Prioritization Schemes Relevant to Great Lakes Islands and Invasive Species

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Michigan Natural Features Inventory

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Introduction

One of the biggest challenges, yet arguably one of the most important, for the conservation community is prioritizing action so that limited resources are allocated effectively to the most important and pressing needs. This is true for funders, planners, managers, practitioners, and the general public. Not only is there a multitude of important things to be done, but there are also many data gaps to be filled. Prioritization is needed at different scales, based on specific goals and targets and there is no one right answer or silver bullet for determining priorities. Effective, durable prioritization efforts must also intertwine ecological, social and economic factors. There is increased recognition of the importance of latter, but it is no easy task. Our efforts uncovered many examples of prioritization schemes relating to ecological factors, but less information on accounting for social and economic dimensions. However, we point to two examples in our *Case Study* document, that are paving the way for Islanders to integrate social and economic factors: *The Northern Lake Michigan Islands Collaborative* and the *Great lakes Island Alliance*. More work is needed to build this component of the *Island Database*. Here, we present examples of two categories of prioritization, one focused on desirable elements of biodiversity and the other focused on invasive species.

Biodiversity Prioritization Examples

Biodiversity of Michigan's Great Lakes Islands (Soule 1993): Inventory Priorities

Scale: Michigan Islands in the Great Lakes

This example considers Michigan Great Lake islands that lack protection and have significant natural features or high potential for having them but lack adequate inventory. Islands were prioritized for high quality natural community rare plant and/or rare animal surveys. Potential for significant natural features was determined based on known natural features on the island, known physical features of the island and known natural features on neighboring islands and the adjacent mainland.

Soule recommends a *scorecard approach* that was developed by Michigan Natural Features Inventory and The Nature Conservancy in the 1990's to rank protection priorities for sites across Michigan. This process was developed as a site-based scoring process but could be utilized at any scale. This scorecard approach uses the following information:

1. The number of different elements (e.g., rare species, exemplary natural communities, or colonial bird nesting sites)
2. A rank of the quality of each element occurrence relative to all the other occurrences of that element in the state
3. The endangerment status of the element across its entire range (G-rank)
4. The endangerment status of the element in the state (S-Rank)
5. The degree of protection afforded the element in the state, and at the site (e.g., special designations, ownership by conservation entity, etc.)

Islands of Life: A Biodiversity and Conservation Atlas of the Great Lakes Islands (Henson et al. 2010)

Scale: Great Lakes

This system builds upon the scorecard approach recommended by Soule (1993) but puts additional emphasis on species of importance specific to Great Lakes islands, such as colonial waterbirds and foraging shorebirds and waterfowl, migratory birds that use islands as stop-over sites to refuel, and fish. These species are selected because they are significantly or completely reliant on the islands for survival during some part of their life cycle or because islands have a high proportion of their habitat, therefore harboring a high proportion of these species in Michigan. The criteria used for this approach including the specific criteria for these additional species are listed below.

A. Criterion Group: Birds
- Criterion 1: Presence of Nesting Colonial Waterbirds
- Criterion 2: Presence of Roosting, Foraging Shorebirds,
- Criterion 3: Presence of Roosting, Foraging Waterfowl
- Criterion 4: Stop-over Sites for Landbirds

B. Criterion Group: Fish
- Criterion 5: Occurrence of Nursery/Spawning Areas for Native Interjurisdictional Fishes

C. Criterion Group: Endangered and Threatened Species
- Criterion 6: Number of State/Provincial Endangered and Threatened Species
- Criterion 7: Number of Federally Endangered and Threatened Species

D. Criterion Group: Species and Communities of Special Interest
- Criterion 8: Species and Communities Identified in the Conservation Blueprint for the Great Lakes
- Criterion 9: High Quality Sites for a Species or Community

Biological Ranking Criteria for Conservation of Islands in the Laurentian Great Lakes (Ewert et al. 2004)

Scale: Laurentian Great Lakes

This example includes additional elements: endemic, disjunct and declining, but not yet listed species; additional ecological systems criteria, such as the number of different natural ecological systems (not just global and state rare natural community occurrences); ecosystem functions, physical diversity, island size; and distinctiveness.

Species

- C1 Diversity of Rare Species – all extant rare species Element Occurrences (EOs)
- C2 Colonial Nesting Waterbirds
  - C2P1 Diversity of colonial water bird use – known breeding by selected species
  - C2P2 Importance for colonial waterbird populations – top breeding island sites-all spp.
- C3 Global Biodiversity Values – Species
  - C3P1 diversity of G1-G2 species
  - C3P2 diversity of Great Lakes endemic species

C3P3 diversity of Great Lakes disjunct species
C3P4 diversity of Great Lakes declining species
C4 Species at Risk (SAR) – Federal and/or provincial SAR (E, T, SC)

Plant Communities

C5 Diversity of Rare Plant Communities – all extant EOs of plant communities
C6 Diversity of Globally Rare Communities – all extant G1-G3 occurrences

Ecological Systems

C7 Ecological system diversity (terrestrial) – # of different natural ecological systems
C8 Presence of key ecological systems
C9 Presence of key shoreline combination type
C10 Presence of rivers and streams
C11 Presence of wetlands
C12 Presence of lakes

Ecosystem Functions

C13 Isolation – distance from mainland and other classes
C14 Birds
C14P1 Presence of roosting, foraging shorebirds
C14P2 Presence of roosting, foraging waterfowl
C14P3 Stop-over sites for landbirds
C15 Fish Habitat
C15P1 Known occurrences of interjurisdictional fish species
C15P2 Suitable habitat for interjurisdictional fish species

Physical Diversity

C16 Shape Complexity - area:perimeter ratio
C17 Geological Diversity
C17P1 Presence of key geology types
C17P2 Number of different geology types
C18 Shoreline Diversity

Size

C19 Size (island or island complex) - based on 10 natural breaks within a coastal environ.

