Pike Chain of Lakes

Bayfield County, Wisconsin

Comprehensive Management Plan

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Funded by: Iron River Area Lakes Association, Inc.
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INTRODUCTION

The Pike Chain of Lakes, Bayfield County (Map 1), comprises six lakes with a surface area of nearly 900 acres. This headwater drainage system leads to the White River which flows through the Bad River Indian Reservation on its way to Lake Superior. The White River is a well known trout stream and popular tourist destination.

Like many lakes in northern Wisconsin, invasive species establishment threatens the health and beauty of the ecosystem. The Pike Chain of Lakes is known to harbor rusty crayfish, Eurasian water milfoil , curly-leaf pondweed, and on its shores, purple loosestrife and giant reed. With the aid of the Great Lakes Indian Fish and Wildlife Commission (GLIFWC), chemical applications for purple loosestrife occur annually and continued monitoring will help keep this invasive species in check along the shorelands of the Chain.

Members of the Iron River Area Lakes Association (IRALA) have been actively mapping known locations of Eurasian Water Milfoil (EWM) and have coordinated 2,4-D treatments aimed at reducing the spread and density of this species.

Over the years, the IRALA has learned that chasing localized occurrences of exotic species with multiple types of management actions on a chain-wide basis is not the proper approach to reach their management goals. The group has realized that the Pike Chain of Lakes must be treated as a whole to fully understand all of its technical and sociological aspects, and that a comprehensive approach must also be utilized in order to develop a management plan with realistic and implementable goals. Aside from the obvious cost savings of completing a chain-wide management planning project, a consistent approach of gathering the technical data can be achieved. Another advantage of completing a chain-wide project is the ability to reach a wider audience of stakeholders with a common message. Because of the interconnectivity of the system, one lake’s management actions affect the other lakes; therefore all stakeholders from all lakes should have an opportunity to bring forth their management ideas, needs, and goals.

The management plan that has resulted from this project is truly the combination of scientific study and the sociologic aspects of the Chain and its stakeholders. The results of those studies not only lead to better management decisions, but also act as a reference point for future studies. The implementation plan found near the end of the document will act as the guide for the IRALA as they continue their advocacy for management and protection of the Pike Chain of Lakes.

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. Stakeholders were also informed about how their use of the lake's shorelands and open water areas impact the lake. Stakeholder input regarding the development of this plan was obtained through communications and meetings with the IRALA and via a stakeholder survey. A description of each stakeholder participation event can be found below, while supporting materials can be found in Appendix A.

Newsletters and Special Mailings

A press release was sent to the following area newspapers on July 5, 2007 announcing the Pike Chain of Lakes Management Planning Project and information about the upcoming kick-off meeting: The Daily Press (Ashland daily newspaper), The County Journal (Bayfield County weekly newspaper), The Connection (bi-monthly Iron River publication), and The Lake Superior Sounder (Ashland and Bayfield County weekly newspaper). WNXR (107.3 FM) was also contacted about announcing the meeting on the radio. Unfortunately, there is no evidence that any of the media sources ran the press release. That same month, a special mailing was sent to IRALA members and Iron River businesses announcing the Kick-off Meeting and explaining the important components that would be discussed at the meeting. This mailing also called for volunteers to serve on a newly formed planning committee to help guide the management plan. A similar article was written for the IRALA newsletter announcing the kick-off meeting and asking for volunteers to serve on the planning committee.

A project update was written for the IRALA newsletter in December 2007 that summarized the Kick-off Meeting, discussed the progress of the management plan, and provided some preliminary data relating to that year's Eurasian water milfoil treatment. This update also announced that a stakeholder survey would soon be sent to Association members and lakeshore landowners to better understand the views of the Pike Chain stakeholders.

In June 2008, a newsletter article was written for the IRALA announcing the upcoming results meeting and the planning meeting scheduled to follow. The article also reiterated the importance for people to complete and send in their stakeholder surveys.

Kick-off Meeting

On July 21, 2007 the IRALA held a special meeting to inform Association members and other interested parties about the lake management planning project the Association was undertaking. This public meeting was attended by 65 interested stakeholders. During the meeting, Tim Hoyman and Eddie Heath, both ecologists with Onterra, presented information about lake eutrophication, native and non-native aquatic plants, the importance of lake management planning, and the goals and components of the Pike Chain of Lakes management planning project. It was anticipated that the management plan would largely focus on Eurasian water milfoil; therefore, the history of Eurasian water milfoil treatments on the Pike Chain was discussed.

Stakeholder Survey

During June 2008, a seven-page, 27-question survey was mailed to Pike Chain of Lakes stakeholders. The mailing included all riparian property owners and all off lake members of the IRALA. When the surveys were returned, the results were entered into an Onterra-provided spreadsheet by John Joseph, then president of the IRALA. The data were summarized and analyzed by Onterra for use at the planning meeting 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.

Project Results Meeting

On June 28, 2008 Tim Hoyman and Eddie Heath of Onterra met with 43 Pike Chain of Lakes stakeholders for approximately 2 hours to deliver the results of the lake management planning project. All study components including aquatic plant inventories, water quality analysis, watershed modeling, stakeholder survey results, and Eurasian water milfoil treatment results were presented and discussed. After approximately 30 minutes of questions following the presentation, attendees were encouraged to converse around a six-foot wide poster which displayed lake-specific data collected during the course of the project.

Planning Committee Meeting I

After the Project Results Meeting, Tim Hoyman and Eddie Heath of Onterra met with 13 members of the IRALA Planning Committee for a little over 3 hours. The primary focus of this meeting was to start developing goals and the corresponding management actions needed to reach those goals which together would make up the implementation plan for the Pike Chain.

Planning Committee Meeting II

During the evening of August 14, 2008 Tim Hoyman and Eddie Heath met with 17 members of the IRALA Planning Committee for approximately 3½ hours to continue working on the implementation plan. At this meeting, timeframes and goal facilitators were discussed along with the need for the creation of several new committees.

Review of Management Plan

On November 26, 2008, a draft copy of the Pike Chain of Lakes Comprehensive Lake Management Plan was sent to members of the IRALA Planning Committee and Pamela Toshner, WDNR. Pamela Toshner forwarded a copy of the report to Frank Koshere for review. Scott Toshner, WDNR Fisheries Biologist, and Robert (Butch) Lobermeier, Bayfield County Conservationist, were both provided a draft copy of the section of the management plan that pertains to their expertise.

RESULTS & DISCUSSION

Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

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

Many types of analysis are available for assessing the condition of a particular lake's water quality. In this document, the water quality analysis focuses upon attributes that are directly related to the ecology of the lake; i.e., the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake. Six 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 analysis is elaborated on below.

Judging the quality of lake water can be difficult because lakes display problems in many different ways. 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. To complete this task, three water quality parameters are focused upon within this document:

> **Phosphorus** is a 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.

Comparisons with Other Datasets

Lillie and Mason (1983) is an excellent source for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Bayfield County lakes are included within the study's Northwest Region (Figure 1) and are among 282 lakes randomly picked from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means, historic, current, and average data from the Pike Chain are displayed in Figures 2-22. 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.

Figure 1. Location of Pike Chain of Lakes within the regions utilized by Lillie and Mason (1983).

In some graphs, a *weighted average* of all years' data may be displayed. The weighted average gives more 'weight' to each year's average value based on the number of samples taken that year. For example, an average total phosphorus value for a particular year that was calculated from 4 samples taken over the course of the summer contributes to the weighted average more than an average phosphorus value that was calculated from only a single sample.

Apparent Water Quality Index

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

Lillie and Mason (1983) used the extensive data they compiled to create the *Apparent Water Quality Index* (WQI). They divided the phosphorus, chlorophyll-*a*, and clarity data of the state's lakes in to ranked categories and assigned each a "quality" label from "Excellent" to "Very Poor". The categories were created based upon natural divisions in the dataset and upon their experience. As a result, using the WQI as an assessment tool is very much like comparing a particular lake's values to values from many other lakes in the state. However, the use of terms like, "Poor", "Fair", and "Good" bring about a better understanding of the results than just comparing averages or other statistical values between lakes. The WQI values corresponding to the phosphorus, chlorophyll-*a*, and Secchi disk values for the six project lakes are displayed on Figures 2-22.

Trophic State

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

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

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

The WTSI is used extensively by the WDNR and is reported along with lake data collected by Citizen Lake Monitoring Network volunteers. The methodology is also used in this document to analyze the past and present trophic state of the Pike Chain of Lakes.

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 is going to need 16 of each ingredient. If he is short two eggs, he will only be able to make three cakes even if he has sufficient amounts of the other ingredients. In this scenario, the eggs are the limiting nutrient (ingredient).

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

Temperature and Dissolved Oxygen Profiles

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

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

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

Internal Nutrient Loading

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

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

Non-Candidate Lakes

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

Candidate Lakes

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

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

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

Pike Chain of Lakes Water Quality Analysis

Unfortunately, very little historic water quality data exists for the Pike Chain of Lakes, so it is impossible to complete any sort of long-term trend analysis. This is unfortunate as reliable anecdotal information from long time lake users indicated that water quality, in terms of clarity and periphytic algae, has decreased slightly during the past two decades. However, these thoughts are not fully supported by the results of the stakeholder survey as nearly 63% of respondents believe the Chain's water quality has remained the same (56.1%) or gotten better (6.7%), while only 29.4% believe the water quality has worsened (Appendix B, Question 13).

While there is a lack of historic water quality data for the Chain, sufficient information was collected as a part of this project to examine the current water quality of the Pike Chain of Lakes (the full dataset is located in Appendix C). As described above, three water quality parameters are of most interest; total phosphorus, chlorophyll *a*, and Secchi disk transparency. Total phosphorus data for each of the Chain lakes are contained in Figures 2-7 and a composite of weighted means from the Chain are contained in Figure 8. Examination of these charts indicates that the total phosphorus levels of all six lakes are very low, especially when compared to other lakes in the region and within the state. While all values would be considered to be within the good to very good range, there are some fluctuations of the phosphorus concentrations between years within the same lake. It should be noted that there is not sufficient data to detect trends as water quality within the same lake normally fluctuates from year-to-year and is largely dependent on precipitation and water levels. These fluctuations are discussed more below in regards to water clarity.

Twin Bear Lake's dataset contains data collected during 1973 and 1974 (Figure 5). These data are considered suspect because they are approximately twice the values recorded during 1991 and 2007. Further, these data do not correspond with the excellent water clarity values reported for the same years (Figure 19).

Lake Millicent has the lowest overall phosphorus values for the Chain and is followed closely by Hart and Buskey Bay. Millicent and Hart are the most voluminous lakes in the Chain and as a result are able to dilute and absorb more phosphorus than the other four lakes. Buskey Bay is the first lake in the Chain and receives comparably lower loads of phosphorus from the Chain's watershed (see the watershed section below).

As with the phosphorus data, little historic chlorophyll *a* data exists for the Chain (Figures 9-14). However, the data that do exist follows the normal phosphorus/chlorophyll *a* relationship in that the low phosphorus values within the chain lakes have lead to incredibly low chlorophyll *a*

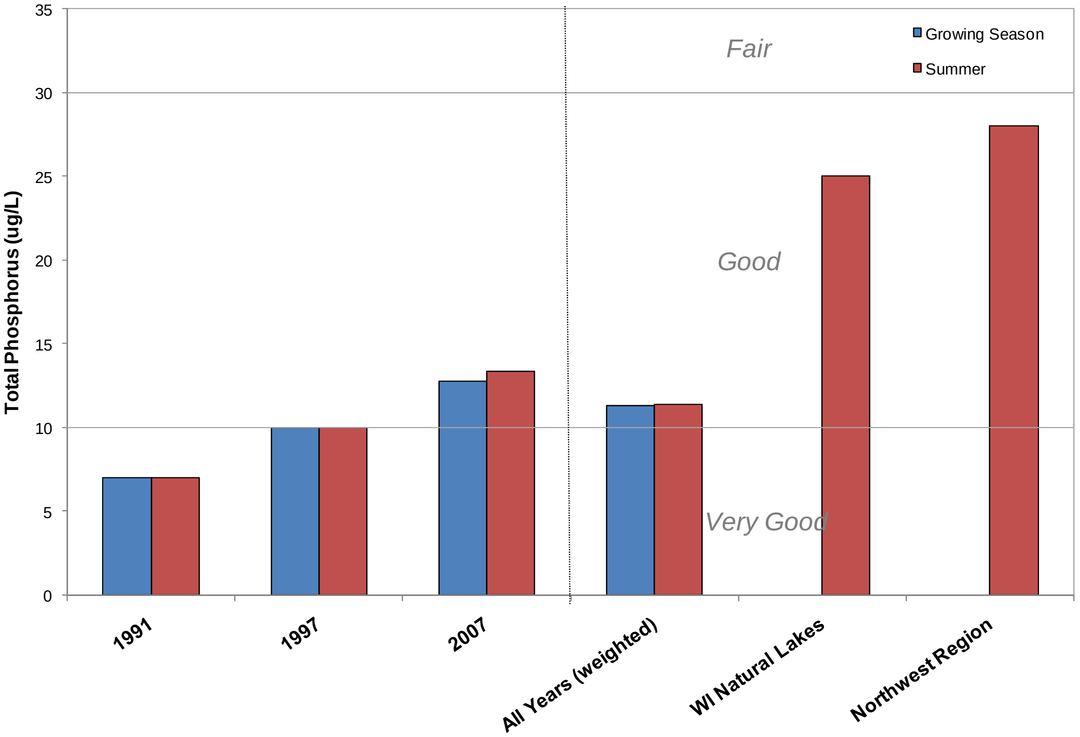

Figure 2. Buskey Bay Lake total phosphorus concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

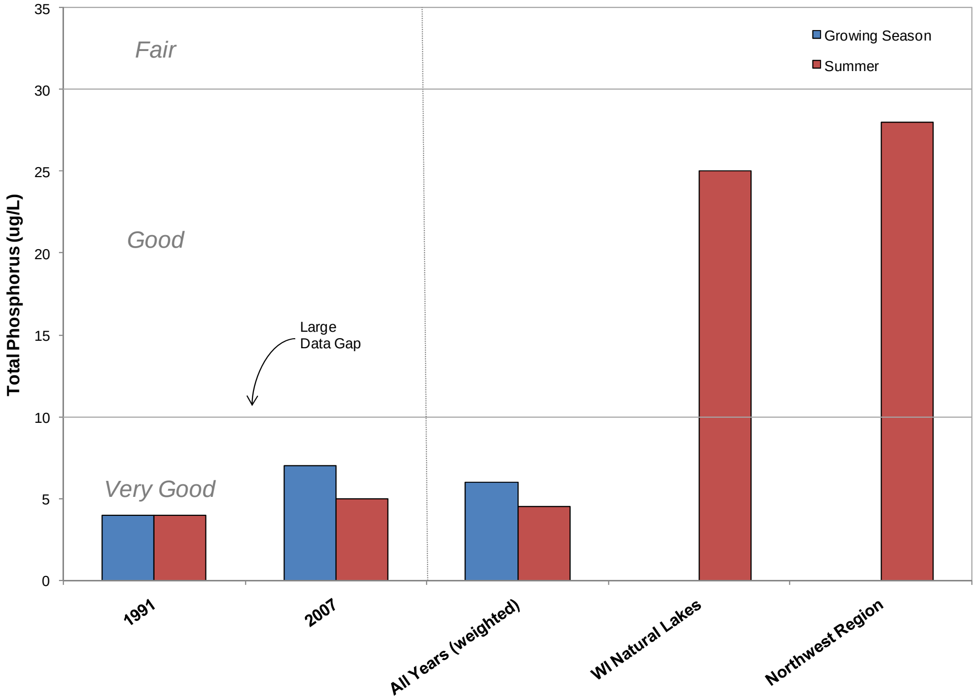

Figure 3. Lake Millicent total phosphorus concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

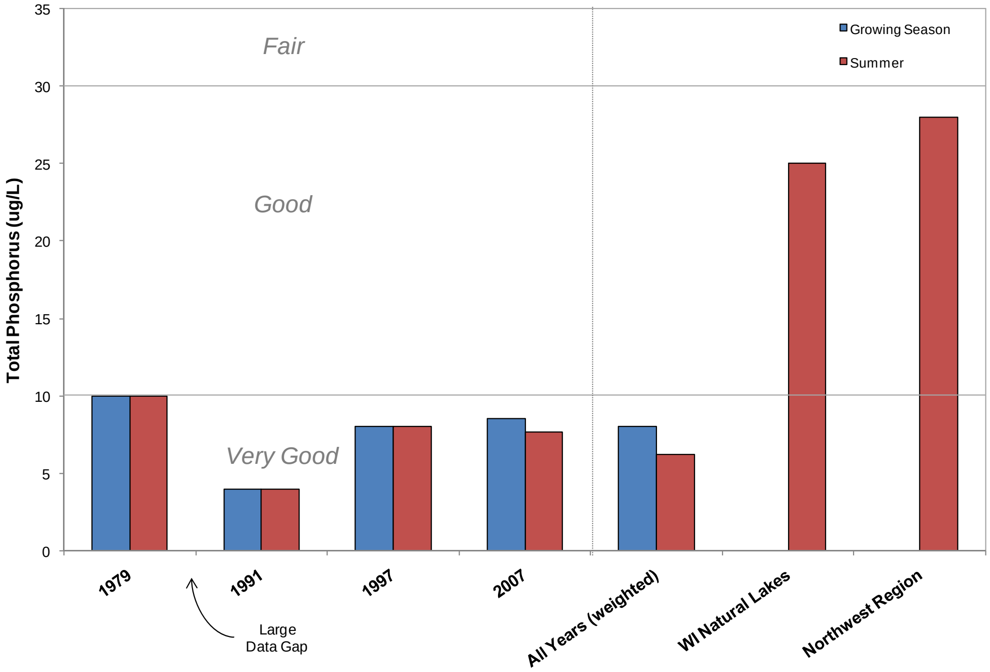

Figure 4. Hart Lake total phosphorus concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

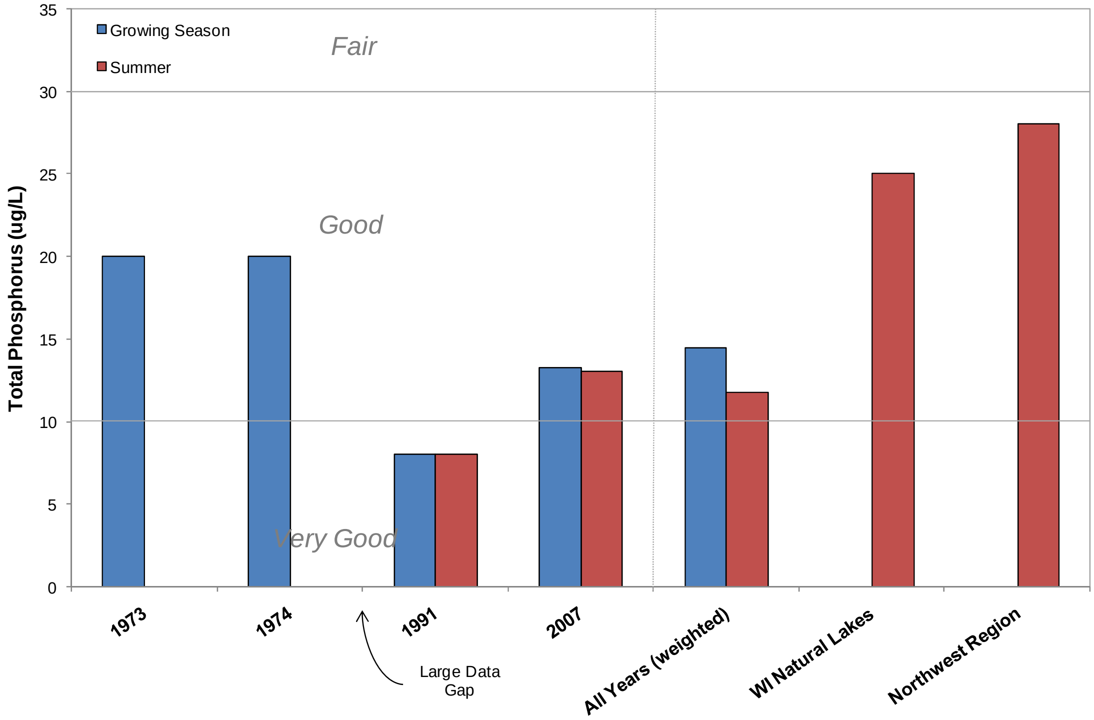

Figure 5. Twin Bear Lake total phosphorus concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

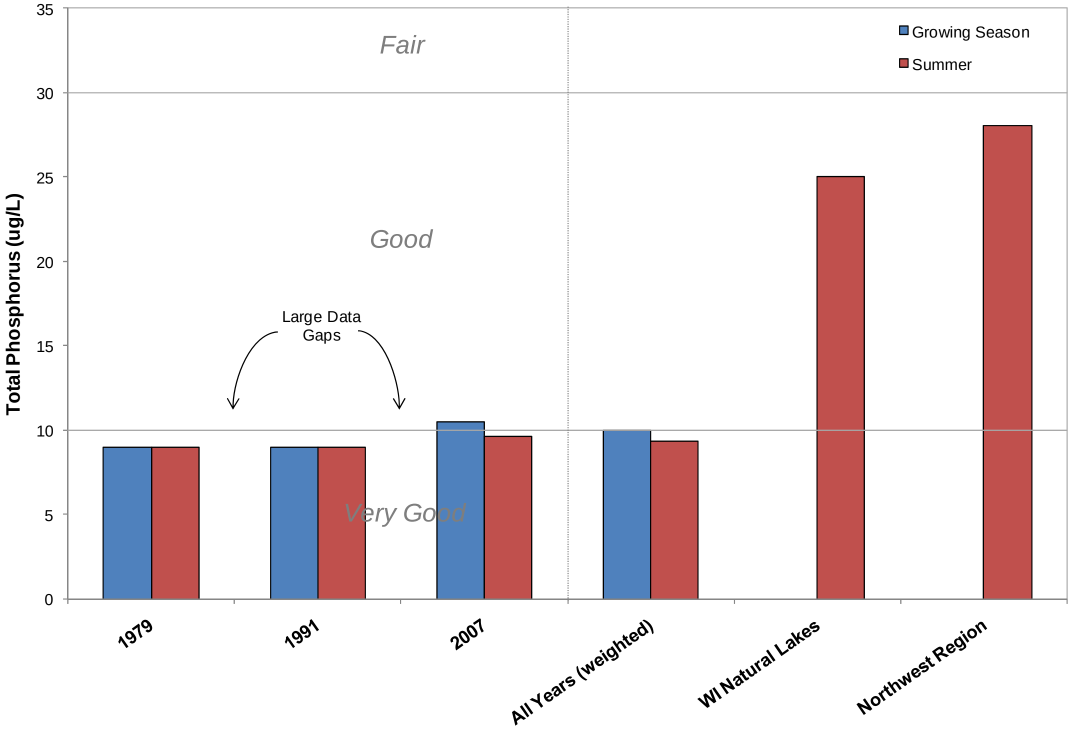

Figure 6. Eagle Lake total phosphorus concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

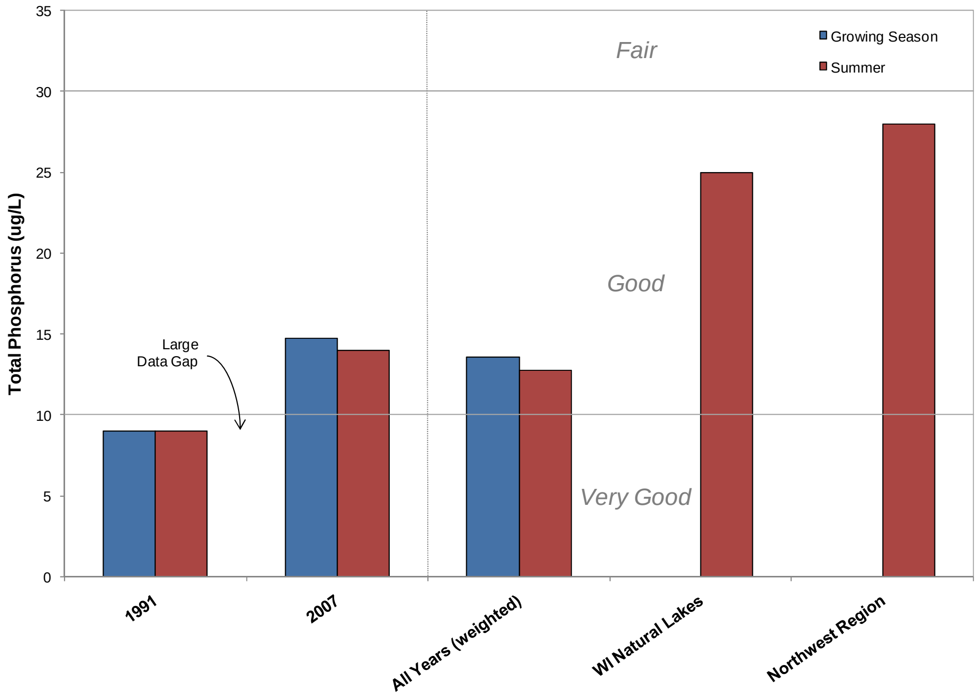

Figure 7. Flynn Lake total phosphorus concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

