible GIS-based computer system that could accommodate spatial representation of these data.

State

At the state level, threatened and endangered species concerns are addressed systematically on private lands only when a developer applies for a permit through the Department of Environmental Quality-Land and Water Management Division (DEQ-LWMD.) DEQ-LWMD uses the MNFI database within the context of a screening system, Coastal and Inland Waters Permit Information System (CIWPIS), to review applications. If there are one or more 'hits' the project is sent to MDNR

Wildlife Division (MDNR-WD) to undergo their environmental review process including consultation with MNFI as appropriate. MDNR ultimately 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 also be involved in high profile, large-scale 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.

Actions on state lands, such as trail routing or land acquisition, go through the environmental review process as above, invoking MNFI review of natural features if MDNR determines there are potential concerns. Prescriptions for state forest compartments are systematically reviewed by MNFI staff for natural features and comments are passed directly to MDNR Forest Management Division.

Federal

At the national level, when 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. 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.

Public Information Meeting

Nineteen people attended the meeting ranging from University professors to young children. There was an enthusiastic response to the presentations and lots of good discussion. Participants were genuinely interested and concerned about the coastal zone and the information that was presented. Many participants were already familiar with at least some of the rare species, while some knew little about them, and all participants indicated that they learned something new. Several people attended the meeting representing the Carnegie Woods Property Owners Association (CWPOA), a non-profit domestic corporation comprised of private landowners. This association is interested in promoting "the spirit of conservation of all natural resources among its members" (CWPOA brochure). Several people attended because they were suspicious of, or simply wanted to more information about MNFI's activities before giving permission to survey their lands. At the end of the meeting, all were comfortable about the project and some property owners who either didn't respond or responded negatively to our survey request, were willing to have surveys done on their properties. All participants who filled out an evaluation form rated the session as 'excellent'.

Discussion of Local Planner and Citizen Outreach

The results of this study corroborate the findings of a similar outreach effort in Schoolcraft County in 2000. 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. Additionally, local agencies in the study area currently do not have any authority to address these concerns directly. Although local officials seem to be aware of at least some shoreline features, 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. Although an attempt is underway to consider planning at the county level and potentially to standardize ordinances, there is currently no specific effort to include systematic review of threatened and endangered species or to specifically consider the integrity of zecosystems.

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. This has resulted in a negative attitude on the part of some local planners who have been frustrated by the process. As indicated by their responses to our request to survey their properties (see Landowner Contact section), at least several landowners have been frustrated by this lack of consistency as well.

Given this scenario, the natural features of the Great Lakes shoreline remain extremely vulnerable. Yet, it is these very features that set the Great Lakes shoreline apart from anywhere else in the world. The scenic beauty and ecological integrity of native coastal communities is the true draw for many individuals who seek their refuge. Even those who don't realize their significance will likely be disappointed as the coastal zone becomes further developed and potentially further degraded. It is almost certain that the presence of high quality natural features on coastal properties is a strong selling point and will increase property values over time. Evidence of an increasing desire to direct the development of coastal properties in an ecologically friendly way can be seen by the enthusiasm and interest of landowners at the public information meeting and by the formation of local groups such as the CWPOA. Groups such as this could play a strong role in shaping development attitudes and activities that are compatible with natural resource conservation. The formation of a Mackinac County Planning Commission may also be a step in this direction. A copy of this report will be provided to both groups and it is hoped that the data provided herein, will be integrated into their planning processes.

Education clearly plays a role in the development of positive attitudes about coastal zone protection. The strongest legislation possible will not bring about a change in attitude to those who automatically resent government "intrusion" or who experience the presence of natural features in a negative way. It may result in the protection of some features, but alone, it is not a very good or efficient way to ensure protection over the long haul. Until the positive value of the coastal zone is integrated into the underlying value system of individuals, it will be much more costly and difficult to protect. With increased knowledge and understanding comes concern and "protectiveness." Over and over again, our contact with individual landowners has shown that if informed, many people are not only happy but also desire to do what they can to protect the natural features of their properties or local region. It is just this sort of "protectiveness" that will make the job of conserving them a lot easier.

It is clear that the approach taken to inform landowners and local planners to date is only a beginning. Education must reach a larger audience including not only landowners and local planners, but others such as developers, township and county administrators, environmental consultants, and planners at other levels. Further, it should be framed within a landscape perspective, whereby long-range planning considers coastal zone ecosystems independently of property boundaries. Assessing natural features property by property conceals cumulative impacts that can often result through alteration and fragmentation of habitats. This has been shown to be of particular concern for coastal ecosystems and their component species (Olson and Soule 1998). A systematic process that requires the consideration of natural features on properties undergoing development should complement education. The data provided in this and previous reports can serve as the foundation for developing landscape level plans that focus on ecological boundaries and identify ecologically significant "hotspots". Providing information up front in a proactive way will also help appease disgruntled landowners and minimize regulatory surprises.

The current project will be finalized by providing a copy of this report to all identified local planner contacts, and making it available on MNFI's web site. Results will be provided to landowners who requested them. A summary article will also be included in one or more newspapers or newsletters in Mackinac County and elsewhere in the State. It is recommended that funds be identified to continue the public information meetings in order to capture a wider audience. Ideally these would be held at various times and locations during the field season.

Summary and Conclusions

The results of this inventory show the study area to be not only rich in natural features but also to encompass large regions of relatively undeveloped lands. Sixty one occurrences of rare plants were either newly found or re-confirmed during this study and an additional 17 previously documented occurrences, although not visited, are considered likely extant. The area provides stop-over and breeding sites for at least 110 bird species, and 10 listed bird species were observed there in 2001. One of the listed bird species, the northern harrier, was confirmed nesting during this study, and three nesting piping plover pairs were documented by the U.S. Forest Service. The latter, a federal and state endangered species, successfully fledged six young. Fifteen occurrences of the state threatened Lake Huron locust are now known from the area, of which eight were newly documented. Several other rare invertebrates have potential for occurring in the area including the globally rare Hine's emerald and incurvate emerald dragonflies, the state special concern dune cutworm moth, and rare land snails. The area also harbors 21 occurrences of eight different natural communities including six occurrences of the globally significant dune and swale community. Since the study was not a comprehensive survey for all rare species, nor could all properties be visited, it is almost certain that additional occurrences will be documented in the future. Many of the natural features noted here, as well as many less rare features, are known only from the Great Lakes shoreline.

Although a significant portion of the region of study is in public ownership and thus afforded some protection, development pressure in coastal areas is high. Coastal habitats are popular areas for home construction, recreation, and business development. Northern Lake Michigan shoreline communities, including those of Mackinac and Schoolcraft counties, are certainly no exception. In the mean time, impacts to natural features by development activities are not being systematically and consistently addressed. Without a strong framework to assess and address impacts, cumulative impacts will increase and natural features of the shoreline will continue to be degraded or lost. This will take an economic toll as well as an ecological toll. 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.

Knowledge of 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. However, simply knowing the distribution and ecological requirements of these elements 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, not the least of which is considering ecological boundaries that cross property ownerships. 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 continues to be 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. The education and outreach efforts of this study are small steps towards this goal, however, a long-term comprehensive approach that coordinates good legislation, high quality and comprehensive data, and a landscape level approach will be most effective. The establishment of a local coordinator or team that focuses on the integration of these intertwined factors can provide an effective means to enhance the protection and economic value of shoreline habitats and ecosystems. This group could also coordinate a landscape level conservation planning effort for the region. The formation of the Mackinac County Planning Commission could provide an important step towards this vision. We reiterate our recommendations presented in last year's report (Higman et al.):

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 there are ecological "hot spots" where high quality natural communities and rare species persist

Site Summaries

Seul Choix Bay

Beginning on the east side of Seul Choix Point as a narrow band of rocky cobble, this site gradually transitions northward to a narrow sand beach just south of Bulldog Creek. In several places the beach widens to include several foredune ridges. The southern half of the site (the peninsula) is backed up by wet boreal forest, while the northern portion forms the western edge of huge dune and swale complex that extends inland for over four miles. Permission-to-survey was not granted for much of this site, however Lake Huron tansy (*Tanacetum huronense*), Pitcher's thistle (*Cirsium pitcheri*), and lesser stitchwort (*Stellaria longifolia*) were documented on the several properties that were accessed. This region of the shoreline is currently little developed and experiences little human disturbance and it is likely that these species occur on other properties here as well. There is a good chance that Houghton's goldenrod (*Solidago houghtonii*) could occur here, especially along the dune and swale edge, where interdunal wetlands are evident.

Bulldog Creek North

A small open dune complex occurs just south of the Milakokia River mouth extending southward to Bulldog Creek and narrowing gradually to several small foredune ridges. Near the river mouth, sheets of limestone bedrock form a limestone pavement. Healthy populations of Lake Huron tansy and Houghton's goldenrod were documented here, as well as an occurrence of Lake Huron locust (*Trimerotropis huroniana*). Wet boreal forest lies behind the dune ridges transected by Highway 432 about ¼ mile inland. Northwest of the highway, a dolomite quarry is currently in operation.

Hughes Point

The Hughes Point site consists of a quality B-ranked open dune complex east of Norton Ogleby Limestone Company, representing the best western-most dunes on Lake Michigan. The dunes retain a nice diversity of native plants and high quality occurrences of Pitcher's thistle, Lake Huron tansy, lesser stitchwort, and Lake Huron locust. For the most part this complex is undisturbed, however, exotic species such as spotted knapweed (*Centaurea maculosa*), bladderwort (*Silene vulgaris*), and hawkweed (*Hieracium* spp.) are abundant near the quarry and are spreading eastward into the dunes. The three successive dune ridges span over a mile parallel to the shoreline and show successional variation, becoming more savanna-like inland. The ridges are separated by equally long B-ranked interdunal troughs. A healthy population of dwarf-lake iris (*Iris lacustris*) occurs along the ecotone of open dune and forested dunes. White pine dominated boreal forest occurs inland. The state owned portion of this site, east of the quarry, is part of a large complex extending east to Point Patterson that has been proposed for dedication as a State Natural Area. Efforts are underway to link the proposed dedication with newly acquired state forest land that connect this region to state lands that extend north to Big Knob Campground.

Seiners Point

Cobble beach, vegetated primarily with pockets of Canada bluejoint (*Calamagrostis canadensis*) and various sedges and rushes (*Carex* spp., *Juncus* spp.) occurs along the shoreline from Hughes Point to Seiners point. Although noted as sparsely vegetated when surveyed in 1983, vegetation was heavy in 2001 over a large expanse of cobble that was exposed due to low water years. Houghton's goldenrod was observed here in 1979, but was not confirmed during a 1991 wooded dune and swale survey. Time constraints coupled with difficulty of access prevented late season surveys at this site in 2001 to confirm the goldenrod. Due to the remoteness and lack of significant disturbance, it is likely that this occurrence persists and future surveys here are recommended. This site forms the western edge of an AB-ranked wooded dune and swale complex that extends east to Birch Point. It is also part of a large complex of undeveloped state land extending west to Hughes Point dunes and east to Big Knob Campground, that has been proposed for dedication as a State Natural Area (see Hughes Point description).

Birch Point East-West

This site spans approximately six miles of undeveloped shoreline from Seiners Point to just west of Scott Point. It consists primarily of a fringe of sand beach on the shoreline edge of two adjacent, large wooded dune and swale complexes drained by several small creeks. Small foredune ridges parallel much of the site west of Birch Point. Pitcher's thistle and Lake Huron tansy occur pretty much continuously throughout the entire site, while lesser stitchwort and dwarf-lake iris are found in patches mostly west of Birch Point. Two Lake Huron locust occurrences were documented at the western and eastern ends of the site. Time constraints prevented survey of suitable habitat between these two occurrences. The species likely occurs throughout the site, and future survey work here is warranted. This site is also part of a large complex of undeveloped state land extending west to Hughes Point dunes and east to Big Knob Campground, which has been proposed for dedication as a State Natural Area (see Hughes Point description).

Scott Point

Scott Point consists of a small, highly disturbed, open dune complex with particularly abrupt topography and many exotic species. Accessible easily from Gould City Road and Township Park, this area appears to be a target of ORV users and other recreationists. Occurrences of Pitcher's thistle and Lake Huron tansy continue here from the previous site (Birch Point East-West) while a small, localized colony of lesser stitchwort and Lake Huron locust were newly documented in the dunes. Sand hill cranes with young were also observed in the dunes during June surveys. Just west of the point, the beach narrows to a fringe of rocky wet sand where small colonies of Houghton's goldenrod and butterwort (*Pinguicula vulgaris*) were observed. This site is also part of a large complex of undeveloped state land extending west to Hughes Point dunes and east to Big Knob Campground, which has been proposed for dedication as a State Natural Area (see Hughes Point description).

Cozy Point

Just east of Gould City Township Park lies a small open dune complex that harbors healthy of populations of Pitcher's thistle and Lake Huron tansy, which continue from the Birch Point East-West site. A previously documented occurrence of Lake Huron locust was updated, and small, localized occurrences of lesser stitchwort and butterwort and newly documented here. Further east, around the Point itself, a previously documented colony of butterwort was confirmed and an occurrence of Houghton's goldenrod consisting of several discrete colonies was newly documented. Dwarf lake iris was also reconfirmed here, extending east and north continuing into subsequent sites. This site is also part of a large complex of undeveloped state land extending west to Hughes Point dunes and east to Big Knob Campground, which has been proposed for dedication as a State Natural Area (see Hughes Point description).

Point Patterson

Point Patterson forms a right angle curve in the shoreline, which consists of a very narrow, rocky fringe backed by dense, wet boreal forest. Previously documented dwarf lake iris continues from the previous site and a discrete colony of Lake Huron tansy was newly documented north along the eastern side of the right angle. This site is also part of a large complex of undeveloped state lands extending west to Hughes Point dunes and east to Big Knob Campground, which has been proposed for dedication as a State Natural Area (see Hughes Point description).

Needle Point -Fox Point

This site consists of a series of small foredune ridges interspersed with parallel interdunal wetlands. The Cataract River mouth bisects the dunes near the south end of the site. The site also forms western edge of large wooded dune and swale complex that extends approximately one mile inland and several miles northward. Recently acquired by the state, these lands harbor occurrences of Pitcher's thistle, Lake Huron tansy and Houghton's goldenrod, and dwarf lake iris

extends in discrete patches here from Birch Point East-West and Cozy Point. A known occurrence of Lake Huron locust was rediscovered in the dunes and greatly expanded in extent. This site is also part of a large complex of undeveloped state land extending west to Hughes Point dunes and east to Big Knob Campground, which has been proposed for dedication as a State Natural Area (see Hughes Point description).

Big Knob Campground

Big Knob Campground is very similar to the previous site, forming the lakeward edge of a large wooded dune and swale complex that abuts the northern end of the previous dune and swale complex. An extensive interdunal swale, bisected by the Crow River mouth and dominated by shrubby cinquefoils and sedges, lies behind a low foredune and there are extensive transitional "flats" between the foredune and pools. This wetland complex is noted as the westernmost example of a true foredune/pool interdunal swale and is included as an AB-ranked occurrence in MNFI's database. The site harbors Pitcher's thistle, Lake Huron tansy, dwarf lake iris and Houghton's goldenrod, and was noted as an area where more than ten bird species were observed during both migration and breeding season bird point counts. A new occurrence of Lake Huron locust was also discovered at this site. Recreationists frequently use the site, and numerous exotic plant species were noted including bull thistle, hawkweeds, dandelion, and yarrow. This site forms the northeastern end of large complex of undeveloped state land that extends west to Hughes Point Dunes and that has been proposed for dedication as a State Natural Area (see Hughes Point description).

