Yellow Birch Lake

Vilas County, Wisconsin

Comprehensive Management Plan

June 2007

Sponsored by:

Yellow Birch Conservation Union

&

Wisconsin Department of Natural Resources
Lake Management Grant Program

(LPL-1019-05 & LPL-1022-05)

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Lake Management Planning

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

Yellow Birch Conservation Union

William Lochte	Robert Kuelthau
Jon Socolofsky	Tim James
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INTRODUCTION

Yellow Birch Lake is an approximate 202-acre, drainage lake with a maximum depth of 23 feet and a mean depth of approximately 11 feet (Map 1). It is the final lake in the Eagle River Chain of Lakes. The system as a whole is heavily used by shoreland property owners and others that trailer their watercraft to one of the many boat launches on the chain or Eagle River.

The Yellow Birch Conservation Union (YBCU) was formed and incorporated in 2003 amid worries by lake stakeholders concerning Eurasian water milfoil (*Myriophyllum spicatum*) and other aquatic invasive species (AIS). The YBCU funded a treatment of approximately 8-acres of Eurasian water milfoil during 2004 and 2.2 acres during the spring of 2006. The YBCU understands the importance of responsible lake management, especially concerning aquatic plant control and therefore resolved to complete a *comprehensive* lake management plan aimed to look at the lake as a part of an ecosystem as opposed to just its aquatic plants.

The management plan and report contained within this document was created from the standpoint that Yellow Birch Lake is a small portion of a very large system. That system includes not only all of the lakes in the Eagle River Chain, but also those in the Three Lakes Chain and the remaining waterways and terrestrial areas in the lake's very large watershed.

The document is divided into three primary sections and each section is written for the understanding of laypersons and professionals alike. The Results and Discussion Section outlines the results of the water quality analysis, watershed assessment, and numerous aquatic plant surveys that were completed on the lake. It also discusses this information in terms of Yellow Birch Lake and in terms of raising the reader's understanding of lakes and their function in a more general sense.

The Summary and Conclusions Section is written to be somewhat of a *stand-alone* document. It highlights the important results of the project and elaborates upon their implications upon the management of the lake. This section also sets the tone for the Implementation Plan.

The Implementation Plan is essentially the path the YBCU will use to manage the lake over the next few years. The lifespan of the Implementation Plan is intentionally ambiguous because it is intended to be a living document that can flex and change with the needs of the group and those of the lake ecosystem. It is based upon realistic *management goals*. Each management goal contains *management actions* designed to lead the YBCU to the meeting of that goal. Specific *action steps* are listed as a part of each management action. The management actions also contain a *timeline* and *facilitator* to guide its implementation.

As stated above, this document, especially the Implementation Plan, is intended to be a living document. This means that its findings and actions must be continuously revisited to ensure that the original management goals are being met and changes to the lake and the needs of the group are being accounted for in the lake's future management.

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 via communications and meetings with the YBCU through their Planning Committee, Board of Directors, and general membership. A description of each stakeholder participation event can be found below, while supporting materials can be found in Appendix A.

Special Mailing I

A special mailing disbursed to members and non-members of the YBCU during the spring of 2005. The mailing included a letter from the YBCU asking current members to renew their memberships and asking non-members to join the group. It also contained a document describing the lake management planning project that was to begin later that spring and announced the time and place of the project kick-off meeting.

Project Kick-off Meeting

The project kick-off meeting was held in conjunction with the annual Eagle River Chain of Lakes Association meeting on August 13, 2005. The meeting was attended by approximately 25 participants and included a presentation by Tim Hoyman, Onterra, LLC. Tim's presentation began with an educational component focusing on the topics of eutrophication, nutrients, the importance of native aquatic plants, and the implications of exotic aquatic plants. This was followed by a description of the project goals and components. A question and answer period was the final topic of the meeting.

Planning Meeting I

Tim Hoyman met with the YBCU Planning Committee following the kick-off meeting on August 13, 2005. The goal of the meeting was to establish a relationship between Onterra and the planning committee and to begin discussions concerning the goals of the management plan. Tim also described the role the committee would have in creating the management plan.

Special Mailing II

The second mailing was disbursed during the early spring of 2006, and again served to remind current members to renew and non-current members to join the YBCU. It also contained a two-page project update created by Onterra.

Planning Meeting II

The second planning meeting was held on July 7, 2006. Tim Hoyman presented the results of the studies to the group and discussed his conclusions. The management goals began to take shape during this meeting.

Project Wrap-up Meeting

The project wrap-up meeting was held with the general membership of the YBCU on July 8, 2006. The primary focus of the meeting's presentation by Tim Hoyman was the study results and a discussion of how they applied to the management of the lake. Over 60 stakeholders attended the meeting.

Newspaper Articles

Four articles were submitted and printed by the Vilas County News Review during this project. The articles were written my Ms. Molly Jaeger with assistance from Onterra. Each article was created to raise public awareness of the project among Yellow Birch Lake riparians and stakeholders that do not own property on the lake. The first article (June 29, 2005) announced the project and its funding by the WDNR and YBCU. It also discussed the components of the project and its objectives. The second article (September 7, 2005) discussed some of the project specifics and stated that no curly-leaf pondweed had been found in the lake. The third article (June 28, 2006) announced the YBCU annual meeting and discussed its agenda. The fourth article was printed following the project wrap-up meeting and outlined the topics discussed by Tim Hoyman of Onterra.

RESULTS & DISCUSSION

Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, not all chemical attributes collected may have a direct bearing on the lake's ecology, but may be more useful as indicators of other problems. Finally, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often 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. In other words, the water quality that impacts and controls the fishery, plant production, and even the aesthetics of the lake are related here. 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.

Comparisons with Other Datasets

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

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

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

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

Lillie and Mason (1983) is an excellent source of data for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Vilas County lakes are included within the study's Northeast Region (Figure 1) and are among 242 lakes randomly sampled from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide natural lake means and historic data from Yellow Birch are displayed in Figures 2-4. Please note that the data in these graphs represent values collected only during the summer months (June-August) from the deepest location in Yellow Birch Lake (Map 1). Furthermore, the phosphorus and chlorophyll-a data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments (see discussion under Internal Nutrient Loading).

Figure 1. Location of Yellow Birch Lake within the regions utilized by Lillie and Mason (1983).

Apparent Water Quality Index

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

Lillie and Mason (1983) used the extensive data they compiled to create the *Apparent Water Quality Index* (WQI). They divided the phosphorus, chlorophyll-*a*, and clarity data of the state's lakes 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 Yellow Birch Lake are displayed on Figures 2-4.

Trophic State

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

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 or not the lake thermally stratifies or not, which is determined primarily through the temperature profiles. Lakes that show strong stratification during the summer and winter months need to be managed differently than lakes that do not. Normally, deep lakes stratify to some extent, while shallow lakes (less than 17 feet deep) do not.

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

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

Internal Nutrient Loading

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

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

Non-Candidate Lakes

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

Candidate Lakes

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

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

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

Yellow Birch Lake Water Quality Analysis

Yellow Birch Lake Long-term Trends

Unfortunately, there is not a great deal of water quality data available for assessing long-term trends within Yellow Birch Lake. Where data exists, there are large gaps between years for which the data was collected. Viewing the total phosphorus, chlorophyll-*a*, and water clarity data (Figures 2-4), it cannot be assessed as a trend towards poorer water quality because of the substantial amount of missing data along this timeline. In many lakes, these parameters, which as stated above are strongly related, fluctuate greatly from year to year. In a drainage lake such as Yellow Birch, precipitation is largely responsible for these fluctuations. Even in lakes with healthy watersheds, high rates of precipitation leading to high rates of runoff often lead to relatively poorer water quality for that year. As shown in Figure 5, Vilas County experienced higher than normal precipitation during 2005. Much of this precipitation occurred in February and June and as a result, the phosphorus concentration may have been abnormally elevated.

During the 2005 growing season, the relationship between phosphorus, chlorophyll-*a*, and water clarity was quite apparent. Compared to past data, the phosphorus levels in Yellow Birch Lake were high, in fact, they would be considered fair within the WQI. These higher phosphorus concentrations fueled algal growth, which in turn, impacted water clarity. During 2005, chlorophyll-*a* and water clarity were found to be poor according to the WQI.

