Pickerel and Crane Lakes

Forest / Langlade Counties, Wisconsin

Comprehensive Management Plan

December 2012

-Updated August 2013-

Sponsored by:

Pickerel Crane Protection & Rehabilitation District

Wisconsin Department of Natural Resources
Grant Program

LPL-1289-09, LPL-1290-09, & LPL-1291-09

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Onterra LLC
Lake Management Planning

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Funded by: Pickerel Crane P & R District
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Acknowledgements

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

Pickerel and Crane Lakes Planning Committee

Lauren Freston	Glen Schwalbach	Ron Freston
Linda Maas	Jim Payne	Greg Borgwardt
Gene Jentink	Phil Hollmann	Craig Farah
Harlan Knudson	Gene Ebben	Walt Ferguson
Jerome Hietpas	Greg Hullar	Pat Payne

Wisconsin Dept. of Natural Resources

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1.0 INTRODUCTION

Pickerel and Crane Lakes, located in Forest and partially in Langlade Counties, are two drainage lakes with a combined surface area of 1,640 acres (Map 1). These eutrophic lakes have a watershed that is much larger (13 and 15 times for Pickerel and Crane lakes, respectively) than the size of each lake. Both lakes hold a combined 32 native plant species, along with a single non-native plant, Eurasian water milfoil.

Field Survey Notes

Pickerel and Crane Lakes are two relatively shallow and productive lakes with abundant plants and good water quality.

Photograph 1.0-1 Crane Lake, Forest County

Lake at a Glance*

	PICKEREL	CRANE
Morphology		
Acreage	1,299	341
Maximum Depth (ft)	19.0	25.0
Mean Depth (ft)	8.3	11.5
Shoreline Complexity*	0.76	2.27
Vegetation		
Curly-leaf Survey Date	June 9 & 10 2009	
Comprehensive Survey Date	August 21 & 22, 2006	
Number of Native Species	27	18
Threatened/Special Concern Species	None	
Exotic Plant Species	Eurasian water milfoil	
Simpson's Diversity	0.85	0.83
Average Conservatism	6.0	5.9
Water Quality		
Trophic State	Eutrophic	Eutrophic
Limiting Nutrient	Phosphorus	Phosphorus
Water Acidity (pH)	8.0	8.0
Sensitivity to Acid Rain	Not sensitive	Not sensitive
Watershed to Lake Area Ratio	15:1	13:1

**These parameters/surveys are discussed within the sections to follow.*

These two lakes may be considered a headwater system; Crane flows into Pickerel Lake, which flows eventually into the Wolf River. The two lakes differ slightly; Crane Lake is fairly deep while Pickerel Lake's shallow depth and dense aquatic vegetation population have become major concerns of the Pickerel Crane Lake Protection and Rehabilitation District (PCLPRD). Harvesting activities have been used on Pickerel Lake to increase recreational opportunities and remove excess plant material along the shoreline. Harvesting is also used on Crane Lake to a limited extent.

The outlet at Pickerel Lake is fitted with a small earthen dam that is owned by the Town of Ainsworth and was built in 1972 to retain water for recreational purposes. The dam is 5.10 feet tall, and holds a hydraulic height of two feet. It has a maximum storage of roughly 5,200 acre-feet, and holds an operating range of between 97.57 and 98.07 feet (a 0.5 foot range). During 2010, WDNR engineers visited the dam to address water level concerns. During calculations following this visit, engineers noted that the correlation between the elevation and gauge settings on the dam are not in alignment, and that there was a need to reestablish this relationship (Terry Cummings, personal communication). At the time of this writing (December 2012), the matter had not been addressed due to travel restrictions of dam employees.

The non-native aquatic plant, Eurasian water milfoil, is also a concern of the PCLPRD. This plant was first located in Pickerel Lake only a few years ago by PCLPRD members (2006) and was later verified by the Wisconsin Department of Natural Resources (WDNR) as being a hybrid species (*Myriophyllum spicatum x sibericum*). These lakes are a highly sought after location amongst recreationists and anglers, who come to stay at any of the six resorts that reside on the lakes or partake in the two fishing tournaments that are put on each year. These intense public use opportunities most likely contributed to Pickerel Lake becoming infested with hybrid Eurasian water milfoil. In 2009, Onterra staff located several Eurasian water milfoil plants in Crane Lake, providing testimony to the fact that Eurasian water milfoil has infested this waterbody as well.

There are four primary reasons why the PCLPRD applied for WDNR grant money to complete studies on their lakes: 1) to learn the extent of the exotic plants which occur in their lakes, 2) to formulate an ecologically sound harvesting program on Pickerel Lake to reduce nuisance levels of native plants that meets stakeholder's interests, 3) to understand their lake ecosystem more fully, and 4) to be eligible to receive additional WDNR grant funds to address AIS and other goals of lake stakeholders. The data included in this project will serve as a baseline for which future management planning projects can call upon. Therefore, this project is important not only in the management and protection of the lake, but also in its likely restoration.

2.0 STAKEHOLDER PARTICIPATION

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

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

Kick-off Meeting
On June 13, 2009, 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 PCLPRD board members. The attendees were first informed about the events that led to the initiation of the project. The presentation given by Tim Hoyman started with an educational component regarding general lake ecology and ending with a detailed description of the project including opportunities for stakeholders to be involved. Mr. Hoyman's presentation was followed by a question and answer session.

Stakeholder Survey
During September 2008, a six-page, 29-question survey was mailed to about 600 riparian property owners in the Pickerel and Crane Lakes watershed. 50 percent of the surveys were returned and those results were entered into a spreadsheet by members of the Pickerel and Crane Lakes Planning Committee. The data were summarized and analyzed by Onterra for use during the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan.

Planning Committee Meeting I
On May 15, 2010, Tim Hoyman of Onterra met with fourteen members of the Pickerel and Crane Lakes Planning Committee for a little over 3 hours. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including, Eurasian water milfoil survey results, aquatic plant inventories, water quality analysis, and watershed modeling were presented and discussed. Many concerns were raised by the committee, including nuisance levels of aquatic plants, water levels, and harvesting plans.

Planning Committee Meeting II

On August 3, 2010, Tim Hoyman and Eddie Heath met with the members of the Planning Committee once again for about three hours. In this meeting, the group began developing management goals and actions for the Pickerel and Crane Lakes management plan. Topics discussed in detail included harvesting plans for 2011, alternatives available for controlling Eurasian water milfoil in Pickerel Lake and other challenges that the PCLPRD and their lakes faced. These discussions are the foundation for the Implementation Plan found near the end of this document.

Management Plan Review and Adoption Process

The Pickerel and Crane Lake Planning Committee received the results of the study (Section 3 of this report) in May of 2010, and reviewed this portion of the document prior to the first committee meeting. Following a second planning meeting, Onterra staff drafted the Implementation Plan, which was sent to the planning committee for their input. An official draft of the Management Plan was sent to the WDNR in March of 2012. Kevin Gauthier of the WDNR reviewed the document and provided comments in December of 2012. His comments were addressed and the plan was finalized later that month. Upon acceptance of the plan by the WDNR, the PCPRD Board of Directors will vote to accept the plan and follow through with its implementation at their next board meeting.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, 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 Pickerel and Crain Lake is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region (Appendix C). In addition, the assessment can also be clarified by limiting the primary analysis to parameters that are important in the lake's ecology and trophic state (see below). Three water quality parameters are focused upon in the Pickerel and Crain 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 descending water depths within a lake. Although it is a simple procedure, the completion of several profiles over the course of a year or more provides a great deal of information about the lake. Much of this information relates to whether the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

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

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

*This project relied on water quality data collected through the citizens lake monitoring network; therefore, temperature and dissolved oxygen profiles were only collected during the three sample events conducted by Onterra staff.

Internal Nutrient Loading

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

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

Non-Candidate Lakes

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

Candidate Lakes

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

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

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

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

Comparisons with Other Datasets

The WDNR publication *Implementation and Interpretation of Lakes Assessment Data for the Upper Midwest* (PUB-SS-1044 2008) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's landcover. For this reason, the water quality of Pickerel and Crane Lakes 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.

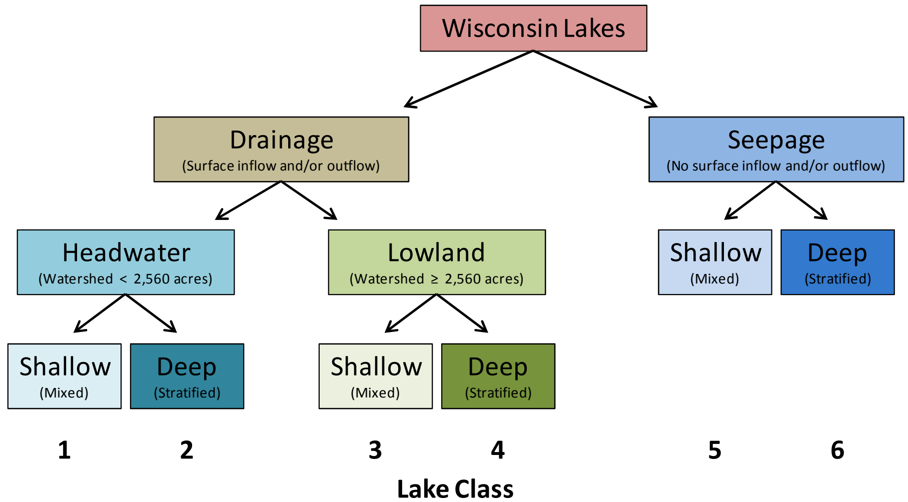

Figure 3.1-1. Wisconsin Lake Classifications. Pickerel and Crane Lakes are classified as shallow (mixed), lowland drainage lakes (Class 3). Adapted from WDNR PUB-SS-1044 2008.

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

The Wisconsin 2010 Consolidated Assessment and Listing Methodology (WisCALM), created by the WDNR, is a process by which the general condition of Wisconsin surface waters are assessed to determine if they meet federal requirements in terms of water quality under the Clean Water Act (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. One of the assessment methods utilized is Carlson's Trophic State Index (TSI). They divided the phosphorus, chlorophyll-*a*, and Secchi disk transparency data of each lake class into ranked categories and assigned each a "quality" label from "Excellent" to "Poor". The categories were based on pre-settlement conditions of the lakes inferred from sediment cores and their experience.

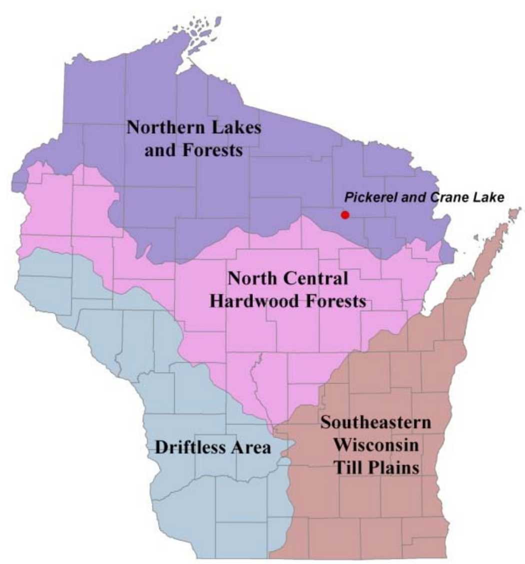

Figure 3.1-2. Location of Pickerel and Crane Lake within the ecoregions of Wisconsin. After Nichols 1999.

These data, along with data corresponding to statewide natural lake means, historic, current, and average data from Pickerel and Crane Lakes are displayed in Figures 3.1-3 - 3.1-10. 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.

Pickerel and Crane Lakes Water Quality Analysis

Pickerel and Crane Lakes Long-term Trends

It is often interesting to examine anecdotal accounts of water quality trends on lakes. In a 2008 survey of lake stakeholders, about 76% of respondents believe that the water quality of Pickerel Lake was fair to excellent, and 66% believe that the water quality in this lake had remained the same or improved (Appendix B, Questions #16a and #17a). On Crane Lake, the majority of respondents (50%; 34% were not sure) believe that the water quality was fair to excellent, though that same 50% believe the water quality had either remained the same or degraded since they obtained their property (Appendix B, Questions #16b and #17b). Water quality degradation was ranked third on a list of concerns for both Pickerel and Crane Lakes by stakeholder survey respondents (Appendix B, Question #20), and septic system discharge, which may or may not impact water quality depending on the degree of pollution, was ranked second on a list of factors that may be negatively impacting these two lakes (Appendix B, Question #21).

A 1992 study on Pickerel and Crane Lakes by E & S Environmental discovered that groundwater inputs were significant in Crane Lake, and to a lesser extent in Pickerel Lake. If faulty septic tanks are located in areas of higher groundwater movement towards the lakes (i.e. properties with a lower elevation or more permeable soils) the potential for septic contamination increases. As part of this study, it was recommended that a septic inventory be performed on shoreline residences as failing septics were believed to be a major contributor of nutrients to the lake. A 1993 Foth & Van Dyke survey confirmed there were a large number of faulty septic systems surrounding Pickerel and Crane Lakes. As part of a grant funded three phase project completed in 1998 by Mid-State Associates, Inc., many residents had their septic systems visually inspected. These sites were hand selected by the PCPRD base- upon the 1993 Foth & Van Dyke study in which problematic systems were identified. The study completed by Mid-State Associates, Inc. aimed to determine which of these systems were passing or failing based upon Wisconsin Administrative Code which applies to existing septic systems. These tanks were pumped and inspected when the property owner was present and able to uncover the septic tank lid. Otherwise, no documentation of corrective action is known of. Table 3.1-1 summarizes the results of these surveys.

Table 3.1-1. Pickerel and Crane Lakes septic survey summary, 1996-1998. Study conducted and data provided by Mid-State Associates, Inc.

Phase	Lake	Survey Date	# Failing Systems	# Systems Evaluated	Failure Rate
Phase I	Crane	Jul-1996	30	37	81%
Phase I	Pickerel	Jul-1996	28	32	88%
Phase II	Pickerel	Aug/Sept 1997	30	57	53%
Phase III	Pickerel	Aug/Sept 1998	19	61	31%
		Total	107	187	57%

As described above, in terms of scientific water quality monitoring, there are three water quality parameters of most interest for this project: total phosphorus, chlorophyll-*a*, and Secchi disk transparency. A fair amount of water quality data exists for both Pickerel and Crane Lakes, spanning the past decade for two water quality parameters and over two decades for the third. Although it is difficult to accurately determine if any long-term trends have occurred, the data provides a solid baseline for these two systems and may indicate initial trends with continued monitoring. Under the WDNR's lake classification system, both Pickerel and Crane Lakes are classified as shallow (mixed), lowland drainage lakes, and thus the TSI thresholds correspond to these Wisconsin lake types.

