Biological Inventory for Conservation of Great Lakes Islands: Year 2000 Progress Report

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Bird inset: American Bittern, by Dan Sudia

Executive Summary

In 1998, Michigan Natural Features Inventory (MNFI) initiated a multi-year project to conduct biological inventories for the conservation of Great Lakes islands. The fundamental goal of this project is to systematically examine selected Great Lakes islands, compile comprehensive information on natural features and significant biodiversity areas, and then convey this information in the most useful form for landowner education and conservation planning purposes. The first year of the project focused on several biological inventories in the Beaver Island archipelago (Beaver and Garden islands in Charlevoix County) and a selective floristic survey of several islands within the Garden Peninsula group (Poverty, Summer, and Little Summer islands in Delta County). In 1999, we continued inventories within the Beaver Island archipelago and also conducted inventory work in northern Lake Huron, focusing on Bois Blanc Island (Mackinac County), Marquette and La Salle islands within the Les Cheneaux chain (Mackinac County), and Drummond Island (Chippewa County). In addition, a prototype conservation planning workshop was held on Beaver Island for residents and other island stakeholders.

In 2000, the third year of the study, inventories were conducted in northern Lake Huron, highlighting Bois Blanc Island, Drummond Island, and selected large islands (Burnt Island and Harbor Island) within Potagannissing Bay (Chippewa County). Preliminary work was also completed for preparation of a conservation-planning workshop to be held in 2001 for Drummond Island. Lastly, analysis of the work completed to date was conducted to assess the status of the project and future direction.

Animal Surveys: Surveys on Bois Blanc Island and Drummond Island focused on assessing the abundance and species richness of migratory and breeding birds. Targeted inventories for the red-shouldered hawk and wetland birds were also conducted on both islands. Surveys were conducted for the federally endangered Hine's emerald dragonfly on Drummond Island and for the eastern massasauga on Bois Blanc Island. Overall, 130 different bird species were observed; 108 species were observed during spring migration and 112 species were observed during the summer breeding season. Mean bird abundance and species richness during spring migration and the summer breeding season were greater on Bois Blanc Island when compared to Drummond Island, although overall, a greater number of birds and a greater number of species were recorded on Drummond Island. An assessment of habitat use by migratory and breeding birds was conducted on each island and the data were compared. Counts of migratory and breeding birds on Bois Blanc Island at shoreline and inland water habitats were higher when compared with counts at interior habitats. On Drummond Island counts of migratory birds were higher at interior and inland water sites while counts of breeding birds were highest at inland water sites. Rare birds observed on the islands included American bittern, bald eagle, black tern, Caspian tern, common tern, common loon, marsh wren, merlin, northern harrier, osprey, and red-shouldered hawk. No Hine's emerald dragonflies were found on Drummond Island although suitable habitat was identified. The eastern massasauga was not found on Bois Blanc Island during targeted surveys although reliable recent reports by local residents were recorded and abundant suitable habitat was found.

Plant Surveys: Rare plant inventories were conducted on Burnt Island and Harbor Island in Potagannissing Bay from July 18-20, focusing on Great Lakes endemic species such as dwarf lake iris, Pitcher's thistle, Michigan monkey-flower, and Houghton's goldenrod, as well as examination of natural communities potentially supporting these species. Other target species included calypso orchid, Alaskan orchid, ram's head orchid, English sundew, and butterwort, all of which can be expected in shoreline and near shoreline habitats. Despite careful searching of both islands, no rare plant populations were identified. A previously documented locality for Lake Huron tansy on the eastern shore of Harbor Island was inventoried, but no individuals could be identified. Although no rare plant colonies were discovered on Harbor and Burnt islands, listed taxa may occur. During the inventory for rare plant taxa, MNFI staff botanists assisted in the delineation of natural communities and the compilation of data for new occurrences of these elements.

Natural Community Surveys: Natural community inventories were conducted on Burnt Island and Harbor Island in mid-July in collaboration with staff botanists. Prior to field inventories, aerial photo review of these sites was conducted, using 1978 MDNR color infrared imagery of 1:24,000 scale. Maps with delineated communities and habitats were prepared for each island. Field survey identified six high quality natural communities. High quality occurrences of Great Lakes marsh and boreal forest were located on both Harbor and Burnt Islands. In addition, a red oak -dominated mesic northern forest was located on Harbor Island. Three high quality natural communities were found on Harbor Island, a boreal forest occurred on both the island's southeast and west sides, Great Lakes marsh occupied the

island's bay, and mesic northern forest was located on the island's east side. On Burnt Island we located a large, contiguous block of high quality boreal forest and two occurrences of Great Lakes marsh, one on the northwest side and the other on the southeast side of the island. As a result of the historically low Great Lakes water levels, all of the Great Lakes marshes had extensive areas of open mudflats which were being colonized by a variety of native wetland plants.

Digitizing Natural Features: Element occurrences were digitized for all species and natural communities identified during 2000 surveys, in addition to all additional occurrences previously known for Bois Blanc Island and Burnt and Harbor islands. This resulted in the digitization of more than 50 occurrences for these three islands.

Conservation Outreach: Preliminary planning activities were initiated for preparation of a 2001 conservation outreach workshop to be held in mid-summer on Drummond Island. This planning consisted of notifying key contacts for participation in this effort and the compilation of land-use and other information (e.g. GIS land cover, presettlement vegetation data) necessary for the presentation. The Nature Conservancy (TNC) Northern Lake Huron Bioreserve Director, Jesse Hadley, was contacted to assist in discussing strategies. TNC will help in communicating with important stakeholders and also take part in the 2001 outreach workshop as appropriate. As part of 2001 activities, it was determined that an MNFI staff ecologist will photo interpret Drummond Island to provide a type map as an additional resource for the conservation planning effort.

Summary of Island Project: Of the 31 islands or island groups identified as the highest priorities by Soule (1993) in her comprehensive island biodiversity report, MNFI has completed inventories for 16, or more than one-half of these sites. A total of 41 elements were identified during three years of island surveys, consisting of 12 natural community types, 16 rare plant species, and 13 rare animal species. Of the grand total of 146 occurrences documented, 62 (42%) consisted of previously known occurrences that were relocated and updated, whereas 84 (58%) were identified as new occurrences. Thirteen, or nearly one-third of the 41 elements identified are classified as globally rare to globally critically imperiled by TNC, indicating the importance of these findings. In addition to the identification of listed species and natural communities, a significant component of island inventory was devoted to migratory and breeding bird surveys. These surveys have been conducted on Beaver Island, Garden Island, Bois Blanc Island, and Drummond Island, and the results have been compared among these sites with regard to bird richness, mean abundance, and habitat use. The findings will provide important guidance in conservation planning recommendations. A final component of surveys was an exploratory year of aquatic investigation, which was initiated on Beaver Island. An inventory of two streams and four lakes concluded that the aquatic systems were unique and had notable ecological diversity.

An important part of island inventories included processing information for use within a Geographic Information System (GIS), and to this end, all MNFI field information and all pre-existing island data were digitized. This has resulted in the digitization of more than 210 occurrences covering all of the Beaver Island archipelago, portions of the Les Cheneaux islands, and Bois Blanc Island, with Drummond Island slated for digitizing in 2001.

Lastly, conservation outreach was initiated by conducting a prototype workshop on Beaver Island, and preliminary planning was completed for a similar exercise scheduled for Drummond Island in 2001. Presentations on Beaver Island provided an opportunity assess what types of information are desired by the local community and how this information is most likely to be integrated into island conservation planning. Assessment of the 1999 workshop will assist in preparation of the 2001 Drummond Island workshop, with a final conservation outreach workshop targeted for Bois Blanc Island in 2002.

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Introduction

This progress report presents the results of year three of a multi-year project to conduct systematic inventories of selected Great Lakes islands and island groups, followed by selected conservation planning workshops. As noted previously (Penskar et al. 1999), a considerable portion of the biological diversity unique to the Great Lakes region is found on islands. Soule (1993) stated that "nowhere else does the combination of vast, interconnected, mid-continental bodies of freshwater and such a number of variety of islands occur." Thus, the nearly 600 islands contained within Michigan's borders comprise a critically important part of this freshwater landscape, owing to their richness in variety of geography, geological origin, indigenous and non-indigenous human history, and biodiversity.

Over the past two decades Michigan Natural Features Inventory (MNFI) has surveyed numerous natural communities and rare species found on or allied with Great Lakes islands. This extensive work was described in part by Soule (1993) and was detailed in previous years' progress reports (Penskar et al. 1999, 2000). Conducting comprehensive biological inventories on Great Lakes islands is both timely and crucial to future conservation planning, as reflected in the findings and recommendations of The State of the Great Lakes Island Report (Vigmostad 1999). Vigmostad reports the proceedings of a 1996 U.S-Canada Great Lakes islands workshop convened by the Great Lakes Island Project (Department of Resource Development, Michigan State University) to determine the state of Great Lakes islands and elucidate potential conservation strategies. Among the three fundamental findings of the workshop was a recommendation for governments and other entities to support island and archipelago conservation, and to that end, to base conservation planning on sound scientific information. Comprehensive inventories are thus critical to building the strong base of scientific knowledge upon which conservation strategies are dependent.

In this compilation of our third-year efforts, we provide the results of various biological inventories conducted by zoologists, botanists, and ecologists on Bois Blanc Island, Drummond Island, and two prominent islands within Potagannissing Bay (Burnt Island and Harbor island), all of which lie in northern Lake Huron. As in the two prior progress reports, important biodiversity areas are highlighted in a conclusion section. Also provided are brief descriptions of inventory targets for 2001 and an overview of planning for a conservation outreach workshop scheduled to be held on Drummond Island in July 2001. In addition, an analysis of the project to date is provided as both an overview and a basis for assessing the future direction of this multi-faceted effort.

Organization of Report

This report has been organized according to the various inventories conducted on the aforementioned islands, followed by a description of preliminary organizational work for a conservation planning effort on Drummond Island and then a comprehensive project overview. Biological inventories in year 2000 consisted of the following types: animal surveys, with an emphasis on migratory birds, breeding birds, and selected reptiles, amphibians, and rare invertebrates; plant surveys, focusing on Great Lakes shoreline endemics and the identification of intact coastal and interior habitats; and lastly, natural community surveys, emphasizing the delineation and assessment of high quality natural communities, with an emphasis on Great Lakes marsh and other important shoreline habitats, as well as interior communities such as boreal forest and mesic northern forest. Methods, results, and discussion are provided separately for each of the aforementioned components. The report concludes with an assessment of significant biodiversity areas and a brief description of the projected and ongoing work for year 2001 surveys.

The Study Areas

In northern Lake Huron, the study sites for the third year of island inventory included Bois Blanc Island in the Mackinac Straits region and Drummond, Burnt, and Harbor islands on the eastern border of the Upper Peninsula (Figure 1). Bois Blanc Island (Figure 2), located just east of the Straits of Mackinac, is the largest island within the immediate Straits region, covering approximately 23,650 acres and comprising about 36 miles of shoreline. A significant portion of Bois Blanc Island consists of state land within Mackinaw State Forest. Drummond Island (Figure 3), an island exceeded in size only by Isle Royale within Michigan, is the easternmost point of Michigan's Upper Peninsula and covers more than 83,000 acres and approximately 130 miles of Great Lakes shoreline. A significant portion of Drummond Island lies within

Lake Superior State Forest. Burnt Island (Figure 4) and Harbor Island (Figure 5) are the largest islands within Potagannissing Bay, occuring in close proximity to the western shore of Drummond Island. Burnt Island, which is among a local cluster of islands owned and managed by the Pym family foundation[1], is slightly more than 433 acres in size, with 7.5 miles of Great Lakes shoreline. Harbor Island, which is federally owned and managed by the U.S. Fish and Wildlife Service as part of the Seney National Wildlife Refuge, is just over 700 acres in size, comprising nearly 9 miles of Great Lakes shoreline.

Methods for Animal Surveys

Animal surveys on Bois Blanc Island and Drummond Island focused on assessing the abundance and richness of migratory and breeding birds, and in particular Neotropical migratory songbirds. Targeted inventories for red-shouldered hawk (*Buteo lineatus*) and wetland birds were also conducted on both islands. Surveys were initiated on Drummond Island for the federally endangered Hine's emerald dragonfly (*Somatochlora hineana*). In addition, surveys for the eastern massasauga (*Sistrurus catenatus catenatus*) were conducted on Bois Blanc Island (Figure 2).

The MNFI Biological and Conservation Database (BCD) was consulted for known occurrences of rare animal species associated with these islands. Information on various 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, landcover maps, and by consulting with individuals knowledgeable about the islands' flora and fauna. 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. 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 or threatened were noted by all project staff when they occurred. Special concern species were also sought and recorded. Data from all sightings of listed animal species were recorded on MNFI field forms, including numbers of individuals observed and the extent and quality of occupied habitat. These data were then entered into the statewide BCD. All birds species observed during spring and summer island visits were noted and recorded.

Justification for Animal Target Selection

The importance of stopover sites to migratory birds that travel great distances between their wintering and breeding grounds has only recently been addressed (Moore and Simons 1992, Moore et al. 1993). Migration is one of the most energy demanding processes in a bird's life, resulting in a weight loss of approximately one-percent per hour of flight (Alerstam 1990). The risks that migratory birds face in seeking to replenish their energy reserves while avoiding predators and adverse weather conditions in unfamiliar habitats have been well-documented (Lindstrom 1989, 1990, Aborn 1993, Wiedenfield and Wiedenfield 1995). Since birds spend as much as half of the year or more en route between breeding grounds and wintering areas, the habitats they depend on during this period are critical links in their survival. Defining the characteristics of suitable stopover habitat, and determining how development and land-use affect their distribution and quality is an important issue that must be addressed. Degradation or elimination of suitable stopover habitats has the potential to increase mortality, reduce reproductive potential, and contribute to overall population declines of migratory birds.

The Great Lakes shorelines serve as important migration corridors for large concentrations of migrant landbirds (Beebe 1933, Perkins 1964, Hussel et al. 1992). Great Lakes islands may act as focal points for migratory birds which tend to accumulate near ecological barriers (Moore and Simons 1992). Scharf (1996) suggested three possible reasons that Great Lakes islands are attractive to Neotropical birds as well as short distance migrants including: 1) nocturnal migrants that find themselves over open water at dawn seek the nearest land, 2) islands often represent northward extensions of the mainland and are included in the flight-path north by internal orientation mechanisms of birds and stochastic events of weather patterns, 3) islands are the intended destination of

[1] Permission to survey Burnt Island on behalf of the Pym family foundation was kindly given by Ms. Sally Campbell of Niles, Michigan.