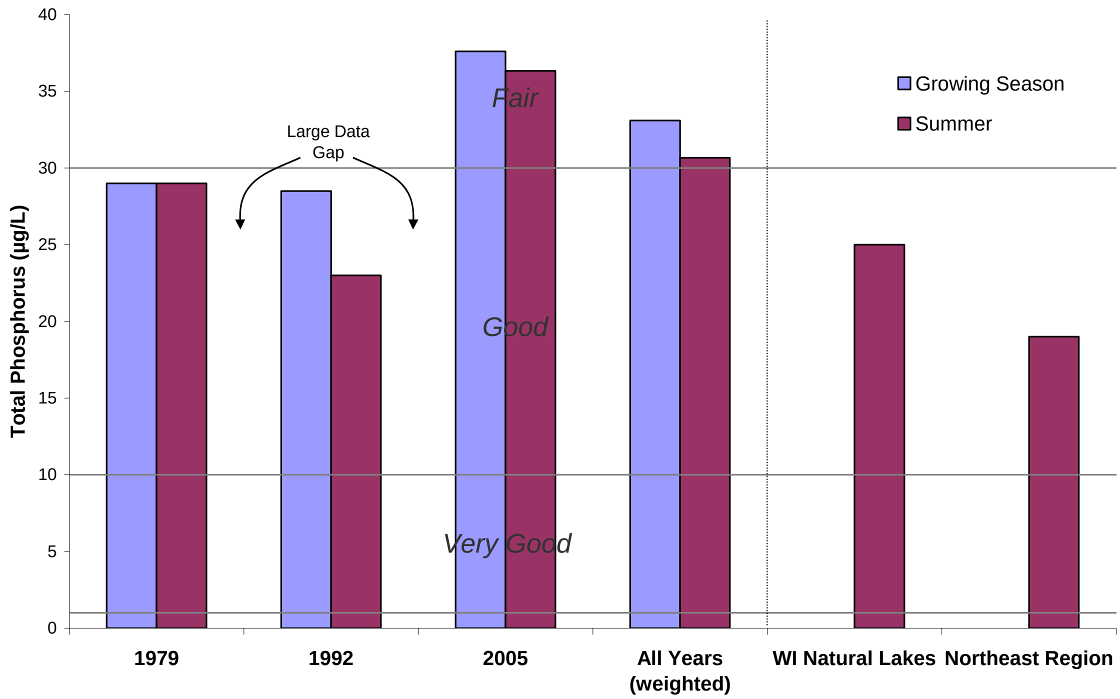

Figure 2. Yellow Birch Lake, regional, and state total phosphorus concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

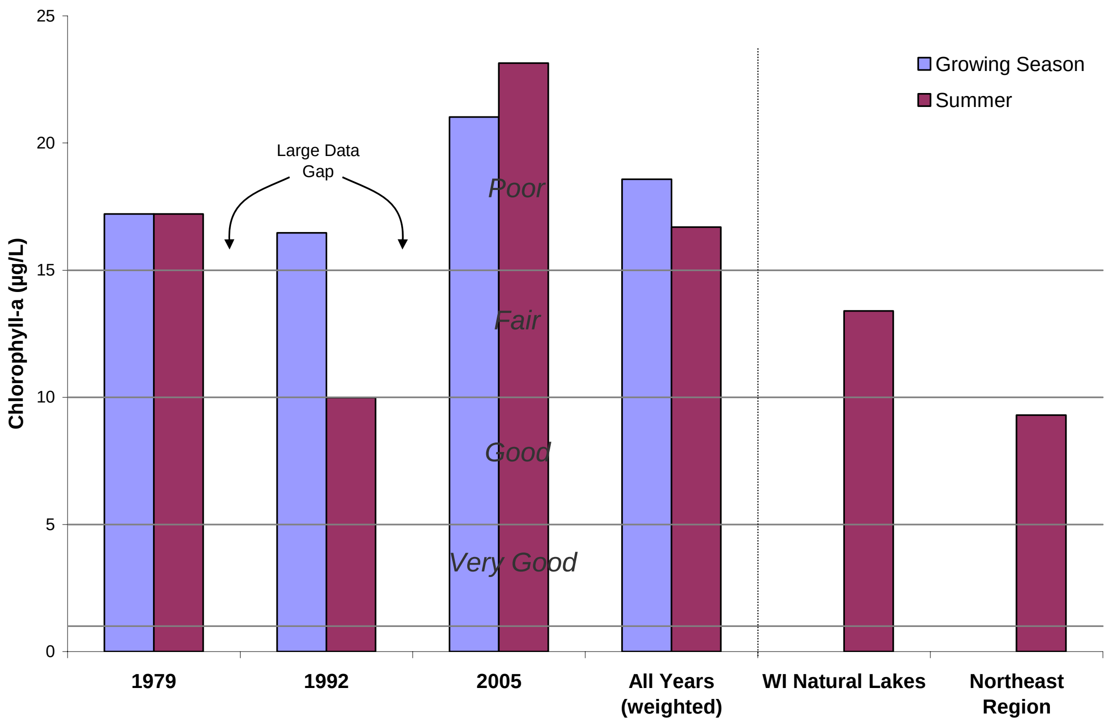

Figure 3. Yellow Birch Lake, regional, and state chlorophyll-*a* concentrations. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

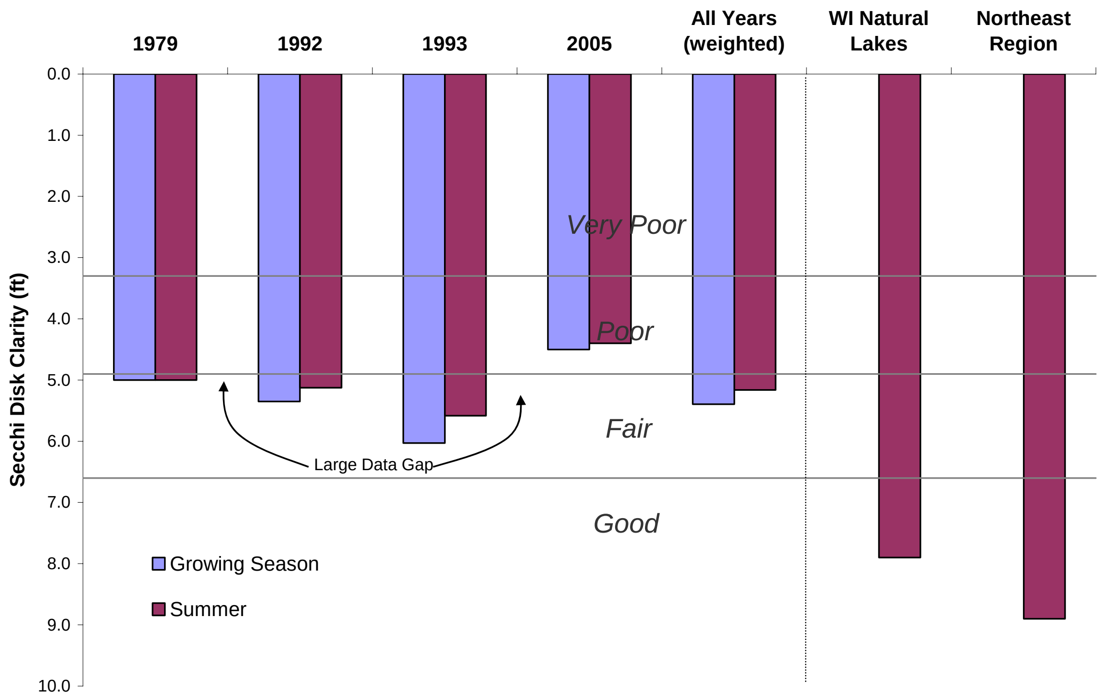

Figure 4. Yellow Birch Lake, regional, and state water clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from Lillie and Mason (1983).

Yellow Birch Lake Trophic State

Figure 6 contains the WTSI values for existing Yellow Birch Lake data and those from regional and state means. Based upon all three parameters, the WTSI indicates that Yellow Birch Lake is a moderately eutrophic system. The tight clustering of the points for each year further demonstrates the strong relationship between phosphorus, algal abundance, and water clarity that exists within the lake. In many lakes, especially those with dense macrophyte communities, this relationship is not as clear and is evidenced by a more scattered placing of the points within each year. This scattered relationship is seen to some degree in the WTSI values for the Wisconsin natural lakes and Northeast Regional lakes in Figure 6.

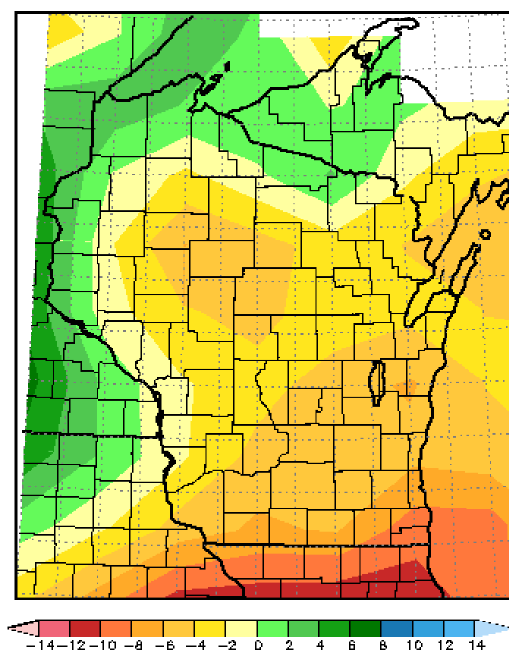

Figure 5. Total precipitation departure from mean in inches 1/1/05-12/31/05. Data from WI State Climatology Office.

As discussed above, the trophic state of a lake essentially describes the productivity of the lake. The fact that Yellow Birch Lake is clearly eutrophic should not be seen as a negative because the lake's relatively high primary (plant) productivity is directly related to the lake's ability to support a large fishery. The fishery of the Eagle Chain of Lakes is well-known for its quality, which would not be possible without the level of productivity found in the system. Although oligotrophic lakes normally have better water clarity than eutrophic lakes, they are unable to support the fish biomass commonly found in more productive systems.

