Lake Julia

Oneida County, Wisconsin

Comprehensive Management Plan

October 2013

Sponsored by:

Lake Julia Association

WDNR Grant Program

LPL-1406-11, LPL-1407-11 & LPL-1434-11

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Onterra, LLC
Lake Management Planning

Lake Julia

Oneida & Forest Counties, Wisconsin

Comprehensive Management Plan

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Funded by: Lake Julia Association, Inc.
Wisconsin Dept. of Natural Resources
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This management planning effort was truly a team-based project and could not have been completed without the input of the following individuals:

Lake Julia Planning Committee

David Mitzner
Paul Melzer
Jim Drought
Greg Uhen

Wisconsin Dept. of Natural Resources

Tim Plude
Kevin Gauthier
John Kubisiak

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1.0 INTRODUCTION

Lake Julia, Oneida and Forest Counties, is a 401-acre drainage lake with a maximum depth of 45 feet and a mean depth of 18 feet (Map 1). This mesotrophic lake has a relatively moderately sized watershed when compared to the size of the lake. Lake Julia contains 58 native plant species, of which northern water milfoil is the most common plant. No exotic plant species are known to exist in Lake Julia.

Field Survey Notes

Darkly stained water observed during fieldwork visits. Many native species encountered during point-intercept survey.

Photograph 1.0-1 Lake Julia, Oneida County

Lake at a Glance - Lake Julia

Morphology	
Acreage	401
Maximum Depth (ft)	45
Mean Depth (ft)	18
Shoreline Complexity	6.0
Vegetation	
Curly-leaf Survey Date	June 21, 2011
Comprehensive Survey Date	July 20, 2011
Number of Native Species	58 (*including incidental species*)
Threatened/Special Concern Species	*None*
Exotic Plant Species	*None*
Simpson's Diversity	0.95
Average Conservatism	6.9
Water Quality	
Trophic State	Mesotrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	7.9
Sensitivity to Acid Rain	Not sensitive
Watershed to Lake Area Ratio	12:1

Lake Julia is a darkly stained, relatively deep lake located on the borderline of Oneida and Forest Counties. Water from Lake Julia flows west into Virgin Lake of the Three Lakes Chain of Lakes, and eventually runs through this chain and into the Lower Eagle River Chain of Lakes, spilling over the Burnt Rollways Dam in the Eagle River in doing so. The water soon after enters the Wisconsin River.

The Lake Julia Association (LJA) became interested in creating a lake management plan for several reasons. First, they wanted to be better prepared to react if Lake Julia becomes populated with an aquatic invasive species. Several nearby waterways (Virgin Lake, Long Lake, the Eagle River Chain of Lakes) are battling Eurasian water milfoil infestations. Secondly, the LJA understood the value of gaining knowledge of the overall condition of Lake Julia. The information contained within this management plan will help to guide future LJA plans and programs, whether these activities are guided towards pro-active approaches or lake restoration and/or enhancement.

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 as well as through the completion of a stakeholder survey.

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

Kick-off Meeting

On July 9, 2011, a project kick-off meeting was held to introduce the project to the general public. The meeting was announced through a mailing and personal contact by LJA board members. The attendees observed a presentation given by Tim Hoyman, an aquatic ecologist with Onterra. Mr. Hoyman'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 July 21, 2012, Tim Hoyman and Dan Cibulka of Onterra met with several members of the Lake Julia Planning Committee for nearly 3.5 hours. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including, aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed. Many discussions followed the presentation, including ways the LJA might protect the lake ecosystem from non-native species, improve the fish habitat and monitor the water quality of the lake.

Project Wrap-up Meeting

On July 20, 2013, the LJA held the project Wrap-up meeting at the Three Lakes Town Library in Three Lakes, WI. Dan Cibulka of Onterra met with the group to present a summary of the project's results, as well as an overview of the management goals and actions the LJA planning committee had decided to undertake. The meeting concluded with a question and answer session.

Management Plan Review and Adoption Process

In fall of 2012, following the Planning Meeting, a draft of the Implementation Plan of this document was created by Onterra staff. This Implementation Plan was crafted through discussions between Onterra and the LJA planning committee. The planning committee commented on the Implementation Plan, as well as the remaining portions of this document in October and November of 2012. Following their approval, a draft was sent to the WDNR for review in November of 2012. On August 16, 2013, the WDNR completed their review and had several comments for Onterra staff to address. A final draft of the management plan was completed in October of 2013.

Stakeholder Survey

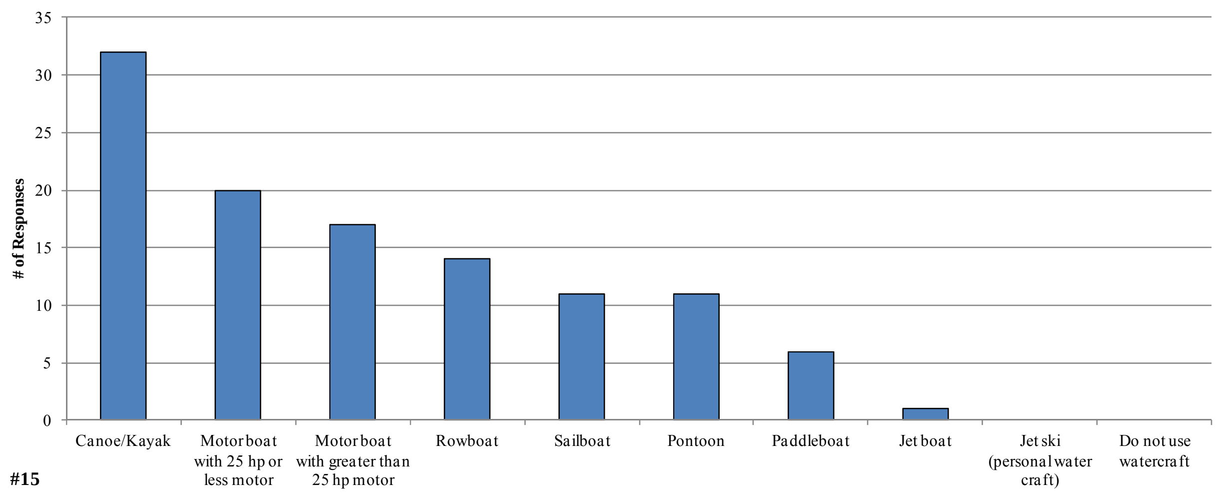
During November 2011, an eight-page, 33-question survey was mailed to 43 riparian property owners in the Lake Julia watershed. 77% of the surveys were returned and those results were entered into a spreadsheet by members of the Lake Julia Planning Committee. The data were summarized and analyzed by Onterra 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.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Lake Julia. The majority of stakeholders (44%) are seasonal residents, while 24% visit on weekends through the year and 18% live on the lake year-round (Appendix B, Question #1). 50% of stakeholders have owned their property for over 25 years (Question #3).

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect to 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 a canoe or kayak on the lake, and many respondents indicated they use a motor boat as well (Question #15). Rowboats were also a popular option. On a long, but narrow lake such as Lake Julia, the importance of responsible boating activities is increased. 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 #16, several of the top recreational activities on the lake involve boat use. Although boat traffic was listed as a factor potentially impacting Lake Julia in a negative manner (Question #22), it was ranked 7th on a list of stakeholder's top concerns regarding the lake (Question #23), behind other issues such as lakeshore development, aquatic invasive species and water quality degradation.

Throughout the survey and at meetings associated with this project, stakeholders indicated several concerns with the lake, of which lakeshore development and fishing issues were the most reoccurring (see Question #23 and survey comments – Appendix B). Lakeshore development on Lake Julia is discussed within the Watershed Section, while issues related to the Lake Julia fishery are discussed in the Fisheries Data Integration Section. These items are also discussed within the Summary and Conclusions Section and Implementation Plan.

Question #15: What types of watercraft do you currently use on the lake?



Question #16: Please rank up to three activities that are important reasons for owning your property on or near the lake.

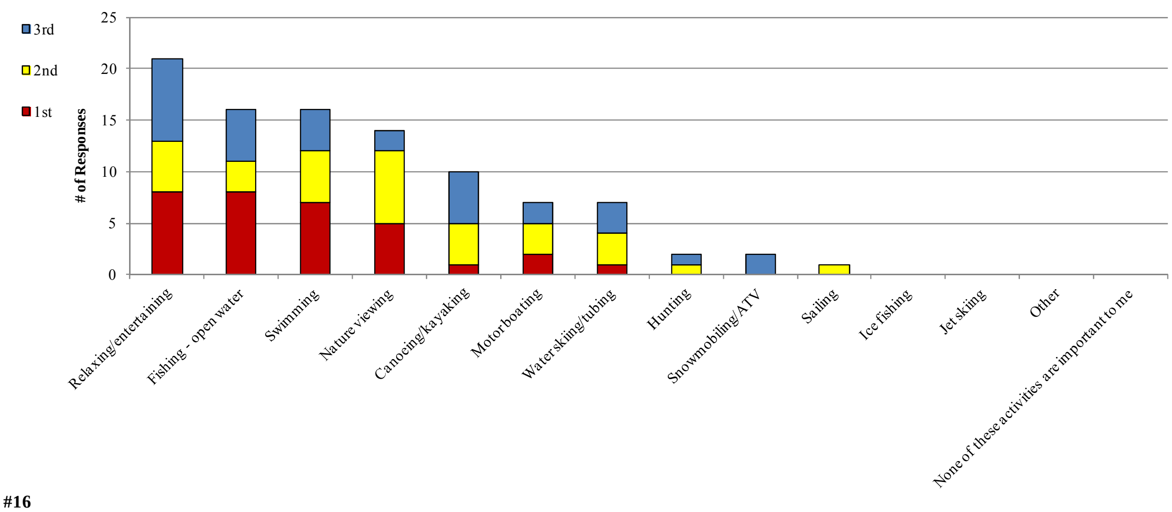
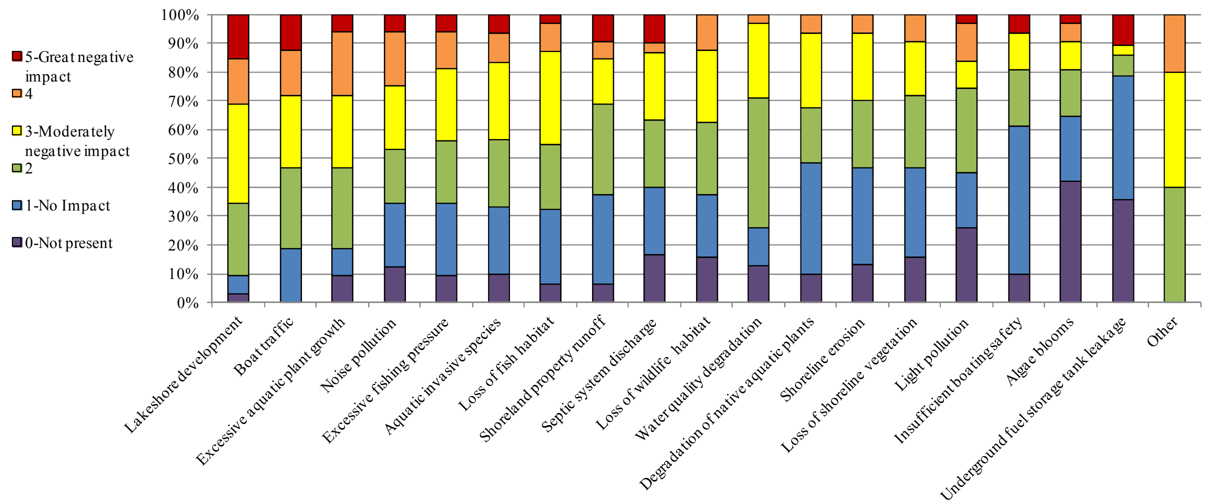


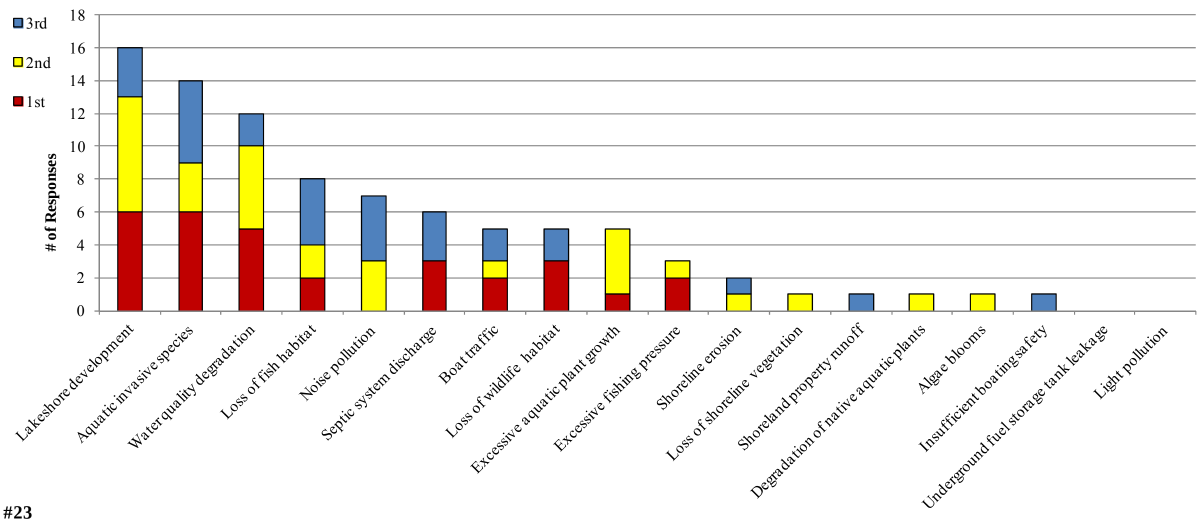
Figure 2.0-1. Select survey responses from the Lake Julia Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question #22: To what level do you believe these factors may be negatively impacting Lake Julia?



