Harris Pond

Marquette County, Wisconsin

Comprehensive Management Plan

June 2012

Sponsored by:

Harris Pond Lake Association
WDNR Grant Program

LPL-1331-10 & LPL-1333-10

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Onterra, LLC
Lake Management Planning

Harris Pond

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Funded by: Harris Pond Lake Association
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Acknowledgements

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

Harris Pond Planning Committee

Terry Coppens	Joe Helmin	Tancy Helmin
Tim Frank	Bob Streicl	Jay Ingram
Mike Mittelstedt	Sue Tutaj	Phyllis Ingram

Organization

University of Wisconsin – Stevens Point Center for Watershed Science and Education

Wisconsin Dept. of Natural Resources

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1.0 INTRODUCTION

Harris Pond, Marquette County, is a drainage lake with a maximum depth of 10 feet and a surface area of 172 acres (Map 1). This eutrophic lake has a relatively large watershed when compared to the size of the lake. Harris Pond contains 25 native plant species, of which floating duckweeds are the most common plant. Curly-leaf pondweed is known to exist in Harris Pond.

Field Survey Notes

Very productive system – quite a bit of duckweed sp., and emergent plants along the perimeter of the lake. Large areas of natural shoreline – great wildlife habitat!

Curly-leaf pondweed (CLP) was mapped throughout the majority of the lake. Few sizable colonies were observed, many occurences of CLP were in the form of isolated, sporadic plants, though numerous.

Photograph 1.0-1 Harris Pond, Marquette County

Lake at a Glance - Harris Pond

Morphology	
Acreage	172
Maximum Depth (ft)	10
Shoreline Complexity	8.3
Vegetation	
Curly-leaf Survey Date	June 2010
Comprehensive Survey Date	September 2010
Number of Native Species	25
Threatened/Special Concern Species	None
Exotic Plant Species	Two – Curly-leaf pondweed and Purple Loosestrife
Simpson's Diversity	0.84
Average Conservatism	6.1
Water Quality	
Trophic State	Eutrophic
Limiting Nutrient	Phosphorus

2.0 STAKEHOLDER PARTICIPATION

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

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

Kick-off Meeting

On April 17, 2010, a project kick-off meeting was held to introduce the project to the general public. The meeting was announced through a mailing and personal contact by HPLA board members. The attendees observed a presentation given by Tim Hoyman, an aquatic ecologist with Onterra. Mr. Hoyman's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including opportunities for stakeholders to be involved. The presentation was followed by a question and answer session.

Planning Committee Meeting

On August 29, 2011, Tim Hoyman of Onterra met with several members of the Harris Pond Planning Committee for nearly 3.5 hours. In advance of the meeting, attendees were provided an early draft of the study report sections to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee. All study components including the shoreline assessment, soft sediment survey and native and exotic aquatic plant inventories were discussed. Many concerns were raised by the committee, including nuisance levels of aquatic plants, low water levels, and the presence of curly-leaf pondweed in the system.

Project Wrap-up Meeting

On April 21, 2012, the HPLA held a special meeting regarding the completion of the Harris Pond Management Planning Project. During the meeting, Tim Hoyman and Dan Cibulka presented the results of the many studies that had been completed on the lake. The issues of water quality, plant production, and sediment accumulation were presented, and potential solutions discussed.

Management Plan Review and Adoption Process

A written results section was presented to HPLA planning committee members in early August 2011, before the Planning Committee meeting. On March 29 of 2012, a preliminary draft of the report was presented to the WDNR and HPLA for review. Following the WDNR review and stakeholder input at the wrap-up meeting, a final draft of the report was produced in late April of 2012, reviewed again by the WDNR, and finalized in June of 2012.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Please note: Water quality information was not collected by Onterra as part of this project. Instead, through an agreement with the University of Wisconsin Stevens – Point (UWSP) and UWSP Center for Watershed Science and Education, data collected on Harris Pond through the Montello River Watershed Study was integrated into this report.

Primer on Water Quality Data Analysis and Interpretation

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

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

Comparisons with Other Datasets

As mentioned above, chemistry is a large part of water quality analysis. In general, there are three water quality parameters that are often focused upon in a water quality analysis due to their ease of sampling and understanding:

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

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

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

Limiting Nutrient

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

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

Trophic State

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

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

Temperature and Dissolved Oxygen

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

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

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

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

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

Non-Candidate Lakes

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

Candidate Lakes

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

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

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

Harris Pond Water Quality

As part of the Montello River Watershed study, several water quality parameters were measured in Harris Pond. Phosphorus samples were collected in spring/summer of 2008 and 2009 on Harris Pond. WDNR phosphorus criteria suggests that the recommended average concentration in shallow, Wisconsin impoundments be below 40 μg/l. Through the UW-Stevens Point study, an average of 73 μg/l was found in Harris Pond. On several occasions, total phosphorus concentrations were measured at above 100 μg/l. The Montello River Watershed study report states that generally, total phosphorus concentrations above 30 μg/l are enough to stimulate algae blooms and aquatic plant growth (Turyk, et al. 2010). The report goes on to indicate that as total phosphorus concentrations increased in Harris Pond, the algae (as measured by chlorophyll-*a*) increased as well. Secchi disk transparency was not recorded on Harris Pond because the Secchi depth was greater than the maximum pond depth. In other words, the Secchi disk was visible lying on the bottom in the deepest spot of the lake which makes the reading invalid.

A total nitrogen to total phosphorus ration of 35:1 was calculated for Harris Pond, indicating that the lake is phosphorus limited. This means that the plant and algal growth in the lake is dependent primarily on phosphorus. Sediment core studies conducted by the UWSP researchers indicate that there is very limited internal nutrient loading occurring in Harris Pond, meaning that the excessive nutrients found in this system arrive via external loading sources.

In shallow, nutrient-rich impoundments supporting a very high vascular plant biomass, such as Harris Pond, dissolved oxygen levels can vary greatly throughout the day, season, and with depth. Aquatic plants produce oxygen during daylight hours, creating an oxygen-rich environment; however, that oxygen may not be distributed equally throughout the water column. During low-light conditions and night, plants respire and as a result, can significantly reduce oxygen levels within the water column. Tributaries normally bring in oxygen-rich waters to impoundment, while continual bacterial decomposition of the dead plant material works to reduce dissolved oxygen levels. All-in-all, these processes can lead to unpredictable and sometimes harmful dissolved oxygen levels within this type of aquatic system.

Between March of 2008 and November of 2009, Harris Pond dissolved oxygen levels ranged between approximately 2 mg/L and 13 mg/L. The lake showed only slight thermal stratification during this time period, as indicated by the temperature profiles (Appendix C, page 18). However, at times the lake was moderately stratified in terms of dissolved oxygen concentration (Appendix C, page 18). At this time, there is no reason to believe that lower dissolved oxygen concentrations are impacting the aquatic organisms (such as fish) in the lake as plenty of oxygen remains in the upper 4 feet of the water column, and much of the lake is 4 feet deep or less. For more information regarding the Montello River Watershed study, refer to Appendix C.

Because of the large amount of land which drains into Harris Pond (discussed more in detail within the Watershed Section), Harris Pond receives a substantial amount of sediment and nutrients, especially phosphorus. As a result, Harris Pond can support an incredibly high abundance of aquatic plants and algae. Based upon the phosphorus levels reported in the Montello River watershed study, Harris Pond is considered highly eutrophic and often hypereutrophic.

3.2 Watershed Assessment

Please note: Watershed information was not collected by Onterra as part of this project. Instead, through an agreement with the University of Wisconsin Stevens – Point (UWSP) and UWSP Center for Watershed Science and Education, data collected on Harris Pond through the Montello River Watershed Study was integrated into this report.

Primer on Watershed Characteristics

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

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

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

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

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

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

Harris Pond Watershed

University of Wisconsin – Stevens Point conducted a study of the Montello River Watershed, of which Harris Pond is a part. Between February and November of 2008, the two primary tributary streams to Harris Pond, Tagatz Creek and Westfield Creek, were monitored extensively for a number of water quality parameters, including discharge and water chemistry. A smaller, unnamed third tributary of the watershed was not monitored. Additionally, UW – Stevens Point researchers delineated numerous tributary watersheds in the Montello watershed and also quantified the land cover types for most of these sub-watersheds.

