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MOON LAKE, BARRON COUNTY

(T35N, R11W, S34)

2017-2021 Aquatic Plant Management Plan
WDNR WBIC: 1867600

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Moon Lake Association
Rice Lake, WI 54868

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PREPARED FOR THE MOON LAKE ASSOCIATION

INTRODUCTION

Moon Lake is a shallow, 84-acre seepage lake in central Barron County adjacent to Rice Lake and Lake Montanis (Figure 1). Maximum depth varies between 6-8 feet depending on rainfall and groundwater and nearly the entire surface of the lake is covered with aquatic vegetation during the summer, making lake use difficult. In addition, a severe winterkill of fish occurred over the 2013-14 season which the lake has still not recovered from. Moon Lake has a small watershed at about 310 acres and is not connected to either Rice or Montanis lakes through surface water flow. The northwest shore of Moon Lake is included in the Rice Lake city limits, therefore also making it also a part of the Rice Lake – Lake Protection and Rehabilitation District (RL-LPRD). Moon Lake Park and Trail (Area 32, Figure 1) is a significant part of that portion of Moon Lake that is included in the RL-LPRD. As a part of the RL-LPRD, the Moon Lake Association (MLA) has been able to tap into resources available to the District to support its own management planning and implementation. The presence of a City of Rice Lake (City) park increases the potential value of Moon Lake as a community resource, a community resource that in the present state of things is being underutilized. This document highlights what can be done to improve the current condition of the lake, increasing the recreational uses of Moon Lake for the general public, which will in turn improve the resource for property owners living on the lake.

Figure 1 – Moon, Rice, and Montanis Lakes (left) (Google Earth 2016); Rice Lake City Limits (right) (City of Rice Lake 2016).

This Aquatic Plant Management Plan (APMP) focuses on the following management actions for the lake: aquatic plant harvesting; aquatic plant monitoring; aquatic invasive species (AIS) monitoring; aeration; fish stocking; water quality monitoring; installation of a public fishing dock and/or public small craft launching dock; and shoreland evaluation and improvement. The success of these management actions requires buy-in and support from the City, Wisconsin Department of Natural Resources (WDNR), the RL-LPRD, and of course the MLA. Through the support of these entities, the goals, objectives and actions included in this APMP will make Moon Lake a much more valuable resource now and into the future.

MOON LAKE ASSOCIATION

The Moon Lake Association is made up of property owners on the lake. There are 21 different property owners on the lake including the City. While it has been in existence for many years, the MLA has never become a "qualified" lake association as it relates to being eligible for WDNR surface water grants. A qualified lake association has at least 25 members, charges a membership fee, and is incorporated under Chapter 181 in Wis. Statures. Not all the property owners on the lake are members of the MLA so it is difficult to reach the required 25 members, and they have never incorporated.

The MLA supports water quality testing on the lake as a part of the Citizen Lake Monitoring Network (CLMN) and from 2001-2014 supported the installation and operation of an aerator in the lake. In 2014, the MLA approached the RL-LPRD for support for completing an aquatic plant survey of the entire lake. Then through the RL-LPRD a small-scale lake management planning grant was applied for on their behalf to complete an APMP. In the last few years, membership in the MLA has increased as the recent activities have given property owners some hope that something might be done to improve the conditions of the lake.

This current management planning effort on Moon Lake started in 2014 when the MLA completed a whole-lake, point-intercept, aquatic plant survey of the entire lake. Members of the MLA met with the RL-LPRD in late 2013 and early 2014 to request funding support for the plant survey. The RL-LPRD and Town of Rice Lake each donated $700 to the MLA and the survey was completed by Aquatic Plant and Habitat Services, LLC (APHS) out of Black Rivers Falls, WI with assistance from members of the MLA. The MLA then approached the RL-LPRD again to ask if they would sponsor a small-scale lake management planning grant on behalf of the MLA so they could use the results of the aquatic plant survey to create an APMP for the lake.

In August of 2015, a meeting of the MLA was held to discuss the results of the aquatic plant survey, the concept of working through the RL-LPRD to apply for WDNR grant support, and just what an APMP would do for the lake. More than 20 people were present at the meeting, reflecting the general interest property owners have to get something done. During the meeting, the first activity was to have each member in attendance at the meeting use a map of Moon Lake to indicate all of the areas of concern on the lake and what each individual hoped would be accomplished with a management plan. Each member at the meeting was instructed to work on the map without input from the people sitting around them. Once completed, the results of this activity were discussed. The majority of respondents wanted to have Moon Lake once again look like a lake with at least some open water in the middle of the lake. They were OK with dense aquatic plant growth in the bays and around the edges of the lake, provided there was access to the open water. All wanted to see fish back in the lake. None wanted to see the lake become algae dominated instead of plant dominated.

Management alternatives were also discussed during this meeting. According to the results from the 2014 aquatic plant survey, the only AIS in the lake were reed canary grass on portions of the shore and a few places with narrow-leaf cattails. Neither of these species is of particular concern and management for them is not proposed. CLP and EWM are two AIS of much greater concern and neither was present in the lake in 2014. The issues of excessive aquatic plant growth are related to several species of native aquatic plants that are particularly dense in the lake: watershield and spiny hornwort (Figure 2). In most cases, the WDNR, who is responsible for issuing permits for aquatic plant control, will not issues permits for chemical management of native plants. Harvesting is usually permitted with an approved APMP, because harvesting typically reduces nuisance and navigation issues caused by the plants, but does not kill the entire plant, allowing it to recover, protecting the habitat.

Figure 2 – Watershield (inset left) and Spiny Hornwort (inset right) in Moon Lake (Hatleli 2014)

Knowing this, the MLA decided to move forward with the development of an APMP focused on coming up with a harvesting plant for the lake provided it was supported by the grant. The small-scale lake management planning grant was awarded and management planning began in 2016.

During the summer of 2016, the consultant preparing the APMP for Moon Lake went out on the lake with MLA volunteers to see first-hand what the lake looked like. Lake characteristics were discussed, the shoreland around the lake was observed, including Moon Lake Park within the Rice Lake city limits and on the shores of Moon Lake. At this time, how Moon Lake could become a better community resource for the City was discussed. Adding a better dock for launching kayaks and other small craft, possibly adding a small building to house a future aerator for the lake that could double as a bathroom and/or picnic pavilion, and providing a public fishing dock once the fish population was restored were discussed. The City has not been approached on any of these ideas, with the MLA preferring to wait until the plan has been approved before doing so.

At a meeting held in mid-December 2016, components of this plan were presented to members of the MLA. They are in support of the management goals, objectives, and actions presented. The MLA has a limited budget, and is not eligible for grants to support harvesting, but feel it is possible for them to raise money on their own and through partners like the RL-LPRD and the City. Several of the actions (other than aquatic plant harvesting) discussed in this project may be eligible for certain grant programs offered by the state.

Through the end of 2016 and early 2017, Dan Graff, President of the Moon Lake Association completed presentations with details about this plan to the City of Rice Lake Parks and Recreation Board, Barron County Conservation Department, and the Rice Lake Utilities Department. Responses were as expected: there is support for doing something with Moon Lake, but not necessarily available funds at the current time. Future funding assistance may be possible, but will require continued advocacy from the Moon Lake Association and supporters of this plan.

The plan has also been presented to the Rice Lake - Lake Protection and Rehabilitation District (RLLPRD) and support for the plan asked for by the Moon Lake Association. While it is the position of the RLLPRD that moving one of their big harvesters into Moon Lake to complete harvesting operations is not a possibility, supporting a separate harvesting program on Moon Lake through management of cut vegetation, inclusion of all of the properties around Moon Lake into the RLLPRD, and general incendiary support is feasible.

In the last 10-15 years, Moon Lake has become overcome with aquatic vegetation covering nearly 100% of the surface of the lake. At a maximum depth of 6-8 ft. the entire lake is considered littoral zone (area of the lake with sufficient light penetration to grow plants). According to long-time residents on Moon Lake, there used to be much more open water, with one resident stating that he taught his daughter how to waterski on the lake (Graff 2016).

Up until a major fish winterkill over the 2013-14 winter which essentially wiped out the entire fish population, Moon Lake was considered a good fishing lake for northern, bass, and panfish, being stocked by the WDNR on a fairly regular basis with both largemouth bass and northern pike. Historically Moon Lake has experienced periodic winterkills, and in 2001, property owners on the lake in cooperation with the WDNR installed a surface aspirating aerator in the lake. Between 2001 and 2014, there was only one minor winterkill in 2003-04. Unfortunately, over this time frame, the growth of aquatic vegetation has expanded. The reasons for this are not easy to determine, but increased fertility caused by surface runoff into the lake and a prolonged period of low water could have contributed. Since the severe winterkill over the 2013-14 season the fish population has not been restored. This is due in part because the existing aerator stopped operating broke down near the end of the 2013-14 winter season and has not been repaired and re-installed. Nuisance level aquatic plant growth that covers nearly 100% of the surface area of the lake makes lake use nearly impossible for lake property owners and other lake users. The excessive aquatic plant growth and subsequent decay each year under the ice likely contributes to the lack of oxygen that leads to winterkills. Until something is done to reduce the issues caused by excessive plant growth, the MLA has not willing to reinstall the aerator (Graff 2016).

Moon Lake Park on the northwest shore of Moon Lake (Figure 3), was once the site of the Rice Lake Municipal Airport, built somewhere around 1934 and abandoned around 1995 when the new Rice Lake Regional Airport was built (Abandoned & Little-known Airfields: Northern Wisconsin 2016). Figure 4 depicts the airport and the Moon Lake Park area in 1998 and 2006. Moon Lake can be seen on the right edge of both aerials in Figure 4.

Figure 3 – Photos from Moon Lake Park, circa 2005 (City of Rice Lake 2016)

Figure 4 – Site of Moon Lake Park and the old Rice Lake Municipal Airport – 1998 USGS aerial photo (left); 2005 USGS aerial after closing (right) (Abandoned & Little-known Airfields: Northern Wisconsin 2016)

Moon Lake Park has 1.5 miles of paved hiking trails, soccer fields, playground, fitness stations, park shelters, and a brand new splash pad. With the exception of the hiking trail which goes along the shore of Moon Lake, the lake itself is not considered a valuable public resource or draw for park goers.

Several goals and objectives in the 2014-2019 Rice Lake Outdoor Recreation Plan (Community Services Department 2014) could be applied to efforts to make Moon Lake a more valuable natural resource for the general public to enjoy.

The overall management goal of this plan is to improve conditions in Moon Lake for the benefit of all potential users including the general public with access through Moon Lake Park and the public boat ramp, property owners on the lake, and the fish and wildlife that call the lake home. The primary action in this plan is to implement an aquatic plant harvesting program in Moon Lake, with secondary actions including re-installation of an aerator, re-establishing a viable fish population, and establishing opportunities for the public to make use of Moon Lake.

The waters of Wisconsin belong to all people. Their management becomes a balancing act between the rights and demands of the public and those who own property on the water's edge. This legal tradition called the Public Trust Doctrine dates back hundreds of years in North America and thousands of years in Europe. Its basic philosophy with respect to the ownership of waters was adopted by the American colonies. The US Supreme Court has found that the people of each state hold the right to all their navigable waters for their common use, such as fishing, hunting, boating and the enjoyment of natural scenic beauty.

The Public Trust Doctrine is the driving force behind all management in Wisconsin lakes. Protecting and maintaining that resource for all of Wisconsin's people are at the top of the list in determining what is done and where. In addition to the Public Trust Doctrine, two other forces have converged that reflect Wisconsin's changing attitudes toward aquatic plants. One is a growing realization of the importance of a strong, diverse community of aquatic plants in a healthy lake ecosystem. The other is a growing concern over the spread of AIS, such as EWM. These two forces have been behind more recent changes in Wisconsin's aquatic plant management laws and the evolution of stronger support for the control of invasive plants.

To some, these two issues may seem in opposition, but on closer examination they actually strengthen the case for developing an Aquatic Plant Management Plan as part of a total lake management picture. Planning is a lot of work, but a sound plan can have long-term benefits for a lake and the community living on and using the lake.

The impacts of humans on Wisconsin's waters over the past five decades have caused public resource professionals in Wisconsin to evolve a certain philosophy toward aquatic plant management. This philosophy stems from the recognition that aquatic plants have value in the ecosystem, as well as from the awareness that, sometimes, excessive growth of aquatic plants can lessen our recreational opportunities and our aesthetic enjoyment of lakes. In balancing these, sometimes competing objectives, the Public Trust Doctrine requires that the State's public resource professionals be responsible for the management of fish and wildlife resources and their sustainable use to benefit all Wisconsin citizens. Aquatic plants are recognized as a natural resource to protect, manage, and use wisely.

Aquatic plant protection begins with human beings. We need to work to maintain good water quality and healthy native aquatic plant communities. The first step is to limit the amount of nutrients and sediment that enter the lake. There are other important ways to safeguard a lake's native aquatic plant community. They may include developing motor boat ordinances that prevent the destruction of native plant beds and reduce shoreline erosion and sediment disturbance caused by boat wakes, limiting aquatic plant removal activities, designating certain plant beds as critical habitat sites and preventing the spread of non-native, invasive plants, such as EWM.

If plant management is needed, it is usually in lakes that humans have significantly altered. If we discover how to live on lakes in harmony with natural environments and how to use aquatic plant management techniques that blend with natural processes rather than resist them, the forecast for healthy lake ecosystems looks bright. To assure no harm is done to the lake ecology, it is important that plant management is undertaken as part of a long range and holistic plan.

In many cases, the development of long-term, integrated aquatic plant management strategies to identify important plant communities and manage nuisance aquatic plants in lakes, ponds or rivers is required by the State of Wisconsin. To promote the long-term sustainability of our lakes, the State of Wisconsin endorses the development of APMPs and supports that work through various grant programs.

There are many techniques for the management of aquatic plants in Wisconsin. Often management may mean protecting desirable aquatic plants by selectively hand pulling the undesirable ones. Sometimes more intensive management may be needed such as using harvesting equipment, herbicides or biological control agents. These methods require permits and extensive planning. Often using and Integrated Pest Management (IPM) strategy that incorporates multiple management actions/alternatives works the best.

While limited management on individual properties is generally permitted, it is widely accepted that a lake will be much better off if plants are considered on a whole lake scale. This is routinely accomplished by lake organizations or units of government charged with the stewardship of individual lakes.

SHALLOW LAKE MANAGEMENT CONSIDERATIONS

Lake management requires consideration of the differences between deep and shallow lakes. Moon Lake is considered a shallow lake. Shallow lakes are those lakes with a maximum depth of less than 20 feet or with an average depth of less than 10 feet (Cooke, et al. 2005). In shallow lakes, much of the lake bed is littoral zone, that is, able to support aquatic plant growth. Shallow lakes generally exist in one of two alternative states: the algae-dominated turbid water state and the plant-dominated clear water state (Figure 5). The turbid water state is characterized by dense algae (phytoplankton) populations, an undesirable bottom feeding fish community, and few aquatic plants whereas the clear water state is characterized by abundant aquatic plant growth, a greater number of zooplankton, and a diverse and productive gamefish community (Moss, Madgwick and Phillips 1996). When asked during a public presentation on aquatic plants, attendees at the 2016 spring meeting indicated they prefer a plant-dominated system over an algae-dominated system.

Aquatic plants are the key to clear water in shallow lakes. A shallow lake that is free of both aquatic plants and algae is uncommon and it is unrealistic to expect such a lake to occur without a large investment in money and energy (Cooke, et al. 2005). The chance of macrophyte (plant)-free clear water is much higher with deep lakes. Shallow lakes are more susceptible to internal nutrient loading (e.g. lake sediment phosphorus release) and bio-manipulation (additions or removals of fish that affect the entire aquatic food web) than deep lakes, which are more responsive to changes in the external nutrient load from the watershed (Cooke, et al. 2005).

The addition or removal of nutrients can change the composition of an aquatic plant community, but can't displace aquatic plants altogether. The mechanism that displaces the plants and allows for algae to take over is called a forward switch. Forward switches include the direct loss of plants through harvesting or herbicide use, repeated boat passage damaging the plants beyond recovery, runoff of herbicides from the surrounding watershed, static water levels, the introduction of carp, and a fish community that favors small fish that eat zooplankton (tiny critters) that would normally be present to eat phytoplankton (tiny plants or algae).

A reverse switch is a process or management option that restores and stabilizes the plant community by overcoming the buffers stabilizing the algae. The most common techniques are bio-manipulation, which is a manipulation of the fish community to reduce the number of zooplankton (often by adding piscivorous fish), and by re-establishing plants under conditions in which they can thrive. An important aspect of plant restoration is the re- establishment of wetland fringes (cattails, rushes, water lilies) that utilize nutrients, buffer wave action, provide refuge zooplankton like daphnia and other algae grazers, and add to the lake's aesthetic appeal.

Each alternative state can persist over a wide range of nutrient concentrations. Aquatic plants can dominate without threat at total phosphorus concentrations below about 25 to 50μg/L (or total nitrogen below about 250 to 500mg/L). At total phosphorus levels greater than about 50μg/L, either plant- or algae-dominated systems can exist, though at these higher nutrient levels there is a greater risk of the system switching from plant to algae dominance. The mean phosphorus in Moon Lake from 2012-2016 was 45.55

μg/l. The lake is near the margin between moderately nutrient enriched (mesotrophic) and heavily nutrient enriched (eutrophic).

Plant diversity also decreases at higher nutrient levels and filamentous algae can be common. Native plants can become a nuisance at high nutrient concentrations as highly competitive species such as coontail and water lilies become dominant.

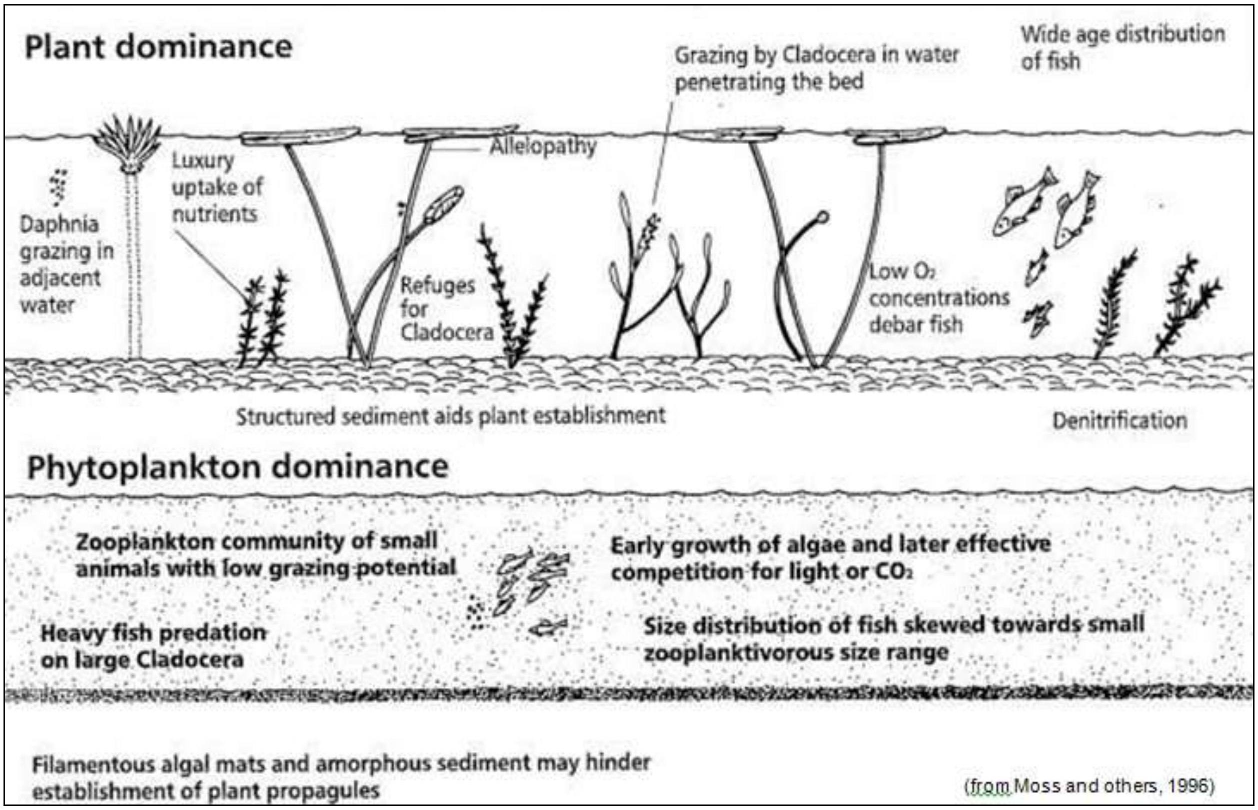


Figure 5- Shallow Lake Alternative States and Stabilizing Mechanisms (Moss, Madgwick and Phillips 1996)

Fortunately, Moon Lake is in the plant-dominated, clear water state and in-lake restoration is not needed. It is, however, important to identify any switch mechanisms currently in operation and remove them. External and internal nutrient sources should be reduced as much as possible (preferably to < 50 μg/L) to buffer against a forward switch. The fisheries management strategy should be evaluated and plant management only undertaken at levels necessary to maintain lake uses. A well-established plant community, such as found in Moon Lake, can withstand moderate impacts without further active management; however, the lakes and watershed should be monitored for changes and activities that might destabilize the system.

In order to make recommendations for aquatic plant and lake management, basic information about the water body of concern is necessary. A basic understanding of physical characteristics including size and depth, critical habitat, water quality, water level, fisheries and wildlife, wetlands and soils is needed to make appropriate recommendations for improvement.

PHYSICAL CHARACTERISTICS

Moon Lake is a seepage lake located in central Barron County, Wisconsin near Rice and Montanis lakes. It is listed as having a surface area of 84 acres, although the total area fluctuates between 74 and 90 acres depending on local rainfall and aquifer condition. The maximum depth ranges from 5 feet to 7 feet depending on natural water level fluctuations. The maximum depth during a 2014 aquatic plant survey was 6.5 feet, but in 2016 after a very wet summer it was closer to 8-ft. The lake is situated with half of its shoreline in the City and the other half in the Town of Rice Lake (Figure 6). The City owns a 61-acre parcel along the northern and northwestern shoreline. Moon Lake Park, as this area is called, houses several soccer fields, baseball diamonds, and a paved walking trail along the shores of the lake. The remaining shoreline of the lake is in trust status, LLC status, or in private ownership (Hatleli 2014).

Figure 6- Moon Lake and Municipal Boundaries (Hatleli 2014)

The area of the lake that is part of the City is also considered a part of the RL-LPRD which has given the MLA access to greater resources and even some financial support for management planning actions.

The Moon Lake watershed is 310 acres (Figure 7) and includes a fair amount of agricultural row crops, mowed lawn (from homes and the City Park), and impervious surfaces including roads, paths, driveways, and rooftops. Table 1 identifies the physical characteristics of and land use in the watershed.

