Kathan Lake

Oneida County, Wisconsin

Comprehensive Management Plan

March 2013

Sponsored by:

Kathan Lake Association

&

Wisconsin Department of Natural Resources

AEPP-154-08

Onterra, LLC
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

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Created by: Tim Hoyman & Eddie Heath
Onterra, LLC
De Pere, WI

Funded by: Kathan Lake Association
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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:

Kathan Lake Planning Committee

Bill Freeman
Larry Kreiter
Lee Treuden
Kevin Weber

Wisconsin Dept. of Natural Resources

Kevin Gauthier
Alison Mikulyuk
Michelle Nault

Great Lakes Indian Fish and Wildlife Commission

Mark Luehring

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1.0 INTRODUCTION

Kathan Lake, Oneida County, is a 189-acre drainage lake with a maximum depth of 15 feet. Kathan Lake drains through the Kathan Creek, eventually flowing into the Rainbow Flowage, a reservoir on the Wisconsin River.

The Kathan Lake Association (KLA) became concerned with increasing amounts of Eurasian water milfoil within the lake and the impacts the plant was having on recreation. Kathan Lake does not have a public boat landing; therefore, the KLA is not eligible for public grant funds aimed at implementing a management plan, such as Lake Management Protection Grants, nor Aquatic Invasive Species (AIS) Established Population Control Grants. The group is eligible for grants funding planning activities and in February 2008, the KLA successfully applied for an AIS Education, Planning, and Prevention Grant.

While Eurasian water milfoil was the predominate concern of the KLA and its members, the group was also concerned with other aspects of the lake and its ecosystem, like impacts of the lake's drainage basin, current and past water quality conditions, and the current state of its native plant population, which was believed to be in jeopardy because of the expanding Eurasian water milfoil population. As a result of the group's concerns, the focus of the proposed management planning project was not strictly on Eurasian water milfoil, but more on the lake and its watershed as an ecosystem. Therefore, the goal of the project was to create a comprehensive management plan for Kathan Lake.

2.0 STAKEHOLDER PARTICIPATION

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

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

Kick-off Meeting

On May 3, 2008, a project kick-off meeting was held at the Kathan Inn to introduce the project to the general public. The meeting was announced through a mailing and personal contact by KLA board members. The approximately 25 attendees were welcomed by Bill Freeman and were informed about the events that led to the initiation of the project. Mr. Freeman's opening remarks were followed by a presentation given by Tim Hoyman that started with an educational component regarding the importance of aquatic vegetation and the affect non-native invasive plants may have on it and ending with a detailed description of the project including opportunities for stakeholders to be involved. Mr. Hoyman's presentation was followed by a question and answer session.

Stakeholder Survey

During October 2008, a six-page, 24-question survey was mailed to 35 riparian property owners in the Kathan Lake watershed. Approximately 77.1 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Kathan Lake Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan.

Planning Committee Meeting I

On March 11, 2010, Tim Hoyman of Onterra met with the Kathan Lake Planning Committee for nearly four hours. The primary focus of this meeting was the delivery of the study results and conclusions to the committee and discussion of management options and actions for the lake.

Following Mr. Hoyman's results and conclusions presentation that lasted approximately 1 ½ hours, the group spent the next 2 ½ hours discussing the condition of the lake, the need for continued vegetation and water quality monitoring, the changes members of the Planning Committee have seen on the lake over the past two or more decades, and the results of the stakeholder survey. Much of the last half of that session, Mr. Hoyman led the group through the many alternatives available for managing the Eurasian water milfoil on Kathan Lake. Those alternatives, which are discussed in more detail within the Summary and Conclusions Section, were split into two groups comprising of those available for nuisance control and those available for ecosystem restoration. Over the course of this discussion, it was clear that the KLA is not ready to submit to the Eurasian water milfoil population and begin managing it as a nuisance infestation. Instead, the group was ready to move forward with an aggressive management strategy to bring the exotic under control on a lake-wide basis and had spent more than a year preparing for that action.

Since the winter of 2009, when Onterra released its first map of Eurasian water milfoil densities in the lake, a core group of KLA members, mostly made up of Board of Directors and Planning Committee members, had been meeting with riparian property owners to discuss the Eurasian water milfoil issue and solicit financial contributions for a herbicide treatment. Kathan Lake has approximately 40 properties around it, therefore nearly all property owners were able to be contacted during this funding drive. As a result of the group's efforts, they were able to raise over $30,000 for the proposed herbicide treatment. The caveat to this successful undertaking is that the majority of contributors fully expect to have their contributions returned if a treatment does not occur during the spring of 2010. The consensus among the Planning Committee members that met on March 11, 2010, was that if a treatment does not happen the spring of 2010, that they will not be able to raise sufficient funds again to complete a whole-lake treatment.

Project Wrap-up Meeting
Meeting planned for the summer of 2010

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, not all chemical attributes collected may have a direct bearing on the lake's ecology, but may be more useful as indicators of other problems. Finally, 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 analysis 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 ecology 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.

Comparisons with Other Datasets

As mentioned above, chemistry is a large part of water quality analysis. In most cases, listing the values of specific parameters really does not lead to an understanding of a lake's water quality, especially in the minds of non-professionals. A better way of relating the information is to compare it to similar lakes in the area. In this document, a portion of the water quality information collected in Kathan Lake are compared to other lakes in the region and state (Kathan Lake water quality is contained in 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 Kathan Lake 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).

Lillie and Mason (1983) is an excellent source of data for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Oneida County lakes are included within the study's Northeast Region (Figure 3.1-1) and are among 242 lakes randomly sampled from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means and historic data from Kathan Lake are displayed in Figures 3.1-2 – 3.1-4. Please note that the data in these graphs represent values collected from the deepest location in Kathan Lake (Map 1). 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 (see discussion under Internal Nutrient Loading on page 9). Surface samples in Kathan Lake were collected at a depth of 3 feet.

Figure 3.1-1. Location of Kathan Lake within the regions utilized by Lillie and Mason (1983).

The data presented in Figures 3.1-2 – 3.1-4 represents samples collected during the growing season (March 31-November 1) and during the summer (May 31-September 1). These values may differ due to seasonal fluctuations in nutrients or physical water events such as lake mixing and stratification (discussed further below); therefore, they are separated and analyzed differently.

Apparent Water Quality Index

Water quality, like beauty, is often in the eye of the beholder. A person from southern Wisconsin that has never seen a northern lake may consider the water quality of their lake to be good if the bottom is visible in 4 feet of water. On the other hand, a person accustomed to seeing the bottom in 18 feet of water may be alarmed at the clarity found in the southern lake.

Lillie and Mason (1983) used the extensive data they compiled to create the Apparent Water Quality Index (WQI). They divided the phosphorus, chlorophyll-a, and clarity data of the state's lakes into ranked categories and assigned each a "quality" label from "Excellent" to "Very Poor". The categories were created based upon natural divisions in the dataset and upon their experience. As a result, using the WQI as an assessment tool is very much like comparing a particular lake's values to values from many other lakes in the state. However, the use of terms like, "Poor", "Fair", and "Good" bring about a better understanding of the results than just comparing averages or other statistical values between lakes. The WQI values corresponding to the phosphorus, chlorophyll-*a*, and Secchi disk values for Kathan Lake are displayed on Figures 3.1-2 – 3.1-4.

Trophic State

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.

Total phosphorus, chlorophyll-a, and water clarity values are directly related to the trophic state of the lake. As nutrients, primarily phosphorus, accumulate within a lake, its productivity increases and the lake progresses through three trophic states: oligotrophic, mesotrophic, and finally eutrophic. Every lake will naturally progress through these states and under natural conditions (i.e. not influenced by the activities of humans) this progress can take tens of thousands of years. Unfortunately, human influence has accelerated this natural aging process in many Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the productivity of their lake over time. Yet, classifying a lake into one of three trophic states often does not give clear indication of where a lake really exists in its trophic progression because each trophic state represents a range of productivity. Therefore, two lakes classified in the same trophic state can actually have very different levels of production. 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. Because Carlson developed his TSI equations on the basis of association among water clarity, chlorophyll-a, and total phosphorus values of a relatively small set of Minnesota lakes, researchers from Wisconsin (Lillie et. al. 1993), developed a new set of relationships and equations based upon the data compiled in Lillie & Mason (1983). This resulted in the Wisconsin Trophic State Index (WTSI), which is essentially a TSI calibrated for Wisconsin lakes. The WTSI is used extensively by the Wisconsin Department of Natural Resources (WDNR) and is reported along with lake data collected by Citizen Lake Monitoring Network volunteers.

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.

Kathan Lake Water Quality Analysis

Kathan Lake Long-term Trends

As described above, the long-term trend analysis focuses upon three parameters, total phosphorus, chlorophyll-*a*, and Secchi disk clarity. For Kathan Lake, very little historic phosphorus and chlorophyll-*a* data exists in the WDNR and Environmental Protection Agency databases. However, there is a strong record of Secchi disk clarities for the lake that lead to some interesting conclusions.

Total phosphorus data for Kathan Lake was collected during 1979 and then again starting in 2006 (Figure 3.1-2). Results from 2006-2009 were collected as a part of the Citizens Lake Monitoring Network (CLMN). Results from 2008 are a combination of data collected by Onterra and the CLMN volunteers.

Overall, there does not seem to be a clear trend within the total phosphorus dataset; however, it is apparent that the limited data available does remain within the "Good" range of the WQI and that the summer values are in line with those from the state and region.

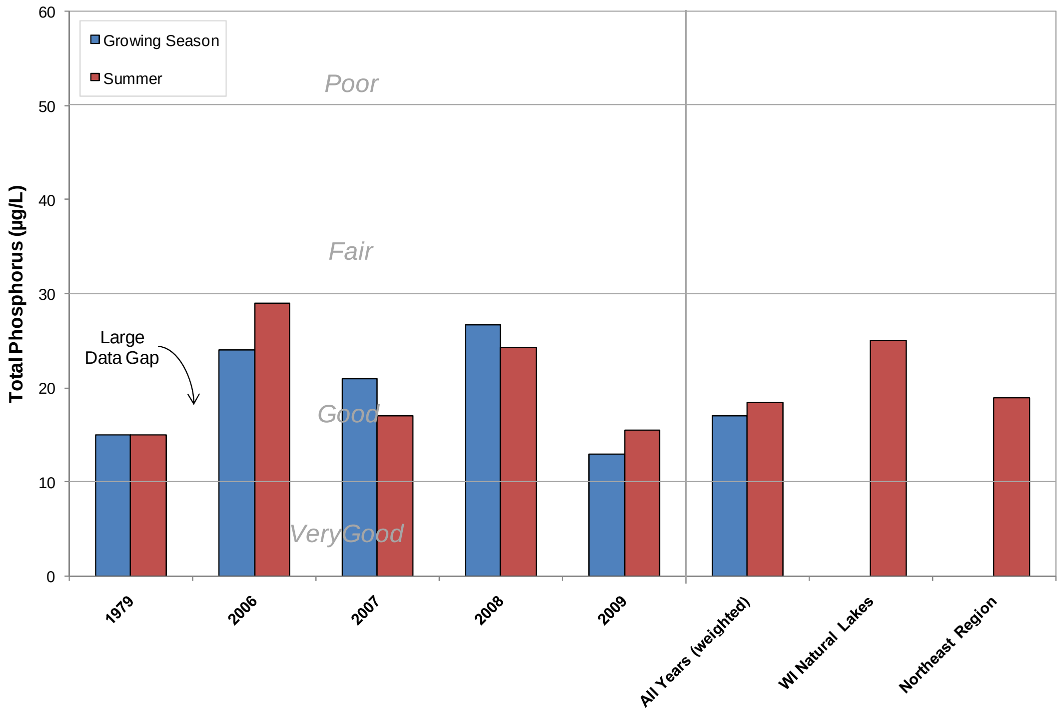

Figure 3.1-2. Kathan Lake, regional, and state total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Chlorophyll-*a* results are available for the same years as those of total phosphorus. Inspection of Figure 3.1-3 could lead to the conclusion that there has been a steady drop in chlorophyll-*a* concentrations within Kathan Lake since 1979. While this may be true, we have no way of knowing whether it is the case or not as there is a very large gap in the data set from 1980-2005. So, we cannot conclude that there has been a steady decline because the values could have fluctuated widely during the missing years – which is the case in many Wisconsin lakes due to precipitation levels, summer air temperatures, level of vascular plant biomass, and many other reasons. The most recent data within the figure (2007-2009) indicates that chlorophyll-*a* concentrations are within WQI range of "Very Good" and that the summer month values are well below averages calculated for lakes within Wisconsin and the Northeast Region.

