

Natural Community Surveys of Great Lakes Islands in the Green Bay National Wildlife Refuge



Prepared By:

Joshua G. Cohen, Jesse M. Lincoln, Tyler J. Bassett, Scott M. Warner, Helen D. Enander, Elizabeth A. Haber, and Rachel A. Hackett
Michigan Natural Features Inventory
Michigan State University Extension
P.O. Box 30444
Lansing, MI 48909-7944

Prepared For:

U.S. Fish and Wildlife Service
National Wildlife Refuge

March 31, 2022

MNFI Report Number 2022-07

Suggested Citation: Cohen, J.G., J.M. Lincoln, T.J. Bassett, S.M. Warner, H.D. Enander, E.A. Haber, and R.A. Hackett. 2022. Natural Community Surveys of Great Lakes Islands in the Green Bay National Wildlife Refuge. Michigan Natural Features Inventory, Report Number 2022-07, Lansing, MI. 160 pp.

Cover Photo: Saint Martin Island limestone lakeshore cliff. Photo by Joshua G. Cohen.

Copyright 2022 Michigan State University Board of Trustees. Michigan State University Extension programs and materials are open to all without regard to race, color, natural origin, gender, religion, age, disability, political beliefs, sexual orientation, marital status, or family status.

Acknowledgements

This project (F20AC11089-01) was generously funded by the United States Fish and Wildlife Service (USFWS) to inform management of Great Lakes Islands that are part of the National Wildlife Refuge System. We are grateful to USFWS Region 3 sponsors Richard King and Joshua Booker for their guidance throughout the project. In addition, we thank the staff at Horicon National Wildlife Refuge Complex, particularly Bill Peterson and Sadie O'Dell. Numerous Michigan Natural Features Inventory (MNFI) staff contributed to this work including Michael Monfils, Brian Klatt, Ashley Adkins, Sarah Carter, Debra Richardson, and Kraig Korroch. We are especially grateful for the contributions of John Paskus and Phyllis Higman, who contributed to the project conceptualization. Matt Preisser with Michigan's Department of Environment, Great Lakes, and Energy played a critical role as an institutional match-maker, connecting MNFI with NWR staff. We thank the Little Traverse Bay Bands of Odawa Indians Natural Resources Department for collaboration on surveys and logistical support, particularly Bill Parsons and Noah Jansen.



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

TABLE OF CONTENTS

ACKNOWLEDGMENTS	iii
INTRODUCTION	1
METHODS	3
Field Survey Prioritization.....	3
Field Survey.....	3
Natural Community Stewardship Prioritization	6
SURVEY RESULTS	7
SITE SUMMARIES	10
DETROIT ISLAND	10
1. Limestone Bedrock Lakeshore	12
2. Limestone Cliff	15
3. Limestone Cobble Shore.....	18
4. Limestone Lakeshore Cliff	21
5. Sand and Gravel Beach.....	24
PLUM ISLAND	26
6. Great Lakes Marsh	28
7. Limestone Cobble Shore.....	31
8. Limestone Lakeshore Cliff	34
9. Mesic Northern Forest	37
POVERTY ISLAND	41
10. Boreal Forest.....	44
11. Limestone Bedrock Lakeshore	48
12. Limestone Lakeshore Cliff	51
ROCKY ISLAND	56
13. Limestone Cobble Shore.....	57
SAINT MARTIN ISLAND	60
14. Boreal Forest.....	62
15. Limestone Cliff	65
16. Limestone Cobble Shore.....	68
17. Limestone Lakeshore Cliff	71
18. Mesic Northern Forest	75
19. Northern Hardwood Swamp	80
STEWARDSHIP PRIORITIZATION RESULTS	83
CONCLUSION	86
CONCLUDING REMARKS	87
REFERENCES	88

LIST OF FIGURES

Figure 1. Overview map of Grand Traverse Islands.....	2
Figure 2. Decision matrix to determine natural community survey targets.	3
Figure 3. Stewardship prioritization score schematic.....	6
Figure 4. Overview map of Detroit and Plum Islands.	9
Figure 5. Natural community element occurrences on Detroit Island.....	11
Figure 6. Natural community element occurrences on Plum Island	27
Figure 7. Overview map of Poverty, Rocky, and Saint Martin Islands.....	42
Figure 8. Natural community element occurrences on Poverty Island	43
Figure 9. Natural community element occurrence on Rocky Island	56
Figure 10. Natural community element occurrences on Saint Martin Island	61
Figure 11. Stewardship prioritization for Poverty, Rocky, and Saint Martin Islands...	84
Figure 12. Stewardship prioritization for Detroit and Plum Islands..	85

LIST OF TABLES

Table 1. Natural community element occurrences.....	8
Table 2. Stewardship prioritization for natural community element occurrences.....	84

APPENDIX

Appendix 1. Historical Imagery and Hillshade	90
Appendix 2. Global and State Element Ranking Criteria	101
Appendix 3. Floristic Quality Assessments	102
Appendix 4. Natural Community Overviews and Distribution Maps	152

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.

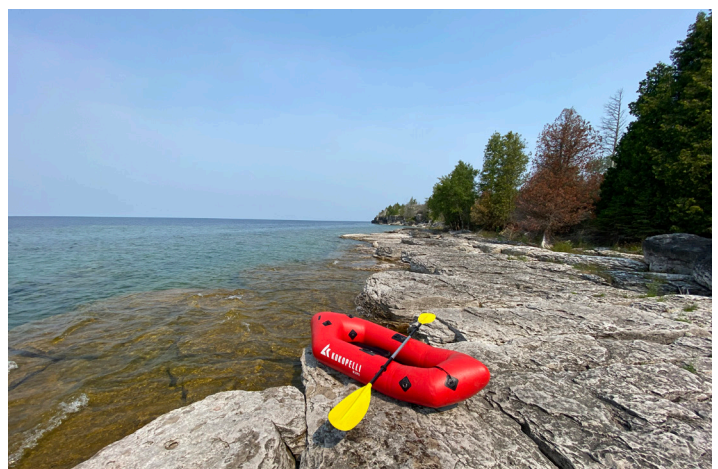
Many of the islands within the Great Lakes that are part of the NWR system are remote, difficult to access, and challenging to survey due to rugged terrain. Despite limited access, these islands face a variety of threats to native biodiversity and rare taxa including establishment and spread of invasive 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 at Michigan Islands NWR and Green Bay NWR. In 2022, surveys will be conducted at West Sister Island NWR, Huron NWR, Harbor Island NWR, and the Detroit River International Wildlife Refuge. Within the Michigan Islands NWR, natural community surveys and forest plot sampling were conducted on Big Charity, Crooked, and Sugar Islands in Lake Huron. Within the Green Bay NWR, natural communities were evaluated on Detroit, Plum, Poverty, Rocky, and Saint Martin Islands in northern Lake Michigan (Figure 1). This report focuses on the natural community surveys conducted in 2021 in the Green Bay NWR. For information on the natural community surveys conducted in 2021 in the Michigan Islands 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. Detailed information on invasive plant treatment objectives and management actions are provided in Invasive Plant Management Plans for Detroit, Plum, Poverty, and Saint Martin Islands (Hackett et al. 2022; Warner et al. 2022a-c)

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 updated and 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 the NWR islands within the Green Bay NWR.



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

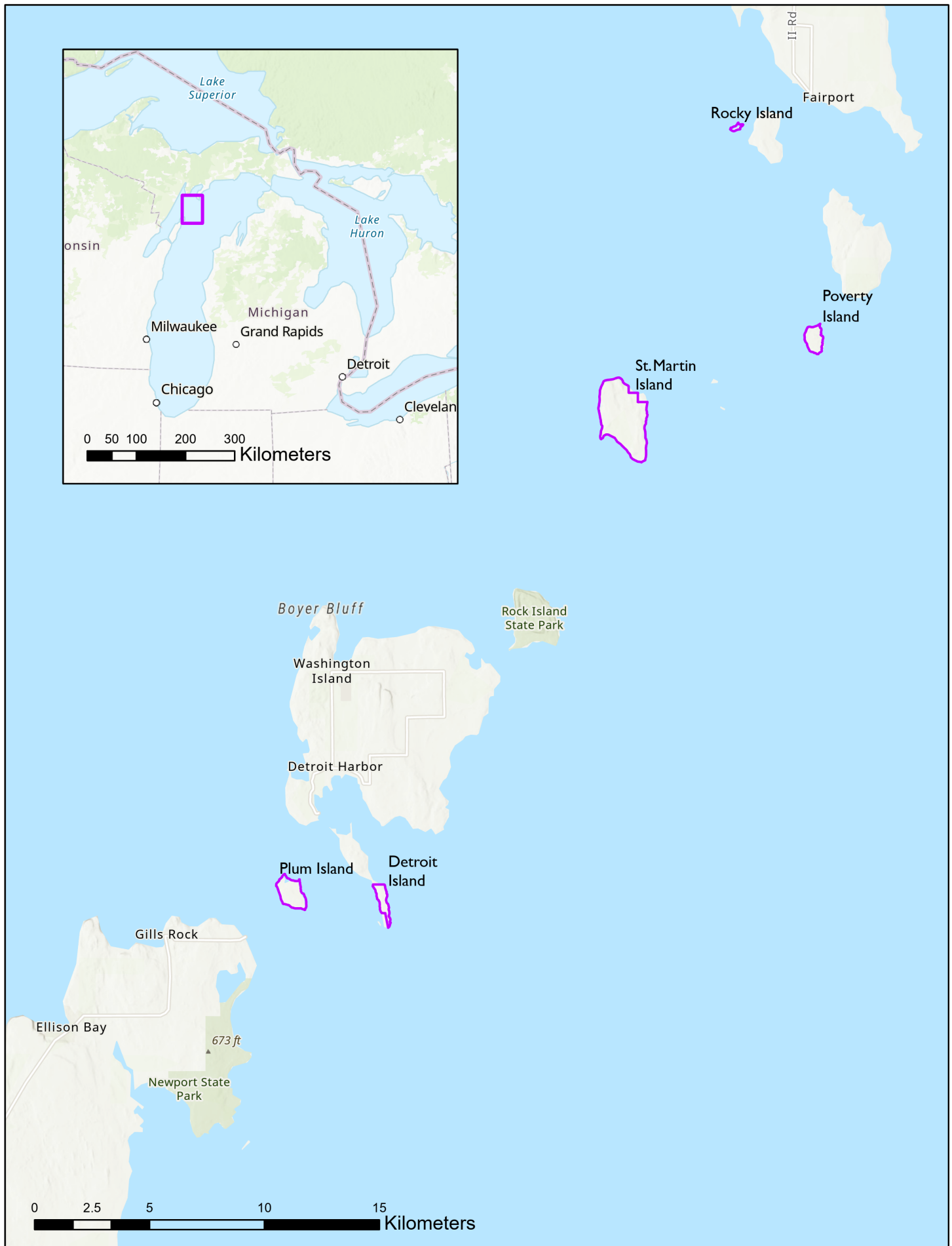


Figure 1. Natural community surveys within the Green Bay National Wildlife Refuge were conducted in 2021 on Detroit, Plum, Poverty, Rocky, and Saint Martin Islands.

Methods

Field Survey Prioritization

The MNFI natural community classification system was used as the classification framework for both Michigan and Wisconsin islands (Kost et al. 2007; Cohen et al. 2015; Cohen et al. 2020). Within the site descriptions in the **Results** section, crosswalks to equivalent Wisconsin natural community types are provided for Wisconsin islands (Epstein 2017) and nomenclature of plant species for all islands 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) (Appendix 1 provides historical imagery and hillshade). 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 2). 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

Decision Matrix to Determine Natural Community Survey Targets.

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.

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 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)
- 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, 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 when possible 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 or updating 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. Poverty Island limestone bedrock lakeshore. Photo by Joshua G. Cohen.

Following completion of the field surveys, the collected data were analyzed and transcribed to update or 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 or re-mapping for previously documented 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 (Namestnik 2014; Parker et al. 2014; 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



Representative canopy trees were measured and aged in forested natural community types. Saint Martin Island mesic northern forest. Photo by Jesse M. Lincoln.

given plant species from region to region. We employed regionally appropriate FQA for islands in Michigan (Reznicek et al. 2014) and Wisconsin (Namestnik 2014), respectively. 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 3.

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 species mapping on Detroit, Plum, Poverty, Rocky, and Saint Martin Islands. Data gathered from these survey efforts was also used to inform the documentation and description of high-quality natural communities. For details on these survey efforts please refer to Bassett 2022a and USFWS 2021a.

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 2) 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 (Figure 3). The stewardship prioritization for the natural community element occurrences is presented in the **Stewardship Prioritization Results** section.

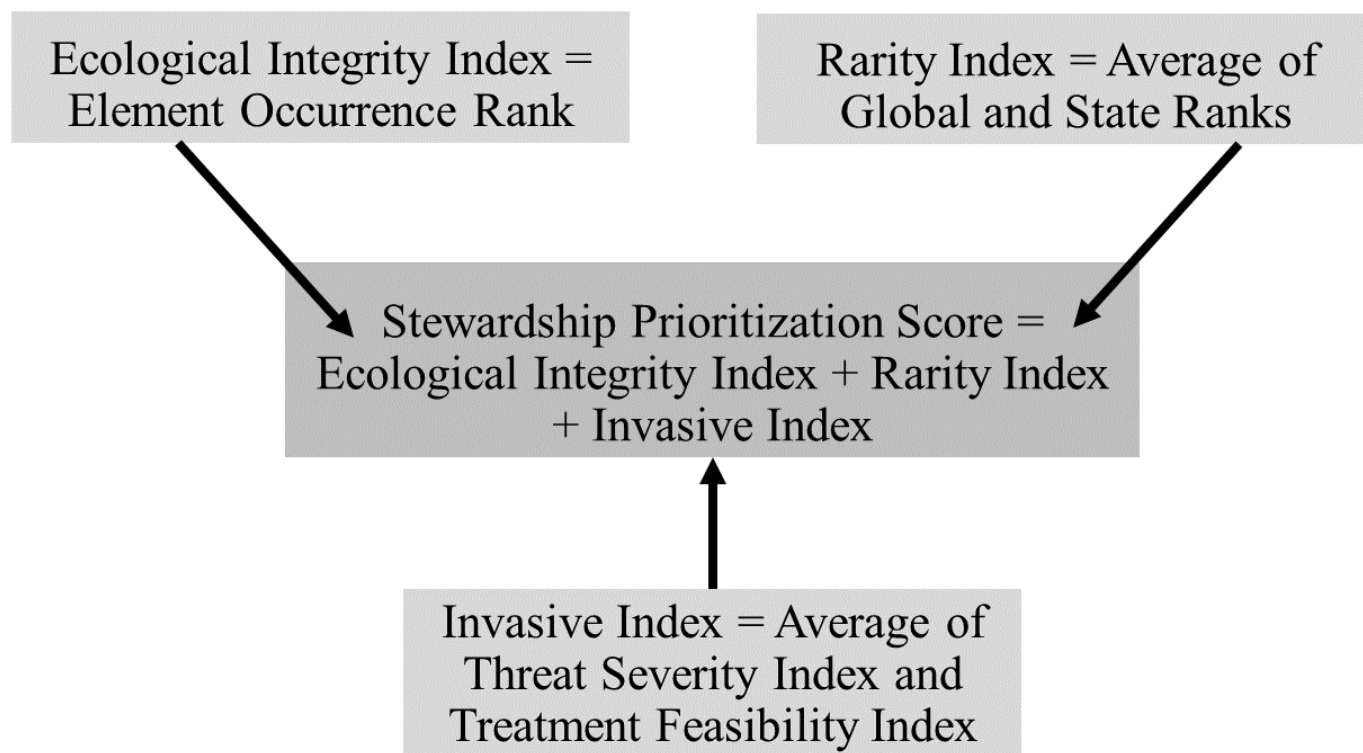


Figure 3. The Stewardship Prioritization score is the sum of the Ecological Integrity Index, Rarity Index, and Invasive Index. This prioritization scoring was derived to help focus finite resources for biodiversity stewardship.

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. Nineteen high-quality natural communities were surveyed during the 2021 field season within the Green Bay NWR on Detroit, Plum, Poverty, Rocky, and Saint Martin Islands. A total of nine different natural community types were visited including: boreal forest (2 element occurrences or EOs), Great Lakes marsh (1 EO), limestone bedrock lakeshore (2 EOs), limestone cliff (2 EOs), limestone cobble shore (4 EOs), limestone lakeshore cliff (4 EOs), mesic northern forest (2 EOs), northern hardwood swamp (1 EO), 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 19 natural community element occurrences visited in 2021 organized by island and then alphabetically by community type. Appendix 4 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 indicate if the site is an update of a previously identified element occurrence or a new element occurrence and provide the following information:

- a) site name
- b) natural community type
- c) global and state rank (see Appendix 2 for ranking criteria)
- d) current element occurrence rank
- e) size
- f) locational information
- g) digital photograph(s)
- h) site description
- i) threat assessment
- j) management recommendations



Limestone Lakeshore Cliff, Saint Martin Island, Green Bay National Wildlife Refuge. Photo by Joshua G. Cohen.

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

Community Type	EO ID	Island	EO RANK
Limestone Lakeshore Cliff	1437	Poverty Island	A
Limestone Lakeshore Cliff	24348	Saint Martin Island	A
Limestone Bedrock Lakeshore	4159	Poverty Island	AB
Limestone Bedrock Lakeshore	24374	Detroit Island	B
Boreal Forest	7488	Poverty Island	B
Boreal Forest	24351	Saint Martin Island	B
Limestone Cliff	24350	Saint Martin Island	B
Limestone Cobble Shore	24353	Saint Martin Island	B
Limestone Cliff	24373	Detroit Island	BC
Limestone Cobble Shore	24375	Detroit Island	BC
Limestone Lakeshore Cliff	24372	Detroit Island	BC
Sand and Gravel Beach	24387	Detroit Island	BC
Mesic Northern Forest	24349	Saint Martin Island	BC
Great Lakes Marsh	24367	Plum Island	C
Limestone Cobble Shore	24370	Plum Island	C
Limestone Lakeshore Cliff	24368	Plum Island	C
Limestone Cobble Shore	24366	Rocky Island	C
Northern Hardwood Swamp	24352	Saint Martin Island	C
Mesic Northern Forest	24369	Plum Island	D



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

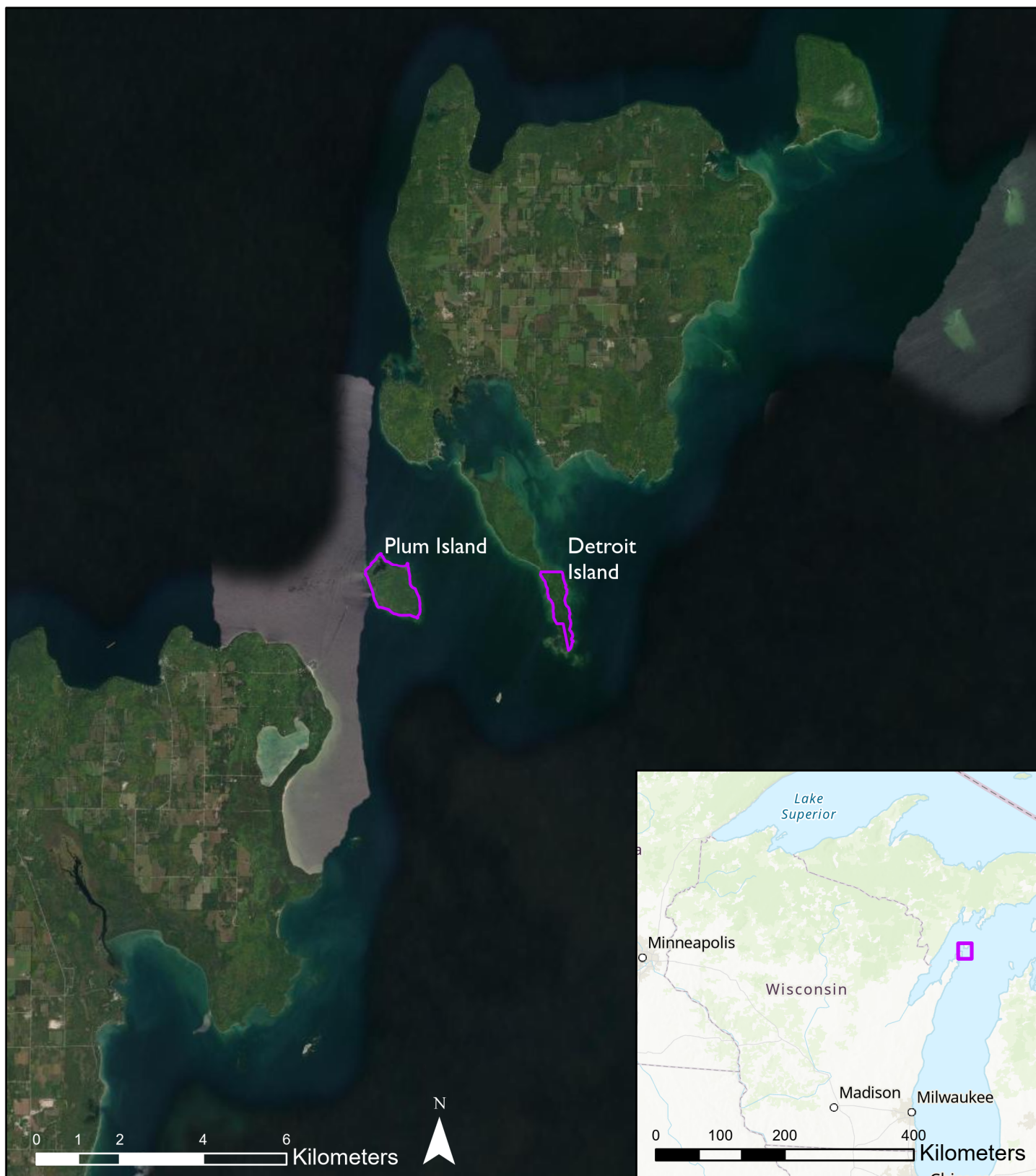


Figure 4. Natural community surveys within the Green Bay National Wildlife Refuge in Wisconsin were conducted in 2021 on Detroit and Plum Islands.

SITE SUMMARIES

DETROIT ISLAND

Detroit Island is part of the Wisconsin section of the Grand Traverse Islands and is located in northern Lake Michigan just south of Washington Island and nearly 8 km northeast of Northport in Wisconsin's Door Peninsula (Figure 4). Detroit Island is a long, narrow island stretching roughly 7 km from its northwest corner to the southeast corner with a maximum width of 1.2 km, for a total area of 60 ha. This island is part of the Niagara Escarpment, and its bedrock is dolomite from the Silurian Period (dolomite is a type of limestone that contains magnesium crystals). A plateau to the north of the island's isthmus reaches a maximum elevation of 25 meters, with numerous lower escarpments occurring elsewhere in the interior of the island (Judziewicz 2001).

Detroit Island comprises a mixture of public and private-held lands. The majority of the southern half of Detroit Island is administered by the USFWS as part of the Green Bay NWR. Several parcels in the northern half of the island are administered by the Wisconsin Department of Natural Resources as the Grand Traverse Island State Park. The rest of the parcels on Detroit Island are owned by private entities, and several seasonal homes are located in the northern half of the island.

The shoreline of Detroit Island consists mostly of limestone substrate in various forms: bedrock, cobble, and cliffs, as well as a few stretches of sand and gravel beach. Limestone bedrock lakeshore occurs along the western and eastern shoreline. The western shore supports limestone cobble shore, sand and gravel beach, and limestone lakeshore cliff. The eastern shore also supports limestone cobble shore and limestone lakeshore cliff. These shoreline ecosystems are backed by degraded mesic northern forest in the interior of the island. The mesic northern forest has been impacted by logging and high deer browse. Small exposures of limestone cliff occur nested within the mesic northern forest.

Five high-quality natural community element occurrences were surveyed on Detroit Island during the 2021 field season including limestone bedrock lakeshore, limestone cliff, limestone cobble shore, limestone lakeshore cliff, and sand and gravel beach (Table 1; Figure 5). The mesic northern forest was deemed to be too degraded to qualify for consideration as an element occurrence. Natural community surveys were conducted on July 15th. Prior to this survey effort, Detroit Island was last visited by Wisconsin heritage staff in 1998.



Detroit Island limestone lakeshore cliff. Photo by Joshua G. Cohen.

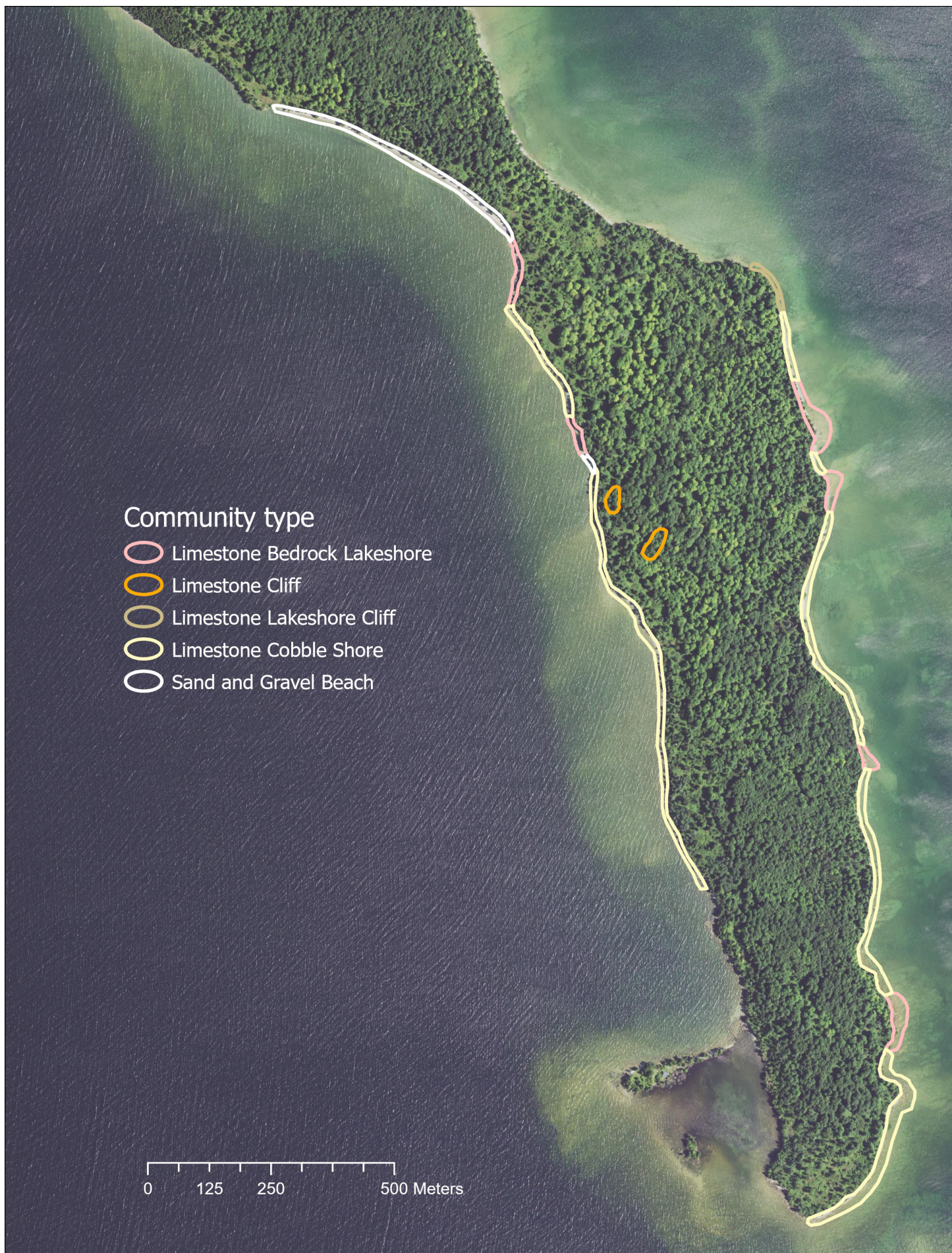


Figure 5. Natural community element occurrences on Detroit Island, Green Bay National Wildlife Refuge.

1. Detroit Island – Limestone Bedrock Lakeshore

Natural Community Type (MI): Limestone Bedrock Lakeshore

Natural Community Type (WI): Great Lakes Alkaline Rockshore

Rank: G3 S2, vulnerable globally and imperiled within the state (WI)

Element Occurrence Rank: B

Size: 3.24 acres

Location: Detroit Island, Green Bay National Wildlife Refuge, Lake Michigan, Wisconsin

Element Occurrence Identification Number: 24374 (EO Update)

Site Description: Approximately a half kilometer of limestone bedrock lakeshore occurs along the western and eastern shoreline of Detroit Island. Limestone bedrock lakeshore and limestone cobble shore intergrade locally. Surveys in 2021 followed 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 reduced the overall cover of herbaceous species in the limestone bedrock lakeshore and the dieback of woody species, especially northern white-cedar (*Thuja occidentalis*) and green ash (*Fraxinus pennsylvanica*). More vegetation persists along the limestone bedrock lakeshore on the eastern side of the island suggesting that there is higher wind and wave activity impacting the western shore of the island. Numerous 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 soils of the limestone bedrock lakeshore are characterized by shallow (1-2 cm), alkaline (pH 8.0) organics with gravel that accumulate in cracks, crevices, and depressions. Fossils are abundant within the limestone bedrock. A 24.8 cm green ash snag was cored and estimated to have lived 20 years before succumbing to the stress of high water living.



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



Dissolution pools or spalsh 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. Photo by Joshua G. Cohen.

The limestone bedrock lakeshore is sparsely vegetated with low cover of herbaceous plants (1-2%) and scattered tree and shrub cover (<1-2%) restricted to the inland edge and cracks and crevices. Characteristic herbaceous species include limestone calamint (*Clinopodium arkansanum*, state special concern), silverweed (*Potentilla anserina*), herb Robert (*Geranium robertianum*), spotted touch-me-not (*Impatiens campensis*), wild strawberry (*Fragaria virginiana*), beak-rush (*Rhynchospora capillacea*), white camas (*Anticlea elegans*, state special concern), and water smartweed (*Persicaria amphibia*). Herbaceous vegetation is primarily found in cracks and crevices within the limestone bedrock but also locally occurs in dry dissolution depressions. Scattered trees and tall shrubs include northern white-cedar, green ash, basswood (*Tilia americana*), choke cherry (*Prunus virginiana*), and red elderberry (*Sambucus racemosa*). Characteristic low shrubs include choke cherry, wild red raspberry (*Rubus strigosus*), and currants (*Ribes* spp.).

The Detroit Island limestone bedrock lakeshore was surveyed on July 15th. Forty-eight plant species were documented with 36 native species and 12 non-native species (Appendix 3.1). The total FQI was 25.6.

Threats: Canada bluegrass (*Poa compressa*) is locally common in the limestone bedrock lakeshore and butter-and-eggs (*Linaria vulgaris*), marsh thistle (*Cirsium palustre*), honeysuckle (*Lonicera* sp.), catnip (*Nepeta cataria*), and bittersweet nightshade (*Solanum dulcamara*) are occasional.

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



2020 aerial photograph of Detroit Island limestone bedrock lakeshore.

2. Detroit Island – Limestone Cliff

Natural Community Type (MI): Limestone Cliff

Natural Community Type (WI): Dry Cliff

Rank: G4G5 S5, apparently secure to secure globally and apparently secure within the state (WI)

Element Occurrence Rank: BC

Size: 0.70 acres

Location: Detroit Island, Green Bay National Wildlife Refuge, Lake Michigan, Wisconsin

Element Occurrence Identification Number: 24373

Site Description: A small pocket of west-facing limestone cliff is nested within mesic northern forest occurring in the interior of Detroit Island. The cliffs are low in stature ranging from 1 to 3 meters tall. The soils are characterized as very shallow (<1-2 cm) fine-textured, alkaline (pH 8.0) organic soils that are accumulating on the ledges, crevices, and at the base of tree boles. A 19.6 cm northern white-cedar (*Thuja occidentalis*) occurring on the lip of the cliff was cored and estimated to be over 33 years old.

The vegetation of the limestone cliff is sparse and generally restricted to the flat, exposed bedrock at the upper edge of the cliff, cracks and joints in the cliff face, ledges along the cliff face, and along the cliff base where limestone blocks occur locally. Herbaceous cover is sparse to patchy (10-20%) and includes common polypody (*Polypodium virginianum*), small enchanter's nightshade (*Circaea alpina*), herb Robert (*Geranium robertianum*), hairy sweet-cicely (*Osmorhiza claytonii*), fringed false buckwheat (*Fallopia cilinodis*), wild sarsaparilla (*Aralia nudicaulis*), wild leek (*Allium tricoccum*), jack-in-the-pulpi (*Arisaema triphyllum*), cow-parsnip (*Heracleum maximum*), blue cohosh (*Caulophyllum thalictroides*), climbing fumitory (*Adlumia fungosa*, state special concern), and Laurentian fragile fern (*Cystopteris laurentiana*, state special concern). In addition, lichens, and mosses are locally common along the cliff face. Sparse shrub cover (5-10%) includes red elderberry (*Sambucus racemosa*), beaked hazelnut (*Corylus cornuta*), choke cherry (*Prunus virginiana*), pin



Detroit Island limestone cliff. Photo by Joshua G. Cohen.

cherry (*P. pensylvanica*), wild red raspberry (*Rubus strigosus*), and thimbleberry (*Rubus parviflorus*). Scattered trees and saplings (2-5%) include sugar maple (*Acer saccharum*), northern white-cedar and paper birch (*Betula papyrifera*) and occur along the lip and on ledges and crevices.

The Detroit Island limestone cliff was surveyed on July 15th. Forty-seven plant species were documented with 42 native species and 5 non-native species (Appendix 3.2). The total FQI was 28.8.

Threats: The non-native Canada bluegrass (*Poa compressa*) is locally common and Tartarian honeysuckle (*Lonicera tatarica*) occurs infrequently.

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



Detroit Island limestone cliff. Photo by Joshua G. Cohen.



2020 aerial photograph of Detroit Island limestone cliff.

3. Detroit Island – Limestone Cobble Shore

Natural Community Type (MI): Limestone Cobble Shore

Natural Community Type (WI): Great Lakes Alkaline Rockshore

Rank: G3 S2, vulnerable globally and imperiled within the state (WI)

Element Occurrence Rank: BC

Size: 9.8 acres

Location: Detroit Island, Green Bay National Wildlife Refuge, Lake Michigan, Wisconsin

Element Occurrence Identification Number: 24375 (EO Update)

Site Description: Limestone cobble shore occurs along the western and eastern shoreline of Detroit Island. The soils are wet, gravelly, alkaline (pH 8.0) sands mixed with organics occurring between and beneath the cobble. Limestone cobble shore and limestone bedrock lakeshore intergrade locally. A 17.8 cm northern white-cedar (*Thuja occidentalis*) growing on the upper margin of the limestone cobble shore was cored and estimated it to be over 114 years old. The coastal complex along the shoreline of Detroit 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 limestone cobble shore and adjacent limestone bedrock lakeshore. In addition, high water levels have likely reduced the overall cover of herbaceous species in the limestone cobble shore as well. More vegetation persists along the limestone cobble shore on the eastern side of the island suggesting that there is higher wind and wave activity impacting the western shore of the island.



Detroit 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 and shrubs occur rarely along the upper margins of the limestone cobble shore and include northern white-cedar, green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus americana*), mountain-ash (*Sorbus decora*), choke cherry (*Prunus virginiana*), ninebark (*Physocarpus opulifolius*) and wild red raspberry (*Rubus strigosus*). Characteristic herbaceous species include silverweed (*Potentilla anserina*), herb Robert (*Geranium robertianum*), wild sarsaparilla (*Aralia nudicaulis*), white camas (*Anticlea elegans*, state special concern), and harebell (*Campanula rotundifolia*).

The Detroit Island limestone cobble shore was surveyed July 15th. Sixty-two plant species were documented with 50 native species and 12 non-native species (Appendix 3.3). The total FQI was 26.

Threats: Non-native species recorded along the limestone cobble shore include catnip (*Nepeta cataria*) and Tartarian honeysuckle (*Lonicera tatarica*).

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



Detroit Island limestone cobble shore. Photo by Joshua G. Cohen.



2020 aerial photograph of Detroit Island limestone cobble shore.

4. Detroit Island – Limestone Lakeshore Cliff

Natural Community Type (MI): Limestone Lakeshore Cliff

Natural Community Type (WI): Moist Cliff

Rank: GNR S4, not ranked globally and apparently secure within the state (WI)

Element Occurrence Rank: BC

Size: 0.27 acres

Location: Detroit Island, Green Bay National Wildlife Refuge, Lake Michigan, Wisconsin

Element Occurrence Identification Number: 24372

Site Description: Short stretches of limestone lakeshore cliff occur along the western and eastern shoreline of Detroit Island. Limestone lakeshore cliff along the western shore of Detroit Island occurs on private property and was not visited or mapped as part of this survey effort but was visible from the shoreline on NWR land. The cliffs are low in stature and range from 2 to 5 meters tall. Very shallow (1-2 cm) fine-textured, alkaline (pH 8.0) organic soils accumulate on the ledges, crevices, and at the base of tree boles. A 32.7 cm northern white-cedar (*Thuja occidentalis*) occurring on the lip of the cliff was cored and estimated it to be over 123 years old. Thin soils, cold winter temperatures, steady winds, and summer droughts make for harsh growing conditions.

Vegetation is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks and joints in the cliff face, ledges along the cliff face, and along the cliff base where talus slope is occasional between the cliff and the open water. Significant areas of vertical cliff face are bare of all vegetation. Sparse herbaceous cover (1-2%) includes harebell (*Campanula rotundifolia*), herb Robert (*Geranium robertianum*), limestone calamint (*Clinopodium arkansanum*, state special concern), wild columbine (*Aquilegia canadensis*), false spikenard (*Maianthemum racemosum*), wild strawberry (*Fragaria virginiana*), and common polypody (*Polypodium virginianum*). Mosses are locally common. Shrub cover is sparse (<1%) with choke cherry (*Prunus virginiana*) being locally common. Stunted and scattered (<1%) northern white-cedar and sugar maple (*Acer saccharum*) occur along the lip and on ledges and crevices.



Detroit Island limestone lakeshore cliff. Photo by Joshua G. Cohen.

The Detroit Island limestone lakeshore cliff was surveyed July 15th. Thirty-five plant species were documented with 29 native species and 6 non-native species (Appendix 3.4). The total FQI was 23.1.

Threats: The non-natives Canada bluegrass (*Poa compressa*), catnip (*Nepeta cataria*), and honeysuckle (*Lonicera* sp.) are locally common.

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



Harebell (*Campanula rotundifolia*) growing in a crevice of the Detroit Island limestone lakeshore cliff. Photo by Joshua G. Cohen.



2020 aerial photograph of Detroit Island limestone lakeshore cliff.

5. Detroit Island – Sand and Gravel Beach

Natural Community Type (MI): Sand and Gravel Beach

Natural Community Type (WI): Great Lakes Beach

Rank: G3 S2, vulnerable globally and imperiled within the state

Element Occurrence Rank: BC

Size: 2.35 acres

Location: Detroit Island, Green Bay National Wildlife Refuge, Lake Michigan, Wisconsin

Element Occurrence Identification Number: 24387 (EO update)

Site Description: Sand and gravel beach occurs along the western shoreline of Detroit Island. 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 gravel and cobble occur intermixed with the sands. The coastal complex along the shoreline of Detroit 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 limestone bedrock lakeshore. In addition, high water levels have likely reduced the overall cover of herbaceous species in these coastal systems.

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 along the upper margins of the sand and gravel beach include northern white-cedar (*Thuja occidentalis*), paper birch (*Betula papyrifera*), and green ash (*Fraxinus pennsylvanica*). White camas (*Anticlea elegans*, state special concern) was also documented occurring along the upper margin of the beach.

