Mann Lake

Vilas County, Wisconsin

Comprehensive Management Plan

January 2016

Sponsored by:

Friends of Mann Lake

WDNR Grant Program

LPL-1551-14

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Onterra, LLC
Lake Management Planning

Mann Lake

Vilas County, Wisconsin

Comprehensive Management Plan

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Acknowledgements

This management planning effort was truly a team-based project and could not have been completed without the input of the following individuals:

Mann Lake Planning Committee

Dave Jones	Jon Leonhard	Bridget Leonhard
Dave Walschinski	Gloria Walschinski	Kathy Bolanowski
Robert Bolanowski	Pete Burditt	John Zwers
Brett Carroll		

Wisconsin Dept. of Natural Resources

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TABLE OF CONTENTS

FIGURES

TABLES

PHOTOS

MAPS

APPENDICES

1.0 INTRODUCTION

Mann Lake, Vilas County, is a 255-acre seepage lake with a maximum depth of 18 feet and a mean depth of 5.4 feet. This eutrophic lake has a relatively small watershed when compared to the size of the lake. Mann Lake contains 30 native plant species, of which common waterweed is the most common plant.

Field Survey Notes

Mann Lake has a primarily soft, organic bottom. Common waterweed and leafy pondweed can be found in high abundance and density along the shoreline of much of the lake. Many frogs and small minnows observed during point-intercept survey

Photograph 1.0-1 Mann Lake, Vilas County

Lake at a Glance - Mann Lake

Morphology	
Acreage	255
Maximum Depth (ft)	18
Mean Depth (ft)	5.4
Shoreline Complexity	5.0
Vegetation	
Comprehensive Survey Date	July 23, 2014
Number of Native Species	31
Threatened/Special Concern Species	-
Exotic Plant Species	Reed canary grass (*naturalized*)
Simpson's Diversity	0.71
Average Conservatism	5.5
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	7.9
Sensitivity to Acid Rain	Not sensitive
Watershed to Lake Area Ratio	7:1

Mann Lake is located within the heart of the Northern Highland American Legion State Forest. Much of the state land borders the lake. Commonly listed as a spring lake, Mann Lake does have a small tributary that drains a wetland complex just north of the lake. It is believed this stream has substantial flow for most of the open-water portion of the year. The water level in Mann Lake is held by a retaining structure at the lake's far west end, which is owned by the Town of Boulder Junction. The dam was constructed in 1965, with a structural height of five feet. At the time it was constructed, the Wisconsin Conservation Department recommended the maximum level of Mann Lake be held at a 98.04 feet, Public Service Commission datum.

For years, Mann Lake residents assisted Wisconsin Department of Natural Resources (WDNR) staff with fisheries studies and stocking. The Friends of Mann Lake (FML) was officially formed in 2012, primarily over concerns of the fishery that had degraded. In past years, Mann Lake has experienced fishkills brought on by low oxygen levels under winter ice. A fish kill in 2011 was particularly significant, and brought about discussions of uniting on the issue.

While the fishery was the driving force in the creation of the FML, the group became concerned with other aspects of the lake's ecology as well. The group met with Ted Ritter, then the Vilas County Aquatic Invasive Species Coordinator, during the fall of 2013 to discuss AIS-related issues on nearby lakes, as well as tour Mann Lake looking for AIS. At this time, the group does not believe the lake contains any AIS. Further discussions with the WDNR led the group to pursue a management planning project. In February of 2014, the FML submitted a Lake Management Planning Grant to the WDNR Surface Water Grant Program, with assistance from consultant Onterra, LLC. Studies began on the lake in spring of 2014, which would mark the beginning of this project.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa. The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All of this information is communicated through multiple meetings that involve the lake group as a whole or a focus group called a Planning Committee, the completion of a stakeholder survey, and a mid-project update report.

The highlights of this component are described below. Materials used during the planning process can be found in Appendix A.

Kick-off Meeting

On June 21, 2014, a project kick-off meeting was held at to introduce the project to the general public. The meeting was announced through a mailing and personal contact by FML board members. The attendees observed a presentation given by Dan Cibulka, an aquatic ecologist with Onterra. Mr. Cibulka's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation was followed by a question and answer session.

Planning Committee Meeting I

On June 19, 2015, the Mann Lake Planning Committee met with Mr. Cibulka for the first of two planning meetings. During this nearly three hour meeting, the results of numerous ecological studies were discussed along with sociological data collected through the the stakeholder survey. Many topics were talked about, though matters pertaining to the lake's abundant plant growth and winter fish kills comprised a good part of the discussion.

Planning Committee Meeting

Onterra ecologist Dan Cibulka met with the same members of the Mann Lake planning committee on August 7, 2015 during a second planning meeting. During this time, the group discussed goals they wished to pursue in order to maintain the healthy ecology of the lake, address winter aeration and aquatic plant abundance concerns, and further develop Friends of Mann Lake association. These goals and actions are presented within this report's Implementation Plan section.

Wrap-Up Meeting

On October 3, a project wrap-up meeting was held at the Town of Boulder Junction Town Hall. Onterra ecologist Dan Cibulka presented a brief summary of the study and outlined the Implementation Plan the planning committee had developed over the past few weeks. The meeting was followed by discussion of the Implementation Plan.

Management Plan Review and Adoption Process

The Results Section (3.0) of this report was provided to the Mann Lake Planning Committee prior to the first of two planning meetings, both for preparatory reading for the meeting and for review opportunity. On August 28, 2015, a draft of the Implementation Plan was produced and sent to the same planning committee for review. The full management plan was completed on October 8, 2015 and sent to the WDNR for a review. During the wrap-up meeting, the FML Board of Directors formally approved of Management Goal 1 of the draft management plan. Formal adoption of the final, WDNR reviewed management plan is planned to occur through a majority vote at the next FML annual meeting, occurring in summer 2016.

Stakeholder Survey

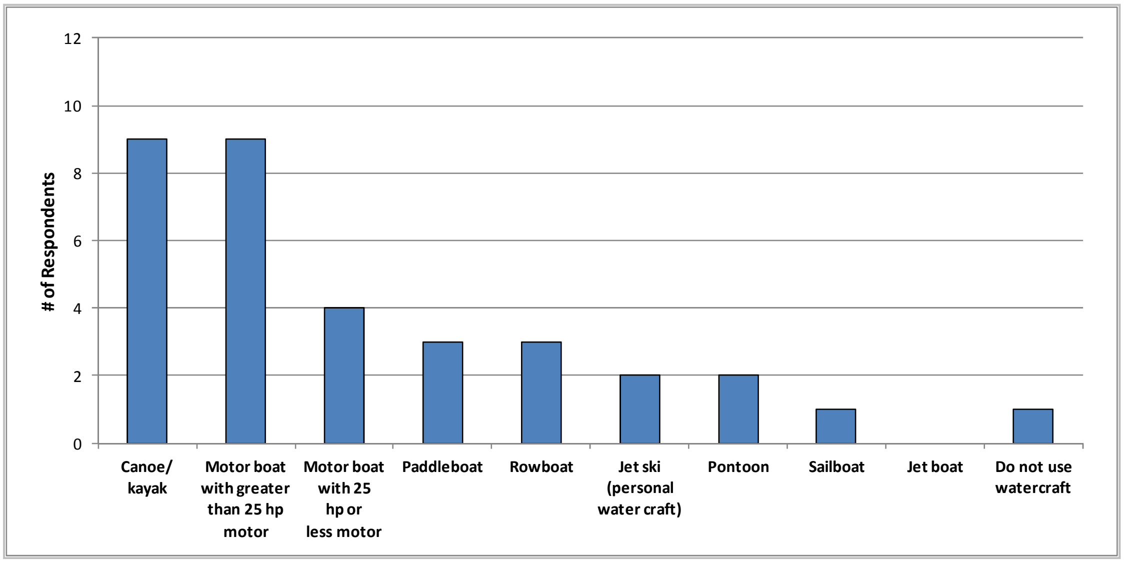
During September of 2014, a seven-page, 30-question survey was created by the FML planning committee and Onterra staff. Following a review and approval by WDNR social scientist Jordan Petchinik, the survey was mailed to 36 Mann Lake riparian property owners as well as all Friends of Mann Lake members. 44 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Mann Lake Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a general summary is discussed below. Please note that typically a benchmark of a 60% response rate is required to portray population projections accurately, and make conclusions with any statistical validity. Due to the lower than desired response rate, survey results cannot be viewed as being statistically representative (i.e., an accurate representation) of the population of the residents on Mann Lake. Therefore, results should be considered with caution because they *may or may not* indicate the true tendencies and opinions of the population. They do however provide valuable information on what a portion of lake stakeholders value as opinions and concerns on management of Mann Lake.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Mann Lake. The majority of respondents (44%) visit Mann Lake on weekends throughout the year, while 25% have a year-round residence and 2% responded that their residence is seasonal. 53% of stakeholders have owned their property for over 15 years, and 27% have owned their property for over 25 years.

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. More than half of survey respondents indicate that they use either a canoe/kayak or motor boat with a large (>25 hp) motor (Question 13). The need for responsible boating increases during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the lake. As seen on Question 14, several of the top recreational activities on the lake may involve boat use. Watercraft traffic was ranked low by Mann Lake stakeholders as a factor potentially impacting Mann Lake in a negative manner (Question 17) or as a concern regarding the lake (Question 18).

A concern of stakeholders noted throughout the stakeholder survey (see Question 18 and survey comments – Appendix B) was excessive aquatic plant growth and water quality degradation. Winter fish kills was added as a concern by several stakeholders. These topics are touched upon in the appropriate Results & Discussion Section, Summary & Conclusions Section and within the Implementation Plan.

Question 13: What types of watercraft do you currently use on the lake?



Question 14: Please rank up to three activities that are important reasons for owning your property on or near the lake.

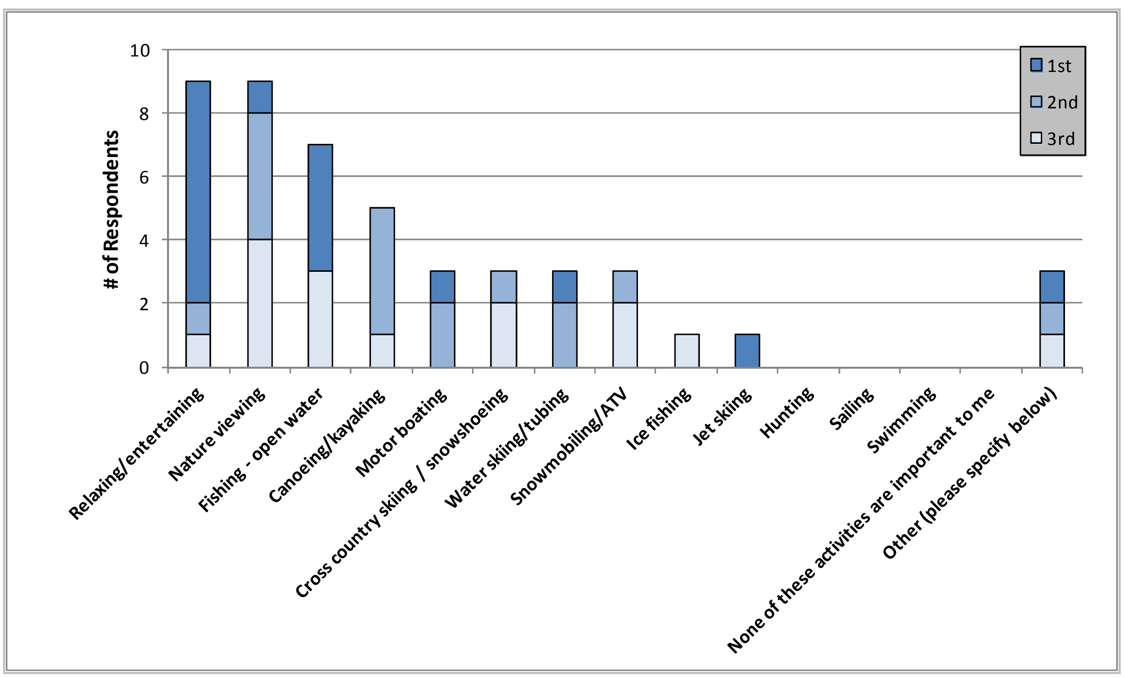
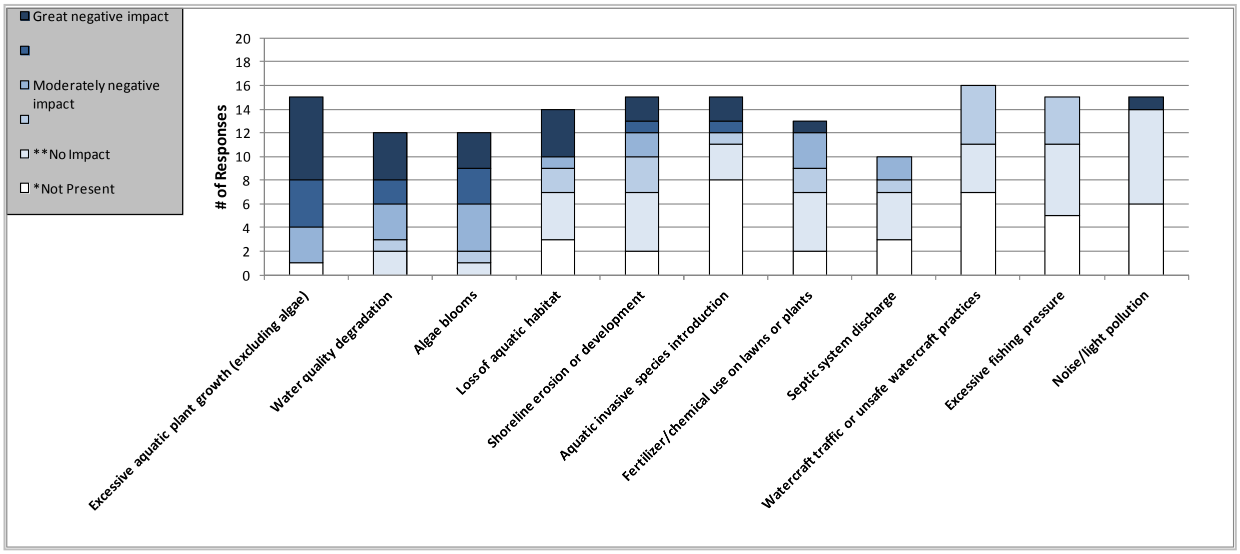


Figure 2.0-1. Select survey responses from the Mann Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question 20: To what level do you believe these factors may be negatively impacting Mann Lake?



Question 21: Please rank your top three concerns regarding Mann Lake.

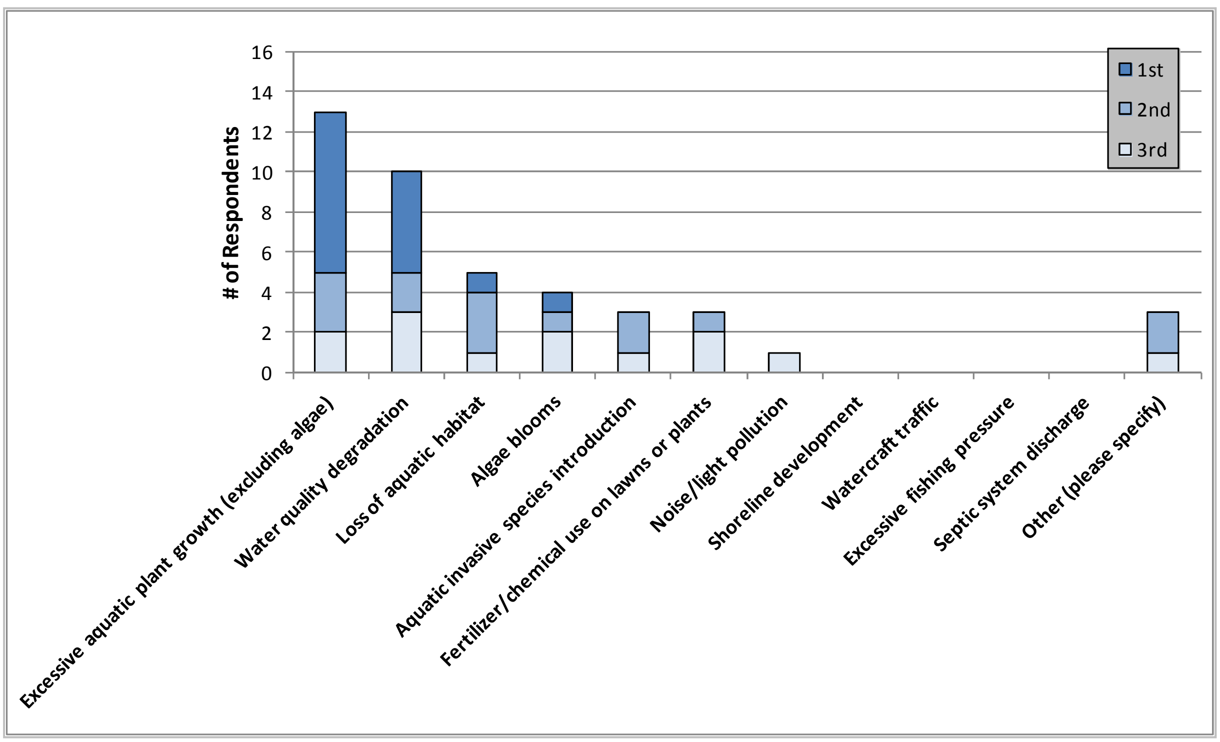


Figure 2.0-2. Select survey responses from the Mann Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

Many types of analyses are available for assessing the condition of a particular lake's water quality. In this document, the water quality analysis focuses upon attributes that are directly related to the productivity of the lake. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. Specific forms of water quality analysis are used to indicate not only the health of the lake, but also to provide a general understanding of the lake's ecology and assist in management decisions. Each type of available analysis is elaborated on below.

As mentioned above, chemistry is a large part of water quality analysis. In most cases, listing the values of specific parameters really does not lead to an understanding of a lake's water quality, especially in the minds of non-professionals. A better way of relating the information is to compare it to lakes with similar physical characteristics and lakes within the same regional area. In this document, a portion of the water quality information collected on Mann Lake is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region (Appendix C). In addition, the assessment can also be clarified by limiting the primary analysis to parameters that are important in the lake's ecology and trophic state (see below). Three water quality parameters are focused upon in the Mann Lake's water quality analysis:

Phosphorus is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both algae and macrophytes. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.

Chlorophyll-*a* is the green pigment in plants used during photosynthesis. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.

Secchi disk transparency is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

The parameters described above are interrelated. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in the water. In the majority of natural Wisconsin lakes, the primary particulate matter is algae; therefore, algal abundance directly affects water clarity. In addition, studies have shown that water clarity is used by most lake users to judge water quality – clear water equals clean water (Canter et al. 1994, Dinius 2007, and Smith et al. 1991).

Trophic State

Total phosphorus, chlorophyll-*a*, and water clarity values are directly related to the trophic state of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: oligotrophic, mesotrophic, and finally eutrophic. Every lake will naturally progress through these states and under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in many Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production.

> Trophic states describe the lake's ability to produce plant matter (production) and include three continuous classifications: Oligotrophic lakes are the least productive lakes and are characterized by being deep, having cold water, and few plants. Eutrophic lakes are the most productive and normally have shallow depths, warm water, and high plant biomass. Mesotrophic lakes fall between these two categories.

However, through the use of a trophic state index (TSI), an index number can be calculated using phosphorus, chlorophyll-*a*, and clarity values that represent the lake's position within the eutrophication process. This allows for a more clear understanding of the lake's trophic state while facilitating clearer long-term tracking. Carlson (1977) presented a trophic state index that gained great acceptance among lake managers.

Limiting Nutrient

The limiting nutrient is the nutrient which is in shortest supply and controls the growth rate of algae and some macrophytes within the lake. This is analogous to baking a cake that requires four eggs, and four cups each of water, flour, and sugar. If the baker would like to make four cakes, he needs 16 of each ingredient. If he is short two eggs, he will only be able to make three cakes even if he has sufficient amounts of the other ingredients. In this scenario, the eggs are the limiting nutrient (ingredient).

In most Wisconsin lakes, phosphorus is the limiting nutrient controlling the production of plant biomass. As a result, phosphorus is often the target for management actions aimed at controlling plants, especially algae. The limiting nutrient is determined by calculating the nitrogen to phosphorus ratio within the lake. Normally, total nitrogen and total phosphorus values from the surface samples taken during the summer months are used to determine the ratio. Results of this ratio indicate if algal growth within a lake is limited by nitrogen or phosphorus. If the ratio is greater than 15:1, the lake is considered phosphorus limited; if it is less than 10:1, it is considered nitrogen limited. Values between these ratios indicate a transitional limitation between nitrogen and phosphorus.

Temperature and Dissolved Oxygen Profiles

Temperature and dissolved oxygen profiles are created simply by taking readings at different water depths within a lake. Although it is a simple procedure, the completion of several profiles over the course of a year or more provides a great deal of information about the lake. Much of this information relates to whether the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

> Lake stratification occurs when temperature gradients are developed with depth in a lake. During stratification the lake can be broken into three layers: The epiliminion is the top layer of water which is the warmest water in the summer months and the coolest water in the winter months. The hypolimnion is the bottom layer and contains the coolest water in the summer months and the warmest water in the winter months. The metalimnion, often called the thermocline, is the middle layer containing the steepest temperature gradient.

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fishkills are often the result of insufficient amounts of dissolved oxygen. However, dissolved oxygen's role in lake management extends beyond this basic need by living organisms. In fact, its presence or absence impacts many chemical process that occur within a lake. Internal nutrient loading is an excellent example that is described below.

Internal Nutrient Loading

In lakes that support strong stratification, the hypolimnion can become devoid of oxygen both in the water column and within the sediment. When this occurs, iron changes from a form that normally binds phosphorus within the sediment to a form that releases it to the overlaying water. This can result in very high concentrations of phosphorus in the hypolimnion. Then, during the spring and fall turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algae blooms decades after external sources are controlled.

The first step in the analysis is determining if the lake is a candidate for significant internal phosphorus loading. Water quality data and watershed modeling are used to screen non-candidate and candidate lakes following the general guidelines below:

Non-Candidate Lakes

- Lakes that do not experience hypolimnetic anoxia.
- Lakes that do not stratify for significant periods (i.e. months at a time).
- Lakes with hypolimnetic total phosphorus values less than 200 μg/L.

Candidate Lakes

- Lakes with hypolimnetic total phosphorus concentrations exceeding 200 μg/L.
- Lakes with epilimnetic phosphorus concentrations that cannot be accounted for in watershed phosphorus load modeling.

