Indian Lake

Oneida County, Wisconsin

Comprehensive Management Plan

May 2014

Sponsored by:

Indian Lake Association
WDNR Grant Program

LPL-1478-12

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Onterra LLC
Lake Management Planning

Indian Lake

Oneida County, Wisconsin

Comprehensive Management Plan

May 2014

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Indian Lake Planning Committee

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Mike McCarthy	Jim Hoover	Al Albee
Steve Newcomb		

Organization

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1.0 INTRODUCTION

Indian Lake, Oneida County, is a 357-acre spring lake with a maximum depth of 26 feet and a mean depth of 10 feet (Map 1). This mesotrophic lake has a relatively small watershed when compared to the size of the lake. Indian Lake contains 57 native plant species, of which fern pondweed is the most common plant. One exotic plant, purple loosestrife, was found on Indian Lake.

Field Survey Notes

Diverse substrate observed during point-intercept survey, with organic rich sediments, sandy areas and rock bars all observed. Many native plant species encountered also.

Photograph 1.0-1 Indian Lake, Oneida County

Lake at a Glance* - Indian Lake

Morphology	
Acreage	357
Maximum Depth (ft)	26
Mean Depth (ft)	10
Shoreline Complexity	4.5
Vegetation	
Early-Season AIS Survey Date	June 5, 2012
Comprehensive Survey Date	July 11 & 12, 2012
Number of Native Species	57
Threatened/Special Concern Species	Vasey's Pondweed *(Potamogeton vaseyi*)
Exotic Plant Species	Purple loosestrife (*Lythrum salicaria*)
Simpson's Diversity	0.90
Average Conservatism	7.2
Water Quality	
Trophic State	Mesotrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	8.0
Sensitivity to Acid Rain	Not sensitive
Watershed to Lake Area Ratio	2:1

These parameters/surveys are discussed within the management plan.

Indian Lake may be considered a spring lake, due to its lack of an input stream and presence of an outlet. Water flows from this outlet through Indian Chain Creek and eventually into nearby Chain Lake.

The Indian Lake Association (ILA) was chartered by the residents of Indian Lake in 2006. Since the association began, the ILA has been increasingly active in management and educational activities involving the lake. The association has distributed newsletters twice a year for the past 2-3 years to its members, which documents information regarding the association and Indian Lake but more importantly promotes communication among lake residents. ILA members are involved in the WDNR's (Wisconsin Department of Natural Resources) Citizen Lake Monitoring Network (CLMN), and have trained volunteers on Clean Boats/Clean Waters (CBCW) protocols. Five lake residents have been trained by Project Loon Watch, and have assisted WDNR biologist Mike Myers in banding and monitoring loons on Indian Lake since 2005.

With an increase in volunteer-based activity and formation of a lake association, the ILA soon became interested in forming a lake management plan. There were two reasons for this interest. First, association members wanted to initiate a program to prevent introduction of aquatic invasive species (AIS). Secondly, they realized the value in gaining a better understanding of lake ecology and the overall condition of their lake. In the end, the information obtained will help guide future ILA plans and programs. Additionally, the association knows that the WDNR can respond more quickly and accurately to address a new invasive species establishment if the lake has a management plan in place. Furthermore, completing a management plan for Indian Lake is consistent with the lake association's mission, which is *to preserve Indian Lake and its surroundings, and to enhance the water quality, fishery, boating safety, and aesthetic values of Indian Lake as a public recreation facility for today and future generations.*

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 and through the completion of a stakeholder survey.

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

Kick-off Meeting
On June 23, 2012, a project kick-off meeting was held to introduce the project to the general public. The meeting was announced through a mailing and personal contact by Indian Lake Association board members. The attendees observed a presentation given by Eddie Heath, an aquatic ecologist with Onterra. Mr. Heath's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation was followed by a question and answer session.

Planning Committee Meeting I
On May 29, 2013, Dan Cibulka and Eddie Heath of Onterra met with the Indian Lake Planning Committee for the first of two planning meetings. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including water quality analyses, watershed modeling, aquatic plant inventories and fisheries data research were discussed at length. Several concerns were raised by the committee including water level monitoring, organic material build-up in the lake, volunteer engagement within the association and keeping Indian Lake free of AIS.

Planning Committee Meeting II
A second planning meeting was held on July 9, 2013 between Dan Cibulka and the Indian Lake Planning Committee. At this meeting, the group underwent brainstorming exercises which helped to shape several management goals the committee wished to follow to better manage Indian Lake.

Project Wrap-up Meeting
At the time of this writing, the project's Wrap-up meeting has been planned for summer of 2014. During this meeting Onterra staff will present the highlights of scientific studies to the ILA general membership as well as present the Implementation Plan that was crafted by the ILA planning committee and Onterra staff.

Management Plan Review and Adoption Process

In mid May 2013, a draft of the Results Section (Sections 2.0 and 3.0) of this management plan was provided to the Indian Lake Planning Committee for review and preparation for the first planning meeting. The Summary and Conclusions as well as the Implementation Plan of this report (Sections 4.0 and 5.0) were provided to the planning committee following the second planning meeting, in December of 2013. The planning committee reviewed the report during January-March of 2014, providing a review to Onterra staff that was addressed during this time. Following commentary provided by the committee, the report was updated and submitted to WDNR reviewers on March 12, 2014. On April 23, 2014, the WDNR presented a review of the plan along with recommendations and comments. The plan was finalized in May of 2014.

Stakeholder Survey

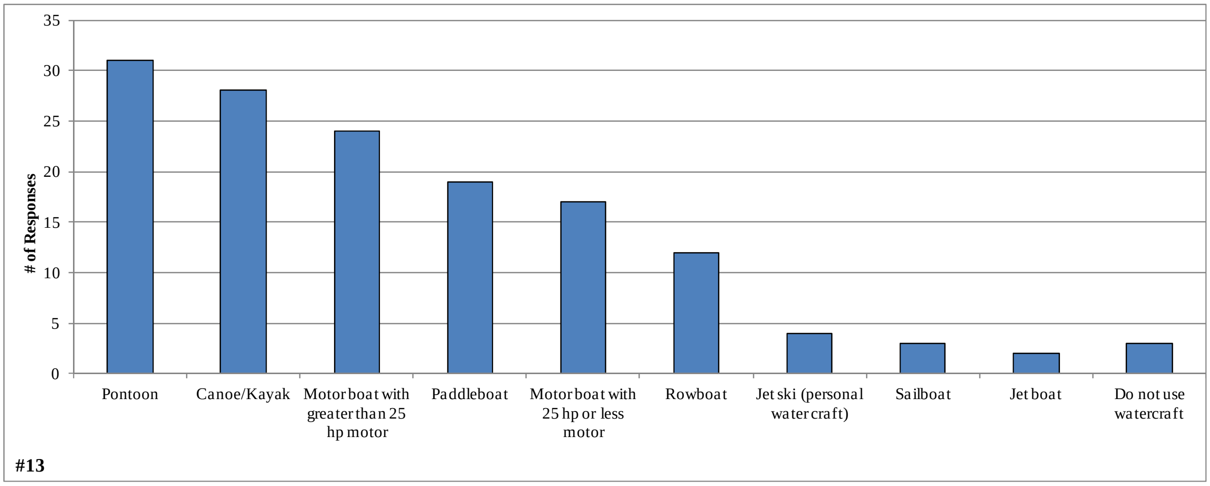
During the summer of 2012, members of the Indian Lake Planning Committee worked with Onterra staff to develop an anonymous stakeholder survey, which would be distributed to all ILA members and non-members with property along Indian Lake. This survey was approved by a WDNR sociologist in August of 2012, and during that same month, a seven-page, 30-question survey was mailed to 116 riparian property owners in the Indian Lake watershed. 53 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Indian Lake Planning Committee. The data were summarized and analyzed by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a general summary is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Indian Lake. The majority of stakeholders who returned the survey (44%) are year-round residents, while 36% visit on weekends through the year and 13% live on the lake during the summer months only (Appendix B, Question #1). About 52% of stakeholders have owned their Indian Lake property for over 15 years, and 24% have owned their property for over 25 years (Question #3).

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. The majority of survey respondents indicated that they use a pontoon boat or canoe/kayak on the lake (Question #13). Motor boats, paddleboats and rowboats were also popular options. On a moderately sized lake with shallow rocky areas such as Indian Lake, the importance of responsible boating activities is increased. The need for responsible boating increases during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the lake. As seen on Question #14, several of the top recreational activities on the lake involve boat use.

Within the anonymous survey, stakeholders had the opportunity to express their thoughts as to what factors might be negatively impacting Indian Lake and which factors are their top concerns regarding the lake. Survey respondents ranked excessive aquatic plant growth, algae blooms and shoreland property runoff as factors that were negatively impacting the lake (Question #20). The top ranking concerns stakeholders had regarding the lake include AIS, water quality degradation and excessive plant growth (Question #21). These topics are discussed at length within the remaining sections of this document, as well as the Summary & Conclusions section and within the Implementation Plan.

Question #13: What types of watercraft do you currently use on the lake?



Question #14: Please rank up to three activities that are important reasons for owning your property on or near the lake.

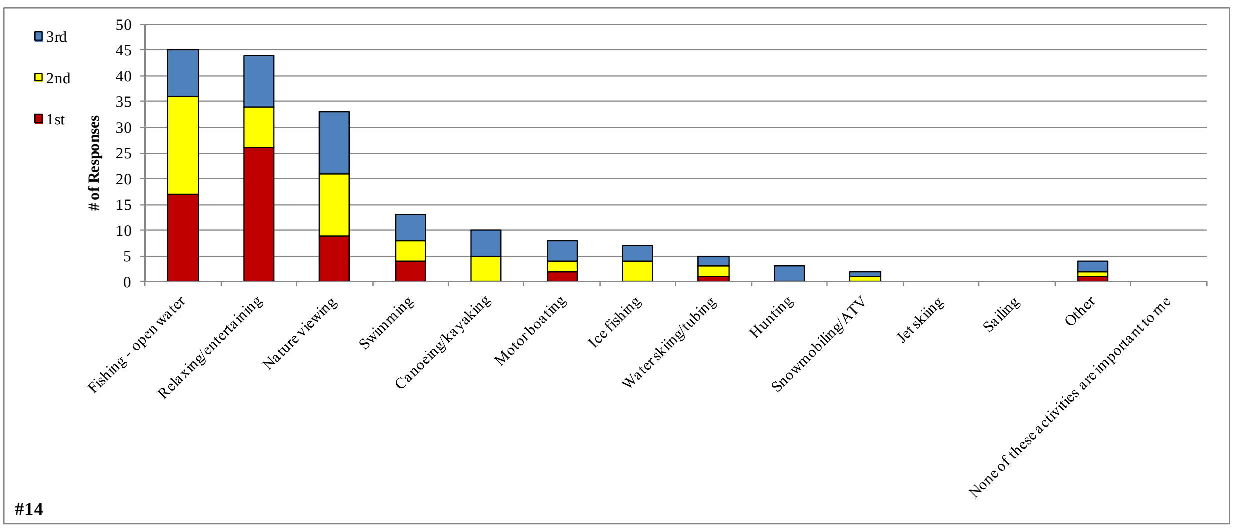
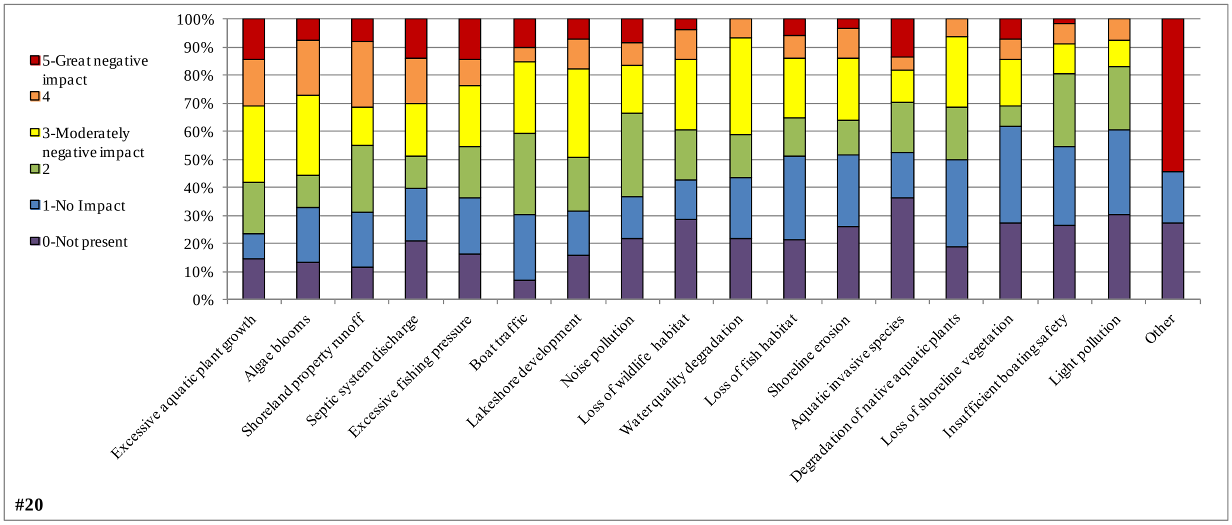


Figure 2.0-1. Select survey responses from the Indian Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question #20: To what level do you believe these factors may be negatively impacting Indian Lake?



Question #21: Please rank your top three concerns regarding Indian Lake.

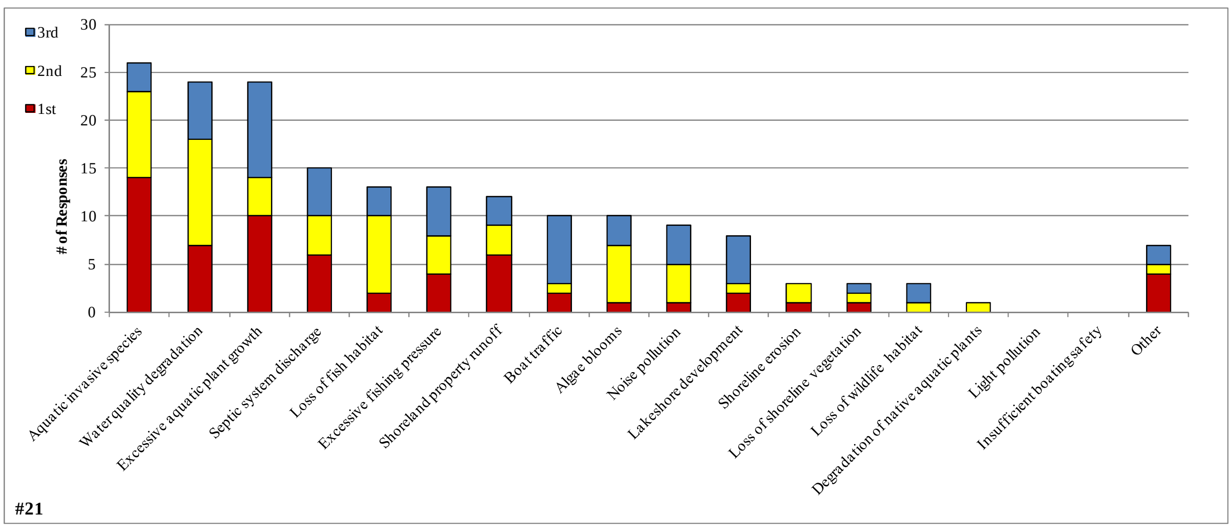


Figure 2.0-2. Select survey responses from the Indian Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

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

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

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

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

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

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

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

Trophic State

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

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

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

Limiting Nutrient

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

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

Temperature and Dissolved Oxygen Profiles

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

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.

