ST. LOUIS RIVER ESTUARY MANOOMIN RESTORATION AND STEWARDSHIP PLAN

2024 Manoomin Plan Update

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Acronyms

AOC	Area of Concern
BUI	Beneficial Use Impairment
DU	Designated Use
FdL	Fond du Lac Band of Lake Superior Chippewa
GLIFWC	Great Lakes Indian Fish and Wildlife Commission
GLRI	Great Lakes Restoration Initiative
MNDNR	Minnesota Department of Natural Resources
MLT	Minnesota Land Trust
MPCA	Minnesota Pollution Control Agency
MRSM	Manoomin Restoration & Stewardship Model
NRCS	Natural Resources Conservation Service
RAP	Remedial Action Plan
RST	Restoration Site Team
SLRAOC	St. Louis River Area of Concern
SLRCAC	St. Louis River Citizens Action Committee
SLRE	St. Louis River Estuary
SLREMRP	St. Louis River Estuary Manoomin Restoration Partnership (Formerly the Restoration Site Team)
WDNR	Wisconsin Department of Natural Resources
USEPA	United States Environmental Protection Agency

Land Acknowledgement

The St. Louis River Estuary Manoomin Restoration Partnership wishes to acknowledge the Anishinaabe people, as well as the Dakota and other Indigenous peoples who preceded them. We gather at *Gichigami-ziibi* (the Great Lake River) to realize a collective restoration vision on lands that the Anishinaabe are inextricably connected to, the place where food grows on the water. Manoomin is a fundamental entity of great spiritual and cultural significance for ancestral and contemporary Anishinaabe who have gathered here and preserved traditional knowledge and experience for centuries. We honor and respect Anishinaabe history and continued kinship with the land, water, air, and the more-than-human beings that live in this place. We affirm tribal sovereignty and treaty rights. We take responsibility for recognizing and countering historical and contemporary injustices that continue to impact the Anishinaabe community and strive for mutually beneficial partnerships, policies, and practices that respect Indigenous values and experience. By joining together to restore manoomin to the St. Louis River Estuary, the individuals and organizations that comprise the St. Louis River Estuary Manoomin Restoration Partnership show their commitment to addressing past harms and supporting the traditional lifeways of current and future Anishinaabe.

Executive Summary

The Wild Rice Restoration Implementation Plan for the St. Louis River Estuary (MNDNR 2014; "2014 Rice Plan") has served as a road map for a collaborative restoration effort to restore healthy, harvestable stands of northern wild rice (*Zizania palustris*; Ojibwemowin: manoomin) to the St. Louis River Estuary (SLRE). Preparation of the 2014 Rice Plan was funded by the Great Lakes Restoration Initiative (GLRI) as part of the St. Louis River Area of Concern (SLRAOC) program. The 2014 Rice Plan's development was part of a management action that was added to the SLRAOC 2014 Remedial Action Plan Update (MPCA and WDNR 2014) although partner commitments to manoomin restoration have always focused on the broader goal of long-term sustainability that extends well beyond the work currently supported by the SLRAOC program. The 2014 Rice Plan summarized important aspects of manoomin's natural history, evaluated habitat suitability at specific restoration sites, and outlined a suite of restoration tools and techniques for implementation. Since that time, considerable effort has been made to reestablish manoomin in the SLRE and much has been learned about the effectiveness of restoration techniques. However, the restoration goals and objectives established in the 2014 Rice Plan have not been met and it is clear that continued restoration action and a revised set of ecological and culturally relevant metrics are needed to measure progress in a more holistic manner. Successful re-establishment of manoomin in the SLRE will require a continued commitment to long-term stewardship and caretaking founded in both Western and Indigenous knowledge systems.

The 2024 St. Louis River Estuary Manoomin Stewardship & Restoration Plan ("2024 Manoomin Plan") builds upon the 2014 Rice Plan and presents a long-term and culturally relevant restoration model developed through the refinement of restoration actions initiated in 2014. The update addresses emerging challenges to manoomin restoration in the SLRE, namely enhancing resiliency in the face of growing threats from climate change. Furthermore, this update establishes a revised set of short-, mid-, and long-term indicators of restoration progress, guides restoration and stewardship actions, defines a set of data-driven management thresholds to inform management decisions, and identifies important information needs associated with manoomin restoration in the SLRE.

The 2024 Manoomin Plan is organized into three sections, as follows.

Section 1: Manoomin Importance describes the cultural and ecological importance of manoomin in the SLRE. This section touches on the manoomin's cultural significance to past, present, and future Anishinaabe. It also highlights aspects of the species' biology that influence restoration outcomes and provides insight into the role that community stewardship and education play in manoomin restoration success.

Section 2: Manoomin Restoration begins by summarizing restoration actions implemented under the 2014 Rice Plan and quantifying progress towards its restoration metrics. It then outlines how management methodologies have adapted to improve the likelihood of success and identifies a framework for future stewardship, referred to as the SLRE Manoomin Restoration & Stewardship Model (MRSM; also see Appendix A).

Section 3: Manoomin Stewardship discusses the importance of harvester participation and recruitment, presents a revised set of restoration indicators of progress, and provides a decision framework for long-term manoomin stewardship. Considerations for adding new restoration sites, management thresholds for stewardship actions (e.g., herbivory management, seeding, etc.), and research needs are also included.

Ultimately, the guidance provided in this document is meant to be coupled with the understanding, experience, and stories shared by the human and more-than-human knowledge holders who have contributed and continue to foster a stewardship ethic for manoomin and other culturally important entities. This document shares some of the lessons learned and approaches taken to welcome manoomin back to the SLRE. The 2024 Manoomin Plan will empower future stewards to make decisions, respond to changing conditions, and utilize the best professional and spiritual understandings to ensure manoomin's long-term persistence in the SLRE.

This update to the 2014 Rice Plan would not have been possible without effective collaboration among the organizations and individuals that have remained committed to manoomin restoration in the SLRE since the 2014 Rice Plan was developed. Many contributors and knowledge holders have supported the important work of restoring manoomin to the SLRE. The St. Louis River Estuary Manoomin Restoration Partnership (SLREMRP) expresses gratitude for all contributions made by human and more-than-human stewards of the good berry – contributions from the past, present, and future.

Miigwech!

Section 1: Manoomin Importance

Cultural Importance to the Anishinaabe

The Ojibwe name for wild rice is manoomin, a name that is often translated as "*the good fruit*" or "*the good berry*" (David et al. 2019). The significance of manoomin as a cultural keystone species for the Anishinaabe people cannot be understated; manoomin is a fundamental, more-than-human entity and relative who provides both spiritual and cultural connection to the land and strengthens relationships within the community (LSMCECS 2020). In the Anishinaabe worldview, the health of the people is inextricably connected to the health of manoomin. Manoomin is central to the Ojibwe migration story and historic manoomin beds in the SLRE are particularly important to that narrative as "*the land where food grows on water*" (Benton-Banai 1985).

Tribal elders describe the Anishinaabe migration from The Great Salt Water on the Atlantic coast to their current homeland in the Lake Superior Basin. According to oral traditions, the Anishinaabeg received seven prophecies which foretold coming threats to their land, culture, and identity (FdL 2018). The migration westward followed the direction of the miigis shell which guided the people along the St. Lawrence River and along the shorelines of the Great Lakes (Benton-Banai 1985; Figure 1). Groups that split to follow the northern and southern shorelines of *Gitchigami* (i.e., Lake Superior) reconnected in the SLRE at an island named *Manidoo Minis* or Spirit Island.

Some Anishinaabeg settled in the SLRE while others continued their journey. Those who traveled eastward along the southern shoreline of *Gitchigami* eventually arrived at *Mooningwanekaaning*, or Madeline Island, which serves a spiritual center for the Lake Superior Chippewa. While some Anishinaabeg continued westward those who remained in the SLRE discovered an abundance of fish, game, and plant life living in the SLRE. Manoomin grew in abundance throughout the SLRE and the people settled under the guidance of their spiritual knowledge (LSNERR 2022). Recent teachings provided by tribal elders reveal that the migration story was preceded by Anishinaabe and Lakota communities who lived in the western Great Lakes region prior to the Anishinaabe migration from the eastern seaboard. From this perspective, Anishinaabeg returned to a place that was already known to them.

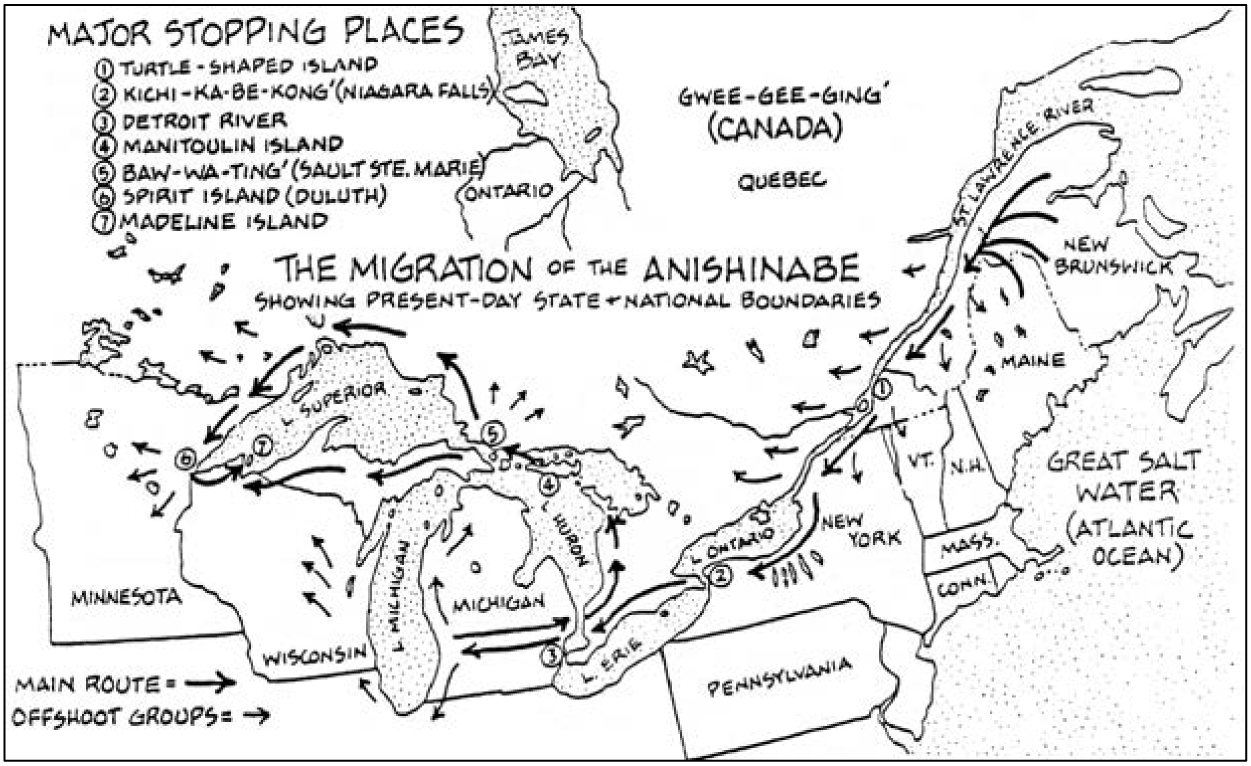

Figure 1. The migration of the Anishinaabe (image source: Benton-Banai 1985).

Manoomin supported Anishinaabe settlements along *Gichigami-ziibi* (SLRE) and is viewed as a gift from the Creator, serving as a sacred entity that represents both the Anishinaabe journey and Anishinaabe identity (Vennum 1988, LaDuke 2005, Tribal Wild Rice Task Force 2018). Rather than simply viewed as a resource to be managed, manoomin is considered a spirit-entity and relative that deserves reverence and stewardship. Manoomin is recognized as a revered member of the community, present at celebrations, and a key participant in many long-standing cultural traditions (David et al. 2019).

Figure 2. Manoomin harvest on a Minnesota Lake (image source: Wikimedia.org).

Manoomin harvest, in particular, is critical to community cohesiveness. The coming manoomin harvest signals an inter-generational gathering at traditional rice camps as the rice seed ripens. Communities come together to participate in manoomin harvest, and the cultural traditions and history are passed down through generations (Figure 2, 3). Ties to the land and spirit are renewed and the community reaffirms their respect and gratitude for the gift of manoomin (Tribal Wild Rice Task Force 2018). Details regarding traditional manoomin harvesting practices can be found in David et al. (2019).

Healthy, harvestable manoomin stands are vitally important for tribal community health and food sovereignty (LSMCECS 2020). Manoomin harvest has cardiovascular benefits resulting from the physical nature of hand harvesting and traditional processing techniques (FdL 2018, David et al. 2019), while the seed is highly nutritious and an excellent source of vitamins, minerals, carbohydrates, dietary fiber, antioxidant phytochemicals, and is low in fat (GLIFWC 2010, Surendiran et al. 2014). Manoomin seed can be preserved for long periods of time when stored properly and is regularly offered in trade or as gifts among tribe members, thereby contributing to the tribal economy (Tom Howes, FdL, personal communication 2022). In addition, rice beds serve as an important food source and/or habitat for a variety of companion plants and animals which also contribute to traditional Anishinaabe lifeways.

Figure 3. Parching manoomin at rice camp (image source: D. Grandmaison).

It is important to point out that Anishinaabe treaties with the United States explicitly retain tribal rights to hunt, fish and gather within the ceded territories (David et al. 2019). This includes the manoomin harvest. Exercising these rights is part of the Anishinaabe way of life and facilitates the transfer of traditional knowledge regarding the importance of manoomin and other entities for religious, ceremonial, medicinal, and economic purposes. The exercise of these treaty rights continues today, and treaties guarantee the right to harvest manoomin in the SLRE. The deep connection between the Anishinaabe and manoomin, combined with traditional knowledge regarding its stewardship has formed the foundation for manoomin restoration efforts in the SLRE.

Ecological Importance

Manoomin is an important part of complex aquatic ecosystems in the western Great Lakes region. Manoomin serves as both food and habitat to a variety of fish and wildlife species throughout its growth cycle (MNDNR 2008, David et al. 2019). For example, the Wisconsin All-Bird Conservation Plan (Kreitinger et al. 2013) identified manoomin as a priority habitat because of its wildlife value and the role it plays in avian conservation. Minnesota's Comprehensive Wildlife Conservation Strategy identifies more than 15 species of conservation need that use manoomin lakes for cover and foraging habitat (Norrgard 2008). Manoomin stands provide important habitat for many marsh breeding birds, particularly soras (*Porzana carolina*; Melvin and Gibbs 1994) which are the likely source of historical references to "rice birds" or *manoominikeshiinh* (David et al. 2019). Manoomin waters are also frequented by waterfowl during the spring and fall migrations to take advantage of open water availability, cover, and food resources (David et al. 2019).

It is estimated that a robust manoomin stand, under ideal growing conditions, can produce over 500 pounds of seed per acre (David et al. 2019). A portion of the manoomin seed produced during the growing season will replenish the seedbank while residual seed becomes available as food for mallard (*Anas platyrhynchos*), wood duck (*Aix sponsa*), American black duck (*Anas rubripes*), northern pintail (*Anas acuta*), blue-winged teal (*Spatula discors*), canvasback (*Aythya valisineria*), and other waterfowl species (Rossman et al. 1982, Fannucchi 1983, Huseby 1997). This seasonally abundant food source can be particularly important for migrating waterfowl as the timing of seed maturation coincides with the fall migration (McAtee 1917, Moyle 1944, Stoudt 1944, Kreitinger et al. 2013). Ironically, the value of manoomin as a high-quality food resource for waterfowl poses a challenge for restoration and subsistence harvesting in some locations. As described later in this document, Canada geese (*Branta canadensis*) are particularly abundant in the SLRE and exert considerable herbivory pressure throughout the manoomin growth cycle (Vogt 2023). The impact of goose herbivory on restoration success is well known and methods to reduce the impact of herbivory have become an important element of the SLRE MRSM (Appendix A).

Manoomin provides food for other herbivores such as white-tailed deer (*Odocoileus virginianus*), muskrat (*Ondatra zibethicus*), and various invertebrate species that themselves support a variety of birds, amphibians, and fish (MNDNR 2008). Muskrats (Ojibwemowin: *wazhashkwag*) have a strong association with manoomin and have been described by tribal elders as gardeners of manoomin (Jeff Savage, FdL, personal communication 2021). Muskrats forage on emergent aquatic vegetation, including manoomin stalks, and often utilize rice straw to construct “houses” where they live and raise their young (Figure 4). In doing so, muskrats facilitate the creation of open-water hemi-marsh conditions that benefit marsh birds, waterfowl, and other species (Weller and Spatcher 1965, Weller and Fredrickson 1974, David et al. 2019).

Figure 4. Muskrats build houses in marshes from mud and emergent plants like cattail, bur-reed and bulrush (image source: WDNR).

Shallow bays and protected wetlands that support manoomin and other emergent and floating-leaf vegetation provide important habitat for fish (Lavergne 2006). Species such as northern pike lay eggs on submergent vegetation in the spring, while mature manoomin stands provide habitat for juvenile fish seeking to avoid predators and feed on the invertebrates that live in the accumulated organic matter (Radomski and Goeman 2001). Many juvenile fish species preferentially utilize densely vegetated/open water edges and or areas of moderate vegetation. This edge habitat provides access to food resources and protection from predators (Höök et al. 2001; Jacobus and Webb 2005). Juvenile muskellunge assessments conducted in the SLRE by the Minnesota Department of Natural Resources (MNDNR) have historically focused survey efforts along the edges of emergent vegetation beds (Jeramy Pinkerton, MNDNR, personal communication 2022).

Fish produced in manoomin stands contribute to adult populations of game and non-game species in the SLRE and Lake Superior. Manoomin stands also provide important habitat for adult fish. Lavergne (2006) found that abundance of yellow perch, small northern pike and three shiner species was higher during the early summer in bays with manoomin when compared to bays without manoomin. Lavergne also found a greater abundance of larger size-class northern pike in manoomin bays (Lavergne 2006). Northern pike and other ambush predators may utilize the cover provided by manoomin and other vegetation to forage on the smaller fish that utilize these areas for protection and food resources.

Manoomin serves other important roles that contribute to ecosystem integrity (Ahmed et al. 2020) and nutrient cycling (Pastor and Walker 2006). Manoomin is an important member of riparian and fringe wetlands along rivers and lakes in the Great Lakes region and serves as an indicator of water quality and aquatic ecosystem health (Drewes and Silbernagel 2012, David 2013, Desmarais 2019). Manoomin's large root mass, for example, can trap sediment and prevent re-suspension in the water column (NRCS 2004, David et al. 2019) thereby reducing turbidity and sediment loads in some systems. The presence of manoomin in these riparian and fringe wetlands suggests a healthy, functioning ecosystem while manoomin decline and extirpation suggests reductions in valuable ecosystem services (Vennum 1988).

Manoomin Life Cycle

Manoomin is a monoecious, annual aquatic plant that exhibits distinct growth stages. It germinates in the spring, remains submergent for the first few weeks of growth before beginning to float on the water surface, and transitions to a standing stage with an upright stalk that produces flowers and seed in the late summer (Figure 5).

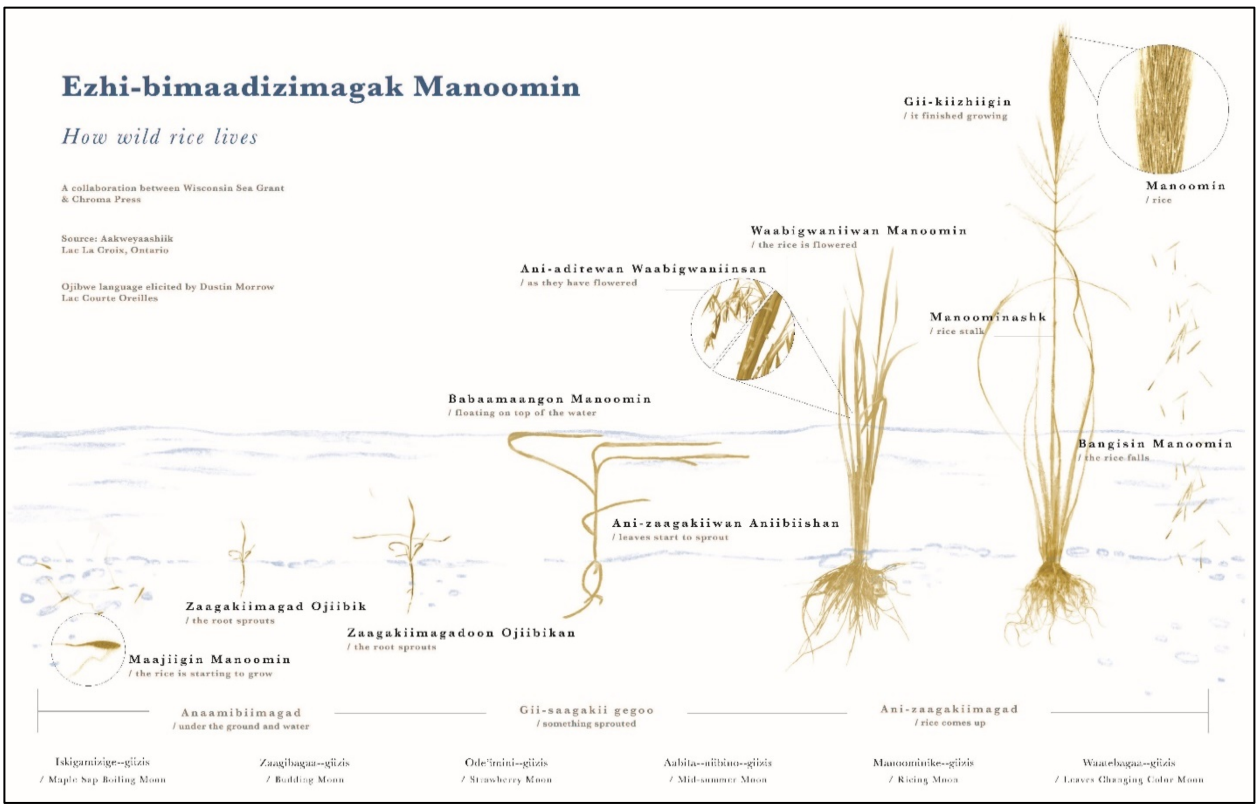

Figure 5. Manoomin life cycle (image source: Wisconsin Sea Grant Manoomin Education and Outreach Project).

Manoomin germinates in soft, organic substates with high nutrient content and grows best in water depths ranging from 0.5ft to 3ft deep (Moyle 1944, Lee 1986, Aiken et al.

1988, Carson 2002). Germination of the previous year’s seed crop requires exposure to water temperatures at, or below, 35° F for a period of three months and is activated when spring substrate and water temperatures reach 40° F. Germination typically occurs in April with the plant developing a shallow root system. Manoomin enters the submergent growth phase as three leaves grow from the main stalk (David et al. 2019).

Submerged plants typically reach a foot in height by mid-May and shortly thereafter the plant enters the floating-leaf stage with photosynthesizing leaves lying flat on the water’s surface. Manoomin is particularly susceptible to uprooting by rapidly rising water levels during this floating-leaf stage. Aerial shoots “stand” upright towards the end of June as emergent stalks begin a rapid growth phase including development of a flowering head on one or multiple upright stalks.

