Hatch Lake

Waupaca County, Wisconsin

Comprehensive Management Plan

August 2022

Sponsored by:

Hatch Lake Iola Wisconsin Association, Inc.

WDNR Grant Program

LPL-1741-20

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Onterra LLC
Lake Management Planning

Hatch Lake

Waupaca County, Wisconsin

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August 2022

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Funded by: Hatch Lake Iola Wisconsin Association
Wisconsin Dept. of Natural Resources
(LPL-1741-20)

Acknowledgements

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

Hatch Lake Planning Committee

Gary Doine	Mary Lutz	Greg Ellie
David Lindenstruth	Debbi Mahler	Tony Voelker
Victoria Vandenberg	John Stewart	

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1.0 INTRODUCTION

According to the 1965 recording sonar WDNR Lake Survey Map, Hatch Lake is 110.6 acres, including the islands. The WDNR website currently lists the lake as 113 acres. At the time of this report, the most current orthophoto (aerial photograph) was from the *National Agriculture Imagery Program* (NAIP) collected in 2018. Based on heads-up digitizing of the water level from that photo, the lake was determined to be 121 acres. Hatch Lake, Waupaca County, is a shallow headwater drainage lake with a WDNR-listed maximum depth of 12 feet and a mean depth of 4 feet. Water levels do fluctuate; however, and the maximum depth that was recorded during Onterra's 2020 water quality samplings was 14.6 feet. This mesotrophic lake has a relatively small watershed when compared to the size of the lake. In 2020, 34 native plant species were located in Hatch Lake during the surveys, of which muskgrasses and naiads were most common. Five exotic plant species are now known to exist in and around Hatch Lake. Of those exotics, Eurasian watermilfoil (EWM) is of the most concern because of its potential impact on recreation.

Field Survey Notes

A water quality assessment indicated that Hatch Lake has overall excellent water clarity, and is in much better standing compared to other lakes within the same ecoregion. Hatch Lake harbors two species of special concern in Wisconsin: Robbins' spikerush and few-flowered spikerush.

Photograph 1.0-1 Hatch Lake, Waupaca County

Lake at a Glance - Hatch Lake

Morphology	
Acreage	121
Shoreline Complexity	2.6
Vegetation (2020)	
Number of Native Species	34
Threatened/Special Concern Species	Robbins' spikerush Few-flowered spikerush (2006)
Exotic Plant Species	5 (see Section 3.5)
Simpson's Diversity	0.86
Average Conservatism	6.4
Water Quality	
Trophic State	Mesotrophic
Limiting Nutrient	Phosphorus
Water Acidity (pH)	8.7
Sensitivity to Acid Rain	Not sensitive
Watershed to Lake Area Ratio	2:1

The primary, local management group for Hatch Lake is the Hatch Lake Iola Wisconsin Association, Inc. (HLIWA). The association's mission statement is, "The purpose of the Association is to preserve and protect Hatch Lake and its surroundings, and to enhance the water quality, fishery, boating safety, and aesthetic values of Hatch Lake, as a public recreational facility for today and for future generations." The HLIWA is active in protecting the lake and has participated in the Waushara County purple loosestrife control program, completed a 3-year fish stick project, and owns and operates an aeration system on the lake to protect and enhance the fishery. The association has also worked with the WDNR on a primarily self-funded stocking program for Hatch Lake. In recent years, the HLIWA has created three standing committees to better facilitate the association's management of the lake; aeration/boat landing committee, fishing committee, and an invasive species committee.

2.0 STAKEHOLDER PARTICIPATION

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

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

General Public Meetings

The general public meetings were used to raise project awareness, gather comments, create the management goals and actions, and deliver the study results These meetings were open to anyone interested and were generally held during the summer, on a Saturday, to achieve maximum participation.

Kick-off Meeting

On August 15, 2020, a project kick-off meeting was held at a residence on Hatch Lake to introduce the project to the general public. The meeting was announced through a mailing and personal contact by Hatch Lake I board members. The approximately 32 attendees at this outdoor meeting observed a presentation given by Tim Hoyman, an aquatic ecologist with Onterra. Tim's presentation started with an educational component regarding general lake ecology and ended with a detailed description of the project including a timeline and opportunities for stakeholders to be involved. The presentation was followed by a question-and-answer session.

Project Wrap-up Meeting

On August 20, 2022, Planning Committee Chair, Gary Doine, gave a summary presentation of the management plan to the HLIWA membership, which included highlights of the project results and the goals and actions contained in the management plan.

Board of Directors Eurasian Watermilfoil Management Strategy Meeting

In April 2021, the HLIWA Board of Directors approached Onterra about creating a strategy for that spring to control EWM in the center of the lake's main basin where much of the recreation occurs. Onterra staff created two options for management, one resulting in seasonal control of EWM and one aimed at two seasons or more of control. The latter strategy proposed the use of a newer herbicide being used in Wisconsin, ProcellaCOR. On May 5, 2021, Onterra hosted a Webex videoconference with the association board of directors to provide additional information regarding the treatment strategies and answer questions. Tim Hoyman started the meeting by providing general information about the use of herbicides in spot-treatment use patterns, including the results of a rhodamine dye study completed on a lake in Shawano County that visually demonstrates the rapid dissipation of herbicides away from treatment sites in the aquatic environment. He also detailed Onterra's AIS mapping methods and the results of the surveys completed on Hatch Lake during 2020. Pre- and post-treatment mapping results from several Onterra-managed lakes that had completed ProcellaCOR treatments in 2019 and 2020 were also presented. The meeting concluded with a discussion of the two treatment options, including board member questions. The board voted to proceed with the ProcellaCOR strategy, which is detailed along with the 2021 results, in the Non-Native Aquatic Plants in Hatch Lake subsection of the Aquatic Plant Section 3.4.

Committee Level Meetings

Planning committee meetings, similar to general public meetings, were used to gather comments, create management goals and actions and to deliver study results. These two meetings were open only to the planning committee and were held during the week. The first, following the completion of the draft report sections of the management plan. The planning committee members were supplied with the draft report sections prior to the meeting and much of the meeting time was utilized to detail the results, discuss the conclusions and initial recommendations, and answer committee questions. The objective of the first meeting was to fortify a solid understanding of their lake among the committee members. The second planning committee meeting was held a few weeks after the first and concentrated on the development of management goals and actions that make up the framework of the implementation plan.

Planning Committee Meeting I

On July 20, 2021, Todd Hanke and Tim Hoyman of Onterra met with four members of the Hatch Lake Planning Committee for over three 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, water quality, watershed, aquatic plants, fisheries, and aquatic plants were covered during the meeting along with a discussion of realities of utilizing herbicides to control Eurasian watermilfoil.

Planning Committee Meeting II

On August 26, 2021, Tim Hoyman met with the members of the Planning Committee to discuss the stakeholder survey results and begin developing management goals and actions for the Hatch Lake management plan. The meeting lasted 3½ hours and resulted in a framework of the implementation plan detailed in Section 5.0, below.

Stakeholder Survey

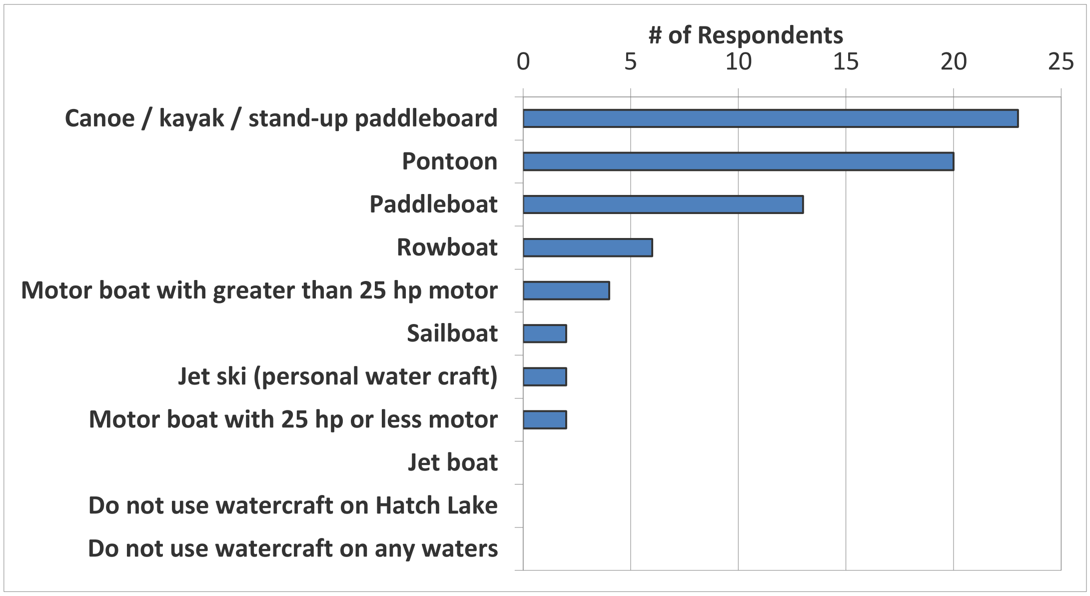
As a part of this project, a stakeholder survey was distributed to HLIWA members and riparian property owners around Hatch Lake. The survey was designed by Onterra staff and the HLIWA planning committee, and reviewed by a WDNR social scientist. During November-December 2020, the eight-page, 34-question survey was posted online through Survey Monkey for property owners to answer electronically. If requested, a hard copy was sent to the property owner with a self-addressed stamped envelope for returning the survey anonymously. The returned hardcopy surveys were entered into the online version by a third-party for analysis. Seventy-two percent of the surveys were returned. Note that a benchmark of a 60% response rate is required to portray population projections accurately, and make conclusions with statistical validity, so this response rate is sufficient for that purpose. The data were analyzed and summarized by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a general summary is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people who use and care for Hatch Lake. 32% of respondents indicated that they live on the lake full-time, while 29% use their property as a part-time residence, and 39% use it as a vacation property. 23% of respondents have owned their property for over 10 years, and 39% have owned their property for over 25 years.

The following sections (Water Quality, Watershed, Aquatic Plants and Fisheries Data Integration) discuss the stakeholder survey data with respect to these particular topics. Figures 2.0-1 and 2.0-2 highlight several other questions found within this survey. More than half of survey respondents indicate that they use either a pontoon boat, canoe/kayak/stand-up paddleboard, or a combination of these vessels on Hatch Lake (Question 12). Paddleboats were also a popular option. On a relatively small lake such as Hatch Lake, the importance of responsible boating activities is increased. The need for responsible boating increases during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the lake. As seen in Question 15, some of the top recreational activities on the lake involve the use of a vessel. Watercraft traffic, however, was not a top concern on a list of stakeholder's concerns regarding the lake (Question 16).

A concern of stakeholders noted throughout the stakeholder survey (see Question 16 and survey comments – Appendix B) was excessive aquatic plant growth, and the introduction and control of aquatic invasive species within Hatch Lake. This topic is touched upon in the Summary & Conclusions section as well as within the Implementation Plan.

Question 12: What types of watercraft do you currently use on Hatch Lake?



Question 15: Please rank up to three activities that are important reasons for owning your property on or near Hatch Lake.

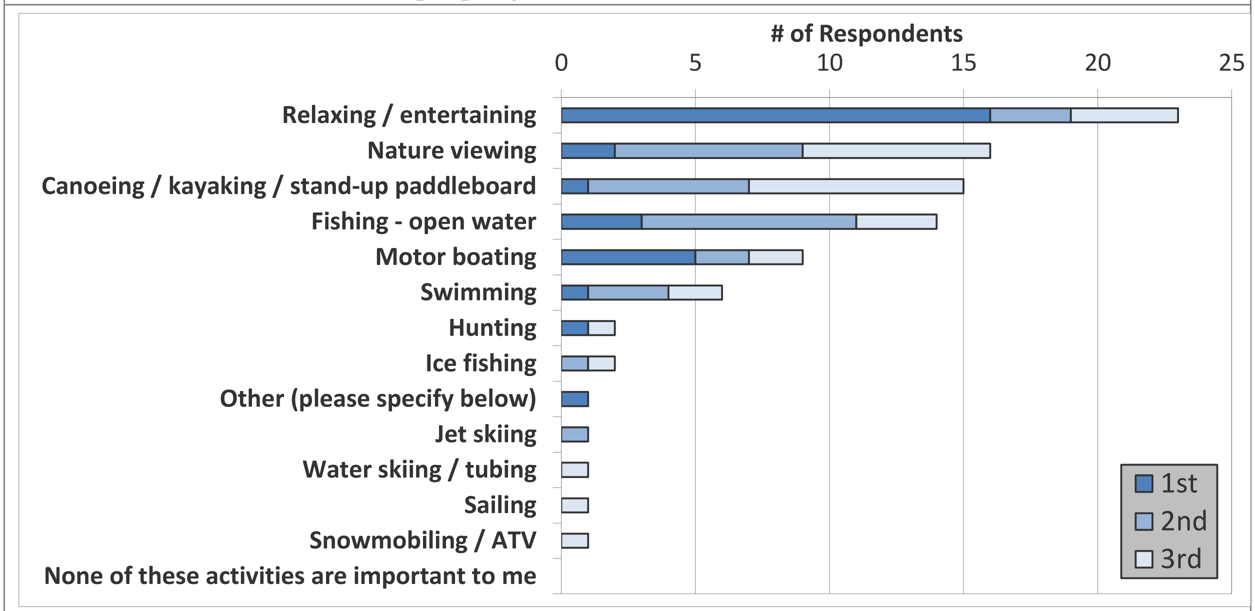


Figure 2.0-1. Select survey responses from the Hatch Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question 16: Please rank your top three concerns regarding Hatch Lake.

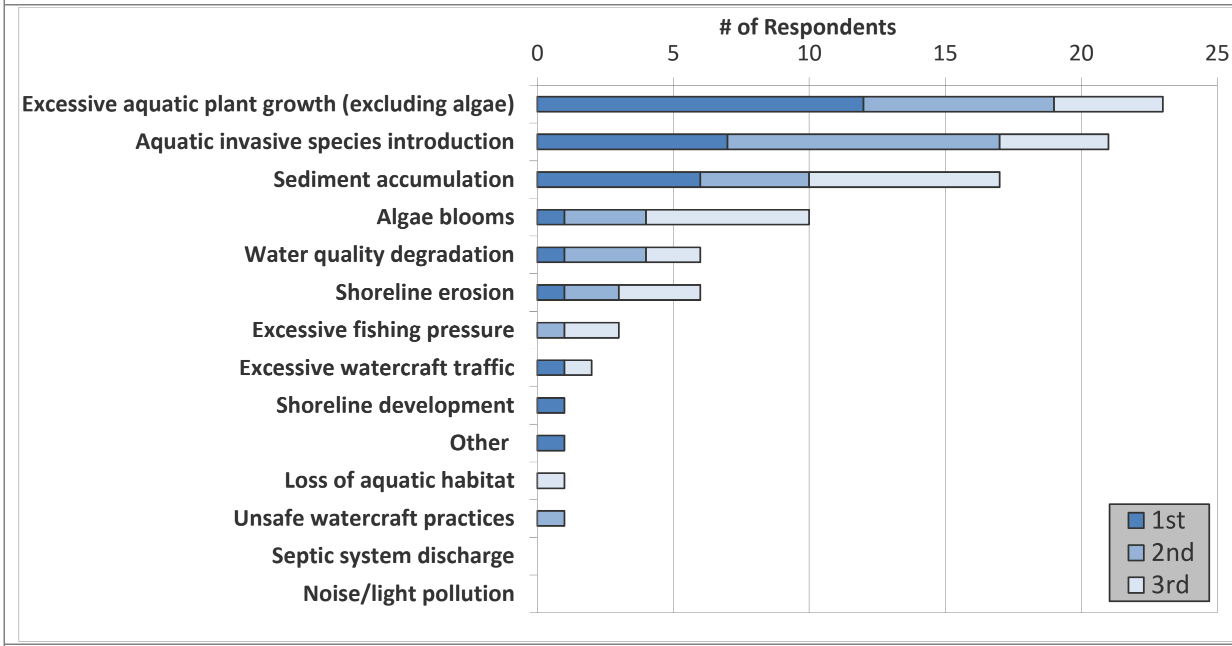


Figure 2.0-2. Select survey responses from the Hatch Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

Management Plan Review and Adoption Process

During November 2021, the HLIWA planning committee was supplied the first draft of the management plan. Minor comments were received and integrated from the committee in February and early spring 2022. On June 7, 2022, the Official First Draft of the Hatch Lake plan was provided to the WDNR. On July 13, 2022, the Official First Draft of the management plan document was posted to Onterra's website. The HLIWA announced the availability of the document for public comment and review via their closed FaceBook Group and via email to their membership. The document remained available through August 8, 2022 and the only comment received was a thank you from a member for all the work the association does to preserve the lake. On August 3, 2022, Ted Johnson, WDNR Water Resources Specialist, supplied comments, which are all addressed in this final version. Mr. Johnson's comments can be found in Appendix F. On August 20, 2022, during the HLIWA Annual Meeting, the Board of Directors voted unanimously to accept the plan.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, water quality values that may be considered poor for one lake may be considered good for another because judging water quality is often subjective. However, focusing on specific aspects or parameters that are important to lake ecology, comparing those values to similar lakes within the same region and historical data from the study lake provides an excellent method to evaluate the quality of a lake's water.

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

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

Phosphorus is the nutrient that controls the growth of plants in the vast majority of Wisconsin lakes. It is important to remember that in lakes, the term "plants" includes both algae and macrophytes. Monitoring and evaluating concentrations of phosphorus within the lake helps to create a better understanding of the current and potential growth rates of the plants within the lake.

Chlorophyll-*a* is the green pigment in plants used during photosynthesis. Chlorophyll-*a* concentrations are directly related to the abundance of free-floating algae in the lake. Chlorophyll-*a* values increase during algal blooms.

Secchi disk transparency is a measurement of water clarity. Of all limnological parameters, it is the most used and the easiest for non-professionals to understand. Furthermore, measuring Secchi disk transparency over long periods of time is one of the best methods of monitoring the health of a lake. The measurement is conducted by lowering a weighted, 20-cm diameter disk with alternating black and white quadrants (a Secchi disk) into the water and recording the depth just before it disappears from sight.

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

Trophic State

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

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

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

Limiting Nutrient

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

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

Temperature and Dissolved Oxygen Profiles

Temperature and dissolved oxygen profiles are created simply by taking readings at 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.

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

Dissolved oxygen is essential in the metabolism of nearly every organism that exists within a lake. For instance, fish kills 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 processes that occur within a lake. Internal nutrient loading is an excellent example that is described below.

Internal Nutrient Loading*

In lakes that support stratification, whether throughout the summer or periodically between mixing events, 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 turnover events, these high concentrations of phosphorus are mixed within the lake and utilized by algae and some macrophytes. In lakes that mix periodically during the summer (polymictic lakes), this cycle can *pump* phosphorus from the sediments into the water column throughout the growing season. In lakes that only mix during the spring and fall (dimictic lakes), this burst of phosphorus can support late-season algae blooms and even last through the winter to support early algal blooms the following spring. Further, anoxic conditions under the winter ice in both polymictic and dimictic lakes can add smaller loads of phosphorus to the water column during spring turnover that may support algae blooms long into the summer. This cycle continues year after year and is termed "internal phosphorus loading"; a phenomenon that can support nuisance algal 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 determine actual and predicted levels of phosphorus for the lake. When the predicted phosphorus level is well below the actual level, it may be an indication that the modeling is not accounting for all of the phosphorus sources entering the lake. Internal nutrient loading may be one of the additional contributors that may need to be assessed with further water quality analysis and possibly additional, more intense studies.

Non-Candidate Lakes

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

Candidate Lakes

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

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

Comparisons with Other Datasets

The WDNR document *Wisconsin 2020 Consolidated Assessment and Listing Methodology* (WDNR 2019) is an excellent source of data for comparing water quality from a given lake to lakes with similar features and lakes within specific regions of Wisconsin. Water quality among lakes, even among lakes that are located in close proximity to one another, can vary due to natural factors such as depth, surface area, the size of its watershed and the composition of the watershed's landcover. For this reason, the water quality of Hatch Lake will be compared to lakes in the state with similar physical characteristics. The WDNR groups Wisconsin's lakes into ten natural communities (Figure 3.1-1).

First, the lakes are classified into three main groups: (1) lakes and reservoirs less than 10 acres, (2) lakes and reservoirs greater than or equal to 10 acres, and (3) a classification that addresses special waterbody circumstances. The last two categories have several sub-categories that provide attention to lakes that may be shallow, deep, play host to cold water fish species or have unique hydrologic patterns. Overall, the divisions categorize lakes based upon their size, stratification characteristics, and hydrology. An equation developed by Lathrop and Lillie (1980), which incorporates the maximum depth of the lake and the lake's surface area, is used to predict whether the lake is considered a shallow (mixed) lake or a deep (stratified) lake. The lakes are further divided into classifications based on their hydrology and watershed size:

> **Seepage Lakes** have no surface water inflow or outflow in the form of rivers and/or streams.
>
> **Drainage Lakes** have surface water inflow and/or outflow in the form of rivers and/or streams.

Headwater drainage lakes have a watershed of less than 4 square miles.

Lowland drainage lakes have a watershed of greater than 4 square miles.

Because of its depth, small watershed and hydrology, Hatch Lake is classified as a shallow headwater drainage lake (category 2 on Figure 3.1-1).

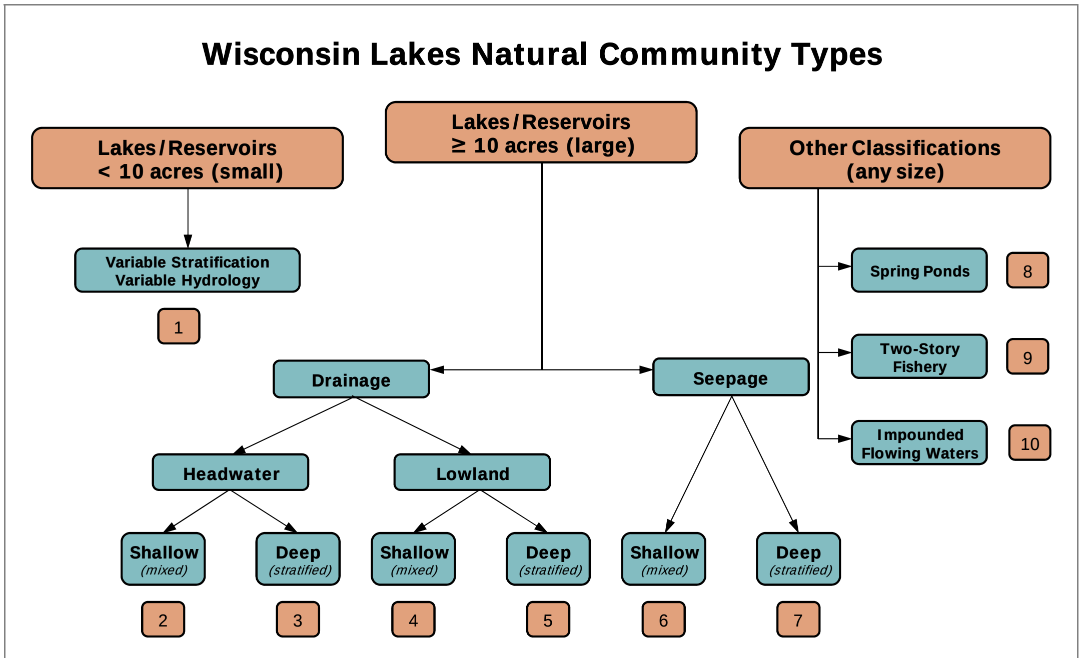


Figure 3.1-1. Wisconsin Lake Natural Communities. Adapted from WDNR 2017.

Garrison, et. al 2008 developed statewide median values for total phosphorus, chlorophyll-*a*, and Secchi disk transparency for six of the lake classifications. Though they did not sample sufficient lakes to create median values for each classification within each of the state's ecoregions, they were able to create median values based on all of the lakes sampled within each ecoregion (Figure 3.1-2). Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems in the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Hatch Lake is within the North Central Hardwood Forests ecoregion.

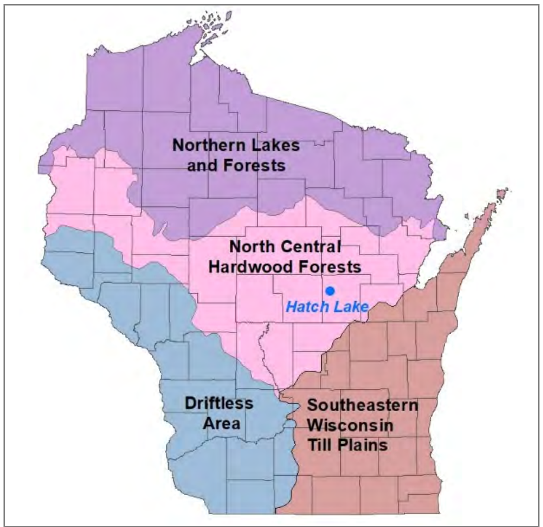


Figure 3.1-2. Location of Hatch Lake within the ecoregions of Wisconsin. After Nichols 1999.

The Wisconsin 2020 Consolidated Assessment and Listing Methodology document also helps stakeholders understand the health of their lake compared to other lakes within the state. Looking at pre-settlement diatom population compositions from sediment cores collected from numerous lakes around the state, they were able to infer a reference condition for each lake's water quality prior to human development within their watersheds. Using these reference conditions and current water quality data, the assessors were able to rank phosphorus, chlorophyll-*a*, and Secchi disk transparency values for each lake class into categories ranging from excellent to poor.

These data along with data corresponding to statewide natural lake means, historic, current, and average data from Hatch Lake is displayed in Figures 3.1-3 - 3.1-6. Please note that the data in these graphs represent concentrations and depths taken only during the growing season (April-October) or summer months (June-August). Furthermore, the phosphorus and chlorophyll-*a* data represent only surface samples. Surface samples are used because they represent the depths at which algae grow and depths at which phosphorus levels are not greatly influenced by phosphorus being released from bottom sediments.

Hatch Lake Water Quality Analysis

Hatch Lake Long-term Trends

Near-surface total phosphorus data are available for Hatch Lake for the years 1999, 2000, 2003, and 2020 (Figure 3.1-3). The mean total phosphorus concentration in 2020 was 17.4 µg/L during the growing season and 18.8 µg/L during the summer, placing the lake in the *good* category for total phosphorus concentrations with Wisconsin's shallow headwater drainage lakes. Including the historical data, the summer average total phosphorus concentration is 16.6 µg/L which places the lake on the border of the *excellent* and *good* categories. Hatch Lake's average summer total phosphorus concentration is much lower when compared to other shallow headwater drainage lakes in Wisconsin (median 29 µg/L) and much lower than lakes within the North Central Hardwood Forests Ecoregion (median 52 µg/L).

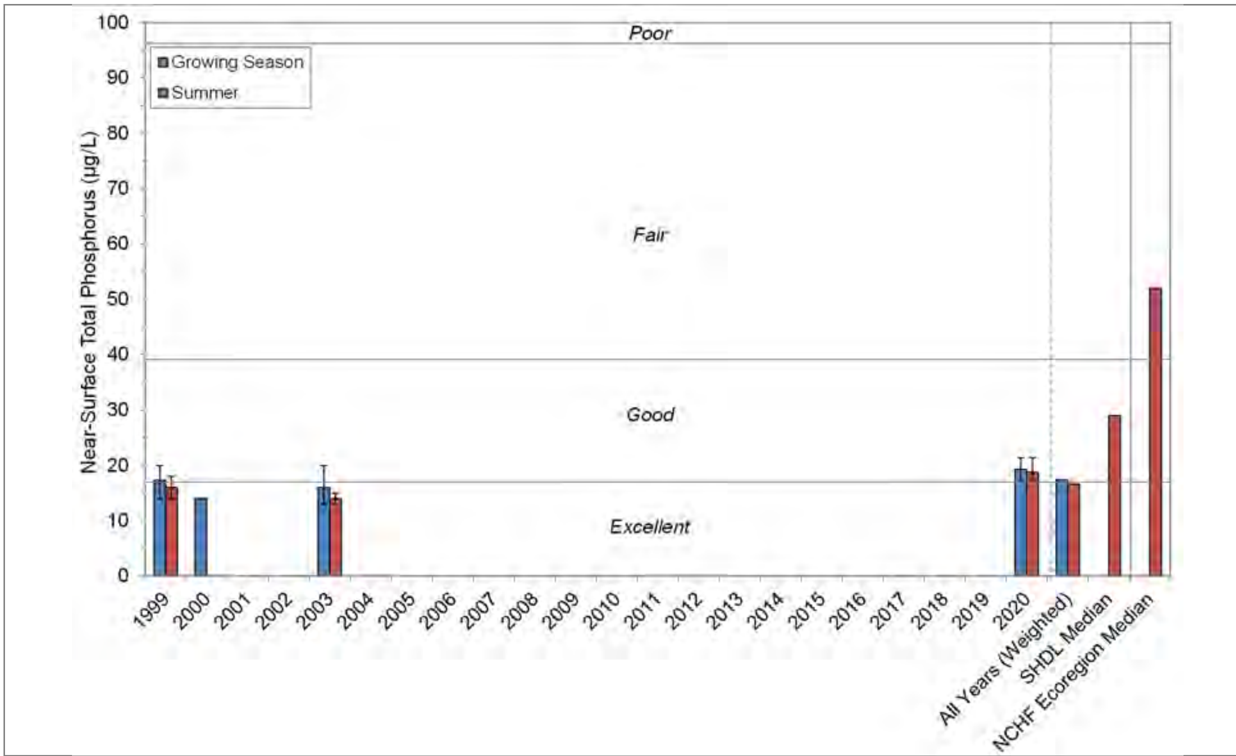


Figure 3.1-3. Hatch Lake average annual near-surface total phosphorus concentrations and median near-surface total phosphorus concentrations for state-wide shallow headwater drainage lakes (SHDL) and North Central Hardwood Forest (NCHF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

As discussed in the primer section, internal nutrient loading is a process by which phosphorus (and other nutrients) are released from sediments when bottom waters become devoid of oxygen (anoxic). Internal nutrient loading is more prevalent in deeper lakes which experience summer stratification or in shallow lakes that are highly productive where high rates of decomposition deplete oxygen near the sediment-water interface. Often as lakes become more productive over time, internal nutrient loading increases. In certain instances, this sediment-released phosphorus can be mobilized to surface waters during the summer where it can fuel nuisance algal blooms. Lake managers often try and determine if internal nutrient loading is a significant source of phosphorus in a lake, particularly when an increasing trend in phosphorus is observed.

To determine if internal nutrient loading of phosphorus is occurring in a stratified lake, phosphorus concentrations are measured near the bottom in the deepest part of the lake during stratification. In lakes which experience high levels of internal nutrient loading, the near-bottom phosphorus concentrations are significantly higher than those measured near the surface.

Near-bottom total phosphorus concentrations were collected on four occasions in 2020 from Hatch Lake (Figure 3.1-4). On all occasions, near-bottom total phosphorus was relatively similar to those measured at the surface. The near-bottom and near-surface data indicate that internal nutrient loading is likely not a consistently significant source of phosphorus to Hatch Lake at this time. Even though near-bottom concentrations were slightly higher in 1999, the concentrations were not high enough to indicate any significant internal loading.

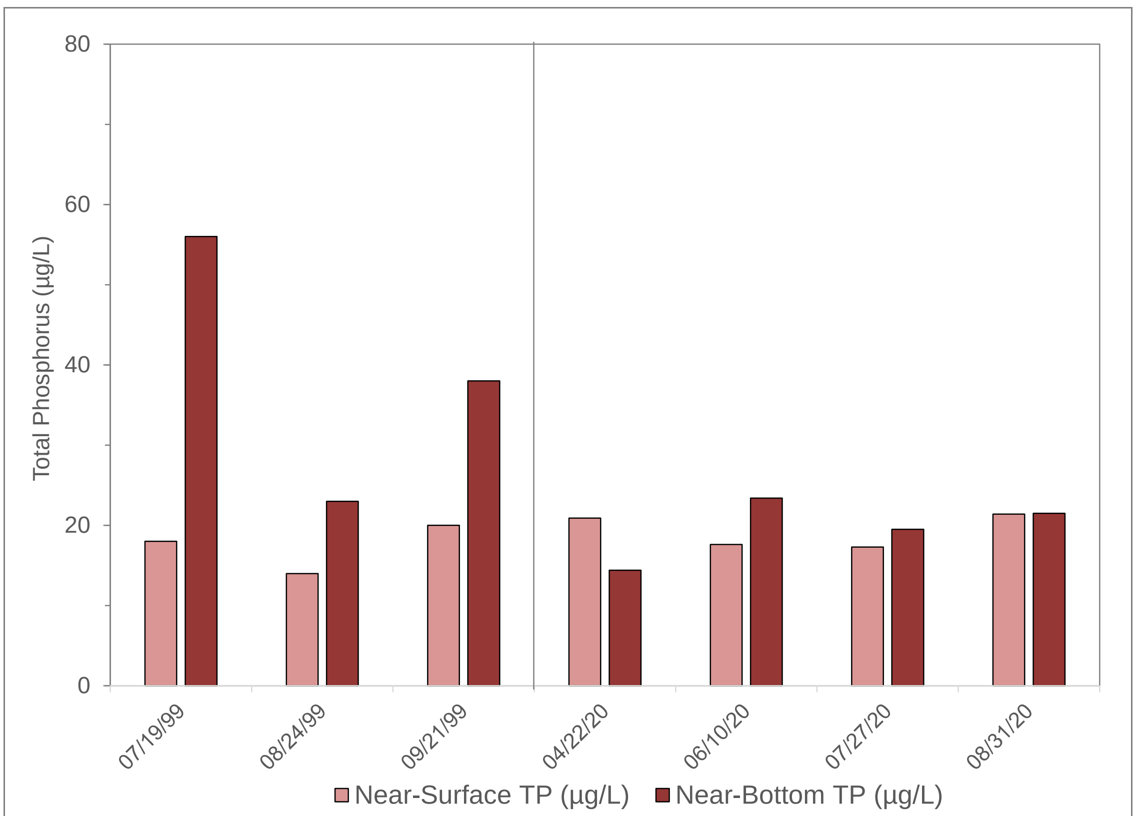


Figure 3.1-4. Hatch Lake near-bottom and corresponding near-surface total phosphorus concentrations. The low concentration in the bottom waters in July indicate internal loading is not a problem in this lake.

