Rare and Invasive Plant Surveys of Great Lakes Islands in Detroit International Wildlife Refuge

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Cover Photo: Looking north from Calf Island. Photo by Tyler J. Bassett. All pictures by Tyler J. Bassett unless otherwise noted.

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Botanist Scott Warner, mapping invasive plant species on Calf Island.

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Introduction

Great Lakes islands provide critical habitat for native biodiversity and support rare and endemic natural communities. A diverse assemblage of more than 32,000 islands occurs across the Great Lakes plus the connecting channels (Henson et al. 2010). 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 existing natural communities to support the needs of priority and migratory bird species, threatened and endangered species, and resident wildlife and provide valuable 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. Despite limited access, these islands still face a variety of anthropogenic pressures including the establishment and spread of invasive plant and animal species and the impacts of climate change. Unfortunately, most biodiversity data are limited or outdated, which hinders effective management and decision-making.

To address this critical information gap, the USFWS contracted Michigan Natural Features Inventory (MNFI) to conduct botanical surveys, including rare and invasive plant species mapping and floristic surveys of natural communities; and ecological surveys, including qualitative natural community surveys and quantitative forest sampling. In 2021, botanical and ecological surveys were conducted in Michigan Islands NWR in Lake Huron (Bassett et al. 2022a, Cohen et al. 2022a) and Gravel Island and Green Bay NWRs in Lake Michigan (Bassett et al. 2022b, Cohen et al. 2022b). In 2022, botanical and ecological surveys were conducted in Huron NWR in Lake Superior (Bassett et al. 2023a, Cohen et al. 2023a), Harbor Island NWR in Lake Huron (Bassett et al. 2023b, Cohen

Marsh along the northern end of Calf Island.

et al. 2023b), Michigan Islands NWR in Lake Michigan (Bassett et al. 2023c, Cohen et al. 2023c), and West Sister Island NWR in Lake Erie (Bassett et al. 2023d, Cohen et al. 2023d). Botanical surveys were also conducted in 2022 in Detroit River International Wildlife Refuge (*this report*). This report focuses on the botanical surveys conducted in 2022 on Calf and Mud Islands in Detroit River International Wildlife Refuge.

There were 442 rare vascular plant species in Michigan that were tracked in the Michigan Natural Heritage Database at the time of these surveys (MNFI 2023). This included species listed at the state- and federal-level as threatened and endangered in that are legally protected. Species of special concern are also tracked and include species that are considered at risk of declining but are not legally protected. Managing populations of rare plants and their habitat is a high conservation priority. These species are frequently associated with high-quality ecosystems, or natural communities, that further warrant prioritized management.

A critical goal of this project was to collect updated and new data for rare plant species occurrences to provide natural resource managers and planners with accurate, detailed, standardized baseline information on the viability and extent of rare plant species populations and the condition of their habitat on these islands. An equally critical goal of this project was to collect updated and new data for invasive plant species that potentially threaten the viability of rare plant species and natural communities on these islands. This baseline information facilitates site-level decisions about biodiversity stewardship; prioritizing protection, management and restoration decisions; monitoring the success of management and restoration; and informing landscape-level biodiversity planning efforts. Data on the location and extent of rare plant species and natural communities enables invasive plant species management to better protect these targets of high conservation value.This report summarizes the findings of MNFI's rare and invasive plant surveys on Calf and Mud Islands in Detroit River International Wildlife Refuge.

Dense patch of invasive reed (*Phragmites australis* subsp. *australis*) on Mud Island.

Methods

Study Area

Calf and Mud Islands are located in the Detroit River north and south of Gross Ile near the cities of Gibraltar and Wyandotte, respectively (Figure 1). These islands are composed of lacustrine silt, to a depth of one to ten meters over primarily dolomitic limestone of Devonian origin (Albert 1995). The Detroit River is a 28-mile narrow strait connecting Lake St. Clair to Lake Erie, and thus connecting Lakes Huron, Michigan, and Superior to Lake Erie, Lake Ontario, and the St. Lawrence Seaway. It is one of the world's busiest waterways and divides the metropolitan areas of Detroit, Michigan, USA, and Windsor, Ontario, Canada. Most of the land within and surrounding the river is developed, which contributed to highly polluted waters in the 20th century.

To help combat the effects of development and pollution, the Wyandotte National Wildlife Refuge was formed in 1961. It occupied the land surrounding Grassy Island. In 2001, the Wyandotte National Wildlife Refuge was absorbed into the inaugural and much larger Detroit River International Wildlife Refuge. This Refuge plays a critical role in protecting what natural habitat remains in the south of the river. The river contains 31 charted islands, 8 of which are entirely or partially within the Refuge.

Calf Island

Calf Island spans 11 acres and is situated a quarter mile west of Grosse Ile in the Trenton Channel of the Detroit River. A review of aerial imagery shows it has been present and above water dating back at least as far as 1937, persisting through a water-level increase alluded to in the following section. In 2002 it was added to the Detroit River International Wildlife Refuge. Information about historical anthropogenic use of the island is not readily available, but the structural remains present on the island today hint of recent anthropogenic use.

Mud Island

Mud Island spans 21 acres and is situated a tenth of a mile east of the mainland town of Ecorse in the Ecorse Channel of the Detroit River. It was donated to what was then the Wyandotte National Wildlife Refuge by National Steel Corp in 2001 (Detroit Free Press 2003). The origin of the island is obscure. A 1912 newspaper passage refers to Mud Island as a "piece of made land" (Detroit Free Press 1912). The first aerial imagery available for the area dates to 1937, at which time the island possessed a natural-appearing, geometrically irregular shape, which corresponds roughly to a zone of shallow water visible on contemporary aerial imagery. By 1949, the island was submersed. It does not reappear in aerial imagery until 1972, when it shows up as geometrically regular, exactly as it appears today, suggesting that it was artificially elevated with fill obtained from a dredging operation.

In 1929, the sole inhabitant of the island was arrested for his role in smuggling Canadian liquor into the United States via an underwater cable (Battle Creek Enquirer 1929). The island is now a popular perching ground for bald eagles and draws many photographers (Great Lakes Moment 2022).

Prioritization and survey targets

Prior to conducting rare and invasive plant surveys, we reviewed previous data and generated target species lists to focus survey effort on known locations and potential habitat for these species. Invasive species targets are prioritized by USFWS for the Great Lakes region (see Table 1). We prioritized survey effort by reviewing natural community delineations and evaluating the conservation status (G- and S-ranks; Appendix 1.1) of each natural community (Table 2; Cohen et al 2020). Rare plant survey targets included species with previously documented element occurrences (EOs) in the Michigan Natural Heritage Database from portions of Detroit River floodplain in the vicinity of Calf and Mud islands. An EO is an area of land or water where

Table 1. USFWS Great Lakes Region target invasive species.

