Mount Morris Lake

Waushara County, Wisconsin

Comprehensive Lake Management Plan

June 2006

Sponsored by:

Mount Morris Lake Management District

&

Wisconsin Department of Natural Resources Lake Management Grant Program

LPL-922-04 & LPL-923-04

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Lake Management Planning

Mount Morris Lake

Waushara County, Wisconsin

Comprehensive Management Plan

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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:

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TABLE OF CONTENTS

FIGURES

TABLES

MAPS

APPENDICES

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 impacts the lake. Stakeholder input regarding the development of this plan was obtained through communications and meetings with the Mount Morris Lake Management District (MMLMD). A description of each stakeholder participation event can be found below, while supporting materials can be found in Appendix A.

Kick-off Meeting

On June 5, 2004 the MMLMD held a special meeting to inform district members and other interested parties about the lake management planning project the district was undertaking. During the meeting, Tim Hoyman presented information about lake eutrophication, native and non-native aquatic plants, and the importance of lake management planning. He also discussed the goals and components of the lake management planning project.

The meeting was announced in the district's newsletter prior to the meeting and summarized by district commissioners during the MMLMD annual meeting that summer.

Stakeholder Comment Form

A comment form describing the project and the importance of stakeholder participation was mailed to each member household in July 2004. The mailing asked that each member provide comments concerning the lake and its management. Unfortunately, only a single form was returned.

Project Update

A project update was mailed to MMLMD members in January 2005 to provide information concerning the project's progress and the development of the management plan.

Planning Committee Meeting

A meeting of the MMLMD Planning Committee was held on December 3, 2005 to discuss the project results and preliminary plan. The primary focus of the meeting was the impact of curly-leaf pondweed on Mount Morris Lake and the newly created harvesting plan developed by Onterra. During the meeting, the results of the aquatic plant studies were discussed and an outline of an intense curly-leaf pondweed control plan was presented. The committee suggested minor alterations to the harvesting plan and agreed with the proposed curly-leaf pondweed treatment project. The MMLMD accepted both at a meeting in January 2006.

Project Results and Discussion Meeting

On March 4, 2006 a special meeting was held to inform district members about the Aquatic Invasive Species project that was planned to be undertaken by the MMLMD beginning in the spring of that year. The meeting was used to present the results of the studies conducted at the lake during the previous two years with a focus on exotic aquatic plants. The meeting was also used to provide the rationale behind the district's newly developed harvesting plan.

RESULTS & DISCUSSION

Lake Water Quality

Judging the quality of lake water can be difficult because lakes display problems in many different ways. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region, and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water. To complete this task, three water quality parameters are focused upon within this document:

> **Phosphorus** is a nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both *algae* and *macrophytes*. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.
>
> **Chlorophyll-*a*** is the green pigment in plants used during *photosynthesis*. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.
>
> **Secchi disk transparency** is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrates (a Secchi disk) into the water and recording the depth just before it disappears from sight.

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

Each of these parameters is also 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; however, 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 most Wisconsin lakes. Monitoring the trophic state of a lake gives stakeholders a method by which to gauge the health of their lake over time. Yet, classifying a lake into one of three trophic states does not give clear indication of where a lake really exists in its trophic progression. To solve this problem, the parameters described above can be used in an index that will specify a lake's trophic state more clearly and provide a means for which to track it over time.

The complete results of these three parameters and the other chemical data that were collected at Mount Morris Lake can be found in Appendix B. The results and discussion of the analysis and comparisons described above can be found in the paragraphs and figures that follow.

Comparisons with Other Datasets

Lillie and Mason (1983) is an excellent source for comparing lakes within specific regions of Wisconsin. They divided the state's lakes into five regions each having lakes of similar nature or apparent characteristics. Waushara County lakes are included within the study's Central Region (Figure 1) and are among 44 lakes randomly picked from the region that were analyzed for water clarity (Secchi disk), chlorophyll-*a*, and total phosphorus. These data along with data corresponding to statewide impoundment means, historic, current, and average data from Mount Morris Lake's five sampling sites (Map 1) are displayed in Figures 2-10. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-a data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

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

All five lakes were sampled during this study; however, the sampling site in Lake D is considered the primary site for the lake based upon its depth and location within the system as a whole. As a result, Lake D has the most extensive historic water quality dataset and was sampled the most intensely during this study (see Methods). Data collected in the other four basins are supplemental to the information collected on Lake D.

Total phosphorus values in Lake D (Figure 3) have been relatively stable since 1988 and with the exception of 1997 and 2004 values, have been in the good to very good range as compared to the Wisconsin Water Quality Index (WQI) (Lillie and Mason 1983). The 2004 phosphorus data from the other lakes are generally in this same range. Using the WQI as a reference, the chlorophyll-*a* data for Lake D (Figure 5) would fall into the good to very good range over the extents of the dataset. Again, the data from the remaining lakes indicate similar results.

Secchi disk clarities from all five basins span from the late 1980's to 2004 and indicate that although the values fluctuate from year to year, they are all again within the good to very good range. As described above, there is a strong relationship between water clarity (Secchi disk), chlorophyll-*a*, and phosphorus levels. Based upon this relationship and the consistently good to very good historic clarity values of the Lakes A, B, C, and E, it can be assumed that phosphorus and chlorophyll-*a* values from past years would also be in this range.

Nitrogen to phosphorus ratios 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 10:1 or less, it is considered nitrogen limited. Ratios in between these values indicate that the lake likely fluctuates between nitrogen and phosphorus limitation. The ratios are related to the normal nitrogen to phosphorus ratio found in most algae. Mount Morris Lake's ratio using July 2004 values is approximately 50:1.

Compared to its water surface area, Mount Morris Lake has a very large watershed (see Watershed Analysis Section) and as a result, the driving force determining the water quality values is runoff. The levels of runoff are of course, driven by precipitation. As precipitation fluctuates from year to year, so do the water quality parameters. Essentially, more rain leads to greater runoff, which means more phosphorus enters the lake and in lakes that are phosphorus limited, like Mount Morris, this fuels more algae production and decreases water clarity. The spring of 2004 was very wet, as a result, Lake D experienced higher phosphorus values than most years in the dataset. These values spurred algal production and raised chlorophyll-*a* values, which in turn, decreased water clarity. The spring of 1993 was also considered very wet and Secchi disk values for all five lakes were lower compared to most other years of record. This is especially true when the data from Lake C, which has two inlets feeding it, and Lake D, which receives most of its water from Lake C.

Overall, the water quality of Mount Morris Lake is good. Even in years with higher than normal runoff, the lake responds well and maintains good clarity values. In fact, in most years, the water quality of Mount Morris Lake is better than the average values found in the Central Region and always much better than those values from other Wisconsin impoundments. The native macrophytes within the lake play an important role in maintaining these good values by utilizing nutrients that would otherwise be used by algae and by providing cover for planktonic animals that graze upon the algae. However, the non-native macrophyte, curly-leaf pondweed, has a negative impact on the phosphorus levels as described in the Aquatic Plant Section.

Mount Morris Lake Trophic State

Figures 11-15 display the Wisconsin Trophic State Index (WTSI) (Lillie, et al. 1993) values calculated from average surface levels of chlorophyll-*a*, total phosphorus, and Secchi disk transparencies measured during the summer months in at the five sampling sites on Mount Morris Lake. The WTSI is based upon the widely used Carlson Trophic State Index (TSI) (Carlson 1977), but is specific to Wisconsin lakes. In essence, a trophic state index is a mathematical procedure that assigns an index number that corresponds to a lake's trophic state based upon three common lake parameters; chlorophyll-*a*, Secchi disk transparency, and total phosphorus. The WTSI is used extensively by the WDNR and is reported along with lake data collected by WDNR Self-Help Volunteers.

The trophic state of a lake is directly related to its production, more precisely – primary production. It is simply a classification based upon the lake's capacity to produce plants in the form of algae and macrophytes. As described above, Mount Morris Lake is phosphorus limited: therefore, as more phosphorus is added to the lake, its production capacity increases as does its trophic state.

The WTSI values for Mount Morris Lake indicate the lake to be mesotrophic-eutrophic. However, the WTSI does not account for macrophyte production, which dominates in Mount

Morris Lake. Taking that production into account is difficult because there is currently no procedure for measuring macrophytic production. However, it can be assumed, based upon the healthy littoral zone of the lake, that the production is significant; therefore, the trophic state of Mount Morris Lake must be considered more eutrophic than mesotrophic.

Internal Nutrient Loading

Internal nutrient loading is the recycling of nutrients, commonly phosphorus, from lake sediments. If a lake's nutrient-rich bottom sediments are exposed to anoxic (devoid of oxygen) conditions during stratification, the iron that normally holds the phosphorus in the sediments releases it into the hypolimnion (bottom water layer) of the lake. During turnover events, this nutrient-rich water is mixed with the other layers often spurring or maintaining algal blooms. Internal nutrient loading can be a significant source of phosphorus in lakes long after external sources have been minimized. In general, when hypolimnetic phosphorus values exceed 500 μg/L, it can be assumed that internal loading is significant. Values between 300 and 500 μg/L are borderline and indicate the internal loading is likely present, but may not be impacting algal production and clarity.

All five lakes stratify during the summer and experience hypolimnetic anoxia. Hypolimnetic phosphorus values ranged from 271 μg/L in Lake A to 397 μg/L in Lake C during July 2004. Lake E did not experience elevated levels during this time. The values in Lakes A-D may indicate that a limited amount of internal nutrient loading occurs within these lakes; however, considering the size of the Mount Morris Lake watershed and the amount of phosphorus that enters the lake via surface runoff, the internal load would be considered negligible at this time.

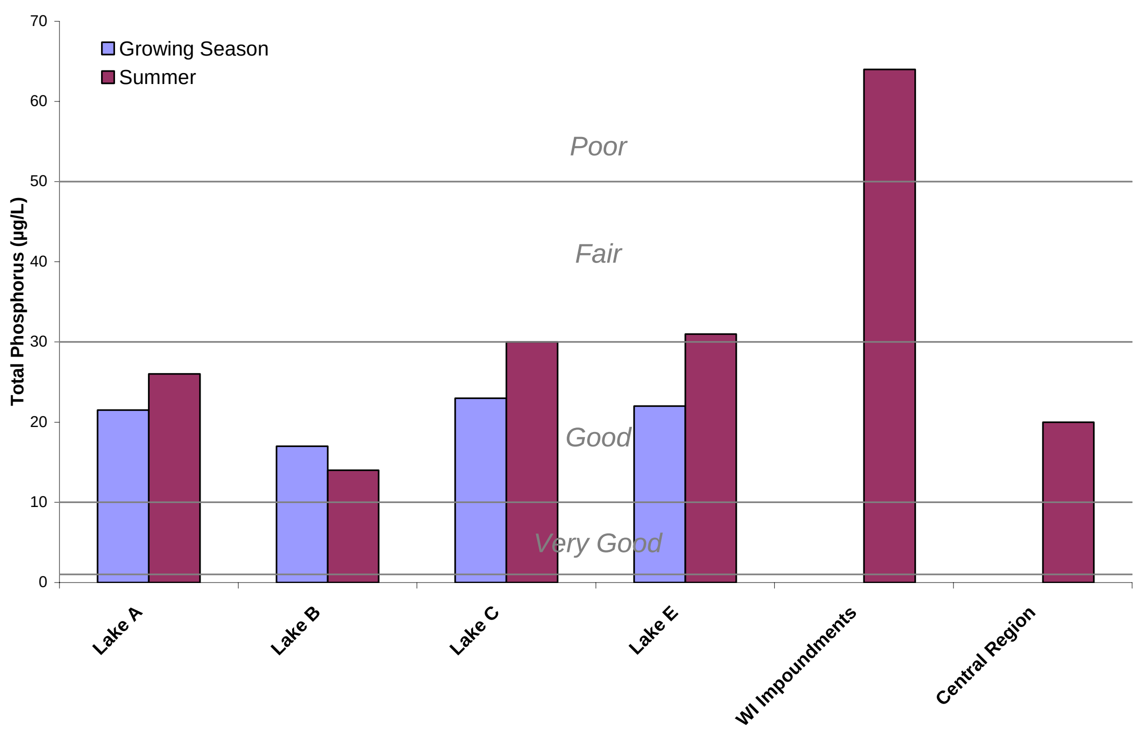

Figure 2. Mount Morris Lake total phosphorus values for Lakes A, B, C, and E. Summer values correspond to July 2004 and growing season values correspond to mean values from spring turnover and July 2004 samples.