Chlorophyll-*a* concentrations, a measure of phytoplankton abundance, are available in Hatch Lake for a similar time period as phosphorus, 1999, 2003, and 2020 (Figure 3.1-5). The mean summer chlorophyll-*a* concentration in 2019 was 3.8 µg/L, placing the lake in the *excellent* category, for shallow headwater drainage lakes in Wisconsin. Chlorophyll-*a* concentrations in 2020 was similar to the overall weighted summer mean concentration of 3.7 µg/L, which falls into the *excellent* category for shallow headwater drainage lakes. Hatch Lake's mean summer chlorophyll-*a* concentration is lower than the median concentration for Wisconsin's shallow headwater drainage lakes (7.5 µg/L) and much lower than the median concentration for lakes within the North Central Hardwood Forests ecoregion (15.2 µg/L).

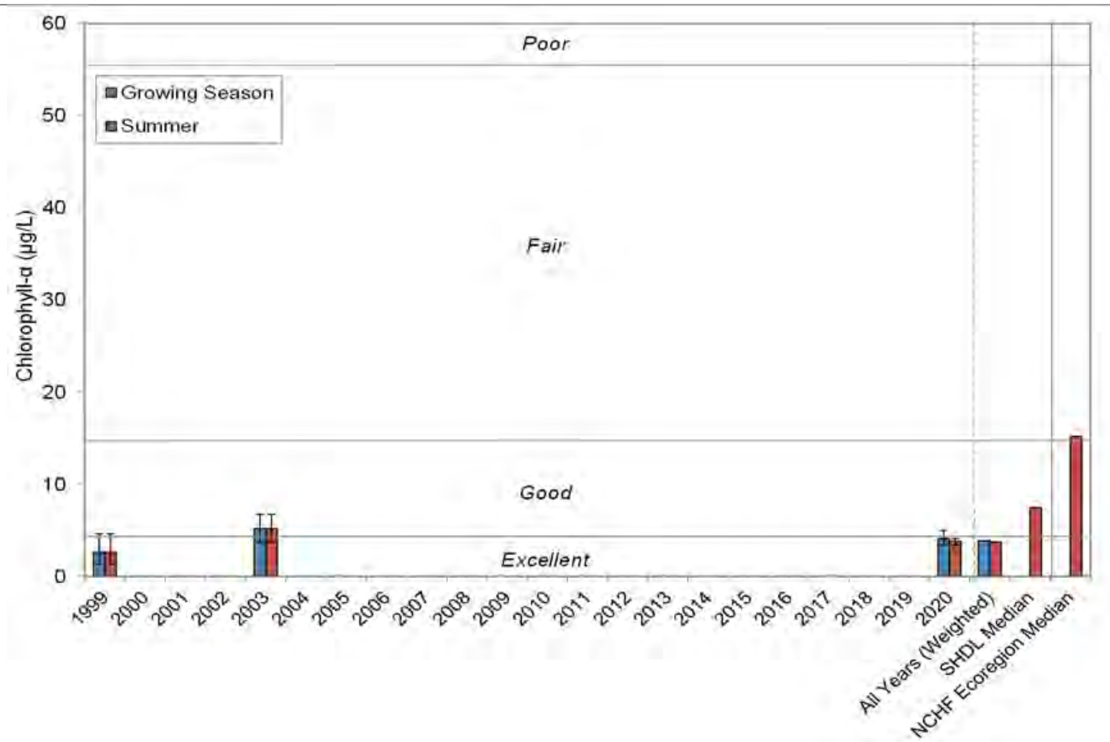


Figure 3.1-5. Hatch Lake average annual chlorophyll-α concentrations and median chlorophyll-α concentrations for state-wide shallow headwater drainage lakes (DLDL) and North Central Hardwood Forests (NCHF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

There is a more complete record of Secchi disk transparency data, a measure of water clarity, than for total phosphorus or chlorophyll-*a*. Data are available in from 1991-92, 1997-2000, 2003 and 2020 (3.1-6). Mean summer Secchi disk depth has ranged from 8.9 feet in 1999 to 11.5 feet in 2000, with an overall weighted mean of 9.9 feet which places the lake in the *excellent* category for Wisconsin's shallow headwater drainage lakes and much better than the median values for other shallow headwater drainage lakes (5.6 feet) and lakes within the North Central Hardwood Forests Ecoregion (5.3 feet).

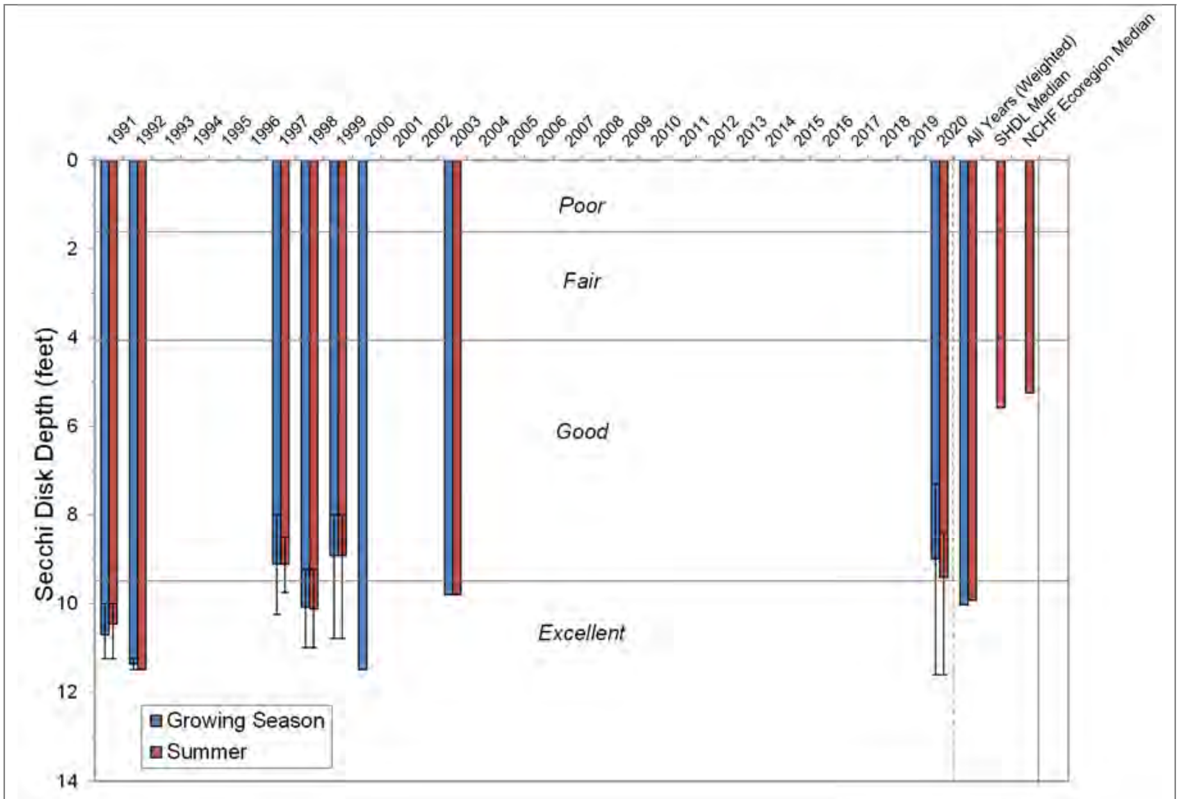


Figure 3.1-6. Hatch Lake average annual Secchi disk depth and median Secchi disk depth for state-wide shallow headwater drainage lakes (SHDL) and North Central Hardwood Forests (NCHF) ecoregion lakes. Water Quality Index values adapted from WDNR PUB WT-913. Error bars represent maximum and minimum values.

The Role of Aquatic Plants in Hatch Lake's Water Quality

As discussed earlier, Hatch Lake is considered a shallow lake and as detailed in the Aquatic Plant Section 3.4, the lake supports an abundant but healthy plant population. In shallow lakes, the aquatic plant community plays a key role in the lake's water quality. Shallow lakes are considered to exist in one of two general stable states: a turbid (low water clarity) state dominated by phytoplankton (free-floating algae) and containing little submersed aquatic vegetation, or a clear state dominated by submersed aquatic vegetation and lower phytoplankton abundance (Scheffer and van Nes 2007). When in the clear state, aquatic vegetation reduces the suspension of bottom sediments, utilizes nutrients that would otherwise be available to phytoplankton, and provide refuge for zooplankton which eat phytoplankton. The aquatic plant community plays a vital role in maintaining this clear-water state. Once a lake transitions from a clear to turbid state, it is highly difficult to return it back to a clear state.

Limiting Plant Nutrient of Hatch Lake

Using mid-summer nitrogen and phosphorus concentrations from Hatch Lake, a nitrogen:phosphorus ratio of 46:1 was calculated. This finding indicates that Hatch Lake is indeed phosphorus limited as are the vast majority of Wisconsin lakes. In general, this means that phosphorus is the primary nutrient regulating algal growth within the lake, and increases in phosphorus will likely result in increased algal production and lower water clarity. Watershed and shoreland conservation and/or restoration efforts for Hatch Lake should have a primary focus on limiting the input of phosphorus to the lake.

Hatch Lake Trophic State

The Trophic State Index (TSI) values for Hatch Lake were calculated using summer near-surface total phosphorus, chlorophyll-*a*, and Secchi disk transparency data collected as part of this project along with historical data (Figure 3.1-7). In general, the best values to use in judging a lake's trophic state are the biological parameters of total phosphorus and chlorophyll-*a* as Secchi disk transparency can be influenced by factors other than algae. Historical data indicate that Hatch Lake was in a mesotrophic state, but with the increase in phosphorus and chlorophyll-*a* in recent years, the lake is currently in a lower eutrophic state.

Using the overall weighed TSI value, it can be said that Hatch Lake is a *mesotrophic* system. Hatch Lake's productivity level is lower than other shallow headwater drainage lakes in the state and other lakes in the North Central Hardwood Forests Ecoregion.

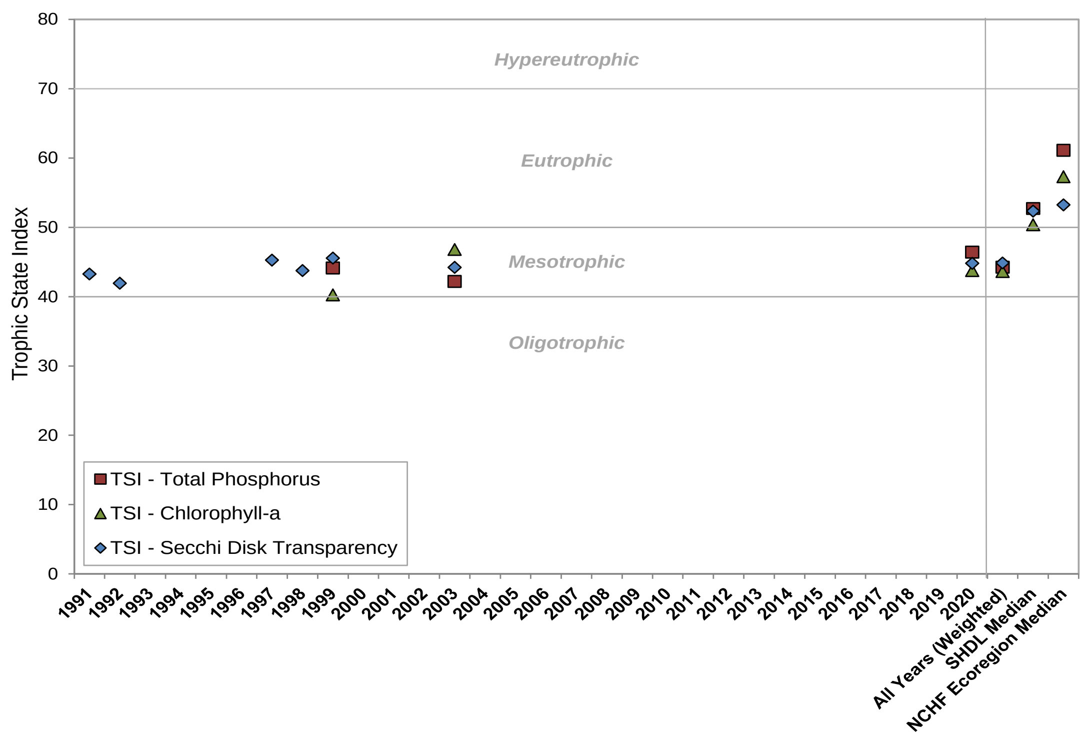


Figure 3.1-7. Hatch Lake, state-wide shallow headwater drainage lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Dissolved Oxygen and Temperature in Hatch Lake

Hatch Lake was sampled by Onterra staff six times during 2020 and February 2021. During each visit by Onterra, dissolved oxygen and temperature were measured. Profiles depicting these data are displayed in Figure 3.1-8. Hatch Lake is *polymictic* meaning the lake frequently mixes during the summer. Even in shallow lakes, at times water movement is not sufficient during the summer to mix the lake. As a result, the bottom layer of water no longer receives atmospheric diffusion of oxygen and decomposition of organic matter within this layer depletes available oxygen. While the data in Figure 3.1-8 do not show it, it is likely that the lake did mix top-to-bottom several times throughout the summer of 2020; however, the limited profiles collected did not record such an event.

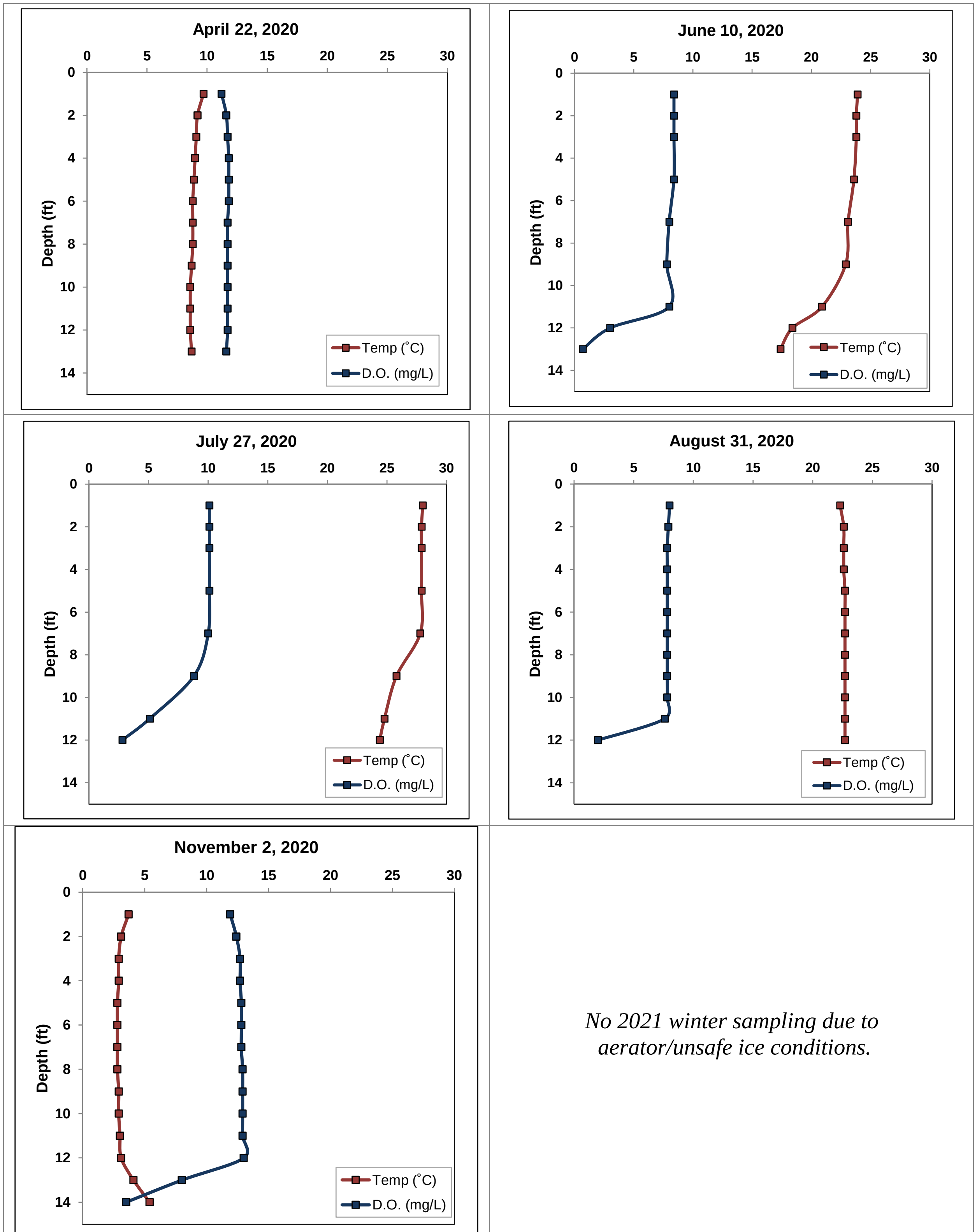


Figure 3.1-8. Hatch Lake 2020/21 dissolved oxygen and temperature profiles.

During the winter, the coldest temperatures are found just under the overlying ice as water is densest at 39 °F, while oxygen gradually declines once again towards the bottom of the lake. In February 2021, Hatch Lake was found to support sufficient levels of dissolved oxygen under the ice throughout most of the water column. This indicates that winter fish kills are not a concern on Hatch Lake.

Additional Water Quality Data Collected at Hatch Lake

The water quality section is centered on lake eutrophication. However, parameters other than water clarity, nutrients, and chlorophyll-*a* were collected as part of the project. These other parameters were collected to increase the understanding of Hatch Lake's water quality and are recommended as a part of the WDNR long-term lake trends monitoring protocol. These parameters include pH, alkalinity, and calcium.

The pH scale ranges from 0 to 14 and indicates the concentration of hydrogen ions (H^+) within the lake's water and is an index of the lake's acidity. Water with a pH value of 7 has equal amounts of hydrogen ions and hydroxide ions (OH^-) and is considered to be neutral. Water with a pH of less than 7 has higher concentrations of hydrogen ions and is considered to be acidic, while values greater than 7 have lower hydrogen ion concentrations and are considered basic or alkaline. The pH scale is logarithmic; meaning that for every 1.0 pH unit the hydrogen ion concentration changes tenfold. The normal range for lake water pH in Wisconsin is about 5.2 to 8.4, though values lower than 5.2 can be observed in some acid bog lakes and higher than 8.4 in some marl lakes. In lakes with a pH of 6.5 and lower, the spawning of certain fish species such as walleye becomes inhibited (Shaw and Nimphius 1985). The mid-summer pH of the water in Hatch Lake was found to be slightly alkaline with a value of 8.7 which falls slightly above the normal range for Wisconsin Lakes (Figure 3.1-9). This value is likely because the lake is a marl lake and is not a concern for aquatic life.

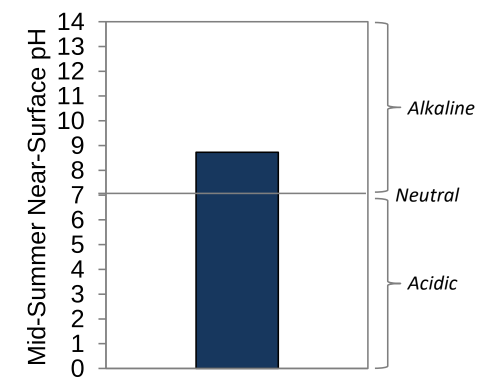


Figure 3.1-9. Hatch Lake mid-summer near-surface pH value.

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

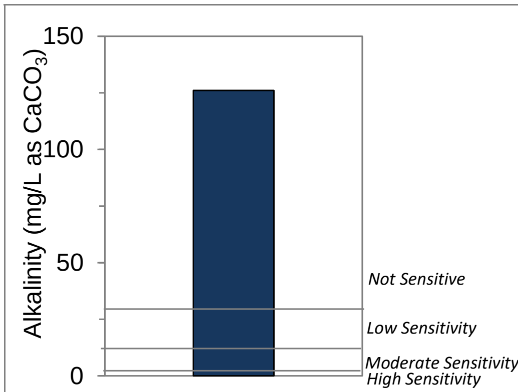


Figure 3.1-10. Hatch Lake average growing season total alkalinity and sensitivity to acid rain. Samples collected from the near-surface.

at 126 (mg/L as $CaCO_3$), indicating that the lake has a capacity to resist fluctuations in pH and is not sensitive to acid rain (Figure 3.1-10).

Like associated pH and alkalinity, the concentration of calcium within a lake's water depends on the geology of the lake's watershed. Recently, the combination of calcium concentration and pH has been used to determine what lakes can support zebra mussel populations if they are introduced. The commonly accepted pH range for zebra mussels is 7.0 to 9.0, so Hatch Lake's pH of 7.8 falls within this range. Lakes with calcium concentrations of less than 12 mg/L are considered to have very low susceptibility to zebra mussel establishment. The calcium concentration of Hatch Lake was found to be 29.1 mg/L, falling in the *high susceptibility* range for zebra mussels (Figure 3.1-11).

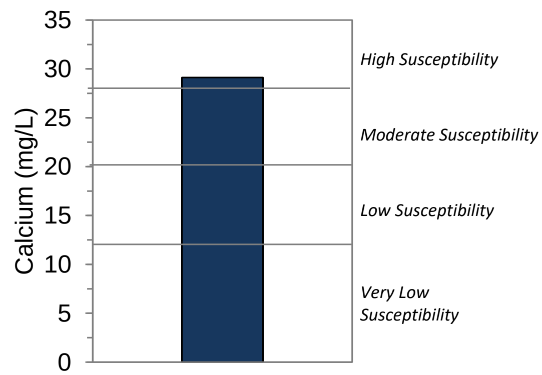


Figure 3.1-11. Hatch Lake spring calcium concentration and zebra mussel susceptibility. Samples collected from the near-surface.

Zebra mussels (*Dreissena polymorpha*) are small bottom dwelling mussels, native to Europe and Asia, that found their way to the Great Lakes region in the mid-1980s. They are thought to have come into the region through ballast water of ocean-going ships entering the Great Lakes, and they have the capacity to spread rapidly. Zebra mussels can attach themselves to boats, boat lifts, and docks, and can live for up to five days after being taken out of the water. These mussels can be identified by their small size, D-shaped shell and yellow-brown striped coloring. Once zebra mussels have entered and established in a waterway, they are nearly impossible to eradicate. Best practice methods for cleaning boats that have been in zebra mussel infested waters is inspecting and removing any attached mussels, spraying your boat down with diluted bleach, power-washing, and letting the watercraft dry for at least five days.

A measure of water clarity once all of the suspended material (i.e., phytoplankton and sediments) have been removed, is termed *true color*, and measures how the clarity of the water is influenced by dissolved components. True color was measured at 10 SU (standard units) in April and 5 SU in July of 2019, indicating the lake's water was *clear colored* in 2019 (Figure 3.1-12).

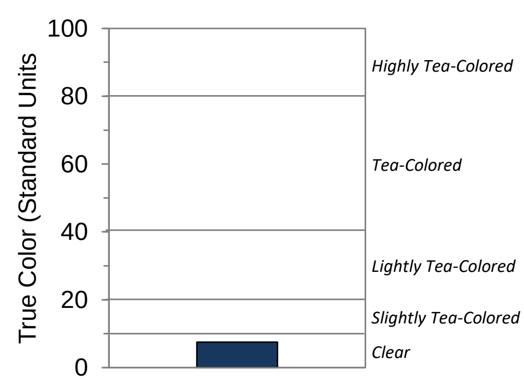


Figure 3.1-12. Hatch Lake 2019 near-surface true color values.

Stakeholder Survey Responses to Hatch Lake Water Quality

As discussed in section 2.0, the stakeholder survey asks many questions pertaining to perception of the lake and how it may have changed over the years. Figures 3.1-13 and 3.1-14 display the responses of members of Hatch Lake stakeholders to questions regarding water quality and how they believe it has changed over their years visiting Hatch Lake.

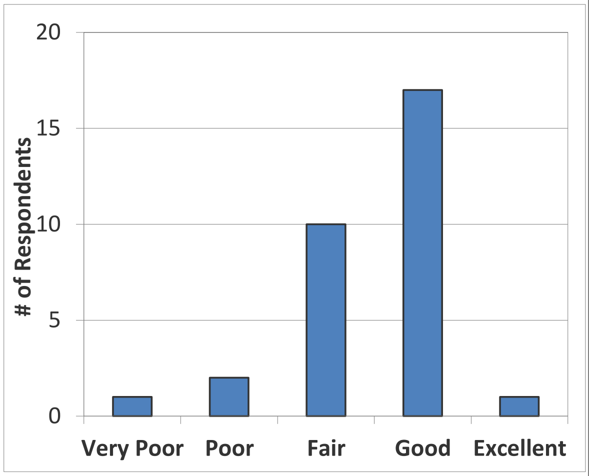


Figure 3.1-13. Stakeholder survey response Question #17. How would you describe the overall current water quality of Hatch Lake?

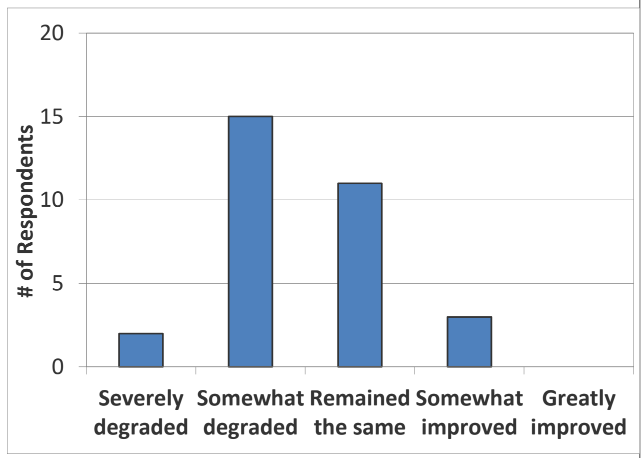


Figure 3.1-14. Stakeholder survey response Question #18. How has the overall water quality changed in Hatch Lake since you first visited the lake?

Paleoecology

Primer on Paleoecology and Interpretation

Questions often arise concerning how a lake's water quality has changed through time as a result of watershed disturbances. In most cases, there is little or no reliable long-term data. They also want to understand when the changes occurred and what the lake was like before the transformations began. Paleoecology offers a way to address these issues. The paleoecological approach depends upon the fact that lakes act as partial sediment traps for particles that are created within the lake or delivered from the watershed. The sediments of the lake entomb a selection of fossil remains that are more or less resistant to bacterial decay or chemical dissolution. These remains include frustules (silica-based cell walls) of a specific algal group called diatoms, cell walls of certain algal species, and subfossils from aquatic plants. The diatom community are especially useful in reconstructing a lake's ecological history as they are highly resistant to degradation and are ecologically diverse. Diatom species have unique features as shown in Photo 3.1-1, which enable them to be readily identified. Certain taxa are usually found under nutrient poor conditions while others are more common under elevated nutrient levels. Some species float in the open water areas while others grow attached to objects such as aquatic plants or the lake bottom.

The chemical composition of the sediments may indicate the composition of particles entering the lake as well as the past chemical environment of the lake itself. By collecting an intact sediment core, sectioning it off into layers, and utilizing all of the information described above, paleoecologists can reconstruct changes in the lake ecosystem over any period of time since the establishment of the lake.

One often used paleoecological technique is collecting and analyzing top/bottom cores. The top/bottom core only analyzes the top (usually 1 cm) and bottom sections. The top section represents present day conditions and the bottom section is hoped to represent pre-settlement conditions by having been deposited at least 100 years ago. While it is not possible to determine the actual date of deposition of bottom samples, a determination of the radionuclide lead-210 estimates if the sample was deposited at least 100 years ago. The primary analysis conducted on this type of core is the diatom community leading to an understanding of past nutrients, pH, and general macrophyte coverage.

Hatch Lake Paleoecological Results

A sediment core was extracted from the deep area of Hatch Lake on July 27, 2020 (Photo 3.1-2) to determine how the water quality and lake ecology has changed during the last century. The total length of the core was 49 cm. The core was dark brown in color throughout the core. The top 1 cm was kept for diatom analysis as it is assumed this represents present day water quality conditions. The section 46-48 cm was kept for analysis of the diatom community and radiochemical analysis. It is assumed that this section represents conditions before the arrival Euroamerican settlers in the nineteenth century but the radiochemical analysis will confirm this.

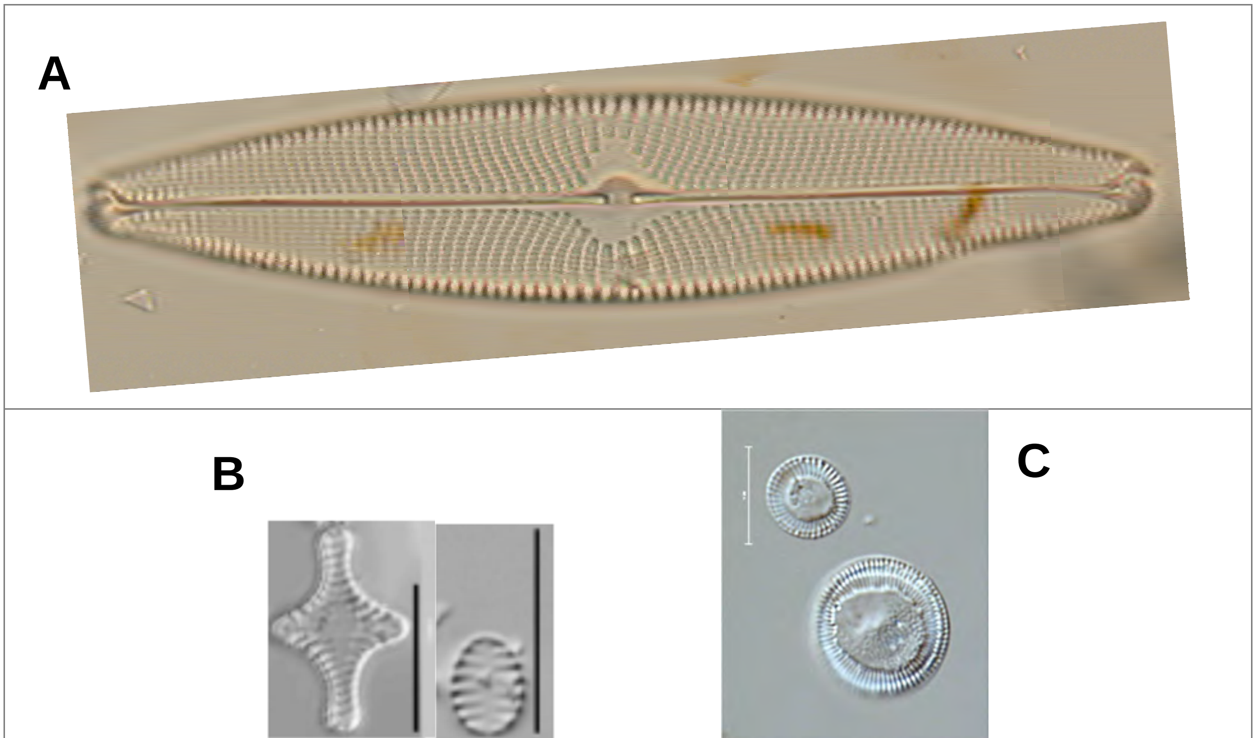


Photo 3.1-1. Photomicrographs of the diatoms commonly found in the sediment core from Hatch Lake. The top diatom (A) *Navicula vulpina* was dominant in the bottom sample and indicates lower nutrient levels. *Staurosira construens* (B left) and *S. pinnata* (B right) are typically found growing on macrophytes and floating algal mats and were much more common in the top sample. *Cyclotella michiganiana* (C) floats in the open water and is generally found in lakes with good water quality.

Multivariate Statistical Analysis

In order to make a comparison of environmental conditions between the bottom and top samples of the core from Hatch Lake, an exploratory detrended correspondence analysis (DCA) was performed using CANOCO 5 software (Ter Braak and Smilauer 2012). The DCA analysis has been done on many WI lakes to examine the similarities of the diatom communities between the top and bottom samples of the same lake.

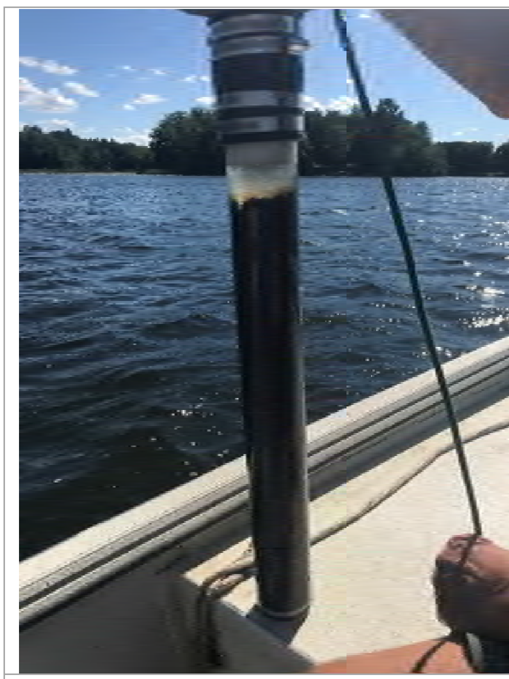


Photo 3.1-2. Photo of sediment core collected from Hatch Lake. Fragments of macrophytes were visible throughout the core.

The results revealed two clear axes of variation in the diatom data, with 37% and 24% of the variance explained by axis 1 and axis 2, respectively (Figure 3.1-13). Sites with similar sample scores occur in close proximity reflecting similar diatom composition. The arrows symbolize the trend from the bottom to the top samples.

In Hatch Lake there is considerable separation between the bottom and the top samples (Figure 3.1-15), indicating a significant difference in the diatom communities. This suggests that there has been changes in the lake's ecology during the last century.

While it is not possible to determine which were the most important environmental variables ordering the diatom communities, one trend is apparent. Axis 1 likely represents the alkalinity of the lakes. Other studies of Wisconsin and Vermont lakes indicate that the most important variable ordering the diatom communities is alkalinity. Lakes on the right side of the DCA graph tend to have the lowest alkalinity values while the highest are on the left side. A study by Eilers et al. (1989) of 149 lakes in north central Wisconsin found that as a consequence of lake shore development, alkalinity and conductivity concentrations increase. This is because of the sediment that enters the lake during cottage and road construction. Even though at the present time there is more development in Hatch Lake's watershed than there was historically, the alkalinity has only changed little a moderate amount. This is because the lake has sufficient alkalinity such that development has not significantly changed the buffering capacity of the lakes. Soft water lakes are much more susceptible to having their alkalinity affected by development.

It is likely that the second axis reflects the abundance of benthic *Fragilaria* (Photo 3.3-1B). These diatoms are often associated with macrophytes and floating algal mats. In Hatch Lake, these diatoms were only found in the top sample. Since there were fragments of macrophytes throughout the core, the dominance of benthic *Fragilaria* at the top of the core likely signals a large increase in floating algal mats in recent times.