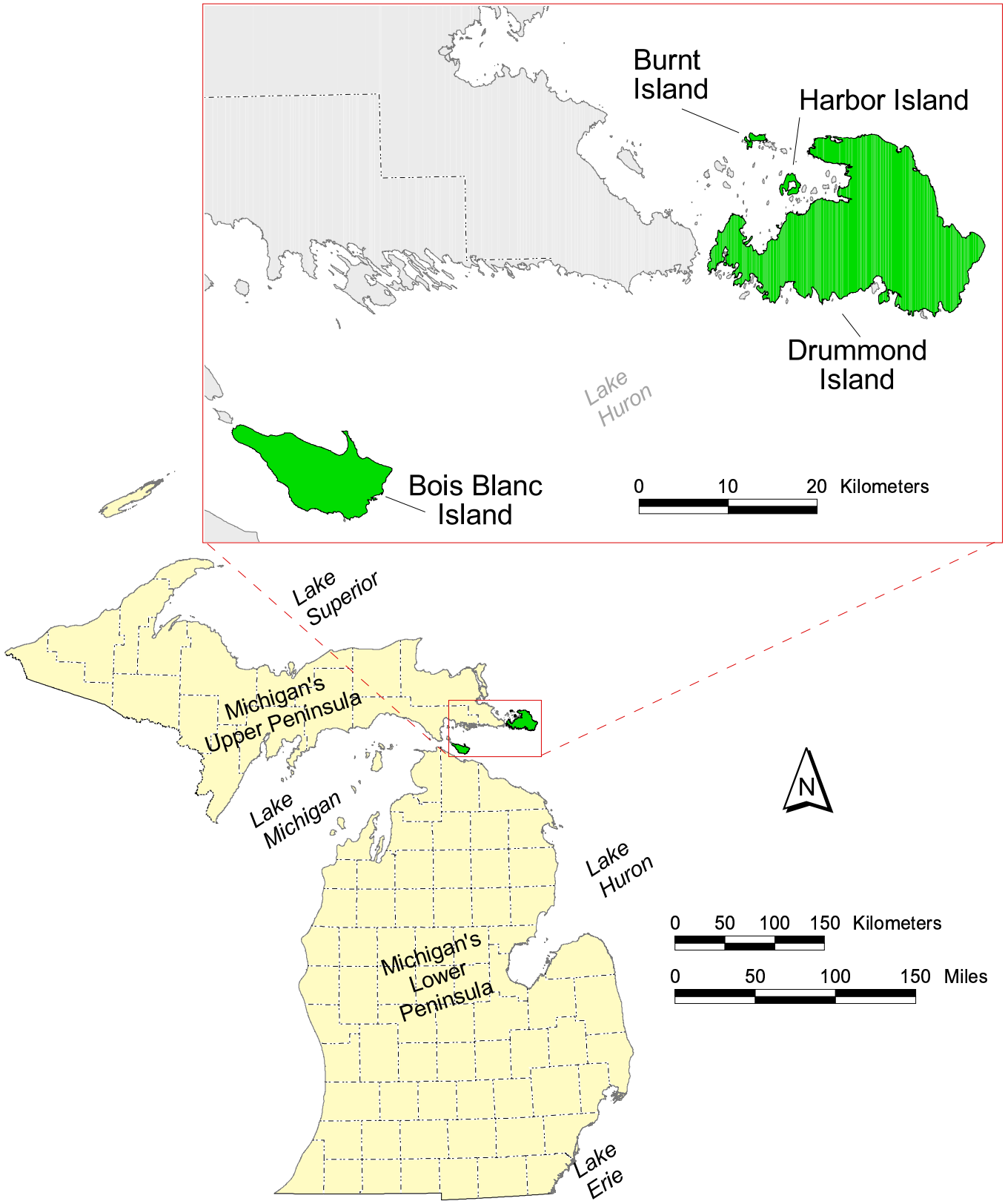


Figure 1. The study areas in northern Lake Huron

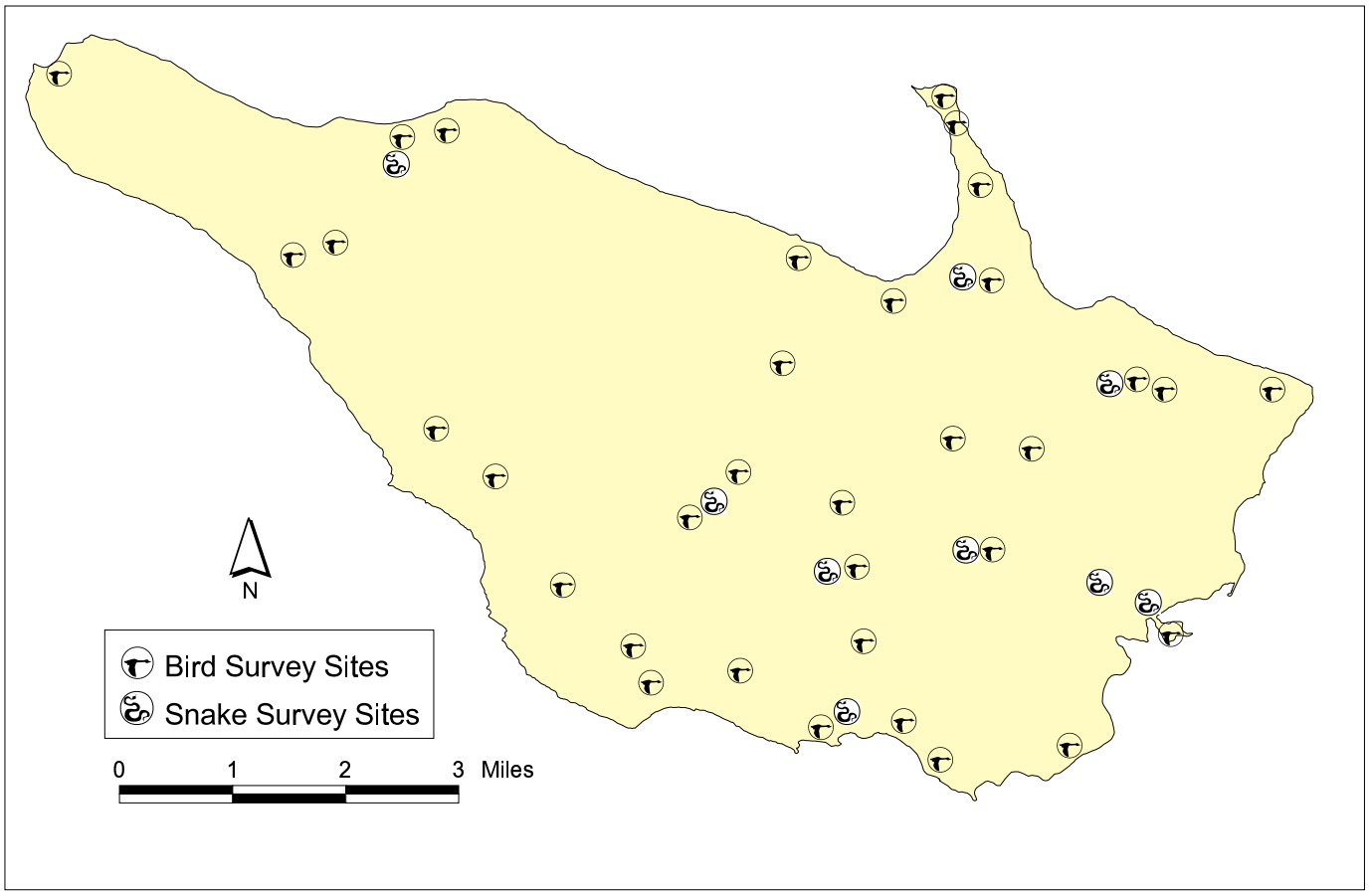


Figure 2. Bird and snake survey sites on Bois Blanc Island

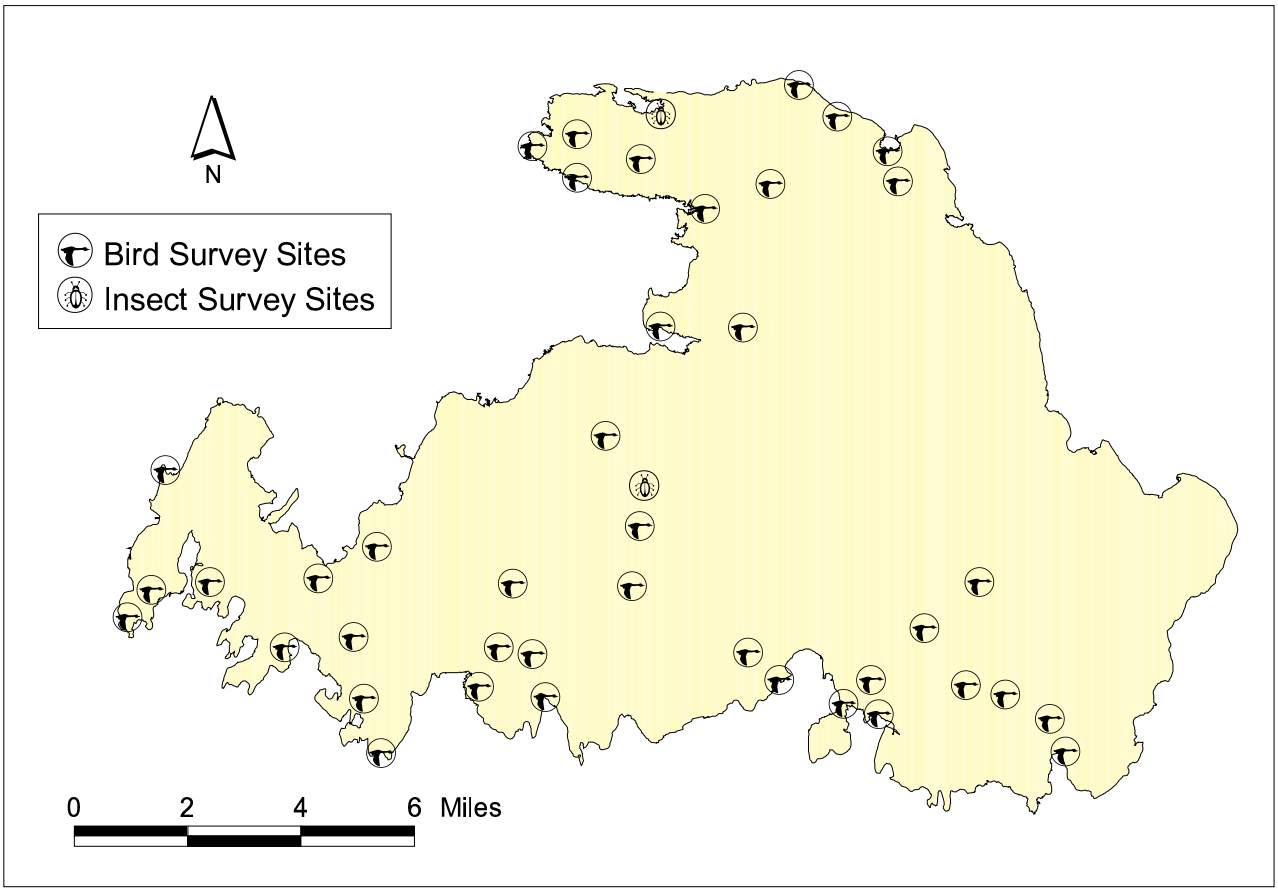


Figure 3. Bird and insect survey sites on Drummond Island

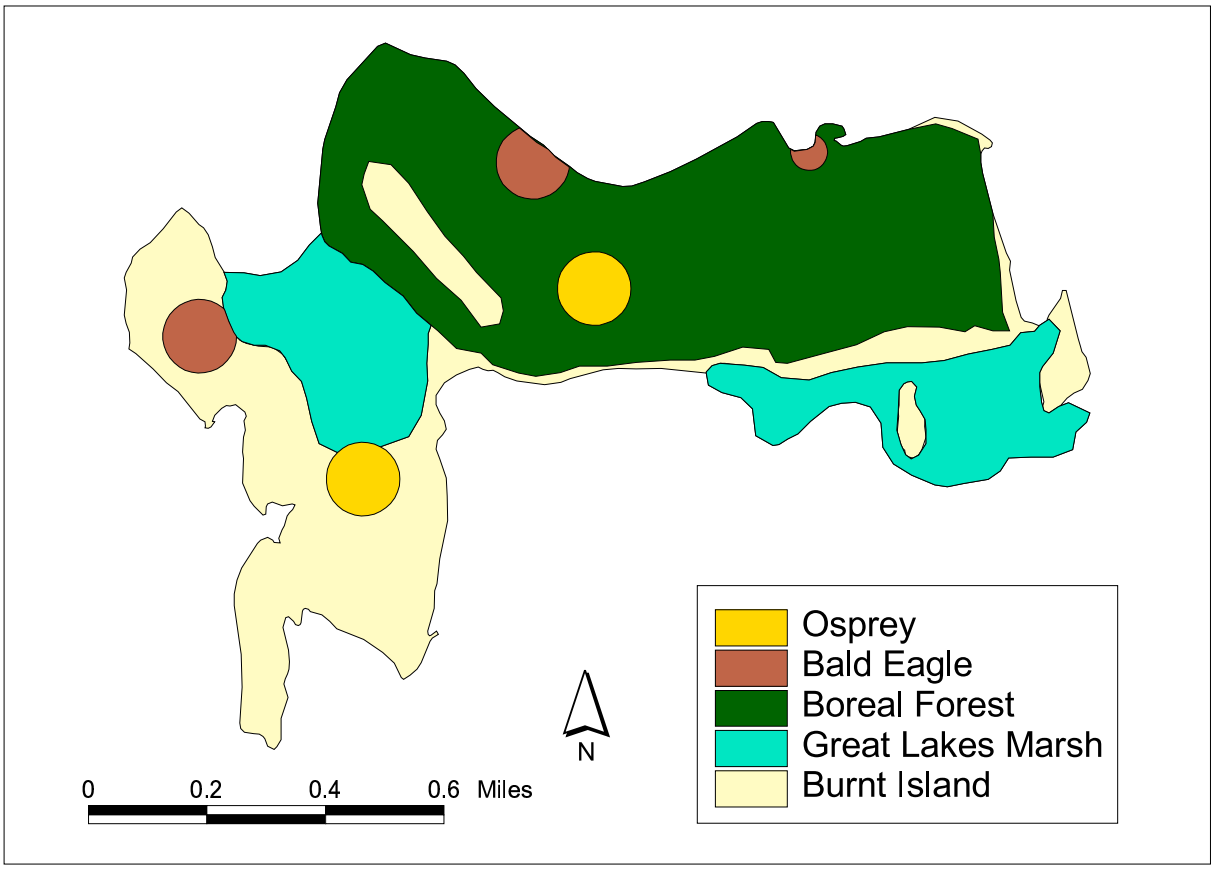


Figure 4. Digitized elements on Burnt Island

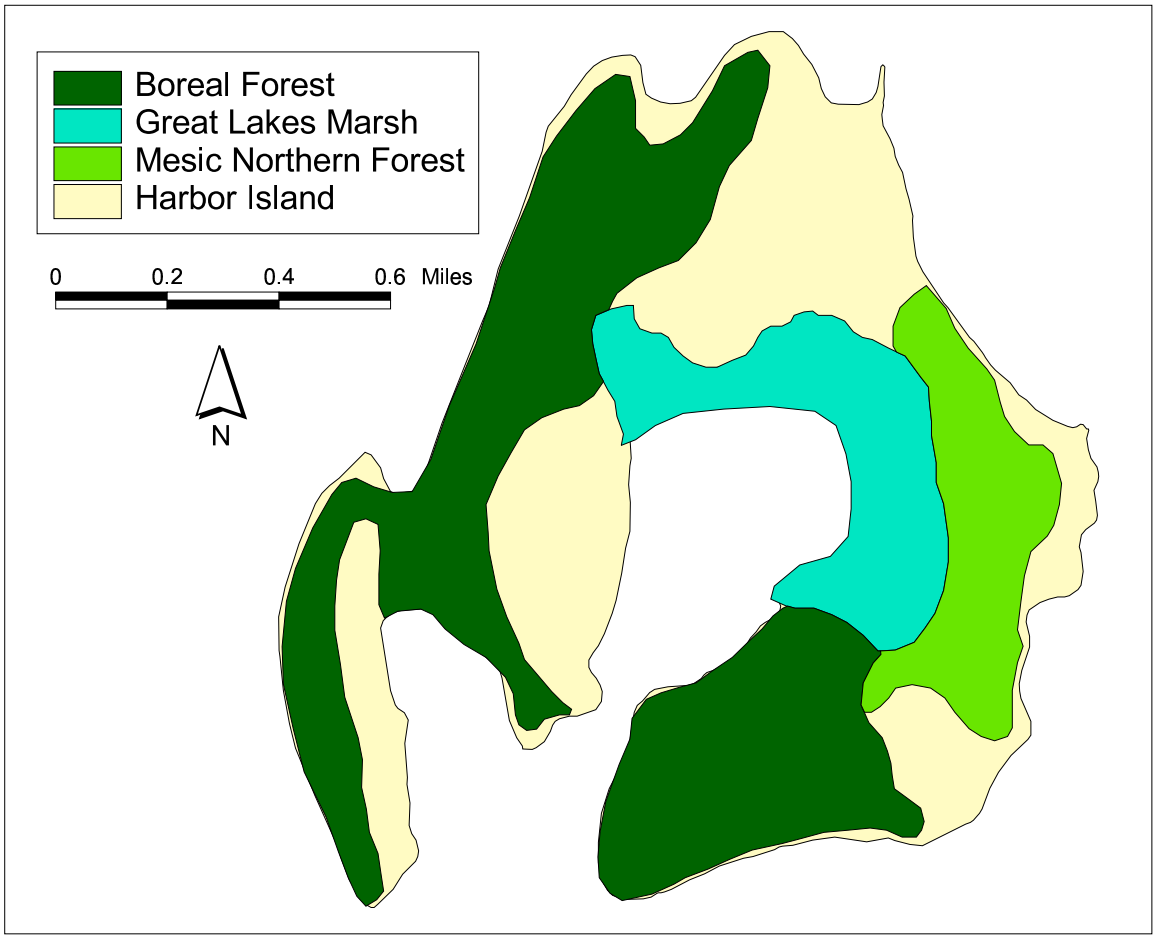


Figure 5. Digitized elements on Harbor Island

migratory species that regularly nest on the islands.

In their 1993 study, Ewert and Hamas (unpubl. data) documented the importance of the immediate shoreline along the northern shore of Lake Huron as critical stopover habitat for Neotropical migratory birds. They found that this shoreline habitat provides an important food source, in the form of aquatic midges, to spring migrants that arrive before terrestrial insects are abundant. It would thus seem logical that Bois Blanc Island, located just southwest of this study area, and Drummond Island located to the east, with similar shoreline habitats, might also provide important stopover sites for migratory songbirds.

The state threatened red-shouldered hawk (*Buteo lineatus*) has experienced declines in Michigan due to loss of its preferred nesting habitat. It nests in floodplain forests or extensive mature deciduous or mixed forest complexes. Typically these forest complexes have wetland habitats nearby or wetlands interspersed among these forested habitats (Cooper 1999). Red-shouldered hawks have not been well documented on Bois Blanc or Drummond Island although suitable habitat exists on both of these islands.

Due to the abundance of wetland habitat on Bois Blanc and Drummond Island, rare wetland birds were targeted for surveys. These include the state endangered yellow rail (*Coturnicops noveboracensis*), which is only known from three locations in Michigan, including one on Drummond Island, the state threatened least bittern (*Ixobrychus exilis*), and the state special concern American bittern (*Botaurus lentiginosus*).

The Hine's emerald dragonfly is an extremely rare dragonfly that was listed as federally endangered in January 1995 (DOI 1995). This species is currently known from northern Michigan, northeastern Illinois, Door County in northeastern Wisconsin, and one site in the Missouri Ozarks (D. Cuthrell pers. comm.). Historically, the species was known to occur in three areas of Ohio, and from one site in Indiana. In addition, one specimen had been collected in northern Alabama. The Hine's emerald dragonfly was first documented in Michigan in 1997. Since this time, three distinct populations at a number of sites have been found in Michigan in the Upper Peninsula, northern Lake Huron (Bois Blanc Island), and the northern Lower Peninsula. The Hine's emerald dragonfly is thought to be restricted to wetland habitats characterized by thin soils over dolomite bedrock with marshes, seeps, and sedge meadows (U.S. Fish and Wildlife Service 1999).

The eastern massasauga is currently listed as a species of special concern in Michigan due to the loss and degradation of its preferred habitat as well as widespread human persecution. These snakes occupy shrubby or marshy lowlands that are immediately adjacent to open uplands and use both habitats at different times of the year (Harding 1997). Michigan appears to be the last U.S. stronghold for this species relative to other states within its range (Szymanski 1998). Thus, conservation and recovery efforts in Michigan are particularly crucial for ensuring the long-term viability of this species. In the past, eastern massasaugas were reportedly common on Bois Blanc Island. They are disjunct from Lower Peninsula populations, are at the northern limit of their range, and are thought to achieve a larger size on the island than elsewhere within their range. The Snake Island wetland complex, a small peninsula that is a designated State Natural Area on the eastern edge of Bois Blanc Island, is thought to provide one of the more important habitats for massasaugas on the island (Taylor 1995).

Birds

Bird counts using the point count method were conducted using standard methodology as outlined by Ralph et al. (1993, 1995). All birds seen or heard within a 50-meter 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 also noted. Spring bird counts were conducted between sunrise and 1200 hr on 16-19 May 2000 on Bois Blanc Island and Drummond Island. Breeding bird counts were conducted between sunrise and 1000 hr on 14-17 June 2000 on Bois Blanc Island and 14-18 June 2000 on Drummond Island. All counts were conducted when there was no precipitation and little or no wind. Surveys began immediately after the observer arrived at the location. Point counts were conducted at least 250m apart to ensure that each bird was counted only once. Standard field forms for point counts were used.

Point counts were conducted at 34 sites on Bois Blanc Island and at 41sites on Drummond Island in a variety of habitats (Figures 2 and 3). Nine major habitat types on Bois Blanc Island were sampled for migratory and breeding birds. They included:

- Four forest habitats: mixed deciduous and coniferous forest, aspen/ birch, northern hardwoods, and white cedar-dominated areas.
- Three wetland habitats: sedge meadow, conifer swamp, and northern fen adjacent to lakes.

- Two open habitats: old field and abandoned orchard.

Ten major habitat types on Drummond were sampled for migratory and breeding birds. They included:

- Four forest habitats: mixed coniferous, white cedar-dominated areas, northern hardwoods, and aspen/birch sites.
- Four wetland habitats: sedge meadow adjacent to lakes or rivers, northern fen adjacent to lakes, Great Lakes Marsh, and scrub/shrub wetland
- Two open habitats: alvar and old field.

Overall mean bird abundance was calculated by dividing the total number of birds observed within 50m at each of the point count stations by the total number of stations censused on each island. Species richness was calculated by dividing the total number of species recorded at each of the point count stations by the total number of stations censused on each island. These means were calculated with a 95% confidence level. Dominant species were identified by calculating the total number of observations for each species at each of the point count stations by the total number of stations censused on each island.

An informal assessment of habitat use by migratory and breeding birds on the islands was conducted. Habitats were delineated as shoreline, interior, or inland water sites. Shoreline sites were those points located between the shoreline and 0.4km (0.25mi) inland. Interior sites were greater than 0.4km (0.25mi) from the shoreline. Inland water sites were greater than 0.4km (0.25mi) from the shoreline. Mean bird abundance and species richness was calculated for shoreline, interior, and inland water sites. Of the 34 point count stations on Bois Blanc Island, 13 were designated as shoreline, 14 were designated as interior, and 7 were designated as inland water sites. Of the 41 point count stations on Drummond Island, 15 were designated as shoreline, 16 were designated interior, and 10 were designated inland water sites.

On Bois Blanc and Drummond islands, surveys for the state threatened red-shouldered hawk were conducted in areas of appropriate habitat. Standard methodology outlined by Kennedy and Stahlecker (1993) was used. Taped conspecific red-shouldered hawk calls were broadcast with a predator caller three times at the following directions and intervals: 60 degrees for 10 seconds, 180 degrees for 10 seconds, and 300 degrees for 10 seconds. This was followed by 30 seconds of listening. This calling sequence was repeated three times at each calling station. When hawks responded to the taped calls, observers intensively searched for birds and/or a nest in the direction the call was initially heard.

Surveys for wetland birds were conducted on both islands in appropriate habitats. Taped American bittern and least bittern calls were broadcast with a predator caller at a number of wetlands on Bois Blanc Island and Drummond Island. Surveys for the yellow rail were conducted during the evening or early morning hours at two sedge meadows on the southern part of Bois Blanc Island and on two nights at Scott Bay on Drummond Island, a known yellow rail breeding site. Surveys were conducted by clicking two metal coins together to mimic the pattern and sound of their territorial call, which is a series of clicks, usually in a “tick tick… tick tick tick” pattern. The state threatened common loon (*Gavia immer*) is known from Bois Blanc and Drummond Islands. Observations with binoculars or a spotting scope were made at inland lakes on these islands to determine if loons were feeding or nesting at these locations.

Insects

Meander surveys were conducted for the Hines emerald dragonfly by walking through suitable habitat during the appropriate time of year on Drummond Island on 25-26 July 2000 around Marl Lake, and Grand Marais Lake. Adult dragonflies in the genus *Somatochlora* 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.

Reptiles

Meander surveys were conducted for eastern massasauga by walking through appropriate habitats on Bois Blanc Island on 16-19 May 2000 and 14-17 June 2000. A variety of habitats were surveyed including; a northern fen community located along the southern shore of the island (east of the ferry dock), the wetlands within the Snake Island and Mud Lake Nature Study Area, the sedge meadow adjacent to East Twin Lake and north of Twin Lake Creek, and along the wetland margins of Thompson Lake, Deer Lake and Lake Mary.

Results of Animal Surveys

Birds

One hundred and thirty different bird species were observed as part of this study during spring migration and the summer breeding season (Table 1). One hundred eight different species were observed during spring migration and 112 species were observed during the summer breeding season. Fifty-two species can be classified as long distance migrants (birds that winter south and breed north of the Tropic of Cancer). Fifty-two species are classified as short distance migrants (birds that winter in the southern U.S. and northern Mexico and breed in the U.S. and Canada). Twenty-six species can be considered residents (birds that winter and breed in the same region).

During spring migration surveys 77 bird species were observed on Bois Blanc Island and 90 bird species were observed on Drummond Island. During the breeding season surveys, 68 bird species were observed on Bois Blanc Island and 99 bird species were observed on Drummond Island. During the migration and breeding season counts a total of 87 species were recorded on Bois Blanc Island and a total of 118 species were recorded on Drummond Island (Table 1).

Mean bird abundance during spring migration was greater on Bois Blanc Island when compared with Drummond Island (Table 2). Species richness during spring migration was greater on Bois Blanc Island than on Drummond Island. During spring migration, the black-throated green warbler (*Dendroica virens*) and the American redstart (*Setophaga ruticilla*) were identified as dominant species on both Bois Blanc and Drummond Island. Other dominant species represented on the islands censused during spring migration include blue jay (*Cyanocitta cristata*), ovenbird (*Seirus aurocapillus*), myrtle warbler (*Dendroica coronata*), Nashville warbler (*Vermivora ruficapilla*), red-eyed vireo (*Vireo olivaceus*), black and white warbler (*Mniotilta varia*), and American robin (*Turdus migratorius*).

Mean bird abundance during the summer breeding season was greater on Bois Blanc Island when compared with Drummond Island (Table 3). Species richness during the summer breeding season was higher on Bois Blanc Island than on Drummond Island. During the summer breeding season the American redstart, black-throated green warbler, song sparrow (*Melospiza melodia*) and myrtle warbler were identified as dominant species on both of the two islands censused. Other dominant species recorded during the summer breeding season include the red-eyed vireo, cedar waxwing (*Bombycilla cedrorum*), ovenbird and white-throated sparrow (*Zonotrichia leucophyrs*).

During both spring migration and the breeding season on Bois Blanc Island, a greater number of individual birds and a greater number of bird species were recorded near cobble shoreline bordered by coniferous forest, or near an inland lake or wetland. Fewer numbers and species of birds were seen or heard in upland deciduous forests at interior locations on the island (Figure 6). The only interior sites on the island where high numbers of birds were counted were in upland habitats characterized by early successional vegetation such as old fields and orchards containing ground juniper and low growing shrubs.

During migration counts on Drummond, a greater number of individual birds and a greater number of bird species were seen at interior and inland water sites when compared with shoreline sites, although these differences are only slight and are certainly not significant (Figure 7). This sharply contrasts with the results on Bois Blanc Island. Habitat types at interior sites included: beech/maple forest, cedar-dominated forest, mixed conifer forest, alvar, old field, and aspen/beech forest. Half of the interior sites on Drummond were either at alvar or beech/maple forest habitats. Alvar and mixed conifer habitats appeared to be the most productive and resulted in higher bird counts. During breeding birds counts there was a greater number of individual birds and a greater number of bird species observed at inland water sites (Figure 8). This was similar to the results for Bois Blanc Island. Inland water habitats included: sedge meadow, scrub/shrub wetland, aspen-birch forest, northern fen, mixed conifer forest, and white cedar-dominated forest. Four of the ten inland water sites were at sedge meadow habitats. Sedge meadow habitats seemed to be the most productive and resulted in greater bird numbers. Species richness was greater on Bois Blanc Island during the breeding season (Figure 9).

It is important to note that habitat type was not controlled for in this informal comparison. It is not known whether differences in bird numbers at shoreline, interior and inland water sites were due to the proximity of the site to the shoreline, inland lake or wetland, or some other habitat-related factor.

State threatened and special concern birds were observed on all of the islands (Tables 4 and 5). The common loon was observed on Bois Blanc Island at Thompson Lake (adults and young) and Lake Mary

Table 1. Bird Species Recorded During Migration (M) and Breeding Seasons (B) on Bois Blanc Island and Drummond Island, Mackinac County and Chippewa County MI, 2000.

Common Name	Scientific Name	Bois Blanc	Drummond
Long Distance Migrants:			
Pied-billed grebe	*Podilymbus podiceps*		M, B
Blue-winged teal	*Anas discors*		B
American widgeon	*Anas americana*		B
Osprey (T)	*Pandion haliaetus*		M, B
Broad-winged hawk	*Buteo platypterus*	M	M, B
Merlin (T)	*Falco columbarius*		B
Solitary sandpiper	*Tringa solitaria*		M
Spotted sandpiper	*Actitis macularia*	M, B	M, B
Caspian tern (T)	*Sterna caspia*	M, B	B
Common tern (T)	*Sterna hirundo*	M	B
Black tern (SC)	*Chlidonias niger*		B
Common nighthawk	*Chordeiles minor*	M	
Chimney swift	*Chaetura pelagica*	M	B
Ruby-throated hummingbird	*Archilochus colubris*	M, B	M
Eastern wood peewee	*Contopus virens*	B	B
Alder flycatcher	*Empidonax alnorum*		B
Willow flycatcher	*Empidonax traillii*	B	B
Least flycatcher	*Empiodonax minimus*	M, B	M, B
Great crested flycatcher	*Myiarchus crinitus*	M, B	M.B
Eastern kingbird	*Tyrannus tyrannus*	B	M, B
Purple martin	*Progne subis*		M, B
Bank swallow	*Riparia riparia*		B
Cliff swallow	*Hirundo pyrrhonata*		M.B
Barn swallow	*Hirundo rustica*	M	B
Veery	*Catharus fuscescens*	M, B	M, B
Swainson's thrush	*Catharus ustulatus*		M, B
Wood thrush	*Hylocichla mustelina*	M, B	B
Gray catbird	*Dumatella carolinensis*	M, B	B
Blue-headed vireo	*Vireo solitarius*	M	M, B
Warbling vireo	*Vireo gilvus*		B
Red-eyed vireo	*Vireo olivaceus*	M, B	M, B
Tennessee warbler	*Vermivora peregrina*		M
Nashville warbler	*Vermivora ruficapilla*	M, B	M, B
Northern parula	*Parula americana*	M, B	B
Yellow warbler	*Dendroica petechia*	M, B	M, B
Chestnut-sided warbler	*Dendroica pensylvanica*	M, B	M
Magnolia warbler	*Dendroica magnolia*		M, B
Cape may warbler	*Dendroica tigrina*	M, B	
Black-throated blue warbler	*Dendroica caerulescens*	M	
Black-throated green warbler	*Dendroica virens*	M, B	M, B
Blackburnian warbler	*Dendroica fusca*	M, B	M
Black-and-white warbler	*Mniotilta varia*	M, B	M, B
American redstart	*Setophaga ruticilla*	M, B	M, B
Ovenbird	*Seiurus aurocapillus*	M, B	M, B
Northern waterthrush	*Seiurus noveboracensis*	M	M
Mourning warbler	*Oporornis philadelphia*		B
Common yellowthroat	*Geothylpis trichas*	M, B	M, B
Scarlet tanager	*Piranga olivacea*	M, B	M

Rose-breasted grosbeak	*Pheuticus ludovicianus*	M, B	M, B
Indigo bunting	*Passerina cyanea*	M, B	B
Chipping sparrow	*Spizella passerina*	M, B	M, B
Northern oriole	*Icterus galbula*	M, B	
Short distance migrants:			
Common loon (T)	*Gavia immer*	M, B	M, B
Double-crested cormorant	*Phalacrocorax auritus*	M	M, B
American bittern (SC)	*Botaurus lentinginosus*		M, B
Great blue heron	*Ardea herodias*	M, B	M, B
Canada goose	*Branta canadensis*	M, B	M, B
Wood duck	*Aix sponsa*		M, B
Green-winged teal	*Anas crecca*		M
American black duck	*Anas rubripes*		B
Northern pintail	*Anas acuta*		B
Gadwall	*Anas strepera*		B
Common merganser	*Mergus merganser*	M, B	M, B
Red-breasted merganser	*Mergus serrator*	B	M
Turkey vulture	*Cathartes aura*	B	M, B
Northern harrier (SC)	*Circus cyaneus*		B
Sharp-shinned hawk	*Accipiter striatus*	M	
Red-shouldered hawk (T)	*Buteo lineatus*	M, B	
Red-tailed hawk	*Buteo jamaicensis*		M
American kestrel	*Falco sparverius*		B
Sandhill crane	*Grus canadensis*	M	M, B
Killdeer	*Charadrius vociferus*	M, B	M, B
Mourning dove	*Zenaida macroura*	M	M, B
Belted kingfisher	*Ceryle alcyon*		M, B
Yellow-bellied sapsucker	*Sphyrapicus varius*	M, B	M, B
Northern flicker	*Colaptes auruatus*	M, B	M, B
Eastern phoebe	*Sayornis phoebe*	M, B	M, B
Tree swallow	*Tachycineta bicolor*	M, B	M, B
Brown creeper	*Certhia americana*	M, B	
Winter wren	*Troglodytes troglodytes*	M, B	M, B
Sedge wren	*Cistothorus platensis*	B	
Marsh wren (SC)	*Citothorus palustris*	M	
Ruby-crowned kinglet	*Regulus calendula*		M
Eastern bluebird	*Sialia sialis*	M	M, B
Hermit thrush	*Catharus guttatus*	M, B	M, B
American robin	*Turdus migratorius*	M, B	M, B
Brown thrasher	*Toxostoma rufum*	M	M, B
Water pipit	*Anthus spinoletta*		M
Myrtle warbler	*Dendroica coronata*	M, B	M, B
Pine warbler	*Dendroica pinus*	M, B	M, B
Field sparrow	*Spizella pusilla*		B
Vesper sparrow	*Pooecetes grammineus*		M
Savannah sparrow	*Passerculus sandwichensis*		M, B
Le conte's sparrow	*Ammodramus leconteii*		M, B
Song sparrow	*Melospiza melodia*	M, B	M, B
Swamp sparrow	*Melospiza georgiana*	M, B	M, B
White-throated sparrow	*Zonotrichia albicollis*	M, B	M, B
White-crowned sparrow	*Zonotrichia leucophrys*		M
Red-winged blackbird	*Abelaius phoeniceus*	M, B	M, B
Eastern meadowlark	*Sturnella magna*		M, B

Eastern meadowlark	*Sturnella magna*		M, B
Common grackle	*Quiscalus quiscula*	M, B	M, B
Brown-headed cowbird	*Moluthrus ater*		M, B
Pine siskin	*Cardeulis pinus*		M
American goldfinch	*Carduelis tristis*	M, B	M, B
Residents:			
Mute swan	*Cygnus olos*	B	
Mallard	*Anas platyrhynchos*	M, B	M, B
Common goldeneye	*Bucepahla clangula*	B	B
Bald eagle (T)	*Haliaeetus leucocephalus*	M, B	M, B
Ring-necked pheasant	*Phasianus colchicus*		M, B
Ruffed grouse	*Bonasa umbellus*	M	M, B
Sharp-tailed grouse	*Tympanuchus phasianellus*		M
Wild turkey	*Meleagris gallopavo*	M, B	
Ring-billed gull	*Larus delawarensis*	M, B	M, B
Herring gull	*Larus argentatus*	M, B	M, B
Rock dove	*Columba livia*		B
Barred owl	*Strix varia*		B
Downy woodpecker	*Picoides pubescens*	M, B	M
Hairy woodpecker	*Picoides villosus*	M, B	M, B
Pileated woodpecker	*Dryocopus pileatus*	B	M, B
Blue jay	*Cyanocitta cristata*	M, B	M, B
American crow	*Corvus brachyrhynchos*	M, B	M, B
Common raven	*Corvus corax*	M	M, B
Black-capped chickadee	*Poecile atricappilus*	M, B	M, B
Red-breasted nuthatch	*Sitta canadensis*		M
White-breasted nuthatch	*Sitta carolinensis*	M	
Golden-crowned kinglet	*Regulus satrapa*	M, B	M, B
European starling	*Sturnus vulgaris*	M	M, B
Cedar waxwing	*Bombycilla cedrorum*	B	B
Purple finch	*Carpodacus purpureus*		M, B
Evening grosbeak	*Coccothraustes vespertinus*		M
TOTAL			
M=MIGRATION		77	90
B=BREEDING		68	99
Total # species recorded		87	118
(SC)=State Special Concern		1	3
(T)=State Threatened		5	6

Table 2. Mean bird abundance, species richness and dominant species recorded during spring migration in 2000 on Bois Blanc Island and Drummond Island.

	Bois Blanc Island	**Drummond Island**
Mean Bird Abundance (Mean No. birds per point count station)	8.1 ± 1.4	5.0 ± 0.9
Mean Species Richness (Mean No. species per point count station)	5.7 ± 1.0	4.0 ± 0.7
Dominant Species (Mean No. of individual species per point count station in order of abundance)	Black-throated green Warbler-1.03 American redstart-0.79 Blue jay-0.65 Ovenbird-0.65 Myrtle warbler-0.41 Red-eyed vireo-0.35 Nashville warbler-0.29 American robin-0.29	Black-throated green warbler-0.56 American redstart-0.39 Nashville warbler-0.37 Black-and-white warbler-0.32 Ovenbird-0.29 Myrtle warbler- 0.22

Table 3. Mean bird abundance, species richness and dominant species recorded during summer breeding season in 2000 on Bois Blanc Island and Drummond Island.