#22

Question #23: Please rank your top three concerns regarding Lake Julia.



#23

Figure 2.0-2. Select survey responses from the Lake Julia 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 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 Lake Julia 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 Lake Julia'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, 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 publication *Implementation and Interpretation of Lakes Assessment Data for the Upper Midwest* (PUB-SS-1044 2008) 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 Lake Julia will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into 6 classifications (Figure 3.1-1).

First, the lakes are classified into two main groups: **shallow (mixed)** or **deep (stratified)**. Shallow lakes tend to mix throughout or periodically during the growing season and as a result, remain well-oxygenated. Further, shallow lakes often support aquatic plant growth across most or all of the lake bottom. Deep lakes tend to stratify during the growing season and have the potential to have low oxygen levels in the bottom layer of water (hypolimnion). Aquatic plants are usually restricted to the shallower areas around the perimeter of the lake (littoral zone). 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.

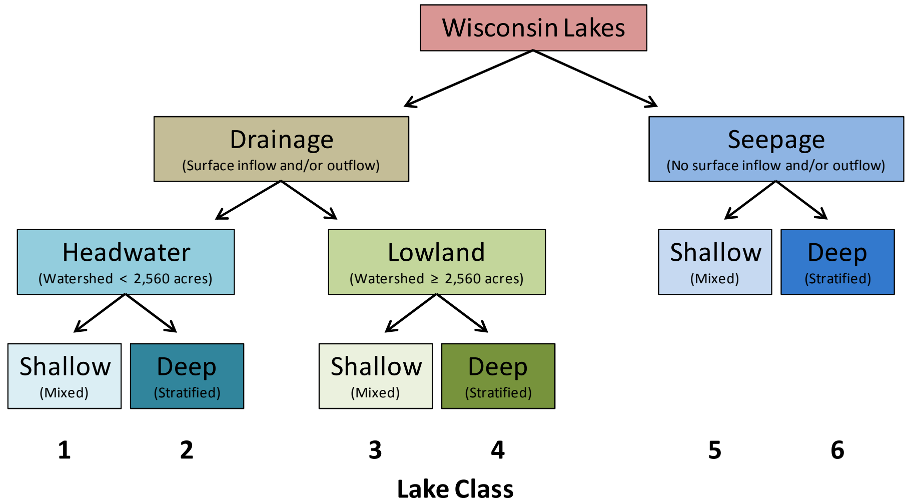


Figure 3.1-1. Wisconsin Lake Classifications. Lake Julia is classified as a deep (stratified), lowland drainage lake (Class 4). Adapted from WDNR PUB-SS-1044 (WDNR 2009).

Lathrop and Lillie developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for each of the six 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. Lake Julia is within the Northern Lakes and Forests ecoregion.

The Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM), created by the WDNR, is a process by which the general condition of Wisconsin surface waters are assessed to determine if they meet federal requirements in terms of water quality under the Clean Water Act (WDNR 2009). It is another useful tool in helping lake stakeholders understand the health of their lake compared to others within the state. This method incorporates both biological and physical-chemical indicators to assess a given waterbody's condition. One of the assessment methods utilized is Carlson's Trophic State Index (TSI). They divided the phosphorus, chlorophyll-*a*, and Secchi disk transparency data of each lake class into ranked categories and assigned each a "quality" label from "Excellent" to "Poor". The categories were based on pre-settlement conditions of the lakes inferred from sediment cores and their experience.

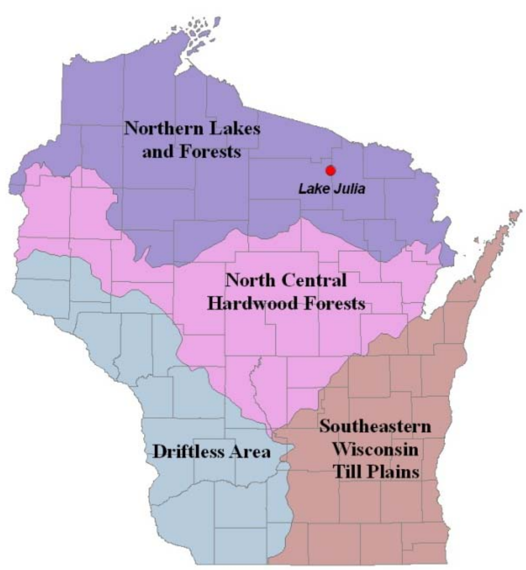


Figure 3.1-2. Location of Lake Julia within the ecoregions of Wisconsin. After Nichols 1999.

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These data along with data corresponding to statewide natural lake means, historic, current, and average data from Lake Julia 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.

Lake Julia Water Quality Analysis

Lake Julia Long-term Trends

As a part of this study, Lake Julia stakeholders were asked about their perceptions of the lake's water quality, among other topics. The majority (78%) of lake residents rated the water quality of Lake Julia as *Good* while 13% ranked the lake's water as *Excellent* (Appendix B, Question #17). Nearly 82% of survey respondents, however, stated that the water quality had *Remained the same* or *Somewhat degraded* since they first visited the lake (Question #18). Further, lakeshore development and water quality degradation ranked highly on a list of top concerns Lake Julia stakeholders had regarding their lake (Question #23).

It is often difficult to determine the status of a lake's water quality purely through observation. Anecdotal accounts of a lake "getting better" or "getting worse" can be difficult to judge because a) a lake's water quality may fluctuate from year to year based upon environmental conditions such as weather and b) differences in observation and perception of water quality can differ greatly from person to person. It is best to analyze the water quality of a lake through scientific data as this gives a concrete indication as to the health of the lake, as whether the lake health has deteriorated or improved. Further, by looking at data for similar lakes regionally and statewide, one can determine what the status of the lake is by comparison.

Unfortunately, there is only minimal data existing for Lake Julia in terms of its water quality. However, the data that is available indicates a healthy ecosystem. Average total phosphorus concentrations were measured at 14.7 µg/L in 2011, and a weighted average across all years ranks as *Excellent*, falling below median values for similar lakes regionally and statewide (Figure 3.1-3). Similar concentrations were found within the lake in 1993-1995.

As with total phosphorus, chlorophyll-*a* has only been measured several times within Lake Julia. In 2011, summer average concentrations were 3.9 µg/L, and a weighted average across all years of data equals 2.9 µg/L (Figure 3.1-4). This value ranks as *Excellent*, and is lower than the median average for deep, lowland drainage lakes within the state and ecoregion.

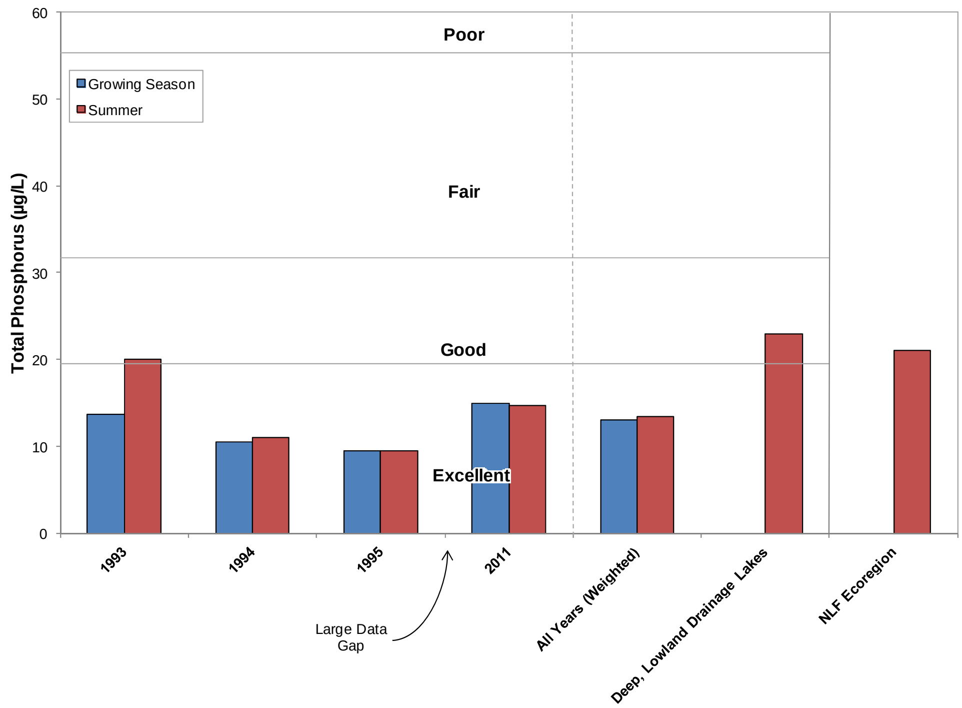

Figure 3.1-3. Lake Julia, state-wide class 4 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

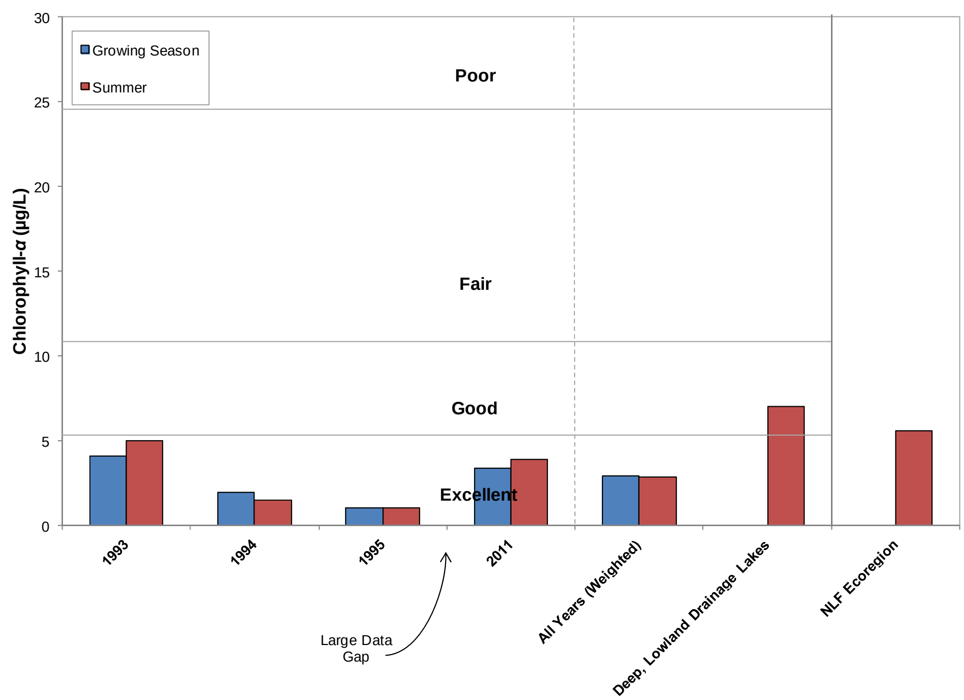

Figure 3.1-4. Lake Julia, state-wide class 4 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Secchi disk clarity has been measured slightly more often on Lake Julia. Average depths collected during the summer months between 1990 and 1995 range between 4.6 and 8.5 feet (Figure 3.1-5). In 2011, the Secchi disk clarity depth averaged 5.9 feet. A weighted average over all years (7.0 feet) is slightly below the median for deep, lowland drainage lakes statewide and within the ecoregion, but still ranks within the *Good* category. A lake's water clarity is determined by several factors, including the presence or absence of dissolved and particulate matter within the water column and the color of the water. During 2011, chlorophyll-*a* concentrations were very low, and suspended sediment samples collected from the surface water of the lake had insignificant traces of sediment within them ("none detected"). During field surveys, Onterra staff did note exceptionally brown stained water. But this staining is not from the presence of algae, sediments or pollutants of some type.

