Big Portage Lake

Vilas County, Wisconsin

Comprehensive Management Plan

November 2012

Sponsored by:

Big Portage Lake Riparian Owners Association
WDNR Grant Program

LPL-1311-10, LPL-1312-10 & LPL-1404-11

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Onterra LLC
Lake Management Planning

Big Portage Lake

Vilas County, Wisconsin

Comprehensive Management Plan

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Funded by: Big Portage Lake Riparian Owners Association
Wisconsin Dept. of Natural Resources
(LPL-1311-10, LPL-1312-10 & LPL-1404-11)

Acknowledgements

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

Big Portage Lake Planning Committee

Alice Muehlethaler	Dave Leifheit	Stacy Hron
Dale Reilley	Susan Johns	Jules Eberhardt
Forrest Muehlethaler	Jill Edwards	Jane Reilley

Wisconsin Dept. of Natural Resources
Kevin Gauthier

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1.0 INTRODUCTION

Big Portage Lake, Vilas County, is a 587-acre seepage lake with a maximum depth of 40 feet. This upper oligotrophic/lower mesotrophic lake has a relatively small watershed when compared to the size of the lake. Big Portage Lake contains 30 native plant species, of which slender naiad is the most common plant. Reed canary grass, a wetland exotic plant was found along the Big Portage Lake shoreline during summer 2010 surveys.

Field Survey Notes

Low water levels observed during summer surveys. Many areas of exposed lake bottom along shoreline. Interesting plant species here, such as spiny-spored quillwort, small purple bladderwort, along with horsetail (pictured at right) *and flowering water lobelia* (also pictured at right).

Photograph 1.0-1 Big Portage Lake, Vilas County

Lake at a Glance - Big Portage Lake

Morphology	
Acreage	587
Maximum Depth (ft)	40
Mean Depth (ft)	19
Shoreline Complexity	4.0
Vegetation	
Curly-leaf Survey Date	June 23, 2010
Comprehensive Survey Date	July 13 & 14, 2010
Number of Native Species	30
Threatened/Special Concern Species	Small purple bladderwort
Exotic Plant Species	Reed canary grass
Simpson's Diversity	0.92
Average Conservatism	7.5
Water Quality	
Trophic State	Upper oligotrophic / lower mesotrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	6.8
Sensitivity to Acid Rain	Low
Watershed to Lake Area Ratio	1:1

The Big Portage Lake Riparian Owners Association (BPLROA) was formed in 1976 for the purpose of protecting the quality of Big Portage Lake by creating an awareness of issues affecting the lake and providing a sense of community and a collective voice for stewardship of the fragile lake resource. Since its inception, the association has worked hard on protection and enhancing the Big Portage Lake ecosystem by monitoring the lake for invasive species, participating in the Clean Boats Clean Waters program, organizing a battle against tent caterpillars, etc.

Big Portage Lake is a highly sought after location amongst recreationists and anglers. These intense public use opportunities expose the lake to numerous occasions for AIS introductions, especially considering the Cisco Chain and Little Saint Germain, both less than 15 miles away, support curly-leaf pondweed (CLP) infestations. Furthermore, Forest Lake, which is only 3.5 miles from Big Portage Lake, supports Eurasian water milfoil.

In 2009, members of the BPLROA became interested in creation of a lake management plan, and contacted the Wisconsin Department of Natural Resources (WDNR) and Onterra, LLC to discuss the planning process and grant funding possibilities. The BPLROA sought a lake management planning project for two primary reasons; first, they wanted to be better prepared to react if Big Portage Lake should become established with an aquatic invasive species. The WDNR advised the association that the department can respond more quickly and accurately to address an establishment if the lake has a management plan in place. Secondly, the BPLROA understood the value in gaining a better understanding of the overall condition of Big Portage Lake.

Between August of 2009 and February of 2010, the BPLROA was awarded 3 grants through the WDNR to fund studies on Big Portage Lake. In the document that follows, the results of these studies are presented, along with a detailed plan the BPLROA will initiate to protect, preserve, and enhance their lake.

2.0 STAKEHOLDER PARTICIPATION

Stakeholder participation is an important part of any management planning exercise. During this project, stakeholders were not only informed about the project and its results, but also introduced to important concepts in lake ecology. The objective of this component in the planning process is to accommodate communication between the planners and the stakeholders. The communication is educational in nature, both in terms of the planners educating the stakeholders and vice-versa. The planners educate the stakeholders about the planning process, the functions of their lake ecosystem, their impact on the lake, and what can realistically be expected regarding the management of the aquatic system. The stakeholders educate the planners by describing how they would like the lake to be, how they use the lake, and how they would like to be involved in managing it. All of this information is communicated through multiple meetings that involve the BPLROA as a whole or a focus group called a Planning Committee, the completion of a stakeholder survey, and updates within the BPLROA'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 July 3rd, 2010, a project kick-off meeting was held to introduce the project to the general public. The meeting was announced through a mailing and personal contact by BPLROA board members. The attendees observed a presentation given by Tim Hoyman, an aquatic ecologist with Onterra. Mr. Hoyman's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation was followed by a question and answer session.

Planning Committee Meeting I
On July 25th, 2011, Tim Hoyman of Onterra met with several members of the Big Portage Lake Planning Committee for nearly 3 hours. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including, aquatic plant inventories, water quality analysis and watershed modeling were presented and discussed. Many concerns were raised by the committee, including low water levels, fishing activities and shoreline conditions along the lake.

Planning Committee Meeting II
On October 6th, 2011, Tim Hoyman and Dan Cibulka met with the members of the Planning Committee to discuss the stakeholder survey results and begin developing management goals and actions for the Big Portage Lake management plan. The group constructed a Mission Statement, found in the beginning of the Implementation Plan section, that will serve to guide the committee and the BPLROA as they manage and monitor their lake ecosystem.

Project Wrap-up Meeting
The project Wrap-up meeting was conducted by Tim Hoyman from Onterra and held on July 7, 2012. This meeting was held to share the results of the scientific studies with the entire BPLROA and general public. Along with the project results, general conclusions and the

management goals the planning committee and Onterra staff had crafted were shared with the attendees.

Management Plan Review and Adoption Process

In December of 2012, a draft of the management plant was sent to the Big Portage Lake Planning Committee for review. In February of 2012, the committee provided a list of comments for Onterra to address. These revisions were completed in March of 2012, and a second draft was then sent to the planning committee members as well as the WDNR for a review. The WDNR completed the review of the second draft on October 18 of 2012. Comments and questions were addressed by Onterra staff in mid-November 2012 and the plan was subsequently finalized at that time.

This report reflects the integration of comments received by both the Big Portage Lake planning committee and WDNR. The document was reviewed by the BPLPOA Board of Directors, who then voted to adopt the four management goals of the plan and implement them through creation of four committees (Education, Water Quality, Aquatic Invasives and Fishery), each led by a board member.

Stakeholder Survey

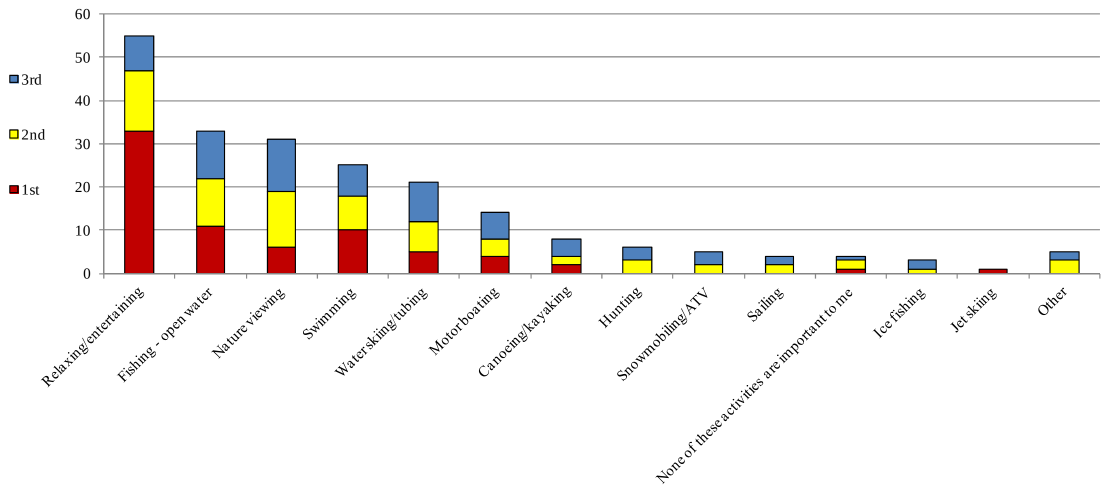
During August 2010, a six-page, 26-question survey was mailed to 106 riparian property owners in the Big Portage Lake watershed. 70 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Big Portage Lake Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a summary of several survey findings is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Big Portage Lake. The majority of stakeholders (50%) are seasonal residents, while 23% visit on weekends through the year and only 18% live on the lake year-round. 69% of stakeholders have owned their property for over 15 years, and 51% have owned their property for over 25 years.

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. More than half of survey respondents indicate that they use a larger motor boat on the lake, while canoe/kayaks, rowboats, and small motor boats are also popular watercraft choices (Question 7). On a moderately sized lake such as Big Portage Lake, the importance of responsible boating activities is increased. The need for responsible boating increases particularly during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the lake. As seen on Question 17, boat traffic was listed as one of the higher ranking factors potentially impacting Big Portage Lake in a negative manner, but was not ranked highly when survey respondents were asked to rank their top three concerns for the lake (Question 18).

A concern of stakeholders noted throughout the stakeholder survey comments was low water levels within Big Portage Lake. Aquatic invasive species (AIS), water quality degradation, septic system discharge and loss of fish habitat ranked highly amongst Big Portage Lake stakeholders as well (Question 18).

Question 6: Please rank up to three activities that are important reasons for owning your property on or near the lake.



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Question 7: What types of watercraft do you currently use on the lake?

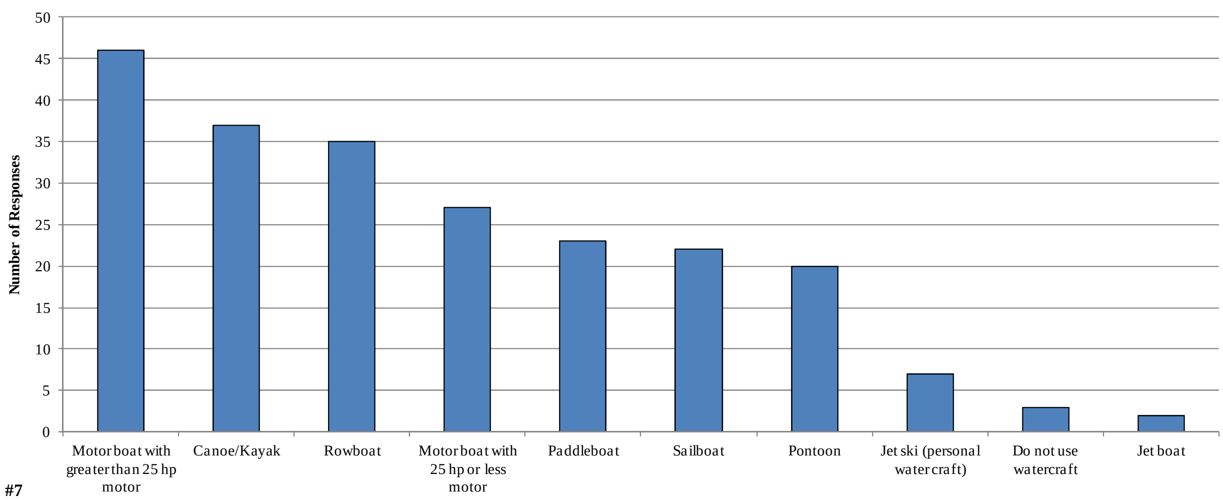

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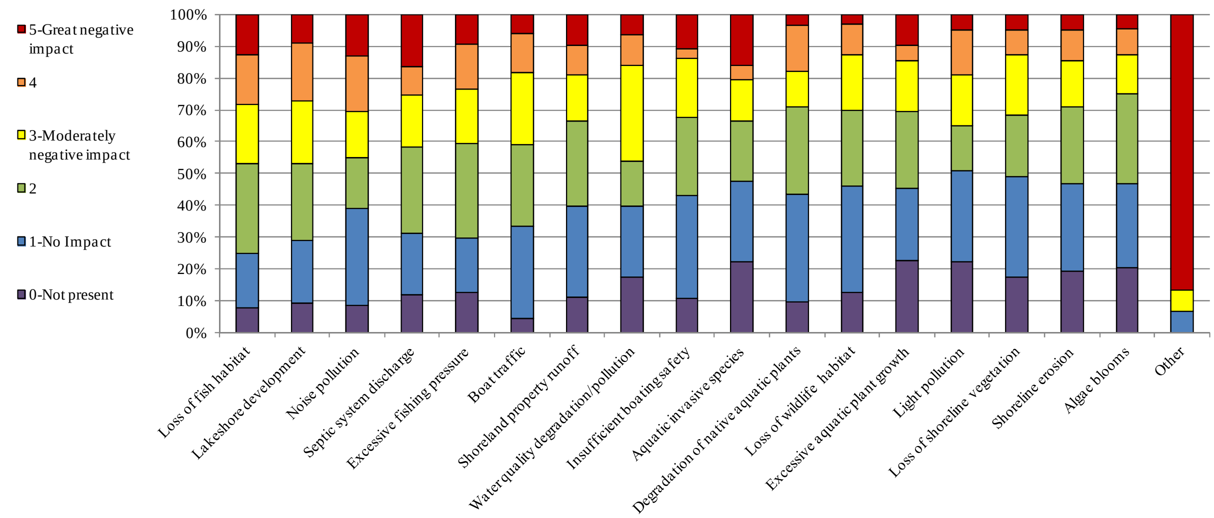
Figure 2.0-1. Select survey responses from the Big Portage Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question 17: To what level do you believe these factors may be negatively impacting Big Portage Lake?



