Little Bearskin Lake

Oneida County, Wisconsin

Comprehensive Management Plan

November 2014

Sponsored by:

Little Bearskin Lake Association, Inc.

WDNR Grant Program

LPL-1456-12

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

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Created by: Brenton Butterfield, Tim Hoyman, Dan Cibulka, & Eddie Heath
Onterra, LLC
De Pere, WI

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Little Bearskin Lake Planning Committee

Carolyn Raymaker
Richard Raymaker
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Karen Schilz
Barbara Szatkiewicz
Donald Szatkiewicz

Wisconsin Dept. of Natural Resources

Kevin Gauthier
Tim Plude

University of Wisconsin - Extension

Dr. Susan Knight

DRAFT

TABLE OF CONTENTS

FIGURES

TABLES

PHOTOS

MAPS

APPENDICES

1.0 INTRODUCTION

Little Bearskin Lake, Oneida County, is an approximate 164-acre drainage lake with a maximum depth of 27 feet and a mean depth of 8 feet (Map 1). It is fed via upstream Big Bearskin Lake and drains via Bearskin Creek into the Tomahawk River within the Wisconsin River Basin. This lower eutrophic lake has a surface watershed that encompasses approximately 8,389 acres, yielding a watershed to lake area ratio of 44:1. Over the course of WDNR plant surveys from 2009-2012 and during Onterra's 2012 surveys, 44 aquatic plant species were located, of which coontail (*Ceratophyllum demersum*) was the most abundant. The non-native plant Eurasian water milfoil (*Myriophyllum spicatum*) was first documented in Little Bearskin Lake in 2008, and was later confirmed as hybrid water milfoil (*M. sibiricum x spicatum*) in 2009.

Field Survey Notes

Areas of surface-matted hybrid water milfoil were observed during the 2012 surveys. The growth of native aquatic plants, particularly coontail, is also abundant. A relatively rare aquatic plant species, Alpine pondweed (Potamogeton alpinus) was also observed.

Photograph 1.0-1. Little Bearskin Lake, Oneida County

Lake at a Glance - Little Bearskin Lake

Morphology	
Acreage	164
Maximum Depth (ft)	27
Mean Depth (ft)	8
Vegetation	
Curly-leaf Survey Date	June 6 & 7, 2012
Comprehensive Survey Date	August 12, 2012 (WDNR)
Number of Native Species	43
Threatened/Special Concern Species	-
Exotic Plant Species	Hybrid water milfoil (*M. sibiricum x spicatum*)
Simpson's Diversity*	0.85
Average Conservatism*	6.6
Water Quality	
Trophic State	Meso-eutrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	8.6
Sensitivity to Acid Rain	Low
Watershed to Lake Area Ratio	44:1

** Indicates value calculated from WDNR 2012 point-intercept survey*

Along with hybrid water milfoil, Little Bearskin Lake also harbors the non-native rusty crayfish and banded and Chinese mystery snails. The Little Bearskin Lake Association (LBLA) was interested in creating a lake management plan for two primary reasons: first, they would like to initiate a program to reduce the hybrid water milfoil within the lake to manageable levels and prevent further introductions of aquatic invasive species (AIS), and second, they understand the value in gaining a better understanding of lake ecology and the overall condition of Little Bearskin Lake, and the information gained will help guide future LBLA plans and programs. Additionally, the association knows that the Wisconsin Department of Natural Resources (WDNR) can respond more quickly and accurately to address invasive species establishment if the lake has a management plan in place.

While the presence of hybrid water milfoil is of great concern to Little Bearskin Lake stakeholders and to the lake's ecology, the studies conducted as part of this project looked at Little Bearskin Lake from an ecosystem perspective and not solely at its aquatic plant community. This report discusses the results of the studies conducted in 2012 that assessed Little Bearskin Lake's shoreline condition, watershed, water quality, and aquatic plants. Little Bearskin Lake is one of numerous lakes included in the WDNR Bureau of Science Services' long-term research on unmanaged lakes containing Eurasian and/or hybrid water milfoil. Specifically, the WDNR has conducted point-intercept surveys annually from 2009-2012, providing valuable data on the dynamics of not only hybrid water milfoil but the entire native plant population within the lake. Also included is the Implementation Plan, which includes goals and actions specific to Little Bearskin Lake's current and future management that were developed by both members of the Little Bearskin Lake Planning Committee and Onterra ecologists.

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 involved the lake group as a whole or a focus group called a Planning Committee, as well as through the completion of an anonymous stakeholder survey.

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

Kick-off Meeting
On July 28, 2012, 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 LBLA 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 Introduction to Onterra Planning Process
Prior to the Kick-off Meeting held in July 2013, Tim Hoyman met with members of the Little Bearskin Planning Committee to introduce them to the process Onterra uses to create a lake management plan. During this meeting, Mr. Hoyman started with an overview of how Onterra combines the technical and sociological aspects of lake management to create a plan that is acceptable and implementable by the lake group. During this meeting, the committee's role in that process was also described, along with how their time is recorded and reflected for the grant reimbursement at the end of the project.

Planning Committee Meeting I
On May 17, 2013, Onterra ecologists Brenton Butterfield and Tim Hoyman met with members of the Little Bearskin Lake Planning Committee. In advance of this meeting, a draft copy of the Results and Discussion Sections (3.0) was provided to attendees. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including the aquatic plant inventories, water quality analyses, and watershed modeling were presented and discussed.

Planning Committee Meeting II
On July 19, 2013, Onterra ecologists Brenton Butterfield and Tim Hoyman met with members of the Little Bearskin Lake Planning Committee to discuss the stakeholder survey results and begin developing management goals and actions for the Little Bearskin Lake Association's

Comprehensive Lake Management Plan. One of the major topics of discussion was related to hybrid water milfoil management and the WDNR's milfoil weevil study that was being initiated on areas of milfoil within the lake.

Project Wrap-up Meeting
Yet to occur.

Management Plan Review and Adoption Process
Yet to occur.

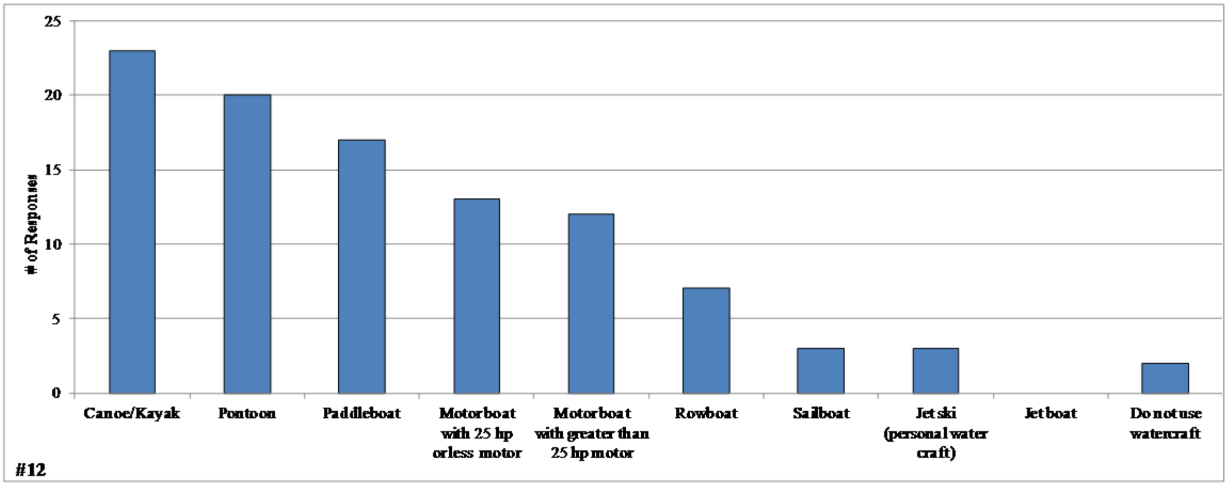
Stakeholder Survey
During late summer of 2012, the Little Bearskin Lake Planning Committee worked with Onterra staff to develop an anonymous stakeholder survey that would be sent to all LBLA members as well as non-members who owned property around the lake. This survey was reviewed and approved by a WDNR sociologist in November of 2012, and later that month, the seven-page, 30-question survey was mailed to 90 riparian property owners in the Little Bearskin Lake watershed. 50 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Little Bearskin 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 general summary is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Little Bearskin Lake. The majority of stakeholders (42%) visit on weekends through the year while 22% have a year-round residence and 18% consider themselves seasonal residents (Appendix B, Question #1). 35% of stakeholders have owned their property for less than 10 years, while 28% have owned their property for over 25 years (Question #3).

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. Roughly half of survey respondents indicate that they use either a canoe or kayak on the lake, while pontoons and paddleboats were also a popular option (Question #12). On a relatively small lake such as Little Bearskin Lake, the importance of responsible boating activities is increased. The need for responsible boating increases during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the lake. As seen on Question #13, several of the top recreational activities on the lake involve boat use.

Through the survey, stakeholders were able to voice their opinion on matters of concern to themselves as well as the health of Little Bearskin Lake. Aquatic invasive species and excessive aquatic plant growth ranked overwhelmingly high on both a list of factors negatively impacting the lake and factors that stakeholders saw as a great concern (Questions #19 and #20). These topics are discussed at length in the Aquatic Plant Section as well as the report's Summary & Conclusions section and Implementation Plan.

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



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

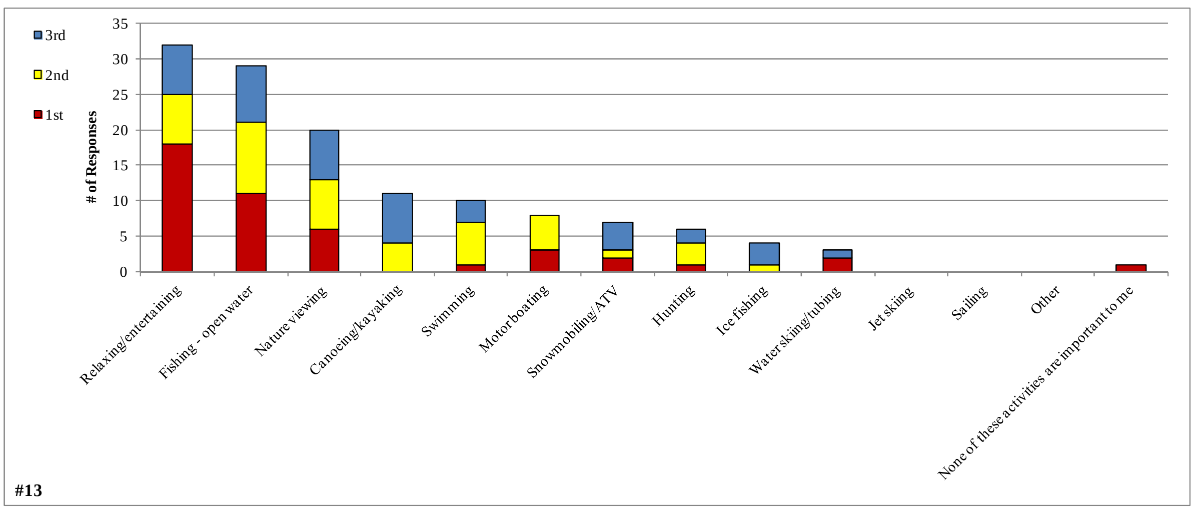
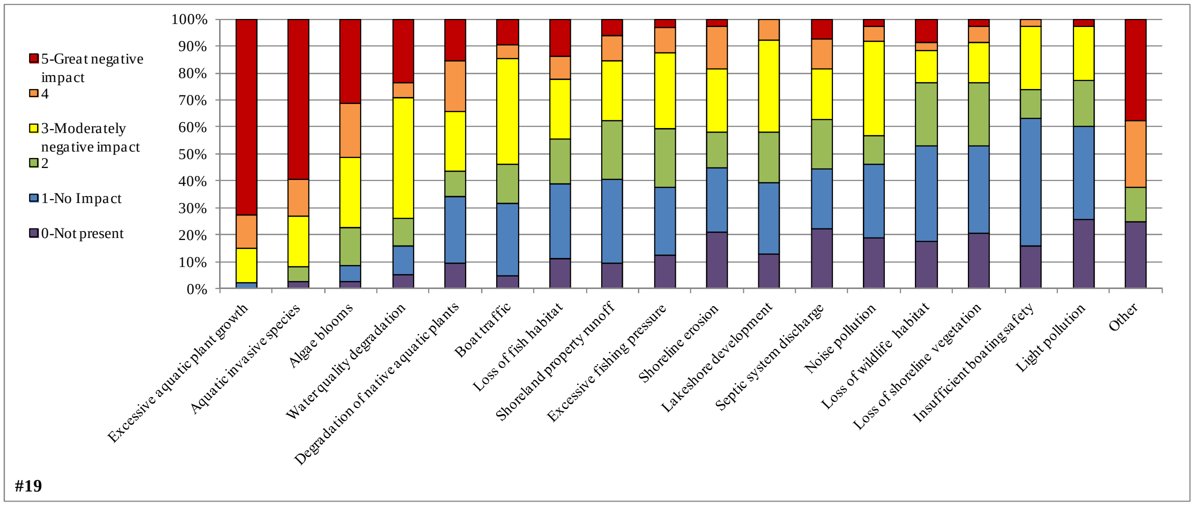


Figure 2.0-1. Select survey responses from the Little Bearskin Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

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



Question #20: Please rank your top three concerns regarding Little Bearskin Lake.

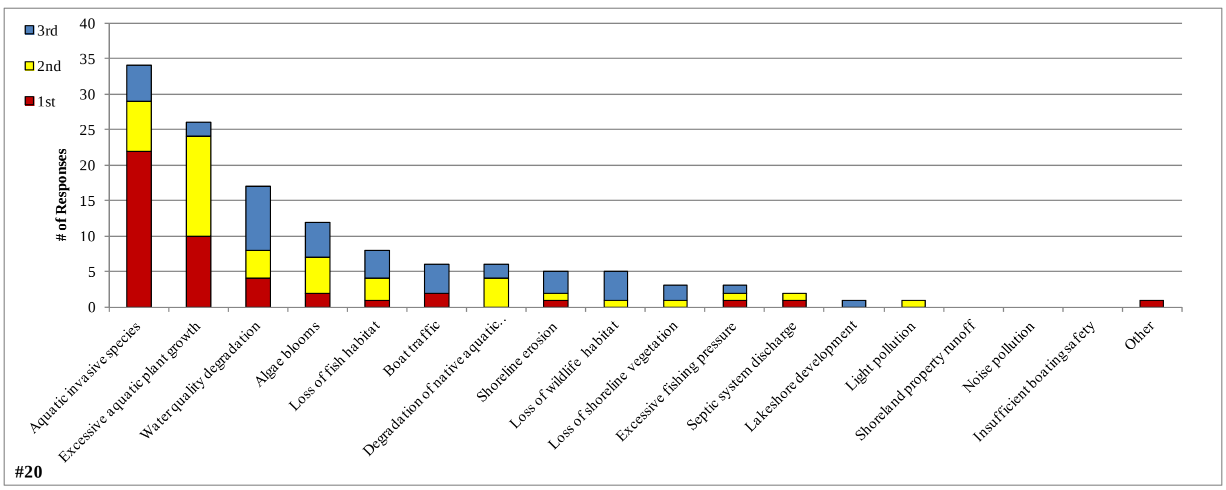


Figure 2.0-2. Select survey responses from the Little Bearskin Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

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

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

As mentioned above, chemistry is a large part of water quality analysis. In most cases, listing the values of specific parameters 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 Little Bearskin 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 Little Bearskin Lake's water quality analysis:

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

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

Trophic State

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

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

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

Limiting Nutrient

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

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

Temperature and Dissolved Oxygen Profiles

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

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

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

Internal Nutrient Loading

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

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

Non-Candidate Lakes

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

Candidate Lakes

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

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

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 Little Bearskin 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) utilizes the maximum depth and surface area of the lake to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

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

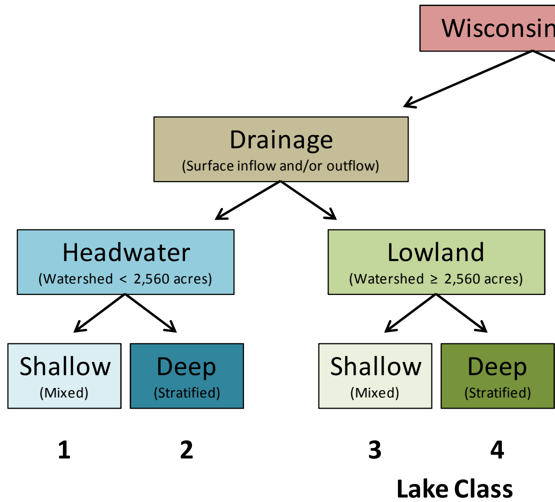


Figure 3.1-1. Wisconsin Lake Classifications. Little Bearskin Lake is classified as a deep (stratified), lowland drainage lake (Class 4). Adapted from WDNR PUB-SS-1044 2008.

Little Bearskin Lake is classified as a deep (stratified), lowland drainage lake (Class 4) (Figure 3.1-1). The WDNR developed state-wide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for each of the six lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state's *ecoregions*, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.1-2). Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Little Bearskin Lake is within the Northern Lakes and Forests ecoregion (Figure 3.1-2).

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

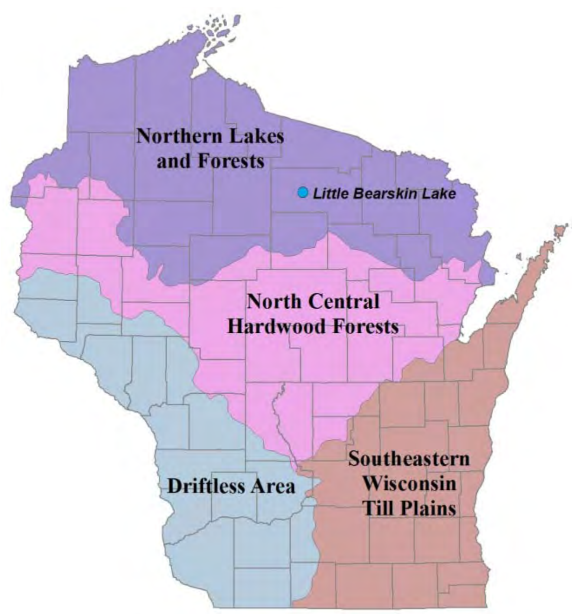


Figure 3.1-2. Location of Little Bearskin Lake within the ecoregions of Wisconsin. After Nichols 1999.

These data along with data corresponding to statewide natural lake means, historic, current, and average data from Little Bearskin Lake is displayed in the Figures within this section. 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.

Little Bearskin Lake Water Quality Analysis

Little Bearskin Lake Long-term Trends

As a part of this study, Little Bearskin Lake stakeholders were asked about their perceptions of the lake's water quality. The majority (53.7%) of respondents rated the water quality of Little Bearskin Lake as *Fair*, 31.7% rated *Good*, 14.6% rated *Poor* or *Very Poor*, and no respondents believed the water quality to be *Excellent* (Appendix B, Question #14). Approximately 59% of survey respondents indicated that the water quality of Little Bearskin Lake has *Somewhat degraded* since they first visited the lake, while approximately 30% believed it has remained the same (Question #15). Little Bearskin Lake survey respondents indicated that algae blooms and water quality degradation were the third and fourth top factors that may be negatively impacting the overall health of the lake (Question #19). Water quality degradation and algae blooms were listed as the third and fourth top concern, respectively, of Little Bearskin Lake stakeholders (Question #20).

Volunteers have been and continue to be actively collecting data from Little Bearskin Lake through the Citizens Lake Monitoring Network (CLMN) Program. Through this WDNR-sponsored program, volunteers are trained to collect water quality data on their lake. Samples are analyzed through the State Lab of Hygiene in Madison, WI and data are entered into the Surface Water Integrated Monitoring System (SWIMS), an online database which allows for quick access to all current and historical water quality data. This process allows stakeholders to become directly engaged in protecting their lake, while producing reliable and comparable data that managers may recall through a streamlined website.

As discussed previously, three water quality parameters are of most interest when assessing a lake's water quality: total phosphorus, chlorophyll-*a*, and Secchi disk transparency. Volunteers from Little Bearskin Lake have been collecting these data on an annual basis since 1990, building a dataset of over twenty years of data that will yield valuable information on Little Bearskin Lake's water quality through time.

Near-surface total phosphorus data are available from Little Bearskin Lake from 1973 and 1974, and for 18 years between the dates of 1988 and 2012. As illustrated in Figure 3.1-3, total phosphorus values from 1973 and 1974 varied greatly, ranging from average values of 50 µg/L to 30 µg/L. Data collected from 1988-2000 were also sporadic, with average total phosphorus values ranging from 41.7 µg/L in 1997 to 17.0 µg/L in 2000. However, average growing season and summer total phosphorus concentrations from 2003-2012 were less variable, and all fell within the *Good* category for deep, lowland drainage lakes. Total phosphorus concentrations measured in 2012 were the highest recorded since 1997 and were approximately 9.0 µg/L higher on average than concentrations measured in 2011. The weighted average for near-surface summer month total phosphorus concentrations from all years with available data falls within the *Good* category for deep, lowland drainage lakes, but slightly higher than the median values for deep, lowland drainage lakes state-wide and for lakes within the Northern Lakes and Forests Ecoregion (Figure 3.1-3).

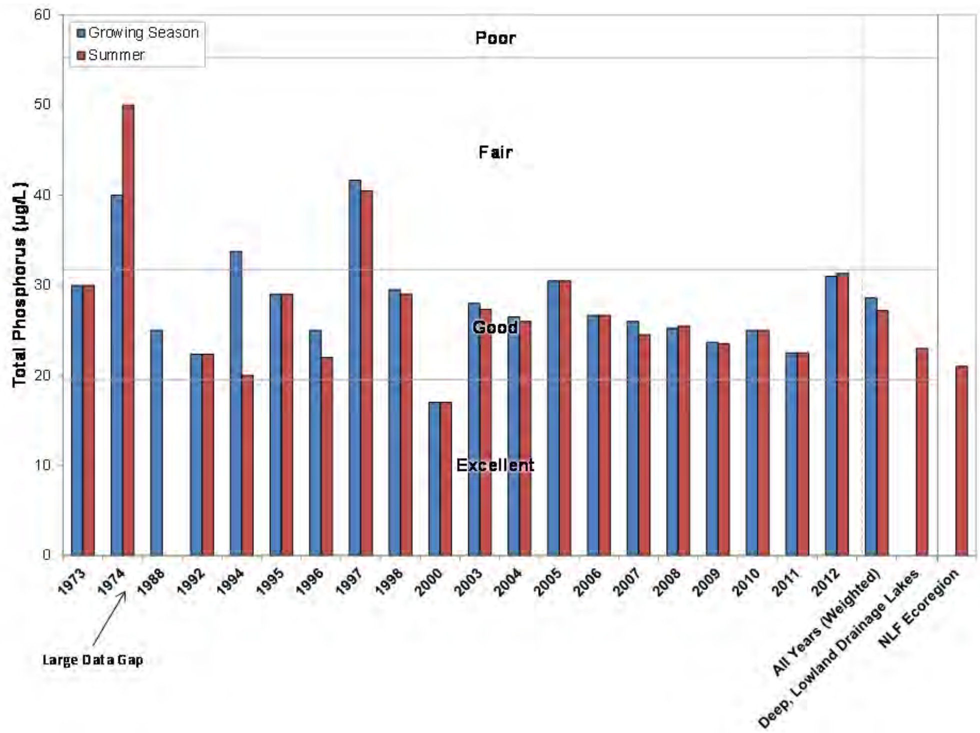


Figure 3.1-3. Little Bearskin Lake, state-wide class 4 lakes, and regional total phosphorus concentrations. Mean values calculated with near-surface total phosphorus data. Water Quality Index values adapted from WDNR PUB WT-913.

As discussed earlier, chlorophyll-*a*, or the measure of free-floating algae within the water column, is usually positively correlated with total phosphorus concentrations. While phosphorus limits the amount of algae growth in the majority of Wisconsin's lakes, other factors also affect the amount of algae produced within the lake. Water temperature, sunlight, and the presence of small crustaceans called zooplankton which feed on algae all also influence algal abundance.

Chlorophyll-*a* data have been collected from Little Bearskin Lake from 1992-2012 (Figure 3.1-4). Annual chlorophyll-*a* levels in Little Bearskin Lake appear to fluctuate periodically, with a few years of lower concentrations followed by years of higher concentrations. Following the most recent period of lower chlorophyll-*a* concentrations in 2008 and 2009, the average annual chlorophyll-*a* concentration has been increasing since 2010. The average growing season and summer chlorophyll-*a* concentrations measured in 2012 were the highest recorded in Little Bearskin Lake since these data have been collected, falling into the *Fair* category for deep, lowland drainage lakes. The chlorophyll-*a* levels recorded in 2012 correspond to some of the highest total phosphorus concentrations recorded in the most recent decade in Little Bearskin Lake.

