White Lake

Waupaca County, Wisconsin

Comprehensive Management Plan

May 2012

Sponsored by:

White Lake Preservation Association, Ltd.

WDNR Grant Program

LPL-1360-10, LPL-1361-10, & LPL-1390-11

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Onterra LLC
Lake Management Planning

White Lake

Waupaca County, Wisconsin

Comprehensive Management Plan

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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:

White Lake Planning Committee

Lee Vesser	Neil Rasmussen	Gary DesJardins
Dave Bruenning	Tom VandenBoogaard	Alvin Theil
Beth Tweed	Bill Brace	Dan Theil

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1.0 INTRODUCTION

White Lake, Waupaca County, is a 1,024-acre drainage lake with a maximum depth of 10 feet (Map 1). This eutrophic lake has a relatively small watershed when compared to the size of the lake. White Lake contains 42 native plant species, of which slender naiad is the most common plant. Three exotic plant species are known to exist in and around White Lake.

Field Survey Notes

Many emergent species covering lake, including wild rice, hardstem and softstem bulrush, cattails, and water willow. Abundant submersed species also. EWM was marked scattered throughout the lake, while CLP was observed growing quite dense in several locations. Wetlands surround much of this lake.

Photograph 3.3-1 White Lake, Waupaca County

Lake at a Glance - White Lake

Morphology	
Acreage	1,026
Maximum Depth (ft)	10
Mean Depth (ft)	4
Shoreline Complexity	3.3
Vegetation	
Curly-leaf Survey Date	June 2nd, 2010
Comprehensive Survey Date	August 30th & 31st 2010
Number of Native Species	42
Threatened/Special Concern Species	None
Exotic Plant Species	Eurasian water milfoil, curly-leaf pondweed, purple loosestrife
Simpson's Diversity	0.84
Average Conservatism	6.3
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	8.1 – 9.2
Sensitivity to Acid Rain	Low
Watershed to Lake Area Ratio	2:1

White Lake is part of a large wetland complex that drains to the South Branch of the Little Wolf River. It is a productive waterbody supporting a dense population of aquatic plants. While these plants provide excellent habitat for fish, waterfowl, and other wildlife, such as Blanding's turtle (threatened species), they also impact the lake's ability to hold oxygen as they decompose during the winter months and hamper navigation and other recreation during the summer months. To combat winter anoxia and fishkills, the White Lake Aeration – Conservation Club maintains and operates an aeration system that it installed within the lake during 1973. To provide navigation to lake users, the White Lake Preservation Association (WLPA) conducts mechanical harvesting operations in specified boating lanes around the lake.

In 1989, the Wisconsin Department of Natural Resources (WDNR) discovered Eurasian water milfoil during a macrophyte study of White Lake. At that time, the department recommended control of exotic species. In 2003, the WLPA contracted with Aquatic Biologists, Inc. to complete a management plan for the lake. Also in 2003, the association obtained partial funding through the Aquatic Invasive Species (AIS) Rapid Response Program to complete a 20-acre treatment of Eurasian water milfoil. Anecdotal information states that the treatment was successful at reducing Eurasian water milfoil density within the treated areas. Unfortunately, no follow up monitoring or treatments occurred until 2009.

With the assistance of a local herbicide applicator, the WLPA treated specific areas of Eurasian water milfoil within the lake. These areas included the lanes that are normally harvested. As with the earlier treatment, the 2009 treatment was considered a success. In preparation for the treatment completed in 2009 and for the submittal of applications for AIS Grant funds, the consultant mapped a reported 148-acre Eurasian water milfoil population in White Lake during the summer of 2008.

The WLPA was formed in 1983 with the intent of purchasing, operating, and maintaining a mechanical harvester to increase navigation on White Lake. Over the course of the next two plus decades, the association has worked to manage and enhance White Lake beyond its initial harvesting activities. At this point, the WLPA is faced with managing a large, highly-used, and productive lake with an expanding population of Eurasian water milfoil.

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 March 5th, 2011, a project kick-off meeting was held to introduce the project to the general public. The meeting was announced through a mailing and personal contact by White Lake Preservation Association, LTD board members. The approximately 31 attendees observed a presentation given by Tim Hoyman, an aquatic ecologist with Onterra. Mr. Hoyman's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation also included a brief update to some of the findings of the studies that were completed the previous summer, especially those concerning mapping of Eurasian water milfoil and curly-leaf pondweed populations. The presentation was followed by a question and answer session.

Planning Committee Meeting I
On November 29th, 2011, Tim Hoyman and Dan Cibulka of Onterra met with members of the White Lake Planning Committee for nearly 3.5 hours. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed. Many concerns were raised by the committee, including nuisance levels of aquatic plants, harvesting operations and management of exotic plant species.

Planning Committee Meeting II
A meeting was held on March 21, 2012 to further discuss matters pertaining to White Lake. At this meeting, the native plant harvesting strategy was discussed, and approaches to managing curly-leaf pondweed and Eurasian water milfoil were deliberated upon as well. Lastly, management goals pertaining to White Lake partnerships and water quality monitoring were addressed and discussed.

Management Plan Review and Adoption Process

Prior to Planning Meeting I, the White Lake Planning Committee reviewed a draft of the Results section of the management plan. Following this meeting, an Implementation Plan was drafted to reflect the management goals White Lake stakeholders wished to pursue. This Implementation Plan was updated following a partial review by Ted Johnson (WDNR) and comments from the White Lake Planning Committee during Planning Meeting II. A copy of the draft management plan was sent to the WDNR and White Lake Planning Committee on May 30, 2012 for further review. Following a final round of comments provided by Ted Johnson, the plan was approved later in 2012.

Stakeholder Survey

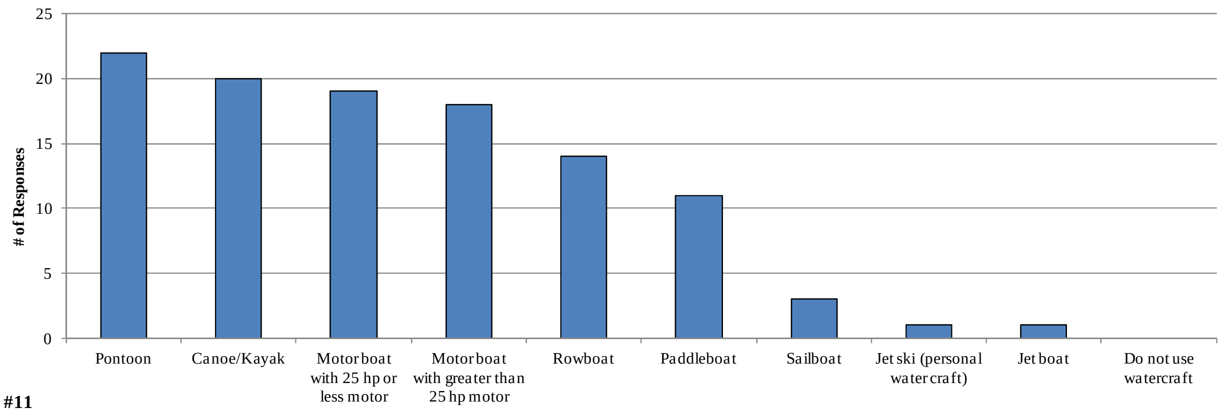
During November of 2011, a seven-page, 31-question survey was mailed to 108 riparian property owners in the White Lake watershed. 45 percent of the surveys were returned and those results were entered into a spreadsheet by members of the White Lake Planning Committee. The data were summarized and analyzed 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.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for White Lake. The majority of stakeholders (76%) are year-round residents, while 11% visit on weekends through the year and 11% live on the lake during the summer months only (Appendix B, Question #1). Nearly half (49%) of stakeholders have owned their property for less than 10 years, while 24% have owned their property for over 20 years.

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. Popular watercraft choices on White Lake include pontoon boats, canoes and kayaks, as well as motorboats of various sizes (Question #11). On a relatively small lake such as White Lake, the importance of responsible boating activities is increased. The need for responsible boating increases during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the lake. Currently, the WLPA operates a mechanical harvester which cuts navigation lanes through aquatic vegetation for watercraft to utilize. Because White Lake is shallow and holds large amounts of aquatic plants, it typically does not experience high speed watercraft that large, deeper lakes may see. Boat traffic was not ranked as a factor potentially impacting White Lake in a negative manner by stakeholders (Question #18). Additionally, it was not ranked highly as a concern of White Lake stakeholders (Question #19).

Survey respondents did, however, consistently rank several other issues as their top concern on the stakeholder survey (see Question #19 and survey comments – Appendix B). These top concerns include wild rice growth, aquatic invasive species and excessive aquatic plant growth. These three topics are discussed within the Aquatic Plants Section, Summary & Conclusions Section as well as within the Implementation Plan.

Question #11: What types of watercraft do you currently use on the lake?



#11

Question #12: Please rank up to three activities that are important reasons for owning your property on or near the lake.

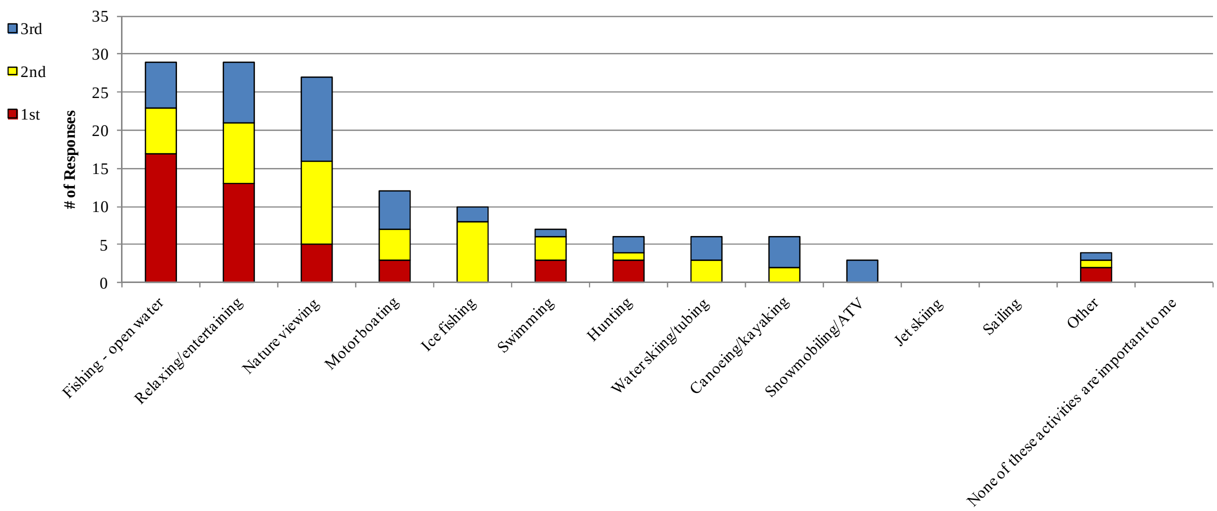


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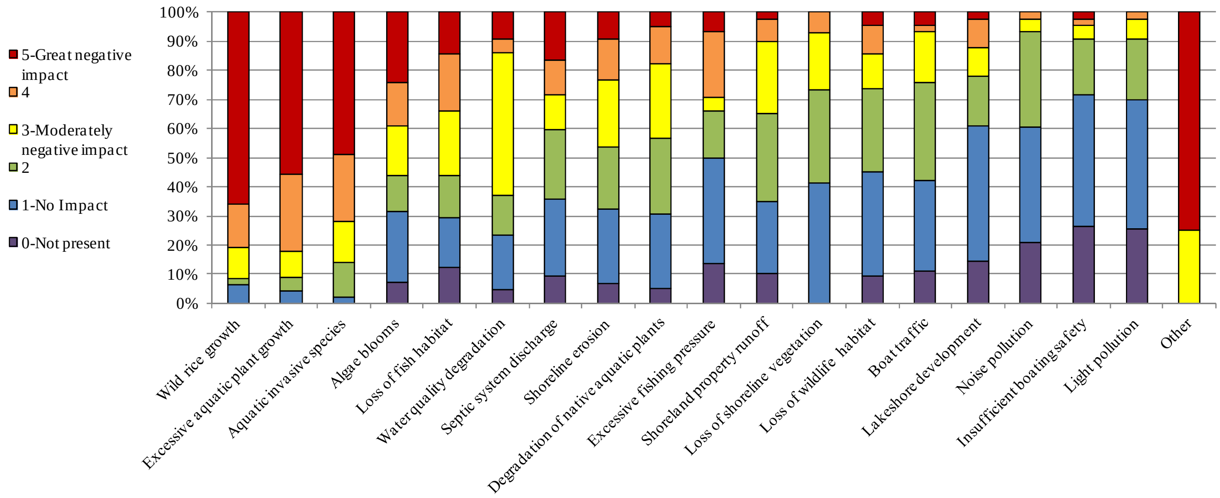
Figure 2.0-1. Select survey responses from the White Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question #18: To what level do you believe these factors may be negatively impacting White Lake?



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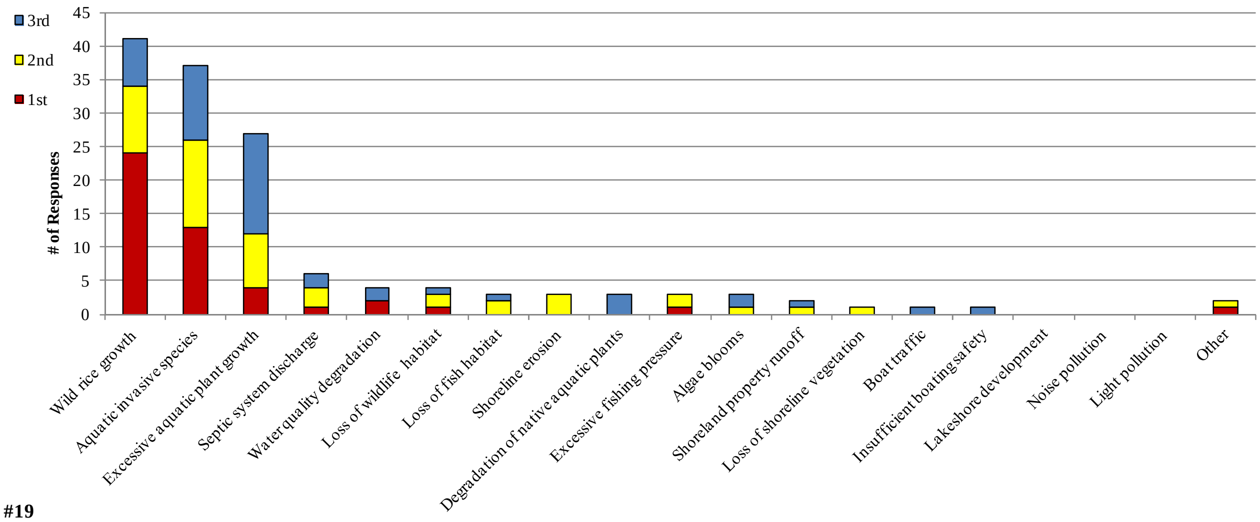
Question #19: Please rank your top three concerns regarding White Lake.