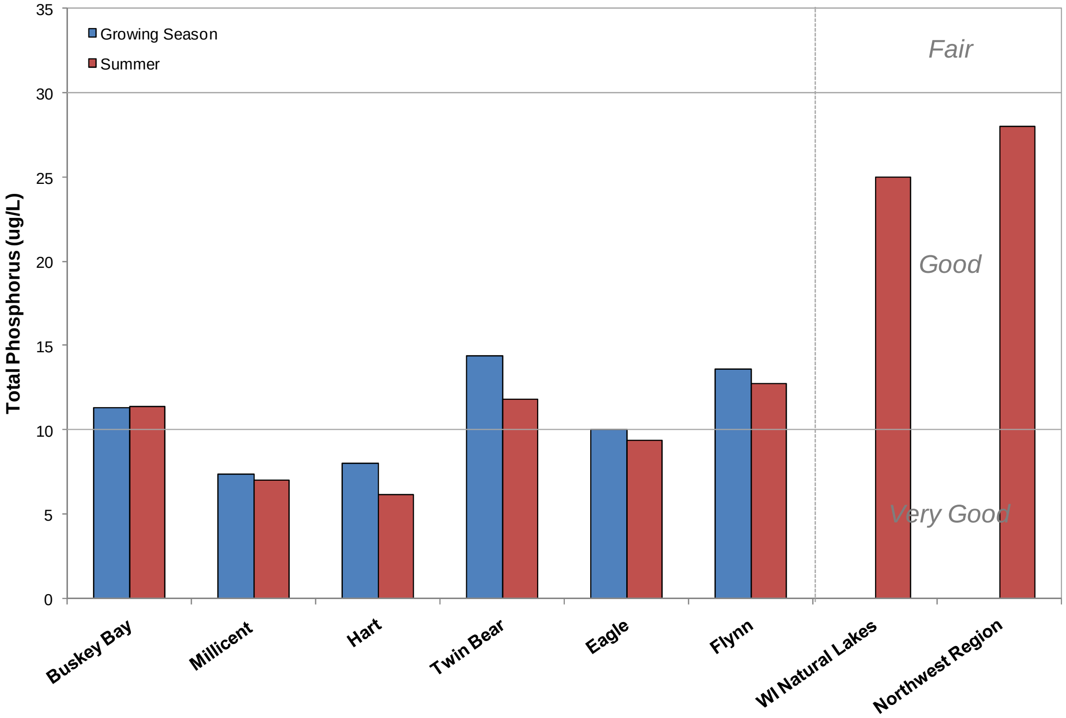

Figure 8. Pike Chain of Lakes total phosphorus concentrations. Weighted mean values from all years, calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

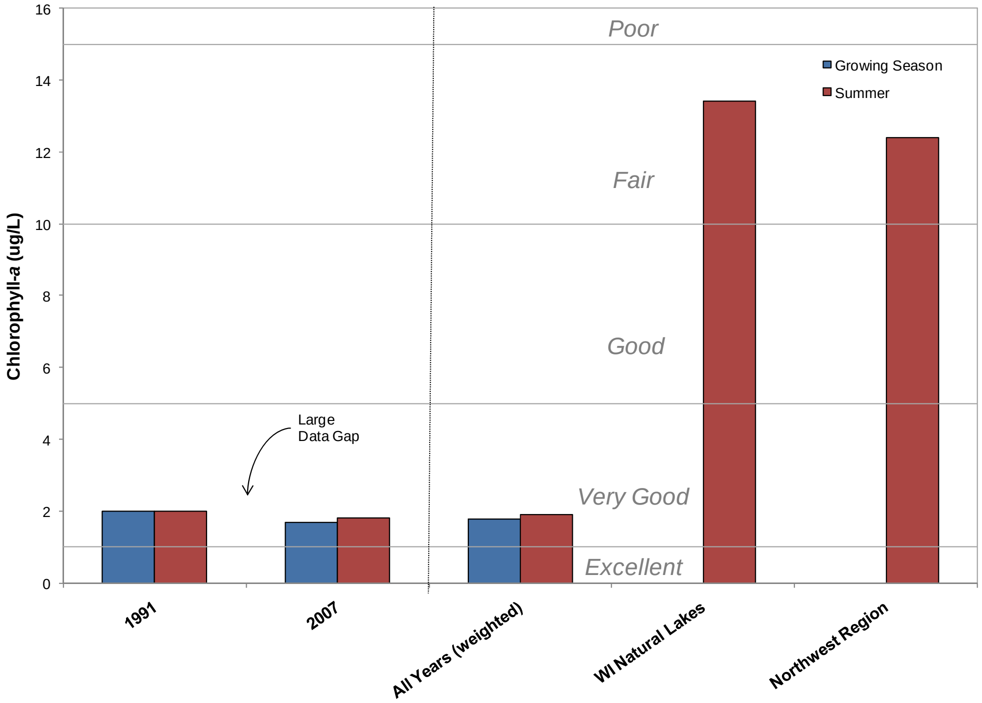

Figure 9. Buskey Bay Lake chlorophyll-*a* concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

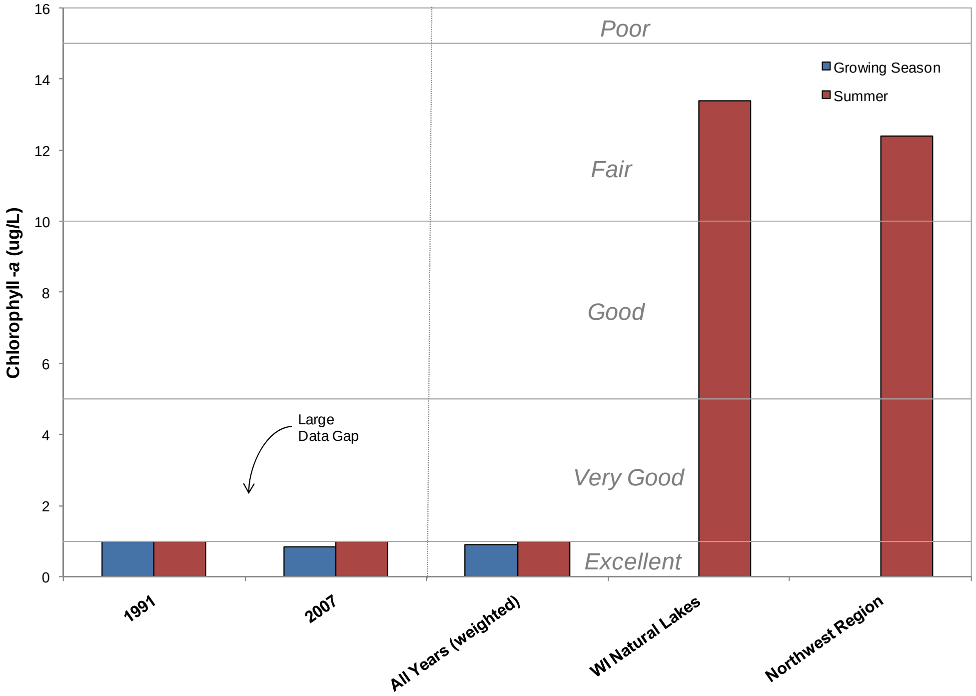

Figure 10. Lake Millicent chlorophyll-*a* concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

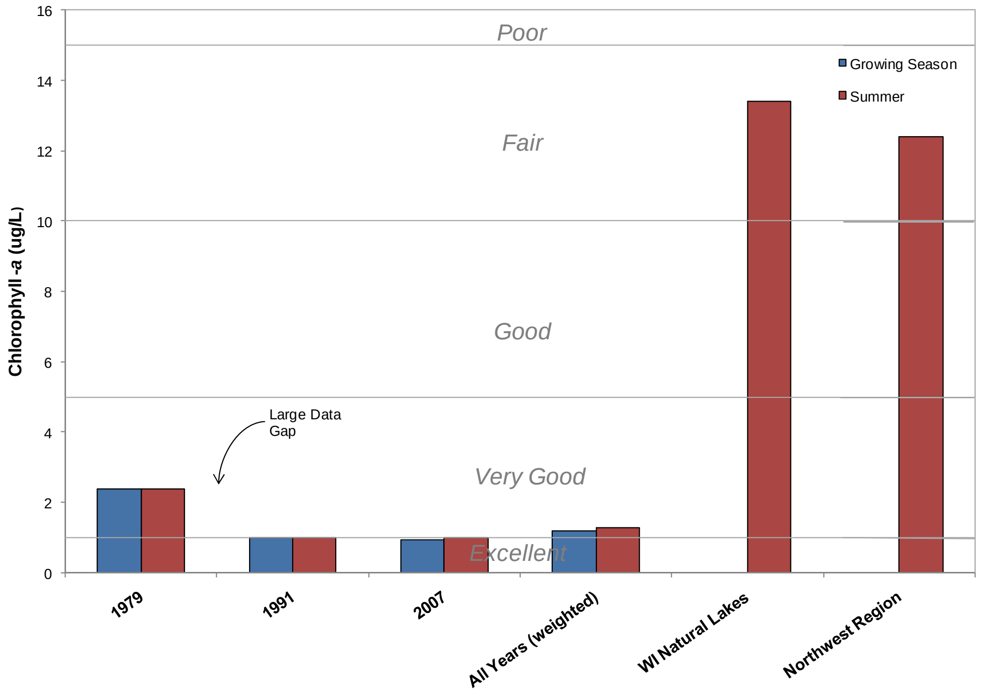

Figure 11. Hart Lake chlorophyll-*a* concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

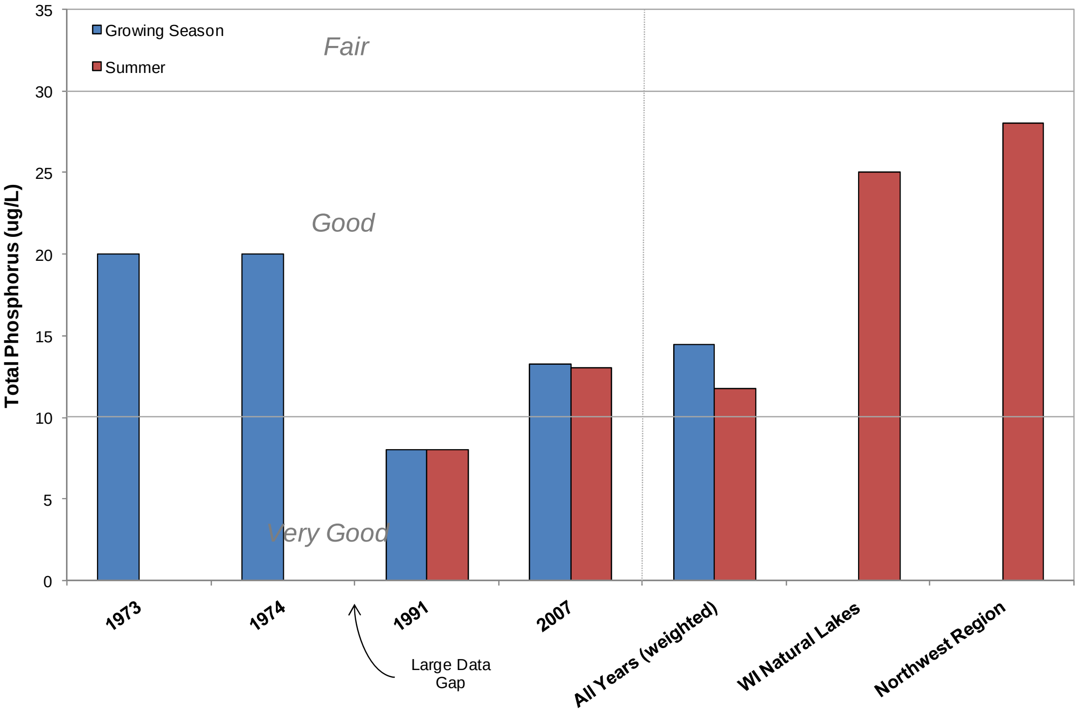

Figure 12. Twin Bear Lake chlorophyll-*a* concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

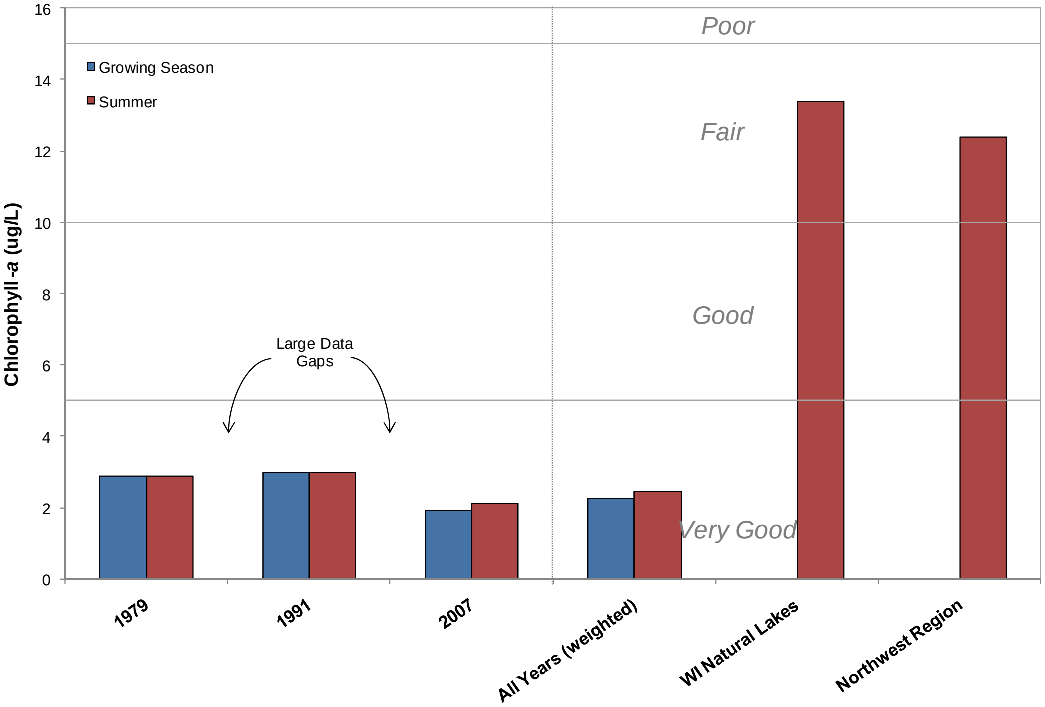

Figure 13. Eagle Lake chlorophyll-*a* concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

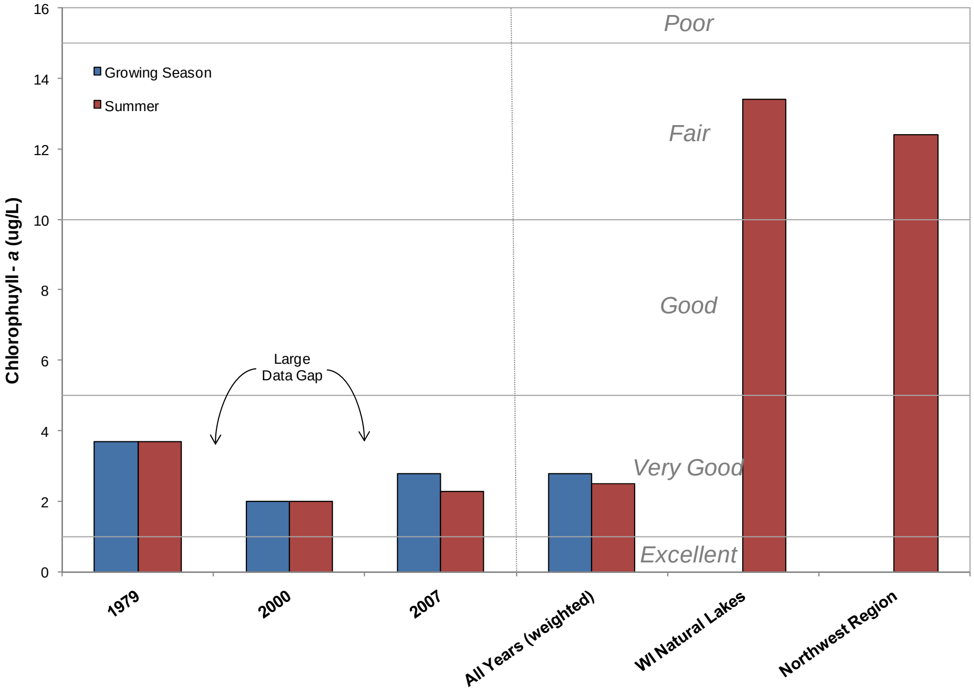

Figure 14. Flynn Lake chlorophyll-*a* concentrations. Mean values calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

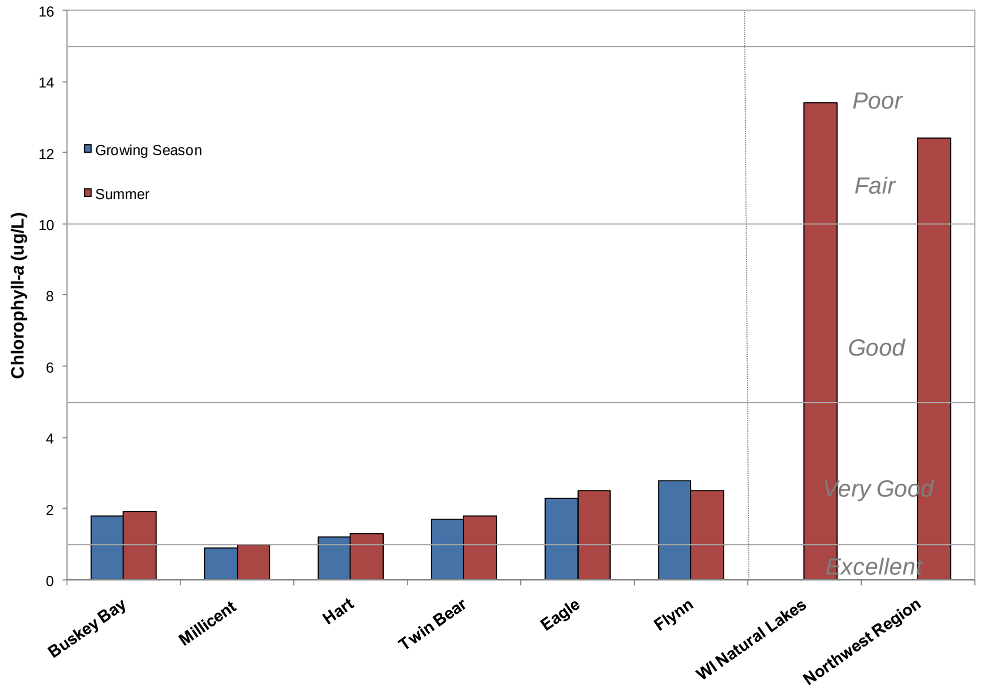

Figure 15. Pike Chain of Lakes chlorophyll-*a* concentrations. Weighted mean values from all years, calculated with summer and growing season surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

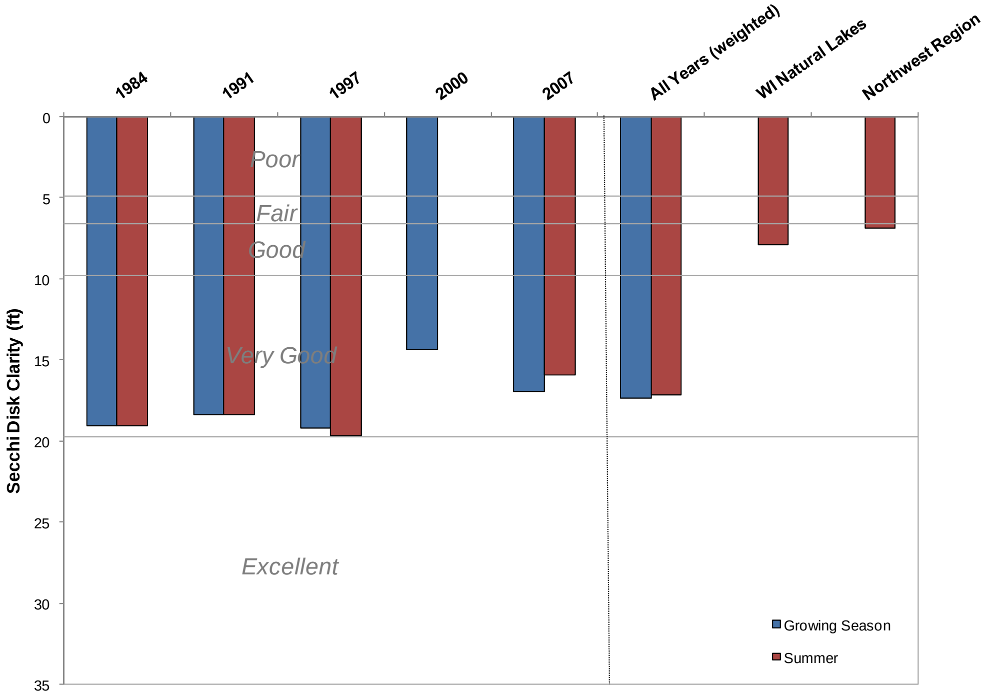

Figure 16. Buskey Bay Lake Secchi disk transparency values. Mean values calculated with summer and growing season sample data. Water Quality Index values adapted from Lillie and Mason (1983).

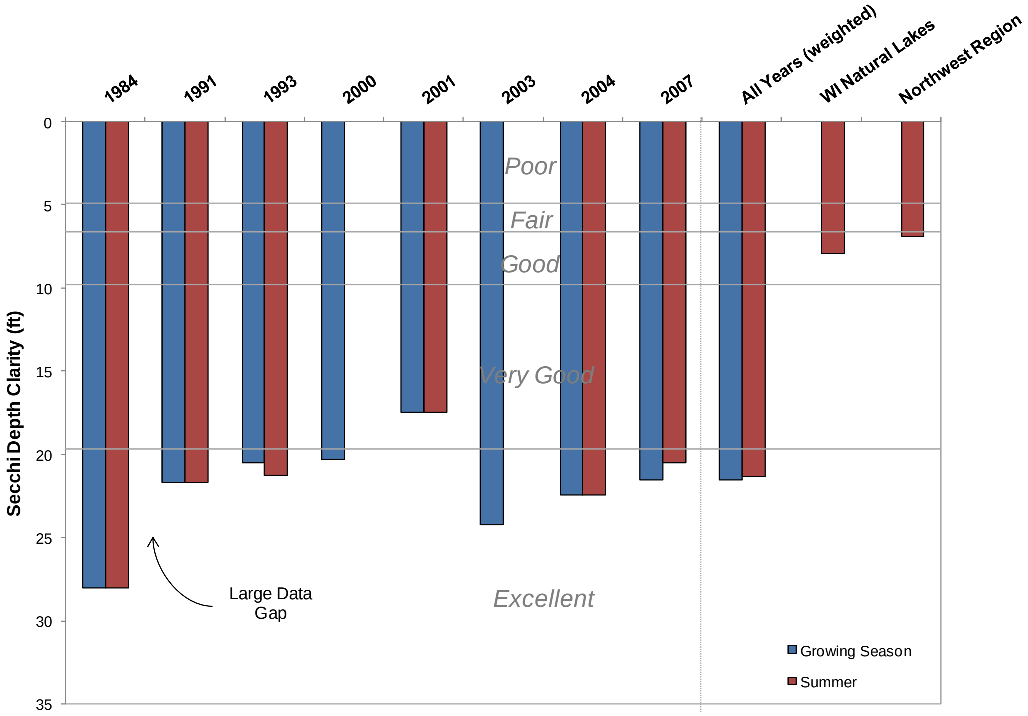

Figure 17. Lake Millicent Secchi disk transparency values. Mean values calculated with summer and growing season sample data. Water Quality Index values adapted from Lillie and Mason (1983).

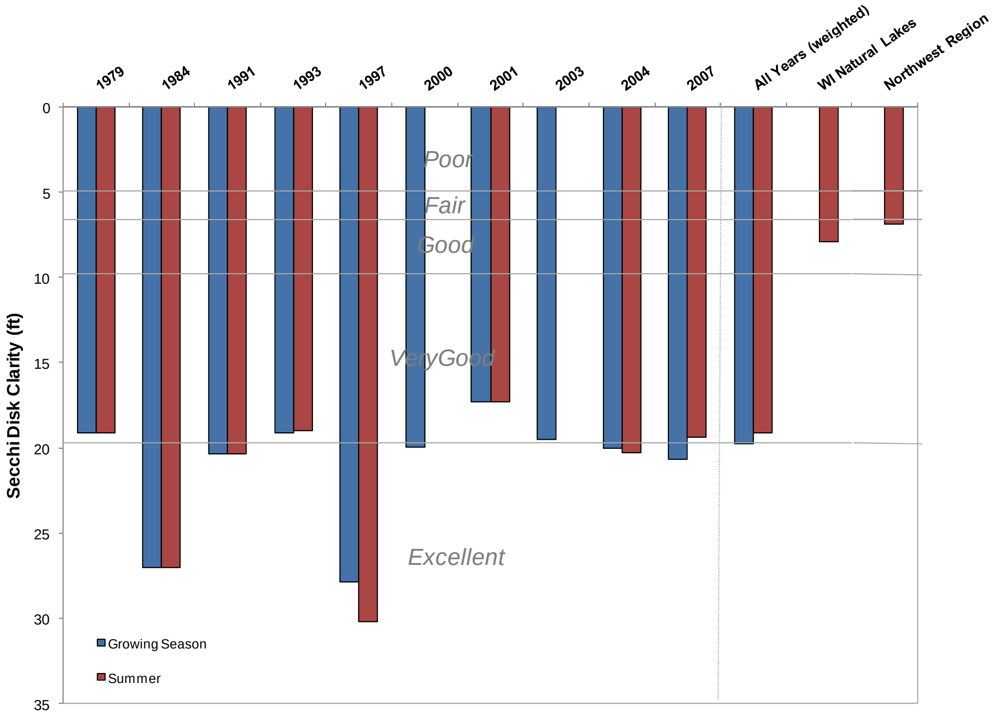

Figure 18. Hart Lake Secchi disk transparency values. Mean values calculated with summer and growing season sample data. Water Quality Index values adapted from Lillie and Mason (1983).

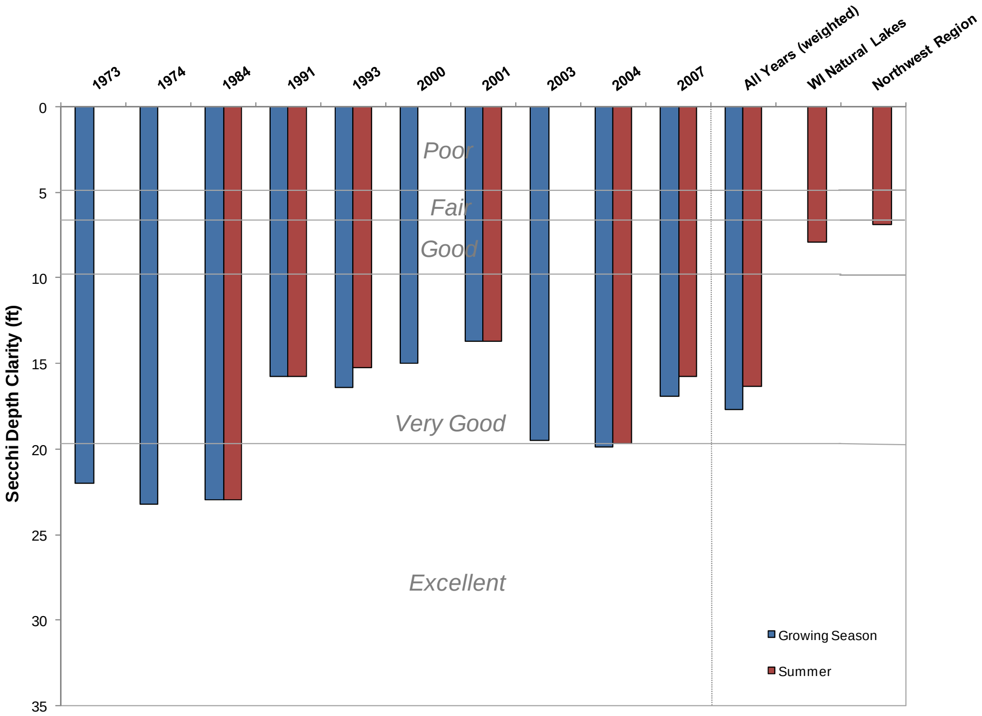

Figure 19. Twin Bear Lake Secchi disk transparency values. Mean values calculated with summer and growing season sample data. Water Quality Index values adapted from Lillie and Mason (1983).

