

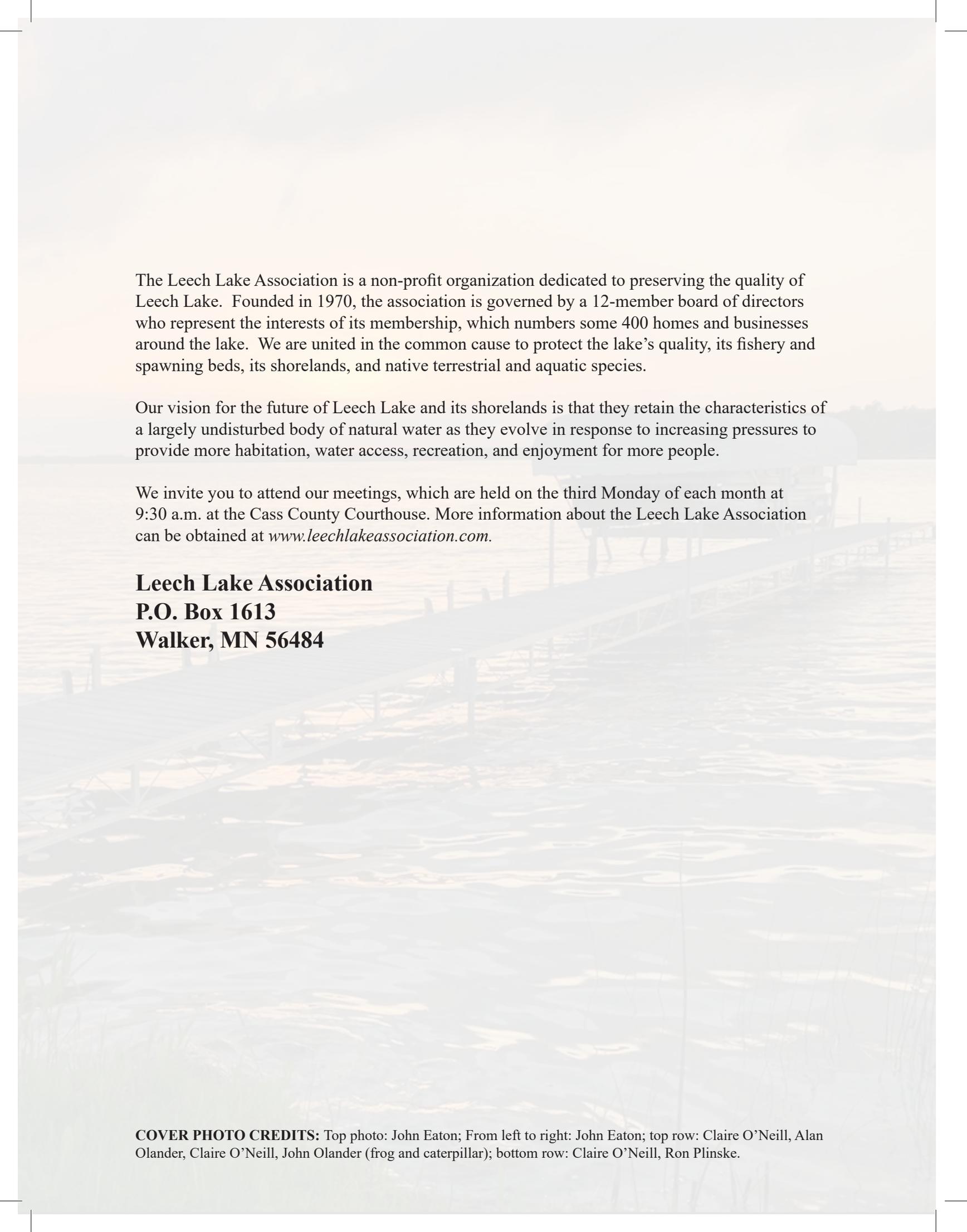


3rd Edition
Summer 2022

Leech Lake Ecosystem Management Plan

Leech Lake Association





The Leech Lake Association is a non-profit organization dedicated to preserving the quality of Leech Lake. Founded in 1970, the association is governed by a 12-member board of directors who represent the interests of its membership, which numbers some 400 homes and businesses around the lake. We are united in the common cause to protect the lake's quality, its fishery and spawning beds, its shorelands, and native terrestrial and aquatic species.

Our vision for the future of Leech Lake and its shorelands is that they retain the characteristics of a largely undisturbed body of natural water as they evolve in response to increasing pressures to provide more habitation, water access, recreation, and enjoyment for more people.

We invite you to attend our meetings, which are held on the third Monday of each month at 9:30 a.m. at the Cass County Courthouse. More information about the Leech Lake Association can be obtained at www.leechlakeassociation.com.

Leech Lake Association
P.O. Box 1613
Walker, MN 56484

COVER PHOTO CREDITS: Top photo: John Eaton; From left to right: John Eaton; top row: Claire O'Neill, Alan Olander, Claire O'Neill, John Olander (frog and caterpillar); bottom row: Claire O'Neill, Ron Plinske.

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I. VISION FOR LEECH LAKE

Our vision for the future of Leech Lake and its shorelands, as stated in the first 2004 Management Plan volume, is to retain the characteristics of a largely undisturbed ecosystem despite increasing pressures to provide more habitation, water access, recreation, and enjoyment for more people. This vision remains the same for this plan.

II. SUMMARY/RECOMMENDATIONS

The current state of Leech Lake suggests the following high priority actions for achieving the vision for the lake (main text support section in parenthesis):

- Assisting the MN Pollution Control Agency, MN DNR, and LLBO DRM in organizing and conducting water quality monitoring activities on Leech Lake, including continuation of citizen lake monitoring programs, and the Leech Lake River Intensive Watershed Monitoring effort started in 2012 and being repeated in 2023; (Water Quality section)
- The 2002-2009 aquatic vegetation survey provided a good baseline of recent condition, location and abundance of the plants composing this important biotic community and will be followed by a comparison with 2019-2021 survey data to observe possible changes due to exotics, boat motors, climate change, anchoring, or other factors. (Vegetation)
- Continuing to monitor the status of the lake's rejuvenated walleye population, as well as other fish populations, through assistance or participation in various DNR projects and programs such as the Leech Lake (fisheries) Advisory Committee, annual DNR Roundtable discussions, field projects, and AIS prevention activities. It is imperative that steps be taken to insure that DNR work on Leech Lake is conducted out of the existing Fisheries Office in Walker and that it not be moved; (Fisheries)
- Taking steps to keep additional aquatic invasive species from invading Leech Lake by supporting DNR, DRM, and Cass Co. efforts to strengthen regulations preventing their transport to new waterbodies, assisting in obtaining equipment to clean watercraft, providing waste containers for left-over bait at public landings, distributing signs on state AIS laws and equipment, posting signs at public and private launch sites, and working with other lake organizations and the Cass County AIS Task Force; (Aquatic Invasive Species)
- Supporting Cass County Environmental Services Department efforts to reduce storm water runoff by promoting the planting or protection of shoreline vegetative buffers and minimizing the construction of impervious surfaces in building projects on the shore; assisting the City of Walker and Cass County efforts to prevent storm sewer effluents and toxic contaminants from directly entering Leech Lake; (Water Quality, Vegetation, Wildlife, Land Use and Zoning)

- Continuously monitoring county activities and decisions on shorelands as a consequence of application for variances and conditional use permits, or changes in the county land use ordinance and state land use regulations; (Development, Housing and Tourism History, and Use and Zoning)
- Continuing support of efforts to preserve and protect sensitive shorelines through the acquisition of conservation easements; supporting the application of higher standards or designations to preserve unique and sensitive shorelands; encouraging the development and enforcement of shoreland and watershed Best Management Practices; (Land Use and Zoning, others)
- Promote and/or take steps to slow or arrest global climate change by urging reduction of emissions of CO₂, methane, and other “greenhouse” gases by individuals, the county, and other area-wide production sources; discuss and provide educational information about climate change with receptive friends and neighbors. (Sustainability and Climate Change)

III. PREFACE

The Leech Lake Association published its first Leech Lake Management Plan in 2004 after a survey of all Leech Lake property owners. The 2004 Plan identified key issues on the lake that needed immediate attention and established a long-term vision for the lake from the Association’s perspective. Among the issues needing attention was a crash in the lake’s walleye population, which was negatively affecting local tourism and property values. Contributing to the poor fishing was an explosion in the lake’s cormorant population, which was believed to be eating some of each year’s hatch of young fish. Also of concern was the burgeoning numbers of invasive rusty crayfish which were affecting the lake’s aquatic vegetation. The 2004 Plan encompassed other factors as well, most directed at the long-term health of the lake, including the protection of sensitive shorelands, water quality, and zoning issues.

The fishing issue was approached in several ways. In 2007, the Minnesota DNR began stocking millions of walleye fry in Leech Lake each year. The stocking program continued until 2014, when walleyes numbers had sufficiently recovered to make further stocking unnecessary. At the same time, the Leech Lake Tribe’s Division of Resource Management began controlling cormorant numbers to approximately 500 nesting pairs, which was considered sustainable relative to the fishery. These efforts proved successful, and good walleye fishing has returned to Leech Lake. The DNR took the added step in those early years of establishing a 17-member Leech Lake Fishing Advisory Committee comprised of resort owners, guides, business owners, and outside fishing experts whose job it is to meet annually with the DNR and provide input to the DNR’s long-term fishery management plans for the lake. These plans affect bag limits, protected slots, and other decisions designed to maintain good fishing, and to protect habitat.

As we publish this 3rd Edition of the Leech Lake Association Management Plan, we should emphasize that while some of the challenges have changed, others arose. In 2015 zebra mussels were found in the lake despite yeoman inspection efforts to keep them out. Their

numbers have since exploded, and their long-term effect on the lake is unknown. Leech Lake Association volunteers have embarked on a long-term water sampling program in an attempt to find out.

In the fall of 2021, another nasty invasive species--starry stonewort--was discovered in and adjacent to a boat harbor on Steamboat Bay. This invasive creates a mat on top of the water which makes boat passage difficult and is expensive to remove. It also is infiltrating the wild rice beds, which is another problem we are closely monitoring.

The management plan discusses these and other issues regarding the lake and our role as a lake association. It identifies new or continuing threats to Leech Lake lands and waters and recommends actions to be taken over the next several years to deal with these issues. This association management plan should not be confused with the MNDNR's Five Year Plans of similar title, though many of the goals in both plans are by nature shared and complementary.

IV. GENERAL INTRODUCTION TO THE PLAN

What constitutes a good lake association? What is a lake management plan and why do we need one? These are questions asked by the Leech Lake Association (LLA) Board and by many of our members.

What Constitutes a Good Lake Association?

Leech Lake Association believes that it can serve its members' interests best by acting as a guardian of the continued health and viability of Leech Lake by:

- Monitoring the intrinsic qualities of the lake, including the development of its shoreline and watershed.
- Educating members and the public on good lake management practices.
- Representing all stakeholders on Leech Lake with a unified and informed voice to government units and agencies.

What is a Lake Management Plan?

A lake management plan results from the process of taking a hard, objective look at a lake. What is the state of the lake today and what contributes to it, good and bad? Where has it been in the past, and what is the future vision of the stakeholders for the lake? Most importantly, how can we get there?

Lake management planning is not a process to be taken on alone by a lake association. For successful implementation of a lake management plan, many people should be part of the planning process, including the local, state, and federal agencies available to assist a lake association.

Why Do We Need a Lake Management Plan Now?

Lake management plans can help establish a consensus for actions to protect natural resource systems, including the water quality of the lake, and native fish, vegetation, and wildlife communities in and around the lake. While Leech Lake is fortunately in a high-quality state, the Leech Lake Association believes a plan is desirable for the following reasons:

- a. Population demographics and resultant development show that the Leech Lake area is one of the fastest developing areas in the state of Minnesota. According to state demographic projections, Cass, Crow Wing, and Aitkin counties – retirement magnets – could grow by 64 percent by 2030 as compared to 27 percent growth statewide.
- b. Minnesota’s lake management authority is spread across a number of county, state and federal agencies. This provides an opportunity for citizens, through lake and watershed associations, to play a role in promoting and coordinating management that will help protect lakes like Leech. Governments and most large organizations (lake and land management authorities in this case) respond more favorably to plans they can review and support rather than to everyday complaints. This is the rationale for this plan.
- c. Planning support and funding are available through grants from state, federal, and private agencies, like Cass Soil and Water Conservation District and the Initiative Foundation, for groups or agencies to develop and implement programs (e.g., Leech Lake River Comprehensive Watershed Management Plan) to enhance stewardship and sustainability of aquatic resources in the Leech Lake watershed. A role of the Leech Lake Association is to encourage and support these efforts at all organizational levels.
- d. While survey data indicate that Leech Lake presently has few serious discernible environmental or water quality problems, it must be remembered that large bodies of water are more tolerant of abuse but also harder to repair once a problem develops. The most effective time to establish a lake management plan is before serious problems occur.