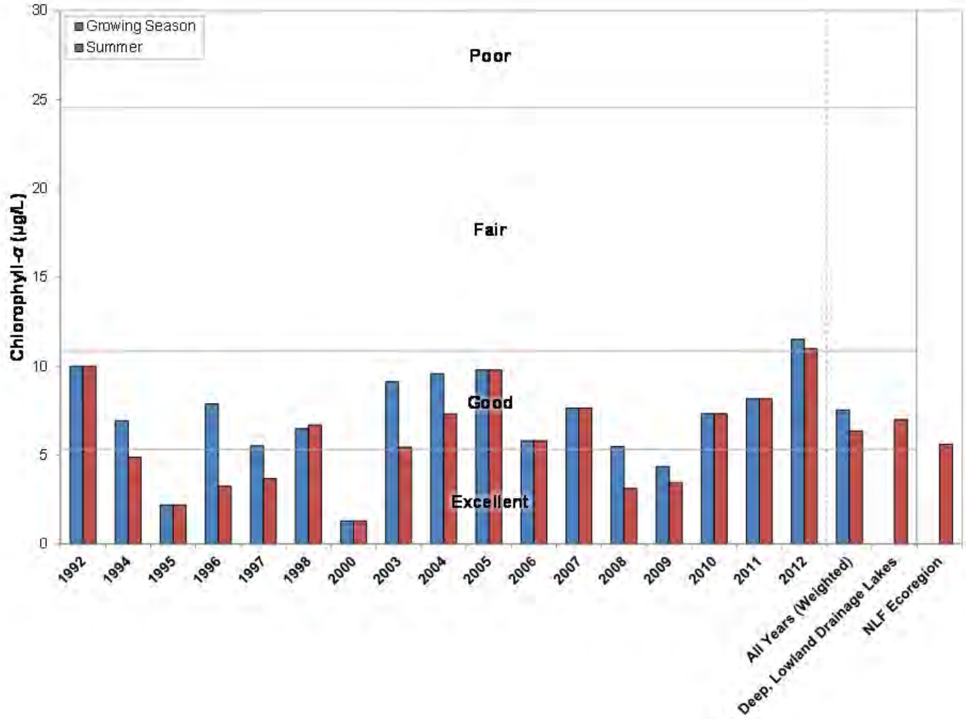


Figure 3.1-4. Little Bearskin Lake, state-wide class 4 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with near-surface chlorophyll-*a* data. Water Quality Index values adapted from WDNR PUB WT-913.

The most abundant historical water quality data available from Little Bearskin Lake are in the form of Secchi disk transparency. Secchi disk transparencies were recorded in 1973, 1974, 1979, and 19 years from 1990-2012. Average growing season and summer Secchi disk transparency in 2012 were 6.7 feet and 7.5 feet, respectively (Figure 3.1-5). Secchi disk transparency data recorded from 1990-2012 indicate that water clarity within Little Bearskin Lake is somewhat variable from year to year, falling in either the *Good* or *Excellent* categories for deep, lowland drainage lakes. Using the data that are available, the weighted summer average for Secchi disk transparency straddles the *Good-Excellent* threshold for deep, lowland drainage lakes, and is comparable to lakes of this type state-wide and to other lakes within the NLF Ecoregion (Figure 3.1-5). From these data, it does not appear that any trends (positive or negative) regarding Little Bearskin Lake's water clarity are occurring over time.

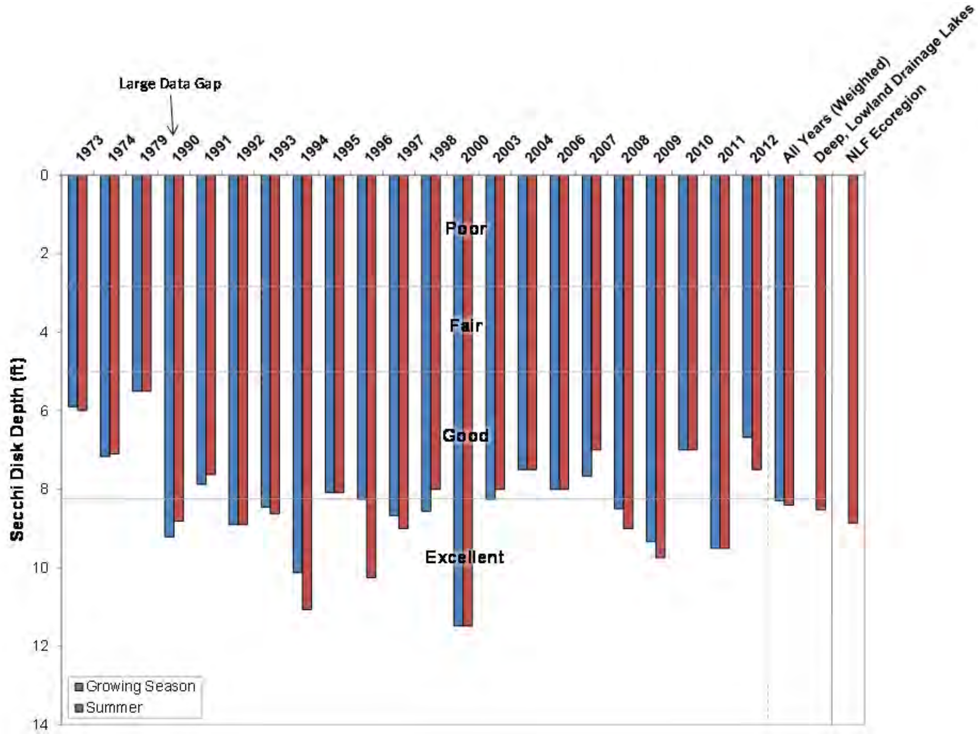


Figure 3.1-5. Little Bearskin Lake, state-wide class 4 lakes, and regional Secchi disk clarity values. Water Quality Index values adapted from WDNR PUB WT-913.

As discussed, average annual near-surface total phosphorus concentrations within Little Bearskin Lake have remained relatively constant over the most recent decade, with a slight increase observed in 2012. However, looking at the near-surface total phosphorus concentrations recorded within each year shows that in some years total phosphorus concentrations tend to be variable, often increasing later in the growing season. For example, Figure 3.1-6 displays the near-surface total phosphorus values collected during the growing season of 2012 along with chlorophyll-*a* concentrations and Secchi disk transparency. As illustrated, total phosphorus concentrations nearly doubled from June 28 to July 7, and in response, chlorophyll-*a* levels increased by a factor of 4.5 and water clarity decreased by one foot. This increase in near-surface total phosphorus concentrations observed from June 28 to July 7 indicates that phosphorus loading to the lake occurred sometime over this period.

In lakes that stratify during the summer and develop a hypolimnion (bottom water layer) devoid of oxygen, accumulated sediment phosphorus can be released where it builds up within the hypolimnion. During turnover events when stratification is broken, the phosphorus that has built-up within the hypolimnion is mixed throughout the entire water column. If stratification is broken during the summer months, phosphorus delivered to near-surface waters becomes available to free-floating algae and can potentially cause algae blooms. This can occur in lakes that are *polymictic*, or have the potential to break stratification during the summer months during strong wind events. Internal phosphorus loading may be less problematic in *dimictic* lakes, or lakes that only turnover twice per year, once in spring and again in fall. In dimictic lakes, there is little exchange of sediment-released phosphorus from the hypolimnion to the epilimnion during the summer when the lake is stratified. And when the lake does turnover (spring and fall) mixing the hypolimnetic phosphorus throughout the water column, the water is generally cool and algae growth is minimal.

To determine if a lake is polymictic or dimictic, a measure called the Osgood Index is used. The Osgood Index relates a lake's average depth to its surface area. Little Bearskin Lake has a calculated Osgood Index value of 2.6, indicating that the lake is polymictic and has the potential to break stratification during high-wind events in the summer. If internal phosphorus loading from bottom sediments is occurring in Little Bearskin Lake during periods of stratification, this phosphorus could periodically be delivered to surface waters during turnover events, fueling occasional algae blooms described by lake stakeholders.

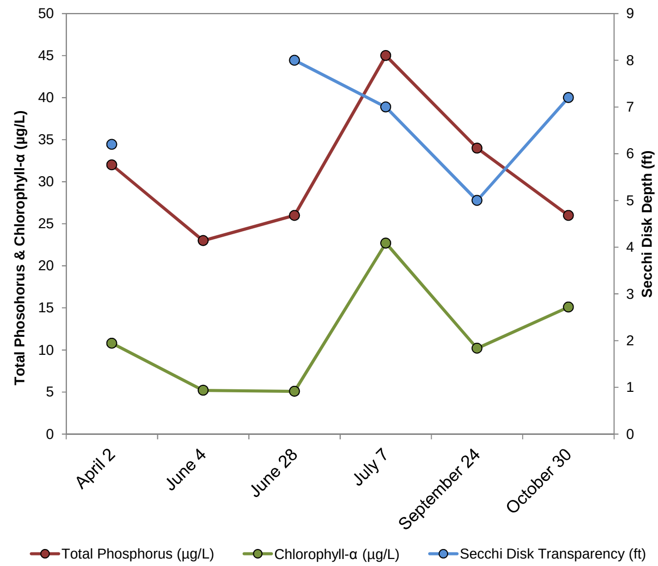


Figure 3.1-6. Little Bearskin Lake, 2012 growing season near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency.

As discussed in the primer section, near-bottom total phosphorus concentrations which exceed 200 µg/L generally indicate that phosphorus loading from bottom sediments may be impacting a lake's water quality. Near-bottom total phosphorus concentrations were not collected from Little Bearskin Lake during stratification in 2012; however, hypolimnetic total phosphorus concentrations greater than 200 µg/L (some greater than 500 µg/L) were recorded in the early and mid-1990s. The Lake and Watershed Management Report completed by Blue Water Science (1993) reported that while hypolimnetic phosphorus was elevated, they did not observe the lake breaking stratification during the summer and mixing the hypolimnetic phosphorus throughout the water column. The report also stated that while Little Bearskin Lake is technically classified as a polymictic lake, the islands shelter the deepest area of the lake (eastern basin) from strong wind events which maintains stratification (Blue Water Science 1993).

Calculations were used to determine if the increase in near-surface total phosphorus concentrations from June 28 to July 7, 2012 could be attributed to internal phosphorus loading given the historical hypolimnetic phosphorus concentrations that have been recorded. Using historical temperature profiles, it was assumed that the epilimnion extended to a depth of 18 feet on June 28, 2012. If the increase in near-surface total phosphorus recorded in July was a result of internal nutrient loading, this would mean the lake would have broken stratification, and phosphorus would be relatively evenly distributed throughout the entire water column.

Using bathymetric data for Little Bearskin Lake, the estimated water volume of the entire lake is approximately 1,378 acre-feet. Assuming that the 45 µg/L of phosphorus was distributed throughout the entire lake on July 7, 2012, calculations indicate that there was approximately 168 pounds of phosphorus within the lake at that time. Assuming the lake was stratified on June 28, 2012, and using the volume of the epilimnion (to 18 feet), the measured 26 µg/L of total phosphorus would mean that approximately 96 pounds of phosphorus were within the epilimnion, with the remaining 72 pounds being in the hypolimnion. Using the volume of the hypolimnion (below 18 feet) and the 72 pounds of phosphorus, if a near-bottom sample were collected on June 28, 2012, the total phosphorus concentration would be an estimated 1,450 µg/L. This estimated concentration is nearly 500 µg/L higher than the highest hypolimnetic phosphorus concentration recorded in September of 1994, and nearly 1,000 µg/L higher than the annual average for hypolimnetic phosphorus values. These calculations indicate that nearly twice the amount of hypolimnetic phosphorus than what has historically been measured would have been needed to create a lake-wide total phosphorus concentration of 45 µg/L measured on July 7, 2012. This means that if internal nutrient loading did occur, it was likely isolated to the eastern basin of the lake, or the phosphorus came from an external source like Bearskin Creek, or both.

As mentioned, the deepest area of Little Bearskin Lake where water quality samples are collected (Map 1) is located in the eastern portion of the lake and is somewhat sheltered by islands to the west. The Bearskin Creek inlet to Little Bearskin Lake and outlet are both located in close proximity to one another within this area. If hypolimnetic phosphorus is delivered to near-surface waters within the eastern basin, it likely does not get distributed throughout the entire lake given the west-to-east flow of water. To test this theory, the calculations discussed previously were repeated, but this time, only the volume of water within the eastern basin of the lake was used. Assuming the epilimnion extended to a depth of 18 feet on June 28, 2012, these calculations indicate that a hypolimnetic total phosphorus concentration of approximately 450 µg/L (17 pounds) of phosphorus were needed to create a basin-wide concentration of 45 µg/L on July 7, 2012. This estimated hypolimnetic concentration is similar to historical total phosphorus concentrations actually measured from the hypolimnion. These calculations indicate that the increase in near-surface total phosphorus measured on July 7, 2012 could be a result of internal nutrient loading, the impacts of which may be restricted to the eastern basin of the lake.

An external delivery of phosphorus to Little Bearskin Lake is another possibility that may explain the measured increase in phosphorus in July 2012. Upstream Big Bearskin Lake is polymictic, and historical total phosphorus data indicates that concentrations increase markedly within the lake during the growing season (Figure 3.1-7). The Big Bearskin Lake Management Plan completed by Blue Water Science (2000) states that the increase in phosphorus observed within Big Bearskin Lake over the course of the growing season is caused by internal phosphorus loading, but not conventionally via sediments in an anoxic environment. Blue Water Science's studies concluded that the measured increase in phosphorus in Big Bearskin Lake on an annual basis is largely due to a genus of algae, *Gloeotrichia*. These algae overwinter on Big Bearskin Lake's lake bottom and uptake phosphorus from the sediment in spring. Using the phosphorus gathered from bottom sediments, *Gloeotrichia* migrates up into the epilimnion in summer where it uses the nutrients gathered from the bottom and propagates, creating the large algae blooms observed on the lake. It is unclear if phosphorus within *Gloeotrichia* can be transferred to epilimnetic waters upon their death, or if it sinks back to the sediment (Forsell and Pettersson 1995). It is possible that phosphorus from internal loading on Big Bearskin Lake flows down Bearskin Creek and is elevating phosphorus concentrations within Little Bearskin Lake. However, as will be discussed in the Watershed Section, modeling indicates that more phosphorus is entering Big Bearskin Lake than is leaving; indicating Big Bearskin Lake may be acting as a phosphorus sink for Little Bearskin Lake.

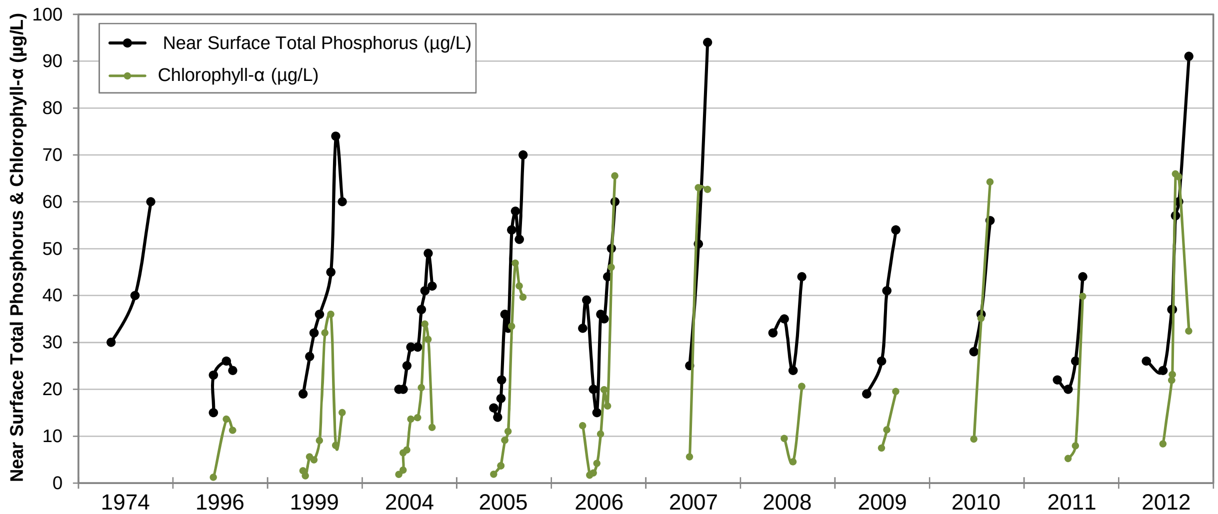


Figure 3.1-7. Big Bearskin Lake growing season near-surface total phosphorus and chlorophyll-*a* concentrations.

The observed increase in near-surface total phosphorus concentrations in Little Bearskin Lake from June 28 to July 7, 2012 indicate that phosphorus is being loaded to the lake via some unknown source(s). As discussed, this phosphorus could be being loaded internally, from the sediments of Little Bearskin Lake, externally from Big Bearskin Lake, or both. A more rigorous water quality study with sampling locations located directly at the mouth of Bearskin Creek and within the western portion of Little Bearskin Lake would be needed to quantify exactly where this phosphorus is originating. However, there is no major concern regarding the degradation of Little Bearskin Lake's water quality at this time. Despite the possibility of occasional algae blooms in late summer, the lake's water quality in terms of total phosphorus and chlorophyll-*a* concentrations fall within the *Good* category for deep, lowland drainage lakes, while water clarity values fall in the *Excellent* category. There are no detectable signs Little Bearskin Lake's water quality is degrading over time. In 1996, sediment cores were collected from Little Bearskin Lake, and after analysis of preserved diatom communities within the sediment, it was concluded that the phosphorus concentrations within Little Bearskin Lake have not changed over the last century (Garrison and Winkelman 1996).

Limiting Plant Nutrient of Little Bearskin Lake

Using midsummer nitrogen and phosphorus concentrations from Little Bearskin Lake, a nitrogen:phosphorus ratio of 17:1 was calculated. This finding indicates that Little Bearskin Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that phosphorus is the primary nutrient driving aquatic macrophyte and algae abundance.

Little Bearskin Lake Trophic State

Figure 3.1-8 contains the Trophic State Index (TSI) values for Little Bearskin Lake. In general, the best values to use in judging a lake's trophic state are total phosphorus and chlorophyll-*a*, as other factors other than algal abundance can affect a lake's water clarity; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, and Little Bearskin Lake's abundant aquatic plant community, it can be concluded that Little Bearskin Lake is currently in a meso-eutrophic state. Little Bearskin Lake's productivity is comparable to other deep, lowland drainage lakes within the state, but is slightly more productive when compared to other lakes within NLF Ecoregion.

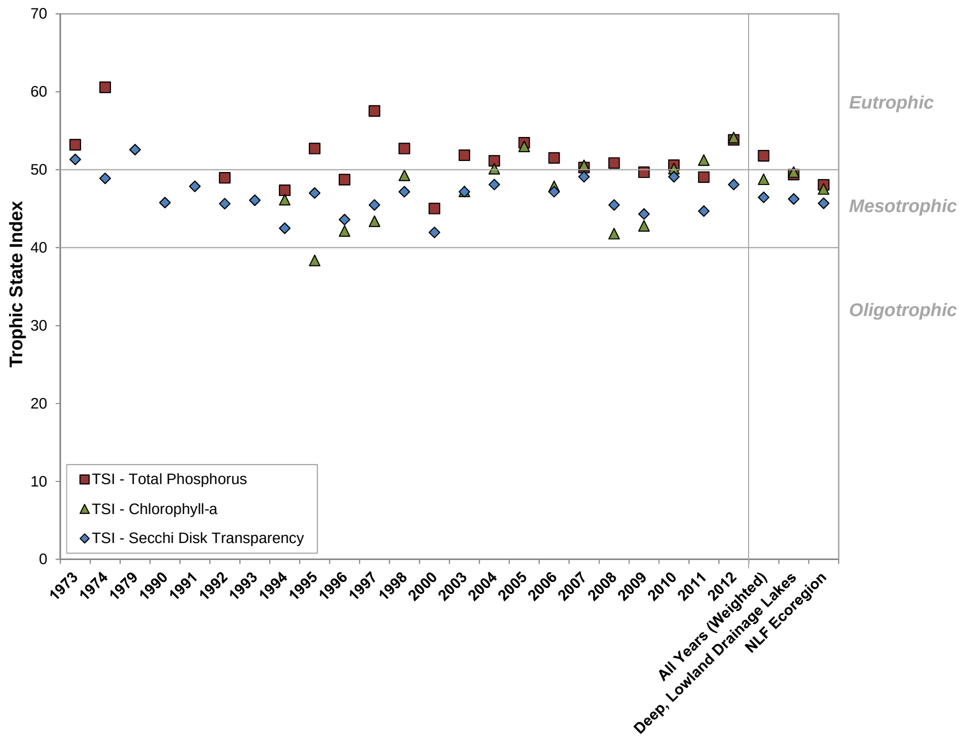


Figure 3.1-8. Little Bearskin Lake, state-wide class 4 lakes, and regional Trophic State Index values.

Dissolved Oxygen and Temperature in Little Bearskin Lake

Dissolved oxygen and temperature were measured at various depths during water quality sampling visits to Little Bearskin Lake by Onterra staff in the spring and fall of 2012, and in the winter of 2013 (Figure 3.1-9). No profiles were collected during the summer months by the Little Bearskin Lake CLMN. As illustrated, Little Bearskin Lake was not stratified during the spring and fall sampling periods, with nearly uniform temperature and dissolved oxygen levels throughout the water column. In winter under the ice, the water was stratified, with the water increasing in temperature with depth. Dissolved oxygen levels under the ice were approximately 13.0 mg/L throughout the water column, indicating that fishkills due to anoxia during winter are unlikely in Little Bearskin Lake.

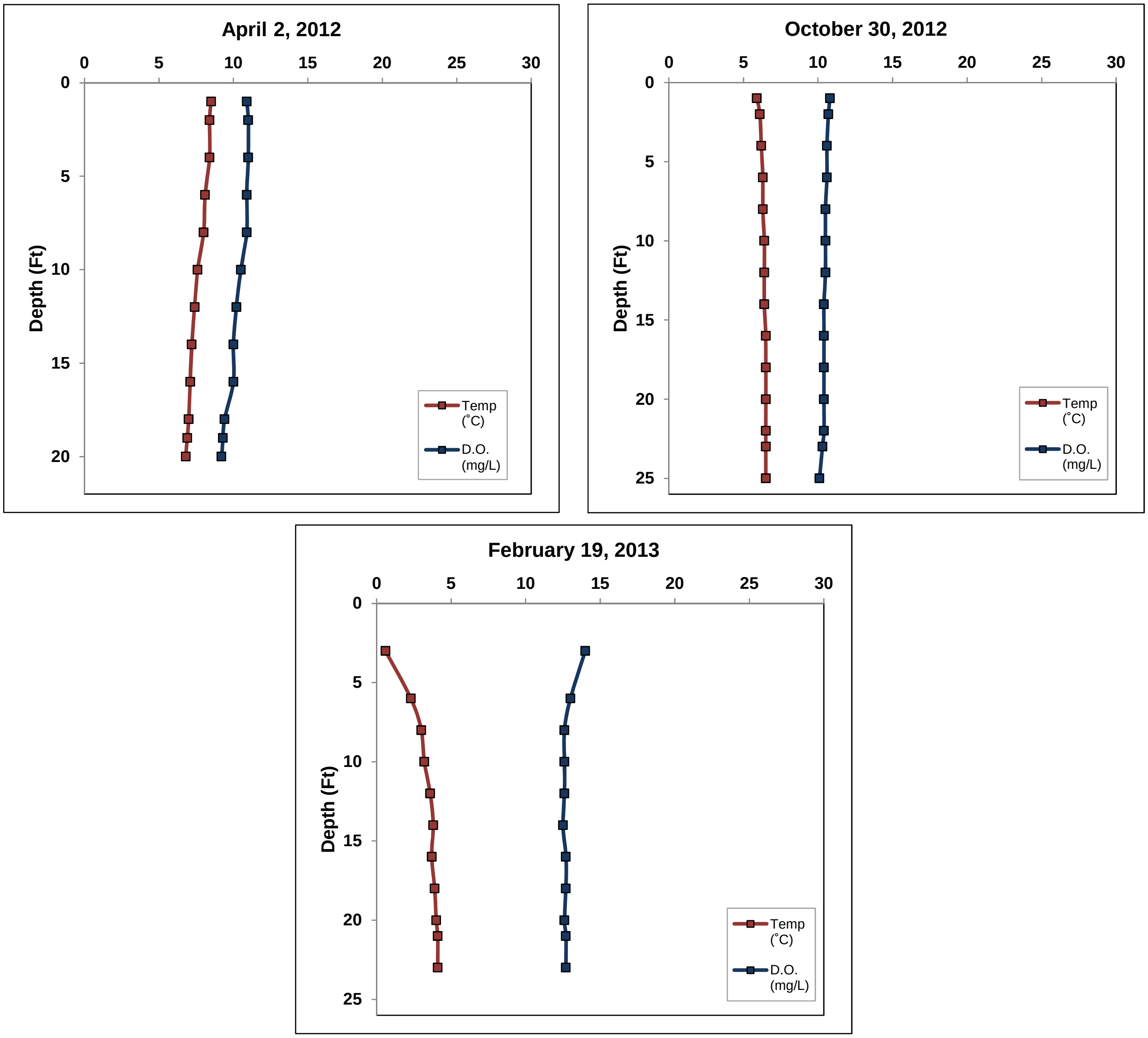


Figure 3.1-9. Temperature and dissolved oxygen profiles collected on Little Bearskin Lake in 2012 and 2013.