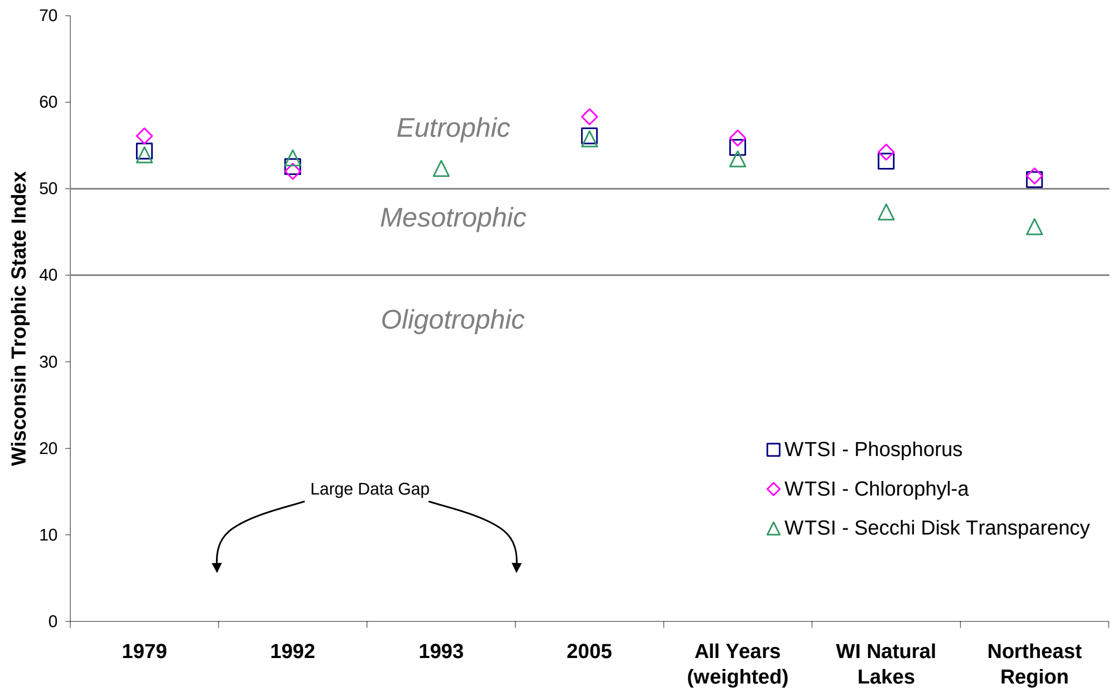

Figure 6. Yellow Birch Lake, regional, and state Wisconsin Trophic State Index values. Values calculated with summer month surface sample data using Lillie et al. (1993).

Limiting Plant Nutrient of Yellow Birch Lake

The nitrogen to phosphorus ratio calculated with growing season means from the available Yellow Birch Lake dataset is approximately 16.1:1. As outlined above, this indicates that plant production in Yellow Birch Lake would be limited by the availability of phosphorus. However, the ratio calculated with means from the 2005 growing season equals 9.3:1, indicating that the productivity is controlled by nitrogen availability. Performing the calculation with actual values collected during July of 2005 indicates that the lake's nutrient limitation is transitional (12:1).

These findings indicate that algal productivity in Yellow Birch Lake, in general, is phosphorus limited, however instances may occur when nitrogen is limiting. The strong relationship between phosphorus and chlorophyll-*a* concentrations discussed above, further indicates that for the most part, Yellow Birch Lake's productivity is controlled by phosphorus.

Dissolved Oxygen and Temperature in Yellow Birch Lake

Profiles completed for Yellow Birch Lake indicate that the lake strongly stratifies during the summer and winter months (Figure 7). The data also indicates that the hypolimnion reaches anoxic or near-anoxic periods during these times; however, sufficient oxygen is present in the epiliminion to support the fishery. Sufficient oxygen is also present during turnover events (May and October, Figure 7).

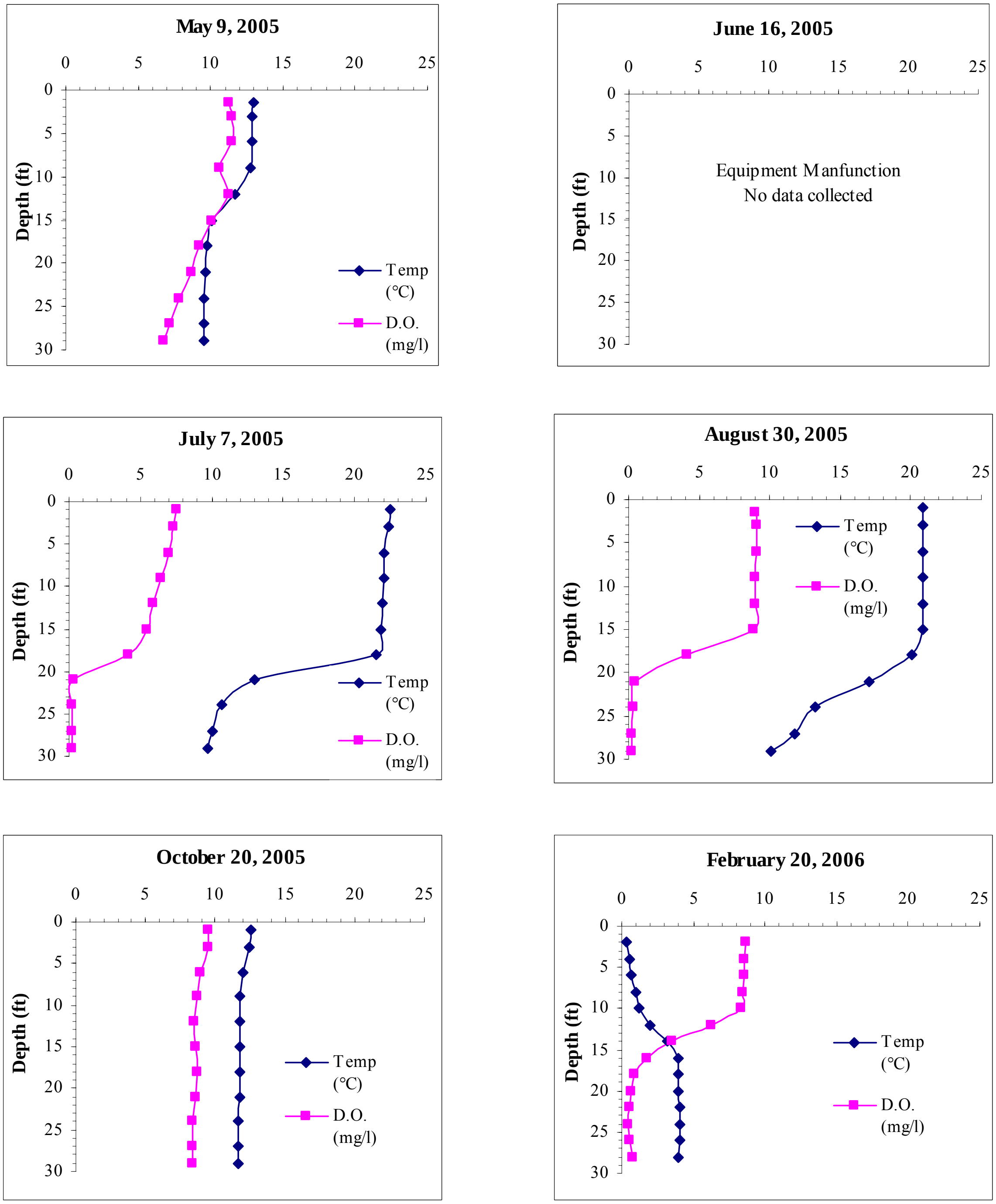

Figure 7. Yellow Birch Lake dissolved oxygen and temperature profiles collected during 2005 and 2006.

Internal Nutrient Loading

Although the hypolimnion supports anoxic conditions throughout the summer and winter months, hypolimnetic phosphorus concentrations during summer stratification averaged only 45 μg/L and the winter sample (February 2006) was only 32 μg/L, which are well below the 200 μg/L threshold. This indicates that it is unlikely that internal phosphorus loading plays an important role in the Yellow Birch Lake phosphorus budget. However, the facts that anoxia develops and is sustained over several months and that phosphorus concentrations reach concentrations much higher than those of the epiliminion, may be an indication that internal nutrient loading may reach significant levels in the future.

Aquatic Plants

Introduction

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

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

Furthermore, rooted aquatic plants prevent shoreline erosion and the resuspension of sediments and nutrients by absorbing wave energy and locking sediments within their root masses. In areas where plants do not exist, waves can resuspend bottom sediments decreasing water clarity and increasing plant nutrient levels that may lead to algae blooms. Lake plants also produce oxygen through photosynthesis and use nutrients that may otherwise be used by *phytoplankton*, which helps to minimize nuisance algal blooms.

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

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

Aquatic Plant Management and Protection

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

Please note: Although many of the control techniques outlined in this section are not applicable to Yellow Birch Lake at this time, it is still important for lake users to have a basic understanding of all the techniques so they can better comprehend why particular methods are or are not applicable in their lake**.**

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now, including manual and mechanical plant removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that length. Furthermore, installation of aquatic plants, even natives, requires approval from the WDNR. It is important to note that local permits and U.S. Army Corps of Engineers regulations may also apply. For more information on permit requirements, please contact the WDNR Regional Water Management Specialist or Aquatic Plant Management and Protection Specialist.