Figure 7: Watershed for Moon Lake, Barron County (Gruetzmacher 2016)

Table 1: Physical Characteristics of Moon Lake in Barron County

Physical Charateristics	
Lake Area (acres)	77
Watershed Area (acres)	310
Watershed to Lake Ratio	4 to 1
Maximum Depth (feet, 2014)	6.5
Mean Depth (feet, 2014)	4.9
Volume (acre-feet)	377.3
Miles of Shoreline	1.61
Lake Type	Seepage

Watershed Land Use	
Open Water (acres)	77
Wetlands (acres)	26.17
Agriculture (acres)	91.49
Urban/residential (acres)	97.07
Shrub/grassland/forest (acres)	18.27
Total (acres)	**310**

Land cover and land use management practices have a strong influence on water quality. Increases in impervious surfaces, such as roads, rooftops and compacted soils, associated with residential and agricultural land uses can reduce or prevent the infiltration of runoff. This can lead to an increase in the amount of rainfall runoff that flows directly into Moon Lake. The removal of riparian, i.e., near shore, vegetation causes an increase in the amount of nutrient-rich soil particles transported directly to the lake during rain events.

The land use in the Moon Lake watershed is led by urban/residential at 31.3%, followed closely by agriculture (29.5%), then open water (24.8%), wetlands (8.4%) and shrub/forest/grassland (6.0%). Open water is a misrepresentation of Moon Lake in the summer as nearly all of the surface area is impacted by aquatic vegetation, although none of it non-native, invasive species.

During the 2014 whole-lake, point-intercept aquatic plant survey (Hatleli 2014), the depth, bottom type, and vegetative cover was documented. The maximum depth in 2014 was 6.5-ft, but two years of average or above average rainfall in the area has increased the maximum depth in 2016 to closer to 8-ft. The lake bottom at almost all survey points was considered to be soft sediment or "muck." Only two survey points were sand, two were rocky, and the remaining 176 (98%) were muck (Figure 8). During the 2014 survey 100% of the points sampled had aquatic plants present. Watershield, a floating leaf plant, and spiny hornwort, a submerged aquatic plant dominated the plant growth covering nearly all (81.2%) of the surface area (Figure 8).

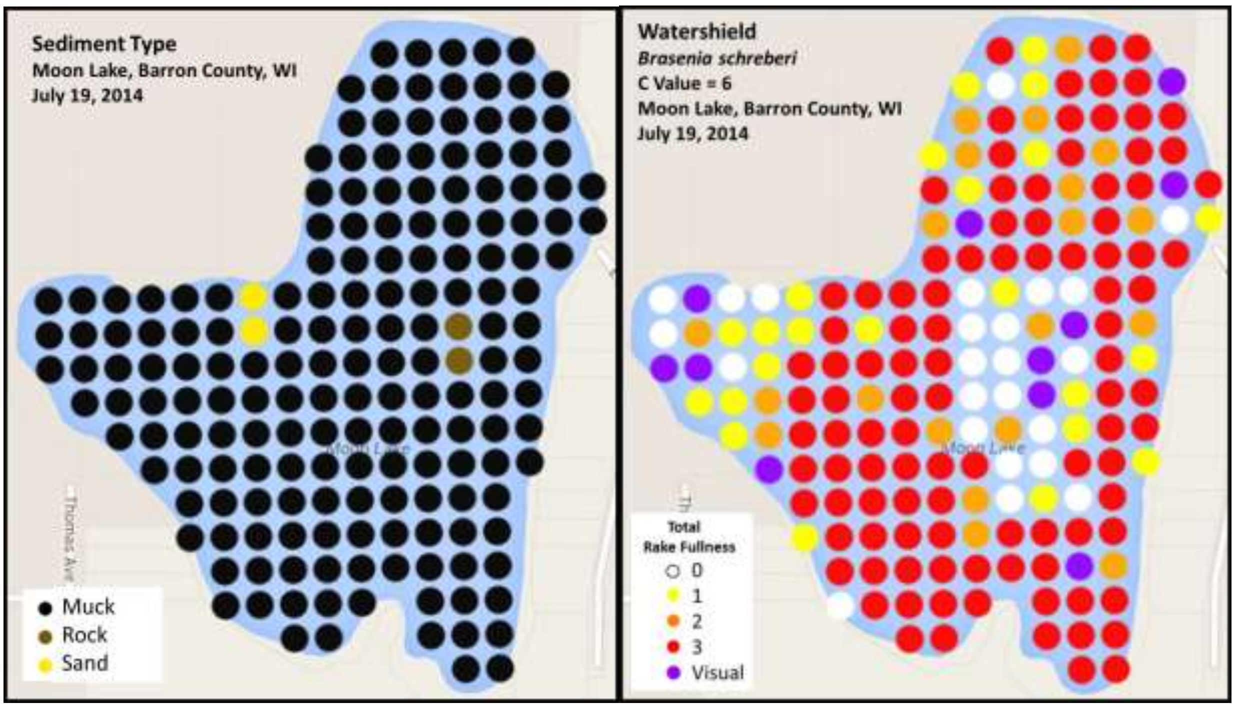


Figure 8 – Sediment type (left) and Watersheild (floating leaf plant) (right) (Hatleli 2014)

CRITICAL HABITAT

Every body of water has areas of aquatic vegetation that offers critical or unique fish and wildlife habitat. Such areas can be identified by the WDNR and identified as Sensitive Areas per Ch. NR 107. A sensitive areas survey has never been completed for Moon Lake. However, during the 2014 aquatic plant survey, three species with a Coefficient of Conservatism (C) value of 9 or 10 were found in Moon Lake. A C-value that ranges from 1-10 is assigned to a given plant. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. Spiny hornwort and small bladderwort both have a C-value of 10 and were present at 94 (52%) and 22 (12%) of sites respectively. Large purple bladderwort has a C-value of 9 and was present at survey point 22 in the west central region of the lake. Presence of these and other species with higher C-values suggests that Moon Lake is not highly impacted by human disturbance.

Spiny hornwort, small bladderwort, and Farwell's milfoil were once on the WDNR Natural Heritage Inventory (NHI) list as "species of special concern." Email correspondence with Julie Bleser of the WDNR clarified that a comprehensive review of all species on the NHI list was done in 2010, resulting in the removal of these three species from the list in February 2011 (Hatleli 2014).

Watershield, Large-leaf pondweed, Illinois pondweed, rushes and spikerush *are* all species identified in Wisconsin Administrative Code NR 109 as "high value species-known to offer important values in specific aquatic ecosystems." Watershield was the most frequently occurring species in Moon Lake (146 sites, 81%) while the remaining high value species were present in varying degrees of occurrence (Hatleli 2014).

A Natural Heritage Inventory data search for T35N, R11W indicates three communities on the working list: Northern Sedge Meadow, Northern Wet Forest, and Open Bog (WDNR 2016). Although the NHI search indicated there are endangered resources present, they are not legally protected so a full Endangered Resources Review is not required.

During Barron County's lake classification process in 1996, Moon Lake received an average environmental attributes value of 2.5 out of 5.0 with 5.0 being the highest value. Moon Lake scored high (4) as a wildlife lake, but low (1) as a wild lake. It was mid-range for the fishery and water clarity. It received a slightly lower value of 2.4 out of 5.0 for social values with low values (1) for public use and motorized recreation, and higher values (4,3,3) for lake size, public access, and non-motorized recreation. Overall Moon Lake averaged 2.44 making it a Class 3 lake (Barron County Ordinances Governing Land Use and Development 2014). Normally, this would mean a required setback for development of 100-ft, but since the changes in state shoreline zoning laws, the setback for all lakes regardless of class is 75-ft from the ordinary high water mark.

The water quality of a lake influences the aquatic plant community, which in turn can influence the chemistry of a lake. Water clarity, total phosphorus and chlorophyll *a* are measures of water quality that can be used to determine the productivity or trophic status of a lake. The Carlson trophic state index (TSI) is a frequently used biomass-related index. The trophic state of a lake is defined as the total weight of living biological material (or biomass) in a lake at a specific location and time. Eutrophication is the movement of a lake's trophic state in the direction of more plant biomass. Eutrophic lakes tend to have abundant aquatic plant growth, high nutrient concentrations, and low water clarity due to algae blooms (Figure 9). Oligotrophic lakes, on the other end of the spectrum, are nutrient poor and have little plant and algae growth (Figure 9). Mesotrophic lakes have intermediate nutrient levels and only occasional algae blooms (Figure 9).

Water clarity and water chemistry are important indicators of water quality. Secchi disk readings of water clarity and chemistry parameters including total phosphorus, chlorophyll a, and temperature and oxygen profiles have been collected by Wisconsin Citizen Lake Monitoring Network (CLMN), formerly the Self-help Lake Monitoring Program, volunteers since 2011. The WDNR website indicates CLMN volunteers have collected water quality data from 2011 to 2016, including data for chlorophyll, and total phosphorus.

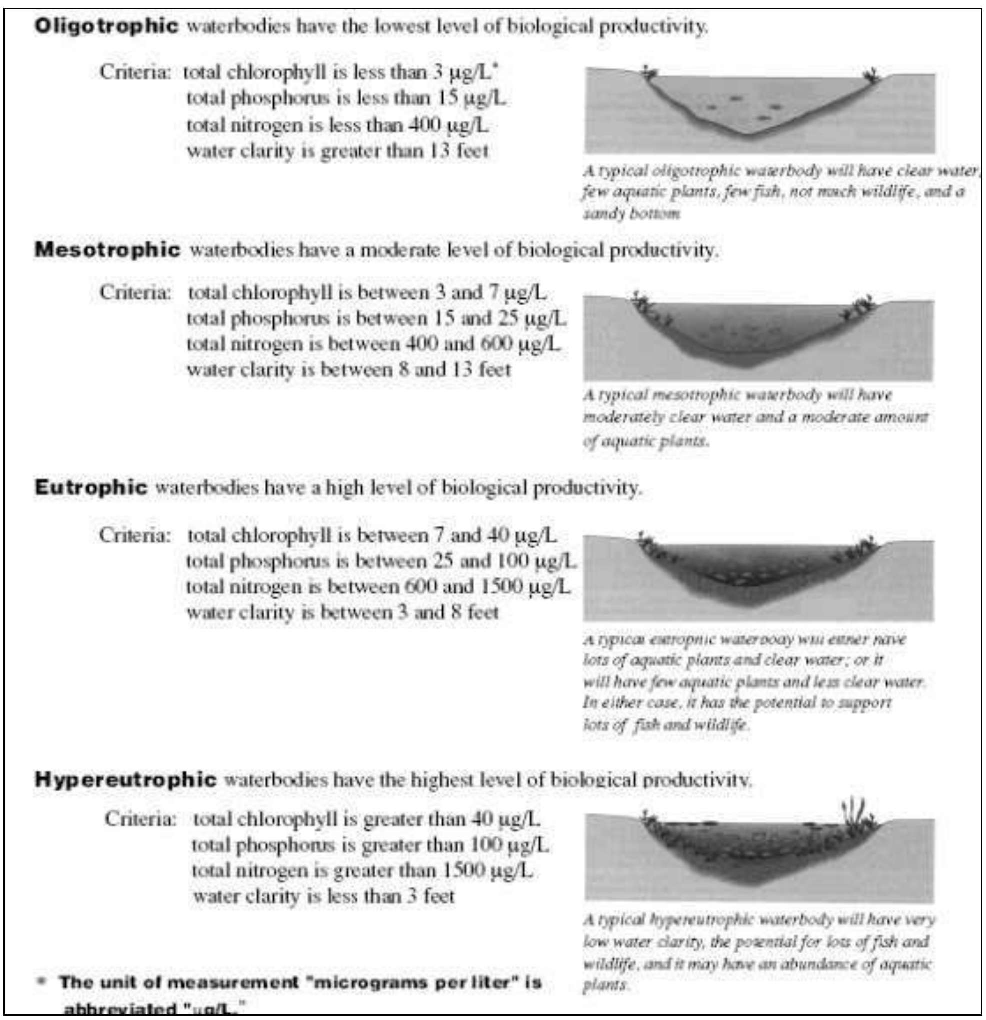


Figure 9 - Trophic status in lakes

WATER CLARITY

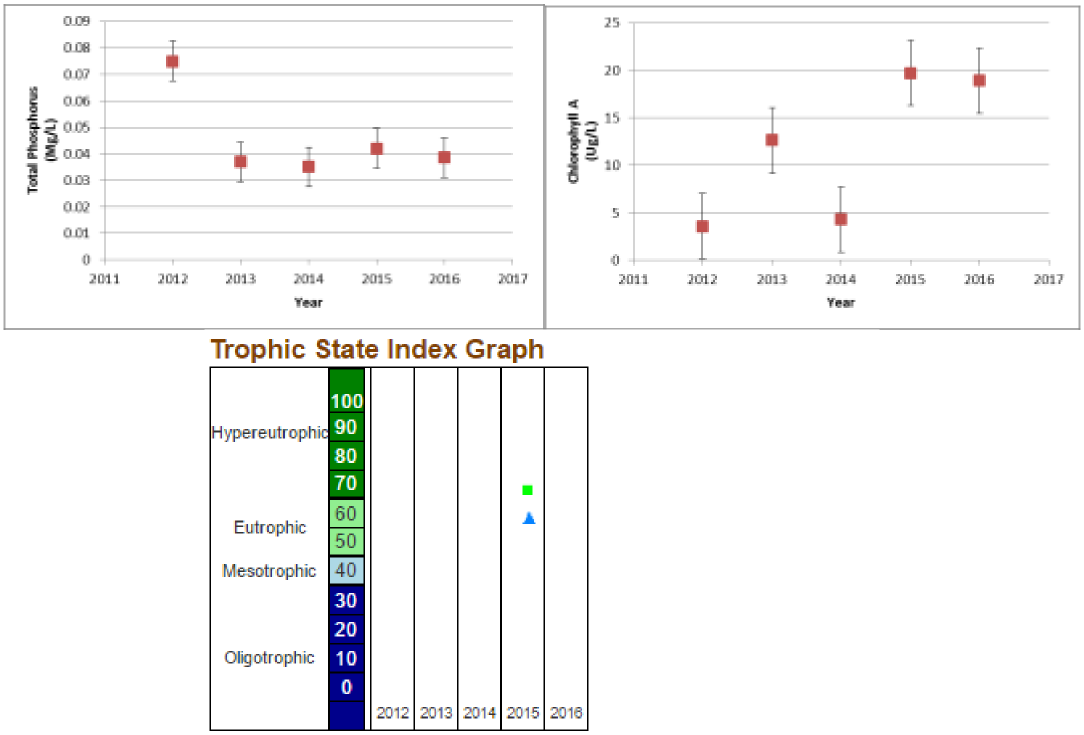
Water clarity is a measurement of how deep sunlight can penetrate into the waters of a lake. It can be measured in a number of ways, the most common being an 8" disk divided into four sections, two black and two white, lowered into the lake water from the surface by a rope marked in measurable increments (Figure 10). The water clarity reading is the point at which the Secchi disk when lowered into the water can no longer be seen from the surface of the lake. Water color (like dark water stained by tannins from nearby bogs and wetlands), particles suspended in the water column (like sediment or algae), and weather conditions (cloudy, windy, or sunlight) can impact how far a Secchi disk can be seen down in the water. Some lakes have Secchi disk readings of water clarity of just a few inches, while other lakes have conditions that allow the Secchi disk to be seen for dozens of feet before it disappears from view.

Figure 10: Black and white Secchi disk

PHOSPHORUS AND CHLOROPHYLL-A

Phosphorus is an important nutrient for plant growth and is commonly the nutrient limiting plant production in Wisconsin lakes. There are many sources of excess phosphorus to lake water including but not limited to farm runoff, roadway runoff, failing septic systems, and decay of grass clippings, leaves, and other lawn debris that end up in the lake. Chlorophyll-a is the green pigment found in plants and algae. The chlorophyll-a concentration is used as a measure of the algal population in a lake. Values greater than 10μg/l are considered indicative of eutrophic conditions and concentrations of 20μg/l or higher are associated with algal blooms. Preference is given to the chlorophyll-a trophic state index for classification because it is the most accurate at predicting algal biomass. Total phosphorus and chlorophyll-a data has been collected at the Deep Hole since 2011.

The water quality of Moon Lake is considered "good" with a trophic state index value of 55 based on satellite water clarity data (WDNR Lakes 2016). There are no Secchi disk readings of water clarity on record, however personal communication with the Citizen Lake Monitoring Network volunteer for the lake suggests that the Secchi disk nearly always went to bottom of the lake when readings were taken. The trophic state index is related to the amount of algae in a lake, which is dependent on the amount of nutrients in a lake. Higher levels of nutrients, especially phosphorus, generally lead to greater concentrations of algae, thereby decreasing the water clarity. The mean phosphorus in Moon Lake from 2012-2016 was 45.55 μg/l (Figure 11). The mean chlorophyll-*a* (a measure of the amount of algae present) over the same time frame was 11.82 μg/l (Figure 11). The Wisconsin Trophic State Index (WTSI) value for chlorophyll-*a* in Moon Lake from 2012-2016 is 53.47. For Total Phosphorus over the same time frame it is 57.73 (Figure 11). WTSI values for water clarity (based on satellite data), total phosphorus, and chlorophyll-*a* indicate that Moon Lake is considered eutrophic, meaning it is relatively high in nutrients and supports high biomass.



Monitoring Station: Moon Lake - Center, Barron County
Past Summer (July-August) Trophic State Index (TSI) averages.

Figure 11: Total Phosphorus and Chlorophyll Graphs (limited data); Summer TSI Values for TP (blue triangle) and Chlorophyll A (green square) (WDNR Lakes 2016)

TEMPERATURE AND DISSOLVED OXYGEN

Temperature and dissolved oxygen are important factors that influence aquatic organisms and nutrient availability in lakes. As temperature increases during the summer in deeper lakes, the colder water sinks to the bottom and the lake develops three distinct layers as shown in Figure 12. This process, called stratification, prevents mixing between the layers due to density differences which limits the transport of nutrients and dissolved oxygen between the upper and lower layers. In most lakes in Wisconsin that undergo stratification, the whole lake mixes in the spring and fall when the water temperature is between 53 and 66°F, a process called overturn. Overturn begins when the surface water temperatures become colder and therefore denser causing that water to sink or fall through the water column. Below about 39°F, colder water becomes less dense and begins to rise through the water column. Water at the freezing point is the least dense which is why ice floats and warmer water is near the bottom (called inverse stratification) throughout the winter.

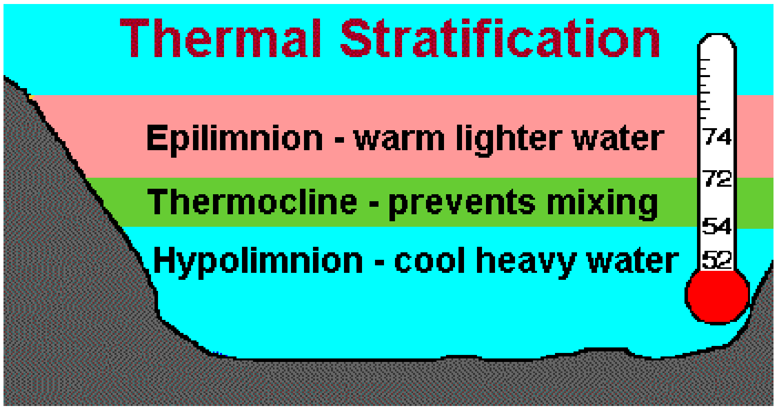


Figure 12: Summer thermal stratification

Moon Lake is a mixed lake, meaning it does not stratify in the summer. Oxygen levels and temperature should remain relatively constant through the summer months. Due to the shallow nature of Moon Lake, an aerator was funded and installed in 2001 by the MLA to prevent winter fish kills. This aerator prevented severe winterkills until the 2013-14 winter when dissolved oxygen levels plummeted leading to an unfortunate severe winterkill in early 2014. Late in the 2013-14 winter season, the aerator failed and has not been repaired and reinstalled to date.

FISHERIES

There is very little data on the current state of the fishery in Moon Lake. It was last surveyed by the WDNR when a winterkill investigation was completed following a severe winterkill during the 2013-14 winter season. At the time of the investigation, no fish were found. Prior to this, the WDNR had stocked northern pike and largemouth bass fingerlings a number of times (Figure 7). Since the 2013-14 winterkill it has not been stocked.

WISCONSIN DNR FISHERIES INFORMATION SHEET

WISCONSIN DEPT OF NATURAL RESOURCES

County: BARRON
Lake Name: MOON LAKE
WBIC: 1867600
Survey Year: 2005

WDNR Fish Biologist Contact Information
[illegible]

Lake Characteristics — Lake Type: SHALLOW SEEPAGE
Acres: 54 — Shoreline miles: 1.0 — Maximum Depth (feet): 5

Fish Stocking History

Year	Species	Strain	Age Class	Number Fish Stocked
2001	LARGEMOUTH BASS	UNSPECIFIED	LARGE FINGERLING	2012
2001	NORTHERN PIKE	UNSPECIFIED	FRY	104000
2001	NORTHERN PIKE	UNSPECIFIED	LARGE FINGERLING	500
2002	LARGEMOUTH BASS	UNSPECIFIED	LARGE FINGERLING	2100
2004	LARGEMOUTH BASS	UNSPECIFIED	SMALL FINGERLING	2100
2011	LARGEMOUTH BASS	UNSPECIFIED	LARGE FINGERLING	2100

Figure 13 – Moon Lake fish stiocking history (Cole 2016)

Winterkill of fish is usually caused when excessive snow sits on the ice for a long period of time, blocking sunlight from getting to plants and algae under the ice that use it to generate oxygen. When sunlight is not available for a long time these plants die and use up more oxygen when they decay. During fishkills, the biggest fish usually die first because they require more oxygen. Small fish and crappies <4 inches usually don't die unless the oxygen depletion gets really bad (Herman 2016). Research data suggest that healthy fish populations require 2-5 mg/l for moderately tolerant warm- water species and 5-9 mg/l for cold-water species (Kalf 2002).

The WDNR Fish Manager for Barron County, Aaron Cole was asked if Moon Lake would go back on the stocking list if a new aerator were installed and if harvesting of aquatic vegetation was implemented to open up a portion of the lake. Mr. Cole was willing to consider restocking the lake, but was not sure if re-installation of an aerator and aquatic plant harvesting would be enough to prevent future winterkills. It was his understanding that the aerator was functioning through much of the 2013-14 winter season and his opinion that the winterkill was caused by the lake "super-cooling", not necessarily due to a lack of oxygen.

According to one source (Herman 2016) lake water can become super cooled when an aerator operated in the winter mixes warmer bottom waters (39°F) with much colder water (32°F) at the surface or just below the ice, cooling the whole lake to temperatures that stress and kill the fish. The frequency and severity of winter fishkills can be reduced by implementing several inexpensive winter actions. Deep snow limits light penetration through the ice that is needed for aquatic plant to make oxygen. Strips of snow can be plowed off the lake through the entire winter season, allowing for greater sunlight penetration through the ice. Lots of holes drilled through the ice on a daily basis can also increase oxygen levels in the lake. If an aerator is re-installed in the lake, a bottom aerator operated through the entire summer season might make the lake healthier going into winter freeze-up. To avoid super-cooling in the winter, the aerator can be installed in shallow water instead of the deep hole, and only operated when oxygen levels start to get low. This means checking dissolved oxygen levels in the lake on a regular basis throughout the open and frozen water seasons.

This same source recommends a re-stocking program after a winterkill that releases larger, but fewer adult fish back into the lake rather than large amounts of small fish. Stocking larger fish typically brings the size structure of fish back into balance quicker than adding small fish.

Re-stocking Moon Lake is reasonable as it used to support a decent fishery. The last year the lake was officially surveyed was in 2005 and results showed the lake to be a warm water fishery supporting primarily bass and bluegill (Figure 14). Crappie and perch were also present and "locals" say northern pike were as well (Cole 2016).