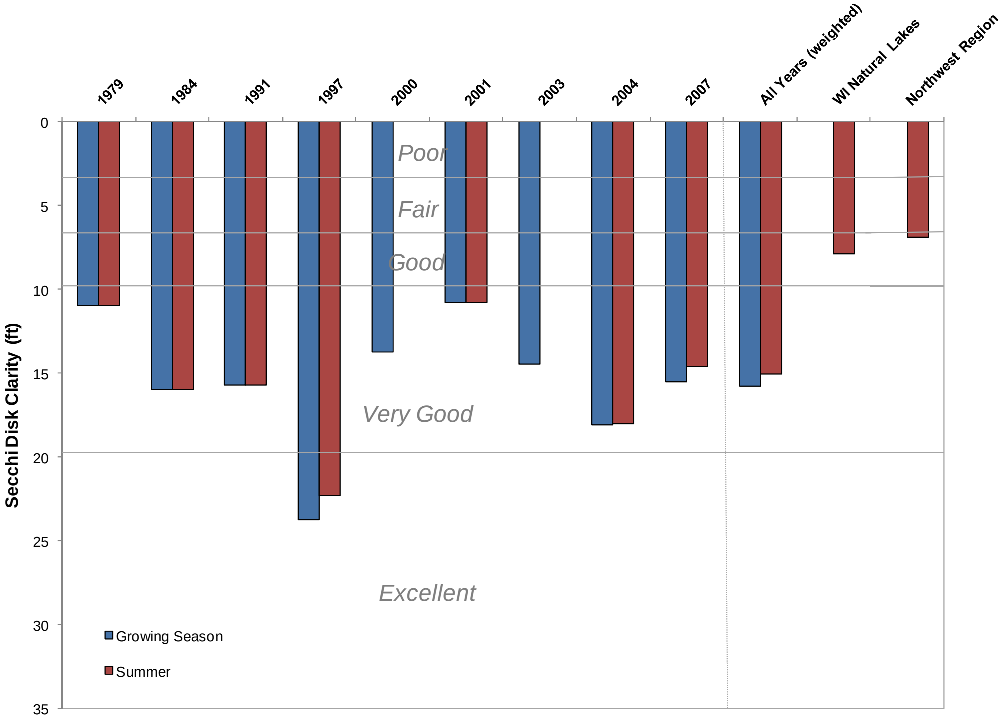

Figure 20. Eagle Lake Secchi disk transparency values. Mean values calculated with summer and growing season sample data. Water Quality Index values adapted from Lillie and Mason (1983).

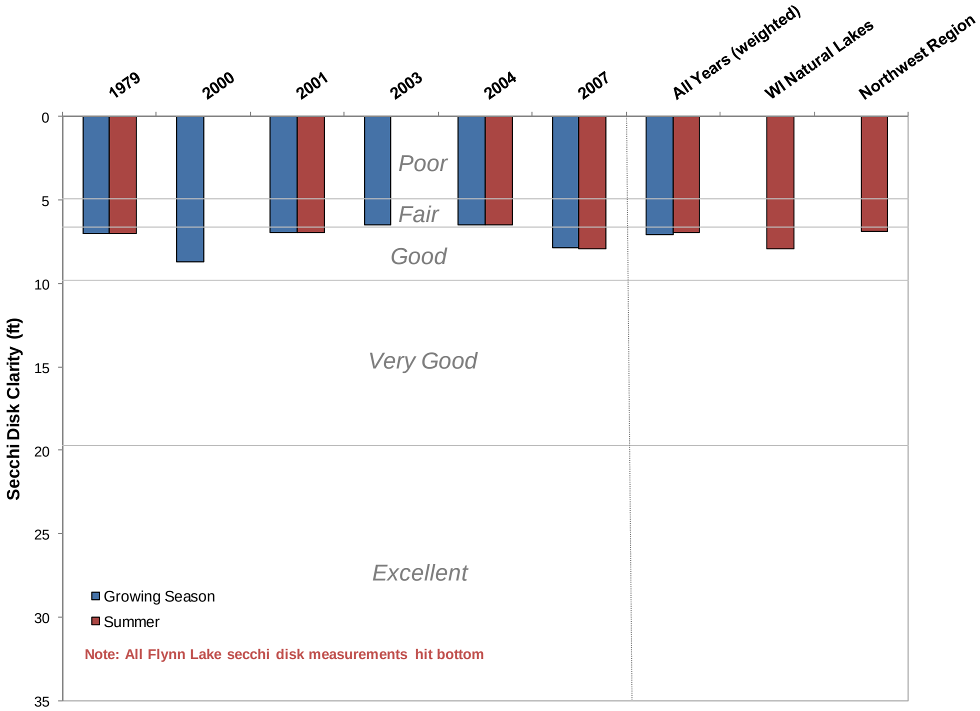

Figure 21. Flynn Lake Secchi disk transparency values. Mean values calculated with summer and growing season sample data. Water Quality Index values adapted from Lillie and Mason (1983). *Please Note:* All Secchi disk measurements hit bottom; clarity is greater than shown.

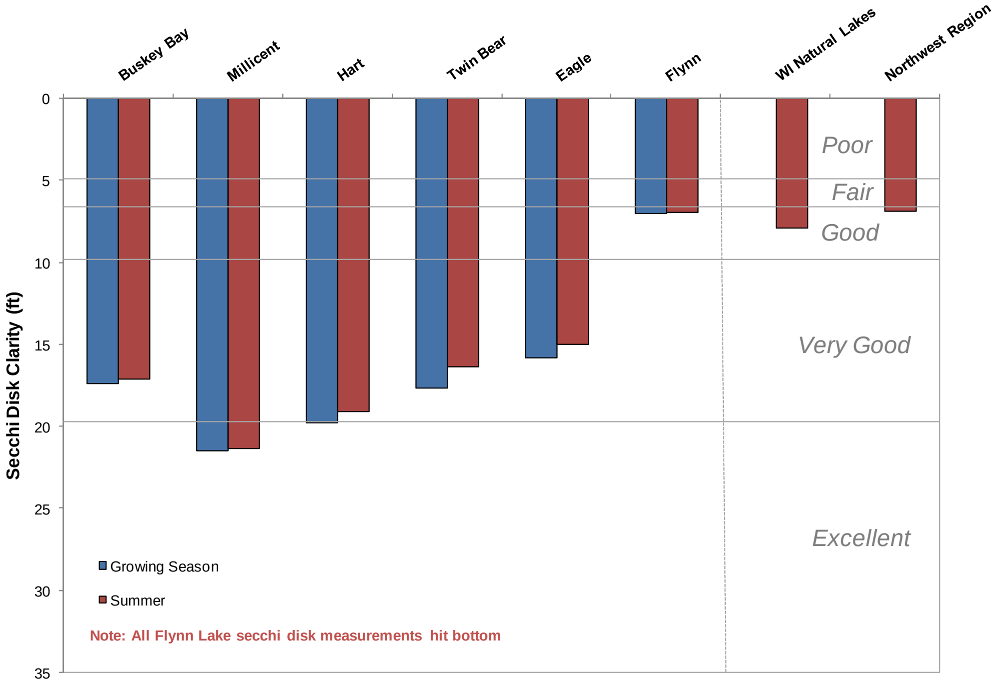

Figure 22. Pike Chain of Lakes Secchi disk transparency values. Weighted mean values from all years, calculated with summer and growing season sample data. Water Quality Index values adapted from Lillie and Mason (1983). *Please Note:* All Flynn Secchi disk measurements hit bottom; clarity is greater than shown.

values. In all six of the lakes, chlorophyll *a* values are well below state and regional means and correspond with very good and excellent readings in the WQI.

Following the relationship with phosphorus levels, Millicent, Hart and Buskey Bay have the lowest overall phosphorus levels on the Chain (Figure 15). Buskey Bay's weighted average is very close to that of Twin Bear, which further discredits the high phosphorus values from the early '70's of Twin Bear Lake as being inaccurate.

Compared to the other two limnological parameters discussed in the paragraphs above, there is more Secchi disk data for the six lakes in the Pike Chain (Figures 16-21). Still, the data are spotty and some of the years may only consist of one or two readings; therefore, long-term trend analysis is questionable at best. From the data of all six lakes, it is obvious that the values fluctuate within the very good to excellent range and again, are of much higher quality than those of the state and region. Please note that although they are included within the charts, the data from Flynn Lake are not technically valid as all Secchi disk samples reached the bottom of the lake before disappearing from site.

Comparisons of weighted averages between lakes (Figure 22) once again indicate that the best results are found in Millicent and Hart which are followed closely by Buskey Bay and Twin Bear. These findings would be expected considering the very low chlorophyll *a* values found in these lakes.

In summary, the limited historic data and those collected as a part of the project, all indicate that the water quality of the Pike Chain of Lakes has seen minor levels of fluctuation over the course of the past two plus decades, but all indicate that the water quality within the lakes is very good to excellent. The primary reason for this level of water quality is the watershed that drains to the lake. That aspect of the Pike Chain of Lakes ecosystem is discussed in detail within the watershed section.

Pike Chain of Lakes Trophic State

Figure 23 displays the Wisconsin Trophic State Index (WTSI) (Lillie et al. 1993) values calculated from average surface levels of chlorophyll-*a*, total phosphorus, and Secchi disk transparencies measured during the summer months in the Pike Chain of Lakes. The WTSI values for Pike Chain of Lakes indicate that the lakes range from upper oligotrophic to moderately mesotrophic (Figure 23). Being that the WTSI values are calculated with the same parameters discussed above, it is not surprising that the trophic state values for the lakes within the Chain follow same pattern found earlier with Hart and Millicent being the least productive with Buskey Bay and Twin Bear following close behind.

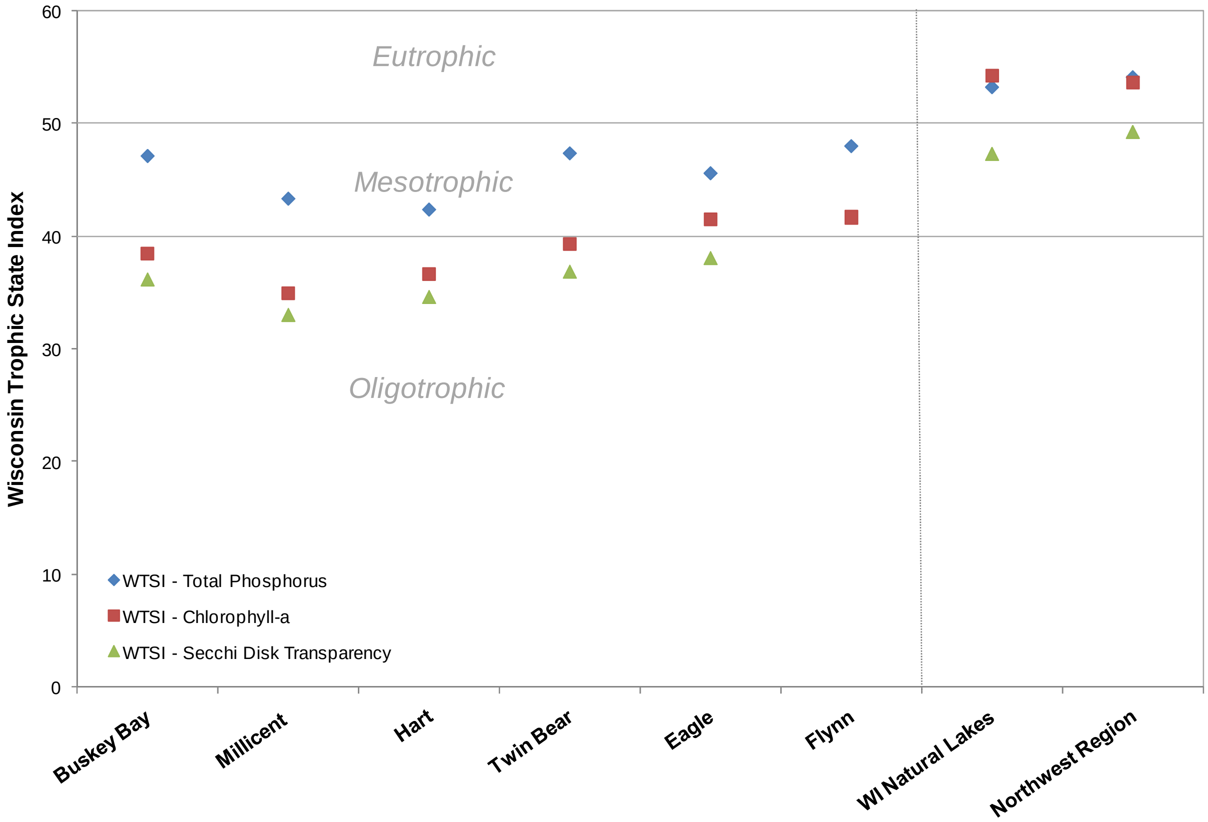

Figure 23. Pike Chain of Lakes Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993). Please Note: Flynn Secchi disk not included because all measurements hit bottom.

Limiting Plant Nutrient of the Pike Chain of Lakes

The following nitrogen to phosphorus ratios were calculated for the Pike Chain of Lakes using summer mean values:

Buskey Bay Lake	24:1
Lake Millicent	17:1
Hart Lake	36:1
Twin Bear Lake	15:1
Eagle Lake	44:1
Flynn Lake	38:1

All of the lakes in the Pike Chain would be considered phosphorus limited. Notably, the ratios for Lake Millicent and for Twin Bear Lake are much lower than the other lakes. These ratios are not an indication that there is so much phosphorus in these lakes that they are approaching nitrogen limitation, which is often the case in lakes that are nitrogen limited. In the case of these two lakes, both have low phosphorus levels, but they also have relatively low nitrogen levels too. The other lakes in the chain also have low nitrogen levels, but during the summer of 2007, they were not as low as Millicent and Twin Bear for some unknown (and unconcerning) reason.

Internal Nutrient Loading and Dissolved Oxygen in the Pike Chain of Lakes

With the exception of Flynn Lake, all of the Pike Chain lakes strongly stratify during the summer and during those times the hypolimnetic layer in each of these lakes does reach anoxia (see profiles for each lake in Appendix C. These anoxic conditions occur at depth in many lakes that stratify and are not a danger to fish populations.

Flynn Lake is not a candidate for significant internal nutrient loading as it does not stratify for long periods of time. The other lakes in chain do stratify and develop anoxia in the hypolimnion; however, none of these lakes exhibit phosphorus levels exceeding 200 µg/l (Appendix C), meaning that internal nutrient loading is not a significant source of phosphorus in these lakes either.

Watershed Analysis

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 are determined by the volume of the lake and the amount of water entering the lake from its watershed. Greater flushing rates equal shorter residence times.

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

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

Table 1. Subwatershed area, lake surface area, and watershed to lake area ratios (WS:LA) of the Pike Chain of Lakes. Subwatershed acreages include lake surface areas. When calculating WS:LA ratio, the watershed value is less the lake surface acreage.

Lake	Watershed Area (acres)	Lake Area (acres)	WS:LA
Buskey Bay Lake	645	91	6:1
Lake Millicent	2,064	186	10:1
Hart Lake	3,625	261	13:1
Twin Bear Lake	5,101	158	31:1
Eagle Lake	5,561	167	32:1
Flynn Lake	5,782	31	186:1

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 will be lessened. 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, there may be a build 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 may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

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

Modeling the watersheds of a chain of lakes presents certain challenges that require special procedures to accurately assess each lakes' hydrographic and phosphorus load information. The most prominent challenge is accounting for the affects of upstream lakes on the phosphorus load of lakes further down the Chain. In the case of the Pike Chain of Lakes, Buskey Bay Lake is at the headwater, so its tributaries do not flow through major waterbodies before reaching its basin. However, much of the watershed that feeds Millicent Lake must flow through Buskey Bay first. This pattern continues through the Chain to Flynn Lake, which accepts water from all of the chain lakes above it.

As the water moves through one lake to another, a portion of the phosphorus load is utilized within the upstream lake through biological process, and as those plants and animals die, the phosphorus settles to the bottom. Further, some of the phosphorus load entering the upstream lake sorbs (attaches) to sediment particles and sinks to the bottom or is precipitated out of the water column by marl or iron. In the end, this means that the upstream lake acts as a large settling basin or retention pond for the downstream lake and only allows a portion of the phosphorus entering it to pass through to the next lake via its outlet. To account for this process in the load modeling of downstream lakes, the upstream lake's outlet is treated as a point-source that contributes to the downstream lake's annual phosphorus load. The upstream lake's contribution is calculated by multiplying the lake's outlet discharge by the lake's average annual water phosphorus concentration. This yields a phosphorus load and water volume that can be added to the downstream lake along with the other watershed information within WiLMS. In order to complete these calculations, in-lake water quality data must be available from the upstream lake. In the case of the Pike Chain of Lakes and the other lakes that feed into the system (Map 2), the only lake outside of the project lakes with the necessary water quality data available to calculate the annual phosphorus average was McCarry Lake, which feeds into Hart Lake on its southwest shore. All of the other lakes in the watershed, such as Muskellunge and Pike, were treated as wetlands in order to estimate their contribution to the receiving lake's phosphorus load.

As described above, watershed land cover is a primary component in determining the amount of phosphorus loaded to a lake on annual basis. Map 2 contains the watershed and subwatershed boundaries and land cover types of the Pike Chain of Lakes, while Figure 24 displays the parsing of land cover types within each of the lakes' subwatersheds. These charts also display the acreage of watershed that flows through upstream lakes before entering the lake in question and that lake's total subwatershed acreage.

The watershed of the Pike Chain of Lakes is highly dominated by forested areas. Remaining areas consist of open water, wetlands, and limited amount of pasture/grass areas. As displayed in the charts found in Figure 24, the impact of direct overland runoff is lessened severely as one moves down the lakes in the Chain. Buskey Bay as the headwater lake is the only lake in the Chain that does not have a significant waterbody draining into and as a result forested areas dominate the land cover types. Hart Lake's subwatershed is the first in the Chain to contain more watershed area that flows through other lakes than enters directly to the lake itself. By the time Flynn Lake is reached, 96% of its watershed is a portion of another lake's watershed that ultimately feeds it. This means that the water entering Flynn Lake is essentially treated by the other lakes in the Chain before entering its basin. This occurrence, tied with the dominance of forested areas in the drainage basin has a enormous benefit on the water quality of Flynn Lake. This is the case because normally a lake with a watershed to lake area ratio of 186:1 (Table 1) would be highly eutrophic as exhibited by high phosphorus levels and poor clarity. These same facts come into play regarding the water quality of Twin Bear and Eagle Lakes as each also has a relatively high watershed to lake area ratio.

Figure 25 displays the estimated phosphorus load entering each of the Chain lakes from its watershed, including that entering from upstream lakes. Each chart also contains a breakdown of how the phosphorus load is divided among the different land cover types and the preceding waterbody in the Chain. As the waters move through the Chain it is evident that they pick up additional amounts of phosphorus and as a result the load to each lake increases. The exception to this rule is the difference between Hart and Twin Bear Lakes' phosphorus load as Hart's load is slightly higher than Twin Bear's even though it precedes it in the flow regime. Although this may be uncontrolled error in the modeling procedure, it is likely caused by the fact that Hart has a larger direct watershed than Twin Bear.

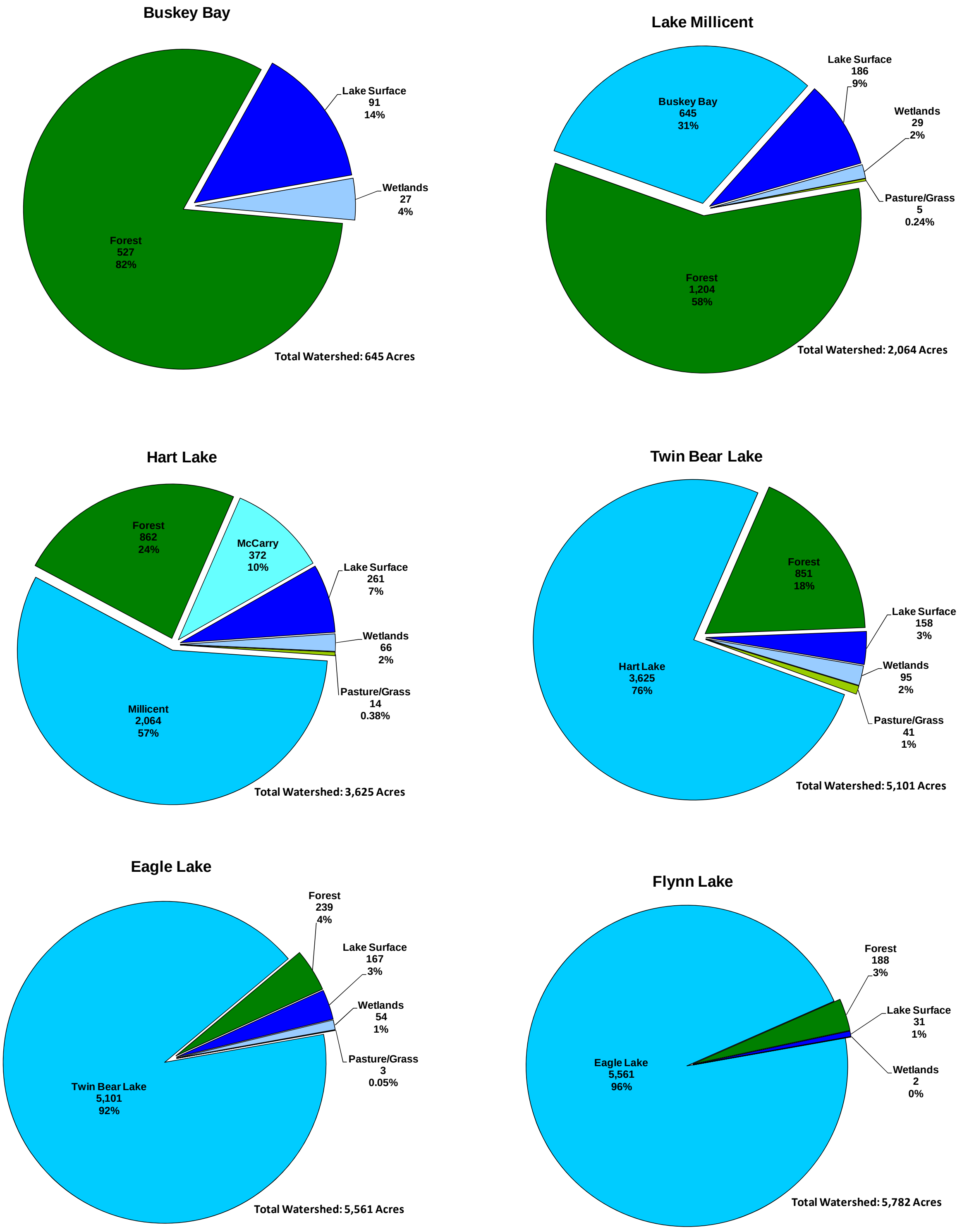

Figure 24. Pike Chain of Lakes watershed land cover types in acres. Based upon Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) (WDNR 1998).

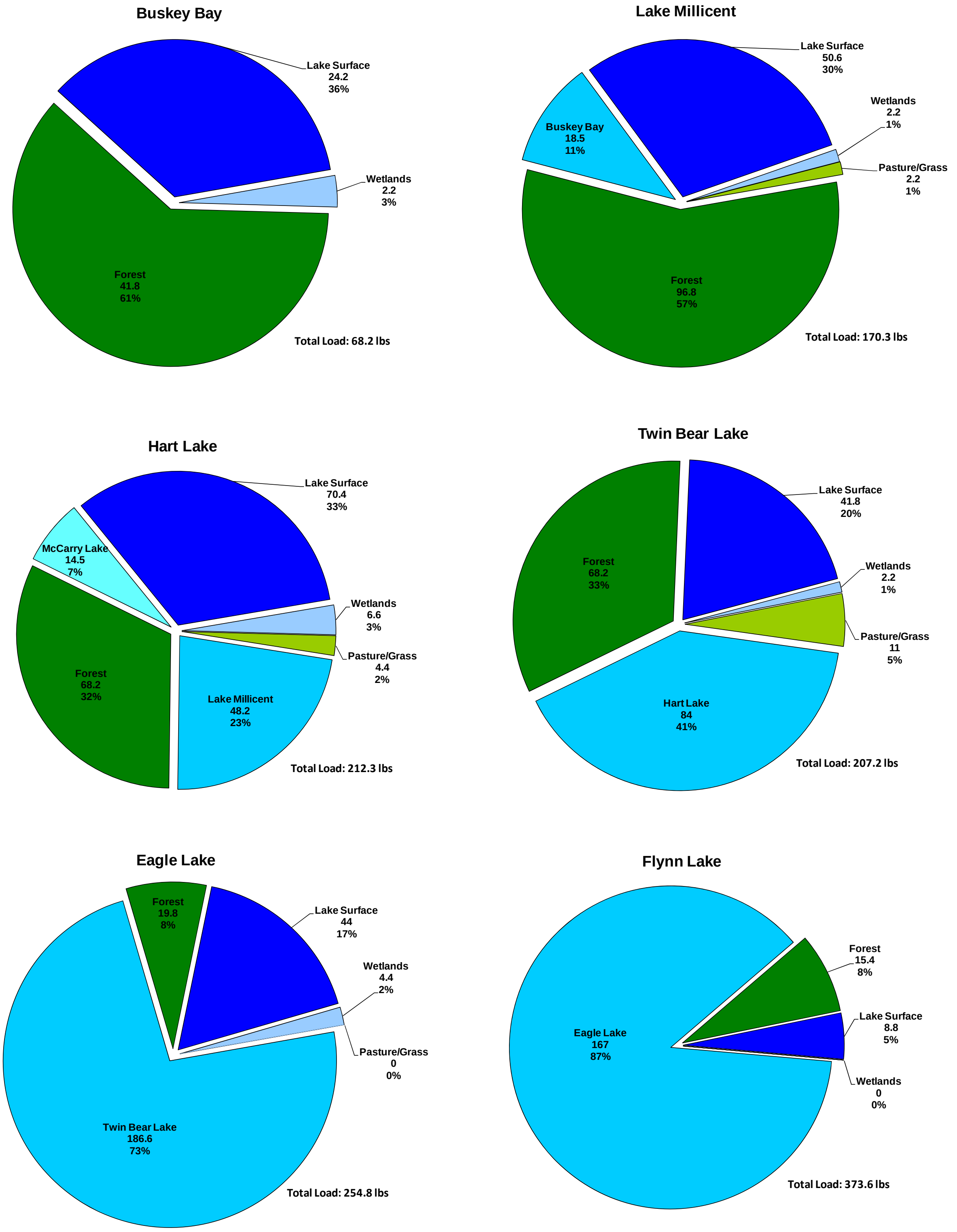

Figure 25. Pike Chain of Lakes watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

Examination of the charts also leads to the understanding of how much phosphorus is removed by the upstream lake before its waters enter the next lake in the Chain. For example, Buskey Bay Lake's annual load is approximately 68 lbs.; however, it only contributes about 18 lbs. to the annual load of Lake Millicent. This means that Buskey Bay removes approximately 73% of the phosphorus that enters it before releasing it to Lake Millicent. Each lake's phosphorus retention efficiency is largely determined by it flushing rate, which is controlled by its volume and the amount of water flowing into it. In general, the greater the flushing rate, the less efficient the lake will be at retaining phosphorus.