There does appear to be a pattern of decreasing chlorophyll-*a* levels from 2006-2009. As discussed in the primer sections above, within Wisconsin Lakes, there is a direct relationship between chlorophyll-*a* concentrations and water clarity values. As chlorophyll-*a* concentrations decrease, we know that algal biomass in the lake is decreasing. Since algae make up the bulk of particulates in the water column, their presence or absence controls the clarity of the lake.

The falling chlorophyll-*a* concentrations seen in Figure 3.1-3 for 2006-2009 are apparent in the rise in Secchi disk clarity values for the same years in Figure 3.1-4. The clarity values shown in Figure 3.1-4 stretch back from the present to 1993, which equates to a solid database for trend analysis over nearly two decades. Inspection of the data indicates a definite flat pattern of clarity values hovering around the break between "Very Poor" and "Poor" until 2005; from that point the values pretty much steadily rise until they just reach the "Good" range in 2009.

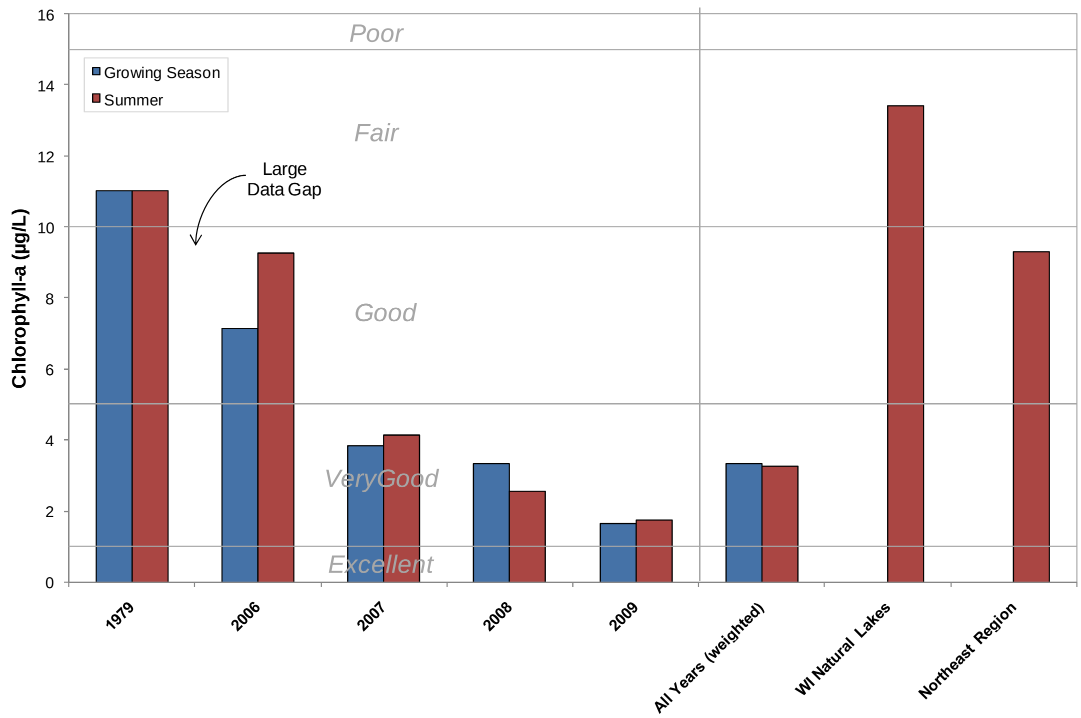

Figure 3.1-3. Kathan Lake, regional, and state chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

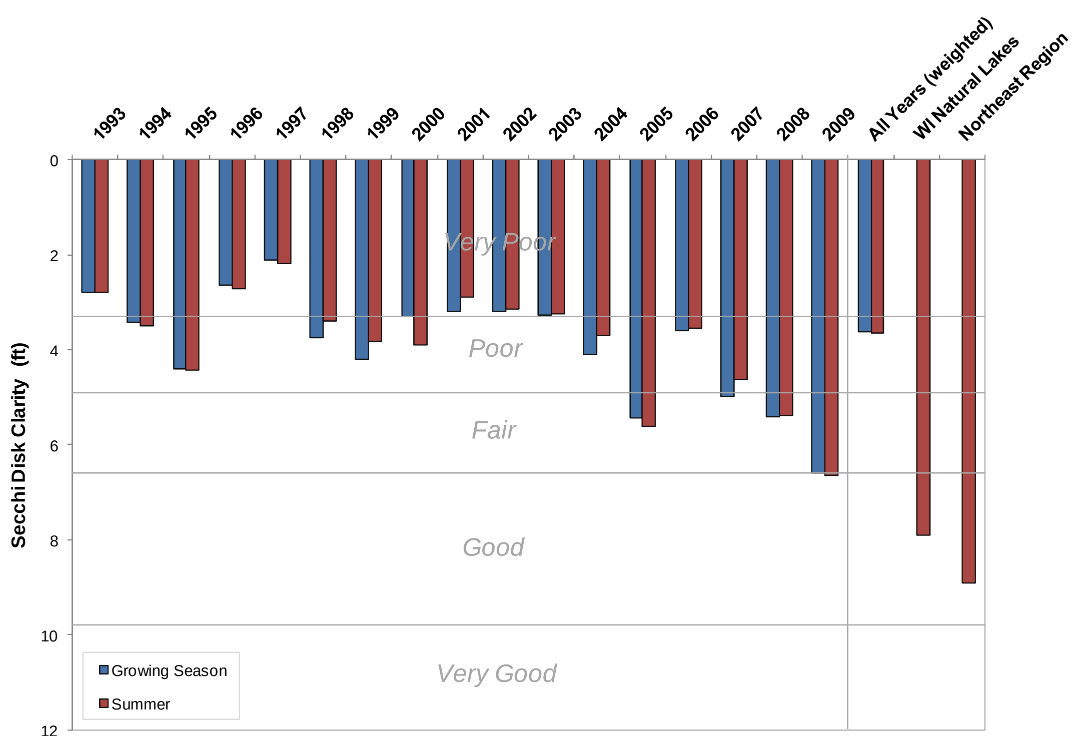

Figure 3.1-4. Kathan Lake, regional, and state Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

In shallow lakes such as Kathan, one of the two plants groups that exist in lakes, either algae or macrophytes (vascular plants) tend to dominate the lake. Lakes dominated by algae are in a turbid state because of the water's turbid nature brought on by the presence of algae. Lakes dominated by macrophytes, have clearer water and are called clear state lakes. Historically, lake scientists believed that the competition between macrophytes and algae only included light and nutrients. However, in the past couple of decades, researchers have discovered that competition between the two groups is impacted greatly by zooplankton, which are microscopic animals, mostly crustaceans, that graze upon algae much like cattle graze on grass. The macrophytes provide cover for the zooplankton against predation by fish and macroinvertebrates. When the macrophytes are removed, the zooplankton population decreases and algae populations flourish. Once a shallow lake is dominated by algae, it is difficult to flip it back to a clear state as the algae tend to block sufficient light to suppress macrophyte growth.

Based upon the known relationship between chlorophyll-a concentrations and water clarity within Kathan Lake, it may be that prior to 2005, the lake was dominated by algae and after 2005, it is, or is becoming, dominated by macrophytes. It is likely not coincidental that Eurasian water milfoil was first discovered in 2004 and has increased its presence tremendously within the lake since then.

Limiting Plant Nutrient of Kathan Lake

Using 2008 mid-summer nitrogen and phosphorus concentrations from Kathan Lake, a nitrogen:phosphorus ratio of 25:1 was calculated. This finding indicates that Kathan Lake is indeed phosphorus limited as are the vast majority of Wisconsin Lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Kathan Lake Trophic State

Figure 3.1-5 contain the WTSI values for Kathan Lake. The WTSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from lower mesotrophic to upper 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, especially those from recent years, it can be concluded that Kathan Lake is in an upper mesotrophic to lower mesotrophic range. However, the WTSI analysis discussed here does not include the level of primary production originative with the macrophytes that occur within the lake. If their production were included, the lake would definitely be considered eutrophic.

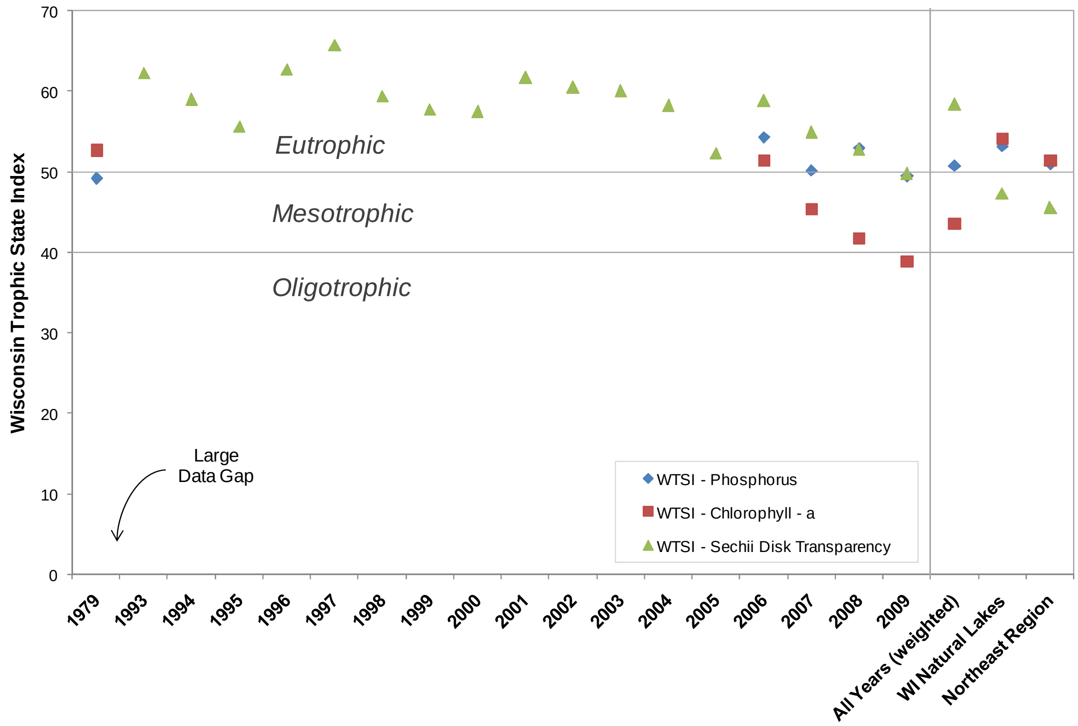

Figure 3.1-5. Kathan Lake, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993).

Dissolved Oxygen and Temperature in Kathan Lake

Dissolved oxygen and temperature profiles were created during each water quality sampling trip made to Kathan Lake by Onterra staff. Graphs of those data are displayed in Figure 3.1-6 for 6 sampling events, one during spring turnover, three during the summer, one during the fall turnover, and finally one during winter ice cover.

Kathan Lake was not found to stratify during the open water season, which is not uncommon in moderately-sized, shallow lakes like Kathan. In these shallow lakes, little wind energy is required to breakdown short periods of stratification that occur. The lake, not surprisingly, does stratify during the winter months. During winter stratification, the lake's hypolimnion does become anoxic as a result of the plant biomass decomposition that occurs during the fall and winter months. At this time, there is likely little danger of significant winter fishkill of occurring as half or more of the lake's volume contains sufficient dissolved oxygen levels to sustain the warm water fishery that exists in Kathan Lake.