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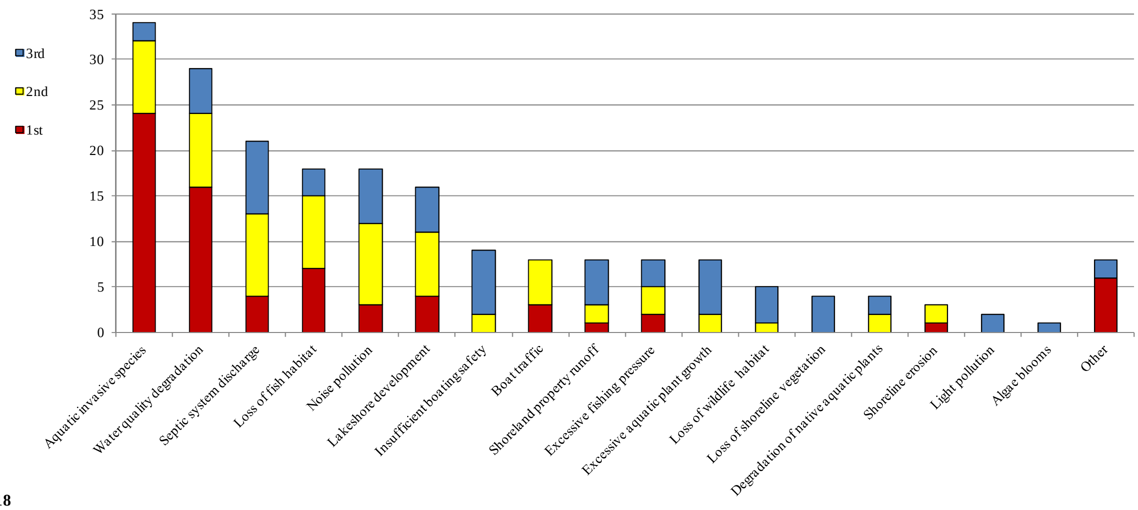
Question 18: Please rank your top three concerns regarding Big Portage Lake.



#18

Figure 2.0-2. Select survey responses from the Big Portage 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, not all chemical attributes collected may have a direct bearing on the lake's ecology, but may be more useful as indicators of other problems. Finally, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

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

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 Big Portage 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 Big Portage Lake's water quality analysis:

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

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

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

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

Trophic State

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

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

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

Limiting Nutrient

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

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

Temperature and Dissolved Oxygen Profiles

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

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

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

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

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

Non-Candidate Lakes

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

Candidate Lakes

- Lakes with hypolimnetic total phosphorus concentrations exceeding 200 μg/L.

- Lakes with epilimnetic phosphorus concentrations that cannot be accounted for in watershed phosphorus load modeling.

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

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

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

Comparisons with Other Datasets

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

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

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

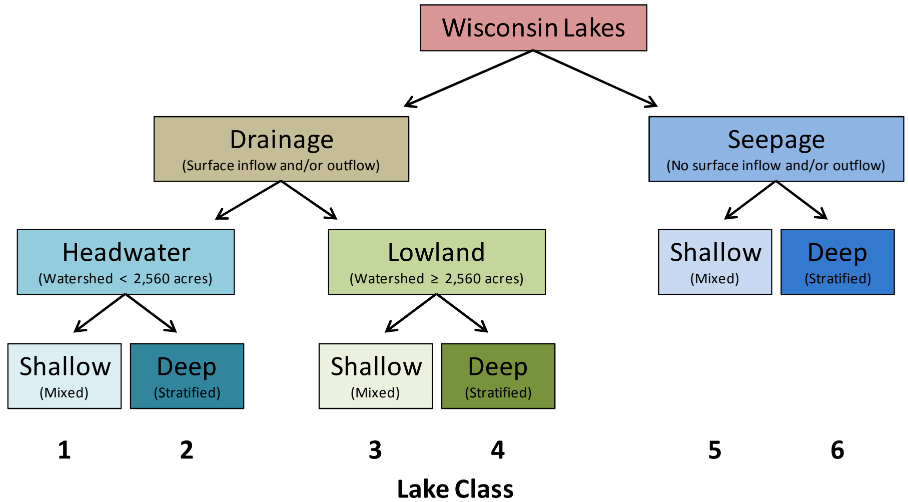


Figure 3.1-1. Wisconsin Lake Classifications. Big Portage Lake is classified as deep (stratified), seepage lakes (Class 6). Adapted from WDNR PUB-SS-1044 2008.

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

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

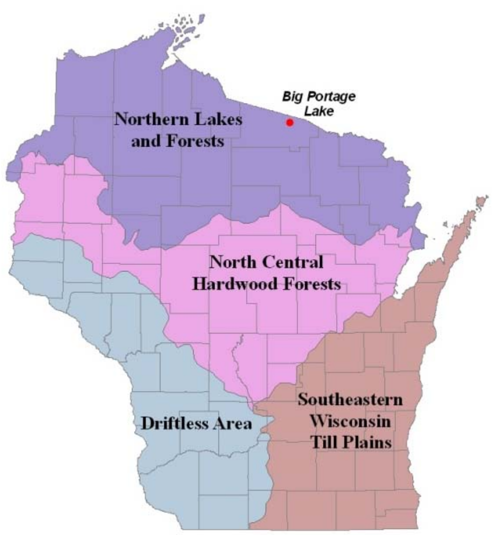


Figure 3.1-2. Location of Big Portage Lake within the ecoregions of Wisconsin. After Nichols 1999.

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

Big Portage Water Quality Analysis

Big Portage Long-term Trends

As part of the stakeholder survey associated with this project, lake residents were asked questions regarding their perspectives on the water quality of Big Portage Lake. Most respondents hold the water quality of Big Portage Lake in high regards; about 86% would describe the current water quality as good or excellent (Appendix B, Question #12). 61% of these same individuals believe the water quality has remained unchanged since they obtained their property (Question #13).

Although the above statements are only an anecdotal testimony as to the quality of Big Portage Lake's water, the data collected over the past 15 years or so provides substance to these observations. Average summer phosphorus concentrations between 1997 and 2010 ranged from 6.7 to 14.5 µg/L. These values rank as Excellent in the WisCALM classification system, and a weighted mean of these values is low when compared to similar lakes state-wide (Figure 3.1-3).

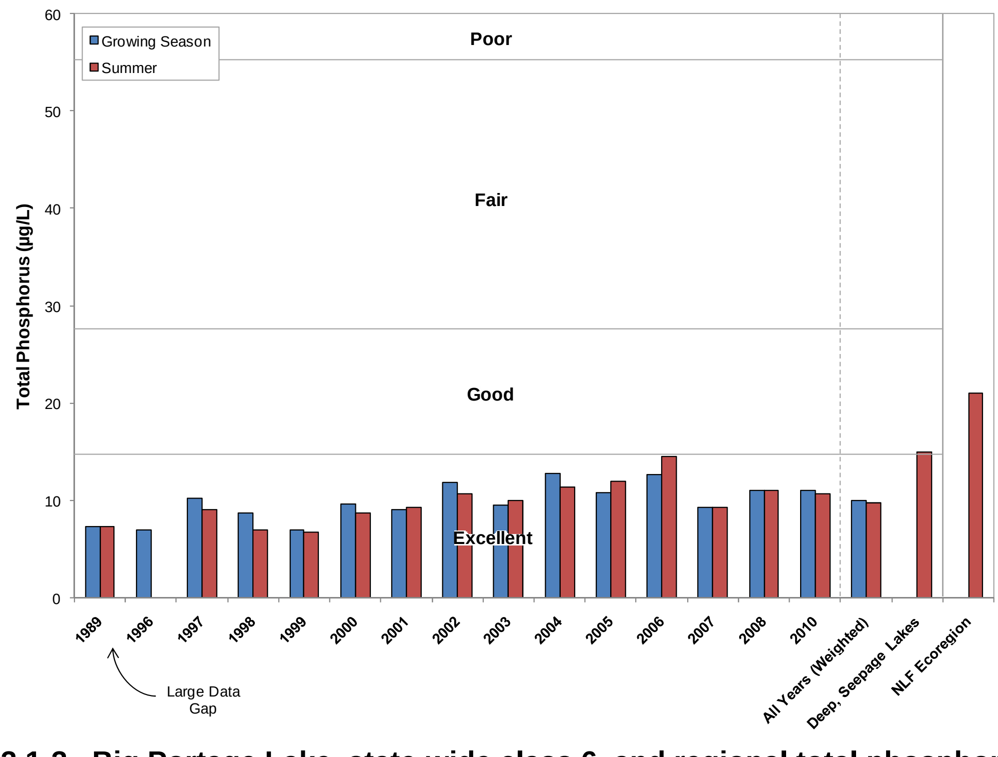


Figure 3.1-3. Big Portage Lake, state-wide class 6, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

During this same time period, chlorophyll-*a* values remained below 7 μg/L, falling into WisCALM categories of mostly Excellent and Good. These values are comparable to those found in other deep seepage lakes (Figure 3.1-4). Although phosphorus and chlorophyll-*a* parameters are closely related these data show only slight variability from year to year, particularly in 2004 and 2005. Algal production is highly dependent upon phosphorus availability, but may be influenced also by water temperature, sunlight, and other environmental factors.

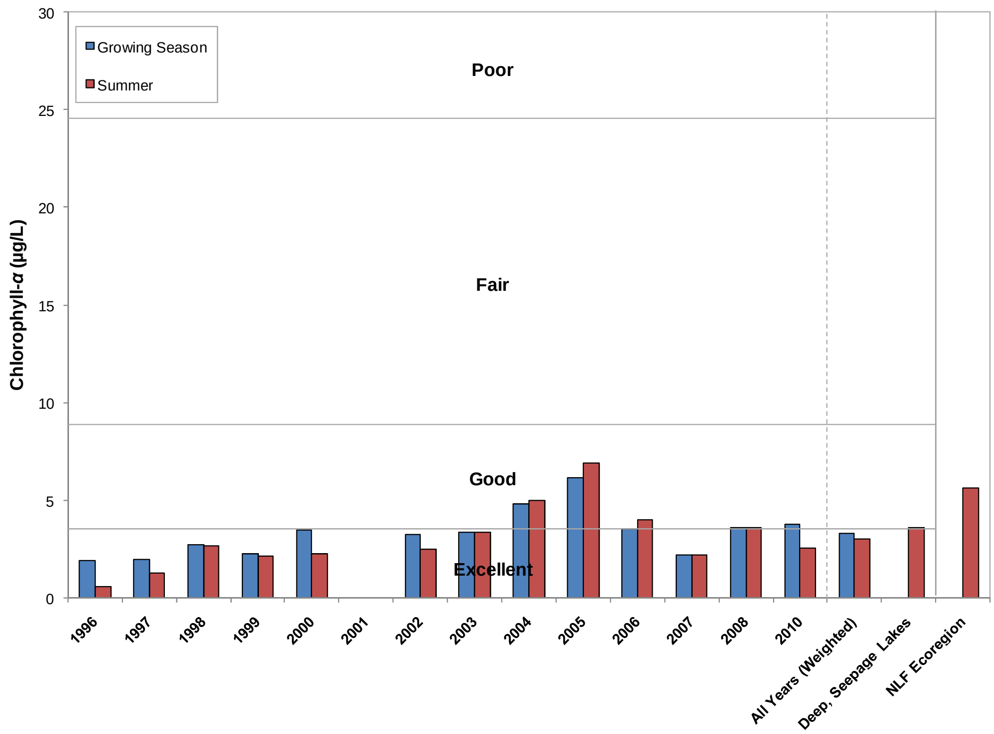


Figure 3.1-4. Big Portage Lake, state-wide class 6, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

The third primary water quality parameter analyzed in this project, Secchi disk clarity has been monitored extensively on Big Portage Lake since 1991. As mentioned above, this parameter is a very cheap and effective way to monitor the water quality of a lake. Figure 3.1-5 shows that the water clarity of Big Portage Lake is exceptional, with most summer average Secchi disk clarity values ranking at Excellent and several falling in the Good category. As with the other two water quality parameters, a weighted average of Secchi disk clarity values tops the average seen in similar deep seepage lakes.