Specific to the final bullet-point, during the watershed modeling assessment, the results of the modeled phosphorus loads are used to estimate in-lake phosphorus concentrations. If these estimates are much lower than those actually found in the lake, another source of phosphorus must be responsible for elevating the in-lake concentrations. Normally, two possibilities exist; 1) shoreland septic systems, and 2) internal phosphorus cycling.

If the lake is considered a candidate for internal loading, modeling procedures are used to estimate that load.

Comparisons with Other Datasets

The WDNR document *Wisconsin 2014 Consolidated Assessment and Listing Methodology* (WDNR 2013) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's land cover. For this reason, the water quality of Mann Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into ten natural communities (Figure 3.1-1).

First, the lakes are classified into three main groups: (1) lakes and reservoirs less than 10 acres, (2) lakes and reservoirs greater than or equal to 10 acres, and (3) a classification that addresses special waterbody circumstances. The last two categories have several sub-categories that provide attention to lakes that may be shallow, deep, play host to cold water fish species or have unique hydrologic patterns. Overall, the divisions categorize lakes based upon their size, stratification characteristics, hydrology. An equation developed by Lathrop and Lillie (1980), which incorporates the maximum depth of the lake and the lake's surface area, is used to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

> **Seepage Lakes** have no surface water inflow or outflow in the form of rivers and/or streams.
>
> **Drainage Lakes** have surface water inflow and/or outflow in the form of rivers and/or streams.
>
> > Headwater drainage lakes have a watershed of less than 4 square miles.
> >
> > Lowland drainage lakes have a watershed of greater than 4 square miles.

Because of its depth, small watershed and hydrology, Mann Lake is classified as a shallow, headwater drainage lake (category 2 on Figure 3.1-1).

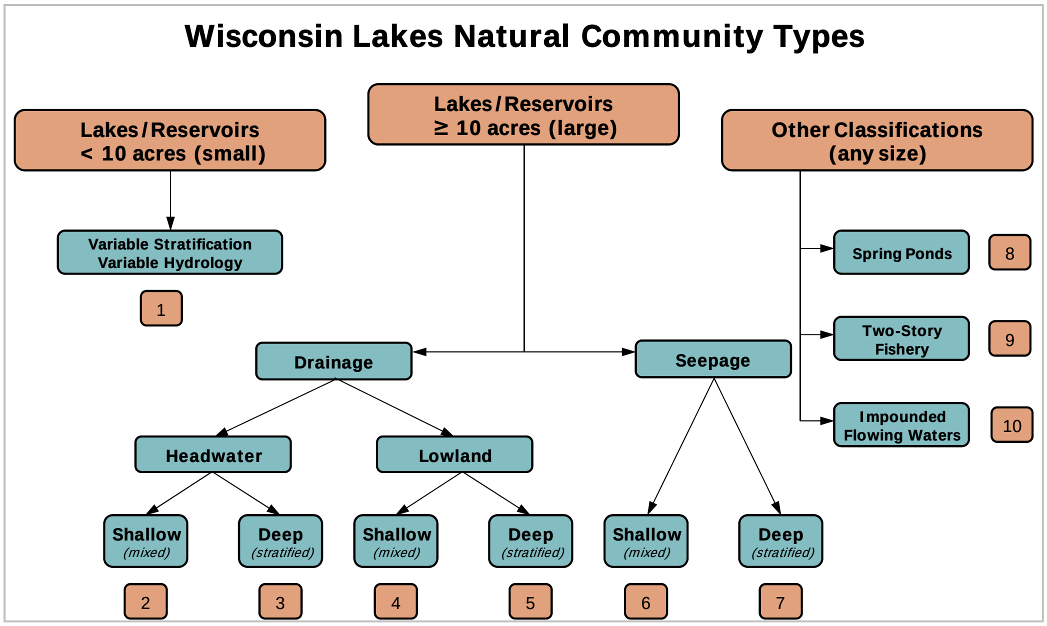


Figure 3.1-1. Wisconsin Lake Natural Communities. Adapted from WDNR 2013A.

Garrison, et. al (2008) developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for six of the lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state's ecoregions, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.1-2). Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Mann Lake is within the Northern Lakes and Forests ecoregion.

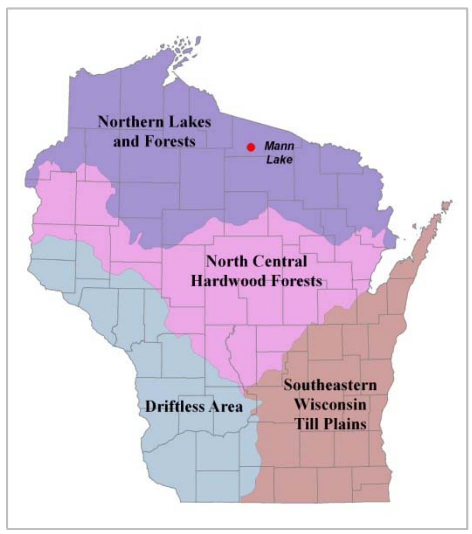


Figure 3.1-2. Location of Mann Lake within the ecoregions of Wisconsin. After Nichols 1999.

The Wisconsin 2014 Consolidated Assessment and Listing Methodology document also helps stakeholders understand the health of their lake compared to other lakes within the state. Looking at pre-settlement diatom population compositions from sediment cores collected from numerous lakes around the state, they were able to infer a reference condition for each lake's water quality prior to human development within their watersheds. Using these reference conditions and current water quality data, the assessors were able to rank phosphorus, chlorophyll-*a*, and Secchi disk transparency values for each lake class into categories ranging from excellent to poor.

These data along with data corresponding to statewide natural lake means, historic, current, and average data from Mann Lake is displayed in Figures 3.1-3 - 3.1-7. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-*a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

Mann Lake Water Quality Analysis

TSI Parameters

The historic water quality data that exists for Mann Lake is minimal, so it is impossible to complete a long-term trend analysis. This is unfortunate because having an understanding of how the lake has changed over time is interesting and leads to sounder management decisions. It also provides a scientific basis behind anecdotal claims of a lake "getting worse" or "getting better". As part of this study, Mann Lake stakeholders were asked how they perceived the water quality of the lake. About 50% of respondents indicated they believe the water quality is "Fair", while 25% responded "Very Poor" to "Poor" and 25% responded "Good" (Appendix B, Question #15). When asked if water quality conditions had changed since they first visited the lake, responses were quite mixed with 50% indicating they lake had "Severely" or "Somewhat" degraded, 19% responding the lake had "Somewhat" or "Greatly" improved, 25% stating the lake had remained the same and 6% of respondents indicating they were "Unsure" (Question #16).

As described above, three water quality parameters are of most interest in a planning project such as this; total phosphorus, chlorophyll-*a*, and Secchi disk transparency. Total phosphorus data from Mann Lake are contained in Figure 3.1-3. A weighted average across the two available years of data indicates that summer concentrations are comparable to the median concentration for similar shallow, headwater drainage lakes across the state of Wisconsin, but higher than the median value for lakes within the Northern Lakes and Forests ecoregion (Figure 3.1-3). Overall, phosphorus levels in Mann Lake can be described as ranking in the WQI category of *Excellent* to *Good* for this parameter.

Total phosphorus surface and bottom lake concentrations are compared in Figure 3.1-4. In August 2014 and February 2015, the bottom phosphorus concentrations were much greater than the relatively low surface concentrations. During these periods, anoxic conditions were recorded near the bottom of the lake through measurement of dissolved oxygen (refer to Figure 3.1-9 and associated text). This is an indication of hypolimnetic nutrient recycling, or internal nutrient loading, which is a process discussed in the Primer Section above. This process may be contributing some phosphorus to Mann Lake's water column; as this phosphorus is released from the sediment, it can mix with the overlying epilimnetic waters when the lake breaks stratification. The area of hypoxia (and thus the area of higher phosphorus) was quite small in August however, so it is possible that when this phosphorus is released to surface waters the impact may be minimal. On some occasions, late summer algae blooms may be observed.

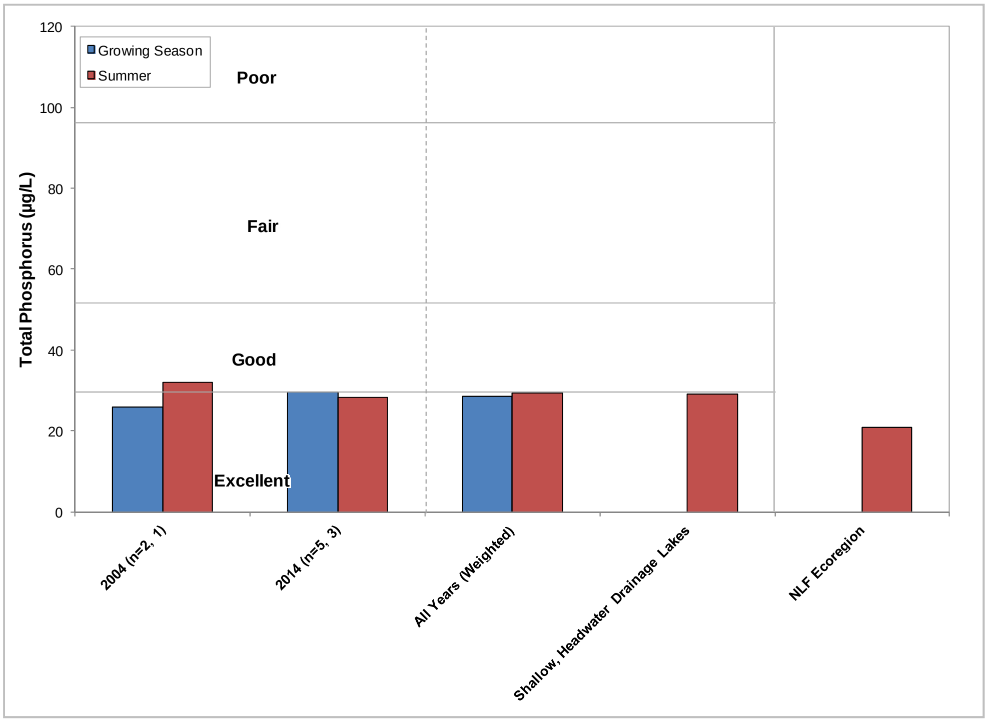


Figure 3.1-3. Mann Lake, state-wide class 2 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

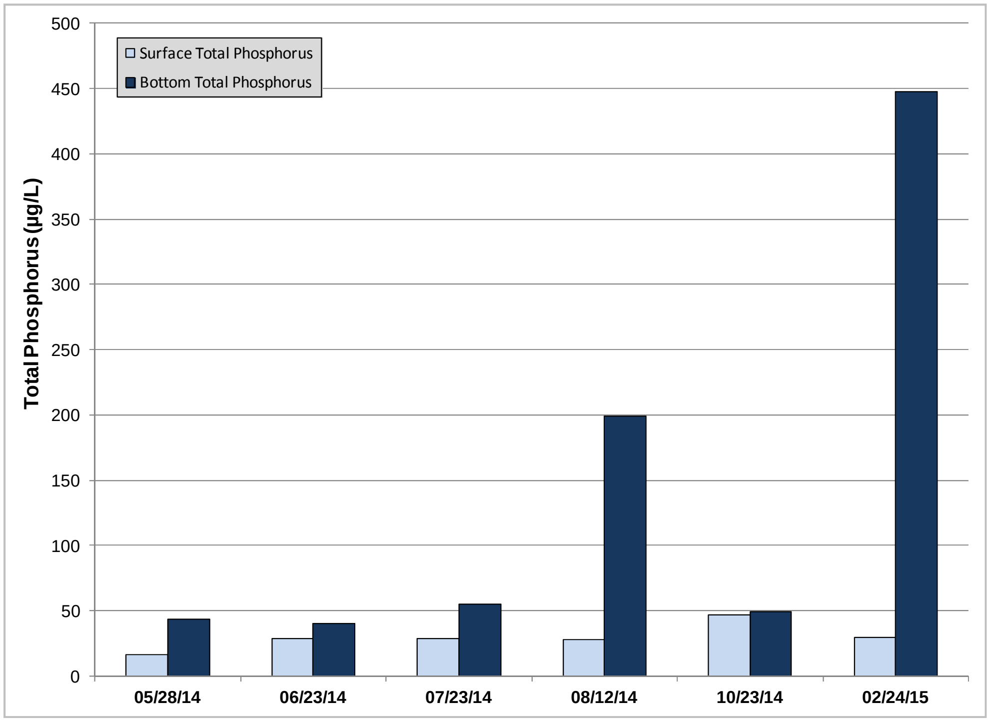


Figure 3.1-4. Mann Lake surface and bottom total phosphorus concentrations, 2014-2015. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Like total phosphorus, chlorophyll-*a* data has been collected from Mann Lake in two separate years; 2004 and 2014. A weighted mean across these years suggests that the concentration of algae in Mann Lake is slightly higher than the median value for similar lakes across the state and also higher than lakes within the Northern Lakes and Forests ecoregion (Figure 3.1-5). However, these values still fall into a category of *Excellent* for the lake type (shallow, headwater drainage lakes).

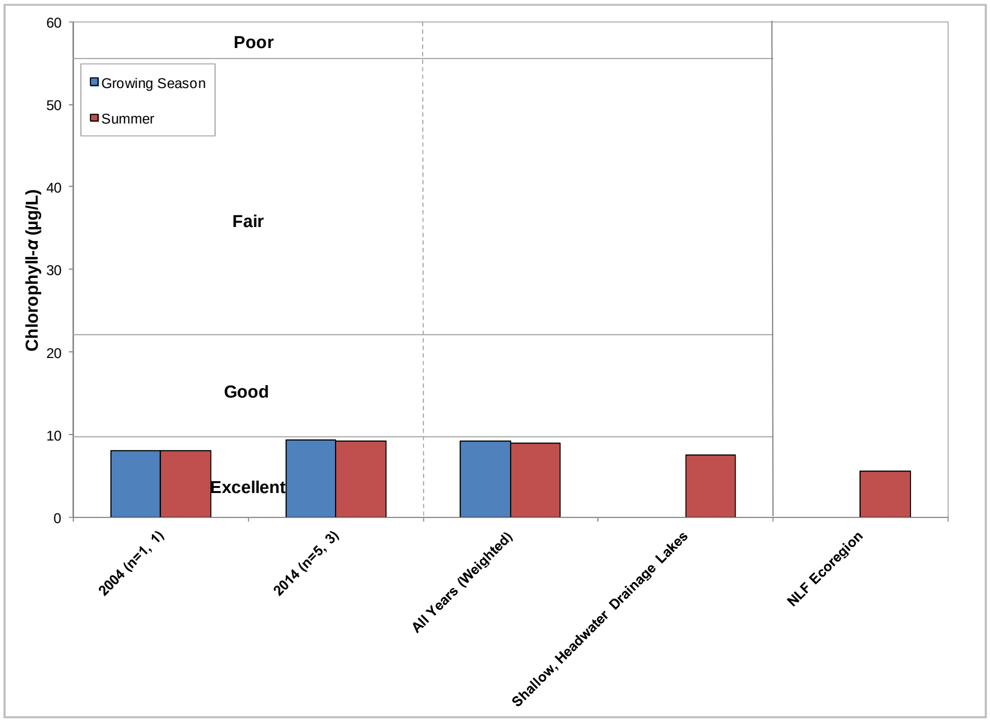


Figure 3.1-5. Mann Lake, state-wide class 2 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

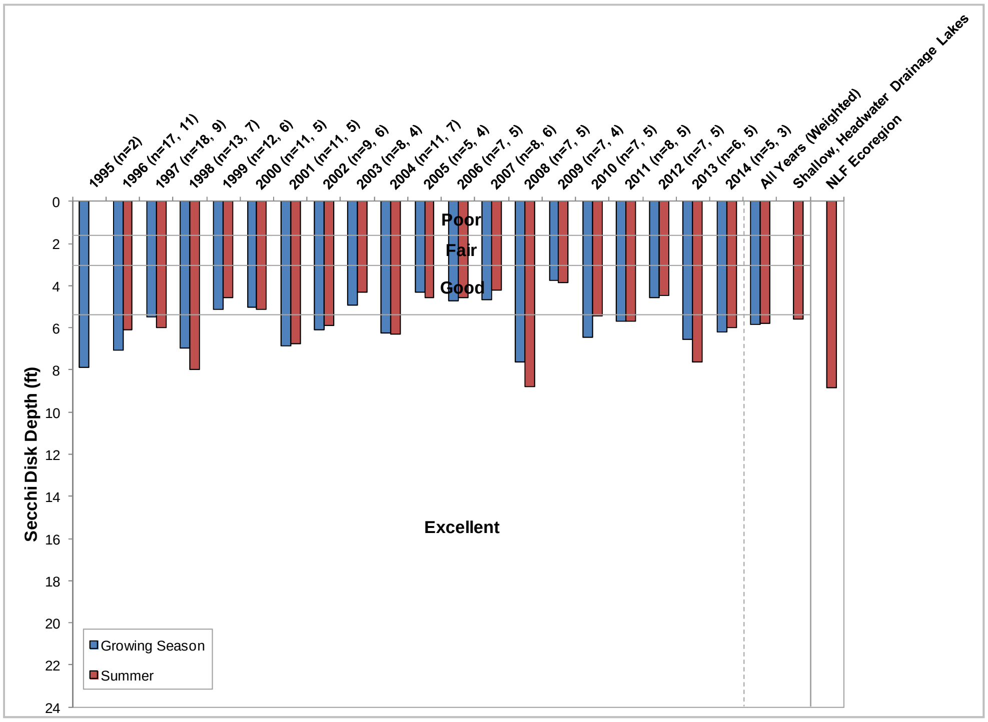


Figure 3.1-6. Mann Lake, state-wide class 2 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Considerably more historical data exists for the third primary water quality parameter – Secchi disk clarity. For a number of years, these data were collected by a volunteer on the lake through the Citizen Lake Monitoring Network, a state-sponsored, volunteer-based monitoring program. In general, these data show that the water clarity in Mann Lake can be described as *Good* to *Excellent* in most years (Figure 3.1-6). The data are comparable to the median value for other shallow, headwater drainage lakes in the state but are less than what is typically seen in the northern lakes and forests ecoregion.

Although water clarity is dependent upon a variety of environmental factors, one of the primary factors determining the clarity of a lake is algal abundance. As stated earlier, phosphorus, algae and water clarity have a very inter-related relationship; as phosphorus increases, we expect algae abundance (chlorophyll-a) to increase as well. With more algae in the water column, clarity should decrease. This relationship is exhibited well in Figure 3.1-7. As phosphorus increased from May to June, an increase in chlorophyll-*a* was also seen, as was a decrease in water clarity. As chlorophyll-*a* was observed to decrease in July and August, clarity increased slightly. In October, during the fall mixing period, total phosphorus was measured at its highest level. With that, chlorophyll-*a* increased and water clarity decreased as well.

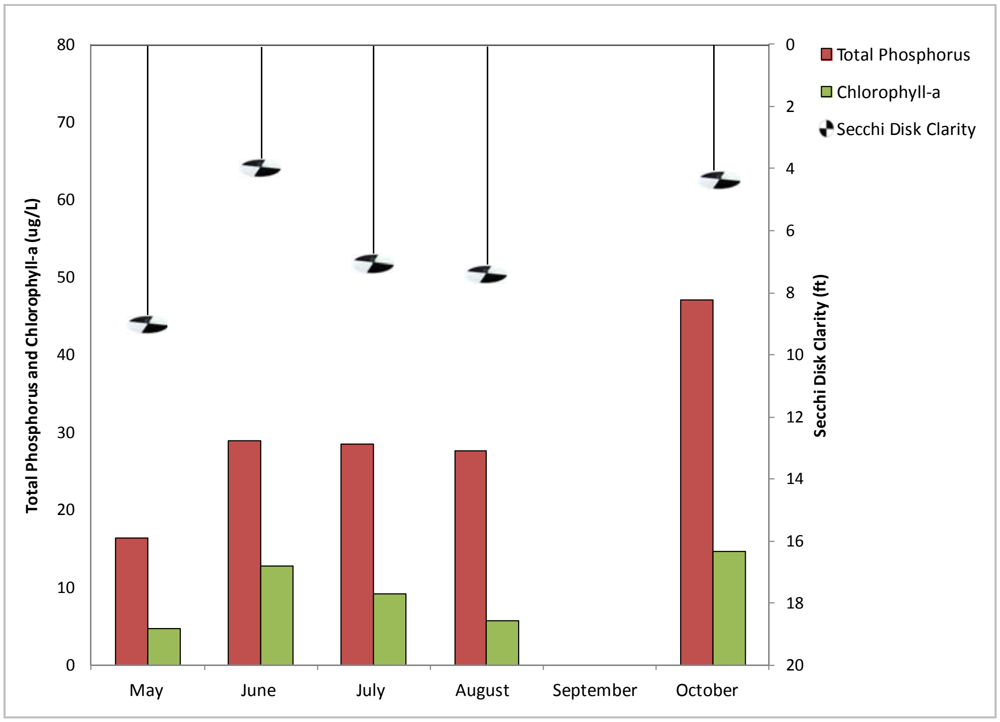


Figure 3.1-7. Mann Lake water quality parameter monthly averages, 2015. Values calculated with summer month surface sample data. No data was collected in September.

The clarity of the water in Mann Lake is also influenced partly by dissolved organic acids that are transported to the lake from the area's wetlands. These weak, natural acids (sometimes called "tannins") are the byproduct of decomposition of organic matter, particularly debris from pine trees. This is often the cause of water in lakes taking on a "root beer" or "tea" color.

"True color" measures the dissolved organic materials in water. Water samples collected in 2014 were measured for this parameter, and were found to be at 15 Platinum-cobalt units (Pt-co units, or PCU) in April and 20 Pt-co in July. Lillie and Mason (1983) categorized lakes with 0-40 PCU as having "low" color, 40-100 PCU as "medium" color, and >100 PCU as high color. In other words, the higher a PCU value is, the more a lake's water clarity may be impacted.

Limiting Plant Nutrient of Mann Lake

Using midsummer nitrogen and phosphorus concentrations from Mann Lake, a nitrogen:phosphorus ratio of 21:1 was calculated. This finding indicates that Mann Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Mann Lake Trophic State

Figure 3.1-8 contain the TSI values for Mann Lake. The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from mid mesotrophic to lower eutrophic. In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, it can be concluded that Mann Lake is in a lower eutrophic state.