Scientific Name	Common Name
Alliaria petiolata	Garlic mustard
Alnus glutinosa	Black alder
Berberis thunbergii	Japanese barberry
Butomus umbellatus	Flowering rush
Celastrus orbiculatus	Oriental bittersweet
Centaurea stoebe	Spotted knapweed
Cirsium arvense	Canada thistle
Dioscorea polystachya	Chinese yam
Dipsacus fullonum	Wild teasel
Dipsacus laciniatus	Cut-leaf teasel
Eichhornia crassipes	Water hyacinth
Elaeagnus umbellata	Autumn olive
Fallopia japonica	Japanese knotweed
Fallopia sachalinensis	Giant knotweed
Frangula alnus (syn. *Rhamnus frangula*)	Glossy buckthorn
Hesperis matronalis	Dame's rocket
Hydrocharis morsus-ranae	European frog-bit
Iris pseudacorus	Yellow flag iris
Ligustrum vulgare	Common privet
Lonicera spp.	Bush honeysuckle
Ludwigia peploides	Floating primrose willow
Myriophyllum aquaticum	Parrot-feather milfoil
Phalaris arundinacea	Reed canary grass
Phragmites australis subsp. *australis*	Invasive reed
Pistia stratiotes	Water lettuce
Populus alba	White poplar
Rhamnus cathartica	Common buckthorn
Robinia pseudoacacia	Black locust
Rosa multiflora	Multiflora rose
Vincetoxicum nigrum (syn. *Cynanchum louiseae*)	Black swallow-wort
Vincetoxicum rossicum (syn. *Cynanchum rossicum*)	Dog-strangling vine

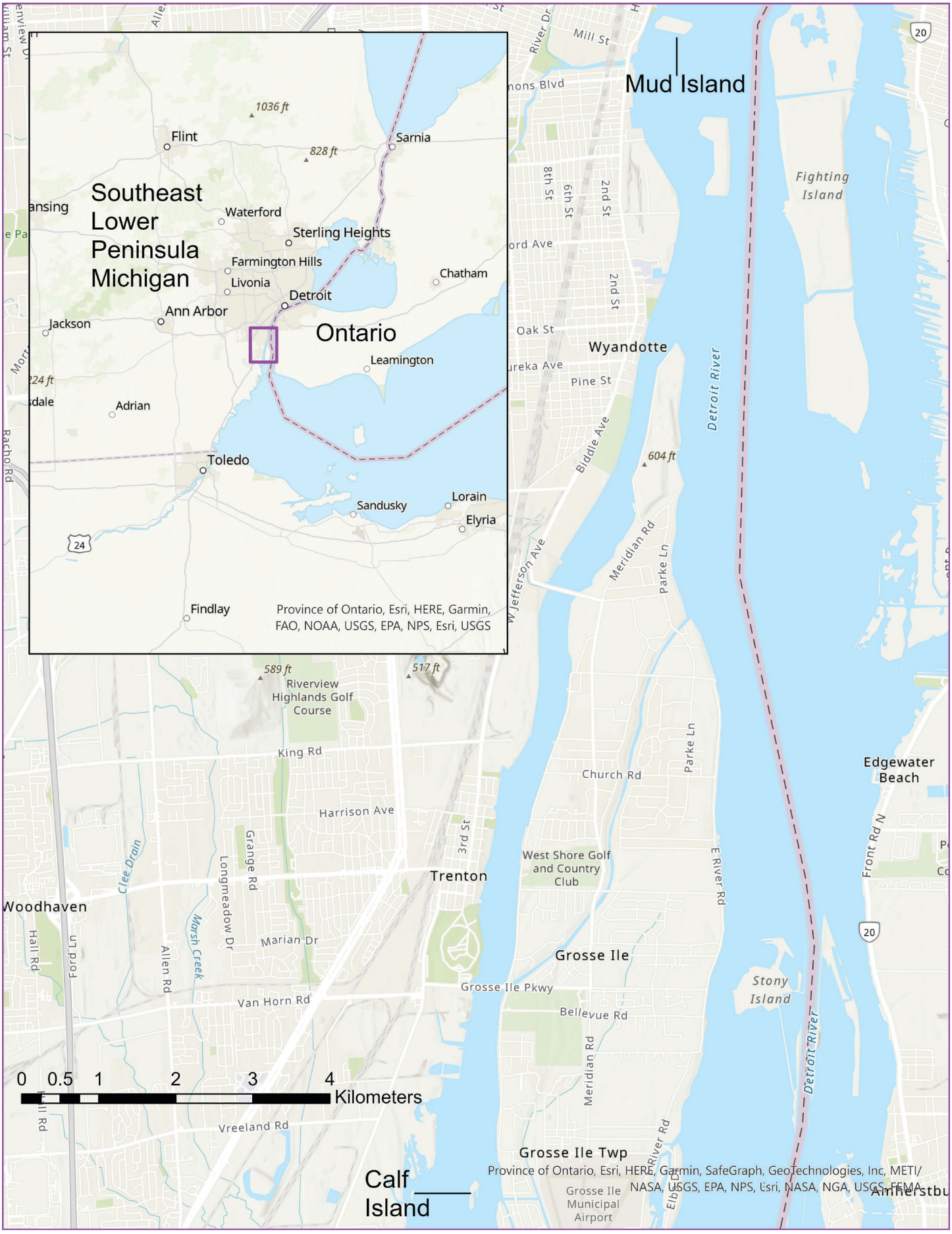

Figure 1. Calf and Mud Islands in the Detroit River. Inset: Location in Detroit Metro area of southeastern Michigan.

a significant element of biodiversity including rare species and natural communities currently occurs or historically occurred. Each EO may be comprised of multiple observations of a species or community through space or time, and is given a unique numeric identifier, an EO ID. No EOs were known on either island prior to 2022 surveys (Table 3; MNFI 2023).

Table 2. Natural community types targeted for surveys on Calf and Mud Islands. Natural community delineations are based on Michigan Natural Features Inventory Classification System, were determined remotely, and may differ from natural communities observed during field surveys. (Cohen et al. 2020). "Not Applicable" or "NA" indicates area(s) that are not natural communities (i.e., Mud Island is entirely anthropogenic in origin). Global and State Rank (G- and S-Rank) values are based on NatureServe (2002) (see Appendix 1).

Natural community	Calf	Mud
Great Lakes marsh	G2/S3	-
Mesic southern forest	G2G3/S3	-
Wet-mesic flatwoods	G2G3/S2	-
Not applicable	-	NA

Field surveys

We conducted meander surveys on each island, using the following approach to maximize the probability of encountering targets and incidental observations of rare and invasive plant species. This approach was repeated across all the NWRs surveyed by MNFI in 2021 and 2022 (Bassett et al. 2022a, 2022b, 2023a, 2023b, 2023c, 2023d). We surveyed the entire perimeter of each island, as a potential entry point for invasive species. We also conducted meanders through the interior of each island, crossing through each natural community as delineated prior to surveys (USFWS 2021). The survey route adequately covered the natural community, including micro-habitats or areas of non-homogenous habitat within each community type. These were noted in either aerial imagery and other GIS data prior to the survey, or while meandering during the survey. We also conducted floristic surveys during the course of meanders. We generated a species list for each island. Botanical surveys were conducted on Calf and Mud Islands on July 6, 2022. This was the first visit to Calf and Mud Islands by MNFI staff.

We collected data on rare and invasive plant species using applications on a Samsung tablet, augmented by hand-written field notes. For rare plant species we used a custom Survey123 form, "MNFI Rare Species App Form" (see Appendix E in USFWS 2021). In this form, we collected data on population parameters including an estimate of abundance and proportion of fertile plants; habitat, including natural community designation and dominant species; any notable microhabitat features; and threats such as invasive species. Refuge staff have access to rare species data through the USFWS subscription to the Michigan Natural Heritage Database. Floristic surveys were completed by recording species lists in a field notebook. Nomenclature follows Voss and Reznicek (2012).

