Windfall Lake

Forest County, Wisconsin

Comprehensive Management Plan

December 2011

Sponsored by:

Windfall Lake Association
WDNR Grant Program

LPL-1193-08 & LPL-1194-08

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Lake Management Planning

Windfall Lake

Forest County, Wisconsin

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Funded by: Windfall Lake Association
Wisconsin Dept. of Natural Resources
LPL-1193-08 & LPL-1194-08

Acknowledgements

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

Windfall Lake Planning Committee

Ronald Tschohl
Barbara McCraus
Steve Cornell
Sandy Kopacz
DJ Huddleston
Bruce Heckert
Kelly Stickles
Ed Kennedy
Joe Weiland
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Wisconsin Dept. of Natural Resources
Kevin Gauthier
Kyle McLaughlin
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David Brum

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1.0 INTRODUCTION

Windfall Lake, Forest County is a 55-acre drainage lake with a maximum depth of 26 feet and mean depth of approximately 9 feet. The lake is near the headwaters of the East Branch of the Lily River which ultimately flows into the Wolf River near Lily, Wisconsin.

The Windfall Lake Association (WLA) has been actively managing the dense stands of aquatic vegetation on the lake with chemical and mechanical control methods for the past 23 years. Before the start of the project, the WLA believed that without intervention, much of the northern basin and the entire southern basin would be completely covered with aquatic plants which would inhibit recreational activities.

An important aspect of this planning project is stakeholder participation. This flow of information between the stakeholders, the principal planners, and the association has ultimately lead to the creation of a management plan for Windfall Lake which attempts to balance the needs of stakeholders with what is best for the lake ecosystem.

An aquatic plant study of Windfall Lake in 1996 revealed no exotic species within the lake and it is still presumed to be free of invasive species. However, Windfall Lake falls within proximity of many infested systems the association has taken a pro-active approach by initiating Clean Boats Clean Waters inspections at the public boat landing. The WLA feels it is important to keep the prevention of invasive species introductions as a major management goal to keep their obviously productive lake free from the negative impacts of these plants.

2.0 STAKEHOLDER PARTICIPATION

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

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

Kick-off Meeting

On July 19, 2008, a project kick-off meeting was held at the Huddleston cabin to introduce the project to the general public. The meeting was announced through a mailing and personal contact by WLA board members. The approximately 12 attendees were welcomed by DJ Huddleston and were informed about the events that led to the initiation of the project. The presentation given by Eddie Heath started with an educational component regarding general lake ecology and ending with a detailed description of the project including opportunities for stakeholders to be involved. Mr. Heath's presentation was followed by a question and answer session.

Stakeholder Survey

During August 2008, a six-page, 25-question survey was mailed to 55 riparian property owners in the Windfall Lake watershed. Approximately 58.2 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Windfall Lake Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan.

Planning Committee Meeting I

On April 11, 2009, Eddie Heath of Onterra met with the Windfall Lake Planning Committee and Kevin Gauthier (WDNR) for nearly four hours at the Tschohl residence. The primary focus of this meeting was the delivery of the study results and conclusions to the committee and discussion of management options and actions for the lake.

Following Mr. Heath's results and conclusions presentation that lasted approximately 1 ½ hours, the group spent the next 2 ½ hours discussing the condition of the lake, the need for continued vegetation and water quality monitoring, the changes members of the Planning Committee have seen on the lake over the past two or more decades, and the results of the stakeholder survey.

Planning Committee Meeting II

On November 11, 2009, Eddie Heath met with 6 members of the Windfall Lake Planning Committee once again to finalize goals generated during Planning Meeting I for the Lake Management Plan. The meeting lasted a little over 2 hours. During this time, actions were developed which would allow the Windfall Lake Planning Committee to work towards the previously discussed goals for the lake.

Management Plan Review and Adoption Process

In August 2010, a draft of the Windfall Lake Management Plan was supplied to the WDNR and the WLA Planning Committee. Comments were received from the planning committee within a few weeks after the draft report was made available.

The WDNR provided written comments to the draft management plan on October 31, 2011. A second draft of the plan was provided to the WDNR during December 2011. This report reflects the integration of WDNR and WLA comments. The final report will be reviewed by the WLA Board of Directors and a vote to adopt the management plan will be held during the association's next annual meeting.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, not all chemical attributes collected may have a direct bearing on the lake's ecology, but may be more useful as indicators of other problems. Finally, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

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

Comparisons with Other Datasets

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

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

lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

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

Lillie and Mason (1983) is an excellent source of data for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Vilas County lakes are included within the study's Northeast region (Figure 3.1-1) and are among 242 lakes randomly sampled from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means and historic data from Windfall Lake are displayed in Figures 3.1-2 – 3.1-4. The data in these graphs are broken into two categories: growing season and summer. The growing season includes all data collected anywhere from April 1st to October 31st of a given year. Summer only includes data collected during June, July, and August of a given year and is broken out so that the data from Windfall Lake can be compared to the regional averages developed by Lillie and Mason (1893). The water quality data was collected from the deepest location in Windfall Lake (Map 1). Furthermore, the phosphorus and chlorophyll-a data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments (see discussion under Internal Nutrient Loading on page 9). Surface samples in Windfall Lake were collected at a depth of 3 feet.

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

Apparent Water Quality Index

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

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

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. 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.

> **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.

Carlson (1977) presented a trophic state index that gained great acceptance among lake managers. Because Carlson developed his TSI equations on the basis of association among water clarity, chlorophyll-*a*, and total phosphorus values of a relatively small set of Minnesota lakes, researchers from Wisconsin (Lillie et. al. 1993), developed a new set of relationships and equations based upon the data compiled in Lillie & Mason (1983). This resulted in the Wisconsin Trophic State Index (WTSI), which is essentially a TSI calibrated for Wisconsin lakes. The WTSI is used extensively by the WDNR and is reported along with lake data collected by Citizen Lake Monitoring Network volunteers.

Limiting Nutrient

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

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

Temperature and Dissolved Oxygen Profiles

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

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

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

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

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

Non-Candidate Lakes

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

Candidate Lakes

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

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

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

*Lack of hypolimnetic phosphorus data prevents these analyses from being performed. The explanation provided under this heading is strictly for the information of the reader.

Windfall Lake Water Quality Analysis

Windfall Lake Long-term Trends

In addition to collection of 2008 water quality data by Onterra and Windfall Lake CLMN volunteers, historic data was gathered from the WDNR Surface Water Integrated Monitoring System (SWIMS) in an effort to examine potential trends in water quality. The available data spans the years 1994 through 2008, and includes Secchi disk transparency, chlorophyll-*a*, and total phosphorus.

Summer average phosphorus concentrations from 1996 to 2008 are displayed in Figure 3.1-2. These averages fall largely into the WQI category of "Good" and varied only slightly since 1998. The yearly fluctuations are likely attributed to climatic or other environmental variability. For example, in "wet" years surface runoff may increase and thus increase phosphorus concentrations in the lake. An opposite effect may be experienced in "dry" years. The average phosphorus concentration, weighted across these years, is comparable to the average for Wisconsin natural lakes, and is only slightly higher than the average for lakes within the Northeast region.

The Windfall Lake chlorophyll-*a* averages range from a WQI category of "Very Good" to "Fair" during a time span of 1996 to 2008 (Figure 3.1-3). When weighted across all years, the average of 5.5 μg/L ranks as "Good" and is well below averages seen statewide and regionally. Although the values fluctuate from year to year, there is no distinct trend in the data. Instead, it is likely that other environmental variables are influencing this water quality parameter, as discussed below.

Chlorophyll-*a* concentrations are quite often correlated highly with phosphorus content in lakes. Often, an increase in total phosphorus will serve as a precursor to an increase in the algal abundance (and thus chlorophyll-*a*) and vice versa. The chlorophyll-*a* concentrations in

Windfall Lake display a bit more variability within the dataset. On some years (i.e. 2007 and 2008) an observed increase or decrease was seen in both phosphorus and chlorophyll-*a* from one year to the next. In other years (i.e. 2004 and 2005) phosphorus concentrations increase or decrease while chlorophyll-*a* react oppositely. A number of factors likely contribute to this relationship. Zooplankton, tiny crustaceans that feed primarily on algae and serve as a food source for fish, may heavily influence algae abundance based upon their population size. Environmental factors such as light or nutrient availability may also influence algae abundance.

Windfall Lake summer Secchi disk averages have fallen within the WQI "Good" category nine times and the WQI "Very Good" category four times out of the past 13 years for which data has been collected (Figure 3.1-4). The weighted average across these years is above the averages for Wisconsin natural lakes and those lakes within the Northeast region. Overall, these Secchi disk readings indicate very high water clarity in Windfall Lake.

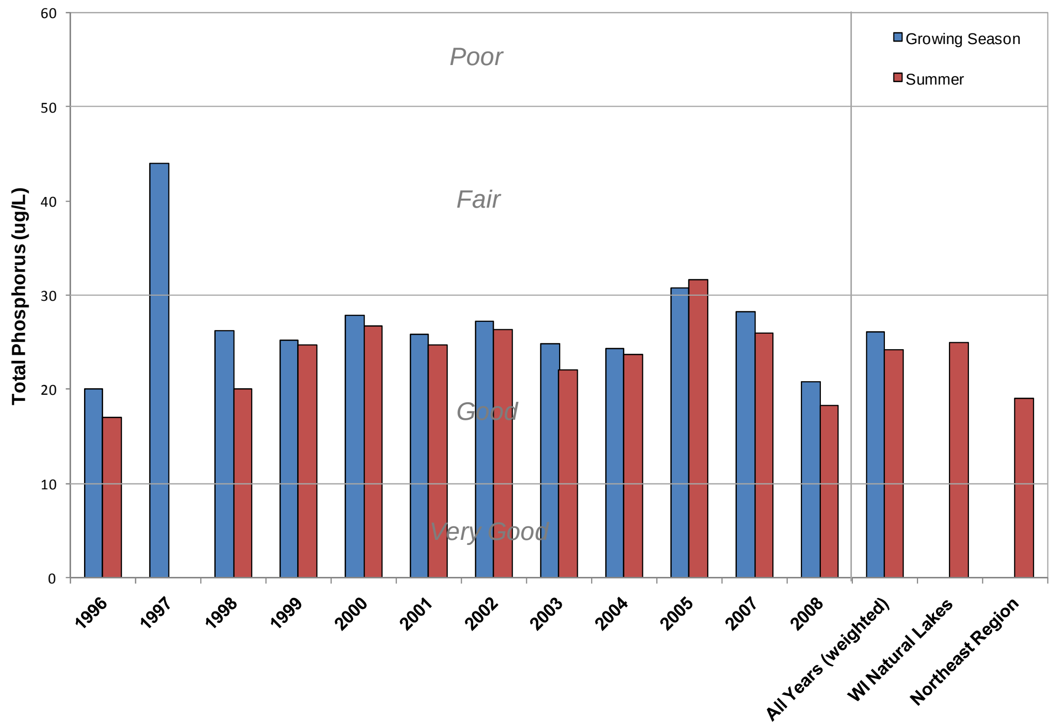

Figure 3.1-2. Windfall Lake, regional, and state total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