Based upon the UW – Stevens Point findings, Harris Pond's two primary tributary watersheds are a combined 61 square miles (~38,990 acres) in size. Table 3.2-1 illustrates the land cover types present in the watershed, in their approximate quantities. Harris Pond's contributing tributary watershed is approximately 160 times larger than the lake, making a very large watershed to lake area ratio (160:1). As previously mentioned, because of this large ratio the amount of land in the Harris Pond watershed plays a larger role in the condition of the lake than the types of land located within the watershed. The land cover within the watershed likely exasperates this impact however, as 25% of the land is in various forms of agriculture. Agricultural lands typically allow for more water and nutrient runoff than forested lands or wetlands because there is less plant material to hold soils intact and assist with water infiltration into the groundwater.

The Montello River Watershed report highlighted the differences and the stressors in each of these sub-watersheds. Tagatz Creek watershed holds more forested land (anecdotally – land cover types were not reported on for this sub-watershed). The forested land cover minimizes the amount of nutrients and sediment exported to the creek. Additionally, the creek receives more groundwater input than surface water input, and as a result is much colder than other streams in the Montello River watershed. Indeed, Tagatz Creek had the coldest temperature of the streams studied in 2008, averaging 58°F throughout the summer months. Parts of this stream are considered Class I Trout habitat, and the report states that this stream is the least impacted tributary to the Montello River, and also Harris Pond.

Table 3.2-1. Watershed statistics for two Harris Pond tributary watersheds. Based upon University of Wisconsin – Stevens Point Center for Watershed Science and Education estimates (Turyk, et al. 2010). Please note that a third, smaller unnamed tributary watershed that contributes to Harris Pond was not analyzed in this study.

Watershed	Watershed Size (sq. miles)	Watershed Size (acres)
Tagatz Creek	17.3	11,050
Westfield Creek	43.7	27,940
Total	61.0	38,990

Westfield Creek Sub-Watershed

Type	Approximate Acres	% of Watershed
Mixed Forest	11,120	40.0
Mixed Agriculture	6,985	25.0
Pasture / Grassland	5,289	19.0
Wetland	2,682	10.0
Developed Land	1,830	6.0

The Montello River Watershed report also indicated numerous stressors impairing Westfield Creek. The primary issues of concern indicated within the report are stream temperature, along with nutrient and sediment **loads** and sediment **yields** (Note: a **load** refers to the amount of quantifiable material being transported in a stream. A **yield** is the total amount of material that leaves a watershed, usually measured in an amount per area per year). The report concluded that Westfield Creek contributes more phosphorus and sediment to downstream impoundments (Harris Pond included) than every other stream included in the Montello River Watershed study.

Because Harris Pond is a flowage system and drains many acres of land, it will always be highly productive (eutrophic). In other words, because of the sheer size of the watershed, there will always be a considerable nutrient and sediment load entering Harris Pond.

Harris Pond Soft Sediment and Water Levels

As the Montello River Watershed report describes, sediment transport in Westfield Creek is of primary concern. Westfield Creek enters Harris Pond at its northernmost end, and as the water loses velocity, much of this sediment falls out of the water column and is deposited in Harris Pond. On June 8, 2010, a survey was conducted by Onterra ecologists to learn the depth of soft sediment at 128 locations throughout the lake (Map 2). Data was collected at locations in which the water depth was less than 6 feet, as the methodology limited data collection in deeper locations.

In many locations, particularly along the lake's eastern shoreline, the soft sediment was relatively shallow (under 4 feet of depth). However in several locations, presumably following the former stream channel in the center/western side of the lake, the depth of soft sediment was greater than 8 feet. As discussed further in the Aquatic Plant Section, this soft, nutrient-rich sediment is the ideal substrate type for many aquatic plants.

The combination of anecdotal sediment buildup and fluctuating water levels are of concern to many Harris Pond residents. Harris Pond is by no means a natural waterbody – it is an impoundment created in the mid-1850's and first permitted and regulated by the Mill Dam Act of 1840. The purpose of the Milldam Act was to encourage the construction of gristmills, sawmills, and other mills by permitting the flowing of the lands of others without acquiring flowage easements for the millpond. This also encouraged settlement within the region, which at the time was the Wisconsin Territory, not yet the State of Wisconsin.

A gristmill was first constructed on Harris Pond in 1853. The construction of the current building that stands on the south end of Harris Pond began around 1915. The project was completed in 1918, and for some time afterwards was the only electricity source for Harrisville, Montello and by some accounts Kingston as well. In 1972 the operations of the Harrisville Dam were deliberated in a civil court hearing. This hearing was initiated by petitions from property owners along the shorelines of Harris Pond, who wanted to establish flow levels for the water body. Following the hearing, the court stipulated that the operating range for the Harrisville Millpond should be 3 inches above and 9 inches below a reading of 41 inches on the dam owner's water level gauge. This translates to a maximum elevation of 98.10 feet and a minimum elevation of 97.10 feet.

Since 1972, more concern has been expressed by Harris Pond residents regarding the fluctuations in water levels on the waterbody. During September and October of 2009, residents monitored the water levels of Harris Pond using a gauge near the Harrisville Dam. During this time, water levels fluctuated, yet remained within the 1 foot operating range dictated by the 1972 court order. Further discussions between Onterra and David Stertz, WDNR Dam Engineer, in winter of 2010 indicate there is no reason to believe the dam has been operated outside of this 1 foot range since 1972.

Shoreline Assessment

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

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

A lake's shoreland zone can be classified in terms of its degree of development. In general, more developed shorelines are more stressful on a lake ecosystem, while definite benefits occur from shorelines that are left in their natural state. Figure 3.2-1 displays a diagram of shoreline categories, from "Urbanized", meaning the shoreland zone is completely disturbed by human influence, to "Natural/Undeveloped", meaning the shoreline has been left in its original state.

On Harris Pond, the development stage of the entire shoreline was surveyed during late summer of 2010, using a GPS unit to map the shoreline. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreline on a property-by-property basis. During the survey, Onterra staff examined the shoreline for signs of development and assigned areas of the shoreland one of the five descriptive categories in Figure 3.2-3.

Harris Pond has stretches of shoreland that fit all five shoreland assessment categories (Figure 3.2-3). In all, 4.1 miles of natural/undeveloped and developed-natural shoreline were observed during the survey (Figure 3.2-2). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 0.9 miles of urbanized and developed–unnatural shoreline were observed. If restoration of the Harris Pond shoreline is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreline lengths around the entire lake.

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

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

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

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

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

Figure 3.2-1. Shoreline assessment category descriptions.

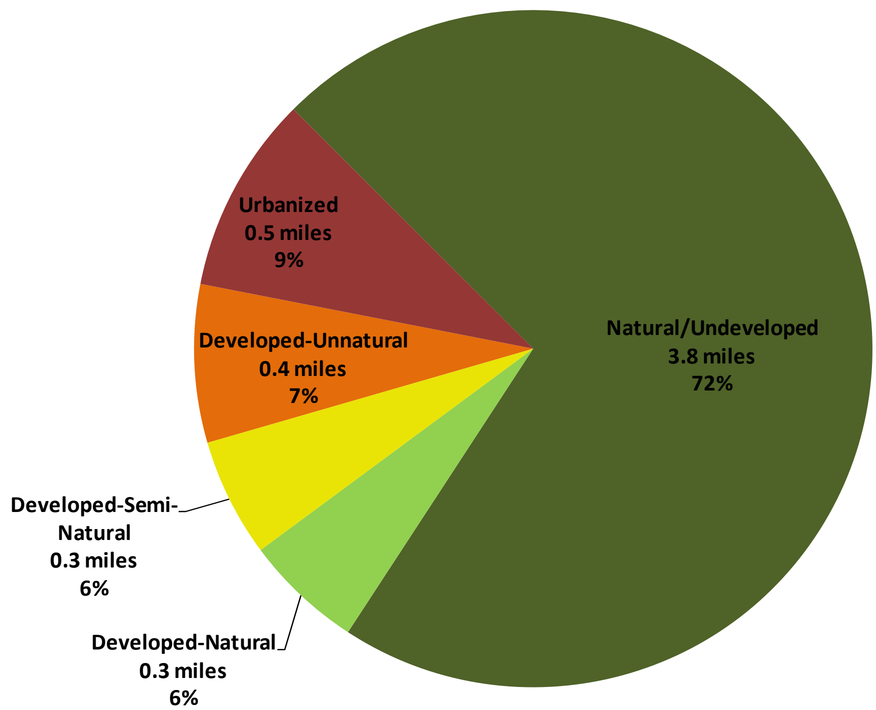

Figure 3.2-2. Harris Pond shoreland categories and total lengths. Based upon a late summer 2010 survey. Locations of these categorized shorelands can be found on Map 3.