The key is to write a lake management plan that gives our lake association the information and tools to preserve and improve our watershed area, including funding to implement the action items proposed in the plan.

V. ECOLOGICAL, HISTORICAL BACKGROUND

General Geology, Hydrology

Leech Lake is the third largest inland lake in Minnesota with 103,039.6 acres of water surface and approximately 200 miles of shoreline. Only the Red Lakes and Mille Lacs Lake are larger. At one time, Leech Lake was covered by glaciers as much as one mile thick. Over the past two

million years, this area has been repeatedly crossed by glaciers coming from the north, northwest and northeast. The effects of the most recent glaciers can be identified throughout the Leech Lake region. The youngest deposits in the region are found mostly north of Highway 2. These were deposited by the St. Louis sublobe of the Late Wisconsinan Age, between 13,500-11,600 years ago. Earlier glaciations include the Wadena lobe (St. Croix phase, 22,800-17,700 years ago) that produced the Itasca moraine, one of the most impressive moraines in the state, and the Hewitt phase (27,300-23,600 years ago) that formed the extensive and well-known Wadena drumlin field. These glaciers left a complex topography that is evident today. The geology can be characterized by thick (200-600ft) glacial deposits in outwash plains, lake plains, till plains, outwash channels, moraines, drumlin fields and debris flows. Additional information on the glacial history of the Leech Lake Watershed can be found in Melchior and Annexstad, 1996.

The Leech Lake we know today is considerably larger than the original due to the construction in 1882-1884 of what is now called Federal Dam. Jane Lamm Carroll describes this era in a 1990 Minnesota History Magazine article titled *The Ojibway, the United States, and the Mississippi Headwaters Reservoirs*. A dam was constructed on the Lake Winnibigoshish outlet at the same time as Leech's and between the two an area of 46,900 acres was flooded. The Leech Lake dam raised water levels an estimated 4-7 feet and incorporated several smaller lakes around it. The flooding had a devastating effect on the natural resources in and surrounding these lakes and on the subsistence of the well-established native communities in the area. Extensive beds of wild rice, a critically important year-round food staple, were demolished by the flooding. Stands of lakeshore maple trees used for production of syrup were lost. Reparations negotiated between the Ojibwe and U.S. Government were very slow in coming and invariably less than promised. The water level of Leech Lake has remained fairly stable for over 50 years since then.

The lake has an irregular shape with many large and small bays. The deepest area of the lake is in Walker Bay where depths reach 150 feet. Approximately 80% of the lake is less than 35 feet. Average annual precipitation for the area is around 27 inches, and evaporation is approximately 31 inches. Average annual runoff is about 6 inches with one-in-ten-year high and low flows of 8 and 2 inches. The "Lakeshed Vitals" table and associated "Assessment" compiled by RMB Environmental Labs (2008) provide additional ecological, geographical, demographic, and land use information for Leech Lake.

Chippewa National Forest

An important ecological influence on Leech Lake and its development is the surrounding Chippewa National Forest, the first National Forest established east of the Mississippi River in 1908. Originally known as the Minnesota National Forest, the name was changed in 1928 to honor the original inhabitants of the area. According to Minnesota DNRs *Native Plant Community Classification* (Aaseng et al., 2003), the forest lies within the Northern Minnesota Drift and Lake Plains Section of the Laurentian Mixed Forest Province, where mesic forests of sugar maple, basswood, paper birch, aspen, and northern red oak are widespread. These occur mostly on moraines or till plains characterized by rough topography and fine textured parent material. Historically, forests and woodlands of jack pine and red pine were very common. The Forest boundaries enclose about 1.6 million acres including Leech, Winnibigoshish and Cass Lakes, three of the five largest in Minnesota. The Forest also includes over 1,300 smaller lakes

and ponds, 925 miles of rivers, 25 watersheds and 440,000 acres of wetlands that provide wildlife habitat for over 250 species. Over 180 pairs of nesting bald eagles are known to inhabit the forest, the highest breeding density in the continental United States. The 200-mile (approximately) shoreline of Leech Lake is primarily forested with some moderate development of residences, resorts, and campgrounds. The city of Walker on the southwest edge of Leech Lake has a few miles of more intensive development.

Visitors to the Chippewa National Forest observe a working forest. Recreational development, wildlife habitat preservation projects and timber harvesting can all be observed in coexistence. About one percent of the forest is harvested for timber each year. Over 160 miles of hiking trails and 315 miles of snowmobile trails provide an opportunity to view the forest in all seasons. The winter season increasingly draws large numbers of nature lovers for snowmobiling, cross country skiing, snowshoeing and ice fishing. White-tailed deer and ruffed grouse provide excellent hunting opportunities.

Much of the Chippewa National Forest and Leech Lake fall within the boundary of the Leech Lake Indian Reservation. Both the Chippewa National Forest and the Leech Lake Band of Ojibwe share responsibility for managing the cultural and natural resources within the Reservation.

Leech Lake Band of Ojibwe - Leech Lake Reservation History

The landscape surrounding Leech Lake tells a story of survival and livelihood to the Ojibwe people. The Ojibwe migrated from the eastern shores of Turtle Island (North America) around 900 A.D. and established their aboriginal territory in the woodlands of Canada, Michigan, Minnesota, Wisconsin, and eventually North Dakota and Montana. A migration that would take generations was guided by prophecies that would lead them to their final homeland near the food that grew on water, Manoomin (wild rice).

When the first settlers arrived in this area, the Pillager and Mississippi Bands of Ojibwe had homes, villages, and seasonal encampments on or near Cass Lake, Lake Winnibigoshish, and Leech Lake. The landscape was covered with a mixture of forests from majestic pines and mixed hardwoods, including sugar maple, to wet lowland forests. Lakes, streams, and marshes contained abundant wild rice, waterfowl, and fisheries. The Ojibwe people have utilized these natural resources to sustain themselves for many generations, so any cultural activity is connected to land, water, or air. Indigenous persons have a hard time knowing themselves and being themselves without this relationship to their homeland. It has taught them how to live with nature and be in balance and harmony with the natural world.

During the years of 1805–1889, the United States government signed a number of treaties with the Native Tribes. The Treaty of 1855 between several Ojibwe Tribes of northern Minnesota and the United States government was responsible for creating the Leech Lake Band of Ojibwe and Leech Lake Reservation boundary. Minnesota has a long history of timber harvesting where in many towns Paul Bunyan and Babe the Blue Ox are folk heroes. Many lakes and rivers were dammed to facilitate the transportation of timber. Timber harvest was one of the reasons US surveyors such as Lewis and Clark and Lewis Cass and Zebulon Pike had explored this area and

identified where the forests, swamps and other resources were located. By the late 1800's the logging industry had reached the borders of the Leech Lake Indian Reservation but could not access the large expanses of virgin white and red pine forests that it contained as the entire Leech Lake Reservation was under Indian ownership and control. That changed with the passage of the Nelson Act in 1889. Over the next several years the land-base of the Leech Lake Reservation diminished at an alarming rate due to the passages of the Dawes and Nelson Acts, 1887 and 1889 respectively, which allowed settlement and ownership of Ojibwe land by non-tribal members. The complex checkerboard ownership that exists today within the reservation is a result of these defining land acts of the late 19th century.

In 1896 and 1898 the towns of Walker and Cass Lake were established. Logging camps and saw and planing mills sprang up. Farming and dairying developed later on the cut-over lands. To protect mature pine stands from timber harvest on lands released by the Dawes and Nelson Acts, the federal government created the first congressionally mandated national forest in 1902. The boundaries of the newly created Chippewa National Forest extended across the entire Leech Lake Reservation and into ceded territory. However, the establishment of this forest did not curb the widespread destruction of the majestic pines as intended. Over 95% of the white and red pines that were still standing when the Chippewa National Forest was established have been cut.

In 1971, the Leech Lake Band challenged Minnesota Commissioner of Natural Resources Robert L. Herbst in federal court on the issue of Minnesota requiring Indians to comply with Minnesota game and fish laws. The federal court ruled the Nelson Act did not, as the state previously argued, dissolve the Leech Lake Reservation and therefore tribal members retained hunting and fishing rights on both trust and non-trust land within its boundaries. In addition, these rights were identified as property rights and therefore required Minnesota to pay Leech Lake Band for non-Indian's privilege of hunting, fishing, or trapping on any lands within the boundaries of the Reservation. Also, as a result of the Herbst decision, the gathering of wild rice and bait fish on Leech Lake Reservation is exclusively regulated by the Leech Lake Band of Ojibwe.

The Leech Lake Conservation Department was established in 1975 after the 1972 Hunting and Fishing agreement between the State of Minnesota and the Leech Lake Band of Ojibwe. Duly constituted and properly identified, Leech Lake Conservation Officers and Minnesota Conservation Officers are empowered with the authority to arrest non-Indians and tribal members for violations of state and reservation game and fish laws committed in their presence and can initiate proceedings for these violations in county or tribal courts. State jurisdiction on hunting and fishing laws over non-members is maintained for all reservations of the state except Red Lake.

Today, the Leech Lake Band of Ojibwe, or Gaa-zagaskwaajimekaag Ojibweg in the Ojibwe language, has approximately 9,500 enrolled tribal members. The Leech Lake Indian Reservation includes eleven communities aggregated into three districts, as defined in the tribal constitution. The Leech Lake Band of Ojibwe is committed to the responsible operation of government, preservation of heritage, promotion of sovereignty, and the protection of natural resources for elders and future generations, while enhancing the health, economic well-being, education, and our inherent right to live as Ojibwe People.

Development, Housing and Tourism History

Leech Lake had a modest tourism industry even before the advent of automobile travel. By 1915 two hotels reigned over Leech Lake, with the Isabel Lodge and New Chase Hotel owned and operated by the Chase family. The 1929 *Minnesota Book* listed four hotels, eight resorts, and one tourist camp. By 1931 the number of resorts had grown to 19. The number continued to grow during the 1930's until 360 privately-owned resorts were listed in 1941 in the Chippewa National Forest region. However, due to increasing property values and shifting demographics the number of resorts began a rapid decline. By 1999 it was estimated that Leech Lake had 64 resorts, and currently it is estimated that only about 36 remain (Dana Gutzmann, Cass AIS Lake Technician and Roxie Parks, Leech Lake Chamber of Commerce, personal communications). A similar trend has been noted for Cass County, as a whole, with resorts declining from 240 in 1999 to about 110 in 2011.

Resorts established many years ago often occupied particularly desirable stretches of shoreline. A substantial inflation of shoreline property valuations over time has resulted in the sale and conversion of existing resorts to individual homesteads, condominiums, and lakeshore associations of homes. In the last ten years there has been an increase in demand for existing Leech Lake properties including lake front homes, lake frontage lots, Leech Lake associated back lots with lake access and new construction homes on Leech Lake. In 2012 there were 17 new lakefront homes built on Leech Lake, 23 new homes in 2020, and 35 in 2021. Comparing sales, there were 59 existing Leech Lake lakefront homes sold in 2012, 93 existing homes sold in 2020, and 70 existing homes sold in 2021 (2022 Regional MLS of MN). In 2022 there are 1,167 lakefront homes on Leech Lake valued in excess of \$50,000.00 and 443 homes on back lots with Leech Lake access valued in excess of \$50,000.00. The above house numbers are thought to be about 10% low because occupied properties under \$50,000.00, and tribal properties or homes not on fee parcels (have no parcel code), are not counted (Cass County MIS, Environmental Services and Assessors offices).

Pricing along with demand has increased significantly since the beginning of Covid 19 in the fall of 2019 (Cass County assessor and regional MLS sales records). Data show significant increases in zoning permits and approved homestead building applications. Prior to Covid 19, many of those moving to the Leech Lake area on a more permanent basis were resort customers or visitors who decided to move North after retiring. Many of the Covid 19-period buyers are individuals that could or were forced to work "remotely" and wanted to "recreate outdoors" and live in less congested areas "now". Covid 19 may also be stimulating population and building permit growth in more rural areas of the county.