Overall, the amount of phosphorus entering each of the Pike Chain lakes is very low, including the 374 lbs. estimated to enter little Flynn Lake every year. These very low loading rates are directly responsible for the exceptional water quality found in the lakes.

Analysis of 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 detectable and provide critical information for management decisions.

As described in more detail in the methods section, multiple aquatic plant surveys were completed on the Pike Chain of Lakes. Some of these focused on native aquatic plants while others focused on a particular invasive species such as Eurasian water milfoil or curly-leaf pondweed. Native aquatic plant surveys were completed by the WDNR in 2005 and Onterra in 2007. Invasive species surveys were completed by Onterra in 2007 and 2008. Combined, these surveys produce a great deal of information about the aquatic vegetation of the system. 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.

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.

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 the Pike Chain of Lakes, 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, relative frequency of occurrence is used to describe how often each species occurred relative to the other plants. 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 that value was described as a percentage, it would mean that water lily made up 10% of the plant 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

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 of species.

A lake with high species diversity is 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.

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 each lake is compared to each other, to lakes in the same ecoregion, and to lakes in the state (Figure 26).

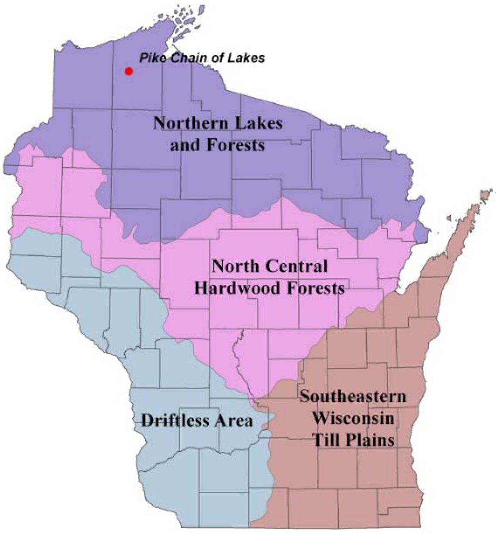

Figure 26. Location of Pike Chain of Lakes within the ecoregions of Wisconsin. After Nichols 1999.

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.

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

Community Mapping Survey

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 completely visible from the surface; therefore, mapping of submergent communities is more difficult and often impossible.

Comprehensive Plant Survey Results – Chain-wide

In 2005, the WDNR completed an aquatic plant surveys on Twin Bear and Hart Lakes utilizing the point-intercept method as described in "Appendix B" of the Wisconsin Department of Natural Resource (WDNR) document, Aquatic Plant Management in Wisconsin - Draft, (April 20, 2006). The same methodology was used by Onterra in 2007 to sample the remaining four lakes (Table 2). Map 3 displays the sample locations.

Table 2. Pike Chain of Lakes Point-intercept Resolutions.

Lake Name	Point-intercept Resolution (meters)	Sample Points
Buskey Bay Lake	30	399
Eagle Lake	30	734
Flynn Lake	30	132
Hart Lake*	33	953
Lake Millicent	38	514
Twin Bear Lake*	32	614

* Completed by WDNR in 2005

Table 3 lists the aquatic plant species found within the Pike Chain of Lakes. Four exotic species were located during the surveys. Purple loosestrife and giant reed are invasive emergent species that have the ability to displace valuable emergent wetland species. Eighteen emergent plant species are known to exist in the Pike Chain of Lakes (Table 3). Curly-leaf pondweed was discovered by WDNR Science Services in one sample location of Hart Lake in 2005 (Map 6), but has not been detected since. Although Eurasian water milfoil was only discovered in one lake (Twin Bear) using the point-intercept method, more intensive surveys focused on this non-native plant located it in five of the six main lakes of the Chain over the course of this project (Table 3). No exotic species were located in Flynn Lake.

Table 3. Pike Chain of Lakes Plant Species List. C Value = Coefficient of conservatism.

Life Form	Common Name	Scientific Name	C Value	Buskey Bay	Millicent	Hart	Twin Bear	Eagle	Flynn
Emergent	Water arum	*Calla palustris*	9			I		X	X
	Bristly sedge	*Carex comosa*	5	I		I	I		I
	Unidentified Sedge	*Carex sp.*	N/A	X				X	
	Three-way sedge	*Dulichium arundinaceum*	9	I	I	I	I	X	X
	Creeping spikerush	*Eleocharis palustris*	6	X	I			X	
	Water horsetail	*Equisetum fluviatile*	7	I	I	I		X	
	Northern blue flag	*Iris versicolor*	5	I	I			X	
	Soft rush	*Juncus effusus*	4	I					
	Purple loosestrife	*Lythrum salicaria*	Exotic	I	I				
	Giant reed	*Phragmites australis*	Exotic					I	
	Pickerelweed	*Pontederia cordata*	9		I				
	Common arrowhead	*Sagittaria latifolia*	3	X			I	X	X
	Hardstem bulrush	*Schoenoplectus acutus*	5		I	I	I	X	X
	Three-square rush	*Schoenoplectus pungens*	5	X					
	Water bulrush	*Schoenoplectus subterminalis*	9	X	X			X	X
	Softstem bulrush	*Schoenoplectus tabernaemontani*	4		X				
	Narrow-leaved cattail	*Typha angustifolia*	1	X					
	Broad-leaved cattail	*Typha latifolia*	1	X	I	I	I	X	X
FF	Lesser duckweed	*Lemna minor*	5	X	I				X
	Forked duckweed	*Lemna trisulca*	6	X				X	
	Slender riccia	*Riccia fluitans*	7						I
	Greater duckweed	*Spirodela polyrrhiza*	5	X	I	I			
FL	Watershield	*Brasenia schreberi*	7	X	X	I		X	X
	Spatterdock	*Nuphar variegata*	6	X	X	X		X	X
	White water lily	*Nymphaea odorata*	6	X	X	X		X	X
	Water smartweed	*Polygonum amphibium*	5	X				X	
FL/E	Narrow-leaf bur-reed	*Sparganium angustifolium*	9					X	X
	Short-stemmed bur-reed	*Sparganium emersum*	8	X	X	I	I	X	X
	Common bur-reed	*Sparganium eurycarpum*	5		I	I			
	Floating-leaf bur-reed	*Sparganium fluctuans*	10			I			
Submergent	Coontail	*Ceratophyllum demersum*	3	X	X	X	X	X	X
	Spiny Hornwort	*Ceratophyllum echinatum*	10		X	X			X
	Muskgrasses	*Chara sp.*	7	X		X	X	X	X
	Common waterweed	*Elodea canadensis*	3	X	X	X	X	X	X
	Water stargrass	*Heteranthera dubia*	6	X	X	X	X	X	
	Lake quillwort	*Isoetes lacustris*	8					X	
	Water marigold	*Megalodonta beckii*	8	X	X	X	X	X	X
	Northern water milfoil	*Myriophyllum sibiricum*	7	X	X	X	X	X	X
	Eurasian water milfoil	*Myriophyllum spicatum*	Exotic	I	I	I	X	I	
	Dwarf water milfoil	*Myriophyllum tenellum*	10	X	X	X		X	
	Whorled water milfoil	*Myriophullum verticilatum*							
	Slender naiad	*Najas flexilis*	6	X	X	X	X	X	X
	Stoneworts	*Nitella sp.*	7	X	X	X	X	X	X
	Large-leaf pondweed	*Potamogeton amplifolius*	7	X	X	X	X	X	X
	Curly-leaf pondweed	*Potamogeton crispus*	Exotic			X			
	Ribbon-leaf pondweed	*Potamogeton epihydrus*	8			X		X	
	Leafy pondweed	*Potamogeton foliosus*	6	X	X	X		X	X
	Variable pondweed	*Potamogeton gramineus*	7	X	X			X	X
	Illinois pondweed	*Potamogeton illinoensis*	6	X	X				
	Floating-leaf pondweed	*Potamogeton natans*	5	X	X	X	I	X	X
	Oakes pondweed	*Potamogeton oakesianus*	10		I	I			I
	White-stem pondweed	*Potamogeton praelongus*	8	X	X			X	X
	Small pondweed	*Potamogeton pusillus*	7	X	X		X	X	X
	Clasping-leaf pondweed	*Potamogeton richardsonii*	5	X	X			X	X
	Fern pondweed	*Potamogeton robbinsii*	8	X	X	X	X	X	X
	Spiral-fruited pondweed	*Potamogeton spirillus*	8					X	
	Stiff pondweed	*Potamogeton strictifolius*	8	X	X		X	X	
	Flat-stem pondweed	*Potamogeton zosteriformis*	6	X	X	X	X	X	X
	White water-crowfoot	*Ranunculus aquatilis*	8	X	X				
	Sago pondweed	*Stuckenia pectinata*	3	X				X	X
	Creeping bladderwort	*Utricularia gibba*	9	X	X			X	X
	Flat-leaf bladderwort	*Utricularia intermedia*	9						X
	Common bladderwort	*Utricularia vulgaris*	7	X	X			X	X
	Wild celery	*Vallisneria americana*	6	X	X	X	X	X	X
S/E	Needle spikerush	*Eleocharis acicularis*	5		I			X	
	Brown-fruited rush	*Juncus pelocarpus*	8	X	X				
	Grass-leaved arrowhead	*Sagittaria graminea*	9		I	I		I	X
	Arrowhead Sp.	*Sagittaria sp. (Rosette)*	N/A				X	X	

FF = Free-floating, FL = Floating leaf, FL/E = Floating leaf/emergent, S/E = Submergent/Emergent, X = Present, I = Incidental

Eleven species were located within the point-intercept surveys of all six lakes (Figure 27). Of these species, common waterweed is the most common species within the Chain. Of the eleven common species, seven are narrow-leaf species, three are broad-leaf (dicot) species (coontail, northern water milfoil, and water marigold), and one is a macro-algae (stoneworts). Common waterweed, stoneworts, and coontail, are species that are not rooted and are usually found at the outer margins of the littoral area. Large-leaf pondweed, sometimes called *musky cabbage* by anglers, provides valuable habitat for ambush predator fish. Wild celery is a turbidity tolerant species that is a premiere food source for ducks, marsh birds, shore birds and muskrats. Northern water milfoil is usually found in soft sediments and its feathery foliage traps filamentous algae and detritus, providing valuable invertebrate habitat. Because northern water milfoil prefers high water clarity, its populations are declining state-wide as lakes are becoming more eutrophic.

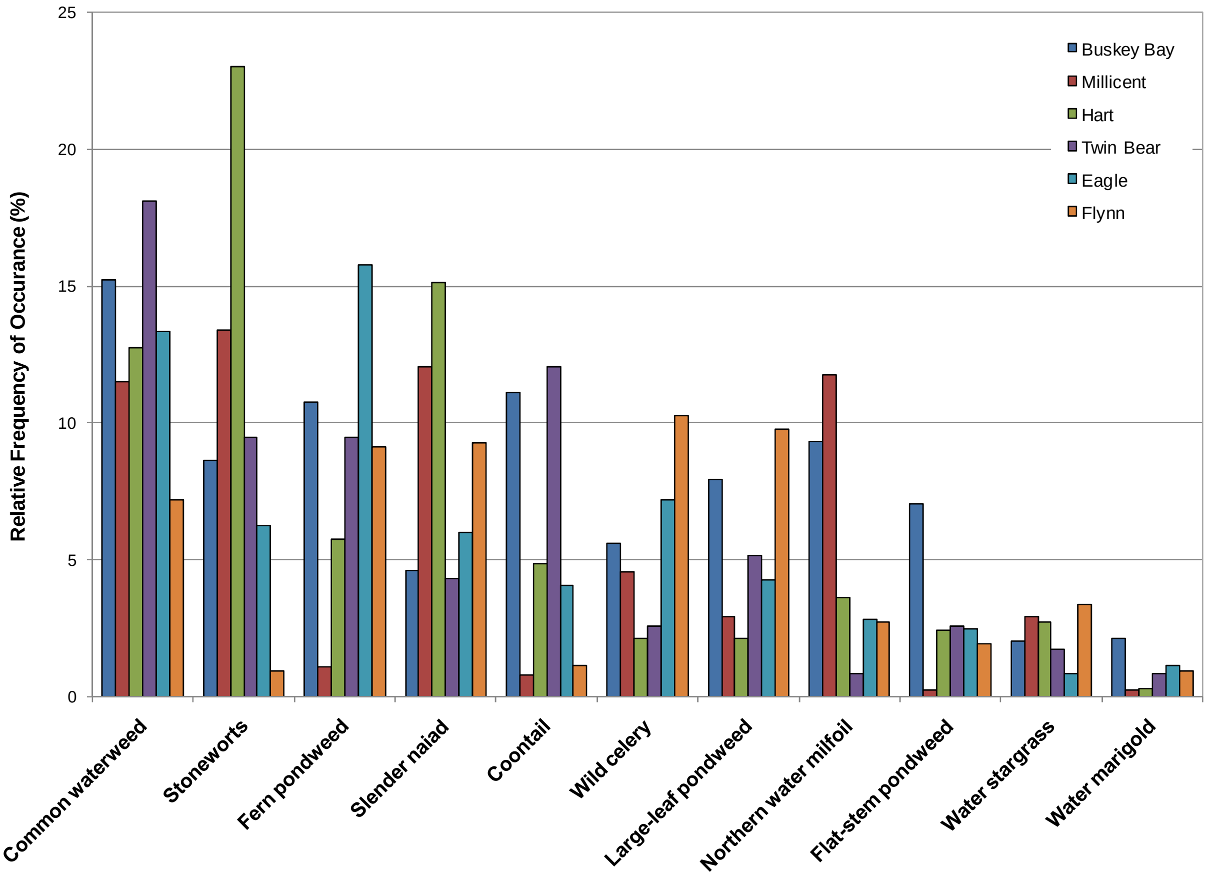

Figure 27. Pike Chain of Lakes aquatic plant relative frequency chart. Displayed are the eleven plant species common to all six lakes using the point-intercept sampling method.

The Pike Chain has a very high number of aquatic plant species, and because of this, one may assume that the system would also have a very high diversity. As discussed earlier, how evenly the species are distributed throughout the system also influence the diversity. In general, the diversity of the Pike Chain is relatively high, with only Twin Bear and Hart Lake containing diversity measures less than 0.90 (Figure 28). Although it is true that these lakes likely contain the lowest diversities within the Chain, it is important to note that the aquatic plant surveys completed on these lakes were completed by the WDNR, with primary focus on submergent plants and invasive species. This may have resulted in minimal representation of near-shore emergent plant species which would not be reflected in the diversity measurement.

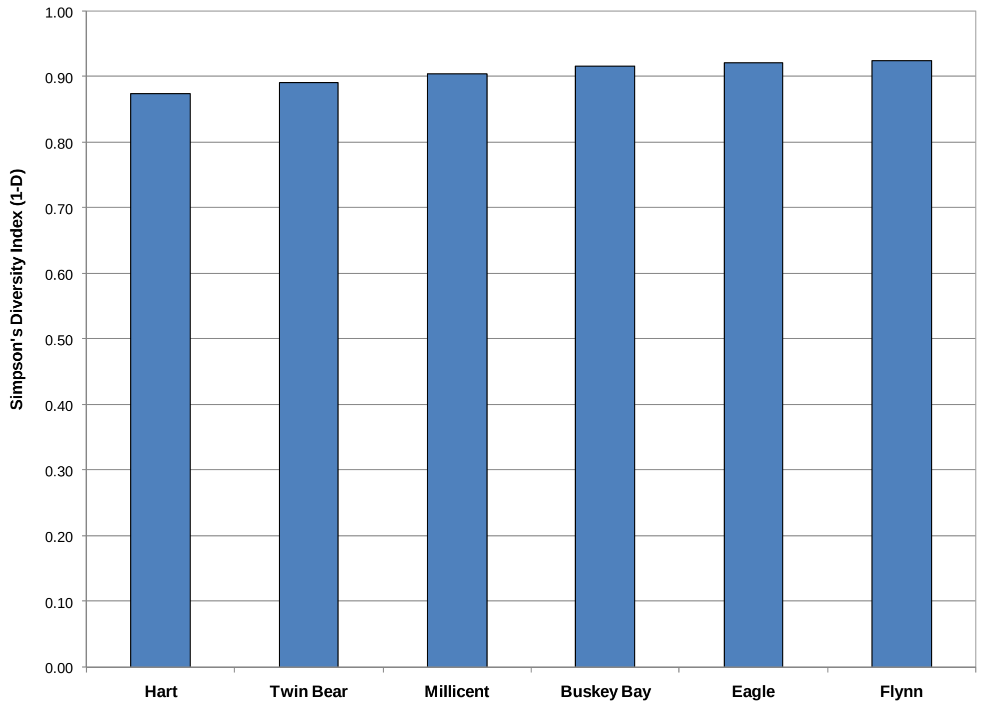

Figure 28. Pike Chain of Lakes species diversity. Displayed by lake, sorted from lowest to greatest diversity.

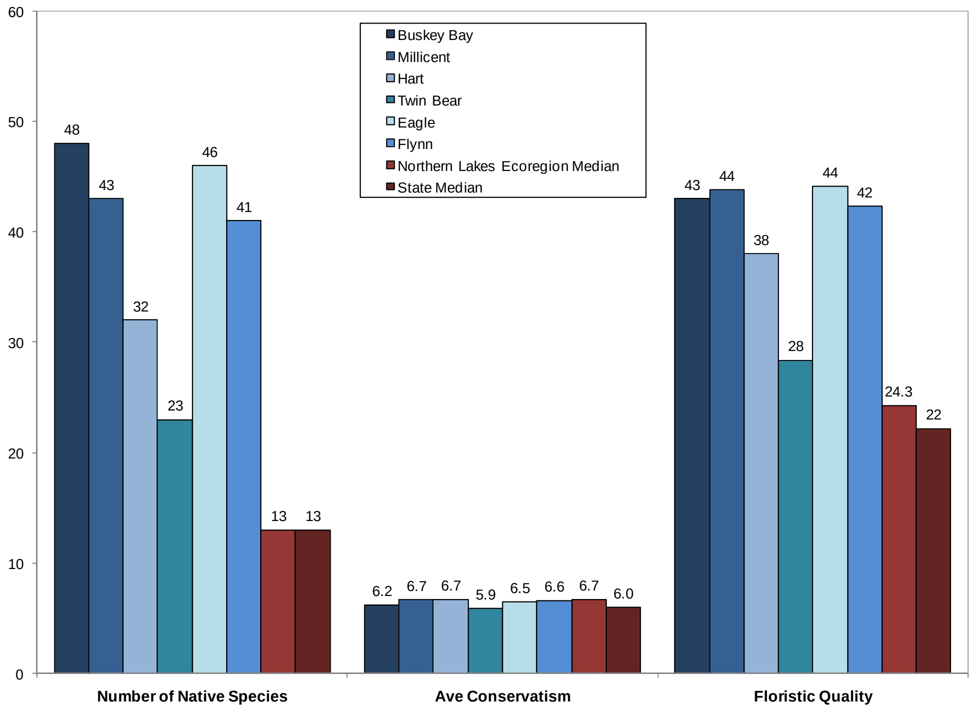

Figure 29. Pike Chain of Lakes Floristic Quality Assessment of 2005 survey data. Analysis following Nichols 1999, displayed by lake.

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.

Data collected from the aquatic plant surveys indicate that the average conservatism values are higher than the state median and similar, or slightly less than the Northern Lakes Ecoregion median. This shows that the aquatic plants within the Pike Chain are more indicative of a pristine condition than those found in most lakes in the state. The Northern Lake and Forest Ecoregion contains some of the most pristine lakes within the state and although some lakes within the Chain contain averages below the ecoregion median, the data needs to be understood within this context. Some of the lakes within the Chain are marginally indicative of a disturbed condition. It is true that the Pike Chain of Lakes is a popular recreation destination in the area and endures considerable use which has potential to negatively impact plant communities. In fact, the stakeholder survey indicates that pontoon boats are the most prevalent and motor boats with greater than a 25 horsepower motor are the third most prevalent watercraft type on the lake (Appendix B, Question 10).

Even though some of the lakes have moderate coefficient of conservatisms values, combining the high species richness of the aquatic plants within the system, the FQA indicates that floristic quality of the Pike Chain (Figure 29) is excellent, especially when compared to median values for the state and ecoregion. As described above, floristic quality utilizes average conservatism value for all of the native species found in the lake and the total number of those species.

The quality is also indicated by the high incidence of emergent and floating leaf plant communities that occur in many areas of the Chain (Maps 4 and 5). 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. Many studies have documented the adverse affects of motorboat traffic on aquatic plants (e.g. Murphy and Eaton 1983, Vermaat and de Bruyne 1993, Mumma et al. 1996, Asplund and Cook 1997). In all of these studies, lower plant biomasses and higher turbidity were associated with motorboat traffic.

The 2007 community maps indicate that there are many areas of each lake where diverse floating-leaf and emergent communities can be found (Maps 4 and 5). Each of these areas provides valuable fish and wildlife habitat important to the ecosystem of the lake. Continuing the analogy that the community map represents a ‘snapshot’ of the important plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within the Chain.

Comprehensive Plant Survey Results – Lake-by-Lake

Buskey Bay

Buskey Bay Lake is a 100-acre lake with a maximum depth of 51 feet and mean depth of 15 feet. Only the 17-acre Pike Lake is upstream of Buskey Bay. Buskey Bay flows into Lake Millicent which ultimately flows into the White River.

More aquatic plant species were found in Buskey than any other lake in the Chain, however their average conservatism values are lower than the ecoregion median, indicating that the plants found within the system are indicative of a slightly disturbed system (Figure 29).

Common waterweed is the most common aquatic plant in Buskey Bay (Figure 30), followed closely by coontail, fern pondweed, and northern water milfoil. Large areas of Buskey Bay are dominated by submergent aquatic plants, specifically within the bay that the public boat landing is located on and the bay which contains the private boat landing (locally known as the Hermitage Boat Landing). While only a few Eurasian water milfoil locations were documented within the lake (Map 7), numerous false identifications consisting of northern water milfoil have emerged over the course of the planning process. Northern water milfoil is known to take on the 'reddish' appearance of Eurasian water milfoil within this lake (and others of the system) as the plant reacts to increased sun exposure, largely from lowering water levels.

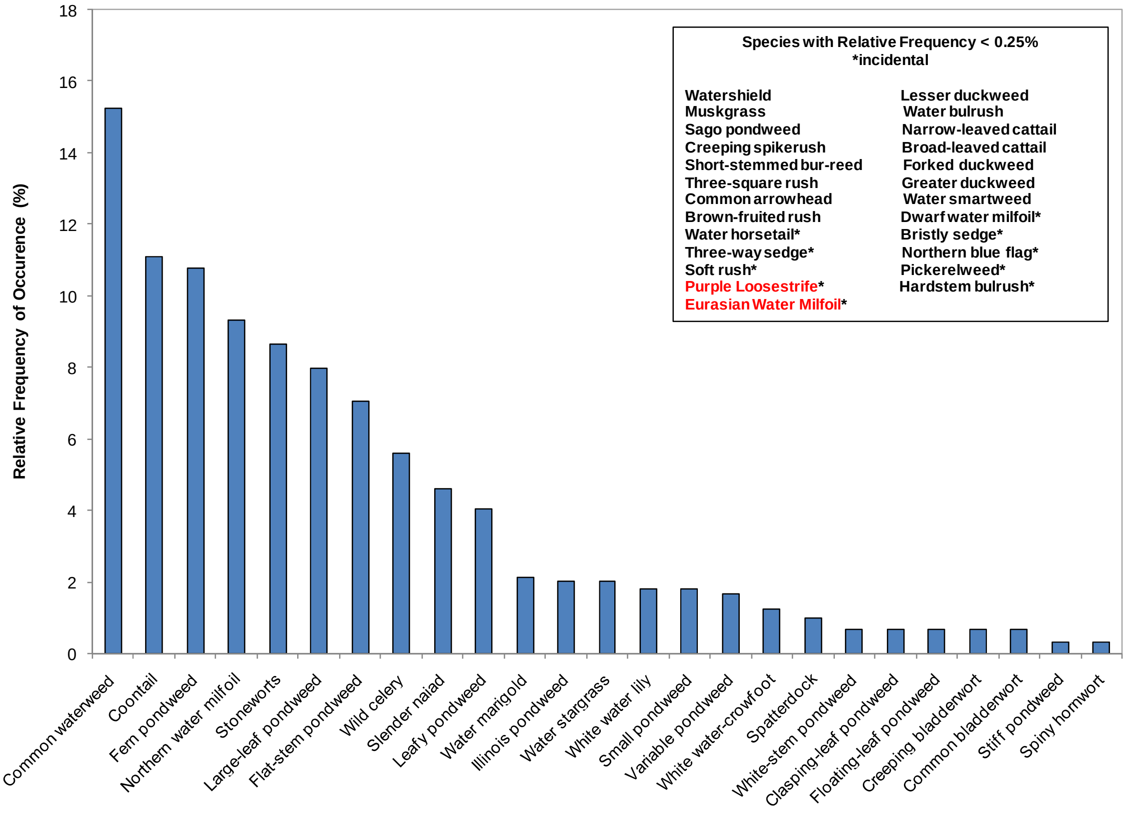

Figure 30. Buskey Bay aquatic plant occurrence analysis of 2007 survey data. Collected by Onterra.