Internal Nutrient Loading in Kathan Lake

Based upon the data collected during this project, it is believed, that Kathan Lake does not experience significant loads of phosphorus through internal nutrient cycling. This conclusion was reached because the lake does not stratify for long periods of time during the open water season. Kathan does stratify during ice cover and the hypolimnion does become anoxic, but water quality samples collected from that depth resulted in a total phosphorus concentration of 71.0 μg/l, which is well below the 200 μg/l threshold discussed above.

Additional Water Quality Data Collected at Kathan Lake

Alkalinity, pH, and calcium analysis was also performed on some of the water quality samples collected from Kathan Lake. Midsummer alkalinity values were found to be roughly 18 mg/L as $CaCO_3$ indicating that the lake has a high buffering capacity, making it have low sensitivity to acid rain. During the same time, the lake's pH hovered around 7.6 or slightly above neutral. The pH value is normal for a lake such as Kathan and is well within the optimum range for zebra mussels. However, calcium analysis from a sample collected during May 2008 returned a value of 5.5 mg/L, which is well below the optimum range for zebra mussels.

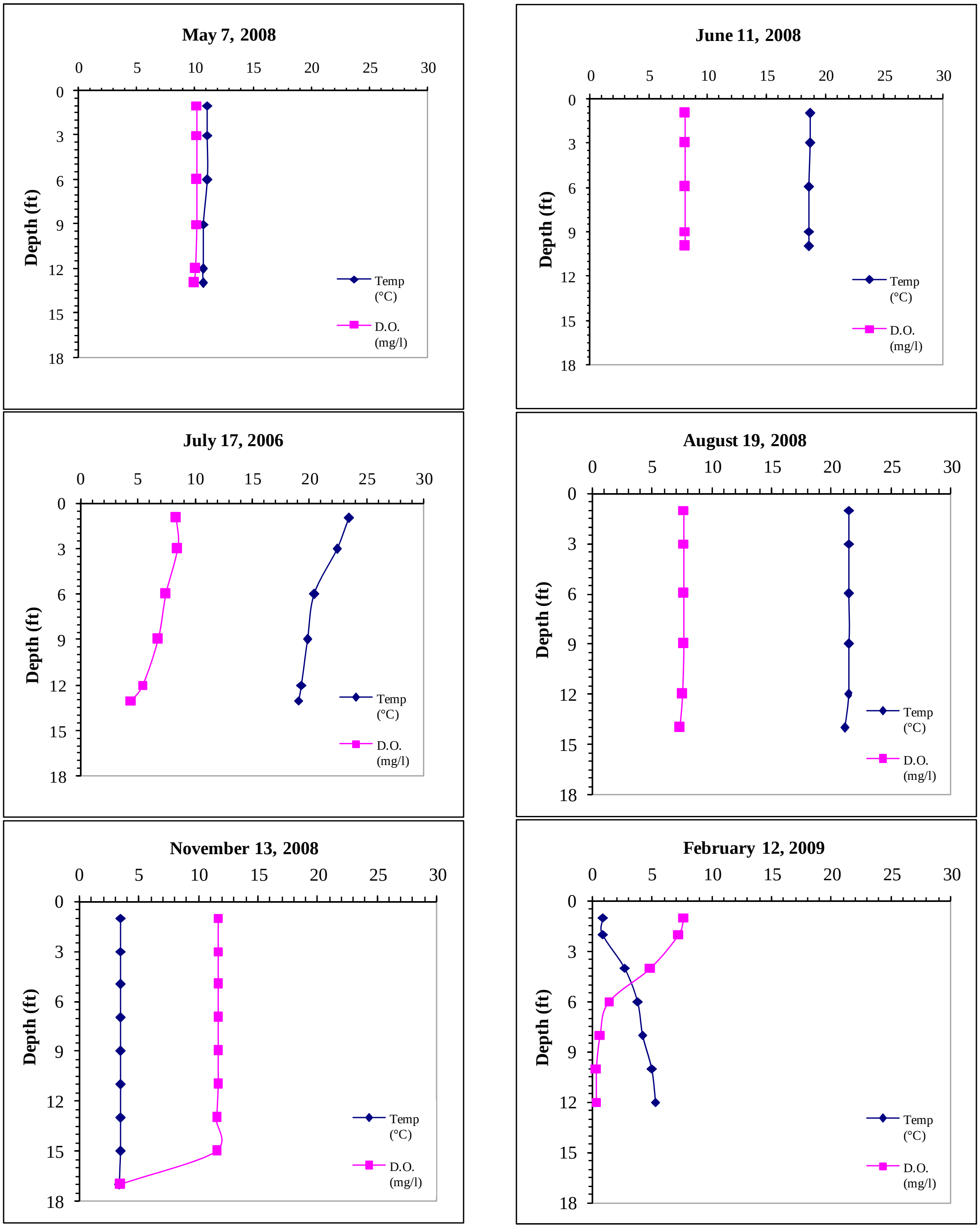

Figure 3.1-6. Kathan Lake dissolved oxygen and temperature profiles.

3.2 Watershed Assessment

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

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

A reliable and cost-efficient method of creating a general picture of a watershed's affect on a lake can be obtained through modeling. The WDNR created a useful suite of modeling tools called the Wisconsin Lake Modeling Suite (WiLMS). Certain morphological attributes of a lake and its watershed can be 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.

Kathan Lake's 3,485 acre watershed is largely dominated by forest (52% or 1,817 acres) and wetland (36% or 1241.4 acres) with agriculture and pastureland making up smaller quantities of the watershed (Figure 3.2-1). The watershed is substantially larger than Kathan Lake itself, as indicated by the moderately high watershed to lake area ratio of 15:1. As discussed above, in watersheds with a relatively large ratio, it is often difficult to improve water quality through land use changes because the large amount of land is a factor that overshadows the actual land type. With 88% of the watershed encompassing either forest or wetlands, the land cover type that may be of concern would be the row crop agriculture, which occupies only 1% (51 acres) of the watershed. This is discussed in more detail below.

WiLMS modeling utilizing the land cover types and acreages found in Figure 3.2-1 results in an estimated annual phosphorus load of 403.4 lbs for Kathan Lake. This is a considerable amount of phosphorus for a lake of this size. This is most likely the result not of the land use of the watershed (88% of the watershed is held in forest and wetlands, which typically export less phosphorus than other land use types), but is more likely the result of the large size of the watershed in relation to the lake. The two largest land uses contribute the majority of the phosphorus load (forests at 36% or 145.5 lbs and wetlands at 27% or 110 lbs.) and the remaining three land uses (row crop agriculture, pasture/grass, and the lake itself) contribute 37% of the phosphorus load despite covering only 12% of the watershed (Figures 3.2-1 and 3.2-2).

As previously discussed the only land use of particular concern would be that of the row crop agriculture. While this land use is found in only 1% of the watershed, it exports 12% of the total phosphorus load to Kathan Lake. The influence of this land use is, however, comparable to that of Kathan Lake itself, as the lake is responsible for 14% of the annual phosphorus load. In terms of actual benefits, reducing the row crop agriculture would have little impact on Kathan Lake. Predictive equations within WiLMS were utilized to model a potential scenario in which the row crop agriculture was converted into forested land. This conversion would decrease the growing season phosphorus by 2 mg/L, and would only increase the Secchi depth on Kathan Lake by 2.4 inches. In the end, the costs of land modification would outweigh the benefits achieved.

While the annual phosphorus load to Kathan Lake is considerable for a lake of this size, there is one factor which helps to reduce the impacts of phosphorus on the system. Kathan Lake has a moderately high flushing rate (3.2 times each year) which in turn results in a fairly short residence time of 113 days. This removes a portion of the phosphorus from the lake before it can fuel aquatic plant growth or otherwise accumulate.

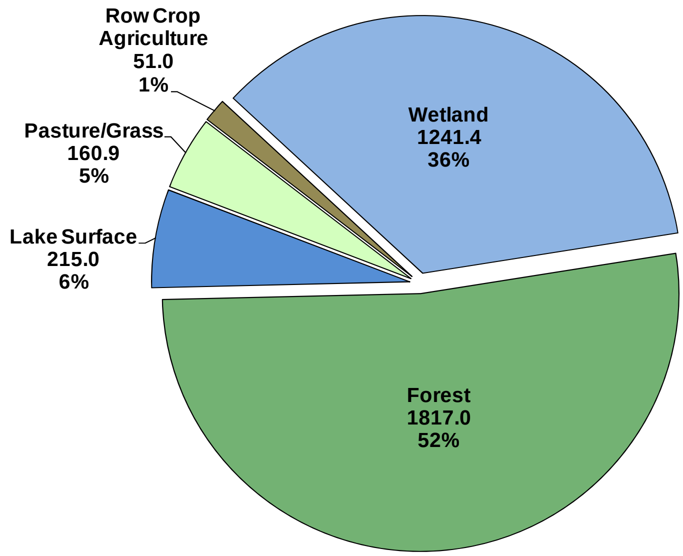

Figure 3.2-1. Kathan Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND, 1993)

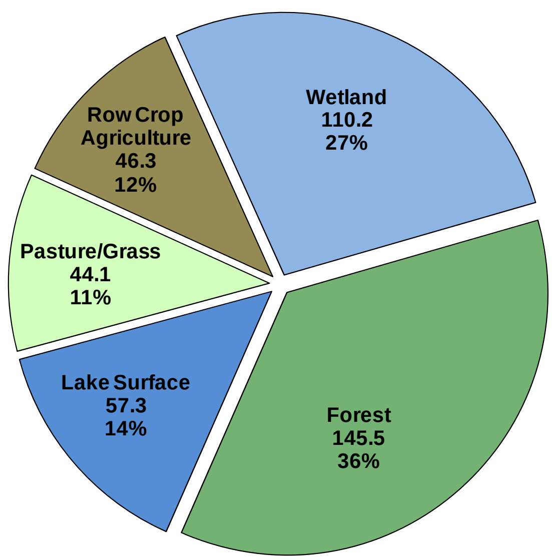

Figure 3.2-2. Kathan Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Onterra LLC
Lake Management Planning

3.3 Aquatic Plants

Introduction

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

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*). In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the periphyton attached to them as their primary food source. The plants also provide cover for feeder fish and zooplankton, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent 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 numbers of predator fish and 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 Kathan Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake**.** The techniques applicable to Kathan Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

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

Permits

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

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

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 shoreline. 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 shoreline 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).

Photograph 3.3-1. Example of a biolog restoration site.

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. Please note that addition of species (even native) to a lake may require WDNR approval.

Cost

The cost of native, aquatic and shoreland plant restorations is highly variable and depend on the size of the restoration area, planting densities, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other factors may include extensive grading requirements, removal of shoreland stabilization (e.g., rip-rap, seawall), and protective measures used to guard the newly planted area from wildlife predation, wave-action, and erosion. In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $4,200.

- The single site used for the estimate indicated above has the following characteristics:
    - An upland buffer zone measuring 35’ x 100’.
    - An aquatic zone with shallow-water and deep-water areas of 10’ x 100’ each.
    - Site is assumed to need little invasive species removal prior to restoration.
    - Site has a moderate slope.
    - Trees and shrubs would be planted at a density of 435 plants/acre and 1210 plants/acre, respectively.
    - Plant spacing for the aquatic zone would be 3 feet.
    - Each site would need 100’ of biolog to protect the bank toe and each site would need 100’ of wavebreak and goose netting to protect aquatic plantings.
    - Each site would need 100’ of erosion control fabric to protect plants and sediment near the shoreline (the remainder of the site would be mulched).
    - 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 shoreline erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • 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.

Manual Removal

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

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

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

Cost

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

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

Bottom Screens

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

Costs

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.

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 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. Some herbicides are applied at a high dose with the anticipation that the exposure time will be short. Granular herbicides are usually applied at a lower dose, but the release of the herbicide from the clay carrier is slower and increases the exposure time.

Below are brief descriptions of the aquatic herbicides currently registered for use in Wisconsin.