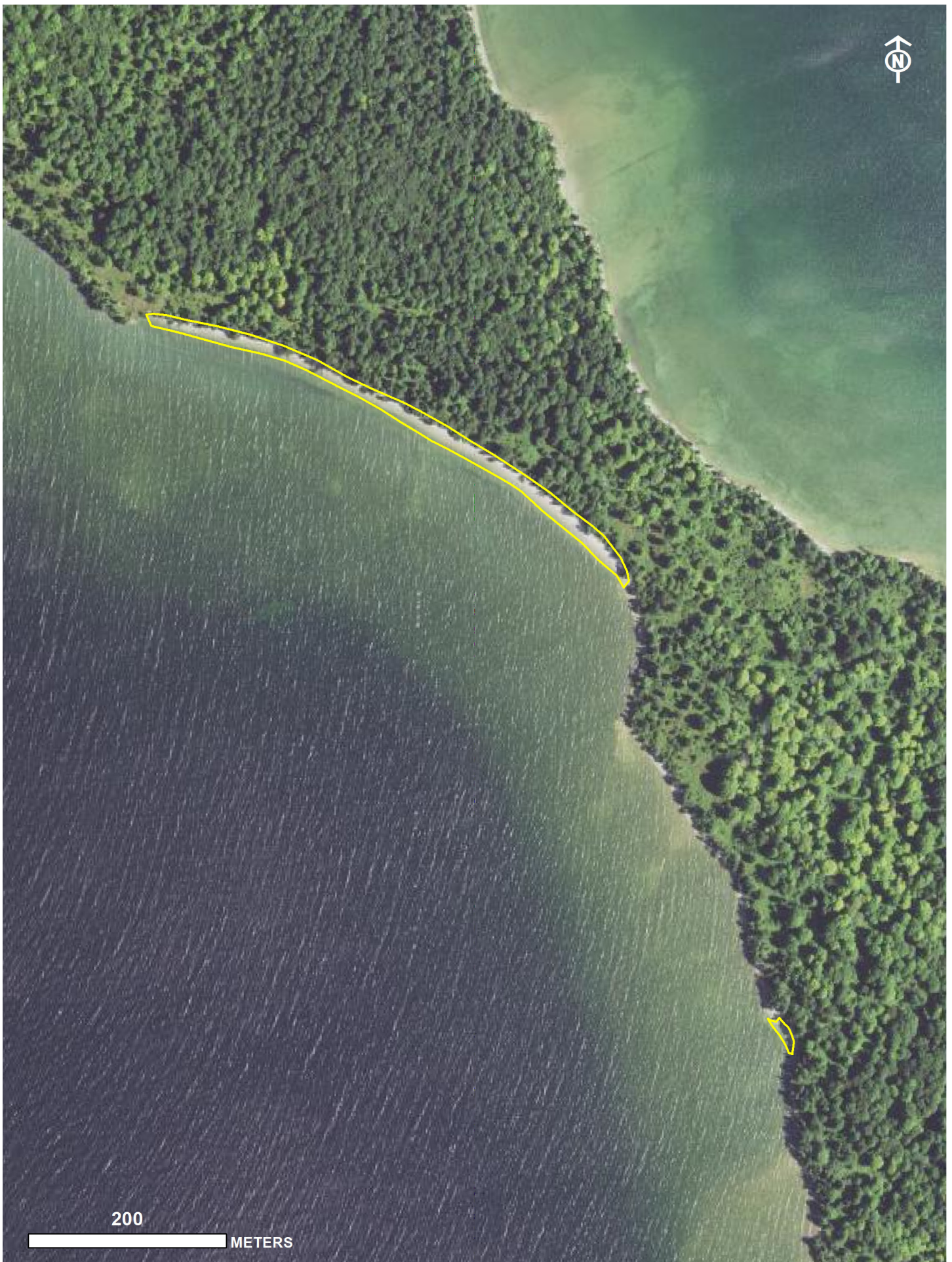
The Detroit Island sand and gravel beach was surveyed July 15th. Four plant species were documented with 4 native species and no non-native species (Appendix 3.5). The total FQI was 11.6.

Threats: Threats are limited to foot traffic and non-native species spread. No invasive plants were noted during the 2021 surveys.

Management Recommendations: The primary management recommendations are to control and monitor invasive species along the shoreline of Detroit Island.



Detroit Island sand and gravel beach. Photo by Joshua G. Cohen.



2020 aerial photograph of Detroit Island sand and gravel beach.

PLUM ISLAND

Plum Island occurs in northern Lake Michigan and is part of the Grand Traverse Islands. It is located approximately halfway between the tip of the Door Peninsula in Wisconsin and the southwest peninsula of Washington Island (Figure 4). Plum Island has a maximum length and width of 1.75 and 0.95 km, respectively, and an area of 130 ha. As part of the Niagara Escarpment, Plum Island's underlying bedrock consists of dolomite from the Silurian Period. With a maximum elevation of 13 m, Plum island is relatively low-lying compared to nearby islands and has gently rolling topography (Judziewicz 2001).

Because of its location within the Death's Door (Porte des Morte) passage, Plum Island has been an important site for maritime navigation-aiding infrastructure. The first lighthouse on the island was completed in 1849. In 1896, two range lights were installed, as well as a fog signal, a life-saving station, and a keeper's dwelling. In 1939, a boathouse was constructed near the pier on the north side of the island. From that year onward until 1990, the U.S. Coast guard operated the life-saving station, range lights, and fog signal (National Register of Historic Places, n.d.). With the establishment of the lighthouses, fog station, and life-saving station, the island was inhabited from the late 1800s through 1990 when the life-saving station was abandoned. Logging on Plum island likely began in the late 1800s and continued through the early 1900s. Plum Island is currently under administration by the USFWS as part of the Green Bay NWR after being transferred from administration by the U.S. Coast Guard in 2007.

The majority of the island's interior is characterized by degraded mesic northern forest that has been logged multiple times, is subject to high deer browse pressure, and is infested with invasive species in both the shrub and ground cover layers. Trails and logging roads occur throughout the island. The shorelines support several coastal ecosystems including limestone lakeshore cliff along the eastern and southern shorelines; limestone cobble shore along the western, southern, and northern shores; and Great Lakes marsh along the northwestern shore. A narrow band of degraded boreal forest occurs locally between the coastal ecosystems and the mesic northern forest in the interior of the island.

Four high-quality natural community element occurrences were surveyed on Plum Island during the 2021 field season including Great Lakes marsh, limestone cobble shore, limestone lakeshore cliff, and mesic northern forest (Table 1; Figure 6). Sand and gravel beach occurs locally along the northwestern portion of the island but was too small to be considered an element occurrence. In addition, small inclusions of limestone bedrock lakeshore occur along the southern shore and intergrade with limestone lakeshore cliff and limestone cobble shore. Natural community surveys were conducted from July 12th through July 14th. Prior to this survey effort, Plum Island was last visited by Wisconsin heritage staff in 1999.



Limestone cobble shore transitioning to limestone lakeshore cliff along the southern shore of Plum Island. Photo by Joshua G. Cohen.



Figure 6. Natural community element occurrences on Plum Island, Green Bay National Wildlife Refuge.

6. Plum Island – Great Lakes Marsh

Natural Community Type (MI): Great Lakes Marsh

Natural Community Type (WI): Emergent Marsh

Rank: G4 S4, apparently secure globally and within the state (WI)

Element Occurrence Rank: C

Size: 17 acres

Location: Plum Island, Green Bay National Wildlife Refuge, Lake Michigan, Wisconsin

Element Occurrence Identification Number: 24367

Site Description: Great Lakes marsh occurs along the northwestern shoreline of Plum Island. The marsh occurs behind a narrow ridge of limestone cobble shore that allows for the development and persistence of the marsh by protecting the marsh from wave action. The soils are shallow, alkaline (pH 7.5-7.8) organics overlying limestone cobble and gravel. In 2021, water depths within the submergent marsh ranged from 50 to 100 cm. 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 wet meadow zone of the Great Lakes marsh including trembling aspen (*Populus tremuloides*), paper birch (*Betula papyrifera*), northern white-cedar (*Thuja occidentalis*), red-osier dogwood (*Cornus sericea*), and meadow willow (*Salix petiolaris*).

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 distinct zonation, primarily submergent marsh, with northern wet meadow occurring on the margins. The submergent marsh zone has 10 to 25% cover of aquatic species including turion duckweed (*Lemna turionifera*), yellow pond-lily (*Nuphar variegata*), and grass-leaved pondweed (*Potamogeton gramineus*). Water depths within the submergent marsh range from 50 to 100 cm. The northern wet meadow zone is dominated



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

by graminoids with scattered clumps of tall shrubs and scattered trees along the margins. Herbaceous cover in the wet meadow zone ranges from 80 to 95%. The wet meadow is dominated by blue-joint (*Calamagrostis canadensis*) and tussock sedge (*Carex stricta*) with ground layer associates including rush (*Juncus balticus*), hardstem bulrush (*Schoenoplectus acutus*), wild blue flag (*Iris versicolor*), common boneset (*Eupatorium perfoliatum*), silverweed (*Potentilla anserina*), water smartweed (*Persicaria amphibia*), northern bugleweed (*Lycopus uniflorus*), purple avens (*Geum rivale*), beak-rush (*Rhynchospora capillacea*), and marsh fern (*Thelypteris palustris*). Sedge tussocks provide microtopographic variability within the wet meadow zone of the marsh. Scattered trees and shrubs (5-25%) include trembling aspen, paper birch, northern white-cedar, red-osier dogwood, and meadow willow. A significant portion of the trees and shrubs have been recently flood-killed following five years of high water.

The Plum Island Great Lakes marsh was surveyed from July 12th through July 14th. Sixty-seven plant species were documented with 57 native species and 10 non-native species (Appendix 3.6). The total FQI was 35.2.

Threats: Non-native species occur occasionally within the wet meadow zone of the marsh and include spotted knapweed (*Centaurea stoebe*), bull thistle (*Cirsium vulgare*), marsh thistle (*C. palustre*), hound's-tongue (*Cynoglossum officinale*), narrow-leaved cat-tail (*Typha angustifolia*), purple loosestrife (*Lythrum salicaria*), and reed canary grass (*Phalaris arundinacea*). Invasive reed (*Phragmites australis* subspecies *australis*) was documented in the past within the Great Lakes marsh (Sadie O'Dell, USFWS, personal communication) but was not observed in 2021 during focused surveys and was likely temporarily eliminated by control efforts working in concert with high water levels.

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



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



2020 aerial photograph of Plum Island Great Lakes marsh.

7. Plum Island – Limestone Cobble Shore

Natural Community Type (MI): Limestone Cobble Shore

Natural Community Type (WI): Great Lakes Alkaline Rockshore

Rank: G3 S2, vulnerable globally and imperiled within the state (WI)

Element Occurrence Rank: C

Size: 2.7 acres

Location: Plum Island, Green Bay National Wildlife Refuge, Lake Michigan, Wisconsin

Element Occurrence Identification Number: 24370 (EO update)

Site Description: Limestone cobble shore occurs along the shoreline of Plum Island. The soils are wet, gravelly, alkaline (pH 8.0) sands mixed with organics occurring between and beneath the cobble. Small inclusions of limestone bedrock lakeshore occur along the southern shore and intergrade with limestone cobble shore and limestone lakeshore cliff. 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 three to six 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.

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 (1-4%) and shrubs (2-5%) occur rarely along the upper margins of the limestone cobble shore and include northern white-cedar (*Thuja occidentalis*), paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), green ash (*Fraxinus pennsylvanica*), choke cherry (*Prunus virginiana*), round-leaved serviceberry (*Amelanchier sanguinea*), and soapberry (*Shepherdia canadensis*). Characteristic herbaceous species (2-6%) include silverweed (*Potentilla anserina*), harebell (*Campanula rotundifolia*), starry false Solomon-seal (*Maianthemum stellatum*), and swamp milkweed (*Asclepias incarnata*).



Plum Island limestone cobble shore. Photo by Joshua G. Cohen.

The Plum Island limestone cobble shore was surveyed from July 12th through July 14th. Sixty-eight plant species were documented with 51 native species and 17 non-native species (Appendix 3.7). The total FQI was 26.4.

Threats: Non-native species recorded along the limestone cobble shore include ox-eye daisy (*Leucanthemum vulgare*), bladder campion (*Silene vulgaris*), spotted knapweed (*Centaurea stoebe*), hound's-tongue (*Cynoglossum officinale*), hybrid honeysuckle (*Lonicera x bella*), Japanese barberry (*Berberis thunbergii*), bittersweet nightshade (*Solanum dulcamara*), and Timothy (*Phleum pratense*).

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



Plum Island limestone cobble shore. Photo by Joshua G. Cohen.



2020 aerial photograph of Plum Island limestone cobble shore.

8. Plum Island – Limestone Lakeshore Cliff

Natural Community Type (MI): Limestone Lakeshore Cliff

Natural Community Type (WI): Moist Cliff

Rank: GNR S4, not ranked globally and apparently secure within the state (WI)

Element Occurrence Rank: C

Size: 5.7 acres

Location: Plum Island, Green Bay National Wildlife Refuge, Lake Michigan, Wisconsin

Element Occurrence Identification Number: 24368 (EO update)

Site Description: Approximately a kilometer of limestone lakeshore cliff occurs along the eastern and southern shorelines of Plum Island. The cliffs are low in stature and range from one to four meters tall. Very shallow (1-2 cm) fine-textured, alkaline (pH 8.0) organic soils accumulate on the ledges, crevices, and at the base of tree boles. Thin soils, cold winter temperatures, steady winds, and summer droughts make for harsh growing conditions. Numerous canopy northern white-cedar (*Thuja occidentalis*) occurring along the top of the cliff ledge were cored to determine the age range of canopy trees: a 26.5 cm tree was over 170 years old; a 32.7 cm tree was over 170 years old; a 17.4 cm tree was over 166 years old; and a 34.2 cm tree was over 205 years old. Horizontal limestone pavement occurs locally at the base of the vertical cliff exposure and is more extensive during low water years. Dissolution pools occur on ledges and stretches of horizontal bedrock. These pools are characterized by red algae that is slowly dissolving the limestone substrate and creating these small depressions.

Vegetation is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks and joints in the cliff face, ledges along the cliff face, and along the cliff base where limestone chunks are occasional between the cliff and the open water. Significant areas of vertical cliff face are bare of all vegetation. Sparse herbaceous



Plum Island limestone lakeshore cliff. Photo by Joshua G. Cohen.

cover (5-10%) includes wild columbine (*Aquilegia canadensis*), harebell (*Campanula rotundifolia*), yarrow (*Achillea millefolium*), climbing fumitory (*Adlumia fungosa*, state special concern), white camas (*Anticlea elegans*, state special concern), beggar's lice (*Hackelia virginiana*), and big-leaved aster (*Eurybia macrophylla*). Moss and feathermoss are locally common. Shrub cover is sparse (2-8%) with choke cherry (*Prunus virginiana*), round-leaved dogwood (*Cornus rugosa*), red elderberry (*Sambucus racemosa*), beaked hazelnut (*Corylus cornuta*), round-leaved serviceberry (*Amelanchier sanguinea*), ninebark (*Physocarpus opulifolius*), bush-honeysuckle (*Diervilla lonicera*), and soapberry (*Shepherdia canadensis*). Scattered and often stunted trees (1-5%) occur along the lip and on ledges and crevices and include northern white-cedar, paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), sugar maple (*Acer saccharum*), and green ash (*Fraxinus pennsylvanica*).

The Plum Island limestone lakeshore cliff was surveyed from July 12th through July 14th. Ninety-five plant species were documented with 70 native species and 25 non-native species (Appendix 3.8). The total FQI was 36.1.

Threats: Non-native species are locally common and include multiflora rose (*Rosa multiflora*), Canada bluegrass (*Poa compressa*), bittersweet nightshade (*Solanum dulcamara*), common burdock (*Arctium minus*), spotted knapweed (*Centaurea stoebe*), bull thistle (*Cirsium vulgare*), hound's-tongue (*Cynoglossum officinale*), butter-and-eggs (*Linaria vulgaris*), honeysuckle (*Lonicera* sp.), catnip (*Nepeta cataria*), Timothy (*Phleum pratense*), and ox-eye daisy (*Leucanthemum vulgare*). Logging in the adjacent boreal forest and mesic northern forest occurred right to the edge of the limestone lakeshore cliff with no buffering provided. This lack of buffering likely contributes to prevalence of non-native species throughout the cliffs.

Management Recommendations: Efforts to control invasive species should be implemented and these control efforts should be monitored. All future management adjacent to the shoreline should include a significant buffer (e.g., a minimum of 100 ft).



Plum Island limestone lakeshore cliff. Photo by Joshua G. Cohen.



2020 aerial photograph of Plum Island limestone lakeshore cliff.

9. Plum Island – Mesic Northern Forest

Natural Community Type (MI): Mesic Northern Forest

Natural Community Type (WI): Northern Mesic Forest

Rank: G4 S4, apparently secure globally and within the state (WI)

Element Occurrence Rank: D

Size: 62 acres

Location: Plum Island, Green Bay National Wildlife Refuge, Lake Michigan, Wisconsin

Element Occurrence Identification Number: 24369 (EO update)

Site Description: Mesic northern forest occurs in the interior of Plum Island on flat to gently rolling topography. The soils are shallow (20 cm), alkaline (pH 7.3-7.5) loams that overly limestone cobble and bedrock. Numerous canopy dominants were cored across the mesic northern forest to estimate the age range of canopy trees in this uneven-aged mesic northern forest: a 57.4 cm sugar maple (*Acer saccharum*) was over 128 years old; a 57.5 cm red oak (*Quercus rubra*) was over 128 years old; a 60.1 cm red oak was over 105 years old; and an 84.4 cm sugar maple was over 220 years old. Cut stumps and old logging roads occur throughout. As the result of past logging interacting with gap-phase dynamics, the forest is characterized by moderate to large canopy trees that are maturing and low volumes of coarse woody debris with mostly paper birch (*Betula papyrifera*), some northern white-cedar (*Thuja occidentalis*), and scattered hemlock (*Tsuga canadensis*) and cedar snags.

This uneven-aged mesic northern forest is dominated by sugar maple with canopy associates including red oak, basswood (*Tilia americana*), paper birch, northern white-cedar, hemlock, and white pine (*Pinus strobus*). The canopy has been selectively cut in the past. Canopy closure ranges from 65 to 85% and canopy trees range from 35 to 60 cm with some larger sugar maple, red oak, northern white-cedar, and hemlock reaching 60 to 90 cm. The subcanopy ranges from 10 to 25% with sugar maple, ironwood (*Ostrya virginiana*), northern white-cedar, and hemlock. The understory layer is sparse to patchy (10-30%) with sugar maple, ironwood, red elderberry (*Sambucus racemosa*), mountain maple (*Acer spicatum*), choke cherry (*Prunus virginiana*), basswood, invasive honeysuckles (*Lonicera* spp.), multiflora rose (*Rosa multiflora*), and Japanese barberry (*Berberis thunbergii*). The low shrub layer is patchy to dense (25-50%) with shrub cover increasing where canopy cover becomes more open and characteristic species including black raspberry (*Rubus occidentalis*), wild red raspberry (*Rubus strigosus*), bush-honeysuckle (*Diervilla lonicera*), sugar maple, choke cherry, ironwood, and Japanese barberry. The ground cover is diverse and dense (60-80%) and characteristic species include wild leek (*Allium tricoccum*), white avens (*Geum canadense*), enchanter's nightshade (*Circaea canadensis*), wild strawberry (*Fragaria virginiana*), white baneberry (*Actaea pachypoda*), woodferns (*Dryopteris* spp.), ostrich fern (*Matteuccia struthiopteris*), blue cohosh (*Caulophyllum thalictroides*), sharp-lobed hepatica (*Hepatica acutiloba*), hairy sweet-cicely (*Osmorhiza claytonii*), poison ivy (*Toxicodendron radicans*), false spikenard (*Maianthemum racemosum*), zigzag goldenrod (*Solidago flexicaulis*), beggar's lice (*Hackelia virginiana*), climbing fumitory (*Adlumia fungosa*, state special concern), and big-leaved aster (*Eurybia macrophylla*). Mosses were observed growing on the boles of the large (> 60 cm) canopy trees. Numerous mammalian distributed plant species are common across the island including beggar's lice, hairy sweet-cicely, and enchanter's nightshade. Areas of high-quality mesic northern forest are characterized by a greater prevalence of ferns in the ground cover.

The Plum Island mesic northern forest was surveyed from July 12th through July 14th. Ninety-five plant species were documented with 75 native species and 20 non-native species (Appendix 3.9). The total FQI was 42.9.

Threats: Species composition and vegetative structure of the mesic northern forest on Plum Island is influenced by the interaction of depth to limestone substrate and by time and intensity of past disturbance factors including windthrow, logging, and deer herbivory. Cut stumps and old logging roads occur throughout and the mesic northern forest has been logged multiple times. As a result of past logging, the forest is characterized by canopy trees that are predominantly young to maturing and low volumes of coarse woody debris. Deer, deer trails, and heavy browse were noted throughout. A high browse line was noted on the northern white-cedar. Non-native plants are prevalent throughout the ground cover and include invasive honeysuckles (*Lonicera* spp.), multiflora rose (*Rosa multiflora*), Japanese barberry (*Berberis thunbergii*), dame's rocket (*Hesperis matronalis*), Canada thistle (*Cirsium arvense*), marsh thistle (*C. palustre*), bull thistle (*C. vulgare*), bittersweet nightshade (*Solanum dulcamara*), moneywort (*Lysimachia nummularia*), catnip (*Nepeta cataria*), common burdock (*Arctium minus*), hound's-tongue (*Cynoglossum officinale*), Timothy (*Phleum pratense*), common St. John's-wort (*Hypericum perforatum*), wild parsnip (*Pastinaca sativa*), reed canary grass (*Phalaris arundinacea*), common buttercup (*Ranunculus acris*), and ox-eye daisy (*Leucanthemum vulgare*). The areas of mesic northern forest with more closed canopy (65-85%) tend to be less weedy than the areas of open canopy (25-50%). Invasive species are pervasive

and diverse and are locally impacting species composition and vegetative structure. Many of the non-native species found in the mesic northern forest are prevalent in floodplain forest ecosystems (e.g., Japanese barberry, dame's rocket, and moneywort). The two polygons of element occurrence mesic northern forest are embedded within degraded mesic northern forest that is characterized by higher levels of invasive species cover. The diversity of invasive species in mesic forest across Plum Island is likely attributed in part to the rich loam soils. Prevalence of invasives is also linked to the past multiple logging events, numerous trails throughout the forest, and high deer herbivory across the island. The invasive species have likely become established on the island through multiple dispersal mechanisms including logging equipment and songbirds. Earthworms were noted within the mesic northern forest and are likely impacting the soil.

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 control and monitor for invasive species. Maintaining low deer densities on Plum Island is critical for restoring the integrity of the island's forested systems.



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



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



Climbing fumitory (*Adlumia fungosa*, state special concern) documented within the Plum Island mesic northern forest. Photos by Tyler J. Bassett.



2020 aerial photograph of Plum Island mesic northern forest.

POVERTY ISLAND

Poverty Island is in the Michigan section of the Grand Traverse Islands and is located in northern Lake Michigan approximately 9.5 km south of the southern coast of Michigan's Garden Peninsula and 7 km northeast of Saint Martin Island (Figure 7). Poverty Island is nearly round in shape, with a length of 1.1 km and a width of 0.8 km for a total approximate area of 75 ha. The island is part of the Niagara Escarpment, and therefore is underlain by dolomite from the Silurian Period. Poverty Island reaches a maximum elevation of 11 meters.

Poverty Island's position near the Poverty Island Passage made it an important location for historical navigation in northern Lake Michigan, as evidenced by the presence of several derelict navigation-aiding structures still present on the island. Active until 1974, the Poverty Island lighthouse was established in 1875 along the southwest shore of the island and the lighthouse was used up until 1995 (National Register of Historic Places, 2005). Selective logging of the boreal forest likely occurred beginning in the late 1800s and continued in the early 1900s. An old railroad grade passes through the southern portion of the island and was likely used for transporting building materials from the southeastern shore to the lighthouse. A small long-abandoned hunting camp was noted within the forest along the eastern shore suggesting that the island has been used for deer hunting in the past.

Three high-quality natural community element occurrences were surveyed on Poverty Island during the 2021 field season including boreal forest, limestone bedrock lakeshore, and limestone lakeshore cliff (Table 1; Figure 8). Limestone lakeshore cliff occurs along the western shoreline and limestone bedrock lakeshore characterizes the eastern coast and gently grades into Lake Michigan. Along the northern and southern shores of the island limestone bedrock lakeshore and limestone lakeshore cliff intergrade. Small inclusions of limestone cobble shore occur locally but are not of sufficient size to qualify for consideration as an element occurrence. Boreal forest occurs in the interior of the island. Poverty Island burned during a 2016 wildfire that was started by a lightning strike and burned for three months. The fire burned the majority of the boreal forest in the interior of the island but also locally burned along the escarpment of the limestone lakeshore cliff, the terraces between the two-tiered cliff exposure, and the upper margin of the limestone bedrock lakeshore. Natural community surveys were conducted from July 27th through July 28th. Prior to this survey effort, Poverty Island was last visited by MNFI ecologists in 1995.



Poverty Island burned during a 2016 wildfire that impacted the majority of the boreal forest in the interior of the island but also locally burned along the escarpment of the limestone lakeshore cliff, the terraces between the two-tiered cliff exposure, and the upper margin of the limestone bedrock lakeshore. Photo by Joshua G. Cohen.



Figure 7. Natural community surveys within the Green Bay National Wildlife Refuge in Michigan were conducted in 2021 on Poverty, Rocky, and Saint Martin Islands.



Figure 8. Natural community element occurrences on Poverty Island, Green Bay National Wildlife Refuge.

10. Poverty Island – Boreal Forest

Natural Community Type: Boreal Forest

Rank: GU S3, globally unrankable and vulnerable within the state

Element Occurrence Rank: B

Size: 177 acres

Location: Poverty Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 7488 (EO update)

Site Description: Boreal forest occurs throughout the interior of Poverty Island. The topography is flat to rolling and the boreal forest occurs on shallow soils overlying limestone bedrock. Limestone ledges and grykes occur throughout the boreal forest. A lightning-ignited wildfire burned on Poverty Island for three months in 2016. The fire burned the majority of the boreal forest in the interior of the island. We estimate that over 30% of the boreal forest burned. The prevalence of charred, downed logs observed during the 2021 surveys suggests that prior to the fire, much of the boreal forest was characterized by high volumes of coarse woody debris from pervasive windthrow. The high combustible fuel levels and the prolonged period of drought leading up to the fire resulted in an intense crown fire that eliminated the tree canopy across much of the boreal forest. Northern white-cedar (*Thuja occidentalis*) and paper birch (*Betula papyrifera*) snags occur throughout the boreal forest and provide perching posts for birds that are contributing to seed dispersal. In addition, the extended time that the fire burned resulted in the elimination or drastic reduction of the organic soil layer. Much of the severely burned boreal forest is characterized by exposed limestone bedrock or a very thin layer (< 1 cm) of soil or feathermoss overlying the bedrock. In less severely burned areas, soil depths range from 5 to 25 cm (pH 5.5). In areas that did not burn, the soil depths range from 20 to 30 cm with slightly acidic (pH 5.5-6.8) silty loams overlying limestone bedrock or cobble. It is possible that the relatively deeper soil depths observed in these unburned areas helped hold more moisture than areas of burned boreal forest and thereby contributed to fire not passing through these areas. In addition, these areas have considerably less windthrow and the lack of fuels may have also been a driving factor. A 38.5 cm northern white-cedar was cored within an unburned pocket along the eastern portion of the island and was estimated to be over 173 years old.



Burned boreal forest on Poverty Island. Photo by Joshua G. Cohen.

Unburned portions of boreal forest are dominated by northern white-cedar with canopy associates including balsam poplar (*Populus balsamifera*), balsam fir (*Abies balsamea*), and paper birch. Canopy closure ranges from 55 to 85% with diameter at breast height (DBH) ranging from 30 to 50 cm. The understory tends to be dense with balsam fir prevalent and mountain maple (*Acer spicatum*) locally common. Sparse to patchy (10-20%) low shrubs include yew (*Taxus canadensis*), mountain maple, bush-honeysuckle (*Diervilla lonicera*), and wild red raspberry (*Rubus strigosus*). The ground cover is sparse to patchy (15-30%) with characteristic species including sedge (*Carex pedunculata*), star-flower (*Trientalis borealis*), and stiff clubmoss (*Spinulum annotinum*).

Areas of burned boreal forest have an open canopy with a dense (40-60%) understory of tree and shrub species regenerating following the fire including northern white-cedar, paper birch, trembling aspen (*Populus tremuloides*), balsam poplar, staghorn sumac (*Rhus typhina*), and pin cherry (*Prunus pensylvanica*). The low shrub layer is patchy to dense (25-75%) and includes dense seedling northern white-cedar and trembling aspen along with staghorn sumac, wild red raspberry, bush-honeysuckle, and black raspberry (*Rubus occidentalis*). The most prevalent species within the burned boreal forest are regenerating northern white-cedar, paper birch, and trembling aspen saplings and seedlings, pin cherry, staghorn sumac, wild red raspberry, fireweed (*Chamaenerion angustifolium*), and feathermosses. Tree seedlings were observed to be abundant within the cracks and crevices in the limestone bedrock. Along the southern end of the island there are unburned windthrown patches of boreal forest with open canopy (5%). These areas are characterized by a dense understory with northern white-cedar, balsam fir, trembling aspen, mountain maple, pin cherry, red elderberry (*Sambucus racemosa*), and wild red raspberry.

The Poverty Island boreal forest was surveyed over the course of two days from July 27th to July 28th. Ninety-three plant species were documented with 73 native species and 20 non-native species (Appendix 3.10). The total FQI was 28.



Unburned boreal forest on Poverty Island. Photo by Joshua G. Cohen.

Threats: Species composition and vegetative structure have been impacted by numerous factors including windthrow, wildfire, logging, and variable soil depth to bedrock. Numerous non-native weedy opportunists have become established in the areas of open-canopied burnt boreal forest including Canada bluegrass (*Poa compressa*), orange hawkweed (*Hieracium aurantiacum*), king devil (*Hieracium caespitosum*), Canada thistle (*Cirsium arvense*), marsh thistle (*C. palustre*), bull thistle (*C. vulgare*), bittersweet nightshade (*Solanum dulcamara*), common mullein (*Verbascum thapsus*), and white sweet-clover (*Melilotus albus*). Invasive reed (*Phragmites australis* subspecies *australis*) is locally common in the burnt boreal forest in the northwestern portion of the island.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered, control the invasive species, especially invasive reed, and monitor control efforts. In addition, the extensive areas of burnt boreal forest should be monitored to evaluate vegetative response to the fire over time.



Extensive windthrow throughout the boreal forest preceded the 2016 wildfire and likely contributed to the severity and longevity of the fire. Charred, downed logs were observed throughout the burnt boreal forest during the 2021 surveys. Photo by Joshua G. Cohen.



2020 aerial photograph of Poverty Island boreal forest.

11. Poverty Island – Limestone Bedrock Lakeshore

Natural Community Type: Limestone Bedrock Lakeshore

Rank: G3 S2, vulnerable globally and imperiled within the state

Element Occurrence Rank: A

Size: 17 acres

Location: Poverty Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 4159 (EO Update)

Site Description: Approximately 1.5 kilometers of limestone bedrock lakeshore occurs along the eastern shoreline of Poverty Island. Limestone bedrock lakeshore and limestone lakeshore cliff intergrade along the northern and southern shores of the island. Small inclusions of limestone cobble shore occur locally within the limestone bedrock lakeshore. Both limestone bedrock lakeshore and limestone lakeshore cliff are backed by boreal forest in the interior of the island. The 2016 wildfire locally burned where the upper margin of the limestone bedrock lakeshore grades into boreal forest. Charred and windthrown trees persist along the upper margin of the limestone bedrock lakeshore. The limestone bedrock lakeshore was surveyed 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 reduced the overall cover of herbaceous species in the limestone bedrock lakeshore and caused the dieback of woody species via prolonged inundation, especially northern white-cedar (*Thuja occidentalis*) and creeping juniper (*Juniperus horizontalis*). The soils of the limestone bedrock lakeshore are characterized by shallow (1-2 cm), alkaline (pH 7.8) organics that accumulate in cracks, crevices, and depressions, along ledges, and at the base of trees. Shallow pools of water or dissolution pools occur locally on the limestone bedrock lakeshore with some of the pools supporting aquatic vegetation. Two trees were cored along the upper margin of the limestone bedrock lakeshore. A 27.8 cm northern white-cedar was estimated to be 121 years old and a 34.9 cm northern white-cedar was estimated to be 120 years old.

The limestone bedrock lakeshore is sparsely vegetated and dominated by herbaceous plants (2-5%) with scattered tree and shrub cover (1-2%) restricted to the inland edge and cracks and crevices. Characteristic herbaceous species include marsh bellflower (*Campanula aparinoides*), rushes (*Juncus balticus* and *J. dudleyi*), limestone calamint (*Clinopodium arkansanum*), Kalm's lobelia (*Lobelia kalmii*), grass-leaved goldenrod (*Euthamia graminifolia*), silverweed (*Potentilla anserina*), spotted touch-me-not (*Impatiens campensis*), blue-joint (*Calamagrostis canadensis*), northern bugleweed (*Lycopus uniflorus*), hair grass (*Deschampsia cespitosa*), ticklegrass (*Agrostis hyemalis*), variegated scouring rush (*Equisetum variegatum*), white camas (*Anticlea elegans*), golden-seeded spike rush (*Eleocharis elliptica*), wild strawberry (*Fragaria virginiana*), wild blue flag (*Iris versicolor*), and smartweeds (*Persicaria* spp.). Herbaceous vegetation is primarily found in cracks and crevices within the limestone bedrock but also locally occurs in dry dissolution depressions. Scattered trees and tall shrubs include northern white-cedar, balsam fir (*Abies balsamea*), white spruce (*Picea glauca*), trembling aspen (*Populus tremuloides*), mountain-ash (*Sorbus decora*), red elderberry (*Sambucus racemosa*), mountain maple (*Acer spicatum*), and ninebark (*Physocarpus opulifolius*). Characteristic low shrubs include shrubby cinquefoil (*Dasiphora fruticosa*), creeping juniper, red-osier dogwood (*Cornus sericea*), and ninebark.

The Poverty Island limestone bedrock lakeshore was surveyed on July 27th and July 28th. One hundred and thirteen plant species were documented with 92 native species and 21 non-native species (Appendix 3.11). The total FQI was 38.3.

Threats: Canada bluegrass (*Poa compressa*) is locally common in the limestone bedrock lakeshore. Additional non-native species found within the limestone bedrock lakeshore include catnip (*Nepeta cataria*), bittersweet nightshade (*Solanum dulcamara*), narrow-leaved cat-tail (*Typha angustifolia*), hound's-tongue (*Cynoglossum officinale*), reed canary grass (*Phalaris arundinacea*), and Canada thistle (*Cirsium arvense*).

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



Poverty Island limestone bedrock lakeshore. Photos by Joshua G. Cohen.





2020 aerial photograph of Poverty Island limestone bedrock lakeshore.

12. Poverty Island – Limestone Lakeshore Cliff

Natural Community Type: Limestone Lakeshore Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled within the state

Element Occurrence Rank: A

Size: 17 acres

Location: Poverty Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 1437 (EO Update)

Site Description: Approximately 1.5 kilometers of limestone lakeshore cliff occurs along the western shoreline of Poverty Island. Limestone lakeshore cliff and limestone bedrock shore intergrade along the northern and southern shores of the island. Both limestone lakeshore cliff and limestone bedrock lakeshore are backed by boreal forest in the interior of the island. The cliffs are typically 3 to 6 meters tall but reach as tall as 10 to 12 meters and are often terraced with talus slope at the base of the cliff face. The complex includes portions of cliff exposure that are immediately adjacent to the lakeshore as well as limestone cliff that is set back behind 15 to 30 meters of boreal forest, much of which has burned. Very shallow (<1 cm) fine-textured, alkaline (pH 8.0) soils have accumulated on the ledges, crevices, and at the base of the cliffs. Thin soils, cold winter temperatures, steady winds, and summer droughts make vegetation especially prone to desiccation. Grykes, vertical fissures in limestone dissolved by water, occur throughout the boreal forest in the terrace between the stair-stepped cliff exposures along the northwestern portion of the island. A 33.3 cm northern white-cedar (*Thuja occidentalis*) along the top of the cliff was cored and estimated to be over 153 years old. The 2016 wildfire locally burned along the escarpment of the limestone lakeshore cliff, the terraces between the two-tiered cliff exposure, and the upper margin of the limestone bedrock lakeshore. Charred and windthrown trees occur along the upper margin of the limestone lakeshore cliff and between the cliff terraces.



Poverty Island limestone lakeshore cliff. Photo by Joshua G. Cohen.

Vegetation is sparse and is generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks and joints in the cliff face, ledges between the terraces, at the base of crevices, and along the cliff base where talus slope is occasional between the cliff and the open water. Significant areas of vertical cliff face are bare of all vegetation. Sparse herbaceous cover (4-8%) includes harebell (*Campanula rotundifolia*), hair grass (*Deschampsia cespitosa*), balsam ragwort (*Packera paupercula*), wild columbine (*Aquilegia canadensis*), yarrow (*Achillea millefolium*), and climbing fumitory (*Adlumia fungosa*, state special concern). Characteristic low shrubs (4-8%) include ninebark (*Physocarpus opulifolius*), bush-honeysuckle (*Diervilla lonicera*), shrubby cinquefoil (*Dasiphora fruticosa*), red-osier dogwood (*Cornus sericea*), and wild red raspberry (*Rubus strigosus*). Tall shrubs (2-5%) include red elderberry (*Sambucus racemosa*), staghorn sumac (*Rhus typhina*), pin cherry (*Prunus pensylvanica*), red-osier dogwood, yew (*Taxus canadensis*), and mountain maple (*Acer spicatum*). Stunted and scattered trees along the lip and on ledges and crevices include northern white-cedar, paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), and balsam fir (*Abies balsamea*).

The Poverty Island limestone lakeshore cliff was surveyed on July 27th and July 28th. Sixty-seven plant species were documented with 55 native species and 12 non-native species (Appendix 3.12). The total FQI was 29.5.



The 2016 wildfire locally burned vegetation along the escarpment of the limestone lakeshore cliff and the terraces between the two-tiered cliff exposure (pictured above). Photo by Joshua G. Cohen.



Poverty Island limestone lakeshore cliff. Photos by Joshua G. Cohen.



Threats: Species composition and structure are patterned by natural processes. The following non-native species were documented along the limestone lakeshore cliff: ox-eye daisy (*Leucanthemum vulgare*), Canada bluegrass (*Poa compressa*), marsh thistle (*Cirsium palustre*), bull thistle (*C. vulgare*), hemp-nettle (*Galeopsis tetrahit*), mossy stonecrop (*Sedum acre*), bittersweet nightshade (*Solanum dulcamara*), king devil (*Hieracium caespitosum*), hound's-tongue (*Cynoglossum officinale*), and catnip (*Nepeta cataria*).

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



Charred and windthrown trees occur along the upper margin of the limestone lakeshore cliff. Photo by Joshua G. Cohen.



2020 aerial photograph of Poverty Island limestone lakeshore cliff.

ROCKY ISLAND

Rocky Island is part of the Grand Traverse Islands and occurs in northern Lake Michigan. It is located east of Little Summer Island, off the southern coast of Michigan's Garden Peninsula (Figure 7). Depending on current water levels of the Great Lakes, Rocky Island's area can range from just over 4 ha to 10.5 ha. Due to its location within the Niagara Escarpment, Rocky Island's bedrock consists of dolomite from the Silurian Period. Because of its small size and low elevation, Rocky Island is subject to high winds and waves from storm events as well as ice scour from freezing and thawing of Lake Michigan's waters. The shoreline of Rocky Island consists of limestone cobble shore that varies in extent with fluctuations of the Great Lakes. The limestone cobble shore is backed by upland shrub thicket that formerly supported boreal forest. The boreal forest transitioned to shrub thicket due to nesting by colonial shorebirds and windthrow. The interior is now dominated by a mix of upland shrubs and opportunistic, weedy, sun-loving herbaceous species and a scattered overstory.

A high-quality limestone cobble shore was documented on Rocky Island during the 2021 field season (Table 1; Figure 9). Natural community surveys were conducted on July 26th.



Figure 9. Limestone cobble shore element occurrence on Rocky Island, Green Bay National Wildlife Refuge.



Rocky Island limestone cobble shore. Photo by Joshua G. Cohen.

13. Rocky 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: C

Size: 3.7 acres

Location: Rocky Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 24366

Site Description: Limestone cobble shore occurs along the shoreline of Rocky Island. The limestone cobble shore is subject to high energy disturbance in the form of frequent storms, high wave activity, and ice scour and is therefore characterized by low vegetative cover. The absence of concave shorelines results in the absence of areas with dampened wave activity. As a result, vegetation and wetland development are limited along the shore of Rocky Island. The soils of the limestone cobble shore are wet gravelly, circumneutral to alkaline (pH 7.0-8.0) sands mixed with organics that occur between and beneath the cobble. A shallow pond occurs along the western end of the island. Small infrequent pockets of limestone bedrock lakeshore occur within the limestone cobble shore. 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 3 to 5 meters wide. High water levels have also caused the dieback of trees and shrubs within the limestone cobble shore. The majority of trees and shrubs within the limestone cobble shore have been flood-killed with standing dead stems, especially green ash (*Fraxinus pennsylvanica*) and paper birch (*Betula papyrifera*). A 24.5 cm green ash along the margin of the limestone cobble shore was cored and estimated to be over 32 years.

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 and shrubs (1-2%) occur rarely along the upper margins of the limestone cobble shore and include green ash, paper birch, northern white-cedar (*Thuja occidentalis*), red-osier dogwood (*Cornus sericea*), willows (*Salix* spp.), and choke cherry (*Prunus virginiana*). Characteristic herbaceous species include silverweed (*Potentilla anserina*), stinging nettle (*Urtica dioica*), smartweed (*Persicaria punctata*), and spotted touch-me-not (*Impatiens campensis*).

