Natural Community Surveys of Michigan Islands National Wildlife Refuge: Big Charity, Crooked, and Sugar Islands

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Cover Photo: Crooked Island coastal fen. Photo by Joshua G. Cohen.

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Big Charity Island dry-mesic northern forest. Photo by Joshua G. Cohen

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Introduction

Great Lakes islands provide critical habitat for native biodiversity and support rare and endemic natural communities. A diverse assemblage of approximately 600 islands occurs across all five Great Lakes plus the connecting channels. The United States Fish and Wildlife Service (USFWS) National Wildlife Refuge (NWR) system includes thirty-six islands across the Great Lakes. These islands are managed to maintain the ecological integrity of natural communities to support the needs of priority and migratory bird species, threatened and endangered species, and resident wildlife and also provide stopover habitat for birds and pollinators migrating across the Great Lakes.

Many of the islands within the Great Lakes that are part of the NWR system are remote, difficult to access, and challenging to survey due to rugged terrain. Despite limited access, these islands face a variety of threats to native biodiversity and rare taxa including establishment and spread of invasive plant and animal species and the impacts of climate change. Unfortunately, within these unique geographies biodiversity data is limited or outdated, which hinders effective management and decision-making.

To address this information gap, the USFWS contracted Michigan Natural Features Inventory (MNFI) to conduct rare and invasive plant species mapping, qualitative natural community surveys, and quantitative forest sampling over the course of two years on NWR Great Lakes islands. In 2021, surveys were conducted in the Green Bay NWR and Michigan Islands NWR. In 2022, surveys will be conducted in the West Sister NWR, Harbor Island NWR, Huron NWR, Michigan Islands NWR, and the Detroit River International Wildlife Refuge. In 2021 natural community surveys and forest plot sampling were conducted on Big Charity, Crooked, and Sugar Islands in the Michigan Islands NWR in Lake Huron (Figure 1). This report focuses on results of the natural community surveys conducted in 2021. For information on the natural community surveys conducted in 2021 in the Green Bay NWR, refer to Cohen et al. 2022. For information on the rare and invasive plant species surveys, refer to Bassett et al. 2022a and Bassett et al. 2022b.

A natural community is defined as an assemblage of interacting plants, animals, and other organisms that repeatedly occurs under similar environmental conditions across the landscape and is predominantly structured by natural processes rather than modern anthropogenic disturbances. Historically, indigenous peoples were an integral part of natural communities across the Great Lakes region with many natural community types being maintained by native management practices such as prescribed fire. MNFI's natural community classification recognizes 77 natural community types in Michigan (Kost et al. 2007, Cohen et al. 2015). Protecting and managing representative natural communities is critical to biodiversity conservation, since native organisms are best adapted to environmental and biotic forces with which they have evolved over the millennia (Kost et al. 2007, Cohen et al. 2015).

A critical goal of this project was to collect new data for natural communities to provide natural resource managers and planners with accurate, detailed, standardized baseline information on the current status of ecosystems on these islands that can help guide biodiversity stewardship and restoration and ongoing planning efforts with a focus on invasive species management. Qualitative surveys assessed the integrity, classification, and delineation of natural community occurrences and detailed the vegetative structure and composition, ecological boundaries, landscape and abiotic context, threats, management needs, and restoration opportunities associated with each site. This baseline information is critical for facilitating site-level decisions about biodiversity stewardship; prioritizing protection, management and restoration; monitoring the success of management and restoration; and informing landscape-level biodiversity planning efforts. This report summarizes the findings of MNFI's natural community surveys and also presents a prioritization of stewardship and monitoring of the natural communities documented on Big Charity, Crooked, and Sugar Islands.

Crooked Island coastal fen. Photo by Jesse M. Lincoln.

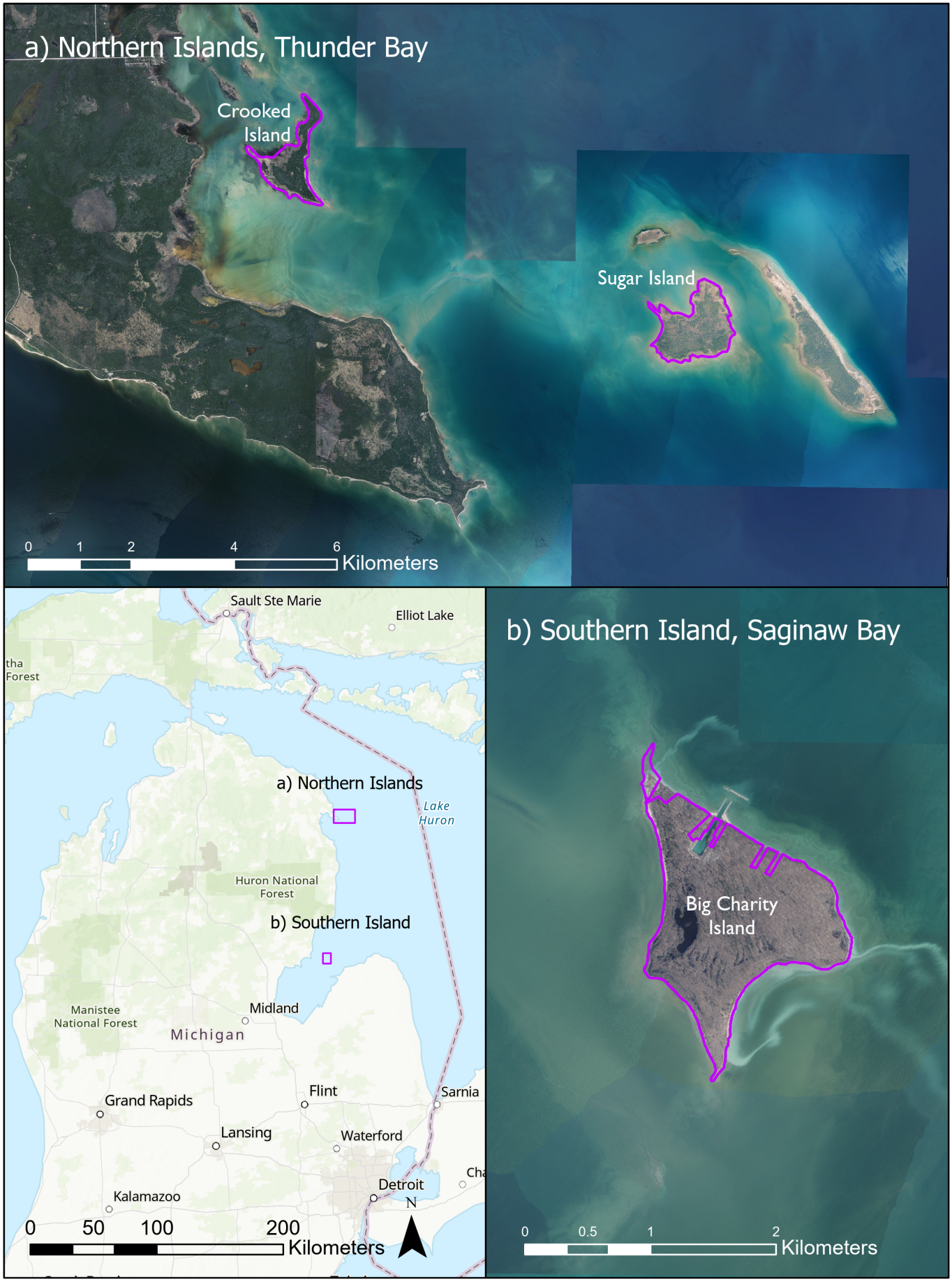


Figure 1. Natural community surveys within the Michigan Islands National Wildlife Refuge were conducted in 2021 on Big Charity, Crooked, and Sugar Islands.

Methods

Field Survey Prioritization

The MNFI natural community classification system was used as the classification framework for this survey effort (Kost et al. 2007; Cohen et al. 2015; Cohen et al. 2020) and nomenclature of plant species follows Michigan Flora (Voss and Reznicek 2012). Prior to on-the-ground-surveys, MNFI ecologists conducted GIS analysis and aerial photo interpretation to delineate preliminary natural communities for each island and identify potential survey targets. To assist with delineation, multiple series of aerial imagery and spatial data layers were evaluated. Available imagery and spatial data layers that informed this process vary from island to island but included historical black-and-white imagery (1937-1940), color infrared imagery (1998), recent true color leaf-off imagery (2015-2018), recent true color leaf-on imagery (2018-2020), topographic maps, digital elevation models, and hillshade (a grayscale 3D representation of the terrain surface). The preliminary delineation of natural community types across each island helped focus subsequent high-quality natural community surveys as well as invasive species and rare plant surveys and provided the framework for stratifying random sampling for the forest plot sampling effort.

For each island, the targets for the natural community assessments were prioritized based on the rarity and estimated integrity of the preliminarily delineated natural communities using the Natural Heritage sampling prioritization principal. This prioritization principal emphasizes that natural community survey efforts should be focused on the rarest and highest quality natural communities (Figure 2) (NatureServe 2002; Rocchio et al. 2018). Rarity is determined by evaluating a natural community's conservation status both at the state and global levels (i.e., S and G Ranks) (Appendix 1). Integrity is determined by employing Natural Heritage methodology, which considers three factors to assess a natural community's ecological integrity or quality: size, landscape context, and condition (Faber-Langendoen et al. 2008).

Field Survey

A qualitative, plotless sampling design was employed to survey natural communities on the NWR islands. For every island, MNFI ecologists evaluated each natural community type that was delineated during the GIS analysis described above and each natural community type polygon was ground-truthed through meander surveys. The meander survey involved investigating unique aerial signatures, traversing topographic variation, and visiting noticeable vegetation zones and soil moisture types. A Samsung Tablet in tracking mode was used during the meander surveys to create a record of routes taken within the surveyed natural community polygons. Prioritized communities (rare community types and high-quality examples of any community type) received more survey effort than common and degraded communities. If a site meets defined requirements for ecological condition, landscape

Global / State Conservation Status Rank Combination	Ecological Integrity Assessment Rank			
	A Excellent Integrity	B Good Integrity	C Fair Integrity	D Poor Integrity
G1S1, G2S1, GNRS1, GUS1				
G2S2, GNRS2, G3S1, G3S2, GUS2				
GUS3, GNRS3, G3S3, G4S1, G4S2, G5S1, G5S2, any SNR				
G4S3, G4S4, G5S3, G5S4, G5S5, GNRS4, GNRS5, GUS4, GUS5				
Red Shading = Natural Community Survey Targets				

Figure 2. Decision matrix to determine natural community survey targets (NatureServe 2002; Rocchio et al. 2018). See Appendix 1 for definition of State and Global Ranks.

context, and size of the area of interest (MNFI 1988) it is categorized as a high-quality example of that specific natural community type, entered into MNFI's database as an element occurrence, and given a letter rank. Ecological field surveys were conducted during the growing season to evaluate the condition and classification of the sites. To assess natural community size and landscape context, a combination of field surveys, aerial photographic interpretation, and Geographic Information System (GIS) analysis was employed.

The ecological field surveys involved:

a) compiling comprehensive plant species lists to be summarized in a floristic quality index and noting dominant, co-dominant, and representative species
b) estimating percent coverage of prevalent or key overstory and understory species
c) describing site-specific structural attributes (e.g., vegetative zonation, vegetative strata, and coarse woody debris) and ecological processes (e.g., windthrow, ground-water seepage, paludification, wildfire, beaver flooding)
d) measuring tree diameter at breast height (DBH) of representative canopy trees and aging canopy dominants (where appropriate)
e) analyzing soils and recording representative soil texture, pH, and depth
f) describing hydrology (e.g., noting high water marks, indicator vegetation, and soil mottling)
g) noting current and historical anthropogenic disturbances (e.g., ditching, trails, pollutants, and logging)
h) evaluating potential threats to ecological integrity (i.e., invasive plant species, pests, diseases, and deer herbivory) with an emphasis on recording geospatial locations of invasive plant infestations
i) ground-truthing aerial photographic interpretation using GPS (Garmin units and Samsung Tablets were utilized)
j) taking digital photos and GPS points at significant locations
k) surveying adjacent lands to assess landscape context
l) evaluating the natural community classification and mapped ecological boundaries
m) determining the ecological integrity of mapped high-quality natural communities by assigning element occurrence ranks
n) noting management needs and restoration opportunities or evaluating past and current restoration activities and noting additional management needs and restoration opportunities

For each high-quality natural community element occurrence, MNFI scientists compiled comprehensive plant species. Sugar Island boreal forest. Photo by Jesse M. Lincoln.

Following completion of the field surveys, the collected data were analyzed and transcribed to create element occurrence records in MNFI's statewide biodiversity conservation database (MNFI 2022). Tracks and GPS points collected during the field visits were transposed on aerial imagery to facilitate the generation of natural community boundaries for new element occurrences. This natural community element occurrence mapping is distinct from the preliminary delineation of natural community types that was based solely on GIS analysis and aerial photo interpretation and was used strictly for planning purposes. Data compiled from the field surveys were used to produce site descriptions, threat assessments, and management recommendations for each natural community element occurrence, which appear within the **Survey Results** section.

For each high-quality natural community, floristic data were compiled into the Universal Floristic Quality Assessment Calculator (Reznicek et al. 2014; Freyman et al. 2016) to determine the Floristic Quality Index (FQI) for each natural community element occurrence. The floristic quality assessment is derived from a mean coefficient of conservatism and floristic quality index. Each native species is assigned a coefficient of conservatism, a value of 0 to 10 based on probability of its occurrence in a natural versus degraded habitat. Species restricted to a specialized or undisturbed habitat are assigned a value of 10, implying the species has extremely strong fidelity to a specific habitat. Native species that are not particular or indicative of natural conditions are assigned a low value of 0 or 1. The coefficient of conservatism is determined by experts on the flora of a region, and so may vary for a given plant species from region to region. From the total list of plant species for an area, a mean C value is calculated and then multiplied by the square root of the total number of plant species to calculate the FQI. Michigan sites with an FQI of 35 or greater possess sufficient conservatism and richness that they are considered floristically important from a statewide perspective (Herman et al. 2001). Species lists for each natural community element occurrence are provided in Appendix 2.

Representative canopy trees were measured and aged in forested natural community types. Big Charity Island mesic northern forest. Photo by Joshua G. Cohen.

In addition to these natural community surveys, MNFI conducted two distinct and concurrent surveys in 2021 on a subset of the islands. This included rare plant and invasive plant species mapping on Crooked and Sugar Islands and forest plot sampling on Big Charity, Crooked, and Sugar Islands. Data gathered from these survey efforts was also used to inform the documentation and description of high-quality natural communities. The forest plot sampling involved quantitative collection of a variety of forest measurements in forested natural community types. For details on these survey efforts refer to Bassett 2022a; USFWS 2021a; and USFWS 2021b.

Natural Community Stewardship Prioritization

MNFI developed a scoring matrix for natural community element occurrences to provide a framework for the prioritization of stewardship. For this scoring matrix, we developed the following three indices: an ecological integrity index, a rarity index, and an invasive index. We used the element occurrence rank to develop the ecological integrity rank, with higher scores for higher-ranked element occurrences. The rarity index was developed by assigning a score for each natural community type's state rank and global rank (Appendix 1) and averaging the two scores. For both state and global ranks, higher scores were assigned to rarer types. The invasive index was developed by calculating the average of an invasive threat severity index and a treatment feasibility index. The threat severity index was developed using knowledge of impacts of invasive plant species to natural community types and site-specific information gained during surveys on invasive infestations. Higher scores for the threat severity index correspond to increased degradation due to invasive infestation. The treatment feasibility index was derived by assigning a score to each natural community element occurrence based on the ease of treating the invasive species recorded within that site. Higher scores for the treatment feasibility index correspond to a greater likelihood of successful treatment and control of targeted invasive species. For each natural community element occurrence, the sum of the scores for the ecological integrity index, rarity index, and invasive index was calculated to sort the natural community element occurrences by their stewardship prioritization score. The stewardship prioritization for the natural community element occurrences is presented in the **Stewardship Prioritization Results** section.

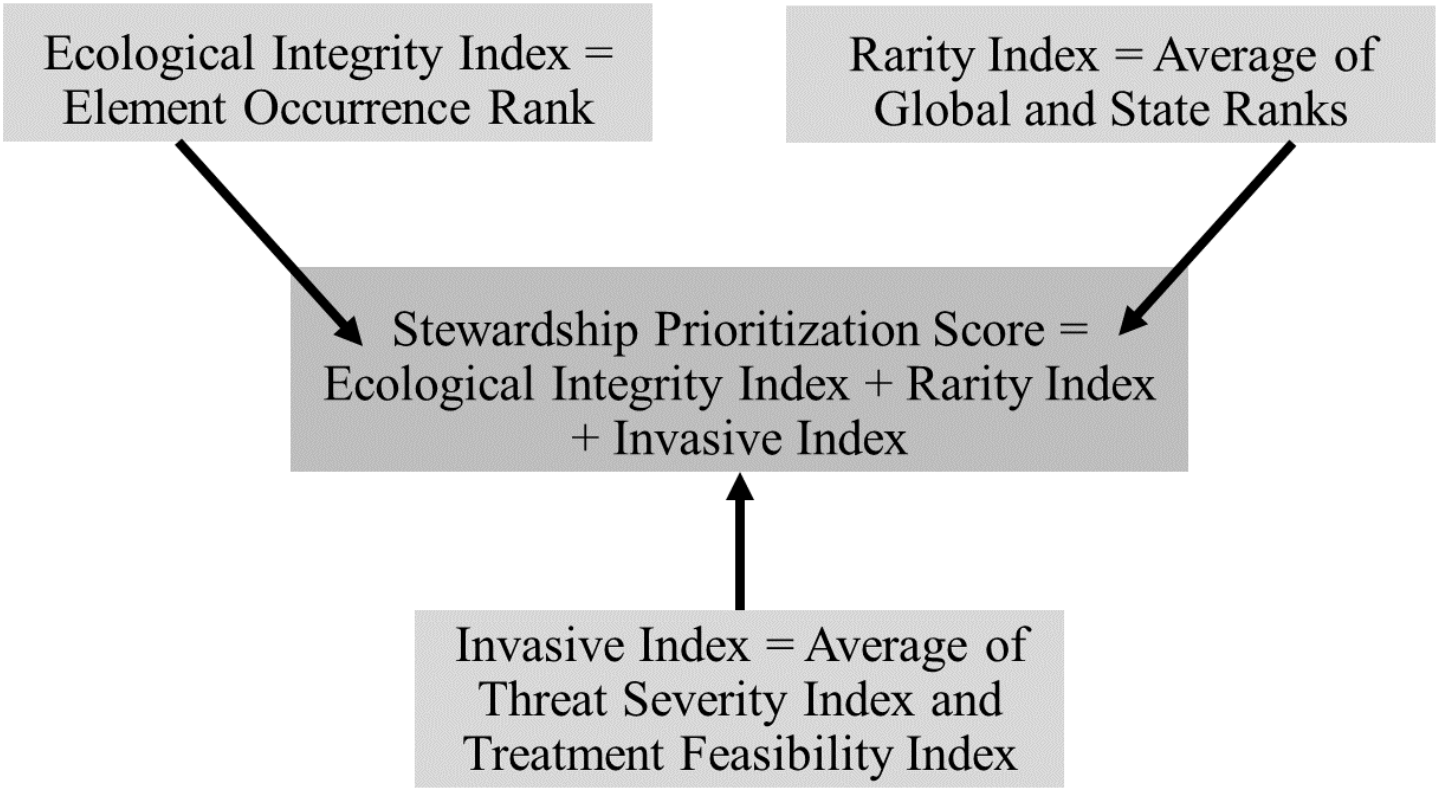


Figure 3. The Stewardship Prioritization score is the sum of the Ecological Integrity Index, Rarity Index, and Invasive Index. This prioritization scoring was derived to help focus finite resources for biodiversity stewardship.

Survey Results

The following results section is organized by island with a short overview that includes a description of the island's geography, geology, anthropogenic disturbance factors, and natural communities. We provide detailed **Site Summaries** for each of the natural community element occurrences documented on those islands. Twenty high-quality natural communities were surveyed during the 2021 field season within the Michigan Islands NWR on Big Charity, Crooked, and Sugar Islands. A total of 11 different natural community types were visited including: boreal forest (2 element occurrences or EOs), coastal fen (2 EOs), dry-mesic northern forest (1 EO), Great Lakes marsh (2 EOs), interdunal wetland (2 EOs), limestone bedrock lakeshore (2 EOs), limestone cobble shore (3 EOs), mesic northern forest (2 EOs), northern hardwood swamp (1 EO), open dunes (2 EOs), and sand and gravel beach (1 EO). Table 1 lists the visited sites and their element occurrence ranks.

The following site summaries summarize threats and management recommendations for each of the 20 natural community element occurrences visited in 2021 organized by island and then alphabetically by community type. Appendix 3 provides an overview of the natural community types adapted from MNFI's natural community classification (Kost et al. 2007, Cohen et al. 2015) and an accompanying ecoregional distribution map for each natural community type (Albert et al. 2008). For each site summary, we provide the following information:

a) site name
b) natural community type
c) global and state rank (see Appendix 1 for ranking criteria)
d) element occurrence rank
e) size
f) locational information
g) digital photograph(s)
h) site description
i) threat assessment
j) management recommendations

Table 1. Natural community element occurrences (EOs) surveyed in 2021 in the Michigan Islands National Wildlife Refuge. EO rank abbreviations are as follows: AB, excellent to good estimated viability; B, good estimated viability; BC, good to fair estimated viability; and C, fair estimated viability.

Community Type	EO ID	Island	EO RANK
Coastal Fen	24354	Crooked Island	AB
Limestone Cobble Shore	24359	Crooked Island	B
Open Dunes	24355	Crooked Island	B
Boreal Forest	24360	Sugar Island	B
Limestone Cobble Shore	24363	Sugar Island	B
Limestone Cobble Shore	24385	Big Charity Island	BC
Sand and Gravel Beach	24384	Big Charity Island	BC
Great Lakes Marsh	24358	Crooked Island	BC
Interdunal Wetland	24356	Crooked Island	BC
Great Lakes Marsh	24365	Sugar Island	BC
Dry-Mesic Northern Forest	24378	Big Charity Island	C
Interdunal Wetland	24382	Big Charity Island	C
Limestone Bedrock Lakeshore	24380	Big Charity Island	C
Mesic Northern Forest	24377	Big Charity Island	C
Northern Hardwood Swamp	24379	Big Charity Island	C
Open Dunes	24381	Big Charity Island	C
Boreal Forest	24357	Crooked Island	C
Coastal Fen	24362	Sugar Island	C
Limestone Bedrock Lakeshore	24361	Sugar Island	C
Mesic Northern Forest	24364	Sugar Island	CD

Crooked Island coastal fen. Photos by Joshua G. Cohen.

Figure 4. Natural community surveys within the Michigan Islands National Wildlife Refuge in Saginaw Bay in Lake Huron were conducted in 2021 on Big Charity Island.

SITE SUMMARIES

BIG CHARITY ISLAND

Big Charity Island is located in Saginaw Bay (Figure 4), roughly equidistant between Sand Point near Caseville on the east side of the bay and Point Lookout near Au Gres on the west side of the bay. At 94 ha, Big Charity Island is the largest island in Saginaw Bay. The island measures approximately 1.6 km long in its north/south axis and 1.2 km wide on its east/west axis. Big Charity Island reaches a maximum elevation of 7 meters on is eastern side.

The underlying bedrock of Saginaw Bay is Bayport Limestone, a 350-million-year-old oceanic deposit from the Mississippian Period that is laden with fossils and chert nodules (Lane 1900; Dustin 1935; Milstein 1987). Chert is a form of finely grained quartz and was used by indigenous peoples to manufacture stone cutting tools and projectile points. Big Charity Island's location in the middle of Saginaw Bay and its geology made it an important landmark for residents of the region over the centuries. The chert found on Big Charity Island was harvested and used by indigenous populations for producing tools for thousands of years (Charity Island Transport Inc. n.d.). It is likely that these Native Americans used fire on the island to promote huckleberry growth and maintain open understories for hunting and travel. The island was called "Shawangunk" by the Chippewa Native Americans who lived in the Saginaw Bay region (Mitchell 1839; Native Americans in Michigan Genealogy Research Center 2008).

By the mid-1800s, Big Charity Island's location made it an important site for navigation aiding infrastructure and a lighthouse was built in 1857 (Clarke Historical Library n.d.). The lighthouse and keeper's quarters became redundant in 1939 when the nearby Gravelly Shoals Light beacon was established. The island was offered for sale in 1987. In 1993, real estate brokers bought Big Charity Island intending to develop it and created the harbor on the island's north shore (The Detroit Free Press 2011). The real estate project was never realized, and the majority of the island was sold to the USFWS in 1999 and became part of the Michigan Islands National Wildlife Refuge (USFWS 2013). Several parcels on the island remain under private ownership including the lighthouse, the rebuilt keeper's dwelling, and several seasonal residences along the northeastern shoreline. A network of roads connects the seasonal homes along the northeastern shore and the lighthouse on the northern point of the island.

The island's interior is characterized by dry-mesic northern forest and mesic northern forest with pockets of northern hardwood swamp concentrated in the southern half of the island in depressions and swales. Mesic northern forest occurs on fine- to medium-textured sands overlying limestone cobble and bedrock and the dry-mesic northern forest occurs on drier, finer textured, and deeper sands. The upland forest ranges from high-quality to degraded. The degraded dry-mesic northern forest and degraded mesic northern forest are characterized by younger and smaller canopy trees and lower species diversity in the ground cover from the impact of more recent and intensive logging compared to their high-quality counterparts. The upland forest on Big Charity Island has been selectively logged and logging likely began with the occupation of the lighthouse in the mid-1800s. Numerous high-quality natural communities occur along the shore of Big Charity Island. Along the western shore, sand and gravel beach is backed by open dunes and a small pocket of interdunal wetland occurs along the northwestern shore near the lighthouse. The eastern shore includes both limestone cobble shore, limestone bedrock lakeshore, and sand and gravel beach.

Eight high-quality natural community element occurrences were documented on Big Charity Island during the 2021 field season including dry-mesic northern forest, interdunal wetland, limestone bedrock lakeshore, limestone cobble shore, mesic northern forest, northern hardwood swamp, open dunes, and sand and gravel beach (Table 1; Figure 5). Natural community surveys were conducted on Big Charity Island from July 6th through July 9th, July 22nd through July 23rd, and August 23rd through August 25th.

Figure 5. Natural community element occurrences on Big Charity Island, Michigan Islands National Wildlife Refuge.

1. Big Charity Island – Dry-Mesic Northern Forest
Natural Community Type: Dry-mesic Northern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 30 acres
Location: Big Charity Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24378

Site Description: Dry-mesic northern forest occurs on flat to gently rolling topography of former dune ridges on Big Charity Island. The dry-mesic northern forest is starting to accrue attributes of a mature forest including a canopy dominated by large diameter trees and coarse woody debris including downed red oak (*Quercus rubra*) logs and standing red pine (*Pinus resinosa*) snags. Numerous canopy dominants were cored across the dry-mesic northern forest to help determine the age range of canopy trees. Twenty canopy trees were cored across the dry-mesic northern forest and the average estimated age of canopy dominants is 126 years with canopy ages ranging from 73 to 215 years and cored canopy trees including red oak, red pine, and white pine (*Pinus strobus*). Dry-mesic northern forest occurs adjacent to mesic northern forest and northern hardwood swamp. Mesic northern forest occurs on fine- to medium-textured sands overlying limestone cobble and bedrock and the dry-mesic northern forest occurs on drier, finer textured, and deeper sands (greater than 100 cm) overlying limestone cobble and bedrock. Soils are characterized by shallow (2-8 cm) organics or mor humus that is acidic to slightly acidic (4.5-6.0) and overlies the fine-textured sands that are acidic to slightly acidic (pH 5.0-6.5). Soil acidity tends to decrease with increasing depth in the soil profile. Burnt snags, fire scars on pine tree boles, burnt cut stumps, and lightning struck red pine were documented within the dry-mesic northern forest. It is likely that this forest was intentionally burned by indigenous peoples.

Big Charity Island dry-mesic northern forest. Photo by Joshua G. Cohen.

The canopy is dominated by red oak, red pine, and white pine with canopy associates including red maple (*Acer rubrum*), black cherry (*Prunus serotina*), big-tooth aspen (*Populus grandidentata*), and paper birch (*Betula papyrifera*). The canopy typically ranges from 60 to 90% and canopy trees typically range in diameter from 30 to 50 cm with scattered larger red oak and white pine reaching 50 to 80 cm. The average diameter of measured canopy trees was 29 cm (N = 378). The subcanopy is sparse (5-15%) with red maple, black cherry, white pine, and, and juneberry (*Amelanchier arborea*). The understory is sparse to patchy (5-35%) with characteristic species including red maple, black cherry, choke cherry (*Prunus virginiana*), white pine, juneberry, and witch hazel (*Hamamelis virginiana*).

The low shrub layer is dense (50-75%) and dominated by huckleberry (*Gaylussacia baccata*) and low sweet blueberry (*Vaccinium angustifolium*) with additional species including common or ground juniper (*Juniperus communis*), bush-honeysuckle (*Diervilla lonicera*), northern dewberry (*Rubus flagellaris*), choke cherry, and red maple, red oak, white pine, and black cherry seedlings. The ground cover is patchy to dense (25-45%) with characteristic species including bracken fern (*Pteridium aquilinum*), wild sarsaparilla (*Aralia nudicaulis*), Canada mayflower (*Maianthemum canadense*), false spikenard (*Maianthemum racemosum*), wintergreen (*Gaultheria procumbens*), star-flower (*Trientalis borealis*), red honeysuckle (*Lonicera dioica*), poison ivy (*Toxicodendron radicans* and *T. rydbergii*), river-bank grape (*Vitis riparia*), and Pennsylvania sedge (*Carex pensylvanica*).

The Big Charity Island dry-mesic northern forest was surveyed from July 6th through July 9th, July 22nd through July 23rd, and August 23rd through August 25th. Forty-five plant species were documented with 44 native species and 1 non-native species (Appendix 2.1). The total FQI was 24.8.

Threats: Species composition and vegetative structure are patterned by natural processes and past logging. Cut stumps occur throughout the dry-mesic northern forest. Logging of the dry-mesic northern forest likely commenced on the island following the construction of the lighthouse in 1857. Additional logging occurred following the purchase of the island by a private developer in 1987. Several oak trees on the island were observed to have rot that may be indicative of oak wilt. The prevalence of mesophytic species in the subcanopy and understory indicates that the dry-mesic northern forest has been impacted by fire suppression for many decades. Deer herbivory was noted on understory species. The non-native bittersweet nightshade (*Solanum dulcamara*) was recorded within the dry-mesic northern forest.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, retain an intact buffer of natural communities surrounding the dry-mesic northern forest, monitor for invasive species and deer herbivory, and implement prescribed fire to promote oak and pine regeneration and knock back mesophytic species (i.e., red maple and black cherry). Several oak trees on the island were observed to have rot that may be indicative of oak wilt. Canopy oak across the island should be monitored for oak wilt.

Data gathered during plot sampling of Big Charity Island dry-mesic northern forest was synthesized to contribute to the development of the site description for this element occurrence. Photos by Joshua G. Cohen.

2018 aerial photograph of Big Charity Island dry-mesic northern forest.

2. Big Charity Island – Interdunal Wetland
Natural Community Type: Interdunal Wetland
Rank: G2? S2, imperiled throughout range
Element Occurrence Rank: C
Size: 0.18 acres
Location: Big Charity Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24382

Site Description: Interdunal wetland occurs along the northwestern shoreline of Big Charity Island. Interdunal wetland is backed by open dunes. This complex has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020) and several woody species along the margins of the wetlands have been flood killed including dogwoods (*Cornus* spp.) and common juniper (*Juniperus communis*). The high water has resulted in the localized accumulation of plant debris and sand burial within the wetland. The soils are wet, medium-textured and alkaline (pH 7.5-7.8) sands with little to no organic matter.

