Lake Superior Manoomin Cultural and Ecosystem Characterization Study

Final Report
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1. Introduction

Manoomin (wild rice) is integral to the culture, livelihood, and identity of the Anishinaabe, a group of Indigenous peoples within Canada and the United States. Manoomin grows only in the clean waters of the Gichi-manidoo gitigaan (The Great Spirits Garden). The arrival of the Anishinaabe to the Great Lakes Basin was in fulfillment of the prophecy that guided their migration from the Atlantic Northeast westward toward the Great Lakes to where "food grows on the water." In addition to the vital role of Manoomin in the lives of the Anishinaabe, it is also recognized as being ecologically important. Migrating and resident wildlife feed on Manoomin seeds in wild rice beds, which provide a nursery for many species of fish and serve as nesting and breeding habitats for many waterfowl and muskrat. Many species feed on the plant. Wild rice plants can also help stabilize shorelines (Tribal Wild Rice Task Force, 2018; David et al., 2019).

In this project we aim to describe the importance of Manoomin to help foster community stewardship and education; and to inform Manoomin management, protection, and policy in the Lake Superior Basin and throughout the Great Lakes. Specifically, our objectives were to document and characterize (1) the importance of Manoomin habitat to cultural perspectives and identity, community connections, and cultural and spiritual practices of the Anishinaabe people; and (2) the ecological importance of Manoomin habitat as indicators *of* a high-quality, high-functioning, and biodiverse ecosystem around the Lake Superior Basin.

In this report we provide a brief background on the cultural and ecological importance of Manoomin, and describe current threats (Chapter 2). We then describe the methodology undertaken to characterize the importance of Manoomin in this study (Chapter 3); and provide the study's results, including cultural and ecological metrics developed to characterize cultural (Chapter 4) and ecological functionality of Manoomin and seven case studies (Chapter 5). Based on these results, we offer cross-case findings and lessons learned over the course of this study (Chapter 6), and provide conclusions and discuss potential next steps (Chapter 7).

Project Team members and audience

We, the Project Team members of this study, are a diverse group of Lake Superior Basin Anishinaabe communities, and federal and state agencies (Exhibit 1.1), supported by Abt Associates (Abt). We are self-identified participants in the study, which originated from annual Lake Superior Manoomin Restoration Workshops. The workshops were held in April 2017, April 2018, and December 2019 to discuss the complexity of Manoomin management, its cultural significance, and the challenges and need for coastal wetland restoration where Manoomin is currently and historically harvested (NOAA, 2017, 2018, 2019a). As an outcome of these workshops, the National Oceanic and Atmospheric Administration (NOAA) applied for and received a Great Lakes Restoration Initiative (GLRI) grant, which provided funding to support this current study. A larger group was involved in the initial 2017 and 2018 workshop discussions; the

Exhibit 1.1. Project Team

The Project Team consists of the following entities:

- Fond du Lac Band of Lake Superior Chippewa
- Keweenaw Bay Indian Community
- Lac du Flambeau Band of Lake Superior Chippewa
- Lac Vieux Desert Band of Lake Superior Chippewa
- Grand Portage Band of Lake Superior Chippewa
- 1854 Treaty Authority
- Great Lakes Indian Fish and Wildlife Commission
- Lake Superior National Estuarine Research Reserve
- National Oceanic and Atmospheric Administration
- National Sea Grant College Program
- U.S. Bureau of Indian Affairs
- Wisconsin Department of Administration.

list in Exhibit 1.1 reflects the entities who continued to be engaged in the GLRI-funded project implementation. As Project Team members, we decided upon the design and study methodology on a consensus basis, which Abt, our contractor providing technical support, then applied. We then reviewed and approved all reports and materials developed during this study.

The primary audiences for this report are Indigenous communities, tribal and non-tribal governments, and organizations who are working to actively manage and restore Manoomin across the Great Lakes.

2. Importance of Manoomin

Manoomin is central to the Anishinaabe cultural identity, traditions, and livelihood. It is an important species to the ecology of waters within the Great Lakes region, proving food and habitat to endemic and migratory species. This chapter first provides a brief overview of the cultural and ecological importance of Manoomin, and then describes some of the threats to Manoomin and its associated habitat. For a more detailed understanding of the relationship Manoomin holds with other beings, see Barton (2018) and David et al. (2019).

Cultural importance

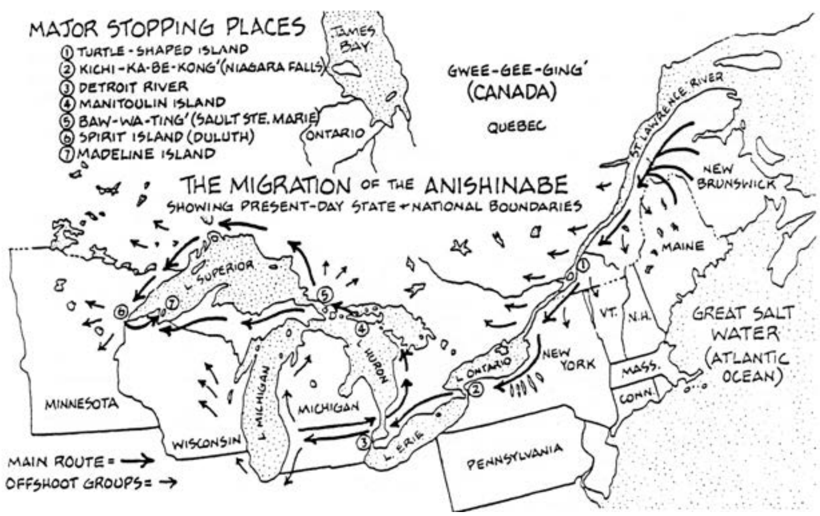
Photo of Kathleen Smith, Habitat Specialist/Plants Program, Keweenaw Bay Indian Community Photo credit: Todd Marsee, Michigan Sea Grant.

Manoomin is a central part of the Anishinaabe migration story: the Anishinaabe people were told to head West to their chosen land by the third of seven prophets, and they would know they were home when they found “the food that grows out of the water” (Exhibit 2.1; Benton-Banai, 1985; David et al., 2019). This food would sustain their families’ bodies and souls for generations. As a result, Manoomin holds a critically important place in Anishinaabe culture.

Manoomin is a sacred symbol – it represents the Anishinaabe people’s journey, their relationship to the land, and their identity as a culture (Tribal Wild Rice Task Force, 2018). For the Anishinaabe people, Manoomin is considered a sacred, animate, more-than-human being and not an inanimate resource. Manoomin accompanies all ceremonies, celebrations, feasts, funerals, and initiations as a food source and a spiritual presence (David et al., 2019).

The Manoomin harvest is critical to Anishinaabe culture and is part of long-standing traditions. The harvest is a major community activity

Exhibit 2.1. The migration story



Source of map: Benton-Banai, 1985.

Ongow Anishinaabeg ogii-piminizha’aawaan iniw miigisan. Mii iw gaa-izhi-dagoshinowaad eteg wiisiniwin imaa nibiikaang.

The Anishinaabe people were to follow the direction of the Miigis Shell and by doing so would find their final destination; a place identifiable because it was where “food grows on water” [The Migration Story: In Search of Wild Rice. *Ayanjigozing, Manoomin Nandawaabanjigaadeg.* As translated and transcribed by Gimiwan (Dustin Burnette)].

Source of text: David et al., 2019.

that strengthens bonds within the community and within families. Families and friends work together, and children and elders come together to harvest. This tradition is passed down through generations and links the past to the present, providing intergenerational connections and allowing young people to participate in their heritage and history (Kjerland, 2015b). An essential part of harvesting Manoomin is the renewal of ties to the land and spirits (Raster and Hill, 2017). Harvesting by hand reaffirms the nature of Manoomin as a gift from the Creator and that Manoomin should be treated with respect and gratitude (Tribal Wild Rice Task Force, 2018).

> ***Wild rice harvesting***
>
> *Mii izhichigewaad ingiw Anishinaabeg dibwaa bawa`amowaad akawe asemaakewag biindaakoojigewag. Mii aw asemaa ayaabadizid biindaakoonind a`aw Manidoo. Geget apiitendaagozi asemaa. Mii akina ge izhichigeyangiban gegoo mamooyan imaa zayaaga`kiigin, gidaa-biindaakoojigemin.*
>
> The first thing Anishinaabe do is make an offering of tobacco before they harvest wild rice. Tobacco is used when making an offering to the spirit. Tobacco is highly valued. When we take from nature, we should make an offering of tobacco.
>
> Source: GLIFWC, 2010.

Manoomin is a healthy, traditional food source for the Anishinaabe. It remains a dietary staple, nourishing the Anishinaabe and providing spiritual and cultural sustenance. Manoomin is highly nutritious, with a low-glycemic index, and provides benefits in preventing chronic diseases. It is a source of vitamins, minerals, fiber, and protein. Manoomin harvesting can also provide cardiovascular benefits from the physical activity associated with traditional food-gathering (Fond du Lac Band, 2018; David et al., 2019). It provides food sovereignty for the Anishinaabe as well, as it can be stored and consumed year-round (David et al., 2019). Hand-harvested Manoomin is often given as a gift or used for trade. This barter-and-trade system surrounding Manoomin also contributes to Anishinaabe food sovereignty by reducing food costs and improving food security (Tribal Wild Rice Task Force, 2018).

Manoomin is so fundamental to the Anishinaabe identity and culture that Anishinaabe treaties with the U.S. government guarantee access to Manoomin. The Treaties of 1837, 1842, and 1854 reserve gathering rights for Manoomin (among other rights) in lands ceded to the United States. In the Treaty of 1837, Manoomin is the only more-than-human being (i.e., the only biological resource) specifically mentioned. The rights to rice waters explicitly reserved in these treaties have been fundamental to Anishinaabe life historically and currently; and ensure Manoomin’s central place in Anishinaabe culture through religious, ceremonial, medicinal, subsistence, and economic uses (David et al., 2019).

Ecological importance


Photo credit: Todd Marsee, Michigan Sea Grant

Manoomin is an essential part of the Great Lakes ecosystem and environment. Natural Manoomin beds are part of complex aquatic ecosystems that support wildlife and waterfowl. Over 17 species of wildlife that use Manoomin habitat for reproduction or foraging are listed in the Minnesota Department of Natural Resources’ Comprehensive Wildlife Conservation Strategy as “species of greatest conservation need” (Fond du Lac Band, 2018). Ducks, geese, swans, muskrat, deer, and moose all feed on wild rice. Additionally, insect larvae feed on Manoomin and, in turn, birds feed on these insects.

Decaying Manoomin supports invertebrates that support birds, fish, and amphibians (Raster and Hill, 2017; Tribal Wild Rice Task Force, 2018). Manoomin beds provide breeding and resting grounds for migratory birds, rearing habitat for resident bird species (Raster and Hill, 2017), and nursery areas for young fish and amphibians (Fletcher and Christin, 2015).

Manoomin also plays an important role in maintaining ecosystem quality by sequestering nutrients, enriching soils, and countering nutrient loading and its negative impacts such as algal growth and turbidity (Tribal Wild Rice Task Force, 2018). Manoomin binds loose soils, which slows sedimentation. Additionally, through binding loose soils and acting as a windbreak, Manoomin limits the mixing of soil nutrients into waters, thus improving water clarity and reducing algal blooms (Loew and Thannum, 2011; Fletcher and Christin, 2015; Tribal Wild Rice Task Force, 2018). Manoomin is also an indicator of overall water quality and ecosystem health because it is highly sensitive to changes in water quality (David et al., 2019).

Threats to Manoomin

Manoomin and its associated habitat face many threats, some of which are highlighted below; for a more comprehensive list of threats, see David et al. (2019).

Hydrologic changes. Manoomin depends on shallow waters and both natural and human-based causes can alter lakes and rivers to make them inhospitable to this plant. Manoomin also depends on occasional hydrological disturbances, as long-term stability allows perennial plants to outcompete Manoomin, which is an annual plant. Therefore, occasional high or low water years allow Manoomin to flourish in the long-term. Damming and releasing water can degrade Manoomin habitat. Dams and ditching – created by humans or through natural causes, such as beavers or vegetation – can result in water-level regimes that are not conducive to Manoomin. Manmade dams on some reservoirs impose a large annual variability in water levels that do not allow Manoomin to flourish, while others that control water levels on lakes with lakefront property often impose highly consistent annual water levels that are also unsuitable for Manoomin growth. These managed water-level regimes can further allow other plant species to outcompete Manoomin for habitat. Other human activities that can lead to hydrologic changes that are detrimental to Manoomin include industrial resource extraction, such as mining. Industrial water appropriations and discharges can change water levels in Manoomin waters, preventing Manoomin from growing (David et al., 2019).

Pollution. Manoomin is highly sensitive to changes in water quality and requires unpolluted water to flourish. Sulfate pollution is particularly notable for its harm to Manoomin. Research dating back to the first half of the 20th century demonstrated that wild rice growth is impaired by elevated sulfate in water, but the specific mechanisms were unknown (Plain, 2017). Several recently published studies provide insight into how sulfate in water impairs wild rice: sulfate, which is converted to sulfide by microorganisms in the soil, becomes directly toxic to wild rice (e.g., Myrbo et al., 2017a, 2017b; Pastor et al., 2017; Pollman et al., 2017). Field research and controlled experiments have shown that waters with sulfate levels over 10 parts per million (ppm) are detrimental to Manoomin (Moyle, 1944; Pastor et al., 2017; David et al., 2019; Vogt, 2020b). Sulfate is commonly discharged in wastewater from mining activities, both from tailings basin discharges and process wastewater from ore processing plants (David et al., 2019).

Invasive and native competitive species. Several aquatic invasive species have locally threatened the survival of Manoomin, including milfoil, pondweed, cattail, common reed, flowering rush, and common carp. Plant species such as milfoil, cattail, and pondweed can directly compete with Manoomin for space, nutrients, and habitat. Other species such as purple loosestrife can indirectly compete with Manoomin by reducing suitable habitat if the loosestrife extent expands down-elevation under drought conditions. Common carp can significantly diminish Manoomin survival by feeding on rice seeds and by uprooting plants (David et al., 2019). Some native plants such as ginoozhegoons (or pickerelweed or moose ear) also directly compete with Manoomin for habitat (see Exhibit 2.1).

Exhibit 2.1. Native plant competition

Ginoozhegoons is a native species that occupies the same habitat as Manoomin. As a perennial species, ginoozhegoons continues to grow each year, whereas Manoomin, an annual species, grows from an individual seed each year (Howes, 2010). Although ginoozhegoons is often considered a competitor, in some instances it appears to protect Manoomin beds by absorbing wind and wave action (David et al., 2019).

Photo credit: www.freepik.com.

Land use impacts. Manoomin is sensitive to changes in land use patterns, such as residential development. Lakeside residential development is often associated with motorized boating activity, which can increase wave damage and chop up rice mats. Channel dredging is also more likely to occur in areas with high boating activity, which can lead to changes in hydrology that negatively impact Manoomin. Residential development is also associated with higher levels of ammonium in wetlands, which can limit Manoomin stands (Pillsbury and McGuire, 2009). Shoreline development can also lead to wide-scale vegetation removal, including Manoomin, from property owners desiring an open view (David et al., 2019).

Herbivory. Large populations of birds, especially resident geese and trumpeter swans, can threaten Manoomin. Geese feed on Manoomin, and can have large impacts on small or sparse stands. These populations have been increasing on treaty territories over the past two decades and can have pronounced impacts on smaller rice lakes (Nichols, 2014; David et al., 2019). Other species such as wazhashk (muskrats) and red-winged blackbirds can also heavily utilize or feed on Manoomin, sometimes causing significant impact. However, wazhashk – often classified as “cleaners” or “gardeners” – are also thought to be beneficial to Manoomin, and may play a role in controlling competing vegetation or stirring sediment to the benefit of Manoomin (David et al., 2019).

Climate change. Climate change has begun to negatively impact Manoomin and is projected to have negative impacts on Manoomin in the future. Climate change is expected to lead to more frequent heavy rainfall events, which will lead to flooding that uproots or drowns Manoomin beds. Warmer temperatures resulting from climate change will also negatively impact Manoomin abundancy by favoring outcompeting plants that are better adapted for warmer climates; and being conducive to brown spot disease, which destroys photosynthetic tissues, reduces seed production, and favors high temperature and humidity (Barton et al., 2013; Cozzetto et al., 2013; Grand Portage Band of Lake Superior Chippewa, 2016; David et al., 2019). Warmer temperatures can also change the range of Manoomin and reduce germination. Projections of future climate in the 1854 Ceded Territory indicate substantial warming over the historical baseline that could lead to a shifting of wild rice outside the Great Lakes region and the 1854 Ceded Territory due to the location of Manoomin at the southern edge of its range. These increased temperatures could also lead to decreased germination of Manoomin if the temperatures are too warm for the dormant hardening-off period that northern wild rice requires (Stults et al., 2016). In a climate change vulnerability assessment conducted by the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), Manoomin was found to be the species most vulnerable to the impacts of climate change out of all the species assessed, both because of the numerous climate-related threats and because it is sensitive to different climate effects at all stages of its life cycle (GLIFWC, 2018).

3. Methodology selected to characterize the importance of Manoomin

We evaluated several methodologies for characterizing the cultural and ecological importance of Manoomin and its associated habitat, and ultimately selected an innovative combined Habitat Equivalency Analysis (HEA) approach. This chapter describes how we selected and then applied this combined HEA approach.

Selecting a method

As a team, we identified several methods to characterize the cultural and ecological importance of Manoomin and its associated habitat. We reviewed the cultural and ecological literature, and used our collective knowledge of cultural and ecological characterization methodologies to develop the following list of possible methods:

- **In-person interviews or listening sessions** with tribal community members to gather qualitative information about perspectives, cultural identify, and value systems.
- **A case study analysis** to conduct a systematic and in-depth examination of the cultural and ecological importance of Manoomin across the Lake Superior region.
- **Indigenous metrics** to evaluate Indigenous priorities for cultural, social, and ecological aspects of the community that are understandable to both Indigenous and non-Indigenous ways of thinking (Donatuto et al., 2016), including themes developed by the community (Fond du Lac Band, 2018).
- **An ecosystem service conceptual model** to link changes caused by external stressors or interventions to Manoomin through the ecological system to socioeconomic and well-being outcomes (Olander et al., 2018).
- **A social-ecological keystone concept** to quantify biocultural elements of Manoomin as a keystone species (Winter et al., 2018).
- **An HEA** to determine the amount of restoration needed as a counter-balance for habitat that has lost cultural and ecological functionality (NOAA, 2000, 2019b).
- **A combined HEA approach** to combine several methodologies that overcome individual shortcomings to develop a strong framework to characterize Manoomin and its associated habitat.

We developed and applied a set of criteria to evaluate possible methods for characterizing the cultural and ecological importance of Manoomin (Exhibit 3.1). Using these criteria, we narrowed the possible methodologies to three options – a case study analysis, Indigenous metrics, and an HEA – and a fourth approach that combined these three methods. Ultimately, we selected the combined HEA approach by consensus.

Exhibit 3.1. Criteria for selecting a characterization method

Methods should be:

1. Non-monetary
2. Capable of combining ecological and cultural characterization into a single analysis
3. Implementable using mainly existing data and information (i.e., study should not involve extensive primary data collection efforts)
4. Based, at least in part, on Indigenous methodologies, or research for and by Indigenous people using techniques and methods drawn from their traditions and knowledge.

Applying the combined HEA approach

We applied the combined HEA approach to determine or "scale" the amount of restoration needed to counter-balance habitat with cultural and ecological functionality losses over time. We developed and applied a set of cultural and ecological metrics to characterize (1) the degree of lost functionality at a given location, and (2) the increased functionality provided by restoration actions at that location. We then "scaled" the restoration gains to the losses to quantify the equivalent amount of that same restoration that would be needed to balance the losses. The case studies describe specific locations with degraded Manoomin habitat with reduced cultural and ecological functionality, and actions undertaken in attempts to restore or improve the cultural and ecological functionality. We applied the combined HEA approach to these locations.

The combined HEA approach included (1) identifying case study sites as examples of degraded and restored Manoomin habitat, (2) refining and applying cultural and ecological metrics to characterize the degraded and restored Manoomin and its associated habitat at the case study sites, and (3) using HEA to quantify the amount of restoration need to counter-balance the lost Manoomin habitat functionality (Exhibit 3.2). We describe these steps in more detail below.

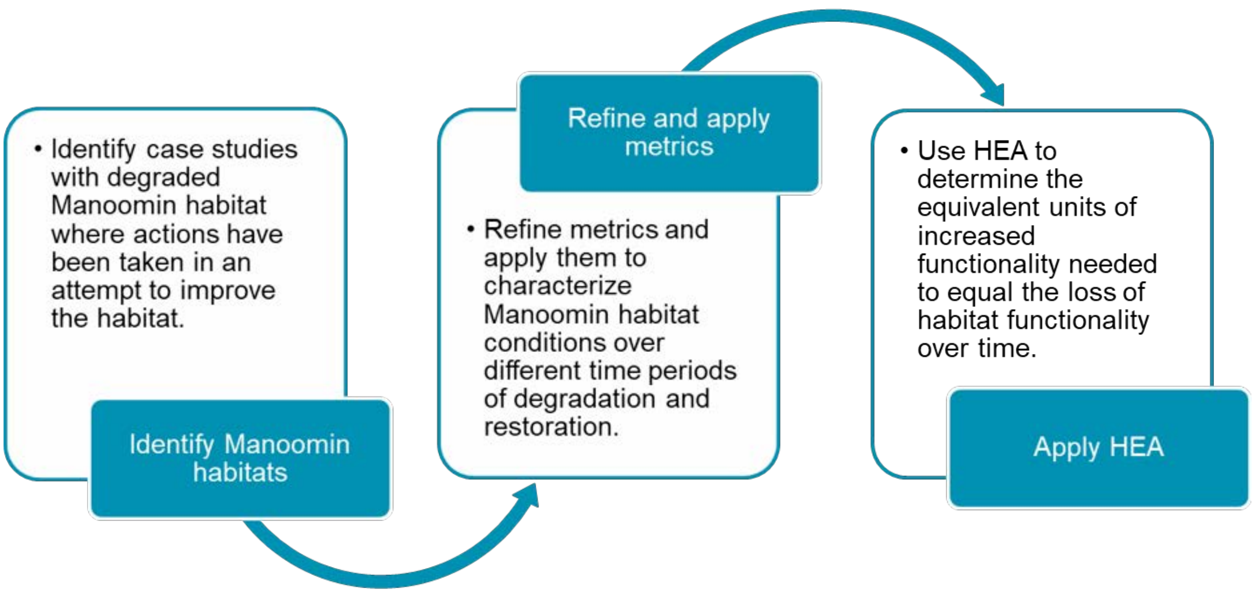


Exhibit 3.2. Steps in the combined HEA approach

Identify Manoomin habitats

We identified areas across the Lake Superior region with current or former Manoomin habitat. Our goal was to identify places that experienced a decline in Manoomin over time, and places where restoration actions have attempted to address the decline. At each site, we aimed to understand:

- The ecological conditions at the site, such as the hydrology, water quality and land use, and climatic conditions
- The cultural and ecological importance of Manoomin at the site, including Manoomin harvest and wildlife dependence on Manoomin
- The cause of Manoomin decline, such as hydrologic changes, invasive species, climate change events, or other threats
- The types of restoration actions undertaken, such as seeding efforts or management of invasive or competitive species
- The success or failure of those restoration actions, including cultural and ecological effects
- The timeline of degradation and restoration actions.

We first selected two pilot case studies to test and refine the approach: Big Rice Lake and Twin Lakes. Once we refined the cultural and ecological metrics and the combined HEA approach, as described below, we then selected five additional case studies. Each Band on our Project Team selected a case study, focusing on places of particular importance to their Band. Case studies could be on reservation lands, in ceded territory, or elsewhere. For each case study, we gathered information about the extent and timeframe of the degradation and restoration. This resulted in a range of types of Manoomin habitat degradation and restoration approaches represented in our case studies, dispersed over a broad geographical area. For each site (or case study), we formed a case study team that assessed the Manoomin habitat degradation and restoration, using cultural and ecological metrics (described below). The case study team included members of our Project Team and other tribal, federal, or state partners with experience managing Manoomin at each case study site.

Refine and apply cultural and ecological metrics

We developed a set of metrics to broadly measure all aspects of community health, with health defined as a coexistence among human beings, nature and natural resources, and spiritual beings (Donatuto et al., 2016). We started with Donatuto et al.'s (2016) indicators of Indigenous health, as well as Fond du Lac Band's (2018) health impact assessment themes and Winter et al.'s (2018) biocultural functional groups; and then adjusted and added to them, to develop a set of cultural and ecological metrics focused on Manoomin and the Great Lakes coastal wetlands.

We refined the descriptive scales used by Donatuto et al. (2016) to rank the relative status of each metric at a specific time period. These rankings provided a baseline from which to compare future rankings of the same metric, and ultimately illustrated health trend data over time. We used the following five-point descriptive scale:

- We're doing great
- We're looking pretty good
- Things are not very good
- Things are very bad
- No use of Manoomin.

We later added numeric scores to the descriptive scales as a scalar for our HEA; our numeric scores ranged from 0% (No use) to 100% (Doing great).

We applied draft metrics to our pilot case study during a workshop in August 2019. We subsequently refined the metrics to incorporate additional considerations, such as incorporating health into the *food sovereignty* metric because eating good foods relates to the mind, body, and spirit. Once we finalized the metrics and agreed to them on a consensus basis, we applied them to our case study sites.

Apply HEA to characterize Manoomin

The HEA tool was developed to determine or "scale" the amount of restoration needed as a counter-balance for habitat that has lost cultural and ecological functionality.

We held a series of webinars for each case study. During these webinars, the case study team defined the case study time periods, and then ranked each metric for each time period. The case study team first identified time periods with distinct or changing Manoomin habitat conditions. This process relied on reviewing historical documents and records, as well as case study team member's specific knowledge of the place. We then stepped through each time period, and formally ranked each metric according to the scale given above. For the Anishinaabe metric, for example, we asked each case study team:

> How would you rank [insert place name] in terms of providing Manoomin, which is sacred to the Anishinaabe and central to the foundations of their culture, sovereignty, and treaty rights? Would you say (a) we're doing great, (b) looking pretty good, (c) not very good, (d) things are bad, or (e) no use?

The case study team members individually ranked each metric, and we took an average of these rankings.

Finally, we used our HEA model to calculate the amount of restoration needed to balance the reduced or lost functions. In other words, given that restoration is challenging and rarely achieves full functionality, and the degradation has often spanned prolonged periods of time, we use the HEA to quantify the additional amount of equivalent restoration that would be needed to counter-balance the lost functionality.

The HEA model includes:

- **Base year** for this economic analysis; we set the base year to the current year, 2020.
- **Intergenerational balancing factor** to account for time preference, where degradation and restoration are put in present-value terms (NOAA, 1999). Because not all communities share this same time preference, we discussed the appropriate factor for this study and decided to apply a constant factor of 3% across all case studies, where things in the past are more valuable than they are today and things in the future are less valuable than they are today. A 3% factor is typical for ecological projects (OMB, 2003).
- **Acres** of Manoomin or Manoomin habitat characterized by the case study team. In some cases, acres included the full area of Manoomin waters and in other cases it was a portion of Manoomin waters.
- **Rankings** of Manoomin habitat over degraded and restored time periods using cultural and ecological metrics.

The amount of restoration in acres needed to counter-balance losses may be significantly larger than the acres of degraded habitat. This may be true because of practical limitations in our ability to produce fully functioning restored habitat. For example, if one acre of restored Manoomin wetland only reaches 50% functionality, then two acres of restored habitat are needed to counter-balance the one acre of lost Manoomin habitat. In addition, the amount of time that the habitat was degraded is counter-balanced with the time the restored habitat takes to reach its maximum functionality. Thus, we can account for habitat degraded for longer periods of time, and restoration actions that take longer to mature.

4. Cultural and ecological metrics

We developed 12 metrics that characterize the cultural and ecological functions of Manoomin and its associated habitat. These metrics describe how Manoomin contributes to maintaining connections with the Anishinaabe culture, how ecological functionality is supported and resilient to changing conditions, and how continued learning and sharing of Anishinaabe values are promoted.

Exhibit 4.1 displays the metrics graphically in the form of a dream catcher. Although many Tribes have adopted dream catchers over time, the Anishinaabe may have originated this tradition. There are many legends and stories behind the origins of dream catchers; in most legends, a dream catcher serves to filter out bad bawedjigewin (dreams) and allow only the good ones to enter (We R Native, 2020). Many indicate that dream catchers were also intended to teach natural wisdom (We R Native, 2020). In this graphical display of the metrics, we group cultural and ecological metrics inside the dream catcher hoop, with the Anishinaabe metric centered as it is critical for all other metrics. The three cultural and ecological education metrics are displayed below the dream catcher, as these educational metrics aim to generate and transmit the cultural and ecological knowledge between generations and communities.

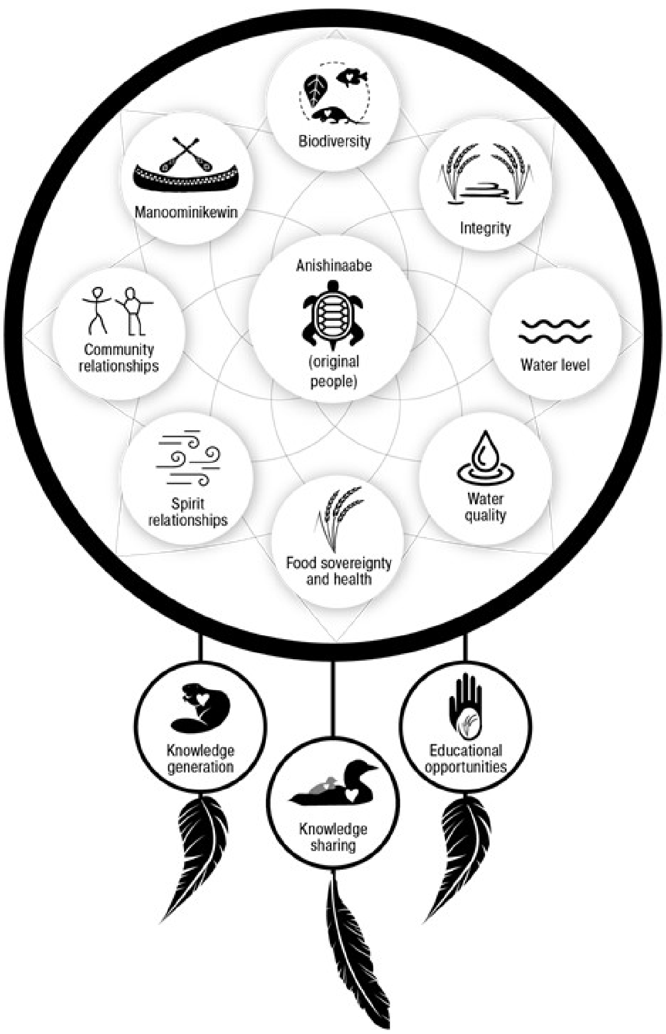


Exhibit 4.1. Dream catcher displaying the 12 metrics developed for this study

Below, we define the cultural, ecological, and cultural and ecological education metrics.

Cultural Metrics

Anishinaabe (original people) – The place provides manoomin, which is sacred to the Anishinaabe and central to the foundations of their culture, sovereignty, and treaty rights.

Community relationships – Manoomin at this place contributes to bonding, traditions, and strengthening family and community connections.

Spirit relationships – Manoomin at this place enables the Anishinaabe to maintain connections and balance with spirit beings (or relatives) from all other orders of creation (first order: rock, water, fire and wind; second order: other plant beings; third order: animal beings; fourth order: human beings).

Manoominikewin – This place allows for the Anishinaabe to harvest, prepare, and share (gifting, healing, and eating) manoomin in the ways practiced by their ancestors for centuries.

Food sovereignty and health – This place provides the capacity to provide for the sustenance, health, and independence of the Anishinaabe.

Ecological Metrics

Biodiversity – Healthy manoomin and appropriate habitat at this place supports diverse biological communities (e.g., free of invasive species) that indicate the capacity of the place to support abundant associated plant and animal species (e.g., other native aquatic vegetation, fish, waterfowl, muskrat), providing for spiritual and subsistence needs.

Integrity – Physical habitat and hydrology, water and sediment chemistry support stands of manoomin that exhibit natural annual variability; viable seed bank ensures that sustainable manoomin populations will persist even after occasional poor production years. Natural genetic diversity is maintained without impact from cultivated strains, or reduced gene flow from the loss of nearby manoomin populations.

Water quality – This place has clean water (e.g., sulfate levels below 10 ppm) and sediments that can support robust stand density and wildlife diversity; is free of contamination or impacts from industrial, agricultural, recreational, or residential influence; and is of sufficient areal extent to sustain a manoomin population.

Water level – This place has a natural or managed hydrologic regime that can maximize resilience under variable or extreme climatic conditions across the growing season (maintaining optimal depth range and flow).

Cultural and Ecological Education Metrics

Knowledge generation – This place allows for continued learning and generation of the Anishinaabe practices, values, beliefs, and language through experience.

Knowledge sharing – This place allows for the continued sharing and transmittal of the Anishinaabe practices, values, beliefs, and language among family members and community.

