Musser Lake

Price County, Wisconsin

Comprehensive Management Plan

April 2013

Sponsored by:

Musser Lake Association

WDNR Grant Program

LPL-1308-10, LPL-1309-10, LPL-1357-10, & LPL-1358-10

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Onterra LLC
Lake Management Planning

Musser Lake

Price County, Wisconsin

Comprehensive Management Plan

April 2013

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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:

Musser Lake Planning Committee

Deb Urbanik
Doris Speich
Ken Urbanik
Bruce Emmerick
Sue Powers
Kathy Miller
Alfred Speich
Frank Spring

Wisconsin Dept. of Natural Resources

Jim Kreitlow
Craig Roesler

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1.0 INTRODUCTION

Musser Lake, Price County, is a 563-acre flowage with a maximum depth of 15 feet. This eutrophic lake has a very large watershed when compared to the size of the lake. Musser Lake contains 49 native plant species, of which coontail is the most common plant. Curly-leaf pondweed, an exotic plant, is known to exist in Musser Lake.

Field Survey Notes

Abundant wildlife observed during surveys of this coffee-water stained flowage. Many different types of habitat observed both within the lake and along shorelines. Curly-leaf pondweed observed in very dense conditions during most of summer.

Photograph 3.3-1 Musser Lake, Price County

Lake at a Glance - Musser Lake

Morphology	
Acreage	563
Maximum Depth (ft)	15
Mean Depth (ft)	5
Shoreline Complexity	13.2
Vegetation	
Curly-leaf Survey Date	June 21-22, 2010 & June 23, 24, 27-2011
Comprehensive Survey Date	August 18-19, 2010
Number of Native Species	49
Threatened/Special Concern Species	None
Exotic Plant Species	Curly-leaf pondweed
Simpson's Diversity	0.90
Average Conservatism	6.6
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	6.8
Sensitivity to Acid Rain	Low
Watershed to Lake Area Ratio	96:1

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 June 19th, 2010, a project kick-off meeting was held at to introduce the project to the general public. The meeting was announced through a mailing and personal contact by Musser Lake Association board members. The attendees observed a presentation given by Eddie Heath, an aquatic ecologist with Onterra. Mr. Heath's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation was followed by a question and answer session.

Planning Committee Meeting

On November 3rd, 2011, Eddie Heath of Onterra met with nine members of the Musser Lake Planning Committee. Mr. Jim Kreitlow, WDNR, was also in attendance. The primary focus of this meeting was the delivery of the study results and conclusions to the committee and the development of concise management goals. All study components including curly-leaf pondweed treatment results, aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed. The most pressing concern by this group was the spread of invasive species in the lake.

Project Wrap-up Meeting

Scheduled to occur during the summer of 2013.

Management Plan Review and Adoption Process

Prior to the Planning Committee Meeting (November 3, 2011), an early draft of the Results Sections (i.e. Water Quality, Watershed, Aquatic Plants, and Fisheries Data Integration Sections) of the Lake Management Plan were provided to meeting attendees to enhance the productivity of the meeting. In December 2011, an official first draft of the Musser Lake Management Plan was supplied to the WDNR and the MLA Planning Committee for review. An official review was received from the WDNR Lakes Specialist (James Kreitlow) and the management plan was finalized in April 2013. Formal acceptance of the Implementation Plan Section by the FBLA occurred on January 14 by the Planning Committee.

Stakeholders of Musser Lake

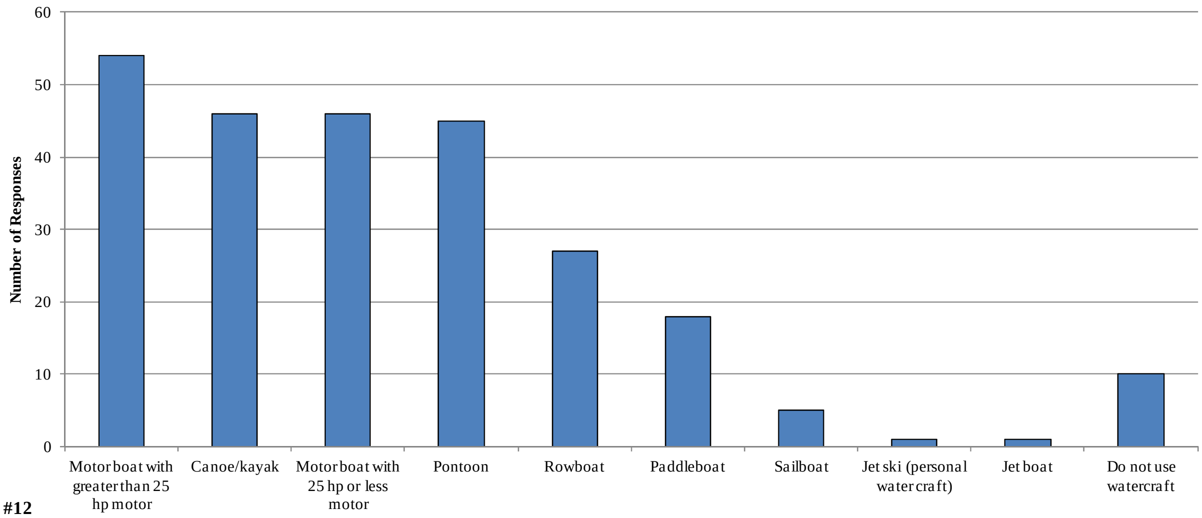
During June 2011, a six-page, 29-question survey was mailed to 261 riparian property owners in the Musser Lake watershed. Forty-six percent of the surveys were returned and those results were entered into a spreadsheet by members of the Musser Lake Planning Committee. The data were summarized and analyzed 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 (Appendix B), much was learned about the people that use and care for Musser Lake. The majority of stakeholders (45%) are part-time residents, either visiting the lake seasonally or on weekends throughout the year (Question #1). About 22% live on the lake year round. Fifty-two percent of stakeholders have owned their property for over 15 years, and 33% have owned their property for over 25 years (Question #3).

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect to these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. Popular watercrafts on Musser Lake include motor boats, canoes/kayaks and pontoon boats (Question 12). As seen on Question #13, several of the top recreational activities on the lake involve boat use. Boat traffic and irresponsible boating was mentioned occasionally within the comments section of the stakeholder survey, but according to Question #19 and #20, this issue ranks below other concerns that stakeholders have for Musser Lake.

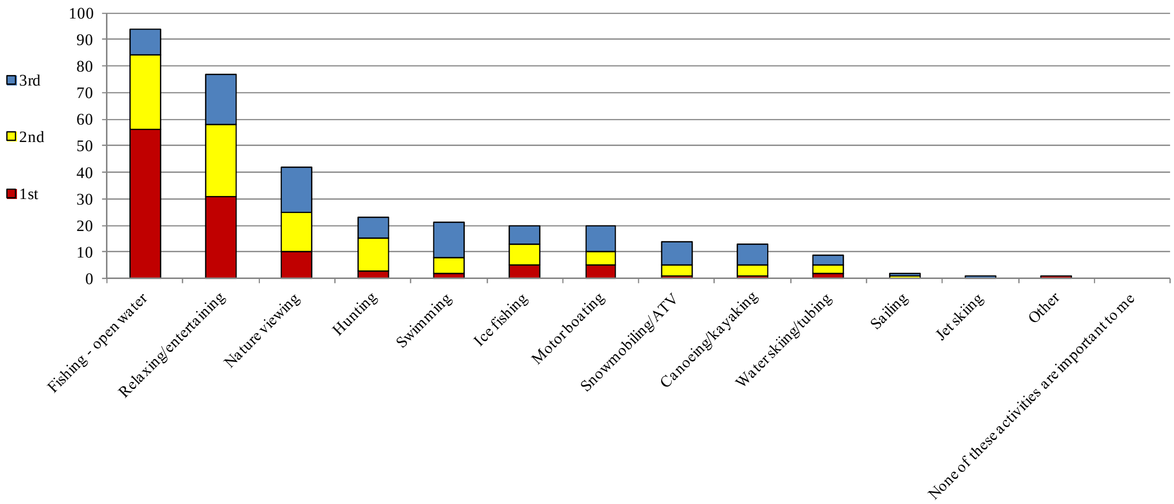
Throughout the stakeholder survey questionnaire and comments, the issue of aquatic invasive species was raised repeatedly (Figure 2.0-2 and comments section of Appendix B). The majority of Musser Lake residents (95%) seem to be aware of the threat aquatic invasive species pose to lake ecosystems (95% of respondents – Question #16), while a slightly lower majority are aware of the species that are located in Musser Lake (86% of respondents – Question #17). While many are aware of the curly-leaf pondweed issue that has affected this waterbody since 2002, a fair amount of survey respondents have misconceptions regarding other aquatic invasive species. For example, 39 respondents believe that Musser Lake holds Eurasian water milfoil. As mentioned in the Aquatic Plant Section, this invasive plant has not been discovered in Musser Lake. Musser Lake currently harbors two aquatic invasive species – Chinese mystery snail and curly-leaf pondweed. More discussion of curly-leaf pondweed can be found in the Aquatic Plant Section, Summary and Conclusions Section and Implementation Plan.

Question 12: What types of watercraft do you currently use on the lake?



#12

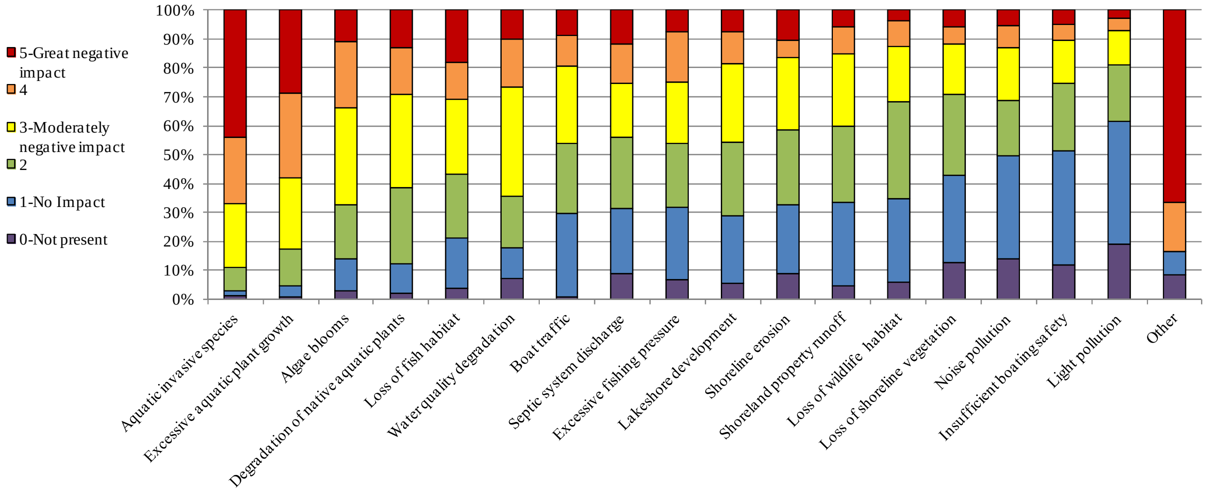
Question 13: Please rank up to three activities that are important reasons for owning your property on or near the lake.



#13

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

Question 19: To what level do you believe these factors may be negatively impacting Musser Lake?



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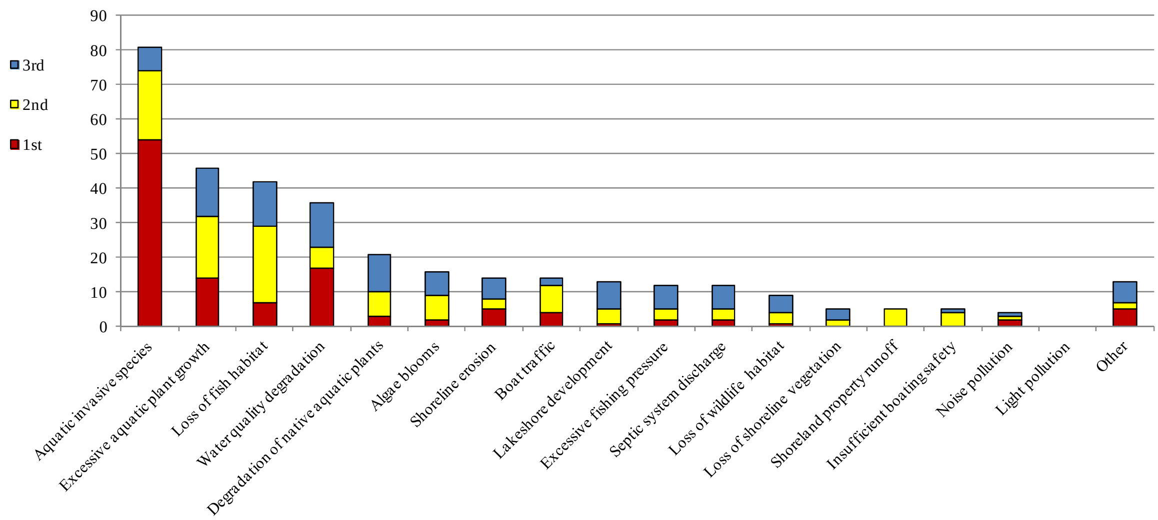
Question 20: Please rank your top three concerns regarding Musser Lake.



#20

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

Question 16: Have you ever heard of aquatic invasive species?

	Total	%
Yes	113	*95.0*
No	6	*5.0*
	119	*100.0*

Question 17: Are you aware of aquatic invasive species in Musser Lake?

	Total	%
Yes	97	*85.8*
No	16	*14.2*
	113	*100.0*

Question 18: Which aquatic invasive species are you aware of in Musser Lake?

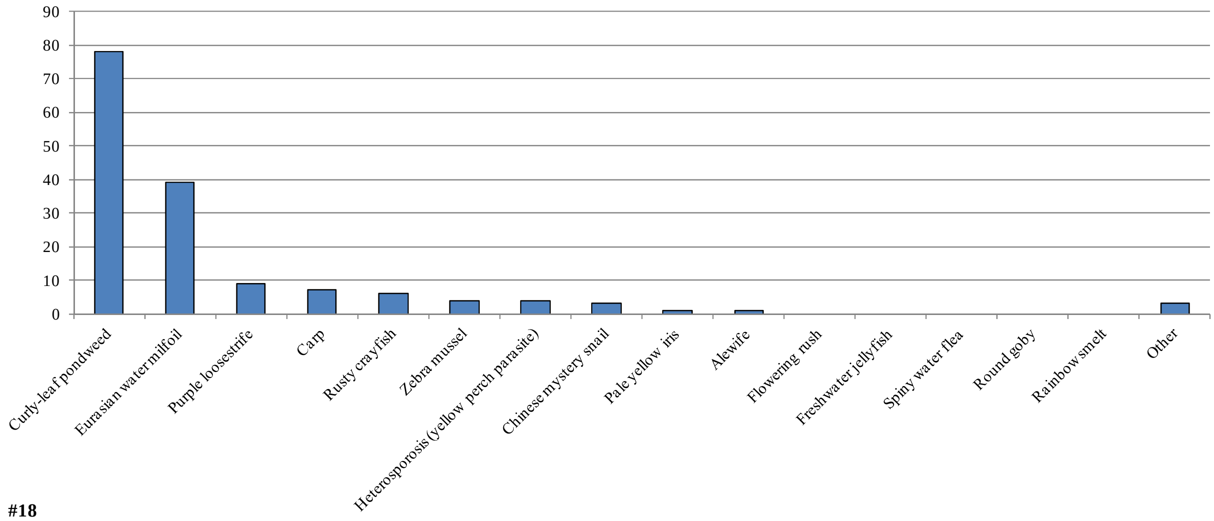


Figure 2.0-3. Select survey responses from the Musser Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

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 Musser 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 Musser 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 because he developed his TSI equations on the basis of association among water clarity, chlorophyll-*a*, and total phosphorus values.

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 month 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 Musser 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 the entire 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) incorporates the maximum depth of the lake and the lake's surface area and 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:

Reservoirs or **Impoundments** are lakes that can attribute half or more of their water volume to a dam or control structure, like Musser Lake. However, current regional water quality data are not yet available for impounded waters, and these systems most closely resemble shallow (mixed), lowland drainage lakes. Therefore, for this report, Musser Lake will be classified as a shallow (mixed), lowland drainage lake.

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.

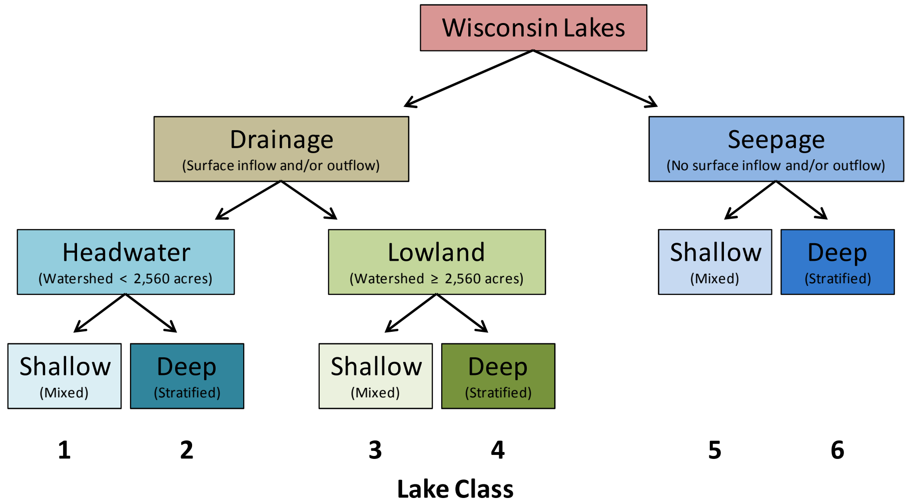


Figure 3.1-1. Wisconsin Lake Classifications. Musser Lake is classified as a shallow (mixed), lowland drainage lake (Class 3). Adapted from WDNR PUB-SS-1044 2008.

The WDNR 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. Musser Lake is within the Northern Lakes and Forests ecoregion.

The Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM), created by the WDNR, is another useful tool in helping lake stakeholders understand the health of their lake compared to others within the state. Looking at pre-settlement diatom population compositions from sediment cores collected from numerous lakes around the state, they were able to infer a reference condition for each lake's water quality prior to human development within their watersheds. Using these reference conditions and current water quality data, they were able to rank phosphorus, chlorophyll-*a*, and Secchi disk transparency values for each lake class into categories ranging from excellent to poor.

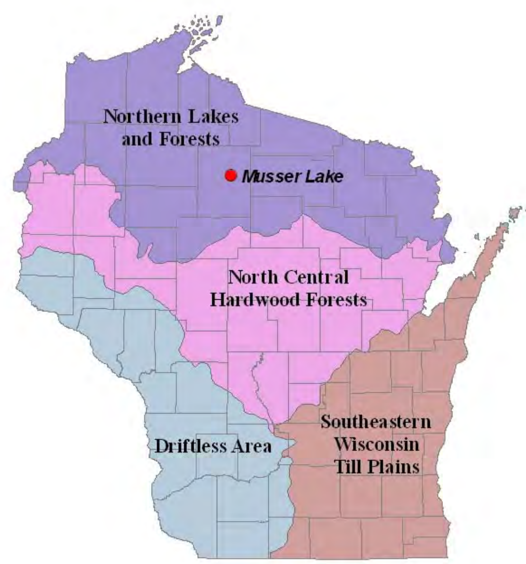


Figure 3.1-2. Location of Musser Lake within the ecoregions of Wisconsin. After Nichols 1999.