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.

Internal Nutrient Loading

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

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

Non-Candidate Lakes

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

Candidate Lakes

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

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

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

Comparisons with Other Datasets

The WDNR publication *Implementation and Interpretation of Lakes Assessment Data for the Upper Midwest* (WDNR 2009) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's land cover. For this reason, the water quality of Indian Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into 6 classifications (Figure 3.1-1).

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

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

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

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

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

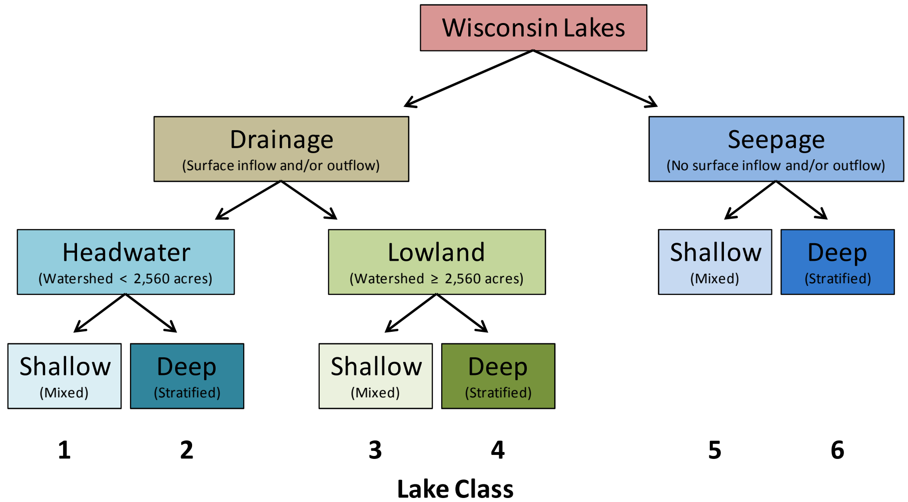


Figure 3.1-1. Wisconsin Lake Classifications. Indian Lake is classified as a shallow (mixed), headwater drainage lake (Class 1). Adapted from WDNR 2009.

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

The Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM), created by the WDNR, is a process by which the general condition of Wisconsin surface waters are assessed to determine if they meet federal requirements in terms of water quality under the Clean Water Act (WDNR 2009). It is another useful tool in helping lake stakeholders understand the health of their lake compared to others within the state. This method incorporates both biological and physical-chemical indicators to assess a given waterbody's condition. In the report, they divided the phosphorus, chlorophyll-*a*, and Secchi disk transparency data of each lake class into ranked categories and assigned each a "quality" label from "Excellent" to "Poor". The categories were based on pre-settlement conditions of the lakes inferred from sediment cores and their experience.

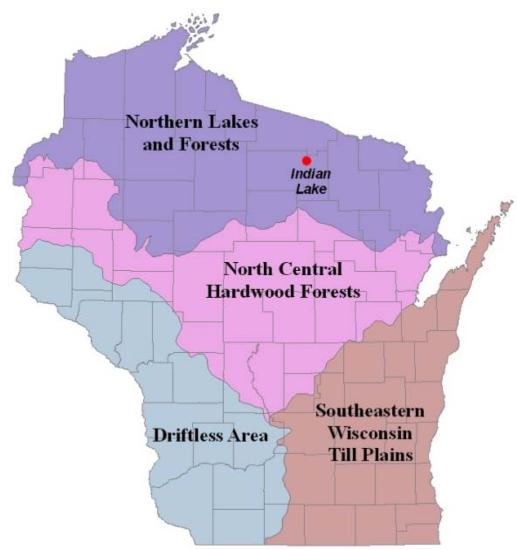


Figure 3.1-2. Location of Indian Lake within the ecoregions of Wisconsin. After Nichols 1999.

These data along with data corresponding to statewide natural lake means, historic, current, and average data from Indian Lake is displayed in Figures 3.1-3 - 3.1-8. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-*a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

Indian Lake Water Quality Analysis

Indian Lake Long-term Trends

As a part of this study, Indian Lake stakeholders were asked about their perceptions of the lake's water quality. The majority (66%) of lake residents rated the water quality of Indian Lake as *Good* while 19% ranked the lake's water as *Fair* (Appendix B, Question #15). Roughly 53% of survey respondents stated that the water quality had *Remained the same* since they first visited the lake, while 37% indicated the water quality had *Somewhat degraded* and 9% were unsure on their opinion (Question #16). Indian Lake survey respondents expressed concern over algae blooms, shoreland property runoff and septic system discharge (Question #20) and ranked water quality degradation as the 2nd of their top three concerns regarding Indian Lake (Question #21).

It is often difficult to determine the status of a lake's water quality purely through observation. Anecdotal accounts of a lake "getting better" or "getting worse" can be difficult to judge because a) a lake's water quality may fluctuate from year to year based upon environmental conditions such as precipitation or lack thereof, and b) differences in observation and perception of water quality can differ greatly from person to person. It is best to analyze the water quality of a lake through scientific data as this gives a concrete indication as to the health of the lake, as whether the lake health has deteriorated or improved. Further, by looking at data for similar lakes regionally and statewide, one can determine what the status of the lake is by comparison.

Total phosphorus, chlorophyll-*a* and Secchi disk clarity data has been collected by numerous entities over the past few decades. Unfortunately, total phosphorus and chlorophyll-*a* have not been collected in a consistent manner. Historic as well as recent total phosphorus values can be viewed in Figure 3.1-3. Values collected in the past as well as through this project (2012) consistently average between 14 and 30 µg/L, with the higher value being collected once in 1976. A weighted average of summer data over all years equals 16.8 µg/L, and falls below median values when compared to other shallow, headwater drainage lakes within the state as well as below the median for all lakes in the Northern Lakes and Forests ecoregion. Overall, phosphorus concentrations have consistently been measured in a category that may be described as *Excellent* for a shallow, headwater drainage lake.

On several occasions, total phosphorus samples have been collected from the surface as well as near the bottom of the lake's deep hole (Figure 3.1-4). As described above, lakes may stratify at times, which reduced the oxygen in the hypolimnion both in the water column and within the sediment. This may result in the release, or recycling of phosphorus into the water. On several occasions, slightly higher concentrations of phosphorus were observed in Indian Lake. Though these concentrations are higher than at the surface, they are not present in levels that are alarming. They do indicate that a minor amount of nutrient recycling is occurring, which is a normal process in lakes such as Indian Lake.

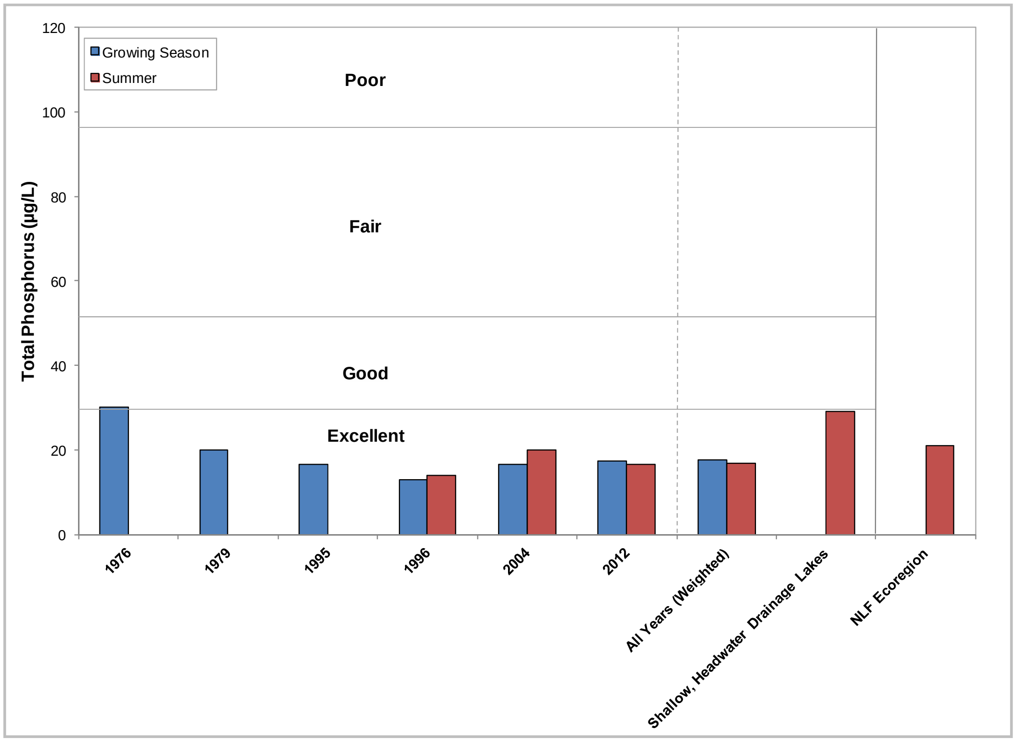


Figure 3.1-3. Indian Lake, state-wide class 1 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR 2009. NLF stands for Northern Lakes and Forests.

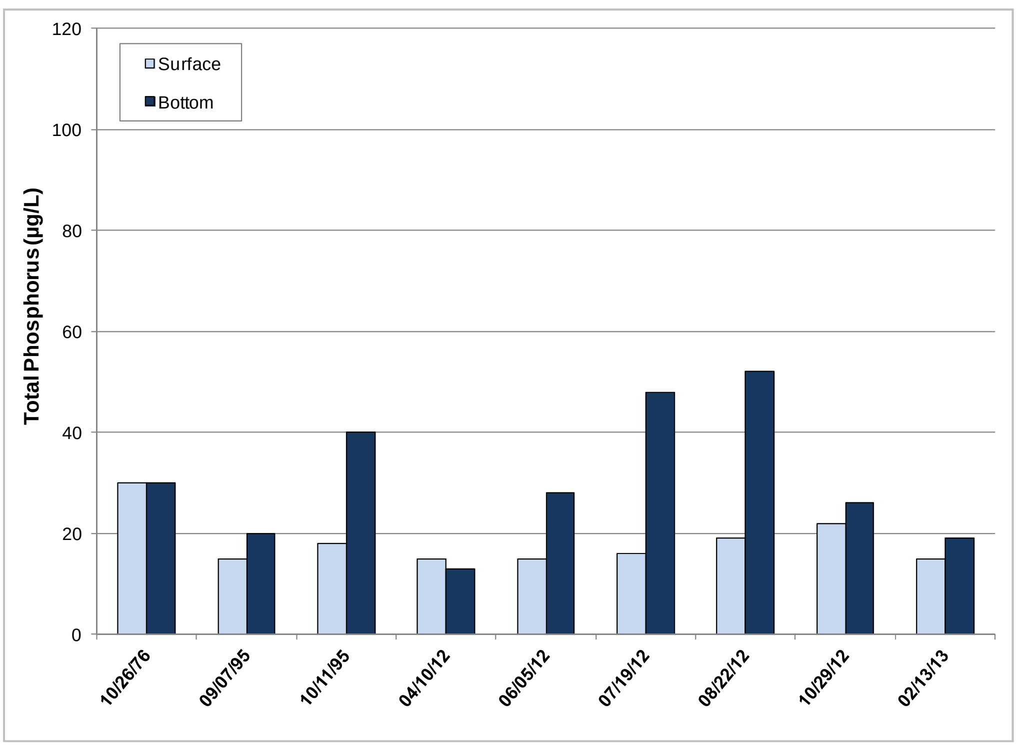


Figure 3.1-4. Indian Lake surface and bottom total phosphorus concentrations. Data collected from historical records (WDNR SWIMS) and Onterra 2012-2013 sampling. All concentrations are actual values, not averages.

Chlorophyll-*a*, the photosynthetic pigment that is found in plants and algae, has been measured several times on Indian Lake to reference the amount of water column algae that are present in the lake (Figure 3.1-5). In the three most recent years of collected data (1996, 2004 and 2012) these concentrations were found to range between summer averages of 5.8 µg/L and 8.5 µg/L. A weighted summer average over all years was calculated to be 6.6 µg/L, which is lower than the median value for similar (class 1) lakes across the state and only slightly higher than lakes within the ecoregion. Still, the values found on Indian Lake rank as *Excellent* in most years when compared to other shallow, headwater drainage lakes in the state.

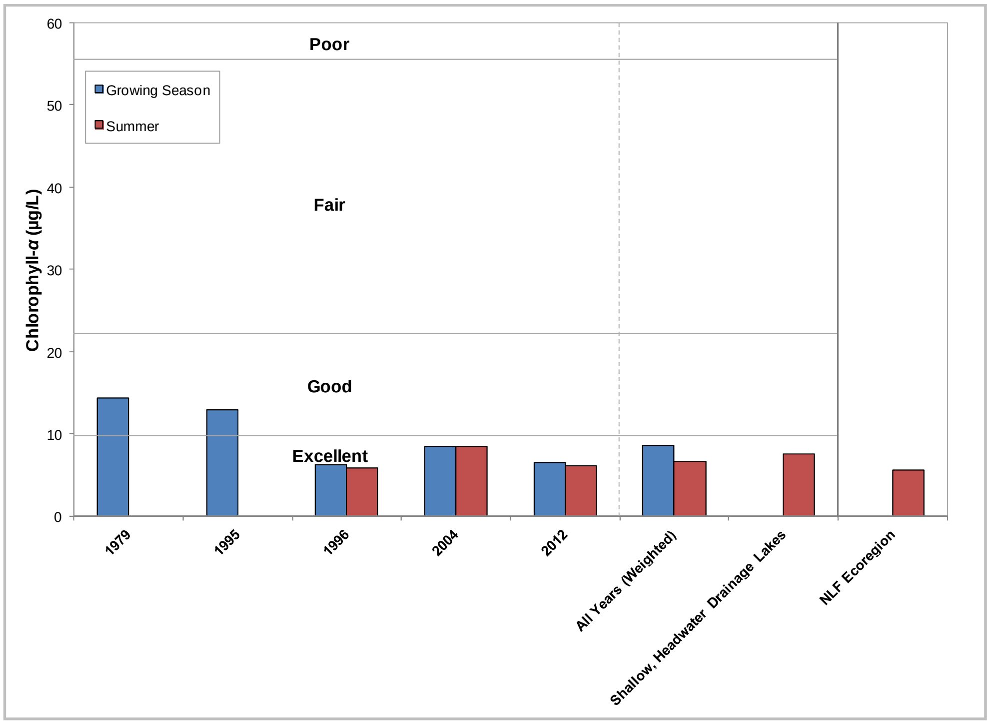


Figure 3.1-5. Indian Lake, state-wide class 1 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR 2009. NLF stands for Northern Lakes and Forests.

Through efforts conducted primarily by Indian Lake volunteers through the State of Wisconsin's Citizens Lake Monitoring Network, much data has been collected on the lake's water clarity by measuring Secchi disk depth. A weighted summer average over 20+ years of data was calculated to be 9.0 feet, which is greater than the median value for all other shallow, headwater drainage lakes in the state and also the median for all lakes in the Northern Lakes and Forests ecoregion (Figure 3.1-6). Though some fluctuations exist in the data, all annual averages fall within a category of *Excellent* for Indian Lake, based upon its lake type (shallow, headwater drainage lake). The fluctuations are a result of annual environmental variability; in addition to algal abundance, factors such as suspended sediment and water color influence a lake's water clarity.