Educational opportunities – This place provides opportunities for language, land stewardship, and other educational programs, such as educational rice camps.

5. Cultural and ecological characterization case study results

The seven case studies, each of which profiles a story of changes in Manoomin cultural and ecological functionality over time, form the heart of this project. The case studies, grouped around the Lake Superior region, are located in the 1854 Ceded Territory and the 1842 Ceded Territory (Exhibit 5.1). Three of the seven case studies are located on reservation lands.

As described in Chapter 3, these case studies are primarily located in places with current or former Manoomin habitat that have experienced a decline in Manoomin over time, and where restoration actions have been undertaken in an effort to restore Manoomin habitat over different time periods. In a few case studies, documentation of Manoomin presence is not available from historical records; however, their physical or hydrologic features make them conducive to growing Manoomin.

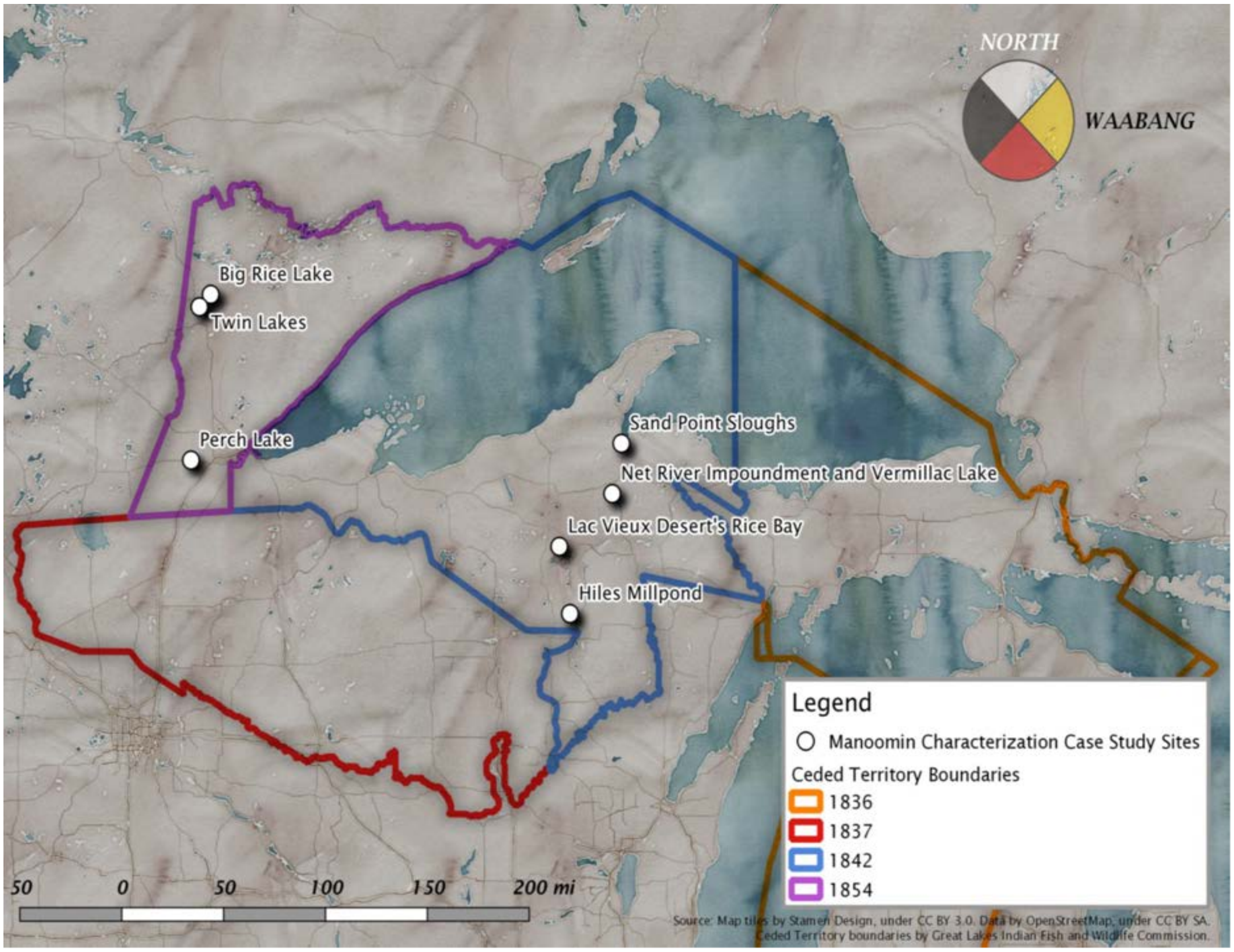


Exhibit 5.1. Map displaying the seven case study locations. The compass is in the form of a medicine wheel, an indigenous symbol used to denote the four directions.

Exhibit 5.2 provides a brief overview of the case studies, including the key threats to Manoomin at these places, some of the actions taken to improve Manoomin habitat, and, if available, the HEA results that indicate how many acres of similar Manoomin restoration habitat are needed to balance lost habitat functionality over time.

Exhibit 5.2. Case study summaries

Case study	Threats to Manoomin	Restoration actions to improve Manoomin	Additional restoration needed
Lac Vieux Desert's Rice Bay *Characterization focused on 243 restoration acres*	• High water levels caused by a concrete and steel dam at the outlet of the lake in the 1930s • High water levels caused by above-average precipitation in the 2010s	• Water level management • Manoomin seeding	**3,034 acres of similar Manoomin restoration** needed to balance the lost habitat functionality over time or **12 equivalent restoration efforts**.
Perch Lake *Characterization focused on 400 restoration acres*	• High water levels caused by agricultural ditching in the 1920s • Competitive vegetation caused by a non-functional dam in the 1960s	• Water level management • Removal of competitive vegetation	**5,204 acres of similar Manoomin restoration** needed to balance the lost habitat functionality over time or **13 equivalent restoration efforts**.
Sand Point Sloughs *Characterization focused on 8 restoration acres*	• Deposited mine tailings from a copper ore processing plant that operated north of the sloughs in the 1920s • High water levels and invasive species after 2005	• Manoomin seeding • Remediation efforts to stabilize the tailings	**175 acres of similar Manoomin restoration** needed to balance the lost habitat functionality over time or **22 equivalent restoration efforts**.
Net River Impoundment and Vermillac Lake *Characterization focused on 97 restoration acres*	Unclear if Manoomin historically grew at site; if it was, land use change likely responsible for Manoomin's depletion	• Manoomin seeding	**1,129 acres of similar Manoomin restoration** needed to balance the lost habitat functionality over time or nearly **12 equivalent restoration efforts**.
Hiles Millpond *Characterization focused on 300 restoration acres*	Unclear if Manoomin historically grew at site; if it was, high water levels caused by dam construction likely responsible for Manoomin's depletion	• Water level management • Manoomin seeding	**864 acres of similar Manoomin restoration** needed to balance the lost habitat functionality over time or **3 equivalent restoration efforts**.
Big Rice Lake *Characterization focused on 1,870 restoration acres*	• Hydrological changes • Competing vegetation	• Water level management • Removal of competitive vegetation	Varies depending on hypothetical improvement scenario.
Twin Lakes *Characterization focused on 210 acres*	• Discharge of mine tailings from an iron ore processing plant upstream of the lakes since the 1960s, which has *increased sulfate levels* and *increased water volume*	• Seepage collection system to collect some of the mine tailings discharge • Manoomin seeding (limited) • Water level management (limited)	Varies depending on hypothetical improvement scenario.

These seven case studies are described in more detail below. For each case study, we briefly describe the cultural and ecological importance of the place, and provide an overview of the threats to Manoomin and the actions taken to restore Manoomin. We then summarize how each case study team characterized the place over time using ecological and cultural metrics; and describe the additional restoration needed, as calculated with the HEA tool.

Lac Vieux Desert's Rice Bay

Exhibit 5.3. Map of Lac Vieux Desert

Lac Vieux Desert, located in Vilas County, Wisconsin, and Gogebic County, Michigan, is over 4,000 acres (Exhibit 5.3). Historically, Manoomin covered many parts of Lac Vieux Desert, including Rice Bay, Thunder Bay, Slaughters Bay, Misery Bay, and along the northwestern shore to the Wisconsin River and parts of the south shore.

Rice Bay is a 243-acre bay on the northeastern portion of Lac Vieux Desert, which historically contained a significant stand of Manoomin that was traditionally managed and harvested by the Lac Vieux Desert Band of Lake Superior Chippewa (LVD Band). West of Rice Bay is Ketegitigaaning, a ricing village used intermittently in the early 18th century by the LVD Band, followed by continuous habitation by 1900. In 2015, Rice Bay was registered as a Traditional Cultural Property on the National Register of Historic Places.

Threats to Manoomin at Rice Bay

Lac Vieux Desert was dammed around 1870 for logging operations. By 1907 the Wisconsin Valley Improvement Company (WVIC) began operating the lake as a storage reservoir and used the dam to create uniform stream flow down the Wisconsin River to reduce flooding events, facilitate hydroelectric power generation, and regulate effluent discharge downstream. In 1937, WVIC replaced the wooden dam with a reinforced concrete and steel structure. The high water levels caused by the dam initiated a decline in Manoomin (Labine, 2017). From 1938 to 1952, Manoomin declined steadily and community members stopped harvesting it during this period (Barton, 2018). During this time period, lakeside property owners became concerned about the erosion caused by rising lake levels.

More recently, heavy rainfall events have negatively affected Manoomin in Lac Vieux Desert (Roger Labine, LVD Band, personal communication, February 15, 2020). In the spring Manoomin is in the floating leaf stage, and can be uprooted by heavy rainfall that raises water levels and uproots Manoomin. In the summer, when Manoomin is in the flowering stage, heavy rainfall can knock Manoomin pollen down from the flower to the water's surface, which prevents pollination and results in "ghost rice" or empty seed hulls that never fill. In addition, the combination of heavy rainfall events and higher air temperatures may also increase the amount of brown spot – a destructive wild rice fungal disease – in Manoomin beds.

Actions taken to improve the abundance of Manoomin at Rice Bay

In 1991, a coalition of tribal, state, and federal governments and governmental agencies determined the operating regime of the dam on Lac Vieux Desert had been detrimental to Manoomin and its associated habitat (Onterra, 2012). By 2001, following a decade of negotiation and litigation, WVIC lowered the maximum operating level by about nine inches and provided financial contribution toward a Manoomin seeding and monitoring program (Barton, 2018). From 2002 to 2005, Lac Vieux Desert was seeded with 14,000 pounds of Manoomin, most of which occurred in Rice Bay (Labine, 2017). From 2007 through 2012, as Manoomin became reestablished on Rice Bay, the LVD Band held traditional ricing camps and workshops, which included traditional practices and activities (Barton et al., 2013).

Exhibit 5.4. Photograph of Lac Vieux Desert Lake's Rice Bay in 2003 (above) and 2010 (below)

Credit: Peter David, Great Lakes Indian Fish & Wildlife Commission (GLIFWC).

From 2000 to 2010, the acreage of Manoomin on Rice Bay significantly increased. In 2000, Rice Bay had just 11 acres of Manoomin coverage (or 5% of Rice Bay). After the first year of seeding, Manoomin coverage increased to over 25 acres (or 10% of Rice Bay). With below-average rainfall conditions in 2010, the extent of Manoomin increased to over 92 acres (or 38% of Rice Bay; Exhibit 5.4). While the extent of Manoomin on Rice Bay was less than its historical coverage, it was considered an improvement over conditions caused by the operating regime of the concrete dam (Barton, 2018).

Since 2011, the acreage of Manoomin on Rice Bay has been declining, with 34 acres in 2019 (GLIFWC, 2019; Exhibit 5.5). Because Manoomin abundance on Rice Bay is generally greatest during low-water years, natural resource managers believe this may be due to above-average precipitation over the past seven years (Peter David, GLIFWC, personal communication, November 12, 2019).

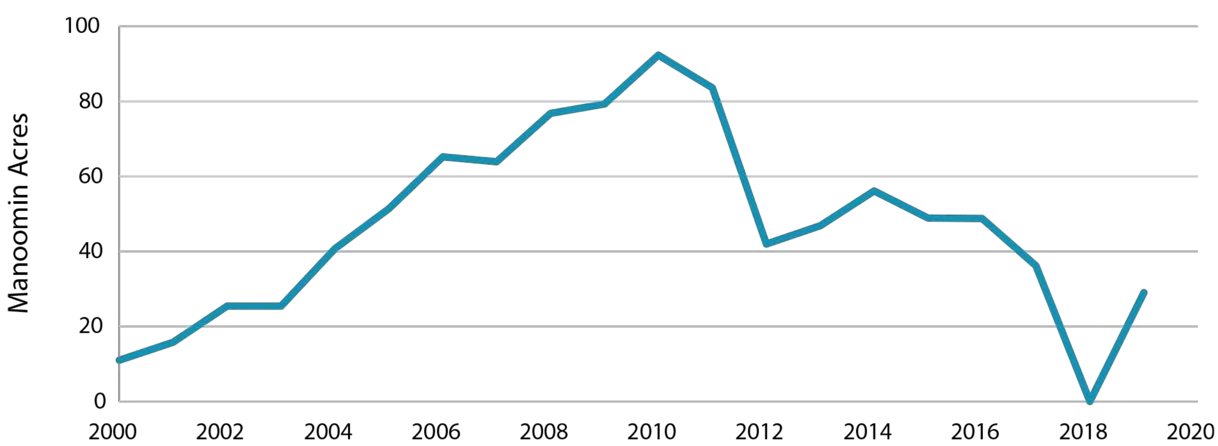


Exhibit 5.5. Manoomin acreage on Rice Bay, 2000 to 2019

Source: GLIFWC, 2019.

Cultural and ecological characterization at Rice Bay

Rice Bay's Manoomin and its associated habitat were characterized over four time periods.

1900 to 1936: With a wooden dam

Based on the combined ranking of cultural and ecological metrics, Rice Bay was characterized as "doing great" during this period. In the early 1900s, Ketegitigaaning was inhabited and the community harvested Manoomin in Rice Bay for gifting, healing, and consumption. The area also boasted a rich biodiversity; and hunting, trapping, fishing, and gathering local resources were common.

1937 to 1990: With a concrete and steel dam

After the replacement of the wooden dam with a concrete and steel structure, Manoomin declined steadily until the mid-1950s to the point that it was no longer harvestable by community members. During this time period, community members moved away from the lake and into surrounding towns, and stopped harvesting Manoomin in Rice Bay. The "disappearance of Manoomin started the deterioration of the Lac Vieux Desert community," where bonding, traditions, and community connections ceased (Roger Labine, LVD Band, personal communication, November 12, 2019). There was a steady decline in cultural and ecological functionality provided by Manoomin from 1937 to the mid-1950s, when Rice Bay was characterized as "very bad" based on the combined ranking of cultural and ecological metrics.

1991 to 2012: With restoration actions

Once restoration actions began in the 1990s, cultural and ecological functionality provided by Manoomin improved. By 2008, the LVD Band opened Rice Bay for Manoomin harvest and began hosting rice camps in the area for the first time since 1940. Although the community began knowledge sharing and knowledge generation, and educational opportunities increased, it remained difficult to get many community members interested in Manoomin because of its absence over the last 50 years. Even so, restoration actions led to an increase in cultural and ecological functionality. By 2012, Rice Bay ranked as "pretty good" based on the combined ranking of cultural and ecological metrics.

2013 to 2019: With restoration actions and above-average precipitation

With heavy rainfall events negatively affecting Manoomin beds during the growing season, cultural and ecological functionality at Rice Bay have declined. Currently, Rice Bay is ranked as "not very good" based on the combined ranking of cultural and ecological metrics. The decrease in ecological and cultural functionality provided by Manoomin in recent years suggests the need for adaptive management of Manoomin. Actions taken that may have been successful in restoring Manoomin in the past may need to be adjusted to respond to additional threats, such as climate change, to be successful in the future.

Cultural and ecological functionality provided by Manoomin and its associated habitat at Rice Bay have changed over time, both in total and for individual metrics (Exhibit 5.6).

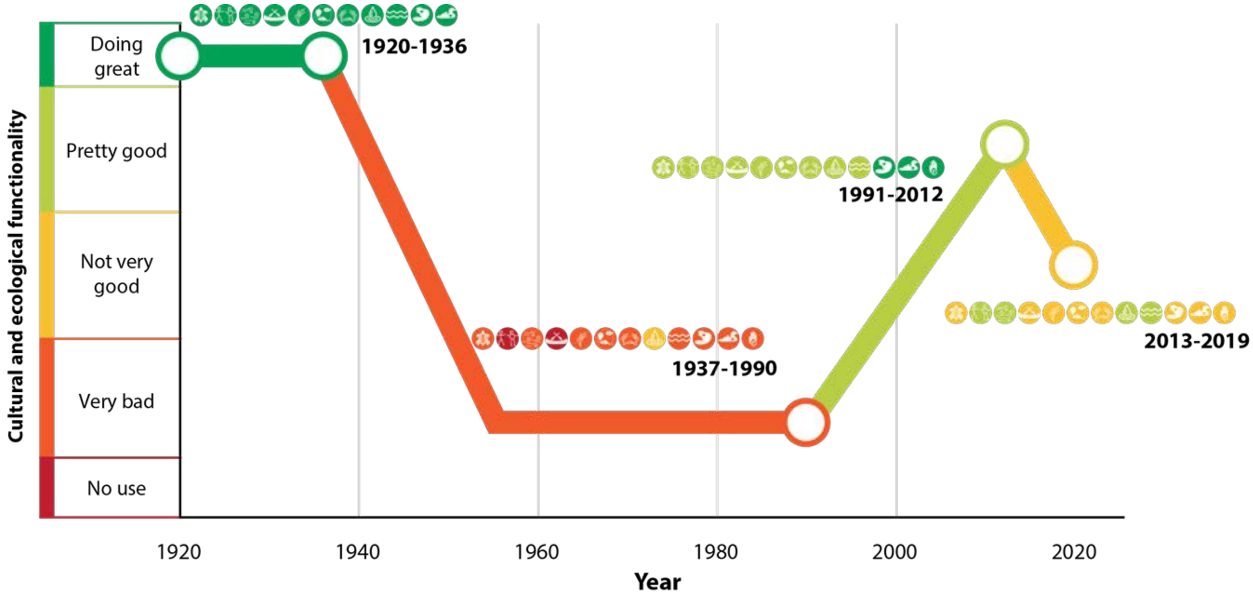


Exhibit 5.6. Characterization of cultural and ecological functionality provided by Manoomin and its associated habitat at Rice Bay

Additional restoration needed

Based on the characterization of the degree of cultural and ecological function over the four time periods, the HEA calculations demonstrate the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. Given the success of restoration at the 243-acre Rice Bay, approximately 3,034 acres of similar Manoomin restoration is needed to counter-balance the lost habitat functionality that has occurred over time (Exhibit 5.7). In other words, 12 equivalent restoration efforts at Rice Bay (from 1991 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1937 to 1990).

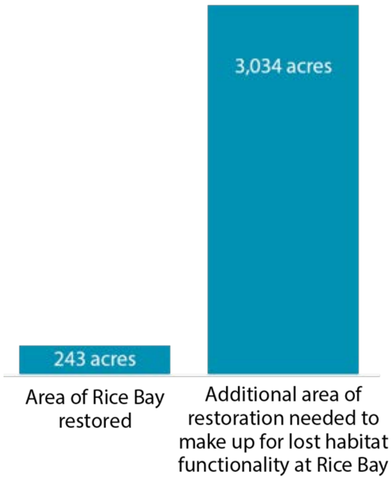


Exhibit 5.7. Additional restoration needed for Lac Vieux Desert Lake's Rice Bay

Case study acknowledgments

The Project Team would like to acknowledge Roger Labine (LVD) and Peter David (GLIFWC) for their valuable input and feedback in the development of this case study, and for participating in the cultural and ecological characterization of Lac Vieux Desert's Rice Bay.

Perch Lake

Perch Lake is located on the Fond du Lac Band of Lake Superior Chippewa Reservation in Minnesota (Exhibit 5.8). It is an approximately 650-acre, double-basin lake. The shallow, southern portion of the lake is approximately 400 acres, and it is the largest Manoomin-containing habitat on the Reservation (Fond du Lac Band, 2008). The northern basin also supports some Manoomin along its fringes.

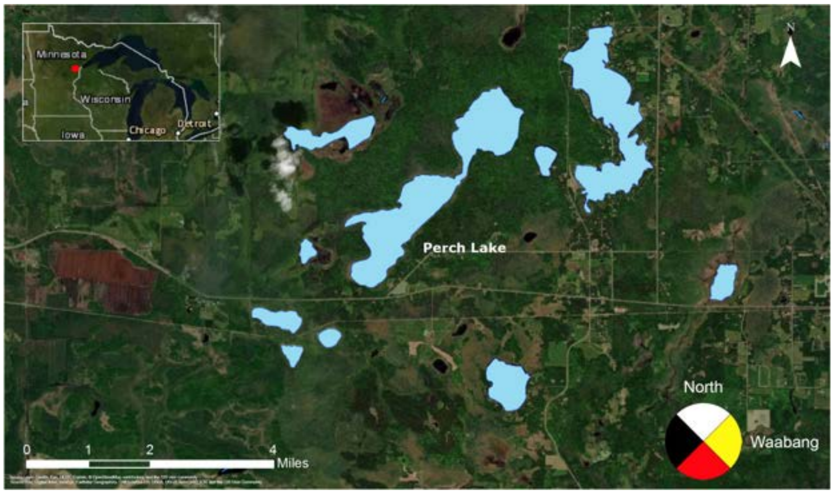


Exhibit 5.8. Map of Perch Lake

Perch Lake is an important traditional cultural property, used as a wild rice lake, a fisheries/spearing and netting site, and hunting grounds (Fond du Lac Band, 2018). Historical evidence suggests that Manoomin has been present at Perch Lake for over 2,000 years, with historical stands on approximately 392 acres (Fond du Lac Band, 2018).

Threats to Manoomin at Perch Lake

Historically, Perch Lake had abundant Manoomin habitat. In the early 1900s, many streams and wetland areas were ditched and drained to accommodate farming. After Perch Lake was ditched for agriculture around 1918 to 1921, the lake experienced a decline in Manoomin (Nancy Schuldt, personal communication, October 7, 2019).

To try to minimize the impacts of ditching, a concrete dam was installed at the lake outlet in 1936. The dam was managed to mimic the natural fluctuation of the water to benefit Manoomin. By the 1960s, the dam fell into disrepair and was non-functional. For the following several decades, lake levels were lower and stagnant, which allowed ginoozhegoons (pickerelweed) to displace Manoomin and become the dominant vegetation in the lake's rice waters (Fond du Lac Band, 2018, 2019).

Actions taken to improve the abundance of Manoomin at Perch Lake

In 1998, a new water control structure was built at the outlet of Perch Lake to manage water levels for Manoomin and improve hydrologic function throughout the watershed (Fond du Lac Band, 2018). In 2001, the Fond du Lac Band began intensive mechanical vegetation removal of ginoozhegoons, a native perennial species that occupies the same habitat as Manoomin and often outcompetes Manoomin (Fond du Lac Band, 2018). Using a sedge mat cutter and aquatic harvesters, the Fond du Lac Band removed ginoozhegoons vegetation at least twice yearly (Exhibit 5.9). This process led to high Manoomin density in restored areas initially. However, three to five years after each removal, ginoozhegoons became dominant again, which called for a rotating schedule for removing this competing plant.

In 2012, Perch Lake experienced a 500-year flood in mid-summer, and the Fond du Lac Band used the water control structure to keep water levels high and eliminate as much ginoozhegoons as possible. The following year, Manoomin stands were so thick that it was difficult to travel through the lake. Learning from the natural flood event, the Fond du Lac Band then developed a management strategy to bring lake levels to flood stage every four years to stress perennial species, such as ginoozhegoons, which compete with Manoomin for habitat. Although this strategy also limits Manoomin production in flood years, it provides Manoomin with a competitive advantage in the years following a flood stage year (Fond du Lac Band, 2018).

With water level management and mechanical removal of competitive vegetation, the Fond du Lac Band has successfully restored Manoomin to over 200 acres on Perch Lake (Fond du Lac Band, 2019).

Exhibit 5.9. Photograph of Sedge mat cutter (above) and aquatic harvester (below)

Credit: Fond du Lac Band, 2018.

Cultural and ecological characterization at Perch Lake

Manoomin and its associated habitat at Perch Lake were characterized over four time periods.

1900 to 1920: Before agricultural ditching

Before it was ditched for agriculture, Perch Lake historically had abundant Manoomin stands. Fond du Lac resource managers estimate that nearly 60% of the lake had extensive Manoomin stands during this time, and it was harvested by the community. Based on the combined ranking of cultural and ecological metrics, Perch Lake was characterized as “doing great” during this first time period.

1921 to 1970: With agricultural ditching

After agricultural ditching of Perch Lake, Manoomin and its associated habitat declined abruptly. Lower and stagnant water levels allowed ginoozhegoons to become the dominant vegetation in the lake, displacing Manoomin, which resulted in a decline in use of the lake by waterfowl and other wildlife. Band members were unable to harvest Manoomin in the ways they did historically, which limited the generation and sharing of Anishinaabe practices, values, and beliefs. During this period of time, Perch Lake was characterized as “not very good” based on the combined ranking of cultural and ecological metrics.

1971 to 1997: Before the new water control structure and restoration actions

During this period, Perch Lake had a significant decline in Manoomin abundance and functionality; approximately 75% of the lake was covered with plant species that occupy the same habitat as and compete with Manoomin. Although Perch Lake's ecological and cultural functionality remained low, Band members continued to try to harvest at the lake; therefore, the lake provided some cultural services during this period. Many elders and wild rice chiefs believe Manoomin is a blessing and is seen as a golden age of their youth. For these reasons, Perch Lake ranked as "pretty good," which was slightly higher than the previous time period.

1998 to 2019: With the new water control structure and restoration actions

The water control structure built at the outlet of Perch Lake in 1998 helped restore the hydrologic conditions of the lake and improve Manoomin and its associated habitat. Active management of the lake started in 2001 and accelerated in 2012, which further restored hydrologic conditions of the lake and removed competing vegetation, all benefiting Manoomin. During this time period, the Fond du Lac Band was fairly successful at restoring Manoomin on Perch Lake. Manoomin covers over 200 acres of Perch Lake, which is about 30% of its historical coverage. Currently, Perch Lake is ranked as "pretty good" based on the combined ranking of cultural and ecological metrics.

The cultural and ecological functionality provided by the Manoomin and its associated habitat at Perch Lake varied over time, both in aggregate and for individual metrics (Exhibit 5.10).

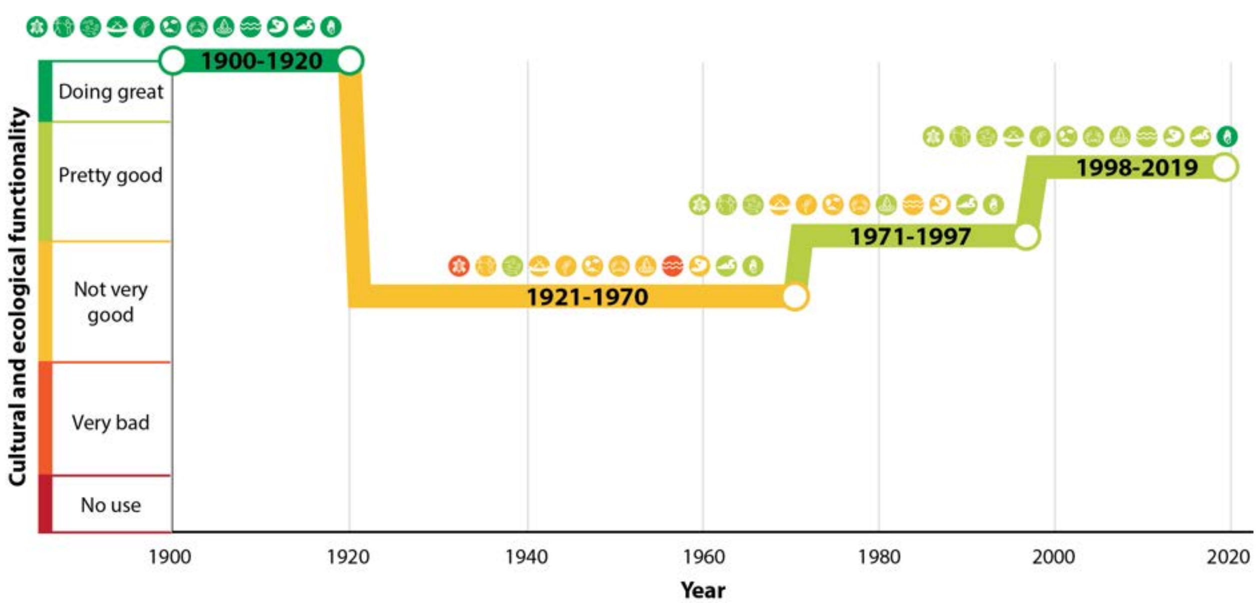


Exhibit 5.10. Characterization of cultural and ecological functionality provided by Manoomin and its associated habitat at Perch Lake

Additional restoration needed

Using the characterization of Perch Lake over the four time periods, an HEA demonstrates the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. Given the success of restoration over the shallow, southern 400 acres of Perch Lake, approximately 5,204 acres of similar Manoomin restoration are needed to counter-balance the lost habitat functionality that has occurred over time (Exhibit 5.11). In other words, 13 equivalent restoration efforts at Perch Lake (from 1971 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1921 to 1970).

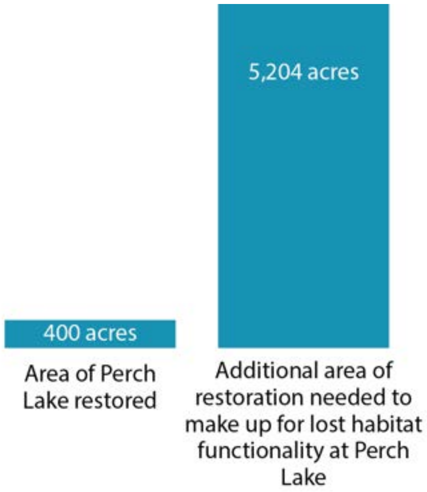


Exhibit 5.11. Additional restoration needed for Perch Lake

Case study acknowledgments

The Project Team would like to acknowledge Nancy Schuldt and Thomas Howes (Fond du Lac Band) for their valuable input and feedback in the development of this case study, and for participating in the cultural and ecological characterization of Perch Lake. We would also like to acknowledge the Fond du Lac Band elders and the wild rice chief who helped us characterize Perch Lake.

Sand Point Sloughs

Sand Point Sloughs are relatively shallow backwater sloughs connected to Lake Superior that are culturally important to the Keweenaw Bay Indian Community (KBIC). Native people used this area for hundreds of years, as indicated by the existence of ancient burial grounds and stories that have been passed on through oral tradition (KBIC, 2003). Manoomin is believed to have been present in Sand Point Sloughs prior to the 1900s (Ravindran et al., 2014). Today, the site contains the KBIC Pow Wow grounds, a traditional healing clinic, extensive wetlands, and Manoomin beds (Exhibit 5.12). A marina, campground, lighthouse, and recreational beaches signify the community's appreciation of this area. This area also holds ecological value as habitat. It provides for a number of species including medicinal plants, insects, fish, and other non-human relatives.

Exhibit 5.12. Map of Sand Point Sloughs

Threats to Manoomin at Sand Point Sloughs

Connected to Lake Superior, Sand Point Sloughs are part of a dynamic coastal system. In the early 20th century, a copper ore processing plant, Mass Mill, operated on the west side of Keweenaw Bay on the south shore of Lake Superior. During the copper ore processing, approximately six billion pounds of mine tailings, locally known as stamp sands, were disposed into Keweenaw Bay. Lake currents continue to carry these tailings southward and redeposit them onto Sand Point, located just four miles south of the Mass Mill. Sand Point has an extensive beach area with approximately 2.5 miles of lake front and is connected to the sloughs. These tailings contain high concentrations of heavy metals that have the potential to cause environmental harm.

More recently, Sand Point Sloughs have been affected by regional hydrologic conditions – including higher water levels – that are occurring at a regional scale and are beyond local control. As a plant species sensitive to changes in water level, higher water levels have negatively affected the establishment and abundance of Manoomin in Sand Point Sloughs. The sloughs' connection to Lake Superior also opens the pathway to aquatic invasive species, such as carp and reed canary grass. Carp, for example, are bottom feeders that uproot Manoomin (Premo et al., 2014). Manoomin abundance may also be impeded by competing native vegetation, such as ginoozhegoons (pickerelweed); and by excessive browsing by wildlife on new stands, such as waterfowl.

Actions taken to improve the abundance of Manoomin at Sand Point Sloughs

Sand Point Sloughs are a KBIC Tribal Trust property, wholly owned by KBIC and located entirely within KBIC L'Anse Reservation boundaries. KBIC took over management of the sloughs in the early 1990s, and shortly after began efforts to reintroduce Manoomin. Between 1991 and 1997, KBIC seeded nearly 1,800 pounds of Manoomin across 8 acres of Sand Point Sloughs. By 1999, Manoomin density was sufficient for KBIC to engage in the tradition of ricing. Between 1999 and 2002, community members harvested an estimated 60 to 150 pounds per year (Ravindran et al., 2014). Since 2013, KBIC has seeded Manoomin annually at Sand Point Sloughs (Exhibit 5.13). KBIC continues to tend to this site in an effort to keep Manoomin teachings and traditions vital. However, since 2002, community members have not been able to harvest Manoomin at Sand Point Sloughs, due to decreased abundance of Manoomin related to regional hydrologic conditions.