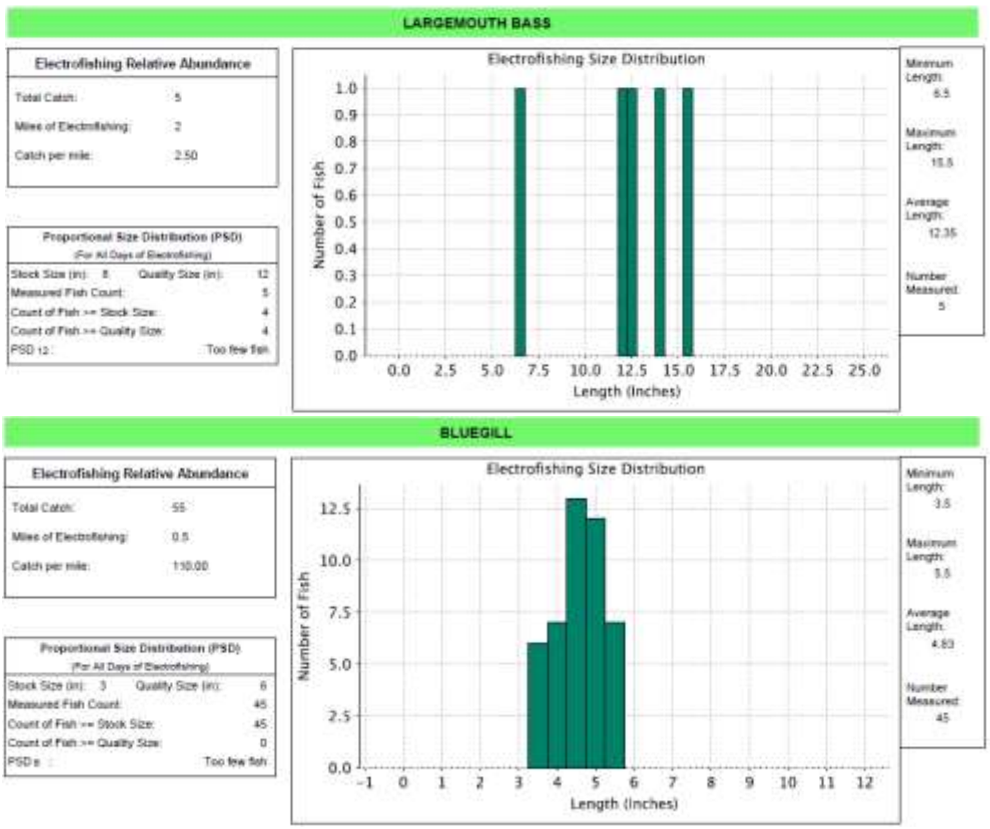


Figure 14 – 2005 WDNR Boom Shocking Survey results for bass and bluegills in Moon Lake (Cole 2016)

AERATION (CORNELIUS 2006)

According to a report prepared by Rick Cornelius, WDNR Fisheries Biologist (retired) in 2006, several landowners on Moon Lake installed one 2-hp aspirating aerator in the lake in 2001. At the time of the 2006 report, a severe winterkill had not occurred in Moon Lake between 2001 and 2006. Surface aspirating aeration systems consists of an aerator floating on a molded polyethylene pontoon. The aerator consists of an electric motor (2 or 3 hp) attached to an adjustable hollow shaft that angles into the water (Figure 15). The shaft drives a propeller/diffuser that draws air through intake holes above the water surface and shoots a stream of air through the shaft into the water. Underwater power cable and mooring cable are necessary, and the open water must be surrounded by a barricade. In 2006, the cost of one 2 hp unit with 200 feet of under water power cable was about $1,350.00. Operating costs were estimated at $120.00 to $180.00 per month in electricity for one 3-hp unit. The aerator stopped working in 2014, and to date has not been re-installed.

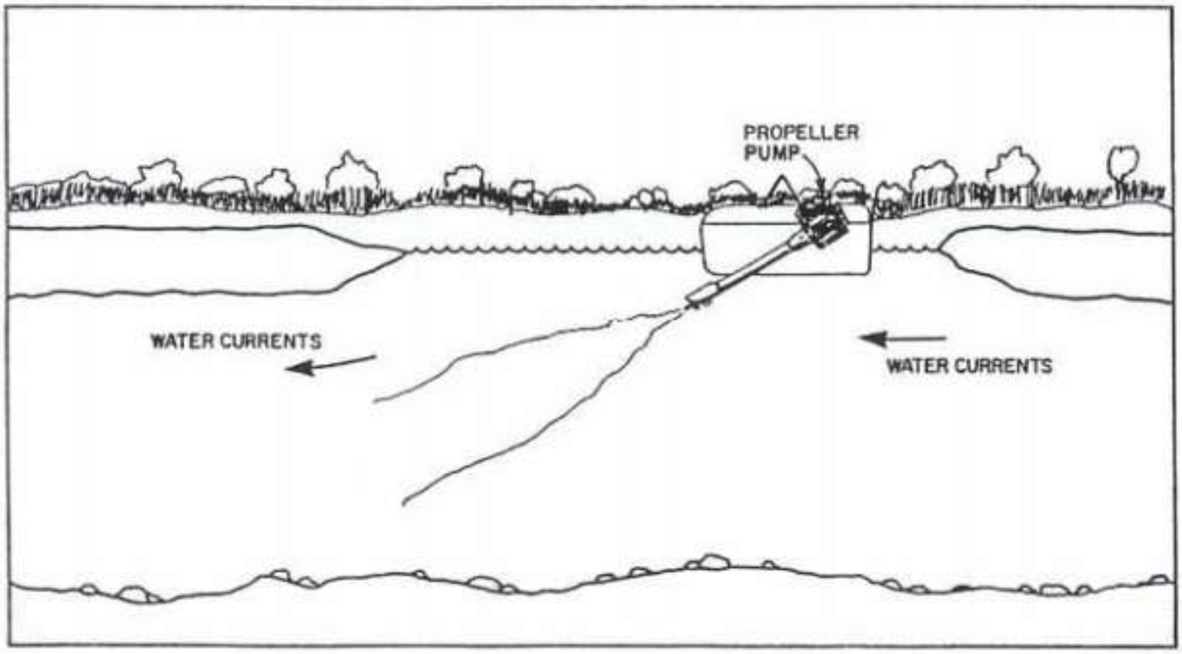


Figure 15 - Surface aspirating aeration system (Cornelius 2006)

WILDLIFE

The Natural Heritage Inventory (NHI) database contains recent and historic observations of rare species and plant communities. Each species has a state status including Special Concern, Threatened or Endangered. There are three ecological communities (northern sedge meadow, northern wet forest, and open bog) that have been documented in the same township and range as Moon Lake (T36N R11W) (WDNR 2016).

Moon Lake is home to a diverse array of wildlife including ducks, geese, swans, birds of prey, deer, furbearers, and reptiles. Opportunities for the public to view the abundant wildlife in and around the lake are provided by a paved hiking trail along the northwest shore which is part of the Moon Lake Park complex. Additional opportunities are made available through the existing public access on the lake that is suitable for the launching of small craft.

WETLANDS

A wetland is an area where water is at, near or above the land surface long enough to be capable of supporting aquatic or hydrophytic vegetation and which has soils indicative of wet conditions. Wetlands have many functions which benefit the ecosystem surrounding Moon Lake. Wetlands with a higher floral diversity of native species support a greater variety of native plants and are more likely to support regionally scarce plants and plant communities. Wetlands provide fish and wildlife habitat for feeding, breeding, resting, nesting, escape cover, travel corridors, spawning grounds for fish, and nurseries for mammals and waterfowl.

Wetlands also provide flood protection within the landscape. Due to the dense vegetation and location within the landscape, wetlands are important for retaining stormwater from rain and melting snow moving towards surface waters and retaining floodwater from rising streams. This flood protection minimizes impacts to downstream areas. Wetlands provide water quality protection because wetland plants and soils have the capacity to store and filter pollutants ranging from pesticides to animal wastes.

Wetlands also provide shoreline protection to Moon Lake because shoreline wetlands act as buffers between land and water. They protect against erosion by absorbing the force of waves and currents and by anchoring sediments. This shoreline protection is important in waterways where boat traffic, water current, and wave action cause substantial damage to the shore. Wetlands also provide groundwater recharge and discharge by allowing the surface water to move into and out of the groundwater system. The filtering capacity of wetland plants and substrates help protect groundwater quality. Wetlands can also stabilize and maintain stream flows, especially during dry months. Aesthetics, recreation, education and science are also all services wetlands provide. Wetlands contain a unique combination of terrestrial and aquatic life and physical and chemical processes.

Most of the shoreline surrounding Moon Lake consists of wetlands. The largest wetland on the north shore reduces the amount of runoff that flows directly into the lake. There are two smaller wetlands on the western and southern shores that help to maintain water quality by collecting a large amount of runoff from the cropland that they boarder. These large wetland complexes, in combination with the smaller wetland areas surrounding the lake, are vital to maintaining the water quality of Moon Lake (Figure 16).

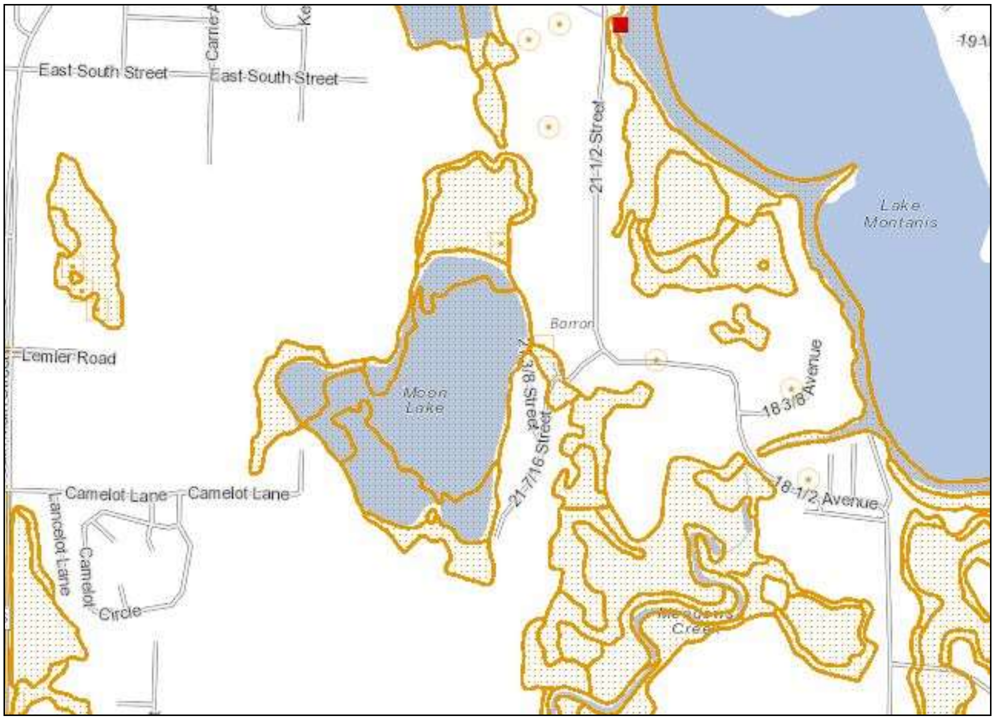


Figure 16: Moon Lake Wetlands (Wetlands Inventory - Wisconsin 2016)

SOILS

The soil in the Moon Lake watershed consists primarily of sandy loams and silt loams, with the somewhat excessively drained Chetek sandy loam comprising most of the watershed not occupied by wetland. The wetlands consist of very poorly drained Seelyeville and Cathro mucks which is to be expected in wetland areas. There are also several areas of well drained Rosholt sandy loam and Anigon silt loam in the northeastern and northwestern sections, respectively, of the watershed.

Soils are classified into hydrologic soil groups to indicate their potential for producing runoff. Much of the soil in Moon Lake watershed is classified as group B (Figure 17). Group B soils have moderately low runoff potential when thoroughly wet and water movement through the soil is unimpeded. Some soils in the near shore area are classified as group A, which have low runoff potential when thoroughly wet and water is transmitted freely through the soil, i.e., the soils have a high infiltration rate. The wetland areas are classified as group A/D. For this classification, the runoff potential is negligible due to the large amount of water it can store.

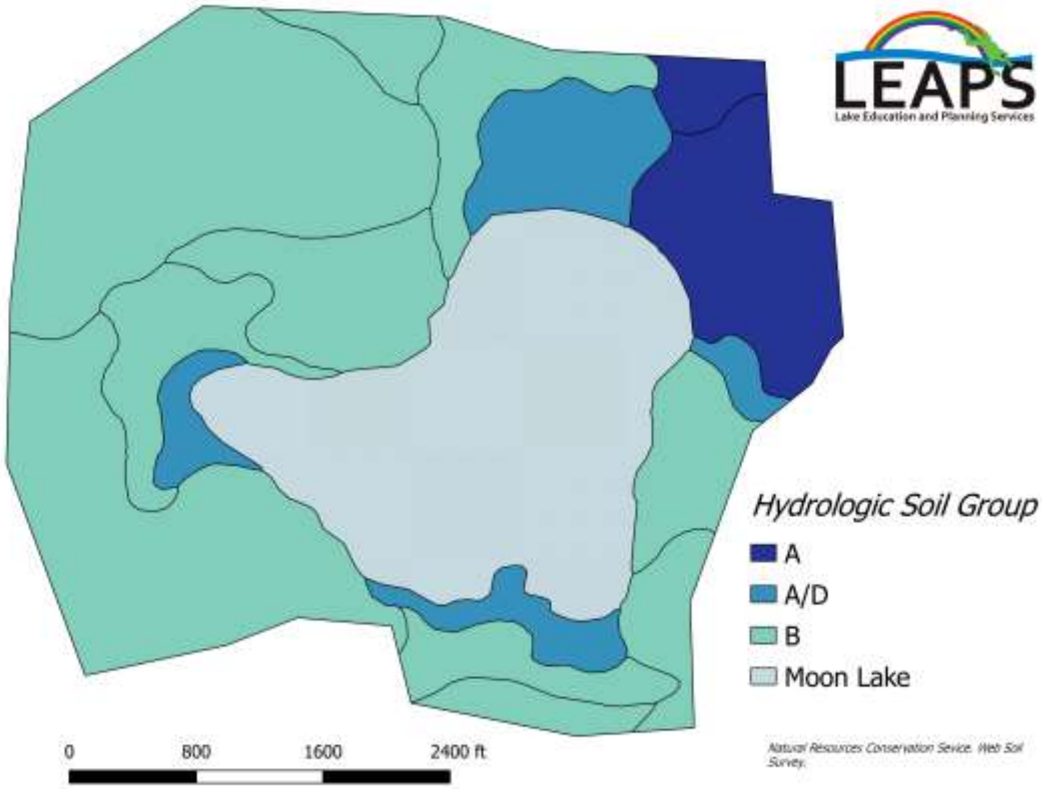


Figure 17 Hydrologic Soil Group Classification in the Moon Lake Watershed

COARSE WOODY HABITAT (WOLTER 2012)

Coarse woody habitat (CWH) in lakes is classified as trees, limbs, branches, roots, and wood fragments at least 4 inches in diameter that enter a lake by natural (beaver activity, toppling from ice, wind, or wave scouring) or human means (logging, intentional habitat improvement, flooding following dam construction). CWH in the littoral or near-shore zone serves many functions within a lake ecosystem including erosion control, as a carbon source, and as a surface for algal growth which is an important food base for aquatic macro invertebrates. Presence of CWH has also been shown to prevent suspension of sediments, thereby improving water clarity. CWH serves as important refuge, foraging, and spawning habitat for fish, aquatic invertebrates, turtles, birds, and other animals. The amount of littoral CWH occurring naturally in lakes is related to characteristics of riparian forests and likelihood of toppling. However, humans have also had a large impact on amounts of littoral CWH present in lakes through time. During the 1800's the amount of CWH in northern lakes was increased beyond natural levels as a result of logging practices. But time changes in the logging industry and forest composition along with increasing shoreline development have led to reductions in CWH present in many northern Wisconsin lakes.

CWH is often removed by shoreline residents to improve aesthetics or select recreational opportunities (swimming and boating). One study (Jennings 2003) found a negative relationship between lakeshore development and the amount of CWH in northern Wisconsin lakes. Another (Christensen 1996) found a negative correlation between density of cabins and CWH present in Wisconsin and Michigan lakes. While it is difficult to make precise determinations of natural densities of CWH in lakes it is believed that the value is likely on the scale of hundreds of logs per mile. The positive impact of CWH on fish communities have been well documented by researchers, making the loss of these habitats a critical concern. One study determined that black crappie selected nesting sites that were usually associated with woody debris, silty substrate, warmer water, and protected from wind and waves (Pope and Willis 1997).

Fortunately, remediation of this habitat type is attainable on many waterbodies, particularly where private landowners and lake associations are willing to partner with county, state, and federal agencies. Large-scale CWH projects are currently being conducted by lake associations and local governments with assistance from the WDNR where hundreds of whole trees are added to the near-shore areas of lakes. For more information on this process visit: http://dnr.wi.gov/topic/fishing/outreach/fishsticks.html (WDNR, Fish sticks: Improving lake habitat 2016).

SHORELANDS

How the shoreline of a lake is managed can have big impacts on the water quality and health of that lake. Natural shorelines prevent polluted runoff from entering lakes, help control flooding and erosion, provide fish and wildlife habitat, may make it harder for AIS to establish themselves, muffle noise from watercraft, and preserve privacy and natural scenic beauty. Many of the values lake front property owners appreciate and enjoy about their properties - natural scenic beauty, tranquility, privacy, relaxation - are enhanced and preserved with good shoreland management. And healthy lakes with good water quality translate into healthy lake front property values.

Shorelands may look peaceful, but they are actually the hotbed of activity on a lake. 90% of all living things found in lakes - from fish, to frogs, turtles, insects, birds, and other wildlife - are found along the shallow margins and shores. Many species rely on shorelands for all or part of their life cycles as a source for food, a place to sleep, cover from predators, and to raise their young. Shorelands and shallows are the spawning grounds for fish, nesting sites for birds, and where turtles lay their eggs. There can be as much as 500% more species diversity at the water's edge compared to adjoining uplands.

Lakes are buffered by shorelands that extend into and away from the lake. These shoreland buffers include shallow waters with submerged plants (like coontail and pondweeds), the water's edge where fallen trees and emergent plants like rushes might be found, and upward onto the land where different layers of plants (low ground cover, shrubs, trees) may lead to the lake. A lake's littoral zone is a term used to describe the shallow water area where aquatic plants can grow because sunlight can penetrate to the lake bottom. Shallow lakes might be composed entirely of a littoral zone. In deeper lakes, plants are limited where they can grow by how deeply light can penetrate the water.

Shorelands are critical to a lake’s health. Activities such replacing natural vegetation with lawns, clearing brush and trees, importing sand to make artificial beaches, and installing structures such as piers, can cause water quality decline and change what species can survive in the lake.

PROTECTING WATER QUALITY

Shoreland buffers slow down rain and snow melt (runoff). Runoff can add nutrients, sediments, and other pollutants into lakes, causing water quality declines. Slowing down runoff will help water soak (infiltrate) into the ground. Water that soaks into the ground is less likely to damage lake quality and recharges groundwater that supplies water to many of Wisconsin's lakes. Slowing down runoff water also reduces flooding, and stabilizes stream flows and lake levels.

Shoreland wetlands act like natural sponges trapping nutrients where nutrient-rich wetland sediments and soils support insects, frogs, and other small animals eaten by fish and wildlife.

Shoreland forests act as filters, retainers, and suppliers of nutrients and organic material to lakes. The tree canopy, young trees, shrubs, and forest understory all intercept precipitation, slowing runoff, and contributing to water infiltration by keeping the soil's organic surface layer well-aerated and moist. Forests also slow down water flowing overland, often capturing its sediment load before it can enter a lake or stream. In watersheds with a significant proportion of forest cover, the erosive force of spring snow melts is reduced as snow in forests melts later than snow on open land, and melt water flowing into streams is more evenly distributed. Shoreland trees grow, mature, and eventually fall into lakes where they protect shorelines from erosion, and are an important source of nutrients, minerals and wildlife habitat.

NATURAL SHORELANDS ROLE IN PREVENTING AIS

In addition to removing essential habitat for fish and wildlife, clearing native plants from shorelines and shallow waters can open up opportunities for invasive species to take over. Like tilling a home garden to prepare it for seeding, clearing shoreland plants exposes bare earth and removes the existing competition (the cleared shoreland plants) from the area. Nature fills a vacuum. While the same native shoreland plants may recover and reclaim their old space, many invasive species possess "weedy" traits that enable them to quickly take advantage of new territory and out-compete natives.

The act of weeding creates continual disturbance, which in turn benefits plants that behave like weeds. The modern day practice of mowing lawns is an example of keeping an ecosystem in a constant state of disturbance to the benefit of invasive species like turf grass, dandelions, and clover, all native to Europe. Keeping shoreline intact is a good way to minimize disturbance and minimize opportunities for invasive species to gain a foothold.

THREATS TO SHORELANDS

When a landowner develops a waterfront lot, many changes may take place including the addition of driveways, houses, decks, garages, sheds, piers, rafts and other structures, wells, septic systems, lawns, sandy beaches and more. Many of these changes result in the compaction of soil and the removal of trees and native plants, as well as the addition of impervious (hard) surfaces, all of which alter the path that precipitation takes to the water.

Building too close to the water, removing shoreland plants, and covering too much of a lake shore lot with hard surfaces (such as roofs and driveways) can harm important habitat for fish and wildlife, send more nutrient and sediment runoff into the lake, and cause water quality decline.

Changing one waterfront lot in this fashion may not result in a measurable change in the quality of the lake or stream. But cumulative effects when several or many lots are developed in a similar way can be enormous. A lake’s response to stress depends on what condition the system is in to begin with, but bit by bit, the cumulative effects of tens of thousands of waterfront property owners "cleaning up" their shorelines, are destroying the shorelands that protect their lakes. Increasing shoreline development and development throughout the lake's watershed can have undesired cumulative effects.

SHORELAND PRESERVATION AND RESTORATION

If a native buffer of shoreland plants exists on a given property, it can be preserved and care taken to minimize impacts when future lake property projects are contemplated. If a shoreline has been altered, it can be restored. Shoreline restoration involves recreating buffer zones of natural plants and trees. Not only do quality wild shorelines create higher property values, but they bring many other values too. Some of these are aesthetic in nature, while others are essential to a healthy ecosystem. Healthy shorelines mean healthy fish populations, varied plant life, and the existence of the insects, invertebrates and amphibians which feed fish, birds and other creatures. Figure 18 shows the difference between a natural and unnatural shoreline adjacent to a lake home. More information about healthy shorelines can be found at the following website: http://wisconsinlakes.org/index.php/shorelands-a-shallows (last accessed 12-2-2016).