Native Species Enhancement

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

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

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

Cost

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

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

Advantages

Improves the aquatic ecosystem through species diversification and habitat enhancement.
Assists native plant populations to compete with exotic species.
Increases natural aesthetics sought by many lake users.
Decreases sediment and nutrient loads entering the lake from developed properties.
Reduces bottom sediment resuspension and shoreline erosion.
Lower cost when compared to rip-rap and seawalls.
Restoration projects can be completed in phases to spread out costs.
Many educational and volunteer opportunities are available with each project.

Disadvantages

Property owners need to be educated on the benefits of native plant restoration before they are willing to participate.
Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in.
Monitoring and maintenance are required to assure that newly planted areas will thrive.
Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Manual Removal

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

In addition to the hand-cutting methods described above, powered cutters are now available for mounting on boats. Some are mounted in a similar fashion to electric trolling motors and offer a 4-foot cutting width, while larger models require complicated mounting procedures, but offer an 8-foot cutting width.

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

Cost

Commercially available hand-cutters and rakes range in cost from \$85 to \$150. Power-cutters range in cost from \$1200 to \$11,000.

Advantages

Very cost effective for clearing areas around docks, piers, and swimming areas.
Relatively environmentally safe if treatment is conducted after June 15th.
Allows for selective removal of undesirable plant species.
Provides immediate relief in localized area.
Plant biomass is removed from waterbody.

Disadvantages

Labor intensive.
Impractical for larger areas or dense plant beds.
Subsequent treatments may be needed as plants recolonize and/or continue to grow.
Uprooting of plants stirs bottom sediments making it difficult to harvest remaining plants
May disturb *benthic* organisms and fish-spawning areas.
Risk of spreading invasive species if fragments are not removed.

Bottom Screens

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

Cost

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

Advantages

Immediate and sustainable control.
Long-term costs are low.
Excellent for small areas and around obstructions.
Materials are reusable.
Prevents fragmentation and subsequent spread of plants to other areas.

Disadvantages

Installation may be difficult over dense plant beds and in deep water.
Not species specific.
Disrupts benthic fauna.
May be navigational hazard in shallow water.
Initial costs are high.
Labor intensive due to the seasonal removal and reinstallation requirements.
Does not remove plant biomass from lake.
Not practical in large-scale situations.

Water Level Drawdown

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

Cost

The cost of this alternative is highly variable. If an outlet structure exists, the cost of lowering the water level would be minimal; however, if there is not an outlet, the cost of pumping water to the desirable level could be very expensive.

Advantages

Inexpensive if outlet structure exists.
May control populations of certain species, like Eurasian water-milfoil for up to two years.
Allows some loose sediments to consolidate.
May enhance growth of desirable emergent species.
Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.

Disadvantages

May be cost prohibitive if pumping is required to lower water levels.
Has the potential to upset the lake ecosystem and have significant affects on fish and other aquatic wildlife.
Adjacent wetlands may be altered due to lower water levels.
Disrupts recreational, hydroelectric, irrigation and water supply uses.
May enhance the spread of certain undesirable species, like common reed (*Phragmites australis*) and reed canary grass (*Phalaris arundinacea*).
Permitting process requires an environmental assessment that may take months to prepare.
Unselective.

Harvesting

Aquatic plant harvesting is frequently used in Wisconsin and involves the cutting and removal of plants much like mowing and bagging a lawn. Harvesters are produced in many sizes that can cut to depths ranging from 3 to 6 feet with cutting widths of 4 to 10 feet. Plant harvesting speeds vary with the size of the harvester, density and types of plants, and the distance to the off-loading area. Equipment requirements do not end with the harvester. In addition to the harvester, a shore-conveyor would be required to transfer plant material from the harvester to a dump truck for transport to a landfill or compost site. Furthermore, if off-loading sites are limited and/or the lake is large, a transport barge may be needed to move the harvested plants from the harvester to the shore in order to cut back on the time that the harvester spends traveling to the shore conveyor.

Some lake organizations contract to have nuisance plants harvested, while others choose to purchase their own equipment. If the later route is chosen, it is especially important for the lake group to be very organized and realize that there is a great deal of work and expense involved with the purchase, operation, maintenance, and storage of an aquatic plant harvester. In either case, planning is very important to minimize environmental effects and maximize benefits.

Costs

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

Advantages

Immediate results.
Plant biomass and associated nutrients are removed from the lake.
Select areas can be treated, leaving sensitive areas intact.
Plants are not completely removed and can still provide some habitat benefits.
Opening of cruise lanes can increase predator pressure and reduce stunted fish populations.
Removal of plant biomass can improve the oxygen balance in the littoral zone.
Harvested plant materials produce excellent compost.

Disadvantages

Initial costs and maintenance are high if the lake organization intends to own and operate the equipment.
Multiple treatments may be required during the growing season because lower portions of the plant and root systems are left intact.
Many small fish, amphibians and invertebrates may be harvested along with plants.
There is little or no reduction in plant density with harvesting.
Invasive and exotic species may spread because of plant fragmentation associated with harvester operation.
Larger harvesters are not easily maneuverable in shallow water or near docks and piers.
Bottom sediments may be resuspended leading to increased turbidity and water column nutrient levels.

Chemical Treatment

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

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

Both types are commonly used throughout Wisconsin with varying degrees of success. The use of herbicides is potentially hazardous to the applicator, fish, amphibians, reptiles, birds, and non-target plant species, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use. The lake group must also take into consideration that even though these chemicals are labeled for aquatic use by the Environmental Protection Agency for use in aquatic systems, there are still inherent risks in their use because they have not been tested under all possible environmental conditions.

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

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

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

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

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

2,4-D (Navigate®, Aqua-Kleen®, etc.) Selective, systemic herbicide that only works on broad-leaf plants. The selectivity of 2,4-D towards broad-leaved plants (dicots) allows it to be used for Eurasian water milfoil without affecting the majority of our native plants, which are narrowleaved species (monocots). However, some native species, like northern water milfoil, coontail, and bladderwort, are dicots; therefore great care must be taken when using 2,4-D in proximity of these important plants. Many times, treating in early spring, before native species start to grow, can reduce the risk to native dicots considerably. Drinking and irrigation restrictions may apply.

Advantages

Herbicides are easily applied in restricted areas, like around docks and boatlifts.
If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain invasive species, such as Eurasian water-milfoil.
Some herbicides can be used effectively in spot treatments.

Disadvantages

Fast-acting herbicides may cause fishkills due to rapid plant decomposition if not applied correctly.
Many people adamantly object to the use of herbicides in the aquatic environment; therefore, all stakeholders should be included in the decision to use them.
Many herbicides are nonselective.
Most herbicides have a combination of use restrictions that must be followed after their application.
Many herbicides are slow-acting and may require multiple treatments throughout the growing season.

Cost

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

Biological Controls

There are many insects, fish and pathogens within the United States that are used as biological controls for aquatic macrophytes. For instance, the herbivorous grass carp has been used for years in many states to control aquatic plants with some success and some failures. However, it is illegal to possess grass carp within Wisconsin because their use can create problems worse than the plants that they were used to control. Other states have also used insects to battle invasive plants, such as waterhyacinth weevils (*Neochetina spp.*) and hydrilla stem weevil (*Bagous spp.*) to control waterhyacinth (*Eichhornia crassipes*) and hydrilla (*Hydrilla verticillata)*, respectively. Fortunately, it is assumed that Wisconsin's climate is a bit harsh for these two invasive plants, so there is not need for either biocontrol insect. However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian water-milfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian water-milfoil. Wisconsin is also using two species of leaf-eating beetles (*Galerucella calmariensis* and *G. pusilla*) to battle purple loosestrife. These biocontrol insects are not covered here because purple loosestrife is predominantly a wetland species.

Advantages

Milfoil weevils occur naturally in Wisconsin.
This is likely an environmentally safe alternative for controlling Eurasian water-milfoil.

Disadvantages

Stocking and monitoring costs are high.
This is an unproven and experimental treatment.
There is a chance that a large amount of money could be spent with little or no change in Eurasian water-milfoil density.

Cost

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

Primer on Aquatic Plant Data Analysis & Interpretation

Aquatic plants are a fundamental part 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 can be detected and provide critical information for management decisions.

As described in more detail in the methods section, two aquatic plant surveys were completed on Yellow Birch Lake during 2005; the first looked strictly for curly-leaf pondweed, and the second inventoried all aquatic plant species found in the lake. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Species List

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

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Yellow Birch Lake, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, relative frequency of occurrence is used to describe how often each species occurred in the plots that contained vegetation. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

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

Species Diversity

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 as diverse as a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

A lake with high species diversity is much more stable than a lake with a low diversity. This is analogous to 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 index of Yellow Birch Lake are compared to lakes in the same ecoregion (Figure 8) and in the state.

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

The floristic quality of a lake is calculated using its species richness and average species conservatism. As mentioned above, species richness is simply the number of species that occur in the lake, for this analysis, only native species are utilized. Average species conservatism utilizes the coefficient of conservatism values for each of those species in its calculation. A species' coefficient of conservatism value indicates that species' likelihood of being found in an undisturbed (pristine) system. The values range from one to ten. Species that are normally found in disturbed systems have lower coefficients, while species frequently found in pristine systems have higher values. For example, cattail, an invasive native species, has a value of 1, while common hard and softstem bulrush have values of 5, and Oakes pondweed, a sensitive and rare species, has a value of 10. On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality.