Additional Water Quality Data Collected at Little Bearskin Lake

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

pH

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw and Nimphius, 1985). The pH of the water in Little Bearskin Lake was found to be alkaline with surface values ranging from 7.3 to 8.6, and falls within the pH range for the majority of lakes sampled by Lillie and Mason (1983) within the northeast region of Wisconsin (Figure 3.1-10).

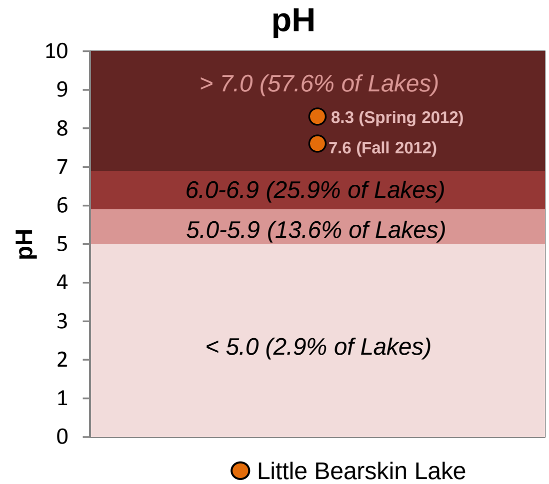


Figure 3.1-10. pH of Little Bearskin Lake compared to pH of 243 northeast Wisconsin Lakes. Created using data from Lillie and Mason (1983).

Alkalinity

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^{2-}), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMg(CO_3)_2$). 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 little to no alkalinity have lower pH due to their inability to buffer against acid inputs. In 2012, the alkalinity in Little Bearskin Lake was approximately 44.8 (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. Little Bearskin Lake's alkalinity falls within the range of 32.1% of northeast Wisconsin lakes sampled by Lillie and Mason (1983) (Figure 3.1-11).

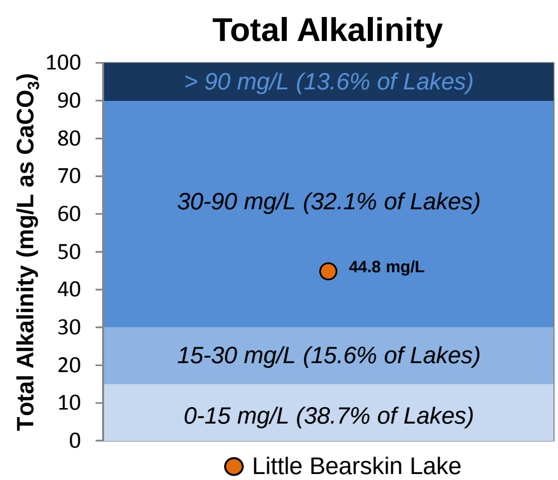


Figure 3.1-11. Total alkalinity of Little Bearskin Lake compared to total alkalinity of 243 northeast Wisconsin Lakes. Created using data from Lillie and Mason (1983).

Calcium

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 were potentially introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so

Little Bearskin Lake's pH range falls within this range. Lakes with calcium concentrations of less than 12.0 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Little Bearskin Lake in 2012 was found to be 12.6 mg/L, indicating Little Bearskin Lake falls within the *low susceptibility* category for zebra mussel establishment.

Researchers at the University of Wisconsin - Madison have also developed an aquatic invasive species suitability model called smart prevention (Vander Zanden and Olden 2008). In regards to zebra mussels, this model relies on measured or estimated dissolved calcium concentrations to indicate whether a given lake in Wisconsin is suitable, borderline suitable, or unsuitable for sustaining zebra mussels. Within this model, suitability was estimated for approximately 13,000 Wisconsin waterbodies and is displayed as an interactive mapping tool (www.aissmartprevention.wisc.edu). Based upon this analysis, Little Bearskin Lake was considered *not suitable* for mussel establishment. Plankton tows were completed by Onterra staff during the summer of 2012 and these samples were processed by the WDNR for larval zebra mussels. They did not detect any zebra mussel veligers within samples.

Total Suspended Solids

Total suspended solids (TSS) are a measure of inorganic and organic particles suspended in the water, and include everything from algae to clay particles. High TSS creates low water clarity, and prevents light from penetrating into the water to support aquatic plant growth. Total suspended solids were measured in Little Bearskin Lake near the surface and near the bottom in spring, fall, and winter of 2012. Average total suspended solids values for Little Bearskin Lake were 2.5 mg/L near the surface and 2.0 mg/L near the bottom. While regional and state-wide values for total suspended solids in Wisconsin's lakes have not been developed, the values measured from Little Bearskin Lake indicate there is little suspended material within the water.

True Color

A measure of water clarity once suspended material has been removed is called true color. True color measures the amount of light scattered and absorbed by organic materials dissolved within the water. Many lakes in the northern region of Wisconsin have natural dissolved organic materials from decomposing plant material delivered from wetlands within the watershed. These give the water a tea-like color and decrease water clarity. In 2012, Little Bearskin Lake had a true color value of 15 SU (standard units) (Figure 3.1-11). Of the 207 lakes sampled within the northeast region of Wisconsin by Lillie and Mason (1983), 34.3% had true color values of 10-40. A true color value of 15 indicates Little Bearskin Lake's water does not contain a high amount of dissolved materials and that water clarity within the lake is mainly driven by the amount of algae within the water.

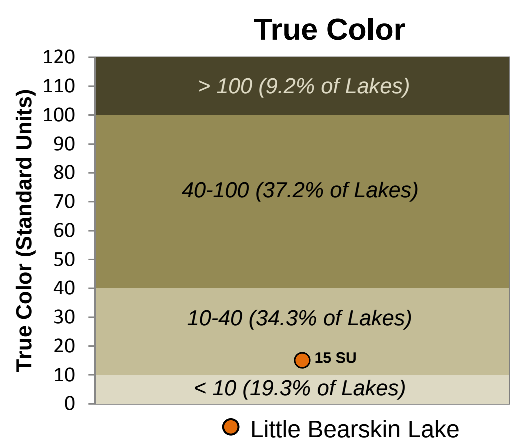


Figure 3.1-12. True Color of Little Bearskin Lake compared to True Color of 243 northeast Wisconsin Lakes. Created using data from Lillie and Mason (1983).

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. For these reasons, it is important to maintain as much natural land cover (forests, wetlands, etc.) as possible within a lake's watershed to minimize the amount runoff (nutrients, sediment, etc.) from entering the lake.

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

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

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

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

The Little Bearskin Lake watershed covers approximately 8,389 acres of land and consists of two sub-watersheds; a watershed that drains surface water into Big Bearskin Lake and a watershed that drains surface water directly into Little Bearskin Lake (Map 2). The Big Bearskin Lake watershed also includes other directly-connected lakes (Birch, Seed, Little Muskie, and Muskie Lakes) which ultimately flow through Big Bearskin Lake. Water draining into Big Bearskin Lake makes its way into Little Bearskin Lake via Bearskin Creek. In fact, the majority (86%) of Little Bearskin Lake's watershed is comprised of Big Bearskin Lake's watershed (Figure 3.2-1). Little Bearskin Lake's direct watershed is mainly comprised of forests (62%) and wetlands (19%), while the lake's surface itself and pasture/grassland areas account for the remaining 16% and 3%, respectively. Little Bearskin Lake's entire watershed is large compared to the surface area of the lake, yielding a watershed to lake area ratio of 44:1. With Little Bearskin Lake draining this amount of land, WiLMS calculated that the lake is able to completely exchange its volume of water 5.96 times per year, or approximately once every 61 days; however, due to the close configuration of the Little Bearskin Lake's inlet and outlet, the entire lake volume may not be consistently included in that exchange.

Using WiLMS, Big Bearskin Lake's watershed was modeled to determine an estimated amount of water discharged from Big Bearskin Lake to Little Bearskin Lake on an annual basis. This was estimated using hydrologic information for Oneida County that is built into the WiLMS model. Using the estimated water discharge rate from Big Bearskin Lake, total phosphorus data collected from Big Bearskin Lake was then used to estimate the potential amount of phosphorus loaded to Little Bearskin Lake through Bearskin Creek. And finally, WiLMS estimated the potential amount of phosphorus being loaded to Little Bearskin Lake from land within its direct watershed. WiLMS estimated that 795 lbs of phosphorus are delivered to Big Bearskin Lake on an annual basis. However, as discussed within the Water Quality Section, studies conducted on Big Bearskin Lake indicate internal phosphorus loading is likely occurring, possibly via the algae *Gloeotrichia*. Based on the land cover types and acreages within Big Bearskin Lake's watershed, the predicted growing season average total phosphorus concentrations is approximately 10 µg/L lower than what has actually been measured within the lake. To attain the growing season average total phosphorus concentrations actually measured in Big Bearskin Lake, an estimated 450 additional pounds of phosphorus from internal loading would need to be released. In total, approximately 1,245 lbs of phosphorus are loaded to Big Bearskin Lake, of which approximately 47% (656 lbs) are loaded to Little Bearskin Lake through Bearskin Creek (Figure 3.2-2).

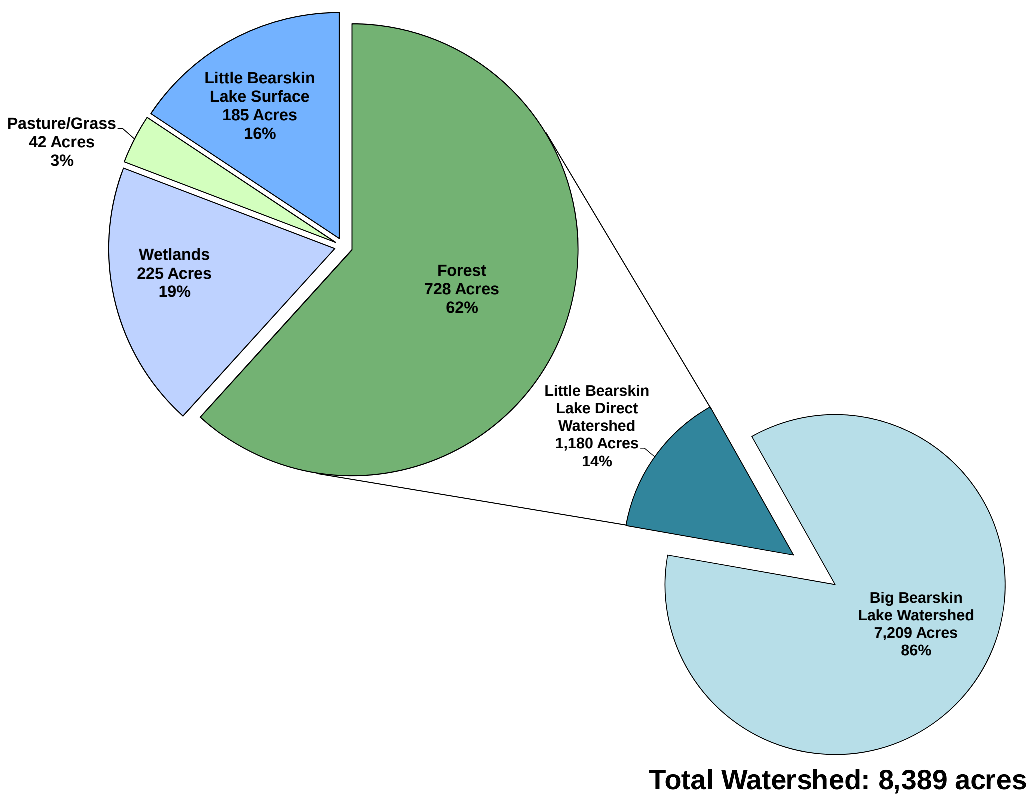


Figure 3.2-1. Little Bearskin Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

The phosphorus input from Big Bearskin Lake was modeled within the Little Bearskin Lake WiLMS model (Appendix D). WiLMS predicted that approximately 145 lbs of phosphorus are loaded to Little Bearskin Lake from its direct watershed. In combination with loading from Big Bearskin Lake, WiLMS estimates that a total of approximately 801 lbs of phosphorus are loaded to Little Bearskin Lake on an annual basis. As Figure 3.1-2 illustrates, 82% of Little Bearskin Lake's phosphorus load comes from Big Bearskin Lake, while the remaining 18% comes from the lake's direct watershed. Forested land cover within Little Bearskin Lake's direct watershed accounts for 7% (60 lbs) of the annual phosphorus load, direct deposition from the atmosphere into the lake accounts for 6% (49 lbs) wetlands (forested and non-forested) account for 3% (20lbs), and areas of pasture/grasslands account for 1% (11 lbs). Septic sources were accounted for within the model, based upon the estimated number of residents living along Little Bearskin Lake and the amount of time they spend there (full time residents, seasonal, etc). These data were collected as a part of questions contained on the stakeholder survey associated with this project (Appendix B). Properly functioning septic sources were estimated to contribute roughly 1% (6 lbs) of the annual phosphorus load to Little Bearskin Lake.

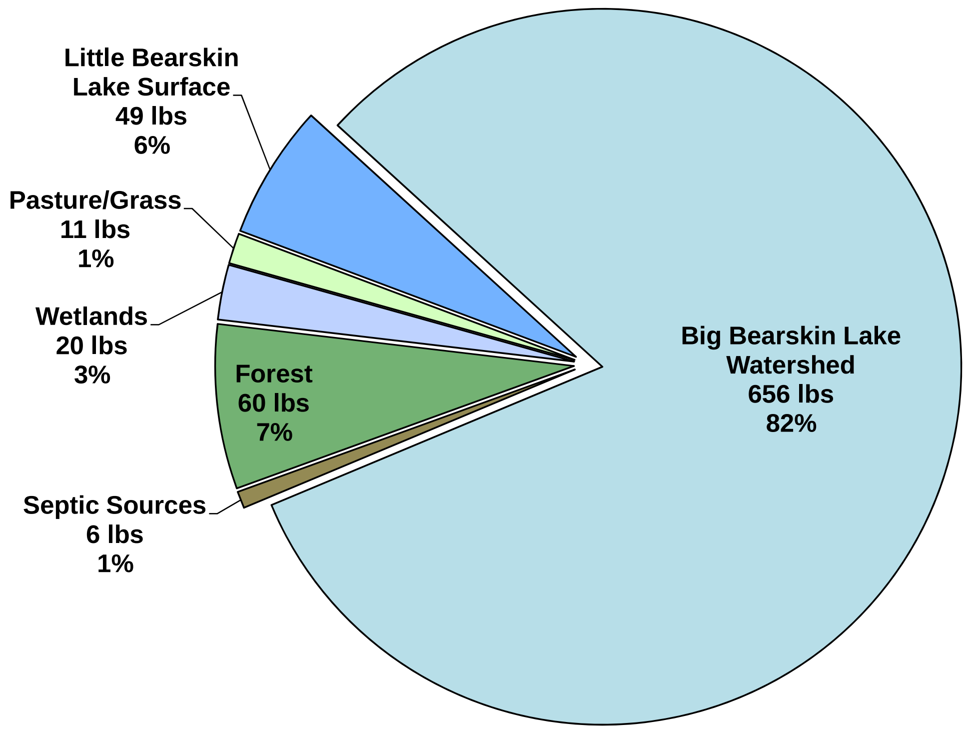


Figure 3.2-2. Little Bearskin Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

During modeling procedures, WiLMS compares observed (measured in the field) and predicted (model-calculated) growing season mean and spring overturn phosphorus concentrations to determine the accuracy of the model. The growing season mean phosphorus concentration is defined as the mean of all surface water data collected from March 31-November 1. The spring overturn phosphorus concentration is defined as the concentration of phosphorus that is collected while the lake is completely mixed, as it was during the April 2, 2012 water quality visit by Onterra staff. This value is a good representation of the phosphorus content of the lake, because during this time the water is thoroughly mixed which means phosphorus is fairly similar within the entire water column.

Utilizing the proportions of land cover types, phosphorus loading from Big Bearskin Lake, and hydrologic data, WiLMS was able to predict what the phosphorus content of Little Bearskin Lake should be and then compare these values to measured values obtained through water quality sampling. A predictive equation within WiLMS (Canfield-Bachman, 1981) estimated that the growing season mean and spring overturn phosphorus value should most likely be 27 µg/L in Little Bearskin Lake. Comparatively, Little Bearskin Lake's observed growing season mean phosphorus concentration was found to be 28.5 µg/L. Because the predicted total phosphorus concentration and the concentration that was actually measured within Little

Bearskin Lake are very closely aligned indicates that the WiLMS model of Little Bearskin Lake's watershed is accurate, including the amount of phosphorus being delivered from Big Bearskin Lake.

While the WiLMS model accurately predicted the amount of phosphorus being loaded to Little Bearskin Lake on an annual basis, these phosphorus concentrations are higher-than-expected given the size and land cover types within the lake's watershed. Within the model, actual phosphorus concentrations measured from Big Bearskin Lake were used, so that part of Little Bearskin's phosphorus budget is assumed to be accurate. However, a model of Big Bearskin Lake's predicted lower phosphorus concentrations than what were measured in the lake, indicating an unaccounted source(s) of phosphorus was entering the lake. The 2000 study on Big Bearskin Lake indicated that this was likely due to internal phosphorus loading. Another WiLMS model of Little Bearskin Lake's watershed was run using the model's predicted phosphorus concentration for Big Bearskin Lake rather than what was actually measured. Given the land cover types and acreages within Big Bearskin Lake's watershed, the model indicated that approximately 400 lbs of phosphorus should be expected to be delivered from Big Bearskin Lake to Little Bearskin Lake on an annual basis; 256 lbs less than actually occurs. This would result in a predicted average growing season total phosphorus concentration of 19 µg/L in Little Bearskin Lake, about 10 µg/L less than what has been measured. In other words, Big Bearskin Lake's in-lake phosphorus values are higher than expected based upon its watershed; therefore, the resulting phosphorus load from Big Bearskin Lake to Little Bearskin Lake is higher as well.

As discussed within the Water Quality Section, the higher-than-expected phosphorus concentrations measured in Little Bearskin Lake could be a result of internal nutrient loading and delivery from Big Bearskin Lake, internal loading within the eastern basin of Little Bearskin Lake, or both. But despite higher-than-predicted phosphorus concentrations, Little Bearskin Lake's total phosphorus concentrations are comparable to other lakes of its type within Wisconsin.

3.3 Shoreland Condition

The Importance of a Lake's Shoreland Zone

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

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

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

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

Shoreland Zone Regulations

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

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

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

- Vegetation Removal: For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed the lesser of 30 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. Vegetation removed must be replaced by replanting in the same area (native species only).

- Impervious surface standards: The amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. A county may allow more than 15% impervious surface (but not more than 30%) on a lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner.

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

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

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

Wisconsin Act 31

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

Shoreland Research

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

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

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

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

Photo 3.3-1. Example of a coarse woody habitat along natural lakeshore

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

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

National Lakes Assessment

Unfortunately, along with Wisconsin's lakes, waterbodies within the entire United States have shown to have increasing amounts of developed shorelands. The National Lakes Assessment (NLA) is an Environmental Protection Agency-sponsored assessment that has successfully pooled together resource managers from all 50 U.S. states in an effort to assess waterbodies, both natural and man-made. Through this collaborative effort, over 1,000 lakes were sampled in 2007, pooling together the first statistical analysis of the nation's lakes and reservoirs.

Through the National Lakes Assessment, a number of potential stressors were examined, including nutrient impairment, algal toxins, fish tissue contaminants, physical habitat, and others. The 2007 NLA report states that "of the stressors examined, poor lakeshore habitat is the biggest problem in the nations lakes; over one-third exhibit poor shoreline habitat condition" (USEPA 2009). Furthermore, the report states that "poor biological health is three times more likely in lakes with poor lakeshore habitat."

The results indicate that stronger management of shoreline development is absolutely necessary to preserve, protect and restore lakes. This will become increasingly important as development pressured on lakes continue to steadily grow.

Native Species Enhancement

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

Photograph 3.3-2. Example of a biolog restoration site.

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

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

Cost

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

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

In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $1,400. The more native vegetation a site has, the lower the cost. Owners should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:

- Spring planting timeframe.
- 100' of shoreline.
- An upland buffer zone depth of 35'.
- An access and viewing corridor 30' x 35' free of planting (recreation area).
- Planting area of upland buffer zone 2- 35' x 35' areas
- Site is assumed to need little invasive species removal prior to restoration.
- Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
- Trees and shrubs planted at a density of 1 tree/100 sq ft and 2 shrubs/100 sq ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
- Turf grass would be removed by hand.
- A native seed mix is used in bare areas of the upland buffer zone.

- o An aquatic zone with shallow-water 2 - 5' x 35' areas.
- o Plant spacing for the aquatic zone would be 3 feet.
- o Each site would need 70' of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- o Soil amendment (peat, compost) would be needed during planting.
- o There is no hard-armor (rip-rap or seawall) that would need to be removed.
- o The property owner would maintain the site for weed control and watering.

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

Little Bearskin Lake Shoreland Zone Condition

Shoreland Development

Little Bearskin Lake's shoreland zone can be classified in terms of its degree of development. In general, more developed shorelands are more stressful on a lake ecosystem, while definite benefits occur from shorelands that are left in their natural state. Figure 3.3-1 displays a diagram of shoreland categories, from "Urbanized", meaning the shoreland zone is completely disturbed by human influence, to "Natural/Undeveloped", meaning the shoreland has been left in its original state.

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

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

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

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

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

Figure 3.3-1. Shoreland assessment category descriptions.

On Little Bearskin Lake, the development stage of the entire shoreland was surveyed during the fall of 2012, using a GPS unit to map the shoreland. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreland on a property-by-property basis. During the survey, Onterra staff examined the shoreland for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.3-2.

Little Bearskin 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 shoreland 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. Approximately 3.2 miles (70%) of Little Bearskin Lake's shoreline is currently in a natural/undeveloped or developed-natural state. Approximately 0.8 miles (18%) is in a developed-natural state and 0.6 miles (12%) is urbanized or developed–unnatural. In addition, approximately 0.2 miles of the lake's shoreline contain rip rap and 0.1 miles contain wooden seawalls. As discussed, these areas completely eliminate immediate shoreline habitat and prevent reptiles and amphibians from migrating between the lake and terrestrial habitat within these areas. If restoration of the Little Bearskin Lake shoreland is to occur, primary focus should be placed on the urbanized and developed-natural areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreland lengths around the entire lake.

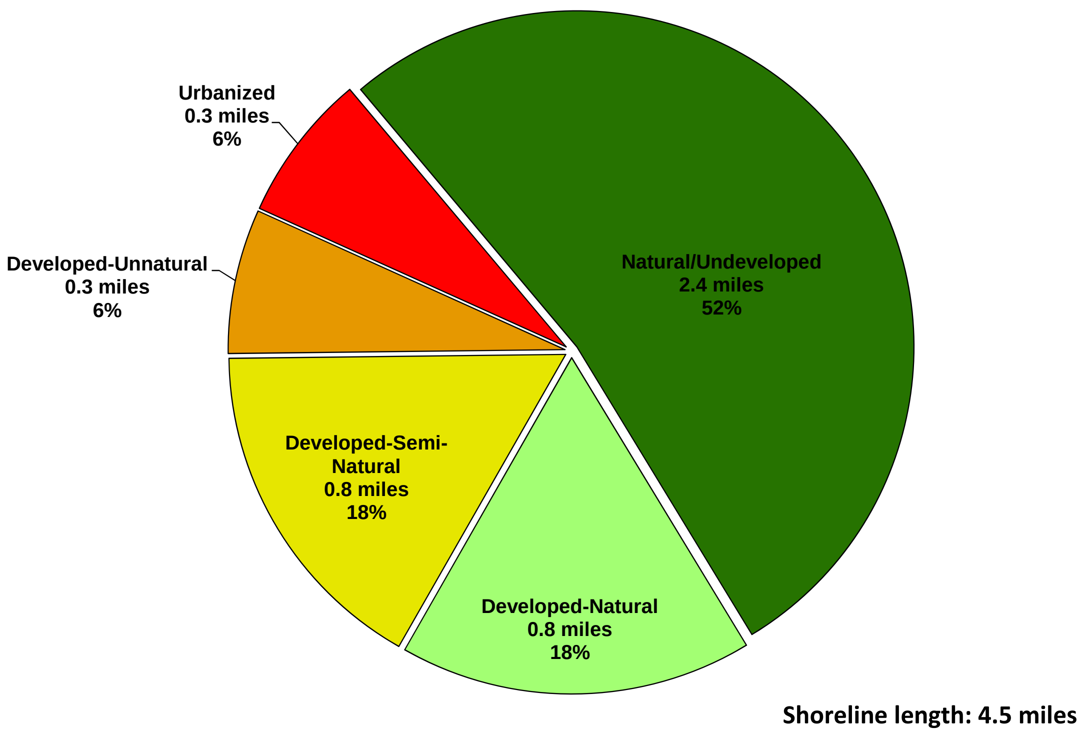


Figure 3.3-2. Little Bearskin Lake shoreland categories and total lengths. Based upon a fall 2012 survey. Locations of these categorized shorelands can be found on Map 3.