For target and select non-target invasive plant species in high-quality natural communities, and for select invasive species occurrences outside high-quality natural communities, we mapped invasive plant species occurrences as a point, line, or polygon using the ArcCollector Web Map "R3 Invasive and Weed Observations layer" managed by the USFWS (see Appendix F in USFWS 2021). In this form, we estimated the percent of mapped area occupied by each invasive plant species, and observer data (e.g., name of observer, observation date). We also noted the presence and abundance of target and select non-target invasive plant species occurring in degraded areas in field notebooks. Refuge staff have access to invasive species data through the USFWS R3 portal on ArcGIS Online.

Ranking and assessment

We assessed the viability of each rare plant EO using standard Natural Heritage Methodology (NatureServe 2002). According to this methodology, each EO is assigned

Table 3. Rare plant species targeted and observed during our surveys. See Appendix 1 for G/S and EO Rank definitions. Species observed during our surveys in **bold**.

Scientific Name	Common Name	State Status	G/S Rank	EOID	EO Rank	Year Last Observed	Natural Communities
Astragalus neglectus	**Cooper's milk-vetch**	**SC**	**G5/S1S2**	**26357**	**BC**	**2022**	**mesic southern forest**
Carex squarrosa	Squarrose sedge	SC	G4G5/S1	12587	BC	2015	wet-mesic flatwoods
Carex trichocarpa	Hairy-fruited sedge	SC	G4/S2	20408	BC	2015	Great Lakes marsh
Strophostyles helvula	Trailing wild bean	SC	G5/S3	12921	E	2014	Great Lakes marsh

a rank from A (excellent estimated viability/ecological integrity) to D (poor estimated viability/ecological integrity) when sufficient data is available to assess a rank. When data is not available and for instances where an EO is not located, additional ranks include E (Verified extant), F (Failed to find), H (Historical), and X (Extirpated). See Appendix 1.2 for EO Rank definitions.

Finally, we conducted Floristic Quality Assessments (FQAs) for each island (Reznicek et al. 2014). The FQA utilizes plant species composition to derive the Floristic Quality Index (FQI), a quantitative metric of habitat quality that can be used as a relatively objective comparison among natural community occurrences of a type. Drawing upon expert consensus among botanists familiar with the flora of Michigan, each vascular plant species in Michigan has been assigned an a priori coefficient of conservatism (C-value) that ranges from 0 to 10 on a scale of increasing conservatism or fidelity to pre-European colonization habitats (Reznicek et al. 2014). Plant species with a C-value of 7-10 are considered highly conservative (Herman et al. 2001). A C-value of 4-6 indicates moderate conservatism and a C-value of 0-3 indicates low or no conservatism (e.g., ruderal species). Non-native species were given a C-value of 0 for these calculations. We calculated FQI for each habitat as

$$FQI = \overline{C} \times \sqrt{n}$$

where $\overline{C}$ = mean C-value and n = species richness. Sites with an FQI of 35 or greater are generally considered to be florstically important from a statewide perspective (Herman et al. 2001).

Cooper's milk-vetch (*Astragalus neglectus*, Special Concern) [redacted].

Results and Discussion

Across Calf and Mud Islands in the Detroit River IWR, we documented one rare plant species EO (Table 3), conducted FQAs for both islands (Table 4), and documented occurrences of 24 invasive plant species (Table 5).

Calf Island

We recorded 126 plant species on Calf Island, with a mean coefficient of conservatism of 2.3 (Table 4, Appendix 2.1). We did not differentiate natural communities on this 11-acre island, as it was less than 25 acres. Calf Island displayed geomorphological variation typical of floodplain forest, with higher ground supporting species associated with mesic and dry-mesic forests, grading to inundated, semi-open marshes. As a result, this island supports a diversity of plant species adapted to the variation in topography, soils, hydrology, and light availability.

We documented one rare plant species on Calf Island, Cooper's milk-vetch (*Astragalus neglectus*, Special Concern) (Table 3, Figure 2). Cooper's milk-vetch is associated with an ecotone between upland forest and marsh, and occurs very locally in filtered light along the western shore of Calf Island.

We documented 18 invasive species on Calf Island (Table 5, Figure 3). Ten of these were target invasive species, including black alder (*Alnus glutinosa*), Canada thistle (*Cirsium arvense*), glossy buckthorn (*Frangula alnus*), common privet (*Ligustrum vulgare*), bush honeysuckle (*Lonicera* spp.), reed canary grass (*Phalaris arundinacea*), invasive reed (*Phragmites australis* subsp. *australis*), common buckthorn (*Rhamnus cathartica*), and multiflora rose (*Rosa multiflora*). Of these target species, bush honeysuckle, common privet, and common buckthorn were abundant throughout the entire island and were not mapped. We mapped eight non-target invasive species: Norway maple (*Acer platanoides*), autumn olive (*Elaeagnus umbellata*), spindle tree (*Euonymus europaeus*), winter creeper (*Euonymus fortunei*), purple loosestrife (*Lythrum salicaria*), white sweet-clover (*Melilotus albus*), curly pondweed (*Potamogeton crispus*), jetbead (*Rhodotypos scandens*), and invasive cat-tail (*Typha* spp.). We considered each of these species, with the possible exceptions of Canada thistle and white sweet-clover, to be significant threats to biodiversity on Calf Island, particularly to the Cooper's milk-vetch. A sustained control management strategy should be considered within at least a 100-meter buffer around this species. Additional considerations for managing invasive species may include sustained control or elimination of species such as black alder that disperse rapidly through river systems, to limit regional spread of such species. We recommend using the principles of integrated pest management to guide the investment of resources (USFWS Cal-IPC 2018).

We observed 25 other non-native species on Calf Island, which we did not consider to be a management priority so did not map. These included white mulberry (Morus alba), bittersweet nightshade (Solanum dulcamara), curly dock (Rumex crispus), common dandelion (Taraxacum officinale), common St. John's wort (Hypericum perforatum), and ox-eye daisy (Leucanthemum vulgare)

Table 4. Floristic quality summaries for Calf and Mud Islands. SR = species richness (% native in parentheses); C = mean coefficient of conservatism; FQI = floristic quality index.

	Calf	Mud
SR	126 (66%)	68 (52%)
C	2.3	1.1
FQI	25.8	9.1

Mud Island

We recorded 69 plant species on Mud Island, with a mean coefficient of conservatism of 1.1 (Table 4, Appendix 2.2). We did not differentiate natural communities on this 21-acre island, as it was less than 25 acres. Furthermore, at least the upper substrate of Mud Island is largely of anthropogenic origin, formed from dredged river bottom (Detroit Free Press 1912). Only 51% of the species documented on Mud Island were native species, and native species populations were typically low in density, compared to non-native and especially to invasive species. We did not document any rare plant species on Mud Island.

We documented 17 invasive plant species on Mud Island (Table 5, Figure 4). Eleven of these were target species, including bush honeysuckle, garlic mustard (*Alliaria petiolata*), black alder, Japanese barberry (*Berberis thunbergii*), Oriental bittersweet (*Celastrus orbiculatus*), Canada thistle, autumn olive, glossy buckthorn, invasive reed, common buckthorn, and multiflora rose. Bush honeysuckle was ubiquitous across the island and thus not mapped. We also mapped six non-target species: Norway maple, tree-of-heaven (*Ailanthus altissima*), winter creeper, white sweet-clover, yellow sweet-clover (*Melilotus officinalis*), and invasive cat-tail. Some of the most abundant invasives included invasive reed, tree-of-heaven, garlic mustard, honeysuckle, and glossy buckthorn.