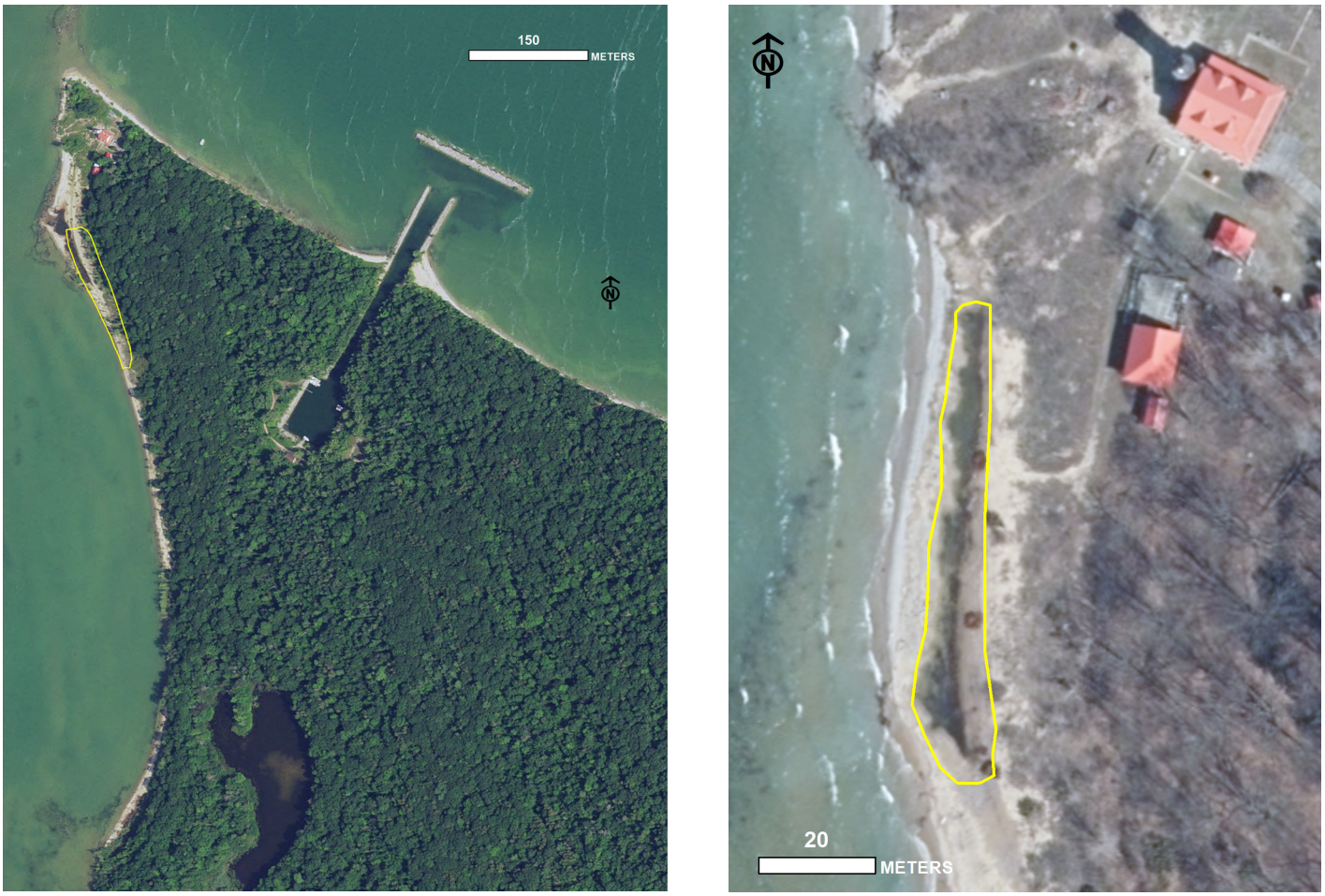
Characteristic ground cover species include beak-rush (*Rhynchospora capillacea*), silverweed (*Potentilla anserina*), Baltic rush (*Juncus balticus*), sedges (*Carex* spp.), northern bugleweed (*Lycopus uniflorus*), water smartweed (*Persicaria amphibia*), and wormwood (*Artemisia campestris*). Herbaceous cover ranges from 10 to 20%. Scattered shrubs (2-4%) include common juniper, red-osier dogwood (*Cornus sericea*), willows (*Salix* spp.), and silky dogwood (*Cornus amomum*). Scattered tree saplings (1-2%) include red maple (*Acer rubrum*) and cottonwood (*Populus deltoides*).

The Big Charity Island interdunal wetland was surveyed August 23rd. Twenty plant species were documented with 15 native species and 5 non-native species (Appendix 2.2). The total FQI was 14.3.

Big Charity Island interdunal wetland. Photo by Joshua G. Cohen.

Threats: Documented threats include foot traffic and non-native species spread. Invasive reed (*Phragmites australis* subspecies *australis*) is locally abundant and spotted knapweed (*Centaurea stoebe*), purple loosestrife (*Lythrum salicaria*), and white sweet-clover (*Melilotus albus*) occur locally. The wetland and adjacent shoreline receive significant foot traffic from the adjacent lighthouse and pavilion.

Management Recommendations: The main management recommendation is to continue efforts to control invasive species, monitor invasive species along the shoreline, and limit foot traffic within the interdunal wetland.



2018 aerial photographs of Big Charity Island interdunal wetland.

Continued control of invasive reed (pictured on the right) is recommended to maintain the ecological integrity of the Big Charity Island interdunal wetland. Photos by Joshua G. Cohen.

3. Big Charity Island – Limestone Bedrock Lakeshore
Natural Community Type: Limestone Bedrock Lakeshore
Rank: G3 S2, vulnerable globally and imperiled within the state
Element Occurrence Rank: C
Size: 1.89 acres
Location: Big Charity Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24380

Site Description: Small pockets of limestone bedrock lakeshore occur on the eastern shore of Big Charity Island. The limestone bedrock lakeshore occurs within a broader stretch of limestone cobble shore. These shoreline ecosystems are backed by mesic northern forest in the interior of the island. The soils of the limestone bedrock lakeshore are characterized by shallow (1-2 cm), alkaline (pH 8.0) organics restricted to the upper margin at the base of tree boles. Fossils and chert nodules are abundant within the limestone bedrock lakeshore. Chert is a form of finely grained quartz and was used by indigenous peoples to manufacture stone cutting tools and projectile points. Big Charity Island was likely utilized for thousands of years by indigenous peoples of the Saginaw Bay Region to gather and work chert or flint for tools. Occasional splash pools or dissolution pools occur along the limestone bedrock lakeshore and are characterized by red algae that is slowly dissolving the limestone substrate and creating these small depressions. The site was surveyed site in 2021 after five consecutive years of high Great Lakes water levels (from 2016 through 2020) resulting in the decrease in the extent of the limestone bedrock lakeshore. High water levels and increased wave activity have likely reduced the overall cover of vegetation. The eastern shore of Big Charity Island is exposed to 200 kilometers of open Lake Huron and is therefore subject to high energy disturbance in the form of frequent storms, high wave activity, and ice scour. This frequent disturbance contributes to the absence of soil accumulation and vegetative establishment along the limestone bedrock lakeshore.

Big Charity Island limestone bedrock lakeshore. Photo by Joshua G. Cohen.

The limestone bedrock lakeshore is sparsely vegetated with scattered tree and shrub cover (1-4%) restricted to the inland edge. Scattered trees and tall shrubs include northern white-cedar (*Thuja occidentalis*), sugar maple (*Acer saccharum*), basswood (*Tilia americana*), paper birch (*Betula papyrifera*), round-leaved dogwood (*Cornus rugosa*), ironwood (*Ostrya virginiana*), and choke cherry (*Prunus virginiana*).

The Big Charity Island limestone bedrock lakeshore was surveyed on July 22nd. Six plant species were documented with 6 native species and no non-native species (Appendix 2.3). The total FQI was 10.5.

Threats: Species composition and structure are patterned by natural processes. No threats were noted within the limestone bedrock lakeshore. Non-native species recorded along the adjacent limestone cobble shore include invasive reed (*Phragmites australis* subspecies *australis*), bittersweet nightshade (*Solanum dulcamara*), and common mullein (*Verbascum thapsus*).

Management Recommendations: Efforts to control invasive species along the shoreline of Big Charity Island should be continued and these control efforts should be monitored.

Big Charity Island limestone bedrock lakeshore. Photo by Joshua G. Cohen.

2018 aerial photograph of Big Charity Island limestone bedrock lakeshore.

4. Big Charity Island – Limestone Cobble Shore
Natural Community Type: Limestone Cobble Shore
Rank: G2G3 S3, imperiled to vulnerable globally and vulnerable within the state
Element Occurrence Rank: BC
Size: 1.60 acres
Location: Big Charity Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24385

Site Description: Approximately a kilometer of limestone cobble shore occurs on the eastern shore of Big Charity Island. In addition to limestone cobble shore, the eastern shore includes small pockets of limestone bedrock lakeshore. The limestone cobble shore is characterized by a mix of limestone cobbles, large blocks of limestone, inclusion of limestone pavement, and numerous fossils and chert nodules. Wet gravelly, alkaline (pH 7.8-8.0) sands mixed with organics occur between and beneath the cobble. Uprooted trees or driftwood have accumulated locally along the limestone cobble shore and foster localized sand accretion, soils development, and vegetation establishment. The limestone cobble shore has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020) resulting in the decrease in the extent of the limestone cobble shore. In 2021, the limestone cobble shore was observed to be very narrow, ranging from 6 to 12 meters wide. High water levels have resulted in the dieback of trees and shrubs within the limestone cobble shore and the reduction of the overall cover of herbaceous species. A 16.8 cm green ash (*Fraxinus pennsylvanica*) snag along the margin of the limestone cobble shore was cored and estimated to be over 25 years old when it died. Based on the bark and fine branching persisting on this snag, the tree likely died in 2020 or 2021.

Big Charity Island limestone cobble shore. Photo by Joshua G. Cohen.

Vegetation within the limestone cobble shore is absent to sparse. Where vegetation has become established, it occurs between cobbles and along the upper margin of the shore. Vegetation was likely especially sparse in 2021 since surveys were conducted following five consecutive years of high Great Lakes water levels. Scattered trees (1-2%) and shrubs (1-2%) occur rarely along the upper margins of the limestone cobble shore and include trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), red-osier dogwood (*Cornus sericea*), willows (*Salix* spp.), silky dogwood (*Cornus amomum*), and choke cherry (*Prunus virginiana*). Characteristic herbaceous species (2-4%) include silverweed (*Potentilla anserina*), herb Robert (*Geranium robertianum*), spotted touch-me-not (*Impatiens campensis*), water smartweed (*Persicaria amphibia*), river-bank grape (*Vitis riparia*), and scouring rush (*Equisetum hyemale*).

The Big Charity Island limestone cobble shore was surveyed July 22nd. Twenty-five plant species were documented with 20 native species and 5 non-native species (Appendix 2.4). The total FQI was 14.

Threats: Species composition and structure are patterned by natural processes. Non-native species recorded along the limestone cobble shore include bittersweet nightshade (*Solanum dulcamara*), common mullein (*Verbascum thapsus*), invasive reed (*Phragmites australis* subspecies *australis*), and purple loosestrife (*Lythrum salicaria*).

Management Recommendations: Efforts to control invasive species should be implemented and these control efforts should be monitored.

Big Charity Island limestone cobble shore. Photo by Joshua G. Cohen.

2018 aerial photograph of Big Charity Island limestone cobble shore.

5. Big Charity Island – Mesic Northern Forest
Natural Community Type: Mesic Northern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 34 acres
Location: Big Charity Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24377

Site Description: Uneven-aged mesic northern forest occurs on flat to gently rolling topography in the southeastern portion of Big Charity Island. Twenty canopy trees were cored and the average estimated age of canopy dominants is 140 years with canopy ages ranging from 64 to 196 years and cored canopy trees including sugar maple (*Acer saccharum*) and red oak (*Quercus rubra*). The mesic northern forest is starting to accrue attributes of a mature forest including a canopy dominated by large diameter trees, mild pit and mound topography, and coarse woody debris and snags. Blowdown is more prevalent in the mesic northern forest closer to the shoreline. The mesic northern forest occurs adjacent to dry-mesic northern forest and northern hardwood swamp. The mesic northern forest occurs on fine- to medium-textured sands overlying limestone cobble and bedrock and the dry-mesic northern forest occurs on drier, finer textured, and deeper sands. The soils of the mesic northern forest are characterized by shallow (2-10 cm) organics or mull humus that is acidic to circumneutral (4.5-7.0) and overlies the fine- to medium-textured sands and loamy sands that are slightly acidic to alkaline (pH 6.0-7.5) and of variable depth (20-> 100 cm) over limestone cobble or bedrock. Where canopy beech is prevalent, the organic layer becomes more acidic (pH 4.5 to 5.5) and acidity decrease with depth of the soil profile. On average, the organics tend to be acidic to slightly acidic, the sands tend to be slightly acidic to alkaline, and the depth to limestone cobble or bedrock is between 20 to 100 cm.

Big Charity Island mesic northern forest. Photo by Joshua G. Cohen.

The canopy is dominated by sugar maple (*Acer saccharum*) with canopy associates including red oak (*Quercus rubra*), American beech (*Fagus grandifolia*), black cherry (*Prunus serotina*), and red maple (*Acer rubrum*). Beech is locally abundant in the canopy along the highest ridge in the southeastern portion of the island. The canopy typically ranges from 70 to 90% and canopy trees typically range in diameter from 30 to 50 cm with scattered larger sugar maple, red oak, and beech reaching 50 to 70 cm. The average diameter of measured canopy trees was 27.7 cm (N = 307). The subcanopy is sparse (10-15%) with sugar maple, ironwood (*Ostrya virginiana*), and juneberry (*Amelanchier arborea*). The understory is also sparse (5-15%) with characteristic species including round-leaved dogwood (*Cornus rugosa*), ironwood, choke cherry (*Prunus virginiana*), juneberry, witch hazel (*Hamamelis virginiana*), and sugar maple and red maple saplings. The low shrub layer is also sparse (10-15%) with scattered sugar maple seedlings, choke cherry, red elderberry (*Sambucus racemosa*), ironwood, round-leaved dogwood, prickly gooseberry (*Ribes cynosbati*), and infrequent yew (*Taxus canadensis*). The ground cover is patchy to dense (25-65%) with characteristic species including wood anemone (*Anemone quinquefolia*), sharp-lobed hepatica (*Hepatica acutiloba*), herb Robert (*Geranium robertianum*), hairy sweet-cicely (*Osmorhiza claytonii*), enchanter's nightshade (*Circaea canadensis*), wild leek (*Allium tricoccum*), yellow violet (*Viola pubescens*), Canada mayflower (*Maianthemum canadense*), false spikenard (*Maianthemum racemosum*), scouring rush (*Equisetum hyemale*), white wild licorice (*Galium circaezans*), wild geranium (*Geranium maculatum*), red honeysuckle (*Lonicera dioicai*), downy Solomon seal (*Polygonatum pubescens*), upright carrion-flower (*Smilax ecirrata*), bluestem goldenrod (*Solidago caesia*), early meadow-rue (*Thalictrum dioicum*) common trillium (*Trillium grandiflorum*), and sugar maple seedlings.

The Big Charity Island mesic northern forest was surveyed from July 6th through July 9th, July 22nd through July 23rd, and August 23rd through August 25th. Fifty-five plant species were documented with 54 native species and 1 non-native species (Appendix 2.5). The total FQI was 30.4.

Threats: Species composition and vegetative structure are patterned by natural processes and past logging. Cut stumps occur throughout the mesic northern forest. Logging of the mesic northern forest likely commenced on the island following the construction of the lighthouse in 1857. Selective logging occurred following the purchase of the island by a private developer in 1987. Several oak trees on the island were observed to have rot that may be indicative of oak wilt.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, retain an intact buffer of natural communities surrounding the mesic northern forest, and monitor for invasive species. Canopy oak across the island should be monitored for oak wilt.

Big Charity Island mesic northern forest. Photos by Joshua G. Cohen.

2018 aerial photograph of Big Charity Island mesic northern forest.

6. Big Charity Island – Northern Hardwood Swamp
Natural Community Type: Northern Hardwood Swamp
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: C
Size: 21 acres
Location: Big Charity Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24379

Site Description: Numerous pockets of northern hardwood swamp occur in swales and depressions throughout the southern half of Big Charity Island. The northern hardwood swamp occurs nested within dry-mesic northern forest and mesic northern forest. The northern hardwood swamp occurs on wet sands overlying limestone bedrock and cobble. Soils are characterized by saturated, shallow (1-20 cm) organics that range from acidic to alkaline (pH 5.5- 7.5) and overlie fine- to medium-textured sands of variable depth (20 to >100 cm) that are acidic to alkaline (pH 5.5-8.0) and overlie limestone cobble or bedrock. On average, the organic soils tend to be slightly acidic to circumneutral, the sands tend to be alkaline, and the depth to limestone cobble or bedrock is greater than 100 cm. Locally sands are mixed with the organics indicating water level fluctuation. Seasonal flooding and windthrow are the primary disturbance factors influencing species composition and vegetative structure of this northern hardwood swamps. High water marks from spring flooding were observed locally at 30 cm up the bole of canopy trees. Windthrow is locally prevalent within the northern hardwood swamp and downed logs and tip up mounds occur locally and provide critical substrate for plant establishment and growth. Twenty canopy trees were cored across the northern hardwood swamp and the average estimated age of canopy dominants is 79 years with canopy ages ranging from 43 to 90 years and cored canopy trees including silver maple (*Acer saccharinum*), red maple (*A. rubrum*), and green ash (*Fraxinus pennsylvanica*).

Big Charity Island northern hardwood swamp. Photo by Joshua G. Cohen.

The canopy of the northern hardwood swamp is dominated by silver maple, red maple, and green ash with canopy associates including paper birch (*Betula papyrifera*), American elm (*Ulmus americana*), cottonwood (*Populus deltoides*), and red oak (*Quercus rubra*). The canopy ranges from 50 to 80% and canopy trees typically range in diameter from 20 to 40 cm with some scattered very large silver maple being 50 to 110 cm. One massive silver maple was recorded to be 200 cm in diameter. The average diameter of measured canopy trees was 23 cm (N = 263). Many of the canopy ash have been impacted by emerald ash borer with many canopy ash dying and numerous snags observed. The understory ranges widely from absent to sparse (0-15%) to patchy to dense (20-40%) with characteristic species including winterberry (*Ilex verticillata*), silky dogwood (*Cornus amomum*), gray dogwood (*C. foemina*), round-leaved dogwood (*C. rugosa*), nannyberry (*Viburnum lentago*), silver maple, and green ash. Areas with more open canopy (50-60%) are characterized by denser understories and greater importance of winterberry and silky dogwood. The low shrub layer is sparse (10-15%) with scattered green ash seedlings, winterberry, nannyberry, wild black currant (*Ribes americanum*), and swamp rose (*Rosa palustris*). The ground cover is sparse to patchy (10-45%) with characteristic species including royal fern (*Osmunda regalis*), sensitive fern (*Onoclea sensibilis*), false nettle (*Boehmeria cylindrica*), marsh fern (*Thelypteris palustris*), mad-dog skullcap (*Scutellaria lateriflora*), spotted touch-me-not (*Impatiens capensis*), wild blue flag (*Iris versicolor*), poison ivy (*Toxicodendron radicans* and *T. rydbergii*), river-bank grape (*Vitis riparia*), Virginia creeper (*Parthenocissus quinquefolia*), enchanters-nightshade (*Circaea canadensis*), spinulose woodfern (*Dryopteris carthusiana*), Canada mayflower (*Maianthemum canadense*), and scouring rush (*Equisetum hyemale*).

The Big Charity Island northern hardwood swamp was surveyed from July 6th through July 9th, July 22nd through July 23rd, and August 23rd through August 25th. Fifty-six plant species were documented with 55 native species and 1 non-native species (Appendix 2.6). The total FQI was 26.9.

Big Charity Island northern hardwood swamp. Photo by Joshua G. Cohen.

Threats: Species composition and structure are patterned by natural processes but have been recently impacted by emerald ash borer. Approximately 15% of the canopy ash have died due to emerald ash borer infestation and damage was observed on several living trees. The non-native bittersweet nightshade (*Solanum dulcamara*) is locally common. Cut stumps were observed infrequently within the northern hardwood swamp but are prevalent throughout the adjacent dry-mesic northern forest and mesic northern forest.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered and to maintain a buffer of natural communities surrounding the northern hardwood swamp to prevent the increase of a weedy seed source. Efforts to control invasive species should be implemented and these control efforts should be monitored.

A 200 cm silver maple was documented in the Big Charity Island northern hardwood swamp. Photo by Joshua G. Cohen.

2018 aerial photograph of Big Charity Island northern hardwood swamp.

7. Big Charity Island – Open Dunes
Natural Community Type: Open Dunes
Rank: G3 S3, vulnerable throughout range
Element Occurrence Rank: C
Size: 1.12 acres
Location: Big Charity Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24381

Site Description: A half kilometer-long stretch of low foredune with a small pocket of interdunal wetland occurs along the western shoreline of Big Charity Island. Sand and gravel beach occurs lakeward and the open dunes are backed by dry-mesic northern forest. The soils are fine-textured wind-blown and wave-worked alkaline sands (pH 8.0) with localized areas being slightly acidic to circumneutral (pH 6.8-7.0) where organic matter mixes with the sands. The coastal complex along the shoreline of Big Charity Island has been impacted by five years of high Great Lakes water levels (from 2016 through 2020). High water levels have resulted in the dieback of trees and shrubs within the adjacent sand and gravel beach and interdunal wetland.

The low foredune is dominated by marram grass (*Ammophila breviligulata*) and sand reed grass (*Calamovilfa longifolia*) with associates including poison ivy (*Toxicodendron rydbergii*), wormwood (*Artemisia campestris*), common milkweed (*Asclepias syriaca*), beach pea (*Lathyrus japonicus*), plains puccoon (*Lithospermum caroliniense*), starry false Solomon-seal (*Maianthemum stellatum*), variegated scouring rush (*Equisetum variegatum*), and river-bank grape (*Vitis riparia*). Pitcher's thistle (*Cirsium pitcheri*, federal/state threatened) occurs locally. Ground cover ranges from 15 to 40% with areas of bare sand occurring throughout.

Pitcher's thistle (*Cirsium pitcheri*, federal/state threatened) occurs locally within the Big Charity Island open dunes. Photo by Joshua G. Cohen.

The low shrub layer is patchy (10-30%) and prevalent low shrubs include common juniper (*Juniperus communis*), sand cherry (*Prunus pumila*), and swamp rose (*Rosa palustris*). The scattered understory (5-15%) contains red-osier dogwood (*Cornus sericea*), choke cherry (*Prunus virginiana*), and red maple (*Acer rubrum*) and red oak (*Quercus rubra*) saplings. Scattered (10-25%) overstory with cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), red oak, willows (*Salix* spp.), paper birch (*Betula papyrifera*), and black cherry (*Prunus serotina*). Floristic composition of the foredune and open dunes is similar to that of the sand and gravel beach but is characterized by greater vegetative cover and higher floristic diversity.

The Big Charity Island open dunes was surveyed July 22nd and August 25th. Forty-two plant species were documented with 37 native species and 5 non-native species (Appendix 2.7). The total FQI was 25.3.

Threats: Observed threats to the open dunes include foot traffic and non-native species spread. Spotted knapweed (*Centaurea stoebe*) is locally common, especially closer to the lighthouse and associated pavilion. White sweet-clover (*Melilotus albus*) and common mullein (*Verbascum thapsus*) occur locally within the open dunes. Scattered Lombardy poplar (*Populus nigra*) and tree-of-heaven (*Ailanthus altissima*) were documented in close proximity to Pitcher's thistle. Invasive reed (*Phragmites australis* subspecies *australis*) is locally common within the adjacent interdunal wetland and along the sandy shoreline to the south. Purple loosestrife (*Lythrum salicaria*) occurs occasionally within the open dunes and was also documented in the sand and gravel beach and limestone cobble shore.

Management Recommendations: The main management recommendations are to control and monitor invasive species along the shoreline and limit human traffic in the dunes by posting signs about the fragile nature of dune ecosystems.

Spotted knapweed (*Centaurea stoebe*) occurs locally within the Big Charity Island open dunes. Biodiversity stewardship efforts to control spotted knapweed and other invasives should be continued and monitored. Photo by Joshua G. Cohen.

2018 aerial photograph of Big Charity Island open dunes.

8. Big Charity Island – Sand and Gravel Beach
Natural Community Type: Sand and Gravel Beach
Rank: G3? S3, vulnerable throughout range
Element Occurrence Rank: BC
Size: 2.44 acres
Location: Big Charity Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24384

Site Description: Approximately 1.5 kilometers of sand and gravel beach occurs on the western and southeastern shores of Big Charity Island. Along the western shore, sand and gravel beach is backed by open dunes and a small pocket of interdunal wetland occurs along the northwestern shore near the lighthouse. The sand and gravel beach ranges from 6 to 12 meters wide. Sands along this beach are alkaline (pH 8.0) and medium-textured and occur intermixed with gravel. The coastal complex along the shoreline of Big Charity Island has been impacted by five years of high Great Lakes water levels (from 2016 through 2020). High water levels have resulted in the dieback of trees and shrubs within the sand and gravel beach and adjacent limestone cobble shore and interdunal wetland. In addition, high water levels have likely reduced the overall cover of herbaceous species in these coastal systems. An 18.3 cm cottonwood (*Populus deltoides*) snag along the margin of the sand and gravel beach was cored and estimated to be over 20 years old when it died. Based on the bark and fine branching persisting on this snag, we estimate that the tree died in 2020 or 2021.

Vegetation within the sand and gravel beach is absent to sparse. Where vegetation has become established, it occurs along the upper margin of the shore. Vegetation was likely especially sparse in 2021 since surveys were conducted following five consecutive years of high Great Lakes water levels. Scattered trees (<1%) along the upper margins of the sand and gravel beach include cottonwood, green ash (*Fraxinus pennsylvanica*), red oak (*Quercus rubra*), and paper birch (*Betula papyrifera*). Shrubs (<1%) along the upper margin of the sand and gravel beach include (*Cornus sericea*), choke cherry (*Prunus virginiana*), common juniper (*Juniperus communis*), and sand cherry (*Prunus pumila*). Sparse herbaceous cover (<1%) is characterized by silverweed (*Potentilla anserina*), rush (*Juncus balticus*), common milkweed (*Asclepias syriaca*), wormwood (*Artemisia campestris*), starry false Solomon-seal (*Maianthemum stellatum*), cordgrass (*Spartina pectinata*), river-bank grape (*Vitis riparia*), and beach pea (*Lathyrus japonicus*). Much of the sand and gravel beach along the western shore of the island is backed by low foredune and open dunes. Floristic composition of the foredune and open dunes is similar to that of the sand and gravel beach but is characterized by greater vegetative cover and higher floristic diversity.

The Big Charity Island sand and gravel beach was surveyed July 22nd. Forty-three plant species were documented with 37 native species and 6 non-native species (Appendix 2.8). The total FQI was 24.3.

Threats: Species composition and community structure are patterned by natural processes. Threats to the sand and gravel beach are limited to foot traffic and non-native species spread. Non-native species found along the sand and gravel beach include spotted knapweed (*Centaurea stoebe*), common mullein (*Verbascum thapsus*), and purple loosestrife (*Lythrum salicaria*). Invasive reed (*Phragmites australis* subspecies *australis*) is locally common within the adjacent interdunal wetland and along stretches of the southwestern shoreline and spotted knapweed, white sweet-clover (*Melilotus albus*), Lombardy poplar (*Populus nigra*), and tree-of-heaven (*Ailanthus altissima*) occur within the adjacent open dunes.

Management Recommendations: The main management recommendations are to control and monitor invasive species along the shoreline.

Big Charity Island sand and gravel beach. Photos by Joshua G. Cohen.

2018 aerial photograph of Big Charity Island sand and gravel beach.

CROOKED ISLAND

Crooked Island is located in Misery Bay in Lake Huron, approximately a kilometer east of the North Point Peninsula to the east of Alpena (Figure 6). Crooked Island stretches approximately 1.4 km on its north/south axis, is quite narrow in its northern part, and increases to a width of nearly 1 km in its southern part, for a total area of 51 ha. The parent material underlying Crooked Island is limestone from the Devonian Period (Milstein 1987). Crooked Island is a low-lying landmass, with a maximum elevation of 4 meters. The islands and mainland coasts of Misery Bay and Thunder Bay were the historical home to a community of Chippewa Native Americans (Native Americans in Michigan Genealogy Research Center 2008). Fishing villages were established on islands in Thunder Bay in the 1800s and selective logging of the upland forest of Crooked Island likely took place during that time period. An abandoned cabin and dilapidated dock occur at the northern end of the island. Old two-tracks descend south from this former encampment, but the camp and roads have not been used in decades. Crooked Island has been part of the Michigan Islands NWR since 2018 and public access is prohibited.

Six high-quality natural community element occurrences were documented on Crooked Island during the 2021 field season including boreal forest, coastal fen, Great Lakes marsh, interdunal wetland, limestone cobble shore, and open dunes (Table 1; Figure 7). Coastal fen and Great Lakes marsh occur in a protected embayment along the western shoreline and Great Lakes marsh also wraps along the southern shore. Open dunes with small inclusions of interdunal wetland characterize the southeastern shoreline. Limestone cobble shore is most prevalent along the northeastern shore but also occurs along the southern margin of the island. The interior of the island is characterized by boreal forest. Localized pockets of rich conifer swamp occur within the boreal forest but are too small to be considered element occurrences. Small anthropogenic openings occasionally occur in the southern portion of the island and degraded boreal forest is found adjacent to the cabin at the north end of the island. Natural community surveys were conducted on Crooked Island from August 2nd through August 5th.

Crooked Island coastal fen. Photo by Jesse M. Lincoln.

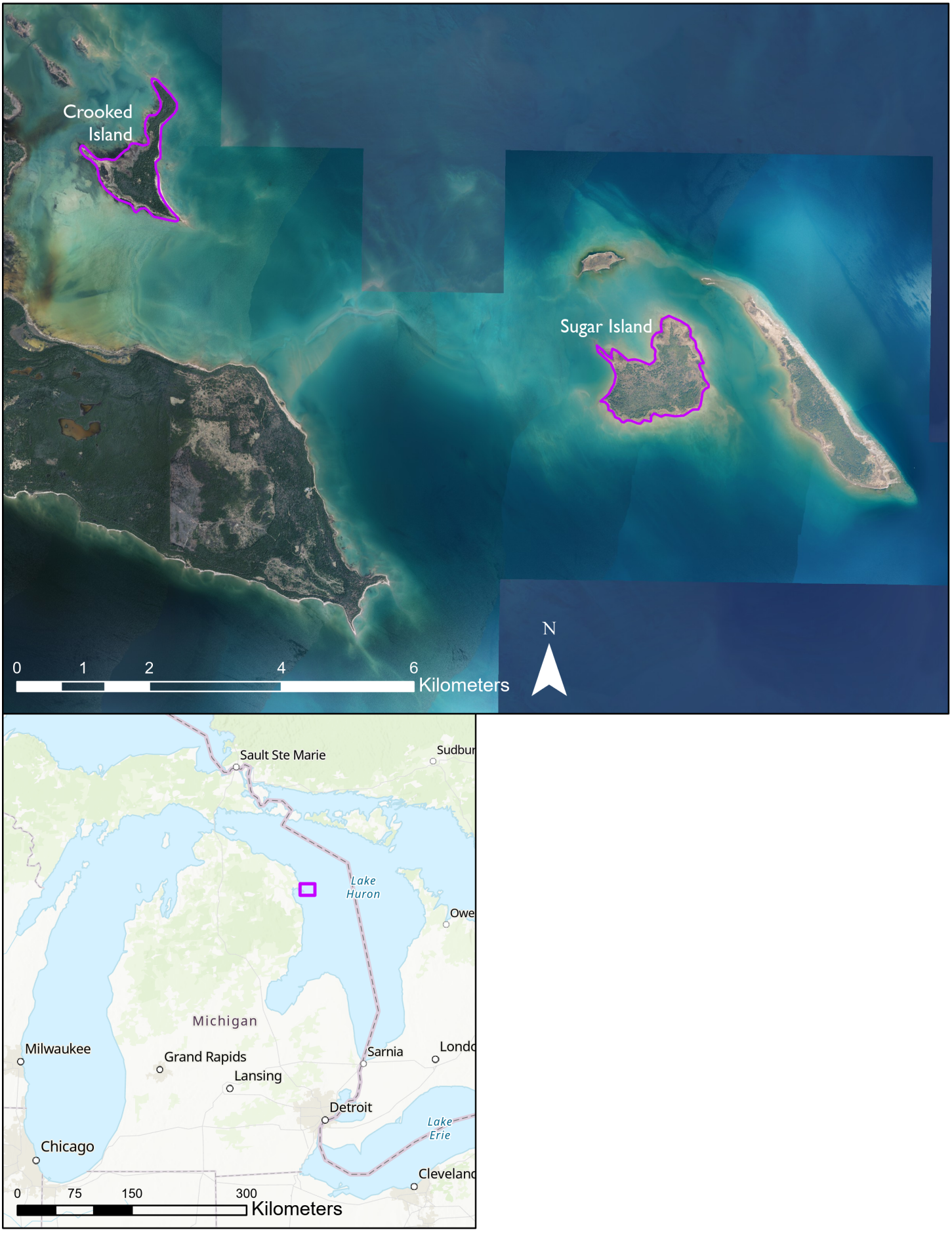


Figure 6. Overview map of Crooked Island and Sugar Island in the Michigan Islands National Wildlife Refuge in Lake Huron.

Figure 7. Natural community element occurrences on Crooked Island, Michigan Islands National Wildlife Refuge.

Figure 8. 1938 aerial imagery of Crooked Island, Michigan Islands National Wildlife Refuge.

9. Crooked Island – Boreal Forest
Natural Community Type: Boreal Forest
Rank: GU S3, globally unrankable and vulnerable within the state
Element Occurrence Rank: C
Size: 68 acres
Location: Crooked Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24357

Site Description: Boreal forest occurs throughout Crooked Islandon flat to gently rolling topography. The soils are characterized by shallow (2-10 cm) organics that are slightly acidic to alkaline (pH 6.8-7.5) and overlie the fine- to medium-textured sands and loamy sands that are alkaline (pH 7.5-7.8) and of variable depth (5 to > 100 cm) over limestone cobble, gravel, or bedrock. Pockets of wet boreal forest occur locally in low areas or swales where shallow wet organic soils occur above the limestone cobble. These wet boreal forest or rich conifer swamp inclusions are more prevalent along the western side of the island. Windthrow is prevalent throughout and as a result, the boreal forest is characterized by moderate levels of coarse woody debris. The coarse woody debris load is primarily composed of early-successional species, namely paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), and balsam fir (*Abies balsamea*). Charring on tree boles and stumps and charcoal in the soil indicates that wildfire has impacted this boreal forest. Twenty canopy trees were cored across the boreal forest and the average estimated age of canopy dominants was 94 years with canopy ages ranging from 70 to 120 years and cored canopy trees including northern white-cedar (*Thuja occidentalis*), white spruce (*Picea glauca*), white pine (*Pinus strobus*), and paper birch.

The boreal forest is dominated by northern white-cedar with canopy associates including paper birch, white spruce, trembling aspen, balsam fir, white pine, red pine (*Pinus resinosa*), and red maple (*Acer rubrum*). Deciduous and pine canopy coverage increases along the southern and southeastern portion of the island. Canopy coverage ranges from 70 to 90% with some local patches having more open canopy (50-70%) where blowdown is more prevalent. Canopy trees typically range in diameter from 20 to 30 cm with some scattered northern white-cedar, red maple, paper birch, and trembling aspen reaching 40 to 60 cm. The average diameter of measured canopy trees was 23 cm (N = 796). The subcanopy layer (5-15%) is characterized by striped maple (*Acer pensylvanicum*), balsam fir, and paper birch with occasional northern white-cedar. The understory layer is sparse to locally dense (15-45%) with balsam fir locally dominant and northern white-cedar locally common, especially in areas where blowdown and a dense understory protect the northern white-cedar from deer browse. The low shrub layer is sparse (5-10%) with balsam fir and northern white-cedar. The ground cover is characterized by relatively low diversity and is sparse to patchy (10-40%) with characteristic species including sedges (*Carex deweyana* and *C. eburnea*), star-flower (*Trientalis borealis*), white lettuce (*Prenanthes alba*), gay-wings (*Polygala paucifolia*), and naked miterwort (*Mitella nuda*). A single seedling of climbing fumitory (*Adlumia fungosa*, state special concern) was documented in the northern portion of the boreal forest. Feathermosses are common throughout the boreal forest on boles of trees and coarse woody debris. Small anthropogenic openings were occasional throughout the boreal forest and are dominated by Kentucky bluegrass (*Poa pratensis*) and other non-native species.