While yearly phosphorus and chlorophyll-*a* averages seem to have varied little in Big Portage Lake in recent years, more variability is seen in the Secchi disk clarity. This parameter is influenced by many factors, such as water color brought on by dissolved elements and compounds, plankton production, and suspended sediments, which themselves vary due to several environmental conditions such as precipitation, sunlight, and nutrient availability. Water clarity may vary on a shorter time frame as well, such as during the short time following a rain event, when nutrients and sediment is washed into the lake from the nearby shorelines.

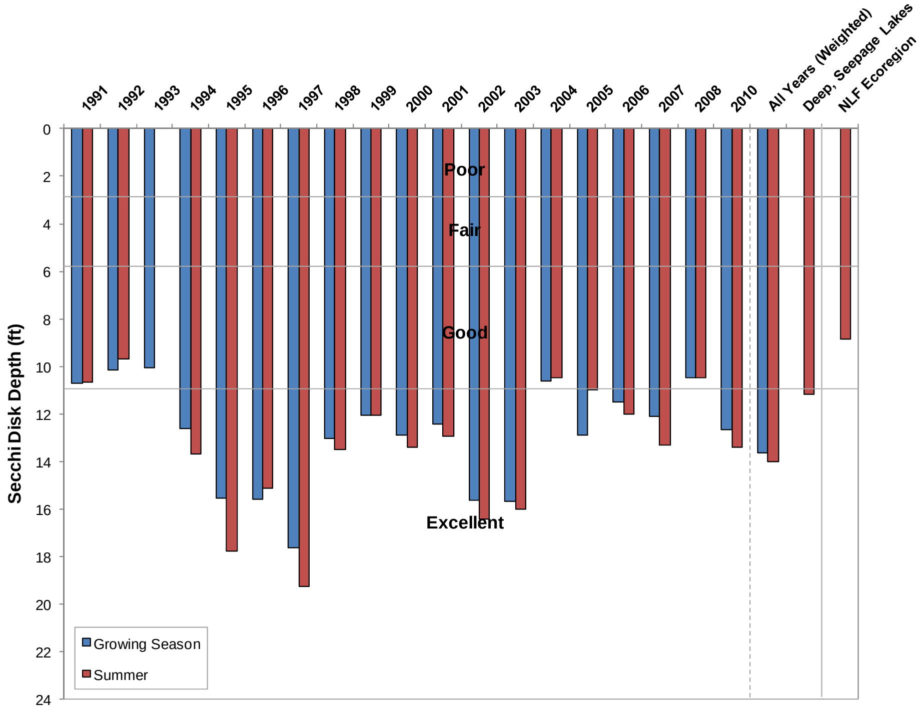


Figure 3.1-5. Big Portage Lake, state-wide class 6, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Big Portage

Using midsummer nitrogen and phosphorus concentrations from Big Portage, a nitrogen:phosphorus ratio of 42:1 was calculated. This finding indicates that Big Portage is indeed phosphorus limited as are the vast majority of Wisconsin lakes.

Big Portage Trophic State

Figure 3.1-6 contain the TSI values for Big Portage. The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from upper mesotrophic to lower oligotrophic. 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 Big Portage is an upper oligotrophic/lower mesotrophic lake. Oligotrophic/mesotrophic lakes have low plant productivity and therefore are not able to produce abundant plant biomass, either in the form of algae or macrophytes. Further, this lack of productivity, while leading to excellent water clarity, will also limit fish production within the lake.

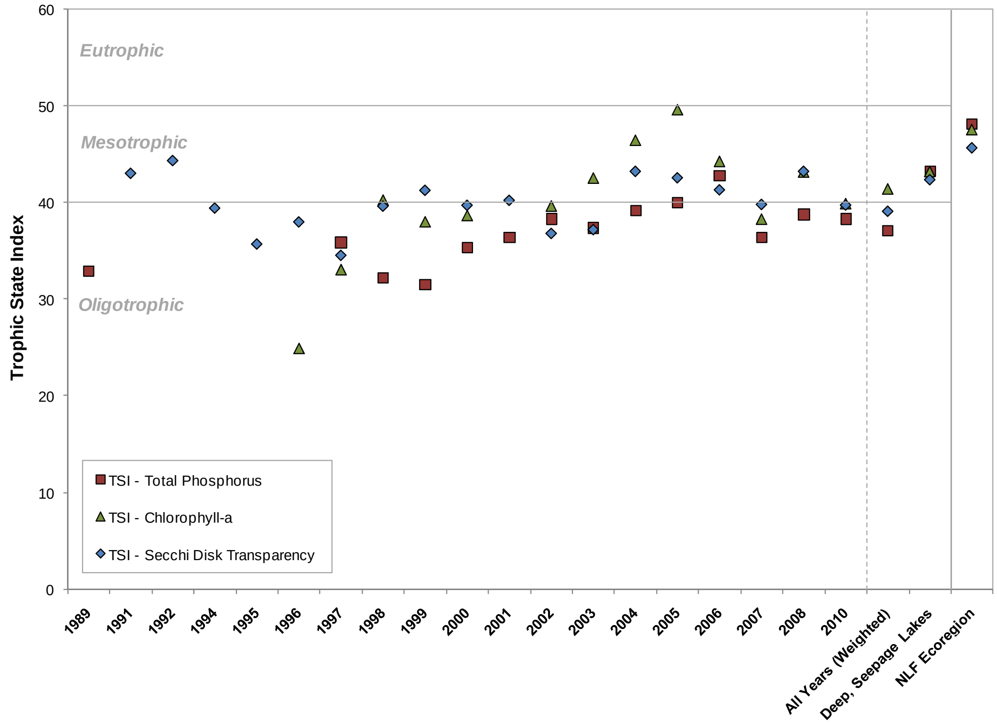


Figure 3.1-6. Big Portage Lake, state-wide class 6, and regional Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Big Portage

Dissolved oxygen and temperature were measured during water quality sampling visits to Big Portage Lake by Onterra staff. Profiles depicting these data are displayed in Figure 3.1-7. In April of 2010, the lake was completely mixed, as temperature and oxygen levels were found to be consistent throughout the entire water column. During August and October, the same scenario was observed. Big Portage Lake, although fairly deep, is large enough that the wind energy is sufficient to mix the water column and distribute oxygen and temperatures. In February, the lake is somewhat stratified as the ice prevents mixing from the wind. During this time, low oxygen levels were observed near the bottom of the lake, however the top 25 feet of the water column contained enough oxygen to support aquatic life.

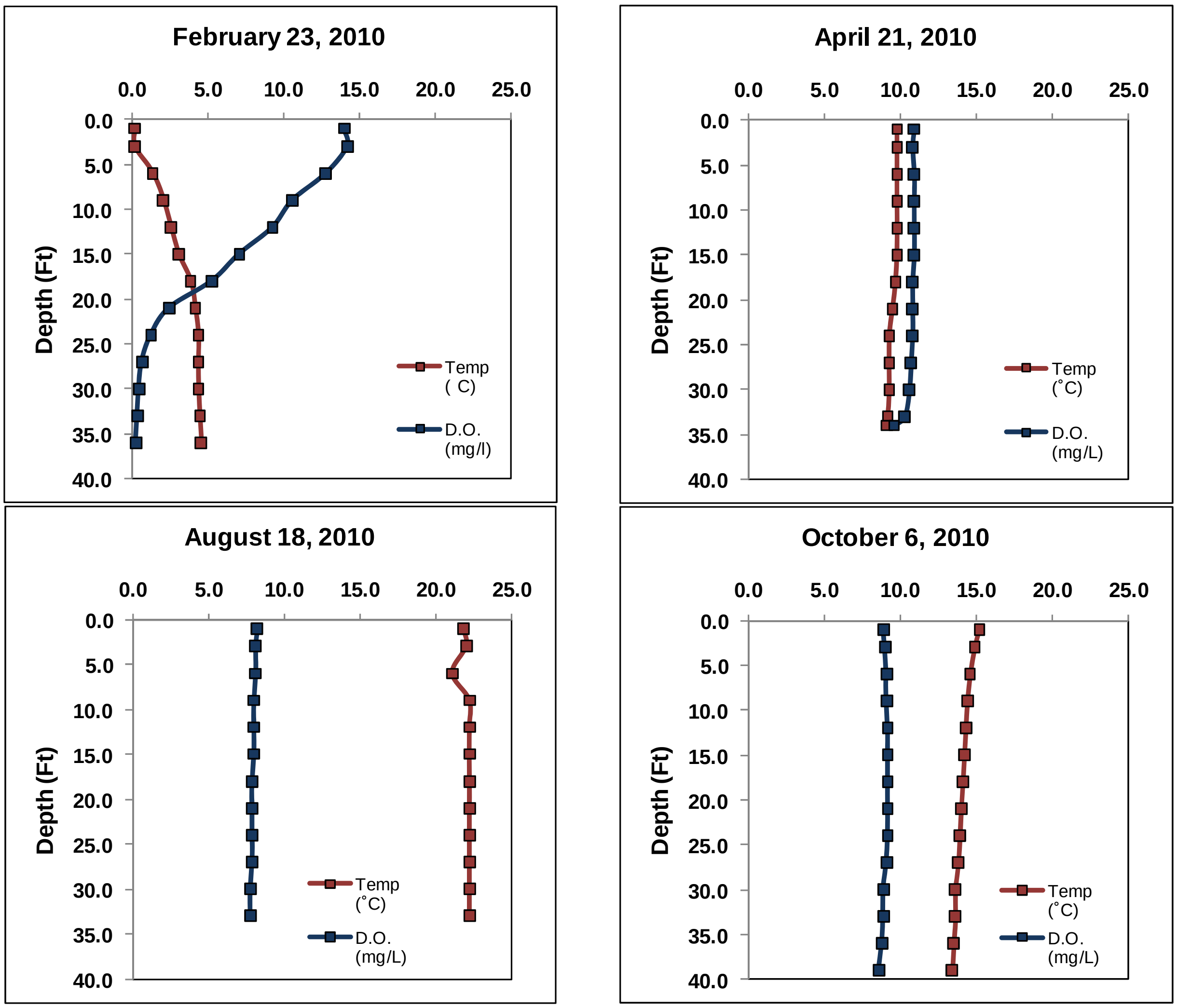


Figure 3.1-7. Big Portage Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Big Portage

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 Big Portage Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include; pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw et al. 2004). The pH of the water in Big Portage Lake was found to be near neutral with a value of 6.8, and falls within the normal range for Wisconsin lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The alkalinity in Big Portage Lake was measured at 16.0 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and has a low sensitivity to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Big Portage Lake's pH of 6.8 falls slightly outside of this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Big Portage Lake was found to be 3.9 mg/L, falling well below the optimal range for zebra mussels. Plankton tows were completed by Onterra staff during the summer of 2010 and these samples were processed by the WDNR for larval zebra mussels during the winter of 2010/11 and no veligers were found.

3.2 Watershed Assessment

Watershed Modeling

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

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

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

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

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

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

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

Note: When researching Big Portage Lake, it became apparent that there were discrepancies in the size of the lake. The WDNR publication "Wisconsin Lakes" (PUB-FH-800, 2009) lists Big Portage Lake as being 638 acres in size. A 2008 WDNR lake survey map states the lake is 586 acres in size. Finally, the WDNR's ArcGIS hydro file has the lake at 587 acres. To double-check this number, the outline of the ArcGIS hydro file was compared to National Agriculture Imagery Program (NAIP) orthophotography files. Because the outline of the hydro file followed the outline of the lake on the NAIP photograph, it was assumed that 587 acres was the most accurate number to select as the size of Big Portage Lake. Therefore, for the purposes of this study, the lake was assumed to be 587 acres in size.

The watershed surrounding Big Portage Lake is approximately 1,455 acres (Map 2). It largely consists of forested land (56%) and the actual surface of the lake (40%) while wetlands contribute a smaller portion (Figure 3.2-1). Small areas of pasture/grass are found in the watershed as well. The watershed is only slightly larger than the lake, making for a watershed to lake area ratio of 1:1. As previously discussed, lakes that have relatively small watershed to lake area ratios can be negatively impacted by even small amounts of agricultural or urban lands.