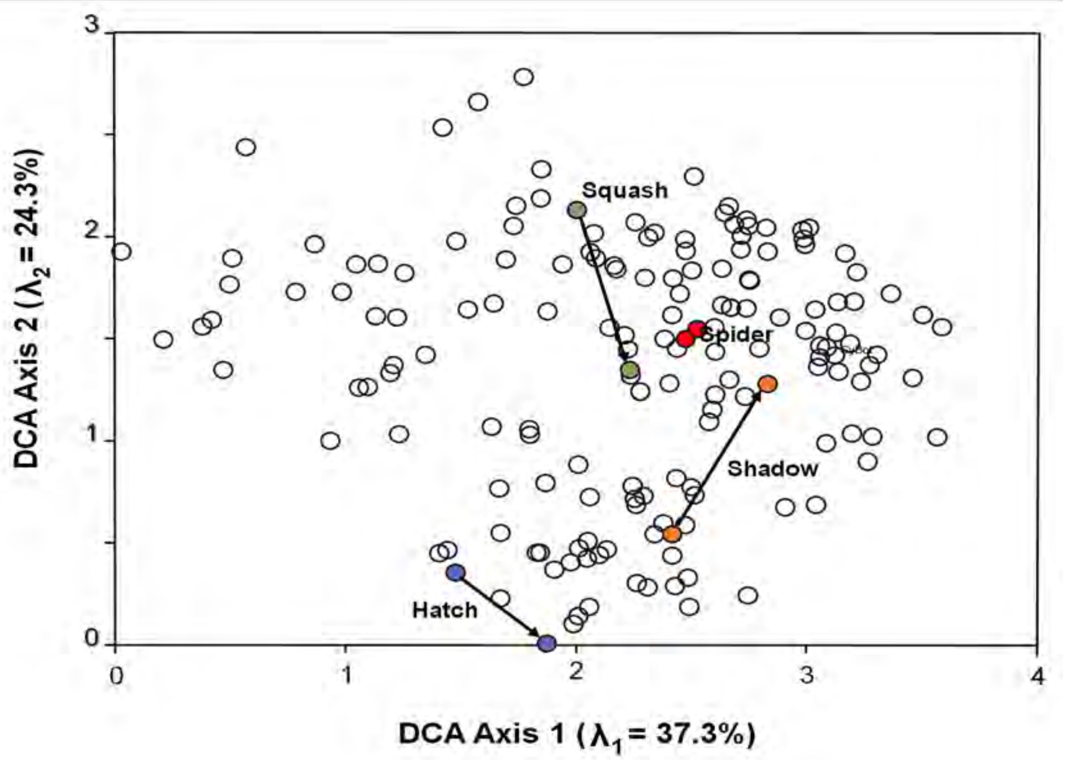


Figure 3.1-15. DCA plot of top/bottom samples, highlighting lakes where Onterra staff collected sediment cores in 2020. The arrows connect bottom to top samples in the same lake. The open circles are other Wisconsin lakes where top/bottom samples have been analyzed. The diatom community in Hatch Lake has changed a significant amount since the arrival of Euroamerican settlers over 150 years ago.

Diatom Community Changes

The diatom community in both samples was dominated by diatoms that grow attached to macrophytes and substrates such as floating algal mats. The bottom sample was dominated by diatoms belonging to the genera *Navicula*. The most common *Navicula* was *N. vulpina* (Photo 3.1-1A) as well as other large diatoms that grow attached to macrophytes. These diatoms are usually found under low nutrient conditions and good water clarity. These large *Navicula* were absent in the top sample and had been replaced by much smaller benthic *Fragilaria* (Photo 3.1-1B, Figure 3.1-16). The number of species in the top sample was one half of what was found in the bottom sample which suggests a degradation in the lake's water quality at the present time compared with historical times.

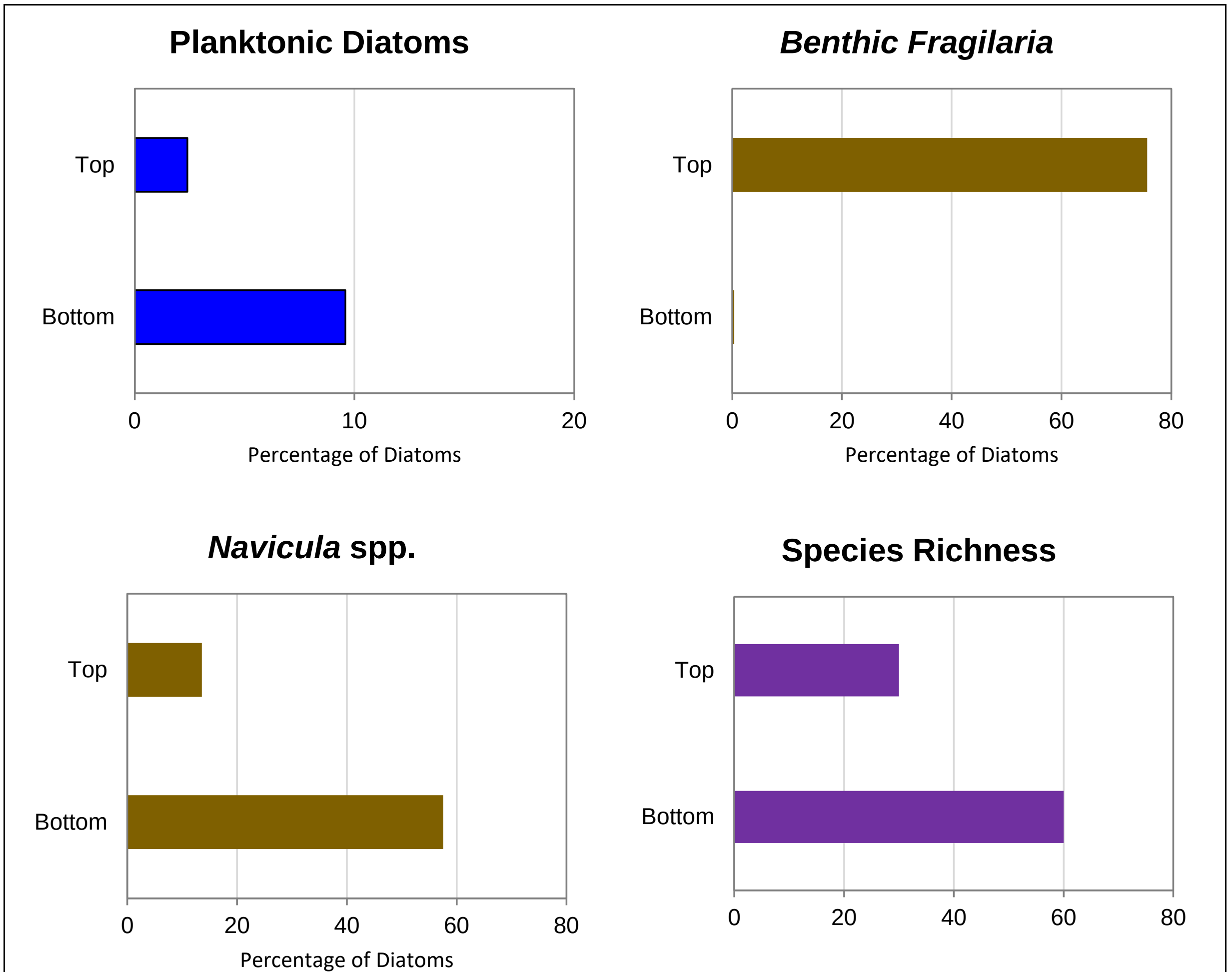


Figure 3.1-16. Changes in abundance of important diatoms found in the top and bottom of the sediment core from Hatch Lake. The decline in *Navicula* spp. and the decrease in species richness likely signals increased nutrients in the lake.

Even though shoreland development results in increased phosphorus runoff from the shoreline, this increased phosphorus input is not reflected in higher phosphorus levels in the lake. This is because with the increase in the size of the macrophytes, there is more surface area for diatoms and other benthic algae to grow. These benthic algae remove a significant amount of phosphorus from the water column. As studies have shown in areas with significant agriculture in the watershed, if enough phosphorus enters the lake, eventually the phosphorus removal by benthic algae is not great enough to prevent increased phosphorus concentrations within the lake and algal blooms result. At the present time, floating algal mats are common, especially in wind protected bays. The diatom community suggests this was uncommon historically.

Lake Diatom Condition Index

The Lake Diatom Condition Index (LDCI) was developed by Dr. Jan Stevenson, Michigan State University (Stevenson, Zalack and Wolin 2013). The LDCI uses diatoms to assess the ecological condition of lakes. The LDCI ranges from 0 to 100 with a higher score representing better ecological integrity. The index is weighted towards nutrients, but also incorporates ecological integrity by examining species diversity where higher diversity indicates better ecological condition. The index also incorporates taxa that are commonly found in undisturbed and disturbed conditions. The breakpoints (poor, fair, good) were determined by the 25th and 5th percentiles for reference lakes in the Upper Midwest. The LDCI was used in the 2007 National Lakes Assessment to determine the biological integrity of the nation's lakes.

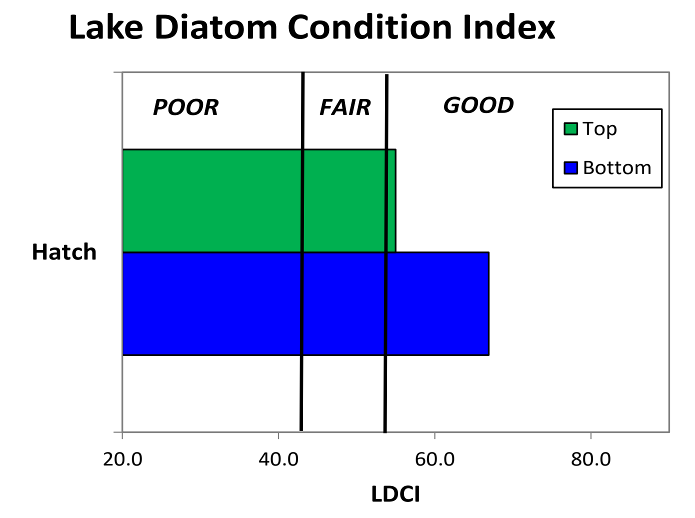


Figure 3.1-17. The Lake Diatom Condition Index (LDCI) for Hatch Lake. While the biotic integrity is good at the present time, it was better historically.

The LDCI analysis indicates the lake's biotic condition historically and now are in the good range (Figure 3.1-17). The index at the present time is not as good as it was historically and this is primarily the result of a decline in species richness.

Inference models

Diatom assemblages have been used as indicators of trophic changes in a qualitative way (Bradbury 1975, Carney 1982, Anderson et al. 1990) but quantitative analytical methods exist. Ecologically relevant statistical methods have been developed to infer environmental conditions from diatom assemblages. These methods are based on multivariate ordination and weighted averaging regression and calibration (Birks et al. 1990). Ecological preferences of diatom species are determined by relating modern limnological variables to surface sediment diatom assemblages. The species-environment relationships are then used to infer environmental conditions from fossil diatom assemblages found in the sediment core.

Weighted averaging calibration and reconstruction (Birks et al. 1990) were used to infer historical water column summer average phosphorus concentration in the sediment cores. A training set that consisted of 60 lakes was used. Training set species and environmental data were analyzed using weighted average regression software, C2 (Juggins 2014).

The diatom inferred phosphorus concentration in the top and bottom samples of Hatch Lake is 16 µg/L which is nearly the same as the measured summer mean concentration in 2020. This indicates that the diatom model works well for the lake. Although the phosphorus concentration has not changed in the lake over the last century, the lake's ecology has degraded. The reason this has not resulted in an increase in phosphorus is that the presence of a large macrophyte community provides a substrate for algae to colonize. This attached algae extracts phosphorus from the water thus reducing the open water phosphorus concentrations. If phosphorus input from the watershed remains high enough, eventually the attached algae are not able to remove enough incoming phosphorus and concentrations in the open water will increase.

Table 3.1-1. Diatom inferred phosphorus concentrations in core samples (µg/L).

Lakes	Phosphorus
Hatch Top	16
Hatch Bottom	16

In summary, Hatch Lake has experienced a degradation of the lake's ecology over the last century. Although the amount of lake area that is covered by macrophytes likely has not changed, there has been an increase in the density of attached algae. The diatom community has shifted from large taxa such as *Navicula* and *Neidium* to much smaller taxa like benthic *Fragilaria,* e.g.*, Staurosira* and *Staurosirella*. These smaller taxa do well under a wide range of nutrient conditions but often increase under increased phosphorus concentrations. There has not been an increase in the phosphorus concentration in the open water even though phosphorus loading from the watershed has almost surely increased over time. This is because the increased growth of attached algae is able to remove nearly all of the incoming phosphorus. If phosphorus loading continues to increase, eventually the attached algae will not be able to remove enough phosphorus to prevent an increase in phosphorus concentration in the open water.

3.2 Watershed Assessment

Watershed Modeling

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.

Two aspects of a lake's watershed are key factors in determining the amount of phosphorus the watershed exports to the lake; 1) the size of the watershed, and 2) the landcover (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.

The type of landcover 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 landcover types leads to increased phosphorus and pollutant loading; which, in turn, can lead to nuisance algal blooms, increased sedimentation, and/or overabundant macrophyte populations. For these reasons, it is important to maintain as much natural landcover (forests, wetlands, etc.) as possible within a lake's watershed to minimize the amount of runoff (nutrients, sediment, etc.) entering the lake.

The majority of Hatch lake's watershed is comprised of wetlands (37%), the lake itself (31%), and forest (12%) (Map 2). Row crops, rural residential, and pasture/grass account for the remaining portions of the of the watershed (Figure 3.2-1). The landcover was originally derived from the NLCD 2016 database (USGS 2019). Since the watershed to lake area ratio is very small, an accurate representation of landcover types is required for total phosphorus prediction within WiLMS. Onterra staff modified the NLCD assigned acreages using aerial photography to most accurately represent acreages of different landcover types for the WiLMS analysis and those are displayed in Figure 3.2-1.

In systems with lower WS:LA ratios, landcover 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 landcover 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. Hatch Lake falls into this category with a very low watershed to lake area ratio of 2:1.

Regardless of the size of the watershed or the makeup of its landcover, 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 (a residence time of years), there may be a buildup of phosphorus in the sediments that may reach sufficient levels over time and lead to a problem such as internal nutrient loading. On the contrary, a lake with a higher flushing rate (low residence time, i.e., days or weeks) may be more productive early on, but the constant flushing of its waters may prevent a buildup of phosphorus and internal nutrient loading may never reach significant levels.

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

Of the estimated 68 pounds of phosphorus delivered to the lake annually, 23 pounds (34%) is derived from the agricultural field in the northwest part of the watershed, 19 pounds 28%) is from the lake itself, 15 pounds (15%) from wetlands, 2 pounds (3%) from grasslands, 4 pounds (7%) from forest, and 4 pounds (6%) from septic systems (Figure 3.2-2).

Hatch Lake observed total phosphorus concentrations during the growing season were on average 17.4 (µg/L). Using the modified NLCD landcover acreages, WiLMS predicted total phosphorus concentrations for Hatch of 32.0 (µg/L). This is considered a very high prediction and could be due to a multitude of reasons. Easily seen on aerial photography are wetlands, within the watershed, surrounding the lake which have the potential some years to self-drain. This means instead of water flowing through the wetlands and draining into Hatch Lake, the majority of water is percolating to groundwater and not reaching Hatch Lake. It is also possible with the inclusion of an outlet, there could be more groundwater entering Hatch Lake than WiLMS is predicting. More groundwater entering the lake, means that phosphorus is removed from the lake at a higher rate thus reducing the concentration in the lake.

Elevated levels of alkalinity, which is present in Hatch Lake, can cause marl to precipitate out of the water. Since phosphorus is attached to the marl, it co-precipitates thereby reducing phosphorus concentrations. Another hypothesis is phosphorus is removed from the water column by algae attached to the abundant macrophyte community. It is likely a combination of these factors that naturally regulates Hatch Lake's low phosphorus levels.

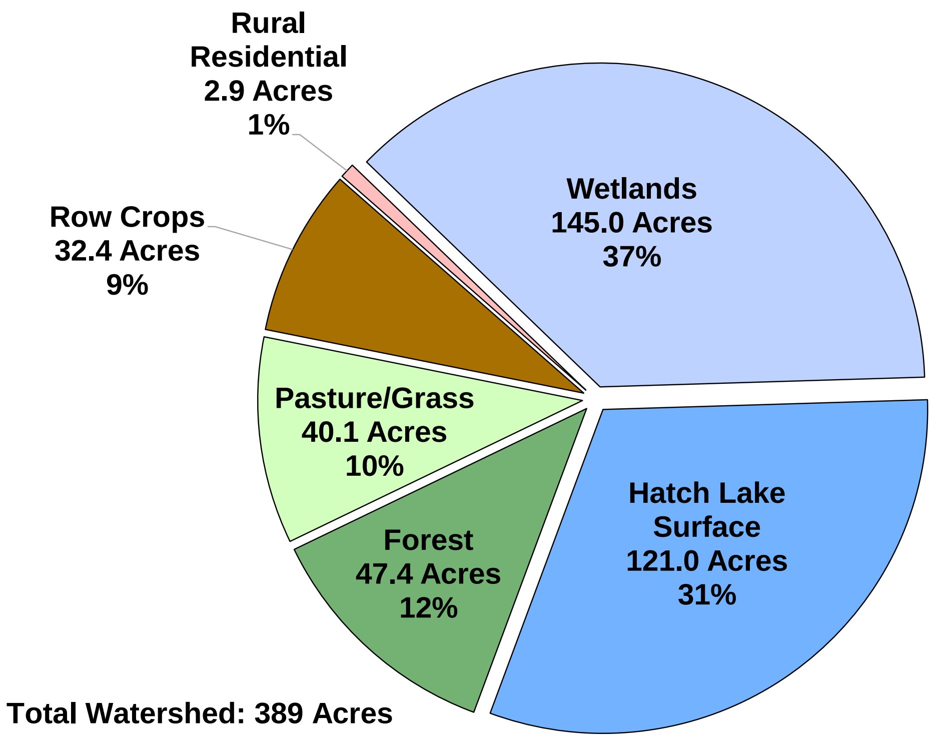


Figure 3.2-1. Hatch Lake watershed landcover types in acres. Based upon National Land Cover Database and modified based on aerial photography.

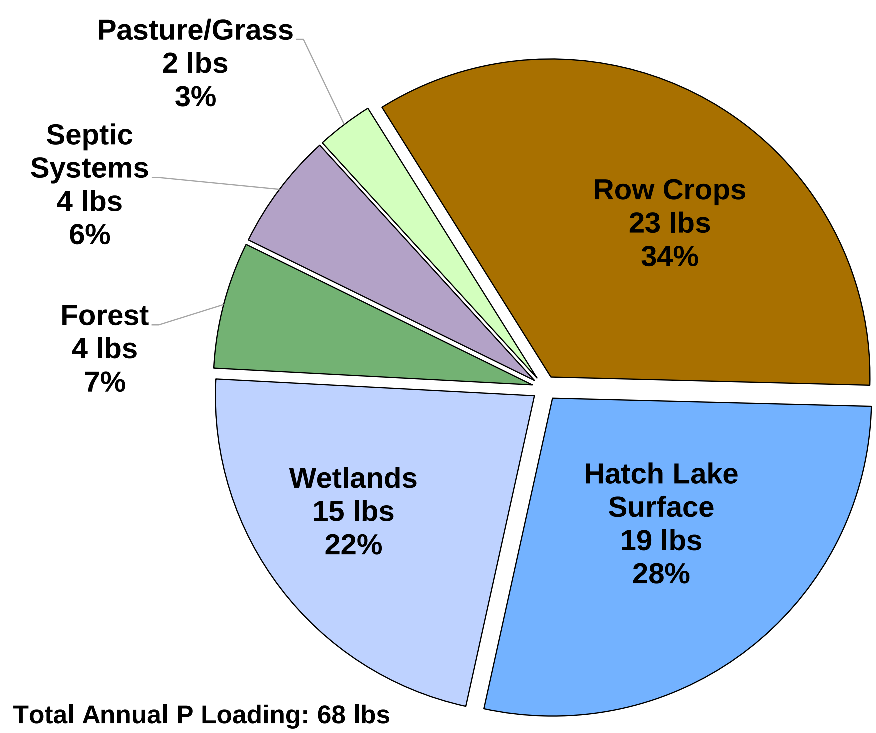


Figure 3.2-2. Hatch Lake phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) modified estimates.

3.3 Shoreland Condition

Lake Shoreland Zone and its Importance

One of the most vulnerable areas of a lake's watershed is the immediate shoreland zone (approximately from the water's edge to at least 35 feet shoreland). When a lake's shoreland is developed, the increased impervious surface, removal of natural vegetation, and other human practices can severely increase pollutant loads to the lake while degrading important habitat. Limiting these anthropogenic (man-made) effects on the lake is important in maintaining the quality of the lake's water and habitat.

The intrinsic value of natural shorelands 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 shoreland 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. Thus, both the removal of vegetation and the inclusion of development reduces many forms of habitat for wildlife.

Some forms of development may provide habitat for less than desirable species. Disturbed areas are often overtaken by invasive species, which are sometimes termed "pioneer species" for this reason. Some waterfowl, such as geese, prefer to linger upon open lawns near waterbodies because of the lack of cover for potential predators. The presence of geese on a lake resident's beach may not be an issue; however, the feces the geese leave are unsightly and pose a health risk. Geese feces may become a source of fecal coliforms as well as flatworms that can lead to swimmers' itch. Development such as rip rap or masonry, steel or wooden seawalls completely remove natural habitat for most animals, but may also create some habitat for snails; this is not desirable for lakes that experience problems with swimmers' itch, as the flatworms that cause this skin reaction utilize snails as a secondary host after waterfowl.

In the end, natural shorelines provide many ecological and other benefits. 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.

Shoreland Zone Regulations

Wisconsin has numerous regulations in place at the state level which aim to enhance and protect shorelands. Additionally, counties, townships and other municipalities have developed their own (often more comprehensive or stronger) policies. At the state level, the following shoreland regulations exist:

Wisconsin-NR 115: Wisconsin's Shoreland Protection Program

Wisconsin's shoreland zoning rule, NR 115, sets the minimum standards for shoreland development. First adopted in 1966, the code set a deadline for county adoption of January 1, 1968. By 1971, all counties in Wisconsin had adopted the code and were administering the shoreland ordinances it specified. Interestingly, in 2007 it was noted that many (27) counties had recognized inadequacies within the 1968 ordinance and had actually adopted stricter shoreland ordinances. Revised in February of 2010, and again in October of 2014, the finalized NR 115 allowed many standards to remain the same, such as lot sizes, shoreland setbacks and buffer sizes. However, several standards changed as a result of efforts to balance public rights to lake use with private property rights. The regulation sets minimum standards for the shoreland zone, and requires all counties in the state to adopt shoreland zoning ordinances. Counties were previously able to set their own, stricter, regulations to NR 115 but as of 2015, all counties have to abide by state regulations. Minimum requirements for each of these categories are described below.

- Vegetation Removal: For the first 35 feet of property (shoreland zone), no vegetation removal is permitted except for: sound forestry practices on larger pieces of land, access and viewing corridors (may not exceed 35 percent of the shoreline frontage), invasive species removal, or damaged, diseased, or dying vegetation. Vegetation removed must be replaced by replanting in the same area (native species only).

- Impervious surface standards: In general, the amount of impervious surface is restricted to 15% of the total lot size, on lots that are within 300 feet of the ordinary high-water mark of the waterbody. If a property owner treats their run off with some type of treatment system, they may be able to apply for an increase in their impervious surface limit, up to 30% for residential land use. Exceptions to this limit do exist if a county has designated highly-developed areas, so it is recommended to consult county-specific zoning regulations for this standard.

- Nonconforming structures: Nonconforming structures are structures that were lawfully placed when constructed but do not comply with distance of water setback. Originally, structures within 75 ft of the shoreline had limitations on structural repair and expansion. Language in NR-115 allows construction projects on structures within 75 feet. Other specifications must be met as well, and local zoning regulations should be referenced.

Mitigation requirements: Language in NR-115 specifies mitigation techniques that may be incorporated on a property to offset the impacts of impervious surface, replacement of nonconforming structure, or other development projects. Practices such as buffer restorations along the shoreland zone, rain gardens, removal of fire pits, and beaches all may be acceptable mitigation methods. Mitigation requirements are county-specific and any such projects should be discussed with local zoning to determine the requirements.

Wisconsin Act 31

While not directly aimed at regulating shoreland practices, the State of Wisconsin passed Wisconsin Act 31 in 2009 in an effort to minimize watercraft impacts upon shorelines. This act prohibits a person from operating a watercraft (other than personal watercraft) at a speed in excess of slow-no-wake speed within 100 feet of a pier, raft, buoyed area or the shoreline of a lake. Additionally, personal watercraft must abide by slow-no-wake speeds while within 200 feet of these same areas. Act 31 was put into place to reduce wave action upon the sensitive shoreland zone of a lake. The legislation does state that pickup and drop off areas marked with regulatory markers and that are open to personal watercraft operators and motorboats engaged in waterskiing/a similar activity may be exempt from this distance restriction. Additionally, a city, village, town, public inland lake protection and rehabilitation district or town sanitary district may provide an exemption from the 100-foot requirement or may substitute a lesser number of feet.

Shoreland Research

Studies conducted on nutrient runoff from Wisconsin lake shorelands have produced interesting results. For example, a USGS study on several Northwoods Wisconsin lakes was conducted to determine the impact of shoreland development on nutrient (phosphorus and nitrogen) export to these lakes (Graczyk et al. 2003). During the study period, water samples were collected from surface runoff and groundwater and analyzed for nutrients. These studies were conducted on several developed (lawn covered) and undeveloped (undisturbed forest) areas on each lake. The study found that nutrient yields were greater from lawns than from forested catchments, but also that runoff water volumes were the most important factor in determining whether lawns or wooded catchments contributed more nutrients to the lake. Groundwater inputs to the lake were found to be significant in terms of water flow and nutrient input. Nitrate plus nitrite nitrogen and total phosphorus yields to the ground-water system from a lawn catchment were three or sometimes four times greater than those from wooded catchments.

A separate USGS study was conducted on the Lauderdale Lakes in southern Wisconsin, looking at nutrient runoff from different types of developed shorelands – regular fertilizer application lawns (fertilizer with phosphorus), non-phosphorus fertilizer application sites, and unfertilized sites (Garn 2002). One of the important findings stemming from this study was that the amount of dissolved phosphorus coming off of regular fertilizer application lawns was twice that of lawns with non-phosphorus or no fertilizer. Dissolved phosphorus is a form in which the phosphorus molecule is not bound to a particle of any kind; in this respect, it is readily available to algae. Therefore, these studies show us that it is a developed shoreland that is continuously maintained in an unnatural manner (receiving phosphorus rich fertilizer) that impacts lakes the greatest. This understanding led former Governor Jim Doyle into passing the Wisconsin Zero-Phosphorus Fertilizer Law (Wis Statue 94.643), which restricts the use, sale, and display of lawn and turf fertilizer which contains phosphorus. Certain exceptions apply, but after April 1 2010, use of this type of fertilizer is prohibited on lawns and turf in Wisconsin. The goal of this action is to reduce the impact of developed lawns, and is particularly helpful to developed lawns situated near Wisconsin waterbodies.

Shorelands provide much in terms of nutrient retention and mitigation, but also play an important role in wildlife habitat. Woodford and Meyer (2003) found that green frog density was negatively correlated with development density in Wisconsin lakes. As development increased, the habitat for green frogs decreased and thus populations became significantly lower. Common loons, a bird species notorious for its haunting call that echoes across Wisconsin lakes, are often associated more so with undeveloped lakes than developed lakes (Lindsay, Gillum and Meyer 2002). And studies on shoreland development and fish nests show that undeveloped shorelands are preferred as well. In a study conducted on three Minnesota lakes, researchers found that only 74 of 852 black crappie nests were found near shorelines that had any type of dwelling on it (Reed 2001). The remaining nests were all located along undeveloped shoreland.

Photograph 3.3-1. Example of coarse woody habitat in a lake.

Emerging research in Wisconsin has shown that coarse woody habitat (sometimes called "coarse woody debris"), often stemming from natural or undeveloped shorelands, provides many ecosystem benefits in a lake. Coarse woody habitat describes habitat consisting of trees, limbs, branches, roots and wood fragments at least four inches in diameter that enter a lake by natural or human means. Coarse woody habitat provides shoreland erosion control, a carbon source for the lake, prevents suspension of sediments and provides a surface for algal growth which important for aquatic macroinvertebrates (Sass 2009). While it impacts these aspects considerably, one of the greatest benefits coarse woody habitat provides is habitat for fish species.

Coarse woody habitat has shown to be advantageous for fisheries in terms of providing refuge, foraging area, as well as spawning habitat (Hanchin, Willis and St. Stauver 2003). In one study, researchers observed 16 different species occupying coarse woody habitat areas in a Wisconsin lake (Newbrey et al. 2005). Bluegill and bass species in particular are attracted to this habitat type; largemouth bass stalk bluegill in these areas while the bluegill hide amongst the debris and often feed upon many macroinvertebrates found in these areas, who themselves are feeding upon algae and periphyton growing on the wood surface. Newbrey et al. (2005) found that some fish species prefer different complexity of branching on coarse woody habitat, though in general some degree of branching is preferred over coarse woody habitat that has no branching.

With development of a lake's shoreland zone, much of the coarse woody habitat that was once found in Wisconsin lakes has disappeared. Prior to human establishment and development on lakes (mid to late 1800's), the amount of coarse woody habitat in lakes was likely greater than under completely natural conditions due to logging practices. However, with changes in the logging industry and increasing development along lake shorelands, coarse woody habitat has decreased substantially. Shoreland residents are removing woody debris to improve aesthetics or for recreational opportunities such as boating, swimming, and ironically, fishing.

National Lakes Assessment

Unfortunately, along with Wisconsin's lakes, waterbodies within the entire United States have shown to have increasing amounts of developed shorelands. The National Lakes Assessment (NLA) is an Environmental Protection Agency sponsored assessment that has successfully pooled together resource managers from all 50 U.S. states in an effort to assess waterbodies, both natural and man-made, from each state. Through this collaborative effort, over 1,000 lakes were sampled in 2007, pooling together the first statistical analysis of the nation's lakes and reservoirs.

Through the National Lakes Assessment, a number of potential stressors were examined, including nutrient impairment, algal toxins, fish tissue contaminants, physical habitat, and others. The 2007 NLA report states that "*of the stressors examined, poor lakeshore habitat is the biggest problem in the nations lakes; over one-third exhibit poor shoreline habitat condition*" (USEPA 2009). Furthermore, the report states that "*poor biological health is three times more likely in lakes with* *poor lakeshore habitat.*" These results indicate that stronger management of shoreline development is absolutely necessary to preserve, protect, and restore lakes. Shoreland protection will become increasingly important as development pressure on lakes continues to grow.

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 shoreland. 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 shoreland 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).

Photograph 3.3-2. Example of a biolog restoration site.

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.

Wisconsin's Healthy Lakes & Rivers Action Plan

Starting in 2014, a program was enacted by the WDNR and UW-Extension to promote riparian landowners to implement relatively straight-forward shoreland restoration activities. This program provides education, guidance, and grant funding to promote installation of best management practices aimed to protect and restore lakes and rivers in Wisconsin. The program has identified five best practices aimed at improving habitat and water quality (Figure 3.3-1).

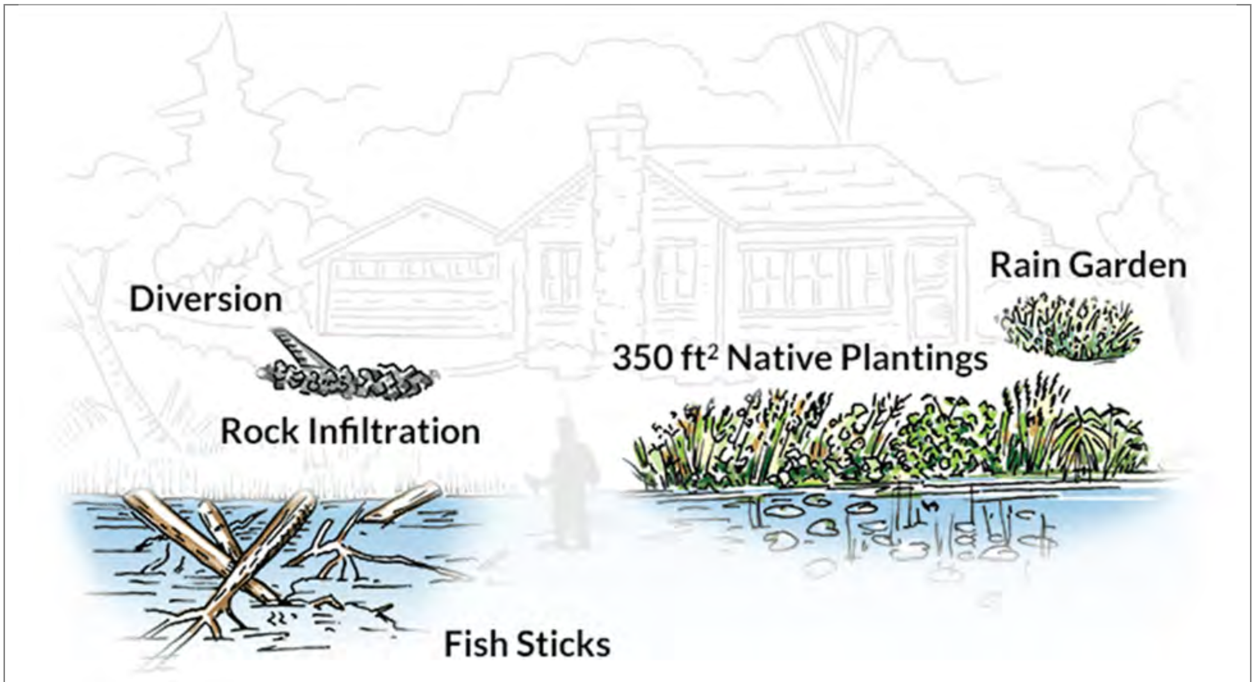


Figure 3.3-1. Healthy Lakes & Rivers 5 Best Practices. Illustration by Karen Engelbretson, extracted from healthylakeswi.com.

- Rain Gardens: This upland best practice consists of a landscaped and vegetated shallow depression aimed at capturing water runoff and allowing it to infiltrate into the soil.
- Rock Infiltration: This upland best practice is an excavated pit or trench, filled with rock, that encourages water to infiltrate into the soil. These practices are strategically placed at along a roof line or the downward sloping area of a driveway.
- Diversion: This best practice can occur in the transition or upland zone. These practices use berms, trenches, and/or treated lumber to redirect water that would otherwise move downhill into a lake. Water diversions may direct water into a Rock Infiltration or Rain Garden to provide the greatest reductions in runoff volumes.
- Native Plantings: This best practice aims to installing native plants within at least 350 square-foot shoreland transition area. This will slow runoff water and provide valuable habitat. One native planting per property per year is eligible.
- Fish Sticks: These in-lake best practices (not eligible for rivers) are woody habitat structures that provide feeding, breeding, and nesting areas for wildlife. Fish sticks consist of multiple whole trees grouped together and anchored to the shore. Trees are not felled from the shoreline, as existing trees are valuable in place, but brought from a short distance or dragged across the ice. In order for this practice to be eligible, an existing vegetated buffer or pledge to install one is required.