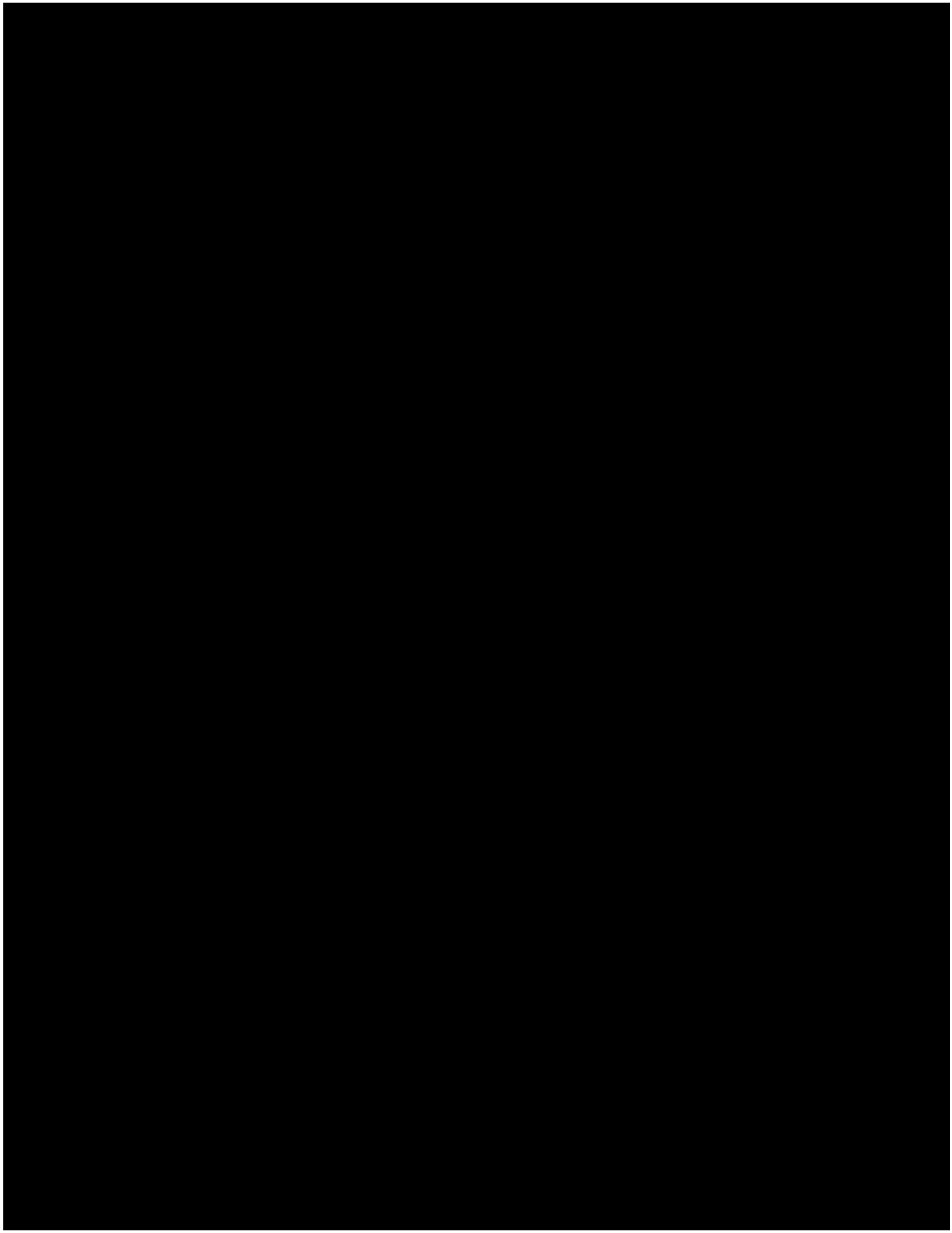

Figure 2. Location of Cooper's milk-vetch (*Astragalus neglectus*, Special Concern) on Calf Island.

Table 5. Invasive plant species observed on Calf and Mud Islands with abundance estimates. Species in bold are USFWS Great Lakes Region target invasive species. Abundance estimates in **bold** indicate very common.

Scientific Name	Common Name	Calf	Mud
Acer platanoides	Norway maple	rare	rare
Ailanthus altissima	Tree-of-heaven		**abundant**
Alliaria petiolata	**Garlic mustard**		**abundant**
Alnus glutinosa	**Black alder**	**locally abundant**	rare
Berberis thunbergii	**Japanese barberry**		rare
Celastrus orbiculatus	**Oriental bittersweet**		rare
Cirsium arvense	**Canada thistle**	**locally abundant**	**abundant**
Elaeagnus umbellata	**Autumn olive**	occasional	frequent
Euonymus europaeus	Spindle tree	rare	
Euonymus fortunei	Winter creeper	rare	occasional
Frangula alnus	**Glossy buckthorn**	**abundant**	**abundant**
Ligustrum vulgare	**Common privet**	**abundant**	
Lonicera spp.	**Bush honeysuckle**	**abundant**	**abundant**
Lythrum salicaria	Purple loosestrife	rare	
Melilotus albus	White sweet-clover	frequent	rare
Melilotus officinalis	Yellow sweet-clover		rare
Phalaris arundinacea	**Reed canary grass**	occasional	
Phragmites australis subsp. australis	**Invasive reed**	rare	**locally abundant**
Potamogeton crispus	Curly pondweed	rare	
Rhamnus cathartica	**Common buckthorn**	**abundant**	frequent
Rhodotypos scandens	Jetbead	rare	
Rosa multiflora	**Multiflora rose**	occasional	frequent
Typha spp.	Invasive cat-tail	rare	rare

We considered invasive species treatment to generally be a low priority here, given Mud Island's likely anthropogenic origin and ruderal status (e.g., FQI = 9.1 and $\overline{C}$ = 1.1) One exception is tree-of-heaven. The Mud Island population could be a significant regional seed source, and the species serves as a host for the invasive insect spotted lanternfly (*Lycorma delicatula*), which is a threat to not only the natural communities of Michigan but to agricultural sectors like Christmas tree production and fruit crops (Dara et al. 2015, Wakie et al. 2020). We recommend starting control efforts by controlling the tree-of-Heaven along the island perimeter and then shifting to eradicating the species in the island's interior.

We observed 17 other non-native species on Mud Island which we did not consider to be a priority so did not map. These species included white mulberry (*Morus alba*), helleborine (*Epipactis helleborine*), bittersweet nightshade (*Solanum dulcamara*), common mullein (*Verbascum thapsus*), Queen Anne's lace (*Daucus carota*), and butter-and-eggs (*Linaria vulgaris*) (Appendix 2.2).

Prairie rose (*Rosa setigera*), one of the few conservative plant species on Mud Island.

Figure 3. Invasive plant species mapped on Calf Island. Bush honeysuckle (*Lonicera* spp.), common privet (*Ligustrum vulgare*), and common buckthorn (*Rhamnus cathartica*) were ubiquitous, and thus not mapped. Glossy buckthorn (*Frangula alnus*) was abundant, thus comprehensive mapping was infeasible.

Left: Cooper's milk-vetch (*Astragalus neglectus*, Special Concern) on Calf Island is threatened by invasive species, white sweet clover (*Melilotus albus*) (bottom right) and Canada thistle (*Cirsium arvense*) (lavender flowers). *Right*: Reed canary grass (*Phalaris arundinacea*) in marshy northern portion of Calf Island. Photos by Scott M. Warner.