The Rocky Island limestone cobble shore was surveyed July 26th. Thirty-one plant species were documented with 16 native species and 15 non-native species (Appendix 3.13). The total FQI was 10.

Threats: Weedy, opportunistic non-native species are common and include common burdock (*Arctium minus*), yellow rocket (*Barbarea vulgaris*), lambs-quarters (*Chenopodium album*), marsh thistle (*Cirsium palustre*), bull thistle (*C. vulgare*), hound's-tongue (*Cynoglossum officinale*), gromwell (*Lithospermum officinale*), birdfoot trefoil (*Lotus corniculata*), white sweet-clover (*Melilotus albus*), catnip (*Nepeta cataria*), wild parsnip (*Pastinaca sativa*), reed canary grass (*Phalaris arundinacea*), curly dock (*Rumex crispus*), mossy stonecrop (*Sedum acre*), and bittersweet nightshade (*Solanum dulcamara*).

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



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





2020 aerial photograph of Rocky Island limestone cobble shore.



Rocky Island limestone cobble shore. Photo by Joshua G. Cohen.

SAINT MARTIN ISLAND

Saint Martin Island is one of the most remote islands in the Grand Traverse Islands and is located in northern Lake Michigan approximately 15 km southwest of Fairport, Garden Peninsula, Michigan, and 26 km northeast of Northport, Door Peninsula, Wisconsin (Figure 7). Saint Martin Island is also one of the larger islands in the Grand Traverse Islands group, measuring approximately 3.8 km long and 2.5 km wide at its widest point, for a total area of 530 ha. As part of the Niagara Escarpment, the bedrock of Saint Martin Island is composed of dolomite from the Silurian Period.

In the mid-1800s, a farming and fishing settlement was established on Saint Martin Island and existed until its abandonment in 1889 (Door County Pulse, 2013). The location of Saint Martin Island made it an important site for maritime navigation infrastructure and in 1905 a lighthouse was constructed on the northeast coast of the island (National Park Service, 2006) and occupied until 1980. Selective logging of the boreal forest and mesic northern forest likely occurred beginning in the mid-1800s and intensified during the early 1900s corresponding to the occupation of the lighthouse. The northeast section of Saint Martin Island, including the site of the lighthouse and associated buildings, is owned and administered by the Little Traverse Bay Bands of Odawa Indians. The majority of Saint Martin Island is part of the Green Bay NWR and was transferred to the USFWS in 2015 from The Nature Conservancy. Before being purchased by The Nature Conservancy in 2013, the majority of the island was owned by a private family. The island was used as a deer hunting camp and there are cabins along the southwestern shore and two-tracks and hunting blinds across the island's uplands. In 2013, the island's deer population was significantly reduced through a culling effort (Sadie O'Dell, USFWS, personal communication).

Six high-quality natural community element occurrences were documented on Saint Martin Island during the 2021 field season including boreal forest, limestone cliff, limestone cobble shore, limestone lakeshore cliff, mesic northern forest, and northern hardwood swamp (Table 1; Figure 10). Natural community surveys were conducted from June 2nd through June 4th and July 28th through July 29th. The most striking coastal feature of the island is the limestone lakeshore cliff, which occurs along the western, northern, and eastern shorelines. In addition to these cliffs, the shoreline also supports limestone cobble shore with small inclusions of limestone bedrock lakeshore. The coastal communities are backed by boreal forest, which occurs as a distinct band just inland from the shoreline. Both high-quality and degraded boreal forest occur on the island with the degraded boreal forest occurring near the lighthouse and the cabins. The island's interior plateau is characterized by mesic northern forest which ranges from high-quality to degraded. Both the degraded boreal forest and degraded mesic northern forest are characterized by younger and smaller canopy trees, lower species diversity in the ground cover, and greater abundance of non-native species resulting from the impact of more recent and intensive logging compared to their high-quality counterparts. Small exposures of limestone cliff occur nested within the mesic northern forest across the island. The remote location of Saint Martin Island and the north-south orientation of the relatively straight shorelines precludes the development of coastal wetland ecosystems. The straight, long, unprotected shorelines on the western and eastern coasts are subject to high energy disturbance in the form of frequent storms, high wave activity, and ice scour. Long-term development of ecosystems across the island following glaciation has been influenced by the shoreline configuration, which has resulted in the prevalence of upland ecosystems across the island. Only one wetland ecosystem was documented on the island. A small pocket of northern hardwood swamp occurs in the northeast part of the island



Limestone lakeshore cliff backed by boreal forest, Saint Martin Island. Photo by Jesse M. Lincoln.



Figure 10. Natural community element occurrences on Saint Martin Island, Green Bay National Wildlife Refuge.

14. Saint Martin 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: Saint Martin Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 24351

Site Description: Boreal forest occurs as a distinct band just inland from the shoreline of Saint Martin Island. The boreal forest is found along gentle slopes on shallow soils above limestone cobble and also as a narrow band along the terraces between limestone cliff exposures. Windthrow is prevalent throughout and as a result, the boreal forest is characterized by high structural diversity as well as high 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*). Charring on tree boles and woody debris and charcoal in the soil profile within the boreal forest on the terrace on the western side of the island indicate that wildfire has occurred locally. Occasional yew (*Taxus canadensis*) and northern white-cedar (*Thuja occidentalis*) in the low shrub layer and robust ground cover and low shrub species suggest that deer browse is currently low and that the boreal forest is recovering from a period of high deer browse. Numerous canopy northern white-cedar were cored across the boreal forest to help determine the age range of canopy trees in the uneven-aged boreal forest: a 35.6 cm cedar was cored and estimated to be over 160 years old; a 39.8 cm cedar was cored and estimated to be over 170 years old; a 37.8 cm cedar was cored and estimated to be over 178 years old; a 42.4 cm cedar was cored and estimated to be over 140 years old; and a 45.5 cm cedar was cored and estimated to be over 104 years old.

The canopy is dominated by northern white-cedar with canopy associates including balsam fir, trembling aspen (*Populus tremuloides*), and paper birch and occasional red pine (*Pinus resinosa*). Canopy coverage typically ranges from 70 to 90% but in areas where windthrow has been more prevalent, the canopy coverage drops to 45 to 65%. Canopy trees typically range in diameter from 30 to 50 cm. The subcanopy layer is sparse (5-10%) with balsam fir, mountain maple (*Acer spicatum*), trembling aspen, round-leaved dogwood (*Cornus rugosa*), and red elderberry (*Sambucus racemosa*). The understory layer is sparse to patchy (15-25%) with balsam fir, mountain maple, red elderberry, round-leaved dogwood, choke cherry (*Prunus virginiana*), and beaked hazelnut (*Corylus cornuta*). In areas with more open canopy from windthrow, the understory is dense (25-45%) with balsam fir, mountain maple, paper birch, and red elderberry increasing in importance.

The low shrub layer is sparse to patchy (10-30%) with bush-honeysuckle (*Diervilla lonicera*), Canadian fly honeysuckle (*Lonicera canadensis*), red honeysuckle (*Lonicera dioica*), mountain maple, balsam fir, ninebark (*Physocarpus opulifolius*), wild red raspberry (*Rubus strigosus*), and bearberry (*Arctostaphylos uva-ursi*). Yew and northern white-cedar occur locally in the low shrub layer. Where the canopy is more open due to blowdown, wild red raspberry and bush-honeysuckle increase in cover. Prevalent species of the patchy (20-45%) ground cover include star-flower (*Trientalis borealis*), Canada mayflower (*Maianthemum canadense*), bluebead-lily (*Clintonia borealis*), wild sarsaparilla (*Aralia nudicaulis*), gay-wings (*Polygala paucifolia*), white lettuce (*Prenanthes alba*), big-leaved aster (*Eurybia macrophylla*), fragrant bedstraw (*Galium triflorum*), cow-parsnip (*Heracleum maximum*), herb Robert (*Geranium robertianum*), and sedge (*Carex eburnea*). Several dwarf lake iris (*Iris lacustris*, federal/state threatened) and ram's head lady-slipper (*Cypripedium arietinum*) were documented in the boreal forest along the southwestern portion of the island.

The Saint Martin Island boreal forest was surveyed from June 2nd through June 4th and July 28th through July 29th. Seventy-two plant species were documented with 61 native species and 11 non-native species (Appendix 3.14). The total FQI was 36.5.

Threats: Species composition and vegetative structure of the boreal forest on Saint Martin 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 with windthrow being the prime driver. In addition, high deer populations within the last decade impacted the species composition and vegetative structure of both the boreal forest and mesic northern forest with browse pressure being especially severe on yew and northern white-cedar. In addition, high mortality of yew was also driven by periodic and widespread caterpillar browsing (Sadie O'Dell, USFWS, personal communication). Scattered non-native plants found within the boreal forest include Canada bluegrass (*Poa compressa*), helleborine (*Epipactis*

helleborine), bittersweet nightshade (*Solanum dulcamara*), and red clover (*Trifolium pratense*). Compared to the adjacent mesic northern forest, non-native species are less pervasive in the boreal forest. Localized anthropogenic disturbance occurs in the boreal forest along the southern end of the island found adjacent to the cabins. This stretch of boreal forest has a higher component of weedy species in the ground cover and has been impacted by localized cutting for firewood.

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. Maintaining low deer densities on Saint Martin Island is critical for maintaining the integrity of the island's forested systems.



Saint Martin Island boreal forest. Photo by Joshua G. Cohen.



2018 aerial photograph of Saint Martin Island boreal forest.

15. Saint Martin Island – Limestone Cliff

Natural Community Type: Limestone Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled within the state

Element Occurrence Rank: B

Size: 7.4 acres

Location: Saint Martin Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 24350

Site Description: Five small stretches of limestone cliff occur in the interior of Saint Martin Island. Two cliff exposures run from north to south in the northeastern portion of the island; one runs from north to south in the southwestern portion of the island; one runs from northwest to southeast in the west central portion of the island; and one runs from west to east at the southern end of the island. The cliff exposures occur nested within mesic northern forest or at the boundary between boreal forest and mesic northern forest. The cliffs are low in stature and range from two to seven meters tall. The soils of the cliff are characterized by very shallow (0-2 cm) fine-textured, alkaline (pH 7.8-8.0) organic soils accumulating on the ledges, crevices, and at the base of tree boles. Portions of the limestone cliff in the northeastern and southern portions of the island occur adjacent to large areas of windthrow and open canopy. As a result, these cliffs have experienced increased light exposure and desiccation and a non-native bluegrass species (*Poa nemoralis*) is locally common within the northern stretch.

Vegetation of this limestone cliff is sparse, being generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks and joints in the cliff face, ledges along the cliff face, and along the cliff base where talus occurs locally. Sparse herbaceous cover (4-8%) includes common polypody (*Polypodium virginianum*), Laurentian fragile fern (*Cystopteris laurentiana*, state special concern), climbing fumitory (*Adlumia fungosa*, state special concern), evergreen woodfern (*Dryopteris intermedia*), wild columbine (*Aquilegia canadensis*), Canada mayflower (*Maianthemum canadense*), false spikenard (*Maianthemum racemosum*), wood millet (*Milium effusum*), downy Solomon seal (*Polygonatum pubescens*), common trillium (*Trillium grandiflorum*), sedge (*Carex deweyana*), and wild strawberry (*Fragaria virginiana*). In addition, lichens, mosses, and liverworts are locally common along the cliff face. Sparse shrub cover (2-4%) includes red elderberry (*Sambucus racemosa*), round-leaved dogwood (*Cornus rugosa*), mountain maple (*Acer spicatum*), choke cherry (*Prunus virginiana*), wild red raspberry (*Rubus strigosus*), yew (*Taxus canadensis*), bush-honeysuckle (*Diervilla lonicera*), and currants (*Ribes* spp.). Scattered (1-2%) northern white-cedar (*Thuja occidentalis*), paper birch (*Betula papyrifera*), sugar maple (*Acer saccharum*), balsam fir (*Abies balsamea*), and trembling aspen (*Populus tremuloides*) occur within the cliff along the lip and on ledges and crevices. The cliffs provide refugia for species that are preferentially browsed by deer including northern white-cedar and yew.

The Saint Martin Island limestone cliff was surveyed from June 2nd through June 4th. Thirty-nine plant species were documented with 37 native species and 2 non-native species (Appendix 3.15). The total FQI was 28.1.

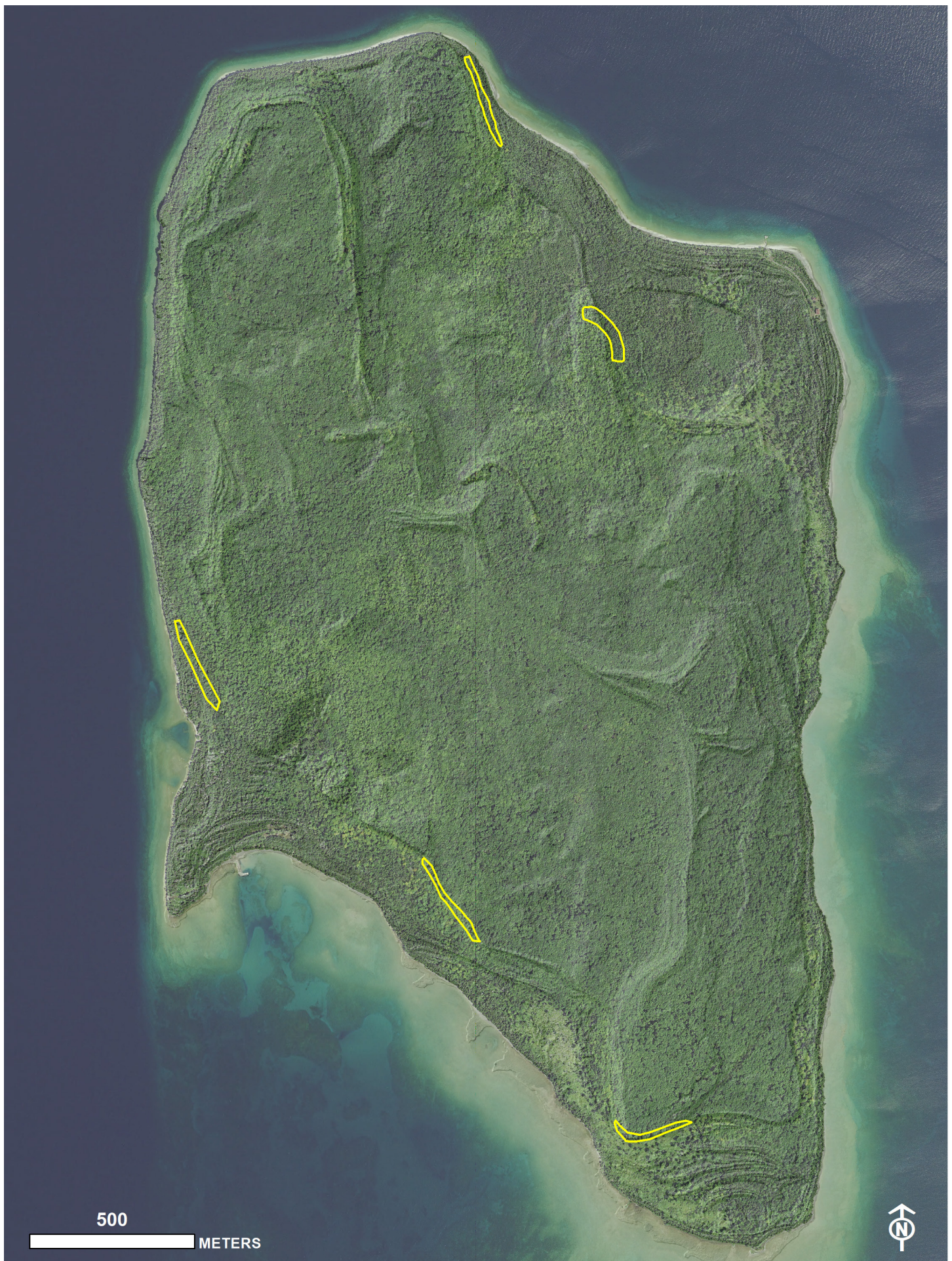
Threats: The non-native bluegrass (*Poa nemoralis*) is locally common along cliff ledges and bittersweet nightshade (*Solanum dulcamara*) was noted occasionally.

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



Saint Martin Island limestone cliff. Photos by Joshua G. Cohen.





2018 aerial photograph of Saint Martin Island limestone cliff.

16. Saint Martin 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: 15 acres

Location: Saint Martin Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 24353

Site Description: Limestone cobble shore occurs along the shoreline of Saint Martin Island. Small infrequent pockets of limestone bedrock lakeshore occur within the limestone cobble shore. The limestone cobble shore along Saint Martin Island is primarily unvegetated storm beach. Saint Martin Island has straight, long, unprotected shorelines on the western and eastern coasts that are subject to high energy disturbance in the form of frequent storms, high wave activity, and ice scour. The absence of concave shorelines results in the absence of areas with dampened wave activity. As a result, vegetation and wetland development are limited along the shore of Saint Martin Island. Soil accumulation and vegetative establishment are absent from the high energy shoreline or storm beaches. Where the shoreline exhibits a slight indentation or curve along the northeastern and southwestern shores of the island, some soil and vegetation have established. Within these areas alkaline (pH 7.5-7.8) sands and gravels mixed with organics occur between and beneath the cobble. 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 three to five meters wide.

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 that have submerged significant portions of the shore and dramatically altered the species composition and structure of this natural community. Scattered trees and shrubs occur rarely along the upper margins of the limestone cobble shore and include northern white-cedar (*Thuja occidentalis*), paper birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), green ash (*Fraxinus pennsylvanica*), red elderberry (*Sambucus racemosa*), and red-osier dogwood (*Cornus sericea*). A high percentage of these woody species have died recently following the high-water levels with northern white-cedar, paper birch, and green ash snags observed. Silverweed (*Potentilla anserina*) was noted locally. The lack of species diversity observed during the 2021 surveys is striking in comparison with the 63 species recorded in 2013 and 2014 (Judziewicz et al. 2016). Species recorded along the limestone cobble shore in 2013 and 2014 during an extended period of low Great lakes water levels included wild columbine (*Aquilegia canadensis*), blue-joint (*Calamagrostis canadensis*), Indian paintbrush (*Castilleja coccinea*), limestone calamint (*Clinopodium arkansanum*), hair grass (*Deschampsia cespitosa*), grass-leaved goldenrod (*Euthamia graminifolia*), Kalm's St. John's-wort (*Hypericum kalmianum*), dwarf lake iris (*Iris lacustris*, federal/state threatened), Kalm's lobelia (*Lobelia kalmii*), grass-of-parnasus (*Parnassia parviflora*), silverweed, bird's-eye primrose (*Primula mistassinica*), little bluestem (*Schizachyrium scoparium*), slender bog arrow-grass (*Triglochin palustris*), and northern bog violet (*Viola nephrophylla*) (Judziewicz et al. 2016). Of note is the absence of dwarf lake iris along the limestone cobble shore, which supported three small colonies of the species in 2014 (Judziewicz et al. 2016).

The Saint Martin Island limestone cobble shore was surveyed from June 2nd through June 4th. Thirty plant species were documented with 27 native species and 3 non-native species (Appendix 3.16). The total FQI was 15.9.

Threats: The non-native bittersweet nightshade (*Solanum dulcamara*) was noted locally. Silver poplar (*Populus alba*) was noted locally near the lighthouse in the northeastern portion of the island and could potentially become established along the limestone cobble shore. Invasive reed (*Phragmites australis* subspecies *australis*) was documented in the past along the southwestern shoreline of Saint Martin Island but was not observed in 2021 during focused surveys and was likely temporarily eliminated by control efforts working in concert with high water levels.

Management Recommendations: The limestone cobble shore should be monitored for invasive species, especially invasive reed and silver poplar.



Saint Martin Island limestone cobble shore. Photos by Joshua G. Cohen.





2018 aerial photograph of Saint Martin Island limestone cobble shore.

17. Saint Martin Island – Limestone Lakeshore Cliff

Natural Community Type: Limestone Lakeshore Cliff

Rank: G4G5 S2, apparently secure to secure globally and imperiled within the state

Element Occurrence Rank: A

Size: 42 acres

Location: Saint Martin Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 24348

Site Description: Approximately three kilometers of limestone lakeshore cliff occurs along the western, northern, and eastern shoreline of Saint Martin Island. The cliffs are typically 3 to 12 meters tall but reach as tall as 18 to 21 meters along the western shore. The cliffs are often stair-stepped or terraced. The complex includes a portion of cliff exposure that is immediately adjacent to the lakeshore as well as limestone cliff that is set back behind 15 to 30 meters of boreal forest along the terrace. Talus slope occurs locally at the base of the cliff face both along the lakeshore and at the top of the terrace. The soils are characterized as very shallow (0-5 cm) fine-textured, and alkaline (pH 7.5-8.0), and are accumulating on the ledges, crevices, and at the base of the cliffs. Thin soils, cold winter temperatures, steady winds, and summer droughts make for harsh growing conditions. The northern white-cedar (*Thuja occidentalis*) occurring along the limestone lakeshore cliff are often gnarled and twisted, exhibiting bonsai growth forms due to centuries of surviving stressful growing conditions and eking out an existence growing from narrow crevices. Some of the cedar are growing downward along the cliff face to maximize interception of light. Numerous northern white-cedar were cored along the top of the cliff and their ages were estimated: a 24 cm tree was over 285 years old; a 16.6 cm tree was over 246 years old; a 25 cm tree was over 150 years old; and a 28.9 cm tree was over 289 years old. This last tree exhibited a unique growth and release pattern with multiple releases occurring during the course of its life-to-date with the best growth occurring in the last 10 years. The release periods are likely linked to disturbance episodes that opened the canopy surrounding the tree and likely corresponded to windthrow events and/or wildfire. Several stretches of boreal forest occurring along the terrace between the cliff outcroppings have canopy northern white-cedar with char marks on their boles. Trees cored on cliffs on the nearby Garden Peninsula were estimated to be between 1,000 and 1,200 years old. Some of the trees growing on the cliffs of Saint Martin Island that are inaccessible without climbing equipment could be reasonably assumed to be of similar age.



Saint Martin Island limestone lakeshore cliff. Photo by Jesse M. Lincoln.

Vegetation is sparse and generally restricted to the flat, exposed bedrock at the upper edge of the cliff (i.e., lip), cracks and joints in the cliff face, ledges along the cliff face, and along the cliff base where talus slope is occasional between the cliff and the open water or the boreal forest terrace. Significant areas of vertical cliff face are bare of all vegetation. Sparse herbaceous cover (1-5%) includes harebell (*Campanula rotundifolia*), herb Robert (*Geranium robertianum*), white camas (*Anticlea elegans*), sedges (*Carex deweyana* and *C. eburnea*), star-flower (*Trientalis borealis*), sand cress (*Arabidopsis lyrata*), hairy rock cress (*Arabis pycnocarpa*), rock whitlow-grass (*Draba arabisans*, state special concern), hairy goldenrod (*Solidago hispida*), and ashy whitlow-grass (*Draba cana*, state threatened) on the lowest cliff terrace along the northernmost cliff face. Ferns are common and include common polypody (*Polypodium virginianum*) and Laurentian fragile fern (*Cystopteris laurentiana*, state special concern). In addition, lichens, mosses, and liverworts are locally common. Sparse shrub cover (2-5%) includes red elderberry (*Sambucus racemosa*), round-leaved dogwood (*Cornus rugosa*), mountain maple (*Acer spicatum*), wild red raspberry (*Rubus strigosus*), soapberry (*Shepherdia canadensis*), currants (*Ribes* spp.), choke cherry (*Prunus virginiana*), and yew (*Taxus canadensis*). Stunted and scattered (2-5%) northern white-cedar occur along the lip and on ledges and crevices. The cliffs provide refugia for species that are preferentially browsed by deer including northern white-cedar and yew.

The Saint Martin Island limestone lakeshore cliff was surveyed from June 2nd through June 4th and July 28th through July 29th. Thirty-six plant species were documented with 34 native species and 2 non-native species (Appendix 3.17). The total FQI was 32.4.

Threats: The non-native bluegrass (*Poa nemoralis*) is locally common along cliff ledges and bittersweet nightshade (*Solanum dulcamara*) was noted occasionally.

Management Recommendations: The main management recommendations are to allow natural processes to operate unhindered and to maintain a buffer of natural communities surrounding the limestone lakeshore cliff to prevent the increase of a weedy seed source and desiccation. Efforts to control non-native species should be implemented and these control efforts should be monitored.



Saint Martin Island limestone lakeshore cliff. Photo by Joshua G. Cohen.



Ashy whitlow-grass (*Draba cana*, state threatened) was documented along the the lowest cliff terrace along the northernmost cliff face of the Saint Martin Island limestone lakeshore cliff. Photo by Jesse M. Lincoln.



Saint Martin Island limestone lakeshore cliff. Photo by Jesse M. Lincoln.



2018 aerial photograph of Saint Martin Island limestone lakeshore cliff.

18. Saint Martin Island – Mesic Northern Forest

Natural Community Type: Mesic Northern Forest

Rank: G4 S3, apparently secure globally and vulnerable within the state

Element Occurrence Rank: BC

Size: 530 acres

Location: Saint Martin Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 24349

Site Description: Mesic northern forest occurs in the interior of Saint Martin Island on flat to gently rolling topography with prevalent pit and mound topography. The soils are characterized by a shallow (1-10 cm), acidic (pH 5.0-6.0) mull humus overlying fine- to medium-textured sandy loam and loam of variable depth that is slightly acidic to alkaline (pH 6.0-7.5). Measured depth of mineral soil over limestone cobble and bedrock ranges from 5 to 30 cm. Where beech is a canopy dominant, the organic and mineral soils tend to be more acidic. Limestone boulders occur scattered throughout the forest. The forest has a history of logging to various degrees with some area featuring a canopy cohort of mature trees approaching 200 years old and other areas with a prevalence of younger trees and sporadic old-growth individuals. Numerous canopy dominants were cored across the mesic northern forest to estimate the age range: a 63 cm sugar maple (*Acer saccharum*) was over 220 years old; a 51 cm sugar maple was over 118 years old; a 67.7 cm red oak (*Quercus rubra*) was over 156 years old; a 52 cm red oak was over 120 years old; a 69.5 cm red oak was over 170 years old; a 38.5 cm American beech (*Fagus grandifolia*) was over 200 years old; a 20.1 cm white ash (*Fraxinus americana*) was over 133 years old; and a 66.5 cm red oak was over 110 years old. Yew (*Taxus canadensis*) seedlings growing in the low shrub layer of the mesic northern forest were estimated to be approximately 10 years old. Past logging and gap phase dynamics are driving species composition and vegetative structure. Single and multiple tree gaps have created small patches within the canopy and allow for diverse canopy species to become established and grow. Windthrow tends to be more prevalent with closer proximity to the shoreline and decreases in the interior of the island. The robust and diverse ground cover as well as the establishment and growth of yew for the past decade suggests that deer browse is currently low and that the mesic northern forest is recovering from a period of high deer browse. Species that appear more robust within the mesic northern forest compared to the mainland are bush-honeysuckle (*Diervilla lonicera*), yellow violet (*Viola pubescens*), Canada mayflower (*Maianthemum canadense*), false spikenard (*Maianthemum racemosum*), cow-parsnip (*Heracleum maximum*), and sharp-lobed hepatica (*Hepatica acutiloba*). The mesic northern forest is starting to accrue attributes of a mature forest including a canopy dominated by large diameter trees, pit and mound topography, and coarse wood debris. Coarse woody debris is primarily composed of early-successional species (i.e., paper birch, big-toothed aspen, and balsam fir) but does also include some large (> 50 cm), longer-lived species that decay more slowly (e.g., sugar maple and northern white-cedar). American beech that has succumbed to beech bark disease is beginning to contribute to the coarse woody debris load. Canopy white ash is locally common in the overstory and has not been impacted by emerald ash borer. The live canopy ash across the mesic northern forest is noteworthy given the decimation of white ash across uplands on the mainland.

The uneven-aged mesic northern forest dominated by sugar maple with diverse canopy associates including red oak, American beech, basswood (*Tilia americana*), white ash, paper birch (*Betula papyrifera*), and big-tooth aspen (*Populus grandidentata*) and occasional northern white-cedar (*Thuja occidentalis*) and yellow birch (*Betula alleghaniensis*). Canopy closure ranges from 70 to 90% and canopy trees range from 35 to 50 cm with some larger sugar maple, red oak, and American beech reaching 60 to 80 cm. The subcanopy ranges from 5 to 15% and is characterized by sugar maple, ironwood (*Ostrya virginiana*), balsam fir (*Abies balsamea*), and American beech. Northern white-cedar was locally abundant in the subcanopy and may have historically been more prevalent, based on the presence of old stumps throughout portions of the forest. The understory layer is sparse to patchy (10-45%) with sugar maple, round-leaved dogwood (*Cornus rugosa*), mountain maple (*Acer spicatum*), red elderberry (*Sambucus racemosa*), beaked hazelnut (*Corylus cornuta*), American beech, and balsam fir. Where canopy beech is being impacted by beech bark disease, there is a pulse in beech sprouting resulting in an increase in beech saplings in the understory layer. Common species in the low shrub layer (15-30%) include fly honeysuckle (*Lonicera canadensis*), wild red raspberry (*Rubus strigosus*), bush-honeysuckle, balsam fir, round-leaved dogwood, American beech, sugar maple, and yew. Yew was formerly dominant in both the understory and low shrub layers but has been decimated by caterpillar infestations (Sadie O'Dell, personal communication) and also impacted by high deer browse prior to 2013 (Judziewicz et al. 2016). The yew understory likely provided an important structural attribute for migrating songbirds. The ground cover is diverse, robust, and dense (60-80%). Characteristic ground cover species include cow-parsnip, sharp-lobed hepatica, bluestem goldenrod (*Solidago caesia*), big-leaved aster (*Eurybia macrophylla*), common trillium (*Trillium grandiflorum*), wild leek (*Allium tricoccum*), herb Robert (*Geranium robertianum*), downy Solomon seal (*Polygonatum pubescens*), woodferns (*Dryopteris* spp.),

wild columbine (*Aquilegia canadensis*), Canada mayflower (*Maianthemum canadense*), false spikenard (*Maianthemum racemosum*), zigzag goldenrod (*Solidago flexicaulis*), spring beauty (*Claytonia virginica*), Carolina spring beauty (*C. caroliniana*), sedges (*Carex deweyana*, *C. eburnea*, *C. pedunculata*), white lettuce (*Prenanthes alba*), toothworts (*Cardamine* spp.), rattlesnake fern (*Botrypus virginianus*), bluebead-lily (*Clintonia borealis*), partridge-berry (*Mitchella repens*), starflower (*Trientalis borealis*), yellow violet (*Viola pubescens*), bloodroot (*Sanguinaria canadensis*), climbing fumitory (*Adlumia fungosa*, state special concern), fragrant bedstraw (*Galium triflorum*), fringed false buckwheat (*Fallopia cilinodis*), dwarf scouring rush (*Equisetum scirpoides*), wood millet (*Milium effusum*), and sugar maple seedlings. Mosses are locally prevalent on the boles of large canopy dominants.

The Saint Martin Island mesic northern forest was surveyed from June 2nd through June 4th and July 28th through July 29th. Seventy-five plant species were documented with 64 native species and 11 non-native species (Appendix 3.18). The total FQI was 36.4.



The robust and diverse ground cover as well as the establishment and growth of yew over the past decade suggests that deer browse is currently low and that the forest is recovering from a period of high deer browse. Wild columbine (*Aquilegia canadensis*) (left) and yellow lady-slipper (*Cypripedium parviflorum*) (right). Photos by Jesse M. Lincoln.

Threats: Species composition and vegetative structure of the mesic northern forest on Saint Martin Island is highly variable and is influenced by the interaction of depth to limestone substrate; the current beech bark disease infestation; and time and intensity of past disturbance factors including windthrow, logging, and deer and caterpillar herbivory. We estimate that 10% of the canopy beech have died from beech bark disease and that 60% of the beech overstory has the scale. High deer populations within the last decade impacted the species composition and vegetative structure of both the mesic northern forest and boreal forest with browse pressure being especially severe on yew. In addition, high mortality of yew was also driven by periodic and widespread caterpillar browsing. Earthworms were noted locally, and it appears that worm herbivory is locally reducing the mull humus of the mesic northern forest. Piled up plant petioles were noted adjacent to worm holes. Earthworms have locally impacted soil decomposition processes. Localized anthropogenic disturbances occur in the mesic northern forest and include logging and hunting roads, deer blinds, localized cutting for firewood, and timber harvest that ranged from selective logging to high grading.

Scattered non-native plants found within the mesic northern forest include morrow honeysuckle (*Lonicera morrowii*), Canada bluegrass (*Poa compressa*), common speedwell (*Veronica officinalis*), common mullein (*Verbascum thapsus*), common burdock (*Arctium minus*), hound's-tongue (*Cynoglossum officinale*), common dandelion (*Taraxacum officinale*), Canada thistle (*Cirsium arvense*), marsh thistle (*C. palustre*), bull thistle (*C. vulgare*), and bittersweet nightshade (*Solanum dulcamara*). Compared to the adjacent boreal forest, non-native species are more pervasive in the mesic northern forest. Non-native species are most prevalent along roads and in areas that were more recently logged. Bittersweet nightshade is especially problematic on the island in a way not observed in mesic northern forests on the mainland.

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. Maintaining low deer densities on Saint Martin Island is critical for maintaining the integrity of island's forested systems.



Yew (*Taxus canadensis*) has been detrimentally impacted by high deer browse pressure as well as periodic and widespread caterpillar herbivory pictured above. Photo by Joshua G. Cohen.



Saint Martin Island mesic northern forest. Photo by Joshua G. Cohen.



Saint Martin Island mesic northern forest. Photos by Joshua G. Cohen.





2018 aerial photograph of Saint Martin Island mesic northern forest.

19. Saint Martin 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: 6.65 acres

Location: Saint Martin Island, Green Bay National Wildlife Refuge, Lake Michigan, Michigan

Element Occurrence Identification Number: 24352

Site Description: The northern hardwood swamp occurs in a small depression on the northeastern portion of Saint Martin Island. The swamp was inundated in June 2021 with high water marks from spring flooding occurring at the 4-foot mark of the canopy ash trees. Standing water ranged from 30 to 60 cm deep. Water is pooling in this depressional basin due to the impermeable clay layer in the soil profile. High water levels within this swamp could also be linked to high Great Lakes water levels since this wetland occurs in close proximity to the shoreline. Soils are inundated, shallow (5 cm) organics (pH 7.0-7.3) overlying alkaline (pH 7.3-7.5) sandy clay. A floating mat of sedges occurs locally. Downed logs, tip up mounds, and sedge tussocks occur locally above the water level and provide critical substrate for plant establishment and growth. A 27 cm green ash (*Fraxinus pennsylvanica*) was cored and estimated to be over 100 years old. The canopy of the swamp is open due to the prevalence of flooding and also the recent mortality of canopy green ash from emerald ash borer. Approximately 25% of the canopy ash have been impacted by emerald ash borer.

The canopy of the northern hardwood swamp is dominated by green ash with the open canopy ranging from 40 to 60%. Canopy ash range in diameter from 20 to 40 cm. The understory is patchy to dense (20-40%) with green ash, winterberry (*Ilex verticillata*), and silky dogwood (*Cornus amomum*). The low shrub layer is sparse (5-10%) with scattered green ash seedlings. The ground cover is dense (90%) with characteristic species including sedge (*Carex utriculata*), blue-joint (*Calamagrostis canadensis*), wild blue flag (*Iris versicolor*), marsh fern (*Thelypteris palustris*), water-parsnip (*Sium suave*), marsh pea (*Lathyrus palustris*), and northern bugleweed (*Lycopus uniflorus*).

The Saint Martin Island northern hardwood swamp was surveyed on June 2nd and July 29th. Sixty plant species was documented with 56 native species and 4 non-native species (Appendix 3.19). The total FQI was 28.7.

Threats: Species composition and structure are patterned by natural processes but have been recently impacted by emerald ash borer. Approximately 25% of the canopy ash have been impacted by emerald ash borer. Invasive species are locally common and include narrow-leaved cat-tail (*Typha angustifolia*), reed canary grass (*Phalaris arundinacea*), invasive reed (*Phragmites australis* var. *australis*), and bittersweet nightshade (*Solanum dulcamara*).

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.



Saint Martin Island northern hardwood swamp. Photos by Joshua G. Cohen.





2018 aerial photograph of Saint Martin Island northern hardwood swamp.

Stewardship Prioritization Results

The stewardship prioritization scores for each natural community element occurrence within the Green Bay NWR 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 occurrence is the Poverty Island boreal forest. Following the 2016 wildfire on Poverty Island, the opening of the canopy and exposure of mineral soil have led to a pulse in non-native species establishment and spread. Most notably, we documented an incipient infestation of invasive reed (*Phragmites australis* subspecies *australis*), which should be immediately

treated. The other element occurrences ranked as high priority for stewardship include limestone bedrock lakeshore from Poverty and Detroit Islands and limestone lakeshore cliff from Poverty and Saint Martin Islands. The stewardship scores for these sites are high because they are all critically imperiled ecosystems at the state scale, each element occurrence has relatively high ecological integrity, and each site is being moderately impacted by invasive species. Lower priority sites within the Green Bay NWR 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 opening of the canopy and exposure of mineral soil and bedrock from the 2016 wildfire make the boreal forest on Poverty Island susceptible to invasive species incursions. The localized infestation by invasive reed (pictured here) should be immediately addressed. Photo by Tyler J. Bassett.

Table 2. Stewardship prioritization for natural community element occurrences in the Green Bay 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	Global		State		Rarity Index	Invasive		Invasive Index	Stewardship Prioritization Score
					Gobal Rank	Rank Score	State Rank	Rank Score		Threat Severity	Treatment Feasibility		
7488	Boreal Forest	Poverty Island	B	4	GU	3	S3	3	3	3	4	3.5	10.5
4159	Limestone Bedrock Lakeshore	Poverty Island	AB	4.5	G3	3	S2	4	3.5	2	3	2.5	10.5
24374	Limestone Bedrock Lakeshore	Detroit Island	B	4	G3	3	S2	4	3.5	2	3	2.5	10
1437	Limestone Lakeshore Cliff	Poverty Island	A	5	G4G5	1.5	S2	4	2.75	2	2.5	2.25	10
24348	Limestone Lakeshore Cliff	Saint Martin Island	A	5	G4G5	1.5	S2	4	2.75	2	2.5	2.25	10
24375	Limestone Cobble Shore	Detroit Island	BC	3.5	G3	3	S2	4	3.5	2	3	2.5	9.5
24350	Limestone Cliff	Saint Martin Island	B	4	G4G5	1.5	S2	4	2.75	2	3	2.5	9.25
24353	Limestone Cobble Shore	Saint Martin Island	B	4	G2G3	3.5	S3	3	3.25	1	3	2	9.25
24367	Great Lakes Marsh	Plum Island	C	3	G4	2	S4	4	3	3	3	3	9
24349	Mesic Northern Forest	Saint Martin Island	BC	3.5	G4	2	S3	3	2.5	3	3	3	9
24366	Limestone Cobble Shore	Rocky Island	C	3	G2G3	3.5	S3	3	3.25	3	2	2.5	8.75
24370	Limestone Cobble Shore	Plum Island	C	3	G3	3	S2	4	3.5	2	2	2	8.5
24372	Limestone Lakeshore Cliff	Detroit Island	BC	3.5	GNR	3	S4	2	2.5	2	3	2.5	8.5
24368	Limestone Lakeshore Cliff	Plum Island	C	3	GNR	3	S4	2	2.5	4	2	3	8.5
24352	Northern Hardwood Swamp	Saint Martin Island	C	3	G4	2	S3	3	2.5	3	3	3	8.5
24351	Boreal Forest	Saint Martin Island	B	4	GU	3	S3	3	3	1	2	1.5	8.5
24369	Mesic Northern Forest	Plum Island	D	2	G4	2	S3	3	2.5	5	2	3.5	8
24373	Limestone Cliff	Detroit Island	BC	3.5	G4G5	1.5	S5	1	1.25	2	3	2.5	7.25
24387	Sand and Gravel Beach	Detroit Island	BC	3.5	G3?	3	S2	4	3.5	0	NA	0	7

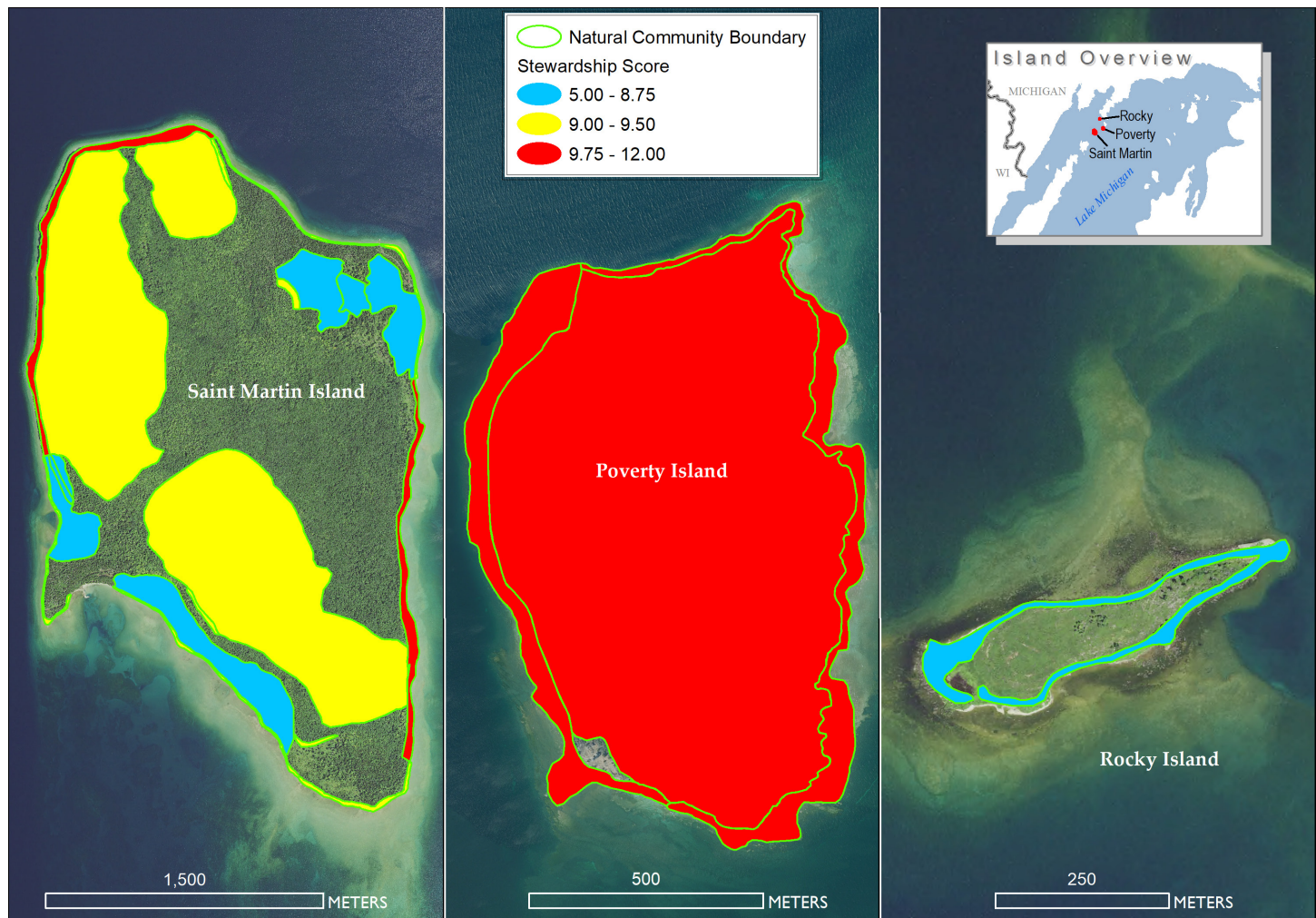


Figure 11. Stewardship prioritization for natural community element occurrences on Saint Martin, Poverty, and Rocky Islands. Element occurrences are displayed by their stewardship prioritization scores and assigned a high (red), medium (yellow), or low (blue) stewardship priority.