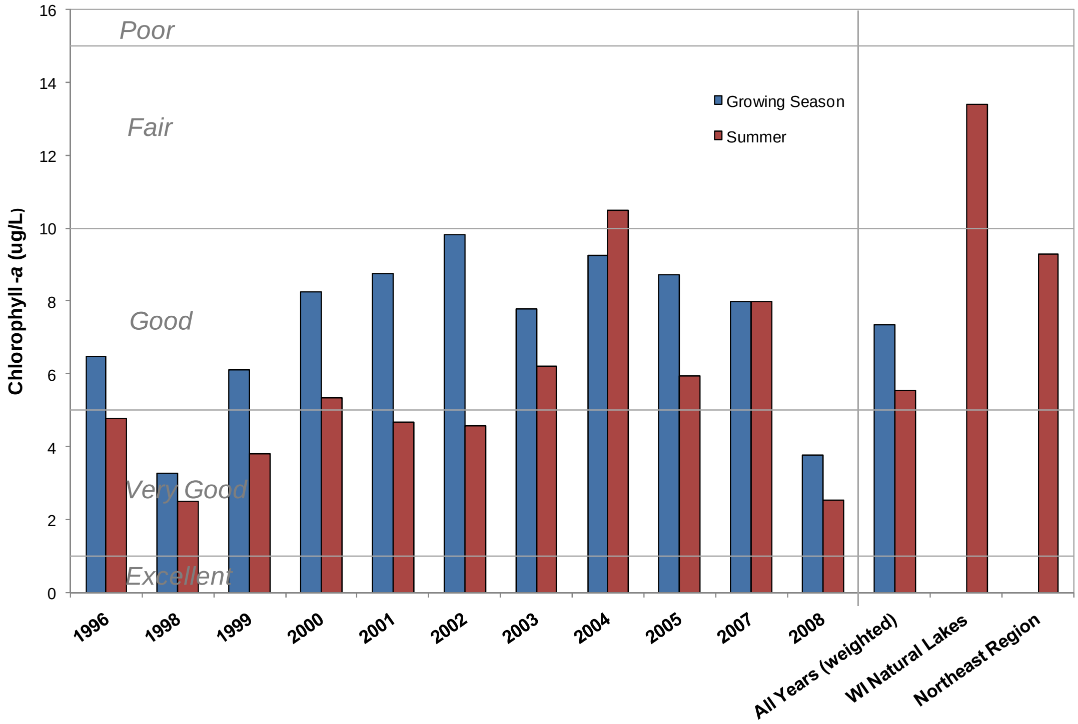

Figure 3.1-3. Windfall Lake, regional, and state chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

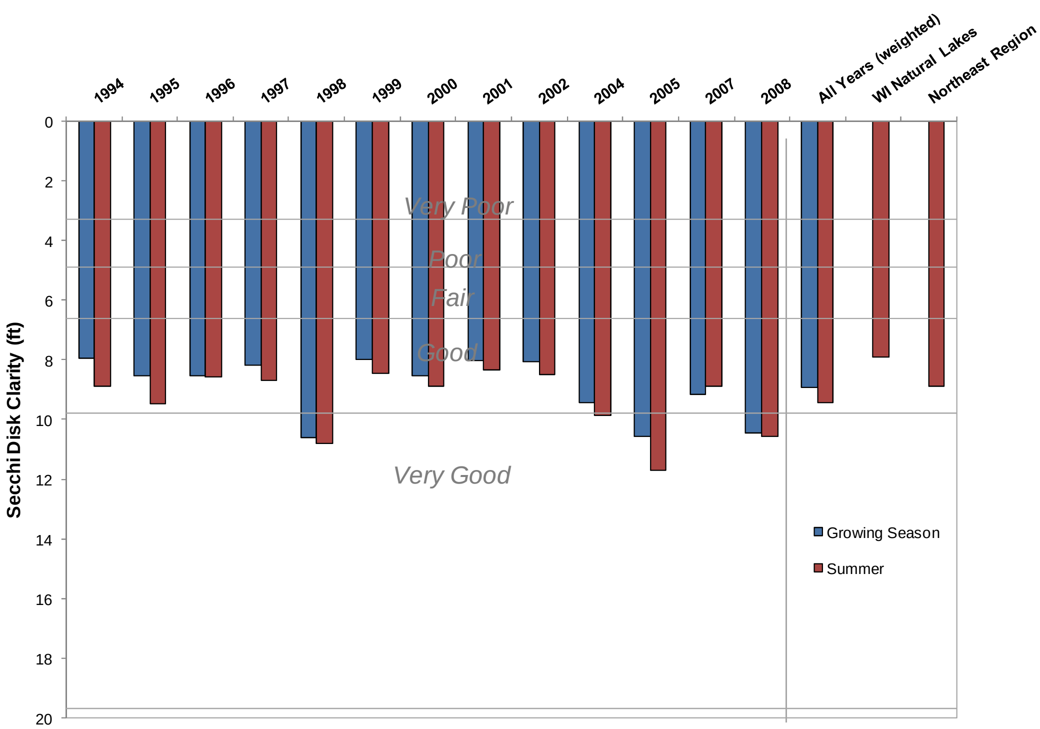

Figure 3.1-4. Windfall Lake, regional, and state Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Limiting Plant Nutrient of Windfall Lake

Using midsummer nitrogen and phosphorus concentrations from Windfall Lake, a nitrogen:phosphorus ratio of 22:1 was calculated. This finding indicates that Windfall Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within the lake.

Windfall Lake Trophic State

Figure 3.1-5 contain the WTSI values for Windfall Lake. The WTSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range from middle eutrophic to upper mesotrophic. In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* WTSI values, it can be concluded that Windfall Lake is in a upper mesotrophic state.

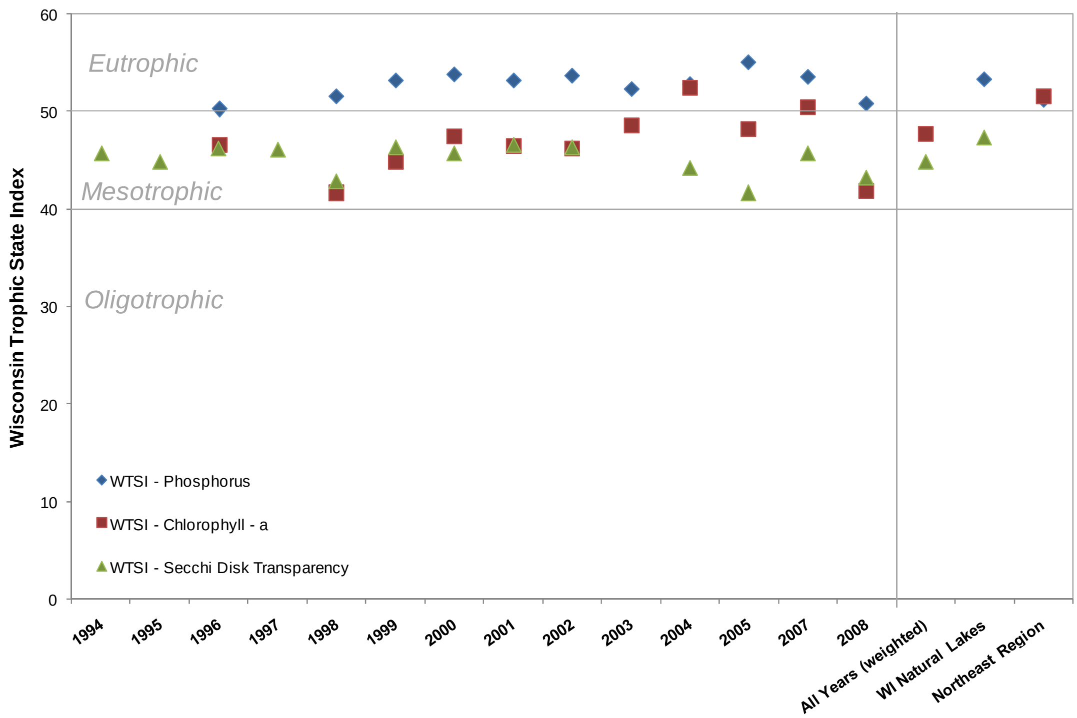

Figure 3.1-5. Windfall Lake, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993).

Dissolved Oxygen and Temperature in Windfall Lake

Onterra staff and Ron Tschohl of the Windfall Lake Citizen Lake Monitoring Network (CLMN) investigated dissolved oxygen and temperature on Windfall Lake several times during 2008 (Figure 3.1-6). The lake was found to stratify and remain stratified throughout spring and summer. This is not uncommon in relatively small lakes that hold considerable depth. Energy from winds "must turn the lake over" in order to mix cooler waters in the hypolimnion with the warmer waters of the epilimnion. The energy needed to do this is great, and on a small lake such as Windfall the surface area is not sufficient enough for the wind to gather this needed energy. In the winter, the lake is stratified in an opposite manner, with the densest water (approximately 4°C) settling at the bottom of the lake and the cooler waters (near 0°C) remaining at the surface.