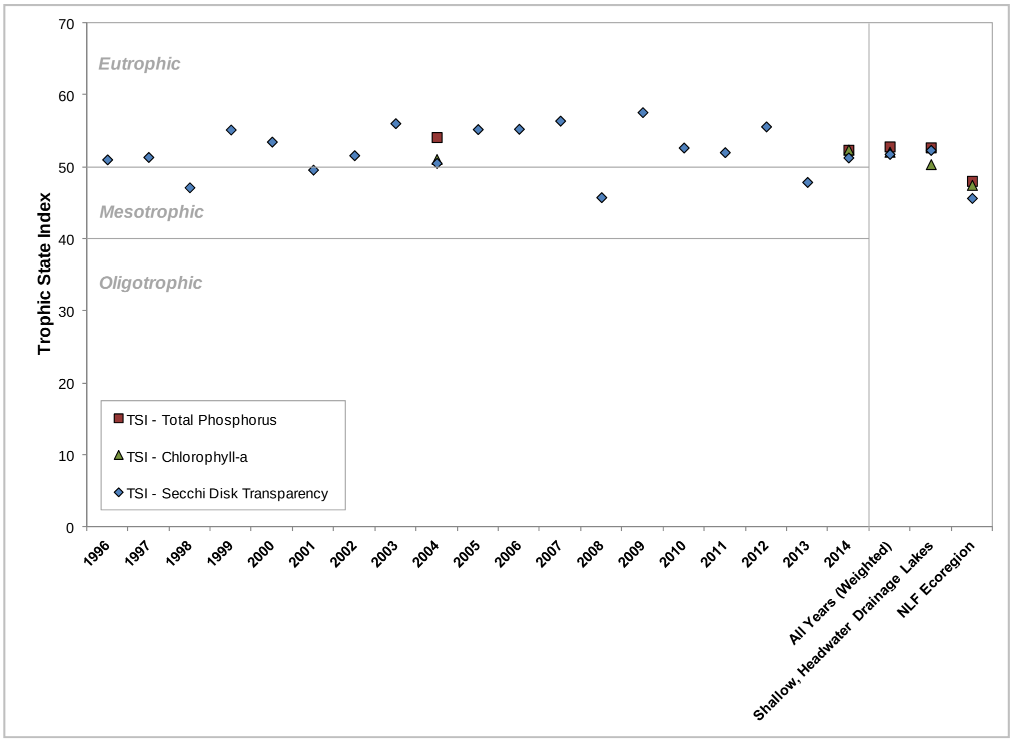


Figure 3.1-8. Mann Lake, state-wide class 2 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Mann Lake

Dissolved oxygen and temperature were measured during water quality sampling visits to Mann Lake by Onterra staff. Profiles depicting these data are displayed in Figure 3.1-9. Most Wisconsin lakes mix during the spring and fall, when changing water temperatures and winds break down any thermal differences that existed between the upper layers of water (epilimnion) and the bottom layers of water (hypolimnion). During the summer, the epilimnion will warm while the bottom of the lake may not. During this time a temperature gradient may form, as observed in the July and August profile. Summer winds may mix the water column at some point and disperse these thermal gradients. The oxygen reduction that takes place in the summer is due to bacteria breaking down organic matter that is found at the bottom of the lake.

During the winter, thermal stratification will occur except in the opposite manner as it does in the summer. Water is most dense at 4°C, so water of this temperature may be found at the bottom of the lake while the coldest water is found at the surface, in the solidified form we know as ice. Dissolved oxygen may decrease during this time as bacteria decompose organic material near the bottom of the lake. The ice cover reduces reintroduction of oxygen from the atmosphere. In February of 2015, dissolved oxygen was found to be quite low – low enough to stress or cause mortality in most Wisconsin game fish species.

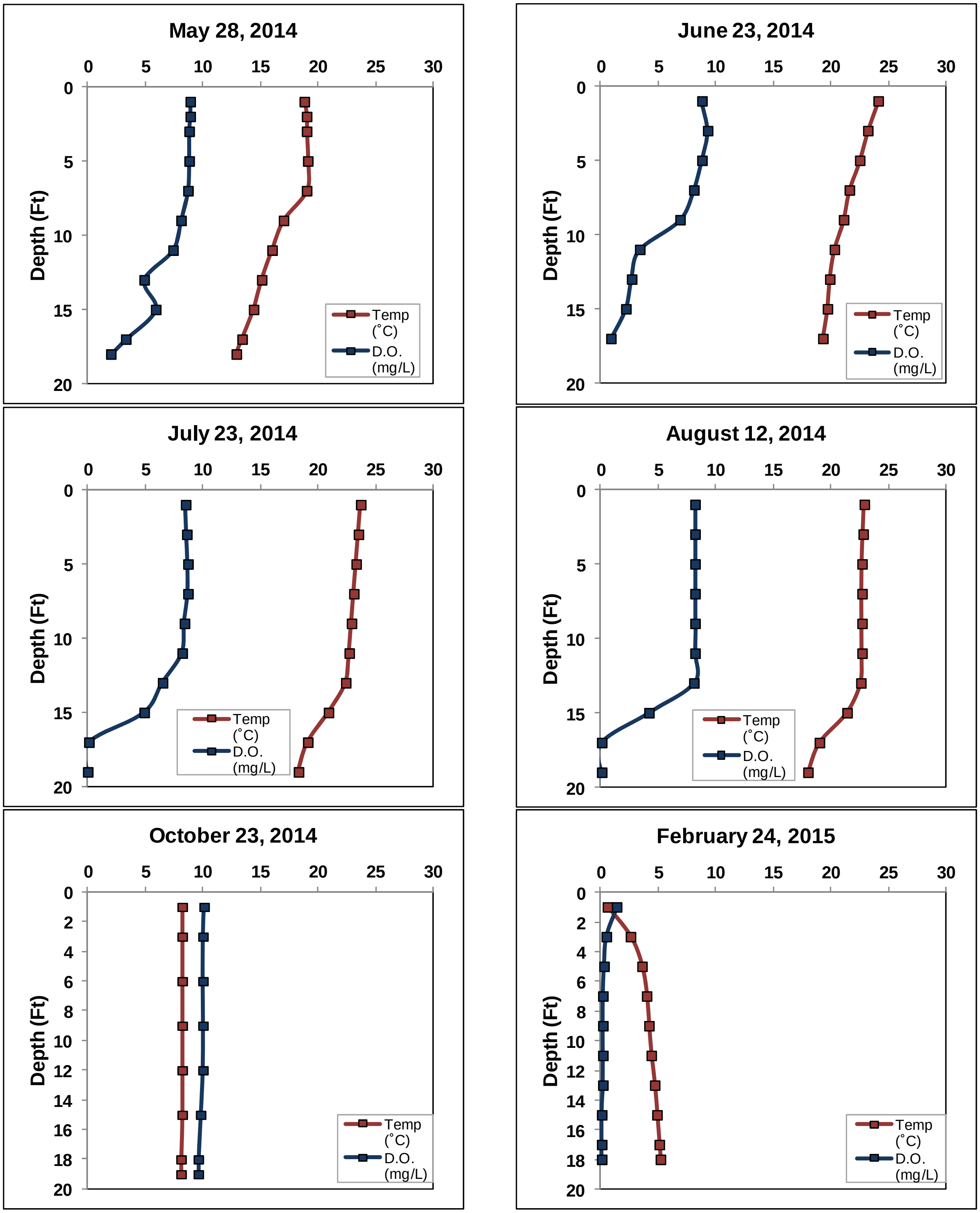


Figure 3.1-9. Mann Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Mann Lake

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Mann Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw and Nimphius 1985). The pH of the water in Mann Lake was measured at 7.9 in May of 2014 and 8.3 in July of 2014. These values are slightly above neutral and falls within the normal range for Wisconsin Lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Mann Lake was measured at 53.0 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and is not sensitive to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Mann Lake's pH of 7.9-8.3 falls within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Mann Lake was found to be 14.7 mg/L, falling within the range for zebra mussel suitability.

Researchers at the University of Wisconsin - Madison have developed an AIS suitability model called smart prevention (Vander Zanden and Olden 2008). In regards to zebra mussels, this model relies on measured or estimated dissolved calcium concentration to indicate whether a given lake in Wisconsin is suitable, borderline suitable, or unsuitable for sustaining zebra mussels. Within this model, suitability was estimated for approximately 13,000 Wisconsin waterbodies and is displayed as an interactive mapping tool (www.aissmartprevention.wisc.edu).

Based upon this analysis, Mann Lake was considered borderline suitable for mussel establishment.

Plankton tows were completed by Onterra staff during the summer of 2014 and these samples were processed by the WDNR for larval zebra mussels. No zebra mussel veligers (larval form of zebra mussels) were found within these samples.

3.2 Watershed Assessment

Watershed Modeling

A lake's flushing rate is simply a determination of the time required for the lake's water volume to be completely exchanged. Residence time describes how long a volume of water remains in the lake and is expressed in days, months, or years. The parameters are related and both determined by the volume of the lake and the amount of water entering the lake from its watershed. Greater flushing rates equal shorter residence times.

Two aspects of a lake's watershed are the key factors in determining the amount of phosphorus the watershed exports to the lake; 1) the size of the watershed, and 2) the land cover (land use) within the watershed. The impact of the watershed size is dependent on how large it is relative to the size of the lake. The watershed to lake area ratio (WS:LA) defines how many acres of watershed drains to each surface-acre of the lake. Larger ratios result in the watershed having a greater role in the lake's annual water budget and phosphorus load.

The type of land cover that exists in the watershed determines the amount of phosphorus (and sediment) that runs off the land and eventually makes its way to the lake. The actual amount of pollutants (nutrients, sediment, toxins, etc.) depends greatly on how the land within the watershed is used. Vegetated areas, such as forests, grasslands, and meadows, allow the water to permeate the ground and do not produce much surface runoff. On the other hand, agricultural areas, particularly row crops, along with residential/urban areas, minimize infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased phosphorus and pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations. For these reasons, it is important to maintain as much natural land cover (forests, wetlands, etc.) as possible within a lake's watershed to minimize the amount runoff (nutrients, sediment, etc.) from entering the lake.

In systems with lower WS:LA ratios, land cover type plays a very important role in how much phosphorus is loaded to the lake from the watershed. In these systems the occurrence of agriculture or urban development in even a small percentage of the watershed (less than 10%) can unnaturally elevate phosphorus inputs to the lake. If these land cover types are converted to a cover that does not export as much phosphorus, such as converting row crop areas to grass or forested areas, the phosphorus load and its impacts to the lake may be decreased. In fact, if the phosphorus load is reduced greatly, changes in lake water quality may be noticeable, (e.g. reduced algal abundance and better water clarity) and may even be enough to cause a shift in the lake's trophic state.

In systems with high WS:LA ratios, like those 10-15:1 or higher, the impact of land cover may be tempered by the sheer amount of land draining to the lake. Situations actually occur where lakes with completely forested watersheds have sufficient phosphorus loads to support high rates of plant production. In other systems with high ratios, the conversion of vast areas of row crops to vegetated areas (grasslands, meadows, forests, etc.) may not reduce phosphorus loads sufficiently to see a change in plant production. Both of these situations occur frequently in impoundments.

Regardless of the size of the watershed or the makeup of its land cover, it must be remembered that every lake is different and other factors, such as flushing rate, lake volume, sediment type, and many others, also influence how the lake will react to what is flowing into it. For instance, a deeper lake with a greater volume can dilute more phosphorus within its waters than a less voluminous lake and as a result, the production of a lake is kept low. However, in that same lake, because of its low flushing rate (a residence time of years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time and lead to a problem such as internal nutrient loading. On the contrary, a lake with a higher flushing rate (low residence time, i.e., days or weeks) may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

A reliable and cost-efficient method of creating a general picture of a watershed's affect on a lake can be obtained through modeling. The WDNR created a useful suite of modeling tools called the Wisconsin Lake Modeling Suite (WiLMS). Certain morphological attributes of a lake and its watershed are entered into WiLMS along with the acreages of different types of land cover within the watershed to produce useful information about the lake ecosystem. This information includes an estimate of annual phosphorus load and the partitioning of those loads between the watershed's different land cover types and atmospheric fallout entering through the lake's water surface. WiLMS also calculates the lake's flushing rate and residence times using county-specific average precipitation/evaporation values or values entered by the user. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

Mann Lake Watershed

Mann Lake's watershed consists of nearly 2,000 acres, much of which is contained within the state-owned Northern Highland American Forest (Map 2). The WDNR lists Mann Lake as a spring lake; spring lakes typically do not have a tributary inlet but often do have an outlet stream. Spring lakes receive the majority of their water from groundwater inputs, while also receiving direct precipitation and overland flow from their surrounding watershed. As indicated on Map 2, Mann Lake does have a small tributary connection with a wetland, located to the north of the lake. This tributary drains approximately 344 acres of wetland and forested land. While this waterway likely does not flow year-round, it is highly likely that spring snow-melt and precipitation events would move water from these wetlands into the lake. This would help explain the lakes slightly stained water; the abundant organic material from this wetland is likely contributing to the staining. With a tributary stream, Mann Lake would be classified not as a spring lake, but as a drainage lake. Because of its unique situation, Mann Lake is more closely aligned with the definition of a drainage lake.

The land within Mann Lake's watershed is largely undeveloped, with 72% of it consisting of forest, 15% as wetlands and less than 1% of pasture/grass land (Figure 3.1-2). The surface water of Mann Lake makes up the remaining 13%. The watershed land to lake area ratio is roughly 7:1. Recall from above that lakes with smaller watershed to lake area ratios may be more sensitive to land developed, so it is fortunate that there is a relatively small amount in this watershed. With the amount of land draining towards the lake, WiLMS calculated that Mann Lake is able to completely exchange its volume of water 1.5 times per year (lake flushing rate).

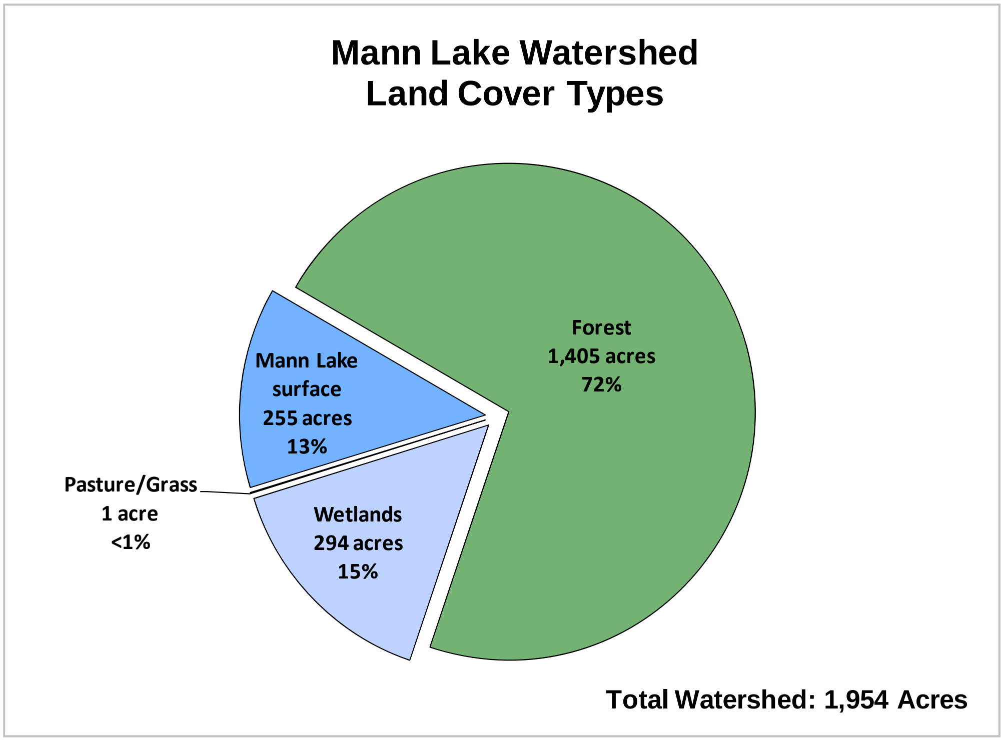


Figure 3.2-1. Mann Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

Modeling of the Mann Lake watershed was conducted using the lake response model WiLMS. The model predicted external phosphorus sources from the watershed to total roughly 210 lbs annually. Forested land, at 72% of the watershed's landcover, exports the highest amount of phosphorus to the lake at 112 lbs (Figure 3.2-2). The Mann Lake surface collects 22% of the annual load through atmospheric deposition, wetlands contribute 9%, and pasture/grass and septic sources make up negligible amounts to the overall annual phosphorus load. It is theorized that there are an additional 93 lbs contributed to the lake's phosphorus budget annually; this is discussed further below.

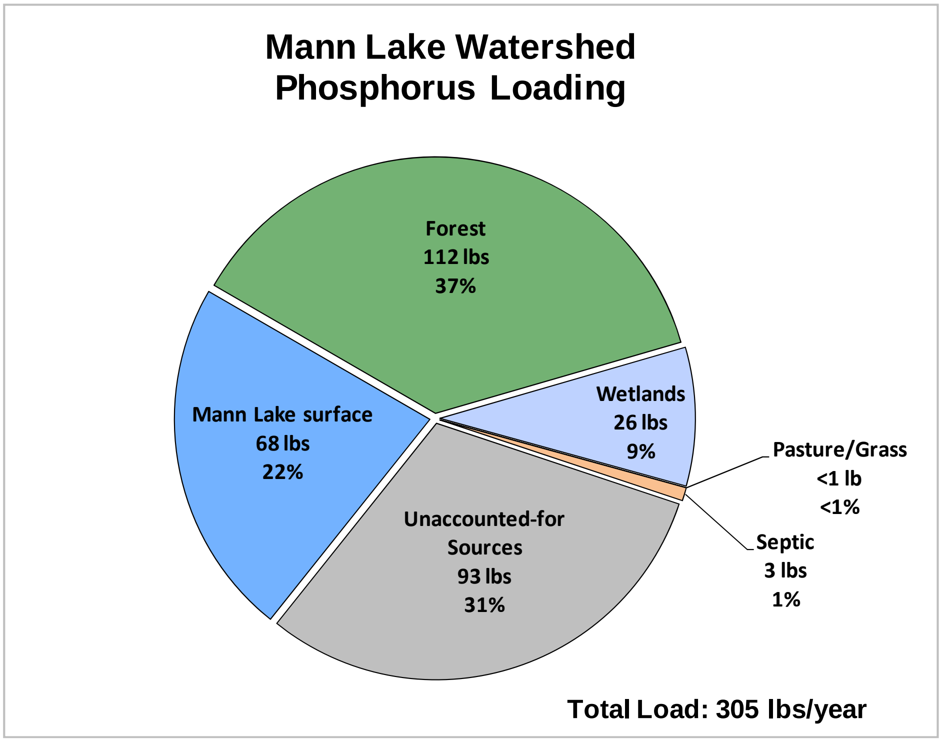


Figure 3.2-2. Mann Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

WiLMS Calibration and Phosphorus Source Discussion

During modeling procedures, WiLMS compares observed (measured in the field) and predicted (model-calculated) growing season mean and spring overturn phosphorus concentrations to determine the accuracy of the model. The growing season mean phosphorus concentration is defined as the mean of all surface water data collected from March 31-November 1. The spring overturn phosphorus concentration is defined as the concentration of phosphorus that is collected while the lake is completely mixed, as it was during the May 28, 2014 water quality visit by Onterra staff. This value is a good representation of the phosphorus content of the lake, because during this time the water is thoroughly mixed which means phosphorus is fairly similar within the entire water column.

Utilizing land cover types proportions and hydrologic data, WiLMS was able to predict what the phosphorus content of Mann Lake should be and then compare these values to observed values obtained through water quality sampling. A predictive equation within WiLMS (Canfield-Bachman, 1981) estimated that the growing season mean value should be most likely 22 µg/L in Mann Lake, with an upper range of 43.0 µg/L. Comparatively, Mann Lake's observed growing season mean phosphorus concentration was found to be 29.7 µg/L. The observed value is higher than what is expected, given Mann Lake's volume and watershed specifics. Essentially this indicates that WiLMS modeling could not account for additional phosphorus that is present in Mann Lake. Back-calculations of Canfield Bachman's 1981 predictive equation indicate that roughly 93 lbs of phosphorus is unaccounted-for within the Mann Lake WiLMS model, which would contribute an extra 31% to the overall phosphorus load. There are several possible sources that may be attributed to this unaccounted-for phosphorus load. These often include 1) development of the immediate shoreland, 2) septic systems located near the lake, 3) groundwater contributions or 4) internal nutrient cycling from the bottom sediments of the lake.

Shoreland development

As discussed in the Shoreland Assessment Section, Mann Lake's shoreland contains very few developed areas. As a result, it is highly unlikely that this source area produces additional phosphorus to Mann Lake beyond what would be expected from a natural, forested shoreland. Developed shorelands allow more surface water runoff of nutrients and sediments to occur when compared to their natural counterparts due to the removal of shoreline vegetation and inclusion of impervious cover such as lawns or pavement, which facilitate higher runoff rates.

Septic systems

Septic systems within the lake's watershed can leach phosphorus which may make its way into a lake. Mann Lake has very few residences, and the stakeholder survey revealed that a small percentage of those residences are occupied more than a few months out of the year. Further, the majority of residents have their system pumped the recommended every 2-4 years (Stakeholder Survey, Appendix B, Question #6). Thus, it is highly unlikely that septic systems are even partially responsible for this additional phosphorus.

Groundwater

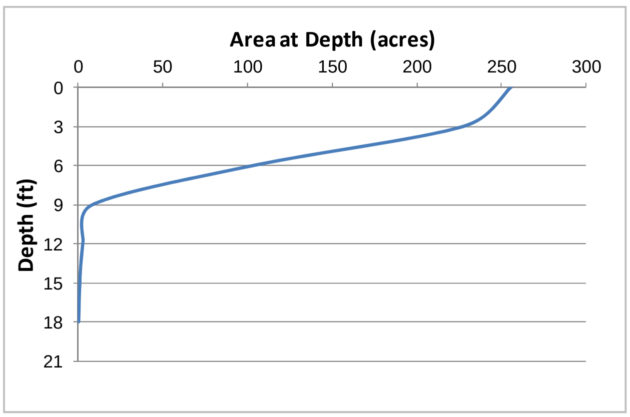
The mobility of phosphorus in shallow groundwater is a complex matter that is highly dependent on local soil types, soil pH, soil redox potential (a measurement of how easily a substance loses or gains electrons in a chemical reaction) and other factors. Traditionally, phosphorus was not believed to transport through groundwater that well. The reason for this is that phosphorus is adsorbed very efficiently, binding with sediment particles, clay minerals, iron manganese and aluminum hydroxides and calcium carbonate coating present on sediment particles. All of these elements are common in the geologic/soil setting. Sorption of phosphorus occurs more efficiently in finer-grained sediments, largely due to the larger overall surface area. Within coarser-grained soils, the flow velocity is higher so contact time between phosphorus molecules and sediment particles is decreased, limiting adsorption. There is a limit to soil adsorption though; once the capacity of soil phosphorus adsorption is exceeded, excess phosphorus may dissolve and move freely within groundwater. This process may occur primarily in soils that become saturated with high inputs of phosphorus, including areas that are inundated with fertilizers or sewage/animal waste.