Carnegie Woods

This site was designated from Big Knob Campground to the Lower Millecoquins River mouth. It is primarily a community of private residential lots, which have been more heavily developed north and east of the Rock River. No properties were accessed in the northern region, however, aerial photos show it has suitable habitat for many of the rare plant species. However, it is not known how the development of this region may have impacted potential occurrences there. South of the river, development has been less intense, and one property was surveyed during this study. This property likely characterizes of much of the remainder of the southern region. It consists of a sand beach with sparse vegetation and a small foredune ridge dominated by dune grass (*Ammophila breviligulata*) backed up to a large wooded dune and swale complex. Lake Huron tansy was abundant on the foredune, becoming sparse on the sand beach. Pitcher's thistle was reported from several other lots, however, we were unable to survey these properties due to time constraints. Although not observed on the property surveyed, appropriate habitat was present and since it is being maintained as an active dune zone, it will likely serve as a colonization site for Pitcher's thistle in future years. Dwarf lake iris was observed by the property owner but was not found during this survey. There is abundant suitable habitat for this species, and it undoubtedly occurs here. Lake Huron locust was not observed on the one property surveyed, but may occur in other parts of the complex. Permission to access additional properties, including interior lands, should be pursued to determine if rarities occur there and to determine if the dune and swale warrants status as an element occurrence.

Lower Millecoquins River

Permission was not obtained to access this site, however occurrences of Lake Huron tansy and Houghton's goldenrod have been previously documented there. The site appears to be primarily wet sand beach and for the most part is not developed, although U.S.-2 runs directly alongside the beach. The beach appears to be little disturbed and it is likely that the previously noted occurrences still persist. This site was also an area where more than ten bird species were observed during both migration and breeding season bird point counts.

Naubinway East

This site encompasses the bay between Naubinway and Mattix (Biddle) Point and is mostly rocky cobble and wet sand beach. Most of the region is in private ownership and permission to survey was not granted. Previous occurrences of

Houghton's goldenrod and butterwort on the small peninsula at about the midpoint of the bay could not be confirmed, but since they both were documented on adjacent state lands, they are considered likely extant. A new occurrence of dwarf-lake iris was observed on this peninsula, from the road. Much of this region of the shoreline holds potential for additional occurrences of rare plants, particularly Houghton's goldenrod, Lake Huron tansy, butterwort, and dwarf lake iris. Lake Huron locust was previously documented at Naubinway, but could not be confirmed due to lack of access. A roadside park located west of Mattix (Biddle) Point was surveyed for the Lake Huron locust. The species was not observed, and the habitat was considered marginal. This site was also noted as an area where more than ten bird species were observed during both migration and breeding season bird point counts.z***Black River Road***

This site extends from east Mattix Point to Hog Island Point and forms a virtually continuous shoreline fringe of plant rarities. An occurrence of Lake Huron locust was reconfirmed here as well. For the most part, the shoreline edge remains undeveloped as part of the right-of-way for U.S.-2, or as undeveloped frontage on residential lots where houses are set well back from the shoreline, retaining the undisturbed dune edge. Primarily a small foredune ridge, vegetated at the peak with balsam poplar (*Populus balsamifera*), red-osier dogwood (*Cornus stolonifera*), and willows (*Salix myricoides*). Dune grass (*Ammophila breviligulata*) dominates the slopes and back parts of dune ridge which slopes down to a broad flat sand beach that is heavily vegetated with American bulrush (*Scirpus americana*), rushes (*Juncus* spp.), grass-leaved goldenrod (*Euthamea graminifolia*), common evening primrose (*Oenothera biennis*). US-2 parallels the shoreline closely, providing easy vectors for the invasion of exotic species such as spotted knapweed, yarrow, and bladder campion (*Silene vulgaris*.) Almost everywhere that was accessed, Pitcher's thistle, Lake Huron tansy, and Houghton's goldenrod were present, the latter species flourishing on both sides of US-2 near the eastern end of the site. Only a small patch of dwarf lake iris was found at Hog Island Campground, but is likely to occur elsewhere in the vicinity.

West Epoufette

East of Hog Island Point is a series of small open dunes separated by regions of narrow rocky cobble and backed up by boreal forest. These comprise the West Epoufette site. Permission to access the westernmost dunes was not granted, however the middle and eastern dunes were explored. Two large foredunes comprise the middle dune at the mouth of Davenport Creek. The dunes retain a nice diversity of native species and harbor healthy populations of Pitcher's thistle and Lake Huron tansy, and a small colony of lesser stitchwort. Lake Huron locust was newly documented here as well. Pitcher's thistle, Lake Huron tansy, and two new occurrences of Lake Huron locust were also found on state lands to the east, as was a new occurrence of Houghton's goldenrod.

West Harbor-Kenyon Bay

This site is primarily rocky, cobble shoreline and emergent marsh, merging inland to a shrub zone and finally to boreal forest. The cobble area is dominated by grass-leaved goldenrod (*Euthamea graminifolia*), silverweed (*Potentilla anserina*), rushes (*Juncus* spp.), willows (*Salix* spp*)*, and balsam poplar (*Populus balsamifera*). Much of the cobble region has the character of northern fen with such species as Kalm's lobelia (*Lobelia kalmii*), false asphodel (*Tofieldia glutinosa*), Ohio goldenrod (*Solidago ohioensis*), and bird's eye primrose (*Primula mistassinica*). Lake Huron tansy occurs in low numbers in a small sandy region of the cobble beach just west of West Harbor. Kenyon Bay has been delineated as a B-ranked Great Lakes marsh consisting of wet meadow, emergent marsh, and submergent marsh zones. Twenty-eight plant species were noted in the original survey. A portion of a small A-ranked wooded dune and swale complex spans the eastern end of the site and includes the Paquin River mouth. It consists of diverse interdunal swales and low ridges with fair white pine regeneration. A small summer home, cabin, and water house occur on the site, but it is otherwise little disturbed. Some exotics are present including yarrow and ox-eye daisy (*Chrysanthemum leucanthemum*). The owners

reported seeing a diversity of wildlife, including a bald eagle, in the area.

Epoufette Bay

The western edge of Epoufette Bay forms a B-ranked Great Lakes marsh with zones of rich conifer swamp, shrub swamp, wet meadow, and emergent marsh and containing together over 30 vascular plant species. Bulrushes (*Scirpus acutis*, *S. americana*) dominate in the emergent zone while bluejoint (*Calamagrostis canadensis*) and strict sedge (*Carex stricta*) dominate the wet meadow. Further east the shoreline is predominantly rocky cobble with some regions of emergent marsh. An occurrence of state and federal endangered Michigan monkey flower (*Mimulus glabratus* var. *Michiganensis*) is found just west of the Township Park along seeps on the beach and spreading into an inland cedar swamp and a roadside ditch. Lake Huron tansy was previously noted in the vicinity of the monkey flower.

Cut River West

This site begins just west of the mouth of the Cut River and extends to the east edge of Epoufette Bay. A steep bluff rises from the Lake and parallels the shore forming a narrow sand beach near the Cut River. The beach broadens to a wide peninsula at the west end of the site forming the eastern lip of Epoufette Bay. Numerous underground drainages emerge from the base of the dune forming cold seeps that flow into Lake Michigan. These seeps are prime habitat for the state and federal endangered Michigan monkey flower and it is here that the highest quality occurrence of this species is found. Many colonies were documented in 2001, varying from small patches in small seeps to large sprawling clones flourishing abundantly on exposed cobble beach where seeps merge together forming small pools. The site is relatively undisturbed, except in the vicinity of the Cut River Bridge scenic site, which receives hundreds of visitors annually. However, since this site is easily accessed, it is also at great risk. Due to the significance of the site for Michigan monkey flower, strong protection measures are encouraged. A mesic northern forest surrounds the Cut River on the bluff. This B-ranked rich forest is dominated by sugar maple, beech, yellow birch, and eastern hemlock and northern fir-moss has been previously documented here. A heavy infestation of the invasive exotic species garlic mustard (*Alliaria petiolata*) was noted during this study. Well known as a significant invader in the southern part of the state, this species appears to be making a strong appearance in the Upper Peninsula.

Cut River East

The steep bluff continues eastward from the mouth of the Cut River forming the primary feature of the Cut River East site, which extends to the west edge of Sand Products Mining Company. The bluff rises very close to the lakeshore throughout this site, leaving only a narrow, sparsely vegetated sand beach at the water's edge. One small colony of Michigan monkey flower was newly documented here in 2001. A small colony of lesser stitchwort, documented previously was not found and is considered extirpated.

Manitou Payment Highbanks

This site, owned by Sand Products Mining Company, encompasses the eastern end of an extensive bluff that extends westward to the Cut River East and West sites (see above.) Similar to these sites, the steep bluff of the dune drops to a narrow sand beach with numerous seeps. Michigan monkey flower has been well documented here, and due to an on-going permit review process, it was not surveyed in 2001. Sand Products ensured that the colonies were in good health, and that the permit conditions will contain provisions for their perpetuation and monitoring. A 1984 occurrence of Pitcher's thistle and a 1991 occurrence of Lake Huron tansy were also not reassessed due to the permit review process. It is assumed that these occurrences still persist, however, once the permit review process has been completed, they should be reassessed.

Brevort

Beginning at the end of the Manitou Payment Highbanks, just west of the town of Brevort, this

site consists of a narrow strip of sandy and rocky beach. It is very weedy in the immediate vicinity of the town, becoming less-so east towards Hiawatha National Forest dunes. We were unable to coordinate access to the eastern portion of this site, but it is believed that previously documented occurrences of Lake Huron tansy and Michigan monkey flower still persist here.

Hiawatha National Forest Dunes

This site encompasses a portion of state right-of-way for US-2 at the west end and approximately six miles of national forest land that extends to Point aux Chenes. It is a large forested dune with a fringe of open dune on the lakeward edge. Although Lake Huron tansy, Pitcher's thistle, lesser stitchwort, and Lake Huron locust occur in the open dunes, they have been highly disturbed by US-2 and the thousands of visitors that flock to these shores. Roadwork and bank stabilizing efforts have impacted many of the dune rarities, leading to a heavy invasion of exotic species. However with aggressive control measures and appropriate education and enforcement, it is probable that these occurrences can be sustained. In fact, the Lake Huron locust occurrence was ranked as having excellent predicted viability based on the relative abundance of locusts observed at the site. Two dry-mesic forest areas have been documented at the eastern end of the site as well as occurrences of Calypso and Ram's-head orchid (*Calypso bulbosa*, *Cypripedium arietinum*).

Pointe aux Chenes

The diverse ecological complex at Point aux Chenes is perhaps the most notable site in the study area. It encompasses high quality occurrences of Great Lakes marsh, open dune, interdunal wetland, sand/gravel beach, as well as significant occurrences of Houghton's goldenrod, Pitcher's thistle, Lake Huron tansy, lesser stitchwort, butterwort, pine drops (*Pterospora andromedea*), dwarf-lake iris, northern fir-moss (*Huperzia selago*) and Lake Huron locust. It was noted as an area where more than ten bird species were observed during both migration and breeding season bird point counts, and as an important nesting area for common terns. Additionally, the state and federal endangered piping plover has nested here historically. Three pairs were observed by the USFS in 2001 resulting in six fledglings. The site currently persists largely undisturbed and its status should be maintained as such.

Gros Cap

The Gros Cap site spans private residential properties from south Point aux Chenes to West Moran Bay. Access to properties in the northern portion of the site was not permitted, however, residences are sparsely distributed near the shoreline and access should be sought in the future to assess the potential for rarities. The several properties that were accessed south of Poupard Bay, were found to harbor high quality occurrences of dwarf-lake iris, Lake Huron tansy, Houghton's goldenrod, Pitcher's thistle and butterwort. For the most part, houses are well set back from the near shore communities, which include a boreal forest edge grading to expanses of rocky flats interspersed with fen-like pools. Landowner education will help to protect these rich areas.

West Moran Bay

Extending south from West Moran Bay to Point La Barbe, this site is marked by a shallow, steep bluff descending to a narrow sandy beach. In the Bay itself, there is a small open dune that harbors Pitcher's thistle, and in wet depressions, Houghton's goldenrod. A new occurrence of Lake Huron tansy was also newly documented here. South of the Bay, residential lots are more intensely developed and heavily landscaped. The sites that were visited were quite weedy and the likelihood of finding high quality occurrences of rarities here is considered fairly low, although not impossible.

Point La Barbe

The shoreline extending from the Mackinac Bridge to just west of Point La Barbe comprised this quite disturbed site. A road parallels the shoreline that is heavily used by tourists and local residents to view Lake Michigan, and a power line right-of-way extends onto the point. The point itself consists of a fen-like rocky flat with carpets of

herbaceous species such as Indian paintbrush and Kalm's lobelia. There are also several pockets of sandy foredunes vegetated with typical dune species. Previously documented occurrences of Pitcher's thistle and Lake Huron tansy were not found, however, Houghton's goldenrod was abundant. The goldenrod extends east and west of the point along the narrow rocky beach that backs up to dense boreal forest and shrub swamps immediately inland. Numerous patches of dwarf lake iris lie along the boreal ecotone forming a nearly continuous occurrence to Mackinac Bridge and a small Great Lakes marsh occurrence is noted in the bay.

Straits State Park

No rarities were documented at the heavily used Straights State Park. This is a highly developed campground in upland boreal forest with a fringe of gravelly sand beach.

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Daria Hyde and David Cuthrell assisted with site selection, development of survey methodology, training of surveyors, and data evaluation. Daria also assisted with field surveys for the Lake Huron locust. Matt Smar conducted surveys for Hine's emerald dragonfly. Lyn Scrimger and Ed and Lisa Schools were willing to rise before the rest of the world on many mornings, in order to help document migrating and breeding bird use in the study area. Steve Sjogren from the Hiawatha National Forest provided us with seven seasonal Forest Service employees during May. We thank them for their assistance and early morning cheer: Darcy Southwell, Kathy Kontio, Nancy Lakiotes, Aaron Mize, Raymie Methvin, Kristina Kasik and Nick Dohm. Jennifer Hansen, a Masters degree student at Central Michigan University, conducted two weeks of plant surveys, providing key data on numerous rare plant occurrences. Naubinway Field Office staff provided maps and information on how best to access survey sites on state forest land. Finally, we are most grateful to Norton Ogleby Limestone Company and all other landowners who gave us permission to survey their property, took time to meet and talk with us, and welcomed us into their homes.

Maureen Houghton provided valuable guidance on sorting out the maze of federal, county, township, and local groups that are of influence in or near the study area. Barb Fillmore, Resources Professional, CRMI, provided the crucial backbone for convening of the public information meeting. Robert Konle, Hendricks Twp. Supervisor, Terry Gouza, Hudson Twp. Supervisor, Donald McArthur, Newton Twp. Supervisor, Jill Eyre, Mackinac County Administrator, Cynthia Oliver, Executive Assistant, David Kovar, Building Inspector, Garfield Twp., and Patrick Durm, Supervisor, Moran Township, all responded attentively to our myriad of questions about local planning processes. We also thank David Anderson and Mary Kostecki of Schoolcraft and Mackinac County Extension Offices, respectively, for their support of our work. Pat Lederle and Mike DeCapita, were instrumental in honing our understanding of state and federal regulations and processes.

Becca Boehm and Michael Fashoway worked cheerfully and patiently to put our visualizations of the study area to paper, reducing hours of fieldwork to skillfully rendered spatial representations. They, along with Ed Schools, also worked with us to produce the final document in PageMaker format. Pat Lederle, Mike Penskar, Dave Cuthrell and Daria Hyde provided valuable editorial review of the report.

To all of you we give a big thank-you!

Appendices

Appendix A. Landonwer Contact Letter

April 18, 2000

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

Dear :

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. While still working very closely with these organizations, we are currently affiliated with Michigan State University Extension. We are in our twenty-first 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? You would be exempt from liability, should anything happen to us during our visit.

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.

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
____No, you may not visit and/or collect on my property

MSU agrees to indemnify the Landowner for losses from any personal injury or property damage claims made by others alleging negligence by MSU in it'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 "estimated 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 "estimated 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 "estimated 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 "estimated" 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.

H = Historical occurrence, assigned when there is a lack of recent field information verifying the continued existence of an occurrence. "Recent" is defined as generally within the last 20 years for animals, and within the last 20 to 40 years for plants and communities.

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[1]

A recent inventory of unique natural features along the Lake Michigan shoreline in Schoolcraft and Mackinac counties in the Upper Peninsula documented 124 occurrences of 20 different rare plant and animal species. These results provide further evidence of the extraordinary ecological diversity associated with Michigan's coastal zone.