3.3 Aquatic Plants

Introduction

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

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

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

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

Aquatic Plant Management and Protection

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

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

Permits

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

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

Native Species Enhancement

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

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

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

Cost

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

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

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

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

Manual Removal

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

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

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

Cost

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

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

Bottom Screens

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

Cost

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

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

Water Level Drawdown

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

Cost

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

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

Mechanical Harvesting

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

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

Chemical Treatment

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

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

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

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

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

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

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

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

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

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

<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 permitted for use near aquatic environments because of its harmful effects on fish, amphibians, and other aquatic organisms.

<u>Imazapyr</u> (Habitat®) Broad spectrum, system herbicide, slow-acting liquid herbicide used to control emergent species. This relatively new herbicide is largely used for

controlling common reed (giant reed, *Phragmites*) where plant stalks are cut and the herbicide is directly applied to the exposed vascular tissue.

Cost

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

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

Biological Controls

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

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

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

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

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

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

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

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

Analysis of Current Aquatic Plant Data

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

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Harris Pond; the first looked strictly for the exotic plant, curly-leaf pondweed, while the others that followed assessed both native and non-native species. Combined, these surveys produce a great deal of information about the aquatic vegetation of the lake. These data are analyzed and presented in numerous ways; each is discussed in more detail below.

Primer on Data Analysis & Data Interpretation

Species List

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

Frequency of Occurrence

Frequency of occurrence describes how often a certain species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of Harris Pond, plant samples were collected from plots laid out on a grid that covered the entire lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. In this section, two types of data are displayed: littoral frequency of occurrence and relative frequency of occurrence. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are less than the maximum depth of plant growth (littoral zone). Littoral frequency is displayed as a percentage. Relative frequency of occurrence uses the littoral frequency for occurrence for each species compared to the sum of the littoral frequency of occurrence from all species. These values are presented in percentages and if all of the values were added up, they would equal 100%. For example, if water lily had a relative frequency of 0.1 and we described that value as a percentage, it would mean that water lily made up 10% of the population.

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

Species Diversity and Richness

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

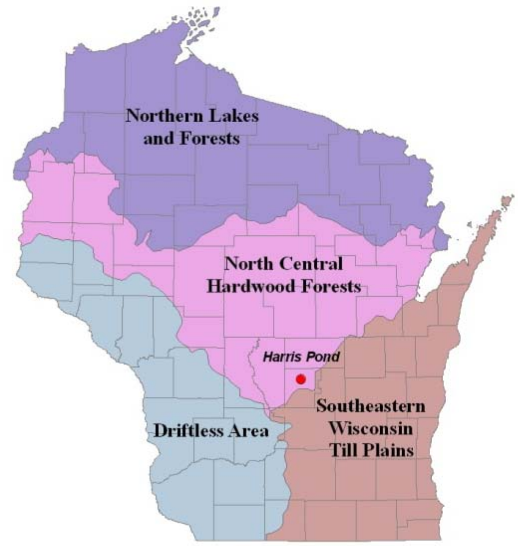

Figure 3.3-1. Location of Harris Pond within the ecoregions of Wisconsin. After Nichols 1999.

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

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

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

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

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species.

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

Floristic Quality Assessment

Floristic Quality Assessment (FQA) is used to evaluate the closeness of a lake's aquatic plant community to that of an undisturbed, or pristine, lake. The higher the floristic quality, the closer a lake is to an undisturbed system. FQA is an excellent tool for comparing individual lakes and the same lake over time. In this section, the floristic quality of Harris Pond will be compared to lakes in the same ecoregion and in the state (Figure 3.3-1).

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

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

Community Mapping

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

Exotic Plants

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

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

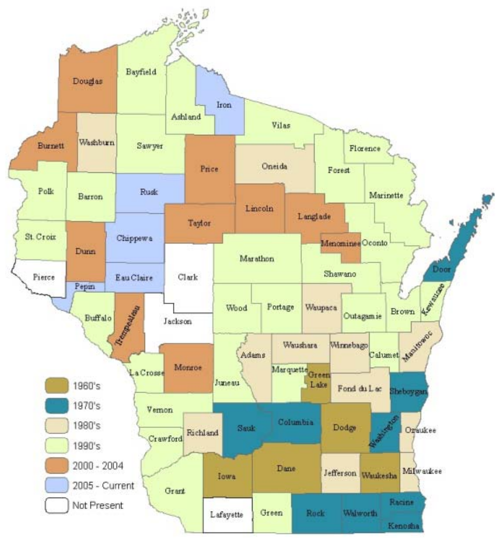

Figure 3.3-2. Spread of Eurasian water milfoil within WI counties. WDNR Data 2011 mapped by Onterra.

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

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

Aquatic Plant Survey Results

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

As mentioned above, numerous plant surveys were completed as a part of this project. In early June 2010, a survey was completed Harris Pond that focused upon curly-leaf pondweed. Before this time, curly-leaf pondweed was not known to exist in Harris Pond. However, this meander-based survey located numerous occurrences of curly-leaf pondweed (Map 4). The results of this survey are discussed in more detail below.

The point intercept survey was conducted on Harris Pond on September 1, 2010 by Onterra (Map 1). Additional surveys were completed by Onterra on Harris Pond to create the aquatic plant community maps (Map 5) during that same timeframe.

During the point-intercept and aquatic plant mapping surveys, 25 species of native aquatic plants were located in Harris Pond (Table 3.3-1), along with two which are considered non-native species: curly-leaf pondweed and purple loosestrife. Because of their importance, these species will be discussed in depth in a separate section. 23 of the 25 native species were sampled during the point intercept survey and will be used in the analysis which follows.

Aquatic plants were found at 97% of all the point-intercept locations sampled (Map 6), including at the deepest location in the lake (9 feet), with the largest number of point intercept locations between 3 and 6 feet containing aquatic plants (Figure 3.3-3). This means that all of Harris Pond is considered littoral, or within the plant growing zone.

Two milfoil species (genus *Myriophyllum*), northern water milfoil and whorled water milfoil, were located from Harris Pond while the invasive Eurasian water milfoil was not. Northern water milfoil, arguably the most common milfoil species in Wisconsin lakes, is frequently found growing in soft sediments and high water clarity. Northern water milfoil is often falsely identified as Eurasian water milfoil, especially since it is known to take on the ‘reddish’ appearance of Eurasian water milfoil as the plant reacts to increased sun exposure, largely from lowering water levels.

Table 3.3-1. Aquatic plant species located on Harris Pond during 2010 surveys. Exotic species are indicated in red font.

Life Form	Scientific Name	Common Name	Coefficient of Conservatism (c)
Emergent	*Bolboschoenus fluviatilis*	River bulrush*	5
	Carex comosa	Bristly sedge	5
	Lythrum salicaria	Purple loosestrife	Exotic
	Sagittaria latifolia	Common arrowhead*	3
	Schoenoplectus tabernaemontani	Softstem bulrush	4
	Sagittaria rigida	Stiff arrowhead	8
	Zizania palustris	Northern wild rice	8
FL	*Nuphar variegata*	Spatterdock	6
Submergent	*Chara spp.*	Muskgrasses	7
	Ceratophyllum demersum	Coontail	3
	Elodea canadensis	Common waterweed	3
	Heteranthera dubia	Water stargrass	6
	Myriophyllum verticillatum	Whorled water milfoil	8
	Myriophyllum sibiricum	Northern water milfoil	7
	Potamogeton friesii	Fries' pondweed	8
	Potamogeton nodosus	Long-leaf pondweed	7
	Potamogeton crispus	Curly-leaf pondweed	Exotic
	Potamogeton amplifolius	Large-leaf pondweed	7
	Potamogeton zosteriformis	Flat-stem pondweed	6
	Ranunculus aquatilis	White water-crowfoot	8
	Stuckenia pectinata	Sago pondweed	3
	Vallisneria americana	Wild celery	6
FF	*Lemna trisulca*	Forked duckweed	6
	Lemna turionifera	Turion duckweed	2
	Spirodela polyrhiza	Greater duckweed	5
	Wolffia columbiana	Common watermeal	5
	Wolffia borealis	Dotted watermeal	6