Distinctiveness

D20 Similarity Index

United Nations Environmental Programme (UNEP)

Scale: Significant islands of the world

This Islands site, hosted by UNEP and assembled by Arthur Dahl, Senior Adviser to the United Nations Environment Programme, provides access to a number of resources concerning islands, primarily from within the United Nations system, that are otherwise rather scattered and difficult to obtain. The island database consists of some 2,000 islands and fields describing their basic geographic, environmental and socio-economic characteristics. Indicators are used to rank islands in various ways. These include additional factors the examples above: coastal index, sea level rise risk, ecosystem richness, species richness, natural protection (e.g., isolation), invasive species, urbanization, human threat, economic pressure and reliability of data.

Explanation of Indicators

The series of simple numerical indicators developed for the Review of the Protected Areas System in Oceania (Dahl, 1986) have been refined and expanded to adapt them to the needs of a world island list. These include indicators for the nature and isolation of the island, for features of conservation interest, for risks to that conservation interest, and for the feasibility of conservation action.

Coastal Index

- a measure of insularity calculated by dividing the length of the shoreline by the land area.

Sea level rise risk

- evaluated as the percentage of the land area less than 5 meters above sea level

Isolation

- Measures the isolation of the island from potential sources of colonization; the square roots of the distances to the nearest equivalent or larger island, the nearest island group or archipelago and the nearest continent are added to give an index of isolation.

Threat

- Number of large-scale catastrophic threats (cyclones, volcanic eruptions, earthquakes, tsunamis, drought, major fires, oil spills) to the island environment.

Natural Protection (NP)

- Rated by a) remoteness (at least 200 km) from the nearest island or other land area; b) not presently inhabited; c) few or no introductions of predatory or competitor species such as feral animals, European rats and aggressive weeds.

Ecosystem Richness (ER)

- Measured as the number of terrestrial or marine ecosystem types or biomes, based where possible on an existing classification or estimated from the island description and structure.

Species Richness (SR)

- The numbers of species of different categories of organisms that occur on an island are an important measure of its biological diversity. The figures most frequently available are for terrestrial plants and/or land birds.

Endemism

- The endemism is rated both for island groups (GE) and individual islands (IE) on the basis of the number of endemic species and sub-species recorded. The two indicators permit identifying both individual islands with endemic species restricted to that island, and islands in a group which may share endemic species with other nearby islands.

Special Features (SpFe)

- Many islands have special features of conservation or tourism importance that need to be highlighted in any evaluation, such as seabird rookeries, turtle nesting beaches, marine mammal breeding areas, lakes, active volcanos, scenic mushroom islets, caves, etc.

Invasive Species (INV)

- The threat represented by invasive introduced species is rated both on the number of such species and their aggressiveness in island situations
- 0 = few or no introductions
- 1 = some introductions (i.e. rats, common weeds)
- 2 = common domestic introductions (dogs, cats, pigs)
- 3 = some problems with invasive species
- 4 = major problems with invasive species
- 5 = devastated by invasive species

Urbanization (UR)

- Based on the proportion of the island population living in urban areas.

Human Threat (HT)

- Estimates the pressure of the local population on the land and resources, based on the percentage of the population in agriculture, mining and fishing.

Economic Pressure (EP)

- This measures the level of economic development based on the Gross Domestic Product, GNP or income per capita (in US$).

Protected Area Coverage (PA)

- The rating for the coverage of the land and marine areas of the island by protected areas.

Reliability of Data (DA)

- It is important to know whether an island situation or local conservation problem is well documented and clearly understood, or only suspected on the basis of inadequate data. The following scale is used to favor islands with problems that are well understood:
    - 0 = no reliable data;
    - 1 = poor data (both partial and out of date);
    - 2 = data only partial or out of date
    - 3 = good recent data (within the last 10 years).

AGGREGATED INDICES

These data for each island are summarized in aggregated indices to give an overall evaluation and to permit comparisons and rankings.

Human Impact (HI)

The Human Impact index measures the overall human pressure or impact on the island and therefore the potential threat to remaining natural areas or endemic species. The HI index is calculated based on the population density, a population trend factor, the Human Threat indicator, the Economic Pressure indicator, the Urbanization indicator, the number of tourists per capita, the Invasive Species rating, and the percentage of developed plus degraded land.

Terrestrial Conservation Importance (CI-T)

The Terrestrial Conservation Importance index is intended to give an overall numerical evaluation of the significance of the land area of the island for the conservation of nature. In a sense the formula tries to reflect the kind of evaluation process used by a conservation planner or a protected area manager in selecting a protected area. The elements of the CI index are: the Ecosystem Richness (ER) indicator, the Species Richness (SR) indicator, the percentage of the land area covered by forest, Island Endemism (IE) and Group Endemism (GE) indicators, the percent endemism of plants and of land birds, measures of threatened species, Special Features (SpFe), the Vulnerability (Vu) and the Natural Protection (NP) indicators.