Though it has traditionally been thought that phosphorus mobility through soils is minimal and thus that this is a small source area to lakes, some studies have shown this is not the case. Meinikmann et al. (2015) and McCobb et al. (2003) have documented man-derived phosphorus plumes that were determined to cause eutrophication in nearby receiving waterbodies. Natural groundwater sources of phosphorus can occur in areas with high-phosphorus containing bedrock. Natural sources of high phosphorus have even been found in a Vilas County lake (Muskellunge Lake, Robertson et al. 2003). Currently, it is not known what the groundwater's contribution to the nutrient budget of Mann Lake is.

Sediment Resuspension

The role of sediment resuspension and nutrient movement from the sediment to the water column is dependent upon many factors. Sediment suspension may occur from winds which stir up the lake bottom, particularly in shallower regions of the lake. As sediment disruption occurs, nutrients that are bound to that sediment may be released into the water column. Kaitaranta et al (2013) found that sediment resuspension was dampened by both submergent and emergent vegetation, with the latter being more effective at this dampening effect. However, resuspension potential of sediments was found to be highly dependent upon sediment properties as well as physical weather and lake properties such as wind speed, direction, lake surface area and orientation, as well as others.

It is likely there is some sediment resuspension occurring in Mann Lake. The lake has a fetch (maximum distance wind may travel over a lake without interruption from land) of nearly 1.5 miles. Additionally, Figure 3.2-2 indicates that a great proportion of the lake is relatively shallow; nearly 60% of the lake is 6 feet or shallower, and this area at 9 feet of depth is nearly 97%. Mann Lake holds ample aquatic vegetation up until about 7-8 feet of depth, with sparse vegetation occurring in deeper water up to 12 feet. These plants may damper wind effects in some areas, but much open sediment does exist over 11 feet of depth. The amount of wind resuspension occurring on Mann Lake is difficult to quantify, thus its contribution to the nutrient budget is unknown at this time.



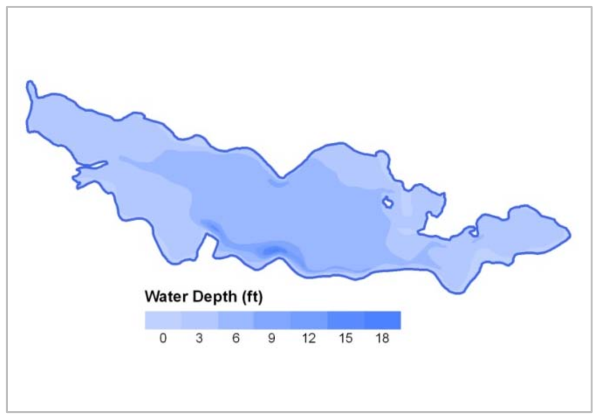


Figure 3.2-3. Mann Lake hypsographic curve and bathymetry

Internal Nutrient Cycling

As discussed within the Water Quality Section, some lakes experience a nutrient "recycling" called internal nutrient loading. Internal nutrient loading occurs when anoxia develops near the bottom sediments of a lake. Iron, which is naturally found in lake sediments and soil, will bind with phosphorus in the presence of oxygen. However, in an anoxic state, iron will release phosphorus into the overlying water. Often, this will occur when bacteria have depleted oxygen from the hypolimnion of the lake while the epilimnion still remains oxygen-rich; at this point the lake is stratified. The phosphorus will remain in the anoxic hypolimnion until the lake mixes. When it does so, phosphorus from the hypolimnion can be released into the epilimnion. Essentially, this recycles phosphorus once removed from the water column back into it.

In lakes that have internal nutrient loading, this process may occur every time a lake stratifies and then mixes. Depending on many factors such as lake depth and morphometry, a lake may mix twice a year, many times a year, or perhaps not at all. The Osgood Index is a measure relating a lake's volume to its surface area and is used to determine whether a lake is dimictic or polymictic. Dimictic lakes completely mix or turnover two times per year, once in spring and again in fall; while polymictic lakes have the potential to turn over multiple times per year depending upon air temperatures and wind events. The Osgood Index uses a ratio of mean depth to square root of lake surface area (mean depth (meters) divided by the square root of lake surface area (square kilometers)). Lakes with values exceeding 6 are considered strongly stratified and have little chance of destratification during summer months (dimictic). Lakes with lower values (less than 6) may stratify and turn over multiple times (polymictic). Mann Lake has a calculated Osgood Index value of 1.6, indicating that it is very likely polymictic. Lakes that are polymictic may not necessarily stratify multiple times in a year however; this is largely dependent upon wind conditions.

It is possible that internal nutrient loading may be playing a contributing role to the unaccounted-for phosphorus that is present in Mann Lake. Higher hypolimnetic phosphorus concentrations were observed during August of 2014 and February of 2015 (Figure 3.1-4, Water Quality Section). However, the area of anoxic sediments within the lake during August 2014 would be roughly 0.25 acres, and the volume of water in this area less than a few acre-feet. This means that once the lake was destratified, there would not be a great amount of phosphorus mixed within the upper water column from the hypolimnion. Further, if this destratification did not occur until late summer or fall, the water may be colder and the impacts of the extra phosphorus (algae blooms, etc.) may not be realized. This is a generalized assessment based upon the evidence collected in 2014 though; it is possible that larger areas of hypoxia and subsequent nutrient release develop in Mann Lake in other years. These occasions may be marked by the onset of mid to late summer algae blooms.

In short, the available data and baseline-screening nature of this project fall short of providing a complete answer to the full sources of phosphorus to Mann Lake. Before a more in-depth knowledge of the nutrient sources to the lake can be obtained, further studies would need to be completed on the lake and its watershed to fully inventory potential sources and accurately quantify the amount of phosphorus being delivered from these sources. What is currently known is that the lake is productive, likely due to a number of the abovementioned processes. This production fuels dense aquatic plant growth, but the water quality of the lake still may be considered in a healthy state.

3.3 Shoreland Condition

The Importance of a Lake's Shoreland Zone

One of the most vulnerable areas of a lake's watershed is the immediate shoreland zone (approximately from the water's edge to at least 35 feet shoreland). When a lake's shoreland is developed, the increased impervious surface, removal of natural vegetation, and other human practices can severely increase pollutant loads to the lake while degrading important habitat. Limiting these anthropogenic (man-made) effects on the lake is important in maintaining the quality of the lake's water and habitat.

The intrinsic value of natural shorelands is found in numerous forms. Vegetated shorelands prevent polluted runoff from entering lakes by filtering this water or allowing it to slow to the point where particulates settle. The roots of shoreland plants stabilize the soil, thereby preventing shoreland erosion. Shorelands also provide habitat for both aquatic and terrestrial animal species. Many species rely on natural shorelands for all or part of their life cycle as a source of food, cover from predators, and as a place to raise their young. Shorelands and the nearby shallow waters serve as spawning grounds for fish and nesting sites for birds. Thus, both the removal of vegetation and the inclusion of development reduces many forms of habitat for wildlife.

Some forms of development may provide habitat for less than desirable species. Disturbed areas are often overtaken by invasive species, which are sometimes termed "pioneer species" for this reason. Some waterfowl, such as geese, prefer to linger upon open lawns near waterbodies because of the lack of cover for potential predators. The presence of geese on a lake resident's beach may not be an issue; however the feces the geese leave are unsightly and pose a health risk. Geese feces may become a source of fecal coliforms as well as flatworms that can lead to swimmers itch. Development such as rip rap or masonary, steel or wooden seawalls completely remove natural habitat for most animals, but may also create some habitat for snails; this is not desirable for lakes that experience problems with swimmers itch, as the flatworms that cause this skin reaction utilize snails as a secondary host after waterfowl.

In the end, natural shorelines provide many ecological and other benefits. Between the abundant wildlife, the lush vegetation, and the presence of native flowers, shorelands also provide natural scenic beauty and a sense of tranquility for humans.

Shoreland Zone Regulations

Wisconsin has numerous regulations in place at the state level which aim to enhance and protect shorelands. Additionally, counties, townships and other municipalities have developed their own (often more comprehensive or stronger) policies. At the state level, the following shoreland regulations exist:

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted more strict shoreland ordinances. Passed in February of 2010, a revised NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances of their own. The revised NR 115 was once again examined in 2012 after some Wisconsin counties identified some provisions that were unclear or challenging to implement. The revisions proposed through Board Order WT-06-12 went into effect in December of 2013. These policy regulations require each county a ordinances for vegetation removal on shorelands, impervious surface standards, nonconforming structures and establishing mitigation requirements for development. Minimum requirements for each of these categories are as follows:

- Vegetation Removal: For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed the lesser of 30 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. No permit is required for removal of vegetation that meets any of the above criteria. Vegetation removed must be replaced by replanting in the same area (native species only).

- Impervious surface standards: The amount of impervious surface is restricted to 15% of the total lot size, on lots that are entirely within 300 feet of the ordinary high-water mark of the waterbody. A county may allow more than 15% impervious surface on a residential lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner. Counties may develop an ordinance, providing higher impervious surface standards, for highly developed shorelines.

- Nonconforming structures: Nonconforming structures are structures that were lawfully placed when constructed but do not comply with distance of water setback. Originally, structures within 75 ft of the shoreline had limitations on structural repair and expansion. New language in NR-115 allows construction projects on structures within 75 feet with the following caveats:
    - No expansion or complete reconstruction within 0-35 feet of shoreline
    - Re-construction may occur if no other build-able location exists within 35-75 feet, dependent on the county.
    - Construction may occur if mitigation measures are included either within the footprint or beyond 75 feet.
    - Vertical expansion cannot exceed 35 feet

- Mitigation requirements: New language in NR-115 specifies mitigation techniques that may be incorporated on a property to offset the impacts of impervious surface, replacement of nonconforming structure, or other development projects. Practices such as buffer restorations along the shoreland zone, rain gardens, removal of fire pits, and beaches all may be acceptable mitigation methods, dependent on the county.

- For county-specific requirements on this topic, it is recommended that lake property owners contact the county's regulations/zoning department.

<u>Wisconsin Act 31</u>

While not directly aimed at regulating shoreland practices, the State of Wisconsin passed Wisconsin Act 31 in 2009 in an effort to minimize watercraft impacts upon shorelines. This act prohibits a person from operating a watercraft (other than personal watercraft) at a speed in excess of slow-no-wake speed within 100 feet of a pier, raft, buoyed area or the shoreline of a lake. Additionally, personal watercraft must abide by slow-no-wake speeds while within 200 feet of these same areas. Act 31 was put into place to reduce wave action upon the sensitive shoreland zone of a lake. The legislation does state that pickup and drop off areas marked with regulatory markers and that are open to personal watercraft operators and motorboats engaged in waterskiing/a similar activity may be exempt from this distance restriction. Additionally, a city, village, town, public inland lake protection and rehabilitation district or town sanitary district may provide an exemption from the 100 foot requirement or may substitute a lesser number of feet.

Shoreland Research

Studies conducted on nutrient runoff from Wisconsin lake shorelands have produced interesting results. For example, a USGS study on several Northwoods Wisconsin lakes was conducted to determine the impact of shoreland development on nutrient (phosphorus and nitrogen) export to these lakes (Graczyk et al. 2003). During the study period, water samples were collected from surface runoff and ground water and analyzed for nutrients. These studies were conducted on several developed (lawn covered) and undeveloped (undisturbed forest) areas on each lake. The study found that nutrient yields were greater from lawns than from forested catchments, but also that runoff water volumes were the most important factor in determining whether lawns or wooded catchments contributed more nutrients to the lake. Ground-water inputs to the lake were found to be significant in terms of water flow and nutrient input. Nitrate plus nitrite nitrogen and total phosphorus yields to the ground-water system from a lawn catchment were three or sometimes four times greater than those from wooded catchments.

A separate USGS study was conducted on the Lauderdale Lakes in southern Wisconsin, looking at nutrient runoff from different types of developed shorelands – regular fertilizer application lawns (fertilizer with phosphorus), non-phosphorus fertilizer application sites, and unfertilized sites (Garn 2002). One of the important findings stemming from this study was that the amount of dissolved phosphorus coming off of regular fertilizer application lawns was twice that of lawns with non-phosphorus or no fertilizer. Dissolved phosphorus is a form in which the phosphorus molecule is not bound to a particle of any kind; in this respect, it is readily available to algae. Therefore, these studies show us that it is a developed shoreland that is continuously maintained in an unnatural manner (receiving phosphorus rich fertilizer) that impacts lakes the greatest. This understanding led former Governor Jim Doyle into passing the Wisconsin Zero-Phosphorus Fertilizer Law (Wis Statue 94.643), which restricts the use, sale and display of lawn and turf fertilizer which contains phosphorus. Certain exceptions apply, but after April 1 2010, use of this type of fertilizer is prohibited on lawns and turf in Wisconsin. The goal of this action is to reduce the impact of developed lawns, and is particularly helpful to developed lawns situated near Wisconsin waterbodies.

Shorelands provide much in terms of nutrient retention and mitigation, but also play an important role in wildlife habitat. Woodford and Meyer (2003) found that green frog density was negatively correlated with development density in Wisconsin lakes. As development increased, the habitat for green frogs decreased and thus populations became significantly lower. Common loons, a bird species notorious for its haunting call that echoes across Wisconsin lakes, are often associated more so with undeveloped lakes than developed lakes (Lindsay et al. 2002). And studies on shoreland development and fish nests show that undeveloped shorelands are preferred as well. In a study conducted on three Minnesota lakes, researchers found that only 74 of 852 black crappie nests were found near shorelines that had any type of dwelling on it (Reed, 2001). The remaining nests were all located along undeveloped shoreland.

Emerging research in Wisconsin has shown that coarse woody habitat (sometimes called "coarse woody debris"), often stemming from natural or undeveloped shorelands, provides many ecosystem benefits in a lake. Coarse woody habitat describes habitat consisting of trees, limbs, branches, roots and wood fragments at least four inches in diameter that enter a lake by natural or human means. Coarse woody habitat provides shoreland erosion control, a carbon source for the lake, prevents suspension of sediments and provides a surface for algal growth which important for aquatic macroinvertebrates (Sass 2009). While it impacts these aspects considerably, one of the greatest benefits coarse woody habitat provides is habitat for fish species.

Coarse woody habitat has shown to be advantageous for fisheries in terms of providing refuge, foraging area as well as spawning habitat (Hanchin et al 2003). In one study, researchers observed 16 different species occupying coarse woody habitat areas in a Wisconsin lake (Newbrey et al. 2005). Bluegill and bass species in particular are attracted to this habitat type; largemouth bass stalk bluegill in these areas while the bluegill hide amongst the debris and often feed upon in many macroinvertebrates found in these areas, who themselves are feeding upon algae and periphyton growing on the wood surface. Newbrey et al. (2005) found that some fish species prefer different complexity of branching on coarse woody habitat, though in general some degree of branching is preferred over coarse woody habitat that has no branching.

With development of a lake's shoreland zone, much of the coarse woody habitat that was once found in Wisconsin lakes has disappeared. Prior to human establishment and development on lakes (mid to late 1800's), the amount of coarse woody habitat in lakes was likely greater than under completely natural conditions due to logging practices. However, with changes in the logging industry and increasing development along lake shorelands, coarse woody habitat has decreased substantially. Shoreland residents are removing woody debris to improve aesthetics or for recreational opportunities (boating, swimming, and, ironically, fishing).

National Lakes Assessment

Unfortunately, along with Wisconsin's lakes, waterbodies within the entire United States have shown to have increasing amounts of developed shorelands. The National Lakes Assessment (NLA) is an Environmental Protection Agency sponsored assessment that has successfully pooled together resource managers from all 50 U.S. states in an effort to assess waterbodies, both natural and man-made, from each state. Through this collaborative effort, over 1,000 lakes were sampled in 2007, pooling together the first statistical analysis of the nation's lakes and reservoirs.

Through the National Lakes Assessment, a number of potential stressors were examined, including nutrient impairment, algal toxins, fish tissue contaminants, physical habitat, and others. The 2007 NLA report states that "*of the stressors examined, poor lakeshore habitat is the biggest problem in the nations lakes; over one-third exhibit poor shoreline habitat condition*" (USEPA 2009). Furthermore, the report states that "*poor biological health is three times more likely in lakes with poor lakeshore habitat*".

The results indicate that stronger management of shoreline development is absolutely necessary to preserve, protect and restore lakes. This will become increasingly important as development pressured on lakes continue to steadily grow.

Native Species Enhancement

The development of Wisconsin's shorelands has increased dramatically over the last century and with this increase in development a decrease in water quality and wildlife habitat has occurred. Many people that move to or build in shoreland areas attempt to replicate the suburban landscapes they are accustomed to by converting natural shoreland areas to the "neat and clean" appearance of manicured lawns and flowerbeds. The conversion of these areas immediately leads to destruction of habitat utilized by birds, mammals, reptiles, amphibians, and insects (Jennings et al. 2003). The maintenance of the newly created area helps to decrease water quality by considerably increasing inputs of phosphorus and sediments into the lake. The negative impact of human development does not stop at the shoreland. Removal of native plants and dead, fallen timbers from shallow, near-shore areas for boating and swimming activities destroys habitat used by fish, mammals, birds, insects, and amphibians, while leaving bottom and shoreland sediments vulnerable to wave action caused by boating and wind (Jennings et al. 2003, Radomski and Goeman 2001, and Elias & Meyer 2003). Many homeowners significantly decrease the number of trees and shrubs along the water's edge in an effort to increase their view of the lake. However, this has been shown to locally increase water temperatures, and decrease infiltration rates of potentially harmful nutrients and pollutants. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife (Scheuerell and Schindler 2004).

In recent years, many lakefront property owners have realized increased aesthetics, fisheries, property values, and water quality by restoring portions of their shoreland to mimic its unaltered state. An area of shore restored to its natural condition, both in the water and on shore, is commonly called a shoreland buffer zone. The shoreland buffer zone creates or restores the ecological habitat and benefits lost by traditional suburban landscaping. Simply not mowing within the buffer zone does wonders to restore some of the shoreland's natural function.

Enhancement activities also include additions of submergent, emergent, and floating-leaf plants within the lake itself. These additions can provide greater species diversity and may compete against exotic species.

Cost

The cost of native, aquatic, and shoreland plant restorations is highly variable and depends on the size of the restoration area, the depth of buffer zone required to be restored, the existing plant density, the planting density required, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other sites may require erosion control stabilization measures, which could be as simple as using erosion control blankets and plants and/or seeds or more extensive techniques such as geotextile bags (vegetated retaining walls), geogrids (vegetated soil lifts), or bio-logs (see above picture). Some of these erosion control techniques may reduce the need for rip-rap or seawalls which are sterile environments that do nott allow for plant growth or natural shorelines. Questions about rip-rap or seawalls should be directed to the local Wisconsin DNR Water Resources Management Specialist. Other measures possibly required include protective measures used to guard newly planted area from wildlife predation, wave-action, and erosion, such as fencing, erosion control matting, and animal deterrent sprays. One of the most important aspects of planting is maintaining moisture levels. This is done by watering regularly for the first two years until plants establish themselves, using soil amendments (i.e., peat, compost) while planting, and using mulch to help retain moisture.

Most restoration work can be completed by the landowner themselves. To decrease costs further, bare-root form of trees and shrubs should be purchased in early spring. If additional assistance is needed, the lakefront property owner could contact an experienced landscaper. For properties with erosion issues, owners should contact their local county conservation office to discuss cost-share options.

In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $1,400. The more native vegetation a site has, the lower the cost. Owners should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:

- Spring planting timeframe.
- 100' of shoreline.
- An upland buffer zone depth of 35'.
- An access and viewing corridor 30' x 35' free of planting (recreation area).
- Planting area of upland buffer zone 2- 35' x 35' areas
- Site is assumed to need little invasive species removal prior to restoration.
- Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
- Trees and shrubs planted at a density of 1 tree/100 sq ft and 2 shrubs/100 sq ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
- Turf grass would be removed by hand.

- A native seed mix is used in bare areas of the upland buffer zone.
- An aquatic zone with shallow-water 2 - 5’ x 35’ areas.
- Plant spacing for the aquatic zone would be 3 feet.
- Each site would need 70’ of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- Soil amendment (peat, compost) would be needed during planting.
- There is no hard-armor (rip-rap or seawall) that would need to be removed.
- The property owner would maintain the site for weed control and watering.

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreland erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Once native plants are established, they require less water, maintenance, no fertilizer; provide wildlife food and habitat, and natural aesthetics compared to ornamental (non-native) varieties. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Mann Lake Shoreland Zone Condition

Shoreland Development

Mann Lake’s shoreland zone can be classified in terms of its degree of development. In general, more developed shorelands are more stressful on a lake ecosystem, while definite benefits occur from shorelands that are left in their natural state. Figure 3.3-1 displays a diagram of shoreland categories, from “Urbanized”, meaning the shoreland zone is completely disturbed by human influence, to “Natural/Undeveloped”, meaning the shoreland has been left in its original state.

Urbanized: This type of shoreland has essentially no natural habitat. Areas that are mowed or unnaturally landscaped to the water's edge and areas that are rip-rapped or include a seawall would be placed in this category.

Developed-Unnatural: This category includes shorelands that have been developed, but only have small remnants of natural habitat yet intact. A property with many trees, but no remaining understory or herbaceous layer would be included within this category. Also, a property that has left a small (less than 30 feet), natural buffer in place, but has urbanized the areas behind the buffer would be included in this category.

Developed-Semi-Natural: This is a developed shoreland that is mostly in a natural state. Developed properties that have left much of the natural habitat in state, but have added gathering areas, small beaches, etc within those natural areas would likely fall into this category. An urbanized shoreland that was restored would likely be included here, also.

Developed-Natural: This category includes shorelands that are developed property, but essentially no modifications to the natural habitat have been made. Developed properties that have maintained the natural habitat and only added a path leading to a single pier would fall into this category.

Natural/Undeveloped: This category includes shorelands in a natural, undisturbed state. No signs of anthropogenic impact can be found on these shorelands. In forested areas, herbaceous, understory, and canopy layers would be intact.

Figure 3.3-1. Shoreland assessment category descriptions.