#19

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

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

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

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

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

> **Phosphorus** is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both algae and macrophytes. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.
>
> **Chlorophyll-*a*** is the green pigment in plants used during photosynthesis. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.
>
> **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

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

Trophic State

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

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

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

Limiting Nutrient

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

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

Temperature and Dissolved Oxygen Profiles

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

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

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

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

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

Non-Candidate Lakes

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

Candidate Lakes

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

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

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

*Lack of summer months temperature/dissolved oxygen profiles and hypolimnetic phosphorus data prevents these analyses from being performed. The explanation provided under this heading is strictly for the information of the reader.

Comparisons with Other Datasets

The WDNR publication *Implementation and Interpretation of Lakes Assessment Data for the Upper Midwest* (PUB-SS-1044 2008) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's land cover. For this reason, the water quality of White Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into 6 classifications (Figure 3.1-1).

First, the lakes are classified into two main groups: **shallow (mixed)** or **deep (stratified)**. Shallow lakes tend to mix throughout or periodically during the growing season and as a result, remain well-oxygenated. Further, shallow lakes often support aquatic plant growth across most or all of the lake bottom. Deep lakes tend to stratify during the growing season and have the potential to have low oxygen levels in the bottom layer of water (hypolimnion). Aquatic plants are usually restricted to the shallower areas around the perimeter of the lake (littoral zone). An equation developed by Lathrop and Lillie (1980), which incorporates the maximum depth of the lake and the lake's surface area, is used to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

Seepage Lakes have no surface water inflow or outflow in the form of rivers and/or streams.

Drainage Lakes have surface water inflow and/or outflow in the form of rivers and/or streams.

Headwater drainage lakes have a watershed of less than 4 square miles.

Lowland drainage lakes have a watershed of greater than 4 square miles.

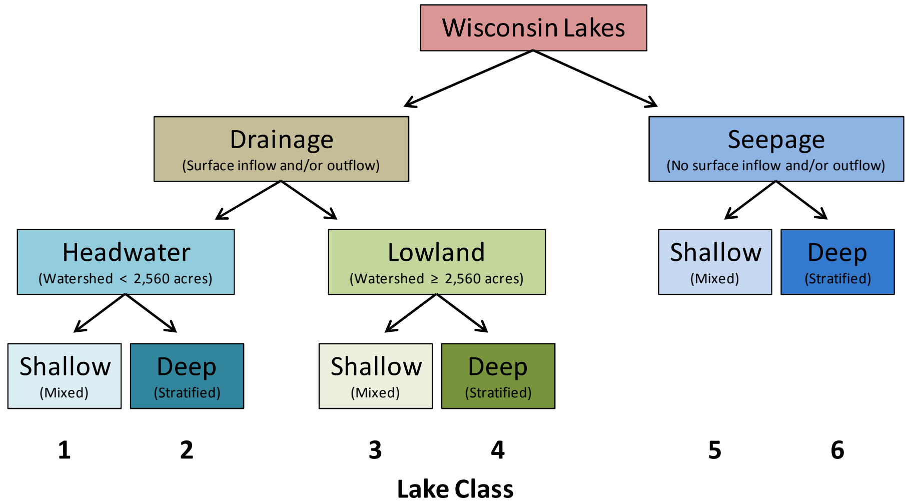


Figure 3.1-1. Wisconsin Lake Classifications. White Lake is classified as a shallow (mixed), lowland drainage lake (Class 3). Adapted from WDNR PUB-SS-1044 2008.

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

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

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

These data along with data corresponding to statewide natural lake means, historic, current, and average data from White Lake is displayed in Figures 3.1-3 - 3.1-10. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-a data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

White Lake Water Quality Analysis

White Lake Long-term Trends

The historic water quality data that exists for White Lake is minimal and was collected sporadically throughout the past ~30 years. This being said, it is difficult to complete a reliable long-term trend analysis. Having an understanding of how a lake's water quality has changed (or not changed) over time is always interesting and leads to sounder management decisions. Anecdotal reports, while valid to a certain extent, are not reliable in determining if an actual difference in a lake's water quality has occurred. Concrete, measurable scientific variables are used to ascertain this distinction.

Public perception of water quality, while not useful to guide management decisions, is nonetheless interesting to examine. In the Stakeholder Survey distributed through this project, the majority of White Lake residents (83%) indicated they believe the water quality in the lake is Fair or Good (Appendix B – Question #13). A number of survey respondents (42%), however, indicated that they believe the water quality has degraded since they first visited the lake (Question #14). About the same number of respondents, 40%, believe the water quality has remained the same however. Despite this, when asked to indicate their top three concerns (Question #19), survey respondents did not rank water quality degradation highly.

As described above, three water quality parameters are of most interest; total phosphorus, chlorophyll-*a*, and Secchi disk transparency. Total phosphorus data from White Lake are displayed in Figure 3.1-3. The weighted average annual data indicates that concentrations are slightly lower than similar lakes across the state. While large gaps exist in the dataset, measurements taken in 2010 seem consistent with those taken in previous years. Overall, phosphorus levels in White Lake can be described as ranking within the WisCALM category of Good.

Chlorophyll-*a* data has been collected on White Lake during the same years that phosphorus data collection occurred (Figure 3.1-4). The 2003 data point is misleading as it actually represents a single reading taken during late August when chlorophyll-*a* levels are normally at their highest level. Even with the 2003 data point included, the weighted average across all years is still lower than averages seen in other shallow, lowland drainage lakes. Many environmental factors influence algal production in lakes, including sunlight, light penetration into the water, precipitation, and nutrient abundance. Therefore, it is not uncommon to see years of varying chlorophyll-*a* concentrations. Overall, chlorophyll-*a* levels in White Lake can be described as ranking within the WisCALM category of Good.

Secchi disk clarity has been measured more frequently in the past 30 years than total phosphorus and chlorophyll-*a* (Figure 3.1-5). However, large gaps in the dataset still exist, making long-term trend analysis unrealistic. The weighted average over the entire time span is just over 6 feet deep, which is slightly higher than similar lakes across Wisconsin. Again, slight variations will exist from year to year based upon environmental conditions. In addition to algal abundance, factors such as suspended sediment and water color also influence a lake's water clarity. The Secchi disk clarity in White Lake ranks within the WisCALM category of Good overall.

Comparable measures of water quality were reported upon in a 2003 White Lake Comprehensive Survey Results and Management Plan by Aquatic Biologists, Inc.

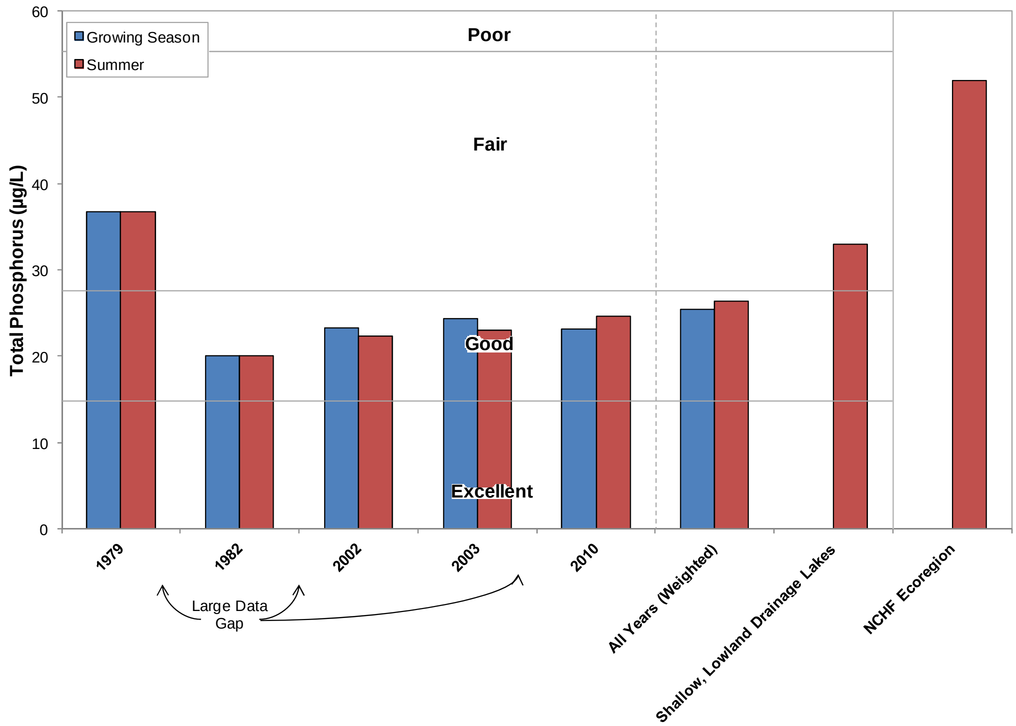


Figure 3.1-3. White Lake, state-wide class 3 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

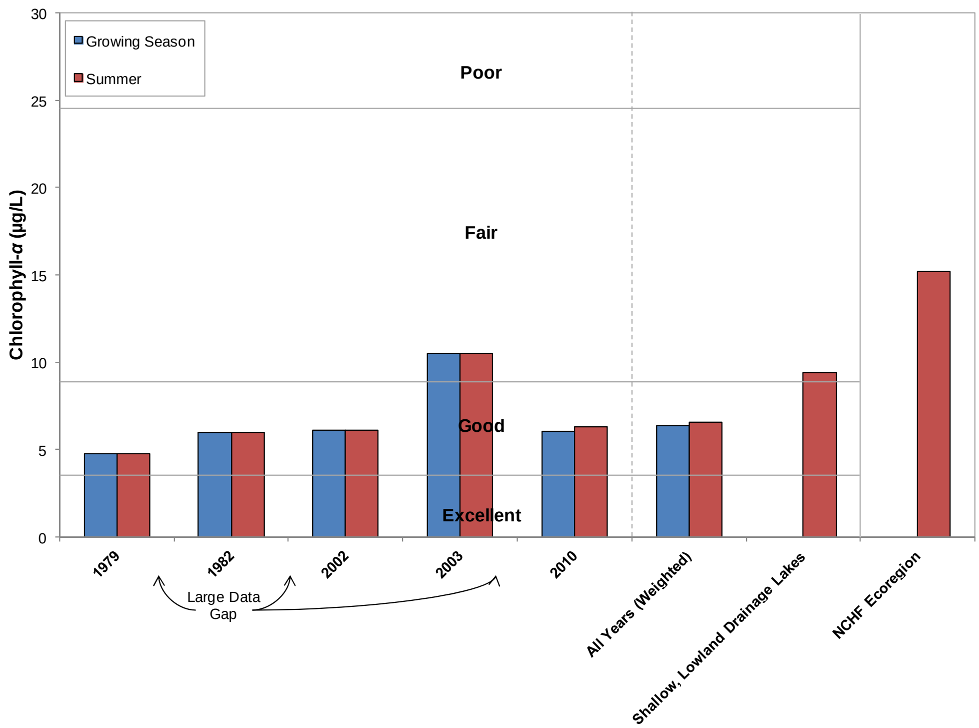


Figure 3.1-4. White Lake, state-wide class 3 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

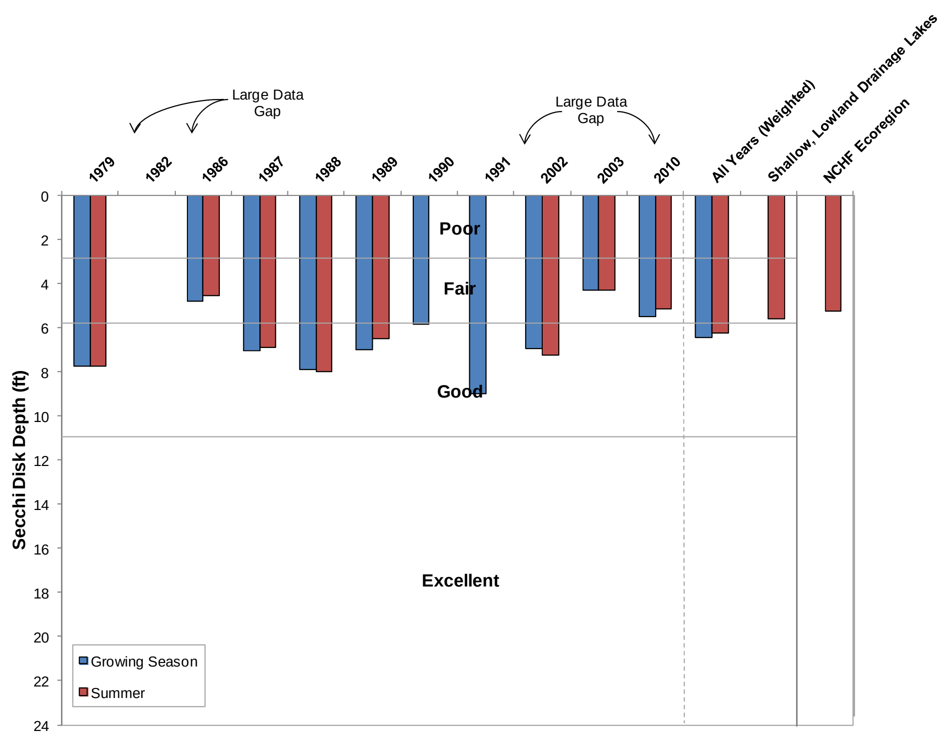


Figure 3.1-5. White Lake, state-wide class 3 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of White Lake

Using midsummer nitrogen and phosphorus concentrations from White Lake, a nitrogen:phosphorus ratio of 74:1 was calculated. This finding indicates that White 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.

White Lake Trophic State

Figure 3.1-5 contain the WTSI values for White Lake. The WTSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from lower eutrophic to upper mesotrophic. 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, White Lake is in an upper mesotrophic/lower eutrophic state. However, when the high amount of aquatic plant biomass the lake has is considered, it can be said that the lake is more productive than what the TSI water quality analysis actually shows. Considering this, it can be concluded that this lake is purely within a eutrophic state.