While producing a completely natural shoreland is ideal for a lake ecosystem, it is not always practical from a human's perspective. However, riparian property owners can take small steps in ensuring their property's impact upon the lake is minimal. Choosing an appropriate landscape position for lawns is one option to consider. Locating lawns on flat, unsloped areas or in areas that do not terminate at the lake's edge is one way to reduce the amount of runoff a lake receives from a developed site. And, allowing tree falls and other natural habitat features to remain along a shoreline may result not only in reducing shoreline erosion, but creating wildlife habitat also.

Coarse Woody Habitat

Little Bearskin Lake was surveyed in fall 2012 to determine the extent of the lake's coarse woody habitat. A survey for coarse woody habitat was conducted in conjunction with the shoreland assessment (development) survey. Coarse woody habitat was identified and classified in two size categories (2-8 inches diameter, >8 inches diameter) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed earlier, research indicates that fish species prefer some branching as opposed to no branching on coarse woody habitat, and increasing complexity is positively correlated with higher fish species richness, diversity and abundance.

During this survey, 23 total pieces of coarse woody habitat were observed along 4.5 miles of shoreline, which gives Little Bearskin Lake a coarse woody habitat to shoreline mile ratio of 5:1. Locations of coarse woody habitat are displayed on Map 4. To put this into perspective, Wisconsin researchers have found that in completely undeveloped lakes, an average of 345 coarse woody habitat structures may be found per mile (Christensen et al. 1996).

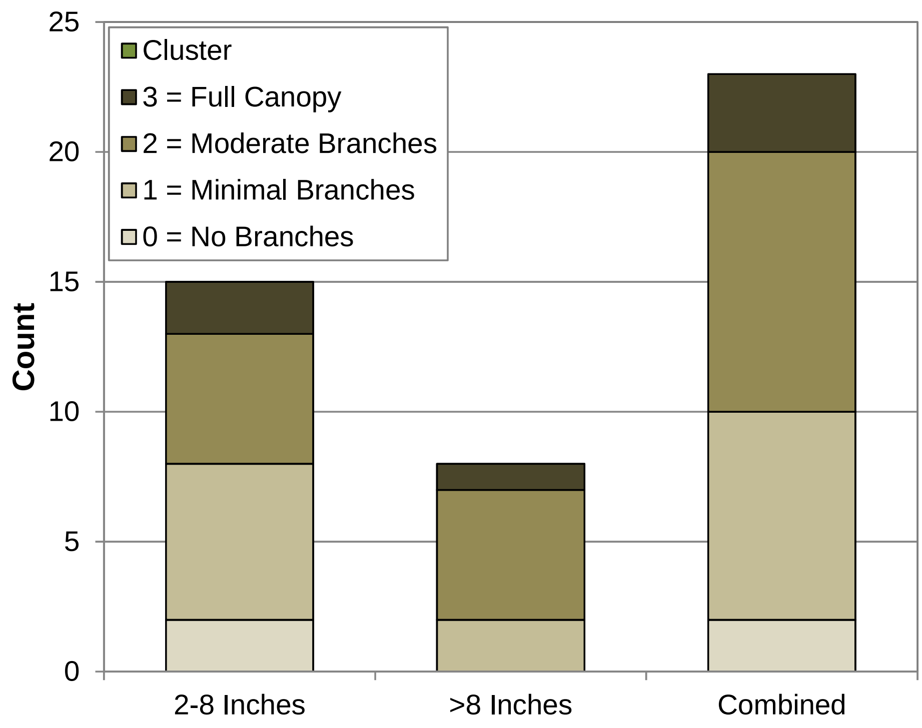


Figure 3.3-3. Little Bearskin Lake coarse woody habitat survey results. Based upon a fall 2012 survey. Locations of Little Bearskin Lake coarse woody habitat can be found on Map 4.

3.4 Aquatic Plants

Introduction

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

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

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.

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

Permits

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

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

Manual Removal

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

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

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

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

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

Bottom Screens

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

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 and reed canary grass. • Permitting process may require an environmental assessment that may take months to prepare. • Non-selective.

Mechanical Harvesting

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

Cost

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

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

Herbicide Treatment

The use of herbicides to control aquatic plants and algae is a technique that is widely used by lake managers. Traditionally, herbicides were used to control nuisance levels of aquatic plants and algae that interfere with navigation and recreation. While this practice still takes place in many parts of Wisconsin, the use of herbicides to control aquatic invasive species is becoming more prevalent. Resource managers employ strategic management techniques towards aquatic invasive species, with the objective of reducing the target plant's population over time; and an overarching goal of attaining long-term ecological restoration. For submergent vegetation, this largely consists of implementing control strategies early in the growing season; either as spatially-targeted, small-scale spot treatments or low-dose, large-scale (whole lake) treatments. Treatments occurring roughly each year before June 1 and/or when water temperatures are below 60°F can be less impactful to many native plants, which have not emerged yet at this time of year. Emergent species are targeted with foliar applications at strategic times of the year when the target plant is more likely to absorb the herbicide.

While there are approximately 300 herbicides registered for terrestrial use in the United States, only 13 active ingredients can be applied into or near aquatic systems. All aquatic herbicides must be applied in accordance with the product's US Environmental Protection Agency (EPA) approved label. There are numerous formulations and brands of aquatic herbicides and an extensive list can be found in Appendix F of Gettys et al. (2009).

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

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

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

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

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

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

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

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

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

Cost

Herbicide application charges vary greatly between $400 and $1,500 per acre depending on the chemical used, who applies it, permitting procedures, and the size/depth of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • Herbicides can target large areas all at once. • 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. • Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g. mammals, insects)	• All herbicide use carries some degree of human health and ecological risk due to toxicity. • 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 aquatic herbicides are nonselective. • Some herbicides have a combination of use restrictions that must be followed after their application. • Overuse of same herbicide may lead to plant resistance to that herbicide.

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as water hyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control water hyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively.

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

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

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

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

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

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

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

Analysis of Current Aquatic Plant Data

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

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

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

Species Diversity and Richness

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

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

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

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

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

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.

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. Between 2005 and 2009, WDNR Science Services conducted point-intercept surveys on 252 lakes within the state. In the absence of comparative data from Nichols (1999), the Simpson's Diversity Index values of the lakes within the WDNR Science Services dataset will be compared to Little Bearskin 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.

As previously stated, species diversity is not the same as species richness. One factor that influences species richness is the "development factor" of the shoreland. 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 shoreland may hold. This value is referred to as the shoreland complexity. It specifically analyzes the characteristics of the shoreland 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 shoreland 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 shoreland complexity increases, species richness increases, mainly because there are more habitat types, bays and back water areas sheltered from wind.

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Little Bearskin Lake will be compared to lakes in the same ecoregion and in the state.

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

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

In this section, the floristic quality of Little Bearskin 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). Little Bearskin Lake is a natural lake and therefore will be compared to other natural lakes within the NLFL ecoregion.

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

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

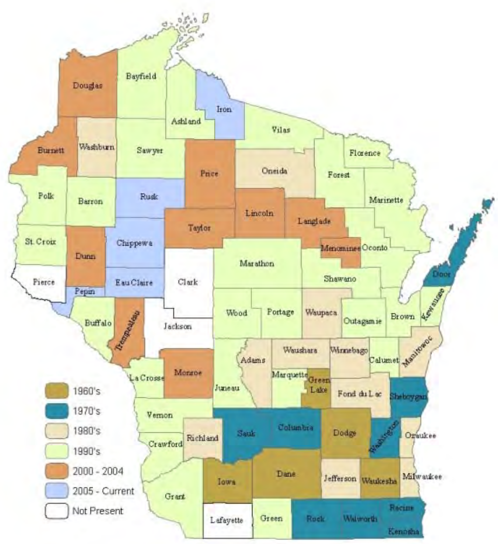


Figure 3.4-1. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

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 earlier, numerous aquatic plant surveys were completed as a part of this project. On June 6 and 7, 2012, an early-season aquatic invasive species (AIS) survey was completed on Little Bearskin Lake. While the intent of this survey is to locate any potential non-native species within the lake, it's primarily focused on locating any occurrences of curly-leaf pondweed which should be at or near its peak growth at this time. During this meander-based survey of the littoral zone, Onterra ecologists did not locate any occurrences of curly-leaf pondweed. Hybrid water milfoil was observed during this survey, and notes regarding its locations were made to aid in the hybrid water milfoil peak-biomass survey conducted in late summer.

Little Bearskin Lake is one of a number of lakes in an ongoing long-term research project being conducted by the Wisconsin Department of Natural Resources (WDNR). Their research is aimed at tracking and comparing Eurasian/hybrid water milfoil populations annually in lakes that are actively managed (herbicide treatments) to control Eurasian water milfoil versus lakes that are currently unmanaged; Little Bearskin Lake is one of their unmanaged lakes. To assess the hybrid water milfoil population and the lake's native aquatic plant community, the WDNR has conducted whole-lake point-intercept surveys on Little Bearskin Lake annually since 2009. These surveys were conducted on August 11, 2009, August 9 and 10, 2010, August 9, 2011, August 12, 2012, August 14, 2013, and August 19, 2014. Additional surveys were completed by Onterra to delineate areas of emergent and floating-leaf vegetation on August 9, 2012.

Over the course of the point-intercept surveys from 2009-2014 and the 2012 community mapping survey, 47 species of aquatic plants were located within Little Bearskin Lake (Table 3.4-1), only one of which is considered to be a non-native, invasive species: hybrid water milfoil Because of its importance, the hybrid water milfoil population in Little Bearskin Lake will be discussed in detail in the Non-Native Aquatic Plant Section.

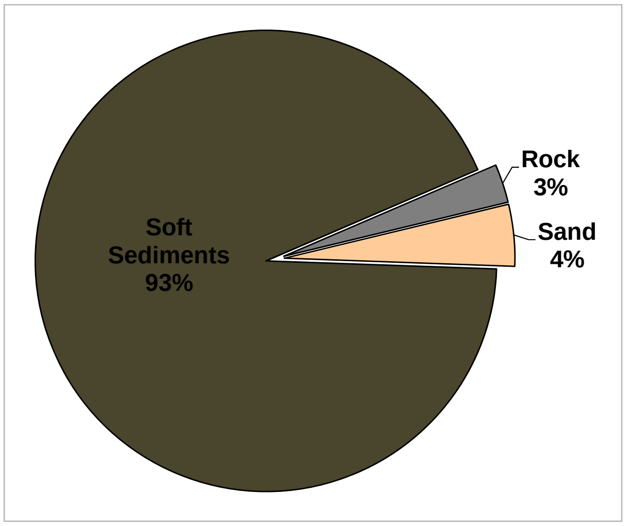


Figure 3.4-2. Little Bearskin Lake proportion of substrate types from 2014. Created using data from WDNR August 2014 point-intercept survey.

As discussed in the previous section, sediment data were collected at each sampling location during the 2009-2014 point-intercept surveys. The data gathered indicates that the majority of Little Bearskin Lake's bottom is comprised of fine, organic sediments, with some areas comprised of sand and rock (Figure 3.4-2). Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available. The vast majority of Little Bearskin Lake's littoral zone is comprised of fine, organic sediments which are very conducive for supporting lush aquatic plant growth.

The maximum depth of aquatic plant growth varied between the WDNR's 2009-2012 point-intercept surveys. Aquatic plants were found growing to maximum depths of 18.0 feet, 16.5 feet, 20.0 feet, and 15.0 feet in 2009, 2010, 2011, and 2012, respectively. The maximum depth of aquatic plant growth in Little Bearskin Lake corresponds with the lake's average growing season water clarity as measured by Secchi disk (Figure 3.4-3). In years when water clarity in Little Bearskin Lake is higher, aquatic plants are able to colonize deeper areas. From the data available, aquatic plants in Little Bearskin Lake grow to a maximum depth of approximately twice the depth of the average growing season Secchi disk depth. The point-intercept data also indicate that Little Bearskin Lake's littoral zone is highly vegetated, with approximately 90%, 88%, 81%, 90%, 86%, and 81% of point-intercept sampling locations containing aquatic vegetation in 2009, 2010, 2011, 2012, 2013, and 2014 respectively.

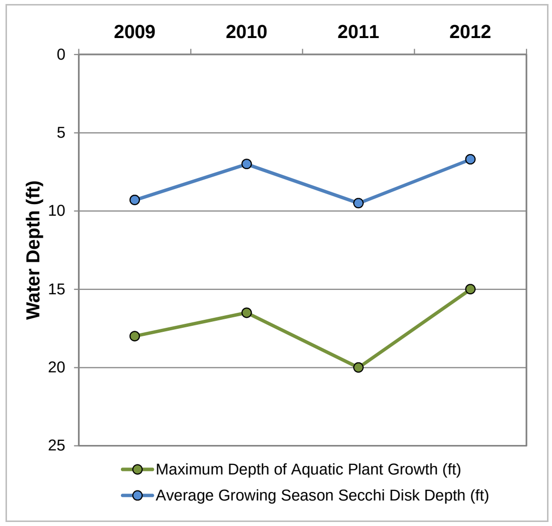


Figure 3.4-3. Little Bearskin Lake maximum depth of aquatic plant growth and average annual Secchi disk depth.

In 2014, 24 aquatic plant species were located on the rake during the point-intercept survey. Of those 24 species, fern pondweed, coontail, flat-stem pondweed, and common waterweed were the four-most frequently encountered (Figure 3.4-4). As its name indicates, the stems and leaves of fern pondweed resemble the frond of a fern. This is a common pondweed species of lakes in northern Wisconsin, and is usually found growing in large beds along the lake bottom. Able to grow deeper than many other aquatic plants, fern pondweed provides habitat and oxygen to deeper areas of the lake. In Little Bearskin Lake, fern pondweed was most abundant between 4 and 12 feet in 2014.

Coontail is a common native aquatic plant that can be found throughout North America and around the world. It produces long stems that contain whorls of stiff leaves, and as its name suggests, resemble the tail of a raccoon. The dense leaves and stems produced by coontail offer excellent structural habitat for a number of aquatic organisms. However, under certain conditions, it can often grow to nuisance levels where it can inhibit recreation. Coontail lacks true roots, and derives all of its nutrients directly from the water. Because of this, and its tolerance of low-light conditions, coontail thrives in more productive, eutrophic lakes like Little Bearskin Lake that contain higher nutrient levels within the water. While it may grow to nuisance levels, its ability to uptake nutrients directly from the water can prevent these nutrients from being utilized by free-floating algae and prevent algae blooms.

Table 3.4-1. Aquatic plant species located in Little Bearskin Lake during 2009-2014 WDNR point-intercept surveys and Onterra 2012 community mapping survey.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2009	2010	2011	2012	2013	2014
Emergent	*Calla palustris*	Water arum	9				I		
	Carex comosa	Bristly sedge	5				I		
	Decodon verticillatus	Water-willow	7		X	X			
	Eleocharis palustris	Creeping spikerush	6				X		
	Equisetum fluviatile	Water horsetail	7				I		
	Iris versicolor	Northern blue flag	5				I		
	Pontederia cordata	Pickerelweed	9	X	X	X	X	X	X
	Sagittaria latifolia	Common arrowhead	3				I		
	Sagittaria rigida	Stiff arrowhead	8				I		
	Sagittaria sp.	Arrowhead species	N/A		X				
FL	*Brasenia schreberi*	Watershield	7	X	X	X	X	X	X
	Nuphar variegata	Spatterdock	6	X	X	X	X	X	X
	Nymphaea odorata	White water lily	6	X	X	X	X	X	X
	Persicaria amphibia	Water smartweed	5				I		
FL/E	*Sparganium* sp.	Bur-reed species	N/A	X			I		
Submergent	*Bidens beckii*	Water marigold	8	X	X		X	X	X
	Ceratophyllum demersum	Coontail	3	X	X	X	X	X	X
	Chara spp.	Muskgrasses	7	X	X	X	X	X	X
	Elodea canadensis	Common waterweed	3	X	X	X	X	X	X
	Heteranthera dubia	Water stargrass	6	X	X	X	X	X	X
	Isoetes spp.	Quillwort species	8	X			X	X	
	Myriophyllum sibiricum	Northern water milfoil	7	X	X				
	Myriophyllum sibiricum X spicatum	Hybrid water milfoil	Exotic	X	X	X	X	X	
	Myriophyllum tenellum	Dwarf water milfoil	10	X					
	Najas flexilis	Slender naiad	6	X	X	X	X	X	X
	Najas guadalupensis	Southern naiad	7					X	
	Nitella spp.	Stoneworts	7	X	X	X			
	Potamogeton alpinus	Alpine pondweed	9	X			X		X
	Potamogeton amplifolius	Large-leaf pondweed	7	X	X	X	X	X	X
	Potamogeton amplifolius X praelongus	Large-leaf X White-stem pondweed	N/A						X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8						X
	Potamogeton friesii	Fries' pondweed	8	X			X	X	X
	Potamogeton gramineus	Variable pondweed	7		X	X	X	X	X
	Potamogeton praelongus	White-stem pondweed	8	X	X	X	X	X	X
	Potamogeton pusillus	Small pondweed	7	X	X	X	X	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X	X	X	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X	X	X	X	X
	Potamogeton strictifolius	Stiff pondweed	8	X	X			X	
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X	X	X		X
	Sagitaria sp. (rosette)	Arrowhead rosette	N/A		X				
	Utricularia geminiscapa	Twin-stemmed bladderwort	9					X	
	Utricularia gibba	Creeping bladderwort	9						X
	Utricularia vulgaris	Common bladderwort	7	X	X	X	X	X	X
	Vallisneria americana	Wild celery	6	X	X	X	X	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X	X	X	X		
FF	*Lemna minor*	Lesser duckweed	5		X	X			
	Lemna trisulca	Forked duckweed	6	X	X	X	X	X	
	Spirodela polyrhiza	Greater duckweed	5	X		X			X

FL = Floating-leaf; FL/E = Floating-leaf & Emergent; S/E = Submergent & Emergent; FF = Free-floating
X = Present on rake during point-intercept survey; I = Incidentally located during 2012 community mapping survey
N/A = Not Applicable

Flat-stem pondweed, the third-most frequently encountered plant in Little Bearskin Lake in 2014, is another common plant found growing in eutrophic lakes. Flat-stem pondweed contains a conspicuously flattened stem with long, slender leaves, and is one of the first native pondweed species to flower and bear fruit in early to mid-summer. Its fruit is an important food source for waterfowl, and the foliage is foraged upon mammals such as beavers and muskrats (Borman et al. 1997). Like other aquatic plants, flat-stem pondweed provides valuable structural habitat for aquatic organisms.

Common waterweed, the fourth-most abundant plant in Little Bearskin Lake, can be found in lakes throughout Wisconsin and North America. It is usually found growing in mucky substrates, and possesses long stems with whorls of three, slender leaves. Like coontail, common waterweed can tolerate and thrive in lakes with lower water clarity, and can often grow to nuisance levels forming large mats on the water's surface. However, when not growing to nuisance levels, common waterweed provides excellent structural habitat for aquatic organisms and is an important food source for animals such as muskrats.

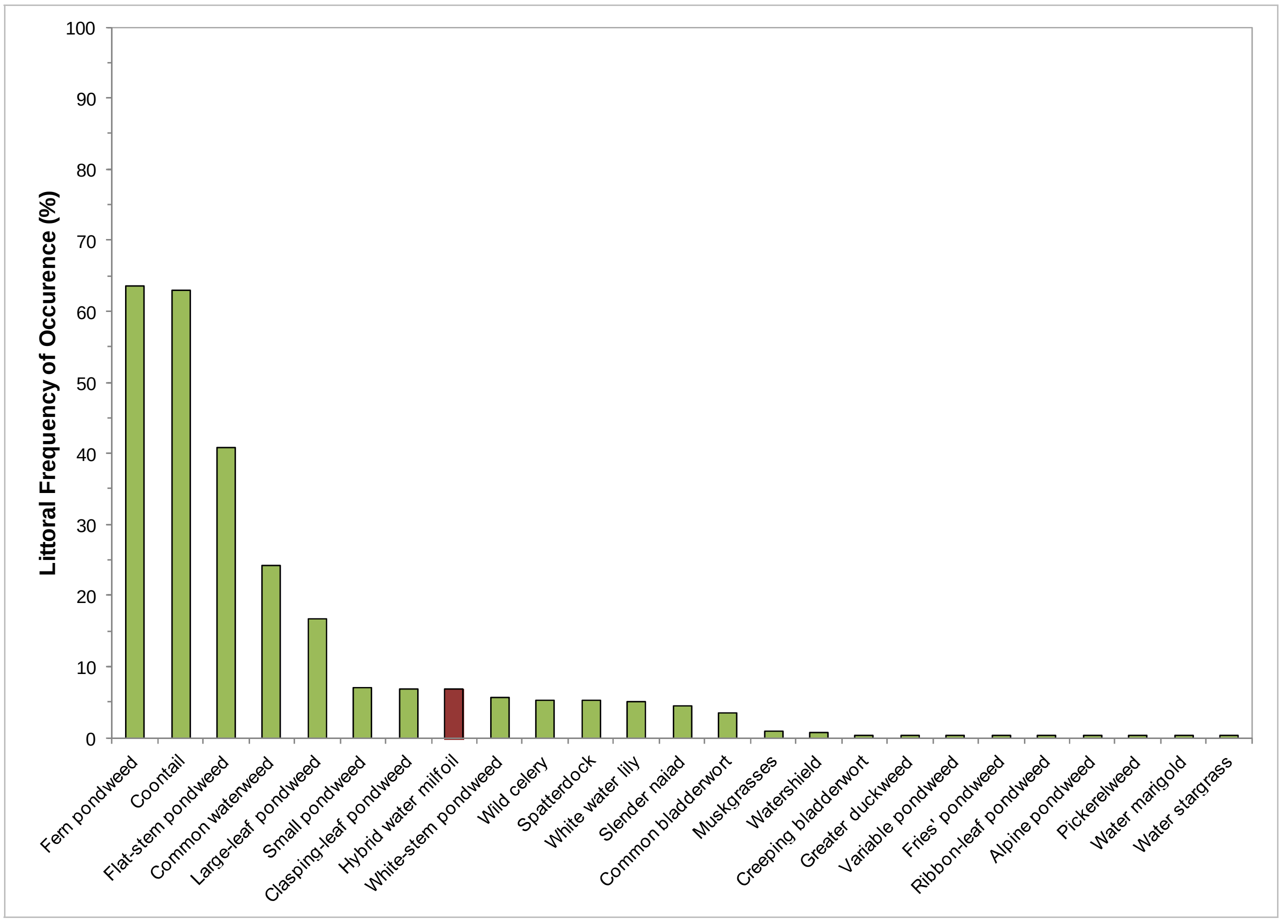


Figure 3.4-4. 2014 littoral frequency of occurrence of aquatic plant species in Little Bearskin Lake. Created using data from WDNR 2014 point-intercept survey (N = 400). Non-native species indicated with red.

No aquatic plant species listed as endangered, threatened, or special concern by the Wisconsin State Natural Heritage Inventory were located during the 2009-2014 surveys on Little Bearskin Lake. However, alpine pondweed, located in 2009, 2012, and 2014 is relatively uncommon (Photo 3.4-1). In Wisconsin, alpine pondweed has only been found growing in northern lakes, and its presence in Little Bearskin Lake is an indicator of a high quality environment.

Photo 3.4-1. Alpine pondweed (*Potamogeton alpinus*). an uncommon native species in Wisconsin, found growing in Little Bearskin Lake.

Because whole-lake point-intercept surveys have been conducted on Little Bearskin Lake annually since 2009, a statistical comparison of aquatic plant species' littoral occurrences from 2009-2014 can be made. A Chi-square distribution analysis (α = 0.05) was used to determine of any statistically valid changes in aquatic plant species' littoral frequency of occurrences have occurred from 2009-2014. Figure 3.4-6 displays the littoral frequency of occurrences of aquatic plant species from 2009-2014 that had an occurrence of at least 5% in one of the six surveys. These data indicate that the occurrence of some species remained relatively constant over this time period (i.e. fern pondweed), some saw reductions in their occurrence (i.e. common waterweed), and others saw increases in their occurrence (i.e. flat-stem pondweed).