Crooked Island boreal forest. Photos by Joshua G. Cohen.

The Crooked Island boreal forest was surveyed from August 2nd through August 5th. Twenty-five plant species were documented with 16 native species and 9 non-native species (Appendix 2.9). The total FQI was 14.

Threats: Species composition and vegetative structure are patterned by natural processes but have been influenced by past logging and deer herbivory. Deer trails and deer browse were noted throughout. Glossy buckthorn (*Frangula alnus*) seedlings were noted within the boreal forest in the northern and southern ends of the island. Hound's-tongue (*Cynoglossum officinale*) occurs occasionally within the boreal forest. Reedgrass (*Calamagrostis epigeios*) was noted locally in anthropogenic openings. Additional non-native species that were noted occasionally within the boreal forest include Canada bluegrass (*Poa compressa*), Canada thistle (*Cirsium arvense*), helleborine (*Epipactis helleborine*), leafy spurge (*Euphorbia virgata*), gromwell (*Lithospermum officinale*), wall lettuce (*Mycelis muralis*), common mullein (*Verbascum thapsus*), and honeysuckle (*Lonicera* sp.).

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, retain an intact buffer of natural communities surrounding the boreal forest, control the invasive species, especially glossy buckthorn and leafy spurge, and monitor control efforts. Reducing deer densities on the island could be accomplished through culling.

Crooked Island boreal forest. Photo by Joshua G. Cohen.

2018 aerial photograph of Crooked Island boreal forest.

10. Crooked Island – Coastal Fen
Natural Community Type: Coastal Fen
Rank: G1G2 S2, globally critically imperiled to imperiled and imperiled within the state
Element Occurrence Rank: AB
Size: 60 acres
Location: Crooked Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24354

Site Description: Coastal fen occurs along the western shoreline of Crooked Island in a protected embayment. The coastal fen grades to Great Lakes marsh and limestone cobble shore locally and the margin between these communities shifts from year to year with fluctuations of the Great Lakes. The coastal fen and limestone cobble shore are backed by boreal forest. This coastal complex has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020) with Great Lakes marsh expanding and coastal fen and limestone cobble shore shrinking. High water levels have resulted in the dieback of trees and shrubs within the coastal fen and adjacent Great Lakes marsh and limestone cobble shore. In addition to the mortality of woody species due to inundation, especially northern white-cedar (*Thuja occidentalis*), shrubby cinquefoil (*Dasiphora fruticosa*), and common juniper (*Juniperus communis*), high water levels have likely also reduced the overall cover of herbaceous species in the coastal fen and caused the erosion of organic soils. A dead 6.8 cm northern white-cedar was cored and estimated to be 23 years old at the time of its death (likely in 2020). During prolonged periods of low Great Lakes levels, the coastal complex on Crooked Island is connected to the coastal complex on the mainland that also includes Great Lakes marsh, coastal fen, and limestone cobble shore. This mainland complex likely provides a source of seed (during low water years) for the vegetation found within the Crooked Island coastal complex.

The coastal fen is diverse and dominated by emergent graminoid vegetation with dominant species including twig-rush (*Cladium mariscoides*), spike-rush (*Eleocharis rostellata*), beak-rush (*Rhynchospora capillacea*), rush (*Juncus balticus*), and blue-joint (*Calamagrostis canadensis*). Additional characteristic species include limestone calamint (*Clinopodium arkansanum*), silverweed (*Potentilla anserina*), hair grass (*Deschampsia cespitosa*), threesquare (*Schoenoplectus pungens*), marsh fern (*Thelypteris palustris*), common bog arrow-grass (*Triglochin maritima*), variegated scouring rush (*Equisetum variegatum*), wild blue flag (*Iris versicolor*), horned bladderwort (*Utricularia cornuta*), and sedges (*Carex aquatilis*, *C. buxbaumii*, and *C. viridula*). In addition, we documented a potential population of flattened spike rush (*Eleocharis compressa*, state threatened) but reccomend early growing season surveys for confirmation. Scattered low shrubs include shrubby cinquefoil and sweet gale (*Myrica gale*), and northern white-cedar is occasional in the low shrub, understory, and overstory layers. Species composition and vegetative structure have been drastically altered by five years of high-water levels with woody species being visibly knocked back by the sustained inundation. Dead standing northern white-cedar occur throughout the coastal fen.

The Crooked Island coastal fen was surveyed from August 2nd through August 5th. Forty-nine plant species were documented with 44 native species and 5 non-native species (Appendix 2.10). The total FQI was 42.

Threats: Non-natives recorded infrequently within the coastal fen include creeping bent (*Agrostis stolonifera*), Canada bluegrass (*Poa compressa*), Canada thistle (*Cirsium arvense*), and common mullein (*Verbascum thapsus*). Invasive reed (*Phragmites australis* subspecies *australis*) is locally common within the adjacent Great Lakes marsh. Additional non-native species noted within the Great Lakes marsh include narrow-leaved cat-tail (*Typha angustifolia*), common mullein, purple loosestrife (*Lythrum salicaria*), and ox-eye daisy (*Leucanthemum vulgare*).

Management Recommendations: The primary management recommendations are to allow natural processes to operate unhindered, maintain a natural community buffer surrounding the shoreline, and monitor for invasive species. The dynamic nature of coastal fen, Great Lakes marsh, and limestone cobble shore demands the substantial buffering of these coastal ecosystems to allow these ecosystems to change in space and time. Efforts to control invasive species (especially reed, narrow-leaved cat-tail, and purple loosestrife) in the adjacent Great Lakes marsh and limestone cobble shore should be implemented immediately and these control efforts should be monitored. Invasive species management of Crooked Island should also include invasive species management along the Misery Bay mainland coastal complex.

Crooked Island coastal fen. Photos by Joshua G. Cohen.

2018 aerial photograph of Crooked Island coastal fen.

11. Crooked Island – Great Lakes Marsh
Natural Community Type: Great Lakes Marsh
Rank: G2 S3, globally imperiled and vulnerable within the state
Element Occurrence Rank: BC
Size: 51 acres
Location: Crooked Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24358

Site Description: Great Lakes marsh occurs along the western shoreline of Crooked Island in an embayment in Misery Bay in Lake Huron. Great Lakes marsh grades to coastal fen and limestone cobble shore locally and the margin between these communities shifts from year to year with fluctuations of the Great Lakes. This coastal complex has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020) with Great Lakes marsh expanding and coastal fen and limestone cobble shore shrinking. High water level has resulted in the dieback of trees and shrubs within the Great Lakes marsh and adjacent coastal fen and limestone cobble shore. During prolonged periods of low Great Lakes levels, the coastal complex on Crooked Island is connected to the coastal complex on the mainland that also includes Great Lakes marsh, coastal fen, and limestone cobble shore. In low water years, this mainland complex likely provides a source of seed for the vegetation found within the Crooked Island coastal complex.

The species composition and ecological zonation of the marsh are patterned by water depth and variability of the substrate. The Great Lakes marsh is characterized by diverse zonation with emergent marsh, wet meadow, sand flats, and sand/cobble spits. The marsh is dominated by emergent graminoid vegetation with hardstem bulrush (*Schoenoplectus acutus*), rush (*Juncus balticus*), threesquare (*Schoenoplectus pungens*), and twig-rush (*Cladium mariscoides*). Additional species include blue-joint (*Calamagrostis canadensis*), silverweed (*Potentilla anserina*), pondweeds (*Potamogeton* spp.), limestone calamint (*Clinopodium arkansanum*), marsh fern (*Thelypteris palustris*), wild blue flag (*Iris versicolor*), reed (*Phragmites australis* subspecies *americanus*), and tussock sedge (*Carex stricta*). Areas of emergent marsh are dominated by hardstem bulrush while the wet meadow is characterized by sedges and blue-joint. Scattered shrubs and trees along the transitional margin between Great Lakes marsh and coastal fen and sand and cobble spits that protrude into areas of marsh include northern white-cedar (*Thuja occidentalis*), shrubby cinquefoil (*Dasiphora fruticosa*), and common juniper (*Juniperus communis*) with many woody species having recently been flood-killed following five years of high water levels.

The Crooked Island Great Lakes marsh was surveyed from August 2nd through August 5th. Thirty-seven plant species were documented with 28 native species and 9 non-native species (Appendix 2.11). The total FQI was 32.3.

Threats: Species composition and structure are patterned by natural processes. Invasive reed (*Phragmites australis* var. *australis*) is locally common within the marsh, occurring both along the sand and cobble spit and also in areas of emergent marsh in over 100 cm of water. Native and non-native reed occur together and are possibly hybridizing. Additional non-native species noted include narrow-leaved cat-tail (*Typha angustifolia*), common mullein (*Verbascum thapsus*), purple loosestrife (*Lythrum salicaria*), ox-eye daisy (*Leucanthemum vulgare*), willow-herb (*Epilobium parviflorum*), Canada thistle (*Cirsium arvense*), bull thistle (*C. vulgare*), and hound's-tongue (*Cynoglossum officinale*).

Management Recommendations: Efforts to control invasive species (i.e., reed, narrow-leaved cat-tail, and purple loosestrife) should be implemented immediately and these control efforts should be monitored. Invasive species management of Crooked Island should also include invasive species management along the Misery Bay mainland coastal complex.

Crooked Island Great Lakes marsh. Photos by Joshua G. Cohen.

2018 aerial photograph of Crooked Island Great Lakes marsh.

12. Crooked Island – Interdunal Wetland
Natural Community Type: Interdunal Wetland
Rank: G2? S2, imperiled throughout range
Element Occurrence Rank: BC
Size: 1.11 acres
Location: Crooked Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24356

Site Description: Five interdunal wetland pockets occur within a half kilometer-long stretch of low foredune along the eastern shoreline on Crooked Island. Sand and gravel beach occurs lakeward and the dune system is backed by boreal forest. In addition, one small pocket of interdunal wetland occurs at the northern tip of the island and is flanked by limestone cobble shore on either side. Soils are characterized by shallow organics (2-5 cm pH 7.5-7.8) over moist, medium-textured alkaline sands (pH 7.8-8.0). Two of the interdunal wetlands within the open dunes still held 2 to 5 cm of water in August of 2021. One of the interdunal wetlands was noted to be filling in with sand and drying out. This complex has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020) and associated mortality was observed for several woody species along the margins of the wetlands, including northern white-cedar (*Thuja occidentalis*) and red pine (*Pinus resinosa*). A 12 cm white pine (*P. strobus*) growing along the margin of the interdunal wetland was cored and estimated to be over 30 years old.

Crooked Island interdunal wetland. Photo by Joshua G. Cohen.

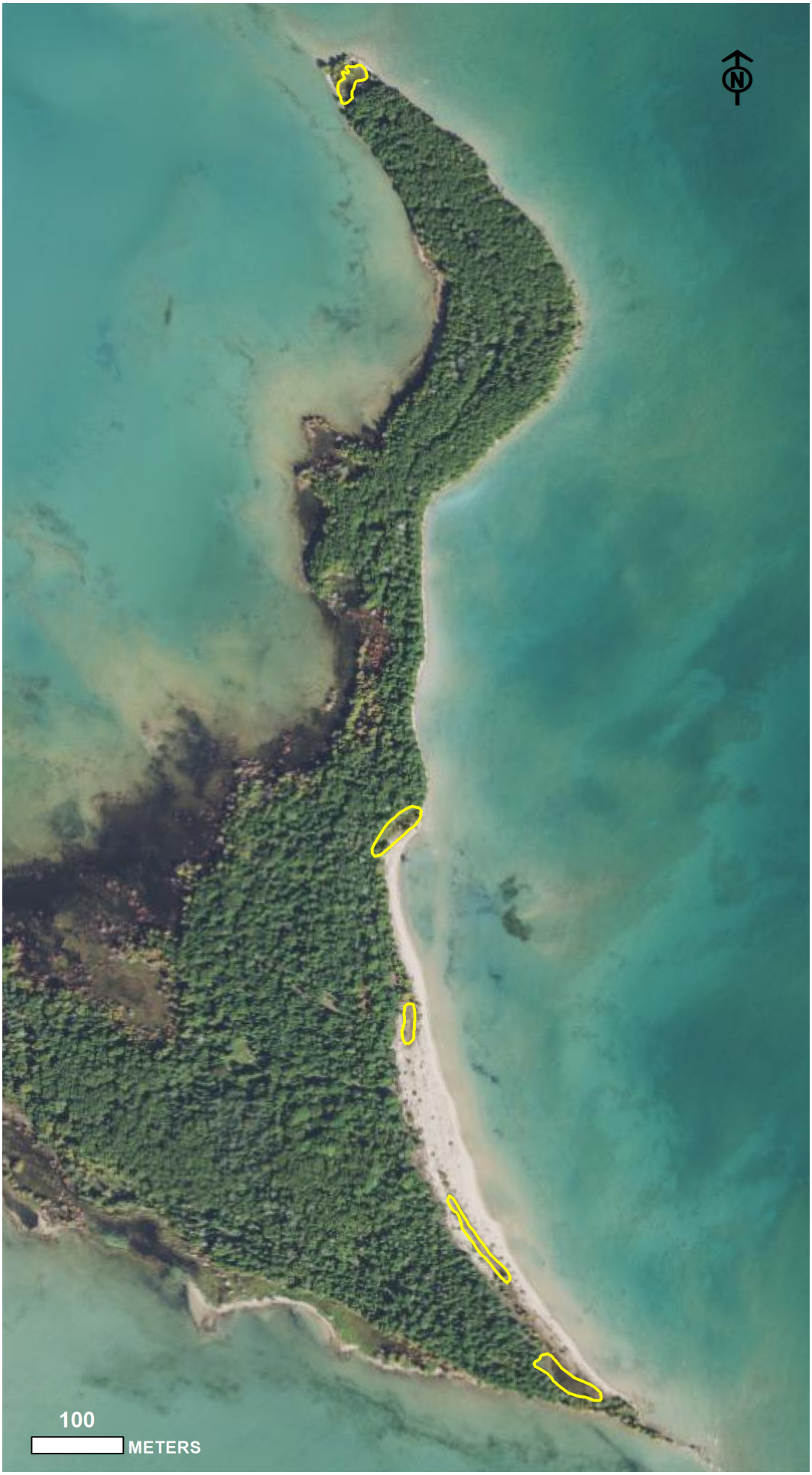
Characteristic ground cover species include blue-joint (*Calamagrostis canadensis*), silverweed (*Potentilla anserina*), rushes (*Juncus balticus* and *J. brachycephalus*), and bog lobelia (*Lobelia kalmia*). Herbaceous cover ranges from 45-65% and additional ground cover species include sedges (*Carex stricta* and *C. viridula*), golden-seeded spike rush (*Eleocharis elliptica*), northern bugle weed (*Lycopus uniflorus*), and white camas (*Anticlea elegans*). Scattered low shrubs (4-8%) include creeping juniper (*Juniperus horizontalis*), common juniper (*J. communis*), bearberry (*Arctostaphylos uva-ursi*), Kalm's St. John's-wort (*Hypericum kalmianum*), and shrubby cinquefoil (*Dasiphora fruticosa*). Scattered conifers in the understory (2-5%) and overstory (1-2%) include white pine, northern white-cedar, tamarack (*Larix laricina*), and balsam fir (*Abies balsamea*).

The Crooked Island interdunal wetland was surveyed August 2nd and August 3rd. Thirty-five plant species were documented with 28 native species and 7 non-native species (Appendix 2.12). The total FQI was 30.2.

Threats: Species composition and structure are patterned by natural processes. Invasive reed (*Phragmites australis* subspecies *australis*) and narrow-leaved cat-tail (*Typha angustifolia*) are locally common and purple loosestrife (*Lythrum salicaria*) and common mullein (*Verbascum thapsus*) are occasional in the northernmost polygon. Additional non-natives include hybrid cat-tail (*Typha* x *glauca*), spotted knapweed (*Centaurea stoebe*), and bull thistle (*Cirsium vulgare*).

Management Recommendations: Efforts to control invasive species should be implemented immediately and these control efforts should be monitored.

Crooked Island interdunal wetland. Photo by Joshua G. Cohen.



2018 aerial photograph of Crooked Island interdunal wetland.

13. Crooked Island – Limestone Cobble Shore
Natural Community Type: Limestone Cobble Shore
Rank: G2G3 S3, imperiled to vulnerable globally and vulnerable within the state
Element Occurrence Rank: B
Size: 2.91 acres
Location: Crooked Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24359

Site Description: Limestone cobble shore occurs along the shoreline of Crooked Island. Along the western shore of Crooked Island, limestone cobble shore grades to coastal fen and Great Lakes marsh locally. The margin between these communities shifts from year to year with fluctuations of the Great Lakes. The coastal fen and limestone cobble shore are backed by boreal forest. This coastal complex has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020) with Great Lakes marsh expanding and coastal fen and limestone cobble shore shrinking. The majority of trees and shrubs within the limestone cobble shore and adjacent coastal fen and Great lakes marsh have been flood-killed with standing dead stems, especially northern white-cedar (*Thuja occidentalis*), currently occurring submerged in water. In addition, high water levels have likely reduced the overall cover of herbaceous species in the limestone cobble shore as well. During prolonged periods of low Great Lakes levels, the coastal complex on Crooked Island is connected to the coastal complex on the mainland that also includes Great Lakes marsh, coastal fen, and limestone cobble shore. This mainland complex likely provides a source of seed for the vegetation found within the Crooked Island coastal complex.

Plant debris and driftwood and recent windthrow from shoreline erosion have accumulated along the margin of the limestone cobble shore. The coarse woody debris along the shoreline provides important habitat for insects and herptiles and the plant debris provides organic matter for soil development. Rocks along this stretch of shoreline range from small cobble to large boulders and the underlying substrate is limestone cobble and bedrock. Surficial cobble includes a mix dominated by limestone with granite, basalts, pudding stones, and fossils also present. The soils of the limestone cobble shore are wet gravelly, alkaline (pH 8.0) sands mixed with organics occurring between and beneath the cobble.

Vegetation within the limestone cobble shore is sparse, occurring patchily between cobbles and concentrated along the upper margin of the shore. Vegetation was likely especially sparse in 2021 since surveys were conducted following five consecutive years of high Great Lakes water levels. Characteristic ground cover species include silverweed (*Potentilla anserina*), twig-rush (*Cladium mariscoides*), blue-joint (*Calamagrostis canadensis*), beak-rush (*Rhynchospora capillacea*), rush (*Juncus balticus*), limestone calamint (*Clinopodium arkansanum*), Kalm's lobelia (*Lobelia kalmii*), and sedge (*Carex viridula*). The patchy low shrub layer supports shrubby cinquefoil (*Dasiphora fruticosa*) and northern white-cedar. The scattered understory and overstory is characterized by northern white-cedar.

The Crooked Island limestone cobble shore was surveyed August 2nd and August 3rd. Fourteen plant species were documented with 10 native species and 4 non-native species (Appendix 2.13). The total FQI was 20.2.

Threats: Species composition and structure are patterned by natural processes. Common mullein (*Verbascum thapsus*) was noted locally along the upper margin of the limestone cobble shore and Scotch pine (*Pinus sylvestris*) was noted along the northern portion of the limestone cobble shore. Additional non-native species noted within the limestone cobble shore include willow-herb (*Epilobium parviflorum*), bull thistle (*Cirsium vulgare*), spotted knapweed (*Centaurea stoebe*), and reedgrass (*Calamagrostis epigeios*). Invasive reed (*Phragmites australis* subspecies *australis*) is locally common within the adjacent Great Lakes marsh. Additional non-native species noted in the adjacent Great Lakes marsh include narrow-leaved cat-tail (*Typha angustifolia*), common mullein, purple loosestrife (*Lythrum salicaria*), and ox-eye daisy (*Leucanthemum vulgare*).

Management Recommendations: Efforts to control invasive species (i.e., Scotch pine and spotted knapweed) should be implemented immediately and these control efforts should be monitored. Invasive species management of Crooked Island should also include invasive species management along the Misery Bay mainland coastal complex.

Crooked Island limestone cobble shore. Photos by Joshua G. Cohen.

2018 aerial photograph of Crooked Island limestone cobble shore.

14. Crooked Island – Open Dunes
Natural Community Type: Open Dunes
Rank: G3 S3, vulnerable throughout range
Element Occurrence Rank: B
Size: 8.79 acres
Location: Crooked Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24355

Site Description: A half kilometer-long stretch of low foredune with small inclusions of interdunal wetland occurs along the eastern shoreline on Crooked Island. Sand and gravel beach occurs lakeward and the open dunes are backed by boreal forest. The soils are fine-textured wind-blown and wave-worked alkaline sands (pH 8.0).

The low foredune is dominated by marram grass (*Ammophila breviligulata*), sand reed grass (*Calamovilfa longifolia*), and little bluestem (*Schizachyrium scoparium*), with associates including Kalm's lobelia (*Lobelia kalmii*), harebell (*Campanula rotundifolia*), wormwood (*Artemisia campestris*), slender wheatgrass (*Elymus trachycaulus*), and white camas (*Anticlea elegans*). Ground cover ranges from 20 to 60% with areas of bare sand occurring throughout. The low shrub layer is patchy (10-15%) and prevalent low shrubs include common juniper (*Juniperus communis*), bearberry (*Arctostaphylos uva-ursi*), sand-dune willow (*Salix cordata*), and shrubby cinquefoil (*Dasiphora fruticosa*). The scattered understory (5-10%) contains white pine (*Pinus strobus*), northern white-cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), and sand-dune willow (*Salix cordata*). Scattered (4-8%) overstory conifers include northern white-cedar, balsam fir, white pine, and white spruce (*Picea glauca*) with red pine (*Pinus resinosa*) and tamarack (*Larix laricina*) less frequent.

Crooked Island open dunes. Photo by Joshua G. Cohen.

The Crooked Island open dunes was surveyed August 2nd and August 3rd. Thirty-five plant species were documented with 28 native species and 7 non-native species (Appendix 2.14). The total FQI was 31.9.

Threats: Spotted knapweed (*Centaurea stoebe*) and invasive reed (*Phragmites australis* subspecies *australis*) occur infrequently within the dunes and Canada bluegrass (*Poa compressa*) is locally common. Additional non-native species found within the dunes include reedgrass (*Calamagrostis epigeios*), narrow-leaved cat-tail (*Typha angustifolia*), hybrid cat-tail (*T.* x *glauca*), purple loosestrife (*Lythrum salicaria*), and bull thistle (*Cirsium vulgare*). Invasive reed is locally common within the northern interdunal wetland nested within the open dunes.

Management Recommendations: Efforts to control these invasive species should be implemented immediately and these control efforts should be monitored.

2018 aerial photograph of Crooked Island open dunes.

Crooked Island open dunes. Photos by Joshua G. Cohen.

SUGAR ISLAND

Sugar Island is located in Thunder Bay in Lake Huron, approximately 3 km to the northeast of North Point, near Alpena (Figure 6). Sugar Island is approximately 1 km wide on its east/west axis and 1 km long on the north/south axis, for a total area of approximately 78 ha. The bedrock under Sugar Island consists of limestone from the Devonian Period, as part of the Traverse Group of limestone deposits (Milstein 1987). The topography of Sugar Island is flat and rolling with a maximum elevation of 6 meters. The islands and mainland coasts of Thunder Bay were the historical home to a community of Chippewa Native Americans (Native Americans in Michigan Genealogy Research Center 2008). In the mid-1800s, a fishing village was established on neighboring Thunder Bay Island to the east, and when that settlement was abandoned, some villagers relocated to Sugar Island (Alpena Area Convention and Visitors Bureau n.d.). Localized logging within the boreal forest on Sugar Island likely occurred during this time. Sugar Island was purchased by the USFWS in 2011 and became part of the Michigan Islands National Wildlife Refuge shortly after (USFWS 2018). As part of the National Wildlife Refuge, Sugar Island is closed to the public.

The shoreline of Sugar Island is characterized by high-quality Great Lakes endemic coastal ecosystems. Great Lakes marsh is found along the northern shore of the island and transitions locally to northern shrub thicket and open-canopied rich conifer swamp. Limestone cobble is prevalent along the shore and grades to Great Lakes marsh along the northwestern shore and occurs along with limestone bedrock lakeshore on the eastern shore. A small pocket of coastal fen occurs along the southeastern shore. The interior of the island is forested, with a pocket of mesic northern forest in the center and boreal forest prevalent throughout the majority of the upland. Inclusions of rich conifer swamp, northern wet meadow, and northern shrub thicket occur within the boreal forest and along the margins of the Great Lakes marsh but are not of sufficient size and quality to be considered as element occurrences. Patches of degraded boreal forest occur along the eastern side of the island and likely correspond with clearing associated with the fishing village.

Six high-quality natural community element occurrences were documented on Sugar Island during the 2021 field season including boreal forest, coastal fen, Great Lakes marsh, limestone bedrock lakeshore, limestone cobble shore, and mesic northern forest (Table 1; Figure 9). Natural community surveys were conducted on Sugar Island from August 10th through August 14th.

Sugar Island limestone bedrock lakeshore. Photo by Jesse M. Lincoln.

Figure 9. Natural community element occurrences on Sugar Island, Michigan Islands National Wildlife Refuge.

Sugar Island Great Lakes marsh. Photo by Joshua G. Cohen.

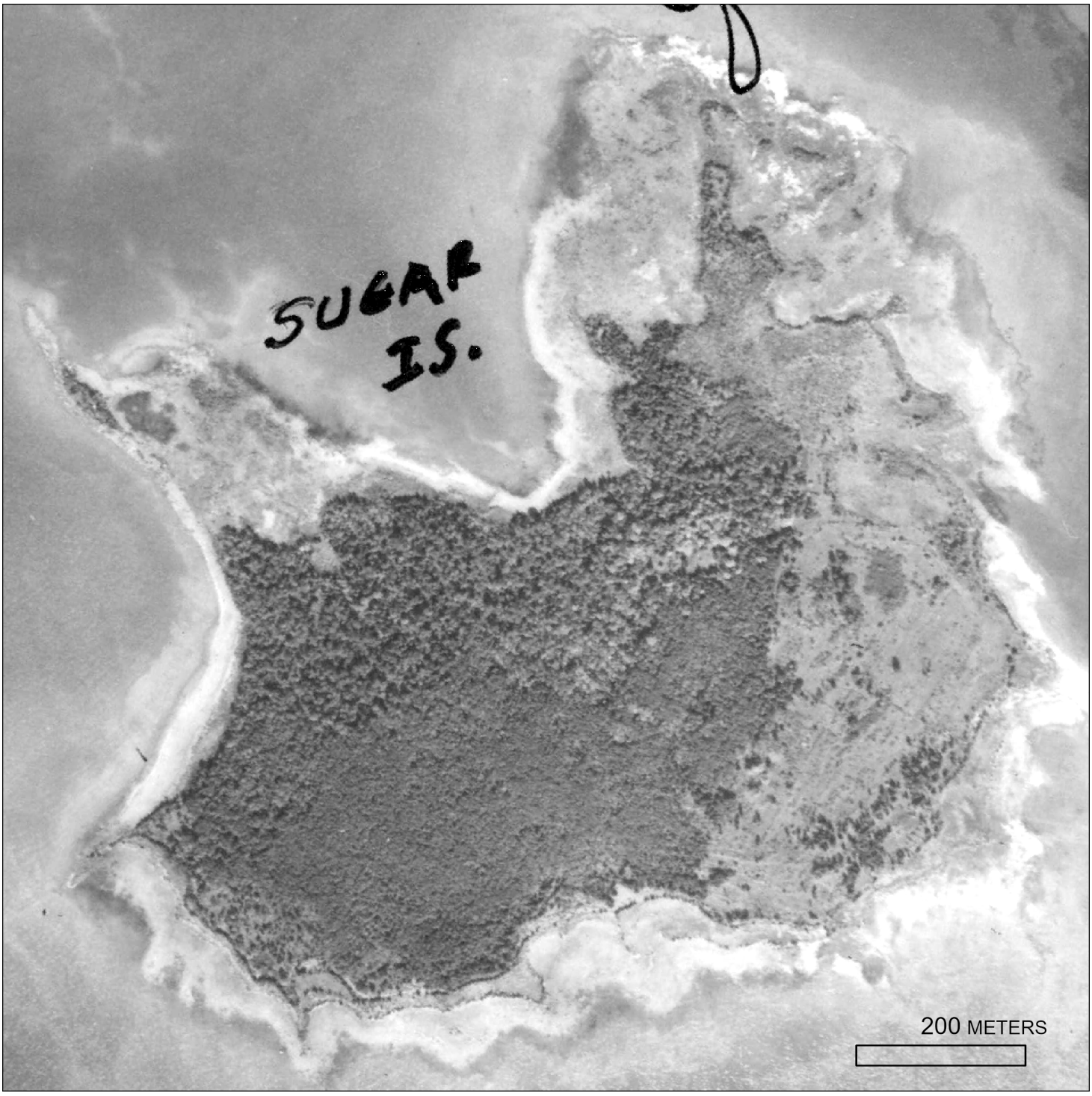


Figure 10. 1938 aerial imagery of Sugar Island, Michigan Islands National Wildlife Refuge.

15. Sugar Island – Boreal Forest
Natural Community Type: Boreal Forest
Rank: GU S3, globally unrankable and vulnerable within the state
Element Occurrence Rank: B
Size: 119 acres
Location: Sugar Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24360

Site Description: Boreal forest occurs on Sugar Island in Thunder Bay in Lake Huron. Thunder Bay is distinguished by frequent storm events. Windthrow is prevalent throughout the boreal forest, which is characterized by moderate levels of coarse woody debris. The coarse woody debris load is primarily composed of early-successional species, namely paper birch (*Betula papyrifera*) and balsam fir (*Abies balsamea*). The boreal forest has flat to rolling topography. Soils are characterized by shallow fine-textured loams and sandy loams mixed with organics that are slightly acidic to alkaline (pH 6.8-7.8) and of variable depth (1 to 30 cm) over limestone cobble or bedrock. On average, the depth to limestone cobble or bedrock is between 5 and 30 cm. Pockets of mesic northern forest, rich conifer swamp, northern wet meadow, and northern shrub thicket occur within the boreal forest. Charring on tree boles and stumps indicates that wildfire has impacted this boreal forest. Twenty canopy trees were cored across the boreal forest and the average estimated age of canopy dominants was 111 years with canopy ages ranging from 38 to 177 years and cored canopy trees including northern white-cedar (*Thuja occidentalis*), paper birch, trembling aspen (*Populus tremuloides*), and choke cherry (*Prunus virginiana*).

Sugar Island boreal forest. Photo by Joshua G. Cohen.

Species composition and vegetative structure of the boreal forest on Sugar Island is highly variable and is influenced by the interaction of depth to limestone substrate and time and intensity of past disturbance factors including windthrow, fire, and logging. The canopy of the boreal forest is dominated by northern white-cedar with canopy associates including white spruce (*Picea glauca*), paper birch, and trembling aspen and less frequently choke cherry (*Prunus virginiana*) and striped maple (*Acer pensylvanicum*). Canopy coverage generally ranges from 70 to 90% with some local patches having more open canopy (50-70%) where blowdown is more prevalent. Canopy trees typically range in diameter from 20 to 40 cm with some scattered northern white-cedar, paper birch, and aspen ranging from 40 to 60 cm. The average diameter of measured canopy trees was 24.1 cm (N = 791). Notably large choke cherry (*Prunus virginiana*) and striped maple (*Acer pensylvanicum*) were measured in the boreal forest including a striped maple with a diameter of 29.5 cm and a choke cherry with a diameter of 34.5 cm. Where shallow soils occur over storm cobble, paper birch and balsam fir are locally dominant. The subcanopy layer (10-20%) is characterized by mountain maple (*Acer spicatum*), round-leaved dogwood (*Cornus rugosa*), balsam fir, mountain-ash (*Sorbus decora*), and striped maple.

The understory layer is patchy to locally dense (25-45%) with balsam fir and yew (*Taxus canadensis*) locally dominant and additional species including northern white-cedar, red elderberry (*Sambucus racemosa*), mountain maple, choke cherry, striped maple, and round-leaved dogwood. Northern white-cedar is reproducing by layering. The low shrub layer is also patchy to dense (20-45%) with yew dominant and associates including choke cherry, bush-honeysuckle (*Diervilla lonicera*), Canadian fly honeysuckle (*Lonicera canadensis*), red honeysuckle (*Lonicera dioica*), balsam fir, American highbush-cranberry (*Viburnum trilobum*), and thimbleberry (*Rubus parviflorus*). The ground cover is sparse to patchy (25-40%) with characteristic species including star-flower (*Trientalis borealis*), Canada mayflower (*Maianthemum canadense*), bluebead-lily (*Clintonia borealis*), wild sarsaparilla (*Aralia nudicaulis*), big-leaved aster (*Eurybia macrophylla*), red baneberry (*Actaea rubra*), jack-in-the-pulpit (*Arisaema triphyllum*), herb Robert (*Geranium robertianum*), twinflower (*Linnaea borealis*), poison-ivy (*Toxicodendron radicans*), and sedges (*Carex deweyana* and *C. eburnea*). Feathermosses are common throughout the boreal forest on boles of trees and coarse woody debris. More open canopied portions of boreal forest occurring on very thin soils (1-2 cm) over limestone cobble are characterized by a unique mix of canopy choke cherry and mountain maple with a dense understory dominated by yew and round-leaved dogwood.

Yew is locally dominant in the understory of the Sugar Island boreal forest. Photo by Jesse M. Lincoln.