"Michigan's Great Lakes shoreline is one of the state's most valuable and unique assets. It not only is a favorite recreation spot and source of great pleasure for many Michigan residents and visitors but also contains some of the most ecologically significant and unique natural features in the state and region," said Phyllis Higman, botanist with Michigan Natural Features Inventory (MNFI) who conducted the plant inventories for this study.

Michigan's coastal zone encompasses a variety of significant natural communities. These include the largest freshwater dune complexes in the world, cobble and bedrock beaches, boreal forests, cedar swamps, Great Lakes marshes, and a globally rare limestone bedrock grassland community known as alvar. Michigan's shoreline also is home to a wide variety of plants and animals including a number of rare species. "Approximately 20 to 30% of the over 12,000 known occurrences of rare plants and animals in the state are found along Michigan's shorelines," explained Michael Penskar, MNFI Program Botanist. "Moreover, many of our rarest species are supported by Great Lakes shores and their ecosystems, including several endemic species which are known only from the Great Lakes region," added Penskar. Examples of such globally rare species include federal and state threatened or endangered plants such as Pitcher's thistle, Houghton's goldenrod, dwarf lake iris (Michigan's state wildflower) and Michigan monkey-flower (known only from Michigan). The Great Lakes population of the piping plover, a federal and state endangered shorebird, nests primarily along northern Michigan's shoreline. The state threatened Lake Huron locust, a rare grasshopper, is known only from coastal sand dunes of Michigan, Wisconsin and Ontario. One of the rarest dragonflies in the country, the Hine's emerald dragonfly, and a number of globally rare land snails also recently have been found along the Upper Peninsula shoreline. Great Lakes shores also serve as important bird migration corridors and provide critical stopover habitat for neotropical migratory birds.

MNFI is a non-profit organization, associated with Michigan State University Extension and the Michigan Department of Natural Resources, whose mission is to collect and provide information on Michigan's rare and declining native plants and animals and array of natural communities and ecosystems. MNFI also maintains the state's only comprehensive database on the status and distribution of rare and significant natural features.

MNFI has conducted systematic surveys for rare species and high quality natural communities along Michigan's shoreline since the mid-1980's. During the summers of 2000 and 2001,with funding from the Michigan Department of Environmental Quality's Coastal Zone Management Program, MNFI botanists and zoologists scoured the Lake Michigan shoreline in Schoolcraft and Mackinac counties in search of known and new occurrences of targeted rare plants and animals. Surveys for migratory and breeding birds also were conducted. These field inventories resulted in the documentation of 48 occurrences of 14 rare plant and animal species in Schoolcraft County, and 76 occurrences of 13 rare species in Mackinac County. Over 70 additional occurrences of rare species and high quality natural communities also have been reported from the study area during previous surveys, although some of these may no longer be present. A total of 116 bird species were observed during migratory and breeding bird surveys in Schoolcraft County, and 110 species in Mackinac County.

However, the long-term viability of Michigan's coastal ecosystems and associated plants and animals remains uncertain as these landscapes continue to experience significant residential, recreational and commercial development pressure. As part of efforts to investigate how threatened and endangered species concerns are addressed at the

local level and to promote awareness of significant shoreline features, MNFI met with local land planners and conducted an educational workshop for property owners in the study area. MNFI's study found that local planning processes and zoning ordinances currently do not specifically address threatened or endangered species concerns. However, local land planners were interested in receiving information on natural features in their jurisdiction. "Although the results from this study indicate that many of the rare shoreline species can withstand some level of human disturbance, the long-term sustainability of coastal 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,"concluded Higman.

For more information, please contact Michigan Natural Features Inventory at 517-373-1552 or at http:\www.dnr.state.mi.us/wildlife/heritage/mnfi.

[1] Article will be provided to MSUE for production of press release, which will be distributed upon submission of final report to CZM.

Appendix E.

Agenda for Informational Meeting – Northern Lake Michigan Shoreline
Manistique, Michigan
July 21, 2001

I.	Introduction	Barb Fillmore	9:00 – 9:10am
II.	Overview of Project	Phyllis Higman	9:10 – 9:20 am
III.	Shoreline Ecology 101	Erica Choberka	9:20 – 9:35am
IV.	Rare Plants	Phyllis Higman	9:35 – 9:50am
V.	Rare Animals	Yu Man Lee/ Jennifer Olson	9:50 – 10:05am
VI.	Break		10:05 – 10:20am
VII.	Endangered Species Protection	Jennifer Olson	10:20 – 10:35am
VIII.	Open Discussion	Barb Fillmore	10:35 – 10:50am
IX.	Field Trip	All	11:00 – 12:00pm

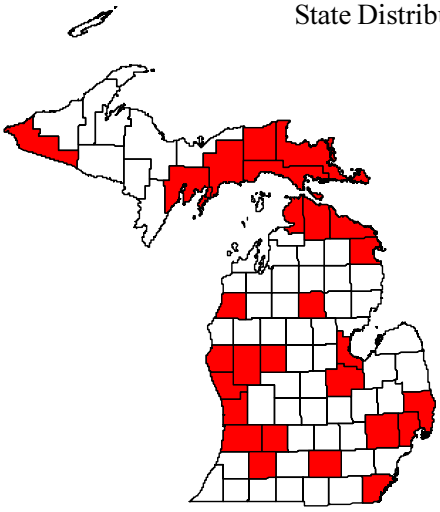
Appendix F.

Species and Natural Community Abstracts

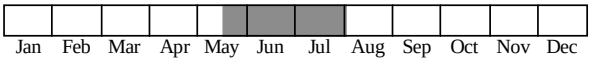
Chlidonias niger Linneaus — black tern

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*)

Selected references:

Bergman, R.D., P. Swain, and M.W. Weller. 1970. A comparative study of nesting Forster's and black terns. Wilson Bull. 82:435-444.

Brewer, R., G.A. McPeek, and R.J. Adams Jr., eds. 1991. The Atlas of Breeding Birds of Michigan. Mich. State Univ. Press, East Lansing, MI. 226 pp.

Chou, P.C. 1994. "Black Tern (*Chlidonias niger*)." In, The Birds of Michigan. McPeek, G.A. and R.J. Adams Jr., eds. Ind. Univ. Press, Bloomington and Indianapolis, IN. 232 pp.

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Dunn, E.H. 1979. Nesting biology and development of young in Ontario black terns. Can. Field Nat. 93:276-281.

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Faber, R.A. and J. Nosek. 1985. Preliminary assessment of tern reproduction in relation to environmental contaminants on the Mississippi River. Unpub. report to Minn. Dept. of Nat. Resources, St. Paul, MN. 22 pp.

Hands, H.M., R.D. Drobney, and M.R. Ryan. 1989. Status of the black tern in the northcentral United States Missouri Cooperative Fish and Wildlife Research Unit School of Forestry, Fisheries, and Wildlife. Univ. of Missouri, Columbia, Missouri.

Hickey, J.M. and R.A. Malecki. 1997. Nest site selection of the black tern in western New York. Colonial Waterbirds 20(3):582-595.

Mazzocchi, I.M., J.M. Hickey, and R.L. Miller. 1997. Productivity and nesting habitat characteristics of the black tern in northern New York. Colonial Waterbirds 20(3):596-603.

Natural Heritage Biological and Conservation Datasystem. 2000. Consolidated by Michigan Natural Features Inventory, March 23, 2000.

Nisbet, I.C. 1997. Status, biology, and management of the black tern: Symposium summary and overview. Colonial Waterbirds 20(3):622-625.

Novak, P.G. 1990. Population status of the black tern (*Chlidonias niger*) in New York State, 1989. New York State Dept. of Environ. Conservation, Div. of Fish and Wildlife - Nongame Unit, Delmar, NY. 30 pp.

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

Peterjohn, B.G. and J.R. Sauer. 1997. Population trends of black terns from the North American Breeding Bird Survey, 1966-1996. Colonial Waterbirds 20(3):566-573.

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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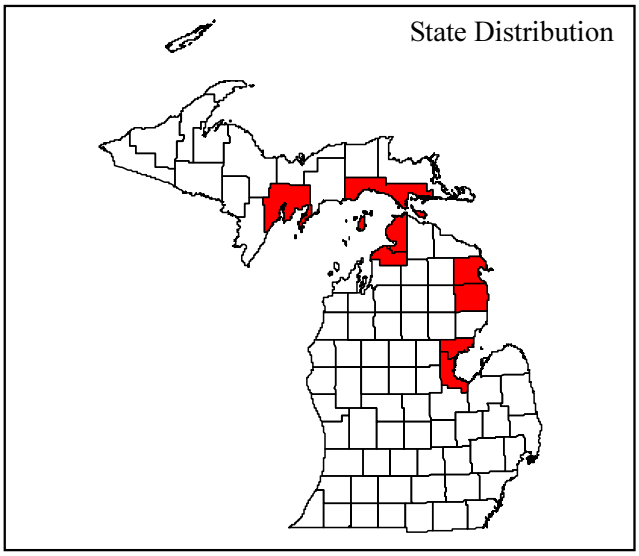
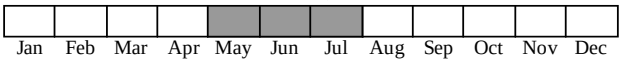
Sterna caspia *Pallas* — Caspian tern

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



Best Survey Period



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

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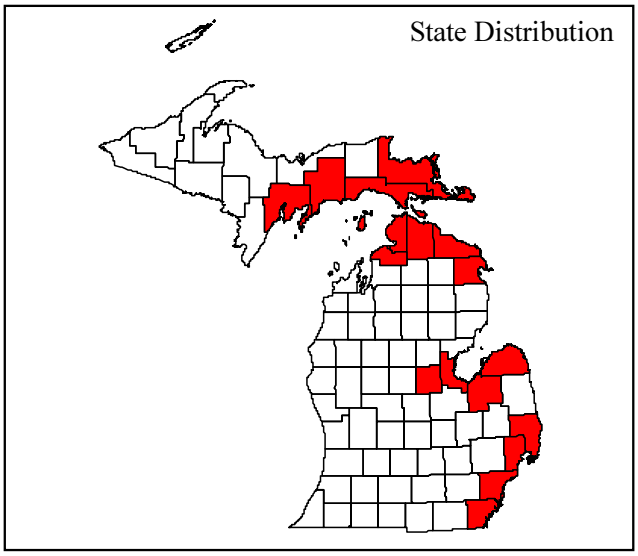
Sterna hirundo Linneaus — common tern



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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Euxoa aurulenta (Smith) dune cutworm

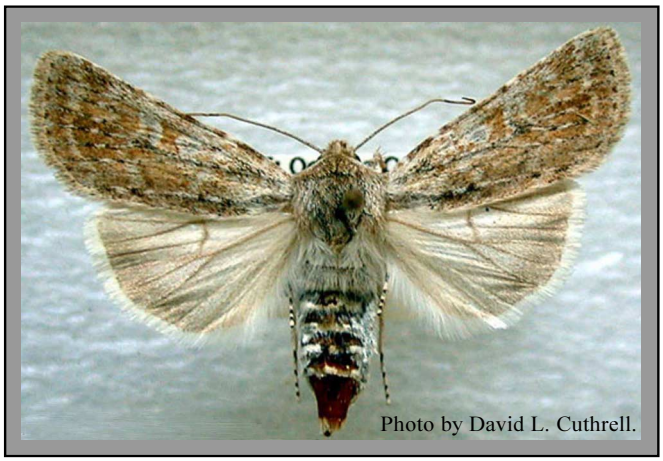
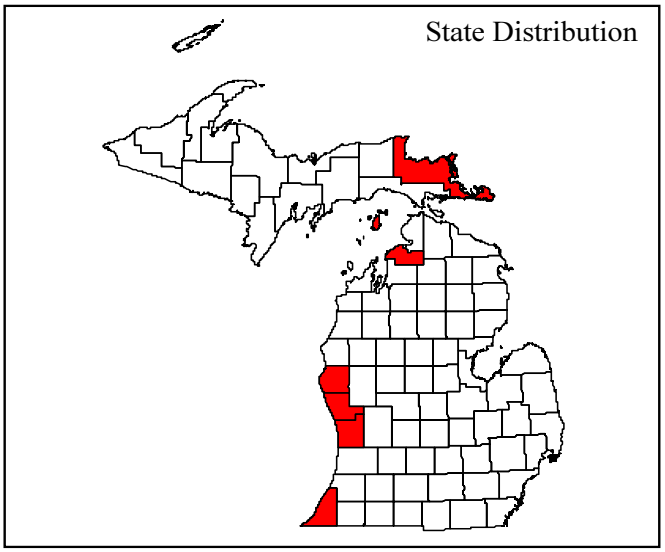
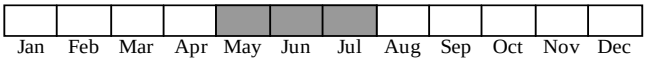


Photo by David L. Cuthrell.



Best Survey Period



Status: State special concern

Global and state rank: G5/S2S3

Family: Noctuidae (owlet moth family)

Range: The dune cutworm moth occurs as a series of disjunct populations throughout a large area of North America having been recorded from the following states: Arizona, Colorado, Idaho, Illinois, Michigan, Montana, Nebraska, North Dakota, Oregon, Utah, and Washington. It has also been recorded from the Canadian provinces of Alberta, Manitoba, Ontario, and Saskatchewan (Hardwick 1970).

State distribution: The dune cutworm is known from a total of nine Lake Michigan shoreline locations. It has been collected from six counties in Michigan including Berrien, Charlevoix (High Island), Chippewa, Muskegon, Oceana, and Ottawa counties.

Recognition: The following descriptive notes follow Hardwick (1970). This moth, in the family Noctuidae, has a wingspan from 1.4-1.6 inches (35.3-39.3 mm). The **forewing of most individuals is light fawn**, often heavily irrorate with white or pale grey. There is a chocolate-brown color phase as well. **Hind wing varying from pure creamy-white to uniform medium smoky-brown; hind wing most frequently white suffused with brown and often with a brown outer-marginal band with a white fringe**. **Underside of forewing white, often suffused with brown**. Underside of hind wing usually paler than forewing. Because there are many similar looking moths within the genus *Euxoa* and *Agrotis*, a voucher specimen(s) need to be collected for this species for positive identification.

Best survey time: The dune cutworm is reported to be an early flier within the *Euxoa* with dates ranging from 6 May to 23 July. The Michigan records range from 26 May to 12 July. The best way to survey for this species is by blacklighting, a technique where a sheet is stretched across two trees or poles and an ultraviolet light is used to attract moths to the sheet. Moths can be collected directly from the sheet.

Habitat: The dune cutworm is reported occuring in disjunct populations in sandy areas throughout North America (Hardwick 1970). No other information on specific habitat requirements is in the literature. The Michigan locations are all sparsely vegetated, high quality coastal dune habitats such as those found at Grand Mere dunes and Warren Dunes State Park in Berrien County; Muskegon State Park, Muskegon County; and Whitefish Point, Chippewa County.

Biology: The dune cutworm moth is univoltine (one generation per year) and likely overwinters as a pupae. The immature stages have not been described for this cutworm. No other information is known on the life history or biology of this species although it is speculated to feed on some species of dune grass. In Michigan specimens have been collected in close proximity to the beach grasses (*Ammophila breviligulata* and *Calmovilfa longifolia*).

Conservation/management: Unfortunately, significant parts of the high-quality dunes habitat have been degraded or destroyed by shoreline home and recreational develop-

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ment. The known remaining sites need to be protected as well as high-quality sand dune habitats. Further survey and resurvey of the nine known Michigan sites along with blacklighting in nearby sandy areas is urgently needed to assess the status and to learn more about this species. Several open sand dunes along the Lake Michigan, Huron, and Lake Superior shorelines should be surveyed. Until we know more about its habitat affinities and more on the species biology, life history, and ecology, we cannot make any specific management recommendations.

Research needs: The species is found in many disjunct localities throughout North America in sandy areas. Nothing else about its life history or biology is known. Research designed to study the life history and ecology of the moth is urgently needed including identification of the larval food plant. In addition to surveys for new sites, known sites should be studied to determine the micro-habitat requirements the moth needs to persist.