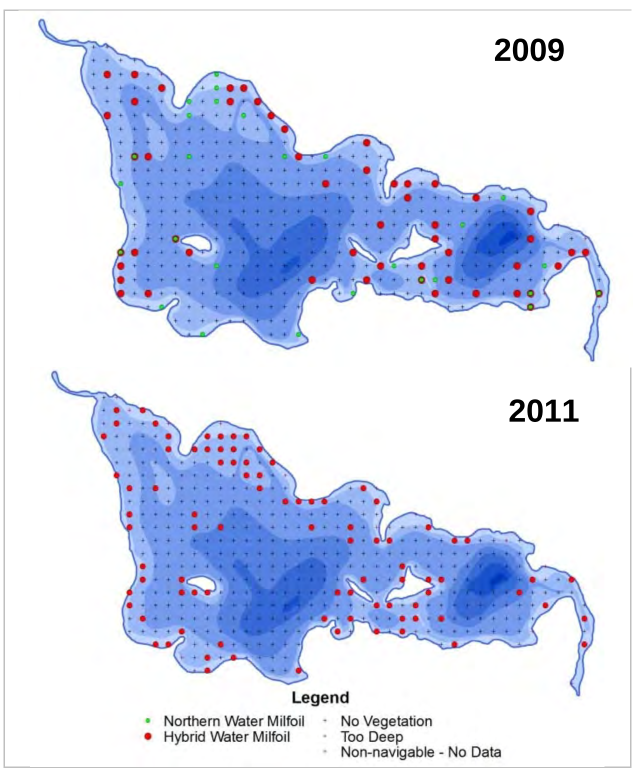


Figure 3.4-5. Point-intercept locations containing Northern and Hybrid water milfoil in 2009 and 2011. Created using WDNR 2009 and 2011 point-intercept data.

While some of the changes in occurrence of certain species were statistically different from 2009 to 2014, most these changes cannot be attributed to a single event and are likely due to natural variations in annual environmental conditions. The declines in occurrence in some species like common waterweed cannot be attributed to the hybrid water milfoil population, as the hybrid water milfoil population has also been declining in Little Bearskin Lake since 2012. These point-intercept data indicate that Little Bearskin Lake's plant community is dynamic, with species fluctuating in their occurrences from year to year.

However, the occurrence of the native northern water milfoil has declined from a littoral occurrence of approximately 7% in 2009 to 0% in each annual survey since 2011. While northern water milfoil is still present in Little Bearskin Lake and was observed during the 2014 surveys, its decline in occurrence may be due to competition and displacement by hybrid water milfoil. While there is no direct evidence that HWM is the primary cause of northern water milfoil's reduction, Figure 3.4-5 illustrates that many of the point-intercept locations that contained northern water milfoil in 2009 were found to contain hybrid water milfoil by 2011.

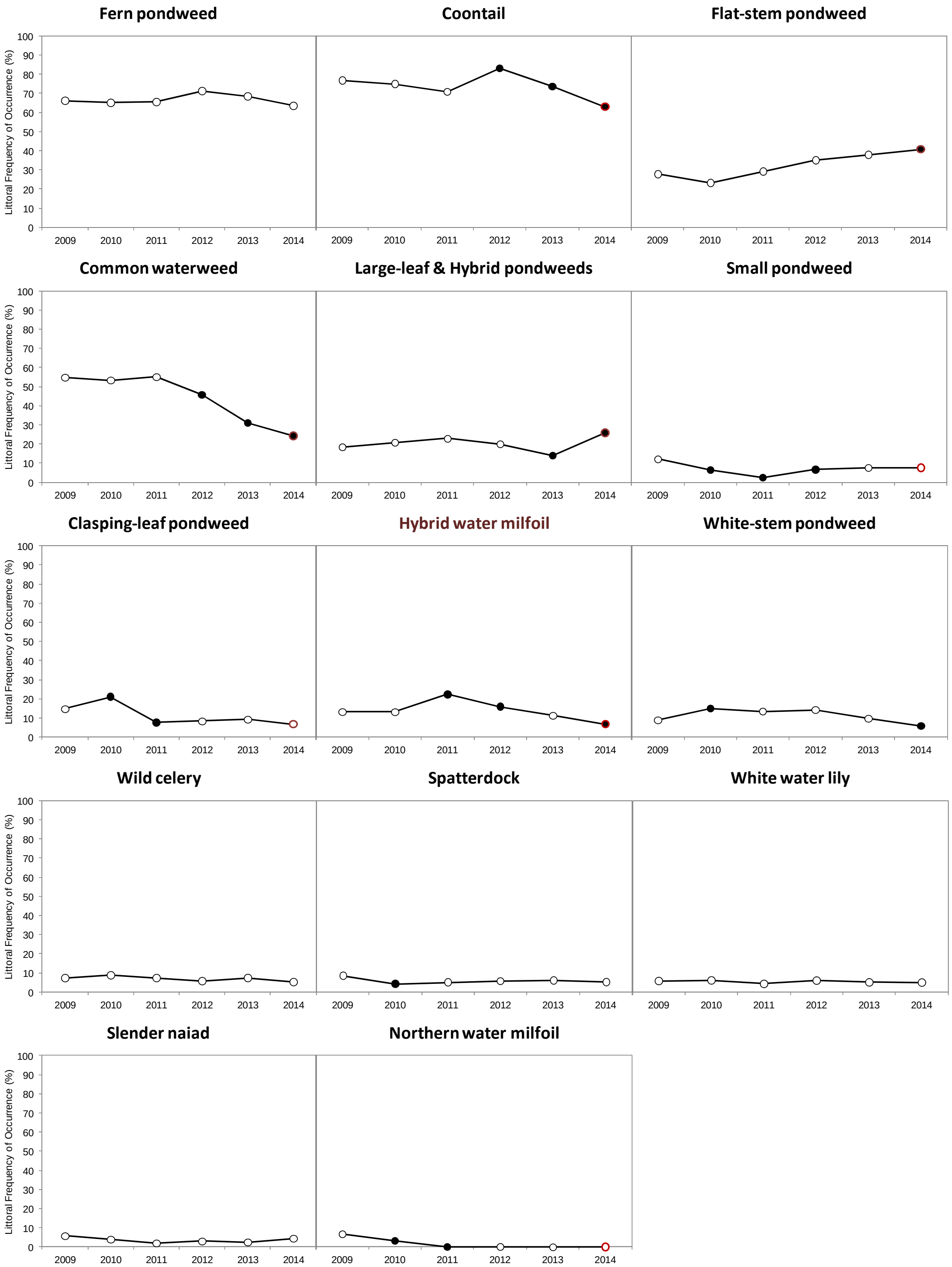


Figure 3.4-6. Littoral frequency of occurrence of select aquatic plant species in Little Bearskin Lake from 2009-2014. Closed circle represents statistically valid change in occurrence from previous survey. Circles outlined in red represent statistically valid change in occurrence from 2009 to 2014. Created using data from WDNR 2009, 2010, 2011, 2012, 2013, and 2014 point-intercept surveys.

As discussed in the primer section, 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 incidentally located species. The native aquatic plant species located on the rake during the WDNR's point-intercept surveys from 2009-2014 and their conservatism values were used to calculate the FQI for each respective year (equation shown below).

FQI = Average Coefficient of Conservatism * √Number of Native Species

Figure 3.4-7 compares the FQI components of Little Bearskin Lake from the 2009-2014 point-intercept surveys to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion as well as the entire State of Wisconsin. The number of native aquatic plant species, located on the rake during the point-intercept surveys, or native species richness, declined from 31 in 2009 to 24 in 2014. The species recorded in 2009 that were not recorded in 2014 were all initially very low in occurrence. These species are still believed to be present within Little Bearskin Lake, but at a level which they can easily evade detection during the point-intercept survey. The number of native aquatic plant species located in 2014 is still substantially higher than the median values for lakes in the NLFL Ecoregion and for lakes throughout Wisconsin.

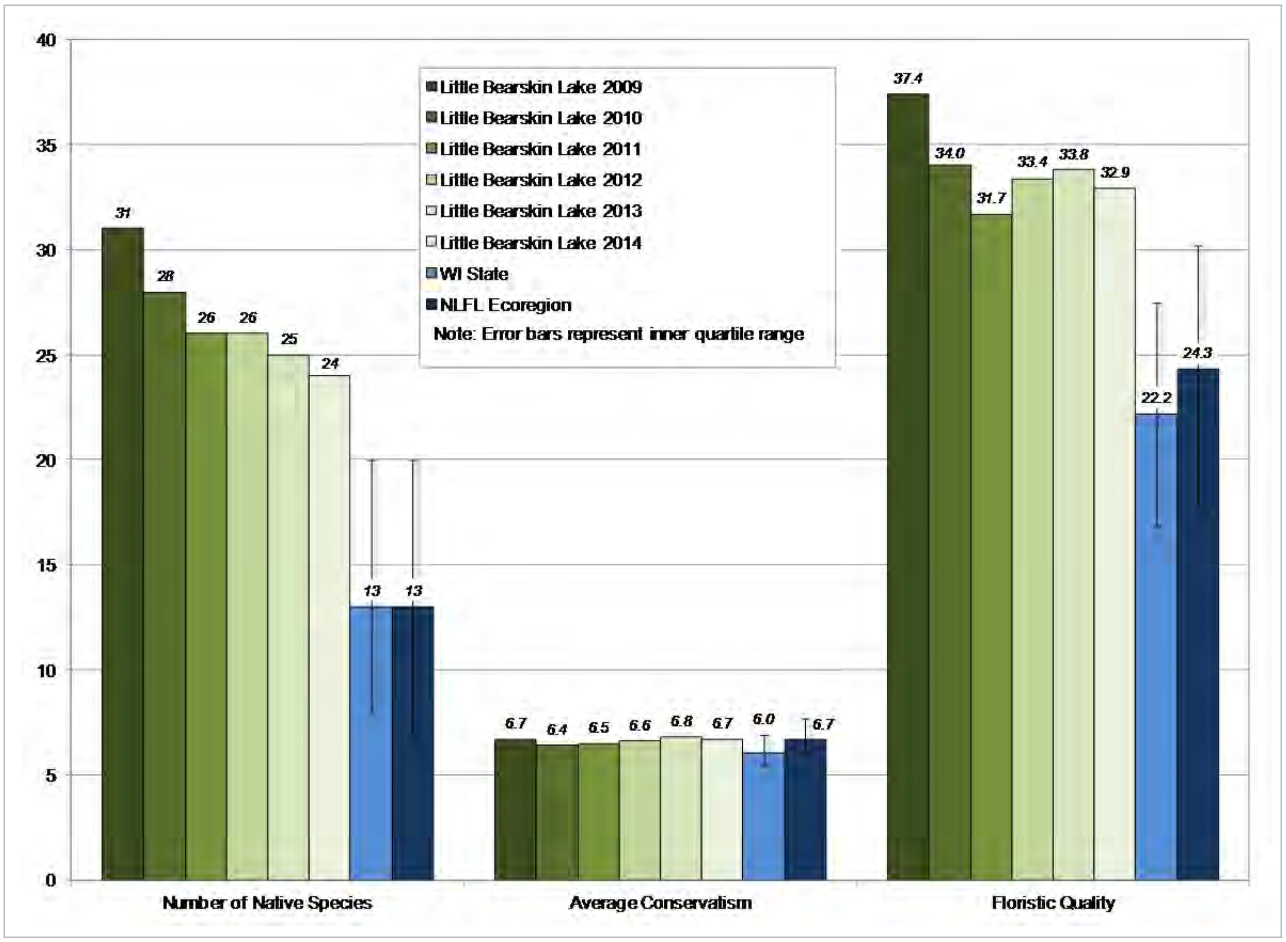


Figure 3.4-7. Little Bearskin Lake Floristic Quality Assessment. Created using data from WDNR 2009, 2010, 2011, 2012, 2013, and 2014 point-intercept surveys. Analysis following Nichols (1999) where NLFL = Northern Lakes and Forest Lakes Ecoregion.

Little Bearskin Lake's average conservatism value has ranged from 6.4 in 2010 to 6.8 in 2014, with an overall average of 6.6. This average is comparable to the median value for lakes within the NLFL Ecoregion and higher than the median value for lakes state-wide. Using Little Bearskin Lake's species richness and average conservatism values to calculate the Floristic Quality Index yields values which exceed the median values for both the NLFL Ecoregion and the state. Overall, this analysis indicates that despite a population of hybrid water milfoil that is widespread throughout the lake, Little Bearskin Lake's native aquatic plant community is of higher quality than most of the lakes within the NLFL Ecoregion and lakes throughout Wisconsin.

As explained earlier, lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. In addition, 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. Because Little Bearskin Lake contains a high number of native aquatic plant species, one may assume the aquatic plant community also has high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community.

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Little Bearskin Lake's diversity values rank. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLFL Ecoregion (Figure 3.4-8). Using the data collected from the WDNR's 2009-2014 point-intercept surveys, Simpson's Diversity Index values were able to be calculated for each year. Values ranged from 0.88 in 2009 to 0.84 in 2014. While there has been a declining trend in species diversity over this time period, there has only been a variation of 0.02 around the mean (0.86) for this time period. While not believed to be a trend caused by the hybrid water milfoil population, this parameter should continue to be monitored with future point-intercept surveys.

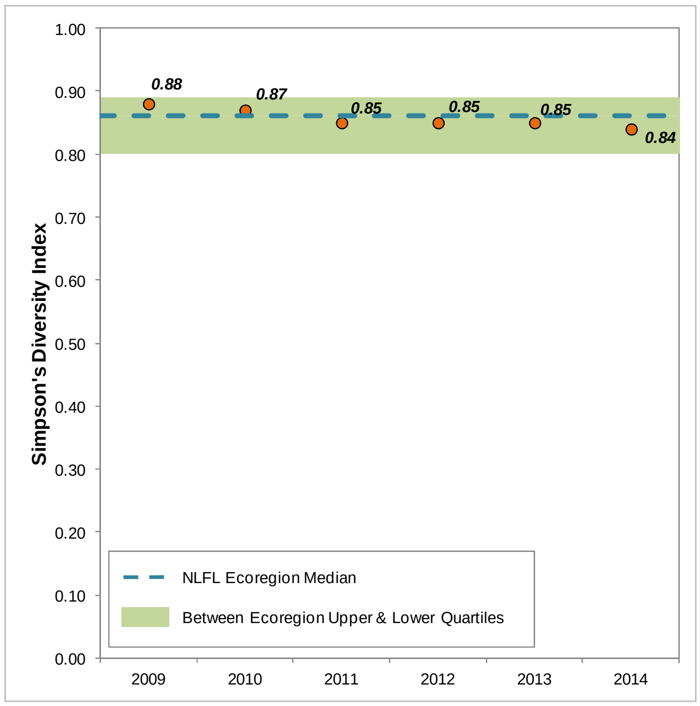


Figure 3.4-8. Little Bearskin Lake Simpson's Diversity Index. Created using data from WDNR 2009, 2010, 2011, 2012, 2013, and 2014 point-intercept surveys. Ecoregion data provided by WDNR Science Services.

Figure 3.4-9 displays the relative frequency of occurrence of aquatic plant species in Little Bearskin Lake from the 2014 point-intercept survey and illustrates relative abundance of species within the community to one another. While Little Bearskin Lake contains a high number of aquatic plant species, approximately three quarters of its aquatic plant community is comprised by fern pondweed, coontail, common waterweed, and large-leaf pondweed. Hybrid water milfoil accounted for approximately 3% of Little Bearskin Lake's aquatic plant community in 2014. In other words, if 100 aquatic plants were randomly sampled from the lake, it would be expected that three of them would be hybrid water milfoil.

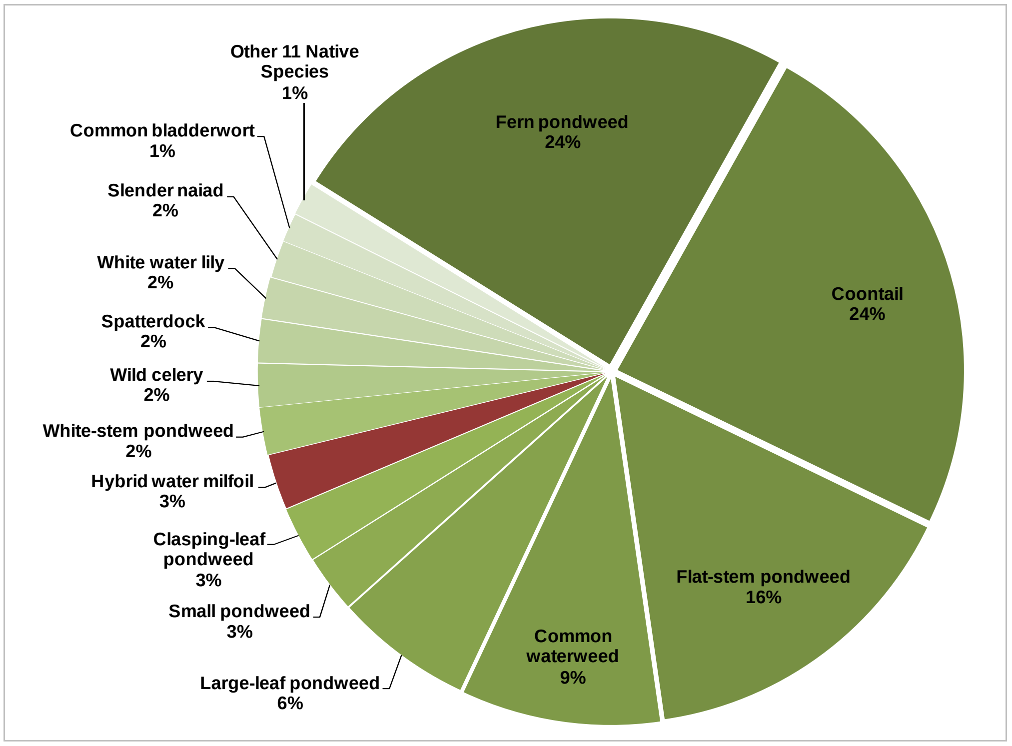


Figure 3.4-9. 2014 Relative frequency of occurrence of aquatic plant species in Little Bearskin Lake. Created using data from WDNR 2014 point-intercept survey. Non-native species indicated with red.

The 2012 aquatic plant community mapping survey revealed that approximately 27.7 acres (15%) of Little Bearskin Lake's 185 acres contains emergent and/or floating-leaf aquatic plant communities (Table 3.4-2, Map 5 and Map 6). Fifteen native emergent and floating-leaf aquatic plant species were recorded in Little Bearskin Lake during the 2009-2012 surveys (Table 3.4-1). These communities provide valuable structural habitat for invertebrates, fish, and other wildlife, and also stabilize bottom sediments and shoreline areas by dampening wave action from wind and watercraft.

Table 3.4-2. Little Bearskin Lake acres of emergent and floating-leaf aquatic plant communities. Created using data from 2012 community mapping survey.

Aquatic Plant Community	Acres
Emergent	2.3
Floating-leaf	23.7
Mixed Emergent & Floating-leaf	1.7
Total	**27.7**

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 Little Bearskin 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.

Non-native Plants in Little Bearskin Lake

Hybrid water milfoil (*Myriophyllum sibiricum x spicatum*)

Eurasian water milfoil was first documented in Little Bearskin Lake in 2008. Exhibiting some morphological characteristics of the native species northern water milfoil, the Eurasian water milfoil in Little Bearskin Lake was sent to the Annis Water Resources Institute at Grand Valley State University in Michigan for DNA analysis in 2009. Their results confirmed that the milfoil present in Little Bearskin Lake is a hybrid between Eurasian water milfoil (*Myriophyllum spicatum*) and the native northern water milfoil (*Myriophyllum sibiricum*). Within the remainder of this document, this species will be referred to as hybrid water milfoil. Genetic research is revealing that hybridization events between Eurasian and northern water milfoil have occurred numerous times, including backcrosses. These numerous sexual reproduction events have produced a number of different genotypes, or strains of hybrid water milfoil. In fact, different strains of hybrid water milfoil can be found within one lake (LaRue et al. 2013). Studies are also showing that some strains of hybrid water milfoil grow at a faster rate than pure Eurasian water milfoil and is potentially less sensitive to auxin (2,4-D and triclopyr) herbicide applications (LaRue et al. 2013). In one case study (Townline Lake, MI), hybrid water milfoil was also shown to be less sensitive to a fluridone application (Netherland, personal comm.).

During the WDNR's 2009 point-intercept survey, 13.4% of the sampling locations that fell within the littoral zone contained hybrid water milfoil (Figure 3.4-10). The littoral occurrence was similar in 2010, increased to approximately 22% in 2011, and has since decreased annually to an occurrence of 6.8% in 2014. It is not clear what has caused the decline in hybrid water milfoil in Little Bearskin Lake over this time period, but from other lakes studies by the WDNR, it is clear that Eurasian/hybrid water milfoil occurrence can vary annually. The spring of 2014 saw a later-than-normal ice-out, and the summer of 2014 was cooler than average. These conditions may have suppressed the growth of hybrid water milfoil and other aquatic plants in lakes throughout the state.

The hybrid water milfoil peak-biomass survey was conducted by Onterra ecologists on September 10, 2012, and provides a detailed representation of the hybrid water milfoil locations and densities on Little Bearskin Lake. Map 7 displays the results of this late-summer survey, and revealed that Little Bearskin Lake contains approximately 65 acres of colonized hybrid water milfoil. Onterra ecologists met with the Little Bearskin Lake Association Planning Committee in the summer of 2013 and discussed the results of this 2012 survey. Following a meeting in the summer of 2013 between the LBLA Planning Committee and Onterra ecologists discussing the 2012 study results, the LBLA decided to postpone any hybrid water milfoil management while the University of Wisconsin-Extension conducted their three-year study on the effectiveness of using milfoil weevils (discussed below).

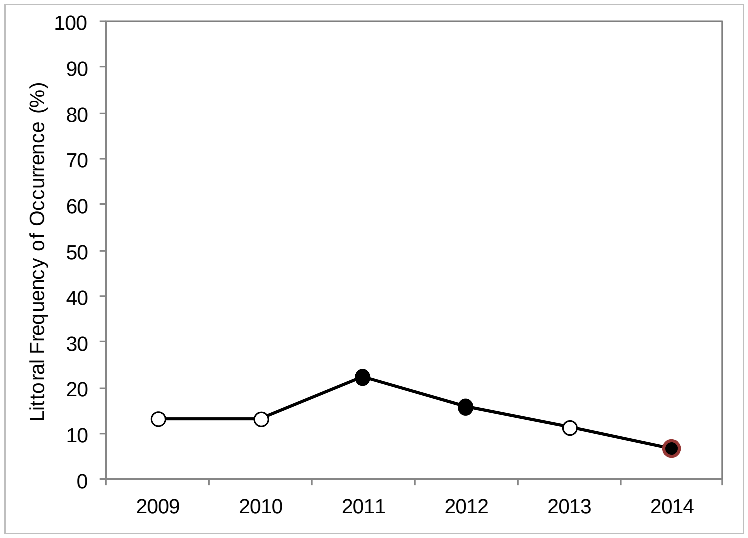


Figure 3.4-10. Little Bearskin Lake hybrid water milfoil littoral frequency of occurrence from 2009-2014. Closed circle indicates statistically valid change in occurrence from previous year. Circle with red outline indicates a statistically valid change in occurrence from 2009 to 2014. Created using data from WDNR 2009, 2010, 2011, 2012, 2013, and 2014 point-intercept survey.

Milfoil Weevil Study

The Little Bearskin Lake Association agreed to be one of a number of lakes to participate in a University of Wisconsin-Extension study to evaluate Eurasian/hybrid water milfoil control using biological agents, specifically the milfoil weevil (*Euhrychiopsis lecontei*). The milfoil weevil is native to Wisconsin, and naturally feeds and reproduces on the indigenous northern water milfoil, but has also been shown to utilize Eurasian water milfoil as a host. The goal of the UW-Extension study is to determine if the application of weevils annually for three years on colonized areas of Eurasian/hybrid water milfoil can significantly reduce its density and/or occurrence. On September 25, 2012, Onterra ecologist Brenton Butterfield and Dr. Susan Knight of the UW-Extension visited Little Bearskin Lake to locate four suitable beds of hybrid water milfoil to receive applications of weevils. Map 8 displays the areas that were selected.

In 2013, weevils were applied to milfoil beds in four lakes across northern Wisconsin. In Little Bearskin Lake, 4,500 weevils were stocked over two of the previously delineated hybrid water milfoil (Sites B & C), while the other two beds were used as control sites. Over the course of the summer, hybrid water milfoil and native aquatic plant biomass and stem density were measured within the four beds, along with weevil density and weevil damage to the hybrid water milfoil.