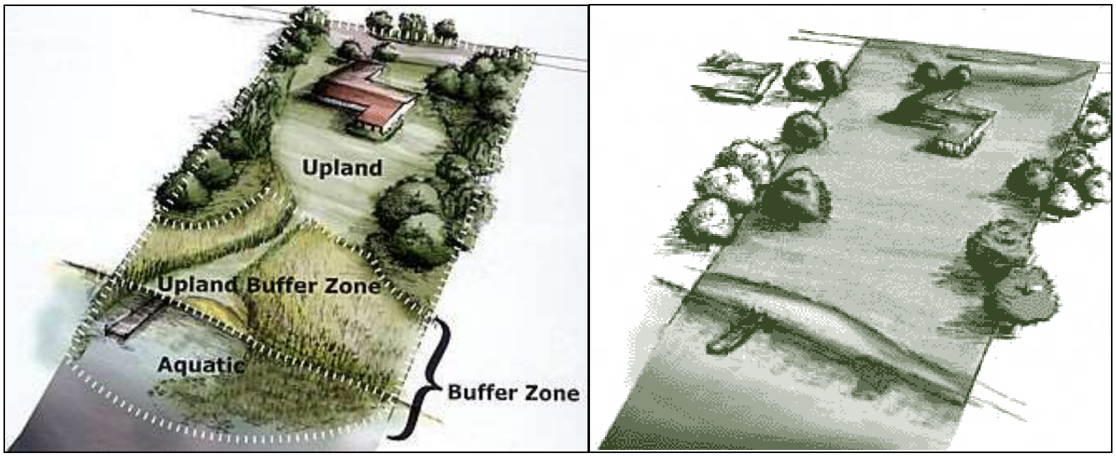


Figure 18 Healthy, AIS Resistant Shoreland (left) vs. Shoreland in Poor Condition

Much of the shoreline of Moon Lake is natural however where development is greater, improvements to the shoreline would help maintain water quality in the lake. Turf grass, mowed lawns to the edge of the lake, exposed earth, and rip rap increase the amount of runoff from roof tops, driveways, lawns and pathways to the lake. The WDNR encourages the installation of relatively simple best management practices including rain gardens, native plantings, and runoff diversion projects through its Healthy Lakes Initiative (WDNR, Healthy Lakes Wisconsin 2016).

2014 WHOLE LAKE POINT INTERCEPT AQUATIC PLANT SURVEY

In 2014, a whole lake point intercept aquatic plant survey was completed to create base data for the aquatic plant community in Moon Lake. This survey also collected data on the dominant sediment type for each of the points.

WARM-WATER FULL POINT-INTERCEPT AQUATIC PLANT SURVEY

All data in this section is taken from the 2014 Aquatic Plant Survey Report created by Aquatic Plant & Habitat Services, LLC (Hatleli 2014). The Moon Lake point-intercept (PI) survey grid contains 181 points, but one point was not surveyed due to inaccessibility caused by shallow water (less than 0.5ft). Moon Lake is a seepage lake which means there are no inlets or outlets and the primary water source for Moon Lake is precipitation. Seasonal changes in rainfall and snow melt can cause the depth and size of the lake to change fairly quickly. At the time of this survey, the deepest point in Moon Lake was measured to be 6.5 feet while in 2016, was measured to be just over 8 feet deep. The shallow nature of Moon Lake produces a littoral zone (area where plants area able to grow) that encompasses the entire lake (Figure 19).

The bottom type was surveyed at every site on the lake. At 176, or 98%, of the points collected the sediment consisted of decomposing organic materials more commonly referred to as muck. The remaining 2% was made up of 1% rock, and 1% sand.

Plants were found growing at all 180 of the points surveyed. The entire lake had very dense vegetation with average rake fullness of 2.79. At 151 points or 84%, the total rake fullness was 3 while only 8 points or 4% had a total rake fullness of 1. There were no points with total rake fullness less than 1 (Figure 19).

Plant diversity was remarkably high with a Simpson Diversity Index value of 0.83. Species richness was also relatively high with 31 total species found growing in lake. Only three of these species were "visual only" (meaning they could be seen within 6 ft. of the boat, but never appeared on the rake.) Richness at each individual site tended to be quite high as a mean of 2.78 native species was found at each site.

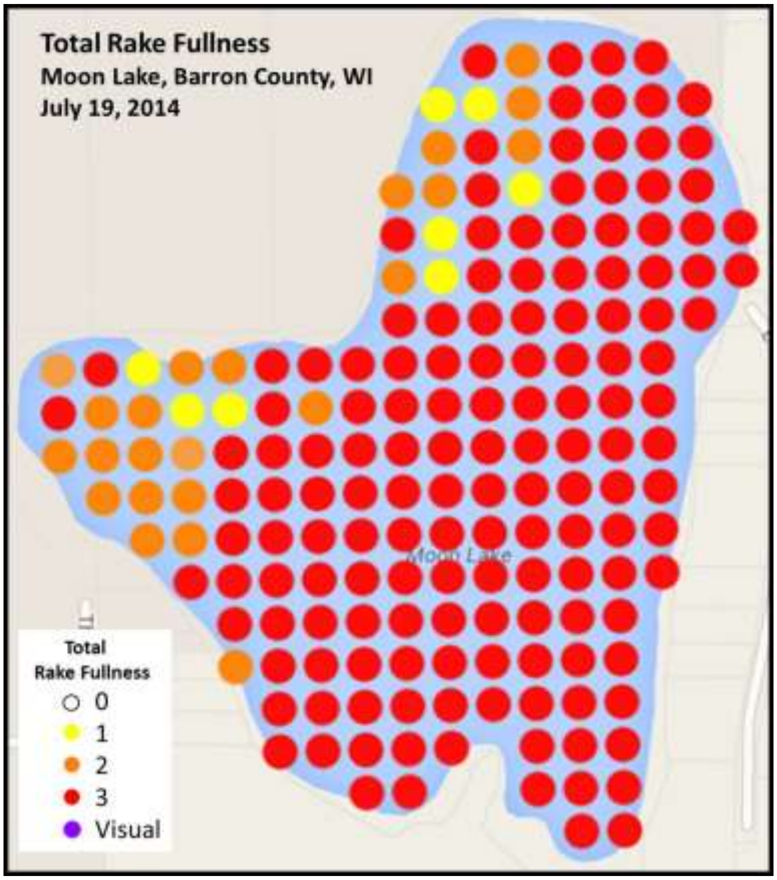


Figure 19: Rake fullness of all plant species (Hatleli 2014).

The Floristic Quality Index (FQI) measures the impact of human development on an area's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each native index species found in the lake during the point-intercept survey, and multiplying it by the square root of the total number of plant species (N) in the lake ($FQI=(\Sigma(c1+c2+c3+\ldots cn)/N)*\sqrt{N}$). Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be. Nichols (Nichols 1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. The values generated on Moon Lake, which is in the Northern Central Hardwood Forests Ecoregion, put Moon Lake above the mean for lakes in this region.

While these values show a healthy and diverse native plant community, there were three species which account for 64% of this community, Watershield, spiny hornwort, and leafy pondweed. This suggests a fairly homogenized population of plants. Of these three species, spiny hornwort has a conservatism value of 10, and was present at 52% of the sites surveyed. This high conservatism value paired with the high frequency suggests that the plant community in Moon Lake is not currently heavily impacted by human activity.

WILD RICE

Wild rice is an aquatic grass which grows in shallow water in lakes and slow flowing streams. This grass produces a seed which is a nutritious source of food for wildlife and people. The seed matures in August and

September with the ripe seed dropping into the sediment, unless harvested by wildlife or people. It is a highly protected and valued natural resource in Wisconsin. Only Wisconsin residents may harvest wild rice in the state. According to the WDNR Surface Water Data Viewer, Moon Lake is not wild rice water. The 2014 whole-lake point-intercept, aquatic plant surveys confirm this designation, as no wild rice was found in this survey, and it has never been found in any of the other survey work completed on the lake.

Within Moon Lake, there is no evidence of non-native invasive plant species. As of 2009, it has been documented that Chinese mystery snails are present within the lake, but the extent and viability of this population is unknown at this time. The 2014, survey noticed the presence of reed canary grass and narrow-leaved cattail in the wetland areas that boarder Moon Lake, but these were not large monocultures that have dominated the area.

NON-NATIVE, AQUATIC INVASIVE PLANT SPECIES

There is no indication of invasive plant species such as Eurasian water milfoil or CLP within the lake. However in wetland areas surrounding the lake reed canary grass and Narrow-leaved cattail have been seen. These populations are not dominating the wetlands they can be found in, so while they should be continually monitored, they are not presenting a large threat to the wetland ecosystems they are present in.

EURASIAN WATERMILFOIL

EWM has not been observed in Moon Lake. The nearest verified populations of EWM are found in Lower Vermillion Lake and Duck Lake east of Cumberland.

EWM is a submersed aquatic plant native to Europe, Asia, and northern Africa (Figure 20). It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, EWM is difficult to distinguish from Northern water milfoil. EWM has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

EWM grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

Unlike many other plants, EWM does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, trailers, bilges, live wells, and bait buckets; and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, EWM is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of EWM provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of EWM also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by EWM may lead to deteriorating water quality and algae blooms in infested lakes.

Figure 20: Eurasian Watermilfoil

PURPLE LOOSESTRIFE

Purple loosestrife has not been identified in the wetlands surrounding Moon Lake, but it has been observed near Rice Lake and several other large lakes relatively close to Moon Lake. It has also been verified near several smaller lakes that are very similar to Moon Lake including Butternut and Sylvan lakes just north of Cumberland.

Purple loosestrife (Figure 21) is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers that vary from purple to magenta possess 5-6 petals aggregated into numerous long spikes, and bloom from August to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

Purple loosestrife is a wetland herb that was introduced as a garden perennial from Europe during the 1800's. It is still promoted by some horticulturists for its beauty as a landscape plant, and by beekeepers for its nectar-producing capability. Currently, more than 20 states, including Wisconsin have laws prohibiting its importation or distribution because of its aggressively invasive characteristics. It has since extended its range to include most temperate parts of the United States and Canada. The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America.

Purple loosestrife was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the state, and has been recorded in 70 of Wisconsin's 72 counties. Low densities in most areas of the state suggest that the plant is still in the pioneering stage of establishment. Areas of heaviest infestation are sections of the Wisconsin River, the extreme southeastern part of the state, and the Wolf and Fox River drainage systems.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes, and rivers.

Purple loosestrife can germinate successfully on substrates with a wide range of pH. Optimum substrates for growth are moist soils of neutral to slightly acidic pH, but it can exist in a wide range of soil types. Most seedling establishment occurs in late spring and early summer when temperatures are high.

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local perturbation is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Plants may be quite large and several years old before they begin flowering. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. Invasion usually begins with a few pioneering plants that build up a large seed bank in the soil for several years. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland. The plant can also make morphological adjustments to accommodate changes in the immediate environment; for example, a decrease in light level will trigger a change in leaf morphology. The plant's ability to adjust to a wide range of environmental conditions gives it a competitive advantage; coupled with its reproductive strategy, purple loosestrife tends to create monotypic stands that reduce biotic diversity.

Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways.

Figure 21: Purple Loosestrife

JAPANESE KNOTWEED

Knotweeds are robust, bamboo-like perennials introduced from Asia that are spreading throughout the Great Lakes states. The main species is Japanese Knotweed (Figure 22). Knotweed grows in dense stands 6-12-ft tall. Its stems are hollow, green to reddish in color and bamboo-like. Its leaves are bright green, broad, egg or heart shaped, with a pointed tip. Small white flowers in branched spray appear July through August. Dormant in winter, the dead reddish brown stems often remain standing. It emerges from root crowns in April and reaches full height in June. The heaviest concentrations of knotweed are usually along rivers and roads, but are also found in parks, backyards, along lake shore, in forests and on farms. Japanese knotweed reproduces occasionally by seed, but spreads primarily by extensive networks of underground rhizomes, which can reach 6 feet deep, 60 feet long, and become strong enough to damage pavement and penetrate building foundations. Controlling Japanese knotweed is difficult and requires persistence and diligence. It can be dug, cut, covered, chemically sprayed, or have herbicide injected into individual stems.

Japanese knotweed has not been found around Moon Lake. There are several lakes, including Rice Lake and Red Cedar Lake, where knotweed has been observed, but these populations have not been verified by the WDNR.

Figure 22: Japanese Knotweed

REED CANARY GRASS

Reed canary grass (Figure 23) is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades 3 1/2 to 10 inches long and 1/4 to 3/4 inch in width. Blades are flat and have a rough texture on both surfaces. The lead ligule is membranous and long. The compact panicles are erect or slightly spreading (depending on the plant's reproductive stage), and range from 3 to 16 inches long with branches 2 to 12 inches in length. Single flowers occur in dense clusters in May to mid-June. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Both Eurasian and native ecotypes of reed canary grass are thought to exist in the U.S. The Eurasian variety is considered more aggressive, but no reliable method exists to tell the ecotypes apart. It is believed that the vast majority of our reed canary grass is derived from the Eurasian ecotype. Agricultural cultivars of the grass are widely planted.

Reed canary grass is a cool-season, sod-forming, perennial wetland grass native to temperate regions of Europe, Asia, and North America. The Eurasian ecotype has been selected for its vigor and has been planted throughout the U.S. since the 1800's for forage and erosion control. It has become naturalized in much of the northern half of the U.S., and is still being planted on steep slopes and banks of ponds and created wetlands.

Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas such as bergs and spoil piles.

Reed canary grass reproduces by seed or creeping rhizomes. It spreads aggressively. The plant produces leaves and flower stalks for 5 to 7 weeks after germination in early spring and then spreads laterally. Growth peaks in mid-June and declines in mid-August. A second growth spurt occurs in the fall. The shoots collapse in mid to late summer, forming a dense, impenetrable mat of stems and leaves. The seeds ripen in late June and shatter when ripe. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.

This species prefers disturbed areas, but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in just a few years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, and deforestation of swamp forests, sedimentation, and intentional planting. The difficulty of selective control makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites.

Reed canary grass can be found in all of the wetland surrounding Moon Lake. For the most part, these wetlands have not become completely overrun by reed canary grass. There are a few patches with dense reed canary grass populations, most notably in the northern wetland bordering Moon Lake. The majority of Moon Lake's surrounding wetlands are still a healthy mix of native vegetation with some reed canary grass mixed.

Figure 23: Reed Canary Grass

CURLY-LEAF PONDWEED

Curly-leaf Pondweed has not been identified in Moon Lake, but it has become one of the most prevalent AIS found in Wisconsin. There are over 15 lakes within Barron County that have CLP present including Rice, Montanis, Poskin, and both Upper and Lower Vermillion lakes.

CLP is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia (Figure 24). It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. CLP is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures. It has been reported in all states but Maine.

CLP spreads through burr-like winter buds (turions) (Figure 24), which are moved among waterways. These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making CLP one of the first nuisance aquatic plants to emerge in the spring. It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out-compete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. CLP forms surface mats that interfere with aquatic recreation.

Figure 24: CLP Plants and Turions

NON-NATIVE AQUATIC INVASIVE ANIMAL SPECIES

Several non-vegetative, aquatic, invasive species are in nearby lakes, but have not been identified in Moon Lake. One species, Chinese mystery snails have been. It is important for lake property owners and users to be knowledgeable of these species in order to identify them if and when they show up in Moon Lake.

CHINESE MYSTERY SNAILS

Chinese mystery snails have been identified in Moon Lake, but banded mystery snails have not. However banded mystery snails are present in Lake Montanis. Moon Lake is an ideal lake for both species of mystery snail due to the shallow depth and primarily muck substrate.

The Chinese mystery snails and the banded mystery snails (Figure 25) are non-native snails that have been found in a number of Wisconsin lakes. There is not a lot yet known about these species, however, it appears that they have a negative effect on native snail populations. The mystery snail's large size and hard operculum (a trap door cover which protects the soft flesh inside), and their thick hard shell make them less edible by predators.

The female mystery snail gives birth to live crawling young. This may be an important factor in their spread as it only takes one impregnated snail to start a new population. Mystery snails thrive in silt and mud areas although they can be found in lesser numbers in areas with sand or rock substrates. They are found in lakes, ponds, irrigation ditches, and slower portions of streams and rivers. They are tolerant of pollution and often thrive in stagnant water areas. Mystery snails can be found in water depths of 0.5 to 5 meters (1.5 to 15 feet). They tend to reach their maximum population densities around 1-2 meters (3-6 feet) of water depth. Mystery snails do not eat plants. Instead, they feed on detritus and in lesser amounts on algae and phytoplankton. Thus removal of plants along the shoreline area will not reduce the abundance of mystery snails.

Lakes with high densities of mystery snails often see large die-offs of the snails. These die-offs are related to the lake's warming coupled with low oxygen (related to algal blooms). Mystery snails cannot tolerate low oxygen levels. High temperatures by themselves seem insufficient to kill the snails as the snails could move into deeper water.

Many lake residents are worried about mystery snails being carriers of the swimmer's itch parasite. In theory they are potential carriers, however, because they are an introduced species and did not evolve as part of the lake ecosystem, they are less likely to harbor the swimmer's itch parasites.

Figure 25: Chinese Mystery Snails (not from Moon Lake)

RUSTY CRAYFISH

Rusty crayfish have not been seen in Moon Lake. They have been found in several lakes within Barron County including Sand Lake, Upper Turtle Lake, and the Red Cedar chain of lakes. There are also established populations found in the Red Cedar and Brill rivers.

Rusty crayfish (Figure 26) live in lakes, ponds and streams, preferring areas with rocks, logs and other debris in water bodies with clay, silt, sand or rocky bottoms. They typically inhabit permanent pools and fast moving streams of fresh, nutrient-rich water. Adults reach a maximum length of 4 inches. Males are larger than females upon maturity and both sexes have larger, heartier, claws than most native crayfish. Dark "rusty" spots are usually apparent on either side of the carapace, but are not always present in all populations. Claws are generally smooth, with grayish-green to reddish-brown coloration. Adults are opportunistic feeders, feeding upon aquatic plants, benthic invertebrates, detritus, juvenile fish and fish eggs.

The native range of the rusty crayfish includes Ohio, Tennessee, Kentucky, Indiana, Illinois and the entire Ohio River basin. However, this species may now be found in Michigan, Massachusetts, Missouri, Iowa, Minnesota, New York, New Jersey, Pennsylvania, Wisconsin, New Mexico and the entire New England state area (except Rhode Island). The Rusty crayfish has been a reported invader since at least the 1930's. Its further spread is of great concern since the prior areas of invasion have led to severe impacts on native flora and fauna. It is thought to have spread by means of released game fish bait and/or from aquarium release. Rusty crayfish are also raised for commercial and biological harvest.

Rusty crayfish reduce the amount and types of aquatic plants, invertebrate populations, and some fish populations--especially bluegill, smallmouth and largemouth bass, lake trout and walleye. They deprive native fish of their prey and cover and out-compete native crayfish. Rusty crayfish will also attack the feet of swimmers. On the positive side, rusty crayfish can be a food source for larger game fish and are commercially harvested for human consumption.

Rusty crayfish may be controlled by restoring predators like bass and sunfish populations. Preventing further introduction is important and may be accomplished by educating anglers, trappers, bait dealers and science teachers of their hazards. Use of chemical pesticides is an option, but does not target this species and will kill other aquatic organisms.

It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except the Mississippi River). It is also illegal to release crayfish into a water of the state without a permit.

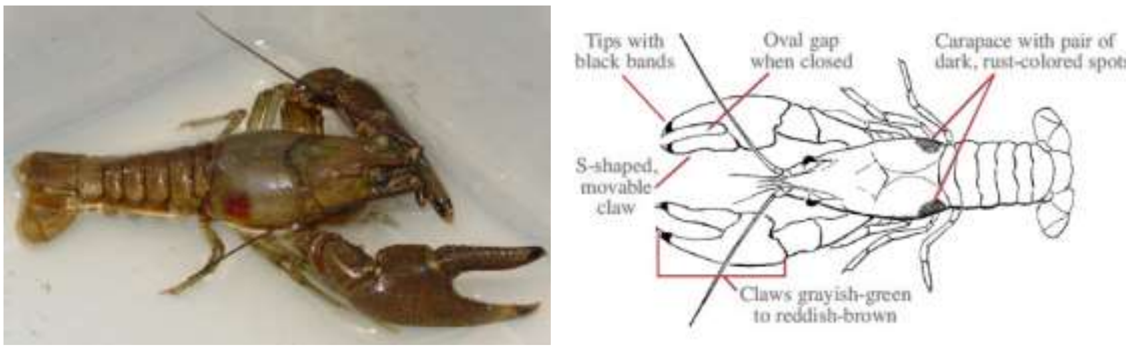


Figure 26: Rusty Crayfish and identifying characteristics

ZEBRA MUSSELS

Statistical models have been used to determine the lakes that are at risk for establishing a zebra mussel population. These models have shown that while nearby Rice Lake and Lake Montanis are both susceptible, Moon Lake is not suitable for zebra mussels.

Zebra mussels (Figure 27) are an invasive species that have inhabited Wisconsin waters and are displacing native species, disrupting ecosystems, and affecting citizens' livelihoods and quality of life. They hamper boating, swimming, fishing, hunting, hiking, and other recreation, and take an economic toll on commercial, agricultural, forestry, and aquacultural resources. The zebra mussel is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986, and have been spreading throughout them since that time. They were most likely brought to North America as larvae in ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes. Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.

Zebra mussels feed by drawing water into their bodies and filtering out most of the suspended microscopic plants, animals and debris for food. This process can lead to increased water clarity and a depleted food supply for other aquatic organisms, including fish. The higher light penetration fosters growth of rooted aquatic plants which, although creating more habitat for small fish, may inhibit the larger, predatory fish from finding their food. This thicker plant growth can also interfere with boaters, anglers and swimmers. Zebra mussel infestations may also promote the growth of blue-green algae, since they avoid consuming this type of algae but not others.

Zebra mussels attach to the shells of native mussels in great masses, effectively smothering them. A survey by the Army Corps of Engineers in the East Channel of the Mississippi River at Prairie du Chien revealed a substantial reduction in the diversity and density of native mussels due to Zebra Mussel infestations. The East Channel provides habitat for one of the best mussel beds in the Upper Mississippi

River. Future efforts are being considered to relocate such native mussel beds to waters that are less likely to be impacted by zebra mussels.

Once zebra mussels are established in a water body, very little can be done to control them. It is therefore crucial to take all possible measures to prevent their introduction in the first place. Some of the preventative and physical control measures include physical removal, industrial vacuums, and back flushing.

Chemical applications include solutions of chlorine, bromine, potassium permanganate and even oxygen deprivation. An ozonation process is under investigation (patented by Bollyky Associates Inc.) which involves the pumping of high concentrations of dissolved ozone into the intake of raw water pipes. This method only works in controlling veligers, and supposedly has little negative impacts on the ecosystem. Further research on effective industrial control measures that minimize negative impacts on ecosystem health is needed.

In the fall of 2016, zebra mussels were found in a northwest Wisconsin lake for the first time. With this discovery, it increases the likelihood that zebra mussels will spread faster in northwest Wisconsin. A study was completed a couple of years back that identified characteristics within lakes that would best support a new infestation of zebra mussels. The result of that study was an on-line application referred to as the AIS Smart Prevention database which ranks lakes in WI as suitable, borderline suitable, or not suitable habitat for zebra mussel survival. Moon Lake is listed as not suitable, but Rice Lake is at high risk and considered suitable and Montanis Lake is borderline suitable (Center for Limnology 2016).

Figure 27: Zebra Mussels

AIS PREVENTION STRATEGY

Moon Lake has almost no issue with AIS at this time, but it is very easy for many of these species to become quickly established. The MLA has and will continue to implement watercraft inspection at the public access point through Clean Boat, Clean Waters. The association will also continue water quality testing and invasive species monitoring through the Citizens Lake Monitoring Network.