Total phosphorus has been measured in these two lakes since 2002. Examination of these data indicate that Pickerel Lake phosphorus concentrations are slightly lower in the "Excellent" category than other shallow, lowland drainage lakes in the state and comparable to those levels found within the Northern Lakes and Forests ecoregion (Figure 3.1-3). Crane Lake concentrations are somewhat higher than Pickerel Lake but comparable to state-wide shallow, lowland drainage lakes and ecoregion values (Figure 3.1-4). Pickerel Lake annual growing season average concentrations and the total weighted average all fall into a category of "Excellent" while Crane Lake averages fall on the cusp of "Excellent" to "Good". While yearly summer averages in Pickerel Lake seem to have remained very consistent since 2002, those in Crane Lake have fluctuated between 22 and 38 μg/L. Fluctuations in lake phosphorus concentrations do occur, and can be a result of natural variations in plant and biological activity, climatic activity, or other environmental factors.

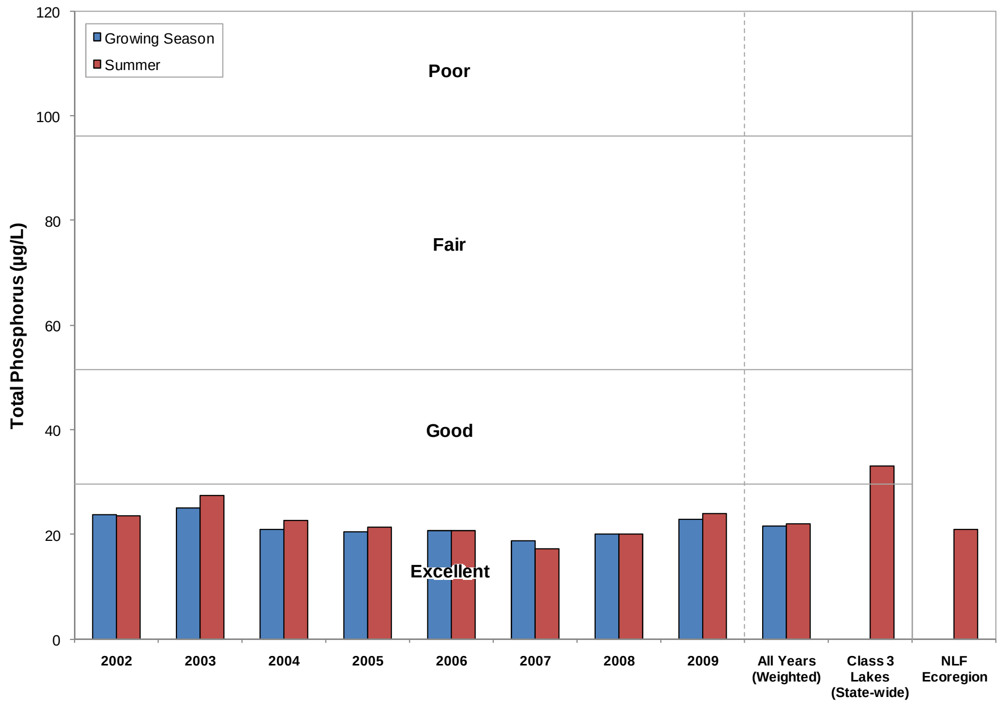

Figure 3.1-3. Pickerel Lake, state-wide class 3 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Along with phosphorus, chlorophyll-*a* has been monitored yearly since 2002 in both of these waterbodies as well. In Pickerel Lake these yearly average concentrations have remained very low when compared to similar lakes state-wide and regionally (Figure 3.1-5). However in Crane Lake these values have typically been found higher than similar state-wide and regional lakes, as well as Pickerel Lake (Figure 3.1-6). The Pickerel Lake chlorophyll-*a* values remained in the "Excellent" category for shallow, lowland drainage lakes, while Crane Lake has fluctuated from "Excellent" to "Fair".

When comparing the phosphorus and chlorophyll-*a* datasets for these two lakes, the relationship between these two water quality parameters is clear. The routinely low phosphorus values in Pickerel Lake support comparable chlorophyll-*a* values for the lake. Interestingly, the observed larger range in chlorophyll-*a* yearly summer averages is observed similar to the larger range seen in the phosphorus dataset for Crane Lake. Also, in years of high and low phosphorus concentrations (e.g. 2004 and 2009) the chlorophyll-*a* values are also observed as higher or lower as the nutrients determine the abundance of the algae producing this photosynthetic pigment.

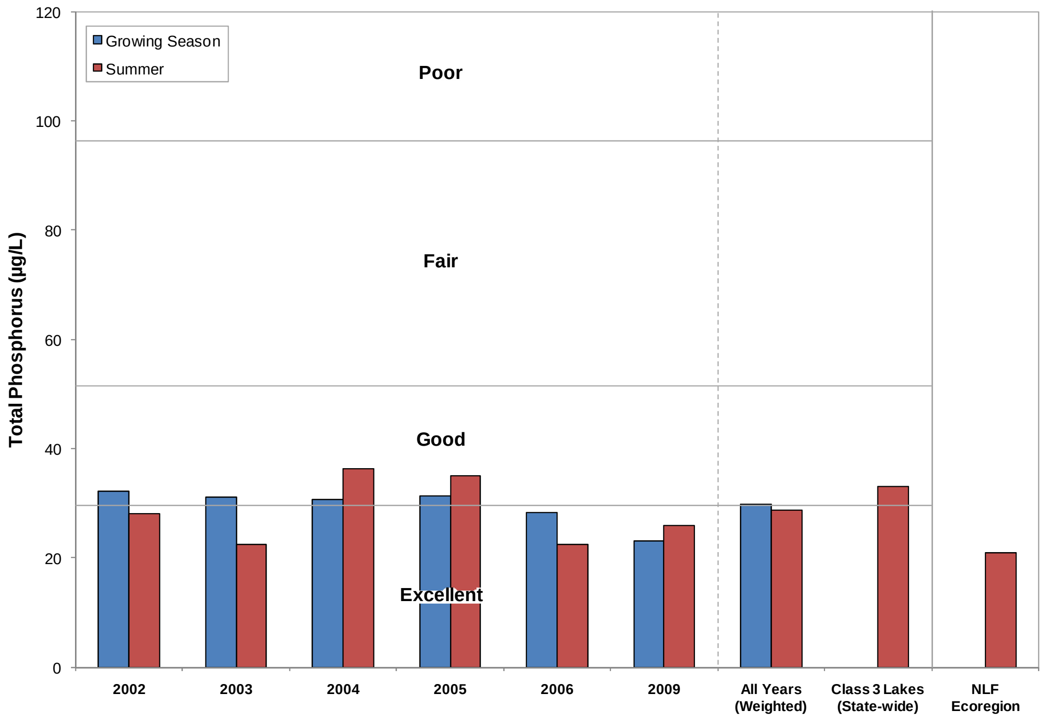

Figure 3.1-4. Crane Lake, state-wide class 3 lakes, and regional total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Considerable Secchi disk clarity data has been collected from Pickerel and Crane Lakes, with data spanning from 1987 to present in Pickerel Lake and 1990 to present (with several data gaps) in Crane Lake. Secchi disk clarity summer averages for both Pickerel and Crane Lakes have typically exceeded averages for shallow, lowland drainage lakes state-wide and regional lakes (Figure 3.1-7 and Figure 3.1-8). Values from both lakes fall in the "Excellent" category for shallow, lowland drainage lakes.

The Secchi disk dataset for these two lakes spans 20+ years. Data such as these are very important in water quality monitoring because it often serves as an important tool for management. Additionally, these data can also support or refute speculative observations about a lake's perceived water quality, or more importantly, perceived changes in water quality. The transparency of the water in Pickerel Lake seems to have changed within the dataset. Between the years of 1992-2001, Secchi disk values were among the highest values recorded (Figure 3.1-7). In the timeframe of 2001-2009, recorded values still ranged in the "Excellent" category, however were slightly lower than the majority of values recorded in 1992-2001. Although one might be led to believe this is a trend in decreasing water transparency, it is important to recall the data from 1987-1992, which includes several values well below the more recent readings taken in 1992-2001. It is likely that a cyclic relationship of increasing and decreasing water clarity is occurring on Pickerel Lake, and this cycle is likely influenced heavily by environmental factors, such as precipitation, temperatures and available sunlight.

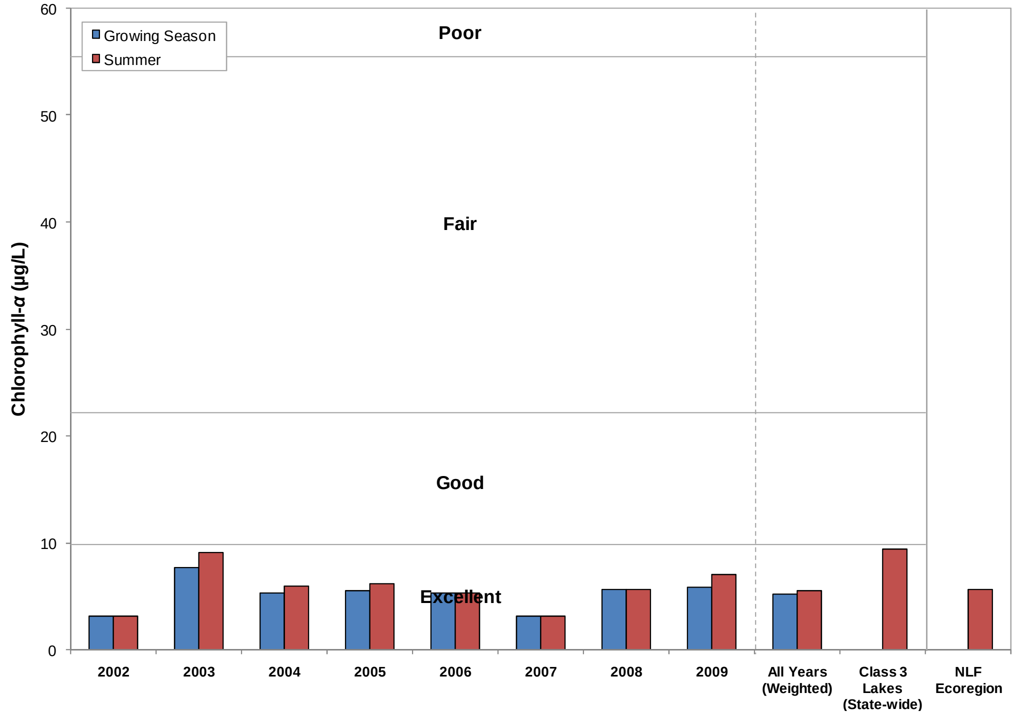

Figure 3.1-5. Pickerel Lake, state-wide class 3 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

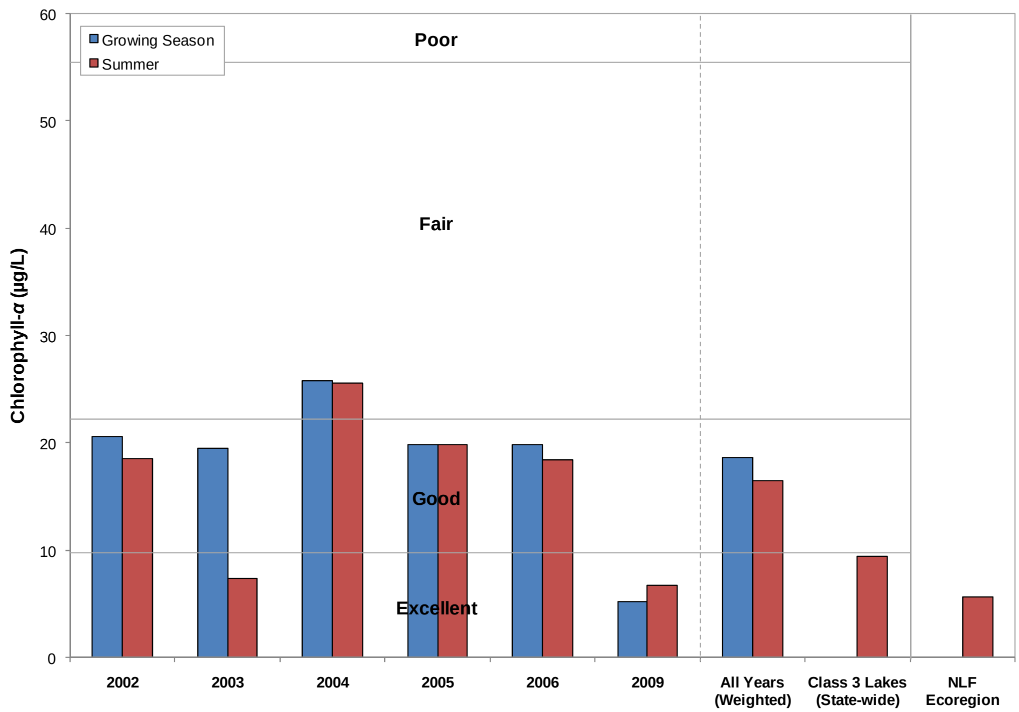

Figure 3.1-6. Crane Lake, state-wide class 3 lakes, and regional chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

The historical Secchi disk clarity recordings on Crane Lake fluctuate on more of an annual or semi-annual basis, rather than in the cyclical manner that is seen on Pickerel Lake. Crane Lake is affected by the same environmental variables that Pickerel Lake experiences, however it is possible that at 1/4th the size of Pickerel Lake, Crane Lake is influenced more heavily by these natural perturbations. This complicates an attempt at a trend distinction, and again indicates that long-term monitoring is of great importance on both of these lakes, and not just one, as they are unique and different ecosystems.