The Healthy Lakes and Rivers Grant Program allows partial cost coverage for implementing best practices. Competitive grants are available to eligible applicants such as lake associations and lake districts. The program allows a 75% state cost share up to $1,000 per practice. Multiple practices can be included per grant application, with a $25,000 maximum award per year. Eligible projects need to be on shoreland properties within 1,000 feet of a lake or 300 feet from a river. The landowner must sign a Conservation Commitment pledge to leave the practice in place and provide continued maintenance for 10 years. More information on this program can be found here:

https://healthylakeswi.com/

It is important to note that this grant program is intentionally designed for relatively simple, low-cost, and shovel-ready projects, limiting 10% of the grant award for technical assistance. Larger and more complex projects, especially those that require engineering design components may seek alternative funding sources potentially through the County. Small-Scale Lake Planning Grants can provide up to $3,000 to help build a Healthy Lakes and Rivers project. Eligible expenses in this grant program are surveys, planning, and design.

Hatch Lake Shoreland Zone Condition

Shoreland Development

Hatch Lake's shoreland zone can be classified in terms of its degree of development. In general, more developed shorelands are more stressful on a lake ecosystem, while definite benefits occur from shorelands that are left in their natural state. Figure 3.3-1 displays a diagram of shoreland categories, from "Urbanized", meaning the shoreland zone is completely disturbed by human influence, to "Natural/Undeveloped", meaning the shoreland has been left in its original state.

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 3.3-2. Shoreland assessment category descriptions.

On Hatch Lake, the development stage of the entire shoreland was surveyed during October of 2020, using a GPS unit to map the shoreland. Onterra staff only considered the area of shoreland 35 feet inland from the water's edge, and did not assess the shoreland on a property-by-property basis. During the survey, Onterra staff examined the shoreland for signs of development and assigned areas of the shoreland one of the five descriptive categories shown in Figure 3.3-2.

Hatch Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 1.7 miles of natural/undeveloped and developed-natural shoreland were observed during the survey (Figure 3.3-3). 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, 0.7 miles of urbanized and developed–unnatural shoreland were observed. If restoration of Hatch Lake's shoreland is to occur, primary focus should be placed on these areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreland lengths around the entire lake.

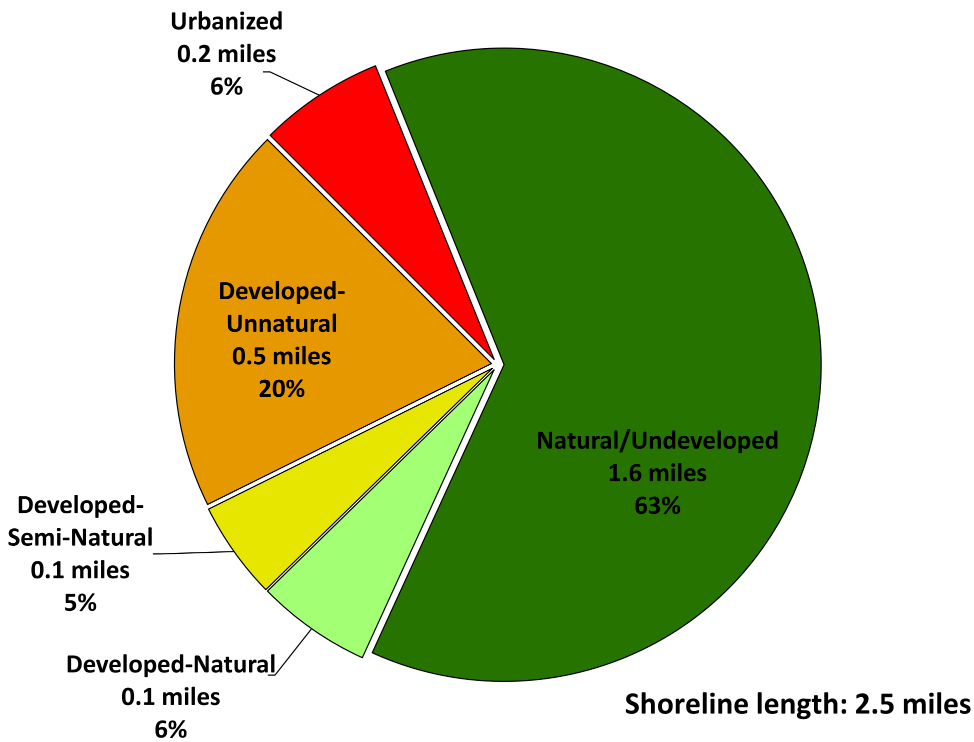


Figure 3.3-3. Hatch Lake shoreland categories and total lengths. Based upon an October 2020 survey.

While producing a completely natural shoreland is ideal for a lake ecosystem, it is not always practical from a human's perspective. However, riparian property owners can take small steps in ensuring their property's impact upon the lake is minimal. Choosing an appropriate landscape position for lawns is one option to consider. Placing lawns on flat, un-sloped areas or in areas that do not terminate at the lake's edge is one way to reduce the amount of runoff a lake receives from a developed site. Allowing tree falls and other natural habitat features to remain along a shoreline may result not only in reducing shoreline erosion, but creating wildlife habitat also.

Coarse Woody Habitat

As part of the shoreland condition assessment, Hatch Lake was also surveyed to determine the extent of its coarse woody habitat. Coarse woody habitat was identified, and classified in three size categories (2-8 inches in diameter, 8+ inches in diameter, or clusters of pieces) as well as four branching categories: no branches, minimal branches, moderate branches, and full canopy. As discussed earlier, research indicates that fish species prefer some branching as opposed to no branching on coarse woody habitat, and increasing complexity is positively correlated with higher fish species richness, diversity and abundance (Newbrey et al. 2005).

During this survey, 86 total pieces of coarse woody habitat were observed along 2.5 miles of shoreline (Map 4), which gives Hatch Lake a coarse woody habitat to shoreline mile ratio of 34:1 (Figure 3.3-4). Only instances where emergent coarse woody habitat extended from shore into the water were recorded during the survey. Of these 86 pieces of coarse woody habitat, 69 were 2-8 inches in diameter, 17 pieces were 8+ inches in diameter, and no instances of clusters were found.

To put this into perspective, Wisconsin researchers have found that in completely undeveloped lakes, an average of 345 coarse woody habitat structures may be found per mile (Christensen et al. 1996). Please note the methodologies between the surveys done on Hatch Lake and those cited in this literature comparison are much different, but still provide a valuable insight into what undisturbed shorelines may have in terms of coarse woody habitat.

Onterra has completed coarse woody habitat surveys on 128 lakes throughout Wisconsin since 2012, with the majority occurring in the Northern Lakes and Forests ecoregion, on lakes with public access. The number of coarse woody habitat pieces per shoreline mile in Hatch Lake falls in the 67th percentile of these 128 lakes (Figure 3.3-4).

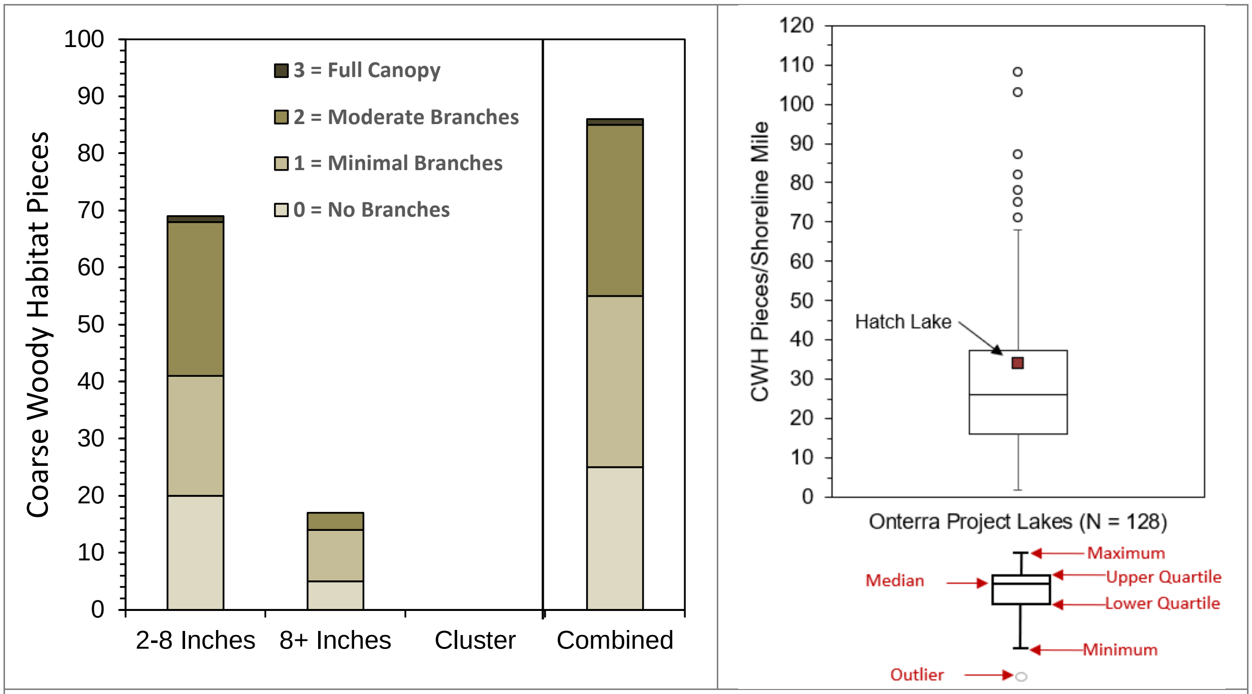


Figure 3.3-4. Hatch Lake coarse woody habitat survey results. Based upon an October 2020 survey. Locations of the Hatch Lake coarse woody habitat can be found on Map 4.

3.4 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.

Photograph 3.4-1. Example of emergent and floating-leaf communities.

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 shoreland 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 watermilfoil (*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 species will be discussed further in depth in the Aquatic Invasive Species section. 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

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.

Important Note:
Even though most of these techniques are not applicable to Hatch Lake, it is still important for lake users to have a basic understanding of all the techniques so they can better understand why particular methods are or are not applicable in their lake**.** The techniques applicable to Hatch Lake are discussed in Summary and Conclusions section and the Implementation Plan found near the end of this document.

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.

Manual Removal

Photograph 3.4-2. Example of aquatic plants that have been removed manually.

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. Please note that depending on the size of the screen a Wisconsin Department of Natural Resources permit may be required.

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 watermilfoil 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 and reed canary grass. • Permitting process may require an environmental assessment that may take months to prepare. • Non-selective.

Mechanical Harvesting


Photograph 3.4-3. Mechanical harvester.

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

Cost

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

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

Herbicide Treatment

Photograph 3.4-4. Liquid herbicide application. Photo credit: Amy Kay, Clarke.

The use of herbicides to control aquatic plants and algae is a technique that is widely used by lake managers. Traditionally, herbicides were used to control nuisance levels of aquatic plants and algae that interfere with navigation and recreation. While this practice still takes place in many parts of Wisconsin, the use of herbicides to control aquatic invasive species is becoming more prevalent. Resource managers employ strategic management techniques towards aquatic invasive species, with the objective of reducing the target plant's population over time; and an overarching goal of attaining long-term ecological restoration. For submergent vegetation, this largely consists of implementing control strategies early in the growing season; either as spatially-targeted, small-scale spot treatments or low-dose, large-scale (whole lake) treatments. Treatments occurring roughly each year before June 1 and/or when water temperatures are below 60°F can be less impactful to many native plants, which have not emerged yet at this time of year. Emergent species are targeted with foliar applications at strategic times of the year when the target plant is more likely to absorb the herbicide.

While there are approximately 300 herbicides registered for terrestrial use in the United States, only 13 active ingredients can be applied into or near aquatic systems. All aquatic herbicides must be applied in accordance with the product's US Environmental Protection Agency (EPA) approved label. There are numerous formulations and brands of aquatic herbicides and an extensive list can be found in Appendix F of Gettys et al. (2009).

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

Aquatic herbicides can be classified in many ways. Organization of this section follows Netherland (2009) in which mode of action (i.e. how the herbicide works) and application techniques (i.e. foliar or submersed treatment) group the aquatic herbicides. The table below provides a general list of commonly used aquatic herbicides in Wisconsin and is synthesized from Netherland (2009).

The arguably clearest division amongst aquatic herbicides is their general mode of action and fall into two basic categories:

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 in some plants does not result in a sustained effect because the root crowns, roots, or rhizomes are not killed.
2. Systemic herbicides act slower than contact herbicides, being transported throughout the entire plant and disrupting biochemical pathways which often result in complete mortality.

Table 3.4-1. Common herbicides used for aquatic plant management.

General Mode of Action		Compound	Specific Mode of Action	Most Common Target Species in Wisconsin
Contact		Copper	plant cell toxicant	Algae, including macro-algae (i.e. muskgrasses & stoneworts)
		Endothall	Inhibits respiration & protein synthesis	Submersed species, largely for curly-leaf pondweed; invasive watermilfoil control when mixed with auxin herbicides
		Diquat	Inhibits photosynthesis & destroys cell membranes	Nusiance species including duckweeds, targeted AIS control when exposure times are low
		Flumioxazin	Inhibits photosynthesis & destroys cell membranes	Nusiance species, targeted AIS control when exposure times are low
Systemic	Auxin Mimics	2,4-D	auxin mimic, plant growth regulator	Submersed species, largely for invasive watermilfoil
		Triclopyr	auxin mimic, plant growth regulator	Submersed species, largely for invasive watermilfoil
		Florpyrauxifen -benzyl	arylpicolinate auxin mimic, growth regulator, different binding afinity than 2,4-D or triclopyr	Submersed species, largely for invasive watermilfoil
	In Water Use Only	Fluridone	Inhibits plant specific enzyme, new growth bleached	Submersed species, largely for invasive watermilfoil
	Enzyme Specific (ALS)	Penoxsulam	Inhibits plant-specific enzyme (ALS), new growth stunted	Emergent species with potential for submergent and floating-leaf species
		Imazamox	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, potential for submergent and floating-leaf species
	Enzyme Specific (foliar use only)	Glyphosate	Inhibits plant-specific enzyme (ALS)	Emergent species, including purple loosestrife
		Imazapyr	Inhibits plant-specific enzyme (EPSP)	Hardy emergent species, including common reed

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.

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 and 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. Much information has been gathered in recent years, largely as a result of an ongoing cooperative research project between the Wisconsin Department of Natural Resources, US Army Corps of Engineers Research and Development Center, and private consultants (including Onterra). This research couples quantitative aquatic plant monitoring with field-collected herbicide concentration data to evaluate efficacy and selectivity of control strategies implemented on a subset of Wisconsin lakes and flowages. Based on their preliminary findings, lake managers have adopted two main treatment strategies: 1) whole-lake treatments, and 2) spot treatments.

Spot treatments are a type of control strategy where the herbicide is applied to a specific area (treatment site) such that when it dilutes from that area, its concentrations are insufficient to cause significant affects outside of that area. Spot treatments typically rely on a short exposure time (often hours) to cause mortality and therefore are applied at a much higher herbicide concentration than whole-lake treatments. This has been the strategy historically used on most Wisconsin systems.

Whole-lake treatments are those where the herbicide is applied to specific sites, but when the herbicide reaches equilibrium within the entire volume of water (entire lake, lake basin, or within the epilimnion of the lake or lake basin); it is at a concentration that is sufficient to cause mortality to the target plant within that entire lake or basin. The application rate of a whole-lake treatment is dictated by the volume of water in which the herbicide will reach equilibrium. Because exposure time is so much longer, target herbicide levels for whole-lake treatments are significantly less than for spot treatments.

Cost

Herbicide application charges vary greatly between $400 and $1,500 per acre depending on the chemical used, who applies it, permitting procedures, and the size/depth of the treatment area.

Advantages	***Disadvantages***
• Herbicides are easily applied in restricted areas, like around docks and boatlifts. • Herbicides can target large areas all at once. • If certain chemicals are applied at the correct dosages and at the right time of year, they can selectively control certain	• All herbicide use carries some degree of human health and ecological risk due to toxicity. • Fast-acting herbicides may cause fish kills due to rapid plant decomposition if not applied correctly. • Many people adamantly object to the use of herbicides in the aquatic environment;

invasive species, such as Eurasian watermilfoil. • Some herbicides can be used effectively in spot treatments. • Most herbicides are designed to target plant physiology and in general, have low toxicological effects on non-plant organisms (e.g. mammals, insects)	therefore, all stakeholders should be included in the decision to use them. • Many aquatic herbicides are nonselective. • Some herbicides have a combination of use restrictions that must be followed after their application. • Overuse of same herbicide may lead to plant resistance to that herbicide.

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.

However, Wisconsin, along with many other states, is currently experiencing the expansion of lakes infested with Eurasian watermilfoil 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 watermilfoil 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 watermilfoil. Currently the milfoil weevil is not a WDNR grant-eligible method of controlling Eurasian watermilfoil.

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 watermilfoil 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 emergent 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 Hatch Lake; 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 aquatic plant species, both native and non-native, that were located during the surveys completed in Hatch Lake in 2016. The list also contains the growth-form of each plant found (e.g. submergent, emergent, etc.), its scientific name, common 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 growth forms that are present, can be an early indicator of changes in the ecosystem.

Frequency of Occurrence

Frequency of occurrence describes how often a certain aquatic plant species is found within a lake. Obviously, all of the plants cannot be counted in a lake, so samples are collected from pre-determined areas. In the case of the whole-lake point-intercept survey completed on Hatch Lake, plant samples were collected from plots laid out on a grid that covered the lake. Using the data collected from these plots, an estimate of occurrence of each plant species can be determined. The occurrence of aquatic plant species is displayed as the *littoral frequency of occurrence*. Littoral frequency of occurrence is used to describe how often each species occurred in the plots that are within the maximum depth of plant growth (littoral zone), and is displayed as a percentage.

Floristic Quality Assessment

The floristic quality of a lake's aquatic plant community is calculated using its native *species richness* and their *average conservatism*. Species richness is the number of native aquatic plant species that were physically encountered on the rake during the point-intercept survey. Average conservatism is calculated by taking the sum of the coefficients of conservatism (C-values) of the native species located and dividing it by species richness. Every plant in Wisconsin has been assigned a coefficient of conservatism, ranging from 1-10, which describes the likelihood of that species being found in an undisturbed environment. Species which are more specialized and require undisturbed habitat are given higher coefficients, while species which are more tolerant of environmental disturbance have lower coefficients.

For example, algal-leaf pondweed (*Potamogeton confervoides*) is only found in nutrient-poor, acid lakes in northern Wisconsin and is prone to decline if degradation of these lakes occurs. Because of algal-leaf pondweed's special requirements and sensitivity to disturbance, it has a C-value of 10. In contrast, sago pondweed (*Stuckenia pectinata*) with a C-value of 3, is tolerant of disturbance and is often found in greater abundance in degraded lakes that have higher nutrient concentrations and low water clarity. Higher average conservatism values generally indicate a healthier lake as it is able to support a greater number of environmentally-sensitive aquatic plant species. Low average conservatism values indicate a degraded environment, one that is only able to support disturbance-tolerant species.

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 surveys (equation shown below). This assessment allows the aquatic plant community of Hatch Lake to be compared to other lakes within the region and state.

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

Species Diversity

Species diversity is often confused with species richness. As defined previously, species richness is simply the number of species found within a given community. While species diversity utilizes species richness, it also takes into account evenness or the variation in abundance of the individual species within the community. For example, a lake with 10 aquatic plant species that had relatively similar abundances within the community would be more diverse than another lake with 10 aquatic plant species were 50% of the community was comprised of just one or two species.

An aquatic system with high species diversity is more stable than a system with a low diversity. This is analogous to a diverse financial portfolio in that a diverse aquatic plant community can withstand environmental fluctuations much like a diverse portfolio can handle economic fluctuations. A lake with a diverse plant community is also better suited to compete against exotic infestations than a lake with a lower diversity. The diversity of a lake's aquatic plant community is determined using the Simpson's Diversity Index (1-D):

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

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.

The Simpson's Diversity Index value from Hatch Lake is compared to data collected by Onterra and the WDNR Science Services on 85 lakes within the North Central Hardwood Forests ecoregion and on 392 lakes throughout Wisconsin.

Community Mapping

A key component of any aquatic plant community assessment is the delineation of the emergent and floating-leaf aquatic plant communities within each lake as these plants are often underrepresented during the point-intercept survey. This survey creates a snapshot of these important communities within each lake as they existed during the survey and is valuable in the development of the management plan and in comparisons with future surveys. Examples of emergent plants include cattails, rushes, sedges, grasses, bur-reeds, and arrowheads, while examples of floating-leaf species include the water lilies. The emergent and floating-leaf aquatic plant communities in Hatch Lake were mapped using a Trimble Global Positioning System (GPS) with sub-meter accuracy.

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 watermilfoil are the primary targets of this extra attention.

Eurasian watermilfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.4-1). Eurasian watermilfoil 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 watermilfoil 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 watermilfoil 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.

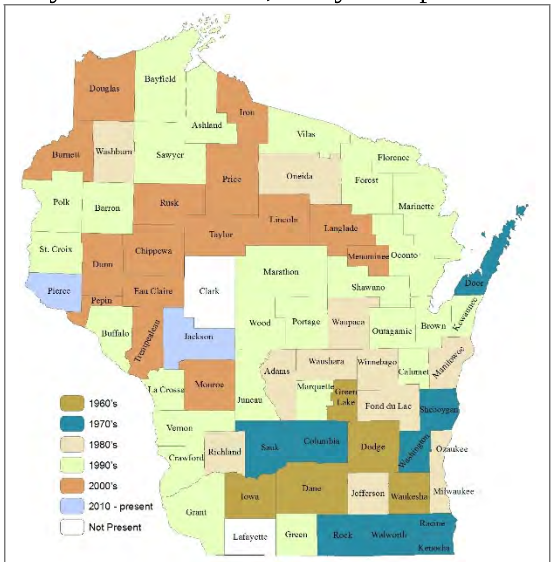


Figure 3.4-1. Spread of Eurasian watermilfoil within WI counties. WDNR Data 2015 mapped by Onterra.

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 watermilfoil, 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 watermilfoil 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.

During an aquatic invasive species (AIS) mapping survey, the entire littoral area of the lake is surveyed through visual observations from the boat. If an AIS population is found, it is mapped using sub-meter GPS technology by using either 1) point-based or 2) area-based methodologies. Large colonies >40 feet in diameter are mapped using polygons (areas) and are qualitatively attributed a density rating based upon a five-tiered scale from *highly scattered* to *surface matting*. Point-based techniques are applied to AIS locations considered as *small plant colonies* (<40 feet in diameter), *clumps of plants*, or *single or few plants*.

Hatch Lake Aquatic Plant Survey Results

As mentioned above, numerous plant surveys were completed as a part of this project, including an early-season AIS survey timed primarily to locate curly-leaf pondweed (CLP) while it is at its peak growth. As discussed later in this section, CLP was documented in Hatch Lake for the first time during the survey that was completed on June 8, 2021.

Photograph 3.4-5. The non-native, invasive curly-leaf pondweed located in Hatch Lake. Photo credit Onterra.

During the early-season AIS survey, Eurasian watermilfoil was also mapped to help guide the mapping done in late-summer. In addition to CLP and EWM, two non-native wetland plants, pale-yellow iris and purple loosestrife, were also observed during the 2020 surveys on Hatch Lake. Because of their ecological and sociological significance, more information about these plants, including EWM, and their occurrence in Hatch Lake can be found in a subsection, Non-native Aquatic Plants in Hatch Lake.

The whole-lake aquatic plant point-intercept survey (Figure 3.4-2; Map 1) and the floating-leaf and emergent community mapping survey were both completed on Hatch Lake by Onterra on August 6, 2020. During these surveys, a total of 38 plant species were located, four of which are non-native (Table 3.4-2). Table 3.4-2 also includes the plant species that were recorded during the 2006 point-intercept survey that was completed by the WDNR. There are a total of 51 species on this list.

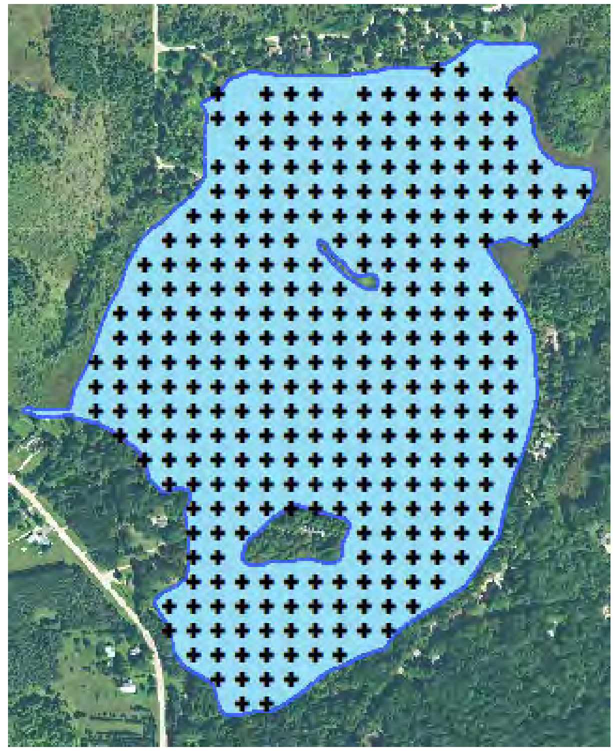


Figure 3.4-2. Hatch Lake whole-lake point-intercept survey sampling locations. N = 334

Lakes in Wisconsin vary in their morphometry, water chemistry, water clarity, substrate composition, management, and recreational use, all factors which influence aquatic plant community composition. Like terrestrial plants, different aquatic plant species are adapted to grow in certain substrate types; some species are only found growing in soft substrates, others only in sandy/rocky areas, and some can be found growing in either. The combination of both soft sediments and areas of harder substrates creates different habitat types for aquatic plants, and generally leads to a higher number of aquatic plant species within the lake.

With a maximum depth of about 14 feet in Hatch Lake, the whole lake is comprised of littoral zone, meaning the entire area of the lake receives sufficient light to support aquatic plant growth. During the 2020 point-intercept survey, plants were found growing out to 13 feet. The sediment within Hatch Lake is very conducive for supporting lush aquatic plant growth. Data from the point-intercept survey indicate that approximately 93% of the sampling locations contained fine organic sediment (muck), just under 7% contained sand, and only one sampling point contained rock (Figure 3.4-3).

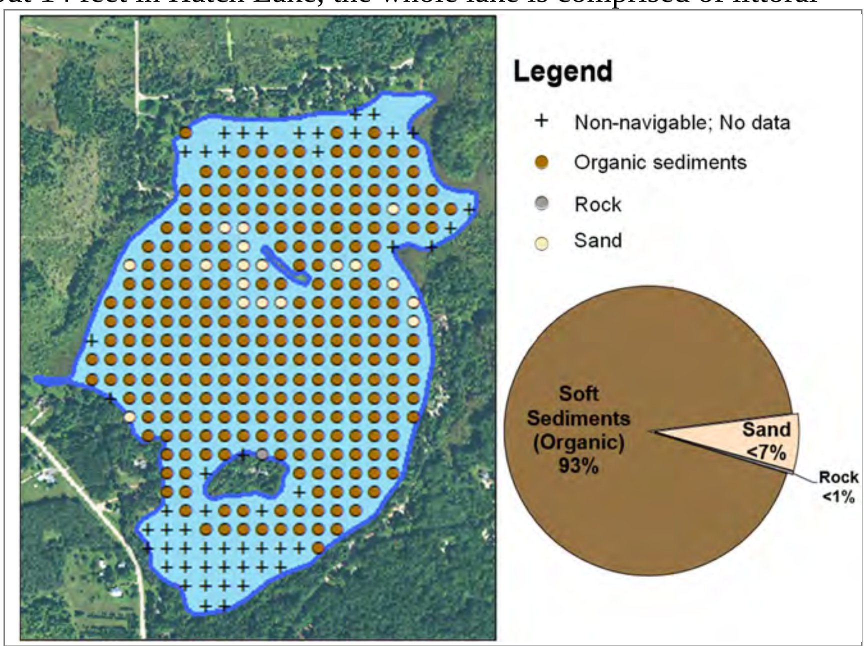


Figure 3.4-3. Hatch Lake proportion of substrate types. Created using data from August 2020 aquatic plant point-intercept survey.

Table 3.4-2. Aquatic plant species located on Hatch Lake during the 2006 and 2020 surveys.

Growth Form	Scientific Name	Common Name	Status in Wisconsin	Coefficient of Conservatism	2006 (WDNR)	2020 (Onterra)
Emergent	*Asclepias incarnata*	Swamp milkweed	Native	5	I	
	Carex aquatilis	Long-bracted tussock sedge	Native	7	I	
	Carex comosa	Bristly sedge	Native	5		I
	Carex sp.	Sedge sp.	Native	N/A	I	
	Carex stricta	Common tussock sedge	Native	7	I	
	Carex vesicaria	Blister sedge	Native	7	I	
	Cladium mariscoides	Smooth sawgrass	Native	10	I	I
	Eleocharis palustris	Creeping spikerush	Native	6	X	I
	Eleocharis robbinsii	Robbins' spikerush	Native - Special Concern	10		I
	Iris pseudacorus	Pale-yellow iris	Non-Native - Invasive	N/A		I
	Iris versicolor	Northern blue flag	Native	5	I	I
	Juncus effusus	Soft rush	Native	4	I	
	Lythrum salicaria	Purple loosestrife	Non-Native - Invasive	N/A		I
	Phalaris arundinacea	Reed canary grass	Non-Native - Invasive	N/A	I	
	Phragmites australis subsp. americanus	Common reed	Native	5		I
	Sagittaria latifolia	Common arrowhead	Native	3		I
	Schoenoplectus acutus	Hardstem bulrush	Native	5		I
	Schoenoplectus pungens	Three-square rush	Native	5	I	I
	Schoenoplectus tabernaemontani	Softstem bulrush	Native	4	X	I
	Scutellaria galericulata	Common skullcap	Native	5	I	
	Triadenum fraseri	Bog St. Johnswort	Native	8		I
	Typha latifolia	Broad-leaved cattail	Native	1		I
	Typha spp.	Cattail spp.	N/A	N/A	I	
FL	*Brasenia schreberi*	Watershield	Native	7	X	X
	Nuphar variegata	Spatterdock	Native	6	X	X
	Nymphaea odorata	White water lily	Native	6	X	X
Submergent	*Ceratophyllum demersum*	Coontail	Native	3	X	X
	Chara spp.	Muskgrasses	Native	7	X	X
	Elodea canadensis	Common waterweed	Native	3	X	X
	Myriophyllum sibiricum	Northern watermilfoil	Native	7	X	X
	Myriophyllum spicatum	Eurasian watermilfoil	Non-Native - Invasive	N/A	X	X
	Najas flexilis	Slender naiad	Native	6	X	X
	Najas guadalupensis	Southern naiad	Native	7		X
	Potamogeton crispus	Curly-leaf pondweed	Non-Native - Invasive	N/A		I
	Potamogeton gramineus	Variable-leaf pondweed	Native	7	X	X
	Potamogeton illinoensis	Illinois pondweed	Native	6	X	I
	Potamogeton natans	Floating-leaf pondweed	Native	5	X	X
	Potamogeton praelongus	White-stem pondweed	Native	8	X	X
	Potamogeton zosteriformis	Flat-stem pondweed	Native	6	X	X
	Sagittaria sp. (rosette)	Arrowhead sp. (rosette)	Native	N/A	I	
	Stuckenia pectinata	Sago pondweed	Native	3	X	X
	Utricularia gibba	Creeping bladderwort	Native	9	X	X
	Utricularia intermedia	Flat-leaf bladderwort	Native	9		X
	Utricularia minor	Small bladderwort	Native	10		I
	Utricularia vulgaris	Common bladderwort	Native	7	X	X
	Vallisneria americana	Wild celery	Native	6	X	X
SE	*Eleocharis acicularis*	Needle spikerush	Native	5	I	I
	Eleocharis quinqueflora	Few-flowered spikerush	Native - Special Concern	8	I	
	Schoenoplectus subterminalis	Water bulrush	Native	9	X	X
FF	*Lemna minor*	Lesser duckweed	Native	5	X	
	Lemna trisulca	Forked duckweed	Native	6	I	

FL = Floating-leaf; SE = Submergent/Emergent; FF = Free-floating
X = Located on rake during point-intercept survey; I = Incidentally located; not located on rake during point-intercept survey

Approximately 80% of the point-intercept sampling locations that were able to be sampled contained aquatic vegetation. Of the 334 sampling points on Hatch Lake, 51 were non-navigable (unable to be sampled), and 16 of these were non-navigable due to valuable emergent and floating-leaf plant communities. Aquatic plant total rake fullness (TRF) is a measure of plant abundance and is illustrated in Figure 3.4.4, along with the locations in Hatch Lake where these ratings were recorded during the point-intercept survey. Approximately 39% of the sampling locations had the lowest TRF rating of 1, 23% had a TRF of 2, and 18% had the highest TRF rating of 3. Figure 3.4-4 shows higher aquatic plant biomass in the more central, deeper portions of the lake, with lower biomass in shallower areas around the lake. In 2006, overall TRF ratings by sampling site were not recorded. However, 90% of the sites that were sampled in 2006 contained aquatic vegetation, which equates to a 10% decrease from 2006 to 2020. Possible factors for this decrease in vegetation are discussed later in this section.