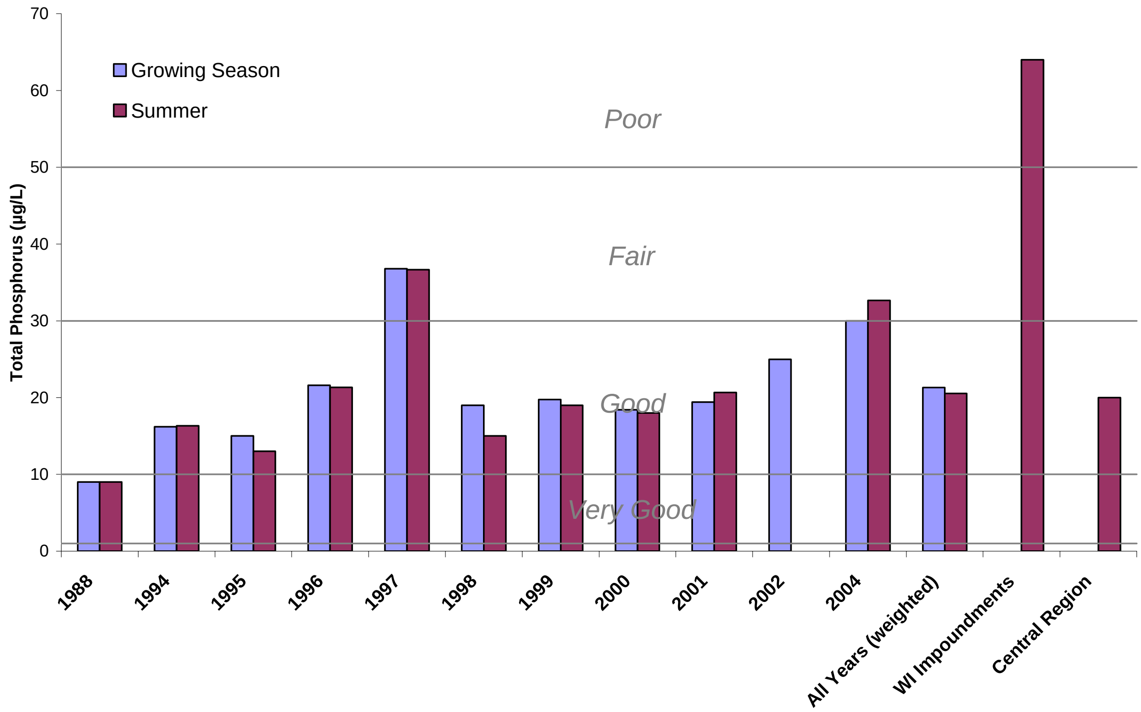

Figure 3. Mount Morris Lake total phosphorus values for Lake D. Summer mean values calculated with data from June, July, and August. Growing season mean values are calculated with data collected from spring turnover to fall turnover.

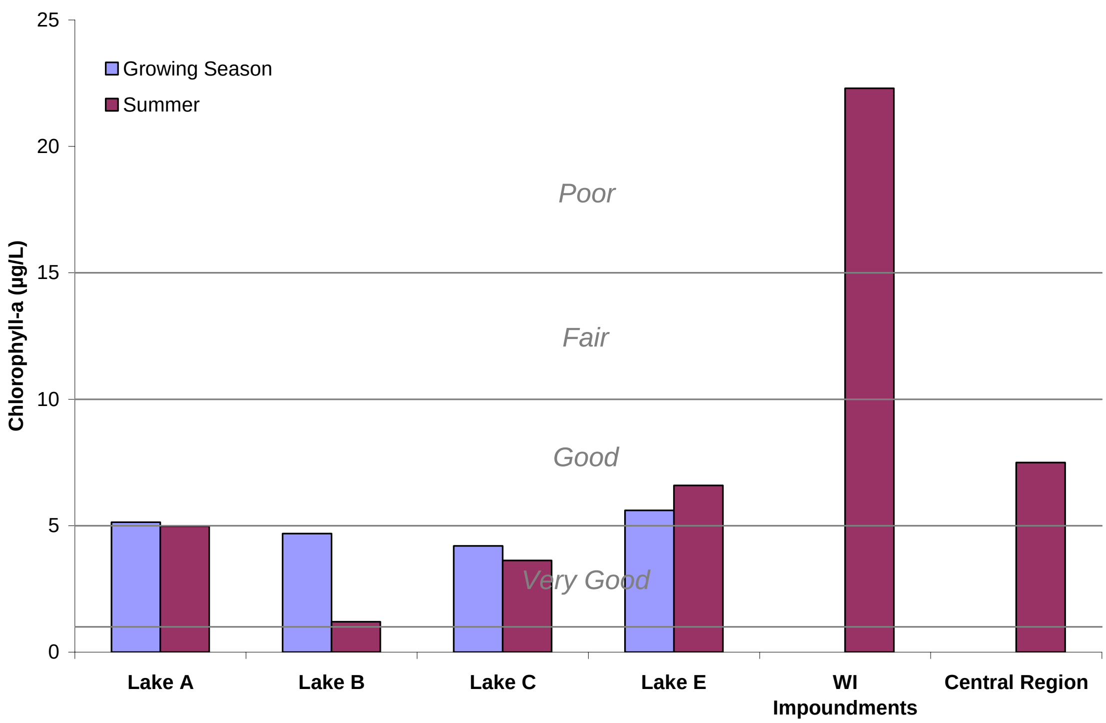

Figure 4. Mount Morris Lake chlorophyll-*a* values for Lakes A, B, C, and E. Summer values correspond to July 2004 and growing season values correspond to mean values from spring turnover and July 2004 samples.

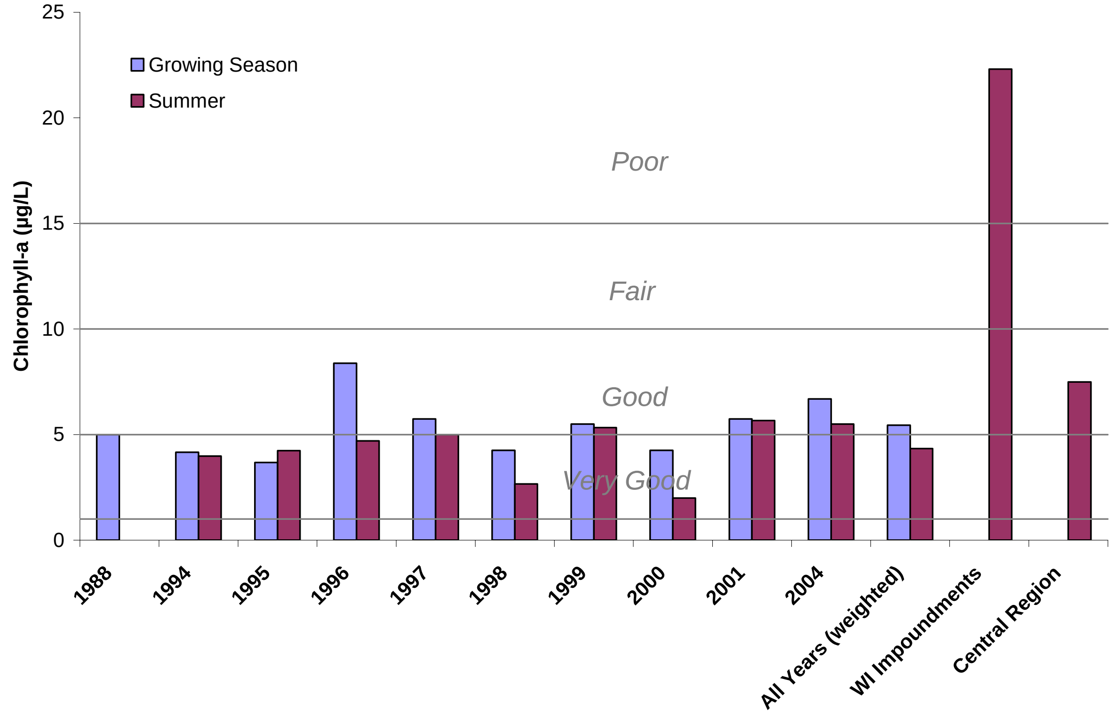

Figure 5. Mount Morris Lake chlorophyll-*a* values for Lake D. Summer mean values calculated with data from June, July, and August. Growing season mean values are calculated with data collected from spring turnover to fall turnover.

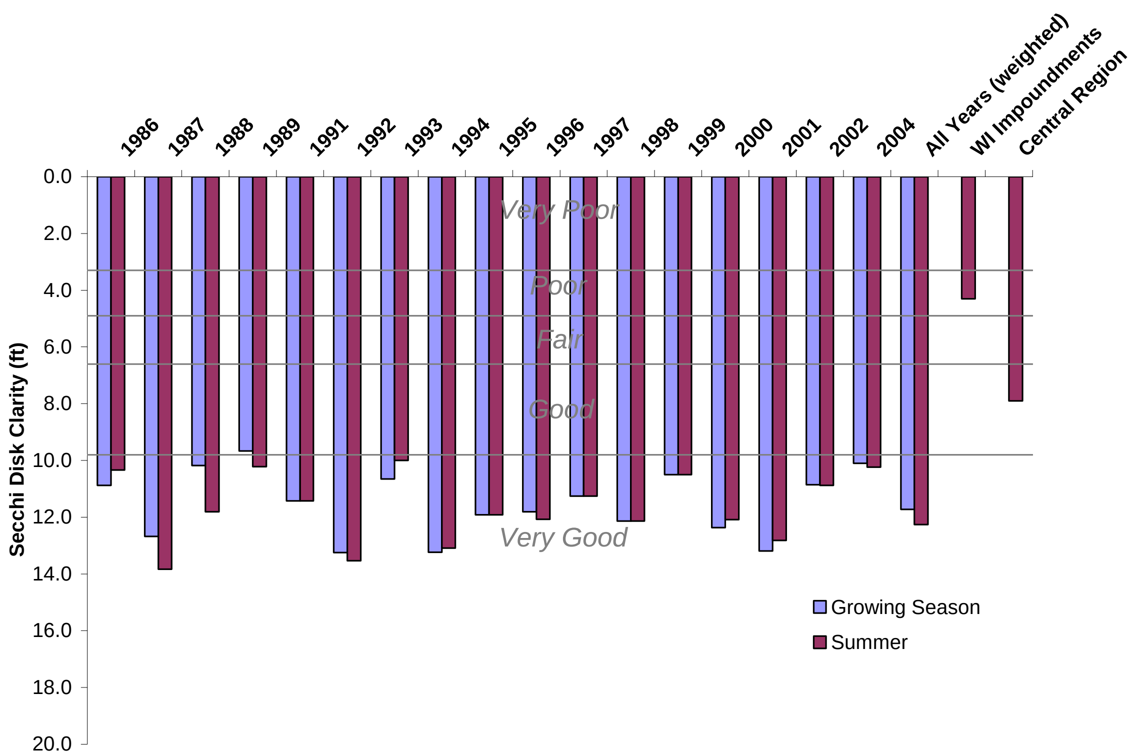

Figure 6. Mount Morris Lake Secchi disk clarity values for Lake A. Summer mean values calculated with data from June, July, and August. Growing season mean values are calculated with data collected from spring turnover to fall turnover.