Nuisance aquatic plants can be managed a variety of ways in Wisconsin. The best management strategy will be different for each lake and depends on which nuisance species needs to be controlled, how widespread the problem is, and the other plants and wildlife in the lake. In many cases, an integrated pest management (IPM) approach to aquatic plant management that utilizes a number of control methods is necessary. The eradication of non-native aquatic invasive plant species is generally not feasible, but preventing them from becoming a more significant problem is an attainable goal. It is important to remember however, that regardless of the plant species targeted for control, sometimes no manipulation of the aquatic plant community is the best management option. Plant management activities can be disruptive to a lake ecosystem and should not be done unless it can be shown they will be beneficial and occur with minimal negative ecological impacts.

Management alternatives for nuisance aquatic plants can be grouped into four broad categories: manual and mechanical removal, chemical application, biological control, and physical habitat alteration. Manual and mechanical removal methods include pulling, cutting, raking, harvesting, suction harvesting, and other means of removing the physical plant from the water and in most cases will require a WDNR permit. Chemical application is typified by the use of herbicides that kill or impede the growth of the aquatic plant and always requires a WDNR permit. Biological control methods include organisms that use the plant for a food source or parasitic organisms that use the plant as a host, killing or weakening it. Biological control may also include the use of species that compete successfully with the nuisance species for available resources. This activity may require a WDNR permit. Physical habitat alteration includes dredging, installing lake-bottom covers, manipulating light penetration, flooding, and drawdown. These activities may require permits under the WDNR waterways and wetlands program. It may also include making changes to or in the watershed of a body of water to reduce nutrients going in.

Each of the above control categories are regulated by the WDNR and most activities require a permit from the WDNR to implement. Mechanical harvesting of aquatic plants and under certain circumstances, physical removal of aquatic plants, is regulated under Wisconsin Administrative Rule NR 109 (Appendix A). The use of chemicals and biological controls are regulated under Administrative Rule NR 107 (Appendix A). Certain habitat altering techniques like the installation of bottom covers and dredging require a Chapter 30/31 waterway protection permit. In addition, anytime wild rice is involved one or more of these permits will be required.

Informed decision-making on aquatic plant management implementation requires an understanding of plant management alternatives and how appropriate and acceptable each alternative is for a given lake. The following sections list scientifically recognized and approved alternatives for controlling aquatic vegetation.

NO MANAGEMENT

When evaluating the various management techniques, the assumption is erroneously made that doing nothing is environmentally neutral. In dealing with nonnative species, the environmental consequences of doing nothing may be high, possibly even higher than any of the effects of management techniques. Unmanaged, these species can have severe negative effects on water quality, native plant distribution, abundance and diversity, and the abundance and diversity of aquatic insects and fish (Madsen, Methods for management of nonindigenous aquatic plants 1997). Nonindigenous aquatic plants are the problem, and the management techniques are the collective solution. Nonnative plants are a biological pollutant that increases geometrically, a pollutant with a very long residence time and the potential to "biomagnify" in lakes, rivers, and wetlands (Madsen, Advantages and disadvantages of aquatic plant management techniques 2000).

Foregoing any plant management in Moon Lake is not a recommended option. Without management, Moon Lake will continue to be overpopulated with vegetation making it unusable for most recreation activities.

HAND-PULLING/MANUAL REMOVAL

Manual or physical removal of aquatic plants by means of a hand-held rake or cutting implement; or by pulling the plants from the lake bottom by hand is allowed by the WDNR without a permit per NR 109.06 Waivers under the following conditions:

- Removal of native plants is limited to a single area with a maximum width of no more than 30 feet measured along the shoreline provided that any piers, boatlifts, swim rafts and other recreational and water use devices are located within that 30-foot wide zone and may not be in a new area or additional to an area where plants are controlled by another method (Figure 28)
- Removal of nonnative or invasive aquatic plants as designated under s. NR 109.07 is performed in a manner that does not harm the native aquatic plant community
- Removal of dislodged aquatic plants that drift on-shore and accumulate along the waterfront is completed.
- The area of removal is not located in a sensitive area as defined by the department under s. NR 107.05 (3) (i) 1, or in an area known to contain threatened or endangered resources or floating bogs
- Removal does not interfere with the rights of other riparian owners
- If wild rice is involved, the procedures of s. NR 19.09 (1) (Appendix B) are followed.

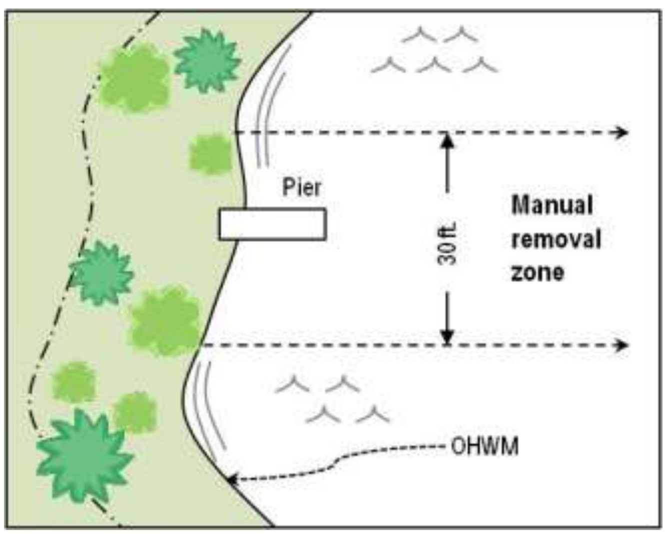


Figure 28: Aquatic vegetation manual removal zone

Although up to 30 feet of aquatic vegetation can be removed, removal should only be done to the extent necessary. There is no limit as to how far out into the lake the 30-ft zone can extend, however clearing large swaths of aquatic plants not only disrupts lake habits, it also creates open areas for non-native species to establish. Physical removal of aquatic plants requires a permit if the removal area is located in a "sensitive" or critical habitat area previously designated by the WDNR. Manual or physical removal can be effective at controlling individual plants or small areas of plant growth. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. In shallow, hard bottom areas of a lake, or where impacts to fish spawning habitat need to be minimized, this is the best form of control. If water clarity in a body of water is such that aquatic plants can be seen in deeper water, pulling AIS while snorkeling or scuba diving is also allowable without a permit according to the conditions in NR 106.06(2) and can be effective at slowing the spread of a new AIS infestation within a lake when done Larger scale hand or diver removal projects have had positive impacts in temporarily reducing or controlling AIS. Typically hand or diver removal is used when AIS has been newly identified and still exists as single plants or isolated small beds, but at least in one lake in New York State, it was used as a means to control a large-scale infestation of EWM. One study (Kelting and Laxson 2010) reported that from 2004 to 2006 an "intensive management effort" which involved "the selective removal of Eurasian water milfoil using diver hand harvesting of the entire littoral zone of the lake at least twice each summer for three years" followed by three years of maintenance management successfully reduced the overall distribution of EWM in the lake.

In Moon Lake, plants growing in some areas of the lake may be best managed by hand-pulling/manual removal. However it is not suitable to manage the entire lake this with manual removal.

DIVER ASSISTED SUCTION HARVESTING

Diver assisted suction harvesting or DASH, as it is often called, is a fairly recent aquatic plant removal technique. It is called "harvesting" rather than "dredging" because, although a specialized small-scale dredge is used, bottom sediment is not removed from the system. The operation involves hand-pulling of the target plants from the lake bed and inserting them into an underwater vacuum system that sucks up plants and their root systems taking them to the surface. It requires water pumps on the surface (generally on a pontoon system) to move a large volume of water to maintain adequate suction of materials that the divers are processing (Figure 29). Only clean water goes through the pump. The material placed by the divers into the suction hose along with the water is deposited into mesh bags on the surface with the water leaving through the holes in the bag. The bags have a large enough 'mesh' size so that silts, clay, leaves and other plant material being collected do not immediately clog them and block water movement. If a fish or other living marine life is sucked into the suction hose it comes out the discharge unharmed and is returned to the body of water. It can have some negative impacts to other nearby non-target plants if not done carefully, particularly those plants that are perennials and expand their populations by sub-sediment runners (Eichler, et al. 1993).


Figure 29: DASH - Diver Assisted Suction Harvest (Aquacleaner Environmental, http://www.aquacleaner.com/index.html); Many Waters, LLC)

DASH would not be an effective method of management for Moon Lake. Because the idea behind DASH removal is the selective nature, this is best suited for the removal of invasive aquatic plants. Being as there are no aquatic invasive plants in Moon Lake, DASH removal would be incredibly expensive and ineffective therefore this is not a recommended management strategy.

MECHANICAL REMOVAL

Mechanical management involves the use of devices not solely powered by human means to aid removal. This includes gas and electric motors, ATV's, boats, tractors, etc. Using these instruments to pull, cut, grind, or rotovate aquatic plants is illegal in Wisconsin without a permit. DASH is also considered mechanical removal. To implement mechanical removal of aquatic plants a Mechanical/Manual Aquatic Plant Control Application is required annually. The application is reviewed by the WDNR and other entities and a permit awarded if required criteria are met. Using repeated mechanical disturbance such as bottom rollers or sweepers can be effective at control in small areas, but in Wisconsin these devices are illegal and generally not permitted.

MECHANICAL HARVESTING

Large-scale mechanical harvesting is more traditionally used for control of CLP, but can be an effective way overall plant biomass in a water body. It is typically used to open up channels through existing beds of vegetation to improve access for both human related activities like boating, and natural activities like fish distribution and mobility.

Mechanical harvesters are large machines which both cut and collect aquatic plants. Cut plants are removed from the water by a conveyor belt system and stored on the harvester until disposal. A barge may be stationed near the harvesting site for temporary plant storage or the harvester carries the cut weeds to shore. The shore station equipment is usually a shore conveyor that mates to the harvester and lifts the cut plants into a dump truck. Harvested weeds are disposed of in landfills, used as compost, or in reclaiming spent gravel pits or similar sites.

Harvesting is usually performed in late spring, summer, and early fall when aquatic plants have reached or are close to the water's surface. Harvesters can cut and collect several acres per day depending on weed type, plant density, and storage capacity of the equipment. Harvesting speeds for typical machines range from 0.5 to 1.5 acres per hour. Depending on the equipment used, the plants are cut from three to five feet below the water's surface in a swath 4 to 20 feet wide. Harvesting can be an excellent way to create open areas of water for recreation and fishing access.

Timing is also important. The ideal time to harvest, in order to maximize the efficiency of the harvester, is just before the aquatic plants break the surface of the lake. If the harvesting work is contracted, the equipment should be inspected before and after it enters the lake. Since these machines travel from lake to lake, they may carry plant fragments with them, and facilitate the spread of AIS from one body of water to another.

Mechanical harvesting of aquatic plants has advantages and disadvantages (Washington 2016):

Advantages

- Harvesting results in immediate open areas of water.
- Removing plants from the water removes the plant nutrients, such as nitrogen and phosphorus, from the system. (Harvesting aquatic plants is not an effective tool for reducing nutrient loads in a lake and it is unlikely that any operational harvesting program will significantly impact the internal nutrient balance of the system (Madsen, Advantages and disadvantages of aquatic plant management techniques 2000).
- Harvesting as aquatic plants are dying back for the winter can remove organic material and help slow the sedimentation rate in a waterbody.
- Since the lower part of the plant remains after harvest, habitat for fish and other organisms is not eliminated.

- Harvesting can be targeted to specific locations, protecting designated conservancy areas from treatment.

Disadvantages

- Harvesting is similar to mowing a lawn; the plant grows back and may need to be harvested several times during the growing season.
- There is little or no reduction in plant density with mechanical harvesting.
- Off-loading sites and disposal areas for cut plants must be available. On heavily developed shorelines, suitable off-loading sites may be few and require long trips by the harvester.
- Some large harvesters are not easily maneuverable in shallow water or around docks or other obstructions.
- Significant numbers of small fish, invertebrates, and amphibians are often collected and killed by the harvester.
- Harvesting creates plant fragments which may increase the spread of invasive plant species such as EWM throughout the waterbody.
- Although harvesters collect plants as they are cut, not all plant fragments or plants may be picked up. These may accumulate and decompose on shore.
- Harvesters are expensive and require routine maintenance.
- Harvesting may not be suitable for lakes with many bottom obstructions (stumps, logs) or for very shallow lakes (3-5 feet of water) with loose organic sediments.
- Harvesters brought into the waterbody from other locations need to be thoroughly cleaned and inspected before being allowed to launch. Otherwise new exotic species could be introduced to the waterbody.

Disposal sites are a key component when considering the mechanical harvesting of aquatic plants. The sites must be on shore and upland to make sure the plants and their reproductive structures don't make their way back into the lake or to other lakes. The number of available disposal sites and their distance from the targeted harvesting areas will determine the efficiency of the operation, in terms of time as well as cost.

Costs per acre vary with numbers of acres harvested, accessibility of disposal sites to the harvested areas, density and species of the harvested plants, and whether a private contractor or public entity does the work. Costs as low as $250 per acre have been reported. Private contractors generally charge $500 to $800 per acre. The purchase price of harvesters ranges from $45,000 to $250,000. There are several harvester manufacturers in the United States (including at least two in Wisconsin) and some lake groups may choose to operate and purchase their own machinery rather than contracting for these services.

Prior to 2017, contracted harvesting services have not been readily available in NW Wisconsin. While there are many companies offering contracted services in Minnesota, most will not contract across the border into WI. There is at least one company out of northern Illinois that would consider offering services in NW Wisconsin, but this has not happened yet. In 2017, a new company out of Chippewa Falls, WI will be offering contracted harvesting services. The company owns two 5-ft Harvesters each with a capacity to hold about 220 cubic feet or 6,500 lbs. of cut vegetation on board.

Using contracted mechanical harvesting to manage the aquatic plants in Moon Lake is recommended to provide greater access for fishing and boating, improve fishing and fish habitat, and to reduce build-up of organic materials in the lake which may in time reduce the number and severity of winter fish kills.

SMALL-SCALE CUTTING WITH REMOVAL

There are a wide range of small-scale mechanical harvesting techniques, most of which involve the use of boat mounted rakes, scythes, and electric cutters. As with all mechanical harvesting, removing the cut plants is required. Commercial rakes and cutters range in prices from $200 for rakes to around $3000 for electric cutters with a wide range of sizes and capacities. Using a weed rake or cutter that is run by human power is allowed without a permit, but the use of any device that includes a motor, gas or electric, would require a permit. Dragging a bed spring or bar behind a boat, tractor or any other motorized vehicle to remove vegetation is also illegal without a permit. Although not truly considered mechanical management, incidental plant disruption by normal boat traffic is a legal method of management. Active use of an area is often one of the best ways for riparian owners to gain navigation relief near their docks. Most aquatic plants won't grow well in an area actively used for boating and swimming. It should be noted that purposefully navigating a boat to clear large areas is not only potentially illegal it can also re-suspend sediments, encourage AIS growth, and cause ecological disruptions.

Small-scale harvesting by human power would be an effective way for property owners on Moon Lake to open up their boating lanes when done within the 30 foot corridor. Any sort of cutting and removal beyond the 30 foot path or by any mechanical means does require a permit. Through information and training, property owners will be instructed on proper physical removal methods.

BOTTOM BARRIERS AND SHADING

Physical barriers, fabric or other, placed on the bottom of the lake to reduce plant growth would eliminate all plants, inhibit fish spawning, affect benthic invertebrates, and could cause anaerobic conditions which may release excess nutrients from the sediment. Gas build-up beneath these barriers can cause them to dislodge from the bottom and sediment can build up on them allowing vegetation to re-establish. Bottom barriers are typically used for very small areas and provide only limited relief. Currently the WDNR does not permit this type of control.

The general intention is to reduce light penetration in the water which in turns limits the depth at which plants can grow. Typically dyes have been added to a small water body to darken the water. Bottom barriers and attempts to further reduce light penetration in Moon Lake are not recommended.

DREDGING

Dredging is the removal of bottom sediment from a lake. Its success is based on altering the target plant's environment. It is not usually performed solely for aquatic plant management but rather to restore lakes that have been filled in with sediment, have excess nutrients, inadequate pelagic and hypolimnetic zones, need deepening, or require removal of toxic substances (Peterson 1982). In shallow lakes with excess plant growth, dredging can make areas of the lake too deep for plant growth. It can also remove significant plant root structures, seeds/turions, rhizomes, tubers, etc. In Collins Lake, New York the biomass of CLP remained significantly lower than pre-dredging levels 10-yrs after dredging (Tobiessen, Swart and Benjamin 1992). Dredging is very expensive, requires disposal of sediments, and has major environmental impacts. It is not a selective procedure so it can't be used to target any one particular species with great success except under extenuating circumstances. Dredging at any level must be permitted by the WDNR if done through mechanical means. Manual dredging of up to 100 cubic feet for may be done without a permit by property owners if all criteria found in the WDNR's exemption checklist (WDNR, Waterway protection Dredging 2016) are met. Dredging should not be performed for aquatic plant management alone. It is best used as a multipurpose lake remediation technique (Madsen, Advantages and disadvantages of aquatic plant management techniques 2000).

Dredging is not a recommended management action for Moon Lake, unless it is needed at the public boat landing to enable the launch of a small aquatic plant harvester.

DRAWDOWN

Drawdown, like dredging, alters the plant environment by removing all water in a water body to a certain depth, exposing bottom sediments to seasonal changes including temperature and precipitation. A winter drawdown is a low cost and effective management tool for the long-term control of certain susceptible species of nuisance aquatic plants. A winter drawdown controls susceptible aquatic plants by dewatering a portion of the lake bottom over the winter, and subsequently exposing vascular plants to the combined effect of freezing and desiccation (drying). The effectiveness of drawdown to control plants hinges on the combined effect of the freezing and drying. If freezing and dry conditions are not sustained for 4-6 weeks, the effectiveness of the drawdown may be diminished.

It is not possible to draw down Moon Lake as there are no outlets to manipulate the water level.

BIOLOGICAL CONTROL

Biological control involves using one plant, animal, or pathogen as a means to control a target species in the same environment. The goal of biological control is to weaken, reduce the spread, or eliminate the unwanted population so that native or more desirable populations can make a comeback. Care must be taken however, to insure that the control species does not become as big a problem as the one that is being controlled. A special permit is required in Wisconsin before any biological control measure can be introduced into a new area.

TYPES OF BIOLOGICAL CONTROLS

There are several forms of biological control being used or researched. Currently the most commonly used biological controls are milfoil weevils for the control of EWM and *Galerucella* beetles (*G. calmariensis and G. pusilla*) for the control of purple loosestrife. It was thought at one time that the introduction of plant eating carp could be successful in controlling invasive plants. It has since been shown that these carp can have a severe negative impact on the lake's ecosystem. These fish they can wipe out almost all of the plants in the lakes they inhabit resulting in a ripple effect that disrupts and damages the entire lake system. Use of "grass carp" as they are referred to in Wisconsin is illegal as there are many other environmental concerns including what happens once the target species is destroyed, removal of the carp from the system, impacts to other fish and aquatic plants, and preventing escapees into other lakes and rivers. Several pathogens or fungi are currently being researched that when introduced by themselves or in combination with herbicide application can effectively control EWM and lower the concentration of chemical used or the time of exposure necessary to kill the plant (Sorsa, Nordheim and Andrews 1988). None of these have currently been approved for use in Wisconsin and are not recommended for use in Moon Lake.

NATIVE PLANT RESTORATION

A healthy population of native plants might slow or prevent invasion of non-native aquatic plants. While the goal of this plan is to remove some of the over abundant native vegetation in Moon Lake, it is important to maintain some areas of healthy, undisturbed aquatic plants. Native plant restoration efforts are not needed in Moon Lake at this time because there is a large community of native plants.

CHEMICAL CONTROL

Aquatic herbicides are granules or liquid chemicals specifically formulated for use in water to kill plants or cease plant growth. Herbicides approved for aquatic use by the U.S. Environmental Protection Agency (EPA) are considered compatible with the aquatic environment when used according to label directions. Some individual states, including Wisconsin, also impose additional constraints on herbicide use.

The Wisconsin Department of Natural Resources evaluates the benefits of using a particular chemical at a specific site vs. the risk to non-target organisms, including threatened or endangered species, and may stop or limit treatments to protect them. The Department frequently places conditions on a permit to require that a minimal amount of herbicide is needed and to reduce potential non-target effects, in accordance with best management practices for the species being controlled. For example, certain herbicide treatments are required by permit conditions to be in spring because they are more effective, require less herbicide and reduce harm to native plant species. Spring treatments also means that, in most cases, the herbicide will be degraded by the time peak recreation on the water starts. Chemical treatment as a means of controlling native plants is legal in Wisconsin, but not generally permitted by the WDNR except in extreme cases.

Chemical treatment of native plants is not recommended as a management option for Moon Lake.

The most recent point-intercept aquatic plant survey on Moon Lake (Hatleli 2014)confirmed what property owners and lake users have known for some time; summer aquatic plant growth in the lake dominates nearly 100% of the 84-acre surface area of the lake (Figure 30) severely limiting recreational use of the lake and providing less than desirable habitat for fish (likely causing winter fishkills that have just about wiped out the entire fish population). Even quiet sports like kayaking and canoeing are somewhat limited due to dense aquatic plant growth. Moon Lake has not always been like it is right now.

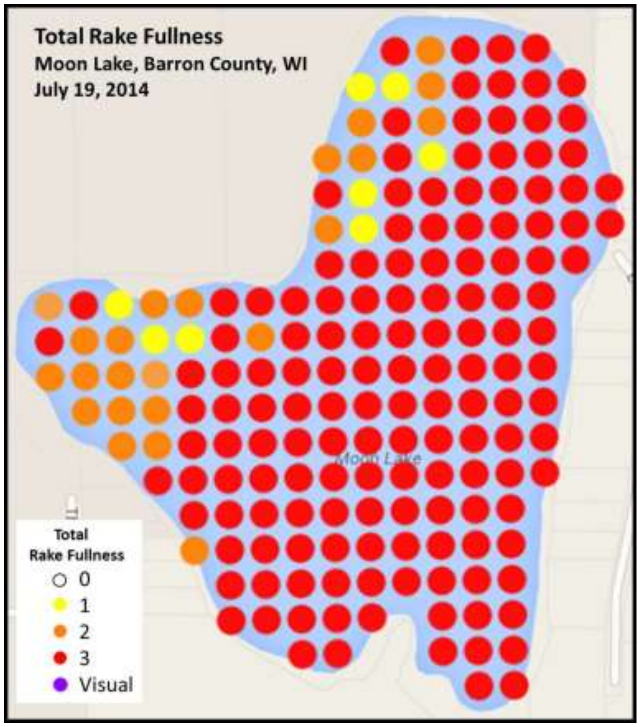


Figure 30 – 2014 Total Rake Fullness Values for all Point-intercept Survey Points (Hatleli 2014)

It is difficult to pinpoint the exact cause of the drastic increase in aquatic plant abundance in Moon Lake over the past 10-15 years. It is likely a combination of factors such as change in land use that lead to nutrient increase in the lake and drought conditions. Between 2003 and 2013, data collected from the Rice Lake area revealed a cumulative rainfall shortage of 51.5 inches when compared to the annual average. In other words, there has been rainfall shortage of 5 inches, on average, every year between 2003 and 2013. The combined impacts of higher nutrient levels and less lake volume could have pushed Moon Lake past a threshold for what is considered an acceptable amount of vegetation for recreation (Hatleli, 2014). This is unfortunate particularly since a large portion of the shoreline borders the very popular Moon Lake Park in Rice Lake, WI (Figure 31). This community park is located on the northwest shore of Moon Lake and offers amenities like soccer and softball fields, a skate park, a splash pad, shelters, ADA compliant restrooms, a picnic shelter, and 0.61 miles of paved hiking trails along the lake. At the present time, the connection between this park and recreational possibilities that Moon Lake could offer is not being realized.