Fluridone (Sonar®, Avast!®) Broad spectrum, systemic herbicide that is effective on most submersed and emergent macrophytes. It is also effective on duckweed and at low concentrations has been shown to selectively remove Eurasian water-milfoil. Fluridone slowly kills macrophytes over a 30-90 day period and is only applicable in whole lake treatments or in bays and backwaters where dilution can be controlled. Required length of contact time makes this chemical inapplicable for use in flowages and impoundments. Irrigation restrictions apply.

Diquat (Reward®, Weedtrine-D®) Broad spectrum, contact herbicide that is effective on all aquatic plants and can be sprayed directly on foliage (with surfactant) or injected in the water. It is very fast acting, requiring only 12-36 hours of exposure time. Diquat readily binds with clay particles, so it is not appropriate for use in turbid waters. Consumption restrictions apply.

Endothall (Hydrothol®, Aquathol®) Broad spectrum, contact herbicides used for spot treatments of submersed plants. The mono-salt form of Endothall (Hydrothol®) is more toxic to fish and aquatic invertebrates, so the dipotassium salt (Aquathol®) is most often used. Fish consumption, drinking, and irrigation restrictions apply.

2,4-D (Navigate®, DMA IV®, etc.) Selective, systemic herbicide that only works on broad-leaf plants. The selectivity of 2,4-D towards broad-leaved plants (dicots) allows it to be used for Eurasian water-milfoil without affecting many of our native plants, which are monocots. Drinking and irrigation restrictions may apply.

Triclopyr (Renovate®) Selective, systemic herbicide that is effective on broad leaf plants and, similar to 2,4 D, will not harm native monocots. Triclopyr is available in liquid or granular form, and can be combined with Endothal in small concentrations (<1.0 ppm) to effectively treat Eurasian water-milfoil. Triclopyr has been used in this way in Minnesota and Washington with some success.

Glyphosate (Rodeo®) Broad spectrum, systemic herbicide used in conjunction with a surfactant to control emergent and floating-leaved macrophytes. It acts in 7-10 days and is not used for submergent species. This chemical is commonly used for controlling purple loosestrife (*Lythrum salicaria*). Glyphosate is also marketed under the name Roundup®; this formulation is not permitted for use near aquatic environments because of its harmful effects on fish, amphibians, and other aquatic organisms.

Imazapyr (Habitat®) Broad spectrum, systemic herbicide, slow-acting liquid herbicide used to control emergent species. This relatively new herbicide is largely used for controlling common reed (giant reed, *Phragmites*) where plant stalks are cut and the herbicide is directly applied to the exposed vascular tissue.

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 waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*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, like variable water levels or negative, like increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways; there may be a loss of one or more species, certain life forms, such as emergents or floating-leaf communities may disappear from certain areas of the lake, or there may be a shift in plant dominance between species. 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 Kathan Lake; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

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

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Kathan Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, relative frequency of occurrence is used to describe how often each species occurred in the plots that contained vegetation. 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

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

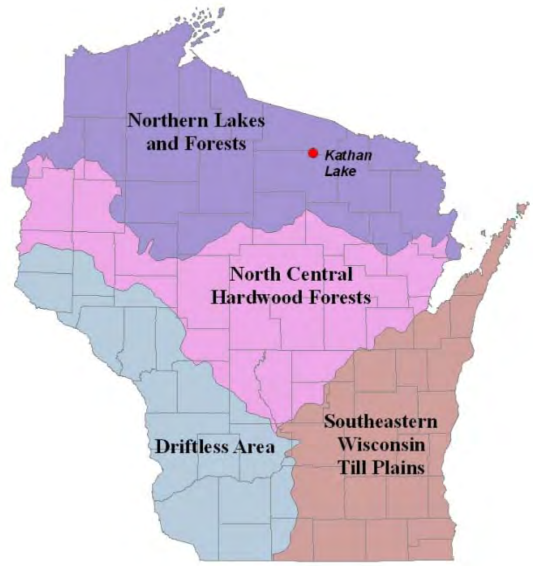

Figure 3.3-1. Location of Kathan Lake within the ecoregions of Wisconsin. After Nichols 1999.

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

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 Kathan Lake will be compared to lakes in the same ecoregion and in the state (Figure 3.3-1).

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

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species coefficient of conservatism value indicates that species likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality (see equation below for the 2007-2009 surveys).

FQI = Average Coefficient of Conservatism (7.0) * √ Number of Native Species (45)
FQI = 47.3

Community Mapping

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

Exotic Plants

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

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.3-2). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it may not stop growing like most native plants, instead it can continue to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

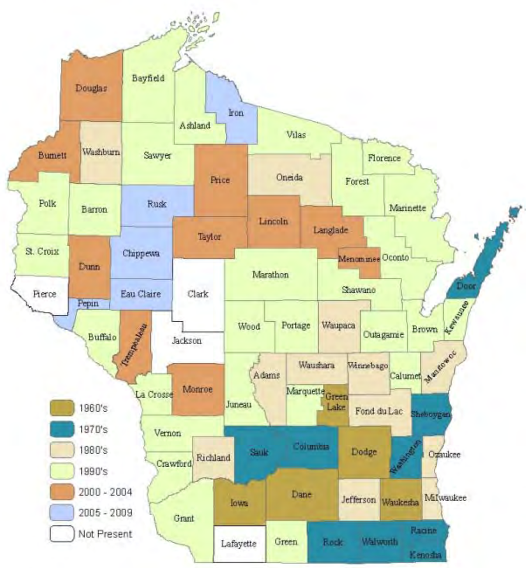

Figure 3.3-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2010b mapped by Onterra.

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

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

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. In June 2008, a survey was completed on Kathan Lake by Onterra staff that focused upon curly-leaf pondweed. This meander-based survey did not locate any occurrences of curly-leaf pondweed. It is believed that this AIS either does not occur in Kathan Lake or exists at an undetectable level.

Kathan Lake has been actively studied by WDNR Science Services since 2007 as part of a research project aimed at understanding natural variation in Eurasian water milfoil populations across the state as well as how management actions affect these populations. Point intercept surveys were conducted on Kathan Lake as a part of this research during the summers of 2007-2009. Additional surveys were completed by Onterra on Kathan Lake to create the aquatic plant community map (Map 3) during August 2008.

During the point-intercept and aquatic plant mapping surveys, 46 species of plants were located in Kathan Lake (Table 3.3-1), only one of which is considered a non-native species: Eurasian water milfoil. Because of its frequency within the lake, Eurasian water milfoil will be discussed in depth in a separate section. Twelve emergent plant species are known to exist in Kathan Lake, including northern wild rice (Map 3, Table 3.3-1). Wild rice is of ecological and cultural importance, especially for the Native American community. Three species are listed by the Natural Heritage Inventory Program as being species of 'Special Concern' in Wisconsin (spiny hornwort, Vasey's pondweed, and twin-stemmed bladderwort) (WDNR 2010a). *Note: At the time of the aquatic plant surveys and first draft of this document, all three of these species were included within the NHI program list. In 2011, this species list was updated and spiny hornwort and twin-stemmed bladderwort were removed as Special Concern species.*

Kathan Lake contains four bladderwort species that together comprised approximately 8% of the plant occurrences found during the 2009 point-intercept survey. As the name suggests, these plants contain small bladders that trap and digest small aquatic organisms. Bladderworts have an advantage in low nutrient and low pH systems where other native plants have difficulty obtaining their required nutrients. As stated within the water quality section, Kathan Lake exhibits a neutral pH during most of the year. However, quite acidic pH levels (4.0 – 5.9) were observed during a single fall turnover event. It is unknown if this periodic acidic condition gives bladderworts and advantage over other aquatic plants in Kathan Lake.

Table 3.3-1. Aquatic plant species located in Kathan Lake during 2007-2009 surveys.

Life Form	Scientific Name	Common Name	Coeffecient of Conservatism	2007	2008	2009
Emergent	Carex sp.	Unknown sedge	N/A	I	I	I
	Carex lasiocarpa	Wooly-fruit sedge	9		O	
	Dulichium arundinaceum	Three-way sedge	9	I	X	X
	Eleocharis erythropoda	Bald spike-rush	3		X	
	Eleocharis palustris	Creeping spikerush	6	X	X	X
	Equisetum fluviatile	Water horsetail	7	X	X	X
	Sagittaria latifolia	Common arrowhead	3		O	X
	Sagittaria rigida	Stiff arrowhead	8		O	
	Schoenoplectus tabernaemontani	Softstem bulrush	4		O	
	Schoenoplectus subterminalis	Water bulrush	9		X	X
	Typha sp.	Cattail species	1	X	X	X
	Zizania palustris	Northern wild rice	8		O	I
FF	Lemna minor	Lesser duckweed	5		X	X
FL	Brasenia schreberi	Watershield	7	X	X	X
	Nuphar variegata	Spatterdock	6	X	X	X
	Nymphaea odorata	White water lily	6	X	X	X
FL/E	Sparganium americanum	Eastern bur-reed	8			X
	Sparganium angustifolium	Narrow-leaf bur-reed	9		O	
	Sparganium fluctuans	Floating-leaf bur-reed	10		O	X
Submergent	Ceratophyllum demersum	Coontail	3	X	X	X
	Ceratophyllum echinatum	Spiny hornwort	10		X	
	Chara sp.	Muskgrasses	7	X	X	X
	Elatine minima	Waterwort	9	X	X	X
	Elodea canadensis	Common waterweed	3	X	X	X
	Eriocaulon aquaticum	Pipewort	9	X	X	X
	Isoetes echinospora	Spiny-spored quilwort	8	X	X	X
	Littorella uniflora	Plantain shoreweed	10	X	I	
	Myriophyllum sibiricum	Northern water milfoil	7	X		
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	X	X	X
	Najas flexilis	Slender naiad	6	X	X	X
	Nitella sp.	Stoneworts	7	X	X	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X	X	X
	Potamogeton gramineus	Variable pondweed	7	X	X	X
	Potamogeton pusillus	Small pondweed	7	X	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X	X	X
	Potamogeton strictifolius	Stiff pondweed	8	X	X	X
	Potamogeton vaseyi	Vasey's pondweed	10		O	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X	X
	Utricularia geminiscapa	Twin-stemmed bladderwort	9	X	X	X
	Utricularia intermedia	Flat-leaf bladderwort	9	X	X	X
	Utricularia minor	Small bladderwort	10	X	X	
	Utricularia vulgaris	Common bladderwort	7	X	X	X
	Vallisneria americana	Wild celery	6	X	X	X
S/E	Eleocharis acicularis	Needle spikerush	5	I	X	X
	Juncus pelocarpus	Brown-fruited rush	8	X	X	X

FF = Free-floating, FL = Floating leaf, FL/E = Floating leaf/emergent, S/E = Submergent/Emergent
X = Present, I = Incidental, O = Additional species located by Onterra during 2008 surveys

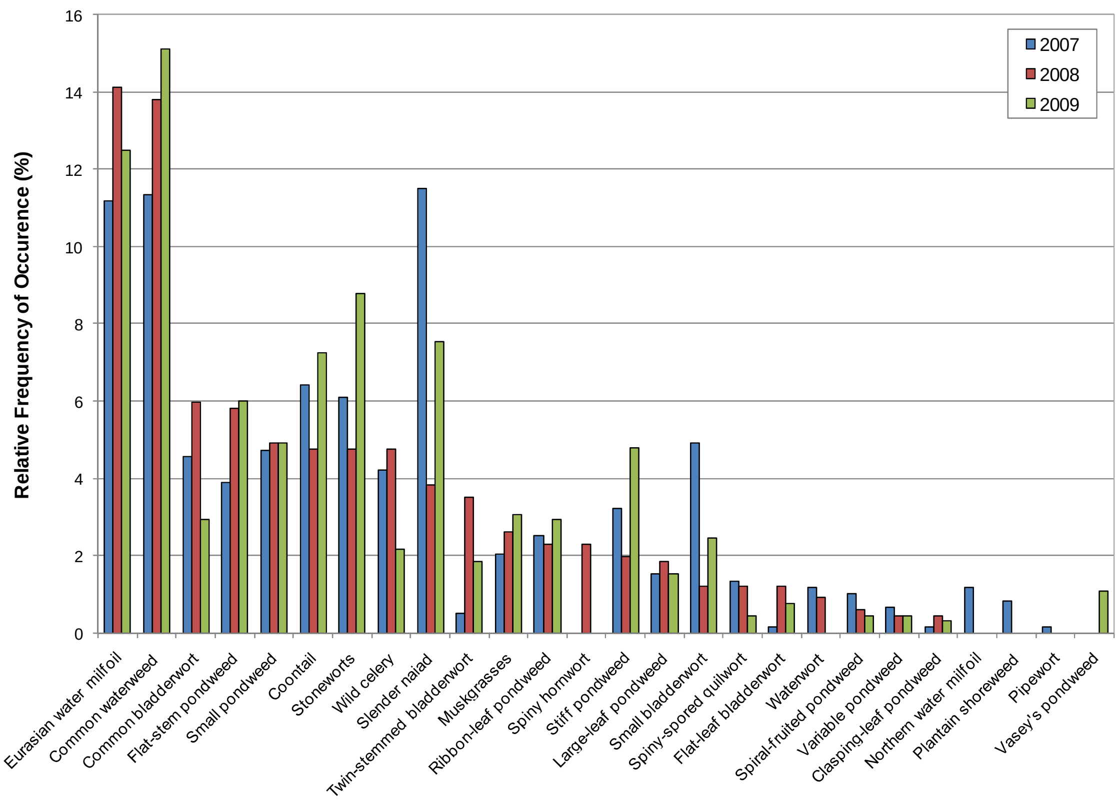

Figure 3.3-3 Kathan Lake relative frequency analysis of submergent aquatic plant species. Created using data from WDNR 2007-2009 point-intercept surveys.