Flowering occurs in mid- to late-July with male and female flowers developing asynchronously on the same plant. Flower phenology is dependent on both day length and temperature (MNDNR 2008). Female flowers at the top of the stem open before the male flowers on the same stalk to promote cross-pollination (David et al. 2019). Pollen from adjacent plants is typically carried by the wind to pollinate neighboring plants, with pollination rates thought to be negatively affected by high temperatures and low humidity (MNDNR 2008, David et al. 2019) and improved where plants grow near each other. Insects such as bees are known to feed on manoomin pollen (Tieret 1971, Terrell and Batra 1984) although the role of insect pollination, if any, is not well known and considered secondary to wind pollination (Terrell and Batra 1984).

Seeds reach maturity by late-August or early-September with considerable variability in seed maturation and ripening occurring gradually on the same stem from the top down. By mid-September, plants reach full maturity and seed kernels begin to shatter from the flower head, fall to the water, and sink into the water column where they become buried in the sediment. It has been estimated that one acre of manoomin can produce more than 500 pounds of seed to support regrowth in subsequent years (MNDNR 2008, David et al. 2019).

Seeds remain dormant during the winter and typically germinate the following spring. However, if unsuitable conditions for growth occur, seeds may remain dormant until conditions improve (David et al. 2019). Temperature is thought to influence seed germination with freezing or near-freezing temperatures being required to break dormancy before the seed will germinate (Simpson 1966, Atkins et al. 1987, Kovach and Bradford 1992). Tribal knowledge holders have indicated that seeds may remain dormant for years and, in some cases, decades before finding conditions suitable for germination (Tom Howes, FdL, personal communication 2021). This adaptation is thought to make manoomin naturally resilient to short-term environmental conditions that are unsuitable for germination and/or maturation as well as impacts from temporary ecological disturbances (Meeker 1993, MNDNR 2008).

Factors Affecting Growth & Persistence

Nutrient Availability

Manoomin abundance varies considerably from year-to-year with a high productivity season often followed by a low productivity season and a few moderate growth seasons in between (Atkins 1986, Lee 1986, Archibold et al. 1989, Pastor and Walker 2006, Walker et al. 2010). This multi-annual growth pattern has been connected to nutrient cycling dynamics, specifically the availably of nitrogen during the early growing season when root systems are forming (Grava and Raisanen 1978, Sims et al. 2012). Demand for nitrogen and phosphorous peaks again during the later part of the growing season when energy is allocated to seed production and maturation. The decomposition of litter from the previous season's growth and microbial mineralization with potential to immobilize nitrogen, is a key driver of nitrogen availability to support germination and biomass production during the subsequent growing season (Moyle 1944, Pastor and Walker 2006, Walker et al. 2006, 2010).

Sediment & Water Quality

Manoomin is typically associated with soft, organic sediments with high organic nutrient content, but is tolerant to a variety of substrate conditions including moderately sandy, rocky, or firm clay-influenced bottoms (David et al. 2019). Dense root masses often develop in soft substrates and can aid in sediment and nutrient retention (Meeker 1996). Manoomin prefers clear to moderately stained waters (David et al. 2019). Darkly stained waters may inhibit seed germination because low water transparency reduces sunlight penetration and affects photosynthesis during early plant development (Myrbo et al. 2017a).

The 2014 Rice Plan included a manoomin habitat suitability model to predict adequate soil substrate, water depth, and logistical feasibility to prioritize restoration sites. A follow up study in 2017 sought to further refine environmental conditions that would facilitate manoomin establishment at new restoration sites by quantifying soil texture, organic content, substrate penetration force, and localized vegetation type and volume at sites where manoomin was present (Barr 2017). Taken together, these habitat modeling efforts further support the body of evidence that manoomin habitat in the SLRE is best described as shallow water environments with soft, organic soils where light penetration is not limiting. These data are particularly useful when evaluating seeding areas within current restoration sites and identifying new sites for future restoration effort.

Although adapted to a range of environmental conditions, manoomin is sensitive to deviations in optimal growing conditions and sensitive to changes in pH, alkalinity, and dissolved organic carbon. Fluctuations in pH outside of the circum-neutral range (i.e., pH 6 to 8) can result in decreased manoomin root mass and productivity (Wild Rice in Minnesota 2008, Pillsbury and McGuire 2009). Shifts in alkalinity can influence wetland plant community composition, favoring macrophytes other than manoomin (Myrbo et al. 2017b, Lee and McNaughton 2004). High dissolved organic carbon can lead to low water transparency, resulting in limited light availability and leading to reduced plant productivity (Myrbo et al. 2017b). Evidence suggests that the distribution of manoomin and potentially competing species can be influenced by microchemical variation within a waterbody (Lee and McNaughton 2004).

Water Depth & Velocity

Water depth is a significant factor influencing annual growth rate, density, and variability in manoomin productivity. As mentioned previously, manoomin typically grows best at 0.5 to 3-ft water depths and is particularly vulnerable to uprooting during the floating-leaf growth stage (Moyle 1944, Aiken et al. 1988). High water levels can drown rice beds resulting in decreased density or a lack of growth altogether. Deep water can negatively affect seed and tiller production (Vennum 1988, Weichel and Archibald 1989) and individuals growing in deeper water will often fail to produce seed or advance beyond the floating leaf stage (David 2013).

Increasing water levels tend to favor highly competitive invasive species, such as narrow-leaf and hybrid cattail (*Typha x Glauca and Typha angustifolia*), which have replaced manoomin stands in other parts of the SLRE during periods of high water (Carol Reschke, personal communication 2022). Conversely, low water and drought conditions can result in high plant productivity but challenging harvest conditions that limit access to manoomin beds. Plants growing on seasonally exposed mudflats and dry land will exhibit decreased seed production and are prone to toppling.

Annual and seasonal fluctuations in water depth and water velocity influence productivity. During a single growing season, stable or gradually decreasing water levels tend to favor manoomin growth (David et al. 2019). Cyclical hydrological disturbances that occur every couple of years and create temporary high or low water conditions tend to favor long-term stability by inhibiting the establishment of perennial plants such as hybrid cattail (*Typa x glauca*) and other native plants. Pickerelweed (*Pontederia cordata*), watershield (*Brasenia schreberi*), water lily (*Nymphaea* spp.) can displace manoomin and are high on the list of concerns for manoomin management (Darren Vogt, 1854 Treaty Authority, personal communication, 2024). However, sudden

Figure 6. Manoomin beds lining the Pokegama River in 2013, one year after a major flood in the SLRE (image credit: Deanna Erickson, Lake Superior Estuarine Research Reserve).

increases in depth and velocity during the growing season that result from heavy precipitation events and flooding can uproot plants and wash out entire beds of manoomin (Aiken et al. 1988). The 500-year flood that occurred in June 2012 impacted the built and natural environment in the SLRE and uprooted portions of the few manoomin beds that existed prior to the flood. Conversely, sediment disturbance from the same 2012 flood appeared to encourage manoomin growth during the following summer in some areas of the SLRE (e.g., Pokegama River; Figure 6).

Hydrologic variability also influences the distribution of manoomin in the SLRE, both directly and indirectly. The SLRE is directly connected to Lake Superior which exerts a strong influence on water levels within the estuary. Seasonal fluctuations in water depth and water velocity are driven by regional precipitation and snowmelt patterns, water discharges from Minnesota Power's St. Louis River dams for hydropower generation, and daily fluctuations influenced by Lake Superior's seiche (Figure 7). This variability directly influences the distribution of SLRE manoomin by limiting colonization of otherwise suitable sites that are prone to deeper water conditions and facilitating manoomin's expansion during low water conditions.

The contribution of seiche currents to sediment and nutrient dynamics in the sheltered bays where manoomin persists in the SLRE are not well understood (Joel Hoffman, EPA, personal communication 2022) and micro-hydrologic differences among bays may affect habitat suitability at the site-level (Hannah Ramage, Lake Superior Estuarine Research Reserve, personal communication 2022). As a result of these various factors, each restoration site within the SLRE will vary in its suitability from year to year with some sites showing greater potential for long-term manoomin persistence than others.

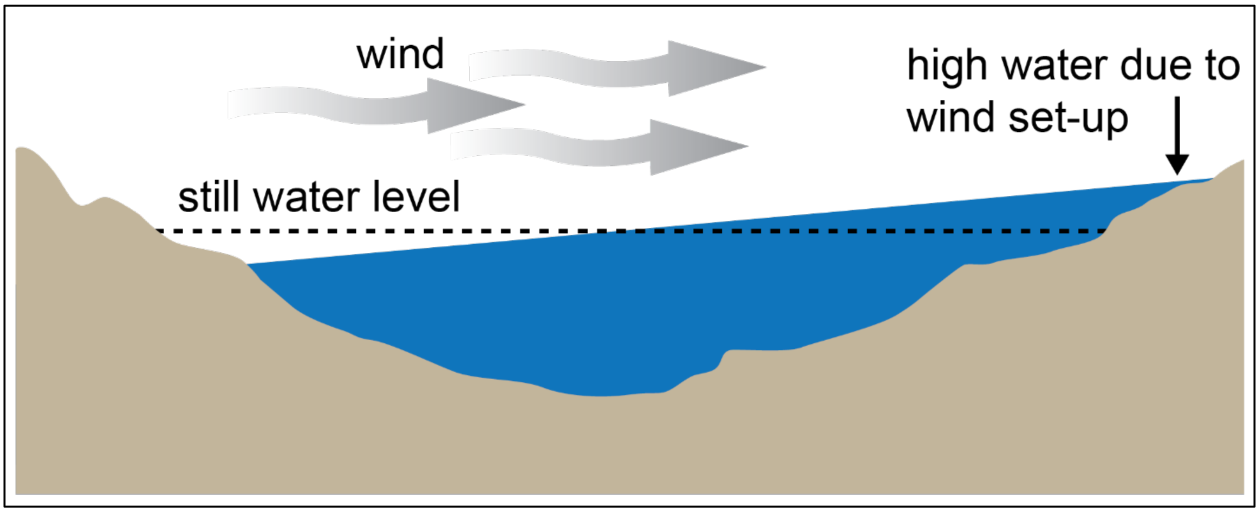

Figure 7. Wind-driven fluctuations in water depth (i.e., seiche) have the potential to impact manoomin distribution in the SLRE (image credit: NOAA).

Manoomin Decline in the St. Louis River Estuary

The SLRE once supported vast stands of manoomin. As described earlier, discovering abundant manoomin in the SLRE fulfilled an Anishinaabe prophecy which guided the people to settle in the land where food grows on water over 500 years ago (Benton-Benai 1985). Stories shared by tribal knowledge holders describe a much older relationship with the SLRE and describe the great migration as a return to a place that was already known to the Anishinaabeg. Generations of Ojibwe have benefited, culturally and spiritually, from an abundance of manoomin and other culturally important more-than-human entities in the SLRE.

The abundance of manoomin featured prominently in documents prepared by white explorers to the region during the 1800s. In 1820, for example, Henry Schoolcraft noted that "*on reaching the mouth of the St. Louis River… we here saw in plenty the folle avoine, or wild rice…*" (Schoolcraft 1855). In 1825, cartographer Henry Bayfield added a notation that "*wild rice and rushes line the banks of the* [St. Louis] *River*" to his chart of Lake Superior (NOAA 2023). And in yet another passage, Reverend T.M. Fullerton described that "*from* [the head of the bay] *the river is full of islands and fields of manoomin…*" at the mouth of the St. Louis River (Fullerton 1872).

Unfortunately, the distribution of manoomin has declined substantially across its historical extent in Minnesota and Wisconsin over the last century (Drewes and Silbernagel 2012), with an estimated 32% decline in the number of watersheds containing manoomin in Wisconsin and Minnesota since the early 1900s (WDNR 2021). A similar pattern of decline threatened the extirpation of manoomin in the SLRE (Schwartzkopf 1999). Analysis of William Hearding's navigational charts from 1861 suggested that upwards of 7,000 acres of suitable manoomin habitat in the SLRE was lost as shallow habitats were deepened by dredging operations for ship traffic or filled to facilitate shoreline development (DeVore 1978, MPCA & WDNR 1992, Hollenhorst et al. 2013).

During the 1930s and 1940s, residents like John Turk, who grew up in the village of Oliver, Wisconsin, recall how there were "*huge beds of rice on the St. Louis… all these bays above and below the Oliver Bridge were full of wild rice*". Tribal elder Marvin Defoe from the Red Cliff Band of Lake Superior Chippewa described how Anishinaabeg would gather in Allouez Bay where they "*lived there for a month and it was loaded with wild rice*" (LSNERR 2022). Similarly, elder Jeff Savage of the Fond du Lac Band of Lake Superior Chippewa shared childhood memories of watching his grandfather harvest manoomin in Spirit Lake and described how the river was still bountiful at that time with dense manoomin beds between Boy Scout Landing and Spirit Island (LSNERR 2022).

These shared memories demonstrate that the SLRE supported harvestable stands of manoomin into the mid-1900s. However, by that time, much of the SLRE had been modified by changes to hydrological patterns and industrialization for mining, logging, iron making, grain trade, shipbuilding, acetylene gas production, hydropower production and the transportation of goods to and from the burgeoning port cities of Duluth and Superior (Figure 8). After the Treaty of LaPointe was signed in 1854, the river was largely transformed from an ecologically intact mosaic of natural floating bogs, open water, hemi-marsh habitat, and vast manoomin beds to a working harbor with the primary function of supporting industry and commerce. Habitat degradation, habitat loss, and water quality impairments would follow these land use changes (MPCA and WDNR 1992).

Figure 8. Lumberjacks working on the St. Louis River (image source: Wikimedia.org).

Modification of the SLRE was accelerated by the opening of the Soo Canal in 1855 which connected the Duluth-Superior Harbor to the Great Lakes and increased commerce into the region. The river, which previously had an average depth of five to eight feet, would be altered in 1867 and again in 1871 to accommodate increased shipping traffic requiring deeper channels to access the Duluth and Superior harbors (MPCA and WDNR 1992). Channel depths increased to 20 feet by 1902 and 27 feet by the 1960s (SLRCAC 2002). Dramatic declines in manoomin distribution and abundance in the 1960s and 1970s would lead to nearly complete extirpation with only a handful of remnant stands in protected bays and backwaters (Angell 1971, Schwarzkopf 1999). Surveys conducted in 1971 estimated that these remnant stands amounted to approximately one acre of manoomin (Angell 1971).

Threats To Manoomin Persistence

Manoomin faces a variety of challenges for long-term persistence. From the perspective of Ojibwe world view, these threats arise when relationships between manoomin and other members of creation are disrupted (David et al. 2019). In many cases, these threats are the direct result of human activity, human ignorance, and historical or on-going socio-ecological impacts. What follows is a brief synopsis of the known threats to manoomin's long-term persistence in the SLRE. While these threats may be shared by manoomin beds in other parts of its range, each manoomin bed faces its own suite of stressors and challenges that may differ from those in the SLRE. A comprehensive list of threats impacting manoomin at a regional scale can be found in FdL (2018) and David et al. (2019).

Increased emphasis has been placed on understanding the impacts of climate change on manoomin, which may be particularly vulnerable. The Great Lakes Indian Fish & Wildlife Commission (GLIFWC) climate change vulnerability assessment (GLIFWC

Climate Change Team 2023) identifies additional threats not addressed in the 2014 Rice Plan. Given the growing influence of human-induced climate impacts on natural systems and emerging information regarding the influence of climate change on the distribution and abundance of manoomin, the 2024 Manoomin Plan addresses these impacts below.

Climate Change

Environmental stressors resulting from climate change pose a considerable challenge for manoomin restoration and stewardship across the species range (GLIFWC Climate Change Team 2023). Rapid or abrupt fluctuations in water level, increasing water temperature and decreasing ice cover, more frequent and severe storm events, increasing wind speeds, and flooding, all impact growing conditions that effect manoomin habitat. Meanwhile, additional development pressures are anticipated as the local human population grows in response to climate impacts in other locations. This matrix of climate stressors requires a new perspective and a strong “caretaker” ethic to guide manoomin stewardship over the long-term.

Members of the SLREMRP attended a manoomin workshop in 2022 focused on climate change adaptation and implementation of the *Dibaginjigaadeg Anishinaabe Ezhitwaad* – Tribal Adaptation Menu (Tribal Adaptation Menu Team 2019). The workshop evaluated the draft 2024 Manoomin Plan indicators of restoration progress and provided an Indigenous perspective on its goals with suggestions for increasing the restoration program’s prospect of success. Workshop participants provided insight and constructive dialogue regarding strategies for community engagement in the face of climate change impacts to manoomin in the SLRE (Table 1).

Table 1. Adaptation approaches and tactics identified during the June 2022 manoomin workshop in Duluth, MN (Tribal Adaptation Menu team 2019).

<table>
<tr><th>Approaches</th><th>Tactics</th></tr>
<tr><td>Consider mindful practices of reciprocity.</td><td rowspan="2">Incorporate goals for increased engagement with more people contributing to the health of the SLRE.

Include opportunities for small or large ceremonies, opportunities to offer tobacco and other gifts of reciprocity.</td></tr>
<tr><td>Maintain and revitalize traditional relationships and uses.</td></tr>
<tr><td>Consult cultural leaders, key community members, and elders.</td><td rowspan="3">Organize an annual rice camp in the Twin Ports that includes local school groups and native communities from the region.

Involve tribal members and knowledge holders and inspire community members to become caretakers of manoomin.</td></tr>
<tr><td>Establish and maintain cultural, environmental education, and youth programs.</td></tr>
<tr><td>Maintain and revitalize cultural</td></tr>
</table>

Approaches	Tactics
approach to harvesting and caretaking.	Facilitate traditional knowledge sharing with presentations, theater, cooking, crafts, canoeing, etc.
Understand the human and landscape history of the community.	Conduct a neighborhood survey to learn about the community's relationship to the SLRE and manoomin. Organize a community meeting to discuss the results of the survey.
Establish, maintain, and identify existing inventory and monitoring programs.	Recruit community members to assist with restoration work – specifically seeding and monitoring. Organize volunteer opportunities and work with tribal community members to train volunteers. Establish paid positions or internships for tribal community members as part of the restoration program.
Adapt significantly disrupted ecosystems to meet expected future conditions and needs. Establish or encourage new mixes of local and/or non-local beings expected to do well under future conditions to meet future needs.	Collaborate with revegetation and invasive species control efforts on embayments protecting manoomin bays in the SLRE. Organize volunteer tree planting of climate adapted species. Reevaluate treatment efforts for non-local beings and work with tribal knowledge holders to consider how to restore balance with these beings.
Use seeds and other biological material from relatives of beings from across a greater geographic range.	Work with local tribal communities to gather manoomin from locations across Minnesota and Wisconsin.
Adjust systems to cope with increased water availability and high-water levels. Respond to or prepare for excessive overland flows (surface runoff).	Prioritize revegetation and restoration on island and peninsular features that buffer manoomin restoration sites from main channel water flow, wind, and boat traffic.

A key insight from the manoomin workshop was the importance of de-colonializing the restoration decision-making framework by engaging tribal communities to better understand the Anishinaabeg approach to climate change adaptation founded in observation, deliberation, recognition, reciprocity, and respect (Tribal Adaptation Menu Team 2019). The 2024 Manoomin Plan strives to incorporate Indigenous experiential and ecological knowledge with western scientific ways of viewing the challenges posed by climate change stressors impacting the SLRE ecosystem. The SLREMRP acknowledges that climate change predictions impose a sense of urgency for action and that manoomin stewardship and restoration require a long-term commitment to build relationships with knowledge holders, community members, and the community of more-than-human beings supporting manoomin stewardship in the SLRE.

The vulnerability assessment published by the Great Lakes Indian Fish & Wildlife Commission (GLIFWC Climate Change Team 2023) identified manoomin as highly vulnerable or extremely vulnerable to climate change models representing the least and the greatest level of temperature change, respectively. Concern for manoomin's long-term persistence stems from its natural sensitivity to environmental conditions and the impact anticipated from climate change and other anthropogenic stressors.

Rising temperatures and other climate related stressors will have significant impacts on the future distribution and abundance of manoomin in the region. Seed germination, for example, requires a period of dormancy of at least 90 days in water at near freezing temperatures, with longer dormancy periods benefiting germination rates (Atkins et al. 1987, Kovach and Bradford 1992). During later growth stages, higher temperatures can result in fewer florets and stunted growth (Oelke et al. 1977). Regional monitoring data collected by the 1854 Treaty Authority indicates that manoomin experiences increased germination rates after winters characterized by higher snow accumulation and longer duration of ice cover than more mild winters (Nyblade et al. 2023). Increased humidity and higher day- and night-time temperatures foster conditions favorable to brown spot disease, which produce lesions on leaf surfaces that damage photosynthetic tissue and reduce seed production (David et al. 2019). Given these, and other predicted climate-related stressors, GLIFWC identified manoomin as the most vulnerable being in their assessment and highlighted that manoomin in currently experiencing climate impacts at each stage of its life cycle (GLIFWC Climate Change Team 2023).

Factors that increase manoomin's vulnerability include natural and man-made barriers to seed dispersal, direct and indirect impacts from land use changes, a narrow thermal and hydrological niche, sensitivity to high-intensity disturbance events (e.g., flooding, drought, wave energy, etc.), dependence on ice cover and low temperatures, sensitivity to pathogens such as brown spot disease and higher rice worm loads, and competition with other aquatic plants – including invasive species (GLIFWC 2023). Some of these factors are detailed below.

Water Level Fluctuation

Water level and velocity are known to influence manoomin productivity. Manoomin occupies a narrow range of water depths (0.5 to 3ft) and can tolerate gradual changes in water depth during the growing season (Aiken et al. 1988, Oelke et al. 2000, Oelke 2007). However, abrupt increases in water depth, particularly during the floating leaf growth stage when manoomin is most vulnerable, can completely uproot plants with potentially significant impacts to productivity. For example, substantial damage was experienced during the 500-year flood event in June 2012 which destroyed entire rice beds and severely impacted infrastructure along the SLRE.

Lake Superior water levels have fluctuated a great deal since 1860 although notable increases toward the top of the historical range have occurred in recent years (Figure 9). Higher water levels on Lake Superior result in increased water depths within the SLRE and an overall reduction in suitable manoomin habitat. Climate scientists agree that precipitation patterns will become more variable and that the likelihood of heavy rain events carrying more precipitation will increase (USGCRP 2018). It is likely that the resulting erosion, sedimentation, and flooding from these storm events will disrupt manoomin productivity and limit its distribution with more frequency.