Another significant change has been the introduction of the VRBO's (Vacation Rental by Owners) that have in some cases significantly increased individual property utilization. The VRBO's directly compete with resorts for the seasonal tourist business. They also have the potential to create problems related to increased domestic waste volumes and lakeshore disturbances as compared to single owner uses of the property. Currently, Cass County has not established ordinances pertaining to the oversight of the VRBO's, but it is closely reviewing

what other counties are doing. In 2010, the MN Dept. of Health identified 55 Rental by Owner properties in Cass County. As of January, 2021 there were 224 Rental by Owner Properties in Cass County and **62** on Leech Lake. (Cass County Management Information Systems office).

Real estate related activity injects significant dollars into the local and regional economy. Property sales boost the local economy by creating high demand for skilled labor, construction, furnishings, specialty contractors (well driller, septic installer) and other aspects of homestead establishment. Real estate activity is increasing lake utilization by owners, their guests, or customers that results in changes to the lake and shoreline. Stretches of Leech that were once considered “undesirable” owing to shoreline vegetation, wetland proximity, offshore shallows, etc., are now being sought for development, often without adequate consideration of their intrinsic value to the lake. The conversion of older and smaller cabins into larger, more modern homes has also impacted shorelines (see County Zoning Permits & Approved Homestead Applications). The net result is that shorelines which ought to be preserved or maintained for legitimate environmental or aesthetic reasons are now being reduced or eliminated with concurrent effects on water quality, AIS prevalence, scenic beauty (‘wildness’), or other irreplaceable attributes that make the lake such a highly valued natural resource. The Leech Lake Association needs to be informed about, and be able to respond to, not only the biological evolution of the lake, but the residential and commercial development of land around the lake, and to do so in conjunction with the Leech Lake Band.

VI. THE STATE OF LEECH LAKE

Water Quality

Water quality is referred to in terms of its utility to support human recreational, domestic, and commercial uses; its suitability as habitat for fish and other wildlife; and the degree to which the water is different from other water bodies or has changed since the advent of human influences. The kinds of measurements employed to judge water quality are usually determined by the kinds of human activity or land use in the surrounding area. In the case of Leech Lake, contaminants from industrial sources would likely not be present unless they were highly persistent, ubiquitous, or transported long distances (e.g., mercury, PCBs, perfluoroalkyl substances (PFAS)). On the other hand, inputs from domestic uses or nearby commercial land use practices such as logging or farming could have an influence on water quality. Fish or wildlife inhabitants can sometimes provide clues about the condition of the water or the nature of disturbances.

The most common potentially solvable water quality problems for lakes in the sparsely populated recreational lakes area of North Central Minnesota are fertilization from lawns, leakage of individual wastewater treatment systems and storm water runoff. Cass County has not attempted any comprehensive examination of individual septic systems recently due to accelerating costs of detailed inspections. However, any change in ownership of county parcels or building of new structures require that attached septic systems meet Cass County and MN Pollution Control Agency (MPCA) high operational standards. Therefore, the relatively rapid turnover of properties and accelerated building rate in Cass County have resulted in a substantial reduction in septic system leakage into the lake (J. Ringle, personal communication, 2022).

The City of Walker has two large storm sewers that empty into Leech Lake next to the urban housing and business areas. In 2021, through a new infrastructure partnership between the city, Cass Soil and Water Conservation District (SWCD) and Board of Water and Soil Resources (BWSR), “Defender Storm Captors” were installed on these sewers. An estimated two-and-a-quarter tons of sediment, 3.8 pounds of phosphorus and 16.5 pounds of nitrogen are removed by these systems annually before water enters the lake. However, runoff from many less centralized sources around the lake are also of concern. For example, the cities of Laporte, Boy River, Federal Dam, Longville and Hackensack are all in watersheds or on streams that drain into Leech Lake. A program to reduce pollutant loading from these tributary sources was recently implemented through the Leech Lake River Comprehensive Watershed Management Plan (LLRCWMP) by the Cass and Hubbard SWCDs. This program has also acquired equipment for treating roads with brine rather than salt pellets, thereby reducing runoff of chloride applied to snow and ice by 20-30% (see Hintz et al, 2022). Continued strong support by Cass Co. for installing lakeshore buffers, rain gardens or natural areas on individual and business (resort, campground) properties is another important component of controlling the impacts of pollutant runoff on Leech Lake water quality. Lots of information on such practices is available from the Cass County Environmental Services Department office in Walker and on their website.

Three water characteristics have been measured most frequently to judge water quality: phosphorus, a highly nutritious (to algae) component of domestic wastes and fertilizer; chlorophyll-a, which reflects the concentration of algae utilizing the phosphorus for photosynthesis; and Secchi disc depth or transparency, which is inversely related to the algae concentrations. These measurements are used together to calculate a trophic state index, or TSI (Carlson, 1977), which is indicative of the total weight of living biological material or biomass in a water body at a specific location and time. Many agencies monitor water quality on the lake, including the MN Pollution Control Agency, Leech Lake Band of Ojibwe, U.S. Army Corps of Engineers, and others. The MN DNR has collected Secchi depth, chlorophyll-a, alkalinity, and total phosphorus data from Walker Bay and the main lake off Stony Point in late July every year since 1984. During this sampling period the water quality has been for the most part very consistent, most likely due to an intact and relatively undisturbed watershed (Pedersen, personal communication, 2022). Annual zooplankton sampling was begun in 2011 to enhance an understanding of fish community dynamics.

Between 2008 and 2019, local volunteers collected Secchi-disk samples as part of the Minnesota Pollution Control Agency (MPCA) Citizen Lake Monitoring Program. The results from these and all more recent sampling activities are available on the MPCA website (<https://www.pca.state.mn.us/surface>). Starting in 2017, Leech Lake Association members working under the professional guidance of RMB Environmental Laboratories, Inc., and with funding from the Leech Lake Association and a MN DNR-Cass SWCD Partnership grant, have collected samples for total-P, chlorophyll-a, and Secchi depth at four Leech Lake stations during five summer months (Table in RMB, 2021). No trends in these studies have been seen so far that would indicate significant changes in water quality. For example, Agency Bay had an annual mean TSI of 40.3 in 2008 and 40.0 in 2021. However, changes are almost certainly coming, making continuation of this program an important water quality monitoring activity. A sampling of the phytoplankton population in Leech has also been initiated, anticipating that the rapidly growing zebra mussel population will reduce the abundance of this valuable food source,

increase transparency, and potentially affect other factors as well (see also pg. 18, AIS section). The Minnesota AIS Research Center (Hansen et al., 2020) has found that walleye are 14% smaller after their first year of growth and consequently that fewer survive their first winter in lakes “infested” with zebra mussels. Invasion of Leech by spiny water fleas, a large zooplankton that eats smaller zooplankton that are important fish food organisms, would very likely compound AIS problems for the lake.

Minnesota is divided into seven ecologically distinct areas or Ecoregions based on land use, vegetation, precipitation, and geology. Leech Lake is in the Northern Lakes and Forests (NLF) Ecoregion. The MPCA has developed a method to determine an "average range" of water quality expected for lakes in each ecoregion. From 1985-1988, the MPCA evaluated the lake water quality for numerous reference lakes, which are not pristine but exhibit little human impact, and therefore are considered representative of lakes within the ecoregion. The average range refers to the 25th - 75th percentile range for the reference lake data within each ecoregion. The total phosphorus, chlorophyll-a and transparency values for the bays and main body of Leech Lake are all within the average range for the NLF ecoregion.

While Leech Lake’s water quality is considered typical for this region, it does exhibit evidence of some mercury contamination. Mercury can be toxic to both humans and aquatic organisms at very low concentrations. The state has a Fish Contaminant Monitoring Program (FCMP; MPCA, 2008) that has analyzed northern pike and walleye muscle tissue samples from Leech Lake and others at three-to-seven-year intervals since 1984, and most recently in 2019 (Monson, personal communication, 2022). This program provides data for science-based fish consumption advice (Minnesota Department of Health, MDH); for mercury trend analysis and water quality standards development (MPCA); and information on other toxic and persistent contaminants. As a result, mercury has been found to exceed the MPCA/U.S. EPA total maximum daily load (TMDL) limit in the main body of Leech Lake and in several bays (MPCA, DNR, personal communications, 2022).

The greatest source of mercury in Minnesota has been emissions from coal-fired power plants, and while atmospheric emissions have gone down at least 80% with the move away from coal as a fuel source and improved waste disposal practices, fish tissue concentrations have continued to go up from levels reported in the previous edition of this document. One hypothesis attributed this increase to changes in global climate (Monson, 2009; personal communication, 2022). Another study (Blinick, 2022) associates elevated tissue levels in perch and walleye in lakes with the presence of zebra mussels. Mercury’s persistence and presence in fish tissues, coupled with its human toxicity, have led the MN Department of Health and DNR to publish a mercury-related fish consumption advisory applicable to Leech (see current Minnesota Fishing Regulations).

In November of 2021, The Leech Lake Band of Ojibwe (LLBO), obtained approval from the U.S. Environmental Protection Agency (EPA) to administer water quality standards and certification programs under Sections 303(c) and 401 of the Clean Water Act (CWA). Section 401 of the CWA gives LLBO authority to grant or deny federally permitted or licensed activities that result in a “discharge into waters of the United States” based on any applicable water quality standards. Currently LLBO operates under CWA Section 401 using adopted standards from the State of Minnesota. The LLBO, Division of Resources Management is in the process of

developing their own water quality standards to be submitted to the EPA for review in the near future. Once approved, LLBO can operate under those standards for the purposes of CWA Section 401. It is anticipated that these standards and programs will help protect the water quality of Leech Lake.

In summary, it appears from the existing water sampling data that Leech Lake water quality is basically in good shape and supports a wide array of healthy endemic biotic communities and human activities. The watershed approach serving as the foundation for the programs and projects developed under the Leech Lake River Comprehensive Watershed Management Plan and implemented by the Cass Soil and Water Conservation District has played, and will continue to play, a major role in the long-term protection of Leech Lake. Planning for a second round of targeted watershed condition investigations is underway and work will begin in 2023. The appearance of Zebra mussels is not good news and is likely to have some undesirable ecological consequences. Mercury tissue residues are a problem but most of the sources are outside the local area, impeding our ability to do much about them directly. The limited water sampling information for other persistent contaminants such as some pesticides, PCBs, dioxins, PFAS, heavy metals, and residues in sewage treatment plant effluents have not been found here or are not considered significant enough water quality problems to issue health protection guidelines for them at this time.

Vegetation

Wetlands and other natural areas support a great diversity of native plants and animals. Plus, they provide a wide variety of biological services, such as flood attenuation, erosion control, nutrient cycling, and community resilience to natural catastrophic events. Potential threats to the native plant community include competition with non-native plants, predation by rusty crayfish, water level manipulation (high water levels in particular), changes in water clarity or quality, and direct destruction of plant beds. Although property owners may not have direct control over vegetation management outside of their property, they can act to protect existing vegetation and restore degraded sites. Lake-friendly land use practices that can improve the overall health of Leech Lake include:

- **Reduce shoreline disturbance of the lake bottom** (substrate or benthic zone). Disturbance can release excess nutrients into the water potentially creating algal blooms, affecting water quality, and/or fueling the growth of invasive organisms.
- **Avoid clearing shoreline vegetation.** Native shoreline plants provide important biological services with wide-ranging benefits.
 - Plants growing along the shoreline are key components of a healthy lake. Native plants provide the critical habitat essential for fish, micro-organisms, invertebrates, amphibians, waterfowl, and other birds to reproduce and develop.
 - Emergent aquatic plants (cattail, bulrush, wild rice) act as wave buffers.
 - They also function as nutrient pumps, pulling nutrients out of the water column and into plant structures, thereby capturing nutrients and reducing the “fuels” for undesirable invasive species.
- **Increase natural near-shore vegetation.** Preserve or restore the *native* shrubs, trees, shoreline plants that naturally occur around lakes. Collectively they reduce nutrient run-off entering lakes to 10% and increase infiltration of rainfall by 55%. Conversely, the

standard lawn creates a hard surface, which increases run-off to 55% and reduces infiltration to 15%.

- **Work with your neighbors.** Shoreline management can have cumulative impacts that affect overall watershed health. Work together to improve the function of the shoreline zone by incorporating some of the ideas above.
- **Consider the watershed impacts of all land use practices.** Stop and consider the potential impacts of fertilizing, using herbicides, dumping yard “waste” near shore, or maintaining your lakeshore or beach area as “weed-free.”
- **Stay positive.** After years of doing things the “same old way” it is difficult to change engrained habits or ideas but stay positive; you are making a difference that will be experienced and appreciated by your grandchildren.