FL = Floating Leaf; FF = Free Floating
** = Incidental species*

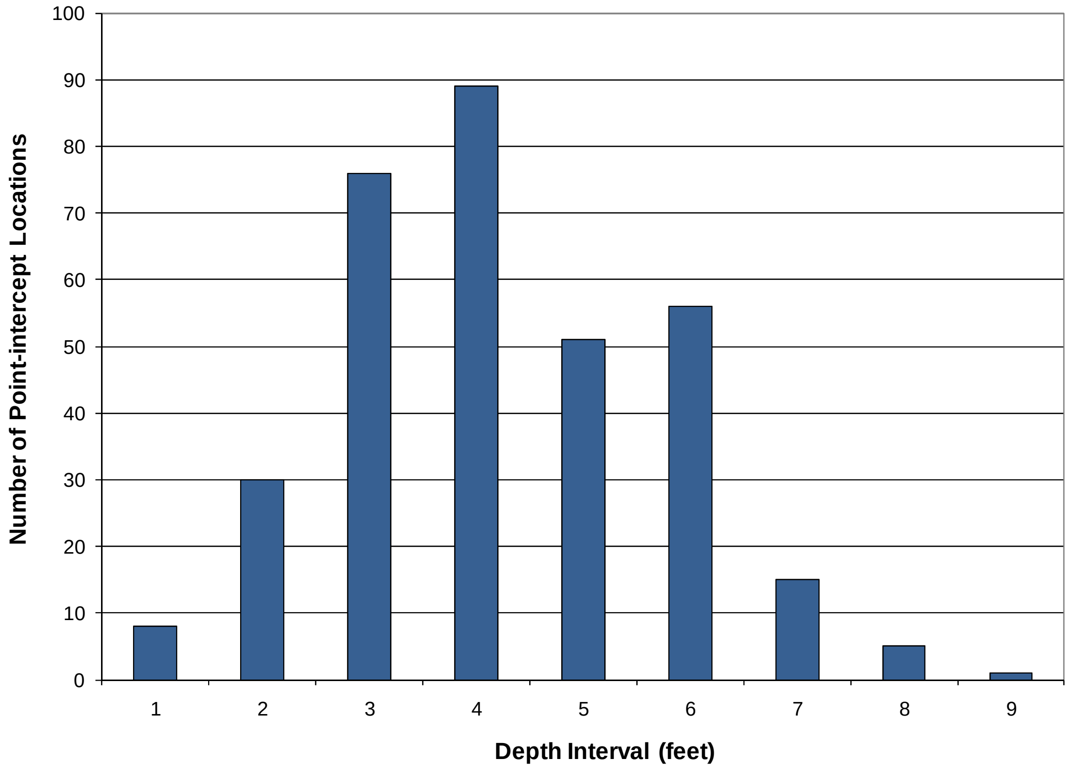

Figure 3.3-3 Harris Pond aquatic plant depth distribution. Created using data from WDNR 2010 survey.

Photo 3.3-1. White-water crowfoot flower amongst floating duckweed species on Harris Pond.

As indicated in Table 3.3-1, five species of free-floating plants were found in Harris Pond. These very small flowering plants belonging to the duckweed family (Lemnaceae) may resemble algae to the untrained eye. Forked duckweed can often be found floating just below the water's surface or aggregating along the bottom. The other four species of floating-leaf species are generally referred to as floating duckweeds. Floating duckweeds are only found at the surface and accumulate amongst flowering or canopied vegetation and other debris that is at the water's surface. Water movement caused by inflowing tributaries or wind can greatly alter the locations of these species in a short timeframe. Floating duckweeds were found at approximately 85% of the point-intercept locations sampled on Harris Pond (Figure 3.3-3). While these species are known for their high value to the waterfowl community for food, they are also known for their rapid growth and ability to cause unfavorable conditionals for lake users.

Figure 3.3-4 shows that of the 27 plant species found, the floating duckweeds were found at the most number of sampling locations; followed by coontail, flat-stem pondweed, and common waterweed. Like the floating duckweeds, common waterweed and coontail are largely unrooted and their locations can be largely a product of water movement. However, these species sometimes possess structures that function similar to roots (rhizoids) or become partially buried in the sediment which greatly limits their susceptibility to be moved around the lake as rapidly as duckweeds. Flat-stem pondweed is a rooted plant with long slender leaves, and as its name suggests possesses a conspicuously flattened stem. All three of these species are very common throughout Wisconsin and are usually found growing in lakes of high productivity, like Harris Pond.

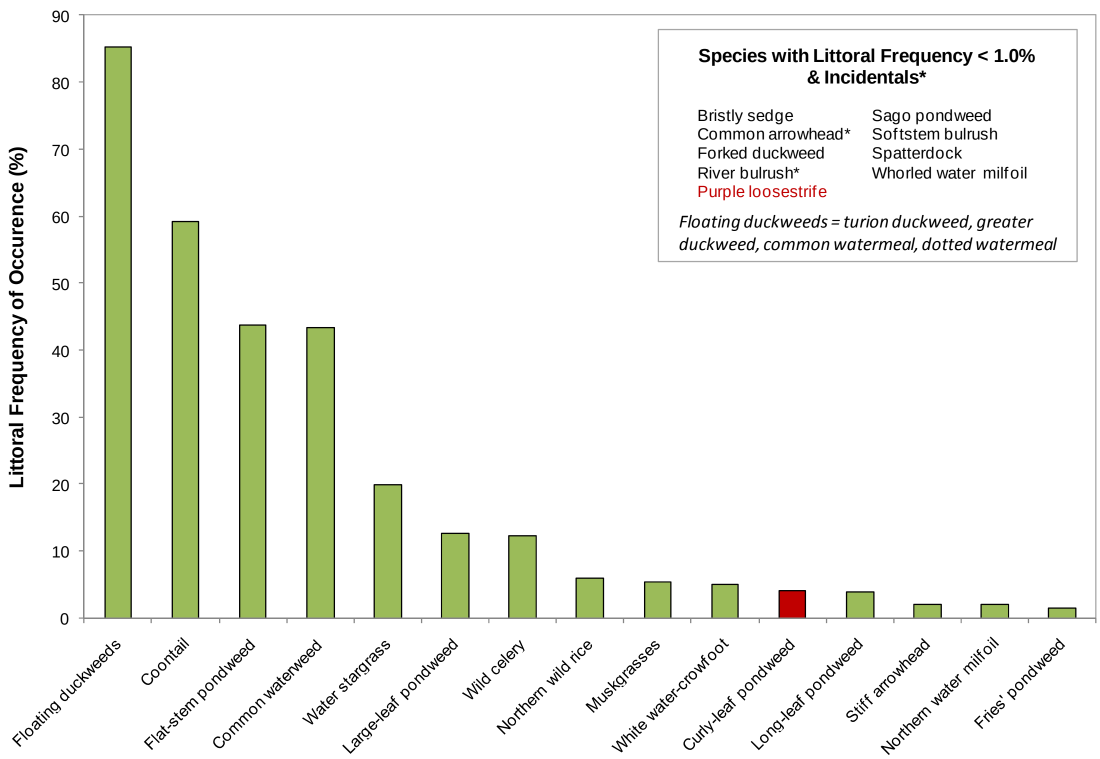

Figure 3.3-4 Harris Pond aquatic plant littoral frequency of occurrence. Created using data from September 2010 surveys. Exotic species indicated with red.

As explained above in the Primer on Data Analysis and Data Interpretation Section, the littoral frequency of occurrence analysis allows for an understanding of how often each of the plants is located during the point-intercept survey. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while coontail was found at almost 60% of the sampling locations, its relative frequency of occurrence is 19%. Explained another way, if 100 plants were randomly sampled from Harris Pond, 19 of them would be coontail.