Fortunately, the land within Big Portage Lake's watershed is predominately types that are very efficient at retaining nutrients and allowing precipitation to be absorbed by the earth, which results in minimal nutrient runoff into the lake. Modeling of phosphorus runoff to Big Portage Lake using WiLMS confirms that very little phosphorus runs off into the lake. The annual phosphorus load for the lake is estimated to be 229 lbs, a very small amount for a lake that is large and holds great volume of water like Big Portage. Of the areas supplying phosphorus to the lake, the largest contributor is actually the surface of the lake itself. Through atmospheric deposition, 157 lbs or 68% of the average annual phosphorus load ends up in the lake. Forested land exports an additional 66 lbs (29%), while wetlands and pasture/grass lands supply minimal amounts of phosphorus to the lake on an annual basis (Figure 3.1-2).

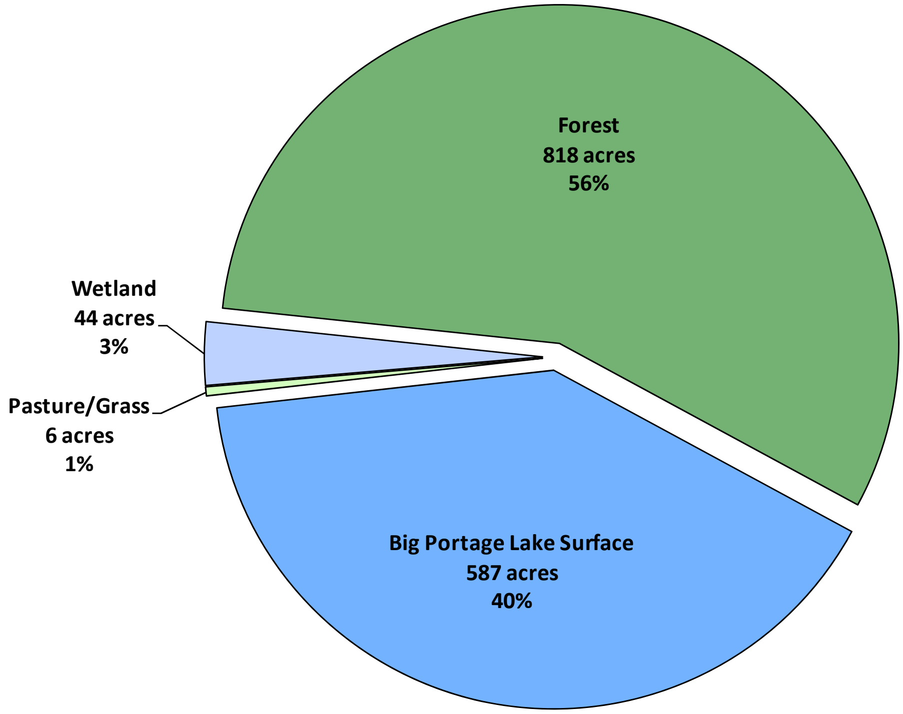


Figure 3.2-1. Big Portage Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

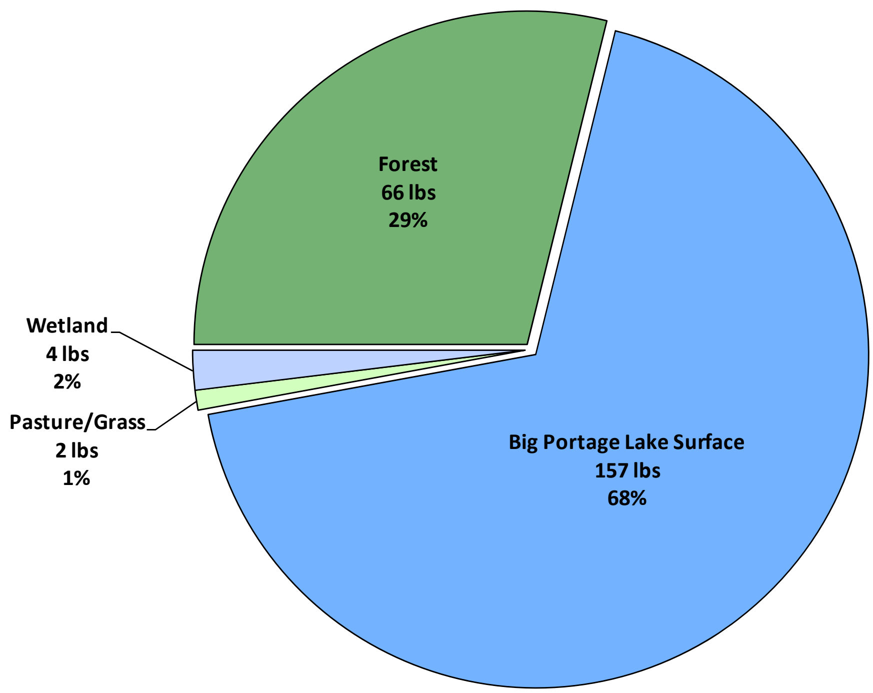


Figure 3.2-2. Big Portage Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Shoreline Assessment

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

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

A lake's shoreland zone can be classified in terms of its degree of development. In general, more developed shorelines are more stressful on a lake ecosystem, while definite benefits occur from shorelines that are left in their natural state. Table 3.2-1 displays a diagram of shoreline categories, from "Urbanized", meaning the shoreland zone is completely disturbed by human influence, to "Natural/Undeveloped", meaning the shoreline has been left in its original state.

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

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

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

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

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

Figure 3.2-3. Shoreline assessment category descriptions.

On Big Portage Lake, the development stage of the entire shoreline was surveyed during late summer of 2010. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreline on a property-by-property basis. During the survey, Onterra staff examined the shoreline for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.2-3.

Big Portage Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 2.7 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 3.2-4). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 1.2 miles of urbanized and developed–unnatural shoreline were observed. If restoration of the Big Portage Lake shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreline lengths around the entire lake.

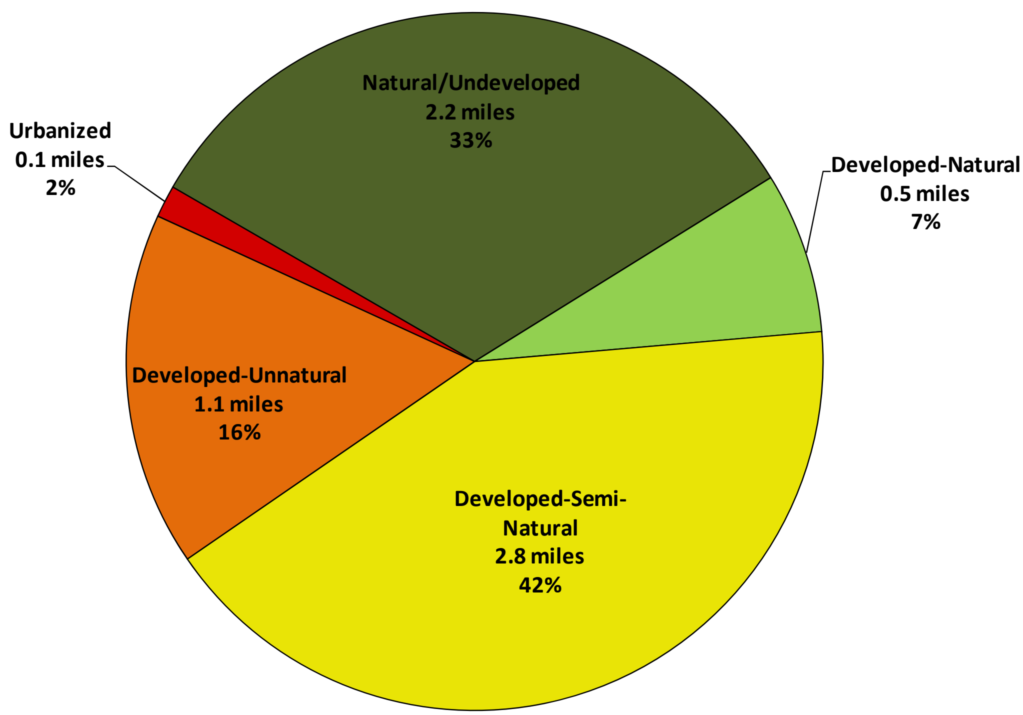


Figure 3.2-4. Big Portage Lake shoreland categories and total lengths. Based upon a late summer 2010 survey. Locations of these categorized shorelands can be found on Map 3.

3.3 Aquatic Plants

Introduction

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

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

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

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

Aquatic Plant Management and Protection

Important Note:
Even though most of these techniques are not applicable to Big Portage 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 Big Portage Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

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

Permits

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

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

Native Species Enhancement

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

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

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

Cost

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

- The single site used for the estimate indicated above has the following characteristics:
  - An upland buffer zone measuring 35’ x 100’.
  - An aquatic zone with shallow-water and deep-water areas of 10’ x 100’ each.
  - Site is assumed to need little invasive species removal prior to restoration.
  - Site has a moderate slope.
  - Trees and shrubs would be planted at a density of 435 plants/acre and 1210 plants/acre, respectively.
  - Plant spacing for the aquatic zone would be 3 feet.
  - Site would need 100’ of biolog to protect the bank toe and each site would need 100’ of wavebreak and goose netting to protect aquatic plantings.
  - Site would need 100’ of erosion control fabric to protect plants and sediment near the shoreline (the remainder of the site would be mulched).
  - There is no hard-armor (rip-rap or seawall) that would need to be removed.
  - The property owner would maintain the site for weed control and watering.

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreline erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Manual Removal

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

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

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

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

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

Bottom Screens

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

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

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

Water Level Drawdown

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

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

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

Mechanical Harvesting

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

Costs

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

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

Chemical Treatment

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

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

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

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

Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to reduce herbicide concentration within aquatic systems. Understanding concentration exposure times are important considerations for aquatic herbicides.

Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Some herbicides are applied at a high dose with the anticipation that the exposure time will be short. Granular herbicides are usually applied at a lower dose, but the release of the herbicide from the clay carrier is slower and increases the exposure time.

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

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

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

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

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

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

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

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

Cost

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

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

Biological Controls

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

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

Floristic Quality Assessment

The floristic quality of a lake is calculated using its species richness and average species conservatism. 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.

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.

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 plant surveys.

In this section, the floristic quality of Big Portage Lake will be compared to median values from lakes in the same ecoregion and in the state as calculated by Nichols (1999). The same ecoregions used in the water quality comparison are utilized for this purpose (Water Quality section, Figure 3.1-2). However, the comparative data within this ecoregion has been divided into two groupings: Northern Lakes and Forest Lakes (NLFL) and Northern Lakes and Forest Flowages (NLFF). Big Portage Lake is a natural lake and therefore will be compared to other natural lakes within the NLFL ecoregion.

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.

Species Diversity

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

Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to Big Portage Lake. Comparisons will be displayed using boxplots that showing median values and upper/lower quartiles of lakes in the same ecoregion (Water Quality section, Figure 3.1-2) and in the state. Please note for this parameter, the Northern Lakes and Forests Ecoregion data includes both natural and flowage lakes.

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

Community Mapping

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

Exotic Plants

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

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

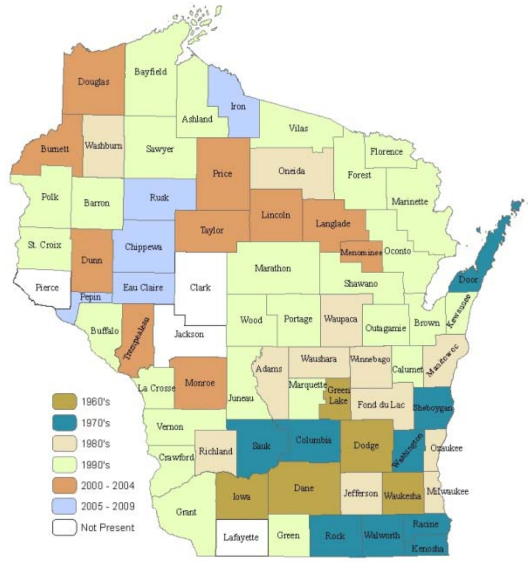


Figure 3.3-1. Spread of Eurasian water milfoil within WI counties. WDNR Data 2009 mapped by Onterra.

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

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

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. On June 23, 2010, a survey was completed on Big Portage Lake that focused upon curly-leaf pondweed. This meander-based survey did not locate any occurrences of curly-leaf pondweed. It is believed that this aquatic invasive species either does not occur in Big Portage Lake or exists at an undetectable level.

The point intercept survey was conducted on Big Portage Lake on July 13 & 14, 2010 by Onterra. Additional surveys were completed by Onterra on Big Portage Lake to create the aquatic plant community map (Map 4) on July 15, 2010.

During the point-intercept and aquatic plant mapping surveys, 30 species of plants were located in Big Portage Lake (Table 3.3-1). 24 of these species were sampled during the point-intercept survey alone and are used in the analysis that follows. An additional emergent plant, reed canary grass, is considered a non-native species and was found in numerous locations along the Big Portage Lake shoreline. A type of *Phragmites* spp. was located along the shoreline in several areas as well, growing in disturbed habitat. Morphologically, this species was confirmed as the native strain of common reed grass. Discussion of these two species can be found at the end of this section.