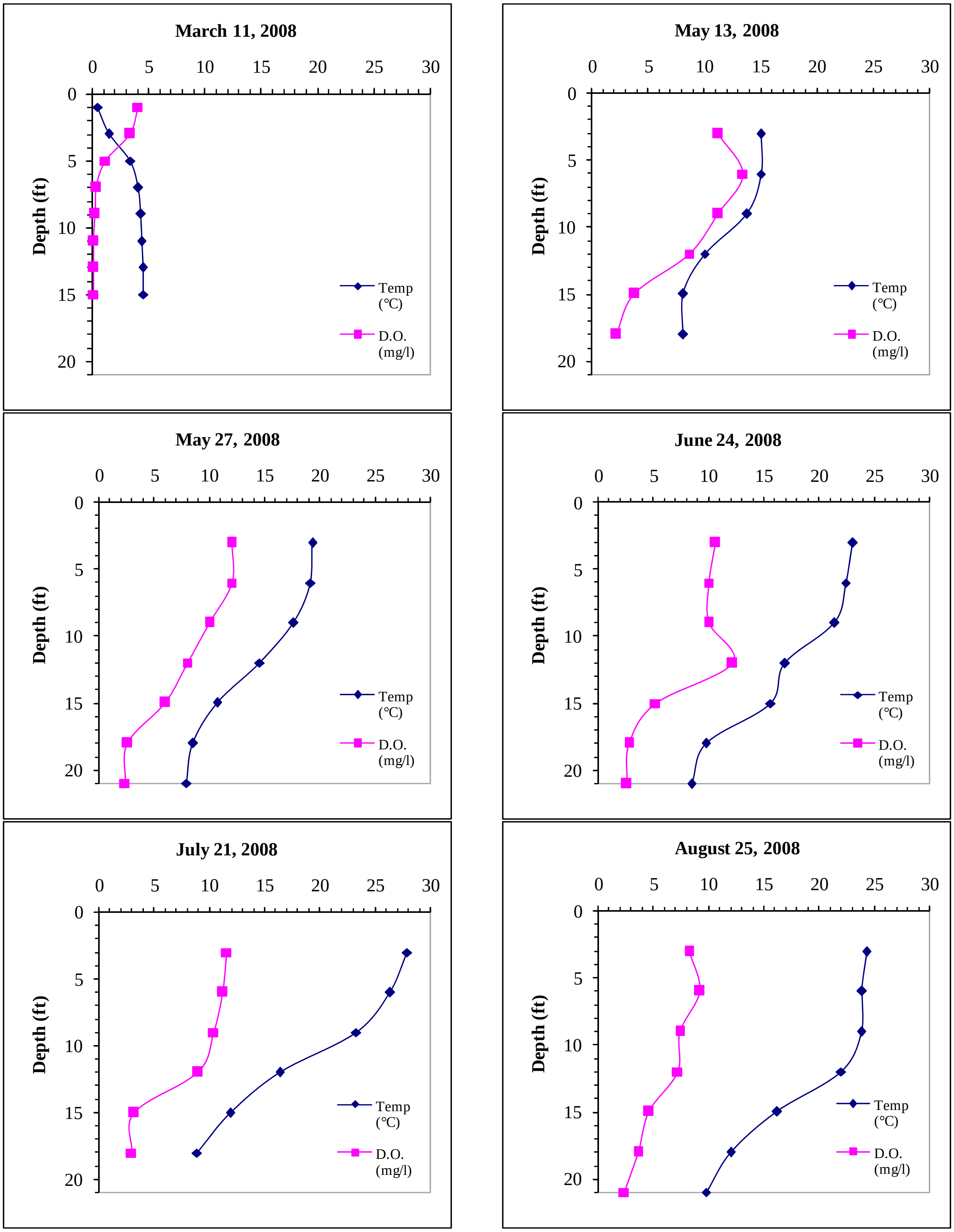

Figure 3.1-6. Windfall Lake dissolved oxygen and temperature profiles.

During these sampling events, dissolved oxygen ranged greatly. In early to mid summer, oxygen concentrations were found to be very high within the upper half of the water column. Interestingly, several spikes in oxygen concentration were observed in mid May and late June. These spikes can be attributed to bands of algae located at these depths. As they photosynthesize, they release oxygen into the water which explains the greater concentrations here. Near the bottom of the lake, decomposition of organic material is occurring. The bacteria that are involved in the decomposition process are using the available oxygen to do so. For the most part, oxygen levels remain above that which is required to support aquatic life (5 mg/L) except for along the very bottom of the lake.

The oxygen concentrations measured in late winter were substantially lower than those found in the summer. At the time that the lake was sampled, oxygen was depleted below 5.0 mg/L at the surface and was measured at 1.2 mg/L at 5 feet. When low oxygen levels are present under the ice, the potential for fish kills exist. However WDNR biologists believe that the sport fish found in warm-water Wisconsin lakes can survive under fairly low oxygen conditions. It is believed that fish may tolerate dissolved oxygen levels of 1 mg/L under the ice for up to 3 weeks at a time. Additionally, it is most often the smaller fish that are more susceptible to winter kill because they have smaller home ranges, and lack the experience to find more suitable (higher oxygenated) waters. With this information in mind, it may become important to monitor winter oxygen levels in future years, as well as observe the lake closely for signs of fish winter kill. Steps to be taken to monitor oxygen levels in Windfall Lake are discussed within the Implementation Plan

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

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw et al. 2004). The 2010-2011 pH of surface water in Windfall Lake was found to be alkaline in 2010-2011, with values ranging from 7.1 to 8.2.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. As previously discussed, these compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite

($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The average alkalinity in Windfall Lake was measured at 116.0 (mg/L as $CaCO_3$), indicating that the lake has a substantial capacity to resist fluctuations in pH and is not sensitive to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Windfall Lake's pH values fall within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Windfall Lake was found to be 31.7 mg/L, placing Windfall Lake in the 'high susceptibility' category for zebra mussel establishment if they are ever introduced. Plankton tows were completed by Onterra staff during the summer of 2008 and these samples were processed by the WDNR for larval zebra mussels. Their analysis did not locate any larval zebra mussels in the 2008 samples. However, Windfall Lake contains optimal conditions for supporting zebra mussels and lake residents should periodically inspect their docks and bottoms of boats for mussels and report any findings to the WDNR or Onterra. Cleaning, removal of water, and inspecting of boats entering and leaving Windfall Lake is especially important for this reason.

3.2 Watershed Assessment

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

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

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

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

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

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

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

Windfall Lake's watershed is 2,855 acres in size, and is largely dominated by forest (45%), pasture / grass land (35%) and wetland (18%) (Figure 3.2-1). The remaining 2% is classified as open water. The watershed is considerably larger than Windfall Lake itself, as indicated by the high watershed to lake area ratio of 50:1. As discussed above, in watersheds with a relatively large ratio, it is often difficult to improve water quality through land use changes because the large amount of land is a factor that overshadows the actual land type. Of the land types that may contribute excessive pollutants to the lake, pasture / grassland is of the most concern. A reduction of this land use would likely result in a decreased export of phosphorus to the lake. This potential conservation action is discussed further below.

WiLMS modeling utilizing the land cover types and acreages found in Figure 3.2-1 results in an estimated annual phosphorus load of 428 lbs for Windfall Lake. This is a considerable amount of phosphorus for a lake of this size. Although forested land is the dominant land use type in the watershed, it is responsible for only 24% of the phosphorus load. On the other hand, pasture / grass land constitutes only 35% of the watershed acreage yet exports 62% of the phosphorus load to Windfall Lake (Figures 3.2-1 and 3.2-2)

As mentioned above, the only land use of particular concern would be that of the pasture / grass land. While it is difficult to manage land in a watershed of this size with the intent on improving water quality within the lake, the pasture / grass land constitutes a large amount of the watershed acreage and benefits from its restoration may be noticeable. Predictive equations within WiLMS were utilized to model a potential scenario in which the 987 acres of pasture / grass land were converted into forested land (Figure 3.2-3). This conversion resulted in a 44% decrease in the phosphorus load (428 lbs to 240 lbs) to Windfall Lake. However this scenario is not entirely feasible, and if a smaller quantity of pasture / grass land was converted to forested land, the reduction in phosphorus loading would be considerably smaller as well.

While the annual phosphorus load to Windfall Lake is substantial for a lake of this size, there are several factors which help to reduce the impacts of phosphorus on the system. Windfall Lake has historically held great densities of macrophytes. These plants utilize the phosphorus early in the growing season, before algae can feed upon it. If fewer macrophytes were present, it would be likely that algal blooms would proliferate, resulting in reduced water clarity. Secondly, Windfall Lake has a high flushing rate (6.1 times each year) which in turn results in a fairly short residence time of 58 days. This high water turnover helps in removing a portion of the phosphorus from the lake before it can accumulate. These factors likely contribute to Windfall Lake's high clarity (Windfall Lake water clarity in the following section – Water Quality).