Purple loosestrife is also known to exist within Buskey Bay, particularly along the northern shoreline near the tributary coming from Pike Lake (Map 4).

Spiny hornwort (prickly hornwort), a species of special concern in Wisconsin was located in Buskey Bay. Although this species is secure globally, it is rare or uncommon in Wisconsin, with less than 20 occurrences of this plant known state-wide (WDNR 2008).

Lake Millicent

Lake Millicent is a 183-acre lake with a maximum depth of 53 feet and mean depth of 26 feet. Lake Millicent flows into Hart Lake which ultimately flows into the White River.

Much of Lake Millicent's littoral area is located on relatively steep slopes. However, the northern lobe of Lake Millicent is dominated by emergent and floating leaf species (Map 4). Leafy pondweed and stoneworts are the two most dominant plants within the lake and were typically found along the steep slopes (Figure 31). Slender naiad and variable pondweed, the third and sixth most abundant plants, respectively, were typically found on the sandy, near-shore areas of the lake. While Lake Millicent had the third most aquatic plants found within its boundaries (Figure 30), it had the third lowest diversity (Simpson's 1-D) because it was dominated by six species (Figure 28). Lake Millicent, because of its high species richness and average conservatism values, contains the highest floristic quality within the Chain (Figure 29).

Pioneering infestations of Eurasian water milfoil were first discovered in Lake Millicent in 2008 (Map 7). Like Buskey Bay, a few occurrences of purple loosestrife were documented along the northern margins of Lake Millicent (Map 4).

Oakes pondweed was indentified from Lake Millicent. Although this species is not listed as threatened or endangered in Wisconsin, it is highly uncommon and is given the highest coefficient of conservatism rank (10) as it is indicative of pristine conditions. Also important to note, water bulrush and creeping bladderwort were located in the northeastern bay of Lake Millicent. These plants are fairly uncommon and contribute to the complexity of the plant community of the Pike Chain.

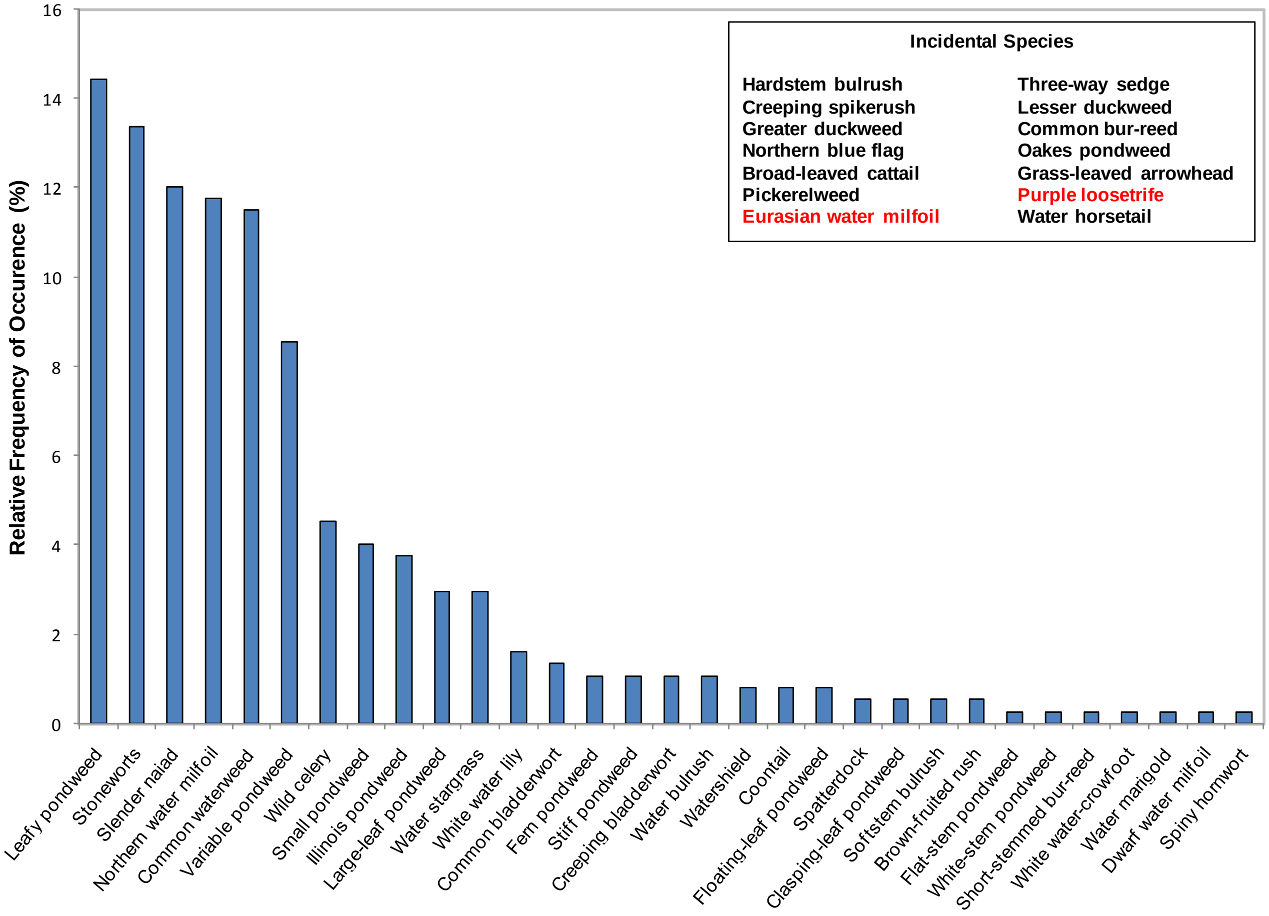

Figure 31. Lake Millicent aquatic plant occurrence analysis of 2007 survey data. Collected by Onterra.

Hart Lake

Hart Lake, the largest lake in the Pike Chain, is a 259-acre lake with a maximum depth of 54 feet and mean depth of 25 feet. Hart Lake flows into Twin Bear Lake which ultimately flows into the White River.

Similar to Lake Millicent, much of the east shore of Hart Lake is characterized by steep shorelines. However Hart Lake does contain a few bays that support developed floating leaf and emergent plant communities including the tributary from McCarry Lake and the channel that leads to Twin Bear Lake (Map 4).

Hart Lake contains the lowest plant diversity in the Chain (Figure 28), largely because four species (stoneworts, slender naiad, muskgrasses, and common waterweed) account for over 65% of the relative frequency within the lake (Figure 32). Of these four species, two are non-rooted macro-algae (stoneworts and muskgrasses), and elodea largely acts as a non-rooted plant. Due to their lack of developed root structures, the locations of these plants are largely influenced by water movement and their tendency to become entangled in plants, rocks, or debris.

Eurasian water milfoil was first detected in Hart Lake in 2004. During the 2005 point-intercept survey completed by the WDNR, no occurrences of EWM were located within the sample locations, but were noted from casual observations (Map 6). Management actions, including herbicide applications and manual removal, have taken place on Hart Lake and are detailed in the Invasive Species Section.

The WDNR located curly-leaf pondweed from one sample location during the 2005 point-intercept survey in Hart Lake (Map 6). In 2007 and in 2008, chain-wide surveys were completed that specifically searched for this species during its peak growth stage (peak biomass). Curly-leaf pondweed was not located at the point-intercept location it was identified from or anywhere else on the Chain. It is concluded that curly-leaf pondweed is most likely not present in the system and if it is present, it is at an undetectable level. Functioning as an annual plant, this plant most likely was not able to produce enough reproductive structures (turions) to successfully establish a population.

Spiny hornwort, a species of special concern in Wisconsin, and Oakes pondweed were located in Hart Lake.

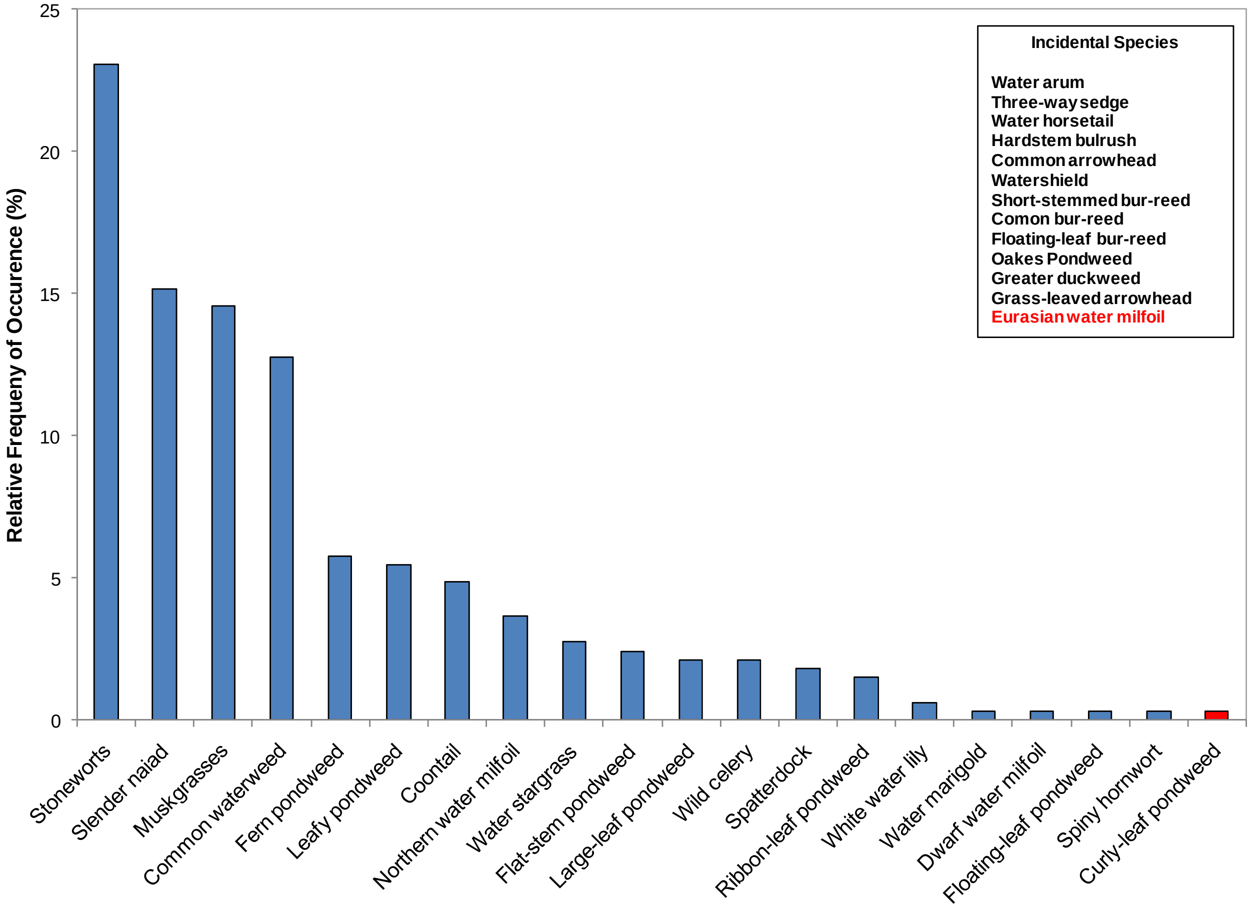

Figure 32. Hart Lake aquatic plant occurrence analysis of 2005 survey data. Collected by WDNR research and incidentals collected by Onterra, 2007..

Although the channel that leads to Twin Bear is considered part of Hart Lake (by WDNR definition), it contains unique characteristics that deserve specific attention. All point-intercept sample locations within the channel were sampled using a rake and therefore an examination of sediment type can be made. Approximately 80% of the sample locations observed a mucky (organic) substrate. Fern pondweed does well in these conditions and is the dominant plant within the channel (Figure 33). Almost the entire shoreline margins of the channel contain complex emergent and floating leaf communities (Map 5), providing valuable habitat for fish, birds, turtles, and amphibians.

The channel contains 24 species with an average conservatism value of 6.0. Although much of the channel is slow-no-wake, it receives considerable boat traffic and may be a reason that the plant species present are indicative of a disturbed system. Eurasian water milfoil is also located within the channel (Map 7) and has been targeted by numerous herbicide applications (Maps 6, 7, and 8).

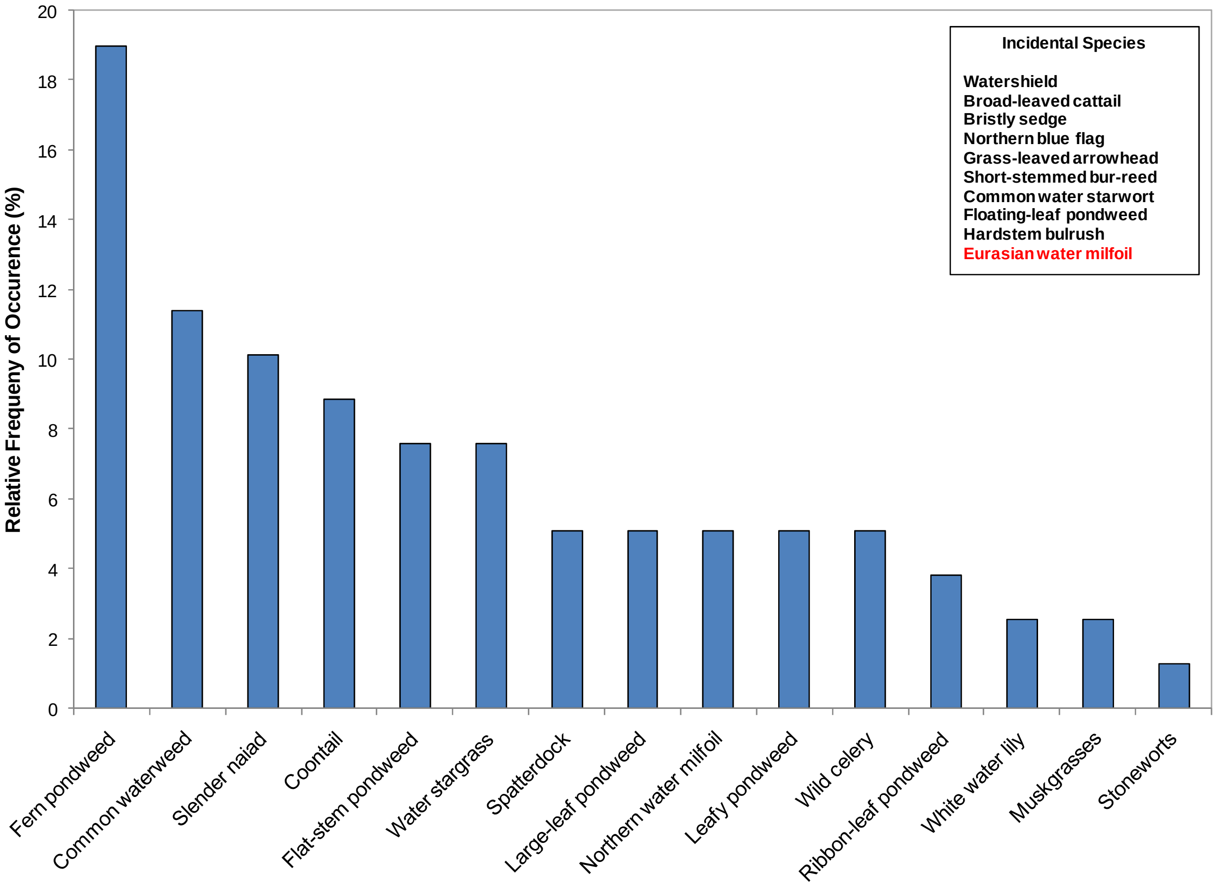

Figure 33. Hart Lake channel aquatic plant occurrence analysis of 2005 survey data. Collected by WDNR research and incidentals collected by Onterra, 2007.

Twin Bear Lake

Twin Bear Lake, the deepest of the Pike Chain, is a 172-acre lake with a maximum depth of 59 feet and mean depth of 23 feet. Twin Bear Lake flows into Eagle Lake which ultimately flows into the White River. A county campground is located on the northeast shore of Twin Bear Lake, near the channel entering from Hart Lake.

Twin Bear contains the lowest number of aquatic plant species of the Pike Chain. Also, the plants that are found within the system contain average conservatism values lower than both the state and ecoregion median (Figure 29). Although this lake arguably has the most human development along its shorelines (especially the western shore) and contains a high-use public boat landing and campground, the cause of its depauperate plant community may not be entirely a symptom of these factors. This lake is largely comprised of sand sediments and this reason may have made it more vulnerable to the effects of rusty crayfish. Anecdotal, but reliable accounts of the rusty crayfish infestation report an almost total removal of plant biomass within this lake (and Hart Lake) during the previous decade. In recent years, the population of rusty crayfish has declined and the plant population has begun to recover. However, species with higher coefficients of conservatism will likely need more time to establish their presence again. Source populations of these species exist within the Chain and reestablishment will likely occur.

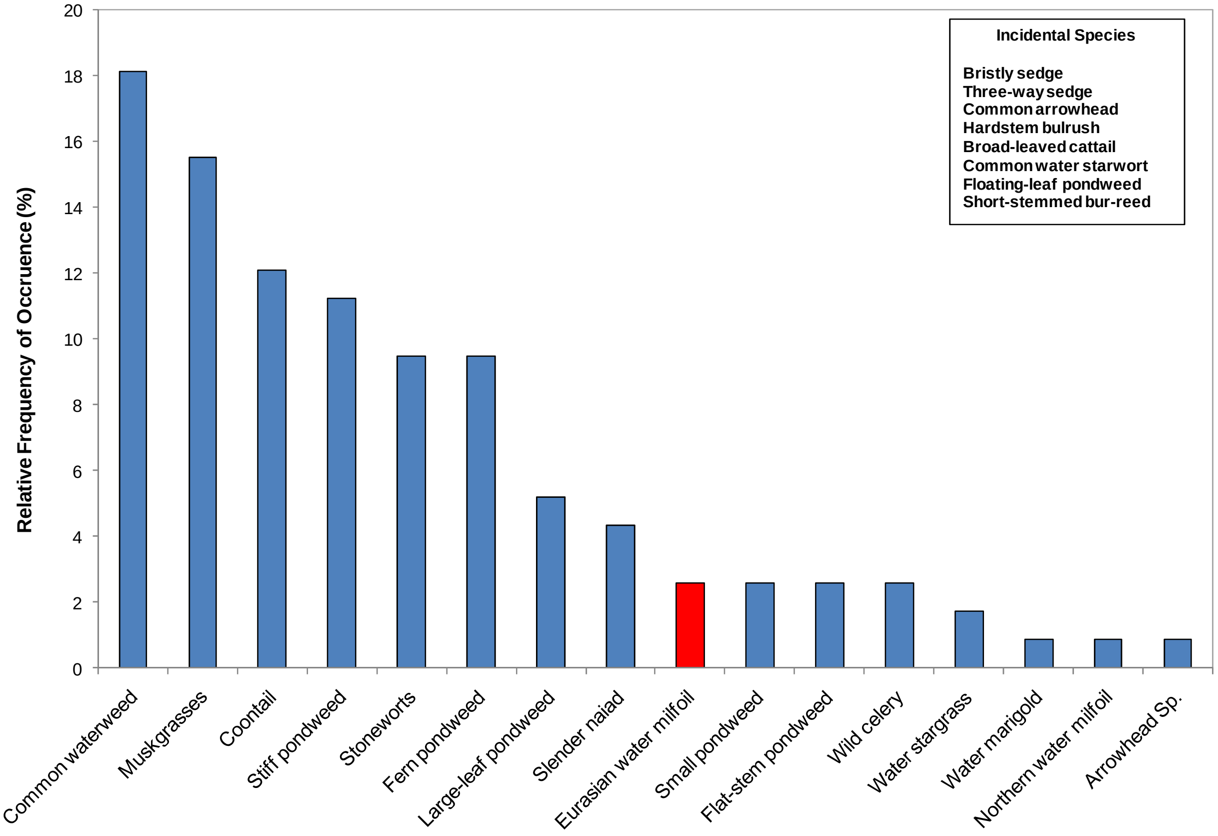

Figure 34. Twin Bear Lake aquatic plant occurrence analysis of 2005 survey data. Collected by WDNR research and incidentals collected by Onterra, 2007.

Possibly because of the disturbances within the system, like Hart Lake, Twin Bear Lake has established populations of Eurasian water milfoil. At this time, navigational or recreational activities are not hindered by Eurasian water milfoil, but it is likely having an effect on the ecology of the system. In 2005, Eurasian water milfoil was the ninth most abundant plant within the lake (Figure 34).

Eagle Lake

Eagle Lake is a 170-acre lake with a maximum depth of 52 feet and mean depth of 14 feet. Eagle Lake flows into Flynn Lake which ultimately flows into the White River. Although winter access to the lake is provided by a snowmobile trail coming from a private resort, open water access is limited to boats that can navigate under the County Highway H Bridge that separates Eagle Lake from Twin Bear.

Large portions of Eagle Lake's shoreline contain floating leaf and emergent plant communities (Map 5). The northern part of this lake that leads from Twin Bear Lake is a slow-no-wake channel lined with wetland communities of leather leaf and other bog-type species. These areas are valuable habitat for many forms of fauna.

Eagle Lake contains the second most aquatic plant species (Figure 29) and the second highest diversity within the Chain (Figure 28). While fern pondweed, common water weed, and variable pondweed are the most abundant plants within the system (Figure 35), they are not overly dominant, giving the lake an exceptionally high diversity metric. Eagle Lake also contains a high richness in *small pondweeds* (leafy pondweed, stiff pondweed, small pondweed, and spiral-fruited pondweed), which provide valuable habitat for many invertebrate species that support the system's fishery.

A pioneer infestation of Eurasian water milfoil has been detected in the northern channel of Eagle Lake (Map 7). Manual removal techniques have been applied in this area but may require a more aggressive management approach in the future. Common reed (giant reed) was located in one location on the Eagle Lake (Map 5), which was the only location on the Pike Chain of Lakes where common reed was found. While contention exists in the scientific community on whether all *strains* of common reed should be considered exotic and invasive, it is important to monitor this plant's population to understand if it is threatening the Pike Chain of Lakes important emergent plant communities.

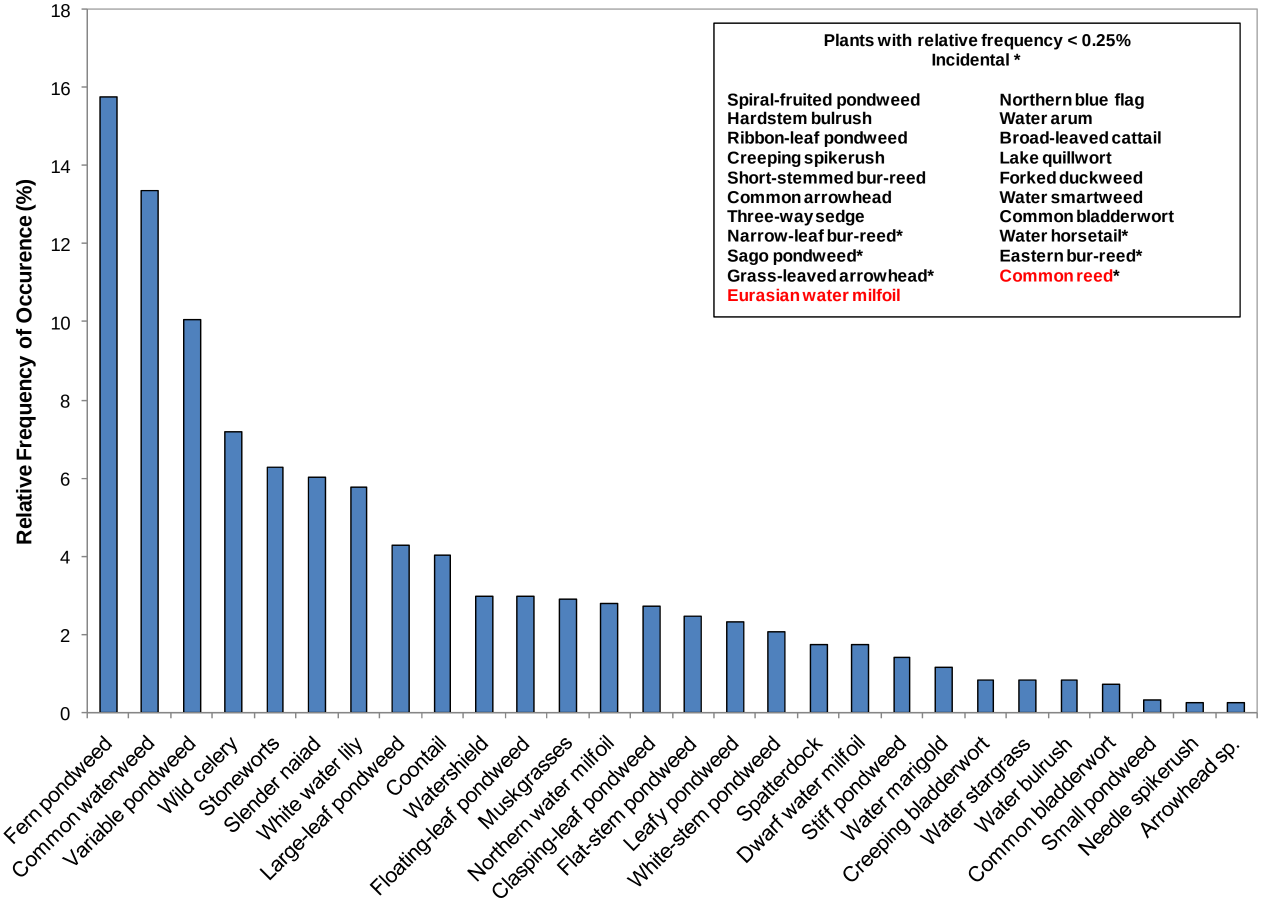

Figure 35. Eagle Lake aquatic plant occurrence analysis of 2007 survey data. Collected by Onterra.