Vegetation Zones and Inventories

Vegetation of Leech Lake can be divided into shoreland, emergent, and submerged zones. Each zone differs in the types of plant communities present and the potential factors that may alter vegetation. The amount and type of baseline data, and the methodologies required for monitoring and the strategies for protection, differ among these three zones. Shoreland zones include both terrestrial and wetland plants. Data from shoreland zones were used to rate the sensitivity of these areas around Leech Lake and the priority of sites described in Thompson and Perleberg (2010).

Emergent plant beds were primarily found in areas of less than six feet and were concentrated in protected bays. Survey data collected in 2008 and 2009 by the MN DNR and Leech Lake Band of Ojibwe (LLBO) were used to delineate bulrush (*Schoenoplectus* spp.) and wild rice (*Zizania palustris*) beds in the emergent plant zone of Leech Lake. About one-third of shallows six feet or less (5,800 acres) were occupied by these two species and other floating-leaf plants.

Lake-wide surveys to describe and quantify submerged plant communities were conducted between 2004 and 2007. The submerged plant muskgrass (*Chara* sp.) was the most frequently recorded taxon in the submerged plant zone and was found in 26% of all sample sites. This was a cooperative project between DNR, LLBO, and several volunteers from the Leech Lake Association. The results indicated this zone extends from shore to a depth of at least 28 feet but the majority of submerged plants occurred at 18 feet or less. Vegetation occurred in only 39% of the survey sites and was influenced by water depth and turbulence. Plant growth was concentrated in protected, shallow bays; the windswept main basin was mostly un-vegetated.

Altogether, forty-nine native plant taxa were identified including 15 emergent, three free-floating, four floating and 27 submerged taxa. The greatest number of plant species occurred in depths of six feet and less. Other important submerged taxa included bushy pondweed (*Najas flexilis*), flat-stem pondweed (*Potamogeton zosteriformis*), northern watermilfoil (*Myriophyllum sibiricum*), a variety of broad-leaf pondweeds (*Potamogeton* spp.), greater bladderwort (*Utricularia vulgaris*), wild celery (*Vallisneria americana*), Canada waterweed (*Elodea canadensis*) and coontail (*Ceratophyllum demersum*).

The goal for the 2002-2009 lake-wide surveys was to describe the current aquatic plant communities and to generate data that could be used as a baseline for setting up specific monitoring projects to track changes in plant community composition and distribution. Since those surveys, two non-native submerged plants, Eurasian watermilfoil (*Myriophyllum sibiricum*) and starry stonewort (*Nitellopsis obtusa*), have been detected in Leech Lake. A ten-year comparison (2008-2009 to 2019-2021) of the current vegetation of Leech Lake will be completed in the spring of 2022. The 2004-2007 lake-wide survey identified muskgrass (*Chara* sp.) as the dominant submerged plant and found that it covered thousands of acres of lake bottom. Muskgrass is a type of submerged algae known as stoneworts that grow in large colonies and often resemble higher plants. In Leech Lake, muskgrass grows as a low-lying “carpet” along the bottom of the lake. Benefits of muskgrass include:

- Critical cover and food...in Leech Lake muskgrass beds occurring at 3-6.5 feet have been identified as optimal habitat for muskellunge spawning (Strand 1986);
- Uptake of phosphorus
- Maintenance of water clarity by competing for nutrients with microscopic algae.

In 2021 the Legislative-Citizens Commission on Minnesota Resources (LCCMR) awarded a grant to the MN DNR to conduct a statewide assessment of stoneworts (Project #2021-055). Part of this study will be a cooperative effort between the MN DNR, LLBO, Leech Lake Tribal College, and the New York Botanical Garden. Leech Lake will be a focus site in this study, and preliminary work has already revealed several unique native stonewort species in Leech. Surveys conducted for this project will also increase efforts to search for the non-native “starry stonewort.”

Fisheries

Fifty years ago, Leech Lake represented quite an attraction to vacationing and resident anglers alike. With a few hours invested in sport fishing, a vacationing family could reasonably expect to provide itself with enough fish for most of its meals if desired. Walleye was the preferred species to catch and they tended to be abundant as any angler from that period can readily demonstrate with photographs of heavily laden stringers. Northern pike, perch and crappies also were caught but typically returned to the lake unless of “keeper” size.

When our initial *Leech Lake Management Plan* was published in 2004, the sport fishery – particularly for walleye – was in decline and adversely affecting the Leech Lake resort and business community. Resorts sat empty. Walleye fishermen were no longer coming to spend their money on lodging or in area businesses. The causes of the decline were unclear, but a number of factors were suspected, including poor year classes in the early 2000’s, the population explosion of cormorants which were suspected of eating large quantities of young perch and walleye, over harvest of brood stock, and the explosion of invasive rusty crayfish which were thought to be preying heavily on walleye eggs and destroying weed beds.

The situation demanded action and actions were taken. In 2005, responding to community interest and legislative decree, the DNR wrote the first of several Five-Year Plans designed to restore good walleye fishing in Leech Lake. These plans had a few long-term goals, which were

arrived at through community involvement and input from a fishing task force created for that purpose. These goals included:

- Protecting mature female walleye with an 18 to 26-inch protected slot and reducing the walleye limit to four.
- Supporting efforts by the Leech Lake Band's Division of Resource Management to reduce the number of double-crested cormorants on the lake. (Their population level had risen to about 10,000 in 2004.)
- Stocking 7.5 million marked walleye fry during years 2005-2007, which, when compared with captured unmarked young walleye, could be used to estimate walleye hatch rates (there were concerns about possible reproductive problems with Leech Lake walleyes).
- Continuing to protect water quality and shorelands sensitive to human disturbance.

These efforts, whether singly or in combination, delivered positive results. Today, Leech Lake boasts one of the best multi-species fisheries in Minnesota. The DNR uses several methods to gauge the status of the fishery: (1) an annual "population assessment" obtained by counting and analyzing fish captured at different times of the year in seines, trawls, electro-fishing, and gill nets; (2) periodic surveys to estimate fishing pressure, harvest, and catch statistics; and (3) information gathered by independent studies by various parties. DNR netting data extending back to the early 1980's forms the basis for determining long term trends of fish abundance. Estimates of walleye hatch rates are similar to those observed for other large Minnesota walleye lakes, and suggest no chronic issues exist with egg or fry survival. As a result, stocking was discontinued in 2014 and natural reproduction has been able to provide strong year classes since then. MN DNR test netting also indicated that there was an adequate number of adult spawners in the lake, allowing the 18-26 inch protected daily slot limit to be removed for the 2019 season. The 2022 daily bag limit is four fish with one over 20 inches allowed to be kept. With strong interest from the Leech Lake fisheries input group and angling public, a reduced bag limit was introduced for bluegill and black crappie on the lake in 2021 to maintain or improve the size structure of the panfish population.

Rusty crayfish observations from lakes in both Wisconsin and Minnesota suggest that predation on walleye eggs is minimal and probably has no significant direct effect on walleye population levels (see further discussion in the AIS section). The current state of cormorant control efforts and consequences are discussed in the Wildlife section of this plan. Yellow perch abundance has decreased to below desirable MN DNR and fisheries input group target levels in recent years. Favorable winter ice and snow conditions and the advent of 'wheelhouses' have resulted in unusually strong ice fishing harvests. It is hoped that population levels will rebound naturally without the need for changes in existing harvest regulations for this species. Catch and harvest rates of other species have remained within ranges considered desirable. To assist in efforts to maintain good fishing in years to come, the MN DNR has established a 17-member Leech Lake Advisory Committee to provide input to fisheries management plans. The LLA has one seat on this committee. The plan is currently updated every 5 years and the most recent *Fisheries Management Plan for Leech Lake 2021-2025* (Petersen, 2020) has been published and is available at the Walker Fisheries Office or at https://files.dnr.stats.mn.us/areas/fisheries/walker/mp_leech.pdf. The Leech Lake Advisory Committee will continue to meet annually to review annual population-assessment results as

compared to established benchmarks. While primarily directed at the walleye fishery, the plan also includes sections on other fishes, protecting habitat, preventing the spread of invasive species, protecting known muskie spawning beds, and monitoring aquatic vegetation.

Aquatic Invasive Species (AIS)

Aquatic Invasive Species quickly establish themselves, displacing native plants and animals, and often cause significant ecological and economic impacts. These include impairment of recreation, navigation, and flood control; degradation of water quality; loss of fish and wildlife habitat; and a decrease in property values. Changes may trigger a cascade of trophic level affects, disrupting the function of aquatic ecosystems. AIS typically exhibit rapid growth and prolific reproduction of propagules, seeds, or offspring. They are often relocated without the predators, diseases, or pathogens that keep their populations in check. In such cases, natural predators or pathogens are sometimes introduced as biological control management tools. To view the most updated infested waters list, visit the DNR website:

<https://www.dnr.state.mn.us/invasives/ais/infested.html>

Submerged and Emergent Aquatic Vegetation

- Eurasian watermilfoil
- Curly leaf pondweed
- Starry stonewort
- Purple loosestrife

Eurasian Watermilfoil (*Myriophyllum spicatum*) Confirmed in Leech in 2004.

Eurasian milfoil was introduced to the United States in the 1940's and has since spread to nearly every state. This submerged aquatic plant can be identified by its feather-like leaves arranged in whorls of four around a long stem. Stems produce several branches forming dense floating mats on the water's surface. Vegetative reproduction by small stem fragments increases this plant's ability to root and form new colonies. Mats of this plant reduce native plant diversity as well as the quality of fish spawning habitat and interfere with recreational activities such as boating and swimming. It is important to note that Eurasian milfoil is strongly associated with total water column phosphorous and loss of native plant cover. The MN DNR is currently conducting a 2004 to 2021 comparison of the plant community that will provide information on changes in the growth of Eurasian watermilfoil (see also Vegetation section).

Curly Leaf Pondweed (*Potamogeton crispus*) Confirmed prior to 2017.

Curly leaf pondweed typically grows in shallow water 3-10 feet deep. It readily invades disturbed areas and tolerates low water clarity. Growth begins in early spring and can even be seen growing under the ice. Early development allows this plant to capture nutrients, grow rapidly ahead of native plants, and die back by mid-summer. Rafts of dying pondweed can cause an increase in available phosphorous (normally a growth-limiting nutrient) resulting in undesirable algal blooms. Transfer and spread of curly leaf occur when turions (hardened stem tips) are carried on other vegetation attached to boat trailers, watercraft, etc.

Starry Stonewort (*Nitellopsis obtusa*) Confirmed 2021.

Starry stonewort is an invasive macro-alga native to Europe and Asia. Starry stonewort is similar in appearance to native charophytes such as musk grasses and native stonewort but appear larger and more robust. It has whorls of long, narrow branchlets in groups of 4 to 6 coming off the main shoots, the end dactyls are asymmetrical, and is a distinguishing feature along with the white star-shaped bulbils. It can grow up to 10 feet tall and can be found as deep as 30 feet in some lakes. To-date, only male species have been found in the United States, so it is thought the reproduction and movement of starry stonewort has primarily been through fragmentation and bulbils, or clonally.

Starry stonewort grows in dense mats that can interfere with recreational activities, clog harbors, and may impact fish and other animals. Human activities have the potential to spread starry stonewort as props, fishing gear, and anchors chop the stonewort into fragments that disperse and re-establish populations elsewhere. The ecological effects of the dense starry mats are not fully understood but have the potential to affect water temperature, oxygenation, and nutrient levels. The first discovery of starry stonewort in Minnesota occurred in 2015 in Lake Koronis in Stearns County.

Leech Lake was the 17th lake or river section in Minnesota to be confirmed to have starry stonewort. It was found on the western edge of Steamboat Bay of Leech Lake in July 2021. It covered roughly 22 acres, largely occurring in the wild rice beds and boating channels. The Leech Lake Band of Ojibwe, the Cass County AIS Program, the Leech Lake Association, and the Minnesota Department of Natural Resources worked collaboratively to respond to the discovery by hiring an aquatic plant management company to conduct diver-assisted suction harvesting (DASH) in Steamboat Bay in September 2021.

In the DASH process, underwater divers hand-pull the starry stonewort from the sediment and feed it into a vacuum tube leading to a screening structure on a pontoon-like boat. While DASH was utilized in open areas and boating channels, removal was not conducted in other areas out of concern for possible harm to culturally and ecologically significant wild rice beds. Studies have shown that hand-pulling for smaller infestations has been successful in decreasing the area of starry stonewort infestations, however, little data exist to-date on use of DASH for removal of larger infestations. Plans are underway to study the efficacy of this process and its timing.