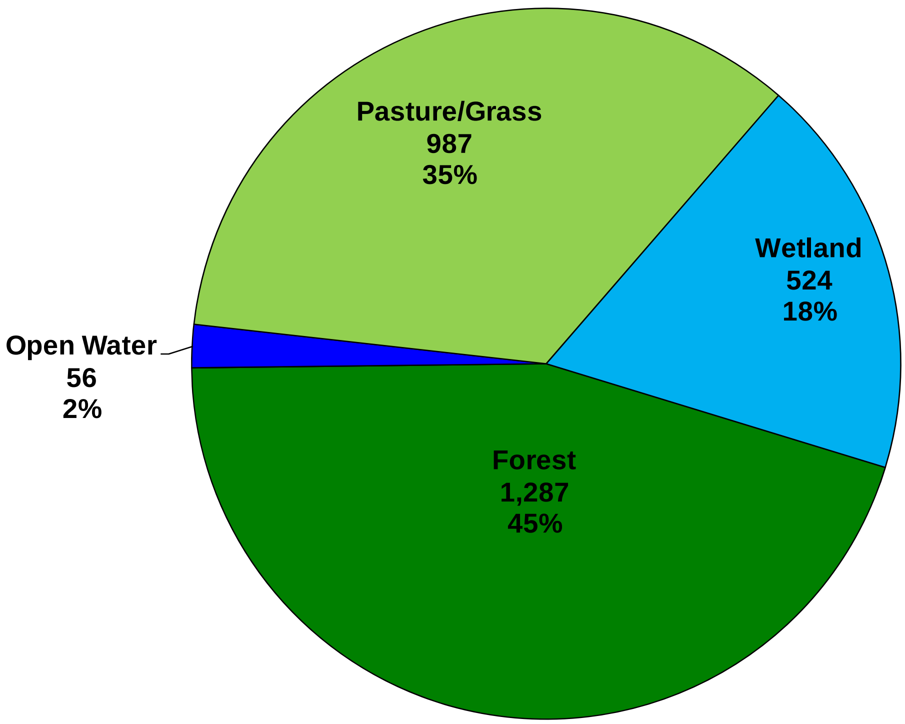

Figure 3.2-1. Windfall Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

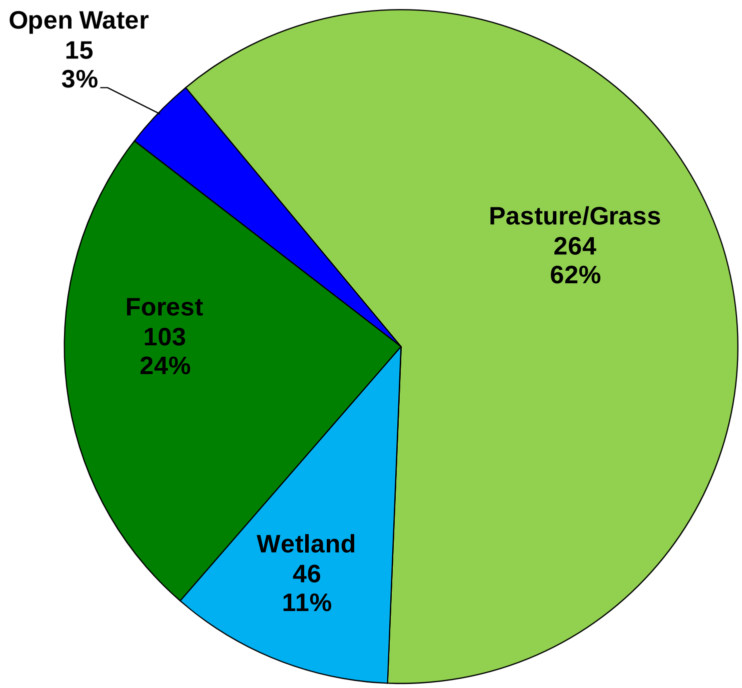

Figure 3.2-2. Windfall watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

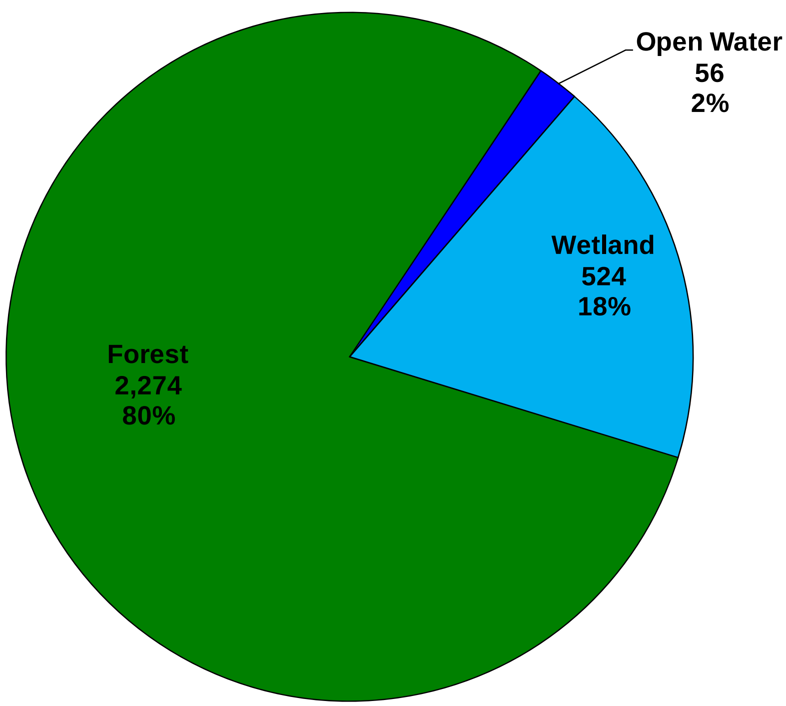

Figure 3.2-3. Windfall Lake alternative scenario watershed land cover types in acres. Land cover is calculated from a theoretical conversion of pasture / grass land to forest. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

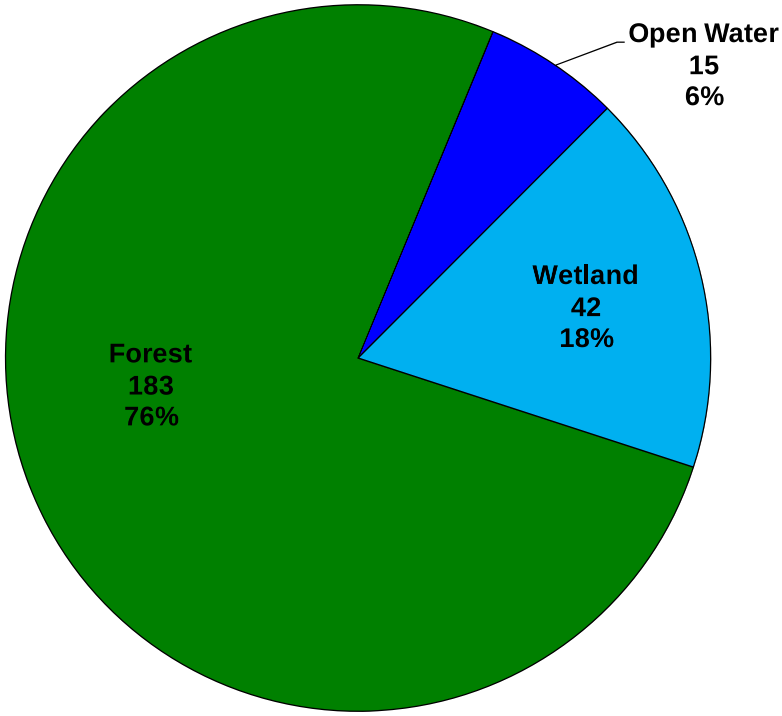

Figure 3.2-4. Windfall Lake alternative scenario watershed phosphorus loading in pounds. Phosphorus load is calculated from a theoretical conversion of pasture / grass land to forest. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Aquatic Plants

Introduction

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

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

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

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

Aquatic Plant Management and Protection

Important Note:
Even though most of these techniques are not applicable to Big Portage Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake. The techniques applicable to Big Portage Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

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

Permits

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

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

Native Species Enhancement

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

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

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

Cost

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

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

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

Manual Removal

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

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

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

Cost

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

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

Bottom Screens

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

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

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

Water Level Drawdown

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

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

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

Mechanical Harvesting

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

Costs

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

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

Chemical Treatment

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

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

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

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

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

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

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

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

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

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

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

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

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

<u>Imazapyr</u> (Habitat®) Broad spectrum, system herbicide, slow-acting liquid herbicide used to control emergent species. This relatively new herbicide is largely used for

controlling common reed (giant reed, *Phragmites*) where plant stalks are cut and the herbicide is directly applied to the exposed vascular tissue.

Cost

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

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

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is no need for either biocontrol insect.

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

Cost

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

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

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

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

Cost

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

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

Analysis of Current Aquatic Plant Data

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

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Big Portage Lake; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

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

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Big Portage Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

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

Floristic Quality Assessment

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. 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 plant surveys.

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

In this section, the floristic quality of Big Portage Lake will be compared to median values from lakes in the same ecoregion and in the state as calculated by Nichols (1999) and shown on Figure 3.3-1. 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). Windfall Lake is natural lake and therefore will be compared to other natural lakes within the NLFL ecoregion.

Species Diversity

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

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

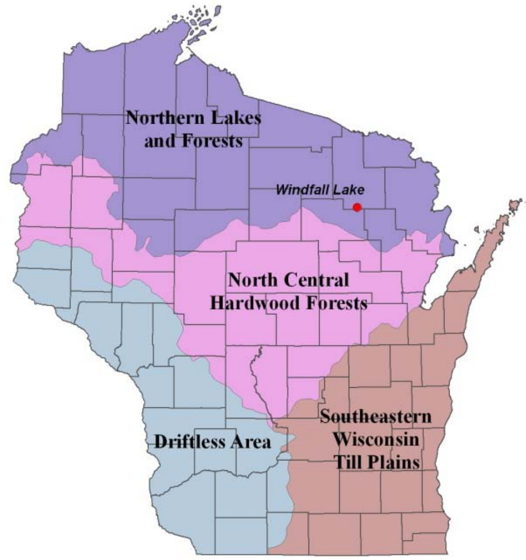

Figure 3.3-1. Location of Windfall Lake within the ecoregions of Wisconsin. After Nichols 1999.

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

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

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

Community Mapping

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

Exotic Plants

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

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.3-2). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it 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.

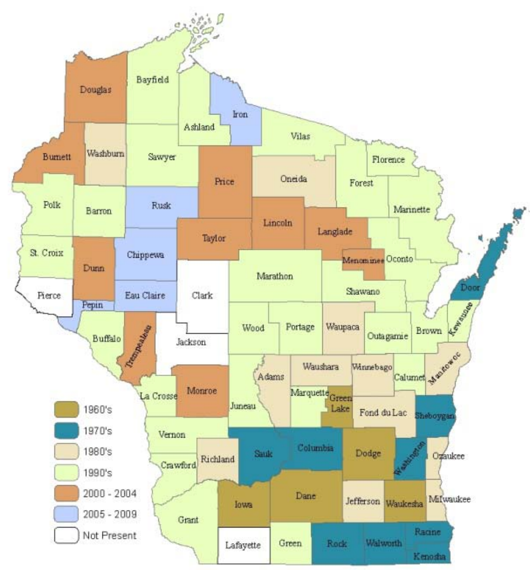

Figure 3.3-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2009 mapped by Onterra.

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 above, numerous plant surveys were completed as a part of this project. On July 1, 2008, a survey was completed on Windfall Lake that focused upon curly-leaf pondweed. This meander-based survey did not locate any occurrences of curly-leaf pondweed. It is believed that this aquatic invasive species either does not occur in Windfall Lake or exists at an undetectable level.

The point intercept survey was conducted on Windfall Lake on July 14, 2008 by Onterra. Additional surveys were completed by Onterra on Windfall Lake to create the aquatic plant community maps (Map 3) during August 2008.

During the point-intercept and aquatic plant mapping surveys, 30 species of plants were located in Windfall Lake (Table 3.3-1), none are considered non-native species. Approximately 85% of the point-intercept sampling locations within the range of plant growth (15 feet) contained aquatic plants. Figure 3.3-3 shows that muskgrasses or 'skunk' cabbage, a type of macro-algae so named for their 'skunk-like' odor, are the most abundant plant found in Windfall Lake. These plants are most prevalent in clear lakes of higher alkalinity. Coontail was the second most abundant species observed in Windfall Lake. Coontail lacks true root structures and its locations are often subject to water movement and their tendency to become entangled in plants, rocks, or debris. Windfall Lake contains a large amount of submergent plants species which at certain times of the year, can be found growing to the surface and likely provide the substrate needed for coontail to become entangled.

Northern water milfoil, arguably Wisconsin's most common native milfoil species, was also fairly widespread in Windfall Lake. It prefers lakes with soft sediments and high water clarity. These conditions can be observed in Windfall Lake and likely explain why northern water milfoil is the third most common plant in the lake. Northern water milfoil is often falsely identified as Eurasian water milfoil, especially since it is known to take on the reddish appearance of Eurasian water milfoil as the plant reacts to sun exposure as the growing season progresses. The feathery foliage of northern water milfoil traps filamentous algae and detritus, providing valuable invertebrate habitat. Because northern water milfoil prefers high water clarity, its populations are declining state-wide as lakes are becoming more eutrophic.

