High Island Rare Species and Invasive Plant Survey

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Cover photos: top left, fascicled broomrape (Photo by Bill Parsons), top right, Lake Huron tansy (Photo by Michael R. Penskar); lower left, Pitcher's thistle (Photo by Bill Parsons); and lower right, Lake Huron Locust (Photo by Bill Parsons).

Executive Summary

High Island is one of two islands within the Beaver Island Archipelago which are part of the 1855 Little Traverse Bay Bands of Odawa (LTBB) Reservation. This project created a partnership between the Michigan Natural Features Inventory (MNFI) and LTBB to assess the current status of the natural features on the island and educate one another about these and other important island features. Early and late season surveys were conducted for 19 rare plants, seven avian species, three invertebrates, and five priority invasive plants. Target species were selected based upon their known or reported occurrence in the northern Lake Michigan area or the presence of suitable habitat as determined through aerial photo interpretation.

Occurrences of state and federal threatened Pitcher's thistle, state threatened fascicled broomrape and Lake Huron tansy were relocated and their status and spatial extent updated. The last reported surveys for these species were from 30, 53, and 25 years ago, respectively. The Pitcher's thistle occurrence is one of the largest and highest quality populations in Michigan. The Lake Huron tansy, restricted to Midwest Great Lakes shores, is one of 128 occurrences in Michigan, and the western disjunct species, fascicled broomrape, is one of only 20 occurrences known in the state.

Weather conditions prevented passage to the island during the optimal survey window for piping plover, bald eagle, merlin, osprey, Caspian tern, common tern, and northern goshawk, and none of these species were documented nesting on the island during in 2011. However, a pair of bald eagles was observed flying near Lake Maria during reconnaissance surveys in 2010 and a pair of merlins were observed flying south of the eastern landing point in August, 2011.

Surveys for the dune cut-worm were also limited by weather conditions and no specimens of this species were collected during two nights of trapping. This species was last observed on the island in 1935. The Lake Huron locust, last reported in 1966, was found in abundance in the western dune complex and in foredunes at three other locations. These observations comprise a single, large element occurrence for this species. No suitable habitat was found for Hine's emerald dragonfly.

Invasive species were not overwhelming on the Island, presenting an opportunity for effective rapid response and on-going early detection monitoring. They were notably absent in the western dune complex, however, a single occurrence of bittersweet was mapped in the main blowout. Identification to the species level was not possible at the time of survey in 2011 and spring surveys when the leaves are unfolding or later during the flowering or fruiting stage are recommended. If identified as the highly invasive Oriental bittersweet, intensive surveys in the vicinity of this occurrence are warranted to delineate the entire extent of the infestation. Immediate control measures are urgently recommended if this is determined to be Oriental bittersweet.

Significant patches of spotted knapweed and bouncing bet, were found in the foredunes on the east side of the island extending up towards the northeastern sand spit. Medium and small patches of invasive phragmites, cat-tail, and reed canary grass, were found on the northwest and eastern coastal wetland areas and are likely to occur in the remaining coastal wetlands. Monitoring and treatment of invasive phragmites has already begun and should be expanded to include other coastal invasive species such as invasive cat-tail and reed canary grass.

Dedicated surveys of trails and other disturbed areas, as well as representative vegetation types are encouraged so that prioritized rapid response efforts can be implemented effectively throughout the Island. Particular attention should be paid to protecting high value sites, containing source populations and disrupting dispersal pathways.

In spite of limited survey time on the High Island, significant rare species data were captured that affirm the Island's ecological importance. These data, however, likely under-represent the natural features on the island and further surveys are recommended for all target species. Of particular interest are the dense areas of boreal forest at the southern end of the island which merit spring surveys for rare orchids and the V-shaped bluff in the southern region of the island which merits surveys for seeps that might harbor rare ferns or fern allies.

The diminutive dunewort should be targeted in the western dune complex and attempts should be made to relocate stitchwort, last documented there in 1986. Trapping for the dune cutworm in these dunes is also a high priority since surveys were limited in 2011. While this species was last documented 23 years ago, the western dune complex remains a high quality, relatively undisturbed ecosystem, and could still harbor this species.

Surveys of the remaining shoreline are recommended to determine the full extent of the rare species documented to date, particularly pitcher's thistle, Lake Huron tansy and Lake Huron locust. These coastal areas, as well as the V-shaped bluff in the southern end of the island may provide habitat for rare snails which could be targeted in future surveys. Early season surveys for shore birds and raptors are also warranted and should be expanded to include neotropical migrants and marsh-dependent species.

Surveys to delineate and assess the status of the natural communities on the island are also encouraged as they provide habitat for rare and vulnerable species. A systematic threat analysis for these communities would be highly beneficial. Maintaining the health and integrity of these ecosystems will allow the diversity of native species, both common and rare, to thrive on the island.

These findings provide important data for consideration when identifying conservation targets for High Island and devising management strategies for their protection.

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Introduction

High Island harbors numerous features that contribute to the rich biodiversity and cultural value of the Beaver Island Archipelago. It is one of two islands within the archipelago which are part of the 1855 Little Traverse Bay Bands of Odawa (LTBB) Reservation. Previous surveys by the Michigan Natural Features Inventory (MNFI) identified several natural community and rare species occurrences on the island; however, these data are now outdated and incomplete. Also, few data are available about the status of invasive plants, such as *Phragmites australis* ssp. *australis* (non-native phragmites) and *Centaurea stoebe [Centaurea maculosa]* (spotted knapweed), that pose a significant and imminent threat to the island's natural features. This project created a partnership between MNFI and LTBB designed to accomplish a number of goals including: 1) gathering current data on previously identified natural features on the island, 2) identifying and filling survey gaps, 3) identifying and mapping priority invasive plant species, and 4) educating LTBB natural resource staff about MNFI's survey methods and the natural features of the island.

The LTBB provided state of the art, 2010, digital orthophotos for the interpretation and identification of natural feature inventory targets. They also provided transportation to the island from Beaver Island and helped guide us during field surveys. Surveys focused on rare and vulnerable plant and animal taxa and selected invasive plants, while gathering general ecological information to inform future survey work. These data are important for defining conservation targets and developing management strategies for their protection.

Organization of the Report

This report provides overviews of the study area, access and timing of surveys, aerial photo interpretation, and selection of survey targets first, as these are common to the three main components of the project. It is then divided into separate sections for rare plants, rare animals, and invasive species, each with its own methods, results, and discussion sections. The overall findings are summarized in the executive summary. The appendices include plant species lists for selected natural communities, detailed species accounts for rare species documented on High Island, and NatureServe element occurrence rank specifications.

Study Area, Access and Timing of Field Surveys

Surveys for this project were conducted on High Island, located in northern Lake Michigan, just north of Beaver Island, Charlevoix County, Michigan (Figure 1). The survey crews set up a home base on Beaver Island and accessed the island using an 18 foot Lund boat piloted by LTBB staff. Two survey periods were selected, coinciding with when the majority of targets were most easily detected, e.g., during breeding and flowering periods. Early season field inventories were planned for the week of June 5-11, 2011 and late season surveys for the week of July 31-August 6, 2011. Emphasis was placed on accessing high priority sites identified from the aerial photo interpretation, although to a large extent surveys were ultimately influenced by the ability to access shoreline areas by boat and by the dictates of weather. Bad weather conditions

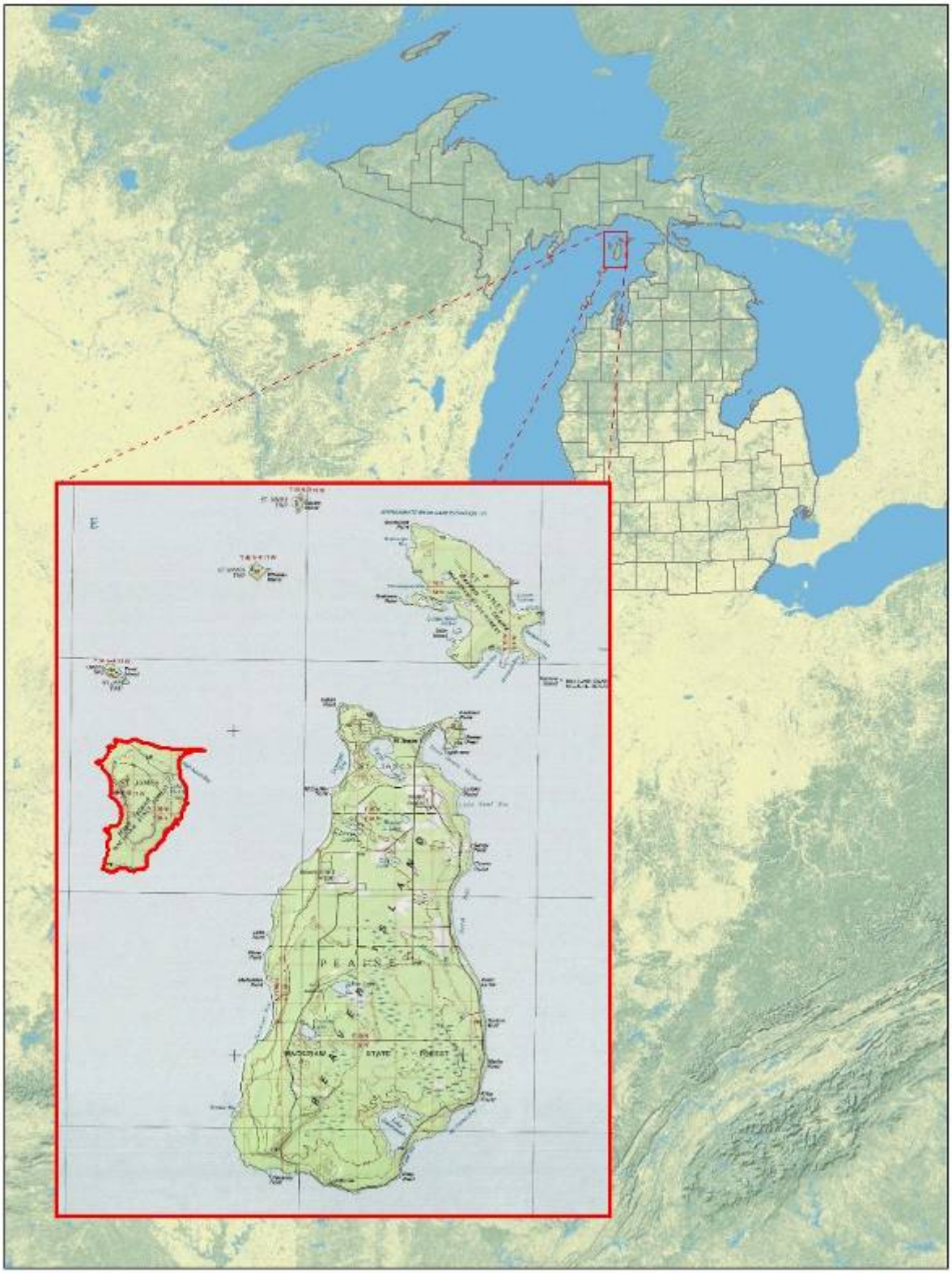

Figure 1. The study area, High Island, lies within the Beaver Island Archipelago in northern Lake Michigan.

prevented access to High Island during the planned early season survey period, thus site visits were limited to late season surveys on August 1 and 4.

Using the LTBB aerial imagery and GIS maps, both in digital form using handheld devices and hard copies, surveyors hiked to delineated areas from several access points, including the west side of the island adjacent to the open dunes, the northwest shore, the extreme southern shore, and the northeastern shore near Lake Maria. The east-west interior trail system was also used to hike from the eastern shore to the large dune complex on the western side of the island. MNFI and LTBB staff conducted surveys together, learning from one another in the process.

Aerial Photo Interpretation

Prior to the field season, color aerial imagery collected April 11, 2010 by LTBB was obtained to conduct a methodical interpretation of High Island for natural features. The imagery consisted of digital orthophotos with a one-foot GSD (Ground Sample Distance) or 0.3048 meters. The imagery was interpreted in conjunction with data from the MNFI Biotics Database. These data included information and associated shapefiles for all known element occurrences (EOs) of high quality natural communities, rare animals, rare plants, and other tracked features, such as exemplary geological formations or lichens. MDNR aerial imagery was also consulted for comparison, particularly the 1998 CIR (color infrared) photos and additional color imagery from 2005 and 2009.

Interpretation focused on the identification of natural communities, with special attention to those occurring along or in close proximity to the shoreline and most likely to support high priority rare taxa. Priority natural communities included such types as coastal fen, rich conifer swamp, boreal forest, mesic northern forest, open dunes, interdunal wetland, wooded dune and swale, and limestone cobble shore and the related sand and gravel beach. These types guided the selection of priority survey sites for each component of the project.

Figure 2 shows the principle areas highlighted for field survey. They consisted primarily of: 1) the large open dunes complex in the middle of the western shore of the island, 2) the coastal area along the northwest shore of the islands, 3) the northeast interior lake (known in some maps as Lake Maria), 4) the steep bluff forming a contiguous, V-shaped rim in the southern interior of the island, 5) the extreme southern shore of the island with adjacent wetland/interdunal depressions, 6) the southeastern shoreline of the island, and 7) the sand spit at the northeast corner of the island.