Kathan Lake contains a high number of aquatic plants, and partially because of this, also contains very high species diversity. As discussed earlier, how evenly the species are distributed throughout the system also influence the diversity. The diversity index for Kathan Lake's plant community (0.93) shows that the lake has a relatively even distribution (relative frequency) of plant species throughout the lake. Figure 3.3-3 shows that Eurasian water milfoil and common waterweed are the most prevalent species in the lake. Due to their lack of developed root structures, the locations of common waterweed are largely influenced by water movement and their tendency to become entangled in plants, rocks, or debris. In Kathan Lake, Eurasian water milfoil can be found growing to the surface and likely provides the substrate needed for common waterweed to become entangled.

Aquatic plant frequencies were compared on Kathan Lake during the 2007-2009 point-intercept surveys (Table 3.3-2, Figure 3.3-4). Table 3.3-2 displays a comparative matrix of different combinations of the 2007, 2008, and 2009 surveys. For the most part, the changes between 2007-2008 and 2008-2009 are additive and together comprise the differences observed when comparing the 2007 and 2009 datasets.

Statistical analysis is used by scientists to determine if an observed difference is sufficient to be attributed to a particular factor or if the difference may have occurred randomly. If the difference is sufficient, it is considered to be significantly different, if it is not sufficient, it is considered to be insignificantly different. In the end, a significant difference can be attributed to some factor, while an insignificant difference can usually be attributed to random variation.

Using slender naiad as an example, this species' frequency within Kathan Lake was reduced between 2007 and 2008. However, slender naiad increased from 2008 to 2009. Still, the plant's increase in 2009 was significantly less than in 2007.

Table 3.3-2. Native plant species change in occurrence on Kathan Lake during 2007-2009 surveys. Statistical significance is determined by Chi-square distribution analysis (alpha = 0.05).

Scientific Name	Common Name	2007-2008	2008-2009	2007-2009
Brasenia schreberi	Watershield	△	▽	△
Ceratophyllum demersum	Coontail	▽	▲	△
Ceratophyllum echinatum	Spiny hornwort		▼	
Chara sp.	Muskgrasses	△	△	△
Elatine minima	Waterwort	▽	▼	▼
Eleocharis acicularis	Needle spikerush		▼	
Eleocharis erythropoda	Bald spike-rush		▽	
Eleocharis palustris	Creeping spikerush	▽	△	△
Elodea canadensis	Common waterweed	▲	△	▲
Equisetum fluviatile	Water horsetail	△	▽	
Eriocaulon aquaticum	Pipewort	▽		▽
Isoetes echinospora	Spiny-spored quilwort		▽	▽
Juncus pelocarpus	Brown-fruited rush	△	▽	▽
Littorella uniflora	Plantain shoreweed	▼		▼
Myriophyllum sibiricum	Northern water milfoil	▼		▼
Myriophyllum spicatum	Eurasian water milfoil	▲	▽	△
Najas flexilis	Slender naiad	▼	▲	▼
Nitella sp.	Stoneworts	▽	▲	▲
Nuphar variegata	Spatterdock	▽	▽	▽
Nymphaea odorata	White water lily	△	▽	△
Potamogeton amplifolius	Large-leaf pondweed	△	▽	△
Potamogeton epihydrus	Ribbon-leaf pondweed		△	△
Potamogeton gramineus	Variable pondweed	▽		▽
Potamogeton pusillus	Small pondweed	△		△
Potamogeton richardsonii	Clasping-leaf pondweed	△	▽	△
Potamogeton spirillus	Spiral-fruited pondweed	▽	▽	▽
Potamogeton strictifolius	Stiff pondweed	▽	▲	△
Potamogeton zosteriformis	Flat-stem pondweed	▲	△	▲
Utricularia geminiscapa	Twin-stemmed bladderwort	▲	▽	▲
Utricularia intermedia	Flat-leaf bladderwort	▲	▽	△
Utricularia minor	Small bladderwort	▼	▲	▼
Utricularia vulgaris	Common bladderwort	△	▼	▽
Vallisneria americana	Wild celery	△	▼	▽

▲ or ▼ = Significant Change
△ or ▽ = Insignificant Change

It is important to note that field identification of particular plant species can be quite difficult at times, especially if the plant species are lacking key characteristics (e.g. flowers, seeds, winter buds). One example is the presence of spiny hornwort during the 2008 survey. This rare plant is morphologically similar to the much more common coontail. It is likely that spiny hornwort was present in 2007 and 2009, but could only be distinguished from coontail effectively in 2008. Similarly, Vasey's pondweed was only identified in 2009, but likely was mixed in with samples of other similar-looking narrow-leaved pondweeds (stiff pondweed, spiral-fruited pondweed, and small pondweed) in 2007 and 2008.

Northern water milfoil was only located during the 2007 survey. Eurasian water milfoil competes heavily with northern water milfoil and in the case of Kathan Lake, may have displaced this species. At this time, northern water milfoil is either not present in Kathan Lake or at undetectable levels.

Figure 3.3-4 illustrates the magnitude of these changes for those species that were found to have statistically significant differences between 2007 and 2009. Please note that Figure 3.3-4 is displaying the difference between frequency of occurrence between these surveys for each plant listed and not a percent change in frequency. For example, slender naiad occurred in approximately 33.5% of the plots during 2007 and 24.1 % during 2009. Therefore, the chart indicates a negative difference (decrease) of approximately 9.4 (33.5% – 24.1%) and not a percent change. If percent change was calculated, we would see in this example that slender naiad decreased by 27.9% ((33.5 – 24.1) / 24.1 x 100%).

Figure 3.3-4 shows that the aquatic plant community of Kathan Lake changes from year to year. The fact that species frequency and distribution can vary within such a short time is not alarming. Actually, it lends to the importance of diversity. As environmental and climactic factors change, a diverse plant community is more resilient to these changes.

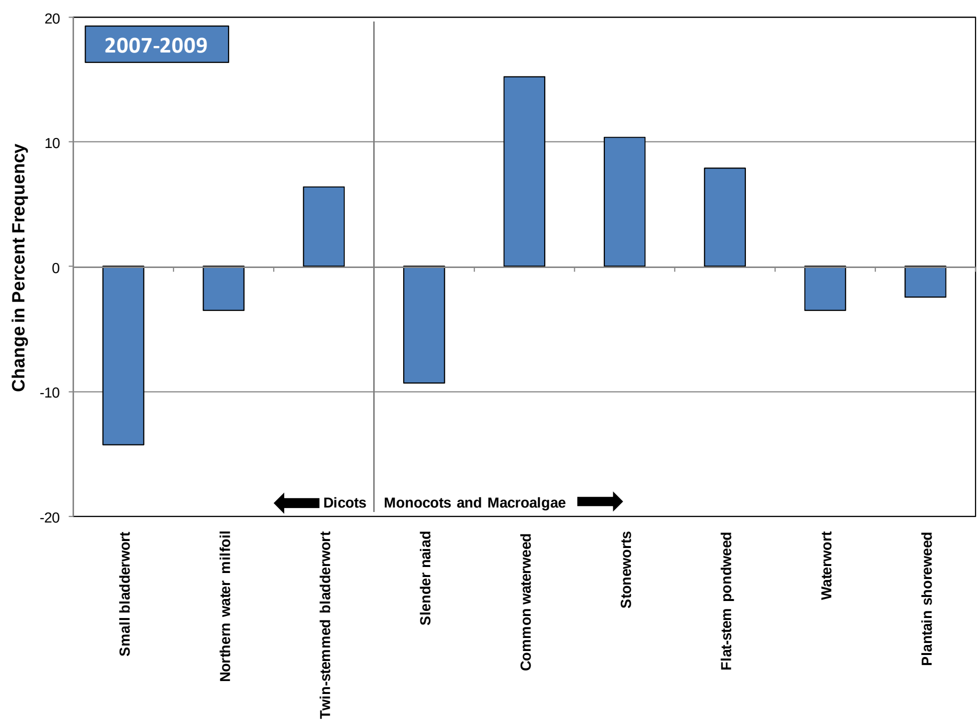

Figure 3.3-4 Kathan Lake changes in native aquatic plant frequency of occurrence analysis of 2007 - 2009 survey data. Please note only plant species shown to significantly change are displayed. Statistical significance is determined by Chi-square distribution analysis (alpha = 0.05).

Comparing the 2007 with the 2009 point-intercept surveys, four plants showed a statistically significant increase and five plants showed a statistically significant decrease in their frequency of occurrence within Kathan Lake (Figure 3.3-4). While the analysis shows that the frequency of these species has changed, the cause remains unknown, but likely is a result of environmental variations. Again, changes in small bladderwort occurrences may be a result in the ability to differentiate this species from other bladderwort species in certain years.

Although the exact date of introduction is unknown, the WDNR lists Kathan Lake as first being known to contain Eurasian water milfoil in 2004 (WDNR 2010b). Since that time, this exotic species has become one of the dominant plants in Kathan Lake (Figure 3.3-3). Surveys were conducted by Onterra in 2008 and 2009 which mapped the presence of this species within the lake (Maps 4 and 5). Within this 189-acre lake, approximately 112 acres contain Eurasian water milfoil of varying density, with surface matting observed at over 59 acres in 2009 (Map 5). Comparing Map 4 with Map 5 shows that the area of the lake containing Eurasian water milfoil did not increase between the two years, however the density did.

Within the 2007-2008 point-intercept surveys conducted by the WDNR, a significant increase in Eurasian water milfoil occurrence was detected in Kathan Lake (Figure 3.3-5). However, after an insignificant decline in Eurasian water milfoil frequency of occurrence in 2009, a statistical significant difference between 2007 and 2009 was not observed. These data may suggest that Eurasian water milfoil is reaching equilibrium in respect to the parts of the lake in which it exists. Researchers also noted visual sightings of Eurasian water milfoil at each location where the rake sampler did not yield Eurasian water milfoil. Utilizing this information, locations that either contained Eurasian water milfoil or had a visual sighting increased significantly from 71 occurrences in 2007 to 107 in 2009.