Related abstracts: Lake Huron locust, Pitcher's thistle, open dunes

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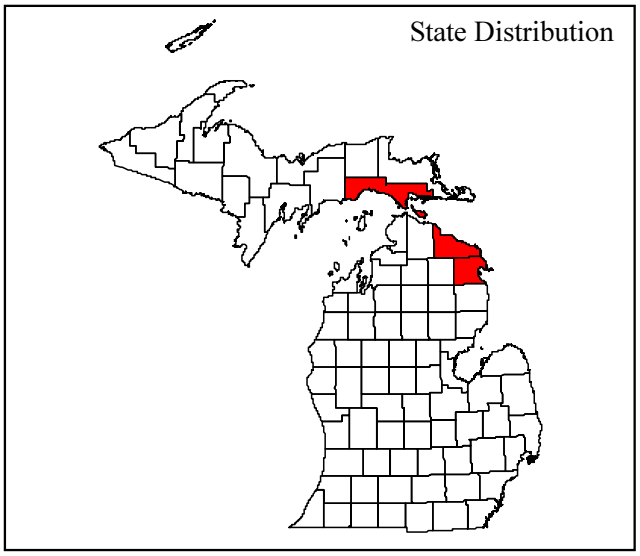
Somatochlora hineana Williamson — Hine's emerald dragonfly


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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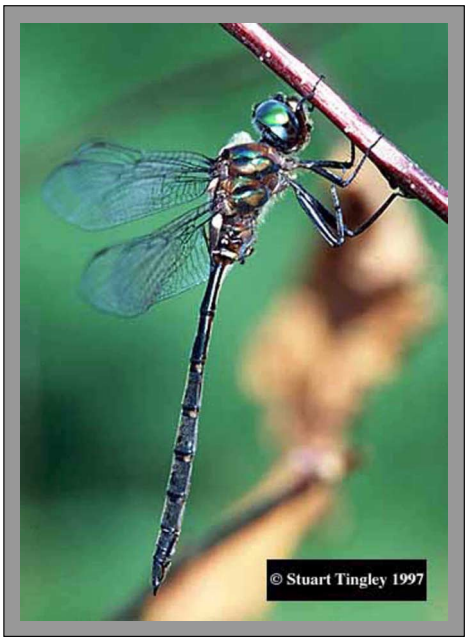
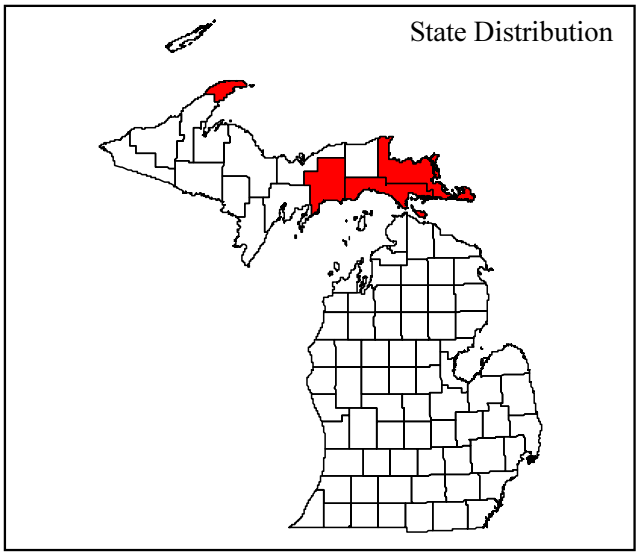
Somatochlora incurvata Walker — incurvate emerald dragonfly



male



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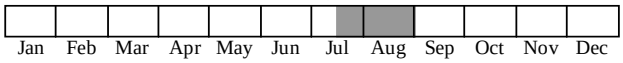

Status: State special concern

Global and state rank: G3/S1S2

Family: Corduliidae (emerald dragonfly family)

Range: This species is one of our rarest North American dragonflies. It is known only from Ontario and Nova Scotia in Canada and Maine, Pennsylvania, Wisconsin, and northern Michigan in the United States.

State distribution: In Michigan, this dragonfly is currently known from only seven sites in five counties in the Upper Peninsula. Three of the sites are located in Chippewa County. However, this species has not been systematically surveyed, and may occur in additional counties in which suitable habitat is available.

Recognition: The incurvate emerald is above-average in size for the *Somatochlora* genus (total length about 63 mm or 2 inches) (Shiffer 1985). The **face** is **yellowish-brown with dark, metallic greenish markings** and **large, green eyes**. The **thorax** (upper body) is **brown with metallic blue-green reflections and a pair of yellowish-brown elongate spots on each side**. The **abdomen** (lower body) is **black with a dull greenish sheen, with pale areas on sides of segments 2 and 3, and smaller dull yellow-brown spots on the rear portions of segments 4 to 9**. The **legs** are **black, and brownish at the base**.

There are nine other species of emerald dragonflies that occur in the Upper Peninsula in Michigan. Several of these occur in the same habitats and fly at the same time as the incurvate emerald, including the federally and state endangered Hine's emerald (*Somatochlora hineana*). The adults of these different species can only be reliably distinguished by their genitalia. Therefore, the only way to positively identify the incurvate emerald is to collect a specimen and have it verified by an expert.

Best survey time: The best time to survey for adults is from mid-July through August. Males are usually seen during sunny weather conditions from mid-morning to mid-afternoon (Shiffer 1985). In contrast, females appear to be most active on warm, but overcast, days when very few males are evident. Adults are best sampled with the use of a mesh aerial net.

Habitat: This species is typically associated with small pools of spring water in sphagnum bogs (Shiffer 1985). In Michigan, this species also has been found in patterned peatlands and northern fens. These wetlands are associated with peat or marl and contain flowing groundwater rich in calcium and magnesium carbonates. Dominant vegetation in these communities includes sedges (*Carex* spp.), bulrushes (*Scirpus* spp.), rushes (*Eleocharis* spp.), and shrubby cinquefoil (*Potentilla fruticosa*). Northern fens also contain calciphiles such as false asphodel (*Tofielda glutinosa*) and grass-of-parnassus (*Parnassia glauca*) and bog plants such as leatherleaf (*Chamaedaphne calyculata*), Labrador tea (*Ledum groenlandicum*), and small cranberry (*Vaccinium oxycoccos*). These wetland communities are often bordered by forest such as rich conifer swamps and white cedar (*Thuja occidentalis*).

Biology: The incurvate emerald was first documented in Michigan (and in the U.S.) in Chippewa County in the early to mid-1900's, and was only recently rediscovered in

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the state in 1993. Very little is currently known about the incurvate emerald. Adults have been seen flying from mid-July to mid-October (Walker and Corbet 1975). Males fly randomly just above the vegetation, occasionally perching on tree branches or hovering over open pools (Shiffer 1985). Females fly among the shrubs in a more direct manner, seeking open pools in which to oviposit. Females oviposit by hovering alone close to the water or wet mud, turning slowly in an irregular fashion and dipping the abdomen to the surface at closely spaced intervals.

The nymph stage and the time needed for egg development in this species are currently unknown. It is believed that the eggs probably hatch the following spring or summer after being deposited, and that the nymphs require at least two winters to reach maturity (Shiffer 1985). Similar to other species in its genus, the nymphs most likely transform into adults by crawling onto vegetation close to the water or on sphagnum moss.

Adults appear to remain fairly close to breeding sites (Shiffer 1985). Walker (1925) observed thousands of incurvate emeralds swarming on a beach along the shore of Lake Superior during the day, when the wind was offshore, but in a clearing about a quarter of a mile away from the lake at the end of a warm day. He observed the incurvate emeralds flying with swarms of darners (*Aeshna*) and other species of emerald dragonflies such as the delicate emerald (*S. franklini*) and Williamson's emerald *(S. williamsoni*).

The incurvate emerald probably feeds on small insects, such as midges, which are usually captured and eaten during flight (Walker 1925). Larger dragonflies and insectivorous birds are likely predators for this species.

Conservation/management: The most likely threat to this species is habitat loss and alteration. For example, commercial and residential development have resulted in the destruction and/or alteration of numerous wetlands in the state. Given that this species has been recorded from so few sites in Michigan and across its range, all known populations should be protected at this time. Maintaining the ecological integrity of the habitat is most important for the continued survival of this species at a site (Shiffer 1985). It is important to maintain the hydrology and water quality of an occupied site. Clearcutting adjacent to occupied sites may adversely impact the incurvate emerald and a number of invertebrate species by altering the site's microclimate (e.g., loss of proper humidity gradient) and reducing the amount of feeding habitat and shelter during the maturation period prior to breeding. Maintaining a no-cut or selective cut buffer around the wetlands would help minimize the potential for adversely impacting this and associated species.

Research needs: A systematic survey is needed to identify additional occupied sites and to determine this species' status and distribution in the state. Known sites should be revisited and monitored. Information on the life history and ecology of the incurvate emerald dragonfly is crucial to better understand its ecological requirements and to assess the potential for impacts on this species from various land use and management activities. Research should particularly focus on the identification, biology and habitat requirements of the larvae. A formal description of the incurvate emerald dragonfly larva is needed so that it can be distinguished from that of other species.

female

Related abstracts: northern fen, patterned peatland, Hine's emerald dragonfly

Selected references

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Abstract citation

Lee, Y. 1999. Special animal abstract for *Somatochlora incurvata* (incurvate emerald dragonfly). Michigan Natural Features Inventory, Lansing, MI. 2 pp.

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Trimerotropis huroniana (Walker) Lake Huron locust

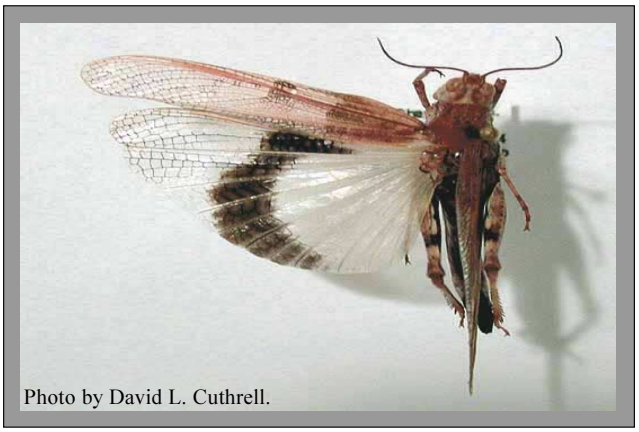
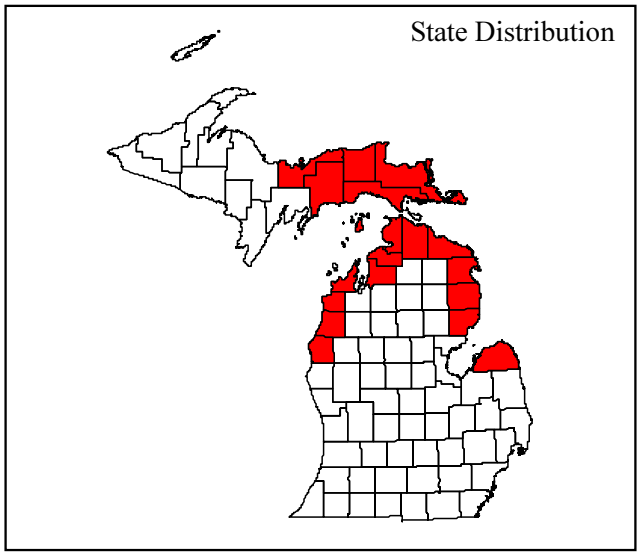
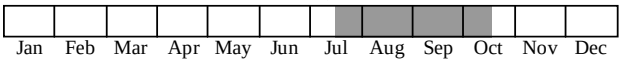


Photo by David L. Cuthrell.



Best Survey Period



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

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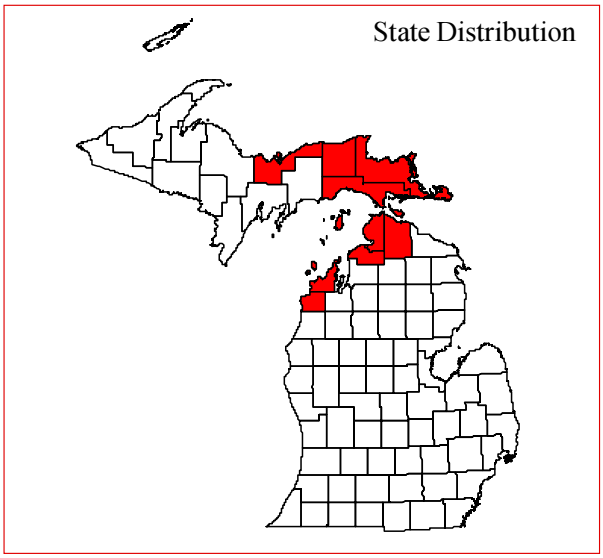
Charadrius melodus Ord — piping plover

Photo by Michigan Natural Features Inventory.



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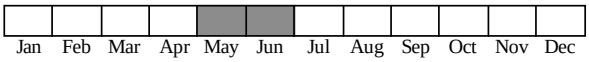

Status: Federal and State endangered

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.

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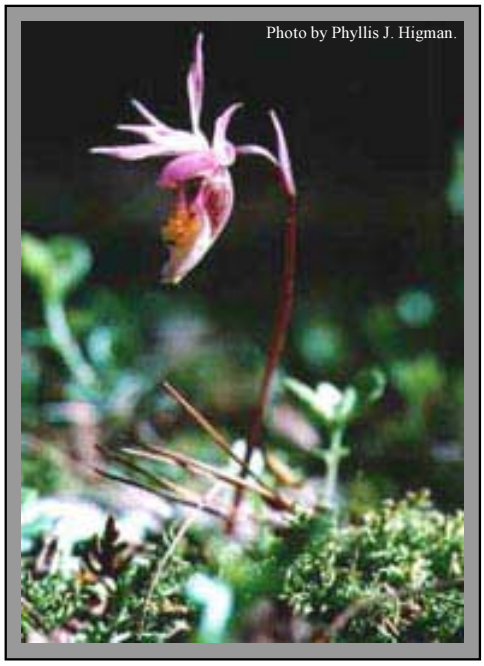
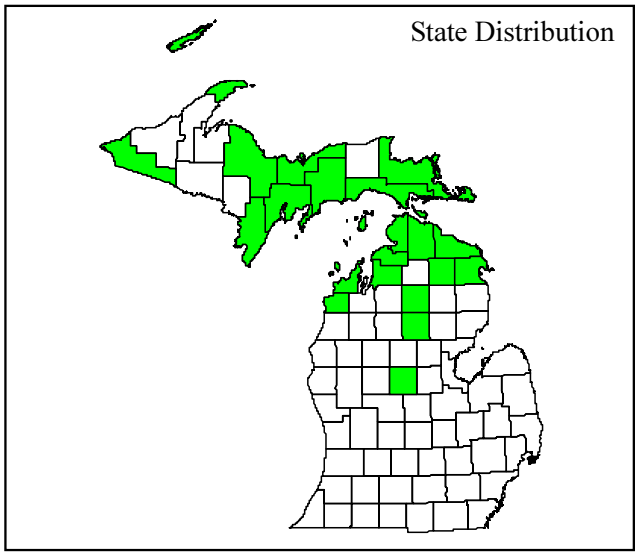
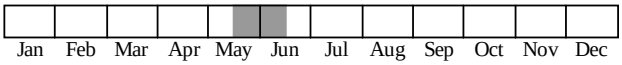
Calypso bulbosa (L.) Oakes — calypso orchid





Best Survey Period



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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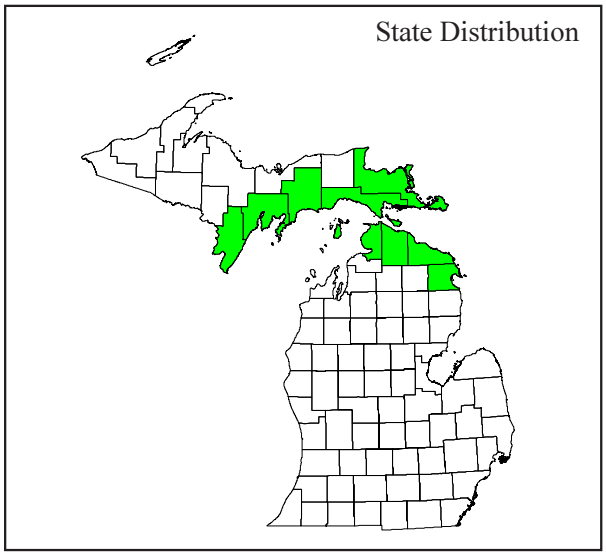
Iris lacustris Nutt. dwarf lake iris


Photo by Thomas Arter



Best Survey Period

Legal status: State threatened, federal threatened

Global and state rank: G3/S3

Other common names: baby iris

Family: Iridaceae (iris family)

Synonyms: *Iris cristata* Ait. ssp. *lacustris* (Nutt.) Iltis; *Iris cristata* Ait. var. *lacustris* (Nutt.) Dykes.