	Bois Blanc Island	Drummond Island
Mean Bird Abundance (Mean No. birds per point count station)	8.7 ± 1.8	6.6 ± 1.1
Mean Species Richness (Mean No. species per point count station)	5.7 ± 1.1	4.5 ± 0.6
Dominant Species (Mean No. of individual species per point count station in order of abundance)	American redstart-1.18 Red-eyed vireo-0.70 Ovenbird-0.61 Black-throated green warbler-0.45 Song sparrow-0.36 Myrtle warbler-0.27	Cedar waxwing-0.66 American redstart-0.46 White-throated sparrow-0.43 Black-throated green Warbler-0.41 Song sparrow-0.32 Myrtle warbler-0.29

(two adults), as well as at several locations along the northern shore of the island. Two bald eagle chicks were observed in a nest at Sucker Creek Swamp, the same location as last year. Bald eagles were seen flying in the vicinity of Deer Lake. A small colony of common terns were seen on Gull Island during migration but were not present during the breeding bird counts. Two Caspian terns were seen on Gull Island in May and in June, although no nest was observed. The marsh wren was heard calling in suitable habitat in a sedge meadow wetland complex located north of the small lake that drains into Twin Lake Creek. Red-shouldered hawks responded to taped calls at five different locations on Bois Blanc Island and were seen and heard in a number of locations during spring and summer bird counts. Since a visit could not be arranged to the island in early spring, the optimal time for nest searches, and since by mid-May the leaves on most of the trees had emerged, minimal effort was directed toward locating their nests. Four red-shouldered hawk territories were delineated based on observations during 1999 and 2000 and it is believed that several additional pairs are nesting on the island.

On Drummond Island a bald eagle was observed flying over Isaacson Lake and foraging in Potagannissing Bay. Common and Caspian terns were observed foraging in Potagannissing Bay although none were observed nesting. Common loons were heard or observed at several locations including Toivola Lake, Marl Lake, the North Channel, Whitney made nesting platform. Ospreys were also observed at Dickenson Lake, Raynold's Bay, and foraging in Potagannissing Bay. A new occurrence for nesting merlins was observed south of Toivola Lake, near the Lake Huron shoreline. Another individual merlin was observed on two occasions near Isaacson Lake, one time carrying food, although no nest was located. Three new occurrences for nesting American bitterns were documented on Drummond Island at the following sites: Dickenson Lake, a marsh southeast of Hay Point, and along the Potagannissing River near First Lake. A known black tern colony was reconfirmed at the mouth of the Potagannissing River. A northern harrier was observed flying over alvar habitat at Maxton Plains. Red-shouldered hawks were surveyed for in May on Drummond Island. Taped calls were played in northern hardwood stands at five locations on the island. No responses were heard and habitat does not seem ideal for this species.

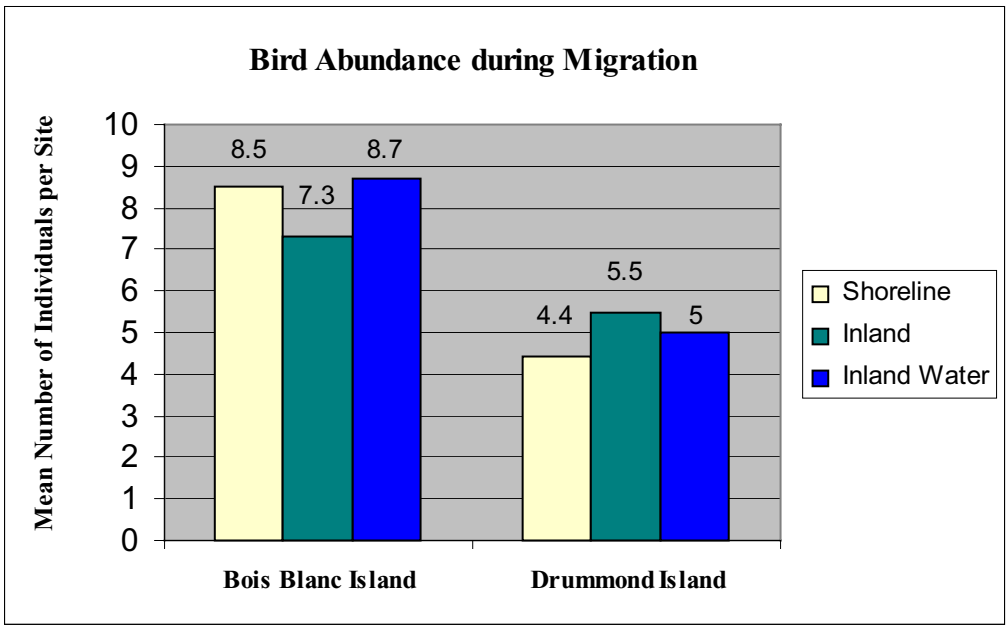


Figure 6. Distribution of migrating birds on Bois Blanc and Drummond Islands

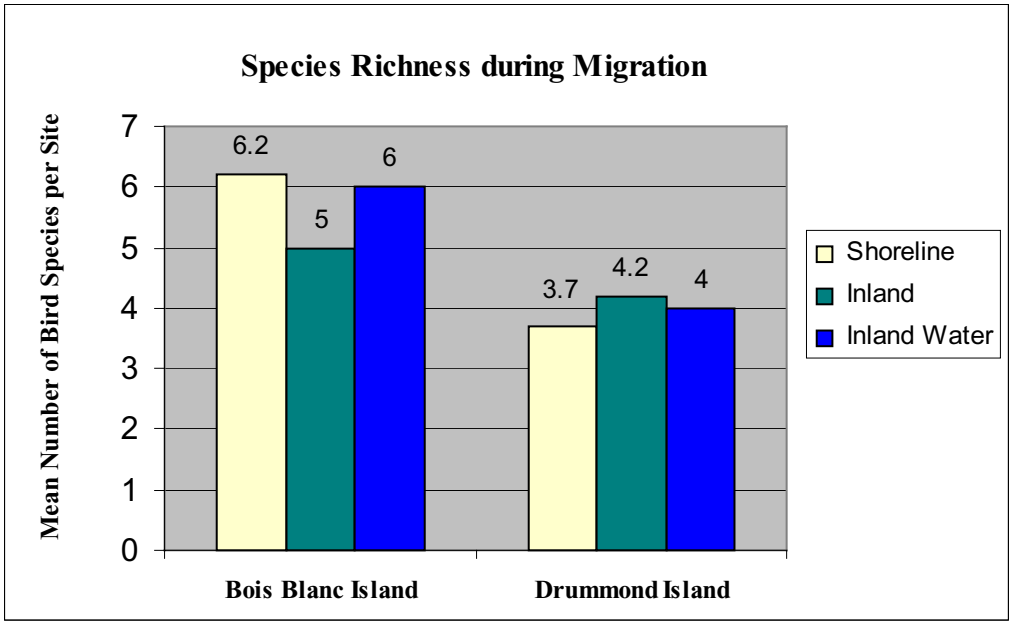


Figure 7. Distribution of migrating bird species on Bois Blanc and Drummond Islands

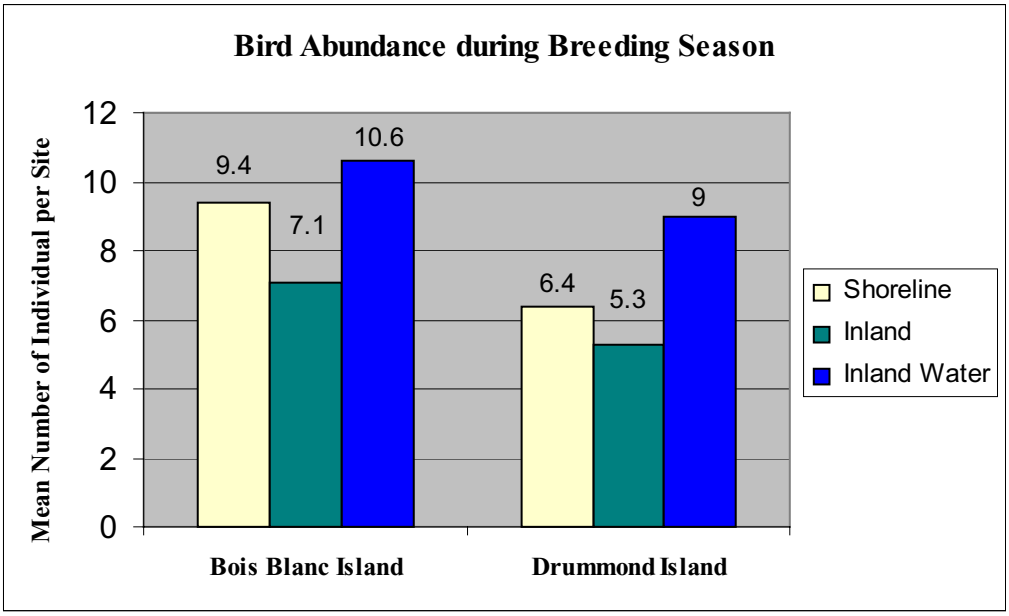


Figure 8. Distribution of breeding birds on Bois Blanc and Drummond Islands

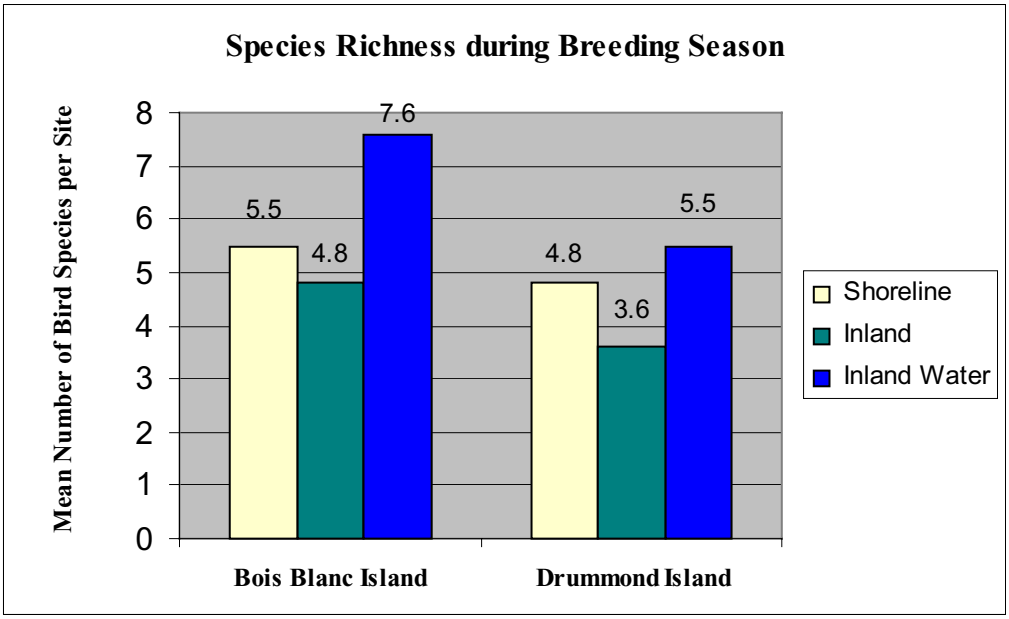


Figure 9. Distribution of breeding bird species on Bois Blanc and Drummond Islands

Table 4. Rare animal sites documented during 2000 surveys of Bois Blanc Island.

Site name	Known occurrences relocated and updated	New occurrences documented
Bois Blanc Airport West		Red shouldered hawk (T)
Central Drive Orchard		Red-shouldered hawk (T)
Central Rd. Fork East		Red-shouldered hawk (T)
Deer Lake	Bald eagle (T)	
Gull Island	Common tern (T)	
Lake Mary	Common loon (T)	
Sucker Creek Swamp	Bald eagle (T)	
Thompson Lake		Common loon (T)
Township Dock East		Eastern massasauga (SC)
Twin Lake Wetland		Red-shouldered hawk (T) Marsh wren (SC)

Table 5. Rare animal sites documented during 2000 surveys of Drummond Island.

Site name	Known occurrences-relocated and updated	New occurrences documented
Scott Bay	Black tern (SC)	
Snively Road		Merlin (T)
Potagannissing River Wildlife Flooding		American bittern (SC)
Bruce Point Marsh		American bittern (SC)
Dickenson Lake		American bittern (SC)
Rabbit Bay		Osprey (T)

Insects

Surveys conducted for the Hine's emerald dragonfly on Drummond Island failed to locate any new populations. However, after searching a number of locations on the island, suitable habitat was identified along the margins of Marl Lake, and in similar habitat located along Pigeon Cove Creek and Isaacson Lake. Further surveys are needed to determine if Hine's emerald dragonflies occur on Drummond Island.

Reptiles

No eastern massasaugas were observed during meander surveys in appropriate habitat during the spring and summer on Bois Blanc Island. An island resident, knowledgeable about massasaugas, reported observing an adult in June, on the south shore of the island on state land, west of the ferry landing dock. The resident usually sees a few in this area every year. A northern fen community with beach ridges characterizes this area. It was noted during the 2000 surveys that the shoreline is more extensive than usual due to low lake levels.

Discussion of Animal Surveys

Birds

The diversity and abundance of birds documented on Bois Blanc and Drummond Islands is impressive and illustrates the important role that these islands play in providing critical stopover and breeding habitat for birds. The previous breeding bird list for Bois Blanc Island compiled in 1996 includes 54 species (Moore and Moore 1996). Surveys conducted in 1999 and 2000 document at least 74 birds during the breeding season and 78 species during migration.

Differences in bird numbers. It was surprising that despite the fact that a greater number of individual birds and a greater number of bird species were observed on Drummond Island overall, that mean bird abundance and mean species richness was significantly higher on Bois Blanc Island. There are a few possible factors that may explain this difference. Only those birds recorded during point counts were included in the calculation of the means. Although all observations of bird species were recorded on both islands whether during point counts or as "casual" observations. Most of the bird species found on Drummond that were not observed on Bois Blanc were observed as casual observations after point counts were completed. These include many waterfowl, shorebirds, raptors and wetland birds rather than songbirds. Sparrows are the only group of songbirds that appear to be unevenly distributed between the two islands, with many more species represented on Drummond Island. Drummond contains more early successional habitats that many of these sparrows prefer, and it is also a significantly larger island.

Another possible factor that may account for the higher bird means on Bois Blanc is that the island's geographic location may more closely correspond with the migratory flight paths of many birds traveling up the Lower Peninsula shoreline to the Upper Peninsula of Michigan and Canada. Drummond Island, located further to the east, may not be as geographically convenient as a stopover site for some migratory birds. It is uncertain to what degree Drummond Island may provide stopover habitat for birds migrating through southern Ontario.

The shoreline habitat of Bois Blanc island is primarily cobble beach. Drummond Island shoreline sites more typically include bedrock, with some areas of sand and cobble. It is possible that the cobble substrate is more conducive to providing habitat for aquatic midges than the bedrock substrate. It would be informative to stratify sampling sites during future island bird surveys so that bedrock, cobble and sand substrates could be compared for associated bird abundance and richness. This type of comparison would be especially useful during spring migration when aquatic midges are thought to provide a critical food source to migrating birds.

Another important factor that may help to explain this difference is the lack of development on Bois Blanc Island and the maturity of its forests. Nearly half of the island lies within state ownership. The only settlement or village is Point Aux Pins, located on the south side of the island. The soil types are not suitable for agriculture and it is currently not economically profitable to support significant timber harvesting. Thus the extensive, intact, and mature forest tracts may provide important habitat for both migrating and breeding birds. Finally, Drummond Island is nearly four times greater in size than Bois Blanc Island (83,000 acres versus nearly 24,000). It is thus plausible that migrating and breeding birds are simply more dispersed on Drummond Island and more concentrated on Bois Blanc Island, which may help explain the differences in the mean number of individual birds and bird species detected during point counts.

It is interesting to note that bird counts on Bois Blanc Island have also been significantly higher than counts conducted on Beaver Island and Garden Island during the past three years. Despite the small sample size there appears to be something unique about Bois Blanc Island which seems to provide quality stopover and breeding habitat for birds, songbirds in particular. Future land use planning for Bois Blanc Island should take this important factor into account.

Distribution of birds. Factors that likely contribute to the distribution of migratory birds using these islands as stopover sites include weather conditions, human use patterns, abundance of potential prey, predation pressure, and the composition, structure, and successional stage of the vegetation. In their 1993 research (unpubl.) Ewert and Hamas note that spring migrants often arrive in Michigan before the leaves on trees have fully emerged. Consequently, lepidopteran larvae, which are a primary source of food for migrants in areas south of Michigan, are not yet abundant. Migratory birds instead take advantage of the swarms of emerging aquatic insects, such as chironomid midges (Family: *Chironomidae*), that are concentrated along Great Lakes beaches, and along inland streams, lakes, and wetlands. It is noteworthy that swarming insects were observed in these areas on the islands during point counts. Trees and shrubs in

close proximity to the shoreline and interior riparian and wetland areas provide an excellent foraging substrate for migratory birds feeding on these insects.

On Bois Blanc Island the greatest diversity and abundance of migrating birds were found near the shoreline or adjacent to inland lakes and wetlands rather than in deciduous forests located in the interior of the islands. The shoreline here is primarily cobble interspersed with interdunal wetlands. Coniferous trees border the shoreline and in some areas cedar swamps encroach very close to the shore. The inland lakes have minimal development and are surrounded by intact natural communities such as sedge meadows, northern fen, mixed forest, and cedar swamp. These inland lakes and wetlands supply an abundance of aquatic insects that are important to migrating and breeding birds.

On Drummond Island the greatest number of individual birds and species recorded during migration were located at interior or inland water sites rather than at shoreline sites, although these differences were not significant. This differs from the Bois Blanc Island migration count results. After closer analysis of the habitat types present on Drummond, it is apparent that early successional or naturally open habitats (i.e. aspen-birch forest, old field, and alvar) are more abundant on Drummond and may attract a higher number of individual birds and bird species, especially at interior sites.

Another explanation of the slightly greater number of migrating birds detected at interior sites may be the presence of a mixed shoreline of bedrock, sand, and cobble substrate on Drummond. Midges may be less available where substrate is sand or bedrock, making birds search out other locations for protein sources. It is equally possible that the influence of the shoreline (and associated aquatic insects) may extend further inland than the 0.4 km (0.25mi) that was used to designate shoreline sites. Thus, interior sites 0.8 km (0.5mi) to 1.6 km (1.0mi) from the shore, where high numbers of birds were observed, may actually still be greatly influenced by the nearby shore.

Aquatic insects are present at inland water locations on Drummond Island while alvar habitat may be providing a food source that has not yet been identified. Closer evaluation of birds in alvar habitat may provide answers to what this food source may be. At this time we are uncertain of the role alvar habitat may play in providing early food sources to migrating birds.

This informal analysis of the abundance and distribution of migrating and breeding birds on Bois Blanc Island and Drummond Island is interesting and provides a good foundation for future work. It is important though to understand that these data are not the result of a highly controlled research study and conclusions should not be casually inferred. Rather, these bird counts provide a valuable "snapshot" of bird use of these particular islands and suggests their relative importance in providing critical habitat to migrating and breeding birds.

Declining bird species. There are three migratory bird species that were recorded during bird surveys that are worth noting, since there is evidence that they are declining in all or part of their range. The wood thrush (*Hylocichla mustelina*) was recorded during migrating and breeding bird surveys on Bois Blanc Island and during breeding surveys on Drummond Island. This species is one of 105 species currently 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). Scores range between 18 (moderate priority) and 30 (the highest priority). Criteria used to score species include: relative abundance, breeding distribution, winter distribution, threats to breeding range, threats to non-breeding range, and population trends. The wood thrush generally prefers dense mesic woodlands with small streams and springs associated with a thick understory. This species has undergone a decline in the Midwest due to forest thinning and fragmentation, loss of wetlands on the wintering grounds and heavy cowbird parasitism in some areas (Pinkowski 1991). Both islands provide suitable habitat for the wood thrush and its forests should continue to support breeding pairs, as long as they are managed to minimize fragmentation and to enhance forest maturity.

The black-throated blue warbler (*Dendroica caerulescens*), which was observed during migration surveys on Bois Blanc Island, has a Conservation Priority Score of 20, and is a species of moderately high priority for conservation action due to its very restricted wintering range (Muehter 1998). It breeds most commonly in mesic deciduous forest, prefers the interior of mature forests and avoids young second-growth. Although previously considered one of Michigan's most abundant migrants it has declined in numbers over the years. The protection of mature hardwood forests is critical for the conservation of this species (Binford 1991). Bois Blanc Island currently contains large tracts of this desirable forest type and consequently provides critical nesting habitat for this

species. It is not known whether the bird observed remained to nest or was using the island as a stopover site, although this species was observed during the breeding season in 1999.

The northern parula, observed on both Bois Blanc Island and Drummond Island, is another species worth noting. Although this species is not on the WatchList, it 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*, a stringy epiphytic lichen appropriately named "old man's beard". This lichen is a crucial component for supporting the warbler's pendant nest, and thus widespread loss of *Usnea* is as suspected cause for substantial population declines of parulas in portions of their breeding range. Humid areas in mature eastern hemlock or balsam fir forests are optimal habitats for *Usnea* and the northern parula. Northern hardwood forest, northern white cedar swamps, mesic mixed forests, and wet coniferous areas with black spruce and tamarack are also used by parulas (Evers 1991). Boreal forest covers much of the northern shoreline areas of Bois Blanc Island, particularly the peninsula at the northeast end of the island and provides important nesting habitat for the northern parula. Parulas were abundant on this peninsula during both migration and breeding counts and it appears that this area provides critical nesting habitat for this bird. On Drummond Island, parulas were noted during breeding bird surveys on Barbed Point Peninsula (cedar-dominated), Cream City Point (mixed coniferous) and Helen Lake (mixed coniferous) all located along the southern shore. Future surveys may reveal additional habitat for this species on Drummond Island.

Red-shouldered hawk surveys. Surveys for the red-shouldered hawk on Bois Blanc Island were quite successful in documenting at least four active breeding territories. Red-shouldered hawks nest in mature deciduous or mixed forest complexes that are located near wetland habitats. The forest cover and geology of Bois Blanc Island provides prime habitat for the red-shouldered hawk. Bois Blanc Island is essentially an outcrop of limestone and dolomite bedrock projecting above the level of Lake Huron. In recent geologic times the waters of Lake Huron covered the entire base of the island. As the waters receded, cobble beach ridges and beach pools became the foundation of a complex ridge and swale topography that now dominates the landscape. Throughout the island shallow soils over bedrock or cobble support mesic northern hardwood forests on ridges and well drained sites, with white cedar-balsam fir forest occurring in poorly drained areas (Taylor 1995). Bois Blanc Island contains an abundance of northern hardwood and mixed forests adjacent to inland lakes, and forested and non-forested wetlands. Hardwoods, including sugar maple, striped maple, beech, white and yellow birch, and ironwood totals approximately 5,110 acres or 23 percent of the island. Mixed deciduous and coniferous forest borders much of the island and occurs in large areas over much of island. Northern hardwoods occur as well especially within the northwest arm of the island. Poplar, white birch, cedar, balsam, spruce, maple, oak, white pine and Norway pine are found growing together with an occasional hemlock, yellow birch and beech (Jenkins 1946, Poole 1973). Although nests were not found, the red-shouldered hawk was heard and observed in at least four of the same areas it was recorded during 1999. It is assumed that there are nests in these areas. Returning to the island to conduct nest searches in April of 2001, prior to leaf out, is recommended since this is the optimal time to locate nests. It is clear that Bois Blanc Island provides an abundance of good quality nesting habitat for this species.

Tape-recorded calls of red-shouldered hawks were played at five locations on Drummond Island. No responses were heard at any of the five locations. The forest cover of Drummond Island is dominated by aspen and white birch. Northern hardwoods (mainly beech, birch, and maple) are the second most important forest type found on the island. The remainder of the forested areas are composed of northern white cedar, upland spruce or fir, swamp conifers, tamarack, and white pine-red pine mixtures (U.S. Department of the Interior, no date). Of the five northern hardwood forest locations where taped calls were played, the age of the forest did not appear to be mature enough to attract nesting red-shouldered hawks. Due to the size of the island and the limited time available, a thorough search of all potential red-shouldered hawk habitat was not undertaken. Additional hawk habitat may exist in areas that are difficult to reach or inaccessible with four-wheel drive vehicles (i.e. east end of the island). A targeted survey for red-shouldered hawks is recommended in the future before confidently identifying the island as either suitable or unsuitable for nesting.

Observations of rare birds. Breeding records for the common loon on both of the islands is not surprising due to the habitat provided by the Great Lakes and the large inland lakes on each of the islands. In addition, these birds enjoy fewer disturbances by recreational boaters and jet skiers due to the absence of extensive development on these islands.

The bald eagle nest observed on Bois Blanc Island was found on a territory that has been active for several years. It was found in an area that receives little

disturbance except for the occasional use of snowmobiles in the winter. The element occurrence record for this eagle was updated and this information was added to the database.

A small colony of common terns were observed nesting on Gull Island off the southern shore of Bois Blanc Island in 1999. Common terns were only seen in May of this year and it is assumed that they nested elsewhere. Last year this colony shared the small island with hundreds of ring-billed gulls and herring gulls and their reproductive success was probably poor. Because the Great Lakes levels have steadily declined to near record levels the terns likely found more suitable habitat elsewhere. The observations of a pair of Caspian terns in June on Gull Island in 1999 and 2000 were probably not of a breeding pair. No nests were noted and they were not a part of a nesting colony.

Observations of a nesting merlin and of another individual carrying food on Drummond Island, during the breeding season, indicates that Drummond Island provides critical breeding habitat for this rare species. Merlin's prefer to nest in forest edges adjacent to extensive openings and are more commonly found close to the shores of the Great Lakes. The island offers the merlin an abundant source of avian prey in the form of trans-lake migrants both during the spring prior to nesting and in the fall when the juvenile birds are becoming independent (Binford 1991).

The American bittern inhabits marshes and the edges of lakes and ponds where cat-tails, sedges and bulrushes are plentiful. The discovery of three new American bittern records on Drummond Island is not surprising, as suitable habitat was plentiful in those places that were surveyed. Habitat appears to be abundant along many of the inland lake edges and shoreline marshes that were not surveyed. It is likely that this species occurs at additional locations on the island. Preserving the marshes and protecting them from human alteration and disturbance will be important if this species is to remain a part of the island's fauna.

Insects

Potential habitat for the federally endangered Hine's emerald dragonfly was identified at two locations on Drummond Island. The marly, northern fen habitats along the margin of Marl Lake appears to be suitable habitat for the dragonfly based on its presence in similar habitat in the Upper Peninsula of Michigan. Another area of suitable habitat, which was identified but not surveyed during 2000, includes the margins of Pigeon Cove Creek and Isaacson Lake. Additional surveys should be conducted during July and/or August to determine if the Hine's emerald dragonfly occurs on the island. Given the difficulty in surveying for invertebrates, especially high flying aerialists, several days should be spent on the island at these sites. Future surveys are targeted for 2001 in these areas and in additional locations as time permits.