Table 3.3-1. Aquatic plant species located in Windfall Lake during July and August 2008 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)
Emergent	*Calla palustris**	Water arum	9
	*Carex pseudo-cyperus**	Cypress-like sedge	8
	*Eleocharis erythropoda**	Bald spike-rush	3
	*Iris versicolor**	Northern blue flag	5
	*Sagittaria latifolia**	Common arrowhead	3
	*Schoenoplectus acutus**	Hardstem bulrush	5
	*Typha latifolia**	Broad-leaved cattail	1
FL	*Nuphar variegata*	Spatterdock	6
	Nymphaea odorata	White water lily	6
	Polygonum amphibium	Water smartweed	5
FF	*Lemna minor*	Lesser duckweed	5
	Lemna trisulca	Forked duckweed	6
	Spirodela polyrrhiza	Greater duckweed	5
	*Wolffia columbiana**	Common watermeal	5
Submergent	*Ceratophyllum demersum*	Coontail	3
	Chara sp.	Muskgrasses	7
	Elodea canadensis	Common waterweed	3
	Megalodonta beckii	Water marigold	8
	Myriophyllum sibiricum	Northern water milfoil	7
	Najas flexilis	Slender naiad	6
	Potamogeton amplifolius	Large-leaf pondweed	7
	Potamogeton foliosus	Leafy pondweed	6
	Potamogeton friesii	Fries' pondweed	8
	Potamogeton illinoensis	Illinois pondweed	6
	Potamogeton pusillus	Small pondweed	7
	Potamogeton richardsonii	Clasping-leaf pondweed	5
	Potamogeton zosteriformis	Flat-stem pondweed	6
	*Ranunculus flabellaris**	Yellow water crowfoot	8
	Stuckenia pectinata	Sago pondweed	3
	*Utricularia vulgaris**	Common bladderwort	7

FL = Floating Leaf
FF = Free-floating
* = Incidental

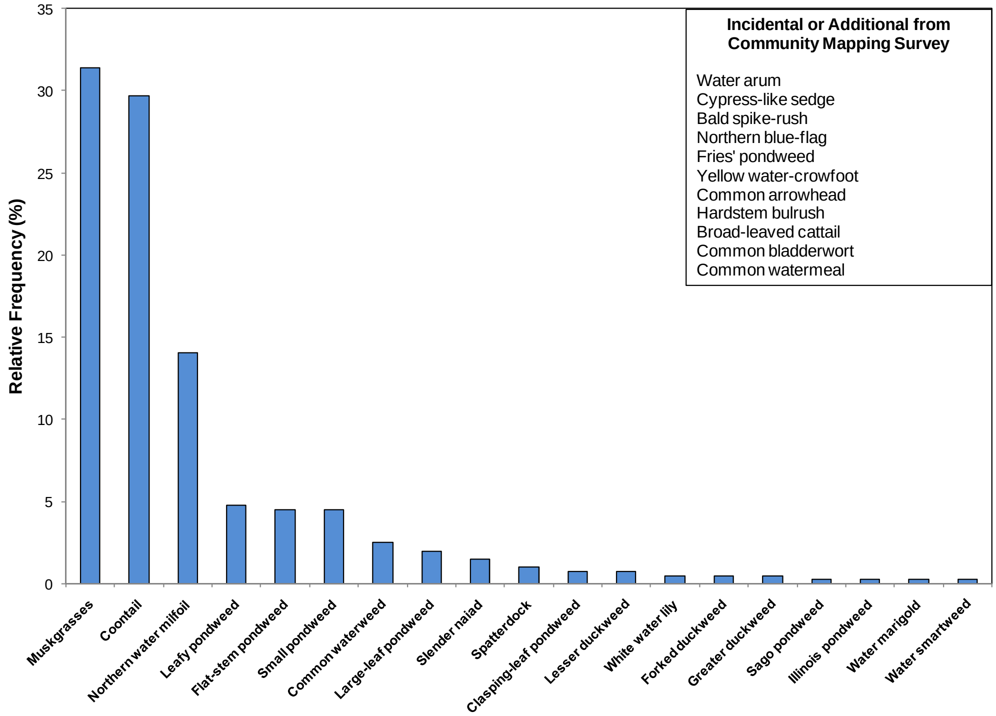

Figure 3.3-3 Windfall Lake aquatic plant occurrence analysis. Created using data from July and August 2008 surveys.

As discussed previously, the calculations used for the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. For example, while 30 native aquatic plant species were located in Big Portage Lake during the 2010 surveys, only 19 were encountered on the rake during the point-intercept survey. Figure 3.3-4 shows that the native species richness for Windfall Lake is above the Northern Lakes and Forests Ecoregion and Wisconsin State medians.

In lakes with higher nutrient inputs, like Windfall Lake, the species that are best adapted to access these nutrients directly from the water, like coontail, out-compete other species for space and light. Data collected from the aquatic plant surveys was used to calculate the average conservatism value (5.6) for Windfall Lake. This value is lower than both the Northern Lakes Ecoregion Median and the state median (Figure 3.3-4), indicating that the majority of Windfall Lake's plant community is composed of species that are more tolerant to disturbance. Combining the lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a value of 24.5 (equation shown below) which is slightly above the median values of the state and ecoregion (Figure 3.3-4).

$$\text{FQI} = \text{Average Coefficient of Conservatism } (5.6) * \sqrt{\text{Number of Native Species } (19)}$$
$$\text{FQI} = 24.5$$

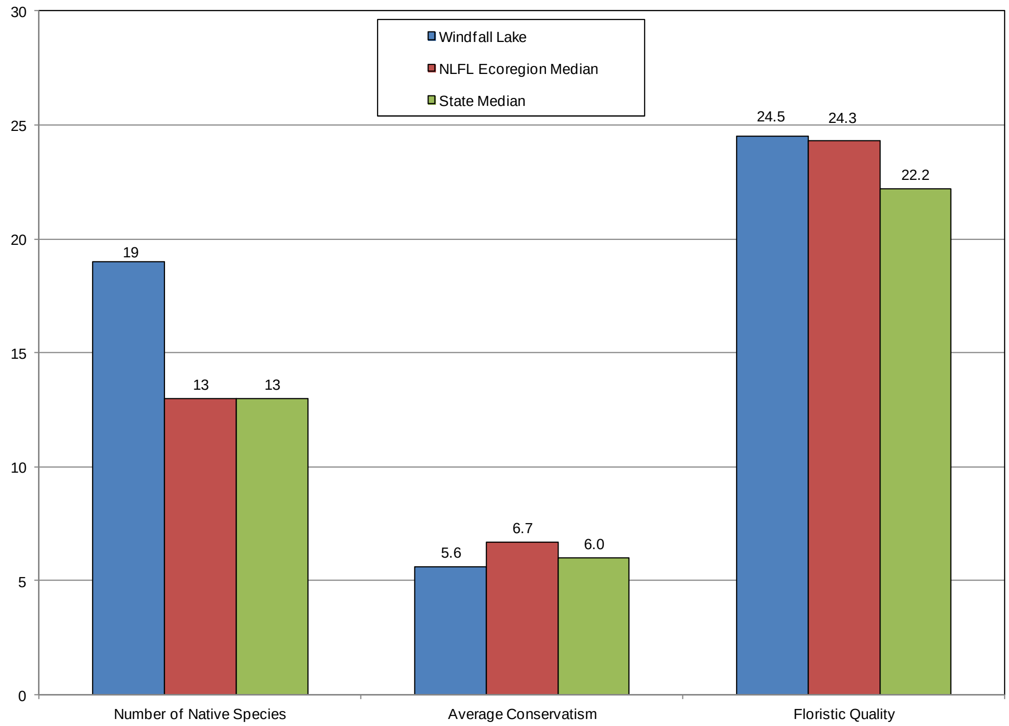

Figure 3.3-4. Windfall Lake Floristic Quality Assessment. Created using data from July and August 2008 surveys. Analysis following Nichols (1999).

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

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

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

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

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

The Simpson's diversity value for Windfall Lake is 0.78 (Figure 3.3-6), indicating that the lake has an uneven distribution (relative frequency) of plant species throughout the lake, and in this case, is overly dominated by muskgrasses and coontail. This value ranks below the ecoregion's lower quartile. Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food.

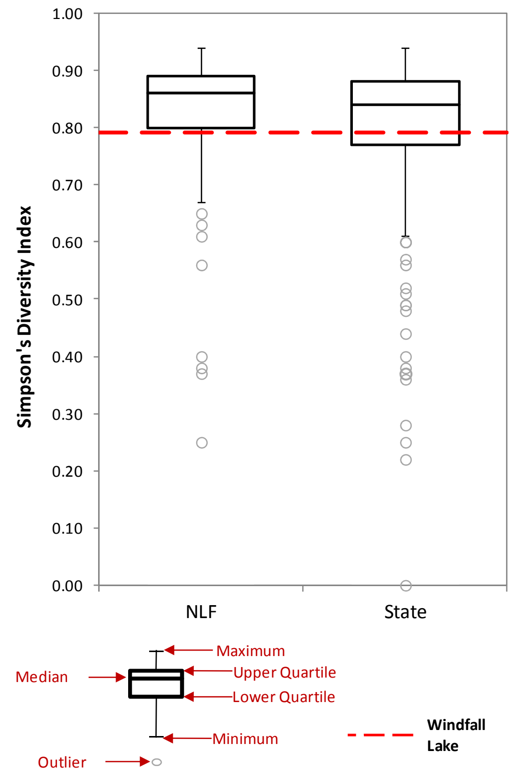

Figure 3.3-5. Windfall Lake species diversity index. Created using data from August 2011 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

While the submergent plant community is of relatively low diversity, the quality of Windfall Lake's plant community is indicated by the high incidence of emergent and floating-leaf plant communities that occur in near-shore areas around the lake. It was observed during summer 2008 vegetation surveys that Windfall Lake contains large areas of emergent and floating-leaf plant communities. The 2008 community map indicates that approximately 14.6 acres (26.5%) of the 55 acre lake contain these types of communities (Table 3.3-2, Map 3). Nine native floating-leaf and emergent species were observed, providing valuable fish and wildlife habitat important to the ecosystem of the lake.

Table 3.3-2. Windfall Lake acres of plant community types from the 2008 community mapping survey.

Plant Community	Acres
Floating-leaf	0.7
Mixed Floating-leaf and Emergent	13.9
Total	14.6

Continuing the analogy that the community map represents a 'snapshot' of the important plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Windfall Lake. This is important, because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill

(*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines.

Herbicide Control Plan

As stated above, nuisance levels of native plants have been controlled on Windfall Lake utilizing herbicides since the late 1960s or early 1970s. WLA members believe they were using diquat and copper sulfate to control the plants until 1984. In 1984, Ron Tschohl became secretary of the WLA and was appointed to be the weed control officer on the lake. Table 3.3-3 shows Mr. Tschohl's records of herbicide use on Windfall Lake between 1984 and 1995. Starting in 1996, the WDNR required the WLA to obtain herbicide application permits to conduct the control actions (Table 3.3-4).

Table 3.3-3. Herbicide treatment record for Windfall Lake between 1984 and 1995.

Year	Diquat (gal)	Copper Sulfate (lbs)
1984	8	300
1985	8	300
1986	6	300
1987	6	300
1988	*No Application(drought)*	*No Application (drought)*
1989	8	400
1990	6	200
1991	6	400
1992	4	200
1993	6	300
1994	5	300
1995	5	200

Table 3.3-4. Herbicide treatment record for Windfall Lake between 1996 and 2007. Years listed twice indicate multiple treatments within the same year.

Year	Diquat (gal)	Cutrine Mix (gal)	Copper Sulfate (lbs)	Cutrine (gal)
1996	4.5	-	14	-
1997	3	-	28	-
1997	3	-	28	-
1998	5	-	20	-
1999	5	-	-	1.25
2000	5	-	*Barley Straw only*	
2001	4	-	50	-
2002	6	3	-	6
2003	3	3	-	4
2003	6	2	-	3.5
2004	3	3	3.5	-
2005	7	3	6	-
2006	-	-	-	-
2007	4	-	*not permitted*	-
2007	3	-	*not permitted*	-

In May 2006, the WLA distributed a one-page member survey requesting information from its members. The results of the survey indicated that 39 of the 40 respondents were in favor of continuing the herbicide control plan including areas in front of their residences and other parts of the lake for fishing and recreational purposes (3 separate questions). Of the respondents, 34 also voted to have the lake tested for residual levels of herbicides; however, this action did not take place. Association members were divided (19 in favor, 21 opposed) on investigating purchasing a mechanical harvester.