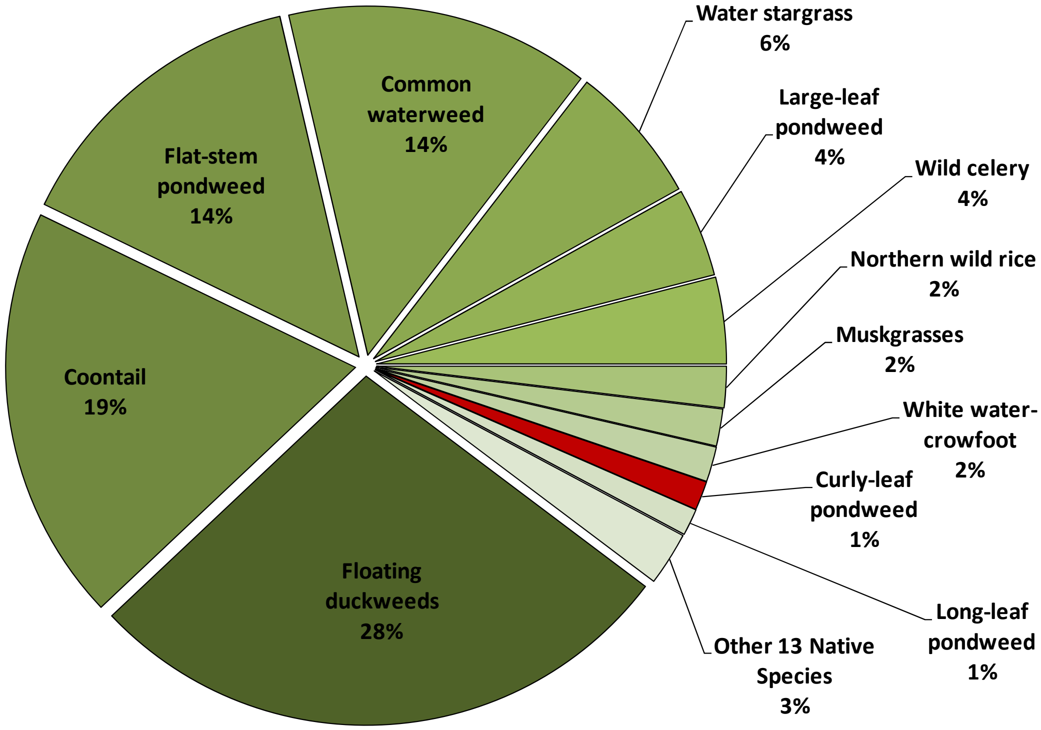

Figure 3.3-5. Harris Pond aquatic plant relative frequency of occurrence. Created using data from 2010 surveys. Exotic species indicated with red.

Harris Pond contains a relatively high number of aquatic plant species, and because of this, one may assume that the system would also have high species diversity. As discussed earlier, how evenly the species are distributed throughout the system also influences the diversity. The diversity index for Harris Pond's aquatic plant community (0.84) shows that the lake has a relatively uneven distribution (relative frequency) of plant species throughout the lake. The relative frequency analysis shows that together floating duckweeds, coontail, flat-stem pondweed, and common waterweed comprise 75% of the population of plants within Harris Pond (Figure 3.3-5).

Figure 3.3-5 shows that the average conservatism value (6.1) for Harris Pond is slightly higher than the ecoregion and state median. This shows that the aquatic plant community of Harris Pond is very much in line with other lakes in the region and in the state, but it does contain some species that are indicative of a disturbed system. Combining the lake's species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a high value of 29.2 (equation shown below), which is well above the median values of the state and ecoregion (Figure 3.3-6). Obviously, the high species richness of Harris Pond is the major factor contributing to its high floristic quality even though the lake's average conservatism values are similar to the state and ecoregion medians.

$$\text{FQI} = \text{Average Coefficient of Conservatism (6.1)} * \sqrt{\text{Number of Native Species (23)}}$$
$$\text{FQI} = 29.2$$

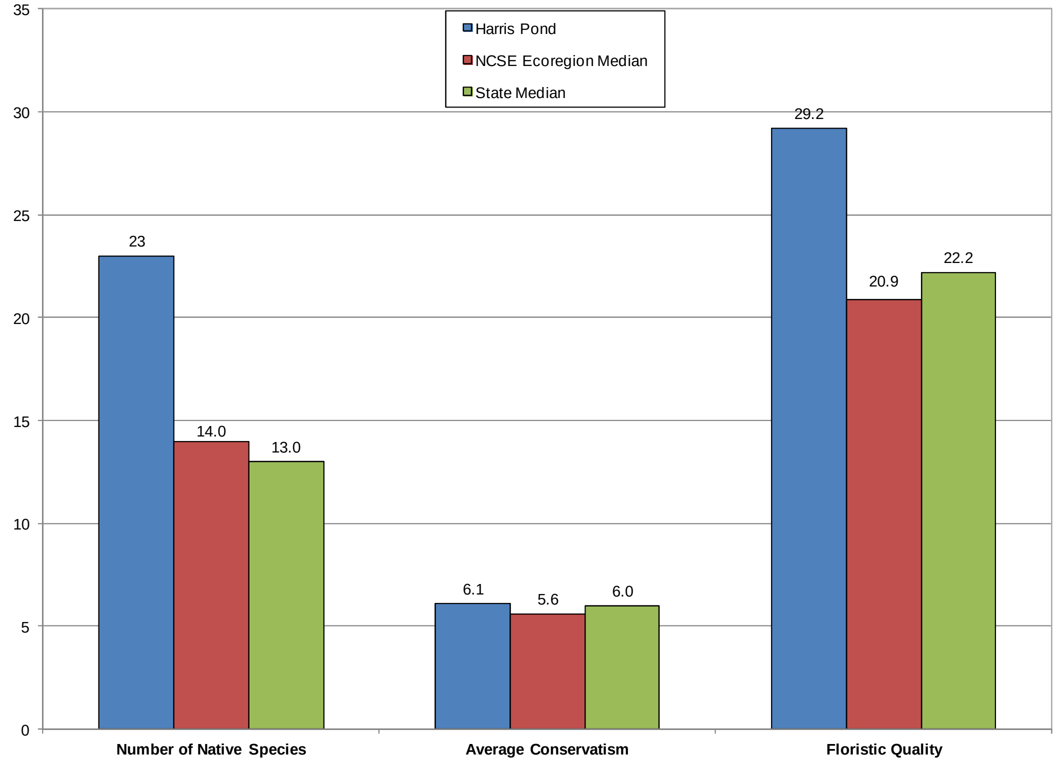

Figure 3.3-6. Harris Pond Floristic Quality Assessment. Created using data from September 2010 surveys. Analysis following Nichols (1999).

The quality of Harris Pond's plant community is also indicated by the high incidence of emergent plant communities that occur throughout the lake (Map 5). Northern wild rice dominates the emergent plant community of Harris Pond.

Wild rice is an emergent aquatic grass that grows in shallow water of lakes and slow-moving rivers. Wild rice has cultural significance to the Chippewa Tribal Communities where the grain historically was an important component of Native American diets. Wild rice is also an important diet component for waterfowl, muskrats, deer, and many other species. Established wild rice plant communities can provide valuable nursery and brooding habitat for wetland bird and amphibian species as well as spawning habitat for various fish. Perhaps one of the most overlooked benefits of having established wild rice communities is their ability to utilize excessive plant nutrients, stabilize soils, and form natural wave breaks to protect shoreland areas.

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

Two factors are likely the primary contributors to Harris Pond's healthy plant community; 1) the fact that much of what is now considered to be a lake was originally a wetland, and 2) the shallow and fluctuating water levels on an annual and seasonal basis. Natural, undisturbed wetlands normally hold diverse plant communities. Remnants of Harris Pond's origins as a riverine wetland still exist in the lake's emergent plant community and contribute to the lakes unusually high FQA values. The lake's shallow, fluctuating water levels also contribute by allowing the emergent species to grow prolifically around the lake, especially in the northern portion of the lake (Map 5). Although these areas are very important to the lake's health and provide valuable ecological habitat, they can, in some occasions reach nuisance levels and impact recreational enjoyment of the lake. Striking a balance between the needs of lake users and those of the lake is often a challenge.

Exotic Plants in Harris Pond

As described above, two invasive plant species were located within Harris Pond during this project's studies: curly-leaf pondweed and purple loosestrife. Purple loosestrife was found in scattered locations along the shoreline of Harris Pond (Map 5). Purple loosestrife is a wetland, emergent perennial which is native to Europe and was brought over to North America as an ornamental garden plant. It escaped from the garden landscapes and into wetland habitats where it can out-compete our native plants for space and resources. Detailed discussion regarding the control of purple loosestrife will be discussed in the implementation plan.

A meander survey of Harris Pond was completed on June 8, 2010 expressly for searching the lake for curly-leaf pondweed. For the first time, curly-leaf pondweed was documented as occurring in Harris Pond. The survey results are contained in Map 4 and show that the majority of the lake contains highly scattered curly-leaf pondweed occurrence. This high incidence and widespread distribution of this species likely indicates that this plant has existed in Harris Pond for quite some time. Much of the curly-leaf pondweed had died back by the time the point-intercept plant survey occurred (September 1), but it was still shown to be the 11^{th} most abundant plants with the lake (Figure 3.3-3).

Along with navigational difficulties, the mid-summer die off of curly-leaf pondweed can lead to elevated phosphorus levels and depending on the lake, can fuel to algal blooms. Because the lake has such a large watershed and an extremely low retention time, it is almost impossible to single out the role a seasonal curly-leaf pondweed die off could have on total phosphorus concentrations. A more comprehensive study of the water quality of Harris Pond specifically aimed at detecting changes in phosphorus concentrations surrounding curly-leaf pondweed die off may lead to a better understanding of the process.