The clarity of the water of Lake Julia is regulated by dissolved, organic acids that are washed into the lake from nearby lands. These weak, natural acids, sometimes called "tannins" are the byproduct of decomposition of organic matter. This is the cause of the reduced clarity and root beer color of Lake Julia's water. Furthermore, it is this factor that is limiting light penetration into the waters of the lake which in turn limits algal production as well as the depth of aquatic plant growth (see the Aquatic Plant Section).

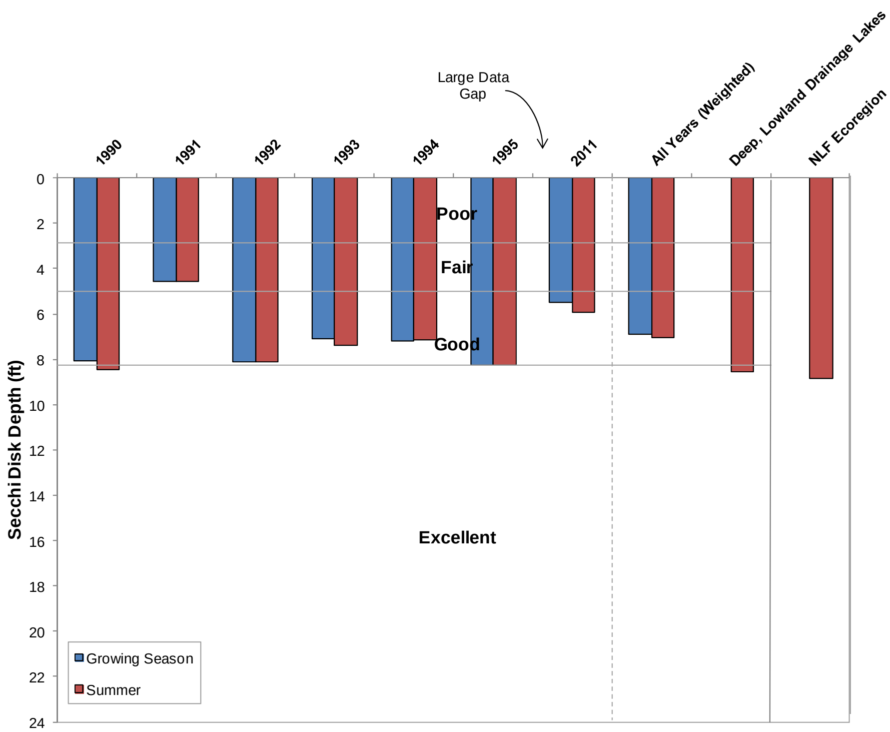

Figure 3.1-5. Lake Julia, state-wide class 4 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Lake Julia

Using midsummer nitrogen and phosphorus concentrations from Lake Julia, a nitrogen:phosphorus ratio of 29:1 was calculated. This finding indicates that Lake Julia 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.

Lake Julia Trophic State

Figure 3.1-5 contain the WTSI values for Lake Julia. The WTSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from upper oligotrophic 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* WTSI values, it can be concluded that Lake Julia is in a mesotrophic state.

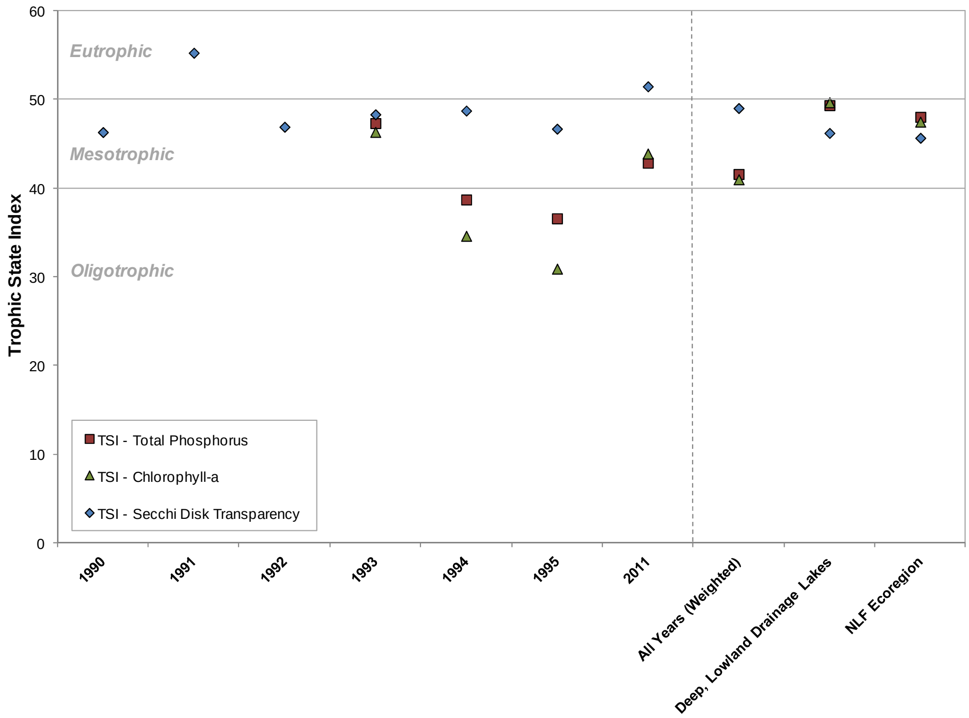

Figure 3.1-6. Lake Julia, state-wide class 4 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Lake Julia

Dissolved oxygen and temperature were measured during water quality sampling visits to Lake Julia by Onterra staff. Profiles depicting these data are displayed in Figure 3.1-6. In March of 2011, the coldest water was found at the surface of Lake Julia. Warmer (4 or 5 degrees C) water is a bit denser, and was found at the bottom of the lake. During the spring and fall (May and October), the winds of the changing seasons stir the lake up from top to bottom, mixing any temperature and dissolved oxygen gradients that had formed previously. During the summer months, the lake becomes stratified as the warm sunlight penetrates only the top 10 feet of the water column, and the winds are not sufficient to stir the lake. In the bottom layer of water, dissolved oxygen slowly depletes over the course of the summer and by August the oxygen concentrations reach 0 mg/L at 15 feet of depth. This is not too concerning, as the upper 15 feet of the lake contains more than enough oxygen to support warm water fish species. On some Wisconsin lakes, winter dissolved oxygen is of concern because the lake is covered by ice and so oxygen replenishment is not available. As seen within the March 2011 profile, this is not the case for Lake Julia, as plenty of oxygen (>5 mg/L) exists.

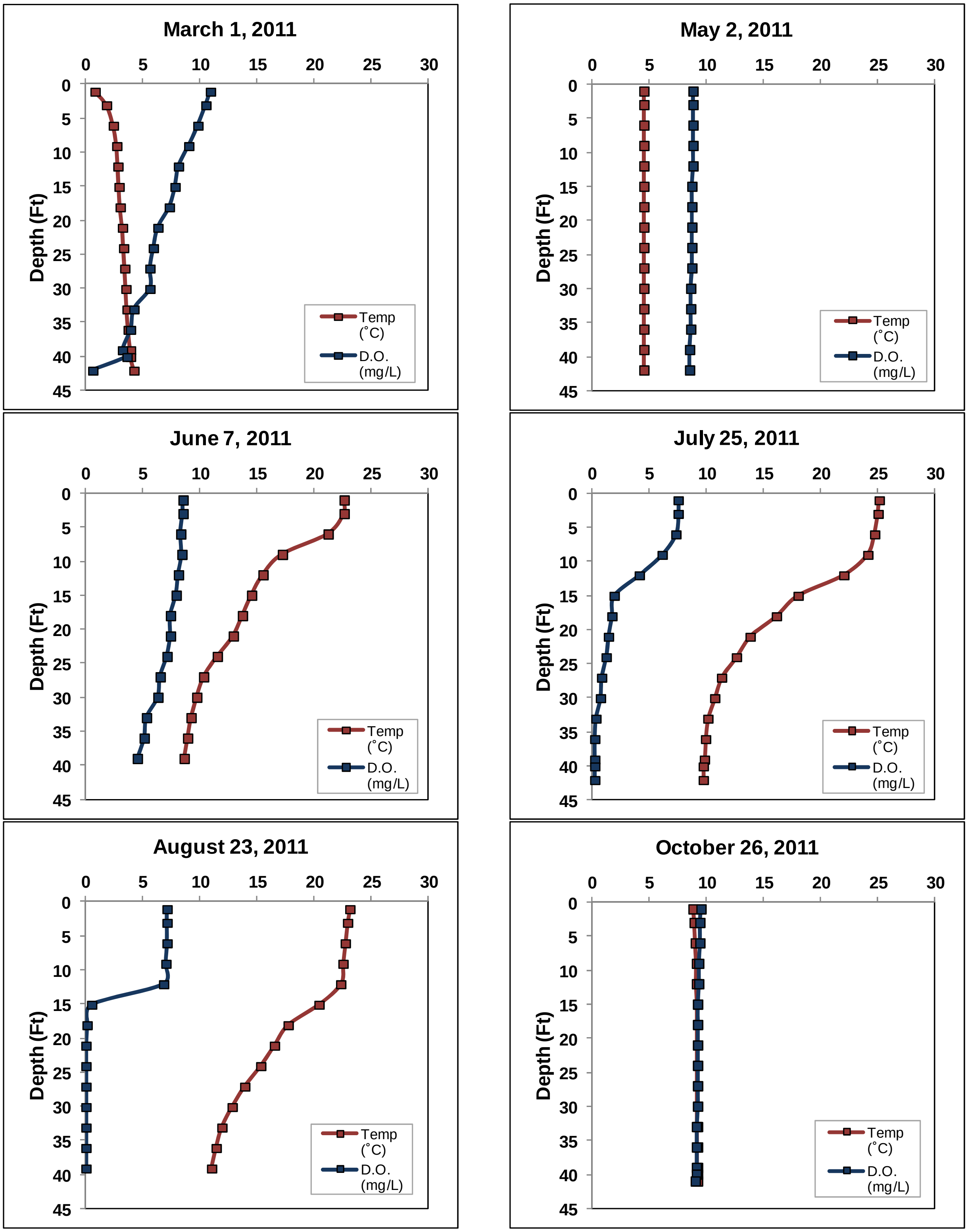

Figure 3.1-7. Lake Julia dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Lake Julia

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 Lake Julia'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 (Olszyk, 1980). The pH of the water in Lake Julia was found to be slightly above neutral (7.9), 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 Lake Julia was measured at 44.8 (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 (Coen 2005), so Lake Julia's pH of 7.9 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 (Whittier et al 2008). The calcium concentration of Lake Julia was found to be 11.5 mg/L, falling just below the optimal range for zebra mussels.

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, Lake Julia was considered borderline suitable for mussel establishment.

Plankton tows were completed by Onterra staff during the summer of 2011 and these samples were processed by the WDNR for larval zebra mussels. No veligers (larval 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.

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 exceeding 10-15:1, 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 (high residence time, i.e., years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time that internal nutrient loading may become a problem. 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.

The Lake Julia watershed is approximately 5,363 acres in size (Map 2). Within the watershed, about 58% (3,110 acres) of the land is considered wetlands (Figure 3.2-1). Forested land covers 31% (1,657 acres) of the watershed, the surface of Lake Julia comprises 7%, and pasture/grassland can be found covering the last 4% of the watershed. The watershed is about 12 times larger than the lake, making a watershed to lake area ratio of 12:1. As explained earlier, a ratio of 12:1 indicates that a lake may be impacted more so by the size of the watershed than the land cover types within the watershed.

Through modeling conducted with WiLMS, it is estimated that roughly 571 lbs of phosphorus enters Lake Julia from the surrounding watershed annually (Figure 3.2-2). This is not a considerable amount, considering Lake Julia's size and volume. The majority of the phosphorus (49% or 278 lbs) is derived from the 3,000+ acres of wetland that are found within the watershed. There are many types of wetlands found in this region of Wisconsin – scrub/shrub wetlands, forested wetlands, sedge meadows, marshes and ponds, etc. Although various wetland types export half of Lake Julia's phosphorus load to the lake each year, it must be remembered that this is a minimal amount from this land type. For example, if the 3,110 acres wetland were actually pasture or grass, the phosphorus load from this source alone would be 864 lbs – over three times greater than what is delivered from the wetland sources. Although wetlands do release nutrients to lakes and streams, their benefits of retaining greater amounts of nutrients, assisting to regulate water levels, and breaking down environmental pollutants, outweigh this small nutrient release by far. Forested lands are the second largest contributor of phosphorus to the lake (132 lbs or 23% of the total), followed by the lake surface, which is a source of 108 lbs of phosphorus to the lake each year through atmospheric deposition. Pasture/grass land, the smallest land cover type within the watershed, accounts for the remaining 9% of the phosphorus load to Lake Julia.