Starry stonewort was not found at other private and public accesses in monitoring done by Cass County AIS Program, the Leech Lake Band of Ojibwe, and the Minnesota Aquatic Invasive Species Research Center (MAISRC) in August and September of 2021. However, the further spread of starry stonewort in Leech Lake is of particular concern. The Leech Lake Association encourages boaters to help prevent fragmentation and further spread by staying out of the infested area. When passing by rice beds, boaters should operate at slow-no-wake speeds as even minor wave action can damage wild rice. Always clean, drain, and dry your boat when traveling to different lakes or accessing Leech via a different access, per DNR requirements and recommendations.

Starry stonewort is best managed when infestations are caught early. The Leech Lake Association encourages its members and all lake users to be watchful for new plant species on the lake. LLA strongly supports the Minnesota AIS Detector program <https://maisrc.umn.edu/detectors-core>, an online or classroom course. Additional mini-detector training sessions may also be offered through the Cass AIS Program: <https://stopais-casscountymn.hub.arcgis.com/>.

Purple Loosestrife (*Lythrum salicaria*) Confirmed as early as 1988.

Purple loosestrife is a tall, emergent, purple-flowered perennial wetland plant imported from Europe in the early 1800's without its natural predators, giving it an advantage over our native wetland plants. Purple loosestrife forms dense stands crowding out native plants, thus degrading food, shelter, and nesting sites for wildlife. It is known to exist at several locations on Leech Lake. Current management of purple loosestrife by the Leech Lake Division of Resource Management includes the use of the natural predator *Galerucella* beetles. Despite yearly efforts to control the size and numbers of plants at these sites, infestations continue to be found in new locations. Various factors such as snowmobile traffic through infested marshes and shorelines may carry seeds to new locations.

Aquatic Invasive Species (AIS) -- Animals

Currently Present

As of 2022, four animal aquatic invasive species are known to occur within Leech Lake:

- Zebra mussels
- Rusty crayfish
- Banded mystery snails

Zebra Mussels (*Dreissena polymorpha*) Confirmed 2016.

Zebra mussels are small, brownish, clam-like animals that are somewhat triangular in shape and have a series of darker or black stripes across their shells. They are 1-1 ½ inches long as adults and usually grow in groups or clusters that are strongly attached to solid surfaces in water up to 30 feet deep. Each adult produces millions of eggs that hatch into near-microscopic, free-swimming larvae called veligers. The veligers become dispersed in the water column and are the form considered most likely to be transported to non-infested water in bait buckets, bilges, and live wells that are not emptied and dried. According to the Minnesota Department of Natural Resources (MN DNR), the attached adult forms can 'clam up' and live for up to 21 days out of the water. Their longevity out of water presents a transport and invasion hazard, especially when moving used docks and lifts, which is why Minnesota state law requires a 21-day dry time for all docks, lifts, and swim platforms before transporting to a different body of water.

In 2016 the MN DNR confirmed that veligers were present in Leech Lake. Isolated adult mussels were seen in 2018 and 2019, and by 2020, greater numbers of adult mussels were seen in some bays. In 2021, significant numbers were seen throughout the lake.

Zebra mussels affect components of aquatic food webs in lakes and streams they invade. In lakes, zebra mussels consume phytoplankton, resulting in increased water clarity and reduced

amounts of these plants being available as food to zooplankton. The disrupted food chain impacts the food supply not only of immature fish but also invertebrates (e.g., insect larva, amphipods, snails) that are a critical food source for larger fish. This chain of events has been found to reduce growth rates and first-year survival of young-of-the-year walleye, and the abundance of adults (Higgins and Vander Zanden 2010, Hansen et al., 2020). In partnership with the MN DNR, the Leech Lake Association is conducting a water monitoring program designed to measure zebra mussel related changes in Leech Lake water chemistry and microorganism populations (see also Water Quality section, pg. 11).

Zebra mussels have a tremendous reproductive capacity: one adult mussel can produce up to 250,000 larval stage veligers. For example, Lake Mille Lacs had an estimated 9 to 12 trillion zebra mussels at peak infestation. An adult mussel filters one liter of water per day resulting in filtering all the water of Lake Mille Lacs in three days, altering the lake's biomass. Physically, they attach to rocks, pilings, docks, boats, motors, intake pipes, locks, and dams, etc., causing many billions of dollars in damage and severe inconvenience to individuals and industries. Dead zebra mussels accumulate in windrows of sharp shells on beaches. Decaying mussels give off a particularly putrid odor impacting the beaches and shorelines. As of 2021, no technology has been available to eliminate or control zebra mussel populations.

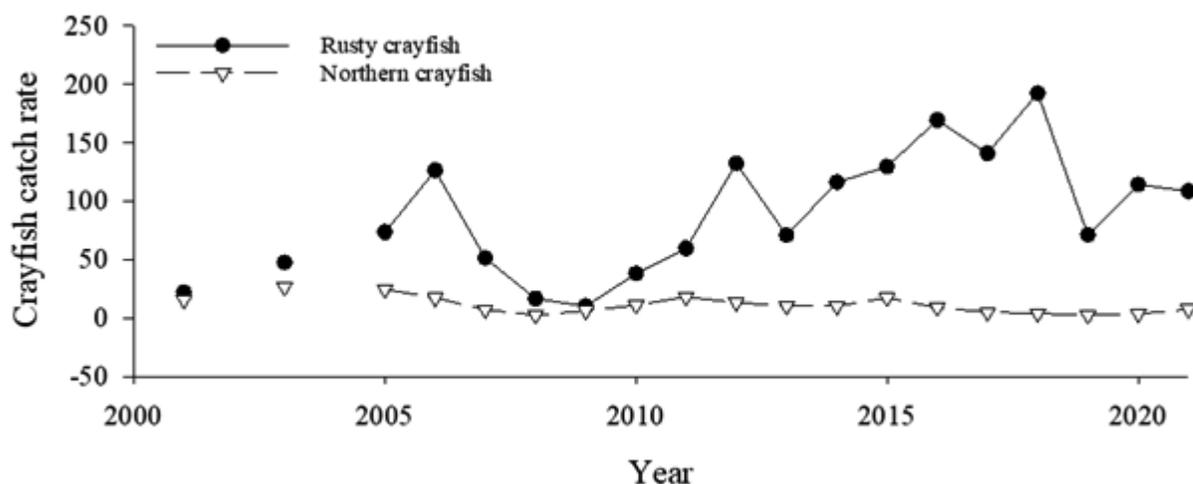
Rusty Crayfish (*Orconectes rusticus*) Confirmed prior to 2017.

With their large size, aggressive nature and high metabolic rate, rusty crayfish tend to reduce or displace native crayfish species. Studies in Wisconsin found that the native crayfish, *Orconectes viriles*, the most common native species in Leech Lake, was eliminated in 75 percent of the lakes invaded by rusty crayfish (Olden et al. 2011). Rusty crayfish generally devour more aquatic vegetation than native crayfish and can reduce species diversity as well (Wilson et al. 2004). High numbers are often accompanied by a reduction in the abundance of a wide variety of other bottom dwelling invertebrate organisms that serve as fish food items (larval life stages of insects such as damsel flies and mayflies, snails, etc.). Data from several published studies (e.g., Roth et al. 2006) indicate that invertebrates are a much higher energy source than plants and are selected first as a food source, and that plants are primarily eaten by rusty crayfish when the invertebrates become scarce.

Rusty crayfish are known to eat the eggs of some fish like bluegill that build nests and spawn at higher temperatures (70 degrees) (Dorn and Mittelbach 2004, Wilson *ibid*, Roth et al. 2007). Being native to more southerly latitudes, rusty crayfish have a growth range between 59 and 84 degrees (Mundahl and Benton 1990, Roth et al. 2006). Walleye, on the other hand, spawn at 38 to 50 degrees and their eggs hatch at 47 to 55 degrees (Becker 1983), so rusty crayfish are largely inactive when the scattered walleye eggs would be susceptible to crayfish predation. Three rusty crayfish-infested lakes in the Tower, MN area have relatively stable, naturally produced walleye populations. However, one of these lakes, Eagle's Nest Three (last stocked in 1985), has experienced a sharp decline in bluegill abundance and in some aquatic plant species (MNDNR 2012 personal communication).

Walleye, perch and bass are known to eat the young of rusty crayfish, which may or may not lead to reductions in crayfish populations. The ecosystem response of Leech Lake to invasion by rusty crayfish is not entirely clear now and is possibly still evolving. Further observations and studies of both the plant and animal communities should help shed light on this issue. Incidental

counts by MN DNR fisheries personnel of rusty crayfish clinging to Leech Lake fish survey nets indicate that the population peaked in 2018 and has since decreased. The decrease may represent rusty crayfish reaching a maximum carrying capacity in Leech Lake. More years of sampling will still be needed to determine if this will be a sustained level for the rusty crayfish population, as well as any impacts or changes that may occur to their population because of new AIS infestations such as zebra mussels now present since 2016. See the figure below for crayfish populations in Leech Lake, provided by the MN DNR in January 2022.



The results of many studies indicate that the response to invasion by rusty crayfish is variable and unpredictable between water bodies, and that profound ecological changes are possible. Therefore, every effort should be made to prevent their spread to other area lakes. Crayfish from one lake should never be used as bait in any other lake. It is suspected that in 1990 rusty crayfish were introduced to Leech Lake by anglers who used them as fish bait. The possibility of transport and distribution by commercial bait dealers should continue to be carefully monitored and controlled through the state’s AIS prevention program.

Banded Mystery Snails (*Viviparus georgianus*) Confirmed 2006, most likely present earlier. Banded mystery snails are native to southeastern United States. They are 1.5 inches long and have wide horizontal brown bands on the shell. Ecological impacts are not well documented, but it is suspected they compete with native snail and mussel species for food. It is a host for multiple trematode parasites that have caused waterfowl die-offs. Large die-offs of the banded mystery snails can be a shoreline nuisance. The similar **Chinese Mystery Snail** has a dark green olive color and is sometimes covered by a thin layer of moss-like algae. Although there are no records of Chinese mystery snails in Leech Lake, its prevalence in hundreds of other Minnesota lakes suggests it may also be present in Leech.

Other Possible Invaders

Quagga Mussels (*Dreissena bugensis*)

Like zebra mussels, quagga mussels were transported to the U.S. in the late 1980s by ships entering the Great Lakes from Eurasia. Although similar to zebra mussels in filter feeding

and other effects on lake ecology, Quagga mussels are unique from zebra mussels in that they inhabit deeper water and often settle on soft bottoms such as sand and silt. Quagga mussels grow slightly larger than zebra mussels, they have less distinct striping (if any) on their shells, form an S-shaped when aperture is closed, and do not stand upright when placed on their ventral edge. It is estimated that over 700 trillion quagga mussels currently inhabit Lake Michigan and that they filter all the water in the lake every 10 days or so. There are no known infestations in inland Minnesota lakes, but the potential is great, given our proximity to Lake Superior.

Spiny Water Flea (*Bythotrephes longimanus*)

Spiny water fleas are zooplankton about 3/8 inches long that were transported to the Great Lakes from Europe prior to the mid-1980s. They have since spread to all the Great Lakes and to many inland waters in the U.S. and Minnesota, including Mille Lacs Lake, Lake Winnibigoshish, Cass Lake, and Lake of the Woods. They are found at all depths and accumulate as gelatinous globs on trolled fishing lines and down rigger cables. Anglers should wipe down their lines and other gear that has been in the water before moving to a different lake. Spiny water fleas eat smaller zooplankton that are an important food source for many other inhabitants, causing the decline or elimination of many native species. Their name comes from a long spiny ‘tail’ that causes fish to reject spiny water fleas as food. Their proximity to Leech, and presence in lakes visited frequently by boaters also using Leech, means that they could easily be transported here unless preventative steps are taken. Their eggs can resist drying for several hours to days. The same measures employed to prevent the spread of other AIS should also work for spiny water fleas and should be carried out *by every property owner, boater, and lake service providers with special attention paid to cleaning gear like fishing lines and down rigger cables.*

The Leech Lake Association is participating in spiny water flea monitoring work on Leech Lake in partnership with the Cass County AIS Program. This involves evening plankton tows in the late summer/early fall when spiny water fleas have been found to be more active in the upper water column. They stay in deeper, darker water during the daylight hours then come up to the surface at night for feeding and/or predator avoidance. Anglers in Leech Lake should also watch for the gelatinous globs on trolled fishing lines and down rigger cables, and report any findings to the local DNR AIS Specialist on this website:

<https://www.dnr.state.mn.us/invasives/ais/contacts.html>

Faucet Snail (*Bithynia tentaculata*)

Faucet snails are another species imported from Europe that has caused problems in nearby waters. They have become established in Lake Winnibigoshish and, as the intermediate host for three intestinal trematodes, they cause mortality in ducks and geese. They are believed to have been responsible for about 9,000 scaup and coot deaths on Winnibigoshish in 2007-2008. The trematodes are not thought to be a threat to humans. They can be spread by attaching to aquatic plants, boats, anchors, decoy anchors, and other recreational gear and equipment placed in water (See MN DNR AIS website). Movement by waterbirds may also spread this invasive to new waters. In addition to the same cleaning procedures described for the above invasive species, additional care and common sense should be employed to prevent

the spread of this species from Winnie to Leech. *Waterfowl hunters as well as fishermen* should take appropriate steps to avoid carrying them elsewhere.