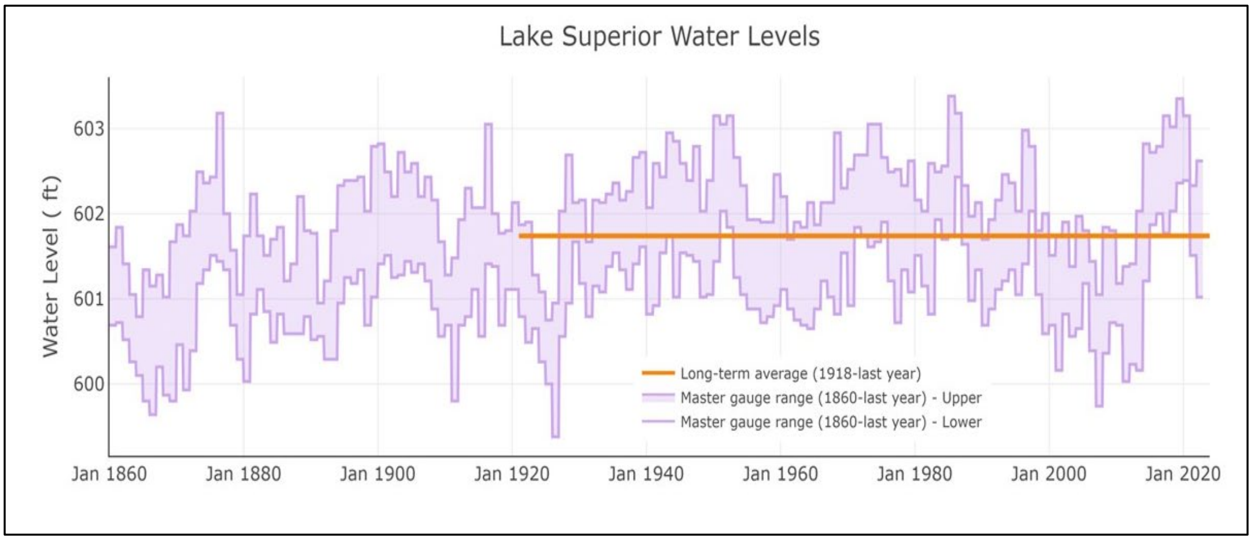

Figure 9. Changes in monthly average water depth on Lake Superior since 1860 with range of monthly averages depicted by the shaded area. Baseline water level (orange line) was determined by the average water level from 1981 through 2020 (image source: https://www.glerl.noaa.gov/data/wlevels/dashboard/#longterm).

More frequent and energy intensive storm events combined with increasing wind speeds caused by the differential between the air and lake surface temperature (Desai et al. 2009) may result in greater impacts to manoomin from wind and wave energy which are known to exert a negative effect on submergent and emergent aquatic vegetation. Reducing exposure to wind and wave energy will enhance opportunities to expand the amount of suitable manoomin habitat within the SLRE. Hydrogeomorphic features, such as sheltered bays and islands in the upper reaches of the SLRE, provide protection from fast-flowing water in the river's main channel, limit motorized access to restoration sites, and have the potential to buffer manoomin beds from wind and wave energy resulting from storm events. As the risks from climate change stressors grow, the value of these protective wavebreak features cannot be understated.

Many of the sheltered bay and island features in the upper SLRE are forested habitats dominated by stands of black ash (*Fraxinus nigra*). Unfortunately, the non-native emerald ash borer (*Agrilus planipennis*) arrived in the SLRE in 2013 and has already begun to modify these forested wetlands by rapidly increasing ash mortality. Beginning in 2023, the Lake Superior National Estuarine Research Reserve (LSNERR), Wisconsin Department of Natural Resources (WDNR), and WisCorps are removing invasive species, primarily glossy buckthorn and honeysuckle, and planting a diverse array of seventeen wetland adapted tree species (LSNERR 2023). These plantings will grow to replace the dying ash trees, maintain important wildlife habitat features, and protect wetland habitat from erosion during high water and floods. Plantings are occurring at Rask Bay, North Bay, Chambers Grove, Landslide Bay, Walleye Alley Bay, North Duck Hunter Bay, and Clough Island, all of which are associated with manoomin restoration.

Manoomin restoration and stewardship in the SLRE will rely, in part, on the structural and ecological integrity of protective features such as sheltered bays and islands. Restoration opportunities that enhance these features through understory planting to replace trees lost to emerald ash borer infestation, invasive species management, and monitoring will also serve to protect manoomin restoration sites. Future opportunities to enhance existing features or create new protective habitat features could be pursued as impacts to these protective features increase.

Herbivory

Herbivory by Canada geese (*Branta canadensis*) continues to hamper manoomin restoration in the SLRE (Vogt 2023) and has been well-documented as an impediment to restoration efforts in other regions (Haramis and Kearns 2007, Nichols 2014). Monitoring data, camera traps and anecdotal observations in the SLRE have documented heavy browse by Canada geese during late spring and summer months when manoomin is in the floating leaf and early emergent stages of its life cycle (Schwartzkopf 1999, Vogt 2023). This vulnerable phase of the manoomin life cycle coincides with an abundance of molt migrant and resident geese (and their offspring) occupying manoomin sites in the SLRE. Efficient foraging by geese impacts manoomin flowering and seed head production and has decimated entire stands of unprotected rice (Figure 10).

Figure 10. Herbivory exclosure protecting manoomin in Kingsbury Bay. The noticeable lack of manoomin outside of the exclosure was the result of intensive Canada goose herbivory at the site (image source: Duluth News Tribune).

Herbivory by Canada geese inhibits the establishment of self-sustaining rice beds within the SLRE. However, as the density of rice stands on the SLRE increases, the impact of goose herbivory should lessen because geese tend to avoid entering interior portions of high-density rice beds, preferring to browse at the perimeter (Tom Howes, personal communication, 2022). Impacts from nesting trumpeter swans (Jason Fleener, personal communication, 2023), foraging red-winged blackbirds (Meanley 1961) and muskrats who use manoomin stalks for both food and in the construction of their lodges have been documented in other locations (David et al. 2019) although noteworthy impacts from these species have not yet been observed at restoration sites in the SLRE. In fact, muskrats – whose numbers in the SLRE are a fraction of historic levels (Greg Kessler, WDNR, personal communication 2021) – are viewed by some tribal partners as "*gardeners of manoomin*". Muskrat activity stirs up sediments and their foraging patterns can open areas of thick emergent vegetation that competes with manoomin (David et al. 2019; Jeff Savage, personal communication, 2021).

Insects have the potential to impact manoomin productivity as well. Rice worm herbivory, which is caused the moth larvae *Apamea apamiformis*, can have a negative effect on seed production in manoomin stands with elevated sediment nitrogen levels

(Dahlberg and Pastor 2014). Although not currently identified as a significant limiting factor for SLRE manoomin productivity, the effect of larval herbivory on seed kernels is well documented in other locations (Peterson et al 1981). Continued monitoring will help to quantify the impacts that herbivory by geese and other species have on manoomin growth over time.

Declining Harvest Participation

Manoomin harvest is vitally important to Anishinaabe culture and tradition and the future of manoomin will depend, in part, on the stewardship of the people who appreciate and protect it. Traditional teachings and tribal wisdom assert that a failure to honor the Creator's gift of manoomin through the act of harvesting will lessen its significance in the community and result in its loss from the landscape (David et al. 2019, Davenport et al. 2020; Kathleen Smith, GLIFWC, personal communication, 2022). The harvest brings people of all ages together and facilitates the inter-generational transfer of historic and cultural tradition (Hosterman et al. 2023) and the act of harvesting manoomin by hand reaffirms the respect and gratitude people have for this gift as it renews the ties between the people and the land (Raster and Hill 2017).

Although regional differences exist, manoomin caretakers have expressed concern in the decline in the number of people participating in the harvest (David et al. 2019; Kathleen Smith, GLIFWC, personal communication, 2022). While harvest participation has declined, consumption of manoomin is growing in popularity and many non-tribal consumers lack the spiritual connection to this entity's ecological and cultural importance (Desmarais 2019). The commodification and domestication of manoomin is antithetical to the well-being of manoomin and its caretakers (FdL 2018). Opportunities to strengthen the connection between humans and manoomin (e.g., rice camps and other educational and volunteer programs) should be supported to ensure that manoomin stewardship efforts continue to find support across the region.

Competition & Displacement

Under ideal growing conditions, dense manoomin beds may appear to grow in monotypic stands because of their considerable above-water biomass while the diverse plant community intermixed with manoomin is obscured (David et al. 2019). Manoomin is often found in association with other aquatic plant species including pond lilies (*Nuphar*, and *Nymphaea*), pondweed (*Potamogeton* spp.), and bur-reed (*Sparganium* sp.) which are considered indicators of potential manoomin habitat in the SLRE because their habitat requirements overlap (MNDNR 2014).

In other cases, manoomin may be absent under otherwise suitable growing conditions due to competition with well-established perennial aquatic vegetation. As stated elsewhere, plant competition is a natural phenomenon and not considered a threat in and of itself (David et al. 2019). However, species such as Eurasian watermilfoil (*Myriophyllum spicatum*), narrow-leaved and hybrid cattail (*Typha angustifolia*, *Typha* x *glauca*), pickerelweed, watershield, water lily, pondweed, and common reed (*Phragmites* spp.) can directly compete with manoomin when natural hydrologic cycles are disrupted. Experiments conducted in Allouez Bay by the Lake Superior Research Institute (LSRI) demonstrated that invasive cattail stands have displaced native plant communities (Eliot et al. 2021). This work also illustrated that cattail removal may be a viable restoration method for native plant communities that have been displaced by the spread of monotypic cattail stands in the SLRE.

Human-induced changes in water levels can favor local and non-local invasive species which can replace manoomin in some circumstances. On the other hand, natural and/or human-induced disturbances to existing vegetation can also release manoomin from competition. In the SLRE, for example, vegetation management was used to reduce thick mats of aquatic vegetation that would have otherwise inhibited manoomin establishment when restoration efforts began in 2015 and 2016 (Vogt 2023).

Displacement of manoomin by invasive cattail has been observed in Allouez Bay (LSRI 2021) and Pokegama Bay (Hannah Ramage, LSNERR, personal communication, 2022). Red Cliff tribal elder Marvin Defoe recalled stories of the Ojibwe gathering on Wisconsin Point each year and that they "*lived there for a month and it was just loaded with Manoomin"* and how *"now there is just cattail*" (LSNERR 2022). Cattail produces an abundance of wind-dispersed seeds that germinate under a range of environmental conditions and exhibits a rapid growth rate and aggressive clonal propagation which can result in dense monotypic stands (Bansal et al. 2019). Manoomin has difficulty penetrating dense cattail mats which rapidly accumulate thick standing debris from previous years growth. When cattails are removed, as they were in portions of the Allouez Bay wetland complex, manoomin propagules in the seedbank below the cattail mat can germinate and mature to produce seed (LSRI 2021).

The SLREMRP also considered the potential impact of introducing *Z. aquatica*, commonly referred to as southern wild rice, to the SLRE. Both species of wild rice are native to the region although *Z. aquatica* is limited to southern latitudes and is generally associated with riverine systems. Although both have habitat value, *Z. palustris* tends to be shorter and produce larger seeds that are more desirable to manoomin harvesters (David et al. 2019). The SLREMRP determined that restoration and stewardship efforts should avoid the intentional or accidental introduction of *Z. aquatica* to the SLRE when sourcing seed. In general, best practices continue to recommend the use of locally sourced seed during restoration seeding efforts (David et al. 2019).

Water Quality

Prior to improvements in local wastewater treatment facilities in the 1970s, water quality in the SLRE was characterized as low in dissolved oxygen with elevated total phosphorous and total suspended solids. Water quality in the SLRE improved considerably with the passing of the Clean Water Act in 1972 and improvements to municipal waste facilities in Duluth and Cloquet which reduced discharge entering the SLRE in the 1970s (Schwartzkopf 1999, Hoffman 2011). Data indicate that water quality parameters for manoomin are improving although threats to water quality persist. For example, the SLRE is situated downstream of a large watershed with valuable mineral resources that have supported the development of an established mining economy, with new copper-nickel mining projects proposed in the watershed. These types of mining developments bring with them concerns regarding sulfur discharges and impacts to aquatic systems.

Sulfur discharges affect manoomin when sulfate is converted to phytotoxic sulfide and reduces the uptake of nitrogen needed for manoomin growth (LaFond-Hudson et al. 2022). Upstream mining activities, which are a regionally significant source of sulfate, have the potential to impact manoomin growth in the SLRE. Studies have shown that low aquatic sulfate levels provide good habitat for manoomin populations (Moyle 1944, Pastor et al. 2017) and a federally approved sulfate standard of 10mg/L has been adopted by the State of Minnesota as well as the Fond du Lac and Grand Portage Bands of Lake Superior Chippewa to protect manoomin waters. Despite extensive research which confirms the deleterious impact of excessive sulfate loading on germination rates, plant biomass, and seed production, the Minnesota standard has been met with legislative opposition and legal challenges which have made enforcement challenging.

There is no analogous water quality standard for manoomin waters in Wisconsin although a variety of protective measures have been offered for consideration, including a statewide sulfate water quality standard and site-specific standards based on waterway characteristics. Sulfate was nominated as a Chemical of Mutual Concern under Annex 3, Part B, Section 2 of the Great Lakes Water Quality Agreement by the Fond du Lac Band of Lake Superior Chippewa and Great Lakes Indian Fish and Wildlife Commission in 2016. Consideration of sulfate under Annex 3 continues following updates to the Binational Screening Criteria and guidance on nominations in 2021. WDNR prepared a brief identifying important uses of sulfates and knowledge gaps and that affect management decisions in 2023 as part of Annex on-going deliberations. These nominations share concerns over sulfate's role in mercury methylation, eutrophication, and production of sulfide, which is directly toxic to animals and plants, including wild rice. This nomination is already informing science and research funded through GLRI and if the nomination is accepted, a binational strategy to address sulfate will be developed.

Recognizing the importance of manoomin to the residents of Wisconsin, the Governor's Office and WDNR are actively devising and implementing strategies to collaborate with tribal partners and develop long-term protections for manoomin waters and surrounding ecosystems (Governor's Task Force on Climate Change Report, Strategy 40). Additionally, a Joint Wild Rice Advisory Committee which includes representatives from WDNR, GLIFWC (Great Lakes Indian Fish & Wildlife Commission), and Wisconsin's Ojibwe tribes advises WDNR. This committee recommends policies, plans, and harvest guidelines for manoomin. Under the 1989 Wild Rice Stipulation, WDNR consultation is required with the Voigt Intertribal Task Force before making a final decision on any activity or permit where impacts to manoomin are anticipated (Executive Summary: Strategic Analysis of Wild Rice Management in Wisconsin). Throughout the history of the Committee, there have been recurring concerns among members regarding the potential impact of sulfates and sulfides on manoomin.

The WDNR Strategic Analysis on Wild Rice Management in Wisconsin (WDNR 2021) also considers establishing manoomin as a Designated Use (DU) for certain lakes, streams and rivers thereby setting the expectation that these waters would maintain manoomin as a use over time. Section 4.2 discusses the impacts that sulfates have on manoomin, and subsequent chapters evaluate activities and alternative approaches that could affect manoomin populations. Should revised regulations include a manoomin DU, waters with a manoomin DU would be considered as candidates for the 303(d) impaired waters list and prioritized for restoration action if it were determined that they no longer supported manoomin. Discussions regarding establishing a DU for manoomin in Wisconsin are ongoing and consideration of developing sulfate criteria or adding a

DU specific to manoomin waters will likely be included in WDNR's 2024-2026 Triennial Standards Review (TSR) cycle.

The complex interaction between manoomin and sulfide (the reduced state of sulfate) and the resulting impact on viability is of particular concern for manoomin's long-term persistence in our region. Sulfate enters manoomin waters from bedrock weathering, mine drainage, wastewater treatment, and other sources and is converted to phytotoxic sulfide by anerobic bacteria present in the sediment. High sulfide concentration reduces the uptake of nitrogen which is essential for plant growth (LaFond-Hudson et al. 2022) and is associated with decreased seedling survival and lower seed biomass (Pastor et al. 2017, LaFond-Hudson et al. 2018). The weight of evidence suggests that sulfide exerts an important control on the presence of manoomin in otherwise suitable habitat (Myrbo et al. 2017a) by influencing seedling emergence and seed production. Historic observations and analysis by Moyle (1944) indicate that manoomin may be present in waters where sulfate concentration is at, or below, 10mg/L and uncommon in waters where sulfate concentration exceeds 50mg/L. Experimental research by Pastor et al. (2017) determined that elevated sulfate concentrations are toxic to manoomin and result in reduced seed production, seed mass, and seedling emergence which, taken together, could lead to extirpation in a matter of years.

Shoreline Development & Recreation

Public opposition to expanding manoomin is often associated with shoreline development and the real, or perceived, impact to recreation and water access. Developed shorelines tend to support less emergent and floating-leaf vegetation, coarse woody debris, and native vegetation than undeveloped shorelines (Christensen et al. 1996, Meyer et al. 1997, Radomski and Goeman 2001). Yet despite the extensive shoreline development that has occurred within the SLRE, there are still several isolated bays that provide suitable manoomin habitat and remain relatively unimpacted by development pressure. These sites are afforded some level of protection from development pressure through state law and county shoreland development ordinances and/or local land use designations.

The City of Superior manages the Pokegama Municipal Forest, a 4,400-acre natural area that protects a considerable amount of estuarine shoreline habitat on the Wisconsin side of the St. Louis River – including Pokegama Bay, which provides manoomin habitat. WDNR manages the St. Louis River Streambank Protection Area which encompasses nearly 7,000 acres. The Dwight's Point and Pokegama Wetlands

State Natural Areas, which also border the SLRE, provide shoreline protection in proximity to manoomin restoration sites.

The WDNR Shoreland Management Program sets statewide minimum standards (Wisconsin Administrative Code, Chapter NR115) for shoreline development, which serve as a foundation for county shoreland zoning ordinances and whose primary purpose is to protect water quality and aquatic and nearshore habitat as well as the public's interest in navigable waters of the state. Douglas County administers applicable shoreline development regulations in the unincorporated areas of the county that are within 300ft of the ordinary high-water mark on navigable rivers. Similarly, Minnesota's Shoreland Management Program guides land development to protect ecological, recreational, and economic values (Minnesota Statutes, Chapter 103F, Minnesota Rules, Parts 6120.2500 – 6120.3900) and informs the development of zoning ordinances at the local level.

The City of Duluth's St. Louis River Natural Area (SLRNA) encompasses approximately 1,200 acres across nine areas on the SLRE shoreline with relevance to manoomin restoration and stewardship (City of Duluth 2019). Five of the SLRNA areas include riparian areas adjacent to, and surrounding, manoomin restoration sites. Establishing protections for these riparian zones prevents development that could influence water quality and habitat suitability and conflict with manoomin restoration goals. Management at these sites has focused on land acquisition, invasive species control, native plant surveys, revegetation work, and coordination with state agencies to protect completed Remedial Action Plan (RAP) projects. As part of the SLRNA, these properties will be managed and maintained to support native plant communities and the species that rely on this habitat, including manoomin (Gini Breidenbach, MLT, personal communication, 2023).

Investments in manoomin restoration at sites adjacent to residential development (e.g., Rask Bay), industrial / shipping activity (e.g., Allouez Bay), and city infrastructure (e.g., Kingsbury Bay) require thoughtful consideration when evaluating the effect of existing or future land use practices that might threaten manoomin persistence. Where possible, natural shoreline buffers can be protected to reduce impacts to manoomin and other aquatic species (Meyer et al. 1997, Radomski and Goeman 2001). Areas with heavy boat traffic may not be suitable as manoomin restoration sites. Recreational boating activity has the potential to increase wave energy and cause physical damage to rice beds and other aquatic vegetation (David et al. 2019). "Slow" and "No-Wake" zones have been used for watercraft safety, shoreline protection, erosion control and during high-water situations. These types of surface water use restrictions could, in some cases, be appropriate for reducing motorized traffic impacts at designated manoomin restoration sites to protect manoomin and manoomin habitat.

Environmental & Tribal Justice

Manoomin has profound cultural significance for the Anishinaabe community, and the depth of native experiential knowledge and ecological expertise that Indigenous partners bring to the SLREMRP is critical to the program's success. With this understanding in mind, the SLREMRP approaches restoration work with a spirit of reciprocity and respect for the gifts that manoomin provides to the community. The SLREMRP also acknowledges that manoomin restoration is an important step in countering the historical and contemporary injustices that continue to impact the Anishinaabe community.

The Treaties of 1836, 1837, 1842, and 1854 used coercion and threat of war to force Ojibwe from the land that they had lived on prior to Euro-American settlement in the Great Lakes region. Despite their relocation to reservations scattered throughout their former homelands, Ojibwe people retained rights to hunt, fish, trap, harvest, and manage the natural resources that had sustained their families for generations, and continue to do so, within northern Minnesota, northern Wisconsin, and upper Michigan

Figure 11. Anishinaabe treaties with the United States government retained sovereign land use rights (image source: Great Lakes Indian Fish & Wildlife Commission).

(Figure 11). It is important to note that treaty rights were not granted to tribal nations by the United States government. Instead, treaty rights represent inherent sovereign land use rights retained by the tribes for the benefit of Ojibwe peoples, in perpetuity.

Industrialization of the SLRE – guided and facilitated, in part, by federal and state governments – resulted in substantial ecological impairments that partners are now addressing. A considerable amount of funding from the federal Great Lakes Restoration Initiative (GLRI), for example, has been used within the SLRE to remediate contaminated sediments, restore habitat, and remove other Beneficial Use Impairments (BUIs) identified by the Great Lakes Water Quality Agreement (GLWQA). From the perspective of some tribal community members, state and federal partners are making good on their promise to honor treaty rights by funding and implementing the restoration of resources upon which those rights are founded – not the least of which is the right of manoomin to flourish and support Indigenous communities (T. Howes, FdL, personal communication, 2021).

The 2014 Rice Plan outlined restoration objectives for specific acreage targets that included harvestable stands of manoomin, which would return a lost harvest opportunity for both tribal and non-tribal community members. Manoomin restoration is one means of bringing justice to the SLRE and to the Indigenous peoples who have been most impacted by the SLRE's degradation. This is an important story to tell, and highlights how state, federal, and tribal partnerships can make a meaningful difference through accountability and collaborative action.

The 2024 Manoomin Plan builds upon the partnerships that were established to implement the 2014 Rice Plan and incorporates additional, culturally significant indicators to gauge restoration progress. Manoomin is as integral to the Ojibwe community's future as it is to their past. Manoomin is an important food and sacred medicine that is inextricably connected to the identity of the Ojibwe community. The 2024 Manoomin Plan update acknowledges that restoration efforts must incorporate not only numerical metrics but also indicators tied to meeting the Ojibwe community's needs, including a commitment to continued stewardship and education.

It is also important to note that environmental justice connection to manoomin restoration and environmental stewardship extends to other, traditionally under-served, communities. Manoomin is a local, natural food source with demonstrated health benefits. The harvest of manoomin provides a seasonally viable economic opportunity for harvesters and a complex micro-economy has developed around the harvest, processing, and sale of manoomin for human consumption and restoration purposes

(Drewes and Silbernagel 2012, Davenport et al. 2020). Furthermore, access to sustainable manoomin beds contributes to food security and sovereignty for Minnesota tribes as well as other peoples taking part in manoomin harvest (FdL 2018).

Section 2: Manoomin Restoration

St. Louis River Area of Concern

The SLRAOC is one of the forty-three Areas of Concern (AOC) designated in the GLWQA signed by the United States and Canada in 1987. AOCs are defined as "*geographic areas designated by the Parties where significant impairment of beneficial uses has occurred as a result of human activities at the local level*" (GLWQA 2012). Of the 14 BUIs listed in the GLWQA, nine beneficial use impairments (BUIs) were identified in the SLRAOC based on its history of unregulated land use, industrial pollution, and habitat degradation (MPCA and WDNR 1992). Projects to remediate contaminated sediment and restore degraded and lost habitat have been the focal point of the work to remove the nine BUIs. Restoration and remediation efforts have been facilitated by a partnership between the United States Environmental Protection Agency (USEPA) and the four coordinating agencies: the Fond du Lac Band of Lake Superior Chippewa (FdL), the Minnesota Department of Natural Resources (MNDNR), the Minnesota Pollution Control Agency (MPCA), and WDNR. Many additional partner organizations and individuals have been involved in this work.