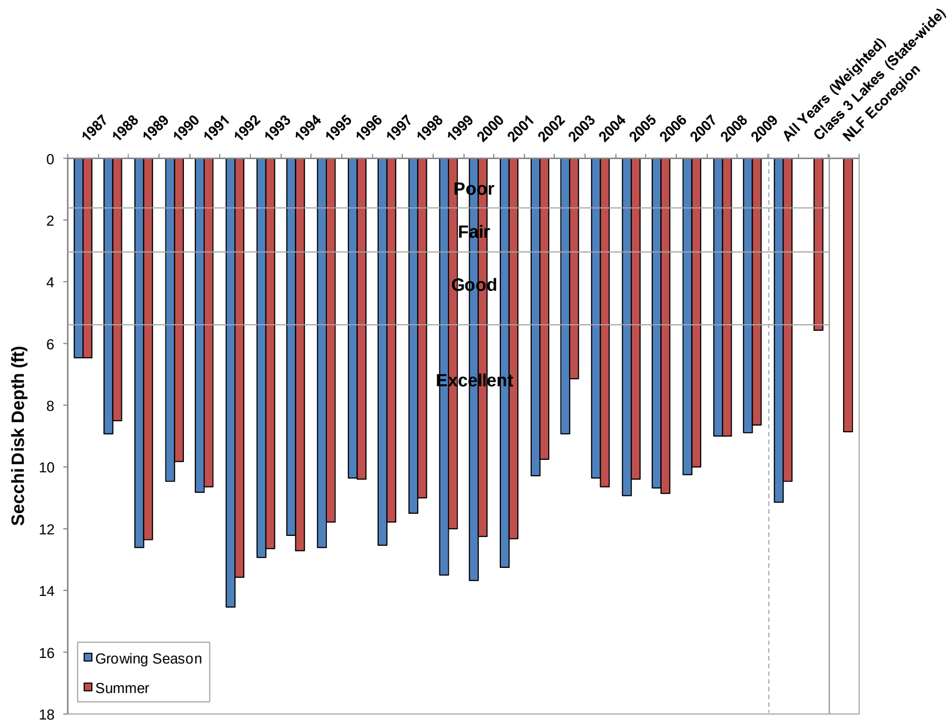

Figure 3.1-7. Pickerel Lake, state-wide class 3 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

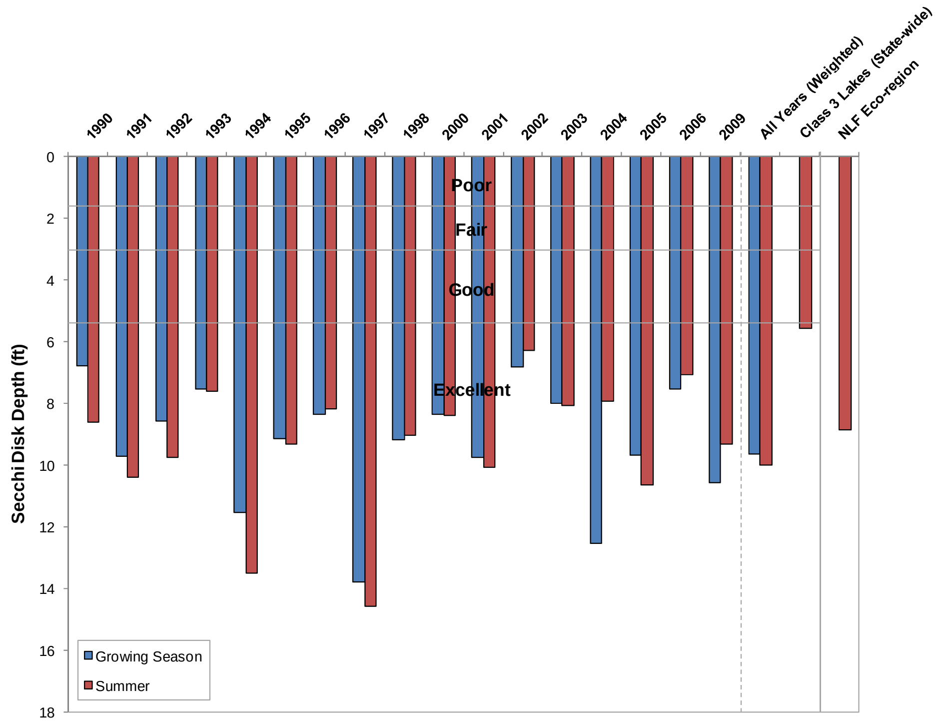

Figure 3.1-8. Crane Lake, state-wide class 3 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Limiting Plant Nutrient of Pickerel and Crane Lakes

Using midsummer nitrogen and phosphorus concentrations, nitrogen:phosphorus ratios of 36:1 and 23:1 were calculated for Pickerel and Crane Lakes, respectively. This finding indicates that the two lakes are indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that cutting phosphorus inputs may limit plant growth within these lakes.

Pickerel and Crane Lakes Trophic State

Figures 3.1-9 and 3.1-10 contain the TSI values for Pickerel and Crane Lakes. The TSI values calculated with Secchi disk, chlorophyll-*a*, and total phosphorus values range in values spanning from lower oligotrophic to upper eutrophic for Pickerel Lake and upper oligotrophic to middle eutrophic for Crane Lake . 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 Pickerel Lake is in an upper mesotrophic state while Crane Lake is in a lower eutrophic state.

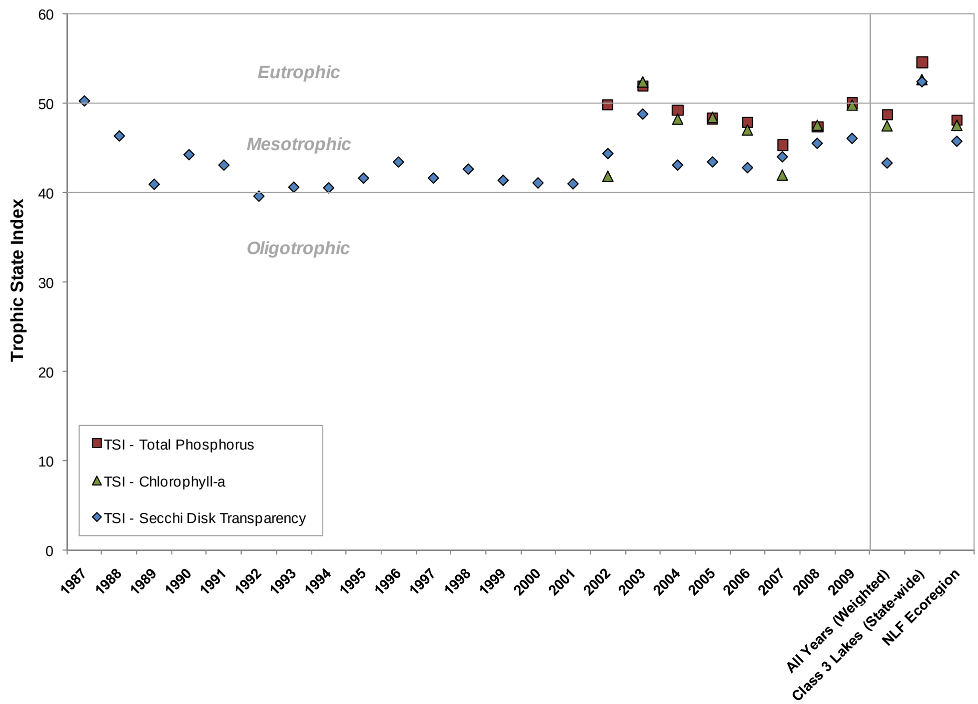

Figure 3.1-9. Pickerel Lake, state-wide class 3 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

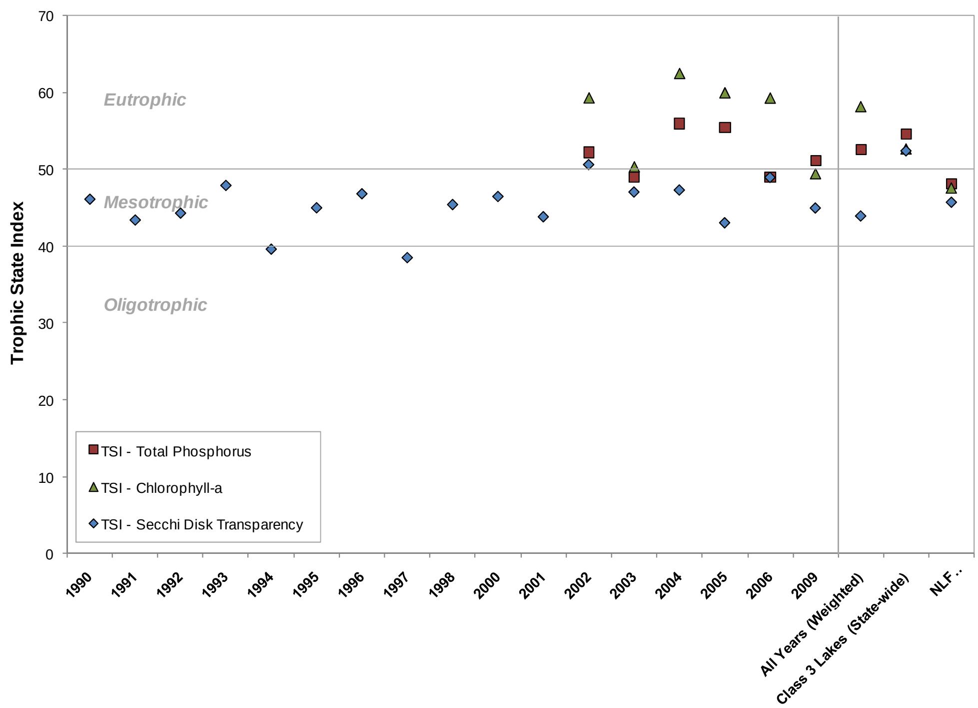

Figure 3.1-10. Crane Lake, state-wide class 3 lakes and, regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Pickerel and Crane Lakes

Dissolved oxygen and temperature data was collected on Pickerel and Crane Lakes during the spring and fall turnover as well as late winter during ice cover by Onterra staff. The data collected in April of 2009 indicate that both lakes mixed thoroughly. Water temperature was uniform throughout the water column during this time, and oxygen levels were also mixed and fairly high (near or above 10 mg/L) from lake surface to lake bottom (Figures 3.1-10 and 3.1-11). A similar situation occurred in November, when cooling water temperatures and fall winds mixed both lakes completely and distributed oxygen throughout the entire water column. In March of 2010, dissolved oxygen concentrations were fairly low (3.8 mg/L) just under the ice at the sample location and fell to 1.0 at seven feet of depth. Please note that these readings do not represent the lake as a whole because the dissolved oxygen levels near the lake's aeration system would be much higher. In the deeper Crane Lake, oxygen was measured at 7.9 mg/L just under the ice and was recorded at 2.3 mg/L on the very bottom of the lake. For warm-water Wisconsin lakes, 5.0 mg/L is generally considered the minimal amount of oxygen to support most aquatic life. However, WDNR fisheries biologists believe that gamefish, particularly larger individuals, can survive to levels as low as 2 mg/L.

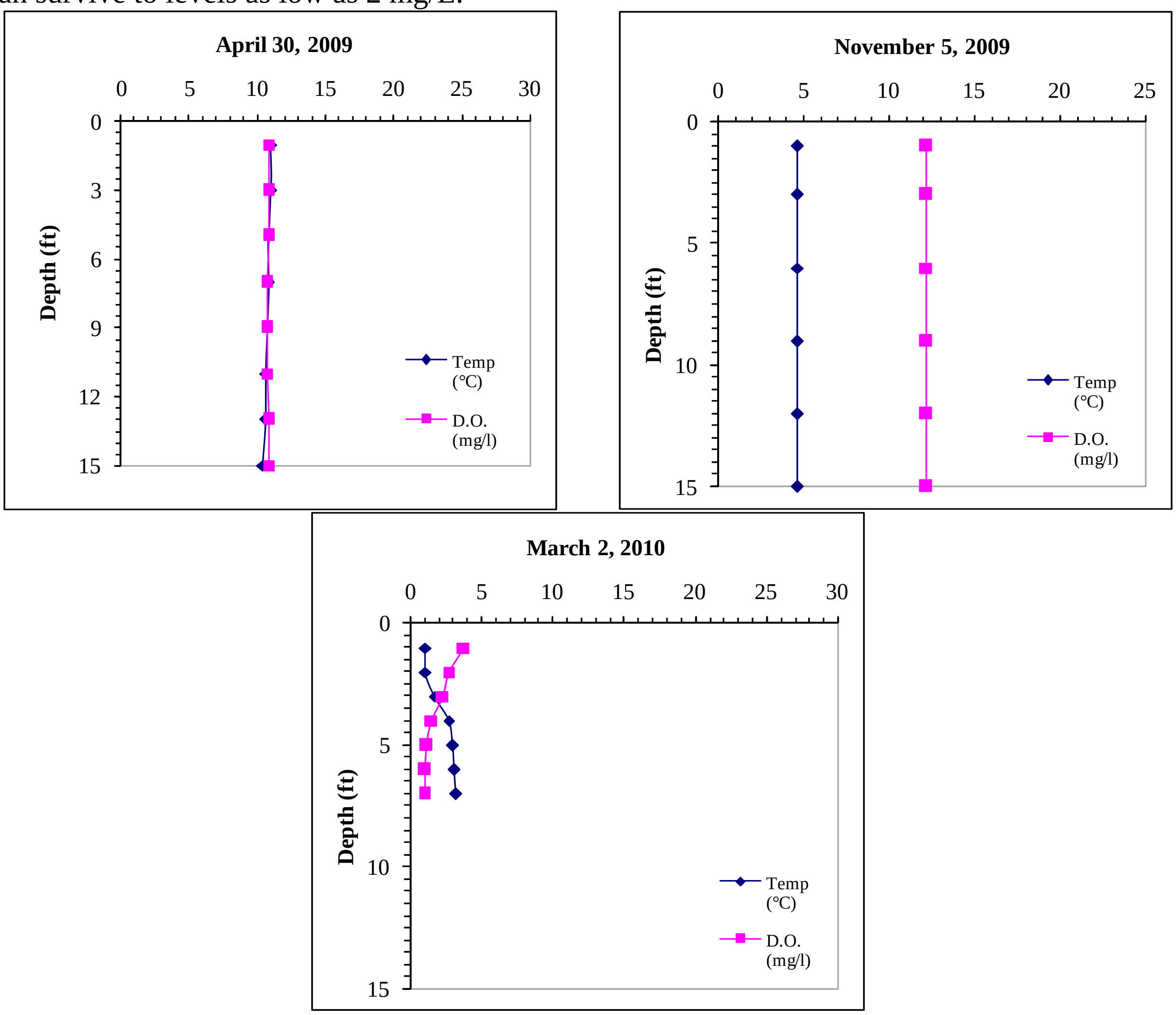

Figure 3.1-11. Pickerel Lake dissolved oxygen and temperature profiles.