These data along with data corresponding to statewide natural lake means, historic, current, and average data from Musser Lake is displayed in Figures 3.1-3 - 3.1-6. 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.

Musser Lake Water Quality Analysis

Musser Lake Long-term Trends

Perception of water quality often varies greatly from person to person. This variance is due to differences in the tolerance and past experiences of people. In short, the water quality of a given lake might be poor to one person, but rather good to another person who has spent considerable time on other lakes that have poor water clarity, algae problems, or other water quality issues. When asked how they would describe the current water quality of Musser Lake, 45% of respondents in a stakeholder survey responded "poor" to "fair", while about 32% stated they believed the water was "good" or "excellent" (Appendix B, Question #14). Thirty-seven percent of survey respondents believe the water quality has degraded since they first visited the lake, while that same percentage believe the water quality has remained the same (Question #15). Water quality degradation was listed as the 4^{th} top concern among Musser Lake stakeholders (Question #20). The use of factual, scientific data regarding water quality allows the ability to indicate with certainty what the water quality of a lake is, and by comparing to historic data, understand if the water quality has changed over time.

As previously stated, there are three primary parameters that are analyzed when determining the water quality of a lake – total phosphorus, chlorophyll-*a*, and Secchi disk clarity. These three measurements are fairly inexpensive to test, but at the same time convey a great amount of information regarding the waterbody. These three parameters are closely related as well; as phosphorus increases, algae consume this nutrient and produce more chlorophyll-*a*, which in turn makes the water column increasingly turbid and lowers the Secchi disk clarity. Of course, examining these data is not always this simple or straightforward. As described below, there are often other factors at work to influence the chemistry and clarity of lake water.

Through monitoring conducted by volunteers with the Citizens Lake Monitoring Network, there has been a great deal of water quality data collected on Musser Lake. Consistent annual data spans the years 1993-2010. Average annual phosphorus values have fluctuated much over this time frame (Figure 3.1-3), as have chlorophyll-*a* concentrations (Figure 3.1-4), though to a lesser extent. Weighted averages for both of these parameters are greater than the averages for other shallow, lowland drainage lakes across the state.

Phosphorus values have ranged between 31 μg/L and 84 μg/L, or categories of Good to Fair. However, most summer annual average values fall around 50 μg/L. Only in 1973, 1997, 2000, 2001 and 2010 did values exceed an average 60 μg/L through the course of the summer months. Similarly, average annual chlorophyll-*a* values have fluctuated during this time period. Summer averages range between 3.6 μg/L and 25.1 μg/L, or categories of Excellent to Fair. Interestingly, the highest recorded average values occurred in years 1997, 2005, 2006, 2007 and 2011. Under most circumstances, phosphorus and chlorophyll-*a* in lakes are highly correlated. During the years in which phosphorus was quite high, only once was chlorophyll-*a* also higher than normal (1997). In fact, in years 2000, 2010 and 2011 it seems that these two parameters were inversely correlated. In 1994, only a single early summer phosphorus sample was collected from Musser Lake, so a comparison between this and the three chlorophyll-*a* samples is not scientifically sound. However in all other years, sufficient sampling occurred to allow for more accurate comparisons to be made. This is an indication that there are likely other environmental factors playing a significant role in the water quality of Musser Lake.

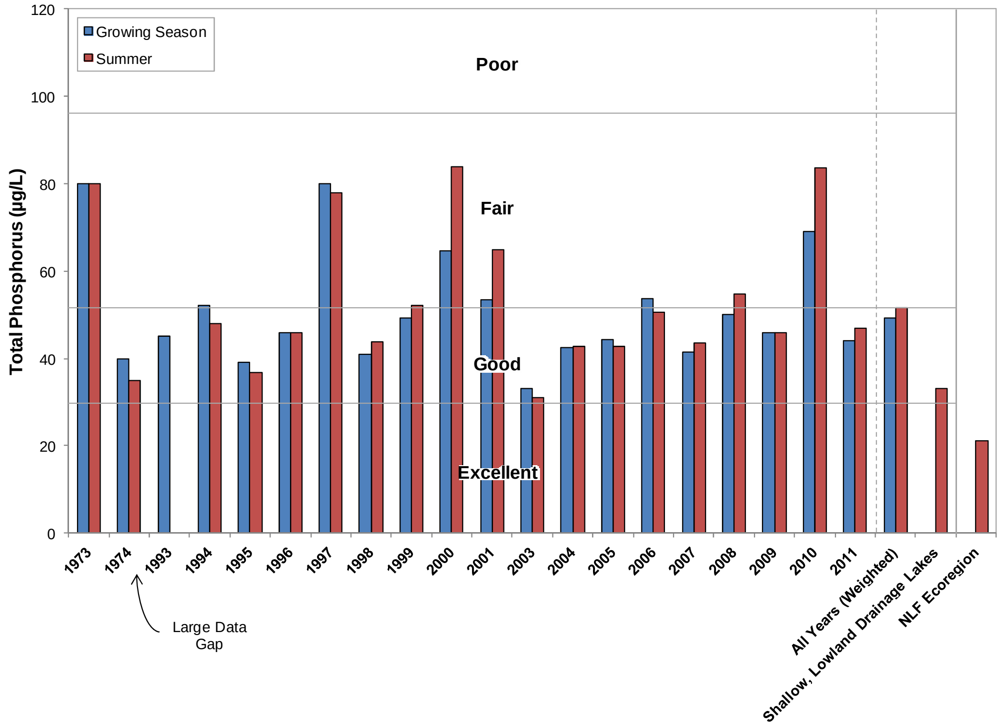


Figure 3.1-3. Musser Lake, state-wide class 3 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

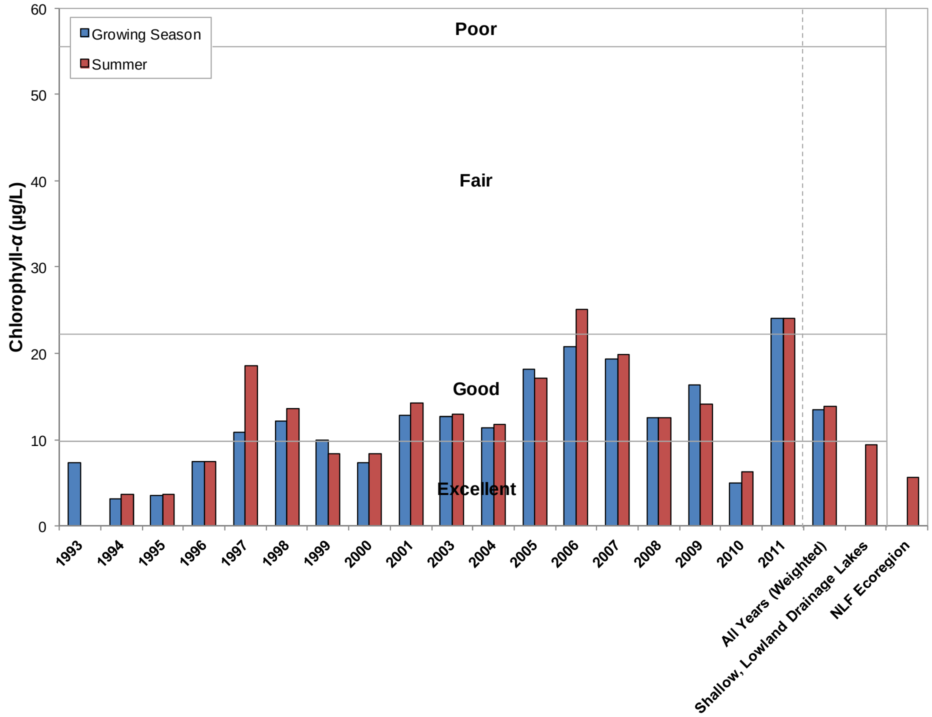


Figure 3.1-4. Musser Lake, state-wide class 3 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Annual average Secchi disk clarity values have remained steadily between 2 and 4 feet deep from 1993-2010, with the exception of a particularly clear-watered year in 2003 (Figure 3.1-5). These values fall primarily within categories of Good and Fair, and are lower than shallow, lowland drainage lakes across the state. There is little to no correlation between this data set and the chlorophyll-*a* dataset, indicating that there is a factor or factors besides algae that is determining the clarity of the water.

Flowages such as Musser Lake often have large watersheds that drain many acres of forested lands and wetlands. When water drains these tracts of land into the lake, naturally occurring organic acids accumulate and stain the lake water a dark brown color. This is the cause of Musser Lake's "root beer" color. Furthermore, it is this factor that is limiting light penetration into the waters of the lake which in turn limits algal production as well as the depth of aquatic plant growth (see the Aquatic Plant Section).

In addition to stained water reducing algal production in Musser Lake, the high flushing rate of the lake (discussed in the Watershed Section) reduces algal growth as well. Water in Musser Lake replenishes itself completely in around 18 days. This high water turnover limits exposure of water column nutrients to algae cells, and thus reduces their abundance.

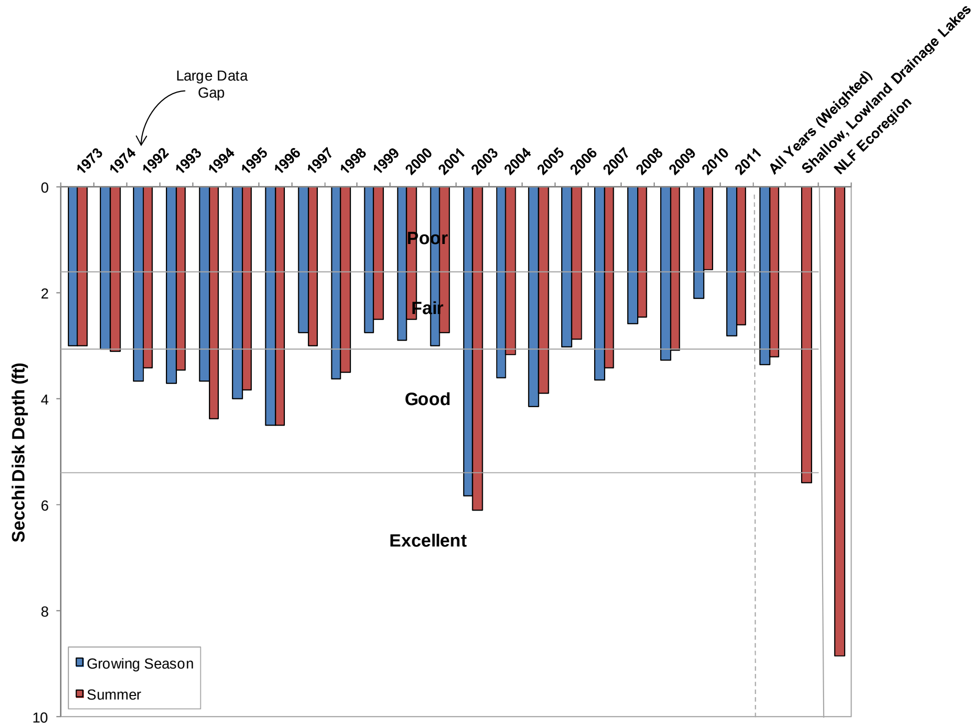


Figure 3.1-5. Musser Lake, state-wide class 3 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Musser Lake

Using midsummer nitrogen and phosphorus concentrations from Musser Lake, a nitrogen:phosphorus ratio of 27:1 was calculated. This finding indicates that Musser 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.

Musser Lake Trophic State

Figure 3.1-6 contain the TSI values for Musser Lake. The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range between mostly eutrophic and 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* TSI values, it can be concluded that Musser Lake is eutrophic.

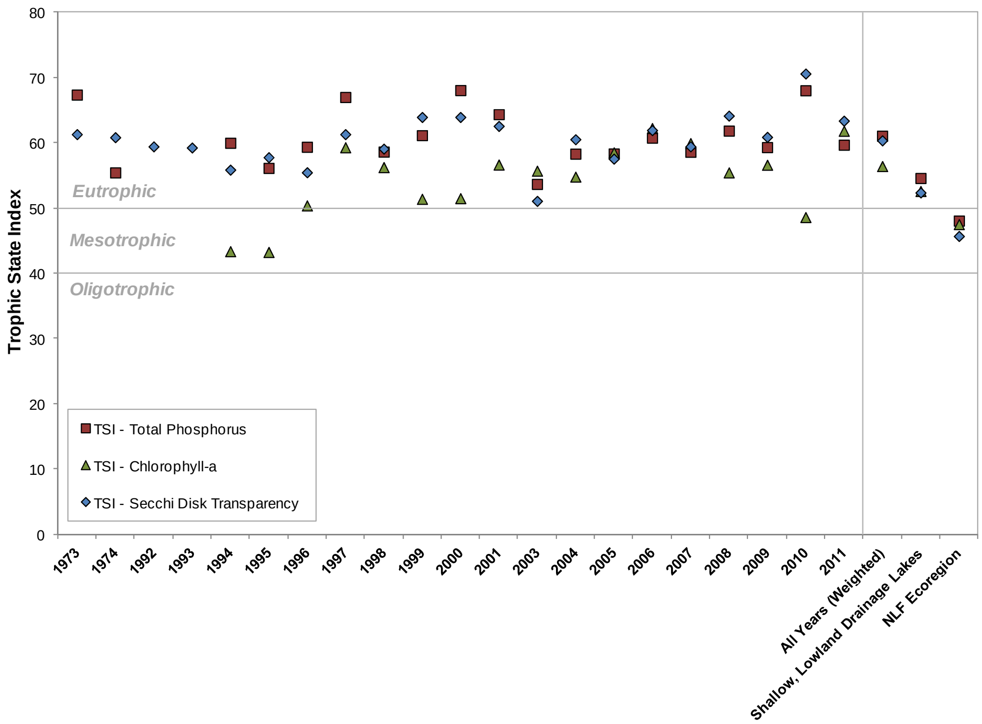


Figure 3.1-6. Musser Lake, state-wide class 3 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Additional Water Quality Data Collected at Musser 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 Musser Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw and Nimphius 1985). The pH of the water in Musser Lake was found to be near neutral with a value of 6.8, and falls within the normal range for Wisconsin Lakes.

The water's 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

Musser Lake's pH of 6.8 falls slightly outside of this range. 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 larval zebra mussels (called "veligers") were discovered in these samples. Musser Lake is also determined to be "Not Suitable" for zebra mussel invasion by Wisconsin AIS Smart Prevention website (www.aissmartprevention.wisc.edu/), while some other lakes within the Elk River basin (Duroy, Elk Lake, and Lac Sault Dore) are considered "Borderline Suitable" for zebra mussel infestation.

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 Musser Lake was measured at 25.5 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and is not sensitive to acid rain.

3.2 Watershed Assessment

Watershed Modeling

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

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

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

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

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

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

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

The watershed draining to Musser Lake is approximately 54,702 acres (Map 2). The majority is comprised of forested land (61%) and wetlands (33%), while pasture/grass, the surface of Musser Lake, and row crop agriculture make up the remaining 6% (Figure 3.2-1). The watershed area is significantly larger than the lake, with a watershed to lake area ratio of 96:1. As previously discussed, lakes that have large watershed to lake area ratios are likely to be productive systems regardless of the land cover types within their watersheds. This is the case with Musser Lake. The land within the system's watershed is predominantly comprised of types that are very efficient at retaining nutrients and allowing precipitation to be absorbed into the ground, which results in minimal nutrient runoff. However, despite minimal nutrient runoff, the sheer size of Musser Lake's watershed delivers sufficient amounts of nutrients to create a productive, eutrophic system.

WiLMS modeling utilizing the land cover types and acreages found in Figure 3.2-1 resulted in a predicted mean growing season phosphorus value of 29.0 µg/L; approximately 20 µg/L less than the weighted growing season total phosphorus for all years (49.3 µg/L). The discrepancy between observed and predicted phosphorus values usually indicates that there are unaccounted phosphorus inputs to the lake normally originating from sources such as faulty septic systems, unknown agricultural draintile lines that enter the lake, internal nutrient loading from bottom sediments or possibly even curly-leaf pondweed die-off. However, it is believed that the discrepancy generated by the Musser Lake watershed model is a result of Musser Lake's morphology; specifically, Musser Lake more closely resembles a riverine system than that of lake. The model estimated that Musser Lake's flushing rate is 0.05 years, meaning that 100% of the water volume within Musser Lake is replaced approximately every 18 days. This high flow rate is believed to be the reason why the WiLMS model cannot generate an accurate phosphorus prediction because the model is setup for lake systems as opposed to a more riverine system such as Musser Lake.

While it is believed the WiLMS modeling was unable to predict an accurate annual growing season phosphorus value for Musser Lake, this model does indicate that forested lands and wetlands are the largest contributors of phosphorus to Musser Lake at 45% and 27% respectively (Figure 3.3-2). Row crops are the third-largest contributor of phosphorus to Musser Lake, accounting for 22% of the annual load despite making up only 3% of the lake's watershed (Figure 3.3-1). As discussed earlier, row crops increase the amount of surface runoff and decrease the amount of water that get absorbed into the ground. The remaining 6% is delivered from pasture/grass and rural open space and via atmospheric deposition directly into the lake (Figure 3.3-2).

Despite the approximately 1,500 acres of row crop agriculture, the vast majority of Musser Lake's watershed is an excellent shape; the majority remaining undeveloped with intact forests and wetlands dominating the land cover. While some small areas exist within shoreline areas of the lake that could qualify as candidates for restoration (discussed in *Shoreline Assessment* below), the restoration of these areas, while beneficial, would likely not have a noticeable impact on improving the water quality of Musser Lake. However, restoration of these areas would improve wildlife habitat, most notably fish, which have been shown to decline in abundance when associated with developed shorelines (Radomski and Goeman 2001). Restoration of these areas would also enhance the aesthetic beauty of the lake. Within areas of row crop agriculture, creating vegetation buffer areas around drainage areas and rotating crops can minimize the phosphorus loading coming from these areas.