Although SLRAOC-supported work and other environmental management improvements in the SLRE have produced water quality improvements over the past five decades, manoomin has not returned to the SLRE unaided. GLRI funding provided the much-needed support to expand efforts initiated in the mid-1990s by FdL natural resource personnel (Schwarzkopf 1999) and serve as a foundation for the long-term goal of manoomin recovery (i.e., increased abundance and distribution) throughout the SLRE where suitable habitat is present or can be restored. These efforts are detailed below.

Early Manoomin Restoration Efforts

FdL began manoomin restoration efforts in the mid-1990s with a goal of returning manoomin to its historic distribution and density within the SLRE (Schwarzkopf 1999). From 1993 to 1996, FdL personnel seeded approximately 2,165lbs of manoomin in Rask Bay, North Bay, Radio Tower Bay, Mud Lake, and Kingsbury Bay (MNDNR 2014;

Figure 12). Exclosure trials were conducted in 1994 and 1995 to evaluate the impact of common carp (*Cyprinus carpio*) and Canada goose herbivory on manoomin growth and to determine if one or the other were hindering restoration efforts. Observations from those trials determined that herbivory was an important factor and confirmed that Canada geese were negatively impacting manoomin restoration efforts in the SLRE.

Early restoration efforts by FdL in the 1990s identified sediment suitability as an important factor for reestablishing manoomin to the upriver SLRE restoration sites

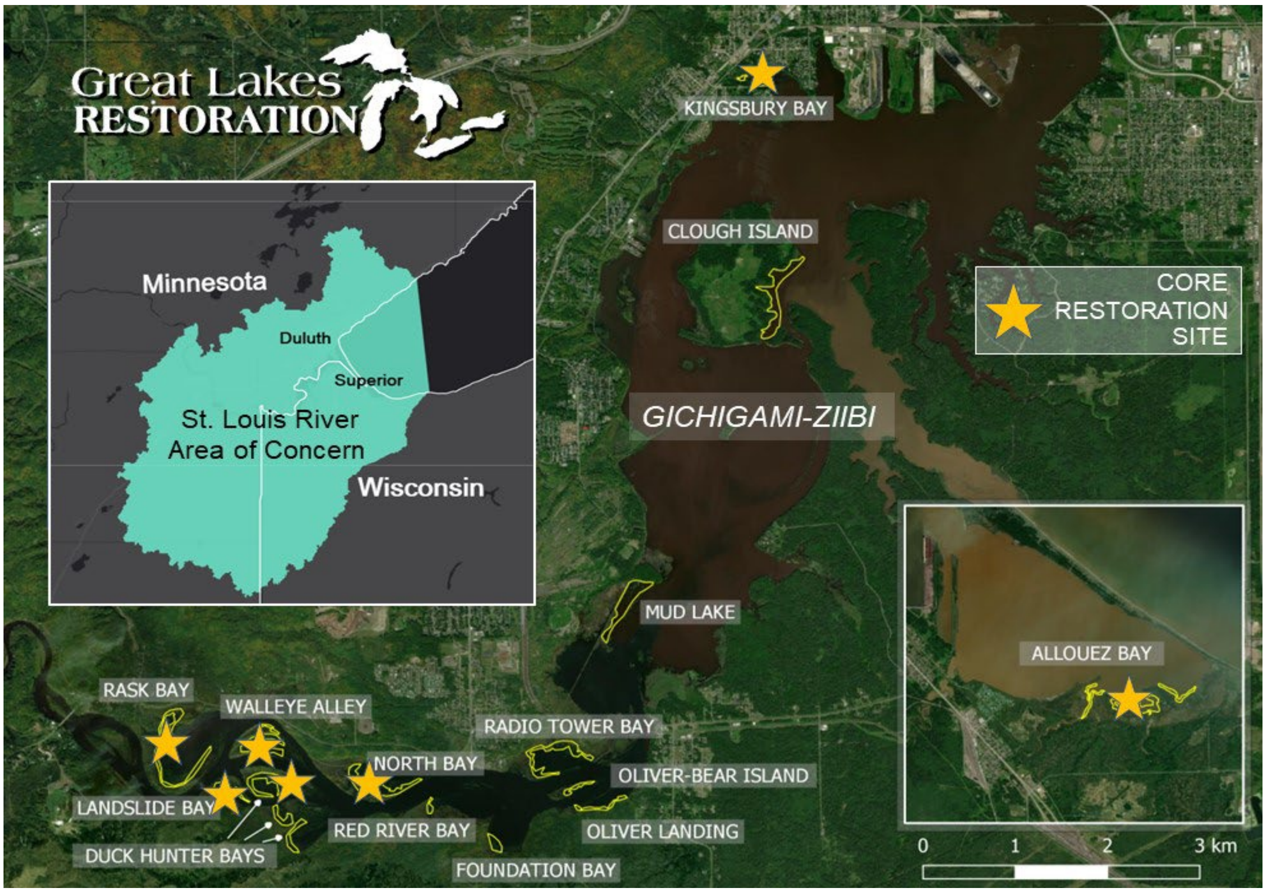

Figure 12. Manoomin restoration sites in the St. Louis River Estuary (2024; map source: WDNR).

(Schwarzkopf 1999). Their initial seeding efforts demonstrated that sites with soft sediments characterized by high organic content had greater success than sites with less suitable substrates. Sites like Rask Bay, containing sediments with high organic content performed well while those with lower organic sediments did not. Although funding for these early restoration efforts was not secured for long-term restoration, much was learned during this period and those lessens formed the basis for the development of the 2014 Rice Plan. Sediment suitability and herbivory management would become important components of later efforts to develop a holistic restoration plan (MDNR 2014).

The St. Louis River Habitat Plan was developed to facilitate and guide the protection of ecological diversity in the SLRE (SLRCAC 2002). Manoomin was the only plant species listed as a conservation target in the Lower St. Louis River Habitat Plan because it was the only plant species evaluated at the time that met any of the qualifying criteria (SLRCAC 2002). The conservation goal established for manoomin was to restore healthy populations in suitable wetland habitats. The presence of manoomin and other aquatic vegetation was also a component of conservation targets for three habitat types identified in the St. Louis River Habitat Plan: upper estuary flats, sheltered bays, and Great Lakes coast wetland complex (SLRCAC 2002). This plan has helped prioritize manoomin restoration in the SLRE and continues to inform project implementation for conservation work which benefits manoomin both directly and indirectly.

The University of Wisconsin – Superior, Lake Superior Research Institute (UWS-LSRI) initiated manoomin restoration work in Allouez Bay in 2010 and has continued to work on rice restoration since that time (Eliot 2017, Eliot et al. 2021). Early efforts by UWS-LSRI in 2010 included seeding and herbivory management using exclosures designed to reduce browsing and damage from carp and geese. As predicted from earlier herbivory investigations at upriver restoration sites by FdL, heavy grazing occurred outside of the Allouez Bay exclosures while protected rice inside of the exclosures matured to produce seed heads.

2014 Wild Rice Restoration Implementation Plan for the St. Louis River Estuary

Large-scale habitat restoration in the SLRE was gaining momentum and the development of a manoomin restoration plan was underway in 2013. At that time, a Wild Rice Restoration Site Team (RST; now referred to as the SLREMRP) was formed to guide plan development with representatives from 1854 Treaty Authority, FdL, GLIFWC, Minnesota Land Trust (MLT), MNDNR, WDNR, and MPCA. The objective of this team was to use available data and experiential knowledge to determine priority manoomin restoration sites and develop guidelines for restoration implementation.

The 2013 Remedial Action Plan (RAP; MPCA and WDNR 2013) identified a set of management actions required for BUI removal that included on-the-ground restoration and remediation projects, monitoring and assessment efforts, and community engagement processes. At the time, the RAP did not include development of a manoomin restoration plan although specific management actions identified manoomin restoration in Mud Lake (Management Action 9.08) and Allouez Bay (Management Action 9.11). However, the 2013 RAP acknowledged that the development of a manoomin restoration plan and associated restoration at Rask Bay and other locations in the SLRE in Minnesota was already underway. SLRAOC staff and resource managers agreed that a plan was needed to guide broader efforts and a decision was made to support the development of the 2014 Rice Plan with GLRI funding. As a result, AOC staff became involved in the development of the 2014 Rice Plan and a goal of restoring 275 acres of manoomin was added as Management Action 9.21. Descriptions of the manoomin-related management actions in the 2013 RAP included:

- Management Action 9.08 Mud Lake – Remediate contaminated sediments, establish more vital hydrologic connection, and restore wetland habitat including wild rice; establish deep water.
- Management Action 9.11 Allouez Bay – Vegetation restoration including removal of aquatic invasive species and re-establishment of wild rice. Upstream sediment control outreach.

In the 2014 RAP, the following manoomin-related management action was added:

- Management Action 9.21 Wild Rice Plan and Associated Restoration Sites – Develop a plan that identifies the high priority restoration sites and provides a process for restoring those sites. Restoration of 275 acres of wild rice.

To be consistent with revised metrics of the 2024 Manoomin Plan, the description for Management Action 9.21 was modified in the 2023 RAP to read:

- Develop and implement a plan that outlines AOC goals and metrics, restoration tactics and identifies restoration sites.

At this time, it is unclear whether the final restoration design for Mud Lake (AOC Management Action 9.08) will include manoomin restoration. It will be up to the SLREMRP to assess Mud Lake and determine if it should be prioritized as a future manoomin core restoration site.

The 2014 Rice Plan (MNDNR 2014) was developed to guide and coordinate manoomin restoration work in the SLRE. The plan articulated the long-term desired vision for manoomin restoration based on healthy, self-sustaining manoomin beds that provide benefits to fish and wildlife habitat and support harvest opportunities. The plan outlined a suite of implementation strategies (e.g., vegetation management, seeding, and herbivory management) with the following restoration goal:

> *Increase abundance and distribution of self-sustaining manoomin within the St. Louis River Estuary including areas in both Minnesota and Wisconsin to increase opportunities for culturally important harvest and benefit fish and wildlife species including contributing to the removal of the Loss of Fish and Wildlife Habitat BUI within the St. Louis River Area of Concern.*

The 2014 Rice Plan's benchmark for manoomin restoration was identified as increased abundance and distribution of self-sustaining beds of manoomin that do not require annual seeding to persist (MNDNR 2014). The 2014 restoration goal highlights the fact that manoomin restoration work in the SLRE was intended to support AOC delisting by contributing to the removal of the Loss of Fish and Wildlife Habitat BUI (BUI 9).

The 2014 RAP identified the goal of restoring 275 acres of manoomin by 2019, while the 2014 Rice Plan included what was considered a more likely achievable goal of restoring a minimum of 275 acres over a 10-year period. The 2014 Rice Plan evaluated potential restoration sites based on sediment characteristics and water depth as a means of focusing restoration efforts. A detailed description of this restoration site evaluation is included in the 2014 Rice Plan (MNDNR 2014; see also Cardno 2014). Some of the sites listed in the 2014 Rice Plan have become core restoration sites in recent years as restoration practices have focused on manoomin establishment at a subset of more responsive sites (Appendix B).

Central to the 2014 Rice Plan was the development of a set of well-defined metrics for measuring restoration progress and a robust monitoring program to evaluate manoomin density and biomass. These metrics served to focus implementation resources and partner efforts across the SLRE. A key element of the plan was a rigorous manoomin monitoring program led by personnel from the 1854 Treaty Authority that has been conducted on an annual basis since 2015 (Kjerland 2015a, 2015b, Vogt 2023).

St. Louis River Estuary Restoration Site History

The 2014 Rice Plan defined a broad manoomin restoration project area within the SLRE that encompassed suitable and/or potential habitat from the Fond du Lac dam at the project area's upstream boundary downstream to Grassy Point and included Allouez Bay (MN DNR 2014). Within this defined project area, specific restoration sites which offered the most potential for manoomin restoration that could be implemented as stand-alone activities were identified by project partners during the initial planning process. The 2014 Rice Plan's site list is included in Appendix B.

The 2014 Plan identified 30 locations within the this broadly defined project area for consideration for restoration action and provided a summary of these locations that included plant community and substrate characteristics, water depth profiles, and detailed location narratives (MN DNR 2014). In addition, the site profiles included an acreage estimate for high, medium, and low restoration potential based on a geospatial site selection model that incorporated the afore mentioned characteristics and SLREMRP member knowledge and experience with the suite of potential restoration sites.

Details regarding site-specific restoration work in the SLRE in furtherance of the 2014 Rice Plan are detailed in the annual monitoring report produced by the 1854 Treaty Authority (Figure 13; Vogt 2023). What follows is a brief timeline summary of restoration and stewardship actions taken in the SLRE since the program's inception in 2015 (see Figure 12 for a map of where restoration work has taken place).

Figure 13. Annual manoomin monitoring efforts inform restoration and stewardship in the SLRE (image source: 1854 Treaty Authority).

- 2015: Vegetation management actions (detailed below) were implemented at Rask Bay, North and South Duck Hunter bays, North Bay, and Radio Tower Bay during the summer of 2015. Manoomin seeding was initiated at these sites as well as Allouez Bay and Clough Island in 2015.

- 2016: Vegetation management actions were implemented at Walleye Alley Bay, Landslide Bay, Oliver-Bear Island, Mud Lake Northeast, and Clough Island in 2016. Manoomin seeding occurred at these sites in addition to those established the previous year. Canada goose herbivory deterrents (including goose exclosures - described below) were implemented at North Duck Hunter Bay.

- 2017: Restoration work in 2017 did not include further vegetation management action. Sites treated in the previous years were seeded again in 2017. Sediment substrate mapping was also completed in 2017 to evaluate habitat suitability within restoration sites.
- 2018: Regional seed production crashed in 2018 and seed for restoration purposes was not available except for seed allocated to the Clough Island restoration site. Canada goose exclosures were installed at North Duck Hunter Bay.
- 2019: Two new restoration sites were added to the program in 2019 – Foundation Bay and Red River. Both sites were seeded along with all previously seeded sites apart from Mud Lake due to planning for remedial action that might impact manoomin plantings in the short term but may include seeding once restoration work is completed. Canada goose exclosures were installed at North Duck Hunter Bay and Allouez Bay.
- 2020: No new restoration sites were added in 2020. However, 2020 was the best year for seed acquisition, to date. Over 14,000 pounds of manoomin seed were distributed across restoration sites with Allouez Bay and Mud Lake Northeast being excluded from seeding. Canada goose exclosures were installed at North Duck Hunter Bay.
- 2021: Seed availability in 2021 was impacted by low water conditions and low harvest participation, limiting seed distribution to two sites – Allouez Bay and the recently completed restoration site at Kingsbury Bay. Canada goose exclosures were installed at North Duck Hunter Bay, North Bay, and Walleye Alley Bay. Goose removal actions were also implemented in Wisconsin to further protect sites from over browsing.
- 2022: Restoration seed acquisition was challenging in 2022 and the overall number of sites seeded was limited to Allouez Bay, North Duck Hunter Bay, Kingsbury Bay, Landslide Bay, North Bay, Rask Bay, and Walleye Alley Bay. Canada goose exclosures were installed at Allouez Bay, Kingsbury Bay, Landslide Bay, North Duck Hunter Bay, North Bay, and Walleye Alley Bay. Goose removal actions were conducted but were limited to the Wisconsin side of the state boundary due to challenges obtaining removal permits in Minnesota.
- 2023: Regionally abundant manoomin seed facilitated the acquisition and distribution of over 12,500 pounds of manoomin seed across six sites: Allouez Bay, North Duck Hunter Bay, Kingsbury Bay, Landslide Bay, North Bay, Rask Bay, and Walleye Alley Bay. Seeding also occurred at Middle Duck Hunter Bay and South Duck Hunter Bay. Herbivory management included the installation of 49 herbivory exclosures at Allouez Bay, Kingsbury Bay, North Duck Hunter Bay, Landslide Bay,

North Bay, Rask Bay, and Walleye Alley Bay. A third year of targeted goose removals were conducted in 2023 with the addition of removal sites in Minnesota.

St. Louis River Estuary Restoration Site Status

Trends In Manoomin Density

Seven SLRE restoration sites have exhibited increasing manoomin density over recent years (Figure 14). These sites have benefitted from increased seed rates when sufficient restoration seed is available and protections from Canada goose herbivory, where possible. Although not all the sites experiencing improved density trends have yet to meet the 2014 Rice Plan's density metric (i.e., ≥1 stalk/plot in ≥50% of the survey plots), monitoring data indicates that additional sites have met this milestone in recent years and monitoring data suggest a positive trend for restoration progress.

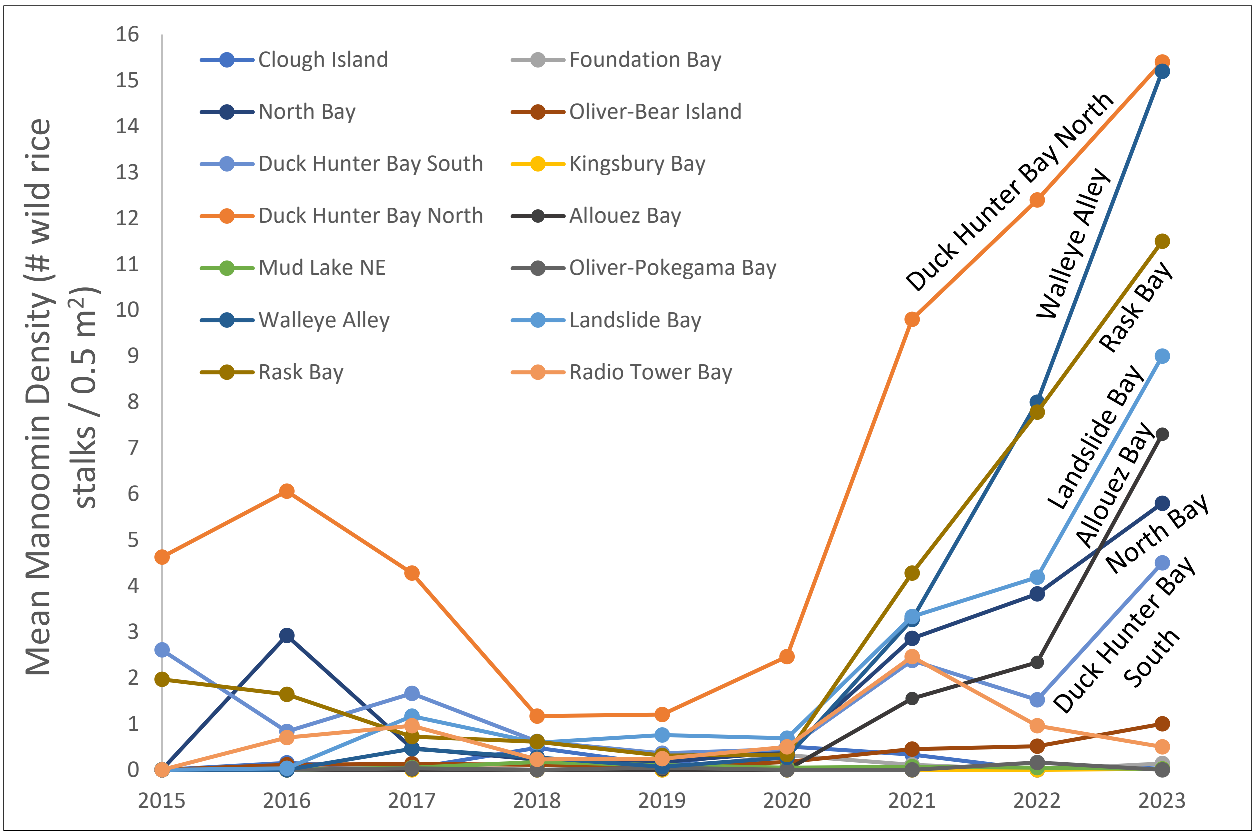

Figure 14. Mean manoomin density estimates derived from long-term monitoring at restoration sites in the SLRE (data source: 1854 Treaty Authority).

Trends In Manoomin Biomass

Manoomin biomass has also improved at some restoration sites in the SLRE, particularly where regular seeding and herbivory management have been implemented (Figure 15). Biomass is calculated for each monitoring point based on established monitoring methods that are implemented across the region (Kjerland 2015a; Vogt 2023). Average annual biomass is then calculated for each restoration site. Although not identified as a goal in the 2014 Rice Plan, estimates of manoomin biomass have been included in annual reports dating back to 2015 when the SLRE monitoring work was initiated. Biomass serves to place the status of SLRE manoomin in a broader, regional context. For example, biomass estimates near or exceeding 100g/m^2 begin to provide the possibility of manoomin harvest and manoomin beds typically range from 100-300g/m^2 during a season of fair to good seed productivity (Vogt 2023). Biomass is an indicator of both cultural and ecological importance as was adopted by the SLREMRP as an indicator of progress in this 2024 Manoomin Plan.

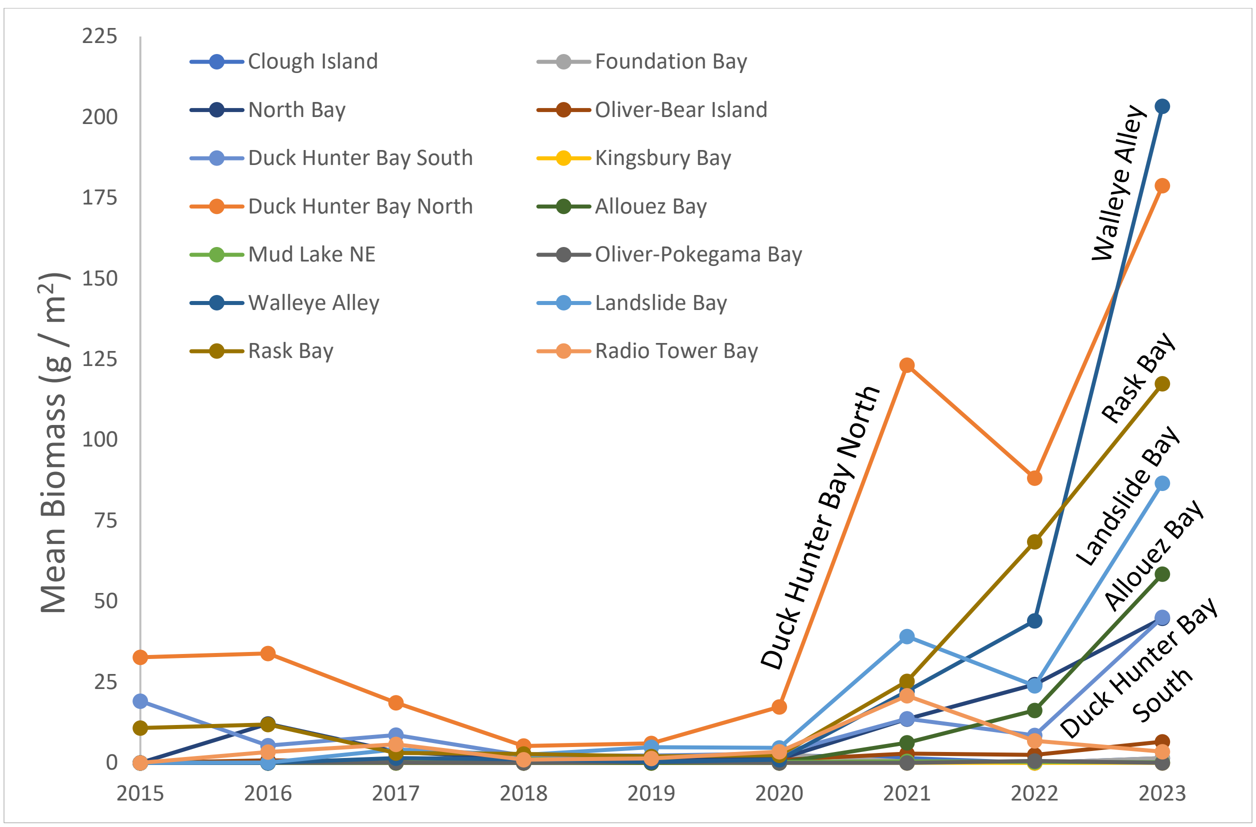

Figure 15. Mean manoomin biomass estimates derived from long-term monitoring at restoration sites in the SLRE (data source: 1854 Treaty Authority).