Table 3.3-1. Aquatic plant species located on Big Portage Lake during July 2010 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2010 Survey
Emergent	*Carex utriculata*	Northwest Territory Sedge	7	I
	Dulichium arundinaceum	Three-way sedge	9	X
	Equisetum fluviatile	Water horsetail	7	X
	Eleocharis palustris	Creeping spikerush	6	X
	Phalaris arundinacea	Reed canary grass	Exotic	I
	Phragmites australis subs. americanus	Common reed grass	N/A	I
	Schoenoplectus tabernaemontani	Softstem bulrush	4	I
	Sagittaria latifolia	Common arrowhead	3	X
	Typha spp.	Cattail spp.	1	I
FL	*Nuphar variegata*	Spatterdock	6	X
	Nymphaea odorata	White water lily	6	X
FL/E	*Sparganium fluctuans*	Floating-leaf bur-reed	10	X
	Sparganium angustifolium	Narrow-leaf bur-reed	9	X
Submergent	*Chara spp.*	Muskgrasses	7	X
	Eriocaulon aquaticum	Pipewort	9	X
	Elatine minima	Waterwort	9	X
	Isoetes echinospora	Spiny-spored quillwort	8	X
	Lobelia dortmanna	Water lobelia	10	X
	Myriophyllum tenellum	Dwarf water milfoil	10	X
	Nitella sp.	Stoneworts	7	X
	Najas flexilis	Slender naiad	6	X
	Potamogeton amplifolius	Large-leaf pondweed	7	I
	Potamogeton gramineus	Variable pondweed	7	X
	Potamogeton pusillus	Small pondweed	7	X
	Ranunculus flammula	Creeping spearwort	9	X
	Utricularia cornuta	Horned bladderwort	10	X
	Utricularia resupinata	Small purple bladderwort	9	X
	Vallisneria americana	Wild celery	6	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X
	Juncus pelocarpus	Brown-fruited rush	8	X
	Sagittaria cristata	Crested arrowhead	9	I

FL = Floating-leaf; FL/E = Floating-leaf aand Emergent; S/E = Submergent and Emergent
X = Found on rake during point-intercept survey, I = Incidental

Eurasian water milfoil, a common aquatic invasive plant in Wisconsin, was not found within Big Portage Lake. Only one milfoil species, dwarf-water milfoil (*Myriophyllum tenellum),* was found in Big Portage Lake and is morphologically much different from the other 6 milfoil species known to occur in Wisconsin. Northern water milfoil, often falsely identified as Eurasian water milfoil, was not found growing in Big Portage Lake, so any other milfoil species observed other than dwarf-water milfoil should be viewed suspiciously as Eurasian water milfoil.

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

Alkalinity is the primary water chemistry factor determining whether a lake is dominated by plant species of the isoetid or elodeid growth form (Vestergaard and Sand-Jensen 2000). Most elodeids are restricted to lakes of relatively higher alkalinity, as their carbon demand for photosynthesis cannot be met solely by the dissolved carbon dioxide (CO_2) present in the water, and they must acquire additional carbon through bicarbonate (HCO_3^-). While isoetids are able to grow in lakes of higher alkalinity, their short stature makes them poor competitors for light, and they are usually outcompeted and displaced by the taller elodeids. Thus, isoetids are most prevalent in lakes of low alkalinity where they can avoid competition from elodeids. However, in lakes with intermediate alkalinity levels, like Big Portage Lake, we see a mixed community of both, with isoetids inhabiting the shallow, sandy/rocky areas and elodeids thriving in the deeper areas of softer sediment.

The exceptional water clarity in Big Portage Lake allows for aquatic plant growth up to 19 feet. However, as Figure 3.3-2 displays, many aquatic plants were found at a depth of less than 1 foot. These plants are of the isoetid growth form – low profile, turf-like species that do well in sandy substrate as discussed above.

Of the 24 native aquatic plants found in Big Portage Lake during the point-intercept survey, slender naiad and members of the muskgrass family were the most common. Slender naiad is a submersed, annual plant that may reach lengths of 2.5 meters. It is sometimes called bushy pondweed because its small leaves branch out in numerous directions and become stiff and recurved as it ages. Slender naiad can reproduce through fragmentation, however its primary means of reproduction is by seed. The seeds form a dual purpose, as they are a delicious food source for waterfowl. Muskgrasses, or species of the genus chara, are actually a form of macro algae, not an actual aquatic macrophyte. They are grey to green colored and grow in large clumps in shallow to deep water. When growing in hard, mineral rich water, muskgrasses sometimes become coated with lime, giving them a rough, "gritty" feel. They are easily identified by their strong skunk-like or garlic odor. As well as providing a food source for waterfowl, muskgrass often serves as a sanctuary for small fish and other aquatic organisms. Slender naiad and muskgrass were seen at 7.8% of the point-intercept locations within the littoral zone of Big Portage Lake (Figure 3.3-3). Relative to all other plant species within Big Portage Lake, slender naiad and muskgrass make up 14% of the population each (Figure 3.3-4).

Two species of carnivorous plants, small purple bladderwort (*Utricularia resupinata*) and horned bladderwort (*Utricularia cornuta*), were found in several locations within Big Portage Lake. These species have small bladders attached to fine filamentous leaflets. The bladders have a "trap door" surrounded by small hairs. When the hairs are touched, the trap door swings inward and the bladder inflates, sucking in water along with small organisms (the bladderwort's prey). Enzymes are released inside the bladder to break down the prey's proteins, and the nutrients are then absorbed by the plant. Until recently, small purple bladderwort was listed as a species of special concern in Wisconsin due to its rarity. Upon recent review of the plant's known distribution and abundance, experts in the field of aquatic ecology decided to remove this species from the special concern list.

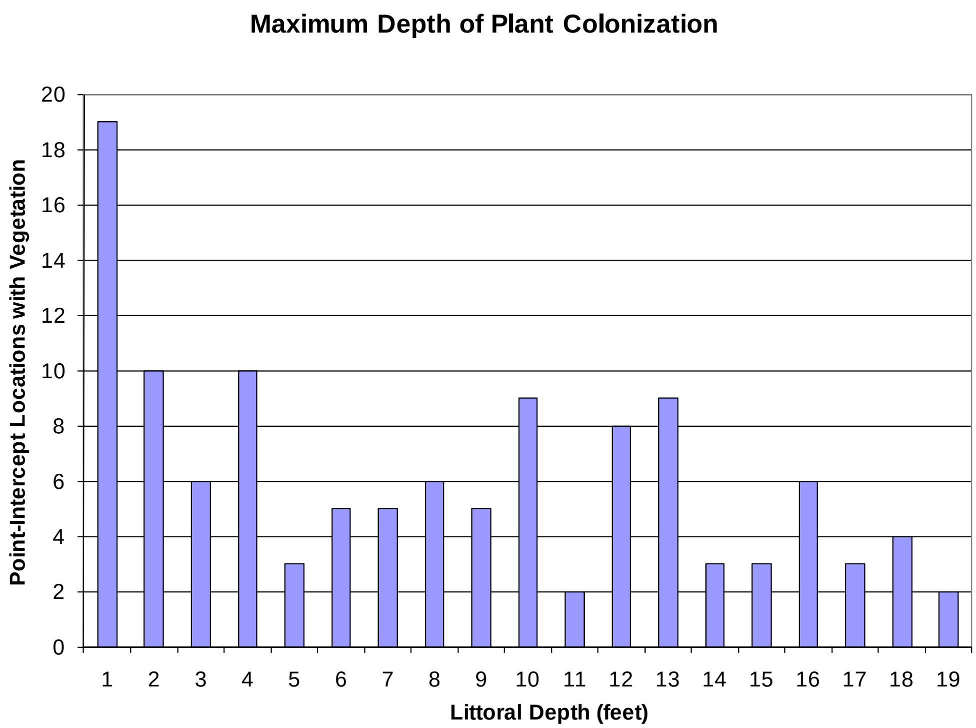


Figure 3.3-2 Big Portage Lake aquatic plant distribution across littoral depths. Created using data from a July 2010 survey.

As explained above in the Primer on Data Analysis and Data Interpretation Section, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while slender naiad was found at less than 8% of the sampling locations in Big Portage Lake, its relative frequency of occurrence is 14%. Explained another way, if 100 plants were randomly sampled from Big Portage Lake, 14 of them would be slender naiad. Looking at relative frequency of occurrence (Figure 7), 6 species comprise approximately 65% of the plant community in Big Portage Lake.

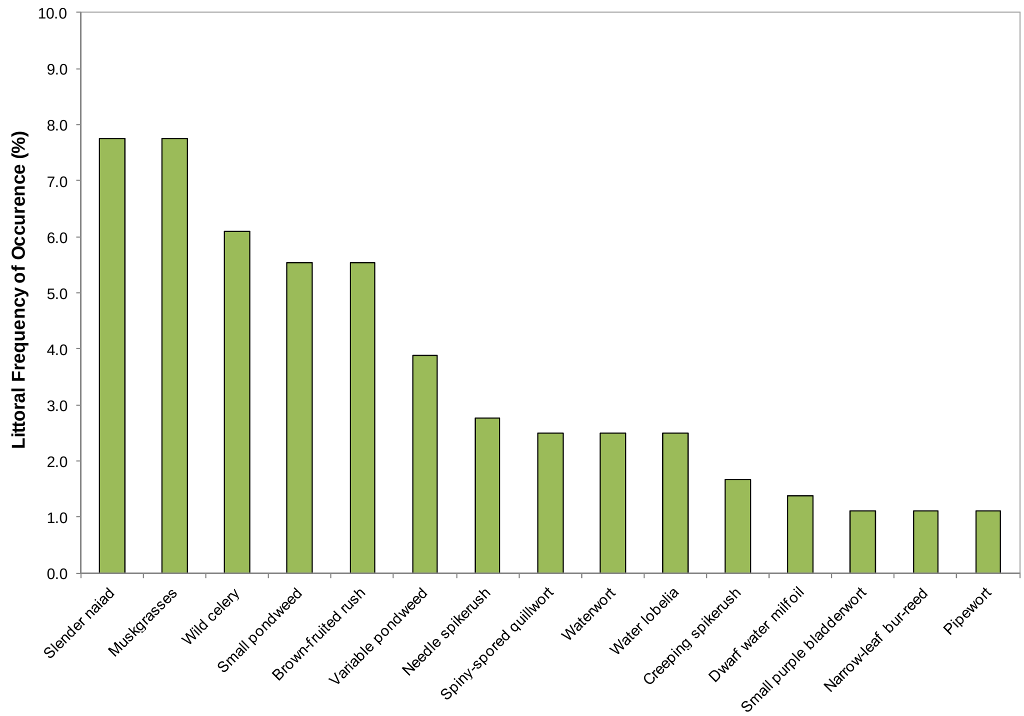


Figure 3.3-3 Big Portage Lake aquatic plant littoral frequency of occurrence. Created using data from July 2010 surveys. Only species with greater than 1.5% littoral frequency are displayed.

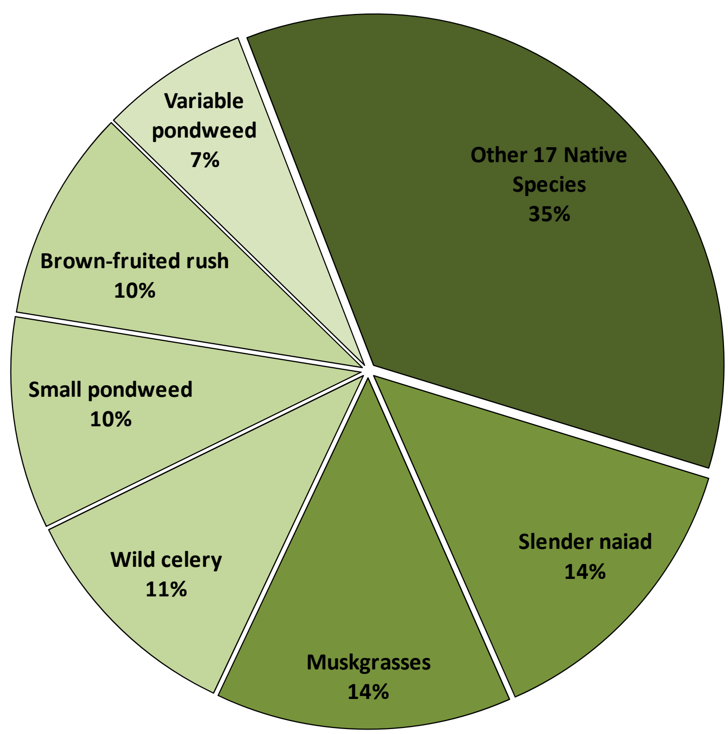


Figure 3.3-4 Big Portage Lake relative plant littoral frequency of occurrence. Created using data from July 2010 surveys.