In addition to seeding efforts, KBIC and partners have undertaken remediation along the Sand Point shoreline, which was listed as a brownfield site. Remediation efforts included capping stamp sands to stabilize the tailings; planting native plants, trees, and shrubs to increase habitat for birds and other wildlife; and installing mounds and boulders to provide relief in the topography, reduce erosion, and protect valuable coastal wetlands, including Manoomin beds (Ravindran et al., 2014).

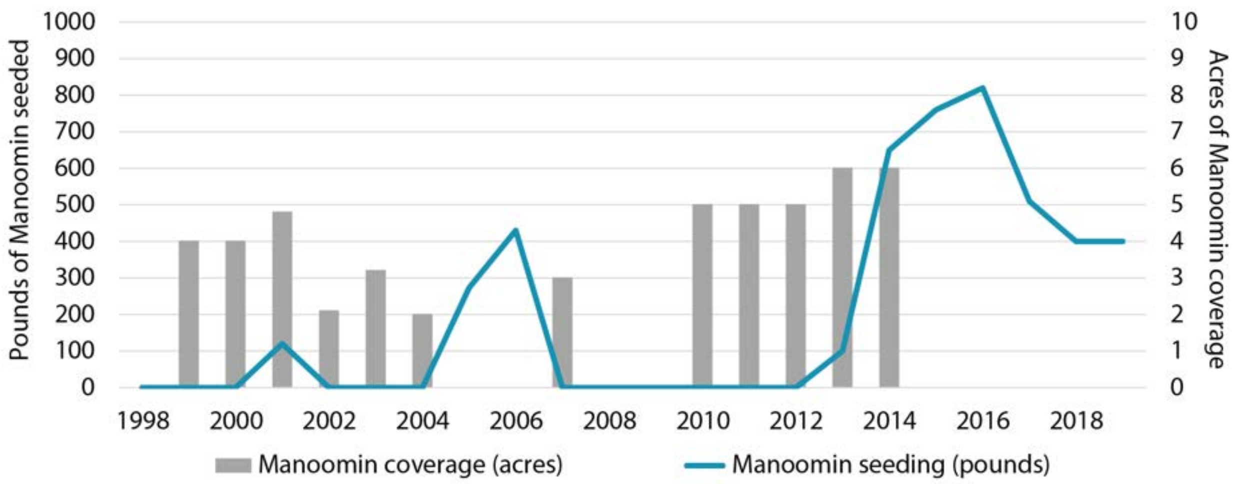


Exhibit 5.13. Manoomin seeding and acres of Manoomin coverage at the Sand Point Sloughs, 1999 to 2019 (data were not collected before 1999, and Manoomin coverage data were not recorded after 2014)

Sources: Ravindran et al., 2014; Karena Schmidt, personal communication, October 31, 2019.

Cultural and ecological characterization at Sand Point Sloughs

Sand Point Sloughs' Manoomin and its associated habitat were characterized over four time periods. This characterization begins after the copper ore processing plant ceased operations around the 1920s.

1920 to 1990: Before KBIC ownership

Based on the combined ranking of cultural and ecological metrics, Sand Point Sloughs was characterized as "not very good" during this period. This ranking reflects the absence of Manoomin from the sloughs and the deposition of mine tailings onto Sand Point. Although Manoomin was absent, the sloughs were still a place of cultural and ecological importance: waterfowl and other wildlife foraged at the sloughs; and community members fished, hunted, and gathered there and held Pow Wows on the grounds. Given the intrinsic cultural and ecological values of the sloughs, some cultural metrics – including spirit relationships, knowledge sharing, and food sovereignty – were characterized with a higher ranking.

Water level

For each of the four time periods, the water level metric was ranked as "not very good." Due to their location, the Sand Point Sloughs are influenced by regional factors such as Lake Superior water levels, which are beyond local control.

1991 to 1998: With active management of Manoomin

Once KBIC took over management of Sand Point Sloughs in the early 1990s and began seeding activities, Manoomin grew modestly. Although community members could not yet harvest Manoomin, the presence of Manoomin significantly improved the ranking of most cultural and ecological metrics. During this period, Sand Point Sloughs ranked as "pretty good" based on the combined ranking of cultural and ecological metrics.

1999 to 2005: With active management and harvesting of Manoomin

Once Manoomin was adequately established at Sand Point Sloughs, KBIC was able to open Sand Point Sloughs to their community members for harvesting. Harvesting allowed the recovery and sharing of Anishinaabe practices, values, beliefs, and language at the sloughs in ways that had not been practiced for years. During this period, Sand Point Sloughs ranked as "doing great" based on the combined ranking of improved cultural and ecological metrics.

2006 to 2019: With higher water levels

Sand Point Sloughs is connected to Lake Superior, and is affected by changes in the lake's water level and invasive and competitive species. Invasive species and competing vegetation that have been documented at Sand Point Sloughs may be impacting Manoomin abundance. Water levels have also fluctuated in Sand Point Sloughs, with lower water levels recorded in 2006 and 2007, and higher water levels in recent years (Ravindran et al., 2014). During this period, Sand Point Sloughs' functionality decreased to "pretty good" based on the combined ranking of cultural and ecological metrics. The decrease in ecological and cultural functionality provided by Manoomin in recent years suggests the need for adaptive management of Manoomin. Actions taken that may have been successful in restoring Manoomin in the past may need to be adjusted to respond to additional threats, such as climate change, to be successful in the future.

The cultural and ecological functionality provided by the Manoomin and its associated habitat at Sand Point Sloughs varied over time, both in aggregate and for individual metrics (Exhibit 5.14).

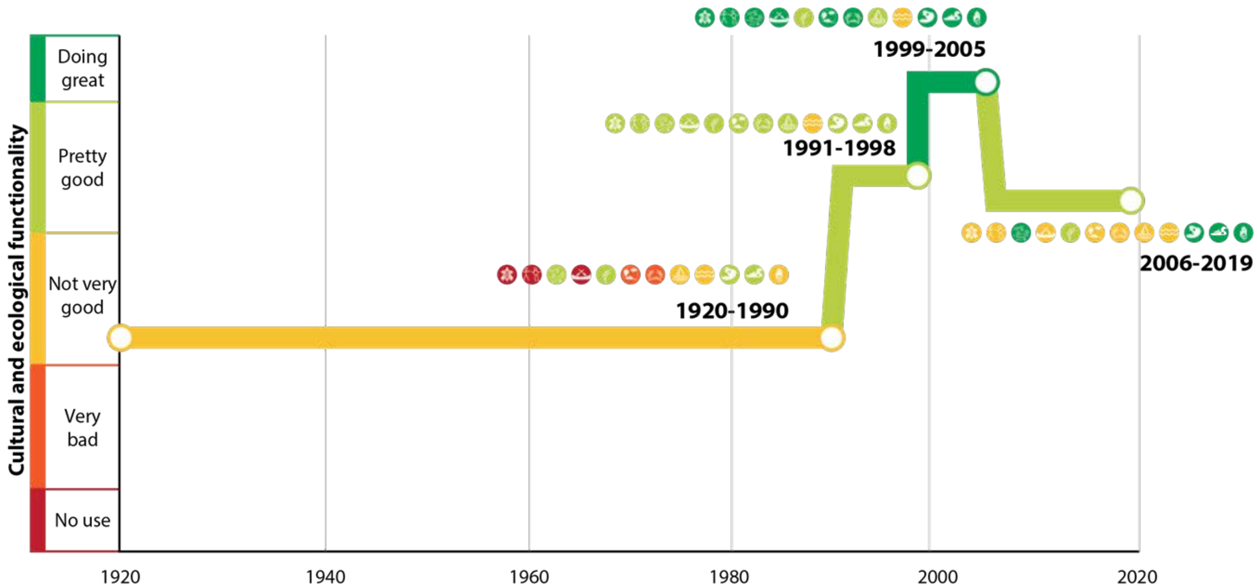


Exhibit 5.14. Characterization of cultural and ecological functionality provided by Manoomin and its associated habitat at Sand Point Sloughs

Additional restoration needed

Based on the characterization of the degree of cultural and ecological function over the four time periods, the HEA calculations demonstrate the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. Given the success of restoration on 8 acres of Sand Point Sloughs, 175 acres of similar Manoomin restoration is needed to counter-balance the lost habitat functionality that has occurred over time (Exhibit 5.15). In other words, 22 equivalent restoration efforts at Sand Point Sloughs (from 1991 to 2019) are needed to counter-balance lost cultural and ecological habitat functionality (from 1920 to 1990).

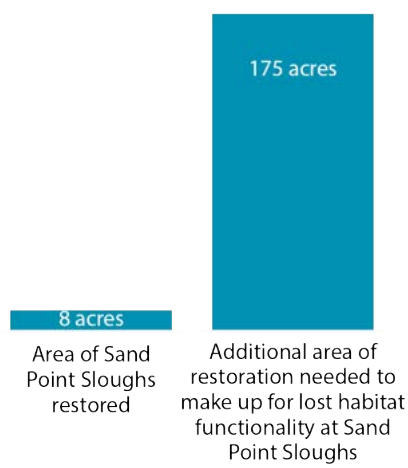


Exhibit 5.15. Additional restoration needed for Sand Point Sloughs

Case study acknowledgments

The Project Team would like to acknowledge Evelyn Ravindran, Karena Schmidt, and Erin Johnston (KBIC) for their valuable input and feedback in the development of this case study, and for participating in the cultural and ecological characterization of KBIC's Sand Point Sloughs.

Net River Impoundment and Vermillac Lake

The Net River is nearly 15 miles long and flows from Baraga County to Iron County, Michigan. Impounded in 1990 as a wetland mitigation site to provide waterfowl benefits, the Net River Impoundment is now 35 acres in size. Vermillac (or Worm) Lake is a 423-acre lake in Baraga County. Both the Net River Impoundment and Vermillac Lake are located outside the L'Anse Indian Reservation, but within Ceded Territory (Exhibit 5.16).

Exhibit 5.16. Map of Net River Impoundment and Vermillac Lake

Threats to Manoomin at Net River Impoundment and Vermillac Lake

Both the Net River Impoundment and Vermillac Lake possibly had Manoomin beds in the past. Many believe that historical trails around the Net River Impoundment indicate traditional use of these places for cultural practices (Evelyn Ravindran, KBIC personal communication, August 20, 2019). Land use changes have altered the local landscape, which may have contributed to the presence or absence of Manoomin at these places.

Actions taken to improve Manoomin at Net River Impoundment and Vermillac Lake

KBIC is receiving more and more teachings from Manoomin and is working to understand which locations on the L'Anse Indian Reservation and within Ceded Territory have conditions that are conducive to grow and sustain Manoomin (BIA, 2019). KBIC is interested in having local sources of Manoomin as seed banks for future restoration activities; as well as places where community members can harvest, prepare, and gift Manoomin. KBIC is currently assessing suitable Manoomin habitat across their territory, and focusing restoration in lakes with the most favorable conditions for Manoomin.

In the early 2010s, KBIC worked with the Michigan Department of Natural Resources to identify additional areas for Manoomin restoration. The Net River Impoundment and Vermillac Lake were selected as lakes with potential for Manoomin beds, and KBIC seeded test plots at both lakes. Given their success, KBIC then seeded the Net River Impoundment and Vermillac Lake with nearly 2,000 pounds of Manoomin seed. Cultural teachings and practices related to Manoomin are beginning to occur at the Net River Impoundment. KBIC continues to seed 97 acres across both lakes with nearly 2,000 pounds of Manoomin each year.

The ultimate goal of the seeding efforts at Net River Impoundment is to produce a Manoomin seed source for Vermillac Lake and other KBIC restoration sites. In keeping with the principles of the honorable harvest, KBIC aims to achieve conditions that will allow the rice to reseed itself to feed wildlife and nourish the people.

Cultural and ecological characterization at Net River Impoundment and Vermillac Lake

Manoomin and its associated habitat at the Net River Impoundment and Vermillac Lake were characterized over two time periods. This characterization begins after the Net River was impounded as a wetland mitigation bank in 1990.

1990 to 2013: Before Manoomin seeding

Based on the combined ranking of cultural and ecological metrics, conditions at the Net River Impoundment and Vermillac Lake were characterized as “not very good” during this period. This ranking reflects the absence of Manoomin from the Net River Impoundment and Vermillac Lake before 2013. Although Manoomin was absent, these areas were culturally and ecological important. Community members used these sites for gathering, fishing, and hunting activities; during these activities, families passed down knowledge to their children or grandchildren about traditional practices and resources. Given the intrinsic cultural and ecological value of these places, some metrics – including spirit relationships, food sovereignty, knowledge generation and sharing, and water level and quality – ranked higher in cultural and ecological characterization.

2014 to 2019: After Manoomin seeding

Once KBIC began seeding the Net River Impoundment and Vermillac Lake, Manoomin grew at these places. Currently, Manoomin supports wildlife and other ecosystem functions. These places have the potential for Manoomin harvesting in the future, although they cannot yet support it. The presence of Manoomin significantly improved the ranking of most of the cultural and ecological metrics. During this period, conditions at the Net River Impoundment and Vermillac Lake ranked as “pretty good” based on cultural and ecological metrics. Although Manoomin provides cultural and ecological functionality, additional management of water levels at the Net River Impoundment could continue to improve the abundance of Manoomin and the long-term sustainability of healthy Manoomin beds.

Cultural and ecological functionality provided by Manoomin and its associated habitat at the Net River Impoundment and Vermillac Lake have increased over time, both in aggregate and for the individual metrics (Exhibit 5.17).

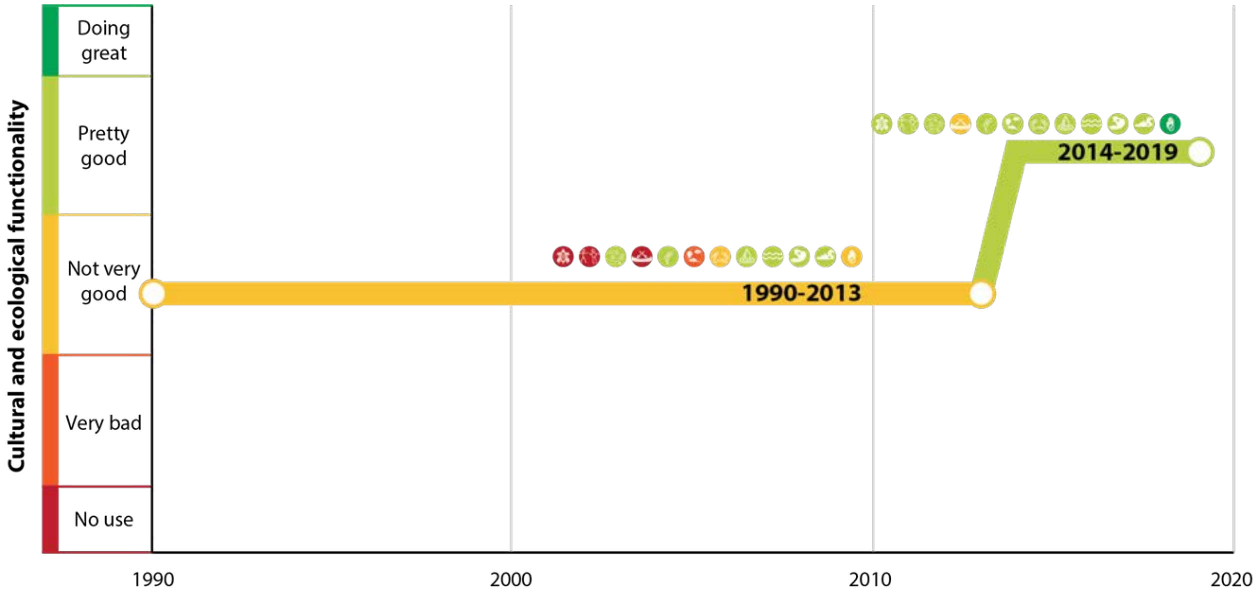


Exhibit 5.17. Characterization of cultural and ecological functionality provided by Manoomin and its associated habitat at Net River Impoundment and Vermillac Lake

Additional restoration needed

Based on the characterization of the degree of cultural and ecological function over the four time periods, the HEA calculations demonstrate the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. With seeding, resource managers successfully established Manoomin across the Net River Impoundment and Vermillac Lake. However, given that the period of degradation is much larger (over 20 years) than the period of restoration (around 5 years), an additional 1,129 acres of similar Manoomin restoration is needed to counter-balance the lost habitat functionality that has occurred over time (Exhibit 5.18). In other words, nearly 12 equivalent restoration efforts at the Net River Impoundment and Vermillac Lake (from 2014 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1990 to 2013).

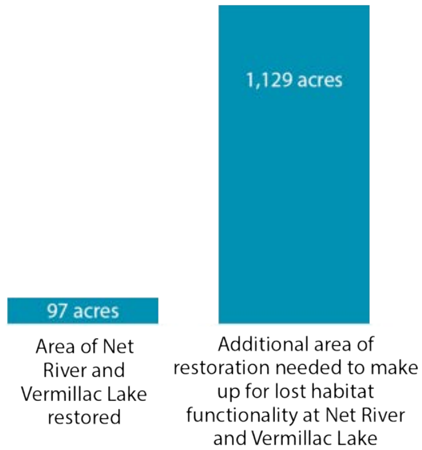


Exhibit 5.18. Additional restoration needed for Net River Impoundment and Vermillac Lake

Case study acknowledgments

The Project Team would like to acknowledge Evelyn Ravindran, Karena Schmidt, and Erin Johnston (KBIC) for their valuable input and feedback in the development of this case study; and for participating in the cultural and ecological characterization of KBIC's Net River Impoundment and Vermillac Lake.

Hiles Millpond

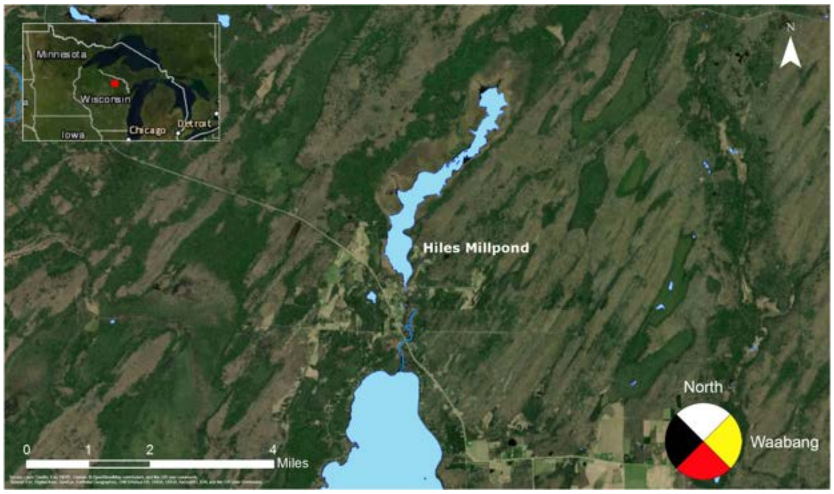


Exhibit 5.19. Map of Hiles Millpond

Hiles Millpond is an approximately 300-acre lake located in Forest County, Wisconsin, an 1842 Ceded Territory (Exhibit 5.19).

The millpond provides excellent wildlife habitat, especially for waterfowl, furbearers, eagles, and other wetland-dependent species. The lake also supports a northern pike and panfish fishery.

Threats to Manoomin at Hiles Millpond

Water ponded at Hiles Millpond in the late 1880s, when the Hiles Lumber Company built a dam for logging purposes. Although there is no record of the presence of Manoomin at Hiles Millpond, it may have been there at some point prior to dam construction, since Manoomin is in nearby waters. If Manoomin was present at Hiles Millpond historically, it could have been negatively affected by changes in water levels associated with construction of the dam.

The area and waters around the Town of Hiles were traditionally used by the Lac du Flambeau Band of Lake Superior Chippewa Indians (LDF Band), the Sokaogon Chippewa Community, and other Ojibwe Bands and their ancestors. However, use of the area by Bands for hunting, gathering, fishing, and trapping was limited during much of the last century up until the 1980s. Use of this area increased after this time when relations with the local community in the Town of Hiles improved.

Actions taken to improve the abundance of Manoomin at Hiles Millpond

In 1992, safety inspections found several problems with the dam structure at Hiles Millpond. To meet contemporary safety standards, the Town of Hiles needed to replace the dam structure. Since the town lacked adequate funds, federal, state, tribal, and nongovernmental organizations entered into a cooperative effort. A Memorandum of Understanding included a provision for the town to cooperate with the Forest Service to manage the millpond for productive wildlife and fish habitats, including possible manipulation of water levels, following completion of the project. The dam and water control structure were rebuilt in fall 1993.

Shortly after, biologists realized that the ecological benefits of Hiles Millpond could be significantly enhanced by establishing Manoomin on the millpond. Establishing Manoomin could also help to make up for the loss of Manoomin on other waters in the region, many of which were difficult or impossible to recover due to excessive development, conflicting uses, or other threats to Manoomin (Peter David, GLIFWC, personal communication, November 27, 2019).

In 1998, GLIFWC and the Forest Service cooperatively seeded the Hiles Millpond flowage with a relatively modest amount of Manoomin (329 pounds). Small patches of Manoomin then expanded modestly over the next several years. In 2011, Manoomin expanded significantly under natural drought conditions, which led biologists to believe that Manoomin might increase if the typical summer water level was lowered slightly.-

Although the Town of Hiles was initially concerned that lower water levels might negatively affect the northern pike fishery, it ultimately agreed to manage the water level for Manoomin. Once lowered, Manoomin showed an immediate response. Manoomin abundance increased significantly from 2013, before water levels were lowered, to 2014, following a lowering of water levels (Exhibit 5.20). In recent years, over 125 acres of Manoomin can be found growing across the lake (Peter David, GLIFWC, personal communication, November 27, 2019).

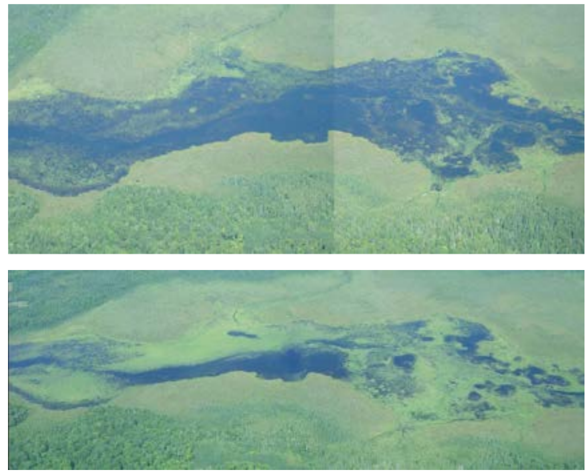


Exhibit 5.20. Manoomin abundance on a portion of the Hiles Millpond in 2013 (above), and in 2014 (below) following a lowering of water levels

Credit: Peter David, GLIFWC.

Cultural and ecological characterization at Hiles Millpond

Manoomin and its associated habitat at Hiles Millpond were characterized over three time periods. The characterization starts in 1980 because prior to that time community members were less likely to travel to Hiles Millpond to harvest Manoomin, and undertake other traditional hunting and gathering practices.

1980 to 1997: Before Manoomin seeding

Based on the combined ranking of cultural and ecological metrics, Hiles Millpond was characterized as "very bad" during this period. Because of the absence of Manoomin in the millpond, most of the metrics – particularly cultural metrics – ranked low on the score range.

1998 to 2013: After Manoomin seeding

Once seeding activities began in 1998, Manoomin began to grow at the millpond. The presence of Manoomin improved the rankings for most cultural and ecological metrics. In particular, the presence of Manoomin at Hiles Millpond allowed for some harvesting, preparation, and sharing of Manoomin by the community. It also improved the Anishinaabe's connections and balance with spirit beings and relatives, and it supported diverse biological communities. During this period, Hiles Millpond ranked as "not very good" based on the combined ranking of cultural and ecological metrics.

2014 to 2019: With water level management

After resource managers adjusted water levels for Manoomin in 2014, its coverage continued to expand. More Manoomin allowed for harvesting, preparation, and sharing of Manoomin in ways practiced by ancestors. It also allowed for knowledge generation and sharing of Anishinaabe practices, values, beliefs, and language. Although Manoomin provides many cultural and ecological functionality, additional management of water levels could continue to improve Manoomin and its associated habitat at Hiles Millpond. During this period, Hiles Millpond ranked as “pretty good” based on the combined ranking of cultural and ecological metrics.

Cultural and ecological functionality provided by Manoomin and its associated habitat at Hiles Millpond have increased over time, both in aggregate and for individual metrics (Exhibit 5.21).

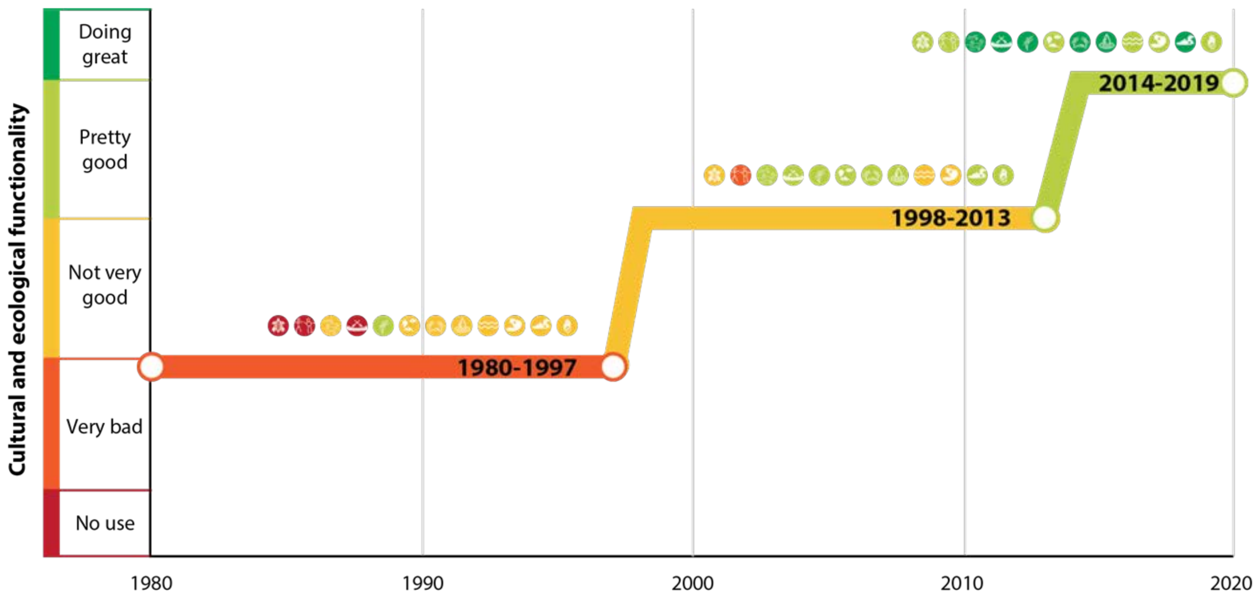


Exhibit 5.21. Characterization of cultural and ecological functionality provided by Manoomin and its associated habitat at Hiles Millpond

Additional restoration needed

Based on the characterization of the degree of cultural and ecological function over the four time periods, the HEA calculations demonstrate the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. With modest seeding and slight modifications in water-level management, resource managers successfully established Manoomin across the Hiles Millpond. The analysis indicates that an additional 864 acres of similar Manoomin restoration is needed to counter-balance the lost habitat functionality that has occurred over time (Exhibit 5.22). In other words, nearly three equivalent restoration efforts at Hiles Millpond (from 1998 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1980 to 1997).

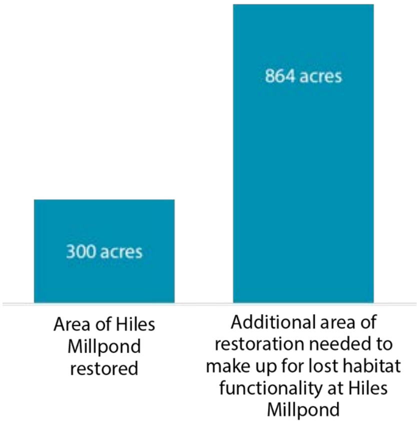


Exhibit 5.22. Additional restoration needed for Hiles Millpond

Case study acknowledgments

The Project Team would like to acknowledge Peter David (GLIFWC), Eric Chapman and Joe Graveen (LDF Band), and Peter McGeshick (Sokaogon Chippewa Community) for their valuable input and feedback in the development of this case study, and for participating in the cultural and ecological characterization of the Hiles Millpond.

Big Rice Lake

Big Rice Lake, located in St. Louis County in northeastern Minnesota, is approximately 1,870 acres (Exhibit 5.23). The area was traditionally used for ricing, sugar bush, and hunting activities; and archeological evidence indicates human use on sites surrounding the lake for hundreds – perhaps thousands – of years.

Exhibit 5.23. Map of Big Rice Lake

The lake is an important feeding and resting area for migrating waterfowl. In years of good Manoomin production, mallards, goldeneyes, wood ducks, blue winged teal, and ring-necked ducks use the lake. In 1992, Big Rice Lake became a Designated Wildlife Lake because of its "outstanding value to wildlife." Currently, the lake supports a bald eagle nesting territory, as well as muskrats, minks, beaver, otter, great blue herons, and trumpeter swans.

Threats to Manoomin at Big Rice Lake

Hydrologic changes, impacts from competing vegetation, and perhaps climate change have threatened Manoomin at Big Rice Lake. Manoomin is very sensitive to changes in water levels. Low or stable water conditions over long periods can encourage the proliferation of other vegetation, such as ginoozhegoons (pickerelweed), which can outcompete Manoomin for space and resources. Ginoozhegoons has expanded considerably on Big Rice Lake, especially on the eastern half of the lake. In addition to the artificial controls on water levels, climate change could change precipitation patterns, which may increase both the likelihood of drought and the frequency of heavy rain events that can cause high water levels and flooding in Big Rice Lake.

Actions taken to improve Manoomin at Big Rice Lake

Natural resource managers have taken several actions with the goal of increasing Manoomin at Big Rice Lake. In 1995, federal and state agencies built a rock weir at the outlet of the lake to increase the water flow out of the lake and reduce rapid water-level changes that can negatively impact Manoomin growth (MN DNR, 2013). Initially, the installation of the rock weir seemed to improve Manoomin coverage at Big Rice Lake; however, despite adjustments to the weir and varied beaver management, the more stable water level appears to have favored ginoozhegoons over Manoomin (Exhibit 5.24).

Since 2006, a cooperative effort of several federal, state, and tribal partners has taken additional management activities to further support Manoomin (Vogt, 2020b). In addition to allowing water levels to vary naturally, natural resource managers are cutting ginoozhegoons. Natural resource managers use an airboat with chains to disturb the substrate of Big Rice Lake to encourage the germination of Manoomin seed in several test plots (Vogt, 2020b). These efforts control about 100 acres of ginoozhegoons each year, but Manoomin regrowth in cut areas has been minimal (Vogt, 2020b). Over the years, partners have also trapped beavers and removed beaver dams to control water levels.

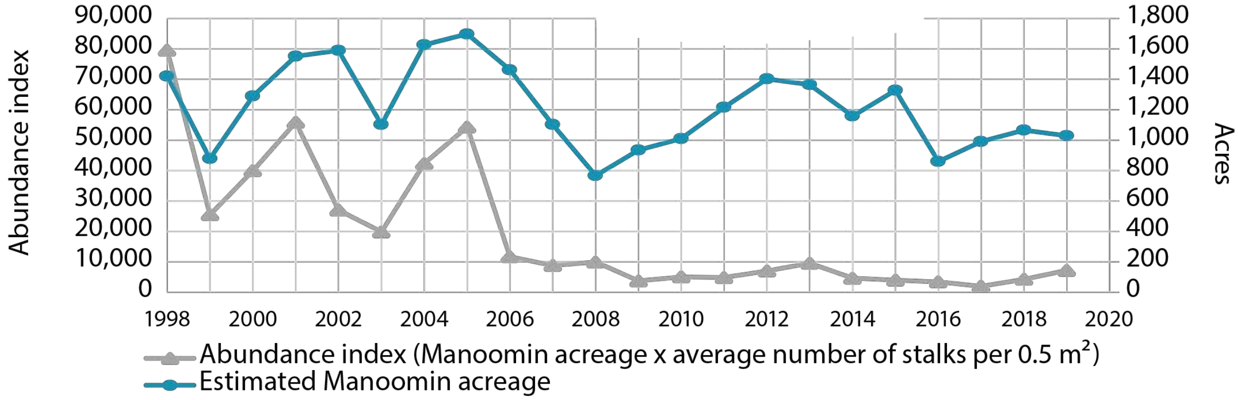


Exhibit 5.24. Manoomin abundance index and acres on Big Rice Lake

Source: Vogt, 2020b.

Cultural and ecological characterization at Big Rice Lake

Big Rice Lake's Manoomin and its associated habitat were characterized over three time periods.