Selection of Survey Targets

Target species for survey were identified for rare plants, rare animals, and invasive plants prior to the field season to help direct inventories. Species selection was based upon the known, historical or reported occurrence within the Beaver Island Archipelago, other islands within northern Lake Michigan, the Straits region, or the coastal zone of adjacent mainland areas (Penskar et al. 2002a, Penskar et al. 2002b, Penskar et al. 2001, Penskar et al. 2000, Penskar et al. 1999, Penskar et al. 1997, Penskar and Leibfreid 1993).

Figure 2. Principle areas highlighted for field survey on High Island in 2011.

Additional species were included for which suitable habitat appeared to be present on the island as determined by the aerial photo interpretation and experience of the surveyors. Surveys were guided by but not limited to seeking targeted species. With extensive experience in habitats throughout Michigan, all surveyors were prepared to gather data on any other significant species unknown or unusual for the region.

Rare Plant Inventories
Methods

Target Species

Nineteen rare plant species were targeted for survey including three species previously documented on the island (Table 1). The latter included records for *Cirsium pitcheri* (Pitcher's thistle, state and federal threatened), *Tanacetum huronense* (Lake Huron tansy, state threatened), and *Orobanche fasciculata* (fascicled broomrape), state threatened).

Field Surveys

Sites were systematically surveyed by conducting methodical meander-searches. Efforts were made to identify previously known rare plant records to determine whether they were extant or not and to update extant occurrences with current, detailed, spatial and population data. When potential habitat for new rare plant taxa was encountered, sites were carefully surveyed to detect any of these species. Plant species lists were compiled for significant natural communities during the dedicated site surveys and foot travel throughout the island. These lists were compiled using the statewide assessment system provided by Herman et al. (2001), to characterize floristic quality. They were also compiled so that known, high quality natural community occurrences could be subsequently updated by MNFI ecology staff. Species not previously known from the island were noted.

Special plant field forms, plant species lists, and representative photographs were compiled as necessary when rare plant populations were identified. Waypoints were recorded via a Garmin 12XL GPS unit to obtain accurate location data for occurrences, in addition to depicting survey areas and routes throughout the island. Where appropriate, voucher specimens were collected and pressed to provide documentation for new plant records, including both rare and more common species. In some cases, voucher specimens were sought to better document known records previously based solely on field observations, or to obtain higher quality, contemporary collections more representative of the population of a site. Specimens were also obtained for the subsequent identification of plants that could not be determined in the field and/or that required determination by a specialist.

Data Processing

Following field surveys, voucher specimens collected during inventories were examined and identified. Data from field forms, notes, and plant lists were compiled and in conjunction with downloaded GPS data and photographs, element occurrence records were evaluated, transcribed, and processed. Where appropriate, new records were mapped and recorded, and known records were updated and remapped as necessary to more accurately reflect their recently observed spatial distributions.

Table 1. Target species identified for rare plant surveys on High Island in 2011.

Species	Common Name	Global, State Rank[1]	State[2], US[3] Status	Associated Natural Community types/habitats
Amerorchis rotundifolia	roundleaf orchid	G5, S1	E	Rich conifer swamp
Asplenium trichomanes-ramosum	green spleenwort	G4, S3	SC	Limestone outcrops
Botrychium campestre	dunewort	G3G4, S2	T	Open dunes, old fields
Bromus pumpellianus	Pumpelly's brome grass	G5T4, S2	T	Open dunes
Calypso bulbosa	Calypso orchid	G5, S2	T	Boreal forest, rich conifer swamp
Carex richardsonii	Richardson's sedge	G4, S3S4	SC	Alvar, limestone bedrock lakeshore, northern fen
Carex scirpoidea	bulrush sedge	G5, S2	T	Coastal fen, limestone bedrock lakeshore, northern fen, alvar
Cirsium pitcheri	Pitcher's thistle	G3, S3	T, LT	Open dunes
Cypripedium arietinum	ram's head orchid	G3, S3	SC	Boreal forest, rich conifer swamp
Drosera anglica	English sundew	G5, S3	SC	Coastal fen, northern fen
Iris lacustris	dwarf lake iris	G3, S3	T, LT	Boreal forest, alvar, limestone bedrock lakeshore
Mimulus michiganensis	Michigan monkey-flower	G5T1, S1	E, LE	Rich conifer swamp
Orobanche fasciculata	fascicled broomrape	G4, S2	T	Open dunes
Panax quinquefolius	ginseng	G3G4, S2S3	T	Mesic northern forest
Pinguicula vulgaris	butterwort	G5, S3	SC	Coastal fen, interdunal wetland, limestone bedrock lakeshore
Pterospora andromedea	pinedrops	G5, S2	T	Boreal forest, dry-mesic northern forest, dry northern forest, wooded dune and swale
Solidago houghtonii	Houghton's goldenrod	G3, S3	T, LT	Alvar, interdunal wetland, limestone cobble shore, coastal fen, northern fen, open dunes
Stellaria longipes	stitchwort	G5, S2	SC	Open dunes
Tanacetum huronense	Lake Huron tansy	G5T4T5, S3	T	Open dunes, limestone cobble shore, wooded dune and swale

[1]NatureServe Global and State Ranks: G1, S1-most imperiled; G5, S5-least imperiled.
[2]State status abbreviation: E, state endangered; T, state threatened; SC, state species of special concern.
[3]US/Federal status abbreviation: LE, legally endangered, LT, legally threatened.

Rare Plant Inventories
Results

Field Surveys

Figure 3 depicts the areas covered during field inventories and the locations of rare plants observed to date. From the west shore access point, large portions of the open dunes complex were traversed, including portions of the large blowout areas. Throughout the dunes and along the shoreline, Pitcher's thistle (Figure 4) was observed in abundance. Localized patches of fascicled broomrape, comprised of occasional, widely spaced stems, were found within the northernmost isolated blowout and also along lower slopes. Although the withered fascicled broomrape stems observed were long since past anthesis (flowering) and seed dispersal, this distinctive species was recognizable (Figure 5). The shoreline was systematically surveyed from the dune complex through the northwestern coastal area, where a small, obscure patch of Lake Huron tansy was observed (Figure 6). A plant species list was compiled to characterize the flora of the dunes, as presented in

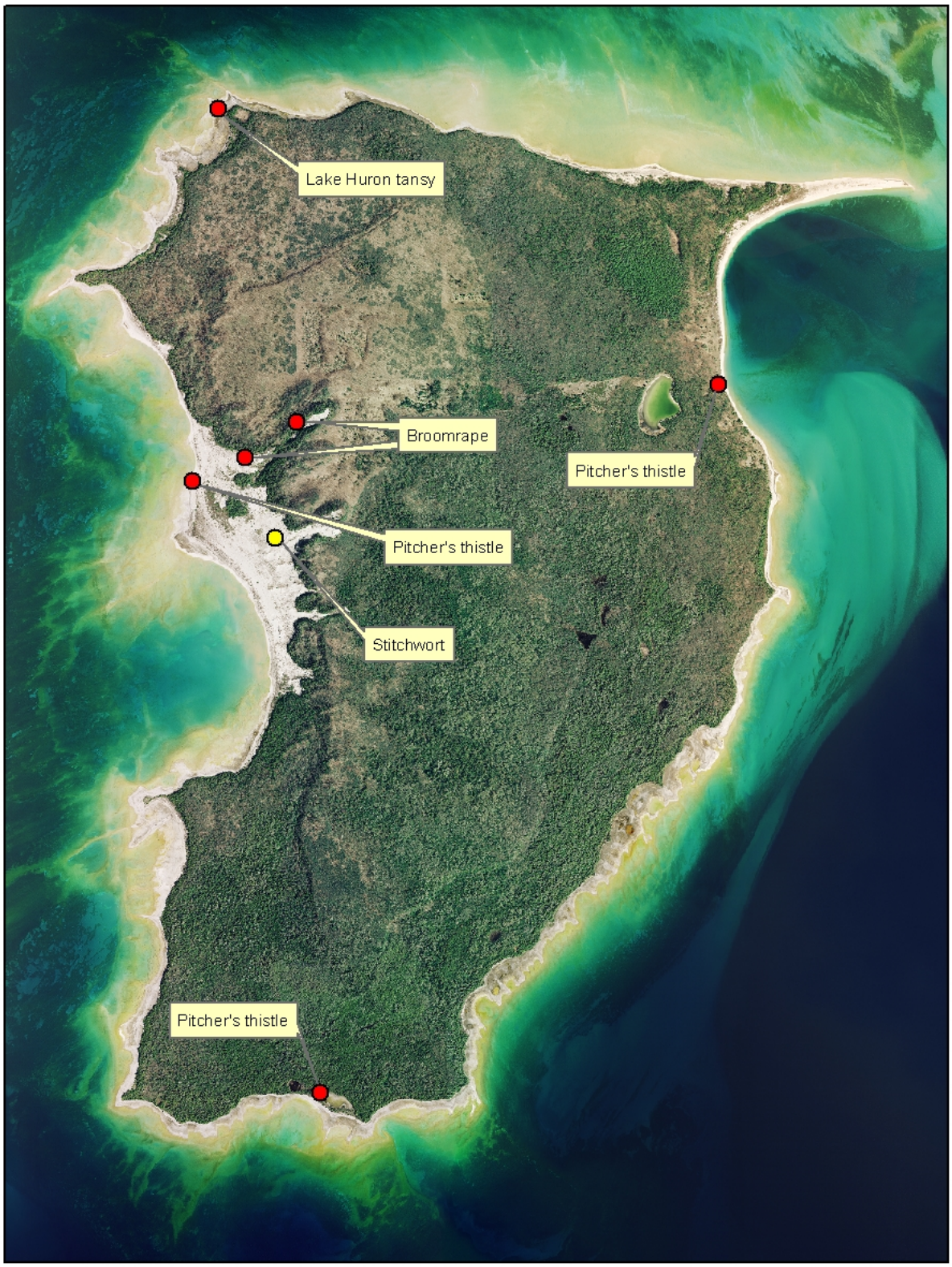

Figure 3. Rare plants documented on High Island to date. Occurrences in red were observed during 2011 field surveys; occurrences in yellow were not relocated in 2011. The Pitcher's thistle represented by three points, is considered a single element occurrence.

Figure 4. State and federal threatened Pitcher's thistle. Photo by S. Crispin.

Figure 5. State threatened fascicled broomrape. Photo by M. R. Penskar.

Figure 6. State threatened Lake Huron tansy. Photo by M. R. Penskar.

Appendix A. The southern shore was accessed and surveyed primarily to assess the potential for coastal fen species, but no such habitat was identified. During the survey of the sandy-cobbly shoreline areas, a single flowering plant of Pitcher's thistle was observed. No rare species were found during surveys of the Lake Maria shoreline. Numerous scattered patches of Pitcher's thistle were observed along the eastern coastal zone, north and south of the landing area. Owing to the limited time for surveys, the interior bluff slope and the southern third of the eastern shoreline were not accessed during the August 2011 site visits. All rare species occurrences documented on the island to date are summarized in Table 2 including their first and last observed dates.

Table 2. Previously documented and updated rare plant element occurrences for High Island, based on the MNFI Natural Heritage Database, 2011.

Scientific Name	Common Name	State, Federal Status	EO Number	Year First Observed	Year Last Observed
Cirsium pitcheri	Pitcher's thistle	T, LT	68	1981	2011
Stellaria longipes	stitchwort	SC	11	1986	1986
Orobanche fasciculata	fascicled broomrape	T	19	1986	2011
Tanacetum huronense	Lake Huron tansy	T	9	1958	2011

Rare Plant Inventories
Discussion

Weather conditions limited surveys on High Island in 2011, but it is clear that similar to Garden, it is one of the most significant islands within the Beaver Island archipelago, sometimes referred to as the Grand Traverse Islands (Judziewicz 2001). Key natural features include the extensive acreage of boreal forest, which dominates much of the island, an exemplary, pristine dune complex with well developed dune fields and blowouts, and long stretches of limestone cobble shore, as well as narrow but high quality foredune areas that collectively support large numbers of the island's extensive Pitcher's thistle population. Given that much of the interior of the island was not inventoried during surveys, this is a conservative assessment of natural features in terms of natural community or habitat types.

Although relatively few rare plant species were identified during inventories, and all were observations of previously documented occurrences, these surveys resulted in the acquisition of important data. All three of the plant occurrences identified resulted in significant updates. The island occurrence of Pitcher's thistle, one of the largest and highest quality populations in the state as indicated by its "AB rank", had not been surveyed and updated since its original documentation in 1981. The island Lake Huron tansy occurrence had not been updated since 1958, when it was first observed on High Island. The occurrence of fascicled broomrape was similarly the first update since its original discovery in 1986. For these species, which had not been observed in 30, 53, and 25 years, respectively, more detailed data on population size, habitat, and spatial extent were compiled to significantly enhance these records for the comprehensive, statewide database.