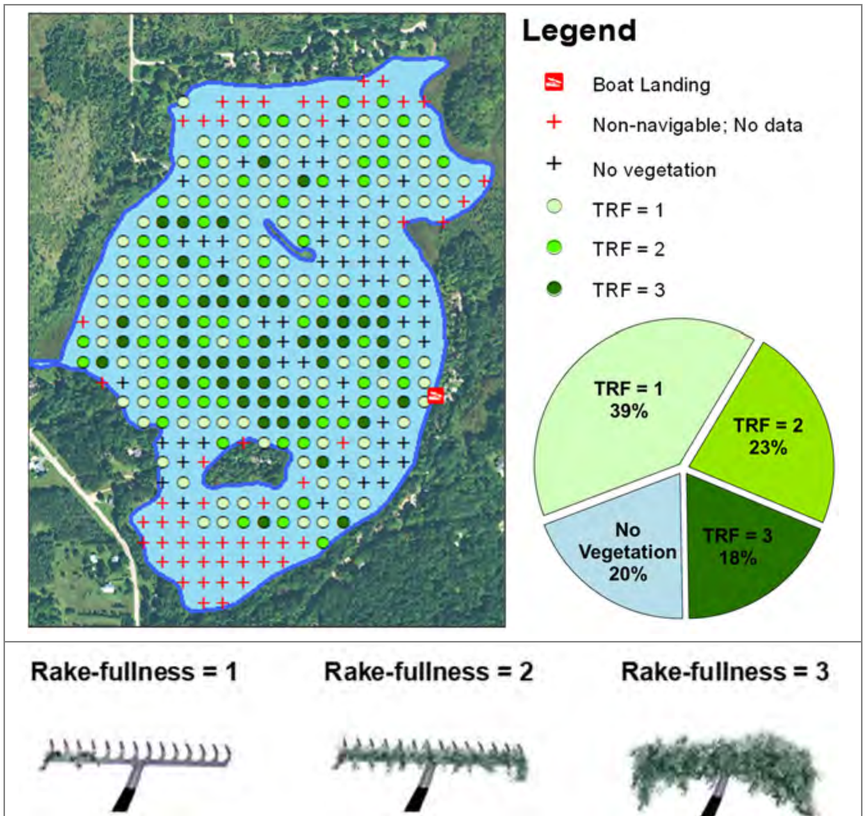


Figure 3.4-4. Hatch Lake aquatic vegetation total rake fullness (TRF) ratings. Created using data from August 2020 aquatic plant point-intercept survey.

The data collected from the whole-lake point-intercept survey was also used to quantify the abundance of individual plant species within the lake. Of the 38 aquatic plant species located in Hatch Lake in 2020, 20 of them were encountered directly on the sampling rake (Figure 3.4-5). The remaining 18 species were located incidentally, meaning they were observed by Onterra ecologists while on the lake but were not directly sampled on the rake at any of the point-intercept sampling locations. Incidental species typically include emergent and floating-leaf species that are often found growing on the fringes of the lake and submersed species that are rare within the plant community. Of the 20 species directly sampled with the rake, muskgrasses, naiads, white water lily, and variable-leaf pondweed were the most frequently encountered (Figure 3.4-5).

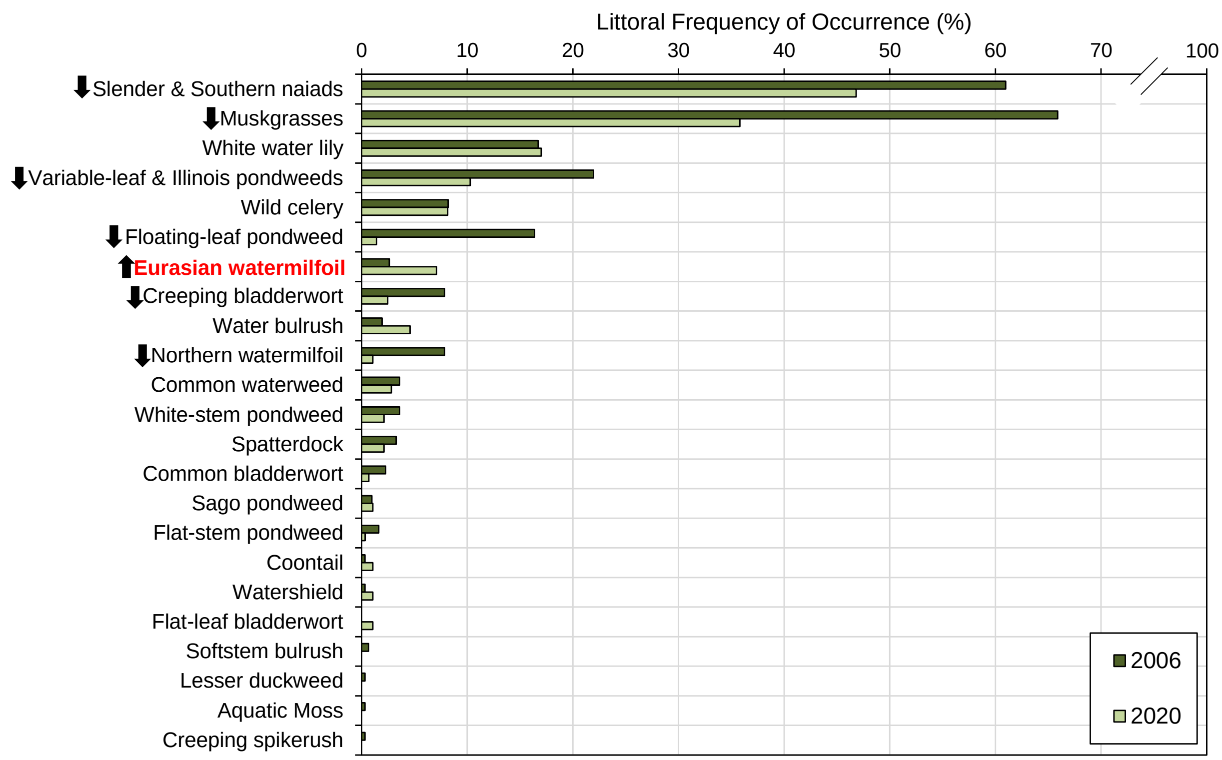
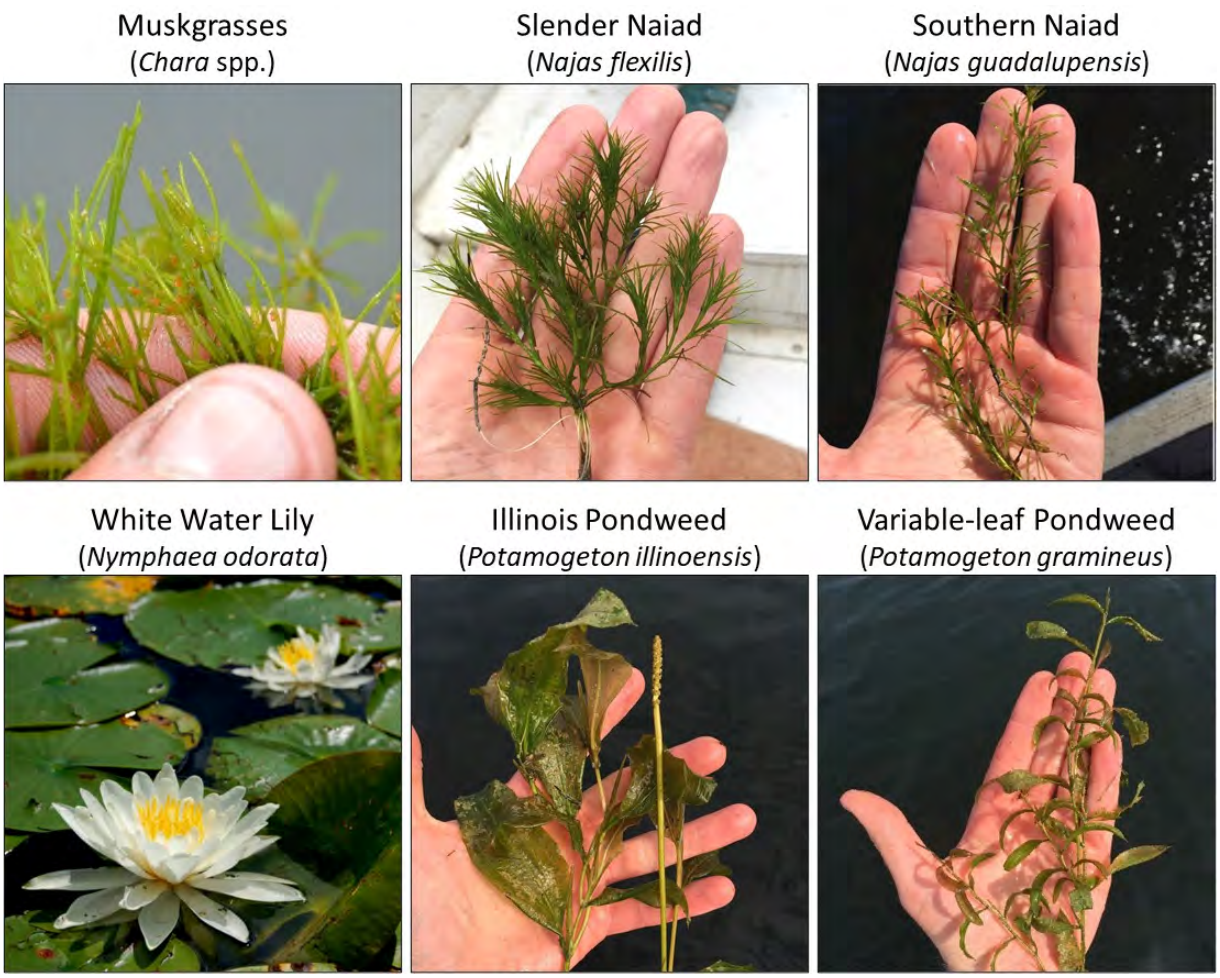


Figure 3.4-5. Littoral frequency of occurrence for Hatch Lake plant species sampled on the rake. Created using data from 2006 and 2020 aquatic plant point-intercept surveys. An arrow next to the common name indicates a statistically significant change (increase or decrease) in occurrence from the 2006 survey to 2020.

Muskgrasses (*Chara* spp.) are a genus of macroalgae, of which there are ten documented species that occur in Wisconsin (Photo 3.4-6). In 2020, muskgrasses had a littoral frequency of approximately 36% in Hatch Lake. This represents a statistically valid decrease in occurrence of 30% from the previous survey in 2006 which found a littoral frequency of just under 66%. Dominance of the aquatic plant community by muskgrasses is common in hardwater lakes and these macroalgae have been found to be more competitive against vascular plants (e.g., pondweeds, milfoils, etc.) in lakes with higher concentrations of calcium carbonate in the sediment (Kufel and Kufel 2002; Wetzel 2001). Muskgrasses require lakes with good water clarity, and their large beds stabilize bottom sediments. Studies have also shown that muskgrasses sequester phosphorus in the calcium carbonate encrustations which form on these plants, aiding in improving water quality by making the phosphorus unavailable to phytoplankton (Coops 2002). Muskgrasses can be easily identified by their strong skunk-like odor. As well as providing a food source for waterfowl, muskgrasses often serves as a sanctuary for small fish and other aquatic organisms.

Slender naiad (*Najas flexilis*) and Southern naiad (*Najas guadalupensis*) were both identified in Hatch Lake during the 2020 point-intercept survey (Photo 3.4-6). These two species are morphologically very similar and can at times be difficult to differentiate in the field. For this reason, their occurrences were combined for analysis. These were the second and third most frequently encountered species in 2020 with a combined littoral frequency of occurrence of just under 47%. Slender naiad is an annual which produces numerous seeds on an annual basis and is considered to be one of the most important food sources for a number of migratory waterfowl species (Borman 2007). In addition, slender naiad's small, condensed network of leaves provide excellent habitat for aquatic invertebrates.

Southern naiad, although native to North America, has been observed exhibiting aggressive growth in some northern Wisconsin lakes in recent years. Southern naiad can dislodge and form surface mats that interfere with navigation, recreation, and aesthetics. Often the plants are not growing in place, but rather have uprooted and aggregated on taller vegetation. This level of growth of southern naiad was not observed in Hatch Lake during the 2020 surveys. The occurrence of slender and southern naiad was found to have decreased by 23% in 2020 when compared to 2006 (Figure 3.4-5).



Photograph 3.4-6. Most prevalent aquatic plant species encountered in Hatch Lake during the 2020 point-intercept survey. Photo credit Onterra.

White water lily (*Nymphaea odorata*) (Photo 3.4-6) was the fourth most frequent aquatic plant in Hatch Lake in 2020, with a littoral frequency of occurrence of 17.0%. Hatch Lake's shallow, quiet water in combination with soft, organic substrates creates large areas of suitable habitat for this species, making it one of the most abundant plants within the lake. White water lily was most prevalent in one to three feet of water in 2020, and the community mapping survey indicated the lake contains over 52 acres of white water lily. White water lily is easy to spot with its round, notched lily pads and bright white and fragrant flowers. Its leaves and rhizomes are eaten by some wildlife, but while floating, provide habitat for aquatic organisms. It also provides a place for some insects and amphibians to lay eggs, and its flowers benefit pollinators. Similar to the 2020 survey, 2006 yielded a littoral frequency of occurrence of 16.7% for white water lily. Approximate acreage cannot be compared between the two years since 2020 was the first time a community mapping survey had been completed on Hatch Lake.

Variable-leaf pondweed (*Potamogeton gramineus*) (Photo 3.4-6) was the fifth most frequently encountered aquatic plant species in Hatch Lake in 2020, with an LFOO of approximately 10%. As its name suggests, the leaves and overall size of this species can vary widely in shape and size depending on growing conditions. Variable-leaf pondweed is found throughout Wisconsin and requires higher-quality environmental conditions to persist. Like other aquatic plants, variable-leaf pondweed provides structural habitat and food sources for wildlife. Illinois pondweed (*Potamogeton illinoensis*) is morphologically similar to variable-leaf pondweed and it can sometimes be difficult to differentiate between the two. Illinois pondweed was located incidentally in Hatch Lake in 2020, but not on the rake, and their occurrences have been combined for analysis in Figure 3.4-5. In 2006, their combined littoral frequency of occurrence was 22%. The combined LFOO of 10.3% in 2020 represents a statistically significant decrease in occurrence from 2006.

Of the species in Figure 3.4-5 which saw statistically significant changes in occurrence from 2006 to 2020, the six native species saw population decreases in 2020, while Eurasian watermilfoil saw a slight increase. The remainder of the species displayed in this figure saw minor changes in occurrence which were not considered statistically valid. For the species which did see statistically valid decreases in occurrence from 2006 to 2020, one contributing factor for the decreases could possibly be the higher than usual water levels. The sites which were sampled during both survey years were approximately 10” deeper in 2020 compared to 2006. Other possible factors related to changes in occurrence are discussed at the end of this section.

A species of special concern in Wisconsin, Robbins’ spikerush (*Eleocharis robbinsii*), was located in Hatch Lake during the 2020 emergent and floating-leaf aquatic plant mapping survey (Photo 3.4-7). The special concern status indicates that the species has a suspected low abundance or distribution, but not enough is known yet about its populations to be proven. The purpose of this special concern designation is to try to prevent the species from becoming threatened or endangered. Robbins’ spikerush can be found in eastern North America as far west as northeastern Minnesota where it was listed as threatened in 2013 (MNDNR 2003).

Photograph 3.4-7. Robbins’ spikerush.

Robbins’ spikerush is easiest to identify from mid-late summer when its spikelets are fully developed. Unlike other spikerush species found in Wisconsin, the fertile stems of Robbins’ spikerush are sharply three-sided (triangular) as opposed to round, like with creeping spikerush which is also found in Hatch Lake. However, when fertile stems are not present, sterile stems of Robbins’ spikerush are limp and submerged often make identification difficult from other species which produce similar submersed leaves like water bulrush. In

Hatch Lake, Robbins' spikerush was found throughout emergent and floating-leaf plant communities in the northern half of the lake (Map 5). Robbins' spikerush is vulnerable to shoreland development and wave action from watercraft, and these areas in Hatch Lake should be focus-points for conservation.

During the 2006 survey, the WDNR had located another species listed as special concern in Hatch Lake: few-flowered spikerush (*Eleocharis quinqueflora*). Like Robbins' spikerush, this species was not located during the point-intercept survey, but was located incidentally. Few-flowered spikerush was not observed during the 2020 surveys, but likely occurs at a low occurrence where it went undetected. Few-flowered spikerush superficially resembles other colony-forming spikerushes, but can be distinguished by its short, thin, wiry stems, distinct seeds, and has fewer than 10 flowers per spikelet. While this species' range includes much of the northern half and western portion of North America, its abundance appears to vary by region. Where present in the US, it has an endangered status in six states, a threatened status in two, and is also a special concern species in other states, including Minnesota.

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 example, while muskgrasses were found at 36% of the sampling locations in Hatch Lake in 2020, their relative frequency of occurrence was approximately 23%. Explained another way, if 100 plants were randomly sampled from Hatch Lake, 23 of them would be muskgrasses. Looking at relative frequency of occurrence (Figure 3.4-6), muskgrasses and the slender and southern naiads alone make up approximately 58% of the plant community in Hatch Lake.

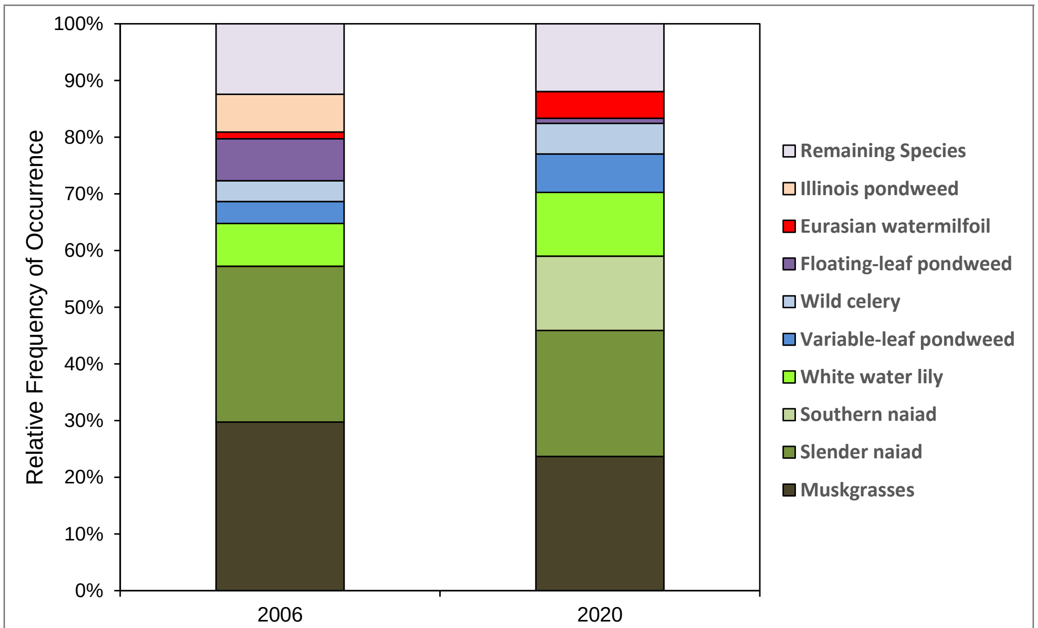


Figure 3.4-6. Relative frequency of occurrence of aquatic plant species in Hatch Lake in 2006 and 2020. Created using data from the 2006 and 2020 point-intercept surveys.

Because Hatch Lake contains a relatively high number of native aquatic plant species, one may assume the aquatic plant communities have high species diversity. However, species diversity is also influenced by how evenly the plant species are distributed within the community (relative frequency). The dominance of Hatch Lake's plant community by just a few species results in a more moderate species diversity value. The diversity of Hatch Lake's aquatic plant community was found to be near the median value for lakes in the NCHF ecoregion in 2006 and 2020 (Figure 3.4-7). Lakes with diverse aquatic plant communities have higher resilience to environmental disturbances and greater resistance to invasion by non-native plants. A plant community with a mosaic of species with differing morphological attributes provides zooplankton, macroinvertebrates, fish and other wildlife with diverse structural habitat and various sources of food.

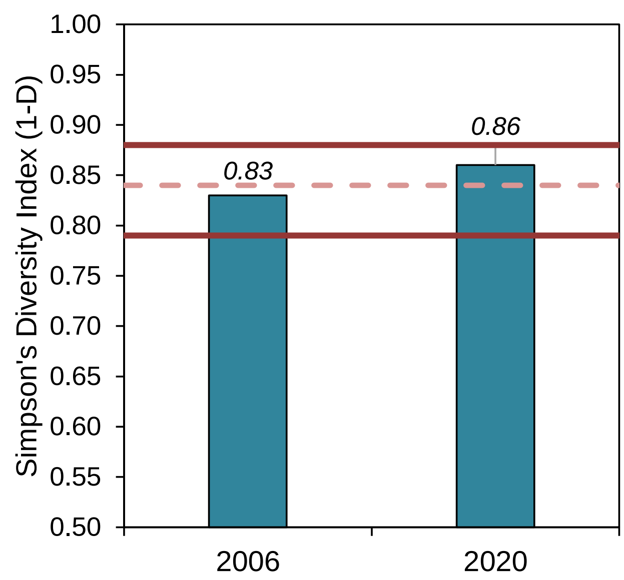


Figure 3.4-7. Hatch Lake species diversity index. Created using data from the 2006 and 2020 aquatic plant surveys. Ecoregion data provided by WDNR Science Services.

As discussed in the primer section, the calculations used to create the Floristic Quality Index (FQI) for a lake's aquatic plant community are based on the aquatic plant species that were encountered on the rake during the point-intercept survey and does not include incidental species. Figure 3.4-8 shows that the native species richness for Hatch Lake is above the North Central Hardwood Forests Ecoregion median and is equal to the Wisconsin State median.

The species that are present in Hatch Lake are indicative of slightly above average conditions. Data collected from the aquatic plant surveys show that the average conservatism value in 2020 (6.4) is above the North Central Hardwood Forests Ecoregion and Wisconsin State medians (Figure 3.4-8), indicating that Hatch Lake has a higher proportion of aquatic plant species that are considered sensitive to environmental disturbance, and their presence signifies good environmental conditions.

Combining Hatch Lake's aquatic plant species richness and average conservatism values to produce its Floristic Quality Index (FQI) results in a value of 27.9 (equation shown below) for 2020. This is above the median values for the ecoregion and state (Figure 3.4-8), and further illustrates the quality of Hatch Lake's plant community. Figure 3.4-8 shows that these values in 2020 were relatively comparable to those from the 2006 survey on Hatch Lake.

FQI = Average Coefficient of Conservatism (6.4) * √ Number of Native Species (19)
FQI = 27.9

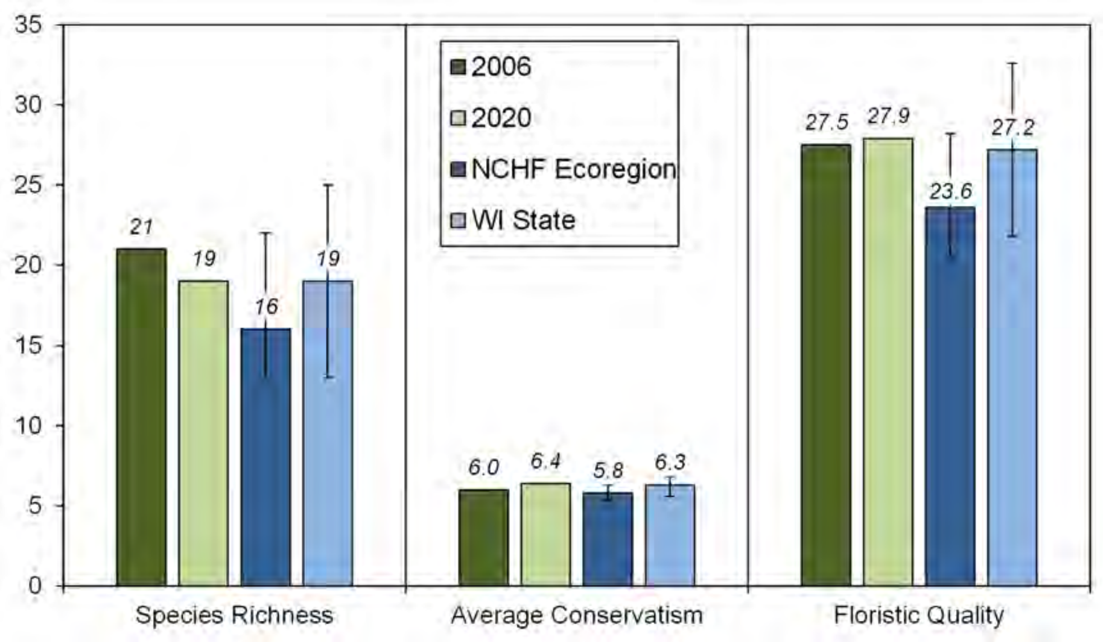
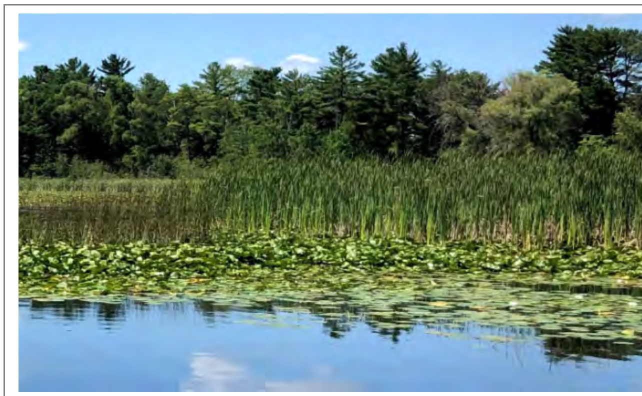


Figure 3.4-8. Hatch Lake Floristic Quality Assessment. Created using data from the 2006 and 2020 point-intercept surveys. Analysis following Nichols (1999) where NCHF = North Central Hardwood Forests Ecoregion.

The quality of Hatch Lake's plant community is also indicated by the high incidence of emergent and floating-leaf plant communities that occur in near-shore areas around the lake. The 2020 community map indicates that approximately 58.2 acres (48%) of the 121 acre-lake contain these types of plant communities (Table 3.4-3 and Map 5). Seventeen floating-leaf and emergent species were located on Hatch Lake in 2020, providing valuable structural habitat for invertebrates, fish, and other wildlife. As mentioned previously, over 52 acres of floating-leaf and emergent communities containing white water lily were mapped during this survey. Other abundant species of these community types included spatterdock, broad-leaved cattail, and hardstem bulrush to name a few. These communities stabilize lake substrate and shoreland areas by dampening wave action from wind and watercraft.



Photograph 3.4-8 Emergent and floating-leaf vegetation in Hatch Lake. Photo credit Onterra.

Table 3.4-3. Hatch Lake acres of plant community types. Created from August 6, 2020 community mapping survey.

Plant Community	Acres
Emergent	5.0
Floating-leaf	23.3
Mixed Emergent & Floating-leaf	29.9
Total	**58.2**

Because the community map represents a 'snapshot' of the important emergent and floating-leaf plant communities, a replication of this survey in the future will provide a valuable understanding of the dynamics of these communities within Hatch Lake. This is important because these communities are often negatively affected by recreational use and shoreland development. Radomski and Goeman (2001) found a 66% reduction in vegetation coverage on developed shorelands when compared to the undeveloped shorelands 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 shorelands.

The data that continues to be collected from Wisconsin lakes is revealing that aquatic plant communities are highly dynamic, and populations of individual species have the capacity to fluctuate, sometimes greatly, in their occurrence from year to year and over longer periods of time. These fluctuations are driven by a combination of interacting natural factors including variations in water levels, temperature, ice and snow cover (winter light availability), nutrient availability, changes in water flow, water clarity, length of the growing season, herbivory, disease, and competition (Lacoul and Freedman 2006). Seasonal and longer-term water level fluctuations are natural in Wisconsin's lakes and play an essential ecological role (e.g., maintaining emergent plant communities).

Non-Native Aquatic Plants in Hatch Lake

Curly-leaf Pondweed (*Potamogeton crispus)*

As described above, on June 8, 2020, a survey was completed on Hatch Lake that focused upon CLP. During this meander-based survey, CLP was located and properly verified with the WDNR for the first time on Hatch Lake (Photo 3.4-5). The majority of the CLP that was mapped was located in deeper areas of the lake in 7-10 feet of water in the east-central portion of the lake (Map 6). Two single CLP plants were also located in the west-central portion of the lake in 6 feet of water. A 0.7-acre contiguous colony of CLP was mapped and given the lowest polygon density rating of *highly scattered*. Many *single or few plants* and *clumps of plants* occurrences were marked in these areas as well.

It is impossible to know how long CLP has been in Hatch Lake; however, considering the high plant biomass the occurs in the lake, its location in central Wisconsin where CLP typically does not become issue unless the lake is severely impaired, and that it already occurs in several areas of the lake, it is likely that the plant was introduced many years ago. Periodic monitoring during the plant's peak growth time in June is the appropriate action at this time.

Eurasian watermilfoil (*Myriophyllum spicatum*)

Eurasian watermilfoil was verified in Hatch Lake in 2003. EWM has an affinity for softer sediments. As shown in the previous section, the bottom of Hatch Lake is comprised mostly (93%) of soft sediments, making it an ideal place for EWM to grow. Information on the propagation of EWM was previously discussed in the Aquatic Plants Primer section. In an effort to control EWM populations in Hatch Lake, past management actions have taken place. The earliest information supplied by the WDNR was of a 2008 granular 2,4-D treatment of 1.5 and two additional treatments completed in 2009 and 2011, without records. In 2013, a 3.5-acre area in Hatch Lake was treated with herbicides targeting EWM. In 2016, a 1.7-acre area was treated, and in 2019, two areas totaling 3 acres were treated for EWM. The HLIWA believes that the earlier treatments were somewhat successful, but no monitoring data were available. Overall, the 2019 treatment, using endothall and diquat, was a failure because it only provided seasonal relief.

WDNR Long-Term EWM Trends Monitoring Research Project

Starting in 2005, WDNR Science Services began conducting annual point-intercept aquatic plant surveys on a set of unmanaged lakes to understand how EWM populations vary over time. This was in response to commonly held beliefs of the time that once EWM becomes established in a lake, its population would continue to increase over time. This information is presented here to understand how unmanaged systems in this ecoregion compare to Hatch Lake.

Like other aquatic plants, EWM populations are dynamic and annual changes in EWM frequency of occurrence have been documented in many lakes, including those that are not being actively managed for EWM control (no herbicide treatment or hand-harvesting program). Figure 3.4-9 shows the EWM populations of three unmanaged EWM lakes in the Northern Central Hardwood Forests ecoregion. To clarify, these lakes have not conducted herbicide treatments or any other forms of strategic EWM management. The EWM population of Montana Lake (Oconto-Marinette counties) has been variable over time, whereas the EWM population of Crystal Lake (Marquette County) has been extremely stable at around 20% during the timeframe of study. After first being detected in 2005, the EWM population of Crooked Lake (Adams County) was below 3% for at least 10 years, and then increased to 7.4% in 2019 after being in the lake for 14 years.

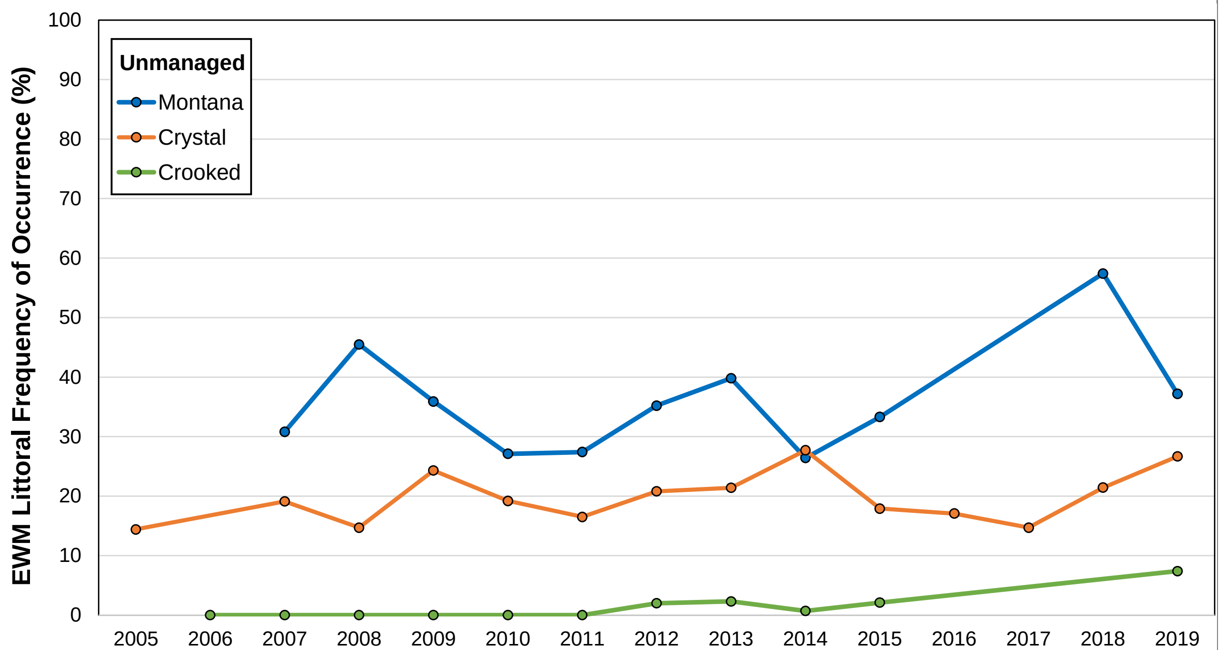


Figure 3.4-9. Littoral frequency of occurrence of Unmanaged EWM populations in the Northern Central Hardwood Forests ecoregion. Data provided by and used with permission from WDNR.

The Science Behind the "So-Called" Super Weed (Nault 2016)

In 2015, the WDNR investigated the most recent point-intercept data from almost 400 Wisconsin Lakes that had confirmed EWM populations. These data show that approximately 65% of these lakes had EWM populations of 10% or less (Figure 3.4-10). At these low population levels, there is not likely to be impacts to recreation and navigation, nor changes in ecological function. At the time of this writing, Hatch Lake's most recent point-intercept survey (2020) yielded EWM at 7.1% of the littoral sampling locations. Only approximately 15% of the lakes in the survey had EWM populations of 30% or higher. This may be due to the fact that the EWM population in some lakes may never reach that level or that management activities may have been enacted to suppress the EWM population to lower levels.

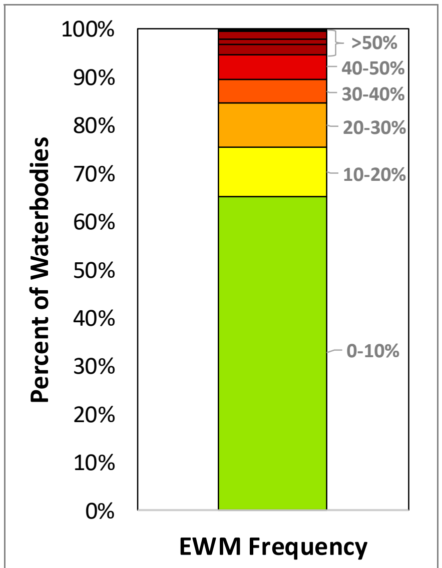


Figure 3.4-10. EWM littoral frequency of occurrence in 397 WI lakes with EWM populations. Data provided by and used with permission from WDNR.