Taxonomy: Though the dwarf lake iris was treated as a variety of the southern *Iris cristata* by Dykes in 1913 (see also Mason and Iltis 1965), it has since come to be widely recognized, including by Dykes (1924), as a distinct species based on consistent differences in morphology, habitat, range, and chromosome number and configuration (Foster 1937).

Total range: *Iris lacustris* is endemic to the northern shores of Lakes Michigan and Huron, growing nowhere else in the world. Its distribution centers around the Mackinac Straits region, with outliers extending to Wisconsin's Door Peninsula and Ontario's Bruce Peninsula. The distribution in the Great Lakes follows the geological feature known as the Niagara Escarpment, a limestone formation extending from the Door Peninsula through Michigan and Ontario to New York.

State distribution: The majority of the world's *Iris lacustris* population lies within Michigan's boundaries, z where it is known from more than 80 locations. Its coastal range in Michigan extends from the Stonington Peninsula (Delta County) to Drummond Island (Chippewa County) and south to Wilderness State Park (Emmet County), Beaver Island (Charlevoix County), and Alpena (Alpena County). Atypical inland stations, which are probably relicts of former post-glacial lake stages, are known from Delta and Menominee counties. The abundance of dwarf lake iris is greatest in three general areas--the Garden Peninsula, southeastern Presque Isle and adjacent Alpena counties, and Cheboygan/Emmet counties--where it occurs almost continuously for many miles along the lakeshores and then densely to discontinuously over a few square miles inland. Colonies range in size from the extensive population clusters covering several hundred acres, such as in southern Presque Isle County, to those consisting of a few straggly stems persisting in isolated inland localities or forming small colonies on Great Lakes islands.

Recognition: This miniature iris is distinctive among the Michigan flora. Its **slender, yellowish**, **finely ribbed rhizomes have enlarged nodes** that give rise to fans of **flattened, slender leaves that range to ca. 15 cm in length and are about 1-2 cm wide**. The **showy, deep blue flowers** are of the typical iris type, with three arching, petal-like sepals (ca. 2 cm long) whose **orange, bearded crests lie partly beneath the smaller petal-like style branches**. The three petals are similar to the three sepals, and alternate with them. *Iris lacustris* can be recognized vegetatively by

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its relatively diminutive leaves and slender rhizomes, the latter of which are useful in distinguishing dwarf lake iris from small individuals and juvenile plants of the widespread *Iris versicolor* (common blue-flag). *Iris lacustris* is notable for its somewhat sparse production of fruit, which when present consists of small, oblong, green capsules on short stalks. The seeds have been shown, in part, to be ant-dispersed (Planisek 1983).

Dwarf lake iris is most likely to be confused with *Tofieldia glutinosa* (false asphodel), a member of the lily family with extremely similar leaves that very commonly occurs in the same northern shoreline habitats. *Tofieldia*, which produces small **clusters of white flowers that develop clumps of reddish capsules**, can be distinguished from dwarf lake iris by its **much narrower, firmer-textured leaves and long, sticky flower stalks**. Moreover, quick observation will show that *Tofieldia* **lacks a rhizome and does not grow in dense clumps or patches** as dwarf lake iris does.

Best survey time/phenology: The leaves and rhizomes of dwarf lake iris can be identified throughout the growing season, and in combination with habitat information can be used fairly reliably to detect this species. It is easiest to detect, however, during the flowering period from mid-May through early June.

Habitat: Dwarf lake iris usually occurs in close proximity to Great Lakes shores on sand or in thin soils over calcareous gravel or bedrock (alvar). It tolerates full sun to nearly complete shade, but appears to flower best in semi-open edge or ecotonal habitats, typically amongst scattered trees or on shozreline forest margins where it usually occurs with northern white cedar (*Thuja occidentalis*) and balsam fir (*Abies balsamea*). Dwarf lake iris is almost invariably associated with northern white cedar, though spruce (principally *Picea glauca*), balsam fir, and trembling aspen (*Populus tremuloides*) are also frequently present in the overstory. Groundcover associates commonly include *Arctostaphylos uva-ursi* (bearberry), *Primula mistassinica* (bird's-eye primrose), *Cypripedium calceolus* (yellow lady-slipper), *Polygala paucifolia* (gay-wings), *Smilacina stellata* (false Solomon-seal), *Castilleja coccinea* (Indian paintbrush), *Tofieldia glutinosa* (false asphodel), *Carex capillaris* (sedge), *C. castanea* (sedge), and especially *C. eburnea* (sedge). Frequent shrub associates are *Shepherdia canadensis* (soapberry), *Juniperus communis* (common juniper), *J. horizontalis (ground juniper),Cornus stolonifera* (red-osier dogwood), and *Potentilla fruticosa* (shrubby cinquefoil).

Other rarities that may be found in association with dwarf lake iris include state and federal threatened *Solidago houghtonii* (Houghton's goldenrod), state threatened *Calypso bulbosa* (calypso orchid), *Carex scirpoides* (bulrush sedge), and *Pterospora andromedea* (pine-drops), and state special concern *Cypripedium arietinum* (ram's-head orchid), *Pinguicula vulgaris* (butterwort), and *Carex richardsonii* (Richardson's sedge). Occasionally, this species extends out into open dune ridges in association with state and federal threatened *Cirsium pitcheri* (Pitcher's thistle) and state threatened *Tanacetum huronense* (Lake Huron tansy). On Drummond Island it is found in alvar habitat associated wtih state special concern *Sporobolus heterolepis* (prairie dropseed).

In many instances, the historical distribution of this iris seems to be as important as habitat in determining where it now grows. For example, many stations, likely consisting of relict colonies, lie along abandoned shores, especially former beach ridges of the ancient Great Lakes, sometimes in habitats that are now obviously unfavorable due to succession and other factors. This species has demonstrated that under certain conditions it can readily spread into artificially cleared areas with dryish, calcareous substrates, where it may advance aggressively.

Biology: Dwarf lake iris usually flowers from about mid-May through early June, depending on site exposure and annual weather variations. Each flower remains open about three days (Planisek 1983). Fruiting capsules ripen from mid-July to mid-August and release seeds that bear a white accessory appendage attractive to ants, which appear to play a role in dispersal (Planisek 1983). Observations show that fertility in this species is low due to: 1) sparse flower production, 2) low fruit-set (only 3% of growing tips develop fruits), and 3) low seed-set (an average of 21 seeds per capsule) (Planisek 1983). The flowers are self-compatible. No pollen vectors have been observed, though other irises are known to be bee- or fly-pollinated. Plants of *Iris lacustris* reproduce readily by rhizome forking and elongation, and plants can be aged by counting the enlarged nodes which mark the locations of past years' growing tips. Extensive clones often form, with tens or possibly hundreds of shoots possibly representing only one or a few genetically distinct individuals. Isozyme analysis of nine populations of dwarf lake iris found this species to be genetically depauperate as a whole (Hannan 2000.) There was a lack of detectable isozyme variation at any locus, and all isozymes found exhibited electrophoretic mobilities similar to those of *I.*


Photo by Susan R. Crispin

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cristata, a similar species found south of the Wisconsonian glacial maximum. These findings support the hypothesis that dwarf lake iris is of geologically recent origin from a single, genetically depauperate *I. cristata* gene pool.

Conservation/management: Since *Iris lacustris* is largely restricted to the Great Lakes shores, it is highly vulnerable to ongoing shoreline development and intensive recreation. Fortunately, this species is a persistent and rather ecologically resilient plant, and can often withstand less-than-catastrophic disturbances (e.g. overstory removal, occasional trampling, shading). It is clearly sensitive to mechanical disturbance or removal of its substrate, but can often recolonize small disturbed areas if it flourishes nearby. At least seven large, thriving colonies of iris lie partly or wholly on state lands, as do numerous other healthy but smaller ones. The Nature Conservancy and Michigan Nature Association each have good colonies of this iris within their preserve systems. Thriving colonies are probably best maintained without active management, though experimental techniques to determine the effects of disturbance, such as the removal of maturing canopy trees, are desirable to learn if this type of management may be necessary to perpetuate dwarf lake iris in some habitats. Colonies which appear to be suffering from shading might be rejuvenated by removing some canopy trees, which is likely to stimulate flowering. Historically, fire may have played a role locally by reducing canopy closure.


Photo by Susan R. Crispin

Comments: Form *albiflora*, bearing white flowers, occurs sporadically among the typical blue-flowered plants at several locations in Emmet, Presque Isle, and Schoolcraft counties, and perhaps elsewhere. Dwarf lake iris was designated Michigan's state wildflower in 1998.

Research needs: Breeding system studies, including investigations of pollination biology, are desirable for this species. Due to the increasing amount of development occurring where the iris occurs, research on experimental management techniques such as canopy removal, to determine the role of disturbance in the natural history of this species, is of high priority.

Related abstracts: Limestone pavement lakeshore, wooded dune and swale, American dune wild-rye, butterwort, calypso orchid, fascicled broom-rape, Houghton's goldenrod, Lake Huron tansy, pine-drops, Pitcher's thistle, prairie dropseed, Pumpelly's brome grass, ram's-head orchid, black tern, Caspian tern, common tern, Hine's emerald, Lake Huron locust, massasauga, piping plover.

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Abstract Citation:

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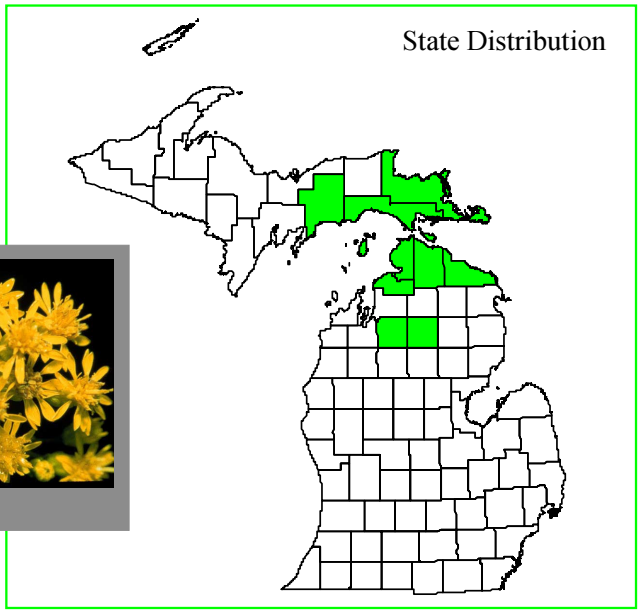
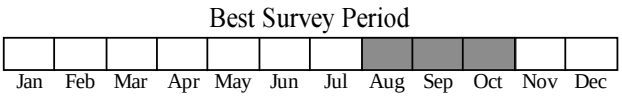
Solidago houghtonii A. Gray — Houghton's goldenrod

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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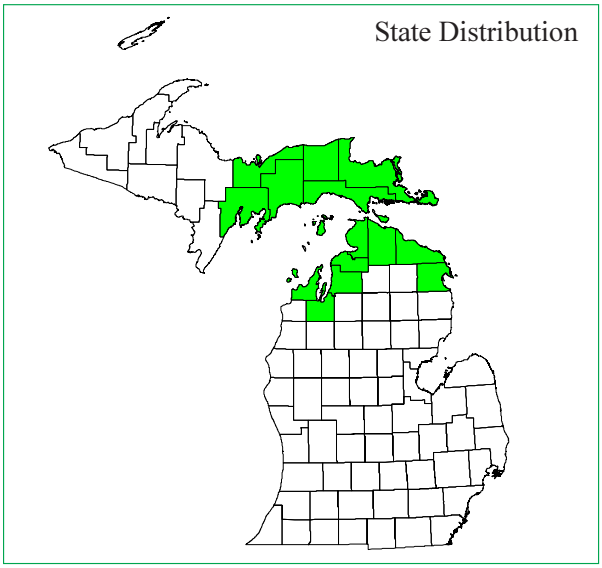
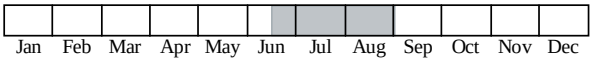
Tanacetum huronense Nutt. — Lake Huron Tansy



Best Survey Period



Legal status: State threatened

Global and state rank: G4Q/S3

Family: Asteraceae (aster family)

Other common names: Huron tansy

Taxonomy: The taxonomy of *Tanacetum huronense* is very complex. Kartesz and Kartesz (1980) treated *Tancetum huronense* as a distinct species. Other authors have treated *T. huronense* as a subspecies of the closely related Siberian and Alaskan *T. bipinnatum* L. (Gleason and Cronquist 1991), whereas Hultén (1971) includes *Tanacetum* within the genus *Chrysanthemum* and treats Great Lakes plants as a subspecies of *C. bipinnatum* L. As noted by Voss (1996), whatever the most appropriate treatment of this group may be, *Tanacetum huronense* at least includes the plants of the Great Lakes, from which the original taxon was described.

Total range: Lake Huron Tansy is a wide-ranging species distributed in North America from Alaska to British Columbia, Hudson Bay, and Newfoundland. Lake Huron tansy has a restricted distribution throughout the Great Lakes. It is found on the northern shores of Michigan, the Door Peninsula in Wisconsin, and adjacent Ontario shores of Lake Superior (Voss 1996, Guire and Voss 1963). This species seems to prefer alkaline (i.e. calcium-rich) substrates throughout its range.

State distribution: Lake Huron Tansy is found in the calcareous dune and beach systems along the north coasts of Lake Michigan and Lake Huron, the southeast shores of Lake Superior, and the islands in northern Lake Michigan. Of the more than 100 known Michigan occurrences for this species, just over 60 have been discovered or confirmed extant since 1980.

Recognition: Lake Huron tansy is a strongly **rhizomatous** plant with 1-3 main stems that may range up to about 8 dm in height. Its leaves are **hairy, inconspicuously glandular-dotted**, and **deeply twice or more divided** (pinnatisect). The ultimate, finely divided segments of each leaf have a short, dull point (a mucro). The basal rosette leaves are persistent, and they are larger (23-36 cm long, 3-9 cm wide) than the successively smaller stem leaves (10-23 cm long, 3-8 cm wide). Lake Huron tansy produces a "daisy type" of flower head, which is composed of **numerous separate small flowers or florets**. There are two flower types that can be found on a head: **disk flowers**, the tubular flowers that form the majority of the flower head, and **ray flowers**, which form a small fringe of tiny

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petals along the outer rim of the head. Each **yellow "petal"** on the outside of the head is a modified individual ray flower (2.5-4mm long). The yellow disk florets are tightly arranged in the center, forming a flower head that is about 13-19 mm in diameter. Each major stem produces about 3-12 heads, but a plant may produce up to 22 heads or more.

Lake Huron tansy is most likely to be confused with Michigan's only other *Tanacetum* species, the common and widespread garden tansy, *T. vulgare*, a non-native species that invades a wide variety of habitats including coastal dunes. Garden tansy, however, is readily distinguished by its **smooth, non-hairy (i.e. glabrous) foliage that is less finely divided** and the **distinctly smaller flower heads (5-10 mm in width)** that are often more numerous than those found in Lake Huron tansy. Despite the ubiquitous nature of garden tansy and its proximity to some Lake Huron tansy populations, no hybrids have been reported to date.

Best survey time/phenology: This species blooms from approximately late June through August, although the peak blooming period is generally within July. Those experienced with this species can reliably identify it by its foliage over a broader period, from leaf emergence through senescence.