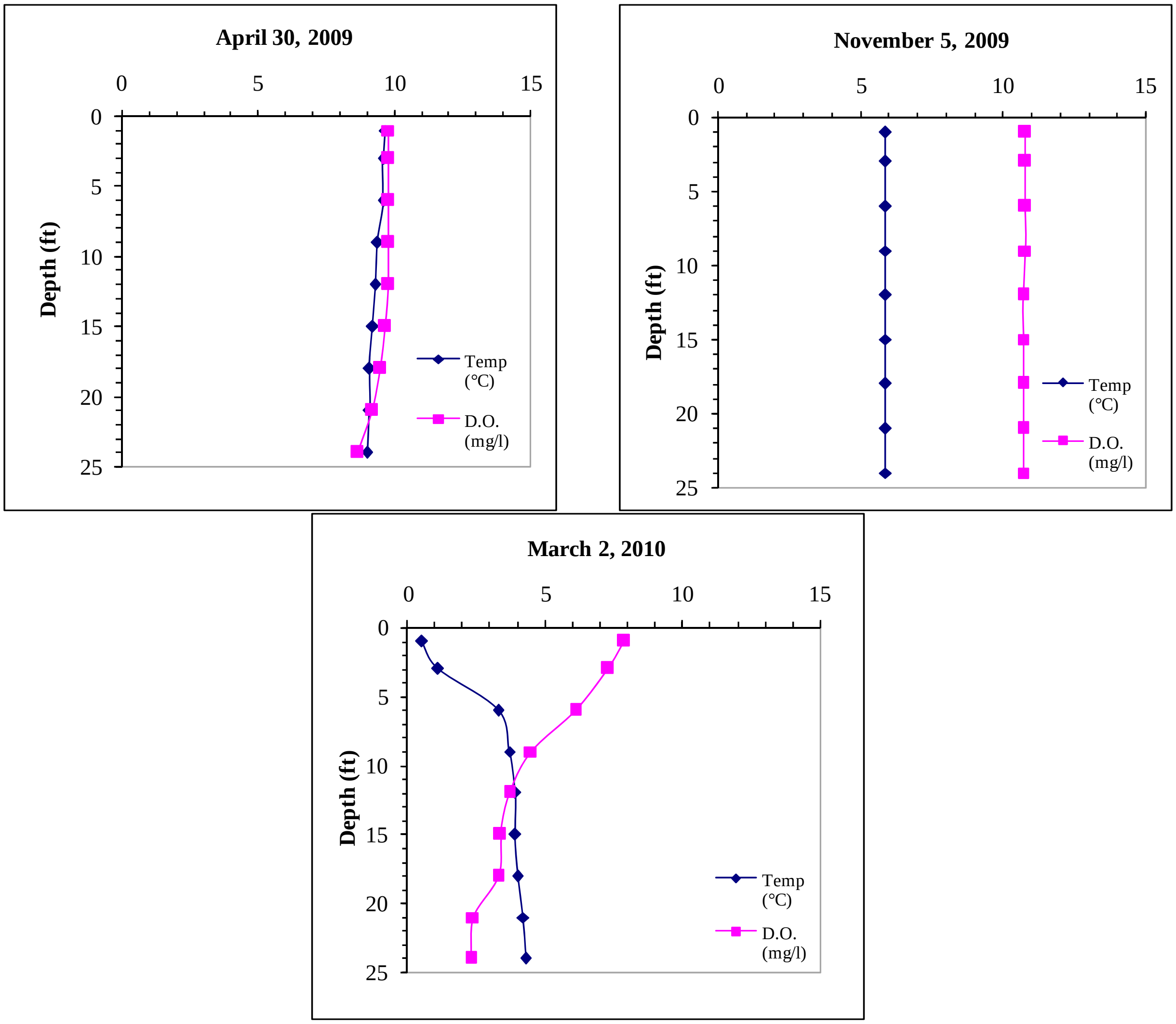

Figure 3.1-12. Crane Lake dissolved oxygen and temperature profiles.

Additional Water Quality Data Collected at Pickerel and Crane Lakes

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 Pickerel and Crane Lakes' 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. pH is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-), and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw et al. 2004). The surface summer pH of Pickerel Lake was found to be 8.2, while Crane Lake was 8.0, both of which fall within the normal range for Wisconsin Lakes.

Alkalinity is a lake's capacity to resist fluctuations in pH by neutralizing or buffering against inputs such as acid rain. The main compounds that contribute to a lake's alkalinity in Wisconsin are bicarbonate (HCO_3^-) and carbonate (CO_3^-), which neutralize hydrogen ions from acidic inputs. These compounds are present in a lake if the groundwater entering it comes into contact with minerals such as calcite ($CaCO_3$) and/or dolomite ($CaMgCO_3$). A lake's pH is primarily determined by the amount of alkalinity. Rainwater in northern Wisconsin is slightly acidic naturally due to dissolved carbon dioxide from the atmosphere with a pH of around 5.0. Consequently, lakes with low alkalinity have lower pH due to their inability to buffer against acid inputs. The surface alkalinity in Pickerel Lake was 111.0 (mg/L as $CaCO_3$) and 117.0 (mg/L as $CaCO_3$) in Crane Lake, indicating that these lakes have a substantial capacity to resist fluctuations in pH and have a very low sensitivity to acid rain.

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so both Pickerel and Crane Lakes fall within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Pickerel Lake was found to be 27.0 mg/L, falling in the *moderately susceptible* category, while Crane Lake was found to be 15.6 mg/L, falling into the *low susceptibility* category for zebra mussel establishment. Plankton tows were completed by Onterra staff during the summer of 2009 and these samples were processed by the WDNR for larval zebra mussels. Their analysis returned a negative result for the presence of these exotic species.

3.2 Watershed Assessment

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.

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.

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

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

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

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

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

The drainage basin for both Pickerel and Crane Lakes covers 23,639 acres in southwestern Forest and northeastern Langlade Counties (Map 2). Pickerel Lake's individual watershed covers 18,954 acres, while Crane Lake's watershed encompasses 4,686 acres. The land cover types are similar for both watersheds and consist of forests, wetlands, pasture/grass, and the surface water of the lakes. Forests and wetlands cover over 90% of each individual watershed, while the lake surface water and pasture/grass comprise less than 10% and also the remainder of the land types in each watershed (Figures 3.1-1 and 3.1-2). As previously mentioned, forests and wetlands typically deliver minimal amounts of pollutants (nutrients and sediment) to lakes.

Though the watersheds are substantially different in size, the lakes are approximately proportionate in size. The result is that the lakes have a similar watershed to lake area ratio (15:1 for Pickerel Lake and 13:1 for Crane Lake). At this level, the size of the watershed begins to become more influential over the water quality in the lakes than just the land cover types in the watershed.

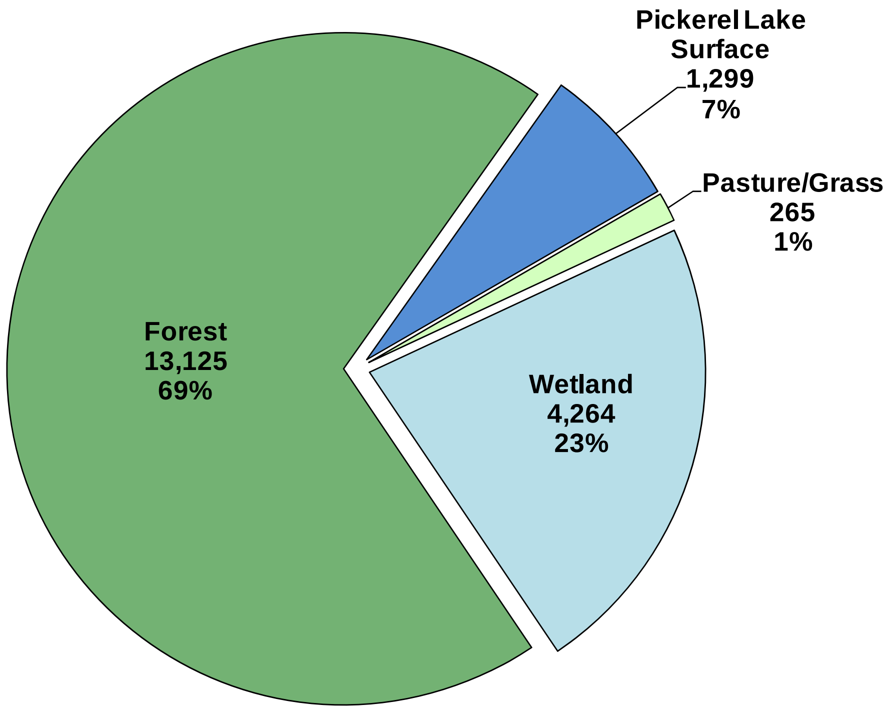

Figure 3.2-1. Pickerel Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

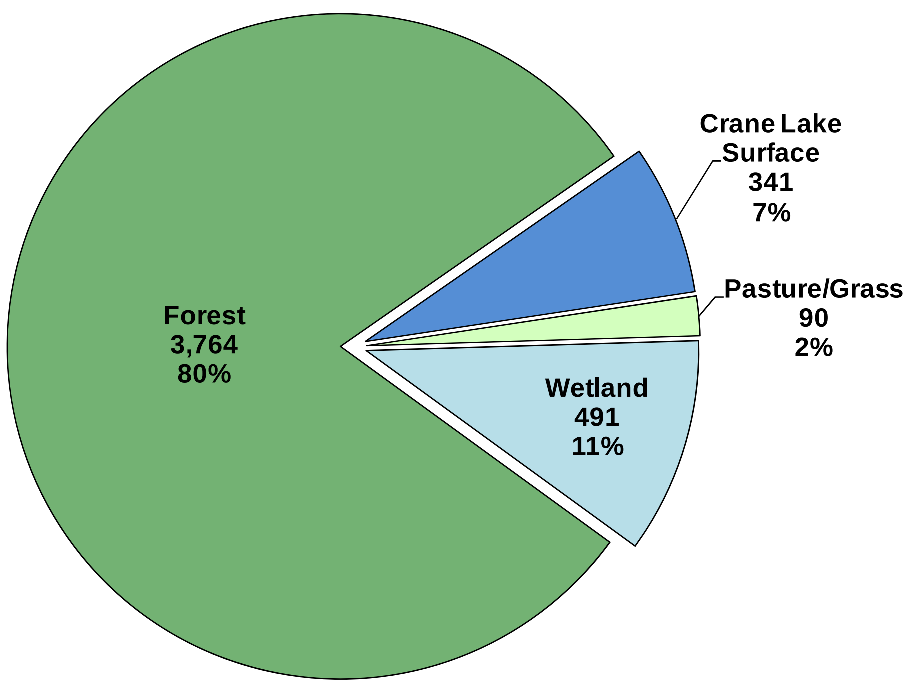

Figure 3.2-2. Crane Lake watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR, 1998).

WiLMS modeling was completed on both Pickerel and Crane Lakes individually using the land cover types and acreages found in Figures 3.2-1 and 3.2-2. The modeling results estimated an annual phosphorus load of 1,850 and 460 lbs. for Pickerel and Crane Lakes, respectively. For both Pickerel and Crane Lakes, forested land (the largest land cover type for each watershed) is the largest contributor of phosphorus (Figure 3.2-3 and 3.2-4). Wetlands contribute 20% of the phosphorus load to Pickerel Lake, while the surface area of the lake accumulates nearly as much at 19%. This accumulation occurs through atmospheric deposition of dust and other particles, which hold small amounts of phosphorus, onto the lake surface. On Crane Lake, this depositional accumulation accounts for 20% of the overall phosphorus load, while wetlands contribute only 10%. In both Pickerel and Crane Lakes, runoff from pasture / grass lands constitute 5% or less of the annual phosphorus load (Figures 3.2-3 and 3.2-4). It is important to mention that although forests and wetlands contribute the largest portion of the annual phosphorus load; this is due to the immense amount of land they encompass. These land cover types are ideal for a lake's watershed; if developed land cover types were to take the place of these vegetatively dense, natural land cover types the resulting phosphorus load to Pickerel and Crane Lakes would be much larger.

A lake's ecology, nutrient and water budgets rely on many factors including its trophic state, the lakes morphology, its age, and also its flushing rate. Based upon average precipitation and evaporation figures for Forest County and the volume of each individual lake, WiLMS was able to estimate the flushing rates for both Pickerel and Crane Lakes. Pickerel Lake flushes its entire volume of water 1.8 times per year, or once every 197 days while Crane lake flushes 1.3 times per year, or once every 292 days. Both lakes are moderately well flushed, which likely results in a removal of a portion of the phosphorus load before it can be utilized by plants or otherwise accumulate. The lakes' flushing rates are also increased due to the amount of groundwater entering the lakes as described in Eilers and Bernert (1992).