Other Potential Invaders

Other aquatic invasive species threaten Leech Lake, and could cause serious ecological disruption, however the risk of them being transported here is considered lower. These include several species that have been carried by both domestic and foreign ships to the Duluth Harbor on Lake Superior: white perch, round goby, Eurasian ruffe, and New Zealand mud snail. The same procedures for preventing other more prevalent AIS from reaching Leech should also work for these species. The invasive carp established in the lower Mississippi are a very serious concern, but with any luck and the necessary resources, the hope is they can be stopped before advancing this far north. Infection of Leech Lake fish populations by the disease Viral Hemorrhagic Septicemia (VHS), also found in Lake Superior, could be calamitous, although some degree of natural resistance might exist here. The MN DNR is trying to control its spread by monitoring and regulating the movement of fish and water between lakes and streams. Lastly, red swamp crayfish is a potential threat, and the MN DNR prohibits the transport of live red swamp crayfish into the state. If you'd like to consume this species at a crayfish boil you need to obtain a permit from the MN DNR to have frozen crayfish shipped to you. If you are looking for fresh crayfish, you can always trap rusty crayfish on Leech Lake for consumption. More information on VHS and the other potential invaders is provided on the MN DNR AIS website.

Current Control Actions

Leech Lake Association is actively working with partner organizations and agencies to prevent the spread of AIS to Leech Lake and other water bodies. Leech Lake Association strongly supports efforts to:

- Enforce all existing laws and regulations aimed at preventing transport of AIS to and their introduction into Leech Lake and other area lakes through either recreational or commercial activities;
- Extend the same level of protection against AIS introductions to all watercraft accesses on Leech Lake, whether public or private;
- Study AIS impacts on the lake ecology and participate in projects that aim to contain or reduce spread of AIS into areas within Leech Lake;
- Increase people's knowledge about AIS, their effects on non-infested waters and native species, and measures to prevent their spread, in partnership with the MN DNR, Cass County AIS, the Leech Lake Band of Ojibwe, the Minnesota Aquatic Invasive Species Research Center (MAIRSC) and others;
- Increase lake users' knowledge and early detection of the spiny water flea and other AIS through the promotion and participation in the AIS Detectors program;
- Improve boaters' usage of decontamination stations through better communication of stations' locations;
- Improve signage at public and private accesses that remind users about laws and regulations to prevent transporting AIS between waterbodies, and what to do if AIS are detected;

- With other lake associations and organizations, promote legislation and acquire resources required to implement effective AIS prevention measures and programs.

Wildlife

Minnesota's lakes are home to many species of wildlife. From our famous loons and bald eagles to muskrats, otters, frogs and fish, wildlife is an important part of our relationship with lakes. In fact, Minnesota's abundant wildlife can be attributed largely to our wealth of surface water. From small marshes to large lakes, these waters are essential to the survival of wildlife.

The most important wildlife habitat begins at the shoreline. The more natural the shoreline, which would include trees, shrubs and herbaceous vegetation, the more likely that wildlife will be there. Just as important is the shallow water zone close to shore. Cattail, bulrush, and wild rice along the shoreline provide both feeding and nesting areas for wildlife. Loons, black terns and red-necked grebes are important Minnesota birds that are particularly affected by destruction of this vegetation. Submerged vegetation is also important to wildlife for many portions of their life cycle, including breeding and rearing of their young.

The MNDNR report *Sensitive Lakeshore Survey Leech Lake (11-0203.00) Cass County, MN* (2010) lists the following wildlife species for Leech Lake.

Bird surveys:

- 130 bird species have been identified and recorded at Leech Lake.
- 38 species in greatest conservation need.
- 2 species listed as threatened in MN: common tern and trumpeter swan.
- 5 special concern species: American white pelican, bald eagle, Forster's tern, Franklin's gull, and yellow rail.
- 18 Loon nesting areas.

Fish surveys:

- 42 species have been identified and recorded in Leech Lake.
- Species in greatest conservation need: pugnose shiner and least darter.

Frog surveys:

- 797 survey stations were conducted along the shoreline of Leech Lake.
- Mink and green frogs were the most common identified and recorded.
- Other frogs and toads identified and recorded include gray tree frogs, American toads, northern leopard frogs, western chorus frogs and wood frogs.

The Water Quality and Vegetation sections of the plan have dealt with the importance of maintaining or improving environmental conditions in the lake or in shorelands that are the essential habitats for wildlife. Often the degree of the presence or absence of these animals is indicative of the health of these ecosystems. Their presence is important not only to the health of the lake, but also to the resident human community and visitors who depend on the observation of wildlife, or knowledge that it's there, as their reason for living on or coming to Leech Lake. The wildlife contributes to the functional, aesthetic, spiritual, and economic components of the surrounding area. Therefore, the Leech Lake Association supports measures aimed at protecting the water and shoreland habitats of indigenous wildlife species, and at maintaining wildlife population levels indicative of healthy, well-balanced ecosystems (more on this in the Land Use and Zoning section).

One native species that is of concern to many fishermen is the **Double-crested Cormorant** (*Phalacrocorax auritus*). This bird has been noted as a resident of Leech Lake as far back as written records are available (Mortensen and Ringle, 2007). They are one of 30 species of cormorants in the world and one of six in North America. They can live up to 17 years in the wild with an average life expectancy of 6.1 years. Cormorants have long been persecuted by humans and were decimated after WWII by the use of chemicals such as DDT. Cormorants were officially protected under the *Migratory Bird Treaty Act* and in 1972 it became a federal offense to kill cormorants or destroy their nests and eggs. Since being protected from killing and with a decline in the use of DDT, the bird numbers started to recover, but have not reached historic numbers. The establishment of catfish farms in the wintering range of cormorants has also been implicated in their rapid increase as the birds now have an abundant source of high-quality food when compared to the Gulf of Mexico where they normally winter. It is estimated that breeding and non-breeding cormorants total upwards of 2 million in North America, with the bulk of them nesting in the Great Lakes region and Canadian provinces. The cormorant population also increased rapidly on Leech Lake, where the Leech Lake Band of Ojibwe Division of Resource Management (DRM) counts found 1,144 nests in 2003, increasing to 2,524 nests in 2004.

With each adult bird consuming about one pound of small fish per day there were concerns that they might be affecting fish populations in the lake. Cormorants are protected under federal and tribal law, but the development in 2003 of the US FWS *Public Resources Depredation Order* does allow for control where cormorant numbers are causing damage to public resources such as fish and rare habitats or species. This order was vacated due to a new permitting process that is more restrictive which was implemented in 2020. The colony on Leech Lake nests on tribal lands and therefore their management is under the control of the Leech Lake Band's Division of Resource Management. In order to initiate a control program, a joint federal, tribal and state Environmental Assessment (EA) was prepared that would cover Leech Lake as well as other sites in Minnesota where there were legitimate impact issues.

Large numbers of cormorants nest on Gull and Little Pelican Island where the DRM was able to demonstrate that they were competing with ring-billed gulls for nesting space and were having a negative effect on common terns, a threatened species. Due to the concerns over common tern populations, the DRM was able to initiate cormorant control efforts in 2005, and by 2021 a total of 32,610 adult and sub-adult cormorants were removed from the lake. There is some evidence that when cormorant numbers were very high they were having a negative effect on young walleye recruitment as a condition of conducting cormorant control, the DRM also had to initiate a diet study to determine what cormorants were actually eating on the lake. This study has found that cormorants consume mainly small yellow perch and lesser amounts of a variety of other species. Walleye consumption was found to range from 1.5 to 6.5% of their diet, by mass, among years. Conversely, the perch diet ranged from 45.1 to 76.2% by mass (Schultz, et al., 2013).

Due to changes that occurred at the same time the diet study was initiated, including walleye fry stocking, an angler bag limit reduction and slot (size) limit, it is difficult to determine the effects of cormorant predation. Preliminary findings of the diet study and modeling indicate that cormorant predation on walleye fingerlings is probably not a significant factor as it is replacing

natural mortality which is very high. If mortality on yearlings is high however, this may result in lower walleye populations in future years. This is all due to the compensatory versus additive mortality in fish populations. The vast majority of all small fish in a lake die each year due to being eaten by other fish or other natural causes. This is compensatory mortality and in the grand scheme of things it makes little difference how these fish die; they just pass through the food web in different ways. Additive mortality is that which is over and above what would naturally occur and should this be too high it can result in changes to a fish population. Human harvest, for example, is highly additive because we take fish that otherwise would have survived most natural mortality. Modeling of Leech Lake's fish population and this complex interaction continue to better understand the effect of cormorant predation.

Cormorant control is very expensive, costing up to \$50,000 per year on Leech Lake, and is becoming increasingly difficult as the birds adapt to control measures. The DRM is working to come up with alternatives to lethal measures to keep cormorant numbers controlled on the lake due to the high cost and controversy over lethal control of a native species. The DRM have been experimenting with the use of artificial eggs as a means of accomplishing this goal. This technique involves replacing three of the typical four-egg-clutch with artificial eggs that results in reproduction being cut in half (Roerick and Mortensen 2019). The one viable egg reduces the chance of the birds from re-nesting or moving to new locations on the lake. It is hoped that over the long term this technique will reduce the need for control of adults, while still reducing cormorant numbers on the lake. The cormorant population goal for Leech Lake is 500 reproducing pairs and this is the level control efforts target each year. At this level the walleye population recovered and has been doing well for many years. The DRM plans to continue control efforts at current levels unless compelling evidence indicates they should do otherwise, and if funding is available. The Leech Lake Association actively supports these studies and the resulting actions developed to deal with cormorants on Leech Lake.

Water Level

The water level of Leech Lake is controlled via US Army Corps of Engineers operation of the dam on the Leech Lake River located at Federal Dam, MN. The Corps is responsible for managing the outflows of 6 reservoirs in the region comprising the Mississippi River Headwaters Lakes Project. The guidelines, regulations, and the general plan for operating the Mississippi River Headwaters Lakes Project are contained in six *Water Control Manuals*, dated January 2003, and the *Reservoir Operating Plan Evaluation (ROPE) Study Report* completed in September 2009 and officially approved January 19, 2010.

General regulations governing the operation of the Mississippi Headwaters dams were first established by the War Department in 1889 and were formally modified in 1931, 1935, 1936, 1944 and 1988. During this period, it was not uncommon to store the entire spring runoff, which often resulted in very high lake levels. The water would then be released over the summer to augment flows downstream for navigation, mill power, and other uses, which in turn often resulted in low lake levels.

Lake level records dating from 1885 show that the Corps has become increasingly sophisticated and successful at managing summer fluctuations, thus dramatic deviations that were recorded in the late 19th and early 20th centuries have all but disappeared in recent decades. Although this may seem like a good thing, the plants and animals in the lake evolved to a system that

periodically experienced fluctuations in water level. Changes in the lake ecosystem will occur when these fluctuations are eliminated or reduced.

During and after the first third of the 1900's, as recreation and the number of homes on the reservoirs increased and agricultural and urban development downstream began to occur, local landowner interests became more important in governing reservoir water levels. For example, in 1929 and 1930 the headwaters reservoirs were lowered to test their capabilities to increase flows below St. Paul, MN. Following drawdown, subsequent dry weather resulted in persistently low water levels. Resort owners and residents organized and demanded the establishment of minimum operating levels to provide greater stability. As a result, on 11 February 1931, following a request from the Minnesota Lake Levels Association, the Secretary of War issued an order establishing high and low reservoir operating limits, minimum outflows, minimum summer flows at St Paul, and other rules. Additional regulations were issued in later years as needed.

Normal Summer Range/Band. The Corps attempts to manage the outflow of Leech Lake so that the summer water level fluctuates within a "band" of 1294.5 to 1294.9 feet above the 1929 National Geodetic Vertical Datum (NGVD). This summer band was determined to be most beneficial to a majority of the users during the summer months based on public consultation.