Seed Acquisition

The availability of manoomin seed for restoration varies from year to year. Manoomin seed can be particularly difficult to acquire for restoration projects during years of regionally low seed production as was experienced in 2018 and in low water years when access to rice beds is difficult as in 2021. Even in moderate productivity years, manoomin seed can be difficult to obtain because of the growing demand for restoration seed across the region. The bulk of restoration seed used in the SLRE has been acquired by partners at FdL Natural Resources who have an extensive network of harvesters across the region who provide manoomin seed for community needs and restoration work (Figure 16). Similarly, the St. Croix Chippewa Indians of Wisconsin have supplied manoomin seed for restoration work in Allouez Bay.

Figure 16. Fond du Lac Band of Lake Superior Chippewa Natural Resources Department staff seeding manoomin in the SLRE (image source: MN Public Radio).

In addition to these regional seed acquisition efforts, there is a statewide seed prioritization process in Wisconsin that helps to coordinate manoomin restoration efforts among GLIFWC, WDNR, and other restoration practitioners such as Ducks Unlimited and the University of Wisconsin (J. Fleener, WDNR, personal communication, 2022). This network has yielded some gains in rice seed acquisition for the SLRE effort. In recent years, SLREMRP personnel have begun to incorporate manoomin harvesting efforts in work plans during the ricing season to procure additional manoomin seed for restoration in the SLRE as well as educational programming.

Seed Prioritization

The availability of manoomin seed for restoration has varied considerably throughout the duration of the restoration effort (Figure 17). To date, over 80,000 pounds of seed have been distributed across restoration sites with annual seeding priorities developed through conversations between personnel from FdL, 1854 Treaty Authority, and WDNR, then approved by the SLREMRP. Seed prioritization is, in part, based on the following factors.

- **Seed availability.** Prioritization is conducted for both high and low seed availability scenarios because harvest success varies annually and cannot be accurately predicted.
- **Previous seeding.** Sites benefiting from regular seeding are given priority status to continue the process of building a robust seedbank. A robust seedbank strengthens manoomin's ability to "rest" during years when growing conditions are unsuitable and "wake up" when conditions improve in subsequent years.
- **Herbivory management.** Sites where herbivory management actions (e.g., Canada goose exclosures and/or goose removal) have been implemented are given priority over sites where herbivory is more difficult to manage.
- **Previous site performance.** Sites where manoomin exhibits an increasing trend in occupancy and biomass are given priority over sites which have had less success, potentially indicating less suitable habitat, higher herbivory pressure, or other unmeasurable factors affecting manoomin productivity.

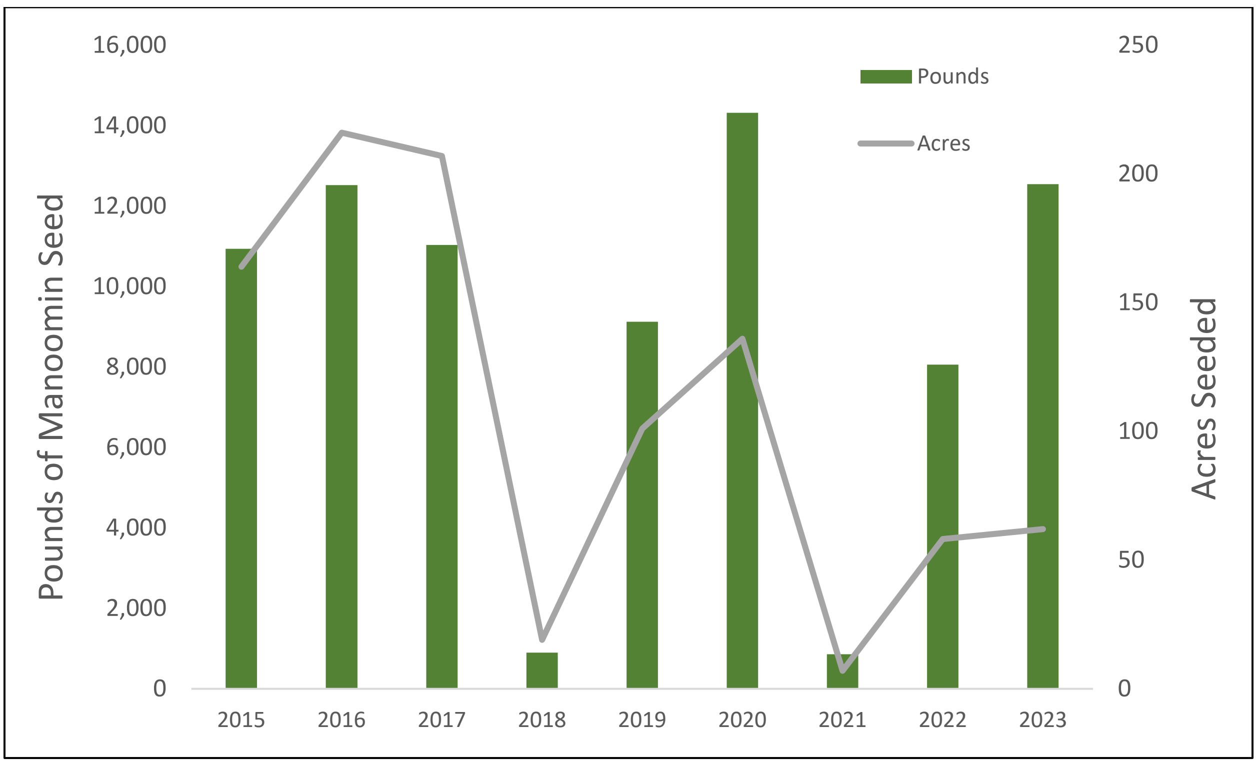

Figure 17. Manoomin seeding effort summary for the SLRE (2015 – 2023; data source: Fond du Lac Resource Management).

The SLREMRP developed the SLRE Manoomin Stewardship Seed Prioritization Decision Support Tool to guide decisions regarding seed prioritization in anticipation of future seeding efforts expanding to additional SLRE restoration sites and discussions regarding when to reallocate manoomin seed resources to new locations (Appendix C). The decision support tool prioritizes seed allocation to core restoration sites and incorporates manoomin biomass and occupancy indicators of progress. Re-prioritization and reallocation of seed resources is considered once a core restoration site meets indicators in four of the past seven years. While this tool provides a decision-making framework, it does not supplant the conversations and deliberations regarding seed prioritization among members of the SLREMRP.

Adaptive Restoration Tactics

A considerable amount of knowledge has been gained since initiating restoration tactics outlined in the 2014 Rice Plan. Site selection, seeding, herbivory and vegetation management, effectiveness monitoring, and cultural & community connections are key tools in the SLRE manoomin restoration toolbox, although some modifications to these tools have developed since the 2014 Rice Plan was completed.

Site Selection & Core Restoration Sites

The 2014 Rice Plan included a detailed manoomin site selection model developed for planning and restoration prioritization purposes (MNDNR 2014). The model served as a planning tool for determining where restoration actions would have the greatest impact and which tactics would be effective at increasing the likelihood of success. Model results indicated that approximately 1,129 acres of high potential habitat for restoration existed in the SLRE (MNDNR 2014). Certainly, habitat suitability and availability are the primary driver of restoration success. However, additional factors such as Canada goose herbivory exert additional constraints on manoomin distribution within that suitable habitat (Haramis and Kearns 2007, Nichols 2014) and have undoubtedly impacted restoration progress in the SLRE.

When the 2014 Rice Plan was developed, restoration site selection focused on two strategies: (1) implementing restoration actions at locations such as Rask Bay, Duck Hunter Bay North, North Bay, and Allouez Bay, where historical accounts and/or remnant beds were documented; and (2) incorporating manoomin habitat restoration either as a component of a management actions or following completion of habitat restoration projects, as was done in Radio Tower Bay where 115,000 cubic yards of wood waste was removed and bathymetric diversification improved habitat conditions for fish and benthic invertebrates. Early restoration efforts attempted to execute restoration actions at a large number of sites across a broad area but were later refocused towards a smaller number of locations where higher seed rates (e.g., 200lbs/acre) and herbivory management tactics were implemented. These focused efforts established the core restoration sites where current progress has been most pronounced. These core restoration sites currently include Rask Bay, Landslide Bay, Walleye Alley Bay, North Duck Hunter Bay, North Bay, Kingsbury Bay, and Allouez Bay.

Resources for manoomin restoration, primarily seed availability, constrain the extent and number of core restoration sites. However, the long-term goal for the restoration program anticipates increasing the number of core restoration sites over time and a few considerations will be applied when determining which sites to add:

- Records (oral and/or written) of historic manoomin presence
- Current manoomin presence and condition
- Current and predicted water depth and/or bathymetric suitability
- Exposure to wind and wave energy
- Substrate quality/suitability
- Herbivory pressure and ability to implement protective tactics (e.g., herbivory exclosures and/or goose removals)
- Presence of dense, well-established vegetation that compete with, or inhibit, manoomin establishment
- Additional SLREMRP recommendations

Vegetation Management

The 2014 Rice Plan outlined the importance of site preparation for new restoration sites where existing aquatic submergent or emergent vegetation may require management to allow for manoomin establishment (MNDNR 2014). Vegetation reduction actions may include mechanical removal using hand-held or boat-mounted mowing equipment, or similar implements, during the summer months prior to manoomin seeding (Figure 18). The use of herbicides to control invasive plants within, or adjacent to, manoomin beds is generally not recommended. However, the SLREMRP acknowledges that herbicide applications are a management tool that could be useful in specific situations. The decision to use chemical control methods for invasive species should only be considered after a thorough evaluation of alternatives that includes conversations among the SLREMRP and community members. In general, the justification for vegetation management will need to be made on a case-by-case basis.

Vegetation removal was conducted in 2015 at Rask Bay, Duck Hunter Bay North, Duck Hunter Bay South, and North Bay with additional cutting at Walleye Alley Bay, Landslide Bay, Oliver-Bear Island, and Mud Lake in 2016 (Vogt 2023). Sites were seeded in the same year that vegetation was removed and manoomin seeds germinated the following spring. Aside from large-scale restoration work in areas like Radio Tower Bay and Kingsbury Bay, additional vegetation removal has not been implemented for the explicit purpose of enhancing manoomin habitat since that time. When implemented, vegetation removal should be followed with manoomin seeding during the same season to maximize the potential for manoomin establishment and reduce colonization by undesirable aquatic vegetation that may compete with, or exclude, manoomin.

Figure 18. Fond du Lac Band of Lake Superior Chippewa personnel operate a weed harvester to reduce vegetation density in the SLRE (image source: 1854 Treaty Authority).

With the appropriate application and permitting, vegetation removal could find utility in circumstances where invasive species such as narrow-leaf and hybrid cattail or

Eurasian watermilfoil threaten to encroach upon manoomin stands. Removal of invasive cattail could open suitable habitat for manoomin reestablishment. For example, cattail cutting conducted by LSRI in Allouez Bay demonstrated that after monotypic cattail patches were removed, manoomin seed in the sediment germinated and plants matured to produce seed (LSRI 2021). Where the seedbank is not as well developed, manoomin seeding should be incorporated into the restoration planning process at an early stage to facilitate manoomin establishment.

Manoomin Seeding

The availability of seed for restoration work varies each year based on growing conditions and harvesting efforts. This variability has influenced both seed prioritization and seed rate (i.e., the amount of seed distributed per acre). Seeding guidelines established by GLIFWC recommend a seeding rate of 50lbs/acre but acknowledges that heavier seeding rates may be advantageous in areas where herbivory pressure from Canada geese is high (David 2018). Initial seeding efforts in the SLRE followed GLIIFWC's seeding recommendations.

Manoomin seed was readily available during the first three years of active restoration (2015-2017; Figure 17) and seed was distributed over a broad area under the assumption that recommended seeding rates (~50lbs/acre) would be sufficient to facilitate manoomin recovery (David 2018). However, appreciable gains in manoomin density, acreage, and biomass did not occur during those initial efforts (Vogt 2023). After a difficult year for seed acquisition in 2018, the SLREMRP decided to focus reseeding efforts at a fewer number of sites rather than spreading program resources over a broader area. The seed rate increased in subsequent years (target: 200lbs/acre; average: ~120lbs/acre; Table 2) with strategic distribution of seed at sites where goose exclosures were being installed to protect manoomin plantings. Seed rates for priority restoration sites in the SLRE may be as high as 200lbs/acre to facilitate seed bank development. A comprehensive summary of manoomin seed distribution since 2015 is provided in Appendix D.

Table 2. Manoomin seed rates (lbs/acre) at restoration sites in the SLRE (data source: WDNR).

Year	Seed Rate (lbs/acre)
2015	67
2016	58
2017	52
2018	49
2019	94
2020	104
2021	123
2022	139
2023	205

Herbivory Management

The 2014 Rice Plan and earlier restoration work by FdL (Schwarzkopf 1999) anticipated the challenges that herbivory would pose for restoration success. Since that time, natural resource managers involved with the SLRE manoomin restoration effort have identified Canada goose herbivory as a significant impediment to the successful establishment of self-sustaining manoomin beds (Figure 19; Figure 20). Herbivory management is challenging in the SLRE due to the remote nature of some restoration sites and their spatial distribution throughout the upper reaches of the estuary while other sites are closer to urban

Figure 19. Manoomin stalks nipped by Canada geese (*Branta canadensis*) in the SLRE (image source: WDNR).

Figure 20. Herbivory exclosures are highly effective at reducing herbivory impacts to manoomin restoration in the SLRE. This North Bay exclosure successfully protected manoomin while herbivory pressure outside the exclosure remained high enough to impede seed formation on most plants (image source: WDNR).

development with suitable loafing, foraging, and nesting areas. The SLREMRP has implemented several non-lethal methods to deter geese from browsing manoomin plantings within the SLRE, including egg addling on the Wisconsin side of the river, hazing geese with kayak and dog activity, mylar tape deterrents, swan decoy placement, and fenced herbivory exclosures. None of these techniques, aside from herbivory exclosures, as resulted in a sufficient reduction in herbivory impacts to manoomin plantings.

Goose exclosures have proven highly effective (Figure 20) and have been implemented at a limited number of restoration sites since 2016 (Table 3). Exclosure size and construction has varied but are typically installed as a rectangular structure approximately 20x100ft, secured with wood or metal u-channel upright posts, and wrapped in plastic snow-fencing or woven wire fencing to exclude geese from manoomin seeding areas.

Table 3. Canada goose (*Branta canadensis*) exclosures installed to reduce herbivory impacts at manoomin restoration sites in the SLRE (data source: WDNR).

Year	# Exclosures	# Sites
2016	3	1
2018	2	1
2019	0	0
2020	8	1
2021	18	3
2022	37	6
2023	49	7

The number of exclosures has increased since 2020 and monitoring data has continued to confirm their effectiveness (Vogt 2023). Geese are unable to access manoomin inside of the exclosures leading to higher manoomin density inside exclosures despite, in many circumstances, substantial herbivory impacts to adjacent, unprotected manoomin (Figure 20). Observational data suggest that geese tend to avoid areas of dense emergent vegetation, preferring to browse around the edges of dense manoomin stands in the SLRE. In recent years, exclosures have been clustered together in a way that attempts to protect manoomin grown in between the exclosures, despite being freely accessible to geese. These observations indicate that there may be a protective effect beyond the area within the exclosure if they are installed as a cluster (Figure 21).

Figure 21. Canada goose (*Branta canadensis*) exclosures in North Duck Hunter Bay demonstrating rectangular exclosure design and clustered orientation to protect manoomin inside and between the exclosures (image source:1854 Treaty Authority).

The status of Canada geese within the SLRE is difficult to quantify although the impact their browsing is striking. A cooperative effort between the Lake Superior Research Institute, St. Croix Chippewa Indians of Wisconsin, and WDNR was initiated in 2018 to document Canada goose presence at manoomin restoration sites in the SLRE to better understand fluctuation in goose numbers throughout a complete growing season. Weekly aerial goose surveys were conducted by personnel from 1854 Treaty Authority from June through September (Vogt 2023). Results indicated that goose numbers in the SLRE peaked during mid-July, a time that coincides with the transition from manoomin's floating-leaf stage to its upright, standing stage (Figure 22).

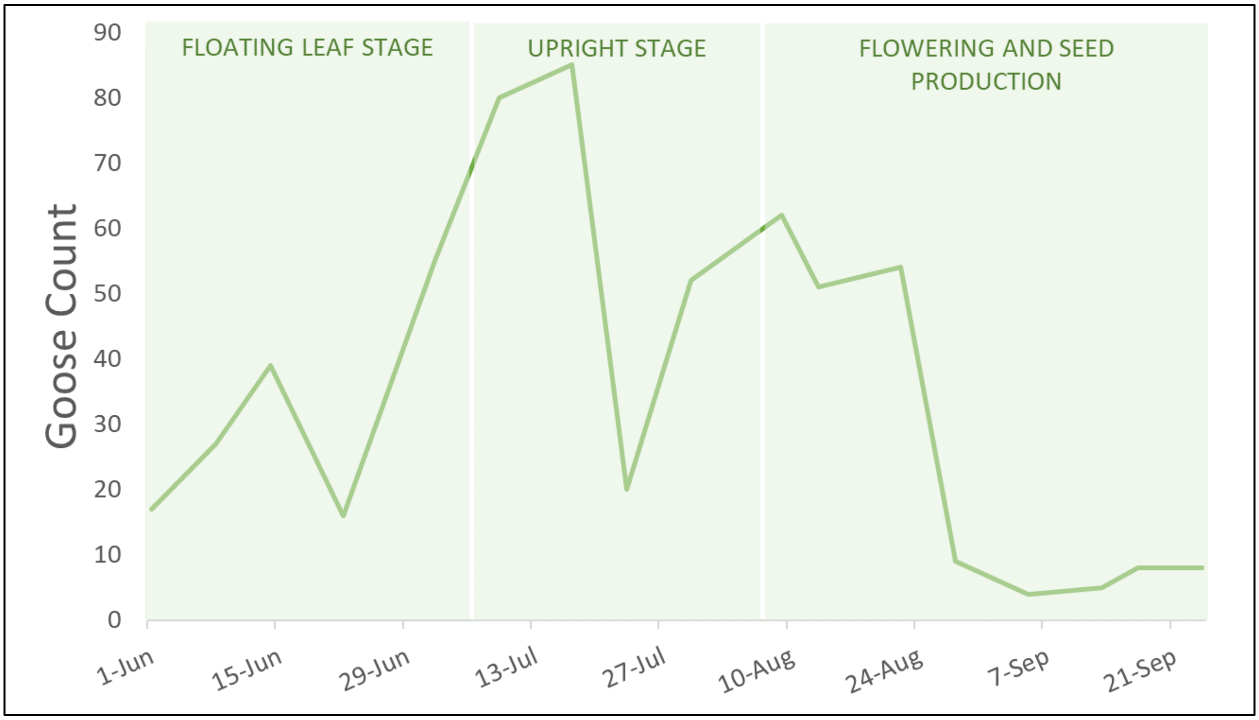

Figure 22. Aerial survey results from the weekly Canada goose (*Branta canadensis*) surveys conducted manoomin restoration sites in 2018 (data source: Vogt 2023). General manoomin growth stages, which vary slightly from year to year, are included for reference.

It should be noted that most of the geese observed in the SLRE during the molting period (i.e., late June/early July) occupy the more industrialized areas of the SLRE near the John A. Blatnik Memorial Bridge which crosses Superior Bay and St. Louis Bay connecting Duluth, MN with Superior, WI. The aggregation of geese in this part of the working harbor is likely connected to the availability of fugitive grain spilt during cargo loading at adjacent grain elevators. However, it is unlikely that geese occupying industrial areas travel to restoration sites to feed on manoomin given the availability of spilt grain adjacent to storage facilities where the largest aggregations of geese tend to occur. However, Canada goose movement patterns within the SLRE are not well understood and could be the focus of future research to better understand and inform goose management in the SLRE.

Although goose exclosures are an effective, non-lethal, means of reducing herbivory on manoomin, their application is limited in geographic scope, and it is not feasible to install exclosures throughout the SLRE where herbivory impacts are prevalent. However, exclosures are effective at protecting core restoration sites with areas of dense rice and increase the likelihood of a site becoming self-sustaining. Exclosures are labor and resource intensive to build, install, and remove and must also be regularly monitored to ensure barrier integrity since wind and wave action can snap upright posts and fencing.

Nevertheless, exclosures remain an important management tool for manoomin restoration work in the SLRE.

Another key herbivory management tool is the removal of Canada geese from manoomin restoration sites and nearby activity areas. Known as a goose "roundup", these removals are conducted in collaboration between the SLREMRP and the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) Wildlife Service. Roundups are implemented during the goose molting period (late June/early July) when most geese in the SLRE are unable to fly. Personnel in watercraft slowly herd the geese to a predetermined capture location where the birds are captured with portable panel nets by USDA personnel (Costanzo et al. 1995) and euthanized with CO_2 gas following methods for Canada goose euthanasia approved by the American Veterinary Medical Association.

Goose roundups conducted between 2021 and 2023 removed Canada geese from SLRE manoomin restoration sites and nearby waters with the specific goal of reducing herbivory at strategic locations in the SLRE (Table 4). These efforts demonstrated that Canada goose removal can be an effective tool for reducing herbivory on manoomin with detectable results during the growing season following a roundup. Allouez Bay, where geese were abundant in 2021, serves as an example of roundup success with manoomin density and biomass increasing in 2022 following removal in 2021 (Table 5). Although geese were present in Allouez Bay during the 2022 growing season, restoration personnel observed geese in low numbers (D. Grandmaison, WDNR, personal communication 2022). Monitoring results demonstrated that removals contributed to a 30% reduction in herbivory and improvements in manoomin density, average plant height, and biomass (Table 5).

Table 4. Canada goose (*Branta canadensis*) removals from manoomin restoration sites in the St. Louis River Estuary (data source: WDNR).

Year	WI	MN	Total
2021	187	0	187
2022	229	0	229
2023	249	300	549

Table 5. Manoomin monitoring results from Allouez Bay in the SLRE (data source: WDNR).