"True color" measures the dissolved organic materials in water. Water samples collected in April of 2012 were measured for true color, and were found to be at 10 Platinum-cobalt units (Pt-co units, or PCU). Lillie and Mason (1983) categorized lakes with 0-40 PCU as having "low" color, 40-100 PCU as "medium" color, and >100 PCU as high color. Having little color to the water increases its clarity, which is one reason why Indian Lake was so clear in 2012.

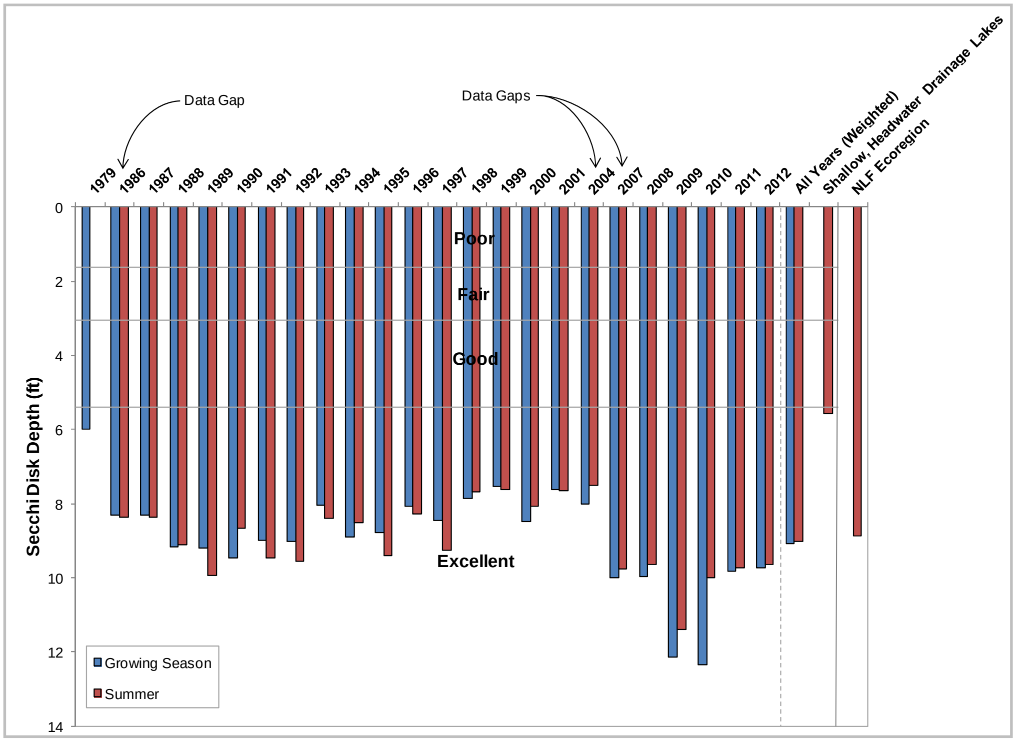


Figure 3.1-6. Indian Lake, state-wide class 1 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR 2009. NLF stands for Northern Lakes and Forests.

Limiting Plant Nutrient of Indian Lake

Using midsummer nitrogen and phosphorus concentrations from Indian Lake, a nitrogen:phosphorus ratio of 23:1 was calculated. This finding indicates that Indian 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.

Indian Lake Trophic State

Figure 3.1-7 contain the TSI values for Indian Lake. Unlike the parameters discussed above, the categorical rankings (*Excellent*, *Good*, *Fair*, etc.) are not applicable to the TSI values. The TSI is calculated directly from these parameters to place lakes as being in an oligotrophic, mesotrophic or eutrophic state. This designation is not meant to signify lake health, as a eutrophic lake can be healthy just as an oligotrophic lake can be. Rather, it describes the age and productivity of the lake ecosystem.

The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from lower mesotrophic to lower eutrophic. In general, the best values to use in judging a lake's trophic state are the biological parameters; therefore, relying primarily on total phosphorus and chlorophyll-*a* TSI values, it can be concluded that Indian Lake is in a mesotrophic state.

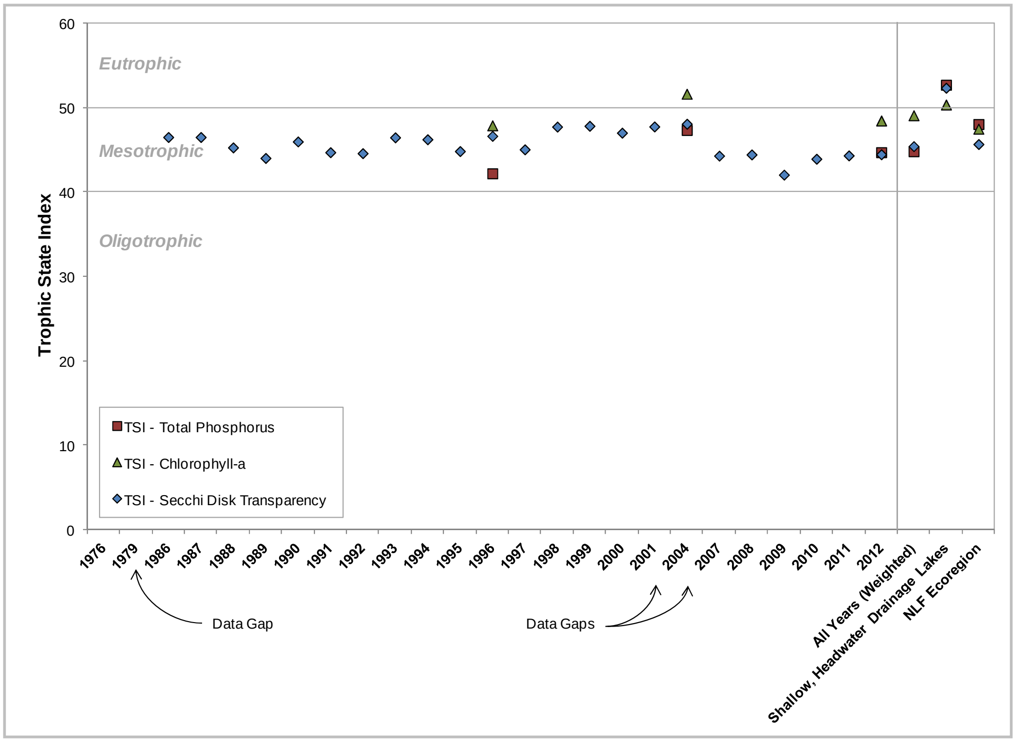


Figure 3.1-7. Indian Lake, state-wide class 1 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR 2009. NLF stands for Northern Lakes and Forests.

Dissolved Oxygen and Temperature in Indian Lake

Dissolved oxygen and temperature were measured during water quality sampling visits to Indian Lake by Onterra staff. Profiles depicting these data are displayed in Figure 3.1-8. In April of 2012, Indian Lake was found to be completely mixed. Most Wisconsin lakes mix during the spring and fall, when changing water temperatures and winds break down any thermal differences that existed between the epilimnion and the hypolimnion. During the summer, the epilimnion will warm quickly, while the bottom of the lake does not receive the sun's warmth. During this time, a temperature gradient may form. Summer winds may mix the water column at some point, and disperse these thermal gradients. Depending on the temperature and the size of the lake, this may occur once, many times, or not at all during the summer months. Indian Lake stratified in July, but then mixed again in August and October. The July 19th dissolved oxygen profile indicates that oxygen became depleted in the bottom 6-7 feet of the lake. This occurs as bacteria decompose organic material near the bottom of the lake. In doing this, they utilize the available oxygen. When a lake mixes again, as it did before August 22nd, oxygen from the upper layers of water is able to mix within the hypolimnion.

During the winter, thermal stratification will occur except in the opposite manner as it does in the summer. Water is most dense at 4°C, so water of this temperature may be found at the bottom of the lake while the coldest water is found at the surface, in the solidified form we know as ice. Dissolved oxygen decreased slightly during February of 2013. The ice cover that occurs this time of year reduces reintroduction of oxygen from the atmosphere. Despite the lower oxygen found in Indian Lake in July and February, the lake had sufficient dissolved oxygen for warm water fish species found in Wisconsin lakes in the upper portions of the water column.

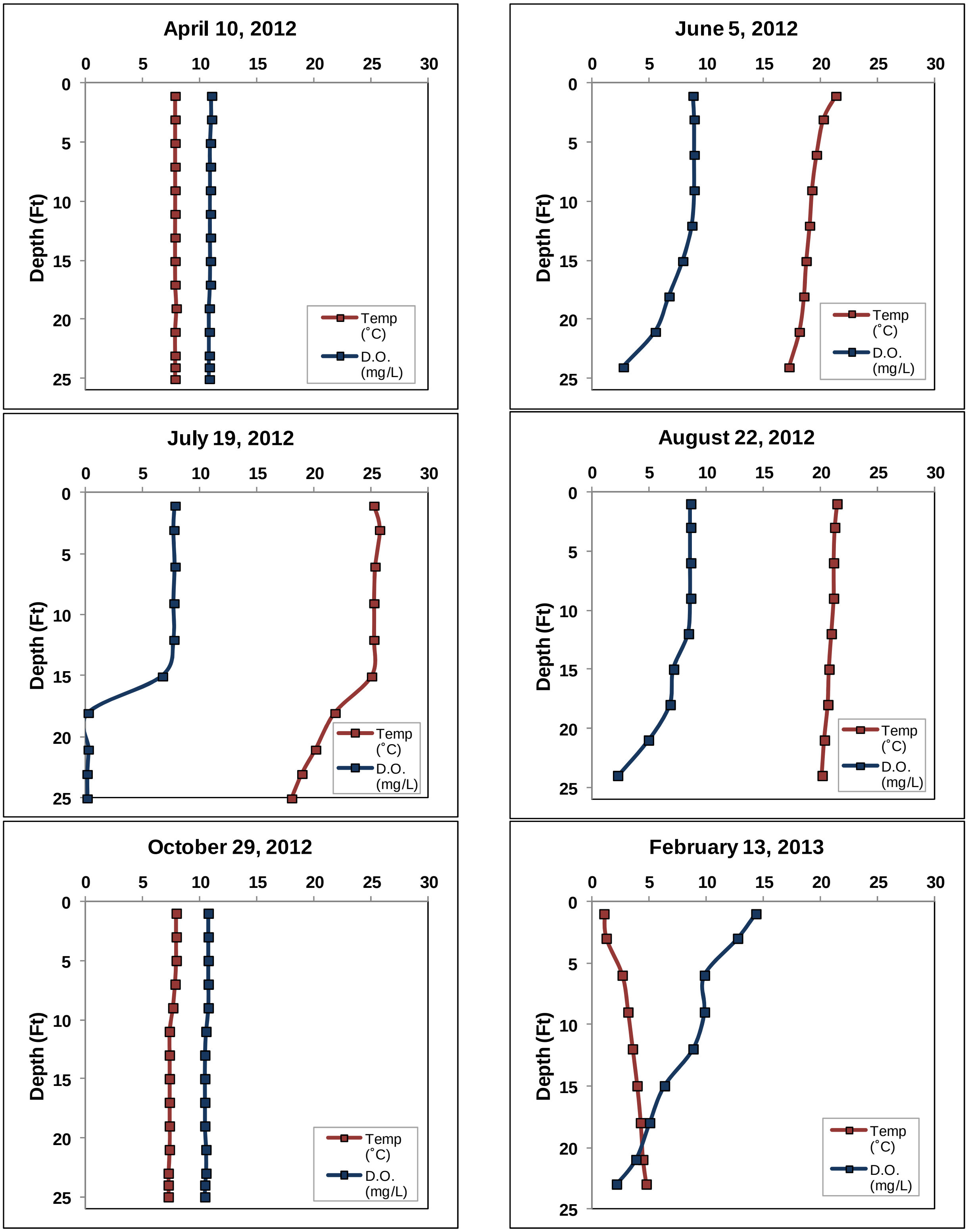


Figure 3.1-8. Indian Lake dissolved oxygen and temperature profiles.

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

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw and Nimphius 1985). The pH of the water in Indian Lake was found to be above neutral with a value of 8.0 measured in June of 2012, and falls within the normal range for Wisconsin Lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. Alkalinity determines the sensitivity of a lake to acid rain. Values between 2.0 and 10.0 mg/L as $CaCO_3$ are considered to be moderately sensitive to acid rain, while lakes with values of 10.0 to 25.0 mg/L as $CaCO_3$ are considered to have low sensitivity, and lakes above 25.0 mg/L as $CaCO_3$ are non-sensitive. The alkalinity in Indian Lake was measured at 25.9 (mg/L as $CaCO_3$) at the lake's surface in July of 2012, indicating that the lake has a substantial capacity to resist fluctuations in pH and has little to no sensitivity to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Indian Lake's pH of 8.0 falls 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 Indian Lake was found to be 6.1 mg/L in July of 2012, falling below the optimal range for zebra mussels.

Researchers at the University of Wisconsin - Madison have developed an AIS suitability model called smart prevention (Vander Zanden and Olden 2008). In regards to zebra mussels, this model relies on measured or estimated dissolved calcium concentration to indicate whether a given lake in Wisconsin is suitable, borderline suitable, or unsuitable for sustaining zebra mussels. Within this model, suitability was estimated for approximately 13,000 Wisconsin waterbodies and is displayed as an interactive mapping tool (www.aissmartprevention.wisc.edu). Based upon this analysis, Indian Lake was considered not suitable for mussel establishment.

Plankton tows were completed by Onterra staff during the summer of 2012 and these samples were processed by the WDNR for larval zebra mussels. No larval zebra mussels were detected within these samples.

3.2 Watershed Assessment

Watershed Modeling

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

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

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

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

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

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

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

Indian Lake's watershed encompasses approximately 922 acres (Map 2). The lake's 357-acre surface comprises the majority of the watershed (39%), areas of forests comprise 260 acres (28%), wetlands comprise 201 acres (22%), rural residential areas comprise 59 acres (6%), pine tree plantations comprise 26 acres (3%), and areas of pasture/grass comprise the remaining 20 acres (2%) (Figure 3.2-1). WiLMS was utilized to estimate the annual phosphorus load to Indian Lake. Model results may be viewed in Appendix D. It is difficult to accurately model lakes with no tributary input, as WiLMS is designed to model drainage systems with an inlet and an outlet most accurately. However, this modeling program may be used to give managers a general idea of the phosphorus load in lakes like Indian Lake. Additionally, in-field samples of the lake's water quality may be used to calibrate the model and ensure accuracy. Because water quality data are readily available through the efforts of Indian Lake volunteers and also through this project, these calibrations were able to be made.

The predicated annual phosphorus load to Indian Lake is approximately 175 lbs (Figure 3.2-2). Because of the small watershed, which is also in good condition, the greatest contributor of phosphorus to Indian Lake is actually atmospheric deposition to the lake surface, which collects 95 lbs (54% of the total load) of phosphorus annually. Despite comprising the second smallest land cover type within the watershed, pine tree plantations account for approximately 14% (24 lbs) of the total phosphorus load, while areas of forest contribute 11% (20 lbs), wetlands contribute 18 lbs (10%), rural residential areas contribute 3% (4 lbs), and pasture/grass areas contribute 2% (4 lbs). Septic sources were modeled within WiLMS using the estimated number of residents living along Indian Lake and the amount of time spent on the lake – full time residents, seasonal, etc. These data were collected as a part of questions contained on the stakeholder survey associated with this project (Appendix B). Septic sources were estimated to contribute roughly 6% (10 lbs) of the annual phosphorus load to Indian Lake.