1900 to 1994: Before rock weir construction

Based on the combined ranking of the cultural and ecological metrics, Big Rice Lake was characterized as "pretty good." During this period, Big Rice Lake was dominated by Manoomin with variable production across years, which provided high-quality waterfowl and wildlife habitats, and the opportunity for harvesting. The lake was culturally and historically important to Ojibwe Bands who used the lake during this period and exercised their treaty rights.

1995 to 2005: After rock weir construction

Immediately after the installation of the rock weir in 1995, Manoomin coverage at Big Rice Lake improved in some years. However, over time the more stable water level favored ginoozhegoons over Manoomin, and Manoomin began to decline, although it remained at the "pretty good" ranking score based on the combined ranking of cultural and ecological metrics.

2006 to 2019: With active management of Manoomin

By 2006, Big Rice Lake ranked as "very bad" based on the combined ranking of cultural and ecological metrics. Hydrologic changes, competition from ginoozhegoons, and perhaps other unknown factors led to the dramatic decline of Manoomin. From 2006 to 2019, natural resource managers took active management steps to recover Manoomin at Big Rice Lake; however, it remained sparse in coverage, with only a few small, moderate-to-good density stands found on the lake. As a result, community members were unable to harvest, prepare, and share Manoomin in ways practiced by their ancestors.

This also limited sharing, transmittal, and generation of Anishinaabe practices. The decline in Manoomin may have also negatively affected migratory waterfowl that use the lake.

Cultural and ecological functionality provided by Manoomin and its associated habitat at Big Rice Lake decreased over time, both in total and for individual metrics (Exhibit 5.25).

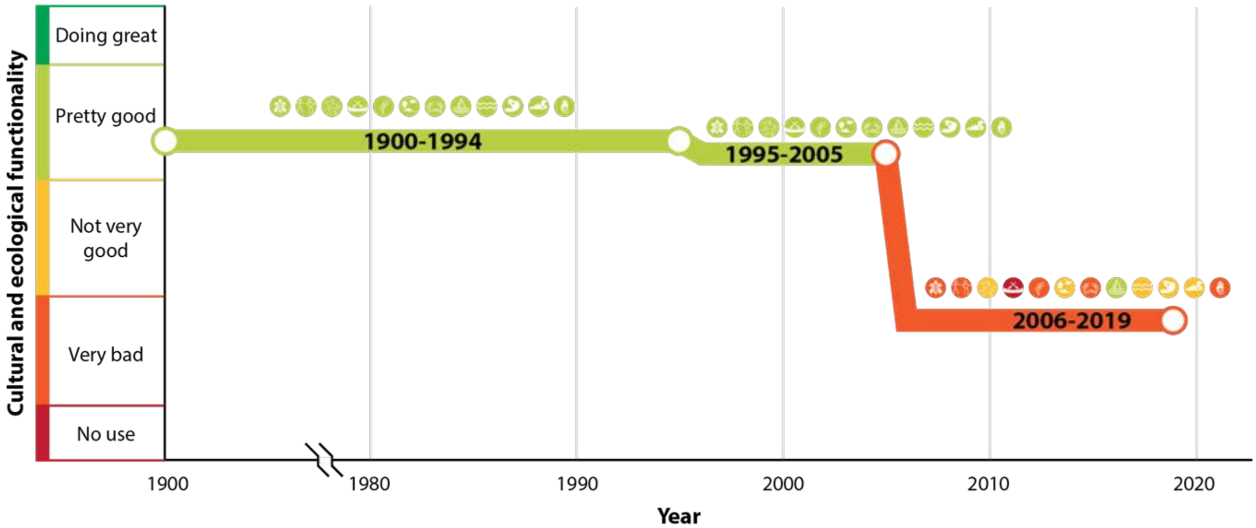


Exhibit 5.25. Characterization of cultural and ecological functionality provided by Manoomin and its associated habitat at Big Rice Lake

Additional restoration needed

Since the 1990s, natural resource managers have tried to improve the conditions of Manoomin and its associated habitat at Big Rice Lake; however, recent actions have not been successful and conditions continue to be diminished.

Restoration funds have recently been awarded to undertake further actions at the lake (Helmberger, 2019). If these actions were to improve functionality, we could use an HEA to demonstrate the additional equivalent units of restoration that would be needed to counter-balance the severity and timespan of degradation. For example, if actions were implemented over the next 20 years (2020 to 2040) to improve habitat functionality by 2.5%, we would need over 400,000 acres of similar Manoomin restoration to counter-balance the lost habitat functionality that has occurred over time (from 1995 to 2019). This is equivalent in size to over 200 Big Rice Lakes. The table below provides the HEA results, assuming several hypothetical scenarios of restoration improving habitat functionality (Exhibit 5.26); it is important to note that we do not know what actions are needed to create these percent improvements or if they are achievable. The main purpose of these scenarios is to highlight that if only minimal restoration is achieved at Big Rice Lake (which may be anticipated, given the long history of attempting restoration, with minimal response), then significant equivalent amounts of this restoration would be needed to balance the prolonged period of degradation at this lake.

Exhibit 5.26. HEA results, assuming several hypothetical scenarios of improvements in habitat functionality

Hypothetical percentage of improvement in habitat functionality from 2020 to 2040	Acres needed to counter-balance historical losses given hypothetical improvement[a]	Number of Big Rice Lakes needed to counter-balance historical losses given hypothetical improvement
2.5%	426,100	228
5.0%	213,100	114
10.0%	106,500	57
20.0%	53,300	29

a. Acres rounded to the nearest hundred.

This case study demonstrates how difficult it is to restore degraded Manoomin and its associated habitat, and how important it is to protect existing Manoomin habitat, as actions taken at Big Rice Lake have not improved its ability to support the various functions of Manoomin. A future characterization of Big Rice Lake could consider the effects of new restoration funding aimed at returning the natural functionality of the lake (Helmberger, 2019). This would refine and improve the current estimate of additional amount of restoration needed. Future restoration actions will include increased efforts to remove ginoozhegoons and return the outlet of the lake to natural rock rapids by removing the rock weir and accumulated sediment (Helmberger, 2019).

Case study acknowledgments

The Project Team would like to acknowledge Darren Vogt (1854 Treaty Authority) and Nancy Schuldt (Fond du Lac Band of Lake Superior Chippewa) for their valuable input and feedback in the development of this case study. In addition, the Project Team would like to thank Thomas Howes (Fond du Lac Band of Lake Superior Chippewa), Tara Geshick (Bois Forte Band of Lake Superior Chippewa), Daniel Ryan (U.S. Forest Service), and Melissa Thompson and Tom Rusch (Minnesota Department of Natural Resources) for participating in the cultural and ecological characterization of Big Rice Lake.

Twin Lakes

Exhibit 5.27. Map of Twin Lakes

The Twin Lakes are located in St. Louis County in northeastern Minnesota. Sandy Lake is approximately 120 acres and Little Sandy Lake is approximately 90 acres (Exhibit 5.27). The Twin Lakes are located immediately downstream of the tailings basin for U.S. Steel's Minntac iron ore operation. Prior to mining operations, the Twin Lakes produced good stands of Manoomin and were important ricing sites for Ojibwe Bands and vital habitat for a range of wildlife species.

Threats to Manoomin at the Twin Lakes

U.S. Steel's Minntac iron ore operation facility includes two mining areas, several processing plants, a heating and utility plant, a water reservoir, and a tailings basin (MWH, 2004). Construction of the tailings basin began in 1966 (MWH, 2004). Part of the seepage from the tailings basin discharges to the east into the Sand River, flows into the Twin Lakes, and into the Sand River watershed. Discharge from the tailings basin has changed the chemical composition and hydrologic condition of the Twin Lakes by increasing sulfate levels and, to a lesser extent, increasing the volume of water in the lakes.

Ongoing sulfate loading renders restoration ineffective at the Twin Lakes

The Twin Lakes are severely degraded by sulfate-laden mine waste from U.S. Steel's tailings basin. Because sulfate concentrations are high, any attempts to restore Manoomin stands that do not address this fundamental issue have proven largely ineffective. For example, multiple attempts by natural resource managers to adjust water levels through beaver management (in the 1970s to 1990s and 2015 to 2018) have not improved Manoomin stands in a measurable way. Modest reseeding efforts (in 1991 and 1992) have also not been effective. Restoration efforts are not successful because sulfate levels at the Twin Lakes are at least 10 times higher than the Manoomin sulfate standard; the current sulfate standard is 10 mg/L (Exhibit 5.20; Tribal Wild Rice Task Force, 2018).

In 2010, U.S. Steel was required to construct a seepage collection system to collect some of the mine wastewater discharging at the base of the tailings basin. While this reduced the total volume of water discharging from the mine site, it did not fully stop it. As a result, mine waste high in sulfate continued to contaminate the Twin Lakes after the collection system was installed. The 1854 Treaty Authority monitored lake conditions before the installation of the seepage collection system (2010) and after (2011 to 2019). Data collected included information on water quality (sulfate and other water quality indicators) and water-depth recordings; as well as data from inlet and outlet field surveys, vegetation surveys, and aerial surveys (Vogt, 2020a). Results showed that sulfate levels remained elevated well above the standard over the nine years of monitoring after the installation of the seepage system, and remained substantially unchanged from conditions prior to the installation (Exhibit 5.28).

During the monitoring study, very limited Manoomin stalks were also observed across the Twin Lakes over the same time period. In 2015, U.S. Steel planted test plots to determine if Manoomin had the potential to grow in the Twin Lakes. In this small-scale test plot, U.S. Steel reseeded with 40 pounds of Manoomin. After seeding, Manoomin success has varied but has been limited across years (Vogt, 2020a). Full-scale reseeding was not attempted.

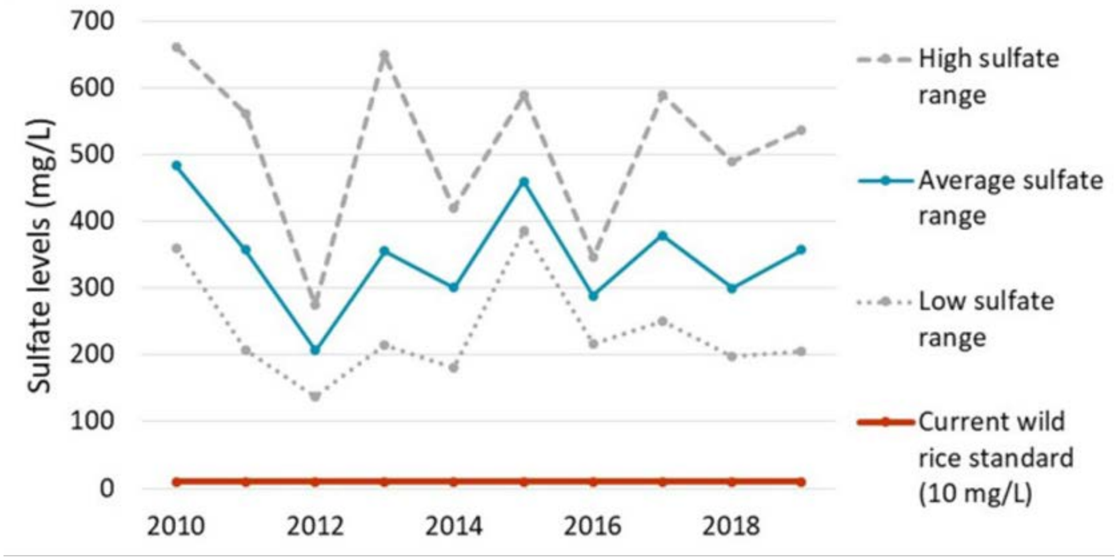


Exhibit 5.28. Sulfate concentrations at the inlet to the Twin Lakes compared to current standard sulfate levels (10 mg/L) for Manoomin, 2010 to 2019

Source: Vogt, 2020a.

Cultural and ecological characterization at the Twin Lakes

The Twin Lakes' Manoomin and its associated habitat were characterized over four time periods.

1950 to 1965: Before construction of the tailings basin

Based on the combined ranking of cultural and ecological metrics, conditions at the Twin Lakes were characterized as "doing great" during this period. Prior to the discharge of mine waste into the Twin Lakes, both lakes had moderately dense to dense stands of Manoomin. The Bois Forte Band of Chippewa, Grand Portage, and other community members historically harvested Manoomin in these lakes. In addition, Manoomin supported waterfowl (e.g., mallard, black ducks, green winged teal, wood ducks), fish such as northern pike, and other wildlife during this period (Minnesota Division of Game and Fish, 1966a, 1966b).

1966 to 1989: After construction of the tailings basin

After the discharge of mine waste started, Manoomin coverage in the Twin lakes steadily declined. Compared to a 1966 vegetation survey of the Twin Lakes (Minnesota Division of Game and Fish, 1966a, 1966b), a 1987 survey found that Manoomin was essentially absent from both lakes, while water levels were considerably higher and water clarity increased dramatically (State of Minnesota, 1987). By 1989, the Twin Lakes ranked as “no use” based on the combined ranking of cultural and ecological metrics.

1990 to 2009: With limited restoration actions

During this period, some actions were undertaken to recover Manoomin, including beaver management and small-scale reseeding efforts. However, these actions did not address the fundamental issue of high levels of sulfate and were largely ineffective at restoring the abundance of Manoomin and its associated habitat at the Twin Lakes. Given the absence of Manoomin on the lakes, community members were unable to harvest, prepare, and share Manoomin in ways practiced by their ancestors. The lost use of the Twin Lakes also limits sharing, transmittal, and generation of Anishinaabe practices at these lakes. During this period, the ranking of the Twin Lakes remained near “no use” based on the combined ranking of cultural and ecological metrics.

2010 to 2019: After construction of the seepage collection system

After U.S. Steel constructed the seepage system, Manoomin remained essentially absent from the Twin Lakes. With the lakes unable to support Manoomin, community members remained unable to harvest, prepare, and share Manoomin in ways practiced by their ancestors. During this period, the ranking of the Twin Lakes remained near “no use” based on the combined ranking of cultural and ecological metrics.

Cultural and ecological functionality provided by Manoomin and its associated habitat at the Twin Lakes declined over time, both in aggregate and for the individual metrics (Exhibit 5.29).

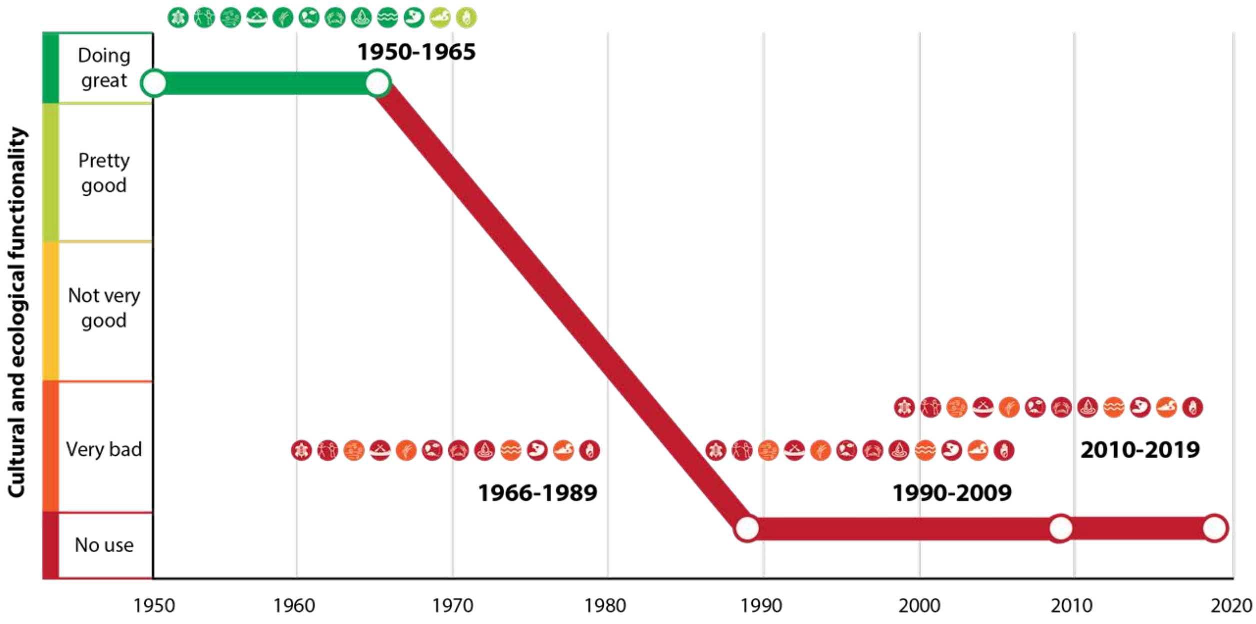


Exhibit 5.29. Characterization of cultural and ecological functionality provided by Manoomin and its associated habitat at the Twin Lakes

Additional restoration needed

Since the installation of a tailings basin for the U.S. Steel's Minntac facility in the mid-1960s, the abundance of Manoomin at the Twin Lakes has steadily declined. Actions taken at the Twin Lakes to improve Manoomin and its associated habitat have been limited and have not addressed the fundamental problem of sulfate loading from the mine. If actions were taken to improve conditions in the future, we could use an HEA to demonstrate the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. For example, if actions were implemented over the next 20 years (2020 to 2040) to improve habitat functionality by 2.5%, over 100,000 acres of similar Manoomin restoration would be needed to counter-balance the lost habitat functionality that has occurred over time (from 1966 to 2019). This is equivalent in size to over 550 Twin Lakes.

Exhibit 5.30 provides the HEA results, assuming several hypothetical scenarios of improvements in habitat functionality; it is important to note that we do not know what actions are needed to create these percent improvements, but they would likely require addressing the fundamental problem of sulfate loading from the mine. The main purpose of these scenarios is to highlight that if only minimal restoration is achieved at Twin Lakes (which may be anticipated, given the long history of attempting restoration, with minimal response), then significant equivalent amounts of this restoration would be needed to balance the prolonged period of degradation at these lakes.

Exhibit 5.30. HEA results, assuming several hypothetical scenarios of improvements in habitat functionality

Hypothetical percentage of improvement in habitat functionality from 2020 to 2040	Acres needed to counter-balance historical losses given hypothetical improvement[a]	Number of Twin Lakes needed to counter-balance historical losses given hypothetical improvement
2.5%	116,700	556
5.0%	58,400	278
10.0%	29,200	139
20.0%	14,600	69

a. Acres rounded to the nearest hundred.

This case study demonstrates the difficulty in restoring Manoomin and its associated habitat when the root cause of the degradation – in this case, sulfate discharge – is not addressed. Given the difficulty of restoring degraded habitat, it is important to protect and preserve existing Manoomin habitat to ensure a future with Manoomin.

Case study acknowledgments

The Project Team would like to acknowledge Darren Vogt (1854 Treaty Authority) and Nancy Schuldt (Fond du Lac Band of Lake Superior Chippewa) for their valuable input and feedback in the development of this case study. The Project Team would also like to thank Wayne Dupuis (Fond du Lac Band of Lake Superior Chippewa), Tara Geshick (Bois Forte), John Coleman and Esteban Chiriboga (Great Lakes Indian Fish & Wildlife Commission), and Amy Myrbo for participating in the cultural and ecological characterization of the Twin Lakes.

6. Cross-case findings and lessons learned

In this chapter, we detail the cross-case findings and lessons learned developed through this study. The cross-case findings represent the collective wisdom of our project team on these seven unique case studies. While each case study is unique, with distinct attributes, here we focus on some common themes that emerged across the studies.

The Anishinaabe have long history of careful tending to Gichi-manidoo gitigaan through Manoomin stewardship; however, restoring Manoomin and its associated habitat remains a significant challenge under current conditions.

> The older term for rice beds, *Gichi-manidoo gitigaan* or the Great Spirit's Garden, "captures (among other concepts) the perspective that while Manoomin is a natural part of the landscape, careful tending to the crop can enhance its health and productivity, in the same way a dedicated gardener benefits her plants."
>
> – David et al., 2019

The Anishinaabe have a long relationship of careful tending to Manoomin to enhance its health and productivity (David et al., 2019). This stewardship is both spiritual and ecological in nature. Wild rice chiefs, for example, conduct ceremonies honoring Manoomin to help protect the crop and ensure its abundance (David et al., 2019). With tribal and other partners, wild rice chiefs also regulate water levels, remove competitive vegetation, and seed new areas. The contemporary restoration undertaken throughout the seven case studies described in this study reflect these stewardship practices.

- *Manoomin seeding* efforts have expanded since the reaffirmation of treaty rights in the Great Lakes region (David et al., 2019). Considerable resources have been expended to increase the abundance of Manoomin through seeding efforts. Most of our case studies include some Manoomin seeding efforts (see Exhibit 5.2). The level of effort varies from modest reseeding efforts in the Twin lakes to more extensive reseeding efforts at Lac Vieux Desert's Rice Bay.
- *Water-level management* can help regulate water levels to benefit Manoomin; these management actions can include traditional water-level management actions (e.g., removing beaver dams), as well as more complex water-level management activities. Most of the restoration efforts in our case studies include water-level management of some form (see Exhibit 5.2). Changing the operating regime of a dam on Lac Vieux Desert to lower water levels, for example, combined with Manoomin seeding efforts, helped to reestablish Manoomin on Lac Vieux Desert's Rice Bay.
- *Removal of competitive vegetation* on a rotational schedule can restore Manoomin density. In several case studies, the native plant ginoozhegoons is outcompeting Manoomin (Exhibit 2.1). Fond du Lac Band of Lake Superior Chippewa, for example, is undertaking mechanical removal of ginoozhegoons at *Perch Lake* and Big Rice Lake to restore Manoomin habitat (Fond du Lac Band, 2018).

Success of these restoration actions has been incremental and at times challenging. Restoration actions taken at historically high-producing Manoomin waters – including Big Rice Lake, Twin Lakes, Lac Vieux Desert's Rice Bay, and *Perch Lake* – have not returned Manoomin and its associated habitat to historical cultural and ecological functionality. And, in some cases, restoration actions have been largely ineffective with Manoomin abundance and density continuing to decline. For example, natural resource managers have tried to improve the conditions of Manoomin and its associated habitat at Big Rice Lake since the 1990s; however, actions have had limited success and Manoomin conditions continue to be diminished.

Several case studies also highlight the need to return to the concept of traditional stewardship and carefully tend to Manoomin through sustained, long-term resource management At Perch Lake, the Fond du Lac Band of Lake Superior Chippewa developed a management strategy that brings lake levels to flood stage every four years in order to stress perennial species, such as ginoozhegoons that otherwise outcompete Manoomin. This long-term restoration approach provides Manoomin with a competitive advantage in the immediate years following the flood stage (Fond de Lac Band, 2018).

Even in places where Manoomin restoration has shown success, more restoration is often needed given the significant historical losses in Manoomin cultural and ecological functionality.

The combined HEA approach applied in this study accounts for the amount of time that Manoomin habitat has been degraded and the time required for restored Manoomin habitat to recover or reach improved functionality. For several case studies, water level modifications through dams and agricultural diching or mining activities led to a decline in Manoomin habitat over 100 years ago. For example, Lac Vieux Desert was first dammed around 1870 for logging operations, and by 1907 the WVIC began operating the lake as a storage reservoir. In 1937, WVIC replaced the wooden dam with a reinforced concrete and steel structure. Changes in water levels caused by the dam initiated a decline in Manoomin and, from 1938 to 1952, Manoomin declined steadily and community members stopped harvesting it during this period (Barton, 2018; Labine, 2017). In addition, mine tailings were carried from a copper ore processing plant that operated from 1902 to 1919 around Keweenaw Bay. Connected to Keweenaw Bay, Sand Point Sloughs, a culturally important site for KBIC, and its natural resources have been exposed to high concentrations of heavy metals for many years.

Even with successful restoration, Manoomin habitat at many of our case study sites has had significant cultural and ecological losses over a long period of time, which often means that many more acres of restoration are needed to counter-balance the lost habitat functionality than the case study footprint. At Lac Vieux Desert's Rice Bay, the equivalent of 12 restoration efforts (from 1991 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1900 to 1990), while at Sand Point Sloughs, 22 equivalent restoration efforts (from 1991 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1920 to 1990).

At some locations, restoration actions may never fully recover all cultural and ecological functionality given that long time period of loss. At Twin Lakes, for example, actions taken to improve Manoomin and its associated habitat have been limited and have not addressed the fundamental problem of sulfate loading from the mine. Given the significant cultural and ecological losses that have occurred since the installation of a tailings basin for the U.S. Steel's Minntac facility in the mid-1960s, it is challenging to foresee a scenario where restoration actions could fully recover all lost functionality. In these cases, protection and/or restoration of Manoomin habitat at additional locations may be one approach to compensate for all the losses that occurred over time.

Seeding to enhance existing Manoomin stands and to introduce it to new locations can be worthwhile and necessary; places with favorable habitat features and conditions seem conducive to growing Manoomin.

Manoomin seeding in waters with favorable physical or hydrologic features can be an effective and inexpensive way to restore Manoomin (David et al., 2019). In addition, seeding at both sites where Manoomin is known to have historically occurred, and sites where there are no records, but hydrologic conditions seem suitable, can be worthwhile and necessary – "worthwhile because of the many ecological and cultural benefits rice provides and because rice abundance in the state remains lower than it was prior to European contact, and necessary because rice seed has a very limited natural ability to disperse" (David et al., 2019, p. 68). Natural resource managers around the Lake Superior region have had some success in identifying good Manoomin habitat, based on physical or hydrologic features, and seeding Manoomin. In two of our seven case studies, natural resource managers selected areas that were not known to have any Manoomin, but were thought to have favorable conditions for Manoomin growth – suitable soils, clean water, and modifications in water-level management. The following two case studies are showing preliminary success in their seeding efforts. At Hiles Millpond, biologists realized that the ecological benefits of this place could be significantly enhanced by establishing Manoomin. With modest seeding and slight modifications in water-level management, resource managers successfully established Manoomin across the Hiles Millpond. At Net River Impoundment and Vermillac Lake, KBIC worked with the Michigan Department of Natural Resources to identify areas for Manoomin restoration, and the Net River Impoundment and Vermillac Lake were selected as lakes with potential for Manoomin beds. After successful seeded test plots at both lakes, KBIC has expanded seeding efforts and has seen successful establishment of Manoomin across these locations. In addition, cultural teachings and practices related to Manoomin are beginning to occur at the Net River Impoundment.

Although the results of seeding efforts are encouraging, more study is needed to confirm whether seeding can lead to culturally and ecologically high-quality Manoomin habitat. In addition, given that the period of degradation is often longer than the period of restoration, additional Manoomin restoration may be needed to counter-balance the lost habitat functionality that has occurred over time. At Net River Impoundment and Vermillac Lake, for example, nearly 12 equivalent restoration efforts (from 2014 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1990 to 2013).

Restoration must be adaptive; what may have worked in the past may not be successful in the future, given additional threats.

Many tribal, state, and federal agencies have been involved in Manoomin restoration around the Lake Superior region for decades and, in the case of tribal communities, for much longer. However, in some cases, actions taken in the past that have had some success at restoring Manoomin are no longer successful. For example, more frequent heavy rainfall events in the spring and summer have negatively affected Manoomin in Lac Vieux Desert's Rice Bay. These above-average precipitation events, which have led to "ghost rice" or empty seed hulls that never fill and brown spot disease in Manoomin beds, are likely driving the decline of Manoomin abundance on Rice Bay. In addition, Sand Point Sloughs is connected to Lake Superior, and affected by changes in the lake's water level and invasive and competitive species. These regional threats to the sloughs may be affecting Manoomin abundance and are largely beyond local control. The decrease in ecological and cultural functionality provided by Manoomin in recent years at several of our case study sites suggests the need for adaptive management of Manoomin habitats. Actions taken that may have been successful in restoring Manoomin in the past may need to be adjusted to respond to additional threats, such as climate change, to be successful in the future.

As conditions change and as we face uncertainty in future environmental conditions, it will be critical to collect monitoring data, evaluate the degree of success of restoration actions based on the interpretation of those data, and then make adaptations, or changes, as needed to future restoration actions to adapt to changing environmental conditions. Adaptive management could include taking initial restoration actions, and then using new information for future decisions. Or it can include exploring a range of options during all phases of restoration to select the best path forward to achieving restoration objectives. Long-term adaptive management of Manoomin and its associated habitat will rely on monitoring and make adjustments in the future based on monitoring results.

Monitoring should be incorporated into all future restoration projects.

Monitoring can help wild rice chiefs and other natural resource managers assess the health of existing Manoomin habitats, evaluate the success of different restoration actions, and make informed resource management decisions. Monitoring can provide information about ecological trends, including Manoomin productivity and biomass, as well as information about other components of Manoomin waters, such as water quality and use of waters by muskrats, beaver, geese, swans, and other beings. It can also provide information about cultural trends, such as harvest levels by tribal members and exercise of treaty-reserved harvesting rights. Monitoring can also evaluate the effectiveness of restoration or inform adaptive management actions. Because of the high variability in the productivity and biomass of Manoomin from year-to-year, monitoring is most useful when undertaken over several years (Kjerland, 2015b). Monitoring should be completed using methods that are both scientifically robust and culturally respectful (Kjerland, 2015a, 2015b).

This project illustrates the critical importance of monitoring data. The seven case studies in this project would not have been possible, if not for existing monitoring data. Around the Lake Superior region, several agencies have undertaken long-term monitoring studies. Since the 1980s, GLIFWC has conducted Manoomin harvest surveys for tribal (off-reservation) and state (statewide) licensed ricers in Wisconsin (David et al., 2019). Nearly all of this harvest comes from the ceded territory. GLIFWC also uses aerial surveys to approximate rice abundance information for over 200 waterbodies each year (David et al., 2019). NOAA is using hyperspectral imaging to delineate aquatic vegetation, with Manoomin as the primary species. In 1998, the 1854 Treaty Authority initiated a Manoomin monitoring program on lakes and rivers within the 1854 Ceded Territory in northern Minnesota (Vogt, 2020b).

This study relies upon the long-term monitoring data from these efforts to understand the cultural and ecological conditions of Manoomin. Where available, case study teams incorporated monitoring data into their cultural and ecological characterization of Manoomin and its associated habitat. For example, the Lac Vieux Desert Band and GLIFWC mapped Manoomin acreage on Lac Vieux Desert's Rice Bay from 2000 to 2019 as part of the 10-year trial Lac Vieux Desert Wild Rice Restoration Plan with the Wisconsin Valley Improvement Company (WVIC; Exhibit 6.1). These data provided background on the condition of Manoomin with restoration actions (the 1991 to 2012 time period) and during the decline in Manoomin abundance with above-average precipitation (2013 to 2019 time period). Our study underscores the importance of long-term monitoring. There should be a concerted effort to inventory all Manoomin waters across the Great Lakes.

Traditional ecological knowledge can help understand habitat functionality across the Lake Superior region.

Cultural leaders, community members, wild rice chiefs, Manoomin harvesters, and elders have essential knowledge and perspectives that can inform the characterization of cultural and ecological functionality provided by Manoomin over long time periods. Our Project Team was composed of many cultural leaders, community members, harvesters, and wild rice chiefs who shaped the development of our cultural and ecological metrics; and informed the characterization of Manoomin at specific sites. In a few instances, our Project Team relied on their wild rice chiefs and elders to provide cultural and traditional ecological knowledge about a place. For example, the Fond du Lac Band of Lake Superior

Chippewa case study team received input from an elder and wild rice chief to characterize a time period for Perch Lake where the case study team had limited knowledge and limited ecological monitoring data.

Educating tribal and nontribal community members can ensure successful Manoomin restoration.

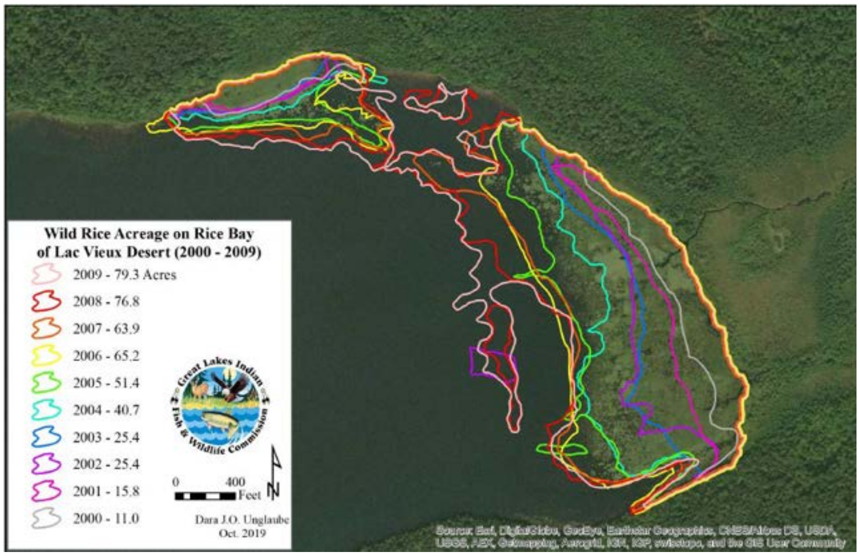


Exhibit 6.1. Manoomin distribution and acreage on Rice Bay on Lac Vieux Desert, 2000–2009

Credit: GLIFWC, 2019.