Year	Sign of Herbivory (% of plots)	Manoomin Density (stalks/0.5 m^2)	Average Plant Height (in)	Biomass (g/m^2)	Water Depth (in)
2021	88.9%	1.55	45.56	6.22	22.45
2022	67.7%	2.35	53.33	16.22	26.23
2023	78.9%	7.3	58.6	58.47	30.07

The 2022 goose roundup did not target geese in Allouez Bay given the low numbers of geese observed during pre-roundup surveys. Monitoring data collected in 2023 identified an increase in herbivory which may have been a result of increased Canada goose activity and a pair of trumpeter swans (*Cygnus buccinator*) that were regularly observed within, and adjacent to, manoomin restoration sites in Allouez Bay. Nevertheless, monitoring data indicated an increased in manoomin density and biomass during the 2023 growing season. Where present, herbivory was generally relegated to the low-density edges of the core manoomin patches within restoration areas.

It is likely that manoomin restoration sites near roundup locations will experience a greater reduction in herbivory than sites that are more distant to roundup locations. Annual monitoring efforts have begun to evaluate the prevalence of herbivory impacts at restoration sites to inform the development of an herbivory threshold. This threshold should provide a signal for determining when removals can be discontinued or reinstated, as needed, to protect manoomin plantings.

Herbivory management in the SLRE should continue to utilize lethal and non-lethal methods to control the impact of Canada geese, where herbivory negatively impacts restoration success. Furthermore, decisions on where and when to implement herbivory management tactics should continue to rely on monitoring data and the judgement of the SLREMRP to inform action. Revised indicators in the 2024 Manoomin Plan set a goal of developing data-driven herbivory and/or density thresholds that would signal the deployment of goose exclosures, implementation of goose roundups, and other actions designed to reduce herbivory impacts to manoomin plantings.

When implemented, Canada goose roundup planning should include the following elements:

- Permitting. State (Wisconsin and Minnesota) permits are required for goose removals and must be covered under U.S. Fish & Wildlife depredation permits and coordinated with U.S.D.A Wildlife Services. These agencies also require post-removal reporting. Copies of all permits should be on-site during roundup implementation.
- Landowner Coordination. Coordination with the cities of Superior and Duluth should be conducted during the permitting stage. When identifying specific locations to conduct captures, the landowner (federal, state, or private) should be contacted. A Work Initiation Document (WID) for Wildlife Damage Management (WS Form 12A) must be obtained prior to implementing capture operations at the

site. Copies of the WIDs should be available, on-site during roundup implementation.

- Communication. WDNR and MN DNR developed a set of talking points (Appendix E) for use in communicating the purpose and need for the roundup and the connection to improved success for manoomin restoration in the SLRE. This document should be consulted prior to landowner coordination and copies of the talking points should be held on-site in the event that they are needed for engaging the press or community members who inquire about the roundup.
- Law Enforcement Coordination. Law enforcement personnel from the cities of Superior and Duluth, and both Wisconsin and Minnesota DNRs should be contacted well in advance of the planned roundup. Requesting law enforcement presence during the roundup is highly recommended.
- Disposition. It is important to implement goose roundups in the best possible way. Goose carcasses should be disposed of responsibly and respectfully. When possible euthanized geese should be utilized locally. Outlets for the carcasses have included the Lake Superior Zoo, local landfills, and local food shelves. Contaminant testing must follow state guidelines prior to goose meat being donated for human consumption (Appendix F).

When combined with exclosures, goose removal is an effective means of reducing herbivory pressure to increase restoration success. Monitoring data indicate that goose exclosures protect manoomin and reduce herbivory regardless of goose numbers. However, goose removal has the potential to reduce herbivory impacts at sites with and without the benefit of exclosures. For example, monitoring data were aggregated across sites to compare the prevalence of goose herbivory at restoration sites where exclosures were not installed with restoration sites where exclosures were installed from 2018 to 2023 (Figure 23). The prevalence of herbivory was high in 2018, 2020, and 2021. Sites where exclosures were installed generally experienced lower herbivory pressure. In 2022 and 2023 there was a decrease in herbivory at sites with, and without, herbivory exclosures. This decrease in herbivory suggests that goose roundups benefitted all sites regardless of whether exclosures were present.

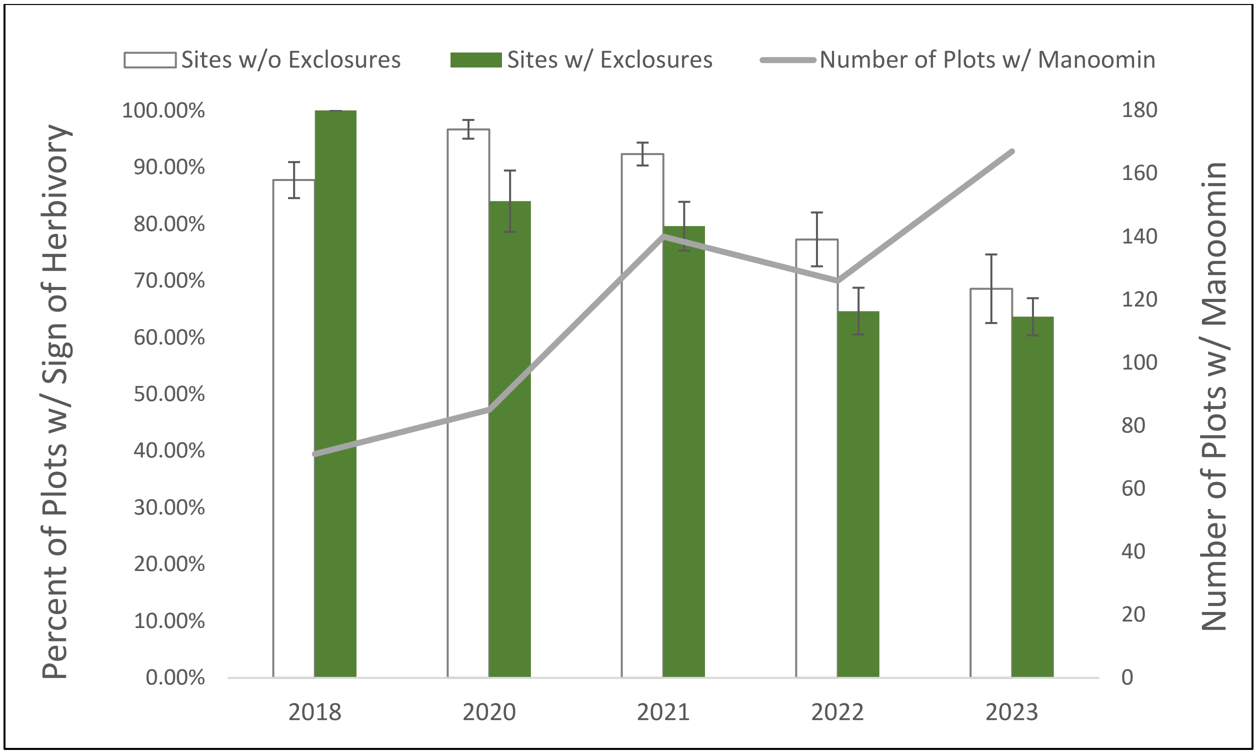

Figure 23. Comparison of herbivory pressure (i.e., percentage of plots browsed ± standard error) at manoomin restoration sites in the SLRE where herbivory exclosures were present and absent. Data compiled from annual monitoring data at sites where exclosures were installed to deter goose herbivory and sites where exclosures were absent. This analysis is limited to monitoring plots where manoomin was detected inside the plot (n = 422) and omits plots located within exclosures. Data from 2019 are omitted because herbivory exclosures were not installed during the 2019 growing season (data source: 1854 Treaty Authority).

Effectiveness Monitoring

Manoomin restoration in the SLRE is supported by long-term monitoring data that is collected annually by the 1854 Treaty Authority (Vogt 2023). This important element of the MRSM provides the SLREMRP with a means of tracking progress towards restoration goals and objectives. The protocols used follow those outlined in Kjerland (2015a, 2015b) and have been invaluable for evaluating the effectiveness of restoration techniques and in making decisions for modifications to techniques, when necessary.

This 2024 Manoomin Plan recommends continuing the current monitoring program to inform future restoration and stewardship actions. The plan also recommends that the following monitoring plan elements be pursued as part of a long-term monitoring and maintenance plan:

- Develop and implement a protocol for annual manoomin acreage estimation that may include aerial and/or remote sensing imagery analysis.
- Develop density and/or herbivory thresholds for signaling restoration and stewardship actions (e.g., seeding prioritization and herbivory management).

Cultural & Community Connection

The 2014 Rice Plan provided guidance for community outreach programming that included developing educational materials and creating opportunities to engage school and community groups in small-scale projects to build community support for manoomin restoration in the SLRE (MNDNR 2014). To this end, GLRI funding has supported an annual community seeding event at Clough Island (2015-2020) and Kingsbury Bay (2021-2023) led by the St. Louis River Alliance (SLRA; Figure 24). The goal of this event is to increase public awareness of manoomin restoration and stewardship in the SLRE and provide an opportunity for direct community involvement in the restoration effort.

Figure 24. Volunteers with the St. Louis River Alliance distribute manoomin in Kingsbury Bay (image source: St. Louis River Alliance).

The SLRA seeding event incorporates educational content covering the ecological and cultural significance of manoomin to tribal and non-tribal community members and typically includes members of the Fond du Lac Band of Lake Superior Chippewa and WDNR who provide cultural and ecological context for the event. Specifically, the program content includes:

- The ecological importance of manoomin and its connection to fish and wildlife habitat,
- The cultural significance of manoomin to Ojibwe community members,
- The history of manoomin in the SLRE, including its decline and links to the industrialization of the SLRE, and
- Past and current manoomin restoration efforts and progress.

The 1854 Treaty Authority hosted a rice camp at Chambers Grove Park in Duluth, MN during the week of September 11–15, 2023, to provide a participatory learning experience for local school groups (Figure 25). Camp facilitators, which included

Figure 25. Manoomin camp facilitators introduce local school children to manoomin (image source:1854 Treaty Authority).

members of the SLREMRP, provided information on the cultural context of manoomin harvest by incorporating the ceremonial offering of *asema* (i.e., tobacco) to show gratitude for the more-than-human relatives involved in manoomin stewardship, ask for safe passage on the water, and welcome manoomin back to the SLRE. Students and facilitators paddled into the manoomin restoration site at Rask Bay where they practiced push-pole and rice knocking techniques. Participants were also guided through the traditional finishing process. More than 500 students participated in the camp and plans are underway to establish an annual rice camp, as resources allow. One of the days was set aside to provide natural resource practitioners with an opportunity to improve their connection to, and understanding of, the cultural importance of manoomin.

In addition to the community seeding event led by the SLRA and rice camp led by the 1854 Treaty Authority, manoomin interpretive signs have been deployed at five water access points and/or high-traffic locations in the SLRE on the Wisconsin and Minnesota sides of the river (Figure 26).

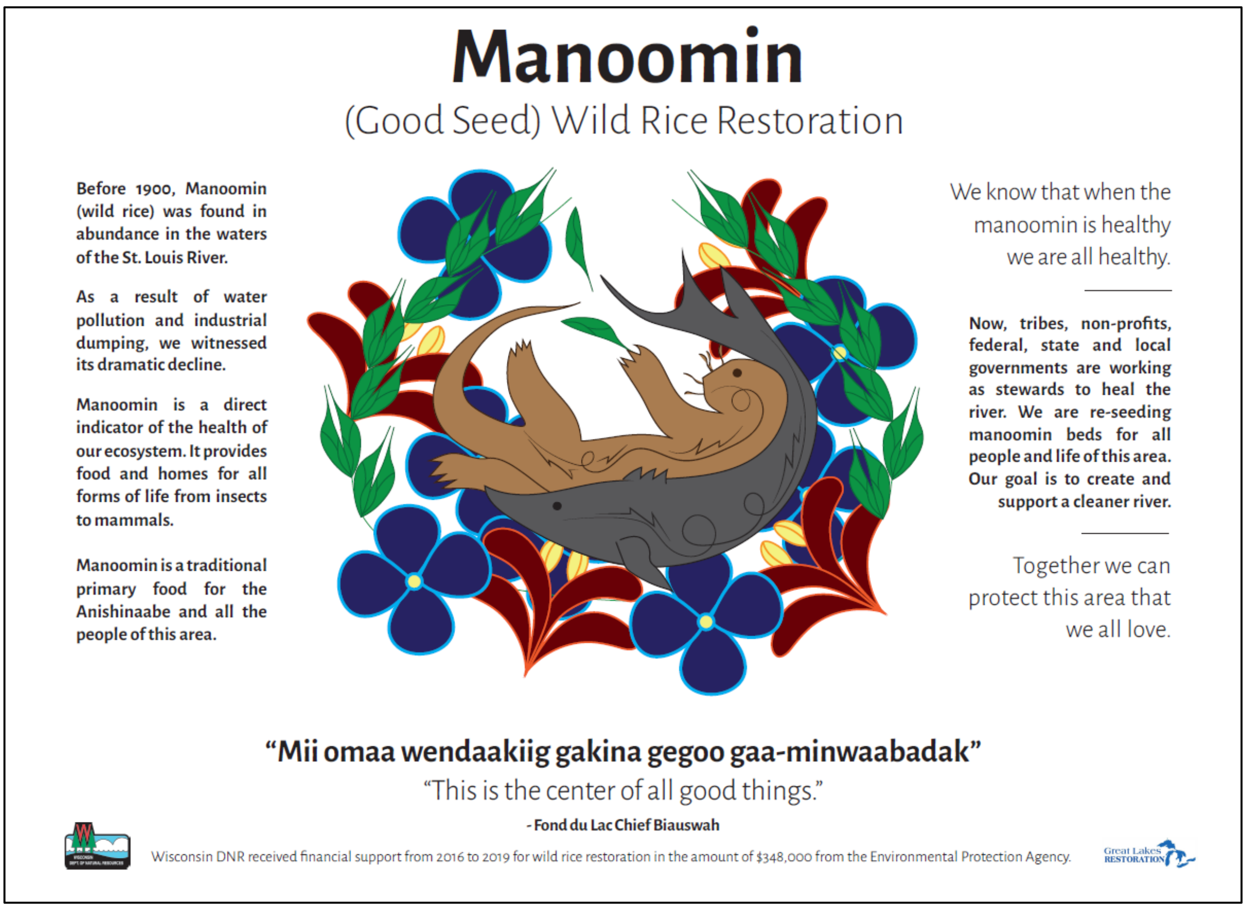

Figure 26. Manoomin informational sign installed at high traffic locations in the SLRE.

The locations of these interpretive signs include:

1. Chamber's Grove Park – Duluth, MN
2. Boy Scout Landing – Duluth, MN
3. Oliver Landing – Oliver, WI
4. Pokegama Bay Landing – Superior, WI
5. Arrowhead Landing – Superior, WI
6. Wisconsin Point – Superior, WI

Additional locations could be considered for educational signage as restoration efforts continue. Potential locations include the Perch Lake fishing pier, Munger Landing, the River West development near Tallas Island, and Kingsbury Bay in Duluth, MN and Mont du Lac Marina and Bungee Dock in Superior, WI.

Additional projects connected to manoomin restoration include an informational video published in 2020 and a mural painted by local artist Adam Swanson in 2021 (Figure 27). The WNDR video about SLRE manoomin restoration was developed in collaboration with personnel from the Lac Courte Oreilles and Fond du Lac bands of

Figure 27. Adam Swanson's "Water Science Manoomin" mural in Duluth's Lincoln Park neighborhood (image credit: Adam Swanson).

Lake Superior Chippewa, LSNERR, SLRA, and other partners to highlight the cultural and ecological significance of the SLRE manoomin restoration effort. The video can be found here. The mural, funded through a grant from the Minnesota State Arts Board and installed in Duluth's Lincoln Park neighborhood, bridges the art and science manoomin restoration. An event to celebrate the mural included a presentation on the cultural significance of manoomin to the Anishinaabe community by FdL Natural Resources Program Manager, Thomas Howes. Information about manoomin restoration can also be found on the SLRAOC's online story map and the WDNR fact sheet. Both of these resources can be accessed online using this link.

Section 3: Manoomin Stewardship

Harvester Participation & Recruitment

Ricing is an important part of the long-term stewardship commitment required to ensure that future generations have a relationship with manoomin (Figure 28). Maintaining and recruiting manoomin harvesters is an important part of restoration and stewardship success. Harvesters support expanding manoomin restoration programs, advocate for funding stewardship activities, and aid in expanding education and outreach to raise awareness about the ecological and cultural values of manoomin (Davenport et al. 2020). Declining harvester recruitment and retention has the potential to impact the sustainability of manoomin restoration and stewardship resources and erode public support for manoomin restoration, protection, and management (MNDNR 2008, Drewes and Silbernagel 2012).

Knowledge holders within the manoomin harvesting community are an important source of information regarding current and historical manoomin productivity and serve as a key link between manoomin and members of the community who seek manoomin for food, ceremony, and medicine but are unable to harvest manoomin themselves. Manoomin harvest is an act of reverence and stewardship and there is ample anecdotal evidence that indicates a history of intentional manoomin seeding to maintain stand diversity and harvest opportunity across the region (Vennum 1988). Effective stewardship requires a holistic program that includes sharing the importance of healthy relationships with manoomin and teaching people how to respect, protect, harvest, and prepare manoomin as well as the participation in ceremony that honors the human connection to manoomin and other more-than-human entities that contribute to ecological integrity (Whyte 2013).

Figure 28. A pair of manoomin harvesters pole through a dense stand of manoomin on a Minnesota lake (image source: 1854 Treaty Authority).

Manoomin Restoration & Stewardship Indicators

It is important to begin by acknowledging that the core intent of manoomin restoration and stewardship in the SLRE is to improve habitat conditions and facilitate natural cycles of manoomin production to support human and more-than-human community members that care for, and benefit from, manoomin. There is no single set of quantitative metrics – including acreage, occupancy, or biomass – that will adequately assess holistic progress towards returning manoomin to the SLRE. While useful for evaluating trends in restoration progress, these traditional metrics are limited when it comes to evaluating the status of manoomin due to the annual variability in germination and productivity that reflects the natural pattern of manoomin growth. Restoration and stewardship require a long-term commitment and the inclusion of additional indicators that incorporate culturally relevant aspects of community engagement and participation.

The 2024 Manoomin Plan refines existing quantitative indicators from the 2014 Rice Plan and establishes a set of qualitative indicators of restoration progress and stewardship effort. Taken together, these indicators of progress help to evaluate the status of restoration and stewardship and provide a means of understanding overall trends. Indicators of progress are milestones for manoomin recovery in the SLRE and contain specificity to allow for unbiased evaluation of progress. These indicators should not be viewed as hardened boundaries between failure and success but, rather, aspirational and motivational milestones for short-, mid-, and long-term restoration and stewardship efforts. Continued monitoring will inform restoration and stewardship action and provide a foundation for a long-term stewardship ethic needed to ensure that manoomin can once again thrive in the SLRE.

The following manoomin stewardship indicators build upon the foundation for manoomin restoration established in the 2014 Rice Plan which established progressive quantitative measures of restoration success, specifically density and acreage targets. These indicators expand to incorporate qualitative measures of success adapted from the Lake Superior Cultural and Ecosystem Characterization Study (Hosterman et al. 2023), and concepts developed during the Dibaginjigaadeg Anishinaabe Ezhitwaad: A Tribal Adaptation Menu workshop attended by members of the SLREMRP in June 2022 (Tribal Adaptation Menu Team 2019).

The quantitative and qualitative indicators outlined below guide manoomin stewardship in the SLRE and allow for adaptability as new information is shared by knowledge holders and additional ways of understanding our relationship with manoomin emerge through ceremony and collaborative, community stewardship engagement.

Manoomin Restoration Model Goal & Objectives

The MRSM (Figure 28; Appendix A) represents an updated approach to furthering restoration progress in the SLRE that builds on the foundation provided by the 2014 Rice Plan and incorporates lessons from Indigenous knowledge holders and experience gained from restoration work in the SLRE. A wealth of insight and information shared through dialogue with tribal community members has provided key Native Experiential Knowledge and Traditional Ecological Knowledge to inform the development of the MRSM goals, objectives, tactics, and metrics (Figure 29; Appendix A).

The MRSM identifies the following restoration goal for manoomin restoration in the SLRE:

> *Increase the abundance and distribution of self-sustaining manoomin within the St. Louis River Estuary to increase opportunities for culturally important harvest, improve fish and wildlife habitat, and enhance Manoomin's resilience for long-term persistence.*

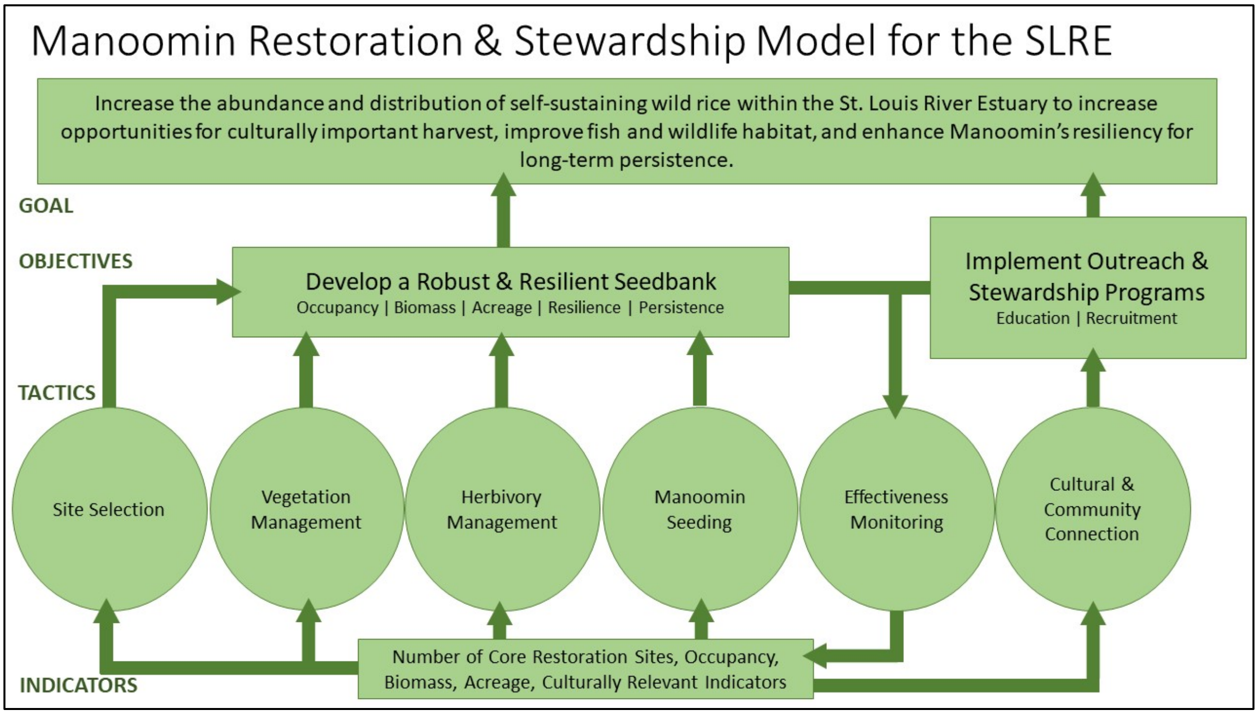

Figure 29. The Manoomin Restoration & Stewardship Model developed for the 2024 SLRE Manoomin Restoration & Stewardship Plan.

Increasing the abundance and distribution of manoomin in the SLRE will provide benefits to the human community by facilitating engagement with, and access to, manoomin stewardship opportunities that include respectful harvest. Restoring manoomin to areas where it once thrived will help ensure that the treaty rights retained by the Ojibwe to hunt, fish, and gather within the ceded territories are protected, preserved, and enhanced for the benefit of present and future tribal members.