On Mann Lake, the development stage of the entire shoreland was surveyed during late summer of 2014, using a GPS unit to map the shoreland. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreland on a property-by-property basis. During the survey, Onterra staff examined the shoreland for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.3-2.

Mann Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 4.5 miles of natural/undeveloped and developed-natural shoreland (91%) were observed during the survey (Figure 3.2-4). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 0.2 miles of urbanized and developed–unnatural shoreland (3%) were observed. If restoration of the Mann Lake shoreland is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreland lengths around the entire lake.

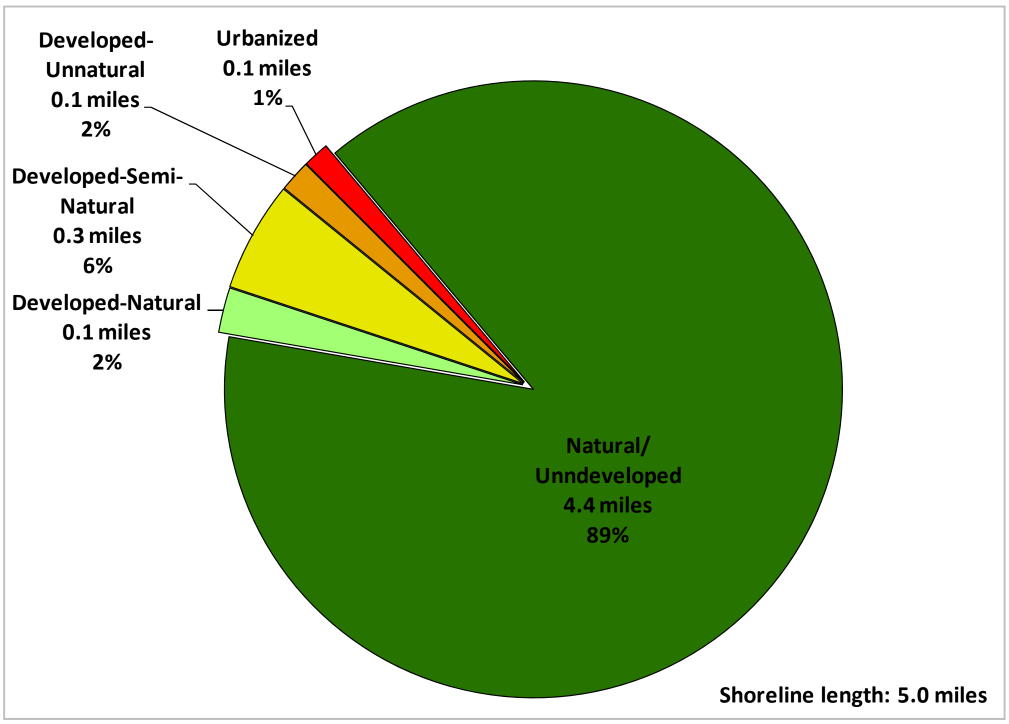


Figure 3.3-2. Mann Lake shoreland categories and total lengths. Based upon a late summer 2014 survey. Locations of these categorized shorelands can be found on Map 3.

While producing a completely natural shoreland is ideal for a lake ecosystem, it is not always practical from a human's perspective. However, riparian property owners can take small steps in ensuring their property's impact upon the lake is minimal. Choosing an appropriate landscape position for lawns is one option to consider. Placing lawns on flat, unsloped areas or in areas that do not terminate at the lake's edge is one way to reduce the amount of runoff a lake receives from a developed site. And, allowing tree falls and other natural habitat features to remain along a shoreline may result not only in reducing shoreline erosion, but creating wildlife habitat also.

Coarse Woody Habitat

Mann Lake was surveyed in 2014 to determine the extent of its coarse woody habitat. A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey. Coarse woody habitat was identified, and classified in two size categories (2-8 inches diameter, >8 inches diameter) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed earlier, research indicates that fish species prefer some branching as opposed to no branching on coarse woody habitat, and increasing complexity is positively correlated with higher fish species richness, diversity and abundance.

During this survey, 355 total pieces of coarse woody habitat were observed along 5.0 miles of shoreline, which gives Mann Lake a coarse woody habitat to shoreline mile ratio of 71:1. The State of Wisconsin owns a little over 4.0 miles of the lakes shoreline, which helps to ensure this habitat type will not be altered. Locations of coarse woody habitat are displayed on Map 4.

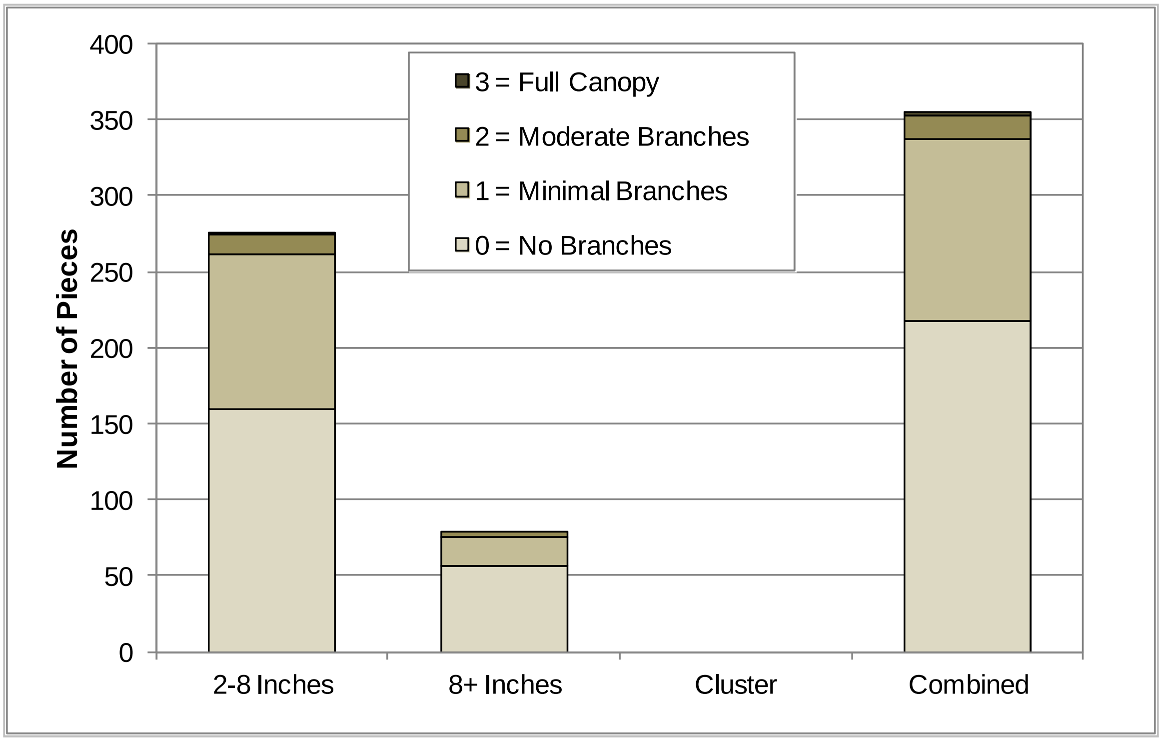


Figure 3.3-3. Mann Lake coarse woody habitat survey results. Based upon a late summer 2014 survey. Locations of Mann Lake coarse woody habitat can be found on Map 4.

3.4 Aquatic Plants

Introduction

Although the occasional lake user considers aquatic macrophytes to be "weeds" and a nuisance to the recreational use of the lake, the plants are actually an essential element in a healthy and functioning lake ecosystem. It is very important that lake stakeholders understand the importance of lake plants and the many functions they serve in maintaining and protecting a lake ecosystem. With increased understanding and awareness, most lake users will recognize the importance of the aquatic plant community and their potential negative effects on it.

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*). In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the periphyton attached to them as their primary food source. The plants also provide cover for feeder fish and zooplankton, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent shoreland erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas where plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by phytoplankton, which helps to minimize nuisance algal blooms.

Under certain conditions, a few species may become a problem and require control measures. Excessive plant growth can limit recreational use by deterring navigation, swimming, and fishing activities. It can also lead to changes in fish population structure by providing too much cover for feeder fish resulting in reduced predation by predator fish, which could result in a stunted pan-fish population. Exotic plant species, such as Eurasian water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing native plants and reducing species diversity. These invasive plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

When plant abundance negatively affects the lake ecosystem and limits the use of the resource, plant management and control may be necessary. The management goals should always include the control of invasive species and restoration of native communities through environmentally sensitive and economically feasible methods. No aquatic plant management plan should only contain methods to control plants, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

Aquatic Plant Management and Protection

Important Note:
Even though most of these techniques are not applicable to Mann Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake. The techniques applicable to Mann Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

Many times an aquatic plant management plan is aimed at only controlling nuisance plant growth that has limited the recreational use of the lake, usually navigation, fishing, and swimming. It is important to remember the vital benefits that native aquatic plants provide to lake users and the lake ecosystem, as described above. Therefore, all aquatic plant management plans also need to address the enhancement and protection of the aquatic plant community. Below are general descriptions of the many techniques that can be utilized to control and enhance aquatic plants. Each alternative has benefits and limitations that are explained in its description. Please note that only legal and commonly used methods are included. For instance, the herbivorous grass carp (*Ctenopharyngodon idella*) is illegal in Wisconsin and rotovation, a process by which the lake bottom is tilled, is not a commonly accepted practice. Unfortunately, there are no "silver bullets" that can completely cure all aquatic plant problems, which makes planning a crucial step in any aquatic plant management activity. Many of the plant management and protection techniques commonly used in Wisconsin are described below.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now, including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that 30 feet. This action can be conducted up to 150 feet from shore. Please note that a permit is needed in all instances if wild rice is to be removed. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR.

Permits are required for chemical and mechanical manipulation of native and non-native plant communities. Large-scale protocols have been established for chemical treatment projects covering >10 acres or areas greater than 10% of the lake littoral zone and more than 150 feet from shore. Different protocols are to be followed for whole-lake scale treatments (≥160 acres or ≥50% of the lake littoral area). Additionally, it is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Manual Removal

Manual removal methods include hand-pulling, raking, and hand-cutting. Hand-pulling involves the manual removal of whole plants, including roots, from the area of concern and disposing them out of the waterbody. Raking entails the removal of partial and whole plants from the lake by dragging a rake with a rope tied to it through plant beds. Specially designed rakes are available from commercial sources or an asphalt rake can be used. Hand-cutting differs from the other two manual methods because the entire plant is not removed, rather the plants are cut similar to mowing a lawn; however Wisconsin law states that all plant fragments must be removed. One manual cutting technique involves throwing a specialized “V” shaped cutter into the plant bed and retrieving it with a rope. The raking method entails the use of a two-sided straight blade on a telescoping pole that is swiped back and forth at the base of the undesired plants.

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width. Please note that the use of powered cutters may require a mechanical harvesting permit to be issued by the WDNR.

When using the methods outlined above, it is very important to remove all plant fragments from the lake to prevent re-rooting and drifting onshore followed by decomposition. It is also important to preserve fish spawning habitat by timing the treatment activities after spawning. In Wisconsin, a general rule would be to not start these activities until after June 15th.

Cost
Commercially available hand-cutters and rakes range in cost from $85 to $150. Power-cutters range in cost from $1,200 to $11,000.

Advantages	***Disadvantages***
• Very cost effective for clearing areas around docks, piers, and swimming areas. • Relatively environmentally safe if treatment is conducted after June 15th. • Allows for selective removal of undesirable plant species. • Provides immediate relief in localized area. • Plant biomass is removed from waterbody.	• Labor intensive. • Impractical for larger areas or dense plant beds. • Subsequent treatments may be needed as plants recolonize and/or continue to grow. • Uprooting of plants stirs bottom sediments making it difficult to conduct action. • May disturb benthic organisms and fish-spawning areas. • Risk of spreading invasive species if fragments are not removed.

Bottom Screens

Bottom screens are very much like landscaping fabric used to block weed growth in flowerbeds. The gas-permeable screen is placed over the plant bed and anchored to the lake bottom by staking or weights. Only gas-permeable screen can be used or large pockets of gas will form under the mat as the result of plant decomposition. This could lead to portions of the screen becoming detached from the lake bottom, creating a navigational hazard. Normally the screens are removed and cleaned at the end of the growing season and then placed back in the lake the following spring. If they are not removed, sediments may build up on them and allow for plant colonization on top of the screen. Please note that depending on the size of the screen a Wisconsin Department of Natural Resources permit may be required.

Cost
Material costs range between $.20 and $1.25 per square-foot. Installation cost can vary largely, but may roughly cost $750 to have 1,000 square feet of bottom screen installed. Maintenance costs can also vary, but an estimate for a waterfront lot is about $120 each year.

Advantages	*Disadvantages*
• Immediate and sustainable control. • Long-term costs are low. • Excellent for small areas and around obstructions. • Materials are reusable. • Prevents fragmentation and subsequent spread of plants to other areas.	• Installation may be difficult over dense plant beds and in deep water. • Not species specific. • Disrupts benthic fauna. • May be navigational hazard in shallow water. • Initial costs are high. • Labor intensive due to the seasonal removal and reinstallation requirements. • Does not remove plant biomass from lake. • Not practical in large-scale situations.

Water Level Drawdown

The primary manner of plant control through water level drawdown is the exposure of sediments and plant roots/tubers to desiccation and either heating or freezing depending on the timing of the treatment. Winter drawdowns are more common in temperate climates like that of Wisconsin and usually occur in reservoirs because of the ease of water removal through the outlet structure. An important fact to remember when considering the use of this technique is that only certain species are controlled and that some species may even be enhanced. Furthermore, the process will likely need to be repeated every two or three years to keep target species in check.

Cost
The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive. If a hydro-electric facility is operating on the system, the costs associated with loss of production during the drawdown also need to be considered, as they are likely cost prohibitive to conducting the management action.

Advantages	***Disadvantages***
• Inexpensive if outlet structure exists. • May control populations of certain species, like Eurasian water-milfoil for a few years. • Allows some loose sediment to consolidate, increasing water depth. • May enhance growth of desirable emergent species. • Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.	• May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant effects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed and reed canary grass. • Permitting process may require an environmental assessment that may take months to prepare. • Non-selective.

Mechanical Harvesting

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 6 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor. Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the latter route is chosen, it is especially important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Cost

Equipment costs vary with the size and features of the harvester, but in general, standard harvesters range between $45,000 and $100,000. Larger harvesters or stainless steel models may cost as much as $200,000. Shore conveyors cost approximately $20,000 and trailers range from $7,000 to $20,000. Storage, maintenance, insurance, and operator salaries vary greatly.

Advantages	***Disadvantages***
• Immediate results. • Plant biomass and associated nutrients are removed from the lake. • Select areas can be treated, leaving sensitive areas intact. • Plants are not completely removed and can still provide some habitat benefits. • Opening of cruise lanes can increase predator pressure and reduce stunted fish populations. • Removal of plant biomass can improve the oxygen balance in the littoral zone. • Harvested plant materials produce excellent compost.	• Initial costs and maintenance are high if the lake organization intends to own and operate the equipment. • Multiple treatments are likely required. • Many small fish, amphibians and invertebrates may be harvested along with plants. • There is little or no reduction in plant density with harvesting. • Invasive and exotic species may spread because of plant fragmentation associated with harvester operation. • Bottom sediments may be re-suspended leading to increased turbidity and water column nutrient levels.

Herbicide Treatment

The use of herbicides to control aquatic plants and algae is a technique that is widely used by lake managers. Traditionally, herbicides were used to control nuisance levels of aquatic plants and algae that interfere with navigation and recreation. While this practice still takes place in many parts of Wisconsin, the use of herbicides to control aquatic invasive species is becoming more prevalent. Resource managers employ strategic management techniques towards aquatic invasive species, with the objective of reducing the target plant's population over time; and an overarching goal of attaining long-term ecological restoration. For submergent vegetation, this largely consists of implementing control strategies early in the growing season; either as spatially-targeted, small-scale spot treatments or low-dose, large-scale (whole lake) treatments. Treatments occurring roughly each year before June 1 and/or when water temperatures are below 60°F can be less impactful to many native plants, which have not emerged yet at this time of year. Emergent species are targeted with foliar applications at strategic times of the year when the target plant is more likely to absorb the herbicide.

While there are approximately 300 herbicides registered for terrestrial use in the United States, only 13 active ingredients can be applied into or near aquatic systems. All aquatic herbicides must be applied in accordance with the product's US Environmental Protection Agency (EPA) approved label. There are numerous formulations and brands of aquatic herbicides and an extensive list can be found in Appendix F of Gettys et al. (2009).

Applying herbicides in the aquatic environment requires special considerations compared with terrestrial applications. WDNR administrative code states that a permit is required if "you are standing in socks and they get wet." In these situations, the herbicide application needs to be completed by an applicator licensed with the Wisconsin Department of Agriculture, Trade and Consumer Protection. All herbicide applications conducted under the ordinary high water mark require herbicides specifically labeled by the United States Environmental Protection Agency

Aquatic herbicides can be classified in many ways. Organization of this section follows Netherland (2009) in which mode of action (i.e. how the herbicide works) and application techniques (i.e. foliar or submersed treatment) group the aquatic herbicides. The table below provides a general list of commonly used aquatic herbicides in Wisconsin and is synthesized from Netherland (2009).

The arguably clearest division amongst aquatic herbicides is their general mode of action and fall into two basic categories:

1. Contact herbicides act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but in some plants does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides act slower than contact herbicides, being transported throughout the entire plant and disrupting biochemical pathways which often result in complete mortality.

General Mode of Action		Compound	Specific Mode of Action	Most Common Target Species in Wisconsin
Contact		Copper	plant cell toxicant	Algae, including macro-algae (i.e. muskgrasses & stoneworts)
		Endothall	Inhibits respiration & protein synthesis	Submersed species, largely for curly-leaf pondweed; Eurasian water milfoil control when mixed with auxin herbicides
		Diquat	Inhibits photosynthesis & destroys cell membranes	Nusiance natives species including duckweeds, targeted AIS control when exposure times are low
Systemic	Auxin Mimics	2,4-D	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
		Triclopyr	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
	In Water Use Only	Fluridone	Inhibits plant specific enzyme, new growth bleached	Submersed species, largely for Eurasian water milfoil
	Enzyme Specific (ALS)	Penoxsulam	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
		Imazamox	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
	Enzyme Specific (foliar use only)	Glyphosate	Inhibits plant-specific enzyme (ALS)	Emergent species, including purple loosestrife
		Imazapyr	Inhibits plant-specific enzyme (EPSP)	Hardy emergent species, including common reed

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to both the applicator and the environment, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration and exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Much information has been gathered in recent years, largely as a result of an ongoing cooperative research project between the Wisconsin Department of Natural Resources, US Army Corps of Engineers Research and Development Center, and private consultants (including Onterra). This research couples quantitative aquatic plant monitoring with field-collected herbicide concentration data to evaluate efficacy and selectivity of control strategies implemented on a subset of Wisconsin lakes and flowages. Based on their preliminary findings, lake managers have adopted two main treatment strategies; 1) whole-lake treatments, and 2). spot treatments.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. This has been the strategy historically used on most Wisconsin systems.

Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (entire lake, lake basin, or within the epilimnion of the lake or lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. The application rate of a whole-lake treatment is dictated by the volume of water in which the herbicide will reach equilibrium. Because exposure time is so much longer, target herbicide levels for whole-lake treatments are significantly less than for spot treatments.

Cost

Herbicide application charges vary greatly between $400 and $1,500 per acre depending on the chemical used, who applies it, permitting procedures, and the size/depth of the treatment area.

Advantages	*Disadvantages*
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • Herbicides can target large areas all at once. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil. • Some herbicides can be used effectively in spot treatments. • Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g. mammals, insects)	• All herbicide use carries some degree of human health and ecological risk due to toxicity. • Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them. • Many aquatic herbicides are nonselective. • Some herbicides have a combination of use restrictions that must be followed after their application. • Overuse of same herbicide may lead to plant resistance to that herbicide.

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as water hyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively.

However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water milfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian water milfoil.

Cost
Stocking with adult weevils costs about $1.20/weevil and they are usually stocked in lots of 1000 or more.

Advantages	***Disadvantages***
• Milfoil weevils occur naturally in Wisconsin. • Likely environmentally safe and little risk of unintended consequences.	• Stocking and monitoring costs are high. • This is an unproven and experimental treatment. • There is a chance that a large amount of money could be spent with little or no change in Eurasian water-milfoil density.

Wisconsin has approved the use of two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These beetles were imported from Europe and used as a biological control method for purple loosestrife. Many cooperators, such as county conservation departments or local UW-Extension locations, currently support large beetle rearing operations. Beetles are reared on live purple loosestrife plants growing in kiddy pools surrounded by insect netting. Beetles are collected with aspirators and then released onto the target wild population. For more information on beetle rearing, contact your local UW-Extension location.

In some instances, beetles may be collected from known locations (cella insectaries) or purchased through private sellers. Although no permits are required to purchase or release beetles within Wisconsin, application/authorization and release forms are required by the WDNR for tracking and monitoring purposes.

Cost
The cost of beetle release is very inexpensive, and in many cases is free.

Advantages	***Disadvantages***
• Extremely inexpensive control method. • Once released, considerably less effort than other control methods is required. • Augmenting populations many lead to long-term control.	• Although considered “safe,” reservations about introducing one non-native species to control another exist. • Long range studies have not been completed on this technique.

Analysis of Current Aquatic Plant Data

Aquatic plants are an important element in every healthy lake. Changes in lake ecosystems are often first seen in the lake's plant community. Whether these changes are positive, such as variable water levels or negative, such as increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways. For example, there may be a loss of one or more species. Certain life forms, such as emergents or floating-leaf communities, may disappear from specific areas of the lake. A shift in plant dominance between species may also occur. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Mann Lake; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in life-forms that are present, can be an early indicator of changes in the health of the lake ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Mann Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

In the end, this analysis indicates the species that dominate the plant community within the lake. Shifts in dominant plants over time may indicate disturbances in the ecosystem. For instance, low water levels over several years may increase the occurrence of emergent species while decreasing the occurrence of floating-leaf species. Introductions of invasive exotic species may result in major shifts as they crowd out native plants within the system.