Summary

There can be many reasons for taking special action to protect an island, and the above choice of measures and weightings may be debatable in particular instances. Overall, however, broadly-based aggregate indices such as these should help to identify and rank the different islands in terms of priorities for conservation and sustainable development action. The Human Impact and Conservation Importance indices can also be combined.

USFWS Midwest Region Coastal Program Focal Area Selection (USFWS 2017)

Scale: Great Lakes

The USFWS Midwest Regional Coastal Program developed an exemplary strategic work plan for 2017-2021 using surrogate species as its foundation (Boyer et al. 2017). They refined their Coastal Program focus areas by intersecting the distribution of coastal surrogate species with locations of important migratory bird stop-over habitat and identifying hotspots of overlap.

The steps used to select focal species and focal areas include the following:

1. Identified a list of Upper Midwest and Great Lake Surrogate Species through extensive vetting process.
2. Initial list: selected surrogate species that occur significantly within Great Lakes coastal habitat.
3. Modified list: added two additional coastally relevant species that were not identified in the surrogate list due to their small range and specific habitat requirements: Hine's emerald dragonfly (LE, T) and dwarf lake iris (LT, T).
4. Final list: identified Coastal Focus Species.
5. Collected shapefiles representing the focal species and important migratory bird stop-over habitat; overlaid these shapefiles.
6. Identified hotspots where multiple species/shapefiles overlapped.
7. Selected geographies based on overlays and Coastal Program knowledge and experience.
8. Added metropolitan areas to help reach a broader constituent base and connect youth with nature.

Focal Species List: Black Tern, Blue-winged Teal, Brook Trout, Canada Warbler, Common Tern, Dwarf Lake Iris, Hine's Emerald Dragonfly, Houghton's Goldenrod, Lake Sturgeon, Monarch, Piping Plover

Focus Areas: Western Lake Superior Focal Areas, Green Bay Focus Area, Straits of Mackinac Focus Area, Western Lake Erie/ Lake St. Clair Focus Area, Saginaw Bay, Urban Opportunity Focus Area

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Prioritization of Natural Community Surveys for Remote Islands (Cohen & Lincoln. 2019)

Scale: individual islands

This example describes a process for prioritizing surveys for high-quality natural communities on North and Fox Islands and Isle Royale, all of which have received some level of survey previously, but not systematical surveys for high-quality natural communities which typically support vulnerable species. These data are not current (North Fox 1986; South Fox 2001) and Isle Royale has never been surveyed for natural communities in spite of its being the largest of Michigan's islands with high heterogeneity. Isle Royale is likely to support high-quality natural communities and associated vulnerable species due to its size and heterogeneity, while at the same time, and with a high number of visitors annually, this increases the likelihood of invasions and their impacts.

Preparation:

- Aerial photo interpretation
- Prior survey effort
- Review of published research on the islands
- Review of state's vegetative mapping system MiFI (Fox Islands only)
- Review of LIDAR for the Fox Islands

Identification of potential survey sites:

- Delineate new and previously documented natural community targets on island aerial imagery

Scoring:

- Rarity of community (higher score for rare ecosystems)
- Inferred integrity (based on literature review, aerial interpretation and date since last survey; higher score for higher inferred integrity)
- Sum scores for each potential site

Results:

- Isle Royale: one hundred and sixty-two site polygons were delineated covering 17 differing natural community types; the top five survey priorities include new potential occurrences of volcanic bedrock glade, volcanic bedrock lakeshore, patterned, mesic northern forest and Great Lakes marsh.
- North Fox: two site polygons were delineated covering four different natural community types; the top five survey priorities include updating and refining three previously known boreal forest, mesic northern forest and northern hardwood swamp occurrences and two new potential occurrences of open dune and sand and gravel beach.
- South Fox: seven site polygons were delineated covering seven different natural community types; the top five survey priorities include updating and refining previously known open dune, mesic northern forest and boreal forest occurrences and three new potential occurrences of Great Lakes barrens and interdunal wetlands.

Summary:

- Surveys will gather detailed information on vegetative structure and composition, landscape and abiotic context, management needs (including invasive species concerns), restoration opportunities and ecological boundaries. These data are needed to inform site-level decisions and landscape level biodiversity planning efforts including the threat of invasive species.

Invasive Species-Based Prioritization Examples

The following examples are focused on prioritizing invasive species. The majority of our findings focus on invasive plants and several different types of categorization emerged from our review. These include: 1) identifying and ranking individual species; 2) identifying invasive species and integrating them with site ranks; 3) ranking *populations* instead of *species* based on the area of concern; and 4) identification of criteria for determining whether to proceed with a particular action or not. We also describe a summary paper that compares invasive plant species ranking systems for the midwestern states. We include one example of a prioritization that includes oceanic vertebrates; however, further research is needed to identify additional examples more specific to invasive animals.

Handbook for Ranking Exotic Plants for Management and Control (Hiebert and Stubbendieck 1993).

This system was one of the earliest ranking systems to receive common recognition and many subsequent systems build off of it. After it was originally published, it was later designed as an automated web-based resource for managers that guides them through a series of 25 questions, divided into three categories:

- Current level of impact
- Potential of a species to become a problem
- Feasibility of control

Users follow these steps:

Step 1. List known and potential alien plants in the area.

Step 2. Survey the site.

Step 3. Search the literature.

Step 4. Fill out the datasheets.

Step 5. Interpret the results.