While Manoomin is one of the most valuable aquatic plants in the Lake Superior region, the benefits and values of Manoomin are often unknown or underappreciated by the general public (David et al., 2019). Education and information about the importance of Manoomin can encourage the stewardship of Manoomin and improve restoration outcomes. On Lac Vieux Desert, for example, some lakeshore owners and boaters viewed Manoomin as a nuisance. After taking the time to educate the non-tribal community about the importance of Manoomin and why it is worth protecting, the LVD Band now works closely with them to ensure the existence of Manoomin in Rice Bay and other parts of the lake.

Preserving existing Manoomin habitat is critical to ensuring a future with Manoomin.

Given the significant challenges in restoring Manoomin that has become degraded, a key management strategy for Manoomin is to protect and preserve existing Manoomin stands and the clean water resources and habitats in which it thrives. In many places, dramatic changes to wetland and lake systems – including hydrologic changes from dams and agricultural ditching and mining activities – has had unforeseen consequences. Protecting areas with Manoomin habitat could reduce some stressors to Manoomin, and allow the plant to adapt to climate change and other changing conditions. Manoomin habitats may be protected through a number of different actions, including first ensuring there is a comprehensive characterization (mapping) of the habitat across the Great Lakes Region, such as the use of hyperspectral imaging to delineate Manoomin habitat. Acquisitions and conservation easements may also be part of the strategy to protect Manoomin habitat. In addition, instituting best management practices to protect existing high-quality habitat from existing stressors should also be considered. This may include controlling invasive species; limiting activities with adverse consequences in sensitive habitats, such as discharging mine waste; and developing climate monitoring and adaptive management plans. Finally, educational outreach could be an important aspect of preserving Manoomin habitat, including outreach to lakeshore landowners with Manoomin stands about the value of this habitat, and to the general public with respect to the ecological and cultural value of Manoomin.

7. Conclusion and next steps

This report documents and characterizes the importance and functions of Manoomin and its associated habitat to cultural perspectives and identity, community connections, and cultural and spiritual practices of the Anishinaabe people; as well as to biodiversity and ecosystem integrity. Using a set of cultural and ecological metrics and a combined HEA approach, we characterized a range of degraded Manoomin waters where restoration actions have been undertaken, with locations dispersed over the Lake Superior region. We quantified lost cultural and ecological functionality in terms of the additional amount of equivalent restoration that would be needed to counter-balance the losses.

We find that restoration is worthwhile, with demonstrable improvements documented in our case studies. However, our case studies also highlight the challenges to return degraded Manoomin stands to full functionality. Many restoration actions have improved cultural and ecological functionality, but have not been successful at fully returning Manoomin to historical conditions or to the potential capacity implied by conditions at the site. In places where Manoomin restoration has shown some success, we find that additional restoration is often needed, given historical losses in cultural and ecological functionality. The challenges in restoring Manoomin habitat after it is degraded serve to highlight the critical importance of protecting existing Manoomin stands.

To provide a path forward for Indigenous communities, tribal and non-tribal governments, organizations, and staff who are working to actively manage and restore Manoomin across the Great Lakes, we would like to offer several possible next steps to further assess the cultural and ecological importance of Manoomin.

Expand the geographic scope of this study

This study focuses on seven case studies around the Lake Superior region. We selected the case studies in places that were of particular importance to our team and had adequate data and information to inform the characterization. As we were only able to delve deep into a limited number of the case studies, it is difficult to generalize our case study findings from these seven places to the Lake Superior region or the Great Lakes basin more broadly.

A cumulative sample of case studies could allow us to aggregate information from places around the Great Lakes – including the full Lake Superior region and across lakes Michigan, Huron, Erie, and Ontario – to allow for greater generalization. With a more representative sample of case studies, we could provide additional insights into threats to Manoomin and different restoration approaches used across the Great Lakes, and better understand the cultural and ecological losses (or gains) in Manoomin and its associated habitat throughout the region. This could help target critical resources to protect the remaining populations of Manoomin and restore Manoomin habitat across the Great Lakes region.

Incorporate cultural and ecological characterizations into annual monitoring efforts

Many of the sites are newly restored, such as Hiles Millpond and the Net River Impoundment, or have recently acquired additional resources to complete more restoration, such as Big Rice Lake and Lac Vieux Desert's Rice Bay. Characterizing future restoration conditions at these places could allow for a continued understanding of how well restoration returns the cultural and ecological functionality of the place and, in some cases, could refine the output from the HEA approach. For example, Big Rice Lake could be characterized after additional restoration efforts are implemented to determine how well those actions return the lake's natural functionality.

Cultural metrics could also inform annual monitoring efforts. Combined with ecological monitoring metrics (e.g., water quality, water level, and Manoomin biomass and stalk density), cultural metrics incorporate Indigenous knowledge, cultural values, beliefs, and practices into the monitoring process; and provide a more holistic understanding of determining if restoration actions are achieving target goals or returning conditions to historical or baseline conditions. Without Indigenous metrics, the cultural values, beliefs, and practices are unseen or invisible and, therefore, the restoration is not adequately characterized. The characterization must be driven and refined by the people in the community. In particular, cultural metrics will need to reflect the unique history of the community or the place, as well as the place-based use of Manoomin or other natural resources.

In the Great Lakes, continuous efforts are needed to protect, restore, and monitor Manoomin and its associated habitat. Understanding the success (or failure) of restoration actions in counterbalancing historical losses in cultural and ecological functionality can help determine how to target future resources toward restoring and protecting Manoomin. We hope that the information and knowledge gained through this study will help Indigenous communities, tribal and non-tribal governments, organizations, and staff in the Great Lakes region ensure a future with healthy Manoomin waters.

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Appendix

In this appendix, we provide the standalone communications materials developed for each case study. In each case study, we provide a brief overview of the place, and describe the threats to Manoomin at the place and the actions taken to improve the abundance of Manoomin at the place. We then describe the case study results, including the metrics used to characterize the cultural and ecological importance of the place, the characterized conditions of Manoomin habitat over time, and the results of the HEA model that calculates the amount of restoration needed to balance the reduced or lost functions. Case studies include:

- Restoration of **Lac Vieux Desert's Rice Bay** increases cultural and ecological functionality: Significant progress made but additional restoration could counter-balance losses
- Restoration of **Perch Lake** increases cultural and ecological services: Efforts by the Fond du Lac Band show some improvement in Manoomin coverage
- Restoration of Keweenaw Bay Indian Community's **Sand Point Sloughs** increases cultural and ecological functionality: Significant progress made but additional restoration could counter-balance losses
- Introduction of Manoomin at **Net River Impoundment and Vermillac Lake** provides cultural and ecological functionality: With favorable conditions, restoration can enhance Gichi-manidoo gitigaan
- Introduction of Manoomin at **Hiles Millpond** provides cultural and ecological functionality: With favorable conditions, restoration can enhance Manoomin habitat
- Efforts to manage **Big Rice Lake** have not improved Manoomin functionality: Manoomin continues to be affected by hydrologic conditions and other threats
- Low ecological and cultural functionality characterized at the **Twin Lakes**: Manoomin is unable to rebound due to ongoing sulfate loading from mine discharges.

Restoration of Lac Vieux Desert's Rice Bay increases cultural and ecological functionality

Significant progress made but additional restoration could counter-balance losses

Recent restoration efforts at Lac Vieux Desert's Rice Bay have improved the cultural and ecological functionality of the bay's Manoomin (wild rice) and its associated habitat. However, given the significant losses, much more restoration is needed. Based on the methods applied in this study, it would take an additional 3,034 acres of similar Manoomin restoration to counter-balance the lost cultural and ecological functionality that has occurred over time. This is equivalent in scale to 12 times the current restoration efforts at Rice Bay. In addition, future restoration actions will need to be adaptive to respond to changing precipitation patterns.

"Manoomin is like the canary in the coal mine for water quality. It grows in high water quality, and when water quality declines, so does Manoomin."

Roger Labine, Lac Vieux Desert Band of Lake Superior Chippewa November 12, 2019

Credit: Todd Marsee, Michigan Sea Grant

Threats to Manoomin at Rice Bay

Lac Vieux Desert was dammed around 1870 for logging operations. By 1907 the Wisconsin Valley Improvement Company (WVIC) began operating the lake as a storage reservoir and used the dam to create uniform stream flow down the Wisconsin River to reduce flooding events, facilitate hydroelectric power generation, and regulate effluent discharge downstream. In 1937, WVIC replaced the wooden dam with a reinforced concrete and steel structure. The high water levels caused by the dam initiated a decline in Manoomin (Labine, 2017). From 1938 to 1952, Manoomin declined steadily and community members stopped harvesting it during this period (Barton, 2018). During this period, lakeside property owners became concerned about the erosion caused by rising lake levels.

More recently, heavy rainfall events have negatively affected Manoomin in Lac Vieux Desert [Roger Labine, Lac Vieux Desert Band of Lake Superior Chippewa (LVD Band), personal communication, February 15, 2020]. In the spring, Manoomin is in the floating leaf stage, and can be uprooted by heavy rainfall that raises water levels. In the summer, when Manoomin is in the flowering stage, heavy rainfall can knock Manoomin pollen down from the flower to the water's surface, which prevents pollination and results in "ghost rice" or empty hulls that never fill. In addition, the combination of heavy rainfall events and higher air temperatures may also increase the amount of brown spot – a destructive wild rice fungal disease – in Manoomin beds.

About Lac Vieux Desert's Rice Bay

Lac Vieux Desert, located in Vilas County, Wisconsin, and Gogebic County, Michigan, is over 4,000 acres. Historically, Manoomin covered many parts of Lac Vieux Desert, including Rice Bay, Thunder Bay, Slaughters Bay, Misery Bay, and along the northwestern shore to the Wisconsin River and parts of the south shore.

Rice Bay is a 243-acre bay on the northeastern portion of Lac Vieux Desert, which historically contained a significant stand of Manoomin that was traditionally managed and harvested by the LVD Band. West of Rice Bay is Ketegitigaaning, a ricing village used intermittently in the early 18th century by the LVD Band, followed by continuous habitation by 1900. In 2015, Rice Bay was registered as a Traditional Cultural Property on the National Register of Historic Places.

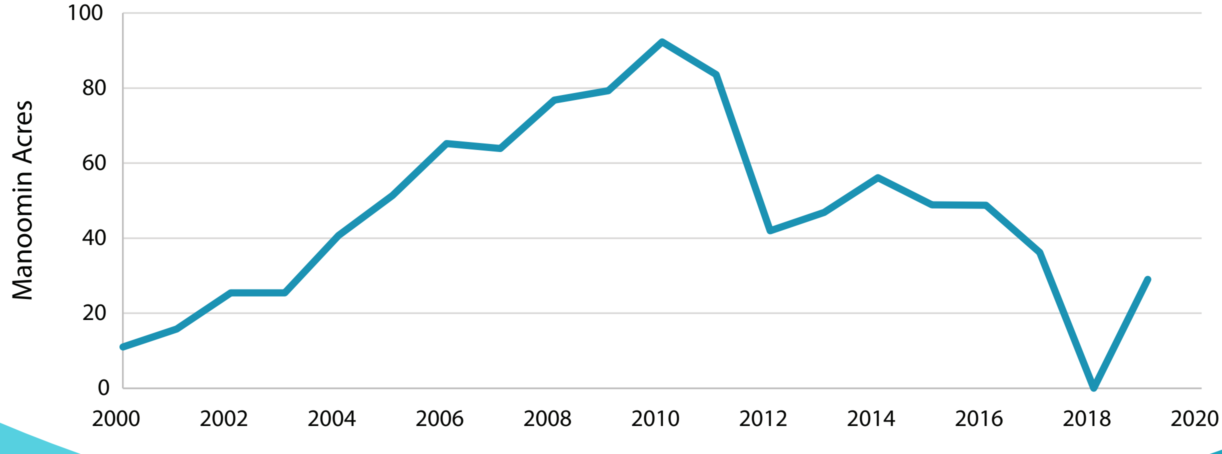
Actions taken to improve the abundance of Manoomin at Rice Bay

In 1991, a coalition of tribal, state, and federal governments and governmental agencies determined the operating regime of the dam on Lac Vieux Desert had been detrimental to Manoomin and its associated habitat (Onterra, 2012). By 2001, following a decade of negotiation and litigation, WVIC lowered the maximum operating level by about nine inches and provided financial contribution toward a Manoomin seeding and monitoring program (Barton, 2018). From 2002 to 2005, Lac Vieux Desert was seeded with 14,000 pounds of Manoomin, most of which occurred in Rice Bay (Labine, 2017). From 2007 through 2012, as Manoomin became reestablished on Rice Bay, the LVD Band held traditional ricing camps and workshops, which included traditional practices and activities (Barton and Labine, 2013).

From 2000 to 2010, the acreage of Manoomin on Rice Bay significantly increased. In 2000, Rice Bay had just 11 acres of Manoomin coverage (or 5% of Rice Bay). After the first year of seeding, Manoomin coverage increased to over 25 acres (or 10% of Rice Bay; top aerial photograph). With below-average rainfall conditions in 2010, the extent of Manoomin increased to over 92 acres (or 38% of Rice Bay; bottom aerial photograph). While the extent of Manoomin on Rice Bay was less than its historical coverage, it was considered an improvement over conditions caused by the operating regime of the concrete dam (Barton, 2018).

Since 2011, the acreage of Manoomin on Rice Bay has been declining, with 34 acres in 2019 (GLIFWC, 2019). Because Manoomin abundance on Rice Bay is generally greatest during low-water years, natural resource managers believe this may be due to above-average precipitation over the past seven years (Peter David, GLIFWC, personal communication, November 12, 2019).

Manoomin abundance on Lac Vieux Desert Lake's Rice Bay in 2003 (above) and 2010 (below). Credit: Peter David, Great Lakes Indian Fish & Wildlife Commission (GLIFWC).

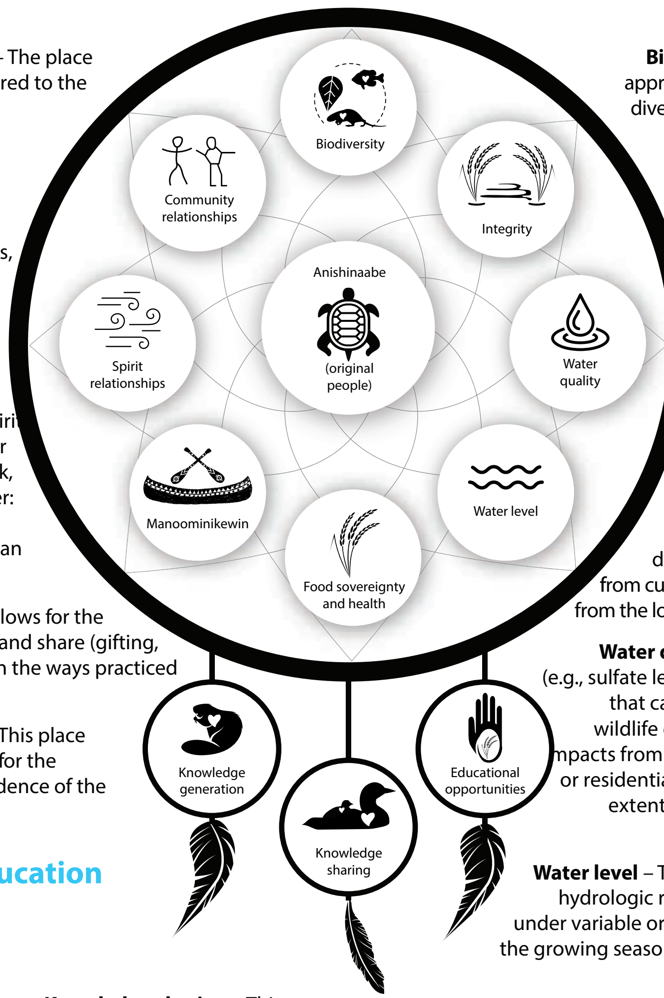


Manoomin acreage on Rice Bay, 2000 to 2019

Credit: GLIFWC, 2019.

Approach to characterizing Manoomin at Rice Bay

Twelve metrics characterize the cultural and ecological functions of Rice Bay's Manoomin and its associated habitat. These metrics describe how Manoomin at Rice Bay contributes to maintaining connections with the Anishinaabe culture, how ecological functionality is supported and resilient to changing conditions, and how continued learning and sharing of Anishinaabe values are promoted.



Cultural Metrics

Anishinaabe (original people) – The place provides Manoomin, which is sacred to the Anishinaabe and central to the foundations of their culture, sovereignty, and treaty rights.

Community relationships – Manoomin at this place contributes to bonding, traditions, and strengthening family and community connections.

Spirit relationships – Manoomin at this place enables the Anishinaabe to maintain connections and balance with spirit beings (or relatives) from all other orders of creation (first order: rock, water, fire and wind; second order: other plant beings; third order: animal beings; fourth order: human beings).

Manoominikewin – This place allows for the Anishinaabe to harvest, prepare, and share (gifting, healing, and eating) Manoomin in the ways practiced by their ancestors for centuries.

Food sovereignty and health – This place provides the capacity to provide for the sustenance, health, and independence of the Anishinaabe.

Ecological Metrics

Biodiversity – Healthy Manoomin and appropriate habitat at this place supports diverse biological communities (e.g., free of invasive species) that indicate the capacity of the place to support abundant associated plant and animal species (e.g., other native aquatic vegetation, fish, waterfowl, muskrat), providing for spiritual and subsistence needs.

Integrity – Physical habitat and hydrology, and water and sediment chemistry support stands of Manoomin that exhibit natural annual variability; viable seed bank ensures that sustainable Manoomin populations will persist even after occasional poor production years. Natural genetic diversity is maintained without impact from cultivated strains, or reduced gene flow from the loss of nearby Manoomin populations.

Water quality – This place has clean water (e.g., sulfate levels below 10 ppm) and sediments that can support robust stand density and wildlife diversity; is free of contamination or impacts from industrial, agricultural, recreational, or residential influence; and is of sufficient areal extent to sustain a Manoomin population.

Water level – This place has a natural or managed hydrologic regime that can maximize resilience under variable or extreme climatic conditions across the growing season (maintaining optimal depth range and flow).

Cultural and Ecological Education Metrics

Knowledge generation – This place allows for continued learning and generation of the Anishinaabe practices, values, beliefs, and language through experience.

Knowledge sharing – This place allows for the continued sharing and transmittal of the Anishinaabe practices, values, beliefs, and language among family members and community.

Educational opportunities – This place provides opportunities for language, land stewardship, and other educational programs, such as educational rice camps.

Cultural and ecological characterization at Rice Bay

Rice Bay's Manoomin and its associated habitat were characterized over four time periods. Each metric was ranked using the following five-point descriptive scale: No use, Very bad, Not very good, Pretty good, Doing great

1900 to 1936: With a wooden dam

Based on the combined ranking of cultural and ecological metrics, Rice Bay was characterized as "doing great" during this period. In the early 1900s, Ketegitigaaning was inhabited and the community harvested Manoomin in Rice Bay for gifting, healing, and consumption. The area also boasted a rich biodiversity; and hunting, trapping, fishing, and gathering local resources were common.

1937 to 1990: With a concrete and steel dam

After the replacement of the wooden dam with a concrete and steel structure, Manoomin declined steadily until the mid-1950s to the point that it was no longer harvestable by community members. During this time period, community members moved away from the lake and into surrounding towns, and stopped harvesting Manoomin in Rice Bay. The "disappearance of Manoomin started the deterioration of the Lac Vieux Desert community," where bonding, traditions, and community connections ceased (Roger Labine, LVD Band, personal communication, November 12, 2019). There was a steady decline in cultural and ecological functionality provided by Manoomin from 1937 to the mid-1950s, when Rice Bay was characterized as "very bad" based on the combined ranking of cultural and ecological metrics.

1991 to 2012: With restoration actions

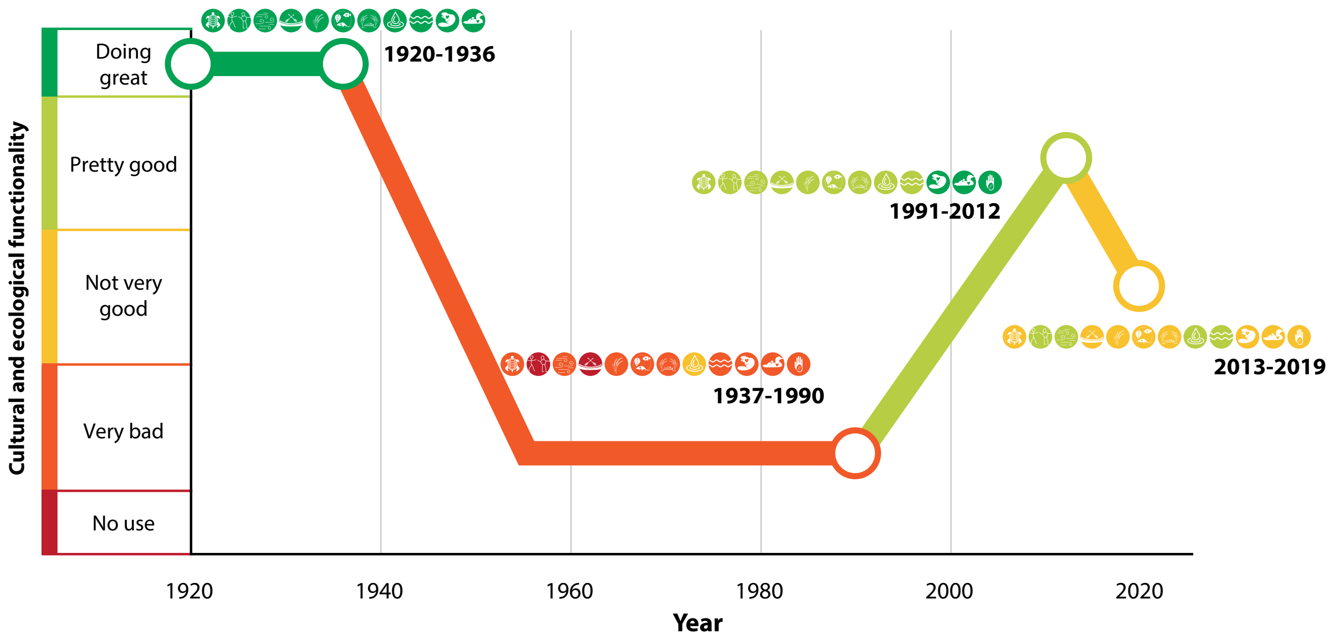
Once restoration actions began in the 1990s, cultural and ecological functionality provided by Manoomin improved. By 2008, the LVD Band opened Rice Bay for Manoomin harvest and began hosting rice camps in the area for the first time since 1940. Although the community began knowledge sharing, knowledge generation, and educational opportunities increased, it remained difficult to get many community members interested in Manoomin because of its absence over the last 50 years. Even so, restoration actions led to an increase in cultural and ecological functionality. By 2012, Rice Bay ranked as "pretty good" based on the combined ranking of cultural and ecological metrics.

2013 to 2019: With restoration actions and above-average precipitation

With heavy rainfall events negatively affecting Manoomin beds during the growing season, cultural and ecological functionality at Rice Bay have declined. Currently, Rice Bay is ranked as "not very good" based on the combined ranking of cultural and ecological metrics. The decrease in ecological and cultural functionality provided by Manoomin in recent years suggests the need for adaptive management of Manoomin. Actions taken that may have been successful in restoring Manoomin in the past may need to be adjusted to respond to additional threats, such as climate change, to be successful in the future.

Cultural and ecological characterization at Rice Bay

Cultural and ecological functionality provided by Manoomin and its associated habitat at Rice Bay have changed over time, both in total and for individual metrics.



Additional Restoration Needed

Based on the characterization of the degree of cultural and ecological function over the four time periods, a Habitat Equivalency Analysis demonstrates the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. Given the success of restoration at the 243-acre Rice Bay, 3,034 acres of similar Manoomin restoration is needed to counter-balance the lost habitat functionality that has occurred over time. In other words, 12 equivalent restoration efforts at Rice Bay (from 1991 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1937 to 1990).

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About this effort

This case study is part of the Lake Superior Manoomin Cultural and Ecosystem Characterization Study. The project was initiated by a team of Lake Superior Basin Anishinaabe communities, and federal and state agencies, with technical support from Abt Associates. This project aims to describe the importance of Manoomin to help foster community stewardship and education; and to inform Manoomin management, protection, and policy in the Lake Superior region and throughout the Great Lakes. Funding for this project was received via Great Lakes Restoration Initiative. For more information on the Initiative and Action Plan go to https://www.glri.us/.

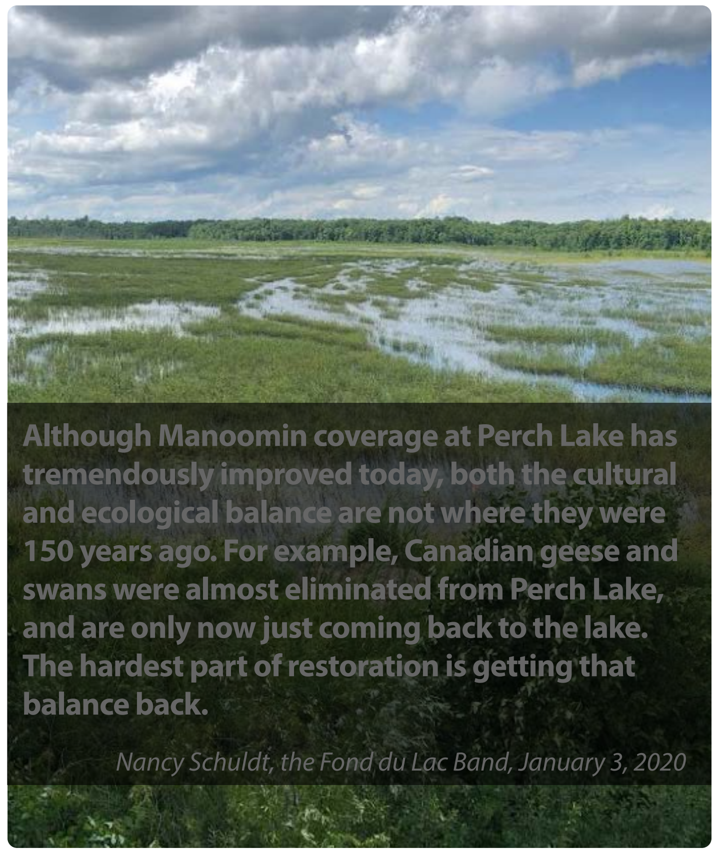
Acknowledgments

The Project Team would like to acknowledge Roger Labine (LVD) and Peter David (GLIFWC) for their valuable input and feedback in the development of this case study, and for participating in the cultural and ecological characterization of Lac Vieux Desert's Rice Bay.

Restoration of Perch Lake increases cultural and ecological services

Efforts by the Fond du Lac Band show some improvement in Manoomin coverage

Recent restoration efforts at Perch Lake, or Aatawemegokokaaning, have improved the cultural and ecological services of the lake's Manoomin (wild rice) and its associated habitat. However, given the significant historical losses, much more restoration is needed. Based on methods applied in this study, it would take an additional 5,204 acres of similar Manoomin restoration to counter-balance the lost cultural and ecological services that have occurred over time. This is equivalent in scale to 13 times the current restoration efforts at Perch Lake.



Credit: Lake Superior National Estuarine Research Reserve education intern Riley Oliver

Threats to Manoomin at Perch Lake

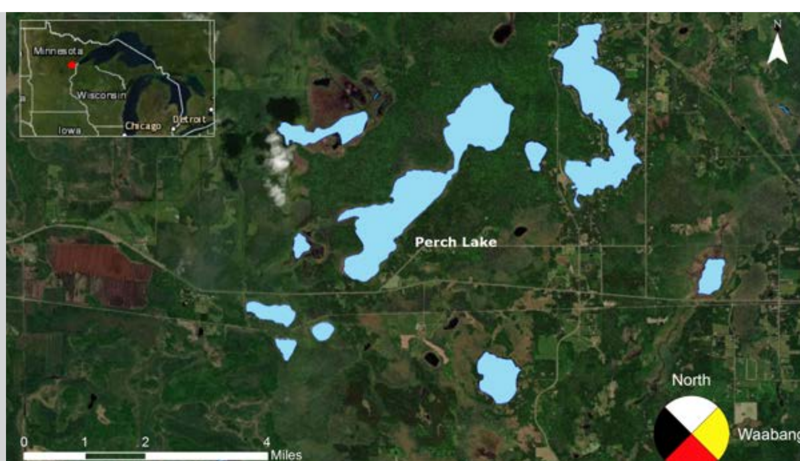
Historically, Perch Lake had abundant Manoomin habitat. In the early 1900s, many streams and wetland areas were ditched and drained to accommodate farming. After Perch Lake was ditched for agriculture around 1918 to 1921, the lake experienced a decline in Manoomin (Nancy Schuldt, personal communication, October 7, 2019).

To try to minimize the impacts of ditching, a concrete dam was installed at the lake outlet in 1936. The dam was managed to mimic the natural fluctuation of the water to benefit Manoomin. By the 1960s, the dam fell into disrepair and was non-functional. For the following several decades, lake levels were lower and stagnant, which allowed ginoozhegoons (pickerelweed) to displace Manoomin and become the dominant vegetation in the lake's rice waters (Fond du Lac Band, 2018, 2019).

About Perch Lake

Perch Lake is located on the Fond du Lac Band of Lake Superior Chippewa Reservation in Minnesota. It is an approximately 650-acre, double-basin lake. The shallow, southern portion of the lake is approximately 400 acres, and it is the largest Manoomin-containing habitat on the Reservation (Fond du Lac Band, 2008). The northern basin also supports some Manoomin along its fringes.

Perch Lake is an important traditional cultural property, used as a wild rice lake, a fisheries/spearing and netting site, and hunting grounds (Fond du Lac Band, 2018). Historical evidence suggests that Manoomin has been present at Perch Lake for over 2,000 years, with historical stands on approximately 392 acres (Fond du Lac Band, 2018).



Actions taken to improve the abundance of Manoomin at Perch Lake

In 1998, a new water control structure was built at the outlet of Perch Lake to manage water levels for Manoomin and improve hydrologic function throughout the watershed (Fond du Lac Band, 2018). In 2001, the Fond du Lac Band began intensive mechanical vegetation removal of ginoozhegoons, a native perennial species that occupies the same habitat as Manoomin and often outcompetes Manoomin (Fond du Lac Band, 2018). Using a sedge mat cutter and aquatic harvesters, the Fond du Lac Band removed ginoozhegoons vegetation at least twice yearly. This process led to high Manoomin density in restored areas initially. However, three to five years after each removal, ginoozhegoons became dominant again, which called for a rotating schedule for removing this competing plant.

In 2012, Perch Lake experienced a 500-year flood in mid-summer, and the Fond du Lac Band used the water control structure to keep water levels high and eliminate as much ginoozhegoons as possible. The following year, Manoomin stands were so thick that it was difficult to travel through the lake. Learning from the natural flood event, the Fond du Lac Band then developed a management strategy to bring lake levels to flood stage every four years to stress perennial species, such as ginoozhegoons, which compete with Manoomin for habitat. Although this strategy also limits Manoomin production in flood years, it provides Manoomin with a competitive advantage in the years following a flood stage year (Fond du Lac Band, 2018).

With water level management and mechanical removal of competitive vegetation, the Fond du Lac Band has successfully restored Manoomin to over 200 acres on Perch Lake (Fond du Lac Band, 2019).

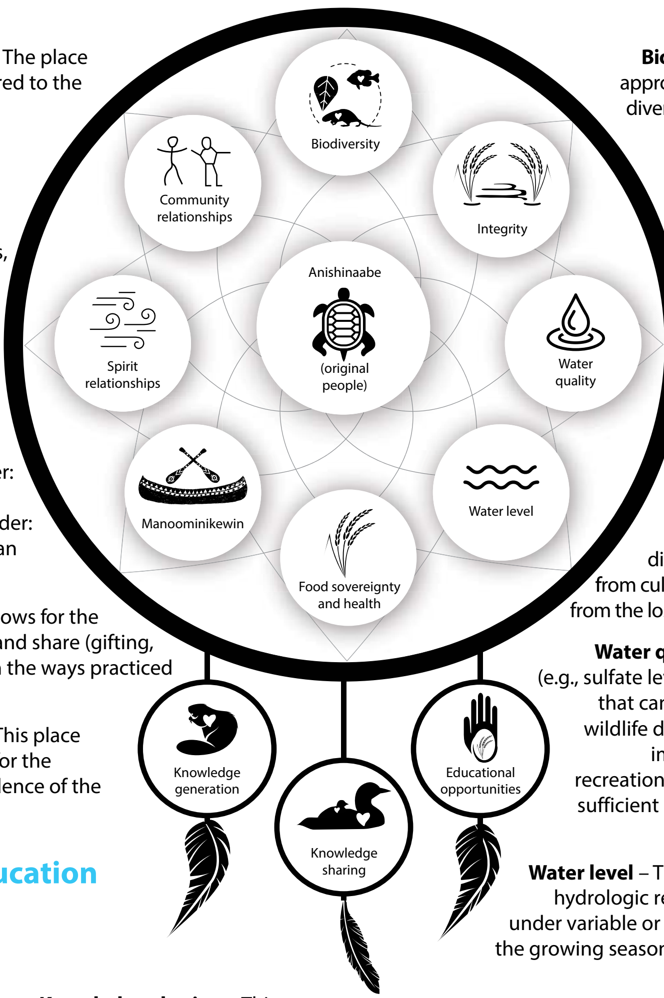
Sedge mat cutter. Credit: Fond du Lac Band, 2018.