The Sugar Island boreal forest was surveyed from August 10th through August 14th. Eighty-eight plant species were documented with 82 native species and 6 non-native species (Appendix 2.15). The total FQI was 39.4.

Threats: Species composition and vegetative structure of the boreal forest on Sugar Island is highly variable and is influenced by the interaction of depth to limestone substrate and time and intensity of past disturbance factors including windthrow, fire, and logging. Cut stumps were noted occasionally within the boreal forest. Fishing villages were established on Sugar Island and Thunder Bay Island in the 1800s and logging within the boreal forest on Sugar Island likely occurred during this time. Browse from snowshoe hare was noted occasionally on paper birch. Non-natives observed infrequently in the boreal forest include bittersweet nightshade (*Solanum dulcamara*) and wall lettuce (*Mycelis muralis*).

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, retain an intact buffer of natural communities surrounding the boreal forest, and monitor for invasive species.

Sugar Island boreal forest. Photo by Joshua G. Cohen.

2018 aerial photograph of Sugar Island boreal forest.

16. Sugar Island – Coastal Fen
Natural Community Type: Coastal Fen
Rank: G1G2 S2, globally critically imperiled to imperiled and imperiled within the state
Element Occurrence Rank: C
Size: 1.7 acres
Location: Sugar Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24362

Site Description: A small pocket of coastal fen occurs along the southeastern shore of Sugar Island. The coastal fen is backed by boreal forest and rich conifer swamp. This coastal fen has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020). High water levels have resulted in the dieback of northern white-cedar (*Thuja occidentalis*) along the fen margins.

The coastal fen is dominated by emergent graminoid vegetation with dominant species including sedges (*Carex lasiocarpa*, *C*. aquatalis, and *C*. *sterilis*), twig-rush (*Cladium mariscoides*), rush (*Juncus balticus*), and blue-joint (*Calamagrostis canadensis*). Additional ground cover species include purple false foxglove (*Agalinis purpurea*), swamp milkweed (*Asclepias incarnata*), limestone calamint (*Clinopodium arkansanum*), marsh cinquefoil (*Comarum palustre*), spike-rush (*Eleocharis quinqueflora*), marsh pea (*Lathyrus palustris*), and Kalm's lobelia (*Lobelia kalmii*). The low shrub layer is patchy (25-40%) with shrubby cinquefoil (*Dasiphora fruticosa*), willows (*Salix* spp.), Kalm's St. John's-wort (*Hypericum kalmianum*), creeping juniper (*Juniperus horizontalis*), and red-osier dogwood (*Cornus sericea*). The scattered overstory (5-10%) is characterized by northern white-cedar, green ash (*Fraxinus pennsylvanica*), and trembling aspen (*Populus tremuloides*) with northern white-cedar and green ash also common in the understory (10-20%).

Sugar Island coastal fen. Photo by Joshua G. Cohen.

The Sugar Island coastal fen was surveyed August 11th. Forty-five plant species were documented with 39 native species and 6 non-native species (Appendix 2.16). The total FQI was 41.6.

Threats: Species composition and zonation are patterned by natural processes. Scattered non-natives include purple loosestrife (*Lythrum salicaria*), hybrid cat-tail (*Typha* x *glauca*), willow-herb (*Epilobium parviflorum*), Canada thistle (*Cirsium arvense*), and bull thistle (*C. vulgare*).

Management Recommendations: The primary management recommendations are to allow natural processes to operate unhindered, maintain a natural community buffer surrounding the shoreline, control invasive species (i.e., hybrid cat-tail and purple loosestrife), and monitor the control efforts.

2018 aerial photograph of Sugar Island coastal fen.

17. Sugar Island – Great Lakes Marsh
Natural Community Type: Great Lakes Marsh
Rank: G2 S3, globally imperiled and vulnerable within the state
Element Occurrence Rank: BC
Size: 15 acres
Location: Sugar Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24365

Site Description: Great Lakes marsh occurs along the northern shoreline of Sugar Island. Limestone cobble shore and Great Lakes marsh intergrade along the northwestern shore and a small inclusion of limestone bedrock lakeshore occurs within the Great Lakes marsh along the northeastern shore. Heading landward, the Great Lakes marsh transitions to northern shrub thicket and open-canopied rich conifer swamp and the surrounding adjacent upland is boreal forest. This coastal complex has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020). High water levels have resulted in the dieback of trees and shrubs within the Great Lakes marsh and adjacent limestone cobble shore.

Species composition of the marsh is patterned by water depth, variability of the substrate, and depth of the organic layer. The marsh is dominated by emergent graminoid vegetation with blue-joint (*Calamagrostis canadensis*), tussock sedge (*Carex stricta*), and rush (*Juncus balticus*). Additional species include common boneset (*Eupatorium perfoliatum*), spotted touch-me-not (*Impatiens campensis*), willow-herb (*Epilobium parviflorum*), broad-leaved cat-tail (*Typha latifolia*), and pondweeds (*Potamogeton* spp.). Scattered to patchy (10-25%) shrubs include meadowsweet (*Spiraea alba*), red-osier dogwood (*Cornus sericea*), pussy willow (*Salix discolor*), and tag alder (*Alnus incana*). Scattered (5-10%) tree saplings along the margin of the marsh include green ash (*Fraxinus pennsylvanica*), tamarack (*Larix laricina*), and northern white-cedar (*Thuja occidentalis*). Standing dead red-osier dogwood and tamarack are prevalent throughout the marsh, mortality resulting from five years of high water.

Sugar Island Great Lakes marsh. Photo by Joshua G. Cohen.

The Sugar Island Great Lakes marsh was surveyed August 11th. Forty-eight plant species were documented with 39 native species and 9 non-native species (Appendix 2.17). The total FQI was 26.3.

Threats: Purple loosestrife (*Lythrum salicaria*) is locally common within the marsh and also is locally abundant in the adjacent limestone cobble shore. Additional non-native species documented in the marsh include reed canary grass (*Phalaris arundinacea*), bittersweet nightshade (*Solanum dulcamara*), bull thistle (*Cirsium vulgare*), European frog's-bit (*Hydrocharis morsus-ranae*), hybrid cat-tail (*Typha* x *glauca*), willow-herb (*Epilobium parviflorum*), and great hairy willow-herb (*E. hirsutum*).

Management Recommendations: Efforts to control invasive species (especially purple loosestrife, hybrid cat-tail, reed canary grass, and European frog's-bit) should be implemented immediately and these control efforts should be monitored.

2018 aerial photograph of Sugar Island Great Lakes marsh.

18. Sugar Island – Limestone Bedrock Lakeshore
Natural Community Type: Limestone Bedrock Lakeshore
Rank: G3 S2, vulnerable globally and imperiled within the state
Element Occurrence Rank: C
Size: 2.7 acres
Location: Sugar Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24361

Site Description: Limestone bedrock lakeshore occurs along the shoreline of Sugar Island in Thunder Bay. Frequent storms in Thunder Bay generate high wave activity along the shore of Sugar Island. Along the eastern shore, limestone bedrock lakeshore and limestone cobble shore intergrade. Locally, storm cobble backs the limestone bedrock lakeshore. Along the northern shore, limestone bedrock lakeshore occurs as an inclusion within Great Lakes marsh. Limestone cobble shore and limestone bedrock lakeshore are backed by boreal forest. This coastal complex has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020) resulting in the decrease in the extent of the limestone bedrock lakeshore. High water levels and increased wave activity have likely reduced the overall cover of herbaceous species in the limestone bedrock lakeshore. The soils of the limestone bedrock lakeshore are characterized by shallow (1-2 cm), alkaline (pH 7.5-7.8) organics that accumulate in cracks, crevices, and depressions. Shallow pools of water occur locally on the limestone bedrock lakeshore.

The limestone bedrock lakeshore is sparsely vegetated and dominated by herbaceous plants (2-5%) with tree and shrub cover (1-2%) generally limited to the inland edge. Characteristic herbaceous species include smartweed (*Persicaria punctata*), common boneset (*Eupatorium perfoliatum*), silverweed (*Potentilla anserina*), stinging nettle (*Urtica dioica*), yellow avens (*Geum aleppicum*), blue vervain (*Verbena hastata*), broad-leaved cat-tail (*Typha latifolia*), and spotted touch-me-not (*Impatiens campensis*). The sparse vegetation is restricted to cracks and crevices. Scattered trees and shrubs include trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), green ash (*Fraxinus pennsylvanica*), and ninebark (*Physocarpus opulifolius*).

Sugar Island limestone bedrock lakeshore. Photo by Joshua G. Cohen.

The Sugar Island limestone bedrock lakeshore was surveyed August 11th. Forty-four plant species were documented with 28 native species and 16 non-native species (Appendix 2.18). The total FQI was 12.6.

Threats: Species composition and structure are patterned by natural processes. Purple loosestrife (*Lythrum salicaria*) occurs infrequently in the limestone bedrock lakeshore and is locally abundant in the adjacent limestone cobble shore and Great Lakes marsh. Additional non-native species found within the limestone bedrock lakeshore include dog mustard (*Erucastrum gallicum*), common mullein (*Verbascum thapsus*), coltsfoot (*Tussilago farfara*), wild parsnip (*Pastinaca sativa*), hybrid cat-tail (*Typha* x *glauca*), willow-herb (*Epilobium parviflorum*), great hairy willow-herb (*Epilobium hirsutum*), and bull thistle (*Cirsium vulgare*).

Management Recommendations: Efforts to control invasive species (i.e., purple loosestrife and hybrid cat-tail) should be implemented and these control efforts should be monitored.

Sugar Island limestone bedrock lakeshore. Photo by Joshua G. Cohen.

2018 aerial photograph of Sugar Island limestone bedrock lakeshore.

19. Sugar Island – Limestone Cobble Shore
Natural Community Type: Limestone Cobble Shore
Rank: G2G3 S3, imperiled to vulnerable globally and vulnerable within the state
Element Occurrence Rank: B
Size: 29 acres
Location: Sugar Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24363

Site Description: Limestone cobble shore occurs along the shoreline of Sugar Island in Thunder Bay. Frequent storms in Thunder Bay generate high wave activity along the shore of Sugar Island. Along the northwestern shore of Sugar Island, limestone cobble shore grades to Great Lakes marsh locally and the margin between these communities shifts from year to year with fluctuations of the Great Lakes. Along the eastern shore, limestone cobble shore and limestone bedrock lakeshore intergrade. Limestone cobble shore is backed by boreal forest. This coastal complex has been recently impacted by five years of high Great Lakes water levels (from 2016 through 2020) resulting in the decrease in the extent of the limestone cobble shore. High water levels have caused the dieback of trees and shrubs within the limestone cobble shore. In addition, high water levels and increased wave activity have likely reduced the overall cover of herbaceous species in the limestone cobble shore. Along the margin of the limestone cobble shore, plant debris and driftwood have accumulated. The coarse woody debris along the shoreline provides important habitat for insects and herptiles and the plant debris provides organic matter for soil development. Organic deposition along the margins of the limestone cobble shore appears to be most prevalent along the northern shore of Sugar Island, suggesting that ice scour from winter storms is more pervasive along this orientation. Rocks within the limestone cobble shore range from small cobble to large boulders and the underlying substrate is limestone cobble and bedrock. Surficial cobble includes a mix dominated by limestone with granite, basalts, pudding stones, and fossils. The soils are wet gravelly, alkaline (pH 7.8-8.0) sands mixed with organics and occur between and beneath the cobble.

Sugar Island limestone coble shore. Photo by Joshua G. Cohen.

Vegetation within the limestone cobble shore is sparse, occurring patchily between cobbles and concentrated along the upper margin of the shore. Vegetation was likely especially sparse in 2021 since surveys were conducted following five consecutive years of high Great Lakes water levels. Characteristic ground cover (15-25%) species include silverweed (*Potentilla anserina*), calamint (*Clinopodium arkansanum*), blue-joint (*Calamagrostis canadensis*), beak-rush (*Rhynchospora capillacea*), common boneset (*Eupatorium perfoliatum*), yellow avens (*Geum aleppicum*), and northern bugleweed (*Lycopus uniflorus*). The sparse (2-6%) low shrub layer supports shrubby cinquefoil (*Dasiphora fruticosa*), sweet gale (*Myrica gale*), balsam fir (*Abies balsamea*), sand cherry (*Prunus pumila*), bearberry (*Arctostaphylos uva-ursi*), soapberry (*Shepherdia canadensis*), and currants (*Ribes* spp.). The scattered understory (2-4%) and overstory (1-2%) are characterized by northern white-cedar (*Thuja occidentalis*), balsam fir, paper birch (*Betula papyrifera*), and willows (*Salix* spp.) with a high percentage of woody species having died recently.

The Sugar Island limestone cobble shore was surveyed from August 10th through August 14th. One hundred and three plant species were documented with 82 native species and 21 non-native species (Appendix 2.19). The total FQI was 32.5.

Threats: Species composition and structure are patterned by natural processes. Purple loosestrife (*Lythrum salicaria*) is locally abundant and narrow-leaved cat-tail (*Typha angustifolia*) is locally common within the limestone coble shore. Additional non-natives noted within the limestone cobble shore include hybrid cat-tail (*Typha* x *glauca*), common mullein (*Verbascum thapsus*), common St. John's-wort (*Hypericum perforatum*), honeysuckle (*Lonicera* sp.), great hairy willow-herb (*Epilobium hirsutum*), Canada thistle (*Cirsium arvense*), and bull thistle (*C. vulgare*).

Management Recommendations: Efforts to control invasive species (i.e., purple loosestrife and cat-tails) should be implemented and these control efforts should be monitored.

Sugar Island limestone coble shore. Photo by Joshua G. Cohen.

2018 aerial photograph of Sugar Island limestone cobble shore.

20. Sugar Island – Mesic Northern Forest
Natural Community Type: Mesic Northern Forest
Rank: G4 S3, apparently secure globally and vulnerable within the state
Element Occurrence Rank: CD
Size: 9.12 acres
Location: Sugar Island, Michigan Islands National Wildlife Refuge, Lake Huron, Michigan
Element Occurrence Identification Number: 24364

Site Description: Mesic northern forest occurs in the central portion of Sugar Island nested in the boreal forest mosaic. The forest is characterized by flat to rolling topography. An 82.9 cm sugar maple (*Acer saccharum*) was cored and estimated to be over 140 years old. The mesic northern forest is starting to accrue attributes of a mature forest including a canopy dominated by large diameter trees and mild pit and mound topography. Where yew (*Taxus canadensis*) is prevalent in the low shrub layer, this species is likely reducing species diversity and regeneration through competition for light resources. The soils are characterized by 50 cm of slightly acidic (pH 5.5-6.0) loamy sand over limestone cobble. The soils become less acidic with increasing depth.

The uneven-aged mesic northern forest is dominated by sugar maple with subcanopy associates including paper birch (*Betula papyrifera*) and mountain-ash (*Sorbus decora*). Canopy closure ranges from 70 to 80% and canopy trees range from 30 to 60 cm with some larger sugar maple reaching > 80 cm. The understory layer is sparse to patchy with American highbush-cranberry (*Viburnum trilobum*), mountain maple (*Acer spicatum*), choke cherry (*Prunus virginiana*), and sugar maple saplings. Common species in the low shrub layer include yew, Canadian fly honeysuckle (*Lonicera canadensis*), black raspberry (*Rubus occidentalis*), mountain maple, American highbush-cranberry, and sugar maple seedlings.

Sugar Island mesic northern forest. Photo by Joshua G. Cohen.

Characteristic ground cover species include bluebead-lily (*Clintonia borealis*), poison-ivy (*Toxicodendron radicans*), jack-in-the-pulipt (*Arisaema triphyllum*), common buttercup (*Ranunculus acris*), cow-parsnip (*Heracleum maximum*), herb Robert (*Geranium robertianum*), spotted touch-me-not (*Impatiens campensis*), fragrant bedstraw (*Galium triflorum*), and Canada mayflower (*Maianthemum canadense*).

The Sugar Island mesic northern forest was surveyed August 13th. Thirty plant species were documented with 30 native species and no non-native species (Appendix 2.20). The total FQI was 24.1.

Threats: Species composition and vegetative structure are patterned by natural processes and past logging. No threats were observed during the course of the survey. Fishing villages were established on Sugar Island and Thunder Bay Island in the 1800s and logging within the mesic northern forest and boreal forest on Sugar Island likely occurred during this time.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, retain an intact buffer of natural communities surrounding the mesic northern forest, and monitor for invasive species.

2018 aerial photograph of Sugar Island mesic northern forest.

Stewardship Prioritization Results

The stewardship scores for each natural community element occurrence within Big Charity, Crooked, and Sugar Islands are presented in Table 2. We sorted the element occurrences by their stewardship prioritization scores and assigned them a high (≥ 10; red), medium (≥ 9 and < 10; yellow), or low (< 9; blue) stewardship priority. The highest-ranking natural community element occurrences include the following four natural community element occurrences documented on Crooked Island: coastal fen, Great Lakes marsh, interdunal wetlands, and open dunes. These element occurrences represent Great Lakes endemic natural community types and are characterized by high integrity but are threatened by incipient invasive species infestations that are readily treated given prompt stewardship action. All documented occurrences of open dunes, Great Lakes marsh, and interdunal wetlands across the three islands ranked as high priorities. These three Great Lakes endemic natural community types are rare or imperiled in Michigan and rare or imperiled globally and susceptible to degradation from invasive species infestation. When a stewardship prioritization analysis was run for Northern Michigan, a similar result was found with Great Lakes marsh ranking highly; Great Lakes marsh was consistently the most abundant natural community in the sites categorized as high stewardship priority (Cohen and Slaughter 2015). Great Lakes marsh is particularly susceptible to infestation by invasive species. The invasives that become established within Great Lakes marsh can quickly expand and dominate, with homogenous beds of reed (*Phragmites australis* subspecies *australis*) and invasive cat-tails (*Typha angustifolia* and *T.* x. *glauca*) dramatically altering floristic composition and structure of affected sites. Lower priority sites across these three islands include more common natural community types, natural community element occurrences with lower overall ecological integrity, and sites that have minimal impacts from invasive species.

The open dunes and interdunal wetland on Crooked Island ranked as high stewardship priorities. These sites represent Great Lakes endemic natural community types and are characterized by high integrity threatened by incipient invasive species infestations that are readily treated given immediate and decisive stewardship action. Photo by Joshua G. Cohen.

Table 2. Stewardship prioritization for natural community element occurrences on Big Charity, Crooked, and Sugar Islands from the Michigan Islands National Wildlife Refuge. Element occurrences are sorted by their stewardship prioritization scores and assigned a high (red), medium (yellow), or low (blue) stewardship priority.

EO ID	Natural Community	Island	EO Rank	Ecological Integrity Index	Gobal Rank	Global Rank Score	State Rank	State Rank Score	Rarity Index	Invasive Threat Severity	Treatment Feasability	Invasive Index	Stewardship Priority Score
24356	Interdunal Wetland	Crooked Island	BC	3.5	G2?	4	S2	4	4	4	5	4.5	12
24382	Interdunal Wetland	Big Charity Island	C	3	G2?	4	S2	4	4	4	5	4.5	11.5
24355	Open Dunes	Crooked Island	B	4	G3	3	S3	3	3	5	4	4.5	11.5
24358	Great Lakes Marsh	Crooked Island	BC	3.5	G2	4	S3	3	3.5	4	4	4	11
24381	Open Dunes	Big Charity Island	C	3	G3	3	S3	3	3	5	4	4.5	10.5
24365	Great Lakes Marsh	Sugar Island	BC	3.5	G2	4	S3	3	3.5	4	3	3.5	10.5
24354	Coastal Fen	Crooked Island	AB	4.5	G1G2	4.5	S2	4	4.25	1	2	1.5	10.25
24359	Limestone Cobble Shore	Crooked Island	B	4	G2G3	3.5	S3	3	3.25	2	3	2.5	9.75
24362	Coastal Fen	Sugar Island	C	3	G1G2	4.5	S2	4	4.25	2	3	2.5	9.75
24363	Limestone Cobble Shore	Sugar Island	B	4	G2G3	3.5	S3	3	3.25	2	3	2.5	9.75
24384	Sand and Gravel Beach	Big Charity Island	BC	3.5	G3?	3	S3	3	3	3	3	3	9.5
24357	Boreal Forest	Crooked Island	C	3	GU	3	S3	3	3	4	3	3.5	9.5
24361	Limestone Bedrock Lakeshore	Sugar Island	C	3	G3	3	S2	4	3.5	3	3	3	9.5
24385	Limestone Cobble Shore	Big Charity Island	BC	3.5	G2G3	3.5	S3	3	3.25	2	3	3	9.25
24379	Northern Hardwood Swamp	Big Charity Island	C	3	G4	2	S3	3	2.5	2	3	2.5	8
24360	Boreal Forest	Sugar Island	B	4	GU	3	S3	3	3	1	1	1	8
24378	Dry-Mesic Northern Forest	Big Charity Island	C	3	G4	2	S3	3	2.5	1	1	1	6.5
24380	Limestone Bedrock Lakeshore	Big Charity Island	C	3	G3	3	S2	4	3.5	0	NA	0	6.5
24377	Mesic Northern Forest	Big Charity Island	C	3	G4	2	S3	3	2.5	0	NA	0	5.5
24364	Mesic Northern Forest	Sugar Island	CD	2.5	G4	2	S3	3	2.5	0	NA	0	5

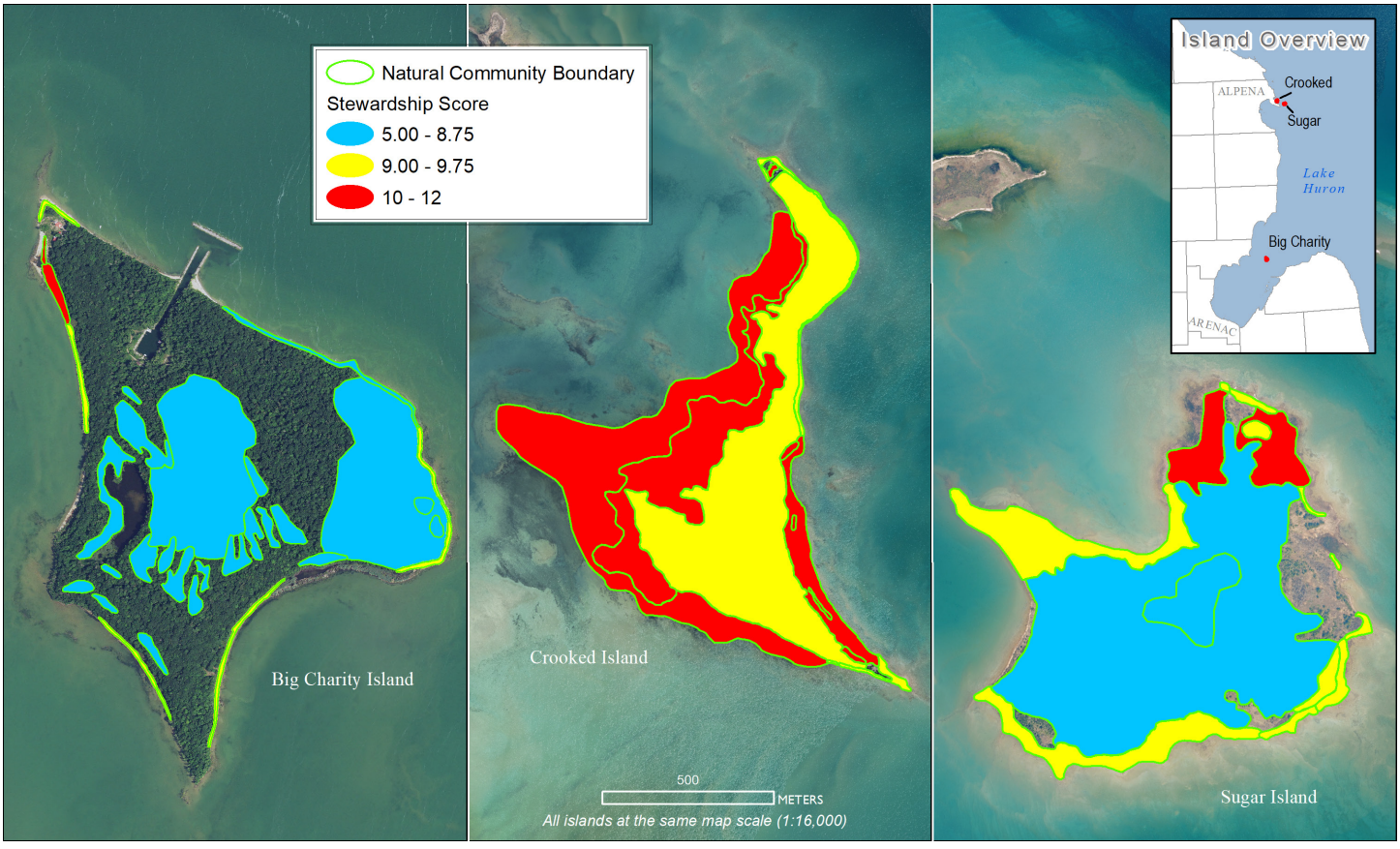


Figure 11. Stewardship prioritization for natural community element occurrences on Big Charity, Crooked, and Sugar Islands. Element occurrences are displayed by their stewardship prioritization scores and assigned a high (red), medium (yellow), or low (blue) stewardship priority.

Conclusion

Through this project we evaluated the ecological integrity of high-quality natural communities on three Great Lakes islands within the Michigan Islands NWR in Lake Huron: Big Charity, Crooked and Sugar Islands. We documented eight new element occurrences on Big Charity Island including six rare (S3) natural community types (dry-mesic northern forest, limestone cobble shore, mesic northern forest, northern hardwood swamp, open dunes, and sand and gravel beach) and two imperiled (S2 and/or G2) natural community types (interdunal wetland and limestone bedrock lakeshore). We documented six new element occurrences on Crooked Island including three rare (S3) natural community types (boreal forest, limestone cobble shore, and open dunes) and three imperiled (S2 and/or G2) natural community types (coastal fen, interdunal wetland, and Great Lakes marsh). We documented six new element occurrences on Sugar Island including three rare (S3) natural community types (boreal forest, limestone cobble shore, and mesic northern forest) and three imperiled (S2 and/or G2) natural community types (coastal fen, Great Lakes marsh, and limestone bedrock lakeshore). In total we documented fourteen rare natural community types and eight imperiled natural community types.

This report provides site-based assessments of 20 natural community element occurrences within Big Charity, Crooked, and Sugar Islands. Threats, management needs, and restoration opportunities specific to each individual site have been discussed. The baseline information presented in the report provides resource managers with an ecological foundation for prescribing site-level biodiversity stewardship, monitoring these management activities, and implementing landscape-level biodiversity planning to prioritize management efforts. The framework for prioritizing stewardship and monitoring efforts across these islands will help facilitate difficult decisions regarding the distribution of finite stewardship resources for site-based management.

Based on our stewardship prioritization framework, we recommend focusing invasive plant species control efforts on the following natural community element occurrences: Big Charity Island interdunal wetland and open dunes; Crooked Island coastal fen, Great Lakes marsh, interdunal wetland, and open dunes; and Sugar Island Great Lakes marsh.

Crooked Island open dunes. Photo by Jesse M. Lincoln.

Closing Remarks

The framework for stewardship prioritization presented in this report offers a method for targeting biodiversity management. This method could be refined to suit the specific and local needs of resource agencies. This stewardship prioritization could also be refined within broader ecological or political regions such as ecological subsection, county, or the entire National Wild Refuge. In addition, other indices could be incorporated into the stewardship prioritization matrix, which focused on invasive plant species management. Additional indices to consider incorporating include indices that incorporate the presence of rare species, priority wildlife species, deer browse pressure, and the functionality of the landscape surrounding the site. The drastic impacts that deer can have on the floristic composition, structure, and successional trajectory of forested ecosystems are amplified on islands. An essential component of holistic management of these islands should also include reduction of deer populations to abate the deleterious impacts of overbrowsing. Implementation of stewardship efforts within prioritized areas will also need to be followed by monitoring to gauge the success of biodiversity management efforts and refine future stewardship prioritization efforts.

In addition to providing opportunities for monitoring past stewardship actions to inform adaptive management, the islands within the National Wildlife Refuge provide critical learning environments where ecologists can study pattern and process to inform ecosystem management and conservation design. In the absence of shoreline development (e.g., breakwaters, jetties, and residences) dynamic coastal ecosystems on Crooked and Sugar Islands can change in spatial extent, floristic composition, and vegetative structure as the Great Lakes water levels fluctuate. The long-term conservation of Great Lakes coastal ecosystems depends on their capacity to change in time and space. One of the more striking results from our surveys was the sharp contrast in Floristic Quality Indices (FQIs) for the Crooked Island boreal forest (14) versus the Sugar Island boreal forest (39.4). In addition to higher overall species richness, the Sugar Island boreal forest was also characterized by dominance of yew, which was absent from the floristically depauperate Crooked Island boreal forest. The marked differences in floristic species composition and richness and structure of Crooked Island and Sugar Island is worth investigating and may help elucidate the potential impacts of deer herbivory and past logging on boreal forests. The incipient infestations of invasive species on Crooked Island (e.g., glossy buckthorn in the Crooked Island boreal forest, reed in the Crooked Island interdunal wetland and Great Lakes marsh, spotted knapweed in the Crooked Island open dunes, and European frog's-bit in the Sugar Island Great Lakes marsh) offer the opportunity to evaluate the effectiveness of early detection and rapid response.

Across the Great Lakes region, natural habitats are declining due to habitat destruction and are eroding in ecological integrity due to habitat fragmentation. Threats associated with habitat fragmentation include invasive species infestation, deer herbivory, mesopredator predation, and fire suppression. Great Lakes islands, especially uninhabited ones, provide unique and essential refuges for native biodiversity. Though these islands face less pressure from habitat destruction and fragmentation, they are still susceptible to the threats prevalent on the mainland although typically to a lesser extent. Biodiversity stewardship actions within these isolated and less disturbed settings have a high likelihood of success if they are prompt and decisive.

Sugar Island limestone coble shore. Photo by Jesse M. Lincoln.

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Appendix 1 - Global and State Element Ranking Criteria

GLOBAL RANKS

G1 = critically imperiled: at very high risk of extinction due to extreme rarity (often 5 or fewer occurrences), very steep declines, or other factors.

G2 = imperiled: at high risk of extinction due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors.

G3 = vulnerable: at moderate risk of extinction due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors.

G4 = apparently secure: uncommon but not rare; some cause for long-term concern due to declines or other factors.

G5 = secure: common; widespread.

GU = currently unrankable due to lack of information or due to substantially conflicting information about status or trends.

GX = eliminated: eliminated throughout its range, with no restoration potential due to extinction of dominant or characteristic species.

G? = incomplete data.

STATE RANKS

S1 = critically imperiled in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the state.

S2 = imperiled in the state because of rarity due to very restricted range, very few occurrences (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation from the state.

S3 = vulnerable in the state due to a restricted range, relatively few occurrences (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.

S4 = uncommon but not rare; some cause for long-term concern due to declines or other factors.

S5 = common and widespread in the state.

SX = community is presumed to be extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

S? = incomplete data.

Appendix 2 - Floristic Quality Assessments

For each high-quality natural community, floristic data were compiled into the Universal Floristic Quality Assessment Calculator (Reznicek et al. 2014; Freyman et al. 2016) to determine the Floristic Quality Index (FQI) for each natural community element occurrence. The floristic quality assessment is derived from a mean coefficient of conservatism and floristic quality index. Each native species is assigned a coefficient of conservatism, a value of 0 to 10 based on probability of its occurrence in a natural versus degraded habitat. Species restricted to a specialized or undisturbed habitat are assigned a value of 10, implying the species has extremely strong fidelity to a specific habitat. Native species that are not particular or indicative of natural conditions are assigned a low value of 0 or 1. The coefficient of conservatism is determined by experts on the flora of a region, and so may vary for a given plant species from region to region. From the total list of plant species for an area, a mean C value is calculated and then multiplied by the square root of the total number of plant species to calculate the FQI. In addition, each species is assigned a coefficient of wetness (W) based on its affinity to wetland or upland habitat. Michigan sites with an FQI of 35 or greater possess sufficient conservatism and richness that they are considered floristically important from a statewide perspective (Herman et al. 2001).

For each high-quality natural community element occurrence, we generated a floristic quality assessment (FQA). The FQA includes a comprehensive list of the species documented in the element occurrence along with each species C and W values. In addition, for each site we present the accompanying conservatism-based metrics, species richness, species wetness, physiognomy metrics, and duration metrics.