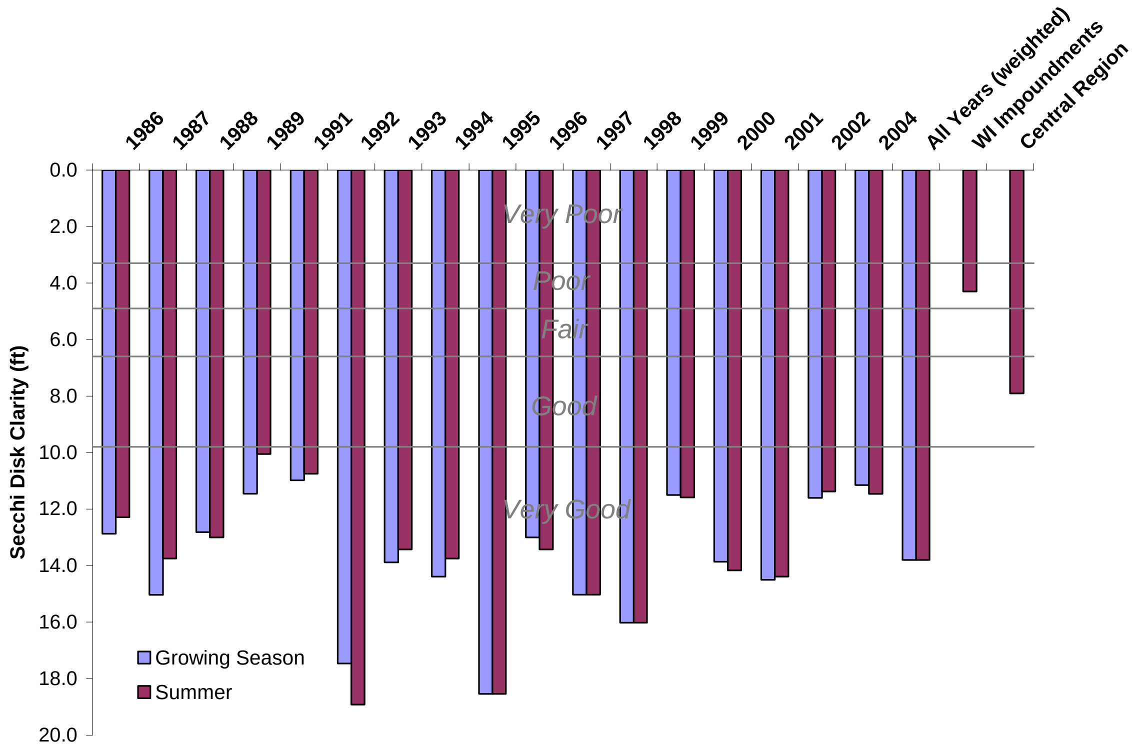

Figure 7. Mount Morris Lake Secchi disk clarity values for Lake B. Summer mean values calculated with data from June, July, and August. Growing season mean values are calculated with data collected from spring turnover to fall turnover.

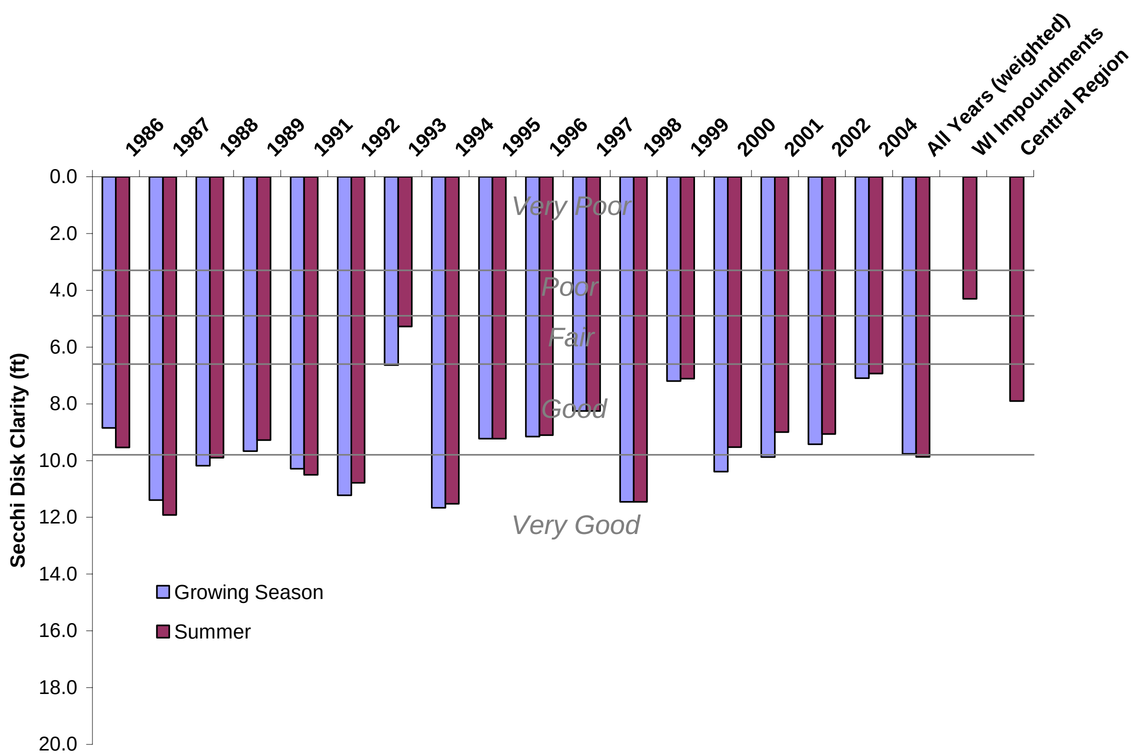

Figure 8. Mount Morris Lake Secchi disk clarity values for Lake C. Summer mean values calculated with data from June, July, and August. Growing season mean values are calculated with data collected from spring turnover to fall turnover.

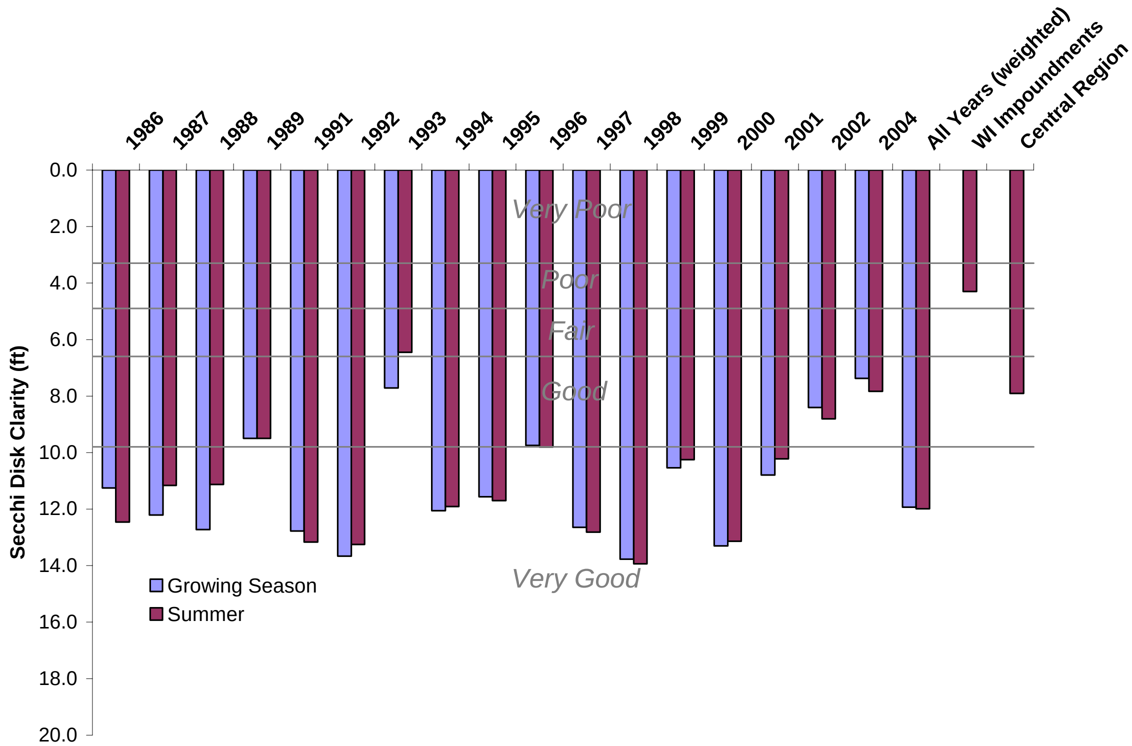

Figure 9. Mount Morris Lake Secchi disk clarity values for Lake D. Summer mean values calculated with data from June, July, and August. Growing season mean values are calculated with data collected from spring turnover to fall turnover.

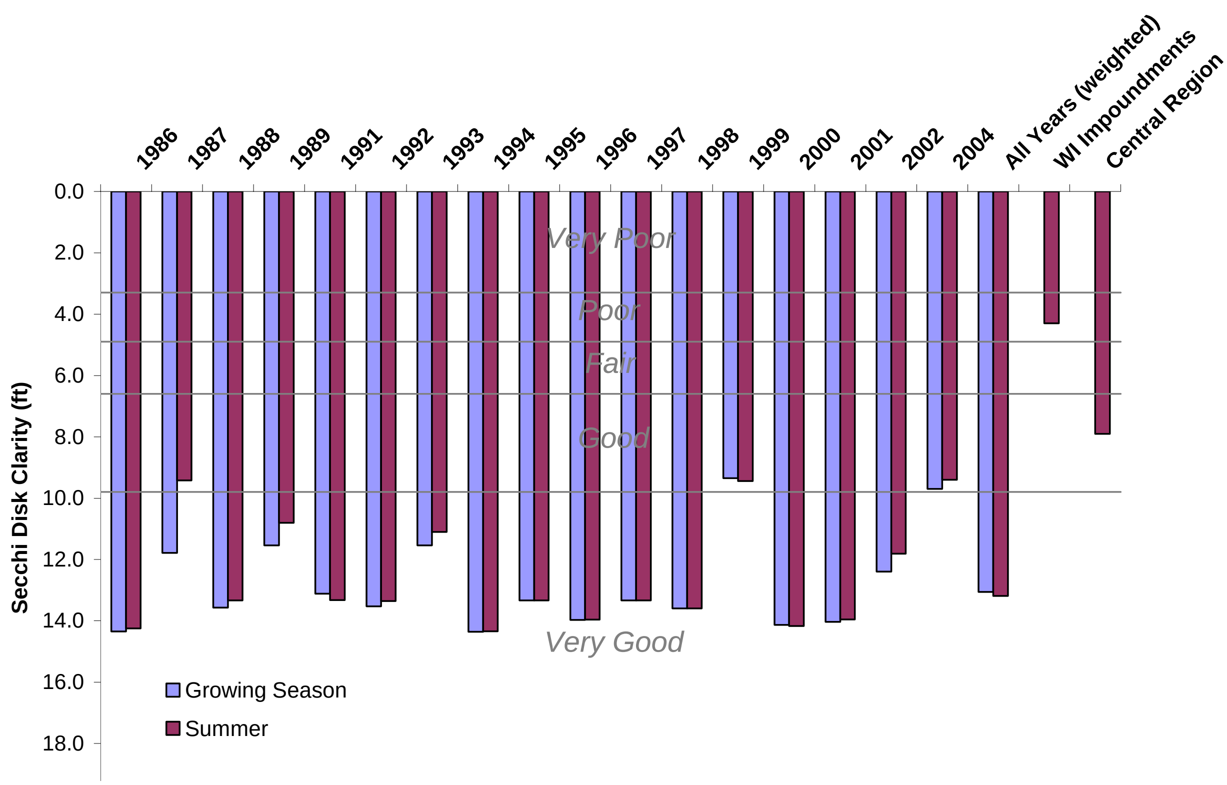

Figure 10. Mount Morris Lake Secchi disk clarity values for Lake E. Summer mean values calculated with data from June, July, and August. Growing season mean values are calculated with data collected from spring turnover to fall turnover.