Species Diversity and Richness

Species diversity is probably the most misused value in ecology because it is often confused with species richness. Species richness is simply the number of species found within a system or community. Although these values are related, they are far from the same because diversity also takes into account how evenly the species occur within the system. A lake with 25 species may not be more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

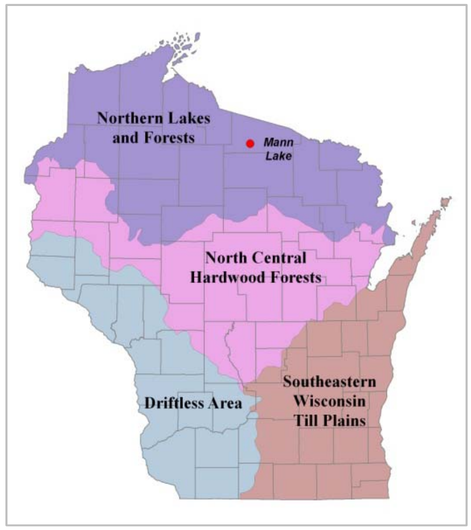


Figure 3.4-1. Location of Mann Lake within the ecoregions of Wisconsin. After Nichols 1999.

A lake with high species diversity is much more stable than a lake with a low diversity. This is analogous to a diverse financial portfolio in that a diverse lake plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. For example, a lake with a diverse plant community is much better suited to compete against exotic infestation than a lake with a lower diversity.

Simpson's diversity index is used to determine this diversity in a lake ecosystem. Simpson's diversity (1-D) is calculated as:

$$D = \sum (n/N)^2$$

where:
n = the total number of instances of a particular species
N = the total number of instances of all species and
D is a value between 0 and 1

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to Mann Lake. Comparisons will be displayed using boxplots that showing median values and upper/lower quartiles of lakes in the same ecoregion (Water Quality section, Figure 3.1-2) and in the state. Please note for this parameter, the Northern Lakes and Forests Ecoregion data includes both natural and flowage lakes.

As previously stated, species diversity is not the same as species richness. One factor that influences species richness is the "development factor" of the shoreland. This is not the degree of human development or disturbance, but rather it is a value that attempts to describe the nature of the habitat a particular shoreland may hold. This value is referred to as the shoreland complexity. It specifically analyzes the characteristics of the shoreland and describes to what degree the lake shape deviates from a perfect circle. It is calculated as the ratio of lake perimeter to the circumference of a circle of area equal to that of the lake. A shoreland complexity value of 1.0 would indicate that the lake is a perfect circle. The further away the value gets from 1.0, the more the lake deviates from a perfect circle. As shoreland complexity increases, species richness increases, mainly because there are more habitat types, bays and back water areas sheltered from wind.

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Mann Lake will be compared to lakes in the same ecoregion and in the state (Figure 3.4-1).

Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states.

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept survey and does not include incidental species or those encountered during other aquatic plan surveys.

Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with surveys completed in the future. A mapped community can consist of submergent, floating-leaf, or emergent plants, or a combination of these life-forms. Examples of submergent plants include wild celery and pondweeds; while emergents include cattails, bulrushes, and arrowheads, and floating-leaf species include white and yellow pond lilies. Emergents and floating-leaf communities lend themselves well to mapping because there are distinct boundaries between communities. Submergent species are often mixed throughout large areas of the lake and are seldom visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

Exotic Plants

Because of their tendency to upset the natural balance of an aquatic ecosystem, exotic species are paid particular attention to during the aquatic plant surveys. Two exotics, curly-leaf pondweed and Eurasian water milfoil are the primary targets of this extra attention.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.4-2). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

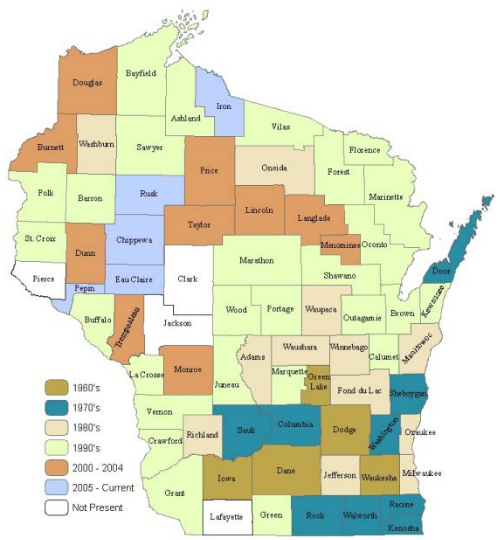


Figure 3.4-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

Curly-leaf pondweed is a European exotic first discovered in Wisconsin in the early 1900's that has an unconventional lifecycle giving it a competitive advantage over our native plants. Curly – leaf pondweed begins growing almost immediately after ice-out and by mid-June is at peak biomass. While it is growing, each plant produces many turions (asexual reproductive shoots) along its stem. By mid-July most of the plants have senesced, or died-back, leaving the turions in the sediment. The turions lie dormant until fall when they germinate to produce winter foliage, which thrives under the winter snow and ice. It remains in this state until spring foliage is produced in early May, giving the plant a significant jump on native vegetation. Like Eurasian water-milfoil, curly-leaf pondweed can become so abundant that it hampers recreational activities within the lake. Furthermore, its mid-summer die back can cause algal blooms spurred from the nutrients released during the plant's decomposition.

Because of its odd life-cycle, a special survey is conducted early in the growing season to inventory and map curly-leaf pondweed occurrence within the lake. Although Eurasian water milfoil starts to grow earlier than our native plants, it is at peak biomass during most of the summer, so it is inventoried during the comprehensive aquatic plant survey completed in mid to late summer.

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. On June 12, 2014, Onterra staff visited Mann Lake to conduct an Early Season AIS Survey. This survey is timed such that curly-leaf pondweed, a common Wisconsin aquatic invasive plant, is at its peak growth period. Eurasian water milfoil, while not at its peak growth, is typically taller in the water column during this time and is more easily observed with the lesser native plant growth along with the often clearer water that occurs this time of the year (less algae in the water column). Additional invasive species, such as wetland emergents are also noted during this time if present.

The point intercept survey was conducted on Mann Lake on July 23, 2014 by Onterra. Additional surveys were completed by Onterra on Mann Lake to create the aquatic plant community map (Map 6) the next day (July 24, 2014). During the point-intercept and aquatic plant mapping surveys, 31 species of plants were located in Mann Lake (Table 3.4-1). One is considered non-native (reed canary grass, *Phalaris arundinacea*) though it is quite common throughout Wisconsin. The remaining 30 native species consist of plants that were sampled directly during the point-intercept survey (13) and those found incidentally during surveys (18 species).

The sediment within littoral areas of Mann Lake was determined to be very conducive for supporting lush aquatic plant growth. Data from the point-intercept survey indicate that approximately 85% of the sampling locations located within the littoral zone contained fine organic sediment (muck), 8% contained sand, and 7% contained rock (Figure 3.4-3).

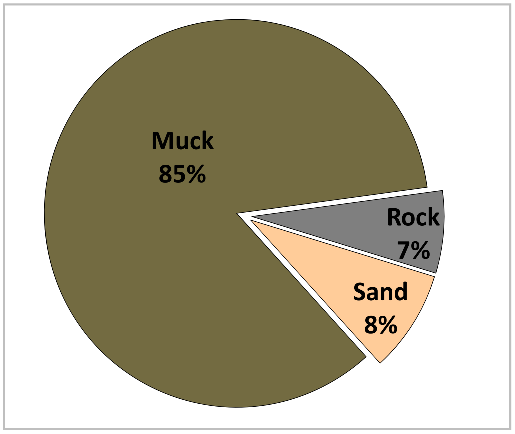


Figure 3.4-3. Mann Lake proportion of substrate types within littoral areas. Created using data from a 2014 aquatic plant point-intercept survey.

Approximately 45% of the point-intercept sampling locations that fell within the maximum depth of aquatic plant growth (11 feet), or the littoral zone, contained aquatic vegetation. Map 5 shows that the majority of the aquatic vegetation in Mann Lake is located within the shallow bays and near-shore areas. As discussed in the water quality section, the water clarity in Mann Lake is relatively low which limits sunlight penetration and restricts aquatic plants from inhabiting deeper areas of the lake.

Table 3.4-1. Aquatic plant species located on Mann Lake during July 2014 surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2014 (Onterra)
Emergent	*Agrostis scabra*	Rough bent grass	N/A	*I*
	Calla palustris	Water arum	9	*I*
	Carex comosa	Bristly sedge	5	*I*
	Carex diandra	Bog panicled sedge	9	*I*
	Carex aquatilis	Water sedge	7	*I*
	Dulichium arundinaceum	Three-way sedge	9	*I*
	Decodon verticillatus	Water-willow	7	*I*
	Eleocharis palustris	Creeping spikerush	6	*I*
	Iris versicolor	Northern blue flag	5	*I*
	Juncus effusus	Soft rush	4	*I*
	Phalaris arundinacea	Reed canary grass	Exotic	*I*
	Rumex crispus	Curly Dock	N/A	*I*
	Schoenoplectus acutus	Hardstem bulrush	5	*I*
	Scirpus cyperinus	Wool grass	4	*I*
	Schoenoplectus tabernaemontani	Softstem bulrush	4	*I*
	Sagittaria latifolia	Common arrowhead	3	*I*
FL	*Nymphaea odorata*	White water lily	6	*X*
Submergent	*Ceratophyllum demersum*	Coontail	3	*X*
	Elodea canadensis	Common waterweed	3	*X*
	Heteranthera dubia	Water stargrass	6	*X*
	Myriophyllum sibiricum	Northern water milfoil	7	*X*
	Najas flexilis	Slender naiad	6	*X*
	Potamogeton zosteriformis	Flat-stem pondweed	6	*I*
	Potamogeton friesii	Fries' pondweed	8	*X*
	Potamogeton richardsonii	Clasping-leaf pondweed	5	*X*
	Potamogeton foliosus	Leafy pondweed	6	*X*
	Utricularia vulgaris	Common bladderwort	7	*I*
	Vallisneria americana	Wild celery	6	*X*
S/E	*Eleocharis acicularis*	Needle spikerush	5	*X*
FF	*Lemna minor*	Lesser duckweed	5	*X*
	Spirodela polyrhiza	Greater duckweed	5	*X*

FL = Floating Leaf; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species

As previously mentioned, aquatic plants were found growing to a depth of 11 feet in Mann Lake. Aquatic plant growth was most prevalent in the shallower waters and decreased rapidly after seven feet of depth. As illustrated on Figure 3.4-4, common waterweed had the highest frequency of occurrence at point-intercept sampling locations at all depths.

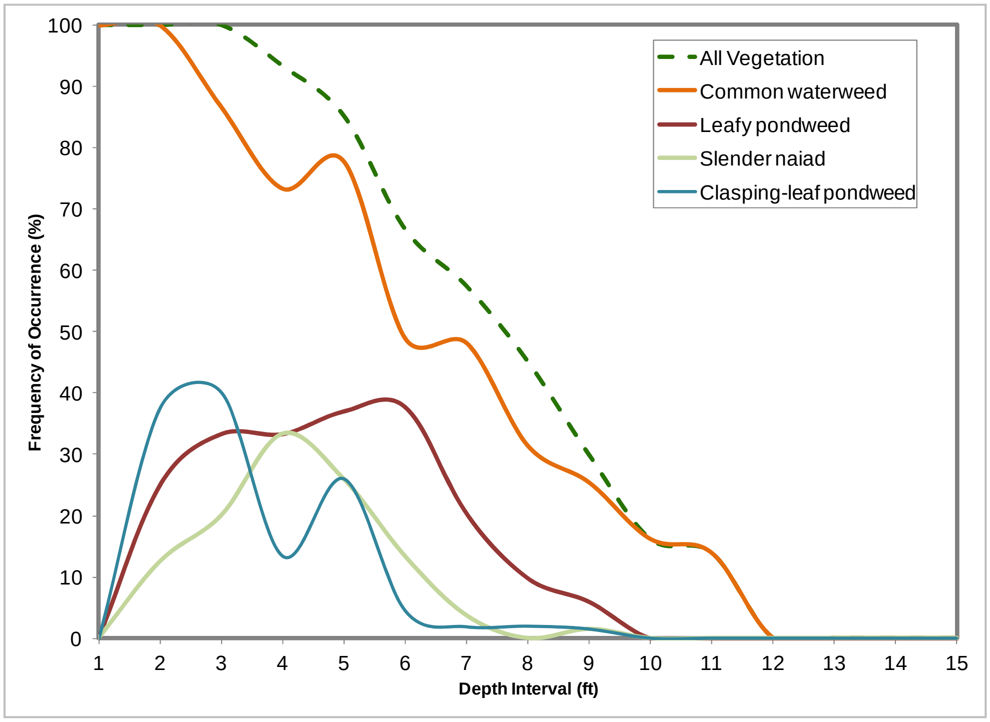


Figure 3.4-4. Frequency of occurrence at littoral depths for several Mann Lake plant species. Created using data from a July 2014 aquatic plant point-intercept survey.

Aquatic plants can be placed in one of two general groups, based upon their form of growth and habitat preferences. These groups include the isoetid growth form and the elodeid growth form. Mann Lake has primarily elodeid species within its waters. Plants of the isoetid growth form are small, slow growing, and inconspicuous submerged plants. They often have evergreen leaves located in a rosette and are usually found growing in sandy soils within the near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000). Some common isoetid species include brown-fruited rush, needle spikerush, and spiny-spored quillwort. Submersed species of the elodeid growth form have leaves on tall, erect stems which grow upwards into the water column. Examples of Mann Lake elodeid species include common waterweed, slender naiad, wild celery and clasping-leaf pondweed.

Alkalinity is the primary water chemistry factor determining whether a lake is dominated by plant species of the isoetid or elodeid growth form (Vestergaard and Sand-Jensen 2000). Most elodeids are restricted to lakes of relatively higher alkalinity, as their carbon demand for photosynthesis cannot be met solely by the dissolved carbon dioxide (CO_2) present in the water, and they must acquire additional carbon through bicarbonate (HCO_3^-). While isoetids are able to grow in lakes of higher alkalinity, their short stature makes them poor competitors for light, and they are usually outcompeted and displaced by the taller elodeids. Thus, isoetids are most prevalent in lakes of low alkalinity where they can avoid competition from elodeids. With higher alkalinity (53 mg/L $CaCo_3$ in 2014), Mann Lakes aquatic plant community is not surprisingly comprised mostly of elodeid species.

45% of the point-intercept locations at or shallower than 11 ft contained aquatic plants (lake-wide littoral frequency of occurrence). Of the 30 native aquatic plants found in Mann Lake, common waterweed and leafy pondweed were the most common. Common waterweed was found at 38% of point-intercept locations within the littoral zone of Mann Lake, while leafy pondweed was found at 14% of these locations (Figure 3.4-5). Common waterweed is able to obtain most of its nutrients through the water and thus does not produce extensive root systems. This plant may produce structures similar to roots (rhizoids) or become partially buried in the sediment. Because of this, the plant is susceptible to being easily uprooted and migrated by water-action and movement. Common waterweed typically stays low growing to the bottom but can become problematic in shallow waters. Leafy pondweed has branching leafy stems that are slender in size and pale green and often "grassy" in appearance. The plant adapts very well to shallow water better than most pondweed species. Due to the dense mats the plant often forms, leafy pondweed provides good cover for minnows, insects and other small aquatic organisms.

As explained above in the Primer on Data Analysis and Data Interpretation Section, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while common waterweed was found at 38% of the sampling locations in Mann Lake, its relative frequency of occurrence is 49%. Explained another way, if 100 plants were randomly sampled from Mann Lake, 49 of them would be common waterweed. Relative to all other plant species within Mann Lake, common waterweed and leafy pondweed make up 67% of the aquatic plant population (Figure 3.4-6).

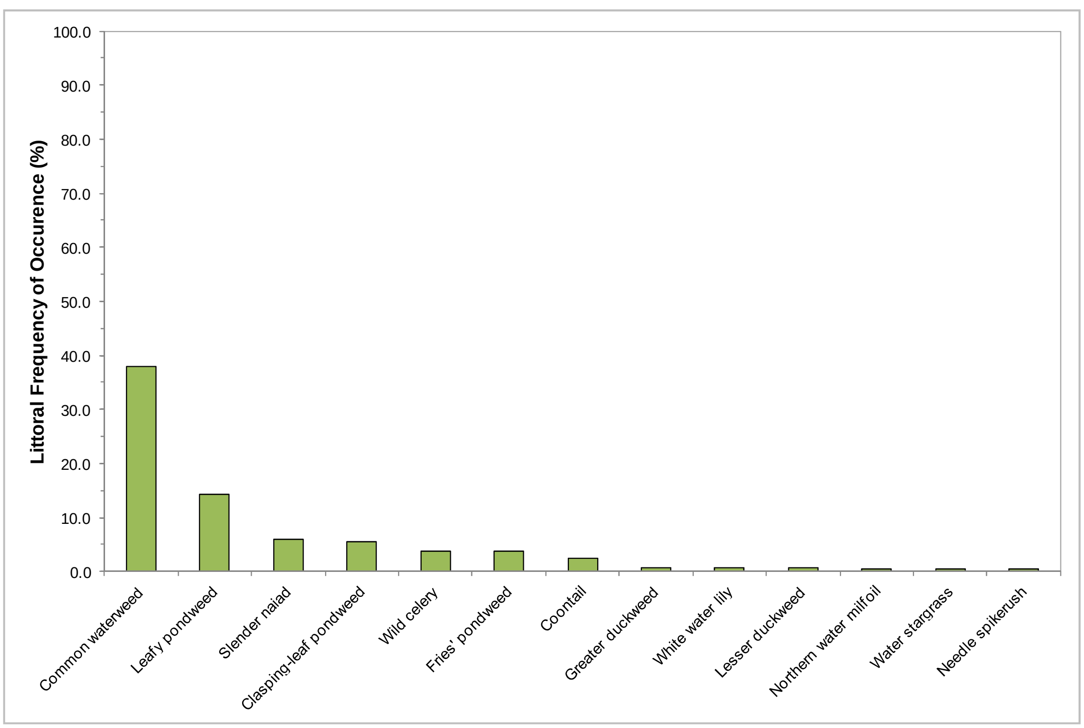


Figure 3.4-5 Mann Lake aquatic plant littoral frequency of occurrence. Created using data from a July 2014 survey.

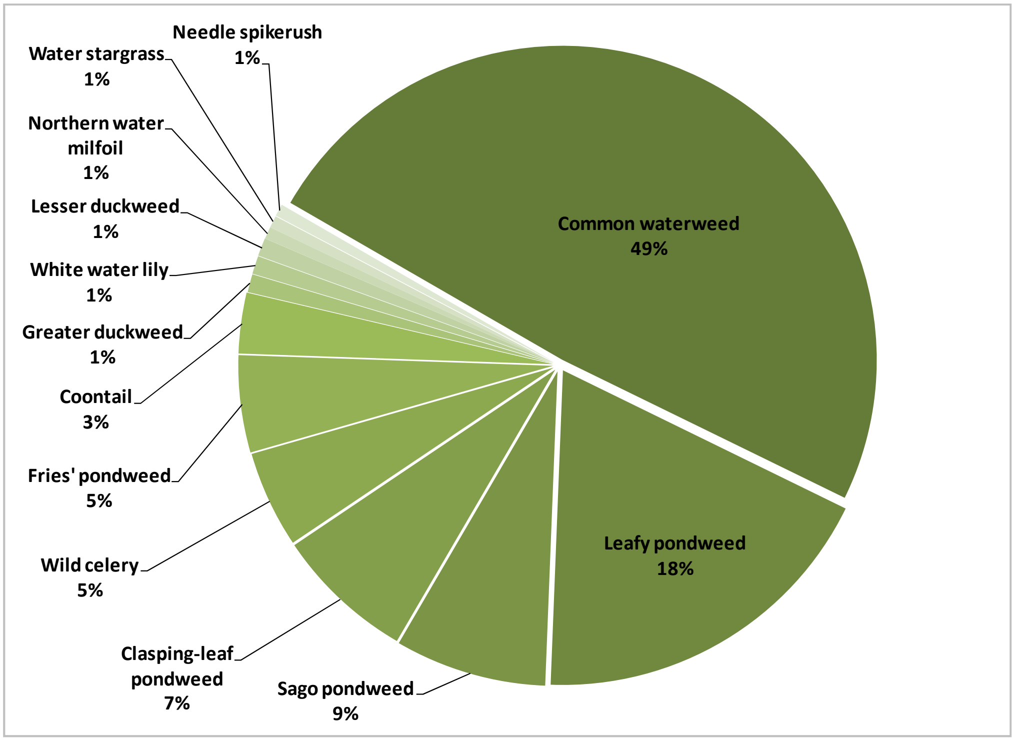


Figure 3.4-6 Mann Lake relative plant littoral frequency of occurrence. Created using data from a July 2014 survey.

As discussed previously, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while 30 native aquatic plant species were located in Mann Lake during the 2010 surveys, 13 were encountered on the rake during the point-intercept survey. Figure 3.4-6 shows that the native species richness for Mann Lake is equal to the Northern Lakes and Forests Ecoregion and Wisconsin State medians.

The species that are present in Mann Lake are indicative of environmentally disturbed conditions. Data collected from the aquatic plant surveys show that the average conservatism value (5.5) is well below the Northern Lakes and Forest Lakes Ecoregion and Wisconsin State medians (Figure 3.4-7), indicating that the majority of the plant species found in Mann Lake are considered tolerant of environmental disturbance and their presence signifies moderate environmental conditions.

Combining Mann Lake's aquatic plant species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a relatively low value of 19.7 (equation shown below); which is below the median values for the ecoregion and state (Figure 3.4-7).

$$FQI = \text{Average Coefficient of Conservatism } (5.5) * \sqrt{\text{Number of Native Species } (13)}$$
$$FQI = 19.7$$

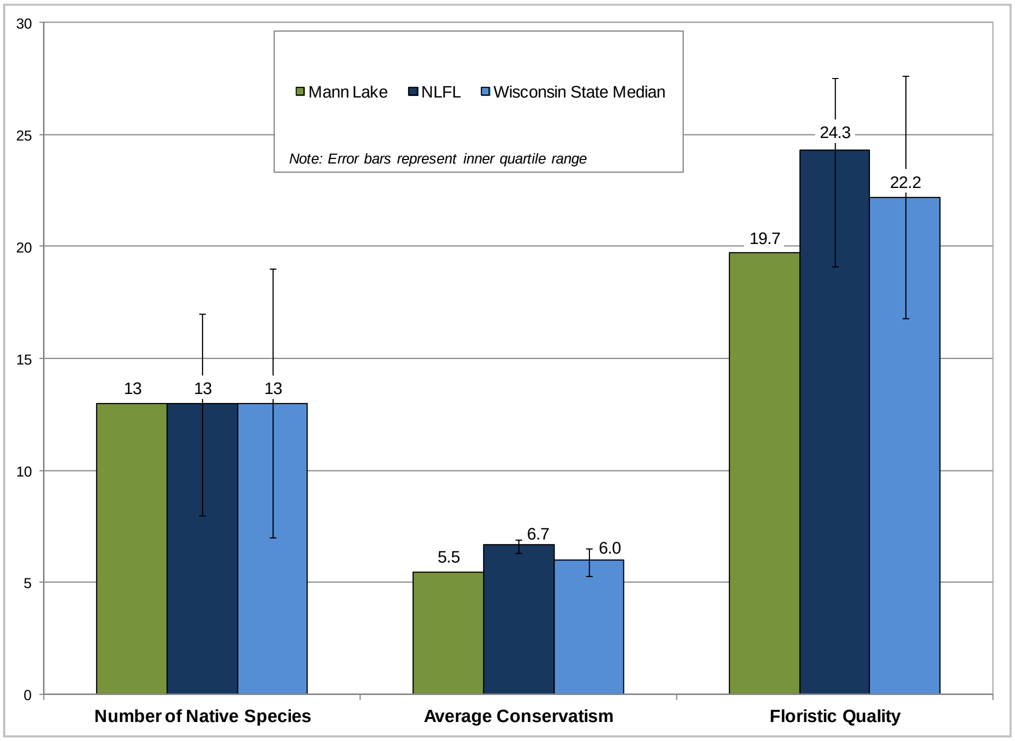


Figure 3.4-7. Mann Lake Floristic Quality Assessment. Created using data from a July 2014 survey. Analysis following Nichols (1999) where NLFL = Northern Lakes and Forest Lakes Ecoregion.