Following the sampling in 2013, their progress report indicates that there was high variability in milfoil and native plant biomass across beds within and between lakes, complicating their efforts to observe changes due to weevil application (Knight and Havel 2013). In addition, they also found that weevil density decreased over the course of the summer, contrary to their hypothesis that they would increase. Their study also indicated that background weevil levels were relatively high, meaning that the number of weevils applied to the milfoil beds was largely insignificant. In summary, they state that while this weevil experiment is the best approach to assess the efficacy of weevils in controlling Eurasian and hybrid water milfoil, the changes may be undetectable at the scale/and or conditions under which they are testing, and they "suggest a guarded outlook that adding weevils will have a noticeable effect on EWM in these systems" (Knight and Havel 2013). Due to these early results, weevils were not raised and reapplied to the milfoil beds within these lakes in 2014, including Little Bearskin Lake. However, they did conduct biomass/density studies and weevil density/damage studies on these beds in 2014.

In 2011 and 2012, UW-Stevens Point graduate student Paul Skawinski conducted a number of studies on Little Bearskin Lake and other area lakes as part of his master's thesis (Paul Skawinski pers. comm.). As part of his studies on Little Bearskin Lake, he looked at the density of weevils within hybrid water milfoil beds, the number of hybrid milfoil plants that exhibited weevil damage, and also documented the presence of the native fungal pathogen (*Mycoleptodiscus terrestris*) which infects Eurasian water milfoil. Paul's study found an average weevil density of 0.12 weevils per stem in 2011, and 19% of the hybrid water milfoil stems examined exhibited weevil damage. Surveys in 2012 revealed a weevil density of 0.13 weevils per stem, and 28% of hybrid milfoil stems sampled contained weevil damage. The weevil densities that were documented in Little Bearskin Lake were similar to the average density for all the lakes sampled in his study. The current consensus for a weevil density threshold that would result in milfoil control is 0.25 weevils per stem, so the density of weevils in Little Bearskin Lake are likely not high enough to provide effective control of the hybrid milfoil population (Paul Skawinski pers. comm.). In addition, Paul recorded a low density of the fungal pathogen and indicated it would likely not have a detectable impact on the hybrid milfoil population (Paul Skawinski pers. comm.).

Because the application of weevils was no longer going to take place on Little Bearskin Lake, the LBLA secured a WDNR Aquatic Invasive Species Education, Planning and Prevention (EPP) grant in February of 2014 to aid in funding a two-year (2014-2015) hybrid water milfoil assessment and management strategy development.

2014 Hybrid Water Milfoil Assessment & Management Strategy

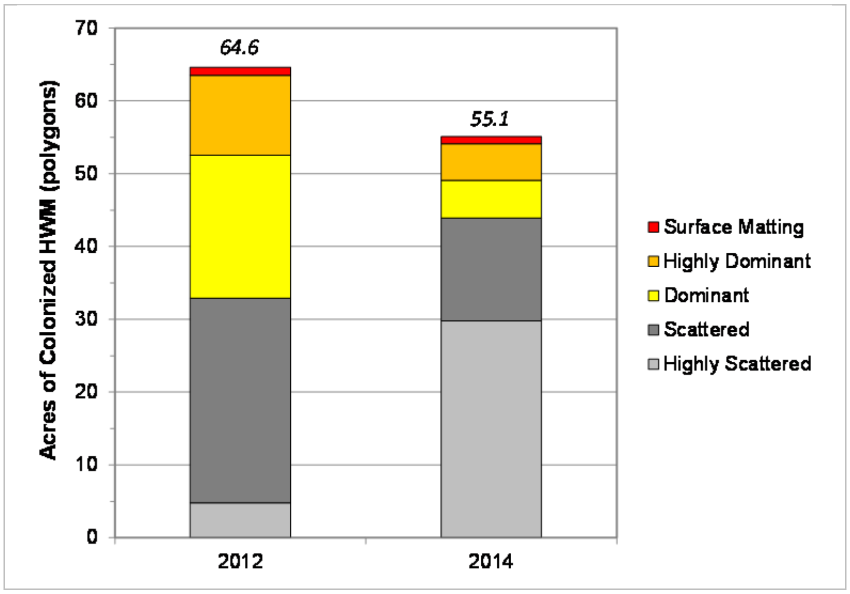


Figure 3.4-11. Colonial acreage of hybrid water milfoil in Little Bearskin Lake in 2012 and 2014. Created using data from Onterra 2012 and 2014 Late-Summer Peak-Biomass Survey.

On August 12, 2014, Onterra ecologists conducted a Late-Summer Peak-Biomass Survey to re-map areas of hybrid water milfoil in Little Bearskin Lake. During this survey, ecologists noted that many of the areas mapped in 2012 had reduced in size and/or density. This survey revealed that the acreage of hybrid water milfoil colonies with a density rating of *dominant* or greater decreased from approximately 32 acres in 2012 to approximately 11 acres in 2014 (Figure 3.4-11, Map 9). The WDNR's point-intercept data also indicated hybrid water milfoil declined in occurrence by approximately 57% from 2012-2014 (Figure 3.4-10).

On August 21, 2014, Onterra ecologist Tim Hoyman met with the LBLA Planning Committee to discuss the 2014 hybrid water milfoil survey results and develop a management strategy. Because both Onterra's mapping data and the WDNR's point-intercept data showed that the hybrid water milfoil had declined in 2014, and the fact that the WDNR's point-intercept survey does not indicate that the hybrid water milfoil is having catastrophic negative impacts to the lake's native aquatic plant community, the LBLA decided that continued monitoring of the hybrid water milfoil population is currently the best strategy moving forward and that no control methods (e.g. herbicide treatment) will occur in 2015. The current WDNR-EPP Grant covers the cost of conducting another Late-Summer Peak-Biomass survey in 2015. In addition, the WDNR will be conducting another whole-lake point-intercept survey in 2015.

Milfoil Challenge Testing

The concept of heterosis, or hybrid vigor, is important in regards to hybrid water milfoil management on Little Bearskin Lake. The root of this concept is that hybrid individuals typically have improved function compared to their pure-strain parents. Hybrid water milfoil typically has thicker stems, is a prolific flowerer, and grows more rapidly than pure-strain Eurasian water milfoil (LaRue et al. 2012). These conditions likely contribute to this plant being particularly less suitable to biological (Enviroscience personal comm.) and chemical control strategies (Glomski and Netherland 2010, Poovey et al. 2007). Data gathered from whole-lake 2,4-D treatments in Wisconsin from 2009-2013 suggest that treatments on lakes with populations of hybrid water milfoil were not as successful when compared to lakes with pure strains of Eurasian water milfoil. In other words, it appears that some strains of hybrid water milfoil, but not all, are more tolerant of 2,4-D treatments than pure-strain Eurasian water milfoil. Hybrid water milfoil can be controlled by 2,4-D, but the concentrations required to do so would also impact native aquatic plants beyond "acceptable" levels. To determine if the hybrid water milfoil in Little Bearskin Lake consists of herbicide-tolerant strains, laboratory studies termed "challenge testing" can be conducted. SePRO, one of the companies that produces aquatic and terrestrial herbicides, has the ability to conduct baseline challenge testing (PlanTEST) of the milfoil on the herbicide products they manufacture (2,4-D – Sculpin®, triclopyr – Renovate®, and fluridone – Sonar®).

During the 2014 Late-Summer Peak-Biomass Survey, Onterra ecologists collected approximately 600 live strands of hybrid water milfoil from Little Bearskin Lake from five different locations (Figure 3.4-12) and sent them to the SePRO Research & Technology Campus for herbicide challenge testing. Plants from each of the five locations were also sent to the Annis Water Resources Institute at Grand Valley State University in Michigan for DNA analysis.

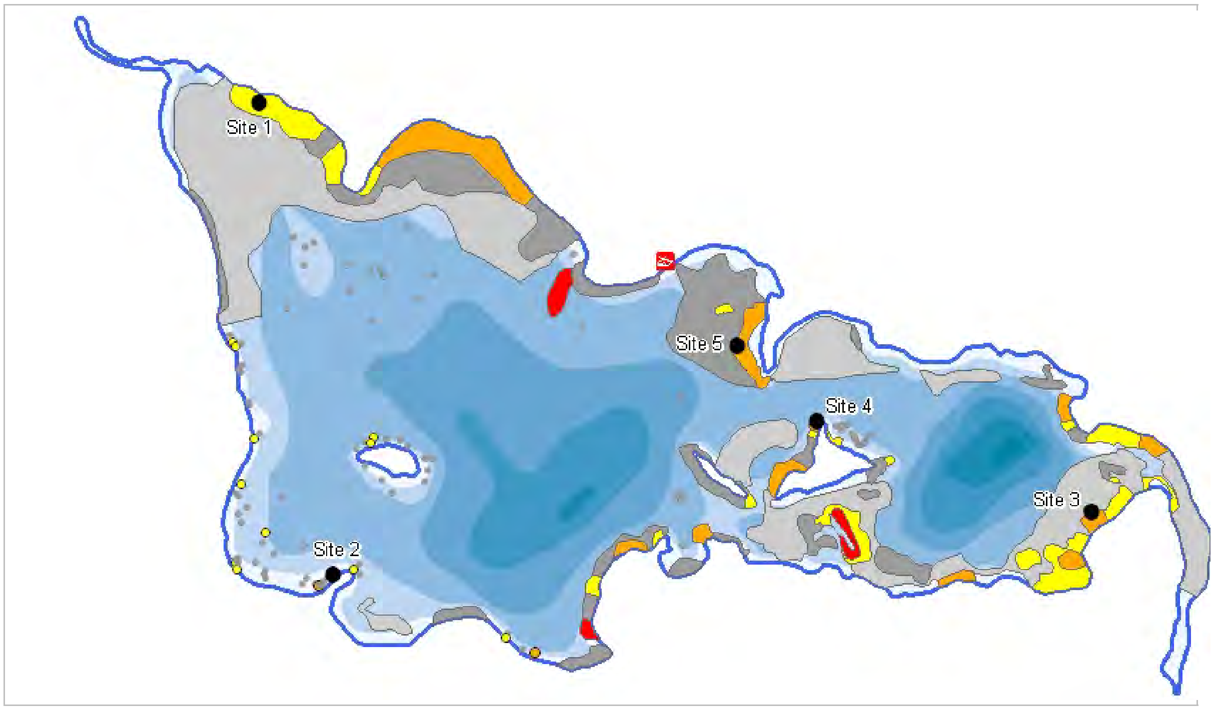


Figure 3.4-12. Locations of plant material collected for challenge testing. 2014 Eurasian water milfoil density ratings shown with symbology used on Map 9.

The hybridity analysis conducted at Grand Valley State University confirmed that all five plants sent in were comprised of hybrid individuals. However, this screening does not indicate if the hybrid individuals are different strains or clones of an individual clone. As discussed earlier there can be lot of genetic variability within hybrid milfoils (LaRue et al. 2013) because a different about of each parent species' genetic material is contributed to the offspring. Ongoing research is attempting to quantify the amount of genetic variation of hybrid milfoils with a particular lake. For instance, if a fragment of a single hybrid milfoil plant came into the lake and spread through only through asexual fragmentation, the entire population of the lake would consist of one hybrid milfoil strain. But if numerous sexual reproduction events occurred in a lake, it could produce a number of different strains of hybrid water milfoil within the lake.

At the SePRO Research & Technology Campus, milfoil plants were planted in aquaria and transitioned into an active growth stage. The plants were then subjected to either a short exposure of 2,4-D (1.5 ppm ae), triclopyr (1.0 ppm ae), or a static exposure of fluridone (6 ppb). The data from the five sites, along with a classically susceptible pure Eurasian water milfoil strain, were evaluated two weeks later and given a biochemical injury percentage in relation to untreated control populations of each site. An expanded summary of the methods can be found in Appendix G.

Photo 3.4-2. Challenge Testing Aquaria

The data suggest that multiple strains of hybrid water milfoil exist in Little Bearskin Lake with slightly different responses to the herbicide challenge testing. The hybrid water milfoil tested from sites 1-3 responded to 2,4-D and triclopyr similarly to the reference Eurasian water milfoil strain, while sites 4-5 experienced a lower percent of biochemical injury to 2,4-D and triclopyr suggesting reduced impacts (tolerance) to these herbicides. As indicated within SePRO's report, the large amount of variation (i.e. size of error bars) indicates that some plants within that site were greatly impacted and others minimally impacted. This may be a result of multiple strains of hybrid water milfoil within that single site. Hybrid water milfoil response to fluridone was similar to that of the reference Eurasian water milfoil strain, suggesting classical susceptibility to this herbicide. Some level of reduced biochemical injury was observed within site 4, but SePRO suggests this is likely not a result of reduced susceptibility.

The challenge testing completed as a part of this project provided important information about the susceptibility of the hybrid water milfoil within the lake. The data indicate that the level of control from a treatment with either of the auxin herbicides (2,4-D or triclopyr) would be lower than anticipated if targeting a pure Eurasian water milfoil strain. SePRO's report postulates that while reduced susceptibility of triclopyr was observed, the differences weren't as large as for 2,4-D and the use of triclopyr at slightly elevated whole-lake concentrations may produce desired efficacy with minimized not target impacts.

This report also indicates that a classically conducted fluridone treatment would be effective at controlling the hybrid water milfoil within Little Bearskin Lake. Fluridone is often critiqued because of reduced selectivity towards specific native aquatic plants (WDNR 2012). An emerging use pattern of this herbicide is described within SePRO's report which is suggested to have reduced impacts to native plants when conducted in this manner.

While understood in terrestrial herbicide applications for years, resistance evolution is an emerging topic amongst herbicide applicators, lake management planners, and researchers. Herbicide resistance is when a plant population develops reduced susceptibility to an herbicide over time. This occurs in a population when some of the targeted plants have an innate tolerance to the herbicide and some do not. Following an herbicide treatment, the more tolerant strains will rebound whereas the others will be controlled. Thus the plants that re-populate the lake will be those that are more tolerant to that herbicide resulting in a more resistant population.

While asexually reproducing populations like pure-strain Eurasian water milfoil may have capacity to evolve resistance through mutation (e.g. hydrilla resistance in Florida occurred through somatic mutation), herbicide resistance is more likely to occur in sexually reproducing population. As shown with the challenge testing, an array of herbicide tolerant hybrid water milfoil strains occurs within Little Bearskin Lake. If large-scale herbicide treatments are considered in the future, it may be appropriate to consider rotating herbicides of different modes of action in subsequent treatments. For instance, if a whole-lake treatment using triclopyr is conducted and knocks the hybrid water milfoil population back for 5 years; adopting a fluridone treatment strategy in year 6 may be appropriate.

3.5 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the numerous fisheries biologists overseeing Little Bearskin 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 LBLA 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 2013 & GLIFWC 2013A and 2013B).

Little Bearskin Lake Fishery

Little Bearskin Lake Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second highest ranked important or enjoyable activity on Little Bearskin Lake (Question #13). Approximately 54% of these same respondents believed that the quality of fishing on the lake was *fair* (Question #10); and approximately 51% believe that the quality of fishing has remained the same or gotten worse since they have obtained their property (Question #11).

Table 3.5-1 shows the popular game fish that are present in the system. When examining the fishery of a lake, it is important to remember what "drives" that fishery, or what is responsible for determining its mass and composition. The gamefish in Little Bearskin 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 piscivores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

A concept called energy flow describes how the biomass of piscivores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscivorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 3.5-1.

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

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Bullhead	*Ictalurus melas*	5	April - June	Matted vegetation, woody debris, overhanging banks	Amphipods, insect larvae and adults, fish, detritus, algae
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (terrestrial and aquatic)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep	Crustaceans, insect larvae, and other invertebrates
Smallmouth Bass	*Micropterus dolomieu*	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye	*Sander vitreus*	18	Mid April - early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish
Yellow Bullhead	*Ameiurus natalis*	7	May - July	Heavy weeded banks, beneath logs or tree roots	Crustaceans, insect larvae, small fish, some algae
Yellow Perch	*Perca flavescens*	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

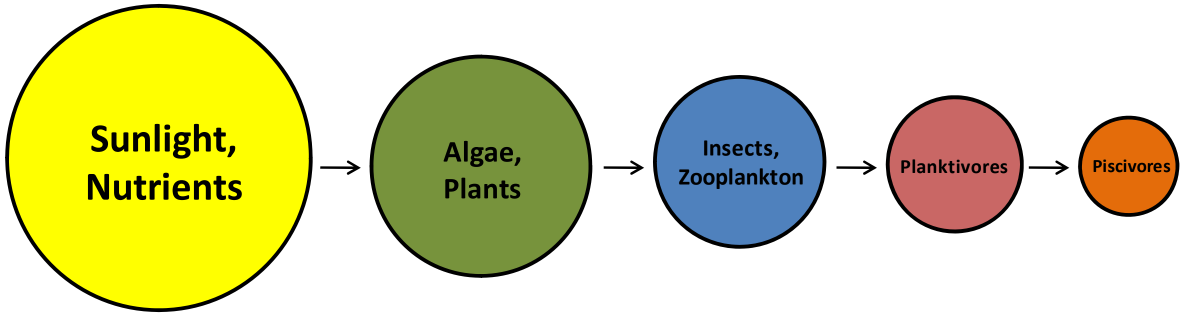


Figure 3.5-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

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

Little Bearskin Lake Spear Harvest Records

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.5-1). Little Bearskin Lake falls within the ceded territory based on the Treaty of 1837. This allows for a regulated open water spear fishery by Native Americans on specified systems. Determining how many fish are able to be taken from a lake, either by spear harvest or angler harvest, is a highly regimented and dictated process. This highly structured procedure begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then a "total 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% (walleye) or 27% (muskellunge) of the lake's known or modeled population, but may vary on an individual lake basis due to other circumstances. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The total allowable catch number may be 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". Often, the biologists overseeing a lake cannot make adjustments due to the regimented nature of this process, so the total allowable catch often equals 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

Figure 3.5-2. Location of Little Bearskin Lake within the Native American Ceded Territory (GLIFWC 2013A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

then multiplied by the Indian communities claim percent. This result is called the declaration, 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 declaration and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season; however, in practice walleye and muskellunge are the only species harvested in significant numbers, so conservative quotas are set for other species. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2010B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly declaration 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 declaration is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller declarations. Starting with the 2011 spear harvest season, on lakes with a harvestable declaration of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

Although Little Bearskin Lake has been declared as a spear harvest lake, GLIFWC and WDNR records indicate that it has historically not seen a walleye or muskellunge harvest. It is possible that spearing efforts have been concentrated on other larger lakes in the region, which would potentially have a higher estimated safe harvest for both walleye and muskellunge.

Little Bearskin Lake Fish Stocking and Management

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

Walleye and muskellunge (to a lesser extent) were stocked historically in Little Bearskin Lake (Table 3.5-2). According to WDNR fisheries biologist John Kubisiak, the lake is better suited towards largemouth bass and northern pike due to its relatively shallow, well-vegetated state. 2008 sampling by WDNR fisheries staff indicated that at the time, bluegills were present in over abundance. The presence of heavy vegetation in the lake provides bluegill with many hiding places from predators; as a result, the bluegill in the lake are rather stunted for their respective age. These gamefish appear to be doing well within the lake, but are unable to impact the over abundant bluegills.

Table 3.5-2. Walleye stocking data available from the WDNR from 1972 to 2006 (WDNR 2013).

Year	Species	Age Class	# Stocked	Avg. Length (inches)
1972	Walleye	Fingerling	9,000	3
1974	Walleye	Fingerling	8,000	-
1976	Walleye	Fingerling	8,000	3
1989	Walleye	Fingerling	12,143	2.5
1990	Walleye	Fingerling	8,320	2
1991	Walleye	Fingerling	4,000	2-8
1992	Walleye	Fingerling	2343	3
1994	Walleye	Fingerling	4,085	2.6
1998	Walleye	Small Fingerling	16,592	1.5
2000	Walleye	Small Fingerling	16,434	1.9
2002	Walleye	Small Fingerling	16,400	1.7
1973	Muskellunge	Fingerling	409	11
1977	Muskellunge	Fingerling	300	8
1979	Muskellunge	Fingerling	200	10

Little Bearskin Lake Substrate and Near Shore Habitat

Just as forest wildlife require proper trees and understory growth to flourish, fish prefer certain substrates and habitat types to nest, spawn, escape predators, and search for prey. Indeed, lakes with primarily a silty/soft substrate and much aquatic plants and coarse woody debris may produce a completely different fishery than lakes that are largely sandy and contain few aquatic plant species or coarse woody habitat.

According to the point-intercept survey conducted by the WDNR in 2009, 92% of the substrate sampled in the littoral zone on Little Bearskin Lake was muck, while 4% was classified as sand and 3% was classified as rock. Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Muskellunge is one species that does not provide parental care to its eggs (Becker 1983). Muskellunge broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Walleye is another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone.

Little Bearskin Lake Regulations and Management

Because Little Bearskin 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 Little Bearskin Lake. In 2013, the daily bag limit was set at one walleye per day in Little Bearskin Lake.

Because Little Bearskin Lake is located within the northern region of Wisconsin, special regulations may occur that differ from those in other areas of the state. For example, Little Bearskin Lake is in the northern large and smallmouth bass management zone, as well as the northern pike and muskellunge northern management zone. Table 3.5-3 displays the 2013-2014 regulations for species that may be found in Little Bearskin Lake. Please note that this table is intended to be for reference purposes only, and that anglers should visit the WDNR website (www. http://dnr.wi.gov/topic/fishing/regulations/hookline.html) for specific fishing regulations or visit their local bait and tackle shop to receive a free fishing pamphlet that would contain this information.

Table 3.5-3. WDNR fishing regulations for Little Bearskin Lake, 2013-2014.

Species	Season	Regulation
Panfish	Open All Year	No minimum length limit and the daily bag limit is 25.
Largemouth and smallmouth bass	May 4, 2013 to June 14, 2013	Fish may not be harvested (catch and release only)
Largemouth and smallmouth bass	June 15, 2013 to March 4, 2014	The minimum length limit is 14" and the daily bag limit is 5.
Muskellunge and hybrids	May 25, 2013 to November 30, 2013	The minimum length limit is 40" and the daily bag limit is 1.
Northern pike	May 4, 2013 to March 2, 2014	No minimum length limit and the daily bag limit is 5.
Walleye, sauger, and hybrids	May 4, 2013 to March 2, 2014	The minimum length limit is 15" and the daily bag limit is 5.
Bullheads	Open All Year	No minimum length limit and the daily bag limit is unlimited.
Rock, yellow, and white bass	Open All Year	No minimum length limit and the daily bag limit is unlimited.

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 Little Bearskin Lake ecosystem.
2) Collect detailed information regarding invasive plant species within the lake, with the primary emphasis being on hybrid water milfoil.
3) Collect sociological information from Little Bearskin 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 Little Bearskin Lake ecosystem, the people who care about the lake, and what needs to be completed to protect and enhance it.

Through the studies conducted on Little Bearskin Lake, it is clear that for a lowland drainage lake, the overall ecosystem is in a healthy condition. As discussed within the Water Quality Section, the water quality of Little Bearskin Lake is what is to be expected given a lake of its type and its watershed; overall, water quality parameters fell within the *Good* and *Excellent* categories for deep, lowland drainage lakes in Wisconsin. Given the levels of phosphorus within the lake, periodic algae blooms in mid- to late summer are to be expected, especially in years when water temperatures are higher. While a pulse of phosphorus was detected during the summer of 2012, it is not exactly clear where the source of this phosphorus originated. The models created and discussed within the Water Quality Section indicate that the most likely source of this phosphorus is delivery from bottom sediments within the eastern basin (internal loading), delivery from Big Bearskin Lake via Bearskin Creek (external loading), or a combination of both. A more rigorous study would need to be conducted to determine the source(s) of this unaccounted phosphorus. However, at this time, the data indicate that the water quality of Little Bearskin Lake is not degrading over time, and paleolimnological studies indicate the lake had been productive for at least the past 100 years (Garrison and Winkelman 1996).

Of course, some fluctuations exist within the water quality dataset, however this are most likely attributable to fluctuations in annual environmental conditions. Understanding these fluctuations and any potential trends in the water quality of Little Bearskin Lake can only be achieved through continued monitoring of the lake's water. Thus, the Implementation Plan that follows outlines a strategy to continue water quality monitoring in Little Bearskin Lake.

A lake's water quality is largely a reflection of its drainage basin, or watershed. Drainage lakes like Little Bearskin Lake generally have a large surface watershed when compared to the size of the lake. Little Bearskin Lake's surface watershed encompasses approximately 8,389 acres and results in a large watershed to lake area ratio of 44:1. While most of the watershed is comprised of intact forests and wetlands, which export the least amount of phosphorus, the cumulative amounts of phosphorus from a large watershed relative to the size of the lake delivers sufficient amounts of nutrients to create a productive, eutrophic system. The majority of Little Bearskin Lake's immediate shoreland zone is completely natural or undeveloped. In regards to protecting Little Bearskin Lake, conserving the existing natural shoreline and restoring areas of disturbed shoreline may be one of the best options at this time.

From the WDNR's point-intercept surveys and Onterra's community mapping survey, Little Bearskin Lake's native aquatic plant community was found to be of very high quality. The overall plant community contains a very high number of native aquatic plant species, many of which are indicative of a high-quality, undisturbed system. The benefits of Little Bearskin Lake stakeholders may see from protecting this plant community include the presence of diverse fish habitat, maintaining the lake's water quality, and providing competition against non-native, invasive plants like hybrid water milfoil.