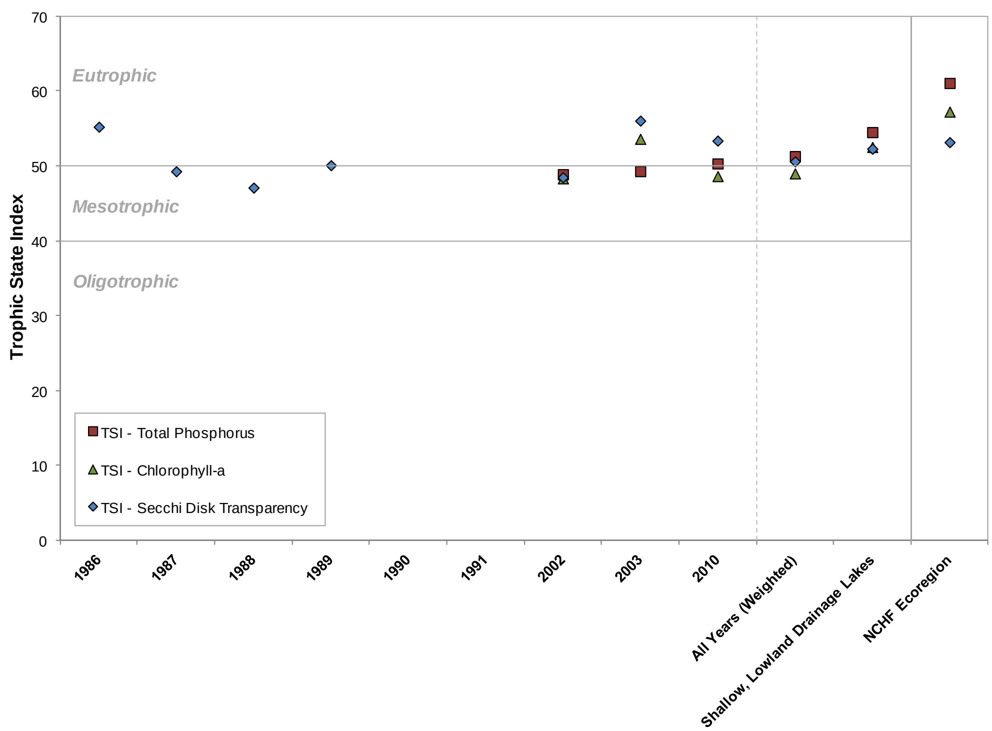


Figure 3.1-6. White Lake, state-wide class 3 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in White Lake

Dissolved oxygen and temperature were measured during water quality sampling visits to White Lake by Onterra staff. Profiles depicting these data are displayed in Figure 3.1-6. White Lake is classified as a shallow, mixed drainage lake. As summer progresses, the sun will gradually warm the upper portion of the water column. Bacterial processes slowly deplete oxygen from the bottom of the lake. Because of White Lake's shallow depth, energy from the wind is able to mix the water column continuously throughout the summer, mixing oxygen and warm water from the water's surface to the bottom of the lake. As a result, throughout the open-water season temperature and dissolved oxygen remains stable within the entire water column.

In February of 2011, temperature and dissolved oxygen was measured through the ice on White Lake. During this time, temperature readings are very similar from lake to lake; colder water is found near the ice at the surface, and slightly warmer and denser water is found near the bottom of the lake. Dissolved oxygen concentrations were observed to drop near anoxic conditions between depths of 1 and 2 feet. On lakes such as White Lake, abundant plant production throughout the summer months leaves much organic material to decay beneath the ice cover. The bacteria that break down this organic matter utilize oxygen in their processes, and thus deplete it from the water. While during the summer months this oxygen is replenished by plant and algal production and mixing between the air and water's surface, there is no natural process to replenish oxygen in the winter months due to the ice cover. The White Lake Aeration Association began winter aeration in 1973 through operation of an aerator on the west side of the small island in White Lake. This aerator oxygenates the nearby water, and creates a sanctuary for fish to seek during the winter months.

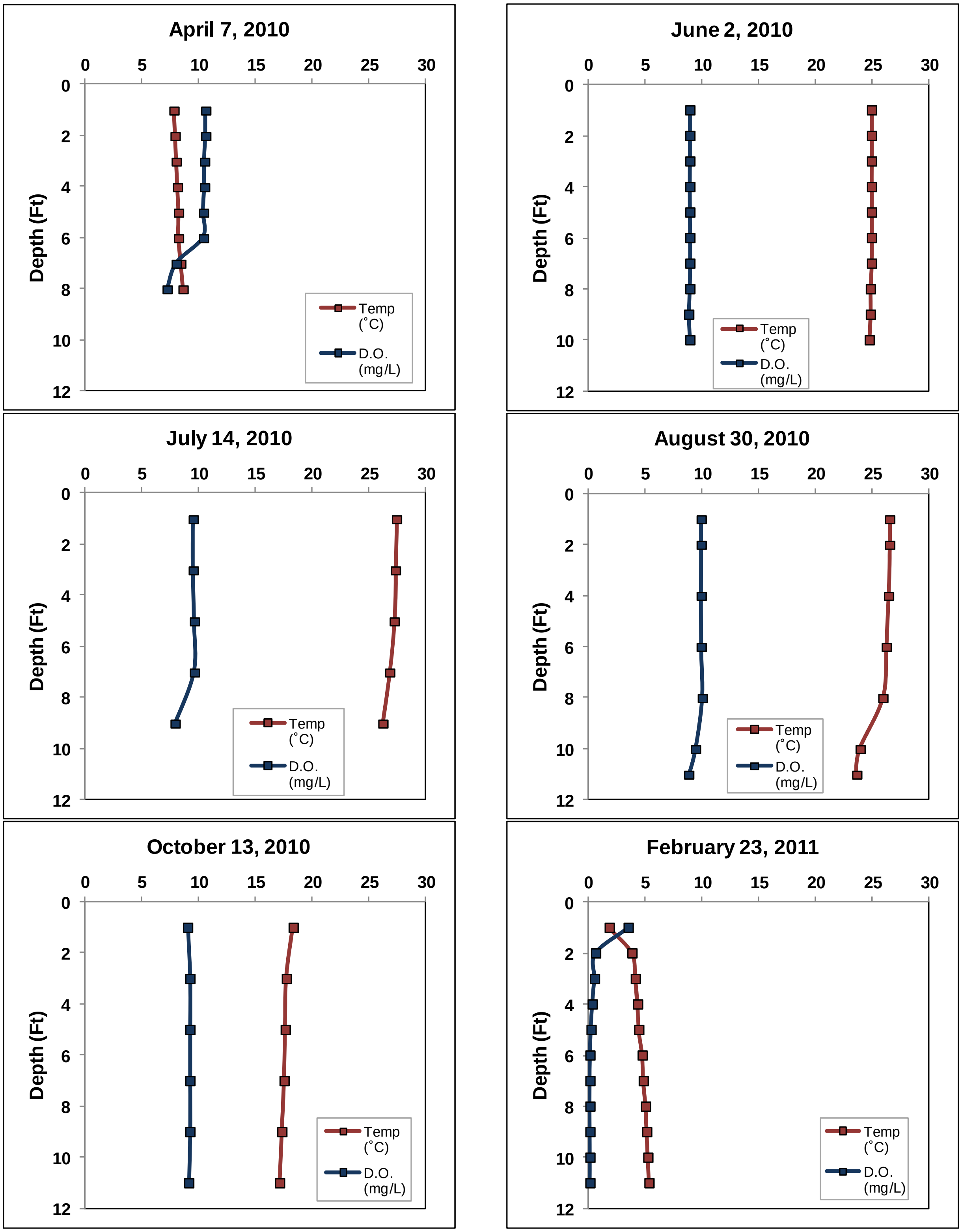


Figure 3.1-7. White Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at White Lake

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

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw et al. 2004). pH was measured twice in White Lake, and both times the pH of the water was found to be above neutral. In April of 2010 pH was measured at 8.1, and in July of the same year pH was measured at 9.2. Both of these values are slightly above the normal range for Wisconsin Lakes.

The variability in pH between lakes is most likely attributable to a number of environmental factors, with the chief determiner being geology near the lake and within its surface and underground watersheds. On a smaller scale within a lake or between similar lakes, photosynthesis by plants can impact pH because the process uses dissolved carbon dioxide, which acts as a carbonic acid in water. Carbon dioxide removal through photosynthesis reduces the acidity of lake water, and so pH increases. As discussed later on in the Aquatic Plant Section, White Lake is home to a very abundant plant community. It is very likely that this abundant plant growth increases the pH within the lake. The difference in pH measured between the early spring (April 2010) and mid-summer (July 2010), when plant growth has peaked, is testimony to this relationship.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in White Lake was measured at 97.6 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so White Lake's pH falls within, but on the upper edge, of this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of White Lake was found to be 26.1 mg/L, falling within the optimal range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2010 and these samples were processed by the WDNR for larval zebra mussels. No veligers (larval zebra mussels) were found within these 2010 samples.

Comparable measures of water quality were reported upon in a 2003 White Lake Comprehensive Survey Results and Management Plan by Aquatic Biologists, Inc. Many similar parameters were measured at this point in time, including nutrients, Secchi disk clarity, dissolved oxygen, temperature, pH, alkalinity and calcium. Overall, there is no noticeable change in these parameters between the times of these two studies. Several similar seasonal patterns were noted in the 2003 study that were described in this report as well, including fluctuating pH concentration in association with plant biomass growth, and the drop in winter dissolved oxygen concentrations.

3.2 Watershed Assessment

Watershed Modeling

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

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

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

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

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

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

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

In a 2003 comprehensive survey report and management plan written by Aquatic Biologists, Inc., White Lake's watershed was determined to be 1,869 acres in size. Including the lake surface area, the total watershed size is approximately 2,895 acres. Onterra staff utilized the same methodology in delineating the White Lake watershed, which is to analyze the elevation of the area surrounding the lake on a United States Geological Survey (USGS) topographical map. Geographic Information System (GIS) software and WDNR watershed boundaries were also used to make this delineation, and following these procedures it was determined that the watershed is slightly larger, at approximately 3,182 acres in size (Map 2).

The 2003 comprehensive survey and management report characterizes land use cover in the White Lake watershed differently than what was derived during studies for this report. In 2003, field observations were used and areas calculated by acreage grid analysis. Onterra staff utilized a 2006 National Land Cover Database dataset (Fry et al 2011) within GIS software to determine land use types and their acreages. This technique uses 30-meter resolution land cover information, and as a result, is arguably more accurate than techniques used in the past to determine watershed information.

The largest land cover type in the watershed is the surface of White Lake, at 1,026 acres or 32% of the total watershed (Figure 3.2-1). Other significant land uses in the watershed include row crops (21% of the watershed), wetlands (18%), forest (14%), pasture/grass land (9%) and rural residential land (6%), while only 1 acre of medium density rural land exists in this basin. Altogether, the watershed is only 2 times larger than the lake itself, making a watershed to lake area ratio of 2:1.

As previously explained, in a small watershed the land cover type plays a very important role in how much phosphorus is exported to a lake. WiLMS modeling predicts the annual phosphorus load from the White Lake watershed to be approximately 1,054 lbs. About 600 lbs (57% of the total load) comes from areas of row crops, while the White Lake surface collects 276 lbs (26%) of phosphorus from atmospheric deposition in a year's time (Figure 3.2-2). Smaller contributors to the phosphorus load include pasture / grass land (7%), wetlands (5%), forests (3%) and rural residential land (2%).

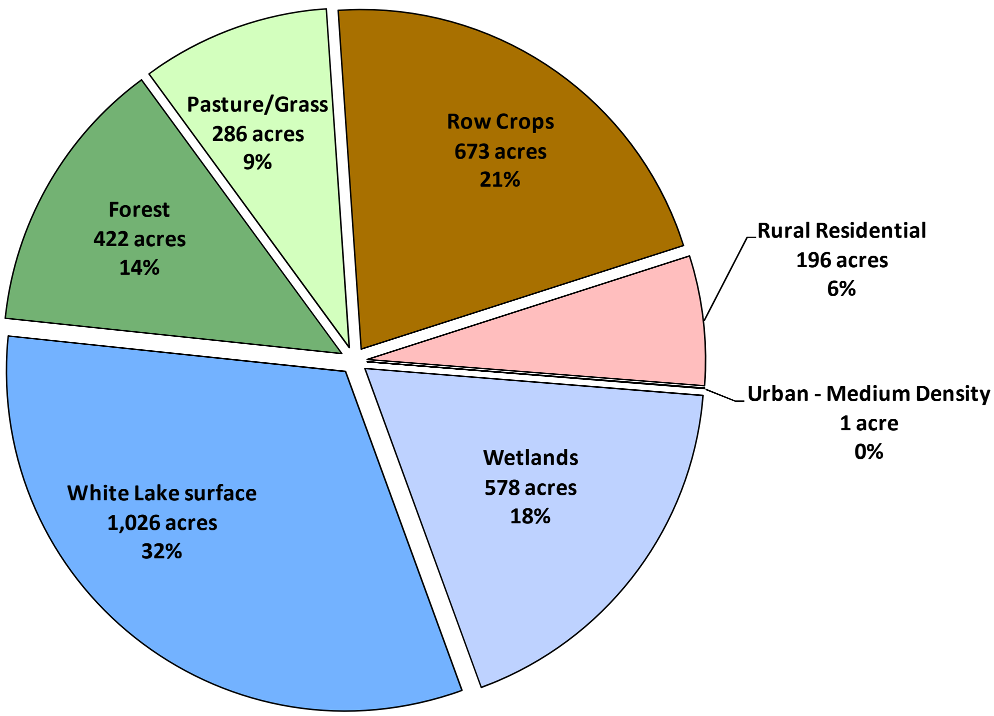


Figure 3.2-1. White Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

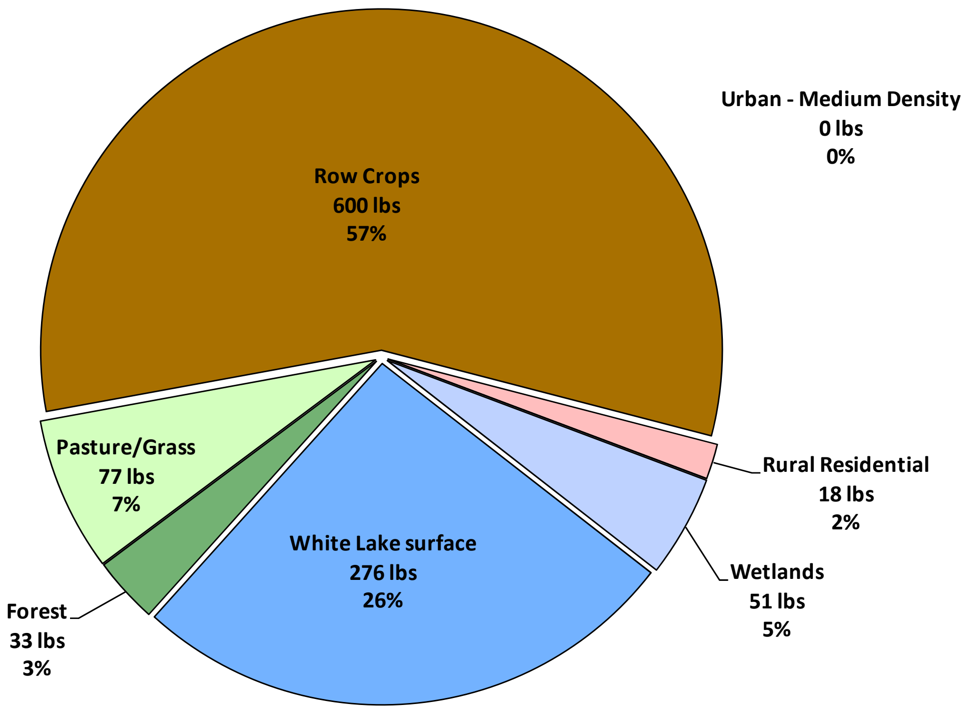


Figure 3.2-2. White Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

In examining Figures 3.2-1 and 3.2-2, the impact of row crops within the watershed can be seen. This land cover type accounts for 21% of the relatively small watershed, yet exports 57% of the phosphorus load to White Lake. WiLMS modeling indicates that reducing the acreage of row crops in the watershed would indeed reduce the phosphorus export, however, it would take an incredible reduction to make these efforts worthwhile. Table 3.2-1 displays modeling scenarios that were tested in which a percentage of the row crop acreage in the White Lake watershed was converted to pasture / grass land. As indicated in this table, while reducing row crop acreage within the watershed reduces the phosphorus export from this land cover type drastically, the total load reduction from the watershed is still minimal. Furthermore, the response of the lake to these reductions is minimal, as indicated by the Trophic State Indicator (TSI) total phosphorus value. This value changes by 5 units from the current watershed phosphorus load to a load reached through a 75% reduction in row crop acres. Recalling the scale of the TSI water quality chart (Figure 3.1-6 of the Water Quality Section), this change of 5 units is not substantial. Lastly, a reduction in significant row crop acreage in a region where agriculture is economically vital is not entirely practical.