Manoomin stewardship in the SLRE will also improve habitat for the benthic organisms, fish, and wildlife that depend on it. Establishing self-sustaining manoomin will directly contribute to the removal of the SLRAOC's BUI 9 by contributing to or completing Management Actions 9.08, 9.11 and 9.21. The short-term restoration and stewardship timelines established in this plan support the completion of these Management Actions and removal of BUI 9. However, the SLREMRP also acknowledges that manoomin stewardship is a long-term endeavor that will continue beyond SLRAOC's delisting. This plan specifies and defines steps towards completion of SLRAOC-focused management actions as well as the framework for achieving long-term restoration and stewardship goals.

The objectives for manoomin restoration and stewardship in the SLRE include:

1. Developing a robust and resilient manoomin seedbank, and
2. Implementing manoomin outreach and stewardship programs in the community.

Robust & Resilient Seedbank

Inter-annual manoomin growth patterns include low productivity years as natural components of manoomin ecology. Seed production during a good growing season and storage of seed in sediments during a poor growing season allows for stand maintenance during subsequent growing seasons when conditions improve. Developing a robust seedbank that promotes manoomin resiliency in the face of changing environmental conditions is a key objective of this restoration effort.

Manoomin seedbanks are inherently robust and resilient to changing conditions, yet environmental fluctuations outside of the historic range of variability have the potential to degrade conditions that support the natural intra-annual pattern of growth and productivity. Water depth and nutrient dynamics, as previously discussed, fluctuate over time and can result in growing seasons where manoomin thrives and growing seasons where manoomin rests. However, more frequent and dramatic changes in water levels and periods of drought have become more common as human-induced climate change modifies natural weather patterns and the hydrogeography of lakes, rivers, and estuaries. A robust and resilient seedbank will ensure that manoomin can flourish when conditions are conducive to germination, pollination, and seed development while resting when conditions are unsuitable. Manoomin resiliency requires a stewardship program that facilitates seed production during suitable growing seasons and maintains stewardship momentum with supplemental seeding efforts during less productive seasons to enhance manoomin's long-term persistence in the face of climate change impacts.

Developing and maintaining a robust and resilient seedbank is a long-term stewardship commitment that will require ongoing monitoring and evaluation. A systematic approach to monitoring and evaluating seedbank resiliency has not yet been developed but is included in the list of Research & Monitoring Needs that will support efforts to assess seed density and viability. Indirect measures of seedbank status can be inferred from continued annual monitoring until those studies are implemented. Manoomin biomass, occupancy, and acreage indicators provide a proxy for seedbank resiliency with measurements taken during seasons that follow a year of low seed production being particularly informative.

Outreach & Stewardship Programs

Implementing meaningful outreach and stewardship programs in the community requires thoughtful planning with members of the community who will be involved. Development and implementation of outreach and stewardship programming will rely on developing relationships and building a dialogue with tribal community members to determine the desired outcome of stewardship programming. The process by which these programs are developed and implemented are themselves part of the culturally relevant progress indicators for manoomin stewardship in the short-, medium-, and long-term timeframes. Successful outreach will require that the SLREMRP consult cultural leaders, knowledge holders, key community members, and elders to consider and honor cultural practices important to building community around manoomin stewardship.

Partners like the 1854 Treaty Authority, SLRA, LSNERR, and others have existing outreach and education programming that includes manoomin-related content. The SLREMRP should support on-going programs and help expand their implementation locally in the communities that border the SLRE as well as regionally where the seed for manoomin restoration partnerships can be developed. Programs focused on educating the community about the cultural and ecological importance of manoomin and recruiting new participants in the traditional techniques of harvesting manoomin should be prioritized (Figure 30). Future generations of manoomin stewards will come from these educated and participatory communities. In the words of tribal elder, Ricky DeFoe from the Fond du Lac Band of Lake Superior Chippewa, "*to be a champion, you must be among the champions*" (Ricky DeFoe, FdL,

Figure 30. Manoomin seed harvested for restoration in the SLRE (image source: D. Grandmaison).

Manoomin·Psíŋ Knowledge Symposium 2023).

Indicators of Progress and Stewardship Actions

Indicators of progress are quantitative and qualitative milestones that assess manoomin restoration and stewardship progress in the SLRE. These indicators relate to the number of core restoration sites where manoomin has been re-established by evaluating manoomin occupancy, biomass, and acreage at those sites with implementation of outreach and stewardship programming to support future stewardship. MRSM indicators have been developed to guide short-, medium-, and long-term progress. These three timeframes allow for incremental restoration progress while identifying specific tasks required to transition from restoration to stewardship. Incorporating an explicit long-term timeframe also highlights the long-term stewardship commitment needed to fully heal our relationship with manoomin in the SLRE.

Box 1: Indicator Terminology

- Core Restoration Site – site where the MRM is fully implemented
- Occupancy Indicator – manoomin is present in ≥ 50% of sampling plots within a site
- Biomass Indicator – manoomin biomass meeting of exceeding 100 g/m^2 (short-term indicator) and 150 g/m^2 (mid-term indicator)
- Self-Sustaining – sites that do not require annual seeding and/or herbivory management

Each set of MRSM restoration indicators includes defined Indicators of Progress and a list of Actions to Complete. Indicators of Progress serve as milestones for restoration success that incorporate incremental increases in the number of core restoration sites that meet manoomin occupancy and biomass indicators and the total acreage of restored and enhanced manoomin across restoration sites (Box 1). Actions to Complete represent important tasks that should be accomplished within designated timeframes to further the restoration effort.

St. Louis River Area of Concern Indicator

The SLRAOC program has contributed substantial resources and support for manoomin restoration in the SLRE but the need for restoration and stewardship will continue well beyond BUI 9 removal and SLRAOC delisting, tentatively planned for 2027 and 2030, respectively. During the 2024 Manoomin Plan update process, the SLREMRP determined that an updated SLRAOC indicator was needed to define when SLRAOC Management Actions 9.08, 9.11 and 9.21 are complete.

The SLREMRP refined the SLRAOC indicator to acknowledge that the SLRAOC program will:

> *Implement the SLRE Manoomin Restoration Model through 2026 – striving to meet the short-term indicators of progress – with the understanding that natural variability in biotic and abiotic conditions may impact occupancy, biomass, and acreage indicators during that timeframe.*

The SLRAOC efforts are a steppingstone to long-term manoomin stewardship in the SLRE. Furthermore, this updated SLRAOC indicator acknowledges that manoomin restoration will extend beyond the responsibility of the SLRAOC program.

Short-Term Indicators of Progress

The MRSM defines short-term indicators of progress as meaningful milestones that can be accomplished by the end of 2026, understanding the presence of uncontrollable variability in environmental conditions and manoomin growth patterns that may influence restoration progress. Members of the SLREMRP share a wealth of knowledge and experience related to manoomin restoration and appreciate that variability in manoomin recovery can arise from factors outside the control of the SLREMRP that are not a reflection of restoration effort. Short-term progress also includes a set of actions that should be accomplished within the designated timeframe to prepare for future restoration and stewardship after the SLRAOC is delisted.

Indicators of Progress (Short-Term):

1. Three core restoration sites that meet manoomin occupancy and biomass indicators in four out of the last seven years (through 2026).
    a. Occupancy Indicator: manoomin present in ≥50% of survey plots within a core restoration site.
    b. Biomass Indicator: manoomin biomass ≥100g/m^2 at each core restoration site.
2. At least 30 acres of restored and enhanced manoomin across restoration sites, with restored and enhanced defined as sites that meet both the occupancy and biomass indicators (see Box 1).

Actions to Complete (Short-Term):

1. Continue MRSM implementation (e.g., herbivory management, seeding, monitoring, contribution to outreach, education, and community engagement).
2. Develop education, outreach, and community engagement metrics and strategies.
3. Develop and implement a protocol for annual manoomin acreage estimation.
4. Develop a long-term monitoring and maintenance plan for the SLRE.

Mid-Term Indicators of Progress

Mid-term progress includes aspirational milestones and actions that are expected to be completed between 2027 and the end of 2032. These indicators expand the number of core restoration sites and acreage of restored or enhanced manoomin beds in the SLRE and increased manoomin biomass as a desired condition. Mid-term progress also specifies crucial actions that need to be accomplished to ensure progress is made towards reaching the broader objectives.

Indicators of Progress (Mid-Term):

1. Six core restoration sites that meet manoomin occupancy and biomass indicators in four out of the last seven years.
    a. Occupancy Indicator: manoomin present in ≥50% of survey plots within a core restoration site.
    a. Biomass Indicator: manoomin biomass ≥150g/m^2 at each core restoration site.
2. At least 60 acres of restored or enhanced manoomin across restoration sites, with restored and enhanced defined as sites that meet both the occupancy and biomass indicators (see Box 1).

Actions to Complete (Mid-Term):

1. Continue MRSM implementation.
2. Continue to implement the long-term monitoring and maintenance plan.
3. Implement annual outreach and stewardship programs with partners.
4. Complete development of density and/or herbivory thresholds that signal when restoration and stewardship actions are needed.

5. Secure funding, develop sampling design, and implement study to evaluate manoomin toxicity levels and consumption risk.

Long-Term Indicators of Progress

Long-term indicators of progress begin in 2033 but are temporally unbounded to acknowledge that manoomin stewardship is a long-term commitment that doesn't end once short- and mid-term indicators are met or exceeded. Future monitoring data will continue to serve as the foundation for stewardship actions with well-defined management thresholds (e.g., density and/or herbivory thresholds) developed to guide management action (e.g., seeding, herbivory management, etc.).

Indicators of Progress (Long-Term):

1. At least 500 acres of self-sustaining manoomin beds in the SLRE.
2. At least one healthy, harvestable stand of manoomin greater than 50 acres in size.
3. Additional core restoration sites established where suitable habitat is present in the SLRE.
4. Manoomin in the SLRE contributes to community relationships and offers education opportunities.

Actions to Complete (Long-Term):

1. Continue MRSM implementation.
2. Implement outreach and stewardship programs with partners.
3. Develop and implement a process to characterize community feedback on restoration progress (e.g., stewardship scorecard).
4. Revise and update the 2024 Manoomin Restoration & Stewardship Plan as determined by the SLREMRP.

Stewardship Thresholds

This section seeks to establish preliminary stewardship thresholds within an adaptive management framework that incorporates what we know about the challenges facing successful restoration and long-term stewardship in the SLRE. In this case, stewardship thresholds refer to levels of manoomin density and/or goose herbivory, that elicit one or more predetermined stewardship actions. For example, the manoomin density metric in the 2014 Rice Plan was established to gauge restoration success at the site-level (i.e., 1 stalk/0.5m^2 in ≥ 50% of suitable sampling plots at a site).

The implication of this restoration metric, under the 2014 Rice Plan, was that once the target was met in in three of the last five years, the site was “restored” (MNDNR 2014). The reality is that there is inherent variability in manoomin’s response to growing conditions and other influences on manoomin density such as goose herbivory that will affect restoration progress over time and that stewardship commitments will include future seeding and herbivory management actions if the condition of a site changes. The question becomes, when should management actions be implemented to improve density and/or reduce herbivory? Stewardship thresholds will serve to guide these decisions.

Importance of Continued Monitoring

Implicit in the development of stewardship threshold is the continued monitoring that provide the data needed to make stewardship decisions. Monitoring should continue to track manoomin density and biomass and should incorporate a standardized methodology for tracking herbivory pressure. In general, high levels of grazing by Canada geese reduces manoomin productivity. Although herbivory impacts are thought to wane as manoomin density increases, a density threshold at which manoomin becomes resilient to the impacts of herbivory has not been established. Research and continued monitoring may help elucidate whether a density threshold exists and help to determine when management actions are needed to reduce herbivory pressure.

Manoomin Occupancy Indicator for Seed Prioritization

The 2024 Manoomin Plan reviewed the 2014 Rice Plan success criteria which included a manoomin density target of greater than 1 stem/0.5 m^2 in ≥ 50% of the sampling plots within the defined site in three of every five years. The 2014 Rice Plan suggested that this density target represented a minimum stand density to support the intended fish and wildlife habitat benefits although the contribution of low density stands to long-term persistence was not considered (MNDNR 2014).

The SLREMRP discussed the 2014 Rice Plan density metric and reframed it as an occupancy indicator of progress. With this understanding, the occupancy indicator is met when ≥50% of the survey plots within a core restoration site are occupied by ≥1 manoomin stalk. This occupancy indicator will serve as an indicator of restoration progress and play a role in the seed prioritization decision-making process. Monitoring data collected at the end of the growing season will inform seed prioritization decisions during the following season.

- Core restoration sites where the MRSM is fully implemented should be seeded every year that seed is available when the site falls below the manoomin occupancy indicator during the previous growing season.
- Seeding should continue at core restoration sites that have met the manoomin occupancy indicator to build up the seedbank prior to redistributing seed resources to other sites. Seeding is recommended for a minimum of four years.
- Seeding may be discontinued at a core restoration site once the site has met the manoomin occupancy indicator during four of the last seven years and the site has been seeded for a minimum of four years.
- Seeding should be re-initiated at a core restoration site if the site falls below the manoomin occupancy indicator during at least four of the past seven years.

The manoomin occupancy indicator was used to develop the SLRE Manoomin Stewardship Seed Prioritization Decision Support Tool in Appendix C. This tool serves as a starting point for decisions regarding the distribution of manoomin seed and should contribute to, rather than supplant, the discussions that the SLREMRP has each season to determine seed prioritization.

Herbivory Impact Threshold

Determining whether the size of manoomin beds (i.e., manoomin acreage) and manoomin density influence Canada goose herbivory is a primary research need addressed in the next section. Until a patch size and density threshold are determined, a flexible target is needed to aid the SLREMRP decision to implement herbivory management actions such as goose exclosures and/or removal. Obtaining an estimate of goose numbers using a systematic aerial survey protocol on an annual basis could help identify the potential herbivory pressure. This approach could yield estimates of goose abundance within the SLRE with some level of inference to manoomin restoration sites. However, annual goose surveys are costly, must account for variability in goose detection, and do not provide a direct means of evaluating herbivory impacts at specific locations. Geese are highly mobile and not all geese within the SLRE have a negative impact on manoomin.

A site-specific method for evaluating goose impacts allows for site-specific decisions regarding exclosure deployment and removal prioritization. To our knowledge, there is no documented level of herbivory below which manoomin can withstand impacts and produce enough seed to replenish the seedbank. Similarly, it is unclear the optimal patch size or manoomin density beyond which herbivory impacts are inconsequential to manoomin persistence. The SLREMRP has recommended these information needs be addressed as funding allows. In the meantime, however, SLRE manoomin monitoring data can provide some insights on the selection of interim herbivory thresholds.

Duck Hunter Bay North is a core restoration site where the MRSM has been fully implemented. The site has been seeded each season since 2015 when seed was available for restoration (Vogt 2023). Goose exclosures have been consistently deployed in the bay since 2018 to protect seeding areas and monitoring data suggests that as herbivory pressure is declines, manoomin is recovering (Figure 31).

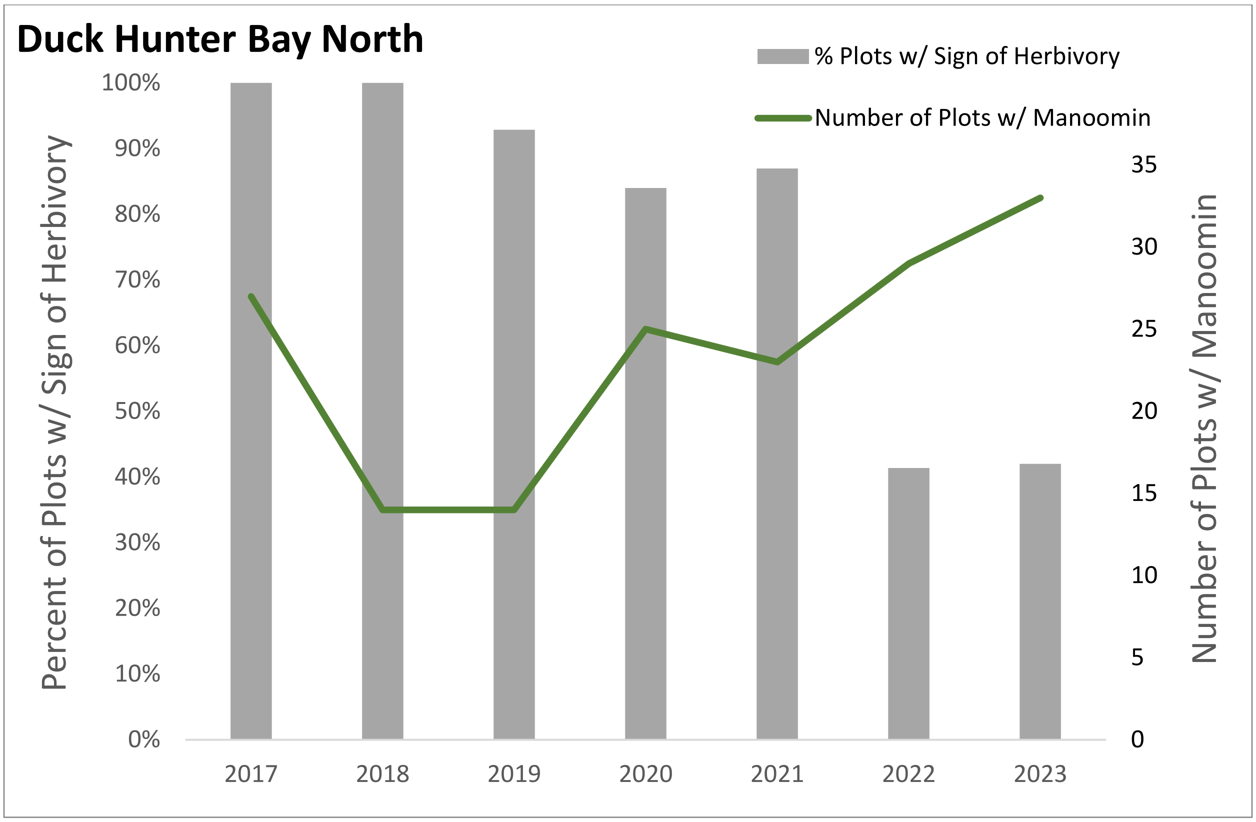

Figure 31. Levels of Canada goose herbivory and manoomin recovery in Duck Hunter Bay North (data source: 1854 Treaty Authority).

In 2022, the percentage of monitoring plots with evidence of manoomin herbivory dropped to 41% while the number of monitoring plots occupied by manoomin increased. Although there are other variables influencing manoomin recovery, protection from herbivory seems to be contributing to recovery at restoration sites where the MRSM is being implemented. In terms of herbivory impact thresholds, 40% may be a reasonable interim target. Further monitoring and research combined with a robust analysis of monitoring data are needed to determine whether an ecologically relevant threshold exists and, if so, identify what the threshold is. Core restoration sites should include herbivory management actions that reduce the impact of Canada goose herbivory including, but not limited to, Canada goose exclosures and goose removal. Applicable permits must be obtained and maintained by the project manager(s) to authorize implementation.

Manoomin Research Needs

Despite the long-standing relationship that humans have with manoomin, and the extensive body of Indigenous and Western scientific knowledge applied to manoomin restoration and stewardship, questions regarding the long-term persistence of this manoomin continue to remain unanswered. Addressing manoomin research questions requires that both Indigenous and Western ways of knowing be brought together in a respectful manner.

Respectful Manoomin research is rooted in working with tribes and Indigenous Peoples by developing and nurturing mutually beneficial relationships. These mutually beneficial relationships are developed by acknowledging and affirming the rights of Indigenous Peoples to control data about themselves, their land, and their resources. Relationships are furthered by direct collaboration with tribes in full partnership and in all aspects of the research endeavor from the outset of project development. This includes (but is not limited to) free and prior informed consent and decisions related to research priorities, question development, the extent of inclusion and application of Indigenous Knowledge, decision making, and direct support to tribes to fully participate in engagement processes (Matson et al. 2021).

The SLREMRP has identified a list of research questions that will further inform MRSM implementation in the SLRE. These questions include:

1. Seed Dormancy: How long can manoomin seed remain viable in SLRE sediments? What factors influence seed viability and, by extension, seedbank resilience?
2. Seedbank Resiliency: What is the most effective means of evaluating seedbank resiliency? What ecological factors impact seedbank resiliency?
3. Herbivory Pressure: At what density and/or patch size is manoomin resilient to herbivory pressure? Is there a herbivory threshold below which manoomin can withstand herbivory?
4. Human Consumption: Is manoomin harvested from the SLRE safe for human consumption?

5. Harvester Recruitment: What are the most effective methods for engaging tribal and non-tribal community members in manoomin stewardship?
6. Monitoring: What technique(s) (e.g., aerial imagery and remote sensing data) are most effective for estimating restored stand acreage?

Closing Statement

In conclusion, the 2024 Manoomin Stewardship & Restoration Plan presents a flexible, long-term, and culturally relevant restoration model that addresses emerging challenges to manoomin restoration in the SLRE, namely building resiliency in the face of growing threats from climate change. The short-, mid-, and long-term indicators of restoration progress will guide restoration and stewardship actions. Data-driven management thresholds will inform management decisions and identify important information needs associated with continued manoomin restoration in the SLRE. A summary of the 2024 Manoomin Plan is presented in Appendix G for quick reference.