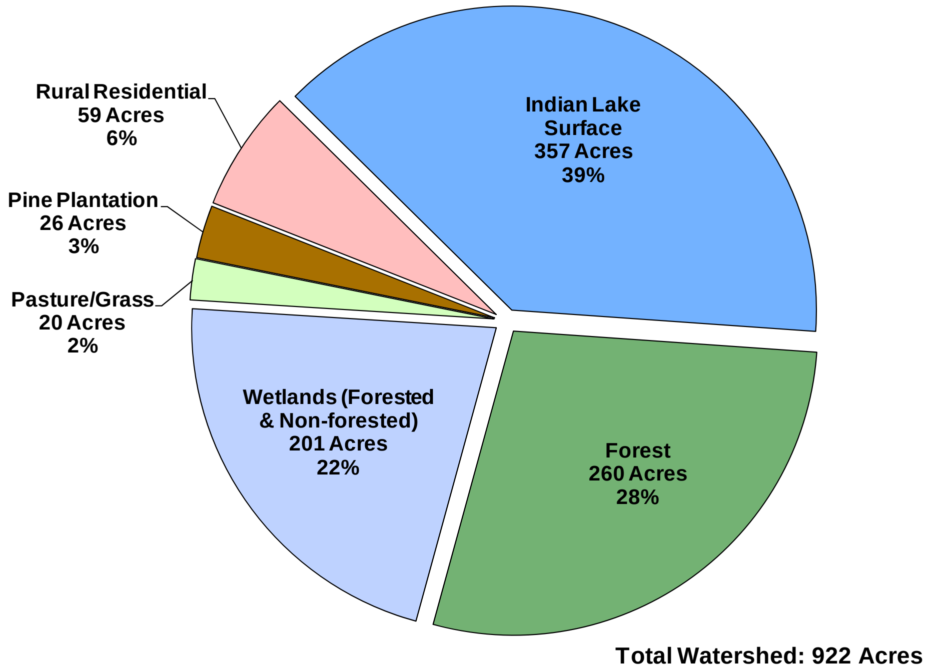


Figure 3.2-1. Indian Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

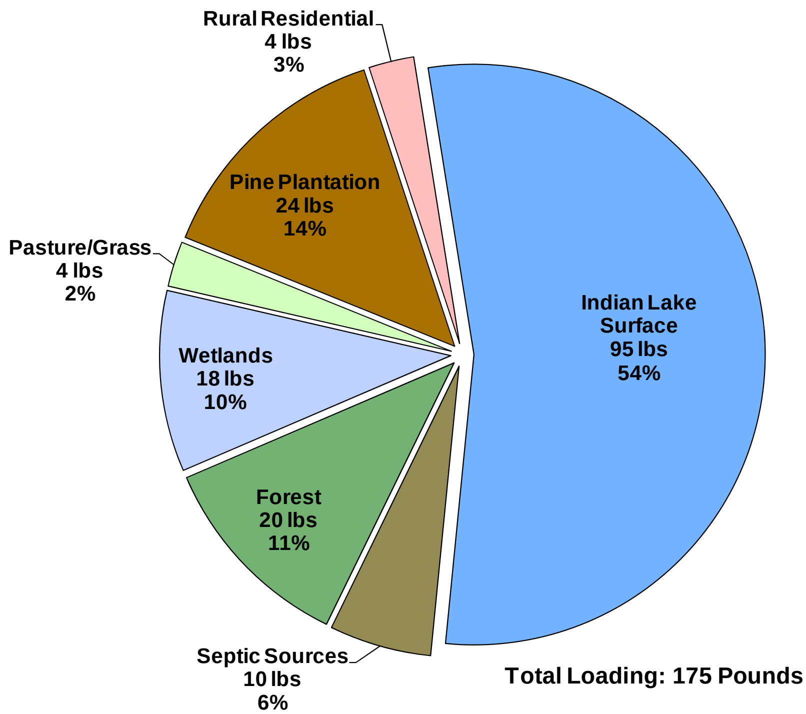


Figure 3.2-2. Indian Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

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

Utilizing the acreages of land cover types within Indian Lake's watershed and hydrologic data, WiLMS was able to predict what the annual growing season total phosphorus concentration within the lake should be. A predictive equation within WiLMS estimated that the growing season mean should most likely be 22 µg/L in Indian Lake. Comparatively, Indian Lake's actual growing season mean phosphorus concentration was found to be 16.3 µg/L. Because the predicted total phosphorus concentration is higher than what was actually measured in Indian Lake indicates that there are no unaccounted sources of phosphorus entering the lake.

Indian Lake's 922-acre watershed results in a watershed to lake area ratio of 2:1. As discussed previously, small changes to the land cover within the watersheds of lakes that have small watershed to lake area ratios can have noticeable impacts to the lake's water quality. A relatively small conversion of one land cover type to another may have significant impacts, likely not in the short-term, upon the lake. WiLMS was utilized to model a scenario in which 25% (65 acres) of the forested land present in the watershed was converted to row crops. This relatively small change in land management resulted in a 31% increase in the annual total phosphorus load to the lake. Using predictive equations from Carlson (1977), this would result in an increase of chlorophyll-*a* from the observed growing season of average of approximately 6.6 µg/L to 10 µg/L, and Secchi disk transparency would decline from the observed growing season average of approximately 9 feet to 8 feet. The shoreline of a lake is a critical zone in terms of protecting the health of a lake, but is often subject to modifications which increase the level of unnatural development. This particular area of the watershed is discussed further in the next section.

3.3 Shoreland Condition

The Importance of a Lake's Shoreland Zone

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

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

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

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

Shoreland Zone Regulations

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

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted more strict shoreland ordinances. Passed in February of 2010, a revised NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances of their own. The revised NR 115 was once again examined in 2012 after some Wisconsin counties identified some provisions that were unclear or challenging to implement. The revisions proposed through Board Order WT-06-12 went into effect in December of 2013. These policy regulations require each county address ordinances for vegetation removal on shorelands, impervious surface standards, nonconforming structures and establishing mitigation requirements for development. Minimum requirements for each of these categories are as follows:

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

- <u>Impervious surface standards</u>: The amount of impervious surface is restricted to 15% of the total lot size, on lots that are entirely within 300 feet of the ordinary high-water mark of the waterbody. A county may allow more than 15% impervious surface on a residential lot provided that the county issues a permit and that an approved mitigation plan is implemented by the property owner. Counties may develop an ordinance, providing higher impervious surface standards, for highly developed shorelines.

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

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

- For county-specific requirements on this topic, it is recommended that lake property owners contact the county's regulations/zoning department.

Wisconsin Act 31

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

Shoreland Research

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

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

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

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

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

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

National Lakes Assessment

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

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

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

Native Species Enhancement

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

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

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

Cost

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

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

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

- Spring planting timeframe.
- 100’ of shoreline.
- An upland buffer zone depth of 35’.
- An access and viewing corridor 30’ x 35’ free of planting (recreation area).
- Planting area of upland buffer zone 2- 35’ x 35’ areas
- Site is assumed to need little invasive species removal prior to restoration.
- Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
- Trees and shrubs planted at a density of 1 tree/100 sq ft and 2 shrubs/100 sq ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
- Turf grass would be removed by hand.
- A native seed mix is used in bare areas of the upland buffer zone.
- An aquatic zone with shallow-water 2 - 5’ x 35’ areas.
- Plant spacing for the aquatic zone would be 3 feet.
- Each site would need 70’ of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- Soil amendment (peat, compost) would be needed during planting.
- There is no hard-armor (rip-rap or seawall) that would need to be removed.
- The property owner would maintain the site for weed control and watering.

Advantages	***Disadvantages***
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreland erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Once native plants are established, they require less water, maintenance, no fertilizer; provide wildlife food and habitat, and natural aesthetics compared to ornamental (non-native) varieties. • 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.

Indian Lake Shoreland Zone Condition

Shoreland Development

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

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

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

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

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

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

Figure 3.3-1. Shoreland assessment category descriptions.

On Indian Lake, the development stage of the entire shoreland was surveyed during late summer of 2012, using a GPS unit to map the shoreland. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreland on a property-by-property basis. During the survey, Onterra staff examined the shoreland for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.3-1.

Indian Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 3.6 miles of natural/undeveloped and developed-natural shoreland were observed during the survey (Figure 3.3-2). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 0.6 miles of urbanized and developed–unnatural shoreland were observed. If restoration of the Indian Lake shoreland is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreland lengths around the entire lake.

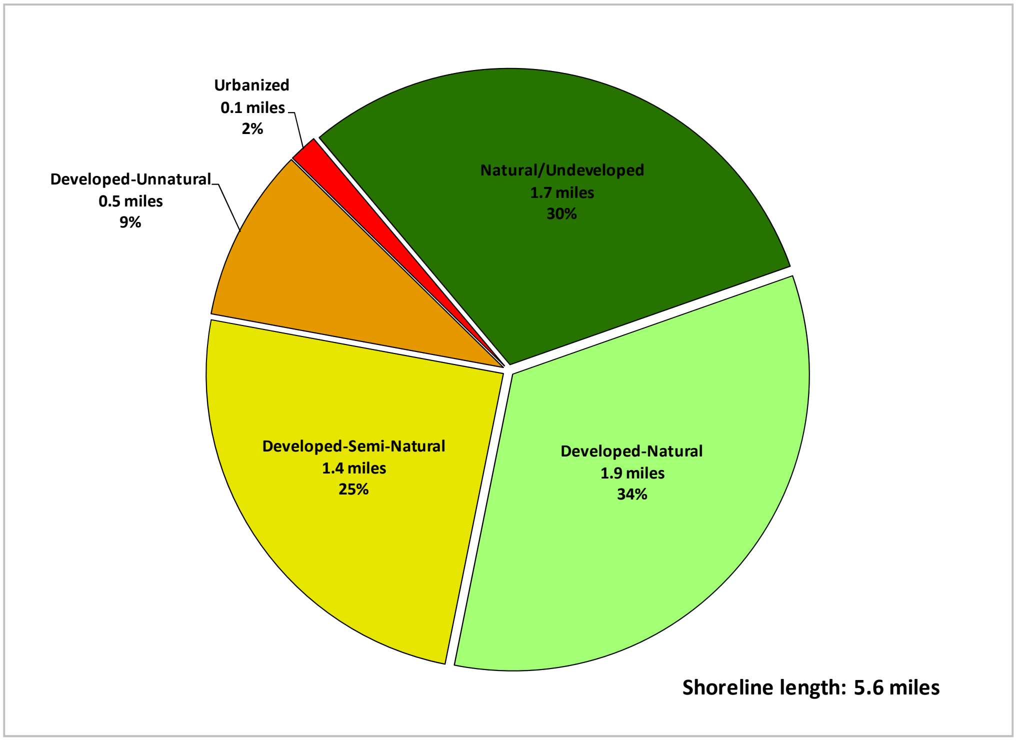


Figure 3.3-2. Indian Lake shoreland categories and total lengths. Based upon a late summer 2012 survey. Locations of these categorized shorelands can be found on Map 3.

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

Coarse Woody Habitat

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

During this survey, 44 total pieces of coarse woody habitat were observed along 5.6 miles of shoreline, which gives Indian Lake a coarse woody habitat to shoreline mile ratio of 8:1. Locations of coarse woody habitat are displayed on Map 4. To put this into perspective, Wisconsin researchers have found that in completely undeveloped lakes, an average of 345 coarse woody habitat structures may be found per mile (Christensen et al. 1996).

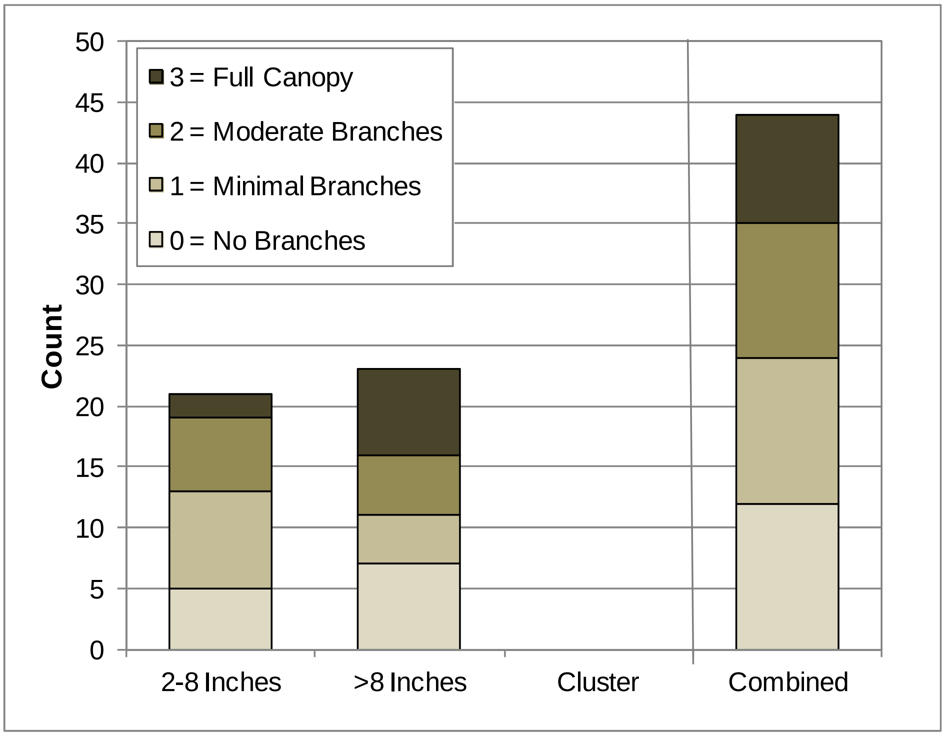


Figure 3.3-3. Indian Lake coarse woody habitat survey results. Based upon a late summer 2012 survey. Note that no “clusters” were observed during the survey. Locations of Indian Lake coarse woody habitat can be found on Map 4.

3.4 Aquatic Plants

Introduction

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

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

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

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

Aquatic Plant Management and Protection

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

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

Permits

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

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

Manual Removal

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

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

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

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

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

Bottom Screens

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

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

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

Water Level Drawdown

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

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

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

Mechanical Harvesting

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

Cost

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

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

Herbicide Treatment

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

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

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

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

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

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

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

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

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

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

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

Cost

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

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • Herbicides can target large areas all at once. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil. • Some herbicides can be used effectively in spot treatments. • Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g. mammals, insects)	• All herbicide use carries some degree of human health and ecological risk due to toxicity. • Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them. • Many aquatic herbicides are nonselective. • Some herbicides have a combination of use restrictions that must be followed after their application. • Overuse of same herbicide may lead to plant resistance to that herbicide.

Biological Controls

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

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

Cost

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

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

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

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

Cost

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

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

Analysis of Current Aquatic Plant Data

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

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

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

Species Diversity and Richness

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

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

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

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

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

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

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

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

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Indian Lake will be compared to lakes in the same ecoregion and in the state (Water Quality Section, Figure 3.1-2).