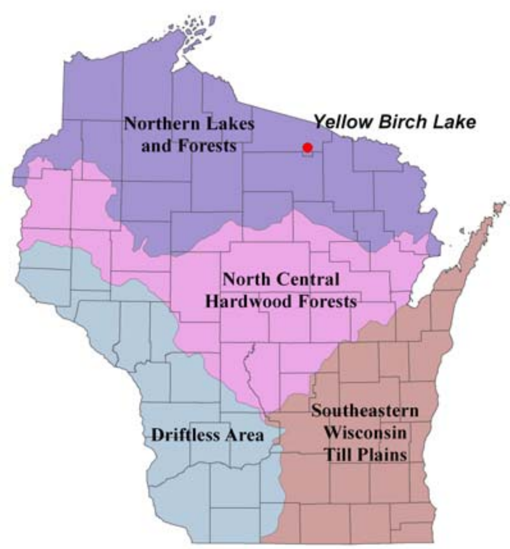

Figure 8. Location of Yellow Birch Lake within the ecoregions of Wisconsin. After Nichols 1999.

Community Mapping

A key component of the aquatic plant survey is the creation of an aquatic plant community map. The map represents a snapshot of the important plant communities in the lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with future surveys. 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.

Exotic Plants

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

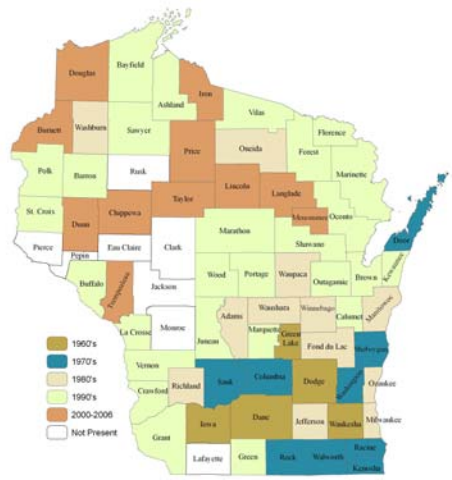

Figure 9. Spread of Eurasian water milfoil within WI counties. WDNR Data 2006 mapped by Onterra.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 9). 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 equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

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

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

2005 Yellow Birch Lake Aquatic Plant Surveys

The aquatic plant surveys completed in 2005 discovered 27 aquatic plant species within Yellow Birch Lake (Table 1). No curly-leaf pondweed was located during the survey completed on June 16, 2005. Eurasian water milfoil was located in Yellow Birch Lake during the comprehensive survey completed on August 23-24, 2005 and is expanded upon below.

Table 1. Aquatic plant species located in Yellow Birch Lake during 2005 surveys.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)
Emergent	Carex comosa*	Bristly sedge	5
	Carex lacustris	Lake sedge	6
	*Eleocharis palustris**	Creeping spikerush	6
	Lythrum salicaria	Purple loosestrife	Exotic
	Sagittaria latifolia	Common arrowhead	3
	Typha latifolia	Broad-leaved cattail	1
FF	*Lemna minor*	Lesser duckweed	5
FL	*Nuphar variegata*	Spatterdock	6
	Nymphaea odorata	White water lily	6
FL/E	*Sparganium angustifolium*	Narrow-leaf bur-reed	9
	Sparganium emersum	Short-stemmed bur-reed	8
Submergent	*Ceratophyllum demersum*	Coontail	3
	Chara sp.	Muskgrasses	7
	Elodea canadensis	Common waterweed	3
	Heteranthera dubia	Water stargrass	6
	Myriophyllum heterophyllum	Various-leaved water milfoil	7
	Myriophyllum sibiricum	Northern water milfoil	7
	Myriophyllum spicatum	Eurasian water milfoil	Exotic
	Najas flexilis	Slender naiad	6
	Potamogeton amplifolius	Large-leaf pondweed	7
	Potamogeton epihydrus	Ribbon-leaf pondweed	8
	Potamogeton pusillus	Small pondweed	7
	Potamogeton richardsonii	Clasping-leaf pondweed	5
	Potamogeton robbinsii	Fern pondweed	8
	Potamogeton spirillus	Spiral-fruited pondweed	8
	Potamogeton zosteriformis	Flat-stem pondweed	6
	Vallisneria americana	Wild celery	6

FF = Free Floating
FL = Floating Leaf
FL/E = Floating Leaf and Emergent
* = Incidental

Common waterweed was found to be the most abundant plant during the August 2005 survey (Figure 10). In fact, common waterweed made up slightly more than 20% of the population. Although it was the most abundant plant, it did not totally dominate the lake as other species, such as spiral-fruited pondweed and wild celery, were also found in relative frequencies over

10%. The remaining species found in the lake were somewhat evenly distributed; therefore, the species diversity of Yellow Birch Lake is relatively high at 0.90. For comparison purposes, other lakes in Vilas County that would be considered less disturbed than Yellow Birch were found to have very high diversities ranging from 0.91 to 0.93 during 2004 and 2005.

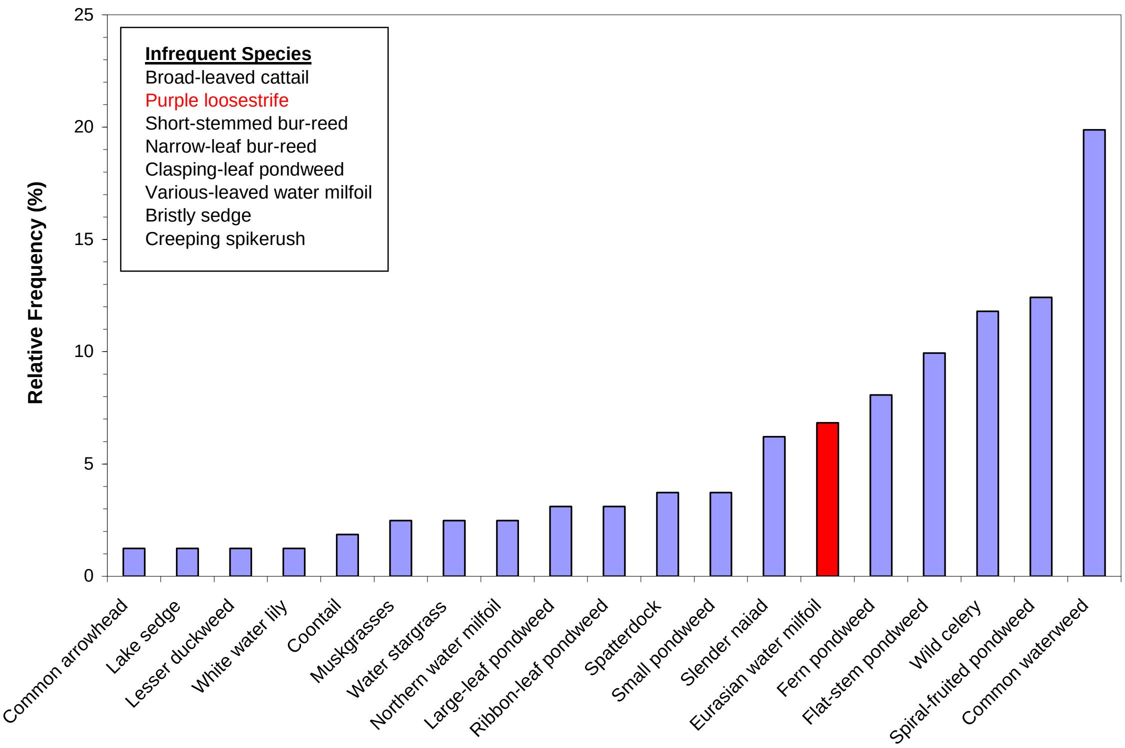

Figure 10. Yellow Birch Lake aquatic plant occurrence analysis of 2005 survey data. Exotic species indicated with red.

Twenty-five native species were included in the Floristic Quality Analysis for Yellow Birch Lake (Figure 11). This value is nearly twice the median values for the state and Northern Lakes and Forests – Lakes ecoregion, and in fact is in the upper quartile for both. The average conservatism value for Yellow Birch Lake is even with the state median and significantly less than that of the ecoregion. Neither of these findings is surprising considering the lakes Yellow Birch is being compared to. The state median takes into account many lakes from all of the ecoregions of the state, including lakes in southern portions of the state which are known to be highly disturbed by shoreland development and recreational activities. On the other hand, the lakes of the Northern Forests and Lakes ecoregion, for the most part, are less disturbed by these activities. In fact, some of the lakes used to calculate the median may be nearly pristine because they lack shoreland development entirely and may only be used for passive recreation. In the end, the average coefficient of conservatism for Yellow Birch Lake reflects the high level of recreational use and shoreland development that occurs at the lake.

Median Value is the value that roughly half of the data are less and half the data are higher. 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.

Combining the native species richness and average conservatism values results in a floristic quality of 29.8, which is higher than both the state and ecoregion means. This value is within the upper quartile among state lakes, but not within it for the ecoregion lakes. Considering the relatively low average conservatism value for Yellow Birch Lake, it is apparent that species richness is largely responsible for the high floristic quality value. In some lakes, a high species richness is found compared to the values listed in Nichols (1998) because native species are included within the lake's value that were not considered "lake plants" by the author. Many of those species were considered by Nichols to be wetland species. Particular to the Yellow Birch Lake findings, only a single species (lake sedge) was included in its species richness that was not included in Nichols (1998); meaning that comparisons between the Yellow Birch Lake data and those from the state and ecoregion are valid. In the end, the floristic quality of Yellow Birch Lake would be considered quite high with the reservation that although the lake has many species, many of those species indicate that the system is moderately disturbed.