The questions help gather information related to the distribution and abundance of species, the number of seeds they produce, their dispersal capabilities and known impacts. When the questions have been answered for all the species on or adjacent to the site, the system ranks them according to current impact, potential impact and feasibility of control. A similar process is used by most invasive plant ranking systems today and requires both site specific information and in-depth knowledge of the biology of the species. Currently, ranking is more often done by experts and managers who can then review and select or modify these data, rather than conduct the time-consuming literature searches themselves. It is helpful, however, to see the criteria used for ranking and determine if they are appropriate for the area of consideration.

The Invasive Species Assessment Protocol: A Tool for Creating Regional and National Lists of Invasive Nonnative Plants That Negative Impact Biodiversity (Randall et al. 2008, iMapInvasives 2019, NatureServe Explorer 2019).

This ranking system was designed to compare species that cause high, medium, low or insignificant impacts to native biodiversity at state, regional or national scales. Twenty questions, grouped into four sections, are used to produce an overall invasive species impact rank (I-Rank) by combining scores for the individual categories. The categories used are listed below. Note the following statement from NatureServe now posted on their web site:

"*While I-Rank information remain available over the NatureServe Explorer, NatureServe is not actively developing or maintaining these data. NatureServe continues to provide these data to serve as a reference; however, the data may not represent the current understanding of the effects and management of the invasive species. Since species with I-Ranks do not represent a random sample of exotic species in the United States; available assessments may be biased toward those species that had higher than average impact at the time of the assessment."*

Section 1. Ecological Impact

1. Impact on ecosystem processes and system-wide parameters
2. Impact on ecological community structure
3. Impacts on ecological community composition
4. Impact on individual native plant or animal species
5. Conservation significance of communities and native species threatened

Section 2. Current distribution and abundance

1. Current range size in region
2. Proportion of current range where it negatively impacts biodiversity
3. Proportion of region's biogeographic units invaded
6. Diversity of habits or ecological systems invaded in region

Section 3. Trends in distribution and abundance

1. Current trend in total range within the region
2. Proportion of potential range currently occupied
3. Long-distance dispersal potential within region
4. Local range expansion or change in abundance
5. Inherent ability to invade conservation areas and other native spp. habitat
6. Similar habitats invaded elsewhere
7. Reproductive characteristics

Section IV. Management difficulty

17 General management difficulty
18. Minimum time commitment
19. Impacts of management on native species
20. Accessibility of invaded areas

Whippet: A novel tool for prioritizing invasive plant populations for regional eradication (Skurka Darin et al. 2011).

The authors of the tool assert: most weed prioritization tools guide the prioritization or eradication towards species uniformly across a focus region, which has several limitations in that it frequently directs limited resources towards invasions that may not be the most important or effective to address in a particular area of interest, and misses others that may be critically important in that area such as:

- prioritizes low impact populations
- prioritizes difficult to access populations
- misses high impact populations of lower priority species.

The WHIPPET (Weed heuristics: Invasive Population Prioritization for Eradication Tool) prioritizes weed *populations as well as weed species* asserting that a blended prioritization based on both species attributes and individual population and site parameters results in more effective control. It is designed to direct limited resources to plant infestations (versus species) with the greatest predicted impacts to the focus area.

The tool uses the Analytic Hierarchy Process (Saaty 1990) including expert opinion, to develop three major criteria, sub-criteria and sub-sub-criteria that consider both population and species characteristics, Experts weighted and scored criteria to assess relative impact, potential spread and feasibility of eradication.

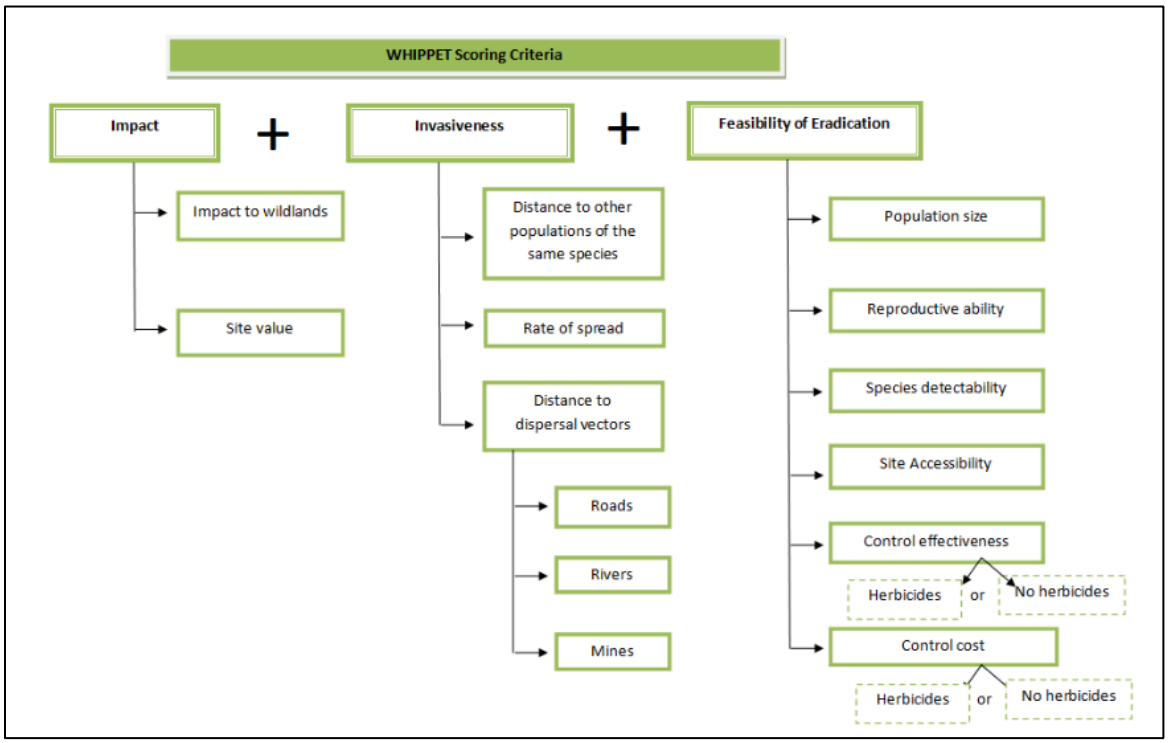
Criteria:

I. Impact:
- Wildlands
- Agriculture
- Human health
- Regional site value
  - Proximity to agricultural commodities at risk
  - Occurrences of rare, threatened or endangered species
  - Important recreation areas
  - Protected federal lands with limited control options

II. Invasiveness: maximum rate of spread
- Distance to propagule sources
- Rate of spread with no management
- Proximity to spread vectors
  - Distance to major roadways
  - Distance to major rivers
  - Distance to mining operations

III. Feasibility of eradication:
- Infestation size
- Reproductive ability
  - Seed production
  - Vegetative reproduction
  - Propagule longevity
  - Length of juvenile phase

    - Length of reproductive phase
- Detectability of invasive species
- Accessibility of infestation site
- Control effectiveness
- Estimated cost of eradication program
    - Driving time to site
    - On-site control cost per area
    - Number of follow-up visits required
    - Other special considerations



The tool does not include suitability of nearby habitat for spread due to lack of data. However, habitat suitability assessments would be a useful follow-up consideration along with a determination of landowner support and treatment history. A guide to the use of this tool can be found here: https://whippet.cal-ipc.org/pages/view/guide.

Prioritizing Species for the Little Bay Bands of Odawa Indians Aquatic Invasive Species Plan (Jansen 2017)

Jansen developed an Aquatic Invasive Species Plan for the Little Bay Band of Odawa Indians (LTBB) lands under their jurisdiction in northwest Lower Peninsula, including properties on High and Garden Island. A component of the plan was to identify and prioritize species for prevention, early detection and response, maintenance and asset-based control. He utilized multiple resources available for the Great Lakes region to assess the threat level of 180 species of

concern to LTTB lands in northeastern Lower Michigan. Below is an excerpt from the plan that describes the process he used, and the resulting species lists for each category.

Species Prioritization

The species prioritization process began with a database of candidate species from the National Oceanic and Atmospheric Administration's (NOAA) Impact Assessment of Great Lakes Aquatic Nonindigenous Species (Sturtevant and colleagues 2014). Additional candidate species were selected from the State of Michigan's invasive species watch list, the list of legally restricted and prohibited species in Michigan, and by using knowledge gained from AIS surveys by LTBB staff and/or colleagues. High threat species reported to be in the vicinity of the LTBB Reservation on the Midwest Invasive Species Information Network (MISIN) website were also included.

In all, 180 species of aquatic algae, plants, fish, mammals, birds, crustaceans, mollusks, and other invertebrates were evaluated. Each species was assigned a threat level between zero (low threat) and five (high threat), and the known geographic extent of each species was evaluated to determine its proximity to the LTBB Reservation. A number of sources were used to determine the level of threat each AIS poses to culturally important species and the extent of each species in the Midwest, in Michigan, and in the counties near the LTBB Reservation. No single source contained information on all candidate species, but by combining multiple sources, each candidate species was able to be evaluated. The sources included the following:

- NOAA Impact Assessment of Great Lakes Aquatic Nonindigenous Species
- Michigan's invasive species watch list
- Michigan's list of legally restricted and prohibited species
- Wisconsin Department of Natural Resources invasive species literature reviews
- Wisconsin's list of legally restricted and prohibited species
- United States Geological Survey (USGS) Nonindigenous Aquatic Species (NAS) online database
- NOAA Great Lakes Aquatic Nonindigenous Species Information System (GLANSIS) online database
- Invasive Plants of the Upper Midwest (Czarapata 2005)
- Invasiveness Assessment Scores and Ranks for 183 Nonnative Plant Species in NYS (Brooklyn Botanic Garden 2013)
- Invasive Plant Atlas of New England website
- The experience of LTTB NRD staff and colleagues

Once the threat level and geographic extent of each species were evaluated, one of four priority levels was assigned to each species. These categories correspond to the IPM goals listed above: Prevention, EDRR, Containment, or Asset-Based Control. Table 4 shows the characteristics of each category, and Tables 5 – 8 show which species are in which of the four priority levels. It should be noted that prevention is always the primary goal for *any* species not currently found within the LTBB Reservation. For example, it is highly desirable to prevent the arrival of any of the EDRR species. However, if an EDRR species is discovered before it is well established, eradication can be attempted using various control methods, but there are no effective treatments for species in the Prevention category. Prevention is the only means of management.

One additional category, "Caution" was added to include high threat species that have not been found in Michigan yet and species of less certain threat level. If any of these species do become problematic in Michigan, they should be added to the Prevention or EDRR category. Species believed to pose little to no threat were not retained on the list.