Lake groups across the state are combating this species using herbicide applications to kill the plants in the spring, sometime before native species have begun growing. Herbicides that target submersed plant species are directly applied to the water, either as a liquid or an encapsulated granular formulation. Factors such as water depth, water flow, treatment area size, and plant density work to dilute herbicide concentration within aquatic systems. Understanding concentration-exposure times are important considerations for aquatic herbicides. Successful control of the target plant is achieved when it is exposed to a lethal concentration of the herbicide for a specific duration of time. Obtaining this specific duration of time is difficult on smaller treatment areas, but also on flowage systems such as Harris Pond as the water flow quickly diffuses the herbicide.

Because curly-leaf pondweed has likely been present within Harris Pond for quite some time and has not, by itself, caused difficulty for navigation or for the current aquatic plant community, initiating an aggressive control strategy is not pertinent at this time. Instead, as the Implementation Plan outlines, continued monitoring of this species is recommended. Future surveys will assess if the scattered plants grow into larger colonies, which may at that point in time impede navigation or impact the native aquatic plant community.

3.4 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a brief summary of available data is included here as reference. The following section is not intended to be a comprehensive plan for the lake's fishery, as those aspects are currently being conducted by the numerous fisheries biologists overseeing Harris Pond. The goal of this section is to provide an incomplete overview of some of the data that exists, particularly in regards to specific issues (e.g. fish stocking, angling regulations, etc) that were brought forth by the HPA stakeholders within the stakeholder survey and other planning activities. Although current fish data were not collected, the following information was compiled based upon data available from the WDNR (WDNR 2010).

Harris Pond Fishing Activity
Based on data collected from a 2008 stakeholder survey administered by the Harris Pond Lake Association (Appendix B), the average survey respondent has fished Harris Pond for 25 years (Question #9). Approximately 61% of these same respondents believed that the quality of fishing on the lake was either very good or excellent (Question #10); and approximately 53% believe that the quality of fishing has stayed the same while 43% responded that the fishing quality has "declined" since they began fishing (Question #11).

Table 3.4-1 shows the popular game fish that are present in the system. If management actions take place on Harris Pond to control invasive species such as curly-leaf pondweed, the timing of these actions must be appropriately planned. Herbicide applications should occur in May when the water temperatures are below 60°F. It is important to understand the effect the chemical has on the spawning environment which would be to remove the submergent plants that are actively growing at these low water temperatures. For example, yellow perch is a species that could potentially be affected by early season herbicide applications, as the treatments could eliminate nursery areas for the emerged fry of these species.

Harris Pond is located within the southern region of the largemouth and smallmouth bass management zones. In this region, bass harvest is limited to 5 fish daily, with a minimum length limit of 14". Additionally, these lakes are located within the southern region of the muskellunge and northern pike management zone. Northern pike harvest is limited to 2 fish daily, with a minimum length limit of 26". For all other species, standard statewide regulations govern any harvest.

Table 3.4-1. Gamefish present in Harris Pond with corresponding biological information (Becker, 1983)**.**

Common Name	Scientific Name	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Black Crappie	*Pomoxis nigromaculatus*	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel	Fish, cladocera, insect larvae, other inverts
Bluegill	*Lepomis macrochirus*	11	Late May - Early August	Shallow water with sand or gravel bottom	Fish, crayfish, aquatic insects and other invertebrates
Brown Bullhead	*Ameiurus nebulosus*	5	Late Spring - August	Sand or gravel bottom, with shelter rocks, logs, or veg	Insects, fish, fish eggs, mollusks and plants
Largemouth Bass	*Micropterus salmoides*	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Northern Pike	*Esox lucius*	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pikes, crayfish, small mammals, water fowl, frogs
Pumpkinseed	*Lepomis gibbosus*	12	Early May - August	Shallow warm bays 0.3-0.8 m, with sand or gravel bottom	Crustaceans, rotifers, mollusks, flatworms, insect larvae (ter. and aq.)
Rock Bass	*Ambloplites rupestris*	13	Late May - Early June	Bottom of course sand or gravel, 1cm-1m deep	Crustaceans, insect larvae, and other inverts
Yellow Perch	*Perca flavescens*	13	April - early May	Sheltered areas, emergent and submergent veg	Small fish, aquatic invertebrates

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

A concept called energy flow describes how the biomass of piscovores is determined within a lake. Because algae and plant matter are generally small in energy content, it takes an incredible amount of this food type to support a sufficient biomass of zooplankton and insects. In turn, it takes a large biomass of zooplankton and insects to support planktivorous fish species. And finally, there must be a large planktivorous fish community to support a modest piscovorous fish community. Studies have shown that in natural ecosystems, it is largely the amount of primary productivity (algae and plant matter) that drives the rest of the producers and consumers in the aquatic food chain. This relationship is illustrated in Figure 3.4-1.

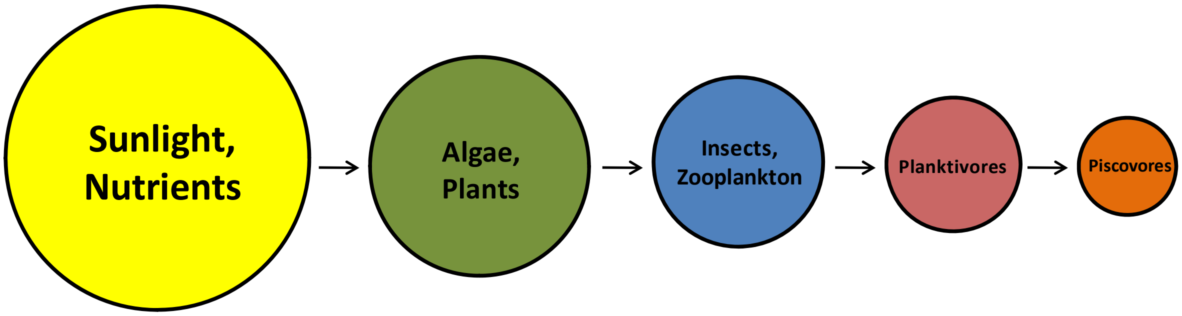

Figure 3.4-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Harris Pond is a eutrophic system, meaning it has high nutrient content and thus relatively high primary productivity. Simply put, this means Harris Pond should be able to support sizable populations of predatory fish (piscovores) because the supporting food chain is relatively robust.

Harris Pond Substrate Type

According to the point-intercept survey conducted by Onterra, 99% of the substrate sampled in the littoral zone on Harris Pond was muck, with about 1% found to be sand. Substrate and habitat are critical to fish species that do not provide parental care to their eggs, in other words, the eggs are left after spawning and not tended to by the parent fish. Walleye and northern pike spawn in this manner (Becker 1983). Northern pike preferentially spawn in shallow, flooded marshes with emergent vegetation. Grasses, sedges or other emergent vegetation make the best substrate for egg deposition. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn in muck as well.

4.0 SUMMARY AND CONCLUSIONS

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

1) Collect baseline data to increase the general understanding of the Harris Pond ecosystem.
2) Determine if any aquatic invasive species are present within the lake and determine their abundance if present.
3) Collect data and analyze possible methods to relieve reported nuisance levels of aquatic plants and sediment build-up.

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

Overall, the studies conducted on Harris Pond have determined that this waterbody, though man-made, is suffering from man-induced activities. The Montello River Watershed study, conducted through the University of Wisconsin-Stevens Point, determined Harris Pond's watershed to be incredibly large - 160 times larger than Harris Pond. The streams that enter Harris Pond have much land from which to draw water; however, with this water comes nutrients and sediment from the watershed as well. It was found that the main tributary to Harris Pond, Westfield Creek, transported more nutrients than any of the streams studied within the Montello River Watershed study.

The effects of this large nutrient load are evident on the Harris Pond ecosystem. WDNR phosphorus criteria suggests that the recommended average concentration in shallow, Wisconsin impoundments be below 40 μg/l. Through the UW-Stevens Point study, an average of 73 μg/l was found in Harris Pond. On several occasions, total phosphorus concentrations were measured at above 100 μg/l. The excessive nutrients in this system spur the abundant aquatic plants and algae blooms that residents have concern over.