Because Mann Lake contains a high number of native aquatic plant species, one may assume their aquatic plant communities have high species diversity. However, as discussed earlier, species diversity is also influenced by how evenly the plant species are distributed within the community.

The aquatic plant community in Mann Lake was found to be minimally diverse, with a Simpson's diversity value of 0.71 (Figure 3.4-8). This value ranks below state and ecoregion upper quartiles. Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food. If the aquatic plant community is lacking these traits, the aquatic habitat benefits these organisms to a lesser degree.

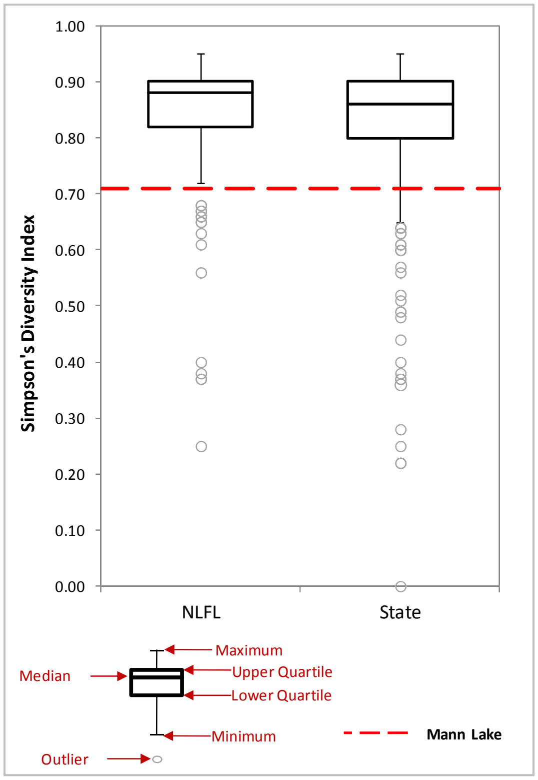


Figure 3.4-8. Mann Lake species diversity index. Created using data from July 2014 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

Mann Lake's aquatic plant community is characterized not only by its submergent plant populations, but also by the incidence of emergent and floating-leaf plant communities that occur in near-shore areas around the lake. The 2014 community map (Map 6) indicates that approximately 3.6 acres (1.4%) of the 255 acre lake contain these types of plant communities (Table 3.4-2 and Map 4). Seventeen floating-leaf and emergent species were located on Mann Lake, providing valuable structural habitat for invertebrates, fish, and other wildlife. These communities also stabilize lake substrate and shoreland areas by dampening wave action from wind and watercraft.

Table 3.4-2. Mann Lake acres of plant community types. Created from a July 2014 community mapping survey.

Plant Community	Acres
Emergent	0.5
Floating-leaf	3.1
Mixed Floating-leaf and Emergent	<0.1
Total	3.6

Because the community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Mann Lake. This is important because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelands when compared to the undeveloped shorelands in Minnesota lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike

(*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelands.

Emergent Plants of Concern – Reed Canary Grass

Reed canary grass (*Phalaris arundinacea*) is a large, coarse perennial grass that can reach three to six feet in height. Often difficult to distinguish from native grasses, this species forms dense, highly productive stands that vigorously outcompete native species. Unlike native grasses, few wildlife species utilize the grass as a food source, and the stems grow too densely to provide cover for small mammals and waterfowl. It grows best in moist soils such as sedge meadows, wetlands, marshes, stream banks and lake shorelands.

Reed canary grass is difficult to eradicate; at the time of this writing there is no efficient control method. Small, discrete patches have been covered by black plastic to reduce growth for an entire season. However, the species must be monitored because rhizomes may spread out beyond the plastic. Chemical applications are difficult because the plant is found in moist environments, and many herbicides are harmful to aquatic organisms.

At this time, populations are not excessive, though it is recommended that continued monitoring of reed canary grass takes place. During the community mapping survey of Mann Lake in July of 2014, Onterra ecologists mapped occurrences of reed canary grass along the shoreland of the lake with sub-meter GPS technology. The spatial data has been provided to the Vilas County GIS Department, and also displayed on Map 5 of this report.

3.5 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the numerous fisheries biologists overseeing Mann Lake. The goal of this section is to provide an overview of some of the data that exists, particularly in regards to specific issues (e.g. spear fishery, fish stocking, angling regulations, etc) that were brought forth by the FML stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2015, Steve Gilbert personal communication and GLIFWC 2015A / 2015B).

Mann Lake Fishery

Mann Lake Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the third highest activity ranked by Mann Lake stakeholders (Question #14), with northern pike, yellow perch and bluegill/sunfish being their favorite species to target (Question #10). Approximately 75% of respondents indicated the fishing was "Very Poor" on Mann Lake, while the remaining 25% rated the fishing at "Poor" (Question #11). 92% of respondents believe that the fishing has gotten "Much" or "Somewhat" worse since they began fishing the lake, while 8% indicated the fishing has remained the same (Question #12).

When examining a typical fishery of a lake, it is important to remember what "drives" that fishery, or what is responsible for determining its mass and composition. The gamefish in Mann Lake are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon algae and plants, and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscivores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscovorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 3.5-1.

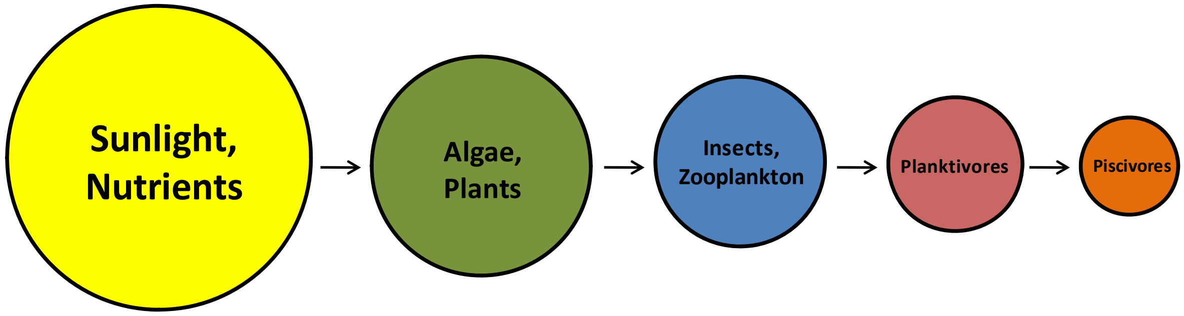


Figure 3.5-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Mann Lake is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means Mann Lake should be able to support sizable populations of predatory fish (piscivores) because the supporting food chain is relatively robust. Of course, a fishery may be highly influenced by other parameters that determine fish growth, abundance and survival. In Mann Lake, a history of periodic winter kills brought about by anoxia has been a strong factor in determining the fishery. This is discussed further later on in this section.

Table 3.5-1 displays the game fish that have been found during WDNR surveys, most recently during fall of 2014. Of the game fish present, northern pike and yellow perch have historically been the most common present due to their ability to survive low winter dissolved oxygen levels.

Table 3.5-1. Mann Lake gamefish with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pikes, crayfish, small mammals, water fowl, frogs
Yellow Perch	*Perca flavescens*	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Mann Lake Spear Harvest Records

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.5-2). Mann Lake falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified systems. Determining how many fish are able to be taken from a lake, either by spear harvest or angler harvest, is a highly regimented and dictated process. This highly structured procedure begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then a "total allowable catch" is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% (walleye) or 27% (muskellunge) of the lake's known or modeled population, but may vary on an individual lake basis due to other circumstances. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The total allowable catch number may be reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level". Often, the biologists overseeing a lake cannot make adjustments due to the regimented nature of this process, so the total allowable catch often equals the safe harvest level. The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent. This result is called the declaration, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal declaration and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

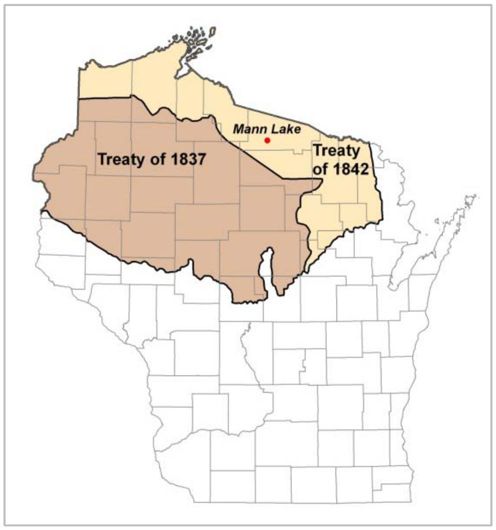


Figure 3.5-2. Location of Mann Lake within the Native American Ceded Territory (GLIFWC 2015A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season; however, in practice walleye and muskellunge are the only species harvested in significant numbers, so conservative quotas are set for other species. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2015B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly declaration is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the declaration is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller declarations. Starting with the 2011 spear harvest season, on lakes with a harvestable declaration of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

Although Mann Lake has been declared as a spear harvest lake, it has not historically seen a harvest. This is likely due to the lake's reputation for experiencing winter kills, along with nearby larger waterbodies being targeted during the spear fishing season.

Mann Lake Substrate and Near Shore Habitat

Just as forest wildlife require proper trees and understory growth to flourish, fish prefer certain substrates and habitat types to nest, spawn, escape predators, and search for prey. Indeed, lakes with primarily a silty/soft substrate and much aquatic plants and coarse woody debris may produce a completely different fishery than lakes that are largely sandy and contain few aquatic plant species or coarse woody habitat.

According to the point-intercept survey conducted by Onterra, 94% of the substrate sampled in the littoral zone on Mann Lake was muck, with the remaining 6% being split evenly between rock and sand. Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Northern pike are a fish that does not provide parental care to its eggs (Becker 1983). Pike broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Similarly, yellow perch lay eggs in gelatinous sheaths over dense vegetation, roots and fallen trees in shallow water. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone.

Mann Lake Fish Stocking

To assist in meeting fisheries management goals, the WDNR may stock fish in a waterbody that were raised in nearby permitted hatcheries. Stocking of a lake is sometimes done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Table 3.5-2 displays the fish stocking history for Mann Lake.

Table 3.5-2. Fish stocking data available from the WDNR (WDNR 2015).

Year	Species	Age Class	# Stocked
1949	Muskellunge	Fry	10
1949	Muskellunge	Yearling	185
1950	Walleye	Fry	4,800,000
1950	Walleye	Fry	2,200,000
1952	Muskellunge	Fingerling	1,240
1953	Walleye	Fingerling	4,900
1954	Muskellunge	Fingerling	106
1955	Walleye	Fingerling	4,800
1956	Walleye	Fry	750,000
1956	Muskellunge	Fingerling	30
1957	Muskellunge	Fingerling	823
1958	Muskellunge		106
1959	Muskellunge	Fry	87,802
1962	Muskellunge	Fingerling	500
1962	Largemouth Bass	Fingerling	3,000
1964	Walleye	Fingerling	5,000
1964	Panfish		10,371
1966	Perch		2,900
1966	Largemouth Bass	Fingerling	2,118
1968	Walleye		3,000
1968	Northern Pike		390
1976	Northern Pike	Fry	120,566
1977	Northern Pike	Fry	116,200
1989	Bluegill	Fingerling	330
1989	Northern Pike	Yearling	11
1990	Largemouth Bass	Adult	200
2001	Muskellunge	Fry	190,350
2001	Walleye	Fry	4,000,000
2004	Walleye	Fry	3,174,400
2005	Walleye	Fry	1,024,000

Mann Lake Regulations and Management

Because Mann Lake is located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. Table 3.5-3 displays the 2015-2016 regulations for species that may be found in Mann Lake, additional Wisconsin species regulations are provided in each annual WDNR fishing regulations publication. Please note that this table is intended to be for reference purposes only, and that anglers should visit the WDNR website (www. http://dnr.wi.gov/topic/fishing/regulations/hookline.html) for specific fishing regulations or visit their local bait and tackle shop to receive a free fishing pamphlet that would contain this information.

Table 3.5-3. WDNR fishing regulations for Mann Lake, 2015-2016.

Species	Season	Regulation
Panfish	Open All Year	No minimum length limit and the daily bag limit is 25.
Northern pike	May 2 to March 6	No minimum length limit and the daily bag limit is 5.

Through both verified documentation and anecdotal reports, Mann Lake has experienced winter kill quite often. A Wisconsin Conservation Department (renamed Wisconsin Department of Natural Resources in 1968) 1950 memo indicates Mann Lake “winterkills quite frequently” (Appendix F). Early in this time, recommendations for management included the use of an aeration system to open a portion of the ice-covered lake in the winter, thus creating an oxygenated refuge for fish. Anecdotally, efforts have been made to alter flow at the dam (raising or lowering the winter water levels) to address winter kill, all with no success. Most recently, WDNR fisheries biologists documented a winter kill during 2013-2014. Other recent substantial winterkills include the winter of 2011-2012 and 2012-2013. In February 2015 the majority of the water column was found to be anoxic once again (Water Quality Section, Figure 3.1-9.

Aeration is a process where air is circulated through an aquatic system for the purpose of re-oxygenating the water. To address winter oxygen depletion, aeration is a common technique. Many believe that the aeration process itself re-oxygenates a lake by providing an air source to the water. While some oxygen may be provided to the lake in this manner, the greatest oxygen accumulation actually occurs through the creation of open water during the winter months, allowing for atmospheric exchange of oxygen with the open water. The overarching goal of winter aeration is to open an area of ice for this oxygen exchange, essentially creating a refuge for fish to last through the winter months. Therefore, it is not necessary to aerate large areas of a lake. Commonly, fish biologists refer to >1 to several acres of aerated area as a “refuge” where fish can overwinter.

In general, aeration systems are best suited in waters greater than five feet of depth within several hundred feet of shoreline. Because aeration units are power operated, an electrical source must be located near the unit. The aerator must be situated on public land or on private land with the landowner’s permission. For an aeration system to be installed off of a private landowner’s property, the landowner must obtain a water regulations permit and become liable for the system, in accordance with Wisconsin Statute 167.26.

One of the most critical responsibilities of the liable party is the erection and maintaining of a barricade. Wisconsin Statute 167.26 outlines the requirements of the barricade, including height of barricade rope off the ice, spacing around the aerated area, reflective tape / ribbon requirements, etc. When a proper barricade is made and maintained, Wisconsin Statute 167.26 specifies that the responsible party for the aeration system is exempt from liability for injury or death of any person entering the ice opening. Setting up the barricade after the onset of ice and initiation of the aeration unit does not meet the standards of Wisconsin Statute 167.26; the barricade must be initiated prior to active aeration.

Appendix F is a report from a retired WDNR fisheries biologist report on aeration projects in Barron and Polk Counties, and includes a good description on when and how to erect the aerator barrier. The report within Appendix F is also good starting point for understanding these costs and time investments, though updated technology and pricing may be available elsewhere.

Aerator cost can vary based upon the type of system and the accessories that are purchased, as well as the monthly costs for electricity. Aeration units used to open a small open water in a lake may cost from $1,000 to $1,800, while electricity costs may range from $30-50 per month for a smaller unit to $120-$180 per month for a larger unit. Installation costs would vary depending upon the type of system selected; on-shore compressors typically require a housing box and tubing would need to be weighted or anchored to the sediment. Finally, the barricade could be built from materials purchased at a hardware store, which would likely run several hundred dollars depending upon the expected area of open water. Annual maintenance costs should be planned for within a lake group’s budget as well.

4.0 SUMMARY AND CONCLUSIONS

The design of this project was intended to fulfill three objectives;

1) Collect baseline data to increase the general understanding of the Mann Lake ecosystem, assess dissolved oxygen conditions and if any invasive species were present.
2) Collect detailed information regarding dissolved oxygen and other habitat-related variables that may be impacting the fishery.
3) Collect sociological information from Mann Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

This project included many scientific investigations aimed at understanding the ecosystem through the analysis of baseline data. Through water quality sampling and analysis, it was found that Mann Lake has water quality that may be described as *Good* to *Excellent* when compared to similar lakes regionally and state-wide. Phosphorus, a nutrient of major concern to lakes across Wisconsin and the United States, was found to be in moderate abundance within the lake. Through modeling of the lake's water phosphorus content, it was suggested that an unaccounted for source existed that the modeling software could not identify. Essentially, this is an additional source of phosphorus to the lake beyond what the model accounts for from overland runoff of the watershed. This source is likely recycling of phosphorus from the lake bottom, which may occur when the bottom waters go anoxic. Iron, which in an oxic state binds with phosphorus, releases this nutrient in anoxic conditions. The phosphorus may then be transported to the upper water column if lake mixing occurs. This is a naturally occurring process. Furthermore, it is believed that this process likely does not cause high nutrient conditions on a regular basis.

A lake's water quality and quantity are often a reflection of the surrounding drainage basin, or watershed. Thus is the case for Mann Lake. The water quality of the lake is good partially because of the advantageous land cover types that are within the lake. The immediate shoreline is in good condition as well, with 90% found to be in a largely natural/developed-natural state. Past and present research has indicated that the immediate shoreline provides many ecological services due to its being located at the interface between the aquatic and terrestrial environment. In regards to protecting Mann Lake, conserving the existing natural shoreline and restoring areas of disturbed shoreline is one of the best ways the FML can preserve their unique resource. As much of the shoreline is in property of the state, this should not be a problem. But Mann Lake property owners may lessen their impact on the lake by following shoreland best management practices.

The aquatic plant community is a good indicator of the lake's overall health; and to this respect, all indications are that Mann Lake is healthy. 31 species of native aquatic plants were found in Mann Lake in 2014. One of the advantages of having a healthy aquatic plant community is its role in assuring better water quality. Aquatic plants provide habitat for small crustaceans, called zooplankton. Zooplankton are able to find cover within the aquatic plants from their primary prey – planktivorous fish. The zooplankton feed upon algae primarily. Their grazing keeps algae numbers low, which further increases the water clarity in the lake. Without the aquatic vegetation, the zooplankton are easy prey for small fish species.

Residents of Mann Lake did comment on the overabundance of two aquatic plant species – common waterweed and leafy pondweed. These plant species are found in abundance within 2-6 feet of water in the lake. Common waterweed, found in the highest abundance, is largely unrooted so it can often be found in shallow water, tangled amongst other plants. The density of these plants may be removing habitat for other native plants to grow, however they are native plants and are simply found in great abundance because the conditions are right for them. Further, they provide excellent habitat for young fish and crustaceans. As discussed in the Implementation Plan, residents may control aquatic plant growth near their piers / docks through manual means in order to gain access to the open water areas of the lake.

Year after year, these aquatic plants die back in the late summer and fall to the lake bottom. There, they partially decompose, leaving behind a nutrient rich organic material.

Each fall, the plants die back to the sediment, where bacteria break down the structures. This decomposition process leaves behind organic material which accumulates over the years. When more plants and algae are present, more material is left behind after their death. This is a naturally occurring process that all lakes undergo, as nature gradually makes them shallower and eventually fills them in.

An unfortunate circumstance resulting from these circumstances is the decrease in dissolved oxygen that accompanies great plant growth. As these plants are decomposed by bacteria, the microbes utilize available oxygen and produce carbon dioxide. Particularly in the winter months, when the lake is ice-covered and not exposed to oxygen diffusion from the open air, oxygen depletion can occur to a great degree. In Mann Lake it is likely that the vast majority of the lake goes anoxic most winters. This is a problem that impacts the fish within the lake, and is compounded by the lack of depth and volume in this relatively small and shallow lake. Within the Implementation Plan, a course of action was mapped by the Mann Lake planning committee and Onterra staff to determine feasibility of an aeration system placement in the lake.

Mann Lake is a healthy ecosystem that holds unique biological features and treasured memories for those that live along its shoreline. The Implementation Plan that follows is the result of conversations between FML lake stakeholders, Onterra staff, and WDNR specialists on ways that the FML may protect this unique resource while enjoying its natural beauty at the same time.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the FML Planning Committee and ecologist/planners from Onterra. It represents the path the FML will follow in order to meet their lake management goals. The goals detailed within the plan are based upon the findings of the studies completed in conjunction with this planning project and the needs of the Mann Lake stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Investigate Feasibility of Aeration System for Mann Lake

Management Action: Send letter to south shore property owner.

Timeframe: Late summer / fall 2015

Facilitator: Jon Leonhard

Description: During this project the subject of Mann Lake's low dissolved oxygen and winter fish kills was discussed extensively, with aeration brought up as a potential solution. For some time, aeration was discussed amongst members of the group but the hurdles of cost, liability and unfamiliarity with process kept pursuit of an aeration system at bay. Through this planning project and discussions with Onterra as well as the WDNR fish biologist Steve Gilbert, the association is more knowledgeable on oxygen cycles in their lake and the process of citing and maintaining an aeration system.

Ideally, aerator diffusers are placed in deeper water. This allows for air bubbles to expand as they reach the surface, creating a larger opening. Additionally, a larger water column allows for more area for fish congregation. There is one property on the lake's south shore, where water deeper than 8 ft exists. This property is privately owned but not visited. Though concerns exist about access and electrical connectivity, etc., this location would be ideal from an aeration standpoint.