AIS found on the State of Michigan's Watch List were generally placed in the Prevention and EDRR categories, with a few exceptions for species that are unlikely to survive overwinter as far north as the LTBB Reservation (e.g. water lettuce, water hyacinth, nutria). These cold-intolerant species were placed in the Asset-Based Control and/or Caution categories. The State of Michigan has identified their Watch List species as key priorities for monitoring and EDRR at the state level, and as such, brings in additional resources to prevent the establishment and spread.

Traits characterizing each priority level for AIS on the LTBB Reservation

Prevention	EDRR	Containment	Asset-Based Control
Threat level 2 - 5 (moderately low to high)	Threat level 3 - 5 (moderate to high)	Threat level 2 - 5 (moderately low to high)	Threat level 1 - 5 (low to high)
Not present in the LTBB Reservation or extremely limited	Not present in the LTBB Reservation or extremely limited	Already established in a few sites on the LTBB Reservation	Established in many areas on the LTBB Reservation, or a lower threat species that may or may not be widely established
Eradication extremely difficult - no effective controls or control methods have unacceptably high costs to non-target species	Eradication may be possible if treated early	Eradication extremely difficult - species already well established in some sites on the LTBB Reservation	Eradication likely impossible - species is already well established in many sites on the LTBB Reservation, but control may be warranted to achieve site-specific objectives

AIS in the Prevention Category for the LTBB Reservation

Life Form	Scientific Name	Common Name	State Status	On State Watch List	Threat Level
Alga	*Didymosphenia geminata*	Didymo			5
Crustacean	*Cercopagis pengoi*	Fishhook waterflea			3
Crustacean	*Procambarus clarkii*	Red swamp crayfish		Yes	4
Fish	*Channa argus*	Northern snakehead	Prohibited	Yes	3
Fish	*Ctenopharyngodon idella*	Grass carp	Prohibited	Yes	4
Fish	*Gymnocephalus cernua*	Ruffe	Prohibited		3
Fish	*Hypophthalmichthys noblis*	Bighead carp	Prohibited	Yes	4
Fish	*Hypophthalmicthys molitrix*	Silver carp	Prohibited	Yes	4
Fish	*Lepomis microlophus*	Redear sunfish			2
Fish	*Morone americana*	White perch			3
Fish	*Mylopharyngodon piceus*	Black carp	Prohibited	Yes	3
Fish	*Neogobius melanostomus*	Round goby	Prohibited		3
Fish	*Scardinius erythrophthalmus*	Rudd	Prohibited		2
Mollusks	*Bithynia tentaculata*	Faucet snail			3
Mollusks	*Corbicula fluminea*	Asian clam			2
Mollusks	*Dreissena bugensis*	Quagga mussel	Restricted		5
Mollusks	*Potamopyrgus antipodarum*	New Zealand mudsnail		Yes	3

AIS in the Early Detection and Rapid Response for the LTBB Reservation

Life Form	Scientific Name	Common Name	State Status	On State Watch List	Threat Level
Alga	*Nitellopsis obtusa*	Starry stonewort	Prohibited		4
Plant	*Butomus umbellatus*	flowering rush	Restricted		4
Plant	*Cabomba caroliniana*	Carolina fanwort	Prohibited		4
Plant	*Egeria densa*	Brazilian elodea	Prohibited	Yes	4
Plant	*Hydrilla verticillata*	Hydrilla	Prohibited	Yes	5
Plant	*Hydrocharis morsus-ranae*	European frogbit	Prohibited	Yes	5
Plant	*Impatiens glandulifera*	Ornamental jewelweed	Yes		3
Plant	*Marsilea quadrifolia*	European water clover	Yes		3
Plant	*Myriophyllum aquaticum*	Parrot feather	Prohibited	Yes	4
Plant	*Najas marina*	Spiny naiad			3
Plant	*Najas minor*	Brittle waternymph			4
Plant	*Nymphoides peltata*	Yellow floating-heart	Prohibited	Yes	3
Plant	*Stratiotes aloides*	Water soldier	Prohibited	Yes	4
Plant	*Trapa natans*	Water chestnut	Prohibited	Yes	4

AIS in the Containment Category for the LTBB Reservation

Life Form	Scientific Name	Common Name	State Status	On State Watch List	Threat Level
Bird	*Cygnus olor*	Mute swan			2
Crustacean	*Orconectes rusticus*	Rusty crayfish	Prohibited		3
Mollusks	*Dreissena polymorpha*	Zebra mussel	Restricted		5
Plant	*Cirsium palustre*	marsh thistle			2
Plant	*Frangula alnus*	Glossy buckthorn			4
Plant	*Iris pseudacorus*	Yellow iris			2
Plant	*Lythrum salicaria*	purple loosestrife	Restricted		4
Plant	*Myriophyllum spicatum*	Eurasian watermilfoil	Restricted		4
Plant	*Phragmites australis subsp. australis*	Phragmites	Restricted		5
Plant	*Potamogeton crispus*	Curlyleaf pondweed	Restricted		3
Plant	*Typha angustifolia*	Narrow-leaved cattail			3