Ordinary Operating Limits. These ordinary operating limits (1293.20 to 1295.70) were also adopted through public consultation. In general, the limits range from the normal winter drawdown level to the elevation where high water begins to accelerate shore erosion in a particular reservoir. They are meant to be a range of elevations residents might expect to experience in an "ordinary" annual cycle. In actual practice, the lower elevations are reached in most years as part of the winter drawdown. The upper limits are reached less frequently. At Leech Lake, a normal drawdown elevation of 1293.80 feet has been found to be adequate.

Total Operating Range. These limits (1292.70 to 1297.94) represent the absolute upper and lower limits within which the Corps is allowed to operate the reservoirs, but Flowage Rights were acquired to approximately 1301.94, 1929 NGVD. Leech Lake Dam and Reservoir controls runoff from 1,163 square miles of the Leech Lake River drainage basin. At normal pool, the backwater effect from the dam effects eight lakes which are connected to the reservoir. When the maximum operating limit is exceeded, a total of fourteen lakes are affected.

Reservoir Operating Plan Evaluation (ROPE Study) finalized January 19, 2010. A plan was developed to provide a good balance between benefits and negative effects to all resources and user groups that depend on the reservoirs and rivers in the Headwaters of the Mississippi. However public support for environmental benefits of a more natural hydrologic regime was limited. Because of the opposition, the final plan does not better simulate a more natural hydrologic regime for the Headwaters reservoirs. The ROPE made some specific changes for Leech Lake: minimum releases will be 120 cubic feet per second (cfs) and will fall to 60 cfs under very low water levels. The operating limits, normal summer elevations, Congressional notification levels, and other operational aspects of Leech Lake were not changed by the ROPE. Stated a different way, the Water Control Manual, dated January 2003, still governs the regulation of the Leech Lake project, with slight changes from the ROPE, as noted.

Flood Damage Reduction. Whereas the northern reservoirs once functioned primarily as a water source for downstream navigation and milling, today they are managed not only to provide stable water levels on the reservoirs, but also to assist with downstream flood control. All six reservoirs can be regulated, if necessary, for this purpose. Winnibigoshish, Leech Lake, and

Pokegama reservoirs are regulated for flood control at Aitkin. Winnibigoshish and Leech also store water to assist Pokegama in accomplishing its final winter drawdown. To alleviate flooding problems upstream of Pokegama, the combined outflow of Leech Lake and Winnibigoshish cannot exceed 2200 cfs. A minimum outflow is required – even during drought periods – to maintain viability of the Leech Lake River downstream from the dam

Drought/Low Flow. In addition to the low flow amounts (120cfs/60cfs) spelled out in the ROPE Final Report, the Water Control Manual of January 2003 refers to a Drought Contingency Plan, dated September 1992. This plan was never approved and exists only in draft form. It will be consulted, along with other documents, in the event of a severe drought situation. Congressional notification is required 14 days prior to Leech Lake going below elevation 1193.20, which would likely create hardships for lakeshore owners and recreational users of the reservoir. The following documents will primarily be used during a drought condition: *Water Control Manual for Leech Lake (January 2003)*, *Drought Contingency Plan Appendix DCP* (dated September 1992), *Mississippi River Headwaters Lakes in Minnesota Low Flow Review* (dated October 1990), *Water Available from Upstream Locations Section 22 Report* (dated September 1994). In addition, related documents may be found in the *Water Control Manual*, paragraph 1-03.

Public Access and Harbors

Research has shown that Minnesotans rely heavily on public access sites to get on to the state’s lakes and rivers. A boater survey conducted by the University of Minnesota showed that three quarters of the state’s boat owners launch a boat at a public water access site at least once a year. In addition, over 80% of boat owners report using public water access sites for recreation activities other than boating (viewing the lake, bird watching, exercise, etc.).

The primary agency responsible for public water accesses in Minnesota is the Department of Natural Resources, Division of Parks and Trails. Responsibilities include local government assistance and cost share for the acquisition, development, and management of state-owned public water access sites. The MN DNR either manages them as individual units or enters into cooperative agreements with county, state, and federal agencies, as well as local units of government such as townships and municipalities. The MN DNR’s efforts to establish and manage public water access sites are guided by Minnesota Statutes and established written MN DNR policy. The goal of the public water access program is free and adequate public access to all of Minnesota’s lake and river resources, consistent with recreational demand and resource capabilities to provide recreation opportunities.

According to Minnesota Department of Natural Resources Regional Headquarters in Bemidji there are ten public accesses on Leech Lake:

Ownership	Type	Description
MN DNR	Concrete	Battle Point
MN DNR	Concrete	Sucker Bay
MN DNR	Asphalt	Shingobee Island
City of Walker	Concrete	Walker City Park
MN DNR	Concrete	Erickson’s Landing

MN DNR	Earthen	Brevik
MN DNR	Concrete	Whipholt Roadside Park
U.S. Army Corps of Engineers	Concrete	Federal Dam
U.S. Forest Service	Concrete	Stony Point
U.S. Forest Service	Earthen	Oak Point, unimproved lane

The Division of Ecological and Water Resources has state authority to oversee construction of private or public boat ramps. No state permit is required if all the conditions listed on their website can be met. These conditions generally apply where a modest amount of lakeshore modification is required; otherwise, a permit from the MN DNR is needed. The *Cass County Land Use Ordinance #2020-01 (May 20, 2021)* and Hubbard County shoreland ordinance state that no private residential watercraft access ramps are permitted on lakes with one or more public accesses, which would include Leech Lake, but many do exist as legally non-conforming structures that were built before the 1996 revision of the ordinance. There is no current lake-wide planning by public or governmental entities to establish future accesses on Leech Lake.

The number and kinds of accesses on Leech Lake has attracted greater attention lately because of the threat of aquatic invasive species being introduced into the lake at these points. The fewer the accesses, the easier it is to examine or clean watercraft entering or leaving the lake. Most of these prevention measures are being considered or designed for the public accesses and for private accesses at resorts. In addition to these accesses, the private residential launch sites around the lake are potential AIS entry points. The Cass County AIS Task Force, of which the Leech Lake Association is a member, is attempting to deal with this problem through educating all users about the dangers of infestations, and the need for and ways to inspect and clean watercraft (page 24, Current Actions).

As resorts are acquired by developers, the harbors that were part of the resort operation are usually retained and often improved as a highly prized attribute of the property. The convenience and safety of boating from a harbor usually costs new owners a considerable premium for harbor rights. There are numerous examples of long-term erosion or disruption of adjacent lakeshores or lakebeds (littoral areas) that have been caused by changes in currents or wave action resulting from harbor and/or breakwater construction. Current MN DNR “guidelines” for breakwater construction (*MN Statutes 326.02*) require that they be designed by a state-certified professional engineer and be based on U.S. Army Corps of Engineers shore protection requirements. Their design must consider possible effects on adjacent littoral and shoreline areas, and they should be oriented *parallel* to shore. They should be a distance from the shore of at least two times their length.

DNR regulations pertaining to harbor construction are contained in 2008 *Minnesota Administrative Rule 6115.0200* titled *Excavation of Public Waters* (3 pp.). Goals are to:

- A. Preserve the natural character of public waters and their shorelines, in order to minimize encroachment, change, or damage to the environment, particularly the ecosystem of the waters.
- B. Regulate the nature, degree, and purpose of excavations so that they will be compatible with the capability of the waters to assimilate the excavation.

C. Control the deposition of materials excavated from public waters and protect and preserve the waters and adjacent lands from sedimentation and other adverse physical and biological effects.

The Rule states that this includes any activity resulting in displacement or removal of bottom materials or the widening, deepening, straightening, realigning, or extending of public waters, and may include proposals for excavations landward or waterward from the ordinary high-water level. The Rule also prohibits excavation where it is intended to gain access to navigable water depths when such access can be reasonably attained by alternative means which would result in less environmental impact.

Cass County is generally opposed to the construction of any new private harbors or breakwaters on Leech Lake, but the county does support maintenance and limited improvement of existing harbors. This requires a *Shoreline Alteration Permit* that explains what is to be done and where dredged sediment or other material removed in the process will be placed or where disposed. Care should be taken to avoid changes that would disrupt adjacent littoral areas or shorelines.

Land Use and Zoning

The water quality of a lake or river is often a reflection of the land uses within its watershed. While the specific impacts on a lake from various land uses vary as a function of local soils, topography, vegetation, precipitation, and other factors, citizens can exercise control over potentially negative land use effects through prudent zoning. Shore zoning regulations are based upon the *Shoreland Management Act* adopted by the Minnesota legislature in 1969 and revised in 1989, and the Minnesota Department of Natural Resources (DNR) classification of a given lake. The MN DNR has classified all lakes within Minnesota as General Development (GD), Recreational Development (RD), or Natural Environmental (NE) lakes, and assigned a unique identification number to each lake for ease of reference (11-0203-00 for Leech Lake). Leech Lake is classified as a General Development lake. Counties in turn have used these classifications as a tool to establish lot setback and size criteria that are intended to protect and preserve the character and uses reflected in the classification. These criteria for Cass County are shown in the tables below:

SINGLE FAMILY RESIDENTIAL

Lake Classification	Min. Lot Area (ft ²)	Min. Lot Width	Min. Buildable Area (ft ²)
General Development -Riparian	37,500	100'	12,000
General Development -Non-Riparian	50,000	150'	20,000
Recreational Development- Riparian	50,000	150'	16,000
Recreational Development-Non-Riparian	50,000	150'	20,000
Natural Environment-Riparian	100,000	200'	40,000
Natural Environment- Non-Riparian	100,000	200'	40,000

SETBACKS FROM THE ORDINARY HIGH WATER LEVEL (IN FEET)

<u>Lake Class</u>	<u>Structure setback</u>	<u>SSTS Setback</u>
General Development	75	50
Recreational Development	100	75
Natural Development	150	150

Most lakes have numerous “legally non-conforming” properties that came into existence prior to development of the regulations in the current *Cass County Land Use Ordinance* dated May 20, 2021. In general, these pre-existing conditions are allowed to remain unless they are identified as a threat to human health or environment, or are destroyed by natural, accidental causes, or in association with significant renovation. Developers often establish covenants for properties within a specified tract which then become legally binding on owners, but such covenants are not stipulated by law. The cities of Walker and Federal Dam have jurisdiction over the shore lands in their municipalities.

Leech Lake, as a General Development lake, is further described in the *Cass County Land Use Ordinance* as generally large, deep lakes, or lakes of varying sizes and depths, with high levels and mixes of existing development. These lakes often are extensively used for recreation and, except for the very large lakes, are heavily developed around the shore. Second and third tiers of development are fairly common. The larger examples of lakes in this class can accommodate additional development and use. The shoreland section of the Cass County Ordinance notes that “the GD management district is established to provide minimum regulations in areas presently developed as high density, multiple use areas; and to provide guidance for future growth of commercial and industrial establishments which require locations on protected waters.” Shorelands are defined as those lands within 1,000 feet of the ordinary high water (OHW) level of a lake and within 300 feet of a river or stream.

Leech Lake, owing to its very long shoreline (~200 miles) and large variety of shoreline features, is not particularly well served by this system. Mixes of large tracts of developed and undeveloped shorelines, and the existence of sensitive natural areas critical to maintaining the character and health of the ecosystem, are not accommodated well by a single set of standards. Development and land alterations in lakeshore areas may have disproportionately greater negative impacts on native plants and animals because of the large number of species inhabiting or frequenting these areas, including many species of greatest conservation need. The existence of water or proximity to it is the key feature here. An important document in this regard is the DNR's intensive ecological study and report titled *Final Report, Sensitive Lakeshore Survey, Leech Lake, Cass County, Minnesota* by K. Thompson and D. Perleberg, 2010, MN DNR, one of 19 such studies on lakes in North Central Minnesota. Sensitive lakeshores, as defined in the survey, are comprised of shorelands and near-shore areas with natural and biological features that provide unique or critical habitat for the health and well-being of fish, wildlife, and native plants. Sensitive lakeshores also include vulnerable shoreland due to soil conditions, areas vulnerable to development (wetlands, shallow bays, etc.), nutrient susceptible areas, areas with high species richness and/or essential fish and wildlife habitat, important habitat for endangered species, and areas that provide habitat connectivity. The DNR may reclassify any public water or modify or expand the existing shoreland classification system to provide specialized shoreland

management standards based on unique protection characteristics and capabilities. It would be foolish not to consider such higher shoreline standards for some basins or areas of Leech Lake.

In 2017 Cass County published a *Shoreline Homeowner's Guide to Lake Stewardship* that describes land use practices for protecting or enhancing lakeshore properties and maintaining water quality of lakes and streams in the county. It also contains a list of shoreline permit requirements, conditions under which county or state permits are required, and contact information for various water-related state and county offices or officials. This document is available free at the Environmental Services office in the Cass County Courthouse.