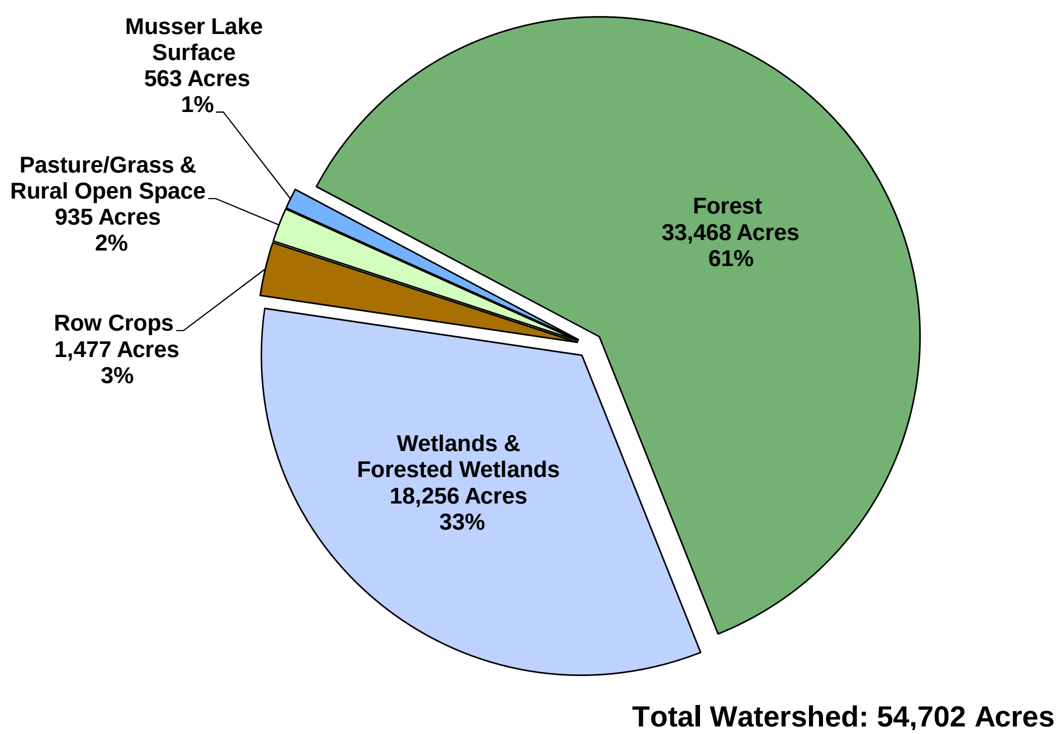


Figure 3.2-1. Musser Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

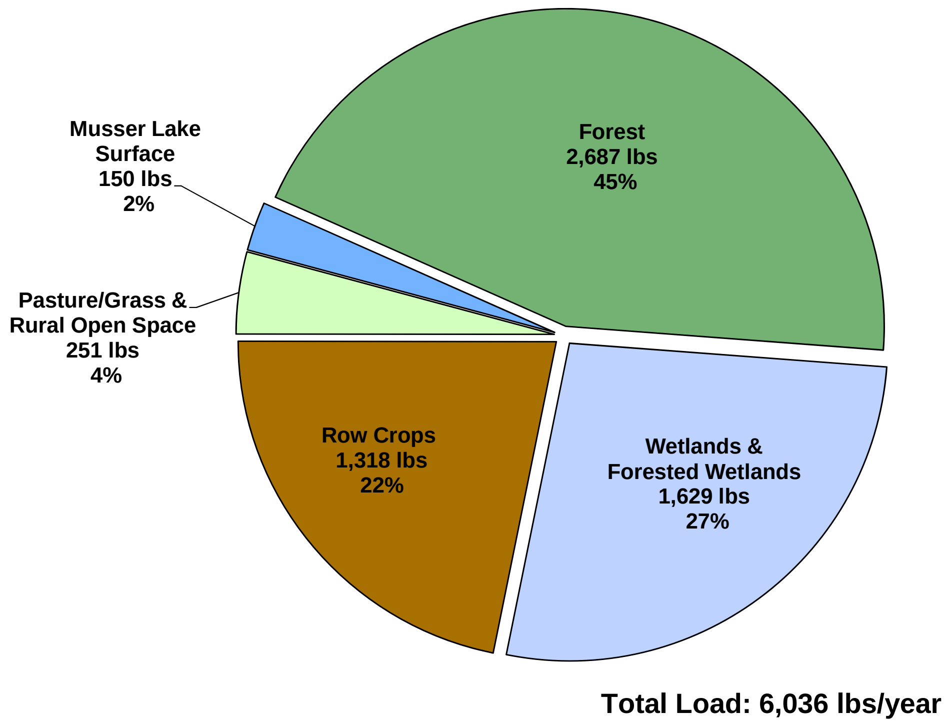


Figure 3.2-2. Musser Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Shoreland Condition Assessment

The Importance of a Lake's Shoreland Zone

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

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

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

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

Shoreland Zone Regulations

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

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted more strict shoreland ordinances. Passed in February of 2010, the final NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances of their own. County ordinances may be more restrictive than NR 115, but not less so. These policy regulations require each county to amend ordinances for vegetation removal on shorelands, impervious surface standards, nonconforming structures and establishing mitigation requirements for development. Minimum requirements for each of these categories are as follows (Note: counties must adopt these standards by February 2014, counties may not have these standards in place at this time):

- <u>Vegetation Removal</u>: For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed the lesser of 30 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. Vegetation removed must be replaced by replanting in the same area (native species only)..
- <u>Impervious surface standards</u>: The amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. A county may allow more than 15% impervious surface (but not more than 30%) on a lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner.

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

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

<u>**Wisconsin Act 31**</u>

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

Shoreland Research

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

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

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

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

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

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

Native Species Enhancement

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

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

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

Cost

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

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

- In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $1,400. The more native vegetation a site has, the lower the cost. Owner's should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:
  - Spring planting timeframe.
  - A 100' of shoreline.
  - An upland buffer zone depth of 35'.
  - An access and viewing corridor 30' x 35' free of planting (recreation area).
  - Planting area of upland buffer zone 2- 35' x 35' areas
  - Site is assumed to need little invasive species removal prior to restoration.
  - Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
  - Trees and shrubs planted at a density of 1 tree/100 sq ft and 2 shrubs/100 sq ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
  - Turf grass would be removed by hand.
  - A native seed mix is used in bare areas of the upland buffer zone.
  - An aquatic zone with shallow-water 2 - 5' x 35' areas.
  - Plant spacing for the aquatic zone would be 3 feet.
  - Each site would need 70' of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
  - Soil amendment (peat, compost) would be needed during planting.
  - There is no hard-armor (rip-rap or seawall) that would need to be removed.
  - The property owner would maintain the site for weed control and watering.

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

Musser Lake Shoreland Zone Condition

Shoreland Development

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

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

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

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

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

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

Figure 3.3-1. Shoreline assessment category descriptions.

On Musser Lake, the development stage of the entire shoreline was surveyed during the fall 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 3.3-1 and shown on Map 3.

Musser Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 11.9 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 3.3-1). 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, 2.0 miles of urbanized and developed–unnatural shoreline were observed. If restoration of the Musser 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. Shoreline enhancements would include leaving 30-foot no-mow zones or by planting native herbaceous, shrub, and tree species as appropriate for Price County. Ecologically high-value areas could also be selected for protection, possibly through conservation easements or land trusts (www.northwoodslandtrust.org).

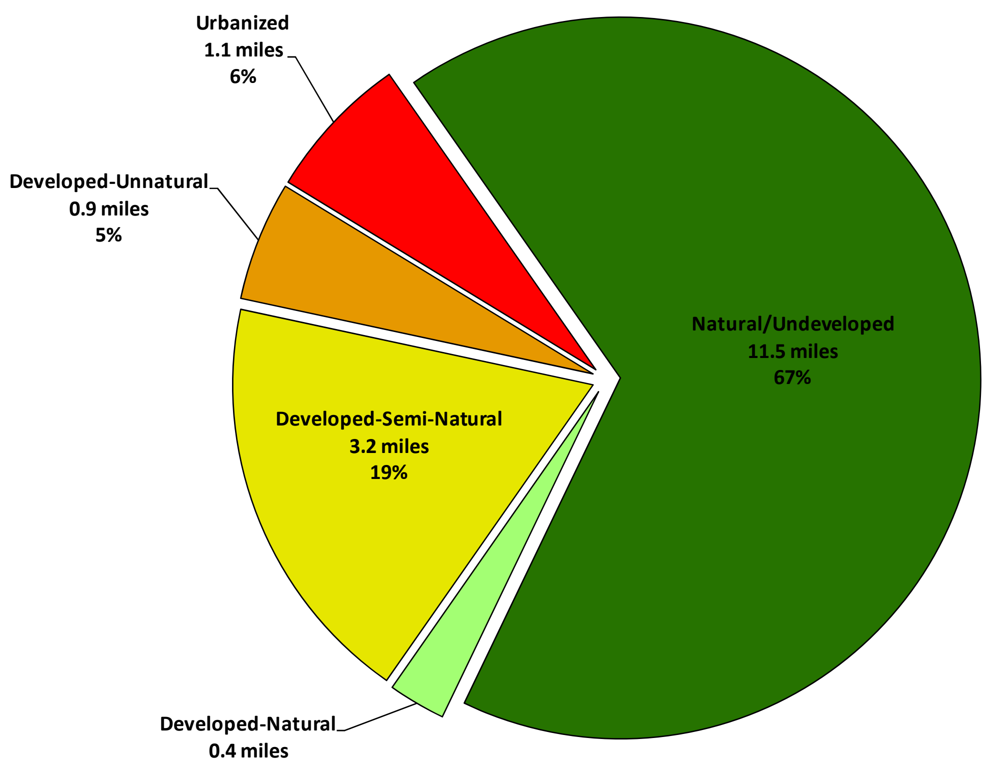


Figure 3.3-2. Musser Lake shoreland categories and total lengths. Based upon a fall 2010 survey. Locations of these categorized shorelands can be found on Map 3.

3.4 Aquatic Plants

Introduction

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

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*) In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the *periphyton* attached to them as their primary food source. The plants also provide cover for feeder fish and *zooplankton*, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent 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 Musser 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 Musser Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

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

Permits

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

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

Manual Removal

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

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

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

Cost

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

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

Bottom Screens

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

Cost

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

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

Water Level Drawdown

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

Cost

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

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

Mechanical Harvesting

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

Costs

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

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

Chemical Treatment

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

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

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

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

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

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

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

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

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

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

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

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

Cost

Herbicide application charges vary greatly between $400 and $1000 per acre depending on the chemical used, who applies it, permitting procedures, and the size of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil. • Some herbicides can be used effectively in spot treatments.	• Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them. • Many herbicides are nonselective. • Most herbicides have a combination of use restrictions that must be followed after their application. • Many herbicides are slow-acting and may require multiple treatments throughout the growing season. • Overuse may lead to plant resistance to herbicides

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*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, like variable water levels or negative, like increased shoreland development or the introduction of an exotic species, the plant community will respond. Plant communities respond in a variety of ways; there may be a loss of one or more species, certain life forms, such as emergents or floating-leaf communities may disappear from certain areas of the lake, or there may be a shift in plant dominance between species. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide very useful information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Musser 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 Musser 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

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.

One factor that influences species diversity 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 Musser Lake will be compared to lakes in the same ecoregion and in the state.

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

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

Community Mapping

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

Exotic Plants

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

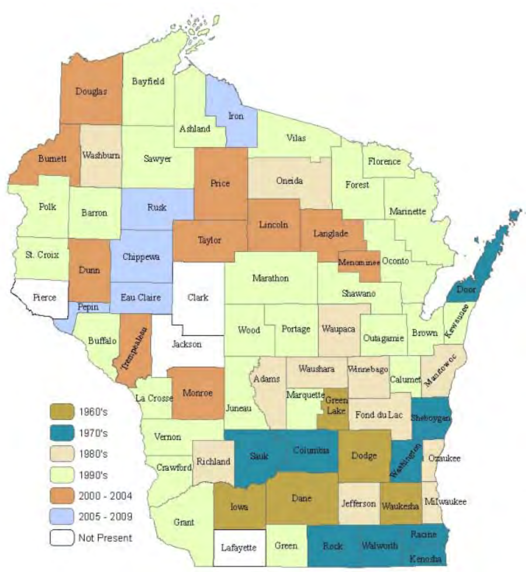


Figure 3.4-1. Spread of Eurasian water milfoil within WI counties. WDNR Data 2009 mapped by Onterra.

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

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

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

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. The first surveys conducted focused upon the invasive curly-leaf pondweed, which was first discovered in Musser Lake in 2002. Because of its importance, these surveys and a detailed discussion regarding curly-leaf pondweed in Musser Lake will be discussed in the next section.

The whole-lake aquatic plant point-intercept and aquatic plant community mapping surveys were conducted on Musser Lake on August 18-19, 2010 by Onterra. During these surveys, 49 species of aquatic plants were located in Musser Lake only one of which is considered to be a non-native, invasive species: curly-leaf pondweed. No other invasive plant species, including Eurasian water milfoil, were located during the 2010 surveys.

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

In 2004, WDNR biologist Craig Roesler conducted a plant survey of Musser Lake. Due to differences in the methodologies between the 2004 and 2010 surveys, it is only appropriate to compare the list of species found during the surveys (Table 3.4-1). The greatest differences between these species list is the emergent life forms which were more intensively focused on during 2010 as a part of the community mapping surveys. The two species lists are very similar in regards to the other aquatic plant life forms. It is also not surprising that even though the surveys were quite different, the most frequently encountered species (e.g. coontail, common water weed, various-leaved milfoil, etc.) were similar between the two surveys.

Table 3.4-1. Aquatic plant species located in Musser Lake during August 2010 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2010 (Onterra)	2004 (WDNR)
Emergent	*Calla palustris*	Water arum	9	I	
	Carex comosa	Bristly sedge	5	I	I
	Carex crinita	Fringed sedge	6	I	
	Carex pseudocyperus	Cypress-like sedge	8	I	
	Carex retrorsa	Retrorse sedge	6	I	
	Carex utriculata	Common yellow lake sedge	7	I	
	Dulichium arundinaceum	Three-way sedge	9	I	
	Eleocharis obtusa	Blunt spike-rush	3	I	
	Eleocharis palustris	Creeping spikerush	6	I	
	Equisetum fluviatile	Water horsetail	7	X	
	Iris versicolor	Northern blue flag	5	I	
	Juncus effusus	Soft rush	4	I	
	Sagittaria latifolia	Common arrowhead	3	I	X
	Scirpus cyperinus	Wool grass	4	I	
	Scirpus pedicellatus	Stalked wool-grass	6	I	X
	Schoenoplectus tabernaemontani	Softstem bulrush	4	X	I
	Typha latifolia	Broad-leaved cattail	1	I	I
	Zizania palustris	Northern wild rice	8	X	
FL	*Brasenia schreberi*	Watershield	7	X	I
	Nuphar variegata	Spatterdock	6	X	X
	Polygonum amphibium	Water smartweed	5	I	
FL/E	*Sparganium androcladum*	Shining bur-reed	8	X	X
	Sparganium natans	Little bur-reed	9		I
	Sparganium fluctuans	Floating-leaf bur-reed	10	X	
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Myriophyllum sibiricum	Northern water milfoil	7		X
	Myriophyllum farwellii	Farwell's water milfoil	9	X	X
	Myriophyllum heterophyllum	Various-leaved water milfoil	7	X	X
	Najas flexilis	Slender naiad	6		X
	Nitella sp.	Stoneworts	7	X	X
	Potamogeton alpinus	Alpine pondweed	9	I	
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X
	Potamogeton crispus	Curly-leaf pondweed	Exotic	X	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X	X
	Potamogeton foliosus	Leafy pondweed	6	I	
	Potamogeton gramineus	Variable pondweed	7		X
	Potamogeton obtusifolius	Blunt-leaf pondweed	9	X	X
	Potamogeton pusillus	Small pondweed	7	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton strictifolius	Stiff pondweed	8	X	
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	
	Potamogeton natans	Floating-leaf pondweed	5	X	X
	Ranunculus aquatilis	White water-crowfoot	8	X	I
	Schoenoplectus subterminalis	Water bulrush	9		X
	Utricularia gibba	Creeping bladderwort	9		X
	Utricularia minor	Small bladderwort	10	X	
	Utricularia intermedia	Flat-leaf bladderwort	9	X	
	Utricularia vulgaris	Common bladderwort	7	X	X
	Vallisneria americana	Wild celery	6	X	X
FF	*Lemna trisulca*	Forked duckweed	6	X	X
	Lemna turionifera	Turion duckweed	2	X	X
	Riccia fluitans	Slender riccia	7	X	X
	Spirodela polyrhiza	Greater duckweed	5	X	X
	Wolffia columbiana	Common watermeal	5	X	X

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

Data collected from the 2010 aquatic plant point-intercept survey reveal that the vast majority of sampling locations (77%) within Musser Lake's littoral area, or area of the lake that can support aquatic plant growth, is comprised of fine organic sediment, or muck, while 20% contained sand, and 3% contained rock (Figure 3.4-2). Map 4 shows that the point-intercept locations containing sand or rock that were located in near-shore areas (i.e. sampled with a pole-mounted rake during the point-intercept survey).

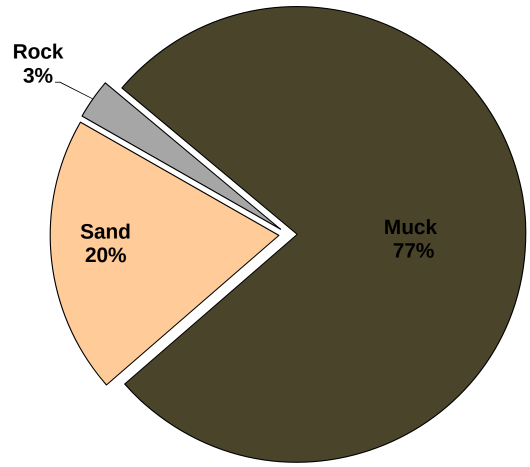


Figure 3.4-2. Musser Lake proportion of substrate types within littoral areas. Created using data from 2010 aquatic plant point-intercept survey.

Approximately 39% of the point-intercept sampling locations that fell within the maximum depth of aquatic plant growth (8 feet), or the littoral zone, contained aquatic vegetation. Map 5 shows that the majority of the aquatic vegetation in Musser Lake is located within the shallow bays and near-shore areas. As discussed in the water quality section, the water clarity in Musser Lake is low due to dissolved organic compounds and algae which limits sunlight penetration and restricts aquatic plants from inhabiting deeper areas of the lake. Figure 3.4-3 shows that the majority of the aquatic vegetation in Musser Lake grows between 2 and 4 feet.

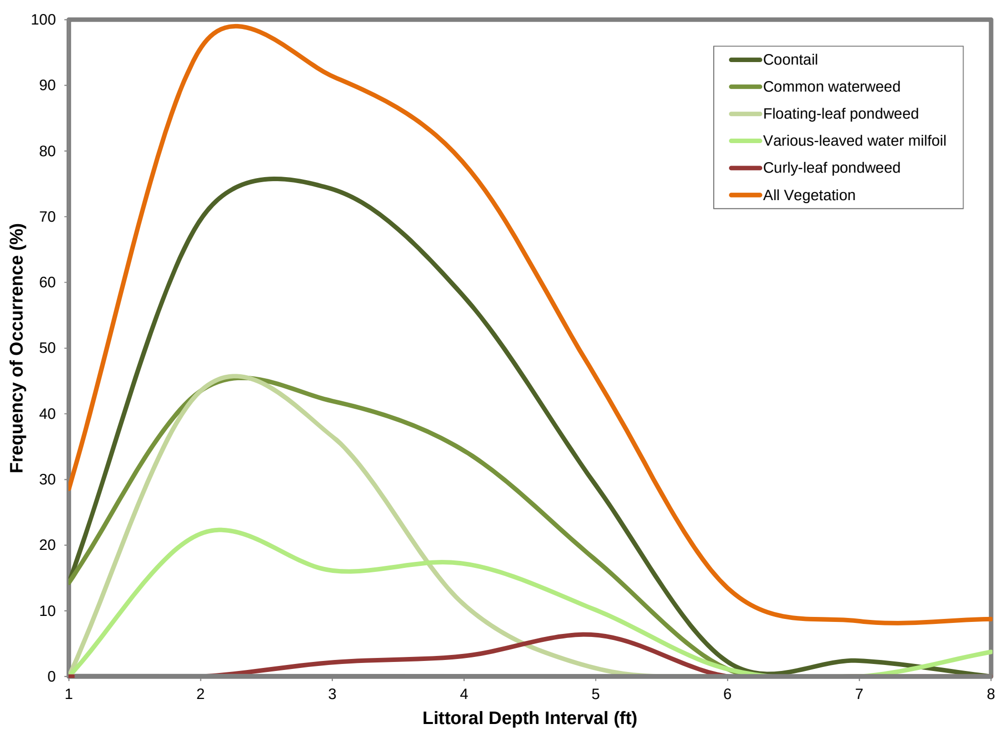


Figure 3.4-3. Frequency of occurrence over water depth of four-most frequently encountered submersed aquatic plant species, curly-leaf pondweed, and all aquatic vegetation. Created using data from 2010 aquatic plant point-intercept survey. Lines are smoothed to ease visualization.