The WDNR's ongoing annual point-intercept surveys reveal that Little Bearskin Lake's aquatic plant community is dynamic, with the occurrences of native aquatic plant species and hybrid water milfoil fluctuating between years. From 2009 to 2014, some species increased in their occurrence, some declines, and others remained the same. At this time, it does not appear that the hybrid water milfoil population is displacing native aquatic plants within the lake, and since 2012, the hybrid water milfoil population has declined. While hybrid water milfoil remains one of the top concerns for Little Bearskin Lake, the LBLA has decided not to take any control actions in 2015 in terms of herbicide application, and they have decided to continue annual monitoring of the hybrid water milfoil population.

As discussed previously, following the results of the UW-Extensions first year of weevil study in 2013 on Little Bearskin Lake, they have decided to not reapply weevils to the beds of hybrid water milfoil in 2014. While the LBLA had originally agreed to postpone any management actions of hybrid water milfoil within the lake through 2015 as to not confound the weevil study, with the new revelations of the weevil study the hybrid water milfoil population be reassessed in 2014, and it was decided that continued monitoring of the population is currently the best strategy moving forward. The Implementation Plan that follows provides a detailed strategy for moving forward with hybrid water milfoil management in Little Bearskin Lake.

Through the process of this lake management planning effort, the LBLA has learned much about their lake, both in terms of its positive and negative attributes. Overall, the lake is healthy, but there are certain aspects which require attention. It is now the LBLA's responsibility to maximize the positive attributes while minimizing the negative attributes as much as possible. The Implementation Plan that follows this section stems from discussions between Onterra ecologists and the LBLA Planning Committee on which action items the association may implement to properly maintain and care for this resource.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the Little Bearskin Lake Association (LBLA) Planning Committee and ecologist/planners from Onterra. It represents the path the LBLA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Little Bearskin Lake stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

Management Goal 1: Maintain or Enhance Current Water Quality Conditions

Management Action:	Monitor water quality through WDNR Citizen Lake Monitoring Network.
Timeframe:	Continuation of current effort.
Facilitator:	Planning Committee
Description:	Monitoring water quality is an important aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason of why the trend is occurring. The Citizen Lake Monitoring Network (CLMN) is a WDNR/UW-Extension program in which volunteers are trained to collect data on Wisconsin's lakes and rivers. One aspect of the CLMN is the collection of water quality data. Water quality data has been actively collected on Little Bearskin Lake by volunteers enrolled within the CLMN's advanced program. This program involves volunteers taking Secchi disk readings and water chemistry samples three times during the summer and once during the spring at the lake's deep hole. It is the responsibility of the current CLMN volunteer in conjunction with the LBLA Planning Committee to coordinate new volunteers as needed. According to the stakeholder survey, 25% of respondents indicated they would be willing to participate in water quality monitoring (Appendix B, Question #28). When a change in the collection volunteer occurs, Sandy Wickman (715.365.8951) or the appropriate WDNR/UW Extension staff should be contacted to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:	
1.	Trained CLMN volunteer(s) collects data and report results to WDNR and to association members during annual meeting.
2.	CLMN volunteer and/or LBLA Planning Committee would facilitate new volunteer(s) as needed.
3.	Coordinator contacts Sandy Wickman (715.365.8951) to acquire necessary materials and training for new volunteer(s).

Management Action:	Sample total phosphorus, chlorophyll-*a*, and water clarity at a secondary water sampling location in Little Bearskin Lake.
Timeframe:	Begin 2014
Facilitator:	Planning Committee
Description:	As discussed in the Water Quality Section, it is believed that data collected from the current water quality sampling location located over Little Bearskin Lake's deepest point may not accurately represent the lake's water quality on a lake-wide level because of its proximity to the Bearskin Creek inlet and outlet (Map 1). It is proposed that a second water quality monitoring station be located in the south-central portion of the lake, the second deepest location (Latitude: 45.710077, Longitude: -89.699181). Water quality monitoring at this station would follow the same CLMN protocols that are used at the deep hole station currently, where water quality samples would be collected three times per year at regular intervals by a volunteer. Data collected from this location will have to be collected on the same day as data collected at the deep hole site. The summer of 2014 will act as a trial year to determine if the data collected between the two sites are significantly different. The LBLA will cover the cost of the samples collected in 2014. If the data are significantly different, the LBLA should contact Sandy Wickman to determine if funds are available to continue sampling at this second location.
Action Steps:	
1.	Planning Committee contacts Sandy Wickman (715.365.8951) to create secondary water quality sampling location for 2014.
2.	Current CLMN volunteer and/or LBLA Planning Committee would facilitate new volunteer(s) if needed for sampling second location.
3.	If a new volunteer is recruited, the Planning Committee will contact Sand Wickman to ensure the proper training occurs and the necessary sampling materials area received by the new volunteer.
4.	If the data are significantly different between the secondary and main water quality sampling locations, the LBLA will contact Sandy Wickman to determine if funds are available to continue monitoring at the secondary location.

Management Goal 2: Initiate appropriate control of Hybrid Water Milfoil and Prevent Aquatic Invasive Species Introduction to and Spread from Little Bearskin Lake.

Management Action:	Reassess hybrid water milfoil population in Little Bearskin Lake in 2015 and reassess management strategy for 2016.
Timeframe:	Continuation of current effort
Facilitator:	Planning Committee
Description:	Eurasian water milfoil was first recorded in Little Bearskin Lake in 2008, and later confirmed as a hybrid between Eurasian water milfoil and the indigenous northern water milfoil in 2009. The 2014 hybrid water milfoil peak-biomass map indicates that in recent years, this invasive species has reduced in density. However this plant still can be found at low densities throughout much of the lake (Map 9). In addition, the WDNR's point-intercept survey revealed that hybrid water milfoil had declined in occurrence by 57% from 2012-2014. Following the 2014 survey, the LBLA Planning Committee and Onterra ecologists reconvened to update the hybrid milfoil management strategy. Because the hybrid water milfoil population was found to have declined in 2014 and the WDNR's point-intercept data indicate that the native aquatic plant community is remaining resilient (other than a few species) in the presence of the hybrid water milfoil population, it was decided that an herbicide treatment was not justified for 2015. Following another assessment of the hybrid water milfoil population in 2015, the management strategy for 2016 can be updated if necessary and will likely include one of or a combination of the following strategies: **<u>No Active Management, Continue Monitoring</u>** The point-intercept data collected annually by the WDNR indicates that the hybrid milfoil population can fluctuate in Little Bearskin Lake on an annual basis. If the 2015 peak-biomass survey reveals that the hybrid milfoil has reduced in density, the LBLA may decide not to take any control actions and continue monitoring the hybrid water milfoil population. **<u>Continue to Understand the Role of Milfoil Weevils</u>** The first year of the weevil study indicated that weevils will likely not be an applicable strategy for controlling hybrid water milfoil in Little Bearskin Lake. However, the four colonies (beds) of hybrid water milfoil were studied again in 2014 to determine if there is a detectable effect of stocking weevils one year following their application. While weevils will not likely be a viable option of HWM control on Little Bearskin Lake, this option should not be completely dismissed, and this strategy can be further evaluated

following the results of the UW-Extension's 2014 study results.

Conduct Prioritized Spot Herbicide Treatments
The areas comprised of dominant or greater hybrid water milfoil likely impact the lake's ecology and/or interfere with recreational activities in these locations. Because of this, a threshold or "trigger" level has been developed than when reached, would initiate a spot herbicide treatment. The trigger level would be areas of approximately three acres or greater with the majority of that area being at a dominant or greater HWM density. However, the shape (broad versus long and narrow) and location (secluded versus deep, open, or flowing water) would also be considered in the strategy development. If an herbicide treatment strategy is implemented, quantitative monitoring using WDNR protocols and qualitative monitoring using observations at individual treatment sties would be implemented.

Conduct Whole-lake Herbicide Treatment
Likely the only way to address hybrid water milfoil on a lake-wide level is to conduct a whole-lake treatment. Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (of the lake, lake basin, or within the epilimnion of the lake or lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. The application rate of whole-lake treatments is dictated by the volume of water in which the herbicide will reach equilibrium with. Because exposure time is so much greater, target herbicide levels for whole-lake treatments are significantly less than for spot treatments.

The challenge testing completed as a part of this project provided important information about the susceptibility of the hybrid water milfoil within the lake. Below is the alternative analysis completed to determine the appropriate control strategy for Little Bearskin Lake if determined appropriate to move forward with a whole-lake herbicide treatment strategy in the future:

Auxin Herbicides – 2,4-D & Triclopyr: Much information has been gathered in recent years, largely as a result of an ongoing cooperative research project between the Wisconsin Department of Natural Resources, US Army Corps of Engineers Research and Development Center, and private consultants (including Onterra). Classically susceptible Eurasian water milfoil populations have been controlled at whole-lake 2,4-D concentrations (1-7 day after treatment average) of 0.3-0.4 ppm ae. However, the challenge test results indicate that some of the hybrid water milfoil strains tested from Little Bearskin Lake were less responsive to 2,4-D than a pure Eurasian water milfoil reference strain. While a higher 2,4-D concentration could provide control of the hybrid water milfoil, the increased collateral impacts at the higher use rate suggest that Little Bearskin Lake may not be a good candidate for this herbicide use pattern.

As discussed within the Aquatic Plant Section (3.4), the challenge testing also indicates a reduced response to triclopyr. However, SePRO's report contends that a slightly higher use pattern than would be typically be used for pure-strain Eurasian water milfoil would produce the desired efficacy and still contain a desired level of selectivity of native plants. The details of this strategy are outlined within the first bulleted point of Appendix G.

Auxin and Endothall Combination – 2,4-D & Endothall: An additive or a synergistic advantage is theorized when combining 2,4-D and endothall. The simultaneous exposure to endothall and 2,4-D have been shown to provide increased control of Eurasian water milfoil in outdoor growth chamber studies (Madsen et. al 2010). A handful of hybrid water milfoil treatments in Wisconsin utilizing this strategy have been conducted to date with promising results of control and selectivity. The current target herbicide concentration for a combination 2,4-D and Endothall treatment is 0.25 ppm ae 2,4-D, 0.75 ppm ai Endothall.

Slow Acting Enzyme Inhibitor– Fluridone. The challenge testing suggests that the hybrid water milfoil strains tested from Little Bearskin Lake would be effectively controlled utilizing a standard fluridone use pattern. Fluridone is a systemic herbicide that disrupts photosynthetic pathways (carotene inhibitor). Because the herbicide degrades via photolysis (some microbial degradation may also occur) and requires long exposure times (60-90 days) to cause mortality to hybrid water milfoil, adding additional herbicide ("bump treatment") a few weeks following the initial application may be required based upon herbicide concentration monitoring results.

More commonly used in Michigan, the standard liquid fluridone use pattern involves applying the herbicide at 6 parts per billion (ppb) and following up with an additional "booster" or "bump" treatment at approximately 3 weeks following the treatment. The goal of the bump treatment would be to bring the level of fluridone in the lake back up to 6 ppb. This use pattern is commonly referred to as a "6-bump-6". While more economical to implement than most other strategies, this herbicide is often critiqued because of reduced selectivity towards native aquatic plants (WDNR 2012).

	A recently developed pelletized fluridone product has been manufactured that is suggested to provide increased selectivity towards native plants by maintaining a lower fluridone concentration (2-4 ppb) for a similarly long time period. This use pattern is outlined within the second bulleted point of Appendix G.
Action Steps:	
1.	Retain qualified professional assistance to aid in development of management strategy utilizing the above methods.
2.	Reassess and discuss hybrid water milfoil strategy.
3.	At the end of the current WDNR-EPP grant in 2015, decide what type of funding to seek depending on the appropriate hybrid water milfoil strategy is recommended.

Management Action:	Initiate Clean Boats Clean Waters watercraft inspections at the Little Bearskin Lake public boat landing.
Timeframe:	Begin 2014
Facilitator:	Planning Committee
Description:	Although Little Bearskin Lake already contains hybrid water milfoil, rusty crayfish, and the Chinese and banded mystery snails, it is still important to minimize the chance that additional AIS be introduced into the system and that AIS are not transported from Little Bearskin Lake to other waterbodies. To that end, the LBLA will initiate a WDNR Clean Boats Clean Waters watercraft inspection program at the Little Bearskin Lake public access. Members of the LBLA will be trained on the Clean Boats Clean Waters protocols and complete boat inspections at the public landing on a regular basis. 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 aquatic invasive species on our lakes and educating people about how they are the primary vector of its spread.
Action Steps:	
1.	Members of the LBLA attend Clean Boats Clean Waters training session during spring or summer of 2013.
2.	LBLA members trained will train other volunteers in 2013.
3.	Begin watercraft inspections during busy, high-use weekends.
4.	Report results to WDNR and LBLA.
5.	Promote enlistment and training of new volunteers to keep the program fresh.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Little Bearskin 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 LBLA members, professional water quality samples were collected at subsurface (S) and near-bottom (B) depths once in spring, winter, and fall. Although LBLA 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.

Parameter	Spring		June	July	August	Fall		Winter	
	S	B	S	S	S	S	B	S	B
Dissolved Phosphorus	●	●						●	●
Total Phosphorus	●♦	●	♦	♦	♦	●	●	●	●
Total Kjeldahl Nitrogen	●	●	■	■	■			●	●
Nitrate-Nitrite Nitrogen	●	●	■	■	■			●	●
Ammonia Nitrogen	●	●	■	■	■			●	●
Chlorophyll-*a*	●		♦	♦	♦	●			
True Color	●								
Hardness	●								
Total Suspended Solids	●	●				●	●		
Laboratory Conductivity	●	●							
Laboratory pH	●	●							
Total Alkalinity	●	●							
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 Little Bearskin Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the National Land Cover Database (NLCD – Fry et. al 2011) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Little Bearskin Lake during a June 6, 2012 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 Little Bearskin 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 the Wisconsin Department of Natural Resource document, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry, and Analysis, and Applications (WDNR PUB-SS-1068 2010) was used to complete this study in August of 2009, 2010, 2011, and 2012. A point spacing of 42 meters was used resulting in 421 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Little Bearskin 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.

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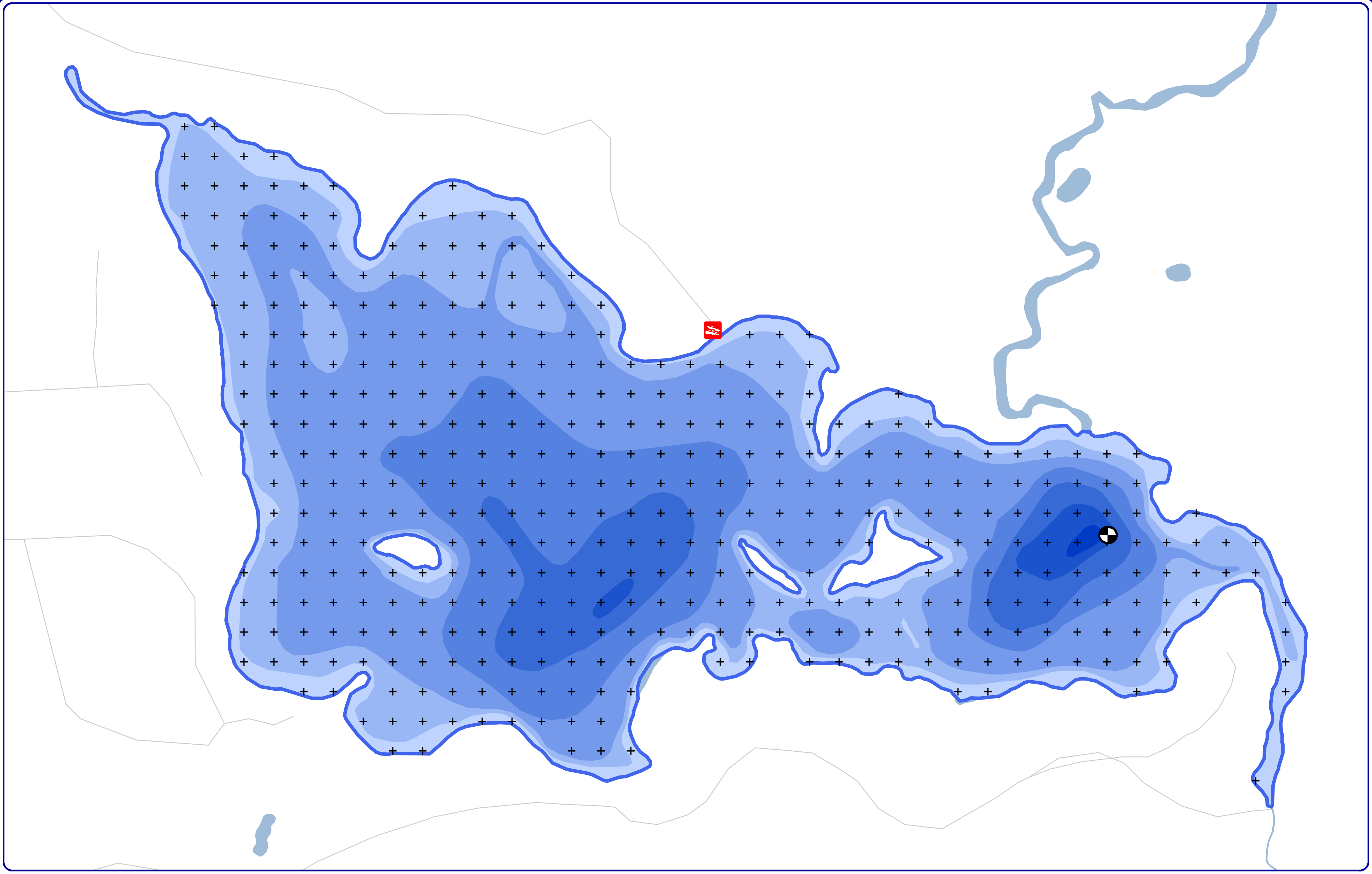

N
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610
Feet

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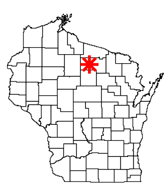
920.338.8860
www.onterra-eco.com

Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR 1969 - digitized by Onterra
Map Date: April 9, 2013
Filename:Map1_LittleBearskin_Location.mxd



Project Location in Wisconsin

Legend

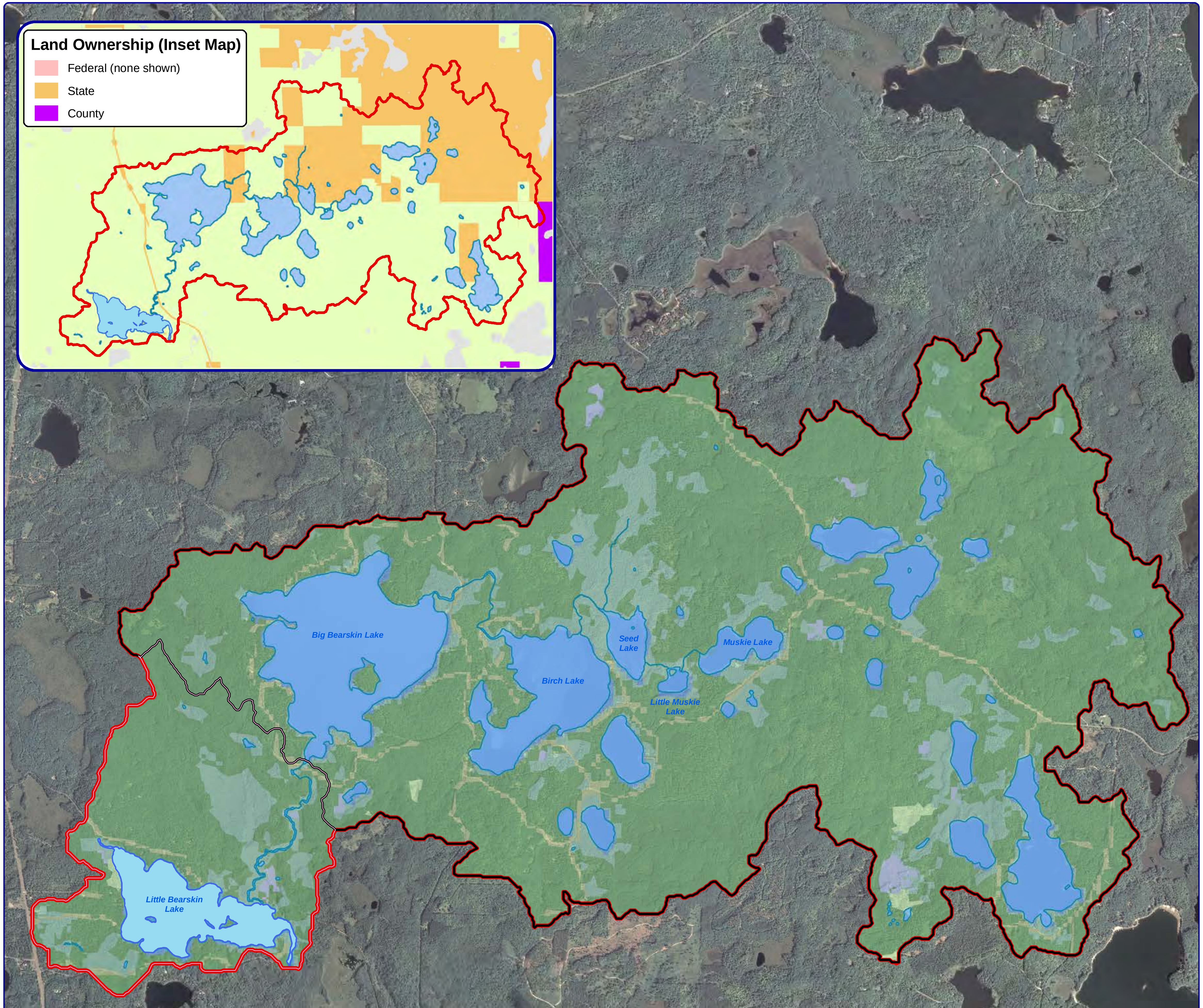
Little Bearskin Lake ~164 acres
WDNR Definition

Point-Intercept Survey Location
42-meter spacing, 421 total points

Water Quality Sampling Location

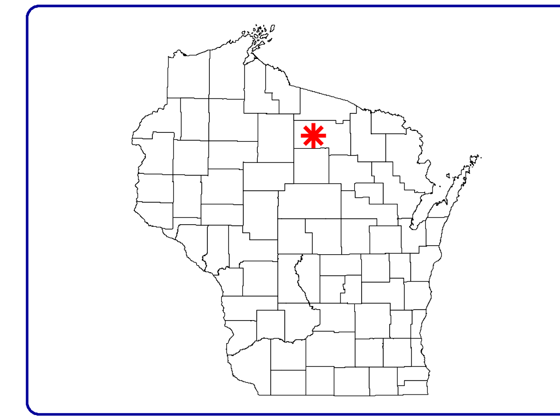
Public Access

Map 1
Little Bearskin Lake
Oneida County, Wisconsin
Project Location & Lake Boundaries



Map 2
Little Bearskin Lake
Oneida County, Wisconsin

Watershed Boundary & Land Cover Types



Project Location in Wisconsin

Legend

- Little Bearskin Lake Watershed
- Big Bearskin Lake Sub-watershed
- Little Bearskin Lake Direct Watershed

Land Cover Types

- Forest
- Forested Wetlands
- Wetlands
- Open Water
- Little Bearskin Lake
- River or Stream
- Rural Open Space
- Pasture/Grass

N W E S

2,900
Feet

Sources:
Land Cover: NCLD, 2006
Hydro: WDNR
Orthophotography: NAIP, 2010
Map Date: April 8, 2013
Filename:Map2_LittleBearskin_Watershed.mxd