Aquatic harvester. Credit: Fond du Lac Band, 2018.

Perch Lake. Credit: Lake Superior National Estuarine Research Reserve education intern Riley Oliver.

Approach to characterizing Manoomin at Perch Lake

Twelve metrics characterize the cultural and ecological functions of Perch Lake's Manoomin and its associated habitat. These metrics describe how Manoomin at Perch Lake contributes to maintaining connections with the Anishinaabe culture, how it supports ecological functionality and is resilient to changing conditions, and how it allows for continued learning and sharing of Anishinaabe values.



Cultural Metrics

Anishinaabe (original people) – The place provides Manoomin, which is sacred to the Anishinaabe and central to the foundations of their culture, sovereignty, and treaty rights.

Community relationships – Manoomin at this place contributes to bonding, traditions, and strengthening family and community connections.

Spirit relationships – Manoomin at this place enables the Anishinaabe to maintain connections and balance with spirit beings (or relatives) from all other orders of creation (first order: rock, water, fire and wind; second order: other plant beings; third order: animal beings; fourth order: human beings).

Manoominikewin – This place allows for the Anishinaabe to harvest, prepare, and share (gifting, healing, and eating) Manoomin in the ways practiced by their ancestors for centuries.

Food sovereignty and health – This place provides the capacity to provide for the sustenance, health, and independence of the Anishinaabe.

Ecological Metrics

Biodiversity – Healthy Manoomin and appropriate habitat at this place supports diverse biological communities (e.g., free of invasive species) that indicate the capacity of the place to support abundant associated plant and animal species (e.g., other native aquatic vegetation, fish, waterfowl, muskrat), providing for spiritual and subsistence needs.

Integrity – Physical habitat and hydrology, and water and sediment chemistry support stands of Manoomin that exhibit natural annual variability; viable seed bank ensures that sustainable Manoomin populations will persist even after occasional poor production years. Natural genetic diversity is maintained without impact from cultivated strains, or reduced gene flow from the loss of nearby Manoomin populations.

Water quality – This place has clean water (e.g., sulfate levels below 10 ppm) and sediments that can support robust stand density and wildlife diversity; is free of contamination or impacts from industrial, agricultural, recreational, or residential influence; and is of sufficient areal extent to sustain a Manoomin population.

Water level – This place has a natural or managed hydrologic regime that can maximize resilience under variable or extreme climatic conditions across the growing season (maintaining optimal depth range and flow).

Cultural and Ecological Education Metrics

Knowledge generation – This place allows for continued learning and generation of the Anishinaabe practices, values, beliefs, and language through experience.

Knowledge sharing – This place allows for the continued sharing and transmittal of the Anishinaabe practices, values, beliefs, and language among family members and community.

Educational opportunities – This place provides opportunities for language, land stewardship, and other educational programs, such as educational rice camps.

Cultural and ecological characterization at Perch Lake

Manoomin and its associated habitat at Perch Lake were characterized over four time periods. Each metric was ranked using the following five-point descriptive scale: No use, Very bad, Not very good, Pretty good, Doing great

1900 to 1920: Before agricultural ditching

Before it was ditched for agriculture, Perch Lake historically had abundant Manoomin stands. Fond du Lac resource managers estimate that nearly 60% of the lake had extensive Manoomin stands during this time, and it was harvested by the community. Based on the combined ranking of cultural and ecological metrics, Perch Lake was characterized as "doing great" during this first time period.

1921 to 1970: With agricultural ditching

After agricultural ditching of Perch Lake, Manoomin and its associated habitat declined abruptly. Lower and stagnant water levels allowed ginoozhegoons to become the dominant vegetation in the lake, displacing Manoomin, which resulted in a decline in use of the lake by waterfowl and other wildlife. Band members were unable to harvest Manoomin in the ways they did historically, which limited the generation and sharing of Anishinaabe practices, values, and beliefs. During this period of time, Perch Lake was characterized as "not very good" based on the combined ranking of cultural and ecological metrics.

1971 to 1997: Before the new water control structure and restoration actions

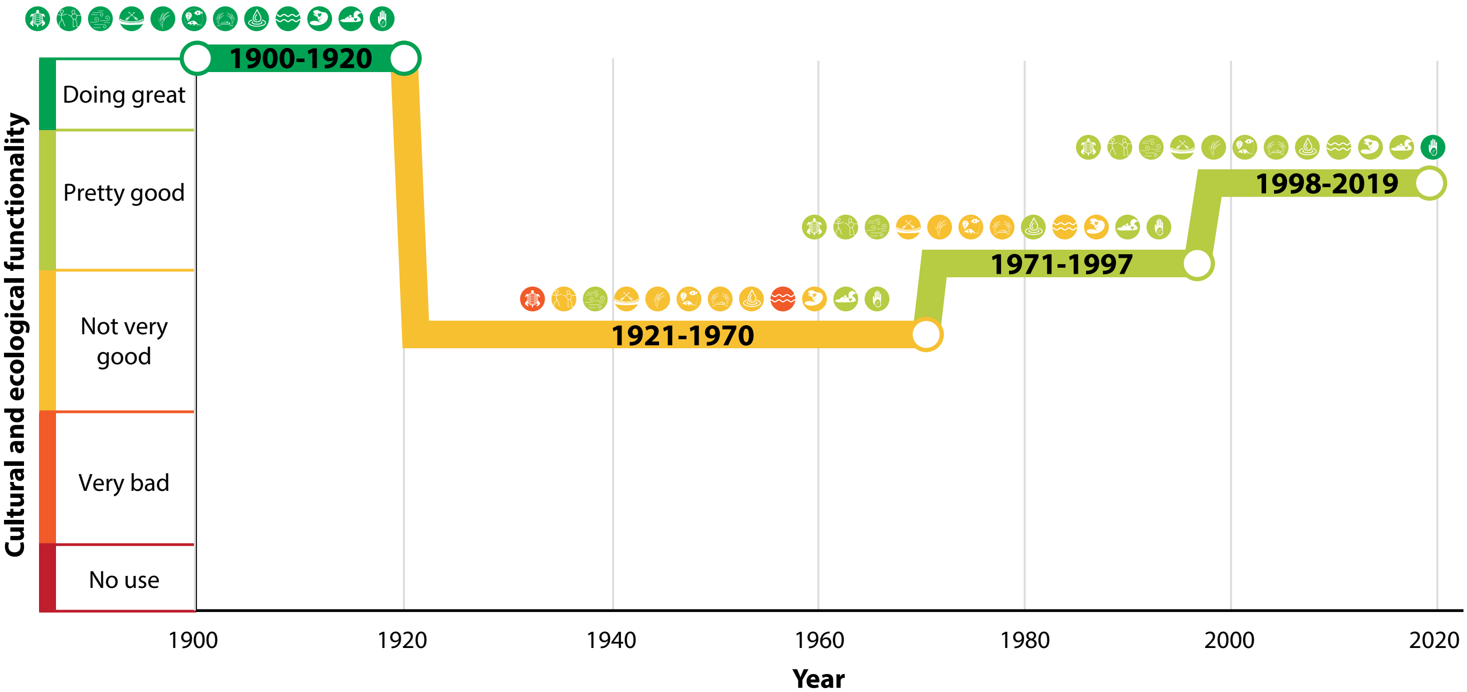
During this period, Perch Lake had a significant decline in Manoomin abundance and functionality; approximately 75% of the lake was covered with plant species that occupy the same habitat as and compete with Manoomin. Although Perch Lake's ecological and cultural functionality remained low, Band members continued to try to harvest at the lake; therefore, the lake provided some cultural services during this period. Many elders and wild rice chiefs believe Manoomin is a blessing and is seen as a golden age of their youth. For these reasons, Perch Lake ranked as "pretty good," which was slightly higher than the previous time period.

1998 to 2019: With the new water control structure and restoration actions

The water control structure built at the outlet of Perch Lake in 1998 helped restore the hydrologic conditions of the lake and improve Manoomin and its associated habitat. Active management of the lake started in 2001 and accelerated in 2012, which further restored hydrologic conditions of the lake and removed competing vegetation, all benefiting Manoomin. During this time period, the Fond du Lac Band was fairly successful at restoring Manoomin on Perch Lake. Manoomin covers over 200 acres of Perch Lake, which is about 30% of its historical coverage. Currently, Perch Lake is ranked as "pretty good" based on the combined ranking of cultural and ecological metrics.

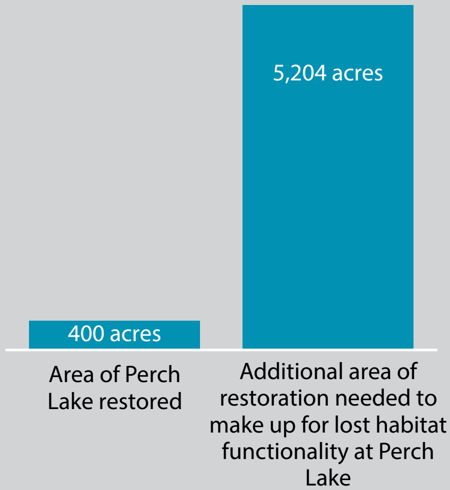
Cultural and ecological characterization at Perch Lake

The cultural and ecological functionality provided by the Manoomin and its associated habitat at Perch Lake varied over time, both in aggregate and for individual metrics.



Additional restoration needed

Using the characterization of Perch Lake over the four time periods, a habitat equivalency analysis demonstrates the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. Given the success of restoration over the shallow, southern 400 acres of Perch Lake, approximately 5,204 acres of similar Manoomin restoration are needed to counter-balance the lost habitat functionality that has occurred over time. In other words, 13 equivalent restoration efforts at Perch Lake (from 1971 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1921 to 1970).



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Acknowledgments

The Project Team would like to acknowledge Nancy Schuldt and Thomas Howes (Fond du Lac Band) for their valuable input and feedback in the development of this case study, and for participating in the cultural and ecological characterization of Perch Lake. We would also like to acknowledge the Fond du Lac Band elders and the wild rice chief who helped us characterize Perch Lake.

Restoration of Keweenaw Bay Indian Community's Sand Point Sloughs increases cultural and ecological functionality

Significant progress made but additional restoration could counter-balance losses

Recent restoration efforts on eight acres at Keweenaw Bay Indian Community's (KBIC's) Sand Point Sloughs have improved the cultural and ecological functionality of the sloughs' Gichi-manidoo gitigaan (The Great Spirit's Garden); however, given the significant historical losses, much more restoration is needed. Based on methods applied in this study, it would take an additional 175 acres of similar Manoomin (wild rice) restoration to counter-balance the lost cultural and ecological functionality that have occurred over time. This is equivalent in scale to 22 times the current restoration efforts at the sloughs. In addition, future restoration actions will need to be adaptive to respond to changing climate conditions.

Threats to Manoomin at Sand Point Sloughs

Connected to Lake Superior, Sand Point Sloughs is part of a dynamic coastal system. In the early 20th century, a copper ore processing plant, Mass Mill, operated on the west side of Keweenaw Bay on the south shore of Lake Superior. During the copper ore processing, approximately six billion pounds of mine tailings, locally known as stamp sands, were disposed into Keweenaw Bay. Lake currents continue to carry these tailings southward and redeposit them onto Sand Point, located just four miles south of the Mass Mill. Sand Point has an extensive beach area with approximately 2.5 miles of lake front and is connected to the sloughs. These tailings contain high concentrations of heavy metals that have the potential to cause environmental harm.

More recently, Sand Point Sloughs has been affected by regional hydrologic conditions – including higher water levels – that are occurring at a regional scale and are beyond local control. As a plant species sensitive to changes in water level, higher water levels have negatively affected the establishment and abundance of Manoomin in Sand Point Sloughs. The sloughs' connection to Lake Superior also opens the pathway to aquatic invasive species, such as carp and reed canary grass. Carp, for example, are bottom feeders that uproot Manoomin (Premo et al., 2014). Manoomin abundance may be impeded by competing native vegetation, such as ginoozhegoons (pickerelweed); and by excessive browsing by wildlife on new stands, such as waterfowl.

About Sand Point Sloughs

Sand Point Sloughs are relatively shallow backwater sloughs connected to Lake Superior that are culturally important to the KBIC. Native people used this area for hundreds of years, as indicated by the existence of ancient burial grounds and stories that have been passed on through oral tradition (KBIC, 2003). Manoomin is believed to have been present in Sand Point Sloughs prior to the 1900s (Ravindran et al., 2014). Today, the site contains the KBIC Pow Wow grounds, a traditional healing clinic, extensive wetlands, and Manoomin beds. A marina, campground, lighthouse, and recreational beaches signify the community's appreciation of this area.

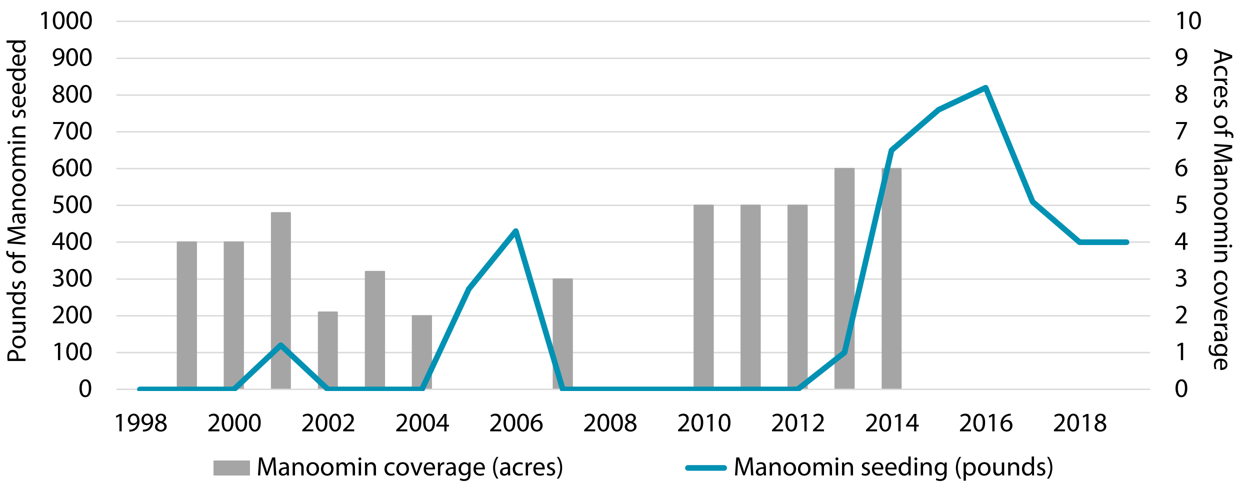
This area also holds ecological value as habitat. It provides for a number of species including medicinal plants, insects, fish, and other non-human relatives.

Actions taken to improve the abundance of Manoomin at Sand Point Sloughs

Sand Point Sloughs are a KBIC Tribal Trust property, wholly owned by KBIC and located entirely within KBIC L'Anse Reservation boundaries. KBIC took over management of the sloughs in the early 1990s, and shortly after began efforts to reintroduce Manoomin. Between 1991 and 1997, KBIC seeded nearly 1,800 pounds of Manoomin across 8 acres of Sand Point Sloughs. By 1999, Manoomin density was sufficient for KBIC to engage in the tradition of ricing. Between 1999 and 2002, community members harvested an estimated 60 to 150 pounds per year (Ravindran et al., 2014). Since 2013, KBIC has seeded annually at Sand Point Sloughs. KBIC continues to tend to this site in an effort to keep Manoomin teachings and traditions vital. However, since 2002, community members have not been able to harvest Manoomin at Sand Point Sloughs due to decreased abundance of Manoomin related to regional hydrologic conditions.

Floating wild rice. Credit: KBIC NRD

In addition to seeding efforts, KBIC and partners have undertaken remediation along the Sand Point shoreline, which was listed as a brownfield site. Remediation efforts included capping stamp sands to stabilize the tailings; planting native plants, trees, and shrubs to increase habitat for birds and other wildlife; and installing mounds and boulders to provide relief in the topography, reduce erosion, and protect valuable coastal wetlands, including Manoomin beds (Ravindran et al., 2014).



Manoomin seeding and acres of Manoomin coverage at the Sand Point Sloughs, 1999 to 2019 (data were not collected before 1999, and Manoomin coverage data were not recorded after 2014). Sources: Ravindran et al., 2014; Karena Schmidt, personal communication, October 31, 2019.

Approach to characterizing Manoomin at Sand Point Sloughs

Twelve metrics characterize the cultural and ecological functions of Sand Point Sloughs' Manoomin and its associated habitat. These metrics describe how Manoomin at the Sloughs contributes to maintaining connections with the Anishinaabe culture, how it supports ecological functionality and is resilient to changing conditions, and how it allows for continued learning and sharing of Anishinaabe values.

Cultural Metrics

Anishinaabe (original people) – The place provides Manoomin, which is sacred to the Anishinaabe and central to the foundations of their culture, sovereignty, and treaty rights.

Community relationships – Manoomin at this place contributes to bonding, traditions, and strengthening family and community connections.

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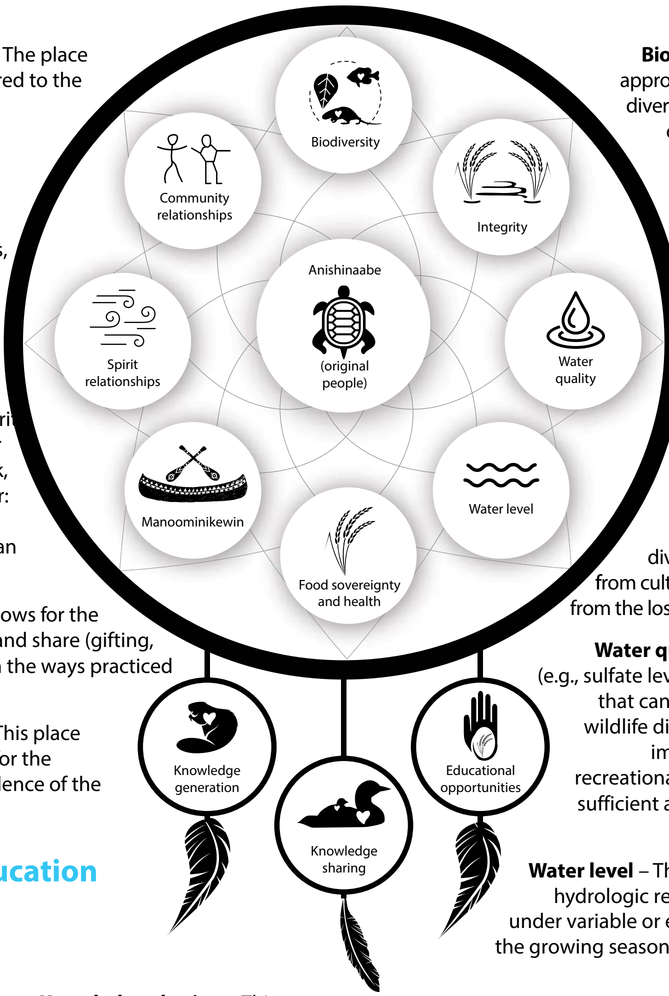


Ecological Metrics

Biodiversity – Healthy Manoomin and appropriate habitat at this place supports diverse biological communities (e.g., free of invasive species) that indicate the capacity of the place to support abundant associated plant and animal species (e.g., other native aquatic vegetation, fish, waterfowl, muskrat), providing for spiritual and subsistence needs.

Integrity – Physical habitat and hydrology, and water and sediment chemistry support stands of Manoomin that exhibit natural annual variability; viable seed bank ensures that sustainable Manoomin populations will persist even after occasional poor production years. Natural genetic diversity is maintained without impact from cultivated strains, or reduced gene flow from the loss of nearby Manoomin populations.

Water quality – This place has clean water (e.g., sulfate levels below 10 ppm) and sediments that can support robust stand density and wildlife diversity; is free of contamination or impacts from industrial, agricultural, recreational, or residential influence; and is of sufficient areal extent to sustain a Manoomin population.

Water level – This place has a natural or managed hydrologic regime that can maximize resilience under variable or extreme climatic conditions across the growing season (maintaining optimal depth range and flow).

Cultural and Ecological Education Metrics

Knowledge generation – This place allows for continued learning and generation of the Anishinaabe practices, values, beliefs, and language through experience.

Knowledge sharing – This place allows for the continued sharing and transmittal of the Anishinaabe practices, values, beliefs, and language among family members and community.

Educational opportunities – This place provides opportunities for language, land stewardship, and other educational programs, such as educational rice camps.

Cultural and ecological characterization at Sand Point Sloughs

Sand Point Sloughs' Manoomin and its associated habitat were characterized over four time periods. Each metric was ranked using the following five-point descriptive scale: No use, Very bad, Not very good, Pretty good, Doing great

This characterization begins after the copper ore processing plant ceased operations around the 1920s.

1920 to 1990: Before KBIC ownership

Based on the combined ranking of cultural and ecological metrics, Sand Point Sloughs was characterized as "not very good" during this period. This ranking reflects the absence of Manoomin from the sloughs and the deposition of mine tailings onto Sand Point. Although Manoomin was absent, the sloughs were still a place of cultural and ecological importance: waterfowl and other wildlife foraged at the sloughs; and community members fished, hunted, and gathered there and held Pow Wows on the grounds. Given the intrinsic cultural and ecological values of the sloughs, some cultural metrics – including spirit relationships, knowledge sharing, and food sovereignty – were characterized with a higher ranking.

1991 to 1998: With active management of Manoomin

Once KBIC took over management of Sand Point Sloughs in the early 1990s and began seeding activities, Manoomin grew modestly. Although community members could not yet harvest Manoomin, the presence of Manoomin significantly improved the ranking of most cultural and ecological metrics. During this period, Sand Point Sloughs ranked as "pretty good" based on the combined ranking of cultural and ecological metrics.

For each of the four time periods, the water level metric was ranked as "not very good." Due to their location, the Sand Point Sloughs are influenced by regional factors such as Lake Superior water levels, which are beyond local control.

1999 to 2005: With active management and harvesting of Manoomin

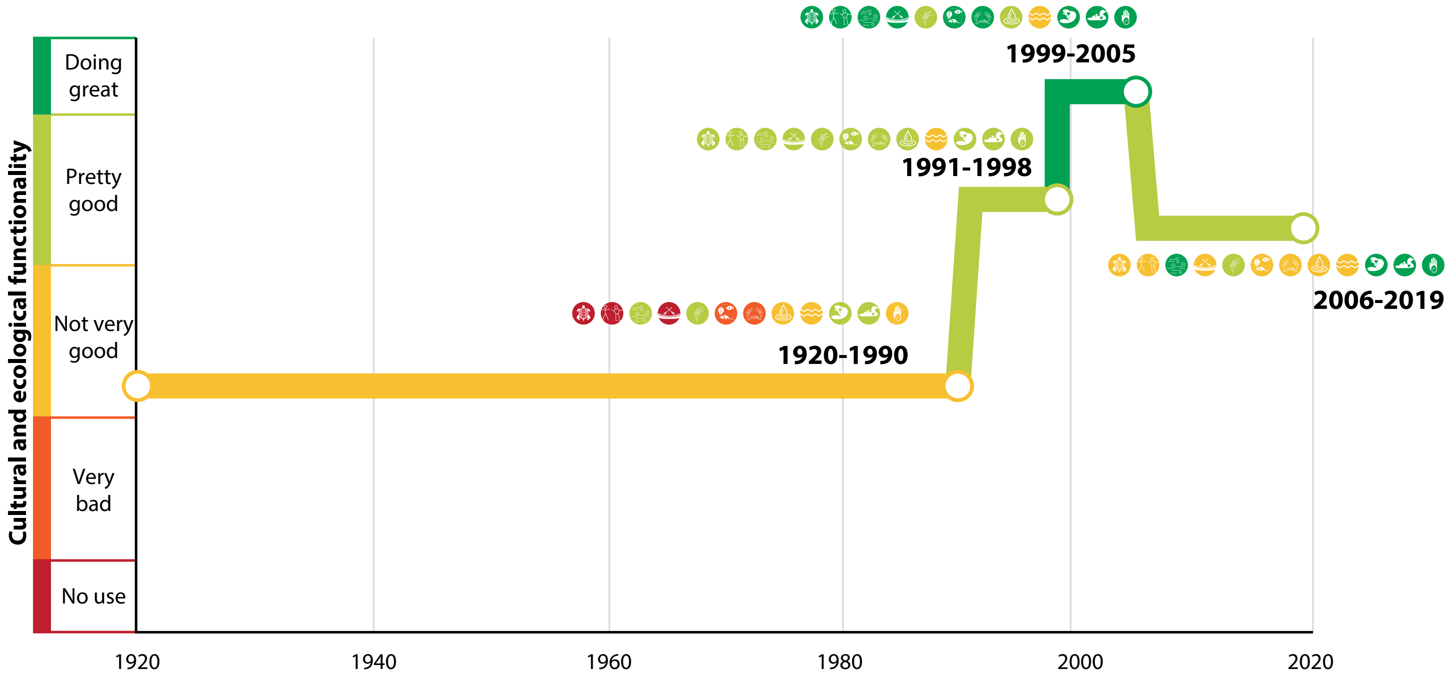
Once Manoomin was adequately established at Sand Point Sloughs, KBIC was able to open Sand Point Sloughs to their community members for harvesting. Harvesting allowed the recovery and sharing of Anishinaabe practices, values, beliefs, and language at the sloughs in ways that had not been practiced for years. During this period, Sand Point Sloughs ranked as "doing great" based on the combined ranking of improved cultural and ecological metrics.

2006 to 2019: With higher water levels

Sand Point Sloughs is connected to Lake Superior, and is affected by changes in the lake's water level and invasive and competitive species. Invasive species and competing vegetation that have been documented at Sand Point Sloughs may be impacting Manoomin abundance. Water levels have also fluctuated in Sand Point Sloughs, with lower water levels recorded in 2006 and 2007, and higher water levels in recent years (Ravindran et al., 2014). During this period, Sand Point Sloughs' functionality decreased to "pretty good" based on the combined ranking of cultural and ecological metrics. The decrease in ecological and cultural functionality provided by Manoomin in recent years suggests the need for adaptive management of Manoomin. Actions taken that may have been successful in restoring Manoomin in the past may need to be adjusted to respond to additional threats, such as climate change, to be successful in the future.

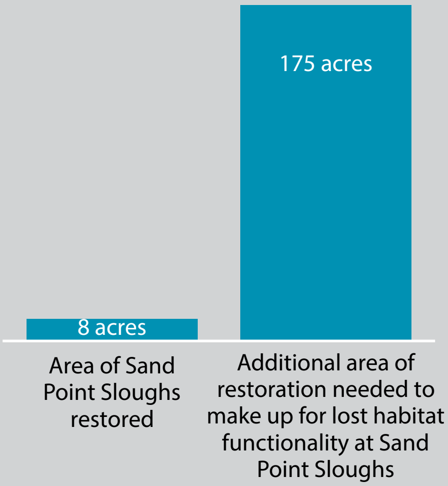
Cultural and ecological characterization at Sand Point Sloughs

The cultural and ecological functionality provided by the Manoomin and its associated habitat at Sand Point Sloughs varied over time, both in aggregate and for individual metrics.



Additional restoration needed

Based on the characterization of the degree of cultural and ecological function over the four time periods, a Habitat Equivalency Analysis demonstrates the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. Given the success of restoration on 8 acres of Sand Point Sloughs, 175 acres of similar Manoomin restoration is needed to counter-balance the lost habitat functionality that has occurred over time. In other words, 22 equivalent restoration efforts at Sand Point Sloughs (from 1991 to 2019) are needed to counter-balance lost cultural and ecological habitat functionality (from 1920 to 1990).



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Acknowledgments

The Project Team would like to acknowledge Evelyn Ravindran, Karena Schmidt, and Erin Johnston (KBIC) for their valuable input and feedback in the development of this case study, and for participating in the cultural and ecological characterization of KBIC's Sand Point Sloughs.

Introduction of Manoomin at Net River Impoundment and Vermillac Lake provides cultural and ecological functionality

With favorable conditions, restoration can enhance Gichi-manidoo gitigaan

Tending to Gichi-manidoo gitigaan (The Great Spirit's Garden) through Manoomin (wild rice) seeding efforts at Net River Impoundment and Vermillac Lake has benefited natural resources at these locations. Seeding the Net River Impoundment also has the potential to create a Manoomin seed bank for other lakes in the area, including Vermillac Lake.

Efforts to introduce Manoomin in these waterbodies have shown preliminary success. Therefore, additional seeding could help counter-balance the lost ecological functionality and inspire cultural practices to occur at these locations. Based on methods applied in this study, it would take an additional 1,129 acres of similar Manoomin seeding to counter-balance the lost ecological functionality that have occurred over time, which is equivalent in scale to nearly 12 times the current restoration efforts at the Net River Impoundment and Vermillac Lake.

Credit: KBIC NRD.

Threats to Manoomin at Net River Impoundment and Vermillac Lake

Both the Net River Impoundment and Vermillac Lake possibly had Manoomin beds in the past. Many believe that historical trails around the Net River Impoundment indicate traditional use of these places for cultural practices (Evelyn Ravindran, KBIC personal communication, August 20, 2019). Land use changes have altered the local landscape, which may have contributed to the presence or absence of Manoomin at these places.

About Net River impoundment and Vermillac Lake

The Net River is nearly 15 miles long and flows from Baraga County to Iron County, Michigan. Impounded in 1990 as a wetland mitigation site to provide waterfowl benefits, the Net River Impoundment is now 35 acres in size. Vermillac (or Worm) Lake is a 423-acre lake in Baraga County. Both the Net River Impoundment and Vermillac Lake are located outside the L'Anse Indian Reservation, but within Ceded Territory.

Actions taken to improve Manoomin at Net River Impoundment and Vermillac Lake

KBIC is receiving more and more teachings from Manoomin and is working to understand which locations on the L'Anse Indian Reservation and within Ceded Territory have conditions that are conducive to grow and sustain Manoomin (BIA, 2019). KBIC is interested in having local sources of Manoomin as seed banks for future restoration activities; as well as places where community members can harvest, prepare, and gift Manoomin. KBIC is currently assessing suitable Manoomin habitat across their territory, and focusing restoration in lakes with the most favorable conditions for Manoomin.

In the early 2010s, KBIC worked with the Michigan Department of Natural Resources to identify additional areas for Manoomin restoration. The Net River Impoundment and Vermillac Lake were selected as lakes with potential for Manoomin beds, and KBIC seeded test plots at both lakes. Given their success, KBIC then seeded the Net River Impoundment and Vermillac Lake with nearly 2,000 pounds of Manoomin seed. Cultural teachings and practices related to Manoomin are beginning to occur at the Net River Impoundment. KBIC continues to seed 97 acres across both lakes with nearly 2,000 pounds of Manoomin each year.

The ultimate goal of seeding efforts at the Net River Impoundment is to produce a Manoomin seed source for Vermillac Lake and other KBIC restoration sites. In keeping with the principles of the honorable harvest, KBIC aims to achieve conditions that will allow the rice to reseed itself to feed wildlife and nourish the people.

Survey point. Credit: KBIC NRD.

Rice stand. Credit: KBIC NRD.

Approach to characterizing Manoomin at Net River Impoundment and Vermillac Lake

Twelve metrics characterize the cultural and ecological functions of the Net River Impoundment's and Vermillac Lake's Manoomin and associated habitats. These metrics describe how Manoomin at these areas contributes to maintaining connections with the Anishinaabe culture, how ecological functionality is supported and resilient to changing conditions, and how continued learning and sharing of Anishinaabe values are promoted.

Cultural Metrics

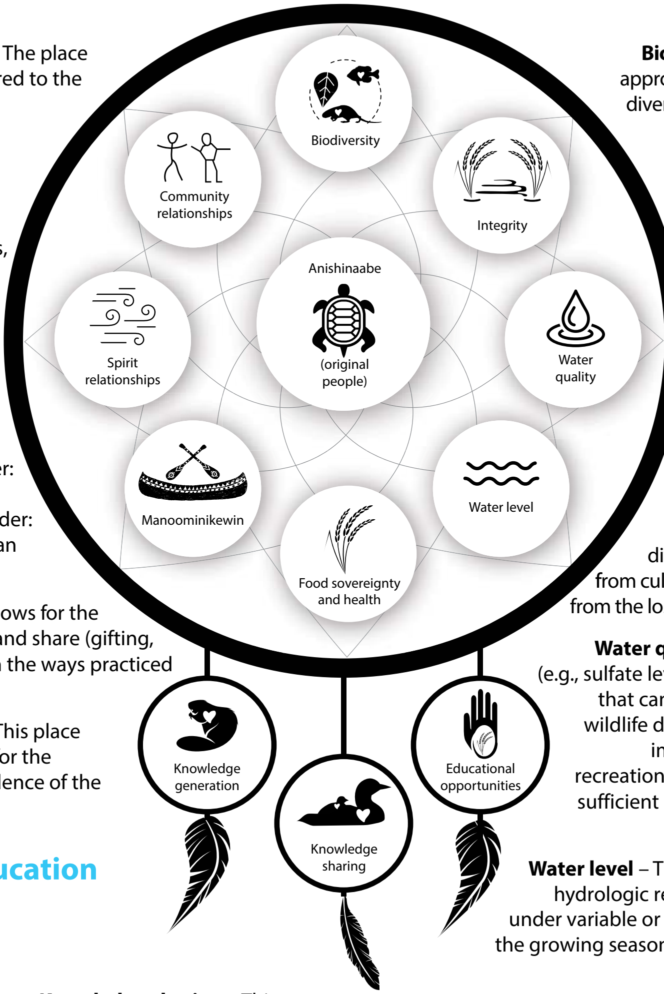
Anishinaabe (original people) – The place provides Manoomin, which is sacred to the Anishinaabe and central to the foundations of their culture, sovereignty, and treaty rights.