During the WiLMS modeling process, it was noticed that actual water column total phosphorus values were much lower than what the predictive model indicated. There are likely a number of reasons for this. White Lake has only a small intermittent tributary entering the lake. Therefore, this "drainage" lake probably does not receive as high of a phosphorus load as other drainage lakes which have a perennial tributary stream. Additionally, White Lake has large tracts of wetland surrounding this input stream, as well as in other areas of the watershed. This area is able to effectively buffer the runoff, removing some nutrients and sediments before the water reaches the lake.

Table 3.2-1. White Lake watershed modeling scenarios. WiLMS was utilized to determine phosphorus export under scenarios where several 25%, 50% and 75% of current row crops were converted to pasture / grass land cover types.

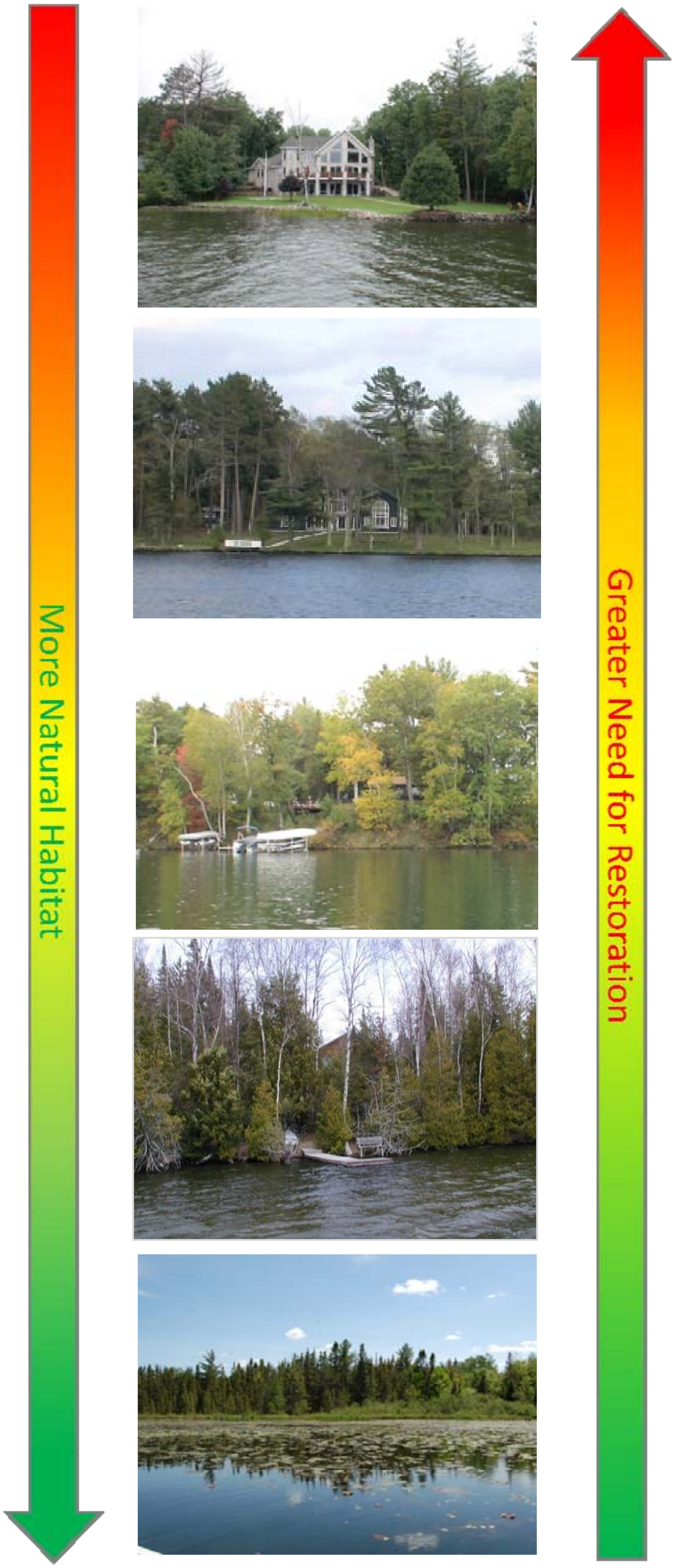
Modeling Procedure	Current	Scenario 1	Scenario 2	Scenario 3
Row Crop land cover type	100% (*673 acres*)	75% (*505 acres*)	50% (*336 acres*)	25% (*126 acres*)
Row Crop TP export (lbs)	600	450	300	150
Total Watershed TP load (lbs)	1054	948	845	739
Total Watershed TP load reduction (%)	0%	10%	20%	30%
Trophic State Indicator TP Value (from predicted in column concentration)	52	51	49	48

Shoreline Assessment

One of the most vulnerable areas of a lake's watershed is the immediate shoreland zone (approximately from the water's edge to 35 feet shoreland). When a lake's shoreline is developed, the increased impervious surface, removal of natural vegetation, installation of septic systems, and other human practices can severally increase nutrient loads to the lake while degrading important habitat. Limiting these anthropogenic (man-made) affects on the lake is important in maintaining the quality of the lake's water and habitat. Along with this, the immediate shoreland area is often one of the easiest and most beneficial areas to restore.

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

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



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

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

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

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

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

Figure 3.2-3. Shoreline assessment category descriptions.

On White Lake, the development stage of the entire shoreline was surveyed during late summer of 2010, using a GPS unit to map the shoreline. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreline on a property-by-property basis. During the survey, Onterra staff examined the shoreline for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.2-4.

White Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 5.2 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 3.2-4). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 1.7 miles of urbanized and developed–unnatural shoreline were observed. If restoration of the White Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreline lengths around the entire lake.

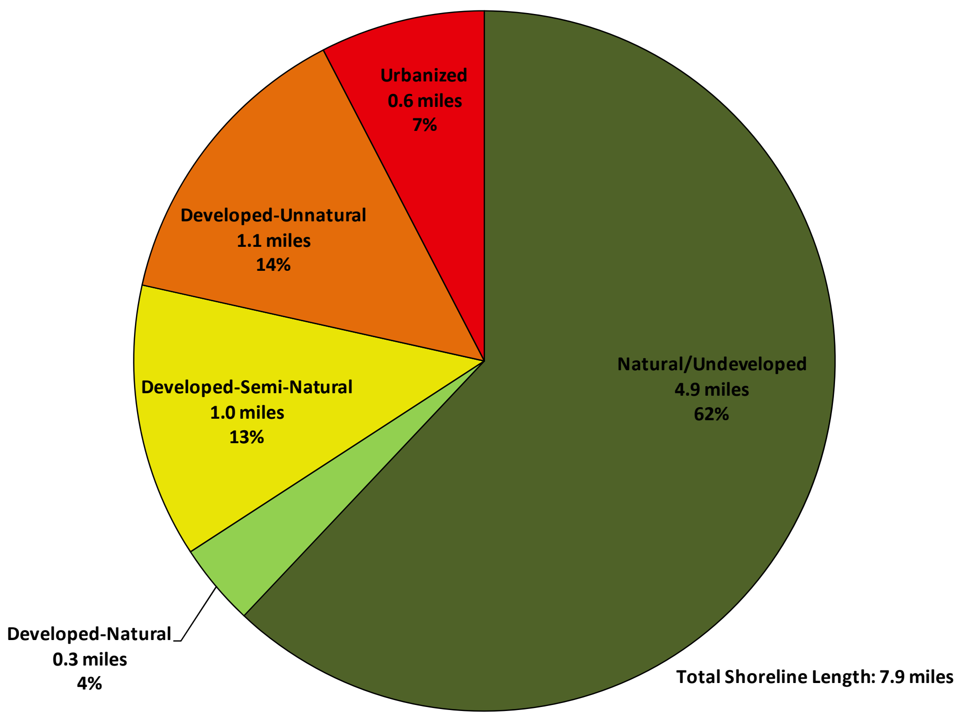


Figure 3.2-4. White Lake shoreland categories and total lengths. Based upon a late summer 2010 survey. Locations of these categorized shorelands can be found on Map 3.

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 predation by predator fish, which could result in a stunted pan-fish population. Exotic plant species, such as Eurasian water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing native plants and reducing species diversity. These invasive plant species can form dense stands that are a nuisance to humans and provide low-value habitat for fish and other wildlife.

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

Aquatic Plant Management and Protection

Important Note:
Even though most of these techniques are not applicable to White 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 White 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).

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

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

Cost

The cost of native, aquatic and shoreland plant restorations is highly variable and depends on the size of the restoration area, 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.

Cost

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

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

Water Level Drawdown

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

Cost

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

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

Mechanical Harvesting

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

Cost

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

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

Chemical Treatment

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

1. Contact herbicides act by causing extensive cellular damage, but usually do not affect the areas that were not in contact with the chemical. This allows them to work much faster, but does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides spread throughout the entire plant and often result in complete mortality if applied at the right time of the year.

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

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

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 were 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, system 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 water hyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for either biocontrol insect.

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

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

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

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

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

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

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

Analysis of Current Aquatic Plant Data

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

As described in more detail in the methods section, multiple aquatic plant surveys were completed on White 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 White Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

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

Species Diversity and Richness

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

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

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

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

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

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

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

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

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of White 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. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept survey and does not include incidental species or those encountered during other aquatic plan surveys.

Community Mapping

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

Exotic Plants

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

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

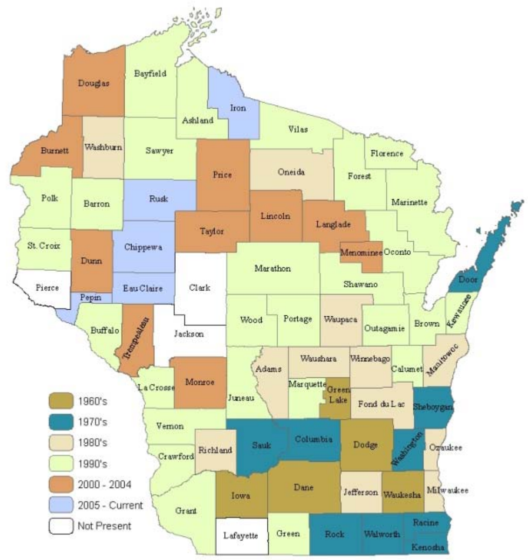


Figure 3.3-1. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

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

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

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. On June 2nd and 13th, 2010, surveys were completed on White Lake that focused upon curly-leaf pondweed. First documented in White Lake in 1992, Onterra ecologists located numerous occurrences of curly-leaf pondweed during this survey. A detailed discussion regarding curly-leaf pondweed in White Lake will be discussed in the next section.

The whole-lake aquatic plant point-intercept and aquatic plant community mapping surveys were conducted on White Lake on August 30th and 31st, 2010 by Onterra. During these surveys, 46 species of aquatic plants were located in White Lake (Table 3.3-1), three of which are considered to be non-native, invasive species: curly-leaf pondweed, Eurasian water milfoil, and purple loosestrife. The distribution of these invasive plants within White Lake will be discussed in the next section. 30 of the native 43 species were sampled directly during the point-intercept survey and are used in the analysis that follows.

White Lake is highly vegetated, with approximately 93% of the 640 point-intercept sampling locations that fell within the maximum depth of native plant growth (9 feet) containing aquatic vegetation. Figure 3.3-2 shows that the occurrence of aquatic vegetation was high across all depths of the lake. However, individual species of aquatic plants were not distributed evenly over water depth (Figure 3.3-2). For example, the floating-leaf species watershield and white water lily and the submergent species Illinois pondweed dominated shallower areas of the lake, while southern naiad, wild celery, and white stem pondweed in particular, were found in their highest abundance in deeper water (Figure 3.3-2).

With the lake's shallow (mean depth 4 feet), relatively clear water, the entire area of the lake supports aquatic plant growth (Map 4). Additionally, the vast majority of the point-intercept locations (89%) contained fine organic sediments, or muck (Figure 3.3-3). Map 5 shows that only a few areas near shore and around the island contained sandy substrates, and no areas of rock were encountered during the survey. The combination of shallow, clear water and nutrient-rich sediments contribute to the areas of nuisance levels of aquatic plants in White Lake. This fact was mirrored in the results of the Stakeholder Survey, in which survey respondents listed excessive aquatic growth as one of their top concerns (Question #19). Approximately 54% of residents often or always experience trouble from aquatic plant growth when they are trying to enjoy the lake (Question #20). About 38% sometimes experience hardship from aquatic plant growth. Wild rice growth, in particular, was the number one concern of White Lake residents. Additionally, both of these issues were the highest ranked as factors that may be impacting While Lake in a negative manner (Question #18). Overall, nearly 94% of survey respondents indicated that aquatic plant control is probably or definitely needed on the lake (Question #21).

The issues concerning aquatic plant growth, wild rice growth as well as other plant related factors are discussed within this section, as well as the Summary & Conclusions Section and Implementation Plan.