The FML will draft a letter to the owner of this property explaining that the group is seeking options for location of an aeration system, and is exploring if their property would be an option. This letter would likely not include specifics of the process, but would explore if the property owner would be willing to further conversations on the matter to determine applicability on their property.

Action Steps:

1. FML member Jon Leonhard to complete letter in late summer 2015.
2. Response from southern property owner will dictate either further conversation or move to second Management Action (below)

Management Action: Identify potential property owners to house aeration system, hold site evaluation with WDNR representatives.

Timeframe: Late summer / fall 2015

Facilitator: Dave Jones and Dave Walschinski

Description: Mann Lake's south shore would be ideal for an aeration system due to the deep water that is found there. However there is one property along the shoreline that is used infrequently. Due to the complications of requiring electrical hook-up, winter access, and frequent monitoring of the aerator's safety barrier, this location is not promising.

Most likely, an aerator will need to be cited along the lake's north-northwest shoreline, where the majority of properties are located. The FML will attempt to determine 2-3 willing property owners who would be receptive to the idea of aerator housing on their property. Considerations such as access, ability to maintain/watch-over a safety barrier and nearby in-lake conditions (depth) will be discussed. Once these property owners are identified, the FML will request a site evaluation with the WDNR. WDNR fish biologist Steve Gilbert and WDNR regional lakes coordinator Kevin Gauthier would be the first individuals to contact. They will complete the site visit or select more suitable individuals to do so if they deem necessary.

During this time, the FML will solicit quotes from several aeration companies to gain a better understanding of the cost involved with aeration. While it is understood that the specifics of an aerator unit will need to be determined based upon it's placement location, early conversations with aerator manufacturers will help FML members understand a reasonable estimate of cost, maintenance, etc. A list of possible manufacturers is provided below:

Vertex Water Features - http://www.vertexwaterfeatures.com/
Cason and Associates - http://www.casonassociates.com/index.php
Kasco Marine - http://www.kascomarine.com/
Lake and Pond Solutions Co. - http://www.lakeandpondsolutions.com/
Wisconsin Lake & Pond Resource - http://www.wisconsinlpr.com/

Action Steps:

1. Facilitators reach out to property owners to discuss potential citing of aeration unit and share their knowledge of how the system would operate and what responsibilities the property owner has. No commitment of the property owner would be required until after a WDNR site evaluation and further discussions would occur.
2. Facilitators coordinate a site evaluation day with WDNR representatives and property owners.
3. Interested property owners will work with WDNR representatives to answer questions pertaining to matters of logistics, liability, etc.
4. Facilitators will solicit quotes for aerator systems from manufacturers.

Management Action: Complete a February 2016 grant application to partially fund aerator on Mann Lake.

Timeframe: Winter 2015 / 2016 – Due date February 1, 2016

Facilitator: FML Board of Directors

Description: Once a WDNR site evaluation has taken place, a location / property for an aeration system has been determined, and an idea of costs involved with the aeration system (unit, estimated electrical costs, housing, barrier, etc.) have been determined, the next step for the FML would be to submit a grant to the WDNR Surface Water Grants program. This would be under the Lake Protection – Lake Management Plan Implementation category of this program (http://dnr.wi.gov/aid/surfacewater.html).

The application would propose a 3-year project and contain partial costs of the aeration system equipment, a water quality / dissolved oxygen sampling plan and laboratory costs, an education program to share results of the aeration project with FML property owners and the public, and in-kind volunteer time for monitoring and implementation of the program. A dissolved oxygen probe is available for lake groups to borrow periodically from the Trout Lake Station Center for Limnology, the FML would borrow this unit from the station to complete winter DO sampling. The FML would ask for support from other management entities (WDNR, County, Town, etc.) in a variety of ways to display to WDNR grant administrators that the project has the backing of numerous groups and a high probability of success.

Notification of the grant application would occur by early April 2016, meaning that the FML would prepare through summer 2016 for a 2017 activation of an aeration system.

Action Steps:

1. FML Board of Directors complete site evaluation and determine best aeration system design with WDNR staff
2. Complete Management Planning Project in fall 2015 to become eligible for Lake Protection Grant funds
3. With appropriate support from FML membership, proceed with February 1, 2016 Lake Protection Grant application

Management Goal 2: Continue Volunteer Monitoring of Mann Lake Ecology

Management Action: Continue water quality monitoring, expand to chemical analysis.

Timeframe: Continuous, expand in 2016

Facilitator: Dick Jenks

Description: Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason as of why the trend is developing.

The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality data on their lake. Volunteers trained by the WDNR as a part of the CLMN program begin by collecting Secchi disk transparency data for at least one year, then if the WDNR has availability in the program, the volunteer may enter into the *advanced program* and collect water chemistry data including chlorophyll-a, and total phosphorus. The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. Note: as a part of this program, these data are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS).

The FML currently has a volunteer that collects Seccki disk clarity data on Mann Lake as a part of this program. The group wishes to move into the advanced program (chemistry monitoring) soon, and has been placed on a waiting list. Once availability is met, the FML will be notified of their acceptance into the program. Should the group be successful in a February 2016 Lake Protection Grant application, this study would fund 3 years of water quality monitoring that would match the CLMN protocols, thus allowing the group to complete advanced water quality monitoring before the CLMN program has availability for their inclusion.

It is the responsibility of the Planning Committee to coordinate new volunteers as needed. When a change in the collection volunteer occurs, it will be the responsibility of the Planning Committee to contact Sandra Wickman (715.365.8951) or the appropriate WDNR/UW Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through

Action Steps:

1. See above description.

<u>Management Action:</u> Develop early detection AIS monitoring program.

Timeframe: Initiate in 2016

Facilitator: Mary Jenks & Judy Burditt

Description: Aquatic invasive species have caused ecological impacts as well as reduced recreational opportunity in many Wisconsin lakes. Early detection of AIS is important, as is a plan to address the invasive plant/animal. Volunteer monitoring is the most cost-effective way the FML can survey their lake for AIS and identify early occurrences. The FML wishes to adopt a volunteer monitoring design that maximizes their volunteer's time as well as maximizes the amount of lake area that is covered. The group has attended seminars in which AIS identification techniques were shared and discussed.

One way that lake residents can spot AIS is through conducting "Lake Sweeps" on their lake. During a lake sweep, volunteers monitor the entire littoral zone in search of non-native plant species. This program uses an "adopt-a-shoreline" approach where volunteers survey specified, assigned areas.

In order for accurate data to be collected during these sweeps, volunteers must be able to identify non-native species such as Eurasian water milfoil and curly-leaf pondweed. Distinguishing these plants from native look-a-likes is very important. Additionally, the collection of suspected plants is important. A specimen of the plant would need to be collected for verification, and, if possible, GPS coordinates should be collected. Vilas County AIS coordinator Catherine Higley is an excellent resource to contact for assistance in developing monitoring techniques, identifying invasive aquatic plants and logging pertinent monitoring information.

Action Steps:

1. Volunteers from the FML update their skills by attending a training session conducted by Vilas County AIS Coordinator as needed.
2. Trained volunteers recruit and train additional association members.
3. Complete lake surveys following designated protocols.
4. Report results to WDNR, Vilas County AIS Coordinator and FML.

<u>Management Action:</u> Continue Loon Watch program.

Timeframe: Continuous

Facilitator: Mary Jenks & Judy Burditt

Description: LoonWatch is a program of the Sigurd Olson Environmental Institute, out of Northland College, Ashland, WI. The program aims to protect loons as well as document their activities through education, monitoring and research. The program focuses upon Wisconsin waters, though education and research activities extend throughout the Upper Great Lakes region.

The FML has several trained "Loon Rangers", which are a group of dedicated volunteers that serve to collect long-term data on loons in their respective surveying area. Volunteers attend a workshop in the spring to learn about monitoring procedures and meet with other enthusiasts. When loons return during the late spring months, data is collected on their arrival date, if they nested, how many chicks were produced, etc.

The Loon Ranger volunteers on Mann Lake wish to continue their efforts, and also engage others that might be interested in loon biology. The volunteers will report their work to the FML, LoonWatch program and other interested parties as necessary and recruit new volunteers if interest develops.

Action Steps:

1. See above description.

Management Goal 3: Educate Lake Property Owners on Methods to Access Open Water Areas Through Dense Aquatic Plant Growth

<u>Management Action:</u> Promote removal of aquatic plants through manual techniques

Timeframe: Initiate in 2016

Facilitator: Dick Jenks

Description: This management planning project found several species of aquatic plants to grow well within the waters of Mann Lake, common waterweed and leafy pondweed. Leafy pondweed is a rooted plant, while common waterweed frequently is found unrooted, floating in the water near the shoreline. These plants have proven to hinder navigation to open water for some Mann Lake property owners; the majority of stakeholder survey respondents indicated that aquatic plant growth "sometimes" impacts their enjoyment of Mann Lake (Appendix B, Question #22). Question 21 on the stakeholder survey displays that "Excessive aquatic plant growth" was the top ranked concern for Mann Lake property owners. Several methods of managing aquatic plants are provided below:

1. Aquatic-environment approved herbicides can be effective on aquatic plants, but is very rarely permitted by the Wisconsin DNR on native plant communities. The reason is that these communities provides natural habitat for fish/insects, as well as a means of dampening waves that would otherwise work to erode the shoreline. . More information on native aquatic plant management may be found in the WDNR's Northern Region Aquatic Plant Management Strategy document (available on the WDNR's website). This was not determined to be a suitable method for aquatic plant control on Mann Lake by the planning committee members, nor did it receive much support within the stakeholder survey (Appendix B, Question 24).

2. Mechanical harvesters may be used to control nuisance conditions of aquatic plants. These units are quite costly to purchase, running anywhere from $45,000 to $100,000. Harvesters may be contracted through a few companies. There are several issues with operating a mechanical harvester. First, a Wisconsin DNR permit is required. These permits are distributed when significant navigational or recreational impairment is documented. Typically, permits are created to harvest multiple acres of navigation lanes in a lake; this is often required when significant navigational impairment is present. The conditions on Mann Lake would likely not be considered significant navigational impairment, as dense aquatic plants occupy a relatively thin length of area surrounding much of the

shoreline. So, it may be difficult to convince the WDNR that navigational concerns are warranted to approve of this permit. Second, mechanical harvesters are usually quite heavy and can only operate in deeper than 3-4 feet of water. The shallow areas present by the shore and people's docks may not be able to be harvested. This was not determined to be a suitable method for aquatic plant control on Mann Lake by the planning committee members, but did receive some support within the stakeholder survey (Appendix B, Question 24).

3. Manual removal of aquatic plants can be completed through tools such as rakes or Y-shaped blades. Wisconsin administrative code NR 109 states that property owners may remove a 30-ft swath of plants in front of their property, as far out in the lake as necessary to gain access to open water. Plant material must be removed from the lake, and no Wisconsin DNR permit is needed so long that wild rice is not present. This is no doubt a labor-intensive task, but its advantage is that it is quite inexpensive and does not require permits to complete. This method was supported highly amongst the Mann Lake Planning Committee members, and was also ranked as being highly supported within the stakeholder survey (Appendix B, Question 24).

The FML will encourage property owners that are experiencing nuisance aquatic plant conditions nearby their property to utilize manual control utensils to alleviate conditions and allow them access to deeper water areas of the lake. Some lake associations have done so by discussing the procedures at annual meetings, or sharing pamphlets distributed by companies who manufacture these tools. Other lake groups have decided to purchase the necessary tools (rakes, cutters, wheel barrows, etc.) and allow members to borrow the tools as needed.

Action Steps:

1. See above description.

Management Goal 4: Strengthen Association Relationships, Effectiveness and Lake Management Capability

Management Action: Enhance involvement with other entities that have a hand in managing Mann Lake.

Timeframe: Continuation of existing efforts

Facilitator: FML Board of Directors

Description: The FML, being a small group, is interested in preserving their lake but also using grant funds whenever possible to do so. Table 5.0-1 outlines grants that are available to Wisconsin lake group. Of particular interest to the FML would be the Large and Small Scale Lake Management Planning Grant category and the Lake Management Plan Implementation category. In the event that AIS are found within Mann Lake, the group may be applicable for funding through the AIS Early Detection & Response category.

The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. It is important that the FML actively engage with all management entities to enhance the association's understanding of common management goals and to participate in the development of those goals. This also helps all management entities reduce the duplication of efforts. While not an inclusive list, the pertinent parties for Mann Lake range from those located locally (Town of Boulder Junction) to those at the County level (Vilas County AIS Coordinator, Vilas County Lakes & Rivers Association) and at the level of the State of Wisconsin (WDNR). Each entity is specifically addressed Table 5.0-1.

Action Steps:

1. Refer to management entity table and contact partners as necessary.

Table 5.0-1 Management Partner List.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Town of Boulder Junction	General Town Chair (Dennis Reuss, 262.993.1857)	Oversees ordinances, funding, other items	As needed.	Town staff may be contacted regarding ordinance reviews or questions and for info on community events.
Boulder Junction Chamber of Commerce	Boulder Junction Executive Director (Kristen Techacek, 715.385.2400)	Disseminate literature and coordinate events	As needed.	Disseminates AIS and lake management materials to the public and coordinate community events.
Vilas County Lakes & Rivers Association (VCLRA)	President (Rollie Alger, president@vclra.us)	Protects Vilas Co. waters through facilitating discussion and education.	Twice a year or as needed.	Become aware of training or education opportunities, partner in special projects, or networking on other topics pertaining to Vilas Co. waterways.
Vilas County AIS Coordinator	AIS Coordinator (Catherine Higley, 715.479.3738, cahigl@co.vilas.wi.us)	Oversees AIS monitoring and education activities county-wide.	Twice a year or more as issues arise.	AIS training and ID, monitoring techniques, CBCW training, report summer activities.
Vilas County Land and Water Conservation Department	Lake Conservation Specialist (Mariquita (Quita) Sheehan, 715.479.3721, mashee@co.vilas.wi.us)	Oversees conservation efforts for lake grants and projects.	Twice a year or more as needed.	Contact for shoreland remediation/restoration techniques and cost-share procedures, wildlife damage programs, education and outreach documents.
Wisconsin Department of Natural Resources	Fisheries Biologists (Steve Gilbert, 715.356.5211)	Manages the fish populations and fish habitat enhancement efforts.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Kevin Gauthier ,– 715.365.8937)	Oversees management plans, grants, all lake activities.	As needed.	Information on planning/AIS projects, grant applications or to seek advice on other lake issues.
	Environmental Grant Specialist (Jane Malischke, 715.635.4062)	Oversees financial aspects of grants.	As needed.	Information on grant financials and reimbursement, CBCW grant applications.
	Conservation Warden (Rich Thole, 715.605.2130)	Oversees regulations handed down by the state.	As needed. May call the WDNR violation tip hotline for anonymous reporting (1-800-847-9367, 24 hours a day).	Contact regarding suspected violations pertaining to recreational activity, include fishing, boating safety, ordinance violations, etc.
University of Wisconsin Extension Office	Citizens Lake Monitoring Network (Sandra Wickman, 715.365.8951) (Paul Skawinski, 715.365.8998)	Provides training on CLMN monitoring and data entry.	Twice a year or more as needed.	Arrange for training as needed, report monitoring activities.
Wisconsin Lakes	General staff (800.542.5253)	Facilitates education and assistance on matters involving lakes.	As needed. May check website (www.wisconsinlakes.org) often for updates	Contact for shoreland remediation/restoration techniques, outreach/education.

<u>Management Action:</u> Support endeavors that increase environmental awareness, communication and quality of life on Mann Lake.

Timeframe: Begin spring 2016

Facilitator: Board of Directors

Description: Education represents a tool to address issues that impact water quality such as lake shore development, lawn fertilization, and other issues. The FML is a small organization whose strength lies in the friendships and bonds that are formed through lake life. The FML will promote lake protection through a variety of educational efforts that unite the group and facilitate relationships amongst Mann Lake property owners.

The FML has several educational initiatives in place for Mann Lake stakeholders. The association holds an annual meeting each summer, and provides updates to all property owners through a Facebook page and electronic newsletter, the latter which is distributed 2-3 times per year. The Board of Directors would like to continue to come up with fresh topics for these meetings and newsletter circulations in order to keep property owners engaged and interested. Potential topics include:

- Aquatic invasive species monitoring updates
- Boating safety and ordinances
- Catch and release fishing
- Shoreland restoration and protection
- Aeration system projects statewide
- Septic system maintenance
- Fishing rules and regulations

The board will be responsible for reaching out to state or local affiliates which can provide them with educational pamphlets, other materials or ideas. These partners may be some of those included in the table found under the previous Management Action. Additional resources include:

Wisconsin Lakes FAQ (water quality, levels, lake health)

http://dnr.wi.gov/lakes/commonquestions/Default.aspx

Shoreland zoning and health

http://dnr.wi.gov/topic/shorelandzoning/

Citizens Lake Monitoring Network

http://dnr.wi.gov/lakes/clmn/

General Resources
http://www.wisconsinlakes.org/
http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/default.aspx

Action Steps:

1. The FML Board of Directors will identify a base level of annual financial support for educational activities to be undertaken.
2. Reach out to assisting management entities (see table under Management Goal 3, Action 1) for resources to help educate property owners.

Management Action: Become knowledgeable on Wisconsin grant funding opportunity for future restoration / preservation work.

Timeframe: Begin in fall 2015

Facilitator: Board of Directors

Description: The FML, being a small group, is interested in preserving their lake but also using grant funds whenever possible to do so. Table 5.0-2 outlines grants that are available to Wisconsin lake group. Of particular interest to the FML would be the Large and Small Scale Lake Management Planning Grant category, from which this project was made possible, the Lake Management Plan Implementation category, and Healthy Lakes Project category. In the event that AIS are found within Mann Lake, the group may be able to apply for funding through the AIS Early Detection & Response category.

While it is not necessary for the Board of Directors to have detailed working knowledge of the grant categories, it is important for the group to recognize when they would benefit from grant funds for projects they are interested in undertaking.

The WDNR Surface Water Grants website is an excellent research tool for someone familiarizing themselves with this grant program:

http://dnr.wi.gov/aid/surfacewater.html

Action Steps:

1. The FML Board of Directors will select individuals to gain a basic understanding on the grant categories listed below.
2. Additional information will be obtained through qualified consultant if necessary, by visiting the WDNR Surface Water Grants website, or by contacting WDNR lakes coordinator Kevin Gauthier.

Table 5.0-2 Grant Category List.

	Grant Type	Details	Funding	Deadline
Planning Grants	**Large Scale Planning**	Suited for comprehensive studies on larger lakes with technical planning challenges	67% of total project costs, not to exceed $25,000	December 10
Planning Grants	**Small Scale Lake Planning**	Addresses the planning needs of lakes where education, enhancing organizational capacity and obtaining information on specific conditions are the primary objective	67% of total project costs, not to exceed $3,000	December 10
Classification / Ordinance	**Lake Classification / Local Ordinance Development**	Provides financial opportunities for Wisconsin counties to assist in lake protection efforts through shoreland zoning or water conservation programs (Note – only WI counties may apply)	75% of total project costs, not to exceed $50,000	December 10
Lake Protection Grants	**Land / Easement Acquisition**	Intended for the acquisition of property or easements to protect lakes	Maximum of 75% of total project costs, not to exceed $200,000	February 1
Lake Protection Grants	**Wetland and Shoreline Habitat Restoration**	Provides assistance to protect or improve the water quality of a system of a lake by restoring adjacent wetlands or tributaries	Maximum of 75% of total project costs, not to exceed $100,000	February 1
Lake Protection Grants	**Lake Management Plan Implementation**	Provides financial assistance to applicants that have completed a lake management plan to implement approved recommendations	75% of total project costs, not to exceed $200,000	February 1
Lake Protection Grants	**Healthy Lakes Project**	Funds installation of a Best Management Practice (BMP) on waterfront properties	Maximum of 75% of total project costs, not to exceed $25,000	February 1
AIS Education and Control Grants	**AIS Early Detection & Response**	Provides rapid funding for the early identification of pioneer AIS colonies – not a competitive grant category	Maximum of 75% of total project costs, not to exceed $20,000	Year-Round
AIS Education and Control Grants	**AIS Maintenance & Containment**	Provide limited assistance for ongoing control of AIS populations on waters where management activity has brought down AIS to target levels	Variable	Year Round
AIS Education and Control Grants	**AIS Education, Prevention & Planning**	Intended to broaden public's awareness of AIS, doing so through prevention projects and education	Maximum of 75% of total project costs, not to exceed $150,000	December 10
AIS Education and Control Grants	**Clean Boats Clean Waters**	Intended to bring AIS education to boaters through manned boat landing inspections and questionnaires	Limited to $4,000 per public boat launch facility	December 10
AIS Education and Control Grants	**Established Population Control Projects**	To assist applicants in targeting established AIS for reduction while protecting native species	Maximum of 75% of total project costs, not to exceed $200,000	February 1

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Mann Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in the lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected with a 3-liter Van Dorn bottle at the subsurface (S) and near bottom (B). Sampling occurred once in spring, fall, and winter and three times during summer. Samples were kept cool and preserved with acid following standard protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included the following:

Parameter	Spring		June		July		August		Fall		Winter	
	S	B	S	B	S	B	S	B	S	B	S	B
Total Phosphorus	●	●	●	●	●	●	●	●	●	●	●	●
Dissolved Phosphorus	●	●			●	●					●	●
Chlorophyll a	●		●		●		●		●			
Total Kjeldahl Nitrogen	●	●			●	●					●	●
Nitrate-Nitrite Nitrogen	●	●			●	●					●	●
Ammonia Nitrogen	●	●			●	●					●	●
Laboratory Conductivity	●	●			●	●						
Laboratory pH	●	●			●	●						
Total Alkalinity	●	●			●	●						
Total Suspended Solids	●	●	●	●	●	●	●	●	●	●	●	●
Calcium	●											

In addition, during each sampling event Secchi disk transparency was recorded and a temperature, pH, conductivity, and dissolved oxygen profile was be completed using a Hydrolab DataSonde 5.

Watershed Analysis

The watershed analysis began with an accurate delineation of Mann Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the National Land Cover Database (NLCD – Fry et. al 2011) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Mann Lake during an early June 2014 field visit, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Mann Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in the Wisconsin Department of Natural Resource document, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry, and Analysis, and Applications (WDNR PUB-SS-1068 2010) was used to complete this study. A point spacing of 49 meters was used resulting in approximately 431 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Mann Lake (emergent and floating-leaved vegetation) were mapped using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy. Furthermore, all species found during the point-intercept surveys and the community mapping surveys were recorded to provide a complete species list for the lake.

Representatives of all plant species located during the point-intercept and community mapping survey were collected and vouchered by the University of Wisconsin – Steven's Point Herbarium.

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