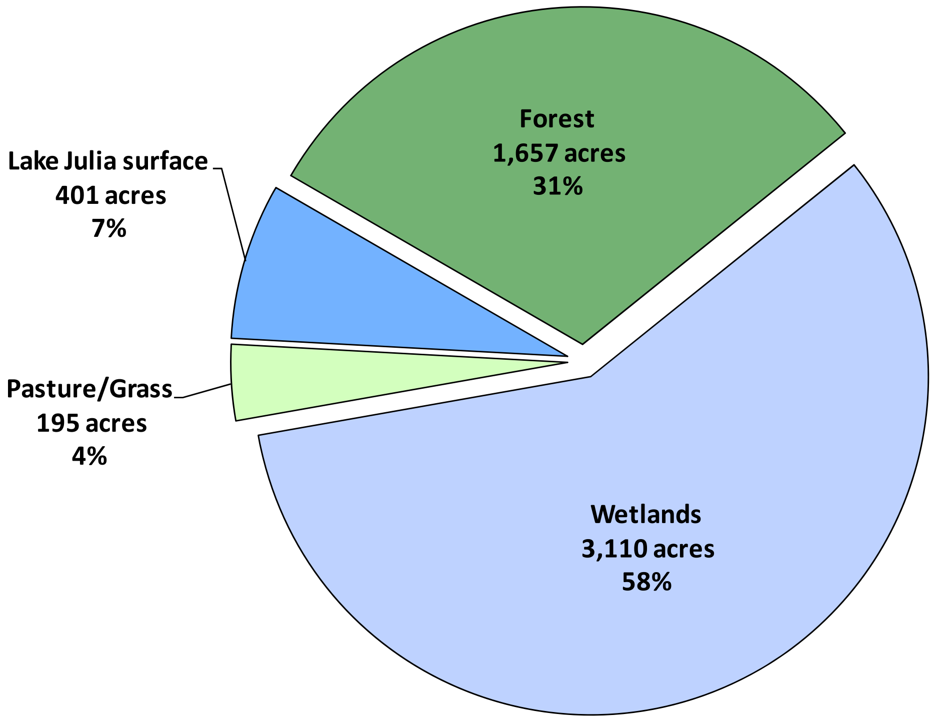

Figure 3.2-1. Lake Julia watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

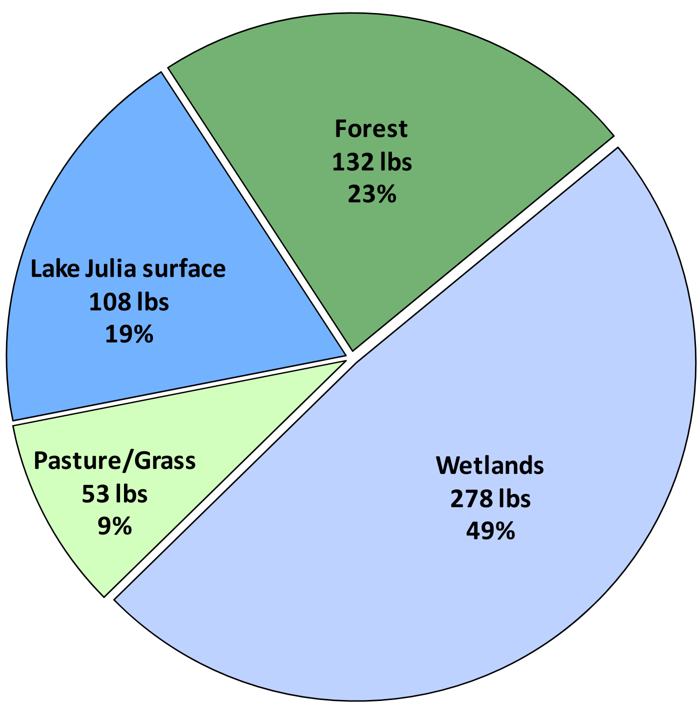

Figure 3.2-2. Lake Julia watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

As previously mentioned, the majority of stakeholders indicated some level of concern regarding the topic of lakeshore development on Lake Julia. The shoreline assessment segment below discusses the importance of shorelines to a lake, in terms of reducing pollutant transport and also increasing biodiversity and habitat for aquatic and terrestrial organisms. To test the sensitivity of the lake to an increase of development along the shoreline zone, WiLMS was used to model a scenario in which development was increased. A 200 ft. buffer was examined around the lake, with 50% of the acreage in this buffer being converted from various wetland types to medium density urban land – a typical category for a grassed lawn with stone patios, sidewalks, driveways, and vegetation removed from the shoreline. This scenario resulted in an additional 29 lbs of phosphorus entering the lake every year. While this is not a tremendous amount and would likely have a negligible effect on the ecosystem in the short term, it is still a 5% increase of the annual load from a relatively small change in watershed land use. Additionally, the advantages of undeveloped and natural shorelines (erosion control, habitat, aesthetics) is reduced greatly with this type of modification.

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, the final 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. County ordinances may be more restrictive than NR 115, but not less so (though Act 170 allows for less restrictive standards for existing non-conforming structures). These policy regulations require each county to amend 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 described below. Please note that at the time of this writing, NR 115 is under review by the State of Wisconsin and updates will likely occur in February of 2014.

- Contact the county's regulations/zoning department for county-specific requirements.

- 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. 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 within 300 feet of the ordinary high-water mark of the waterbody. A county may allow more than 15% impervious surface (but not more than 30%) on a lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner.

- 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 existing 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.

Wisconsin Act 31

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.

Lake Julia Shoreland Zone Condition

Shoreland Development

A lake’s shoreland zone can be classified in terms of its degree of development. In general, more developed shorelines are more stressful on a lake ecosystem, while definite benefits occur from shorelines that are left in their natural state. Figure 3.2-3 displays a diagram of shoreline categories, from “Urbanized”, meaning the shoreland zone is completely disturbed by human influence, to “Natural/Undeveloped”, meaning the shoreline has been left in its original state.

Urbanized: This type of shoreline 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 shorelines 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 shoreline 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 shoreline that was restored would likely be included here, also.

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

Figure 3.3-1. Shoreline assessment category descriptions.

On Lake Julia, the development stage of the entire shoreline was surveyed during late summer of 2011, using a GPS unit to map the shoreline. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreline on a property-by-property basis. During the survey, Onterra staff examined the shoreline for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.2-4.

Lake Julia has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 5.0 miles of natural/undeveloped and developed-natural shoreline 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, only 0.2 miles of urbanized and developed–unnatural shoreline were observed.

Lakeshore development was ranked as the top factor possibly impacting Lake Julia in a negative manner, and as the top concern of Lake Julia stakeholders during the stakeholder survey (Appendix B, Questions #22 & #23). If restoration of the Lake Julia shoreline 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 shoreline lengths on the lake.

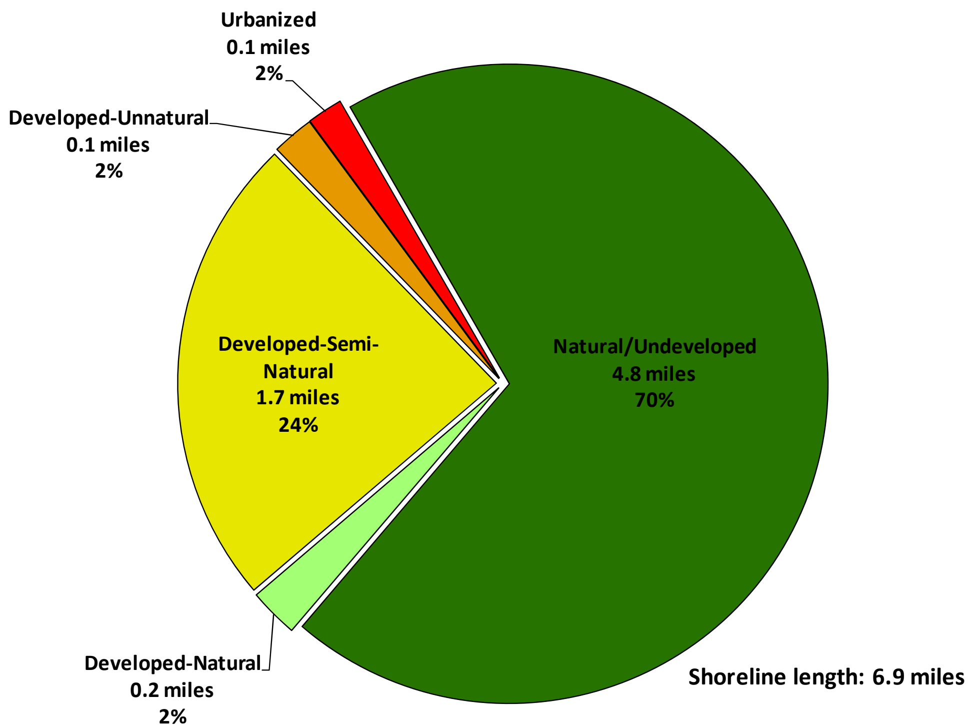

Figure 3.3-2. Lake Julia shoreland categories and total lengths. Based upon a late summer 2011 survey. Locations of these categorized shorelands can be found on Map 3.

Private Onsite Wastewater Treatment Systems (POWTS)

POWTS Background

Improperly maintained or faulty septic systems may impact both the health of individuals using the lake and also the water quality of a lake. A properly operating system will remove most disease-causing pathogens, but may not remove or treat nutrients such as phosphorus or nitrogen entirely. Besides the obvious health concerns, faulty septic systems may contribute nutrients to a lake, which can promote algae and aquatic plant growth.

The Wisconsin Department of Commerce oversees private onsite wastewater treatment systems (POWTS) through Chapter Comm 83. Although there are an estimated 760,000 to 790,000 private septic systems located in the state of Wisconsin, the exact number and location of these systems is unknown. Recent legislation has prompted counties to develop a comprehensive inventory of their septic systems. This inventory has a statutory deadline of October 1, 2013 (Comm 83.255(1)(a), updated through 2009 Wisconsin Act 392). Currently, it is believed that the statewide POWTS inventory is about 75% complete. According to the Planning & Zoning Department of Oneida County, there are approximately 21,952 POWTS, of which about 13,500 are tracked actively since July 1980. It is anticipated that 100% of POWTS will be inventoried in Oneida County by 2013 (K. Jennrich, personal communication).

Creating an inventory of POWTS throughout the state of Wisconsin is important, but maintaining these systems so that they operate correctly is critical. The enacted legislation has developed rules that establish a maintenance program for private sewage systems, and even encourages failing system replacement and rehabilitation through a funding program called the Wisconsin Fund. A condition for a county to participate in this program is that the county must adopt and implement a maintenance program, and must do so by the state-wide deadline of October 1, 2015. Because each program is governed on a county basis, your local health or zoning and planning department will be able to inform you on the maintenance program and funding opportunities in your county.

It is generally recommended that POWTS are pumped or inspected every three years for proper functioning. Between inspections, there are several ways to determine if your septic system may require maintenance:

- Sewage has backed up in your drains, toilets or basement
- Drains begin to run slower than normal
- Wet areas or bright green grass appear over the drain field
- A dense colony of aquatic plants or algae appears near your shoreland
- Bacteria or nitrates are found in your well water
- Biodegradable dye flushed through the system appears in the lake or stream

Additionally, there are many ways to keep your septic system in top shape, and reduce the chances of system failure:

- Have your system inspected on a regular basis (every 3 years is recommended)
- Avoid driving or parking vehicles on the drain field

- Do not dispose of materials in drains that enter the septic tank. These items (fats, grease, paper towels, disposable diapers, sanitary napkins, etc.) may clog the septic tank and other items (cleaning fluids, oils, paints, etc.) may not be treated and end up in groundwater.

POWTS Concerns on Lake Julia

During the development of the stakeholder survey, members of the Lake Julia planning committee constructed questions to poll survey recipients on private onsite wastewater treatment systems. Through this survey, 50% of respondents indicated their septic system was older than 10 years, and 13% had systems older than 25 years (Question #6). 27% were unsure of the age of their septic system (Question #6). 63% of respondents indicated their septic system was pumped every 2-4 years (Question #5), which is the timeframe recommended by most professionals. The majority (49%) of survey respondents had tanks that were approximately 100 to 199 feet away from the lake (Question #7). Overall, survey respondents did not rank septic system discharge highly on a list of potentially negative impacts or top concerns for Lake Julia (Question #22 & #23).

During the water quality and watershed analysis, along with field observations, there was no indication to Onterra staff that faulty septic systems were present along Lake Julia. However, the results of faulty septic systems would be seen last within the lake, and may go undetected for some time as well. Faulty septic systems are best identified by a licensed professional, and are done by inspecting the system itself.