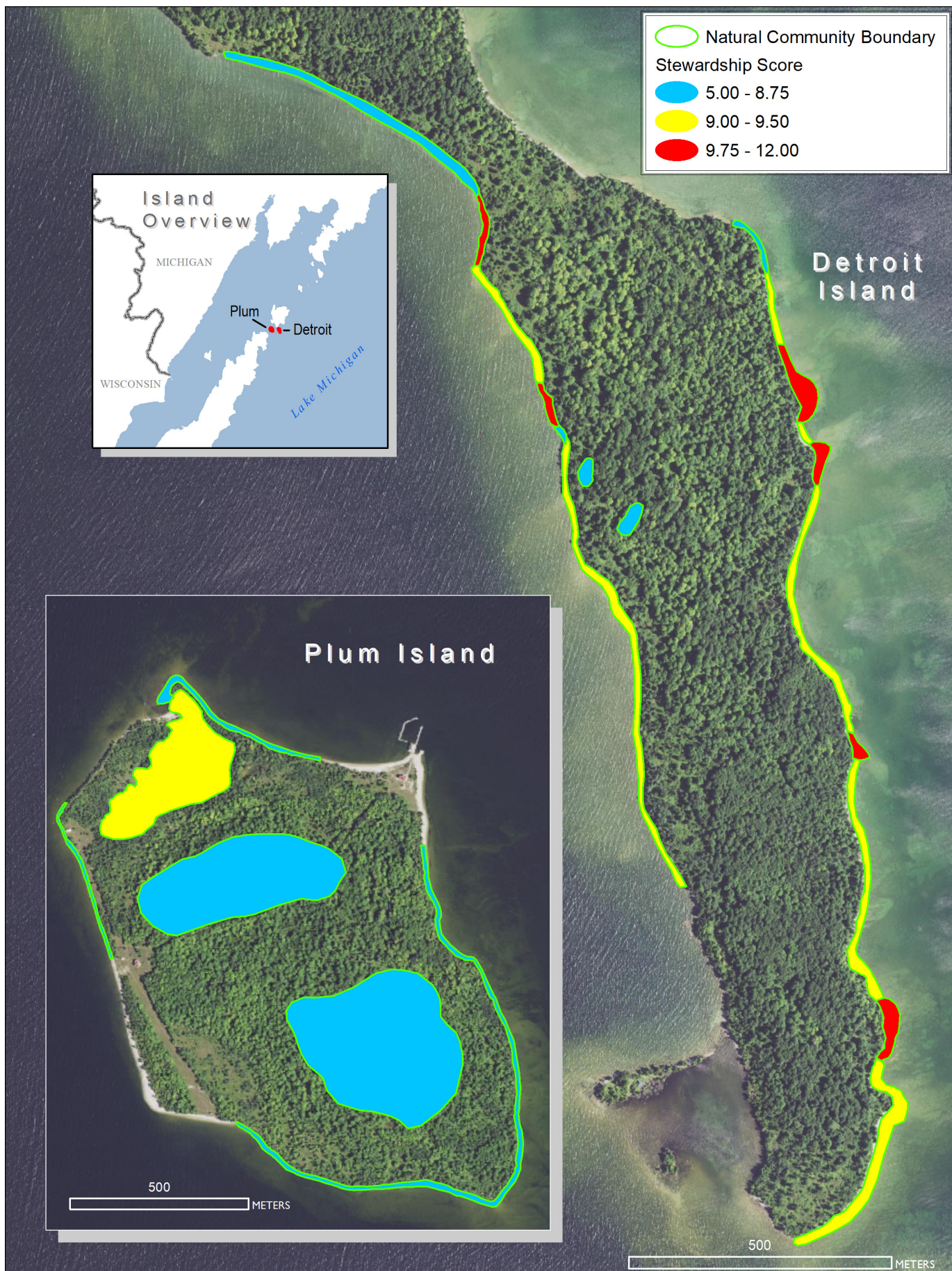


Figure 12. Stewardship prioritization for natural community element occurrences on Plum and Detroit Islands. Element occurrences are displayed by their stewardship prioritization scores and assigned a high (red), medium (yellow), or low (blue) stewardship priority.

Conclusion

Through this project we evaluated the ecological integrity of high-quality natural communities on five Great Lakes islands within the Green Bay NWR: Detroit, Plum, Poverty, Rocky, and Saint Martin Islands. On Detroit Island we updated three element occurrences (limestone bedrock lakeshore, limestone cobble shore, and sand and gravel beach) and documented two new element occurrences (limestone cliff and limestone lakeshore cliff). On Plum Island we updated three element occurrences (limestone cobble shore, limestone lakeshore cliff, and mesic northern forest) and documented a new Great Lakes marsh element occurrence. We updated three element occurrences on Poverty Island including boreal forest, limestone bedrock lakeshore, and limestone lakeshore cliff. A new element occurrence for limestone cobble shore was documented on Rocky Island. We documented six new element occurrences on Saint Martin Island including four rare (S3) natural community types (boreal forest, limestone cobble shore, mesic northern forest, and northern hardwood swamp) and two imperiled (S2) natural community types (limestone cliff and limestone lakeshore cliff). In total we documented ten new element occurrences and updated nine element occurrences.

This report provides site-based assessments of 19 natural community element occurrences within the Green Bay NWR. 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 sites across the islands within the Green Bay NWR 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: Poverty Island boreal forest, limestone bedrock lakeshore, and limestone lakeshore cliff; Detroit Island limestone bedrock lakeshore; and Saint Martin Island limestone lakeshore cliff.



Poverty Island limestone lakeshore cliff. Photo by Joshua G. Cohen.

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 management 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 Detroit, Poverty, and Saint Martin 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. Poverty Island is a potential research site to chronicle post-wildfire succession in both boreal forest and coastal bedrock ecosystems. In over forty years of surveys across Michigan, MNFI ecologists have never recorded wildfire impacting limestone bedrock lakeshore and limestone lakeshore cliff. Wildfire has been documented in only one other bedrock lakeshore system; volcanic bedrock lakeshore along Keweenaw Point burned following a crown fire in the adjacent boreal forest (MNFI 2022). The incipient infestations of invasive reed in boreal forest on Poverty Island following the wildfire offers the opportunity to evaluate the effectiveness of early detection and rapid response. On Saint Martin Island scientists can track the recovery of ground cover and understory species following the reduction of the deer herd. Comparative studies of island versus mainland flora can help illustrate the drastic impact herbivory has on forested ecosystems.

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.



Great Lakes islands offer unique research opportunities to help inform our understanding of ecological processes. We recommend long-term monitoring of the boreal forest, limestone bedrock lakeshore, and limestone lakeshore cliff on Poverty Island that were impacted by wildfire. In addition, we urge the immediate control of opportunistic invasive plant species that colonized these ecosystems post fire. Photo by Joshua G. Cohen.

References

- Albert, D.A., J.G. Cohen, M.A. Kost, B.S. Slaughter, and H.D. Enander. 2008. Distribution Maps of Michigan's Natural Communities. Michigan Natural Features Inventory, Report No. 2008-01, Lansing, MI. 314 pp.
- Bassett, T.J., S.M. Warner, J.G. Cohen, R.A. Hackett, J.M. Lincoln, H.D. Enander, and E.A. Haber. 2022a. Rare and Invasive Plant Surveys of Great Lakes Islands in the Green Bay and Gravel Islands National Wildlife Refuges. Michigan Natural Features Inventory, Report No. 2022-10, Lansing, MI.
- Bassett, T.J., S.M. Warner, J.G. Cohen, J.M. Lincoln, H.D. Enander, E.A. Haber, and R.A. Hackett. 2022b. Rare and Invasive Plant Surveys of Great Lakes Islands in the Michigan Islands National Wildlife Refuge (Lake Huron). Michigan Natural Features Inventory, Report No. 2022-11, Lansing, MI.
- Cohen, J.G., M.A. Kost, B.S. Slaughter, and D.A. Albert. 2015. A Field Guide to the Natural Communities of Michigan. Michigan State University Press, East Lansing, MI. 362 pp.
- Cohen J.G., and B.S. Slaughter. 2015. Natural Community Surveys and Stewardship Prioritization of Michigan's Coastal Zone. Michigan Natural Features Inventory Report Number 2015-27, Lansing, MI. 244 pp.
- Cohen, J.G., M.A. Kost, B.S. Slaughter, D.A. Albert, J.M. Lincoln, A.P. Kortenhoven, C.M. Wilton, H.D. Enander, and K.M. Korroch. 2020. Michigan Natural Community Classification[web application]. Michigan Natural Features Inventory, Michigan State University Extension, Lansing, Michigan. Available <https://mnfi.anr.msu.edu/communities/classification>. (Accessed: March 7, 2022).
- Door County Pulse, Peninsula Pulse. St. Martin Island:Frequently Asked Questions. Published November 26, 2013. Retrieved from: <https://doorcountypulse.com/st-martin-island-frequently-asked-questions>.
- Epstein, E.E. 2017. Natural communities, aquatic features, and selected habitats of Wisconsin. Chapter 7 in The ecological landscapes of Wisconsin: An assessment of ecological resources and a guide to planning sustainable management. Wisconsin Department of Natural Resources, PUB-SS-1131H 2017, Madison.
- Faber-Langendoen, D., J. Rocchio, P. Comer, G. Kudray, L. Vance, E. Byers, M. Schafale, C. Nordman, E. Muldavin, G. Kittel, L. Sneddon, M. Pyne, and S. Menard. 2008. Overview of Natural Heritage Methodology for Ecological Element Occurrence Ranking based on Ecological Integrity Assessment Methods [Draft for Network Review]. NatureServe, Arlington, VA.
- Faber-Langendoen, D., W. Nichols, F.J. Rocchio, K. Walz, and J. Lemly. 2016. An Introduction to NatureServe's Ecological Integrity Assessment Method. NatureServe, Arlington, VA. 33 pp.
- Freyman, W.A., L.A. Masters, and S. Packard. 2016. The Universal Floristic Quality Assessment (FQA) Calculator: an online tool for ecological assessment and monitoring. *Methods in Ecology and Evolution* 7(3): 380–383.
- Hackett, R.A., S.M. Warner, J.G. Cohen, and T.J. Bassett. 2022. Invasive Plant Management Plan for Detroit Island in Horicon-Green Bay National Wildlife Refuge. Michigan Natural Features Inventory, Report No. 2022-06, Lansing, MI.
- Herman, K.D., L.A. Masters, M.R. Penskar, A.A. Reznicek, G.S. Wilhelm, W.W. Brodovich, and K.P. Gardiner. 2001. Floristic quality assessment with wetland categories and examples of computer applications for the State of Michigan - Revised, 2nd Edition. Michigan Department of Natural Resources, Wildlife, Natural Heritage Program, Lansing, MI. 19 pp. + appendices.
- Judziewicz, E.J. 2001. Flora and Vegetation of the Grand Traverse Islands (Lake Michigan), Wisconsin and Michigan. *The Michigan Botanist*. Vol. 40. Pg. 81–208.
- Judziewicz, E.J., Fewless, G., Grimm, M. 2016. Vascular Plants of St. Martin Island, Delta County, Michigan. *The Michigan Botanist*. Vol. 55. Pg. 18–53.
- Kost, M.A., D.A. Albert, J.G. Cohen, B.S. Slaughter, R.K. Schillo, C.R. Weber, and K.A. Chapman. 2007. Natural Communities of Michigan: Classification and Description. Michigan Natural Features Inventory Report Number 2007-21, Lansing, MI. 314 pp.
- Michigan Natural Features Inventory (MNFI). 1988. Draft criteria for determining natural quality and condition grades, element occurrence size-classes and significance levels for palustrine and terrestrial natural communities in Michigan. Michigan Natural Features Inventory, Lansing, MI. 39 pp.
- Michigan Natural Features Inventory (MNFI). 2022. Biotics database. Michigan Natural Features Inventory, Lansing, MI.
- Namesnik, S. 2014. Wisconsin Floristic Quality Assessment (FQA) Databases for the Northcentral-Northeast Region for Universal FQA Calculator Web site (<http://universalfqa.org/>).
- National Park Service Maritime Heritage Program. 2006. Inventory of Historic Michigan Light Stations Michigan Lighthouses: St. Martin Island Light. Retrieved from: <https://web.archive.org/>

- web/20121024025356/http://www.nps.gov/history/maritime/light/stmartin.htm.
- National Register of Historic Places. n.d. "Plum Island". Door County, Wisconsin. Reference no. 10000385. Retrieved from: <https://www.wisconsinhistory.org/Records/NationalRegister/NR2313>.
- National Register of Historic Places. 2005. "Poverty Island Light Station". Delta County, Michigan. Reference no. 05000984. Retrieved from: <https://nationalregisterofhistoricplaces.com/mi/delta/state.html>.
- NatureServe. 2002. Element Occurrence Standard. NatureServe: Arlington, VA. 201 pp.
- NatureServe. 2010. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Available <http://www.natureserve.org/explorer>. (Accessed: May 3, 2011).
- Parker E.C., M. Curran, Z.S. Waechter, and E.A. Grosskopf. 2014. Wisconsin Floristic Quality Assessment (FQA) Databases for Midwest and Northcentral-Northeast Regions for Universal FQA Calculator Web site (<http://universalfqa.org/>).
- Reznicek, A.A., M.R. Penskar, B.S. Walters, and B.S. Slaughter. 2014. Michigan Floristic Quality Assessment Database. Herbarium, University of Michigan, Ann Arbor, MI and Michigan Natural Features Inventory, Michigan State University, Lansing, MI. <http://michiganflora.net>
- Rocchio, F.J., T. Ramm-Granberg, and R.C. Crawford. 2018. Field Manual for Applying Rapid Ecological Integrity Assessments in Upland Plant Communities of Washington State. Washington Natural Heritage Program, Washington Department of Natural Resources, Olympia, Washington. 113 pp.
- Voss, E.G., and A.A. Reznicek. 2012. Field Manual of Michigan Flora. University of Michigan Press, Ann Arbor, MI. 990 pp.
- U.S. Fish and Wildlife Service (USFWS). 2021a. Inventory and Monitoring of Natural Communities and Forests on Great Lakes Islands. Version 0.1. Department of Interior Great Lakes Region, US Fish and Wildlife Service Regional Office, Bloomington, MN.
- U.S. Fish and Wildlife Service (USFWS). 2021b. Regional Protocol Framework for Rare and Invasive Plant Monitoring on Great Lakes Islands. Version 0.1. Department of Interior Great Lakes Region, US Fish and Wildlife Service Regional Office, Bloomington, MN.
- Warner, S.M., R.A. Hackett, J.G. Cohen, and T.J. Bassett. 2022a. Invasive Plant Management Plan for Plum Island in Horicon-Green Bay National Wildlife Refuge. Michigan Natural Features Inventory, Report No. 2022-05, Lansing, MI.
- Warner, S.M., R.A. Hackett, J.G. Cohen, T.J. Bassett, and J.M. Lincoln. 2022b. Invasive Plant Management Plan for Poverty Island in Horicon-Green Bay National Wildlife Refuge. Michigan Natural Features Inventory, Report No. 2022-04, Lansing, MI.
- Warner, S.M., R.A. Hackett, J.G. Cohen, T.J. Bassett, and J.M. Lincoln. 2022c. Invasive Plant Management Plan for St. Martin Island in Horicon-Green Bay National Wildlife Refuge. Michigan Natural Features Inventory, Report No. 2022-03, Lansing, MI.

Appendix 1 - Historical Imagery and Hillshade

HISTORICAL IMAGERY

US Department of Agriculture Farm Service Agency (FSA) Aerial Photography Field Office (APFO). Aerial photographs from 1937-1940. Nominal scale 1: 20,000, Black and White Panchromatic.

Wisconsin photos obtained from:

Wisconsin Historic Aerial Imagery Finder <https://maps.sco.wisc.edu/WHAIFinder/#7/44.750/-89.750>

Michigan photos obtained from:

Michigan Imagery Server, RS&GIS Historic Aerial Archive Collection.

Historic photos were downloaded and rectified to current (NAIP) aerial imagery. Multiple photos were mosaiced to a single image by island if more than one photo was required for coverage of the island.

HILLSHADE MAP PRODUCTION

U.S. Geological Survey standard one-meter digital elevation models (DEM) were produced exclusively from high resolution light detection and ranging (lidar) source data of one-meter or higher resolution. Where available for the islands, one-meter DEMs were downloaded and reprojected to NAD_83_Michigan_GeoRef_Meters. A shaded relief hillshade raster was created from the DEMs using the ArcGIS Spatial Analyst Hillshade geoprocessing tool and the default azimuth and altitude settings. (ArcGIS Desktop 10.3.1).

A hillshade is a grayscale 3D representation of the terrain surface, with the sun's relative position (set by the azimuth and altitude parameters) taken into account for shading the image. Shaded relief maps are an appealing and information dense technique for viewing surface relief and landforms. DEMs or aerial imagery can be overlaid with some transparency turned on over the hillshade in GIS software, combining multiple layers of information in an effective visualization tool. Elevation presented in these maps is in reference to sea level and not lake level.

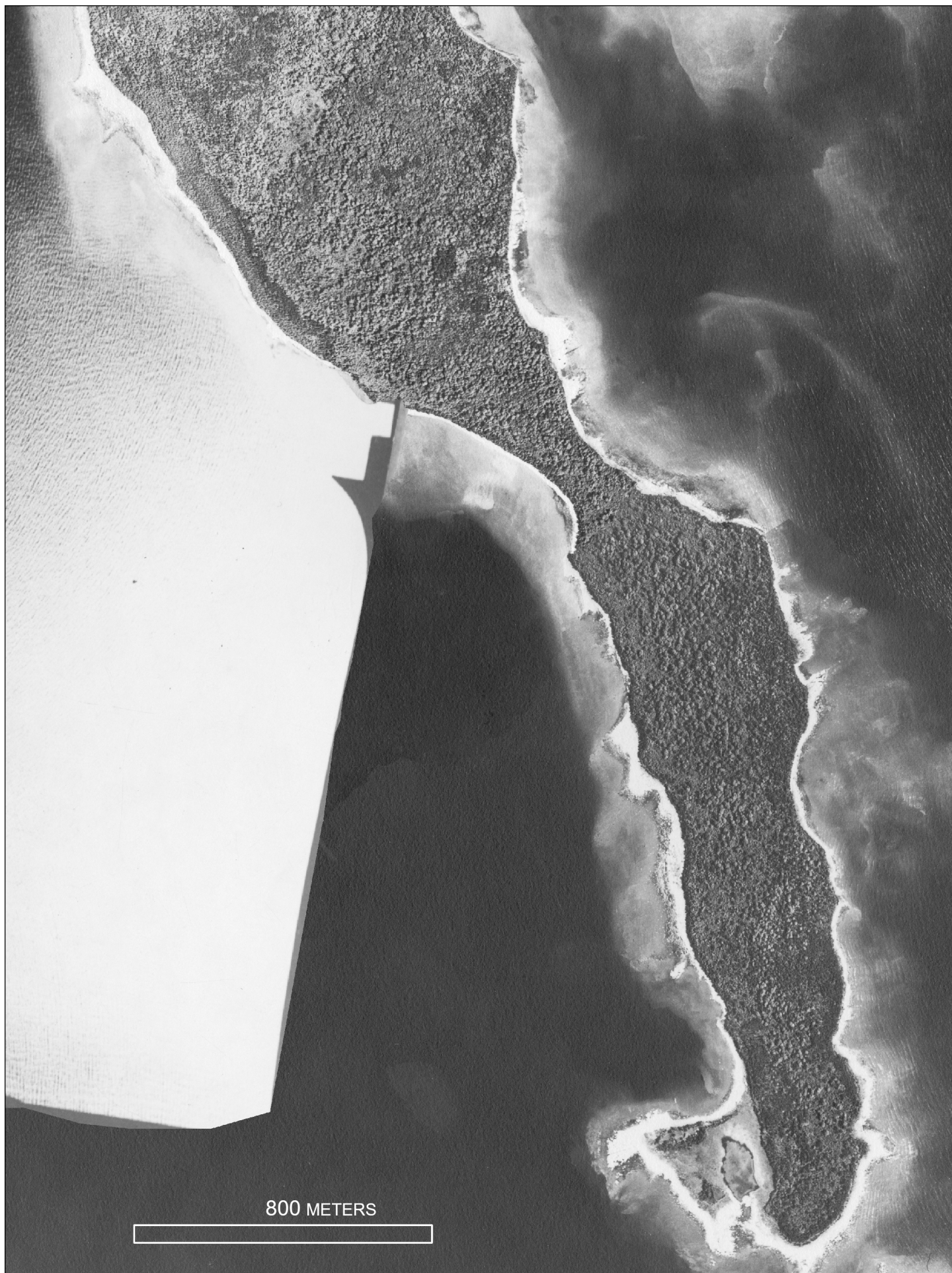
Individual DEM Dates and Specifications:

Michigan

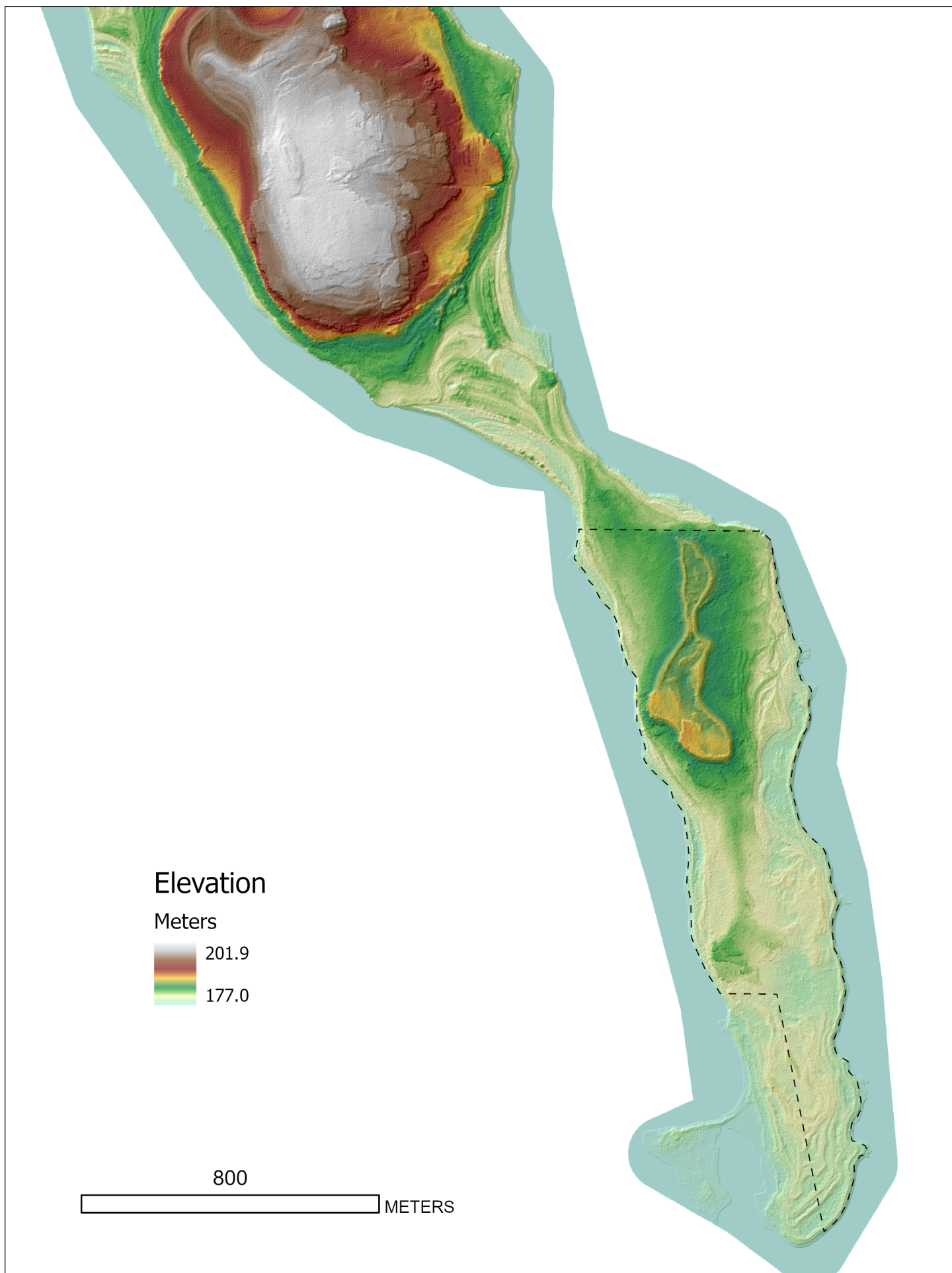
USGS one-meter Delta County 2015 QL2 USGS Lidar Base Specification 1.0

Wisconsin

USGS one-meter FEMAHQ 2018 QL2 USGS Lidar Base Specification 1.2



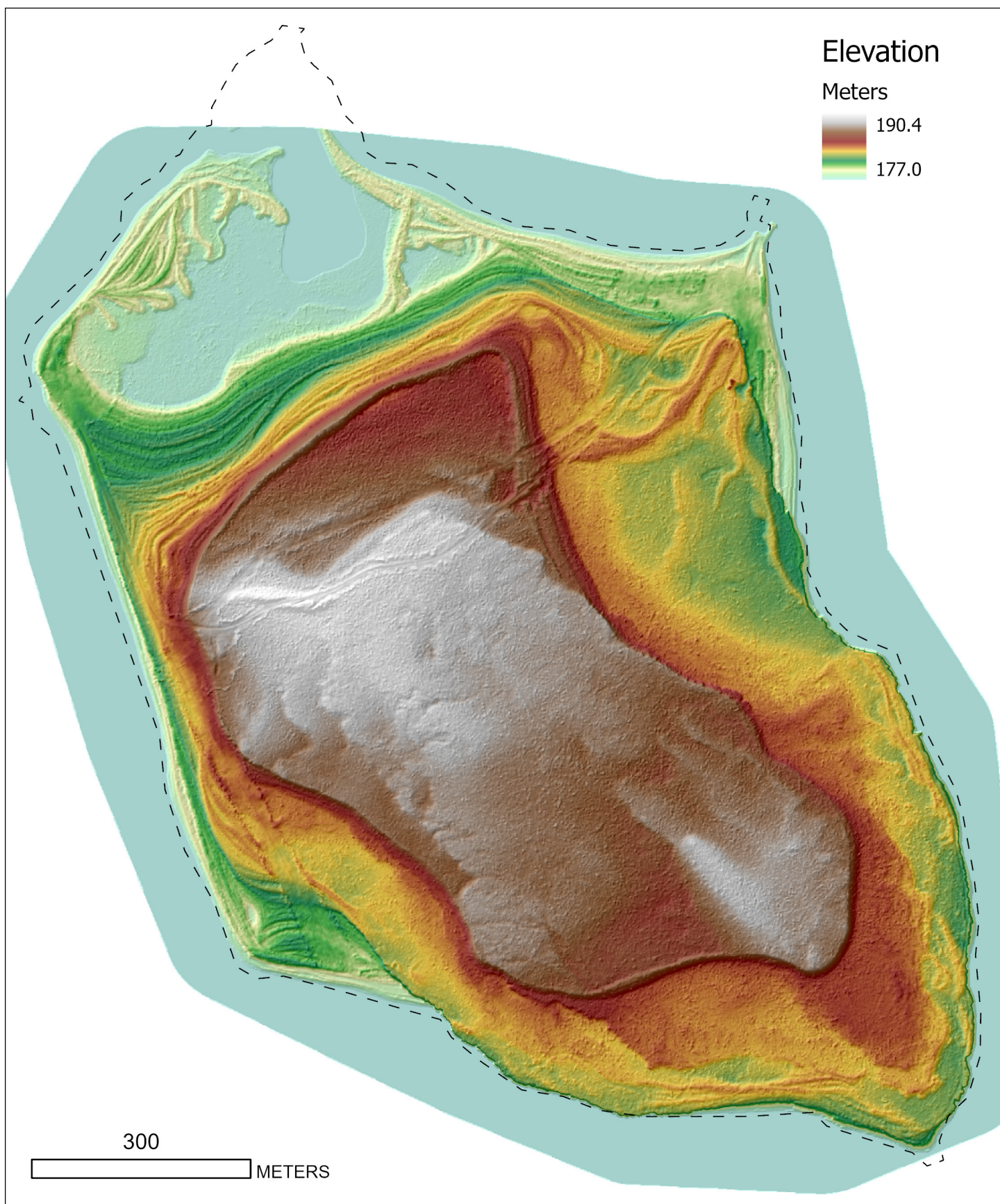
Detroit Island 1938 aerial imagery.



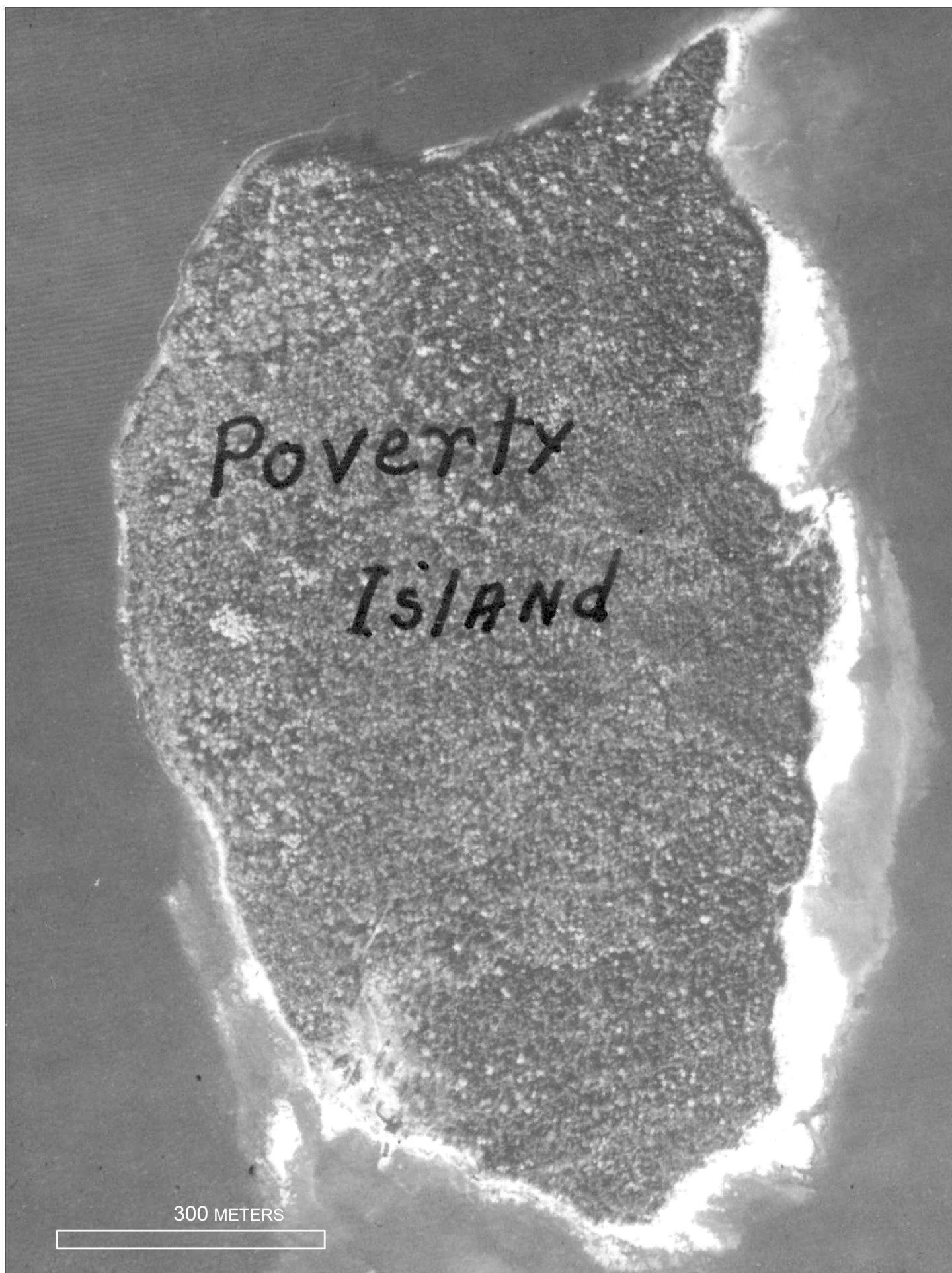
Detroit Island Hillshade.



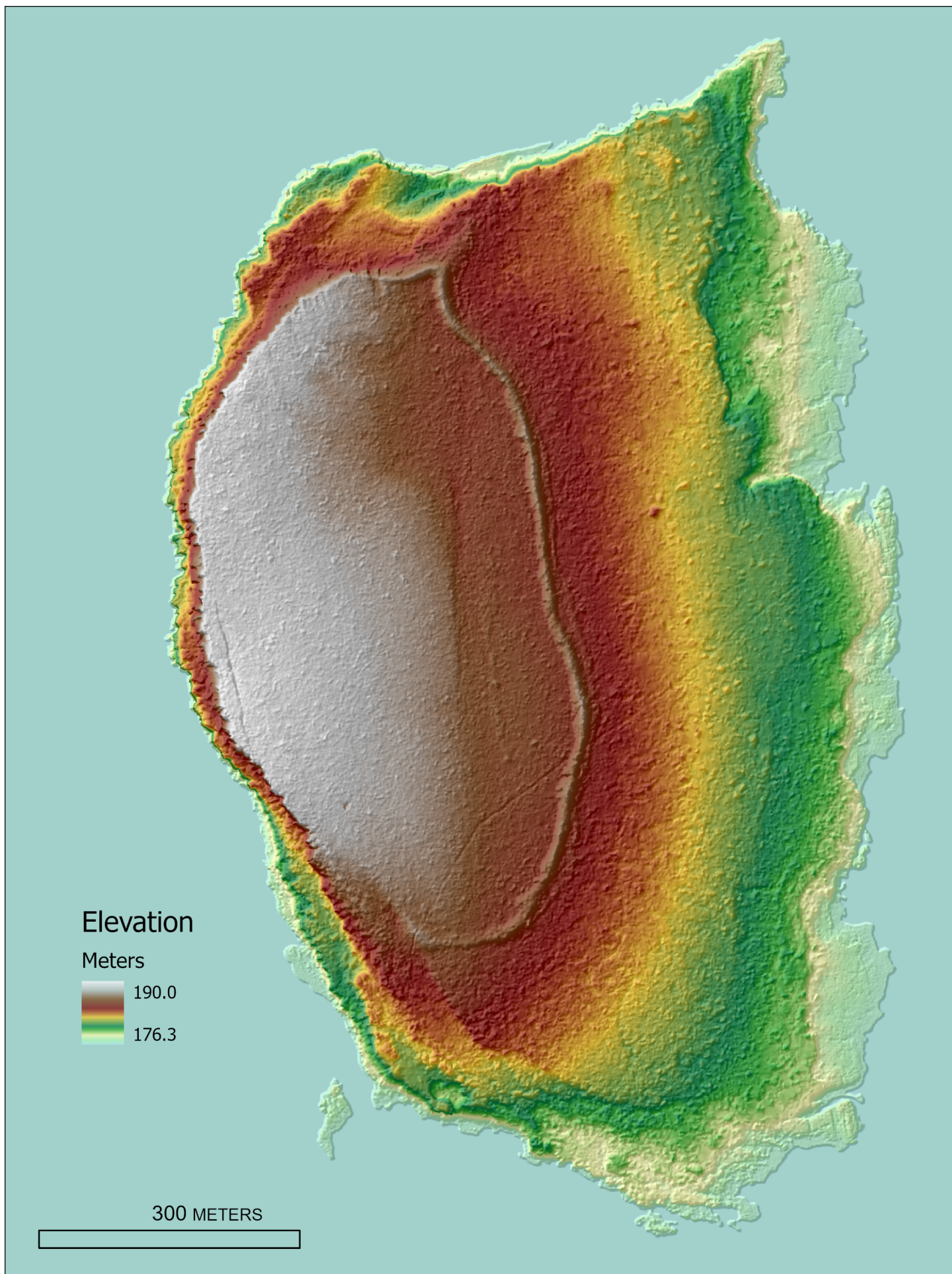
Plum Island 1938 aerial imagery.



Plum Island Hillshade.