Black alder (*Alnus glutinosa*) forms a dense thicket on the north end of Calf Island. Photo by Scott M. Warner.

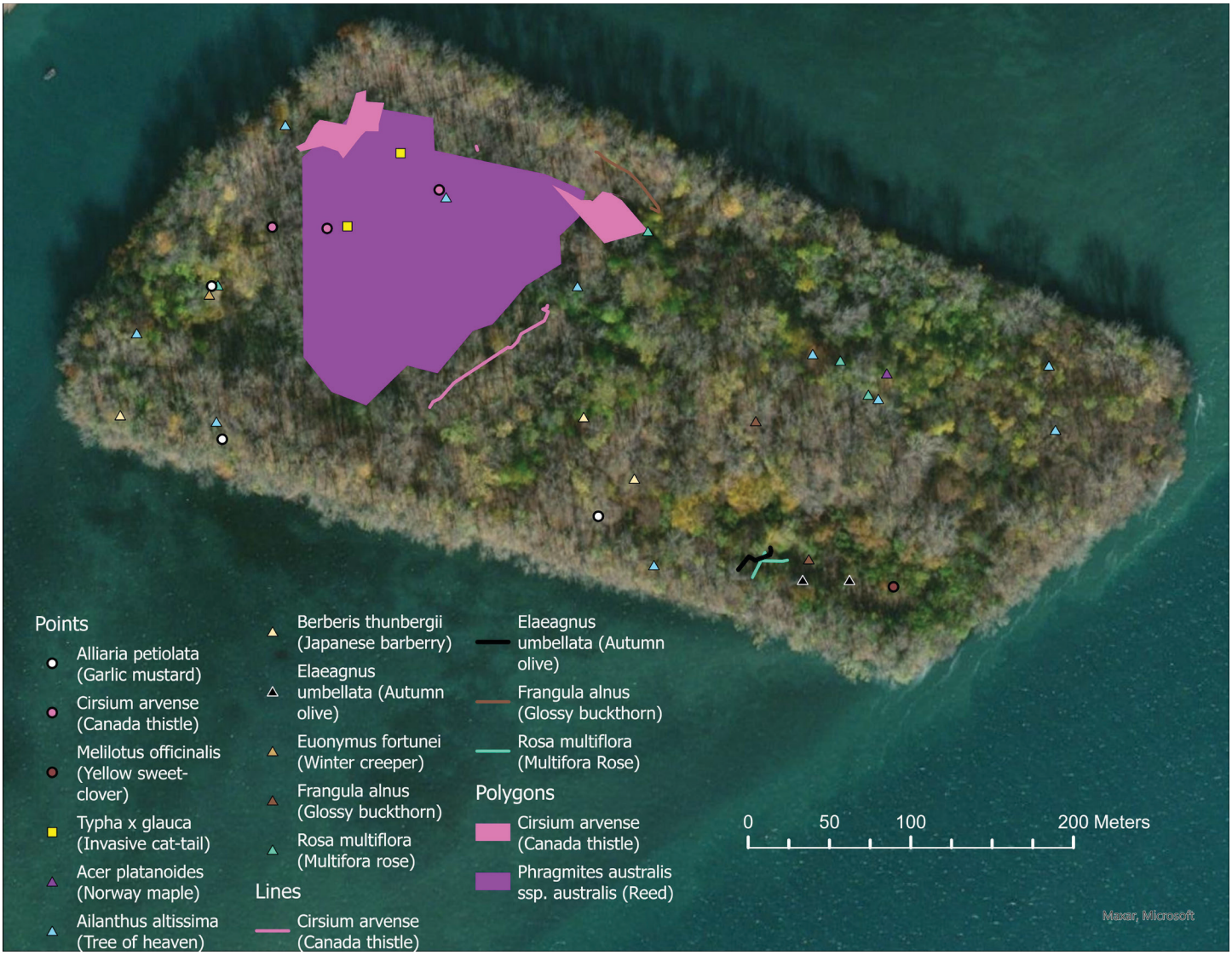

Figure 4. Invasive plant species mapped on Mud Island. Certain species were too abundant for comprehensive mapping, and are thus underrepresented on the map: tree-of-heaven (*Ailanthus altissima*), garlic mustard (*Alliaria petiolata*), glossy buckthorn (*Frangula alnus*), bush honeysuckle (*Lonicera* spp.), and Canada thistle (*Cirsum arvense*).

Invasive shrubs such as bush honeysuckle (*Lonicera* spp.) dominate the interior of Mud Island. Photo by Scott M. Warner.

Conclusion

We conducted botanical surveys on two islands in the Detroit River IWR to collect new data for rare and invasive plant species occurrences. Data on the extent and distribution of these occurrences was collected to guide management prioritization and serve as a baseline for tracking the efficacy of that management. Management priorities across Detroit River IWR are outlined in the context of individual islands in this report. Here, we summarize these priorities, emphasizing the conservation of rare plant species as a factor for guiding management.

We documented one rare plant species on Calf Island during our surveys, and none on Mud Island. A localized population of Cooper's milk-vetch (*Astragalus neglectus*, Special Concern) was discovered [redacted]. This is the first report of this species from both the Detroit River and Wayne County (Reznicek et al. 2011, MNFI 2023). Reducing woody encroachment and canopy closure to prevent shading will benefit this population of Cooper's milk-vetch, as will limiting competition from invasive species. This species should be sought elsewhere in sunny aspects in mineral soil on nearby islands or undeveloped sections of floodplain along the Detroit River.

Floristic quality of natural community occurrences can help managers to prioritize systems with the greatest native plant diversity. Natural community occurrences with an FQI greater than 35 are considered management priorities with exceptional floristic quality (Herman et al. 2001). Floristic quality was not exceptional on Calf and Mud Islands (Table 4). Due to its anthropogenic origin, Mud Island is not comprised of any natural community, so considerations of floristic quality have little bearing. Calf Island has characteristics of a floodplain forest natural community, supporting both mesic upland forest and marsh. Due to the small size of the island, we did not document separate lists for uplands and marsh on Calf Island. The mean C-value is still a valuable metric for assessing floristic quality in sites that span natural community boundaries. The mean C-value is low for both Calf and Mud Islands ($\overline{C}$ = 2.3 and 1.1, respectively), indicating low floristic quality.

The prioritization of invasive species management is best focused on conserving high-quality natural communities and rare species. Due to the ruderal nature of Mud Island, and low floristic quality of Calf Island, neither island is a high regional priority for invasive species management. However, Calf Island does support a diverse native plant community for its small size, and one population of state special concern Cooper's milk-vetch that warrants protection. Management should be considered for species such as invasive reed (*Phragmites australis* subsp. *australis*), black alder (*Alnus glutinosa*), and tree-of-heaven (*Ailanthus altissima*) that are high regional priorities for control. Tree-of-heaven is also the primary host of the very invasive insect spotted lanternfly (*Lycorma delicatula*), so controlling tree-of-heaven should indirectly control spotted lanternfly (Dara et al 2015). This sap-feeding insect feeds on a wide range of herbaceous and woody species, has the potential to incur widespread agricultural and ecological damage, and is rapidly spreading westward from the Northeastern United States (Dara et al. 2015, Wakie et al. 2020).

Anthropogenic debris, particularly piles of rocks and broken concrete, are common on Mud Island.

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Appendix 1. Element and Element Occurrence Ranking Criteria

Appendix 1.1. Subnational (State) and Global element ranking criteria.