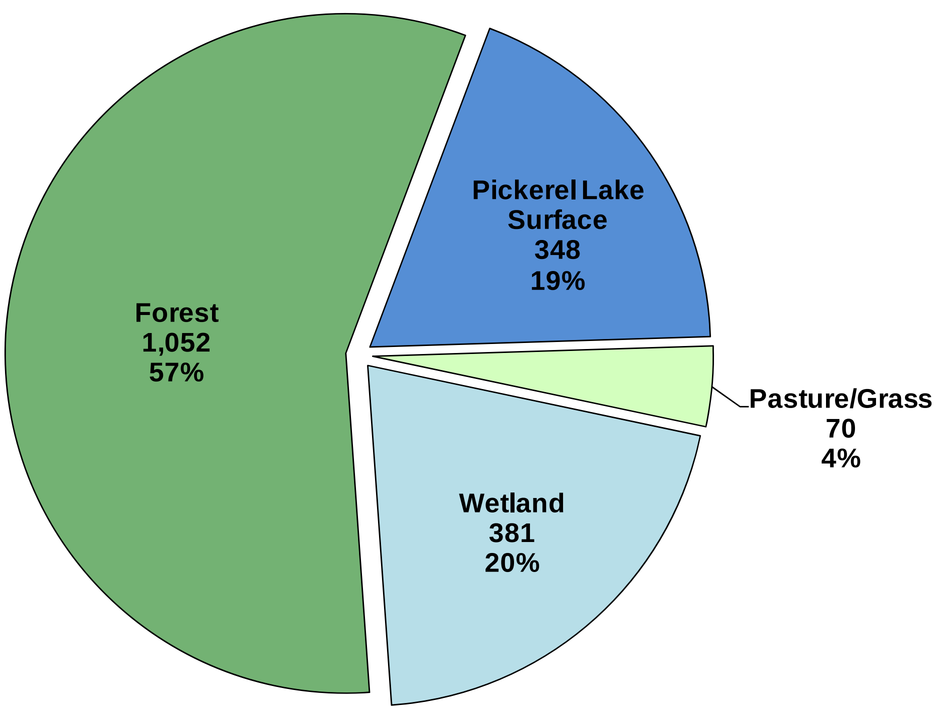

Figure 3.2-3. Pickerel Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

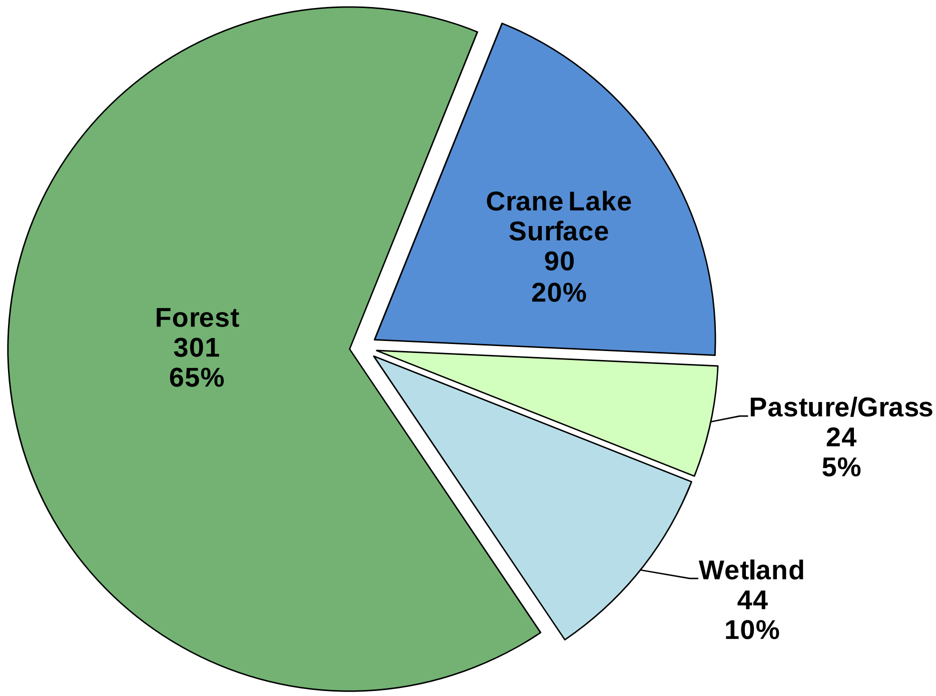

Figure 3.2-4. Crane Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

It is important to remember the impact that the immediate area of the watershed, the lake shoreline, has on a waterbody. In the 2008 stakeholder survey, about 30% of respondents indicated some concern over lakeshore development, loss of shoreline vegetation and shoreline erosion on Pickerel and Crane Lakes (Appendix B, Question #20). When a lake's shoreline is developed, the increased impervious surface, removal of natural vegetation, installation of septic systems, and other human practices can severely increase nutrient loads to the lake while degrading important habitat.

It is likely that disturbance of the immediate shoreline has already had an impact on both Pickerel and Crane Lakes. In a 1990 study of the two lakes, sediment core samples taken from the deepest points in each lake were analyzed. These cores essentially give researchers an indication of the lakes conditions in years past, with deeper portions of the core relating to years in the past and shallower sediments in the core relating to more recent years. The cores revealed that sedimentation accumulation had increased around 1890 (when development of the watershed began) and then increased eight-fold within the past 50 years (Eilers and Bernert 1992). The dramatic increase in sedimentation was linked to a dramatic increase in residences around the lake that occurred during the same timeframe. While clearly anthropogenic (human derived) activities have impacted the lakes already, limiting these affects on both Pickerel and Crane Lakes becomes even more important in maintaining the quality of the water and habitat.

3.3 Aquatic Plants

Introduction

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

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

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

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

Aquatic Plant Management and Protection

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

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

Permits

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

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

Native Species Enhancement

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

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

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

Cost

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

- The single site used for the estimate indicated above has the following characteristics:

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

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

Manual Removal

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

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

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

Cost

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

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

Bottom Screens

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

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

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

Water Level Drawdown

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

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

Advantages	***Disadvantages***

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

Mechanical Harvesting

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

Cost

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

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

Chemical Treatment

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Cost

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

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

Biological Controls

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

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

Cost

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

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

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

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

Cost

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

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

Analysis of Current Aquatic Plant Data

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

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Pickerel and Crane Lakes; 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 Pickerel and Crain 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 Pickerel and Crain 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 shoreline. This is not the degree of human development or disturbance, but rather it is a value that attempts to describe the nature of the habitat a particular shoreline may hold. This value is referred to as the shoreline complexity. It specifically analyzes the characteristics of the shoreline and describes to what degree the lake shape deviates from a perfect circle. It is calculated as the ratio of lake perimeter to the circumference of a circle of area equal to that of the lake. A shoreline complexity value of 1.0 would indicate that the lake is a perfect circle. The further away the value gets from 1.0, the more the lake deviates from a perfect circle. As shoreline complexity increases, species richness increases, mainly because there are more habitat types, bays and back water areas sheltered from wind.

Floristic Quality Assessment

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

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

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

Community Mapping

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

Exotic Plants

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

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

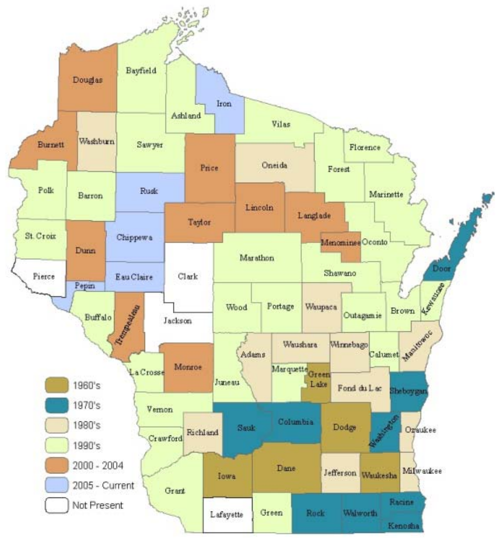

Figure 3.3-1. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

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

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

Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project. On June 9-10, 2009, surveys were completed on Pickerel and Crane Lakes that focused upon curly-leaf pondweed. These meander-based surveys did not locate any occurrences of curly-leaf pondweed in either lake. It is believed that this aquatic invasive species either does not occur in Pickerel and Crane Lake or exists at an undetectable level.

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

In 2006, staff from the Mole Lake Sokaogon Chippewa Community conducted point intercept surveys on Pickerel and Crane Lakes. Additional surveys were completed by Onterra on Pickerel and Crane Lakes to create the aquatic plant community maps (Maps 3 & 4) during August, 2009.

During the point-intercept and aquatic plant mapping surveys, a total of 32 species of plants were found in Pickerel and Crane Lakes (Table 3.3-1), one is considered non-native species: Eurasian water milfoil. Twenty-seven native species were located in Pickerel Lake and sixteen were located in Crane Lake. Two additional Crane Lake species were encountered incidentally, and are omitted from the analyses discussed below but are included within Table 3.3-1. Eurasian water milfoil was not found in Crane Lake during the 2006 survey conducted by the Mole Lake Sokaogon Chippewa Community, but it was found during the 2009 curly-leaf pondweed survey conducted by Onterra. Because of its frequency and ecological significance, Eurasian water milfoil will be discussed in depth in a separate section below.

Plants were found growing to a maximum depth of 20 feet in Pickerel Lake and 22 feet in Crane Lake, a testament to the relatively high water transparency in both lakes. Within the range of maximum plant growth, approximately 97% of the point-intercept sampling points in Pickerel Lake and 67% in Crane Lake contained vegetation.

Table 3.3-1. Aquatic plant species located on Pickerel and Crane Lake during August, 2006. Survey conducted by the Mole Lake Sokaogon Chippewa Community.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)	Pickerel	Crane
Emergent	*Schoenoplectus acutus*	Hardstem bulrush	5	X	
	Schoenoplectus tabernaemontani	Softstem bulrush	4	X	
	Typha latifolia	Broad-leaved cattail	1		I
FL	*Nuphar variegata*	Spatterdock	6	X	I
	Nymphaea odorata	White water lily	6	X	X
FL/E	*Sparganium angustifolium*	Narrow-leaf bur-reed	9	X	
	Sparganium fluctuans	Floating-leaf bur-reed	10		X
	Sparganium sp.	Bur-reed species	N/A	X	
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X
	Chara sp.	Muskgrasses	7	X	X
	Elodea canadensis	Common waterweed	3	X	X
	Elodea nuttallii	Slender waterweed	7	X	
	Heteranthera dubia	Water stargrass	6	X	X
	Myriophyllum alterniflorum	Alternate-flowered water milfoil	10	X	
	Myriophyllum heterophyllum	Various-leaved water milfoil	7	X	
	Myriophyllum sibiricum	Northern water milfoil	7	X	X
	Myriophyllum spicatum	Eurasian water milfoil	Exotic	X	
	Najas flexilis	Slender naiad	6	X	X
	Nitella sp.	Stoneworts	7	X	
	Potamogeton amplifolius	Large-leaf pondweed	7	X	
	Potamogeton friesii	Fries' pondweed	8	X	
	Potamogeton gramineus	Variable pondweed	7	X	
	Potamogeton illinoensis	Illinois pondweed	6	X	
	Potamogeton praelongus	White-stem pondweed	8	X	X
	Potamogeton pusillus	Small pondweed	7	X	
	Potamogeton richardsonii	Clasping-leaf pondweed	5	X	X
	Potamogeton robbinsii	Fern pondweed	8	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	6	X	X
	Stuckenia pectinata	Sago pondweed	3		X
	Vallisneria americana	Wild celery	6	X	X
FF	*Lemna minor*	Lesser duckweed	5		X
	Lemna trisulca	Forked duckweed	6	X	X

FL = Floating Leaf
FL/E = Floating Leaf and Emergent
FF = Free Floating
X = Present
I = Incidental

Both Pickerel and Crane Lake have a relatively high number of aquatic plant species, and because of this one may assume that these systems would also have high diversity. As discussed earlier, how evenly the species are distributed throughout the system also influence the diversity. However, the diversity index for Pickerel Lake (0.85) and Crane Lake (0.83) indicate that these lakes have a moderately uneven distribution (relative frequency) of plant species throughout them, when compared to similar lakes regionally (Figure 3.3-2). Their values fall within the upper and lower quartiles for lakes in the northern forests and lakes ecoregion, but are below the ecoregion median value. Figures 3.3-3 and 3.3-4 show that slender naiad, coontail, and common waterweed are the three most abundant species in Pickerel Lake, and Figures 3.3-5 and 3.3-6 show that coontail, forked duckweed, and wild celery are the three most abundant species found in Crane Lake. Forked duckweed, unlike other duckweed species, does not float on the water's surface, but resides suspended in the water column becoming tangled in other plants, rocks, or debris.

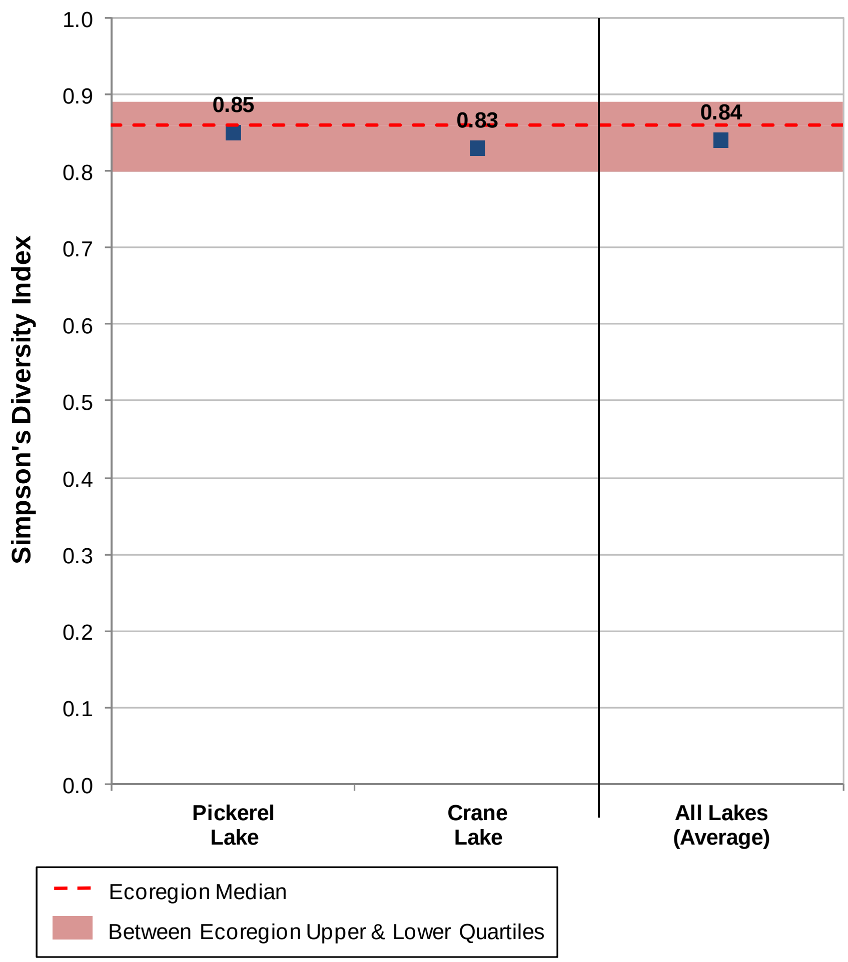

Figure 3.3-2. Pickerel and Crane Lake species diversity index. Created using data from 2006 Mole Lake Sokaogon Chippewa Community aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