Appendix 2.1. Big Charity Island Dry-Mesic Northern Forest FQA

Conservatism-Based Metrics:

Total Mean C:	3.7
Native Mean C:	3.8
Total FQI:	24.8
Native FQI:	25.2
Adjusted FQI:	37.6
% C value 0:	4.4
% C value 1-3:	33.3
% C value 4-6:	55.6
% C value 7-10:	6.7
Native Tree Mean C:	3.2
Native Shrub Mean C:	4.4
Native Herbaceous Mean C:	3.9

Species Richness:

Total Species:	45	
Native Species:	44	97.80%
Non-native Species:	1	2.20%

Species Wetness:

Mean Wetness:	2.2
Native Mean Wetness:	2.3

Physiognomy Metrics:

Tree:	14	31.10%
Shrub:	13	28.90%
Vine:	5	11.10%
Forb:	11	24.40%
Grass:	0	0%
Sedge:	1	2.20%
Rush:	0	0%
Fern:	1	2.20%
Bryophyte:	0	0%

Duration Metrics:

Annual:	1	2.20%
Perennial:	43	95.60%
Biennial:	1	2.20%
Native Annual:	1	2.20%
Native Perennial:	42	93.30%
Native Biennial:	1	2.20%

Appendix 2.1. Big Charity Island Dry-Mesic Northern Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer rubrum	red maple	ACERUB	native	1	0
Acer saccharum	sugar maple	ACESAU	native	5	3
Amelanchier arborea	juneberry	AMEARB	native	4	3
Amelanchier laevis	smooth shadbush	AMELAE	native	4	5
Apocynum androsaemifolium	spreading dogbane	APOAND	native	3	5
Aralia nudicaulis	wild sarsaparilla	ARANUD	native	5	3
Aronia prunifolia	chokeberry	AROPRU	native	5	-3
Betula papyrifera	paper birch	BETPAP	native	2	3
Cardamine pensylvanica	pennsylvania bitter cress	CARPEN	native	1	-3
Carex pensylvanica	sedge	CXPENS	native	4	5
Chimaphila maculata	spotted wintergreen	CHIMAC	native	8	5
Diervilla lonicera	bush-honeysuckle	DIELON	native	4	5
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Gaultheria procumbens	wintergreen	GAUPRO	native	5	3
Gaylussacia baccata	huckleberry	GAYBAC	native	7	3
Hamamelis virginiana	witch-hazel	HAMVIR	native	5	3
Juniperus communis	common or ground juniper	JUNCOI	native	4	3
Kalmia angustifolia	sheep-laurel	KALANG	native	7	0
Lonicera dioica	red honeysuckle	LONDIO	native	5	3
Maianthemum canadense	canada mayflower	MAICAN	native	4	3
Maianthemum racemosum; smilacina r.	false spikenard	MAIRAC	native	5	3
Maianthemum stellatum; smilacina s.	starry false solomon-seal	MAISTE	native	5	0
Parthenocissus quinquefolia	virginia creeper	PARQUI	native	5	3
Pinus resinosa	red pine	PINRES	native	6	3
Pinus strobus	white pine	PINSTR	native	3	3
Polygala sanguinea	field milkwort	POLSAN	native	4	3
Polygonatum biflorum	solomon-seal	POLBIF	native	4	3
Polygonatum pubescens	downy solomon seal	POLPUB	native	5	5
Populus deltoides	cottonwood	POPDEL	native	1	0
Populus grandidentata	big-tooth aspen	POPGRA	native	4	3
Prunus serotina	wild black cherry	PRUSER	native	2	3
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Pteridium aquilinum	bracken fern	PTEAQU	native	0	3
Quercus rubra	red oak	QUERUB	native	5	3
Rubus flagellaris	northern dewberry	RUBFLA	native	1	3
Rubus pensilvanicus	dewberry	RUBPEN	native	2	3
Sambucus racemosa	red-berried elder	SAMRAC	native	3	3
Solanum dulcamara	**bittersweet nightshade**	**SOLDUL**	**non-native**	**0**	**0**
Thalictrum dioicum	early meadow-rue	THADIO	native	6	3
Tilia americana	basswood	TILAME	native	5	3
Toxicodendron radicans	poison-ivy	TOXRAD	native	2	0
Trientalis borealis	star-flower	TRIBOR	native	5	0
Ulmus americana	american elm	ULMAME	native	1	-3
Vaccinium angustifolium	low sweet blueberry	VACANG	native	4	3
Vitis riparia	river-bank grape	VITRIP	native	3	0

Appendix 2.2. Big Charity Island Interdunal Wetland FQA

Conservatism-Based Metrics:

Total Mean C:	3.2
Native Mean C:	4.2
Total FQI:	14.3
Native FQI:	16.3
Adjusted FQI:	36.4
% C value 0:	25
% C value 1-3:	25
% C value 4-6:	40
% C value 7-10:	10
Native Tree Mean C:	1
Native Shrub Mean C:	4
Native Herbaceous Mean C:	5

Species Richness:

Total Species:	20	
Native Species:	15	75%
Non-native Species:	5	25%

Species Wetness:

Mean Wetness:	-1.7
Native Mean Wetness:	-2.2

Physiognomy Metrics:

Tree:	2	10%
Shrub:	4	20%
Vine:	0	0%
Forb:	9	45%
Grass:	1	5%
Sedge:	3	15%
Rush:	1	5%
Fern:	0	0%
Bryophyte:	0	0%

Duration Metrics:

Annual:	2	10%
Perennial:	15	75%
Biennial:	3	15%
Native Annual:	1	5%
Native Perennial:	13	65%
Native Biennial:	1	5%

Appendix 2.2. Big Charity Island Interdunal Wetland FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer rubrum	red maple	ACERUB	native	1	0
Artemisia campestris	wormwood	ARTCAM	native	5	5
Cakile edentula	sea-rocket	CAKEDE	native	5	3
Carex stricta	sedge	CXSTRI	native	4	-5
Carex viridula	sedge	CXVIRU	native	4	-5
Centaurea stoebe; c. maculosa	**spotted knapweed**	**CENSTO**	**non-native**	**0**	**5**
Cornus amomum	silky dogwood	CORAMO	native	2	-3
Cornus sericea; c. stolonifera	red-osier	CORSER	native	2	-3
Juncus balticus	rush	JUNBAL	native	4	-5
Juniperus communis	common or ground juniper	JUNCOI	native	4	3
Lycopus uniflorus	northern bugle weed	LYCUNI	native	2	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Melilotus albus	**white sweet-clover**	**MELALB**	**non-native**	**0**	**3**
Persicaria amphibia; polygonum a.	water smartweed	PERAMP	native	6	-5
Phragmites australis var. australis	**reed**	**PHRAUU**	**non-native**	**0**	**-3**
Populus deltoides	cottonwood	POPDEL	native	1	0
Potentilla anserina	silverweed	POTANS	native	5	-3
Rhynchospora capillacea	beak-rush	RHYCAL	native	10	-5
Salix pedicellaris	bog willow	SALPED	native	8	-5
Xanthium strumarium	**common cocklebur**	**XANSTR**	**non-native**	**0**	**0**

Appendix 2.3. Big Charity Island Limestone Bedrock Lakeshore FQA

Conservatism-Based Metrics:

Total Mean C:	4.3
Native Mean C:	4.3
Total FQI:	10.5
Native FQI:	10.5
Adjusted FQI:	43
% C value 0:	0
% C value 1-3:	16.7
% C value 4-6:	83.3
% C value 7-10:	0
Native Tree Mean C:	4.5
Native Shrub Mean C:	4
Native Herbaceous Mean C:	n/a

Physiognomy Metrics:

Tree:	4	66.70%
Shrub:	2	33.30%
Vine:	0	0%
Forb:	0	0%
Grass:	0	0%
Sedge:	0	0%
Rush:	0	0%
Fern:	0	0%
Bryophyte:	0	0%

Species Richness:

Total Species:	6	
Native Species:	6	100%
Non-native Species:	0	0%

Duration Metrics:

Annual:	0	0%
Perennial:	6	100%
Biennial:	0	0%
Native Annual:	0	0%
Native Perennial:	6	100%
Native Biennial:	0	0%

Species Wetness:

Mean Wetness:	2.3
Native Mean Wetness:	2.3

Scientific Name	Common Name	Acronym	Native?	C	W
Acer saccharum	sugar maple	ACESAU	native	5	3
Cornus rugosa	round-leaved dogwood	CORRUG	native	6	5
Ostrya virginiana	ironwood; hop-hornbeam	OSTVIR	native	5	3
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Sorbus decora	mountain-ash	SORDEC	native	4	3
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3

Appendix 2.4. Big Charity Island Limestone Cobble Shore FQA

Conservatism-Based Metrics:

Total Mean C:	2.8
Native Mean C:	3.5
Total FQI:	14
Native FQI:	15.7
Adjusted FQI:	31.3
% C value 0:	20
% C value 1-3:	44
% C value 4-6:	32
% C value 7-10:	4
Native Tree Mean C:	3
Native Shrub Mean C:	2.8
Native Herbaceous Mean C:	4.2

Physiognomy Metrics:

Tree:	7	28%
Shrub:	4	16%
Vine:	2	8%
Forb:	9	36%
Grass:	1	4%
Sedge:	1	4%
Rush:	0	0%
Fern:	1	4%
Bryophyte	0	0%

Duration Metrics:

Annual:	2	8%
Perennial:	22	88%
Biennial:	1	4%
Native Anr	2	8%
Native Per	18	72%
Native Bie	0	0%

Species Richness:

Total Species:	25	
Native Species:	20	80%
Non-native Species:	5	20%

Species Wetness:

Mean Wetness:	-0.6
Native Mean Wetness:	-0.4

Appendix 2.4. Big Charity Island Limestone Cobble Shore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer saccharum	sugar maple	ACESAU	native	5	3
Betula papyrifera	paper birch	BETPAP	native	2	3
Carex viridula	sedge	CXVIRU	native	4	-5
Cornus rugosa	round-leaved dogwood	CORRUG	native	6	5
Cornus sericea; c. stolonifera	red-osier	CORSER	native	2	-3
Equisetum hyemale	scouring rush	EQUHYE	native	2	0
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Geranium robertianum	herb robert	GERROB	native	3	3
Impatiens capensis	spotted touch-me-not	IMPCAP	native	2	-3
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Ostrya virginiana	ironwood; hop-hornbeam	OSTVIR	native	5	3
Persicaria amphibia; polygonum a.	water smartweed	PERAMP	native	6	-5
Phragmites australis var. australis	**reed**	**PHRAUU**	**non-native**	**0**	**-3**
Populus deltoides	cottonwood	POPDEL	native	1	0
Populus tremuloides	quaking aspen	POPTRE	native	1	0
Potentilla anserina	silverweed	POTANS	native	5	-3
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Rumex orbiculatus	great water dock	RUMORB	native	9	-5
Salix petiolaris	slender willow	SALPET	native	1	-3
Solanum dulcamara	**bittersweet nightshade**	**SOLDUL**	**non-native**	**0**	**0**
Tilia americana	basswood	TILAME	native	5	3
Typha angustifolia	**narrow-leaved cat-tail**	**TYPANG**	**non-native**	**0**	**-5**
Verbascum thapsus	**common mullein**	**VERTHA**	**non-native**	**0**	**5**
Vernonia missurica	missouri ironweed	VERMIS	native	4	0
Vitis riparia	river-bank grape	VITRIP	native	3	0

Appendix 2.5. Big Charity Island Open Dunes FQA

Conservatism-Based Metrics:

Total Mean C:	3.9
Native Mean C:	4.4
Total FQI:	25.3
Native FQI:	26.8
Adjusted FQI:	41.3
% C value 0:	14.3
% C value 1-3:	35.7
% C value 4-6:	33.3
% C value 7-10:	16.7
Native Tree Mean C:	2.1
Native Shrub Mean C:	4.3
Native Herbaceous Mean C:	5.5

Species Richness:

Total Species:	42	
Native Species:	37	88.10%
Non-native Species:	5	11.90%

Species Wetness:

Mean Wetness:	1.1
Native Mean Wetness:	0.9

Physiognomy Metrics:

Tree:	11	26.20%
Shrub:	8	19%
Vine:	2	4.80%
Forb:	13	31%
Grass:	5	11.90%
Sedge:	0	0%
Rush:	1	2.40%
Fern:	2	4.80%
Bryophyte:	0	0%

Duration Metrics:

Annual:	2	4.80%
Perennial:	36	85.70%
Biennial:	4	9.50%
Native Annual:	2	4.80%
Native Perennial:	33	78.60%
Native Biennial:	2	4.80%

Appendix 2.5. Big Charity Island Open Dunes FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer rubrum	red maple	ACERUB	native	1	0
Ailanthus altissima	**tree-of-heaven**	**AILALT**	**non-native**	**0**	**5**
Ammophila breviligulata	marram grass	AMMBRE	native	10	5
Artemisia campestris	wormwood	ARTCAM	native	5	5
Asclepias syriaca	common milkweed	ASCSYR	native	1	5
Betula papyrifera	paper birch	BETPAP	native	2	3
Cakile edentula	sea-rocket	CAKEDE	native	5	3
Calamovilfa longifolia	sand reed grass	CALLON	native	10	5
Centaurea stoebe; c. maculosa	**spotted knapweed**	**CENSTO**	**non-native**	**0**	**5**
Cirsium pitcheri	pitchers thistle	CIRPIT	native	10	5
Cornus sericea; c. stolonifera	red-osier	CORSER	native	2	-3
Elymus canadensis	canada wild rye	ELYCAN	native	5	3
Equisetum variegatum	variegated scouring rush	EQUVAR	native	6	-3
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Geranium robertianum	herb robert	GERROB	native	3	3
Juncus balticus	rush	JUNBAL	native	4	-5
Juniperus communis	common or ground juniper	JUNCOI	native	4	3
Lathyrus japonicus	beach pea	LATJAP	native	10	3
Lithospermum caroliniense	plains puccoon	LITCAR	native	10	5
Lycopus uniflorus	northern bugle weed	LYCUNI	native	2	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Maianthemum stellatum; smilacina s.	starry false solomon-seal	MAISTE	native	5	0
Persicaria amphibia; polygonum a.	water smartweed	PERAMP	native	6	-5
Populus deltoides	cottonwood	POPDEL	native	1	0
Populus nigra	**lombardy poplar**	**POPNIG**	**non-native**	**0**	**5**
Populus tremuloides	quaking aspen	POPTRE	native	1	0
Potentilla anserina	silverweed	POTANS	native	5	-3
Prunus pumila	sand cherry	PRUPUM	native	8	5
Prunus serotina	wild black cherry	PRUSER	native	2	3
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Pteridium aquilinum	bracken fern	PTEAQU	native	0	3
Quercus rubra	red oak	QUERUB	native	5	3
Rosa palustris	swamp rose	ROSPAL	native	5	-5
Rubus flagellaris	northern dewberry	RUBFLA	native	1	3
Salix myricoides	blueleaf willow	SALMYR	native	9	-3
Schizachyrium scoparium; andropogon s.	little bluestem	SCHSCO	native	5	3
Sorbus decora	mountain-ash	SORDEC	native	4	3
Spartina pectinata	cordgrass	SPAPEC	native	5	-3
Toxicodendron rydbergii; t. radicans	poison-ivy	TOXRYD	native	3	0
Ulmus americana	american elm	ULMAME	native	1	-3
Verbascum thapsus	**common mullein**	**VERTHA**	**non-native**	**0**	**5**
Vitis riparia	river-bank grape	VITRIP	native	3	0

Appendix 2.6. Big Charity Island Mesic Northern Forest FQA

Conservatism-Based Metrics:

Total Mean C:	4.1
Native Mean C:	4.1
Total FQI:	30.4
Native FQI:	30.1
Adjusted FQI:	40.6
% C value 0:	3.6
% C value 1-3:	23.6
% C value 4-6:	69.1
% C value 7-10:	3.6
Native Tree Mean C:	4.1
Native Shrub Mean C:	3.8
Native Herbaceous Mean C:	4.2

Species Richness:

Total Species:	55	
Native Species:	54	98.20%
Non-native Species:	1	1.80%

Species Wetness:

Mean Wetness:	2.9
Native Mean Wetness:	2.9

Physiognomy Metrics:

Tree:	13	23.60%
Shrub:	8	14.50%
Vine:	3	5.50%
Forb:	24	43.60%
Grass:	2	3.60%
Sedge:	2	3.60%
Rush:	0	0%
Fern:	3	5.50%
Bryophyte:	0	0%

Duration Metrics:

Annual:	1	1.80%
Perennial:	54	98.20%
Biennial:	0	0%
Native Annual:	1	1.80%
Native Perennial:	53	96.40%
Native Biennial:	0	0%

Appendix 2.6. Big Charity Island Mesic Northern Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer nigrum; a. saccharum	black maple	ACENIG	native	4	3
Acer rubrum	red maple	ACERUB	native	1	0
Acer saccharum	sugar maple	ACESAU	native	5	3
Actaea pachypoda	dolls-eyes	ACTPAC	native	7	5
Allium tricoccum	wild leek	ALLTRI	native	5	3
Amelanchier arborea	juneberry	AMEARB	native	4	3
Amelanchier laevis	smooth shadbush	AMELAE	native	4	5
Anemone quinquefolia	wood anemone	ANEQUI	native	5	3
Aquilegia canadensis	wild columbine	AQUCAN	native	5	3
Aralia nudicaulis	wild sarsaparilla	ARANUD	native	5	3
Betula papyrifera	paper birch	BETPAP	native	2	3
Carex pensylvanica	sedge	CXPENS	native	4	5
Carex rosea; c. convoluta	curly-styled wood sedge	CXROSE	native	2	5
Celastrus orbiculatus	**oriental bittersweet**	**CELORB**	**non-native**	**0**	**5**
Circaea canadensis; c. lutetiana	enchanters-nightshade	CIRCAN	native	2	3
Cornus rugosa	round-leaved dogwood	CORRUG	native	6	5
Diervilla lonicera	bush-honeysuckle	DIELON	native	4	5
Dryopteris carthusiana	spinulose woodfern	DRYCAR	native	5	-3
Equisetum hyemale	scouring rush	EQUHYE	native	2	0
Fagus grandifolia	american beech	FAGGRA	native	6	3
Festuca subverticillata; f. obtusa	nodding fescue	FESSUB	native	5	3
Galium circaezans	white wild licorice	GALCIR	native	4	3
Geranium maculatum	wild geranium	GERMAC	native	4	3
Geranium robertianum	herb robert	GERROB	native	3	3
Geum canadense	white avens	GEUCAN	native	1	0
Hamamelis virginiana	witch-hazel	HAMVIR	native	5	3
Hepatica acutiloba	sharp-lobed hepatica	HEPACU	native	8	5
Lonicera dioica	red honeysuckle	LONDIO	native	5	3
Maianthemum canadense	canada mayflower	MAICAN	native	4	3
Maianthemum racemosum; smilacina r.	false spikenard	MAIRAC	native	5	3
Onoclea sensibilis	sensitive fern	ONOSEN	native	2	-3
Oryzopsis asperifolia	rough-leaved rice-grass	ORYASP	native	6	5
Osmorhiza claytonii	hairy sweet-cicely	OSMCLI	native	4	3
Ostrya virginiana	ironwood; hop-hornbeam	OSTVIR	native	5	3
Phryma leptostachya	lopseed	PHRLEP	native	4	3
Pinus resinosa	red pine	PINRES	native	6	3
Polygonatum biflorum	solomon-seal	POLBIF	native	4	3
Polygonatum pubescens	downy solomon seal	POLPUB	native	5	5
Populus grandidentata	big-tooth aspen	POPGRA	native	4	3
Prunus serotina	wild black cherry	PRUSER	native	2	3
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Quercus rubra	red oak	QUERUB	native	5	3
Ranunculus abortivus	small-flowered buttercup	RANABO	native	0	0
Ribes cynosbati	prickly or wild gooseberry	RIBCYN	native	4	3
Rubus pensilvanicus	dewberry	RUBPEN	native	2	3
Sambucus racemosa	red-berried elder	SAMRAC	native	3	3

Appendix 2.6. Big Charity Island Mesic Northern Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Sanguinaria canadensis	bloodroot	SANCAA	native	5	3
Smilax ecirrata	upright carrion-flower	SMIECI	native	6	5
Solidago caesia	bluestem goldenrod	SOLCAE	native	6	3
Thalictrum dioicum	early meadow-rue	THADIO	native	6	3
Tilia americana	basswood	TILAME	native	5	3
Toxicodendron radicans	poison-ivy	TOXRAD	native	2	0
Trillium grandiflorum	common trillium	TRIGRA	native	5	3
Vaccinium angustifolium	low sweet blueberry	VACANG	native	4	3
Viola pubescens	yellow violet	VIOPUB	native	4	3

Appendix 2.7. Big Charity Island Northern Hardwood Swamp FQA

Conservatism-Based Metrics:

Total Mean C:	3.6
Native Mean C:	3.7
Total FQI:	26.9
Native FQI:	27.4
Adjusted FQI:	36.7
% C value 0:	3.6
% C value 1-3:	41.1
% C value 4-6:	53.6
% C value 7-10:	1.8
Native Tree Mean C:	2.6
Native Shrub Mean C:	3.6
Native Herbaceous Mean C:	4.1

Species Richness:

Total Species:	56	
Native Species:	55	98.20%
Non-native Species:	1	1.80%

Species Wetness:

Mean Wetness:	-0.2
Native Mean Wetness:	-0.2

Physiognomy Metrics:

Tree:	11	19.60%
Shrub:	15	26.80%
Vine:	5	8.90%
Forb:	17	30.40%
Grass:	0	0%
Sedge:	0	0%
Rush:	0	0%
Fern:	8	14.30%
Bryophyte:	0	0%

Duration Metrics:

Annual:	1	1.80%
Perennial:	55	98.20%
Biennial:	0	0%
Native Annual:	1	1.80%
Native Perennial:	54	96.40%
Native Biennial:	0	0%

Appendix 2.7. Big Charity Island Northern Hardwood Swamp FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer rubrum	red maple	ACERUB	native	1	0
Acer saccharinum	silver maple	ACESAI	native	2	-3
Aralia nudicaulis	wild sarsaparilla	ARANUD	native	5	3
Aronia prunifolia	chokeberry	AROPRU	native	5	-3
Betula papyrifera	paper birch	BETPAP	native	2	3
Boehmeria cylindrica	false nettle	BOECYL	native	5	-5
Circaea canadensis; c. lutetiana	enchanters-nightshade	CIRCAN	native	2	3
Cornus amomum	silky dogwood	CORAMO	native	2	-3
Cornus foemina	gray dogwood	CORFOE	native	1	0
Cornus rugosa	round-leaved dogwood	CORRUG	native	6	5
Dryopteris carthusiana	spinulose woodfern	DRYCAR	native	5	-3
Equisetum arvense	common horsetail	EQUARV	native	0	0
Equisetum hyemale	scouring rush	EQUHYE	native	2	0
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Geranium maculatum	wild geranium	GERMAC	native	4	3
Ilex verticillata	michigan holly	ILEVER	native	5	-3
Impatiens capensis	spotted touch-me-not	IMPCAP	native	2	-3
Iris versicolor	wild blue flag	IRIVER	native	5	-5
Lemna turionifera; l. minor	red duckweed	LEMTUR	native	5	-5
Lysimachia ciliata	fringed loosestrife	LYSCIL	native	4	-3
Lysimachia terrestris	swamp-candles	LYSTER	native	6	-5
Maianthemum canadense	canada mayflower	MAICAN	native	4	3
Maianthemum racemosum; smilacina r.	false spikenard	MAIRAC	native	5	3
Maianthemum stellatum; smilacina s.	starry false solomon-seal	MAISTE	native	5	0
Onoclea sensibilis	sensitive fern	ONOSEN	native	2	-3
Osmunda regalis	royal fern	OSMREG	native	5	-5
Ostrya virginiana	ironwood; hop-hornbeam	OSTVIR	native	5	3
Parthenocissus quinquefolia	virginia creeper	PARQUI	native	5	3
Pinus strobus	white pine	PINSTR	native	3	3
Populus deltoides	cottonwood	POPDEL	native	1	0
Prunus serotina	wild black cherry	PRUSER	native	2	3
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Quercus rubra	red oak	QUERUB	native	5	3
Ranunculus recurvatus	hooked crowfoot	RANREC	native	5	-3
Ribes americanum	wild black currant	RIBAME	native	6	-3
Rosa palustris	swamp rose	ROSPAL	native	5	-5
Rubus flagellaris	northern dewberry	RUBFLA	native	1	3
Rubus occidentalis	black raspberry	RUBOCC	native	1	5
Rubus pubescens	dwarf raspberry	RUBPUB	native	4	-3
Sambucus racemosa	red-berried elder	SAMRAC	native	3	3
Sceptridium dissectum	cut-leaved grape-fern	SCEDIS	native	5	0
Scutellaria elliptica	hairy skullcap	SCUELL	native	10	5
Scutellaria lateriflora	mad-dog skullcap	SCULAT	native	5	-5
Smilax hispida; s. tamnoides	bristly greenbrier	SMIHIS	native	5	0
Solanum dulcamara	**bittersweet nightshade**	**SOLDUL**	**non-native**	**0**	**0**
Symphyotrichum lateriflorum; aster l.	calico aster	SYMLAT	native	2	0

Appendix 2.7. Big Charity Island Northern Hardwood Swamp FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Thelypteris noveboracensis	new york fern	THENOV	native	5	0
Thelypteris palustris	marsh fern	THEPAL	native	2	-3
Tilia americana	basswood	TILAME	native	5	3
Toxicodendron radicans	poison-ivy	TOXRAD	native	2	0
Toxicodendron rydbergii; t. radicans	poison-ivy	TOXRYD	native	3	0
Ulmus americana	american elm	ULMAME	native	1	-3
Viburnum cassinoides	wild-raisin	VIBCAS	native	6	3
Viburnum lentago	nannyberry	VIBLEN	native	4	0
Viola pubescens	yellow violet	VIOPUB	native	4	3
Vitis riparia	river-bank grape	VITRIP	native	3	0

Appendix 2.8. Big Charity Island Sand and Gravel Beach FQA

Conservatism-Based Metrics:

Total Mean C:	3.7
Native Mean C:	4.3
Total FQI:	24.3
Native FQI:	26.2
Adjusted FQI:	39.9
% C value 0:	18.6
% C value 1-3:	34.9
% C value 4-6:	30.2
% C value 7-10:	16.3
Native Tree Mean C:	2.1
Native Shrub Mean C:	4.3
Native Herbaceous Mean C:	5.3

Species Richness:

Total Species:	43	
Native Species:	37	86%
Non-native Species:	6	14%

Species Wetness:

Mean Wetness:	0.8
Native Mean Wetness:	0.7

Physiognomy Metrics:

Tree:	9	20.90%
Shrub:	8	18.60%
Vine:	2	4.70%
Forb:	15	34.90%
Grass:	6	14%
Sedge:	0	0%
Rush:	1	2.30%
Fern:	2	4.70%
Bryophyte:	0	0%

Duration Metrics:

Annual:	2	4.70%
Perennial:	36	83.70%
Biennial:	5	11.60%
Native Annual:	2	4.70%
Native Perennial:	33	76.70%
Native Biennial:	2	4.70%

Appendix 2.8. Big Charity Island Sand and Gravel Beach FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer rubrum	red maple	ACERUB	native	1	0
Ammophila breviligulata	marram grass	AMMBRE	native	10	5
Artemisia campestris	wormwood	ARTCAM	native	5	5
Asclepias syriaca	common milkweed	ASCSYR	native	1	5
Betula papyrifera	paper birch	BETPAP	native	2	3
Cakile edentula	sea-rocket	CAKEDE	native	5	3
Calamovilfa longifolia	sand reed grass	CALLON	native	10	5
Centaurea stoebe; c. maculosa	**spotted knapweed**	**CENSTO**	**non-native**	**0**	**5**
Cirsium pitcheri	pitchers thistle	CIRPIT	native	10	5
Cornus sericea; c. stolonifera	red-osier	CORSER	native	2	-3
Elymus canadensis	canada wild rye	ELYCAN	native	5	3
Equisetum variegatum	variegated scouring rush	EQUVAR	native	6	-3
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Geranium robertianum	herb robert	GERROB	native	3	3
Juncus balticus	rush	JUNBAL	native	4	-5
Juniperus communis	common or ground juniper	JUNCOI	native	4	3
Lathyrus japonicus	beach pea	LATJAP	native	10	3
Lithospermum caroliniense	plains puccoon	LITCAR	native	10	5
Lycopus uniflorus	northern bugle weed	LYCUNI	native	2	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Maianthemum stellatum; smilacina s.	starry false solomon-seal	MAISTE	native	5	0
Melilotus albus	white sweet-clover	MELALB	non-native	0	3
Persicaria amphibia; polygonum a.	water smartweed	PERAMP	native	6	-5
Phalaris arundinacea	reed canary grass	PHAARU	native	0	-3
Phragmites australis var. australis	**reed**	**PHRAUU**	**non-native**	**0**	**-3**
Populus deltoides	cottonwood	POPDEL	native	1	0
Populus tremuloides	quaking aspen	POPTRE	native	1	0
Potentilla anserina	silverweed	POTANS	native	5	-3
Prunus pumila	sand cherry	PRUPUM	native	8	5
Prunus serotina	wild black cherry	PRUSER	native	2	3
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Pteridium aquilinum	bracken fern	PTEAQU	native	0	3
Quercus rubra	red oak	QUERUB	native	5	3
Rosa palustris	swamp rose	ROSPAL	native	5	-5
Rubus flagellaris	northern dewberry	RUBFLA	native	1	3
Salix myricoides	blueleaf willow	SALMYR	native	9	-3
Saponaria officinalis	**bouncing bet**	**SAPOFF**	**non-native**	**0**	**3**
Sorbus decora	mountain-ash	SORDEC	native	4	3
Spartina pectinata	cordgrass	SPAPEC	native	5	-3
Toxicodendron rydbergii; t. radicans	poison-ivy	TOXRYD	native	3	0
Ulmus americana	american elm	ULMAME	native	1	-3
Verbascum thapsus	**common mullein**	**VERTHA**	**non-native**	**0**	**5**
Vitis riparia	river-bank grape	VITRIP	native	3	0

Appendix 2.9. Crooked Island Boreal Forest FQA

Conservatism-Based Metrics:

Total Mean C:	2.8
Native Mean C:	4.4
Total FQI:	14.3
Native FQI:	18.1
Adjusted FQI:	35.6
% C value 0:	34.6
% C value 1-3:	23.1
% C value 4-6:	30.8
% C value 7-10:	11.5
Native Tree Mean C:	2.7
Native Shrub Mean C:	5
Native Herbaceous Mean C:	5.6

Physiognomy Metrics:

Tree:	7	27%
Shrub:	2	8%
Vine:	1	4%
Forb:	12	46%
Grass:	1	4%
Sedge:	2	8%
Rush:	0	0%
Fern:	1	4%
Bryophyte:	0	0%

Species Richness:

Total Species:	26	
Native Species:	17	64%
Non-native Species:	9	36%

Duration Metrics:

Annual:	0	0%
Perennial:	22	88%
Biennial:	4	12%
Native Annual:	0	0%
Native Perennial:	16	64%
Native Biennial:	1	0%

Species Wetness:

Mean Wetness:	1.9
Native Mean Wetness:	1.1

Appendix 2.9. Crooked Island Boreal Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Abies balsamea	balsam fir	ABIBAL	native	3	0
Acer pensylvanicum	striped maple	ACEPEN	native	5	3
Adlumia fungosa	climbing fumitory	ADLFUN	native	4	5
Acer rubrum	red maple	ACERUB	native	1	0
Asclepias exaltata	poke milkweed	ASCEXA	native	6	5
Betula papyrifera	paper birch	BETPAP	native	2	3
Calamagrostis epigeios	**reedgrass**	**CALEPI**	**non-native**	**0**	**3**
Carex deweyana	sedge	CXDEWE	native	3	3
Carex eburnea	sedge	CXEBUR	native	7	3
Cirsium arvense	**canada thistle**	**CIRARV**	**non-native**	**0**	**3**
Cynoglossum officinale	**hounds-tongue**	**CYNOFF**	**non-native**	**0**	**5**
Dryopteris carthusiana	spinulose woodfern	DRYCAR	native	5	-3
Epipactis helleborine	**helleborine**	**EPIHEL**	**non-native**	**0**	**0**
Euphorbia virgata; e. esula	**leafy spurge**	**EUPVIR**	**non-native**	**0**	**5**
Frangula alnus; rhamnus frangula	**glossy buckthorn**	**FRAALN**	**non-native**	**0**	**0**
Lithospermum officinale	**gromwell**	**LITOFF**	**non-native**	**0**	**5**
Mitella nuda	naked miterwort	MITNUD	native	8	-3
Mycelis muralis; lactuca m.	**wall lettuce**	**MYCMUR**	**non-native**	**0**	**5**
Picea glauca	white spruce	PICGLA	native	3	3
Polygala paucifolia	gay-wings	POLPAU	native	7	3
Populus tremuloides	quaking aspen	POPTRE	native	1	0
Prenanthes alba	white lettuce	PREALB	native	5	3
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3
Trientalis borealis	star-flower	TRIBOR	native	5	0
Verbascum thapsus	**common mullein**	**VERTHA**	**non-native**	**0**	**5**
Viburnum trilobum; v. opulus	american highbush-cranberry	VIBTRI	native	5	-3

Appendix 2.10. Crooked Island Coastal Fen FQA

Conservatism-Based Metrics:

Total Mean C:	6
Native Mean C:	6.7
Total FQI:	42
Native FQI:	44.4
Adjusted FQI:	63.5
% C value 0:	12.2
% C value 1-3:	8.2
% C value 4-6:	34.7
% C value 7-10:	44.9
Native Tree Mean C:	2.3
Native Shrub Mean C:	7.3
Native Herbaceous Mean C:	6.9

Physiognomy Metrics:

Tree:	3	6.10%
Shrub:	4	8.20%
Vine:	1	2%
Forb:	23	46.90%
Grass:	5	10.20%
Sedge:	10	20.40%
Rush:	1	2%
Fern:	2	4.10%
Bryophyte:	0	0%

Species Richness:

Total Species:	49	
Native Species:	44	89.80%
Non-native Species:	5	10.20%

Duration Metrics:

Annual:	3	6.10%
Perennial:	44	89.80%
Biennial:	2	4.10%
Native Annual:	3	6.10%
Native Perennial:	40	81.60%
Native Biennial:	1	2%

Species Wetness:

Mean Wetness:	-3.5
Native Mean Wetness:	-3.9

Appendix 2.10. Crooked Island Coastal Fen FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer rubrum	red maple	ACERUB	native	1	0
Agalinis purpurea	purple false foxglove	AGAPUR	native	7	-3
Alnus incana; a. rugosa	speckled alder	ALNINC	native	5	-3
Calamagrostis canadensis	blue-joint	CALCAN	native	3	-5
Calamagrostis epigeios	**reedgrass**	**CALEPI**	**non-native**	**0**	**3**
Calamagrostis stricta; c. inexpansa; c. lacustris	narrow-leaved reedgrass	CALSTR	native	10	-3
Campanula aparinoides	marsh bellflower	CAMAPA	native	7	-5
Carex aquatilis	sedge	CXAQUA	native	7	-5
Carex buxbaumii	sedge	CXBUXB	native	10	-5
Carex crawei	sedge	CXCRAE	native	10	-3
Carex viridula	sedge	CXVIRU	native	4	-5
Cirsium arvense	**canada thistle**	**CIRARV**	**non-native**	**0**	**3**
Cirsium muticum	swamp thistle	CIRMUT	native	6	-5
Cirsium vulgare	**bull thistle**	**CIRVUL**	**non-native**	**0**	**3**
Cladium mariscoides	twig-rush	CLAMAR	native	10	-5
Clinopodium arkansanum; calamintha a.	limestone calamint	CLIARK	native	10	-3
Conyza canadensis	horseweed	CONCAN	native	0	3
Dasiphora fruticosa; potentilla f.	shrubby cinquefoil	DASFRU	native	8	-3
Deschampsia cespitosa	hair grass	DESCES	native	9	-3
Eleocharis compressa	flattened spike rush	ELECOM	native	9	-3
Eleocharis elliptica	golden-seeded spike rush	ELEELL	native	6	-5
Eleocharis rostellata	spike-rush	ELEROS	native	10	-5
Equisetum variegatum	variegated scouring rush	EQUVAR	native	6	-3
Eupatorium perfoliatum	boneset	EUPPER	native	4	-3
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Hypericum kalmianum	kalms st. johns-wort	HYPKAL	native	10	-3
Iris versicolor	wild blue flag	IRIVER	native	5	-5
Juncus balticus	rush	JUNBAL	native	4	-5
Lathyrus palustris	marsh pea	LATPAL	native	7	-3
Lobelia kalmii	bog lobelia	LOBKAL	native	10	-5
Lysimachia thyrsiflora	tufted loosestrife	LYSTHY	native	6	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Myrica gale	sweet gale	MYRGAL	native	6	-5
Panicum flexile	panic grass	PANFLE	native	8	-3
Potentilla anserina	silverweed	POTANS	native	5	-3
Proserpinaca palustris	mermaid-weed	PROPAL	native	6	-5
Rhynchospora capillacea	beak-rush	RHYCAL	native	10	-5
Sagittaria latifolia	common arrowhead	SAGLAT	native	4	-5
Schoenoplectus pungens; scirpus americanus	threesquare	SCHPUN	native	5	-5
Scutellaria galericulata	marsh skullcap	SCUGAL	native	5	-5
Thelypteris palustris	marsh fern	THEPAL	native	2	-3
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3
Triadenum fraseri	marsh st. johns-wort	TRIFRA	native	6	-5
Triantha glutinosa; tofieldia g.	false asphodel	TRIGLU	native	10	-5
Triglochin maritima	common bog arrow-grass	TRIMAR	native	8	-5
Typha Ã—glauca	**hybrid cat-tail**	**TYPGLA**	**non-native**	**0**	**-5**
Utricularia cornuta	horned bladderwort	UTRCOR	native	10	-5
Utricularia intermedia	flat-leaved bladderwort	UTRINT	native	10	-5
Viola nephrophylla	northern bog violet	VIONEP	native	8	-3

Appendix 2.11. Crooked Island Great Lakes Marsh FQA

Conservatism-Based Metrics:

Total Mean C:	4.6
Native Mean C:	6.1
Total FQI:	28
Native FQI:	32.3
Adjusted FQI:	53.1
% C value 0:	24.3
% C value 1-3:	5.4
% C value 4-6:	43.2
% C value 7-10:	27
Native Tree Mean C:	4
Native Shrub Mean C:	6
Native Herbaceous Mean C:	6.2

Species Richness:

Total Species:	37	
Native Species:	28	75.70%
Non-native Species:	9	24.30%

Species Wetness:

Mean Wetness:	-3.1
Native Mean Wetness:	-4.1

Physiognomy Metrics:

Tree:	1	2.70%
Shrub:	3	8.10%
Vine:	0	0%
Forb:	19	51.40%
Grass:	5	13.50%
Sedge:	7	18.90%
Rush:	1	2.70%
Fern:	1	2.70%
Bryophyte:	0	0%

Duration Metrics:

Annual:	2	5.40%
Perennial:	33	89.20%
Biennial:	2	5.40%
Native Annual:	2	5.40%
Native Perennial:	26	70.30%
Native Biennial:	0	0%

Appendix 2.11. Crooked Island Great Lakes Marsh FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Agalinis purpurea	purple false foxglove	AGAPUR	native	7	-3
Calamagrostis canadensis	blue-joint	CALCAN	native	3	-5
Calamagrostis epigeios	**reedgrass**	**CALEPI**	**non-native**	**0**	**3**
Carex aquatilis	sedge	CXAQUA	native	7	-5
Carex stricta	sedge	CXSTRI	native	4	-5
Cirsium arvense	**canada thistle**	**CIRARV**	**non-native**	**0**	**3**
Cirsium vulgare	**bull thistle**	**CIRVUL**	**non-native**	**0**	**3**
Cladium mariscoides	twig-rush	CLAMAR	native	10	-5
Clinopodium arkansanum; calamintha a.	limestone calamint	CLIARK	native	10	-3
Comarum palustre; potentilla p.	marsh cinquefoil	COMPAL	native	7	-5
Cynoglossum officinale	**hounds-tongue**	**CYNOFF**	**non-native**	**0**	**5**
Dasiphora fruticosa; potentilla f.	shrubby cinquefoil	DASFRU	native	8	-3
Eleocharis quinqueflora; e. pauciflora	spike-rush	ELEQUI	native	10	-5
Epilobium parviflorum	**willow-herb**	**EPIPAR**	**non-native**	**0**	**-5**
Iris versicolor	wild blue flag	IRIVER	native	5	-5
Juncus balticus	rush	JUNBAL	native	4	-5
Juniperus communis	common or ground juniper	JUNCOI	native	4	3
Leucanthemum vulgare	**ox-eye daisy**	**LEUVUL**	**non-native**	**0**	**5**
Lysimachia terrestris	swamp-candles	LYSTER	native	6	-5
Lysimachia thyrsiflora	tufted loosestrife	LYSTHY	native	6	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Myrica gale	sweet gale	MYRGAL	native	6	-5
Panicum flexile	panic grass	PANFLE	native	8	-3
Phragmites australis var. americanus	reed	PHRAUM	native	5	-3
Phragmites australis var. australis	**reed**	**PHRAUU**	**non-native**	**0**	**-3**
Potamogeton gramineus	pondweed	POTGRM	native	5	-5
Potamogeton richardsonii	richardsons pondweed	POTRIC	native	5	-5
Potentilla anserina	silverweed	POTANS	native	5	-3
Proserpinaca pectinata	mermaid-weed	PROPEC	native	9	-5
Schoenoplectus acutus; scirpus a.	hardstem bulrush	SCHACU	native	5	-5
Schoenoplectus pungens; scirpus americanus	threesquare	SCHPUN	native	5	-5
Schoenoplectus tabernaemontani; scirpus validus	softstem bulrush	SCHTAB	native	4	-5
Thelypteris palustris	marsh fern	THEPAL	native	2	-3
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3
Typha angustifolia	**narrow-leaved cat-tail**	**TYPANG**	**non-native**	**0**	**-5**
Utricularia intermedia	flat-leaved bladderwort	UTRINT	native	10	-5
Utricularia vulgaris	common bladderwort	UTRVUL	native	6	-5

Appendix 2.12. Crooked Island Interdunal Wetland FQA

Conservatism-Based Metrics:

Total Mean C:	5.1
Native Mean C:	6.4
Total FQI:	30.2
Native FQI:	33.9
Adjusted FQI:	57.2
% C value 0:	20
% C value 1-3:	14.3
% C value 4-6:	31.4
% C value 7-10:	34.3
Native Tree Mean C:	4.2
Native Shrub Mean C:	7.7
Native Herbaceous Mean C:	6.5

Species Richness:

Total Species:	35	
Native Species:	28	80%
Non-native Species:	7	20%

Species Wetness:

Mean Wetness:	-1.9
Native Mean Wetness:	-2.3

Physiognomy Metrics:

Tree:	5	14.30%
Shrub:	6	17.10%
Vine:	0	0%
Forb:	15	42.90%
Grass:	3	8.60%
Sedge:	4	11.40%
Rush:	2	5.70%
Fern:	0	0%
Bryophyte:	0	0%

Duration Metrics:

Annual:	0	0%
Perennial:	32	91.40%
Biennial:	3	8.60%
Native Annual:	0	0%
Native Perennial:	28	80%
Native Biennial:	0	0%

Appendix 2.12. Crooked Island Interdunal Wetland FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Abies balsamea	balsam fir	ABIBAL	native	3	0
Anticlea elegans; zigadenus glaucus	white camas	ANTELE	native	10	-3
Arctostaphylos uva-ursi	bearberry	ARCUVA	native	8	5
Calamagrostis canadensis	blue-joint	CALCAN	native	3	-5
Carex crawei	sedge	CXCRAE	native	10	-3
Carex stricta	sedge	CXSTRI	native	4	-5
Carex viridula	sedge	CXVIRU	native	4	-5
Centaurea stoebe; c. maculosa	**spotted knapweed**	**CENSTO**	**non-native**	**0**	**5**
Cirsium vulgare	**bull thistle**	**CIRVUL**	**non-native**	**0**	**3**
Clinopodium arkansanum; calamintha a.	limestone calamint	CLIARK	native	10	-3
Dasiphora fruticosa; potentilla f.	shrubby cinquefoil	DASFRU	native	8	-3
Deschampsia cespitosa	hair grass	DESCES	native	9	-3
Eleocharis elliptica	golden-seeded spike rush	ELEELL	native	6	-5
Hypericum kalmianum	kalms st. johns-wort	HYPKAL	native	10	-3
Juncus balticus	rush	JUNBAL	native	4	-5
Juncus brachycephalus	rush	JUNBRP	native	7	-5
Juniperus horizontalis	creeping juniper	JUNHOR	native	10	3
Larix laricina	tamarack	LARLAR	native	5	-3
Lobelia kalmii	bog lobelia	LOBKAL	native	10	-5
Lycopus uniflorus	northern bugle weed	LYCUNI	native	2	-5
Lysimachia thyrsiflora	tufted loosestrife	LYSTHY	native	6	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Phragmites australis var. australis	**reed**	**PHRAUU**	**non-native**	**0**	**-3**
Pinus resinosa	red pine	PINRES	native	6	3
Pinus strobus	white pine	PINSTR	native	3	3
Potentilla anserina	silverweed	POTANS	native	5	-3
Prunus pumila	sand cherry	PRUPUM	native	8	5
Salix eriocephala	willow	SALERI	native	2	-3
Scutellaria galericulata	marsh skullcap	SCUGAL	native	5	-5
Solidago ptarmicoides	upland white goldenrod	SOLPTA	native	6	3
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3
Typha angustifolia	**narrow-leaved cat-tail**	**TYPANG**	**non-native**	**0**	**-5**
Typha Ã—glauca	**hybrid cat-tail**	**TYPGLA**	**non-native**	**0**	**-5**
Utricularia cornuta	horned bladderwort	UTRCOR	native	10	-5
Verbascum thapsus	**common mullein**	**VERTHA**	**non-native**	**0**	**5**

Appendix 2.13. Crooked Island Limestone Cobble Shore FQA

Conservatism-Based Metrics:

Total Mean C:	5.4
Native Mean C:	7.5
Total FQI:	20.2
Native FQI:	23.7
Adjusted FQI:	63.4
% C value 0:	28.6
% C value 1-3:	0
% C value 4-6:	28.6
% C value 7-10:	42.9
Native Tree Mean C:	4
Native Shrub Mean C:	8
Native Herbaceous Mean C:	7.9

Physiognomy Metrics:

Tree:	1	7.10%
Shrub:	1	7.10%
Vine:	0	0%
Forb:	6	42.90%
Grass:	2	14.30%
Sedge:	3	21.40%
Rush:	1	7.10%
Fern:	0	0%
Bryophyte:	0	0%

Species Richness:

Total Species:	14	
Native Species:	10	71.40%
Non-native Species:	4	28.60%

Duration Metrics:

Annual:	0	0%
Perennial:	12	85.70%
Biennial:	2	14.30%
Native Annual:	0	0%
Native Perennial:	10	71.40%
Native Biennial:	0	0%

Species Wetness:

Mean Wetness:	-2.4
Native Mean Wetness:	-4

Scientific Name	Common Name	Acronym	Native?	C	W
Calamagrostis epigeios	**reedgrass**	**CALEPI**	**non-native**	**0**	**3**
Calamagrostis stricta	narrow-leaved reedgrass	CALSTR	native	10	-3
Carex viridula	sedge	CXVIRU	native	4	-5
Centaurea stoebe; c. maculosa	**spotted knapweed**	**CENSTO**	**non-native**	**0**	**5**
Cirsium vulgare	**bull thistle**	**CIRVUL**	**non-native**	**0**	**3**
Cladium mariscoides	twig-rush	CLAMAR	native	10	-5
Clinopodium arkansanum; calamintha a.	limestone calamint	CLIARK	native	10	-3
Dasiphora fruticosa; potentilla f.	shrubby cinquefoil	DASFRU	native	8	-3
Epilobium parviflorum	**willow-herb**	**EPIPAR**	**non-native**	**0**	**-5**
Juncus balticus	rush	JUNBAL	native	4	-5
Potentilla anserina	silverweed	POTANS	native	5	-3
Rhynchospora capillacea	beak-rush	RHYCAL	native	10	-5
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3
Utricularia cornuta	horned bladderwort	UTRCOR	native	10	-5

Appendix 2.14. Crooked Island Open Dunes FQA

Conservatism-Based Metrics:

Total Mean C:	5.4
Native Mean C:	6.7
Total FQI:	31.9
Native FQI:	35.5
Adjusted FQI:	59.9
% C value 0:	20
% C value 1-3:	8.6
% C value 4-6:	34.3
% C value 7-10:	37.1
Native Tree Mean C:	4
Native Shrub Mean C:	8.4
Native Herbaceous Mean C:	6.9

Species Richness:

Total Species:	35	
Native Species:	28	80%
Non-native Species:	7	20%

Species Wetness:

Mean Wetness:	0.7
Native Mean Wetness:	0.9

Physiognomy Metrics:

Tree:	6	17.10%
Shrub:	8	22.90%
Vine:	0	0%
Forb:	11	31.40%
Grass:	9	25.70%
Sedge:	0	0%
Rush:	1	2.90%
Fern:	0	0%
Bryophyte:	0	0%

Duration Metrics:

Annual:	0	0%
Perennial:	32	91.40%
Biennial:	3	8.60%
Native Annual:	0	0%
Native Perennial:	27	77.10%
Native Biennial:	1	2.90%

Appendix 2.14. Crooked Island Open Dunes FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Abies balsamea	balsam fir	ABIBAL	native	3	0
Ammophila breviligulata	marram grass	AMMBRE	native	10	5
Anticlea elegans; zigadenus glaucus	white camas	ANTELE	native	10	-3
Arctostaphylos uva-ursi	bearberry	ARCUVA	native	8	5
Artemisia campestris	wormwood	ARTCAM	native	5	5
Calamagrostis epigeios	**reedgrass**	**CALEPI**	**non-native**	**0**	**3**
Calamovilfa longifolia	sand reed grass	CALLON	native	10	5
Campanula aparinoides	marsh bellflower	CAMAPA	native	7	-5
Campanula rotundifolia	harebell	CAMROT	native	6	3
Centaurea stoebe; c. maculosa	**spotted knapweed**	**CENSTO**	**non-native**	**0**	**5**
Cirsium vulgare	**bull thistle**	**CIRVUL**	**non-native**	**0**	**3**
Dasiphora fruticosa; potentilla f.	shrubby cinquefoil	DASFRU	native	8	-3
Elymus canadensis	canada wild rye	ELYCAN	native	5	3
Elymus trachycaulus; agropyron t.	slender wheatgrass	ELYTRA	native	8	3
Festuca saximontana	fescue	FESSAX	native	6	5
Hypericum kalmianum	kalms st. johns-wort	HYPKAL	native	10	-3
Juncus balticus	rush	JUNBAL	native	4	-5
Juniperus communis	common or ground juniper	JUNCOI	native	4	3
Juniperus horizontalis	creeping juniper	JUNHOR	native	10	3
Larix laricina	tamarack	LARLAR	native	5	-3
Lobelia kalmii	bog lobelia	LOBKAL	native	10	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Phragmites australis var. australis	**reed**	**PHRAUU**	**non-native**	**0**	**-3**
Picea glauca	white spruce	PICGLA	native	3	3
Pinus resinosa	red pine	PINRES	native	6	3
Pinus strobus	white pine	PINSTR	native	3	3
Poa compressa	**canada bluegrass**	**POACOM**	**non-native**	**0**	**3**
Potentilla anserina	silverweed	POTANS	native	5	-3
Prunus pumila	sand cherry	PRUPUM	native	8	5
Salix cordata	sand-dune willow	SALCOR	native	10	0
Salix myricoides	blueleaf willow	SALMYR	native	9	-3
Schizachyrium scoparium; andropogon s.	little bluestem	SCHSCO	native	5	3
Solidago ptarmicoides	upland white goldenrod	SOLPTA	native	6	3
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3
Typha angustifolia	**narrow-leaved cat-tail**	**TYPANG**	**non-native**	**0**	**-5**

Appendix 2.15. Sugar Island Boreal Forest FQA

Conservatism-Based Metrics:

Total Mean C:	4.2
Native Mean C:	4.5
Total FQI:	39.4
Native FQI:	40.7
Adjusted FQI:	43.4
% C value 0:	10.2
% C value 1-3:	23.9
% C value 4-6:	53.4
% C value 7-10:	12.5
Native Tree Mean C:	3.9
Native Shrub Mean C:	5
Native Herbaceous Mean C:	4.5

Species Richness:

Total Species:	88	
Native Species:	82	93.20%
Non-native Species:	6	6.80%

Species Wetness:

Mean Wetness:	1.3
Native Mean Wetness:	1.2

Physiognomy Metrics:

Tree:	12	13.60%
Shrub:	14	15.90%
Vine:	5	5.70%
Forb:	47	53.40%
Grass:	1	1.10%
Sedge:	2	2.30%
Rush:	0	0%
Fern:	7	8%
Bryophyte:	0	0%

Duration Metrics:

Annual:	4	4.50%
Perennial:	81	92%
Biennial:	3	3.40%
Native Annual:	4	4.50%
Native Perennial:	77	87.50%
Native Biennial:	1	1.10%

Appendix 2.15. Sugar Island Boreal Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Abies balsamea	balsam fir	ABIBAL	native	3	0
Acer pensylvanicum	striped maple	ACEPEN	native	5	3
Acer spicatum	mountain maple	ACESPI	native	5	3
Actaea pachypoda	dolls-eyes	ACTPAC	native	7	5
Actaea rubra	red baneberry	ACTRUB	native	7	3
Agrimonia gryposepala	tall agrimony	AGRGRY	native	2	3
Anemone canadensis	canada anemone	ANECAN	native	4	-3
Aquilegia canadensis	wild columbine	AQUCAN	native	5	3
Aralia nudicaulis	wild sarsaparilla	ARANUD	native	5	3
Aralia racemosa	spikenard	ARARAC	native	8	3
Arctium minus	**common burdock**	**ARCMIN**	**non-native**	**0**	**3**
Arctostaphylos uva-ursi	bearberry	ARCUVA	native	8	5
Arisaema triphyllum	jack-in-the-pulpit	ARITRI	native	5	0
Betula alleghaniensis	yellow birch	BETALL	native	7	0
Betula papyrifera	paper birch	BETPAP	native	2	3
Botrypus virginianus	rattlesnake fern	BOTVIR	native	5	3
Carex deweyana	sedge	CXDEWE	native	3	3
Carex eburnea	sedge	CXEBUR	native	7	3
Caulophyllum thalictroides	blue cohosh	CAUTHA	native	5	5
Circaea alpina	small enchanters-nightshade	CIRALP	native	4	-3
Circaea canadensis; c. lutetiana	enchanters-nightshade	CIRCAN	native	2	3
Cirsium muticum	swamp thistle	CIRMUT	native	6	-5
Clinopodium vulgare	wild-basil	CLIVUL	native	3	5
Clintonia borealis	bluebead-lily; corn-lily	CLIBOR	native	5	0
Cornus rugosa	round-leaved dogwood	CORRUG	native	6	5
Corylus cornuta	beaked hazelnut	CORCOR	native	5	3
Cypripedium parviflorum; c. calceolus	yellow lady-slipper	CYPPAR	native	5	0
Diervilla lonicera	bush-honeysuckle	DIELON	native	4	5
Dryopteris carthusiana	spinulose woodfern	DRYCAR	native	5	-3
Dryopteris intermedia	evergreen woodfern	DRYINT	native	5	0
Epilobium coloratum	cinnamon willow-herb	EPICOL	native	3	-5
Epipactis helleborine	**helleborine**	**EPIHEL**	**non-native**	**0**	**0**
Eurybia macrophylla; aster m.	big-leaved aster	EURMAC	native	4	5
Fraxinus nigra	black ash	FRANIG	native	6	-3
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Galium triflorum	fragrant bedstraw	GALTRR	native	4	3
Geranium robertianum	herb robert	GERROB	native	3	3
Geum canadense	white avens	GEUCAN	native	1	0
Geum fragarioides; waldsteinia f.	barren-strawberry	GEUFRA	native	6	5
Gymnocarpium dryopteris	oak fern	GYMDRY	native	5	3
Halenia deflexa	spurred gentian	HALDEF	native	7	0
Heracleum maximum	cow-parsnip	HERMAX	native	3	-3
Hieracium caespitosum	**king devil**	**HIECAE**	**non-native**	**0**	**5**
Huperzia lucidula	shining clubmoss	HUPLUC	native	5	0
Impatiens capensis	spotted touch-me-not	IMPCAP	native	2	-3
Linnaea borealis	twinflower	LINBOR	native	6	0

Appendix 2.15. Sugar Island Boreal Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Lonicera canadensis	canadian fly honeysuckle	LONCAN	native	5	3
Lonicera dioica	red honeysuckle	LONDIO	native	5	3
Lonicera hirsuta	hairy honeysuckle	LONHIR	native	6	0
Maianthemum canadense	canada mayflower	MAICAN	native	4	3
Maianthemum racemosum; smilacina r.	false spikenard	MAIRAC	native	5	3
Maianthemum stellatum; smilacina s.	starry false solomon-seal	MAISTE	native	5	0
Melampyrum lineare	cow-wheat	MELLIN	native	6	3
Milium effusum	wood millet	MILEFF	native	8	3
Monotropa uniflora	indian-pipe	MONOUN	native	5	3
Mycelis muralis; lactuca m.	**wall lettuce**	**MYCMUR**	**non-native**	**0**	**5**
Petasites frigidus; p. palmatus	sweet-coltsfoot	PETFRI	native	10	-3
Physocarpus opulifolius	ninebark	PHYOPU	native	4	-3
Picea glauca	white spruce	PICGLA	native	3	3
Polygala paucifolia	gay-wings	POLPAU	native	7	3
Populus tremuloides	quaking aspen	POPTRE	native	1	0
Prunella vulgaris	self-heal	PRUVUL	native	0	0
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Pteridium aquilinum	bracken fern	PTEAQU	native	0	3
Pyrola elliptica	large-leaved shinleaf	PYRELL	native	6	3
Ranunculus abortivus	small-flowered buttercup	RANABO	native	0	0
Ranunculus acris	**tall or common buttercup**	**RANACR**	**non-native**	**0**	**0**
Ranunculus hispidus	swamp buttercup	RANHIS	native	5	0
Ribes americanum	wild black currant	RIBAME	native	6	-3
Rubus parviflorus	thimbleberry	RUBPAR	native	6	3
Rubus pubescens	dwarf raspberry	RUBPUB	native	4	-3
Sambucus racemosa	red-berried elder	SAMRAC	native	3	3
Shepherdia canadensis	soapberry	SHECAN	native	7	5
Solanum dulcamara	**bittersweet nightshade**	**SOLDUL**	**non-native**	**0**	**0**
Sorbus decora	mountain-ash	SORDEC	native	4	3
Symphyotrichum ciliolatum; aster c.	northern heart-leaved aster	SYMCIO	native	4	5
Symphyotrichum lateriflorum; aster l.	calico aster	SYMLAT	native	2	0
Taxus canadensis	yew	TAXCAN	native	5	3
Thelypteris palustris	marsh fern	THEPAL	native	2	-3
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3
Tilia americana	basswood	TILAME	native	5	3
Toxicodendron radicans	poison-ivy	TOXRAD	native	2	0
Trientalis borealis	star-flower	TRIBOR	native	5	0
Trillium grandiflorum	common trillium	TRIGRA	native	5	3
Viburnum trilobum; v. opulus	american highbush-cranberry	VIBTRI	native	5	-3
Viola labradorica; v. conspersa	dog violet	VIOLAB	native	3	0
Viola renifolia	kidney-leaved violet	VIOREN	native	6	-3
Vitis riparia	river-bank grape	VITRIP	native	3	0

Appendix 2.16. Sugar Island Coastal Fen FQA

Conservatism-Based Metrics:

Total Mean C:	4.2
Native Mean C:	4.5
Total FQI:	39.4
Native FQI:	40.7
Adjusted FQI:	43.4
% C value 0:	10.2
% C value 1-3:	23.9
% C value 4-6:	53.4
% C value 7-10:	12.5
Native Tree Mean C:	3.9
Native Shrub Mean C:	5
Native Herbaceous Mean C:	4.5

Species Richness:

Total Species:	88	
Native Species:	82	93.20%
Non-native Species:	6	6.80%

Species Wetness:

Mean Wetness:	1.3
Native Mean Wetness:	1.2

Physiognomy Metrics:

Tree:	12	13.60%
Shrub:	14	15.90%
Vine:	5	5.70%
Forb:	47	53.40%
Grass:	1	1.10%
Sedge:	2	2.30%
Rush:	0	0%
Fern:	7	8%
Bryophyte:	0	0%

Duration Metrics:

Annual:	4	4.50%
Perennial:	81	92%
Biennial:	3	3.40%
Native Annual:	4	4.50%
Native Perennial:	77	87.50%
Native Biennial:	1	1.10%

Appendix 2.16. Sugar Island Coastal Fen FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Abies balsamea	balsam fir	ABIBAL	native	3	0
Acer pensylvanicum	striped maple	ACEPEN	native	5	3
Acer spicatum	mountain maple	ACESPI	native	5	3
Actaea pachypoda	dolls-eyes	ACTPAC	native	7	5
Actaea rubra	red baneberry	ACTRUB	native	7	3
Agrimonia gryposepala	tall agrimony	AGRGRY	native	2	3
Anemone canadensis	canada anemone	ANECAN	native	4	-3
Aquilegia canadensis	wild columbine	AQUCAN	native	5	3
Aralia nudicaulis	wild sarsaparilla	ARANUD	native	5	3
Aralia racemosa	spikenard	ARARAC	native	8	3
Arctium minus	**common burdock**	**ARCMIN**	**non-native**	**0**	**3**
Arctostaphylos uva-ursi	bearberry	ARCUVA	native	8	5
Arisaema triphyllum	jack-in-the-pulpit	ARITRI	native	5	0
Betula alleghaniensis	yellow birch	BETALL	native	7	0
Betula papyrifera	paper birch	BETPAP	native	2	3
Botrypus virginianus	rattlesnake fern	BOTVIR	native	5	3
Carex deweyana	sedge	CXDEWE	native	3	3
Carex eburnea	sedge	CXEBUR	native	7	3
Caulophyllum thalictroides	blue cohosh	CAUTHA	native	5	5
Circaea alpina	small enchanters-nightshade	CIRALP	native	4	-3
Circaea canadensis; c. lutetiana	enchanters-nightshade	CIRCAN	native	2	3
Cirsium muticum	swamp thistle	CIRMUT	native	6	-5
Clinopodium vulgare	wild-basil	CLIVUL	native	3	5
Clintonia borealis	bluebead-lily; corn-lily	CLIBOR	native	5	0
Cornus rugosa	round-leaved dogwood	CORRUG	native	6	5
Corylus cornuta	beaked hazelnut	CORCOR	native	5	3
Cypripedium parviflorum; c. calceolus	yellow lady-slipper	CYPPAR	native	5	0
Diervilla lonicera	bush-honeysuckle	DIELON	native	4	5
Dryopteris carthusiana	spinulose woodfern	DRYCAR	native	5	-3
Dryopteris intermedia	evergreen woodfern	DRYINT	native	5	0
Epilobium coloratum	cinnamon willow-herb	EPICOL	native	3	-5
Epipactis helleborine	**helleborine**	**EPIHEL**	**non-native**	**0**	**0**
Eurybia macrophylla; aster m.	big-leaved aster	EURMAC	native	4	5
Fraxinus nigra	black ash	FRANIG	native	6	-3
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Galium triflorum	fragrant bedstraw	GALTRR	native	4	3
Geranium robertianum	herb robert	GERROB	native	3	3
Geum canadense	white avens	GEUCAN	native	1	0
Geum fragarioides; waldsteinia f.	barren-strawberry	GEUFRA	native	6	5
Gymnocarpium dryopteris	oak fern	GYMDRY	native	5	3
Halenia deflexa	spurred gentian	HALDEF	native	7	0
Heracleum maximum	cow-parsnip	HERMAX	native	3	-3
Hieracium caespitosum	**king devil**	**HIECAE**	**non-native**	**0**	**5**
Huperzia lucidula	shining clubmoss	HUPLUC	native	5	0
Impatiens capensis	spotted touch-me-not	IMPCAP	native	2	-3
Linnaea borealis	twinflower	LINBOR	native	6	0

Appendix 2.17. Sugar Island Great Lakes Marsh FQA

Conservatism-Based Metrics:

Total Mean C:	3.8
Native Mean C:	4.7
Total FQI:	26.3
Native FQI:	29.4
Adjusted FQI:	42.4
% C value 0:	20.8
% C value 1-3:	20.8
% C value 4-6:	39.6
% C value 7-10:	18.8
Native Tree Mean C:	3.7
Native Shrub Mean C:	4
Native Herbaceous Mean C:	5

Species Richness:

Total Species:	48	
Native Species:	39	81.30%
Non-native Species:	9	18.80%

Species Wetness:

Mean Wetness:	-3.6
Native Mean Wetness:	-3.9

Physiognomy Metrics:

Tree:	3	6.30%
Shrub:	8	16.70%
Vine:	1	2.10%
Forb:	24	50%
Grass:	2	4.20%
Sedge:	8	16.70%
Rush:	2	4.20%
Fern:	0	0%
Bryophyte:	0	0%

Duration Metrics:

Annual:	4	8.30%
Perennial:	41	85.40%
Biennial:	3	6.30%
Native Annual:	4	8.30%
Native Perennial:	34	70.80%
Native Biennial:	1	2.10%

Appendix 2.17. Sugar Island Great Lakes Marsh FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Agalinis purpurea	purple false foxglove	AGAPUR	native	7	-3
Alnus incana; a. rugosa	speckled alder	ALNINC	native	5	-3
Calamagrostis canadensis	blue-joint	CALCAN	native	3	-5
Campanula aparinoides	marsh bellflower	CAMAPA	native	7	-5
Carex aquatilis	sedge	CXAQUA	native	7	-5
Carex lacustris	sedge	CXLACU	native	6	-5
Carex stricta	sedge	CXSTRI	native	4	-5
Carex viridula	sedge	CXVIRU	native	4	-5
Cirsium vulgare	**bull thistle**	**CIRVUL**	**non-native**	**0**	**3**
Cladium mariscoides	twig-rush	CLAMAR	native	10	-5
Clinopodium arkansanum; calamintha a.	limestone calamint	CLIARK	native	10	-3
Cornus sericea; c. stolonifera	red-osier	CORSER	native	2	-3
Dasiphora fruticosa; potentilla f.	shrubby cinquefoil	DASFRU	native	8	-3
Eleocharis elliptica	golden-seeded spike rush	ELEELL	native	6	-5
Eleocharis palustris; e. smallii	spike-rush	ELEPAL	native	5	-5
Epilobium hirsutum	**great hairy willow-herb**	**EPIHIR**	**non-native**	**0**	**-3**
Epilobium leptophyllum	fen willow-herb	EPILEP	native	6	-5
Epilobium parviflorum	**willow-herb**	**EPIPAR**	**non-native**	**0**	**-5**
Eupatorium perfoliatum	boneset	EUPPER	native	4	-3
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Hydrocharis morsus-ranae	**european frogs-bit**	**HYDMOR**	**non-native**	**0**	**-5**
Impatiens capensis	spotted touch-me-not	IMPCAP	native	2	-3
Juncus balticus	rush	JUNBAL	native	4	-5
Juncus dudleyi	dudleys rush	JUNDUD	native	1	-3
Larix laricina	tamarack	LARLAR	native	5	-3
Lemna turionifera; l. minor	red duckweed	LEMTUR	native	5	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Mentha Ã—piperita	**peppermint**	**MENPIP**	**non-native**	**0**	**-5**
Myriophyllum sibiricum; m. exalbescens	spiked water-milfoil	MYRSIB	native	10	-5
Najas flexilis	slender naiad	NAJFLE	native	5	-5
Oenothera biennis	common evening-primrose	OENBIE	native	2	3
Persicaria amphibia; polygonum a.	water smartweed	PERAMP	native	6	-5
Phalaris arundinacea	reed canary grass	PHAARU	native	0	-3
Potamogeton gramineus	pondweed	POTGRM	native	5	-5
Ranunculus sceleratus	cursed crowfoot	RANSCE	native	1	-5
Sagittaria latifolia	common arrowhead	SAGLAT	native	4	-5
Salix discolor	pussy willow	SALDIS	native	1	-3
Salix eriocephala	willow	SALERI	native	2	-3
Salix myricoides	blueleaf willow	SALMYR	native	9	-3
Salix petiolaris	slender willow	SALPET	native	1	-3
Schoenoplectus tabernaemontani	softstem bulrush	SCHTAB	native	4	-5
Solanum dulcamara	**bittersweet nightshade**	**SOLDUL**	**non-native**	**0**	**0**
Spiraea alba	meadowsweet	SPIALB	native	4	-3
Stuckenia filiformis	narrow-leaved pondweed	STUFIL	native	7	-5
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3
Typha angustifolia	**narrow-leaved cat-tail**	**TYPANG**	**non-native**	**0**	**-5**
Verbascum thapsus	**common mullein**	**VERTHA**	**non-native**	**0**	**5**
Verbena hastata	blue vervain	VERHAS	native	4	-3