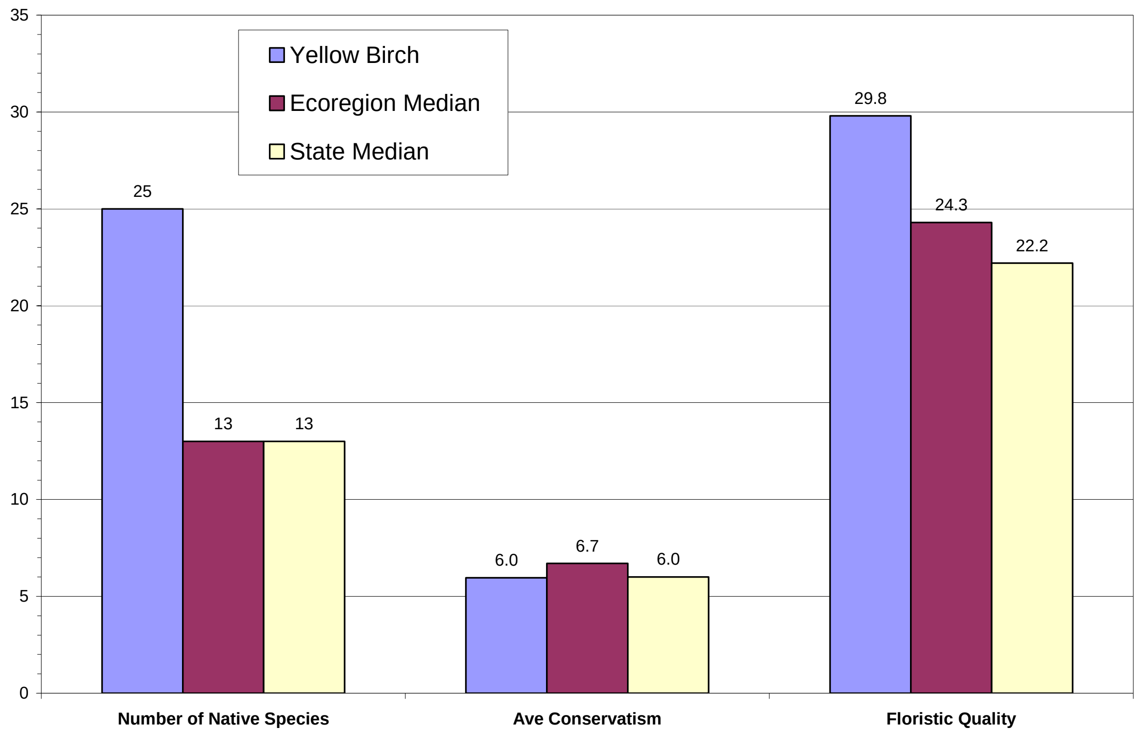

Figure 11. Floristic Quality Analysis using data from 2005 aquatic plant surveys completed on Yellow Birch Lake. Analysis following Nichols 1999.

The most surprising result of the plant surveys completed at Yellow Birch Lake was that very little macrophytic biomass occurs within the lake as a whole. In fact, only 24.9% of the plots sampled under the maximum depth of plant growth (12 feet) found during the study contained plants. This means that much of the area considered as the littoral area of the lake is actually barren of plants. Furthermore, just over 50% of the sites sampled at 4 feet or less contained plants. This finding was also demonstrated during the community mapping survey. As Map 2 indicates, very few emergent and floating-leaf communities were located and in fact, the vast majority of the shoreline is without this type of habitat. The exception to this are the dominant emergent and floating-leaf communities that thrive in the near-shore areas of the bay northeast of the boat landing. In fact, this area also showed the densest growth of submergents too.

Multiple factors are probably responsible for the lack of macrophytic biomass; the most obvious being light penetration because of the relatively high amount of algae in the lake (see Water Quality Section). The average growing season Secchi disk reading using all available data for Yellow Birch Lake is approximately 5.2 feet. In most lakes, sufficient light for plant growth penetrates to about 2.5 times the Secchi disk depth, or about 13 feet in Yellow Birch Lake. This appears to be in order because, as mentioned above, plants were found in Yellow Birch Lake at a maximum depth of 12 feet. However, this suggests that although light penetration may be somewhat limiting, it cannot be the sole factor.

Substrate composition often limits the amount of plant growth within a lake, especially if much of the substrate is rocky. In Yellow Birch Lake, over 80% of the plots sampled were sandy, while roughly 14% were mucky and 5% were rocky. Sand is not the preferred substrate for many aquatic plants native to Wisconsin, however, both slender naiad and wild celery prefer these harder substrates. Also, both of these plants do well in turbid waters, yet both were only found to a very limited degree in Yellow Birch Lake.

Considering the eutrophic nature of Yellow Birch Lake, lack of nutrients is not likely the primary cause either. Again, it is likely a combination of factors, including those discussed above and to some extent, those brought to the lake by humans. It may well be that shoreland development and recreational use, especially high-speed boating, may be at least partially responsible for the lack of macrophytic vegetation in the lake. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. 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/or declines and higher turbidity were associated with motorboat traffic.

Exotic Plant Species

Eurasian Water Milfoil

The YBCU was formed under the concerns of Eurasian water milfoil infestation and spread within Yellow Birch Lake. The organization sponsored chemical treatments of Eurasian water milfoil in 2004 and 2006 (8 acres and 2.2 acres, respectively) and voluntarily abstained from treatment in 2005 so the studies completed during that summer would not be affected.

Only a few single plants and small clumps of Eurasian water milfoil were located during the plant inventories completed in June and August of 2005, with the greatest amount being in the bay northeast of the boat landing (known locally as the "Bullpen") (Map 2). These locations along with those found later in the summer by Mr. Cliff Schmidt of Schmidt's Aquatic Plant Control, were combined to create an approximate 2.7-acre treatment plan for the early spring of 2006 (Map 3). Restrictions placed upon the treatment by the WDNR limited the application areas to within 100 feet of the shoreline, which ultimately excluded Site 6 from treatment and reduced the treatment area to approximately 2.2 acres.

Mr. Schmidt visited the lake in the late summer of 2006 and reported only minor sightings of Eurasian water milfoil within the lake that may require a 2-acre or less treatment during the spring of 2007.

The density and extents of Eurasian water milfoil growth within Yellow Birch Lake are likely limited by many of the same factors as the native plants. Most prevalent are the predominant hard substrates and light penetration. The area most threatened by Eurasian water milfoil is the bay north of the boat landing because of its soft substrates and relatively shallow depths.

Purple Loosestrife

Purple loosestrife was found in numerous locations on the shoreline of Yellow Birch Lake (Map 2). The densest area was located just east of the boat landing on the point before entering the bay.

Photo 1. Purple loosestrife on the east shore of Yellow Birch Lake. Photo taken August 2006.

Purple loosestrife is native to Europe and Asia where local insects and diseases keep its population in check. This wetland perennial spreads primarily by seed and each plant is capable of producing more than 100,000 seeds per year. These seeds remain viable in the soil until environmental conditions become right for them to germinate. In North America, this plant is free from its natural control mechanisms and is able to out-compete and literally shade-out the vulnerable native wetland plants. It is these native plants that are at the foundation of the wetland ecosystem and are what the native wildlife depend on for food and shelter.

Fortunately, many methods of control are available for purple loosestrife. Furthermore, the Vilas County Land and Water Conservation Department has been active in purple loosestrife control in many other areas of the county.

Watershed Analysis

The watershed of Yellow Birch Lake is extremely large at approximately 154,131 acres (Map 4). It is made up of two large subwatersheds, the Deerskin Creek watershed of approximately 40,237 acres and the 113, 894-acre Eagle River watershed. The watershed to lake area ratio of these combined systems is roughly 763:1, meaning that every acre of Yellow Birch Lake (202) has about 763 acres of land draining to it. This would be considered an incredibly large watershed to lake area ratio.

In most cases, a watershed to lake area ratio of this size would mean that the lake would be highly eutrophic regardless of the land coverages that occur in the watershed. However a number of factors work to buffer Yellow Birch Lake from these negative impacts and allow it to be moderately eutrophic as discussed in the Water Quality Section. First, Yellow Birch Lake is one of many lake systems within the watershed. In fact, Geographic Information System (GIS) analysis indicates that the Deerskin Creek watershed contains over 3,100 acres of open water while the Eagle River watershed contains nearly 13,600 acres. Essentially, these open water areas act to buffer Yellow Birch Lake from the negative impacts of the large watershed by acting as expansive settling basins for nutrients and sediments.

Second, the large watershed produces a great deal of runoff to Yellow Birch Lake and results in a very high flushing rate. Because of the sheer magnitude of the watershed, determining the actual flushing rate of the Yellow Birch Lake would be impossible without conducting long-term flow studies at the lake's inlet and outlet. However, through the use of modeling procedures the flushing rate can be roughly estimated. Modeling of the watershed in the Wisconsin Lake Modeling Suite (WiLMS) indicates that the flushing rate of Yellow Birch Lake to be approximately 83.26 times per year; meaning that the water in Yellow Birch Lake is replaced about every 4 days. With higher flushing rates comes better water quality, especially when the inflowing water is moderately good quality as described below.