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, both wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) 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 shoreline 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 Lake Julia, 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 Lake Julia 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.

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 (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*). • Permitting process may require an environmental assessment that may take months to prepare. • Unselective.

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.

Chemical Treatment

There are many herbicides available for controlling aquatic macrophytes and each compound is sold under many brand names. Aquatic herbicides fall into two general classifications:

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 does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides spread throughout the entire plant and often result in complete mortality if applied at the right time of the year.

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.

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, trageted 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 $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • 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.	• 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 herbicides are nonselective. • Most herbicides have a combination of use restrictions that must be followed after their application. • Many herbicides are slow-acting and may require multiple treatments throughout the growing season. • Overuse may lead to plant resistance to herbicides

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 Lake Julia; 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.

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 Lake Julia, 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.

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 Lake Julia. 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.

> Box Plot or box-and-whisker diagram graphically shows data through five-number summaries: minimum, lower quartile, median, upper quartile, and maximum. Just as the median divides the data into upper and lower halves, quartiles further divide the data by calculating the median of each half of the dataset.

As previously stated, species diversity is not the same as species richness. One factor that influences species richness is the "development factor" of the shoreline. 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 shoreline may hold. This value is referred to as the shoreline complexity. It specifically analyzes the characteristics of the shoreline 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 shoreline 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 shoreline 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 Lake Julia will be compared to lakes in the same ecoregion and in the state (Figure 3.1-2 in the Water Quality Section).

> 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.

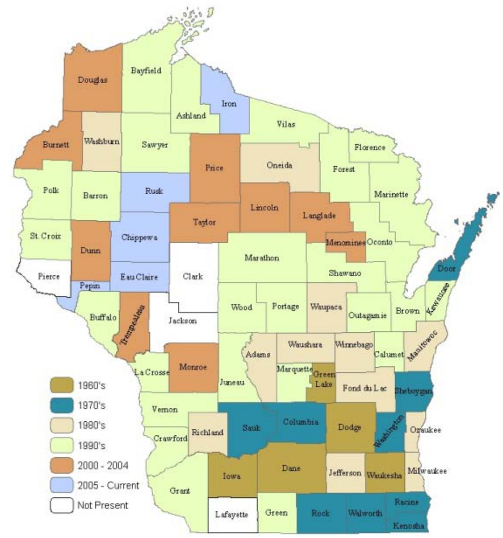

Figure 3.4-1. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.4-1). 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.

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 21, 2011, a survey was completed Lake Julia that focused upon curly-leaf pondweed. The meander-based survey did not locate any occurrences of curly-leaf pondweed. It is believed that this aquatic invasive species either does not occur in Lake Julia or exists at an undetectable level.

On July 20, 2011, three crews (six staff members) visited Lake Julia to complete further aquatic plant surveys. Two crews began the day by conducting the point-intercept survey – a survey that focuses on all plant species, but generates a tremendous amount of data concerning the submergent plant species within the lake. While two crews completed this, the third crew conducted the aquatic plant community mapping survey. During this survey, emergent and floating-leaf plants were mapped with highly accurate GPS technology.

During the point-intercept and aquatic plant mapping surveys, 58 species of plants were located in Lake Julia (Table 3.4-1). No exotic, invasive plant species were discovered during these surveys. Forty-four of the 58 species were sampled directly during the point-intercept survey and are used in the analysis that follows. The 14 additional plant species were not sampled during this survey, but were encountered either as visual sightings during the point-intercept survey or mapped as a part of the community mapping survey. These species are listed on Table 3.4-1 as incidentals. As indicated by the coefficient of conservatism value on Table 3.4-1 and within the analysis that follows in this section, several of the plants found within Lake Julia are of exceptional quality and are indicative of a healthy aquatic ecosystem.

The sediment within littoral areas of Lake Julia is quite diverse, which helps to support a variety of aquatic plant community types. Additionally, the varieties of sediment types are useful for spawning preferences of different fish species (discussed within the Fisheries Data Integration Section.) Data from the point-intercept survey indicate that approximately 47% of the sampling locations located within the littoral zone contained sand, 30% contained fine organic sediment (muck), and 23% contained rock (Figure 3.4-2 and Map 4).

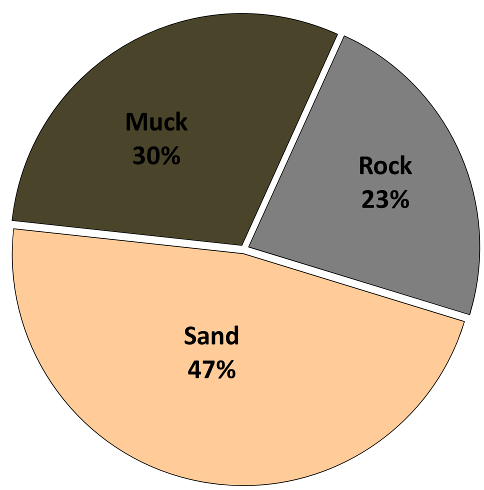

Figure 3.4-2. Lake Julia proportion of substrate types within littoral areas. Created using data from the summer 2011 aquatic plant point-intercept survey.

Approximately 56% of the point-intercept sampling locations that fell within the maximum depth of aquatic plant growth (14 feet), or the littoral zone, contained aquatic vegetation. Map 5 shows that the majority of the aquatic vegetation in Lake Julia is located within the shallow bays and near-shore areas. As discussed in the water quality section, the water clarity in Lake Julia is relatively low which limits sunlight penetration and restricts aquatic plants from inhabiting deeper areas of the lake. Figure 3.4-3 shows that the majority of the aquatic vegetation in Lake Julia grows between 2 and 7 feet.

Table 3.4-1. Aquatic plant species located in Lake Julia during July 2010 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2011 (Onterra)
Emergent	*Carex hystericina*	Porcupine sedge	3	I
	Carex lasiocarpa	Woolly-fruit sedge	9	I
	Carex rostrata	Beaked sedge	10	I
	Carex stricta	Common tussock sedge	7	I
	Dulichium arundinaceum	Three-way sedge	9	I
	Eleocharis palustris	Creeping spikerush	6	X
	Equisetum fluviatile	Water horsetail	7	X
	Iris versicolor	Northern blue flag	5	I
	Pontederia cordata	Pickerelweed	9	X
	Sagittaria latifolia	Common arrowhead	3	X
	Schoenoplectus acutus	Hardstem bulrush	5	X
	Schoenoplectus pungens	Three-square rush	5	X
	Schoenoplectus subterminalis	Water bulrush	9	X
	Schoenoplectus tabernaemontani	Softstem bulrush	4	I
	Scirpus cyperinus	Wool grass	4	I
	Typha spp.	Cattail spp.	1	I
	Zizania palustris	Northern wild rice	8	X
FL	*Brasenia schreberi*	Watershield	7	X
	Nuphar variegata	Spatterdock	6	X
	Nymphaea odorata	White water lily	6	X
	Polygonum amphibium	Water smartweed	5	I
FL/E	*Sparganium fluctuans*	Floating-leaf bur-reed	10	I
Submergent	*Ceratophyllum echinatum*	Spiny hornwort	10	X
	Ceratophyllum demersum	Coontail	3	X
	Chara spp.	Muskgrasses	7	X
	Elodea canadensis	Common waterweed	3	X
	Heteranthera dubia	Water stargrass	6	X
	Isoetes spp.	Quilwort species	8	X
	Megalodonta beckii	Water marigold	8	X
	Myriophyllum alterniflorum	Alternate-flowered water milfoil	10	X
	Myriophyllum sibiricum	Northern water milfoil	7	X
	Najas flexilis	Slender naiad	6	X
	Najas guadalupensis	Southern naiad	7	X
	Nitella spp.	Stoneworts	7	X
	Potamogeton alpinus	Alpine pondweed	9	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	I
	Potamogeton foliosus	Leafy pondweed	6	X
	Potamogeton friesii	Fries' pondweed	8	X
	Potamogeton gramineus	Variable pondweed	7	X
	Potamogeton natans	Floating-leaf pondweed	5	X
	Potamogeton praelongus	White-stem pondweed	8	X
	Potamogeton pusillus	Small pondweed	7	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X
	Potamogeton robbinsii	Fern pondweed	8	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X
	Potamogeton strictifolius	Stiff pondweed	8	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Ranunculus aquatilis	White water-crowfoot	8	X
	Sagitaria sp. (rosette)	Arrowhead rosette	N/A	X
	Utricularia intermedia	Flat-leaf bladderwort	9	X
	Utricularia minor	Small bladderwort	10	X
	Utricularia vulgaris	Common bladderwort	7	X
	Vallisneria americana	Wild celery	6	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X
FF	*Lemna turionifera*	Turion duckweed	2	I
	Lemna trisulca	Forked duckweed	6	X
	Spirodela polyrhiza	Greater duckweed	5	I

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

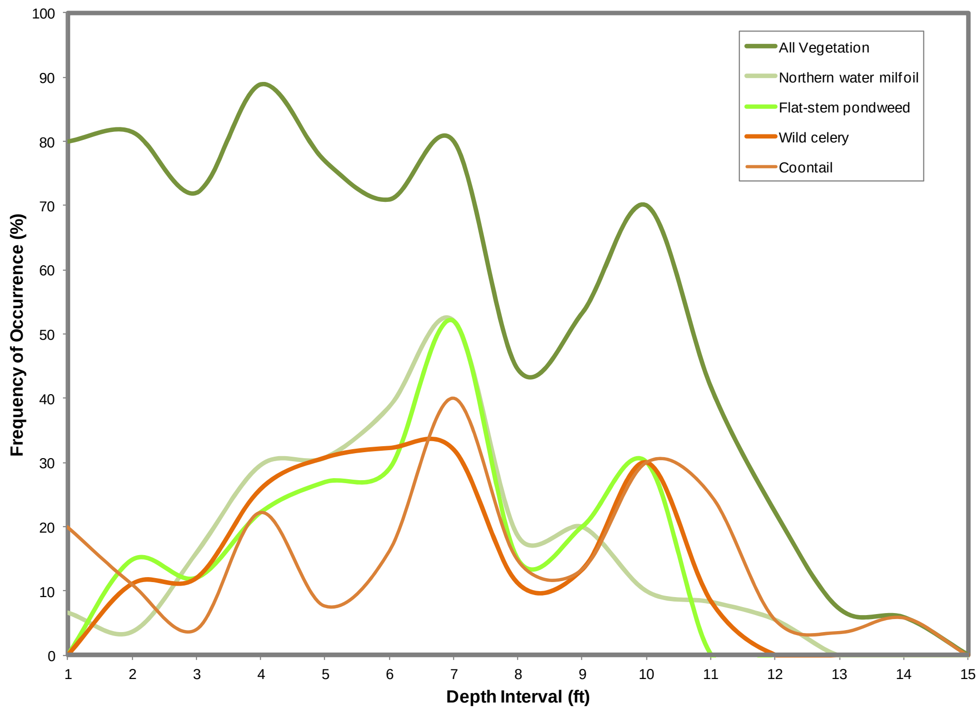

Figure 3.4-3. Frequency of occurrence at littoral depths for several Lake Julia plant species. Created using data from the July 20, 2011 aquatic plant point-intercept survey. Lines are smoothed to ease visualization.

Eurasian water milfoil, a common aquatic invasive plant in Wisconsin, was not found within Lake Julia. Of the eight milfoil species that may be found within the state, two milfoil species, alternate-flowered water milfoil (*Myriophyllum alterniflorum)* and northern water milfoil (*Myriophylum sibiricum*), were found in Lake Julia. Both of these species are morphologically similar to Eurasian water milfoil, and in fact are sometimes falsely identified as Eurasian water milfoil, especially since they may take on the reddish appearance of this invasive as the plant reacts to sun exposure as the growing season progresses. Northern water milfoil, more often confused with its Eurasian relative, has leaves that are divided like a feather and have 5-12 pairs of thread-like leaflets. Eurasian water milfoil has 12+ pairs of these thread-like leaflets. Alternate-flowered water milfoil is an overall smaller, slender species that has shorter leaves (less than 3/8" long), as well as an alternate arrangement of flowers.

Northern water milfoil was the most commonly occurring aquatic plant during the 2011 point-intercept survey (Figure 3.4-4). Other common species include flat-stem pondweed (*Potamogeton zosteriformis*) and wild celery (*Vallisneria americana*). Flat-stem pondweed, as its name implies, is a freely branched plant with strongly flattened stems and long, stiff leaves. Flat-stem pondweed lacks floating leaves, a feature many plants in the *Potamogeton* genus have. This plant can be a locally important food source to many aquatic and terrestrial organisms. Wild celery is a long, limp, ribbon-leaved and turbidity-tolerant species that is a premiere food source for ducks, marsh birds, shore birds and muskrats. Animals may eat the entire plant, including the tubers that reside within the sediment.