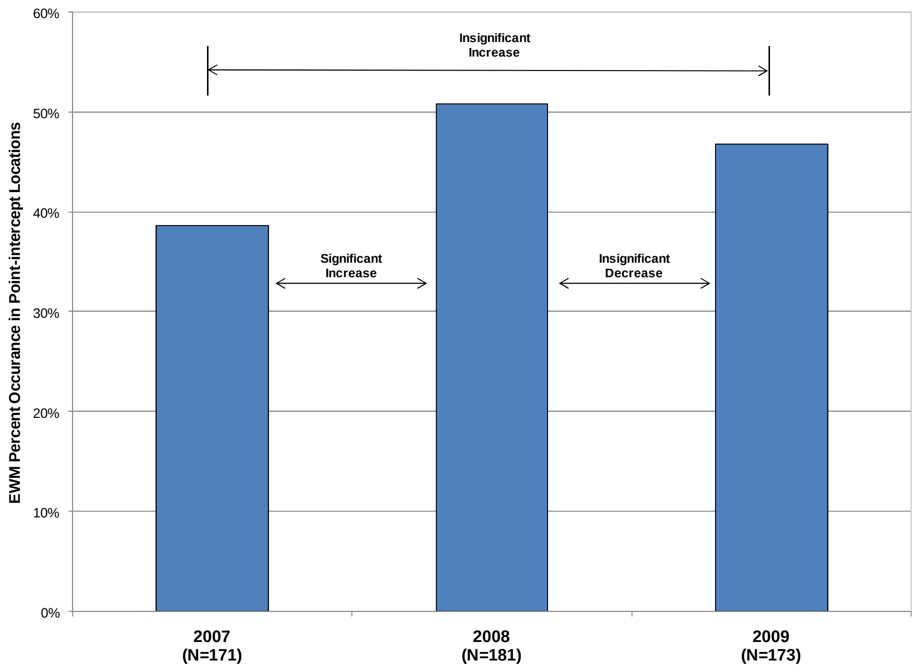

Figure 3.3-5 Kathan Lake changes in Eurasian water milfoil frequency of occurrence analysis of 2007-2009 survey data. Statistical significance is determined by Chi-square distribution analysis (alpha = 0.05).

As stated above, Kathan Lake has been actively studied by the WDNR Science Services since 2007 as part of a research project aimed at understanding natural variation in Eurasian water milfoil populations across the state as well as how management actions affect these populations. Thirty lakes containing Eurasian water milfoil have been surveyed by the WDNR within the Northern Lakes Forests (NLF) Ecoregion. Figure 3.3-6 shows that Kathan Lake it is an outlier that contains the highest Eurasian water milfoil frequency of occurrence within this dataset (47%).

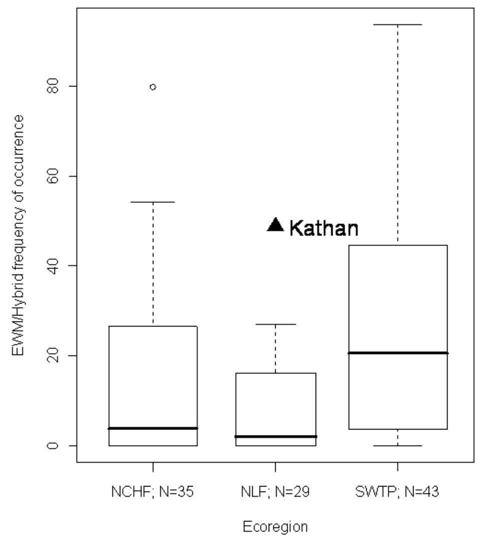

Figure 3.3-6 Kathan Lake Eurasian water milfoil frequency of occurrence relative to study lakes within NLF ecoregion. Data collected and compiled by WDNR Science Services.
NCHF = North Central Hardwood Forests,
NLF = Northern Lakes and Forests,
SWTP = Southeastern Wisconsin Till Plains.

It is unrealistic to quantitatively define the term "nuisance," as this designation is subjective by nature. However, WDNR Science Services researchers indicate that nuisance levels of Eurasian water milfoil likely occur when frequency of occurrences exceed 35% (Alison Mikulyuk, personal comm.). Eurasian water milfoil frequency in Kathan Lake greatly exceeds this benchmark and ecologists from WDNR Science Services and Onterra agree that this plant species is at nuisance levels. As Map 5 shows, almost 70 acres of Kathan Lake contains Eurasian water milfoil at highly dominant or surface matting densities where navigability is greatly reduced or halted. Twenty-five of the 27 members of the KLA that responded to the stakeholder survey indicated that AIS were a great negative threat to Kathan Lake (Appendix B, Question #14) and all respondents felt aquatic plant control was needed on Kathan Lake (Question #17).

The median value a value in which roughly half of the data are smaller and half the data are larger. A median is used when a few data are so large or so small that they skew the average value to the point that it would not represent the population as a whole.

The high frequency of occurrence of Eurasian water milfoil largely threatens the health of the aquatic plant community of Kathan Lake. Data collected from the 2007-2009 surveys indicate that the average conservatism values in Kathan Lake are much higher than the state and Northern Lakes Ecoregion medians (Figure 3.3-7). This indicates that many of the species present in the lake are normally associated with an undisturbed system. Eurasian water milfoil can certainly be viewed as a disturbance and likely cause a shift of the aquatic plant community, particularly in respect to those species with higher coefficients of conservatism (Table 3.3-1). Without data from before Eurasian water milfoil infestation, it is unknown if a shift in the aquatic plant community has already occurred or if these changes will manifest slowly over years or decades. But it is known that Eurasian water milfoil was not historically present in Kathan Lake and the space that is currently occupied by this species was formerly inhabited by native plant species.

Other forms of disturbance that often affect lakes include human development of the lake's shoreline and motorboat traffic. A stakeholder survey sent to KLA members indicate that motor boats with a 25 horsepower or less motor are the most prevalent watercraft on the lake, followed by three passive watercrafts (Appendix B, Question #8). Many studies have documented the adverse affects of motorboat traffic on aquatic plants (e.g. Murphy and Eaton 1983, Vermaat and de Bruyne 1993, Mumma et al. 1996, Asplund and Cook 1997). In all of these studies, lower plant biomasses and/or declines and higher turbidity were associated with motorboat traffic.

Combining the number of species with the average conservatism, the Floristic Quality Index indicates that the aquatic plant population of Kathan Lake is of high quality (Figure 3.3-7). The quality is also indicated by the high incidence of emergent and floating-leaf plant communities that occur in many areas. The 2008 community map indicates that over 1/3 of the surface area (over 81 acres) of the lake contains these types of plant communities (Table 3.3-3, Map 3). Each of these areas provides valuable fish and wildlife habitat important to the ecosystem of the lake.

Table 3.3-3. Kathan Lake acres of plant community types from the 2008 community mapping survey.

Plant Community	Acres
Emergent	8.6
Floating-leaf	4.7
Mixed Floating-leaf and Emergent	68.5
Total	81.8

Continuing the analogy that the community map represents a 'snapshot' of the important plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Kathan Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to 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.

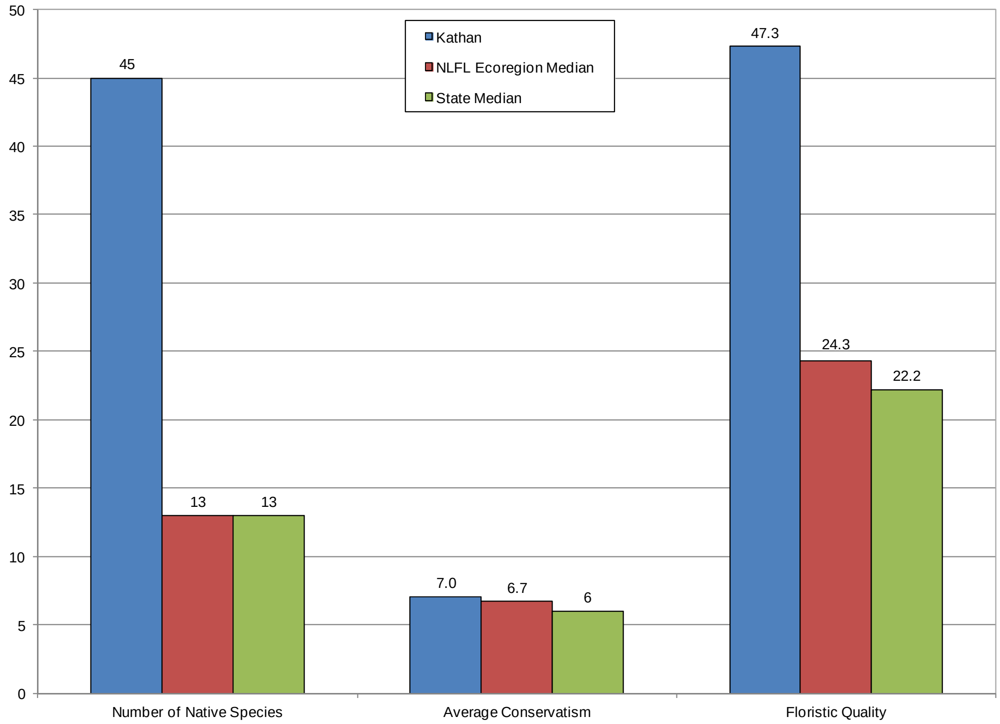

Figure 3.3-7. Kathan Lake Floristic Quality Assessment. Created using data from 2007-2009 surveys. Analysis following Nichols (1999). Note that NLFL = Northern Lakes and Forest lakes ecoregion as per Nichols 1999.

3.4 Fisheries Overview

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. Although current fisheries data were not collected, the following information was compiled based upon data made available through social websites and management entities such as the WDNR and Great Lakes Indian Fish and Wildlife Commission (GLIFWC). Largely because Kathan Lake does not contain public access, there has not been a comprehensive fisheries study done by the WDNR or other groups.

Table 3.4-1. Gamefish present in Kathan Lake with corresponding biological information (Lake-Link 2010, WDNR 2010c, Becker 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
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 muskellunges, 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 pikes, crayfish, small mammals, water fowl, frogs
Walleye	*Sander vitreus*	18	Mid April - Early May	Rocky, wave-washed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish

Fishery

Based on data collected from the stakeholder survey fishing was the highest ranked important or enjoyable activity on Kathan Lake (Appendix B, Question #9). Approximately 70% of these same respondents believed that the quality of fishing on Kathan Lake was fair (Appendix B, Question #6) and 100% believe that the quality of fishing has remained the same or gotten worse since they have obtained their property (Appendix B, Question #7).

Table 3.4-1 (above) shows the popular game fish that are present in Kathan Lake. According to the stakeholder survey data, respondents stated that they believe aquatic invasive species are the number one factor negatively impacting the lake, and were also the top concern regarding Kathan Lake(Appendix B, #14 and #15). If any actions are taken to address the Eurasian water milfoil infestation in Kathan Lake, it will be important to understand potential impacts this may have on the fish community, and plan their implementations accordingly. Specifically, the alteration of these elements may impact spawning habitat for fish species. Muskellunge may be impacted by early season treatments as water temperatures and spawning locations often overlap. Herbicide applications should occur in May when water temperatures are below 60°F and the majority of the lake's native plants have not begun growing. If mechanical harvesting of plants is to occur, a general rule of thumb is to begin harvesting after June 1st, which would allow the vast majority of fish species to complete their spawning season.

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 3.4-1). Kathan Lake falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified systems. GLIFWC and WDNR fisheries biologist believe that approximately 35% of a lake's walleye or muskellunge population can be removed annually without adversely affecting the ability of the population to maintain itself. This 35% exploitation rate is called the total allowable catch. The safe harvest level is set at approximately one third (33%) of the total allowable catch. The six Wisconsin Chippewa Tribes declare a tribal quota based on a percent of the estimated safe harvest each year by March 15. The tribal declaration will influence the daily bag limits for hook-and-line anglers. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

Figure 3.4-1. Location of Kathan Lake within the Native American Ceded Territory (GLIFWC 2010). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest. 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.

Kathan Lake was declared as a spear harvest lake in 2009. The estimated safe harvest of walleye was set at 76 fish for 2009, and a tribal quota of 64 was decided upon (Mark Luehring. personal comm.) However, there was no harvest from Kathan Lake recorded in 2009 or any other year. It is likely that spearing will not occur in Kathan Lake in the future with ample opportunity occurring on other nearby lakes that have public access.