Community relationships – Manoomin at this place contributes to bonding, traditions, and strengthening family and community connections.

Spirit relationships – Manoomin at this place enables the Anishinaabe to maintain connections and balance with spirit beings (or relatives) from all other orders of creation (first order: rock, water, fire and wind; second order: other plant beings; third order: animal beings; fourth order: human beings).

Manoominikewin – This place allows for the Anishinaabe to harvest, prepare, and share (gifting, healing, and eating) Manoomin in the ways practiced by their ancestors for centuries.

Food sovereignty and health – This place provides the capacity to provide for the sustenance, health, and independence of the Anishinaabe.



Ecological Metrics

Biodiversity – Healthy Manoomin and appropriate habitat at this place supports diverse biological communities (e.g., free of invasive species) that indicate the capacity of the place to support abundant associated plant and animal species (e.g., other native aquatic vegetation, fish, waterfowl, muskrat), providing for spiritual and subsistence needs.

Integrity – Physical habitat and hydrology, and water and sediment chemistry support stands of Manoomin that exhibit natural annual variability; viable seed bank ensures that sustainable Manoomin populations will persist even after occasional poor production years. Natural genetic diversity is maintained without impact from cultivated strains, or reduced gene flow from the loss of nearby Manoomin populations.

Water quality – This place has clean water (e.g., sulfate levels below 10 ppm) and sediments that can support robust stand density and wildlife diversity; is free of contamination or impacts from industrial, agricultural, recreational, or residential influence; and is of sufficient areal extent to sustain a Manoomin population.

Water level – This place has a natural or managed hydrologic regime that can maximize resilience under variable or extreme climatic conditions across the growing season (maintaining optimal depth range and flow).

Cultural and Ecological Education Metrics

Knowledge generation – This place allows for continued learning and generation of the Anishinaabe practices, values, beliefs, and language through experience.

Knowledge sharing – This place allows for the continued sharing and transmittal of the Anishinaabe practices, values, beliefs, and language among family members and community.

Educational opportunities – This place provides opportunities for language, land stewardship, and other educational programs, such as educational rice camps.

Cultural and ecological characterization at Net River Impoundment and Vermillac Lake

Manoomin and its associated habitat at the Net River Impoundment and Vermillac Lake were characterized over two time periods. Each metric was ranked using the following five-point descriptive scale:

No use, Very bad, Not very good, Pretty good, Doing great

This characterization begins after the Net River was impounded as a wetland mitigation bank in 1990.

1990 to 2013: Before Manoomin seeding

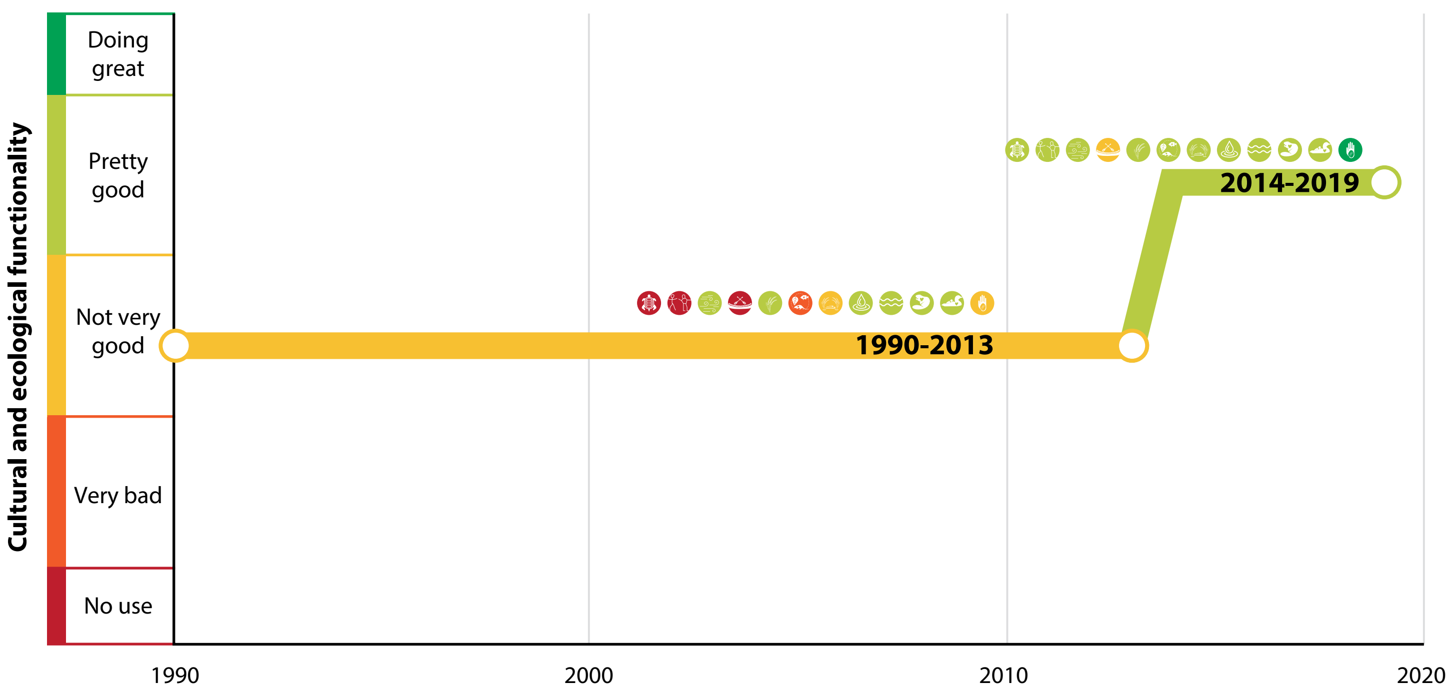
Based on the combined ranking of cultural and ecological metrics, conditions at the Net River Impoundment and Vermillac Lake were characterized as "not very good" during this period. This ranking reflects the absence of Manoomin from the Net River Impoundment and Vermillac Lake before 2013. Although Manoomin was absent, these areas were culturally and ecological important. Community members used these sites for gathering, fishing, and hunting activities; during these activities, families passed down knowledge to their children or grandchildren about traditional practices and resources. Given the intrinsic cultural and ecological value of these places, some metrics – including spirit relationships, food sovereignty, knowledge generation and sharing, and water level and quality – ranked higher in cultural and ecological characterization.

2014 to 2019: After Manoomin seeding

Once KBIC began seeding the Net River Impoundment and Vermillac Lake, Manoomin grew at these places. Currently, Manoomin supports wildlife and other ecosystem functions. These places have the potential for Manoomin harvesting in the future, although they cannot yet support it. The presence of Manoomin significantly improved the ranking of most of the cultural and ecological metrics. During this period, conditions at the Net River Impoundment and Vermillac Lake ranked as "pretty good" based on cultural and ecological metrics. Although Manoomin provides cultural and ecological functionality, additional management of water levels at the Net River Impoundment could continue to improve the abundance of Manoomin and the long-term sustainability of healthy Manoomin beds.

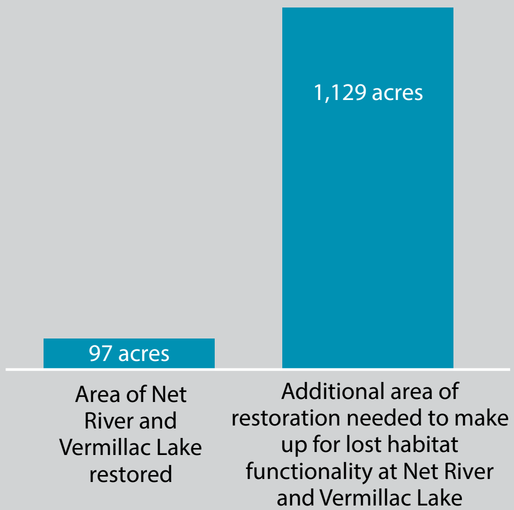
Cultural and ecological characterization at Net River Impoundment and Vermillac Lake

Cultural and ecological functionality provided by Manoomin and its associated habitat at the Net River Impoundment and Vermillac Lake have increased over time, both in aggregate and for the individual metrics.



Additional restoration needed

Based on the characterization of the degree of cultural and ecological function over the two time periods, a Habitat Equivalency Analysis can demonstrate the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. With seeding, resource managers successfully established Manoomin across the Net River Impoundment and Vermillac Lake. However, given that the period of degradation is much larger (over 20 years) than the period of restoration (around 5 years), an additional 1,129 acres of similar Manoomin restoration is needed to counter-balance the lost habitat functionality that has occurred over time. In other words, nearly 12 equivalent restoration efforts at the Net River Impoundment and Vermillac Lake (from 2014 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1990 to 2013).



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Introduction of Manoomin at Hiles Millpond provides cultural and ecological functionality

With favorable conditions, restoration can enhance Manoomin habitat

Establishing Manoomin (wild rice) at Hiles Millpond significantly enhances its cultural and ecological functionality. It also helps to make up for the loss of Manoomin on other waters throughout the region. Although recent restoration efforts have shown preliminary success, Manoomin has been absent from Hiles Millpond for a long time. Therefore, additional restoration could help counter-balance lost cultural and ecological functionality. Based on the methods applied in this study, 864 additional acres of similar Manoomin restoration would counter-balance the lost cultural and ecological functionality that have occurred over time. This is equivalent in scale to nearly three times the current restoration efforts at Hiles Millpond. The successful introduction of Manoomin at Hiles Millpond suggests that naturally suitable soils, combined with seeding and modifications in water-level management, can yield high-quality Manoomin and habitat.

Threats to Manoomin at Hiles Millpond

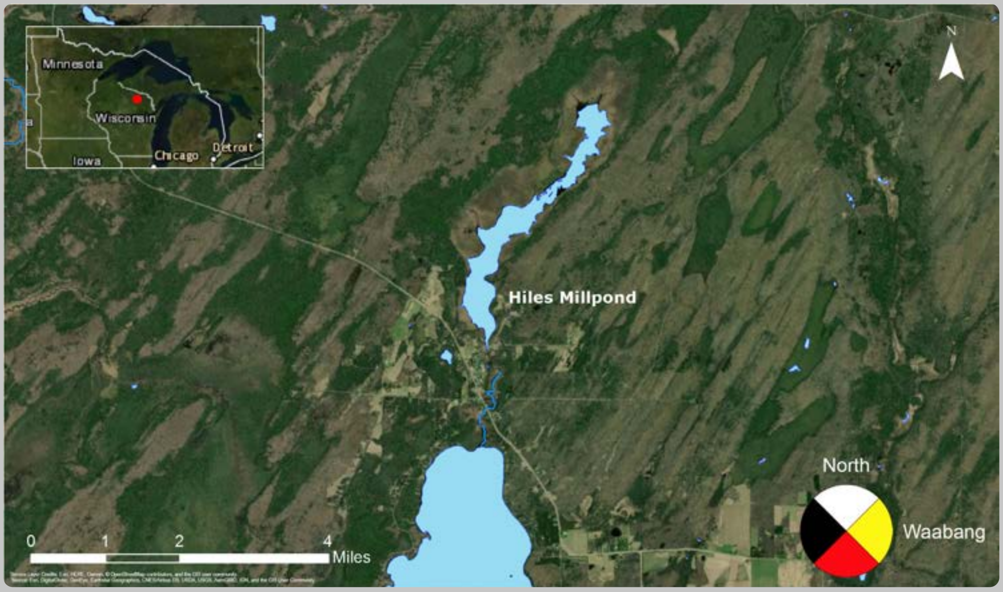
Water became ponded at Hiles Millpond in the late 1880s when the Hiles Lumber Company built a dam for logging purposes. Although there is no record of the presence of Manoomin at Hiles Millpond, it may have been there prior to dam construction since Manoomin is in nearby waters. If Manoomin was present at Hiles Millpond historically, it could have been negatively affected by changes in water levels associated with construction of the dam.

The area and waters around the Town of Hiles were traditionally used by the Lac du Flambeau Band of Lake Superior Chippewa Indians (LDF Band), the Sokaogon Chippewa Community, and other Ojibwe Bands and their ancestors. However, use of the area by Bands for hunting, gathering, fishing, and trapping was limited during much of the last century up until the 1980s. Use of this area increased after this time when relations with the local community in the Town of Hiles improved.

About Hiles Millpond

Hiles Millpond is an approximately 300-acre lake located in Forest County, Wisconsin, an 1842 Ceded Territory.

The millpond provides excellent wildlife habitat, especially for waterfowl, furbearers, eagles, and other wetland-dependent species. The lake also supports a northern pike and panfish fishery.



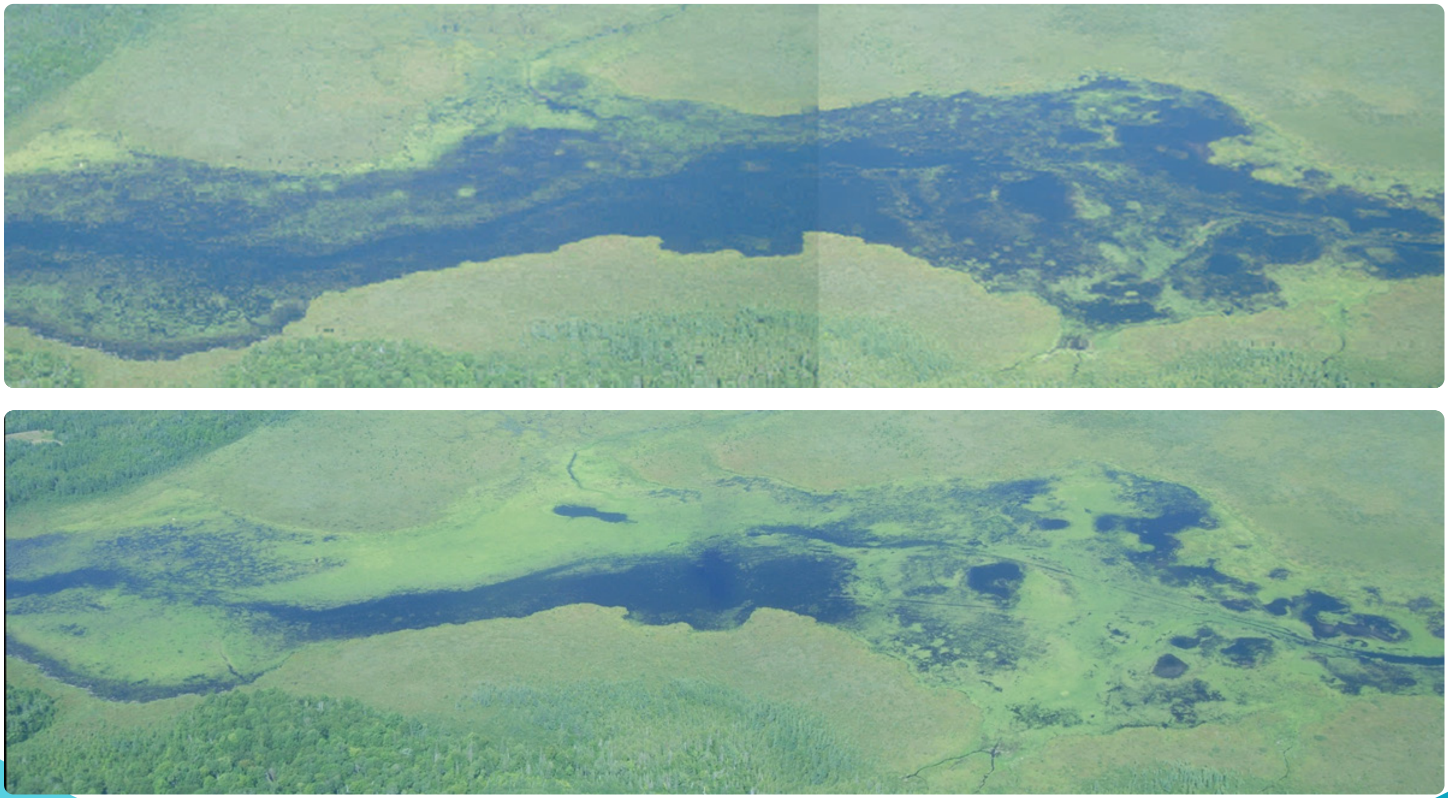
Actions taken to improve the abundance of Manoomin at the Hiles Millpond

In 1992, safety inspections found several problems with the dam structure at Hiles Millpond. To meet contemporary safety standards, the Town of Hiles needed to replace the dam structure. Since the town lacked adequate funds, federal, state, tribal, and nongovernmental organizations entered into a cooperative effort. A Memorandum of Understanding included a provision for the town to cooperate with the Forest Service to manage the millpond for productive wildlife and fish habitats, including possible manipulation of water levels, following completion of the project. The dam and water control structure were rebuilt in fall 1993.

Shortly after, biologists realized that the ecological benefits of Hiles Millpond could be significantly enhanced by establishing Manoomin on the millpond. Establishing Manoomin could also help to make up for the loss of Manoomin on other waters in the region, many of which were difficult or impossible to recover due to excessive development, conflicting uses, or other threats to Manoomin (Peter David, GLIFWC, personal communication, November 27, 2019).

In 1998, GLIFWC and the Forest Service cooperatively seeded the Hiles Millpond flowage with a relatively modest amount of Manoomin (329 pounds). Small patches of Manoomin then expanded modestly over the next several years. In 2011, Manoomin expanded significantly under natural drought conditions, which led biologists to believe that Manoomin might increase if the typical summer water level was lowered slightly.

Although the Town of Hiles was initially concerned that lower water levels might negatively affect the northern pike fishery, it ultimately agreed to manage the water level for Manoomin. Once lowered, Manoomin showed an immediate response. Manoomin abundance increased significantly from 2013, before water levels were lowered, to 2014, following a lowering of water levels. In recent years, over 125 acres of Manoomin can be found growing across the lake (Peter David, GLIFWC, personal communication, November 27, 2019).



Manoomin abundance on a portion of the Hiles Millpond, 2013 above, and 2014 below, following a lowering of water levels. Credit: Peter David, GLIFWC

Approach to characterizing Manoomin at Hiles Millpond

Twelve metrics characterize the cultural and ecological functions of Hiles Millpond Manoomin and its associated habitat. These metrics describe how Manoomin at Hiles Millpond contributes to maintaining connections with the Anishinaabe culture, how ecological functionality is supported and resilient to changing conditions, and how continued learning and sharing of Anishinaabe values are promoted.

Cultural Metrics

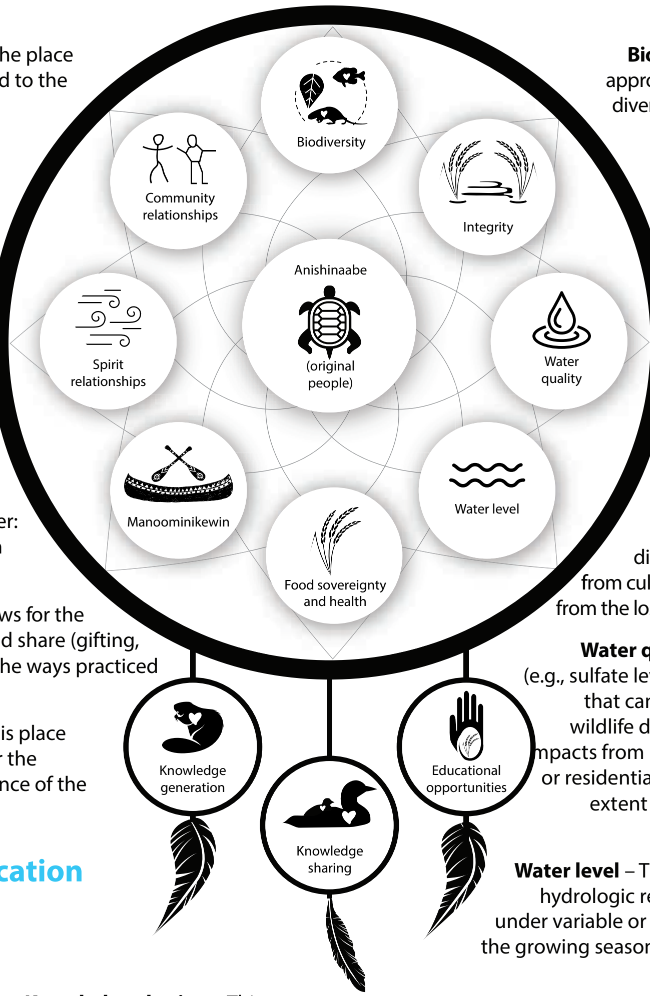
Anishinaabe (original people) – The place provides Manoomin, which is sacred to the Anishinaabe and central to the foundations of their culture, sovereignty, and treaty rights.

Community relationships – Manoomin at this place contributes to bonding, traditions, and strengthening family and community connections.

Spirit relationships – Manoomin at this place enables the Anishinaabe to maintain connections and balance with spirit beings (or relatives) from all other orders of creation (first order: rock, water, fire and wind; second order: other plant beings; third order: animal beings; fourth order: human beings).

Manoominikewin – This place allows for the Anishinaabe to harvest, prepare, and share (gifting, healing, and eating) Manoomin in the ways practiced by their ancestors for centuries.

Food sovereignty and health – This place provides the capacity to provide for the sustenance, health, and independence of the Anishinaabe.



Ecological Metrics

Biodiversity – Healthy Manoomin and appropriate habitat at this place supports diverse biological communities (e.g., free of invasive species) that indicate the capacity of the place to support abundant associated plant and animal species (e.g., other native aquatic vegetation, fish, waterfowl, muskrat), providing for spiritual and subsistence needs.

Integrity – Physical habitat and hydrology, and water and sediment chemistry support stands of Manoomin that exhibit natural annual variability; viable seed bank ensures that sustainable Manoomin populations will persist even after occasional poor production years. Natural genetic diversity is maintained without impact from cultivated strains, or reduced gene flow from the loss of nearby Manoomin populations.

Water quality – This place has clean water (e.g., sulfate levels below 10 ppm) and sediments that can support robust stand density and wildlife diversity; is free of contamination or impacts from industrial, agricultural, recreational, or residential influence; and is of sufficient areal extent to sustain a Manoomin population.

Water level – This place has a natural or managed hydrologic regime that can maximize resilience under variable or extreme climatic conditions across the growing season (maintaining optimal depth range and flow).

Cultural and Ecological Education Metrics

Knowledge generation – This place allows for continued learning and generation of the Anishinaabe practices, values, beliefs, and language through experience.

Knowledge sharing – This place allows for the continued sharing and transmittal of the Anishinaabe practices, values, beliefs, and language among family members and community.

Educational opportunities – This place provides opportunities for language, land stewardship, and other educational programs, such as educational rice camps.

Cultural and ecological characterization at Hiles Millpond

Manoomin and its associated habitat at Hiles Millpond were characterized over three time periods. Each metric was ranked using the following five-point descriptive scale: No use, Very bad, Not very good, Pretty good, Doing great

The characterization starts in 1980 because prior to that time community members were less likely to travel to Hiles Millpond to harvest Manoomin, and undertake other traditional hunting and gathering practices.

1980 to 1997: Before Manoomin seeding

Based on the combined ranking of cultural and ecological metrics, Hiles Millpond was characterized as "very bad" during this period. Because of the absence of Manoomin in the millpond, most of the metrics – particularly cultural metrics – ranked low on the score range.

1998 to 2013: After Manoomin seeding

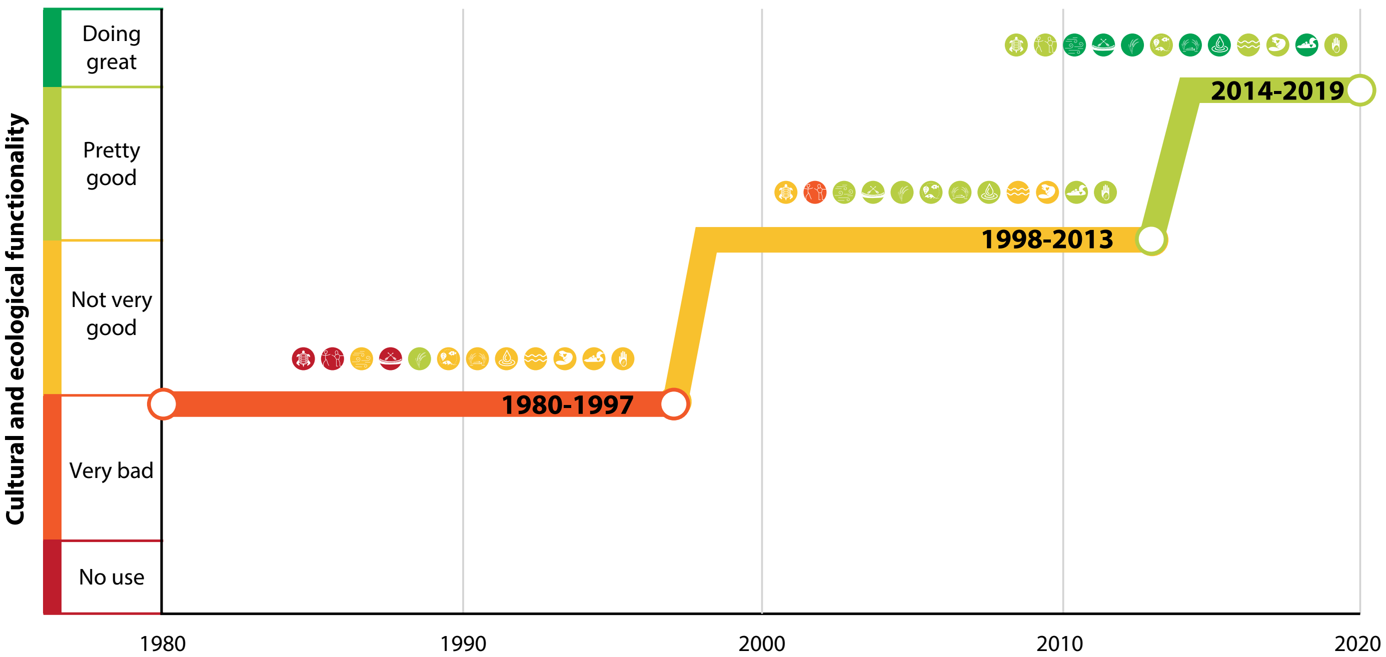
Once seeding activities began in 1998, Manoomin began to grow at the Millpond. The presence of Manoomin improved the rankings for most of the cultural and ecological metrics. In particular, the presence of Manoomin at Hiles Millpond allowed for some harvesting, preparation, and sharing of Manoomin by the community. It also improved the Anishinabee's connections and balance with spirit beings and relatives, and it supported diverse biological communities. During this period, Hiles Millpond ranked as "not very good" based on the combined ranking of the cultural and ecological metrics.

2014 to 2019: With water level management

After resource managers adjusted water levels for Manoomin in 2014, its coverage continued to expand. More Manoomin allowed for harvesting, preparation, and sharing of Manoomin in ways practiced by ancestors. It also allowed for knowledge generation and sharing of Anishinaabe practices, values, beliefs, and language. Although Manoomin provides many cultural and ecological functionality, additional management of water levels could continue to improve Manoomin and its associated habitat at Hiles Millpond. During this period, Hiles Millpond ranked as "pretty good" based on the combined ranking of cultural and ecological metrics.

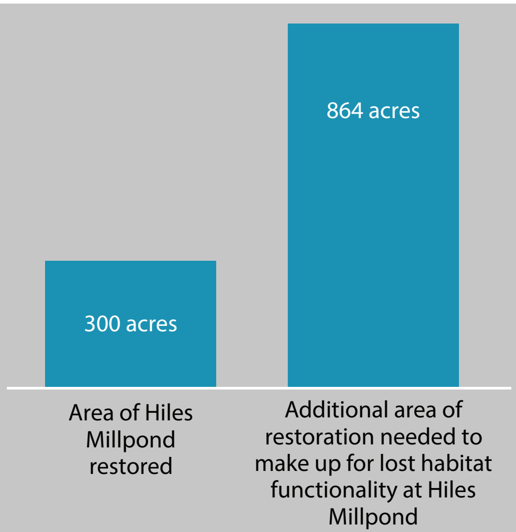
Cultural and ecological characterization at Hiles Millpond

Cultural and ecological functionality provided by Manoomin and its associated habitat at Hiles Millpond have increased over time, both in aggregate and for individual metrics.



Additional restoration needed

Based on the characterization of the degree of cultural and ecological function over the three time periods, a Habitat Equivalency Analysis demonstrates the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. With modest seeding and slight modifications in water-level management, resource managers successfully established Manoomin across the Hiles Millpond. The analysis indicates that an additional 864 acres of similar Manoomin restoration is needed to counter-balance the lost habitat functionality that has occurred over time. In other words, nearly three equivalent restoration efforts at Hiles Millpond (from 1998 to 2019) are needed to counter-balance the lost cultural and ecological habitat functionality (from 1980 to 1997).



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Acknowledgments

The Project Team would like to acknowledge Peter David (GLIFWC), Eric Chapman and Joe Graveen (LDF Band), and Peter McGeshick (Sokaogon Chippewa Community) for their valuable input and feedback in the development of this case study, and for participating in the cultural and ecological characterization of the Hiles Millpond.

Efforts to manage Big Rice Lake have not improved Manoomin functionality

Manoomin continues to be affected by hydrologic conditions and other threats

Historically, Big Rice Lake was one of the best-producing Manoomin (wild rice) lakes in northeastern Minnesota, and Manoomin on this lake provided cultural, ecological, and educational services to the Anishinaabe people. Over the last two decades, natural resource managers actively managed Big Rice Lake to improve conditions of Manoomin and its associated habitat. However, their actions – including water management, vegetation control, and beaver control – have been largely ineffective in recent years and Manoomin abundance continues to remain low. Manoomin and its habitat at Big Rice Lake have declined across all cultural and ecological metrics, and ginoozhegoons (pickerelweed) continues to outcompete Manoomin in parts of the lake. This case study highlights the difficulties in restoring degraded Manoomin and its associated habitat, and the importance of protecting it.

Threats to Manoomin at Big Rice Lake

Hydrologic changes, impacts from competing vegetation, and perhaps climate change have threatened Manoomin at Big Rice Lake. Manoomin is very sensitive to changes in water levels. Low or stable water conditions over long periods can encourage the proliferation of other vegetation, such as ginoozhegoons (pickerelweed), which can outcompete Manoomin for space and resources. Ginoozhegoons has expanded considerably on Big Rice Lake, especially on the eastern half of the lake. In addition to the artificial controls on water levels, climate change could change precipitation patterns, which may increase both the likelihood of drought and the frequency of heavy rain events that can cause high water levels and flooding in Big Rice Lake.

"Big Rice Lake is culturally and historically important to local Ojibwe Bands who have utilized the lake for centuries and continue to exercise treaty rights there today. State residents also have strong ties to Big Rice Lake for wild rice harvesting, waterfowl hunting, and fur trapping."

MN DNR, 2013.

Credit: 1854 Treaty Authority.

About Big Rice Lake

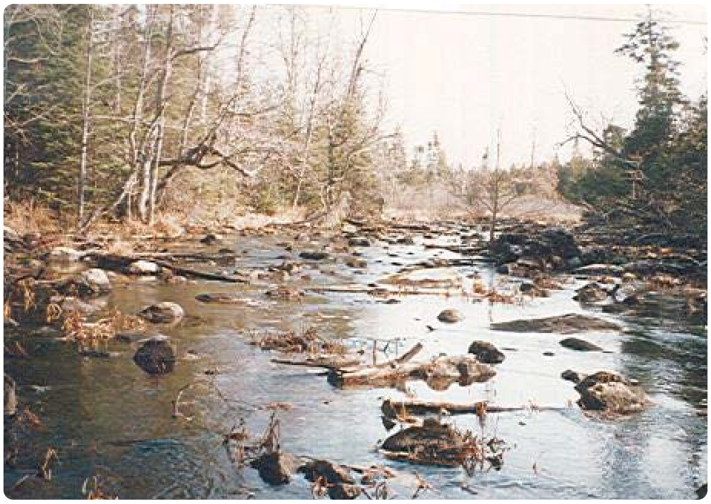
Big Rice Lake, located in St. Louis County in northeastern Minnesota, is approximately 1,870 acres. The area was traditionally used for ricing, sugar bush, and hunting activities; and archaeological evidence indicates human use on sites surrounding the lake for hundreds – perhaps thousands – of years.

The lake is an important feeding and resting area for migrating waterfowl. In years of good Manoomin production, mallards, goldeneyes, wood ducks, blue winged teal, and ring-necked ducks use the lake. In 1992, Big Rice Lake became a Designated Wildlife Lake because of its "outstanding value to wildlife." Currently, the lake supports a bald eagle nesting territory, as well as muskrats, minks, beaver, otter, great blue herons, and trumpeter swans.