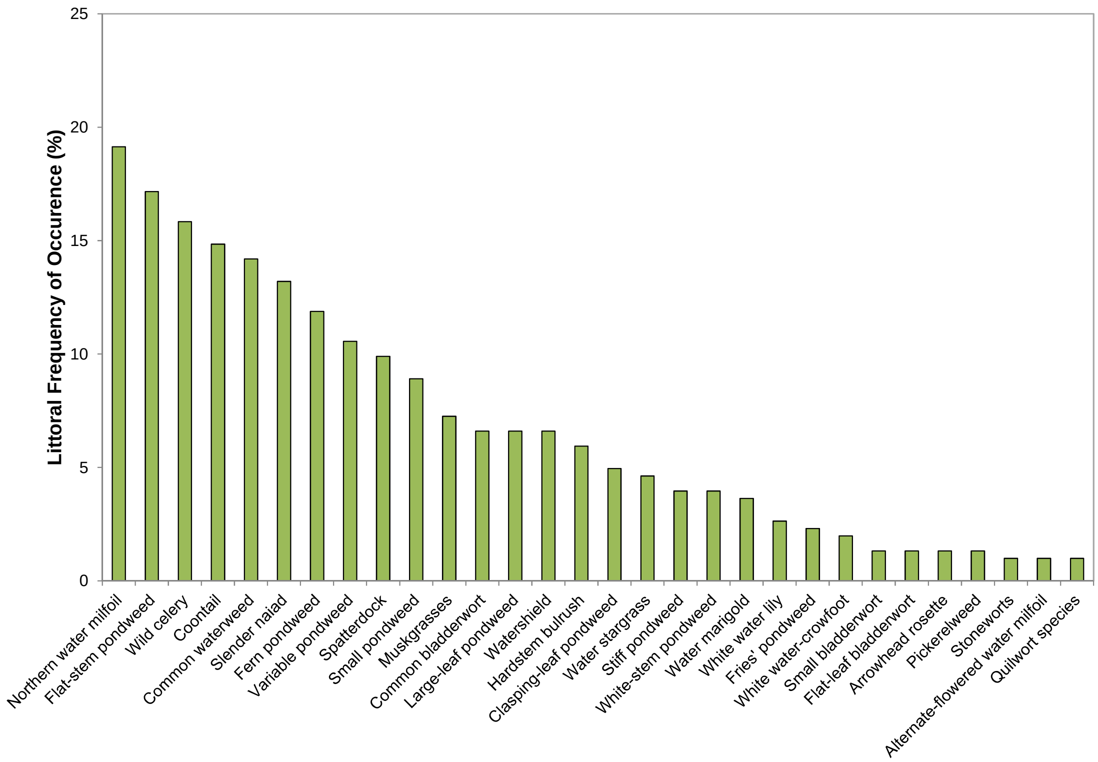

Figure 3.4-4 Lake Julia aquatic plant littoral frequency of occurrence. Species with a littoral occurrence of <1% are not displayed. Created using data from the July 20, 2011 point-intercept aquatic plant survey.

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. Lake Julia 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 elodeid species, which are found in Lake Julia, include northern water milfoil, wild celery, coontail, and all of the pondweeds (*Potamogeton* species).

Alkalinity, as it relates to carbon availability, 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 carbon through bicarbonate (HCO_3^-). As previously stated, the alkalinity in Lake Julia is moderate, at 44.8 (mg/L as $CaCO_3$). 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. However, in lakes with intermediate alkalinity levels, there may be a mixed community of both, with isoetids inhabiting the shallow, sandy/rocky areas and elodeids thriving in the deeper areas of softer sediment. As seen from the multitude of tall, lush and broad-leaved species that are commonly found within the lake, Lake Julia is a good host to aquatic plants of the elodeid growth form.

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 northern water milfoil was found at roughly 19% of the sampling locations in Lake Julia, its relative frequency of occurrence is 9%. Explained another way, if 100 plants were randomly sampled from Lake Julia, nine of them would be northern water milfoil. Looking at relative frequency of occurrence (Figure 3.4-5), 12 species comprise approximately 71% of the plant community in Lake Julia, while another 32 species are found less frequently and round out the remaining 29% of the plant community.

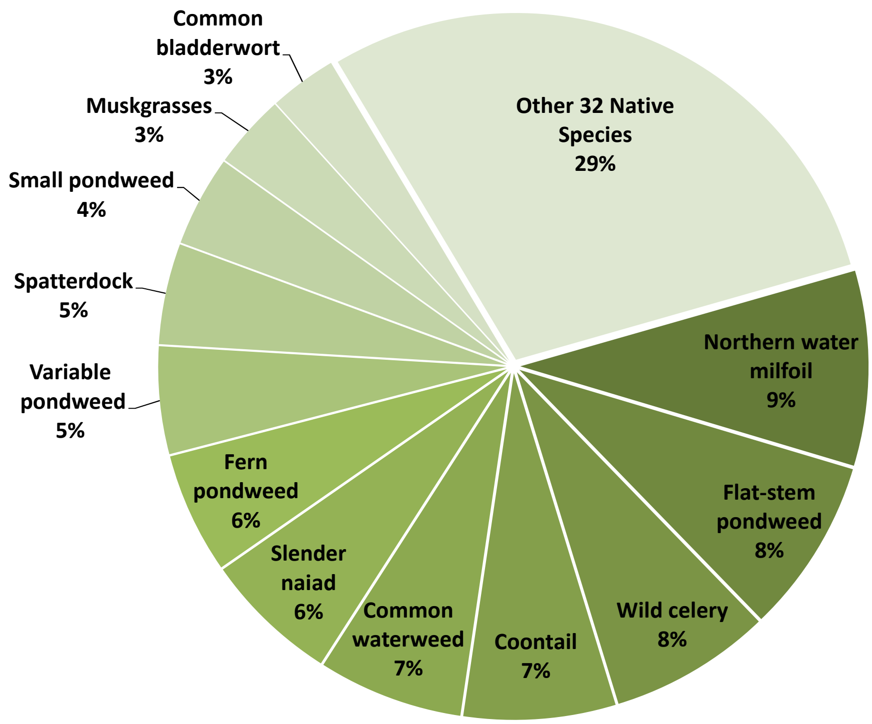

Figure 3.4-5 Lake Julia relative plant littoral frequency of occurrence. Created using data from the July 20, 2011 point-intercept aquatic plant survey.

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 58 native aquatic plant species were located in Lake Julia during the 2010 surveys, 44 were encountered on the rake during the point-intercept survey. Figure 3.4-6 shows that the native species richness for Lake Julia is above the Northern Lakes and Forests Ecoregion and Wisconsin State medians.

The species that are present in Lake Julia are indicative of high-quality conditions. Data collected from the aquatic plant surveys show that the average conservatism value (6.9) is above the Northern Lakes and Forest Lakes Ecoregion and Wisconsin State medians (Figure 3.4-6), indicating that the majority of the plant species found in Lake Julia are considered sensitive to environmental disturbance and their presence signifies excellent environmental conditions.

Combining Lake Julia's aquatic plant species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in an exceptionally high value of 45.7 (equation shown below); well above the median values for the ecoregion and state (Figure 3.4-6), and further illustrating the quality of Lake Julia's plant community.

$$FQI = \text{Average Coefficient of Conservatism } (6.9) * \sqrt{\text{Number of Native Species } (44)}$$
$$FQI = 45.7$$

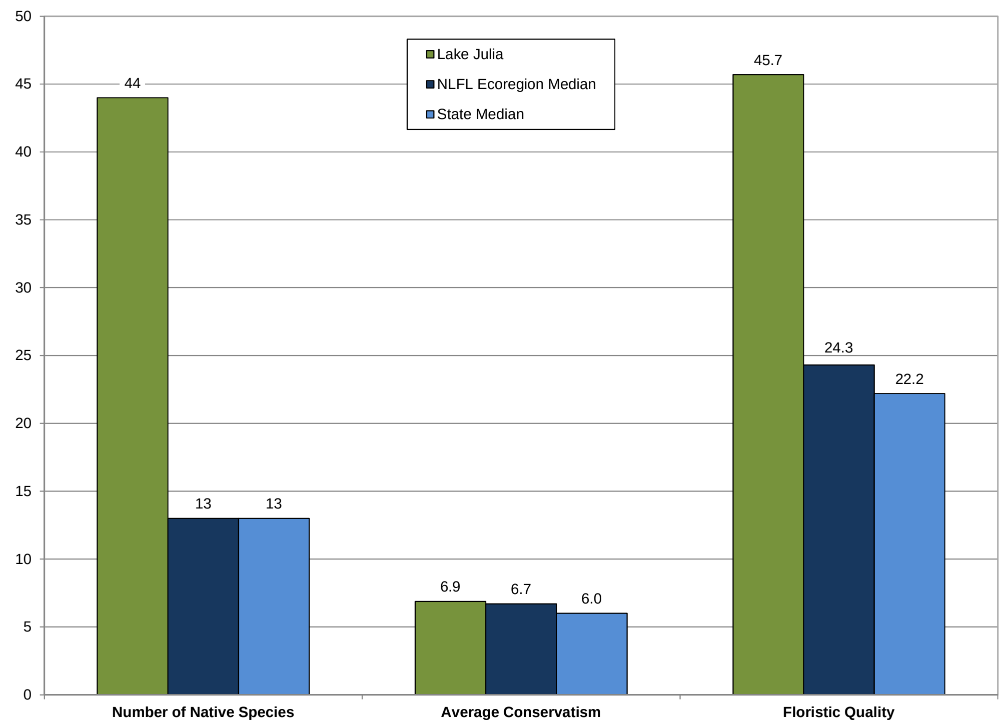

Figure 3.4-6. Lake Julia Floristic Quality Assessment. Created using data from the July 20, 2011 point-intercept aquatic plant survey. Analysis following Nichols (1999) where NLFL = Northern Lakes and Forest Lakes Ecoregion.

Because Lake Julia 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 Lake Julia was found to be highly diverse, with a Simpson's diversity value of 0.95 (Figure 3.4-7). This value ranks above 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 habitat and various sources of food.

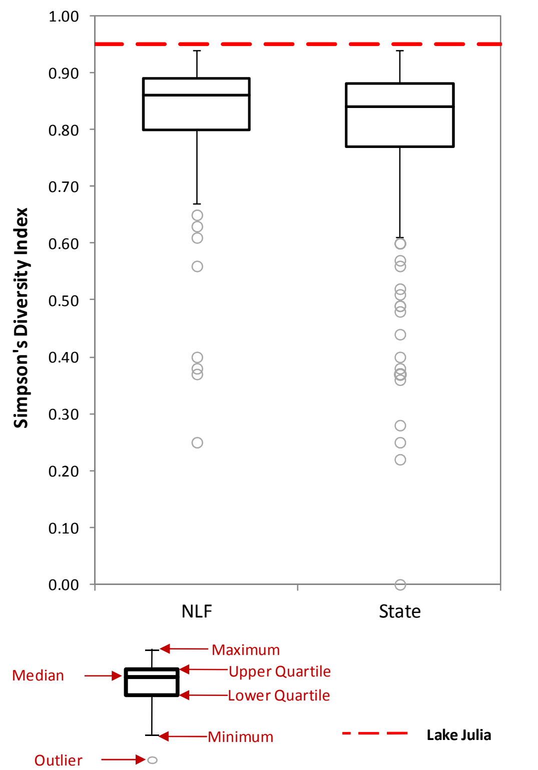

Figure 3.4-7. Lake Julia species diversity index. Created using data from the July 20, 2011 point-intercept aquatic plant survey. Ecoregion data provided by WDNR Science Services.

The quality of Lake Julia's plant community is also indicated by the high incidence of emergent and floating-leaf plant communities that occur in near-shore areas around the lake. The 2011 community map indicates that approximately 57.3 acres (14.2%) of the 404 acre-lake contain these types of plant communities (Table 3.4-2 and Map 6). Twenty-two floating-leaf and emergent species were located on Lake Julia, providing valuable structural habitat for invertebrates, fish, and other wildlife. These communities also stabilize lake substrate and shoreline areas by dampening wave action from wind and watercraft.

Table 3.4-2. Lake Julia acres of plant community types. Created from the July 20, 2011 community mapping survey.

Plant Community	Acres
Emergent	6.4
Floating-leaf	13.2
Mixed Floating-leaf and Emergent	37.7
Total	57.3

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 Lake Julia. 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 shorelines when compared to the undeveloped shorelines 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 shorelines.

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 Lake Julia. The goal of this section is to provide a partial overview of some of the readily available data that exists, particularly in regards to specific issues (e.g. spear fishery, fish stocking, angling regulations, etc) that were brought forth by the LJA 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 2012 & GLIFWC 2012A and 2012B).