AIS in the Asset-Based Control category on the LTBB Reservation

Life Form	Scientific Name	Common Name	State Status	On State Watch List	Threat Level
Fish	*Cyprinus carpio*	Common carp			2
Fish	*Petromyzon marinus*	Sea lamprey			5
Plant	*Alnus glutinosa*	Black alder			2
Plant	*Conium maculatum*	Poison hemlock			1
Plant	*Eichhornia crassipes*	Water hyacinth		Yes	2
Plant	*Epilobium hirsutum*	Great hairy willow herb			3
Plant	*Lysimachia nummularia*	Moneywort			1
Plant	*Myosotis scorpioides*	True forget-me-not			2
Plant	*Phalaris arundinacea*	Reed canary grass			5
Plant	*Pistia stratiotes*	Water lettuce		Yes	1
Plant	*Polygonum persicaria*	Spotted lady's thumb			1
Plant	*Solanum dulcamara*	Bittersweet nightshade			2
Plant	*Solidago semperviren*	Seaside goldenrod			2
Plant	*Veronica beccabunga*	European brooklime			1

Oakland County Pathway Assessment Overlay with Priority Natural Areas (Applied Ecological Services 2017)

A Strategic Invasive Species Management Plan (Applied Ecological Services 2017) was developed for the Oakland County CISMA, through a collaborative planning process including a diverse set of stakeholders. This plan provides an excellent example of compiling and overlaying relevant spatial data layers to rank the threat level posed by invasive species dispersal pathways on high-value sites. The baseline data sets that were compiled included the following:

1) location and extent of state and regional invasive species management areas,
2) jurisdictional boundaries of Oakland County Cities, Villages, and Townships (CVTs),
3) hydrological features (wetlands, waterbodies and watershed boundaries),
4) distribution of natural and cultural land use types (Land Use 2015), and
5) priority natural areas identified by MNFI (2004).

Thirteen additional data layers were then compiled to conduct a pathway assessment, including the following:

Corridors	Sources	Sources
▪ trails	▪ recreational lands	▪ landfills
▪ utility ROW	▪ water courses	▪ extraction sites
▪ railroad ROW	▪ boat landings	▪ agricultural lands
▪ road ROW	▪ bridges	▪ vacant parcels
	▪ cemeteries	

A collaborative stakeholder-scoring process was then utilized to weight the various dispersal pathways, and the resultant data layer was overlaid with the baseline data layers. This provided a spatial view of the weighted dispersal pathways and their proximity to high quality natural areas. This assessment can then be used to prioritize vector, species, and site-based strategies to address priority invasive species in highly valued sites.

The Phragmites Prioritization / Management Tool (EGLE 2014;)

In response to the rapid invasion of invasive phragmites in Michigan, the EGLE (formerly DEQ) Water Resources Division developed a tool to help groups prioritize and manage infestations. The tool is intended primarily for use by coordinated local and regional group efforts and guides users through a series of questions about the distribution of phragmites in the area of concern. The questions are focused in three categories of criteria: ecological, human values, and feasibility/coordination of treatment.

Ecological Criteria

- Region
- Local abundance
- Infestation size
- Linear feature
- Seed source
- Habitat quality

Human Values

- Ownership
- Aesthetics
- Recreational Impacts
- Human safety Hazard

Feasibility/Coordination of Treatment

- Nearby treatment sites
- Difficulty of treatment

This tool provides an excellent framework for thinking about phragmites management priorities and was recently incorporated, in part, in a photo-monitoring protocol proposed for use in a Comprehensive Management Plan for Invasive *Phragmites* in Saginaw Bay (Bourgeau-Chavez and colleagues 2019).

Invasive Plant Inventory and Early Detection Prioritization Tool (IPIEDT) (Olsen et al. 2018)

The IPIEDT resulted from an identified need for improving the process of planning and implementing invasive plant inventories and early detection efforts to improve management on USFWS lands. The USFWS partnered with Utah State University to conduct a series of workshops on National Wildlife Refuges across the United States. One of the outcomes of these workshops was the development of a tool that provides an objective, transparent and documented process for deciding which invasive plant species should be a focus of inventory or early detection and where. The IPIEDT is a Microsoft Access database (2010 or later) and uses site specific knowledge and existing invasive species rankings to produce a ranked list of areas and invasive plant species to consider for inventory or early detection. This tool incorporates both area and species prioritization a shown by the criteria shown below.

Area Prioritization

Area description

- Ecological integrity
- Innate Resistance to invasion
- Area size
- Importance to federal or state-listed species
- Importance to other priority natural resources of conservation conc

Invasion Risk

- Terrestrial pathways
- Aquatic pathways
- Transport vectors
- Anthropogenic disturbance

Invasive Plant Status

- Inventory and monitoring data
- Infestation levels (perceived)
- Number of invasive plant species (perceived)

Species Prioritization

Invasiveness

- Invasiveness rank (using existing system)

Status and Habitat Suitability

- Proximity
- Abundance (perceived)
- Distribution (perceived)
- Potential to spread

Ecological Impacts

- Ecological impacts (current)
- Ecological impacts (potential)

Legal Mandates

- Larger landscape management importance

Species-Area Link

Species Presence/Proximity

- Presence (perceiver)
- Status and distribution (perceived)

Species Habitat Suitability

- Potential to spread

Invasive Plant Management Decision Analysis Tool (IPMDAT) (Zimmerman et al. 2011 (https://ipmdat.org/)

The IPMDAT was developed by The Nature Conservancy and is a computer-based decision analysis tool that helps managers determine whether to implement control or not. It is provided under the iMapInvasives Project (The Nature Conservancy 2019). The tool is based on the following premises:

- The invasive species must cause serious environmental or economic harm or harm to human health.
- The project should be feasible.
- The project should have a good return on the investment of resources.