An herbicide control program was at least moderately supported by 28 of the 32 respondents to the stakeholder survey sent to WLA members in 2008 (Appendix B, Question #18). This survey was distributed before mechanical harvesting activities commenced on Windfall Lake, with 24 of the 32 respondents being in favor of this action.

3.4 Windfall Lake Fishery

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

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

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near Chara or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other inverts
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge	*Esox masquinongy*	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pikes, crayfish, small mammals, water fowl, frogs
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3-0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (ter. and aq.)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1cm-1m deep	Crustaceans, insect larvae, and other inverts
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 vegetation	Small fish, aquatic invertebrates

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

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Central Mudminnow	*Umbra limi*	4	March - April	Eggs deposited on leaves of plants	Insects, amphipods and other aquatic invertebrates
Golden Shiner	*Notemigonus crysoleucas*	5	May - August	Over areas of Submerged Vegetation	Aquatic Invertebrates
White Sucker	*Catostomus commersoni*	8	April - Early May	Swift water or rapids, occasionally over gravel in lakes	Fish, fish eggs, plants, mollusks, insects, crustaceans and protazoans

Windfall Lake Fishing Activity

Based on data collected from the stakeholder survey fishing was the highest ranked important or enjoyable activity on Windfall Lake (Appendix B, Question #9). Approximately 97% of these same respondents believed that the quality of fishing on Windfall Lake was either fair or better (Appendix B, Question #6). 50% believed the quality of fishing had remained the same since they purchased their property, while 23.3% believe fishing has gotten worse and 26.6% believe fishing has improved (Appendix B, Question #7).

By several accounts, Windfall Lake has historically been a fertile lake, producing native aquatic plants at nuisance levels in the littoral section of the lake. Respondents in the 2008 stakeholder survey listed this excessive aquatic plant growth as the top factor negatively impacting the lake, and this was also their top ranked concern (Appendix B, Question #14 and # 15). Furthermore, 100% of respondents stated that aquatic plant growth sometimes or always impacts their enjoyment of the lake, and 93.8% believe aquatic plant control is needed in the lake (Questions #16 and #17). Table 3.4-1(above) shows the popular game fish and that are present in Windfall Lake. With all actions that are taken to address plant growth in Windfall Lake, it will be important to understand the potential impacts they will have on the fish community and plan their implementations accordingly. Specifically, the alteration of these elements may impact spawning habitat for fish species. Yellow perch is a species that could potentially be affected by early season plant management, as this could eliminate nursery areas for the emerged fry of these species. When aquatic plants are controlled utilizing a mechanical harvester, as has been done on Windfall Lake in years past, a general rule of thumb is to begin harvesting after June 1st, which would allow the vast majority of fish species to complete their spawning season.

Following a survey conducted in 1992-1994, David Brum of the WDNR stated that the dense aquatic plant growth in Windfall Lake was protecting panfish from predation and resulted in over-population (Appendix F). The management recommendation was to establish an intensive plant harvesting program, which would reduce cover for panfish and hopefully balance the predator / prey relationship in the lake.

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.4-1). Windfall Lake falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified systems. Studies suggest that up to 35% of a lake's walleye population and 20% of a muskellunge population can be removed annually without adverse affects. Each year, a "Safe Harvest" level is set at 35% of the walleye population and 20% of the muskellunge population. 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. In late winter, the six Wisconsin Chippewa Bands declare their intent to harvest a tribal quota. The tribal quota is a portion of the safe harvest. Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal quota and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

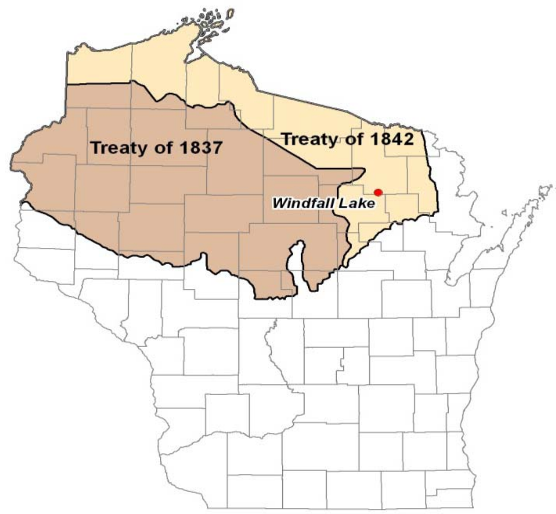

Figure 3.4-1. Location of Windfall Lake within the Native American Ceded Territory (GLIFWC 2009). This map was digitized by Onterra; therefore it is a representation and not legally binding.

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest. Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly quota is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the quota is met or the season ends.

In 2009, an estimated safe harvest for Windfall Lake was not designated for walleye, and was set at 3 muskellunge. Tribal declaration is usually set at 50-80% of the estimated safe harvest for a given lake. A combination of a low estimated safe harvest for walleye and the availability to spear other lakes in the region with higher estimated safe harvest have likely contributed to a lack of spearing activity on the lake.

Windfall Lake is located within ceded territory and special fisheries regulations may occur for muskellunge. There are currently no lake specific restrictions on muskellunge, so the one fish daily bag limit of 34” is in effect for Windfall Lake. There is one regulation specific to Windfall Lake bass species. After the third Saturday of June, the minimum length is increased from 14” to 18”, while the bag limit is decreased from five to one fish. This regulation was enacted to reduce over harvest of the species. Resident anglers conveyed that this rule has essentially created a 'catch and release' bass fishery, with almost no individuals being larger than 18 inches.

Windfall Lake Fish Stocking

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

The WDNR has stocked muskellunge and walleye in Windfall Lake, though recently only muskellunge has been stocked. It was determined through various WDNR surveys that walleyes were not naturally reproducing in the lake, and that stocked walleyes were also not surviving. In 1981 it was recommended that the walleye stocking program end in Windfall Lake, and that efforts take place to manage the fishery for muskellunge, bass and panfish. Table 3.4-2 displays both historic and more recent stocking efforts.

Table 3.4-3. Fish stocking data available from the WDNR from 1972 to 2009 (WDNR 2010).

Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
1972	Walleye	Fingerling	5,270	5
1973	Walleye	Fingerling	6,160	5
1974	Walleye	Fingerling	5,000	5
1975	Walleye	Fingerling	5,000	3
1977	Walleye	Fingerling	7,000	3
1994	Walleye	Fingerling	8,729	2.7
1974	Muskellunge	Fingerling	100	11
1977	Muskellunge	Fingerling	100	7
1981	Muskellunge	Fingerling	100	8
1985	Muskellunge	Fingerling	100	12
1987	Muskellunge	Fingerling	300	14
1991	Muskellunge	Fingerling	50	12
1992	Muskellunge	Fingerling	50	10
1997	Muskellunge	Large Fingerling	25	9.9
2001	Muskellunge	Large Fingerling	55	10.2
2003	Muskellunge	Large Fingerling	55	10.9
2005	Muskellunge	Large Fingerling	55	11.6
2007	Muskellunge	Large Fingerling	37	13

Windfall Lake Substrate Type

According to the point-intercept survey conducted by Onterra in 2008, all sampling locations had a soft, mucky substrate. Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Muskellunge is one species that does not provide parental care to its eggs. Muskellunge broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate so the eggs do not get buried in sediment and suffocate. Walleye is another species that does not provide parental care to its eggs. 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. Largemouth bass prefer habitats very similar to that of bluegill and prefer to both occupy and spawn in substrates of sand and gravel but like bluegill will spawn in softer substrates if necessary (Becker 1983).

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 Windfall Lake ecosystem.
2) Collect detailed information regarding whether invasive plant species occur within the lake.
3) Collect sociological information from Windfall Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

The three objectives were fulfilled during the project and have led to a good understanding of much of the Windfall Lake ecosystem, the folks that care about the lake, and what needs to be completed to protect and enhance it. As discussed in many of the sections above, nuisance levels of native aquatic plants within Windfall Lake ultimately spurred the WLA to initiate this planning effort. The WDNR requires that lakes conducting large-scale manipulations, like herbicide applications or mechanical harvesting, to update their management plan to the latest standards every 5-7 years.

Thirty native aquatic plant species and no non-native species were found during the summer 2008 plant surveys – an outstanding level of species richness when compared to other lakes within the state and the Northern Lakes and Forests ecoregion. With an average conservatism value of 5.6, the plant community of Windfall Lake is comprised of species that can tolerate disturbance and not those found primarily in more pristine environments. Some possible forms of disturbance on the system include maintenance of unnaturally stable water levels by the lake's dam, herbicide control strategies, and mechanical harvesting activities.

The plant community of Windfall Lake is clearly dominated by muskgrasses, which are actually macroalgae and not true vascular plants. Muskgrasses do very well in clear, calcium-rich systems like Windfall Lake and when found in such high abundance, make an unsuitable environment for more sensitive aquatic plants (i.e. those with higher conservatism values).

The abundance of native plant species within Windfall Lake likely has made it difficult for aquatic invasive species, like Eurasian water milfoil and curly-leaf pondweed, to take residence in Windfall Lake. Windfall Lake has the ability to support a large amount of aquatic plants. If aquatic invasive species become established in Windfall Lake, the nuisance plant problems that the association currently manages with will seem quite small in comparison.

In Wisconsin, high-speed boating can occur on all lakes greater than 50 acres unless more restrictive local ordinances have been put into place. Although greater than 55 acres, high speed boating on Windfall Lake due to its shape would likely have significant impacts including increased sediment resuspension, and destruction of near-shore aquatic habitat. Currently, a Town of Freedom ordinance restricts the use of combustion motors on Windfall Lake. Because of the large amount of aquatic plants within the lake and the navigation challenges that accompany small, electric motors within these situations, riparians discussed the possibility of removing the combustion motor restriction but restricting the size of the motors. While this would increase the ability to navigate on the lake, transient boating activity may also increase which would elevate the possibility of AIS exposure to Windfall Lake.

Between the late 1960s and 2007, the WLA applied aquatic herbicides (diquat, copper sulfate, and Cutrine) to reduce plant growth within the lake. WLA members and WDNR staff have expressed interest in sampling the lake sediments to determine if residual concentrations of these herbicides, particularly the copper-based herbicides, persist within the lake. Superficially, sampling the sediments for herbicide residuals appears simple; however, it is not. Before such an activity begins, a strategy needs to be developed which includes sample methodology, analysis, and interpretation.

During the planning process, the WLA was educated on the WDNR's updated policies on controlling native aquatic plants (Appendix G). Starting in 2009, the herbicide control plan was abandoned on Windfall Lake and a mechanical harvesting plan was created. The mechanical harvesting plan included within the Implementation Plan is solely aimed at improving navigation within Windfall Lake. This two-fold strategy includes riparian access lanes linking piers to open (deeper) water as well as common-use lanes allowing accessibility within the outlet and through the narrows linking the two basins.