Pitcher's thistle is a Great Lakes endemic known from 171 sites in Michigan, with the majority of large, high quality populations found in the northern Lake Michigan basin, typically growing in open dunes but also occasionally on gravelly-sandy shores

(Higman and Penskar 1999, Appendix B). On High Island, this species was abundant in the open dunes complex, but was also found to occur in good numbers along the east and northeast shores, the northwest shore, and then sparsely elsewhere.

Lake Huron tansy, while not an endemic, is restricted to Great Lakes shores in the Midwest. It is known from 128 occurrences in Michigan, where it typically inhabits foredunes. It may also be found on sand and gravelly beaches (Choberka et al. 2001, Appendix B). Fascicled broomrape is a western disjunct that reaches the eastern edge of its distribution in the Great Lakes region in Indiana and Michigan. It is known from 20 occurrences in Michigan where it is restricted to coastal dunes and requires its obligate host plant, *Artemisia campestris* (wormwood) (Higman and Penskar 1996, Appendix B).

Owing to its size and rugged nature, High Island has considerable merit for further survey, warranted in part by the delineated areas that could not be accessed in 2011 due to weather. Of particular interest is the marked V-shaped bluff (Figure 2) that forms a distinct topographic feature in the southern region of the island. Due to the relatively steep slope, this bluff may be somewhat more mesic in nature and contain seeps that are of potential habitat for both rare plant and animal species, such as ferns and fern allies (e.g. clubmosses), snails, and other taxa.

All remaining shoreline areas not thoroughly explored for rare plant species should be methodically inventoried to catalogue Pitcher's thistle and Lake Huron tansy colonies and to identify any other associated habitats for additional rarities. These areas consist of the northern shoreline, and the southern portions of the eastern and western shoreline. The dense areas of boreal forest at the southern end of the island merit spring surveys for such species as calypso orchid and ram's head orchid. Efforts should be made to relocate stitchwort which was last observed in the western dune complex in 1986. Lastly, a principal target species to be sought in the open dunes is *Botrychium campestre* (dunewort), which is known to occur in perched dunes in the northern Great Lakes basin (such as Sleeping Bear dunes) and also on islands (North Manitou, South Manitou, and South Fox) in the region. This diminutive fern can only be found during early season surveys, which must be conducted from about early to mid-June.

Rare Animal Inventories

Methods

Target Species

Animal inventories focused on surveys for eight rare avian and three rare invertebrates (Table 3). Avian targets included rare birds that typically nest along Great Lakes shorelines or on islands, such as the piping plover (*Charadrius melodus,* state and federal endangered), Caspian tern (*Sterna caspia,* state threatened), and common tern (*Sterna hirundo,* state threatened); and rare raptor species that require suitable forest nest trees. These include the bald eagle (*Haliaeetus leucocephalus,* state special concern*),* northern goshawk (*Accipiter gentilis,* state threatened*),* osprey (*Pandion haliaetus,* state special concern) and merlin (*Falco columbarius,* state threatened).

Table 3. Target species identified for rare bird and invertebrate surveys on High Island.

Scientific Name	Common Name	Global Rank[1]	State Rank[1]	State Status[2]	US Status[3]	Habitats
Charadrius melodus	Piping Plover[4]	G3	S1	E	LE	Open, sandy beach, dunes
Haliaeetus leucocephalus	Bald Eagle[4]	G5	S4	SC		Forests near open water
Falco columbarius	Merlin	G5	S1S2	T		Boreal forest near open water/wetlands
Pandion haliaetus	Osprey	G5	S4	SC		Swamp forests , floodplain forest, and open wetlands along open water
Sterna caspia	Caspian Tern[4]	G5	S2	T		Sand and gravel beach
Sterna hirundo	Common Tern[4]	G5	S2	T		Sand and gravel beach
Accipiter gentilis	Northern Goshawk	G5	S3	SC		Northern forests, swamp forests, floodplain forest, and boreal forest
Euxoa aurulenta	Dune cutworm	G5	S1S2	SC		Dunes
Trimerotropis huroniana	Lake Huron locust	G2G3	S2S3	T		Dunes
Somatochlora hineana	Hine's emerald dragonfly	G2G3	S1	E	LE	Calcareous wetlands, northern fens

[1]NatureServe Global and State Ranks: G1, S1-most imperiled; G5, S5-least imperiled.
[2]State status abbreviation: E, state endangered; T, state threatened; SC, state species of special concern.
[3]US/Federal status abbreviation: LE, legally endangered, LT, legally threatened.
[4]Previously recorded breeding on High Island.

Invertebrate targets included the Lake Huron locust (*Trimerotropis huroniana*, state threatened) and the dune cutworm (*Euxoa aurulenta*, state special concern), both of which inhabit open dunes, and the Hine's emerald dragonfly (*Somatochlora hineana*, state and federal endangered), known from calcareous wetlands.

Inventories were conducted where previous occurrences were known and at additional suitable sites, during periods when the targeted animals were most active or when adults would be expected to occur. Surveys emphasized both the identification of new occurrences and the review of known or historical occurrences of rare species. Brief descriptions of these species, their habitats, and survey methods are provided below.

Avian Surveys

Shore Birds

The piping plover is a small, robin-sized shorebird with sand-colored plumage on top and a white underside with a single, narrow, black band across the upper chest. It also has a small black band across its forehead, a very short, stout, orange bill with a black tip, and orange-yellow legs. The Michigan population of piping plovers is part of the Great Lakes population, one of three remaining breeding populations of this species in the world. 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). Piping plovers were last documented on High Island in 2006 along the sand and gravel beaches near the middle of the

western shoreline. Nesting was also documented in 2001 near the far end of the northeast sand spit along High Island Bay (MNFI 2011). Foot surveys using a high-powered spotting scope to search for nesting plovers, were planned for the week of June 5-11. The two areas in which it had been documented previously were targeted, especially the sand and gravel beach extending along the northwest shoreline (Figure 7).

The Caspian tern is the largest of the terns, with a wing span averaging 1.4 meters (4.5 feet; Hyde 1996). It has a black cap and red bill similar to other white terns in the state but its large size and lack of a deeply forked tail distinguishes it from these other terns (Hyde 1996). The common tern also has a black head and nape and a red bill, but is smaller than the Caspian tern, with an average wingspan of 0.8 meter (2.6 feet). It has a slender body, long pointed wings, and a deeply forked tail (Hyde 1997). Terns typically nest on islands and sand and gravel beaches and jetties to avoid terrestrial predators (MNFI 2007). The last documented breeding records for both Caspian and common terns on High Island were near the far end of the northeast sand spit along High Island Bay. Caspian terns were last documented in 1985 when some 900 nests were observed. The last Common Tern colony, comprised of 65 nests, was documented in 1982, and was heavily preyed upon by great horned owls (*Bubo virginianus*) (MNFI 2011). Casual foot surveys using a high-powered spotting scope to locate nesting terns were planned for the northeast sand spit and other areas of suitable habitat on the island in June 2011.

Raptors

The only documented raptor nesting record from High Island in the MNFI database is a 2002 Bald Eagle nest along the northwest shore of the island (MNFI 2011). Bald eagles will nest in a variety of forested habitats that provide suitable nest sites close to open water (Gehring 2006, MNFI 2007). Osprey also nest in a variety of forested habitats with suitable nest sites, such as trees, snags or cliffs, near open water with an adequate fish supply or prey base (Gibson 2007, MNFI 2007). Foot and boat surveys were planned along the shoreline for bald eagles and osprey during the June survey period.

Call playback surveys in the extensive boreal forest in the southern part of the island, were planned for the merlin and northern goshawk. The merlin is a medium-sized falcon, about the size of a blue jay, characterized by long, pointed wings that beat rapidly, a vertically streaked underside, and a long, heavily-barred tail (MNFI 2007, Cuthrell 2002). Merlins typically nest in boreal forests, preferring spruce forests near bogs or open water, in Michigan (Johnson and Coble 1967, Jordan and Shelton 1982). They do not build their own nests but use those of other birds, most commonly those of corvids (crows, ravens) (Cuthrell 2002). The northern goshawk is a large, gray bird with long, broad wings and a long tail which is rounded on the end. The head has a black cap with a pronounced white eyeline. Northern goshawks prefer large tracts of forest with an intermediate amount of canopy closure, small forest openings for foraging, and an open understory (Cooper 1999). This species can be found in a variety of forest types including coniferous stands, deciduous stands, riverine forests, and cultivated conifer stands (Cooper 1999).

Invertebrate Surveys

Dune cutworm

The dune cutworm is reported occurring in disjunct populations in sandy areas throughout North America. No other information on specific habitat requirements is in the literature. The Michigan locations are all

Figure 7. Survey sites and documented occurrences of rare animals on High Island. The point for dune cutworm is a historic, general record from 1935, lacking specific location data.

sparsely vegetated, high quality coastal dune habitats with both marram grass (*Ammophila breviligulata*) and sand reed grass (*Calamovilfa longifolia*). All Michigan specimens have been collected in close proximity to these grasses and it is speculated that the dune cutworm feeds on them.

Blacklight trapping was conducted at one site in a large open dune on the west side of High Island (Figure 7). Sampling occurred during the nights of June 29 and 30. A bucket-type trap was placed in the dune with a 15 watt UV light powered by a 12 volt marine battery. Attracted moths hit a baffle that directs them down a funnel and into the bucket for collection during trap checks. The traps were placed in a central location with the larval host plants (dune grasses) on all sides to maximize the likelihood of collecting adults. The trap location was recorded using a hand-held GPS unit.

Lake Huron locust

The Lake Huron locust is a small ash-gray grasshopper with darker brown and white markings, and wings with a prominent dark band. The pronutum (saddle-like structure behind the head) is cut by two narrow grooves (sulci), and a broad (not narrow) black band covers half the inner surface of the hind femora near the body. This species occurs only in sparsely vegetated, high quality Great Lakes sand dunes along northern Lake Michigan, northern Lake Huron, and eastern Lake Superior. Ideal habitat includes at least a mile of shoreline with two or more sets of dunes with blowouts. It primarily feeds on sand reed grass, marram grass, and wormwood, but will eat other forbs also, including the federal threatened pitcher's thistle (*Cirsium pitcheri*). The Lake Huron locust is most active in late morning, after 9:30 or 10 am. Males crepitate in flight, making a cracking noise.

Surveys were conducted by walking through appropriate habitat and flushing individuals, and counting and recording points with a handheld GPS unit. Close-focusing binoculars and an aerial net were used to confirm identification. Surveys occurred on High Island on August 1 and 4 in four areas with suitable habitat (Figure 7).

Hine's emerald dragonfly

Hine's emerald dragonfly 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. 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). 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. The shallow, flowing, cool water provides important larval habitat and the open areas with adjacent woodland edge provide adult hunting and roosting habitat. Hine's emerald dragonfly sites in Michigan are classified as calcareous wetlands or northern fens with an underlying layer of shallow dolomite.

Adult Hine's emeralds feed over meadows or at forest edges by 7 am on hot days, but are most active from 9:30 am to 1:30 pm, occasionally hanging from twigs. Sometimes they feed in swarms during the day or near sunset. Males patrol territories 1-3 m over rivulets, darting between hovering points where they pivot in different directions. The rear half of the abdomen on females looks muddy and two-toned, and their flickering brown wings are visible at

some distance. Meander surveys through potential habitat were planned for the August field trip. Surveyors use close-focusing binoculars and aerial nets during surveys, as netting individuals to examine and photograph them before release provides the most definitive method for identification.

Data Processing

Following field surveys, data from field forms, notes, and species lists were compiled and examined, and GPS locations and photographs were downloaded. Voucher specimens collected during inventories were examined and identified. Element occurrence records were evaluated, transcribed, and processed. New element occurrence records were mapped and entered into the MNFI Natural Heritage Database, and known element occurrence records were updated and remapped as necessary to more accurately represent their spatial distribution in the database.

Rare Animal Inventories
Results

Avian Surveys

Weather and lake conditions prevented safe passage to High Island when early season surveys were scheduled. Thus, rare bird surveys were not conducted during the appropriate survey window in 2011. However, a pair of bald eagles was observed near Lake Maria, during a reconnaissance trip in September 2010 with LTBB staff, and a pair of merlins was observed flying south of the eastern landing point in August 2011.

Invertebrate Surveys

Dune Cutworm

Only one potential dune cutworm specimen was collected during the blacklight surveys, however the determination was negative.

Hine's emerald dragonfly

Suitable habitat for the Hine's emerald dragonfly was not found during field evaluation on August 1 and no official surveys were conducted for this species.

Lake Huron locust

The Lake Huron locust was found in all four areas surveyed on High Island in 2011 (Figure 8). Large numbers of Lake Huron locusts were observed in the extensive, high quality open dunes on the west side of the island and the northeast end of the island (Figures 7, 9). These areas contain well-developed foredunes and backdunes with blowouts. Over 400 individual locusts were observed throughout the dunes in each of these two areas. Fewer Lake Huron locusts were observed in areas with small sand dunes on the northwest end and south side of the island (Figure 7). The more common Carolina locust (*Dissosteira carolina*) was also found in some of the same areas as the Lake Huron locust. These two species often occur together.