As stated above, Kathan Lake is located within ceded territory and special fisheries regulations may occur if the lake receives tribal declaration. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which would explain the more restrictive bag or length limits for the lake. There are currently no special regulations on Kathan Lake, allowing for 5 walleye greater than 15 inches to be harvested per day and 1 muskellunge greater than 34 inches to be harvested per day.

Dissolved Oxygen

In shallow Wisconsin lakes that hold plants and algae in a higher biomass are susceptible to lower oxygen levels in the winter, particularly in the hypolimnion (deeper part of the lake below thermocline). As discussed in the water quality section, the decay of plants and algae at the end of the growing season may use considerable amounts of dissolved oxygen. In winter, when ice cover prevents mixing of oxygen within the lake, dissolved oxygen may fall below levels that are necessary to support aquatic life, including fish.

Although there are many compounding factors to determine if winter fishkills might occur in a lake, WDNR fish biologists believe that dissolved oxygen levels as low as 1.0 mg/L are sufficient for sport fish species for short periods of time (2 to 4 weeks). Often low ranges of dissolved oxygen will occur first in the hypolimnion of the lake, allowing fish to migrate towards the surface to find sufficient oxygen. While smaller fish are more susceptible to winterkill because they have smaller home ranges, larger fish with more experience are able to move towards areas that may provide adequate dissolved oxygen through the winter, such as the epilimnion, springs, or lake inlets (Dave Seibel, personal comm.). As mentioned in the water quality section, while winter dissolved oxygen levels fall below those required for fish survival in the hypolimnion the majority of the lake contains sufficient oxygen levels to support all warm water fish species.

Fish Stocking

To assist in meeting fisheries management goals, the WDNR may stock fish in a waterbody that were raised in nearby permitted hatcheries. Stocking of a lake is sometimes done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Fish can be stocked as fry, fingerlings or even as adults.

The WDNR has stocked muskellunge and walleye in Kathan Lake, though not in recent years. Table 3.4-2 displays both historic and more recent stocking efforts.

Table 3.4-2. Fish stocking data available from the WDNR from 1982 to 2009 (WDNR 2010c).

Year	Species	Age Class	# Fish Stocked	Average Length
1983	Muskellunge	Fingerling	150	11 inches
1984	Muskellunge	Fingerling	150	11 inches
1982	Walleye	Fingerling	10,000	3 inches
1985	Walleye	Fingerling	9,000	2 inches

Substrate Type

According to the point-intercept survey conducted by the WDNR in 2009, the vast majority of the substrate sampled in the littoral zone on Kathan Lake was muck (73%), followed by sand (24%), and rock (3%) (Map 6). 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. 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 do not get buried and suffocate in the sediment. Walleye is another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with 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 spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

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 Kathan ecosystem.
2) Collect detailed information regarding invasive plant species within the lake, with the primary emphasis being on Eurasian water milfoil.
3) Collect sociological information from Kathan Lake 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 much of the Kathan Lake ecosystem, the folks that care about the lake, and what needs to be completed to protect and enhance it.

As discussed in many of the sections above, the expansion of Eurasian water milfoil with Kathan Lake was what ultimately spurred the KLA to initiate the planning effort. Inclusion of the other planning and study components, such as the water quality and watershed assessments, the stakeholder survey and other participation opportunities, and the numerous plant surveys of native and non-native plants, were brought about through KLA interest and concern in those aspects. Through the analysis of the study results, the impact of Eurasian water milfoil on the Kathan Lake was clarified in some aspects, as with the possible relationship between water quality improvements and the exotic's introduction and expansion. However, the influence of Eurasian water milfoil remains very unclear in other aspects, such as its impact on native aquatic plant species diversity and richness.

While only limited historic nutrient and chlorophyll-*a* data are available for Kathan Lake; a solid historic record of Secchi disk water clarity values does exist extending from the early 1990s to the present. That dataset indicates that since the first discovery of Eurasian water milfoil in 2004, the lake has seen a dramatic increase in growing season water clarity. In the Water Quality Section, it is hypothesized that this increase is due to the lake shifting from a turbid state to a clear state as Eurasian water milfoil increased in abundance and eventually dominated the submergent plant community within the lake.

Seventy-seven percent of stakeholders responded to the stakeholder survey they were sent by the KLA. Of those that returned the survey, 70% believe that Kathan's water quality is fair to poor, while only 30% believe it is fair to excellent (Appendix B, Question # 10). Approximately 74% of those same stakeholders believe that the water quality of the lake has gotten worse since they obtained their property and only 25% believe it has remained the same or improved slightly (Appendix B, Question #11). Obviously, stakeholder perception does not align well with the water clarity data discussed above. The likely reason for this dissimilarity is that the stakeholders are not truly ranking "water quality", but are instead, they are ranking overall "lake quality", which in their minds has decreased over their ownership of Kathan Lake property. It would be realistic to conclude that much, if not all, of the perceived decrease in lake quality has coincided with Eurasian water milfoil dominance within the lake.

Within the vegetation discussion, there is a great deal of information relating the excellent health of the Kathan Lake plant community. The plant community's healthy state is brought forth with very high species diversity, high species richness, and an extremely high floristic quality. Unlike other lakes, this healthy state does not rest mostly in the lake's emergent community as much of it is found in its submergent community. There are also numerous rare and sensitive species growing within the lake. Yet, the lake is dominated by the exotic Eurasian water milfoil and common waterweed – a disturbance-tolerant native plant lacking true roots. The combination seems contrary to basic ecological principals in that a lake dominated by Eurasian water milfoil, which is known to be a severe ecosystem disruption, should not exhibit such a high quality plant community. While this combination is peculiar, it may be the result of timeframe.

The Kathan Lake plant community may be reacting to the sudden expansion and dominance of Eurasian water milfoil much like a human body, which was once fit and healthy, may react to a sudden stoppage of activity and good nutrition. If a 35 year-old man, who had always ate well and exercised regularly, suddenly gave up those healthy habits, it would not be long before the outward signs of obesity would be noticeable. However, it may take years for the inward effects, such as high blood pressure, cholesterol, and triglycerides, to reach alarming levels.

Kathan Lake's plant community has been studied by professional researchers since 2006, just two years since Eurasian water milfoil was first verified to be present in the lake. In that time, the outward sign of Eurasian water milfoil dominance has been documented each year, while the quality of the native plant community has remained high. Relating to the analogy in the paragraph above, we may only be seeing the beginning changes to the lake's plant community as our study timeframe has been short. Based upon what we have seen in other shallow, productive lakes, we can expect the plant community's health to steadily decrease as the density of Eurasian water milfoil increases. In fact, the exotic's impact on native habitat is the foundation for the rationale of nearly all control actions being taken against Eurasian water milfoil on Wisconsin's northern lakes.

Allowing the continued expansion in density of Eurasian water milfoil is not in the best interest of Kathan Lake, neither in terms of its ecological health nor its recreational function. This fact was related to the Planning Committee during the meeting held on March 11, 2009. While the group had not had the concept explained to them in terms of the lake's ecology before, the group understood prior to the meeting that Eurasian water milfoil was having a profound negative impact on their lake (Appendix B, Question #15). As a result of that realization, the group, as explained earlier in the section, had already made great strides in preparing for an aggressive management action aimed at controlling Eurasian water milfoil. The KLA, as a whole, is in favor of plant control on their lake (Appendix B, Question # 17).

While many options exist for controlling Eurasian water milfoil, only a few make sense for each lake's situation. The alternative available for controlling this exotic can be grouped into two categories; those with the intention of nuisance control and those aiming at restoring native habitat. Some control alternatives, like herbicide use can be placed in either category, while others, such as mechanical harvesting, can only be placed in a single category.

Nuisance control methods are aimed at creating navigation lanes and areas within a lake. They include mechanical harvesting, chemical herbicides, dredging, and manual harvesting. Manual harvesting (hand pulling or raking) of Eurasian water milfoil, along with some native plants, is already occurring on Kathan Lake. This methodology does produce desired results in near-shore areas and will likely continue within the bounds of state regulations on a small scale.

Mechanical harvesting on Kathan Lake is not appropriate as it would increase the occurrence and density of Eurasian water milfoil through fragmentation. Contracting harvesting services would be difficult due to the lack of a suitable landing on the lake and the fact that any navigation lanes created would need to be harvested multiple times through the growing season to maintain navigability. Purchasing, operating, and maintaining a harvester is beyond the financial and logistical capabilities of the KLA at this time.

Nuisance control of Eurasian water milfoil with herbicides, likely 2,4-D or some other systemic, broad-leaf specific herbicide, would likely maintain adequate navigation within Kathan Lake. Further a single, early summer treatment may be sufficient to maintain the navigability of treated areas throughout the growing season. Use of this methodology may be considered if ecological restoration is not possible.

Dredging is not a feasible for control of Eurasian water milfoil for nuisance control or ecological restoration. This technique is very expensive, creates incredible disruption within the lake, and would leave highly suitable habitat for recolonization of Eurasian water milfoil along with other exotic aquatic plant species.

As stated in the beginning of this section, KLA is not supportive of nuisance control of Eurasian water milfoil. Instead, as evidenced by the association's incredible fund-raising effort, they would prefer to move forward with restoring the native habitat by bringing Eurasian water milfoil under control on a lake-wide basis.

Three methods could potentially be used to bring Eurasian water milfoil control in a lake; herbicides, biological agents, and water level manipulations. Since Kathan Lake is not impounded with a dam, water level manipulation is not truly a feasible alternative. Biological control with milfoil weevils would be a possibility; however, with their unproven nature and high cost, the KLA is very leery of this technique.

As illustrated in the stakeholder survey responses (Appendix B, Question #18), 92% of respondents are supportive or highly supportive of the use of herbicides to control plants in Kathan Lake. Again, support for this control strategy is also verified by the level of funds raised by the KLA from lake residents to perform such an action during the spring of 2010. That control strategy is related in the implementation plan below.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the KLA Planning Committee and ecologist/planners from Onterra. It represents the path the KLA 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 Kathan Lake stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Maintain Current Water Quality Conditions

Management Action: Monitor water quality through WDNR Citizens Lake Monitoring Network.

Timeframe: Continuation of current effort.

Facilitator: James Hughes and Denis Boehm

Description: Monitoring water quality is an important 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. While Secchi disk transparency data were collected regularly since the early 1990s, the lack of historical data reflecting other water quality characteristics hampered the water quality analysis during this project.

Since 2006, monitoring of water quality has been conducted by KLA volunteers through the Citizens Lake Monitoring Network's advanced protocol. It is important to continue this monitoring as early discovery of negative trends may lead to the reason as to why the trend is developing. The volunteer monitoring of the water quality is a large commitment and new volunteers may be needed in the future as the volunteer's level of commitment changes. It is the responsibility of the facilitator to coordinate new volunteers as needed. Note: as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:

Please see description above.

Management Action: Reduce phosphorus and sediment loads from shoreland watershed to Kathan Lake.

Timeframe: Begin 2009

Facilitator: Education Committee

Description: As the watershed section discusses, the Kathan Lake watershed is in good condition; however, watershed inputs still need to be focused upon, especially in terms of the lake's shoreland properties. These sources include faulty septic systems, shoreland areas that are maintained in an unnatural manner, impervious surfaces.

On April 14th, 2009, Governor Doyle signed the "Clean Lakes" bill (AB3) which prohibits the use of lawn fertilizers containing phosphorus. Phosphorus containing fertilizers were identified as a major contributor to decreasing water quality conditions in lakes, fueling plant growth. This law will go into effect in April 2010. While this law also bans the display and sale of phosphorus containing fertilizers, educating lake stakeholders about the regulations and their purpose is important to ensure compliance.

To reduce these negative impacts, the KLA will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include newsletter articles and guest speakers at association meetings.

Topics of educational items may include benefits of good septic system maintenance, methods and benefits of shoreland restoration, including reduction in impervious surfaces, and the options available regarding conservation easements and land trusts.