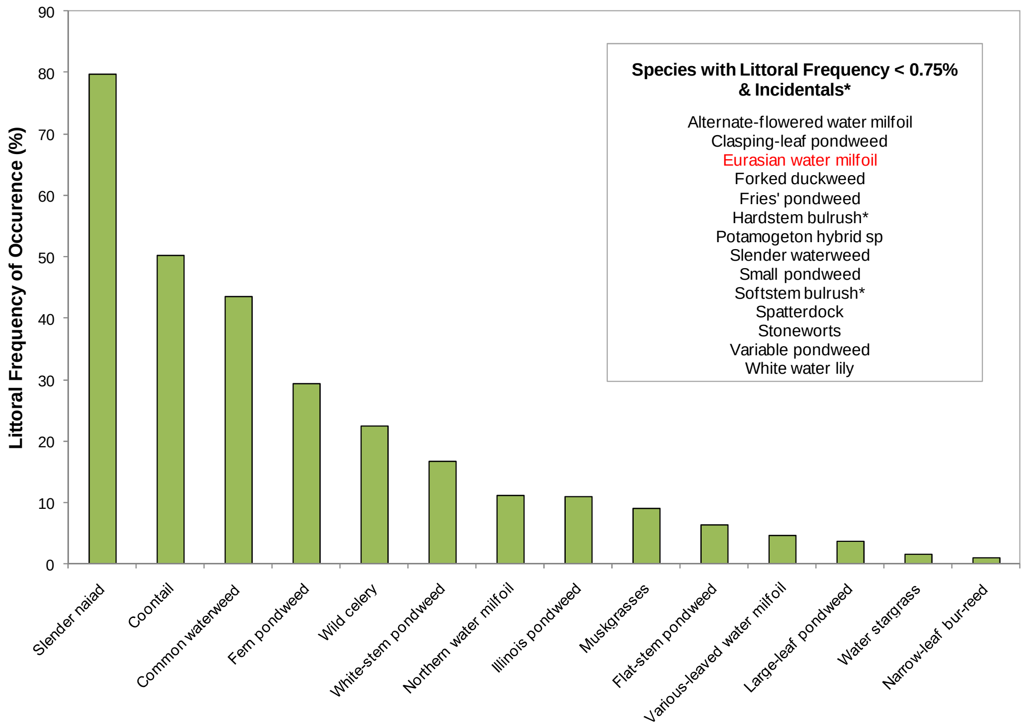

Figure 3.3-3. Pickerel Lake aquatic plant littoral frequency of occurrence Created using data from 2006 Mole Lake Sokaogon Chippewa Community survey. Exotic species indicated with red.

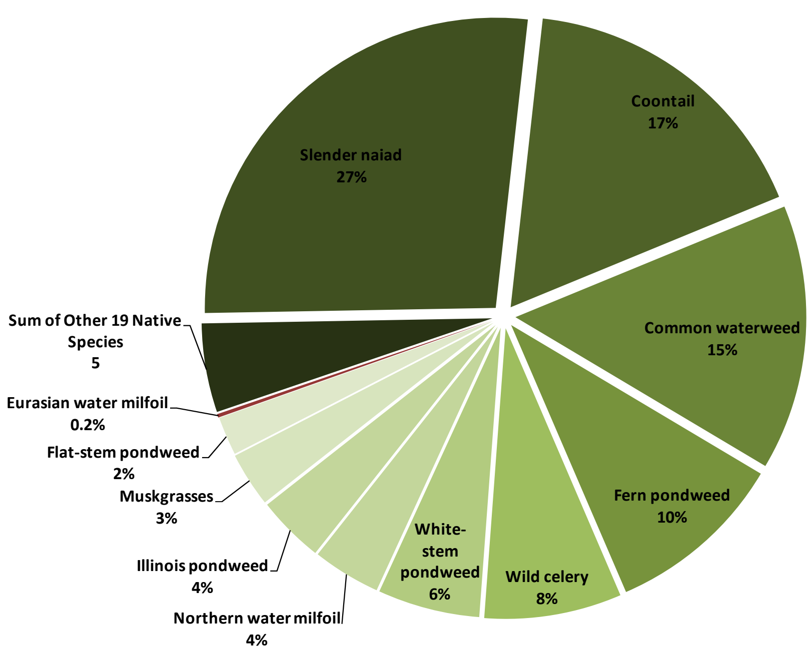

Figure 3.3-4. Pickerel Lake aquatic plant relative frequency of occurrence. Created using data from 2006 Mole Lake Sokaogon Chippewa Community survey.

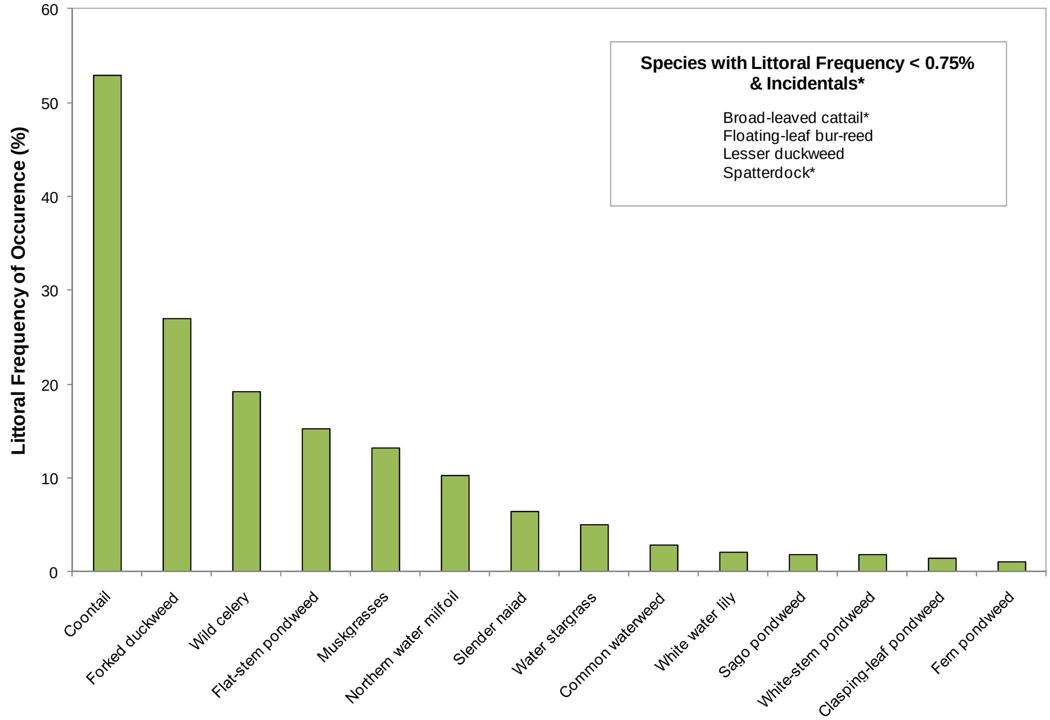

Figure 3.3-5. Crane Lake aquatic plant littoral frequency of occurrence. Created using data from 2006 Mole Lake Sokaogon Chippewa Community survey. Exotic species indicated with red.

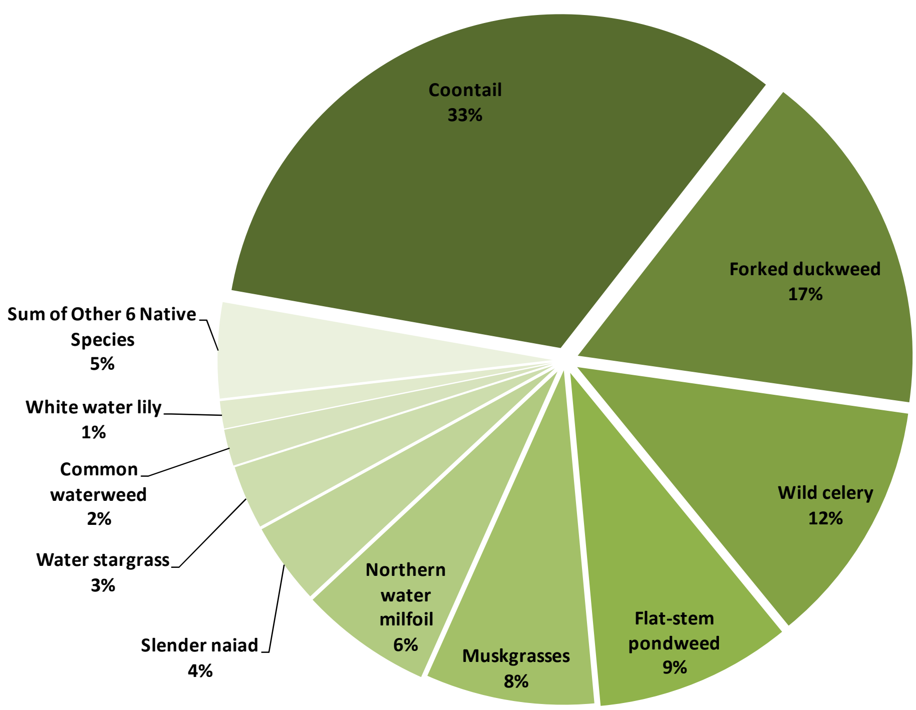

Figure 3.3-6. Crane Lake aquatic plant relative frequency of occurrence. Created using data from 2006 Mole Lake Sokaogon Chippewa Community survey.

The aquatic plant data collected by the WDNR indicates that the average conservatism values for Pickerel Lake (6.0) and Crane Lake (5.9) are both lower than the Northern Lakes Ecoregion median (Figure 3.3-7). The value for Pickerel Lake is even with the state median, but Crane Lake is slightly below. This shows that the aquatic plants within both Pickerel and Crane Lake are indicative of disturbed systems, and are rather tolerant of anthropogenic disturbances.

Traditional forms of anthropogenic disturbance that often affect lakes include human development of the lake's shoreline and motorboat traffic. Many studies have documented the adverse effects of motorboat traffic on aquatic plants (e.g. Vermaat and de Bruyne 1993, Mumma et al. 1996, Asplund and Cook 1997). In all of these studies, lower plant biomasses and/or declines and higher turbidity were associated with motorboat traffic. It is important to note that in a 2008 stakeholder survey, 52% of respondents stated that they use motor boats with at least a 25 horsepower motor on Pickerel or Crane Lakes (Appendix B, Question #8). Eurasian water milfoil infestation can also be viewed as a disturbance, and given its high occurrence in Pickerel Lake has likely out-competed and displaced many native plant species. Fluctuating water levels can increase species diversity by not allowing a single or few species to dominate. The lack of naturally fluctuating water levels, such as in Pickerel and Crane Lake, allows competitive species such as slender naiad and coontail to become dominant.

In addition to questions related to recreational use of Pickerel and Crane Lakes, the 2008 survey asked stakeholders about aquatic plants on these lakes. About 88% of respondents indicated that aquatic plant growth sometimes to always negatively impacts their enjoyment of either Pickerel or Crane Lake (Appendix B, Question # 22). Respondents also listed excessive aquatic plant growth as their top concern on Pickerel or Crane Lake (Question #20). Furthermore, 81% believe that aquatic plant control is needed on either of the lakes (Appendix B, Question #23).

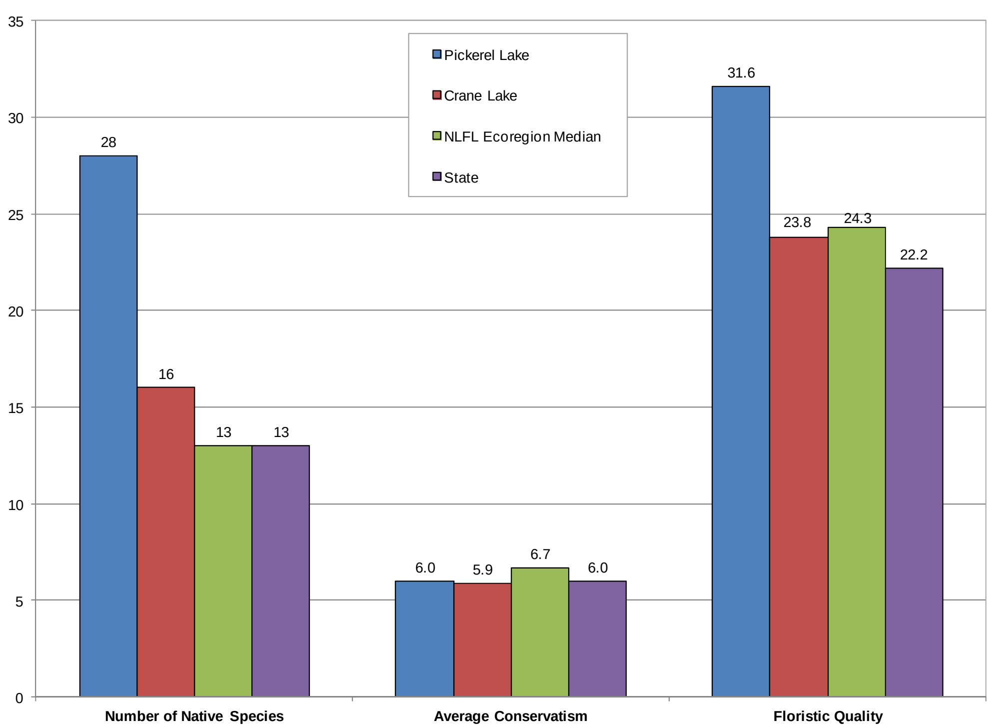

Figure 3.3-7. Pickerel and Crane Lake Floristic Quality Assessment. Created using data from 2006 Mole Lake Sokaogon Chippewa Community surveys. Analysis following Nichols (1999).