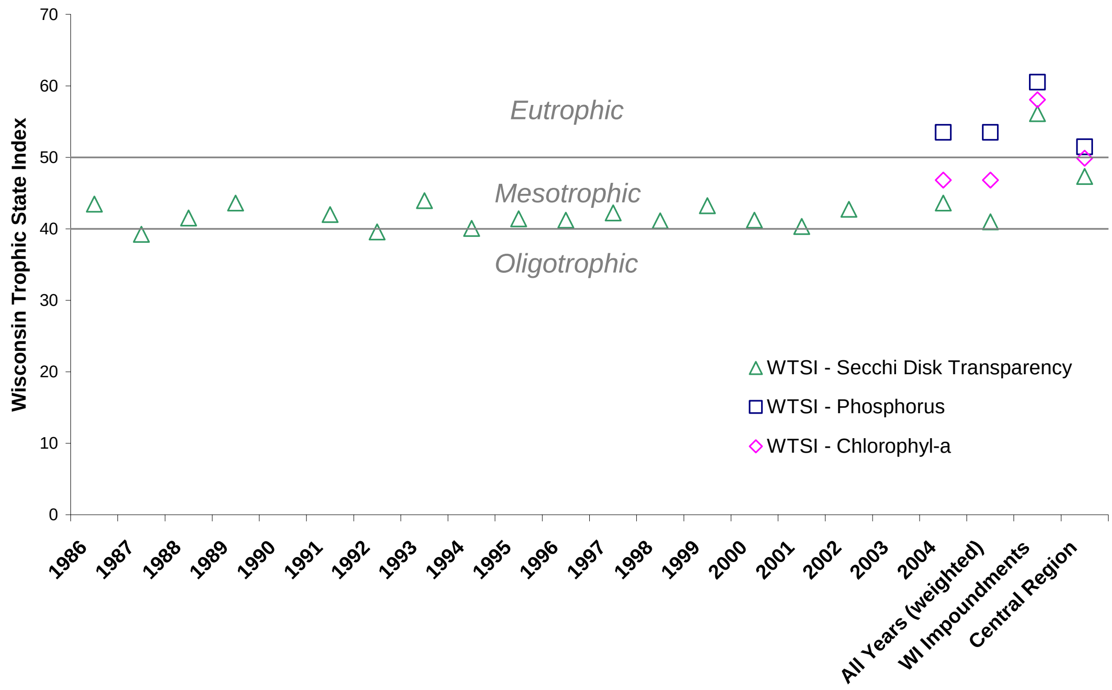

Figure 11. Mount Morris Lake Wisconsin Trophic State Index values for Lake A. Calculated with surface sample data collected during June, July, and August.

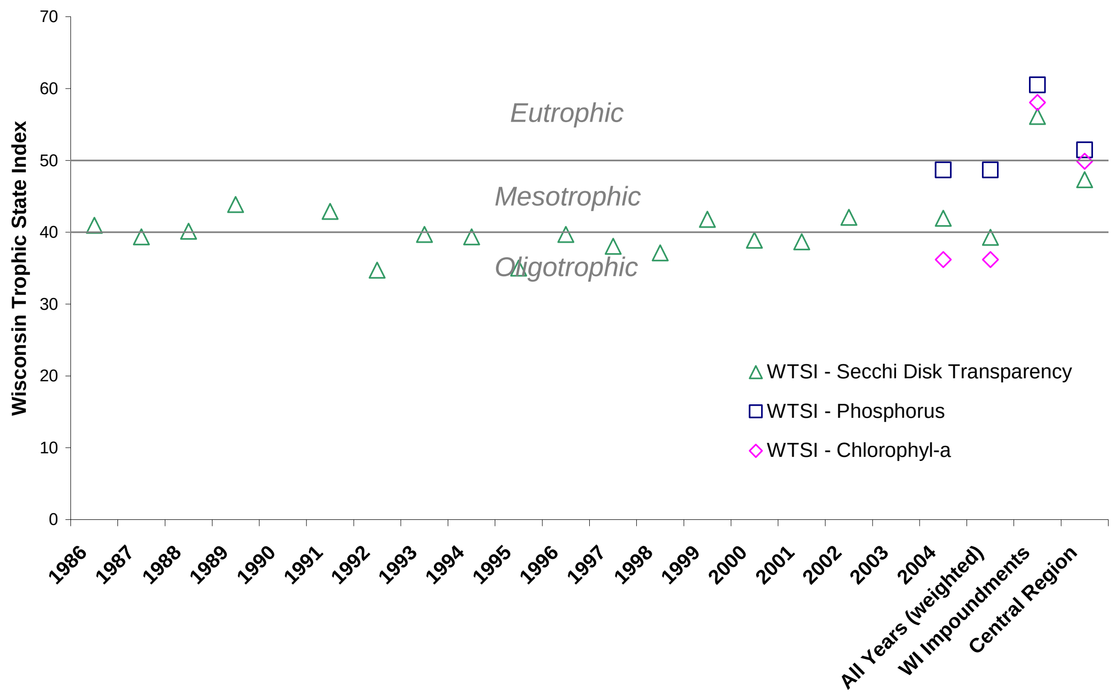

Figure 12. Mount Morris Lake Wisconsin Trophic State Index values for Lake B. Calculated with surface sample data collected during June, July, and August.

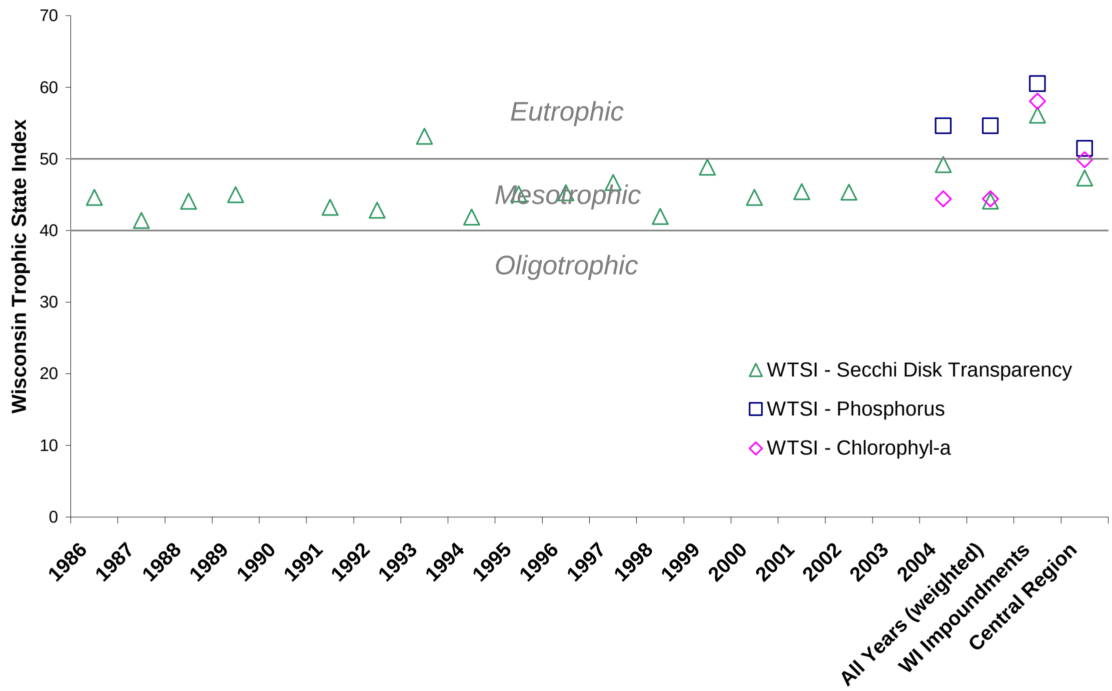

Figure 13. Mount Morris Lake Wisconsin Trophic State Index values for Lake C. Calculated with surface sample data collected during June, July, and August.

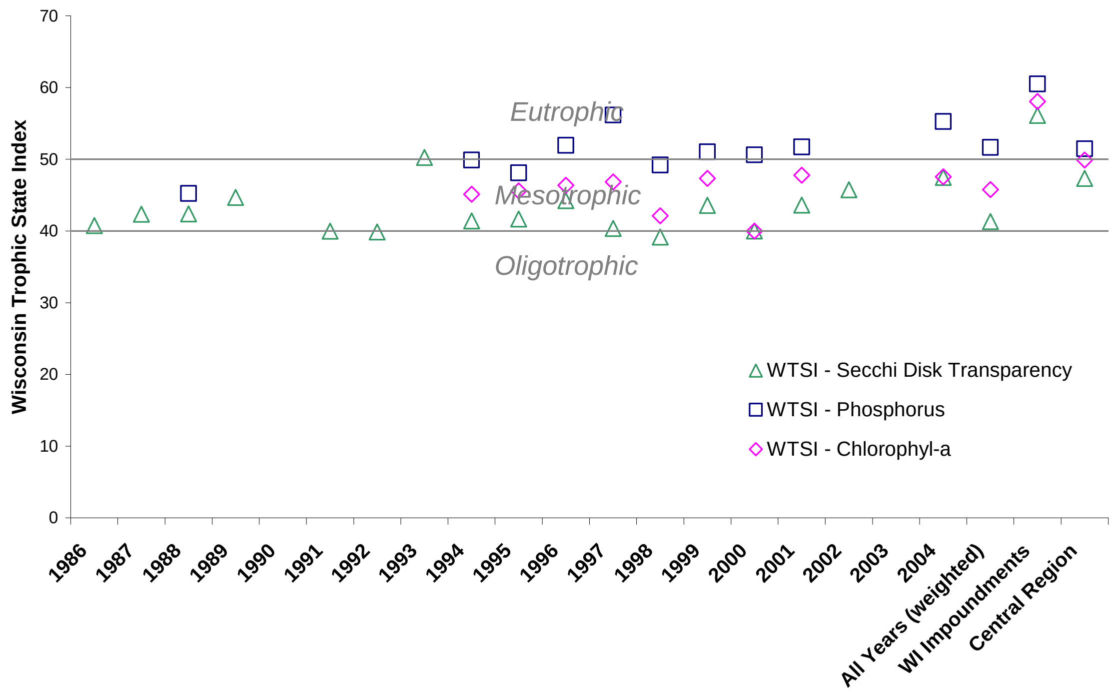

Figure 14. Mount Morris Lake Wisconsin Trophic State Index values for Lake D. Calculated with surface sample data collected during June, July, and August.

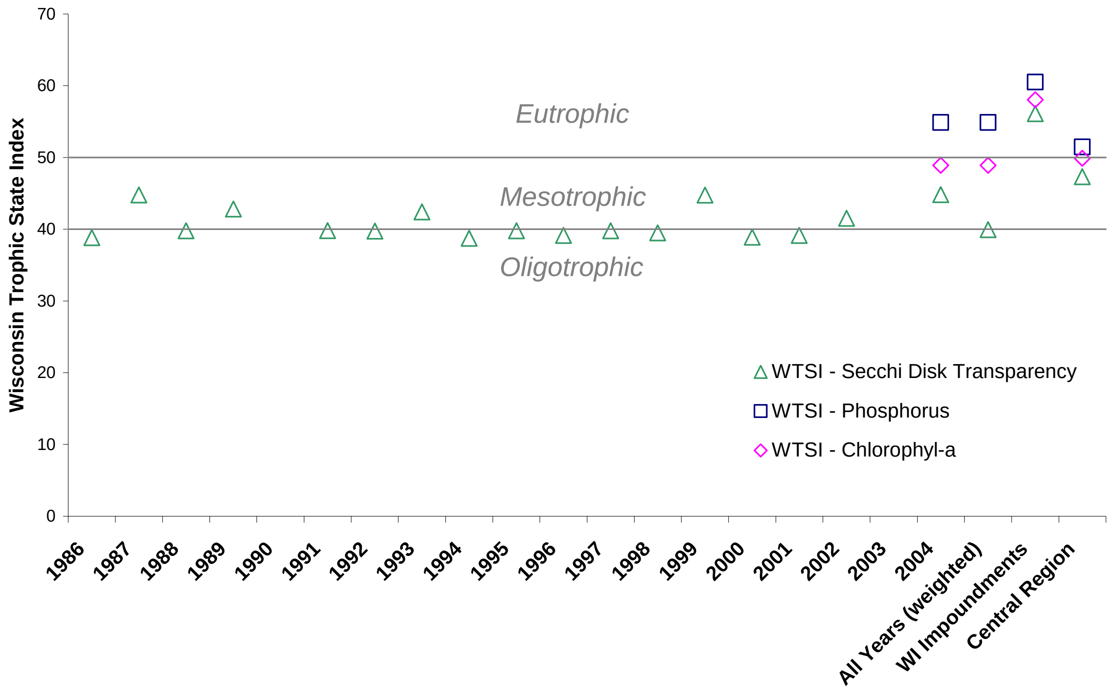

Figure 15. Mount Morris Lake Wisconsin Trophic State Index values for Lake E. Calculated with surface sample data collected during June, July, and August.

Watershed Analysis

The Mount Morris Lake watershed is approximately 5712 acres and includes the watersheds of both Norwegian Lake (1406 acres) and Porters Lake (163 acres) (Map 2). This yields a watershed to lake area ratio of approximately 42:1. This means that for every acre of lake there are 42 acres of watershed draining to it. In general, lakes with higher watershed to lake area ratios, those exceeding 10:1, tend to exhibit higher in-lake phosphorus levels. However, land use, or land cover, within the watershed is the primary factor controlling the amount of sediment and nutrients loaded to a lake. Heavily vegetated areas, such as forests and grasslands export the least amount of pollutants because the majority of the precipitation that falls on them penetrates the soil and enters the groundwater. This creates very little surface runoff to carry sediment and nutrients to the lake. Land uses with little vegetative cover, such as agricultural areas (especially row crops) and residential areas tend to allow much of the precipitation that falls on them to become surface runoff, while very little enters the groundwater. As the water moves over the surface of these land covers, it picks up sediment and nutrients which are eventually delivered to the lake.