Figure 31 – Moon Lake Park in Rice Lake, WI on the northwest shore of Moon Lake (City of Rice Lake 2016)

Moon is a great lake for viewing wildlife including ducks, geese, cranes, muskrats, marsh birds, and deer. It could be more recreationally friendly serving as a local kayaking destination (particularly if navigation impairment caused by dense growth aquatic vegetation was reduced); a shore and small craft fishing destination (if a better dock and aeration system was installed off the park); a better fishing lake (if the fish population was restored and maintained); and a terrific location to watch wildlife (if a viewing platform was created). All of these uses would benefit the community of Rice Lake, property owners on the lake, and lake users in general and could be met.

AQUATIC PLANT HARVESTING

Given that there are currently no AIS in Moon Lake, mid-summer navigation and lake use issues are caused by excessive native aquatic plant growth, primarily watershield and spiny hornwort. A harvesting plan will be created annually and will be used as the basis for completing a Mechanical/Manual Aquatic Plant Control Application required by the WDNR (Appendix C).

Harvesting plans will be designed to enhance both the ecological balance and recreational uses of the lake by establishing a "common use navigation channel" around the outside of the lake; "riparian access lanes" from the shore to open water; and an "open water navigation area" in the center of the lake. A common use navigation channel is a common navigation route created for the general lake user. It is 10-ft wide and circles the lake in water at least 3-ft deep to provide a small craft lane for private and public benefit. Riparian access lanes that are 10-ft wide provide access to the common use navigation channel and open water from Moon Lake Park, the public boat landing, and property owners around the lake. The open water navigation area is in deeper water (5-7 feet) and covers approximately 1/3 of the surface area of the lake. Aquatic vegetation in this area will be harvested to a depth of about 3-ft at least once a season. This area creates a weed line for improved fishing, reduces competition from several dominant plant species, creates more opportunity for boating, and a keeps Moon Lake looking like a lake with at least some open water. Once harvested, these areas should be kept open and even expanded through regular use of watercraft. If the navigation channels or access lanes fill in again, they can be re-cut in the same year under the same harvesting permit that allowed the initial cutting (Figure 32). However, if a harvested area fills in due to lack of use after initial harvesting, it will likely not be harvested again in the same season.

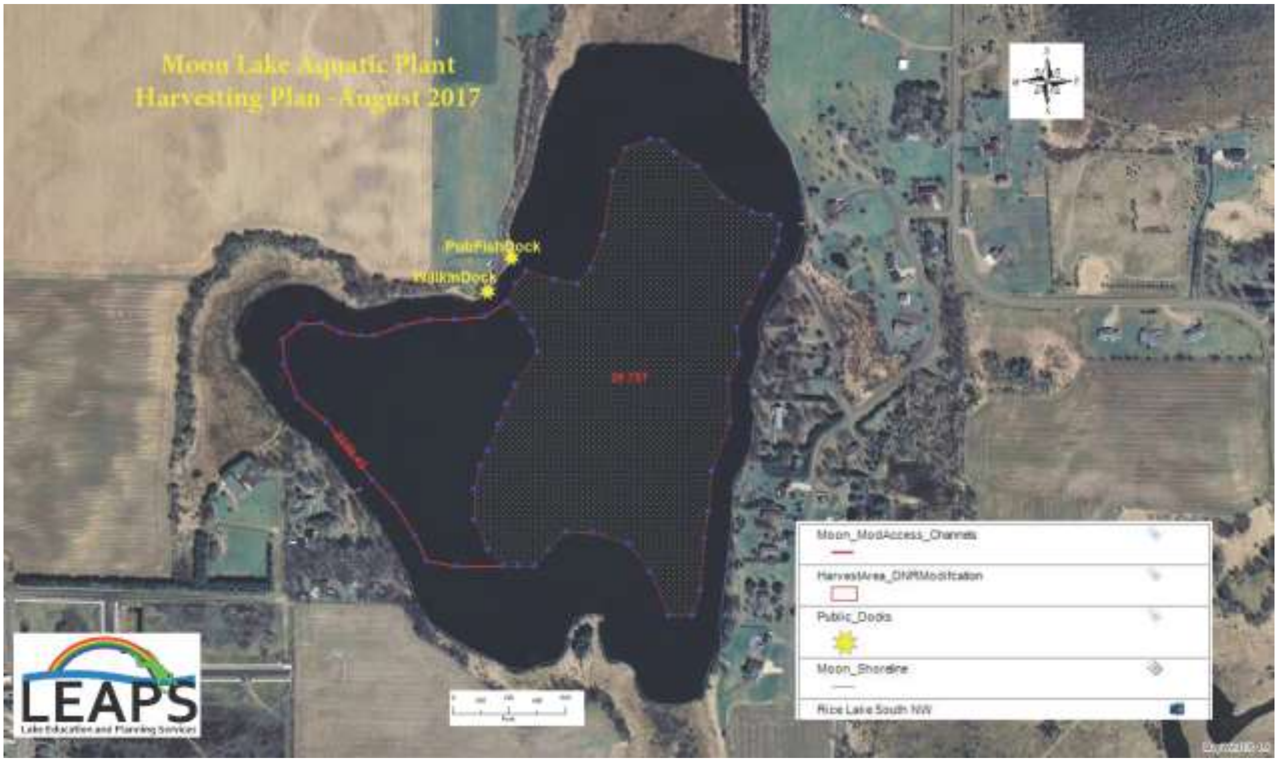


Figure 32 – Moon Lake Proposed Aquatic Plant Harvesting Map (LEAPS, Aug.2017)

Mechanical harvesting of aquatic plants will only be completed in water 3-ft or greater in depth. Harvesting in waters shallower than this can greatly disturb bottom sediments causing them to be re-suspended in the water column decreasing water quality. Bottom dwelling biota critical to the health of the lake can also be negatively impacted. Damage to the harvester may also occur. In waters at or deeper than 3-ft, aquatic plants can be cut to the maximum depth of the harvester or two-thirds of the water column, whichever is less. At off-loading sites, the operator will attempt to return game fish, turtles, and other wildlife back to the water. Plant survey work in 2014 documented nearly 100% coverage of the 84-acre surface area of the lake. In an effort to protect the existing health of the lake, harvesting of the navigation channel, riparian access lanes, and open water navigation area will not exceed one-third (28 acres) of the total surface area of the lake. This acreage does not include areas where aquatic vegetation is managed by physical means.

Having a plan to dispose of the vegetation harvested it extremely important for the success of a harvesting program. Contracted services are much less expensive if the contractor does not have to dispose of the vegetation as a part of the project. A portion of Moon Lake is within the boundaries of the RL-LPRD who operates a large harvesting program on Rice Lake. The MLA has approached the RL-LPRD about using their truck and claw to pick up vegetation temporarily piled near the public access site after harvest and take it to their dump site in the Town of Oak Grove and they are open to this idea.

Clear-cutting of aquatic vegetation adjacent to riparian shoreline for the purpose of creating weed free areas for swimming or other recreational purposes is not an acceptable use of the mechanical harvester and is not recommended. Landowners, however, are not prohibited from physically removing aquatic vegetation in these areas, provided guidelines presented in NR 109 are followed.

The harvesting plan will be assessed annually to determine if changes should be made. Areas designated for harvesting in a given year, can be repeatedly harvested as needed in that year to maintain their function without the need for additional WDNR permitting or fees. An example harvesting plan is included in Appendix D. Changes in the harvesting plan can be requested by property owners, and will be evaluated on an individual case basis as they come up. Larger changes in the harvesting plan may be necessary due to variability in water levels, changes in lake use patterns, or with the introduction of new AIS.

Prior to 2017, contracted aquatic plant harvesting services were not available in northwestern WI. However a new company out of Chippewa Falls, WI has just added two small 5-ft aquatic plant harvesters, each with a maximum holding capacity of 220 cubic feet of harvested vegetation (Figure 33). Both of these units are on trailers and able to be taken to different lakes without special transportation requirements. At the present time, the company is expecting to charge around $300.00/hr. of harvesting time if hauling away of vegetation is not necessary. This amounts to around $250.00 to $450.00 per acre of aquatic vegetation harvested. The current harvesting plan for Moon Lake includes 28 acres of harvesting which would have an estimated cost of $7,000.00 to $12,600.00 annually for one cutting.

Figure 33 – Aquarius Systems EH-220 Aquatic Plant Harvester with a 5-ft cutting blade and 210 cu.ft cut material storage

AQUATIC PLANT SURVEYING

Harvesting aquatic plants from up to 1/3 of the lakes surface area will have an impact on the aquatic vegetation in the lake. In 2014, 31 different species of aquatic plants were identified in Moon Lake during a summer survey. Of these, only four species are likely to be impacted by the harvesting program proposed. Watershield, Spiny hornwort, Leafy pondweed, and White waterlily are present in any abundance within the larger "open water navigation area" proposed for harvesting (Figure 34). Watershield, Spiny hornwort, and Leafy pondweed are the most abundant aquatic plants in the lake, together accounting for 64.2% of the total relative frequency of aquatic plants in the lake. A combined relative frequency of >50% suggests a somewhat homogeneous plant community because these three plant species dominate. Reducing the relative frequency of these three species may make the habitat more suitable for species like Large-leaf pondweed, Illinois pondweed, Stiff pondweed, Slender waterweed, Nitella, and Common waterweed that are only marginally present in the deeper water (Figure 35).

Aquatic plant management actions should not negatively impact the overall health of the aquatic plant community in Moon Lake. Measurements of plant community health including Species Richness, Simpson's Diversity Index (SDI), and the Floristic Quality Index (FQI)will be should not be negatively impacted. Species richness is the total number of species found on the rake at all sites including visual observations within 6 feet of the sample sight and boat survey, but not including moss, sponges, algae, or liverworts. The SDI estimates the heterogeneity of a plant community by calculating the probability that two individuals randomly selected from the data set will be different species. The index ranges from 0-1, and the closer the value is to one, the more diverse the community. The FQI estimates how similar the aquatic plant community is to one that is undisturbed by human influences (Nichols 1999). This index only factors species raked at survey points and does not include non-native species.

After five years of active management, the entire aquatic plant community in the lake will again be surveyed, repeating what was done in 2014. Annual impacts of harvesting will be tracked by identifying what species are harvested the first time each season. Then an estimate of the percent of the total harvested vegetation each identified plant species represents will be made. A visual survey within the larger "open water navigation area" will be completed each season a few weeks after the first harvesting of the area has been completed and the plants present identified. These observations will be made by trained lake volunteers and/or resource professional retained by the MLA.

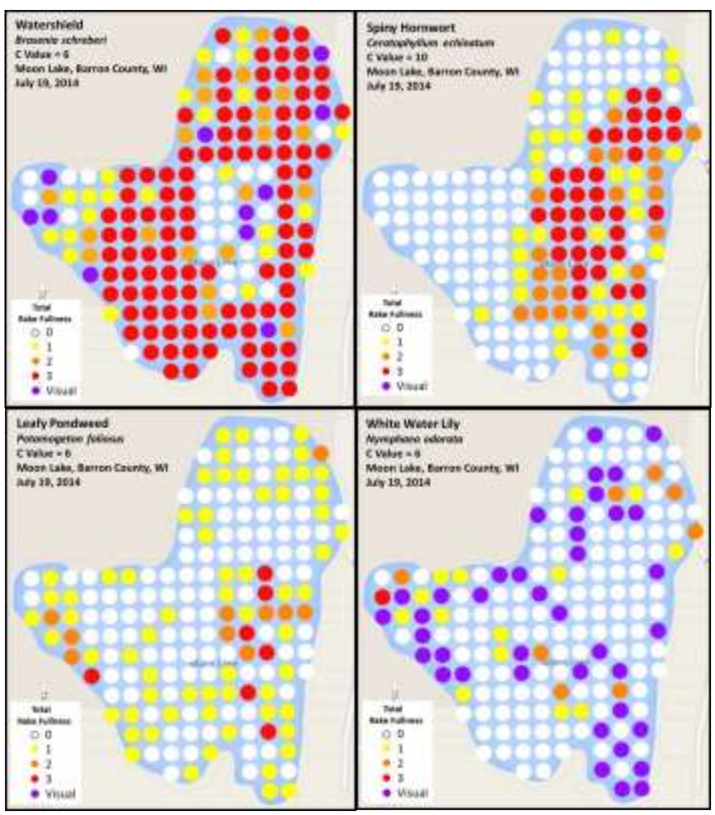


Figure 34 – Aquatic Plant Species most likely to be negatively impacted by a harvesting program (Hatleli 2014)

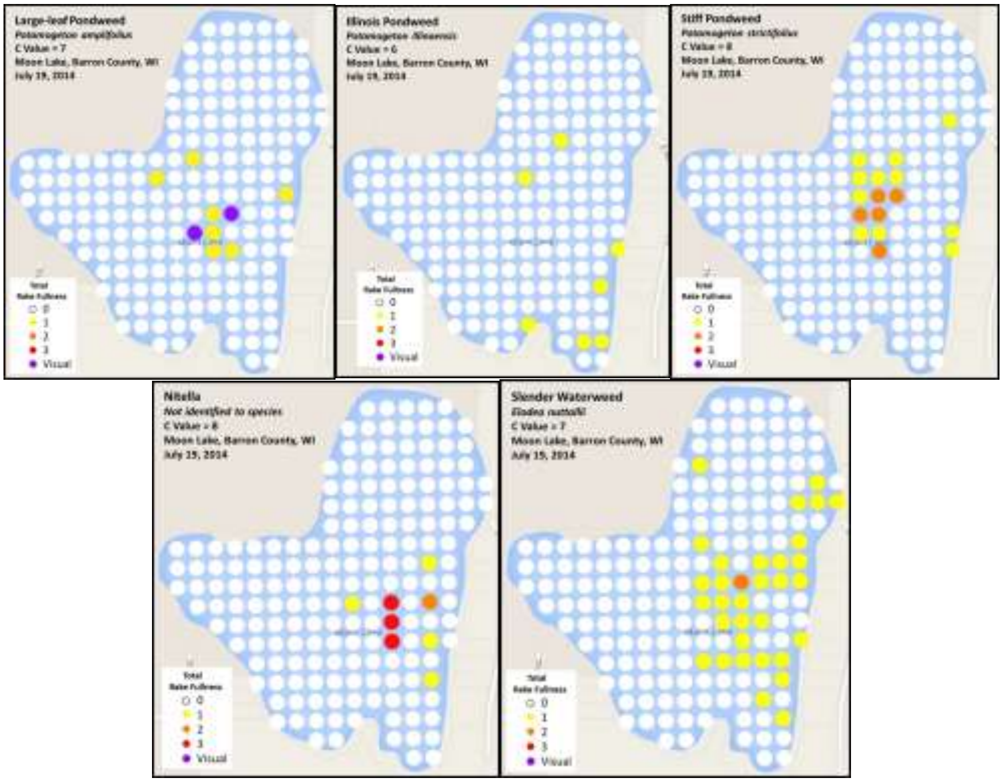


Figure 35 – Aquatic Plant Species that may increase as a result of a harvesting program (Hatleli 2014)

AIS MONITORING

With contracted harvesting, there is an increased risk of aquatic plant species not currently in Moon Lake being introduced. Of most concern would be AIS like CLP and EWM. Also, with improved access to the lake and more recreational activities made available through management implementation, there is greater risk that general lake users will bring unwanted aquatic plant and/or animal species into the lake. As such, AIS Education, Prevention, and Planning including a watercraft inspection program through Clean Boats, Clean Waters; and an AIS monitoring program through the CLMN AIS Monitoring program will be implemented if any aquatic plant harvesting is planned and implemented.

AERATION

Before re-stocking Moon Lake, aeration should again be considered. Aerating the lake requires many other actions be taken. A very important part of any aeration project is the placement and maintenance of a barricade around the open water created by the aeration system. Wisconsin Statute 167.26 states that "Any person creating ice holes by aeration of water, may, in lieu of the requirements of sub (1), erect and maintain a barricade around such holes consisting of uprights spaced every 25 feet or less, connected by a continuous rope, cord or similar material placed 3 ½ feet off the surface of the ice. The connecting rope, and/or similar material shall have reflector ribbon or tape attached to it, so as to be highly visible, and shall be of sufficient strength to permit retrieval of the barricade following melting of ice. Any person erecting such a barricade shall remove the barricade and all parts thereof from the ice or water immediately after the ice has melted. (3) Persons barricading ice holes in the manner specified in this section shall not be liable for damages suffered by persons who enter within the barricaded area."

Before installing an aerator again, a discussion should be had with the WDNR about installing a permanent compressed air aeration system in shallow water on Moon Lake, instead of a surface aspirating system. A compressed air system consists of one or more air compressors housed in a shelter on the shoreline, which push air through two or more air lines which extend along the lake bottom to a portion of the lake that can be reached in 400 feet or less (Figure 36). Air is released from the end of the air lines into the water where it bubbles up through the water column to the surface. This action creates a current which causes warmer water near the lake bottom to rise to the surface, creating an ice-free area which allows water to be re-oxygenated. This aeration system may need to be operated throughout the winter months, from December into March. Most compressed air aeration systems are not powerful enough to increase dissolved oxygen levels, or even hold them steady, but they slow the rate of decline so that adequate dissolved oxygen (greater than 2.0 ppm in the upper five to ten feet of water) is still available in late winter. By installing this system in shallow verses the deepest water, super cooling may be avoided in the future. It could also be run during the summer months and into fall to make sure oxygen levels are as good as they can be going into ice-on.

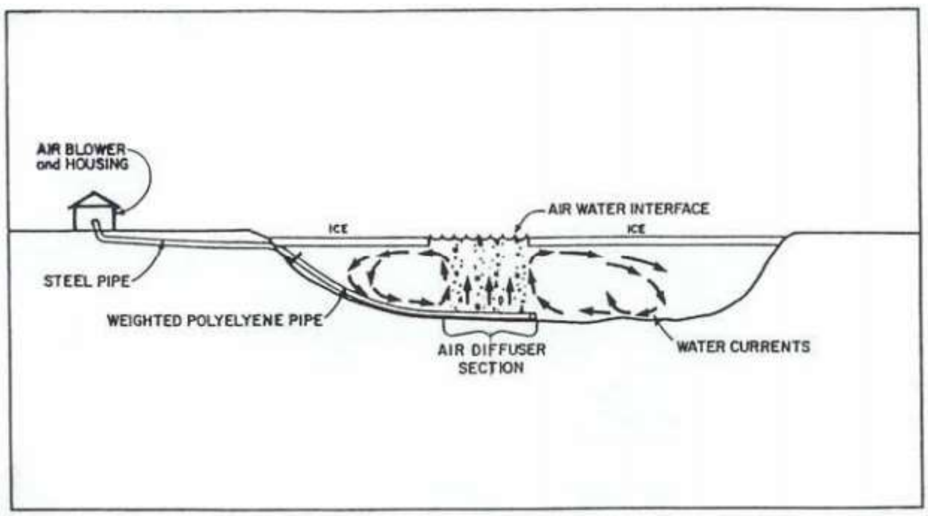


Figure 36 – Compressed air aeration system (Cornelius 2006)

A single aeration unit consists of a ¾-hp or 1-hp oil-less vane compressor, a two-valve outlet, a muffler system, and two air lines each consisting of ¾ inch weighted heavy duty polyethylene tubing. Pre-weighted polyethylene tubing is available, but regular heavy duty polyethylene tubing weighted with ½ inch by 20 foot reinforcing rod placed end to end works well and is more cost-effective. In 2006, the cost of one ¾-hp aeration unit was approximately $1,150.00, and the cost of operation of one ¾-hp unit was about $30.00 to $50.00 per month in electricity. Ceramic diffusers are available which can be placed at the ends of the airlines to create smaller bubbles and thereby increase the aerators efficiency. However, the diffusers are a maintenance problem in that the micropores become clogged, and satisfactory results have been obtained simply by capping the ends of the airlines and drilling several 1/8 inch holes into the last several feet of tubing (Cornelius 2006).

It would be expected that the City would support the building of a small shed to house the aerator (Figure 37). The same building could include public bathrooms, a picnic shelter, and even an observation deck on the top. By installing a public fishing pier and kayaking dock, Moon Lake could become a much more valuable recreational resource for the City. Much of the infrastructure to see this vision for Moon Lake and Moon Lake Park come to fruition could be funded by a WDNR Recreational Boating Facilities grant.

1

Figure 37 – Public Restroom – Hillsboro, Oregon (left); Observation desk on a small outbuilding (right) (FontanaLakeNC.com)

FISH STOCKING

Once aquatic plant management and aeration has been implemented in Moon Lake, the MLA and the WDNR need discuss re-stocking the lake. In the past, Moon Lake has supported stocking northern pike and largemouth bass in the lake. It may be necessary to stock panfish as well. Comments made by property owners on the lake in the last couple of years suggest there may be a very limited number of fish in the lake at the present time. Harvesting excess vegetation in the summer and implementing the plowing of snow lanes and opening of ice-fishing holes in the winter may improve conditions while working through the re-installation of an aeration system in cooperation with the City.

WATER QUALITY MONITORING

The success of an aquatic plant harvesting program and a re-stocking of the fishery hinges on what happens with water quality. It is possible that harvesting too many aquatic plants could trip a forward switch to an algae dominated system verses an aquatic plant dominated system. As this is not a desirable outcome, extensive water quality monitoring including total phosphorus, chlorophyll a, and dissolved oxygen throughout the year including through the ice in winter is necessary.

INSTALLATION OF A PUBLIC DOCK AT MOON LAKE PARK

Although not a requirement of this plan, the installation of a public fishing pier (Figure 38) off the southern most point of Moon Lake Park into Moon Lake would increase the recreational opportunities provided by Moon Lake to park goers. The same dock, or another much smaller dock could be installed near the public fishing pier to serve kayakers and other small craft users. A navigation channel approximately 1.4 miles long is a part of the aquatic plant harvesting plan being proposed for Moon Lake. This navigation channel would be 10-ft wide and circumvent the entire distance of shoreline on the lake, providing an outstanding place for kayakers and other small craft to see wildlife and the beauty of the lake. Aquatic plant harvesting in Moon Lake would keep this navigation channel open throughout the warm water season.

Figure 38 – Public fishing dock installed at Veterans Landing on Rice Lake (City of Rice Lake 2016)

SHORELAND EVALUATION AND IMPROVEMENT

The WDNR has a new Lake Shoreland and Shallows Habitat Monitoring Field Protocol (Appendix E) that involves the evaluation of a 35-ft buffer area around the entire lake, documents shoreland condition through digital photography, and documents coarse woody debris in a lake. Additional information about the condition of the shoreland around Moon Lake would benefit future shoreland improvement planning and implementation through the WDNR Healthy Lakes Initiative and BMP grant program. The RL-LPRD also has a shoreland improvement program. Both programs offer funding support to install shoreland BMPs. It is recommended that a shoreland survey be completed on Moon Lake following the new WDNR protocol during the time frame covered by this APMP.