Reptiles

It is disappointing, although not surprising that the eastern massasauga, a special concern species, was not found on Bois Blanc Island during targeted surveys in 2000. These snakes are quite cryptic and difficult to detect even during the most optimal conditions for inventory. Surveys were conducted during May and June in conjunction with bird surveys. It is most optimal to conduct surveys in the spring or fall when the snakes are moving to and from their hibernacula or in the late summer when the females give birth to their young in upland locations. It is encouraging, however, to have received a reliable report of a massasauga from a landowner this year. Further discussion with this landowner revealed that he is quite knowledgeable about the history of these rattlesnake occurrences on the island. He reported that he usually finds two to three massasaugas a year. He agreed to provide information on his sightings of the snake and these data will be incorporated into the statewide biological and conservation database (BCD).

Suitable habitat is abundant on Bois Blanc Island with a good juxtaposition of wetland and upland sites. Thus it appears that habitat is not a limiting factor and that the island has the potential to support a healthy population of the eastern massasauga. The primary threat to this species appears to be mortality from being hit by vehicles on the roads and from human persecution. Island residents have reported observing numerous snakes killed on the road that circles the island over the past twenty years or more. In addition residents have admitted to killing large numbers of snakes over the years. It is unknown whether the effects of inbreeding have had an impact on eastern massasaugas on the island.

Initiating a research study that would provide a realistic estimate of the population of eastern massasaugas and knowledge of their distribution on the island would be very useful. The use of mark recapture technique, DNA analysis and radio telemetry to count

Plate 1. Four red-shouldered hawk territories were found on Bois Blanc Island in 1999 and 2000 in the interior of the island.
Photo by Gerald and Janet Finnegan

Plate 2. The federally endangered Hine's emerald dragonfly was found on Bois Blanc Island in 1999. Potential habitat was identified on Drummond Island in 2000.
Photo by David L.Cuthrell

Plate 3. Bald eagles successfully fledged chicks from this nest on Bois Blanc Island near Sucker Creek Swamp (south of Twin Lakes) in 1999 and 2000.
Photo by Daria A. Hyde

Plate 4. Common loons were documented on both Bois Blanc and Drummond Islands in 2000.
Photo by Dave Kenyon

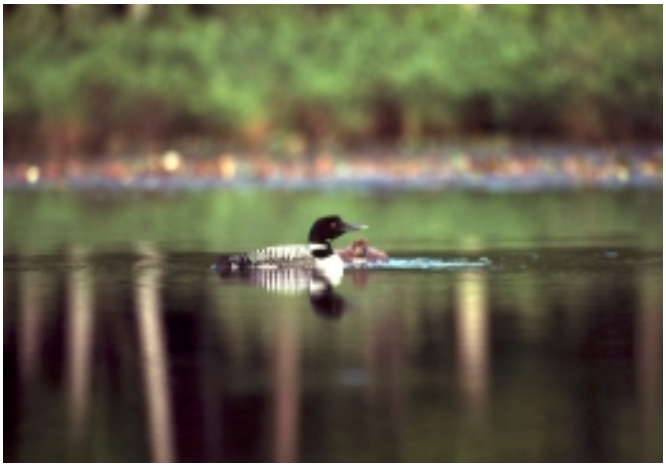
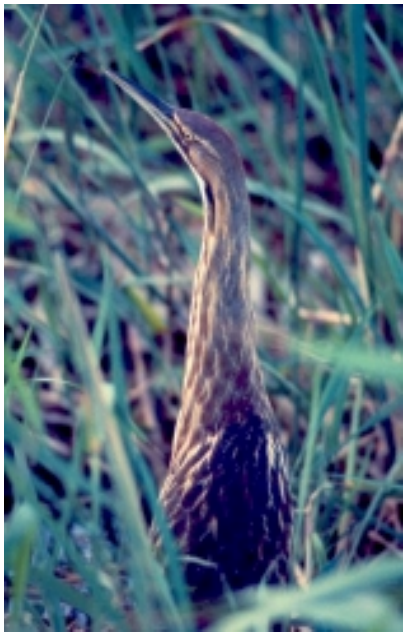


Plate 5. Nesting osprey were recorded on Drummond Island on a nesting platform in Rabbit Bay in 2000.
Photo by Dave Kenyon

Plate 6. American bitterns were documented on Bois Blanc Island in 1999 (north of Twin Lake Creek) and on Drummond Island (Potoganissing Wildlife Flooding, Bruce Point Marsh and Dickenson Lake) in 2000.



individual snakes, determine genetic differentiation, assess snake movement and to identify key habitat (e.g. hibernacula, basking sites and maternity dens) would provide a good foundation for guiding management decisions on the island. Over the past eight years this type of research has been conducted in Killbear Provincial Park in Ontario and as a result much has been learned about the population size, distribution and behavior of the massasauga in the park. This information has been used to design and implement a successful public education program as well (Parent 2000).

Clearly, protection and management of suitable habitat and a change in people's attitudes and actions toward the eastern massasauga are crucial for ensuring the long-term viability of this species. One of the most important elements of a successful conservation and recovery program for this species is public outreach and education. Public education is needed to promote a better understanding of the species' status, life history, role in ecosystems, and minimal threat to human safety. This improved understanding will cultivate tolerance and positive attitudes toward the eastern massasauga and help the general public find ways to co-exist with the snake. Public and private land managers and others that impact massasauga habitat also need to be educated on the species' habitat needs, the presence or potential for massasaugas on their property, and the potential impacts of management practices on the snake. Most importantly, public education and outreach are needed to generate long-term, local community support for the conservation and recovery of the eastern massasauga.

Methods for Plant Surveys

Islands selected for plant field inventories were identified following examination of the statewide BCD and consultation with MNFI staff ecologists and other scientists. As in previous island and Great Lakes shoreline studies (Penskar et al. 1999, Penskar et al. 1998, Penskar et al. 1997, and Penskar et al. 1993), our high priority targets were Great Lakes endemic species such as dwarf lake iris (*Iris lacustris*), Houghton's goldenrod (*Solidago houghtonii*), Pitcher's thistle (*Cirsium pitcheri*), and Michigan monkey-flower (*Mimulus glabratus* var. *michiganensis*), all of which are federal and state listed. Additional target taxa included such well known coastal rarities as calypso orchid (*Calypso bulbosa*), English sundew (*Drosera anglica*), butterwort (*Pinguicula vulgaris*), Alaska orchid (*Piperia unalascensis*), ram's head orchid (*Cypripedium arietinum*), and several other potential species known in this region of the state. These taxa are strongly associated with shoreline areas, where they occur in such natural communities as open dunes, coastal rich conifer swamps, bedrock beaches, alvar, cedar glades, northern fens, boreal forests, and forest dune and swale complexes. However, emphasis was also placed on delineating notable natural communities. This was done both to identify significant potential rare plant habitats as well as to conduct a preliminary assessment for high quality community remnants for subsequent evaluation and possible transcription by MNFI ecologists. All plant inventories were conducted in collaboration with a staff ecologist, who provided the primary evaluation of potential natural community occurrences and also assisted in rare plant surveys.

Potagannissing Bay, an area with a relatively high concentration of islands, was selected as the study area based on the paucity of previous inventories for rare plants and natural communities. Two of the largest islands within the bay were targeted, consisting of Burnt Island and Harbor Island (Figures 4 and 5). The specific botanical survey methods, which essentially consisted of meander searches, closely follow those used during the previous two years of island inventories. These have been presented in detailed by Penskar et al. (1999) and thus will not be presented again here. Notably different for the present study, however, is the fact these particular surveys were conducted simultaneously with a staff ecologist. Thus, detailed aerial photo interpretations prepared by the ecologist enabled several specific areas to be targeted, such as potential shoreline alvar habitats and other potentially interesting sites.

Burnt Island. Surveys on Burnt Island were conducted on July 18, 2000. As described previously, Burnt Island is privately owned, and permission to access and survey the island was granted prior to our inventory. The majority of the shoreline of the island was inventoried, focusing on coastal communities such as limestone pavement, bedrock beaches, Great Lakes marsh, potential small dune areas, interdunal wetlands, and seeps or unique and interesting microhabitats. Traverses through representative portions of the island's largely forested interior were also conducted, including areas with boreal forest (the primary forest type delineated) and small portions with mixed hardwoods. General shoreline and forest interior species lists were compiled, especially at sites where the MNFI ecologist identified a high quality natural community.

Harbor Island. Surveys on Harbor Island were conducted from July 19-20, 2000. The majority of the

shoreline was inventoried over the two-day survey period. As for Burnt Island, meander searches were conducted through representative areas of the mostly forested interior areas, focusing on boreal forest and a large area of mesophytic forest covering a significant portion of the eastern arm of the island. Species lists were compiled to assist in the completion of field forms for high quality natural community examples verified by the MNFI ecologist.

Results of Plant Surveys

Botanists and ecologists jointly conducted rare plant and natural community surveys, and therefore the results of these surveys are combined. Natural community results are discussed more thoroughly in the community section below. No rare plant occurrences were identified during our surveys. For Burnt and Harbor islands, a collective total of 6 natural community occurrences were documented. For Burnt Island, two high quality Great Lakes marshes were identified, as well as one occurrence of boreal forest. On Harbor Island, three community occurrences, one each of boreal forest, Great Lakes marsh, and mesic northern forest, were documented, and a previously known occurrence for Lake Huron tansy was unsuccessfully sought.

Discussion of Plant Surveys

Although several rare plant species had been highlighted as potentially occurring on Burnt and Harbor islands, no species were detected despite relatively wide-ranging surveys in a variety of habitats. Overall, this is not particularly surprising, owing to the fairly limited time available for surveys, as well as the smaller size of the islands in comparison to those studied previously. In addition, certain taxa, such as calypso orchid, are extremely small and thus difficult to find, whereas some rarities may also have been in less than optimal condition for identification. Smaller and more isolated islands can be expected to support fewer species and in general should be lower in diversity. Further explanation might possibly be linked to the fact that both islands support significant deer populations, as evidenced by the frequent browsing observed throughout. Portions of the islands appear to experience fairly heavy browsing, and this may impact rare species as well as general plant diversity. Little to no Canada yew (*Taxus canadensis*) was observed, although this common shrub is to be commonly expected on northern Michigan islands where it commonly forms a dense, nearly impenetrable understory. The virtual absence of this species gives further testimony to the presence of relatively high deer populations. Although the islands are isolated, white-tailed deer can easily access them during the winter or less commonly at other times of the year, and thus colonization can occur from adjacent mainland areas and other islands.

Methods for Natural Community Surveys

The primary objectives of the natural community inventory were to determine priority communities and locate potential high quality examples on Burnt and Harbor Islands (Figures 4 and 5). Aerial photo interpretation of the islands was conducted using 1978 color infrared imagery of 1:24,000 scale and revealed they had the potential to support high quality examples of boreal forest, Great Lakes marsh, mesic northern forest, alvar, and northern fen. Using the photo interpretation and USGS 7.5-minute topographic maps, natural community inventories of the targeted communities were undertaken in from July 18-20, 2000 with the aid of MNFI staff botanists.

Site visits involved mapping the boundaries of each delineated natural community occurrence on topographic maps and collecting detailed biotic and abiotic data. Data collection included compiling comprehensive plant species lists with notations of relative abundance, describing structural information for the vegetation layers in each plant community, and recording information on the landforms and soils that characterized the site. Site-specific information was also gathered related to signs of past human disturbance and land-use. Insights into future protection and/or management activities if apparent during site visits were also recorded on field forms. High quality natural communities were defined according to the MNFI Natural Community Classification (MNFI 1989). Each natural community occurrence was given a grade based on its relative quality, condition, and landscape context compared to other known occurrences within the state and Great Lakes region. Finally, information from field forms was transcribed and submitted for mapping and incorporation into the MNFI statewide database.

Table 6. Rare plant and natural community sites inventoried during 2000 surveys of Burnt Island and Harbor Island (Chippewa County).

Site name	Known occurrences sought and/or relocated and updated	New occurrences documented
Burnt Island		Boreal forest Great Lakes marsh (northern shore) Great Lakes marsh (southern shore)
Harbor Island	*Tanacetum huronense* #.055	Boreal forest Great Lakes marsh Mesic northern forest

Discussion of Natural Community Surveys

We picked the two largest islands in Potagannissing Bay for our rare plant and natural community surveys. The three Great Lakes marshes we located and mapped during our surveys are among the highest quality marshes in Michigan. Out of 74 total occurrences of Great Lakes marsh recorded in Michigan, only 15, including the three we identified as part of this year's survey, have been assigned an A rank. Though the other islands in Potagannissing Bay have not yet been surveyed, it is quite possible that they may also contain high quality examples of Great Lakes marsh.

Our understanding of boreal forest in Michigan has been greatly enhanced by the island surveys and we suspect that several other exemplary occurrences of boreal forest may be found on other islands within Potagannissing Bay. This community type is not well studied in Michigan and the island surveys have provided us with a better understanding of its range, landscape context, and condition. Currently only 22 occurrence of this community type, including the two we located as part of this survey, have been recorded in Michigan. This survey has helped further develop MNFI's community database for this rare element. Unlike Great Lakes marsh and boreal forest, the mesic northern forest on Harbor Island is likely to be the only exemplary occurrence of this community type with in Potagannissing Bay. Typically small occurrences of mesic northern forest are not tracked by MNFI and since Harbor Island is the largest island in Potagannissing Bay, other islands within the bay are unlikely to have sizable occurrences of this community type. The significance of the red-oak dominated mesic northern forest on Harbor Island if further enhanced as a natural feature because its origin likely stems from presettlement Native American land use practice (Albert and Minc 1987).

Digitization of Island Data

As detailed in the 1999 progress report (Penskar et al. 2000), a critical task of the island project has consisted of preparation of island natural features data for use within a Geographic Information System (GIS). As island surveys are conducted, field data and pre-existing BCD data have been processed and systematically digitized. In this manner, element occurrences were digitized for all species and natural communities identified during 2000 inventories, as well as all additional occurrences previously known for Bois Blanc Island, Burnt Island, and Harbor Island. This resulted in the collective digitizing of 52 occurrences, with 43 occurrences digitized for Bois Blanc Island, five completed for Burnt Island, and four completed for Harbor Island. Drummond Island, well known for its many natural features, will undergo a second year of multi-disciplinary inventories, and these data will be queued for digitizing in 2001.

Plate 7. Extensive Great Lakes marsh on south side of Burnt Island.

Plate 8. Stranded water-lily (*Nymphaea odorata*) in Burnt Island Great Lakes marsh, indicating marked drop in water levels.

Plate 9. Great Lakes marsh on north side of Burnt Island.

Plate 10. Recent marsh development due to drop in Great Lakes water levels on north side of Burnt Island.

Plate 11. Remnant white cedar old-growth (ca. 1 m dbh) on the north side of Harbor Island.

Plate 12. Mature red oak in extensive mesic northern forest on the eastern peninsula of Harbor Island.

Preliminary Conservation Outreach for Drummond Island

The conservation outreach portion of the island project will be focused on Drummond Island in 2001, and will be based on the model developed for Beaver Island in 1999. Outreach activities will be based on two consecutive years of migratory and breeding bird surveys and numerous systematic plant and natural community surveys on Drummond Island and nearby islands such as Harbor and Burnt islands located in Potagannissing Bay. Activities for fiscal year 2000 focused on preparing for conservation outreach in 2001. Primary tasks included identifying and contacting key contacts, and collecting and reviewing existing ecological information.

John Paskus, conservation planning specialist, recently spoke with The Nature Conservancy's Northern Lake Huron Bioreserve Director, Jesse Hadley, to discuss the conservation outreach portion of the island project. The Northern Lake Huron Bioreserve was started in 1993 to develop a community-based conservation project aimed at the protection of the region's unique natural features. Although the Bioreserve project encompasses the entire shoreline from just west of the Mackinac Bridge eastward to Drummond Island, the primary focus has been on the Les Cheneaux Islands. The Bioreserve Director stated that The Nature Conservancy (TNC) would like to start focusing more attention on Drummond Island, and that they are currently in the process of developing a site conservation plan for this island. In order to complete the plan, however, TNC needs to gain more knowledge about the local community. During discussions, it was agreed that MNFI's outreach activities could assist TNC with the development of conservation strategies, understanding the values and attitudes of the local community, and gauging the community's awareness and interest in the Drummond Island's natural features. In addition, outreach activities such as presentations and workshops may help catalyze community involvement in the long-term conservation of Drummond Island's most unique and highest priority natural areas.

To assist MNFI's conservation outreach activities, Jesse Hadley volunteered to identify key government officials, stakeholders, and community leaders interested in conservation, and promote MNFI's outreach activities planned for the summer. Jesse will share information about MNFI's recent and future ecological survey work on Drummond, and announce the upcoming presentation and conservation workshop that will take place during the summer of 2001. She will target organized groups, and already plans to give a presentation at a Lion's Club meeting in March 2001. Jesse will also notify key people and groups in the community, and inform as many people she personally knows on Drummond Island about the MNFI outreach activities planned for the summer of 2001.

In addition, John Paskus plans to contact the local MSU-E agent to share information about MNFI activities and learn about any current and/or planned Extension projects on the island. John will also contact government officials from Drummond Township, as well as the MDNR regional wildlife biologist. He also plans to contact Joe Vandermeullen, Director of the Land Information Access Association (LIAA), sometime in January. In 1998, MNFI contracted LIAA to help develop and facilitate an interactive workshop on Beaver Island. The workshop was very successful, and MNFI would possibly like to develop a similar workshop for Drummond Island.

Preliminary research was also conducted on land cover changes, landscape patterns, and distribution of known rare species and natural communities. This including the study of several TNC site conservation plans, site basic records, element occurrence records, site ecological summaries, and academic reports regarding Drummond Island. John Paskus also developed and studied digital GIS maps displaying 1978 land cover, circa 1800 vegetation, and known element occurrences to date. Lastly, John met with representatives from botany, ecology, and zoology to discuss results of recent surveys, preliminary plans for 2001 survey work, and reviewed survey gaps for listed species and unique and exemplary natural communities.

Site Summaries

As established in the format of several previous MNFI reports concerning coastal zone inventories, we provide here a summary description of the significant inventory sites. These descriptions are provided primarily for inventory sites covered by MNFI botanists, community ecologists, and aquatic ecologists. However, because migratory and breeding bird surveys comprised the majority of 2000 inventory work on Bois Blanc and Drummond islands, site summaries for these two islands are based primarily on habitat data compiled during bird inventories. Standard ecological site summaries were prepared for islands inventoried for rare plants and high quality natural communities.

Bois Blanc Island. Bird surveys were conducted at 34 sites on Bois Blanc Island in a variety of habitats

along the shoreline, in the interior of the island, and adjacent to inland lakes, streams, and wetlands. The shoreline consisted primarily of cobble interspersed with interdunal wetlands, most notably northern fen communities. Mixed forests dominated by white cedar bordered the shoreline. Boreal forest dominated the peninsula at the northeast end of the island, providing important nesting habitat for the northern parula, which requires the epiphytic lichen *Usnea* for building its pendulous nests. This peninsula was found to be one of the most productive areas for both migrating and breeding birds. In general, the 13 shoreline points that were censused were highly productive for bird counts. It is likely that the aquatic-terrestrial interface produces an important food source and foraging substrate for birds feeding on aquatic insects such as midges (Family: *Chironomidae*).

The seven point count stations located at inland lakes and interior wetlands had the highest bird abundance and species richness for both migrating and breeding birds. Deer Lake, located at the base of the aforementioned peninsula, was found to provide very important habitat for birds. The mature red oak, sugar maple, and white pine overstory, as well as the ample dead woody debris on the forest floor provided important nesting and foraging habitat for not only the songbirds but bald eagle as well. Loons, ducks, and other wetland birds were observed in and around the lake. Numerous songbirds were observed using the cavities in the standing snags in the lake for foraging and nesting. Lake Mary is bordered by maple and birch forest to the east with a fringe of sedge (*Carex* spp.) and cat-tail (*Typha* spp.) adjacent to the lake. The northern part of this lake was fringed with several private homes and cottages. Additional development activity is currently occurring on the south side of the lake. Loons were observed on the lake and it is likely that they nested here in 1999. East Twin Lake is bordered to the south by a sedge meadow near tamarack, white cedar, black spruce, and aspen. This wetland community provides habitat for a variety of birds, which use the wetland and adjacent forest for nesting and foraging. Only one home was noted on the northwestern shore of this lake. Similarly, Thompson Lake had no noticeable development except for a public access site and a camping and picnic site. A family of loons was observed swimming and feeding on Thompson Lake. White spruce, aspen, balsam fir, and white birch occurred around the lake and bird activity was abundant.

Another inland wetland that was rich in birds includes the area south of Point Catosh on the northwestern part of the island. This wetland consists of a wet meadow with snags of dead tamarack and white cedar. The dominant vegetation included narrow-leaved cattail (*Typha angustifolia*), alder (*Alnus rugosa*) and brambles (*Rubus* spp.). White cedar, white pine, maple, and birch bordered this wetland. The large sedge meadow just north of Twin Creek in the center of the island is another interior wetland that was highly productive for bird counts. An American bittern was heard here in 1999 and red-shouldered hawks were seen at this location in 1999 and 2000. This area is characterized by a large open area of sedge with standing dead snags and was surrounded by cedar and tamarack. Finally, Sucker Creek Swamp just south of the West Twin Lake was very active with birds. The bald eagle nest noted here during the past two years has been productive, with two chicks fledged each year. The area is characterized by cedar, balsam fir, black spruce, downy viburnum, sedges, grasses and young fir, and was saturated with standing water in 1999 and 2000.

The remaining 14 bird point count stations were located at interior sites in either northern hardwood and mixed forests dominated by sugar maple, hemlock, beech, white birch, yellow birch, or aspen and oak in early successional habitats such as old fields and abandoned orchards. The stations located in the interior forests were less active, especially during migration before trees had fully leafed out. There was less bird diversity represented here although these forests provide important nesting habitat to birds such as ovenbird, black-throated green warbler, American redstart, red-eyed vireo, rose-breasted grosbeak, scarlet tanager, and a variety of woodpeckers. These mature interior forests in proximity to numerous lakes and wetlands also provided excellent habitat for the state threatened red-shouldered hawk (*Buteo lineatus*). A great variety of birds were abundant in the early successional habitats that had a more complex structure of trees, shrubs, and grasses. These included many sparrows, warblers, vireos, thrushes, flycatchers, woodpeckers and raptors. Overall, the variety of habitats represented on Bois Blanc Island were found to provide critical migratory stopover habitat and breeding bird habitat unmatched by any other island surveyed thus far during the course of this project.

Drummond Island. Bird surveys were conducted at 41 sites on Drummond Island. Ten major habitats were surveyed including: boreal forest, rich conifer swamp (white cedar-dominated), alvar, beech/maple forest, aspen/birch forest, sedge meadow adjacent to open water, northern fen, Great Lakes marsh, old field, and inundated shrub swamp. A unique characteristic of Drummond Island is the alvar community. Alvar is characterized as a sedge and grass community, with scattered shrubs and occasionally trees, growing in thin

soil over calcareous, limestone and dolomite bedrock. This bedrock is exposed in the Maxton Plains region on the northern end of the island and in several other scattered areas. The shoreline of Drummond is composed of cobbles, boulders, or medium sized gravel. Sandy beaches are rare, being found only in protected coves. Most sandy beaches were observed on the southern shoreline.

Boreal forest dominated the 15 shoreline survey points. Warner's Cove, Big Shoal Cove, Cream City Point, the Barbed Peninsula, and Meade Island/ Scammon Cove are all southern shoreline sites that were highly productive areas for both migrating and breeding birds. Another productive shoreline site was the boat access area near the mouth of the Potagannissing River. This site was influenced by Great Lakes marsh vegetation, open water, and old field with scattered dogwood *(Cornus* sp.*)*, spruce *(Picea* sp.*)*, and ash *(Fraxinus* sp.*).* The upland area was identified as an undeveloped campground (no campers observed). This early successional upland habitat adjacent to the open water and marsh vegetation supported an abundance and diversity of birds.

Alvar, beech/maple forest, or rich conifer swamp dominated the 16 interior sites. Productive interior sites included the alvar dominated Maxton Plains and a alvar opening on Killstrom's Road, an aspen-birch windthrow area east of Johnswood, and a beech/maple forest along Bass Cove Road.

Sedge meadows adjacent to open water dominated the ten inland water sites. The Potagannissing Wildlife Flooding was productive for both migrating and breeding birds. Open water, marsh vegetation, aspen-birch forest, pasture, and scattered spruce *(Picea* sp.*)* along the river provided a variety of habitats for feeding, nesting, and roosting. Sedge meadow *(Carex* sp.*)*, red maple *(Acer rubrum)*, quaking aspen *(Populus tremuloides)*, scattered white cedar *(Thuja occidentalis)*, and balsam poplar *(Populus balsamifera)* surrounded Dickenson Lake. The American bittern *(Botaurus lentiginosus)* was heard calling at the Potagannissing Wildlife Flooding and Dickenson Lake. Both of these sites provide adequate habitat for nesting, and an adequate prey base including fish, frogs, tadpoles, mice, snakes, crayfish, snails, aquatic insects, and minimal human disturbance, which are required to sustain American bittern populations. Scott Bay marsh just south of Maxton Plains on Maxton Road was the only place where the secretive LeConte's sparrow *(Ammodramus leconteii)* was heard. This site can be described as a sedge meadow with willow *(Salix* sp.*)* shrubs scattered throughout. Scott Bay marsh also has records for yellow rail and American bittern, although these species were not heard in 2000. Helen Lake, near the southern shore of Drummond, was surrounded with boreal forest. Northern parula was heard at this site, along with a single common loon. An inundated shrub swamp along Bald Knobs Road produced the sole northern waterthrush *(Seiurus noveboracensis)* heard on the island. Open water, willow, sedges, tag alder *(Alnus rugosa)*, and balsam poplar (*Populus balsamifera*) in the drier portions characterized this site.

Burnt Island. Most of the Burnt Island shoreline was ringed by wave-worn cobble beach composed mainly of water-transported limestone with lesser amounts of granite. Boreal forest abuts the cobble beach in most areas of the island and occupies nearly all the island's interior. Where the boreal forest meets the cobble beach shoreline stands a thick band northern white cedar (*Thuja occidentalis*). The boreal forest interior was composed of white cedar, balsam fir *(Abies balsamea),* trembling aspen (*Populus tremuloides*), white spruce (*Picea glauca*) and paper birch (*Betula papyrifera*). White cedar and balsam fir dominated the forest canopy and were present in the shrub layer as well. White cedar regeneration, as evidenced by its presence in the shrub layer, is an important indication of the system's overall health. No artificial disturbance was noted within the boreal forest and of particular significance was an absence of cut stumps. In an effort to gauge past land use history we cored several trees to determine their age and discovered that white cedar in the 30 - 40 cm diameter at breast height (dbh) size range were more than 110 years in age. The balsam fir were typically much smaller than the white cedar, ranging from 12 – 19 cm dbh and were approximately 48 years old. If the island has been logged it appears to have since recovered well. Common ground layer species in the boreal forest included wild sarsaparilla (*Aralia nudicaulis*), big-leaved aster (*Aster macrophyllus*), sedge (*Carex deweyana*), spinulose woodfern *(Dryopteris carthusiana),* twinflower *(Linnaea borealis),* American fly honeysuckle *(Lonicera canadensis),* Canada mayflower (*Maianthemum canadensis*), naked miterwort (*Mitella nuda*), and Pyrola (*Pyrola* sp.).