The Leech Lake Association is working closely with the Northern Waters Land Trust to protect shorelands, adjoining waters and upland areas identified as particularly environmentally sensitive. These may include wetland areas or offshore spawning beds that would be seriously damaged by development. During the past five years some of these areas have been protected through acquisition, such as lakeshore along Five-Mile Point and Miller Bay which was purchased by the Leech Lake Area Watershed Foundation (LLAWF) and the DNR to protect offshore muskie spawning beds. Other sensitive areas can be protected through donation of Conservation Easements, which allow landowners to maintain all rights of ownership while agreeing to limit future development in return for certain tax benefits. Through state grants provided to Cass County and the LLAWF, landowners who treasure their properties now have additional financial incentive to maintain their holdings in a pristine state for future generations. Landowner grants funded from the Minnesota Environment and Natural Resources Trust Fund (lottery proceeds) or the Outdoor Heritage Fund (dedicated sales tax) help defray the out-of-pocket costs of establishing a conservation easement by covering such upfront costs as appraisals, land surveys, legal review, and so on. The 2010 *Sensitive Lakeshore Survey, Leech Lake* by Thompson and Perleberg is valuable in targeting areas for special protection or procurement of conservation easements. It can be accessed through the MN DNR website at <http://www.dnr.mn.us/eco/sli/index.html>.

Safety and Managing Use Conflicts

The dimensions of Leech Lake and its many connecting bays and channels support a multitude of boating and other water resource uses. However, this diversity of commercial and recreational uses creates a wide array of potential or actual safety problems and use conflicts.

Because of the danger of underwater hazards and increasing travel at night, the Leech Lake Association took the lead in purchasing both lighted and unlighted buoys for key locations around the lake. The buoys are placed and retrieved each year by the Sheriff's office. Funding comes from Association memberships, grants, resorts, businesses, and personal donations. The Leech Lake Association has also been instrumental in maintaining boat travel through the Roosevelt Canal by dredging when necessary and providing buoys to mark the entrances. Dredging is required every seven to nine years because of drifting sand on both sides of the Canal. The Leech Lake Tribe, working in partnership with the Leech Lake Association, transports the dredged sand from the Agency Bay side of the Canal to a suitable location on Tribal property. Sand dredged from the Traders Bay side of the canal is put on Tribal property adjacent to the canal. Without this help, dredging of the canal would be difficult if not impossible. Funding for dredging also comes from membership dues, grants, and area

businesses. The Association has assisted in the promotion of lake safety generally through presentations to civic groups on current state watercraft regulations and boating hazards. It has distributed packets of educational materials and applications for certification of youth watercraft operators.

The primary agency responsible for managing surface water use conflicts is the Minnesota Department of Natural Resources. The Boat and Water Safety Program within the DNR oversees surface water use and is in charge of administering the operations, goals and regulations of the program. The goals of this program are to enhance the recreational use, safety and enjoyment of the water resources in Minnesota and to use these water resources in a way that reflects the state's concern for their protection.

Within this context, any governmental unit may formulate, amend or remove controls for water surface use by adopting a suitable ordinance, but which must have the following characteristics:

- Where practical and feasible the ordinance must accommodate all compatible recreational uses;
- Minimize adverse impacts on natural resources,
- Minimize conflicts between users in a way that provides for maximum use, safety and enjoyment, and
- Conform to the established standards set by the MN DNR, state, tribe and other agencies responsible for protecting users and the lake.

The Leech Lake Association is working with local municipal and tribal law enforcement agencies to develop use restrictions that can be effectively enforced. It is working with the local and tribal communities in attempts to develop other softer, non-legal measures to deal with use conflicts. A complementary approach might entail annual distribution of information on state standards for hours of operation, operational setbacks from shorelands, locations of loon nests or other sensitive areas, locations of swimming areas, etc., to help create "peer pressure" to minimize the types of behavior that tend to lead to conflicts.

Sustainability and Climate Change

It is now widely accepted that carbon dioxide (CO₂) is the most important climate-changing agent in the planet's atmosphere, and that human activities involving the combustion of fossil fuels are the largest source of increased CO₂ in our air (US National Academy of Science and Engineering, Intergovernmental Panel on Climate Change (IPCC, 2022), American Meteorological Society, etc.). Carbon dioxide also has the longest half-life, about 10 years, among the heat-trapping "greenhouse" gasses (GHG) in our atmosphere. Concentrations of CO₂ have risen from a relatively constant 'baseline' level of 280 PPM before the industrial revolution to 420 PPM today (National Oceanographic and Atmospheric Administration Mauna Loa Global Monitoring Laboratory, April 2022), resulting in record high global air temperatures, melting glaciers, sea level rise, dying coral reefs, less stable weather, and human climate avoidance migrations. We are halfway to a doubling of baseline concentrations with no respite in sight. In 2022, the US ranked second (at 13%) to China (at 30%) in global CO₂ production (Union of Concerned Scientists, 2022). Global warming is occurring faster at higher latitudes, as in the northern US and Canada, than it is occurring closer to the equator. Even with reduced CO₂

emissions, the need for it to come back into equilibrium with the huge reservoir of elevated ocean concentrations of CO₂ will delay the time required to reduce atmospheric concentrations. The point is that CO₂ emissions from human activity must be drastically reduced soon to achieve an acceptable degree of long-term human and environmental sustainability on planet Earth (IPCC, *ibid*).

Two questions come to mind when considering Leech Lake in this context: 1) what specific physical and biological effects will it have, and 2) what can we do to prevent it, reduce it, or adapt to it? The main body of Leech Lake is relatively shallow (5-35 ft.), moderately productive (meso- to oligotrophic), cool water (supports walleyes, northern pike, black crappies, etc.), and nearly completely mixed (monomictic) in the summer (MN DNR). The western basin of Leech Lake has several deep areas of 50-150 feet that serve as refuges for small populations of cold-water species (ciscos and whitefish) during warm water periods in the summer (dimictic or temperature-stratified areas) (*ibid*).

Annual average air temperatures in the Leech Lake River watershed have increased by about 1.7 °F since 1895 but more so in the winter than the summer (3.1 vs. 0.8 °F) (MN DNR, 2019). On lakes at this latitude for which reliable long-term records exist, ice coverage has been reduced by 10-18 days since 1997 (MPCA, 2021). July and August lake-water temperatures around the state are 3.0-3.9 °F warmer than they were 50 years ago (MPCA, 2021). These conditions will promote greater algal growth (eutrophication) and probably extend the life cycles of bottom organisms (benthos) associated with aquatic plants. Modeling of lake temperature and dissolved oxygen concentrations under significantly increased CO₂ levels indicate most cool water fish species in lakes like Leech will not suffer a drastic loss of suitable habitat (Eaton et al., 1995; Stefan et al., 2004), but they will be faced with increased competition as warm water species like largemouth bass and bluegill become more numerous. Already, largemouth and smallmouth bass have made noticeable range expansion and abundance increases throughout Minnesota (MN DNR, Schultz, personal communication) and nearby states such as Wisconsin (Hansen et al., 2015).

Cold water fish (trout, whitefish, cisco) in some streams and lakes in this area are very likely to experience water temperatures high enough or dissolved oxygen concentrations low enough to eliminate populations of these species (Eaton and Scheller, 1996; Mohseni et al., 2003; Stefan et al., *ibid*; Abraham, 2008; Jacobson, et al., 2019; Barbarosa, et al., 2021). Invasions of zebra mussels or other exotic aquatic organisms could increase harmful biological or physical effects by a wide range of mechanisms, such as oxygen depletion resulting from increased algal growth that is followed by organic matter deposition and decomposition near the bottom. Jane, et al. (2021) have documented widespread deoxygenation of 393 temperate lakes between 1941 and 2017 that they attribute mostly to reduced oxygen solubility under warmer water temperatures.

The impacts of many other changed climate variables or ecosystem responses such as the amounts and the form of precipitation, cloud cover, storm frequency, ground water depletion, and runoff are harder to model or predict. Wild rice is a natural resource of particular concern to the indigenous peoples in the Leech Lake area and about which the effects of warming are poorly known. One report suggests that water level fluctuations associated with extreme weather and heavy rain events can result in failed rice crops. Seven of the state's largest two-day rainfall

totals on record occurred after the year 2000 (MN DNR, 2022). As in all very large-scale perturbations like this one there will be surprises, effects that weren't predicted ahead of time. And with continued warming being extremely likely, adaptation to many environmental changes will be necessary. Habitat protection and wise land and water resource planning will be vital components of any adaptation strategies. Here again, the Leech Lake River Comprehensive Management Plan could and ought to provide a foundation for development of protection and adaptation strategies for dealing with climate change effects as well as other effects discussed previously.

The answer to the second question, what can we do about it, is simple: reduce emissions of greenhouse gasses, particularly CO₂, as rapidly as possible. Perhaps a method will be developed some time in the future to remove large quantities of CO₂ from the atmosphere, but no such silver bullet currently exists. The US EPA, MN DNR, US Dept. of Energy, National Oceanographic and Atmospheric Administration and others provide an abundance of information and assistance to individuals and local communities through the internet, libraries, schools, municipalities, and utilities on saving energy to reduce emissions. In nearly all cases this can be accomplished with little or no inconvenience while saving money at the same time. For example, everyone can help by adopting measures to reduce fossil fuel use, many of which are recommended or even provided by local public utilities, and by supporting local conservation and renewable energy projects or programs. Many large and small communities around the US, or groups of them, have developed Climate Change Response Plans to audit energy use, increase efficiency of services, reduce emissions, save money, and plan for expected climate and environmental changes. Cass County might be an organizational unit suitable for developing such a plan. The Minnesota Climate Change Subcabinet has begun developing a "Climate Action Framework" with these objectives in mind (mn.gov/climate, 2022).

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Leech Lake Association Officers and Board Members

Officers:

Bob Gisvold, President	612 801-5971	
Dave Laursen, Secretary/Treasurer, Newsletter Editor	218 820-2327	dlaur@arvig.net ,
Tom McGovern, Vice-President, Water Quality Sampling	612 306-9586	tommcgovern2@gmail.com

Board Members:

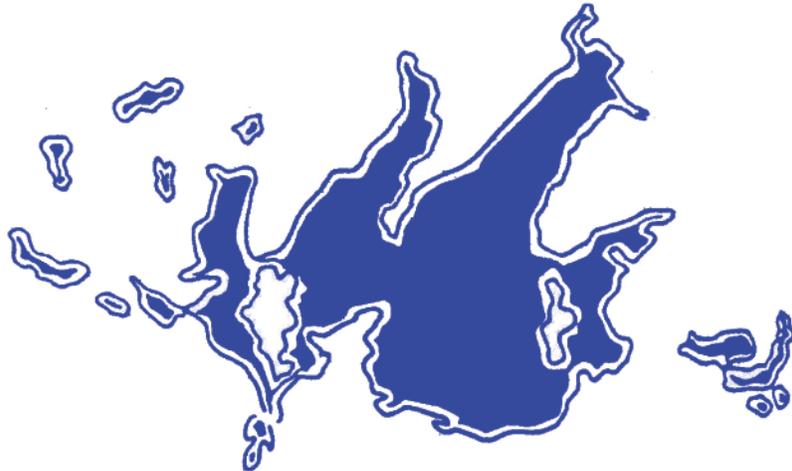
Steve Mortensen, Conservation	218 766-6574	steve.mortensen@llojibwe.net
John Eaton, Healthy Lakes	218 547-4011	eatonjg@arvig.net
Jeff Brockberg, Lake Safety	507 227-9927	jffbrckberg@gmail.com
Jennifer O'Neill, Communications	218 839-6825	jennyanyspot@gmail.com
Bill Schultz, AIS Prevention	612 599-8742	william.schultz1@comcast.net
Sharyn Nepsha, Planning	763 355-7742	sneps15@gmail.com
Jeff Holten, Government	651 270-5577	holtenjeff@gmail.com
Mark Bovee, Healthy Lakes	218 390-7230	mgbovee@gmail.com

Associates:

Doug Schultz, Supervisor, Walker Fisheries Office, MN DNR	218 552-2338	doug.schultz@dnr.state.mn.us
Carl Pedersen, Large Lakes Specialist, MN DNR, Walker	218 552-2333	carl.pedersen@dnr.state.mn.us
Dana Gutzmann, AIS Lake Technician, Cass Co., MN	218 536-0584	dana.gutzmann@co.cass.mn.us
Jason Hauser, Federal Dam Station Chief, USACE, Federal Dam, MN	651 290-5470	jason.a.hauser@usace.army.mil

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