An unintended benefit to the mechanical control program is that the access lanes will also serve as openings to increase predation of ambush predators, such as muskellunge, on panfish. Many riparians have expressed their wishes to increase mechanical harvesting intensity to include more predator lanes as well as accessibility for angling. As brought forth a number of times by WLA members, a fisheries report written in 1995 also indicates that mechanical harvesting would be beneficial for the fishery. As stated above, mechanical harvesting is a disturbance that should be minimized. Over the past 15 years, thoughts about mechanical harvesting and fisheries management have evolved. If WDNR fisheries biologists determine that increasing mechanical harvesting intensity is warranted, an updated mechanical harvest plan would need to be created.

Because the lake contains a very high biomass of aquatic plants, low oxygen levels have been documented during the winter. The decomposition of plant material over the winter can deplete the oxygen within the lake. These anoxic conditions may cause 'minor' fishkills, as observed when dead fish washed up on the shores after ice-out. Aeration systems can be used to alleviate this problem, but the cost of these systems and the dangers associated with open water on the lake during the winter may outweigh the benefits. As discussed within the Water Quality Section and outlined within the Implementation Section, monitoring these levels will provide valuable information to fisheries biologists and lake managers in determining if an aeration system is applicable for use within Windfall Lake.

While the majority of Windfall Lake's watershed is comprised of forested land, pasture/grasslands also comprise a large percentage of this area. Converting these areas into forest would be beneficial for Windfall Lake, reducing inputs of the limiting plant nutrient (phosphorus) from entering the lake. While much of Windfall Lake's near-shore landscapes have been maintained in a natural manner, efforts should be focused on educating new landowners of the importance of these practices.

Overall, Windfall Lake is in good condition. It is a productive lake that will always contain high quantities of aquatic plants. It will be important for the WLA to accept that this intrinsic nature of their lake is not a negative trait and simply understand that they will need to learn how to utilize the lake considering this quality. While significant and legitimate navigational issues occur on the lake, riparians will also need to increase their tolerance for aquatic plants to ensure the long-term health of Windfall Lake.

5.0 IMPLEMENTATION PLAN

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

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

Management Goal 1: Increase Windfall Lake Association's Capacity to Communicate with Lake Stakeholders

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

Timeframe: Begin summer 2010

Facilitator: Association Board of Directors to form Education Committee

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

Currently, the Windfall Lake Association does not regularly publish newsletters to association members due to the small number of members. However, the need for formal communication within the lake group is important because it builds a sense of community while facilitating the spread of important association news, educational topics, and even social happenings. It also provides a medium for the recruitment and recognition of volunteers. Perhaps most importantly, the dispersal of a well written news release can be used as a tool to increase awareness of many aspects of lake ecology and management among association members. By doing this, meetings can often be conducted more efficiently and misunderstandings based upon misinformation can be avoided. Educational pieces within the association newsletter may contain monitoring results, association management history, as well as other educational topics listed below.

Example Educational Topics:

Aquatic invasive species identification
Encouraging anglers harvesting slightly smaller size classes of panfish
Noise, air, and light pollution
Shoreland restoration and protection
Improving aquatic plant diversity
Septic system maintenance
Specific topics brought forth in other management actions

Action Steps:

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

Management Goal 2: Maintain Current Water Quality Conditions

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

Timeframe: Continuation of current effort.

Facilitator: Ron Tschohl

Description: Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason as of why the trend is developing. Volunteers from the WLA have been collecting Secchi disk clarities and water chemistry samples through the WDNR Citizen Lake Monitoring Program. The volunteer monitoring of the water quality is a large commitment and new volunteers may be needed in the future as the volunteer's level of commitment changes. It is the responsibility of the Planning Committee to coordinate new volunteers as needed. Note: as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Winter dissolved oxygen levels were shown to be quite low on Windfall Lake. If increasing concerns about these levels exist within the WLA, the association should purchase a dissolved oxygen probe. This would allow this parameter to be monitored in conjunction with the regularly scheduled CLMN water sample collection. A WDNR small-scale Lake Planning Grant would be applicable for the costs of the equipment purchase.

Action Steps:

Please see description above.

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

Timeframe: Begin 2009

Facilitator: Education Committee

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

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

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

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

Action Steps:

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

Management Action: Complete Shoreland Condition Assessment as a part of next management plan update.
Timeframe: Begin 2009
Facilitator: Board of Directors
Description: As discussed above, unnatural shorelands can negatively impact the health of a lake, both by decreasing water quality conditions as well as removing valuable habitat for fish and other aquatic species that reside within the lake. Understanding the shoreland conditions around Windfall Lake will serve as an educational tool for lake stakeholders as well as identify areas that would be suitable for restoration. Shoreland restorations would include both in-lake and shoreline habitat enhancements. In-lake enhancements would include the introduction of course woody debris, a fisheries habitat component lacking around the shores of Windfall Lake. Shoreline enhancements would include leaving 30-foot no-mow zones or by planting native herbaceous, shrub, and tree species as appropriate for Forest County.

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

Action Steps: See description above.

Management Goal 3: Maintain Public Access to Windfall Lake

Management Action: Support reasonable and responsible actions by shoreland property owners to gain navigational access to open water areas of Windfall Lake
Timeframe: Begin 2009
Facilitator: Association Board of Directors
Description: Overwhelmingly, all but two respondents of the stakeholder survey believed aquatic plant control is needed on Windfall Lake, with the other two being unsure. (Appendix B, Question #17). Nuisance levels of aquatic plants were also stated to be the single greatest factor negatively impacting Windfall Lake (Appendix B, Question #14 & 15). The plant species of concern on the lake are largely emergent species such as pickerelweed and floating-leaf species such as water lilies and watershield.

The WLA supports reasonable and environmentally sound actions to facilitate access to open water areas of Windfall Lake consistent with Aquatic Plant Management Strategy Northern Region WDNR (Appendix G) These actions would target nuisance levels of native aquatic plants in order to restore watercraft access to open water areas of the lake. Reasonable and environmentally sound actions are those that meet WDNR regulatory and permitting requirements and do not impact anymore shoreland or lake surface area required to permit the access. These actions do not include areas that can be controlled through manual removal such as riparian swimming areas. This guidance document clearly states that no individual permits will be issued.

Three possibilities exist to maintain access to open water from the impacted riparian properties: 1) contract to have the plants removed manually, 2) contract to have the plants cut and removed through mechanical harvesting, and 3) apply herbicides to kill the plants. With any of these options, the ecology of the area must be seriously considered. Loss of native plants in any area of a lake is unfortunate because they are the foundation of the lake ecosystem. Further, in a lake such as Windfall Lake where invasive plant species are not known to exist, the destruction of native plant stands may cause a disturbance that would allow for easier non-native establishment.

At this time it is unknown if a contractor exists that is able to manually remove the plants in feasible manner that would create navigation lanes to open water from the shoreland properties. Local landscaping companies may fill this niche as more lakes seek this service.

In 2009, a small mechanical harvester-like service was contracted from Silver Mist Aquatic Services to allow navigability in certain areas of the lake that contain dense, nuisance levels of native aquatic plants that are almost entirely impenetrable without gas-powered motors. Map 4 shows the mechanical harvesting plan that was developed in conjunction with Onterra ecologists, WDNR staff, and association members. A 20-foot general access lane was created in the outlet and a 40-foot lane within the narrow restriction between the two basins allowing navigation throughout the lake. Harvesting activities also occurred within 20-foot access lanes that extended lakeward from the docks of impaired riparians to deeper water where plants do not hinder navigation.

In 2010, there was some consolidation of riparian access lanes along the western shoreline of the southern basin into a community access lane for the few riparians within that area (Map 4).

The WLA understands that harvesting activities are **not** to include:

- Clear cutting areas for any reason.
- Removing plants to increase a riparians ability to fish off of their dock.
- Cutting an access lane from a riparian's property if there is already a sufficient alternative (i.e. path to the lake).
- Cutting a lane when manual removal techniques can be used.

Within the WDNR issued harvesting permit, conditions will likely be placed on the association to ensure that harvesting activities are warranted, sediment re-suspension is monitored, and all harvested plants are removed from the lake and disposed of properly. Appendix H includes the conditions placed on the 2010 mechanical control actions.

Mechanical harvesting activities have the ability to spread aquatic invasive species throughout a lake. Harvesting activities will not occur if Eurasian water milfoil or curly-leaf pondweed is found within the harvest areas.

Action Steps:

1. Association applies annually for a harvesting permit.
2. Association contracts harvesting services and follows the plan listed above and restrictions indicated on WDNR permit.
3. Harvest summary report is provided to the WDNR annually after each harvesting season.

Management Goal 4: Prevent Introduction and Establishment of Aquatic Invasive Species within Windfall Lake

Management Action: Initiate Clean Boats Clean Waters watercraft inspections at Windfall Lake public access.

Timeframe: In progress

Facilitator: Board of Directors to form Invasive Species Committee

Description: Windfall Lake is believed to be free of aquatic invasive species. Initiating a program of watercraft inspections based upon the WDNR Clean Boats Clean Waters program will help to reduce the chance that exotic species, such as Eurasian water milfoil, zebra mussels, and curly-leaf pondweed would be introduced to the lake. Windfall Lake is not considered a primary fishing destination in Forest County, largely because its small size and ban on gas motors.

Because of these factors, it is not visited on a frequent basis by lake users that do not have property on the lake. An inspection program aimed at the most busy weekends of the year would be targeted for watercraft inspections by volunteers from Windfall Lake.

Action Steps:

1. Training of additional volunteers completed by those already trained in Clean Boats Clean Waters protocols.
2. Begin inspections during high-risk weekends
3. Report results to WDNR and WLA.
4. Promote enlistment and training of new of volunteers to keep program fresh.

Management Action: Initiate volunteer-based monitoring of aquatic invasive species.
Timeframe: Start 2009.
Facilitator: Invasive Species Committee
Description: In lakes without Eurasian water milfoil, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. Using trained volunteers is a feasible method to monitor for the occurrence of these unwanted species. The keys to success are proper training and persistence by the lake group.

Action Steps:

1. Volunteers from WLA attend training session conducted by WDNR/UW-Extension.
2. Trained volunteers recruit and train additional Association members.
3. Complete lake surveys following protocols.
4. Report results to WDNR and WLA.

6.0 METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Windfall 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 protocols and occurred once in spring and winter and three times during the summer. 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 table below. Secchi disk transparency was also included during each visit.

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

The diamond shape indicates samples collected as a part of the Citizen Lake Monitoring Network and the circle indicates samples collected under the proposed project funding. *The winter samples were collected by Onterra. Winter dissolved oxygen was determined with a calibrated probe and all samples were collected with a 3-liter Van Dorn bottle.

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were Windfall Lake on July 1, 2008 during field visits, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat. No curly-leaf pondweed was located during this survey.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Windfall Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in Appendix C of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin, (April, 2008) was used to complete this study on July 14, 2008. A point spacing of 33 meters was used resulting in approximately 196 points.