Two high quality Great Lakes marshes were also identified on Burnt Island. The marsh on the northwest part of the island occupied a large, shallow bay and contained several distinct vegetation zones. A northern shrub thicket containing speckled alder *(Alnus rugosa),* sweet gale (*Myrica gale*) and Bebb's willow (*Salix bebbiana*) occupied an area in the rear of the bay and bordered upland forest. A sedge-dominated (*Carex stricta*) northern wet meadow bordered the shrub zone and a wide band of hardstem bulrush (*Scirpus acutus*)

separated its from extensive open mud flats. The open mud flats which are especially common near the water's edge were being colonized by a variety of native wetland species including sedge (*Carex viridula*), pipewort (*Eriocaulon septangulare*), brown fruited rush (*Juncus pelocarpus*), and rush (*Juncus brachycephalus*). The marsh also contained an active beaver lodge.

A second Great Lakes marsh occurred on the southeast side of the island in a bay separating Burnt and Wilson Islands. This marsh also contained several distinct vegetation zones. A thin shrub zone dominated by speckled alder occurred along the upland edge. This zone was bordered by a northern wet meadow comprised chiefly of sedges (*Carex stricta* and *C. lacustris*) and blue-joint grass (*Calamagrostis canadensis*) but also containing sweet-flag (*Acorus calamus*), hardstem bulrush, and water smartweed (*Polygonum amphibium*). A band of softstem bulrush bordered the sedge-dominated zone and contained bur-reed (*Sparganium* sp.), pickerelweed (*Pontederia cordata*), common arrowhead (*Sagittaria latifolia*), and yellow cress (*Rorippa* aquatica). Lastly, a thin band of rushes (*Juncus brachycephalus* and J. *nodosus*) separated the extensive open mud flats from open water in the bay's center. The open mud flats contained stranded sweet scented water-lily (*Nymphaea odorata*) and were being colonized by spike rush (*Eleocharis acicularis*) (see plates in the natural community section).

Harbor Island. Harbor Island contained several high quality natural communities including boreal forest, northern mesic forest, and Great Lakes marsh. Like Burnt Island, much of Harbor Island's shoreline is covered with wave-worn limestone cobble beach. Harbor Island is appropriately named as the island surrounds a large, extremely well protected bay. Great Lakes marsh occupied the north and east sides of the bay and several distinct vegetation zones occurred within the marsh. A zone of northern wet meadow dominated by sedge (Carex stricta) and blue-joint grass abutted the upland forest and graded into a wide band of bulrush (Scirpus acutus and *Scirpus validus*) and then open water. Open mudflats occurred throughout the bulrush zone and were being colonized by Canadian rush (*Juncus canadensis*), rush (*Juncus brachycephalus*), and green-fruited bur-reed (*Sparganium chlorocarpum*). An active beaver lodge occurred at the edge of the bulrush zone, in a cove on the northwest side of the bay. Behind the beaver lodge was a patch of reed (Phragmites australis) surrounded by northern wet meadow.

Northern mesic forest and boreal forest dominated the island's interior. The substrate of both forest types appeared similar, with 5 – 8 cm of duff over cobblestone and sand. Two large areas of boreal forest occurred on the island. Because of their close proximity to one another and similar species composition and structure, they were treated as a single natural community occurrence. The boreal forest canopy was dominated by white cedar, quaking aspen, white spruce, and balsam fir. The larger white cedars ranged in size from 56 – 25 cm dbh with the 40 cm dbh size class individuals were aged to approximately 115 years old. Small patches of windthrow were fairly common within the boreal forest. A thick mat of sedge (*Carex deweyana*) blanketed the ground in most of these openings and balsam fir and white cedar appeared to be regenerating here. Outside of the blowdown areas, little white cedar regeneration was observed and deer browse sign was common wherever young cedar and quacking aspen occurred. Common ground layer species in the boreal forest included sedge (*Carex deweyana*), spinulose woodfern (*Dryopteris carthusiana*), Canada mayflower (*Maianthemum canadensis*), partridgeberry (*Mitchella repens*), and naked miterwort (*Mitella nuda*). The northeast corner of the island contained an area of boreal forest we did not include as part of the delineated element occurrence because white cedar had been selectively cut from the area. However, the area was found to be white cedar-dominated over portions and also contained some remnant old-growth, with one tree measuring 99cm in dbh (see photo plates).

Northern mesic forest occurred throughout the island, however, an exemplary red oak-dominated stand was located on the island's east side. Occupying an isthmus between the island's sheltered bay and Lake Huron, the long narrow patch of towering red oaks stood out from the island's other stands of mesic northern forest. The forest canopy was dominated by red oaks ranging in size from 95 – 45 cm dbh. Large yellow birch (*Betula alleghaniensis*) measuring 50 - 60cm dbh were widely scattered throughout the stand. While red maple (Acer rubrum) was the most common species in the understory, several small patches of balsam fir ranging 2 –6 cm dbh in size, also formed a component of the understory. Vegetation in the ground layer was very sparse except for several large patches of stiff clubmoss (*Lycopodium annotinum*) and a ridgetop where sedge (*Carex pensylvanica*) blanketed the ground. Other common ground *layer* species included sedges (*C. articulata, C. deweyana,* and *C. pedunculata),* and bracken fern (*Pteridium aquilinum*). Old, stranded cobble stone beach ridges running parallel to the present day shoreline were clearly visible on the forest floor. An absence of red oak regeneration was observed, however, this is not uncommon in a

closed-canopy mesic northern forest. The dominance of red oak in this stand indicates that the site was probably not forested when these trees were first established. Similar stands in Michigan are thought to have been associated with Native American agricultural use (Albert and Minc 1987).

Summary of Island Project 1998-2000: The Results and Their Significance

Priority Islands and Status of Inventories

In her 1993 overview of Michigan's nearly 600 Great Lakes islands, Soule's biodiversity analysis provided a thorough compilation of island data and status information as well as several important findings and recommendations. Key to these findings was the recognition that inventories are necessary as a critical step in maintaining both the aesthetic and biological values of islands. Among the numerous and highly diverse array of islands found within Michigan's borders, 31 specific islands or island groups were identified as having the highest priority needs for biological inventory. Soule's listing of high priority sites and their respective inventory needs are reprised below in Table 7. Islands in bold are sites at which MNFI has conducted inventories in one or more years from 1998-2000 during the course of this CZM project. Sites in italics consist of islands that have been selectively inventoried since 1993 through other MNFI studies (Cuthrell et al. 2000; Albert et al. 1997, Albert et al. 1995, Albert et al. 1994, Albert and Penskar 1993).

Focusing on the above 31 islands and island groups, MNFI has completed inventories for 16, or more than one-half of the high priority sites identified by Soule. Surveys have resulted in the identification of a large number of occurrences that have been entered into the statewide biological and conservation database (BCD). Table 8 provides a summary of the results of our CZM island inventories from 1998-2000, detailing the natural community, rare plant, and rare animal surveys completed for each island and the number and types of elements that were documented.

Natural Community and Rare Species Inventories

A total of 41 different elements were identified during the three years of island surveys, consisting of 12 different natural community types, 16 rare plant species, and 13 rare animal species, as summarized in Table 9. Of the grand total of 146 occurrences documented during our inventories, 62 (42%) consisted of previously known occurrences that were relocated and updated, whereas 84 (58%) were identified as new occurrences (Table 8). A detailed compilation of these elements, with a listing of their respective global and state ranks, as well as federal and state listing status where appropriate, is provided in Appendix I. An explanation of the criteria used to establish global and state ranks is provided in Appendix II. MNFI abstracts for several natural communities and rare plant and animal species identified during our surveys are provided in Appendix III.

Among natural communities identified on all islands surveyed, the most occurrences were for mesic northern forest, followed by northern fen, Great Lakes marsh, open dunes, boreal forest, alvar, dry-mesic northern forest, northern wet meadow, bog, forest-dune swale complex, hardwood swamp, and dry non-acid cliff. Of the 12 different community types, five (alvar, forest-dune swale complex, Great Lakes marsh, northern fen, open dunes) are ranked globally rare to imperiled by TNC (Appendix I).

For the 16 rare plant species identified, the most occurrences documented were for Pitcher's thistle, followed by Lake Huron tansy, dwarf lake iris, beauty sedge, butterwort, Michigan monkey-flower, Pumpelly's brome grass, ram's head orchid, American shore-grass, English sundew, Houghton's goldenrod, Richardson's sedge, yellow pitcher-plant, climbing fumitory, wall-rue, and purple cliff-brake. Of these rare plant taxa, five (dwarf lake iris, Houghton's goldenrod, Michigan monkey-flower, Pitcher's thistle, and yellow pitcher-plant) are ranked globally rare to globally critically imperiled by TNC (Appendix I).

Among rare animal species identified during our surveys, the most occurrences were documented for Lake Huron locust, followed by American bittern, common loon, red-shouldered hawk, bald eagle, common tern, common moorhen, Hine's emerald dragonfly, eastern massasauga, marsh wren, black tern, merlin, and osprey. Of the 13 rare species, three (Hine's emerald dragonfly, Lake Huron locust, and eastern massasauga) are ranked globally rare to imperiled by TNC (Appendix I).

Table 7. Michigan islands and island groups identified as high priority for inventory as a result of the biodiversity analysis by Soule (1993).

County	Island or Island group	Inventories needed
Alger	Grand Island	plant, animal
Chippewa	**Drummond Island**	community, plant, animal
	Sugar	community, plant, animal
	Neebish	community, plant, animal
	Lime	community, plant, animal
	Harbor	community, plant, animal
	Potagannissing Bay & Detour Passage islands	plant, animal
Mackinac	**Bois Blanc**	community, plant, animal
	Marquette	community, plant, animal
	Albany	plant, animal
	Little LaSalle	community, plant, animal
	LaSalle	community, plant, animal
	Big St. Martin	community, plant, animal
	St. Martin	community, plant, animal
Charlevoix	**Beaver**	community, plant
	Garden	community
	Hog	plant, invertebrates
	High	plant, invertebrates
	Whiskey	community, plant
Delta	**Summer**	community, plant
	Little Summer	community, plant
	Poverty	community, plant
	St. Martin	community, plant
Bay	Wildfowl Bay Islands	community, plant, animal
Alpena	Thunder Bay Island	plant
	Crooked Island	community, plant
	Middle Island	community, plant
St. Clair	*Harsens*	community, plant
	Dickinson	community, plant
Leelanau	South Fox	community, plant, animal
	North Fox	plant, animal

Table 8. Summary of MNFI inventory results for island inventories conducted from 1998-2000 in northern Lake Michigan and northern Lake Huron.

County Island	Inventory type	Elements identified	Number of known occurrences identified and updated	Number of new occurrences documented
Charlevoix				
Beaver Island	Natural community	Bog		1
		Dry-mesic northern forest		1
		Mesic northern forest		4
		Open dunes		5
	Rare plants	*Bromus pumpellianus*		1
		Carex concinna	1	
		Cirsium pitcheri	10	4
		Cypripedium arietinum	1	
		Iris lacustris	3	
		Littorella uniflora	1	
		Mimulus glabratus var. *michiganensis*	2	
		Pinguicula vulgaris	2	
		Tanacetum huronense	10	4
	Rare animals	American bittern		1
		common loon	2	
		common moorhen		1
		Lake Huron locust	1	10
Garden Island	Natural community	boreal forest	1	1
		Great Lakes marsh		2
		mesic northern forest	1	1

County Island	Inventory type	Elements identified	Number of known occurrences identified and updated	Number of new occurrences documented
Garden Island (continued)	Natural community	northern fen	3	3
		northern wet meadow	1	1
	Rare plants	*Carex concinna*		1
		Cirsium pitcheri	2	1
		Drosera anglica		1
		Pinguicula vulgaris	2	
		Solidago houghtonii		1
Hog Island	Natural community	dry-mesic northern forest		1
		forest-dune swale complex		1
		Great Lakes marsh		1
		hardwood swamp		1
		northern fen		1
	Rare plants	*Iris lacustris*		1
		Cirsium pitcheri	1	
	Rare animals	Lake Huron locust	1	
Delta **Poverty Island**	Natural community	alvar	1	
	Rare plants	*Carex richardsonii*	1	

County Island	Inventory type	Elements identified	Number of known occurrences identified and updated	Number of new occurrences documented
Summer Island	Natural community	Alvar	1	
	Rare plants	*Carex concinna*	1	
		Iris lacustris	1	
Little Summer Island	Rare plants	*Adlumia fungosa*		1
		Iris lacustris		1
Mackinac **Bois Blanc Island**	Natural community	mesic northern forest	3	
	Rare animals	American bittern		1
		bald eagle	2	
		common loon	1	1
		common tern	1	1
		Hine's emerald dragonfly		1
		red-shouldered hawk		4
		Eastern massasauga		1
		marsh wren		1
Marquette & LaSalle islands (Les Cheneauxs)	Natural community	boreal forest		2
		Great Lakes marsh	1	
		northern fen		1
		open dunes		1
	Rare plants	*Carex concinna*		3
		Iris lacustris	1	1

County Island	Inventory type	Elements identified	Number of known occurrences identified and updated	Number of new occurrences documented
Marquette & LaSalle islands (Les Cheneauxs) (continued)	Rare plants	*Sarracenia purpurea* f. *heterophylla*		1
Chippewa				
Drummond Island	Natural community	dry non-acid cliff		1
	Rare plants	*Asplenium ruta-muraria*	1	
		Pellaea atropurpurea		1
	Rare animals	American bittern		3
		Black tern	1	
		merlin		1
		osprey		1
Harbor Island	Natural community	boreal forest		1
		Great Lakes marsh		1
		mesic northern forest		1
Burnt Island	Natural community	boreal forest		1
		Great Lakes marsh		2
	Rare animals	bald eagle	1	
TOTALS		**41 different elements**	**62 updated occurrences**	**84 new occurrences**

Table 9. Number of occurrences identified for each element during 1998-2000 island surveys.

Element	# of occurrences
Natural Communities	
Mesic northern forest	10
Northern fen	8
Great Lakes marsh	7
Open dunes	6
Boreal forest	6
Alvar	2
Dry-mesic northern forest	2
Northern wet meadow	2
Bog	1
Forest-dune swale complex	1
Hardwood swamp	1
Dry non-acid cliff	1
Rare Plant Species	
Pitcher's thistle	18
Lake Huron tansy	14
Dwarf lake iris	8
Beauty sedge	6
Butterwort	4
Michigan monkey-flower	2
Pumpelly's brome grass	1
Ram's head orchid	1
American shore-grass	1
English sundew	1
Houghton's goldenrod	1
Richardson's sedge	1
Yellow pitcher-plant	1
Climbing fumitory	1
Wall-rue	1
Purple cliff-brake	1
Rare Animal Species	
Lake Huron locust	12
American bittern	5
Common loon	4
Red-shouldered hawk	4
Bald eagle	3
Common tern	2
Common moorhen	1
Hine's emerald dragonfly	1
Eastern massasauga	1
Marsh wren	1
Black tern	1
Merlin	1
Osprey	1

Migratory and Breeding Bird Surveys

In addition to documenting occurrences of listed species and high quality natural communities, significant inventory efforts were conducted on targeted islands to assess the status of both migratory and breeding birds. In 1998 only migratory birds were assessed, then it was subsequently decided that adding a census of breeding bird populations would better characterize the function of Great Lakes islands in supporting avian biodiversity. Migratory and breeding bird censuses were subsequently conducted over two-year periods on Beaver Island, Garden Island,[2] and Bois Blanc Island, and an initial year of census was completed on Drummond Island.

In 1998, 52 bird species were observed on Beaver Island and 33 bird species were observed on Garden Island during spring migration surveys. In 1999, spring migration surveys documented 76 bird species from Beaver Island, 63 bird species from Garden Island, and 78 bird species from Bois Blanc Island. During summer breeding season surveys, 89 bird species were observed on Beaver Island, 58 species were observed on Garden Island, and 74 species were observed on Bois Blanc Island. For the combined 1999 censuses, 133 different bird species were observed; 108 bird species were observed during spring migration and 109 species were observed during the summer breeding season. Mean bird abundance was greater on Bois Blanc Island when compared to Beaver and Garden islands for both spring migration and breeding season surveys. Species richness was greater on Beaver and Bois Blanc islands than on Garden Island during spring migration, whereas species richness was slightly higher on Bois Blanc Island versus Beaver and Garden islands during the breeding season.

In 2000, migratory and breeding season surveys were conducted on Bois Blanc Island and Drummond Island. Overall, 130 bird species were observed during the migration and breeding seasons. During spring migration, 77 bird species were observed on Bois Blanc Island and 90 bird species were observed on Drummond Island. During summer breeding season surveys, 68 bird species were observed on Bois Blanc Island and 99 bird species were observed on Drummond Island. Mean bird abundance and species richness during spring migration and the summer breeding season was greater on Bois Blanc Island when compared to Drummond Island, although overall, a greater number of birds and a greater number of species were recorded on Drummond Island. An assessment of habitat use by migratory and breeding birds was conducted on each island and the data compared. Counts of migratory and breeding birds on Bois Blanc Island at shoreline and inland water habitats were higher when compared with counts at interior habitats. On Drummond Island, counts of migratory birds were higher at interior and inland water sites while counts of breeding birds were highest at inland water sites.

Aquatic Surveys

Aquatic surveys were implemented in 1999 primarily to assess the potential for conducting detailed, more systematic inventories during the course of this and other projects. Initial aquatic surveys focused on four inland lakes and two significant streams on Beaver Island, and included dedicated surveys to determine the status of the rare deepwater snail (*Stagnicola contracta*). No rare or sensitive taxa were identified during these brief surveys, but it was concluded identified that the aquatic systems of Beaver Island are diverse and of high quality, and that there was notable ecological diversity among the lakes considering the relatively small geographic area represented. Coastal aquatic sampling did not take place; however, that type of inventory is now being conducted within the context of other coastal zone projects (Higman et al. 2001), and Beaver Island provided useful data to help characterize the northern Great Lakes region.

[2] Because breeding bird surveys were not implemented until the second year of the project, only one year of this census type was conducted on Beaver and Garden islands.

Digitizing Natural Features Data

An important component of island inventories included preparing field information for use within the MNFI Geographic Information System (GIS). Natural features data were transcribed and entered with respect to new heritage data standards developed for the spatial representation of element occurrences. In addition to digitizing data obtained during island inventories, existing natural features information for survey sites was also carefully reviewed and digitized. This entailed closely examining source information for previously documented records, particularly field forms and any associated maps indicating the specific locations of natural features and their spatial extent.

Using this new GIS and data platform methodology, several islands were systematically examined and digitized. This included the entire Beaver Island archipelago in northern Lake Michigan (Beaver, Garden, High, Hog, Whiskey, Trout, Gull, Squaw, and associated smaller islands), Bois Blanc Island in northern Lake Huron, and Burnt and Harbor islands within Potagannissing Bay, also within northern Lake Huron. This resulted in the digitization of 210 natural feature occurrences (161 for the Beaver Island archipelago, 43 for Bois Blanc Island, and a total of six for Burnt and Harbor islands). Digitizing will continue for all islands inventoried during this project, with Drummond Island slated for completion in 2001.

Conservation Outreach

Conservation outreach was initiated with a pilot presentation conducted on Beaver Island in 1999, following the first year of inventory. Using a community based approach, an interactive workshop was held to enable residents and other important stakeholders to determine what types of MNFI data were desired in order to make effective conservation planning decisions. The workshop was held following the annual meeting of the Beaver Island Property Owners Association (BIPOA), the most active group within the community. More than 100 people attended the annual meeting presentation, which was conducted with the assistance of the Land Information and Access Association (LIAA). As a result of these presentations, recommendations were made to develop an arrival guide to inform new residents and visitors about the area's unique natural and cultural features and how to be good land stewards. It was also suggested that a use-friendly kiosk be installed accompanied by instructive brochures. Most importantly, a recommendation was made to integrate natural features information with the current values of islanders into the master planning process for each of the island's two townships.

In addition to the Beaver Island activities, preliminary planning was conducted in 2000 for a similar conservation outreach effort scheduled for Drummond Island in 2001. This planning was initiated by contacting The Nature Conservancy (TNC) Northern Lake Huron Bioreserve Director, Jesse Hadley, to discuss strategies. It was subsequently determined that TNC will assist by notifying key contacts and participating as appropriate in the outreach effort. Preliminary information regarding current natural features data was reviewed as well as pertinent available GIS information (e.g. land cover, presettlement vegetation), all of which will be necessary in order to prepare the outreach presentation for the desired audiences. As part of 2001 inventories, Drummond Island will be photo-interpreted by a staff ecologist, and the resulting type map will provide an additional resource to aid the conservation outreach effort. It is expected that most of the components of the previous pilot workshop will be used, yet the workshop will also be customized as appropriate to adapt to what is likely to be a markedly different set of stakeholders and island community.

Conclusions

Three years of comprehensive, systematic island inventories have resulted in significant findings. This is demonstrated in part by the identification of a large number of new occurrences, as well as the many previously known occurrences for which current status information was obtained. Compiling detailed information on previously documented occurrences was particularly important, given that prior to our surveys the majority of these records provided little information beyond noting the presence of the element. Updating numerous records and fully documenting new occurrences with reliable and current data enables local officials, planners, landowners, and others to make sound land-use decisions that will help to conserve and sustain natural features. Incorporation of these data within a GIS-based system will also ultimately enhance the ability for all stakeholders to

utilize this information.

Further demonstrating the importance of the inventory is the large number of globally rare to globally critically imperiled (G3-G1) natural features documented during the project, including five natural community types, five rare plant species, and three rare animal species. Among the globally rare species were four of Michigan's eight federally listed plant taxa, including all of the well known shoreline endemics, Pitcher's thistle, dwarf lake iris, Houghton's goldenrod, and Michigan monkey-flower. Among the globally rare animal species documented were the federally endangered Hine's emerald dragonfly, the eastern massasauga, (a federal candidate species), and the Lake Huron locust, a Great Lakes endemic. Overall, nearly 33% of the 41 elements identified during inventories are globally significant, strongly underscoring the critical role of islands in supporting Great Lakes biodiversity.

In addition to standard, element-based inventories, an assessment of bird populations was conducted to determine the importance of islands in providing habitat to migratory as well as resident breeding birds. Bird counts conducted on Beaver, Garden, Bois Blanc, and Drummond islands support the contention that islands provide critical stopover habitat and support significant breeding bird populations. Owing to a well-documented decline in many bird species, especially Neotropical migrants, assessing the role of island habitats in maintaining Great Lakes bird populations is critical. It is particularly important to assess bird populations due to increasing human activities that tend to fragment and degrade habitats, especially along shoreline areas vital to these species.

Lastly, the conservation outreach workshop and presentation represent our effort to explore how natural features data can be optimally used by island residents and decision makers to improve land-based decisions that influence the conservation of biodiversity. This can only be determined by meeting with stakeholders, presenting our information in a useful format, and ascertaining the effectiveness of the approach. Beaver Island provided an opportunity to work within a well-established human community to test what types and levels of information are desired by the local community. Through the workshop and presentation, we were able to raise awareness of unique natural features, identify sites that were of high priority for both islanders and MNFI, and identify a preliminary list of ways to communicate heritage information to the larger community. It is our hope that this information will be integrated into land use planning at the township level. From our experience, we realize that there is a disconnect between scientific surveys and research and the day to day activities that occur in the communities throughout Michigan. Not only are people largely unaware of the unique natural features in their area, they are also unaware of how their decisions and actions can impact the long-term viability of rare species and high quality natural communities. Conducting conservation outreach is thus essential if island biodiversity is expected to be maintained, and thus should be considered the capstone to comprehensive biological inventory efforts.

Identification of Significant Biodiversity Areas

The following consists of a brief overview of significant areas identified during 2000 surveys. As noted in previous progress reports (Penskar et al. 2000), a cumulative summary of these areas will be provided in a final project report.

Bois Blanc Island. This island, as described in previous reports, is an important landscape within the Straits of Mackinac region, supporting several high quality natural communities and many rare plant and animal occurrences, several of which are federally listed. A second year of migratory and breeding bird surveys once again demonstrated the importance of the island. Mean bird abundance and mean species richness were both higher when compared to Drummond Island during spring migration as well during the summer breeding season. Bois Blanc Island is also noteworthy because it serves as the northernmost location in Michigan for the eastern massasauga. The unique combination of old-growth forest, shoreline endemics, and many additional rarities clearly indicate the significance of this island. Of particular importance are the cobble shorelines and interior wetlands, as well as mature forest tracts and coniferous forest areas.

Drummond Island. Bird surveys further corroborated the importance of this large island, which is well known for its extensive alvar habitat and numerous rare plant and animal species. Although mean bird abundance and mean species richness were lower in comparison to Bois Blanc Island, overall species richness was greater (see Animal Surveys section). Moreover, Drummond Island was characterized by a number of different species, including waterfowl, shorebirds, and raptors, and wetland birds which were not observed on Bois Blanc. This may be due to the island's geographic location with regard to migration

as well as its larger size and more interior habitats such as lakes, rivers, and wetland complexes.

Burnt Island. The island itself constitutes a significant site, based on the extent of boreal forest and Great Lakes marsh identified during field surveys. In addition to natural community occurrences, which include a large expanse of boreal forest and two high quality Great Lakes marshes, an active eagle nest was observed. The island is also known as an osprey nesting site. Although no rare plant species were identified, there is a potential for occurrences of the state threatened calypso orchid and concern species such as ram's head orchid (*Cypripedium arietinum*) and Alaskan orchid (*Piperia unalascensis*), as these species are known in nearby sites.

Harbor Island. This site is significant in that it is the largest island within Potagannissing Bay, and because it supports several natural features. The majority of the island contains significant community occurrences, including two occurrences of boreal forest, a mesic northern forest dominated by mature red oak, and an extensive Great Lakes marsh within the large, horseshoe-shaped interior bay. Despite shoreline searches, a previously documented population of Lake Huron tansy could not be relocated, although the colony may yet persist. Lastly, the island has been known as a bald eagle nesting site, although there are no recent records, and presumably suitable habitat remains.

Projected Work for 2001

Natural community surveys. Community surveys will be focused on Drummond Island and the remaining large islands within Potagannissing Bay that can be accessed. Large portions of Drummond Island have been inventoried in previous surveys, including a statewide alvar and bedrock shoreline inventory (Albert et al. 1994, 1995, 1997, Lee 1998), as well as selected areas during this island project. However, aerial photo interpretation will be conducted for the entire island to identify any remaining communities that merit survey. In addition, a more comprehensive inventory of the extensive cliffs on the Marblehead peninsula will be conducted by accessing this remote site from the interior. A community type map will be produced for assisting in conservation outreach. Aerial photo interpretation will also be performed for additional significant islands within Potagannissing Bay, including Wilson Island, Cedar island, Macomb Island, Maple Island, and possibly others, including the island group east of Harbor Island. Islands that are ultimately selected for survey depend upon obtaining permission from private landowners, but it is anticipated that this will not be a problem.