The substrate in Musser Lake is very conducive for supporting lush, aquatic plant growth. This fact was mirrored in the stakeholder survey sent to Musser Lake residents. Excessive aquatic plant growth ranked as the 2nd top factor negatively impacting Musser Lake (Appendix B, Question #19) and the 2nd top concern regarding the lake (Question #20). Furthermore, 75% of survey respondents stated that aquatic plant growth, including algae, negatively impacts their enjoyment of the lake either "sometimes" or "often" (Question #21). Because of this impact, 82% of survey respondents believe that aquatic plant control is needed on Musser Lake (Question #22).

However, it is believed that the majority of the concerns regarding excessive aquatic plant growth on Musser Lake can be attributed to the non-native curly-leaf pondweed. While Onterra ecologists did observe high levels of native species growth in the shallower bays, no nuisance native growth was observed in main areas of the lake that would interfere with navigation and recreation. As will be discussed later, during the early summer curly-leaf pondweed was observed growing at or near the surface in many areas of the lake, and is certainly inhibiting lake users in these areas.

Coontail, common waterweed, floating-leaf pondweed, and turion duckweed were the four-most frequently encountered aquatic plant species during the 2010 aquatic plant point-intercept survey (Figure 3.4-4). Both coontail and common waterweed are prevalent throughout waterbodies in Wisconsin, and under the proper conditions can grow to densities which hamper navigation and recreational activities. Able to obtain the majority of their essential nutrients directly from the water, coontail and common waterweed do not produce extensive root systems, making them susceptible to uprooting by water-action and water movement. When this occurs, uprooted plants float and aggregate on the water's surface where they can continue to grow and form dense mats. Further, both species are able to tolerate low-light conditions; this in addition to their ability to obtain nutrients directly from the water, allow these species to thrive in productive systems like Musser Lake.

Floating-leaf pondweed, as its name suggests, lacks true submersed leaves and produces leaves which float on the water's surface. Usually found growing in shallower water, this species provides valuable structural habitat for invertebrates and fish as well as food from seeds and tubers to aquatic and terrestrial organisms. Turion duckweed is a small, free-floating plant that forms dense, green mats on the surface and may be mistaken for algae. Because these plants obtain 100% of their nutrients directly from the water, they usually are found growing in nutrient-rich systems like Musser Lake. As their name indicates, these plants are an important food source for waterfowl.

During the 2010 aquatic plant point-intercept survey, curly-leaf pondweed was found to have a littoral occurrence of near 2% (Figure 3.4-4). As discussed earlier, this plant dies back in early summer, well before the aquatic plant point-intercept surveys are completed. The large amount of curly-leaf pondweed that was observed in Musser Lake in June compared to its relatively low occurrence during the August point-intercept survey indicate that the true occurrence of this species is underestimated. When curly-leaf pondweed is at its peak growth in June, it would likely be one of the most frequently encountered species in Musser Lake.

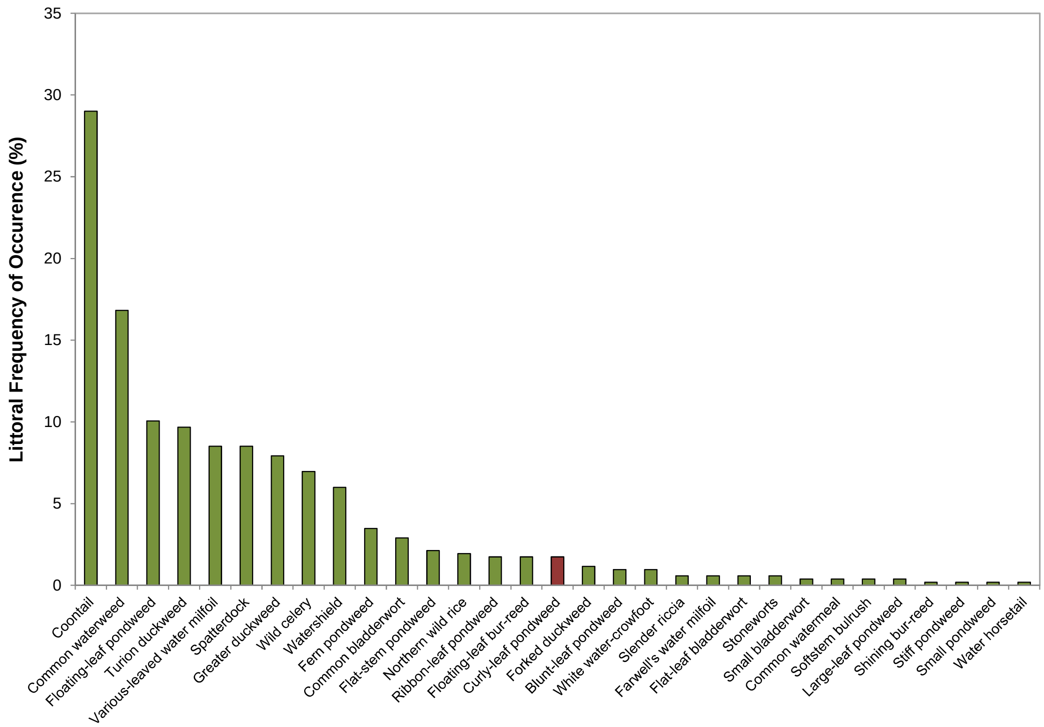


Figure 3.4-4. Musser Lake aquatic plant littoral occurrence analysis. Created using data from 2010 aquatic plant point-intercept survey. Exotic species indicated with red.

Musser Lake contains a high number of aquatic plant species. The native species richness (30), as determined from species solely encountered on the rake during the point-intercept survey, is well above the Northern Lakes and Flowages Ecoregion and Wisconsin state medians (Figure 3.4-5). Given the high number of native aquatic species, one may assume that the lake also has high species diversity. As discussed earlier, 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.

Using the data collected from the 2010 aquatic plant point-intercept survey, the diversity of Musser Lake's aquatic plant community was found to be high, with a Simpson's diversity value of 0.90. In other words, if two individual plants were randomly sampled from Musser Lake's plant community, there would be a 90% probability that the two individuals would be of different species. Figure 3.4-6 displays the relative frequency of aquatic plant species within Musser Lake and shows that the aquatic plant community is not overly dominated by a single or few species.

Flowages, such as Musser Lake, tend to have higher species richness than natural lakes because they are usually larger and contain diverse habitats differing in substrate type, water depth, and water movement. Some aquatic plants, like coontail, are habitat generalists able to grow in many habitat types, while other species are more habitat-specific, like alpine pondweed which is usually found growing in shallow, mucky areas with quiet water. The combination of large littoral area and varying habitats generally leads to a species-rich environment, and this is what is observed in Musser Lake.

The conservatism value (6.7) of Musser Lake's aquatic plant community falls above the ecoregion and state medians, indicating that the aquatic plant community of Musser Lake is of higher quality to most of the flowages in the ecoregion and lakes in the state (Figure 3.4-5). Combining Musser Lake's aquatic plant species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in an exceptionally high value of 37.5 (equation shown below); well above the median values for both the ecoregion and state (Figure 3.4-5).

FQI = Average Coefficient of Conservatism (6.7) * √ Number of Native Species (30)
FQI = 36.9

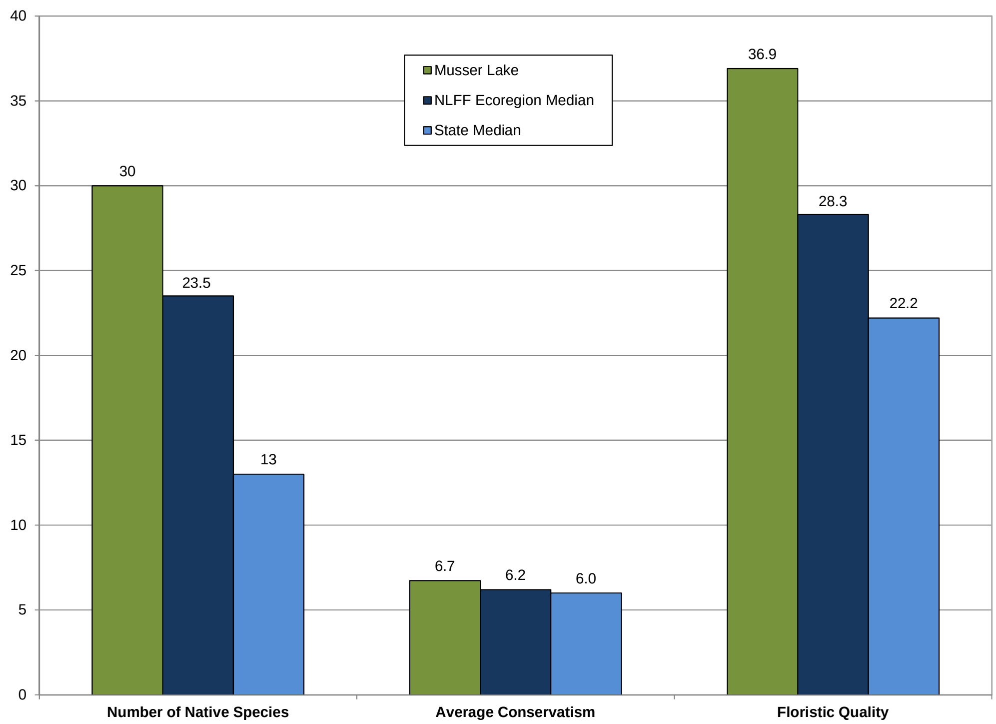


Figure 3.4-5. Musser Lake Floristic Quality Assessment. Created using data from 2010 aquatic plant point-intercept survey. Analysis following Nichols (1999).

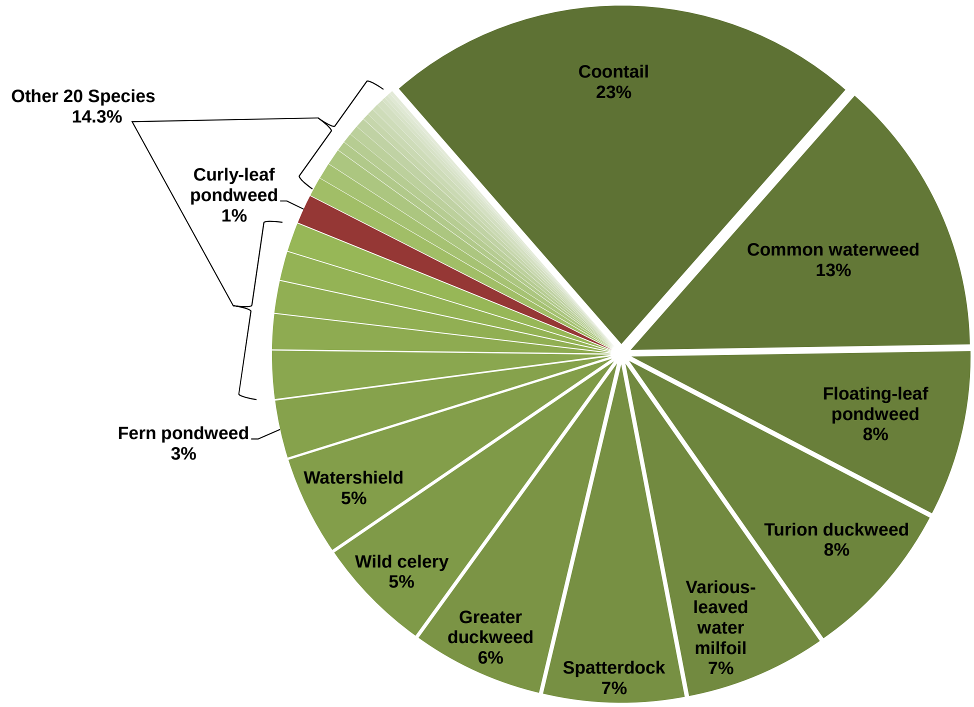


Figure 3.4-6. Musser Lake aquatic plant relative occurrence analysis. Created using data from 2010 aquatic plant point-intercept survey.

The quality of Musser Lake's aquatic plant community is also indicated by the high incidence of floating-leaf and emergent aquatic plant communities. The 2010 community map indicates that approximately 113 acres (20%) of the 563-acre flowage contains these types of communities (Table 3.4-2). Twenty-one emergent and floating-leaf plant species were located during the 2010 surveys. These communities provide valuable habitat to wildlife and stabilize the lake's substrate and shoreline areas by dampening wave action from wind and watercraft.

Table 3.4-2. Musser Lake acres of floating-leaf and emergent plant communities. Created using data from 2010 community mapping survey.

Plant Community	Acres
Floating-leaf	5.8
Emergent	3.7
Mixed Floating-leaf & Emergent	103.7
Total	**113.2**

Continuing the analogy that the community map may represent a 'snapshot' of the important emergent and floating-leaf plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Musser 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.

Curly-leaf Pondweed Control Program

History

Curly-leaf pondweed was first documented in Musser Lake in 2002 and as discussed above, the WDNR completed a series of aquatic plant surveys on the flowage in 2004. During a June 2004 survey, the WDNR identified 38 locations which contained curly-leaf pondweed, ranging in size from a few plants to occupying up to 900 square feet (Map 8). The majority of the curly-leaf pondweed was indentified either near the main boat landing or in the eastern basin on the nutrient rich sediments brought in by the three inlets entering the basin.

One-acre of curly-leaf pondweed was treated in the spring of 2005 by Schmidt's Aquatic Plant Control. Due to concerns over cost and with the support of the WDNR, the 2006 herbicide treatment of about ¾ of an acre was conducted by a MLA volunteer with the proper certification to apply aquatic herbicides. In 2007, a more aggressive strategy was implemented where approximately 600 lbs of granular endothall (Aquathol Super K) was applied to the lake. The MLA believed that this treatment was extremely effective (Appendix F).

Craig Roesler, WDNR, and Butch Lobermeirer, Price County Land Conservation Department, assisted the MLA to receive a 3-year Aquatic Invasive Species Rapid Response Grant starting in 2008 to fund the ongoing control efforts. Subsequent treatments were conducted in 2008 and 2009 (Table 3.4-3).

Table 3.4-3. Musser Lake Curly-leaf Pondweed Treatment Record. Reported by the MLA.

Year	Aquathol K Prouct used (lbs)	Target Area (Acres)	Target Dose (ppm a.i.)
2005	40	1.0	*Not Available*
2006	32	0.8	*Not Available*
2007	600	17.0	2.5
2008	350	15.0	1.5
2009 area	600	23.5	1.5
2009 spot		3.5	2.5
2010 area	300	10.7	1.5
2010 spot		8.0	2.5
2011	0	-	-

In 2009, the WDNR suggested that the MLA create a WDNR-approved lake management plan to more formally document the curly-leaf pondweed population in the flowage and develop a long-term strategy to control the plant on a lake-wide basis. Also, an approved lake management plan would make the MLA eligible to receive additional WDNR grant funds to address curly-leaf pondweed through an Aquatic Invasive Species Established Population Control Grant. The MLA contracted with Onterra to conduct this work and guide them through the grant application process. The project failed to receive funding in February 2009; however, the grant application was successful during the following cycle (August 2009).

During the early spring of 2010, MLA members provided Onterra with information on known locations of curly-leaf pondweed in Musser Lake. These areas were focused on by Onterra staff during a May 6-7, 2010 field survey. Curly-leaf pondweed locations were mapped and a preliminary treatment strategy was proposed to the MLA. Based on a number of factors including financial restrictions, the MLA treated 10.7 acres with Aquathol Super-K at 1.5 ppm active ingredient (a.i.) (Map 9). They also targeted 9.1 acres with what they refer to as "spot treatment" where Aquathol Super K was applied to individual spots within that area at a dose of 2.5 ppm a.i. The MLA also targeted six sites for manual removal where plants were cut near the substrate by a chord stretched between two moving boats. The plant fragments were then seined and removed from the lake.

A curly-leaf pondweed peak-biomass survey was conducted on June 21-22, 2010, by Onterra not only to search the entire lake for the exotic while the plant is at its peak biomass (growth stage), but also to qualitatively assess the 2010 treatment areas. The survey discovered much more curly-leaf pondweed than the May survey and further that the plant was wide-spread throughout much Musser Lake (Map 10). An herbicide treatment of approximately 64 acres was originally proposed for 2011. However, due to lack of funds, the MLA prioritized 9 acres for treatment contingent upon a pretreatment survey by Onterra. Unfortunately water temperatures exceeded the window of treatment (50-60°F) before the MLA submitted the herbicide application permit to the WDNR. As a result, no herbicide treatment was conducted in 2011. Since the MLA's harvesting technique utilizes motorized boats, a mechanical harvesting permit is required by the WDNR. The WDNR denied the MLA's permit application to conduct these activities in 2011 because based upon some emerging science, these activities might not be providing the benefit they are intended to.

Conclusions

A second curly-leaf pondweed peak biomass survey was conducted by Onterra on June 23, 2011 that revealed curly-leaf pondweed had increased in density in many areas and spread to new locations (Map 11). While association members have taken an active role in the effort to reduce the curly-leaf pondweed in Musser Lake, it is believed that the control strategies implemented thus far have only been successful in reducing the density of curly-leaf pondweed locally in areas where navigation and recreational activities have been impeded, and have not been effective at reducing the curly-leaf pondweed population on a lake-wide basis. Until recently, lake managers would claim that a curly-leaf pondweed treatment was successful if after the herbicide application there was a visible reduction of target plants in that area. However, an ineffective treatment might also show these results as injured plants may not be visible from the surface following the treatment, but are still able to produce viable turions on their rhizomes and remaining above ground biomass. To truly begin to gain control of the curly-leaf pondweed on Musser Lake, large-scale, repeat treatments of sufficient concentration and exposure times will need to occur on an annual basis for several years (3-5 years or more) to deplete the turion base.

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to dilute herbicide concentration within aquatic systems. Understanding concentration-exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Much information has been gathered in recent years, largely as a result of a joint research project between the WDNR and the US Army Corps of Engineers (USACE). Based on their preliminary findings, lake managers have adopted two main treatment strategies; 1) spot treatments, and 2) whole-lake treatments.

Not to be confused with the definition of spot treatment that the MLA has adopted, spot treatments are a type of treatment strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. For curly-leaf pondweed, endothall is typically applied between 1.5 and 3.0 ppm a.i. in spot treatment scenarios. A newly adopted term, micro-treatments are small spot treatments (working definition is less than 5 acres) and because of their small size, rarely are effective because of the rapid dilution of the herbicide. Larger treatment areas tend to be able to hold effective concentrations for a longer time.

Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (of the lake or a lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. Endothall application rates are typically applied based upon active ingredient (a.i.) while herbicide residual analysis, which is a measure of the herbicide within the water column, is based upon acid equivalent (a.e.). The application rate of whole-lake treatments is dictated by the volume of water which the herbicide will reach equilibrium within. The target herbicide concentration is typically between 0.225 and 0.300 ppm a.e. when exposed to the target plants for 7-14 days or longer.

Due to the small size of the areas that have been historically targeted by the MLA, this strategy falls into the spot treatment category and in many instances, the micro treatment subcategory. Frankly most treatments conducted within the state fell into this category because it was traditionally thought that it would be best for the treatment to affect as small an area as possible. However, this new research confirms what many lake managers were observing, little or no positive treatment effects following these treatments.