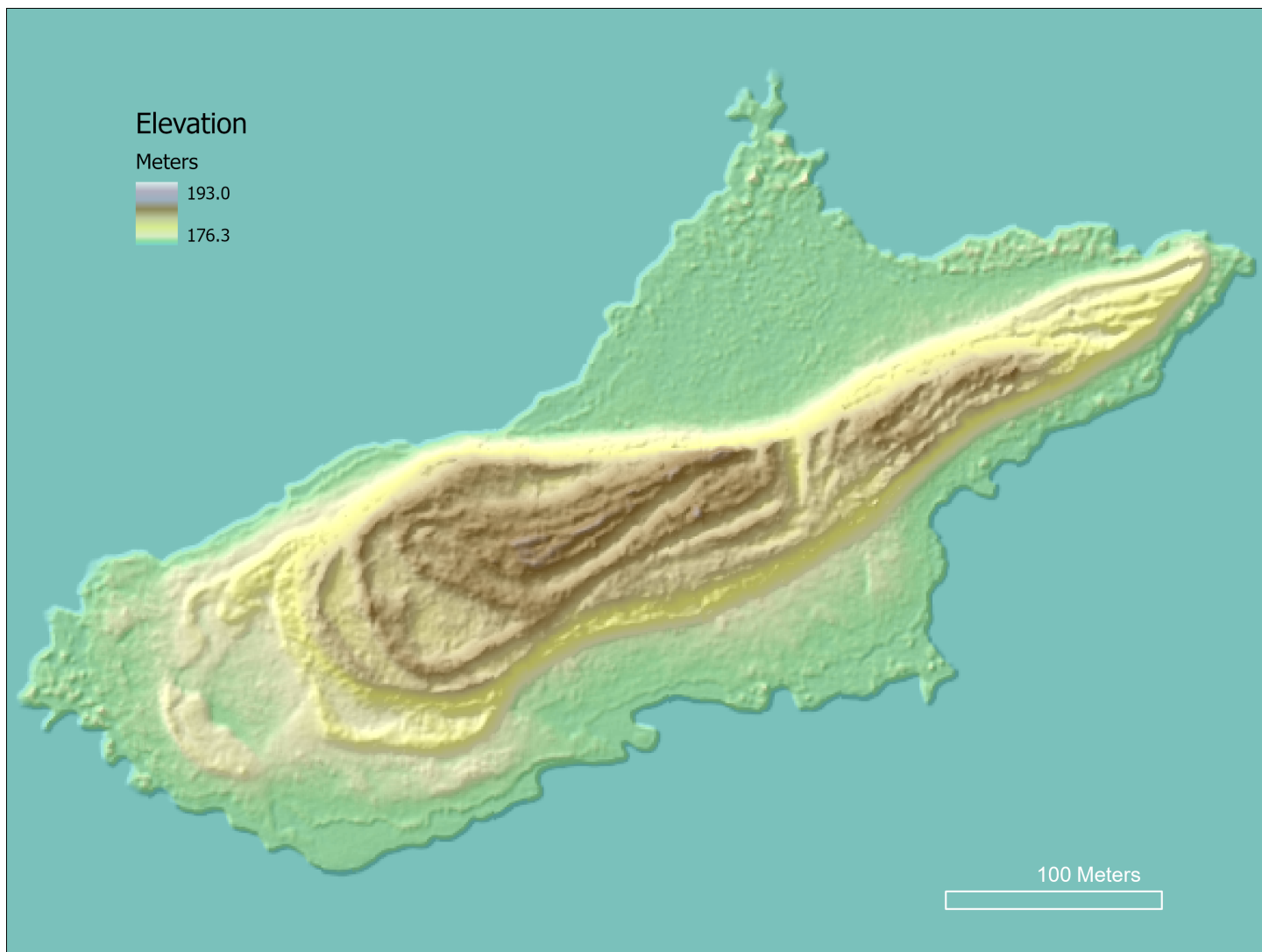
Poverty Island 1939 aerial imagery.



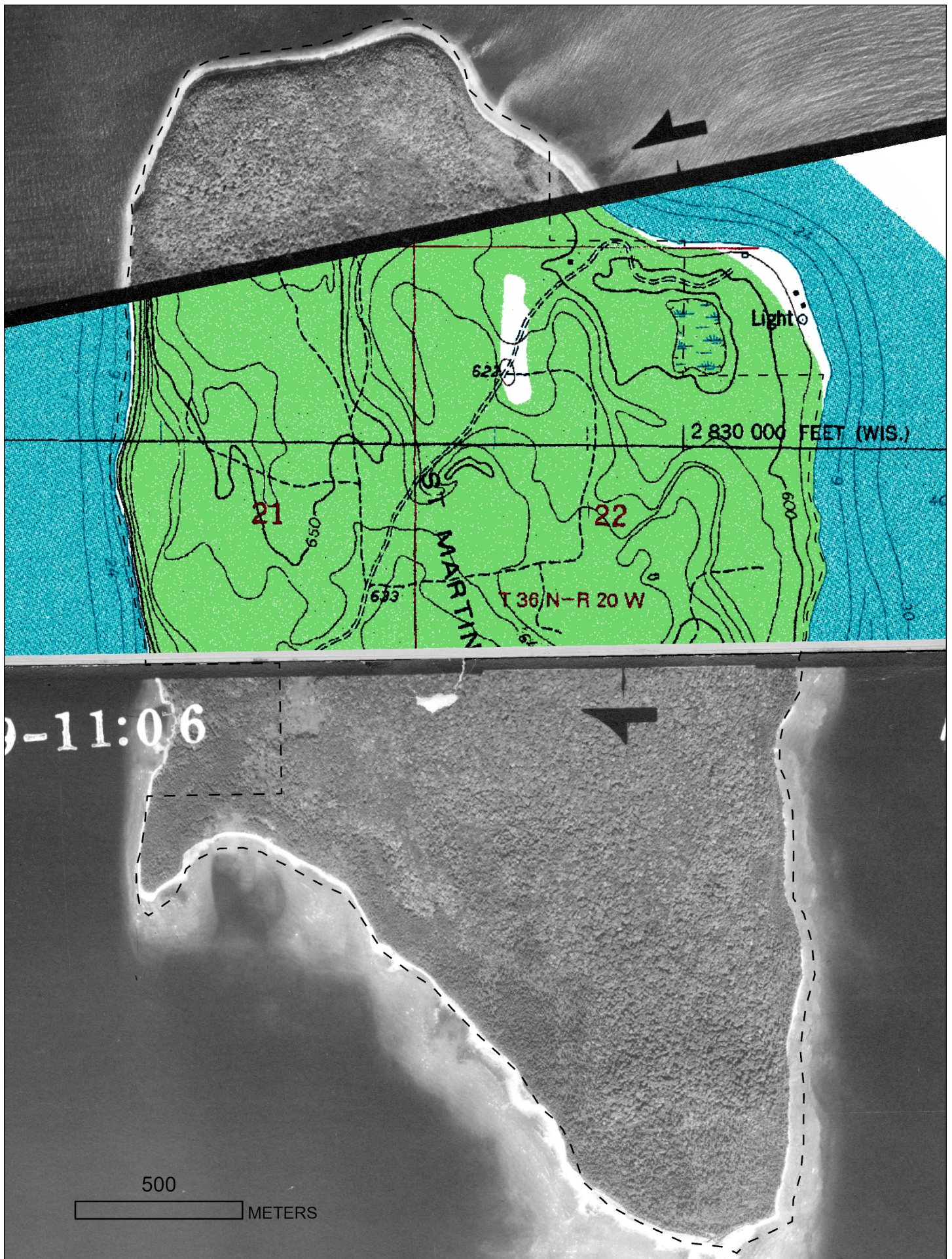
Poverty Island Hillshade.



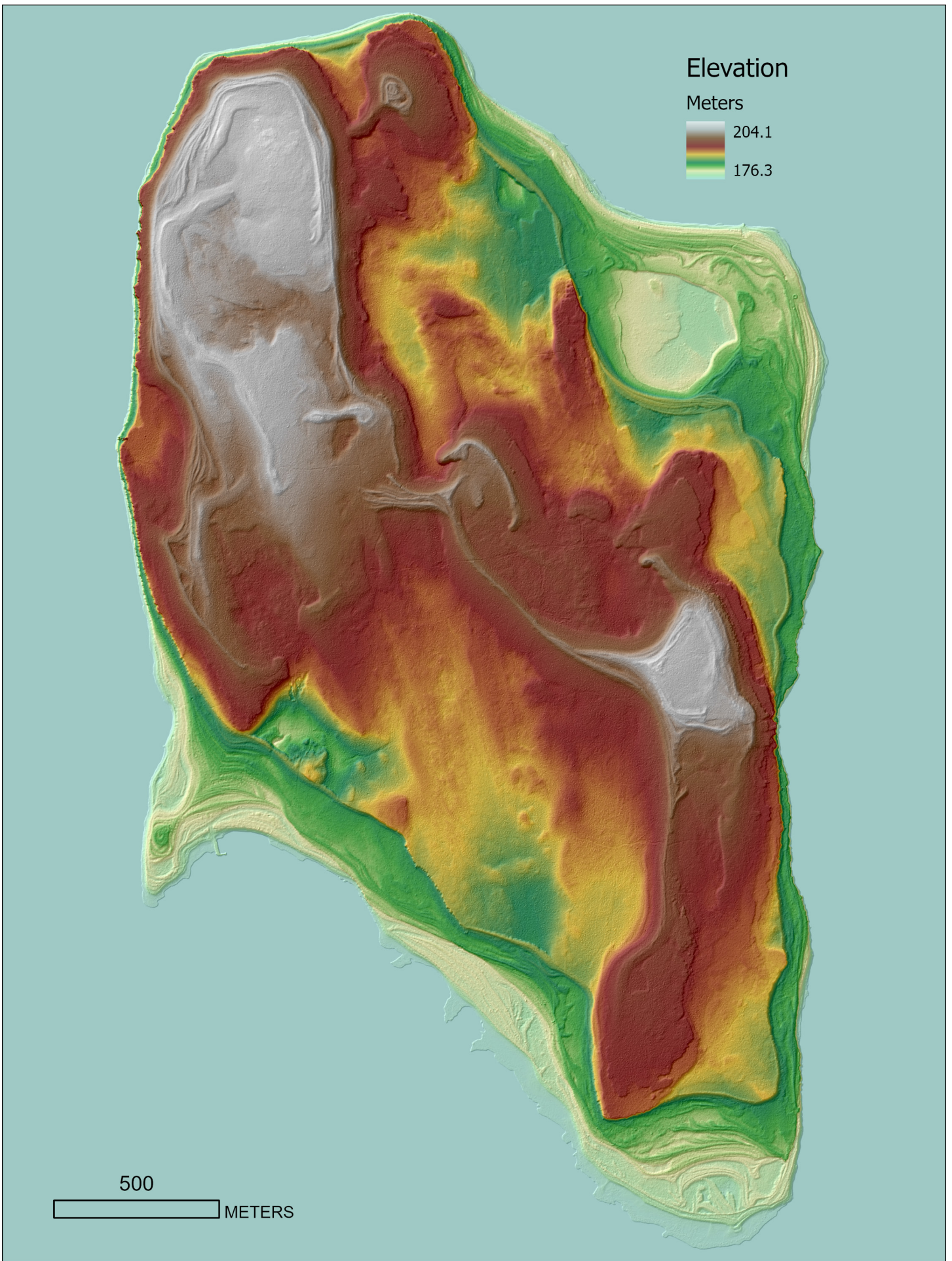
Rocky Island 1939 aerial imagery.



Rocky Island Hillshade.



Saint Martin Island 1939 aerial imagery (no historical imagery was available for the north central portion of the island).



Poverty Island Hillshade.

Appendix 2 - 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 3 - Floristic Quality Assessments

For each high-quality natural community, floristic data were compiled into the Universal Floristic Quality Assessment Calculator (Namestnik 2014, Parker et al. 2014, 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. We employed regionally appropriate FQA for islands in Michigan (Reznicek et al. 2014) and Wisconsin (Namestnik 2014), respectively. 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.

For Poverty, Rocky, and Saint Martin Islands we used the Michigan FQA (Reznicek et al. 2014) and nomenclature within the species lists follows Michigan Flora. For Detroit and Plum Islands we used the Wisconsin FQA (Namestnik 2014) and nomenclature within the species lists follows Wisconsin Flora.

Appendix 3.1. Detroit Island Limestone Bedrock Lakeshore FQA

Conservatism-Based Metrics:

Total Mean C:	3.7
Native Mean C:	4.9
Total FQI:	25.6
Native FQI:	29.4
Adjusted FQI:	42.4
% C value 0:	25
% C value 1-3:	18.8
% C value 4-6:	39.6
% C value 7-10:	16.7
Native Tree Mean C:	5.4
Native Shrub Mean C:	4.8
Native Herbaceous Mean C:	4.8

Species Richness:

Total Species:	48	
Native Species:	36	75%
Non-native Species:	12	25%

Species Wetness:

Mean Wetness:	0.3
Native Mean Wetness:	-0.6

Physiognomy Metrics:

Tree:	5	10.40%
Shrub:	6	12.50%
Vine:	3	6.30%
Forb:	26	54.20%
Grass:	4	8.30%
Sedge:	1	2.10%
Rush:	2	4.20%
Fern:	1	2.10%
Bryophyte:	0	0%

Duration Metrics:

Annual:	8	16.70%
Perennial:	34	70.80%
Biennial:	6	12.50%
Native Annual:	6	12.50%
Native Perennial:	27	56.30%
Native Biennial:	3	6.30%

Appendix 3.1. Detroit Island Limestone Bedrock Lakeshore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Amelanchier laevis</i>	smooth serviceberry	AMELAE	native	6	5
<i>Anemone canadensis</i>	canada anemone	ANECAN	native	4	-3
<i>Anticlea elegans</i>	mountain death camas	ANTELE	native	9	-3
<i>Apios americana</i>	common groundnut	APIAME	native	5	-3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Arabis pycnocarpa</i>	cream-flower rock-cress	ARAPYC	native	6	3
<i>Aralia nudicaulis</i>	wild sarsaparilla	ARANUD	native	6	3
<i>Calamagrostis canadensis robusta</i>	blue-joint grass	CALCAN	native	5	-5
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	5	3
<i>Cerastium fontanum</i>	big mouse-ear chickweed	CERFON	non-native	0	3
<i>Cirsium palustre</i>	invasive european marsh thistle	CIRPAL	non-native	0	-3
<i>Clinopodium arkansanum; calamintha arkansana</i>	limestone calamint	CLIARK	native	10	-3
<i>Corydalis aurea</i>	golden corydalis	CORAUR	native	4	5
<i>Dryopteris carthusiana</i>	spinulose wood fern	DRYCAR	native	7	-3
<i>Elymus canadensis</i>	canada wild-rye	ELYSAN	native	4	3
<i>Erysimum cheiranthoides</i>	worm-seed mustard	ERYCHE	non-native	0	3
<i>Fallopia convolvulus</i>	black-bindweed	FALCON	non-native	0	3
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	1	3
<i>Fraxinus pennsylvanica</i>	green ash	FRAPEN	native	2	-3
<i>Geranium robertianum</i>	roberts geranium	GERROB	native	2	3
<i>Hypericum perforatum</i>	common st. johns-wort	HYPPER	non-native	0	5
<i>Impatiens capensis</i>	orange jewelweed	IMPCAP	native	2	-3
<i>Juncus balticus</i>	baltic rush	JUNBAL	native	5	-5
<i>Juncus tenuis</i>	path rush	JUNTEN	native	1	0
<i>Linaria vulgaris</i>	butter-and-eggs	LINVUL	non-native	0	5
<i>Lycopus uniflorus</i>	northern bugleweed	LYCUNI	native	4	-5
<i>Persicaria lapathifolia</i>	curly-top smartweed	PERLAP	native	2	-3
<i>Persicaria punctata</i>	dotted smartweed	PERPUN	native	5	-5
<i>Phleum pratense</i>	timothy	PHLPRA	non-native	0	3
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Potentilla anserina</i>	silverweed cinquefoil	POTANS	native	4	-3
<i>Prunus virginiana</i>	chokecherry	PRUVIR	native	3	3
<i>Rhynchospora capillacea</i>	hair beak-rush	RHYCAL	native	10	-5
<i>Ribes americanum</i>	american black currant	RIBAME	native	4	-3
<i>Ribes glandulosum</i>	skunk currant	RIBGLA	native	7	-3
<i>Rubus idaeus var. strigosus</i>	american red raspberry	RUBIDAVS	native	3	3
<i>Rudbeckia hirta</i>	black-eyed susan	RUDHIR	native	4	3
<i>Rumex obtusifolius</i>	bitter dock	RUMOBT	non-native	0	0
<i>Sambucus racemosa</i>	red elderberry	SAMRAC	native	5	3
<i>Sedum acre</i>	gold-moss stonecrop	SEDACR	non-native	0	5
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Sorbus decora</i>	showy mountain-ash	SORDEC	native	8	3
<i>Thuja occidentalis</i>	eastern white cedar	THUOCC	native	9	-3
<i>Tilia americana</i>	american basswood	TILAME	native	5	3
<i>Urtica dioica</i>	stinging nettle	URTDIO	native	1	0
<i>Verbascum thapsus</i>	common mullein	VERTHA	non-native	0	5
<i>Veronica anagallis-aquatica</i>	blue water speedwell	VERANA	native	4	-5
<i>Viola nephrophylla</i>	northern bog violet	VIONEP	native	9	-3

Appendix 3.2. Detroit Island Limestone Cliff FQA

Conservatism-Based Metrics:

Total Mean C:	4.2
Native Mean C:	4.7
Total FQI:	28.8
Native FQI:	30.5
Adjusted FQI:	44.4
% C value 0:	10.6
% C value 1-3:	27.7
% C value 4-6:	42.6
% C value 7-10:	19.1
Native Tree Mean C:	4.8
Native Shrub Mean C:	4.4
Native Herbaceous Mean C:	4.8

Species Richness:

Total Species:	47	
Native Species:	42	89.40%
Non-native Species:	5	10.60%

Species Wetness:

Mean Wetness:	2.5
Native Mean Wetness:	2.4

Physiognomy Metrics:

Tree:	5	10.60%
Shrub:	6	12.80%
Vine:	1	2.10%
Forb:	25	53.20%
Grass:	4	8.50%
Sedge:	1	2.10%
Rush:	0	0%
Fern:	5	10.60%
Bryophyte:	0	0%

Duration Metrics:

Annual:	2	4.30%
Perennial:	43	91.50%
Biennial:	2	4.30%
Native Annual:	2	4.30%
Native Perennial:	38	80.90%
Native Biennial:	2	4.30%

Appendix 3.2. Detroit Island Cliff FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
Acer saccharum	sugar maple	ACESAU	native	5	3
Adlumia fungosa	allegheny-vine	ADLFUN	native	7	5
Ageratina altissima	white snakeroot	AGEALT	native	1	3
Allium tricoccum	wild leek	ALLTRI	native	6	3
Anemone acutiloba	sharp-lobed hepatica	ANEACU	native	7	5
Aquilegia canadensis	wild columbine	AQUCAN	native	5	3
Arabis glabra	tower mustard	ARAGLA	native	5	5
Aralia nudicaulis	wild sarsaparilla	ARANUD	native	6	3
Arisaema triphyllum	jack-in-the-pulpit	ARITRI	native	5	0
Athyrium angustum	common lady fern	ATHANG	native	5	0
Betula papyrifera	paper birch	BETPAP	native	3	3
Carex rosea	curly-styled wood sedge	CXROSE	native	4	3
Caulophyllum thalictroides	blue cohosh	CAUTHA	native	8	5
Circaea alpina	alpine enchanters-nightshade	CIRALP	native	7	-3
Circaea canadensis	broad-leaf enchanters-nightshade	CIRCAA	native	2	3
Corylus cornuta	beaked hazelnut	CORCOR	native	5	3
Cystopteris laurentiana	laurentian bladder fern	CYSLAU	native	9	5
Dryopteris carthusiana	spinulose wood fern	DRYCAR	native	7	-3
Elymus villosus	downy wild-rye	ELYVIL	native	6	3
Fallopia cilinodis	black-fringe bindweed	FALCIL	native	1	5
Festuca subverticillata	nodding fescue	FESSUB	native	4	3
Fragaria virginiana	wild strawberry	FRAVIR	native	1	3
Geranium robertianum	roberts geranium	GERROB	native	2	3
Geum canadense	white avens	GEUCAN	native	2	0
Heracleum maximum	american cow-parsnip	HERMAX	native	3	-3
Impatiens capensis	orange jewelweed	IMPCAP	native	2	-3
Leonurus cardiaca	motherwort	LEOCAR	non-native	0	5
Lonicera tatarica	tartarian invasive honeysuckle	LONTAT	non-native	0	3
Maianthemum canadense	canada mayflower	MAICAN	native	5	3
Nepeta cataria	catnip	NEPCAT	non-native	0	3
Osmorhiza claytonii	hairy sweet cicely	OSMCLI	native	5	3
Osmunda claytoniana	interrupted fern	OSMCLA	native	6	0
Poa compressa	canada bluegrass	POACOM	non-native	0	3
Poa pratensis	kentucky bluegrass	POAPRA	non-native	0	3
Polygonatum pubescens	downy solomons-seal	POLPUB	native	6	3
Polypodium virginianum	common polypody	POLVIR	native	9	5
Prunus pensylvanica	fire cherry	PRUPEN	native	4	3
Prunus virginiana	chokecherry	PRUVIR	native	3	3
Ribes cynosbati	eastern prickly gooseberry	RIBCYN	native	3	3
Rubus occidentalis	black raspberry	RUBOCC	native	2	5
Rubus parviflorus	thimbleberry	RUBPAR	native	7	3
Sambucus racemosa	red elderberry	SAMRAC	native	5	3
Sanguinaria canadensis	bloodroot	SAGCAN	native	6	3
Symphyotrichum ciliolatum	northern heart-leaved aster	SYMCIO	native	4	5
Thuja occidentalis	eastern white cedar	THUOCC	native	9	-3
Trillium grandiflorum	large-flowered trillium	TRIGRA	native	6	5
Urtica dioica	stinging nettle	URTDIO	native	1	0

Appendix 3.3. Detroit Island Limestone Cobble Shore FQA

Conservatism-Based Metrics:

Total Mean C:	3.3
Native Mean C:	4.1
Total FQI:	26
Native FQI:	29
Adjusted FQI:	36.8
% C value 0:	22.6
% C value 1-3:	30.6
% C value 4-6:	35.5
% C value 7-10:	11.3
Native Tree Mean C:	4.8
Native Shrub Mean C:	5.1
Native Herbaceous Mean C:	3.7

Species Richness:

Total Species:	62	
Native Species:	50	80.60%
Non-native Species:	12	19.40%

Species Wetness:

Mean Wetness:	1.3
Native Mean Wetness:	0.8

Physiognomy Metrics:

Tree:	8	12.90%
Shrub:	10	16.10%
Vine:	0	0%
Forb:	37	59.70%
Grass:	6	9.70%
Sedge:	0	0%
Rush:	0	0%
Fern:	1	1.60%
Bryophyte:	0	0%

Duration Metrics:

Annual:	9	14.50%
Perennial:	46	74.20%
Biennial:	7	11.30%
Native Annual:	8	12.90%
Native Perennial:	39	62.90%
Native Biennial:	3	4.80%

Appendix 3.3. Detroit Island Limestone Cobble Shore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Acer saccharum</i>	sugar maple	ACESAU	native	5	3
<i>Achillea millefolium</i>	common yarrow	ACHMIL	native	1	3
<i>Amelanchier laevis</i>	smooth serviceberry	AMELAE	native	6	5
<i>Anemone canadensis</i>	canada anemone	ANECAN	native	4	-3
<i>Anemone virginiana</i>	tall thimbleweed	ANEVIR	native	5	3
<i>Anticlea elegans</i>	mountain death camas	ANTELE	native	9	-3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Arabis glabra</i>	tower mustard	ARAGLA	native	5	5
<i>Aralia nudicaulis</i>	wild sarsaparilla	ARANUD	native	6	3
<i>Asclepias syriaca</i>	common milkweed	ASCSYR	native	1	5
<i>Betula papyrifera</i>	paper birch	BETPAP	native	3	3
<i>Calamagrostis canadensis robusta</i>	blue-joint grass	CALCAN	native	5	-5
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	5	3
<i>Cardamine pensylvanica</i>	pennsylvania bitter-cress	CARPEN	native	3	-3
<i>Cerastium fontanum</i>	big mouse-ear chickweed	CERFON	non-native	0	3
<i>Circaea canadensis</i>	broad-leaf enchanters-nightshade	CIRCAA	native	2	3
<i>Cirsium vulgare</i>	bull thistle	CIRVUL	non-native	0	3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	7	5
<i>Corydalis aurea</i>	golden corydalis	CORAUR	native	4	5
<i>Corylus cornuta</i>	beaked hazelnut	CORCOR	native	5	3
<i>Elymus canadensis</i>	canada wild-rye	ELYSAN	native	4	3
<i>Elymus repens</i>	quackgrass	ELYREP	non-native	0	3
<i>Elymus villosus</i>	downy wild-rye	ELYVIL	native	6	3
<i>Elymus virginicus</i>	virginia wild-rye	ELYVIR	native	6	-3
<i>Erigeron canadensis</i>	canadian horseweed	ERICAN	native	0	3
<i>Eupatorium perfoliatum</i>	common boneset	EUPPER	native	6	-3
<i>Fallopia cilinodis</i>	black-fringe bindweed	FALCIL	native	1	5
<i>Fraxinus pennsylvanica</i>	green ash	FRAPEN	native	2	-3
<i>Geranium robertianum</i>	roberts geranium	GERROB	native	2	3
<i>Geum aleppicum</i>	yellow avens	GEUALE	native	3	0
<i>Geum canadense</i>	white avens	GEUCAN	native	2	0
<i>Hieracium caespitosum</i>	field hawkweed	HIECAE	non-native	0	5
<i>Hypericum perforatum</i>	common st. johns-wort	HYPPER	non-native	0	5
<i>Impatiens capensis</i>	orange jewelweed	IMPCAP	native	2	-3
<i>Linaria vulgaris</i>	butter-and-eggs	LINVUL	non-native	0	5
<i>Lonicera tatarica</i>	tartarian invasive honeysuckle	LONTAT	non-native	0	3
<i>Maianthemum stellatum</i>	starry false solomons-seal	MAISTE	native	5	0
<i>Mentha arvensis</i>	wild mint	MENARV	native	3	-3
<i>Nepeta cataria</i>	catnip	NEPCAT	non-native	0	3
<i>Oenothera biennis</i>	common evening-primrose	OENBIE	native	1	3
<i>Persicaria lapathifolia</i>	curly-top smartweed	PERLAP	native	2	-3
<i>Persicaria maculosa</i>	lady's thumb smartweed	PERPER	non-native	0	0
<i>Physocarpus opulifolius</i>	common ninebark	PHYOPU	native	6	-3
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Potentilla anserina</i>	silverweed cinquefoil	POTANS	native	4	-3
<i>Potentilla norvegica</i>	rough cinquefoil	POTNOR	native	0	0

Appendix 3.3. Detroit Island Limestone Cobble Shore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Prunus virginiana</i>	chokecherry	PRUVIR	native	3	3
<i>Ribes cynosbati</i>	eastern prickly gooseberry	RIBCYN	native	3	3
<i>Ribes glandulosum</i>	skunk currant	RIBGLA	native	7	-3
<i>Rubus idaeus var. strigosus</i>	american red raspberry	RUBIDAVS	native	3	3
<i>Rudbeckia hirta</i>	black-eyed susan	RUDHIR	native	4	3
<i>Sambucus racemosa</i>	red elderberry	SAMRAC	native	5	3
<i>Silene latifolia</i>	white campion	SILLAT	non-native	0	5
<i>Solidago altissima</i>	tall goldenrod	SOLALT	native	1	3
<i>Sorbus decora</i>	showy mountain-ash	SORDEC	native	8	3
<i>Thalictrum dasycarpum</i>	tall meadow-rue	THADAS	native	4	-3
<i>Thelypteris palustris</i>	eastern marsh fern	THEPAL	native	7	-3
<i>Thuja occidentalis</i>	eastern white cedar	THUOCC	native	9	-3
<i>Tilia americana</i>	american basswood	TILAME	native	5	3
<i>Ulmus americana</i>	american elm	ULMAME	native	3	-3
<i>Verbascum thapsus</i>	common mullein	VERTHA	non-native	0	5
<i>Viola nephrophylla</i>	northern bog violet	VIONEP	native	9	-3

Appendix 3.4. Detroit Island Limestone Lakeshore Cliff FQA

Conservatism-Based Metrics:

Total Mean C:	3.9
Native Mean C:	4.7
Total FQI:	23.1
Native FQI:	25.3
Adjusted FQI:	42.8
% C value 0:	17.1
% C value 1-3:	28.6
% C value 4-6:	42.9
% C value 7-10:	11.4
Native Tree Mean C:	5.1
Native Shrub Mean C:	4.5
Native Herbaceous Mean C:	4.6

Species Richness:

Total Species:	35	
Native Species:	29	82.90%
Non-native Species:	6	17.10%

Species Wetness:

Mean Wetness:	2.4
Native Mean Wetness:	2.3

Physiognomy Metrics:

Tree:	7	20%
Shrub:	7	20%
Vine:	0	0%
Forb:	16	45.70%
Grass:	4	11.40%
Sedge:	0	0%
Rush:	0	0%
Fern:	1	2.90%
Bryophyte:	0	0%

Duration Metrics:

Annual:	1	2.90%
Perennial:	32	91.40%
Biennial:	2	5.70%
Native Annual:	1	2.90%
Native Perennial:	27	77.10%
Native Biennial:	1	2.90%

Appendix 3.4. Detroit Island Limestone Lakeshore Cliff FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Acer saccharum</i>	sugar maple	ACESAU	native	5	3
<i>Acer spicatum</i>	mountain maple	ACESPI	native	6	3
<i>Amelanchier arborea</i>	common serviceberry	AMEARB	native	6	3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Arabis pycnocarpa</i>	cream-flower rock-cress	ARAPYC	native	6	3
<i>Aralia nudicaulis</i>	wild sarsaparilla	ARANUD	native	6	3
<i>Betula papyrifera</i>	paper birch	BETPAP	native	3	3
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	5	3
<i>Cerastium fontanum</i>	big mouse-ear chickweed	CERFON	non-native	0	3
<i>Clinopodium arkansanum</i>	limestone calamint	CLIARK	native	10	-3
<i>Corylus cornuta</i>	beaked hazelnut	CORCOR	native	5	3
<i>Elymus canadensis</i>	canada wild-rye	ELYSAN	native	4	3
<i>Elymus villosus</i>	downy wild-rye	ELYVIL	native	6	3
<i>Fallopia cilinodis</i>	black-fringe bindweed	FALCIL	native	1	5
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	1	3
<i>Geranium robertianum</i>	roberts geranium	GERROB	native	2	3
<i>Geum canadense</i>	white avens	GEUCAN	native	2	0
<i>Lonicera morrowii</i>	morrows honeysuckle	LONMOR	non-native	0	3
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	5	3
<i>Maianthemum racemosum</i>	feathery false solomons-seal	MAIRAC	native	5	3
<i>Nepeta cataria</i>	catnip	NEPCAT	non-native	0	3
<i>Physocarpus opulifolius</i>	common ninebark	PHYOPU	native	6	-3
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Poa pratensis</i>	kentucky bluegrass	POAPRA	non-native	0	3
<i>Polygonatum pubescens</i>	downy solomons-seal	POLPUB	native	6	3
<i>Polypodium virginianum</i>	common polypody	POLVIR	native	9	5
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	2	0
<i>Prunus virginiana</i>	chokecherry	PRUVIR	native	3	3
<i>Ribes cynosbati</i>	eastern prickly gooseberry	RIBCYN	native	3	3
<i>Rosa blanda</i>	early wild rose	ROSLA	native	4	3
<i>Rubus idaeus var. strigosus</i>	american red raspberry	RUBIDAVS	native	3	3
<i>Solidago altissima</i>	tall goldenrod	SOLALT	native	1	3
<i>Sorbus decora</i>	showy mountain-ash	SORDEC	native	8	3
<i>Taraxacum officinale</i>	common dandelion	TAROFF	non-native	0	3
<i>Thuja occidentalis</i>	eastern white cedar	THUOCC	native	9	-3

Appendix 3.5. Detroit Island Sand and Gravel Beach FQA

Conservatism-Based Metrics:

Total Mean C:	5.8
Native Mean C:	5.8
Total FQI:	11.6
Native FQI:	11.6
Adjusted FQI:	58
% C value 0:	0
% C value 1-3:	50
% C value 4-6:	0
% C value 7-10:	50
Native Tree Mean C:	4.7
Native Shrub Mean C:	n/a
Native Herbaceous Mean C:	9

Species Richness:

Total Species:	4	
Native Species:	4	100%
Non-native Species:	0	0%

Species Wetness:

Mean Wetness:	-1.5
Native Mean Wetness:	-1.5

Physiognomy Metrics:

Tree:	3	75%
Shrub:	0	0%
Vine:	0	0%
Forb:	1	25%
Grass:	0	0%
Sedge:	0	0%
Rush:	0	0%
Fern:	0	0%
Bryophyte:	0	0%

Duration Metrics:

Annual:	0	0%
Perennial:	4	100%
Biennial:	0	0%
Native Annual:	0	0%
Native Perennial:	4	100%
Native Biennial:	0	0%

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Anticlea elegans</i>	mountain death camas	ANTELE	native	9	-3
<i>Betula papyrifera</i>	paper birch	BETPAP	native	3	3
<i>Fraxinus pennsylvanica</i>	green ash	FRAPEN	native	2	-3
<i>Thuja occidentalis</i>	eastern white cedar	THUOCC	native	9	-3

Appendix 3.6. Plum 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 3.6. Plum Island Great Lakes Marsh FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Anemone canadensis</i>	canada anemone	ANECAN	native	4	-3
<i>Berberis thunbergii</i>	japanese barberry	BERTHU	non-native	0	3
<i>Betula papyrifera</i>	paper birch	BETPAP	native	3	3
<i>Calamagrostis canadensis</i>	blue-joint grass	CALCAN	native	5	-5
<i>Calamagrostis stricta</i>	slim-stem reed grass	CALSTR	native	7	-3
<i>Carex aquatilis</i>	long-bracted tussock sedge	CXAQUA	native	7	-5
<i>Carex bebbii</i>	bebb's oval sedge	CXBEBB	native	4	-5
<i>Carex hystericina</i>	porcupine sedge	CXHYST	native	3	-5
<i>Carex lacustris</i>	common lake sedge	CXLACU	native	6	-5
<i>Carex leptalea</i>	bristle-stalked sedge	CXLEPA	native	9	-5
<i>Carex pellita</i>	broad-leaved woolly sedge	CXPELL	native	4	-5
<i>Carex prairea</i>	prairie sedge	CXPRAI	native	10	-3
<i>Carex straminea</i>	awned oval sedge	CXSTRA	native	9	-5
<i>Carex stricta</i>	hummock sedge	CXSTRI	native	7	-5
<i>Carex viridula</i>	green yellow sedge	CXVIRI	native	6	-5
<i>Centaurea stoebe</i>	spotted knapweed	CENSTO	non-native	0	5
<i>Cicuta bulbifera</i>	bulblet water-hemlock	CICBUL	native	7	-5
<i>Circaea alpina</i>	alpine enchanters-nightshade	CIRALP	native	7	-3
<i>Cirsium vulgare</i>	bull thistle	CIRVUL	non-native	0	3
<i>Cirsium palustre</i>	European marsh thistle	CIRPAL	non-native	0	-3
<i>Clinopodium vulgare</i>	wild-basil	CLIVUL	native	3	5
<i>Cornus alba</i> ; <i>Cornus sericea</i>	red-osier dogwood	CORALB	native	3	-3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	7	5
<i>Corydalis aurea</i>	golden corydalis	CORAUR	native	4	5
<i>Cynoglossum officinale</i>	common comfrey	CYNOFF	non-native	0	5
<i>Epilobium ciliatum macounii</i>	hairy willow-herb	EPICIL	native	3	-3
<i>Erysimum cheiranthoides</i>	worm-seed mustard	ERYCHE	non-native	0	3
<i>Eupatorium perfoliatum</i>	common boneset	EUPPER	native	6	-3
<i>Euthamia graminifolia</i>	common flat-topped goldenrod	EUTGRA	native	4	0
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	1	3
<i>Fraxinus pennsylvanica</i>	green ash	FRAPEN	native	2	-3
<i>Geum rivale</i>	purple avens	GEURIV	native	8	-5
<i>Impatiens capensis</i>	orange jewelweed	IMPCAP	native	2	-3
<i>Iris versicolor</i>	northern blue flag	IRIVER	native	5	-5
<i>Juncus balticus</i>	baltic rush	JUNBAL	native	5	-5
<i>Juncus brachycephalus</i>	short-headed rush	JUNBRA	native	9	-5
<i>Lathyrus palustris</i>	marsh pea	LATPAL	native	5	-3
<i>Lemna turionifera</i>	turion duckweed	LEMTUR	native	2	-5
<i>Lycopus americanus</i>	cut-leaf water-horehound	LYCAME	native	4	-5
<i>Lycopus uniflorus</i>	northern bugleweed	LYCUNI	native	4	-5
<i>Lysimachia thyrsoiflora</i>	tufted loosestrife	LYSTHY	native	7	-5
<i>Lythrum salicaria</i>	invasive purple loosestrife	LYTSAL	non-native	0	-5
<i>Mentha arvensis</i>	wild mint	MENARV	native	3	-3
<i>Myriophyllum heterophyllum</i>	two-leaf water-milfoil	MYRHET	native	7	-5
<i>Nuphar variegata</i>	variegated yellow pond-lily	NUPVAR	native	6	-5
<i>Persicaria amphibia</i>	water smartweed	POLAMP	native	5	-5
<i>Phalaris arundinacea</i>	reed canary grass	PHAARU	non-native	0	-3

Appendix 3.6. Plum Island Great Lakes Marsh FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	2	0
<i>Potamogeton gramineus</i>	grass-leaved pondweed	POTGRM	native	7	-5
<i>Potentilla anserina</i>	silverweed cinquefoil	POTANS	native	4	-3
<i>Potentilla norvegica</i>	rough cinquefoil	POTNOR	native	0	0
<i>Rhynchospora capillacea</i>	hair beak-rush	RHYCAL	native	10	-5
<i>Rorippa palustris</i>	common yellow-cress	RORPAL	native	3	-5
<i>Sagittaria latifolia</i>	broad-leaved arrowhead	SAGLAT	native	3	-5
<i>Salix petiolaris</i>	meadow willow	SALPET	native	6	-3
<i>Schoenoplectus acutus</i>	hard-stem bulrush	SCHACU	native	6	-5
<i>Schoenoplectus tabernaemontani</i>	soft-stem bulrush	SCHTAB	native	4	-5
<i>Scirpus atrovirens</i>	dark-green bulrush	SCIATV	native	3	-5
<i>Spirodela polyrrhiza</i>	greater duckweed	SPIPOL	native	5	-5
<i>Stachys aspera</i>	hyssop-leaf hedge-nettle	STAASP	non-native	0	-3
<i>Stachys tenuifolia</i>	narrow-leaved hedge-nettle	STATEN	native	6	-3
<i>Thelypteris palustris</i>	eastern marsh fern	THEPAL	native	7	-3
<i>Thuja occidentalis</i>	eastern white cedar	THUOCC	native	9	-3
<i>Typha angustifolia</i>	narrow-leaved cat-tail	TYPANG	non-native	0	-5
<i>Urtica dioica</i>	stinging nettle	URTDIO	native	1	0
<i>Veronica anagallis-aquatica</i>	blue water speedwell	VERANA	native	4	-5
<i>Viola cucullata</i>	marsh blue violet	VIOCUC	native	7	-5

Appendix 3.7. Plum Island Limestone Cobble Shore FQA

Conservatism-Based Metrics:

Total Mean C:	3.2
Native Mean C:	4.2
Total FQI:	26.4
Native FQI:	30
Adjusted FQI:	36.4
% C value 0:	25
% C value 1-3:	32.4
% C value 4-6:	29.4
% C value 7-10:	13.2
Native Tree Mean C:	3.7
Native Shrub Mean C:	4.9
Native Herbaceous Mean C:	4.2

Species Richness:

Total Species:	68	
Native Species:	51	75%
Non-native Species:	17	25%

Species Wetness:

Mean Wetness:	0.7
Native Mean Wetness:	-0.1

Physiognomy Metrics:

Tree:	7	10.30%
Shrub:	9	13.20%
Vine:	3	4.40%
Forb:	42	61.80%
Grass:	4	5.90%
Sedge:	2	2.90%
Rush:	1	1.50%
Fern:	0	0%
Bryophyte:	0	0%

Duration Metrics:

Annual:	6	8.80%
Perennial:	58	85.30%
Biennial:	4	5.90%
Native Annual:	3	4.40%
Native Perennial:	47	69.10%
Native Biennial:	1	1.50%