Actions taken to improve the abundance of Manoomin at Big Rice Lake

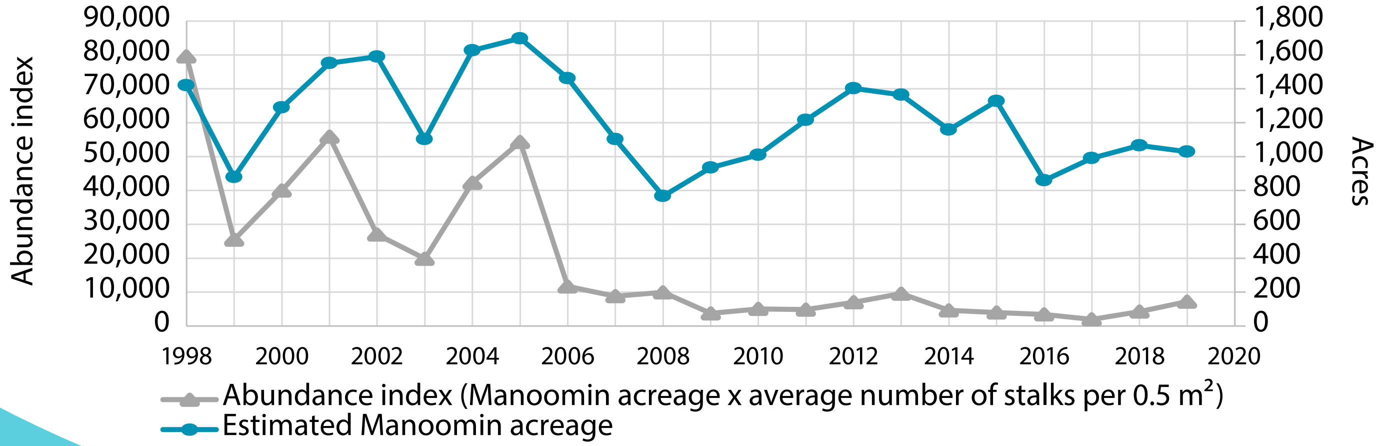
Natural resource managers have taken several actions to increase Manoomin at Big Rice Lake. In 1995, federal and state agencies built a rock weir at the outlet of the lake to increase the water flow out of the lake and reduce rapid water-level changes that can negatively impact Manoomin growth (MN DNR, 2013). Initially, the installation of the rock weir seemed to improve Manoomin coverage at Big Rice Lake; however, despite adjustments to the weir and varied beaver management, the more stable water level appears to have favored ginoozhegoons over Manoomin.

Since 2006, a cooperative effort of several federal, state, and tribal partners has taken additional management activities to further support Manoomin (Vogt, 2020). In addition to allowing water levels to vary naturally, natural resource managers are cutting ginoozhegoons. Natural resource managers use an airboat with chains to disturb the substrate of Big Rice Lake to encourage the germination of Manoomin seed in several test plots (Vogt, 2020). These efforts control about 100 acres of ginoozhegoons each year, but Manoomin regrowth in cut areas has been minimal (Vogt, 2020). Over the years, partners have also trapped beavers and removed beaver dams to control water levels.



Natural rock rapids at the outlet of Big Rice Lake in 1992. Credit: MN DNR, 2019.

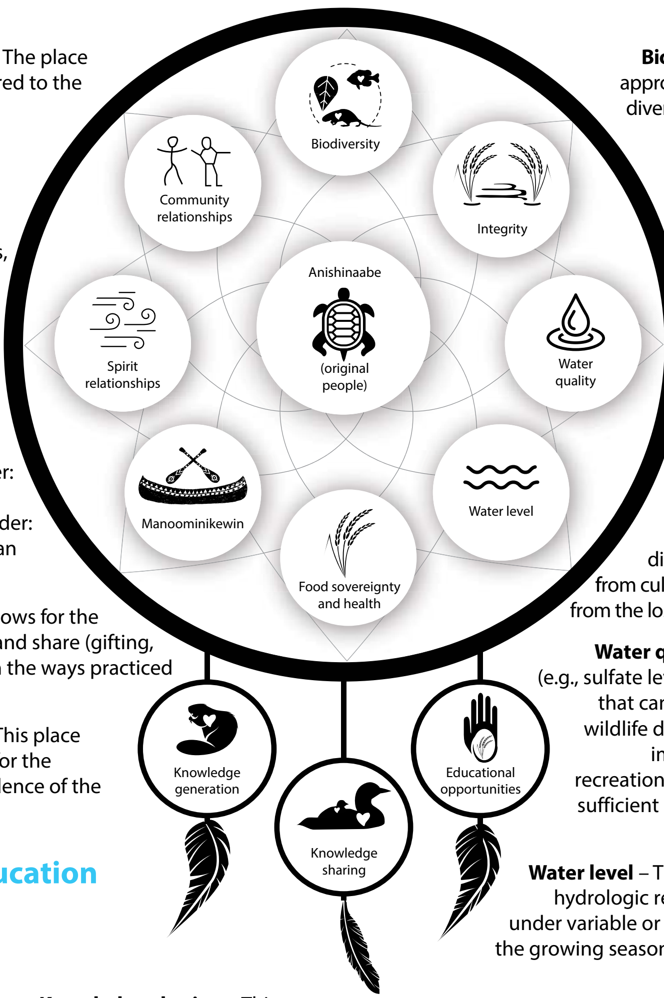
Rock weir at the outlet of Big Rice Lake in 2016. Credit: MN DNR, 2019.



Manoomin abundance index and acres on Big Rice Lake.

Approach to characterizing Manoomin at Big Rice Lake

Twelve metrics characterize the cultural and ecological functions of Big Rice Lake's Manoomin and its associated habitat. These metrics describe how Manoomin at Big Rice Lake contributes to maintaining connections with the Anishinaabe culture, how ecological functionality is supported and resilient to changing conditions, and how continued learning and sharing of Anishinaabe values are promoted.



Cultural Metrics

Anishinaabe (original people) – The place provides Manoomin, which is sacred to the Anishinaabe and central to the foundations of their culture, sovereignty, and treaty rights.

Community relationships – Manoomin at this place contributes to bonding, traditions, and strengthening family and community connections.

Spirit relationships – Manoomin at this place enables the Anishinaabe to maintain connections and balance with spirit beings (or relatives) from all other orders of creation (first order: rock, water, fire and wind; second order: other plant beings; third order: animal beings; fourth order: human beings).

Manoominikewin – This place allows for the Anishinaabe to harvest, prepare, and share (gifting, healing, and eating) Manoomin in the ways practiced by their ancestors for centuries.

Food sovereignty and health – This place provides the capacity to provide for the sustenance, health, and independence of the Anishinaabe.

Ecological Metrics

Biodiversity – Healthy Manoomin and appropriate habitat at this place supports diverse biological communities (e.g., free of invasive species) that indicate the capacity of the place to support abundant associated plant and animal species (e.g., other native aquatic vegetation, fish, waterfowl, muskrat), providing for spiritual and subsistence needs.

Integrity – Physical habitat and hydrology, and water and sediment chemistry support stands of Manoomin that exhibit natural annual variability; viable seed bank ensures that sustainable Manoomin populations will persist even after occasional poor production years. Natural genetic diversity is maintained without impact from cultivated strains, or reduced gene flow from the loss of nearby Manoomin populations.

Water quality – This place has clean water (e.g., sulfate levels below 10 ppm) and sediments that can support robust stand density and wildlife diversity; is free of contamination or impacts from industrial, agricultural, recreational, or residential influence; and is of sufficient areal extent to sustain a Manoomin population.

Water level – This place has a natural or managed hydrologic regime that can maximize resilience under variable or extreme climatic conditions across the growing season (maintaining optimal depth range and flow).

Cultural and Ecological Education Metrics

Knowledge generation – This place allows for continued learning and generation of the Anishinaabe practices, values, beliefs, and language through experience.

Knowledge sharing – This place allows for the continued sharing and transmittal of the Anishinaabe practices, values, beliefs, and language among family members and community.

Educational opportunities – This place provides opportunities for language, land stewardship, and other educational programs, such as educational rice camps.

Cultural and ecological characterization at Big Rice Lake

Big Rice Lake's Manoomin and its associated habitat were characterized over three time periods. Each metric was ranked using the following five-point descriptive scale: No use, Very bad, Not very good, Pretty good, Doing great

1900 to 1994: Before rock weir construction

Based on the combined ranking of the cultural and ecological metrics, Big Rice Lake was characterized as "pretty good." During this period, Big Rice Lake was dominated by Manoomin with variable production across years, which provided high-quality waterfowl and wildlife habitats, and the opportunity for harvesting. The lake was culturally and historically important to Ojibwe Bands who used the lake during this period and exercised their treaty rights.

1995 to 2005: After rock weir construction

Immediately after the installation of the rock weir in 1995, Manoomin coverage at Big Rice Lake improved in some years. However, over time the more stable water level favored ginoozhegoons over Manoomin, and Manoomin began to decline, although it remained at the "pretty good" ranking score based on the combined ranking of cultural and ecological metrics.

Credit: 1854 Treaty Authority.

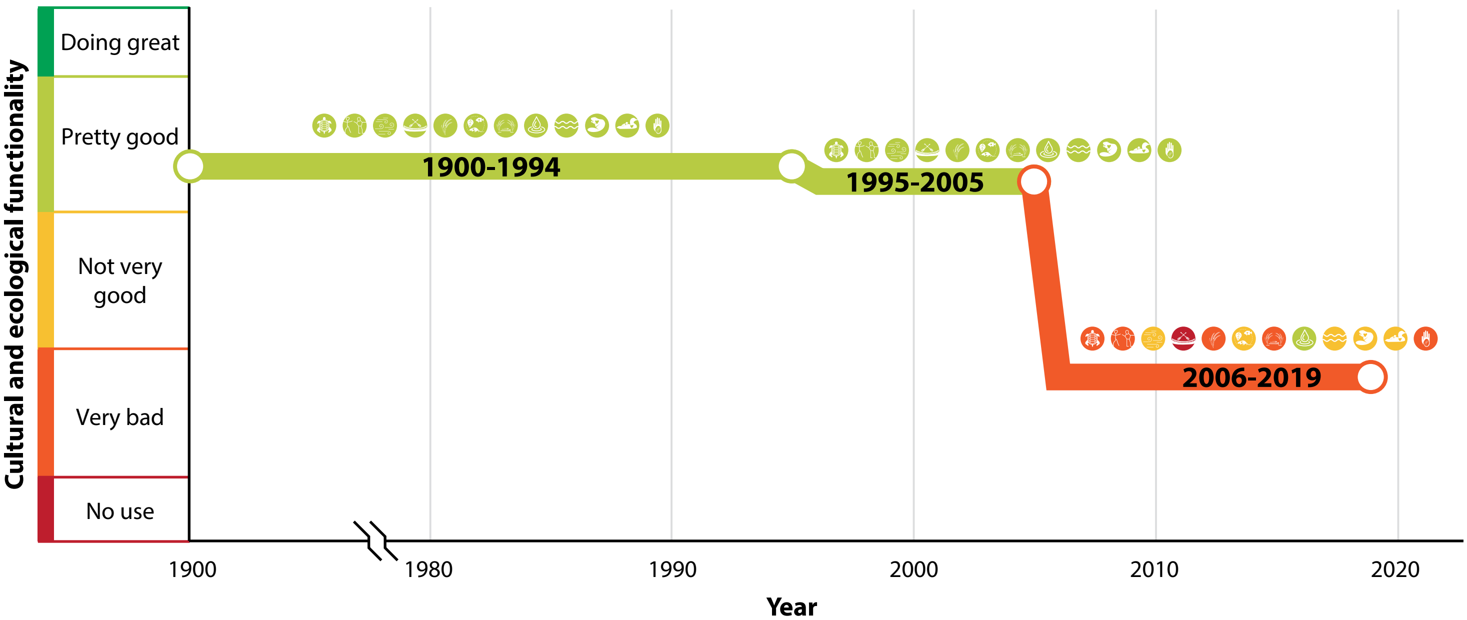
2006 to 2019: With active management of Manoomin

By 2006, Big Rice Lake ranked as "very bad" based on the combined ranking of cultural and ecological metrics. Hydrologic changes, competition from ginoozhegoons, and perhaps other unknown factors led to the dramatic decline of Manoomin. From 2006 to 2019, natural resource managers took active management steps to recover Manoomin at Big Rice Lake; however, it remained sparse in coverage, with only a few small, moderate-to-good density stands found on the lake. As a result, community members were unable to harvest, prepare, and share Manoomin in ways practiced by their ancestors. This also limited sharing, transmittal, and generation of Anishinaabe practices. The decline in Manoomin has also negatively affected migratory waterfowl that use the lake.

Credit: 1854 Treaty Authority.

Cultural and ecological characterization of Big Rice Lake

Cultural and ecological services provided by Manoomin and its associated habitat at Big Rice Lake decreased over time, both in total and for individual metrics.



Additional restoration needed

Since the 1990s, natural resource managers have tried to improve the conditions of Manoomin and its associated habitat at Big Rice Lake; however, recent actions have not been successful and conditions continue to be diminished.

Restoration funds have recently been awarded to undertake further actions at the lake (Helmberger, 2019). If these actions were to improve functionality, we could use a Habitat Equivalency Analysis (HEA) to demonstrate the additional equivalent units of restoration that would be needed to counter-balance the severity and timespan of degradation. For example, if actions were implemented over the next 20 years (2020 to 2040) to improve habitat functionality by 2.5%, we would need over 400,000 acres of similar Manoomin restoration to counter-balance the lost habitat functionality that has occurred over time (from 1995 to 2019). This is equivalent in size to over 200 Big Rice Lakes. The table to the right provides the HEA results, assuming several hypothetical scenarios of improvements in habitat functionality; it is important to note that we do not know what actions are needed to create these percent improvements. The main purpose of these scenarios is to highlight that if only minimal restoration is achieved at Big Rice Lake (which may be anticipated, given the long history of attempting restoration, with minimal response), then significant equivalent amounts of this restoration would be needed to balance the prolonged period of degradation at this lake.

Hypothetical percentage of improvement in habitat functionality from 2020 to 2040	**Acres needed to counter-balance historical losses given hypothetical improvement** *(Acres rounded to the nearest hundred)*	**Number of Big Rice Lakes needed to counter-balance historical losses given hypothetical improvement**
2.5%	426,100	228
5.0%	213,100	114
10.0%	106,500	57
20.0%	53,300	29

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About this effort

This case study is part of the Lake Superior Manoomin Cultural and Ecosystem Characterization Study. The project was initiated by a team of Lake Superior Basin Anishinaabe communities, and federal and state agencies, with technical support from Abt Associates. This project aims to describe the importance of Manoomin to help foster community stewardship and education; and to inform Manoomin stewardship, protection, and policy in the Lake Superior region and throughout the Great Lakes. Funding for this project was received via Great Lakes Restoration Initiative. For more information on the Initiative and Action Plan go to https://www.glri.us/.

Acknowledgments

The Project Team would like to acknowledge Darren Vogt (1854 Treaty Authority) and Nancy Schuldt (Fond du Lac Band of Lake Superior Chippewa) for their valuable input and feedback in the development of this case study. In addition, the Project Team would like to thank Thomas Howes (Fond du Lac Band of Lake Superior Chippewa), Tara Geshick (Bois Forte Band of Lake Superior Chippewa), Daniel Ryan (U.S. Forest Service), and Melissa Thompson and Tom Rusch (Minnesota Department of Natural Resources) for participating in the cultural and ecological characterization of Big Rice Lake.

Low ecological and cultural functionality characterized at the Twin Lakes

Manoomin is unable to rebound due to ongoing sulfate loading from mine discharges

Historically, Sandy Lake and Little Sandy Lake, also known as the Twin Lakes, were important ricing sites for Ojibwe Bands in northeastern Minnesota. Manoomin (wild rice) on these lakes provided cultural and ecological services to the Anishinaabe people. Since U.S. Steel constructed a tailings basin for their Minntac iron ore operation in the mid-1960s, Manoomin has declined drastically in these lakes, with only remnant plants and no stands existing today. While some restoration actions – including beaver dam management and small-scale Manoomin reseeding – have been attempted, they have not addressed the fundamental problem of sulfate discharge from the mine. A seepage collection system, constructed to collect mine waste water discharging from the tailings basin, has not fully stopped the flow of sulfate into the lakes. This case study highlights the difficulties in restoring degraded Manoomin habitat, the relationship between water pollution and Manoomin, and the importance of protecting existing Manoomin and its associated habitat.

Threats to Manoomin at the Twin Lakes

U.S. Steel's Minntac iron ore operation facility includes two mining areas, several processing plants, a heating and utility plant, a water reservoir, and a tailings basin (MWH, 2004). Construction of the tailings basin began in 1966 (MWH, 2004). Part of the seepage from the tailings basin discharges to the east into the Sand River, flows into the Twin Lakes, and into the Sand River watershed. Discharge from the tailings basin has changed the chemical composition and hydrologic condition of the Twin Lakes by increasing sulfate levels and, to a lesser extent, increasing the volume of water in the lakes.

Water seeping out of the Minntac tailings basin and moving toward the Twin Lakes in Minnesota. Credit: GLIFWC, 2016.

About the Twin Lakes

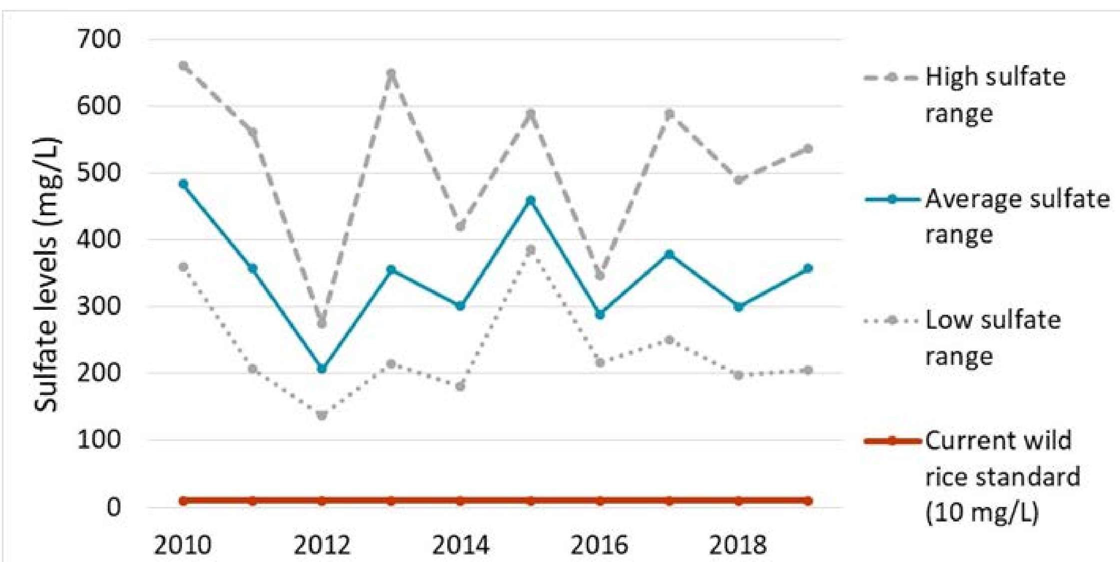
The Twin Lakes are located in St. Louis County in northeastern Minnesota. Sandy Lake is approximately 120 acres and Little Sandy Lake is approximately 90 acres. The Twin Lakes are located immediately downstream of the tailings basin for U.S. Steel's Minntac iron ore operation. Prior to mining operations, the Twin Lakes produced good stands of Manoomin and were important ricing sites for Ojibwe Bands and vital habitat for a range of wildlife species.

Ongoing sulfate loading renders restoration ineffective at the Twin Lakes

The Twin Lakes are severely degraded by sulfate-laden mine waste from U.S. Steel's tailings basin. Because sulfate concentrations are high, any attempts to restore Manoomin stands that do not address this fundamental issue have proven largely ineffective. For example, multiple attempts by natural resource managers to adjust water levels through beaver management (in the 1970s to 1990s and 2015 to 2018) have not improved Manoomin stands in a measurable way. Modest reseeding efforts (in 1991 and 1992) have also not been effective. Restoration efforts are not successful because sulfate levels at the Twin Lakes are at least 10 times higher than the Manoomin sulfate standard; the current sulfate standard is 10 mg/L (see graph below; Tribal Wild Rice Task Force, 2018).

In 2010, U.S. Steel was required to construct a seepage collection system to collect some of the mine wastewater discharging at the base of the tailings basin. While this reduced the total volume of water discharging from the mine site, it did not fully stop it. As a result, mine waste high in sulfate continued to contaminate the Twin Lakes after the collection system was installed. The 1854 Treaty Authority monitored lake conditions before the installation of the seepage collection system (2010) and after (2011 to 2019). Data collected included information on water quality (sulfate and other water quality indicators) and water-depth recordings; as well as data from inlet and outlet field surveys, vegetation surveys, and aerial surveys (Vogt, 2020). Results showed that sulfate levels remained elevated well above the standard over the nine years of monitoring after the installation of the seepage system, and remained substantially unchanged from conditions prior to the installation (see graph below).

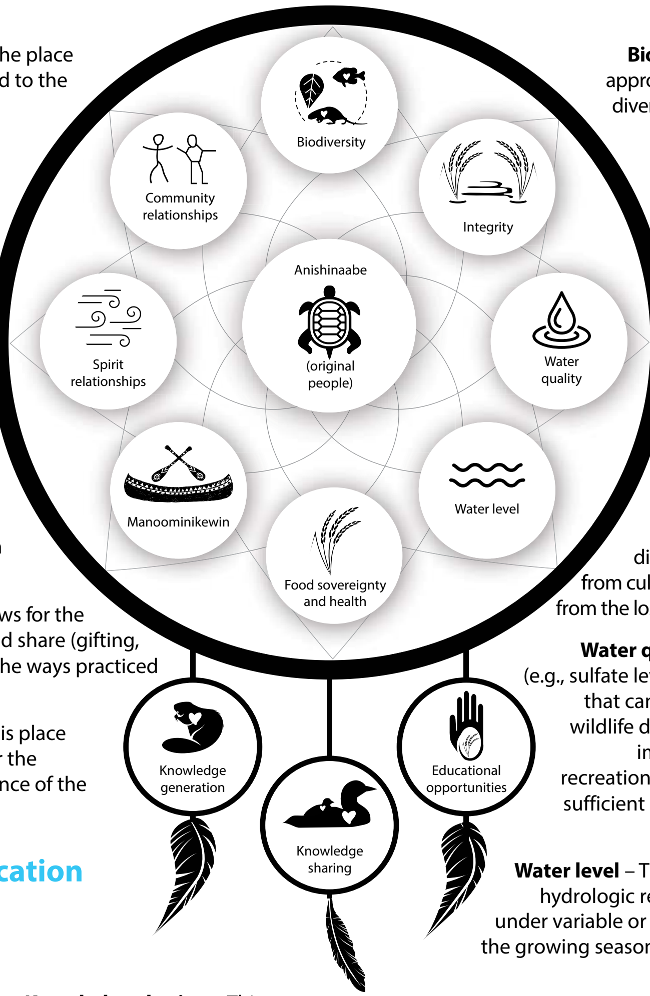
During the monitoring study, very limited Manoomin stalks were also observed across the Twin Lakes. In 2015, U.S. Steel planted test plots to determine if Manoomin had the potential to grow in the Twin Lakes. In this small-scale test plot, U.S. Steel reseeded with 40 pounds of Manoomin. After seeding, Manoomin success has varied but has been limited across years (Vogt, 2020). Full-scale reseeding was not attempted.



Sulfate concentrations at the inlet to the Twin Lakes compared to current standard sulfate levels (10 mg/L) for Manoomin, 2010 to 2019.

Approach to characterizing Manoomin at the Twin Lakes

Twelve metrics characterize cultural and ecological functions of the Twin Lakes' Manoomin and its associated habitat. These metrics describe how Manoomin at the Twin Lakes contributes to maintaining connections with the Anishinaabe culture, how ecological functionality is supported and resilient to changing conditions, and how continued learning and sharing of Anishinaabe values are promoted.



Cultural Metrics

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Ecological Metrics

Biodiversity – Healthy Manoomin and appropriate habitat at this place supports diverse biological communities (e.g., free of invasive species) that indicate the capacity of the place to support abundant associated plant and animal species (e.g., other native aquatic vegetation, fish, waterfowl, muskrat), providing for spiritual and subsistence needs.

Integrity – Physical habitat and hydrology, and water and sediment chemistry support stands of Manoomin that exhibit natural annual variability; viable seed bank ensures that sustainable Manoomin populations will persist even after occasional poor production years. Natural genetic diversity is maintained without impact from cultivated strains, or reduced gene flow from the loss of nearby Manoomin populations.

Water quality – This place has clean water (e.g., sulfate levels below 10 ppm) and sediments that can support robust stand density and wildlife diversity; is free of contamination or impacts from industrial, agricultural, recreational, or residential influence; and is of sufficient areal extent to sustain a Manoomin population.

Water level – This place has a natural or managed hydrologic regime that can maximize resilience under variable or extreme climatic conditions across the growing season (maintaining optimal depth range and flow).

Cultural and Ecological Education Metrics

Knowledge generation – This place allows for continued learning and generation of the Anishinaabe practices, values, beliefs, and language through experience.

Knowledge sharing – This place allows for the continued sharing and transmittal of the Anishinaabe practices, values, beliefs, and language among family members and community.

Educational opportunities – This place provides opportunities for language, land stewardship, and other educational programs, such as educational rice camps.

Cultural and ecological characterization at the Twin Lakes

The Twin Lakes' Manoomin and its associated habitat were characterized over four time periods. Each metric was ranked using the following five-point descriptive scale: No use, Very bad, Not very good, Pretty good, Doing great

1950 to 1965: Before construction of the tailings basin

Based on the combined ranking of cultural and ecological metrics, conditions at the Twin Lakes were characterized as "doing great" during this period. Prior to the discharge of mine waste into the Twin Lakes, both lakes had moderately dense to dense stands of Manoomin. The Bois Forte Band of Chippewa, Grand Portage, and other community members historically harvested Manoomin in these lakes. In addition, Manoomin supported waterfowl (e.g., mallard, black ducks, green winged teal, wood ducks), fish such as northern pike, and other wildlife during this period (Minnesota Division of Game and Fish, 1966a, 1966b).

1966 to 1989: After construction of the tailings basin

After the discharge of mine waste started, Manoomin coverage in the Twin Lakes steadily declined. Compared to a 1966 vegetation survey of the Twin Lakes (Minnesota Division of Game and Fish, 1966a, 1966b), a 1987 survey found that Manoomin was essentially absent from both lakes, while water levels were considerably higher and water clarity increased dramatically (State of Minnesota, 1987). By 1989, the Twin Lakes ranked as "no use" based on the combined ranking of cultural and ecological metrics.

1990 to 2009: With limited restoration actions

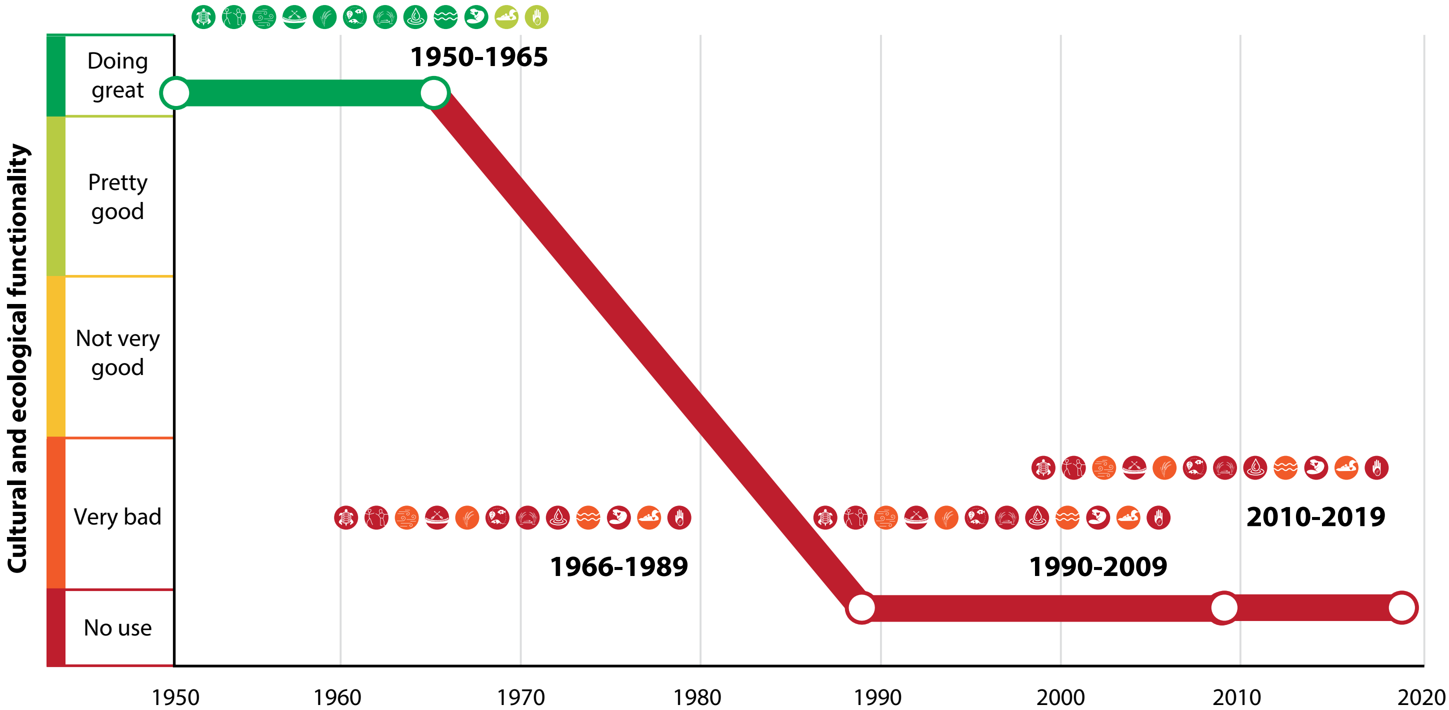
During this period, some actions were undertaken to recover Manoomin, including beaver management and small-scale reseeding efforts. However, these actions did not address the fundamental issue of high levels of sulfate and were largely ineffective at restoring the abundance of Manoomin and its associated habitat at the Twin Lakes. Given the absence of Manoomin on the lakes, community members were unable to harvest, prepare, and share Manoomin in ways practiced by their ancestors. The lost use of the Twin Lakes also limits sharing, transmittal, and generation of Anishinaabe practices at these lakes. During this period, the ranking of the Twin Lakes remained near "no use" based on the combined ranking of cultural and ecological metrics.

2010 to 2019: After construction of the seepage collection system

After U.S. Steel constructed the seepage system, Manoomin remained essentially absent from the Twin Lakes. With the lakes unable to support Manoomin, community members remained unable to harvest, prepare, and share Manoomin in ways practiced by their ancestors. During this period, the ranking of the Twin Lakes remained near "no use" based on the combined ranking of cultural and ecological metrics.

Cultural and ecological characterization of the Twin Lakes

Cultural and ecological functionality provided by Manoomin and its associated habitat at the Twin Lakes declined over time, both in aggregate and for the individual metrics.



Additional actions needed

Since the installation of a tailings basin for the U.S. Steel's Minntac facility in the mid-1960s, the abundance of Manoomin at the Twin Lakes has steadily declined. Actions taken at the Twin Lakes to improve Manoomin and its associated habitat have been limited and have not addressed the fundamental problem of sulfate loading from the mine. If actions were taken to improve conditions in the future, we could use a Habitat Equivalency Analysis (HEA) to demonstrate the additional equivalent units of restoration needed to counter-balance the severity and timespan of degradation. For example, if actions were implemented over the next 20 years (2020 to 2040) to improve habitat functionality by 2.5%, over 100,000 acres of similar Manoomin restoration would be needed to counter-balance the lost habitat functionality that has occurred over time (from 1966 to 2019). This is equivalent in size to over 550 Twin Lakes. The table to the right provides the HEA results, assuming several hypothetical scenarios of improvements in habitat functionality; it is important to note that we do not know what actions are needed to create these percent improvements, but they would likely require addressing the fundamental problem of sulfate loading from the mine. The main purpose of these scenarios is to highlight that if only minimal restoration is achieved at Twin Lakes (which may be anticipated, given the long history of attempting restoration, with minimal response), then significant equivalent amounts of this restoration would be needed to balance the prolonged period of degradation at these lakes.

Hypothetical percentage of improvement in habitat functionality from 2020 to 2040	**Acres needed to counter-balance historical losses given hypothetical improvement** *(Acres rounded to the nearest hundred)*	**Number of Twin Lakes needed to counter-balance historical losses given hypothetical improvement**
2.5%	116,700	556
5.0%	58,400	278
10.0%	29,200	139
20.0%	14,600	69

This case study demonstrates the difficulty in restoring Manoomin and its associated habitat when the root cause of the degradation – in this case, sulfate discharge – is not addressed. Given the difficulty of restoring degraded habitat, it is important to protect and preserve existing Manoomin habitat to ensure a future with Manoomin.

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