Subnational Rank		DEFINITION
S1	Critically Imperiled	At very high risk of extirpation in the jurisdiction due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors.
S2	Imperiled	At high risk of extirpation in the jurisdiction due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
S3	Vulnerable	At moderate risk of extirpation in the jurisdiction due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
S4	Apparently Secure	At a fairly low risk of extirpation in the jurisdiction due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
S5	Secure	At very low or no risk of extirpation in the jurisdiction due to a very extensive range, abundant populations or occurrences, with little to no concern from declines or threats.
Global Rank		**DEFINITION**
G1	Critically Imperiled	At very high risk of extinction or elimination due to very restricted range, very few populations or occurrences, very steep declines, very severe threats, or other factors.
G2	Imperiled	At high risk of extinction or elimination due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors.
G3	Vulnerable	At moderate risk of extinction or elimination due to a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors.
G4	Apparently Secure	At fairly low risk of extinction or elimination due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of local recent declines, threats, or other factors.
G5	Secure	At very low risk or extinction or elimination due to a very extensive range, abundant populations or occurrences, and little to no concern from declines or threats.
GU	Unrankable	Currently unrankable due to lack of information or due to substantially conflicting information about status or trends. NOTE: Whenever possible (when the range of uncertainty is three consecutive ranks or less), a range rank (e.g., G2G3) should be used to delineate the limits (range) of uncertainty.

Appendix 1.2. Element occurrence ranking criteria.

Rank	Definition
A	**Excellent estimated viability** - Based on current information on EO rank factors (i.e., condition, size, and landscape context) for the EO, it is believed to have an excellent probability of persisting, if current conditions prevail, for a defined period of time, typically 20-100 years (for communities, persistence within the bounds of natural disturbance regimes).
B	**Good estimated viability** - Based on current information on EO rank factors (i.e., condition, size, and Iandscape context) for the EO, it is believed to have a good probability of persisting, if current conditions prevail, for a defined period of time, typically 20-100 years (for communities, persistence within the bounds of natural disturbance regimes).
C	**Fair estimated viability** - Based on current information on EO rank factors (i.e., condition, size, and landscape context) for the EO, it is believed to have a fair probability of persisting, if current conditions prevail, for a defined period of time, typically 20-100 years (for communities, persistence within the bounds of natural disturbance regimes).
D	**Poor estimated viability** - Based on current information on EO rank factors (i.e., condition, size, and landscape context) for the EO, it is believed to have a poor probability of persisting, if current conditions prevail, for a defined period of time, typically 20-100 years (for communities, persistence within the bounds of natural disturbance regimes).
E	**Verified Extant** - EO has been recently verified as still existing, but sufficient information on the factors used to estimate viability of the occurrence has not yet been obtained. Use of the E rank should be reserved for those situations where the occurrence is thought to be extant, but an A, B, C, D, or range rank cannot be assigned.
H	**Historical** - There is a lack of recent[1] field information verifying the continued existence of the EO, such as when the occurrence is based only on historical collections data, or when the occurrence was ranked A, B, C, D, or E at one time and is later, without field survey work, considered to be possibly extirpated due to general habitat loss or degradation of the environment in the area.
F	**Failed to find** - EO has not been found despite a search by an experienced observer at a time and under conditions appropriate for the Element at a Iocation where it was previously reported, but that still might be confirmed to exist at that location with additional field survey efforts. For EOs with vague locational information, the search must include areas of appropriate habitat within the range of locational uncertainty. An F rank, when applicable, supersedes an A, B, C, D, E, or H rank.
X	**Extirpated** - There is documented destruction of the habitat or environment of the EO, or persuasive evidence of its eradication based on adequate survey (i .e. , thorough or repeated survey efforts by one or more experienced observers at times and under conditions appropriate for the Element at that location).
U	**Unrankable** - An EO rank cannot be assigned due to lack of sufficient information on the occurrence.
NR	**Not Ranked** - An EO rank has not yet been assigned to the occurrence.

Appendix 2. Floristic Quality Assessments

We conducted Floristic Quality Assessments (FQAs) for each island (Reznicek et al. 2014). The FQA utilizes plant species composition to derive the Floristic Quality Index (FQI), a quantitative metric of habitat quality that can be used as a relatively objective comparison among natural community occurrences of a type. Drawing upon expert consensus among botanists familiar with the flora of Michigan, each vascular plant species in Michigan has been assigned an a priori coefficient of conservatism (C-value) that ranges from 0 to 10 on a scale of increasing conservatism or fidelity to pre-European colonization habitats (Reznicek et al. 2014). Plant species with a C-value of 7-10 are considered highly conservative (Herman et al. 2001). A C-value of 4-6 indicates moderate conservatism and a C-value of 0-3 indicates low or no conservatism (e.g., ruderal species). Non-native species were given a C-value of 0 for these calculations. We calculated FQI for each habitat as

$$FQI = \overline{C} \times \sqrt{n}$$

where $\overline{C}$ = mean C-value and n = species richness. Sites with an FQI of 35 or greater are generally considered to be florstically important from a statewide perspective (Herman et al. 2001).

Appendix 2.1. Calf Island FQA.

Conservatism-Based Metrics:

Total Mean C:	2.3
Native Mean C:	3.5
Total FQI:	25.8
Native FQI:	31.9
Adjusted FQI:	28.4
% C value 0:	37.3
% C value 1-3:	31
% C value 4-6:	27
% C value 7-10:	4.8
Native Tree Mean C:	4.1
Native Shrub Mean C:	3
Native Herbaceous Mean C:	3.5

Species Richness:

Total Species:	126	
Native Species:	83	65.90%
Non-native Species:	43	34.10%

Species Wetness:

Mean Wetness:	0.6
Native Mean Wetness:	-0.1

Physiognomy Metrics:

Tree:	20	15.90%
Shrub:	25	19.80%
Vine:	8	6.30%
Forb:	66	52.40%
Grass:	5	4%
Sedge:	1	0.80%
Rush:	1	0.80%
Fern:	0	0%
Bryophyte:	0	0%

Duration Metrics:

Annual:	13	10.30%
Perennial:	107	84.90%
Biennial:	6	4.80%
Native Annual:	9	7.10%
Native Perennial:	73	57.90%
Native Biennial:	1	0.80%

Appendix 2.1. Calf Island FQA, continued.