Figure 16 contains the field-verified land cover data for the Mount Morris Lake watershed, including the Porters Lake and Norwegian Lake subwatersheds. Phosphorus load modeling using standard export coefficients contained in the Wisconsin Lake Modeling Suite (WiLMS) resulted in an annual load of approximately 1086 lbs. This figure was used in other models to estimate in-lake phosphorus levels, including growing season, annual, and spring turnover means. To check the alignment of the model, estimates were compared to corresponding data collected in Lake D during 2004. The modeled in-lake values were much higher than those actually measured within the lake, indicating that the annual phosphorus load of 1086 lbs is unrealistically high. Discussions with Mr. Ed Hernandez, Waushara County Conservationist, helped to discover why this may be the case.

As described above, WiLMS utilizes standard export coefficients to calculate the amount of phosphorus loaded to a lake or tributary for a particular land cover type. In most cases, these coefficients provided appropriate estimates for a given watershed and lake. However, the export coefficient used for row crops was likely developed in watersheds using standard agricultural practices. The Mount Morris Lake watershed is part of the Pine River and Willow Creek watershed – a WDNR priority watershed since 1995. As a result of the Priority Watershed Program and the work of the Waushara County Land Conservation Department much of the agricultural areas in the watershed have been enlisted in management activities aimed at significantly reducing soil erosion. One such activity includes the implementation of *high residue management* on croplands. High residue management is a system which leaves at least 30% of the ground covered with crop residue after crops are planted. Summarizing, studies completed by the University of Wisconsin-Extension, Mr. Hernandez stated that high residue management can result in soil loss reductions of 60%. Mr. Hernandez estimates that between 50% and 80% of the croplands in the Mount Morris Lake watershed are likely using high residue management techniques at this time.

To simulate the affects of high residue management, 65% of the row crop acres of the Mount Morris Lake watershed (not including the Porters Lake and Norwegian Lake subwatersheds) were modeled with export coefficients set at 40% of the standard coefficients. This effort resulted in a annul phosphorus load of approximately 882 lbs (Figure 17). Using this new estimate, the in-lake phosphorus estimates were decreased significantly, but were still considered a bit higher than those actually measured in the lake.

A likely answer for the difference is the fact that most of the row crop areas are surrounded by forested areas, grasslands, or wetlands (Map 2). In addition, the tributaries that these lands drain to, which eventually make their way to Mount Morris Lake, are surrounded by floodplain wetlands. All of these factors reduce the actual amount of phosphorus loaded to the lake through filtering and soil percolation. These factors are not anticipated within WiLMS and as a result, the modeling indicates a higher load than actually occurs.

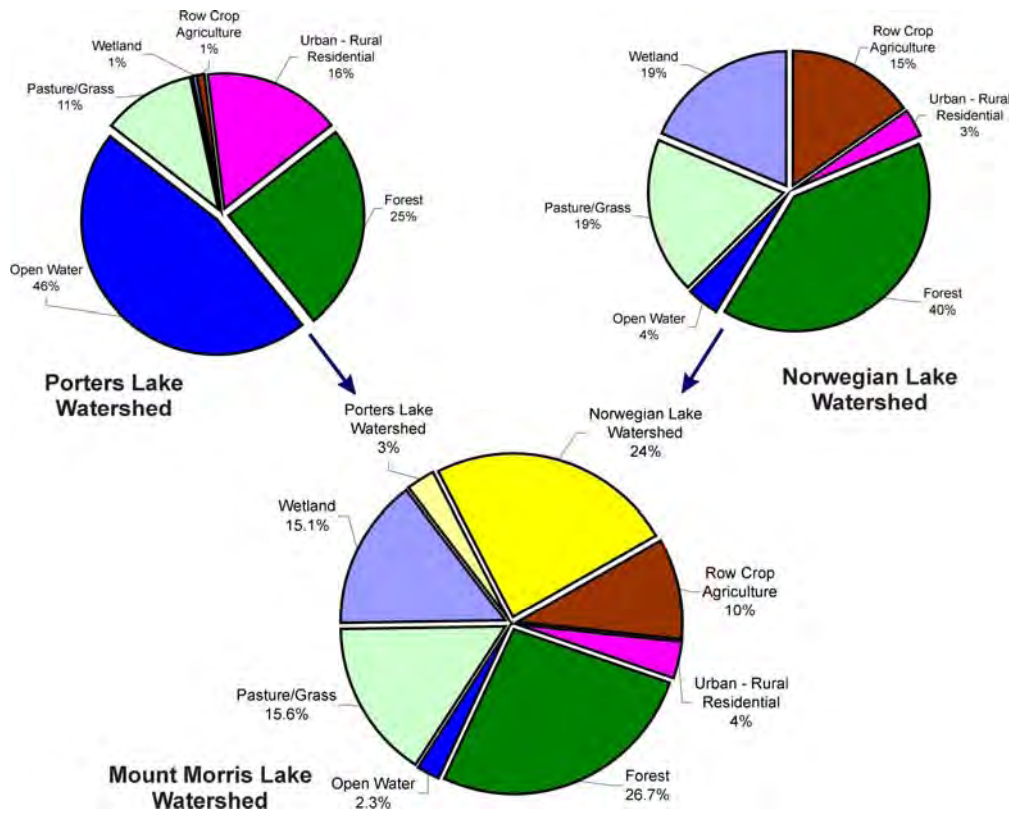

Figure 16. Mount Morris Lake watershed land cover types. The Porter and Norwegian Lake watersheds feed into Mount Morris Lake and are treated as separate point sources.

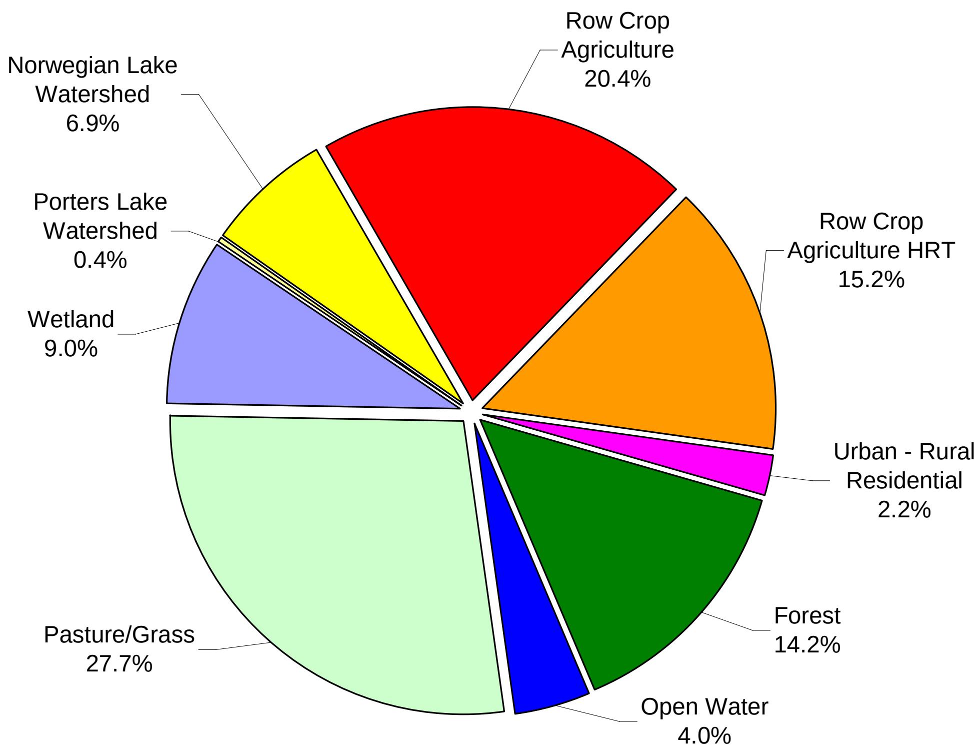

Figure 17. Mount Morris Lake watershed phosphorus loading with High Residue Management reductions.

Aquatic Plants and the Lake Ecosystem

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 were 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 aquatic plant management plan should only contain methods to control plants, they should also contain methods on how to protect and possibly enhance the important plant communities within the lake. Unfortunately, the latter is often neglected and the ecosystem suffers as a result.

Introduction to 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: Even though all of these techniques may not be applicable to Mount Morris Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake**.** The techniques applicable to Mount Morris Lake are located in the management section.

Permits

The signing of the 2001-2003 State Budget by Gov. McCallum enacted many aquatic plant management regulations. The rules for the regulations have been set forth by the WDNR as NR 107 and 109. A major change includes that all forms of aquatic plant management, even those that did not require a permit in the past, require a permit now, including manual and mechanical removal. Manual cutting and raking are exempt from the permit requirement if the area of plant removal is no more than 30 feet wide and any piers, boatlifts, swim rafts, and other recreational and water use devices are located within that 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, and decrease infiltration rates of potentially harmful nutrients and pollutants. Furthermore, the dumping of sand to create beach areas destroys spawning, cover and feeding areas utilized by aquatic wildlife.

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 litoral 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 both the applicator and the environment, so all lake organizations should seek consultation and/or services from professional applicators with training and experience in aquatic herbicide use.

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

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

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

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

<u>Endothal</u> (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.

<u>2,4-D</u> (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 many of our native plants, which are monocots. Drinking and irrigation restrictions 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.

Analysis of Current Aquatic Plant Data

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

As described in more detail in the methods section, two aquatic plant surveys were completed on Mount Morris Lake; the first looked strictly for curly-leaf pondweed, and the second inventoried all aquatic 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.

Primer on Data Analysis & Data Interpretation

Species List

The species list is simply a list of all of the species that were found within the lake, both exotic and native. The list also contains the life-form of each plant found, its scientific name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and loses 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 Mount Morris 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 more diverse than a lake with 10 if the first lake is highly dominated by one or two species and the second lake has a more even distribution.

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

Floristic Quality Assessment

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

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

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

Community Mapping

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

Exotic Plants

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

Figure 18. Spread of Eurasian water milfoil throughout Wisconsin counties. WDNR Data 2004.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 18). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

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

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.

2004 Surveys

The aquatic plant surveys completed in 2004 located 35 species within Mount Morris Lake (Table 1); of these, 31 were native species and four were exotics. The non-native species included Eurasian water milfoil, curly-leaf pondweed, reed canary grass, and purple-loosestrife.

Curly-leaf pondweed and Eurasian water milfoil are covered in more detail below, while purple loosestrife and reed canary grass are covered in the implementation plan.

Table 1. Aquatic plant species located in Mount Morris Lake during the 2004 surveys.

Life-Form	Scientific Name	Common Name	Coefficient of Conservatism
Emergent	*Calla palustris**	Water arum	9
	Carex comosa	Bristly sedge	5
	*Carex stricta**	Common tussock sedge	7
	Eleocharis palustris	Creeping spikerush	6
	*Impatiens capensis**	Orange Jewelweed	2
	*Iris versicolor**	Northern blue flag	5
	*Lythrum salicaria**	Purple loosestrife	Exotic
	*Phalaris arundinacea**	Reed canary grass	Exotic
	*Pontederia cordata**	Pickerelweed	9
	*Sagittaria latifolia**	Common arrowhead	3
	Schoenoplectus acutus[1]	Hardstem bulrush	5
	Schoenoplectus tabernaemontani[2]	Softstem bulrush	4
	Typha latifolia	Broad-leaved cattail	1
FF	*Lemna minor*	Small duckweed	5
	Lemna trisulca	Forked duckweed	6
	Spirodela polyrhiza	Great duckweed	5
FL	*Nuphar variegata*	Spatterdock	6
	Nymphaea odorata	White water lily	6
Submergent	*Callitriche palustris**	Common water starwort	8
	Ceratophyllum demersum	Coontail	3
	Chara sp.	Muskgrasses	7
	Elodea canadensis	Common waterweed	3
	*Myriophyllum spicatum**	Eurasian water milfoil	Exotic
	Myriophyllum sibiricum	Northern water milfoil	7
	Najas flexilis	Slender naiad	6
	Potamogeton crispus	Curly-leaf pondweed	Exotic
	Potamogeton illinoensis	Illinois pondweed	6
	Potamogeton natans	Floating-leaf pondweed	5
	Potamogeton praelongus	White-stem pondweed	8
	Potamogeton richardsonii	Clasping-leaf pondweed	5
	Potamogeton zosteriformis	Flat-stem pondweed	6
	Ranunculus aquatilis[3]	Stiff water crowfoot	8
	Stuckenia pectinata[4]	Sago pondweed	3
	Utricularia vulgaris	Common bladderwort	7
	Vallisneria americana	Wild celery	6

FF = Free Floating
FL = Floating Leaf
*Incidental (found outside of sampled plots)
[1]Formally known as *Scirpus acutus*.
[2]Formally known as *Scirpus validus*
[3]Formally known as *Ranunculus longirostris*.
[4]Formally known as *Potamogeton pectinatus*.