Not only is there incredible amounts of aquatic plant abundance within the lake, but the species that are found within Harris Pond are indicative of plants occurring in a disturbed system. Several species of floating duckweeds cover the lake surface in the summer months. These species thrive on warm, nutrient rich waters such as millponds. Two aquatic invasive species, purple loosestrife and curly-leaf pondweed, were also around and within Harris Pond. Presence of these species indicate human disturbance on an ecosystem as well. Purple loosestrife, as the Aquatic Plant Section discusses, is a wetland species that was found in several locations on the Harris Pond shoreline. The establishment of this plant is likely recent - good news in terms of the plant's control. Management of purple loosestrife has been successful within the state of Wisconsin utilizing small-scale herbicide applications, biological control, and volunteer hand-pulling. A control strategy for managing purple loosestrife on Harris Pond is outlined within the Implementation Plan.

Curly-leaf pondweed management is considerably more complicated than purple loosestrife management. Curly-leaf pondweed was found to occur throughout much of Harris Pond. Although the invasive plant was only first documented in 2010 in the lake, its abundance and dispersion likely indicates that it has been present in the system for quite some time. At this point, investing time and money into intensive herbicide treatments is likely not necessary as the plant has had little to no impact on the already disturbed native aquatic plant community. Furthermore, the plant itself has not limited recreational activities on Harris Pond – it is the abundant native plants that residents are concerned about. The Implementation Plan that follows outlines steps for monitoring this species. If further professional mapping surveys indicate that expansion of areas into dominant plant growth has occurred, a control strategy involving herbicide applications would need to be developed.

During the project, Harris Pond stakeholders expressed great concern over fluctuating water levels and sediment build-up within the lake. While sediment enters Harris Pond from external sources through the inlet stream, these sediments, mostly comprised of mineral particulates, fall out of the water column in the northern part of the lake, where stream velocity slows as it hits the open water and numerous emergent plant species. The sediment buildup further south in the lake, and largely within the back bays of Harris Pond, are likely not from external sources as they are composed primarily of organic material. The sediment accumulation within these areas of the lake is from internal sources because much of the buildup consists of dead plant matter that is accumulating on the lake bottom. Harris Pond, like most millponds, supports abundant plant growth, so this is expected.

As indicated within the Montello River Watershed report, nutrient transport into Harris Pond is incredibly high. These nutrients enter the lake in a dissolved form and are taken up into aquatic plants as they grow. The plants die, are partially decomposed, and the remaining biomass is deposited on the lake bottom in a solid form. The incomplete decomposition of the plants causes a buildup of organic, nutrient rich sediments from which additional plants continue to grow.

While the aquatic plants can be a nuisance, their presence is responsible for the clear water that is found in Harris Pond. Shallow, productive waterbodies typically fall into one of two categories: *clear-state* and *turbid-state* lakes. Clear-state lakes are characterized by having clear water, yet enough nutrients to produce abundant vegetation. The vegetation provides cover to microscopic animals called “zooplankton” that graze upon algae much as a cow grazes upon grass. The vegetation also reduces nutrient and light availability for algae as well. Once the aquatic plants are removed, the zooplankton are left uncovered and are preyed upon heavily by fish. Plus, the nutrients once used by the plants are now available for algae. Turbid-state lakes may have the same amount of nutrients within them; however, it is algae that utilize these nutrients. As a result, the water becomes turbid and vegetation is relatively sparse. These two states are “stable” in that the lake will persist in this way until a disturbance shifts the system from one state to the other.

The accumulation of organic sediments within Harris Pond is the most concerning issue Harris Pond stakeholders have regarding this ecosystem. Options for slowing the buildup, or controlling it altogether are few and not without side effects. The options include 1) implementing best management practices within the watershed to reduce nutrient input, 2) removal of bottom sediments (dredging) and 3) compacting the bottom sediments to increase lake depth. These three options are discussed further below.

Remediating the lands draining into Harris Pond, as to reduce nutrient (namely phosphorus) input, could be accomplished through best management land use practices. These methods include reducing soil erosion, managing nutrients and sediments on agricultural land carefully, and through conservation efforts such as grassed waterways, conservation tillage, etc. The land draining to Harris Pond is 160 times larger than Harris Pond itself (approximately 38,990 acres). Even if these lands were completely forested, the most ideal land cover for the health of a waterbody, an estimated 3,000 lbs of phosphorus would still be transported into the lake annually. Harris Pond is a man-made waterbody created to provide flow to a powerhouse and ultimately produce electricity – it is not a natural lake ecosystem. When the forces of nature fight back to fill in the lake, there is not always a perfect solution to keep the waterbody in its unnatural state. Since it is impractical to convert the entire watershed to forested land, and even if this occurred little benefit would be seen, this is not a viable option to reach the goal of reducing soft sediment buildup in Harris Pond.

The advantages of dredging are that there are few limitations as to how much depth is gained in the waterbody and the results are obtained very quickly. However, dredging is an incredibly expensive solution as it involves much time, heavy equipment, and transport/regulation of dredging spoils. For example, a typical cost to remove a cubic yard of sediment is roughly $14. To dredge one acre of bottom to be three feet deeper, the costs (at the estimate of $\$14/yd^3$) would be $67,760. The costs of removing three feet of sediment from five acres would be an estimated $338,800. Additionally, dredging exposes the lake bed to pioneering species, which includes aquatic invasives such as curly-leaf pondweed. In other words, exposing fresh lake bottom would give curly-leaf pondweed an opportunity to grow aggressively within the lake and soon become an incredible nuisance. Because of the high costs of implementation and danger in exposing fresh sediment beds to curly-leaf pondweed, this option is not viable for Harris Pond.

The third option for mitigating the build-up of organic sediments in Harris Pond would be the compaction of these sediments through a drawdown of the lake. A drawdown of the water in Harris Pond has been discussed numerous times amongst Harris Pond stakeholders, the WDNR, and Onterra ecologists. During a drawdown, the water level is reduced significantly in a waterbody. The sediments are exposed to the air and begin to dry. Additionally, the soil becomes oxygenated and microbial processes change the chemical composition of the sediment from organic material to its mineral components. The benefits of drawdowns include an increase in plant diversity, improved lake average depth, improving fish spawning substrate, and an export of nutrients from the system. In short, a drawdown adds to the life of a lake.

Drawdowns have been conducted within the state of Wisconsin for several reasons. Often, maintenance on dams warrant the need for a drawdown. Control of invasive species, such as Eurasian water milfoil or carp, have been achieved through drawdowns. On Marion Lake control of Eurasian water milfoil and curly-leaf pondweed was the anticipated goal of the drawdown. On this system, the frequency of occurrence of these plants went from 74% Eurasian water milfoil and 40% curly-leaf pondweed in 2005 to 5% and 6%, respectively, in 2008 (Ted Johnson, WDNR, personal communication). This technique was also utilized locally on Montello Lake, where Eurasian water milfoil had once covered the entire littoral region. It is important to note that the intent of the drawdowns on Marion and Montello Lakes were specific – to control exotic plant species. Because of this, the methodology was different as well. The drawdown lasted one winter season on these lakes, as freezing of the plant root structures was required.

Drawdowns are utilized to increase lake depth also. For example, following a drawdown on Neenah Lake, an average increase in depth of 2.4 feet was achieved. In general, the length of a drawdown plan is in reference to the goal. Summer drawdowns allow sediments to dry out, while winter drawdowns, such as the ones conducted on Marion and Montello Lakes, allow plants to freeze out. For sediment compaction, a year or more is necessary. The reason for this is that in order to achieve good microbial decomposition of the soft sediments, a full growing season must pass. On Harris Pond, around two feet of depth could be obtained through a drawdown that lasts approximately 18 months or more.

Additionally, drawdowns may be completed on a "full" or "partial" basis. A full drawdown involves a complete draining of the lake, with the only water remaining being that of the flowing Westfield Creek. With a partial drawdown, a limited amount of the lake volume is drawn down. On Harris Pond, this may be anywhere from 2 to 4 feet. When the lake is partially drawn down, some pooled water is left for fish species to utilize; therefore, a smaller amount of the fish population is lost. However, the benefits of sediment compaction are also less with a partial drawdown when compared to a full drawdown.

With drawdowns, there is a loss of recreation during the time water levels are low and the potential for fish populations to be impacted. Additionally, overcoming the logistical and financial hurdles, as well as short-term economic loss can be challenging and frustrating. However, despite these obstacles a drawdown is in the best interest for extending the life of Harris Pond. The WDNR has overseen several projects, and is currently planning drawdowns for other nearby flowage systems such as Iola, Ogdensburg and the Weyauwega millpond to extend the life of these systems.