Lake Julia Fishery

Lake Julia Fish Species and Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the 2nd highest ranked important or enjoyable activity on Lake Julia (Question #16). Nearly 97% of survey respondents indicated they have fished on the lake (Question #9), and about 65% of these stakeholder have fished the lake for greater than 25 years (Question #10). Approximately 61% of these same respondents believed that the quality of fishing on the lake was either fair or poor (Question #11); and approximately 57% believe that the quality of fishing has gotten worse since they have obtained their property (Question #14). Smallmouth bass, walleye and muskellunge are the commonly sought after species within the lake (Question #12). Lastly, most stakeholders who fish Lake Julia indicated that they never (17%), rarely (40%) or only sometimes (30%) keep the fish they catch (Question #13).

Table 3.5-1 shows the popular game fish that are present in the system. When examining the 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 Lake Julia 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 piscivorous 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.

Table 3.5-1. Gamefish present in Lake Julia 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
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge	*Esox masquinongy*	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass	*Micropterus dolomieu*	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye	*Sander vitreus*	18	Mid April - early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch	*Perca flavescens*	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

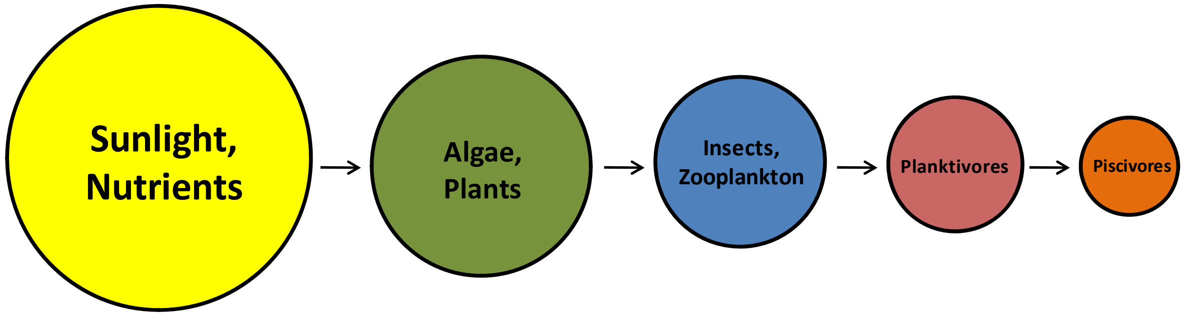

Figure 3.5-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Lake Julia is mesotrophic, meaning it has a moderate amount of nutrients and thus moderate primary productivity. Simply put, this means it is reasonable for the lake to support a sizable population of predatory fish (piscovores) because the food chain is sufficient to do so.

Lake Julia 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 3.5-1). Lake Julia 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. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then an "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% of a lake's fishing stock, but may vary on an individual lake basis. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The allowable catch number is then 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". 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, or declaration. This result is called the quota, 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 quota and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are

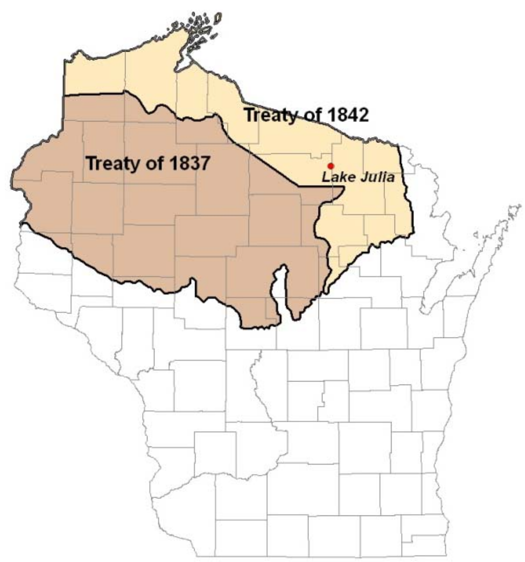

Figure 3.5-2. Location of Lake Julia within the Native American Ceded Territory (GLIFWC 2012A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

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).

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2012B). 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 quota 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 quota is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller quotas. Starting with the 2011 spear harvest season, on lakes with a harvestable quota of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

Although Lake Julia has been declared as a spear harvest lake, it has not historically seen a harvest, with the exception of 2003 in which 25 walleyes were harvested. It is possible that spearing efforts have been concentrated on other larger lakes in the region, which would potentially have a higher estimated safe harvest for both walleye and muskellunge. Walleye open water spear harvest records are provided in Table 3.5-2. During this time period, there were no recorded harvests for muskellunge.

Table 3.5-2. Spear harvest data of walleye for Lake Julia (GLIFWC annual reports for Lake Julia, Krueger 2001-2009).

Year	Tribal Quota	Tribal Harvest	%Quota	Mean Length* (in)
2001	26	0	0.0	-
2002	91	0	0.0	-
2003	92	25	27.2	15.9
2004	29	0	0.0	-
2005	28	0	0.0	-
2008	43	0	0.0	-
2009	43	0	0.0	-
2010	44	0	0.0	-

**Based on Measured Fish*

Lake Julia Fish Stocking and Management

Currently, the WDNR is managing Lake Julia to produce a diverse gamefish population of moderate sizes and densities. The managed species include walleye, muskellunge, northern pike, bass species and panfish. 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. Fish can be stocked as fry, fingerlings or even as adults.

In recent years, Lake Julia has been stocked with both walleye and muskellunge on a fairly regular basis. Walleye stockings have occurred about every other year, on even years, at a density of between 34 and 98 fish per acre (Table 3.5-3). Muskellunge have been stocked every other year (odd years) as well (Table 3.5-4). Recently, evidence of natural reproduction has been observed for this species on Lake Julia, and therefore stocking density has been reduced from roughly 1 fish per acre to 0.5 fish per acre (John Kubisiak – personal communication).

Table 3.5-3. Walleye stocking data available from the WDNR from 1987 to 2010 (WDNR 2012).

Year	Age Class	# Stocked	Avg. Length (inches)
1987	Fingerling	36,000	2
1988	Fingerling	12,000	2
1989	Fingerling	17,096	3
1990	Fingerling	12,090	2
1999	Small Fingerling	20,050	1.3
2000	Small Fingerling	39,200	2.4
2002	Small Fingerling	19,600	1.4
2004	Small Fingerling	19,595	1.2
2006	Small Fingerling	14,031	1.4
2010	Small Fingerling	13,708	1.4

Table 3.5-4. Muskellunge stocking data available from the WDNR from 1987 to 2012 (WDNR 2012).

Year	Age Class	# Stocked	Avg. Length (inches)
1972	Fingerling	400	13
1976	Fingerling	352	13
1990	Fingerling	524	11
1991	Fingerling	280	11
1992	Fingerling	800	10.75
1993	Fingerling	800	11
1995	Fingerling	800	11.3
1997	Large Fingerling	390	11.9
1999	Large Fingerling	400	12.1
2001	Large Fingerling	401	10.6
2003	Large Fingerling	401	10.9
2005	Large Fingerling	401	9.8
2007	Large Fingerling	267	13
2009	Large Fingerling	390	9.9
2011	Large Fingerling	196	9.3

Lake Julia Substrate Type

According to the point-intercept survey conducted by Onterra, 47% of the substrate sampled in the littoral zone on Lake Julia was sand, with 30% being classified as muck (soft, organic substrate) and the remaining 23% evenly between rock and sand (Figure 3.3-2 and Map 4). 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. Muskellunge is one species that does not provide parental care to its eggs (Becker 1983). Muskellunge 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. Walleye is another species that does not provide parental care to its eggs. Walleye spawn in areas with rock and moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of substrates. 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.

Lake Julia Fishing Regulations and Studies

Because Lake Julia is located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to Lake Julia. In 2012-2013, the daily bag limit was set at three walleye. On Lake Julia, there is no minimum length limit on walleye. WDNR fisheries biologists removed the minimum length limit on walleye due to mercury concerns in larger fish. Currently, the WDNR recommends that a Lake Julia walleye larger than 15 inches be consumed not more than once per month by adults men and women, and is not at all recommended for consumption by women of childbearing age and children under 15 years old. More information regarding mercury accumulation in Wisconsin fishes may be found at http://dnr.wi.gov/fish/consumption/.

Another Lake Julia special fishing regulation concerns muskellunge. In 1993, the length limit for muskellunge was 32 inches on most Wisconsin lakes. Lake Julia managers decided that because the lake had a record of good numbers of small muskies, that the fishery may benefit from a longer length limit. In 2012, most other Wisconsin muskellunge lakes received a 40 inch limit on this species. Because survey data showed that Lake Julia still had high densities of muskellunge with lower numbers of large fish, the length limit was reverted to 28 inches.

For bass, the first Saturday in May through the third Saturday in June is reserved for a catch and release season only. Following the third Saturday in June, five bass of either species may be harvested, with a minimum length of 14 inches. No minimum length limit exists for northern pike; five pike may be kept in a single day. Statewide regulations apply for all other fish species.

During 2011, University of Wisconsin-Stevens Point graduate student Jessica Orlando and assistants visited Lake Julia to assess structural fish habitats in the nearshore littoral zone. Lake Julia was one of 11 lakes assessed in this study, which aimed to develop and test metrics that could be used to characterize habitat types in lakes. During this study, Ms. Orlando and assistants identified 16 species within their study site. While Ms. Orlando is currently completing her research, her studies found that fish assemblage is sensitive to a variety of habitat conditions. Not surprisingly, consistencies in fish-habitat relations were seen among the lakes involved with the study.

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 Lake Julia ecosystem.
2) Survey the lake's aquatic plant community to determine if any non-native, invasive plant species were present.
3) Collect sociological information from Lake Julia stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

The three objectives were fulfilled during the project and have led to a good understanding of the Lake Julia ecosystem, the folks that care about the lake, and what needs to be completed to protect and enhance the lake ecosystem.

Overall, the studies conducted on Lake Julia indicate the ecosystem is in very good health and shows few signs of human disturbance. When compared to similar lakes across the state, and all lakes within the Northern Lakes and Forests Ecoregion, Lake Julia can be described as having excellent water quality. Phosphorus, the nutrient of most concern in Wisconsin lakes, is found in limited quantities within the water column of the lake. In some lake systems, overabundant phosphorus is responsible for fueling summer algae blooms and nuisance levels of aquatic plants. These conditions are aesthetically unpleasing and indicate great disturbance within the ecosystem. Lake Julia holds enough phosphorus to support slight algae production and a healthy aquatic plant community. As the primary production within a lake, the algae and plants found in Lake Julia are important for providing food and habitat for a variety of other species, including insects, fish and various mammals.

One of the key reasons the lake is in such good shape is that the surrounding watershed is ideal from a lake's perspective. The 5,363 acres of land draining towards Lake Julia largely consist of wetlands and forests. Vegetated land cover types such as these are ideal, as they allow surface water to permeate the ground and thus reduce the amount of surface water runoff a waterbody receives. Agricultural and urban areas (mostly non-vegetated) allow for more surface runoff, which results in increasing nutrient and sediment export to waterbodies. As it is, roughly 571 lbs. of phosphorus are transported to Lake Julia annually, which is a small amount considering Julia's great size and volume. If the amount of non-vegetated land was to increase within Lake Julia's watershed, it would be likely that the phosphorus load would increase as well, which could have negative impacts upon the lake.

As a part of this project, the immediate watershed, the shoreland area, of Lake Julia was assessed for its level of human disturbance as well. This survey found that the vast majority of the shoreland area (70%) is in a natural/undeveloped condition. These areas serve two functions in a lake ecosystem: 1) they buffer surface water runoff as it reaches the lake, and 2) they provide essential habitat for a variety of aquatic and terrestrial species. The amount of disturbed (urbanized or developed-unnatural) shoreland along Lake Julia is minimal; the LJA should place emphasis on protecting the natural lands surrounding the lake as this would be more beneficial than attempting to restore developed shoreland areas.

As hinted to above, the conditions found in Lake Julia support an aquatic plant community that is exceptionally rich. 58 species (44 sampled directly through the point-intercept survey and 14 incidental observations) were found on Lake Julia in 2011. This is an extraordinary number of aquatic plants to be found in a single lake ecosystem. Lake Julia's Floristic Quality Index value, a number that describes the quality of the aquatic plant community, is much higher (45.7) than the ecoregion median value (24.3) as well as the state median value (22.2) which indicates that the plant community includes species that are considered sensitive to environmental disturbances. The presence of these species within the lake tell scientists that Lake Julia is in excellent ecological condition, because these species require these pristine-like conditions in order to survive.