AQUATIC PLANT MANAGEMENT GOALS, OBJECTIVES, AND ACTIONS (APPENDIX F)

Moon Lake supports an aquatic plant community with a number of high value species, but at the present time, does not support any significant fishery due to recent and severe winterkills. The lake does not have any aquatic invasive plant species other than reed canary grass and narrow-leaf cattails along parts of the shore. These invasive species will not be directly managed as a part of this APMP. Nuisance conditions and navigation impairment caused by dense native plant growth occur throughout the open water season over the entire surface water area of the lake. This APMP establishes the following eight goals for aquatic plant and other management planning, monitoring, and surveying; and for increasing the value of Moon Lake to the surrounding community, lake users, and property owners:

1. **Monitor and Maintain a Healthy Lake Plant Community**
2. **Manage Aquatic Plants to provide Greater Lake Use and Improve Habitat**
3. **Prevent the Introduction of new AIS**
4. **Monitor and Maintain Water Quality**
5. **Restore the Fish Community**
6. **Improve Public Recreational Access and Nature Immersion Opportunities for Community Members**
7. **Evaluate and Improve Shoreland**
8. **Implement Adaptive Management**.

Each of these goals has several management objectives and associated actions to be implemented over the next five years.

GOAL 1 - MAINTAIN A HEALTHY LAKE PLANT COMMUNITY

It is the goal of the management actions in this plan to maintain and protect the native aquatic plant community in Moon Lake, causing no decline in the following measures of a healthy, diverse, and sustainable aquatic plant community: Floristic Quality Index, Simpson's Diversity Index, and total species richness including visuals. Aquatic plant management actions will be completed in ways to minimize disruptive changes in the aquatic plant community in the lake.

OBJECTIVE 1: OVER THE COURSE OF THE NEXT FIVE YEARS (2017-21) THE FOLLOWING MEASURES OF A HEALTHY NATIVE AQUATIC PLANT COMMUNITY WILL BE MAINTAINED OR EXCEEDED:

Table 2: Values to Measure the Health of the Native Aquatic Plant Community in Moon Lake

All Plants	**2014**
Simpson's Diversity Index (SDI)	0.83
Floristic Quality Index (FQI)	26.73
Total Species Richness including boat survey	31

i. **Action Item**: Implement aquatic plant management actions that will minimize disruption of the native aquatic plant population and wildlife habitat.

   a. No more than one-third (1/3) of the surface area of the lake (28 acres) will be harvested in any single year.

   b. Harvesting depth in any location will not exceed two-thirds (2/3) of the depth of the water column.

   c. Harvesting will not be completed in water <3-ft deep.

ii. **Action Item**: Determine appropriate management actions annually based on management and survey results from the previous year.

   a. Representatives from the MLA and/or a resource professional retained by the MLA will use prior year management results and impacts identified by aquatic plant survey actions to propose current year management actions.

OBJECTIVE 2: MEASURE THE IMPACTS OF ANNUAL HARVESTING ON NATIVE AQUATIC PLANTS IN THE LAKE.

i. **Action Item**: During actual harvesting, trained MLA volunteers or a resource professional retained by the MLA will identify as many individual species as possible removed by the harvesting and estimate what percent of the total harvest each species represents.

ii. **Action Item**: Approximately three weeks after harvesting, trained MLA volunteers or a resource professional retained by the MLA will visually inspect the harvested area from a boat and identify the species present.

OBJECTIVE 3: MEASURE THE FIVE YEAR IMPACT OF AQUATIC PLANT MANAGEMENT COMPLETED ON MOON LAKE.

i. **Action Item**: Repeat a whole lake, point-intercept, aquatic plant survey in 2021 using the same points generated for the 2014 survey.

ii. **Action Item**: Review and revise the existing APM Plan in 2012 for implementation in 2022.

GOAL 2 - MANAGE AQUATIC PLANTS TO PROVIDE GREATER LAKE USE AND IMPROVE HABITAT

Management of native aquatic plants to provide improved navigation, open water, and riparian access to open water is necessary in Moon Lake. By doing so, the lake will be made more valuable for fish and wildlife, provide the local community with an opportunity to experience and appreciate nature, and make the lake more usable for property owners and others to enjoy the lake. The best alternatives for completing this goal are manual removal and mechanical harvesting.

Using contracted mechanical harvesting to manage the aquatic plants in Moon Lake is recommended to provide greater access for fishing and boating, improve fishing and fish habitat, and to reduce build-up of organic materials in the lake which may in time reduce the number and severity of winter fish kills.

Manual or physical removal is the recommended method to control plant growth around docks and in areas where the water depth is shallower than 3 feet. For aquatic plant control in small, shallow lake areas adjacent to shore, it is recommended that plant removal rakes and/or razors be used by riparian property owners. As mentioned in a previous section, physical removal of aquatic plants is allowable without a permit within an area up to 30-ft wide near a dock or along a shoreline used for recreational activities, provided the parts of the plant cut or pulled are removed completely from the water and disposed of properly. By its very nature, physical removal is often a difficult and daunting task, thus minimizing how much plant material is actually removed. Native plant removal should be limited only to the amount needed to access open water areas or provide navigation and access lanes. Coarse woody habitat (tree falls, logs, etc.) should be left in the water as it is a critical feature of lakes influencing fish behavior, spawning, predator-prey interactions, growth, and species diversity. Research has shown that the growth of largemouth bass and bluegill are positively correlated with coarse woody habitat in lakes and a whole lake removal of coarse woody habitat led to the collapse of a yellow perch population (Radomski and Goeman 2001).

OBJECTIVE 1: ESTABLISH A COMMON USE NAVIGATION CHANNEL AROUND THE PERIMETER OF THE LAKE.

i. **Action Item**: Through contracted harvesting services, a common use navigation channel approximately 0.45 miles long and 10-ft wide may be harvested and maintained around the perimeter of the lake.

    a. The navigation channel will not be harvested prior to June 15th annually

    b. The navigation channel may be harvested at a depth of up to 2-ft and will not be harvested in water less than 3-ft deep

    c. The navigation channel may be harvested more than once during a season

OBJECTIVE 2: ESTABLISH AN OPEN WATER NAVIGATION AREA IN THE CENTER OF MOON LAKE

i. **Action Item**: Through contracted harvesting services, an open water navigation area of approximately 28 acres in water 5-7 feet deep may be harvested and maintained in the center of the lake.

    a. The open water navigation area will not be harvested prior to June 15th annually.

    b. The open water area may be harvested at a depth of up to 3.5-ft.

    c. The open water area may be harvested more than once during a season.

OBJECTIVE 3: ESTABLISH RIPARIAN ACCESS LANES FROM PUBLIC ACCESS POINTS AND PROPERTY OWNERS ON MOON LAKE

i. **Action Item**: Through contracted harvesting services, riparian access lanes may be harvested and maintained to allow access to lake property owners and users to the navigation channel and open water.

a. Riparian access lanes will not be harvested prior to June 15th annually.

b. Riparian access lanes will not be harvested in water <3-ft deep.

c. Riparian access lanes may be harvested more than once during a season.

OBJECTIVE 4: WORK WITH THE RICE LAKE – LAKE PROTECTION AND REHABILITATION DISTRICT AND TOWN OF RICE LAKE TO DUMP, PICK UP, AND DISPOSE OF HARVESTED AQUATIC VEGETATION FROM MOON LAKE

i. **Action Item**: Establish a partnership where the RL-LPRD uses its equipment to pick up harvested vegetation from the Moon Lake public access and dispose of it at their dumping location.

a. Harvested aquatic vegetation will be temporarily unloaded at the Moon Lake public access maintained by the Town of Rice Lake and removed within 3-days by the RL-LPRD.

b. Harvested aquatic vegetation will be discarded by the RL-LPRD at their dump site in the Town of Oakland.

OBJECTIVE 4: PREPARE WNDR HARVESTING PERMIT APPLICATIONS TO SUPPORT ANNUAL HARVESTING OF AQUATIC VEGETATION IN MOON LAKE.

i. **Action Item**: The MLA representatives or a resource professional retained by the MLA will complete WDNR Mechanical/Manual Aquatic Plant Control Application (Form 3200-113) annually based on a mechanical harvesting proposal prepared in February or March.

OBJECTIVE 5: COMPLETE PHYSICAL REMOVAL OF AQUATIC PLANTS IN WATERS <3-FT DEEP AND ADJACENT TO PRIVATE PROPERTY.

i. **Action Item**: Property owners on Moon Lake will use physical removal methods to open areas of dense vegetation near docks and adjacent to their property in so much as to gain access to the harvested riparian access lanes and navigation channel.

GOAL 3 – WORK TO PREVENT THE INTRODUCTION OF NEW AIS

AIS can be transported via a number of vectors, but most invasions are associated with human activity. One of the highest risk activities is implementing contracted aquatic plant harvesting on the lake. Harvesters owned by a private contractor are undoubtedly being used to harvest AIS and native aquatic vegetation in the same season. Of particular concern is CLP. Mechanical harvesting of CLP is one of the most accepted forms of AIS management. CLP is an early season aquatic plant so will be harvested before any harvesting of natives plants is completed. CLP fragments and turions (Figure 24) can easily become lodged in the many nooks and crannies of a harvester. It is less likely that EWM will be carried in by contracted harvesting services since harvesting of EWM is not a readily acceptable management action for control of EWM, but it is possible. It is recommended that the harvester brought in by a contractor be inspected for prior harvesting remains by trained MLA volunteers and/or a resource professional retained by the MLA before being launched into the lake

It is recommended that the MLA implement an AIS monitoring program. At least three times during the open water season, trained volunteers should patrol the lake and shoreline looking for CLP, EWM, purple loosestrife, Japanese knotweed, giant reed grass, zebra mussels, and other invasive species. Free support for this kind of monitoring program is provided as a part of the UW-Extension Lakes/WDNR Citizen Lake Monitoring Network (CLMN) AIS Monitoring Program. Any monitoring data collected should be recorded annually and submitted to the WDNR SWIMS database.

It is further recommended that monitoring of the boat launch on Moon Lake be completed by volunteer and/or paid inspectors following WDNR/UW-Extension Clean Boats, Clean Waters guidelines. All watercraft inspection data collected should be submitted to the WDNR SWIMS database. It is recommended that the MLA participate in the June Drain Campaign and Fourth of July Landing Blitz, two state-wide outreach efforts to remind boaters to drain all water from their boats, livewells, and motors; and to highlight the dangers of transporting invasive species that takes place on the Fourth of July, a high-boat traffic day. It is also recommended that the MLA continue to maintain and update signage at the boat launch as necessary.

It is also recommended that all property owners be encouraged to learn about AIS and monitor their shoreline and open water areas for new AIS. Table 3 shows the life stage of some invasive plant and animal species and the best times of the open water season to monitor for them (Scholl 2006). If a suspect AIS is found, or even suspected, it should be reported to the MLA, County, and WDNR resource personnel.

Table 3: AIS Monitoring Timetable (Scholl 2006)

	April	May	June	July	August	Septemb
Eurasian watermilfoil						
Sprout						
Growth						
Bloom						
Die Back						
Curly-leaf pondweed						
Sprout	→					
Growth	→					
Bloom						
Die Back						
Purple Loosestrife						
Sprout						
Growth						
Bloom						
Die Back						
Zebra						
Rusty						
Spiny water						

OBJECTIVE 1 – REDUCE THE CHANCE THAT A NEW AIS IS INTRODUCED INTO MOON LAKE BY AQUATIC PLANT HARVESTING ACTIVITIES.

i. **Action Item**: Inspect all harvesting equipment brought to the lake by a contractor prior to it being launched into the lake.

a. Ask the contractor for a list of the lakes and aquatic plants harvested in the same year as MLA contracts.

b. Ask and confirm the contractor's harvester cleaning and disinfection protocol between jobs.

c. Ask for a signed document from the contractor that the harvesting equipment has been cleaned and inspected prior to completing the job.

OBJECTIVE 2 - REDUCE THE LIKELIHOOD THAT NEW AIS GOES UNDETECTED IN MOON LAKE.

i. **Action Item**: Participate in and complete AIS monitoring actions through the Citizen Lake Monitoring Network (CLMN) AIS Monitoring Program.

a. MLA volunteers or a resource professional retained by the MLA will complete AIS monitoring of the lake and shoreline at least three times each open water season following CLMN AIS Monitoring Guidelines.

b. AIS monitoring data will be entered into the WDNR SWIMS database annually.

OBJECTIVE 3 - IMPLEMENT A CLEAN BOATS CLEAN WATERS (CBCW) WATER CRAFT INSPECTION PROGRAM ANNUALLY.

i. **Action Item**: Determine an appropriate amount of watercraft inspection time at the Moon Lake public access to prevent introduction of AIS through transient boaters.

a. Participate in the WDNR June Drain Campaign and 4th of July landing Blitz annually.

b. Install updated AIS education signs at the Moon Lake public access and at the Walk-in Access from Moon Lake Park.

OBJECTIVE 4 – EDUCATE AND INFORM PROPERTY OWNERS AND LAKE USERS ABOUT AIS AND HOW TO IDENTIFY THEM

i. **Action Item:** Seek out AIS education events sponsored by other entities and/or sponsor AIS education events and then encourage property owners on Moon Lake to attend.

ii. **Action Item**: Research AIS and lake stewardship materials with little or no cost to attain and distribute to property owners at events including but not limited to Annual Meetings, Lake Fairs, Summer Picnic, etc.

iii. **Action Item**: Report findings of suspect AIS to the MLA, Barron County, WDNR, and other Resource entities.

GOAL 4 - MONITOR AND MAINTAIN WATER QUALITY

At the present time, Moon Lake is a plant dominated and fairly fertile body of water. The level of phosphorus in the lake is bordering on eutrophic or nutrient rich. Chlorophyll a, which is a measurement of the amount of algae in the water, is at present pretty low indicating that abundant aquatic plant growth, stimulated by clear water is using up a majority of the available phosphorus before it can be used by algae. By removing a substantial amount of aquatic vegetation, there is a risk that the harvesting could trigger a forward switch causing the lake to shift from plant dominance and clear water to algae dominance and green water. This is not an acceptable outcome for this project, so extensive water quality monitoring is necessary to track changes in water quality before they become irreversible. In addition, it is expected that aquatic plant harvesting and other actions implemented through this APMP will maintain or improve adequate dissolved oxygen (DO) levels in the lake throughout the year, but particularly under the ice. Winter monitoring of nutrients and oxygen is highly recommended if any management is to occur.

OBJECTIVE 1 – MONITORING WATER CLARITY AND NUTRIENT LEVELS (TOTAL PHOSPHORUS & CHLOROPHYLL A) IN MOON LAKE ANNUALLY

i. **Action Item**: Continue involvement in the WDNR/UWEX-Lakes CLMN Water Quality Monitoring Program at the Center location in Moon Lake.

   a. Collect Secchi Disk readings of water clarity and temperature at least monthly May through October.

   b. Make a request to the CLMN Program to move Moon Lake into the Expanded Monitoring program which collects monthly total phosphorus samples from May to August; and monthly chlorophyll a samples from June to August.

OBJECTIVE 2 – COLLECT DISSOLVED OXYGEN AND TEMPERATURE PROFILES MONTHLY THROUGH THE ENTIRE YEAR

i. **Action Item**: Either through the CLMN Program or another program, DO profiles should be collected at least monthly through the entire year (Jan.-Dec.)

ii. **Action Item**: When resources are available, increase total phosphorus and chlorophyll a sampling to include September and October.

GOAL 5 - RESTORE THE FISH COMMUNITY

Despite having an aeration system operating in the lake, a severe winterkill over the 2013-14 winter season nearly wiped out the entire fish population in Moon Lake. To date, the fish population in Moon Lake has not recovered. It is thought that the winterkill was caused by super cooling of the lake water in the winter. Super cooling occurs when warm bottom water in a shallow lake is mixed too rapidly with colder surface water just under the ice, creating undue stress on the existing fish population. The super cooling in Moon Lake may have been caused by the surface aspirating aeration system that was operated in the lake. Along with low oxygen levels to begin with, this undue stress weakened and killed the fish. There may be ways to maintain or improve oxygen levels under the ice that would reduce the potential for super cooling and/or low DO. Heavy snow cover that lasts well into the spring limits production of DO by aquatic plant alive under the ice. Plowing snow-free lanes on the surface of the ice can increase the amount of sunlight that gets to the plants under the ice. Lots of ice fishing holes can be drilled in the ice to increase the transfer of oxygen in the air to the water. Removal of aquatic plants can reduce the amount of vegetation that dies and decays under the ice using up available DO.

Aeration can again be installed, but a different system which may reduce the likelihood of super cooling could be used. A compressed air system is often installed in shallow lakes and operated continuously, year round. By operating the aerator in the late summer and fall, it may be possible to increase DO levels in the water before it freezes over. By installing the aerator in shallow water, and only operating it when it is shown that DO levels are falling, it may be possible to reduce the chance of super cooling.

Once aquatic plant harvesting has been implemented and aeration re-installed, re-stocking Moon Lake to restore its former warm water fishery of bass, panfish, and northern pike can be completed. Restoring the fish population in the lake will increase the recreational value of the lake for property owners, community members and other lake users.

OBJECTIVE 1 – IMPLEMENT MANAGEMENT ACTIONS THAT MAY MAINTAIN OR IMPROVE DISSOLVED OXYGEN LEVELS IN THE LAKE THROUGHOUT THE SEASON

i. **Action Item**: Implement aquatic plant harvesting actions in Goal 2

ii. **Action Item**: Plow snow-free lanes across the frozen surface of Moon Lake

   a. Work with property owners on Moon Lake to identify a volunteer or a contractor who could plow snow-free lanes on the ice once it is strong enough to drive on

iii. **Action Item**: Drill lots of holes through the ice when DO levels start to fall under the ice

   a. When DO monitoring under the ice shows DO levels starting to drop, encourage property owners and lake users to drill as many ice fishing holes as they can until ice conditions prevent access.

OBJECTIVE 2 – RE-INSTALL AN AERATION SYSTEM IN MOON LAKE

i. **Action Item**: Work with the WDNR and City to determine logistics for re-installation of an aeration system.

   a. Determine the type and location of aeration to install, surface aspirating vs. compressed air

   b. Determine support from the City and WDNR grant programs (Recreational Boating Facilities and/or Sport Fish Restoration) for making improvements to Moon Lake Park that would support an aeration system.

ii. **Action Item**: Install, operate, and maintain an Aeration System in Moon Lake

OBJECTIVE 3 – RE-STOCK MOON LAKE WITH FISH

i. **Action Item**: Work with the WDNR to determine an appropriate time to begin re-stocking fish into Moon Lake

   a. Discuss plans to complete aquatic plant harvesting and actions to improve DO including snow-free lanes, ice holes, and installation of an aeration system with the WDNR and how they impact the decision to re-stock the lake.

ii. **Action Item**: Discuss options for re-stocking the lake with the WDNR including species, size, and number to re-stock.

GOAL 6 - IMPROVE PUBLIC RECREATIONAL ACCESS AND NATURE IMMERSION OPPORUNITIES FOR COMMUNITY MEMBERS

In its Outdoor Recreation Plan, the City's lists several goals that improving the conditions in Moon Lake and improving community access to the lake would help meet. The following four goals are on page 8 of the 2014-2019 Comprehensive Outdoor Recreation Plan:

- To enhance the quality of life and encourage healthy lifestyles while reconnecting people, especially children, to the outdoors through our parks and open spaces, natural areas, trails, and outdoor recreation programs.
- To develop a stewardship ethic, protect our natural environment for sustainable conservation for our community and generations to come.
- To ensure all people the access to a safe, affordable and healthy way to experience and appreciate nature while improving social and economic value to the City.
- Provide a mix of affordable, quality outdoor recreation facilities, programs, and amenities at various scales and development intensities which meet the needs of residents while taking advantage of tourism opportunities.

Along with these four goals, the Outdoor Recreation Plan also lists the following objectives on page 9-10:

- To provide a safe environment for play and physical activity and areas for active and passive recreation opportunities that meet the needs of all age groups, cultures, and ethnicity within the community.
- To improve and revitalize our parks as gathering places for our youth, families and adults to play, exercise, relax, enjoy time with family and friends, and experience the natural environment.
- To provide space for social interaction, health and wellness, and cultural diversity.
- To obtain, when opportunities are feasible, sites for open green space, playgrounds, parks, trails, etc.
- To provide opportunities for rural residents to enjoy the community's parks, natural resources, and recreation areas.
- To establish priorities for needed outdoor recreation facilities based on prominent outdoor recreation trends, as well as existing recreational land distribution and existing and/or future deficiencies.
- To raise awareness to help preserve and protect our natural resources within our parks and adjacent to, along with the promotion of good conservation and stewardship practices.
- To coordinate the community's recreation program with other agencies, organizations, schools, other levels of government and private enterprise to ensure maximum public benefit.
- To ensure that all people have access and adequate parking to our water amenities and public recreation areas.
- To protect scenic values by managing billboards, signs, junkyards and other unsightly land uses and practices.
- To make improvements and modifications to accommodate Adaptive/ADA compliant facilities, play structures and accessibility that meet the needs of the physically challenged including the elderly and disabled that meet the American Disabilities Act standards.
- To provide for the periodic review and updating of the city outdoor recreation plan so that it will reflect the changing needs and trends of the community.
- To provide for annual planning, programming and maintenance of park and recreation facilities throughout the community with funding from the Capital Improvements Program (CIP), general obligation borrowing and other funding sources private or public.
- To create and promote alternative means of transportation within the City by the establishment of trails and sidewalk connections for recreational and multimodal transportations activities.

Nearly all of the goals and objectives listed in the City Comprehensive Outdoor Recreation Plan can be addressed at some level with the management actions and activities recommended in this APMP. Moon Lake is a valuable natural resource within the city limits that is being under-utilized at the present time, due in part to the poor condition of the lake. One of the property owners on Moon Lake is a well-respected and popular (with students) Rice Lake High School biology teacher who encourages students to get involved in natural resource activities in the community and surrounding area.

This APMP recommends that the MLA work with the City, Rice Lake High School, and other community partners to determine how what is done in Moon lake can improve its value in the community. Through the efforts of the MLA; support from WDNR grants and City outdoor recreation programs; and partnerships with the City, Rice Lake High School, Rice Lake – Lake Protection and Rehabilitation District, and other community organizations Moon Lake can be utilized as the valuable resource that it should be.

OBJECTIVE 1 – WORK WITH THE CITY OF RICE LAKE AND OTHER ENTITIES TO IMPROVE PUBLIC ACCESS TO MOON LAKE AT THE SOUTH END OF MOON LAKE PARK

i. **Action Item**: Improve walk-in access and launching facilities for kayakers and users of other small craft; wildlife enthusiasts; and small group learning opportunities off the south end of the Park.

ii. **Action Item**: Install a public fishing dock off the south end of the Park.

iii. **Action Item**: Build a bathroom/shelter/aeration storage shed at the south end of the Park

iv. **Action Item**: Build a road to, and a small parking area at the south end of the Park. Bring electricity to the south end of the Park.

OBJECTIVE 2 – WORK WITH RICE LAKE AREA SCHOOLS TO FIGURE OUT HOW MOON LAKE AND MOON LAKE PARK CAN BE BETTER UTILIZED AS A NATURAL RESOURCE LEARNING TOOL

i. **Action Item**: Discuss how Moon Lake and Moon Lake Park can be improved to provide outdoor education opportunities for students and teachers.