The final factor allowing Yellow Birch Lake to be moderately eutrophic is the condition of the watershed. In other words, the quality land cover that exists in the watershed minimizes 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 reduce infiltration and increase surface runoff. The increased surface runoff associated with these land cover types leads to increased pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations.

GIS analysis of the Yellow Birch Lake watershed using land cover data from the Wisconsin Initiative for Statewide Cooperation on Landscape Analysis and Data (WISCLAND) indicates that the vast majority of land to be in the forested state (Figure 12). Forested land exports the least amount of phosphorus compared to other land use types.

Overall, this means that even though Yellow Birch Lake has a very large watershed, its water quality is better than would be expected.

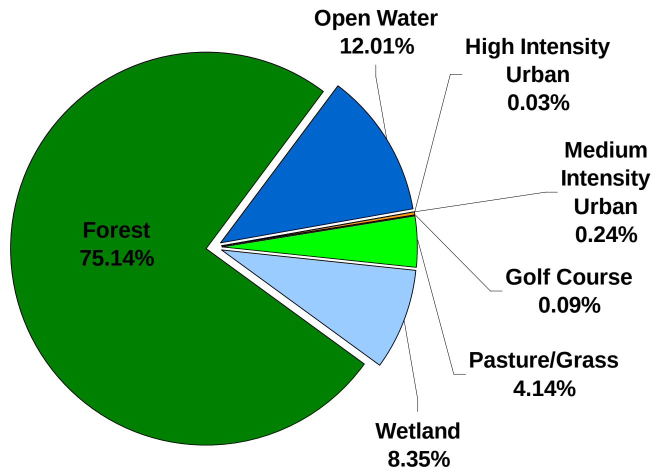

Figure 12. Yellow Birch Lake watershed land cover types. WISCLAND data.

SUMMARY AND CONCLUSIONS

Much of what occurs in Yellow Birch Lake is, in reality controlled by its geography. The fact of the matter is that Yellow Birch Lake is a relatively small lake among 16,700 acres of lakes, within a vast watershed. As a result, many of the lake's attributes are controlled by factors that originate far from the shores of Yellow Birch Lake. Fortunately, like most situations, there are advantages and disadvantages to this one too. The key to successful management of Yellow Birch Lake is working to maximize the advantages while minimizing the disadvantages.

The water quality assessment indicates that Yellow Birch Lake is moderately eutrophic; meaning that the lake is able to support moderately high rates of plant production. The data suggests that the production, for the most part, is controlled by phosphorus as evidenced by average nitrogen to phosphorus ratios and the close correlation between chlorophyll-*a* levels and phosphorus concentrations. The chlorophyll-*a* – phosphorus relationship extends to the clarity of the water because Secchi disk depths decrease with increased phosphorus concentrations.

As stated in the Water Quality Section, the eutrophic nature of Yellow Birch Lake should not be regarded as a negative, but as a positive because the lake's production allows it to support a higher fish biomass than a lake that is less productive. Considering the high watershed to lake area ratio, Yellow Birch Lake has likely been eutrophic from nearly the beginning of its existence. This can be demonstrated by modeling the phosphorus inputs to the lake using the current watershed boundaries and presettlement coverages.

By assuming that the watershed was primary forested and existing wetland areas (including open water areas) occurred before settlement by humans, we can roughly estimate the watershed load of phosphorus to Yellow Birch Lake. For this scenario, the land coverages displayed in Figure 12 that are considered anthropogenic modifications to the original watershed (urban development, golf course, and pasture/grass) were changed to forested. Modeling of this scenario indicates that just over 6 tons of phosphorus would enter Yellow Birch Lake from its watershed yielding a growing season mean phosphorus level of approximately 24 μg/L. Using the WTSI procedure, that level of phosphorus would indicate that Yellow Birch Lake is moderately eutrophic. Comparing the modeled growing season mean to that of the actual mean found in the lake (24 and 33.2 μg/L, respectively) indicates that humans have likely accelerated the eutrophication of Yellow Birch Lake, but not to the extent that its category of production (trophic state) has been severely altered.

The analysis described above should not be taken as an indication that controlling the production in, especially that of algae, is beyond our control. Actually, minimizing the eutrophication rate of Yellow Birch Lake can be achieved by controlling the actions that increase runoff to the lake. The clearest target for this control rests on the immediate shorelands of the lake. In other words, reducing nutrient runoff to the lake from shoreland properties is likely the best short-term action that can be undertaken to minimize the rate of cultural eutrophication in Yellow Birch Lake. Efforts should focus on minimizing shoreland habitat loss, which equates to reduced buffering capacity of these areas and through minimization of impervious surfaces which increase runoff rates and pollutant delivery to the lake. This does not mean that controlling runoff in other areas and shorelands of the watershed will not have a positive impact, but a realistic management plan would start with a goal to minimize the impacts in the areas immediately adjacent to Yellow Birch Lake and move out to other areas of the watershed once that goal is met.

The aquatic plant survey analysis indicated that the existing plant community of Yellow Birch Lake is of high floristic quality and diversity. It also indicated that although the lake's plant community is very good, there is evidence of disturbance based upon the species of plants that occur in the lake. Furthermore, there is a surprising lack of plant abundance as evidenced by the point-intercept survey results and the community mapping efforts. The cause of the unexpected lack of plant abundance is not fully understood; however, a combination of factors may be responsible, including predominantly hard substrates, low light penetration, and human impacts through shoreland development and recreational use. An important aspect of the management of this lake will be to increase the understanding of the lake's plant community by completing the point-intercept survey and community mapping again in five to seven years. This should be done sooner if large-scale manipulations, such as chemical treatments, are completed on an annual basis.

Two exotic plants were found during the surveys completed during the summer of 2005; Eurasian water milfoil and purple loosestrife. Both plants were not found to be abundant or dense within any areas of the lake, so control is definitely feasible at this time.

The primary goal of any aquatic plant management activities that occur within the lake should be to protect the limited occurrence of native aquatic plants within Yellow Birch Lake. This means that activities that directly destroy the habitat are refrained from and that activities that protect it are completed. As described in the Aquatic Plant Section, shoreland development has been shown to have definite negative impacts on native plant communities and in the long-term, is likely the biggest threat to the well being of the lake's plant community. These impacts include the direct loss of important habitat and indirect impacts on lake fisheries. Protecting existing natural shorelands and restoring those areas already lost to urbanization would do much to protect and possibly enhance the native aquatic plant habitat of Yellow Birch Lake. Further, these activities would also reduce nutrient loading to the lake as discussed above.

In the short-term, the expansion of Eurasian water milfoil and purple loosestrife abundances will likely have the most profound impact on the lake's native habitat value. As described above, control of both plants is probable and has already been demonstrated with Eurasian water milfoil. The key to controlling the plant on a lake-wide basis will be keeping on top of it, not only in terms of treatment activities, but more importantly in terms of monitoring the areas of occurrence and treatment effectiveness. Building partnerships between Yellow Birch Lake volunteers, Vilas County, and the WDNR will increase the effectiveness of the control plan.

The fact that Yellow Birch Lake is the final lake in a long chain of lakes has been mentioned in the document numerous times. The fact is important in the terms of the study results, but it is also important in the terms of how the lake should be managed. Managing Yellow Birch Lake as if it were not apart of Eagle River Chain of Lakes would be pointless because so much of what happens in Yellow Birch Lake is determined through the actions of those on the other chain lakes. One example is the management of Eurasian water milfoil. Even if it could be eradicated from Yellow Birch Lake, its downstream position and highly used boat landing would likely result in re-infestation at some time. Another example is shoreland impacts. Although reducing shoreland loadings from the properties of Yellow Birch Lake would be good for the lake, a greater impact could be realized if all the lakes in the chain reduced their shoreland loadings too.

It is realistically beyond the ability of the YBCU to solely initiate and complete these management activities outside of Yellow Birch Lake. However, continued partnerships with the Eagle River Chain of Lakes Association, the Town of Washington, Vilas County, the WDNR and the newly formed Unified Lower Eagle River Chain of Lakes Commission will do much to spur these activities chain-wide.

IMPLEMENTATION PLAN

The Implementation Plan outlined below is the first step in the continued management of Yellow Birch Lake. It is comprehensive in scope by not focusing on any single aspect of lake management planning. The plan is intended to be flexible to accommodate future changes in the needs of the lake and its watershed, those of the YBCU and other stakeholders, and future changes in the YBCU itself.

Management Goal 1: Create a Better Understanding of Yellow Birch Lake Water Quality

Management Action: Initiate lake water quality monitoring and subsequent reporting of results to stakeholders and WDNR.

Timeframe: In progress

Facilitator: Board of Directors

Description: A volunteer from Yellow Birch Lake has been partially trained by the WDNR as a part of their Citizens Lake Monitoring Network. Completing the training and initiating the water quality sampling will be important in building the long-term data set that is currently lacking for Yellow Birch Lake. As this database is created, a better understanding of the lake's water quality will be possible.

Action Steps:

1. Contact current volunteer to see if he is still interested in participating and if not, recruit new volunteer.
2. Complete volunteer training and initiate monitoring under current WDNR Citizen Lakes Monitoring Network protocols.
3. Provide periodic reports comparing results to stakeholders.
4. Consult with WDNR water resource specialists if unusual trends, either positive or negative, develop in the dataset.