The floristic quality index (FQI) can be determined using the aquatic plant species richness and the average conservatism value (calculation shown below). This results in a value for Pickerel Lake (31.6) that is higher than both the state and ecoregion median. This higher value is a result of the species richness in Pickerel Lake, which is considerably higher than the state and ecoregion median (Figure 3.3-7). The FQI for Crane Lake (23.8) is above the state median but slightly below the ecoregion median. Crane Lake not only had fewer species than Pickerel Lake, but also had a lower average conservatism value, resulting in a lower FQI.

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

Both Pickerel and Crane Lake had many areas of emergent and floating-leaf plant communities. The 2009 community maps indicate that approximately 46.9 acres (3.6 % of lake area) of Pickerel Lake and 14.6 acres (4.3% of lake area) of Crane Lake contain these types of plant communities (Table 3.3-2). These communities provide valuable fish and wildlife habitat important to the ecosystem of the lake.

Table 3.3-2. Pickerel and Crane Lake acres of plant community types. Data collected during a 2009 community mapping survey.

Plant Community	Pickerel Acres	Crane Acres
Emergent	5.3	0.2
Floating-leaf	22.0	14.4
Mixed floating-leaf and Emergent	19.6	0.0
Total	46.9	14.6

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

Eurasian Water Milfoil

DNA testing of a few Eurasian water milfoil specimens from Pickerel and Crane Lake revealed that it is actually 'hybrid' milfoil, a cross between Eurasian water milfoil and a native milfoil species, northern water milfoil. This plant is still considered invasive and is treated as Eurasian water milfoil.

Eurasian water milfoil was first documented in Pickerel Lake in 2006, and given its relative frequency of occurrence (0.2%) from the 2006 point-intercept survey; it has spread throughout the lake significantly since its discovery. During the 2009 curly-leaf pondweed meander survey, the field crew took a 'rapid fire' GPS point every time they observed Eurasian water milfoil. As indicated by Map 5 most of the Eurasian water milfoil was located throughout the western basin of Pickerel Lake. The majority of the Eurasian water milfoil observed in the eastern basin appeared to be restricted along the northern and southern shorelines. The control strategy for controlling Eurasian water milfoil in Pickerel Lake is discussed in the implementation plan section.

A few Eurasian water milfoil plants were found for the first time in Crane Lake during the 2009 curly-leaf pondweed survey. These plants were located along the shoreline in the southern end of the channel leading into Pickerel Lake (Map 5). Many Eurasian water milfoil plants were observed just on the other side of the culvert in Pickerel Lake, and fragments from this population probably passed through the culvert via boats or wind and established themselves in Crane Lake. Controlling this newly found infestation will be imperative to prevent future spread to other areas of Crane Lake. The control strategy for Eurasian water milfoil in Crane Lake is discussed in the implementation plan.

3.4 Pickerel & Crane Lakes Fishery

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR and the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) (WDNR 2010 & GLIFWC 2010A and 2010B).

Table 3.4-1. Gamefish present in Pickerel and Crane Lakes with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other invertebrates
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Brown Bullhead	*Ameiurus nebulosus*	5	Late Spring - August	Sand or gravel bottom, with shelter rocks, logs, or vegetation	Insects, fish, fish eggs, mollusks and plants
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
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)
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

Pickerel and Crane Lakes Fishing Activity

Based on data collected from the 2008 stakeholder survey (Appendix B), fishing was the highest ranked important or enjoyable activity on both Pickerel and Crane Lakes (Question #9). The majority (almost 88%) of survey respondents indicated that they had fished on either lake within the past 3 years (Question #10). Approximately 88% of these same respondents believed that the quality of fishing on the lake was either fair or excellent on Pickerel Lake (Question #11a); though 76% believe that the quality of fishing has remained the same or gotten worse since they have obtained their property (Question #12a). On Crane Lake, 46% stated the current quality of fishing was fair while 26% were unsure of the fishing quality (Question #11b). 61% of respondents believe that the quality of fishing in Crane Lake has either stayed the same or gotten worse since they have obtained their property (Question #12b).

In the survey, questions were asked regarding specifics of the fish populations in the two lakes. With regards to largemouth bass populations, most (74%) respondents indicated they believe the population has either remained stable or greatly increased (Question #13). About 75% of respondents stated in the survey that both the size and number of gamefish in both lakes has either stayed the same or definitely gotten smaller/decreased (Question #14 and #15). Loss of fish habitat and fishing pressure are moderate concerns with survey respondents, as indicated on Questions #20 and #21, when compared to other factors such as excess aquatic plant growth, water quality degradation, and aquatic invasive species.

Table 3.4-1 (above) shows the popular game fish that are present in the system. Management actions that may take place on Pickerel Lake according to this plan could include herbicide applications to control Eurasian water milfoil. These applications should occur in May when the water temperatures are below 65°F. It is important to understand the effect the chemical has on the spawning environment which would be to remove the submergent plants that are actively growing at these low water temperatures. Yellow perch is a species that could potentially be affected by early season herbicide applications, as the treatments could eliminate nursery areas for the emerged fry of these species.

Pickerel and Crane Lakes Fish Spearing Harvest

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842 (Figure 3.4-1). Pickerel and Crane Lakes fall within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on specified systems. This highly structured process begins with an annual meeting between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then an “allowable catch” is established, based upon estimates of a sustainable harvest of the fishing stock (age 3 to age 5 fish). This figure is usually about 35% of a lake's fishing stock, but may vary on an individual lake basis. In lakes where population estimates are out of date by 3

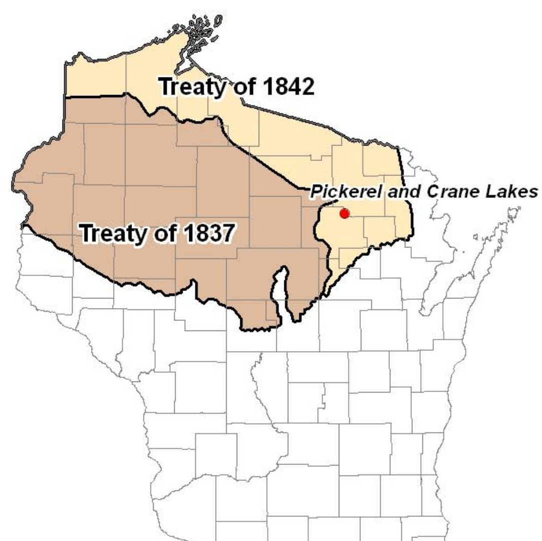

Figure 3.4-1. Location of Pickerel and Crane Lakes within the Native American Ceded Territory (GLIFWC 2010A). This map was digitized by Onterra; therefore it is a representation and not legally binding.

years, a standard percentage is used. The allowable catch number is then reduced by a percentage agreed upon by biologists that reflects the confidence they have in their population estimates for the particular lake. This number is called the "safe harvest level". The safe harvest is a conservative estimate of the number of fish that can be harvested by a combination of tribal spearing and state-licensed anglers. The safe harvest is then multiplied by the Indian communities claim percent, or declaration. This result is called the quota, and represents the maximum number of fish that can be taken by tribal spearers (Spangler, 2009). Daily bag limits for walleye are then reduced for hook-and-line anglers to accommodate the tribal quota and prevent over-fishing. Bag limits reductions may be increased at the end of May on lakes that are lightly speared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

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

Walleye quotas have been published every year since 1999 for Crane Lake and 2001 for Pickerel Lake; however a harvest has not occurred on either lake. Quotas have ranged from 11 to 61 fish for a given year, based upon estimates of the walleye population. A combination of a low estimated safe harvest for walleye and the availability to spear other lakes in the region with a higher estimated safe harvest have likely contributed to Crane Lake not holding a spear harvest.

Because Pickerel and Crane Lakes are located within ceded territory, special fisheries regulations may occur, specifically in terms of walleye. The minimum length limit on walleye is 18 inches and a daily bag limit of 3 fish. For both large and smallmouth bass, daily bag limits are set at 1 fish with a minimum length of 18" after the start of bass season. Before the season begins, catch and release rules apply.

In the mid-1990's, an 18" minimum size limit was placed upon largemouth and smallmouth bass harvest. The goal of this regulation was to 1) increase bass abundance and size structure and 2) improve pan fish size structure by increasing predation on pan fish by bass. In June of 2011, Florence and Forest County WDNR fish biologist Greg Matzke and other WDNR personnel conducted an electro fishing survey of both lakes to examine the bass population. Their findings, presented in a Summary Report to the PCPRD (Appendix F), were that the 18-inch minimum size limit has resulted in an increase in both the abundance and size structure of bass within these lakes. The WDNR will revisit Pickerel and Crane Lakes again in 2012 to assess the panfish community.

Pickerel and Crane Lakes Fish Stocking

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

Walleye have been actively stocked in recent years by the WDNR in an effort to influence the populations of these species. A summary table of these stocking efforts is included below for both Pickerel and Crane Lakes (Table 3.4-2 and 3.1-3). GLIFWC recruitment surveys done on the system in 2001 and 2003 suggest there may be little to no natural reproduction of walleye occurring, as no young-of-year walleyes were found in either of these surveys. Additionally, the WDNR has seen poor survival of smaller fingerling walleyes in their surveys. In written communication with Onterra, Greg Matzke writes that an option to increase the survivability of walleyes in the lakes would be to stock larger sized fish. Unfortunately, the state is not capable of producing these fish in large enough numbers, so this type of stocking would need to be done by private entities operating under a private stocking permit issued by the WDNR.

Table 3.4-2. Pickerel Lake walleye stocking data available from the WDNR from 1972 to 2009 (WDNR 2010).

Year	Age Class	# Stocked	Avg. Length (inches)
1995	Fingerling	59,301	2.9
1996	Fry	500,000	0.3
2003	Small Fingerling	81,865	1.3
2004	Small Fingerling	64,950	1.4
2006	Large Fingerling	6,495	7.5
2006	Small Fingerling	45,465	1.45
2008	Small Fingerling	45,465	1.6

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

Year	Age Class	# Stocked	Avg. Length (inches)
1973	Fingerling	11,200	5
1975	Fingerling	8,000	3
1977	Fingerling	21,500	3
1988	Fingerling	18,000	3
1989	Fingerling	33,196	3
1990	Fingerling	2,249	7
1991	Fingerling	2,520	5
1992	Fingerling	4,400	4
1994	Fingerling	100	9.95
1994	Fingerling	3,400	7.3
1999	Small Fingerling	34,100	1.5
2001	Small Fingerling	2,800	1.5
2001	Small Fingerling	36,900	1.4
2003	Small Fingerling	34,100	1.3
2004	Small Fingerling	17,050	1.4
2005	Small Fingerling	34,100	1.5
2006	Large Fingerling	3,410	7.5
2008	Large Fingerling	3,709	6.7
2009	Small Fingerling	11,935	1.8

Pickerel and Crane Lakes Substrate Type

According to the point-intercept survey conducted by the Mole Lake Sokaogon Chippewa Community, 88% of the substrate sampled in the littoral zone on Pickerel Lake was muck, with 8% classified as sand and 4% classified as rock (Map 6). Similarly, in Crane Lake 89% of the substrate was classified as muck, 8% as sand, and 3% as rock. Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Muskellunge is one species that does not provide parental care to its eggs (Becker 1983). Muskellunge broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so they do not get buried in sediment and suffocate. 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.

4.0 SUMMARY & CONCLUSIONS

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

1) Collect data to increase the general understanding of the Pickerel and Crane Lakes ecosystem.
2) Collect detailed information regarding the presence and density of invasive plant species within the lake.
3) Collect sociological information from Pickerel and Crane Lakes stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

The three objectives were fulfilled during the project and have led to a good understanding of much of the Pickerel and Crane Lakes' ecosystem, the folks that care about the system, and what needs to be completed to protect and enhance it.

As learned during the course of this project, Pickerel and Crane Lakes water quality is "better than average". This is largely due to the fact that much of the system's water budget is made up of groundwater inputs and surface runoff which mostly originates from forested areas and wetlands. Based upon the water quality data, it is clear that these lakes display seasonal, annual, and sometimes multi-year cycles in water quality. This may be due to the lakes' relatively large watershed, which directs a large amount of water runoff towards the lake. In wet years, it is likely that water clarity may decrease, while in dry years, the opposite may occur. Crane Lake seems to be more dynamic than Pickerel Lake by responding to environmental conditions to a greater degree, whereas Pickerel Lake's response is in more of a several year cycle. Each of these lakes functions as different and unique ecosystems. It should be pointed out that these conclusions could not have been drawn without the hard work of CLMN volunteers, who have collected water quality data on Pickerel and Crane Lakes for many years. Their work is to be commended. The continuation of this monitoring effort would be very beneficial to the lakes.

Most of the watershed is in good condition, but, like most Wisconsin lakes, impacts have occurred along the immediate shoreline of the lake which has negatively impacted each lake's health. Efforts must be focused upon areas of the shoreline where native vegetation or habitat have been removed by restoring them to a more natural habitat.

Between the Mole Lake Sokaogon Chippewa Community's 2006 and Onterra's 2009 aquatic plant surveys, a total of 32 native species were found on Pickerel and Crane Lakes. Incredibly, plants were found growing in excess of 20 feet deep in both lakes. Although a variety of species were found, several individual species dominate the substrate in these lakes, fostering a plant community of low diversity. In Pickerel Lake, one of the dominant plants has quickly become Eurasian water milfoil.

In summer of 2009, Onterra ecologists mapped the extent of Eurasian water milfoil on Pickerel and Crane Lakes. Because of the abundance of the plant, the Pickerel Lake survey was done using a transect method in which all visual occurrences were taken into account along the transect line (Map 5). It is apparent that this plant has spread throughout most of the western basin of Pickerel Lake, and has established itself in numerous areas along the north and south shorelines of the eastern basin as well. Such an infestation is hard to control at this stage because the plant is so well established in the lake. Mechanically harvesting the plant is not recommended because, as discussed in the Aquatic Plant Section and the Implementation Plan, this actually helps to spread the plants occurrence in the lake. Chemical treatments of Eurasian water milfoil are becoming more common (and more effective) in Wisconsin lakes. However, treating the amount of Eurasian water milfoil that exists in Pickerel Lake would be incredibly expensive (most treatments need to re-occur for 3-5 years).