Table 3.3-1. Aquatic plant species located in White Lake during 2010 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)
Emergent	*Decodon verticillatus*	Water-willow	7
	Eleocharis palustris	Creeping spikerush	6
	Lythrum salicaria	Purple loosestrife	Exotic
	Pontederia cordata	Pickerelweed	9
	Sagittaria latifolia	Common arrowhead	3
	Sagittaria rigida	Stiff arrowhead	8
	Schoenoplectus pungens	Three-square rush	5
	Schoenoplectus subterminalis	Water bulrush	9
	Schoenoplectus tabernaemontani	Softstem bulrush	4
	Schoenoplectus acutus	Hardstem bulrush	5
	Typha latifolia	Broad-leaved cattail	1
	Typha angustifolia	Narrow-leaved cattail	1
	Zizania aquatica	Southern wild rice	8
FL	*Brasenia schreberi*	Watershield	7
	Nuphar variegata	Spatterdock	6
	Nymphaea odorata	White water lily	6
Submergent	*Ceratophyllum demersum*	Coontail	3
	Chara sp.	Muskgrasses	7
	Elodea canadensis	Common waterweed	3
	Lobelia dortmanna	Water lobelia	10
	Myriophyllum verticillatum	Whorled water milfoil	8
	Myriophyllum sibiricum	Northern water milfoil	7
	Myriophyllum spicatum	Eurasian water milfoil	Exotic
	Megalodonta beckii	Water marigold	8
	Nitella sp.	Stoneworts	7
	Najas guadalupensis	Southern naiad	7
	Potamogeton friesii	Fries' pondweed	8
	Potamogeton crispus	Curly-leaf pondweed	Exotic
	Potamogeton pusillus	Small pondweed	7
	Potamogeton strictifolius	Stiff pondweed	8
	Potamogeton gramineus	Variable pondweed	7
	Potamogeton natans	Floating-leaf pondweed	5
	Potamogeton illinoensis	Illinois pondweed	6
	Potamogeton zosteriformis	Flat-stem pondweed	6
	Potamogeton amplifolius x illinoensis	Large-leaf x Illinois pondweed	N/A
	Potamogeton praelongus	White-stem pondweed	8
	Potamogeton amplifolius	Large-leaf pondweed	7
	Stuckenia pectinata	Sago pondweed	3
	Utricularia purpurea	Large purple bladderwort	9
	Utricularia minor	Small bladderwort	10
	Utricularia vulgaris	Common bladderwort	7
	Utricularia gibba	Creeping bladderwort	9
	Vallisneria americana	Wild celery	6
S/E	*Eleocharis acicularis*	Needle spikerush	5
	Sagittaria cuneata	Arum-leaved arrowhead	7
	Sagittaria cristata	Crested arrowhead	9

FL = Floating Leaf
S/E = Submergent and/or Emergent

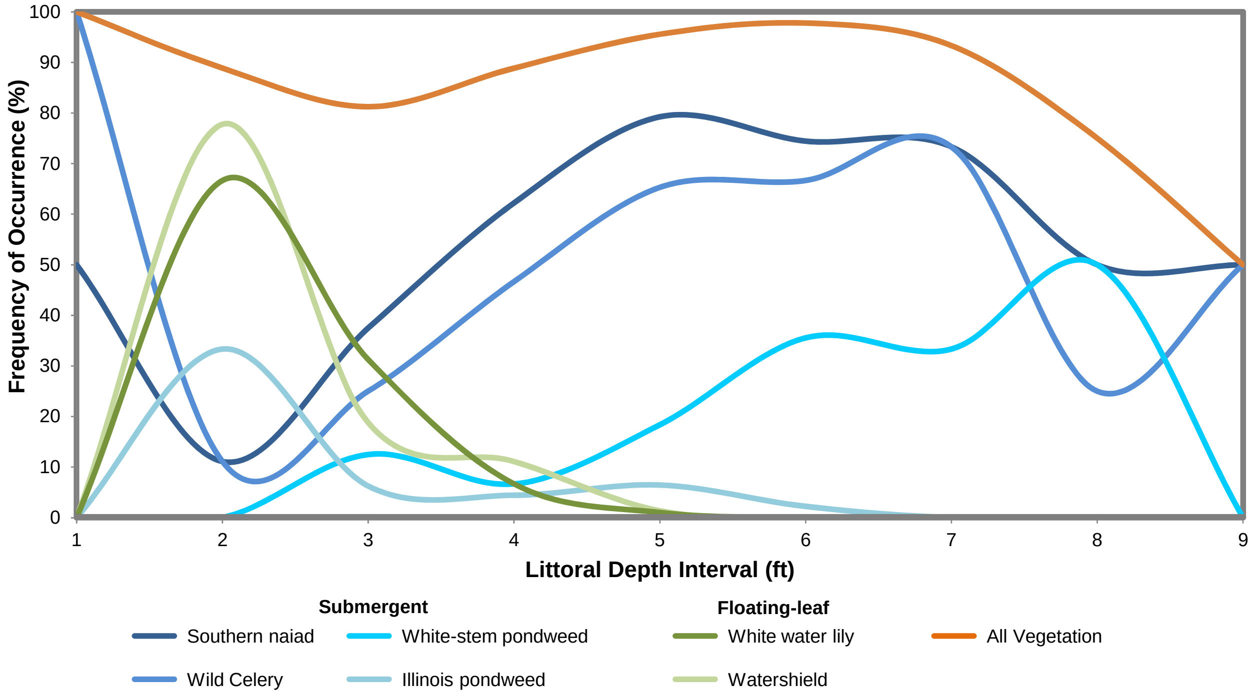


Figure 3.3-2 Frequency of occurrence of White Lake aquatic plants by depth. Created using data from 2010 aquatic plant point-intercept survey.

Southern naiad, wild celery, and large-leaf pondweed were the most frequently encountered aquatic plant species during the 2010 aquatic plant point-intercept survey (Figure 3.3-3). All three of these species are common throughout Wisconsin and play an important role in White Lake's ecosystem. In previous aquatic plant surveys conducted on White Lake, it is believed that southern naiad (*Najas guadalupensis*) was misidentified as slender naiad or bushy pondweed (*Najas flexilis*). These two species are closely related and morphologically similar, so distinguishing between them is often difficult. However, while other naiad species in Wisconsin are annuals and rely on the production of fruit for reproduction, southern naiad is often perennial and lacking fruit (Les et al. 2010). No fruit was observed on these plants in White Lake in 2010, and shoots and leaves were observed growing out of blackened, dead stems from the previous year indicating a perennial life-cycle.

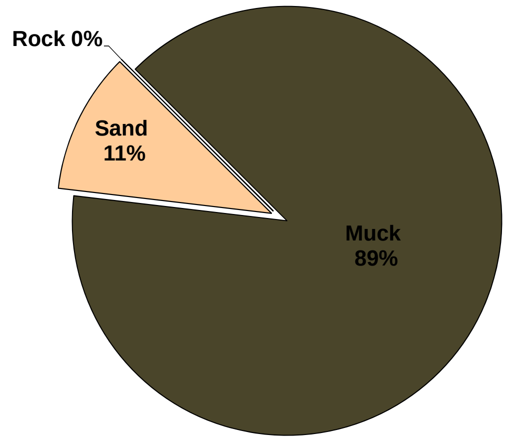


Figure 3.3-3. White Lake substrate types, by percentage. Created using data from 2010 aquatic plant point-intercept survey.

Emerging research is indicating that hybrids between southern naiad subspecies exist and are often observed acting aggressively and growing to nuisance levels (Les et al. 2010). Southern naiad was observed growing at or near the surface in areas of White Lake in 2010, which certainly interfere with navigation and recreational activities.

Because of the growth nature of southern naiad in White Lake, specimens collected in 2010 will be sent to the University of Connecticut for DNA analysis to determine if it is a hybridized species. Past and present harvesting activities on White Lake have likely largely been targeting this species. A more detailed discussion surrounding aquatic plant harvesting on White Lake will be discussed in the Implementation Plan Section. Despite the excessive growth of southern naiad in areas of White Lake, it provides aquatic organisms with valuable structural habitat and sources of food. Additionally, it aids in maintaining the water quality of White Lake by stabilizing bottom sediments and utilizing nutrients that would otherwise be available to free-floating algae.

Wild celery, the second-most frequently encountered species during the point-intercept survey, was most abundant between 4 and 7 feet (Figure 3.3-2 and 3.3-4). The long, tapering leaves of wild celery provide excellent structural habitat for numerous aquatic organisms while its extensive root systems stabilize bottom sediments. Additionally, the leaves, fruit, tubers, and winter buds are food sources for numerous species of waterfowl and other wildlife. While wild celery is abundant in White Lake, it was observed growing well below the surface and not at levels which would interfere with lake users.

The third-most frequently encountered species in 2010 was large-leaf pondweed, or as many fisherman know it, musky cabbage (Figure 3.3-4). Large-leaf pondweed, as its name suggests, has the largest leaves of any pondweed species in Wisconsin. This species is often one of the first aquatic plants observed growing in early spring, providing valuable habitat. Large-leaf pondweed does not grow as dense as many other aquatic plant species, allowing larger fish, such as muskellunge, to maneuver and forage for prey through them more easily. Later in the summer when plants are close to the surface, large-leaf pondweed produces floating leaves and a flower spike which protrudes above the water's surface. Once pollinated, a number of large fruits are produced which feeds numerous species of migratory water fowl.

During the 2010 aquatic plant point-intercept survey, Onterra ecologists encountered an aquatic plant species that had characteristics of both large-leaf pondweed and closely related Illinois pondweed, which is also found in White Lake (Figure 3.3-4). While analysis of DNA is ultimately required to positively determine the parental species of the hybrid, Dr. Freckmann of the University of Wisconsin-Stevens Point Herbarium believes this hybrid from White Lake is a cross between large-leaf and Illinois pondweed. This hybrid species was observed growing within large-leaf pondweed and Illinois pondweed beds, but had distinct bright-green leaves, and other characteristics that did not define it as either large-leaf or Illinois pondweed (Photograph 3.3-1). This species was not observed growing at nuisance levels and is not a concern to the ecology of White Lake; solely a curiosity.

Photograph 3.3-1. Suspected large-leaf x Illinois pondweed hybrid from White Lake.

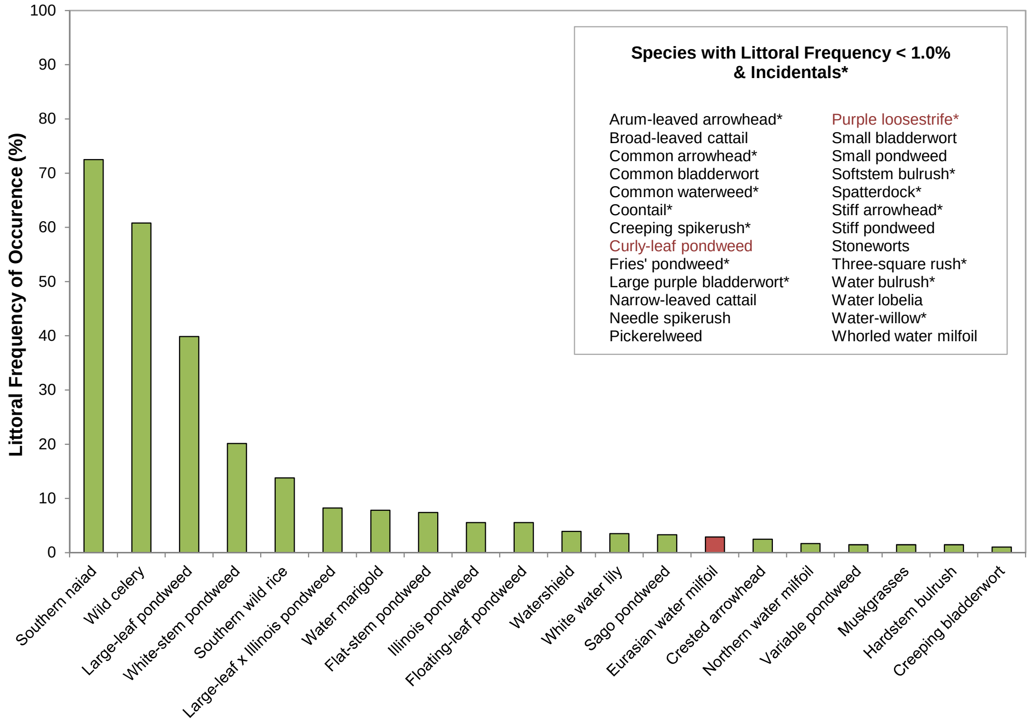


Figure 3.3-4 White Lake aquatic plant littoral occurrence analysis. Created using data from 2010 aquatic plant point-intercept survey. Exotic species indicated with red.

As discussed earlier, the calculation for the Floristic Quality Index (FQI) for a lake's plant community only uses the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. Thirty of the 43 native plant species located during the 2010 surveys on White Lake were encountered on the rake during the point-intercept survey. This native species richness (30) is well above the North Central Hardwood Forests ecoregion and Wisconsin State medians (Figure 3.3-5).

The average conservatism value (6.5) of these 30 species indicates that the plant community of White Lake is of higher quality than many of the lakes in the ecoregion and the state, having a higher number of species that require undisturbed habitats (Figure 3.3-5). Combining White Lake's native aquatic plant species richness and average conservatism values to produce its FQI results in an exceptionally high value of 35.4 (equation shown below); exceeding the median values for both the ecoregion and the state (Figure 3.3-5).

$$\text{FQI} = \text{Average Coefficient of Conservatism (6.5)} * \sqrt{\text{Number of Native Species (30)}}$$
$$\text{FQI} = 35.4$$

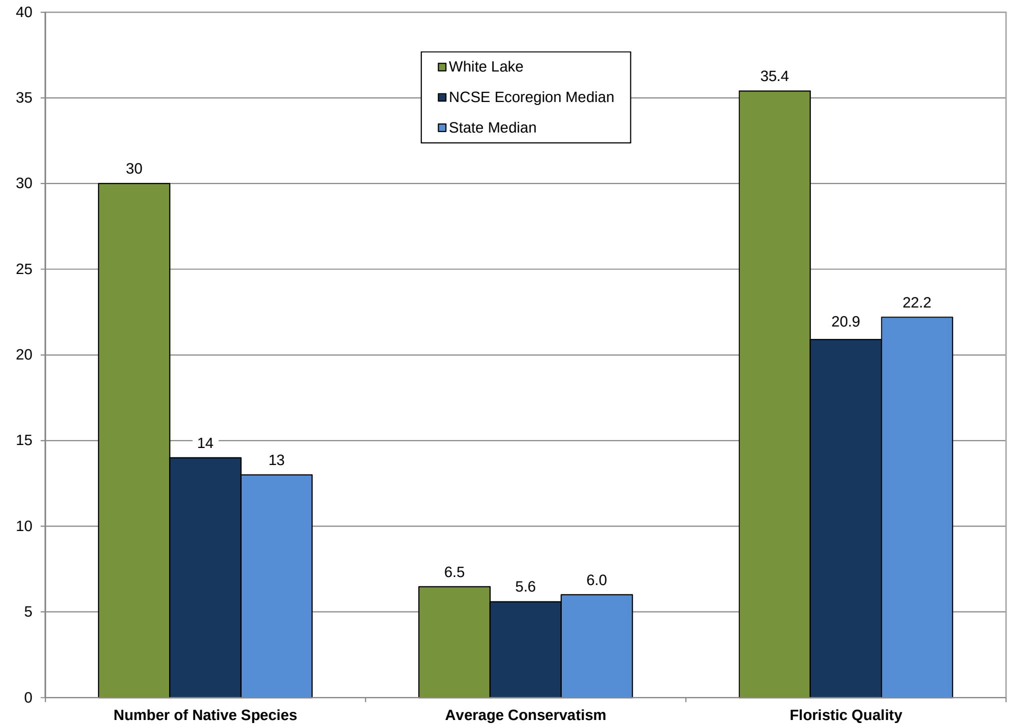


Figure 3.3-5. White Lake Floristic Quality Assessment. Created using data from 2010 aquatic plant point-intercept survey. Analysis following Nichols (1999).