Observations of the Lake Huron locust on the island resulted in an update of a known occurrence, previously documented in 1996 (Table 4). Twenty-five to 30 locusts had been observed along a 600-m transect in the extensive dunes on the west side of the island (MNFI 2011). Based on the NatureServe (2011) element occurrence specifications, these observations represent one element occurrence record with multiple locations on the island. Based on the 2011 survey results and the NatureServe element occurrence rank specifications (Schweitzer and Whittaker (2007), the Lake Huron locust occurrence on High Island was ranked as having good to fair viability (Appendix C).

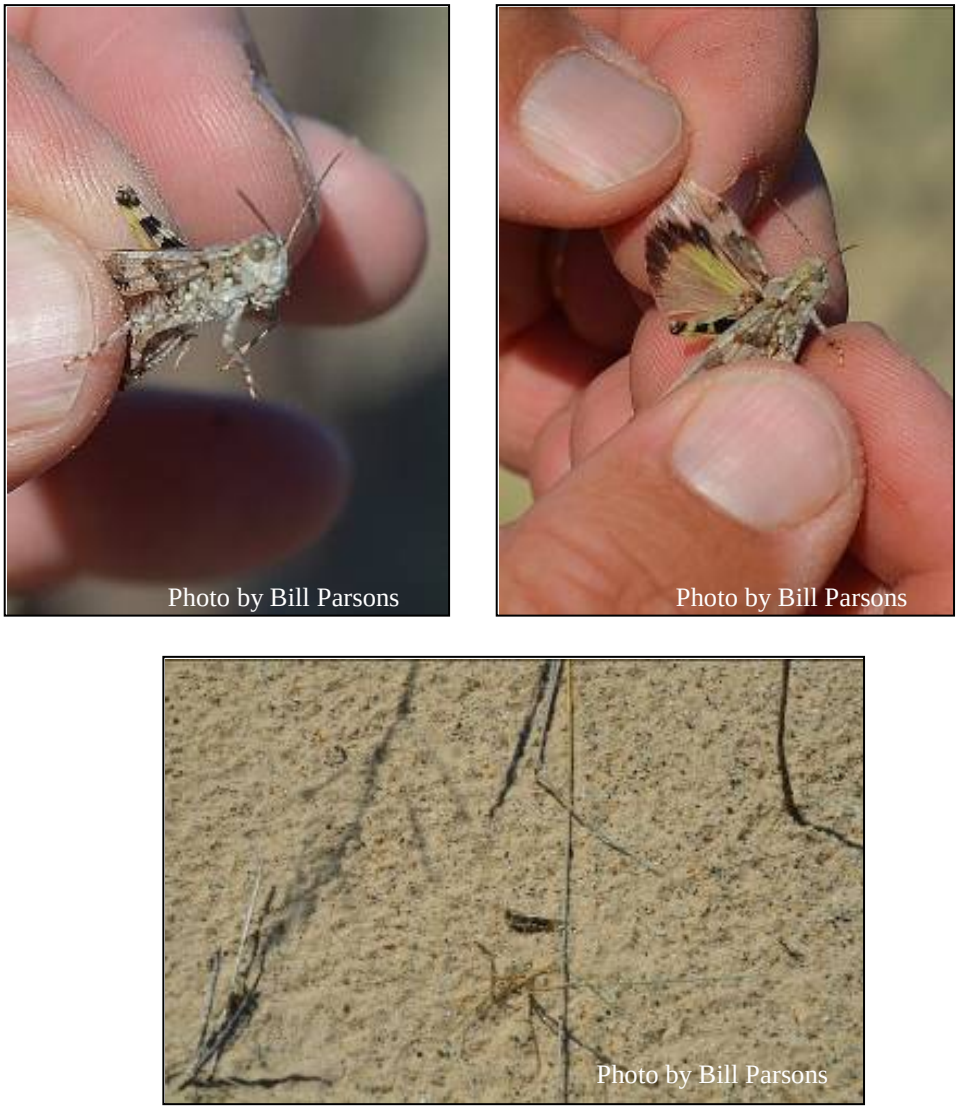

Figure 8. Photos of Lake Huron locusts found on High Island in 2011.

Rare Animal Inventories
Discussion

Avian Species

Due to the historical occurrence of many of the targeted birds on or near the island and casual observation of eagles and merlins, additional surveys for all target bird species are recommended. Neotropical migrants could also be targeted since suitable habitat occurs on the island. Surveys for marsh-dependent species may also reveal suitable wetlands along the eastern coastal zone.

Invertebrates

Dune Cutworm

Efforts to expand surveys for the dune cutworm, last documented on High island in 1935, are warranted. Documenting an extant population would be significant at both state and global levels. The dune cutworm is known only from disjunct populations in a small number of states or provinces in the U.S. and Canada (Cuthrell 1999, Nature-

Figure 9. Photos of suitable habitat where Lake Huron locusts were found on High Island in 2011. (Photos taken by Bill Parsons.)

Table 4. Previously documented and updated rare animal element occurrences for High Island, based on MNFI Natural Heritage Database, 2011.

Scientific Name	Common Name	State, Federal Status	EO Number	Year First Observed	Year Last Observed
Birds					
Charadrius melodus	Piping Plover	E, LE	29	1979	2006
Charadrius melodus	Piping Plover	E, LE	31	1979	2001
Haliaeetus leucocephalus	Bald Eagle	SC	592	2002	2005
Sterna caspia	Caspian Tern	T	3	196?	1985
Sterna hirundo	Common Tern	T	36	1960	1985
Invertebrates					
Euxoa aurulenta	Dune Cutworm	SC	4	1935	1935
Trimerotropis huroniana	Lake Huron Locust	T	49	1996	2011

Serve 2011). It has been documented from only nine locations in six counties in Michigan, including the 1935 High Island occurrence. Additionally, most of the known occurrences in the state are historical; last observed over 20 years ago (MNFI 2011). Documentation of the dune cutworm on High Island would be the most recently

confirmed site and one of only two recent known occurrences of this species in Michigan.

Additional information is needed to manage and conserve the dune cutworm since very little is known about its status, distribution, and ecology in Michigan or throughout its range. Additional surveys should be conducted in the western dune complex sampled in 2011 as well as smaller dunes, such as those along the northeast end of the island, to determine if the population persists and its extent. Surveys of other previously documented sites in Michigan as well as new sites with suitable habitat are needed to establish its current distribution and status statewide. Research is also needed at known sites to obtain information on the species' life history and ecology, particularly identification of the larval food plant and other habitat requirements (Cuthrell 1999). Because this species has been documented from such a small number of sites in the state, all known sites should be protected and high quality dune habitat at these sites should be maintained.

Lake Huron locust

Surveys for the Lake Huron locust revealed that this species is more prevalent on High Island than previously documented. It was known from only one dune area on the island prior to 2011. It was reconfirmed at its original site and documented in three additional areas. It is very likely that the species is more widespread on the island in open sandy habitats. Additional surveys for the species should be conducted to determine the full extent and size of the island population and to monitor its status and viability.

The Lake Huron locust population on High Island is significant from global and state perspectives. It is a Great Lakes endemic known only from sand dunes in Michigan, Wisconsin, and Ontario (Otte 1984, Ballard 1989, Rabe 1999, NatureServe 2011). However, the species may be extirpated from Ontario and restricted to only a small number of sites in Wisconsin (NatureServe 2011). Thus, Michigan contains the majority of the global population and range of this species. The population on High Island is ranked as having good to fair viability and is among about 51 (57%) of the 89 known sites in Michigan that have been ranked as having excellent (A), good (B) or fair (C) viability (MNFI 2011; Appendix C). The remaining sites have been ranked as having fair to poor (CD) or poor (D) viability or are considered historical sites (MNFI 2011, Appendix C). Scholtens (1996, 1997) also identified the Lake Michigan islands as one of six major shoreline areas in the state with significant populations of the locust.

Because of the rarity and endemic status of Lake Huron locust and the extent and condition of the population and habitat on High Island, it is important to sustain this island population. Throughout its range, significant portions of the species' dune habitat have been degraded or destroyed by residential and/or recreational development (Rabe 1999). Protection of any remaining habitat is critical from state and global perspectives. Shorelines that are one mile or more in length with extensive, wide dunes that contain at least two sets of dunes and blow-out areas appear to be ideal habitat for this species (Scholtens 1997, Rabe 1999). These large areas typically sustain the natural processes that maintain and create habitat, particularly areas of bare sand where the locust likely lays its eggs and overwinters. The dunes on the west side of the island and along the northeast end of the island where large numbers of Lake Huron locusts were observed in 2011, represent good examples of optimal or high quality habitat for the species. The Lake Huron locust can also

persist in areas with smaller dunes and with low to moderate levels of natural and/or anthropogenic disturbance (Scholtens 1997, Rabe 1999). However, the species generally occurs in large numbers in high quality sites, and quickly diminishes or disappears when dunes become heavily vegetated or disturbed (Ballard pers. comm.).

In addition to surveys and monitoring, research is needed to obtain additional information on the life history and ecology of the Lake Huron locust to provide a stronger basis for management and conservation of this species. Additional information about the species' microhabitat requirements, particularly for different stages of its life history, is needed. Information about the species' movement and dispersal patterns and capabilities would also be useful (Rabe 1999).

Invasive Plant Inventories
Methods

Target Species

Species targeted for survey were selected from the list of invasive species with potential to impact Michigan's native biodiversity, presented in *Meeting the Challenge of Invasive Plants: A Framework for Action* (Higman and Campbell 2009). Species that were already known from, or near the Beaver Archipelago, that spread quickly and pose significant threats to the vulnerable natural features of the island were prioritized. Currently known distributions, anticipated threat, and rates of spread were based on data from the Midwest Invasive Species Information Network (MISIN), the University of Michigan Herbarium, local networks of conservation organization staff, the extensive review conducted for developing the *Framework,* and personal experience of the project team.

Table 5 lists the invasive species targeted, the natural communities they are most likely to colonize, and the rare species they are most likely to impact. While these species were the primary focus for survey, observations of any species listed in the *Framework* or any other species known to be invasive elsewhere, but not yet documented from the region were also noted.

Field Surveys

Since comprehensive surveys throughout the entire island were beyond the scope of this project, the primary focus was to conduct invasive plant surveys where rare species were known or likely to occur, thereby identifying threats to the most vulnerable species and their habitats first. The secondary focus was to target disturbed areas, which are often key entry points for invasive species. Surveys were conducted on August 1 and 4, while en route to rare species survey sites and at the survey sites themselves. Additional surveys were conducted along the coastal zone, trails, and clearings where feasible and as time allowed. Surveyors meandered along the route and through survey sites, covering as much ground as possible, while deliberately targeting the heterogeneity of the habitat (Goff et al. 1982). Occurrences of invasive plants were documented by marking their location with a GPS point and indicating their extent and abundance using standardized drop-down menus. The area and density categories are shown in Table 6 and are based on protocols established by the Michigan DNR Parks and Stewardship Program (Clancy pers. comm. 2011). Separate occurrences were marked for infestations that were separated by 100 feet or more of un-infested area.

Table 5. Priority invasive species targeted on High Island, the natural communities they are likely to colonize and the vulnerable features they are likely to impact.

Invasive Species	Natural Communities	Vulnerable Plants	Vulnerable Animals
hybrid cat-tail non-native phragmites narrow-leaved cat-tail reed canary grass	coastal fen northern fen Great Lakes marsh limestone cobble shore	bulrush sedge (T) butterwort (SC) English sundew (SC) stitchwort (SC) Houghton's goldenrod (LT, T) Lake huron tansy (LT, T) Pumpelly's brome grass (T) Richardson's sedge (SC)	American bittern (SC) Caspian tern (T) common loon (T) common tern (T) Hine's emerald dragonfly (LE, E) least bittern (T)
spotted knapweed lyme grass baby's-breath	open dune	dunewort (T) dwarf lake iris (LT, T) fascicled broomrape (T) Lake Huron tansy (T) pitcher's thistle (LT, T)	dune cutworm Lake Huron locust (T)
autumn olive common buckhorn Eurasian honeysuckles garlic mustard glossy buckthorn multiflora rose	boreal forest dry-mesic northern forest dry northern forest mesic northern forest rich conifer swamp wooded dune and swale	calypso orchid (T) dwarf-lake iris (LT, T) ginseng (T) green spleenwort (SC) pine drops (T) ram's-head orchid (SC) roundleaf orchid (E) Michigan monkey-flower (LE, E)	Lake Huron locust (T) Merlin (T) Northern Goshawk (T) Osprey (SC) Red-shouldered Hawk (T)

Table 6. Size and density codes for invasive species occurrences

Area Code	Area Description	Density Code	Density Description
1	Individual/few/several	1	Sparse (scattered individual stems or very small stands)
2	less than 1,000 square feet	2	Patchy (a mix of sparse and dense areas)
3	1,000 ft^2 to 0.5 acre	3	Dense (greater than 40% of the area)
4	0.5 acre to 1 acre	4	Monoculture (nearly 100% of area)
5	greater than 1 acre		

Data Processing

The invasive species GPS data points were downloaded to a GIS project file and maps depicting the species, location and size of each mapped infestation were created. A scaled map of a portion of the island was also produced where individual occurrences can be more easily discerned. The density of an occurrence was not depicted on these maps, but can be determined using the identify feature in ArcMap, by clicking on a mapped point in the project shapefile.