Emerging information suggests that in order for an application of 1.5 ppm a.i. endothall to be effective at controlling curly-leaf pondweed, the concentration needs to be maintained for at least 12-24 hours. That length of exposure time is very difficult to achieve, especially in micro-treatment situations. As indicated within the watershed section, the modeling indicates that the residence time of Musser Lake is 18 days. This high flushing rate greatly works against the ability for herbicide treatments to be effective on Musser Lake. Based on the 2011 curly-leaf pondweed peak biomass survey results, only scatted curly-leaf pondweed plants were observed near the main boat landing (Map 11). This area has been actively targeted by the MLA and because this area is relatively protected from the main parts of the lake, the herbicide likely was able to maintain sufficient concentration and exposure times in this area to effectively control curly-leaf pondweed. However it seems quite apparent that control of curly-leaf pondweed has not occurred in the eastern basin as evidenced by a 60 acre contiguous colony of curly-leaf pondweed being mapped in this area during the 2011 survey (Map 11).

Additional research by the 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 herbicide treatments may have appeared to be effective, the plants were still able to produce turions particularly low on the plant and on the rhizome. This is also likely the case for the manual control strategy implemented by the MLA. Similar to mechanical harvesting, it was traditionally thought that removing as much above ground biomass of curly-leaf pondweed would be more advantageous than allowing the plants to mature and produce turions. But now it appears that despite the efforts, these plants are still producing turions.

Within the Implementation Plan, a control strategy is outlined that build from the information gathered over the years by the MLA and those research projects being conducted throughout the Midwest by the WDNR and the USACE.

3.5 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of readily available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the various fisheries biologists overseeing Musser Lake (e.g. WDNR, GLIFWC).

The goal of this section is to provide an incomplete overview of some of the data that exists, particularly in regards to specific issues (e.g. spear fishery, fish stocking, angling regulations, etc) that were brought forth by the MLA stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2010 & GLIFWC 2010A and 2010B).

Musser Lake Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the highest ranked important or enjoyable activity on Musser Lake (Question #13). Approximately 93% of survey respondents indicate that they do fish on the lake (Question #7) and 49% of these same respondents have fished the lake for greater than 25 years (Question #8). 63% of the stakeholders that fish the lake believe that the quality of fishing on the lake was either fair or poor (Question #19); and this same percentage believe that the fishing has gotten worse since they began fishing the lake (Question #10). Overall, survey respondents indicated that walleye, crappie and bluegill/sunfish were their favorite species to fish for in Musser Lake (Question #11).

Table 3.4-1 shows the popular game fish that are present in the system. Management actions that have taken place and will likely continue on Musser Lake according to this plan include herbicide applications to control curly-leaf pondweed. In the future, these applications will occur in late spring when the water temperatures are below 60 - 65°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. Muskellunge is another species that may be impacted by early season treatments as water temperatures and spawning locations often overlap.

Table 3.5-1. Gamefish present in the Musser Lake with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Bullhead	*Ictalurus melas*	5	April - June	Matted vegetation, woody debris, overhanging banks	Amphipods, insect larvae and adults, fish, detritus, algae
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other inverts
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Brown Bullhead	*Ameiurus nebulosus*	5	Late Spring - August	Sand or gravel bottom, with shelter rocks, logs, or veg	Insects, fish, fish eggs, mollusks and plants
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge	*Esox masquinongy*	30	mid April - mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pikes, 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 (ter. and aq.)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1cm-1m deep	Crustaceans, insect larvae, and other inverts
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

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 Musser 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 3.5-1.

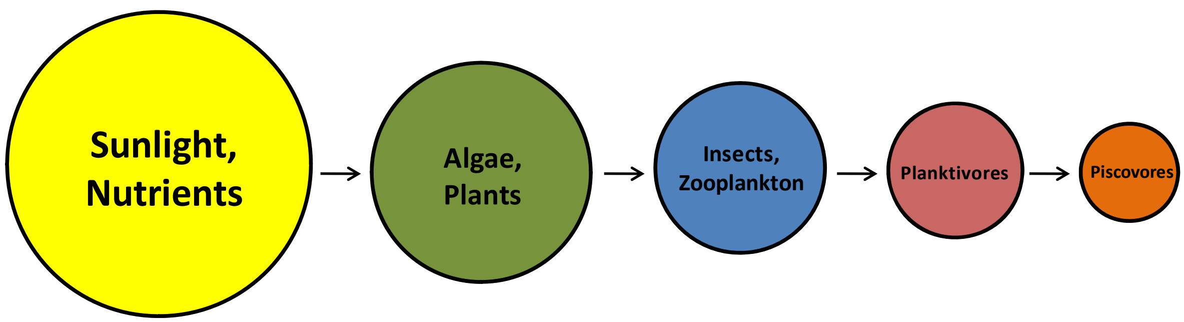


Figure 3.5-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Musser Lake is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means Musser Lake should be able to support sizable populations of predatory fish (piscovores) because the supporting food chain is relatively robust.

Figure 3.5-2. Location of Musser Lake within the Native American Ceded Territory (GLIFWC 2010A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.5-2). Musser Lake falls within the ceded territory based on the Treaty of 1837. This allows for a regulated open water spear fishery by Native Americans on specified systems. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then an "allowable catch" is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% of a lake's fishing stock, but may vary on an individual lake basis. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The allowable catch number is then reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level". The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent, or declaration. This result is called the quota, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal quota and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2010B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly quota is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the quota is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller quotas. Starting with the 2011 spear harvest season, on lakes with a harvestable quota of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

Although declared as a spear harvest lake, records indicate that a spear harvest has not occurred on Musser Lake. However, because Musser Lake is located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to Musser Lake. In 2011, no restrictions were placed upon length or bag limits. Currently, there is no minimum length limit for walleye on the lake, and the statewide bag limit of 5 fish applies to this waterbody. Musser Lake is in the northern half of the muskellunge and northern pike management zone, meaning that muskellunge must be 34” to be harvested, with a daily bag limit of one fish, while no minimum length limit exists for northern pike and only 5 pike may be kept in a single day. Statewide regulations apply for all other fish species. Unlike most Wisconsin counties, motor trolling is allowed in Price County.

Musser Lake Fish Stocking

To assist in meeting fisheries management goals, the WDNR may stock fish in a waterbody that were raised in nearby permitted hatcheries. Stocking of a lake is sometimes done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Fish can be stocked as fry, fingerlings or even as adults. The WDNR stocks muskellunge as large fingerlings at 0.5 per acre and walleye as small fingerlings at 35 per acre in alternate years (Table 3.5-2).

Table 3.5-2 Musser Lake stocking data available from the WDNR from 1972 to 2006 (WDNR 2010).

Year	Species	Age Class	# Stocked	Avg. Length (inches)
1993	Muskellunge	Fingerling	1,126	8
1995	Muskellunge	Fingerling	1,126	9.3
2001	Muskellunge	Large Fingerling	281	10.6
2003	Muskellunge	Large Fingerling	281	10.9
2005	Muskellunge	Large Fingerling	281	10.6
2007	Muskellunge	Large Fingerling	188	12.3
2009	Muskellunge	Large Fingerling	282	10.5
1992	Walleye	Fingerling	21,301	3.33
1994	Walleye	Fingerling	15,118	3
1996	Walleye	Fingerling	28,150	1.4
1998	Walleye	Small Fingerling	56,300	1.3
2000	Walleye	Small Fingerling	28,150	1.7
2002	Walleye	Small Fingerling	28,150	1.4
2004	Walleye	Small Fingerling	28,135	1.2
2006	Walleye	Small Fingerling	19,724	1.6
2008	Walleye	Small Fingerling	19,705	1.4
2010	Walleye	Small Fingerling	28,330	1.7

Jeff Scheirer, WDNR fisheries biologist for Price County, hopes to work with his fishery team and the Musser Lake residents in the near future to identify species of importance and specific management goals and objectives for the Musser Lake fishery. Recent information gathered through the Musser Lake stakeholder survey (Appendix B) may be of assistance to fishery managers. In the survey, many respondents commented on walleye and muskellunge issues in the lake (Stakeholder survey comments) and on Question #11, identified walleye, crappie and bluegill/sunfish as their favorite species to catch. In the meantime, traditional management strategies towards general and presumed goals for muskellunge and walleye are being carried out. Recently completed surveys (spring 2011) will assist managers in scientific based decision-making regarding these populations.

Musser Lake Substrate Type and Habitat.

According to the point-intercept survey conducted by Onterra, 77% of the substrate sampled in the littoral zone on Musser Lake was muck, with 20% being classified as sand and 3% classified as rock (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. Muskellunge is one species that does not provide parental care to its eggs (Becker 1983). Muskellunge broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Walleye is another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

In 1996, 1998 and 2002 the WDNR carried out habitat projects to provide walleye spawning habitat within Musser Lake. These projects consisted of ten rock blankets covering approximately 46,125 square feet of the lake bottom. Unfortunately, post-project evaluations have concluded that "no positive effect can be attributed to the 10 rock blankets" (Dave Neuswanger, unpublished summary of case histories, March 2004 as received by Jeff Scheirer, WDNR). In addition to these rock blanket areas, the Musser Lake Association and WDNR built and installed 110 fish cribs and 20 half-log structures within the Musser Flowage. However, the Price County Fishery Team is no longer encouraging lake groups to conduct fish crib projects because the cribs tend to concentrate both fish and the anglers that are targeting these fish. Instead, protection and replacement of woody structure along the shoreline is now being encouraged to produce more natural, dispersed habitat.

4.0 SUMMARY AND CONCLUSIONS

The design of this project was intended to fulfill four main objectives;

1) Collect baseline data to increase the general understanding of the Musser Lake ecosystem.
2) Collect detailed information regarding the presence of any invasive plant species within the lake.
3) Evaluate the efficacy of the MLA's ongoing curly-leaf pondweed control strategy.
4) Collect sociological information from Musser 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 four objectives were fulfilled during the project and have led to a good understanding of much of the Musser Lake's ecosystem, the folks that care about the system, and what needs to be completed to protect and enhance it.

As indicated within the Water Quality Section, a great deal of historic water quality information exists for Musser Lake which has provided an invaluable resource for understanding the condition of Musser Lake. To reiterate topics discussed within that section, the three main water quality parameters (total phosphorus, chlorophyll-*a*, and transparency) do not follow the strong relationship observed in natural lakes. Typically as the limiting nutrient, phosphorus, increases within a lake, the lake becomes more productive as indicated by an increased population of free-floating algae. These algae are particulates within the water column and reduce light penetration and thus decrease water transparency as measured through Secchi disk values. In Musser Lake, the water transparency is almost entirely a product of the organic staining of the lake from its watershed which gives the flowage its brown, coffee-stained color.

The water quality of Musser Lake is controlled by its massive watershed. The vast majority of the watershed contains quality land cover types like grasslands, forests, and wetlands, so not a great deal of phosphorus is exported on an acre-by-acre basis. However, there are very many acres within the watershed and each exports some phosphorus to the lake. Cumulatively, this leads to a great deal of phosphorus making its way to the lake and as a result, the total phosphorus values for the lake are quite high. Actually, if these high phosphorus values were observed in a natural lake, that lake would certainly exhibit high chlorophyll-*a* values due to the large amount of algae utilizing the available nutrients. However, this is not the case for Musser Lake, as the high flushing rate prevents the algae from building up to noticeable levels. Flowages like Musser Lake often have a higher amount of filamentous and attached algae (periphyton) which are not as subject to being swept downstream.

The surveys completed by Onterra reveal that from an ecological standpoint, the aquatic plant community of Musser Lake is excellent. This is indicated by the lake's high diversity and outstanding floristic quality. The makeup of Musser Lake's plant community could be considered among the best in the state, and as pointed-out in the Aquatic Plant Section, is an important aspect in not only the health of the fish and wildlife populations that flourish in the lake, but also in the health of the lake itself. It is the lake's quality native plant community that has worked to keep curly-leaf pondweed from spreading and completely taking over the littoral zone of the lake, although it is beginning to lose this battle. Musser Lake withstands unnaturally constant water levels, shoreland development pressure, and recreational use making it a disturbed system that is ripe for exotic infestation. Without the competition provided by the existing native plant community, it is likely that the curly-leaf pondweed infestation would resemble those that have occurred in some of our state's more southern lakes that require annual mechanical harvesting budgets exceeding $50,000 in order to maintain navigation lanes around the lake.

Aquatic invasive species are a major concern of Musser Lake's stakeholders (Appendix B, Questions #19 and #20). Furthermore, based upon the Planning Committee and Kick-off meetings, continued spread of curly-leaf pondweed within the lake is a major portion of that concern. Many alternatives exist for controlling curly-leaf pondweed; however, many are not applicable to Musser Lake. Currently, harvesting is not a feasible alternative because of the increased spread that would likely occur as a result of turion dispersal and because it would not would not work to improve the ecology of the lake but only provide temporary relief in nuisance areas. Harvesting may be considered as a future management action if sufficient control of curly-leaf pondweed cannot be met with other alternatives.

Much attention was also given to using a winter water drawdown as on option for curly-leaf pondweed control. The dam that controls Musser Lake's water level requires maintenance and in order for that to occur, a winter drawdown may occur during the winter of 2012/2013 (Bob Lepke, personal comm.). The scientific literature really does not indicate that a winter water level drawdown is an appropriate tool for curly-leaf pondweed control. While the drawdown may impact a single year's curly-leaf pondweed population in areas that are dewatered during the drawdown, the existing turion bank within the sediment is likely not greatly affected. However, a drawdown might be similarly effective as a single year's herbicide control program, perhaps more so as its impact area is much greater than that of an herbicide control program.

Currently, the most feasible method for bringing curly-leaf pondweed under control is repeated annual herbicide applications until the turion base is exhausted. This technique is well supported among stakeholder survey respondents (Appendix B, Question #'s 22 and 23). But as indicated within the Aquatic Plant Section, the likelihood of successfully controlling curly-leaf pondweed using herbicides may not be high. The enormous watershed and subsequently high flushing rate greatly decreases this technique's ability to be effective. It will be important for MLA stakeholders to be objective and if this strategy is proven not able to effectively control curly-leaf pondweed on a lake-wide basis that increases the ecological stability of the system, they will need to modify their control program accordingly.

5.0 IMPLEMENTATION PLAN

The intent of this project was to complete a *comprehensive* management plan for Musser Lake. As described in the proceeding sections, a great deal of study and analysis were completed involving many aspects of the ecosystem. This section stands as the actual "plan" portion of this document as it outlines the steps the MLA will follow in order to manage Musser Lake, its watershed, and the association itself.

The implementation plan is broken into individual *Management Goals*. Each management goal has one or more management actions that if completed, will lead to the specific management goal in being met. Each management action contains a timeframe for which the action will be taken, a facilitator that will initiate or carry out the action, a description of the action, and if applicable, a list of prospective funding sources and specific actions steps.

Management Goal 1: Maintain Current Water Quality Conditions

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

Timeframe: Continuation of current effort.

Facilitator: 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.

Through the WDNR Citizen Lake Monitoring Network Program, volunteers from Musser Lake (Alfred Speich) have collected Secchi disk clarities and water chemistry samples. The volunteer monitoring of the water quality is a large commitment and new volunteers may be needed in the future as the volunteer's level of commitment changes.

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

In addition, MLA volunteers currently monitor dissolved oxygen concentrations in the lake using a colorimetric kit. While monitoring dissolved oxygen in this fashion can be useful, using a calibrated probe on a metered line is a much more accurate. With the large amount of flow in Musser Lake, sufficient dissolved oxygen concentrations for fish or other aquatic life really is not a concern. However, if increasing concerns about these levels exist within the Musser Lake, the association should purchase a dissolved oxygen probe. This would allow this parameter to be monitored in conjunction with the regularly scheduled CLMN water sample collection. A WDNR small-scale Lake Planning Grant would be applicable for the costs of the equipment purchase.

Action Steps:

Please see description above.

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

Management Action: Continue Clean Boats Clean Waters watercraft inspections at Musser Lake Public Boat Landing.

Timeframe: In progress

Facilitator: Planning Committee

Description: Currently the MLA monitors several public boat landings using training provided by the Clean Boats Clean Waters program. Musser Lake is a popular destination by recreationists and anglers, making the lake vulnerable to new infestations of exotic species. Although the lake already contains aquatic invasive species, it is still important to minimize the chance of new infestations of aquatic invasive species to be introduced to the lake and ensure that Musser Lake is not the source of aquatic invasive species for other waterbodies.

Action Steps:

1. Training of additional volunteers completed by those trained in the past or by attending Clean Boats Clean Waters regional training sessions
2. Focus volunteerism during high-risk periods such as weekends and holidays
3. Report results to WDNR and MLA
4. Promote enlistment and training of new of volunteers to keep program fresh

Management Action: Monitor the scheduled winter water level drawdown to access if it can be used as a curly-leaf pondweed control method on Musser Lake

Timeframe: Initiate 2013

Facilitator: Planning Committee with professional help as needed

Applicable Grant Funding: WDNR Aquatic Invasive Species Education, Planning, and Prevention Grant

Description: Following the submission of a conditional herbicide treatment permit in early April 2012 and a subsequent multi-agency review by the WDNR and Great Lakes Indian Fish and Wildlife Commission (GLIFWC), a targeted herbicide treatment of curly-leaf pondweed on Musser Lake was suspended due to concerns regarding the proximity of wild rice populations. Based on laboratory and outdoor growth chamber research, wild rice has been shown to be vulnerable to early season herbicide treatments (Nelson et al 2003; Madsen et al. 2008). Closer investigation of this and additional research may identify potential herbicide use patterns that would minimize the impact on wild rice. It is anticipated that ongoing management discussions between the WDNR, GLIFWC, and private consultants will result in a solution to implement AIS management strategies in areas of wild rice.

Meanwhile, Price County recently received a WDNR cost share grant to perform maintenance work on the dam which impounds Musser Lake. The maintenance work requires a 6 foot drawdown and is scheduled to occur during the autumn of 2013 to minimize recreation and tourism effects that may be associated with a summer drawdown. While the maintenance work would only take a month to complete, it was determined appropriate to keep the lake drawdown over the winter of 2013/2014. Refilling the lake late in the autumn would potentially have detrimental impacts to reptiles (e.g. turtles) and amphibians (e.g. frogs, salamanders). These species would have chosen shallow, muddy areas of the dewatered system to burrow into ground and hibernate. If the water levels are brought back up 6 feet at this time of the year, these species will certainly drown.

It is also believed that a winter drawdown could be ecologically beneficial for the system in reducing the CLP population. Unfortunately, not much information exists within the scientific literature regarding whether a winter water level drawdown is an appropriate tool for curly-leaf pondweed control. It is theorized that a drawdown at a minimum should impact a single year's curly-leaf pondweed population in areas that are dewatered during the drawdown, and possibly even have an effect on the existing turion bank within the sediment.

In February 2013, the MLA successfully was awarded a WDNR AIS grant to monitor the ecological effects of the 2013/2014 drawdown to be used in future management planning of Musser Lake. Following the drawdown, the proposed project would also dovetail with the following management action: to initiate an early-season herbicide control strategy in 2015.

Action Steps:

1. Retain qualified professional assistance to develop a specific project designed to implement and monitor the control strategy outlined above (occurred).
2. Apply for an AIS Education, Prevention, and Planning Grant based on developed project design (occurred).
3. Initiate control and monitoring plan.

Management Action: Initiate large-scale herbicide application strategy to control curly-leaf pondweed infestation on Musser Lake.