There are many advantages to having an exceptional aquatic plant community. For example, healthy, diverse plant communities have been shown to reduce the occurrence of aquatic invasive plant species such as Eurasian water milfoil and curly-leaf pondweed. An aquatic plant community of high quality also provides a variety of habitat for fish species. Lake Julia is home to a diverse gamefish assemblage. While the trophic state of the lake indicates that it is difficult for the lake to produce a large forage base for predatory game fish, the lake is at an advantage due to the presence of a variety of aquatic plant species. Additionally, the lake has a variety of substrate types (sand, muck, and rock) that benefit the fishery by allowing fish different substrate to spawn upon. Lastly, the natural shoreline surrounding the lake likely means there is a fair amount of woody debris that has fallen into the lake. Woody debris of various sizes has been shown time and time again to benefit the aquatic food chain – starting with the insects and other crustaceans that inhabit a lake and ending with the predatory game fish. Coarse woody habitat, in particular, has been researched extensively in Wisconsin and its benefits in altering water movements, transporting organic material from land to freshwater, and lastly providing physical structure are well documented.

With Lake Julia in such good shape, it would be difficult for the LJA to begin a process of enhancing the ecosystem. Instead, what is needed is effort to maintain the exceptional nature of this resource and protect it from human disturbance as much as possible. The Implementation Plan that follows this section stems from discussions between Onterra ecologists and the LJA Planning Committee on what action items the LJA may implement to properly care for this resource.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the Lake Julia Planning Committee and ecologist/planners from Onterra. It represents the path the LJA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Lake Julia 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 continuing 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: Increase Lake Julia Association's Capacity to Communicate with Lake Stakeholders

Management Action: Support an Education Committee to promote safe boating, water quality, public safety, and quality of life on Lake Julia

Timeframe: Begin summer 2013

Facilitator: Board of Directors to form Education Committee

Description: Education represents an effective tool to address issues that impact water quality such as lake shore development, lawn fertilization, and other issues such as air quality, noise and light pollution, and boating safety. An Education Committee will be created to promote lake protection through a variety of educational efforts.

One of the first projects the Education Committee will undertake is a newsletter to be distributed to LJA members and non-members who own or acquire property on the lake. Communication amongst these stakeholders is important because it builds a sense of community while facilitating the spread of important association news, educational topics, and even social happenings. It also provides a medium for the recruitment and recognition of volunteers. Perhaps most importantly, the distribution of a well written newsletter can be used as a tool to increase awareness of many aspects of lake ecology and management among association members. By doing this, meetings can often be conducted more efficiently and misunderstandings based upon misinformation can be avoided. Educational pieces within the association newsletter may contain monitoring results, association management history, as well as other educational topics listed below. This newsletter may be sent out at any interval (e.g annually, bi-annually, etc.).

In addition to creating regularly published association newsletter a variety of educational efforts will be initiated by the Education Committee. These may include educational materials, awareness events and demonstrations for lake users as well as activities which solicit local and state government support. Specifically, during planning activities associated with this project three primary educational areas were identified:

1. Maintaining natural aesthetics and features of the lake. Maintaining the condition of Lake Julia is key to keeping the ecosystem as vibrant and diverse as it can possibly be. Additionally, a lake that is maintained in a natural manner provides more of an "up north scenic" atmosphere for lake stakeholders to enjoy. As the majority of stakeholders enjoy passive activities such as relaxing/entertaining, fishing, swimming, nature viewing and canoeing/kayaking on the lake (Appendix B, Question #16), it is important to maintain the natural state of this lake so these activities can be enjoyed. Some areas of educational material discussed at the Planning Committee Meeting include maintaining wildlife habitat, maintaining natural shoreline, land conservation and preservation controls as well as guiding development to be sustainable and low-impact.

2. Maintaining the current level of quiet enjoyment on the lake. Currently, there is an informal agreement amongst riparian property owners to prohibit the use of personal watercraft (jet ski) on the lake. As learned within the stakeholder survey, quiet enjoyment of the lake was something that the majority of stakeholders place great value upon. Therefore, educational efforts aimed at maintaining this level of peace and serenity will be conducted by the Education Committee. This may include discussion of unofficial "quiet hours", ways of reducing light pollution, etc.

3. Increase overall level of education and communication. In order for all lake stakeholders to understand the resource that is Lake Julia, and what must be done to preserve it, effective communication is required. Communication between riparian property owners may be achieved through newsletters, periodic emails and annual meetings. However, given that the lake is surrounded by thousands of other lakes in the Northwoods of Wisconsin, it is important for Lake Julia stakeholders to collaborate with neighboring lakes and discuss issues as they arise. Lake Julia is situated at the headwaters of the Three Lakes Chain of Lakes, and a large part of the lake is located within the Township of Three Lakes. The Three Lakes Waterfront Association (TWLA) is a very proactive, diligent group that has been actively managing many of the lakes in the Township of Three Lakes for some time. The group is a tremendous resource on local lake management activities. An appointed person from the Lake Julia Planning Committee will be in touch with the TWLA regarding local lake issues, and will attend TLWA meetings when they are conducted.

Other Potential Educational Topics:

- Aquatic invasive species monitoring updates
- Boating safety and ordinances (slow-no-wake zones and hours)
- Catch and release fishing
- Littering
- Noise, air, and light pollution
- Shoreland restoration and protection
- Septic system maintenance
- Fishing Rules

- Specific topics brought forth in other management actions

Action Steps:

1. Recruit volunteers to form Education Committee.
2. Investigate if WDNR small-scale Lake Planning Grant would be appropriate to cover initial setup costs.
3. The LJA Board will identify a base level of annual financial support for educational activities to be undertaken by the Education Committee.

Management Goal 2: Maintain Current Water Quality Conditions

<u>Management Action:</u> Monitor water quality through WDNR Citizens Lake Monitoring Network.

Timeframe: Begin summer 2013.

Facilitator: Planning Committee

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 information on their lake. At this time, there are no LJA members currently collecting data as a part of the CLMN. 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 volunteers 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).

At a minimum, CLMN volunteers collecting Secchi disk data should be in place on Lake Julia. Currently, the advanced CLMN program is not accepting additional lakes to participate in the program. However, it is important to get volunteers on board with the base Secchi disk data CLMN program so that when additional spots open in the advanced monitoring program, volunteers from LJA will be ready to make the transition into more advanced monitoring.

It is the responsibility of the Planning Committee to coordinate new volunteers as needed. When a change in the collection volunteers 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 made available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:

1. The LJA locates a volunteer to conduct water quality monitoring.
2. Volunteer contacts Sandra Wickman (715.365.8951) to coordinate beginning steps of the CLMN program.
3. Volunteer prepares annual summary to submit to the LJA and WDNR if necessary.

Management Goal 3: Prevent Aquatic Invasive Species Introductions to Lake Julia

Management Action: Initiate Clean Boats Clean Waters watercraft inspections at Lake Julia public access

Timeframe: In progress

Facilitator: Planning Committee

Description: At this time, Lake Julia is believed to be free of Eurasian water milfoil and curly-leaf pondweed. At this time, the only invasive species known to exist in the system are rusty crayfish.

Members of the LJA have been trained on Clean Boats Clean Waters (CBCW) protocols and complete boat inspections at the public landings on a regular basis. Because Lake Julia is currently free of exotic species, the intent of the boat inspections is to prevent additional invasives from entering the lake through its public access point. The goal would be to cover the landing during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on our lakes and educating people about how they are the primary vector of its spread. In 2011, 167 boats were inspected and 318 people contacted during over 72 hours of watercraft inspections.

In an effort to keep invasive species from reaching Lake Julia, these inspections should continue at the public access point. The Planning Committee should continuously seek out volunteers to join in on the inspections so as to keep more people involved, and spread out this task amongst a greater number of people.

Action Steps:

1. Members of association periodically attend Clean Boats Clean Waters training session through the volunteer AIS Coordinator (Erin McFarlane – 715.346.4978) to update their skills to current standards.
2. Begin inspections during high-risk weekends
3. Report results to WDNR and LJA
4. Promote enlistment and training of new of volunteers to keep program fresh.

Management Action: Coordinate annual volunteer monitoring for Aquatic Invasive Species

Timeframe: Summer 2013

Facilitator: Planning Committee

Description: In lakes without Eurasian water milfoil and other invasive species, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. One way in which lake residents can spot early infestations of AIS is through conducting "Lake Sweeps" on their lake. During a lake sweep, volunteers monitor the entire area of the system in which plants grow (littoral zone) annually in search of non-native plant species. This program uses an "adopt-a-shoreline" approach where volunteers are responsible for surveying specified areas of the system. Typically, an annual lake sweep is conducted by the lake group however several sweeps may be planned per year by ambitious groups.

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 by WDNR or Oneida County staff, and, if possible, GPS coordinates should be collected.

Action Steps:

1. Volunteers from LJA update their skills by attending a training session conducted by WDNR/UW-Extension through the AIS Coordinator for Oneida County (Michele Saduaskas– 715.365.2750).
2. Trained volunteers recruit and train additional association members.
3. Complete an annual lake surveys following established protocols.
4. Report results to WDNR and LJA.

Management Goal 4: Improve Fishery Resources and Fishing Habitat on Lake Julia

Management Action: Work with fisheries managers to enhance the fishery on Lake Julia

Timeframe: Ongoing

Facilitator: Board of Directors

Description: The results of the stakeholder survey associated with this project show that approximately 61% of survey respondents believe that the quality of fishing on Lake Julia is either fair or poor (Question #11); and approximately 57% believe that the quality of fishing has gotten worse since they have obtained their property (Question #14). Fishing was ranked as the 2nd most enjoyable activity on the lake, which confirms its importance to stakeholders.

The Water Quality Section discusses the relatively low abundance of nutrients in Lake Julia. Overall, the system is characterized as being mesotrophic, meaning it holds low to moderate primary productivity. Simply put, it is difficult for a system such as Lake Julia to hold large populations of fish (especially large fish), because the food and habitat found in productive lakes is not present. This would be analogous to comparing a forest versus a desert ecosystem. A forest holds larger populations of large animals (whitetail deer, black bear, coyotes, wolves etc.) because there is 1) abundant food to support the appetite of these large animals and 2) trees and understory growth which is used by predators to stalk prey and used by prey to hide young from predators. In a desert ecosystem, the majority of animals are small and innumerous because this ecosystem lacks food resources and cover/shelter. Being in a mesotrophic state, Lake Julia is somewhere between the two examples used in the above demonstration.

Despite the lower primary productivity, WDNR fisheries biologist John Kubisiak believes the current fish population in Lake Julia is reaching its management goals, which include a diverse fish assemblage of moderate sizes and densities. Additionally, good levels of natural reproduction have been observed in walleye, a commonly sought-after fish species.

At this time, a creel survey has not been completed by the WDNR on Lake Julia. Creel surveys are a series of short, informal interviews with fisherman and are conducted right on the lake of interest. They provide valuable information on sport angler activities and their impacts on the fish populations of a waterbody. From this data, fisheries managers can determine trends in total catch and harvest for the lake, and make further management decisions based upon this data. In short, this data allows managers a glimpse into what kind of fishing activity is taking place on the lake.

Understanding the limitations and stresses on the Lake Julia ecosystem is the first step in developing a solution to angler concerns. From here, realistic goals and actions may be developed. Lake Julia is currently overseen by WDNR fisheries biologist John Kubisiak (715.365.8919). In order to keep informed of survey studies that are occurring on Lake Julia, a volunteer from the LJA should contact Mr. Kubisiak at least once a year (perhaps during the winter months when field work is not occurring) for a brief summary of activities. Conversations about regulations the WDNR is considering that impact Lake Julia (e.g. size and bag limits) could be discussed at this time. Additionally, the LJA should discuss options for improving the fishery in Lake Julia, which may include changes in angling regulations, habitat enhancements, or private stocking. In particular, members of the LJA have expressed interest in enhancing natural shoreline habitat enhancement on Lake Julia. Mr. Kubisiak should be consulted for assistance in choosing habitat enhancement types (fish cribs, “fish sticks” etc.) as well as the location and placement of these projects. Please note that a WDNR Water Regulations permit would be needed for placement of lake-bed structures.

Action Steps:

1. Volunteer from LJA contact John Kubisiak on annual or as-needed basis.
2. LJA identifies volunteers interested in fishery enhancement projects, proceeds with such projects following conversations with Mr. Kubisiak.
3. LJA volunteer shares fisheries information with membership, including survey results, regulation changes, as well as educational material (advantages of catch-and-release vs. harvest, importance of natural wood structures in the lake, etc.)

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Lake Julia (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 completed using a Hydrolab DataSonde 5.

Watershed Analysis

The watershed analysis began with an accurate delineation of Lake Julia'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 Lake Julia during a June 21, 2011 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 Lake Julia 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 (Hauxwell 2010) was used to complete this study on July 20, 2011. A point spacing of 47 meters was used resulting in approximately 741 sampling points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Lake Julia (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. A set of samples was also provided to the LJA.

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