Late-Season EWM Mapping Survey

While the point-intercept survey is a valuable tool to understand the overall occurrence of a given plant within a lake, it does not offer a full account (census) of where a particular species exists in the lake to understand where recreation and navigation impairments may exist, and how to direct management activities. Following the same general methodologies as outlined for the Early-Season AIS Survey (for CLP mapping), the Late-Season EWM Mapping Survey is completed in late-summer when EWM is typically at its peak-biomass for the growing season. On September 1, 2020 Onterra ecologists completed the late-season survey on Hatch Lake in search of EWM. During the survey, a total of 8.2 acres of contiguous colonies of EWM were mapped, as well as numerous point-based occurrences (Figure 3.4-11). Note that the acreage only takes into account the colonies of EWM that were mapped using polygons and does not include point-based occurrences. Of the total 8.2 acres of EWM mapped, approximately 3.5 acres of this was of higher density, including ratings of *dominant* (2.5 acres) and *highly-dominant* (1.0 acre). No *surface matting* (highest density rating) was observed. The remaining acreage consisted of lower densities colonies: *highly scattered* (3.6 acres) and *scattered* (1.1 acres).

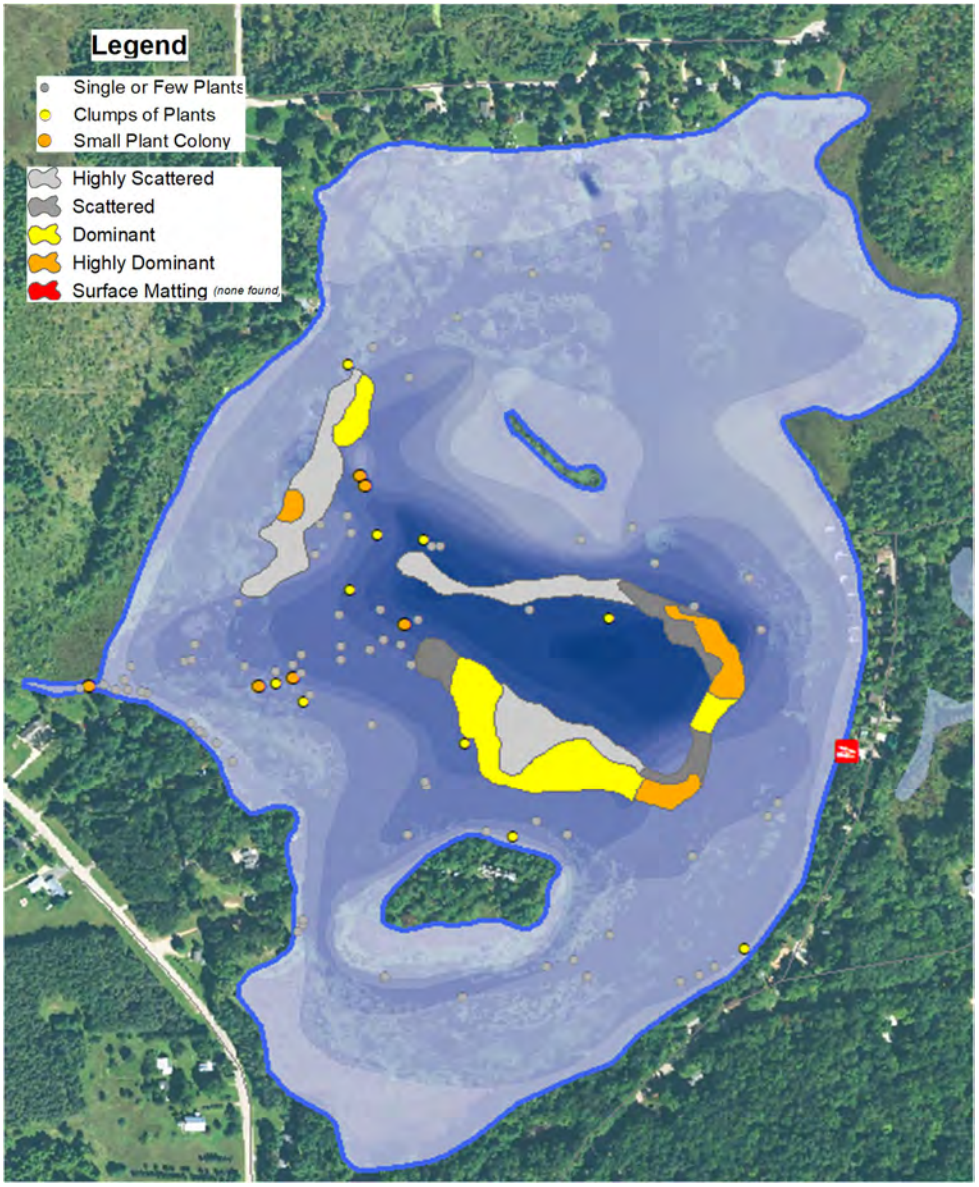


Figure 3.4-11. Eurasian watermilfoil mapped in Hatch Lake on September 1, 2020. Created using data from Onterra's Late-Season AIS survey.

Milfoil Weevil Study

The Aquatic Plants Primer section included information about biological controls for managing non-native plant species. One of the examples given that is still in its earlier study stages is the native milfoil weevil (*Euhrychiopsis lecontei)* to help manage Eurasian watermilfoil. This weevil typically feeds on native Northern watermilfoil, but has been observed to prefer Eurasian watermilfoil over northern when both are present.

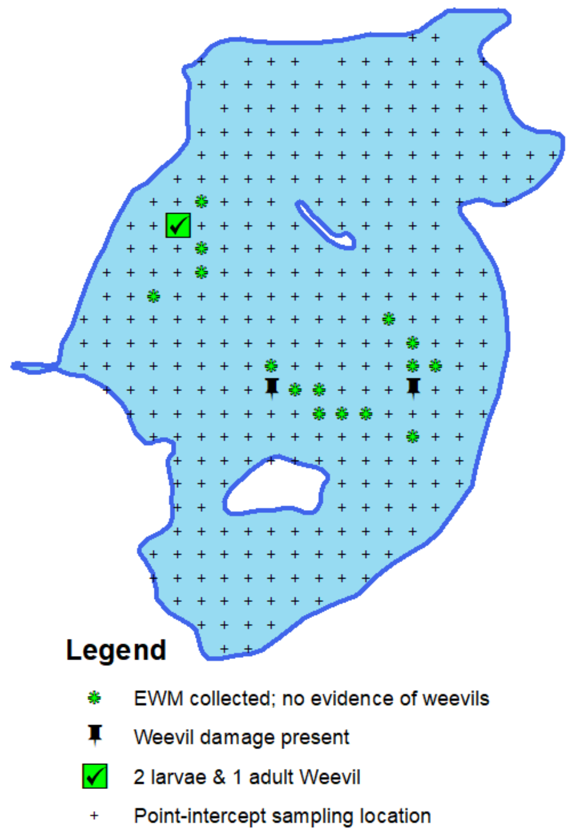


Figure 3.4-12. Locations of weevil evidence in Hatch Lake.

During the 2020 point-intercept survey, Onterra collected samples of EWM at each of the point-intercept sample location where it was present. These samples were sent to Golden Sands RC&D to be analyzed for the presence of these native weevils. A total of 35 EWM samples, from 18 sampling points were sent for analysis. Only one EWM sample came back with confirmed weevil presence – this sample contained two weevils in the larval stage, and one adult. Two additional samples showed damage consistent with weevil presence, but no actual weevils. These findings equate to only about 9% of the samples showing signs of weevil presence, which is a low abundance. The locations of these three positive sampling sites are shown in Figure 3.4-12. The distance between these locations is promising, as it suggests the weevils do not congregate in just one area of the lake. Finding weevils in the larval stage is also a positive, as it suggests the conditions of Hatch Lake are able to support a reproducing population of milfoil weevils.

As discussed in Golden Sands' Milfoil Weevil Survey Report (Appendix G), while the current weevil densities within Hatch Lake do not appear to be sufficient for controlling EWM, actions can be taken to support their populations in an effort to incorporate them into an EWM management plan. Successful biocontrol is not expected to remove the entirety of the population, but to help bring the population to a more manageable level. Appendix G contains more detailed information regarding weevil identification, life cycle, potential as a biological control agent, lake-specific studies, etc.

Hatch Lake 2021 ProcellaCOR Spot-treatment

The 2020 late-season AIS survey mapped several areas of dense EWM in around the deeper basin between the lake's two islands (Figure 3.4-11). This is the primary location for recreational boating in Hatch Lake so the HLIWA board expressed interest in managing the EWM population in 2021 and asked Onterra for guidance in constructing an appropriate management strategy. Onterra developed two strategies for consideration, one utilizing 2,4-D, which had been used in the past on Hatch Lake, and ProcellaCOR, a relatively new herbicide that had only been in use in

Wisconsin for the past three years. On May 5, 2021, Onterra staff hosted a videoconference for the HLIWA Board of Directors to discuss the two strategies, including the expected results and associated risks of each strategy. Onterra's presentation focused primarily on the use of ProcellaCOR, focusing on factors related to possible impacts to native aquatic plant species and the potential for EWM impacts beyond the application area.

Ultimately, the HLIWA elected to move forward with the proposed treatment strategy which included applying ProcellaCOR to one 3.0-acre site in Hatch Lake to target some of the most dominant EWM colonies known to be present in the lake (Figure 3.4-13, left frame). The treatment location was placed in a high-use area in the vicinity of the public boat landing. Calculations indicated a potential whole-lake concentration of 0.32 ppb of the active ingredient in ProcellaCOR – florpyrauxifen-benzyl. Based on past monitoring of other treatments with this chemistry, Onterra expected some amount of EWM reductions outside of the herbicide application area. The HLIWA shared the proposed control strategy with the local WDNR lakes biologist and solicited cost estimates from an herbicide applicator prior to submitting a permit to the WDNR.

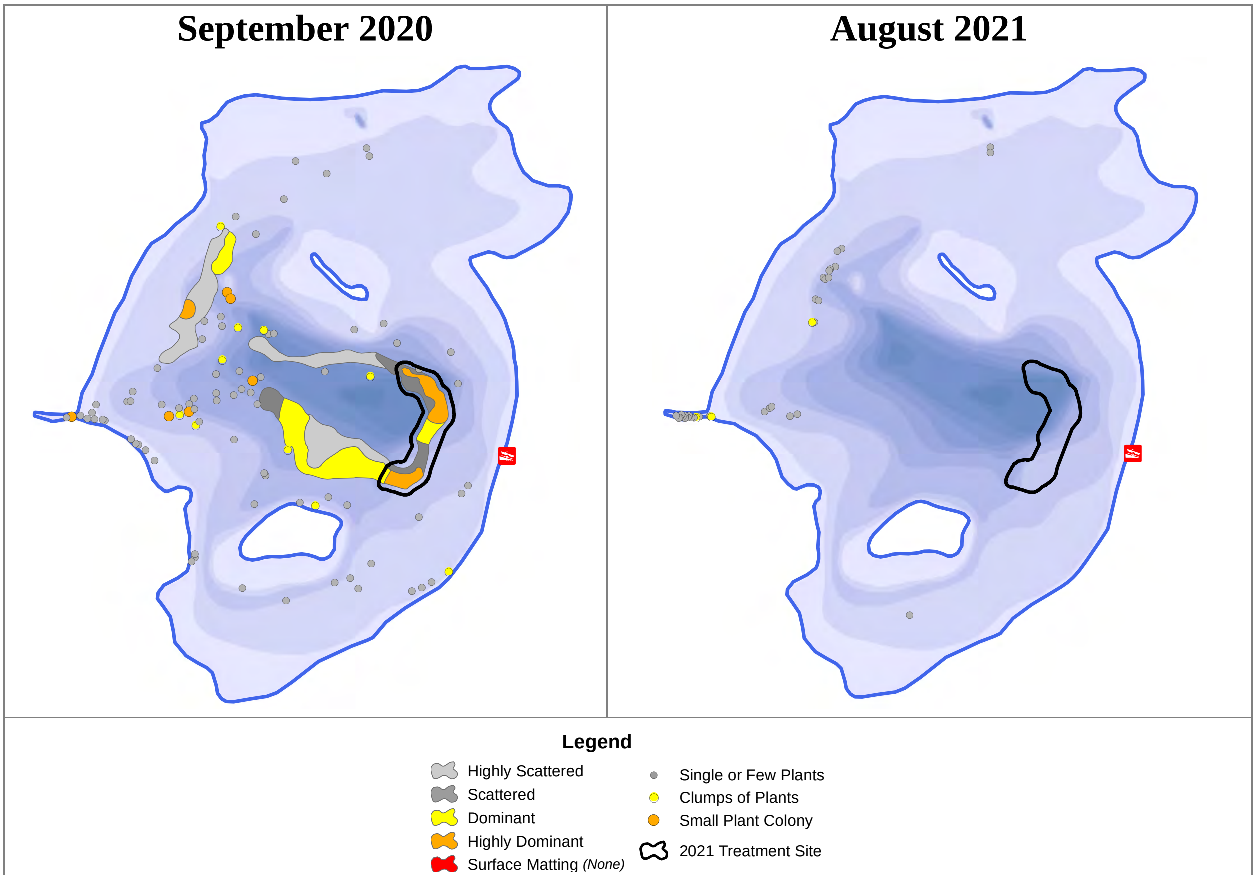


Figure 3.4-13. Eurasian watermilfoil population before (September 2020) and after (August 2021) a June 2021 herbicide treatment in Hatch Lake.

A qualitative monitoring assessment of the herbicide treatment is made by comparing the late-season EWM mapping survey results from before and after the herbicide treatment. Figure 3.4-13 displays the EWM mapping survey results from September 2020 (pre-treatment) and August 2021 (post-treatment) and indicates a high level of initial EWM control. No EWM was located within the application area or the immediate vicinity (Figure 3.4-13, right frame). A reduction in the lake-wide EWM population is also evident when comparing the two mapping surveys.

Although environmental factors can naturally influence year-to-year aquatic plant growth, it is believed that the herbicide treatment was the main driver responsible for the decreased EWM population throughout much of Hatch Lake. Ongoing research and case studies continue to investigate the herbicide concentrations that are measured in lakes following a treatment using ProcellaCOR to gain further understanding of the impact of lake-wide or basin-wide treatments with this chemistry. Of the approximately 20 ProcellaCOR herbicide treatments that Onterra has been monitoring since 2019, nearly all have shown impacts to EWM beyond the targeted area, similar as to what was observed following the 2021 treatment on Hatch Lake.

The 2021 herbicide treatment will meet lake manager's expectations for control if the EWM population reduction is found to extend beyond the year of treatment and into year-after-treatment (2022). A replication of the late-summer EWM mapping survey in 2022 would serve to provide a better understanding of the longevity of control from the 2021 treatment.

Pale-yellow iris

Photograph 3.4-9. Pale-yellow iris in shoreland area. Photo credit Onterra.

Pale yellow iris (*Iris pseudacorus*) is a large, showy iris with bright yellow flowers (Photo 3.4-9). Native to Europe and Asia, this species was sold commercially in the United States for ornamental use and has since escaped into Wisconsin's wetland areas forming large monotypic colonies and displacing valuable native wetland species. Pale-yellow iris is typically in flower during the second half of June. The foliage of pale-yellow iris and northern blue flag iris (a valuable native species) is too similar to make a definitive identification based off of the foliage alone. Positive identification needs to come from the flowers or the seed pods, which develop after the flower is pollinated. Pale-yellow iris was first verified in Hatch Lake in 2017, and was observed by Onterra during the 2020 surveys. Map 5 shows the locations of both pale-yellow iris (non-native) and northern blue flag (native) which were located around Hatch Lake during the Early-Season AIS survey.

Purple loosestrife

Purple loosestrife (*Lythrum salicaria*) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental (Photo 3.4-10). This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930's, it has now spread to 70 of the state's 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments. Onterra observed purple loosestrife growing in several areas around Hatch Lake during the 2020 surveys. These specific locations can be found on the Emergent & Floating-leaf Aquatic Plant Communities (Map 5) for Hatch Lake.

Photograph 3.4-10. Purple loosestrife. Photo credit Onterra.

Reed canary grass

Reed canary grass (*Phalaris arundinacea*) is a large, coarse perennial grass that can reach up to six feet in height. Often difficult to distinguish from native grasses, this species can form dense, highly productive stands that outcompete native species. Unlike native grasses, few wildlife species utilize the grass as a food source, and the stems grow too densely to provide cover for small mammals and waterfowl. It grows best in moist soils such as wetlands, marshes, stream banks and lake shorelines. It is difficult to eradicate and is quite resilient to herbicide applications. A useful tool for viewing the extents of reed canary grass populations within the state is the WDNR's Lakes & AIS Mapping Tool, which can be accessed here: https://dnr.wi.gov/lakes/viewer/.

Stakeholder Survey Responses to Eurasian watermilfoil in Hatch Lake

As discussed in section 2.0, the stakeholder survey asks many questions pertaining to perception of the lake and how it may have changed over the years. Figures 3.4-14 - 3.4-16 display the responses of members of Hatch Lake stakeholders to questions regarding EWM, its impact on enjoyment of the lake, and whether past and future herbicide use is supported or opposed.

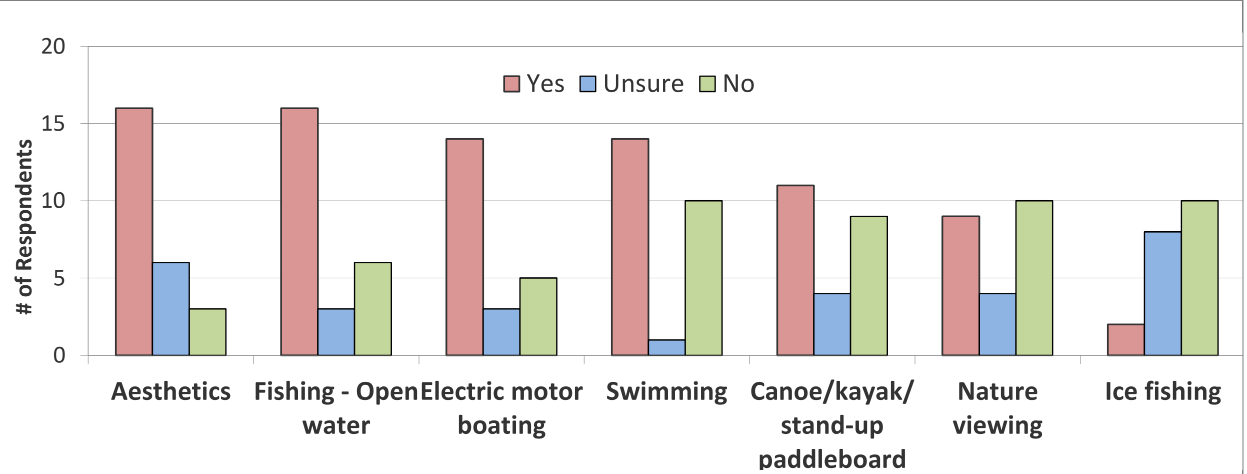


Figure 3.4-14. Stakeholder survey response to Question #24. Has the Eurasian watermilfoil population ever had a negative impact on your enjoyment of Hatch Lake?

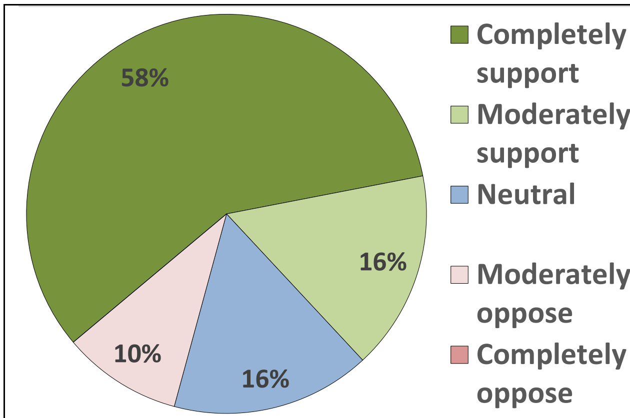


Figure 3.4-15 Stakeholder survey response to Question# 26. *What is your level of support or opposition for the past use of aquatic herbicides to treat Eurasian watermilfoil in Hatch Lake?*

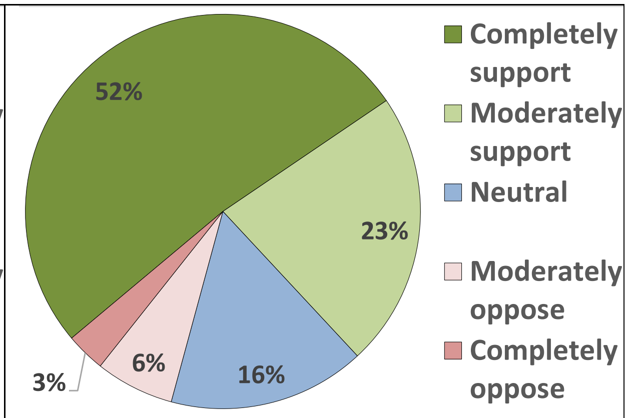


Figure 3.4-16 Stakeholder survey response to Question# 27. *What is your level of support or opposition for the future use of aquatic herbicides to treat Eurasian watermilfoil in Hatch Lake?*

3.5 Aquatic Invasive Species in Hatch Lake

As is discussed in section 2.0 Stakeholder Participation, the lake stakeholders were asked about aquatic invasive species (AIS) and their presence in Hatch Lake within the anonymous stakeholder survey. Onterra and the WDNR have confirmed that there are six AIS present (Table 3.5-1).

Table 3.5-1. AIS present within Hatch Lake

Type	Common name	Scientific name	Location within the report
Plants	Curly-leaf pondweed	*Potamogeton crispus*	Section 3.4 – Non-native Aquatic Plants
	Eurasian watermilfoil	*Myriophyllum spicatum*	Section 3.4 – Non-native Aquatic Plants
	Pale-yellow iris	*Iris pseudocarus*	Section 3.4 – Non-native Aquatic Plants
	Purple loosestrife	*Lythrum salicaria*	Section 3.4 – Non-native Aquatic Plants
	Reed canary grass	*Phalaris arundinacea*	Section 3.4 – Non-native Aquatic Plants
Invertebrates	Banded mystery snail	*Viviparus georgianus*	See below

Figure 3.5-1 below displays the aquatic invasive species that Hatch Lake stakeholder survey respondents believe are in Hatch Lake. Only the species present in Hatch Lake are discussed below or within their respective locations listed in Table 3.5-1. While it is important to recognize which species stakeholders believe to present within their lake, it is more important to share information on the species present and possible management options. More information on these invasive species or any other AIS can be found at the following links:

- http://dnr.wi.gov/topic/invasives/
- https://nas.er.usgs.gov/default.aspx
- https://www.epa.gov/greatlakes/invasive-species

Aquatic Animals

Mystery snails

There are two types of mystery snails found within Wisconsin waters, the Chinese mystery snail (*Cipangopaludina chinensis*) and the banded mystery snail (*Viviparus georgianus*). Both snails can be identified by their large size, thick hard shell and hard operculum (a trap door that covers the snail's soft body). These traits also make them less edible to native predators. These species thrive in eutrophic waters with very little flow. They are bottom-dwellers eating diatoms, algae and organic and inorganic bottom materials. One study conducted in northern Wisconsin lakes found that the Chinese mystery snail did not have strong negative effects on native snail populations (Solomon

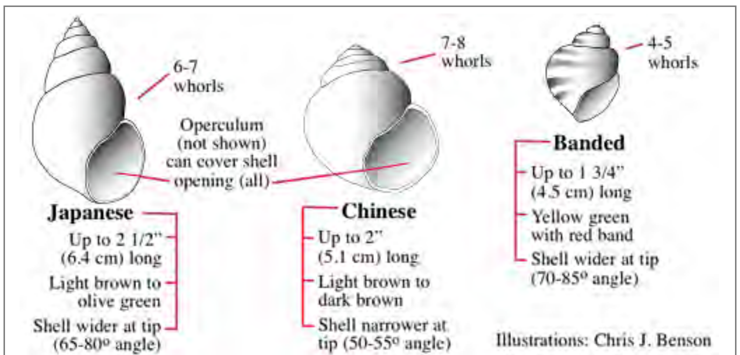


Figure 3.5-1. Identification of non-native mystery snails. Courtesy of Minnesota Sea Grant: (http://www.seagrant.umn.edu/ais/mysterysnail).

et al. 2010). However, researchers did detect negative impacts to native snail communities when both Chinese mystery snails and the rusty crayfish were present (Johnson et al. 2009). Only banded mystery snails have been found in Hatch Lake and were confirmed in 2011.

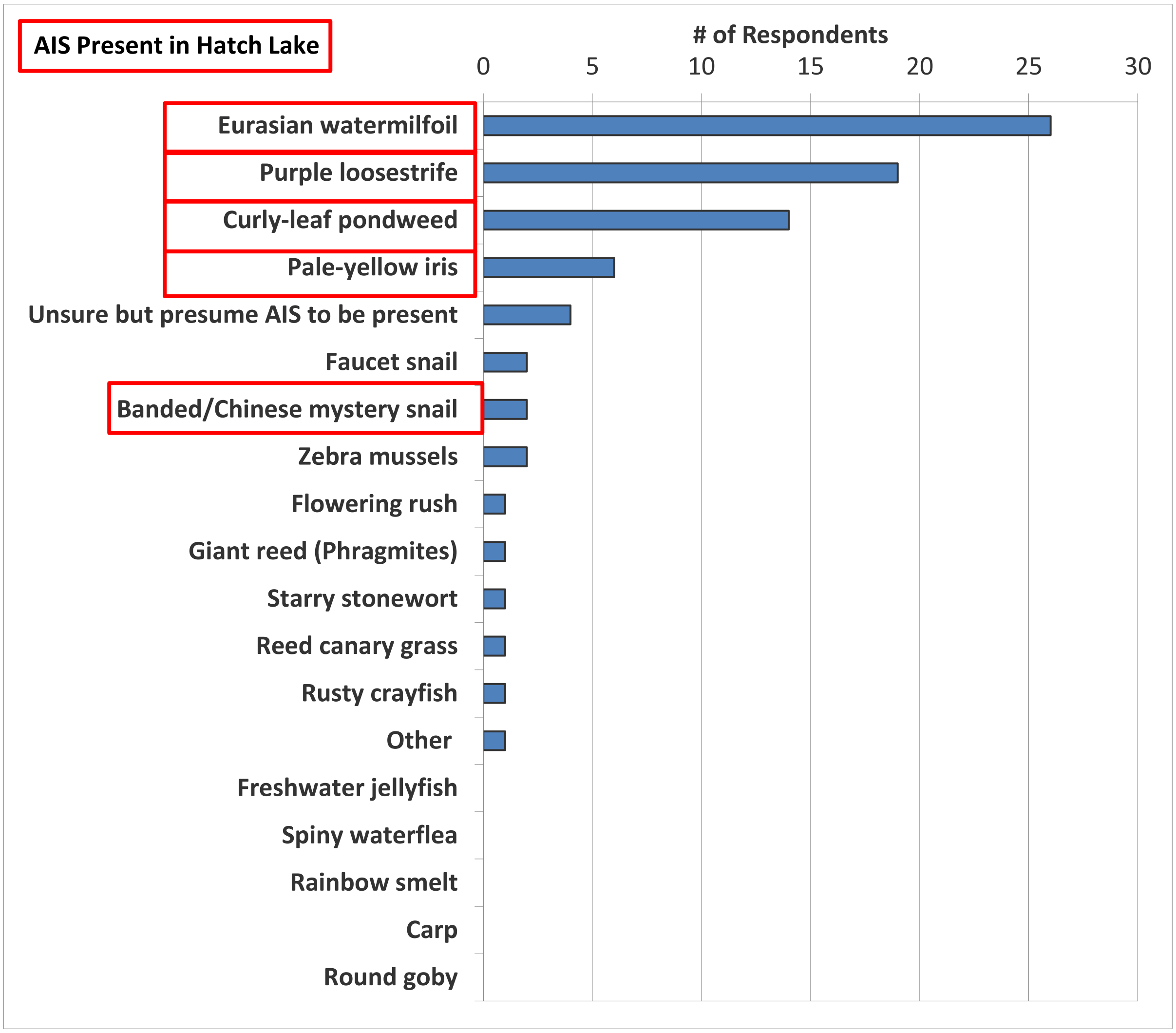


Figure 3.5-2. Stakeholder survey response Question #22. Which aquatic invasive species do you believe are present in or immediately around Hatch Lake?

3.6 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 a 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 fisheries biologists overseeing Hatch Lake. The goal of this section is to provide an overview of some of the data that exists. Although current fish data were not collected as a part of this project, the following information was compiled based upon data available from the Wisconsin Department of Natural Resources (WDNR) and personal communications with WDNR Fisheries Biologist Jason Breeggemann (WDNR 2021).

Hatch Lake Fishery

Energy Flow of a Fishery

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 Hatch Lake 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 piscivores, 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 piscivores 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 piscivorous 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 3.6-1.

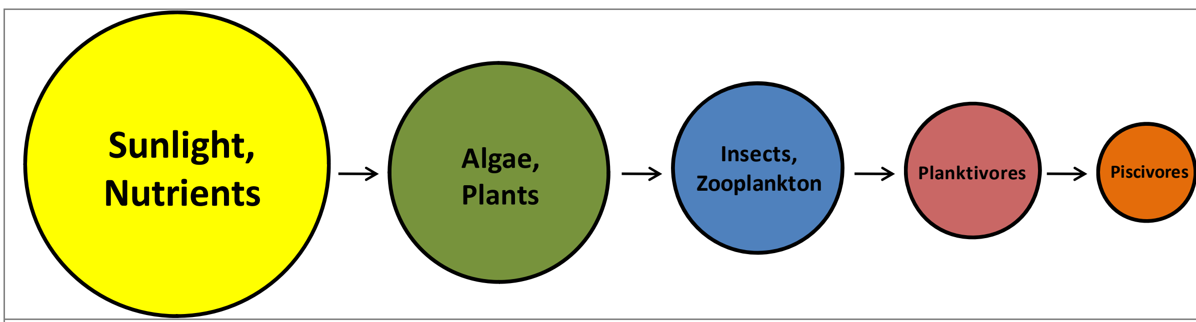


Figure 3.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, Hatch Lake is a mesotrophic system, meaning it has a moderate amount of nutrients and thus a moderate amount of primary productivity. This is relative to an oligotrophic system, which contains fewer nutrients (less productive) and a eutrophic system, which contains more nutrients (more productive). Simply put, this means Hatch Lake should be able to support an appropriately sized population of predatory fish (piscivores) when compared to eutrophic or oligotrophic systems. Table 3.6-1 shows the popular game fish present in the system.

Table 3.6-1. Gamefish present in Hatch Lake with corresponding biological information (Becker, 1983).

Common Name (*Scientific Name*)	**Max Age (yrs)**	**Spawning Period**	**Spawning Habitat Requirements**
Black Bullhead (*Ameiurus melas*)	5	April - June	Matted vegetation, woody debris, overhanging banks
Black Crappie (*Pomoxis nigromaculatus*)	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel
Bluegill (*Lepomis macrochirus*)	11	Late May - Early August	Shallow water with sand or gravel bottom
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation
Northern Pike (*Esox lucius*)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves
Pumpkinseed (*Lepomis gibbosus*)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom
Rock Bass (*Ambloplites rupestris*)	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms
Yellow Bullhead (*Ameiurus natalis*)	7	May - July	Heavy weeded banks, beneath logs or tree roots
Yellow Perch (*Perca flavescens*)	13	April - Early May	Sheltered areas, emergent and submergent veg

Survey Methods

In order to keep the fishery of a lake healthy and stable, fisheries biologists must assess the current fish populations and trends. To begin this process, the correct sampling technique(s) must be selected to efficiently capture the desired fish species. A commonly used passive trap is a fyke net (Photograph 3.6-1). Fish swimming towards this net along the shore or bottom will encounter the lead of the net, be diverted into the trap and through a series of funnels which direct the fish further into the net. Once reaching the end, the fisheries technicians can open the net, record biological characteristics, mark (usually with a fin clip), and then release the captured fish.

The other commonly used sampling method is electrofishing (Photograph 3.6-1). This is done, often at night, by using a specialized boat fit with a generator and two electrodes installed on the front touching the water. Once a fish comes in contact with the electrical current produced, the fish involuntarily swims toward the electrodes. When the fish is in the vicinity of the electrodes, they become stunned making them easier to net and place into a livewell to recover. Contrary to what some may believe, electrofishing does not kill the fish and after being placed in the livewell fish generally recover within minutes. As with a fyke net survey, biological characteristics are recorded and any fish that has a mark (considered a recapture from the earlier fyke net survey) are also documented before the fish is released.

The mark-recapture data collected between these two surveys is placed into a statistical model to calculate the population estimate of a fish species. Fisheries biologists can then use this data to make recommendations and informed decisions on managing the future of the fishery.


Photograph 3.6-1. Fyke net positioned in the littoral zone of a Wisconsin Lake (left) and an electroshocking boat (right).

Fish Stocking

Photograph 3.6-2. Largemouth bass fingerling.

To assist in meeting fisheries management goals, the WDNR may permit the stocking of fingerling or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 3.6-2). Stocking a lake may be done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Hatch Lake was stocked periodically from 2005-2013 with fingerling walleye (Table 3.6-2). White suckers were also stocked in 2005, with 3,500 large fingerlings being released. Additionally, 1,000 largemouth bass fingerlings in were stocked 2017 (Table 3.6-3). Historical stocking efforts were retrieved from the HLIWA and the WDNR.

Table 3.6-2. Stocking data available for walleye in Hatch Lake (2005-2013).

Year	Age Class	# Fish Stocked	Avg Fish Length (in)
2013	Large Fingerling	490	6
2009	Large Fingerling	2,400	4.75
2008	Large Fingerling	500	7
2007	Large Fingerling	646	5.5
2006	Large Fingerling	647	6
2005	Large Fingerling	500	6.5

Table 3.6-3. Stocking data available for northern pike and largemouth bass in Hatch Lake (1972-2017).

Lake	Year	Species	Age Class	# Fish Stocked	Avg Fish Length (in)
Hatch Lake	2017	Largemouth bass	Fingerling	1,000	4
Hatch Lake	1990	Largemouth bass	Fry	1,000	3
Hatch Lake	1979	Northern pike	Fry	100,000	-
Hatch Lake	1978	Northern pike	Fry	65,000	-
Hatch Lake	1976	Northern pike	Fry	100,000	-
Hatch Lake	1972	Northern pike	Fry	165,000	1

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing (open-water) was the fourth-most important reason for owning property on or near Hatch Lake (Question #15). Figure 3.6-2 displays the fish that Hatch Lake stakeholders enjoy catching the most, with bluegill/sunfish, yellow perch and crappie being the most popular. Approximately 80% of these same respondents believed that the quality of fishing on the lake was either good or fair (Figure 3.6-3). Approximately 72% of respondents who fish Hatch Lake believe the quality of fishing has remained the same or gotten better since they first started to fish the lake (Figure 3.6-4).