The uncertainty and at times animosity stakeholder have regarding drawdowns likely stems from anecdotal evidence as well as short-term observations. It seems as though this management technique has not quite gained enough public acceptance to be deemed viable. At this time, Harris Pond stakeholder may wish to observe the drawdowns occurring on nearby flowages and learn from these experiences. More information regarding the results of these projects will be available in two years. Following these studies, we will have a better understanding of drawdowns, their advantages, their disadvantages, and more importantly, their calculated effectiveness on a system such as Harris Pond.

5.0 IMPLEMENTATION PLAN

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

Management Goal 1: Maintain Current Water Quality Conditions

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

Timeframe: Initiate in 2012

Facilitator: Planning Committee

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

The Citizens Lake Monitoring Network (CLMN) is a WDNR program in which volunteers are trained to collect water quality information on their lake. At this time, there are no HPLA members currently collecting data as a part of the CLMN. Volunteers trained by the WDNR as a part of the CLMN program begin by collecting Secchi disk transparency data for at least one year, then if the WDNR has availability in the program, the volunteer may enter into the advanced program and collect water chemistry data including chlorophyll-a, and total phosphorus. The Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. Note: as a part of this program, these data are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS).

At a minimum, CLMN volunteers collecting Secchi disk data should be in place on Harris Pond. Currently, the advanced CLMN program is not accepting additional lakes to participate in the program. However, it is important to get volunteers on board with the base Secchi disk data CLMN program so that when additional spots open in the advanced monitoring program, volunteers from the Harris Pond will be ready to make the transition into more advanced monitoring.

It is the responsibility of the Planning Committee to coordinate new volunteers as needed. When a change in the collection volunteer occurs, it will be the responsibility of the Planning Committee to contact Jay Schiefelbein (920.303.5449) or the appropriate WDNR/UW Extension staff to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.

Action Steps:

Please see description above.

Management Goal 2: Monitor and Manage Aquatic Invasive Species On Harris Pond

Management Action: Reduce occurrence of purple loosestrife on Harris Pond shorelands
Timeframe: Begin 2012
Facilitator: Planning Committee
Description: Purple loosestrife can be found in low occurrence along the shorelands of Harris Pond (Map 5). The purple loosestrife occurrences on Harris Pond appear to be at an early stage of development with only a few individual plants observed. As with any invasive species, early control strategies are more effective on the population. In regards to purple loosestrife, this hardy perennial is more resilient the longer it is allowed to grow in one location as its root crown becomes more robust. It also produces a large seed bank which germinates years after the parent plant is controlled and requires continued management.

Manually removing isolated purple loosestrife plants is likely the best control strategy at this time. Once the property owner grants permission to remove the plant, it should be dug out of the ground, roots and all. If flowers or seeds are present at the time of the extraction, the flower heads should be carefully cut off and bagged to make sure seeds don't inadvertently get spread around during removal. Plants and seed heads should either be burned or bagged and put into the garbage.

Information sources, such as the WDNR, UW-Extension and Marquette County will be used to properly identify purple loosestrife and provide guidance on the proper time to perform management actions.

Important aspects of this management action will be the monitoring and record keeping that will occur in association with the control efforts. These records will include maps indicating infested areas and associated documentation regarding the actions that were used to control the areas, the timing of those actions, and the results of the actions. These maps and records will be used to track and document the successfulness of the program and to keep the HPLA and all management entities updated.

Action Steps:

1. Recruit members to begin monitoring and control efforts
2. Volunteers become trained by WDNR, UW-Extension and Marquette County AIS professionals on identification and removal techniques.

3. Group completes field surveys to identify infested areas
4. Initiate manual removal control methods
5. Monitor results and reapply control as necessary
6. Keep stakeholders and managers informed regarding program results

<u>Management Action:</u> Monitor curly-leaf pondweed populations in Harris Pond.
Timeframe: 2013
Facilitator: Board of Directors with professional help as needed
Description: As described in the Aquatic Plant section, highly scattered occurrences of curly-leaf pondweed occur throughout Harris Pond (Map 4). Like Eurasian water milfoil, curly-leaf pondweed has the potential to displace native aquatic plant species. Traditionally, curly-leaf pondweed control consists of numerous annual herbicide treatments conducted in May of each year. This will kill each year's plants before they are able to produce reproductive turions (asexual seed-like structures). After multiple years of treatment, the turion base becomes exhausted and the curly-leaf pondweed infestation becomes significantly less.

Because curly-leaf pondweed occurs in all parts of Harris Pond, an herbicide control program would need to target the entire lake if the goal was for ecological restoration. Applying herbicides at this scale would be quite costly and in order to be successful, would need to be repeated for several years. As previously discussed in the Summary and Conclusions Section, herbicide treatments on flowage systems is difficult to predict as well, because the flow quickly disperses the herbicide.

During the 2010 surveys this exotic plant did not seem to show any indication of inhibiting navigation or crowding out native vegetation. At this time, it does not appear that the benefits of implementing a large-scale treatment strategy are warranted. However, it is possible that these areas may reach nuisance levels in the near future, potentially interfering with navigation and other recreational activities. The HPLA will contract professionals to conduct an assessment of the curly-leaf pondweed population in Harris Pond. This assessment would include mapping surveys to be conducted in mid-June, in anticipation of the plants peak growth. It is anticipated that the next survey will take place in June 2013. If curly-leaf pondweed occurrences in Harris Pond expand to levels that warrant the implementation of a control strategy, one would need to be formally developed and the HPLA's management plan would need to be updated accordingly.

Action Steps:

1. Retain professional consultant to map curly-leaf pondweed in 2013.
2. Surveys will be conducted every three years, unless the HPLA observes denser growth in lake and wishes for additional surveys and strategy development to occur.

Management Goal 3: Research Potential for Sediment Accumulation Issue In Harris Pond

Management Action: Keep drawdown as an option for sediment accumulation control.
Timeframe: Begin 2012
Facilitator: Planning Committee
Description: Right now, Harris Pond stakeholders are not receptive to the idea of a drawdown on Harris Pond. The negative perceptions associated with other projects, the unknowns about the outcome of a drawdown on Harris Pond, and perceived legal and logistical problems associated with a drawdown are too significant of issues. Simply put, in the eyes of the folks who care about Harris Pond, there is a lack of clear information regarding this management technique.

Unfortunately, few feasible options exist to mitigate the naturally accumulating sediment. Because the HPLA stakeholders are actively trying to enhance their lake, sitting and letting this problem worsen is not an option. Continued research into drawdowns and examination of soon-to-be-completed projects in other waterbodies may be the solution for now. In the next two years, WDNR lake managers will be conducting drawdowns on several flowage systems in the Upper Fox River watershed region of Wisconsin. WDNR managers will better understand drawdown techniques, benefits and consequences, and more importantly be able to share these results with stakeholders on other lakes, including Harris Pond. Following these studies, discussions of drawdown possibilities can continue, including options of a full or partial drawdown (discussed within the Summary and Conclusions Section).

It is important that during this time, Harris Pond stakeholders establish a working relationship with WDNR managers and discuss the implications of this technique fairly. Conversations with Ted Johnson (920.787.3048) may be held regarding the results of other drawdown projects, Linda Hyatt (920.787-7604) regarding dam maintenance and operation, and David Bartz (608.297.7058) regarding the fishery of the lake and potential for remediating the fishery after a drawdown. Most importantly, the appropriate options of dealing with the sedimentation in Harris Pond must be met with an objective approach, an open mind and a realistic attitude.

Action Steps:

1. See above description.

6.0 METHODS

Lake Water Quality

Water quality information was not collected by Onterra as part of this project. Instead, through an agreement with the University of Wisconsin Stevens – Point (UWSP) and UWSP Center for Watershed Science and Education, data collected on Harris Pond through the Montello River Watershed Study was integrated into this report.

Watershed Analysis

Watershed information was not collected by Onterra as part of this project. Instead, through an agreement with the University of Wisconsin Stevens – Point (UWSP) and UWSP Center for Watershed Science and Education, data collected on Harris Pond through the Montello River Watershed Study was integrated into this report.

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Harris Pond during a June 8, 2010 field visit, in order to correspond with the anticipated peak growth of the plant. Visual inspections were completed throughout the lake by completing a meander survey by boat.

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Harris Pond to characterize the existing communities within the lake and include inventories of emergent, submergent, and floating-leaved aquatic plants within them. The point-intercept method as described in "Appendix D" of the Wisconsin Department of Natural Resource document, Aquatic Plant Management in Wisconsin, (April, 2007) was used to complete this study on August 1, 2010. A point spacing of 41 meters was used resulting in approximately 415 points.

Community Mapping

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

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

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