Action Steps:

1. Recruit facilitator.
2. Facilitator gathers appropriate information from WDNR, UW-Extension, Oneida County, and other sources.
3. Facilitator summarizes information for newsletter articles and recruits appropriate speakers for association meetings.

Management Action: Complete Shoreland Condition Assessment as a part of next management plan update

Timeframe: Begin 2009

Facilitator: Board of Directors

Description: As the discussed above, unnatural shorelands can negatively impact the health of a lake, both by decreasing water quality conditions as well as removing valuable habitat for fish and other aquatic species that reside within the lake. Understanding the shoreland conditions around Kathan Lake will serve as an educational tool for lake stakeholders as well as identify areas that would be suitable for restoration. Shoreland restorations would include both in-lake and shoreline habitat enhancements. In-lake enhancements would include the introduction of course woody debris, a fisheries habitat component lacking around the shores of Kathan Lake. Shoreline enhancements would include leaving 30-foot no-mow zones or by planting native herbaceous, shrub, and tree species as appropriate for Oneida County.

Projects that include shoreline condition assessment and restoration activities will be better qualified to receive state funding in the future. These activities could be completed as an amendment to this management plan and would be appropriate for funding through the WDNR small-scale Lake Planning Grant program.

Action Steps: See description above.

Management Goal 2: Control Existing and Prevent Further Aquatic Invasive Species Infestations within Kathan Lake

Management Action: Reduce further infestation and reemergence of AIS in Kathan Lake through education.

Timeframe: Begin summer 2010

Facilitator: Board of Directors to form Education Committee

Description: Considering Kathan Lake does not have a public access, the outstanding mode of non-native species introduction is likely through the many private access points that are located around the lake and utilized by lake residents and their guests. This potentially makes the lake more vulnerable to exotic introduction than a lake with a single, public access that could be more easily monitored. As a result, boats are not inspected and many water users are not aware of AIS issues. Education represents a good tool to address these issues. 100% of respondents to the stakeholder survey indicated that the KLA has kept them at least adequately informed regarding the management of Kathan Lake (Appendix B, Question #21), demonstrating their ability to convey information to stakeholders. In general, this would be conducted by 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.

One component of the education process would be to inform Kathan Lake riparians about the need to inspect the boats that use their properties for access. This action would not only work to prevent additional invasives from entering the lake, but also to prevent the infestation of other waterways with invasives that originated in Kathan Lake.

Similar to how AIS are spread between lakes, plants like Eurasian water milfoil can be spread within a lake as watercraft activity creates plant fragments that can be transported by wind, wave, and boat traffic to other parts of the lake. While Eurasian water milfoil infestation currently extends to almost all suitable areas of Kathan Lake, this component will become increasingly important if control activities reduce its occurrence. On most lakes where Eurasian water milfoil occurs in specific locations of the lake, primarily in a colonized form, reducing the boat traffic in those areas until management actions can occur reduces the capabilities of this species to spread to uninhabited areas of the lake. In addition to pure educational activities, the KLA, in coordination with WDNR enforcement agencies, could implement temporary boating restrictions in these areas by placing marker buoys around the colonies.

Action Steps: See description above.

Management Action: Control Eurasian water milfoil infestations within Kathan Lake using herbicide applications.

Timeframe: Initiate 2009

Facilitator: Board of Commissioners with professional help as needed

Description: As described in the Aquatic Plant section the most pressing threat to the health of Kathan Lake's aquatic plant community is Eurasian water milfoil. Approximately 112 of the 189 acres of Kathan Lake contains varying densities of Eurasian water milfoil (Map 5) and approximately 50% of the lake's point-intercept sample locations contained this species (Figure 3.3-5).

During the planning process, KLA stakeholders discussed the difference between the control of Eurasian water milfoil for nuisance relief or for ecological restoration. Applicable management actions for Kathan Lake aimed at alleviating the nuisance conditions caused by this plant would likely include the use of herbicides to create 30-foot access lanes in strategic locations around the lake.

Before the KLA pursues this form of a control program, they would like to attempt to impact Eurasian water milfoil on a whole-lake level in an effort to improve the health of their lake ecosystem. Likely the only way to address the Eurasian water milfoil on a lake-wide level is to treat the entire lake. At this time, it appears that the use of liquid 2,4-D (DMA IV) would be the most applicable option for a whole lake treatment on Kathan Lake.

The responsible use of this technique is well supported by Kathan Lake stakeholders as indicated by 100% of stakeholder survey respondents indicating that they believe aquatic plant control is needed on the lake and 92% indicating they are supportive of an herbicide control program (Appendix B, Questions #17 & #18, respectively). Because Kathan Lake does not contain "adequate public access" as defined by NR 1.91, the KLA is ineligible to receive AIS Grant funds under the Established Population Control program (NR 198.42). Please note that adequate public access could be satisfied if a private landing met specific conditions under the Wisconsin Administrative Code. Therefore, all herbicide application costs would have to be borne solely by the KLA. The KLA is eligible for grant funds to share the costs of the associated monitoring of an herbicide control program, but preference is given to those lakes with greater access opportunities.

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 dilute herbicide concentration within aquatic systems. Understanding concentration-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 (2009-current), largely as a result of a joint research project between the WDNR and USACE. 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 effects 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.

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 (of the 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 whole-lake treatments is dictated by the volume of water in which the herbicide will reach equilibrium with. Because exposure time is so much greater, target herbicide levels for whole-lake treatments are significantly less than for spot treatments

Members of the WDNR, USACE, and private consultants continue to monitor aquatic plant communities of lakes that have undergone whole-lake treatments to understand the longer-term effects of this treatment strategy. Their data collected annually for two and three years following whole-lake treatments indicate that some native plant species recovery immediately, while others remain slower to recover.

Short Term Control Plan

The KLA is planning a chemical treatment of Eurasian water milfoil in the spring of 2010. Digitizing the lake survey map of Kathan Lake from 1947 and exporting the associated acreages in GIS, the lake's volume was calculated at approximately 1,074 acre-feet and an average depth of approximately 5 feet. At this time, it appears that the most prudent approach would be to apply liquid 2,4-D to the approximately 112 reachable-acres of Kathan Lake that contain Eurasian water milfoil at dose allowing herbicide concentrations and exposure times to be in line with current WDNR and USACOE research. Further correspondence with the KLA, their herbicide applicator, WDNR, and professional lake managers will yield specifics regarding dose and anticipated whole-lake residual concentrations. One of the most complex components of this discussion relates to exposure time and degradation of herbicide concentrations – areas that researchers continue to prioritize as missing pieces of the puzzle.

Qualitative monitoring of the herbicide treatment would be conducted by replicating the Eurasian water milfoil peak biomass survey during the summer of 2010 to compare against the 2009 survey. Qualitatively, a successful treatment on Kathan Lake would include a reduction of exotic density as demonstrated by a decrease in density rating (e.g. dominant reduced to scattered).

Quantitative monitoring of the treatment would be completed by repeating the whole-lake point-intercept survey in August 2010. This would be the post treatment survey and be compared to the point-intercept survey conducted in 2009. As they have done since 2007, WDNR Science Services will be collecting this data on Kathan Lake during the summer of 2010. Quantitatively, a successful treatment on a specific-site level would include a significant reduction in Eurasian water milfoil frequency following the treatments as exhibited by at least a 50%

decrease in exotic frequency from the pre- and post treatment point-intercept survey. In other words, if the Eurasian water milfoil frequency of occurrence before the treatment was 50%, the post treatment frequency would need to be 25% or lower for the treatment to be considered a success. Further, there would be a noticeable decrease in rake fullness ratings within the fullness categories of 2 and 3.

This strategy would greatly benefit from having residual water samples taken in association with the 2010 treatment. This would allow for an understanding of whether the herbicide dose was high enough and sustained long enough to kill the Eurasian water milfoil. It would also be advantageous to understand if the dose was too high or sustained for too long in which unintended collateral damage to the lake's native plants occurs. Combining this information with the vegetation surveys completed on the lake, much information will be learned that would lead to an effective long-term control plan being developed for Kathan Lake. The KLA would attempt to solicit a volunteer to collect these data if the USACOE selects Kathan Lake to be a part of their current research project.

Please Note: A whole-lake 2,4-D treatment was conducted on Kathan Lake in 2010, resulting in exceptional EWM control and some minor collateral effects on the native aquatic plant community. Ongoing monitoring indicates that many of the native plant species have recovered, and there has been a gradual increase in the EWM population but it continues to be at low densities.

Long-Term Control Plan

It should be noted that it is highly unlikely that any single herbicide treatment will completely control the EWM in Kathan Lake. The objective is to bring the invasive species down to more easily controlled levels. In other words, the goal is to reduce the amount of Eurasian water milfoil to levels that would only require spot treatments to keep them under control. To complete this objective efficiently, a cyclic series of steps is used to plan and implement the treatment strategies. The series includes:

1. A lake-wide assessment of Eurasian water milfoil completed while the plant is at peak biomass.
2. Creation of treatment strategy for the following spring.
3. Verification and refinement of treatment plan immediately before treatments are implemented (not applicable to whole-lake treatments).
4. Completion of treatments.
5. Assessment of treatment results.

Once Step 5 is completed, the process would begin again that same summer with the completion of a peak biomass survey. The survey results would then be used to create the next spring's treatment strategy.

If Eurasian water milfoil populations are brought down to levels requiring smaller treatments of specific colonies, treatment monitoring activities would follow protocols currently being developed by the WDNR and in general, use guidance supplied in Aquatic Plant Community Evaluation with Chemical Manipulation (2010 Draft). This form of monitoring is required for all large scale herbicide applications (exceeding 10 acres in size or 10% of the area of the water body that is 10 feet or less in depth and treatment areas that are more than 150 feet from shore) and grant-funded projects where scientific and financial accountability are required.

As a part of the treatment monitoring, sub-sampling sites within the treatment areas at a resolution of approximately 4 points per acre would be visited before and after the treatments to produce the pre- and post treatment data. By comparing those data, it can be determined if there is differences in native and non-native plant abundances between the surveys. If there is a difference between the pre- and post treatment data, statistical analysis is used to determine if the difference is sufficient to be attributed to the treatment or if the difference may have occurred randomly. If the difference is sufficient, it is considered to be significantly different, if it is not sufficient, it is considered to be insignificantly different. In the end, a significant difference can be attributed to some factor, while an insignificant difference can only be attributed to random chance.

With guidance from WDNR Integrated Sciences, a Chi-square distribution analysis (alpha = 0.05) was used to determine if the quantitative data collected before the treatment are statistically different from the data collected after the treatment. The alpha value is set such that we consider the results statistically significant when the test is 95% confident that the results are truly different and non-random.

Action Steps:

1. Retain qualified professional assistance to develop a specific project design utilizing the cyclic series of steps discussed above.
2. Initiate control plan
3. Revisit control plan in 5-7 years
4. Update management plan to reflect changes in control needs and those of the lake ecosystem.

6.0 METHODS

Lake Water Quality

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

Parameter	Spring		June		July		August		Fall		Winter	
	S	B	S	B	S	B	S	B	S	B	S	B
Total Phosphorus	●	●	●	●	●	●	●	●	●	●	●	●
Dissolved Phosphorus	●	●			●	●					●	●
Chlorophyll <u>a</u>	●		●		●		●		●			
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.

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Kathan Lake during a June 30, 2008 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. No curly-leaf pondweed was found in this survey.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Kathan Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in "Appendix C" of the Wisconsin Department of Natural Resource document, <u>Aquatic Plant Management in Wisconsin</u>, (April, 2007) was used by the WDNR to complete this study on August 21-22, 2007; September 11, 2008, and August 12, 2009. A point spacing of 65 meters was used resulting in approximately 203 points.

Community Mapping

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

Eurasian Water Milfoil Peak Biomass Survey

During the 2008 community mapping survey, Eurasian water milfoil was mapped using the same technology. The survey was replicated on August 12, 2009 to aid in the management of Kathan Lake, at no charge to the KLA.

Watershed Analysis

The watershed analysis began with an accurate delineation of the Kathan Lake 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 Wisconsin initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) 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).

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