Appendix 3.7. Plum Island Limestone Cobble Shore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Abies balsamea</i>	balsam fir	ABIBAL	native	5	0
<i>Achillea millefolium</i>	common yarrow	ACHMIL	native	1	3
<i>Amelanchier sanguinea</i>	round-leaved serviceberry	AMESAN	native	7	5
<i>Anemone virginiana</i>	tall thimbleweed	ANEVIR	native	5	3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Aralia nudicaulis</i>	wild sarsaparilla	ARANUD	native	6	3
<i>Asclepias incarnata</i>	marsh milkweed	ASCINC	native	5	-5
<i>Asclepias syriaca</i>	common milkweed	ASCSYR	native	1	5
<i>Berberis thunbergii</i>	japanese barberry	BERTHU	non-native	0	3
<i>Betula papyrifera</i>	paper birch	BETPAP	native	3	3
<i>Calamagrostis canadensis robusta</i>	blue-joint grass	CALCAN	native	5	-5
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	5	3
<i>Carex lacustris</i>	common lake sedge	CXLACU	native	6	-5
<i>Carex stricta</i>	hummock sedge	CXSTRI	native	7	-5
<i>Centaurea stoebe</i>	spotted knapweed	CENSTO	non-native	0	5
<i>Clinopodium vulgare</i>	wild-basil	CLIVUL	native	3	5
<i>Comandra umbellata</i>	bastard-toadflax	COMUMB	native	6	3
<i>Cornus alba</i> ; <i>Cornus sericea</i>	red-osier dogwood	CORALB	native	3	-3
<i>Corydalis aurea</i>	golden corydalis	CORAUR	native	4	5
<i>Cynoglossum officinale</i>	common comfrey	CYNOFF	non-native	0	5
<i>Elymus trachycaulus</i>	slender wheat grass	ELYTRA	native	4	3
<i>Epilobium ciliatum macounii</i>	hairy willow-herb	EPICIL	native	3	-3
<i>Erysimum cheiranthoides</i>	worm-seed mustard	ERYCHE	non-native	0	3
<i>Fallopia convolvulus</i>	black-bindweed	FALCON	non-native	0	3
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	1	3
<i>Fraxinus pennsylvanica</i>	green ash	FRAPEN	native	2	-3
<i>Geum aleppicum</i>	yellow avens	GEUALE	native	3	0
<i>Hypericum perforatum</i>	common st. johns-wort	HYPPER	non-native	0	5
<i>Impatiens capensis</i>	orange jewelweed	IMPCAP	native	2	-3
<i>Iris lacustris</i>	dwarf lake iris	IRILAC	native	9	0
<i>Iris versicolor</i>	northern blue flag	IRIVER	native	5	-5
<i>Juncus tenuis</i>	path rush	JUNTEN	native	1	0
<i>Juniperus communis</i>	common juniper	JUNCOM	native	3	3
<i>Lathyrus japonicus</i>	beach pea	LATJAP	native	9	3
<i>Lemna turionifera</i>	turon duckweed	LEMTUR	native	2	-5
<i>Leucanthemum vulgare</i>	ox-eye daisy	LEUVUL	non-native	0	5
<i>Linaria vulgaris</i>	butter-and-eggs	LINVUL	non-native	0	5
<i>Lonicera hirsuta</i>	hairy honeysuckle	LONHIR	native	7	0
<i>Lonicera x bella</i>	bells invasive honeysuckle	LONXBEL	non-native	0	3
<i>Lycopus americanus</i>	cut-leaf water-horehound	LYCAME	native	4	-5
<i>Lysimachia terrestris</i>	swamp-candles	LYSTER	native	7	-5
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	5	3
<i>Maianthemum stellatum</i>	starry false solomons-seal	MAISTE	native	5	0
<i>Mentha arvensis</i>	wild mint	MENARV	native	3	-3
<i>Oenothera biennis</i>	common evening-primrose	OENBIE	native	1	3
<i>Persicaria amphibia</i>	water smartweed	POLAMP	native	5	-5

Appendix 3.7. Plum Island Limestone Cobble Shore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Persicaria lapathifolia</i>	curly-top smartweed	PERLAP	native	2	-3
<i>Persicaria maculosa</i>	ladys thumb smartweed	PERPER	non-native	0	0
<i>Phleum pratense</i>	timothy	PHLPRA	non-native	0	3
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Populus deltoides</i>	eastern cottonwood	POPDEL	native	2	0
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	2	0
<i>Potentilla anserina</i>	silverweed cinquefoil	POTANS	native	4	-3
<i>Prunus virginiana</i>	chokecherry	PRUVIR	native	3	3
<i>Rubus idaeus</i> var. <i>strigosus</i>	american red raspberry	RUBIDAVS	native	3	3
<i>Rumex obtusifolius</i>	bitter dock	RUMOBT	non-native	0	0
<i>Saponaria officinalis</i>	bouncing-bet	SAPOFF	non-native	0	3
<i>Scutellaria galericulata</i>	marsh skullcap	SCUGAL	native	5	-5
<i>Shepherdia canadensis</i>	russet buffalo-berry	SHECAN	native	7	5
<i>Silene vulgaris</i>	bladder-campion	SILVUL	non-native	0	5
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Solidago altissima</i>	tall goldenrod	SOLALT	native	1	3
<i>Spirodela polyrrhiza</i>	greater duckweed	SPIPOL	native	5	-5
<i>Stachys tenuifolia</i>	narrow-leaved hedge-nettle	STATEN	native	6	-3
<i>Symphoricarpos albus</i> var. <i>albus</i>	common snowberry	SYMALBVA	native	7	3
<i>Thuja occidentalis</i>	eastern white cedar	THUOCC	native	9	-3
<i>Urtica dioica</i>	stinging nettle	URTDIO	native	1	0
<i>Verbascum thapsus</i>	common mullein	VERTHA	non-native	0	5

Appendix 3.8. Plum Island Limestone Lakeshore Cliff FQA

Conservatism-Based Metrics:

Total Mean C:	3.7
Native Mean C:	5.1
Total FQI:	36.1
Native FQI:	42.7
Adjusted FQI:	43.8
% C value 0:	26.3
% C value 1-3:	17.9
% C value 4-6:	34.7
% C value 7-10:	21.1
Native Tree Mean C:	4.5
Native Shrub Mean C:	5.8
Native Herbaceous Mean C:	5

Species Richness:

Total Species:	95	
Native Species:	70	73.70%
Non-native Species:	25	26.30%

Species Wetness:

Mean Wetness:	2.4
Native Mean Wetness:	2.1

Physiognomy Metrics:

Tree:	8	8.40%
Shrub:	13	13.70%
Vine:	5	5.30%
Forb:	55	57.90%
Grass:	10	10.50%
Sedge:	2	2.10%
Rush:	0	0%
Fern:	2	2.10%
Bryophyte:	0	0%

Duration Metrics:

Annual:	6	6.30%
Perennial:	77	81.10%
Biennial:	12	12.60%
Native Annual:	6	6.30%
Native Perennial:	59	62.10%
Native Biennial:	5	5.30%

Appendix 3.8. Plum Island Limestone Lakeshore Cliff FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Acer saccharum</i>	sugar maple	ACESAU	native	5	3
<i>Achillea millefolium</i>	common yarrow	ACHMIL	native	1	3
<i>Adlumia fungosa</i>	allegheny-vine	ADLFUN	native	7	5
<i>Allium tricoccum</i>	wild leek	ALLTRI	native	6	3
<i>Amelanchier arborea</i>	common serviceberry	AMEARB	native	6	3
<i>Amelanchier laevis</i>	smooth serviceberry	AMELAE	native	6	5
<i>Anemone virginiana</i>	tall thimbleweed	ANEVIR	native	5	3
<i>Anticlea elegans</i>	mountain death camas	ANTELE	native	9	-3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Arabis pycnocarpa</i>	cream-flower rock-cress	ARAPYC	native	6	3
<i>Aralia nudicaulis</i>	wild sarsaparilla	ARANUD	native	6	3
<i>Aralia racemosa</i>	american spikenard	ARARAC	native	7	3
Arctium minus	common burdock	ARCMIN	non-native	0	3
<i>Arisaema triphyllum</i>	jack-in-the-pulpit	ARITRI	native	5	0
<i>Betula papyrifera</i>	paper birch	BETPAP	native	3	3
<i>Boechera stricta</i>	drummonds rock-cress; canadian rock-cress	BOESTR	native	6	3
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	5	3
<i>Carex eburnea</i>	bristle-leaf sedge	CXEBUR	native	8	3
<i>Carex rosea</i>	curly-styled wood sedge	CXROSE	native	4	3
Centaurea stoebe	spotted knapweed	CENSTO	non-native	0	5
Cerastium fontanum	big mouse-ear chickweed	CERFON	non-native	0	3
<i>Circaea alpina</i>	alpine enchanters-nightshade	CIRALP	native	7	-3
<i>Cirsium vulgare</i>	bull thistle	CIRVUL	non-native	0	3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	7	5
<i>Corylus cornuta</i>	beaked hazelnut	CORCOR	native	5	3
Cynoglossum officinale	common comfrey	CYNOFF	non-native	0	5
<i>Cystopteris tennesseensis</i>	tennessee bladder fern	CYSTEN	native	7	5
Dactylis glomerata	orchard grass	DACGLO	non-native	0	3
Daucus carota	queen annes-lace	DAUCAR	non-native	0	5
<i>Diervilla lonicera</i>	northern bush-honeysuckle	DIELON	native	6	5
<i>Dryopteris marginalis</i>	marginal shield fern	DRYMAR	native	9	3
<i>Elymus trachycaulus</i>	slender wheat grass	ELYTRA	native	4	3
Epipactis helleborine	broad-leaved helleborine	EPIHEL	non-native	0	5
<i>Erigeron strigosus</i>	daisy fleabane	ERISTR	native	2	3
<i>Eurybia macrophylla</i>	large-leaved aster	EURMAC	native	4	5
<i>Festuca subverticillata</i>	nodding fescue	FESSUB	native	4	3
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	1	3
<i>Fraxinus pennsylvanica</i>	green ash	FRAPEN	native	2	-3
<i>Galium triflorum</i>	fragrant bedstraw	GALTRL	native	5	3
<i>Geranium robertianum</i>	roberts geranium	GERROB	native	2	3
<i>Geum aleppicum</i>	yellow avens	GEUALE	native	3	0
<i>Geum canadense</i>	white avens	GEUCAN	native	2	0
<i>Hackelia deflexa</i>	american stickseed	HACDEF	native	3	5
<i>Hackelia virginiana</i>	virginia stickseed	HACVIR	native	3	3
Hieracium caespitosum	field hawkweed	HIECAE	non-native	0	5
<i>Hieracium umbellatum</i>	narrow-leaved hawkweed	HIEUMB	native	6	5

Appendix 3.8. Plum Island Limestone Lakeshore Cliff FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Impatiens capensis</i>	orange jewelweed	IMPCAP	native	2	-3
<i>Lactuca canadensis</i>	canada lettuce	LACCAN	native	2	3
<i>Leonurus cardiaca</i>	motherwort	LEOCAR	non-native	0	5
<i>Leucanthemum vulgare</i>	ox-eye daisy	LEUVUL	non-native	0	5
<i>Lilium philadelphicum</i>	wood lily	LILPHI	native	9	0
<i>Linaria vulgaris</i>	butter-and-eggs	LINVUL	non-native	0	5
<i>Lonicera canadensis</i>	american fly honeysuckle	LONCAN	native	8	3
<i>Lonicera dioica</i>	red honeysuckle	LONDIO	native	7	3
<i>Lonicera hirsuta</i>	hairy honeysuckle	LONHIR	native	7	0
<i>Lycopus americanus</i>	cut-leaf water-horehound	LYCAME	native	4	-5
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	5	3
<i>Melampyrum lineare</i>	narrow-leaved cow-wheat	MELLIN	native	7	3
<i>Milium effusum</i>	american millet grass	MILEFF	native	7	3
<i>Nepeta cataria</i>	catnip	NEPCAT	non-native	0	3
<i>Phleum pratense</i>	timothy	PHLPRA	non-native	0	3
<i>Physocarpus opulifolius</i>	common ninebark	PHYOPU	native	6	-3
<i>Pilea pumila</i>	canadian clearweed	PILPUM	native	3	-3
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Poa nemoralis</i>	wood bluegrass	POANEM	non-native	0	3
<i>Poa pratensis</i>	kentucky bluegrass	POAPRA	non-native	0	3
<i>Polygaloides paucifolia</i>	gay-wings	POLPAU	native	7	3
<i>Polygonatum pubescens</i>	downy solomons-seal	POLPUB	native	6	3
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	2	0
<i>Prunus virginiana</i>	chokecherry	PRUVIR	native	3	3
<i>Ranunculus acris</i>	tall european buttercup	RANACR	non-native	0	0
<i>Rosa blanda; rosa williamsii</i>	early wild rose	ROSBLA	native	4	3
<i>Rubus idaeus var. strigosus</i>	american red raspberry	RUBIDAVS	native	3	3
<i>Sambucus racemosa</i>	red elderberry	SAMRAC	native	5	3
<i>Schedonorus pratensis</i>	meadow fescue	SCHPRA	non-native	0	3
<i>Sedum acre</i>	gold-moss stonecrop	SEDACR	non-native	0	5
<i>Shepherdia canadensis</i>	russet buffalo-berry	SHECAN	native	7	5
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Solidago altissima</i>	tall goldenrod	SOLALT	native	1	3
<i>Solidago flexicaulis</i>	zigzag goldenrod	SOLFLE	native	6	3
<i>Solidago hispida</i>	hairy goldenrod	SOLHIS	native	6	5
<i>Sorbus americana</i>	american mountain-ash	SORAME	native	7	0
<i>Sphenopholis intermedia</i>	slender wedge grass	SPHINT	native	7	0
<i>Symphoricarpos albus var. albus</i>	common snowberry	SYMALBVA	native	7	3
<i>Symphyotrichum ciliolatum</i>	northern heart-leaved aster	SYMCIO	native	4	5
<i>Symphyotrichum lanceolatum</i>	white panicle aster	SYMLAN	native	4	-3
<i>Taraxacum officinale</i>	common dandelion	TAROFF	non-native	0	3
<i>Thuja occidentalis</i>	eastern white cedar	THUOCC	native	9	-3
<i>Tilia americana</i>	american basswood	TILAME	native	5	3
<i>Toxicodendron radicans</i>	eastern poison-ivy	TOXRAD	native	4	0
<i>Verbascum thapsus</i>	common mullein	VERTHA	non-native	0	5
<i>Veronica serpyllifolia ssp. Serpyllifolia</i>	thyme-leaved speedwell	VERSERVS	non-native	0	0
<i>Viburnum opulus</i>	european highbush-cranberry	VIBOPUVO	non-native	0	-3
<i>Viola labradorica</i>	alpine violet	VIOLAB	native	4	0
<i>Viola pubescens</i>	downy yellow violet	VIOPUB	native	5	3

Appendix 3.9. Plum Island Mesic Northern Forest FQA

Conservatism-Based Metrics:

Total Mean C:	4.4
Native Mean C:	5.6
Total FQI:	42.9
Native FQI:	48.5
Adjusted FQI:	49.8
% C value 0:	21.1
% C value 1-3:	14.7
% C value 4-6:	35.8
% C value 7-10:	28.4
Native Tree Mean C:	5.1
Native Shrub Mean C:	5.8
Native Herbaceous Mean C:	5.7

Species Richness:

Total Species:	95	
Native Species:	75	78.90%
Non-native Species:	20	21.10%

Species Wetness:

Mean Wetness:	2
Native Mean Wetness:	1.9

Physiognomy Metrics:

Tree:	12	12.60%
Shrub:	14	14.70%
Vine:	6	6.30%
Forb:	49	51.60%
Grass:	4	4.20%
Sedge:	3	3.20%
Rush:	0	0%
Fern:	7	7.40%
Bryophyte:	0	0%

Duration Metrics:

Annual:	4	4.20%
Perennial:	81	85.30%
Biennial:	10	10.50%
Native Annual:	3	3.20%
Native Perennial:	69	72.60%
Native Biennial:	3	3.20%

Appendix 3.9. Plum Island Mesic Northern Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Acer saccharum</i>	sugar maple	ACESAU	native	5	3
<i>Acer spicatum</i>	mountain maple	ACESPI	native	6	3
<i>Actaea pachypoda</i>	dolls-eyes	ACTPAC	native	6	5
<i>Adlumia fungosa</i>	allegheny-vine	ADLFUN	native	7	5
<i>Allium tricoccum</i>	wild leek	ALLTRI	native	6	3
<i>Amelanchier arborea</i>	common serviceberry	AMEARB	native	6	3
<i>Amelanchier laevis</i>	smooth serviceberry	AMELAE	native	6	5
<i>Anemone acutiloba</i>	sharp-lobed hepatica	ANEACU	native	7	5
<i>Anticlea elegans</i>	mountain death camas	ANTELE	native	9	-3
<i>Arabis hirsuta</i>	hairy rock-cress	ARAHIR	native	6	5
<i>Aralia nudicaulis</i>	wild sarsaparilla	ARANUD	native	6	3
<i>Aralia racemosa</i>	american spikenard	ARARAC	native	7	3
Arctium minus	common burdock	ARCMIN	non-native	0	3
<i>Arisaema triphyllum</i>	jack-in-the-pulpit	ARITRI	native	5	0
<i>Asclepias incarnata</i>	marsh milkweed	ASCINC	native	5	-5
Berberis thunbergii	japanese barberry	BERTHU	non-native	0	3
<i>Betula papyrifera</i>	paper birch	BETPAP	native	3	3
<i>Boechera stricta</i>	drummonds rock-cress	BOESTR	native	6	3
<i>Botrypus virginianus</i>	rattlesnake fern	BOTVIR	native	6	3
<i>Carex eburnea</i>	bristle-leaf sedge	CXEBUR	native	8	3
<i>Carex lacustris</i>	common lake sedge	CXLACU	native	6	-5
<i>Carex pedunculata</i>	long-stalk sedge	CXPEDU	native	7	3
<i>Caulophyllum thalictroides</i>	blue cohosh	CAUTHA	native	8	5
Centaurea stoebe	spotted knapweed	CENSTO	non-native	0	5
<i>Circaea alpina</i>	alpine enchanters-nightshade	CIRALP	native	7	-3
<i>Circaea canadensis</i>	broad-leaf enchanters-nightshade	CIRCAA	native	2	3
Cirsium arvense	canada thistle	CIRARV	non-native	0	3
Cirsium palustre	invasive european marsh thistle	CIRPAL	non-native	0	-3
Cirsium vulgare	bull thistle	CIRVUL	non-native	0	3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	7	5
Cynoglossum officinale	common comfrey	CYNOFF	non-native	0	5
<i>Cystopteris tennesseensis</i>	tennessee bladder fern	CYSTEN	native	7	5
<i>Diervilla lonicera</i>	northern bush-honeysuckle	DIELON	native	6	5
<i>Dryopteris intermedia</i>	fancy wood fern	DRYINT	native	7	0
<i>Dryopteris marginalis</i>	marginal shield fern	DRYMAR	native	9	3
<i>Eupatorium sessilifolium</i>	upland boneset	EUPSES	native	9	5
<i>Eurybia macrophylla</i>	large-leaved aster	EURMAC	native	4	5
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	1	3
Galeopsis tetrahit	common hemp-nettle	GALTET	non-native	0	3
<i>Geranium robertianum</i>	roberts geranium	GERROB	native	2	3
<i>Geum canadense</i>	white avens	GEUCAN	native	2	0
<i>Heracleum maximum</i>	american cow-parsnip	HERMAX	native	3	-3
Hesperis matronalis	dames rocket	HESMAT	non-native	0	3
<i>Hieracium umbellatum</i>	narrow-leaved hawkweed	HIEUMB	native	6	5
<i>Hydrophyllum virginianum</i>	johns-cabbage	HYDVIR	native	4	0
Hypericum perforatum	common st. johns-wort	HYPPER	non-native	0	5
Leucanthemum vulgare	ox-eye daisy	LEUVUL	non-native	0	5

Appendix 3.9. Plum Island Mesic Northern Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Lilium philadelphicum</i>	wood lily	LILPHI	native	9	0
<i>Linaria vulgaris</i>	butter-and-eggs	LINVUL	non-native	0	5
<i>Lonicera canadensis</i>	american fly honeysuckle	LONCAN	native	8	3
<i>Lonicera dioica</i>	red honeysuckle	LONDIO	native	7	3
<i>Lonicera hirsuta</i>	hairy honeysuckle	LONHIR	native	7	0
<i>Lysimachia nummularia</i>	money-wort	LYSNUM	non-native	0	-3
<i>Maianthemum racemosum</i>	feathery false solomons-seal	MAIRAC	native	5	3
<i>Maianthemum stellatum</i>	starry false solomons-seal	MAISTE	native	5	0
<i>Matteuccia struthiopteris</i>	ostrich fern	MATSTR	native	5	0
<i>Melampyrum lineare</i>	narrow-leaved cow-wheat	MELLIN	native	7	3
<i>Milium effusum</i>	american millet grass	MILEFF	native	7	3
<i>Nepeta cataria</i>	catnip	NEPCAT	non-native	0	3
<i>Onoclea sensibilis</i>	sensitive fern	ONOSEN	native	5	-3
<i>Osmunda claytoniana</i>	interrupted fern	OSMCLA	native	6	0
<i>Ostrya virginiana</i>	eastern hop-hornbeam	OSTVIR	native	5	3
<i>Parthenocissus quinquefolia</i>	virginia creeper	PARQUI	native	5	3
<i>Pastinaca sativa</i>	invasive wild parsnip	PASSAT	non-native	0	5
<i>Phalaris arundinacea</i>	reed canary grass	PHAARU	non-native	0	-3
<i>Phleum pratense</i>	timothy	PHLPRA	non-native	0	3
<i>Physocarpus opulifolius</i>	common ninebark	PHYOPU	native	6	-3
<i>Pilea pumila; adicea deamii</i>	canadian clearweed	PILPUM	native	3	-3
<i>Polygaloides paucifolia</i>	gay-wings	POLPAU	native	7	3
<i>Polygonatum pubescens</i>	downy solomons-seal	POLPUB	native	6	3
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	2	0
<i>Prunus serotina</i>	wild black cherry	PRUSER	native	3	3
<i>Prunus virginiana</i>	chokecherry	PRUVIR	native	3	3
<i>Quercus rubra</i>	northern red oak	QUERUB	native	5	3
<i>Ranunculus acris</i>	tall european buttercup	RANACR	non-native	0	0
<i>Ranunculus recurvatus</i>	hooked buttercup	RANREC	native	5	-3
<i>Rosa multiflora</i>	multiflora invasive rose	ROSMUL	non-native	0	3
<i>Rubus idaeus var. strigosus</i>	american red raspberry	RUBIDAVS	native	3	3
<i>Rubus occidentalis</i>	black raspberry	RUBOCC	native	2	5
<i>Rubus parviflorus</i>	thimbleberry	RUBPAR	native	7	3
<i>Sambucus racemosa</i>	red elderberry	SAMRAC	native	5	3
<i>Shepherdia canadensis</i>	russet buffalo-berry	SHECAN	native	7	5
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Solidago flexicaulis</i>	zigzag goldenrod	SOLFLE	native	6	3
<i>Solidago gigantea</i>	giant goldenrod	SOLGIG	native	3	-3
<i>Solidago hispida</i>	hairy goldenrod	SOLHIS	native	6	5
<i>Sorbus americana</i>	american mountain-ash	SORAME	native	7	0
<i>Sphenopholis intermedia</i>	slender wedge grass	SPHINT	native	7	0
<i>Symphoricarpos albus var. albus</i>	common snowberry	SYMALBVA	native	7	3
<i>Thuja occidentalis</i>	eastern white cedar	THUOCC	native	9	-3
<i>Tilia americana</i>	american basswood	TILAME	native	5	3
<i>Toxicodendron radicans</i>	eastern poison-ivy	TOXRAD	native	4	0
<i>Tsuga canadensis</i>	eastern hemlock	TSUCAN	native	8	3
<i>Urtica dioica</i>	stinging nettle	URTDIO	native	1	0
<i>Viola pubescens</i>	downy yellow violet	VIOPUB	native	5	3

Appendix 3.10. Poverty Island Boreal Forest FQA

Conservatism-Based Metrics:

Total Mean C:	2.9
Native Mean C:	3.7
Total FQI:	28
Native FQI:	31.6
Adjusted FQI:	32.8
% C value 0:	26.9
% C value 1-3:	35.5
% C value 4-6:	28
% C value 7-10:	9.7
Native Tree Mean C:	3
Native Shrub Mean C:	3.7
Native Herbaceous Mean C:	3.9

Species Richness:

Total Species:	93	
Native Species:	73	78.50%
Non-native Species:	20	21.50%

Species Wetness:

Mean Wetness:	1.5
Native Mean Wetness:	1.1

Physiognomy Metrics:

Tree:	10	10.80%
Shrub:	16	17.20%
Vine:	2	2.20%
Forb:	45	48.40%
Grass:	8	8.60%
Sedge:	7	7.50%
Rush:	0	0%
Fern:	5	5.40%
Bryophyte:	0	0%

Duration Metrics:

Annual:	4	4.30%
Perennial:	79	84.90%
Biennial:	10	10.80%
Native Annual:	4	4.30%
Native Perennial:	65	69.90%
Native Biennial:	4	4.30%

Appendix 3.10. Poverty Island Boreal Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Abies balsamea</i>	balsam fir	ABIBAL	native	3	0
<i>Acer spicatum</i>	mountain maple	ACESPI	native	5	3
<i>Agrostis hyemalis</i>	ticklegrass	AGRHYE	native	4	0
<i>Amelanchier sanguinea</i>	round-leaved serviceberry	AMESAN	native	5	5
<i>Anaphalis margaritacea</i>	pearly everlasting	ANAMAR	native	3	5
<i>Anticlea elegans; Zigadenus glaucus</i>	white camas	ANTELE	native	10	-3
<i>Apocynum androsaemifolium</i>	spreading dogbane	APOAND	native	3	5
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Asclepias syriaca</i>	common milkweed	ASCSYR	native	1	5
<i>Betula papyrifera</i>	paper birch	BETPAP	native	2	3
<i>Boechera stricta</i>	drummond rock cress	BOESTR	native	6	3
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	6	3
<i>Carex arctata</i>	sedge	CXARTT	native	3	5
<i>Carex bebbii</i>	sedge	CXBEBB	native	4	-5
<i>Carex deweyana</i>	sedge	CXDEWE	native	3	3
<i>Carex eburnea</i>	sedge	CXEBUR	native	7	3
<i>Carex granularis</i>	sedge	CXGRAN	native	2	-3
<i>Carex hystericina</i>	sedge	CXHYST	native	2	-5
<i>Carex pedunculata</i>	sedge	CXPEDU	native	5	3
<i>Chamaenerion angustifolium</i>	fireweed	CHAANG	native	3	0
<i>Cinna latifolia</i>	wood reedgrass	CINLAT	native	5	-3
<i>Circaea alpina</i>	small enchanters-nightshade	CIRALP	native	4	-3
<i>Cirsium arvense</i>	canada thistle	CIRARV	non-native	0	3
<i>Cirsium palustre</i>	marsh thistle	CIRPAL	non-native	0	-3
<i>Cirsium vulgare</i>	bull thistle	CIRVUL	non-native	0	3
<i>Clinopodium arkansanum</i>	limestone calamint	CLIARK	native	10	-3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Cornus sericea; c. stolonifera</i>	red-osier	CORSER	native	2	-3
<i>Cynoglossum officinale</i>	hounds-tongue	CYNOFF	non-native	0	5
<i>Diervilla lonicera</i>	bush-honeysuckle	DIELON	native	4	5
<i>Dryopteris intermedia</i>	evergreen woodfern	DRYINT	native	5	0
<i>Elymus trachycaulus</i>	slender wheatgrass	ELYTRA	native	8	3
<i>Epilobium strictum</i>	downy willow-herb	EPISTR	native	8	-5
<i>Epipactis helleborine</i>	helleborine	EPIHEL	non-native	0	0
<i>Equisetum arvense</i>	common horsetail	EQUARV	native	0	0
<i>Erigeron annuus</i>	daisy fleabane	ERIANN	native	0	3
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	2	3
<i>Galium tinctorium</i>	stiff bedstraw	GALTIN	native	5	-5
<i>Geranium robertianum</i>	herb robert	GERROB	native	3	3
<i>Glyceria striata</i>	fowl manna grass	GLYSTR	native	4	-5
<i>Gymnocarpium dryopteris</i>	oak fern	GYMDRY	native	5	3
<i>Hackelia deflexa</i>	stickseed	HACDEF	native	2	5
<i>Hieracium aurantiacum</i>	orange hawkweed	HIEAUR	non-native	0	5
<i>Hieracium caespitosum</i>	king devil	HIECAE	non-native	0	5
<i>Impatiens capensis</i>	spotted touch-me-not	IMPCAP	native	2	-3
<i>Juniperus horizontalis</i>	creeping juniper	JUNHOR	native	10	3

Appendix 3.10. Poverty Island Boreal Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Lactuca canadensis</i>	tall lettuce	LACCAN	native	2	3
<i>Leucanthemum vulgare</i>	ox-eye daisy	LEUVUL	non-native	0	5
<i>Lilium philadelphicum</i>	wood lily	LILPHI	native	7	0
<i>Lonicera dioica</i>	red honeysuckle	LONDIO	native	5	3
<i>Lonicera</i> Ã— <i>bellâ</i>	hybrid honeysuckle	LONBEL	non-native	0	3
<i>Melampyrum lineare</i>	cow-wheat	MELLIN	native	6	3
<i>Melilotus albus</i>	white sweet-clover	MELALB	non-native	0	3
<i>Nepeta cataria</i>	catnip	NEPCAT	non-native	0	3
<i>Phragmites australis</i> var. <i>australis</i>	reed	PHRAUU	non-native	0	-3
<i>Picea abies</i>	norway spruce	PICABI	non-native	0	5
<i>Picea glauca</i>	white spruce	PICGLA	native	3	3
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Poa pratensis</i>	kentucky bluegrass	POAPRA	non-native	0	3
<i>Polygala paucifolia</i>	gay-wings	POLPAU	native	7	3
<i>Populus balsamifera</i>	balsam poplar	POPBAL	native	2	-3
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	0
<i>Potentilla norvegica</i>	rough cinquefoil	POTNOR	native	0	0
<i>Prunella vulgaris</i>	self-heal	PRUVUL	native	0	0
<i>Prunus pensylvanica</i>	pin cherry	PRUPEN	native	3	3
<i>Prunus virginiana</i>	choke cherry	PRUVIR	native	2	3
<i>Pteridium aquilinum</i>	bracken fern	PTEAQU	native	0	3
<i>Rhus typhina</i>	staghorn sumac	RHUTYP	native	2	3
<i>Ribes glandulosum</i>	skunk currant	RIBGLA	native	5	-3
<i>Rubus occidentalis</i>	black raspberry	RUBOCC	native	1	5
<i>Rubus strigosus</i>	wild red raspberry	RUBSTR	native	2	0
<i>Rudbeckia hirta</i>	black-eyed susan	RUDHIR	native	1	3
<i>Salix bebbiana</i>	bebb's willow	SALBEB	native	1	-3
<i>Salix eriocephala</i>	willow	SALERI	native	2	-3
<i>Sambucus racemosa</i>	red-berried elder	SAMRAC	native	3	3
<i>Sedum acre</i>	mossy stonecrop	SEDACR	non-native	0	5
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Solidago altissima</i>	tall goldenrod	SOLALT	native	1	3
<i>Solidago hispida</i>	hairy goldenrod	SOLHIS	native	3	5
<i>Solidago rugosa</i>	rough-leaved goldenrod	SOLRUG	native	3	0
<i>Solidago simplex</i>	gillmans goldenrod	SOLSIM	native	10	3
<i>Sorbus decora</i>	mountain-ash	SORDEC	native	4	3
<i>Sphenopholis intermedia</i>	slender wedgegrass	SPHINT	native	4	0
<i>Spinulum annotinum</i> ;	stiff clubmoss	SPIANN	native	5	0
<i>Symphoricarpos albus</i> var. <i>albus</i>	snowberry	SYMALA	native	5	3
<i>Symphyotrichum pilosum</i>	hairy aster	SYMPIL	native	1	3
<i>Taraxacum officinale</i>	common dandelion	TAROFF	non-native	0	3
<i>Taxus canadensis</i>	yew	TAXCAN	native	5	3
<i>Thuja occidentalis</i>	arbor vitae	THUOCC	native	4	-3
<i>Tragopogon pratensis</i>	common goats beard	TRAPRA	non-native	0	5
<i>Trientalis borealis</i>	star-flower	TRIBOR	native	5	0
<i>Urtica dioica</i>	stinging nettle	URTDIO	native	1	0
<i>Verbascum thapsus</i>	common mullein	VERTHA	non-native	0	5

Appendix 3.11. Poverty Island Limestone Bedrock Lakeshore FQA

Conservatism-Based Metrics:

Total Mean C:	3.6
Native Mean C:	4.4
Total FQI:	38.3
Native FQI:	42.2
Adjusted FQI:	39.7
% C value 0:	21.2
% C value 1-3:	33.6
% C value 4-6:	29.2
% C value 7-10:	15.9
Native Tree Mean C:	3
Native Shrub Mean C:	5
Native Herbaceous Mean C:	4.4

Species Richness:

Total Species:	113	
Native Species:	92	81.40%
Non-native Species:	21	18.60%

Species Wetness:

Mean Wetness:	-0.6
Native Mean Wetness:	-1.2

Physiognomy Metrics:

Tree:	6	5.30%
Shrub:	11	9.70%
Vine:	3	2.70%
Forb:	66	58.40%
Grass:	12	10.60%
Sedge:	8	7.10%
Rush:	5	4.40%
Fern:	2	1.80%
Bryophyte:	0	0%

Duration Metrics:

Annual:	14	12.40%
Perennial:	92	81.40%
Biennial:	7	6.20%
Native Annual:	9	8%
Native Perennial:	79	69.90%
Native Biennial:	4	3.50%

Appendix 3.11. Poverty Island Limestone Bedrock Lakeshore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Abies balsamea</i>	balsam fir	ABIBAL	native	3	0
<i>Acer spicatum</i>	mountain maple	ACESPI	native	5	3
<i>Agrostis gigantea</i>	redtop	AGRGIG	non-native	0	-3
<i>Agrostis hyemalis</i>	ticklegass	AGRHYE	native	4	0
<i>Anticlea elegans</i>	white camas	ANTELE	native	10	-3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Arabis pycnocarpa</i>	hairy rock cress	ARAPYC	native	6	3
<i>Bidens cernua</i>	nodding beggar-ticks	BIDCER	native	3	-5
<i>Calamagrostis canadensis</i>	blue-joint	CALCAN	native	3	-5
<i>Calamagrostis stricta</i>	narrow-leaved reedgrass	CALSTR	native	10	-3
<i>Campanula aparinoides</i>	marsh bellflower	CAMAPA	native	7	-5
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	6	3
<i>Carex aquatilis</i>	sedge	CXAQUA	native	7	-5
<i>Carex aurea</i>	sedge	CXAURE	native	3	-3
<i>Carex bebbii</i>	sedge	CXBEBB	native	4	-5
<i>Carex eburnea</i>	sedge	CXEBUR	native	7	3
<i>Carex hystericina</i>	sedge	CXHYST	native	2	-5
<i>Carex leptalea</i>	sedge	CXLEPA	native	5	-5
<i>Carex viridula</i>	sedge	CXVIRU	native	4	-5
<i>Centaurea stoebe</i>; <i>c. maculosa</i>	spotted knapweed	CENSTO	non-native	0	5
<i>Cerastium fontanum</i>	mouse-ear chickweed	CERFON	non-native	0	3
<i>Chamaenerion angustifolium</i>	fireweed	CHAANG	native	3	0
<i>Cicuta bulbifera</i>	water hemlock	CICBUL	native	5	-5
<i>Cirsium arvense</i>	canada thistle	CIRARV	non-native	0	3
<i>Cirsium vulgare</i>	bull thistle	CIRVUL	non-native	0	3
<i>Clinopodium arkansanum</i>	limestone calamint	CLIARK	native	10	-3
<i>Conyza canadensis</i>	horseweed	CONCAN	native	0	3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Cornus sericea</i> ; <i>c. stolonifera</i>	red-osier	CORSER	native	2	-3
<i>Corydalis aurea</i>	golden corydalis	CORAUR	native	5	5
<i>Cynoglossum officinale</i>	hounds-tongue	CYNOFF	non-native	0	5
<i>Dasiphora fruticosa</i>	shrubby cinquefoil	DASFRU	native	8	-3
<i>Deschampsia cespitosa</i>	hair grass	DESCES	native	9	-3
<i>Dichanthelium implicatum</i>	panic grass	DICIMP	native	3	0
<i>Dichanthelium lindheimeri</i>	panic grass	DICLID	native	8	-5
<i>Eleocharis elliptica</i>	golden-seeded spike rush	ELEELL	native	6	-5
<i>Elymus trachycaulus</i>	slender wheatgrass	ELYTRA	native	8	3
<i>Epilobium ciliatum</i>	willow-herb	EPICIL	native	3	-3
<i>Epilobium parviflorum</i>	willow-herb	EPIPAR	non-native	0	-5
<i>Epilobium strictum</i>	downy willow-herb	EPISTR	native	8	-5
<i>Epipactis helleborine</i>	helleborine	EPIHEL	non-native	0	0
<i>Equisetum variegatum</i>	variegated scouring rush	EQUVAR	native	6	-3
<i>Erysimum cheiranthoides</i>	wormseed mustard	ERYCHE	non-native	0	3
<i>Euthamia graminifolia</i>	grass-leaved goldenrod	EUTGRA	native	3	0
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	2	3
<i>Fraxinus pennsylvanica</i>	red ash	FRAPEN	native	2	-3

Appendix 3.11. Poverty Island Limestone Bedrock Lakeshore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Galeopsis tetrahit</i>	hemp-nettle	GALTET	non-native	0	3
<i>Geranium robertianum</i>	herb robert	GERROB	native	3	3
<i>Hieracium aurantiacum</i>	orange hawkweed	HIEAUR	non-native	0	5
<i>Hieracium kalmii</i>	kalms hawkweed	HIEKAL	native	3	5
<i>Hypericum kalmianum</i>	kalms st. johns-wort	HYPKAL	native	10	-3
<i>Impatiens capensis</i>	spotted touch-me-not	IMPCAP	native	2	-3
<i>Iris versicolor</i>	wild blue flag	IRIVER	native	5	-5
<i>Juncus alpinoarticulatus</i>	rush	JUNALP	native	5	-5
<i>Juncus balticus</i>	rush	JUNBAL	native	4	-5
<i>Juncus canadensis</i>	canadian rush	JUNCAN	native	6	-5
<i>Juncus dudleyi</i>	dudleys rush	JUNDUD	native	1	-3
<i>Juncus tenuis</i>	path rush	JUNTEN	native	1	0
<i>Juniperus horizontalis</i>	creeping juniper	JUNHOR	native	10	3
<i>Lactuca canadensis</i>	tall lettuce	LACCAN	native	2	3
<i>Leucanthemum vulgare</i>	ox-eye daisy	LEUVUL	non-native	0	5
<i>Lobelia kalmii</i>	bog lobelia	LOBKAL	native	10	-5
<i>Lycopus americanus</i>	common water horehound	LYCAME	native	2	-5
<i>Lycopus uniflorus</i>	northern bugle weed	LYCUNI	native	2	-5
<i>Lysimachia ciliata</i>	fringed loosestrife	LYSCIL	native	4	-3
<i>Lysimachia thyrsoiflora</i>	tufted loosestrife	LYSTHY	native	6	-5
<i>Maianthemum stellatum</i>	starry false solomon-seal	MAISTE	native	5	0
<i>Medicago lupulina</i>	black medick	MEDLUP	non-native	0	3
<i>Melampyrum lineare</i>	cow-wheat	MELLIN	native	6	3
<i>Mentha canadensis</i>	wild mint	MENCAS	native	3	-3
<i>Nepeta cataria</i>	catnip	NEPCAT	non-native	0	3
<i>Packera paupercula</i>	balsam ragwort	PACPAU	native	3	0
<i>Panicum miliaceum</i>	broomcorn millet	PANMIL	non-native	0	5
<i>Persicaria maculosa</i>	lady's-thumb	PERMAC	non-native	0	0
<i>Persicaria punctata</i>	smartweed	PERPUN	native	5	-5
<i>Phalaris arundinacea</i>	reed canary grass	PHAARU	native	0	-3
<i>Physocarpus opulifolius</i>	ninebark	PHYOPU	native	4	-3
<i>Picea glauca</i>	white spruce	PICGLA	native	3	3
<i>Pilea pumila</i>	clearweed	PILPUM	native	5	-3
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Polygonum ramosissimum</i>	bushy knotweed	POLRAM	native	7	0
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	0
<i>Potentilla anserina</i>	silverweed	POTANS	native	5	-3
<i>Prunella vulgaris</i>	self-heal	PRUVUL	native	0	0
<i>Rorippa palustris</i>	yellow cress	RORPAL	native	1	-5
<i>Rosa acicularis</i>	wild rose	ROSACI	native	4	3
<i>Rubus strigosus</i>	wild red raspberry	RUBSTR	native	2	0
<i>Rudbeckia hirta</i>	black-eyed susan	RUDHIR	native	1	3
<i>Salix petiolaris</i>	slender willow	SALPET	native	1	-3
<i>Sambucus racemosa</i>	red-berried elder	SAMRAC	native	3	3
<i>Sedum acre</i>	mossy stonecrop	SEDACR	non-native	0	5
<i>Selaginella eclipes</i>	selaginella	SELECL	native	5	-3