Habitat: Lake Huron tansy inhabits active dunes, old, stabilized dunes, and sandy or even substantially cobbly beaches. At times of high water periods, it can withstand wave action. Along foredunes and in other active dune areas, it commonly grows with such characteristic associates as *Ammophila breviligulata* (marram grass), *Calamovilfa longifolia* (sand reed grass), *Agropyron dasystachyum* (wheat grass), *Salix cordata* and *S. myricoides* (dune willows), *Prunus pumila* (sand cherry), *Juniperus horizontalis* (creeping juniper), *Lathyrus japonicus* (beach pea), *Elymus canadensis* (Canada wild rye), *Arabis lyrata* (lyre-leaved rockcress), and *Artemisia campestris* (wormwood). Rare associates that may occur with Lake Huron tansy include *Cirsium pitcheri* (Pitcher's thistle), *Bromus pumpellianus* (Pumpelly's brome grass), *Stellaria longipes* (stitchwort), *Orobanche fasciculata* (fascicled broom-rape), *Botrychium campestre* (dunewort), and *Solidago houghtonii* (Houghton's goldenrod).

Biology: Lake Huron tansy is a perennial that forms colonies through rhizomatous growth. It blooms primarily from late June through July, fruiting from late July through September. In the fluctuating conditions of active dunes and shifting beaches, Lake Huron tansy uses two strategies for reproduction; abundant seed production and the asexual propagation of plants through its rhizomatous growth habit.

Conservation/management: Destruction or disturbance of natural habitat is the primary threat to Lake Huron tansy populations. Although Lake Huron tansy is well adapted to the natural disturbances that characterize and sustain its coastal habitats, it is vulnerable to a variety of threats such as erosion and direct impacts via excessive foot traffic and recreation, and especially the use of all-terrain vehicles. Landscape fragmentation and the direct destruction of the dunes through development activities also comprise ongoing threats. Lake Huron tansy and other coastal dune species are particularly vulnerable to much less obvious threats that may have a high impact on the function of coastal dune systems. This includes the use of a wide variety of shoreline stabilizing structures such as retaining walls, piers, and revetments, as well as the placement of beach armoring materials (e.g. rip-rap) to prevent erosion. These structures and practices, while understandably devised to protect property, also collectively impede natural sand movement and nourishment processes that maintain the integrity of coastal dune systems.

Lastly, owing to many forms of artificial disturbance, coastal dunes have been invaded by a number of highly invasive non-native plant species, including well known invaders such as *Centaurea maculosa* (spotted knapweed), *Gypsophila paniculata* (baby's breath), *Saponaria officinalis* (soapwort), and *Populus nigra* var. *italica* (Lombardy poplar). Control measures for these species will become ever more important as a component of conservation and management.

Research needs: The life history of this species is relatively poorly known, and thus most investigations of the biology of this species would be highly useful, including studies of seed dispersal and ecology, pollination, and the response of this species to natural disturbance features of the dunes. It would be especially useful to study the ecology of this species in

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relation to landscape fragmentation and the effects of human activities that affect the movement of sand along coastal regions.

Related abstracts: Open dunes, wooded dune and swale complex, dunewort, fascicled broom-rape, Houghton's goldenrod, Pitcher's thistle, Lake Huron locust, prairie warbler dune cutworm, caspian tern, common tern, piping plover.

Selected references:

Gleason, H.A. and A. Cronquist. 1991. Manual of Vascular Plants of Northeastern United States and Adjacent Canada. New York Botanical Garden, Bronx, New York. 910pp.

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

Hultén, E. 1971. The Circumpolar Plants. II Dicotyledons. Sv. Vetakad. Handl. IV. 13(1). 463 pp.

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Abstract citation:

Choberka, E.G., M.R. Penskar, and P.J. Higman. 2001. Special plant abstract for *Tanacetum huronense* (Lake Huron tansy). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

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

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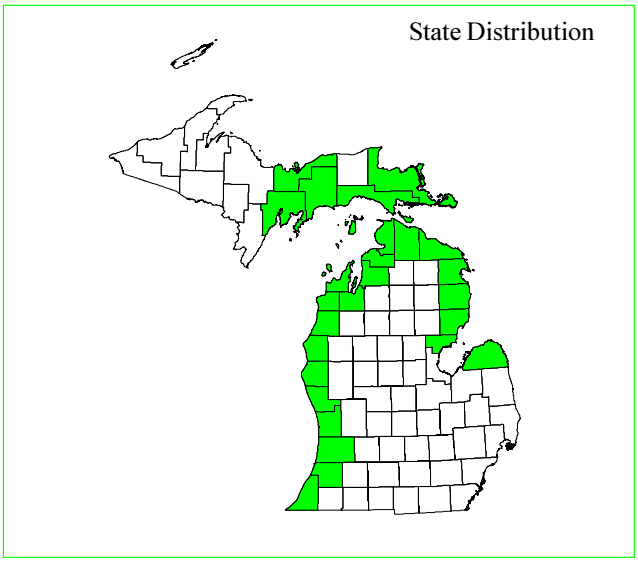
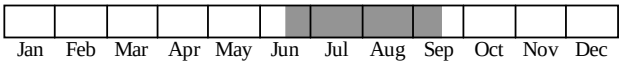
Cirsium pitcheri (Torrey and Gray) Pitcher's thistle

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.

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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.

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Abstract citation:

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

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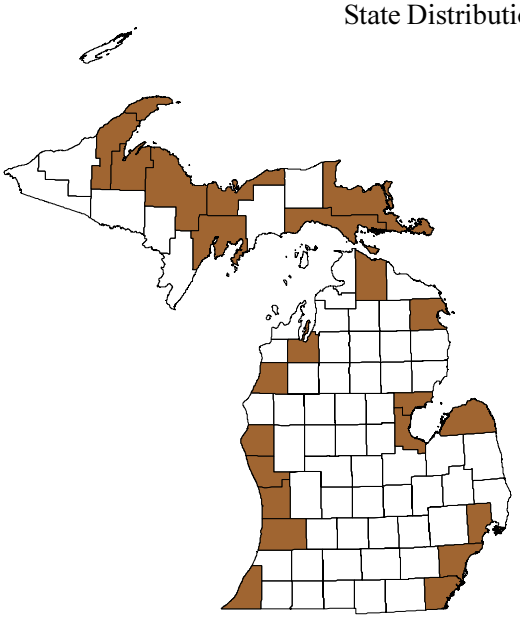
Great Lakes marsh — Community Abstract

Photo by Ted Cline

State Distribution



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

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

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

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

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

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

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

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

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

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

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

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

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

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

Morphometric Types of Great Lakes Coastal Wetlands

Ia. Lacustrine - Open embayment. Embayment open to the lake, but shallow water depth reduces wave height and energy. Wetland are limited to a narrow fringe of emergent vegetation.
Ib. Lacustrine – Protected embayment. Deep indentation or embayment in upland shoreline provides protection from wind and wave energy, allowing extensive emergent wetland development.
Ic. Lacustrine – Barrier-beach lagoon. Sand and gravel deposition create a barrier bar across the mouth of an embayment resulting in the formation of a shallow pond or lagoon. Extensive shallow water emergent vegetation; composition reflects degree of connectivity with Great Lakes.
Id. Lacustrine – Sand-spit embayment and Sand-spit swale. Sand spits projecting along the coast create and

protect shallow embayments on their landward side; large compound sand spits also enclose small swales. Sheltered embayments allow for sediment accumulation and wetland development.

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

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

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

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

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

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

Climate: Regional patterns of climatic variability within the Great Lakes Basin are largely determined by latitude, with the modifying influence of the lakes (i.e. lake effect) operating at a more local level (Derecki 1976; Eichenlaub et al. 1990). The strong latitudinal gradient from southern Lake Erie to northern Lake Superior creates marked differences in length of growing season. These differences are reflected in the regional distributions of a number of species common to Great Lakes wetlands.

While most aquatic macrophytes are widely distributed, species with known southern or northern affinities also occur. Lake Erie wetlands, for example, are rich in southern marsh species at the northern edge of their range; a southern wet-prairie floristic element is present as well (Stuckey 1989; Keddy and Reznicek 1985, 1986). Both of these southern floras differ significantly from the complex of boreal, subarctic, and arctic species found in the northern portions of Lakes Huron, Michigan, and Superior. Other species common to many Great Lakes coastal wetlands reveal regional concentrations corresponding to a north-south gradient (Minc 1997c).

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

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

Coastal wetland systems are adapted to and require periodic inundation. Water-level regulation has significantly reduced the occurrence of extreme high and low water levels on Lake Ontario and to a lesser degree on Lake Superior. This disruption of the natural cycle

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favors species intolerant of water-depth change, excludes species requiring periodic exposure of fertile substrates, and potentially leads to a reduction of species diversity. The dominance of cat-tails in many Lake Ontario marshes suggests a trend toward reduced species diversity following a reduction in the amplitude of natural water-level fluctuations (Wilcox et al. 1993).

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

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

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

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

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

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

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

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

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

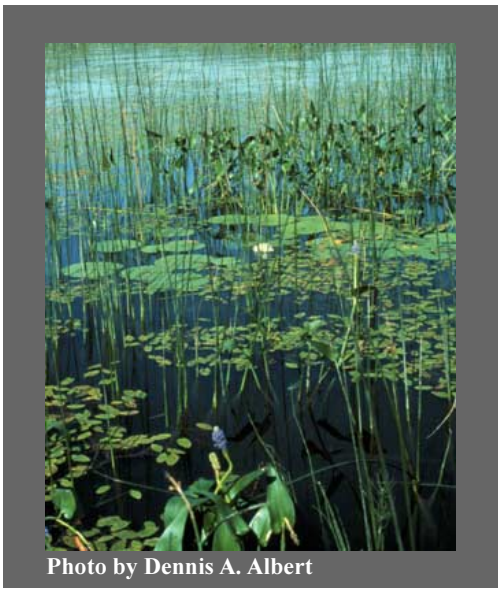

Photo by Dennis A. Albert

Northern Great Lakes Marsh type

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

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

Owing to the relatively flat topography, fluctuations in Lake Michigan's water level considerably alter the size of these coastal wetlands as well as their species composition (Harris et al. 1977). Receding high waters expose substantial portions of sandy beach and open mud flats, which are quickly colonized by dense stands

of *Schoenoplectus tabernaemontani* (softstem bulrush), *Bidens cernuus* (nodding bur-marigold), and one or more species of *Polygonum* (smartweed). Over a period of several years, these colonizing species decline and are replaced by a sedge meadow consisting primarily of *Carex* spp. and *Calamagrostis canadensis* (Harris et al. 1981).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Urban development has impacted coastal wetlands in the following ways:

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

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

Agriculture has had the following impacts on coastal wetlands:

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

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

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

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

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

Other Classifications:

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

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

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

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

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

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

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

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

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

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

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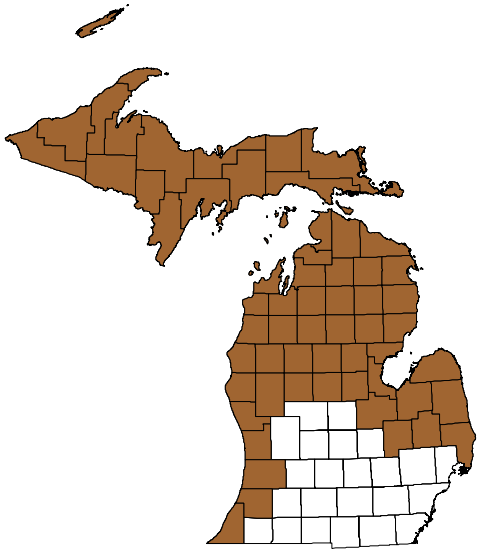
Mesic Northern Forest — Community Abstract

Photo by Jodi B. Raab

State Distribution



Global and State Rank: G4/S4

Range: The mesic northern forest community has existed as a dominant assemblage for approximately 2000 years (Davis, 1981) extending from southeastern Manitoba and northern Minnesota east across the northern U.S. and southern Canada to Maine and Nova Scotia (Barnes, 1991). Within Michigan, this forest type is predominantly found throughout the Upper Peninsula and in the northern half of the Lower Peninsula above the transition zone. This community also sporadically occurs below the transition zone along the Great Lakes shores of the Lower Peninsula.

Rank Justification: Widespread selective logging of white pine and hemlock at the end of the 19th century and the beginning of the 20th century followed by extensive slash fires greatly diminished the role of conifers as a wide-spread component of the mesic northern forest. In the Great Lakes region more than 99% of the mature hemlock-hardwood forest has been eliminated (Noss et al., 1995) and hemlock has been reduced from its former position as a regional dominant to where it now occupies only .5% of the landscape (Mladenoff and Stearns, 1993). Hemlock regeneration has diminished with this drastic reduction in seed source, the rise of winter browse pressure from the increasing deer population (Alverson et al., 1988) and the paucity of suitable establishment substrate such as decaying logs (nurse logs) and tip up mounds, features associated with old growth stands and also necessary for yellow birch establishment (Curtis, 1959). Logging, with a shift in focus from conifers to hardwoods, has continued as the primary disturbance in this forest (Frelich and Lorimer, 1991; Metzger and Schultz, 1984). Gaps generated by selective logging tend to be filled by sugar maple (Curtis, 1959), the seedlings of which often saturate the shaded understory of mesic northern forests (Barnes, 1991). Sustained and ubiquitous harvesting has reduced the structural and compositional complexity of this community. Old growth forest has dwindled from 68.0% to 5.2-8.3% of the Great Lakes landscape (Frelich, 1995). Remnants of northern hemlock-hardwood forests unscathed by logging are among the rarest vegetation types in the lake states, with just .6% remaining (Frelich and Reich, 1996). According to Noss et al. (1995), old growth eastern deciduous forest is among the 21 most endangered ecosystems in the United States.

In Michigan, 5.8% of the northern hardwood commercial forest is old growth (Frelich, 1995). In the 1800s, approximately 32.0% (over 12 million acres) of Michigan was mesic northern forest (Comer et al., 1995). Just over .4% of mesic northern forest in presettlement condition remains in Michigan. Large tracts of primary old growth forest remain in the Upper Peninsula in the Porcupine Mountains (31,000 acres), the Sylvania Wilderness (17,950 acres) and the Huron Mountains (4000 acres). Currently there are 59 documented occurrences of the mesic northern forest community. Only 8 of those occurrences, constituting just over 56,000 acres, are high quality representations of this type.

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Landscape, Abiotic and Historical Context: Mesic northern forest occurs on a wide variety of soils, typically on loamy sand to sandy loam and occasionally on sand, loam and clay. Soils range widely in pH from extremely acid to moderately alkaline but are more commonly extremely acid to medium acid. According to the Köppen classification, the Northern Hardwood-Conifer region has a cool snow-forest climate with warm summers. The daily maximum temperature in July ranges from 24 to 29 °C (75 to 85 °F) and the daily minimum temperature in January ranges from –21 to –9 °C (-5 to 15 °F). The mean length of freeze-free days is between 90 to 160 days and the average number of days per year with snow cover of 2.5 cm or more is between 80 and 140 days. The normal annual total precipitation ranges from 610 to 1270 mm (Albert et al., 1986; Barnes, 1991).

A forest type of moist to dry-mesic sites lying predominantly north of the tension zone, mesic northern forest is found chiefly on coarse-textured ground and end moraines, but also occurs commonly on silty/clayey lake plains, thin glacial till over bedrock and medium-textured moraines. It also occurs locally on kettle-kame topography, moderately well-drained to well-drained sandy lake plain and sand dunes (MNFI, 1990).

Presettlement forests of eastern hemlock and yellow birch were frequent on moderate to poorly drained till plains and outwash plains, especially in the western Upper Peninsula. This assemblage was predominately found around lake and bog margins and in complex mosaics with sugar maple-hemlock forest on the surrounding better- drained soils. Beech-sugar maple-hemlock forests, which dominated nearly 17% of the state's surface in the 1800's, were mostly found on large expanses of rolling moraines in the northern Lower Peninsula and eastern Upper Peninsula. This species mix was also found on the clay lakeplain along Saginaw Bay. Eastern hemlock and white pine were the conifers most commonly occurring in mixed stands with hardwoods. Eastern hemlock and American beech were occasionally co-dominant, most commonly on moderately drained sand plains. Assemblages dominated by hemlock and white pine were prevalent in the 1800's on moderately drained lake plain and outwash plain extending from Saginaw Bay through the Upper Peninsula. Large areas of hemlock–dominated forest grew on the clay plain of Huron and Sanilac counties. Extensive tracts of sugar maple and white cedar located in dunes or over calcareous bedrock were known from the surveyor's notes and are found today locally in dunes and on the drumlin fields of Menominee County (Comer et al., 1995).