Community Mapping

On August 5, 2008, the aquatic vegetation community types within Windfall 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 (Appendix E) and the community mapping surveys were recorded to provide a complete species list for the lake.

Watershed Analysis

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

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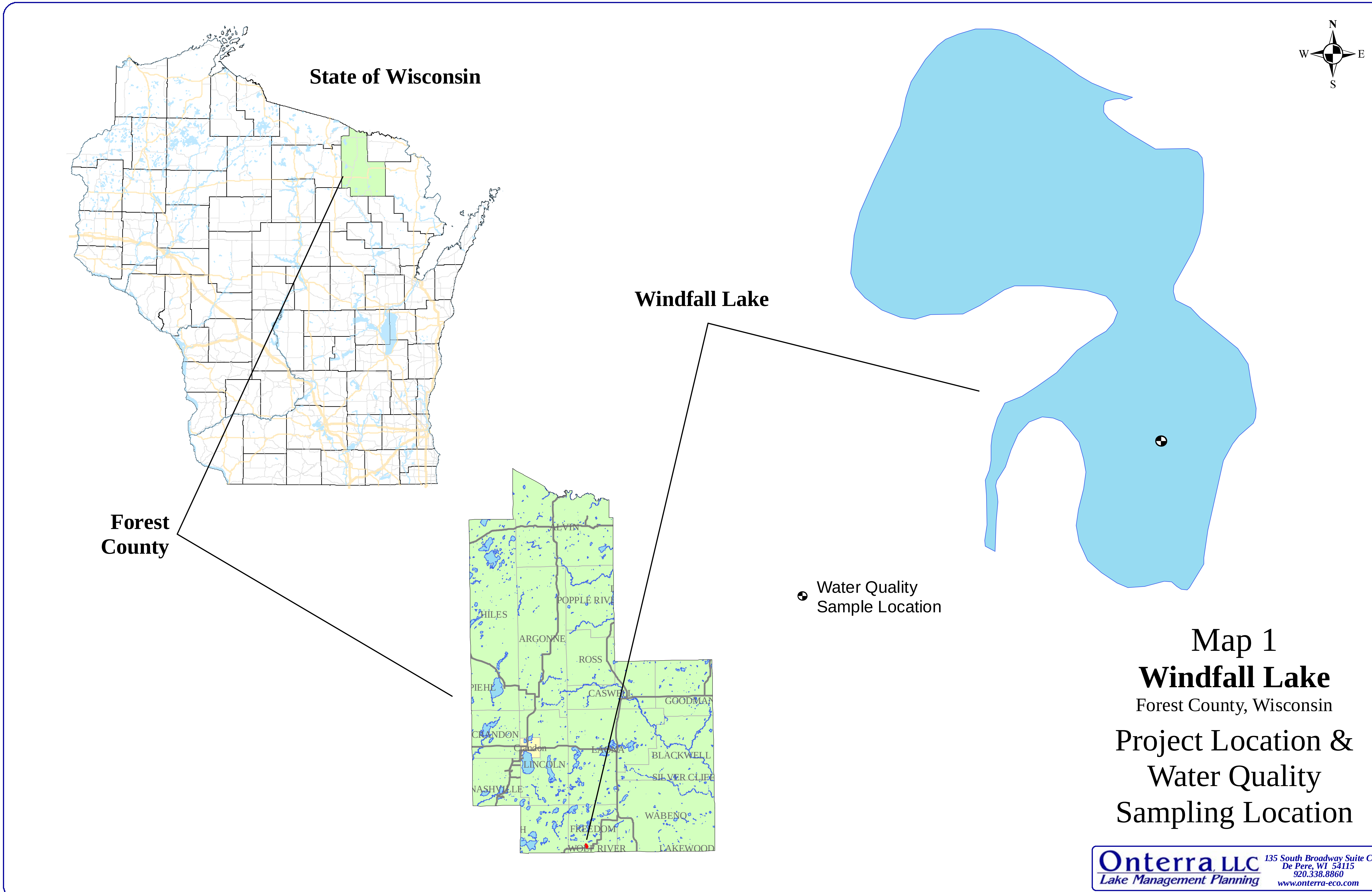
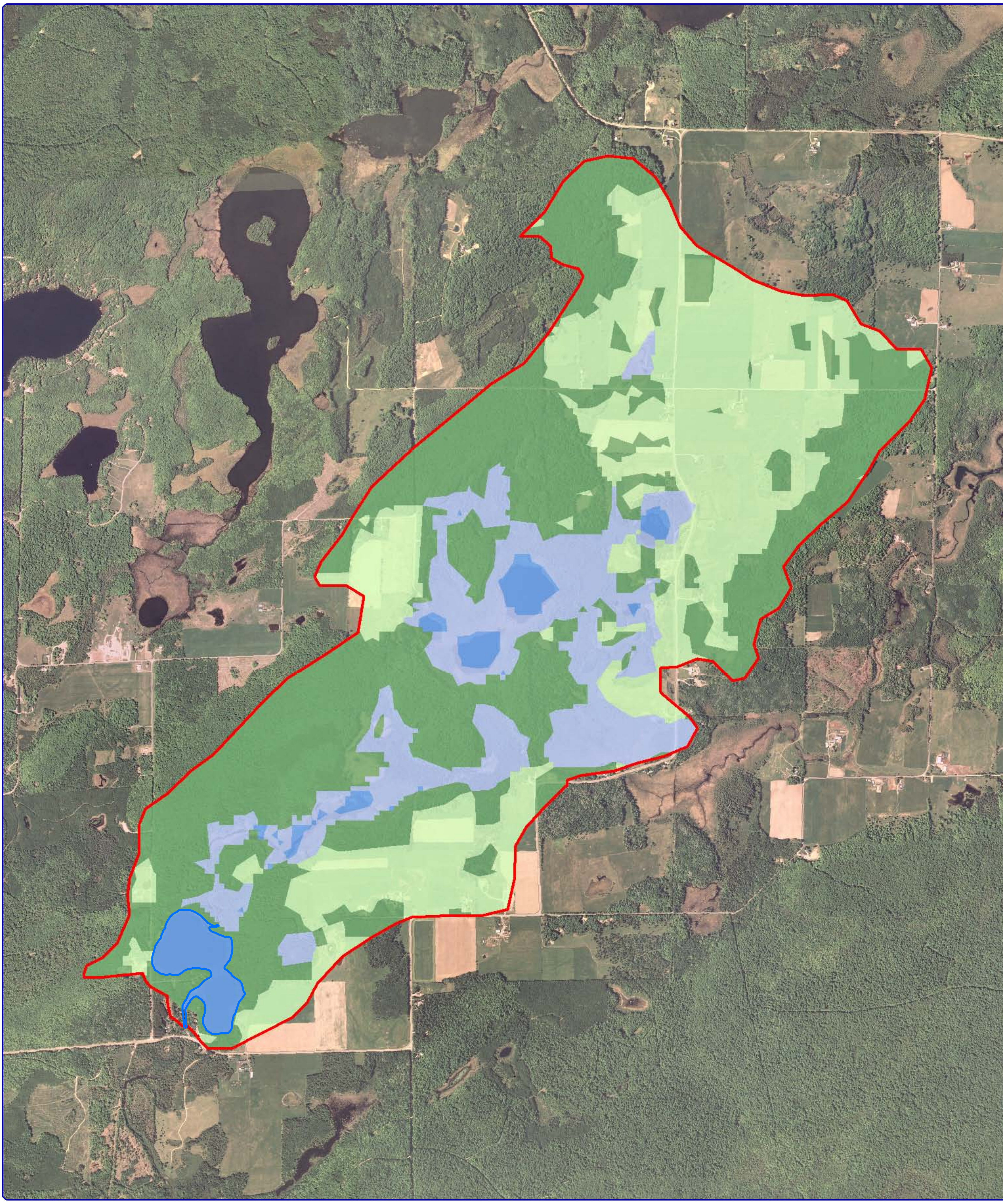
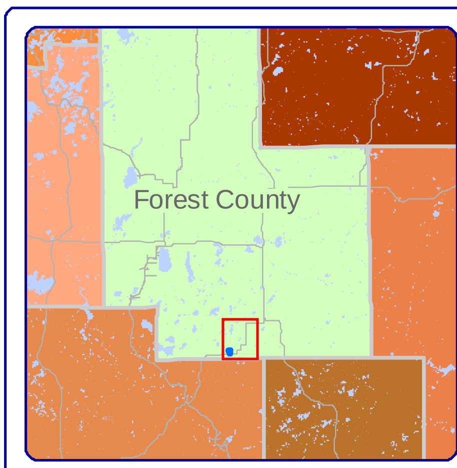


State of Wisconsin
Windfall Lake
Forest County
N
S
E
W
ARGONNE
ROSS
CRANDON
LINCOLN
BLACKWELL
WABENO
FREEDOM
WOLF RIVER
LAKEWOOD
Water Quality
Sample Location
Map 1
Windfall Lake
Forest County, Wisconsin
Project Location &
Water Quality
Sampling Location
Onterra, LLC
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com



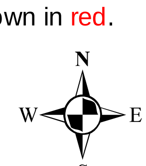


Extent of large map shown in red.

Sources:

Watershed: WDNR & Onterra
Landcover: WISCLAND
Roads & Hydro: WDNR
Orthophotography: NAIP, 2005

Map Date: November 6, 2008



Legend

Watershed Boundary

Land Cover Types

Pasture/Grass

Forest

Open Water

Wetland

Map 2

Windfall Lake

Forest County, Wisconsin

Watershed and Land Cover types

2,000

Feet

Onterra, LLC
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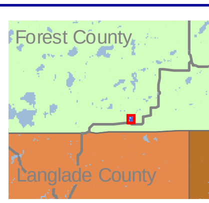
N
W E
S

350

Feet

Onterra LLC
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Orthophotography: NAIP 2005
Aquatic Plant Survey: Onterra, 2008
Map Date: December 3, 2008



Extent of large map shown in red.

Legend

Small Plant Communities
- Emergent
- Floating-leaf *(none found)*
- Mixed floating-leaf & emergent *(none found)*

Large Plant Communities
- Emergent *(none found)*
- Floating-leaf
- Mixed floating-leaf & emergent

Map 3
Windfall Lake
Forest County, Wisconsin

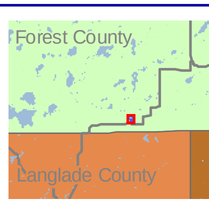
Aquatic Plant Communities

N
W E
S

300
Feet

Onterra LLC
Lake Management Planning
135 South Broadway Suite C
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Orthophotography: NAIP 2005
Aquatic Plant Survey: Onterra, 2008
Map Date: March 11, 2010



Extent of large map shown in red.

Legend
Harvest Lanes (~1.6 acres)
20-foot wide lane
40-foot wide lane
Aquatic Plant Communities
Floating-leaf
Mixed floating-leaf & emergent

Map 4
Windfall Lake
Forest County, Wisconsin
Mechanical Harvest Plan