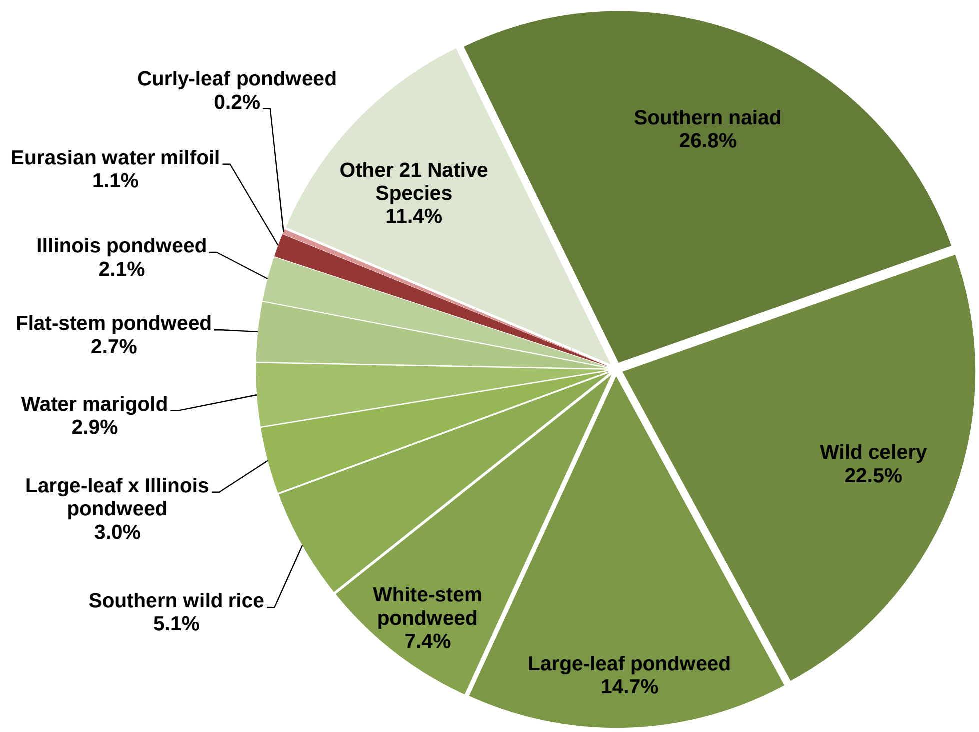


Figure 3.3-6 White Lake aquatic plant relative occurrence analysis. Created using data from 2010 aquatic plant point-intercept survey. Exotic species indicated with red.

The littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while southern naiad was found at approximately 72% of the sampling locations, its relative frequency of occurrence is approximately 27%. Explained another way, if 100 plants were randomly sampled from White Lake, 27 of them would be southern naiad. Figure 3.3-6 indicates that the three species southern naiad, wild celery, and large-leaf pondweed comprise 64% of White Lake's plant community, while the other 27 native species comprise approximately 27.2%, and the non-native species Eurasian water milfoil and curly-leaf pondweed comprise the remaining 1.3%.

Because White Lake contains a high number of native aquatic plant species, one may assume that the lake has high species diversity. However, as discussed previously, species diversity is also influenced by how evenly the plant species are distributed within the community. Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food.

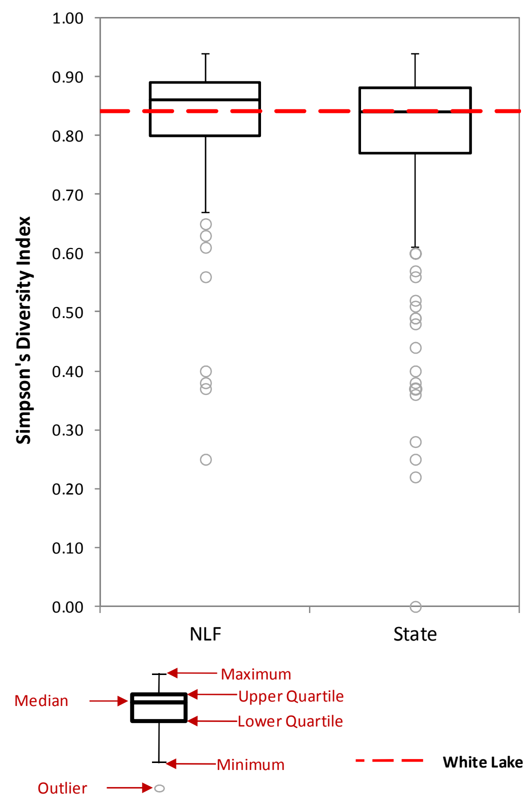


Figure 3.3-7. White Lake species diversity index. Created using data from 2010 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

Using the data collected from the 2010 aquatic plant point-intercept survey, White Lake's plant community was found to be moderately diverse, with a Simpson's Diversity value of 0.84 (Figure 3.3-7). In other words, if two individual plants were randomly sampled from White Lake, there would be an 84% probability that the two individuals would be of different species. This moderate value can be attributed to a plant community that is primarily comprised of southern naiad, wild celery, and large-leaf pondweed (Figure 3.3-6).

The quality of White Lake's aquatic plant community is also indicated by the high number of native emergent and floating-leaf plant species (15) that occur throughout the lake (Map 6). The 2010 community map indicates that approximately 486 acres (47%) of the 1,026 acre lake contain these types of plant communities. Figure 3.3-8 shows that the vast majority (90%) of these communities in White Lake are comprised of both emergent and floating-leaf aquatic plants, while 10% is comprised of just emergent species. The majority of these communities (88%) are dominated by southern wild rice (Figure 3.3-8, Map 6).

Wild rice is an emergent aquatic grass that grows in shallow water of lakes and slow-moving rivers. Wild rice has cultural significance to the Chippewa Tribal Communities where the grain historically was an important component of Native American diets. Wild rice is also an important diet component for waterfowl, muskrats, deer, and many other species. Established wild rice plant communities can provide valuable nursery and brooding habitat for wetland bird and amphibian species as well as spawning habitat for various fish. Perhaps one of the most overlooked benefits of having established wild rice communities is their ability to utilize excessive plant nutrients, stabilize soils, and form natural wave breaks to protect shoreland areas.

The community map may represent a 'snapshot' of the important emergent and floating-leaf plant communities, and a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within White 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 the undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines. Although these areas are very important to the lake's health and provide valuable ecological habitat, they can, in some occasions reach nuisance levels and impact recreational enjoyment of the lake. Striking a balance between the needs of lake users and those of the lake is often a challenge.

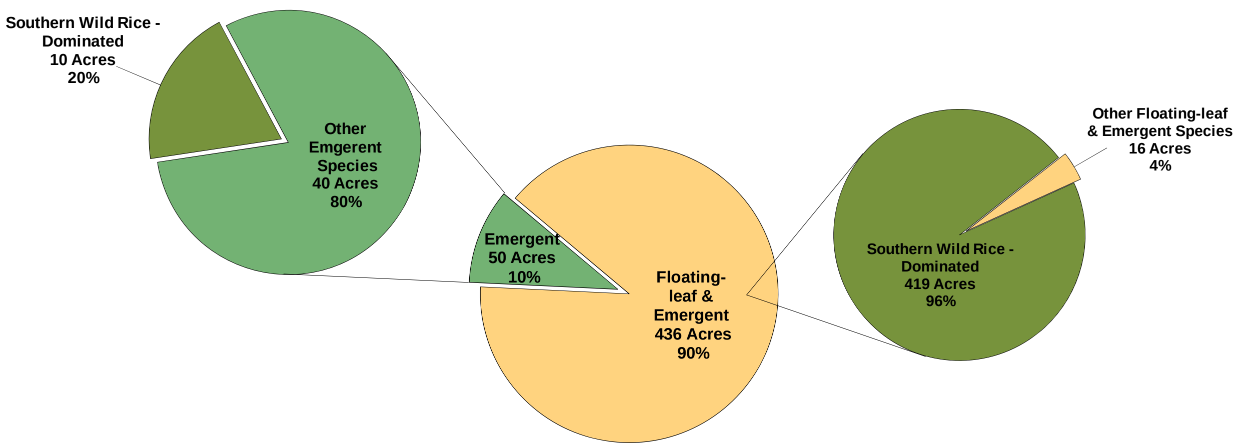


Figure 3.3-8 White Lake proportions of emergent and floating-leaf aquatic plant communities. Created using data from 2010 community mapping survey.

Exotic Plants in White Lake

During field surveys, Onterra staff located several exotic plant species within White Lake. As previously mentioned, numerous surveys were conducted which sought to geospatially map these species and indicate priority areas in terms of biomass density. Aquatic invasive plant species cause nuisance conditions on many Wisconsin lakes, which is the reason for concern over their presence. This concern was reflected in the White Lake Stakeholder Survey, in which residents indicated aquatic invasive species as a factor negatively impacting White Lake (Appendix B – Question #18). Survey respondents also listed this issue as a top concern for White Lake (Question #19).

Curly-leaf Pondweed

Curly-leaf pondweed was first documented in White Lake nearly 20 years ago in 1992. Onterra ecologists completed a curly-leaf pondweed survey on June 2, 2010, when this plant is at its peak growth. During this survey, approximately 8.5 acres of dominant, highly dominant, and surface matted curly-leaf pondweed colonies were mapped (Map 7). The largest colony was located just west of the island, and single plants and clumps were located throughout most of the lake.

Another curly-leaf pondweed survey was conducted on June 13, 2011. This survey located approximately 11 acres of highly dominant and surface matted curly-leaf pondweed. The colonies that were mapped in 2010 had increased slightly in size as well as density (Map 8). It should be noted here that the slight increase could be the result of mapping error and/or survey timing as well as an actual increase in curly-leaf pondweed within White Lake. Like in 2010, single plants and clumps were located throughout most of the lake. Once the planning process on White Lake is complete, a control strategy for curly-leaf pondweed will be developed. Since this plant has been established in the lake for quite some time, large-scale repeat treatments will likely need to occur on an annual basis for several years. This can be achieved via successfully applying for stat AIS Control Grant funds and enlist the services of a professional applicator that can accurately apply (using advanced on-board GPS technology and calibrated delivery systems) a wider repertoire of herbicides including endothall, the most commonly used herbicide to target established infestations of curly-leaf pondweed.

Although curly-leaf pondweed has been in White Lake for at least the past 20 years, it has not become a dominant species within the lake's aquatic plant community as a whole. While a couple larger monotypic colonies of curly-leaf pondweed exist in the lake, much of it is comprised of scattered single plants and clumps around the lake. Curly-leaf pondweed likely has not been able to colonize the majority of White lake due to the diverse and lush native aquatic plant community which to not allow it to gain an easy foothold.

Eurasian water milfoil

Eurasian water milfoil has been present in White Lake since at least 1989 (ABI 2003). Onterra ecologists mapped Eurasian water milfoil on White Lake in June of 2010, and located single plants, clumps, and small colonies scattered throughout the entire lake (Map 9). Though Eurasian water milfoil is widespread in White Lake, at this time there are no large colonies that would be candidates for an herbicide treatment.

Like curly-leaf pondweed, Eurasian water milfoil has been present in White Lake for a considerable amount of time, yet it was found to only have a littoral occurrence of approximately 3% during the 2010 point-intercept survey. Some lakes in Wisconsin have seen Eurasian water milfoil become the most dominant plant species in the lake only a few years after the discovery of introduction. The low occurrence of this species given the time it has been present within White Lake is another testament to the high quality, diverse native aquatic plant community present.

Purple loosestrife

During the 2010 community mapping survey, numerous occurrences of purple loosestrife were located along the shorelines of White Lake and within shallow emergent plant communities (Map 6). Purple loosestrife (*Lythrum salicaria*) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930's, it has now spread to 70 of the state's 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments.

Purple loosestrife has likely been present in and around White Lake for some time. There are a number of effective control strategies for combating this aggressive plant, including herbicide application, biological control by native beetles, and manual hand removal. At this time, hand removal by volunteers is likely the best option as it would decrease costs significantly. Additional purple loosestrife monitoring would be required to ensure the eradication of the plant from the shorelines of White Lake. Detailed discussion regarding this control effort will be discussed in the Implementation Plan.

3.4 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR (WDNR 2010).

Table 3.4-1. Gamefish present in the White Lake with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Brown Bullhead	*Ameiurus nebulosus*	5	Late Spring - August	Sand or gravel bottom, with shelter rocks, logs, or vegetation	Insects, fish, fish eggs, mollusks and plants
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Common Carp	*Cyprinus carpio*	47	April - August	Shallow, weedy areas from 3 - 6 ft	Insect larvae, crustaceans, mollusks, some fish and fish eggs
Green Sunfish	*Lepomis cyanellus*	7	Late May - Early August	Shelter with rocks, logs, and clumps of vegetation, 4 - 35 cm	Zooplankton, insects, young green sunfish and other small fish
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Walleye	*Sander vitreus*	18	Mid April - early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Bullhead	*Ameiurus natalis*	7	May - July	Heavy weeded banks, beneath logs or tree roots	Crustaceans, insect larvae, small fish, some algae
Yellow Perch	*Perca flavescens*	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

White Lake Fishing Activity

Table 3.4-1 shows the popular game fish that are present in the system. When examining the fishery of a lake, it is important to remember what "drives" that fishery, or what is responsible for determining its mass and composition. The gamefish in White Lake are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon algae and plants, and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscovores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

A concept called energy flow describes how the biomass of piscovores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscovorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 3.4-1.