Invasive Plant Inventories

Results

Five of the priority invasive plants targeted were documented on High Island, including non-native phragmites, reed canary grass, narrow-leaved cat-tail, hybrid cat-tail, and spotted knapweed (Table 7). Numerous large and small patches of the grasses and cat-tails were found along the northwest coastal zone and south of the eastern landing where surveys were conducted in 2011 (Figures 10, 11). Spotted knapweed was abundant along the eastern shore in the narrow foredunes and cobble shore south of the

landing and north throughout the sand spit. It was also found along the surveyed areas in the northwestern and southern shore. A possible occurrence of Oriental bittersweet (*Celastrus orbiculata*) was documented at high elevation in a major blowout within the western dune complex. Confirmation was not possible since it wasn't flowering and the leaves were fully emerged. Because this species is a rapid proliferator and poses a significant threat to forests and dunes, it is included with the other priority invasive species in Table 7. No other priority invasive species were documented in the western dune complex. Notably absent in the surveyed areas were garlic mustard, Eurasian honeysuckles, autumn olive, common buckthorn, glossy buckthorn, and multiflora rose. None of these species were noted during 2010 reconnaissance surveys along the trails of the northeastern forest either. Figure 12 shows the noted occurrences of these species as well as identified patches of native phragmites, which were also encountered. Figure 13 shows a close-up view of priority species infestations documented in the northwest corner of the island. Species are distinguished by color with the size of the icon corresponding to the area description code for each occurrence. Shapefiles with both area and density data for each occurrence are provided with this report.

Table 7. Priority invasive species documented on High Island during 2011 surveys.

Common Name	Scientific Name	Common Name	Scientific Name
hybrid cat-tail	*Typha Xglauca*	reed canary grass	*Phalaris arundinacea*
narrow-leaved cat-tail	*Typha angustifolia*	spotted knapweed	*Centaurea stoebe*
non-native phragmites	*Phragmites australis*	Oriental bittersweet*	*Celastrus orbiculata*

* Requires confirmation.

Figure 10. Large patch of invasive phragmites on the east side of High Island with Lake Michigan in the background.

Figure 11. Sparse patch of invasive phragmites spreading along the east side of High Island.

Occurrences of ten additional species, noted as invasive in the *Framework*, were also documented (Table 8). Bouncing bet and common St. John's-wort were fairly abundant along with spotted knapweed in the eastern foredunes and in several clearings just inland on the bluff. The other species were found scattered in the surveyed areas outside of the western dune complex. The locations of these lower threat species are shown in Figure 14.

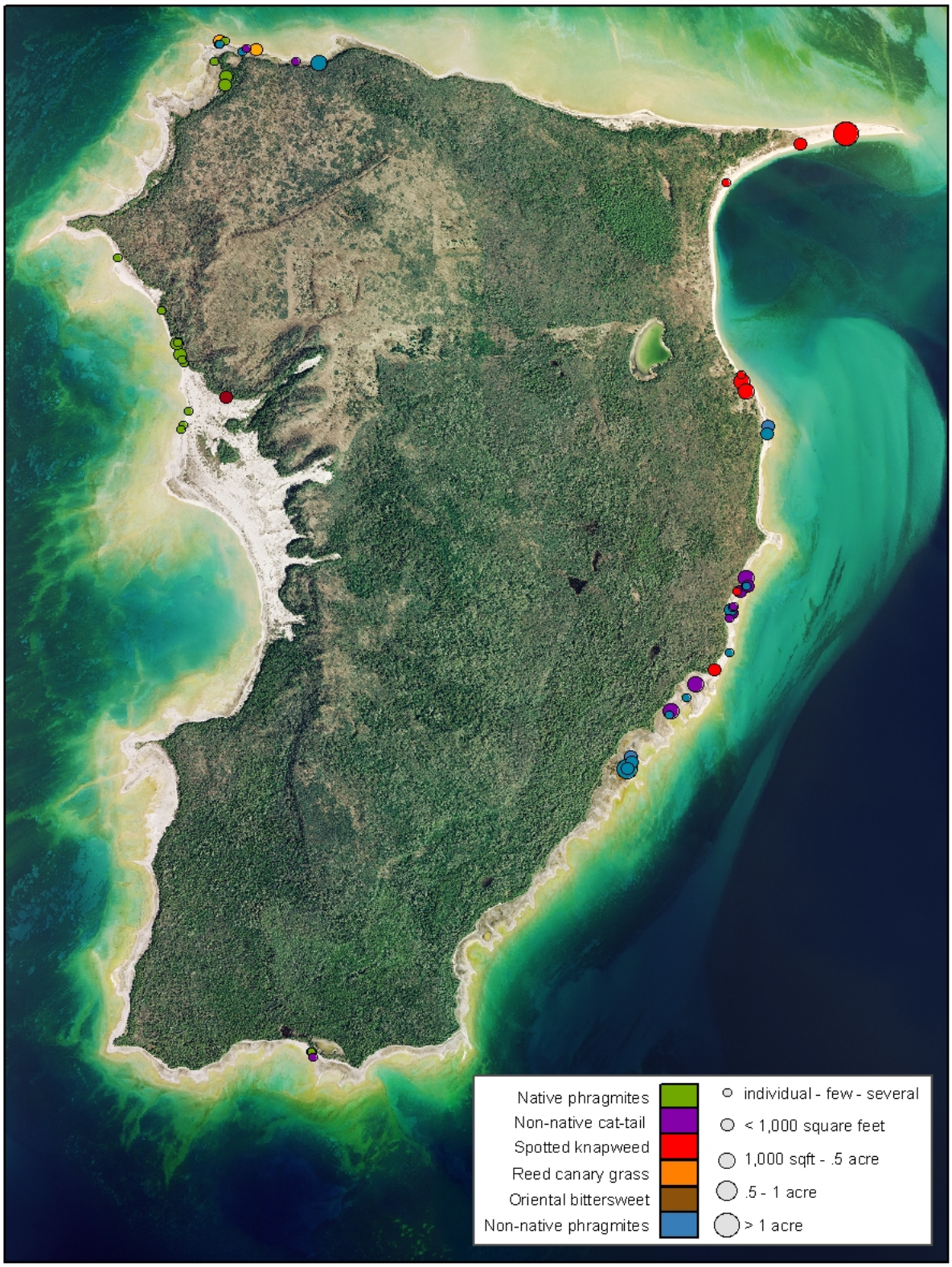

Figure 12. Priority invasive species and native phragmites mapped on High Island during 2011 surveys.

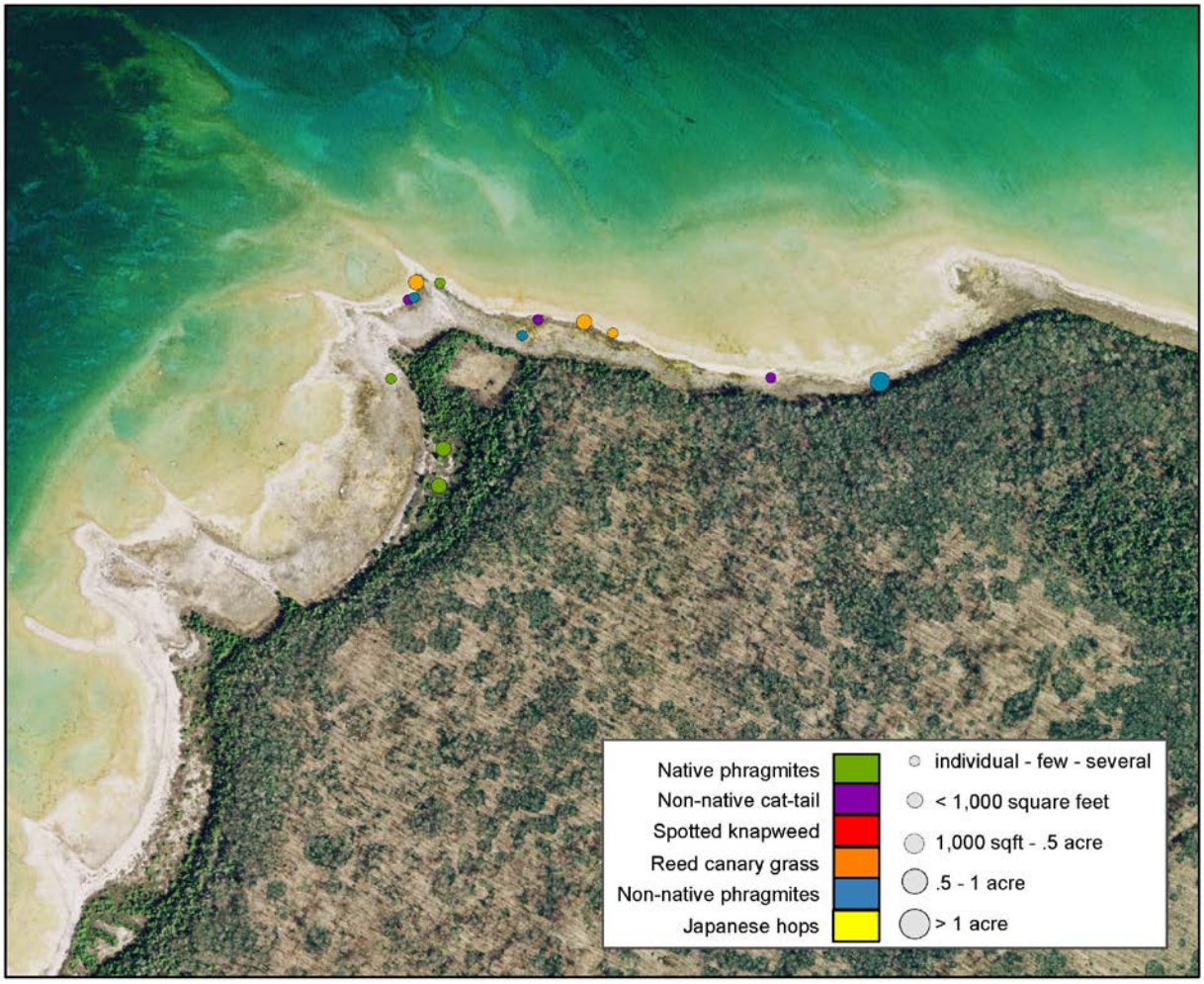

Figure 13. View of northwest High Island showing priority invasive species infestations and native phragmites occurrences by size.

Table 8. Lower threat invasive species documented on High Island during 2011 surveys.

Common Name	Scientific Name	Scientific Name	Common Name
bittersweet nightshade	*Solanum dulcamara*	common mullein	*Verbascum thapsis*
bladder campion	*Silene vulgaris*	common St. John's-wort	*Hypericum perforatum*
bouncing bet	*Saponaria officinalis*	European marsh thistle	*Cirsium palustre*
bull thistle	*Cirsium vulgare*	white sweet clover	*Melilotis alba*
Canada thistle	*Cirsium arvense*	yellow sweet clover	*Melilotis officinale*

Invasive Plant Inventories
Discussion

The absence of invasive species from the high quality western dune complex is highly significant, as few dunes in Northern Michigan have not been impacted by species such as spotted knapweed, lyme grass, baby's-breath, bouncing bet, or bladder campion. The eastern foredunes and cleared areas are more typical of Lower Peninsula dunes, with relatively high abundance of spotted knapweed and bouncing bet. The patches of

Figure 14. Lower threat invasive species mapped on High Island during 2011 surveys.

invasive phragmites and cat-tails are typical of early infestations of northern Lake Michigan coastal marshes, cobble shores, coastal fens, and sand and gravel beaches. Treatment of such patches, with regular maintenance, has proven highly effective in northern Michigan and have already been initiated on the island.

These findings, coupled with the noted absence, thus far, of garlic mustard, Eurasian honeysuckles, autumn olive, common buckthorn, glossy buckthorn, multiflora rose and lyme grass, present a window of opportunity for mounting a highly successful, prioritized rapid response effort. Figure 15 demonstrates how costs increase and level of success declines the longer aggressive invasive species remain unchecked. Due to the relatively low levels of infestation, implementation of an intensive, focused control effort *now*, could significantly reduce priority and medium-threat invasive species populations to acceptable maintenance levels and keep the long-term cost of control low.

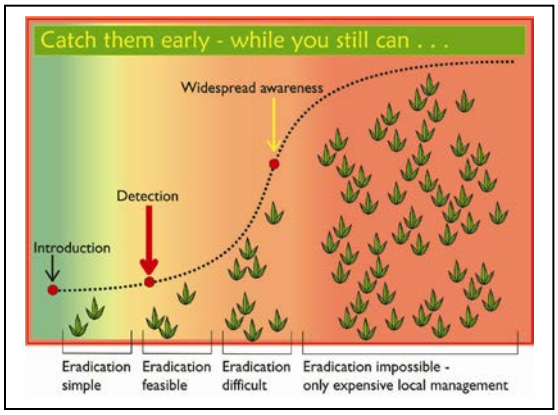

Figure 15. Cost effectiveness of early detection and rapid response.