Timeframe: Initiate 2015

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, the most pressing threat to the health of Musser Lake's aquatic plant community is curly-leaf pondweed. The 2011 curly-leaf pondweed peak biomass survey indicates that this plant is widespread within the lake (Map 11).

At this time, the most feasible method of control would be herbicide applications - specifically, early-spring treatments with liquid endothall. Starting in 2015 after the effects of the winter drawdown are understood, annual herbicide treatments would occur each spring when surface water temperatures are close to 50°F. The responsible use of this technique is supported by Musser Lake stakeholders as indicated by approximately 69% of stakeholder survey respondents (excluding those that stated they need more information) indicating that they are at least moderately supportive of an herbicide control program (Appendix B, Question #23).

During the planning process, MLA stakeholders discussed the difference between the control of curly-leaf pondweed for nuisance relief and for ecological restoration. Applicable management actions for Musser Lake aimed at alleviating the nuisance conditions caused by this plant would likely include the use of a mechanical harvester to create access lanes in strategic locations around lake. Because this effort would not aim to restore the Musser Lake ecosystem, it would not qualify for WDNR funding under the Aquatic Invasive Species Grant program.

As indicated within the Aquatic Plant and Conclusion Sections, significant concerns exists about the likelihood of success from a herbicide control program on Musser Lake because the flow of water through the lake may be too high to achieve the necessary herbicide concentrations and exposure times required. This uncertainty has resulted in the WDNR being reluctant to allow the control strategy to be eligible for WDNR funds.

The MLA understands this reality, but in the absence of other options for controlling this aquatic invasive species and protecting their lake, feels that it is warranted to conduct a well monitored experimental treatment to help guide their future management of the lake. Map 11 and 12 outline the originally proposed strategy for 2012 where two main areas were targeted for treatment; 1) a contiguous 60-acre colony of curly-leaf pondweed source population in the eastern basin of the lake (Site A-12), and 2) an the area in front of the main public boat landing (Site B-12).

The MLA received a one-year WDNR AIS Established Population Control Grant in February 2012 to fund the proposed experimental curly-leaf pondweed treatment in 2012. As indicated within the previous action, the 2012 herbicide treatment was suspended due to the proximity of this control strategy to culturally significant wild rice. Following the results of the 2013/2014 winter drawdown monitoring project, a spring 2014 herbicide treatment strategy will be devised. Likely this strategy will mimic that originally proposed in 2013 (Maps 11 and 12), but additional information regarding herbicide treatments might be learned in the interim that would result in a modified control strategy. The 2015 application would be conducted using sub-surface liquid injection with advanced onboard GPS technology. Flow rates would be carefully monitored by the Price County Dam Tender and the date of treatment would correspond with when he anticipates the lowest flows available in that given timeframe.

Based on the results of the spring 2015 treatment, the following long-term strategies would likely follow:

- If the proper herbicide exposure time is achieved, the MLA would apply for an additional AIS Established Population Control Grant (Phase II) which would carry the project out 2-4 additional years.
- If the proper herbicide exposure time is not reached, but it appears that they may be attained with an increased application dose or by implementing a slightly different strategy (e.g. dual treatment spaced 1 day apart), the MLA would apply for an additional AIS Established Infestation Control Grant (Phase II) which would carry the project out 2-4 additional years with the modified strategy.
- If it appears that there is no chance of finding an effective combination of exposure time/dose due to the flow of the system, convert the program into a nuisance control project that would not be eligible for WDNR grant funds.

However, if treating the large area proves to be ineffective, it is unrealistic to expect any control strategy to be effective aside from a mechanical harvesting program or select herbicide treatment of isolated bays.

Action Steps:

1. Retain qualified professional assistance to develop a specific project designed to implement and monitor the control strategy outlined above (occurred).
2. Apply for an AIS Established Population Control Grant based on developed project design (occurred).
3. Initiate control and monitoring plan.
4. Based upon monitoring results, initiate long-term strategy and if applicable, apply for Phase II of AIS Established Population Control Grant-funded Project.

6.0 METHODS

Watershed Analysis

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

Aquatic Vegetation

Curly-leaf Pondweed Survey

Pretreatment curly-leaf pondweed surveys were completed on May 6-7, 2010 and May 31, 2011. Surveys of curly-leaf pondweed were completed on Musser Lake in June 21-22, 2010 and June 23, 25, 27-2011 in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Musser Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them.

Point-intercept Survey

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 18-19, 2011. A point spacing of 57 meters was used resulting in approximately 629 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within each 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 each of the lakes.

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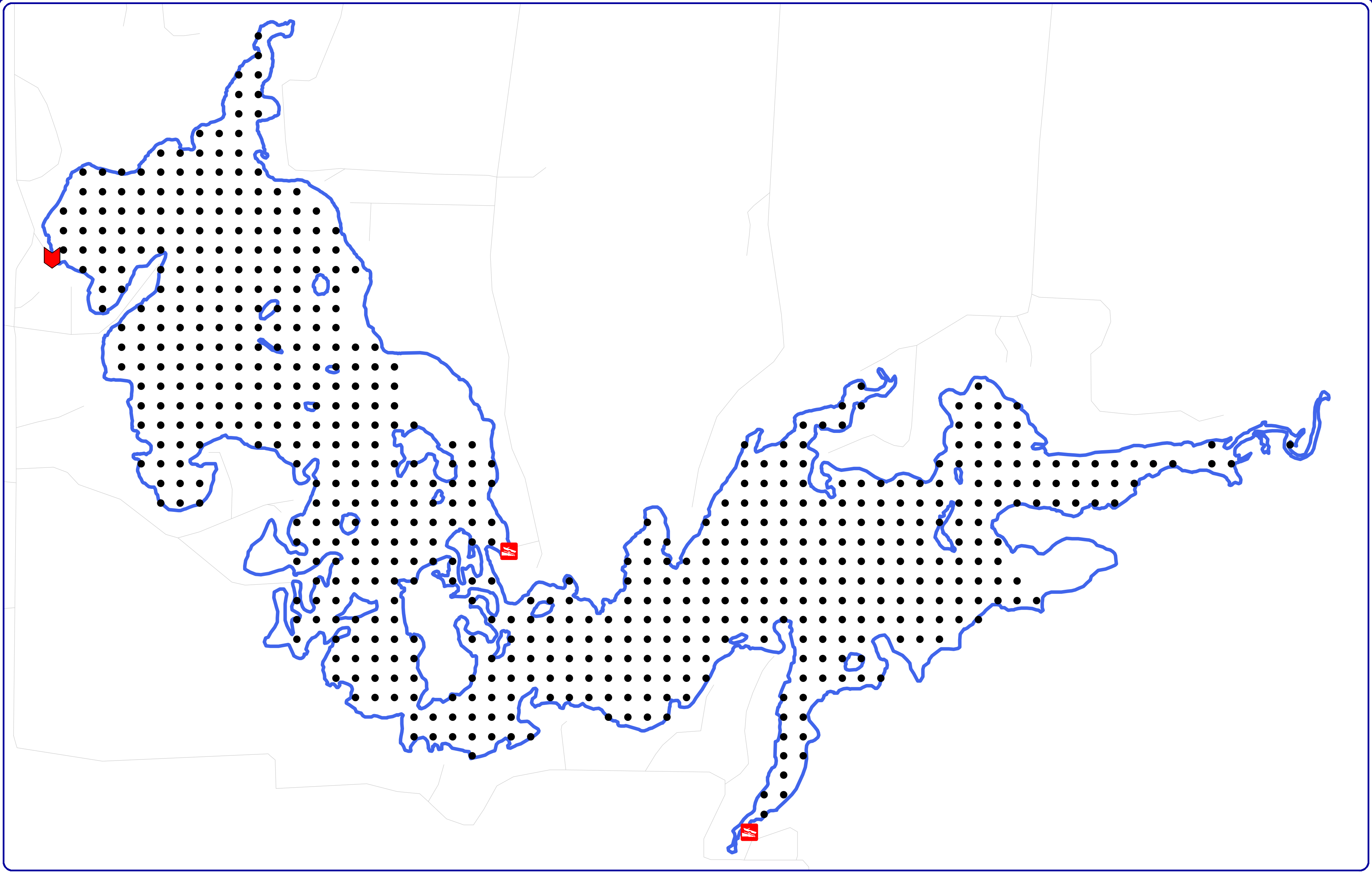

N
W E
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1,250

Feet

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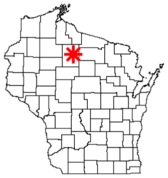
Sources:
Roads & Hydro: WDNR
Map date: October 27, 2011
Filename: *Map1_Musser_Location.mxd*



Project Location in Wisconsin

Legend

Musser Lake ~ 563 acres
WDNR Definition

Point-intercept Sample Location
57-meter spacing, 630 total points

Public Access Location

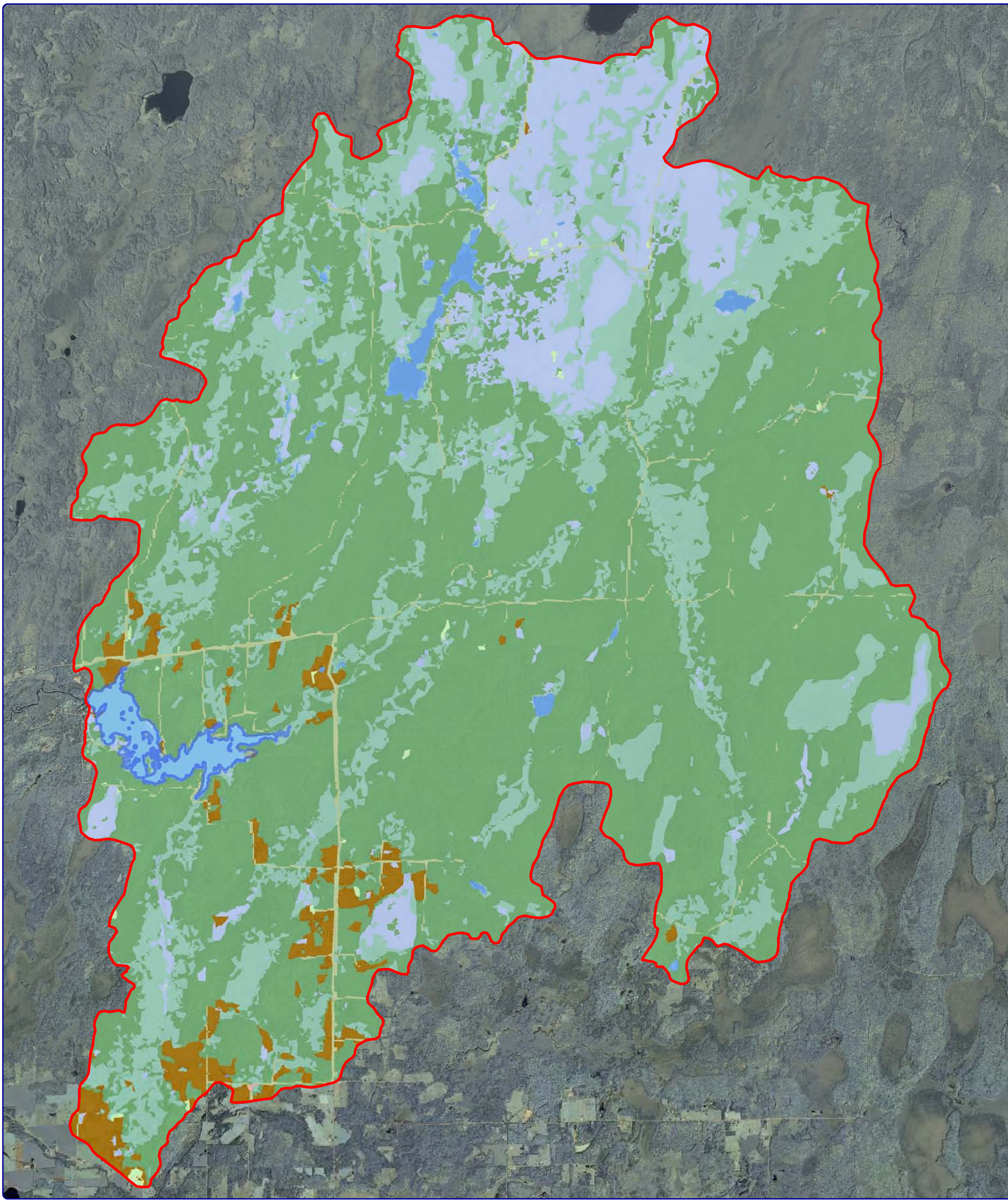
Dam

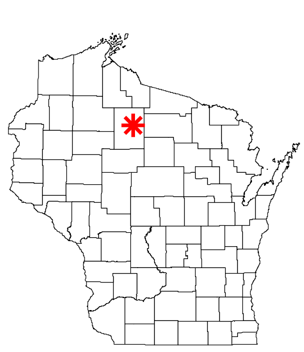
Map 1

Musser Lake

Price County, Wisconsin

Project Location & Lake Boundaries





Project Location in Wisconsin

Sources:
Land Cover: NLCD 2006
Hydro: WDNR
Orthophotography: NAIP, 2010
Map Date: October 27, 2011
Filename: *Map2_Musser_Watershed.mxd*

Legend

Watershed Boundary

Land Cover Types

- Forest
- Forested Wetlands
- Pasture/Grass
- Rural Open Space
- Row Crops
- Open Water
- Wetlands
- Rural Residential

Map 2
Musser Lake
Price County, Wisconsin
Watershed and Land Cover Types

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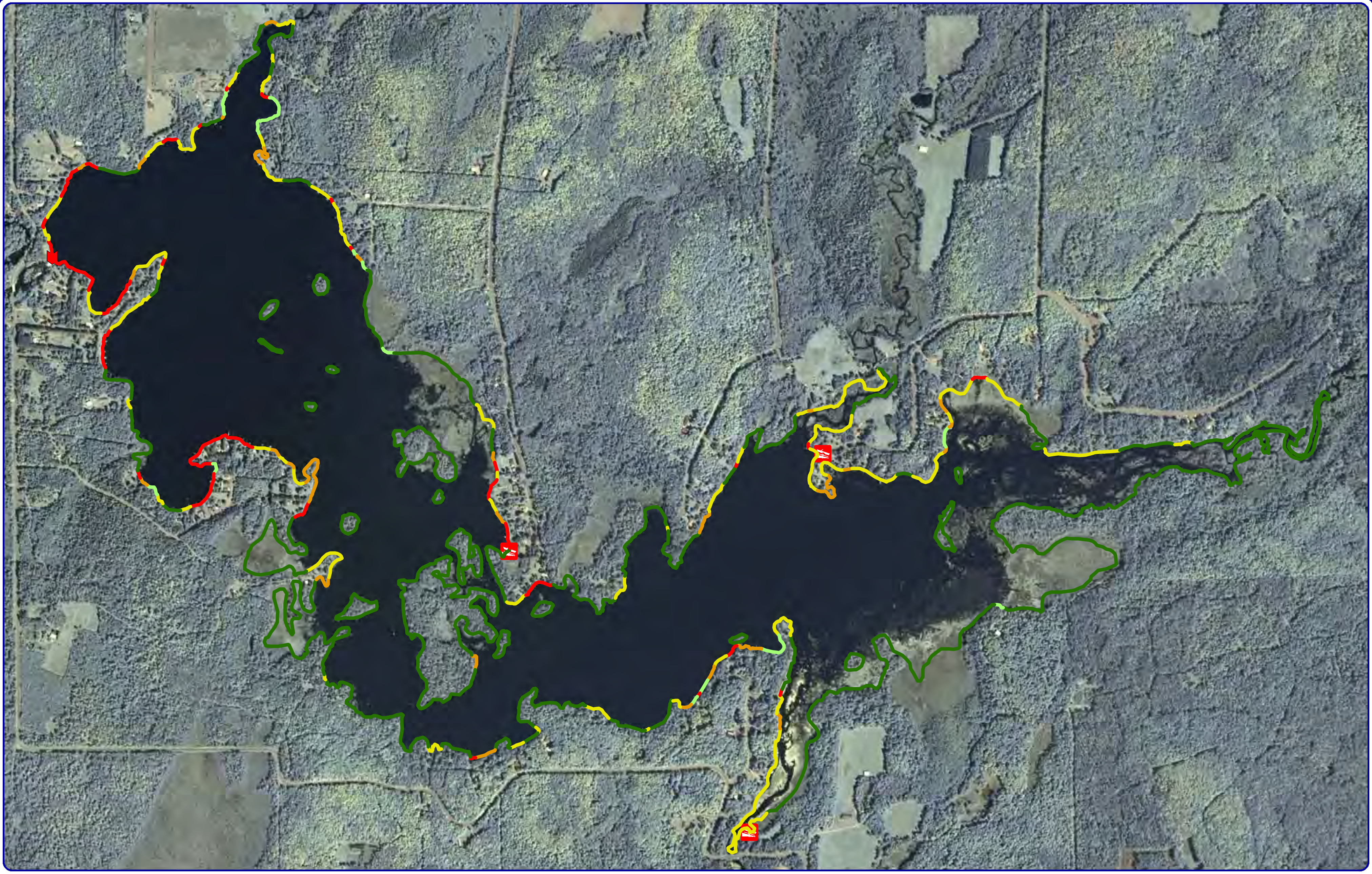


Project Location in Wisconsin

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Legend

- Natural/Undeveloped
- Developed-Natural
- Developed-Semi-Natural
- Developed-Unnatural
- Urbanized

Map 3
Musser Lake
Price County, Wisconsin

2010 Shoreline Condition

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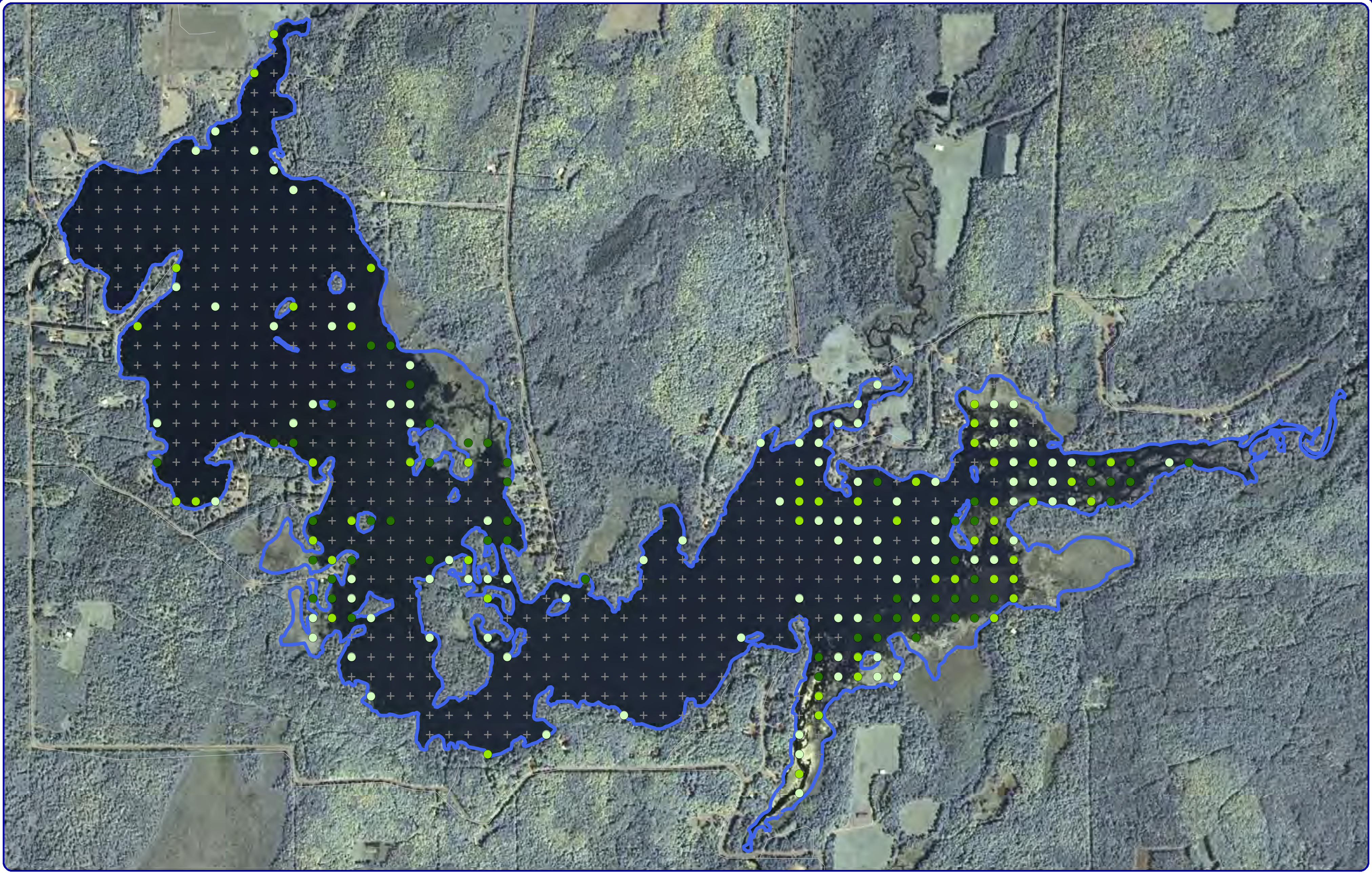
920.338.8860
www.onterra-eco.com