The user follows these steps:

Step 1: Enters background information on the site

Step 2: Determines if the impact or harm caused warrants control and uses plant's abundance and distribution to determine the appropriate control strategy

Step 3: Determines if the project is feasible by considering the socio-political environment, plant attributes the effectiveness of control methods, and the risk unintended consequences and non-target impacts.

Step 4: Completes a financial assessment to gage the return on investment

The IPMDAT has four possible outcomes:

1) Proceed with control strategy implementation: project has a high probability of success and has conservation value,
2) Stop: secure sustainable funding source,
3) Stop: control not feasible and/or not warranted, or
4) Peer-review required: feasibility and/or conservation value is uncertain

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Risk Assessment for Invasive Plants: A Midwest U.S. Comparison (Buerger et al. 2016)

This paper summarizes and compares plant risk assessment processes for the Great Lake states. Key topics and sub-topics are shown below that capture the overall universe of considerations that are found in at least one or more of these assessments. The paper lists many more specific sub-sub topics within these categories. The paper provides a summary table that lists all of these in the first column, lists the Midwest states across the header row and then marks which items each state's assessment includes.

Broad topics

- Distribution/current invasion status
- Establishment and expansion capabilities: a life history
- Ecological impacts
- Socioeconomic and cultural impacts
- Prevention, control, and management options

Specific question/criteria and subtopics

- **Distribution/current invasion status**
  - Presence in natural areas
  - Habitat and climate areas
  - Regulation and identification in other places
- **Establishment and expansion capabilities: a life history**
  - General plant characteristics
  - Habitat and climate requirements
  - Mode(s) of reproduction
  - Dispersal
  - Maturation and reproductive period
  - Invasion
- **Ecological Impacts**
  - Changes induced in the receiving ecosystem by the species
  - Invasive species' contributing properties
- **Socioeconomic and cultural impacts**
  - General commercial values
  - Agriculture
  - Horticulture
  - Managed and constructed landscapes
  - Safety

- Recreation and culture

- **Prevention, control, and management options**
  - Historic intervention
  - State Prevention
  - State control
  - Evaluation of species for control

How to Select Management Goals for a Species or Site on (Oceanic) Islands (IUCN 2018)

The guidelines below summarize the IUCN's recommended approach for sorting actions and their associated costs for 6 categories of action. A major focus for oceanic islands has been on the eradication of invasive vertebrate species and is reflected in many of the techniques noted below. However, these guidelines are similar to and applicable to approaches for other taxa and invasive species planning scenarios.

Priority	Management Goal	Techniques used	Cost characteristic	Most useful for
1	Prevention	Inspections, trapping, baiting, etc. at points of entry	Cheapest method for multiple species	Species not yet present
2	Eradication	Physical (shooting, trapping, uprooting…), chemical (pesticides), genetic (sterile male, transgenes, etc.)	High initial cost but minimal after eradication achieved	Species present in small areas, including new arrivals.
3	Permanent reduction in population size, vigor or impact	Biological control, genetic pest management	Cost high for new agents, low for well-known ones, and minimal after effective agent established	Widespread, damaging, non-useful species
4	Containment	Physical, chemical, or genetic techniques	Permanent costs	Useful but damaging species; new arrivals
5	Long-term popula-tion management, site-based control, exclusion	Physical, chemical, or genetic techniques; mainland island techniques	Permanent costs	Widespread, damaging species for which goals 1-4 not feasible
6	Mitigation	Direct protection of the value((.e.g., protection of nests or saplings, etc.)	Permanent costs	Species impossible to control)goals 1-5 not feasible)

Summary

The minimum set of criteria needed to address the problem of prioritizing action on Great Lakes Islands include the conservation value of the beneficiary species, invasive species type and threat, island characteristics, and a measure of technical feasibility. Other criteria considered by individual projects include cost, socio-political feasibility, reinvasion risk, and resilience to climate change impacts (Island Conservation for the US National Invasive Species Council Secretariat 2018). The following list summarizes criteria that have been used in one or more of the examples presented above.

Conservation value of beneficiary species/ecosystem

- globally threatened
- Federally threatened
- State threatened
- rarity
- endemism
- shared species, e.g., species that islands have in common; (opportunity to leverage management goals and funding; redundancy of species on different islands increases resiliency)
- ecosystem services
- diversity of ecological systems, physical environments

Strategic value – cost, feasibility of control efforts (or other action), reinvasion potential

- island size or scope
- feasibility of potential alternatives
- partnerships (NGO, state, federal ownership)
- master plan status
- land protection status
- risk assessment (multiple taxa, USDA PPQ WRA, possibility of establishment, vectors; impact types (environmental, socioeconomic, other beneficial; endpoint setting, quantitative or qualitative approach, data gaps, amount of uncertainty); reinvasion risk; non-target impacts or unintended consequences
- resilience, to climate change or other stressors

In addition to finding few examples of prioritization schemes that fully consider criteria for cultural and socio-economic factors, most schemes we reviewed score biodiversity elements independently from invasive species elements. The IUCN system combines biodiversity and invasion criteria into a score for individual oceanic islands, however, it does not include Great Lakes islands, which, although similar in many regards, are in a unique setting with very different site conditions, invasive species of highest concern and socio-economic drivers. The IPIEDT uses existing ranks of invasive species (compiled from other sources) and ties them to area (site) ranks, but it is mainland-focused. It would be useful to conduct a follow-up study to consider the *Island Database* and associated non-spatial data in their entirety to determine if there are unexplored, unique vector, site and species-based criteria specific to Great Lakes islands that could be utilized to better inform invasive species planning.

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