Appendix 2.18. Sugar Island Limestone Bedrock Lakeshore FQA

Conservatism-Based Metrics:

Total Mean C:	1.9
Native Mean C:	3
Total FQI:	12.6
Native FQI:	15.9
Adjusted FQI:	23.9
% C value 0:	40.9
% C value 1-3:	34.1
% C value 4-6:	20.5
% C value 7-10:	4.5
Native Tree Mean C:	1.7
Native Shrub Mean C:	5
Native Herbaceous Mean C:	2.9

Physiognomy Metrics:

Tree:	3	6.80%
Shrub:	4	9.10%
Vine:	1	2.30%
Forb:	29	65.90%
Grass:	4	9.10%
Sedge:	1	2.30%
Rush:	2	4.50%
Fern:	0	0%
Bryophyte:	0	0%

Species Richness:

Total Species:	44	
Native Species:	28	63.60%
Non-native Species:	16	36.40%

Duration Metrics:

Annual:	9	20.50%
Perennial:	31	70.50%
Biennial:	4	9.10%
Native Annual:	6	13.60%
Native Perennial:	22	50%
Native Biennial:	0	0%

Species Wetness:

Mean Wetness:	-0.8
Native Mean Wetness:	-1.8

Appendix 2.18. Sugar Island Limestone Bedrock Lakeshore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Agrostis gigantea	**redtop**	**AGRGIG**	**non-native**	**0**	**-3**
Agrostis scabra; a. hyemalis	ticklegrass	AGRSCA	native	4	0
Ambrosia artemisiifolia	common ragweed	AMBART	native	0	3
Barbarea vulgaris	**yellow rocket**	**BARVUL**	**non-native**	**0**	**0**
Betula papyrifera	paper birch	BETPAP	native	2	3
Calamagrostis canadensis	blue-joint	CALCAN	native	3	-5
Carex stricta	sedge	CXSTRI	native	4	-5
Cirsium vulgare	**bull thistle**	**CIRVUL**	**non-native**	**0**	**3**
Cornus sericea; c. stolonifera	red-osier	CORSER	native	2	-3
Dasiphora fruticosa; potentilla f.	shrubby cinquefoil	DASFRU	native	8	-3
Elymus repens; agropyron r.	**quack grass**	**ELYREP**	**non-native**	**0**	**3**
Epilobium coloratum	cinnamon willow-herb	EPICOL	native	3	-5
Epilobium hirsutum	**great hairy willow-herb**	**EPIHIR**	**non-native**	**0**	**-3**
Epilobium parviflorum	**willow-herb**	**EPIPAR**	**non-native**	**0**	**-5**
Erechtites hieraciifolius	fireweed	EREHIE	native	2	3
Erucastrum gallicum	**dog mustard**	**ERUGAL**	**non-native**	**0**	**3**
Erysimum cheiranthoides	**wormseed mustard**	**ERYCHE**	**non-native**	**0**	**3**
Eupatorium perfoliatum	boneset	EUPPER	native	4	-3
Fallopia cilinodis; polygonum c.	fringed false buckwheat	FALCIL	native	3	5
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Geum aleppicum	yellow avens	GEUALE	native	3	0
Hypericum perforatum	**common st. johns-wort**	**HYPPER**	**non-native**	**0**	**5**
Impatiens capensis	spotted touch-me-not	IMPCAP	native	2	-3
Juncus balticus	rush	JUNBAL	native	4	-5
Juncus tenuis	path rush	JUNTEN	native	1	0
Leucanthemum vulgare	**ox-eye daisy**	**LEUVUL**	**non-native**	**0**	**5**
Lycopus americanus	common water horehound	LYCAME	native	2	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Pastinaca sativa	**wild parsnip**	**PASSAT**	**non-native**	**0**	**5**
Persicaria maculosa; polygonum persicaria	**ladys-thumb**	**PERMAC**	**non-native**	**0**	**0**
Persicaria punctata; polygonum p.	smartweed	PERPUN	native	5	-5
Physocarpus opulifolius	ninebark	PHYOPU	native	4	-3
Polygonum ramosissimum	bushy knotweed	POLRAM	native	7	0
Populus tremuloides	quaking aspen	POPTRE	native	1	0
Potentilla anserina	silverweed	POTANS	native	5	-3
Potentilla norvegica	rough cinquefoil	POTNOR	native	0	0
Ribes americanum	wild black currant	RIBAME	native	6	-3
Symphyotrichum lanceolatum; aster l.	panicled aster	SYMLAN	native	2	-3
Tussilago farfara	**coltsfoot**	**TUSFAR**	**non-native**	**0**	**3**
Typha latifolia	broad-leaved cat-tail	TYPLAT	native	1	-5
Typha Ã—glauca	**hybrid cat-tail**	**TYPGLA**	**non-native**	**0**	**-5**
Urtica dioica	stinging nettle	URTDIO	native	1	0
Verbascum thapsus	**common mullein**	**VERTHA**	**non-native**	**0**	**5**
Verbena hastata	blue vervain	VERHAS	native	4	-3

Appendix 2.19. Sugar Island Limestone Cobble Shore FQA

Conservatism-Based Metrics:

Total Mean C:	3.2
Native Mean C:	4
Total FQI:	32.5
Native FQI:	36.2
Adjusted FQI:	35.7
% C value 0:	24.3
% C value 1-3:	35
% C value 4-6:	28.2
% C value 7-10:	12.6
Native Tree Mean C:	3
Native Shrub Mean C:	5
Native Herbaceous Mean C:	3.8

Physiognomy Metrics:

Tree:	11	10.70%
Shrub:	20	19.40%
Vine:	5	4.90%
Forb:	54	52.40%
Grass:	8	7.80%
Sedge:	4	3.90%
Rush:	1	1%
Fern:	0	0%
Bryophyte:	0	0%

Species Richness:

Total Species:	103	
Native Species:	82	79.60%
Non-native Species:	21	20.40%

Duration Metrics:

Annual:	14	13.60%
Perennial:	85	82.50%
Biennial:	4	3.90%
Native Annual:	9	8.70%
Native Perennial:	72	69.90%
Native Biennial:	1	1%

Species Wetness:

Mean Wetness:	-0.4
Native Mean Wetness:	-0.8

Appendix 2.19. Sugar Island Limestone Cobble Shore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Abies balsamea	balsam fir	ABIBAL	native	3	0
Achillea millefolium	yarrow	ACHMIL	native	1	3
Ambrosia artemisiifolia	common ragweed	AMBART	native	0	3
Andropogon gerardii	big bluestem	ANDGER	native	5	0
Anemone canadensis	canada anemone	ANECAN	native	4	-3
Anemone virginiana	thimbleweed	ANEVIR	native	3	3
Arctostaphylos uva-ursi	bearberry	ARCUVA	native	8	5
Asclepias syriaca	common milkweed	ASCSYR	native	1	5
Asparagus officinalis	**garden asparagus**	**ASPOFF**	**non-native**	**0**	**3**
Barbarea vulgaris	**yellow rocket**	**BARVUL**	**non-native**	**0**	**0**
Betula papyrifera	paper birch	BETPAP	native	2	3
Bidens trichosperma; b. coronatus	tickseed-sunflower	BIDTRI	native	7	-5
Calamagrostis canadensis	blue-joint	CALCAN	native	3	-5
Carex crawei	sedge	CXCRAE	native	10	-3
Carex pellita; c. lanuginosa	sedge	CXPELL	native	2	-5
Cirsium arvense	**canada thistle**	**CIRARV**	**non-native**	**0**	**3**
Cirsium vulgare	**bull thistle**	**CIRVUL**	**non-native**	**0**	**3**
Clinopodium arkansanum; calamintha a.	limestone calamint	CLIARK	native	10	-3
Clinopodium vulgare	wild-basil	CLIVUL	native	3	5
Comandra umbellata	bastard-toadflax	COMUMB	native	5	3
Cornus rugosa	round-leaved dogwood	CORRUG	native	6	5
Cornus sericea; c. stolonifera	red-osier	CORSER	native	2	-3
Dasiphora fruticosa; potentilla f.	shrubby cinquefoil	DASFRU	native	8	-3
Dichanthelium implicatum; panicum i.	panic grass	DICIMP	native	3	0
Eleocharis elliptica	golden-seeded spike rush	ELEELL	native	6	-5
Elymus canadensis	canada wild rye	ELYCAN	native	5	3
Epilobium coloratum	cinnamon willow-herb	EPICOL	native	3	-5
Epilobium hirsutum	**great hairy willow-herb**	**EPIHIR**	**non-native**	**0**	**-3**
Epipactis helleborine	**helleborine**	**EPIHEL**	**non-native**	**0**	**0**
Erucastrum gallicum	**dog mustard**	**ERUGAL**	**non-native**	**0**	**3**
Erysimum cheiranthoides	**wormseed mustard**	**ERYCHE**	**non-native**	**0**	**3**
Eupatorium perfoliatum	boneset	EUPPER	native	4	-3
Fallopia cilinodis; polygonum c.	fringed false buckwheat	FALCIL	native	3	5
Fallopia convolvulus; polygonum c.	**false buckwheat**	**FALCON**	**non-native**	**0**	**3**
Fragaria virginiana	wild strawberry	FRAVIR	native	2	3
Fraxinus nigra	black ash	FRANIG	native	6	-3
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Geranium robertianum	herb robert	GERROB	native	3	3
Geum aleppicum	yellow avens	GEUALE	native	3	0
Hypericum perforatum	**common st. johns-wort**	**HYPPER**	**non-native**	**0**	**5**
Impatiens capensis	spotted touch-me-not	IMPCAP	native	2	-3
Juncus balticus	rush	JUNBAL	native	4	-5
Linnaea borealis	twinflower	LINBOR	native	6	0
Lycopus americanus	common water horehound	LYCAME	native	2	-5
Lycopus uniflorus	northern bugle weed	LYCUNI	native	2	-5
Lythrum salicaria	**purple loosestrife**	**LYTSAL**	**non-native**	**0**	**-5**
Maianthemum canadense	canada mayflower	MAICAN	native	4	3
Maianthemum stellatum; smilacina s.	starry false solomon-seal	MAISTE	native	5	0
Medicago lupulina	**black medick**	**MEDLUP**	**non-native**	**0**	**3**
Mentha canadensis; m. arvensis	wild mint	MENCAS	native	3	-3
Myrica gale	sweet gale	MYRGAL	native	6	-5

Appendix 2.19. Sugar Island Limestone Cobble Shore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Oenothera biennis	common evening-primrose	OENBIE	native	2	3
Panicum flexile	panic grass	PANFLE	native	8	-3
Persicaria lapathifolia; polygonum l.	nodding smartweed	PERLAP	native	0	-3
Persicaria maculosa; polygonum persicaria	**ladys-thumb**	**PERMAC**	**non-native**	**0**	**0**
Persicaria pensylvanica; polygonum p.	bigseed smartweed	PERPEN	native	0	-3
Phleum pratense	**timothy**	**PHLPRA**	**non-native**	**0**	**3**
Physocarpus opulifolius	ninebark	PHYOPU	native	4	-3
Picea glauca	white spruce	PICGLA	native	3	3
Poa compressa	**canada bluegrass**	**POACOM**	**non-native**	**0**	**3**
Polygonum ramosissimum	bushy knotweed	POLRAM	native	7	0
Populus balsamifera	balsam poplar	POPBAL	native	2	-3
Populus deltoides	cottonwood	POPDEL	native	1	0
Populus tremuloides	quaking aspen	POPTRE	native	1	0
Potentilla anserina	silverweed	POTANS	native	5	-3
Potentilla norvegica	rough cinquefoil	POTNOR	native	0	0
Prunus pumila	sand cherry	PRUPUM	native	8	5
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Ranunculus recurvatus	hooked crowfoot	RANREC	native	5	-3
Rhus typhina	staghorn sumac	RHUTYP	native	2	3
Rhynchospora capillacea	beak-rush	RHYCAL	native	10	-5
Ribes americanum	wild black currant	RIBAME	native	6	-3
Ribes hirtellum	swamp gooseberry	RIBHIR	native	6	-3
Rosa acicularis	wild rose	ROSACI	native	4	3
Rubus strigosus	wild red raspberry	RUBSTR	native	2	0
Rudbeckia hirta	black-eyed susan	RUDHIR	native	1	3
Salix bebbiana	bebbs willow	SALBEB	native	1	-3
Salix candida	hoary willow	SALCAN	native	9	-5
Salix exigua	sandbar willow	SALEXI	native	1	-3
Salix myricoides	blueleaf willow	SALMYR	native	9	-3
Schizachyrium scoparium; andropogon s.	little bluestem	SCHSCO	native	5	3
Scutellaria galericulata	marsh skullcap	SCUGAL	native	5	-5
Scutellaria lateriflora	mad-dog skullcap	SCULAT	native	5	-5
Shepherdia canadensis	soapberry	SHECAN	native	7	5
Solanum dulcamara	**bittersweet nightshade**	**SOLDUL**	**non-native**	**0**	**0**
Solidago altissima	tall goldenrod	SOLALT	native	1	3
Sonchus arvensis; s. uliginosus	**perennial sow-thistle**	**SONARV**	**non-native**	**0**	**3**
Sorbus decora	mountain-ash	SORDEC	native	4	3
Sparganium eurycarpum	common bur-reed	SPAEUR	native	5	-5
Spiraea alba	meadowsweet	SPIALB	native	4	-3
Symphyotrichum lanceolatum; aster l.	panicled aster	SYMLAN	native	2	-3
Thuja occidentalis	arbor vitae	THUOCC	native	4	-3
Tilia americana	basswood	TILAME	native	5	3
Toxicodendron radicans	poison-ivy	TOXRAD	native	2	0
Tussilago farfara	**coltsfoot**	**TUSFAR**	**non-native**	**0**	**3**
Typha angustifolia	**narrow-leaved cat-tail**	**TYPANG**	**non-native**	**0**	**-5**
Typha Ã—glauca	**hybrid cat-tail**	**TYPGLA**	**non-native**	**0**	**-5**
Urtica dioica	stinging nettle	URTDIO	native	1	0
Verbascum thapsus	**common mullein**	**VERTHA**	**non-native**	**0**	**5**
Verbena hastata	blue vervain	VERHAS	native	4	-3
Viburnum trilobum; v. opulus	american highbush-cranberry	VIBTRI	native	5	-3
Viola nephrophylla	northern bog violet	VIONEP	native	8	-3
Vitis riparia	river-bank grape	VITRIP	native	3	0

Appendix 2.20. Sugar Island Mesic Northern Forest FQA

Conservatism-Based Metrics:

Total Mean C:	4.4
Native Mean C:	4.4
Total FQI:	24.1
Native FQI:	24.1
Adjusted FQI:	44
% C value 0:	3.3
% C value 1-3:	26.7
% C value 4-6:	60
% C value 7-10:	10
Native Tree Mean C:	3.6
Native Shrub Mean C:	5
Native Herbaceous Mean C:	4.3

Species Richness:

Total Species:	30	
Native Species:	30	100%
Non-native Species:	0	0%

Species Wetness:

Mean Wetness:	1.1
Native Mean Wetness:	1.1

Physiognomy Metrics:

Tree:	5	16.70%
Shrub:	9	30%
Vine:	2	6.70%
Forb:	10	33.30%
Grass:	1	3.30%
Sedge:	1	3.30%
Rush:	0	0%
Fern:	2	6.70%
Bryophyte:	0	0%

Duration Metrics:

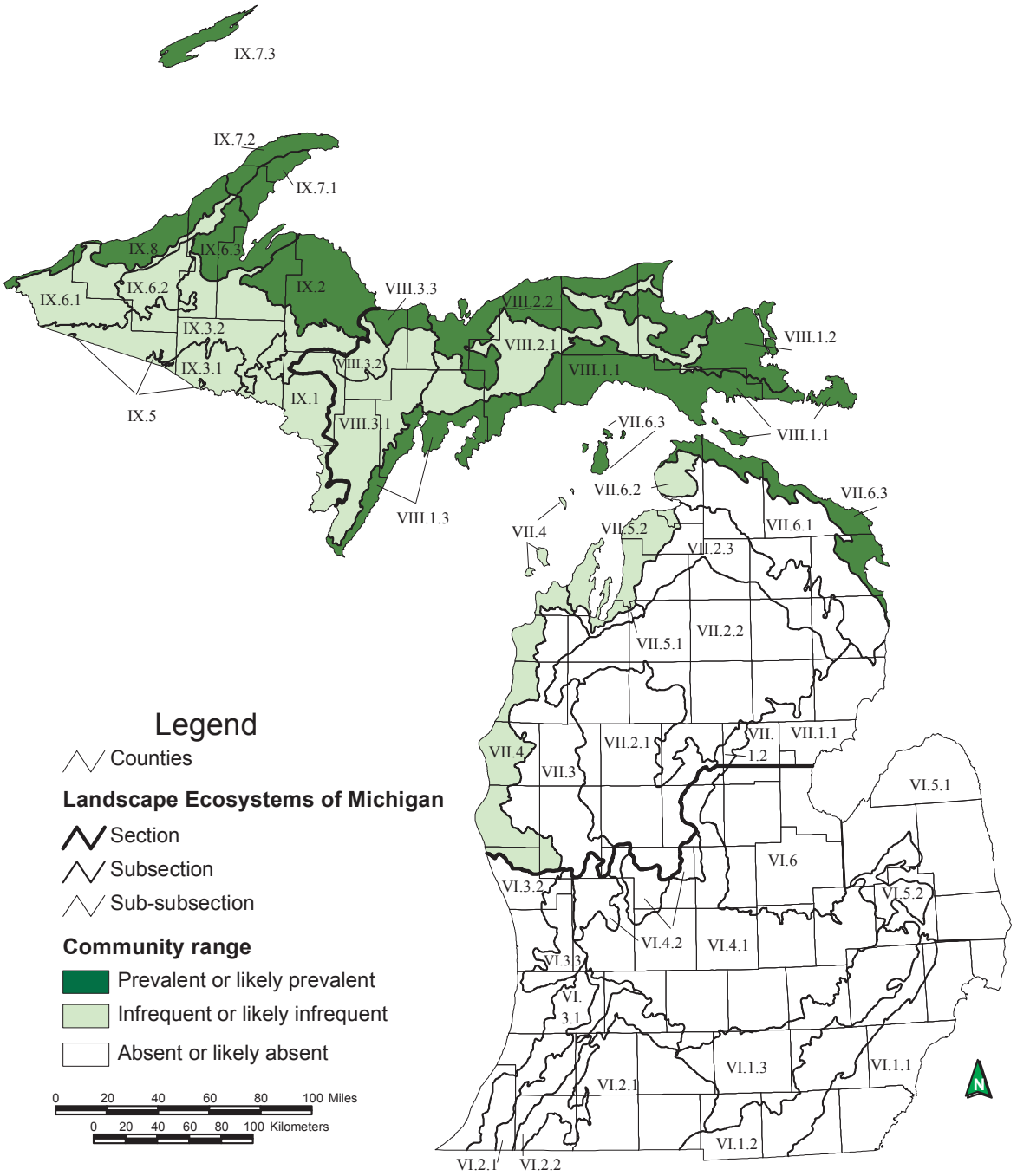
Annual:	2	6.70%
Perennial:	28	93.30%
Biennial:	0	0%
Native Annual:	2	6.70%
Native Perennial:	28	93.30%
Native Biennial:	0	0%

Appendix 2.20. Sugar Island Mesic Northern Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer saccharum	sugar maple	ACESAU	native	5	3
Acer spicatum	mountain maple	ACESPI	native	5	3
Actaea pachypoda	dolls-eyes	ACTPAC	native	7	5
Actaea rubra	red baneberry	ACTRUB	native	7	3
Arisaema triphyllum	jack-in-the-pulpit	ARITRI	native	5	0
Betula papyrifera	paper birch	BETPAP	native	2	3
Carex deweyana	sedge	CXDEWE	native	3	3
Clintonia borealis	bluebead-lily; corn-lily	CLIBOR	native	5	0
Cornus rugosa	round-leaved dogwood	CORRUG	native	6	5
Dryopteris carthusiana	spinulose woodfern	DRYCAR	native	5	-3
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Galium triflorum	fragrant bedstraw	GALTRR	native	4	3
Geranium robertianum	herb robert	GERROB	native	3	3
Heracleum maximum	cow-parsnip	HERMAX	native	3	-3
Impatiens capensis	spotted touch-me-not	IMPCAP	native	2	-3
Lonicera canadensis	canadian fly honeysuckle	LONCAN	native	5	3
Lonicera dioica	red honeysuckle	LONDIO	native	5	3
Maianthemum canadense	canada mayflower	MAICAN	native	4	3
Milium effusum	wood millet	MILEFF	native	8	3
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Pteridium aquilinum	bracken fern	PTEAQU	native	0	3
Ranunculus hispidus	swamp buttercup	RANHIS	native	5	0
Ribes americanum	wild black currant	RIBAME	native	6	-3
Ribes hirtellum	swamp gooseberry	RIBHIR	native	6	-3
Rubus parviflorus	thimbleberry	RUBPAR	native	6	3
Rubus pubescens	dwarf raspberry	RUBPUB	native	4	-3
Sorbus decora	mountain-ash	SORDEC	native	4	3
Taxus canadensis	yew	TAXCAN	native	5	3
Toxicodendron radicans	poison-ivy	TOXRAD	native	2	0
Viburnum trilobum; v. opulus	american highbush-cranberry	VIBTRI	native	5	-3

BOREAL FOREST

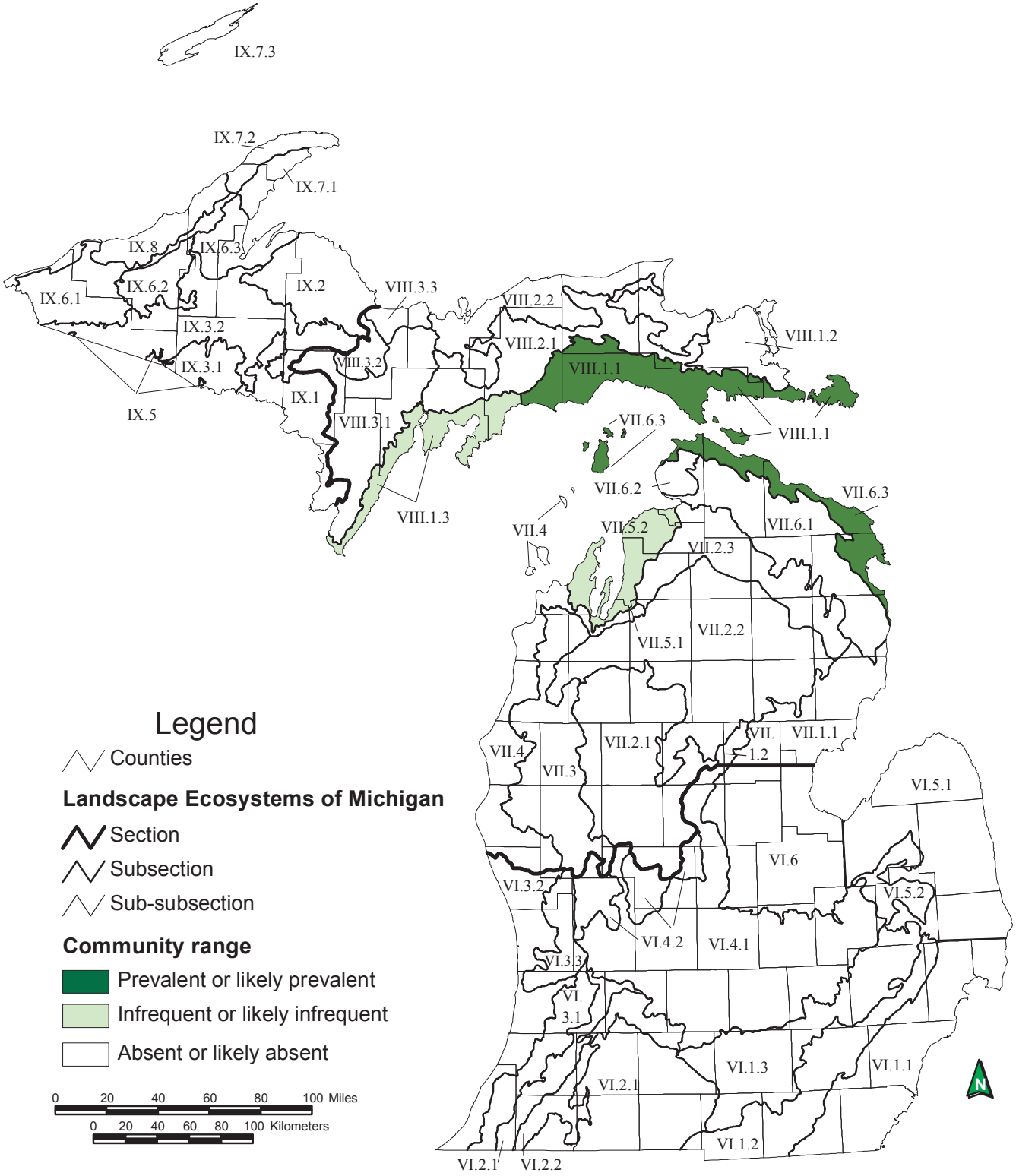
Overview: Boreal forest is a conifer or conifer-hardwood forest type occurring on moist to dry sites characterized by species dominant in the Canadian boreal forest. It typically occupies upland sites along shores of the Great Lakes, on islands in the Great Lakes, and locally inland. The community occurs north of the climatic tension zone primarily on sand dunes, glacial lakeplains, and thin soil over bedrock or cobble. Soils of sand and sandy loam are typically moderately acid to neutral, but heavier soils and more acid conditions are common. Proximity to the Great Lakes results in high levels of windthrow and climatic conditions characterized by low summer temperatures and high levels of humidity, snowfall, and summer fog and mist. Additional important forms of natural disturbance include fire and insect epidemics (Kost et al. 2007, Cohen et al. 2015).



Map 1. Distribution of boreal forest in Michigan (Albert et al. 2008).

COASTAL FEN

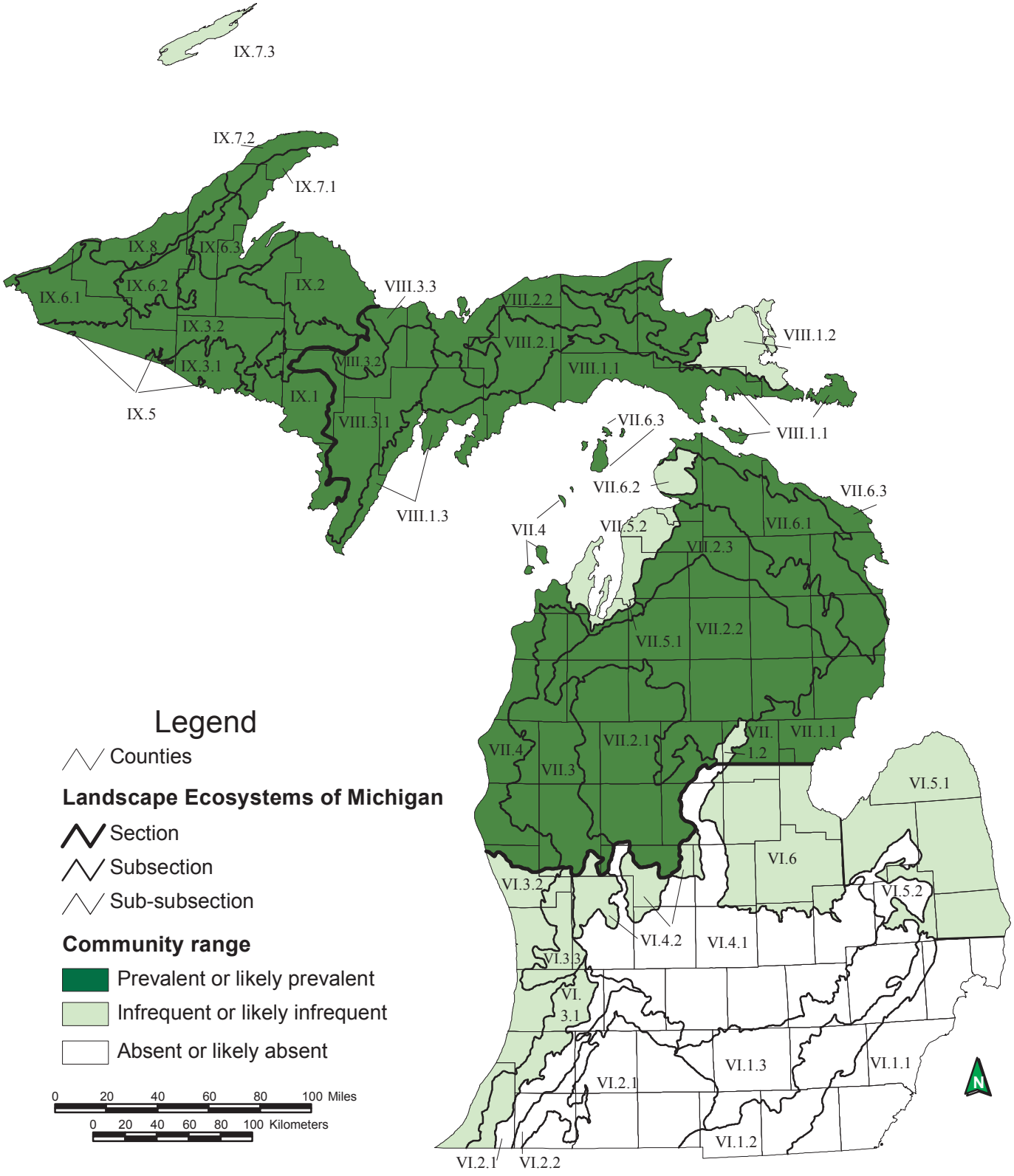
Overview: Coastal fen is a sedge- and rush-dominated wetland that occurs on calcareous substrates along Lake Huron and Lake Michigan north of the climatic tension zone. The community occurs where marl and organic soils accumulate in protected coves and abandoned coastal embayments and grade to moderately alkaline glacial tills and lacustrine sediments lakeward. Sediments along the lakeshore are typically fine-textured and rich in calcium and magnesium carbonates. Vegetation is comprised primarily of calcicolous species capable of growing on wet alkaline substrates (Kost et al. 2007, Cohen et al. 2015).



Map 2. Distribution of coastal fen in Michigan (Albert et al. 2008).

DRY-MESIC NORTHERN FOREST

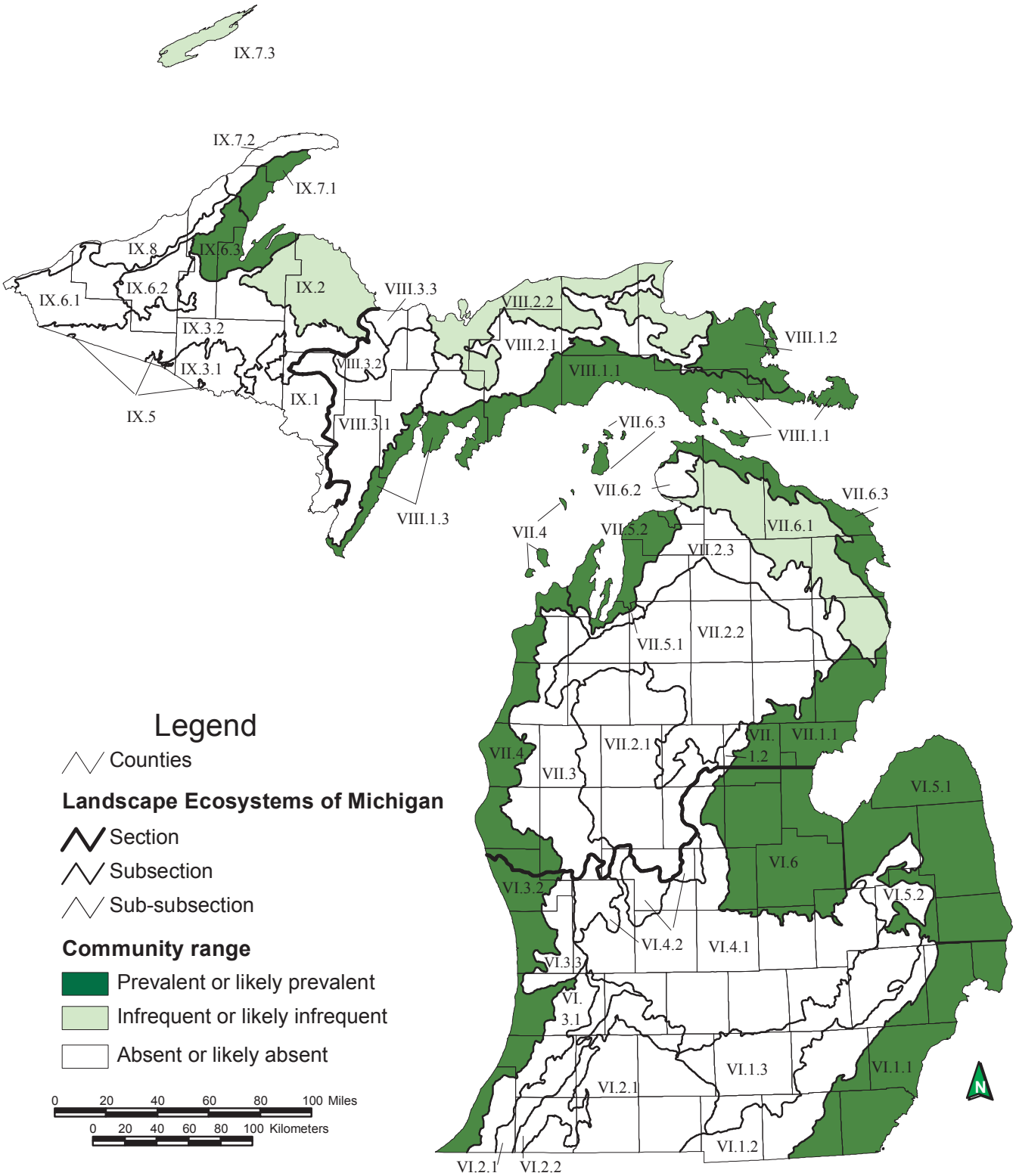
Overview: Dry-mesic northern forest is a pine or pine-hardwood forest type of generally dry-mesic sites located mostly north of the transition zone. Dry-mesic northern forest is characterized by acidic, coarse- to medium-textured sand or loamy sand and occurs principally on sandy glacial outwash, sandy glacial lakeplains, and less often on inland dune ridges, coarse-textured moraines, and thin glacial drift over bedrock. The community historically originated in the wake of catastrophic fire and was maintained by frequent, low-intensity ground fires (Kost et al. 2007, Cohen et al. 2015).