Sources:
Orthophotography: NAIP, 2010
Shoreline Assessment: Onterra, 2010
Map date: October 27, 2011
Filename: *Map3_Musser_SA_2010.mxd*



N
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1,250

Feet

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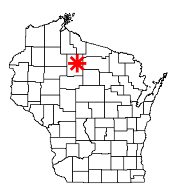
Sources:
Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plant Survey: Onterra, 2010
Map Date: October 27, 2011
Filename: *Map4_Musser_2010_Veg_Locations.mxd*



Project Location in Wisconsin

Legend

Point-intercept Sampling Locations

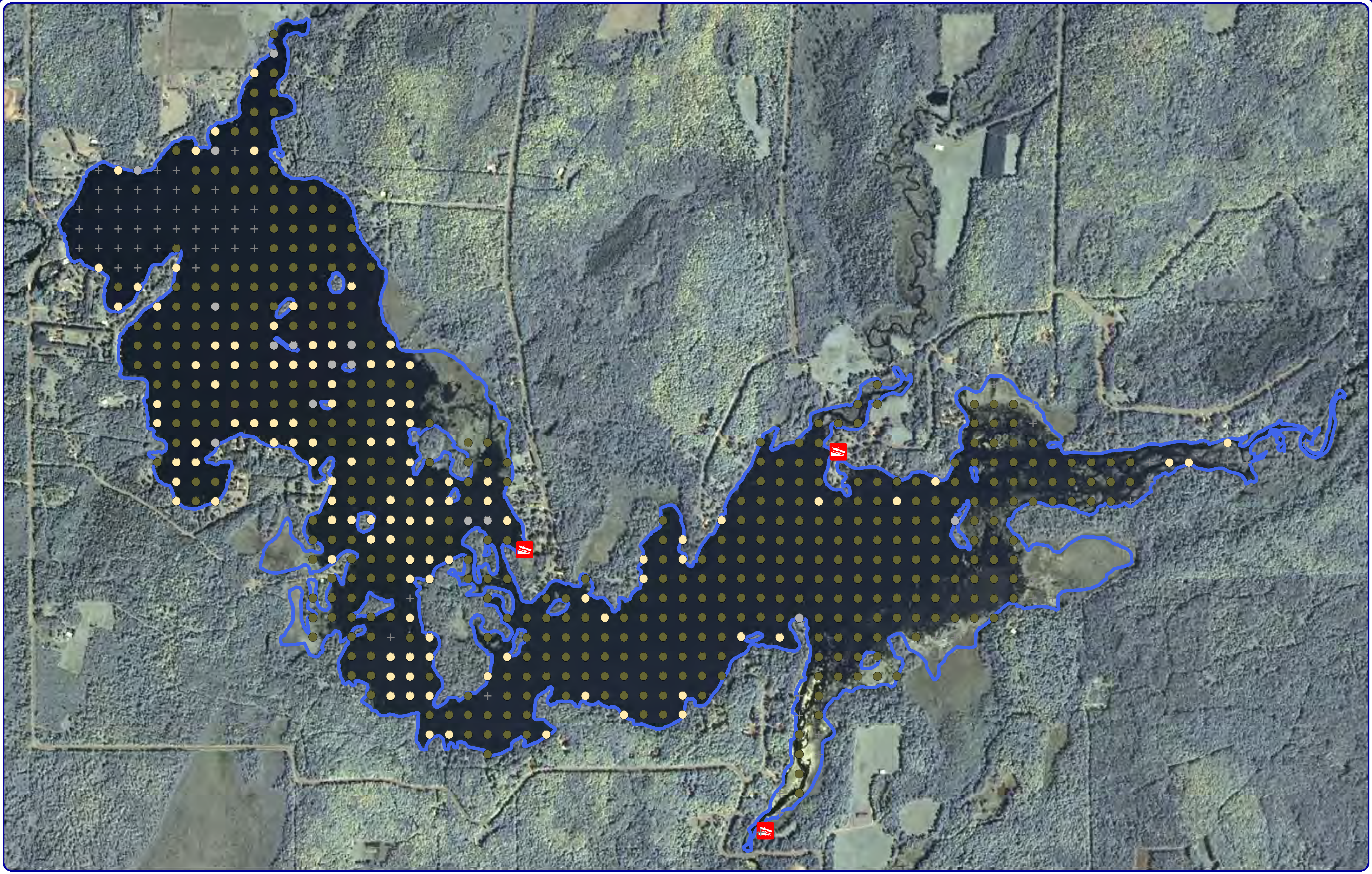
- + No Vegetation
- Rake-fullness = 1
- Rake-fullness = 2
- Rake-fullness = 3

Map 4

Musser Lake

Price County, Wisconsin

2010 PI Survey:
Aquatic Plant Distribution



N
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1,250
Feet

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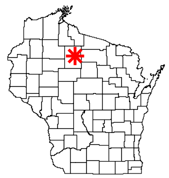
Sources:
Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plant Survey: Onterra, 2010
Map Date: October 27, 2011
Filename: *Map5_Musser_2010_Sediment.mxd*



Project Location in Wisconsin

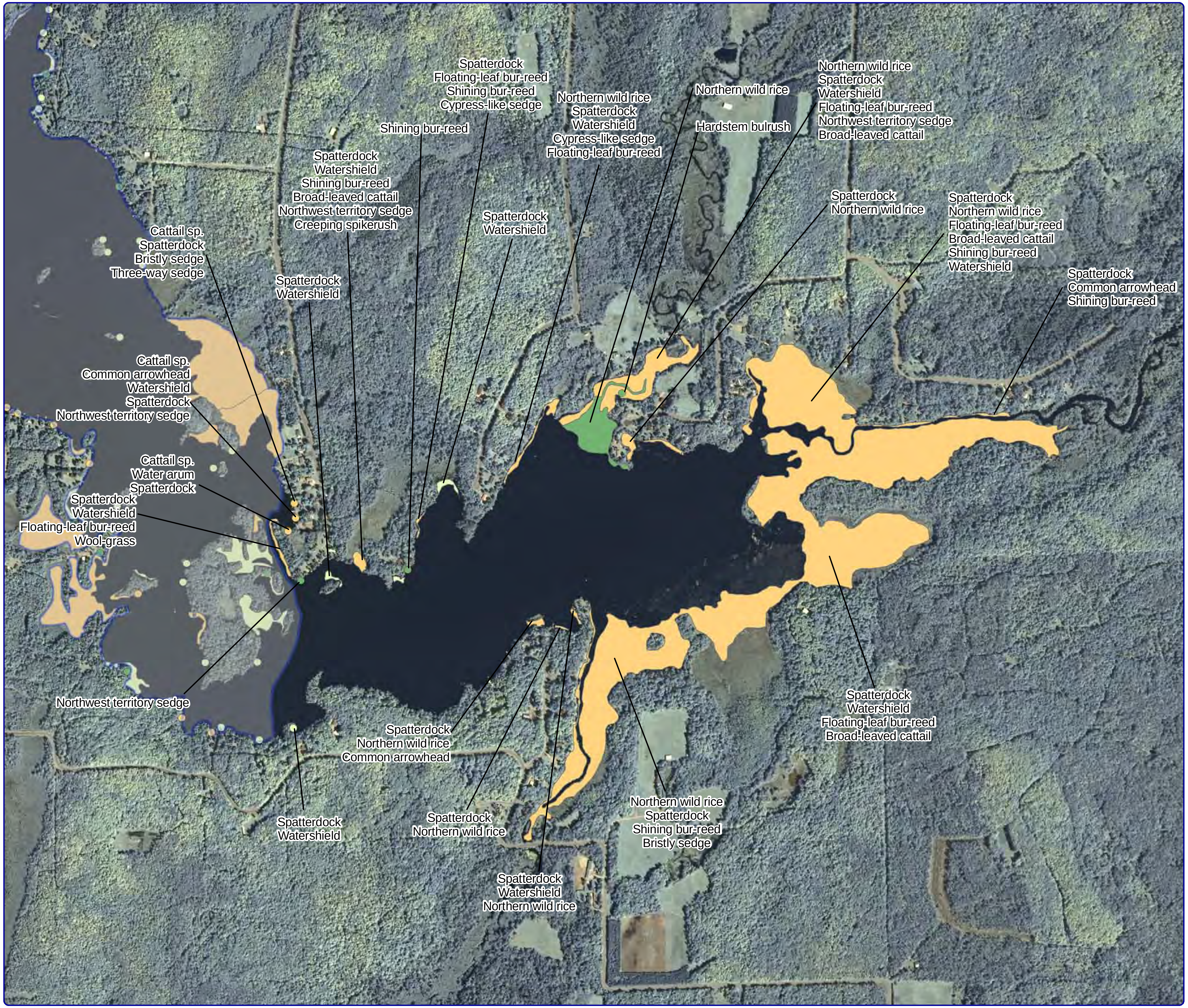
Legend

Point-intercept Sampling Locations

+ No Data
- Muck
- Sand
- Rock

Map 5
Musser Lake
Price County, Wisconsin

2010 PI Survey:
Littoral Substrate Types



Map 6
Musser Lake East

Price County, Wisconsin

Aquatic Plant Communities

Project Location in Wisconsin

Small Plant Communities

- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities

- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Sources:
Orthophotography: NAIP, 2010
Aquatic Plants: Onterra, 2010

Map Date: March 22, 2010

Filename: *Map6_Musser_EastComm_2010.mxd*

900
Feet

N W E S

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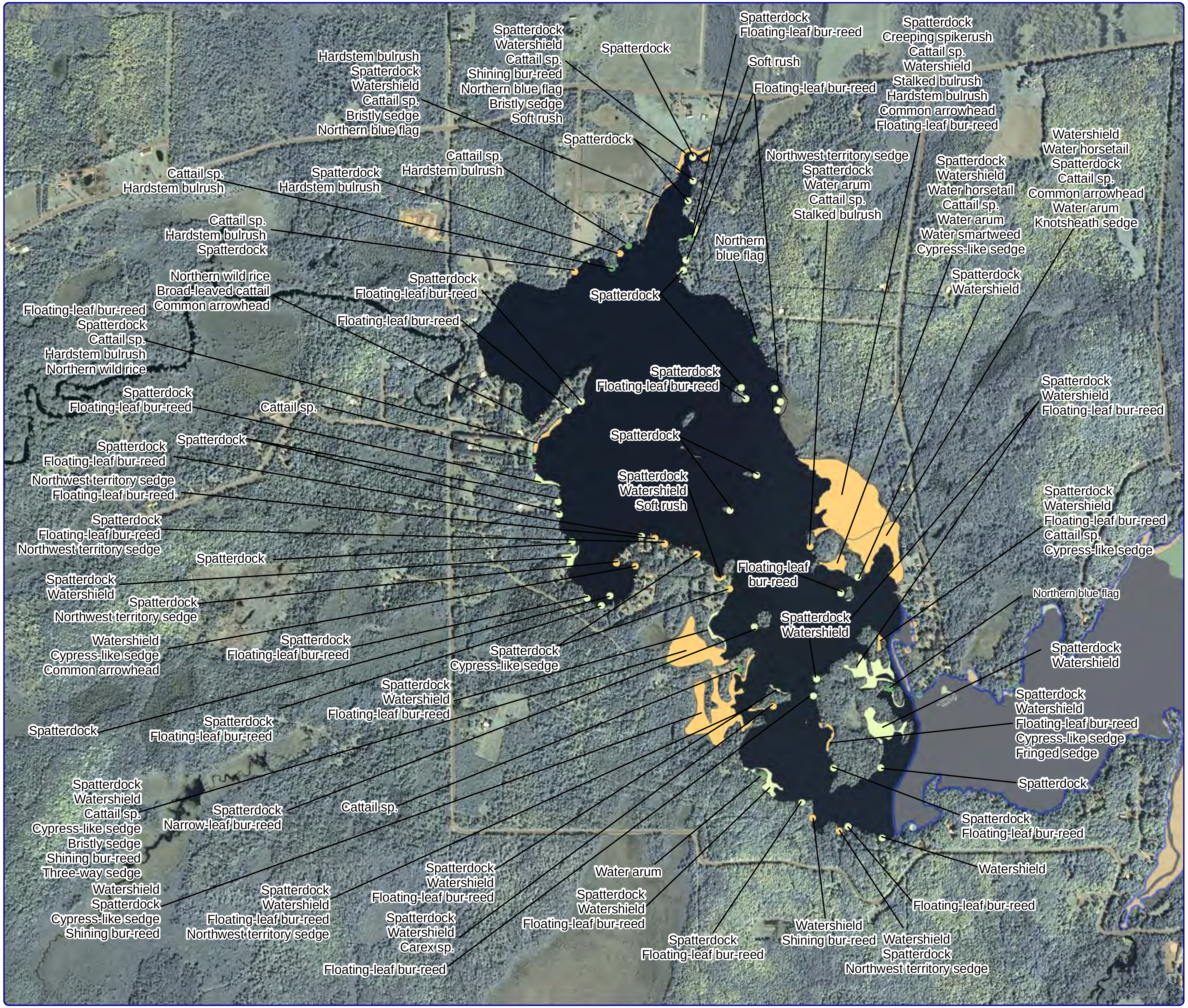
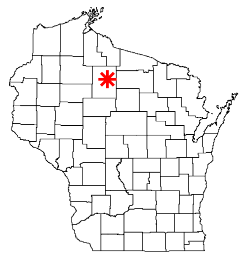


Map 7
Musser Lake West

Price County, Wisconsin

Aquatic Plant Communities



Project Location in Wisconsin

Small Plant Communities

- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Large Plant Communities

- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent

Sources:
Orthophotography: NAIP, 2010
Aquatic Plants: Onterra, 2010
Map Date: March 22, 2010
Filename: Map7_Musser_WestComm_2010.mxd

1,000 Feet

N W E S

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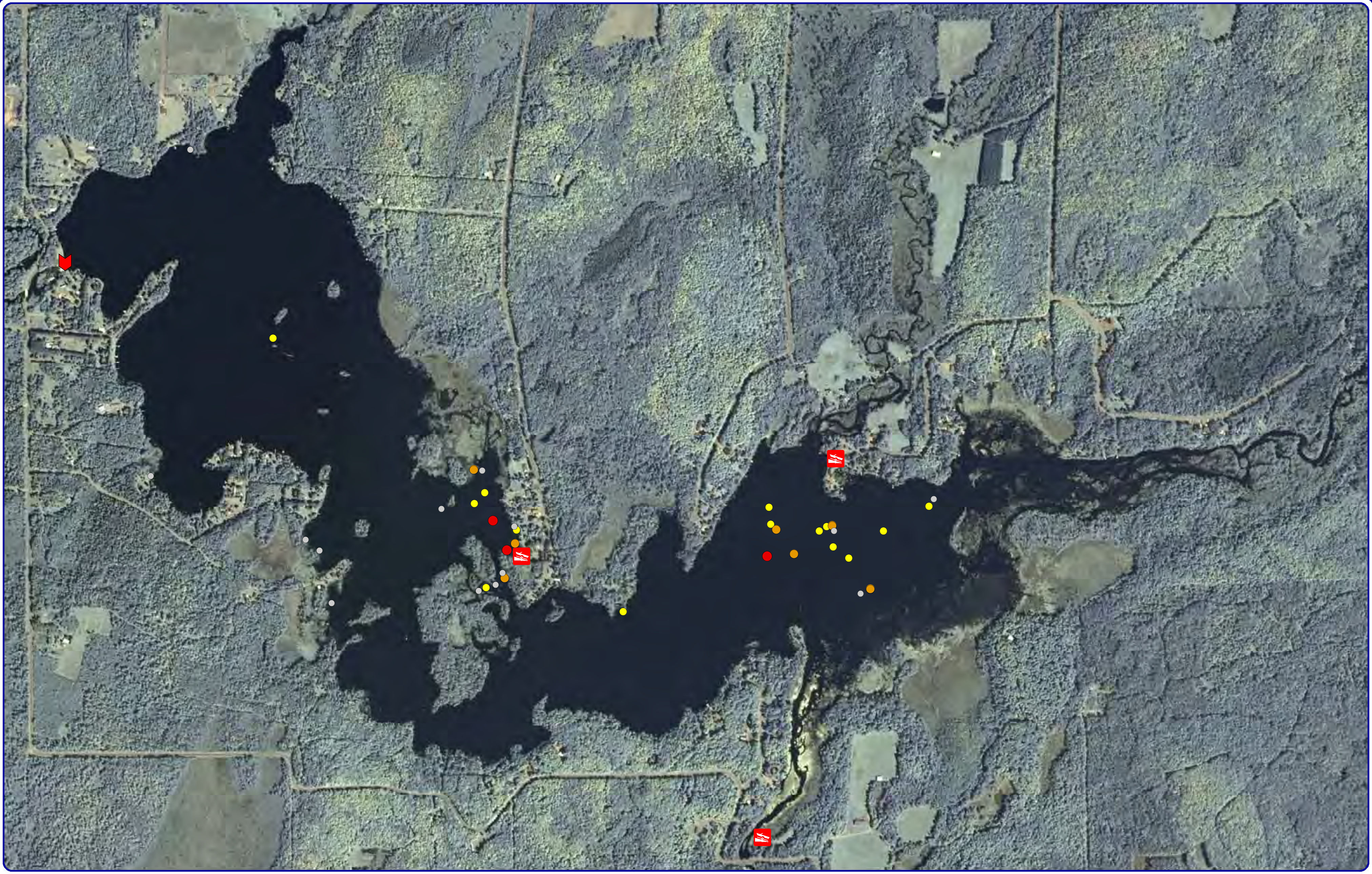

N
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1,250
Feet

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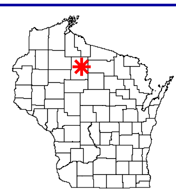
Sources:
Aquatic Plant Survey: WDNR, 2004
Orthophotography: NAIP, 2010
Map Date: November 15, 2011
Filename: Map8_Musser_04CLP.mxd