Botanical surveys. Rare plant fieldwork will be conducted in conjunction with all natural community surveys, including participation in photo interpretation and mapping of Drummond Island. Botanical inventories will include Drummond Island and all islands that can be accessed as noted above. In addition to plant surveys, the project leader will assist in conservation outreach activities and participate as necessary in a mid-summer outreach workshop with the MNFI Conservation Planner.

Animal surveys. Scheduled fieldwork for animal surveys consists of a second year of migratory and breeding bird surveys on Drummond Island. In addition, dedicated insect surveys will be conducted on Drummond Island to search for the federal endangered Hine's emerald dragonfly.

Conservation outreach. Following preliminary planning work in 2000, formal conservation outreach efforts will be conducted on Drummond Island based on the model developed for Beaver Island in 1999. This work will be carried out in coordination with TNC and their Northern Lake Huron Bioreserve Director. Activities will consist of making key contacts and presenting a conservation workshop tentatively planned for mid-July.

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Appendix I

Natural Communities and Listed Species Identified During 1998-2000 Island Inventories

Element	Common Name	Global/State Rank	Federal/State Listing Status
Natural Communities			
Alvar	-	G2/S1	-
Bog	-	G4/S4	-
Boreal forest	-	GU/S3	-
Dry-mesic northern forest	-	G4?/S3	-
Dry non-acid cliff	-	G4/S3	-
Wooded dune and swale complex	-	G3/S3	-
Great Lakes marsh	-	G3/S3	-
Hardwood-conifer swamp	-	G4/S3	-
Mesic northern forest	-	G4/S4	-
Northern fen	-	G3/S3	-
Northern wet meadow	-	G4/S4	-
Open dune	-	G3/S3	-
Rare Plant Species			
Adlumia fungosa	Climbing fumitory	G4/S3	SC
Asplenium ruta-muraria	Wall rue	G5/S1	E
Bromus pumpellianus	Pumpelly's brome grass	G4G5T4/S2	T
Carex concinna	Beauty sedge	G4G5/S3	SC
Carex richardsonii	Richardson's sedge	G4/S3S4	SC
Cirsium pitcheri	Pitcher's thistle	G3/S3	LT, T
Cypripedium arietinum	Ram's head orchid	G3/S3	SC
Drosera anglica	English sundew	G5/S3	SC
Iris lacustris	Dwarf lake iris	G3/S3	LT, T
Littorella uniflora	American shore-grass	G5/S2S3	SC
Mimulus glabratus var. *michiganensis*	Michigan monkey-flower	G5T1/S1	LE, E
Pellaea atropurpurea	Purple cliff-brake	G5/S2	T
Pinguicula vulgaris	Butterwort	G5/S2S3	SC
Sarracenia purpurea f. *heterophylla*	Yellow pitcher-plant	G5T1T2Q/S1	T
Solidago houghtonii	Houghton's goldenrod	G3/S3	LT, T
Tanacetum huronense	Lake Huron tansy	G-/S-	T
Rare Animal Species			
Botaurus lentiginosus	American bittern	G4/S3S4	SC
Buteo lineatus	Red-shouldered hawk	G5/S3S4	T
Chlidonias niger	Black tern	G4/S3	SC
Cistothorus palustris	Marsh wren	G5/S3S4	SC
Falco peregrinus	Merlin	G5/S1S2	T
Gallinula chloropus	Common moorhen	G5/S3	SC
Gavia immer	Common loon	G5/S3S4	T
Haliaeetus leucocephalus	Bald eagle	G4/S4	LT, T
Pandion haliaetus	Osprey	G5/S4	T
Sistrurus catenatus catenatus	Eastern massasauga	G3G4T3T4/S3S4	C, SC
Somatochlora hineana	Hine's emerald dragonfly	G2G3/S1	LE, T
Sterna hirundo	Common tern	G5/S2	T
Trimerotropis huroniana	Lake Huron locust	G2G3/S2S3	T

G = Global Rank ("U" = Undetermined, "T" = Subspecies, "Q" = Taxonomy in question)
S = State Rank, LE = Federal Endangered, LT = Federal Threatened, C = Federal Candidate,
E = State endangered, T = state threatened, SC = State special concern

Appendix II.

GLOBAL AND STATE ELEMENT RANKING CRITERIA

The Nature Conservancy

GLOBAL RANKS

G1 = critically imperiled globally because of extreme rarity (5 or fewer occurrences range-wide or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extinction.
G2 = imperiled globally because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extinction throughout its range.
G3 = either very rare and local throughout its range or found locally (even abundantly at some of its locations) in a restricted range (e.g. a single western state, a physiographic region in the East) or because of other factor(s) making it vulnerable to extinction throughout its range; in terms of occurrences, in the range of 21 to 100.
G4 = apparently secure globally, though it may be quite rare in parts of its range, especially at the periphery.
G5 = demonstrably secure globally, though it may be quite rare in parts of its range, especially at the periphery.
GH =of historical occurrence throughout its range, i.e. formerly part of the established biota, with the expectation that it may be rediscovered (e.g. Bachman's Warbler).
GU = possibly in peril range-wide, but status uncertain; need more information.
GX = believed to be extinct throughout its range (e.g. Passenger Pigeon) with virtually no likelihood that it will be rediscovered.

STATE RANKS

S1 = critically imperiled in the state because of extreme rarity (5 or fewer occurrences or very few remaining individuals or acres) or because of some factor(s) making it especially vulnerable to extirpation in the state.
S2 = imperiled in state because of rarity (6 to 20 occurrences or few remaining individuals or acres) or because of some factor(s) making it very vulnerable to extirpation from the state.
S3 = rare or uncommon in state (on the order of 21 to 100 occurrences).
S4 = apparently secure in state, with many occurrences.
S5 = demonstrably secure in state and essentially ineradicable under present conditions.
SA = accidental in state, including species (usually birds or butterflies) recorded once or twice or only at very great intervals, hundreds or even thousands of miles outside their usual range.
SE = an exotic established in the state; may be native elsewhere in North America (e.g. house finch or catalpa in eastern states).
SH = of historical occurrence in state and suspected to be still extant.
SN = regularly occurring, usually migratory and typically nonbreeding species.
SR = reported from state, but without persuasive documentation which would provide a basis for either accepting or rejecting the report.
SRF = reported falsely (in error) from state but this error persisting in the literature.
SU = possibly in peril in state, but status uncertain; need more information.
SX = apparently extirpated from state.

Appendix III.

Species Abstracts

Animals

Buteo lineatus (red-shouldered hawk)
Charadrius melodus (piping plover)
Chlidonias niger (black tern)
Sistrurus catenatus catenatus (eastern massasauga)
Somatochlora hineana (Hine's emerald dragonfly)
Sterna caspian (Caspian tern)
Sterna hirundo (common tern)
Trimerotropis huroniana (Lake Huron locust)

Communities

Limestone pavement lakeshore
Mesic northern forest
Open dunes
Wooded dune and swale

Plants

Bromus pumpellianus (Pumpelly's brome grass)
Calypso bulbosa (calypso orchid)
Cirsium pitcheri (Pitcher's thistle)
Drosera anglica (English sundew)
Sarracenia purpurea f. *heterophylla* (yellow pitcher-plant)
Solidago houghtonii (Houghton's goldenrod)

Buteo lineatus red-shouldered hawk

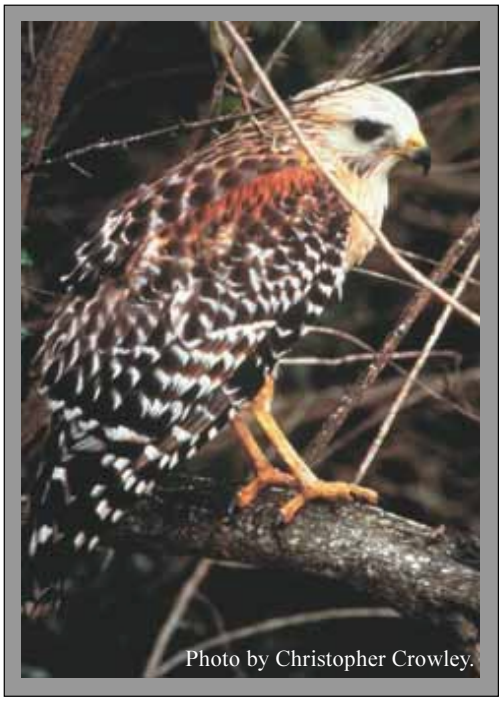
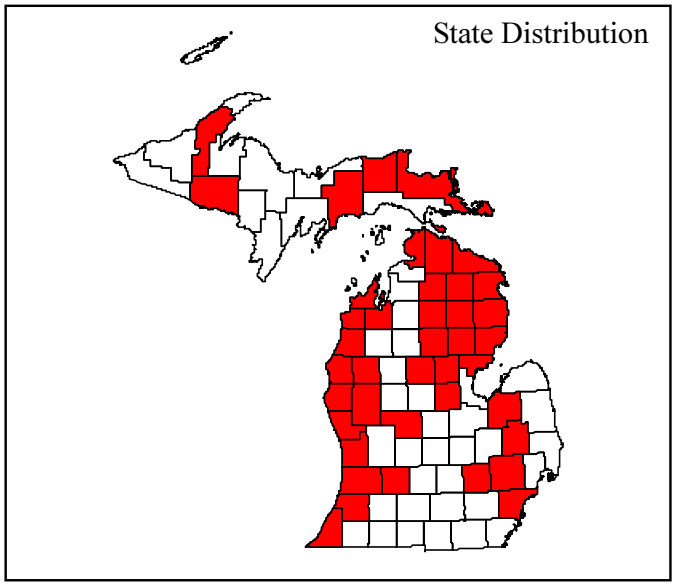
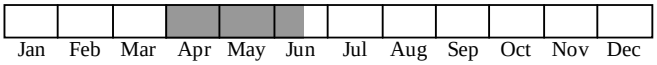


Photo by Christopher Crowley.



Best Survey Period



Status: State threatened

Global and State Rank: G5/S3S4

Family: Accipitridae (hawk family)

Total range: Breeding range for eastern populations is from Maine and southern Quebec west to Minnesota, and south to Florida, Texas, and central Mexico (Evers 1994). Wintering range for eastern populations is from Oklahoma, southern Wisconsin, southern Ohio and southern New England south to the Gulf Coast and Mexico (Johnsgard 1990).

State distribution: The distribution of breeding red-shouldered hawks has apparently shifted from their historical range in the southern Lower Peninsula to their present concentration in the northern Lower Peninsula. Breeding records are known from 42 Michigan counties. Currently, however, most breeding activity occurs mainly in two Lower Peninsula regions centering on Manistee County in the northwest and on the Straits area, from Cheboygan and Emmet counties to Alpena County (Ebbers 1991). High concentrations of nesting red-shouldered hawks with good reproductive success have been documented in the Manistee county area (Ebbers 1989). Also, recent survey work in Cheboygon, Emment, and Otsego counties (Pigeon River Country and Indian River forest areas) revealed numerous new nest locations that were highly successful over a two year period (Cooper et al. 1999). The Pigeon River Country and Indian River state forests areas and the Manistee County area provide good habitat for this species and these areas probably are important in terms of maintaining a viable population in Michigan.

Recognition: Adult red-shouldered hawks can be distinguished by the **reddish** coloration of their **underparts and wing linings** and their **five to six narrow, white tail bands**. In flight, they show **crescent-shaped translucent patches** lining the bases of the long, **outermost wing feathers** (the "primaries"). These patches are sometimes referred to as "windows". The bird's red shoulders are often not readily visible. Their **call** during the breeding season is distinctive, a **loud, rapidly repeated "kee-yer"**, though it is closely imitated by blue jays. Immatures have their underparts streaked with brown, teardrop-shaped spots. They may be readily identified by their underwing windows, as in the adults, and by their many narrow tail bands. Red-shouldered hawks can be distinguished from northern goshawks, Cooper's hawks, and sharp-shinned hawks by their shape, with a wider, more rounded tail and broader, longer wings than these other forest-dwelling hawks. The red-tailed hawk, a very common species, can be differentiated by the band of dark feathers running horizontally across its light belly, by the dark feathers lining the leading edge of its underwings, and by its reddish tail, which looks pinkish underneath in flight. The red-shouldered hawk can also be confused with the broad-winged hawk, but that species has three distinct black tail bands and creamy white wings outlined in black.

Best survey time/phenology: The red-shouldered hawk is migratory along the northern edge of its range and generally returns to Michigan in late February to early March, moving north with the retreating snow. Pairs arrive on

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their northern Lower Peninsula breeding grounds typically in mid-March (Ebbers 1991). Incubation of eggs occurs from late March to mid-April. Most young fledge in June (Craighead & Craighead 1956) and along with the adults remain near the nest site until migration in late fall.

Surveys are best accomplished from mid-April through early May, when birds are exhibiting territorial behavior, roads are relatively accessible, and leaves have not obscured nests. A standard and effective survey methodology for this species is to broadcast a red-shouldered hawk call with a tape recorder or predator caller in suitable habitat. Calling stations can be placed every 0.25 mile through suitable habitat. At each calling station a con-specific red-shouldered hawk call should be broadcast at 60 degrees for 10 seconds, 180 degrees for 10 seconds, and 300 degrees for 10 seconds. This calling sequence should be repeated three times (Kennedy and Stahlecker 1993). If a bird responds observers should look for a nest in the direction the call was initially heard.

Productivity surveys (i.e., nestling counts) can be conducted from early to mid-June. During this time period, young can often be viewed from the ground (Kochert 1986) or white wash (i.e., droppings from young) may be observed below the nest structure, which is evidence that young are or were recently present in a nest (Postupalsky, pers. comm.)

Habitat: In Michigan red-shouldered hawks utilize mature forested floodplain habitat, especially along the Manistee River. However, the majority of nests in Michigan have been found in large (usually >300 acres.), relatively mature deciduous or mixed forest complexes (medium to well stocked pole or saw timber stands). Typically these forest complexes have wetland habitats nearby or wetlands interspersed among these forested habitats (Cooper et al. 1999). Wetland areas such as beaver ponds, wet meadows and lowland forest are used primarily for foraging purposes (Howell and Chapman 1997). Upland openings are also used to some extent for foraging habitat (Evers 1994). Nests are typically placed in mature deciduous trees. American beech is the most commonly documented nest tree in Michigan and the presence of mature beech trees in forest stands may be an important factor that influences hawk utilization (Cooper et al. 1999, Ebbers 1989) However, a variety of nest trees have been utilized in Michigan (e.g., aspen, birch, ash, oak, etc.) which seems to indicate that tree structure and not the type of tree species is the most important factor that influences use of a tree for nest placement (Cooper et al. 1999). Nests are typically placed 35-40 feet above the ground but below the canopy, in a crotch 1/2 to 2/3 of the way up the tree (Ebbers 1989; Johnsgard 1990, Bednarz and Dinsmore 1981, Cooper et al. 1999). Also, nest sites tend to be housed in dense stands of timber with a closed canopy structure and very near wetland habitat (typically within 1/8 mile) (Johnsgard 1990, Cooper et al. 1999).

Biology: The red-shouldered hawk is a highly territorial breeder, and territories and nest sites are often reused for many years (Craighead & Craighead 1956, Bent 1937). In a recent two-year study in Michigan, territorial re-occupancy was high (78% of breeding territories were re-occupied between years) and nest re-occupancy between years was reported at a high rate as well (50% of the same nests were re-used between years) (Cooper et al. 1999). This species is very vocal in territorial defense as well as during its high-flying nuptial displays. The large, bulky nests are built of twigs and are usually "decorated" with greenery and other materials. Two to four eggs are typically laid. Eggs are incubated for about one month primarily by the female, while the male supplies food to her, and later also to the chicks. Great-horned owls and raccoons are common nest predators. The young fledge at about six weeks of age and begin to breed typically at two years old. Prey includes small rodents and birds, snakes, frogs, crayfish, and larger insects, with the proportion taken varying in different locations and possibly over time (Palmer 1988). The bird hunts below the forest canopy and in open, nearby wetlands by perching and waiting for prey. They may also glide low to the ground and surprise prey up close (Palmer 1988).

Conservation/management: The primary threat to this species in Michigan is habitat alteration and destruction due to timber harvest, road construction, and residential development (Evers 1994). Habitat manipulation directly impacts the species by alteration of suitable structure around the nest site and indirectly by influencing the abundance, distribution, and vulnerability of prey species. Fragmentation of forest stands and the creation of larger openings favor the immigration of nest competitors and predators such as the red-tailed hawk (*Buteo jamaicensis*) and great-horned owl (*Bubo virginianus*) (Bryant 1986). These species can either displace a nesting pair or directly depredate young and/or adults from a nest site. Management practices that maintain greater than 70% canopy closure, retain large trees for nesting, and conserve large contiguous blocks of deciduous or mixed forest stands and associated wetland habitat should benefit this species. Currently management has focused on maintaining the critical components of individual home ranges such as the nest area, post fledgling area, and foraging area. However, a more proactive and ecologically sound practice, to ensure conservation of the species on a long term scale, would be to manage large tracts of forest as ecological units. Ecological units should be analyzed and managed across vegetation types and land ownership pattern in order to maintain the array of ecological processes needed for this species (Graham et al. 1994).

Research needs: There are many research needs concerning this species some of which are listed below. More systematic survey of Michigan is needed in order to gain a better sense of breeding pair density and habitat use, especially in the Upper Peninsula. Further, once breeding territories are located productivity (i.e., the percentage of nests that produced at least 1 young to the fledgling stage)

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needs to be monitored in order to assess where viable populations occur. Also, little research has been conducted on the impacts of silvicultural practices on habitat use and nest productivity. Other research needs include but are not limited to home range size, movement patterns, analysis of landscape-level habitat patterns, impacts of predation, and investigation of post-fledgling habitat.

Related abstracts: northern hardwood forest, northern goshawk, woodland vole

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Abstract citation

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12-99/jlc

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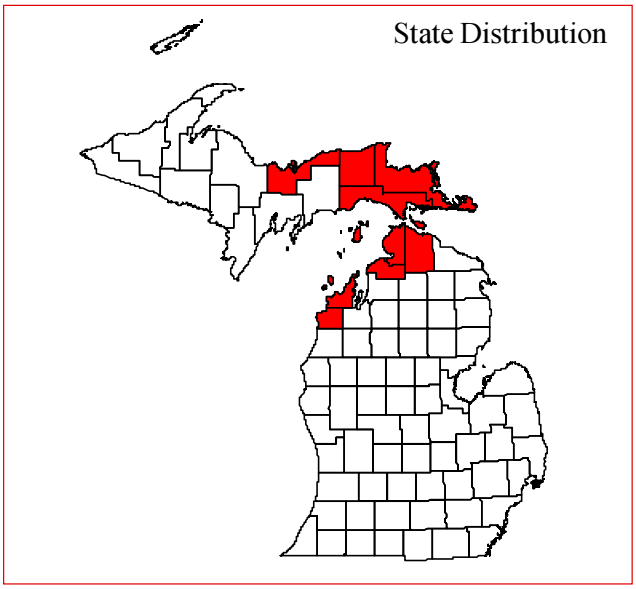
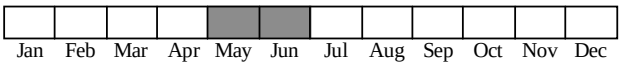
Charadrius melodus Ord — piping plover

Photo by Michigan Natural Features Inventory.



Best Survey Period



Status: Federal and State endangered

Global and state rank: G3/S1

Family: Charadriidae (plovers)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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Wemmer, L. 1999. Piping plover (*Charadrius melodus*) Great Lakes population. Revised recovery plan. Unofficial draft submitted to USFWS - Region 3, Fort Snelling, MN. 75 pp.

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Wilcox, L. 1959. A twenty year banding study of the piping plover. Auk 75:129-152.

Abstract citation:

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

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

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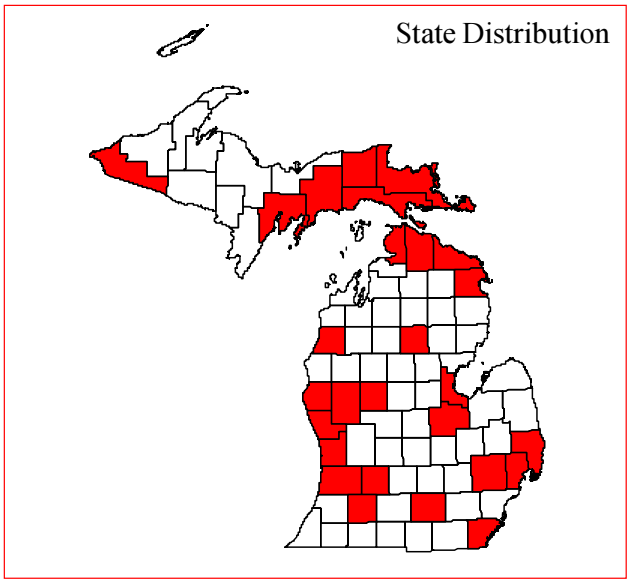
Chlidonias niger Linneaus — black tern

Photo by Barbara Simpson



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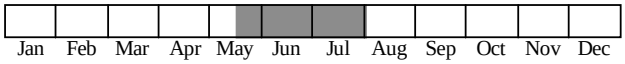

Status: State special concern

Global and state rank: G4/S3

Family: Laridae (gull and terns)

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

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

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

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

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

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

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

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

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

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

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

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

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

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Abstract citation:

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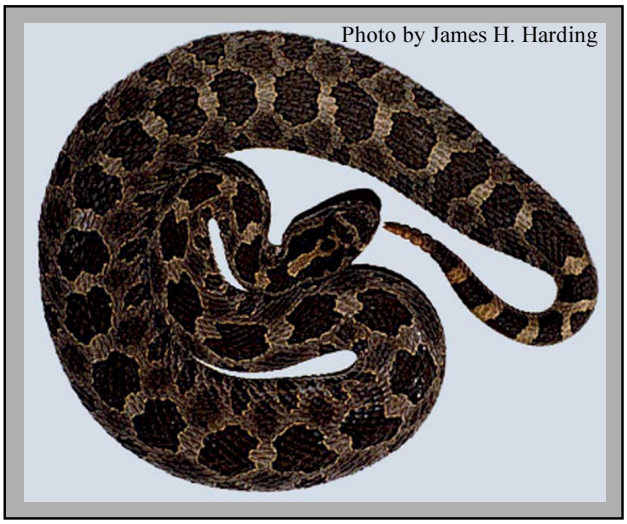
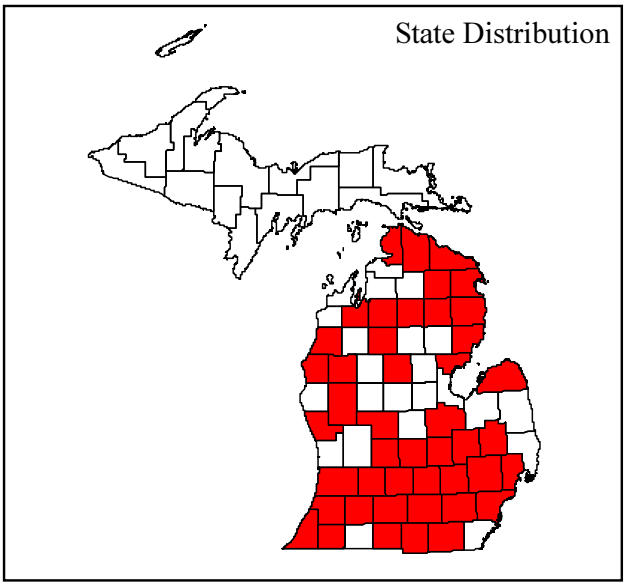
Sistrurus catenatus catenatus eastern massasauga





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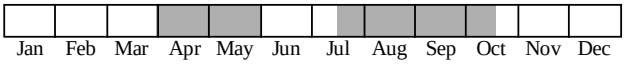

Status: Federal candidate species, State special concern

Global and state rank: G3G4T3T4/S3S4

Family: Viperidae (pit vipers and vipers)

Range: The eastern massasauga occurs from southeastern Minnesota, eastern Iowa, and northeastern Missouri east to southern Ontario, western New York, and northwestern Pennsylvania (Harding 1997). This species was once common across its range, but has declined drastically since the mid-1970s (Szymanski 1998). Massasaugas now mainly occur in disjunct, isolated populations, and have been afforded some level of legal protection in every state or province in which this subspecies occurs (Szymanski 1998).

State distribution: Michigan appears to be the last U.S. stronghold for this species relative to other states within its range. Historically, eastern massasaugas were found throughout the Lower Peninsula and on Bois Blanc Island. Within the last decade, eastern massasaugas have been reported from about 150 sites in 50 counties. These sightings appear to cluster in several regions across the Lower Peninsula, indicating areas where massasaugas may be concentrated (Legge and Rabe 1994). These include Oakland, Livingston, Jackson and Washtenaw counties in southeast Michigan, Allegan, Barry and Kalamazoo counties in southwest Michigan, and Iosco, Crawford and Kalkaska counties in northern Michigan. Nearly one-third of the historical occurrences in the state has not been reconfirmed in the past ten years (Legge 1996). Massasaugas have not been reported from Branch, Ingham, Shiawassee, Macomb, Huron, Clare, Oscoda, Montmorency and Emmet counties since prior to 1980 (some since the early 1900's) (Legge and Rabe 1994, Legge 1996). It is important to note, however, that a statewide, systematic field survey for this species has not been conducted. Also, massasaugas are highly cryptic and difficult to observe in its natural habitat. Therefore, massasaugas may still be present in areas that lack recent, as well as historical, records.

Recognition: Several characteristics readily identify this species from all other snakes in Michigan. The massasauga is a medium-sized (18.5 to 39.5 inches in length), thick-bodied snake (Harding 1997). It has a distinctive color pattern of **dark brown rectangular blotches** down the back with two or three additional rows of **dark spots along the sides**, and **alternating dark and light bands along the tail**. The **background color is gray, gray-brown or brown**. The belly or underside of the snake is usually black with gray, white or yellowish mottling (Harding 1997). The massasauga is a rattlesnake, and therefore has a **segmented rattle** at the end of its tail. It also has a **triangular-shaped head** (i.e., widens at the back of the head and narrows at the neck), **vertical slit-shaped pupils**, and **large, heat-sensing pits or openings** between the nostrils and the eyes. The scales are keeled (i.e., have a raised ridge), and the anal plate (i.e., enlarged scale partly covering the anal opening) is divided into two parts. It is the only **venomous** snake found in the state. Newborn massasaugas range

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in length from 7 to 10 inches and look similar to adults except are lighter in color (Harding 1997). They have only a single button at the end of their tails, and are unable to produce the sound of a rattle.