Flynn Lake

Flynn Lake, the smallest of the Pike Chain, is a 29-acre lake with a maximum depth of 9 feet and mean depth of 5 feet. All other lakes in the Pike Chain flow into Flynn Lake which ultimately flows into the White River. Access to Flynn Lake is through Eagle Lake. A small dam exists on Flynn Lake which artificially raises the water level of the entire chain.

Because the plant species within Flynn Lake are fairly evenly distributed (Figure 36), this lake contains the most diverse plant community within the Chain (Figure 28). Due to its shallow nature, almost the entire floor of Flynn Lake is populated with aquatic plants. While these plants are important to the ecological function of the Pike Chain, they do have the capacity to impair navigation and recreational activities of lakeshore landowners. When chain users were asked how often aquatic plant growth negatively impacted their enjoyment of the system, slightly over 12% reported that it did more than *sometimes* (Appendix B, Question 19). This figure more than doubled (25%) when only Flynn Lake riparians were considered (Question 2).

Spiny hornwort, Oakes pondweed, water bulrush, and creeping bladderwort, all discussed previously in terms of their importance, were located in Flynn Lake. Whorled water milfoil was located near the outlet of Flynn Lake, marking its only occurrence within the Chain (Table 3).

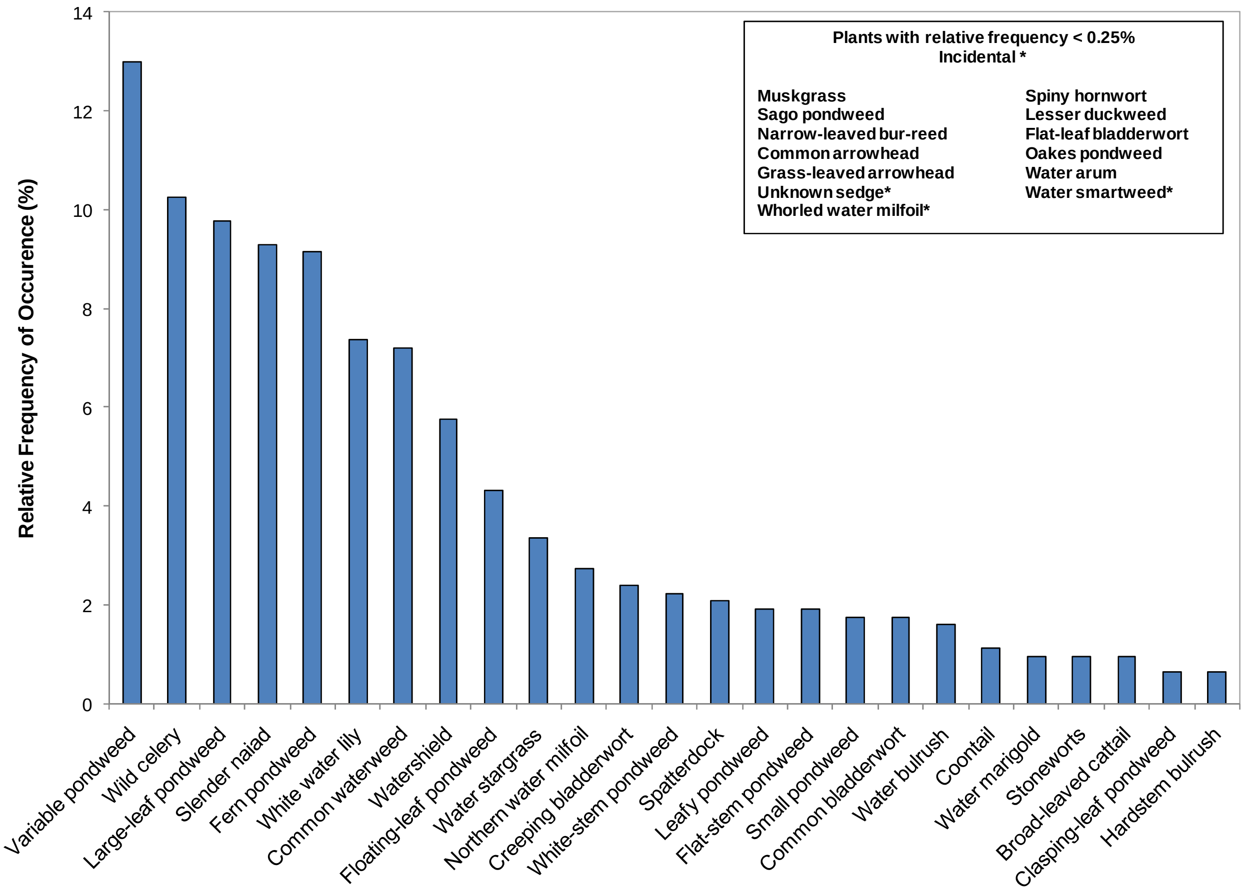

Figure 36. Flynn Lake aquatic plant occurrence analysis of 2005 survey data. Collected by WDNR research and incidentals collected by Onterra, 2007.

Non-native Aquatic Plants

At the start of the project, the IRALA was primarily concerned with the threats of exotic species to their chain. During the 1990's plant populations were decimated in Twin Bear and Hart Lakes by rusty crayfish. During 2004, Eurasian water milfoil was discovered in the channel between Twin Bear and Hart Lake and was verified by the WDNR later that summer. The following summer, WDNR research conducted point-intercept surveys on Twin Bear and Hart Lake locating Eurasian water milfoil in both lakes and a single plant in Eagle Lake. Curly-leaf pondweed was also located in one sample location on Hart Lake during this survey. Purple loosestrife was first observed in July of 2005 along the northeast bay of Lake Millicent. The previous section discussed exotic species as they pertain to each of the lakes. The following text outlines each exotic species in terms of their affect on the Pike Chain of Lakes ecosystem.

Curly-leaf Pondweed

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 almost immediately following ice-out, giving the plant a significant jump on native vegetation. 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.

A meander survey was completed the week of July 11, 2007 in search of this invasive plant. No curly-leaf pondweed was observed during this study. The survey was repeated the week of June 23, 2008 to ensure that the plant had not escaped detection in 2007 because of the survey timing. As stated earlier, it is concluded that curly-leaf pondweed is most likely not present in the system and if it is present, it is at an undetectable level.

Eurasian water milfoil

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 37). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads mostly by shoot fragmentation, which has supported its transport between lakes via boats and other aquatic 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.

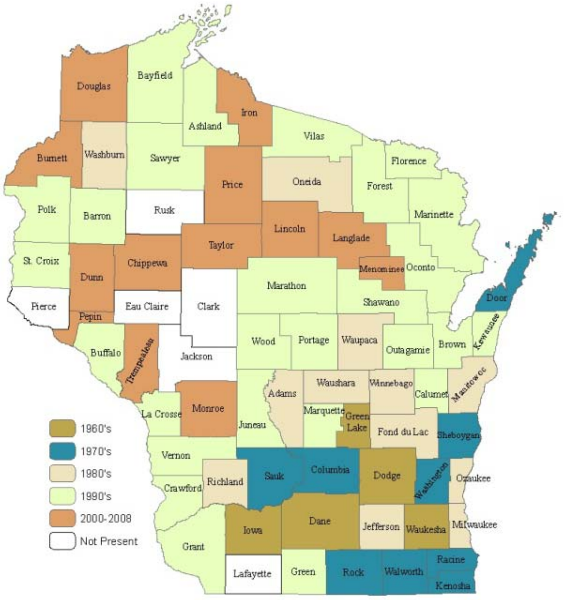

Figure 37. Spread of Eurasian water milfoil within WI counties. WDNR Data 2008 mapped by Onterra.

In response to discovering Eurasian water milfoil in the channel between Twin Bear and Hart Lake in August 2004, the Town of Delta sponsored an Aquatic Invasive Species (AIS) Grant to cover costs associated with boat inspections at the Twin Bear and Lake Delta boat landings starting in 2005. With the help of the WDNR and Bayfield County, an AIS Rapid Response Grant was awarded to fund a 6-acre treatment in the Hart Lake channel and small sections of Twin Bear and Hart Lake in June 2005 (Figure 38). A second herbicide treatment, funded by the IRALA, was conducted in June 2006 of approximately 8-10 acres targeting small colonies along the northwest shore of Twin Bear and colonies in Hart Lake including the Hart Lake Channel (Figure 38).

In February 2007, the IRALA partnered with Onterra to complete seven grant applications in hopes of receiving partial funding for the development of a lake management plan for the Pike Chain of Lakes. In April 2007, the Iron River Area Lakes Association was notified that they were successful and would receive over $49,000 in funds.

Onterra ecologists visited the lake in May with Jane Swenson who was coordinating the upcoming herbicide treatment. Onterra ecologists were able to gain an understanding of the Eurasian water milfoil in the system before it was affected by the treatment. In June 2007, approximately 27 acres were treated on Twin Bear and Hart Lakes, including the Hart Lake channel (Map 6). At this time, the bay that contained one curly-leaf pondweed finding from the 2005 WDNR point-intercept survey was also visited in a failed attempt to locate this exotic (Map 6).

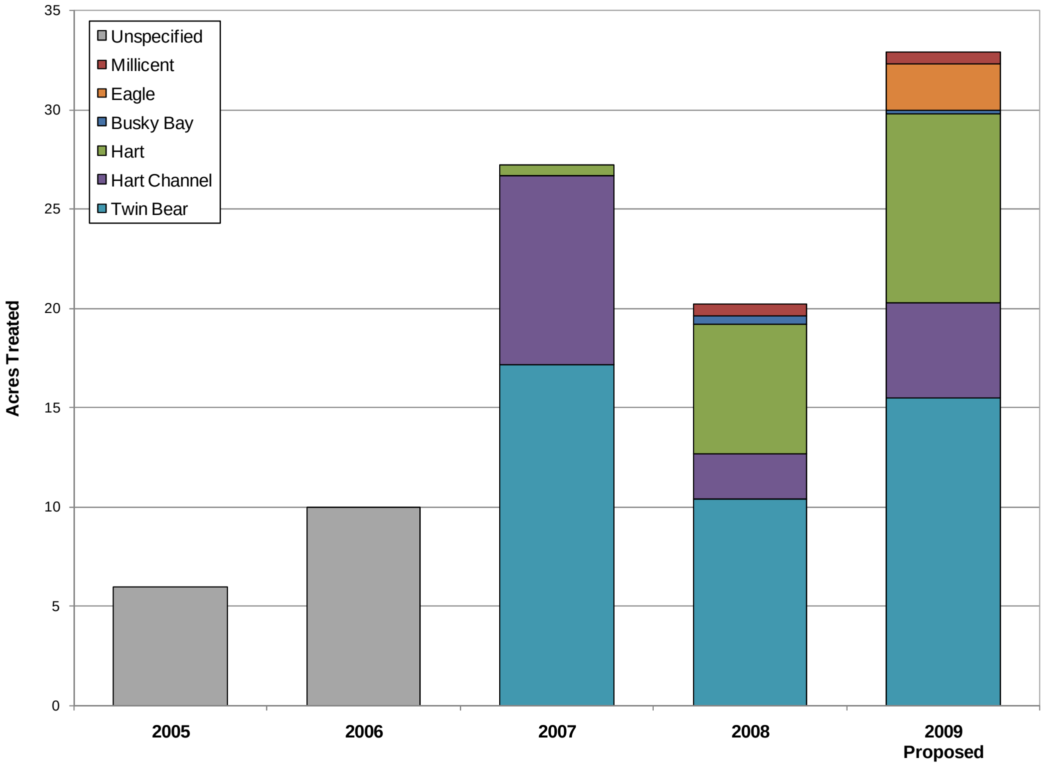

Figure 38. Acres of Eurasian water milfoil treated on the Pike Chain of Lakes. Hart Lake, Twin Bear Lake, and the Hart Lake Channel were treated in 2005 and 2006, but specific acreages were not available.

Eurasian water milfoil locations were mapped during the July 2007 curly-leaf pondweed survey, the August 2008 comprehensive plant survey, and the June 2008 curly-leaf pondweed survey (Map 7). Based on the results of the 2007 surveys, 8.2 acres were recommended for treatment. However, after visiting the system previous to the treatment in June 2008, an additional 12.2 acres were recommended for treatment which consisted of expansions of known colonies and some new findings, particularly in Buskey Bay and Lake Millicent (Map 7).

Determining the success or failure of chemical treatments on Eurasian water milfoil is often a difficult task because the criteria used in determining success or failure is ambiguous. Most people involved with Eurasian water milfoil management, whether professionals or laypersons, understand that the eradication of an established Eurasian water milfoil population from a lake, or even a specific area of a lake, is nearly, if not totally, impossible. Most understand that achieving control of these types of colonies is the best criteria for success. Early detection of pioneer infestations of Eurasian water milfoil offers the highest probability of eradication and therefore these areas are usually targeted more aggressively with different expectations of success. The scope of the current project was not intended to monitor the success or failure of the treatments, but to create a management strategy that addresses the Eurasian water milfoil within the lake. This management strategy is outlined within the implementation plan section of this document. Jane Swenson and the herbicide applicator, Dale Dressel of Northern Aquatic Services, believe that the 2008 treatments were effective at reducing the density of the Eurasian water milfoil within the treatment areas, but plants continue to persist in many of them.

Utilizing data collected during the field surveys of 2007 and 2008 along with subsequent conversations with IRALA members, Jane Swenson, and applicator, Dale Dressel, a proposed treatment strategy of approximately 35 acres for 2009 was created (Map 8, Figure 38). This treatment strategy is elaborated on within the implementation plan.

In addition to using herbicide to control Eurasian water milfoil colonies, manual removal using volunteer snorkelers and divers has and will continue to occur on the Chain. Because of the excellent water clarity within the system, volunteers can effectively harvest small colonies and isolated Eurasian water milfoil plants. However, areas with many natives and hard sediments make hand removal difficult and the limited volunteer resources should not be wasted on them. Herbicide application becomes more efficient and effective for these situations.

In 2008, volunteers focused on the east shore of Twin Bear Lake, the northern part of Eagle Lake, the east/northeast shore of Hart Lake, around Bear Island in Hart Lake, and the isolated pioneer infestations in Buskey Bay and Lake Millicent. The hand removal expeditions were aimed at removing plants that persist within treatment areas and isolated and new occurrences throughout the Chain.

Although not just applicable to Eurasian water milfoil management, Clean Boats Clean Waters boat landing inspections have become an important aspect of invasive species management on the Chain. The IRALA took on the responsibility from the Town of Delta in 2006 for funding the boat landing inspection program. Starting in 2007 and continuing to the present, the boat landing monitoring program has been funded by Bayfield County and has been coordinated with the help of the county's Aquatic Invasive Species Coordinator. Continued monitoring of the boat landings will promote education and awareness as well as potentially stopping new infestations of aquatic invasive species to the Pike Chain.

Purple Loosestrife

Purple loosestrife (*Lythrum salicaria*) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930's, it has now spread to 70 of the state's 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments. The following text was written with the help of Jane Swenson.

After infestations in Lake Millicent and Buskey Bay were located in 2005, Miles Falk, Wildlife Biologist/Director of Great Lakes Indian & Wildlife Commission (GLIFWC) was contacted and a management strategy was devised involving removing the plant's seed heads and applying an herbicide application of Rodeo. After notifying the IRALA Board of the management strategy, Jane. Swenson contacted the residents in the treatment area and explained the procedure, provided education materials, and received written permission from those within the vicinity. The first herbicide treatment on purple loosestrife within the Chain was completed in September 2005.

In 2006, Jane Swenson trained residents on how to remove purple loosestrife seed heads and advised them to mark the plants with surveyor ribbon to simplify the treatment for the GLIFWC field crew. In mid September 2006, the plants identified by IRALA members were treated by GLIFWC.

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. In 2006, Jane Swenson accompanied GLIFWC staff to collect over 2,500 *Galerucella* spp. beetles from an established population in Bayfield County and distributed them to purple loosestrife infested areas on Buskey Bay and Lake Millicent.

In 2007, volunteers continued to mark purple loosestrife locations for GLIFWC to treat with herbicide. Beetle populations were monitored and appear to be establishing their presence in the area. Due to time and budget constraints, no beetles were released in 2008 and no herbicide applications were conducted.

Common Reed

Common (giant) reed (*Phragmites australis*) is also an invasive species that has the ability to take over wetland ecosystems. It is believed that populations of common reed existed in pre-colonial Wisconsin, but exotic strains from Europe have been introduced and have invaded the genetic line of the native strain. Genetic identification of the plant is needed to determine whether the plant is a native or non-native strain, however the majority of this plants occurrences are exotic.

One small population of common reed was identified on Eagle Lake (Map 5). A pressed specimen of this species was sent to Dr. Robert Freckman at University of Wisconsin – Steven's Point where morphologically it appeared to be a native strain. However, it is recommended that this population be monitored for expansion. If it appears that the plant is spreading, the regional WDNR Lake Specialist should be contacted to coordinate sending in plant specimens for genetic testing. If the common reed is determined to be an exotic strain, it should be removed by cutting and bagging the seed heads and applying herbicide to the cut ends. This management strategy is most effective when completed in late summer or early fall when the plant is actively storing sugars and carbohydrates in its root system in preparation for over-wintering. If this or other populations expand greatly, a management action would need to be developed to coordinate its control.

Pike Chain of 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 2007 & GLIFWC 2007). A summary report is provided in Appendix F, written by Scott Toshner, Wisconsin Department of Natural Resources Northern Region Fisheries Biologist.

Table 4 shows the popular game fish and Table 5 shows the non-game fish that are present in the system.

Table 4. Gamefish present in the Pike Chain of Lakes with corresponding biological information (Becker, 1983).

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1cm-1m deep	Crustaceans, insect larvae, and other inverts
Black Bullhead	*Ictalurus melas*	5	April - June	Matted vegetation, woody debris, overhangin banks	Amphipods, insect larvae and adults, fish, detritus, algae
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pikes, crayfish,small mammals, water fowl, frogs
Muskellunge	*Esox masquinongy*	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Green Sunfish	*Lepomis cyanellus*	7	Late May - Early August	Shelter with rocks, logs, and clumps of vegetation, 4-35cm	Zooplankton, insects, young green sunfish and other small fish
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3-0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (ter. and aq.)
Warmouth	*Lepomis gulosus*	13	Mid May - Early July	Shallow water 0.6-0.8 m, with rubble slightly covered with silt	Crayfish, small fish, odonata, and other invertebrates
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Smallmouth Bass	*Micropterus dolomieu*	13	Mid May - June	Nests more common on North and West shorelines, over gravel	Small fish including other bass, crayfish, insects (aq. and ter)
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates

Table 4. con't

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Yellow Perch	*Perca flavescens*	13	April - Early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other inverts
Walleye	*Sander vitreus*	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	fish, fly and other insect larvae, crayfish

Table 5. Non-gamefish present in the Pike Chain of Lakes with corresponding biological information (Becker, 1983).

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Blackchin Shiner	*Notropis heterodon*	3	June - August	Sand and Gravel	Aquatic invertebrate adults and larvae
Blacknose Shiner	*Notropis heterolepis*	1	June - August	Sand	Zooplankton, mollusks and crustaceans, some algae
Bluntnose Minnow	*Pimephales notatus*	3	May - August	Sand or Gravel Shoals	Diatoms, filamentous algae, aquatic invertebrates
Central Mudminnow	*Umbra limi*	4	March - April	Eggs deposited on leaves of plants	Insects, amphipods and other aquatic invertebrates
Common Shiner	*Notropis cornutus*	5	Late May - Late July	Gravel shoals of lakes	Plant matter and Aquatic Invertebrates
Creek Chub	*Semotilus atromaculatus*	5	May - July	Littoral areas of gravel	Fish, insects, vegetation
Emerald Shiner	*Notropis atherinoides*	5	Late May - Early August	Gravel shoals, rounded boulders, and sand	Terrestrial insects, algae, aquatic invertebrates
Golden Shiner	*Notemigonus crysoleucas*	5	May - August	Over areas of Submerged Vegetation	Aquatic Invertebrates
Iowa Darter	*Etheostoma exile*	4	Late April - Mid June	Along lake or stream shores with slow moving current	Amphipods, chironomids and other invertebrates
Spottail Shiner	*Notropis hudsonius*	4	Late May - Early June	Sandy shoals	Aquatic Invertebrates
Tadpole Madtom	*Noturus gyrinus*	3	June - July	Under objects or in cavities on the bottom	Aquatic invertebrates
White Sucker	*Catostomus commersoni*	8	April - Early May	Swift water or rapids, occasionally over gravel in lakes	Fish, fish eggs, plants, mollusks, insects, crustaceans and protazoans

Based on data collected from the stakeholder survey (Appendix B), fishing was the third highest ranked important or enjoyable activity on the Pike Chain. Over 75% of these same respondents believed that the quality of fishing on the Pike Chain was either fair or poor and approximately 92% believe that the quality of fishing has remained the same or gotten worse since they have obtained their property.

Management actions that have taken place and will likely continue on the Pike Chain according to this plan include herbicide applications to control EWM. In the future, these applications will occur in May when the water temperatures are below 60°F. It is important to understand the effect the chemical has on the spawning environment which would be to remove broad-leaf (dicot) submergent plants that are actively growing at these low water temperatures. Black bullhead and yellow perch are two species that could be affected by early season herbicide applications, as the treatments could eliminate nursery areas for the emerged fry of these species.

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 39). The Pike Chain falls within the ceded territory based on the Treaty of 1842. This allows for a regulated spear fishery by Native Americans on specified systems. The spear harvest is regulated by having the six Wisconsin Chippewa Tribes declare a tribal quota based on a percent of the estimated safe harvest each year by March 15. The tribal declaration will influence the daily bag limits for hook-and-line anglers, possibly reducing it to zero if 100% of the safe harvest is declared. The tribes have historically selected a percentage which allows for a 2-3 daily bag limit for hook-and-line anglers (USDI 2007).

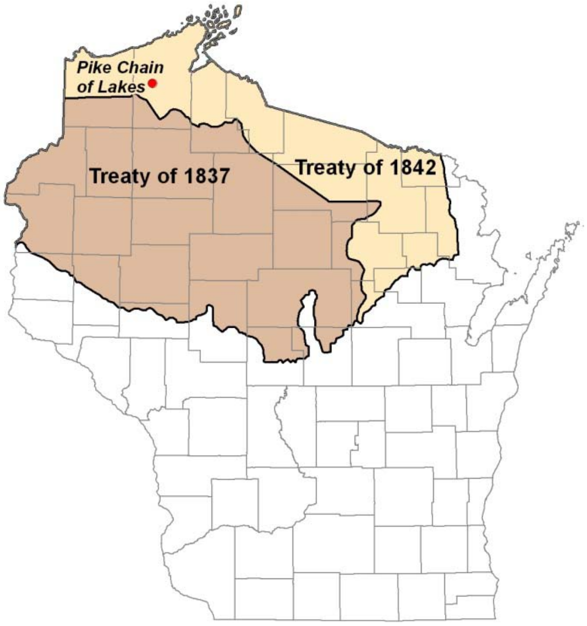

Figure 39. Location of the Pike Chain within the Native American Ceded Territory (GLIFWC 2007). This map was digitized by Onterra; therefore it is a representation and not legally binding.

The Red Cliff tribe exercises their rights to spear on the Pike Chain of Lakes. Spearers are able to harvest muskellunge, walleye, northern pike, and bass. Walleye harvest records are provided in Table 6. One common misconception noted from the stakeholder survey (Appendix B – Written Comments) is that the spear harvest targets the large spawning females. Although the data is redundant from Table 6, Figure 40 is used to clearly show that the opposite is true with only 7.9% of the total walleye harvest (2,196 fish) since 1998 comprising female fish on the Chain.

Table 6. Spear harvest data of walleye for the Pike Chain of Lakes (WDNR Northern Region, 1989-1997 & 2008 and GLIFWC annual reports for the Pike Chain, Krueger 1998-2007).

Year	Tribal Quota	Tribal Harvest	% Quota	Mean Length* (inches)	% Male*	% Female*	% Unknown*
1989	n/a	181	n/a	n/a	n/a	n/a	n/a
1990	n/a	249	n/a	n/a	n/a	n/a	n/a
1991	n/a	177	n/a	n/a	n/a	n/a	n/a
1992	n/a	247	n/a	n/a	n/a	n/a	n/a
1993	n/a	190	n/a	n/a	n/a	n/a	n/a
1994	n/a	230	n/a	n/a	n/a	n/a	n/a
1995	n/a	198	n/a	n/a	n/a	n/a	n/a
1996	n/a	226	n/a	n/a	n/a	n/a	n/a
1997	n/a	187	n/a	n/a	n/a	n/a	n/a
1998	255	253	99.2	14.3	84.2	2.8	13.0
1999	178	177	99.4	14.9	87.4	8.6	4.0
2000	256	256	100.0	14.6	98.0	2.0	0.0
2001	186	186	100.0	14.9	83.0	8.8	8.2
2002	402	402	100.0	14.6	97.2	2.6	0.3
2003	269	267	99.3	15.6	87.6	11.5	1.0
2004	264	264	100.0	15.2	78.8	7.3	13.9
2005	175	175	100.0	16	87.4	10.3	2.3
2006	250	250	100.0	16.1	79.6	18.4	2.0
2007	178	178	100.0	16.2	82.0	12.9	5.1
2008	n/a	250	n/a	n/a	n/a	n/a	n/a

*Based on Measured Fish

In 2001 one unidentified bass species, measuring 18.5 inches, was harvested. In 2003 one largemouth bass that was 15.1 inches and one smallmouth bass that was 11.1 inches were harvested. Table 7 shows muskellunge statistics of fish harvested since 1998. Muskellunge have been actively stocked in recent years by the WDNR (Table 8) in an effort to influence the populations of these species. The minimum length limit on muskellunge is 40 inches.