OBJECTIVE 3 – EXPLORE FUNDING PROGRAMS THAT MIGHT BE USED TO SUPPORT IMPROVED LAKE ACCESS FOR RECREATIONAL ACTIVITIES, OUTDOOR LEARNING ACTIVITIES, AND HABITAT IMPROVEMENTS

i. **Action Item**: Evaluate how and if certain WDNR grant programs including the Recreational Boating Facilities and Sport Fish Restoration can be used to increase the community value of Moon Lake.

ii. **Action Item**: Work with the City and Rice Lake – Lake Protection and Rehabilitation District funding opportunities could be used to increase the community value of Moon Lake.

GOAL 7 - EVALUATE AND IMPROVE THE SHORELAND AROUND MOON LAKE

Once harvesting of aquatic plants in Moon Lake is started, there is a risk of causing the lake to go from plant dominated clear water to algae dominated green water. Removal of aquatic plant may make more nutrients in the lake available to grow algae. Reducing the amount of nutrients entering Moon Lake from its rather small watershed may lessen the chance the lake switches over. One inexpensive way to reduce nutrients entering the lake is to make shoreland improvements around the lake. There are many shoreland best management practices (BMPs) including establishing buffer strips through no mowing, native plantings, shoreland restoration, installation of rain gardens, and diversion of surface water runoff away from the lake that will reduce nutrient loading over time.

To maintain the quality and diversity of the Moon Lake, it is recommended that the MLA provide riparian owners with educational materials on shoreland improvement and/or sponsor/promote shoreland improvement training events. Not knowing where to begin with a shoreland restoration is often the main hurdle preventing property owners from implementing a practice that would help improve the lake. General information on shoreland restoration could be provided to all property owners in a newsletter and/or during public events. There are many free, down-loadable on-line resources, and both free and low cost paper resources including guides, pamphlets, and brochures available to help the average person work toward making improvements on their own properties. UW-Extension has offices in nearly every county in Wisconsin and offers these materials for free or at very low prices. They also sponsor local workshops and/or training sessions, or can direct people to others who do. Local greenhouses and landscaping companies often have shoreland restoration packages for specific project types available to the public.

The WDNR has a new Lake Shoreland and Shallows Habitat Monitoring Field Protocol that involves the evaluation of a 35-ft buffer area around the entire lake, documents shoreland condition through digital photography, and documents coarse woody debris in a lake. Additional information about the condition of the shoreland around Moon Lake would benefit future shoreland improvement planning and implementation through the WDNR Healthy Lakes Initiative and BMP grant program. The RL-LPRD also has a shoreland improvement program. Both programs offer funding support to install shoreland BMPs. It is recommended that a shoreland survey be completed on Moon Lake following the new WDNR protocol during the time frame covered by this APMP.

OBJECTIVE 1: REDUCE THE AMOUNT OF SHORELAND WITHOUT A NATURAL BUFFER IN PLACE BY THROUGH SHORELAND RESTORATION AND OTHER BEST MANAGEMENT PRACTICES.

i. **Action Item:** Complete a shoreland inventory of all developed properties to determine the amount of shoreland that is not in a natural state.

ii. **Action Item:** Distribute shoreland improvement education and information materials to lake property owners through the newsletter, webpage, and general mailings.

iii. **Action Item:** Host and/or sponsor lake events that encourage land owner participation in best management practices.

iv. **Action Item:** Support property owners who wish to complete shoreland or habitat improvement projects through the WDNR Healthy Lakes and RL-LPRD programs.

v. **Action Item:** Recognize property owners who participate in and/or complete shoreland restoration and habitat improvement projects in the newsletter, on the webpage, in local news publications, and/or at the site of the project.

GOAL 8 - ADAPTIVE MANAGEMENT

This APMP is a working document guiding management actions on Moon Lake over the next five years. This plan will follow an adaptive management approach by evaluating results and adjusting actions on the basis of what has been learned. This plan is therefore a living document, successively evolving and improving to meet environmental, social, and economic goals, to increase scientific knowledge, and to reduce tensions among stakeholders. If WDNR grant funds are used to support implementation of this APMP, the MLA and their retainers will compile, analyze, and summarize management operations, public education efforts, and other pertinent data into an annual report each year. The information will be presented to members of the MLA, the WDNR, and others upon request.

OBJECTIVE 1 – IMPLEMENT AS MANY OF THE RECOMMENDATIONS IN THIS APMP AS POSSIBLE OVER THE NEXT FIVE YEARS WITH THE RESOURCES AVAILABLE TO THE MLA

i. **Action Item**: Utilize the Implementation and Funding Matrix included with this APMP (Appendix G) to prioritize and determine the timing for implementation of specific recommendations included in this plan.

IMPLEMENTATION AND EVALUATION

This plan is intended to be a tool for use by the MLA to move forward with aquatic plant management actions that will maintain the health and diversity of Moon Lake - its aquatic plant community, and the value of the lake to the community. This plan is not intended to be a static document, but rather a living document that will be evaluated on an annual basis and updated as necessary to ensure goals and community expectations are being met. Implementation of as many of the actions in this plan as there are resources available is recommended. Funding to support implementation of this plan may be obtained through diverse sources including WDNR grants, City funding, Rice Lake – Protection and Rehabilitation District funding, community donations of time and money, and MLA dues and fundraising. An Implementation and Funding Matrix is provided.

WISCONSIN DEPARTMENT OF NATURAL RESOURCES GRANT PROGRAMS

There are several WDNR grant programs that may be able to assist the Sand Lake Management District in implementing its new APMP. AIS grants are specific to actions that involve education, prevention, planning, and in some cases implementation of AIS management actions. Lake Management Planning grants can be used to support a broad range of management planning and education actions. Lake Protection grants can be used to help implement approved management actions that would help to improve water quality. WDNR Healthy Lakes grants are part of the Lake Protection program.

AIS PREVENTION AND CONTROL GRANTS

The AIS Prevention and Control grants are a cost-share effort by the WDNR to provide information and education on types of existing and potential AIS in Wisconsin, the threats that invasive species pose to the state's aquatic resources, and available techniques for invasive species control. These grants also assist in the planning and implementation of projects that will prevent the introduction of invasive species into waters where they currently are not present, controlling and reducing the spread of invasive species from waters where they are present, and restoring native aquatic communities.

There are five AIS Prevention and Control grants subprograms:

- Education, Prevention and Planning Projects (including Clean Boats Clean Waters)
- Early Detection and Response Projects
- Established Population Control Projects
- Maintenance and Containment Projects
- Research and Demonstration Projects

The MLA, with the RL-LPRD sponsoring may be eligible for Education, Prevention, and Planning; Clean Boats, Clean Waters, and Maintenance and Containment grants.

EDUCATION, PREVENTION AND PLANNING PROJECTS

Education projects are intended to broaden the public's awareness and understanding of, and ability to identify, AIS; the threats that AIS pose to the health of aquatic ecosystems; the measures to prevent the spread of AIS; and the management practices used for control of AIS. Prevention projects are intended to prevent the introduction of new AIS into a waterbody/wetland, or prevent the spread of an AIS population from one waterbody to another unpopulated waterbody/wetland. Planning projects are intended to assist in the development of plans for the prevention and control of AIS. Eligible projects include:

- Educational programs including workshops, training sessions, or coordinated volunteer monitors. Projects will be reviewed for consistency with the DNR's statewide education strategy for controlling AIS including the use of existing publications and outreach materials.
- Development of AIS prevention and control plans
- Monitoring, mapping, and assessing waterbodies for the presence of AIS or other studies that will aid in the AIS prevention and control.
- Watercraft inspection and education projects following the guidelines of the DNR's Clean Boats, Clean Waters program.

This subprogram is not intended to provide support for any management action that may be taken.

Funding Possibilities

Maximum amount of grant funding is 75% of the total project costs, not to exceed $150,000. Applications will be separated into two classes: less than $50,000 in state funding and between $50,001 and $150,000 in state funding. Clean Boats Clean Waters projects are limited to $4,000 per public boat launch facility but may be a component of a larger project.

ESTABLISHED POPULATION CONTROL PROJECTS

Established population control grants are intended to assist applicants in eradicating or substantially reducing established populations of AIS to protect and restore native species communities. Established populations are defined as substantial reproducing populations of AIS that are not pioneer populations. Eligible projects include activities recommended in a DNR-approved control plan including monitoring, education, and prevention activities. Ineligible projects include the following:

- Dredging
- Chemical treatments or mechanical harvesting of aquatic plants to provide single season nuisance or navigational relief.
- Maintenance and operation of aeration systems and mechanical structures used to suppress aquatic plant growth.
- Structural facilities for providing boat washing stations. Equipment associated with boat washing facilities is eligible if included in a management plan.

Funding Possibilities

Maximum amount of the grant funding is 75% of the total project costs, not to exceed $200,000.

MAINTENANCE AND CONTAINMENT PROJECTS

Maintenance and containment grants are intended to provide sponsors limited financial assistance for the ongoing control of established AIS population without the assistance of an Established Population Control grant. These projects are intended for waters where management activity has achieved the target level of control identified in an approved plan that meets the criteria of s. NR 198.43, Wis. Adm. Code. Ongoing maintenance is needed to contain these populations so they do not re-establish throughout the waterbody, spread to other waters, or impair navigation and other beneficial uses of the waterbody.

Funding Possibilities

Maximum amount of grant funding will be determined by DNR based on the sponsor's permit application fee, specified monitoring and reporting requirements in the permit, or DNR-approved management plan. The maximum grant amount shall not exceed the cost of the permit application fee.

LAKE MANAGEMENT PLANNING GRANTS

Lake management planning grants are intended to provide financial assistance to eligible applicants for the collection, analysis, and communication of information needed to conduct studies and develop management plans to protect and restore lakes and their watersheds. Projects funded under this subprogram often become the basis for implementation projects funded with Lake Protection grants. There are two categories of lake management planning grants: small-scale and large-scale.

The MLA, with the RL-LPRD sponsoring, may be eligible for either small or large scale lake management planning grants to support planning and implementation of certain activities included in this document.

SMALL SCALE LAKE MANAGEMENT PROJECTS

Small-scale projects are intended to address the planning needs of lakes where education, enhancing lake organizational capacity, and obtaining information on specific lake conditions are the primary project objectives. These grants are well suited for beginning the planning process, conducting minor plan updates, or developing plans and specification for implementing a management recommendation. Eligible projects include:

- Collect and report chemical, biological, and physical data about lake ecosystems for a Tier I assessments, Tier II diagnostic or Tier III project evaluation.
  - Tier I if initial basic monitoring is needed to assess the general condition or health of the lake.
  - Tier II if an assessment has been conducted and more detailed data collection is needed to diagnose suspected problems and identify management options.
  - Tier III if the monitoring and assessment will be used to evaluate the effectiveness of a recently implemented project or lake management strategy.
- Collecting and disseminating existing information about lakes for the purpose of broadening the understanding of lake use, Lake Ecosystem conditions and lake management techniques.
- Conducting workshops or trainings needed to support planning or project implementation.
- Projects that will assist management units as defined in s. NR191.03 (4) & s. NR 190.003 (4) the formation of goals and objectives for the management of a lake or lakes.

Funding Possibilities

Maximum amount of grant funding is 67% of the total project costs, not to exceed $3,000.

LARGE SCALE LAKE MANAGEMENT PROJECTS

Large-scale projects are intended to address the needs of larger lakes and lakes with complex and technical planning challenges. The result will be a lake management plan; more than one grant may be needed to complete the plan. Eligible projects include:

- Collection of new or updated, physical, chemical and biological information about lakes or lake ecosystems.
- Definition and mapping of Lake Watershed boundaries, sub-boundaries and drainage system components.
- Descriptions and mapping of existing and potential land conditions, activities and uses within lake watersheds that may affect the water quality of a lake or its ecosystem.
- Assessments of water quality and of fish, aquatic life, and their habitat.
- Institutional assessment of lake protection regulations - review, evaluation or development of ordinances and other local regulations related to the control of pollution sources, recreational use or other human activities that may impact water quality, fish and wildlife habitat, natural beauty or other components of the lake ecosystem.
- Collection of sociological information through surveys or questionnaires to assess attitudes and needs and identify problems necessary to the development of a long-term lake management plan.
- Analysis, evaluation, reporting and dissemination of information obtained as part of the planning project and the development of management plans.
- Development of alternative management strategies, plans and specific project designs, engineering or construction plans and specifications necessary to identify and implement an appropriate lake protection or improvement project.

Funding Possibilities

Maximum amount of grant funding is 67% of the total project costs, not to exceed $25,000. Multiple grants in sequence may be used to complete a planning project, not to exceed $100,000 for each lake. The maximum grant award in any one year is $50,000 for each lake. If phasing is necessary, all phases should be fully identified and a timeline identified in the initial application.

LAKE PROTECTION GRANTS

Lake protection and classification grants assist eligible applicants with implementation of lake protection and restoration projects that protect or improve water quality, habitat or the elements of lake ecosystems. There are four basic Lake Protection subprograms: a) Fee simple or Easement Land Acquisition b) Wetland and Shoreline Habitat Restoration c) Lake Management Plan Implementation d) Healthy Lakes Projects.

The MLA, with the RL-LPRD sponsoring, may be eligible for Healthy Lakes Projects.

HEALTHY LAKES PROJECTS

The Healthy Lakes grants are a sub-set of Plan Implementation Grants intended as a way to fund increased installation of select best management practices (BMPs) on waterfront properties without the burden of developing a complex lake management plan. Details on the select best practices can be found in the Wisconsin Healthy Lakes Implementation Plan and best practice fact sheets.

Eligible best practices with pre-set funding limits are defined in the Wisconsin Healthy Lakes Implementation Plan, which local sponsors can adopt by resolution and/or integrate into their own local planning efforts. By adopting the Wisconsin Healthy Lakes Implementation Plan, your lake organization is immediately eligible to implement the specified best practices. Additional technical information for each of the eligible practices is described in associated factsheets. The intent of the Healthy Lakes grants is to fund shovel-ready projects that are relatively inexpensive and straight-forward. The Healthy Lakes grant category is not intended for large, complex projects, particularly those that may require engineering design. All Healthy Lake grants have a standard 2-year timeline.

Funding Possibilities

Maximum amount of grant funding is 75% of the total project cost, not to exceed $25,000. Grants run for a 2-year time period. Maximum costs per practice are also identified in the Wisconsin Healthy Lakes Implementation Plan.

RECREATIONAL BOATING FACILITIES (RBF) GRANTS

These grants may be used by counties, towns, cities, villages, tribes, sanitary districts, public inland lake protection and rehabilitation districts and qualified lake associations for recreational boating facility projects. Past projects have included ramps and service docks to gain access to the water, feasibility studies, purchase of aquatic weed harvesting equipment, navigation aids and dredging of waterway channels. Project under this grant program may receive cost-sharing of up to 50% of the total project cost. Eligible projects include:

- Channel dredging - Dredging of inland water channels for recreational boating (not more than once in ten years).
- Construction projects including:
    - Facilities such as ramps and boarding docks required to gain access to the water.
    - Harbors of refuge – structures such as bulkheads and breakwaters necessary to provide safe water conditions.
    - Dredging to provide safe water depths. Dredging of basins is an eligible activity only when it is associated with project development.
    - Support facilities include parking lots and signage, sanitary facilities, fencing and security lighting for the convenience of boaters.
- Feasibility studies - An investigation of the environmental, economic, and engineering aspects of a recreational boating facility project to determine if the project may be successfully carried out.
- Improvement and repair of locks - Cost of improvement and repair of locks and facilities that provide access between waterways for operators of recreational watercrafts.

- Navigation aids - Cost of aids to navigation and regulatory markers including the cost of appropriate ground tackle.
- Rehabilitation - Rehabilitation of capital improvements that are related to recreational boating facilities.
- Trash skimming equipment - Acquisition of equipment to collect and remove floating trash and debris from a waterway.
- Weed harvesting equipment - Acquisition of equipment that is necessary to cut and remove aquatic plants.

SPORT FISH RESTORATION (SFR) GRANTS

These grants may be used to construct fishing piers and motorboat access projects. Eligible projects include new boat ramp construction and renovations, development and renovation of parking lots, accessible paths, lighting and restroom facilities; channel dredging and feasibility studies. Funding for this program comes from federal excise taxes on fishing equipment and a portion of the federal gas tax. Counties, towns, cities, villages, tribes, sanitary districts, public inland lake protection and rehabilitation districts, and qualified lake associations are eligible to apply for this grant program.

Projects that have received funding from other federal grants are not eligible to receive sport fish restoration grant funding.

CITY OF RICE LAKE – CAPITAL IMPROVEMENT PLAN

A Capital Improvement Plan (Program), or CIP, is a short-range plan, usually four to ten years, which identifies capital projects and equipment purchases, provides a planning schedule and identifies options for financing the plan. Essentially, the plan provides a link between a municipality, school district, parks and recreation department and/or other local government entity and a comprehensive and strategic plan and the entity's annual budget. The City develops a CIP plan regularly. Certain projects included in this APMP could potentially be funded through the City's CIP, assuming the City supports the project at all.

WORKS CITED

Abandoned & Little-known Airfields: Northern Wisconsin. 2016. www.airfields-freeman.com/WI/Airfields_WI_N.htm (accessed December 2016).

"Barron County Ordinances Governing Land Use and Development." 2014. http://www.co.barron.wi.us/misc%20docs/land%20use%20ordinance.pdf (accessed December 2016).

Center for Limnology, UW-Madison. *Aquatic Invasive Species Smart Prevention.* 2016. http://www.aissmartprevention.wisc.edu/ (accessed December 2016).

Christensen, D.L., Hewig, B.R., Schindler, D. E., and Carpenter, S.R. "Impacts of lakeshore residential development on coarse woody debris in north temperate lakes." *Ecological Applications 6 (4)*, 1996: 1143-1149.

City of Rice Lake. 2016. www.ci.rice-lake.wi.us/ (accessed December 2016).

Cole, Aaron, interview by Dave Blumer. *WDNR Fisheries Manager, Barron County* (December 2016).

Community Services Department, Rice Lake. *Comprehensive Outdoor Recreation Plan 2014-19.* Comprehensive Plan, Rice Lake: City of Rice Lake, 2014.

Cooke, D.G., E.B. Welch, S.A. Peterson, and S.A. and Nichols. *Restoration and Management of Lakes and Reservoirs, Thrid Edition.* Boca Raton, FL: CRC Press, Taylor and Francis Group, 2005.

Cornelius, Rick. *Decription and Summary of Lake aeration Projects to Prevent Fish Winterkill in Barron and Polk Counties, WIsconsin.* Barron: WDNR, 2006.

Eichler, L.W., R.T. Bombard, J.W. Sutherland, and C.W. Boylen. "Suction harvesting of Eurasian watermilfoil and its effect on native plant communities." *Journal of Aquatic Plant Management 31*, 1993: 144-148.

Google Earth. December 2016. https://earth.google.com/ (accessed December 2016).

Graff, Dan, interview by Dave Blumer. *MLA President* (2016).

Gruetzmacher, Tyler. "Moon Lake Watershed Map." Barron, WI: Barron County, November 2016.

Hatleli, Sara. *Aquatic Plant Survey Report, Moon Lake, Barron County.* Taylor, WI: Aquatic Plant and Habitat Services, LLC, 2014.

Herman, Nathan. *Herman Brothers Blog.* 2016. http://thediaryofalakenerd.blogspot.com/2014/04/winter-fish-kills-101.html (accessed December 2016).

Jennings, M.J., Emmons, E.E., Hatzenbeler, G.R., Edwards, C. and Bozek, M.A. "Is littoral habitat affected by residential development and land use in watersheds of Wisconsin lakes?" *Lake Reservoir Management, 19 (3)*, 2003: 272-279.

Kalf, J. *Limnology - Inland Water Ecosystems.* New Jersey: Prentice Hall, 2002.

Kelting, D.L., and C.L. Laxson. "Cost and effectiveness of hand harvesting to control the Eurasian watermilfoil population in Upper Saranac Lake, New York." *Journal of Aquatic Plant Management 48*, 2010.

Madsen, J.D. *Advantages and disadvantages of aquatic plant management techniques.* Vicksburg, MS: US Army Corps of Engineers Aquatic Plant Control Research Program, 2000.

Madsen, J.D. *Methods for management of nonindigenous aquatic plants.* New York: Springer, 1997.

Moss, B., J. Madgwick, and G. Phillips. *A Guide to the Restoration of Nutrient Enriched Shallow Lakes.* The Broads Authority, 1996.

Nichols, S.A. "Floristic Quality Assessment of Wisconsin Lake Plant Communities wiht Example Applications." *Journal of Lake and Reservoir Management*, 1999: 133-141.

Peterson, Spencer A. "Lake Restoration by Sediment Removal." *Journal of the American Water Resources Association*, 1982: 423-436.

Pope, K.L., and D.W. Willis. "environmental Characteristics of Black Crappie Nesting Sites in Two South Dakota Waters." *Ecology of Freshwater Fish*, 1997: 183-189.

Radomski, P., and T.J. Goeman. "Consequences of Human Lakeshore Development on Emergent and Floating-Leaf Abundance." *North American Journal of Fisheries Management*, 2001: 46-61.

Scholl, C. *Aquatic Invasive Species: A Guide for Proactive and Reactive Management.* Project # ASP-001-04, Rhinelander: WDNR, 2006.

Sorsa, K.K., E.V. Nordheim, and J.H. Andrews. "Integrated control of Eurasian wataer milfoil by a fungal pathogen and herbicide." *Journal of Aquatic Plant Management 26*, 1988: 12-17.

Tobiessen, P., J. Swart, and S. Benjamin. "Dredging to control curly-leaf pondweed: a decade later." *Journal of Aquatic Plant Management*, 1992: 71-72.

Washington, State of. *Aquatic Plant Management - Mechanical Harvesting.* 2016. http://www.ecy.wa.gov/programs/wq/plants/management/aqua026.html (accessed December 2016).

WDNR. *Fish sticks: Improving lake habitat.* 2016. http://dnr.wi.gov/topic/fishing/outreach/fishsticks.html (accessed April 2016).

Healthy Lakes Wisconsin. 2016. http://healthylakeswi.com/ (accessed December 2016).

WDNR Lakes. 2016. http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=1867600 (accessed November 2016).

WDNR. "Waterway protection Dredging." 2016. http://dnr.wi.gov/topic/waterways/documents/permitExemptionChecklists/14-manualDredging.pdf (accessed December 2016).

Wisconsin's Natural Heritage Inventory (NHI). 2016. http://dnr.wi.gov/topic/nhi/ (accessed December 2016).

Wetlands Inventory - Wisconsin. 2016. http://dnr.wi.gov/topic/wetlands/inventory.html (accessed November 2016).

Wolter, M. *Lakeshore Woody Habitat in Review.* Hayward, WI: Wisconsin Department of Natural Resources, 2012.

Appendix A

NR 109 and NR 107

Appendix B

NR 19

Appendix C

Mechanical/Manual Aquatic Plant Control Application, Form 3200-113

Appendix D

Moon Lake Aquatic Plant Harvesting Plan

Appendix E

Lake Shoreland and Shallows Habitat Monitoring Field Protocol

Appendix F

Moon Lake Aquatic Plant Management Goals, Objectives, and Actions

Appendix G

Moon Lake Implementation and Funding Matrix