Map 3. Distribution of dry-mesic northern forest in Michigan (Albert et al. 2008).

GREAT LAKES MARSH

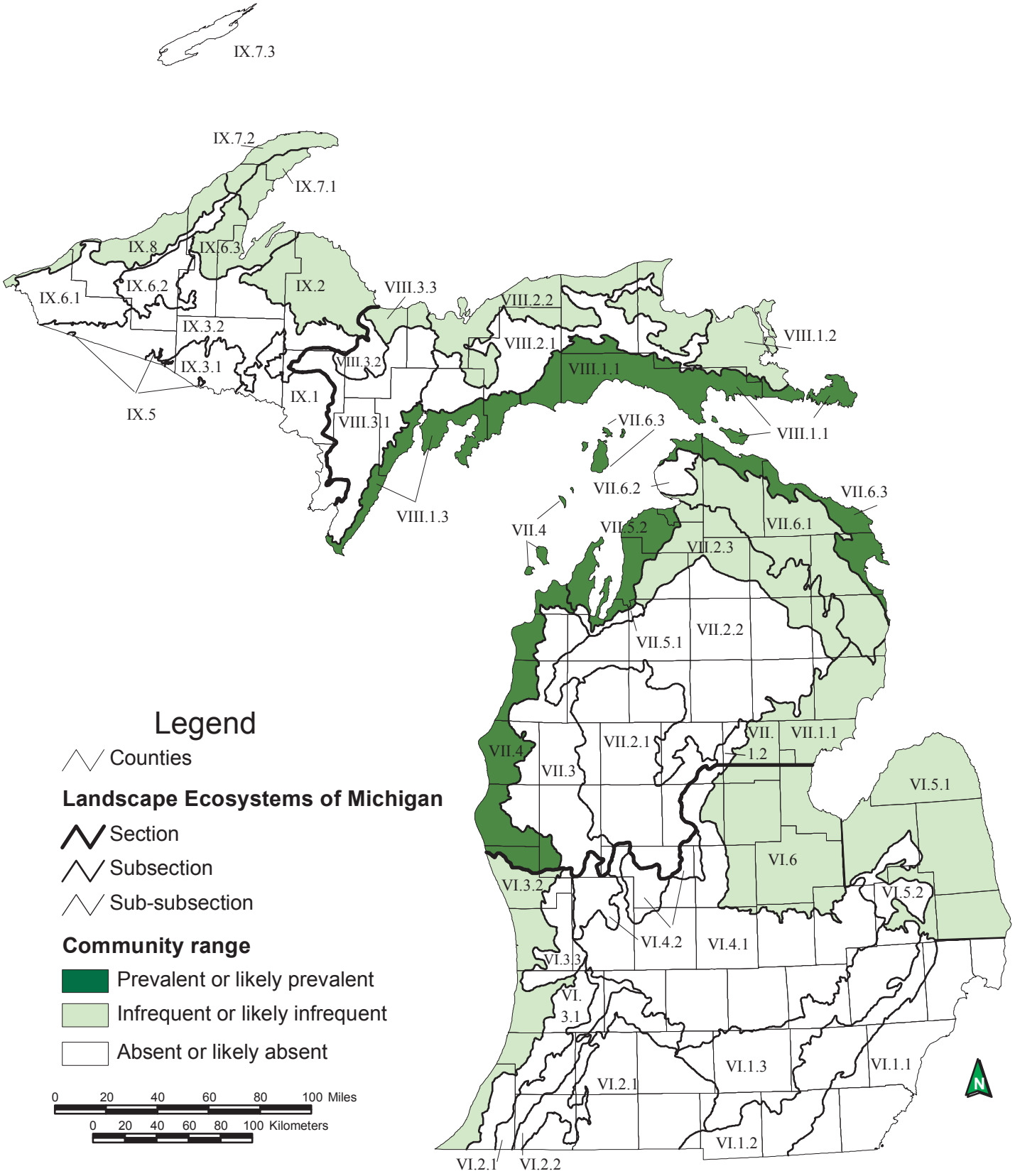
Overview: Great Lakes marsh is an herbaceous wetland community occurring statewide along the shoreline of the Great Lakes and their major connecting rivers. Vegetational patterns are strongly influenced by water level fluctuations and type of coastal feature, but generally include the following: a deep marsh with submerged plants; an emergent marsh of mostly narrow-leaved species; and a sedge-dominated wet meadow that is inundated by storms. Great Lakes marsh provides important habitat for migrating and breeding waterfowl, shore-birds, spawning fish, and medium-sized mammals (Kost et al. 2007, Cohen et al. 2015).



Map 4. Distribution of Great Lakes marsh in Michigan (Albert et al. 2008).

INTERDUNAL WETLAND

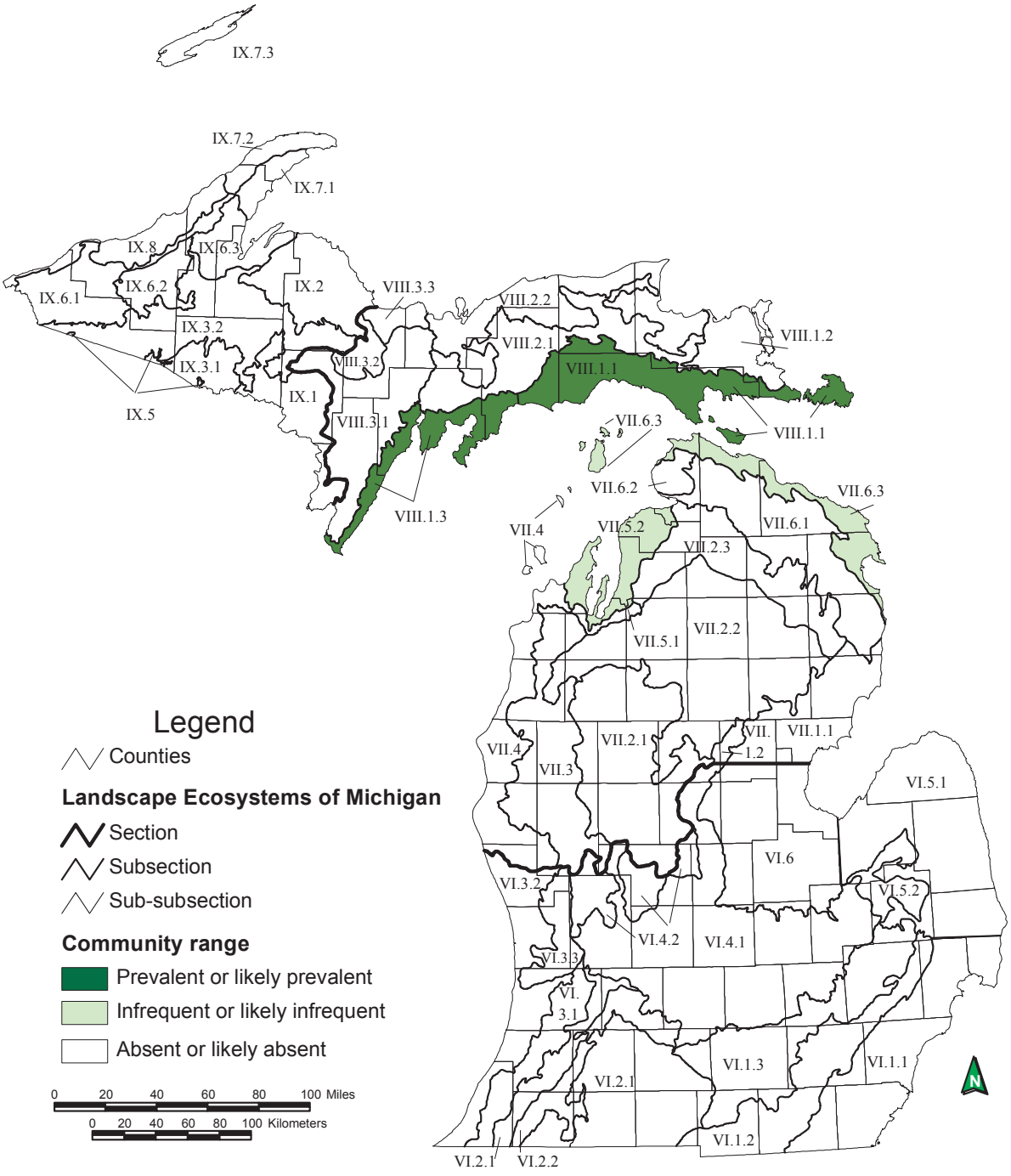
Overview: Interdunal wetland is a rush-, sedge-, and shrub-dominated wetland situated in depressions within open dunes or between beach ridges along the Great Lakes. This system is patterned by a dynamic water table that fluctuates seasonally and yearly in synchrony with lake level changes (Kost et al. 2007, Cohen et al. 2015).



Map 5. Distribution of interdunal wetland in Michigan (Albert et al. 2008).

LIMESTONE BEDROCK LAKESHORE

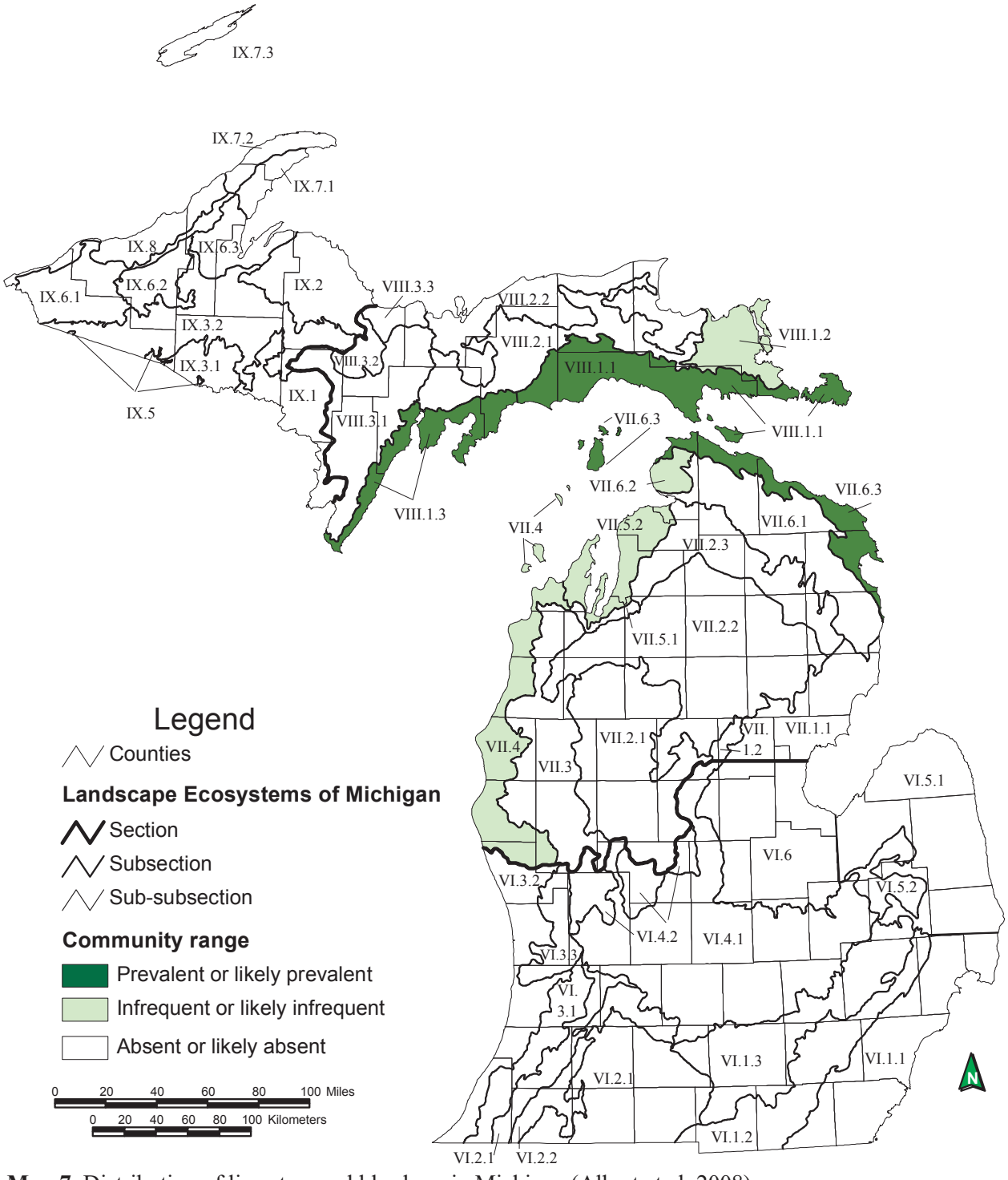
Overview: Limestone bedrock lakeshore is a sparsely vegetated natural community dominated by lichens, mosses, and herbaceous vegetation. This community, which is also referred to as alvar pavement and limestone pavement lakeshore, occurs along the shorelines of northern Lake Michigan and Lake Huron on broad, flat, horizontally bedded expanses of limestone or dolomite bedrock. On the Lake Michigan shoreline, limestone bedrock lakeshore is concentrated along the Garden Peninsula and adjacent islands and also occurs along the southern part of Schoolcraft County. Along Lake Huron, it is located east of the Les Cheneaux Islands, on Drummond Island, and on islands in Thunder Bay. Limestone bedrock lakeshore is subject to seasonal fluctuations in Great Lakes water levels, short-term changes due to seiches and storm surges, and long-term, multi-year lake level fluctuations. Storm waves frequently disturb limestone bedrock lakeshore, removing fine mineral sediments and organic soils. Winter storms scour vegetation from limestone bedrock lakeshore. Long-term cyclic fluctuations of Great Lakes water levels significantly influence vegetation patterns of limestone bedrock lakeshore, with vegetation and organic soils becoming well established during low-water periods and reduced or eliminated during high-water periods (Kost et al. 2007, Cohen et al. 2015).



Map 6. Distribution of limestone bedrock lakeshore in Michigan (Albert et al. 2008).

LIMESTONE COBBLE SHORE

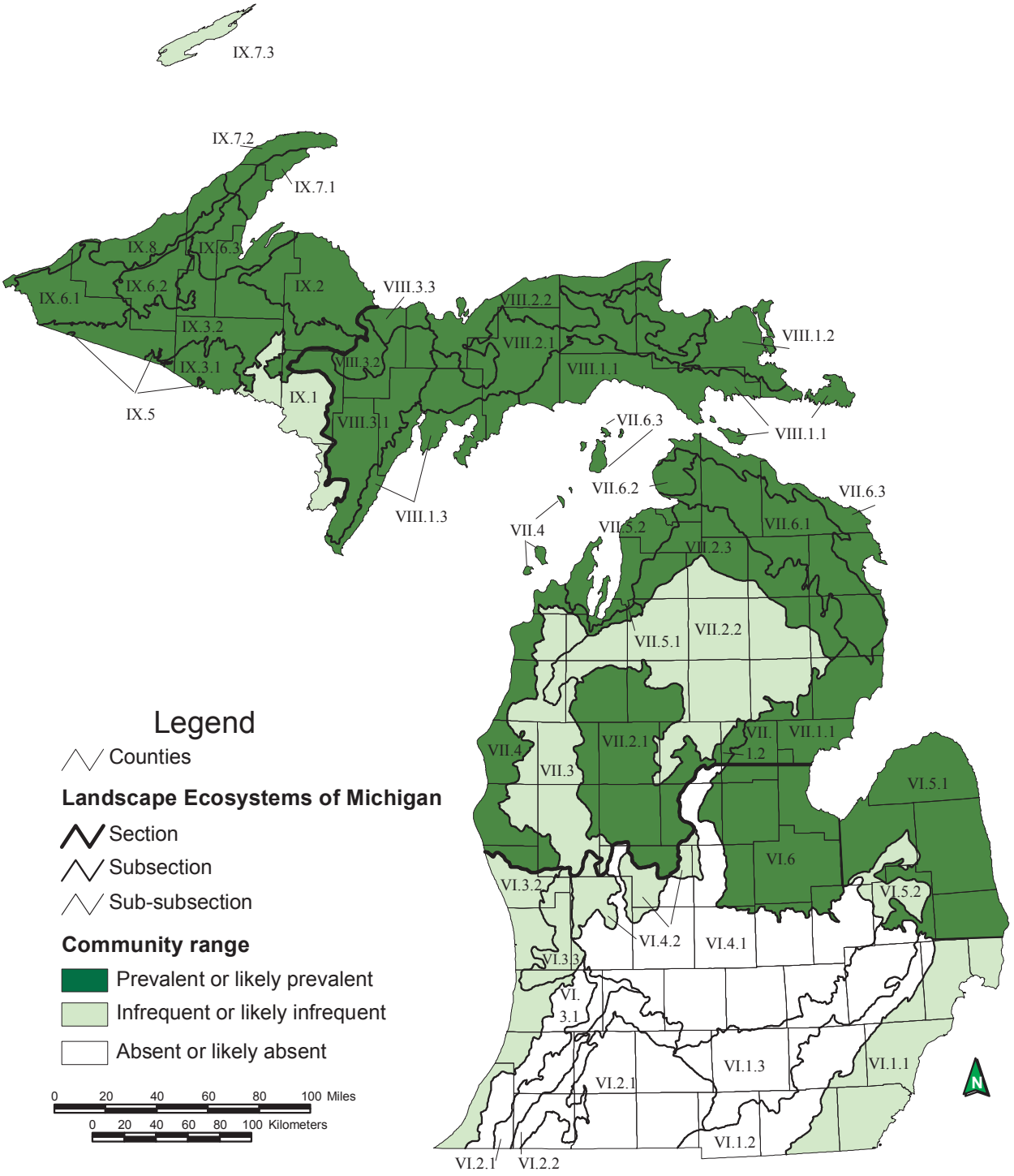
Overview: Limestone cobble shore occurs along gently sloping shorelines of Lake Michigan and Lake Huron. The community is studded with cobbles and boulders and is frequently inundated by storms and periods of high water. Limestone cobble shore is typically sparsely vegetated, because cobbles cover most of the surface and storm waves and ice scour prevent the development of a diverse, persistent plant community. Soils are neutral to slightly alkaline mucks and sands that accumulate between cobbles and boulders. Limestone cobble shore is subject to seasonal fluctuations in Great Lakes water levels, short-term changes due to seiches and storm surges, and long-term, multi-year lake level fluctuations. Storm waves frequently disturb limestone cobble shore, reconfiguring the substrate and removing fine mineral sediments and organic soils. Long-term cyclic fluctuations of Great Lakes water levels significantly influence vegetation patterns of limestone cobble shore, with vegetation and organic soils becoming well established during low-water periods and reduced or eliminated during high-water periods (Kost et al. 2007, Cohen et al. 2015).



Map 7. Distribution of limestone cobble shore in Michigan (Albert et al. 2008).

MESIC NORTHERN FOREST

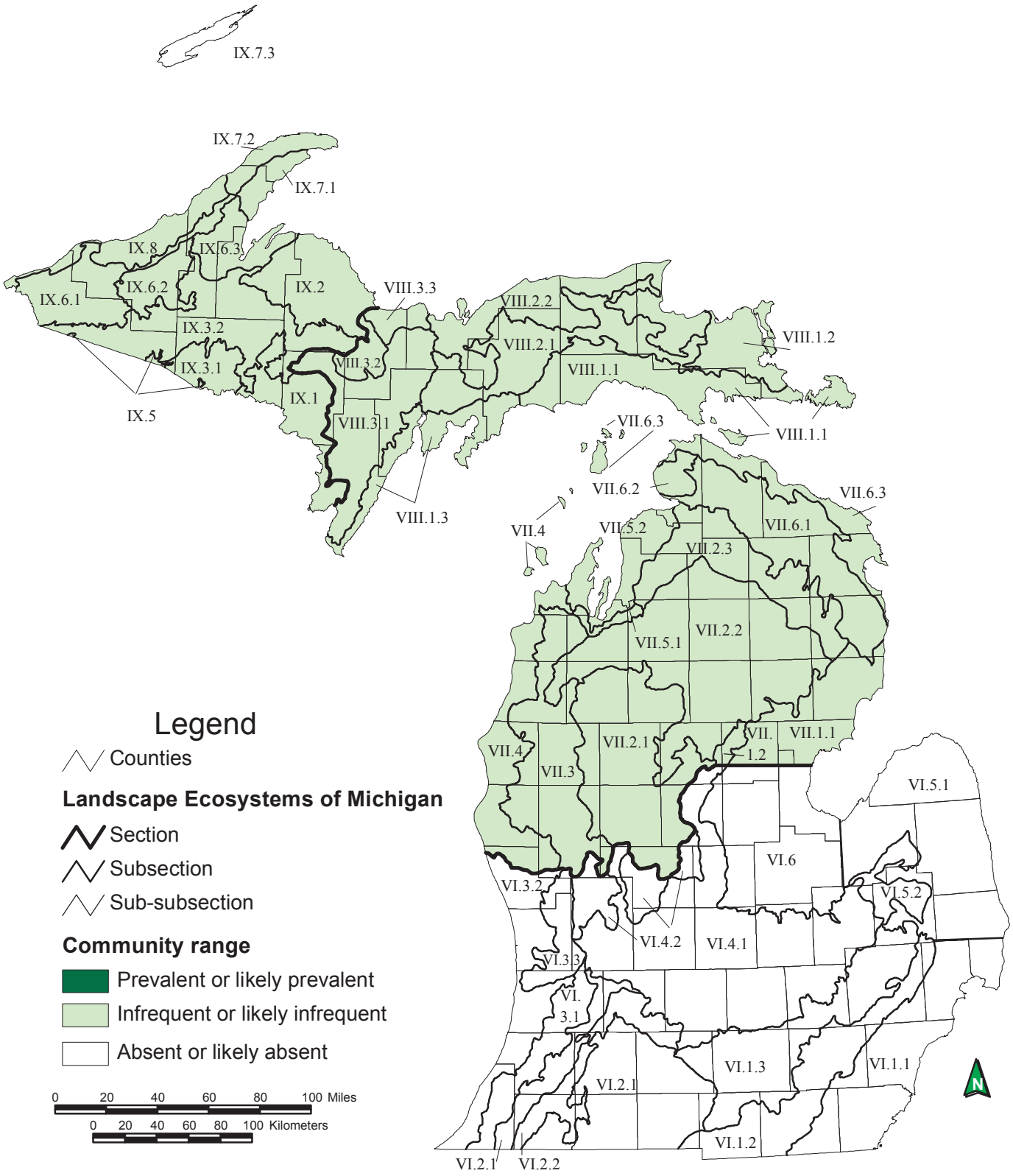
Overview: Mesic northern forest is a forest type of moist to dry-mesic sites lying mostly north of the climatic tension zone, characterized by the dominance of northern hardwoods, particularly sugar maple (*Acer saccharum*) and American beech (*Fagus grandifolia*). Conifers such as hemlock (*Tsuga canadensis*) and white pine (*Pinus strobus*) are frequently important canopy associates. This community type breaks into two broad classes: northern hardwood forest and hemlock-hardwood forest. It is primarily found on coarse-textured ground and end moraines, and soils are typically loamy sand to sandy loam. The natural disturbance regime is characterized by gap-phase dynamics; frequent, small windthrow gaps allow for the regeneration of the shade-tolerant canopy species. Catastrophic windthrow occurs infrequently with several generations of trees passing between large-scale, severe disturbance events. Historically, mesic northern forest occurred as a matrix system, dominating vast areas of mesic uplands in the Great Lakes region. These forests were multi-generational, with old-growth conditions lasting many centuries (Kost et al. 2007, Cohen et al. 2015).



Map 8. Distribution of mesic northern forest in Michigan (Albert et al. 2008).

NORTHERN HARDWOOD SWAMP

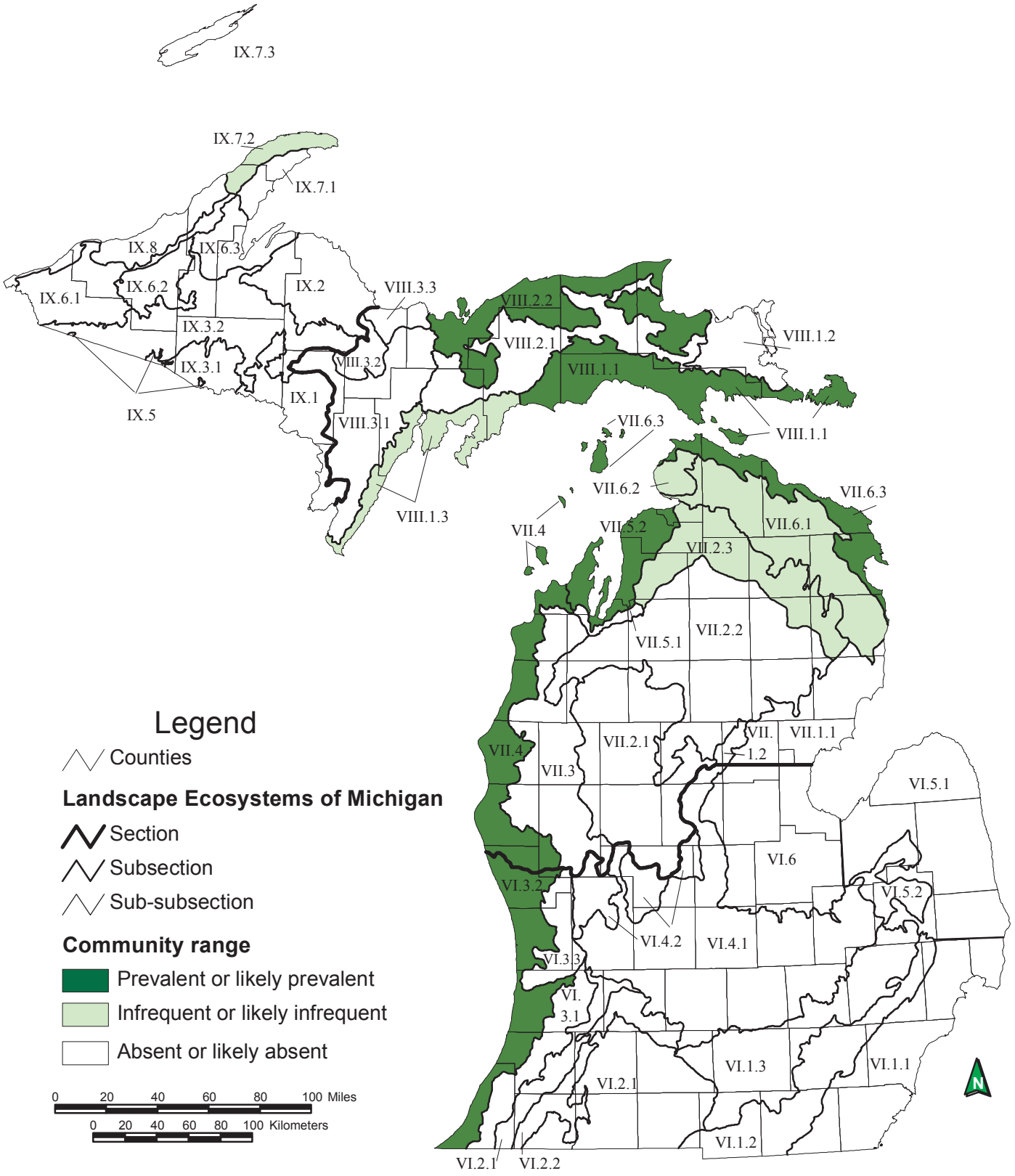
Overview: Northern hardwood swamp is a seasonally inundated, deciduous swamp forest community dominated by black ash (*Fraxinus nigra*) that occurs on neutral to slightly acidic, hydric mineral soils and shallow muck over mineral soils. Located north of the climatic tension zone, northern hardwood swamp is found primarily in depressions on level to hummocky glacial lakeplains, fine- and medium-textured glacial tills, and broad flat outwash plains. Fundamental disturbance factors affecting northern hardwood swamp development include seasonal flooding and windthrow (Kost et al. 2007, Cohen et al. 2015).



Map 9. Distribution of northern hardwood swamp in Michigan (Albert et al. 2008).

OPEN DUNES

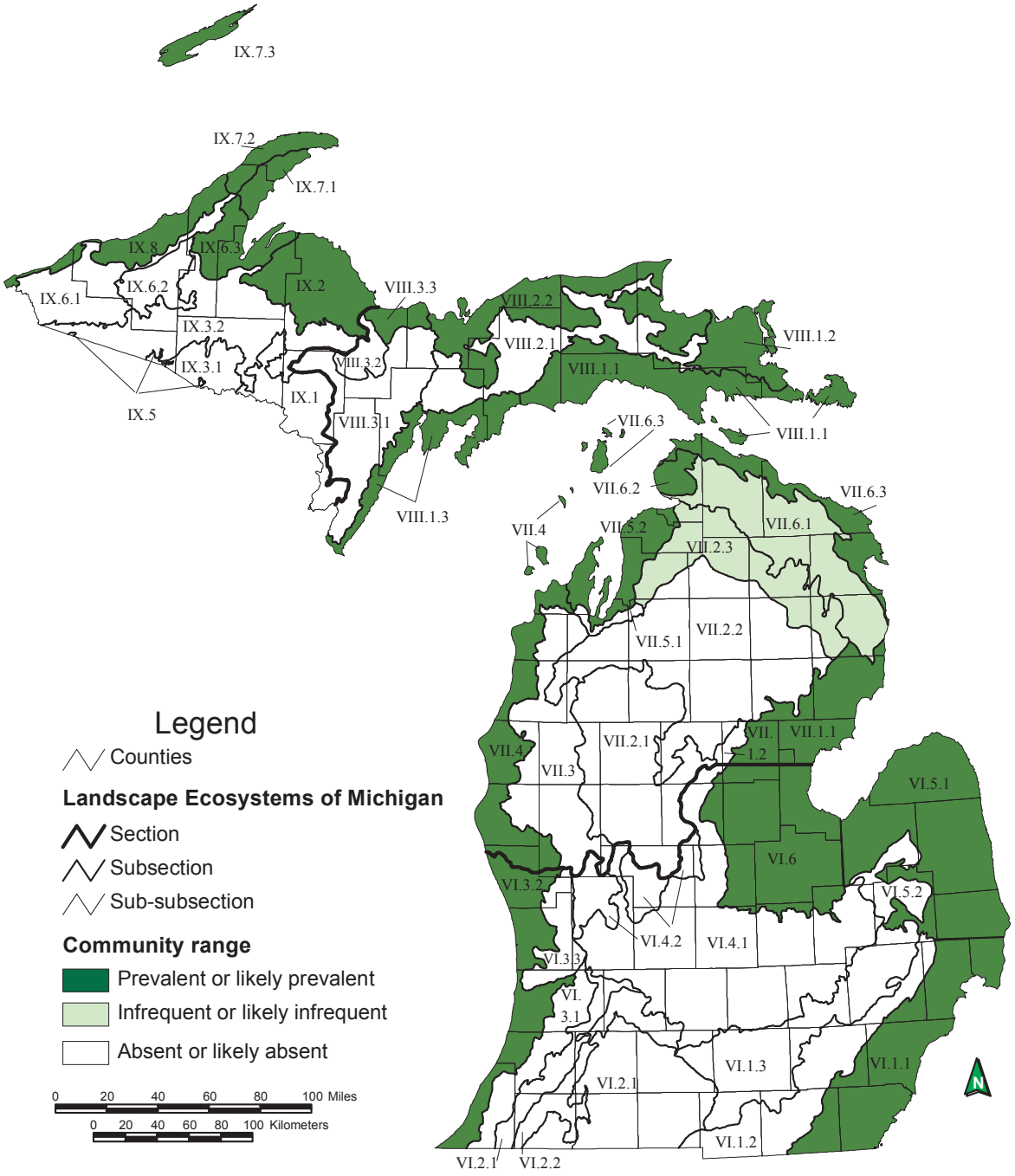
Overview: Open dunes is a grass- and shrub-dominated multi-seral community located on wind-deposited sand formations near the shorelines of the Great Lakes. Dune formation and the patterning of vegetation are strongly affected by lake-driven winds. The greatest concentration of open dunes occurs along the eastern and northern shorelines of Lake Michigan, with the largest dunes occurring along the eastern shoreline due to the prevailing southwest winds (Kost et al. 2007, Cohen et al. 2015).



Map 10. Distribution of open dunes in Michigan (Albert et al. 2008).

SAND AND GRAVEL BEACH

Overview: Sand and gravel beaches occur along the shorelines of the Great Lakes and on some of Michigan's larger inland lakes, where wind, waves, and winter ice cause the shoreline to be too unstable to support aquatic vegetation. Because of the high levels of disturbance, these beaches are typically quite open, with sand and gravel sediments and little or no vegetation. Sand and gravel beach is characterized by both a low diversity of plant species and low levels of plant cover (<1%). A wide variety of plants can develop at the inland margin of sand and gravel beaches, but few establish and persist on the active beach, where there is often intense wind and wave action, resulting in almost constantly moving sand. The dynamic nature of open sand and gravel beaches greatly inhibits soil development. Uprooted trees or driftwood accumulate on the beach, fostering localized sand accretion and often vegetation establishment. Finer organic material also builds up seasonally on beaches, and can include plant debris, algae, and dead lake or wetland organisms. These aggregations can be large, greatly increasing the nutrient availability and changing the sediment characteristics of the beach, although these changes are often temporary due to the dynamics of the shoreline environment. Storm waves and winter ice typically prevent permanent vegetation establishment and soil development (Kost et al. 2007, Cohen et al. 2015).



Map 11. Distribution of sand and gravel beach in Michigan (Albert et al. 2008).