Management Goal 2: Minimize Watershed Nutrient Loads to Yellow Birch Lake

Management Action: Provide education and information to shoreland property owners regarding shoreline protection and restoration, including shoreland protection/restoration and minimizing impact of impervious surfaces.

Timeframe: 2008

Facilitator: Education Committee

Description: Assuming the watershed outside of the immediate shorelines of Yellow Birch Lake remains in its current, nearly natural condition, the most likely source of increased nutrient loading to the lake is shoreland properties. Many of the current developed areas surrounding the lakes are in acceptable condition to buffer the lake from increased nutrient loads. However, as properties exchange owners, or the perceived needs of current riparians change, modifications to existing buffer areas may impact the lake. The education of current and new land owners concerning their property's impact to the lake is important in minimizing this threat.

As this initiative builds a foundation within the YBCU, other chain lakes should be contacted to initiate a similar management action (if one does not exist) among their riparians.

WDNR Lake Protection Grants would be an appropriate source to provide partial funding of this initiative.

Action Steps:

1. Using existing information and materials available from UW-Extension, the WDNR, and Vilas County, along with data and conclusions included in the management plan to create a guide to shoreland property ownership on Yellow Birch Lake.
2. Distribute guide to current property owners.
3. Monitor sales of existing properties and provide copies of the guide to the new owners.
4. Reinforce the information presented in the guide by providing updates and additional information in YBCU newsletter (see below).

Management Goal 3: Increase Organizational Capacity of the Yellow Birch Lake Conservation Union and its Partnerships

Management Action: Increase and maintain membership of Yellow Birch Lake Conservation Union

Timeframe: Begin 2007

Facilitator: Membership Committee and/or Jon Socolofsky

Description: Strength truly lies in numbers. There are 106 households on the lake, having all of those households as members may be unrealistic, but having 80% as members may not be. With increased membership comes a more stable volunteer base, increased funds, and a diverse range of ideas.

A WDNR Small-scale Planning Grant would be an applicable source of partial funding for these actions.

Action Steps:

1. Verify current membership using existing YBCU records and Vilas County parcel information (already obtained).
2. Contact non-member households via a special mailing. The special mailing will include descriptions of past accomplishments of the YBCU and its future plans along with a summary of this project's conclusions.
3. Follow through with calls and/or home-visits of non-responsive households.
4. Conduct YBCU annual meetings using the successful methods utilized in July 2006.

Management Action: Increase YBCU communication capacity with its members and non-members.

Timeframe: Begin 2007

Facilitator: Board of Directors and/or Molly Jaeger

Description: Communication is an important aspect of every conservation organization. Continued and informative communication within an organization keeps its presence, goals, and ideology fresh in the minds of its members. Similar communications with potential members helps the organization to gain respect and portrays the group's stability.

A WDNR Small-scale Planning Grant would be an applicable source of partial funding for these actions.

Action Steps:

1. Recruit volunteers to form Communication Committee.
2. Committee gathers information and creates layout of first YBCU newsletter.
3. Board of Directors reviews and provides guidance on newsletter draft.
4. Revisions incorporated into first newsletter.
5. Mailings completed.

Management Action: Foster new and fortify existing partnerships with other area conservation organizations.

Timeframe: Begin 2007

Facilitator: Board of Directors and/or Communication Committee

Description: The creation and maintenance of productive partnerships among conservation organizations allows for efficient meeting of common goals. This is important in any conservation organization; however, because of Yellow Birch Lake's existence with the Eagle River Chain of Lakes and that chain's association with the Three Lakes Chain, the YBCU's participation in these partnerships is vital to the meeting of nearly all of its management goals. Potential partners of the YBCL include Eagle River Chain of Lakes Association, the Town of Washington, City of Eagle River, Three Lakes Waterfront Association, Vilas County Invasive Species Partnership, and the Wisconsin Association of Lakes.

Currently, the Town of Washington (list other sponsors here) are sponsoring the completion of a chain-wide management plan for the Eagle River Chain of Lakes. At this time, the findings of the studies associated with the project are unknown, as are the management goals and actions of the plan. Integrating this missing information into the Yellow Birch Lake Management Plan would be completed as a part of this management action.

Action Steps:

1. Finalize list of potential YBCU partners.
2. Research purpose of each entity to determine basis of partnership with YBCU.
3. In none exists, establish contact with each prospective partner.
4. Continue communication with partners through one or multiple avenues as applicable:
    a. Attend partner meetings.
    b. Subscribe to partner newsletters and general communications.
    c. Send YBCU newsletters and applicable communications to partners.

   d. One-to-one contact via email, conventional mail, telephone, and face-to-face meetings.
5. Report relevant partnership news and events to Yellow Birch Lake Stakeholders through the YBCU newsletter.

Management Goal 4: Control Aquatic Invasive Species

Management Action: Initiate watercraft inspections at Yellow Birch Lake public boat landing.
Timeframe: 2008 or sooner
Facilitator: Aquatic Invasive Species Committee
Description: Participating in an in-lake aquatic invasive species control project without attempting to prevent further introductions is pointless. This is especially important in lakes such as Yellow Birch where light infestations occur and the boat landing is heavily used. Furthermore, this action will have an additional objective of preventing AIS from leaving Yellow Birch Lake and as a result help to stop the further spread of these exotics to area waterways.

If this management action is a part of the Eagle River Chain of Lakes management plan, our efforts will be integrated with the chain's efforts.

Action Steps:

1. Train core group of volunteers through WDNR Clean Boats Clean Waters training sessions. This group can then train others to assist in the monitoring efforts.
2. Initiate periodic boat inspections during high-risk weekends and expand as volunteer capacity allows.
3. Report results to YBCU and WDNR.
4. Promote enlistment and training of new of volunteers to keep program fresh.

Management Action: Initiate in-lake invasive species monitoring.
Timeframe: 2007
Facilitator: Aquatic Invasive Species Committee
Description: Early detection of aquatic invasive species is key to preventing the establishment of these species if introduction were to occur. This task includes the monitoring of Yellow Birch Lake for Eurasian water milfoil (primarily new infestation sites), curly-leaf pondweed, purple loosestrife, and adult zebra mussel infestations. The monitoring would be completed using the protocols created by the WDNR and UW-Extension. Expansion of the program to include other AIS, such as rusty crayfish will be determined through discussions with WDNR specialists.

Action Steps:

1. Train a core group of volunteers based upon the WDNR/UW-Extension protocols. This group can then train others to assist in the monitoring efforts.
2. Perform annual lake inspections for invasives.
3. Report annual results to YBCU and WDNR and adjust invasives control plan accordingly.
4. Promote enlistment and training of new of volunteers to keep invasives monitoring program fresh.

Management Action: Continue Eurasian water milfoil control efforts through monitoring and chemical treatments.

Timeframe: Begin early spring 2007

Facilitator: Aquatic Invasive Species Committee

Description: The YBCU has been successfully controlling Eurasian water milfoil with 2,4-D applications since 2004. However, monitoring of the effectiveness of these treatments has been somewhat lacking. The YBCU, in conjunction with other management units as applicable, will continue annual, early spring treatments of Eurasian water milfoil as needed and permitted by the WDNR. The need and extents of treatments will be determined annually as the findings of the in-lake invasive species monitoring (see above) dictates. The objective of this management action is to stop the spread of Eurasian water milfoil within Yellow Birch Lake through efficient treatments and monitoring of treatment effectiveness. Treatment monitoring will be based upon guidance supplied by the WDNR.

Action Steps:

1. Obtain conditional chemical application permit based upon 2006 Eurasian water milfoil findings of Mr. Cliff Schmidt (approximately 2-3 acres).
2. Complete pretreatment survey of treatment areas based upon WDNR guidance.
3. Refine treatment areas and finalize permit based upon pretreatment survey findings.
4. Assess treatment effectiveness following WDNR guidelines.
5. Determine treatment plan for 2008 based upon findings of post treatment assessment and findings of 2007 in-lake invasives monitoring.
6. Continue same pattern into the future taking into consideration alternative methods of control as applicable.

Management Action: Initiate purple loosestrife control program.

Timeframe: Begin 2007

Facilitator: Aquatic Invasive Species Committee

Description: As described above, numerous, but small occurrences of purple loosestrife have been identified along the shoreline of Yellow Birch Lake. Control of the AIS is essential in protecting the native emergent habitat that also occurs in these areas. The YBCU would rely primarily on the expertise of the Vilas County Lakes Specialist to guide this action.

Action Steps:

1. Contact Vilas County Lakes Specialist
2. Review applicable control options.
3. Initiate control procedure and monitor results.
4. Alter plan as applicable.

METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Yellow Birch Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in the lake and 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 normal protocols. All samples were shipped to the Wisconsin State Laboratory of Hygiene for analysis. The parameters measured included the following:

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

In addition, during each sampling event Secchi disk transparency was recorded and a temperature, pH, conductivity, and dissolved oxygen profile was be completed using a Hydrolab DataSonde 4.

Aquatic Vegetation

A quantitative aquatic vegetation survey was conducted during July 2005 using the point-intercept method as described in "Appendix C" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin - Draft, (April 25, 2005) was be used to complete the study. Based upon advice from the WDNR, a point spacing of 45 meters was used resulting in 416 points (Appendix C). Furthermore, all species found outside the set points were recorded to provide a complete species list for the lake.

Watershed Analysis

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