As discussed previously, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while 30 native aquatic plant species were located in Big Portage Lake during the 2010 surveys, only 24 were encountered on the rake during the point-intercept survey. Figure 3.3-5 shows that the native species richness for Big Portage Lake is above the Northern Lakes and Forests Ecoregion and Wisconsin State medians.

The species that are present in Big Portage Lake are indicative of very high-quality conditions. Data collected from the aquatic plant surveys show that the average conservatism value (8.3) is well above the Northern Lakes and Forest Lakes Ecoregion and Wisconsin State medians (Figure 3.3-5), indicating that the majority of the plant species found in Big Portage Lake are considered sensitive to environmental disturbance and their presence signifies excellent environmental conditions.

Combining Big Portage Lake's aquatic plant species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in an exceptionally high value of 40.8 (equation shown below); well above the median values for the ecoregion and state (Figure 3.3-5), and further illustrating the quality of Big Portage Lake's plant community.

$$\text{FQI} = \text{Average Coefficient of Conservatism (8.3)} * \sqrt{\text{Number of Native Species (24)}}$$
$$\text{FQI} = 40.83$$

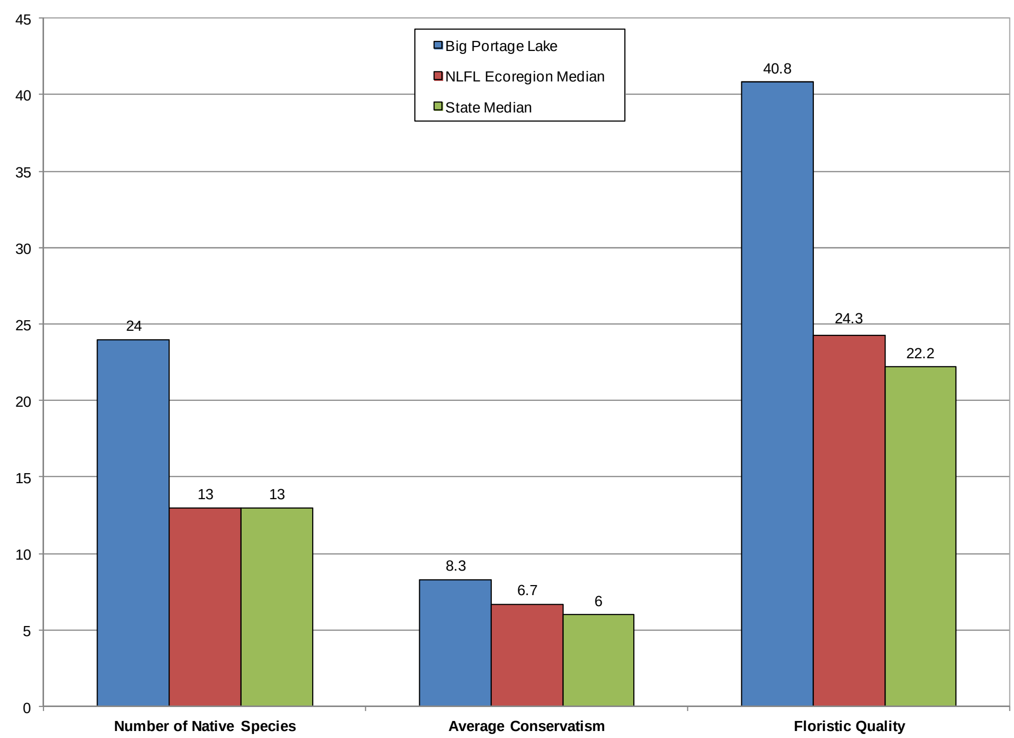


Figure 3.3-5. Big Portage Lake Floristic Quality Assessment. Created using data from July 2010 surveys. Analysis following Nichols (1999) where NLFL = Northern Lakes and Forest Lakes Ecoregion.

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

Simpson's diversity index (1-D) is used to determine this distribution. Simpson's diversity is calculated as:

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

D is a value between 0 and 1 where:

n = the total number of instances of a particular species
N = the total number of instances of all species

For example, if a lake had a diversity index value of 0.90, it would mean that if two individual plants were randomly sampled from this lake there would be a 90% probability that the two individuals would be different species.

The aquatic plant community in Big Portage Lake was found to be highly diverse, with a Simpson's diversity value of 0.92 (Figure 3.3-6). This value ranks above state and ecoregion upper quartiles. Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food.

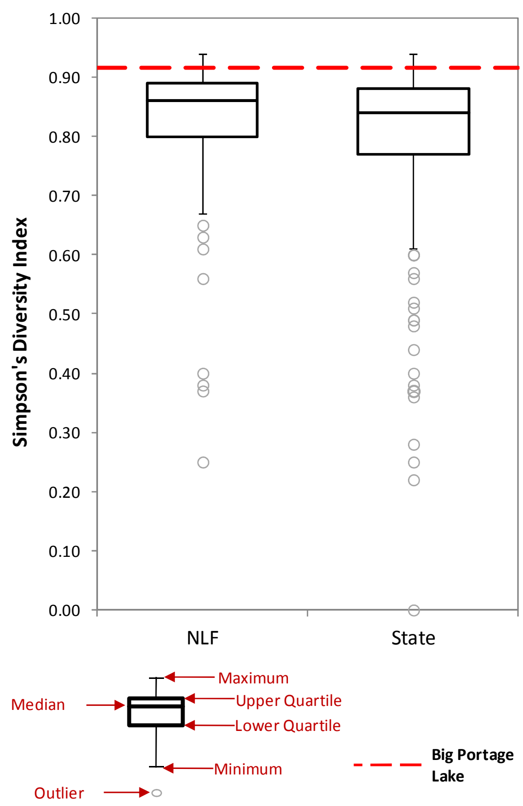


Figure 3.3-6. Big Portage Lake species diversity index. Created using data from August 2011 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

Big Portage Lake's plant community includes the presence of emergent and floating-leaf plant communities that occur in near-shore areas around the lake. The 2010 community map indicates that approximately 8.1 acres (1.4%) of the 587 acre-lake contain these types of plant communities (Table 3.3-2 and Map 4). 10 floating-leaf and emergent species were located on Big Portage Lake, providing valuable structural habitat for invertebrates, fish, and other wildlife. These communities also stabilize lake substrate and shoreline areas by dampening wave action from wind and watercraft. In this manner, they provide different benefits to a lake ecosystem than submergent plants and should be protected and enhanced if possible.

Table 3.3-2. Big Portage Lake acres of plant community types. Created from July 2010 community mapping survey.

Plant Community	Acres
Emergent	4.7
Floating-leaf	0.9
Mixed Floating-leaf and Emergent	2.5
Total	8.1

Because the community map represents a ‘snapshot’ of the important emergent and floating-leaf plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Big Portage 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.

Emergent Plants of Concern – Reed Canary Grass and Common Reed Grass

Reed Canary Grass

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

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

At this time, populations are not excessive, though it is recommended that continued monitoring of reed canary grass takes place. During the community mapping survey of Big Portage Lake in July of 2010, Onterra ecologists mapped occurrences of reed canary grass along the shoreline of the lake with sub-meter GPS technology. The spatial data has been provided to the Vilas County GIS Department, and also displayed on Map 5 of this report. In the future, a similar type of survey could provide information as to if the colonies are changing in size. Should a change in the size of these colonies be suspected, the WDNR and Vilas County AIS Coordinator should be notified, along with appropriate personnel to conduct mapping of the colonies.

Common Reed Grass

Phragmites australis subs. americanus, or, common reed grass, is a sub species of a plant that calls every continent on Earth but Antarctica its home. It is believed that populations of common reed grass existed in pre-colonial Wisconsin, but exotic strains from Europe have been introduced and have invaded the genetic line of the native strain. Genetic identification of the plant is needed to determine whether the plant is of the native or non-native strain. A pressed specimen of this species from Big Portage Lake was sent to Dr. Robert Freckman at the University of Wisconsin – Steven's Point where morphologically it appeared to be a native strain. The sub species *americanus* is native to North America and typically does not display invasive behavior, as the exotic *Phragmites australis* does. These characteristics include towering, dense colonies that overtake native vegetation and replace it with a monoculture that provides inadequate food and habitat for wildlife.

Although this plant appears to be morphologically native, it is recommended that this population be monitored for expansion. During the community mapping survey of Big Portage Lake in July of 2010, Onterra ecologists mapped occurrences of common reed grass along the shoreline of the lake with sub-meter GPS technology. The spatial data has been provided to the Vilas County GIS Department, and also displayed on Map 5 of this report. If it appears that the plant is spreading along the shorelines of Big Portage Lake, the regional WDNR Lake Specialist should be contacted to coordinate sending in plant specimens for genetic testing. If the common reed is determined to be an exotic strain, it should be removed by cutting and bagging the seed heads and applying herbicide to the cut ends. This management strategy is most effective when completed in late summer or early fall when the plant is actively storing sugars and carbohydrates in its root system in preparation for over-wintering. If this or other populations expand greatly, a management action would need to be developed to coordinate its control.

3.4 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the numerous fisheries biologists overseeing Big Portage Lake. 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 BPLROA 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 2011 & GLIFWC 2011A and 2011B).

Big Portage Lake Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second highest ranked important or enjoyable activity on Big Portage Lake (Question #6). Approximately 47% of these same respondents believe that the quality of fishing on the lake is either very poor or poor, while 49% believe that the fishing is either fair or good (Question #10). Almost 79% believe that the quality of fishing has remained the same or gotten worse since they have obtained their property (Question #11). Survey respondents believe that there is a loss of fish habitat on Big Portage Lake (Question #17), and listed this as one of their top concerns regarding the lake (Question #18).

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

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

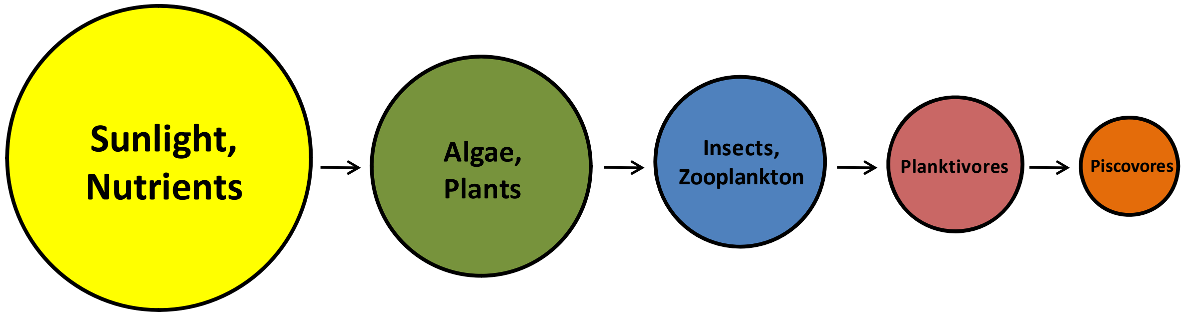


Figure 3.4-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Big Portage Lake is oligotrophic/mesotrophic, meaning it has high water clarity, but a low amount of nutrients and thus low primary productivity. Simply put, this means it is difficult for the lake to support a large population of predatory fish (piscovores) because the supporting food chain is relatively small.

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

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
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 (aquatic and terrestrial)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1cm-1m deep	Crustaceans, insect larvae, and other inverts
Smallmouth Bass	*Micropterus dolomieu*	13	Mid May - June	Nests more common on North and West shorelines, over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye	*Sander vitreus*	18	Mid April - early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Perch	*Perca flavescens*	13	April - early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

Table 3.4-2. Non-gamefish present in Big Portage Lake with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Common Name	Scientific Name
Bluntnose minnow	*Pimephales notatus*	Johnny darter	*Etheostoma nigrum*
Burbot	*Lota lota*	Mimic Shiner	*Notropis volucellus*
Common shiner	*Luxilus cornutus*	White sucker	*Catostomus commersoni*
Iowa Darter	*Etheostoma exile*		

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.4-2). Big Portage Lake falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified systems. 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 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.

Figure 3.4-2. Location of Big Portage Lake within the Native American Ceded Territory (GLIFWC 2011A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2011B). 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.

A muskellunge spear harvest has not been recorded on Big Portage Lake. Walleye open water spear harvest records are provided in Table 3.4-3. One common misconception is that the spear harvest targets the large spawning females. Table 3.4-3 and Figure 3.4-3 clearly show that the opposite is true with only 14% of the total walleye harvest (164 fish) between 1998 and 2007 comprising of female fish on Big Portage Lake. Tribal spearers may only take two walleyes over twenty inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIWC 2011B). This regulation limits the harvest of the larger, spawning female walleye.