Project Location in Wisconsin

Legend

CLP Locations (WDNR, June 2004)

- Less than 200 ft^2
- Between 200 ft^2 and 400 ft^2
- Between 400 ft^2 and 600 ft^2
- Between 600 ft^2 and 900 ft^2

Map 8
Musser Lake
Price County, Wisconsin

2004 Curly-leaf Pondweed Survey Locations

2010 CLP Treatment and Hand Harvest Areas

Area Treat - Aquathol Super-K @ 1.5 ppm

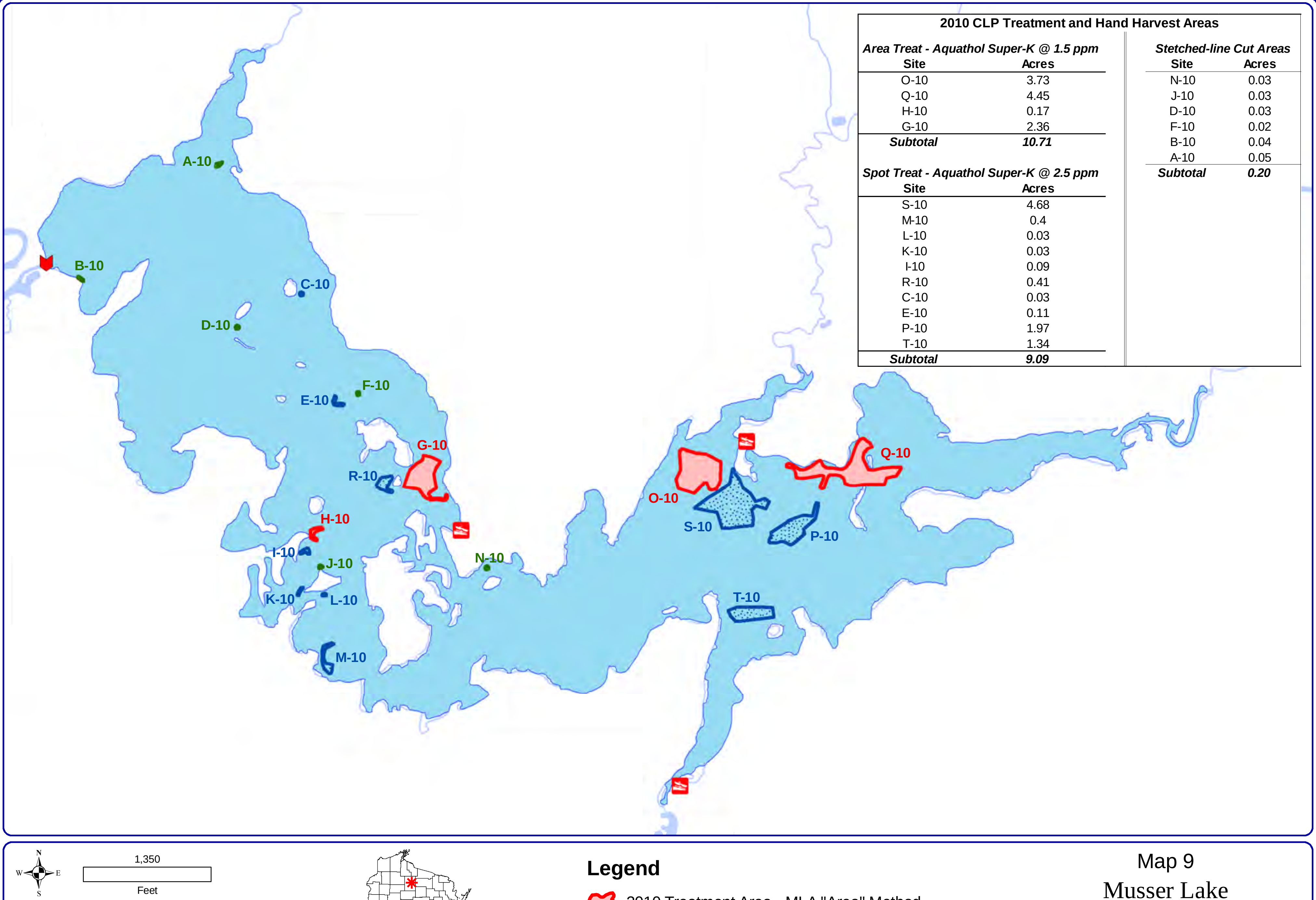
Site	Acres
O-10	3.73
Q-10	4.45
H-10	0.17
G-10	2.36
Subtotal	***10.71***

Spot Treat - Aquathol Super-K @ 2.5 ppm

Site	Acres
S-10	4.68
M-10	0.4
L-10	0.03
K-10	0.03
I-10	0.09
R-10	0.41
C-10	0.03
E-10	0.11
P-10	1.97
T-10	1.34
Subtotal	***9.09***

Stetched-line Cut Areas

Site	Acres
N-10	0.03
J-10	0.03
D-10	0.03
F-10	0.02
B-10	0.04
A-10	0.05
Subtotal	***0.20***



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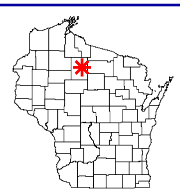
Sources:
Roads and Hydro: WDNR
Aquatic Plant Survey: Onterra, 2010
Map Date: November 17, 2011
Filename: Map9_Musser_T2010CLPTrt_Perm1.mxd



Project Location in Wisconsin

Legend

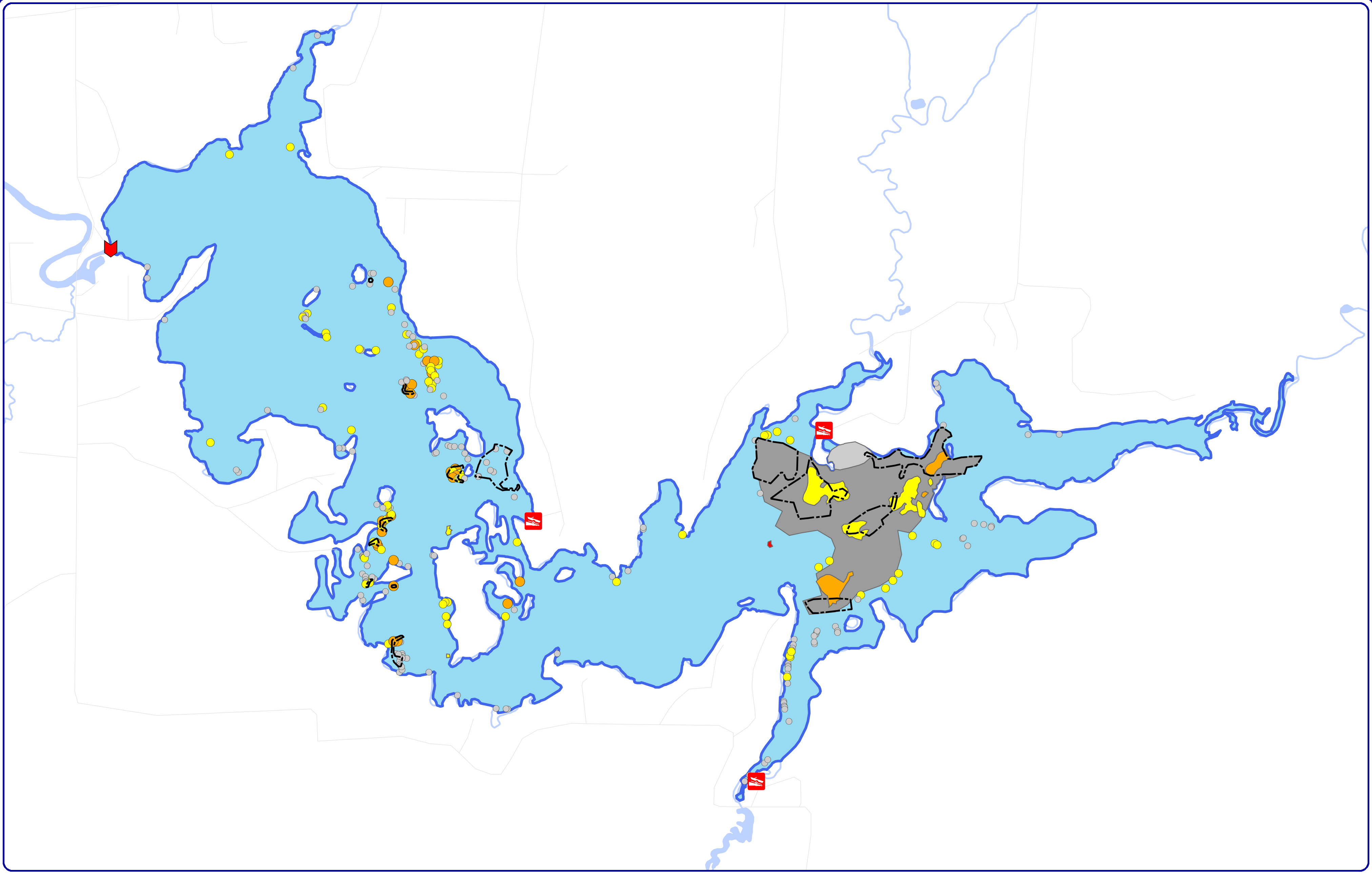
- 2010 Treatment Area - MLA "Area" Method
- 2010 Treatment Area - MLA "Spot" Method
- Mechanical Harvest - MLA "Stretched-line" Method

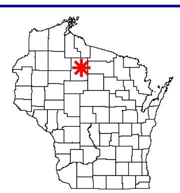
Map 9

Musser Lake

Price County, Wisconsin

2010 Final CLP Treatment Areas





N
W E
S

1,350

Feet

Onterra LLC
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Sources:
Roads and Hydro: WDNR
Aquatic Plant Survey: Onterra, 2010
Map Date: November 17, 2011
Filename: Map10_Musser_2010_CLP_PB.mxd

Project Location in Wisconsin

Legend

2010 Herbicide Treatment Areas

CLP Survey Results (June 2010)
- Single Plants
- Clump of Plants
- Small Plant Colony

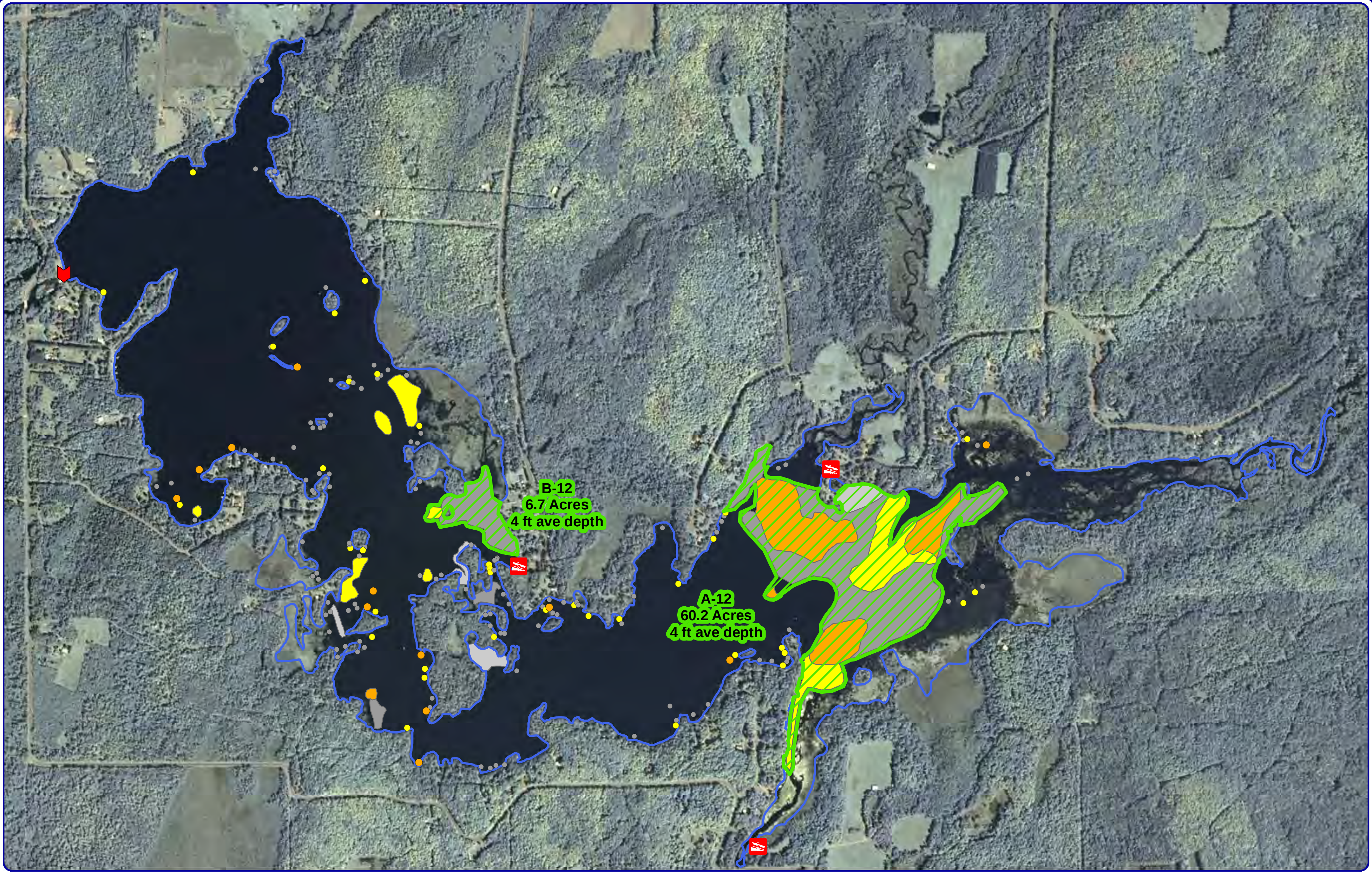
CLP Survey Results (June 2010)
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting

Map 10

Musser Lake

Price County, Wisconsin

June 2010 CLP Survey Results



N
W E
S

1,250

Feet

Onterra LLC
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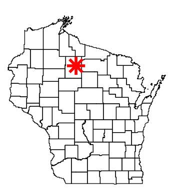
Sources:
Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plant Survey: Onterra, 2011
Map Date: November 14, 2011
Filename: *Map11_2011_CLP_PB.mxd*



Project Location in Wisconsin

Legend

2012 Proposed Treatment Area

CLP Survey Results (June 2011)
- Single Plants
- Clump of Plants
- Small Plant Colony

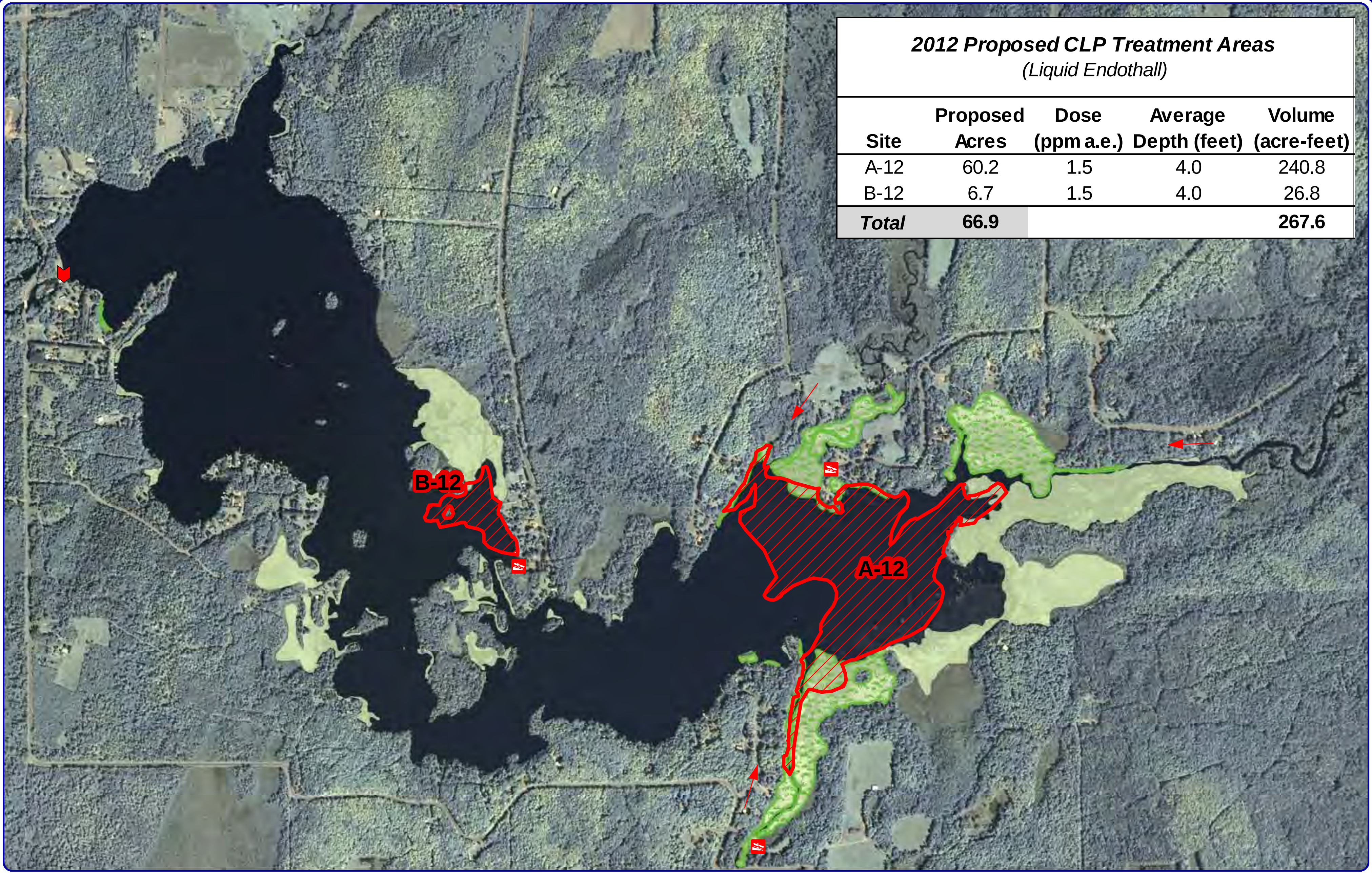
CLP Survey Results (June 2011)
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting

Map 11

Musser Lake

Price County, Wisconsin

2012 Proposed CLP Treatment Areas v.1



2012 Proposed CLP Treatment Areas
(Liquid Endothall)

Site	Proposed Acres	Dose (ppm a.e.)	Average Depth (feet)	Volume (acre-feet)
A-12	60.2	1.5	4.0	240.8
B-12	6.7	1.5	4.0	26.8
Total	**66.9**			**267.6**

N
W E
S
1,250
Feet

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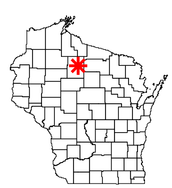
Sources:
Hydro: WDNR
Orthophotography: NAIP, 2010
Aquatic Plant Survey: Onterra, 2011
Map Date: April 3, 2012
Filename: *Map12_Musser_T2012CLP_Cond1_RiceOverlay.mxd*



Project Location in Wisconsin

Legend

- Floating-leaf and/or Emergent Plant Community
- Northern Wild Rice is First or Second Most Dominant Plant
- Proposed 2012 Treatment Area

Map 12
Musser Lake
Price County, Wisconsin
2012 Proposed CLP Treatment Areas v.1 with Wild Rice Overlay