In general, it is most effective to treat small isolated infestations first and work backwards towards larger source infestations, ultimately eradicating or containing them. Otherwise, the small, isolated occurrences will grow into larger infestations. If resources are limited, prioritizing high value sites and species of highest threat can be effective. Based on current data for High Island, several immediate priorities are recommended:

- Confirm the identity of the bittersweet; in the western dune complex; this is best undertaken in early spring when the leaves are unfurling (USGS 2007). If it is Oriental bittersweet, carefully survey the surrounding area and map, treat, and monitor all occurrences.
- Continue surveying and treating invasive phragmites around the perimeter of the island and expand this effort to include reed canary grass and invasive cat-tails.
- Regularly monitor the western dune complex working outward from the center to control spotted knapweed and any other invasive species that may become established.
- Treat isolated patches of priority and lower threat species (Tables 7, 8; Figures 12-14).
- Complete surveys and mapping of high value sites, trails, and other disturbed areas and use these findings prioritize treatment efforts.

Since treatment rarely completely eradicates an infestation and new propagules will con-

tinue to arrive, rapid response efforts are most cost-effective when complemented by strategic, long-term monitoring. This entails periodic monitoring for new infestations near high value sites to keep them out, and in disturbed areas where invasive species are likely to establish first. It is further recommended that routine monitoring of the entire coastal zone and all high value sites be conducted annually, to keep established species at low levels and to detect and eradicate any newly colonizing invasive species.

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Literature Cited

Ballard, H. E., Jr. 1989. *Trimerotropis huroniana* (Orthoptera: Acrididae), a new record for Wisconsin. Great Lakes Entomologist 22(1):45-46.

Campbell, S.L., P.J. Higman, K. Borland, & B. Schillo. 2009. A Field Identification Guide to Invasive Plants in Michigan's Natural Communities. http://web4.msue.msu.edu/mnfi/education/fieldguide.cfm. [Accessed Feb 17 2012]

Campbell, S.L., P.J. Higman, B. Slaughter, E. Schools. 2010. A Field Guide to Invasive Plants of Aquatic and Wetland Habitats for Michigan. Submitted to DNRE Water Bureau. 91 pp. http://web4.msue.msu.edu/mnfi/education/AquaticsFieldGuide.pdf [Accessed Feb 17 2012]

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

Clancy, Robert. 2011. Personal Communication. MDNR Parks Stewardship Program.

Cooper, J.L. 1999. Special animal abstract for *Accipiter gentilis* (northern goshawk). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Cuthrell, D. L. 1999. Special animal abstract for *Euxoa aurulenta* (dune cutworm). Michigan Natural Features Inventory, Lansing, MI. 2pp.

Cooper, J.L. 1999. Special animal abstract for *Buteo lineatus* (red-shouldered hawk). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Cuthrell, D. L. 2002. Special animal abstract for *Falco columbarius* (merlin). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Gehring, J. L. 2006. Special animal abstract for *Haliaeetus leucocephalus* (bald eagle). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Gibson, J. M. 2007. Special animal abstract for *Pandion haliaetus* (Osprey). Michigan Natural Features Inventory, Lansing, MI. 4pp.

Goff, F.G., G.A. Dawson, and J.J. Rochow. 1982. Site examination for threatened and endangered plant species. Environmental Management 6(4):307–316.

Haas, S.C.G. 2010. Merlin (Falco columbarius). In A.T. Chartier, J.J. Baldy, and J.M. Brenneman, editors. The Second Michigan Breeding Bird Atlas. Kalamazoo Nature Center. Kalamazoo, MI. Accessed online at: www.mibirdatlas.org/Portals/12/MBA2010/MERLaccount.pdf [Accessed Dec 21, 2011].

Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, W.W. Brodovich, and K.P. Gardiner. 2001. Floristic quality assessment with wetland categories and examples of computer applications for the State of Michigan. Mich. Dept. Nat. Res., Wildlife Div., Natural Heritage Program. Lansing, MI. 19 pp + appendices.

Higman, P.J., and S.L. Campbell. 2009. Meeting the Challenge of Invasive Plants: A Framework for Action. 2009. http://www.michigan.gov/documents/dnr/Invasives_strategy_final_289799_7.pdf [Accessed Feb 17 2012]

Higman, P.J., E. Schools, and H. Enander. 2005. Invasive Plant Species Survey and Management Recommendations for Camp Grayling. Submitted to MDMVA, Grayling, MI. 35pp. +app.

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

Higman, P.J. and M.R. Penskar. 1996. Special plant abstract for *Orobanche fasciculata* (fascicled broomrape). Michigan Natural Features Inventory, Lansing, MI. 2 pp.

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

Hyde, D. A. 1997. Special animal abstract for *Sterna hirundo* (common tern). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Hyde, D. A. 1999. Special animal abstract for *Charadrius melodus* (piping plover). Michigan Natural Features Inventory, Lansing, MI. 4 pp.

Johnson, W. J., and J. A. Coble. 1967. Food habits of merlins. Jack-Pine Warbler 45: 97-98.

Jordan, P. A., and P. C. Shelton. 1982. Wildlife of Isle Royale. Natural History Association, Houghton, Michigan.

Judziewicz E.J. 2001. Flora and vegetation of the Grand Traverse Islands (Lake Michigan), Wisconsin and Michigan. Mich. Bot. 40. (4): 81-208.

Michigan Department of Natural Resources (MDNR). 2006. Michigan's Wildlife Action Plan. Available online at http://www.michigan.gov/dnr/0,4570,7-153-10370_30909---,00.html [Accessed Dec 27 2011].

Michigan Natural Features Inventory. 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer [Accessed Dec 20, 2011].

Monfils, M.J. 2004. Special animal abstract for *Botaurus lentiginosus* (American bittern). Michigan Natural Features Inventory, Lansing, MI. 6 pp.

Monfils, M.J. 2003. Special animal abstract for *Ixobrychus exilis* (least bittern). Michigan Natural Features Inventory, Lansing, MI. 6 pp.

Monfils, M.J. 2010. Michigan Marsh Bird Survey Protocol. Michigan Natural Features Inventory, East Lansing. 11 pp. + appendices.

Lambert, A. and B. Ratcliff. 1981. Present status of the piping plover in Michigan. Jack Pine Warbler 59:44-52.

Michigan Department of Environmental Quality. Undated. A Landowner's Guide to Invasive Phragmites Control.

Michigan Natural Features Inventory (MNFI). 2007. Rare Species Explorer (Web Application). Available online at http://web4.msue.msu.edu/mnfi/explorer [Accessed Dec 20, 2011].

Michigan Natural Features Inventory (MNFI). 2011. Natural Heritage Database. Lansing, MI.

NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer [Accessed: Dec 20, 2011].

Norwood, G. 2010. Common Tern (*Sterna hirundo*). In A.T. Chartier, J.J. Baldy, and J.M. Brenneman, editors. The Second Michigan Breeding Bird Atlas. Kalamazoo Nature Center. Kalamazoo, MI. Accessed online at: www.mibirdatlas.org/Portals/12/MBA2010/COTOaccount.pdf [Accessed Dec 21, 2011].

Otte, D. 1984. The North American grasshoppers. Vol. 2. Acrididae: Oedipodinae. Harvard Univ. Press, Cambridge, MA.

Penskar, M.R. and J.A. Hansen. Special Plant Abstract for *Pinguicula vulgaris* (butterwort). Michigan Natural Features Inventory, Lansing, MI. 4 pp.

Penskar, M.R. and P.J. Higman. 1999. Special Plant Abstract for *Drosera anglica* (English sundew). MI Natural Features Inventory. Lansing, MI. 2 pp.

Penskar, M.R., P.J. Higman, and Susan R. Crispin. 1996. Special Plant Abstract for *Solidago houghtonii* (Houghton's goldenrod). Michigan Natural Features Inventory, Lansing, MI. 3 pp.

Penskar, M.R., Y.M. Lee, M.A. Kost, D.A. Hyde, J.J. Paskus, D.L. Cuthrell, H.D. Enander. 2002a. Biological Inventory for Conservation of Great Lakes Islands: 2001 Progress Report. Report to Michigan Dept. of Environmental quality, Land and Water Mgt. Div., Coastal Mgt. Program. MNFI Report #2002-27. 42 pp. + appendices.

Penskar, M.R., J.A. Olson, M.A. Kost, J.J. Paskus, D.L. Cuthrell, R.L. Boehm, E.H. Schools, and M.T. Fashoway. 2002b. Biological Inventory for Conservation of Great Lakes Islands: 2001 Progress Report. Report to Michigan Dept. of Environmental quality, Land and Water Mgt. Div., Coastal Mgt. Program. MNFI Report #2002-21. 38 pp. + appendices.

Penskar, M.R., D.A. Hyde, J.A. Olson, M.A. Kost, P.J. Higman, J.J. Paskus, R.L. Boehm, and M.T. Fashoway. 2001. Biological Inventory for Conservation of Great Lakes Islands: 2000 Progress Report. Report to Michigan Dept. of Environmental quality, Land and Water Mgt. Div., Coastal Mgt. Program. MNFI Report #2000-15. 110 pp.

Penskar, M.R., D.A. Hyde, P.J. Higman, J.J. Paskus, R.R. Goforth, D.L. Cuthrell, D.A. Albert, and R.L. Boehm. 2000. Biological Inventory for Conservation of Great Lakes Islands: 1999 Progress Report. Report to Michigan Dept. of Environmental quality, Land and Water Mgt. Div., Coastal Mgt. Program. MNFI Report #2000-11. 68 pp.

Penskar, M.R., P.J. Higman, D.A. Hyde, D.L. Cuthrell, R.A. Corner, M.A. Kost, and E.J. Judziewicz. 1999. Biological Inventory for Conservation of Great Lakes Islands: 1998 Progress Report. Report to Michigan DEQ, Land and

Water Mgt. Div., Coastal Mgt. Program. MNFI Report #1999-01. 38 pp.

Penskar, M.R., P.J. Higman, J.D. Soule, and L.J. Scrimger. 1997. A survey of the Lake Huron and Lake Michigan coastal zones for Great Lakes endemic plant species. Report to the Michigan Dept. of Env. Quality, Land and Water Mgt., Coastal Mgt. Program. MNFI. Lansing, MI. 80 pp. + appendices.

Penskar, M.R. and T.R. Leibfreid. 1993. A survey of the Lake Michigan coastal zones for Great Lakes endemic plant species. Report to the Michigan Dept. of Natural Resources, Land and Water Mgt. Division, Coastal Mgt. Program. MNFI. Lansing, MI. 38 pp. + appendices.

Pilette, J. 2011. Little Traverse Bay Bands of Odawa Indians Native Plants Initiative. Revision 1. Little Traverse Bay Bands of Odawa Indians, Environmental Services Department, Harbor Springs, MI. 56 pp.

Powell, A. N. and F. J. Cuthbert. 1992. Habitat and reproductive success of piping plovers nesting on Great Lakes islands. Wilson Bull. 104:151-161.

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

Seefelt, N. 2010. Caspian Tern (*Sterna capia*). In A.T. Chartier, J.J. Baldy, and J.M. Brenneman, editors. The Second Michigan Breeding Bird Atlas. Kalamazoo Nature Center. Kalamazoo, MI. Accessed online at: www.mibirdatlas.org/Portals/12/MBA2010/CATEaccount.pdf [Accessed Dec 21, 2011].

Seefelt, N. 2010. Northern Goshawk (*Accipiter gentilis*). In A.T. Chartier, J.J. Baldy, and J.M. Brenneman, editors. The Second Michigan Breeding Bird Atlas. Kalamazoo Nature Center. Kalamazoo, MI. Accessed online at: www.mibirdatlas.org/Portals/12/MBA2010/NOGOaccount.pdf [Accessed Dec 21, 2011].

Scholtens, B. G. 1996. Status of the Lake Huron locust (*Trimerotropis huroniana*) in northern Michigan. Unpublished report to the Michigan DNR. 23 pp.

Scholtens, B. G. 1997. Distribution and habitat selection of the Lake Huron locust (*Trimerotropis huroniana*). Unpublished report to the Michigan DNR. 18 pp.

Schweitzer, D. F. and J. C. Whiitaker. 2007. Population/element occurrence viability rank specifications for the Lake Huron locust (*Trimerotropis huroniana*). In: NatureServe. 2011. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. [Accessed: Dec 20, 2011].

The Midwest Invasive Species Information Network (MISIN). [Accessed Feb 17 2012] http://www.misin.msu.edu/

United States Geological Survey. 2007. American and Oriental Bittersweet Identificaiton. [Accessed Feb 17 2012] http://www.glsc.usgs.gov/_files/factsheets/2007-2%20Identifying%20Bittersweet.pdf

University of Michigan Herbarium. Ann Arbor, Michigan. [Accessed Feb 17 2012] http://herbarium.lsa.umich.edu/

Voss, E.G. 1996. Michigan Flora. Part III. Dicots (Pyrolaceae-Compositae). Bull. Cranbrook Inst. Sci. 61 and Univ. of Michigan Herbarium. xix + 622 pp.