Appendix 3.11. Poverty Island Limestone Bedrock Lakeshore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Solidago altissima</i>	tall goldenrod	SOLALT	native	1	3
<i>Solidago gigantea</i>	late goldenrod	SOLGIG	native	3	-3
<i>Solidago hispida</i>	hairy goldenrod	SOLHIS	native	3	5
<i>Solidago juncea</i>	early goldenrod	SOLJUN	native	3	5
<i>Solidago ohioensis</i>	ohio goldenrod	SOLOHI	native	8	-5
<i>Solidago simplex</i>	gillmans goldenrod	SOLSIM	native	10	3
<i>Solidago uliginosa</i>	bog goldenrod	SOLULI	native	4	-5
<i>Sphenopholis intermedia</i>	slender wedgegrass	SPHINT	native	4	0
<i>Stuckenia pectinata</i>	sago pondweed	STUPEC	native	3	-5
<i>Symphoricarpos albus</i> var. <i>albus</i>	snowberry	SYMALA	native	5	3
<i>Symphyotrichum lanceolatum</i>	panicked aster	SYMLAN	native	2	-3
<i>Symphyotrichum pilosum</i>	hairy aster	SYMPIL	native	1	3
<i>Taraxacum officinale</i>	common dandelion	TAROFF	non-native	0	3
<i>Thuja occidentalis</i>	arbor vitae	THUOCC	native	4	-3
<i>Toxicodendron radicans</i>	poison-ivy	TOXRAD	native	2	0
<i>Turritis glabra</i> ; <i>arabis</i> g.	tower mustard	TURGLA	native	3	5
<i>Typha angustifolia</i>	narrow-leaved cat-tail	TYPANG	non-native	0	-5
<i>Veronica anagallis-aquatica</i>	water speedwell	VERANA	native	4	-5
<i>Vicia americana</i>	american vetch	VICAME	native	5	3
<i>Viola nephrophylla</i>	northern bog violet	VIONEP	native	8	-3

Appendix 3.12. Poverty Island Limestone Lakeshore Cliff FQA

Conservatism-Based Metrics:

Total Mean C:	3.6
Native Mean C:	4.4
Total FQI:	29.5
Native FQI:	32.6
Adjusted FQI:	39.9
% C value 0:	20.9
% C value 1-3:	31.3
% C value 4-6:	28.4
% C value 7-10:	19.4
Native Tree Mean C:	3.1
Native Shrub Mean C:	4.8
Native Herbaceous Mean C:	4.6

Species Richness:

Total Species:	67
Native Species:	55 82.10%
Non-native Species:	12 17.90%

Species Wetness:

Mean Wetness:	1.9
Native Mean Wetness:	1.6

Physiognomy Metrics:

Tree:	8	11.90%
Shrub:	11	16.40%
Vine:	3	4.50%
Forb:	36	53.70%
Grass:	5	7.50%
Sedge:	1	1.50%
Rush:	0	0%
Fern:	3	4.50%
Bryophyte:	0	0%

Duration Metrics:

Annual:	4	6%
Perennial:	55	82.10%
Biennial:	8	11.90%
Native Annual:	3	4.50%
Native Perennial:	47	70.10%
Native Biennial:	5	7.50%

Appendix 3.12. Poverty Island Limestone Lakeshore Cliff FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Abies balsamea</i>	balsam fir	ABIBAL	native	3	0
<i>Acer spicatum</i>	mountain maple	ACESPI	native	5	3
<i>Achillea millefolium</i>	yarrow	ACHMIL	native	1	3
<i>Adlumia fungosa</i>	climbing fumitory	ADLFUN	native	4	5
<i>Agrimonia gryposepala</i>	tall agrimony	AGRGRY	native	2	3
<i>Agrostis hyemalis</i>	ticklegrass	AGRHYE	native	4	0
<i>Amelanchier sanguinea</i>	round-leaved serviceberry	AMESAN	native	5	5
<i>Anticlea elegans; zigadenus glaucus</i>	white camas	ANTELE	native	10	-3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Arabidopsis lyrata; arabis l.</i>	sand cress	ARALYR	native	7	3
<i>Betula papyrifera</i>	paper birch	BETPAP	native	2	3
<i>Campanula aparinoides</i>	marsh bellflower	CAMAPA	native	7	-5
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	6	3
<i>Carex eburnea</i>	sedge	CXEBUR	native	7	3
<i>Cerastium fontanum</i>	mouse-ear chickweed	CERFON	non-native	0	3
<i>Chamerion angustifolium; epilobium a.</i>	fireweed	CHAANG	native	3	0
<i>Cirsium palustre</i>	marsh thistle	CIRPAL	non-native	0	-3
<i>Cirsium vulgare</i>	bull thistle	CIRVUL	non-native	0	3
<i>Conyza canadensis</i>	horseweed	CONCAN	native	0	3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Cornus sericea; c. stolonifera</i>	red-osier	CORSER	native	2	-3
<i>Cynoglossum officinale</i>	hounds-tongue	CYNOFF	non-native	0	5
<i>Cystopteris laurentiana</i>	laurentian fragile fern	CYSLAU	native	9	5
<i>Cystopteris tenuis</i>	fragile fern	CYSTEN	native	5	5
<i>Dasiphora fruticosa; potentilla f.</i>	shrubby cinquefoil	DASFRU	native	8	-3
<i>Deschampsia cespitosa</i>	hair grass	DESCES	native	9	-3
<i>Diervilla lonicera</i>	bush-honeysuckle	DIELON	native	4	5
<i>Elymus trachycaulus; agropyron t.</i>	slender wheatgrass	ELYTRA	native	8	3
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	2	3
<i>Galeopsis tetrahit</i>	hemp-nettle	GALTET	non-native	0	3
<i>Hackelia deflexa</i>	stickseed	HACDEF	native	2	5
<i>Hieracium caespitosum</i>	king devil	HIECAE	non-native	0	5
<i>Impatiens capensis</i>	spotted touch-me-not	IMPCAP	native	2	-3
<i>Juniperus horizontalis</i>	creeping juniper	JUNHOR	native	10	3
<i>Krigia biflora</i>	false dandelion	KRIBIF	native	5	3
<i>Lactuca canadensis</i>	tall lettuce	LACCAN	native	2	3
<i>Leucanthemum vulgare</i>	ox-eye daisy	LEUVUL	non-native	0	5
<i>Lilium philadelphicum</i>	wood lily	LILPHI	native	7	0
<i>Lonicera dioica</i>	red honeysuckle	LONDIO	native	5	3
<i>Maianthemum stellatum; smilacina s.</i>	starry false solomon-seal	MAISTE	native	5	0
<i>Nepeta cataria</i>	catnip	NEPCAT	non-native	0	3
<i>Packera paupercula; senecio p.; senecio plattensis</i>	balsam ragwort	PACPAU	native	3	0
<i>Physocarpus opulifolius</i>	ninebark	PHYOPU	native	4	-3
<i>Picea glauca</i>	white spruce	PICGLA	native	3	3
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Polypodium virginianum</i>	common polypody	POLVIR	native	8	5

Appendix 3.12. Poverty Island Limestone Lakeshore Cliff FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	0
<i>Potentilla anserina</i>	silverweed	POTANS	native	5	-3
<i>Potentilla norvegica</i>	rough cinquefoil	POTNOR	native	0	0
<i>Prunus pensylvanica</i>	pin cherry	PRUPEN	native	3	3
<i>Ribes cynosbati</i>	prickly or wild gooseberry	RIBCYN	native	4	3
<i>Rubus strigosus</i>	wild red raspberry	RUBSTR	native	2	0
<i>Sambucus racemosa</i>	red-berried elder	SAMRAC	native	3	3
<i>Sedum acre</i>	mossy stonecrop	SEDACR	non-native	0	5
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Solidago altissima</i>	tall goldenrod	SOLALT	native	1	3
<i>Solidago hispida</i>	hairy goldenrod	SOLHIS	native	3	5
<i>Solidago simplex</i>	gillmans goldenrod	SOLSIM	native	10	3
<i>Sorbus decora</i>	mountain-ash	SORDEC	native	4	3
<i>Sphenopholis intermedia</i>	slender wedgrass	SPHINT	native	4	0
<i>Symphyotrichum pilosum; aster p.</i>	hairy aster	SYMPIL	native	1	3
<i>Taraxacum officinale</i>	common dandelion	TAROFF	non-native	0	3
<i>Taxus canadensis</i>	yew	TAXCAN	native	5	3
<i>Thuja occidentalis</i>	arbor vitae	THUOCC	native	4	-3
<i>Turritis glabra; arabis g.</i>	tower mustard	TURGLA	native	3	5
<i>Urtica dioica</i>	stinging nettle	URTDIO	native	1	0
<i>Viola nephrophylla</i>	northern bog violet	VIONEP	native	8	-3

Appendix 3.13. Rocky Island Limestone Cobble Shore FQA

Conservatism-Based Metrics:

Total Mean C:	1.8
Native Mean C:	3.4
Total FQI:	10
Native FQI:	13.6
Adjusted FQI:	24.4
% C value 0:	54.8
% C value 1-3:	22.6
% C value 4-6:	16.1
% C value 7-10:	6.5
Native Tree Mean C:	2.7
Native Shrub Mean C:	4.5
Native Herbaceous Mean C:	2.9

Species Richness:

Total Species:	31	
Native Species:	16	51.60%
Non-native Species:	15	48.40%

Species Wetness:

Mean Wetness:	0.4
Native Mean Wetness:	-1.4

Physiognomy Metrics:

Tree:	3	10%
Shrub:	6	19%
Vine:	1	3.20%
Forb:	20	64.50%
Grass:	1	3.20%
Sedge:	0	0%
Rush:	0	0%
Fern:	0	0%
Bryophyte:	0	0%

Duration Metrics:

Annual:	6	19%
Perennial:	18	58.10%
Biennial:	7	22.60%
Native Ann:	4	12.90%
Native Per:	12	39%
Native Bie:	0	0%

Appendix 3.13. Rocky Island Limestone Cobble Shore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Arctium minus</i>	common burdock	ARCMIN	non-native	0	3
<i>Barbarea vulgaris</i>	yellow rocket	BARVUL	non-native	0	0
<i>Betula papyrifera</i>	paper birch	BETPAP	native	2	3
<i>Chenopodium album</i>	lambs-quarters	CHEALB	non-native	0	3
<i>Cirsium palustre</i>	marsh thistle	CIRPAL	non-native	0	-3
<i>Cirsium vulgare</i>	bull thistle	CIRVUL	non-native	0	3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Cornus sericea; c. stolonifera</i>	red-osier	CORSER	native	2	-3
<i>Cynoglossum officinale</i>	hounds-tongue	CYNOFF	non-native	0	5
<i>Fraxinus pennsylvanica</i>	red ash	FRAPEN	native	2	-3
<i>Impatiens capensis</i>	spotted touch-me-not	IMPCAP	native	2	-3
<i>Lithospermum officinale</i>	gromwell	LITOFF	non-native	0	5
<i>Lotus corniculatus</i>	birdfoot trefoil	LOTCOR	non-native	0	3
<i>Melilotus albus</i>	white sweet-clover	MELALB	non-native	0	3
<i>Nepeta cataria</i>	catnip	NEPCAT	non-native	0	3
<i>Pastinaca sativa</i>	wild parsnip	PASSAT	non-native	0	5
<i>Persicaria lapathifolia; polygonum l.</i>	nodding smartweed	PERLAP	native	0	-3
<i>Persicaria maculosa; polygonum persicaria</i>	ladys-thumb	PERMAC	non-native	0	0
<i>Persicaria punctata; polygonum p.</i>	smartweed	PERPUN	native	5	-5
<i>Phalaris arundinacea</i>	reed canary grass	PHAARU	native	0	-3
<i>Polygonum ramosissimum</i>	bushy knotweed	POLRAM	native	7	0
<i>Potentilla anserina</i>	silverweed	POTANS	native	5	-3
<i>Prunus virginiana</i>	choke cherry	PRUVIR	native	2	3
<i>Ribes triste</i>	swamp red currant	RIBTRI	native	6	-5
<i>Rumex crispus</i>	curly dock	RUMCRI	non-native	0	0
<i>Salix bebbiana</i>	bebb's willow	SALBEB	native	1	-3
<i>Salix cordata</i>	sand-dune willow	SALCOR	native	10	0
<i>Sedum acre</i>	moosy stonecrop	SEDACR	non-native	0	5
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Thuja occidentalis</i>	arbor vitae	THUOCC	native	4	-3
<i>Urtica dioica</i>	stinging nettle	URTDIO	native	1	0

Appendix 3.14. Saint Martin Island Boreal Forest FQA

Conservatism-Based Metrics:

Total Mean C:	4.3
Native Mean C:	5.1
Total FQI:	36.5
Native FQI:	39.8
Adjusted FQI:	46.9
% C value 0:	16.7
% C value 1-3:	12.5
% C value 4-6:	55.6
% C value 7-10:	15.3
Native Tree Mean C:	3.3
Native Shrub Mean C:	5
Native Herbaceous Mean C:	5.6

Species Richness:

Total Species:	72	
Native Species:	61	84.70%
Non-native Species:	11	15.30%

Species Wetness:

Mean Wetness:	1.8
Native Mean Wetness:	1.6

Physiognomy Metrics:

Tree:	10	13.90%
Shrub:	11	15.30%
Vine:	3	4.20%
Forb:	43	59.70%
Grass:	2	2.80%
Sedge:	1	1.40%
Rush:	0	0%
Fern:	2	2.80%
Bryophyte:	0	0%

Duration Metrics:

Annual:	2	2.80%
Perennial:	65	90.30%
Biennial:	5	6.90%
Native Annual:	2	2.80%
Native Perennial:	57	79.20%
Native Biennial:	2	2.80%

Appendix 3.14. Saint Martin Island Boreal Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Abies balsamea</i>	balsam fir	ABIBAL	native	3	0
<i>Acer saccharum</i>	sugar maple	ACESAU	native	5	3
<i>Acer spicatum</i>	mountain maple	ACESPI	native	5	3
<i>Actaea pachypoda</i>	dolls-eyes	ACTPAC	native	7	5
<i>Amelanchier laevis</i>	smooth shadbush	AMELAE	native	4	5
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Arabis pycnocarpa</i> ; <i>a. hirsuta</i>	hairy rock cress	ARAPYC	native	6	3
<i>Aralia nudicaulis</i>	wild sarsaparilla	ARANUD	native	5	3
<i>Arctostaphylos uva-ursi</i>	bearberry	ARCUVA	native	8	5
<i>Betula papyrifera</i>	paper birch	BETPAP	native	2	3
<i>Boechera stricta</i> ; <i>arabis drummondii</i>	drummond rock cress	BOESTR	native	6	3
<i>Botrypus virginianus</i>	rattlesnake fern	BOTVIR	native	5	3
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	6	3
<i>Carex eburnea</i>	sedge	CXEBUR	native	7	3
<i>Cirsium arvense</i>	canada thistle	CIRARV	non-native	0	3
<i>Cirsium palustre</i>	marsh thistle	CIRPAL	non-native	0	-3
<i>Clintonia borealis</i>	bluebead-lily; corn-lily	CLIBOR	native	5	0
<i>Corallorhiza striata</i>	striped coral-root	CORSTR	native	6	3
<i>Corallorhiza trifida</i>	early coral-root	CORTRF	native	6	-3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Corylus cornuta</i>	beaked hazelnut	CORCOR	native	5	3
<i>Cynoglossum officinale</i>	hounds-tongue	CYNOFF	non-native	0	5
<i>Cypripedium acaule</i>	pink lady-slipper; moccasin flower	CYPACA	native	5	-3
<i>Cypripedium arietinum</i>	rams head lady-slipper	CYPARI	native	10	-3
<i>Diervilla lonicera</i>	bush-honeysuckle	DIELON	native	4	5
<i>Dryopteris intermedia</i>	evergreen woodfern	DRYINT	native	5	0
<i>Epipactis helleborine</i>	helleborine	EPIHEL	non-native	0	0
<i>Eurybia macrophylla</i> ; <i>aster m.</i>	big-leaved aster	EURMAC	native	4	5
<i>Fraxinus pennsylvanica</i>	red ash	FRAPEN	native	2	-3
<i>Galium triflorum</i>	fragrant bedstraw	GALTRR	native	4	3
<i>Geranium robertianum</i>	herb robert	GERROB	native	3	3
<i>Halenia deflexa</i>	spurred gentian	HALDEF	native	7	0
<i>Hepatica acutiloba</i>	sharp-lobed hepatica	HEPACU	native	8	5
<i>Heracleum maximum</i>	cow-parsnip	HERMAX	native	3	-3
<i>Hieracium aurantiacum</i>	orange hawkweed	HIEAUR	non-native	0	5
<i>Iris lacustris</i>	dwarf lake iris	IRILAC	native	9	0
<i>Linnaea borealis</i>	twinflower	LINBOR	native	6	0
<i>Lonicera canadensis</i>	canadian fly honeysuckle	LONCAN	native	5	3
<i>Lonicera dioica</i>	red honeysuckle	LONDIO	native	5	3
<i>Lonicera hirsuta</i>	hairy honeysuckle	LONHIR	native	6	0
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	4	3
<i>Maianthemum racemosum</i> ; <i>smilacina r.</i>	false spikenard	MAIRAC	native	5	3
<i>Osmorhiza claytonii</i>	hairy sweet-cicely	OSMCLI	native	4	3
<i>Oxypolis rigidior</i>	cowbane	OXYRIG	native	6	-5
<i>Pastinaca sativa</i>	wild parsnip	PASSAT	non-native	0	5
<i>Petasites frigidus</i> ; <i>p. palmatus</i>	sweet-coltsfoot	PETFRI	native	10	-3

Appendix 3.14. Saint Martin Island Boreal Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Phleum pratense</i>	timothy	PHLPRA	non-native	0	3
<i>Physocarpus opulifolius</i>	ninebark	PHYOPU	native	4	-3
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Polygala paucifolia</i>	gay-wings	POLPAU	native	7	3
<i>Polygonatum pubescens</i>	downy solomon seal	POLPUB	native	5	5
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	0
<i>Prenanthes alba</i>	white lettuce	PREALB	native	5	3
<i>Prunus pensylvanica</i>	pin cherry	PRUPEN	native	3	3
<i>Prunus virginiana</i>	choke cherry	PRUVIR	native	2	3
<i>Pyrola americana</i> ; <i>p. rotundifolia</i>	round-leaved pyrola	PYRAME	native	7	0
<i>Ranunculus abortivus</i>	small-flowered buttercup	RANABO	native	0	0
<i>Ribes lacustre</i>	swamp black currant	RIBLAC	native	6	-3
<i>Sambucus racemosa</i>	red-berried elder	SAMRAC	native	3	3
<i>Shepherdia canadensis</i>	soapberry	SHECAN	native	7	5
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Solidago flexicaulis</i>	zigzag goldenrod	SOLFLE	native	6	3
<i>Sorbus decora</i>	mountain-ash	SORDEC	native	4	3
<i>Streptopus lanceolatus</i> ; <i>s. roseus</i>	rose twisted-stalk	STRLAN	native	5	3
<i>Taxus canadensis</i>	yew	TAXCAN	native	5	3
<i>Thuja occidentalis</i>	arbor vitae	THUOCC	native	4	-3
<i>Trientalis borealis</i>	star-flower	TRIBOR	native	5	0
<i>Trifolium pratense</i>	red clover	TRIPRA	non-native	0	3
<i>Trillium grandiflorum</i>	common trillium	TRIGRA	native	5	3
<i>Veronica officinalis</i>	common speedwell	VEROOF	non-native	0	3
<i>Viola pubescens</i>	yellow violet	VIOPUB	native	4	3
<i>Viola renifolia</i>	kidney-leaved violet	VIOREN	native	6	-3

Appendix 3.15. Saint Martin Island Limestone Cliff FQA

Conservatism-Based Metrics:

Total Mean C:	4.5
Native Mean C:	4.8
Total FQI:	28.1
Native FQI:	29.2
Adjusted FQI:	46.8
% C value 0:	5.1
% C value 1-3:	28.2
% C value 4-6:	51.3
% C value 7-10:	15.4
Native Tree Mean C:	3.6
Native Shrub Mean C:	4.1
Native Herbaceous Mean C:	5.6

Species Richness:

Total Species:	39	
Native Species:	37	94.90%
Non-native Species:	2	5.10%

Species Wetness:

Mean Wetness:	2.5
Native Mean Wetness:	2.5

Physiognomy Metrics:

Tree:	9	23.10%
Shrub:	9	23.10%
Vine:	2	5.10%
Forb:	10	25.60%
Grass:	2	5.10%
Sedge:	2	5.10%
Rush:	0	0%
Fern:	5	12.80%
Bryophyte:	0	0%

Duration Metrics:

Annual:	1	2.60%
Perennial:	36	92.30%
Biennial:	2	5.10%
Native Annual:	1	2.60%
Native Perennial:	34	87.20%
Native Biennial:	2	5.10%

Appendix 3.15. Saint Martin Island Limestone Cliff FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Abies balsamea</i>	balsam fir	ABIBAL	native	3	0
<i>Acer saccharum</i>	sugar maple	ACESAU	native	5	3
<i>Acer spicatum</i>	mountain maple	ACESPI	native	5	3
<i>Adlumia fungosa</i>	climbing fumitory	ADLFUN	native	4	5
<i>Amelanchier laevis</i>	smooth shadbush	AMELAE	native	4	5
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Arctostaphylos uva-ursi</i>	bearberry	ARCUVA	native	8	5
<i>Betula papyrifera</i>	paper birch	BETPAP	native	2	3
<i>Boechera stricta; arabis drummondii</i>	drummond rock cress	BOESTR	native	6	3
<i>Carex deweyana</i>	sedge	CXDEWE	native	3	3
<i>Carex pedunculata</i>	sedge	CXPEDU	native	5	3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Cryptogramma stelleri</i>	slender rock-brake	CRYSTE	native	10	3
<i>Cystopteris laurentiana</i>	laurentian fragile fern	CYSLAU	native	9	5
<i>Diervilla lonicera</i>	bush-honeysuckle	DIELON	native	4	5
<i>Draba arabisans</i>	rock whitlow-grass	DRAARA	native	10	5
<i>Dryopteris carthusiana</i>	spinulose woodfern	DRYCAR	native	5	-3
<i>Dryopteris intermedia</i>	evergreen woodfern	DRYINT	native	5	0
<i>Fagus grandifolia</i>	american beech	FAGGRA	native	6	3
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	2	3
<i>Geranium robertianum</i>	herb robert	GERROB	native	3	3
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	4	3
<i>Maianthemum racemosum</i>	false spikenard	MAIRAC	native	5	3
<i>Milium effusum</i>	wood millet	MILEFF	native	8	3
<i>Poa nemoralis</i>	bluegrass	POANEM	non-native	0	3
<i>Polygonatum pubescens</i>	downy solomon seal	POLPUB	native	5	5
<i>Polypodium virginianum</i>	common polypody	POLVIR	native	8	5
<i>Populus balsamifera</i>	balsam poplar	POPBAL	native	2	-3
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	0
<i>Prenanthes alba</i>	white lettuce	PREALB	native	5	3
<i>Prunus virginiana</i>	choke cherry	PRUVIR	native	2	3
<i>Ribes cynosbati</i>	prickly or wild gooseberry	RIBCYN	native	4	3
<i>Rubus strigosus</i>	wild red raspberry	RUBSTR	native	2	0
<i>Sambucus canadensis</i>	elderberry	SAMCAN	native	3	-3
<i>Sambucus racemosa</i>	red-berried elder	SAMRAC	native	3	3
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Taxus canadensis</i>	yew	TAXCAN	native	5	3
<i>Thuja occidentalis</i>	arbor vitae	THUOCC	native	4	-3
<i>Trillium grandiflorum</i>	common trillium	TRIGRA	native	5	3

Appendix 3.16. Saint Martin Island Limestone Cobble Shore FQA

Conservatism-Based Metrics:

Total Mean C:	2.9
Native Mean C:	3.3
Total FQI:	15.9
Native FQI:	17.1
Adjusted FQI:	31.3
% C value 0:	13.3
% C value 1-3:	46.7
% C value 4-6:	36.7
% C value 7-10:	3.3
Native Tree Mean C:	2.8
Native Shrub Mean C:	4.4
Native Herbaceous Mean C:	2.8

Species Richness:

Total Species:	30	
Native Species:	27	90%
Non-native Species:	3	10%

Species Wetness:

Mean Wetness:	1
Native Mean Wetness:	0.8

Physiognomy Metrics:

Tree:	5	16.70%
Shrub:	8	26.70%
Vine:	3	10%
Forb:	13	43.30%
Grass:	0	0%
Sedge:	0	0%
Rush:	0	0%
Fern:	1	3.30%
Bryophyte:	0	0%

Duration Metrics:

Annual:	3	10%
Perennial:	25	83.30%
Biennial:	2	6.70%
Native Annual:	3	10%
Native Perennial:	22	73.30%
Native Biennial:	2	6.70%

Appendix 3.16. Saint Martin Island Limestone Cobble Shore FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Acer spicatum</i>	mountain maple	ACESPI	native	5	3
<i>Achillea millefolium</i>	yarrow	ACHMIL	native	1	3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Betula papyrifera</i>	paper birch	BETPAP	native	2	3
<i>Calystegia sepium</i>	hedge bindweed	CALSEP	native	2	0
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Cornus sericea; c. stolonifera</i>	red-osier	CORSER	native	2	-3
<i>Cystopteris bulbifera</i>	bulblet fern	CYSBUL	native	5	-3
<i>Diervilla lonicera</i>	bush-honeysuckle	DIELON	native	4	5
<i>Fragaria virginiana</i>	wild strawberry	FRAVIR	native	2	3
<i>Fraxinus pennsylvanica</i>	red ash	FRAPEN	native	2	-3
<i>Geranium robertianum</i>	herb robert	GERROB	native	3	3
<i>Impatiens capensis</i>	spotted touch-me-not	IMPCAP	native	2	-3
<i>Lactuca canadensis</i>	tall lettuce	LACCAN	native	2	3
<i>Lonicera dioica</i>	red honeysuckle	LONDIO	native	5	3
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	4	3
<i>Oenothera biennis</i>	common evening-primrose	OENBIE	native	2	3
<i>Persicaria lapathifolia; polygonum l.</i>	nodding smartweed	PERLAP	native	0	-3
<i>Physocarpus opulifolius</i>	ninebark	PHYOPU	native	4	-3
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	0
<i>Potentilla anserina</i>	silverweed	POTANS	native	5	-3
<i>Ribes lacustre</i>	swamp black currant	RIBLAC	native	6	-3
<i>Rudbeckia hirta</i>	black-eyed susan	RUDHIR	native	1	3
<i>Sambucus canadensis</i>	elderberry	SAMCAN	native	3	-3
<i>Sambucus racemosa</i>	red-berried elder	SAMRAC	native	3	3
<i>Sedum acre</i>	mossy stonecrop	SEDACR	non-native	0	5
<i>Shepherdia canadensis</i>	soapberry	SHECAN	native	7	5
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Taraxacum officinale</i>	common dandelion	TAROFF	non-native	0	3
<i>Thuja occidentalis</i>	arbor vitae	THUOCC	native	4	-3

Appendix 3.17. Saint Martin Island Limestone Lakeshore Cliff FQA

Conservatism-Based Metrics:

Total Mean C:	5.4
Native Mean C:	5.7
Total FQI:	32.4
Native FQI:	33.2
Adjusted FQI:	55.4
% C value 0:	5.6
% C value 1-3:	19.4
% C value 4-6:	44.4
% C value 7-10:	30.6
Native Tree Mean C:	3.2
Native Shrub Mean C:	4.6
Native Herbaceous Mean C:	6.7

Species Richness:

Total Species:	36	
Native Species:	34	94.40%
Non-native Species:	2	5.60%

Species Wetness:

Mean Wetness:	2.5
Native Mean Wetness:	2.6

Physiognomy Metrics:

Tree:	6	16.70%
Shrub:	5	13.90%
Vine:	2	5.60%
Forb:	15	41.70%
Grass:	2	5.60%
Sedge:	1	2.80%
Rush:	0	0%
Fern:	5	13.90%
Bryophyte:	0	0%

Duration Metrics:

Annual:	2	5.60%
Perennial:	31	86.10%
Biennial:	3	8.30%
Native Annual:	2	5.60%
Native Perennial:	29	80.60%
Native Biennial:	3	8.30%

Appendix 3.17. Saint Martin Island Limestone Lakeshore Cliff FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Abies balsamea</i>	balsam fir	ABIBAL	native	3	0
<i>Anticlea elegans; zigadenus glaucus</i>	white camas	ANTELE	native	10	-3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
<i>Arabidopsis lyrata; arabis l.</i>	sand cress	ARALYR	native	7	3
<i>Arabis pycnocarpa; a. hirsuta</i>	hairy rock cress	ARAPYC	native	6	3
<i>Aralia nudicaulis</i>	wild sarsaparilla	ARANUD	native	5	3
<i>Aralia racemosa</i>	spikenard	ARARAC	native	8	3
<i>Arctostaphylos uva-ursi</i>	bearberry	ARCUVA	native	8	5
<i>Betula papyrifera</i>	paper birch	BETPAP	native	2	3
<i>Boechera stricta; arabis drummondii</i>	drummond rock cress	BOESTR	native	6	3
<i>Campanula rotundifolia</i>	harebell	CAMROT	native	6	3
<i>Carex eburnea</i>	sedge	CXEBUR	native	7	3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Cryptogramma stelleri</i>	slender rock-brake	CRYTE	native	10	3
<i>Cystopteris laurentiana</i>	laurentian fragile fern	CYSLAU	native	9	5
<i>Cystopteris tenuis</i>	fragile fern	CYSTEN	native	5	5
<i>Draba arabisans</i>	rock whitlow-grass	DRAARA	native	10	5
<i>Draba cana</i>	ashy whitlow-grass	DRACAN	native	10	5
<i>Geranium robertianum</i>	herb robert	GERROB	native	3	3
<i>Linnaea borealis</i>	twinflower	LINBOR	native	6	0
<i>Lonicera dioica</i>	red honeysuckle	LONDIO	native	5	3
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	4	3
<i>Melampyrum lineare</i>	cow-wheat	MELLIN	native	6	3
<i>Pellaea glabella</i>	smooth cliff-brake	PELGLA	native	10	5
<i>Poa nemoralis</i>	bluegrass	POANEM	non-native	0	3
<i>Polypodium virginianum</i>	common polypody	POLVIR	native	8	5
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	0
<i>Quercus rubra</i>	red oak	QUERUB	native	5	3
<i>Rubus pubescens</i>	dwarf raspberry	RUBPUB	native	4	-3
<i>Rubus strigosus</i>	wild red raspberry	RUBSTR	native	2	0
<i>Sambucus racemosa</i>	red-berried elder	SAMRAC	native	3	3
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Solidago hispida</i>	hairy goldenrod	SOLHIS	native	3	5
<i>Sorbus decora</i>	mountain-ash	SORDEC	native	4	3
<i>Sphenopholis intermedia</i>	slender wedgegrass	SPHINT	native	4	0
<i>Thuja occidentalis</i>	arbor vitae	THUOCC	native	4	-3

Appendix 3.18. Saint Martin Island Mesic Northern Forest FQA

Conservatism-Based Metrics:

Total Mean C:	4.2
Native Mean C:	5
Total FQI:	36.4
Native FQI:	40
Adjusted FQI:	46.2
% C value 0:	16
% C value 1-3:	12
% C value 4-6:	61.3
% C value 7-10:	10.7
Native Tree Mean C:	4.5
Native Shrub Mean C:	4.2
Native Herbaceous Mean C:	5.3

Species Richness:

Total Species:	75	
Native Species:	64	85.30%
Non-native Species:	11	14.70%

Species Wetness:

Mean Wetness:	2.2
Native Mean Wetness:	2.2

Physiognomy Metrics:

Tree:	15	20%
Shrub:	10	13.30%
Vine:	2	2.70%
Forb:	39	52%
Grass:	1	1.30%
Sedge:	3	4%
Rush:	0	0%
Fern:	5	6.70%
Bryophyte:	0	0%

Duration Metrics:

Annual:	3	4%
Perennial:	65	86.70%
Biennial:	7	9.30%
Native Annual:	3	4%
Native Perennial:	59	78.70%
Native Biennial:	2	2.70%

Appendix 3.18. Saint Martin Island Mesic Northern Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Abies balsamea</i>	balsam fir	ABIBAL	native	3	0
<i>Acer nigrum; a. saccharum</i>	black maple	ACENIG	native	4	3
<i>Acer saccharum</i>	sugar maple	ACESAU	native	5	3
<i>Acer spicatum</i>	mountain maple	ACESPI	native	5	3
<i>Actaea pachypoda</i>	dolls-eyes	ACTPAC	native	7	5
<i>Adlumia fungosa</i>	climbing fumitory	ADLFUN	native	4	5
<i>Allium tricoccum</i>	wild leek	ALLTRI	native	5	3
<i>Aquilegia canadensis</i>	wild columbine	AQUCAN	native	5	3
Arctium minus	common burdock	ARCMIN	non-native	0	3
<i>Betula alleghaniensis</i>	yellow birch	BETALL	native	7	0
<i>Betula papyrifera</i>	paper birch	BETPAP	native	2	3
<i>Botrypus virginianus</i>	rattlesnake fern	BOTVIR	native	5	3
<i>Cardamine concatenata; dentaria laciniata</i>	cut-leaved toothwort	CARCON	native	5	3
<i>Cardamine diphylla; dentaria d.</i>	two-leaved toothwort	CARDIP	native	5	3
<i>Carex deweyana</i>	sedge	CXDEWE	native	3	3
<i>Carex garberi</i>	sedge	CXGARB	native	8	-3
<i>Carex pedunculata</i>	sedge	CXPEDU	native	5	3
Cirsium arvense	canada thistle	CIRARV	non-native	0	3
Cirsium palustre	marsh thistle	CIRPAL	non-native	0	-3
Cirsium vulgare	bull thistle	CIRVUL	non-native	0	3
<i>Claytonia caroliniana</i>	carolina spring-beauty	CLACAR	native	6	3
<i>Clintonia borealis</i>	bluebead-lily; corn-lily	CLIBOR	native	5	0
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Corydalis aurea</i>	golden corydalis	CORAUR	native	5	5
<i>Corylus cornuta</i>	beaked hazelnut	CORCOR	native	5	3
Cynoglossum officinale	hounds-tongue	CYNOFF	non-native	0	5
<i>Diervilla lonicera</i>	bush-honeysuckle	DIELON	native	4	5
<i>Dryopteris carthusiana</i>	spinulose woodfern	DRYCAR	native	5	-3
<i>Dryopteris intermedia</i>	evergreen woodfern	DRYINT	native	5	0
<i>Epifagus virginiana</i>	beech-drops	EPIVIR	native	10	5
Epipactis helleborine	helleborine	EPIHEL	non-native	0	0
<i>Equisetum scirpoides</i>	dwarf scouring rush	EQUSCI	native	7	0
<i>Eurybia macrophylla; aster m.</i>	big-leaved aster	EURMAC	native	4	5
<i>Fagus grandifolia</i>	american beech	FAGGRA	native	6	3
<i>Fraxinus americana</i>	white ash	FRAAME	native	5	3
<i>Galium triflorum</i>	fragrant bedstraw	GALTRR	native	4	3
<i>Geranium robertianum</i>	herb robert	GERROB	native	3	3
<i>Gymnocarpium dryopteris</i>	oak fern	GYMDRY	native	5	3
<i>Halenia deflexa</i>	spurred gentian	HALDEF	native	7	0
<i>Hepatica acutiloba</i>	sharp-lobed hepatica	HEPACU	native	8	5
<i>Heracleum maximum</i>	cow-parsnip	HERMAX	native	3	-3
<i>Linnaea borealis</i>	twinline	LINBOR	native	6	0
<i>Lonicera canadensis</i>	canadian fly honeysuckle	LONCAN	native	5	3
Lonicera morrowii	morrow honeysuckle	LONMOR	non-native	0	3
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	4	3
<i>Maianthemum racemosum; smilacina r.</i>	false spikenard	MAIRAC	native	5	3

Appendix 3.18. Saint Martin Island Mesic Northern Forest FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Mitchella repens</i>	partridge-berry	MITREP	native	5	3
<i>Ostrya virginiana</i>	ironwood; hop-hornbeam	OSTVIR	native	5	3
<i>Pinus resinosa</i>	red pine	PINRES	native	6	3
<i>Platanthera lacera</i> ; <i>habenaria l.</i>	green-fringed orchid	PLALAC	native	6	-3
<i>Platanthera orbiculata</i> ; <i>habenaria o.</i>	round-leaved orchid	PLAORB	native	10	0
<i>Poa compressa</i>	canada bluegrass	POACOM	non-native	0	3
<i>Polygonatum pubescens</i>	downy solomon seal	POLPUB	native	5	5
<i>Populus grandidentata</i>	big-tooth aspen	POPGRA	native	4	3
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	0
<i>Prenanthes alba</i>	white lettuce	PREALB	native	5	3
<i>Prunus virginiana</i>	choke cherry	PRUVIR	native	2	3
<i>Pyrola elliptica</i>	large-leaved shinleaf	PYRELL	native	6	3
<i>Quercus rubra</i>	red oak	QUERUB	native	5	3
<i>Ranunculus abortivus</i>	small-flowered buttercup	RANABO	native	0	0
<i>Rubus parviflorus</i>	thimbleberry	RUBPAR	native	6	3
<i>Rubus strigosus</i>	wild red raspberry	RUBSTR	native	2	0
<i>Sambucus racemosa</i>	red-berried elder	SAMRAC	native	3	3
<i>Solanum dulcamara</i>	bittersweet nightshade	SOLDUL	non-native	0	0
<i>Solidago caesia</i>	bluestem goldenrod	SOLCAE	native	6	3
<i>Solidago flexicaulis</i>	zigzag goldenrod	SOLFLE	native	6	3
<i>Taraxacum officinale</i>	common dandelion	TAROFF	non-native	0	3
<i>Taxus canadensis</i>	yew	TAXCAN	native	5	3
<i>Thuja occidentalis</i>	arbor vitae	THUOCC	native	4	-3
<i>Tilia americana</i>	basswood	TILAME	native	5	3
<i>Trientalis borealis</i>	star-flower	TRIBOR	native	5	0
<i>Trillium grandiflorum</i>	common trillium	TRIGRA	native	5	3
<i>Verbascum thapsus</i>	common mullein	VERTHA	non-native	0	5
<i>Viola pubescens</i>	yellow violet	VIOPUB	native	4	3
<i>Viola renifolia</i>	kidney-leaved violet	VIOREN	native	6	-3

Appendix 3.19. Saint Martin Island Northern Hardwood Swamp FQA

Conservatism-Based Metrics:

Total Mean C:	3.7
Native Mean C:	3.8
Total FQI:	28.7
Native FQI:	28.7
Adjusted FQI:	37
% C value 0:	8.3
% C value 1-3:	38.3
% C value 4-6:	48.3
% C value 7-10:	5
Native Tree Mean C:	3.1
Native Shrub Mean C:	4.1
Native Herbaceous Mean C:	3.9

Species Richness:

Total Species:	60	
Native Species:	57	95%
Non-native Species:	3	5%

Species Wetness:

Mean Wetness:	-2.4
Native Mean Wetness:	-2.4

Physiognomy Metrics:

Tree:	7	11.70%
Shrub:	12	20%
Vine:	4	6.70%
Forb:	15	25%
Grass:	5	8.30%
Sedge:	11	18.30%
Rush:	0	0%
Fern:	6	10%
Bryophyte:	0	0%

Duration Metrics:

Annual:	0	0%
Perennial:	60	100%
Biennial:	0	0%
Native Annual:	0	0%
Native Perennial:	57	95%
Native Biennial:	0	0%

Appendix 3.19. Saint Martin Island Northern Hardwood Swamp FQA (continued)