Since 1990, the Native American spear harvest quotas have ranged from 133 to 215 walleye, while actual harvests have ranged from 55 to 168 walleye. As explained above, the allowable catch, safe harvest level, and finally the spearing quota is all determined by the estimated adult population number. This system allows fishery managers to allow a spear harvest, a regular season harvest, and enough reproducing adults to sustain the fishery into the future. For example, in 1992, the adult walleye population was estimated to be 2,107 by the WDNR (WDNR 2011). In that year, the Native American spear fishermen harvested 6% of this harvest. In 2006, spearers harvested 4% of the estimated 3,186 walleye in the lake. In comparison, the 1992 and 2006 creel surveys (discussed below) on Big Portage Lake estimated angler harvest at 574 walleyes (27% of the population) in 1992 and 1,561 walleyes (49% of the population) in 2006.

Because Big Portage 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 Big Portage Lake. In 2011, the daily bag limit remained at 3 for the lake. There is currently no minimum length limit for walleye, but a slot limit is in effect. Fish between 14" and 18" may not be kept and only one fish over 18" is allowed. For bass species, after June 17th the minimum length limit is 18" and a daily bag limit is limited to one fish. Big Portage Lake is in the northern half of the muskellunge and northern pike management zone. 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. Please note that in a 2006 WDNR fisheries survey (attached as Appendix F), no muskellunge were found in Big Portage Lake. Additionally, no largemouth bass and only a single northern pike was captured in that same survey. Statewide regulations apply for all other fish species.

Table 3.4-3. Spear harvest data of walleye for Big Portage Lake (GLIFWC annual reports for Big Portage Lake, Krueger 1998-2009; and GLIFWC communication, 1990-1997 and 2010-2011).

Year	Tribal Quota	Tribal Harvest	%Quota	Mean Length* (in)	% Male*	% Female*	% Unknown
1990	164	156	95.1				
1991	149	122	81.9				
1992	142	129	90.8				
1993	141	55	39.0				
1994	168	168	100.0				
1995	140	140	100.0				
1996	215	125	58.1				
1997	139	139	100.0				
1998	139	139	100.0	14.5	79.9	13.7	6.5
1999	137	137	100.0	13.9	86.9	10.9	2.2
2000	139	139	100.0	14.3	95.0	2.2	2.9
2001	142	139	97.9	15.3	91.4	5.8	2.9
2002	142	142	100.0	14.5	85.2	1.4	13.4
2003	142	142	100.0	16.0	69.0	23.2	7.7
2004	143	143	100.0	15.3	90.2	8.4	1.4
2005	136	135	99.3	16.4	58.5	34.8	5.2
2006	138	137	99.3	15.3	83.9	5.8	10.2
2007	155	155	100.0	15.0	87.1	11.0	1.9
2008	133	133	100.0				
2009	134	134	100.0				
2010	136	136	100.0				
2011	138	136	98.6				

*Based on Measured Fish

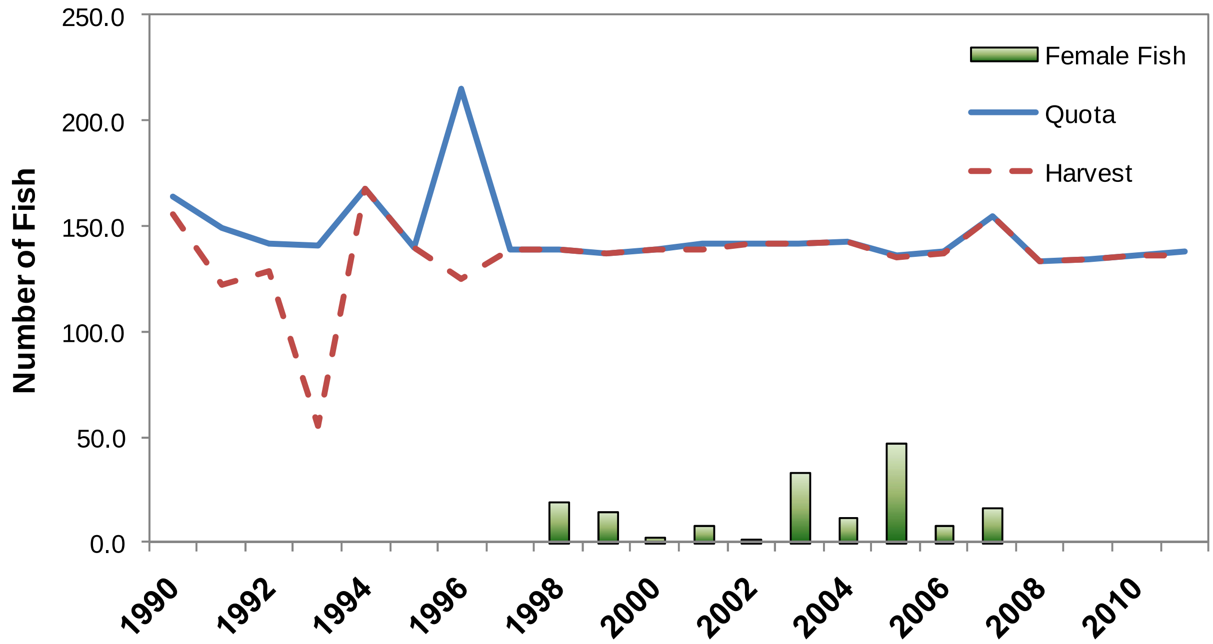


Figure 3.4-3. Walleye spear harvest data. Annual total walleye harvest and female walleye harvest are displayed since 1998 from GLIFWC annual reports for Big Portage Lake (Krueger 1998-2009; GLIFWC communication 1990-1997 and 2010-2011).

Big Portage Lake WDNR Surveys

Big Portage Lake was surveyed in 2006 by WDNR staff to determine the health of its fishery. The aim of the survey was to determine what species were present, and to establish an abundance estimate for fish populations – primarily the lake's walleye and bass fisheries. Walleye and smallmouth bass dominated the catch from the lake. Adult walleye populations were estimated to be at roughly 5 fish per acre, while smallmouth bass sized 8" or greater were estimated to populate the lake at 1 fish per 3 acres. Additional results from this survey can be found within Appendix F – Wisconsin DNR Fisheries Information Sheet.

Periodically, the WDNR will conduct creel surveys on Wisconsin lakes to gather information on the fishery. Creel surveys are a series of short, informal interviews with fisherman and are conducted right on the lake of interest. They provide valuable information on sport angler activities and their impacts on the fish populations of a waterbody. From these data, fisheries managers can determine trends in total catch and harvest for the lake, and also estimate the number of hours it takes anglers to catch a particular species of fish.

The latest creel survey to take place on Big Portage Lake was from May 6 of 2006 thru March 4 of 2007. In that year, anglers spent over 9,000 hours fishing. This is less than half of both the statewide and Vilas County average. Walleye were targeted most often, followed by panfish species, particularly yellow perch. May was the busiest month for fishing activities. Table 3.4-4 displays summary statistics from creel surveys in 1992 and 2006. The 2006-07 WDNR creel survey report is attached as Appendix F.

Table 3.4-4. Big Portage Lake WDNR Creel Survey Summary (WDNR 2011)

Species	Year	Total Angler Effort / Acre (Hours)	Directed Effort / Acre (Hours)	Catch / Acre	Harvest / Acre
Largemouth Bass	2006	14.3	0.1	0	0
Muskellunge	2006	14.3	0.1	0	0
Northern Pike	1992	12.9	0	0	0
	2006	14.3	0.1	0	0
Smallmouth Bass	1992	12.9	1	0.6	0.1
	2006	14.3	0.1	1.3	0
Walleye	1992	12.9	10.3	1.8	0.9
	2006	14.3	13.1	6.6	2.4

Big Portage Lake Substrate Type

According to the point-intercept survey conducted by Onterra, 91% of the substrate sampled in the littoral zone on Big Portage Lake was sand, with the remaining 9% being rock and less than 1% being muck (Map 6). Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Northern pike is one species that does not provide parental care to its eggs (Becker 1983). Northern pike broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. 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 can be 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. Smallmouth bass prefer to build perfectly circular nests on gravel, coarse sand or silt, preferably beside a natural or artificial object such as a large boulder, stump, log, etc. Male smallmouth bass may guard recently hatched fish for as long as 28 days, longer than most other fish in the sunfish family (*Centrarchidae*).

4.0 SUMMARY AND CONCLUSIONS

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

1) Collect baseline data to increase the general understanding of the Big Portage Lake ecosystem.
2) Collect detailed information regarding invasive plant species within the lake, if any were found.
3) Collect sociological information from Big Portage Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

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

As indicated throughout most of this document, Big Portage Lake is in a very healthy condition. The water quality of the lake has remained in great condition throughout the past 10-20 years, as indicated by current and historical data analysis. Secchi disk clarity is commonly measured at depths in excess of ten to twelve feet within the lake, and nutrient content along with algal production has been low to moderate as well. It should be mentioned that drawing these conclusions would have been impossible without the efforts of volunteers through the Citizen's Lake Monitoring Network.

The relatively small watershed surrounding Big Portage Lake aids in protecting the water's fine quality. The watershed is predominately forested; the land types that would impact the lake in a negative manner (e.g. agricultural land, urban land, etc.) are not present to a significant degree. Additionally, as stated within the Watershed Section, only a small portion of the shoreland zone has been excessively developed. Within small watersheds such as the one found around Big Portage Lake, it is this area that impacts the lake greatly.

Although small watersheds typically are beneficial to the water quality of a lake, the opposite is true when considering the water *quantity* in a lake. Because of its hydrology, Big Portage Lake is classified as a seepage lake. While some lakes have streams that carry water to them, seepage lakes receive water only through groundwater inputs, surface runoff, and precipitation; of which groundwater is normally the most important. Drought conditions in northern Wisconsin have greatly reduced the amount of regional precipitation in the past 8 – 10 years. Without adequate precipitation, seepage lakes will collect water only from the ground. The lake water level, also a reflection of the groundwater level, will slowly lower as precipitation fails to "recharge" depleted groundwater stocks. And as evaporation occurs, the water levels in the lake will continue to decrease. This has been apparent on Big Portage Lake, and has become a great concern to riparian stakeholders.

While these changing water levels may have negative recreational and short-term ecological impacts, it is important to remember that lake water level fluctuations are part of a naturally occurring cycle and may actually benefit the lake ecosystem in the long-term by increasing the level of habitat diversity. During times of low water, it is important for riparian property owners to leave fallen logs and other structure alone. Additional modifications to the exposed shoreline are discouraged as well. When the water rises eventually, these objects will serve as very beneficial habitat to a variety of aquatic organisms.

With low water levels moving once submerged logs and rocks out of the water, the aquatic plant communities become the primary source of habitat and spawning structure for most aquatic life. Through the plant studies conducted on Big Portage Lake in 2010, it was discovered that the lake holds 30 species of aquatic plants, some of which grow to a depth of nearly 20 feet. Many of these plants are of higher quality. Together, the plant community ranks very high in terms of its floristic quality, surpassing the regional and state median.

No submergent exotic species were located in Big Portage Lake during summer surveys. However, two wetland species of concern were found. The first, reed canary grass, is an exotic plant that is very difficult to properly control. The second plant of concern, common reed grass, may or may not be exotic – only genetic testing will tell for certain. At this time, the extent of these plant colonizations are not too concerning. It is recommended that these species are watched closely however for signs of colonial expansion. If expansion of these colonies is suspected, further management actions may be warranted.

As indicated within the planning process through the stakeholder survey and meetings with BPLROA members, there is concern over the fishery in Big Portage Lake. Some stakeholders claim this fishing has not "been what it used to be", and as with many lakes in the region there were misconceptions as to the amount of Native American spear fishing that occurs on the lake. As pointed out within the Fisheries Data Integration Section, a highly regulated tribal spear fishing harvest does occur on the lake yearly; however, the harvest is minimal in comparison to the estimated harvest taken by anglers.

The Water Quality Section discusses the high water clarity and low abundance of nutrients in Big Portage Lake. The Aquatic Plant Section goes on to describe the presence of many areas of sandy substrate, that held small isoteid species of aquatic plants. Overall, the system is characterized as being on the edge of oligotrophic and mesotrophic, meaning it holds very low primary productivity. Simply put, it is difficult for a system such as Big Portage Lake to hold large populations of fish (especially large fish), because the food and habitat found in more productive lakes are not present. This would be analogous to comparing a forest versus a desert ecosystem. A forest holds larger populations of large animals (whitetail deer, black bear, coyotes, wolves etc.) because there is 1) abundant food to support the appetite of these large animals and 2) trees and understory growth which is used by predators to stalk prey and used by prey to hide young from predators. In a desert ecosystem, the majority of animals are small and innumerous because this ecosystem lacks food resources and cover/shelter.