Voss, E. G. 1985. Michigan Flora. Part II. Dicots (Saururaceae-Cornaceae). Bull. Cranbrook Inst. Sci. 59 and Univ. of Michigan Herbarium. xix + 724 pp.

Voss, E. G. 1972. Michigan Flora. Part I. Gymnosperms and Monocots. Bull. Cranbrook Inst. Sci. 55 and Univ. of Michigan Herbarium. xv + 488 pp.

Appendix A. Plant Species List for High Island Dunes Using the Floristic Quality Assessment

Floristic Quality Data
August 1, 2011 by Mike Penskar

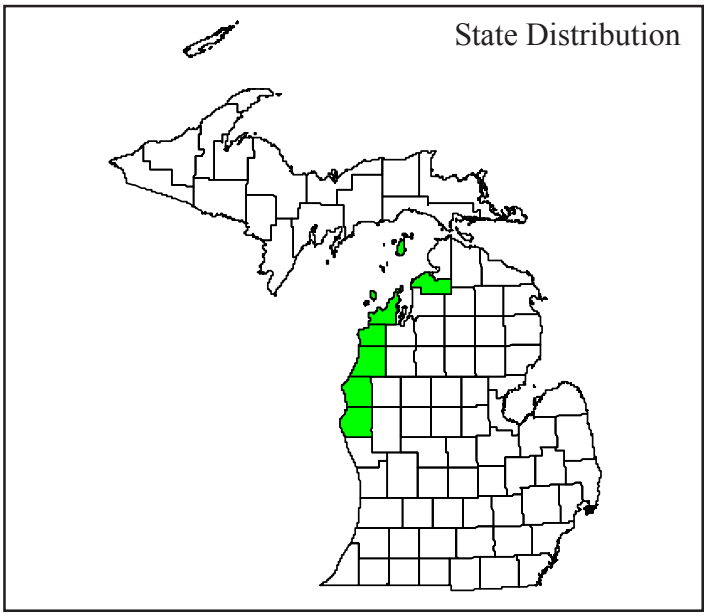
NATIVE SPECIES	37	Native	37	88.10%	Adventive	5	11.90%
Total Species	42	Tree	5	11.90%	Tree	1	2.40%
NATIVE MEAN C	6.2	Shrub	10	23.80%	Shrub	0	0.00%
W/Adventives	5.4	W-Vine	0	0.00%	W-Vine	0	0.00%
NATIVE FQI	38	H-Vine	0	0.00%	H-Vine	0	0.00%
W/Adventives	35	P-Forb	9	21.40%	P-Forb	3	7.10%
NATIVE MEAN W	1	B-Forb	3	7.10%	B-Forb	0	0.00%
W/Adventives	1.4	A-Forb	2	4.80%	A-Forb	0	0.00%
Facultative (-)		P-Grass	7	16.70%	P-Grass	1	2.40%
		A-Grass	0	0.00%	A-Grass	0	0.00%
		P-Sedge	0	0.00%	P-Sedge	0	0.00%
		A-Sedge	0	0.00%	A-Sedge	0	0.00%
		Fern	1	2.40%			

Scientific Name	Common Name	C	W	Wetness	Physiognomy
Agropyron dasystachyum	wheat grass	10	4	FACU-	Nt P-Grass
Ammophila breviligulata	marram grass	10	5	UPL	Nt P-Grass
Andropogon scoparius	little bluestem grass	5	3	FACU	Nt P-Grass
Arabis lyrata	sand cress	7	4	FACU-	Nt B-Forb
Arctostaphylos uva-ursi	bearberry	8	5	UPL	Nt Shrub
Artemisia campestris	wormwood	5	0	FAC	Nt B-Forb
Asclepias syriaca	common milkweed	1	5	UPL	Nt P-Forb
Betula papyrifera	paper birch	2	2	FACU+	Nt Tree
Cakile edentula	sea rocket	5	3	FACU	Nt A-Forb
Calamovilfa longifolia	sand reed grass	10	5	UPL	Nt P-Grass
Campanula aparinoides	marsh bellflower	7	-5	OBL	Nt P-Forb
Cirsium pitcheri	Pitcher's thistle	10	5	UPL	Nt B-Forb
Cornus stolonifera	red osier dogwood	2	-3	FACW	Nt Shrub
Elymus canadensis	Canada wild rye	7	1	FAC-	Nt P-Grass
Epipactis Helleborine	helleborine	0	5	UPL	Ad P-Forb
Equisetum variegatum	variegated scouring rush	8	-3	FACW	Nt Fern Ally
Euthamia graminifolia	grass leaved goldenrod	3	-2	FACW-	Nt P-Forb
Festuca saximontana	fescue	6	5	UPL	Nt P-Grass
Hieracium Piloselloides	glaucous king devil	0	5	UPL	Ad P-Forb
Juncus balticus	rush	4	-5	OBL	Nt P-Forb
Juniperus communis	common or ground juniper	4	3	FACU	Nt Shrub
Juniperus horizontalis	creeping juniper	10	1	FAC-	Nt Shrub
Lathyrus japonicus	beach pea	10	4	FACU-	Nt P-Forb
Lithospermum caroliniense	plains puccoon	10	5	UPL	Nt P-Forb
Malus pumila	apple	0	5	UPL	Ad Tree
Picea glauca	white spruce	3	3	FACU	Nt Tree
Pinus resinosa	red pine	6	3	FACU	Nt Tree

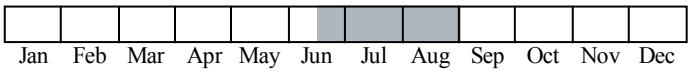
Scientific Name	Common Name	C	W	Wetness	Physiognomy
Poa compressa	canada bluegrass	0	2	FACU+	Ad P-Grass
Polygonum ramosissimum	bushy knotweed	7	1	FAC-	Nt A-Forb
Populus balsamifera	BALSAM POPLAR	2	-3	FACW	Nt Tree
Potentilla anserina	silverweed	5	-4	FACW+	Nt P-Forb
Potentilla fruticosa	shrubby cinquefoil	10	-3	FACW	Nt Shrub
Prunus pumila	sand cherry	8	5	UPL	Nt Shrub
Salix exigua	sandbar willow	1	-5	OBL	Nt Shrub
Salix lucida	shining willow	3	-4	FACW+	Nt Shrub
Salix myricoides	blueleaf willow	9	-3	FACW	Nt Shrub
Sedum acre	mossy stonecrop	0	5	UPL	Ad P-Forb
Shepherdia canadensis	soapberry	7	5	UPL	Nt Shrub
Smilacina stellata	starry false solomon seal	5	1	FAC-	Nt P-Forb
Solidago simplex	Gillman's goldenrod	10	3	FACU	Nt P-Forb
Sphenopholis intermedia	slender wedgegrass	4	0	FAC	Nt P-Grass
Thuja occidentalis	arbor vitae	4	-3	FACW	Nt Tree

Appendix B. Rare Species Abstracts

Orobanche fasciculata Nutt. — fascicled broom-rape



Best Survey Period



Status: State threatened

Global and state rank: G4/S2

Family: Orobanchaceae (broom-rape)

Other common names: broom rape, clustered or yellow cancer-root, sand cancer-root

Synonyms: *Thalesia fasciculata* (Nutt.) Britton, *Anoplanthus fasciculata*

Total range: This species reaches its easternmost distribution in the Great Lakes region, extending into Michigan and Indiana. In western North America it ranges to the Yukon and British Columbia, extending south to Arizona, California, and northern Mexico. It is considered rare in Illinois, Indiana, Wisconsin, Kansas, Minnesota, Ontario, and the Yukon.

State distribution: Fascicled broom-rape is restricted to the Lake Michigan shore from Charlevoix to Oceana Counties—including Beaver, South Fox and South Manitou Islands—with barely more than a dozen localities recorded. Most and the largest of these lie in Leelanau and Benzie Counties. One Oceana County population appears to be no longer extant. No inland localities are known. The species is relatively scarce at all sites except one occurrence in Sleeping Bear Dunes National Lakeshore.

Recognition: *Orobanche fasciculata* is a parasitic plant that **completely lacks chlorophyll**, the stem and scale-like leaves appearing a **pale yellow-brown in color**. The **fleshy, somewhat succulent stem** is primarily subterranean, with the aerial portion, including the inflorescence, reaching 5-15 cm in height. The reduced **scale-leaves are hairy** and widest toward the stem base, becoming more narrow and pointed upward. A cluster of **3-10, tubular, bilaterally symmetrical flowers** terminates the stem, each flower on a stalk 2-6 cm long. The flowers are rose-purple when in bud, becoming **pinkish to creamy white upon maturity**. **Bright yellow splotches**, which serve as nectar guides for pollinators, are visible within the throat of the floral tube. After flowering, this plant becomes dark brown and **forms erect fruiting capsules**. It is easiest to see at this time, when in contrast with the buff-colored open dune sands of its habitat.

Orobanche uniflora (one-flowered broom-rape), a similarly obscure species but not considered particularly rare within the state, is easily distinguished by its shorter stature (1-5 cm), hairless scale-leaves, fewer flowers (1-3) on longer stalks (6-20 cm), and violet-tinged flowers. This species occurs in association with juniper, its host species, whereas the host of *O. fasciculata* is wormwood (*Artemisia campestre*; shown in lefthand corner of photo).

Best survey time/phenology: Due to its small size and inconspicuous coloring, fascicled broom-rape is best sought when in flower, or better yet, in fruit when the dark brown color of the fruiting capsules poses a better contrast to the dune sands than the sandy buff colored flowers. Most of the occurrences in Michigan are noted to flower in late June and fruit in the latter part of July and August. Since wormwood is it's only known host plant in Michigan, surveys should focus on sites where this species is present.

Habitat: In Michigan, fascicled broom-rape inhabits

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dunes along the northern Lake Michigan shoreline and usually grows on the leeward slope of the first or second dune ridge inland from the lake. It favors zones of sand deposition where *Calamovilfa longifolia* (sand reed grass) often dominates and its host *Artemesia campestre* (wormwood) is common. Other common dune associates of this species include *Ammophila breviligulata* (beach grass), *Andropogon scoparius* (little bluestem*), Arabis lyrata* (lyre-leaved rock cress), *Monarda punctata* (horse-mint), *Asclepias syriaca* (milkweed), *Salix myricoides* and *S. cordata* (dune willows), and the Great Lakes endemic *Cirsium pitcheri* (Pitcher's thistle). Farther west where it is more common, it is primarily a plant of dry plains and prairies, and parasitizes a variety of other plant species, including several western species of *Artemisia*.

Biology: This annual plant is a parasite on other species, and is dependent on *Artemisia campestre* (wormwood) as its host plant in Michigan and Wisconsin. It is believed that germination of its seed is triggered by root secretions from the host plant (Kuijt 1969), after which a haustorium, or root connection, establishes between the seedling's primary root and the host root. Fleshy, tuberous structures then emerge around the apical meristem and develop into flowering stalks in June and July. The flowers of fascicled broom-rape are well adapted to cross-pollination by bees and bumblebees (Kuijt 1969), but are capable of setting seed without fertilization (Reuter 1986). The copious seeds produced are dispersed by wind and rainwater via their minute size and the numerous air-retaining cavities (testa) on their surfaces (Kuijt1969).

Conservation/management: Dunes supporting fascicled broom-rape should be protected from heavy disturbance (e.g., from pedestrians or vehicles) and from development. However, light disturbance may tend to increase the frequency of this species' host-plant and thus enhance conditions for germination. Fortunately, six colonies of *Orobanche* have been found within Sleeping Bear National Lakeshore, two others on State Park property, and one on Nordhouse Dunes Research Natural Area/Wilderness Area in Manistee National Forest. Recent surveys of a known fascicled broom-rape site discovered several years previously did not result in observations of any plants; within this site there were many signs of artificial disturbances, including ORV traffic, increased recreational use of the site by pedestrians, and evidence of exotic plant invasion. Protection of shoreline habitat may thus be essential to maintaining viable populations of this rare species within the state.

Comments: An extract from one member of this genus has been used to treat kidney stones (Thieret, 1971).

Research needs: An important need for *O. fasciculata* is to assess genetic variability within and between known populations and the relative rates of outcrossing and self fertilization. This will ultimately be important for determining which and how many populations are necessary for successful conservation of the species. Long term demographic studies are also suggested in order to better predict the long-term viability of individual populations.

Key words: open dune, American dune wild-rye, Lake Huron tansy, Pitcher's thistle, Pumpell's brome grass, Lake Huron locust, piping plover

Selected references

Guire, K.E. and E.G. Voss. 1963. Distributions of distinctive shoreline plants in the Great Lakes Region. Mich. Bot. 2(4):99-114.

Kuijt, F. 1969. The biology of parasitic flowering plants. Univ. Calif. Press, Berkeley, CA.