Scientific Name	Common Name	Acronym	Native?	C	W
Acer platanoides	norway maple	ACEPLA	non-native	0	5
Acer saccharinum	silver maple	ACESAI	native	2	-3
Acer saccharum	sugar maple	ACESAU	native	5	3
Ageratina altissima	white snakeroot	AGEALT	native	4	3
Alnus glutinosa	black alder	ALNGLU	non-native	0	-3
Amelanchier sanguinea	round-leaved serviceberry	AMESAN	native	5	5
Amorpha fruticosa	false indigo	AMOFRU	non-native	0	-3
Anemone virginiana	thimbleweed	ANEVIR	native	3	3
Asclepias incarnata	swamp milkweed	ASCINC	native	6	-5
Astragalus neglectus	coopers milk-vetch	ASTNEG	native	9	3
Barbarea vulgaris	yellow rocket	BARVUL	non-native	0	0
Calystegia sepium	hedge bindweed	CALSEP	native	2	0
Carex cephalophora	sedge	CXCEPP	native	3	3
Carpinus caroliniana	blue-beech	CARCAO	native	6	0
Carya laciniosa	shellbark hickory	CARLAC	native	9	-3
Carya ovata	shagbark hickory	CAROVA	native	5	3
Celtis occidentalis	hackberry	CELOCC	native	5	0
Circaea canadensis	enchanters-nightshade	CIRCAN	native	2	3
Cirsium arvense	canada thistle	CIRARV	non-native	0	3
Cirsium vulgare	bull thistle	CIRVUL	non-native	0	3
Comandra umbellata	bastard-toadflax	COMUMB	native	5	3
Conyza canadensis	horseweed	CONCAN	native	0	3
Cornus amomum	silky dogwood	CORAMO	native	2	-3
Cornus drummondii	rough-leaved dogwood	CORDRU	native	6	0
Cornus foemina	gray dogwood	CORFOE	native	1	0
Cornus sericea	red-osier	CORSER	native	2	-3
Cuscuta gronovii	common dodder	CUSGRO	native	3	-3
Daucus carota	queen-annes-lace	DAUCAR	non-native	0	5
Desmodium marilandicum	small-leaved tick-trefoil	DESMAR	native	7	5
Dichanthelium implicatum	panic grass	DICIMP	native	3	0
Elaeagnus umbellata	autumn-olive	ELAUMB	non-native	0	3
Elodea canadensis	common waterweed	ELOCAN	native	1	-5
Epilobium coloratum	cinnamon willow-herb	EPICOL	native	3	-5
Epilobium parviflorum	willow-herb	EPIPAR	non-native	0	-5
Epipactis helleborine	helleborine	EPIHEL	non-native	0	0
Erechtites hieraciifolius	fireweed	EREHIE	native	2	3
Erysimum cheiranthoides	wormseed mustard	ERYCHE	non-native	0	3
Euonymus europaeus	spindle tree	EUOEUR	non-native	0	5
Euonymus fortunei	wintercreeper	EUOFOR	non-native	0	5
Eupatorium perfoliatum	boneset	EUPPER	native	4	-3
Frangula alnus	glossy buckthorn	FRAALN	non-native	0	0
Fraxinus nigra	black ash	FRANIG	native	6	-3
Fraxinus pennsylvanica	red ash	FRAPEN	native	2	-3
Geranium maculatum	wild geranium	GERMAC	native	4	3
Geum canadense	white avens	GEUCAN	native	1	0
Heuchera americana	alum root	HEUAME	native	8	3

Appendix 2.1. Calf Island FQA, continued.

Scientific Name	Common Name	Acronym	Native?	C	W
Hylotelephium telephium	live-forever	HYLTEL	non-native	0	5
Hypericum perforatum	common st. johns-wort	HYPPER	non-native	0	5
Impatiens capensis	spotted touch-me-not	IMPCAP	native	2	-3
Juncus tenuis	path rush	JUNTEN	native	1	0
Lespedeza violacea	bush-clover	LESVIO	native	7	5
Leucanthemum vulgare	ox-eye daisy	LEUVUL	non-native	0	5
Ligustrum vulgare	common privet	LIGVUL	non-native	0	3
Lonicera morrowii	morrow honeysuckle	LONMOR	non-native	0	3
Lycopus americanus	common water horehound	LYCAME	native	2	-5
Lysimachia ciliata	fringed loosestrife	LYSCIL	native	4	-3
Lythrum salicaria	purple loosestrife	LYTSAL	non-native	0	-5
Maianthemum racemosum	false spikenard	MAIRAC	native	5	3
Maianthemum stellatum	starry false solomon-seal	MAISTE	native	5	0
Medicago lupulina	black medick	MEDLUP	non-native	0	3
Melilotus albus	white sweet-clover	MELALB	non-native	0	3
Menispermum canadense	moonseed	MENCAE	native	5	0
Mimulus ringens	monkey-flower	MIMRIN	native	5	-5
Morus alba	white mulberry	MORALB	non-native	0	3
Oenothera biennis	common evening-primrose	OENBIE	native	2	3
Parthenocissus quinquefolia	virginia creeper	PARQUI	native	5	3
Penthorum sedoides	ditch stonecrop	PENSED	native	3	-5
Persicaria hydropiper	water-pepper	PERHYR	native	1	-5
Persicaria punctata	smartweed	PERPUN	native	5	-5
Phalaris arundinacea	reed canary grass	PHAARU	native	0	-3
Phragmites australis var. australis	reed	PHRAUU	non-native	0	-3
Phytolacca americana	pokeweed	PHYAME	native	2	3
Plantago major	common plantain	PLAMAJ	non-native	0	3
Poa compressa	canada bluegrass	POACOM	non-native	0	3
Podophyllum peltatum	may-apple	PODPEL	native	3	3
Populus deltoides	cottonwood	POPDEL	native	1	0
Potamogeton crispus	pondweed	POTCRI	non-native	0	-5
Potentilla norvegica	rough cinquefoil	POTNOR	native	0	0
Potentilla recta	rough-fruited cinquefoil	POTREC	non-native	0	5
Prunus avium	sweet cherry	PRUAVI	non-native	0	5
Prunus serotina	wild black cherry	PRUSER	native	2	3
Prunus virginiana	choke cherry	PRUVIR	native	2	3
Quercus alba	white oak	QUEALB	native	5	3
Quercus rubra	red oak	QUERUB	native	5	3
Ranunculus abortivus	small-flowered buttercup	RANABO	native	0	0
Ranunculus sceleratus	cursed crowfoot	RANSCE	native	1	-5
Rhamnus cathartica	common buckthorn	RHACAT	non-native	0	0
Rhodotypos scandens	jetbead	RHOSCA	non-native	0	5
Rhus typhina	staghorn sumac	RHUTYP	native	2	3
Rosa multiflora	multiflora rose	ROSMUL	non-native	0	3
Rosa palustris	swamp rose	ROSPAL	native	5	-5
Rosa setigera	prairie rose	ROSSET	native	5	3

Appendix 2.1. Calf Island FQA, continued.

Scientific Name	Common Name	Acronym	Native?	C	W
Rubus setosus	bristly blackberry	RUBSET	native	3	-3
Rudbeckia hirta	black-eyed susan	RUDHIR	native	1	3
Rumex crispus	curly dock	RUMCRI	non-native	0	0
Salix amygdaloides	peach-leaved willow	SALAMY	native	3	-3
Salix discolor	pussy willow	SALDIS	native	1	-3
Salix exigua	sandbar willow	SALEXI	native	1	-3
Sambucus canadensis	elderberry	SAMCAN	native	3	-3
Scutellaria lateriflora	mad-dog skullcap	SCULAT	native	5	-5
Senecio vulgaris	common groundsel	SENVUL	non-native	0	3
Solanum dulcamara	bittersweet nightshade	SOLDUL	non-native	0	0
Solidago altissima	tall goldenrod	SOLALT	native	1	3
Sonchus oleraceus	common sow-thistle	SONOLE	non-native	0	3
Stachys hispida	hedge-nettle	STAHIS	native	5	-3
Symphyotrichum cordifolium	heart-leaved aster	SYMCOR	native	4	5
Symphyotrichum laeve	smooth aster	SYMLAE	native	5	3
Symphyotrichum ontarionis	lake ontario aster	SYMONT	native	6	0
Syringa vulgaris	common lilac	SYRVUL	non-native	0	5
Taenidia integerrima	yellow-pimpernel	TAEINT	native	8	5
Taraxacum officinale	common dandelion	TAROFF	non-native	0	3
Thalictrum dioicum	early meadow-rue	THADIO	native	6	3
Tilia americana	basswood	TILAME	native	5	3
Toxicodendron radicans	poison-ivy	TOXRAD	native	2	0
Trifolium repens	white clover	TRIREP	non-native	0	3
Typha Ã—glauca	hybrid cat-tail	TYPGLA	non-native	0	-5
Ulmus americana	american elm	ULMAME	native	1	-3
Urtica dioica	stinging nettle	URTDIO	native	1	0
Verbascum thapsus	common mullein	VERTHA	non-native	0	5
Verbena hastata	blue vervain	VERHAS	native	4	-3
Veronica anagallis-aquatica	water speedwell	VERANA	native	4	-5
Viburnum lantana	wayfaring tree	VIBLAN	non-native	0	5
Viburnum lentago	nannyberry	VIBLEN	native	4	0
Viburnum opulus	european highbush-cranberry	VIBOPU	non-native	0	-3
Vitis riparia	river-bank grape	VITRIP	native	3	0
Vulpia octoflora	six-weeks fescue	VULOCT	native	5	3

Appendix 2.2. Mud Island FQA.