The issue becomes compounded when angler harvest, habitat modification, and low water levels become issues as well. As demonstrated through a creel survey that was recently conducted (2006-2007), angler harvest of walleye is significant on Big Portage Lake. This likely reduces the population of walleye considerably each year, leaving fewer walleye to spawn the following spring. Note that WDNR and GLIFWC biologists set tribal spear harvest and angler harvest regulations knowing that a certain percentage of fish need to remain in the system to carry on the population the following year.

The Big Portage Lake fishery will likely never be as productive as other nearby lakes; however, with smart, goal-oriented management it can reach its full potential. Continued communication with the Vilas County WDNR fish biologist (Steve Gilbert – 715.356.5211) is recommended to keep the BPLROA informed of planned surveys, stockings and other information pertaining to the Big Portage Lake fishery.

Right now, despite several concerns by lake residents, Big Portage Lake is in pretty good shape. The Implementation Plan that follows identifies goals and actions the BPLROA identified as crucial to addressing stakeholder concerns, maintaining the quality of Big Portage Lake, and enhancing its positive features for future generations.

5.0 IMPLEMENTATION PLAN

During the second Planning Meeting, the Big Portage Lake Planning Committee discussed the results of the Management Plan study with ecologists/planners from Onterra and closely examined Big Portage Lake as well as the people who live around it. The committee developed a mission statement to set a focus point for the next step in the lake management process, which would be to develop goals and strategies to deal with challenges raised during the study.

Mission Statement

To preserve and protect the natural environment and quality of Big Portage Lake for current and future generations, through continued education and involvement of stakeholders, monitoring of the lake environment, and being prepared to respond to change.

Following the development of this Mission Statement, the Planning Committee examined the strengths and weaknesses of Big Portage Lake and its stakeholders, as well as the opportunities and threats they face. These issues were discussed in terms of 1) feasibility of addressing, and 2) level of importance. As a result of this discussion, the BPLROA was able to identify goals for protecting and enhancing Big Portage Lake.

The Implementation Plan presented below represents the path the BPLROA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and achievable, as are the action steps required to reach these goals. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Increase Big Portage Lake Riparian Owners Association's Capacity to Communicate with Lake Stakeholders

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

Timeframe: Begin summer 2012

Facilitator: Board of Directors to form Education Committee

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

Currently, the BPLROA distributes newsletters to association members biannually and has launched a website (www.bigportagelake.org) which allows for exceptional communication within the lake group. This level of communication is important within a management group because it builds a sense of community while facilitating the spread of important association news, educational topics, and even social happenings. It also provides a medium for the recruitment and recognition of volunteers. Perhaps most importantly, the dispersal of a well written newsletter can be used as a tool to increase awareness of many aspects of lake ecology and management among association members. By doing this, meetings can often be conducted more efficiently and misunderstandings based upon misinformation can be avoided. Educational pieces within the association newsletter may contain monitoring results, association management history, as well as other educational topics listed below.

In addition to creating regularly published association newsletter a variety of educational efforts will be initiated by the Education Committee. These may include educational materials, awareness events and demonstrations for lake users as well as activities which solicit local and state government support.

Example Educational Topics:

- Aquatic invasive species monitoring updates
- Boating safety and ordinances (slow-no-wake zones and hours)
- Catch and release fishing
- Littering (particularly on ice)
- Noise, air, and light pollution
- Shoreland restoration and protection
- Septic system maintenance
- Fishing Rules
- Specific topics brought forth in other management actions

Action Steps:

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

<u>Management Action:</u> Raise riparian owners' awareness on the issue of lake shoreline condition.

Timeframe: Begin Spring 2012

Facilitator: BPLROA volunteer

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

On April 14th, 2009, Governor Doyle signed the "Clean Lakes" bill (enacted as 2009 Wisconsin Act 9) which prohibits the use of lawn fertilizers containing phosphorus. Phosphorus containing fertilizers were identified as a major contributor to decreasing water quality conditions in lakes, fueling plant growth. This law went into effect in April 2010. While this law also bans the display and sale of phosphorus containing fertilizers, educating lake stakeholders about the regulations and their purpose is important to ensure compliance.

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

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

Action Steps:

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

Management Goal 2: Maintain Current Water Quality Conditions

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

Timeframe: Continuation of current effort.

Facilitator: Board of Directors

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. In fact, within this document a more complete analysis was able to be conducted on Big Portage Lake's water quality because of the extended dataset that is available. Early discovery of negative trends may lead to the reason as of why the trend is developing. Volunteers from the BPLROA have collected Secchi disk clarities and water chemistry samples during this project and in the past through the WDNR Citizen Lake Monitoring Program. Stability will be added to the program by selecting an individual from the BPLROA to coordinate the lake's volunteer efforts and to recruit additional volunteers to keep the program fresh.

Action Steps:

1. Board of Directors recruits volunteer coordinator from association.
2. Coordinator directs water quality monitoring program efforts and volunteers.
3. Volunteers collect data and coordinator/volunteers report results to WDNR and to association members during annual meeting.

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

Timeframe: Begin Spring 2012

Facilitator: BPLROA volunteer

Description: As indicated within the stakeholder survey, stakeholders of Big Portage Lake believe that loss of fish habitat and lakeshore development are impacting their lake in a negative manner (Appendix B, Question 17). These concerns were brought up and discussed during the Planning II meeting with the Big Portage

Lake Planning Committee and Onterra staff as well. In conjunction with an educational campaign aimed at raising awareness about shoreline condition (discussed above), the BPLROA may choose to work towards restoration of specific shoreline areas. The shoreline assessment associated with this project identified 18% of the Big Portage Lake shoreline as being highly disturbed (Urbanized or Developed-Unnatural). However, an additional 42% is classified as Developed-Semi-Natural, indicating that under half of the lakes shoreline is truly in a natural or developed-natural state.

Map 3 indicates the locations of highly disturbed shoreland (Urbanized and Unnatural/Developed areas). If restoration of the Big Portage Lake shoreland is to occur, these areas should be considered a priority. However, areas of Developed-Semi-Natural shoreline would also benefit from enhancement also. A volunteer from the BPLROA will work in conjunction with the education initiative volunteer (this may also be the same person) to research grant programs, shoreland restoration techniques, and other pertinent information that will aid the BPLROA in making enhancements to the Big Portage Lake shoreline. Several valuable resources for this type of conservation work include the WDNR, UW-Extentions and Vilas County Lakes and Rivers Association. Several websites of interest include:

- Wisconsin Lakes website: (www.wisconsinlakes.org/shorelands)
- Langlade County Land Records and Regulations Department – Shoreland Restoration: (http://lrrd.co.langlade.wi.us/shoreland/index.asp)
- Vilas County Land and Water Conservation Cost-Share Program: (http://www.vilaslandandwater.org/cost_share_program_pages/cost_share_lakes_project_page.htm)
- UW-Extention Shoreland Restoration: http://www.uwex.edu/ces/shoreland/Why1/whyres.htm)

Action Steps:

1. Recruit facilitator.
2. Facilitator gathers appropriate information from sources described above. This includes biological research as well as grant/funding opportunities.
3. Facilitator assists residents that are interested in shoreland restoration with process of contacting shoreland restoration specialists (public or private) and carrying out restoration plan.
4. Retain potential of having completed projects serve as a "model" for other residents who may be interested in restoration work.

Management Goal 3: Prevent Aquatic Invasive Species Introductions to Big Portage Lake

Management Action: Continue Clean Boats Clean Waters watercraft inspections at Big Portage Lake public access

Timeframe: Continue current effort

Facilitator: Board of Directors

Description: At this time, Big Portage Lake is believed to be free of Eurasian water milfoil and curly-leaf pondweed. The only exotic species known to exist in the system are rusty crayfish and reed canary grass, (an emergent wetland exotic plant). While trapping and manipulation of smallmouth bass populations has been examined for usefulness in combating rusty crayfish, these methodologies have not proven themselves except in isolated situations; a sure-fire methodology for controlling this exotic is not known at this time besides prevention. Reed canary grass control is difficult as well, with no "silver bullet" methodology known at this time.

Members of the BPLROA have been trained on Clean Boats Clean Waters (CBCW) protocols and complete boat inspections at the public landings on a regular basis. These members have monitored the public boat launch since 2006. Because this system is currently free of exotic species, the intent of the boat inspections is to prevent additional invasives from entering the lake through its public access point. The goal would be to cover the landing during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on our lakes and educating people about how they are the primary vector of AIS spread. In 2011, 114 boats were inspected and 146 people contacted during over 127 hours of watercraft inspections.

In addition to continuing these efforts, the Education Committee (see Management Goal 1) will incorporate materials and programs that will promote clean boating and responsible use of these waters into educational initiatives such as newsletters, annual or other meetings, etc.

Action Steps:

1. Members of association continue to attend Clean Boats Clean Waters training session through the Vilas County AIS Coordinator (Ted Ritter – 715.479.3738) on an annual basis to update their skills to current standards.
2. Training of additional volunteers completed by those trained during the summer of 2011.
3. Continue to conduct inspections during high-risk weekends
4. Continue to report results to WDNR and BPLROA
5. Promote enlistment and training of new of volunteers to keep program fresh.

Management Action: Coordinate annual volunteer monitoring for Aquatic Invasive Species

Timeframe: Continue current effort

Facilitator: Board of Directors

Description: In lakes without Eurasian water milfoil and other invasive species, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. One way in which lake residents can spot early infestations of AIS is through conducting "Lake Sweeps" on their lake. During a lake sweep, volunteers monitor the entire area of the system in which plants grow (littoral zone) annually in search of non-native plant species.

This program uses an "adopt-a-shoreline" approach where volunteers are responsible for surveying specified areas of the system.

In order for accurate data to be collected during these sweeps, volunteers must be able to identify non-native species such as Eurasian water milfoil and curly-leaf pondweed. Distinguishing these plants from native look-a-likes is very important Additionally, the collection of suspected plants is important. A specimen of the plant would need to be collected for verification, and if possible, GPS coordinates should be collected.

Action Steps:

1. Volunteers from BPLROA continue to update their skills by attending a training session conducted by WDNR/UW-Extension through the AIS Coordinator for Vilas County (Ted Ritter – 715.479.3738).
2. Trained volunteers recruit and train additional association members.
3. Continue to complete lake surveys following protocols.
4. Continue to report results to WDNR and BPLROA.

Management Goal 4: Improve Fishery Resources and Fishing on Big Portage Lake

<u>Management Action:</u> Work with fisheries managers to enhance the fishery on Big Portage Lake

Timeframe: Ongoing

Facilitator: Board of Directors

Description: The results of the stakeholder survey associated with this project show that Big Portage Lake stakeholders feel the fishery is poor to very poor, and has worsened with time (Appendix B). Fishing was ranked as the 2^{nd} most enjoyable activity on the lake, which confirms its importance to stakeholders. While the BPLROA does not expect a trophy or highest quality fishery out of Big Portage Lake, they would like it to reach full potential.

Understanding the limitations and stresses on the Big Portage Lake ecosystem is the first step in developing a solution to angler concerns. From here, realistic goals and actions may be developed. Big Portage Lake is currently overseen by WDNR fisheries biologist Steve Gilbert (715.356.5211). In order to keep informed of survey studies that are occurring on Big Portage Lake, a volunteer from the BPLROA should contact Mr. Gilbert at least once a year (perhaps during the winter months when field work is not occurring) for a brief summary of activities. Additionally, the BPLROA may discuss options for improving the fishery in Big Portage Lake, which may include changes in angling regulations, habitat enhancements, or private stocking.

Action Steps:

1. See description above.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Big Portage Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point on the lake that would most accurately depict the conditions of the lake (Map 1). Samples were collected using WDNR Citizen Lake Monitoring Network (CLMN) protocols which occurred once in spring and three times during the summer. In addition to the samples collected by BPLROA members, professional water quality samples were collected at subsurface (S) and near bottom (B) depths once in spring, winter, and fall. Although BPLROA members collected a spring total phosphorus sample, professionals also collected a near bottom sample to coincide with the bottom total phosphorus sample. Winter dissolved oxygen was determined with a calibrated probe and all samples were collected with a 3-liter Van Dorn bottle. Secchi disk transparency was also included during each visit.

All samples that required laboratory analysis were processed through the Wisconsin State Laboratory of Hygiene (SLOH). The parameters measured, sample collection timing, and designated collector are contained in the table below.

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

♦ indicates samples collected as a part of the Citizen Lake Monitoring Network.
● indicates samples collected by volunteers under proposed project.
■ indicates samples collected by consultant under proposed project.

Watershed Analysis

The watershed analysis began with an accurate delineation of Big Portage Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the Wisconsin initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Big Portage Lake during a June 23rd, 2010 field visit, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Big Portage Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in "Appendix D" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin, (April, 2007) was used to complete this study on July 13th and 14th, 2010. A point spacing of 60 meters was used resulting in approximately 653 points.

Community Mapping

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

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

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