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

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

Community Mapping

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

Exotic Plants

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

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

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

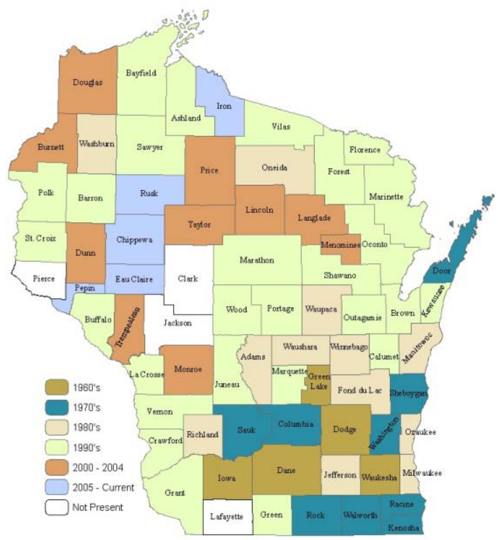


Figure 3.4-1. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

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

Aquatic Plant Survey Results

As mentioned earlier, numerous aquatic plant surveys were completed as a part of this project. On June 5, 2012, an early-season aquatic invasive species (ESAIS) survey was completed on Indian Lake. While the intent of this survey is to locate any potential non-native species within the lake, it's primarily focused on locating any occurrences of curly-leaf pondweed which should be at or near its peak growth at this time. During this meander-based survey of the littoral zone, Onterra ecologists did not locate any occurrences of curly-leaf pondweed or any other non-native aquatic plant species.

The comprehensive aquatic plant point-intercept and aquatic plant community mapping surveys were conducted on Indian Lake on July 11 and 12, 2012 by Onterra (data may be found in Appendix E). During these surveys, 57 species of aquatic plants were located in Indian Lake, none of which are considered to be non-native species (Table 3.4-1). One species, Vasey's pondweed (*Potamogeton vaseyi*), is listed by the Wisconsin Natural Heritage Inventory as a species of special concern in Wisconsin due to uncertainty regarding its distribution and abundance in Wisconsin.

As discussed in the previous section, sediment data were collected at each sampling location that was less than 15 feet in depth during the point-intercept survey. The data gathered shows that the majority of these areas (68.6%) are comprised of fine, organic sediments (muck), 18.6% contain sand, and 12.9% contain rock (Figure 3.4-2). Map 5 illustrates that most of the point-intercept sampling locations containing sand or rock were found in shallow and/or near-shore areas. Areas of muck dominated the western portion of the lake as well as deeper areas within the eastern portion. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in mucky substrates, others only in sandy areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because the different habitat types that are available.

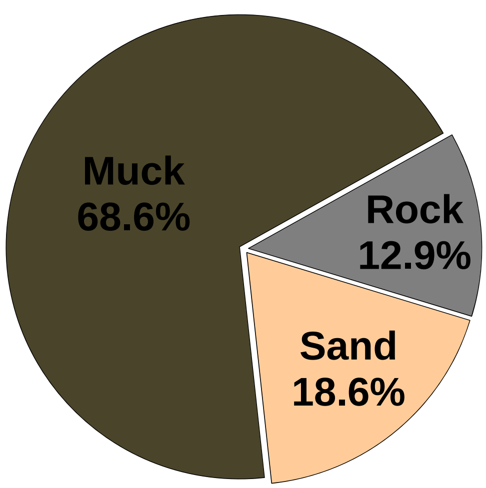


Figure 3.4-2. Indian Lake proportion of substrate types in areas of less than 15 feet of water depth. Created using data from 2012 point-intercept survey.

As discussed in the Water Quality Section, Indian Lake has high water clarity. This allows sunlight to penetrate deeper into the water and support aquatic plant growth to deeper depths. In 2012, aquatic plants were found growing to a maximum depth of 19 feet. Of the 415 point-intercept sampling locations that fell at or below the maximum depth of plant growth, 74% contained aquatic vegetation. Map 6 illustrates that most of Indian Lake supports aquatic plant growth, and areas of muck generally contained higher densities of aquatic plants as opposed to sand.

Table 3.4-1. Aquatic plant species located in Indian Lake during summer 2012 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	2012 (Onterra)
Emergent	*Carex aquatilis*	Water sedge	7	I
	Carex comosa	Bristly sedge	5	I
	Carex lasiocarpa	Wooly-fruit sedge	9	I
	Carex utriculata	Common yellow lake sedge	7	I
	Cladium mariscoides	Smooth sawgrass	10	I
	Dulichium arundinaceum	Three-way sedge	9	X
	Eleocharis erythropoda	Bald spike-rush	3	X
	Eleocharis palustris	Creeping spikerush	6	X
	Juncus effusus	Soft rush	4	I
	Leersia oryzoides	Rice cut grass	3	I
	Pontederia cordata	Pickerelweed	9	X
	Sagittaria latifolia	Common arrowhead	3	I
	Sagittaria rigida	Stiff arrowhead	8	I
	Schoenoplectus acutus	Hardstem bulrush	5	I
	Schoenoplectus pungens	Three-square rush	5	I
	Schoenoplectus tabernaemontani	Softstem bulrush	4	I
	Scirpus cyperinus	Wool grass	4	I
	Sparganium sp.	Bur-reed species	N/A	X
	Typha spp.	Cattail spp.	1	I
FL	*Brasenia schreberi*	Watershield	7	X
	Nuphar variegata	Spatterdock	6	X
	Nymphaea odorata	White water lily	6	X
FL/E	*Sparganium androcladum*	Shining bur-reed	8	X
	Sparganium angustifolium	Narrow-leaf bur-reed	9	X
	Sparganium fluctuans	Floating-leaf bur-reed	10	X
Submergent	*Bidens beckii*	Water marigold	8	X
	Ceratophyllum demersum	Coontail	3	X
	Ceratophyllum echinatum	Spiny hornwort	10	X
	Chara spp.	Muskgrasses	7	X
	Elatine minima	Waterwort	9	X
	Elodea canadensis	Common waterweed	3	X
	Eriocaulon aquaticum	Pipewort	9	X
	Isoetes spp.	Quillwort species	8	X
	Lobelia dortmanna	Water lobelia	10	X
	Myriophyllum tenellum	Dwarf water milfoil	10	X
	Najas flexilis	Slender naiad	6	X
	Najas gracillima	Northern naiad	7	X
	Nitella spp.	Stoneworts	7	X
	Potamogeton amplifolius	Large-leaf pondweed	7	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X
	Potamogeton gramineus	Variable pondweed	7	X
	Potamogeton natans	Floating-leaf pondweed	5	I
	Potamogeton praelongus	White-stem pondweed	8	X
	Potamogeton pusillus	Small pondweed	7	X
	Potamogeton robbinsii	Fern pondweed	8	X
	Potamogeton spirillus	Spiral-fruited pondweed	8	X
	*Potamogeton vaseyi**	Vasey's pondweed	10	I
	Potamogeton zosteriformis	Flat-stem pondweed	6	X
	Utricularia intermedia	Flat-leaf bladderwort	9	X
	Utricularia vulgaris	Common bladderwort	7	X
	Vallisneria americana	Wild celery	6	X
SE	*Eleocharis acicularis*	Needle spikerush	5	X
	Juncus pelocarpus	Brown-fruited rush	8	X
	Sagittaria cristata	Crested arrowhead	9	X
	Sagittaria cuneata	Arum-leaved arrowhead	7	I
FF	*Lemna turionifera*	Turion duckweed	2	X
	Spirodela polyrhiza	Greater duckweed	5	X

FL = Floating Leaf; FL/E = Floating Leaf and Emergent; S/E = Submergent and Emergent; FF = Free Floating
X = Located on rake during point-intercept survey; I = Incidental Species
** = Species listed as 'special concern' in Wisconsin*

While a total of 57 aquatic plant species were located during the 2012 surveys on Indian Lake, 40 were physically recorded on the rake during the point-intercept survey while the remaining 17 were incidentally located. Of the 40 aquatic plant species located on the rake, fern pondweed, common waterweed, small pondweed, and stoneworts were the four-most frequently encountered (Figure 3.4-3). As its name indicates, the stems and leaves of fern pondweed resemble the frond of a fern. This is a common pondweed species of lakes in northern Wisconsin, and is usually found growing in large beds along the lake bottom. Able to grow deeper than many other aquatic plants, fern pondweed provides habitat and oxygen to deeper areas of the lake. In Indian Lake, fern pondweed was most abundant between 3 and 10 feet of water.

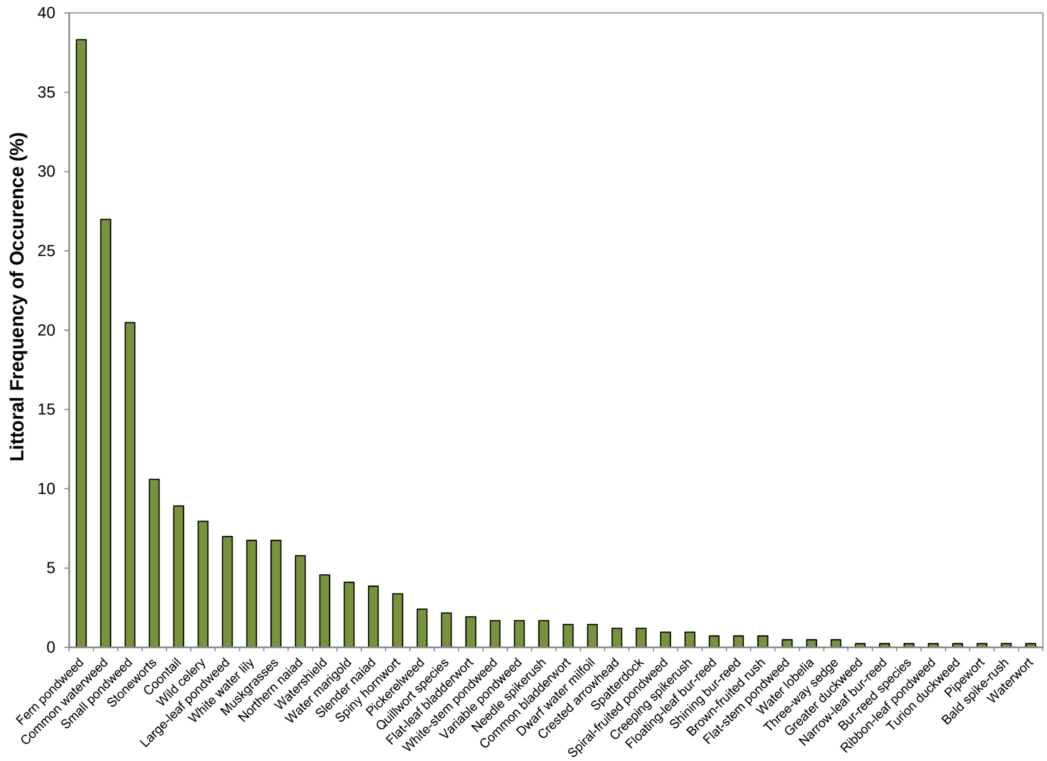


Figure 3.4-3. Indian Lake aquatic plant littoral frequency of occurrence. Created using data from 2012 point-intercept survey.

Common waterweed, the second-most abundant plant in Indian Lake, can be found in lakes throughout Wisconsin and North America. It is usually found growing in mucky substrates, and possesses long stems with whorls of three slender leaves. Under certain conditions common waterweed can often grow to nuisance levels forming large mats on the water's surface. However, when not growing to nuisance levels, common waterweed provides excellent structural habitat for aquatic organisms and is an important food source for animals such as muskrats. In Indian Lake, common waterweed was not observed to be a nuisance, and was relatively evenly distributed between 2 and 15 feet of water.

Small pondweed was the third-most frequently encountered aquatic plant species during the 2012 point-intercept survey. Small pondweed is one of several narrow-leaf pondweed species that can be found in Wisconsin. It possesses long, slender stems with alternating narrow, linear leaves. Interestingly, the western bay of Indian Lake possessed an abundance of small pondweed in 2012; the plants observed were growing in approximately 9 to 12 feet of water and were flowering at the water's surface. Small pondweed observed throughout the rest of the lake was found growing well below the water's surface. Like fern pondweed and common waterweed, the colonies of small pondweed in Indian Lake provide excellent structural habitat for wildlife.

Stoneworts, the fourth-most frequently encountered aquatic plant in Indian Lake, are actually a group of macroalgae and not vascular plants. They are generally found growing in deeper water in lakes with higher water clarity, and in Indian Lake stoneworts were most abundant between 9 and 15 feet of water. Forming dense beds along the lake's bottom, their fine branches provide excellent habitat for macroinvertebrates and small fish.

One species of pondweed located incidentally, Vasey's pondweed, is a native species listed as special concern in Wisconsin due to uncertainty regarding its abundance and distribution within the state (WDNR 2011). Like small pondweed, Vasey's pondweed is one of the narrow-leaf pondweeds, and possesses long, thread-like leaves. When growing in shallow water, Vasey's pondweed produces small, fingernail-sized floating leaves that aid in keeping the flower spike above the water (Photo 3.4-1). Its presence in Indian Lake is an indicator of a high-quality environment.

Photo 3.4-1. Entire plant of Vasey's pondweed (*Potamogeton vaseyi)* (left) and close-up of floating-leaves and flower spikes (right).

While only the most dominant aquatic plant species encountered in Indian Lake were discussed, all of the native aquatic plant species encountered on the rake in 2012 are used in calculating Indian Lake's Floristic Quality Index (FQI). These calculations do not include species that were located "incidentally" during the 2012 surveys. For example, as discussed, while a total of 57 aquatic plant species were located in Indian Lake during the 2012 surveys, 40 were physically encountered on the rake during the point-intercept survey. These 40 native species encountered on the rake and their conservatism values were used to calculate the FQI of Indian Lake's aquatic plant community (equation shown below).

$$\text{FQI} = \text{Average Coefficient of Conservatism} * \sqrt{\text{Number of Native Species}}$$

Figure 3.4-4 compares the FQI components from Indian Lake calculated from the 2012 point-intercept survey to median values of lakes within the Northern Lakes and Forests Lakes (NLFL) Ecoregion as well as to lakes within the entire State of Wisconsin. As displayed in Figure 3.4-4, the native species richness (40) greatly surpasses the upper quartile of 20 for lakes in the ecoregion and the state. The aquatic plant community's average conservatism value (7.2) also exceeds both the upper quartile values for the ecoregion and the state, and indicates that Indian Lake contains a higher number of sensitive aquatic plant species, or species that are not tolerant of environmental degradation. Combining Indian Lake's native species richness and average conservatism values yields and exceptionally high value of 45.4, greatly exceeding upper quartile values for lakes within the ecoregion and the state. The FQI analysis indicates that Indian Lake's aquatic plant community is of higher quality than the majority of lakes in within the Northern Lakes and Forests Lakes Ecoregion and lakes throughout the State of Wisconsin.