Conservatism-Based Metrics:

Total Mean C:	1.1
Native Mean C:	2.2
Total FQI:	9.1
Native FQI:	13
Adjusted FQI:	15.7
% C value 0:	52.2
% C value 1-3:	37.7
% C value 4-6:	10.1
% C value 7-10:	0
Native Tree Mean C:	1.9
Native Shrub Mean C:	3.5
Native Herbaceous Mean C:	2.2

Species Richness:

Total Species:	69	
Native Species:	35	50.70%
Non-native Species:	34	49.30%

Species Wetness:

Mean Wetness:	1.4
Native Mean Wetness:	0.1

Physiognomy Metrics:

Tree:	14	20.30%
Shrub:	8	11.60%
Vine:	5	7.20%
Forb:	35	50.70%
Grass:	3	4.30%
Sedge:	3	4.30%
Rush:	0	0%
Fern:	1	1.40%
Bryophyte:	0	0%

Duration Metrics:

Annual:	11	15.90%
Perennial:	51	73.90%
Biennial:	7	10.10%
Native Annual:	7	10.10%
Native Perennial:	27	39.10%
Native Biennial:	1	1.40%

Appendix 2.2. Mud Island FQA, continued.

Scientific Name	Common Name	Acronym	Native?	C	W
Acer negundo	box-elder	ACENEG	native	0	0
Acer platanoides	norway maple	ACEPLA	non-native	0	5
Acer saccharinum	silver maple	ACESAI	native	2	-3
Ailanthus altissima	tree-of-heaven	AILALT	non-native	0	5
Alliaria petiolata	garlic mustard	ALLPET	non-native	0	3
Alnus glutinosa	black alder	ALNGLU	non-native	0	-3
Apocynum androsaemifolium	spreading dogbane	APOAND	native	3	5
Arctium minus	common burdock	ARCMIN	non-native	0	3
Asclepias exaltata	poke milkweed	ASCEXA	native	6	5
Asclepias syriaca	common milkweed	ASCSYR	native	1	5
Berberis thunbergii	japanese barberry	BERTHU	non-native	0	3
Betula pendula	european white birch	BETPEN	non-native	0	3
Boehmeria cylindrica	false nettle	BOECYL	native	5	-5
Botrypus virginianus	rattlesnake fern	BOTVIR	native	5	3
Carex blanda	sedge	CXBLAN	native	1	0
Carex vulpinoidea	sedge	CXVULP	native	1	-5
Carpinus caroliniana	blue-beech	CARCAO	native	6	0
Celastrus orbiculatus	oriental bittersweet	CELORB	non-native	0	5
Chenopodium album	lambs-quarters	CHEALB	non-native	0	3
Circaea canadensis	enchanters-nightshade	CIRCAN	native	2	3
Cirsium arvense	canada thistle	CIRARV	non-native	0	3
Conyza canadensis	horseweed	CONCAN	native	0	3
Daucus carota	queen-annes-lace	DAUCAR	non-native	0	5
Echinochloa muricata	barnyard grass	ECHMUR	native	1	-5
Elaeagnus umbellata	autumn-olive	ELAUMB	non-native	0	3
Epilobium ciliatum	willow-herb	EPICIL	native	3	-3
Epipactis helleborine	helleborine	EPIHEL	non-native	0	0
Erechtites hieraciifolius	fireweed	EREHIE	native	2	3
Euonymus fortunei	wintercreeper	EUOFOR	non-native	0	5
Frangula alnus	glossy buckthorn	FRAALN	non-native	0	0
Hackelia virginiana	beggars lice	HACVIR	native	1	3
Linaria vulgaris	butter-and-eggs	LINVUL	non-native	0	5
Lonicera maackii	amur honeysuckle	LONMAA	non-native	0	5
Lonicera morrowii	morrow honeysuckle	LONMOR	non-native	0	3
Lycopus uniflorus	northern bugle weed	LYCUNI	native	2	-5
Melilotus albus	white sweet-clover	MELALB	non-native	0	3
Melilotus officinalis	yellow sweet-clover	MELLOF	non-native	0	3
Morus alba	white mulberry	MORALB	non-native	0	3
Nepeta cataria	catnip	NEPCAT	non-native	0	3
Osmorhiza claytonii	hairy sweet-cicely	OSMCLI	native	4	3
Parietaria pensylvanica	pellitory	PARPEN	native	2	3
Persicaria hydropiper	water-pepper	PERHYR	native	1	-5
Phragmites australis var. australis	reed	PHRAUU	non-native	0	-3
Phytolacca americana	pokeweed	PHYAME	native	2	3
Plantago major	common plantain	PLAMAJ	non-native	0	3
Poa annua	annual bluegrass	POAANN	non-native	0	3

Appendix 2.2. Mud Island FQA, continued.

Scientific Name	Common Name	Acronym	Native?	C	W
Populus deltoides	cottonwood	POPDEL	native	1	0
Populus tremuloides	quaking aspen	POPTRE	native	1	0
Potentilla indica	indian-strawberry	POTIND	non-native	0	3
Prunus avium	sweet cherry	PRUAVI	non-native	0	5
Prunus serotina	wild black cherry	PRUSER	native	2	3
Ranunculus sceleratus	cursed crowfoot	RANSCE	native	1	-5
Rhamnus cathartica	common buckthorn	RHACAT	non-native	0	0
Rhus typhina	staghorn sumac	RHUTYP	native	2	3
Rosa multiflora	multiflora rose	ROSMUL	non-native	0	3
Rosa setigera	prairie rose	ROSSET	native	5	3
Sanicula odorata	black snakeroot	SANODO	native	2	0
Schoenoplectus tabernaemontani	softstem bulrush	SCHTAB	native	4	-5
Senecio vulgaris	common groundsel	SENVUL	non-native	0	3
Solanum dulcamara	bittersweet nightshade	SOLDUL	non-native	0	0
Solanum ptychanthum	black nightshade	SOLPTY	native	1	3
Taraxacum officinale	common dandelion	TAROFF	non-native	0	3
Toxicodendron radicans	poison-ivy	TOXRAD	native	2	0
Trifolium campestre	low hop clover	TRICAM	non-native	0	5
Typha latifolia	broad-leaved cat-tail	TYPLAT	native	1	-5
Ulmus americana	american elm	ULMAME	native	1	-3
Urtica dioica	stinging nettle	URTDIO	native	1	0
Verbascum thapsus	common mullein	VERTHA	non-native	0	5
Vitis riparia	river-bank grape	VITRIP	native	3	0