As outlined in the Implementation Plan below, the current strategy entails monitoring the Eurasian water milfoil infestation within Pickerel Lake, and aggressively searching Crane Lake (particularly the channel between Crane and Pickerel Lakes) for the plant, and hand-removing any suspected occurrences. Furthermore, a harvesting plan has been implemented for both Pickerel and Crane Lakes with the issue of Eurasian water milfoil in mind. Abiding by the harvesting strategy outlined in Management Goal 4 of the Implementation Plan will help in reducing the nuisance of native vegetation, but also ensure that spread of Eurasian water milfoil is minimized within Pickerel Lake, and not transferred at all into Crane Lake.

As a result of the studies involved in this project, a good baseline understanding of this ecosystem has been documented in the pages above. The results show that some aspects of these lakes are in good condition; however, other challenges lay ahead for the PCLPRD and other entities that play a role in the management of Pickerel and Crane Lakes. The Implementation Plan that follows this section highlights steps to preserve and maintain the quality of these lakes, while outlining a strategy for monitoring in the years to come. These steps include obvious actions that will take place on the lake, such as continued water quality monitoring and aquatic invasive species monitoring. However, communication between the PCLPRD and other stakeholders will be as vital in the success of managing Pickerel and Crane Lakes in a holistically, responsibly and ecologically sound manner.

5.0 IMPLEMENTATION PLAN

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

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

Management Goal 1: Increase Pickerel and Crane Lakes PRD’s Capacity to Communicate with Lake Stakeholders

Management Action: Support an Education Committee to promote safe boating, water quality, public safety, and quality of life on Pickerel and Crane Lakes.

Timeframe: Begin summer 2012

Facilitator: Board of Directors to form Education Committee

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

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

While many ecological similarities exist between Pickerel Lake and Crane Lake, these lakes are different and the PCLPRD must be sensitive to the fact that the stakeholders on each lake may have different management priorities. The Education Committee will foster transparency and understanding of these differences allowing the relationship between the riparians on each lake to remain united.

In addition to creating regularly published district newsletter a variety of educational efforts will be initiated by the Education Committee. These may include educational materials, awareness events and demonstrations for lake users as well as activities which solicit local and state government support. This committee will also investigate the creation of a district website and/or other social media such as Facebook. This will directly increase the district's ability to communicate with interested stakeholders by allowing them to post information and social messages.

Example Educational Topics:

- Specific topics brought forth in other management actions
- Aeration activities
- Function of Town of Ainsworth Dam
- Aquatic invasive species monitoring updates
- Boating safety and ordinances (slow-no-wake zones and hours)
- Catch and release fishing
- Noise, air, and light pollution
- Shoreland restoration and protection
- Septic system maintenance
- Fishing Regulations

Action Steps:

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

Management Goal 2: Maintain Current Water Quality Conditions

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

Timeframe: Continuation and expansion of current effort.

Facilitator: Planning Committee

Description: Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason as of why the trend is developing and aid the issue's remediation.

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

It is the responsibility of the Planning Committee to coordinate new volunteers as needed. When a change in the collection volunteer occurs, it will be the responsibility of the Planning Committee to contact Sandra Wickman (715.365.8951) or the appropriate WDNR/UW Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:

Please see description above.

Management Action: Reduce phosphorus and sediment loads from shoreland watershed to Pickerel and Crane Lakes.

Timeframe: Begin 2012

Facilitator: Education Committee

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

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

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

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

Action Steps:

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

Management Action: Complete Shoreland Condition Assessment as a part of next management plan update
Timeframe: Begin 2012 or 2013
Facilitator: Board of Directors
Description: As discussed above, unnatural and developed shorelands can negatively impact the health of a lake, both by decreasing water quality conditions as well as removing valuable habitat for fish and other animal species that reside in and around the lake. Understanding the shoreland conditions around Pickerel and Crane Lakes will serve as an educational tool for lake stakeholders as well as identify areas that would be suitable for restoration. Shoreland restorations would include both in-lake and shoreline habitat enhancements. In-lake enhancements would include the introduction of coarse woody debris in the littoral zone, a valuable fisheries habitat component around the shores of Pickerel and Crane Lakes. Shoreline enhancements would include leaving 35-foot no-mow zones to act as a buffer between residences and the lake or by planting native herbaceous, shrub, and tree species as appropriate for Langlade and Forest Counties in this sensitive area. Ecologically high-value areas delineated during the survey would also be selected for protection, possibly through conservation easements or land trusts (www.northwoodslandtrust.org).

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

Action Steps: See description above.

Management Goal 3: Control Aquatic Invasive Species within Pickerel and Crane Lakes.

Management Action: Initiate Clean Boats Clean Waters watercraft inspections at Pickerel and Crane Lake Public Boat Landings.
Timeframe: Begin 2012
Facilitator: Planning Committee
Description: Pickerel and Crane Lakes are a popular destination by recreationists and anglers, making the system vulnerable to new infestations of exotic species. Although Pickerel Lake already contains significant occurrences of Eurasian water milfoil and both lakes contain Chinese banded mystery snail, it is still important to minimize the chance of new infestations of aquatic invasive species to be introduced and ensure that the Pickerel and Crane Lakes are not the source of aquatic invasive species for other waterbodies. Volunteers would be trained through the Clean Boats Clean Waters program and monitor the public boat landings throughout the summer with higher intensity monitoring occurring during periods of higher use (e.g. weekends and holidays). WDNR Deputy Water Guards have aided in the monitoring of the public landings on Pickerel and Crane

Lakes and coordination of the volunteers with these individuals would be beneficial.

In addition to continuing these efforts, an Education Initiative comprised of developing materials and programs that will promote clean boating and responsible use of these waters will be conducted (See Education Goal). This Educational Initiative will also address the steps that can be taken to educate lake users that access the lakes through private landings at resorts or private residences.

Action Steps:

1. Members of district attend a Clean Boats Clean Waters training session through the volunteer AIS Coordinator (Erin McFarlane – 715.346.4978) to update their skills to current standards.
2. Training of additional volunteers completed by those trained.
3. Begin inspections during high-risk weekends (weekends of nearby annual events, holidays, etc.) in coordination with WDNR Deputy Water Guards.
4. Report results to WDNR and PCLPRD.
5. Promote enlistment and training of new of volunteers to keep program fresh

Management Action: Coordinate annual volunteer monitoring of Aquatic Invasive Species

Timeframe: Start 2012

Facilitator: Planning Committee

Description: In lakes without aquatic invasive species, early detection of pioneer colonies commonly leads to successful control and in cases of very small infestations, possibly even eradication. Even in lakes where these plants occur, monitoring for new colonies is essential to successful control.

Volunteers from the PCLPRD would monitor Eurasian water milfoil, curly-leaf pondweed, and other aquatic invasive species within Pickerel and Crane Lakes after receiving training through the UW Extension, or county AIS coordinator as appropriate. Initial training would include identification of target species and native look-a-likes and expand to proper use of GPS for recording aquatic plant occurrences, note taking, and transfer of spatial data. If this form of training is not available through the organizations listed above, the PCLPRD may seek professional training on these tasks.

Only a few Eurasian water milfoil plants were observed in the channel between Pickerel and Crane Lakes and no Eurasian water milfoil was detected in Crane Lake. Intense volunteer monitoring of Crane Lake and the channel for Eurasian water milfoil will be very important for the long-term health of this ecosystem.

Pickerel Lake currently contains an established Eurasian water milfoil population and therefore volunteer efforts should be focused on other aquatic invasive species such as curly-leaf pondweed. Only a few miles away, the Post Lakes have an established curly-leaf pondweed population and a pioneer curly-leaf population was just discovered in Rolling Stone Lake (2010).

Action Steps:

1. Volunteers from PCLPRD attending a training session conducted by WDNR/UW-Extension through the AIS Coordinator for Langlade and Forest Counties (John Preuss – 715.369.9886).
2. Trained volunteers recruit and train additional district members.
3. Complete lake surveys following protocols.
4. Report results to WDNR and PCLPRD.

Management Action: Control and monitor Eurasian water milfoil infestations in Pickerel and Crane Lakes.

Timeframe: Initiate 2014

Facilitator: Planning Committee

Description: Managing two lakes connected by a channel as a single system presents certain challenges, especially when the management of invasive aquatic species is involved. In the case of managing Eurasian water milfoil on Pickerel and Crane Lakes, special attention must be paid to the level of infestation on each lake in terms of how the plant will be managed. Specifically, Pickerel Lake has an advanced infestation of Eurasian water milfoil and Crane Lake is not known to contain the exotic plant, with the exception of the few plants that were hand-removed from the channel leading to Pickerel Lake.

Eurasian water milfoil populations in the western basin of Pickerel Lake occur almost everywhere that can support submergent aquatic plants. There are significantly less Eurasian water milfoil occurrences in the eastern basin of Pickerel Lake and these occurrences primarily occur in water that is 5 feet deep or less. These factors make it impractical to control Eurasian water milfoil in Pickerel Lake using conventional herbicide treatment strategies (i.e spot treatments using granular 2,4-D). One alternative that was discussed during the planning process was conducting a whole-lake, low-dose liquid 2,4-D treatment on Pickerel Lake, or perhaps on the western basin. This technique is highly experimental and costly and is not recommended at this time. The use of native milfoil weevils (elaborated upon within the Aquatic Plant Section) was also discussed. This strategy is also expensive and ongoing studies funded through the WDNR grant program are gaining an understanding of what requirements (e.g. shoreland habitat, type and density of fish predators, Eurasian water milfoil colony size and distance from shore) are needed for this method to be effective. At this time, no control actions are proposed for Pickerel Lake. However, periodically monitoring the Eurasian water milfoil population in the lake will allow managers to understand the rate of spread and if alternate strategies should be implemented. It is recommended that a point-intercept survey be completed in 2014 (6 years after last survey) as well as a replication of the mapping survey shown on Map 5.

Crane Lake must be managed aggressively with the goal of eradicating these pioneer infestations. Preventing infestation is the key to managing Crane Lake. The narrow bridge between Pickerel and Crane Lakes combined with the long shallow channel which includes high quality communities of native plants should serve as a large obstacle to keep Eurasian water milfoil originating in Pickerel Lake out of Crane Lake. Surveys conducted to this point have identified only a few isolated Eurasian water milfoil plants on the Crane Lake side of the bridge (Map 5). These occurrences have been hand removed. To assure that development of beds too large for hand removal do not develop in the future, volunteer monitoring and hand removal surveys will need to be conducted multiple times per year starting in mid-June. Where Eurasian water milfoil is encountered, the volunteers will record the coordinates and remove all plants and any fragments which might break off.

Action Steps: See description above.

Management Goal 4: Maintain Navigation in Near-shore Areas on Pickerel and Crane Lakes

Management Action: Use district-owned mechanical harvester to maintain reasonable navigation on Pickerel and Crane Lakes.

Timeframe: Ongoing

Facilitator: PCLPRD Board of Directors

Description: The purpose of the harvesting is to allow navigability in certain areas of the lake that contain dense, nuisance levels of native aquatic plants. Maps 6 & 7 show the mechanical harvesting plan that was developed in conjunction with Onterra ecologists, WDNR staff, and district members. A single 30-foot common use lane follows the shoreline where riparian properties exist and where excessive plants hinder navigation.

The harvesting activities normally start in June and continue throughout the summer until early September. The district understands the importance of these areas for spawning refuge and therefore does not start harvesting until after the spawning season (approximately after June 1st). Harvesting activities are also not to occur in the approximately 61.4 acres of emergent and floating-leaf plant communities that occur near the system's margins. Traditionally harvesting activities would occur for approximately 4 weeks on Pickerel Lake and then the harvester would be transported by land for activities to resume on Crane Lake.

Mechanical harvesting in areas that contain aquatic invasive species may increase the rate of spread of these species as it 'drags' cut fragments to other parts of the system. With the current level of Eurasian water milfoil infestation in Pickerel Lake, it would be impossible to operate a harvester without encountering this invasive plant and thus encouraging fragmentation of its structure. However, Eurasian water milfoil will fragment due to natural factors such as wind and wave action. On a large waterbody such as Pickerel Lake, this is to be expected. The biology of the plant is such that it also auto-fragments, producing offshoots that disperse to colonize new areas. Therefore, a harvester unit, while fragmenting plants in the lake, may fragment plants that will soon just fragment on their own. Therefore, harvesting activities will not occur if *colonized* Eurasian water milfoil or curly-leaf pondweed is found within the harvest areas. This will limit the amount of fragmentation that occurs by the harvester unit. Additionally, it will limit fragmentation of these plants by watercraft as the watercraft will have clean cut navigation lanes to use instead of crossing the lake and cutting plants with motor props.

Also initiated in 2010, harvesting activities should start on Crane Lake and then be transferred to Pickerel Lake. This will reduce the chance that hidden Eurasian water milfoil fragments on the mechanical harvester will be transferred from Pickerel Lake to Crane Lake.

While the amount of area being harvested on Pickerel Lake is not considerable relative to its overall size, anytime there is modification of a lake's ecology it is important to quantify changes that may occur as a result. As stated previously, monitoring of the Eurasian water milfoil population in the lake is important to gain an understanding of the dynamics of this plant's population. Additionally, changes in the native plant community may be evaluated through future point-intercept surveys, which can be compared to those conducted in 2006.

Action Steps:

1. District applies for a multiyear harvesting permit (3 year).
2. District harvests only in areas shown on Maps 6 & 7 while following the plan listed above and restrictions indicated on WDNR permit.
3. Harvest summary report is provided to the WDNR annually after each harvesting season.

6.0 METHODS

Lake Water Quality

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

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

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

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

Watershed Analysis

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

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Pickerel and Crane Lakes during June 9 & 10 2009 field visits, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on the system to characterize the existing communities within each lake and included inventories of emergent, submergent, and floating-leaved aquatic plants within them. These surveys were conducted by the Mole Lake Sokaogon Chippewa Community in 2006. The point-intercept method as described in "Appendix C" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin - Draft, (April 20, 2006) was used to complete the studies. Based upon advice from the WDNR, the following point spacing and resulting number of points comprised the surveys:

Lake	Point-intercept Resolution	Number of Points	Survey Dates
Pickerel	85 meters	711	August 21, 2006
Crane	60 meters	401	August 22, 23 2006

Community Mapping

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

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