Reuter, B.C. 1986. The habitat, reproductive ecology and host relations of *Orobanche fasciculata* Nutt. (Orobanchaceae) in Wisconsin. Bull. Torr. Bot. Club. 113:110-117.

Thieret, J.W. 1971. Orobanchaceae in the southeastern United States. J. Arn. Arb. 52: 404-434.

Wisconsin Department of Natural Resources. 1982. Endangered and nongame species handbook. Unpubl.

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Higman, P.J. and M.R. Penskar. 1996. Special plant abstract for *Orobanche fasciculata* (fascicled broom-rape). Michigan Natural Features Inventory, Lansing, MI. 2 pp.

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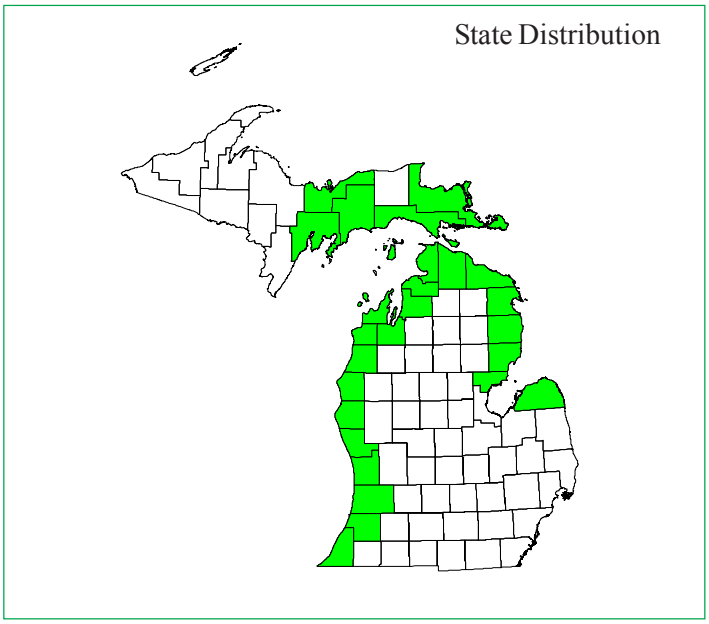
2-00/pjh

Cirsium pitcheri (Torrey and Gray) Pitcher's thistle

Photos by Sue Crispin



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.

Related abstracts: Open duens, dune cutworm, Lake Huron locust, piping plover, dunewort, fascicled broomrape, Houghton's goldenrod, Lake Huron tansy.

Selected References:

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

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

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

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

Wisconsin Endangered and Nongame Species Handbook. Wisconsin DNR.

Abstract citation:

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

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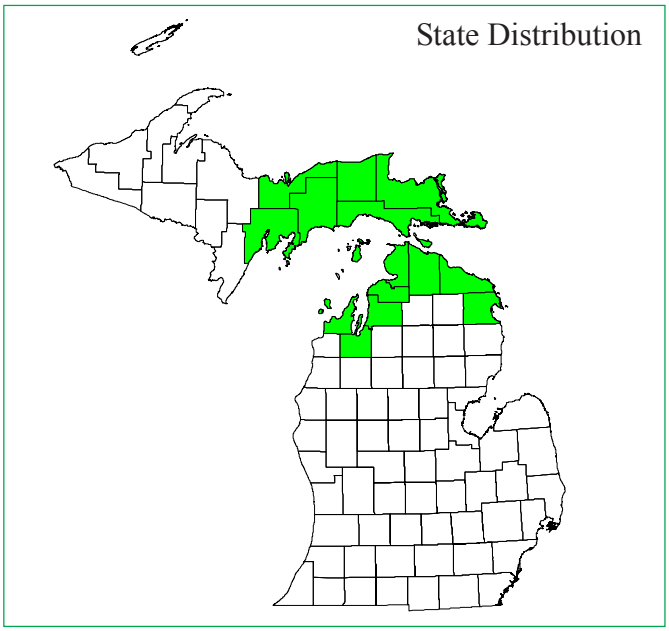
Tanacetum huronense Nutt. — Lake Huron Tansy



Best Survey Period

Legal status: State threatened

Global and state rank: G4Q/S3

Family: Asteraceae (aster family)

Other common names: Huron tansy

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Selected references:

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

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

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

Kartesz, J. T. and Kartesz, R. 1980. A symnonimized checklist of the vascular flora of the United States, Canada, and Greenland. Volume 2: The Biota of North America. University of North Carolina Press, Chapel Hill.

Voss, E.G. 1996. Michigan Flora. Part III. Dicots (Pyrolaceae-Compositae). Bull. Cranbrook Inst. Sci. 61 & Univ. of Michigan Herbarium. Xix + 622

Abstract citation:

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

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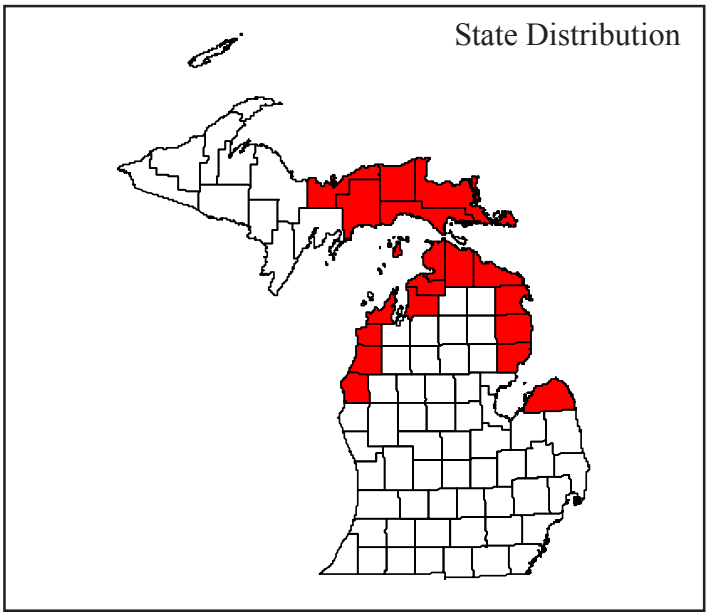
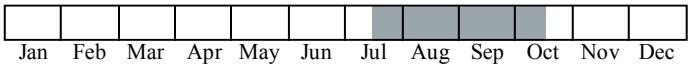
Trimerotropis huroniana (Walker) Lake Huron locust



Best Survey Period



Status: State threatened

Global and state rank: G2G3/S2S3

Family: Acrididae (short-horned grasshopper)

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

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

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

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

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

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

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

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

Adults communicate through visual and auditory signals (Otte 1970). Only males crepitate in flight by flashing and snapping their wings, making a cracking noise with each snap. Crepitation occurs during a hovering courtship flight in which the males snap their wings two or three times while hovering; this display typically occurs on sunny days when temperatures reach 80^{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: open dunes, Pitcher's thistle, Houghton's goldenrod, Lake Huron tansy, piping plover, prairie warbler, dune cutworm

Selected references

Ballard, H.E., Jr. 1989. *Trimerotropis huroniana* (Orthoptera: Acrididae), a new record for Wisconsin. Great Lakes Entom. 22(1):45-46.

Hubbell, T.H. 1929. The distribution of the beach-grasshoppers *Trimerotropis huroniana* and *Trimerotropis maritima interior* in the Great Lakes region. J. New York Entomol. Soc. 37:31-38.

Mattson, W.J., Jr. 1980. Herbivory in relation to plant nitrogen content. Ann. Rev. Ecol. Syst. 11:119-161.

Mulkern, G.B., K.P. Preuss, H. Knutson, A.F. Hagen, J.B. Campbell, and J.D. Lambley. 1969. Food habits and preference of grassland grasshoppers of the North Central Great Plains. Bull. Agric. Exp. Sta. N. Dakota St. Univ. 481:1-32.

Otte, D. 1970. A comparative study of communicative behavior in grasshoppers. U. of Mich. Mus. Zool. Misc. Publ. No. 141:1-168.

Otte, D. 1984. The North American grasshoppers. Vol. 2. Acrididae: *Oedipodinae*. Harvard Univ. Press, Cambridge, MA.

Sholtens, B.G. 1996. Status of the Lake Huron locust (*Trimerotropis huroniana*) in northern Michigan. Unpubl. Rep. to Mich. DNR. 23 pp.

Sholtens, B.G. 1997. Distribution and habitat selection of the Lake Huron locust (*Trimerotropis huroniana*). Unpubl. Rep. to Mich. DNR. 18 pp.

Abstract citation

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

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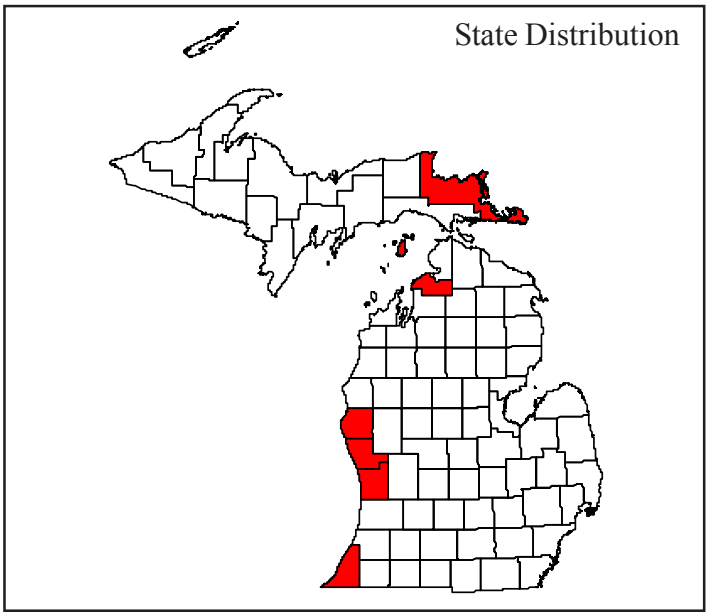
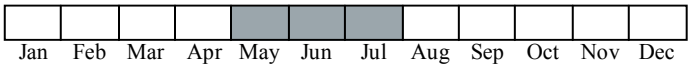
11-99/mlr

Euxoa aurulenta (Smith) dune cutworm


Photo by David L. Cuthrell



Best Survey Period



Status: State special concern

Global and state rank: G5/S2S3

Family: Noctuidae (owlet moth family)

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

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

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

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

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

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

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

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

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

Related abstracts: open dunes, Lake Huron locust, fascicled broomrape, Houghton's goldenrod, Lake Huron tansy, Pitcher's thistle

Selected references

Forbes, W.T.M. 1954. Lepidoptera of New York and Neighboring states. Part III. Noctuidae. Cornell Univ. Agric. Exp. Sta. Mem. 329. 433 pp.

Hardwick, D.F. 1970. The Genus *Euxoa* (Lepidoptera: Noctuidae) in North America. I. Subgenera Orosagrotis, Longivesica, Chorizagrotis, Pleonectopoda, and Crassivesica. Memoirs of the Ent. Soc. of Canada, No. 67. 177 pp.

Lafontaine, J.D. 1987. The moths of American North of Mexico including Greenland. Noctuoidea, Noctuidae (part) Noctuinae (*Euxoa*). The Wedge Entomological Research Foundation, Washington, D.C. 237 pp. 40 pls.

Rockburne, E.W. and J.D. Lafontaine. 1976. The cutworm moths of Ontario and Quebec. Canada Dept. Agric. Res. Branch Pub. 1593. 164 pp. 613 figs.

Abstract citation

Cuthrell, D.L. 1999. Special animal abstract for *Euxoa aurulenta* (dune cutworm). Michigan Natural Features Inventory, Lansing, MI. 2 pp.

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10-99/dlc

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Appendix C. NatureServe Element Occurrence Rank Specifications

Lake Huron Locust

Population or element occurrence (EO) viability rank specifications for the Lake Huron locust, as defined by NatureServe (Schweitzer and Whittaker 2007)

A- Rank: If the B-criteria are accepted as reasonable, then perhaps 1000 adults estimated in 3000 acres would be a reasonable basis for an A. An A ranked occurrence should be among the best all time and should contain substantially more than the minimum required for persistence in present or better condition--including maintaining genetic diversity.

B- Rank: A persistent population estimated after a survey of 1 hour to be greater than 300 individuals in greater than 1000 acres (approx. 405 ha) of suitable habitat. Threats are manageable.

C- Rank: A persistent population estimated after a survey of 1 hour to be between 10 and 50 individuals in less than 100 acres (approx. 40.5 ha) of required habitat. Threats are typically more serious.

D- Rank: A non-persistent population, or an apparently persistent estimated after a survey of 1 hour to be less than 10 individuals in a habitat strip less than 10 m wide, even if it is a long (> 1 km) stretch of habitat. Threats are greater and more difficult to control.

EO Rank Specs Justifications:
The present B-criteria are modified (e.g. 150 estimated changed to 300) from 1994 A-criteria which presumably would define a very good occurrence but are too low to be reasonable as an A for an insect or other animal with a one year or less generation time. Since this would be a good occurrence in the opinion of Whittaker, such is accepted as a reasonable basis for a B. The A-criteria are derived from inflating the B, and it is not certain and current A quality occurrences exist. All criteria are lower than usual for an insect.