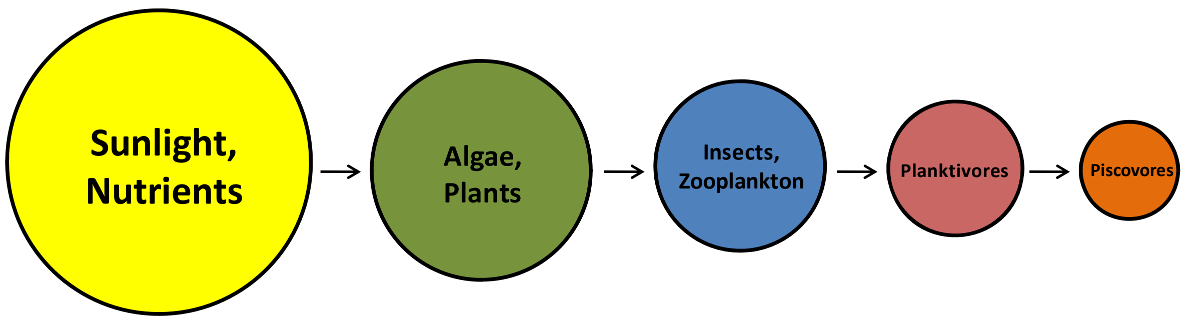


Figure 3.4-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality and Watershed Sections, White Lake is a highly productive lake, meaning it has high nutrient and primary biomass. Simply put, this means that the lake is able to support a larger population of panfish (planktivors) and predatory fish (piscovores) because the supporting food chain is relatively large.

Because White Lake is so productive, it is great habitat for fish, waterfowl and other animals. Fishing and hunting are popular recreational activities that take place on White Lake. According to a stakeholder survey sent to area residents in November 2011, 73% of respondents indicate that they have fished the lake within the past three years (Appendix B – Question #7). Open water fishin was tied with relaxing/entertaining as the top reason for stakeholders to own their property on or near the lake (Question #12). 76% of these survey respondents feel the fishing in the lake is currently fair or good (Question #9). 42% believe the quality of fishing has remained the same since they began fishing the lake, while others are equally divided between feeling the fishing has gotten either better or worse (Question #10).

Management actions that have taken place and will likely continue on White Lake according to this plan include herbicide applications to control Eurasian water milfoil and curly-leaf pondweed. In the future, these applications will occur in May when the water temperatures are below 60°F. It is important to understand the effect the chemical has on the spawning environment which would be to remove the submergent plants that are actively growing at these low water temperatures. Yellow perch is a species that could potentially be affected by early season herbicide applications, as the treatments could eliminate nursery areas for the emerged fry of these species.

White Lake Fisheries Management

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. WDNR records indicate that stocking or northern pike, walleye, and largemouth bass occurred in the 1970's and 1980's, however, stocking has ceased since then. Walleye have not been stocked in the lake because of habitat limitations. Other species, including panfish, largemouth bass and northern pike, reproduce very well within White Lake so stocking these species is no longer justified.

In 2008, WDNR biologists visited White Lake to conduct a comprehensive fisheries survey. This survey report can be found in Appendix F, while discussion of the data collected and WDNR management conclusions is summarized below. Northern pike were found to be the dominant predators in the lake, however the fish exhibited poor size structure and growth. These findings were similar to surveys conducted in 1986, 1993 and 2002. White Lake's large littoral area and abundant plant growth provide exceptional habitat for northern pike spawning. The lake lacks large areas of deep, cool water which is preferable to grow pike of larger size. During this survey, walleye abundance was shown to increase from 2002, but only slightly (0.4 per acre in 2002 compared to 0.5 per acre in 2008). Between predation from other fish species and lack of spawning habitat, walleye populations really do not have the necessary variables to expand.

One problematic species for White Lake, common carp, was found to be in greater abundance in 2008 when compared to the 2002 survey. Carp were brought into North America in the late 1800's when they were used as a domesticated food fish. They soon escaped from fish farms and were introduced into nearby lakes and streams. These large, omnivorous fish feed upon submersed vegetation – uprooting plants and stirring up organic sediments into the water column as they do so. This activity can harm aquatic habitats. The WDNR has advised lake residents to do several things in order to reduce carp activity, including:

1. Remove any carp that are encountered while angling or bowfishing
2. Encourage abundant predator fish to feed upon small carp
3. Maintain the weir on the outlet structure along the east side of White Lake. This will reduce or prevent future carp emigration from downstream areas.

The WDNR will also monitor carp abundance in White Lake. Current plans call for a four year monitoring schedule of fish populations, meaning that a survey will be conducted in 2012.

Regarding other management recommendations for White Lake, Alan Niebur, WDNR fisheries biologist, has had discussions with the WLPA about expanding aeration operations to the east side of the island on White Lake. Winter dissolved oxygen levels are very low throughout the entire water column in this area (Water Quality Section – Figure 3.1-7). An additional aerator would provide more winter habitat for fish and reduce winterkill further.

White Lake Substrate Type

According to the point-intercept survey conducted by Onterra, 94% of the substrate sampled in the littoral zone on White Lake was muck, with the remaining 6% being split evenly between rock and sand (Map 5). 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. Walleye is one species that does not provide parental care to its eggs (Becker 1983). 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. Northern pike is another species that does not provide parental care for their young. Northern pike prefer to lay eggs on aquatic vegetation in shallow, marshy areas of lakes or wetlands. 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 White Lake ecosystem.
2) Collect detailed information regarding invasive plant species within the lake, with the primary emphasis being on Eurasian water milfoil and curly-leaf pondweed.
3) Collect sociological information from White 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 the White Lake ecosystem, the folks that care about the lakes, and what needs to be completed to protect and enhance them.

The studies conducted on White Lake show that the lake is a healthy ecosystem, albeit with several pressing issues that are of concern to lake residents. As discussed in many of the sections above, the lake is host to many aquatic plants. The abundance of plants found in White Lake is troublesome to some residents as they sometimes impede recreational opportunities, such as swimming and fishing, and are a nuisance to clean off of boatmotor props. Furthermore, residents feel that some species, one in particular, wild rice, has increased its presence in some areas of the lake and is reducing the amount of open water. While the presence of an abundance of aquatic plants in a shallow, large lake certainly has some disadvantages, the advantages of this plant growth are present as well.

One of the advantages of having a healthy aquatic plant community is of its role in better water quality. White Lake is a productive system, meaning that nutrient content is sufficient to produce high levels of plant and algal biomass. Shallow, productive lakes typically fall into one of two categories – *clear-state* and *turbid-state* lakes. Clear state lakes are characterized by having clear water, yet enough nutrients to produce abundant vegetation. Turbid state lakes may have the same amount of nutrients within them; however, it is algae that utilize these nutrients. As a result, the water becomes turbid and vegetation, especially submersed forms, are sparse. These two states are "stable" in that the lake will persist in this way until a disturbance shifts the system from one state to the other.

White Lake is definitely a clear state lake. The Watershed Section describes that White Lake receives a moderately large amount of phosphorus from the surrounding land. As the results of chlorophyll-*a* monitoring indicates, this nutrient supports a modest amount of algae, which in turn allows for high water clarity for a lake with a relatively high nutrient load. Instead of supporting highly abundant algae growth, which is the case for turbid state lakes, nutrients in White Lake support abundant aquatic plant growth. The Fisheries Section discusses the diverse and productive gamefish community, which is the result of the large amount of habitat the aquatic macrophytes provide.

A second advantage of an abundant population is the habitat opportunity. Small crustaceans, called zooplankton, are able to find cover within the aquatic plants from their primary prey – planktivorous fish. The zooplankton feed upon algae primarily. Their grazing keeps algae numbers low, which further increases the water clarity in the lake. Without the aquatic vegetation, the zooplankton are easy prey for small fish species. When zooplankton numbers decrease, the algae population increases, lowering light and nutrients availability for aquatic plant growth. In some lakes, as the plant population continues to crash, the algae population increases to the point that the lake "flips" from a clear state to a turbid state system.

Clear state lakes also provide good habitat for aquatic organisms like fish. Abundant plant life creates refuge for small fish, who are able to avoid from larger predatory fish using the plants as cover. However, despite this situation working out well for the smaller fish species and younger predatory fish, mature predatory fish can have difficulty feeding upon smaller fish without expending a great deal of energy. Some fisheries biologists believe that the solution in productive lakes such as White Lake is to harvest open lanes throughout the lake. Besides aiding in navigation for recreationalists and anglers, this creates some open area for predatory fish to hunt prey fish. Because predation is increased upon smaller fish species, it is hoped that predatory fish size structure and numbers increase while smaller fish species are decreased in number yet an increase is seen in size structure. Currently, the WLPA operates a mechanical harvester to clear navigation lanes on the lake.

Finally, an added benefit of a healthy, productive aquatic plant community is that the lake is better able to compete against exotic plant communities. Exotic plants such as curly-leaf pondweed and Eurasian water milfoil need to first displace native vegetation in order to establish themselves. While these exotic plants have several ecological advantages that do allow them to displace native plants, a healthy native plant community makes it more difficult for this displacement to occur. As mentioned in the Introduction, Eurasian water milfoil was discovered by the WDNR in 1989. So, the plant has existed within White Lake for quite some time already. The abundant native plant community has likely aided in keeping this plant from colonizing strongly and "taking over" large areas of the lake.

The analysis described in the Aquatic Vegetation Section indicates that while abundant plant biomass exists within White Lake, the plant community is of high quality, adding additional evidence to the general good health of the lake. The number of native species is exceptionally high, and many of these species are of high quality as well. Species such as wild rice provide habitat and food for aquatic organisms, as well as waterfowl. However, as previously stated, residents on White Lake believe the wild rice population is expanding and taking over new areas of the lake. While their anecdotal reports are likely true, it is difficult to quantify this change as accurate mapping of the species has never taken place before 2010. Additionally, wild rice is an annual plant, which means that each year new plants sprout upward from seed that was laid the previous year. Seed dispersal may change from year to year, and as a result fluctuations exist in the density and extent of these rice communities annually. These changes are often seen every 3 years or so. The 2010 community map provides accurate delineations and acreages of wild rice dominated areas. It is recommended that this survey be conducted again in approximately 5 years to determine changes that have occurred in the wild rice community.

Currently, the most pressing problem the WPLA and other White Lake residents are facing is the threat of aquatic invasive plants, specifically, curly-leaf pondweed and to a lesser extent Eurasian water milfoil and purple loosestrife. At this time, the occurrence of purple loosestrife is not alarming, however, action should be taken to reduce the population while it is minimal.

Management of this plant should not be costly, as long as funding opportunities are taken advantage of and volunteer efforts are sufficient.

Eurasian water milfoil was observed growing throughout the entire lake, however, there were no significantly dense areas spotted. Rather, the plant is sporadically growing throughout the lake in the form of single plants, small clumps of plants, and only several sizable (10-20 feet in diameter) colonies. At this time, no immediate control action is recommended. Further monitoring of the plant will be necessary in the years to come though, as the density may increase to the point where a control action (such as an herbicide treatment) is warranted.

The presence of 17+ acres of primarily surface-matted curly-leaf pondweed on White Lake is of particular concern. Curly-leaf pondweed has an interesting life cycle - in fall, new plants sprout up from turions (asexual reproductive structures) left by plants from the previous summer. These plants grow ever so slightly during the winter months. As soon as the ice leaves the lake in the spring, the plants grow very rapidly. In early summer, the plants begin producing turions. New research suggests that these turions are produced both on the above sediment portions and on the rhizomes of the plant. In midsummer, when native plants are just starting to reach their peak growth, the curly-leaf pondweed dies back, leaving a new crop of turions behind to produce plants for the following year.

In the past few years, managers have theorized that harvesting curly-leaf pondweed may be of benefit to control this species. The control strategy was to harvest the plant in late spring, before turion production began. However, additional research by the United States Army Corps of Engineers (USACE) indicates that injured curly-leaf pondweed plants are still able to produce turions, and these stressed plants may produce even more turions in this condition (John Skogerboe, personal comm.). While harvesting may appear to be effective at removing the upper and middle portions of the plant, turions are still produced low on the plant and on the rhizome.

Curly-leaf pondweed has likely been in the White Lake ecosystem for quite some time to grow to this extent. As a result, the plant has likely built a large turion base as well, which will continue to produce new plants for years to come. Now that mechanical harvesting curly-leaf pondweed as a method of control is out of the picture, herbicide treatments targeting the densest areas of the plant are recommended in the near future. These treatments will consist of a contact herbicide application. Applications for curly-leaf pondweed control occur in early spring, as this action targets the plant prior to its producing turions. As discussed within the Implementation Plan, this control strategy takes numerous years of effort as the turion base must be exhausted in order to achieve relief from this aggressively growing plant.

A somewhat controversial issue amongst White Lake residents is the use of a mechanical harvester to cut navigation lanes within the lake. The WLPA oversees operation of this harvester. As mentioned previously, these lanes likely impact the fishery in a beneficial nature as well as improving navigation for boaters on White Lake. Some lake residents believe operation of the harvester is spreading exotic plants further within the lake. This is likely true for curly-leaf pondweed to a small extent, and not a crucial element in the spread of Eurasian water milfoil. Eurasian water milfoil is already spread throughout the lake in low densities. Furthermore, Eurasian water milfoil undergoes auto-fragmentation periodically through the summer months, so it is likely that this plant is spread on its own more efficiently than if a harvester was to spread it.

When it comes to curly-leaf pondweed, however, the harvester has probably contributed to the spread of this invasive plant in the upper reaches of the lake, likely contributing to the narrow strip of plants observed outside of the harvester offloading location (Map 10). In the future, the harvester should be operated as it currently has, which would be to avoid areas of dense curly-leaf pondweed. Efforts to avoid Eurasian water milfoil could be implemented as well, particularly if dense areas are observed nearby navigation lanes.

Overall, White Lake is good condition. At this time, the most pressing issues facing the lake consist of reducing the curly-leaf pondweed population and ensuring that Eurasian water milfoil does not proliferate within the lake. The fact that White Lake is managed by several entities (White Lake Preservation Association and White Lake Aeration Club) is going to be one of the largest management difficulties. Despite disputes that have occurred in the past, a partnership and line of communication between these organizations is needed to ensure that management strategies dovetail and the health of the entire waterbody is considered.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the WLPA Planning Committee and ecologist/planners from Onterra. It represents the path the WLPA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the White 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: Facilitate Partnerships with Other Management Entities

Management Action: Coordinate all entities that have a hand in managing (management units) White Lake.

Timeframe: Begin summer 2013

Facilitator: Board of Directors to appoint WLPA representatives

Description: The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. Some of these entities are governmental while others organizations are citizen-based like the WLPA

It is important that the WLPA actively engage with all management entities to enhance the association's understanding of common management goals and to participate in the development of those goals. This also helps all management entities understand the actions that others are taking to reduce the duplication of efforts. While not an inclusive list, the primary management units regarding White Lake are the White Lake Preservation Association, Ltd., White Lake Aeration Club, WDNR, Waupaca County Land and Water Conservation Department (WCLWCD). Each entity will be specifically addressed below.