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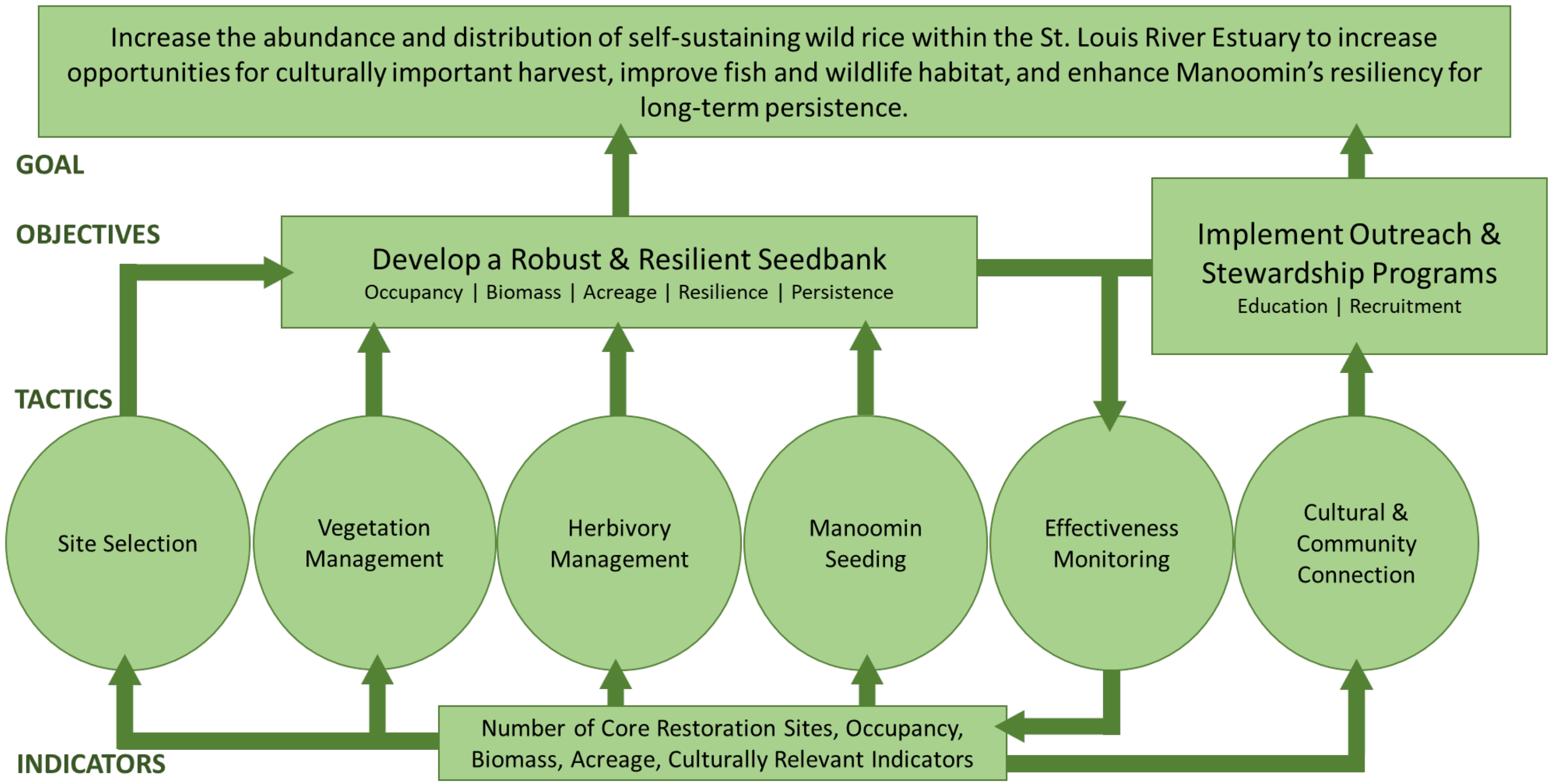
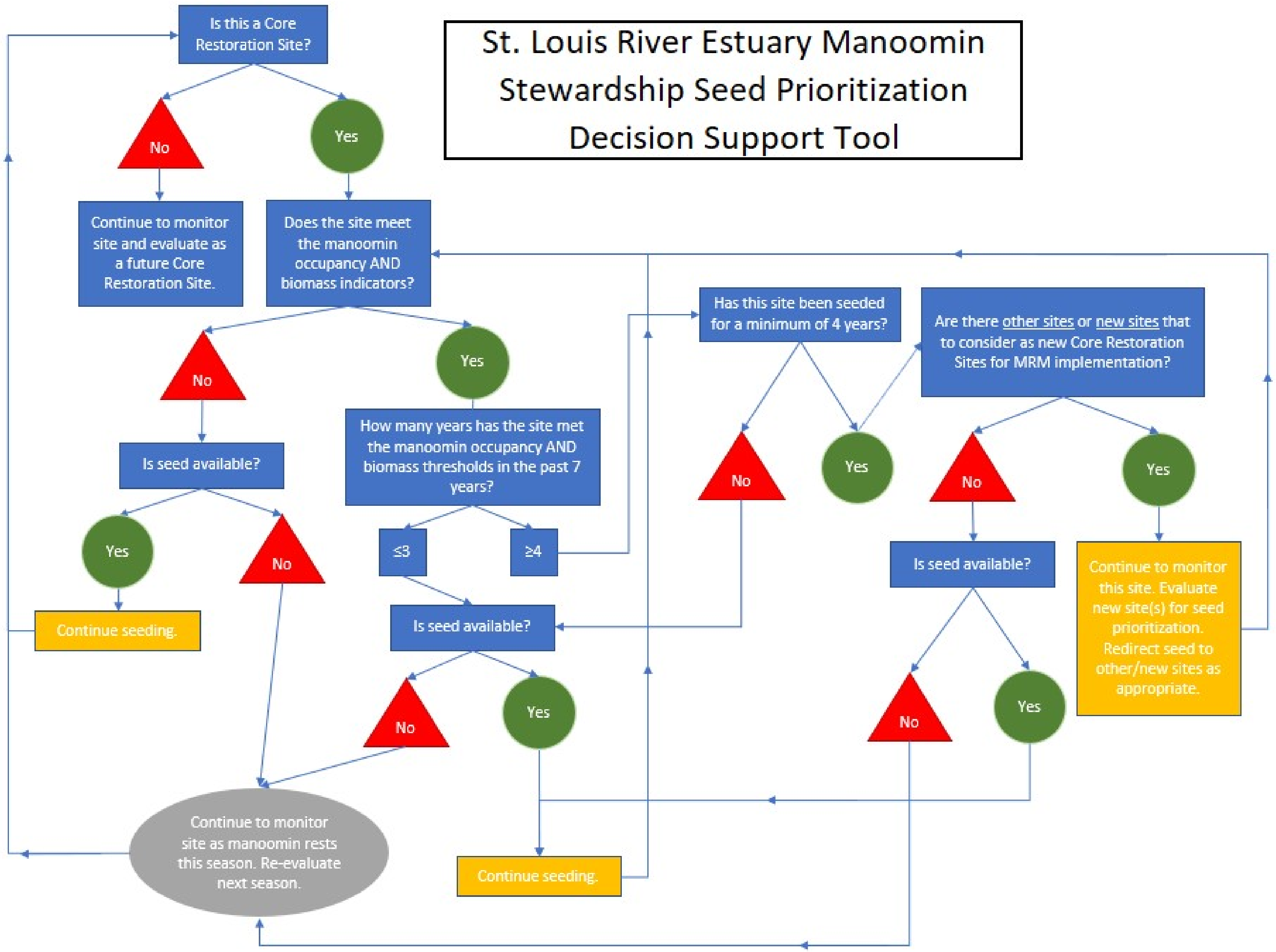
Appendix A. Manoomin Restoration Model



Appendix B. Summary of Restoration Actions

Site Name	State	Plant Management	Seeding	Herbivory Exclosures	Monitoring[1]
Kekuk Island	WI				
Rask Bay	MN	2015	2015-2017, 2019-2020, 2022-2023	2023	2015-2023
Perch Lake	MN				
Walleye Alley Bay	WI	2016	2016-2017, 2019-2020, 2022-2023	2021-2023	2016-2023
Landslide Bay	WI	2016	2016-2017, 2019-2020, 2022-2023	2022-2023	2016-2023
Duck Hunter Bay North	WI	2015	2015-2017, 2019-2020, 2022-2023	2016, 2018-2023	2015-2023
Duck Hunter Bay Middle	WI		2023		
Duck Hunter Bay South	WI	2015	2015-2017, 2019-2020, 2023		2015-2023
North Bay	MN	2015	2015-2017, 2019-2020, 2022-2023	2021-2023	2015-2023
Red River	WI		2019-2020		
Foundation Bay	WI		2019-2023		2017-2023
Radio Tower Bay	MN	2015	2015-2017, 2019-2020		2015-2023
Oliver-Bear Island	WI & MN	2016	2016-2017, 2019-2020		2016-2023
Mud Lake West	MN				
Mud Lake Northeast	MN	2016	2016-2017		2016-2023
Oliver Bay - Little Pokegama Bay	WI				2017-2023
Spirit Lake	MN				
Munger Landing	MN				
Clough Island	WI	2016	2015-2020		2016-2023
Tallus Island	MN				
Indian Point Bay	MN				
Kingsbury Bay	MN		2021-2023	2022-2023	2017-2023
Stryker Bay	MN				
Dwight's Point	WI				
Wisconsin Tributaries	WI				
Pokegama Bay	WI				2017*, 2020-2023*
Billings Park	WI				
Grassy Point	MN				
Allouez Bay	WI	2017-2018	2015, 2018-2023	2019, 2022-2023	2020*, 2021-2023

Appendix C. Seed Prioritization Decision Support Tool



Appendix D. Seed Distribution in the St. Louis River Estuary

	2015 Seeding		2016 Seeding		2017 Seeding		2018 Seeding		2019 Seeding		2020 Seeding		2021 Seeding		2022 Seeding		2023 Seeding	
Restoration Site	**Pounds**	**Acres**	**Pounds**	**Acres**	**Pounds**	**Acres**	**Pounds**	**Acres**	**Pounds**	**Acres**	**Pounds**	**Acres**	**Pounds**	**Acres**	**Pounds**	**Acres**	**Pounds**	**Acres**
Allouez Bay	1,932	38	0	0	0	0	500	9	0	7	0	0	363	4	1,176	7	2,000	10
Clough Island	500	5	508	10	550	5	400	10	1,500	10	500	10	0	0	0	0	0	0
Duck Hunter Bay North	2,165	19	948	19	953	19	0	0	1,642	7	2,805	19	0	0	1,304	13	514	2
Duck Hunter Middle	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1,210	6
Duck Hunter Bay South	1,642	40	1,935	40	2,006	40	0	0	1,151	8	2,306	23	0	0	0	0	1,759	9
Foundation Bay	.	.	.	.	.	.	.	.	285	1	101	1	0	0	0	0	0	0
Kingsbury Bay	.	.	.	.	.	.	.	.	.	.	.	.	500	3	500	3	500	3
Landslide Bay	.	.	553	9	425	9	0	0	419	7	812	8	0	0	864	7	1,390	7
Mud Lake	.	.	2,089	33	1,788	33	0	0	0	0	0	0	0	0	0	0	0	0
North Bay	1,666	14	718	14	707	14	0	0	379	6	1,534	14	0	0	557	4	1,704	8
Oliver-Bear Island	.	.	2,120	26	1,341	27	0	0	743	5	130	1	0	0	0	0	0	0
Radio Tower Bay	946	15	750	15	767	15	0	0	701	13	1,499	15	0	0	0	0	0	0
Rask Bay	2,085	33	1,650	33	1,647	33	0	0	1,530	18	3,349	33	0	0	1,866	12	2,362	12
Red River	.	.	.	.	.	.	.	.	180	1	175	1	0	0	0	0	0	0
Walleye Alley Bay	.	.	1,247	17	850	17	0	0	592	18	1,105	11	0	0	1,790	12	1,108	5
	10,936	**164**	**12,518**	**216**	**11,034**	**212**	**900**	**19**	**9,122**	**101**	**14,316**	**136**	**863**	**7**	**8,057**	**58**	**12,547**	**61**

Appendix E. Goose Roundup Talking Points

Wild Rice Restoration and Canada Goose Management in the St. Louis River Estuary

Wild Rice Restoration Partnership Talking Points

Updated: 20 February 2024

Project Purpose & Justification:

The restoration of wild rice (*Zizania palustris*) in the St. Louis River Estuary is of cultural and ecological significance. Restoration goals developed in the Wild Rice Restoration Implementation Plan for the St. Louis River Estuary (Minnesota Department of Natural Resources 2014) include the establishment of 275 acres of self-sustaining rice beds. These efforts will contribute to the removal of beneficial use impairments for the St. Louis River Area of Concern (BUI 9 – Loss of Fish and Wildlife Habitat).

Wild rice restoration efforts are hampered by Canada goose (*Branta canadensis*) herbivory and a variety of techniques have been implemented to reduce the impacts (e.g., adapting restoration techniques, hazing, egg addling, mylar flashing, swan decoys, and exclosures). Despite this effort, the impact of Canada goose herbivory has not been sufficiently reduced to allow for the establishment of self-sustaining wild rice beds. As a result, the Wisconsin Department of Natural Resources, in partnership with the Minnesota Department of Natural Resources and the Animal and Plant Health Inspection Service (APHIS) – Wildlife Services will coordinate a Canada goose roundup in the St. Louis River Estuary in support of the 2014 Wild Rice Restoration Implementation Plan for the St. Louis River Estuary.

Key Talking Points:

1. **Wild rice restoration is an ecological and cultural priority in the St. Louis River Estuary with large-scale, collaborative restoration efforts beginning in 2015. Recent studies have identified Canada goose herbivory as a major impediment to successful establishment of self-perpetuating wild rice beds.**

   a. Monitoring data, camera traps and observations have documented heavy browse by Canada geese.
   b. Goose herbivory stops rice plants from maturing to the flowering stage and producing seed.
   c. Wild rice is an annual grass and needs to produce a seed head each year to sustain a rice bed.
   d. Canada goose herbivory is occurring during the plant's development and goose feather molt coincides with rice emergence, a time when rice is extremely vulnerable to herbivory. This results in high herbivory during this critical wild rice growth stage.

2. **This roundup effort has been preceded by multiple attempts to reduce the impact of goose herbivory. And despite these efforts, the impact of Canada goose herbivory has not been sufficiently reduced to allow for the establishment of self-sustaining wild rice beds.** Non-lethal techniques have been implemented to reduce the impacts (e.g., adapting restoration techniques (e.g., seeding sites and rates), hazing, egg addling, mylar flashing, swan decoys, and exclosures).
   a. The greatest impact of herbivory occurs during the floating leaf and emergent stages of the wild rice growth cycle (typically late-June thru August).
   b. Canada goose hunting in the Wisconsin side of the St. Louis River Estuary has not sufficiently reduced the impact of goose herbivory on wild rice restoration. All the WI restoration areas are open to waterfowl hunting.

3. **Canada goose management in the St. Louis River Estuary is guided by wildlife professionals utilizing proven management practices for Canada goose control.**
   a. We have worked with our partners to develop a plan for reducing the impacts of goose herbivory that utilizes goose exclosures and goose roundups where monitoring data indicates high levels of herbivory.
   b. Geese are euthanized using carbon dioxide, an approved method by the American Veterinary Medical Association. This technique is considered humane by wildlife and veterinary professionals and conducted by USDA-APHIS personnel.
   c. When possible, geese are donated to the Lake Superior Zoological Society in Duluth to be utilized as food for carnivores at the zoo and provides enrichment to the animals.
   d. Efforts are being made to determine if geese removed from the St. Louis River Estuary can be donated to local food pantries for human consumption.

4. Canada goose management is succeeding in estuary locations within Wisconsin such as Allouez Bay.
   a. The 2021 goose roundup in Allouez Bay resulted in fewer geese present in 2022 and improved wild rice productivity in 2023.
   b. Herbivory was significantly reduced.
   c. Density, plant height, and biomass increased.

Appendix F. Contaminant Testing Protocol

State of Wisconsin \ DEPARTMENT OF NATURAL RESOURCES

Jim Doyle, Governor
Matthew J. Frank, Secretary

101 S. Webster St.
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Madison, Wisconsin 53707-7921
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FAX 608-267-3579
TTY Access via relay - 711

June 21, 2010

Subject: Contaminant Testing of Canada Geese for Human Consumption in Wisconsin

The WDNR initially established Guidelines for Contaminants Screening of Harvested Urban Geese in 2000. At that time, sampling for contaminants from geese captured and processed during population management actions was required only once without further need for testing. With the change in landscape, environmental conditions, and an increase in detection of some contaminants in recently screened goose meat, it was decided to increase the frequency of testing for contaminants in geese harvested during the summer molt period.

The current protocol for contaminant testing is as follows:

- Sampling for contaminants occurs during the first <u>two</u> years of the proposed management action, this may or may not be consecutive years. If both of these two consecutive tests result in an advisory that allows for human consumption, the entity is not required to conduct contaminant tests for the next <u>two</u> calendar years.

  In the <u>fifth</u> management year, testing reoccurs and if an advisory that allows for human consumption is again recommended, the entity is not required to conduct contaminant tests for two calendar years.

  Testing is then required every third calendar year after the last test, provided the results allow for human consumption.

- A community that receives an advisory that **does not** allow for human consumption is required to conduct a contaminant test each year removal is requested until **three** consecutive tests result in an advisory that allows for human consumption. Thereafter, refer to protocol above.

- The processed meat is held until WDNR Wildlife Health Team, in consultation with Wisconsin Department of Health and Family Services, evaluates and make recommendations for meat consumption advisories.

- Samples shall represent ten percent of the adult population proposed for management, with a minimum of at least **five** samples submitted. This level of testing is consistent with the sampling that was required to detect health issues for juvenile Canada geese translocation when that was an option to resolve conflicts.

- Samples submitted for contaminant testing will consist of ground blended meat that is free of skin, and consistent with the product that is provided for human consumption.

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- Testing for 2,4-D (broadleaf herbicide) is only required for communities which use this product where geese frequent. Communities which do not use this product are exempt from testing for it.

The remaining items: 1) Analysis of goose tissue samples for contaminants must be conducted by a certified laboratory that meets WDNR standards, 2) Costs associated with goose sampling and analysis is the responsibility of the community/entity that has requested population management and 3) The community/entity is responsible for acquiring necessary permits.

If test results allow for human consumption advisory, but increased level of contaminant is detected (e.g., lead) it is up to the discretion of the WDNR Wildlife Health Team to request further testing for the contaminant(s) in question regardless of the sampling protocol.

EXAMPLE

Community X (new to goose management)
2009 Conduct test, 79 adults and 126 juvenile captured, **8** samples of ground, blended meat submitted for PCBs, lead, pesticides, and mercury. Results indicate that advisory allows for human consumption and held processed meat is released to charitable organization.

2010 No Resident Canada goose management

2011 Conduct test, 26 adults and 43 juvenile captured, **5** samples of ground, blended meat submitted for PCBs, lead, pesticides, and mercury. Results indicate that advisory allows for human consumption and held processed meat is released to charitable organization.

2012 No Resident Canada goose management

2013 Testing not required, 20 adults and 47 juveniles captured, two years of advisories that allow for human consumption permit processed meat distribution to charitable organization.

2014 Conduct test, 22 adults and 39 juveniles captured, **5** samples of ground, blended meat submitted for PCBs, lead, pesticides, and mercury. Results indicate that advisory allows for human consumption; however lead level is elevated in both samples. WDNR Wildlife Health Team requests further lead testing at next management opportunity. Processed meat is released to charitable organization.

2015 No Resident Canada goose management

2016 Testing not required, however due to elevated lead levels WDNR Wildlife Health Team requested further lead testing in 2014. 27 adults and 32 juveniles captured, **5** samples of ground, blended meat submitted for lead testing. Results indicate that advisory does not allow for human consumption and held, processed meat is not released to charitable organization.

Appendix G. 2024 Manoomin Plan Summary

Timeframe	Indicator	Status	Actions to Complete	Challenges & Needs	Likelihood of Meeting Indicator During Timeframe (High, Medium, Low)
Overall Project Coordination and Implementation					
	1. The St. Louis River Estuary Manoomin Restoration Partnership (SLREMRP) continues collaborative decision making to guide progress towards meeting short-, mid-, and long-term indicators of success.	In progress. The SLREMRP is composed of a diverse group whose organizations support involvement with partner meetings and planning.	- Conduct SLREMRP spring and winter coordination meetings each year. - Partnership organizations continue to actively support Manoomin Restoration & Stewardship Model (MRSM) implementation, outreach, education, and community engagement.	Personnel commitments and participation may be limited by capacity, funding, and time constraints.	High
	2. The Manoomin Restoration Coordinator leads MSRM implementation under the guidance of the SLREMRP.	In progress. Funding for the Manoomin Restoration Coordinator is secured through 2024. WDNR submitted a GLRI AOC funding request to fund the position through 2027. The grant will fund MRSM implementation through 2026. Funding sources thereafter are undetermined.	- Secure funding for Manoomin Restoration Coordinator to lead project coordination & management. - Secure funding for MRSM implementation beginning in 2027 (e.g., obtain applicable permits, coordinate restoration & stewardship actions, support and implement stewardship and outreach programs with partners). - Identify future sources of funding to support project coordination needs beyond 2027.	Additional funding is needed support the Manoomin Restoration Coordinator and MRSM implementation beyond 2026.	High
	3. The SLREMRP collaborates to develop and implement culturally relevant indicators and programs for community engagement, outreach, and stewardship.	In progress. The 1854 Treaty Authority and partners collaborated on the first SLRE Rice Camp in 2023 and planning is underway for subsequent years. The GLRI funding request described above includes support for the 1854 Treaty Authority to implement the SLRE rice camp in 2025 – 2027. Funding is also included for St. Louis River Alliance's education and outreach programming specific to the manoomin restoration work being conducted.	- Continue to support the 1854 Treaty Authority rice camp and seek opportunities to add financial and in-kind support. - Develop a long-term funding plan to continue this rice camp implementation on an annual basis. - Similarly, develop a long-term funding plan to support continued (and possibly expanded) implementation of the St. Louis River Alliance outreach and education programming associated with MRSM implementation.	Funding sources and capacity to implement community engagement and environmental justice components of the MRSM.	High

Timeframe	Indicator	Status	Actions to Complete	Challenges & Needs	Likelihood of Meeting Indicator During Timeframe (High, Medium, Low)
Short-Term (through 2026)					
	1. Three core restoration sites that meet manoomin occupancy and biomass indicators in four out of the past seven years (2021 - 2026).	In progress. Two sites currently meet the occupancy indicator, and 3 sites meet the biomass indicator in four of the past seven years. However, there are additional sites that have shown an increasing trend in manoomin density over the past 3 years.	- Secure AOC funding to continue MRSM implementation (2025 - 2026). WDNR submitted a GLRI AOC funding request to support MRSM implementation (seeding, herbivory management, and monitoring) through 2026.	Funding not yet confirmed for this GLRI funding request	High
	2. At least 30 acres of restored or enhanced manoomin across restoration sites that have met the occupancy and biomass indicators.	In progress. Reliable and repeatable methods for estimating acreage are not fully developed. However, conversations and coordination are taking place to better estimate this important indicator.	- Develop and implement a protocol for acreage estimation utilizing aerial and/or remote sensing data.	There is no standardized method used for estimating the size of manoomin patches in the SLRE.	High
Mid-Term (2027 - 2032)					
	1. Six core restoration sites that meet manoomin occupancy and biomass indicators in four out of the last seven years.	In progress. Two sites currently meet the occupancy indicator, and 3 sites meet the biomass indicator in four of the past seven years. However, there are additional sites that have shown an increasing trend in manoomin density over the past 3 years.	- Continue MRSM implementation. - Develop occupancy & herbivory thresholds for triggering management actions.	Additional funding is needed for MRSM implementation through 2032.	Medium
	2. At least 60 acres of restored or enhanced manoomin across restoration sites that have met the occupancy and biomass indicators.	In progress. Reliable and repeatable methods for estimating acreage are not fully developed. However, conversations and coordination are taking place to better estimate this important indicator.			Medium
Long-Term (2033 - beyond)					
	1. At least 500 acres of self-sustaining manoomin beds in the St. Louis River Estuary.	Progress being made on short- and mid-term indicators.	Lots.	Many.	Uncertain
	2. At least 1 healthy, harvestable stand of manoomin greater than 50 acres in size.	Focusing efforts on Rask Bay as the likely location for the 50-acre bed.	- Address community concerns about the safety of consuming manoomin from the St. Louis River Estuary.		Medium

Timeframe	Indicator	Status	Actions to Complete	Challenges & Needs	Likelihood of Meeting Indicator During Timeframe (High, Medium, Low)
	3. Successful application of the MRSM at additional restoration sites in the St. Louis River Estuary.	New restoration site selection guidance and seed prioritization decision support tool in the 2025 Manoomin Plan will support expanding the MRSM to new locations which may include sites identified in the 2014 Rice Plan, where applicable.	- Evaluate list of potential		Medium
	4. Manoomin in the St. Louis River Estuary contributes to community relationships and offers educational opportunities.	This indicator could be achieved at an earlier timeframe but is included here to indicate that it is a long-term commitment.	- Continue to prioritize rice camp implementation and community engagement opportunities that connect people with manoomin.		High