Scientific Name	Common Name	Acronym	Native?	C	W
<i>Agrostis hyemalis</i>	ticklegass	AGRHYE	native	4	0
<i>Betula papyrifera</i>	paper birch	BETPAP	native	2	3
<i>Calamagrostis canadensis</i>	blue-joint	CALCAN	native	3	-5
<i>Campanula aparinoides</i>	marsh bellflower	CAMAPA	native	7	-5
<i>Carex aurea</i>	sedge	CXAURE	native	3	-3
<i>Carex bebbii</i>	sedge	CXBEBB	native	4	-5
<i>Carex interior</i>	sedge	CXINTE	native	3	-5
<i>Carex intumescens</i>	sedge	CXINTU	native	3	-3
<i>Carex lacustris</i>	sedge	CXLACU	native	6	-5
<i>Carex pedunculata</i>	sedge	CXPEDU	native	5	3
<i>Carex utriculata</i> ; c. <i>rostrata</i>	sedge	CXUTRI	native	5	-5
<i>Carex viridula</i>	sedge	CXVIRU	native	4	-5
<i>Cornus amomum</i>	silky dogwood	CORAMO	native	2	-3
<i>Cornus rugosa</i>	round-leaved dogwood	CORRUG	native	6	5
<i>Cornus sericea</i> ; c. <i>stolonifera</i>	red-osier	CORSER	native	2	-3
<i>Diervilla lonicera</i>	bush-honeysuckle	DIELON	native	4	5
<i>Dryopteris carthusiana</i>	spinulose woodfern	DRYCAR	native	5	-3
<i>Eleocharis palustris</i> ; e. <i>smallii</i>	spike-rush	ELEPAL	native	5	-5
<i>Equisetum arvense</i>	common horsetail	EQUARV	native	0	0
<i>Fraxinus nigra</i>	black ash	FRANIG	native	6	-3
<i>Fraxinus pennsylvanica</i>	red ash	FRAPEN	native	2	-3
<i>Ilex verticillata</i>	michigan holly	ILEVER	native	5	-3
<i>Iris versicolor</i>	wild blue flag	IRIVER	native	5	-5
<i>Lathyrus palustris</i>	marsh pea	LATPAL	native	7	-3
<i>Lycopus americanus</i>	common water horehound	LYCAME	native	2	-5
<i>Lycopus uniflorus</i>	northern bugle weed	LYCUNI	native	2	-5
<i>Lysimachia thyrsiflora</i>	tufted loosestrife	LYSTHY	native	6	-5
<i>Maianthemum canadense</i>	canada mayflower	MAICAN	native	4	3
<i>Maianthemum stellatum</i> ; <i>smilacina</i> s.	starry false solomon-seal	MAISTE	native	5	0
<i>Mentha canadensis</i> ; m. <i>arvensis</i>	wild mint	MENCAS	native	3	-3
<i>Onoclea sensibilis</i>	sensitive fern	ONOSEN	native	2	-3
<i>Osmunda regalis</i>	royal fern	OSMREG	native	5	-5
<i>Ostrya virginiana</i>	ironwood; hop-hornbeam	OSTVIR	native	5	3
<i>Persicaria amphibia</i> ; <i>polygonum</i> a.	water smartweed	PERAMP	native	6	-5
<i>Phalaris arundinacea</i>	reed canary grass	PHAARU	native	0	-3
<i>Phragmites australis</i> var. <i>australis</i>	reed	PHRAUU	non-native	0	-3
<i>Poa palustris</i>	fowl meadow grass	POAPAS	native	3	-3
<i>Polystichum acrostichoides</i>	christmas fern	POLACR	native	6	3
<i>Populus balsamifera</i>	balsam poplar	POPBAL	native	2	-3
<i>Populus tremuloides</i>	quaking aspen	POPTRE	native	1	0
<i>Ribes hudsonianum</i>	northern black currant	RIBHUD	native	10	-5
<i>Rubus pubescens</i>	dwarf raspberry	RUBPUB	native	4	-3
<i>Rubus strigosus</i>	wild red raspberry	RUBSTR	native	2	0
<i>Salix eriocephala</i>	willow	SALERI	native	2	-3
<i>Schoenoplectus acutus</i> ; <i>scirpus</i> a.	hardstem bulrush	SCHACU	native	5	-5
<i>Scirpus cyperinus</i>	wool-grass	SCICYP	native	5	-5

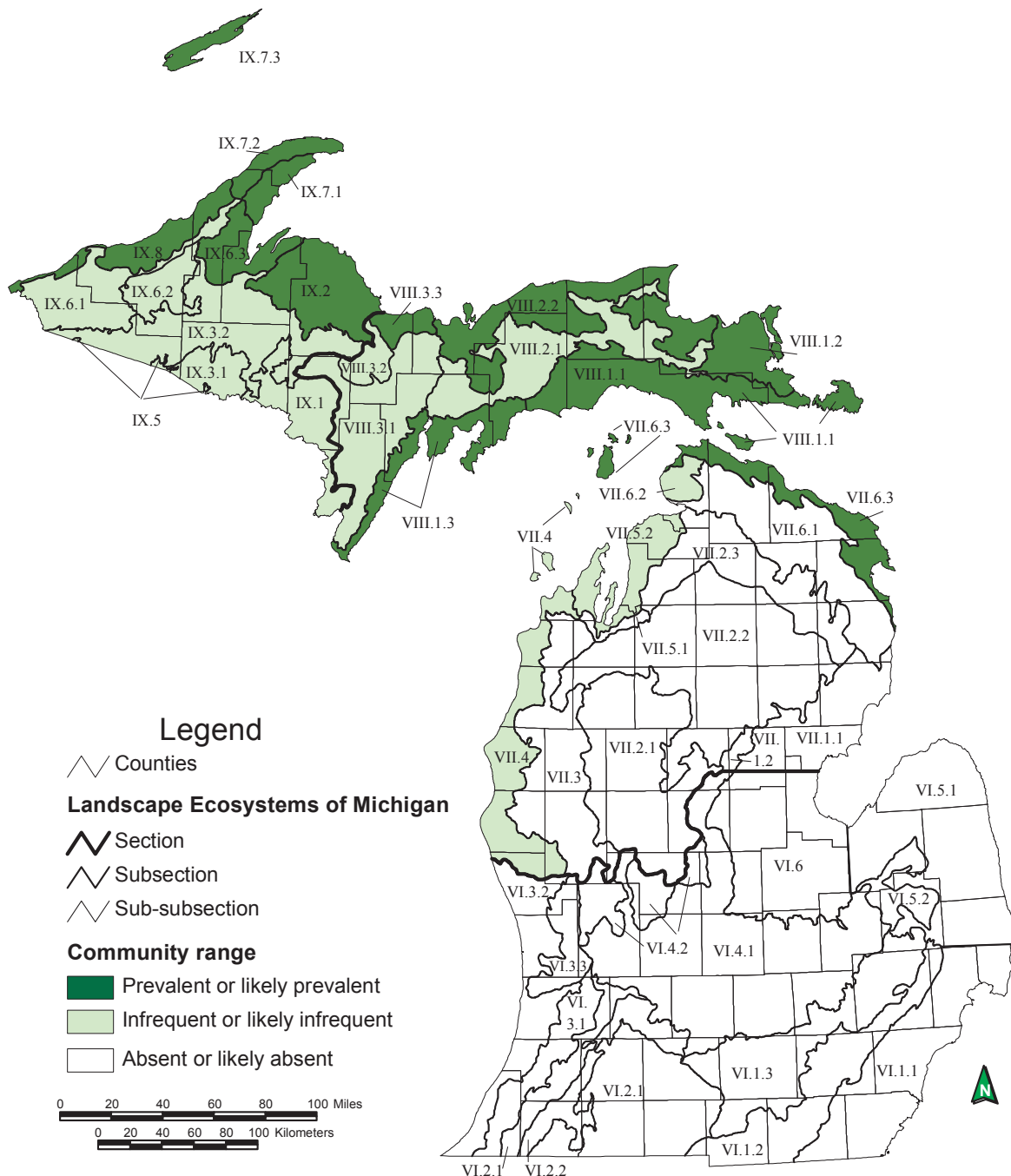
Appendix 3.19. Saint Martin Island Northern Hardwood Swamp FQA (continued)

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

Appendix 4 - Natural Community Overviews and Distribution Maps

BOREAL FOREST

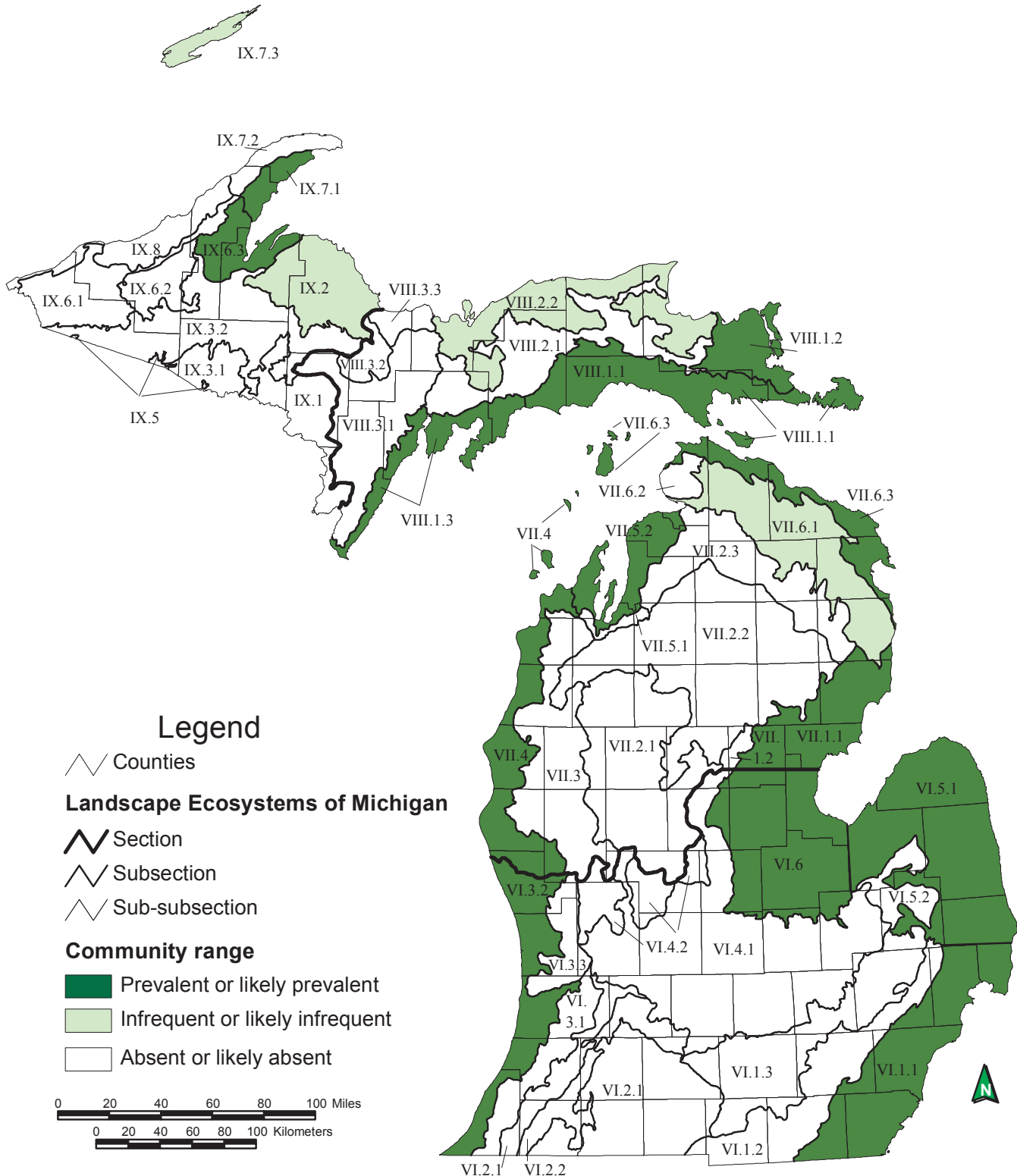
Overview: Boreal forest is a conifer or conifer-hardwood forest type occurring on moist to dry sites characterized by species dominant in the Canadian boreal forest. It typically occupies upland sites along shores of the Great Lakes, on islands in the Great Lakes, and locally inland. The community occurs 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).

GREAT LAKES MARSH

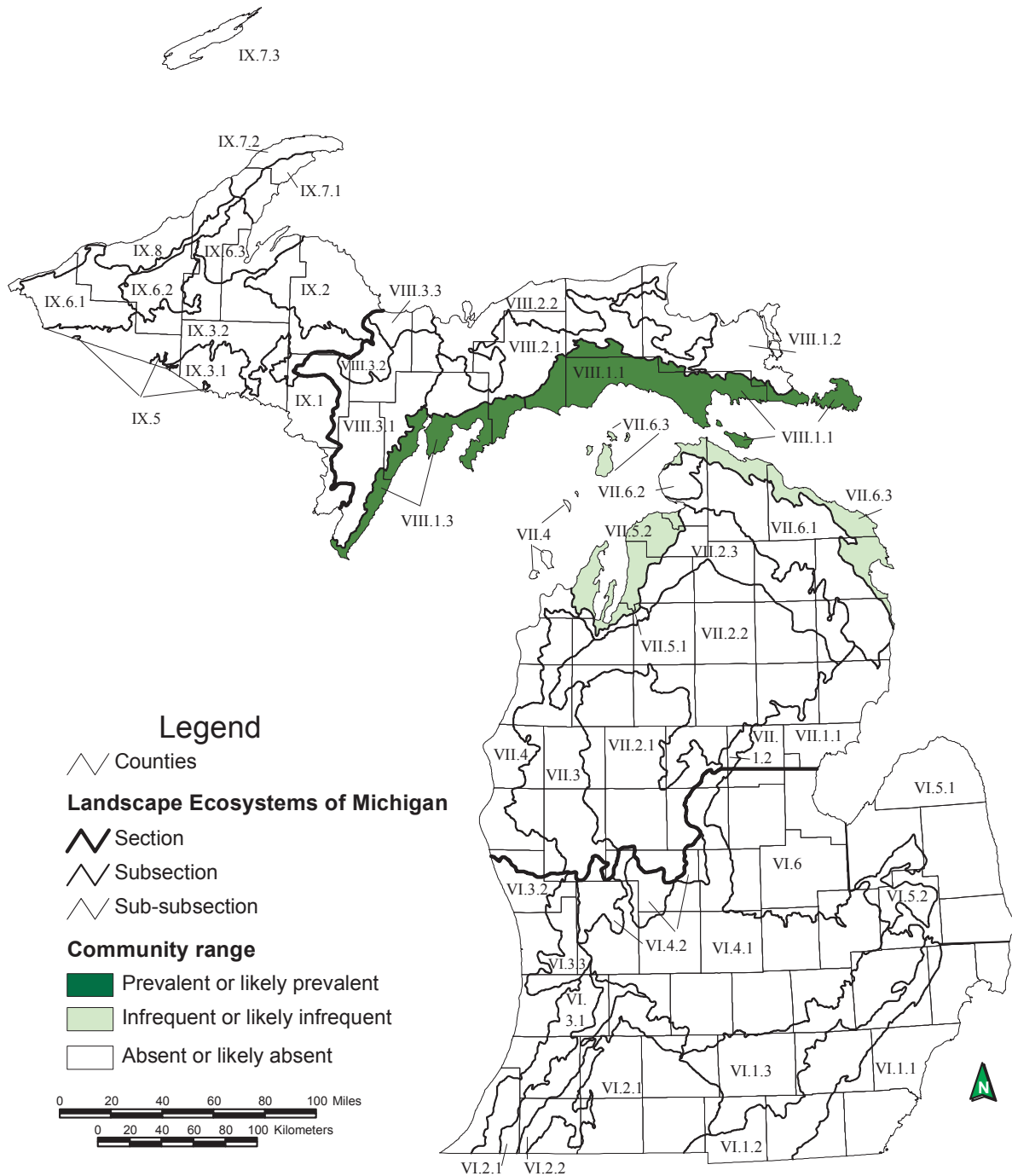
Overview: Great Lakes marsh is an herbaceous wetland community occurring statewide along the shoreline of the Great Lakes and their major connecting rivers. Vegetational patterns are strongly influenced by water level fluctuations and type of coastal feature, but generally include the following: a deep 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 2. Distribution of Great Lakes marsh in Michigan (Albert et al. 2008).

LIMESTONE BEDROCK LAKESHORE

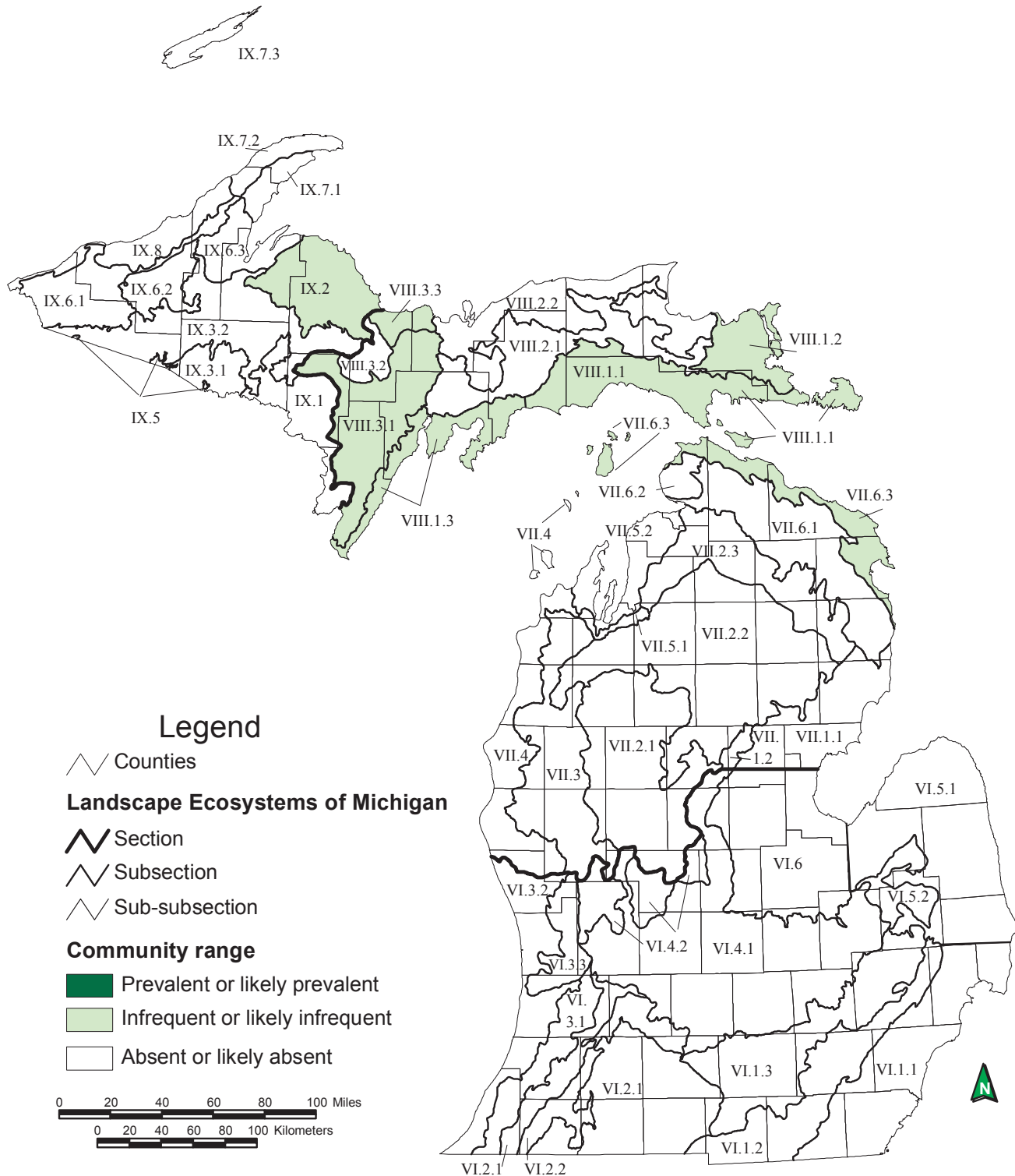
Overview: Limestone bedrock lakeshore is a sparsely vegetated natural community dominated by lichens, mosses, and herbaceous vegetation. This community, which is also referred to as alvar pavement and limestone pavement lakeshore, occurs along the shorelines of northern Lake Michigan and Lake Huron on 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 3. Distribution of limestone bedrock lakeshore in Michigan (Albert et al. 2008).

LIMESTONE CLIFF

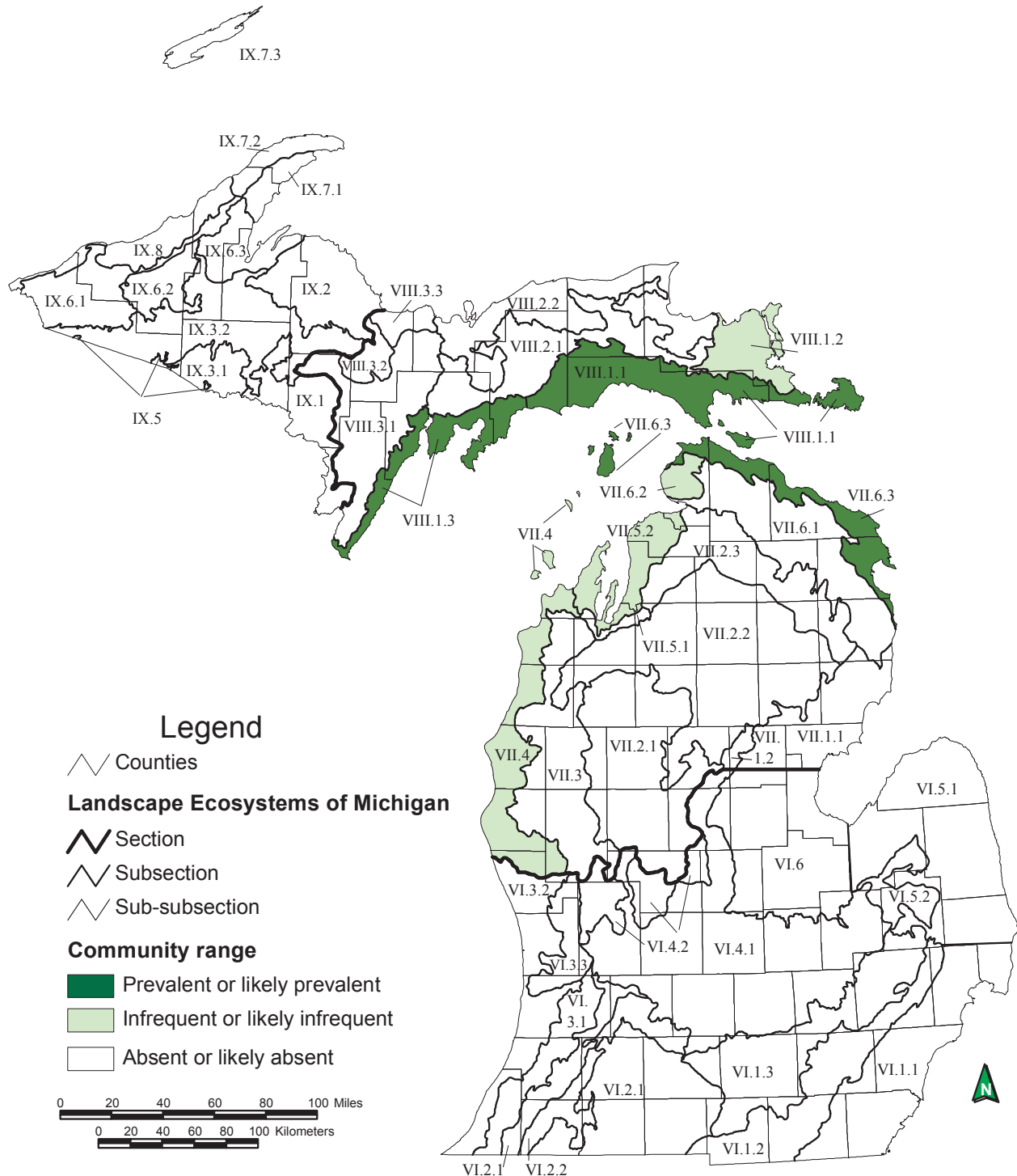
Overview: Limestone cliff consists of vertical or near-vertical exposures of bedrock, which typically support less than 25% vascular plant coverage, although some rock surfaces can be densely covered with lichens, mosses, and liverworts. The community occurs predominantly in the Upper Peninsula, most typically within a few kilometers of the Lake Michigan and Lake Huron shorelines, on the Niagara Escarpment, but with isolated occurrences of much older Precambrian-aged limestones and dolomites in the western Upper Peninsula. Limestone cliffs also occur within sinkholes within Devonian Limestone in the northern Lower Peninsula. Like most of Michigan's cliffs, vegetation cover is sparse, but abundant cracks and crevices combined with calcareous conditions result in greater plant diversity and coverage than on most other cliff types (Kost et al. 2007, Cohen et al. 2015).



Map 4. Distribution of limestone cliff in Michigan (Albert et al. 2008).

LIMESTONE COBBLE SHORE

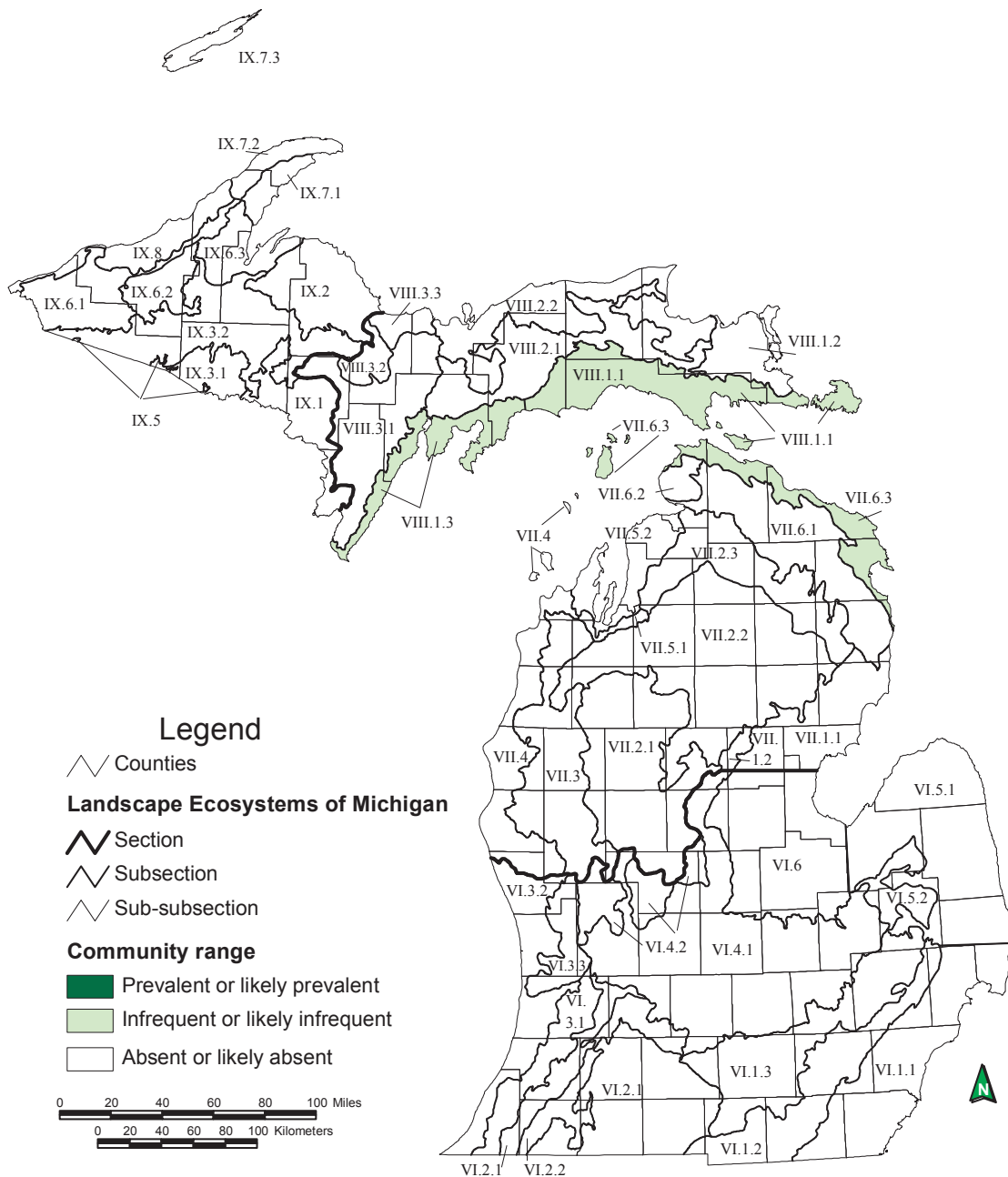
Overview: Limestone cobble shore occurs along gently sloping shorelines of Lake Michigan and Lake Huron. The community is studded with cobbles and boulders and is frequently inundated by storms and periods of high water. Limestone cobble shore is typically sparsely vegetated, because cobbles cover most 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 5. Distribution of limestone cobble shore in Michigan (Albert et al. 2008).

LIMESTONE LAKESHORE CLIFF

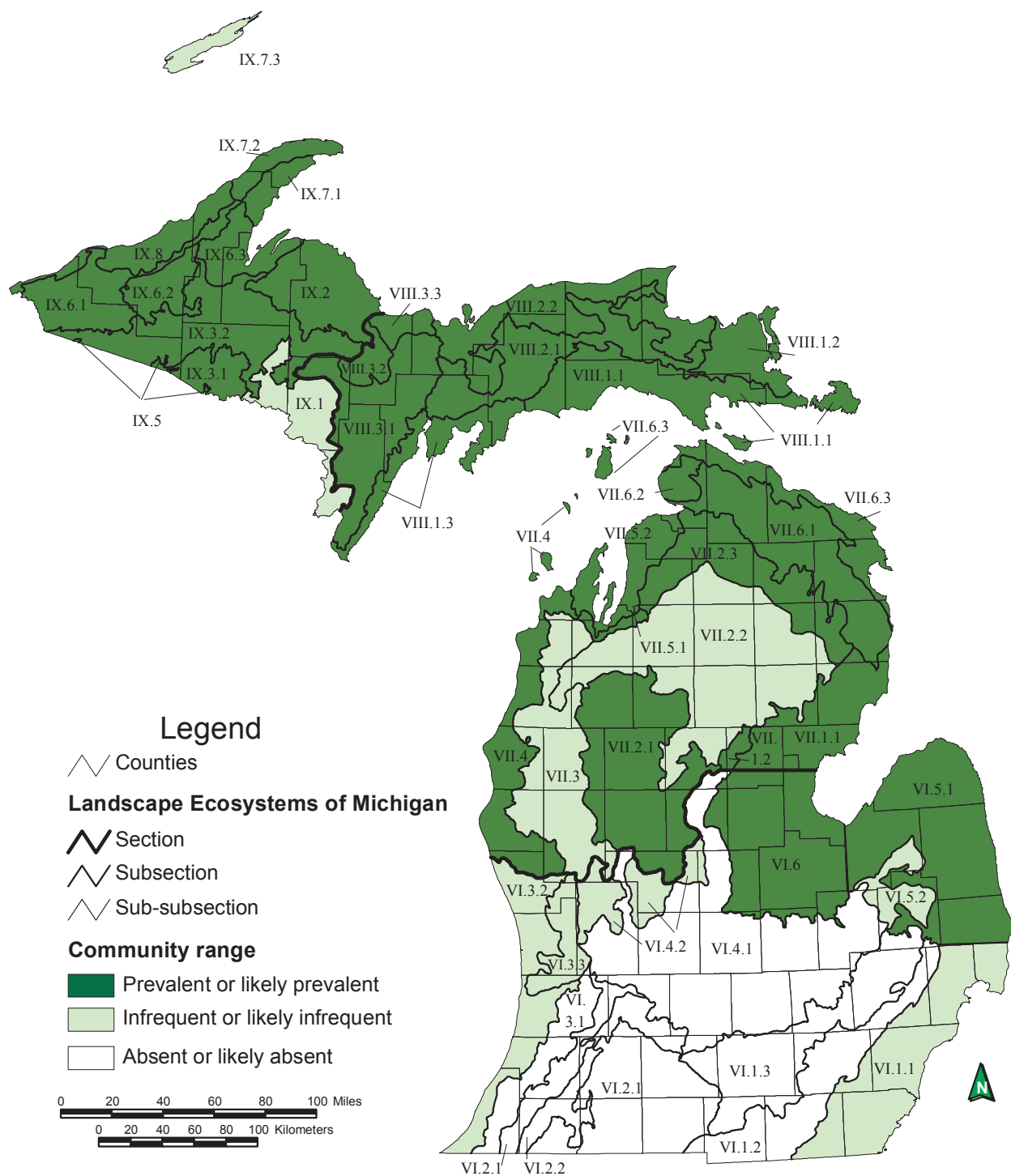
Overview: Limestone lakeshore cliff consists of vertical or near-vertical exposures of bedrock, which typically support less than 25% vascular plant coverage, although some rock surfaces can be densely covered with lichens, mosses, and liverworts. The community occurs in the Upper Peninsula along the shorelines of Lake Michigan and Lake Huron. Like all of Michigan's lakeshore cliffs, vegetation cover is sparse but abundant cracks and crevices combined with calcareous conditions result in greater plant diversity and coverage than on most other cliff types. Limestone lakeshore cliffs are characterized by high site moisture due to the proximity to the Great Lakes and a stressed and unstable environment because of severe waves, wind, and winter ice. The vertical structure of cliffs causes constant erosion and restricts soil development to the cliff edge, cracks, ledges, and the base of the cliff where organic matter and soil particles can accumulate. The thin soils and direct exposure to wind, ice, and sun produce desiccating conditions that limit plant growth. Weathering results in the gradual exfoliation of exposed limestone along the cliff face, which adds to the instability of the ecosystem, reducing dependable habitat for plant establishment. As portions of the bedrock slough off, they form talus slopes of boulders and slabs along the base of cliffs and expose fresh, bare rock substrates along the cliff face. Windthrow of canopy trees along the cliff escarpment is common due to the thin soils, unstable substrate, and high wind activity. Windblown trees along ledges and at the base of the cliff provide localized areas for soil accumulation (Kost et al. 2007, Cohen et al. 2015).



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

MESIC NORTHERN FOREST

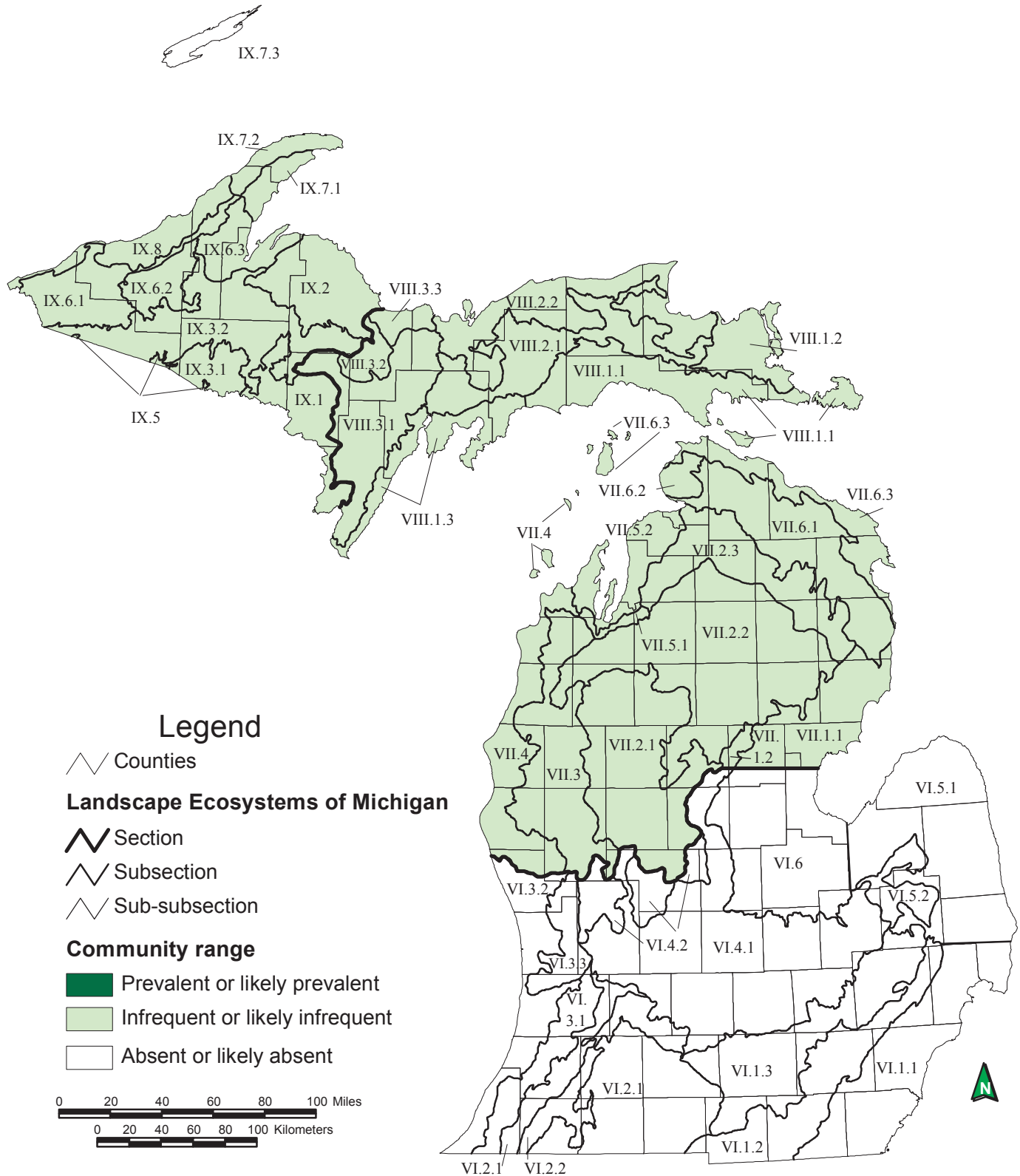
Overview: Mesic northern forest is a forest type of moist to dry-mesic sites lying mostly north of the climatic tension zone, characterized by the dominance of northern hardwoods, particularly sugar maple (*Acer saccharum*) and American beech (*Fagus grandifolia*). Conifers such as hemlock (*Tsuga canadensis*) 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 7. Distribution of mesic northern forest in Michigan (Albert et al. 2008).

NORTHERN HARDWOOD SWAMP

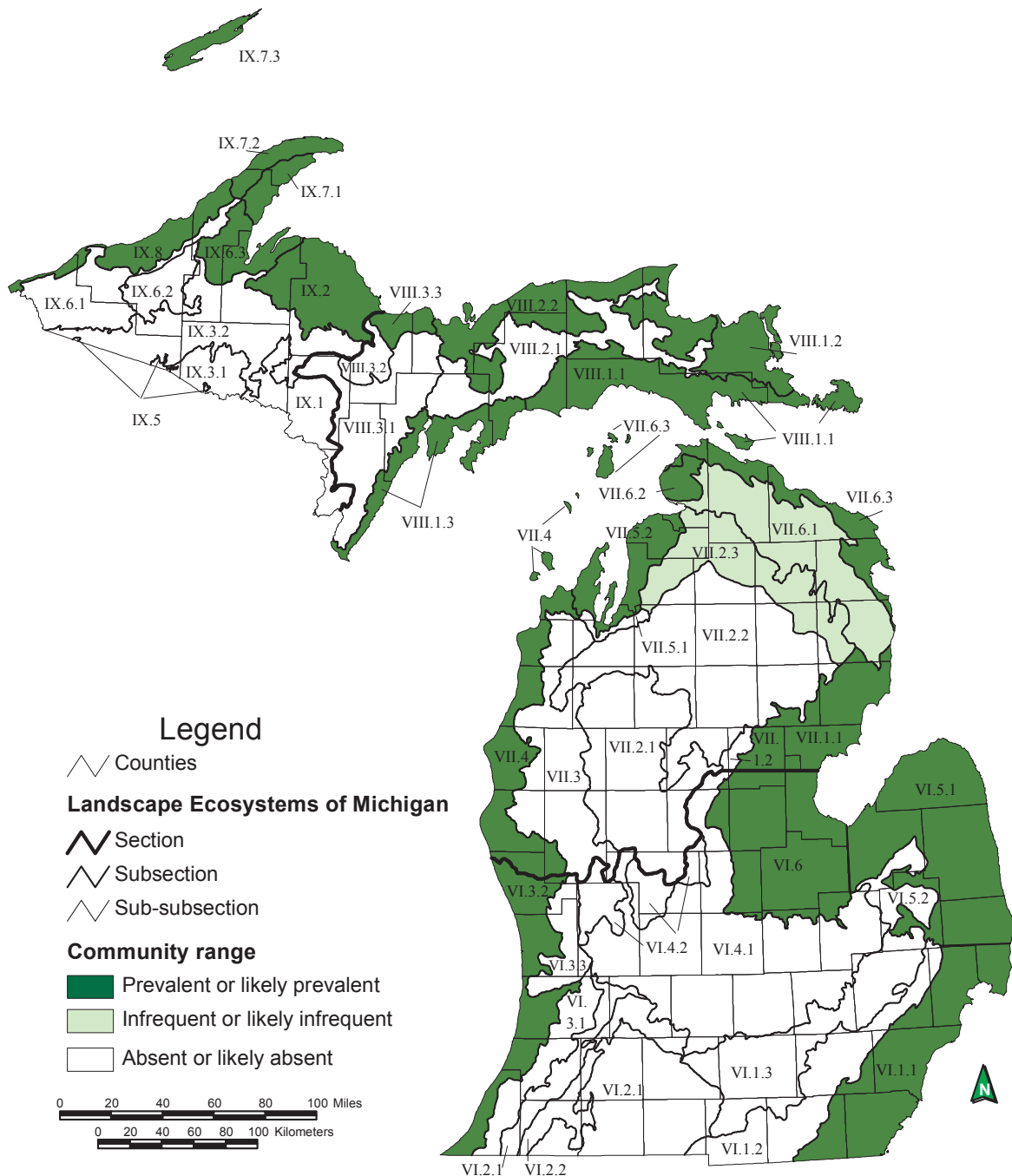
Overview: Northern hardwood swamp is a seasonally inundated, deciduous swamp forest community dominated by black ash (*Fraxinus nigra*) that occurs on neutral to slightly acidic, hydric mineral soils and shallow muck over mineral soils. Located north of the climatic tension zone, northern hardwood swamp 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 8. Distribution of northern hardwood swamp 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 9. Distribution of sand and gravel beach in Michigan (Albert et al. 2008).