Natural Processes: The natural disturbance regime in northern mesic forests is dominated by wind (Frelich et al., 1993). The Great Lakes region is one of the most active weather zones in the northern hemisphere with polar jet streams positioned overhead much of the year. More cyclones pass over this area than any other area in the continental U.S (Frelich and Lorimer, 1991). Severe low-pressure systems are a significant source of small-scale canopy gaps, which generate diversity of age structure in these stands (Canham and Loucks, 1984). In a study in the western Upper Peninsula, Frelich and Lorimer (1991) found that 60% of the canopy trees attained their canopy ascendance as the result of periodic small-gap formation. Because of the ability of shade tolerant species to remain in a suppressed understory state for prolonged periods of time, small canopy gaps are filled by advanced regeneration (Runkle, 1982). Sugar maple seedlings often survive in the shaded understory for over 30 years (Marks and Gardescu, 1998) and suppressed hemlock seedlings can live over 100 years (Davis et al., 1996).

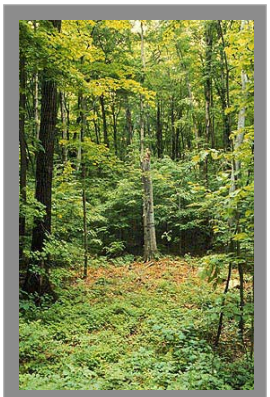
Photo by Gary Reese

Catastrophic windthrow is an important yet infrequent component of the disturbance regime of the northern mesic forests. Canham and Loucks (1984) estimated that the return time for large-scale windthrow (> 1.0 ha) to be 1210 years in forests of northern Wisconsin. This return time is remarkably similar to Whitney's (1986) estimated windthrow recurrence interval of 1220 years in hemlock-white pine-northern hardwood forests of the Northern Lower. Investigating primary hemlock-hardwood forests of the Upper Peninsula, Frelich and Lorimer (1991) estimated that the rotation period of wind disturbance which leveled greater than 60% of the canopy on a given site to be more than 1500 years. The principal mechanisms for large-scale windthrow are tornadoes and downbursts from thunderstorms. Downbursts are parcels of air in down drafts that shoot out from the base of thunderstorms and splatter in all directions upon impact with the earth (Frelich and Reich, 1996). Frelich et al. (1993) proposed that unless followed by catastrophic fire, catastrophic windthrow would cause little change in species composition because of the prevalence of advanced regeneration of shade-tolerant species. Using 19th-century land-survey evidence, Whitney (1986) estimated a fire rotation of 1400 years in hemlock-hardwood forests of northern Lower Michigan. Catastrophic fire in the wake of windthrow would result in the following successional sequence: invasion by shade intolerant species such as aspen and paper birch followed by the encroachment into

the disturbed stand by white pine and ending with replacement by shade tolerant species. Evidence of charcoal in the forest floor and fire scars on canopy dominants indicates that stands dominated by hemlock in the overstory are often the result of crown fires (Hix and Barnes, 1984; Simpson et al., 1990). However, the infrequency of fire historically in northern mesic forests is manifest by the paucity of successional species in land survey evidence: less than 5% of the presettlement northern hardwood forest was composed of pioneer species (Frelich and Lorimer, 1991).

Because of the long rotation period of large-scale disturbance in this community type, several generations of trees can pass between catastrophes. As a result, mesic northern forests tend to be multi-generational, with old-growth conditions lasting several centuries in the absence of anthropogenic disturbance (Frelich, 1995). In addition, the high degree of compositional stability of this forest type (Curtis, 1959) allows for ample opportunity for competitive interactions between dominant species to influence the patch structure of the landscape (Frelich et al., 1993). Studying old-growth hemlock-hardwood forest in the Sylvania Wilderness of the western Upper Peninsula, Frelich et al. (1993) concluded that hemlock and sugar maple exhibit strong positive self-association and negative reciprocal association. Each species alters their local environment, creating conditions in their immediate vicinity that favors self-recruitment and discourages establishment of seedlings of the other dominant. Sugar maple is disadvantaged by the dense shade and low nutrient conditions in the podzolized understory of hemlock-dominated stands. In sugar maple-dominated stands, hemlock seedlings are unable to penetrate the thick coarse duff and are often smothered by the ubiquitous leaf fall of sugar maple.

Vegetation Description: The mesic northern forest is a broadly defined community type with numerous regional, physiographic and edaphic variations. The following tolerant trees can dominate or co-dominate the canopy of this community*: Acer saccharum* (Sugar maple), *Tsuga canadensis* (Eastern hemlock), *Fagus grandifolia* (American Beech) and *Betula alleghaniensis* (yellow birch). Other important components of the canopy include: *Tilia americana* (American basswood), *Pinus strobus* (white pine), *Quercus rubra* (Red oak), *Thuja occidentalis* (white cedar*), Acer rubrum* (red maple), *Betula papyrifera* (paper or white birch) and *Fraxinus americana* (white ash). Tree species associated with this community but most commonly found in the sub-canopy include: *Ostrya virginiana* (ironwood or hop-hornbeam), *Ulmus americana* (american elm) and *Abies balsamea* (balsam fir).
In terms of their relative importance as arboreal components in the mesic northern forest, these trees differ greatly among themselves in different parts of the region and locally within the same region (Nichols, 1935). Significant variation in composition of communities is proportional to marked differences in local topography, soil, disturbance factors, geographic context (Barnes, 1991) and biotic factors such as competitive interactions (Frelich et al., 1993) and browsing pressure (Alverson et al., 1988).

The leading dominant of this community is sugar maple (Curtis, 1959) which thrives on moderately well drained to excessively drained deep soils (Pregitzer, 1981). Sugar maple is typically found in association with beech, basswood, yellow birch, and red oak. Basswood, characteristic on nutrient rich sites, is most prevalent in mixed-hardwood stands in the western Upper Peninsula. In a study in the McCormick Experimental Forest in the western Upper Peninsula, Pregitzer (1981) found that when ground water or bedrock influences the rooting zone, the proportion of conifers and hardwoods other than sugar maple increases. In the northern Lower Peninsula and in the eastern Upper Peninsula, sugar maple and beech occur commonly as co-dominants, frequently thriving on heavy-textured soils such as silt loam and clay loam. The absence of beech in the western Upper Peninsula is probably due to the increased dryness, shorter growing seasons and extreme minimum winter temperatures of this region (Barnes, 1991).

Conifer-dominated mesic northern forests usually have hemlock and yellow birch as the primary canopy components. Often present in these stands are white cedar and large, but widely spaced white pine, relicts of an earlier successional stage generated by forest fire and/or windthrow (Nichols, 1935). The conifer-dominated stands are generally found on moist or poorly drained sites. Mixed stands of hemlock and yellow birch or pure stands of yellow birch occur primarily in depressions or sites adjacent to swamps (Barnes, 1991).

The ground and shrub layer of mesic northern forests, like the overstory, is diverse in compositional variation. Communities of beech and sugar maple have relatively few shrubs but do support many spring ephemerals and perennial herbs. Stands composed of mixed hardwoods tend to have a well-developed shrub layer and a fairly diverse groundlayer. A plethora of spring ephemeral herbs in these assemblages can be attributed to the development of moisture holding and nutrient-rich soils. Sugar maple, yellow birch and basswood enhance the soil with their nutrient rich leaf-fall. In contrast, in hemlock-dominated stands, groundlayer diversity is low due to the nutrient-poor and acidic mor humus as well as the low understory light intensity caused by the perpetually dense hemlock canopy (Curtis, 1959).

Prevalent herbs of the mesic northern forest include: *Actaea pachypoda* (white baneberry), *Actaea rubra* (red

baneberry), *Allium tricoccum* (wild leek), *Aralia nudicaulis* (wild sarsparilla), *Aralia racemosa* (spikenard), *Arisaema triphyllum* (jack-in-the-pulpit), *Carex deweyana, Carex hirtifolia, Carex leptonervia, Carex plantaginea, Carex woodii, Caulophyllum thalictroides* (blue cohosh), *Circea alpina* (enchanter's nightshade), *Circea lutetiana* (enchanter's nightshade), *Clintonia borealis* (blue-bead lily), *Cornus canadensis* (bunchberry), *Galium triflorum* (bedstraw), *Maianthemum canadense* (Canada mayflower), *Mitchella repens* (partridge berry), *Osmorhiza claytoni* (sweet cicily), *Polygonatum pubescens* (Solomon's seal), *Smilacina racemosa* (false spikenard), *Streptopus roseus* (twisted stalk), *Uvularia grandiflora* (bellwort), *Trientalis borealis* (star flower), *Trillium cernuum* (nodding trillium) and *Trillium grandiflorum* (common trillium)

Common ferns and clubmosses of this community include: *Adiantum pedatum* (maidenhair fern), *Athyrium filix-femina* (lady fern), *Athyrium thelypteroides* (silvery spleenwort), *Botrychium virginianum* (rattlesnake fern), *Dryopteris spinulosa* (spinulose woodfern), *Lycopodium annotinum* (stiff clubmoss), *Lycopodium lucidulum* (shining clubmoss) and *Lycopodium obscurum* (groundpine).

Charcteristic shrubs include: *Acer pennsylvanicum* (striped maple), *Acer spicatum* (mountain maple or moosewood), *Cornus alternifolia* (alternate-leaved dogwood), *Corylus cornuta* (beaked hazelnut), *Dirca palustris* (leatherwood), *Lonicera canadensis* (fly honeysuckle), *Ribes cynosbati* (wild gooseberry), *Sambucus pubens* (red elderberry), *Taxus canadensis* (Canada yew) and *Viburnum acerifolium* (maple-leaf viburnum). (Above species lists compiled from MNFI database and from Curtis, 1959; Gleason and Cronquist, 1964; and Nichols, 1935.)

A unique feature of this forest type is the presence of chlorophyll-free, parasitic and saprophytic seed plants such as: Indian pipes (*Monotropa*), coral root orchids (*Corallorhiza*) and beech drops (*Epifagus virginiana*) when beech is a component of the forest. These saprophytes are fed by the thick organic matter in the humus layer of the soil and are further benefited by the constant moisture supply (Curtis, 1959).

Michigan indicator species: *Aralia nudicaulis* (wild sarsparilla), *Betula alleghaniensis* (yellow birch), *Botrychium virginianum* (rattlesnake fern), *Carex hirtifolia, Caulophyllum thalictroides* (blue cohosh), *Circaea alpina* (enchanter's nightshade), *Corylus cornuta* (beaked hazelnut), *Dirca palustris* (leatherwood), *Smilacina racemosa* (false spikenard), *Taxus canadensis* (Canada yew) and *Tsuga canadensis* (hemlock).

Other noteworthy species: Rare plants associated with mesic northern forests include: *Asplenium rhizophyllum* (walking fern), *Asplenium scolopendrium* (hart's-tongue fern), *Asplenium trichomanes-ramosum* (green spleenwort), *Botrychium mormo* (goblin moonwort), *Carex assiniboinensis* (Assiniboia sedge), *Cystopteris laurentiana, Disporoum hookeri* (fairy bells), *Dryopteris filix-mas* (male fern), *Panax quinquefolius* (ginseng), *Tipularia discolor* (cranefly orchid), *Triphora trianthophora* (three-birds orchid), and *Viola novae-angliae* (New England violet).

Two rare raptor species frequently nest in mesic northern forests; *Buteo lineatus* (red-shouldered hawk) and *Accipiter gentilis* (Northern goshawk). Extensive tracts of mesic northern forest provide habitat for large mammals such as moose, wolves and martens. This community provides summer nesting habitat for many neotropical migrants, especially interior forest obligates such as, *Dendroica caerulescens* (black-throated blue warbler), *Dendoica cerulea* (cerulean warbler), *Dendroica virens* (black-throated green warbler), *Piranga olivacea* (scarlet tanager) and *Seiurus aurocappilus* (ovenbird). Rapids clubtail (*Gomphus quadricolor*, state special concern) is a rare dragonfly that utilizes quiet water pools and cool rapid streams that flow through mesic northern forests.

Conservation/management: When the primary conservation objective is to maintain biodiversity in mesic northern forests, the best management is to leave large tracts unharvested and to allow natural processes (growth, senescence, windthrow, fire, disease, insect infestation *etc.*) to operate unhindered. Lorimer and Frelich (1991) estimated the maximum size of an individual downburst in the Great Lakes region to be 3785 ha. Given the large-scale of the catastrophic disturbance to the landscape, recovery from perturbation requires protection of substantial area of forest. Johnson and Van Wagner (1985) suggest that a landscape should be at least twice the size of the largest disturbance event.

When tracts of mesic northern forest are being managed for timber harvest, care should be taken to minimize fragmentation, preserve as much area as possible in a forested matrix and maintain a range of canopy closure comparable to pre-harvest closure. Animal species associated with vernal pools and the groundlayer plant community would benefit from winter harvests. Presently, commercial timber harvest is the most common disturbance occurring in this community. Given time to recuperate, mesic northern forests have shown a high degree of resilience following logging disturbance. Metzger and Schultz (1984) and Albert and Barnes (1987) found that 50 years after logging a well-developed herb layer persisted in the understory of harvested stands.

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Timber management practices that maintain or enhance characteristics of mature structure will help protect the biodiversity value of managed stands. Components of mature structure include: standing snags and dead and down woody material in various stages of decomposition and representing a diversity of species and diameter classes, a diversity of living tree species and an overstory dominated by large diameter trees but including individuals of all age classes.

Research needs: In 1931 George McIntire wrote the following: "Northern Hardwoods as a type has been considered justified because of long, wide and consistent use. This term certainly has been long and widely used but the most consistent thing about it has been the indefiniteness of its application. It is a convenient term but it means little unless accompanied by explicit description." McIntire's turn of the century criticism is still pertinent today and is applicable to the use of the phrase mesic northern forest. Misunderstanding and misuse of the term can be alleviated by the continued refinement of regional classifications that correlate species composition and landscape context.

Given the historical importance of catastrophic windthrow in this system, an important research question to be addressed is how the disturbance regime and species composition of this community will change as the Great Lakes region becomes increasingly fragmented. The prevalence of timber activity in this community demands increased post-harvest monitoring of rare species that depend on this forest and/or old growth conditions. Factors limiting hemlock and yellow birch regeneration need to be continually assessed and techniques for enhancing their regeneration need to be further explored.

Similar communities: Southern Mesic Forest, Dry-Mesic Northern Forest, Dry Northern Forest, Conifer-Hardwood Swamp

Other Classifications:

Michigan Natural Features Inventory Pre-settlement Vegetation (MNFI):
Beech-Sugar Maple-Hemlock, Hemlock-White Pine, Hemlock-Yellow Birch

Michigan Department of Natural Resources (MDNR): M-Northern Hardwoods, H-Hemlock

Michigan Resource Information Systems (MIRIS): 411 (Northern Hardwood), 41101-411109 (Undifferentiated Northern Hardwood), 41111-411119 (Sugar Maple), 41143-41149 (Beech), 41115 (Yellow Birch), 41179 (Basswood), 42 (Coniferous Forest),

The Nature Conservancy National Classification:
CODE; ALLIANCE; ASSOCIATION;
COMMON NAME

I.C.3.N.a; *Tsuga Canadensis-Betula alleghaniensis* Forest Alliance; *Tsuga canadensis-Acer saccahrum-Betula alleghaniensis* Forest; North Central Hemlock-Hardwood Forest.

I.C.3.N.a; *Tsuga Canadensis-Betula alleghaniensis* Forest Alliance; *Tsuga canadensis-Fagus grandifolia-(Acer saccharum)* Great Lakes Forest; Great Lakes Hemlock-Beech-Hardwood Forest.

I.A.8.N.c; *Tsuga Canadensis* Forest Alliance; *Tsuga Canadensis-(Betula alleghaniensis*) Forest; Hemlock Mesic Forest.