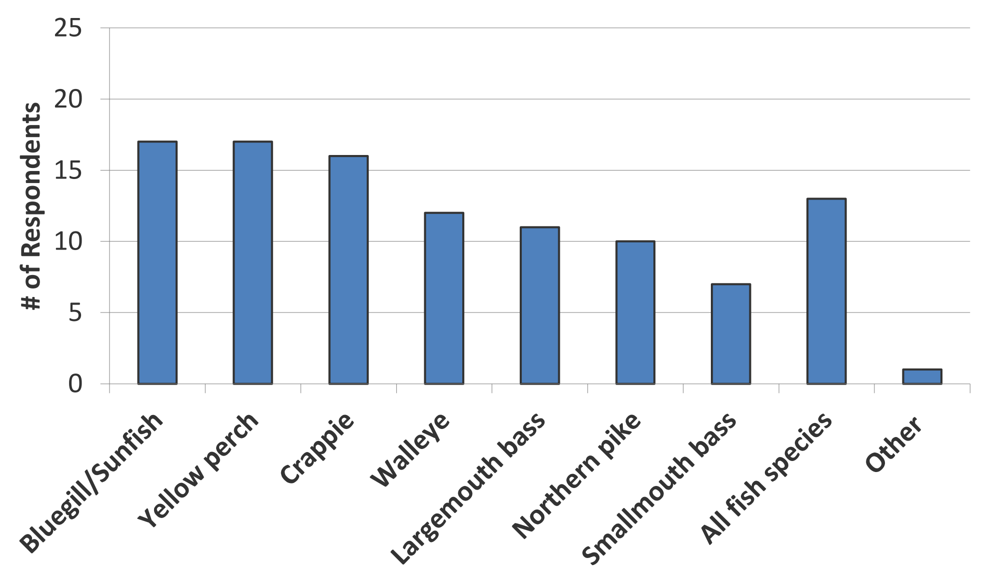


Figure 3.6-2. Stakeholder survey response Question #9. What species of fish do you like to catch on Hatch Lake?

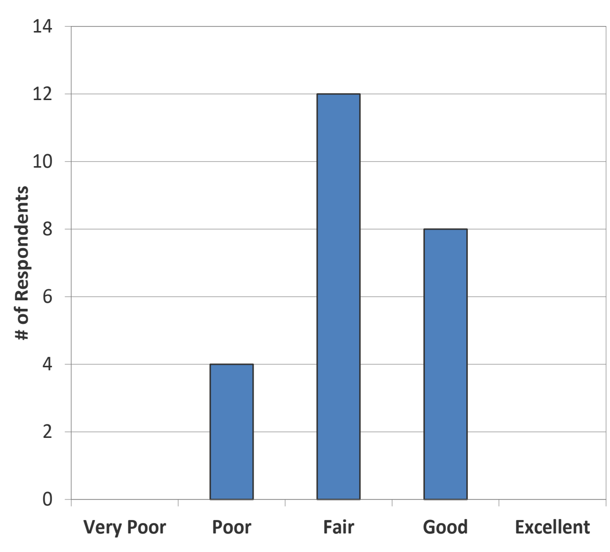


Figure 3.6-3. Stakeholder survey response Question #10. How would you describe the current quality of fishing on Hatch Lake?

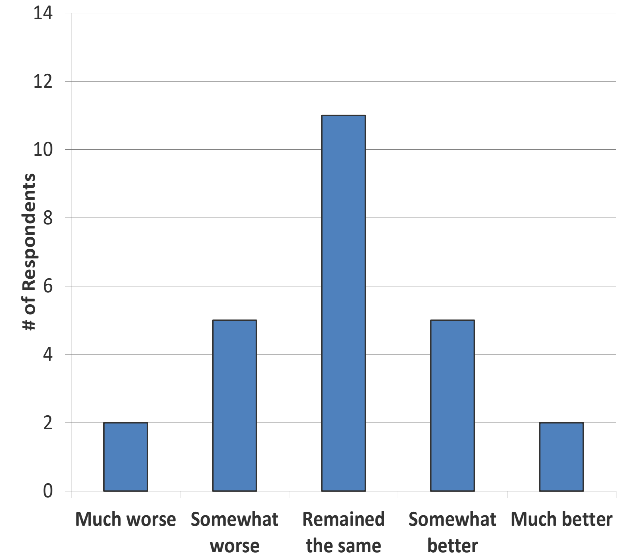


Figure 3.6-4. Stakeholder survey response Question #11. How has the quality of fishing changed on Hatch Lake since you started fishing the lake?

Fish Populations and Trends

Utilizing the fish sampling techniques mentioned above and specialized formulas, WDNR fisheries biologists can estimate populations and determine trends of captured fish species. One method used in calculating the numbers captured is catch per unit effort (CPUE). This number provides a standardized way to compare fish abundances between years when the amount of fishing effort (number of nights' fyke nets are set) differs. When comparing within the same year, CPUE indexes are compared to statewide data by percentiles. For example, if a CPUE is in the 90th percentile, it is higher than 90% of the other CPUEs in the state (Niebur 2015). Another index that is commonly used is the Proportional Stock Density (PSD). This metric is used to assess size structure within a species by calculating dividing the number of quality size fish by the number of stock fish. PSD values in the 40-60 percent range generally describe a balanced fish population. Tables 3.6-4 – 3.6-6 provide total and calculated fishery data for fish captured during the electroshocking survey on Hatch Lake in 2014. Ultimately this data shows a healthy population of fish from low to moderate abundances. The lowest percentile rank of species captured was largemouth bass (26th) and the highest being pumpkinseed (71st). This is one example of how data is analyzed by fisheries biologists to better understand the fishery and how it should be managed.

Table 3.6-4. Abundance metrics from 2014 WDNR electroshocking survey (WDNR 2014).

Species	Total CPUE (no per mile)	Percentile Rank	Overall Abundance Rating	Length Index (inches)	Length Index CPUE (no per mile)	Percentile Rank	Abundance Rating
BLUEGILL	124.2	57th	Moderate	≥ 7.0	9	55th	Moderate
LARGEMOUTH BASS	8.1	26th	Low	≥ 14.0	1.3	24th	Low
PUMPKINSEED	20.2	71st	Moderate-high	≥ 7.0	3.6	83rd	Moderate-High
YELLOW PERCH	11.7	53rd	Moderate	≥ 8.0	0	0	Low

Table 3.6-5. Size structure from 2014 WDNR electroshocking survey (WDNR 2014).

Species	Total	Average Length and (Range)	Stock and Quality size (inches)	Stock No.	Quality No.	PSD	Percentile Rank	Size rating
BLUEGILL	277	4.6 (2.5-7.7)	3.0 and 6.0	257	58	23%	55th	Moderate
LARGEMOUTH BASS	18	12.4 (10.0-14.3)	8.0 and 12.0	18	13	72%	24th	Low
PUMPKINSEED	45	5.2 (2.9-7.9)	3.0 and 6.0	17	17	40%	83rd	Moderate-High
YELLOW PERCH	26	4.9 (3.0-5.7)	5. and 8.0	0	0	0%	0	Low

Table 3.6-6. Growth metrics from 2014 WDNR electroshocking survey (WDNR 2014).

Species	Age Sample No.	Length Bin	Mean Age and Range (inches)	Percentile rank	Growth rating
BLUEGILL	277	6.0-6.5	6.6 (6-8)	< 33rd	Slow
BLUEGILL	18	7.0-7.5	6.4 (6-8)	< 33rd	Slow
LARGEMOUTH BASS	18	14.14.5	10.3 (8-12)	< 33rd	Slow

Gamefish

The gamefish present on Hatch Lake represent different population dynamics depending on the species. The results for the stakeholder survey show landowners prefer to catch walleye and largemouth bass on Hatch Lake (Figure 3.6-2). Brief summaries of gamefish with fishable populations in Hatch Lake are provided based off of the report submitted by WDNR fisheries biologist Jason Breeggemann following the fisheries survey completed in 2014 (Appendix E).

Largemouth bass are considered common in Hatch Lake. In the 2014 survey, 18 largemouth bass were captured and averaged 12.4 inches in size with the largest being 14.3 inches. A total of three fish between 14-14.3 inches were sampled to determine growth metrics (Table 3.6-6). On average, in took approximately 10 years for largemouth bass to reach the length of 14 inches. This is considered slow when compared to the state average and falls below the 33rd percentile. In an effort to increase the largemouth bass population and panfish predation, 1,000 largemouth bass fingerlings were stocked in 2017. Fishing regulations to largemouth bass size limits also increased in 2020, changing from 14 inches to 18 inches, in hopes of increasing predator numbers (Table 3.6-7).

Walleyes are a valued sportfish in Wisconsin and are present in Hatch Lake. Although not specifically targeted, two individuals were captured during the 2014 survey. No size or growth metrics were recorded for these fish. Walleye were stocked frequently in the early 2000's, with the latest event being in 2013. Walleye size limits recently changed in 2020, increasing to a minimum size of 18 inches to be harvested. This regulation was put into place in hopes of increasing predator numbers and reducing panfish numbers.

Northern Pike are considered present in Hatch Lake. One northern pike was captured as an incidental catch during the 2014 survey. No size measurements were recorded for this fish.

Panfish

The panfish present on Hatch Lake represent different population dynamics depending on the species. Abundant panfish populations are present but are lacking numbers of quality sized fish. The results for the stakeholder survey show anglers prefer to catch bluegill/sunfish, yellow perch, and crappie on Hatch Lake (Figure 3.6-2). Brief summaries of panfish with fishable populations in Hatch Lake are provided based off of the WDNR fisheries survey completed in 2014 and personal communications with fish biologist Jason Breeggemann.

Bluegill were the most abundant panfish in Hatch Lake, however, few quality sized fish were captured during the 2014 survey. Hatch Lake ranks in the 57th percentile for abundance and was given a moderate overall abundance rating (Table 3.6-4). Size structure metrics were also examined during the 2014 survey. With an average size of 4.6 inches and size range of 2.5-7.7 inches, bluegill size structure in Hatch Lake ranks low in the 32nd percentile when compared to the rest of the state (Table 3.6-5). Additionally, growth rates for bluegills were also ranked in the bottom third percentile of the state. On average, it takes over 6 years for bluegill to reach 6 inches in Hatch Lake (Table 3.6-6). DNR fish biologists hope that increasing predator populations will have a positive effect on overall bluegill size structure.

Pumpkinseed were the second most abundant panfish species captured in the 2014 survey. Hatch Lake ranked in the 71st percentile for pumpkinseed abundance, resulting in a moderate-high overall abundance rating (Table 3.6-4). Size structure metrics were also examined during the 2014 survey with an average size of 5.2 inches in a sample size of 45 individuals. The largest individual measured was 7.9 inches. The number of pumpkinseed measuring $\geq$ 7 inches ranked in the 83rd percentile, meaning a good number of larger individuals were present. With a PSD of 40 %, pumpkinseed in Hatch Lake showed a balanced size structure with a decent number of quality-sized fish (Table 3.6-5).

Yellow perch were also captured in the 2014 survey. In total, 26 perch were sampled ranging from 3.0-5.7 inches in length (Table 3.6-4). While ranking in the 53rd percentile and recording a moderate overall abundance rating, size ratings were low. (Table 3.6-5).

Black crappie were recorded in low abundance during the 2014 survey. In total, four crappies were captured. No attempts were made to assess size structure or growth metrics.

Fish Kill

Hatch Lake has experienced periodic fish kills over winter caused by a lack of dissolved oxygen in the water. Anoxic conditions can develop during the winter months when dissolved oxygen is depleted from biological processes in which oxygen is consumed. Between 1958-1979, nine severe winterkills were reported in Hatch Lake. Because of this, WDNR stocking was stopped in 1980. (per. Jason Breeggemann, WDNR).

Aeration

In 1989, an aeration system was installed in Hatch Lake to maintain sufficient dissolved oxygen levels to avoid further fish kills. Aeration is a process where air is circulated through an aquatic system for the purpose of re-oxygenating the water. To address winter oxygen depletion, aeration is a common technique. Many believe that the aeration process itself re-oxygenates a lake by providing an air source to the water. While some oxygen may be provided to the lake in this manner, the greatest oxygen accumulation actually occurs through the creation of open water during the winter months, allowing for atmospheric exchange of oxygen with the open water. The overarching goal of winter aeration is to open an area of ice for this oxygen exchange, essentially creating a refuge for fish to last through the winter months. Therefore, it is not necessary to aerate large areas of a lake. Commonly, fish biologists refer to >1 to several acres of aerated area as a "refuge" where fish can overwinter. No major winterkills have been recorded since the installation of the aerator (Jason Breeggemann, WDNR).

Hatch Lake Fish Habitat

Substrate Composition

Just as forest wildlife require proper trees and understory growth to flourish, fish require certain substrates and habitat types to nest, spawn, escape predators, and search for prey. Lakes with primarily a silty/soft substrate, many aquatic plants, and coarse woody debris may produce a completely different fishery than lakes that are largely sandy/rocky, and contain few aquatic plant species or coarse woody habitat.

Substrate and habitat are critical to fish species that do not provide parental care to their eggs. Northern pike is one species that does not provide parental care to its eggs (Becker 1983). Northern pike broadcast their eggs over woody debris and detritus, which can be found above sand or muck. This organic material suspends the eggs above the substrate, so the eggs are not buried in sediment and suffocate as a result. Walleye are another species that does not provide parental care to its eggs. Walleye preferentially spawn in areas with gravel or rock in places with moving water or wave action, which oxygenates the eggs and prevents them from getting buried in sediment. Fish that provide parental care are less selective of spawning substrates. Species such as bluegill tend to prefer a harder substrate such as rock, gravel or sandy areas if available, but have been found to spawn and care for their eggs in muck as well.

According to the point-intercept survey conducted by Onterra in 2020, 93% of the substrate sampled in the littoral zone of Hatch Lake was composed of soft sediments, <7% was composed of sand and < 1% were composed of rock.

Woody Habitat

As discussed in the Shoreland Condition Section, the presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2009). A fall 2020 survey documented 86 pieces of coarse woody along the shores of Hatch Lake, resulting in a ratio of approximately 34 pieces per mile of shoreline. Fisheries biologists do not suggest a specific number of fish sticks for a lake but rather highly encourage their installation wherever possible. To learn how Hatch Lake's coarse woody habitat is compared to other lakes in its region please refer to section 3.3.

Fish Habitat Structures

Some fisheries managers may look to incorporate fish habitat structures on the lakebed or littoral areas extending to shore for the purpose of improving fish habitats and spawning areas. These projects are typically conducted on lakes lacking significant coarse woody habitat in the shoreland zone. The "Fish sticks" program, outlined in the WDNR best practices manual, adds trees to the shoreland zone restoring fish habitat to critical near shore areas. Typically, every site has 3 – 5 trees which are partially or fully submerged in the water and anchored to shore (Photograph 3.6-3). The WDNR recommends placement of the fish sticks during the winter on ice when possible to prevent adverse impacts on fish spawning or egg incubation periods. The program requires a WDNR permit and can be funded through many different sources including the WDNR, County Land & Water Conservation Departments or partner contributions.

Photograph 3.6-3. Examples of fish sticks (left) and half-log habitat structures. (Photos by WDNR)

Fish cribs are a type of fish habitat structure placed on the lakebed. These structures are more commonly utilized when there is not a suitable shoreline location for fish sticks. Installing fish cribs may also be cheaper than fish sticks; however some concern exists that fish cribs can concentrate fish, which in turn leads to increased predation and angler pressure. Having multiple locations of fish cribs can help mitigate that issue.

Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 3.6-3). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills, Bremigan and Haynes 2004). If the waterbody is exempt from a permit or a permit has been received, information related to the construction, placement and maintenance of half-log structures are available online.

An additional form of fish habitat structure is spawning reefs. Spawning reefs typically consist of small rubble in a shallow area near the shoreline for mainly walleye habitat. Rock reefs are sometimes utilized by fisheries managers when attempting to enhance spawning habitats for some fish species. However, a 2004 WDNR study of rock habitat projects on 20 northern Wisconsin lakes offers little hope the addition of rock substrate will improve walleye reproduction (Neuswanger and Bozek 2004).

Placement of a fish habitat structure in a lake may be exempt from needing a permit if the project meets certain conditions outlined by the WDNR's checklists available online:

(https://dnr.wi.gov/topic/waterways/Permits/Exemptions.html)

If a project does not meet all of the conditions listed on the checklist, a permit application may be sent in to the WDNR and an exemption requested.

If interested, the HLIWA may work with the local WDNR fisheries biologist to determine if the installation of fish habitat structures should be considered in aiding fisheries management goals for Hatch Lake.

Fishing Regulations

Regulations for Hatch Lake fish species as of January 2021 are displayed in Table 3.6-4.

For specific fishing regulations on all fish species, anglers should visit the WDNR website (*www.http://dnr.wi.gov/topic/fishing/regulations/hookline.html)* or visit their local bait and tackle shop to receive a free fishing pamphlet that contains this information.

Table 3.6-7. WDNR fishing regulations for Hatch Lake (As of January 2021).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Largemouth bass and smallmouth bass	1	18"	May 2, 2020 to March 7, 2021
Smallmouth bass	1	18"	May 2, 2020 to March 7, 2021
Largemouth bass	1	18"	May 2, 2020 to March 7, 2021
Muskellunge and hybrids	1	40"	May 23, 2020 to December 31, 2020
Northern pike	5	None	May 2, 2020 to March 7, 2021
Walleye, sauger, and hybrids	3	18"	May 2, 2020 to March 7, 2021
Bullheads	Unlimited	None	Open All Year
Cisco and whitefish	10	None	Open All Year

Mercury Contamination and Fish Consumption Advisories

Freshwater fish are amongst the healthiest of choices you can make for a home-cooked meal. Unfortunately, fish in some regions of Wisconsin are known to hold levels of contaminants that are harmful to human health when consumed in great abundance. The two most common contaminants are polychlorinated biphenyls (PCBs) and mercury. These contaminants may be found in very small amounts within a single fish, but their concentration may build up in your body over time if you consume many fish. Health concerns linked to these contaminants range from poor balance and problems with memory to more serious conditions such as diabetes or cancer. These contaminants, particularly mercury, may be found naturally to some degree. However, the majority of fish contamination has come from industrial practices such as coal-burning facilities, waste incinerators, paper industry effluent and others. Though environmental regulations have reduced emissions over the past few decades, these contaminants are greatly resistant to breakdown and may persist in the environment for a long time. Fortunately, the human body is able to eliminate contaminants that are consumed however this can take a long time depending upon the type of contaminant, rate of consumption, and overall diet. Therefore, guidelines are set upon the consumption of fish as a means of regulating how much contaminant could be consumed over time.

General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 3.6-8. There is an elevated risk for children as they are in a stage of life where cognitive development is rapidly occurring. As mercury and PCB both locate to and impact the brain, there are greater restrictions on women who may have children or are nursing children, and also for children under 15.

Fish Consumption Guidelines for Most Wisconsin Inland Waterways		
	Women of childbearing age, nursing mothers and all children under 15	**Women beyond their childbearing years and men**
Unrestricted*	-	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout
1 meal per week	Bluegill, crappies, yellow perch, sunfish, bullhead and inland trout	Walleye, pike, bass, catfish and all other species
1 meal per month	Walleye, pike, bass, catfish and all other species	Muskellunge
Do not eat	Muskellunge	-

**Doctors suggest that eating 1-2 servings per week of low-contaminant fish or shellfish can benefit your health. Little additional benefit is obtained by consuming more than that amount, and you should rarely eat more than 4 servings of fish within a week.*

Figure 3.6-8. Wisconsin statewide safe fish consumption guidelines. Graphic displays consumption guidance for most Wisconsin waterways. Figure adapted from WDNR website graphic (http://dnr.wi.gov/topic/fishing/consumption/)

Fishery Management & Conclusions

The WDNR's recommendations for Hatch Lake are to focus on preservation of habitat and water quality. Furthermore, management strategies to help improve panfish growth and size structure are recommended. Currently, regulations are in place to help increase predator numbers. A one fish, 18-inch minimum length bag limit was implemented for largemouth bass in 2020, as well as a three fish, 18-inch minimum length limit for walleye. By reducing competition for food and other resources through predation, panfish densities should decline and growth rates should increase (Jason Breeggemann, 2021). The WDNR is completing a comprehensive fish study on Hatch Lake during spring 2022, including netting and shoreline shocking.

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 Hatch Lake ecosystem.
2) Collect detailed information regarding invasive plant species within the lake, with the primary emphasis being on Eurasian watermilfoil.
3) Collect sociological information from Hatch Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

The three objectives were fulfilled during the project and have led to a good understanding of the Hatch Lake ecosystem, the folks that care about the lakes, and what needs to be completed to protect and enhance them.

Overall, when considering the studies completed and the historical information collected, Hatch Lake is considered in good ecological health. Very limited water quality data are available for Hatch Lake, but what is available indicates that the water quality is good to excellent. Paleoecological analysis of the 2020 sediment cores collected by Onterra supports the conclusion that the lake has good water quality. While the sediment core analysis indicated that the lake's water quality has decreased slightly over the past century and a half, it is still considered good. The decrease in water quality from pre-European settlement, to present times is not unexpected due to the development around the lake and in the lake's watershed.

In most lakes, water quality is largely determined by the condition of the watershed, and while this is true for Hatch Lake as well, other factors come into play. Hatch Lake's watershed is very small and is made up of several landcover types. Some of the landcover, like the agricultural areas, export higher levels of phosphorus, while some landcovers, like forested areas, export very low amounts of phosphorus to the lake. The agricultural lands around Hatch Lake could potentially impact Hatch Lake by raising the lake's phosphorus levels, which would likely increase algal abundance and decrease water clarity. However, due to the location of the wetlands on the northside of the lake, much of the water that exists the agricultural area in the watershed is intercepted by those wetlands. The wetlands not only filter the water that moves through them, but they also slow the flows and allow the water to percolate into the groundwater where it is further purified.

Hatch Lake also has a great deal of groundwater that enters it. That groundwater dilutes the lake water and also brings in calcium carbonate, which precipitates marl in the water column and locks phosphorus in the sediments. Finally, as described in the Water Quality Section 3.1, Hatch Lake's shallowness and abundant plant population also regulates the lake's water quality. The aquatic plants utilize nutrients that may otherwise be used by algae, the provide refuge to an abundant zooplankton population that grazes upon algae, and they provide structure to periphyton (algae that attach to plants) that also utilize nutrients that could be used by free-floating (planktonic) algae. All-in-all, the plant population is the largest contributor to Hatch Lake's clear water.

The immediate watershed, or the shoreland area, of a lake is also important in not only maintaining the lake's water quality, but also in providing critical habitat for wildlife, including everything from insects to amphibians to mammals to fish. The shoreland assessment of Hatch Lake revealed that over 60% of the lake's shoreline is undeveloped. Much of that area is naturally undevelopable because of the existence of nearshore wetlands, which as described above, buffer the lake from nutrient-polluted runoff, but also provide important habitat that translates into a healthy fish population. Understanding the impact of developed shorelands on a lake is a critical aspect of maintaining the overall ecological health of a lake. On a lake like Hatch, the developed areas of the shoreline likely contribute little nutrient pollution to the lake, but they definitely impact available habitat and reduce the atheistic quality of the lake. Protecting semi-developed areas and restoring developed areas to more natural conditions is an important aspect in maintaining the current state of Hatch Lake's high quality.

While Hatch Lake's aquatic plant population is abundant and includes 5 non-native species, it is still considered high-quality in terms of its diversity and its species make-up. It is very important for Hatch Lake riparians to understand the abundant plant population in the lake natural and an indicator of a healthy shallow lake system. While the native plants can present a nuisance to some recreational activities on the lake, they are not a sign of deteriorating lake health like some riparians may believe. Riparians must also remember that the plant population in any lake is fluid and densities of certain species and their locations will cycle over years and decades. Conditions that exist today do not necessarily represent what the aquatic plant community will look like in the coming years, and the changes that do occur do not always reflect a decrease in lake quality.

Mechanical harvesting to create access lanes through dense plants was discussed during plan development; however, it was not included in the implementation plan due to concerns over its practicality and fiscal feasibility. If interest increases among riparian property owners, they would need to work with the HLIWA Board of Directors to create a specific mechanical harvesting plan and to apply for a permit through the WDNR. The harvesting plan would need to include a map showing harvest lane locations and widths, such as those found in Figure 4.0-1. The harvesting plan would need to avoid high quality plant communities, consider depth limitations, and assure that bottom sediments would not be disrupted. It would also need to include an offloading location and a nearby disposal site. While the HLIWA would sponsor the permit, it is likely that the individual property owners would be responsible for the permit fees and harvesting contractor costs.

Hatch Lake's aquatic plant community include two submergent AIS and three emergent AIS. One of the emergent AIS, reed canary grass, is common throughout the state and likely not manageable, but it also does not present much of a threat. The other two emergent AIS, purple loosestrife and pale-yellow iris, are currently found in very low abundancies around the lake and easily controlled by volunteers.

The two submergent AIS, Eurasian watermilfoil and curly-leaf pondweed, are currently at low densities and even before the 2021 Eurasian watermilfoil treatment, have not caused ecological harm to the lake. Curly-leaf pondweed was first documented in 2020 by Onterra field crews but it was also listed by an applicator in a 2019 herbicide treatment record. At its current density, curly-leaf pondweed produces no ill-effects in the lake. It has likely been in the lake for many years, so it is prudent to continue monitoring it, but no control is currently warranted.

Eurasian watermilfoil has produced relatively dense colonies in the past and unfortunately those colonies primarily occur in the area of the lake where recreational boating occurs and can be a real nuisance. It is important for HLIWA members to understand that the Eurasian watermilfoil population in Hatch Lake is established and has been in the lake for decades. The entire lake has likely been exposed to Eurasian watermilfoil many times. If Eurasian watermilfoil was going to take over the lake, it would have done so years ago. Like all invasive populations, Eurasian watermilfoil reaches a density in the lake at which if fluctuates around. Some years there is more, some years there is less. This is a dynamic equilibrium, and that average level of density varies by lake. In some lakes, the average level is very low and the plant never causes an issue. In some lakes that average density is high and must be controlled. Hatch Lake's Eurasian watermilfoil population has always been at a relatively low density, so concerns over it harming the lake's ecological health is not warranted. Also, believing that every occurrence of the AIS in the lake should be controlled is irrational. In Hatch Lake, if the Eurasian watermilfoil is not impacting recreation, it does not need to be controlled.

Figure 4.0-1. Hatch Lake example harvest plan map. Red line indicates 20-foot wide harvest lane.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the HLIWA Planning Committee and ecologist/planners from Onterra. It represents the path the HLIWA 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 Hatch Lake 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 Quality Environmental Conditions on Hatch Lake

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

Timeframe: Begin in 2022.

Facilitator: HLIWA Board of Directors

Description: Monitoring water quality is an import aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. The lack of this type of historical information hampered the water quality analysis during this project. Early discovery of negative trends may lead to the reason as of why the trend is developing. Stability will be added to the program by selecting an individual from the HLIWA to coordinate the lake's volunteer efforts and to recruit additional volunteers to keep the program fresh. The WDNR will first require the association to collect Secchi disk transparencies during the first year, then, if openings exist, would let the group into the Advanced Water Quality Program in which a volunteer collects water quality samples for processing by the Wisconsin State Laboratory of Hygiene once during the spring and three times during the summer months (June, July, and August).

Action Steps:

1. Board of Directors recruits volunteer(s).
2. Volunteers contact Ted Johnson, WDNR for enlistment, training, and materials (see Table 5.0-1).
3. Volunteers collect data and report results to WDNR and to association members during annual meeting.

Management Action: Reduce phosphorus and sediment loads from shoreland watershed to Hatch Lake.

Timeframe: Start 2022

Facilitator: HLIWA Board of Directors

Description: As the Watershed Section discusses, the Hatch Lake watershed is in good condition; however, watershed inputs still need to be focused upon, especially in terms of the lake's shoreland properties. These sources include shoreland areas that are maintained in an unnatural manner and impervious surfaces. To reduce these impacts, the HLIWA will initiate an educational initiative aimed at raising awareness among shoreland property owners concerning their impacts on the lake. This will include newsletter articles and guest speakers at association meetings.

Topics of educational items may include benefits of good septic system maintenance, methods and benefits of shoreland restoration, including reduction in impervious surfaces, and for those large undeveloped areas on Hatch Lake, the options available regarding conservation easements and land trusts.

Action Steps:

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

<u>Management Action:</u> Conduct periodic quantitative vegetation monitoring on Hatch Lake.

Timeframe: Point-Intercept Survey every 5 years, Community Mapping every 10 years, AIS survey as deemed necessary by HLIWA.

Possible Grant: Surface Water Planning Grant

Facilitator: HLIWA Board of Directors

Description: As part of the ongoing AIS and vegetation management program, a whole-lake point-intercept survey will be conducted at a minimum once every 5 years. This will allow a continued understanding of the submergent aquatic plant community dynamics within Hatch Lake and allow for periodic, lakewide surveillance of the lake for new and existing AIS. A point-intercept survey was conducted on Hatch Lake in 2020 as a part of this management planning project. The AIS control strategy defined below calls for another whole-lake point-intercept survey in 2023; therefore, the next anticipated point-intercept survey on Hatch Lake would be in 2028. Ultimately, the final schedule of the AIS strategy would determine when the next point-intercept would be completed on Hatch Lake.

In order to understand the dynamics of the emergent and floating-leaf aquatic plant community in Hatch Lake, a community mapping survey would be conducted approximately every 10 years. A community mapping survey was conducted on Hatch Lake in 2020 as a part of this management planning effort. The next community mapping survey will be completed in 2032 to coincide with the point-intercept survey that would potentially occur 5 years after the 2028 point-intercept survey discussed above. Note that the community mapping survey should be done during the same summer as a point-intercept survey, so the schedule of point-intercept surveys, as laid out above, would be the determinant of the community mapping survey.

There is a potential for Eurasian watermilfoil and/or curly-leaf pondweed to expand in both density and area within Hatch Lake. The HLIWA is fortunate to have several members that keep an unofficial watch on AIS in the lake, so this plan does not include a regimented schedule of professional AIS monitoring. Instead, the HLIWA would determine when professional AIS surveys are needed beyond those included in the AIS management strategy below. Note that opportunities for grant funding of AIS surveys on Hatch Lake would be greatest if they were completed in tandem with point-intercept surveys.

Action Steps:

See description above.

Management Goal 2: Manage Current AIS Populations in Hatch Lake

Management Action: Monitor and control Eurasian Watermilfoil in Hatch Lake.

Timeframe: Continuation of current action.

Facilitator: HLIWA Board of Directors

Potential Grant: Surface Water Planning and Small-Scale AIS Control

Description: During spring 2021, the HLIWA sponsored an herbicide treatment of Eurasian watermilfoil with the herbicide ProcellaCOR. The first season's results of the treatment were very good (Figure 3.4-13) and based upon monitoring on other lakes that completed similar ProcellaCOR control strategies, are expected to last at least three years. After three years, it is expected that the Eurasian watermilfoil occurrence will begin to increase and within the next one to three years, may approach or reach pretreatment levels. Predicting the longevity of herbicide treatments is impossible, so the strategy described here will be flexible based upon actual observations by the HLIWA; therefore, the timeline displayed below may be delayed by one or more years if the EWM populations does not recover as predicted.

The primary objective of the Hatch Lake EWM control strategy is to reduce the impact the AIS has on recreation on the lake. Historically, the EWM population has been the densest between the two islands, which is the deepest area in this shallow lake and the area where most power boating occurs. A secondary objective is to reduce the likelihood the plant will be taken out of the lake through the public landing which is adjacent to this focus area. If EWM populations increase in the shallow areas where passive recreation occurs, the HLIWA may consider control in those areas as well.

The near-future EWM management strategy on Hatch Lake includes the following:

2022 Complete a late-season AIS survey to reassess EWM population one-year-after treatment. While the EWM population is not expected to rebound within a year following a ProcellaCOR treatment, the results of this survey will document any rebound and be useful in future decision making by the association. This survey would be completed as an out-of-pocket cost for the association.

2023 Complete early-season AIS survey for CLP, a whole-lake point-intercept survey, late-season AIS survey, and possibly sub-point-intercept survey over any expected treatment area over 5 acres. The HLIWA would apply for a Surface Water Planning Grant to help fund these surveys. The results of these surveys would be used to create the following year's treatment and monitoring strategy.

2024 Implement treatment and monitoring strategy formulated with previous year's monitoring results. Monitoring would likely include a pretreatment survey to determine final treatment areas and document correct treatment timing and a late-season AIS survey to document remaining EWM. These surveys, the herbicide application, and the 2025 surveys would be partially funded

2025 Complete one 1 year-after-treatment monitoring, including whole-lake point-intercept survey, sub-point-intercept survey if pretreatment data were collected, and late-season AIS survey.

Please Note: As described above, the timeline above, starting with 2023, may be delayed based upon the rate at which the EWM rebounds in Hatch Lake and will ultimately be the decision of the HLIWA Board of Directors.

Action Steps:

1. See description above.

<u>Management Action:</u> Monitor curly-leaf pondweed in Hatch Lake.

Timeframe: Begin 2023

Facilitator: HLIWA Board of Directors

Description: During the 2020 early-season AIS survey, Onterra crews located curly-leaf pondweed within Hatch Lake and while this is considered the first official finding of this AIS in the lake, it was noted as present within one treatment area during the 2019 Eurasian watermilfoil treatment. It is likely that the species has existed in the lake for several years and has gone unnoticed.

In many lakes, curly-leaf pondweed does not create an issue with the ecology of the lake or with recreational use. This may be the case with Hatch Lake; however, continued, periodic monitoring is important. Determining the frequency of the monitoring can be difficult, but typically more frequent monitoring to see if the population is expanding is prudent after the AIS is first documented in the lake. If the population does not appear to be increasing, then the time between surveys can be increased.

As described in the Eurasian watermilfoil for management strategy above, the HLIWA will likely apply for WDNR grant funding to complete Eurasian watermilfoil surveys during 2023. The summer of 2023 would mark three years since Onterra crews first map curly-leaf pondweed in the lake. Curly-leaf pondweed and Eurasian watermilfoil have different lifecycles; curly-leaf pondweed peaks in mid-June, while Eurasian watermilfoil peaks in late July-September; therefore, they cannot be accurately mapped at the same time.

A separate early-season AIS survey would be included in the grant application funding the 2023 Eurasian watermilfoil surveys. The same mapping method would be utilized so comparisons between 2020 and 2023 can be made to determine if the population is expanding. Those results would be used to determine how often curly-leaf pondweed surveys should be completed in the future.

Action Steps:

1. See description above.

Management Action: Control purple loosestrife and pale-yellow iris on Hatch Lake.