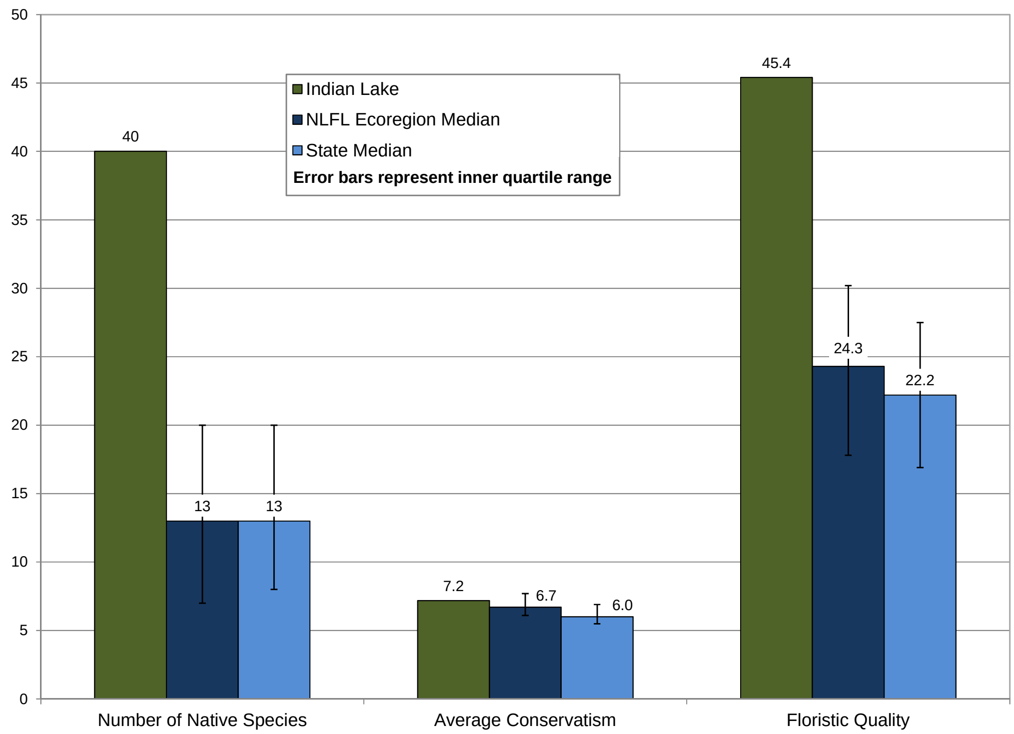


Figure 3.4-4. Indian Lake Floristic Quality Assessment. Created using data from 2012 point-intercept survey. Analysis following Nichols (1999) where NLFL = Northern Lakes and Forest Lakes Ecoregion. Error bars display 25^{th} and 75^{th} percentiles for regional and state data.

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

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Indian Lake's diversity value ranks. Using data obtained from WDNR Science Services, quartiles were calculated for 109 lakes within the NLFL Ecoregion (Figure 3.4-5). Using the data collected from the 2012 point-intercept survey, Indian Lake's aquatic plant community was shown to have exceptionally high species diversity with a Simpson's diversity value of 0.90. In other words, if two aquatic plants were randomly sampled from two different locations in Indian Lake, there would be a 90% probability that they would be of different species. This diversity value falls above the upper quartile for the lakes within the ecoregion and the state (Figure 3.4-5).

Figure 3.4-6 displays the relative frequency of occurrence of aquatic plant species in Indian Lake from the 2012 point-intercept survey and illustrates relative abundance of species within the community to one another; the aquatic plant community is not overly dominated by a single or few species, which would create a less-diverse community.

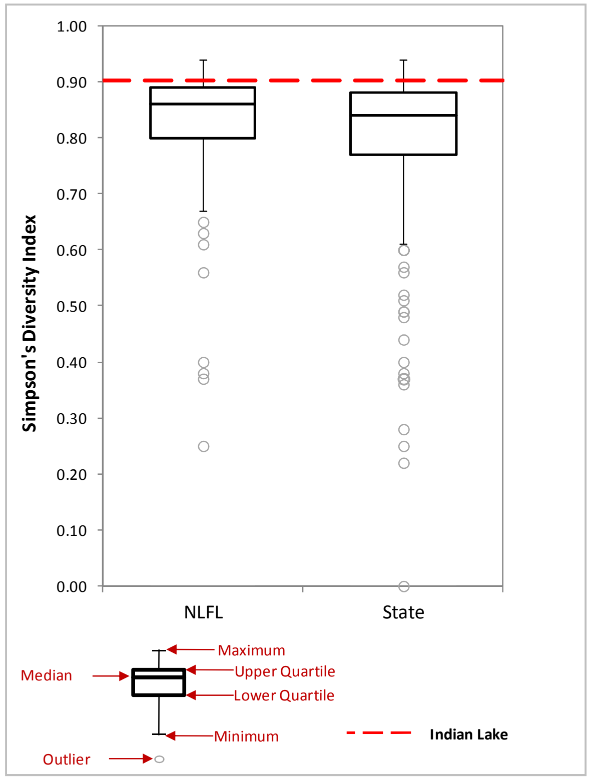


Figure 3.4-5. Indian Lake species diversity index. Created using data from 2012 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

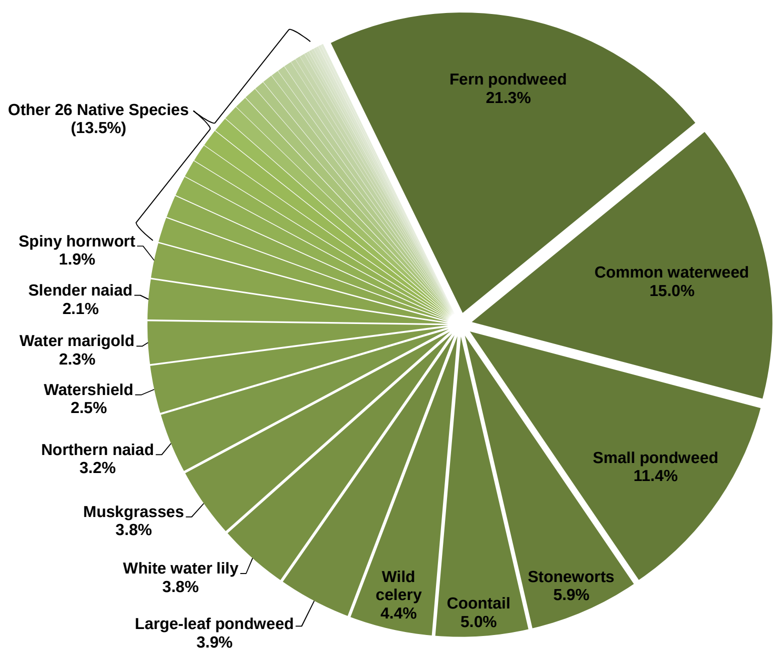


Figure 3.4-6. Indian Lake aquatic plant relative frequency of occurrence. Created using data from 2012 surveys.

The 2012 community mapping survey revealed that Indian Lake has a species-rich and high-quality emergent and floating-leaf aquatic plant community. Table 3.4-1 shows that 25 emergent and floating-leaf aquatic plant species were identified during the 2012 community mapping and point-intercept surveys. The 2012 community map (Map 7) indicates that approximately 32.9 acres of Indian Lake contain these types of plant communities (Table 3.4-2). These communities provide valuable structural habitat for invertebrates, fish, and other wildlife, and also stabilize bottom sediments and shoreline areas by dampening wave action from wind and watercraft.

Table 3.4-2. Indian Lake acres of floating-leaf and emergent aquatic plant communities. Created from August 2012 community mapping survey.

Plant Community	Acres
Emergent	8.4
Floating-leaf	18.4
Mixed Emergent & Floating-leaf	6.1
Total	**32.9**

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

3.5 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the numerous fisheries biologists overseeing Indian Lake. The goal of this section is to provide an incomplete overview of some of the data that exists, particularly in regards to specific issues (e.g. spear fishery, fish stocking, angling regulations, etc) that were brought forth by the ILA stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2013 & GLIFWC 2013A and 2013B).

Indian Lake Fishery

Indian Lake Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the highest ranked important or enjoyable activity on Indian Lake (Question #14). Approximately 85% of these same respondents believed that the current quality of fishing on the lake is either fair or good (Question #11); though approximately 69% believe that the quality of fishing has remained the same or gotten worse since they have obtained their property (Question #12).

Table 3.5-1 shows the popular game fish that are present in the system. When examining the fishery of a lake, it is important to remember what "drives" that fishery, or what is responsible for determining its mass and composition. The gamefish in Indian Lake are supported by an underlying food chain. At the bottom of this food chain are the elements that fuel algae and plant growth – nutrients such as phosphorus and nitrogen, and sunlight. The next tier in the food chain belongs to zooplankton, which are tiny crustaceans that feed upon algae and plants, and insects. Smaller fish called planktivores feed upon zooplankton and insects, and in turn become food for larger fish species. The species at the top of the food chain are called piscivores, and are the larger gamefish that are often sought after by anglers, such as bass and walleye.

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

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

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

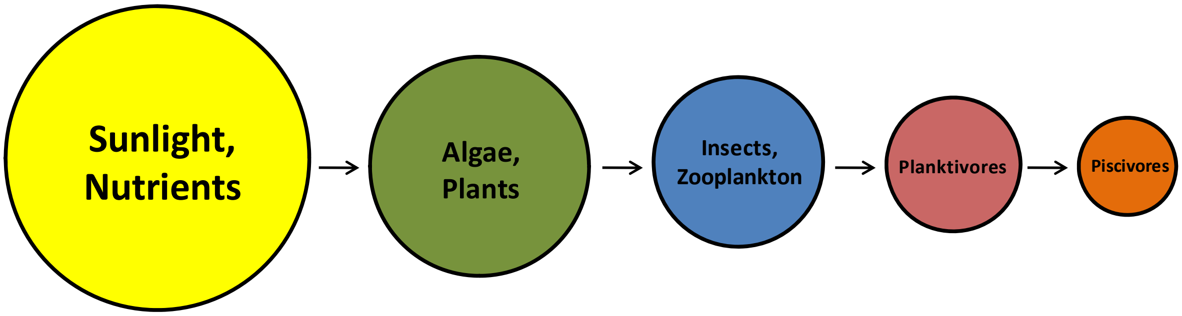


Figure 3.5-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Indian Lake is a mesotrophic system, meaning it has a moderate amount of nutrients and thus a moderate amount of primary productivity. This is relative to an oligotrophic system, which contains fewer nutrients (less productive) and a eutrophic system, which contains more nutrients (more productive). Simply put, this means Indian Lake should be able to support an appropriately sized population of predatory fish (piscovores) when compared to eutrophic or oligotrophic systems.

Indian Lake Spear Harvest Records

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.5-2). Indian 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. Determining how many fish are able to be taken from a lake, either by spear harvest or angler harvest, is a highly regimented and dictated process. This highly structured procedure begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then a "total allowable catch" is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% (walleye) or 27% (muskellunge) of the lake's known or modeled population, but may vary on an individual lake basis due to other circumstances. In lakes where population estimates are out of date by 3 years, a standard percentage is used. The total allowable catch number may be reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level". Often, the biologists overseeing a lake cannot make adjustments due to the

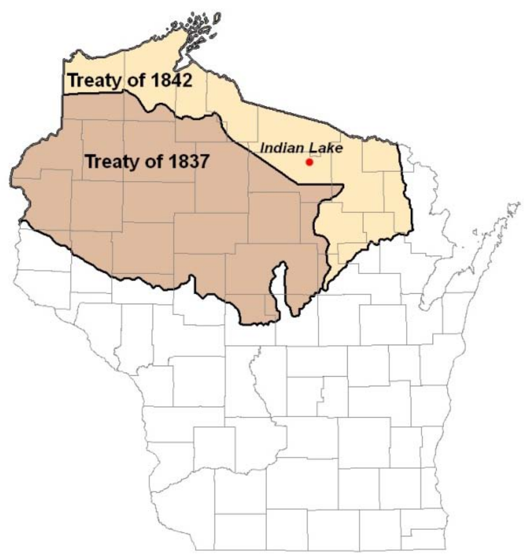


Figure 3.5-2. Location of Indian Lake within the Native American Ceded Territory (GLIFWC 2013A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

regimented nature of this process, so the total allowable catch often equals the safe harvest level. The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent. This result is called the declaration, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal declaration and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007). One common misconception is that the spear harvest targets the large spawning females. Tribal spearers may only take two walleyes over twenty inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIWC 2013B). This regulation limits the harvest of the larger, spawning female walleye.

Spearers are able to harvest muskellunge, walleye, northern pike, and bass during the open water season; however, in practice walleye and muskellunge are the only species harvested in significant numbers, so conservative quotas are set for other species. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2013B). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. An updated nightly declaration is determined each morning by 9 a.m. based on the data collected from the successful spearers. Harvest of a particular species ends once the declaration is met or the season ends. In 2011, a new reporting requirement went into effect on lakes with smaller declarations. Starting with the 2011 spear harvest season, on lakes with a harvestable declaration of 75 or fewer fish, reporting of harvests may take place at a location other than the landing of the speared lake.

Although Indian Lake has been declared as a spear harvest lake, it has not historically seen a harvest except in 1990, when two walleye were harvested. It is possible that spearing efforts have been concentrated on other larger lakes in the region, which would potentially have a higher estimated safe harvest for both walleye and muskellunge.

Indian Lake Substrate and Near Shore Habitat

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

According to the point-intercept survey conducted by Onterra, 69% of the substrate sampled in the littoral zone on Indian Lake was muck, with the remaining 32% being split between 19% sand and 16% rock (Map 5). Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Northern pike is one species that does not provide parental care to its eggs (Becker 1983). Northern pike broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Walleye is another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

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

Indian Lake Regulations and Management

Because Indian Lake is located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to Indian Lake. In 2013-2014, the daily bag limit is set at two walleye for the lake. Indian Lake is in the northern management zone for large and smallmouth bass as well as muskellunge and northern pike. Table 3.5-2 displays the 2013-2014 regulations for species that may be found in Indian Lake. Please note that this table is intended to be for reference purposes only, and that anglers should visit the WDNR website (www. http://dnr.wi.gov/topic/fishing/regulations/hookline.html) for specific fishing regulations or visit their local bait and tackle shop to receive a free fishing pamphlet that would contain this information.

Table 3.5-2. WDNR fishing regulations for Indian Lake, 2014-2015.

Species	Season	Regulation
Panfish	Open All Year	No minimum length limit and the daily bag limit is 25.
Largemouth bass	May 3, 2014 – March 1, 2015	The minimum length limit is 14" and the daily bag limit is 5.
Smallmouth bass	May 3, 2014 – June 20, 2014	Fish may not be harvested (catch and release only)
	June 21, 2014 – March 1, 2015	The minimum length limit is 14" and the daily bag limit is 5.
Muskellunge and hybrids	May 24, 2014 - November 30, 2014	The minimum length limit is 40" and the daily bag limit is 1.
Northern pike	May 3, 2014 – March 1, 2015	No minimum length limit and the daily bag limit is 5.
Walleye, sauger, and hybrids	May 3, 2014 – March 1, 2015	The minimum length limit is 15" and the daily bag limit is 1*.
Bullheads	Open All Year	No minimum length limit and the daily bag limit is unlimited.
Rock bass	Open All Year	No minimum length limit and the daily bag limit is unlimited.

**Walleye bag limits will likely change following the Native American spear fishing period.*

Currently, the WDNR is managing Indian Lake for consumptive opportunity of panfish and northern pike, and for quality sized bass and walleye. At this time, fisheries biologist John Kubisiak reports that the lake seems to be maintaining a moderate to low-density walleye population. Natural recruitment of walleye has been poor, so in early 2013 Mr. Kubisiak placed the lake on the 2013 stocking list for this species. In September of that year, 1,983 large fingerling walleye averaging 7.6 inches in size were stocked. The lake is primarily shallow and vegetated in the western basin, but Mr. Kubisiak believes there should be ample rock substrate in the southeast portion of the lake to sustain moderate populations of walleye and smallmouth bass. Regarding muskellunge, Mr. Kubisiak reports that the lake has never been able to produce a great fishery with respect to this species. This is likely due to the abundant northern pike that are found in Indian Lake. Because of this occurrence, muskellunge stocking was discontinued in 1986 and is no longer considered a muskellunge water.