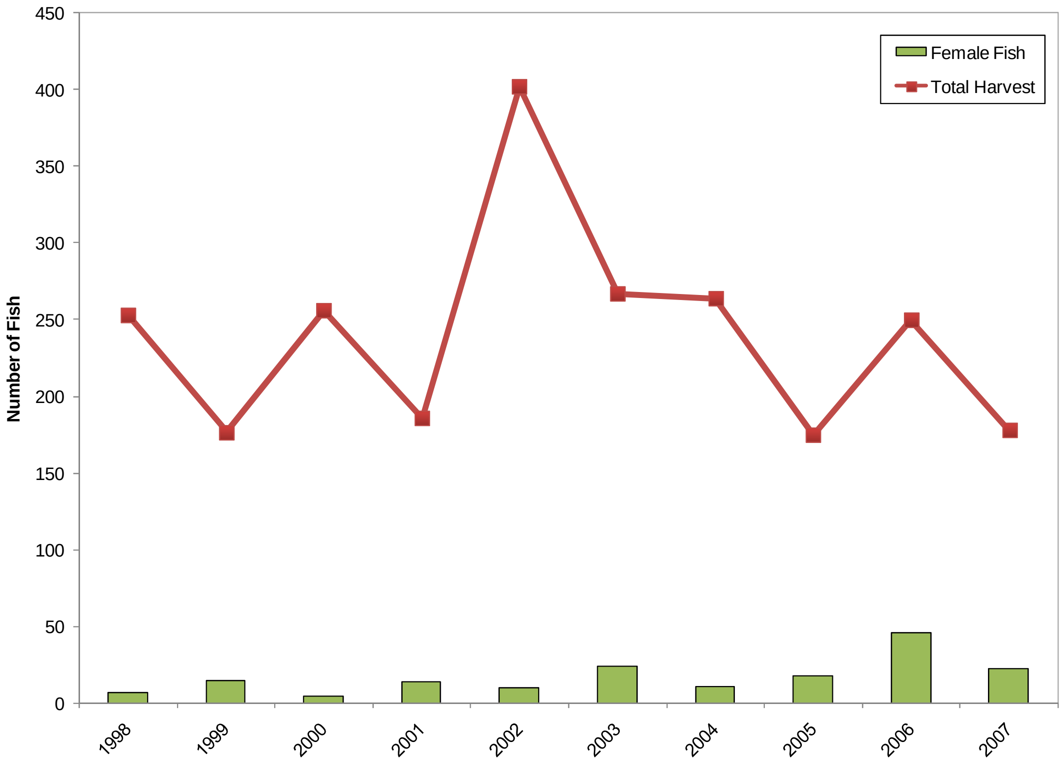

Figure 40. Walleye spear harvest data. Annual total walleye harvest and female walleye harvest are displayed since 1998 from GLIFWC annual reports for the Pike Chain (Krueger 1998-2007).

Table 7. Spear harvest data of muskellunge for the Pike Chain of Lakes (WDNR Northern Region, 1990-1993 and GLIFWC annual reports for the Pike Chain, Krueger 1998-2007).

Year	Tribal Quota	Tribal Harvest	% Quota	Mean Length* (inches)
1990	n/a	2	n/a	n/a
1991	n/a	5	n/a	n/a
1992	n/a	4	n/a	n/a
1993	n/a	1	n/a	n/a
1998	11	0	0.0	n/a
1999	12	0	0.0	n/a
2000	10	0	0.0	n/a
2001	10	1	10.0	n/a
2002	10	0	0.0	n/a
2003	11	1	9.1	25.7
2004	11	3	27.3	37.5
2005	11	1	9.1	29.9
2006	12	2	16.7	33.3
2007	12	0	0.0	n/a

*Based on Measured Fish

Table 8. Fish stocking data available from the WDNR from 1972 to 2006 (WDNR 2007).

Year	Waterbody	Species	# Stocked	Age Class	Ave Length (inches)
1972	Eagle	Walleye	4,300	Fingerling	4.0
1972	Millicent	Walleye	3,560	Fingerling	3.0
1973	Eagle	Walleye	8,034	Fingerling	3.0
1974	Eagle	Walleye	8,030	Fingerling	3.0
1975	Eagle	Walleye	8,030	Fingerling	3.0
1976	Eagle	Walleye	8,125	Fingerling	3.0
1976	Twin Bear	Muskellunge	300	Fingerling	13.0
1976	Hart	Muskellunge	500	Fingerling	13.0
1977	Eagle	Walleye	16,018	Fingerling	4.0
1977	Twin Bear	Muskellunge	160	Fingerling	13.0
1977	Hart	Muskellunge	250	Fingerling	13.0
1977	Hart	Walleye	768,000	Fry	n/a
1978	Eagle	Walleye	6,032	Fingerling	3.0
1978	Twin Bear	Muskellunge	100	Fingerling	11.0
1978	Hart	Muskellunge	125	Fingerling	11.0
1978	Hart	Walleye	128,000	Fry	n/a
1979	Twin Bear	Muskellunge	206	Fingerling	12.0
1979	Hart	Muskellunge	480	Fingerling	12.0
1980	Twin Bear	Muskellunge	160	Fingerling	7.0
1980	Hart	Muskellunge	250	Fingerling	7.0
1983	Twin Bear	Muskellunge	160	Fingerling	9.0
1983	Hart	Muskellunge	250	Fingerling	9.0
1984	Twin Bear	Muskellunge	160	Fingerling	9.0
1984	Hart	Muskellunge	250	Fingerling	9.0
1985	Twin Bear	Muskellunge	380	Fingerling	11.0
1985	Hart	Muskellunge	560	Fingerling	11.0
1986	Twin Bear	Muskellunge	180	Fingerling	9.0
1986	Hart	Muskellunge	260	Fingerling	9.0
1987	Twin Bear	Muskellunge	540	Fingerling	9.0
1987	Hart	Muskellunge	780	Fingerling	9.0
1988	Twin Bear	Muskellunge	180	Fingerling	9.0
1988	Hart	Muskellunge	260	Fingerling	9.0
1989	Twin Bear	Muskellunge	180	Fingerling	11.0
1989	Hart	Muskellunge	260	Fingerling	11.0
1990	Twin Bear	Muskellunge	100	Fingerling	13.0
1990	Hart	Muskellunge	130	Fingerling	13.0
1991	Twin Bear	Muskellunge	200	Fingerling	11.0
1991	Hart	Muskellunge	260	Fingerling	11.0
1992	Twin Bear	Muskellunge	200	Fingerling	10.0

Table 8. con't

Year	Waterbody	Species	# Stocked	Age Class	Ave Length (inches)
1992	Hart	Muskellunge	260	Fingerling	10.0
1993	Twin Bear	Muskellunge	400	Fingerling	10.0
1993	Hart	Muskellunge	520	Fingerling	10.0
1996	Twin Bear	Muskellunge	250	Fingerling	11.6
1996	Hart	Muskellunge	300	Fingerling	11.6
1997	Twin Bear	Muskellunge	125	Large Fingerling	12.1
1997	Hart	Muskellunge	150	Large Fingerling	12.1
2000	Twin Bear	Muskellunge	250	Large Fingerling	12.7
2000	Hart	Muskellunge	300	Large Fingerling	12.1
2002	Pike Chain	Muskellunge	944	Large Fingerling	10.70
2004	Pike Chain	Muskellunge	945	Large Fingerling	11.10
2006	Pike Chain	Muskellunge	520	Large Fingerling	11.40

Walleye is prized game fish in northern Wisconsin and can be found in the Pike Chain. As stated above, the Pike Chain is located within ceded territory and special fisheries regulations occur, specifically in terms of walleye. An adjusted walleye bag limit pamphlet is distributed each year by the WDNR which explains the more restrictive bag or length limits that may pertain to the Pike Chain. On the Pike Chain, there is no minimum length limit on walleye, but only one fish over 14 inches is allowed. Motor trolling is permitted on the Pike Chain.

Bluegill and other panfish are also popular amongst anglers on the Pike Chain. Growth studies of Eagle Lake bluegills show that size is below the Wisconsin Northern Region (NOR) average, but not out of line with other NOR lakes (Figure 41). Factors that can affect bluegill growth include trophic status, bluegill abundance, habitat quality and quantity, and angling pressure. Scott Toshner, WDNR Fisheries Biologist, states that management tools such as a reduced bag limit (10 per day) and/or closing the fishing season during spawning may help increase growth rates.

While comparing WDNR fish surveys from the 1960s to 2001, the limited data suggests that yellow perch abundances have changed very little (Toshner, personal comm.). However, resident angler observations believe that yellow perch populations have *collapsed* in recent years as a result of intensive winter fishing pressure, mostly focused on Eagle Lake.

Resident anglers also believe smallmouth bass abundances have decreased in recent years as a response to increased fishing pressure. Again with limited data from WDNR fisher surveys, smallmouth bass populations have increased in the past 4 decades. However, harvest data has declined since 1986 and has remained stable since 1991 (Toshner, personal comm.).

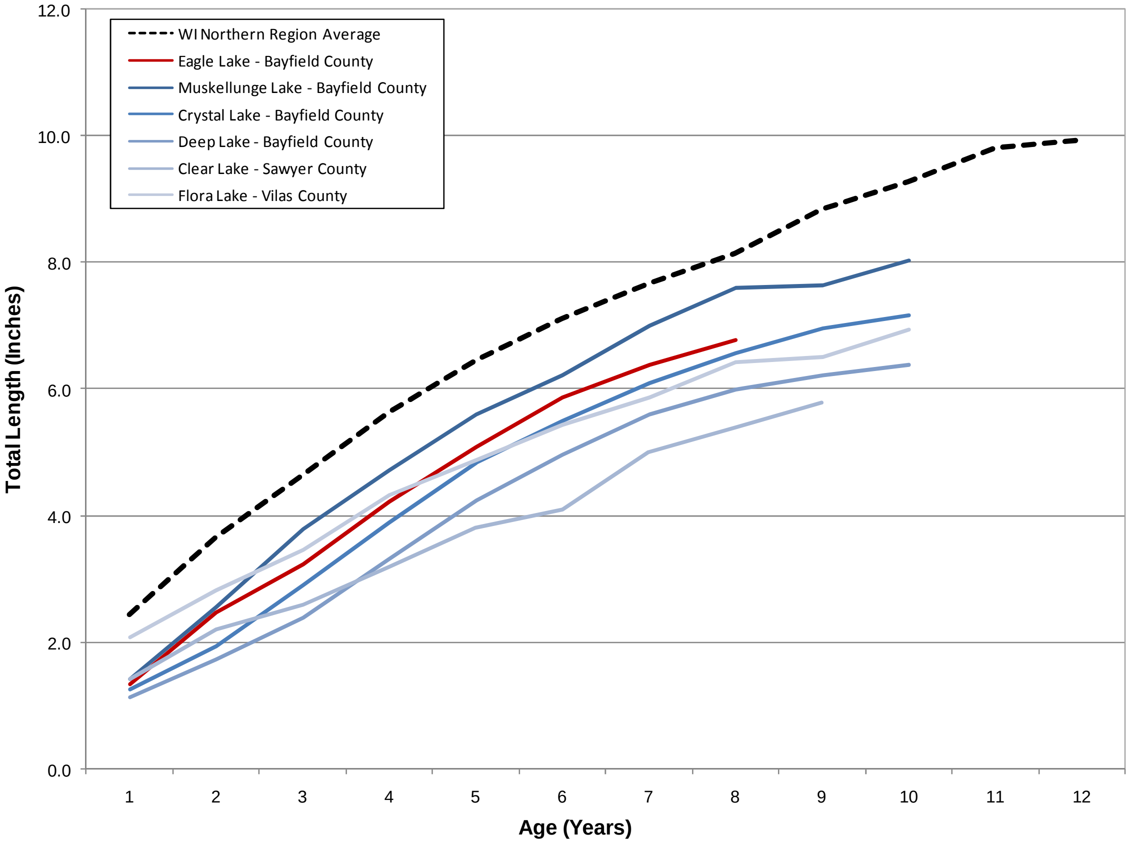

Figure 41. Bluegill Length at Age. Data from Eagle Lake, Muskellunge Lake, Crystal Lake, and Deep Lake are from Swenson, (unpublished data). Data from Clear Lake is from Becker, 1969. Data from Flora Lake is from Becker, 1965.

The Pike Chain of Lakes is an important fishery resource for Bayfield County. The WDNR has listed the Pike Chain along with Lake Owen, Lake Namakagon, the Eau Claire Chain of Lakes, Lake Nebagamon, and Whitefish Lake as high profile resources in the inland waters of Bayfield and Douglas Counties. Based on reports from concerned stakeholders that live on and utilize the Pike Chain of Lakes fishery there seem to be changes that have occurred since the 2001 comprehensive fisheries survey. Fortunately another comprehensive fisheries survey is scheduled to be completed in 2010. Below are future management actions that have been proposed by the WDNR after meeting with the Fisheries Committee of the lake association in August of 2008. The meeting summary notes are provided in Appendix F.

Future Action (Provided by Scott Toshner, WDNR Fisheries Biologist):

- A comprehensive fisheries survey will be conducted on the Pike Chain of Lakes in 2010. This survey will provide data that is directly comparable to the 2001 survey and, in some cases, historic data. Species abundance, length frequency and growth information will be collected as well as angler harvest of all species. In addition to the creel survey, an effort will be made to develop an angler questionnaire which could be distributed by creel clerks in 2010 to better gauge the opinions and preferences of Pike Chain anglers regarding fish populations and possible management actions.

- After collecting data in 2010, the WDNR will complete a survey report to be shared with the public. This report will include two parts: 1) biologically based management recommendations that will serve to set the range of management actions (e.g., length limits, bag limits) that can be considered; and 2) a summary of social and cultural factors, determined from the angler questionnaire, which affect the acceptance of management actions by the angling public. The WDNR will form the final management recommendations by considering both the biologically and sociologically acceptable actions suggested from the data. If desired, the WDNR would be willing to provide the IRALA the opportunity to comment on the draft stage of the report to allow discussion of the data behind these recommendations. The final recommendations for managing the fishery and its users could be meshed with the broader recommendations from the lake management plan. The management recommendations could then be used to direct future actions by both the WDNR and the public in an effort to protect and enhance the Pike Chain of Lakes.

SUMMARY AND CONCLUSIONS

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

1) Collect baseline data to increase the general understanding of the Pike Chain of Lakes ecosystem.
2) Collect detailed information regarding invasive plant species within the lake with a primary focus on Eurasian water milfoil.
3) Collect sociological information from Pike Chain stakeholders regarding their use of the Chain and their thoughts pertaining to the past and current condition of the Chain and its management.

The three objectives were fulfilled during the project and have lead to a good understanding of the Pike Chain ecosystem, the people that care about the lakes, and what needs to be completed to protect and enhance the lakes.

Three primary aspects of the Pike Chain of Lakes ecosystem were studied as a part of this management planning project; the system's water quality, its native and non-native aquatic plant community, and the watershed that supplies much of the systems' water. Within the context of these three items, the studies indicate that the six project lakes that make up the Chain are in exceptionally good health. The paragraphs that follow cover the highlights of the studies that were completed and elaborate on the conclusions that were drawn from them.

The Pike Chain watershed is largely covered with forested areas. In fact, nearly 72% of the watershed's 5,782 acres contain forest cover. Forests export very little phosphorus and other pollutants within runoff as most of the precipitation that falls on them infiltrates the ground. Having so much of the Chain's drainage basin in forest cover means that little phosphorus enters the lakes through surface runoff. Modeling of the Chains watershed indicates that each lake's annual phosphorus load is small, with a range from 68 lbs annually in Buskey Bay Lake to 374 lbs annually in Flynn Lake. The low phosphorus loads lead to the outstanding water quality apparent within the lakes as discussed below.

Current data collected from the Pike Chain indicate that its water quality is superior to most lakes in the state and northwest region. Unfortunately, long-term trend analysis that would lead to an understanding of how the Chain's water quality has changed over the years was precluded by the nearly complete absence of historic data. Still, the fact remains that the Chain's nutrient levels are currently quite low and, as a result, the water remains unusually clear. Degradation of water quality is of great concern among Pike Chain stakeholders (Appendix B, Questions 17 & 18).

As mentioned above, the high quality of the Chain's lake water is largely the result of the high quality of the water that arrives from it drainage basin. As a result, this means that the Chain is very sensitive to increases in nutrient loads, and the most likely source for those increases occurs in the lakes' immediate shoreland watershed. In other words, continued impacts in the shoreland areas of the Chain will most likely result in higher nutrient loads entering the lakes and those higher loads will first be seen in decreased water clarity. These impacts include further shoreland development, overcutting of trees, fertilizer use, faulty septic systems, and increases in impervious surfaces. Control of these impacts is required to maintain the water quality and habitat value within the Chain.

Numerous plant surveys were completed on the Pike Chain in order to better understand the native and exotic plant communities that exist within it. The results of these surveys are used as a baseline for future studies that will result in to more effective management strategies.

Overall it was found that each of the lakes on the Pike Chain contains a healthy and somewhat unique aquatic plant community. Sixty-four native species were located within the Chain while only 11 were common to all 6 lakes. A species of special concern was located within the Chain as were numerous species considered to be rare within the state. Floristic quality analysis concluded that while the lakes all support high quality plant communities above those found as indicated by the majority of lakes in the state and ecoregion, some of the lakes contain signs of disturbance in the species that make up their aquatic plant communities. Specifically, Buskey Bay and Twin Bear Lakes both were found to have average conservatism values well below that of median values from lakes within the northern ecoregion. The other lakes were even with or slightly below the ecoregion median. Some of the disturbance that is indicated by the plant communities can be attributed to the past high population of rusty crayfish, but it is more likely the result of the high rate of recreational use that occurs on the lakes and the increasing levels of development occurring on their shorelands.

Four exotic species were also found to occur on the Chain; of the most concern at this time is Eurasian water milfoil because its spread has been verified by numerous surveys. Only a single occurrence of curly-leaf pondweed was discovered in 2005 and since that time has not been found again. Giant reed was found in only one location and purple loosestrife is currently being controlled through the combined efforts of the IRALA and GLIFWC.

Question 18 of the stakeholder survey (Appendix B) asked respondents to rank their top three concerns regarding the Pike Chain of Lakes from a general list. Aquatic invasive species was ranked in the top three by over 61% of the people that took the survey. Most likely, the respondents are concerned about Eurasian water milfoil as it has been at the forefront of many Association meetings and communications. However, a portion of the concern also rests on introductions of other invasives to the Chain, which is a serious threat considering the Chain's proximity to Lake Superior.

Eurasian water milfoil was first discovered in the channel linking Hart and Twin Bear Lakes in 2004. Since that time the known locations of the exotic plant were treated in an attempt to keep it under control and from spreading from those locations to other lakes in the Chain. Eurasian water milfoil has spread to many locations in Twin Bear and Hart Lakes and both are now accepted as having established infestations. Occurrences to a much less degree have also been found in Buskey Bay, Millicent, and the channel leading to Eagle Lake. These lakes are considered to have pioneer infestations.

Controlling the spread of Eurasian water milfoil on a lake wide basis is a difficult and complicated undertaking. Basically, five somewhat realistic alternatives exist for controlling Eurasian water milfoil within the Pike Chain; drawdown, mechanical harvesting, weevil introduction, herbicides (specifically 2,4-D), and hand-removal.

Studies have shown that the freezing and/desiccation of Eurasian water milfoil root crowns prevents re-emergence of the plant and thus acts as an excellent form of control in some lakes.

Drawdown is not a feasible option in the Pike Chain of Lakes because the lakes could only be lowered 3-5' using the dam and spillway as they currently exist. Without even considering impact on native plants, the fishery, and recreation, dewatering the lakes to the 5-foot contour line would have little impact on the current Eurasian water milfoil because much of it exists in deeper waters.

Mechanical harvesting involves the use a barge-mounted cutting and conveyor apparatus to cut plants and remove them from the lake. Harvesting is not appropriate for the Pike Chain as Eurasian water milfoil does not occur at nuisance levels in any of the lakes and most importantly, the use of harvesting would accelerate the spread of the infestation through fragmentation.

The milfoil weevil (*Euhrychiopsis lecontei*) is not a feasible option because of high costs and the technique's unproven record. Purchase of milfoil weevils currently not eligible for WDNR grants; however, the state is supporting research and monitoring efforts associated with weevils. Although their use may not be appropriate now on the Pike Chain, they may be at sometime in the future.

Controlling Eurasian water milfoil with hand-removal is time consuming, involves a great deal of hard work, and often requires the skills of certified scuba divers in deeper areas. All of this together limits hand-removal's effectiveness to small areas and/or in conjunction with herbicide use.

As of 2009, the acreage infested and density of Eurasian water milfoil within the Pike Chain of Lakes calls for chemical herbicides to be used in the control of this exotic plant. The herbicide 2,4-D would be the most appropriate for use because of it selectivity against broadleaf plants such as Eurasian water milfoil. The selectivity of 2,4-D can be increased further against Eurasian water milfoil if the chemical is applied early in spring before our native broadleaf plants begin to grow. These early spring treatments should be completed before the water temperatures reach 60º F.

Contact herbicides, such as endothal would not be appropriate for use against Eurasian water milfoil as they only impact the exposed foliage of the plant. While an application of a contact herbicide would likely knock the Eurasian water milfoil back, it would not kill it completely like a systemic herbicide, such as 2,4-D would. However, the US Army Corps of Engineers are doing studies on combination treatments using a contact herbicide in conjunction with 2,4-D, both at low dose, to combat Eurasian water milfoil. That treatment strategy, along with the use of liquid 2,4-D in place of the normal granular 2,4-D, should be considered in the future as their effectiveness is refined.

As mentioned above, two levels of Eurasian water milfoil occurrence exist in the Pike Chain as Twin Bear and Hart Lakes have established populations and Eagle, Buskey Bay, and Millicent have only pioneer populations. These two situations need to be handled differently in terms of how the Eurasian water milfoil is managed. The established infestations need to be controlled in order to minimize the impact of these exotics on native plant populations and to slow their spread. The pioneer infestations must be managed more aggressively with the goal of eradicating the Eurasian water milfoil from the lakes. While eradication may not be possible using our current technology, striving towards this goal would assure that maximum containment could occur. Both management scenarios need to include integrated techniques for controlling the exotic, including early season herbicide treatments in late May or before water temperatures reach 60°F, and strict monitoring plans to guide the treatments and monitor their effectiveness.

IMPLEMENTATION PLAN

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

Management Goal 1: Promote Lake Protection and Enjoyment through Education

Management Action: Support an Education & Communication Committee to promote clean boating, water quality, public safety, and quality of life on the Pike Chain of Lakes.

Timeframe: Begin 2008-2009

Initial Facilitator: Board of Directors

Continuous Facilitator: Education & Communication Committee

Prospective Funding: WDNR Small-scale Lake Management Planning Grant, Aquatic Invasive Species- Education, Prevention, and Planning Grant, Aquatic Invasive Species- Established Infestation Control Grant

Description: In addition to public boat landings, many private properties are used for boat launching and renting of private cabins is common. As a result boats are not inspected and many water users are not aware of AIS issues, boating regulations and the general impacts of their activities on the lakes and the enjoyment of others. In addition to boats, the dumping of aquaria is ranked among the top mechanisms through which AIS is introduced to public waters and is not being addressed. Education represents a good tool to address issues that impact water quality such as lake shore development, lawn fertilization and other issues such as air quality, noise and boating safety. An Education & Communication Committee has been created and will be supported by the IRALA Board to promote lake protection and the quality of life through a variety of educational efforts. These may include educational materials, awareness events and demonstrations for lake users as well as activities which solicit local and state government support.

Strategy for Educational Initiative

In general, two types of access are utilized on the Pike Chain of Lakes; public and private, and each of these types of access supports a somewhat unique usership. Public access includes the public boat landings located on Buskey Bay and at the Bayfield County Campground. Private access includes those used at private residences, resorts, and rental properties. While there would be some overlap, each of these audiences would require specialized approaches to assure the message is being received.

General Public Multiple media types will be used to reach the general public and Association members. These will include an Association website (http://www.ironriverlakes.org), newsletter and newspaper articles, signage at public landings, demonstrations, speakers at Association meetings and other events, posters displayed at local businesses, and placemats supplied to local restaurants. In most of these cases, the educational message will be on a broad or general topic (see list below); however, educational items aimed primarily at Association members and other Pike Chain riparians will start with these general topics and then be followed with more refined topics. For example, a general topic of the importance of shoreland buffers would be followed up with a more refined educational piece that may include methods of installing a shoreland buffer and species of plants that would be appropriate for the area.

Private Access Usership The primary point of reaching these lake users is to provide them with important and timely information intended to help them minimize their impact on the lake. The specific methods and timing of delivery of this information is important, but at this point not completely understood. Essentially, the IRALA is not sure of the best method of reaching people that utilize the resorts and the rental units. Therefore, the following steps will be used to maximize the efficiency and effectiveness of this management action:

1) A list of resort owners and rental property owners will be compiled. The list will include the manager of the Bayfield County Campground
2) A letter will be sent to the list with the following sections:
    a) Explanation of the educational goals of the group and the Association's wish to distribute information to the patrons of the establishment.
    b) A list of potential avenues of communication, such as posters, signs near water access points, leaflets for insertion within confirmation letters or other information disbursed to the establishment's users.
    c) Notice that an Association member will be calling the addressee to discuss the Association's request and the contact's opinion on what would be the best method of providing the information to the intended audience.
3) Once the opinions of the owners/managers are compiled, the Education & Communication Committee will create the materials for dispersal using the most effective method. Different materials be disbursed to each of the groups depending on what types are most appropriate.

Example Educational Topics:

Specific topics brought forth in other management actions
Noise, air, and light pollution
Water safety

ATV use and safety
Courtesy code (based upon Vilas County Lakes Association Code)
Littering on ice
Shoreland restoration and protection
Septic system maintenance

Action Steps:

1. The IRALA Board will identify a base level of annual support for educational activities to be undertaken by the Education & Communication Committee.
2. The Education & Communication Committee will develop specific proposals identifying educational efforts and present them to the IRALA Board for approval.
3. Where possible the activity will be approved and move forward with a vote of the majority of the Board.
4. When questions are raised about the activity or additional financial support is required, the IRALA Board and Education & Communication Committee will work together to address the issues.

Management Goal 2: Maintain Current Water Quality Conditions

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

Timeframe: Begin Summer 2009

Facilitator: Water Quality Committee and Education & Communication 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. The lack of this type of historical information hampered the water quality analysis during this project. Early discovery of negative trends may lead to the reason as to why the trend is developing. Volunteers trained by the WDNR as a part of the Citizens Lake Monitoring Network (CLMN) begin by collecting Secchi disk transparency data for at least one year, then as a part of the advanced training, may collect chlorophyll-a, and total phosphorus. The Secchi disk readings and water quality samples are collected three times during the summer and once during the spring. Note: as a part of this program, these data are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS).

Action Steps:

1. Water Quality Committee recruits one or more volunteers from each lake.
2. Water Quality Committee or volunteer contact Kris Larsen, WDNR (715-635-4072, kris.larsen@wisconsin.gov*)* to arrange for training and equipment.
3. Volunteers collect data and report results to WDNR and to Association members during annual meeting.
4. Following one year of Secchi disk sampling, the Association should request to be included in the advanced water chemistry program.