Several snakes in Michigan are frequently mistaken for eastern massasaugas. These include the eastern fox snake (*Elaphe vulpina gloydi*, State threatened), northern water snake (*Nerodia sipedon*), eastern milk snake (*Lampropeltis triangulum triangulum*), and eastern hog-nosed snake (*Heterodon platirhinos*). Although these snakes have a similar pattern of dark blotches on the back, these snakes usually have a lighter background color. They also lack the rattle, head shape, and pupil shape of the massasauga. Eastern fox snakes generally have a more slender and longer body than the massasauga (total adult lengths of 35 – 67 inches) (Harding 1997). The eastern hog-nosed snake has an upturned snout and is able to flatten and spread its neck out when threatened. Also, several of these snakes often will mimic the eastern massasauga and vibrate their tails rhythmically when threatened. If the snake is located in dry leaf litter, it can produce a buzzing sound similar to the massasauga's rattle.

Best survey time: Massasaugas typically are active between April and late October (Seigel 1986), and can be seen anytime during the active period. However, the best times to survey for this species are during spring emergence (i.e., April and May) for all age classes and during the basking and birthing period in mid- to late summer (i.e., late July, August and early September) for gravid females (Szymanski 1998, Casper et al. *in prep.*). Massasaugas are presumed to be most active during these time periods. Another survey window for this species is during fall ingress (i.e., mid-September through October) when snakes are moving to hibernacula (Seigel 1986, Johnson 1995, Szymanski 1998).

The recommended survey method currently is visual searches (Casper et al**.** *in prep*.). Optimal weather conditions for visual surveys include greater than 50% cloud cover, less than 15 mph wind speed, and air temperatures between 50 and 80° F (Casper et al. *in prep.*). Casper et al. (*in prep*.) recommend morning and evening surveys. However, although daily activity cycles vary among populations, Seigel (1986) found that during the spring and fall, massasaugas tend to be most active during the warmest parts of the day (e.g., 1200 – 1600 h). During the summer, they tend to be more active in late afternoon during cooler temperatures and may even become nocturnal.

Habitat: Eastern massasaugas have been found in a variety of wetland habitats, including bogs, fens, shrub swamps, wet meadows, marshes, moist grasslands, wet prairies, and floodplain forests (Hallock 1990, Harding 1997). Populations in southern Michigan are typically associated with open wetlands, particularly prairie fens, while those in northern Michigan are better known from lowland coniferous forests, such as cedar swamps (Legge and Rabe 1996). Massasaugas also generally occupy wetland habitats in the spring, fall, and winter, but in the summer, snakes migrate to drier, upland sites, ranging from forest openings to old fields, agricultural lands and prairies. In general, structural characteristics of a site appear to be more important than vegetative characteristics for determining habitat suitability (Beltz 1992). Specifically, all known sites appear to be characterized by the following: (1) open, sunny areas intermixed with shaded areas, presumably for thermoregulation; (2) presence of the water table near the surface for hibernation; and (3) variable elevations between adjoining lowland and upland habitats (Beltz 1992).

Ecology: Massasaugas usually are active between April and late October. Spring emergence typically starts in late March and early April as groundwater levels rise and ground temperature approaches air temperature (Harding 1997, Szymanski 1998). Massasaugas spend most of the time in the spring basking on elevated sites such as sedge and grass hummocks, muskrat and beaver lodges, or dikes and other embankments. Individuals may spend up to several weeks in the wetlands near their hibernation sites before moving to their summer habitats (Johnson 1995). This seasonal shift in habitat use appears to vary regionally and among populations (Szymanski 1998). In Wisconsin, King (1997) documented only gravid females dispersing to the drier uplands to have their young, while the males and non-gravid females remained in the wetlands.

Mating occurs in the spring, summer and fall (Reinert 1981, Vogt 1981, Harding 1997). The females give birth to litters of 5 to 20 live young in August or early September in mammal burrows or fallen logs in the uplands (Vogt 1981, Harding 1997). Female massasaugas reach sexual maturity at three or four years of age, after which they have been reported to reproduce both annually and biennially in different parts of their range (Reinert 1981, Seigel 1986, Harding 1997).

Massasaugas usually hibernate in the wetlands in crayfish or small mammal burrows. They also have been known to hibernate in tree roots and rock crevices as well as submerged trash, barn floors, and basements (Johnson and Menzies 1993). Hibernation sites are located below the frost line, often close to groundwater level. The presence of water that does not freeze is critical to hibernaculum suitability (Johnson 1995). Individuals tend to return to the same hibernation site each year (Prior 1991) and tend to hibernate singly or in small groups of two or three (Johnson and Menzies 1993).

Massasauga home ranges and movement distances can be quite variable. King (1997) reported mean home ranges of approximately 5 to 7 acres for neonates and gravid females, 17 acres for non-gravid females and 398 acres for males. Other studies have reported mean home ranges of less than 2.5 acres (Reinert and Kodrich 1982) to 64 acres (Johnson 1995). Reported maximum movements range from 0.1 mile in Michigan (Hallock 1990) to 2 miles in Wisconsin (King 1997). King (1997) recorded average movement distances of 0.03 mile for neonates, 0.2 mile for non-gravid females, 0.4 mile for gravid females, and 0.8 mile for males.

Massasaugas feed primarily on small mammals such as voles, moles, jumping mice, and shrews. They also will consume other snake species and occasionally birds and frogs. Natural predators for the massasauga, particularly the eggs and young, include hawks, skunks, raccoons, and foxes (Vogt 1981).

When they are threatened, eastern massasaugas will typically remain motionless, relying on their cryptic coloration to blend into their surroundings. They sound their rattle when alarmed but will occasionally strike without rattling when surprised. This species is generally considered unaggressive; it is unusual for the species to strike unless it is directly disturbed (Johnson and Menzies 1993). Although the venom is highly toxic, fatalities are very uncommon because the species' short fangs can inject only a small volume (Klauber 1972). Small children and people in poor health are thought to be at greatest risk.

Conservation/management: The greatest threats to eastern massasauga populations are habitat loss and degradation due to human activities, including the draining of wetlands for agriculture, residential development, roads and pollution (Szymanski 1998). In addition to the loss of wetlands, essential upland habitat has been destroyed and fragmented. Vegetative succession also has reduced habitat availability (Beltz 1992, Johnson 1995). Current land use practices, hydrological changes and fire suppression have altered or eliminated the natural disturbance regimes necessary for maintaining the early successional structure with which massasaugas are associated (Szymanski 1998). Vehicle-caused mortality and injury also pose a significant threat to populations as suitable habitat becomes fragmented by roads (Szymanski 1998).

Overcollection for commercial, recreational, scientific, or educational purposes has greatly reduced massasauga numbers at many sites, particularly collection for the pet trade and bounty hunting in states other than Michigan (Szymanski 1998). The lack of uniform protection for the massasauga across its range can create loopholes for illegal take and trade (Szymanski 1998), and lead to increased collecting pressure in states where take is not prohibited. Indiscriminant persecution by humans also has contributed to this species' decline. In Michigan, the eastern massasauga is protected under the Director's Order No. DFI-166.98, Regulations on the Take of Reptiles and Amphibians, which is administered by the Michigan Department of Natural Resources' Fisheries Bureau. It is unlawful to take an eastern massasauga from the wild except as authorized under a permit from the Director (legislated by Act 165 of the Public Acts of 1929, as amended, Sec.302.1c (1) and 302.1c (2) of the Michigan Compiled Laws). Public land managers and the general public should be informed that this species is protected and should not be collected or harmed. Any suspected illegal collection of eastern massasaugas should be reported to local authorities, conservation officers or wildlife biologists. The eastern massasauga also was listed as a federal candidate species by the U.S. Fish and Wildlife Service in 1999, and may be proposed for listing as threatened or endangered under the Endangered Species Act in the future.

Habitat protection of suitable wetlands and associated uplands is crucial for successful conservation of the eastern massasauga. Where populations are concentrated on public lands, land management practices need to be sensitive to protecting massasauga habitat. For instance, potential adverse impacts of land management practices such as timber harvesting, mowing, or prescribed burning can be avoided or minimized if these activities are conducted in late fall, winter, or early spring (i.e., November through early March) when the snakes are hibernating. Hydrological alterations such as winter drawdowns should be conducted prior to the initiation of hibernation to reduce the potential for causing winter mortality due to desiccation or freezing (Szymanski 1998). Viable massasauga populations in the state should be identified and targeted for long-term conservation and management efforts. Finally, people need to be educated about the biology and ecology of the eastern massasauga in order to reduce direct harassment and harm to individual snakes. This is especially important in areas where human-massasauga interactions are frequent (e.g. state and local parks).

Research needs: Currently, the greatest obstacle to effective conservation and management of the eastern massasauga in Michigan is incomplete knowledge of the distribution and abundance of the species. While recent sightings have been summarized (Legge and Rabe 1994), additional and systematic field surveys are needed. Additional work is needed to obtain long-term data on selected populations to identify healthy or viable massasauga populations. A reliable and efficient protocol or methodology for surveying and monitoring this species and estimating population size needs to be developed. Continued research is needed to improve our understanding of the specific biology

and ecology of Michigan massasaugas as well as potential impacts of various management practices. The genetic diversity of extant populations needs to be examined. Effective methods to educate the public about how to co-exist with massasaugas also need to be researched and implemented.

Related abstracts: Mitchell's satyr butterfly, prairie fen, spotted turtle, Blanchard's cricket frog, eastern fox snake, wood turtle, Blanding's turtle, small white lady's-slipper, mat muhly, red-legged spittlebug, swamp metalmark

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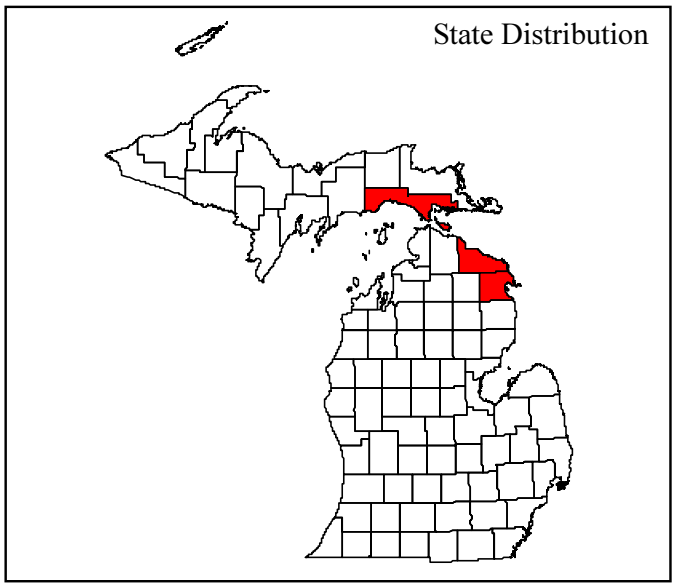
Somatochlora hineana Williamson — Hine's emerald dragonfly


Photo by William A. Smith.



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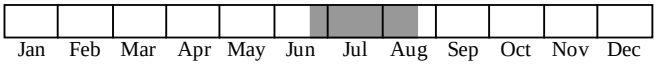

Status: Federal and State endangered

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

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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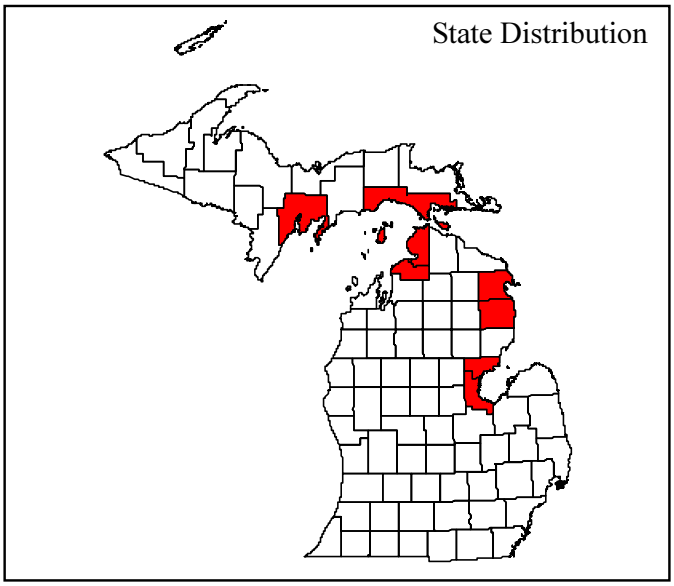
Sterna caspia *Pallas* — Caspian tern


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



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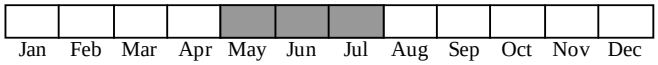

Status: State threatened

Global and state rank: G5/S2

Family: Laridae (gull and tern family)

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

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

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

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

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

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

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

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

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

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

Related abstracts: common tern (*Sterna hirundo*)

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Abstract citation

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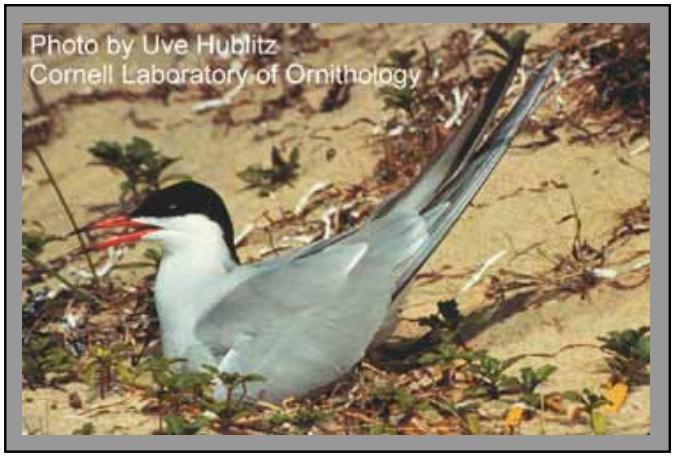
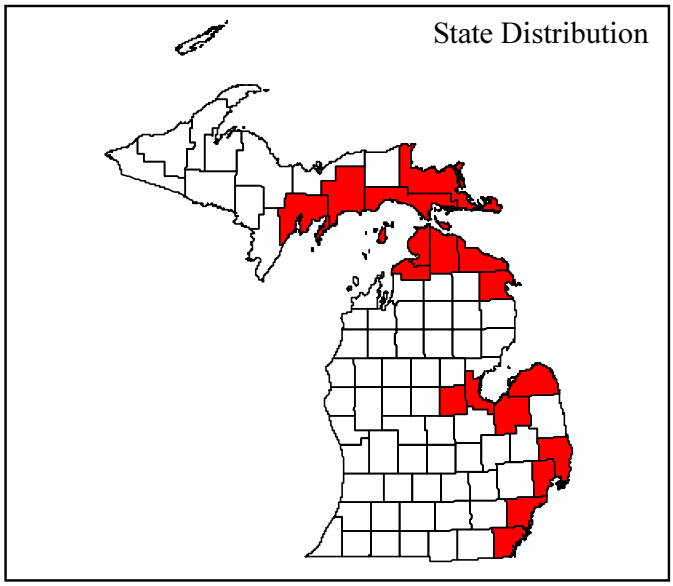
Sterna hirundo Linneaus — common tern





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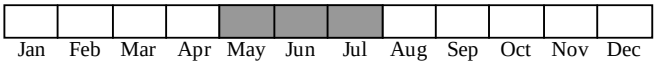

Status: State threatened

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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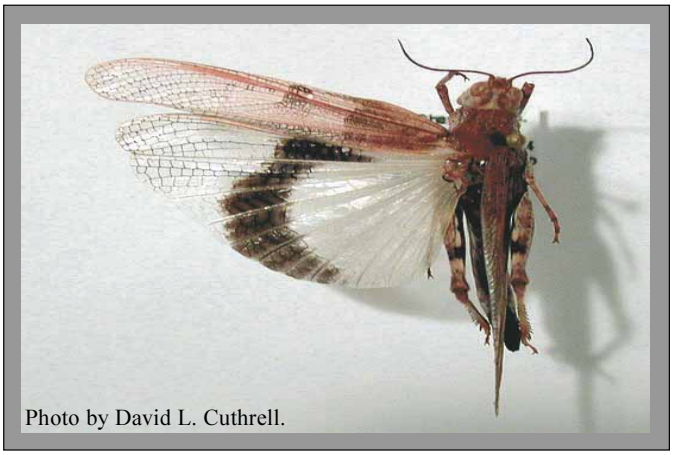
Trimerotropis huroniana (Walker) Lake Huron locust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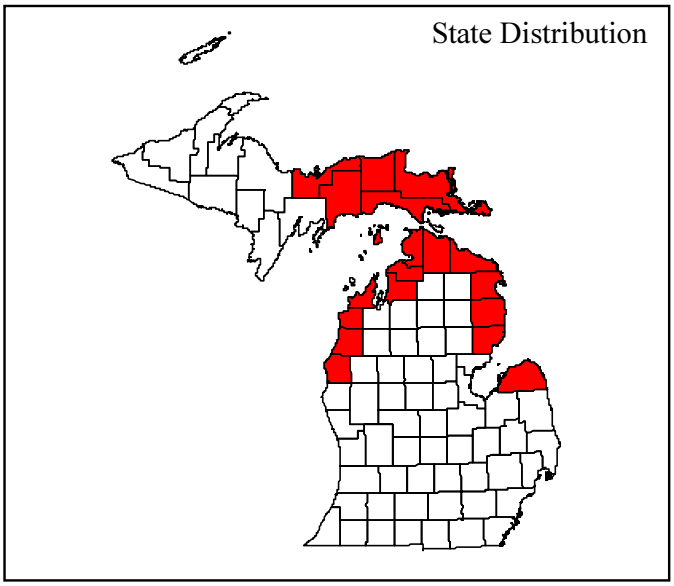

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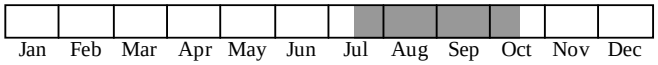

Status: State threatened

Global and state rank: G2G3/S2S3

Family: Acrididae (short-horned grasshopper)

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

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

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

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

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

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

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

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

Adults communicate through visual and auditory signals (Otte 1970). Only males crepitate in flight by flashing and snapping their wings, making a cracking noise with each snap. Crepitation occurs during a hovering courtship flight in which the males snap their wings two or three times while hovering; this display typically occurs on sunny days when temperatures reach 80^{o}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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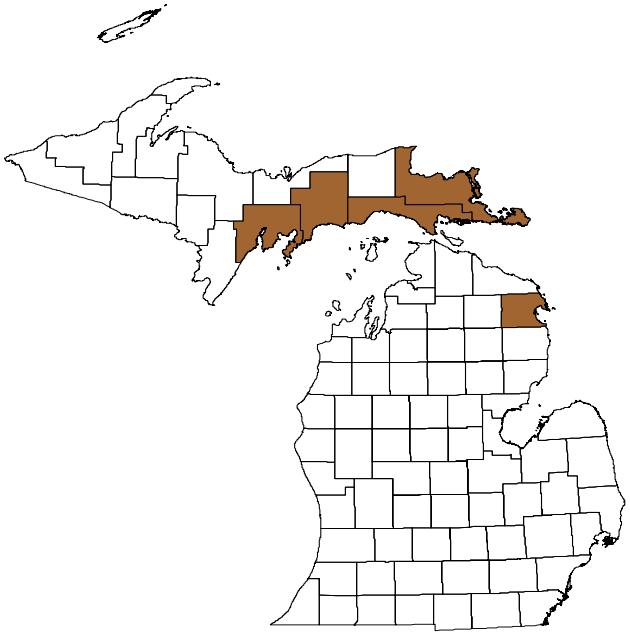
Limestone pavement lakeshore — Community Abstract

Photo by Patrick J. Comer

State Distribution



Global and state rank: G3G4/S2

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Other classifications:

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

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

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

National Wetland Inventory (NWI): none.

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The Nature Conservancy National Vegetation Classification:

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

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

Selected references:

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

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

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

Abstract citation:

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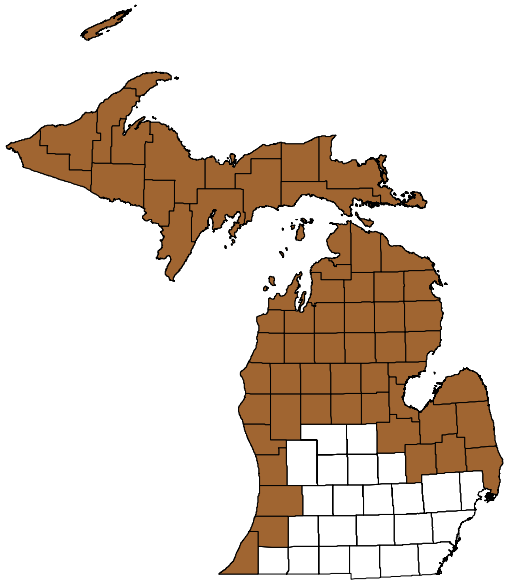
Mesic Northern Forest — Community Abstract

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.

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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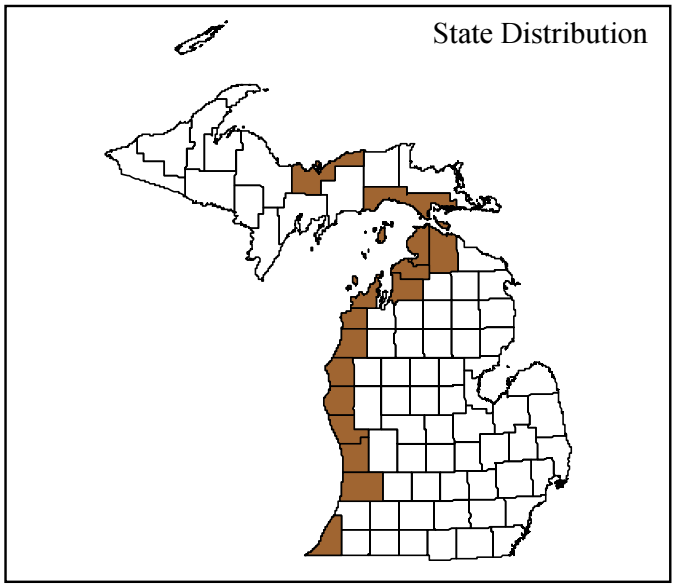
Open dunes Community Abstract



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

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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Abstract citation

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9-99/daa

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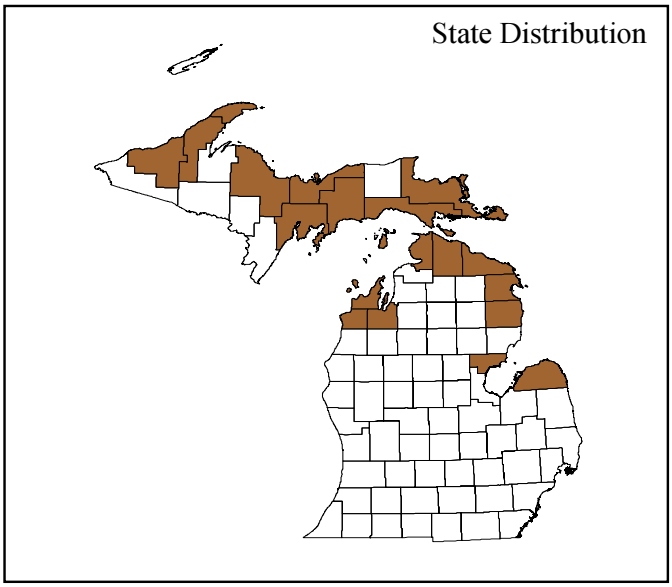
Wooded dune and swale complex — Community Abstract


Photo by Dennis A. Albert.



Global and state rank: G3/S3

Common name: Great Lakes wooded dune and swale

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

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

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

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

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

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

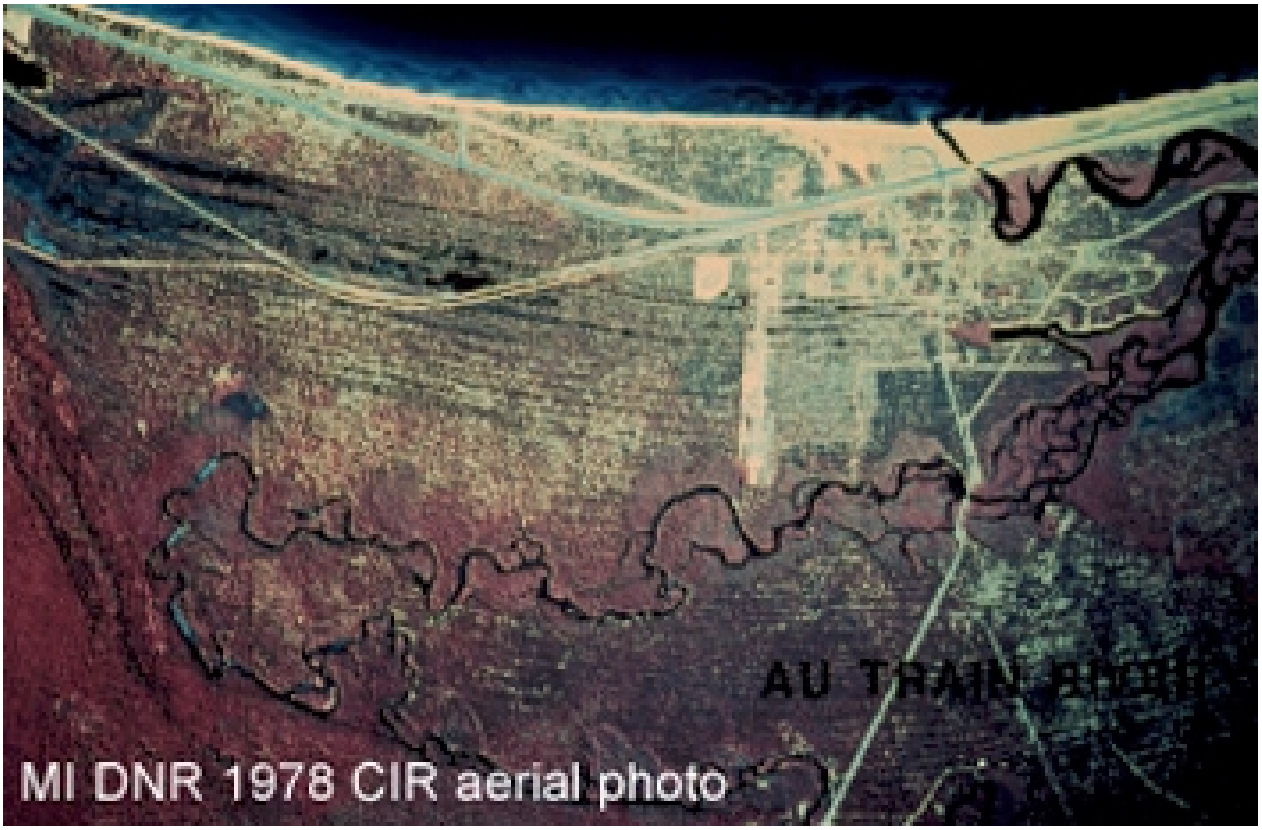
Both swales and upland dune ridges were studied by MNFI (Comer and Albert 1991, 1993). Of the 17 sites where elevations were measured from the shoreline inland, only 3 sites contained swales where the sandy bottoms of all or most of the swales lay below the current Great Lakes water levels. This suggests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

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

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

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

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



Aerial photo of dune and swale complex.