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

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

The studies that were completed on lake indicate that it is healthy in terms of its watershed and water quality, and also it is aquatic plant community. Within the water quality section, an analysis on the available (historic and current) water quality is presented. It is unfortunate that more total phosphorus and chlorophyll-*a* data is not available for Indian Lake, as few conclusions can be drawn from the limited dataset that exists. However, the data that has been collected points to the fact that Indian Lake's water quality is in good condition, ranking similarly to other regional lakes as well as those deep, lowland drainage lakes within the state. A larger dataset exists for Secchi disk clarity, which is useful to monitor the clarity of the lake's water. Additionally, this type of monitoring is useful in that it can signal that nutrient enrichment or other kinds of pollution are occurring.

The lake's great water quality is the direct result of its relatively small and mostly natural watershed. The watershed is roughly twice as large as Indian Lake's surface area. The surface area of the lake actually is the largest land cover type, as well as the largest contributor of phosphorus to the lake which happens through atmospheric deposition. Overall, modeling exercises predicted that Indian Lake receives 175 lbs of phosphorus from the watershed annually. This is a minimal to moderate amount for a lake with Indian's size and volume. This being said, with most of the watershed in a natural state the most sensitive area is likely the immediate shoreland areas around Indian Lake. As the Shoreland Assessment Section points out, the majority of the shoreland zone is in a natural to developed-natural state, though some moderately disturbed shorelands exist as well as heavily disturbed areas, albeit to a limited extent. It is vital that the ILA do whatever possible to ensure that the shoreland zone continues to be minimally developed, as this could produce negative impacts on the lake's ecology and available habitat.

Indian Lake is classified as a spring lake due to its hydrology, and has a relatively small watershed (roughly twice the size of the lake). The water levels of spring and seepage lakes may fluctuate with changing precipitation periods more so than drainage systems. This is due to the watershed size of drainage lakes; typically a larger watershed catches more precipitation and delivers this to a lake through an input stream. In spring and seepage lakes, the watershed is smaller so there is less land to draw from. Because of Indian Lake's hydrology, it would be expected that the water levels would drop during periods of relative drought. While this occurrence may be unsightly and cause some recreational or navigational impairments, naturally fluctuating water levels are not necessarily bad for a lake ecosystem. Periodic low water levels may actually benefit the lake ecosystem in the long-term by increasing the level of habitat diversity. During times of low water, it is important for riparian property owners to leave fallen logs and other structure alone. Additional modifications to the exposed shoreline are discouraged as well. When the water rises eventually, these objects will serve as very beneficial habitat to a variety of aquatic organisms.

As highlighted in the Aquatic Plant Section, there are many different species from a variety of community types – emergent, submergent, and floating-leaf. Indian Lake is somewhat unique in that it has an irregular shoreline, along with varied slopes and substrates and several secluded bay areas which slow water movement. These various habitat characteristics contribute to the richness of the plant community by providing numerous conditions for many habitat specific species to flourish. The extraordinary diversity of the aquatic plant community, in turn, provides outstanding habitat for other aquatic species such as fish, insects, birds and mammals. Additionally, having a diverse and healthy aquatic plant community will help to prevent invasive submergent plants such as Eurasian water milfoil and curly-leaf pondweed.

Integration of stakeholder input facilitated discussions throughout this planning process. The stakeholder survey highlighted many interesting conclusions about stakeholder lake use, preference on management and overall engagement with the ILA and health of Indian Lake. It is clear that Indian Lake stakeholders hold concern for the well-being of Indian Lake and are willing to work towards protecting it. In the Implementation Plan that follows, steps have been outlined that the ILA will follow in order to care for their lake in a responsibly and ecologically sound manner.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the Indian Lake Association Planning Committee and ecologist/planners from Onterra. It represents the path the ILA will follow in order to meet their lake management goals. The goals and initiatives detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Indian Lake stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders.

The Implementation Plan is divided into two sections – Management Goals and Initiatives. These two components will work hand-in-hand; while Management Goals describe measurable achievements the ILA will pursue, the Initiatives describe direct actions that will be implemented in order to reach the Management Goals. Through this process, the ILA will strengthen their community ties while working collectively to protect and enhance Indian Lake.

Management Goal 1: Deepen the Community's Commitment to Protect, Preserve and Enhance the Health and Aesthetic Value of Indian Lake

Management Action 1:	Develop a Property Certification Program that provides educational opportunities and incentives for Best Management Practice implementation on private properties.
Timeframe:	*Within five years, 50% of lake front owners will have completed the program.*

Management Action 2:	Encourage lakefront residents to participate in ILA Lake Recreation, Protection and Community Development Program.
Timeframe:	*Within three years, 50% of lake front owners will attend at least two events per year.*

Description: Though there are many management entities that oversee Indian Lake (See Table 5.1-1), it is ultimately the property owners around the lake that influence the habitat, water quality and aesthetic value of this natural resource. It is primarily their inherited responsibility to protect the lake environment as well – what some refer to as being a good "lake steward". This is best achieved when all property owners are knowledgeable about lake related issues, particularly their properties' impact on the lake.

Action 1 and 2 of this Management Goal aim to unite and involve Indian Lake property owners around a common cause – protecting the Indian Lake environment for generations to come. This will be achieved through the Property Certification Initiative (See Initiatives at end of this section) and the Lake Recreation, Protection and Community Development Initiative.

Management Goal 2: Develop and Maintain Appropriate Communication and Coordination Between the Indian Lake Association, Non-Association Residents and Other Lake Management Entities.

Management Action 1:	Produce and distribute at least three ILA newsletters per year, including non-association residents in at least one mailing per year.
Timeframe:	*Initiate during 2014, continue indefinitely*

Management Action 2:	Develop an official ILA web presence.
Timeframe:	*Initiate during 2014, continue indefinitely*

Management Action 3:	Present the final Indian Lake Management Plan to the Sugar Camp Town Board.
Timeframe:	*Complete during 2014.*

Management Action 4:	Provide an annual presentation of ILA activities to the Sugar Camp Town Board.
Timeframe:	*Initiate during 2014 and continue annually.*

Management Action 5:	Maintain ILA membership, support and a representative to the OCLRA and Wisconsin Lakes.
Timeframe:	*Achieve during 2014 and continue indefinitely.*

Management Action 6:	Maintain and update as required, for ILA internal use, a list of pertinent contacts.
Timeframe:	*Achieve during 2014.*

Description: As with most organizations, open lines of communication are essential to successful operation. Communication among lake stakeholders is important because it builds a sense of community around a lake while encouraging the spread of information regarding association news, educational topics or social events. Communication also ensures that volunteer or other efforts are not duplicated and that resources are spent efficiently.

Following through with communication to the general ILA membership as well as to other stakeholders is also essential. In addition to an annual meeting, the ILA currently communicates to the lake residents through a biannual newsletter and special release emails. As specified in Action 1 and 2, the ILA is planning to increase the frequency in their distribution of newsletters to members and non-members. Additionally, the Board of Directors will give consideration to a website and/or Facebook® page to communicate information via the internet. Inclusion of these communication methods may be useful for posting special announcements, educational material, etc. and allowing individuals to become informed at their leisure as opposed to a formal meeting type of setting. Please note that in addition to the above mentioned electronic communications, the ILA is committed to continue to deliver paper versions of all newsletters, as requested, to those lake residents who do not have access to email or the internet.

It is important that the ILA actively engage with outside management entities to enhance the association's understanding of common management goals and to participate in the development of those goals. As stated in Action 3 and 4, the ILA present the culminating work of this management planning process, as well as an annual update on lake protection activities to the Town of Sugar Camp. In addition to the town, relationships with county and statewide management entities must be maintained if the ILA is to manage Indian Lake efficiently and with the most up-to-date information on lake related matters. The ILA will retain membership within several organizations, such as those listed in Action 5, while maintaining a database of contact information of other lake management units. The primary management units regarding Indian Lake include organizations such as those previously mentioned in addition to entities such as the WDNR and Oneida County AIS Coordinator. Each entity is specifically addressed within Table 5.1-1.

The actions identified within this Management Goal are supported by a number of initiatives, including the Property Certification and Outdoor Activities Initiatives.

Table 5.5-1. Indian Lake management unit contact list.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Oneida County Lakes & Rivers Association (OCLRA)	Indian Lake representative (Kathy Noel – 715-272-2016)	Protects Oneida Co. waters through facilitating discussion and education.	Twice a year or as needed.	Become aware of training or education opportunities, partnering in special projects, or networking on other topics pertaining to Oneida Co. waterways.
Oneida County AIS Coordinator	AIS Coordinator (Michele Saduaskas – 715.365.2750)	Oversees AIS monitoring and prevention activities locally.	Twice a year or more as issues arise.	Spring: AIS training and ID, AIS monitoring techniques Summer: Report activities to Ms. Saduaskas.
Oneida County Land and Water Conservation Department	Conservation specialist (Jean Hansen – 715-365-2750)	Oversees conservation efforts for land and water projects.	Twice a year or more as needed.	Contact for shoreland remediation techniques and cost-share procedures, wildlife damage programs, education and outreach documents.
Town of Sugar Camp	Town Chair (Scott Holewinski – 715-493-4647)	Oversees ordinances and other items pertaining to town.	As needed.	Town staff may be contacted regarding ordinance reviews or questions, and for information on community events.
Wisconsin Department of Natural Resources	Fisheries Biologist (John Kubisiak – 715.365.8919)	Manages the fishery of Indian Lake.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Kevin Gauthier – 715.365.5211 ext. 214)	Oversees management plans, grants, all lake activities.	Every 5 years, or more as necessary.	Information on updating a lake management plan (every 5 years) or to seek advice on other lake issues.
	Warden (Patrick Novesky – 715.365.8948)	Oversees regulations handed down by the state.	As needed. May call the WDNR violation tip hotline for anonymous reporting (1-800-847-9367, 24 hours a day).	Contact regarding suspected violations pertaining to recreational activity on Indian Lake, include fishing, boating safety, ordinance violations, etc.
	Citizens Lake Monitoring Network contact (Sandra Wickman – 715.365.8951)	Provides training and assistance on CLMN monitoring, methods, and data entry.	Twice a year or more as needed.	Late winter: arrange for training as needed, in addition to planning out monitoring for the open water season. Late fall: report monitoring activities.
Wisconsin Lakes	General staff (800.542.5253)	Facilitates education, networking and assistance on all matters involving WI lakes.	As needed. May check website (www.wisconsinlakes.org) often for updates.	ILA members may attend WL's annual conference to keep up-to-date on lake issues. WL reps can assist on grant issues, AIS training, habitat enhancement techniques, etc.
UW-Extension	Northern WI Regional Contact (Laura Herman – 715-365-8984)	Provides volunteer monitoring training, educational materials	As needed.	May contact for educational material on lake related issues, contact for assistance on lake monitoring of various types.

Management Goal 3: Increase ILA's Capacity to Educate and Involve Lake Stakeholders

Management Action 1:	Increase and maintain ILA membership to include at least 50% of all lake residents.
Timeframe:	*Achieve within three years and maintain indefinitely.*

Management Action 2:	Increase the number of active ILA members to at least 50% of the ILA membership. **Note: Active member defined as an individual who attends at least two association meetings or gatherings per years.*
Timeframe:	*Achieve within four years.*

Description: Even through lake associations consist of individuals who are passionate about their lake, it is often difficult to recruit help with monitoring or protecting the lake. Many lake association members are elderly/retired, so labor intensive volunteer jobs can be difficult to perform. Other residents may only visit the lake several times during the year. Some have cut back on volunteering or have concerns over the time commitment involved, while others may have not been asked to lend their services. Those that have volunteered in the past and have had a poor experience may be hesitant to volunteer again. Some may have been turned off by an impersonal, tense or cold atmosphere. Volunteers want to feel good about themselves for helping out, so every effort must be made by volunteer managers to see to it that the volunteer crews enjoy their tasks and their co-volunteers.

The ILA is proud of their active role in preserving Indian Lake for all stakeholders; however, they are in constant need of volunteers to continue this high level of commitment. As a result of this lake management planning project, the association has adopted an approach of building a tight-knit community that participates in fun and educational activities on Indian Lake and in the surrounding area. The Lake Recreation, Protection and Community Development Initiative, which promotes regular outdoor ILA organized and sponsored events, is the lever for building this community. The benefit of a lake community is added involvement within the lake association, more volunteers available to assist in monitoring and protective measures as well as a deepened appreciation of the lake environment.

Management Goal 4: Maintain Current Water Quality Conditions

Management Action 1:	Continue monitoring lake water quality on a regular basis through the WDNR Citizen Lake Monitoring Network.
Timeframe:	*Initiate during 2014, continue indefinitely*

Management Action 2:	Protect existing natural shoreland zones along Indian Lake, ensuring that natural and developed-natural shorelands remain so.
Timeframe:	*Initiate during 2014, continue indefinitely*

Management Action 3:	Initiate restoration on at least 50% of the highly developed shoreland areas identified in 2012.
Timeframe:	*Achieve within five years, and continue to grow indefinitely.*

Management Action 4:	Perform a physical inspection of the Indian Lake watershed at least once per year to ensure that conditions have not changed that would negatively impact Indian Lake water quality.
Timeframe:	*Initiate during 2014 and continue annually.*

Management Action 5:	Update Management Plan in 5-10 years.
Timeframe:	*Initiate during 2019-2024*

Description: Water Quality/Quantity Monitoring

The water quality of a lake is, in many respects, paramount as far as environmental concern goes and influences many other factors in a lake ecosystem. Water quality may influence the aquatic plant community in many ways, including what species are present, how deep plants may be found, and determining the abundance of algae in a lake. A lake's water quality may also determine what species of fish are present. From a lake property owner's perspective, water clarity and condition is a critical matter in determining recreational use and aesthetics.

Monitoring water quality is of great importance, and aids in management of a lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends will likely aid in an earlier definition of what may be causing the trend.

The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. Volunteers trained by the WDNR as a part of the CLMN program begin by collecting Secchi disk transparency data for at least one year, then if the WDNR has availability in the program, the volunteers may enter into the *advanced program* and collect water chemistry data including chlorophyll-a, and total phosphorus. The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring.

At this time, there are a couple of ILA members currently collecting data as a part of the CLMN. Specifically, those trained collect Secchi disk clarity on Indian Lake. The ILA will pursue stepping up their collection efforts to the advanced program and collect water chemistry data as well as dissolved oxygen. Dissolved oxygen monitoring would be made possible through connections made with Oneida County. It will be the Board of Directors responsibility to ensure that a volunteer is prepared to communicate with WDNR representatives and collect water quality samples on the lake each year.

In addition to monitoring of water chemistry and clarity, the ILA wishes to document and monitor lake water levels. Like many lakes in Wisconsin, the water levels in the lake have fluctuated in response to changing precipitation conditions over the past 10-15 years. Lakes that lack a tributary input (drained lakes, spring or seepage lakes) are typically impacted more so by lower precipitation levels than drainage lakes, which are tempered by the larger amount of land that drains to them. Like monitoring water quality, water level monitoring should be conducted using standardized methodology such as a calibrated staff gauge. Additionally, measurements should be made available in a public forum so that those managing Indian Lake in the future can retrieve the data.