Although Mount Morris Lake is largely dominated by muskgrasses, common waterweed and northern water milfoil (Figure 19), the lake would still be considered a diverse system (Simpson's diversity = 0.92). Muskgrasses are normally low-growing and northern water milfoil does not create surface mats like its exotic relative, so normally, neither of these species is considered a nuisance. Common waterweed, or Elodea, may reach nuisance levels and create navigation problems within some lakes. Areas of Mount Morris Lake, especially near the northern inlet of Lake C were found to have nuisance levels of common waterweed, although most of these areas were also dominated by spatterdock and white water lily. Floating-leaf species, such as spatterdock and white water lily provide important habitat and structure for fish and other wildlife; therefore, the options available for reducing these high levels of common waterweed are limited due to their association with the floating-leaf species.

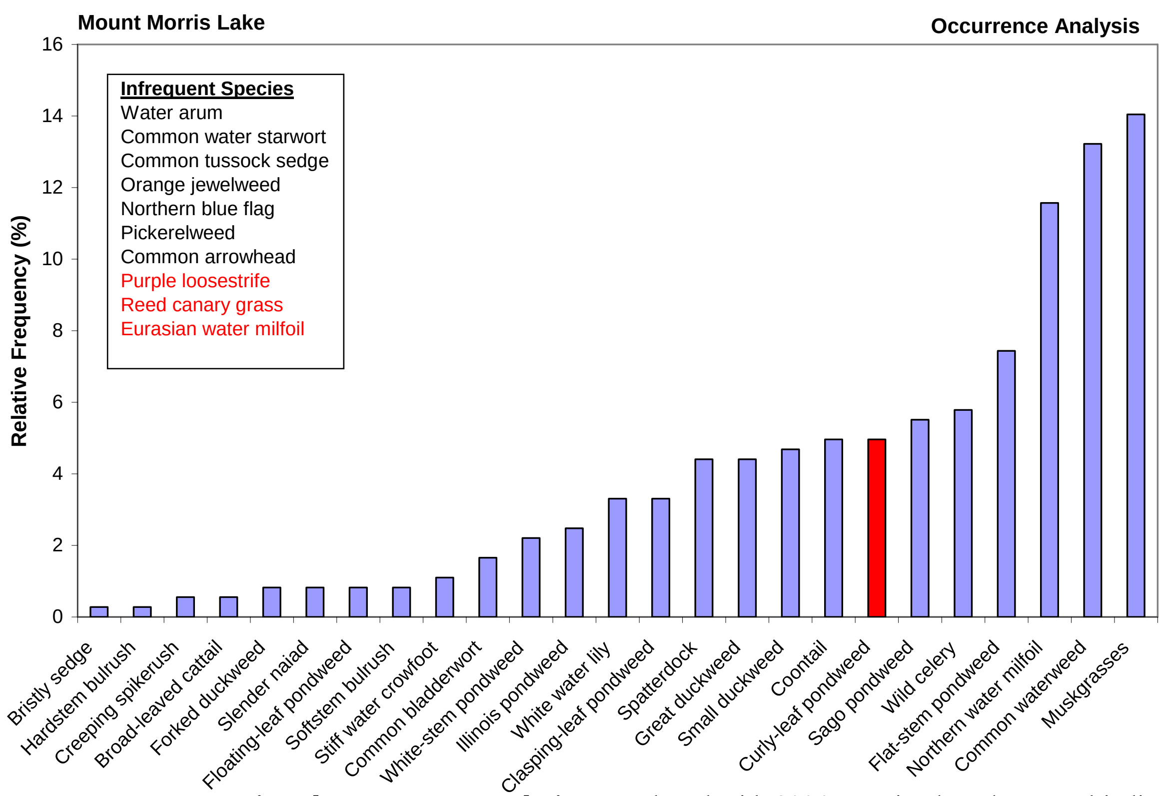

Figure 19. Mount Morris Lake occurrence analysis. Developed with 2004 aquatic plant data. Red indicates exotic species.

Overall, the FQA indicates that floristic quality of Mount Morris Lake is excellent, especially when compared to median values for the state and ecoregion (Figures 20 and 21). As described above, floristic quality utilizes average conservatism value for all of the native species found in the lake and the total number of those species. Obviously, the high species richness of the lake is the major factor contributing to its excellent floristic quality as the average conservatism value is below the state and even with the ecoregion medians. The median values reported in Figure 21 were derived from a large dataset of plant studies from Wisconsin (Nichols 1999); however, only certain species were considered to be "lake plants" by the author and only those plants were assigned coefficient of conservatism values. The method states that if a species is included that is not in the list, then the average conservatism for the lake should be used as its coefficient of conservatism and the species richness should increase by one. Basically, this means that the species is given "credit" in the calculation only for being in the lake, but its fidelity towards a disturbed or undisturbed system (i.e., its coefficient of conservatism) is not considered. Recently, the WDNR has developed coefficients of conservatism for nearly every native plant in the state (WDNR 2003). Incidentally, the values listed in Nichols 1999 were used in the state values. The values reported in Figure 21 were calculated using the WDNR coefficients of conservatism for the plants that were not listed in Nichols (1999). In some cases, using the procedure in this way can inflate the species richness value to the point that comparisons with the median values developed by Nichols are unreasonable. In the case of Mount Morris Lake, only three species not included in Nichols (1999) were used in the calculations. Removing those species reduces the species richness to 28, increases the average conservatism to 5.6, and decreases the floristic quality to 29.5. In the end, these are not significant changes; therefore, the values, as listed, are valid for comparison with the state and ecoregion medians.

Figure 20. Location of Mount Morris Lake within the ecoregions of Wisconsin. After Nichols 1999.

The Mount Morris Lake average conservatism value is even with that of the ecoregion and less than the state. This is likely the result of disturbances such as shoreland development, recreational use, harvesting, and the spread of non-native species. Still, the lake's plant community is outstanding as evidenced by the very high floristic quality and high index of diversity. The quality is also indicated by the high incidence of emergent and floating-leaf plant communities that occur in many areas of the lake (Map 3). This is important, because these communities are often affected by these factors. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelines when compared to undeveloped shorelines in Minnesota Lakes. Furthermore, they also found a significant reduction in abundance and size of northern pike (*Esox lucius*), bluegill (*Lepomis macrochirus*), and pumpkinseed (*Lepomis gibbosus*) associated with these developed shorelines. Many studies have documented the adverse affects of motorboat traffic on aquatic plants (e.g. Murphy and Eaton 1983, Vermaat and de Bruyne 1993, Mumma et al. 1996, Asplund and Cook 1997). In all of these studies, lower plant biomasses and/or declines and higher turbidity were associated with motorboat traffic.

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

At this time, the largest potential threat to the high quality plant community of Mount Morris Lake rests with the spread of exotics, in particular, curly-leaf pondweed and Eurasian water milfoil. In mid May 2004, approximately 28% of the lake's surface area was mapped as containing curly-leaf pondweed, including areas that contained scattered occurrences to areas that were obviously dominated by the plant (Map 4). Furthermore, curly-leaf pondweed was found to be the 7th most frequent plant in the lake during the comprehensive plant survey (Figure 19). A small colony of Eurasian water milfoil was also found during this survey and then verified during a follow-up site visit in August 2005 (Map 3). Both of these plants are problematic, but currently curly-leaf pondweed is of the most concern.

During the late spring and early summer, curly-leaf pondweed reaches nuisance levels in Mount Morris Lake. As a result, much of the biomass removed during the district's harvesting efforts is

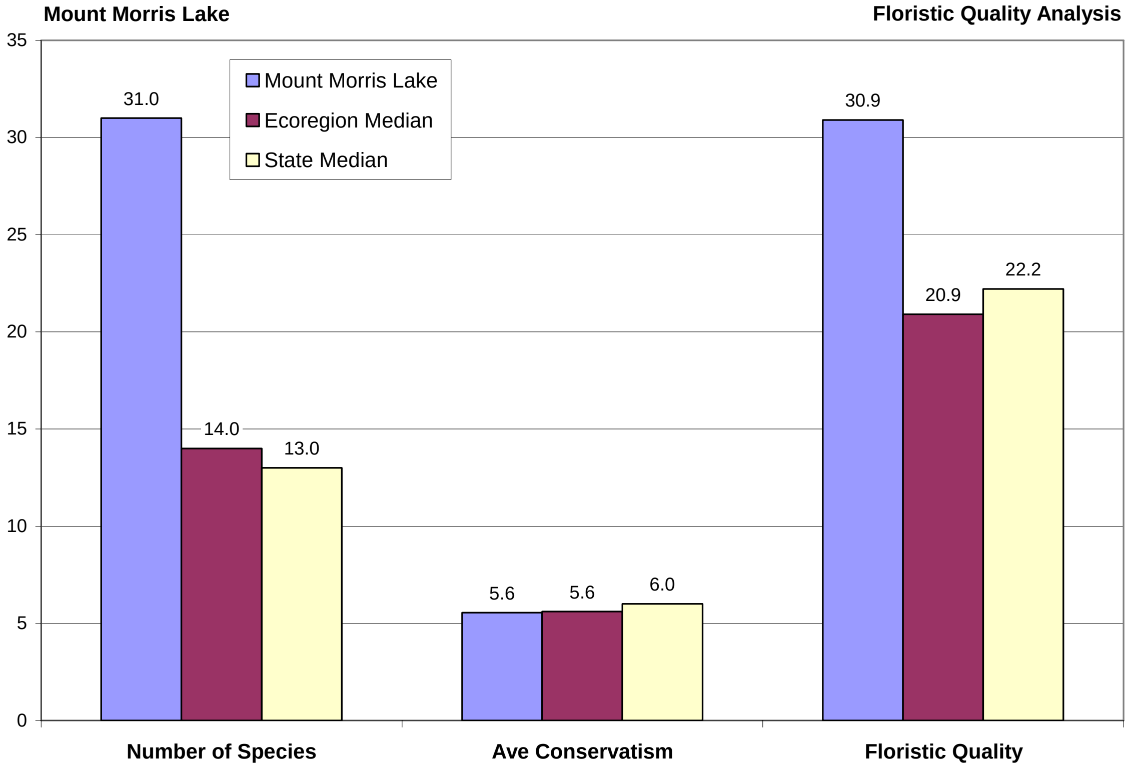

Figure 21. Mount Morris Lake Floristic Quality Assessment. Developed with 2004 aquatic plant data.

likely curly-leaf pondweed. However, navigational difficulties are not the only problems caused by the plant. In many lakes, the mid summer die-back of curly-leaf pondweed can lead to elevated phosphorus levels and depending on the lake, these can lead to algal blooms. Mount Morris Lake is not exception when it comes to elevated phosphorus levels. Figure 22 includes surface and bottom concentrations of total phosphorus in Lake D during the extent of the study. As the graph indicates, there is s definite upswing in July's phosphorus levels following the die back of curly-leaf pondweed earlier in the season. The surface levels drop back down in August, but then come back up in the fall as a result of the fall turnover event. If the curly-leaf pondweed continues to spread and densities increase, the resultant increase in phosphorus may reach the point were algal blooms are a common event in Mount Morris Lake.

Harvesting has probably played a big role in the spread of curly-leaf pondweed around Mount Morris Lake. Unfortunately, it could have the same impact on Eurasian water milfoil. Combined, these two plants could have a profound impact on the recreational value and the ecological stability of the lake; therefore, aquatic plant management within the lake must be converted from strictly nuisance level relief to a combination of that and control and reductions in exotics in order to protect the valuable native aquatic plant community.