<u>Management Action:</u> Reduce phosphorus and sediment loads from immediate watershed.

Timeframe: Begin 2009

Facilitator: Education & Communication Committee

Prospective Funding: WDNR Small-scale Lake Management Planning Grant, Aquatic Invasive Species- Education, Prevention, and Planning Grant, Aquatic Invasive Species- Established Infestation Control Grant

Description: The Pike Chain of Lakes has a relatively small watershed draining to it and as a result, the impacts that are most controllable at this time originate along the lake's immediate shoreline. These sources include faulty septic systems, the use of phosphorus-containing fertilizers, shoreland areas that are maintained in an unnatural manner, and impervious surfaces. To reduce these impacts, the IRALA will conduct an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include news letter articles and guest speakers at Association meetings.

This Management Action will be completed in conjunction with the Shoreland Restoration Action listed below.

Action Steps:

1. Recruit facilitators
2. Facilitators summarize educational material collected from WDNR, UW-Extension, and County Land Conservation sources for the creation of informative materials
3. Facilitators disperse materials to stakeholders

<u>Management Action:</u> Complete Shoreland Restoration Demonstration Sites on Pike Chain of Lakes Properties

Timeframe: Begin 2009

Facilitator: Water Quality Committee and Fisheries Committee

Prospective Funding: WDNR Small –scale Lake Management Planning Grant (start up), WDNR Lake Protection Grant & Bayfield County Cost Sharing (restorations).

Description: Mr. Robert (Butch) Lobermeier, Bayfield County Conservationist has shown great interest in not only completing a shoreland restoration within the Bayfield County Campground, but also on private shoreland properties of the Pike Chain of Lakes. Mr. Lobermeier has considerable experience managing such projects and is willing to assist lake groups in completing the restorations; however, the lake group must be the driving force in recruiting property owners to participate and in completing the restorations as Mr. Lobermeier's department budget does not account for much of his time to complete these tasks.

Shoreland restorations would include both in-lake and shoreline habitat enhancements. In-lake enhancements would include the introduction of course woody debris, a fisheries habitat component severely lacking around the shores of the Pike Chain of Lakes. Shoreline enhancements would include the native plantings of herbaceous, shrub, and tree species as appropriate for Bayfield County. Further, if public funds are utilized to complete the project, the property owner must agree that a land conservation covenant be placed upon the property's deed to assure the property will remain in its restored state in perpetuity.

Action Steps:

1. Water Quality Committee contacts Mr. Lobermeier (715-373-6167, blobermeier@bayfieldcounty.org).
2. Develop a strategy with Mr. Lobermeier to include the IRALA in the completion of the Bayfield County Campground restoration project with the intent of familiarizing Association representatives in proper site selection and the benefits, methodologies, and costs in completing such projects.
3. IRALA creates preliminary list of appropriate shoreland properties for restoration on the Pike Chain of Lakes.
4. Study results will determine appropriate management action

Management Action: Gain an understanding of filamentous algae and periphytic algae within the Pike Chain of Lakes

Timeframe: Begin 2009

Facilitator: Water Quality Committee

Description: Pike Chain stakeholders have raised concerns over large mats of filamentous algae observed growing on submersed aquatic vegetation and rocks. Based on reliable anecdotal accounts, the filamentous algae population has increased within the past few years, especially on areas of Eagle Lake. Abnormal algal growth is often associated with increased concentrations of nutrients, specifically phosphorus, that enter the lake through natural or human-induced sources. During the current study, no examination of periphyton was conducted. An examination of the algal species and their populations are needed to create management goals associated with them.

Action Steps:

1. Recruit facilitators
2. Facilitators gather appropriate information from WDNR, UW-Extension, Bayfield County and other sources on appropriate survey methodology
3. If necessary, retain consultant to coordinate monitoring strategy
4. Obtain WDNR grant to fund study
5. Study results will determine appropriate management action, if needed

Management Action: Assist Bayfield County in private septic pumping and inspection tracking system.

Timeframe: Begin 2009

Facilitator: Water Quality Committee

Prospective Funding: WDNR Small –scale Lake Management Planning Grant

Description: As with many lake groups, the IRALA is concerned with possible impacts that private septic systems may be having on the Pike Chain of Lakes. Discussions during the planning meetings considered a wide range of actions associated with this concern, including doing nothing at all to completing system inspections and dye tests. It was determined that the Association needs to learn more about what Bayfield County may be doing to address the situation.

Following the first planning meeting, the Bayfield County Planning and Zoning Department was contacted. As a result of this contact, it was learned that Bayfield County is in year 2 of a 3 year project to identify and evaluate privately owned wastewater treatment systems (POWTS) that predate 2000. In fact, the first enforcement letters have gone out to noncompliant owners. It is not known when properties near the Pike Chain of Lakes are scheduled to be inventoried and evaluated. Wisconsin administrative rules provide standards for POWTS: Comm 83.255 requires all Wisconsin counties to inventory and establish a maintenance program for systems that predate current construction standards (pre July 1, 2000). Comm 83.54 (3) and (4) and Comm 83.55 provide reporting and evaluation requirements for such systems.

In short, it appears that Bayfield County is moving along in the process of addressing concerns about the impact of substandard sanitary systems on water quality and public health issues. Still, the IRALA would like to support and expedite the process; therefore the Association will provide a list of Pike Chain riparian property addresses for the county to use and compare with their database. That list will be developed by the IRALA using parcel maps and information provided by the Bayfield County Land Information Department. The IRALA will create a spreadsheet of addresses corresponding to the original parcel numbers included in the county's base information. That list will be checked against the county's list and visual inspections to make sure all improvements are accounted for and that all applicable properties are receiving notices.

Further, during 2010, the Association will monitor the progress of the county's process by providing a short survey to their lakeshore landowner mailing list asking if they had been contacted by the county regarding their POWTS. The survey results will determine further and appropriate management action, if needed.

Action Steps: See description above.

Management Goal 3: Improve Fishery Resource and Fishing, While Striving to Control Rusty Crayfish

<u>Management Action:</u> Work with WDNR fisheries managers to promote development of special fishing regulations for the Pike Chain of Lakes

Timeframe: Currently and following 2010 WDNR fish surveys

Facilitator: Fisheries Committee & Education & Communication Committee

Description: During the period when invasive rusty crayfish were abundant in the Pike Chain of Lakes, much of the fishing pressure became focused on Eagle Lake, which maintained a healthy aquatic plant community. Resident angler observations suggest that fishing pressure has remained concentrated on Eagle Lake and is highest during late winter and spring when panfish populations are most vulnerable. Long time residents have observed that some people fish day after day for weeks at a time taking "their daily bag limit of 25 fish". A possession limit of 50 panfish is in place and suspected violations should be reported to WDNR enforcement personnel (1-800-tipWDNR).

As stated above, growth studies of Eagle Lake bluegills indicate growth is below the Wisconsin Northern Region average (Figure 41). Research by both Minnesota and Wisconsin Departments of Natural Resources (Drake et al., 1997 and Beard and Essington, 2000) suggests intensive selective sport fishing for larger fish may result in genetic selection and slower growth as exhibited by Eagle Lake bluegills.

Resident angler observations indicate a high abundance of smallmouth bass may have served as an effective control for rusty crayfish populations in the past and has resulted in a partial resurgence of aquatic plant communities throughout the Pike Chain. Observations made by several experienced stakeholders suggests however, that abundance of smallmouth has declined in recent years in response to increased fishing pressure. Maintaining high abundance of smallmouth bass is likely important to control the abundance of rusty crayfish and to the resurgence of native plant communities throughout the Pike Chain of Lakes.

Members of the Planning Committee met with Scott Toshner, Fisheries Biologist with the WDNR, to discuss altering fisheries regulations on the Pike Chain of Lake with the objective of not only maintaining a high smallmouth bass population in order to maintain low rusty crayfish numbers, but also to assure a sustainable fishery that can withstand the fishing pressure exerted on the lakes in the Chain. The meeting notes are provide in Appendix F. Scott Toshner stated that the WDNR will be completing a comprehensive fish survey on the Chain during 2010. The data collected during 2010 will be compared with data collected during 2000 to verify changes within the Chain's fishery. Based upon those results, the department will consider applicable changes to the regulations as brought forth by the IRALA.

Action Steps:

1. Maintain contact with WDNR fisheries managers and offer support for the completion of the studies and development of applicable regulations.

<u>Management Action:</u> Develop and distribute appropriate information of the value of catch and release fishing and fishing etiquette to promote quality fish populations, fishing, and Pike Chain for Lakes ecosystem stability.

Timeframe: 2009

Facilitator: Fisheries Committee & Education & Communication Committee

Description: The information and documents developed as a part of this action would follow the same guidelines and path as described in the first management action of this Implementation Plan.

Action Steps: See description above.

Management Goal 4: Control Aquatic Invasive Species within Pike Chain of Lakes

Management Action: Reduce occurrence of purple loosestrife on Pike Chain shorelands

Timeframe: Ongoing

Facilitator: Invasive Species Committee

Description: IRALA volunteers would continue to control purple loosestrife using mechanical, chemical, and biological control methods. Volunteers would mark purple loosestrife occurrences in late May to Early June with surveyor ribbon and evaluated to determine which control method best suits the population.

If biological control methods are chosen, *Gallerucella spp.* beetles would be collected during early June using aspirators from established populations in the area during. GLIFWC will determine appropriate locations for IRALA volunteers to collect the beetles. The same day the beetles are collected, they would be released directly onto the target colony.

If chemical control methods are chosen, a certified applicator would need to apply the herbicide. As stated within Wisconsin Administrative Code NR 107, a WDNR permit ($20 permit application fee plus $25 per acre) is required to use herbicides if the applicator is “standing in your socks and they get wet.’ Along with a permit, a certified applicator is required to conduct the treatment if the area is wet. In the past, IRALA volunteers have marked purple loosestrife locations using surveyor ribbon and later treated by GLIFWC field crew. While this may be a possibility in the future, the IRALA should not rely on GLIFWC to conduct these treatments. A contracted applicator would need to be sought or a lake resident would need to obtain the proper certification to apply herbicides in these situations.

At this time, there is not an established WNDR monitoring protocol aimed at quantifying the level of control achieved for purple loosestrife. Success of purple loosestrife control on the Pike Chain would be evaluated in 2013 by completing a community mapping survey. During this survey, purple loosestrife occurrences would be professionally mapped. This survey would replicate the 2006 survey (Maps 4 and 5) and would allow un understanding of changes in location and frequency of this species to be made.

Action Steps: See description above.

Management Action: Maintain and expand boater education, boat inspection and boat cleaning operations at boat landings.

Timeframe: Begin 2009

Facilitator: Invasive Species Committee and Education & Communication Committee

Prospective Funding: WDNR Aquatic Invasive Species- Education, Prevention, and Planning Grant, Aquatic Invasive Species- Established Infestation Control Grant, Bayfield County Cost Sharing

Description: Current boater education, boat inspection and cleaning operations are limited to the Bayfield County Park boat landing primarily on weekends. With over 80 non-native species in Lake Superior within 20 miles of the Pike Chain and the large number of boats entering and leaving these lakes, the current effort is not sufficient to prevent additional invasive species from becoming established in the Pike Chain or to prevent Eurasian water milfoil from spreading to other area waters. Although the concern about AIS expressed by property owners in recent surveys was likely focused on EWM, no known control procedures are available for other species such as Viral Hemorrhagic Septicemia (VHS) and zebra mussels. These and other species may be expected to be introduced and become established at present levels of preventative activities. Establishment of these species will be devastating to the lakes, water use, property values and the regional economy. To minimize the chance that other species will become established, the IRALA will work to expand the boater education, boat inspection and boat cleaning operations.

In addition, an Education Committee comprised of stakeholder volunteers will develop materials and programs that will promote clean boating and responsible use of these waters (See Education Goal).

Action Steps: See description above.

<u>Management Action:</u> Coordinate annual volunteer monitoring of Aquatic Invasive Species

Timeframe: Start 2009

Facilitator: Invasive Species Committee

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

Specific to the Pike Chain of Lakes and the control plan described below, the group already performs a considerable amount of Eurasian water milfoil monitoring on its own; therefore, the framework for such a volunteer network is essentially in place. As a part of the control program, the volunteers will provide locations of Eurasian water milfoil for professional ecologists to focus their efforts upon, making more efficient use of professional time while engaging stakeholders in the program.

This management action will also provide benefits to the Pike Chain of Lakes beyond the Eurasian water milfoil control program by providing monitoring of other invasive species such as curly-leaf pondweed, giant reed, etc.

Action Steps:

1. Recruit volunteers to conduct field surveys
2. Retain consultant to coordinate monitoring strategy

3. Obtain WDNR grant
    a. Purchase GPS unit for Association
    b. Consultant trains volunteers on GPS use and data collection
    c. Consultant trains volunteers on native/non native species identification
    d. Volunteers transfer data to consultant for integration and graphical representation during control program described below.

Introduction - Eurasian Water Milfoil Control and Prevention Actions

Managing a chain of lakes 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 the Pike Chain of Lakes, special attention must be paid to the level of infestation on each lake in terms of how the plant will be managed. Specifically, Hart and Twin Bear Lakes have advanced infestations of Eurasian water milfoil which have been treated numerous times since 2005. Lake Millicent, Buskey Bay Lake, and the channel leading to Eagle Lake have very limited levels of Eurasian water milfoil, while Eagle and Flynn Lakes are not known to contain the invasive plant. All three levels of infestation need to be managed differently. Twin Bear and Hart Lakes need to be managed to control further spread within the lakes themselves and to other lakes in the Chain. Lake Millicent, Buskey Bay Lake, and the Eagle Lake must be managed aggressively with the goal of eradicating these pioneer infestations. Preventing infestation is the key to managing Eagle and Flynn Lakes, which includes the management of Eurasian water milfoil in the rest of the Chain and the prevention of introduction through the Clean Boats/Clean Waters Program and other educational initiatives.

Two *Management Actions* are presented below, one with the intent of controlling Eurasian water milfoil in Hart and Twin Bear Lakes, and the other for eradicating Eurasian water milfoil from Lake Millicent, Buskey Bay Lake, and the Eagle Lake channel. Both actions call for chemical treatments of Eurasian water milfoil and hand-harvesting of the plant. Further, both actions call for regular monitoring of the exotic plant and the effects of the two treatment types on it occurrence. The monitoring discussed in the first action would also be used to monitor the results of eradication action.

The primary differences between the two actions revolve around the intensity of volunteer monitoring and treatments (chemical and hand-removal). Within Twin Bear and Hart Lakes, annual surveys will be completed by volunteers with that data being refined by professional surveys late in the summer. Within Lake Millicent, Buskey Bay Lake, and the Eagle Lake channel, volunteer surveys will be completed numerous times throughout the growing season, with professional surveys being completed later in the summer with the work being completed on the other lakes.

Within Twin Bear and Hart Lakes, the strategy is not to eradicate the established infestations of Eurasian water milfoil, but instead to minimize the plant's occurrence and hence its ability to spread. Within these lakes, every occurrence of Eurasian water milfoil will not be treated with chemical herbicides, and may or may not be slated for hand-removal. Chemical treatment will be triggered if the abundance of Eurasian water milfoil in an area approaches 30% or greater coverage (scattered occurrence or greater). Hand-harvesting within these lakes will be completed at the discretion of the Association volunteers and depend on the availability of volunteers, the substrate, and the density of plants (both native and non-native).

Eurasian water milfoil within Lake Millicent, Buskey Bay Lake, and the Eagle Lake channel, will be managed much more aggressively by treating areas with 15% or more aerial coverage of Eurasian water milfoil (highly scattered or greater). Further, hand-harvesting will be completed on an as-needed basis and every attempt will be made to complete the effort. In some situations, if hand-harvesting is impossible, the Association may place bottom barriers over the Eurasian water milfoil to smoother the plants.

Details of each management action are discussed within the text below.

<u>Management Action:</u> Control established Eurasian water milfoil infestations within The Pike Chain of Lakes.

Timeframe: Initiate 2009

Facilitator: Board of Directors & Invasive Species Committee with professional help as needed

Prospective Funding: Aquatic Invasive Species- Established Infestation Control Grant

Description: As described in the Aquatic Plant section and elaborated upon within the Summary and Conclusions, The Pike Chain of Lakes is believed to currently contain approximately 20 to 30 acres of Eurasian water milfoil, which is located largely in Twin Bear and Hart Lakes. Very limited occurrences consisting of individual plants, clumps of plants, and small colonies have been located in Lake Millicent, Buskey Bay Lake, and the channel leading to Eagle Lake. At this time, in the lakes that contain well-established infestations, the most feasible method of control is herbicide applications, specifically, early-spring treatments with 2,4-D. The treatments would occur each year before June 1 and/or water temperatures reach 60°F. The responsible use of this technique is well supported by the Pike Chain of Lakes stakeholders as indicated by nearly 60% of stakeholder survey respondents indicating that they are supportive of an herbicide control program (Question 21).

Eurasian water milfoil was first discovered in the Pike Chain during the late summer of 2004 and later confirmed by the WDNR during May of 2005. Following the WDNR confirmation, the first treatment (approximately 16 acres) was completed on the Chain. The 2005 treatment has since been followed by treatments during 2006 (6.5 acres), 2007 (25 acres), and 2008 (20 acres). Qualitative observations by professionals and volunteers indicate that in general, the treatments are working in the individual treatment areas; however, the plant is still spreading within the Chain.

In Twin Bear and Hart Lakes, the objective of this management action is not to eradicate Eurasian water milfoil from The Pike Chain of Lakes, as that would be impossible. The objective is to bring Eurasian water milfoil down to more easily controlled levels. In other words, the goal is to reduce the amount of Eurasian water milfoil in these two lakes to levels that would only require spot treatments to keep the exotic under control. In the remaining portions of the Chain were very moderate occurrences are found, the goal will be to eradicate from those areas. The action to meet the eradication objective is presented below.

To complete the control objective in Twin Bear and Hart Lakes efficiently, a cyclic series of steps is used to plan and implement the treatment strategies. The series includes:

1. A lakewide assessment of Eurasian water milfoil completed while the plant is at peak biomass (July or August).
2. Creation of treatment strategy for the following spring.
3. Verification and refinement of treatment plan immediately before treatments are implemented.
4. Completion of treatments during May or early June.
5. Assessment of treatment results (summer after treatment).

Once Step 5 is completed, the process would begin again that same summer with the completion of a peak biomass survey. The survey results would then be used to create the next spring's treatment strategy.

Obviously, monitoring is a key aspect of the cycle, both to create the treatment strategy and monitor its effectiveness. The monitoring would also facilitate the "tuning" or refinement of the treatment strategy as the control project proceeds. It must be remembered, that this portion of the management plan (control plan) would be intended to span approximately 3 to 7 years, before it would need to be updated to account for changes within the ecosystem. The ability to tune the treatment strategies is important because it would allow for the most effective results to be achieved within the plan's life span.

Two types of monitoring would be completed to determine treatment effectiveness; 1) quantitative monitoring using WDNR protocols, and 2) qualitative monitoring using observations at individual treatment sites and on a treatment wide basis. Results of both of these monitoring strategies would be used to create the subsequent treatment strategies. The quantitative strategies include sampling plants, both Eurasian water milfoil and native species, at predetermined locations (points) within treatment areas, while the qualitative monitoring includes the determination of Eurasian water milfoil abundance based upon a continuum of density. The density continuum ranges from non-detectable levels of Eurasian water milfoil to what is considered a monoculture where Eurasian water milfoil is essentially the only plant that exists in the area. Both monitoring types would be completed before and after the treatments (pretreatment surveys and post treatment surveys). Comparing the monitoring results from the pretreatment and post treatment surveys would determine the effectiveness of the treatment on a site-by-site basis and on a treatment wide basis. Finally, a lakewide plant survey (point-intercept survey) would be completed after this management action is completed (3 to 7 years) to determine the effectiveness of the intense control program.

Success Criteria

Determining the effectiveness of the treatment program is impossible unless specific success criteria (goals) are set before beginning the program. For this control program, the criteria would be evaluated at three levels

1. Treatment area (site specific)
2. Annual treatment (treatment wide)
3. Control program

Treatment Area

Qualitatively, a successful treatment on a particular site would include a reduction of Eurasian water milfoil density as demonstrated by a decrease in density rating.

Quantitatively, a successful treatment on a specific-site level would include a significant reduction in Eurasian water milfoil frequency following the treatments as exhibited by at least a 50% decrease in Eurasian water milfoil frequency from the pre- and post treatment point-intercept sub-sampling. In other words, if the Eurasian water milfoil frequency of occurrence before the treatment was 40%, the post treatment frequency would need to be 20% or lower for the treatment to be considered a success for that particular site. Further, there would be a noticeable decrease in rake fullness ratings within the fullness categories of 2 and 3.

Annual Treatment

Qualitatively, success would be achieved annually when 75% of the treatment areas are reduced by a density rating (as described above).

Similar to the site specific evaluation, annual treatment success would be observed when a 50% decrease in Eurasian water milfoil frequency from the sub-sampling occurs. Preferably, there would be no rake tows completed during the post treatment surveys exhibiting a fullness of 2 or 3.

Control Program

At the end of the project, it is hoped that no Eurasian water milfoil colonies would exist over *density=1*. Ecological function of a particular area is thought to be greatly reduced when Eurasian water milfoil becomes the dominant plant which corresponds to a *density=1* rating.

The control program would be quantitatively evaluated by recompleting the whole-lake point-intercept survey at the end of the project and observing a reduction in frequency of Eurasian water milfoil.

Control Program Specifics

This control program is anticipated to span 4 treatment years. Although it is very difficult, if not impossible, to accurately estimate how many acres of Eurasian water milfoil will need to be treated for some number of years in the future, it is obviously needed for budgeting purposes. Based upon the Eurasian water milfoil surveys completed in recent years and the results of recent treatments, a conservative estimate of treatment acreages is listed below. It includes chemical treatments of all known areas throughout the Chain and is conservative in anticipation of some areas requiring treatment for multiple years to reduce densities as discussed in the success criteria.

Project Year	Treatment Year	Estimated Acreage
2009	1	35
2010	2	35
2011	3	25
2012	4	15

Project Funding Assistance

Funds from the Wisconsin Department of Natural Resources Aquatic Invasive Grant Program will be sought to partially fund this control program and other elements of this management plan. Specifically, funds would be applied for under the Established Infestation Control Project classification.

Action Steps:

1. Retain qualified professional assistance to develop a specific project design utilizing the cyclic series of steps discussed above.
2. Apply for a WDNR Established Infestation Control Grant based on developed project design.
3. Initiate control plan
4. Revisit control plan in 4 years
5. Update management plan to reflect changes in control needs and those of the lake ecosystem.

Management Action: Prevent Eurasian water milfoil establishment in Eagle Lake, Flynn Lake, Lake Millicent, Buskey Bay Lake, and the White River.

Timeframe: Initiate 2009

Facilitator: Board of Directors & Invasive Species Committee with professional help as needed

Prospective Funding: Aquatic Invasive Species- Established Infestation Control Grant

Description: Because of the high water clarity in the Pike Chain, many stakeholders, are avid snorkelers or SCUBA divers and often look for excuses to spend time in the water. Many have participated in surveys and hand pulling efforts to control EWM during the past few years. The high water clarity combined with other physical features and the interest and experience of Stakeholders should make it feasible to prevent establishment of Eurasian Water Milfoil in most of the lakes in the Chain. In these lakes more intensive surveying and low impact hand removal of EWM will serve as the primary method of control. The few small established beds, that cannot be effectively removed by hand, will be eradicated using a combination of chemical and physical control methods.

The narrow bridge between Eagle and Twin Bear combined with the long shallow channel which includes high quality beds of native plants should serve as a barrier to keep EWM out of Eagle Lake, Flynn Lake, the White River and the connected lakes downstream. Surveys conducted to this point have identified only one small bed of EWM on the Eagle Lake side of the bridge. This bed can be eradicated using spring chemical treatments with follow-up spot treatments and hand pulling. Physical light barriers may also be applied if necessary. To assure that development of beds too large for hand removal do not develop in the future, complete survey / hand removal programs will be conducted in the channel three to four times per year starting in mid-June. Where EWM is encountered, the teams will record the coordinates and remove all plants and any fragments which might break off. The mid-June and early August surveys will cover the channel and all of Eagle and Flynn lakes. The volunteer teams will work with professional consultants to refine plant identification the details of the surveys /hand removal programs. The consultants and Invasive Species Committee will work together to develop any chemical or physical control approaches.

To prevent EWM from becoming well established in Buskey Bay and Millicent Lakes, a similar approach will be used. Unlike Eagle, these lakes suffered major reductions in density of native plant communities during the 1980s when Rusty Crayfish established high density populations. Native plants are in the process of reestablishing however, population densities remain low compared to Eagle and Flynn lakes. Although, EWM expansion will not be slowed through competition with native plants, individual plants and beds of EWM are easily spotted in the crystal clear water of these lakes. Surveys conducted to date indicate very limited occurrences of EWM in Millicent and Buskey Bay Lakes. These beds will be eradicated using the similar approaches described above for Eagle Lake. Intensive treatments may be completed without incurring much damage to native plants which are sparse. This approach will actually provide native plants communities the opportunity to become better established because competition from EWM could be eliminated. Survey / hand pulling teams will conduct complete survey-hand removal program on these lakes as described for Eagle and Flynn Lakes above. Where small spot treatments may be needed the teams will construct barriers if necessary to keep chemicals from drifting off the beds. The IRALA Invasive Species Committee will work with professional consultants to define the most effective treatment approaches.

Finally, the areas treated as described in the paragraphs above, would be monitored using the same methods as described in the preceding management action.

Action Steps: See description above.

METHODS

Lake Water Quality

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

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

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

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on the Pike Chain of Lakes during 07/11/07 – 07/12/07 and 06/23/08 – 06/24/08 field visits. Surveys were completed in both 2007 and 2008 because the WDNR felt the curly-leaf pondweed survey was bordering on being completed too late in the season. In order to be assured the survey corresponded with the anticipated peak growth of the plant, the survey was completed again in 2008. 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. 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
Buskey Bay	30-meter	399	08/08/07
Millicent	38-meter	514	08/08/07
Hart	33-meter	953	08/09/05
Twin Bear	32-meter	614	07/12/05 - 07/13/05
Eagle	30-meter	734	08/07/07
Flynn	30-meter	132	08/07/07

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.

Watershed Analysis

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

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