Shoreland Protection and Restoration

As discussed within the Shoreland Condition Section, the shoreland zone of a lake is highly important to the ecology of a lake. When shorelands are developed, the resulting impacts on a lake range from a loss of biological diversity to impaired water quality. Because of its proximity to the waters of the lake, even small disturbances to a natural shoreland area can produce ill effects.

The ILA will address this critical habitat and buffering zone through a two-tiered effort; promoting natural shoreland area protection and developed shoreland restoration. Currently 64% of the Indian Lake shoreland may be considered Natural/Undeveloped or Developed-Natural; these shorelands should be prioritized for preservation. This may be achieved through educational initiatives or physical safeguarding through conservation easements or land trusts.

At the same time, 11% of the Indian Lake shoreland may be classified as Urbanized or Developed-Unnatural. The ILA will work to focus restoration efforts upon these areas. This will be conducted through education first and foremost, but also through integration of the Property Certification Initiative.

Watershed Inspection

Indian Lake's watershed is roughly 922 acres in size – not too much larger than Indian Lake itself (357 acres). At planning meetings associated with this project, Indian Lake Planning Committee members indicated great interest in taking it upon themselves to increase awareness of watershed issues and preservation. With the Indian Lake Association being small and in good communication, members know the majority of ownership in the watershed. Through these relationships, and an organized event held through the Lake Recreation, Protection and Community Development Initiative, a tour of the watershed would occur annually by interested ILA members to discover first-hand the conditions present in the watershed. This would be largely an educational endeavor, but may also shed light on issues that may be occurring in the watershed that could impact the lake.

Management Plan Update

Continued monitoring of an environment is only useful if the data collected is analyzed in an objective manner. Long term trend data, in particular, must be analyzed carefully to detect if the observed values are influenced purely by ecosystem factors or by outside variables such as precipitation, temperature, sunlight, etc. To that extent, the ILA will solicit professional assistance in completing a management plan update in 5-10 years. This update would build upon pre-existing data, while including new data to be collected from the lake and its watershed. Components may include long term water quality analysis, watershed assessments, aquatic plant inventories and stakeholder integration. Evaluation of ILA educational and ecosystem preservation efforts may be included also.

Management Goal 5: Prevent Aquatic Invasive Species Introductions to Indian Lake

Management Action 1:	Mitigate any known occurrences of AIS immediately.
Timeframe:	*Initiate during 2014, continue indefinitely*

Management Action 2:	Continue Clean Boats Clean Waters inspections at the Indian Lake public landing.
Timeframe:	*Initiate during 2014 and achieve full implementation by 2015.*

Management Action 3:	Perform a complete lake sweep for AIS at least twice each summer.
Timeframe:	*Initiate during 2014, continue indefinitely*

Management Action 4:	Develop an AIS rapid response plan that can be implemented upon the identification of a new infestation.
Timeframe:	*Adopt in 2014, initiate if necessary.*

Description: Mitigation of known AIS

Currently, Indian Lake is known to only hold one non-native plant: purple loosestrife. Therefore, Action 1 of this Management Goal pertains to a direct action to mitigate this occurrence. The single plant that was found on the shoreland of Indian Lake during 2012 surveys was removed and has since been watched by ILA members. The ILA, through lake sweeps conducted through the AIS Prevention and Control Initiative, will continue to keep watch for purple loosestrife and other non-native species and will remove them in accordance with training provided by Oneida County AIS Coordinator Michelle Saduaskas.

Prevention of AIS introductions

Realizing the threat that AIS pose to the ecosystem of Indian Lake, the ILA has decided to take a strong stance on implementation of preventative measures. These measures are outlined in Actions 2 and 3 of this Management Goal.

The ILA will seek volunteers to complete watercraft inspections at the Indian Lake public access in accordance with Clean Boats Clean Waters protocols. Ideally, inspections would occur on all weekends through the summer months and on holidays during June, July and August. These are known as “high traffic periods”. This method is considered to be the best way of reducing the chance of AIS introduction to a lake.

Although it is preferred to catch non-native plants or animals before they enter the lake environment, it is understood that public access points cannot be monitored at all times. Therefore, the ILA wishes to implement a volunteer-based program aimed at identifying early infestations of AIS. Called "lake sweeps", these visual inspections of the Indian Lake littoral zone would take place twice a year – in June and August. The goal is to look for non-native plant or animal species that are best visible during these times. Volunteers will need to be trained by Oneida County AIS Coordinator Michelle Saduaskas on surveying and data collection methods.

Aquatic Invasive Species Rapid Response Plan
In the event that a submergent AIS is suspected on Indian Lake, the ILA has adopted a Rapid Response Plan to deal with the infestation. This process is described below:

The location of the non-native plant would be marked (e.g. GPS, maker buoy) and a specimen would be taken to Oneida County Invasive Species Coordinator Michele Sadauskas for verification. Once verified, WDNR Lake Coordinator Kevin Gauthier would be contacted to discuss a formal monitoring and/or control strategy. The WDNR would also be able to help financially through the AIS Grant Program's Early Detection and Response program. This grant program is non-competitive and doesn't have a specific application deadline, but is offered on a first-come basis to the sponsor of project waters that contain new infestations (less than 5 years). Currently this program will fund up to 75% percent of monitoring and control costs, up to $20,000.

If verified as an AIS, the area would be professionally surveyed, either by agency personnel or a private consulting firm during that plant species' peak growth phase (late summer for Eurasian water milfoil, early summer for curly-leaf pondweed). The results of the survey would be used to create a prospective control strategy.

Hand-removal Control Strategy

Small isolated infestations of Eurasian water milfoil and curly-leaf pondweed can most be controlled using strategic manual removal methods, likely through snorkeling. In order for this technique to be successful, the entire plant (including the root) needs to be removed from the lake. During manual extraction, careful attention would need to be paid to all plant fragments that may detach during the control effort. Additional guidance on hand-removal methods can be found within educational pamphlet, *Eurasian Water Milfoil Manual Removal*, co-authored by the Lumberjack Resource Conservation & Development (RC&D) Council, Inc. and Golden Sands RC&D Council, Inc. This pamphlet can be obtained by contacting the

Golden Sands RC&D (www.goldensandsrcd.org).

Herbicide Control Strategy

At this time, the most feasible method to control larger infestations is through herbicide applications, specifically, early-spring treatments with 2,4-D. Out of 46 responses, 22 (47%) of ILA stakeholders were not supportive of a herbicide control method, as determined through the stakeholder survey. 24% displayed various levels of support while 26% were unsure on this management technique (Appendix B, Question #24). Note however that at the time this question was asked, submergent invasive plant species were not known to exist within Indian Lake.

If an AIS population is too large to be controlled using manual removal techniques, the ILA would need to be educated on potential alternative strategies including what would likely happen if no action is taken. Fifty-nine percent of stakeholder survey respondents indicated that they would like to learn more about AIS control methods and 44% indicated they wanted to learn more about the risks of AIS control (Appendix B, Question #25). The ILA would like to address these issues through an educational initiative, such as described in Management Goals 1 and 2. ILA members would create educational pieces within the biannual newsletters, as well as solicit area research managers (e.g. WDNR, Oneida County AIS Coordinator, etc) to present at association meetings.

If large populations of AIS are located and the ILA would like to initiate an herbicide control program, a formal monitoring strategy consistent with the Appendix D of the WDNR Guidance Document, *Aquatic Plant Management in Wisconsin* (Hauxwell 2010) would need to be developed. This form of monitoring is required by the WDNR for all large scale herbicide applications (exceeding 10 acres in size or 10% of the area of the water body that is 10 feet or less in depth) and grant-funded projects where scientific and financial accountability are required.

The ILA Board of Directors, with help from an herbicide applicator if applicable, would be required to obtain the proper permits to implement this management action. The websites below outline several helpful resources:

WDNR Plant Management and Protection Program:

- www.dnr.state.wi.us/lakes/plants

The UW Extension Lake List is a great resource for locating an herbicide applicator:

- www.uwsp.edu/cnr/uwexlakes/lakelist/businessSearch.asp

Management Goal 6: Maintain as Well as Enhance Indian Lake Fisheries and Fisheries Habitat

Management Action 1:	Coordinate with WDNR and private landowners to expand coarse woody habitat in Indian Lake by at least 100%.
Timeframe:	*Achieve within five years and continue to grow indefinitely.*

Description: Fishing, a hobby that is no stranger to Wisconsin residents, was ranked as the most important activity by Indian Lake stakeholders in a 2012 survey (Appendix B, Question #14). Survey respondents indicated that smallmouth bass, walleye, and panfish species were their favorite to fish for (Question #9). If possible, ILA requested that management emphasis be placed upon walleye more so than other species (Question #10).

ILA stakeholders must realize the complexities and capabilities of the Indian Lake ecosystem with respect to the fishery it can produce. With this, an opportunity for education and habitat enhancement is present in order to help the ecosystem reach its maximum fishery potential. As part of the Property Certification Initiative, residents may learn of the value in having coarse woody habitat along their shoreland. There may also be room for improvement of these structures; interested ILA members will coordinate with the ILA Board of Directors to implement coarse woody habitat projects along their shoreland properties. Please note that not all locations may be suitable for coarse woody habitat structures, and these structures may not directly benefit all gamefish species, such as walleye. Habitat design and location placement would be determined in accordance with WDNR fisheries biologist John Kubisiak.

The ILA planning committee has identified a numeric benchmark of a 100% increase in coarse woody habitat within five years. To measure this, the ILA will repeat the coarse woody habitat study completed during this project, mimicking the methodology as to be consistent. The ILA may also elect to have this survey replicated during a management plan update by a professional group.

Indian Lake Association Initiatives

The following Initiatives are projects specifically designed to help achieve the Indian Lake Management Goals. In most cases a single initiative is intended to facilitate the achievement of multiple Goals. It is proposed that the following four (4) initiatives be chartered immediately by the ILA Board of Directors in order to initiate the specific actions required to achieve our management goals.

1. Property Certification Initiative

Description: The ILA will develop and implement a property evaluation and education program similar to Maine's "LakeSmart" program that offers lakefront residents the opportunity to learn how to manage their home and yard to protect the water quality and shoreland habitat of the lake. Ultimately residents earn official certification and recognition for completing the program.

http://www.maine.gov/dep/water/lakes/lakesmart/

Timeframe: *Develop pilot program during 2014. Achieve program implementation by 2015. Achieve program goals within 5 years.*

Funding: Though still a work in progress, shoreland restoration work may be applicable for grant funding through a new program in development by the WDNR. This new program is tentatively titled, "Lake Health Initiatives: Packaging Funding and Best Practices for Waterfront Properties". The ILA will watch the progression of this program and examine its usefulness, as well as other cost-sharing opportunities through the state or county, for ILA shoreland restoration projects.

This initiative is intended to help achieve the following Management Goals:

- ✓ Goal 1: Develop an environmental education program.
- ✓ Goal 3: Increase and maintain ILA membership.
- ✓ Goal 3: Increase the number of active ILA members.
- ✓ Goal 4: Protect existing natural shoreline zones.
- ✓ Goal 4: Initiate restoration on at least 50% of the highly developed shoreline areas.
- ✓ Goal 6: Coordinate with WDNR and private landowners to expand course woody habitat.

Initiative Charter and Team: Once this initiative is chartered by the Board of Directors and an initiative team is formed, it is the responsibility of the team to develop a 2-year plan outlining how they intend to develop the program as described above, and meet the stated goals. The Initiate Team leader is directed to report progress to the Goals Management Team on a quarterly basis.

2. Lake Recreation, Protection and Community Development Initiative

Description: Literature and research supports the idea that individuals who spend time outdoors generally are more likely to support environmental preservation programs. The intent of this initiative is to develop and implement a fun outdoor activity program intended to encourage residents to get out and enjoy the lake with other ILA members, as well as eventually join and participate in the Association. These ILA sponsored events could be recreational events such as canoe/kayak outings, fishing derby, pontoon party, fishing lessons, ice fishing, or a BBQ/picnic event; or they could also be fun activities designed to support other goals, such as:

- Onsite AIS training
- AIS sweep of the lake in kayaks, canoes, and/or a pontoon boat
- Hike around the lake to explore and inspect the Indian Lake watershed
- Learn how our volunteers collect and report water samples on lake quality
- Canoe & kayak to identify and record course woody habitat

Timeframe: *Initiate program during 2014 with at least 8 events.*

This initiative is intended to help achieve the following Management Goals:

- ✓ Goal 1: Encourage lakefront residents to participate in ILA-sponsored outside events.
- ✓ Goal 3: Increase and maintain ILA membership.
- ✓ Goal 3: Increase the number of active ILA members.
- ✓ Goal 4: Monitor lake water quality on a regular basis.
- ✓ Goal 4: Perform physical inspection of the Indian Lake watershed at least once per year.
- ✓ Goal 5: Perform a complete lake AIS sweep at least twice each summer.

Initiative Charter and Team: Once this initiative is chartered by the Board of Directors and an initiative team is formed, it is the responsibility of the team to develop a 2-year plan outlining how they intend to develop the program as described above, and meet the stated goals. The Initiate Team leader is directed to report progress to the Goals Management Team on a quarterly basis.

3. AIS Prevention and Control Initiative

Description: It will be the responsibility of this initiative team to coordinate the ILA's efforts in monitoring AIS. Although the most recent evaluation found no significant sign of AIS in the lake, it is important that the lake community is able to identify the most common forms of AIS in our area and prepared to remove any that are identified. Additionally this team is tasked with organizing the lake community to work on our Clean Boats – Clean Water at the public landing.

This initiative is intended to help achieve the following Management Goals:

- ✓ Goal 5: Perform a complete lake sweep for AIS at least twice each summer.
- ✓ Goal 5: Develop an AIS rapid response plan that can be implemented upon the identification of new infestation.
- ✓ Goal 5: Continue the Clean Boats Clean Water inspections at the Indian Lake public landing.
- ✓ Goal 5: Mitigate any known occurrences of AIS immediately.

Initiative Charter and Team: Once this initiative is chartered by the Board of Directors and an initiative team is formed, it is the responsibility of the team to develop a 2-year plan outlining how they intend to develop the program as described above, and meet the stated goals. The Initiate Team leader is directed to report progress to the Goals Management Team on a quarterly basis.

4. Goals Management Team

Description: This team, chaired by the Board of Directors Vice President and made-up of selected Board members, is tasked with monitoring the progress of the Initiative Teams, as well as tracking the achievement of Management Goals.

Responsibilities:

- Monitor the progress of the Initiative Teams and prepare a progress report and recommendations as they deem appropriate to the ILA Board on a quarterly basis.
- Recommend changes in the initiative teams as appropriate.
- Monitor and evaluate the progress in achieving each Management Goals, especially those not directly addressed by an initiative.
- Present a progress report to the ILA membership once per year at the Annual Meeting.

6.0 METHODS

Lake Water Quality

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

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

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

Watershed Analysis

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

Aquatic Vegetation

Curly-leaf Pondweed Survey

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

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Indian Lake to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in the Wisconsin Department of Natural Resource document, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry, and Analysis, and Applications (Hauxwell 2010) was used to complete this study. A point spacing of 53 meters was used resulting in approximately 515 points.

Community Mapping

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

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

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