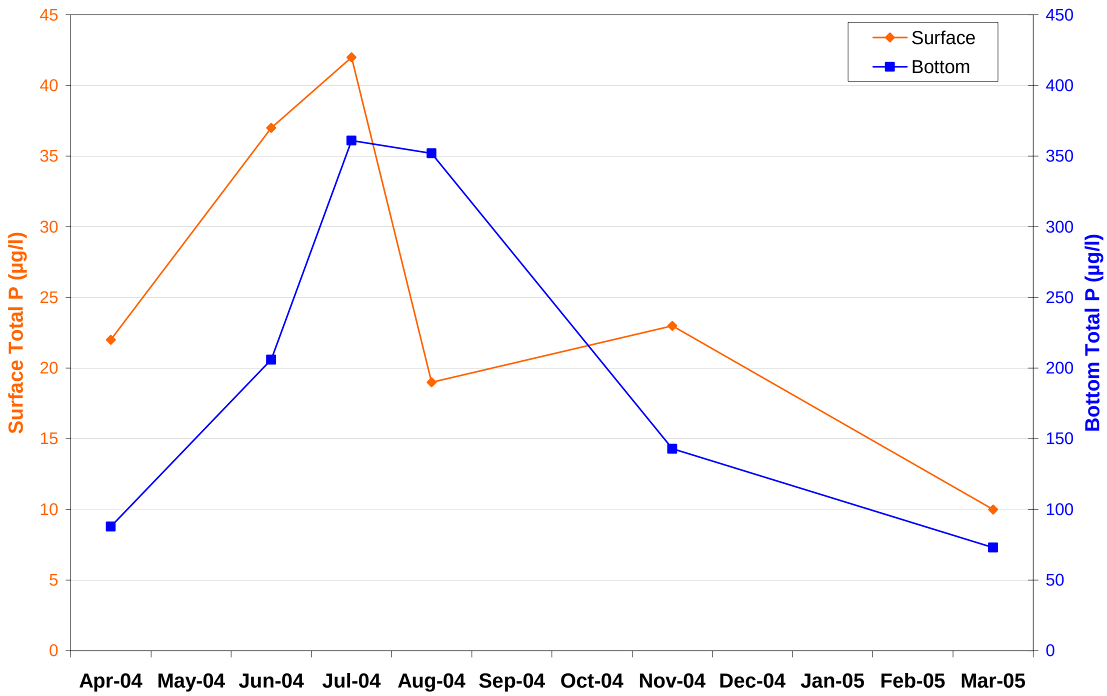

Figure 22. Total phosphorus concentrations in Mount Morris Lake D during portions of 2004 and 2005. Please note that scale for Bottom Total P is ten times that of the scale for Surface Total P.

SUMMARY AND CONCLUSIONS

The water quality analysis indicates that in general, Mount Morris Lake is healthy and comparable with other lakes in the region. Although the lake would be considered to be eutrophic, it is only mildly so and it is this eutrophic nature that supports the outstanding plant community that exists there. Unfortunately, the production extends to non-native species too, especially curly-leaf pondweed, which thrives in the lake's relatively nutrient-rich sediments. The nutrient-rich sediments are evidenced by the high levels of phosphorus that are released from them into the anoxic hypolimnion while the lake is stratified. While these hypolimnetic phosphorus values may indicate mild internal phosphorus loading, the majority of the lake's phosphorus is loaded from its watershed.

As described above, the watershed of Mount Morris Lake is quite large and loads significant amounts of phosphorus to the lake. However, two pieces of evidence indicate that the loadings could be much higher:

1. Analysis of the modeled watershed loadings from WiLMS result in higher in-lake phosphorus levels than actually occur at Mount Morris Lake.
2. Data and analysis from Lillie and Mason (1983) indicate that Wisconsin lakes with watershed to lake area ratios typically exhibit average summer phosphorus values of 56 μg/L. The average value for Mount Morris Lake using all of the data available is much lower at 20.6 μg/L.

Two factors likely aid in reducing the actual phosphorus loads that reach the lake; the first being the diligent work of the Waushara County Land Conservation Department in enlisting area farmers into better crop and soil management practices. The second is the extensive amount of wetlands that surround the agricultural areas and the tributaries that carry runoff to the lake. These wetlands not only filter the runoff, but also reduce it by allowing it to seep into the groundwater. Considering the farmers are required to continue their conservation practices even after the Priority Watershed Program cost sharing runs out in 2009 and the wetlands are undevelopable under current state and federal regulations, it is apparent they will likely stay in its current state. The fact of the matter is, the most influential and alterable portion of the watershed is the area immediately around the lake.

The majority of the properties around the lake resemble urban landscapes more than a natural lakescape. Properties such as these increase nutrient and sediment loading to the lake, while robbing the lake ecosystem of important habitat and increasing shoreline erosion. Nutrient loading is significantly increased from properties utilizing fertilizers containing phosphorus.

An additional source of nutrient loading from shoreland properties may be faulty septic systems. As systems age and soils loose their filtering capacities, phosphorus loads increase to the lake via groundwater inputs. At this time, it is unknown if shoreland septic systems affect the nutrient budget of Mount Morris Lake, but they should definitely be a concern.

By far, the greatest impact to Mount Morris Lake has been the introduction and establishment of curly-leaf pondweed. This deleterious plant has affected the lake in many ways, it has decreased native habitat, its midsummer die off increases lake phosphorus concentrations, and it has decreased recreational use by shoreland property owners and the general public. Much of its spread was unknowingly facilitated through the district's harvesting activities. However, the implementation of the new harvesting plan and the initiation of five-year Aquatic Invasive Specie project in 2006, should greatly decrease the impact curly-leaf pondweed has had on the lake. The protection and prevention strategies outlined in the Aquatic Plant Management Plan, if implemented, will do much to keep additional invasive species from having similar affects on the lake.

IMPLEMENTATION PLAN

Management Goal 1: Enhance and Protect Native Aquatic Plant Habitat

Management Action: Reduce curly-leaf pondweed occurrence within lake.
Timeframe: In progress
Facilitator: Mr. Rob Adams & Board of Directors
Description: As described in the Aquatic Plant section and Conclusions, curly-leaf pondweed is currently the biggest threat to the native aquatic plant community of Mount Morris Lake. Reducing this noxious plant's densities within the four main basins through efficient chemical treatments will do much to reduce its competitiveness and as a result allow native plant species to begin restoring themselves. The five-year project outlined in the February 2006 Aquatic Invasive Species Grant Application Project Scope (Appendix D) includes intense chemical treatment and monitoring of curly-leaf pondweed densities throughout the lake. Through these efforts, the district will maintain control of curly-leaf pondweed while protecting and enhancing the native plant communities.
Action Steps:

1. See Aquatic Plant Management Plan and Appendix D

Management Action: Prevent further invasive infestation of Mount Morris Lake from outside sources.
Timeframe: In progress
Facilitator: Mr. Tim Dahlstrand
Description: Although Eurasian water milfoil and curly-leaf pondweed are known to exist within Mount Morris Lake, it is still important to prevent further introductions from entering through the lake's primary boat landing. This will be accomplished through the implementation of a Clean Boats Clean Waters Program at Mount Morris Lake. An additional benefit of this program will be the decreased chance that other area lakes will be infested with invasives from Mount Morris Lake.
Action Steps:

1. See Aquatic Plant Management Plan and Appendix D

Management Action: Reduce impacts of harvesting on native plant communities through the adoption of an updated harvesting plan.
Timeframe: In progress
Facilitator: Board of Directors
Description: As stated in the Results and Discussion section, curly-leaf pondweed has likely been spread to its current locations largely through the district's harvesting efforts. To reduce further spread of curly-leaf pondweed and that of Eurasian water milfoil, the district has adopted a new harvesting plan effective spring 2006.
Action Steps:

1. See Aquatic Plant Management Plan and Appendix D

Management Action: Reduce occurrence of purple loosestrife and reed canary grass on Mount Morris Lake shorelands.

Timeframe: Begin 2008

Facilitator: Board of Directors

Description: Purple loosestrife and reed canary grass were found in numerous locations around Mount Morris Lake. Although these plants are not in high abundances at this time, their spread may lead to reductions in native plant biomasses in the diverse wetland and emergent areas that are found around the lake. At this time appropriate methods of control are not known as they would be based upon current levels of occurrence.

Action Steps:

1. Recruit member to facilitate district efforts.
2. Facilitator contacts WDNR to gather information concerning appropriate assessment and control methods
3. Facilitator initiates surveys using district volunteers
4. Initiate applicable control methods
5. Monitor results and reapply control as necessary

Management Goal 2: Maintain Current Water Quality Conditions

Management Action: Continue water quality monitoring beyond 5-year AIS Project.

Timeframe: Start in 2010

Facilitator: Board of Directors

Description: Monitoring of water quality is an important aspect of all lake management efforts. The district is currently monitoring water quality as a part of its AIS Project and understands the importance of continuing the work. In order to accomplish this task, the district will participate in the WDNR Citizen Lake Monitoring Network program.

Action Steps:

1. Contact Mr. Mark Sesing, WDNR to enroll in program.
2. Recruit volunteers to collect samples and maintain data.
3. Report results to district on an annual basis.

Management Action: Reduce phosphorus and sediment loads from immediate watershed.

Timeframe: Begin 2007

Facilitator: Board of Directors

Description: Although the Mount Morris Lake watershed is rather large when compared to the size of the lake, it is believed that nutrient loads are minimal considering the best management practices that have been implemented by Waushara County and the large amount of wetlands and forested areas that exist within it. As a result, the impacts that are most controllable at this time originate along the lake's immediate shoreline. These sources include faulty septic systems, the use of phosphorus-containing fertilizers, shoreland areas that are maintained in an unnatural manner, and impervious surfaces. To reduce these impacts, the district will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include news letter articles and guest speakers at district meetings. This action will also include participation in Waushara County shoreland restoration programs as deemed appropriate by the Waushara County Land Conservation and Zoning Department and the Mount Morris Lake Management District.

Action Steps:

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

Management Action: Reduce potential loadings from near-lake agricultural area.
Timeframe: Undetermined
Facilitator: Board of Directors
Description: A parcel of land between the lake and County Highway G is currently used in rotational agriculture. Although the land is not considered highly erodible by the Natural Resources Conservation Service and farmed using conservation tillage, due to its proximity of the lake, the area is believed to be a potential source for sediments and nutrients that enter the lake. Ultimately, the district would like to see the area reforested and believes this objective could best be met through the district's purchase of the property. Partial funding for this protective step may be available through the WDNR Lake Protection Grant Program. At this time, the district does not believe the owners would be willing to sell the property, but initial contact will be made according to the timeframe below.

Action Steps:

1. Contact property owners to initiate dialog with district.
2. Construct timetable for purchase, if applicable.
3. Contact WDNR to investigate possible funding opportunities.

AQUATIC PLANT MANAGEMENT PLAN

Introduction

The Mount Morris Lake aquatic plant management plan contains two major components; 1) the reduction and control of exotic species, specifically, curly-leaf pondweed and Eurasian water milfoil, and 2) nuisance relief of native and non-native aquatic plants through harvesting. Although the components are detailed independently, they are naturally intertwined with the mutual goal of providing recreational opportunities for lake users while protecting and enhancing a valuable natural resource.

Exotic Plant Species Control Plan

As described in the Results and Discussion Section, the aquatic plant community of Mount Morris Lake is outstanding as evidenced by the system's high diversity, plethora of native floating-leaf and emergent plant communities, and its exceptional floristic quality. Unfortunately, the value of this unique system as an ecological and recreational resource is threatened by an established infestation of curly-leaf pondweed and a pioneer colony of Eurasian water milfoil. The plan outlined below is a multi-year plan with basically two phases. The first phase will last four years and is an intense attack on existing exotics with the intent on significantly reducing their occurrence. The second phase is the continued control of the exotics, primarily through the efforts of the MMLMD. The goals of this portion of the plan are to:

- Reduce the occurrence of curly-leaf pondweed within the lake and as a result, minimize its spread through harvesting.
- Control or possibly eradicate the small amount of Eurasian water milfoil that is currently known to exist within the lake.
- Minimize the opportunities for additional introductions of these species through the lake's public access.
- Prepare the MMLMD to continue the management and control efforts past the initial four-year project.