I.A.8.N.b; *Pinus strobus-Tsuga canadensis* Forest Alliance; *Pinus strobus-Tsuga canadensis* Great Lakes Forest; Great Lakes White Pine-Hemlock Forest.

I.B.2.N.a; *Acer saccharum-Betula alleghaniensis-(Fagus grandifolia)* Forest Alliance; *Acer saccharum-Betula alleghaniensis-(Tilia americana)* Forest; Maple-Yellow Birch Northern Hardwoods.

I.B.2.N.a; *Acer saccharum-Betula alleghaniensis-(Fagus grandifolia)* Forest Alliance; *Acer saccharum-Fagus grandifoli-Betula spp./Maianthemum canadense* Forest, Beech-Maple-Northern Hardwood Forest.

Related Abstracts: Assiniboia sedge, cerulean warbler, fairy bells, ginseng, goblin moonwort, Northern goshawk, rapids clubtail and red-shouldered hawk.

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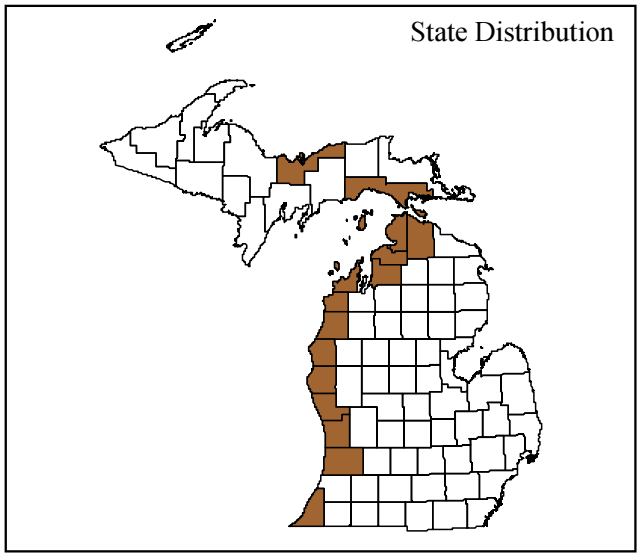
Open dunes — Community Abstract


Photo by Dennis A. Albert.



Global and state rank: G3/S5

Common names: Great Lakes beachgrass dune. Other communities of the dunes include Great Lakes dune pine forest, Great Lakes pine barrens, Great Lakes juniper dune shrubland.

Range: Open dunes are biologically distinct geological features associated with the Laurentian Great Lakes and other large inland lakes, as well as the shorelines of many oceans and seas. Those along the Laurentian Great Lakes are distinguished from other coastal dunes by a distinctive Great Lakes flora and fauna, although some plant species are shared with dunes of the Pacific Northwest (Wiedemann 1984). Great Lakes open dunes occur in Illinois, Indiana, Michigan, New York, Pennsylvania, Wisconsin, and in the Canadian province of Ontario. Small, isolated dune areas also occur on the shores of Lake Champlain in Vermont (Thompson and Sorenson, draft).

Rank justification: There are approximately 275,000 acres of sand dune along Michigan's Great Lakes shoreline, including areas of Lakes Superior, Michigan, and Huron. Other major areas of sand dune are located at Long Point, Ontario; Presque Isle, Pennsylvania; and on Lake Erie along the eastern end of Lake Ontario in New York.

Currently, there are over 40 occurrences for open dune in Michigan. The foredune of many **wooded dune and swale complexes** support the same plant species typically found on open dunes.

While most dune areas remain intact, degradation has occurred on many dunes as the result of residential and road development, sand mining, golf course development, and recreational use by off-road vehicles (Boven et al. 1988). Logging has altered the forested portions of many dunes, generally reducing the amount of upland conifer dominance. Many exotic plants are introduced as a result of residential development (Leege 1997, Comer and Albert 1991, 1993). These exotics are a major source of degradation, disrupting normal dune migration, causing dune stabilization, and often replacing native plant species.

Landscape context: Great Lakes dunes are relatively young, as the Great Lakes were occupied by ice until approximately 16,000 years ago. The dune sands are derived from glacial sediments, including lacustrine and outwash sands and sandy tills (Dorr and Eschman 1970). Most of our larger dune complexes are associated with the Lake Nipissing stage of the Great Lakes, when water levels were 25 to 30 feet higher than present day lake levels (Dorr and Eschman 1970). These higher lake levels resulted in greater amounts of coastal erosion and dune formation. There are also numerous dune features further inland, often associated with glacial Lake Algonquin water levels, from about 12,000 years ago. Most of these older dunes are completely forested and are not represented in our database of open dunes.

Natural processes: A combination of water erosion and wind deposition resulted in the formation of Great Lakes coastal dunes. The sand source for the coastal dunes was glacial sediment that was eroded by streams and by waves eroding bluffs along the Great Lakes shoreline. These sediments were then moved along the Great Lakes shoreline by near-shore currents, and then deposited along the shoreline by wave action. Strong winds then carried the sands inland, creating dunes.

Elaborate classifications of dune types have been developed (Tague 1947, Calver 1947, Buckler 1979, Kelly 1962, Bird 1969). Open dunes includes the full range of dune types found in Michigan, including foredunes, parallel dunes, perched dunes, blow outs, and barrier

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dunes.

Several major dune types are briefly described in the following paragraphs. **Parabolic dunes** are U-shaped, with the bottom of the U inland. Parabolic dunes typically form when stable, forested dunes are destabilized, and they often occur as series of overlapping dune ridges. These are common along the eastern shore of Lake Michigan. Areas of open, destabilized dune are called **blowouts**. While blowouts can occur because of human activities, the original surveyor's notes (Comer et al. 1995) indicated that blowouts were widespread along the coast, probably largely the result of wind storms and lightning strikes.

Parallel dunes is a term used for the series of dune and swale features along major Great Lakes embayments. We use the term **wooded dune and swale complex** for parallel dune complexes and a separate abstract has been written for this community (Albert and Comer 1999).

Perched dune is a term describing wind-blown sand dunes that are perched on top of glacial moraines. Some of Michigan's most famous dunes are perched dunes, including Sleeping Bear Dunes National Lakeshore on Lake Michigan and Grand Sable Banks near Grand Marais (Lake Superior).

Within the dune fields there are often wetlands. Within the wooded dune and swale complexes, both herbaceous and forested wetlands can comprise a major part of the complex. Within other types of dune complexes, wetlands and water bodies range from small, seasonally moist depressions to ponds or lakes.

While wind is the prevalent form of natural disturbance process within the dune fields, fire resulting from lightning strikes probably also occurred, but was likely much less common. Both oaks and pines were common on the dunes, indicating fire was a natural disturbance factor.

Vegetation description: Historically, there has been extreme interest in studying the vegetation of the Great Lakes sand dunes, especially those of southern Lake Michigan, where the concepts of plant succession were developed (Cowles 1899, Olson 1958). On the dunes it is possible to follow succession from unvegetated, recently deposited sand along the shoreline to late-successional forests on the oldest, most stable dunes farther inland.

Physical conditions responsible for the vegetation zones on the dunes include 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 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 further inland, resulting in an 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 forest, with mesic northern hardwood forests increasing in dominance farther from the shoreline.

The foredunes are commonly quite open, harsh habitats, with moving sand, extremely dry conditions, and little organic material for nutrients. Common plants of the foredune include sea rocket (*Cakile edentula*), wormwood (*Artimesia campestris*), Pitcher's thistle (*Cirsium pitcheri,* federally threatened), Lake Huron tansy (*Tanacetum huronense*, state threatened), beach grass (*Ammophila breviligulata*), dune grass (*Calamovilfa longifolia*), autumn willow (*Salix serissima*), dune willow (*S. cordata)*, and balsam poplar (*Populus balsamifera*).

As one leaves the foredune, dune grasses and shrubs continue to stabilize the moving sand, although blowouts can form, maintaining open sand quite far inland. Several shrubs, including ground juniper (*Juniperus communis*), creeping juniper (*J. horizontalis*), bear berry (*Arctostaphylos uva-ursi*), and sand cherry (*Prunus pumila*), begin to stabilize the moving sand, leading to further accumulation of sand into dune features.

As the dunes stabilize farther from the foredune, forests begin to develop. Typically pines, including jack pine *(Pinus banksiana)*, white pine (*P. strobus)*, and red pine (*P. resinosa*), are among the first tree species to establish, forming a scattered overstory canopy. Oaks, especially red oak (*Quercus rubra*) and black oak (*Q. velutina*), also establish in the early stages of forest succession. Gradually forest succession leads to development of a mesic hardwood forest, usually dominated by American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), basswood (*Tilia americana*) and other hardwoods. In the more protected, cooler ravines between dunes, northern white cedar (*Thuja occidentalis*) or eastern hemlock (*Tsuga canadensis*) often grow. This succession is by no means one directional; it is very common to see a stand of cedar or northern hardwoods being buried by a newly activated blowout. As the blowout progresses, it sometimes re-exposes "ghost forests" that were buried far in the past.

Succession can also be seen in the swales and interdunal wetlands within the dune complexes. Wetlands near the shoreline have lake-influenced hydrology and the substrate is calcareous sand. Swales can contain twig-rush (*Cladium mariscoides)*, bladderwort (*Utricularia cornuta*), rush (*Juncus balticus),* and sweet gale (*Myrica gale*), with shrubby cinquefoil (*Potentilla fruticosa*), blue joint grass (*Calamagrostis canadensis*), Kalm's lobelia (*Lobelia kalmii*), false asphodel (*Tofieldia glutinosa*), and grass-of-Parnassus (*Parnassia glauca*) along the drier edges. In the Straits of Mackinac area, federally-threatened Houghton's goldenrod (*Solidago houghtonii*) can be found in the swales. Jack pine sometimes grows along with wetland plants.

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Farther inland the interdunal wetlands typically support shrub swamps or treed swamps. Swamp dominants typically include northern white cedar, balsam fir (*Abies balsamea*), black spruce (*Picea mariana*), paper birch (*Betula paperifera*), red maple (*Acer rubrum*), trembling aspen (*Populus tremuloides*).

Characteristic vegetation of open foredune

Strata	Most abundant
Tree canopy	*Populus balsamifera* (balsam poplar)
Short shrub	*Salix serissima* (autumn willow), *S. cordata* (dune willow), *S. exigua* (sandbar willow), *Juniperus communis* (ground juniper), *J. horizontalis* (creeping juniper), *Arctostaphylos uva-ursi* (bear berry), *Prunus pumila* (sand cherry), *Hudsonia tomentosa* (beach-heath)
Herbaceous	*Cakile edentula* (sea rocket), *Artimesia campestris* (wormwood), *Cirsium pitcheri* (Pitcher's thistle, federally threatened), *Lathyrus japonicus* (beach pea), *Arabis lyrata* (sand cress), *Tanacetum huronense* (Lake Huron tansy, state-threatened), *Asclepias syriaca* (common milkweed), *Lithospermum caroliniense* (hairy puccoon), *Ammophila breviligulata* (beach grass), *Calamovilfa longifolia* (dune grass), *Andropogon scoparius* (little blue stem), *Festuca saximontana* (fescue)

Characteristic vegetation of open interdunal 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 lasiocarpa*, *C. oligosperma* (sedges), *Eleocharis acicularis* (spike-rush), *Cladium mariscoides* (twig rush), *Calamagrostis canadensis* (blue joint grass), *Juncus balticus* (rush), *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 procumbers* (wintergreen)

Michigan indicator species: *Cakile edentula* (sea rocket), *Artimesia campestris* (wormwood), *Ammophila breviligulata* (beach grass), *Calamovilfa longifolia* (dune reed), *Cirsium pitcheri* (Pitcher's thistle), *Tanacetum huronense* (Lake Huron tansy), *Juniperus horizontalis* (creeping juniper), *Prunus pumila* (sand cherry), *Solidago simplex* (Gillman's goldenrod).

Other noteworthy species: Several rare animals are associated with the dunes, including *Charadrius melodus* (piping plover), *Trimerotropis huroniana* (Lake Huron locust), *Sterna herundo* (common tern), *Sterna caspia* (Caspian tern), *Euxoa aurulenta* (dune cutworm), and *Dendroica discolor* (prairie warbler).

Rare plants associated with the dunes include *Cirsium pitcheri* (Pitcher's thistle), *Solidago houghtonii* (Houghton's goldenrod), *Tanacetum huronense* (Lake Huron tansy), *Botrichium campestre*, (dunewort), *B. acuminatum* (acute-leasved moonwort), *B. Hesperium* (western moonwort), and fascicled broomrape.

Invasive, non-native plant species include *Gypsophila paniculata* (baby's-breath), *Rumex acetosella* (red sorrel), *Pinus nigra* (black pine), *Centaurea maculosa* (spotted knapweed), *Populus nigra* var. *italica* (Lombardy poplar), *Saponaria officinalis* (bouncing bet), *Melilotus alba* (white sweet clover), *Elaeagnus umbellata* (autumn olive), and within the interdunal wetlands, *Lythrum salicaria* (purple loosestrife) and *Phragmites australis* (reed) (Penskar et al. 1997, Leege 1997).

Conservation/management: The Atlas of Critical Dunes (Michigan DNR 1989) identifies sand dune areas within the state that are subject to development restrictions. While residential development of the dunes is not forbidden, it is restricted in the law, limiting much of the development to the forested portions of the dunes, where slopes are not as steep and unstable as on the open dunes. Building structures, building roads, or changing contours on slopes steeper than 33% percent is prohibited.

Control of invasive plants is necessary on dunes to restore natural vegetative patterns of diversity. Manual removal and limited herbicide treatment have proven effective in controlling exotics and native woody invasives

Research needs: Monitoring of exotic plants is needed, as well as the monitoring of the effectiveness of exotic plant management. Long-term effectiveness of sand dune regulations on dune processes also needs to be evaluated. Populations of threatened and endangered species associated with open dunes and wetlands within the dunes also

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need monitoring.

Similar communities: sand/gravel beach, wooded dune and swale complex, interdunal swale, Great Lakes barrens

Other classifications

Michigan Natural Features Inventory (MNFI) pre-settlement vegetation: open sand dune and wooded dune and swale complex. Numerous other upland and wetland forest and shrub types occur within the open dune complexes.

Michigan Department of Natural Resources (MDNR): sand dune (code = Y), but several other cover types can occur in open dune complexes.

Michigan Resource Information Systems (MIRIS): sand dune, exposed bluff (code = 73), but several other MIRIS cover types can also occur within open dune complexes.

Other: special, detailed dune classifications were developed as part of the MDNR dune-mining monitoring program (Beckler 1979).

The Nature Conservancy National Classification: code = V.A.5.N.c, alliance: Ammophila breviligulata – (Schizachyrium scoparium) herbaceous vegetation.

Related abstracts: piping plover, Lake Huron locust, common tern, Caspian tern, dune cutworm, prairie warbler, Pitcher's thistle, Houghton's goldenrod, Lake Huron tansy, dunewort, fascicled broomrape

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Photo by Sue R. Crispin.

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Wooded dune and swale complex — Community Abstract


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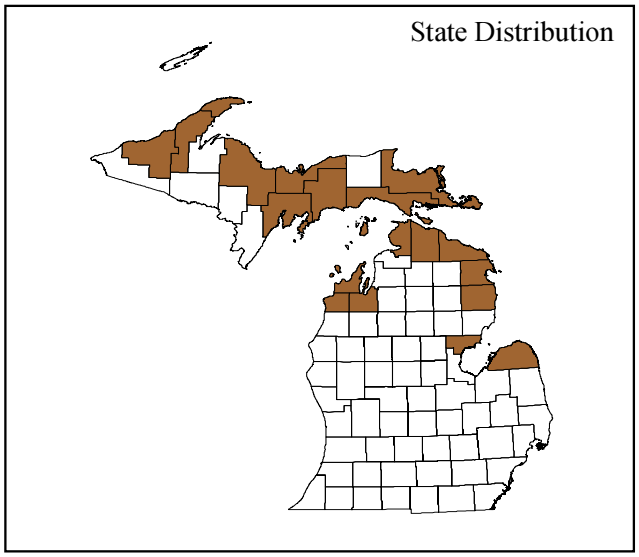

Global and state rank: G3/S3

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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