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

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

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

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

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

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

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

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

A PRELIMINARY CLASSIFICATION OF MICHIGAN WOODED DUNE AND SWALE COMPLEXES

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

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

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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)

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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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Bromus pumpellianus Scribn. Pumpelly's brome grass

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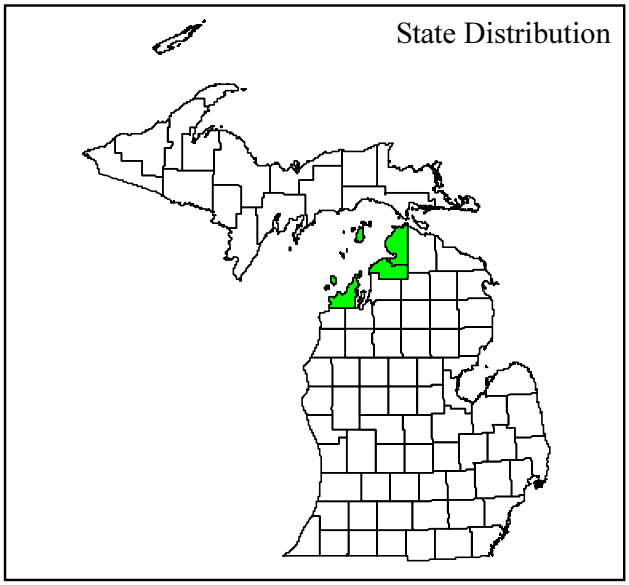

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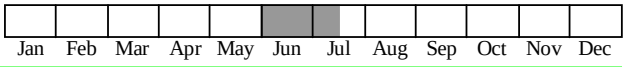

Status: State threatened

Global and state rank: G4G5T4/S2

Family: Poaceae (grass)

Other common names: Arctic brome grass

Synonyms: *Bromus inermis* Leyss. ssp. *pumpellianus* (Scribn.) Wagnon; *B. polyanthus* Scribn.; *B. arcticus* Shear.

Taxonomy: Wagnon (1952) treated this taxon as *Bromus inermis* ssp. *pumpellianus*. The European *Bromus inermis* has become established throughout North America, hybridizing with the native plants as described by Elliot (1949). If the species *B. pumpellianus* is recognized, our plants are var. *pumpellianus*, or var. *purpurascens* (Hook) Wagnon, though at least three collections have been referred to var. *arcticus*.

Total range: *Bromus pumpellianus* occurs primarily in western North America, ranging from Alaska and the Northwest Territories to the Colorado Rockies. It is disjunct rather locally in the northern Great Lakes region, occurring along northeastern Lake Michigan shores, and is considered rare in Ontario.

State distribution: *Bromus pumpellianus* is restricted to the northwestern Lower Peninsula in Emmet, Charlevoix, and Leelanau counties, where it occurs on the mainland as well as on South Fox, Beaver, and the Manitou Islands. The sole (1912) Cheboygan County locality has likely been extirpated with the development of Mackinaw City. Fifteen stations have been discovered or confirmed extant since 1980, including a 1999 discovery on the north shore of Beaver Island. Plants at three colonies are known to number in the thousands, and four others have estimates of between 100 and 500 clumps.

Recognition: Stems of *B. pumpellianus* are 5-10 dm tall and have **nodes with long hairs** and leaves (5-8 mm wide) that are **hairy on the upperside**. The narrowly cylindrical inflorescences bear slender spikelets on short, erect stalks. The short-awned lemmas are **distinctly hairy on the margins, nerves, and lower back** and are **slightly indented** at the tip. The lower glume is typically one-nerved while the upper is three-nerved. Well-developed **auricles (lobes) at the summit of the leaf sheath** help distinguish this native species from the introduced and widely distributed *B. inermis* (smooth or rocket brome), which also can be distinguished by its glabrous or only finely hairy nodes, and leaves that are usually hairless.

Best survey time/phenology: Pumpelly's brome grass is best sought while in full fruit, typically during July and August. The characters for determination are rather subtle; thus attempts to distinguish this species during less optimal periods should occur only after considerable experience with the species.

Habitat: This rare grass grows on low sand dunes and along beaches in Lake Michigan usually in association with *Ammophila breviligulata* (beach grass), *Arctostaphylos uva-ursi* (bearberry), *Artemisia caudata* (worm-

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wood), *Agropyron dasystachyum* (dune wheatgrass), *Cirsium pitcheri* (Pitcher's thistle), and *Prunus pumila* (sand cherry). In its main range, to the west and north, *B. pumpellianus* habitat includes gravelly or sandy slopes, shores, and tundra. In Ontario, it inhabits sandy prairies and beaches, and is occasionally adventive along railroads on the north shore of Lake Superior (Riley & Reznicek, 1984).

Biology: Pumpelly's brome grass is a perennial, which spreads vegetatively via rhizome growth. Its spikelets mature from late June to September, though most collections have been made in July and early August.

Conservation/management: Although this grass can be found on moderately disturbed beaches and dunes, its shoreline habitat is vulnerable to heavy recreational use and residential development, the latter being responsible for its destruction in at least two cases. However, because large colonies have been found at sites moderately disturbed by foot and/or ORV traffic, it can evidently tolerate some disturbance. Since it is found primarily in open dune or exposed shoreline communities where active disturbance is an integral ecological process, it is likely adapted to natural shoreline disturbances.

Comments: Hitchcock (1935) and Gleason (1952) refer to Great Lakes occurrences as adventive; however, Elliot (1949) points out that numerous other western and arctic species occur naturally in the Great Lakes region. Wagnon (1952) notes that the habitat of Great Lakes plants resembles that of the western var. *purpurascens* less than that of var. *arcticus,* although the latter has been only rarely collected in Michigan.

Research needs: Study of virtually any aspect of the biology and ecology of this species, as well as systematic surveys to assess its status in Michigan, would help inform management decisions and facilitate the development of optimal protection strategies. Due to increasing development pressures on the shoreline habitat of *B. pumpellianus*, research on the role of disturbance, particularly the effects of human disturbance, is of immediate concern.

Related abstracts: open dunes, fascicled broom-rape, Lake Huron tansy, Pitcher's thistle, Lake Huron locust, piping plover

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Abstract citation

Higman, P.J. and M.R. Penskar. 1996. Special plant abstract for *Bromus pumpellianus* (Pumpelly's brome grass). Michigan Natural Features Inventory, Lansing, MI. 2 pp.

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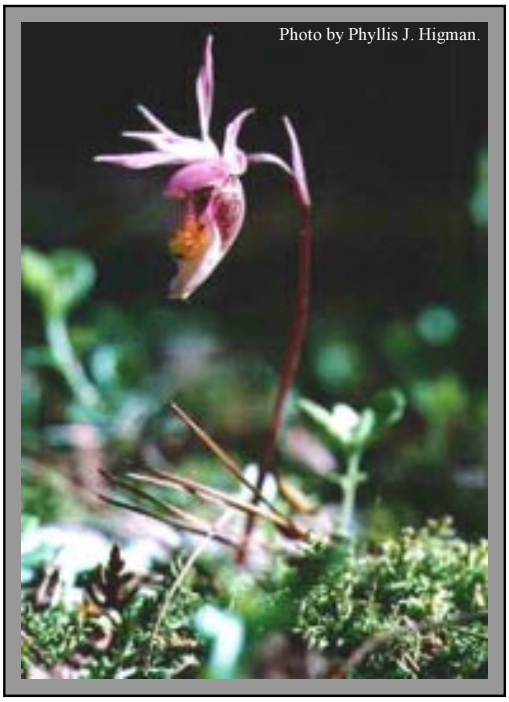
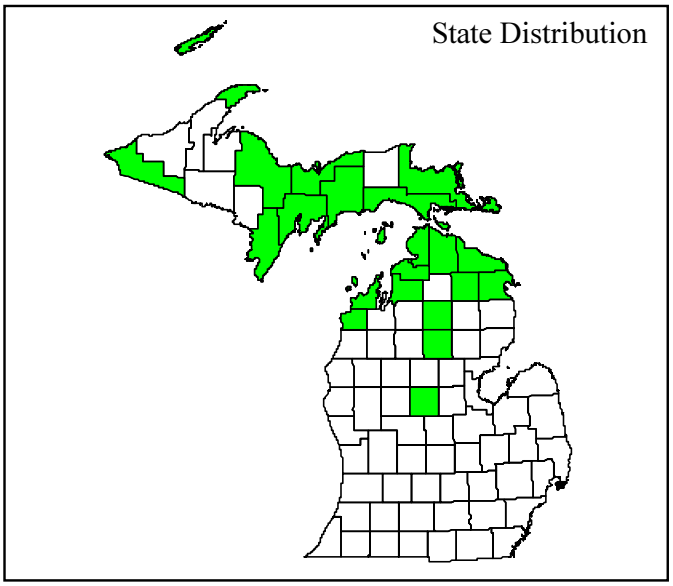
Calypso bulbosa (L.) Oakes — calypso orchid





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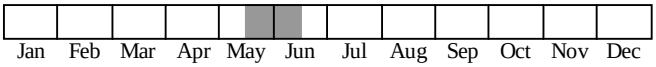

Status: state threatened

Global and state rank: G5/S2

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

Family: Orchidaceae

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

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

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

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

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

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

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

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

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

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

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

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

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

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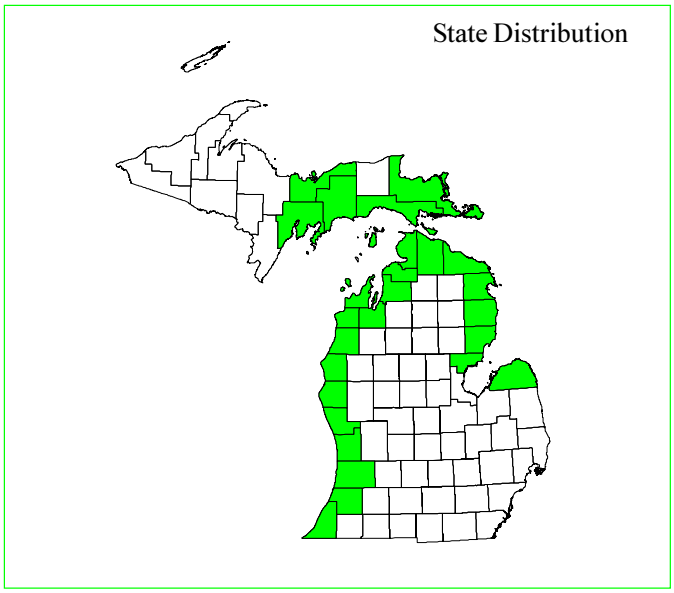
Cirsium pitcheri (Torrey and Gray) Pitcher's thistle

Photos by Sue Crispin



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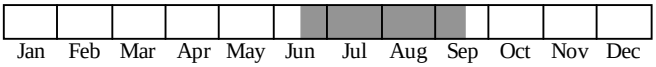

Status: State threatened, Federal threatened

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:

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Abstract citation:

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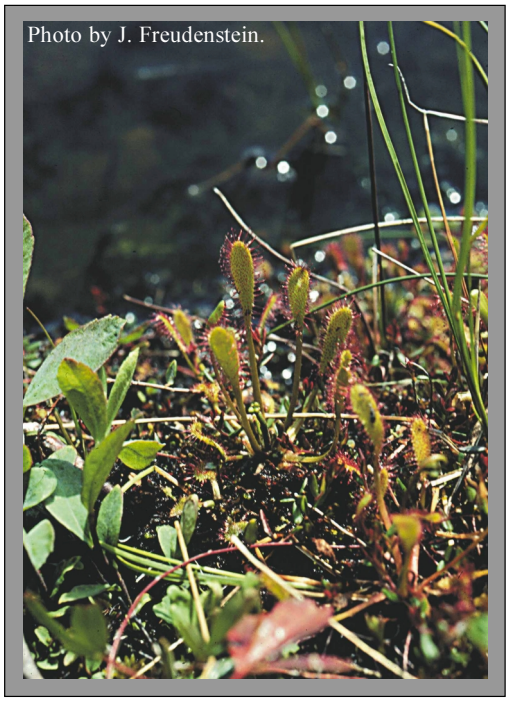
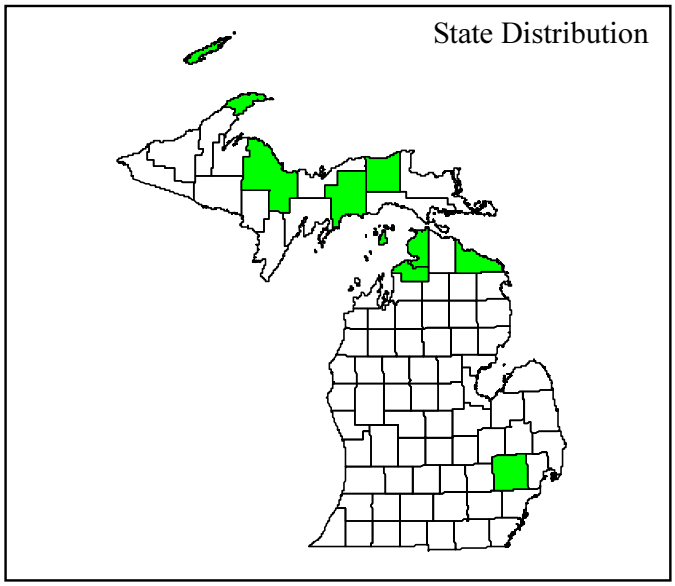
Drosera anglica Hudson — English sundew





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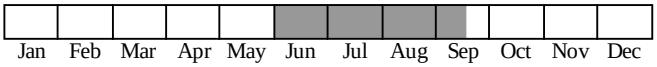

Status: State special concern

Global and state rank: G5/S3

Other common names: sundew

Family: Droseraceae (sundew)

Synonyms: *Drosera* X*anglica* Hudson

Taxonomy: *Drosera anglica* exists in two forms, occurring as a sterile, diploid hybrid (*D.* X*anglica*) between the common *D. rotundifolia* (round-leaved sundew) and *D. linearis* (linear-leaved sundew), and also as a fertile tetraploid (i.e. having four sets of chromosomes). The presence of filled seed capsules is evidence of the fertile form of this plant, which otherwise is indistinguishable from the diploid hybrids.

Total range: English sundew is a circumboreal species, ranging south in North America to Quebec, northern Maine, and southern Ontario, in the Midwest occurring south primarily to the northern regions of Michigan, Wisconsin, and Minnesota, and in the West, ranging south to California (Gleason & Cronquist 1991).

State distribution: *Drosera anglica* occurs primarily in the Upper Peninsula and northern Lower Michigan, ranging from Isle Royale and the Keweenaw Peninsula to Luce and Mackinac counties. In northern Lower Michigan, this species ranges through Charlevoix, Emmet, Cheboygan, and Presque Isle counties. Somewhat disjunct occurrences have been documented in marl fens in southern Lower Michigan, where this species has been in Oakland and Livingston counties.

Recognition: English sundew is a diminutive plant similar to other species of *Drosera*, forming small clumps or rosettes of leaves covered with numerous sticky, red, glandular hairs. The rosettes, which are approximately 5-10 cm or more in diameter, are composed of **long-petioled, glandular leaves that become broadened and narrowly paddle-shaped (spatulate) toward the tip**. The **leaves**, which are somewhat **erect to ascending**, are covered with long, reddish, hairs, each tipped with a small droplet of sticky fluid. **Tiny, white, five-petaled flowers** are borne toward the end of a slender stem that arises from the center of the rosette.

There are only four species of sundew known in Michigan, and these taxa may rarely occur in close proximity within the same site, such as in patterned peatlands in eastern Upper Peninsula. English sundew, however, is most likely to be confused with *D. intermedia*, a species that usually occurs in bogs and other acid substrates. ***D. intermedia* is a markedly smaller, more delicate plant with leaf blades that range only from 2-4 mm wide versus 3-8 mm wide in *D. anglica***. Additional differences include **smooth petioles in *D. intermedia* versus at least slightly glandular petioles in *D. anglica* and the laterally borne flowering stem in *D. intermedia* in contrast to the centrally arising flowering stem in *D. anglica*** (Voss 1985). *Drosera rotundifolia* (round-leaved sundew), which often occurs with English sundew, is generally a smaller and distinctly prostrate plant with shorter petioles that terminate abruptly in very roundish, orbicular leaf blades.

Best survey time/phenology: English sundew is observable by the latter part of May, and is probably best sought

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from late spring through early summer, though it will persist through August and perhaps later in recognizable form. Flowering occurs approximately in late June through July.

Habitat: English sundew typically occurs in northern fens, including marl flats, cobble shores, and other calcareous habitats such as interdunal wetlands along the northern shores of Lake Huron and Lake Michigan. It also occurs in rock pools on Isle Royale (Voss 1985). In these sites, typical associates include such species as *Drosera linearis*, *D. rotundifolia*, *Thuja occidentalis* (northern white cedar), *Larix laricina* (Eastern larch), *Triglochin* spp. (arrow-grasses), *Sarracenia purpurea* (pitcher-plant), *Tofieldia glutinosa* (false asphodel), *Primula mistassinica* (bird's-eye primrose), *Lobelia kalmii* (Kalm's lobelia), *Scirpus cespitosus* (bulrush), *Pogonia ophioglossoides* (rose pogonia), *Calopogon tuberosus* (marsh-pink), as well as several *Sphagnum* species and brown mosses such as *Scorpidium scorpioides* (scorpidium). Elsewhere, English sundew also occurs in interior areas on floating peat mats and in wet depressions (termed "flarks") of patterned peatland complexes in the eastern Upper Peninsula. In southern Lower Michigan, this species is very rare, being restricted to the wet, marly zones of a few prairie fens, where it occurs with many of the aforementioned plant associates.

Biology: Similar to *Sarracenia purpurea* (pitcher-plant) and *Pinguicula vulgaris* (butterwort), sundews are carnivorous plants, capturing insects (primarily) with their nectar-like, mucilaginous secretions to supplement nutrients, such as nitrogen, that are otherwise in low availability in their habitats. Sundew leaves curl around their insect prey, when captured, to digest it.

Conservation/management: The primary conservation need for this species is simply the protection of its habitat, including the maintenance of local hydrological and natural disturbance regimes to sustain wetland function and the generally open, non-forested habitat required for perpetuation.

Research needs: There are relatively few published studies concerning the biology and ecology of this species, although there is widespread interest in insectivorous and carnivorous plants. Research likely to be of the greatest benefit to conservation would include studies of population dynamics, demography, and virtually any aspect of life history, especially if such investigations incorporate habitat information.

Related abstracts: prairie fen, lady's-slipper orchid, mat muhly, prairie dropseed, Eastern massassauga, Mitchell's satyr

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Abstract citation

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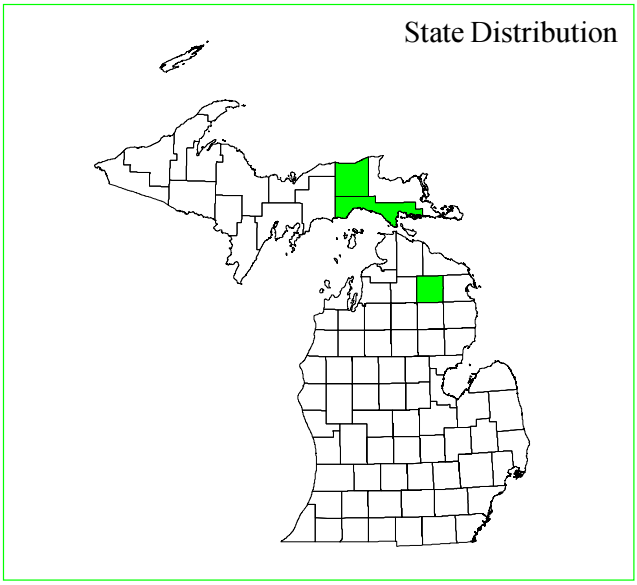
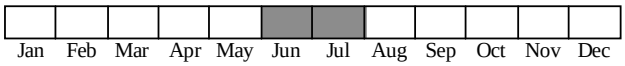
Sarracenia purpurea f. *heterophylla* (Eaton) Fern. yellow pitcher-plant

Photo by Phyllis J. Higman



Best Survey Period



Legal Status: State threatened

Global and State Rank: G5T2/S1

Other common names: side-saddle flower

Taxonomy: This variant of the common pitcher–plant was originally described as a species by Eaton in 1822, then subsequently reduced to a variety and ultimately to a form in 1922 by M. L. Fernald (Schnell 1979). Cytotaxonomic studies by Bell in 1949, as well as contemporary concepts of plant species, support recognizing the status of yellow pitcher-plant as a form (i.e. a sub-specific taxon).

Total range: *Sarracenia purpurea* f. *heterophylla* has been found in few, widely scattered localities principally along the northeastern North American coast including occurrences in Newfoundland, Nova Scotia, Maine, Massachusetts, and New Jersey. Sites are now also known in Ontario, upper Lower Michigan, and Minnesota (Case 1956; Schnell 1979).

State distribution: Yellow pitcher-plant was known only from the northeastern North American coast until Case reported it from Montmorency County, Michigan in 1956. He reported it as frequent to relatively abundant in five acid bogs all within two miles of each other in the southeastern portion of the county. Earlier reports for Michigan by Gillman in 1870 (naming Marquette County as an occurrence) and O. A. Farwell in 1894 are unsubstantiated by specimens (Voss 1985). In 1999, new localities were discovered in the eastern Upper Penninsula, in Mackinac and Luce counties.

Recognition: The yellow form of pitcher-plant is morphologically identical to *Sarracenia purpurea*, **differing only in the complete absence of red pigment in its leaves and flowers** (Case 1956). In the common or typical form of *S. purpurea*, the leaves are at least faintly reddish-veined, the persistent sepals are reddish-purple, and the drooping ephemeral petals are a deep maroon-red. Red pigmentation of leaves of the typical form can be highly variable, particularly in individuals growing in more shaded situations; however, some red pigment is present, usually as faint red veins. Forma *heterophylla* has **flower petals that are pale-lemon yellow to greenish-yellow in color, and the leaves are yellow-green to a rich yellow when growing in the open** (Case 1956). Case notes that **shaded plants** of f. *heterophylla* **have leaves that are very similar to shade leaves of the typical variety** and that confirmation of the identity must be reserved until flowering specimens can be seen.

Best survey time: Since flowers must be observed in order to confirm the identity of yellow pitcher-plant, the optimal survey time is during the peak of the flowering period, which is typically during June and July.

Habitat: Yellow pitcher-plant is found in acid *Sphagnum* bogs, occurring on Greenwood peats with such typical associated species as black spruce (*Picea mariana*), tamarack (*Larix laricina*), Canada blueberry (*Vaccinium myrtilloides*), rose pogonia (*Pogonia*

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ophioglossoides), grass-pink (*Calopogon tuberosus*), leatherleaf (*Chamaedaphne calyculata*), Labrador-tea (*Ledum groenlandicum*), bog laurel (*Kalmia polifolia*), sundews (*Drosera* spp.), *Vaccinum oxycoccos* (cranberry), several *Sphagnum* species, and other typical bog species.

Biology: Pitcher-plants have many complex interactions with insects. As a carnivorous plant, yellow pitcher-plant obtains supplemental nutrients through the entrapment of insects and other small invertebrates in its pitcher-like leaves. One insect, *Wyeomyia smithii* Cog., a non-biting mosquito, has aquatic larvae that are obligate inhabitants of the leaves (Istock 1975). Pollination is carried out primarily by Halictid bees and to a much lesser extent by bumblebees (Apidae) (O'Neil 1983).

Conservation/Management: Management for sustainable populations of yellow pitcher-plant in Michigan will require aggressive protection of the habitat conditions in which this species thrives, as well as pro-active efforts to discourage overzealous plant collectors from gathering specimens. The unique physical parameters of acid bogs, i.e., the acidity, hydrology, and nutrient status are most certainly critical to the persistence of healthy populations of yellow pitcher-plant. Activities that would alter these in any substantial way should be avoided. This would include direct alteration of the habitat as well as disturbances resulting from adjacent land-use activities such as extensive clearing of forested lands or nutrient loading resulting from adjacent agricultural practices. The placement of gas and oil pipelines is also a current threat to the relatively small kettle-hole bogs that support yellow pitcher-plant, and without careful routing, these habitats may be degraded.

Comments: Hybrids between the typical form of pitcher-plant and f. *heterophylla* reportedly occur (Schnell 1979), exhibiting an intermediate orange-red coloration (Case 1956).

Research Needs: Given the recent findings of two new populations of yellow pitcher-plant, surveys for additional occurrences of the yellow pitcher-plant are warranted, especially in the Upper Peninsula. Also of interest is the study of mechanisms that result in the lack of red pigmentation. The observation of pitcher-plants with additional unusual leaf coloration, found only in locations where both the typical and yellow form were growing, led Case (1956) to believe that it is not simply the result of the expression of recessive alleles. Other research needs include virtually any aspect of life history and ecology. Conducting a long-term biological monitoring program of a selected population or two would provide useful demographic information, as well as help determine the status of this species on a yearly basis.

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Abstract citation:

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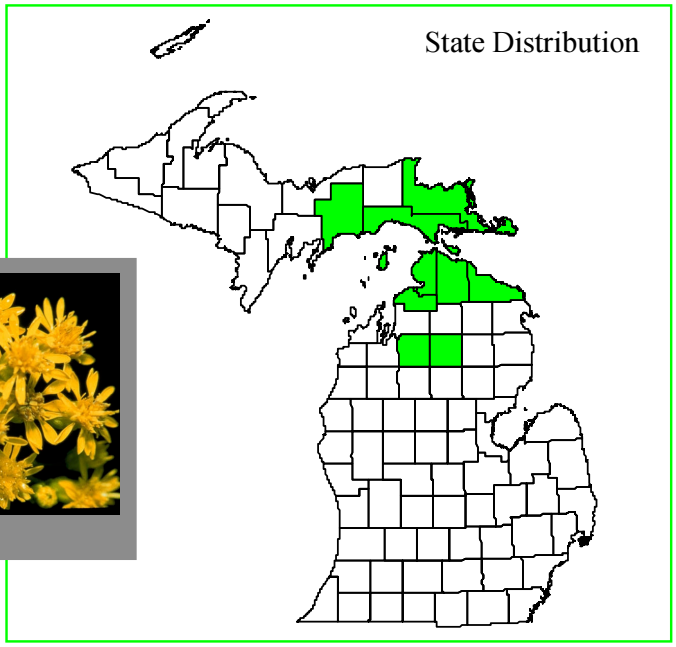
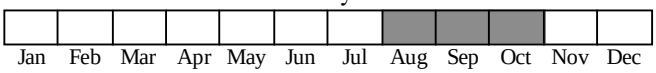
Solidago houghtonii A. Gray — Houghton's goldenrod

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.

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Abstract citation:

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