These goals will be met with a multi-faceted plan aimed at attacking the exotics problem through chemical, mechanical, and manual treatments, prevention of additional introductions from outside sources, and monitoring to guide efficient treatments, determine treatment effectiveness, and locate exotic infestations within the lake that are currently unrealized or may occur in the future. Much of the work involved with this plan will be completed through volunteer efforts which raise stakeholder awareness and ownership in the project, while equipping the group to continue the efforts into the future.

Control Treatments

Three types of treatments will be utilized to control curly-leaf pondweed and reduce its occurrence throughout the lake; chemical control using endothal (Aquathol-K®), deep mechanical harvesting, and hand-removal by divers in select areas utilizing scuba. Hand-removal will also be utilized on the limited amount of Eurasian water milfoil found in Lake D. These efforts would be guided through pre-treatment monitoring performed by professionals (please see section on Pre-Treatment Monitoring below).

Chemical Applications

The plan includes multiple chemical treatments of curly-leaf pondweed within the lake. Chemicals will be applied by a licensed applicator at an initial rate of 1.5 ppm of Aquathol K® before turions are produced. If the proposed treatment rate does not appear to be providing acceptable effectiveness, the MMLMD would consult with the WDNR concerning the applicability of higher dose rate per acre.

As described above, the focus of this plan is the protection of important habitat; therefore, early spring treatments will be utilized to reduce impacts on native plants. The first treatment, proposed to occur in spring 2006, will include a total of approximately 26 acres in Lakes A, B, C, and D (Map 5). Locations targeted for chemical treatment include areas containing curly-leaf pondweed above what would be considered a scattered occurrence to areas clearly dominated by the plant and locations that cannot be reached by the district's harvesters. All target areas pose a definite threat to the ecosystem because they act as sources for potential spread to other areas of the lake through turion production.

Hand-Removal

Hand-removal by divers is still an experimental procedure for curly-leaf pondweed and Eurasian water milfoil control; however, the method appears sound. Hand-removal of curly-leaf pondweed would be restricted to Lake E where only a few scattered plants were found (Map 5). Eurasian water milfoil would be hand-removed in its currently known area of Lake E. Removal would be performed by certified scuba divers with Onterra following pre-treatment monitoring. During hand-removal, extra care will be taken not to disturb and spread existing turions to other locations in the lake. Furthermore, if turions are able to be seen while in the water, they will also be removed from lake.

To monitor effectiveness of hand-removal, select areas would be marked with single metal stakes so the precise locations could be visited each year. If conditions warrant, underwater photography would be used to further document treatment effectiveness.

Mechanical Harvesting

Mechanical harvesting of approximately 14 acres (Map 5) will be performed with the intent of minimizing turion production in those areas. Harvesting will begin in early May before turion production starts and continue until evidence of native growth appears. Harvesting will be completed to the maximum depth possible without disturbing bottom sediments. These areas will be monitored as a part of the pre- and post-treatment efforts described below in order to document turion reduction.

Monitoring

Monitoring is an important element of a complete management plan. For this plan in particular, monitoring would be completed to assess long- and short-term effectiveness, to ensure efficiency in control techniques, and to determine if reductions in curly-leaf biomass within the lake suppresses the total phosphorus spike that was documented during the summer of 2004. Monitoring would be completed by professionals and volunteers in conjunction with the first four years of this plan. Volunteers would be trained to make certain that proper protocols would be followed and reliable data would be collected. As mentioned above, volunteer involvement is essential to raise awareness about the project and the value of responsible lake stewardship, while creating ownership in the project. The involvement would also raise the capacity of the MMLMD to continue the management efforts in the future.

Pre-treatment Monitoring

Pre-treatment monitoring would be completed annually to guide each year's control program. Doing this would ensure that chemicals are used sparing within the system and practical hand-removal areas would be selected. It would also allow professionals the opportunity to monitor and to quantify the success of the previous year's management effort.

Monitoring would be completed using surface surveys via boat, rake tows, scuba, and a limited amount of submerged video. Suspect areas located during the 2004 aquatic plant surveys and through the volunteer monitoring program would be the primary targets of the site visits and would naturally include all previously treated areas, as applicable. Monitoring would begin soon after ice-out when water temperatures reach approximately 45ºF. Once the monitoring is complete, the findings would be analyzed and that year's treatment plan would be formulated. The newly created plan would be shared with the WDNR to obtain concurrence and ensure a smooth and rapid permitting process. Cooperation and preparedness would be essential for the success and ultimate usefulness of this component. Some of the permitting process may be completed based upon the previous year's treatments and monitoring; however, if all involved are not prepared to respond quickly, then the opportunity for an early season treatment may be lost.

Prior to the treatment, buoys would be placed to mark treatment areas for chemical application. Following the application, volunteers in charge of post-treatment monitoring (see below) would familiarize themselves with the treatment locations before retrieving the buoys.

Post-treatment Monitoring

The premise of completing early-season curly-leaf pondweed treatments, through harvesting and herbicide applications, is the reduction of turion production. If turion production is reduced, then a reduction in plant biomass can be assumed. Post-treatment monitoring will be completed by volunteers and professionals following each application. Specifically, volunteer monitoring will be completed during mid June, while professional monitoring will be performed the following spring previous to that year's treatment. Essentially, the volunteers will monitor if that year's treatment reduced turion production and then the professional monitoring will assess if the biomass is being reduced.

A key benefit of this component would be the ability to make alterations to the treatment plan as the project progresses. The ability to make these short-term assessments and changes would increase the likelihood of success in the long-term. These adjustments may include changes in treatment timing, dosage rate, and location, or possibly the complete discontinuation of treatments in particular areas.

Volunteer Monitoring

Volunteers will be trained by professionals following the first treatment to collect data aimed at determining if turion production is being stifled. On the second weekend following treatment, 2 teams of 2 volunteers will be used to gather post-treatment data. At roughly 80, pre-determined locations arranged in a grid pattern based on a 40-meter resolution within select treatment areas, volunteers will observe the condition of curly-leaf pondweed plants from the surface and record if the plants appear to be dead or dying. At each location, the volunteers will also complete two rake tows. From each tow, biomass of curly-leaf pondweed (dead or living) on the rake head will be recorded on a scale of 1-3, as will the number of turions found either loose or attached to plants. Two sediment samples will also be retrieved at each location using a bottom dredge and each of those samples will be screened (washed) and the turions enumerated. It is estimated that each team will volunteer approximately 5 hours of time gathering data. These data will be summarized annually.

Professional Monitoring

Professional monitoring will be completed concurrently with each year's pre-treatment survey. Two rake tows will be completed at the same locations used by the volunteer monitors. Biomass of curly-leaf pondweed and native plants will be recorded for each tow on a scale of 1-3. These data will be summarized annually.

Water Quality Monitoring

As described in the Results and Discussion section, a definite phosphorus spike was detected in Lake D following the senescence of curly-leaf pondweed (Figure 22). It is expected that as the biomass of curly-pondweed is reduced through the efforts of this plan, that the associated phosphorus spike will also be reduced. It is the intent of this component to document this phenomenon through periodic water quality testing.

During the first four years of this plan, a volunteer would collect water quality samples from the deep holes of Lakes C and D. Near-surface and near-bottom samples would be collected bi-monthly May – October and would be analyzed for total and soluble reactive (ortho) phosphorus by the Wisconsin State Laboratory of Hygiene. The volunteer would be trained by professionals during the first season of monitoring. The results would be summarized annually.

Annual Monitoring for Aquatic Invasives

In lakes without curly-leaf pondweed and Eurasian water milfoil, early detection of pioneer colonies commonly leads to successful control and in some cases, eradication. Even in lakes where these plants occur, monitoring for new colonies is essential to successful control.

Volunteers from the MMLMD would be trained to monitor for curly-leaf pondweed and Eurasian water milfoil within both lakes. The training would be based upon a protocol created for volunteer monitoring within the Town of Saint Germain and would include identification of the target species and native look-alikes, methods to divide monitoring areas among participants, and a course of action to follow should suspect plants be found. The protocol would be modified slightly from that used in Saint Germain because of the existing populations of curly-leaf pondweed with the lake. The primary modification would be the familiarization of the volunteers with known areas of curly-leaf pondweed occurrence within their respective areas. This would be accomplished by visiting the sites after the first pre-treatment survey, but before the application is completed. An added benefit to this modification is the fact that volunteers would be exposed to curly-leaf pondweed as it occurs in situ.

Comprehensive Aquatic Plant Study

A survey of all aquatic plants, native and non-native, would be completed following the procedures used in the 2004 study (point-intercept). The results of this study would be the basis for determining if the 4-year control plan was successful at meeting the goals outlined above. It would also provide an additional baseline for determining the success of the MMLMD's continued management efforts.

Volunteer Watercraft Inspection

Despite the fact that Mount Morris Lake currently contains curly-leaf pondweed and a limited amount of Eurasian water milfoil, it is still important to help stop further infestation of these species. Furthermore, the educational value instilled to the volunteers during the training and then passed onto others as they do their work is invaluable to a project such as this.

Mr. Tim Dahlstrand of the MMLMD has attended a UW-Extension Clean Boats Clean Water training session and will lead this effort. Other members of the MMLMD will also attend training sessions to assist Mr. Dahlstrand in the facilitation of this component.

Nuisance Relief Harvesting Plan

Many areas of Mount Morris Lake contain nuisance levels of aquatic plants, mostly common waterweed, coontail, and curly-leaf pondweed. The original harvesting plan (Map 6) allowed for cutting of approximately 43.5 acres in Lakes A, B, C, and D. Its intent was to reduce nuisance levels of aquatic plants while protecting important native communities of emergent and floating-leaf species. Unfortunately, many of the areas that had been harvested in past years contained dense stands of curly-leaf pondweed and as a result, have likely spread the plant to other areas of the lake. Continued harvesting under the original plan would be counter-productive to the control plan outlined above and as mentioned in the Results and Discussion section, may lead to the spread of the limited amount of Eurasian water milfoil that has been documented in Lake D. It would also hamper the ability of native plants to compete against these exotics. As a result, the MMLMD will be following a new harvesting plan with the same goal of reducing nuisance plant growth that impedes navigation, but with the additional goal of not being counter-productive to the control plan.

The approximate locations of the newly created harvesting areas are shown on Map 6. These areas total approximately 15.5 acres and as indicated, represent 30-foot wide navigation lanes. These areas were created to allow lake users to access open water areas while avoiding important plant communities. Some of the newly created areas impede upon areas indicated as "No Cut" areas in the original plan; however, based upon the aquatic plant survey completed in 2005, these impacts are minimal to native communities.

The following guidelines will be used to realistically implement the harvesting plan on the lake:

- The proposed areas are essentially navigation lanes, so if navigation is not a problem, then cutting will not occur.
- If a harvesting area indicated on Map 6 is too deep, then the lane will be moved towards the shoreline as long as it does not impede on the native communities.

- If a harvesting area is too shallow for the harvesting equipment to reach, then the lane will be moved to deeper water, but not so deep that navigation is no longer a problem and native communities are impacted.
- If a harvesting area indicated on Map 6 is found to contain dense stands of curly-leaf pondweed or Eurasian water milfoil, an alternate route will be chosen so these exotics are not spread via harvesting activities.
- Harvesting activities will begin May 1 and end by October 1 each year.

METHODS

Lake Water Quality

Baseline water quality conditions were studied to assist in identifying potential water quality problems in Mount Morris Lake (e.g., elevated phosphorus levels, anaerobic conditions, etc.). Water quality was monitored at the deepest point in Lakes A-E. Samples were collected with a 3-liter Van Dorn bottle at the subsurface (S) and near bottom (B), and occurred once in spring, fall, and winter and three times during summer in Lake D. Lakes A, B, C, and E were sampled once in the spring, summer, fall, and winter. 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	●											

NOTE: ■ = Samples collected at all 5 Lakes. ● = Samples collected only at Lake D.

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 June and July 2004 by sampling 98 points spaced at 75 meters (1 point was unreachable) (Appendix C). The sampling resolution was based upon the original point-intercept guidance provided by the WDNR during 2004. At each sample point, a visual assessment was made from the boat in shallow water or via snorkeling in deeper water (over 5 feet). Water depth and substrate were also recorded at each site.

Watershed Analysis

The watershed analysis began with an accurate delineation of Mount Morris 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 East Central Regional Planning Commission were then combined to determine the preliminary watershed land cover classifications. The land cover data within the watershed were then field verified and updated during March 2006. These data along with modified data representing the different scenarios outlined in the management plan were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

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