State of Wisconsin The WDNR is responsible for managing the natural resources of the State of Wisconsin. Primary interaction with the WDNR is from an advisory and regulatory perspective. The WLPA has worked closely with the Regional Lakes Coordinator (Ted Johnson – 920-787-3048) and that relationship should continue. White Lake contains a highly valued fishery. The WLPA should be in contact with the WDNR fisheries biologist (Alan Neibur – 715.526.4227) at least once a year to discuss pertinent fisheries-related issues. Current discussions with the WLAA concern addition of a second aerator to alleviate winter fish kill due to lack of dissolved oxygen.

County Conservation Department Conservation specialists at the WCLWCD (Greg Peterson – 715.258.6245) are available to discuss specific conservation projects applicable to White Lake. Officials within the WCLWCD such as Mr.

Peterson may be able to assist White Lake residents with conservation projects such as shoreline enhancement or conservation easements.

<u>Golden Sands Resource Conservation & Development Council, Inc</u>. Golden Sands RC&D is an independent, non-profit organization operated out of the University of Wisconsin-Stevens Point. Amongst other natural resources services, their specialty is working with aquatic invasive species. Kaycie Stushek (715.343.6278) is the contact for Waupaca County and may be reached to coordinate a number of projects for White Lake, such as purple loosestrife control and Clean Boats/Clean Waters training.

<u>WLPA and WLAA</u> These are the primary management units on White Lake. According to some lake residents' reports, there has been a long-standing discontent between the two groups, primarily over the use of the harvester on the lake. With such important pressing issues facing White Lake (exotic species, low winter dissolved oxygen, etc.), it is vital that these two groups put any past differences aside and work together to ensure these issues are faced properly. With a management plan in place that calls for specific actions that are enacted in the best interest of the lake, it should be easier for these two groups to rally around protecting White Lake as a united front.

Action Steps:

Please see description above.

Management Goal 2: Maintain Current Water Quality Conditions

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

Timeframe: Beginning Summer 2013

Facilitator: Planning Committee

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

The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. At this time, there are no WLPA members currently collecting data as a part of the CLMN. Volunteers trained by the WDNR as a part of the CLMN program begin by collecting Secchi disk transparency data for at least one year, then if the WDNR has availability in the program, the volunteer may enter into the *advanced program* and collect water chemistry data including chlorophyll-a, and total phosphorus. The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. Note: as a part of this program, these data are automatically added to a WDNR database called the Surface Water Integrated Monitoring System (SWIMS).

At a minimum, CLMN volunteers collecting Secchi disk data should be in place on White Lake. It is the responsibility of the Planning Committee to find volunteers to collect these data, as well as coordinate new volunteers as needed. When a change in the collection volunteer occurs, it will be the responsibility of the Planning Committee to contact Andrew Hudak (920.662.5117) or the appropriate WDNR to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer.

Action Steps:

Please see description above.

Management Goal 3: Control Existing and Prevent Further Aquatic Invasive Species Infestations within White Lake

Management Action: Continue Clean Boats Clean Waters watercraft inspections at the White Lake public access

Timeframe: In progress

Facilitator: Planning Committee

Description: Members of the WLPA have been trained on Clean Boats Clean Waters (CBCW) protocols and complete boat inspections at the public landings on a regular basis. The intent of the boat inspections is to prevent additional invasives from entering the lake through its public access points, in addition to preventing exotics from White Lake being transported to other waterbodies. The goal is to cover the landings during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on lakes and educating people about how they are the primary vector of its spread. In 2010, 191 boats were inspected and 348 people contacted during over 226 hours of watercraft inspections.

Action Steps:

1. Members of association periodically attend Clean Boats Clean Waters training session through the volunteer AIS Coordinator Kaycie Stushek (715.343.6278) to update their skills to current standards.
2. Training of additional volunteers completed by those trained during the summer of 2012.
3. Begin inspections during high-risk weekends
4. Report results to WDNR and WLPA
5. Promote enlistment and training of new of volunteers to keep program fresh.

Management Action: Coordinate AIS identification for CBCW volunteers, harvester operators, and other interested stakeholders.

Timeframe: Initiate in 2013

Facilitator: Planning Committee

Description: Members of the WLPA have been trained on Clean Boats Clean Waters (CBCW) protocols, however training these individuals to identify AIS such as Eurasian water milfoil and curly-leaf pondweed is important as well. Additionally, it would be useful to have White Lake harvester operators trained on AIS identification techniques so they may avoid large colonies of AIS during harvester operation (see Management Goal 4). AIS Coordinator Kaycie Stushek will be contacted by the White Lake Planning Committee to arrange for an identification training session.

Action Steps:

1. Members of association periodically attend identification sessions through the volunteer AIS Coordinator Kaycie Stushek (715.343.6278) to update their skills to current standards.
2. CBCW volunteers and harvester operators will be required to attend this session.
3. Announcements of identification sessions can be advertised in the WLPA newsletter to seek additional stakeholders that would be interested in identification training.

<u>Management Action:</u> Monitor Eurasian water milfoil within White Lake.

Timeframe: Beginning in 2013

Facilitator: Planning Committee

Applicable Grant Funding: WDNR Aquatic Invasive Species Established Population Control Grant

Description: Eurasian water milfoil was mapped in 2010 by Onterra ecologists. During this survey, plants were found to be spread throughout the entire lake, though at low densities. It is believed that the strong native plant community is preventing dense clumping of this exotic plant. In some lakes, exotic species exist much as a native species and do not significantly impact the ecology of the lake. At this time, Eurasian water milfoil is not believed to be impacting the lake in a significantly negative manner. However, despite low urgency of enacting a control strategy on Eurasian water milfoil now, the WLPA needs to be prepared for the worst case scenario, which would be if Eurasian water milfoil gains a further competitive edge and is able to form dense colonies of significant size within the lake.

During the summer of 2012 the Eurasian water milfoil mapping survey will be repeated on White Lake. The results of that survey will be compared with those of the 2010 survey to determine if the plant is spreading and becoming denser within the lake. If it is spreading and becoming denser, a control strategy will be devised and the management plan will be updated to include those actions. If Eurasian water milfoil population is found to be remaining approximately the same, an appropriate monitoring strategy will be formulated. It is expected that monitoring will be completed by professional ecologists on an annual basis. Crews mapping curly-leaf pondweed (discussed within the next management goal) could take a quick peek at known Eurasian water milfoil locations to catch early signs of colonial formation or expansion, then revisit these areas during late season peak growth, if necessary.

Action Steps:

1. Obtain survey bids from professional lake management firms during spring 2012.

2. Apply for a WDNR grant during August 1, 2012 cycle. This grant may be written in conjunction with a grant written for curly-leaf pondweed control (see below Management Action).
3. Follow steps outlined in description above.

Management Action: Initiate herbicide control strategy to address curly-leaf pondweed infestation on White Lake.

Timeframe: Initiate in 2013

Facilitator: Planning Committee with professional help as needed

Applicable Grant Funding: WDNR Aquatic Invasive Species Established Population Control Grant

Description: As described in the Aquatic Plant Section and in the Summary & Conclusions, the most pressing threat to the health of White Lake's aquatic plant community is curly-leaf pondweed. The 2011 curly-leaf pondweed peak biomass survey indicates that this plant has produced dense colonies covering almost 18 acres within the lake (Map 8).

At this time, the most feasible method of control would be herbicide applications - specifically, early-spring treatments with endothall. As discussed within the Summary & Conclusions Section, curly-leaf pondweed has an interesting life cycle that is different from that of native Wisconsin plants. Because the plant reaches peak growth and turion production in mid-summer, it is important to treat colonies with herbicide before this turion production occurs. As a result, curly-leaf pondweed treatments traditionally occur each year when surface water temperatures are close to 50°F. After multiple years of treatment, the turion base becomes exhausted and the curly-leaf pondweed infestation becomes significantly less. Normally a control strategy such as this includes 3-5 years of treatments of the same area.

The objective of this management action is not to eradicate curly-leaf pondweed from White Lake, as that would be impossible. The objective is to bring curly-leaf pondweed down to more easily controlled levels. In other words, the goal is to reduce the amount of curly-leaf pondweed in White Lake to levels that may be suitable for smaller harvest areas to keep the exotic under control. To complete this objective efficiently, a cyclic series of steps is used to plan and implement this control strategy. These control actions would be conducted during 2012 – 2016. The series includes:

1. A lake-wide assessment of curly-leaf pondweed completed while the plant is at peak biomass (late June 2012-2016). Essentially, areas mapped during the 2011 peak biomass survey would be revisited to determine density levels and if colonial expansion has occurred.
2. Application during the August 1st, 2012 grant cycle for a WDNR Aquatic Invasive Species - Education, Prevention, and Control Grant.
3. Verification and refinement of early-season curly-leaf pondweed treatment areas in spring of 2013-2016.

4. Updated treatment areas submitted to the WDNR to serve as the final treatment permit, followed by completion of a curly-leaf pondweed herbicide treatment.
5. Areas surveyed (post-treatment survey) to determine treatment efficacy and strategy for the following year.
6. Reports generated on treatment success level and following year's strategy.

Once Step 5 is completed, the process would begin again that same summer with the completion of a peak biomass survey. Treatment areas would be visually inspected to determine the efficacy of the treatment with treatment areas. The treatment would be deemed successful if few or no curly-leaf pondweed plants were observed within them. Of course, even with a successful treatment these areas would have to receive further treatments in subsequent years in order to remove plants which would sprout from the turion base built up in the lake sediments. During the annual peak biomass survey, the remaining littoral region (essentially the entire lake) would be visually inspected to determine if other areas of dense, treatable curly-leaf pondweed exist. The survey results would then be used to create the next spring's treatment strategy. The following spring, monitoring would be conducted to "tune" or refine the control strategy as the project proceeds. It is important to note that in order to truly assess the efficacy after several years of treatment, the WLPA would have to forgo treating curly-leaf pondweed colonies for one summer. That way, remaining plants can be viewed and mapped during the peak growth season. Once an updated understanding of the curly-leaf pondweed situation exists, further strategies can be developed.

Funds from the Wisconsin Department of Natural Resources Aquatic Invasive Grant Program will be sought to partially fund this control program. Specifically, funds would be applied for under the Established Population Control classification. These funds will be applied for in the August 1st, 2012 grant cycle in order to allow the WLPA time to financially prepare for their portion of the project costs. The approved project would have a timeline of 2012-2017. In 2016, a series of comprehensive studies would be conducted on White Lake, including a full-lake point-intercept survey and community mapping survey. The results of these studies would be compared to studies conducted as a part of this management planning project. Additionally, a series of meetings would be held to convey the project results and information to the White Lake Planning Committee and then the general public.

The above described project would also include funding for peak-biomass surveys of Eurasian water milfoil, if necessary. During curly-leaf pondweed post-treatment surveys, known locations of Eurasian water milfoil could be visited and mapped. Areas of highly dense and potentially treatable Eurasian water milfoil would be surveyed later in the summer, when this plant reaches its peak growth. At this time, a strategy would be developed to determine if a Eurasian water milfoil herbicide treatment would be necessary for the following spring.

Action Steps:

1. Retain qualified professional assistance to develop a specific project design utilizing the cyclic series of steps discussed above.
2. Apply for a WDNR Aquatic Invasive Species - Established Population Control Grant during the August 1st, 2012 grant cycle.
3. Initiate control plan in 2012.
4. Update management plan to reflect changes in control needs and those of the lake ecosystem.

Management Goal 4: Maintain Navigation in Open Water and Near Shore Areas on White Lake

Management Action: Use mechanical harvesting to maintain reasonable navigation on White Lake.

Timeframe: Ongoing activity

Facilitator: White Lake Preservation Association

Description: As White Lake stakeholders know, and this project's field studies have confirmed, White Lake is a eutrophic system which includes abundant aquatic plant growth. So much plant growth, in fact, that at times navigation is impeded in areas of the lake. Map 10 displays the mechanical harvesting plan that the WLPA will follow to ensure navigability for White Lake stakeholders. This harvesting plan is similar to the plan outlined within the lake's 2003 management plan, though some changes (e.g. lane width) have occurred. Several guidelines for harvesting were discussed between Onterra ecologists, White Lake Planning Committee members, and the WDNR, have been written to protect the ecosystem:

1. The harvesting lanes should not exceed 100 feet in width.
2. Harvesting paths should steer clear of any emergent plant beds.
3. Harvesting paths should remain at least 150 feet from shore.
4. Harvesting should be done after June 30th to avoid damaging fish spawning beds.
5. Marker buoys should be placed in the lake to identify boating lanes and facilitate harvesting operations.
6. The harvester should avoid areas of dense curly-leaf pondweed and Eurasian water milfoil growth.

While the plan above describes navigation lanes of 100 feet in width, this is to be held as a maximum width, not a defined width. This stipulation allows harvester operators some flexibility in navigating around emergent plant communities and colonies of invasive plant species.

As elaborated upon throughout this report, White Lake stakeholders are facing a complicated management issue in the form of invasive species control, namely curly-leaf pondweed and Eurasian water milfoil. Eurasian water milfoil and curly-leaf pondweed may spread aggressively upon entering a lake ecosystem. Eurasian water milfoil may auto-fragment several times throughout the summer months, producing viable fragments that float away from the parent plant and may produce offspring in another location. When curly-leaf pondweed dies off in mid-summer, it produces asexual reproductive structures that disperse to the surrounding sediments, sprouting to form new plants that coming fall.

Because these AIS excel at spreading themselves throughout an aquatic ecosystem on their own means, there is little concern of the harvester operating over areas of single, scattered plants. However, as stated above, the harvester operator should avoid areas of dense AIS growth as to not spread large amounts of plant fragments within the lake.

Action Steps:

1. Contact Ted Johnson, WDNR (920.787.3048), regarding permit applications for 2013 harvesting activities.
2. WLPA harvests in areas shown on Map 10 while following the conditions listed above and on the WDNR permit.
3. Harvest summary report is provided to the WDNR annually after each harvesting season.

6.0 METHODS

Lake Water Quality

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

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

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

Watershed Analysis

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

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on White Lake during June 2nd and June 13th, 2010 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.

Colonies and single occurrences of this AIS were mapped using a Trimble GeoXT Global Positioning System (GPS) with sub-meter accuracy.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on White 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 D" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin, (April, 2007) was used to complete this study on August 30th and 31st of 2010. A point spacing of 82 meters was used resulting in approximately 640 points.

Community Mapping

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

Representatives of all plant species located during the point-intercept and community mapping survey were collected and vouchered by the University of Wisconsin – Steven's Point Herbarium. A set of samples was also provided to the WLPA.

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