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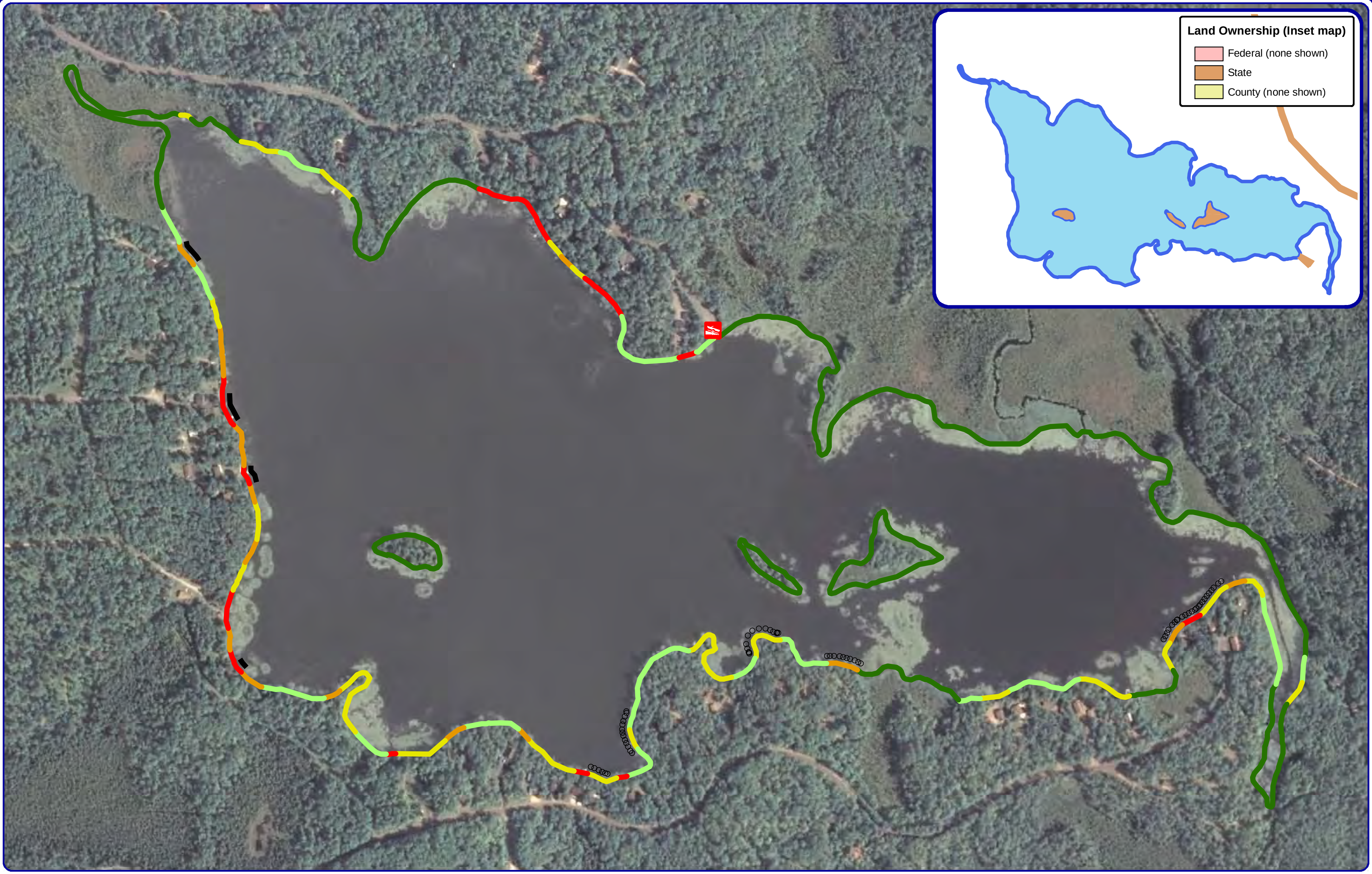

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Feet

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Sources:
Hydro and State Land: WDNR
Orthophotography: NAIP, 2010
Shoreline Assessment: Onterra, 2012
Map Date: April 9, 2013
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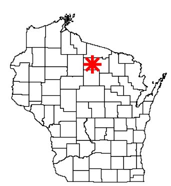


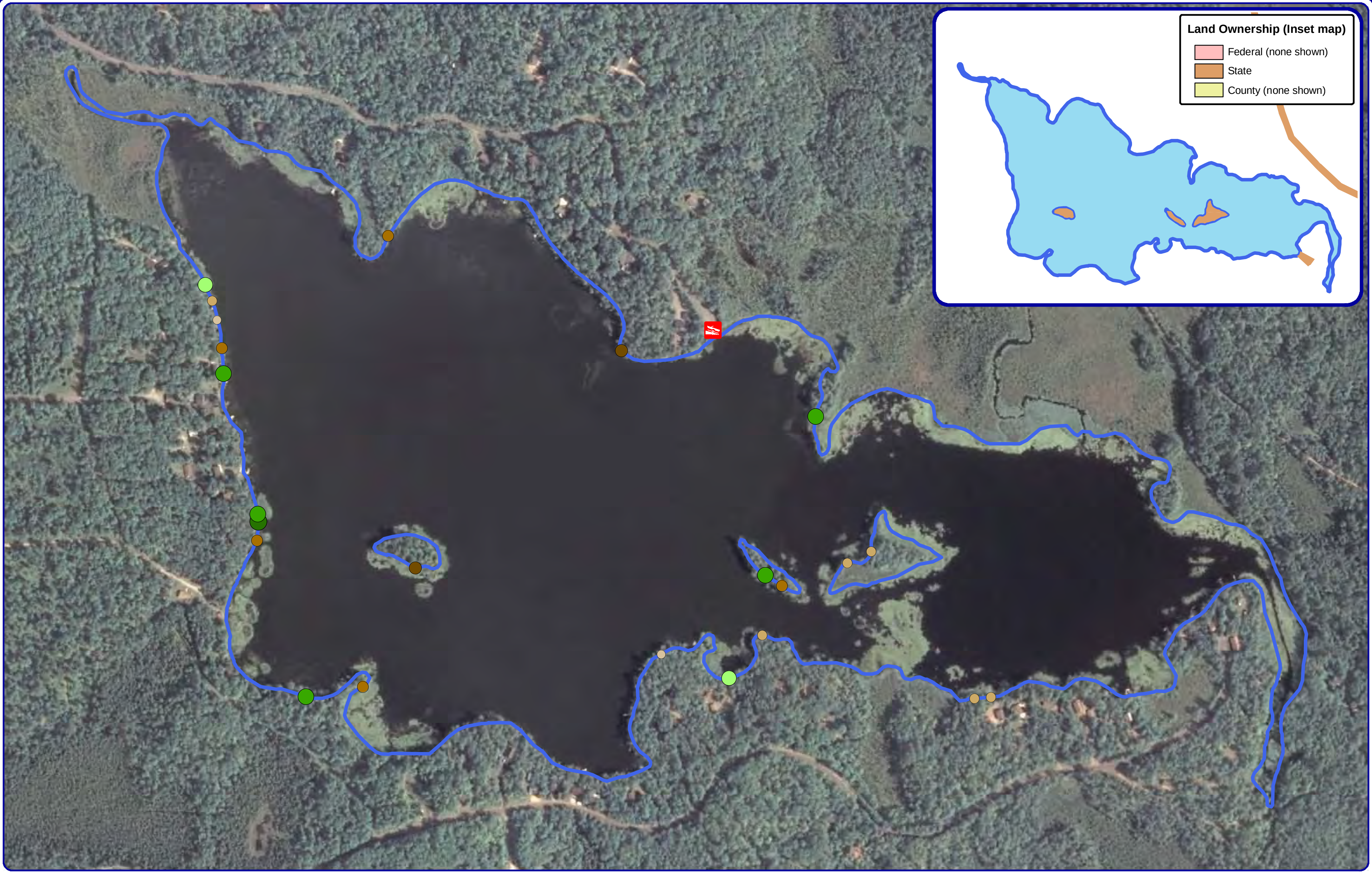
Project Location in Wisconsin

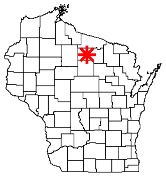
Legend

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

Seawall
Rip-Rap
Wood Seawall

Map 3
Little Bearskin Lake
Oneida County, Wisconsin
2012 Shoreland Condition





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Legend

2-8 Inches in Diameter	> 8 Inches in Diamter
No Branches	No Branches (none)
Minimal Branches	Minimal Branches
Moderate Branches	Moderate Branches
Full Canopy	Full Canopy
	Cluster (none)

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Sources:
Hydro and State Land: WDNR
Orthophotography: NAIP, 2010
CWH Assessment: Onterra, 2012
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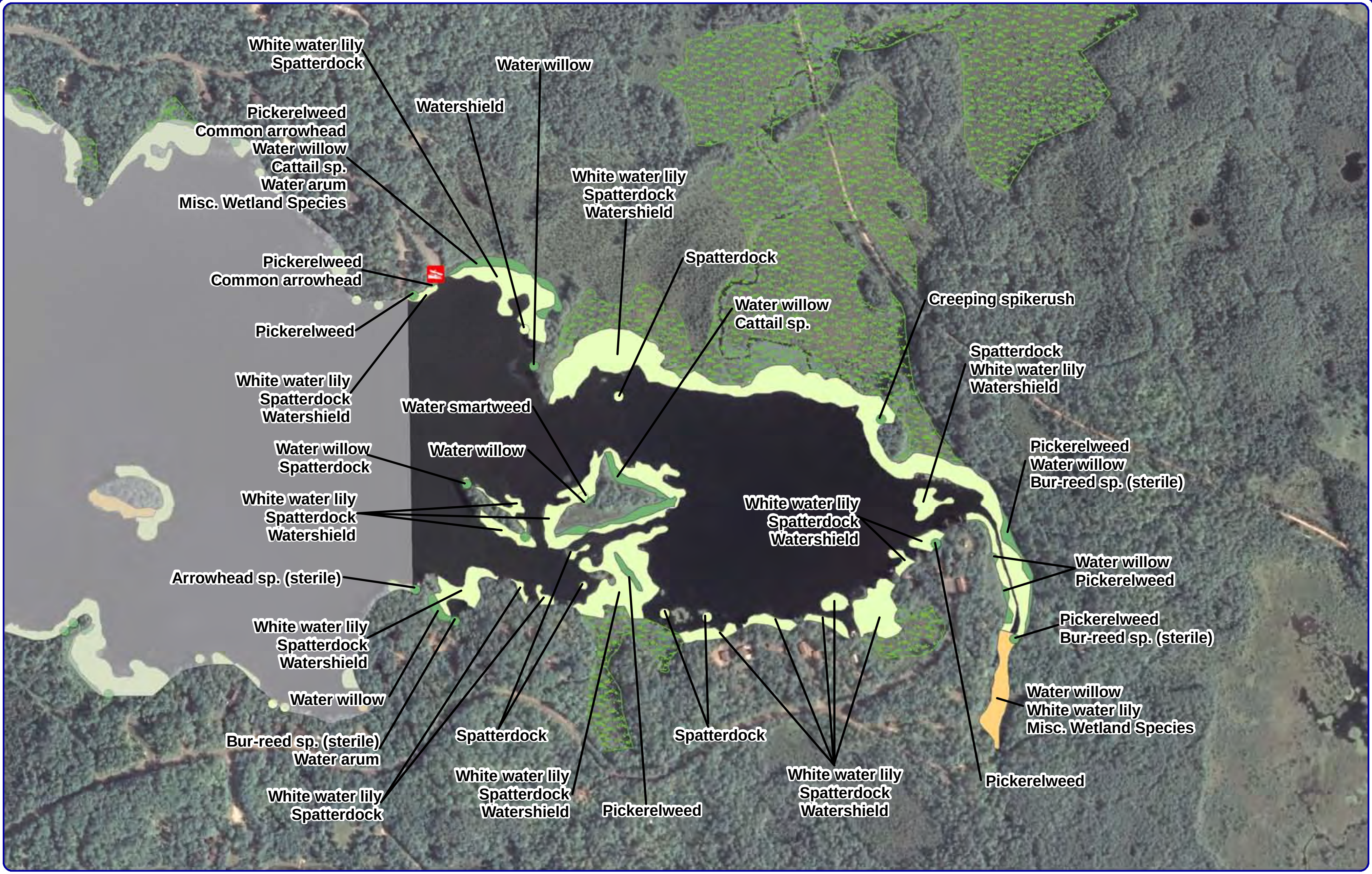
Filename:Map3_LittleBearskin_CWH.mxd

Map 4
Little Bearskin Lake
Oneida County, Wisconsin

2012 Coarse Woody Habitat



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Legend

Small Plant Community
- Emergent
- Floating-leaf
- Mixed Emergent & Floating-leaf

Large Plant Community
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent
- Adjacent Wetland Habitat

Project Location in Wisconsin

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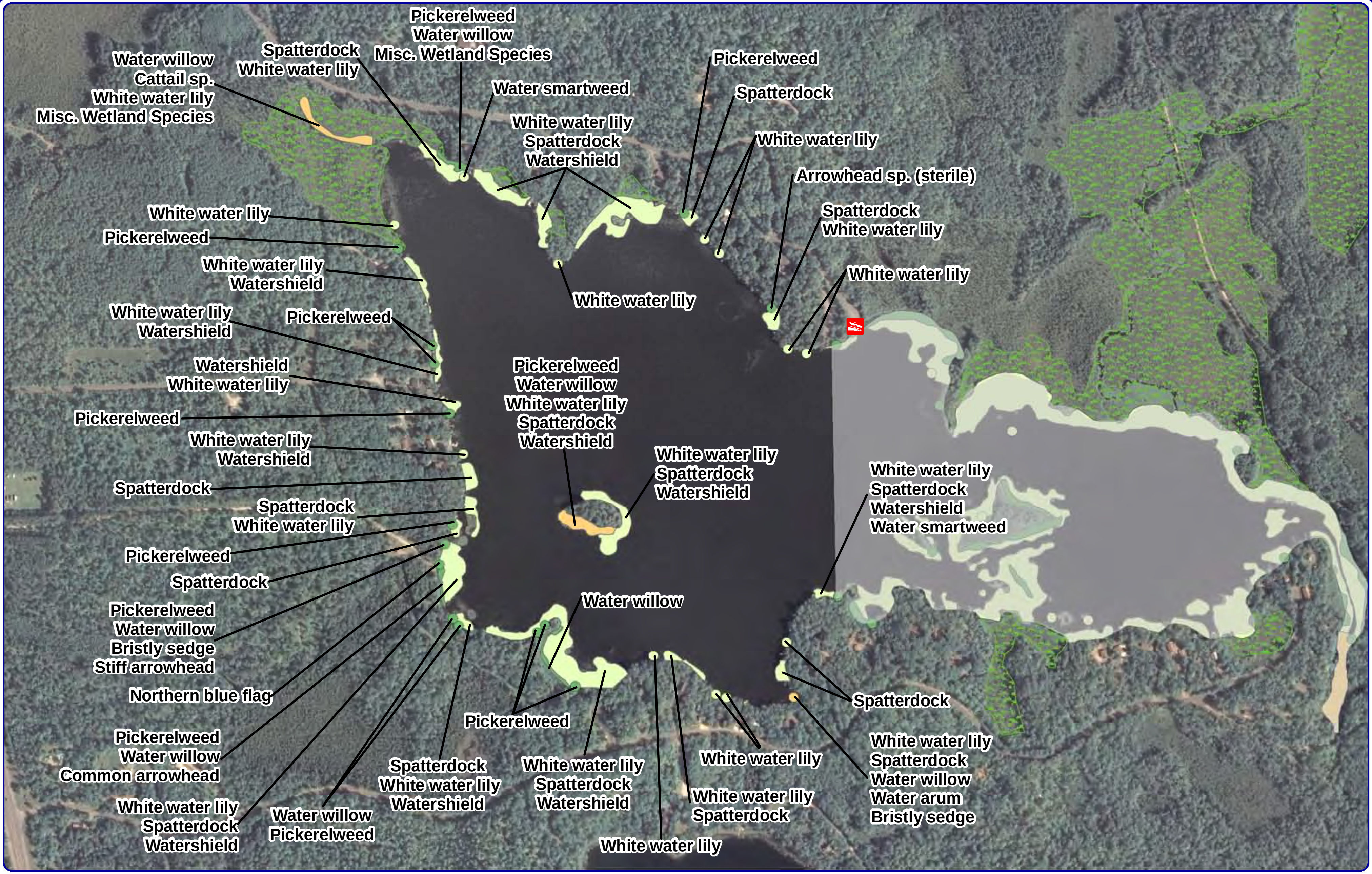
Sources:
Orthophotography: NAIP, 2010
Plant Survey: Onterra, 2012
Map Date: April 9, 2013
Filename:Map5_LittleBearskin_CommEast.mxd

Map 5

Little Bearskin Lake - East

Oneida County, Wisconsin

Emergent & Floating-leaf Aquatic Plant Communities



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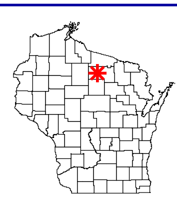
Sources:
Orthophotography: NAIP, 2010
Plant Survey: Onterra, 2012
Map Date: April 9, 2013
Filename:Map6_LittleBearskin_CommWest.mxd



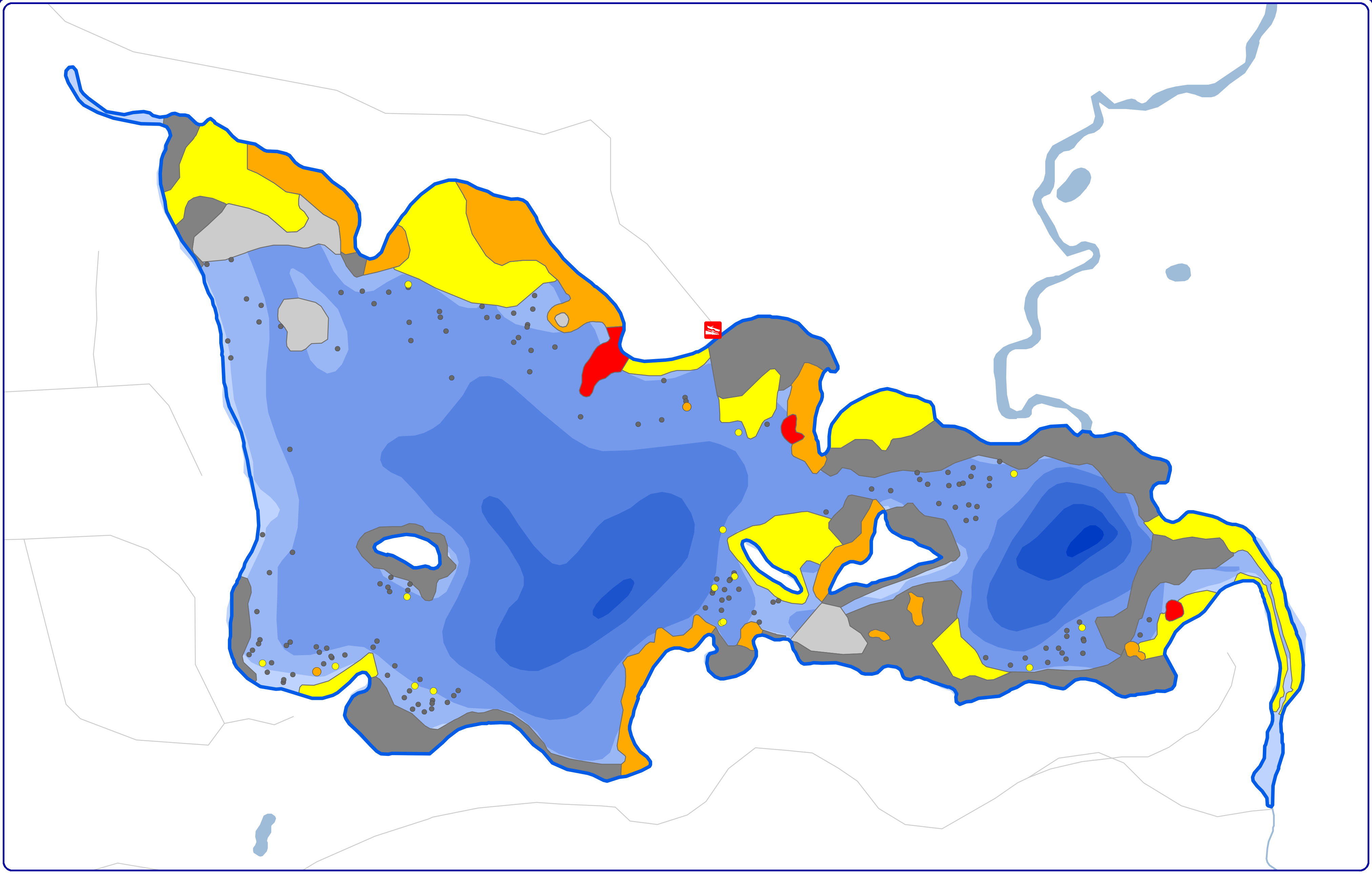
Project Location in Wisconsin

Legend

Small Plant Community
- Emergent
- Floating-leaf
- Mixed Emergent & Floating-leaf

Large Plant Community
- Emergent
- Floating-leaf
- Mixed Floating-leaf & Emergent
- Adjacent Wetland Habitat

Map 6
Little Bearskin Lake - West
Oneida County, Wisconsin
Emergent & Floating-leaf Aquatic Plant Communities



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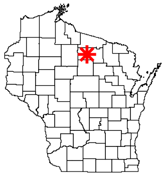
Feet



Project Location in Wisconsin

Legend

Eurasian water milfoil (September 2012)

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clump of Plants
- Small Plant Colony

Map 7
Little Bearskin Lake
Oneida County, Wisconsin
2012 EWM Locations

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Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR. 1969 - digitized by Onterra
Aquatic Plant Survey: Onterra, 2012
Map Date: April 9, 2013
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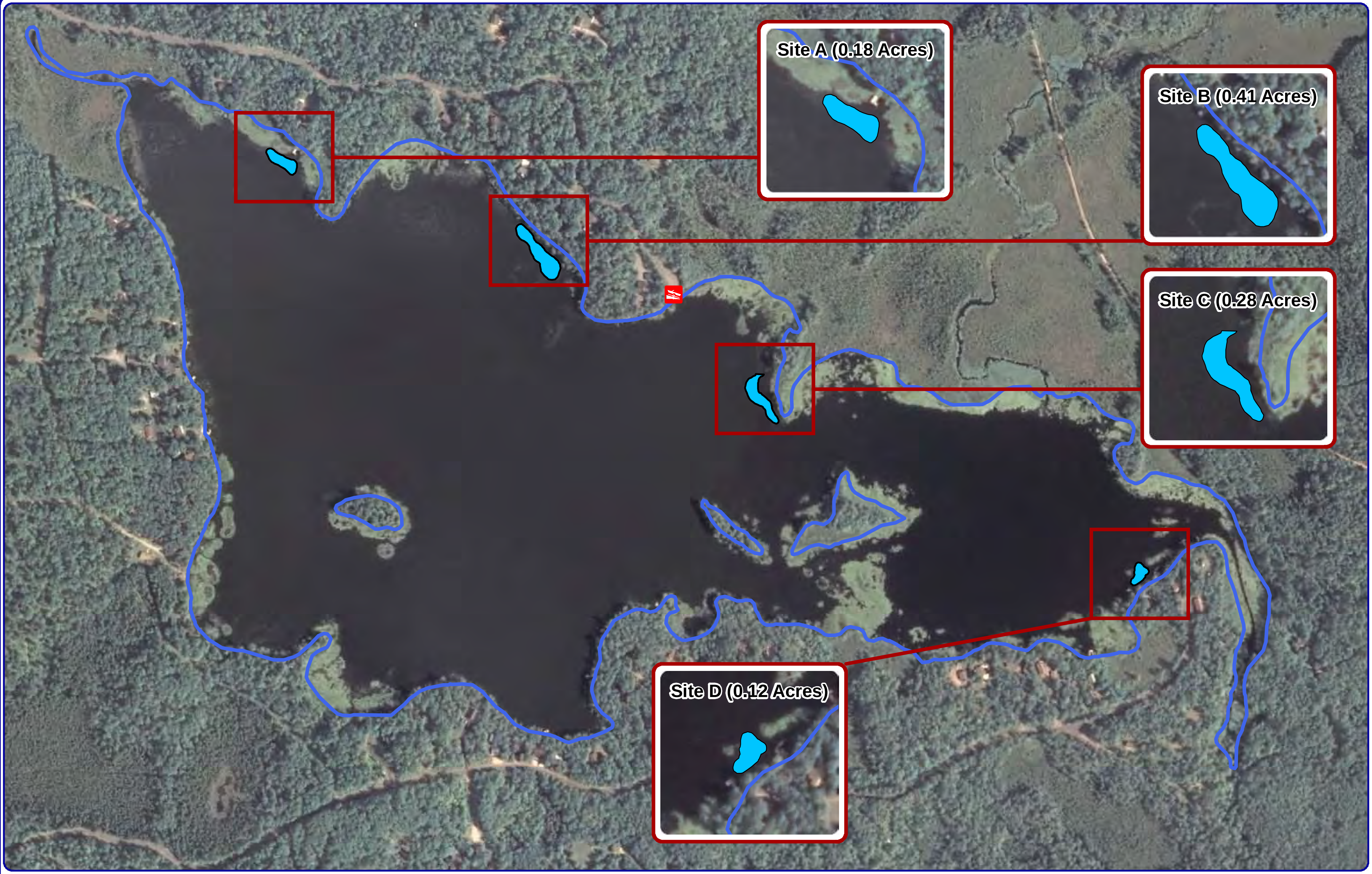

620
Feet

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Sources:
Hydro: WDNR
Aerial Photography: NAIP, 2010.
Map Date: September 27, 2012
Filename: Map8_LittleBearskin_WeevilBeds.mxd

Project Location in Wisconsin

Legend

Eurasian watermilfoil Weevil Study Location

Map 8
Little Bearskin Lake
Oneida County, Wisconsin

2012 EWM Weevil Project Locations