Timeframe: Begin 2022

Facilitator: HLIWA Board of Directors

Description: During the 2020 aquatic plant surveys, Onterra crews mapped incidences of two invasive emergent wetland species on the shores of Hatch Lake, purple loosestrife and pale-yellow iris. In the low densities these two AIS were mapped, control can easily be completed by hand with trained volunteers. Golden Sands Resource Conservation & Development Council staff (See Table 5.0-1) can train HLIWA volunteers to identify and remove purple loosestrife and pale-yellow iris from near-shore areas on Hatch Lake.

Action Steps:

1. Board of Directors assembles volunteer crew of 4-8 members.
2. Volunteers contact Golden Sands and set up training days (two will likely be required because these two emergent wetland AIS bloom at different times of the year.
3. Volunteers attend training and implement control actions.
4. Volunteers report on activities and progress at HLIWA annual meeting.

Management Goal 3: Improve the Capacity of the Hatch Lake Iola Wisconsin Association to Effectively Manage Hatch Lake

Management Action: Participate in annual Wisconsin Lakes Partnership Convention.

Timeframe: Annually

Facilitator: HLIWA Board of Directors

Description: Wisconsin is unique in that there is a long-standing partnership between a governmental body, a citizen-based lake lobbying and protection association, and the state's primary educational outreach program. That unique group is the Wisconsin Lakes Partnership and its three members, the Wisconsin Dept. of Natural Resources, Wisconsin Lakes, and the UW-Extension Lakes Program, facilitate many lake-related events throughout the state. The primary event is the Wisconsin Lakes Partnership Convention held each spring in Stevens Point. This is the largest citizen-based lakes conference in the nation and is specifically suited to the needs of lake associations and districts. It is an exceptional opportunity for lake group members to learn about lake management and monitoring; network with other lake groups, agency staff, and lake management contractors; and learn how to effectively operate a lake association/district.

The HLIWA will sponsor the attendance of 1-3 association members annually at the convention. Following the attendance of the convention, the members will report specifics to the board of directors regarding topics that may be applicable to the management of Hatch Lake and operations of the HLIWA. The attendees will also create a summary in the form of a newsletter article and if appropriate, update the association membership at the annual meeting.

Information about the convention can be found at: https://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/programs/convention/default.aspx.

Action Steps:

See description above.

Management Action: Continue HLIWA's involvement with other entities that have responsibilities in managing (management units) Hatch Lake.

Timeframe: Continuation of current efforts

Facilitator: HLIWA Board of Directors

Description: The waters of Wisconsin belong to everyone and therefore the objective of protecting and enhancing these shared resources is also held by other entities. Some of these entities are governmental, while others are organizations rely on voluntary participation.

It is important that the HLIWA actively engage with all management entities to enhance the association's understanding of common management goals and to participate in the development of those goals. This also helps all management entities understand the actions that others are taking to reduce the duplication of efforts. Each entity will be specifically addressed in the table below:

Action Steps:

See guidelines in Table 5.0-1.

Table 5.0-1 Management Partner List.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Village of Iola	Village Clerk/Treasurer (Betty Aanstad 715.445.2913)	Hatch Lake falls within this township.	Once a year, or more as issues arise.	Village staff may be contacted regarding ordinance reviews or questions, and for information on community events
Golden Sands Resource Conservation & Development Council	Staff (715.343.6215)	Nonprofit organization that covers central WI	Once a year, or more as issues arise.	Provide information on conservation and natural resource preservation
Waupaca County Highway Department	Commissioner (Casey Beyersdorf, casey.beyersdorf@co.waupaca.wi.us or 715.258.7152)	Maintains county highways near lake.	As needed	Contact to discuss issues with county highways.
Waupaca County Land Conservation Department/ Committee	County Conservationist (Brian Haase - Brian.Haase@co.waupaca.wi.us or 715.258.6482)	Oversees conservation efforts for land and water projects.	Continuous as it relates to lake and watershed activities	Can aid with shoreland restorations and habitat improvements.
Wisconsin Department of Natural Resources	Fisheries Biologist (Jason Breeggemann – 920.420.4619)	Manages the fishery of Hatch Lake.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery and fish structure
	Lakes Coordinator (Ted Johnson – TedM.Johnson@wisconsin.gov 920.362.0181)	Oversees management plans, grants, all lake activities.	Continuous as it relates to lake management activities	Information on updating a lake management plan (every 5 years) or to seek advice on other lake issues including AIS management.
	Citizens Lake Monitoring Network contact (Ted Johnson – 920.424.2104)	Provides training and assistance on CLMN monitoring, methods, and data entry.	Twice a year or more as needed.	Early spring: arrange for training as needed, in addition to planning out monitoring for the open water season. Late fall: report monitoring activities.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
University of Wisconsin – Extension Lakes Program	Eric Olson, Director and Lakes Specialist (715.346.2192) Paul Skawinski, Citizens Lake Monitoring Network Educator (715.346.4853)	Provide general information regarding lakes and lake districts. Assist in CLMN training and education.	As needed.	The UW-Ext Lakes Program is a resource for educational materials and guidance regarding lakes, lake monitoring, and the operations of lake management districts.
Wisconsin Lakes	General staff (608.661.4313 or info@wisconsinlakes.org)	Facilitates education, networking and assistance on all matters involving WI lakes.	As needed. May check website (www.wisconsinlakes.org) often for updates.	LILD members may attend WL's annual conference to keep up-to-date on lake issues.

6.0 METHODS

Lake Water Quality

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

	Spring		**June**		**July**		**August**		**Fall**		**Winter**	
Parameter	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**	**S**	**B**
Total Phosphorus	●	●	●	●	●	●	●	●	●	●	●	●
Dissolved Phosphorus	●	●			●	●					●	●
Chlorophyll - *a*	●		●		●		●		●			
Total Nitrogen	●	●			●	●					●	●
True Color	●				●							
Laboratory Conductivity	●	●			●	●						
Laboratory pH	●	●			●	●						
Total Alkalinity	●	●			●	●						
Hardness	●				●							
Total Suspended Solids	●	●			●	●			●	●		
Calcium	●				●							

In addition, during each sampling event Secchi disk transparency was recorded and a temperature and dissolved oxygen profile was completed using a HQ30d with a LDO probe.

Watershed Analysis

The watershed analysis began with an accurate delineation of Hatch Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with landcover data from the National Land Cover Database (USGS 2019) were then combined to determine the watershed landcover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003).

Aquatic Vegetation

Curly-leaf Pondweed Survey

Surveys of curly-leaf pondweed were completed on Hatch Lake during a June 8, 2020 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 Hatch Lake 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 the Wisconsin Department of Natural Resource document, Recommended Baseline Monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry, and Analysis, and Applications (WDNR PUB-SS-1068 2010) was used to complete this study on August 6, 2020 (Hauxwell et al. 2010). A point spacing of 37 meters was used resulting in approximately 334 points.

Community Mapping

During the species inventory work, the aquatic vegetation community types within Hatch Lake (emergent and floating-leaved vegetation) were mapped using a Trimble Pro6T 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, vouchered, and sent to the University of Wisconsin – Steven's Point Herbarium.

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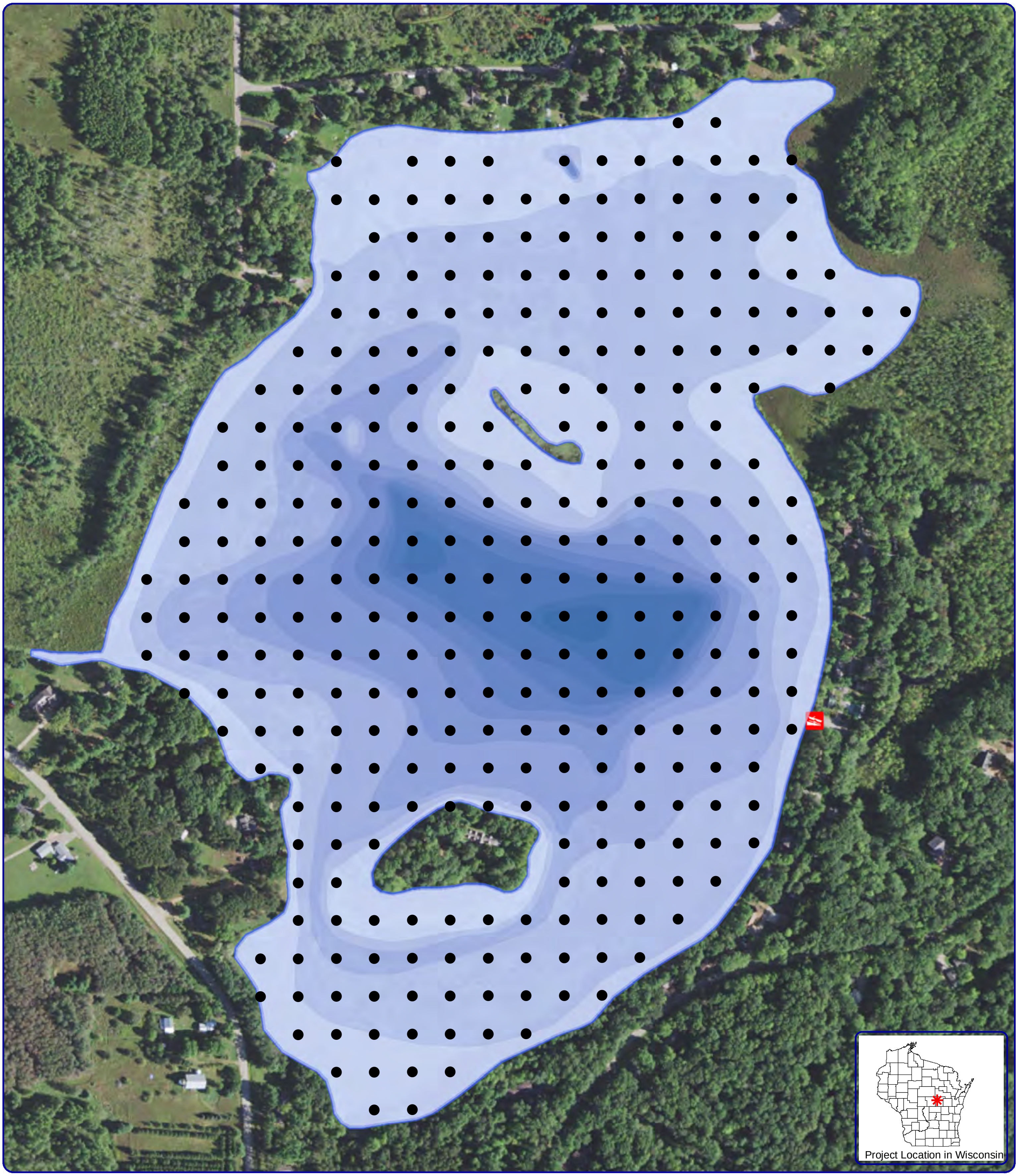

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Legend

Hatch Lake - 113 acres
DNR Definition

Hatch Lake Point-Intercept
Sample Location (WDNR 2019)
37 meter points, 334 points

Boat Launch

Onterra LLC
Lake Management Planning
815 Prosper Rd
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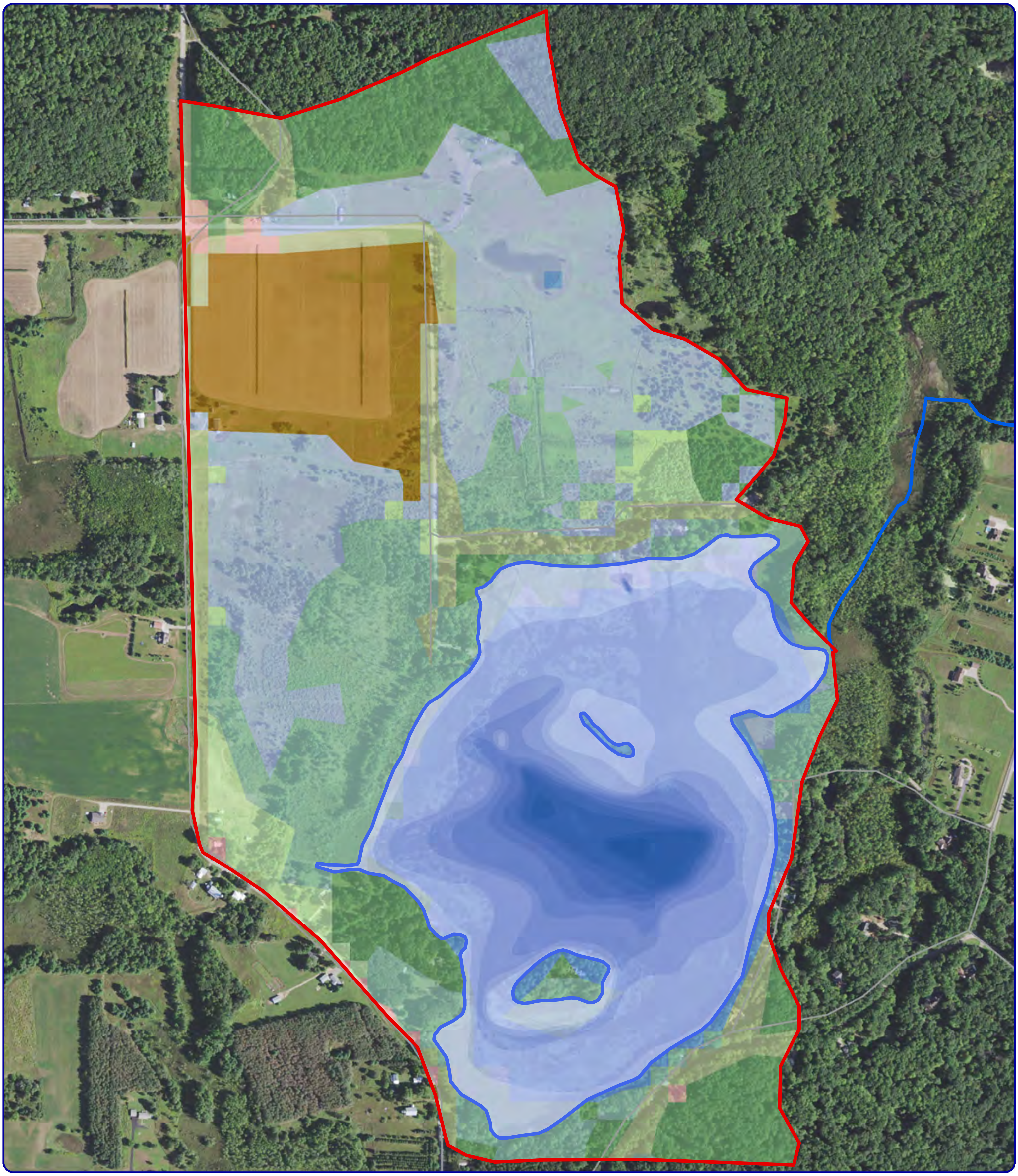
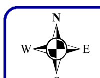
www.onterra-eco.com

Sources
Roads and Hydro: WDNR
Map Date: December 5, 2019 AMS
Filename: *Hatch_Waupaca_Location.mxd*

Map 1
Hatch Lake
Waupaca County, Wisconsin
Project Location & Lake Boundaries





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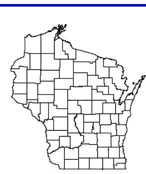
Sources:
Hydro: WDNR
Bathymetry: WDNR
Orthophotography: NAIP 2020
Land Cover: NLCD, 2016
Watershed Boundaries: Onterra, 2020
Map Date: December 28, 2020 JMB
File Name: MapX_Hatch_Watershed.mxd



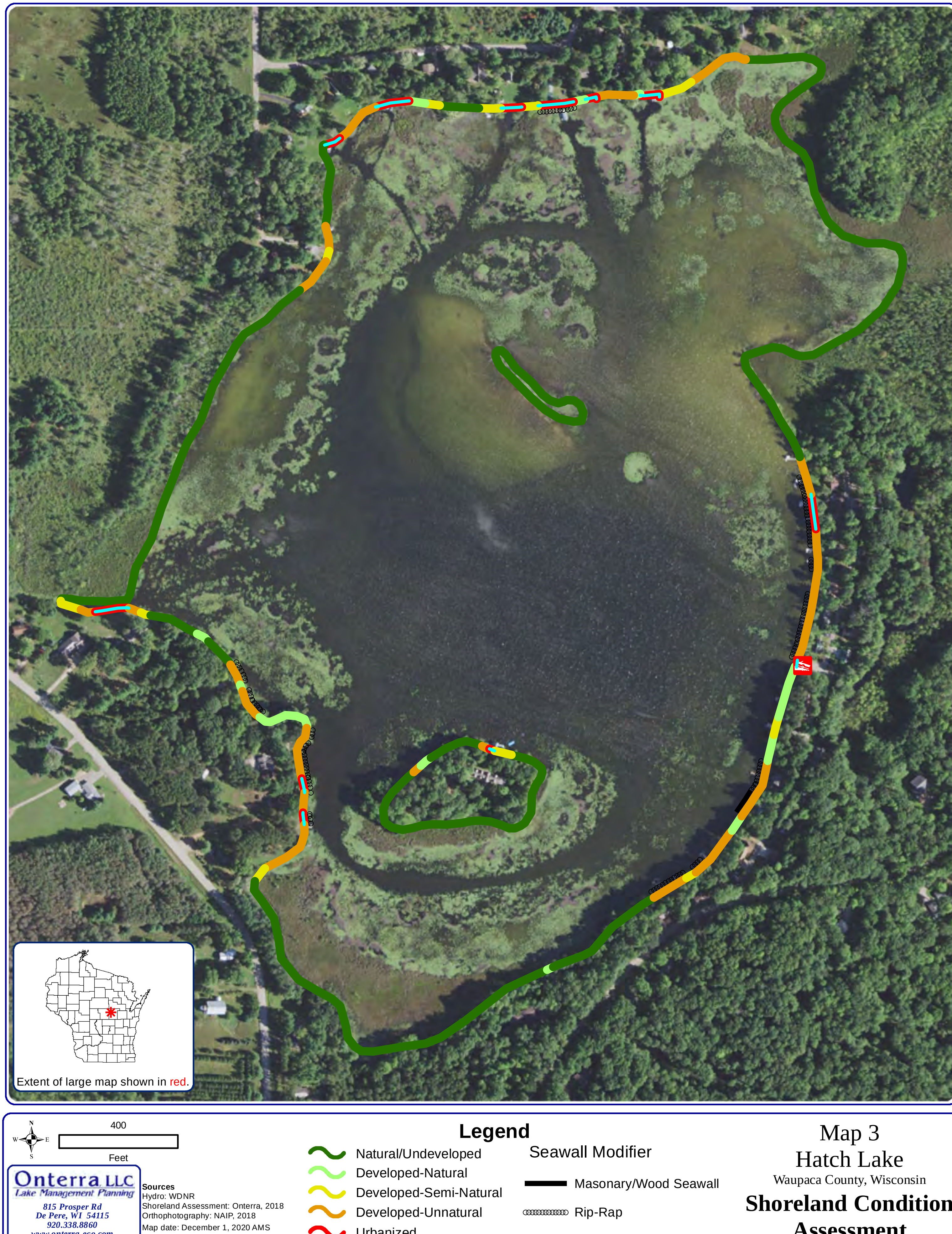
Extent of large map shown in red.

Legend

- Forest
- Forested Wetlands
- Pasture/Grass
- Open Water
- Wetland
- Row Crop Agriculture
- Rural Open Space
- Rural Residential
- Urban - High Density
- Urban - Medium Density
- Hatch Lake Watershed Boundary

Map 2
Hatch Lake
Waupaca County, Wisconsin

Watershed Boundaries & Land Cover Types



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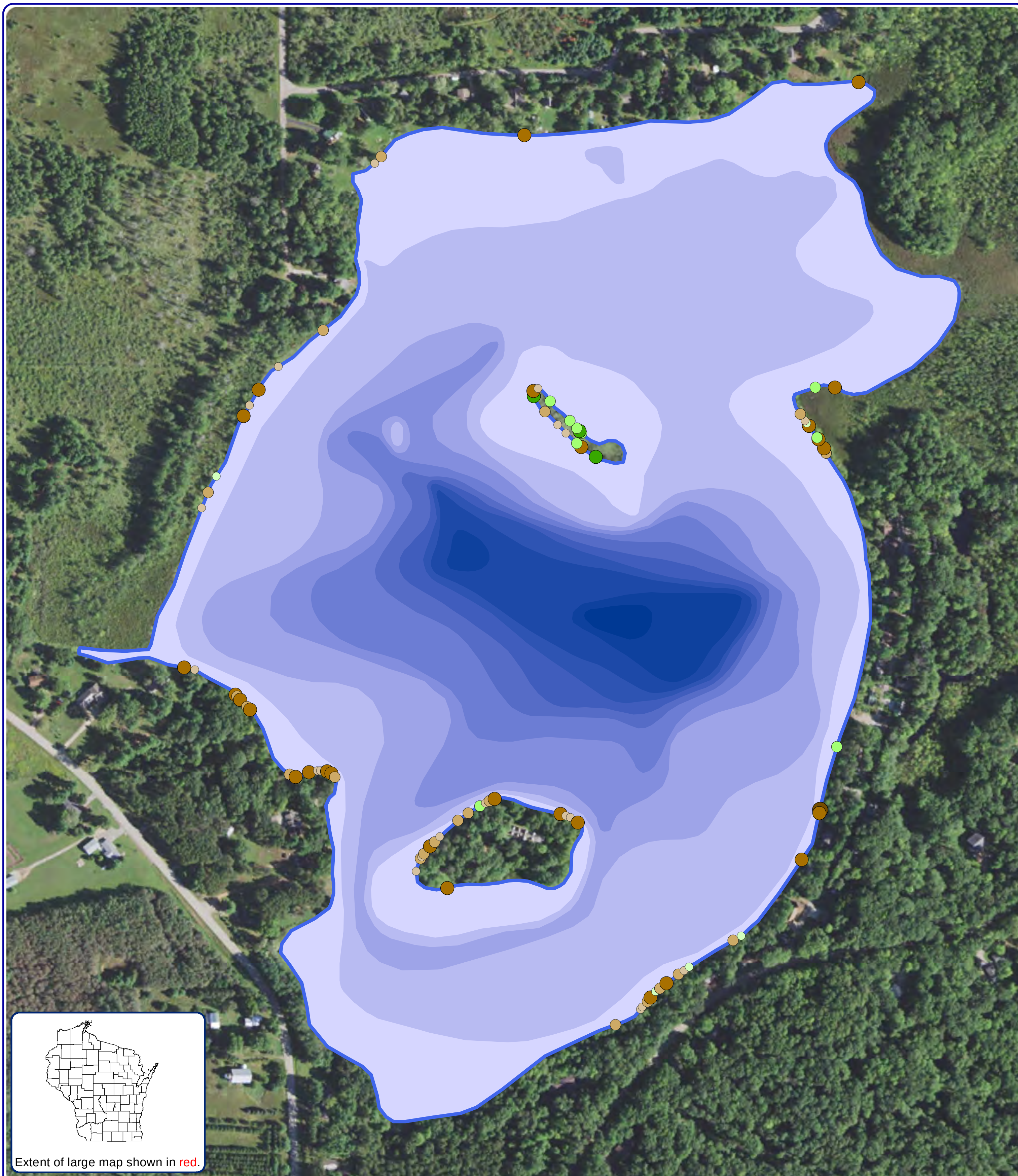
Sources
Hydro: WDNR
Shoreland Assessment: Onterra, 2018
Orthophotography: NAIP, 2018
Map date: December 1, 2020 AMS

Map 3
Hatch Lake
Waupaca County, Wisconsin

Shoreland Condition Assessment



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Feet

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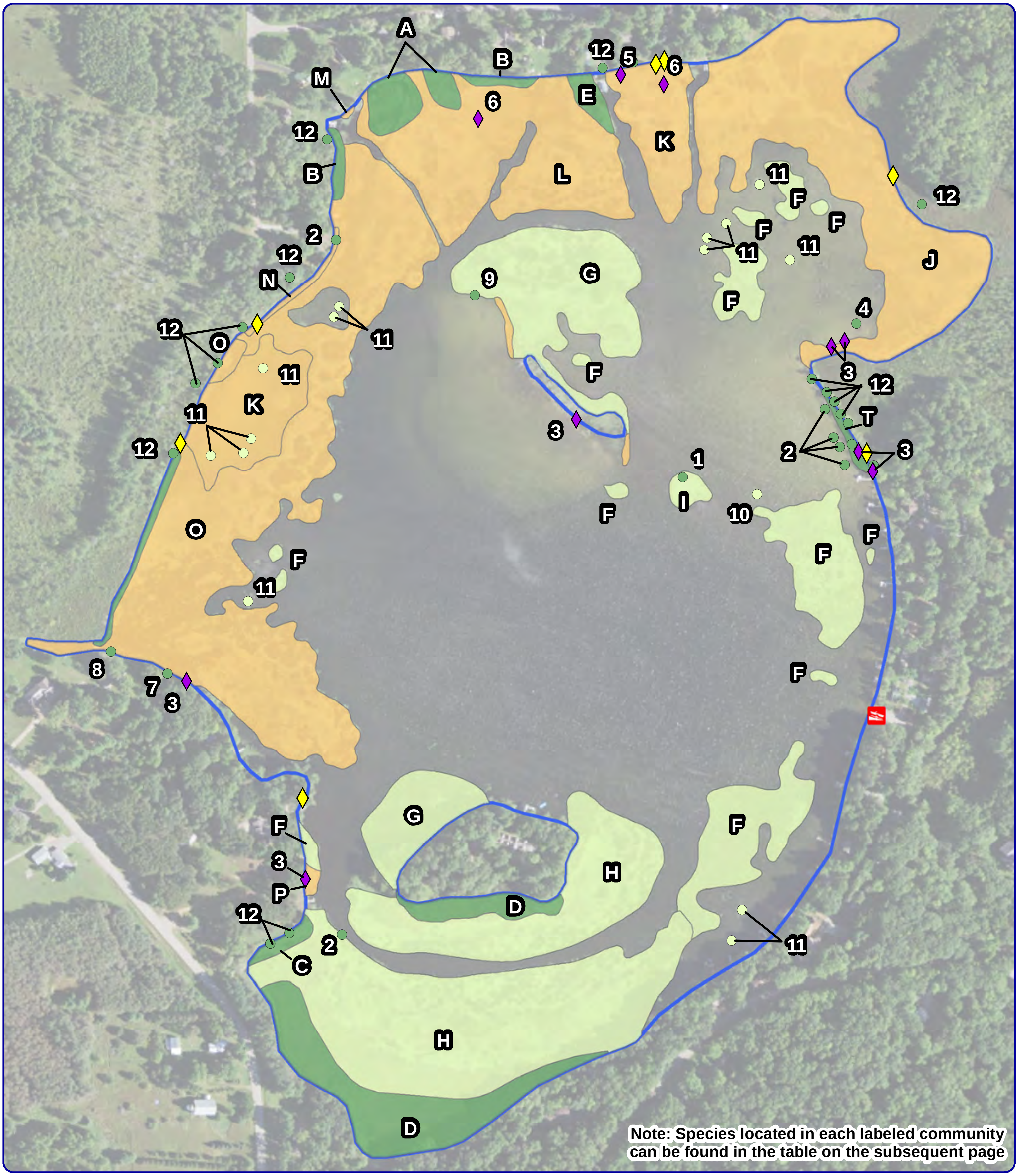
Sources
Hydro: WDNR, digitized by Onterra
CWH Survey: Onterra, 2020
Orthophotography: NAIP, 2020
Map date: November 25, 2020 HAL
Filename: Hatch_CWH_2020.mxd

Legend

2-8 Inch Pieces	8+ Inch Pieces	Cluster of Pieces
No Branches	No Branches	No Branches (*None found*)
Minimal Branches	Minimal Branches	Minimal Branches (*None found*)
Moderate Branches	Moderate Branches	Moderate Branches (*None found*)
Full Canopy	Full Canopy (*None found*)	Full Canopy (*None found*)

Map 4
Hatch Lake
Waupaca County, Wisconsin

2020 Coarse Woody Habitat Survey



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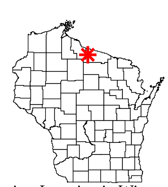
Sources
Hydro: WDNR
Aquatic Plants: Onterra, 2020
Orthophotography: NAIP, 2020
Map date: June 10, 2021 - EJH



Project Location in Wisconsin

Legend

Small Plant Communities	Large Plant Communities
Emergent	Emergent
Floating-leaf	Floating-leaf
Mixed Floating-leaf & Emergent	Mixed Floating-leaf & Emergent
Purple Loosestrife Present	Pale-yellow Iris

Map 5
Hatch Lake
Waupaca County, Wisconsin
Aquatic Plant Communities

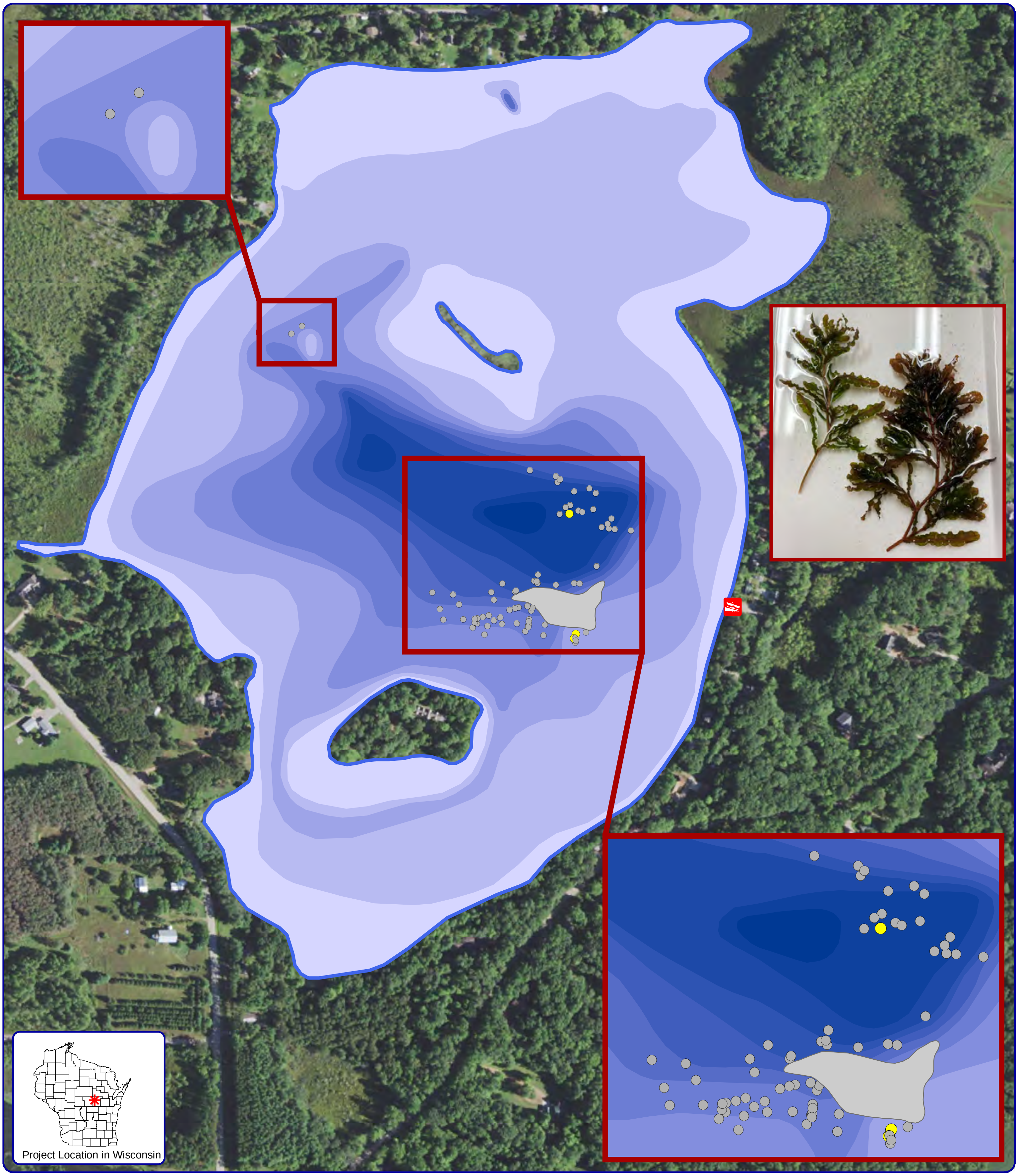
Hatch Lake 2020 Emergent & Floating-Leaf Plant Species

Corresponding Community Polygons and Points are displayed on Map 5

Large Plant Community (Polygons)								
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Acres**
A	Broad-leaved cattail	Twig rush	Purple loosestrife	Misc. Wetland Species				0.20
A	Broad-leaved cattail	Twig rush	Purple loosestrife	Misc. Wetland Species				0.52
B	Broad-leaved cattail	Purple loosestrife	Misc. Wetland Species					0.12
B	Broad-leaved cattail	Purple loosestrife	Misc. Wetland Species					0.14
C	Broad-leaved cattail							0.19
D	Broad-leaved cattail	Hardstem bulrush	Purple loosestrife	Misc. Wetland Species				2.74
D	Broad-leaved cattail	Hardstem bulrush	Purple loosestrife	Misc. Wetland Species				0.60
E	Broad-leaf cattail	Hardstem bulrush	Purple loosestrife					0.25
E	Broad-leaved cattail	Hardstem bulrush	Purple Loosestrife					0.26
T	Spatterdock	White water lily						0.23
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Acres**
F	White water lily							0.06
F	White water lily							1.86
F	White water lily							0.02
F	White water lily							0.08
F	White water lily							0.24
F	White water lily							0.04
F	White water lily							0.61
F	White water lily							0.08
F	White water lily							0.04
F	White water lily							0.08
F	White water lily							0.08
F	White water lily							0.06
F	White water lily							0.04
F	White water lily							2.03
F	White water lily							0.10
G	White water lily	Spatterdock						3.77
G	White water lily	Spatterdock						1.45
H	White water lily	Watershield	Spatterdock					8.54
H	Whie water lily	Watershield	Spatterdock					3.91
Floating-leaf & Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**	**Acres**
I	Twig rush	Hardstem bulrush	Creeping spikerush	Three-square rush	Common arrowhead	Robbins' spikerush		0.14
J	White water lily	Watershield	Spatterdock	Robbins' spikerush	Twig rush	Broad-leaf cattail	Purple loosestrife	7.78
K	White water lily	Spatterdock	Watershield	Robbins' spikerush				1.71
K	White water lily	Spatterdock	Watershield	Robbins' spikerush				2.16
L	White water lily	Watershield	Spatterdock	Robbins' spikerush	Water bulrush			5.30
M	White water lily	Spatterdock	Broad-leaved cattail	Water bulrush				0.02
N	Broad-leaved cattail	Purple loosestrife	Common reed	Bristly sedge	Spatterdock	white water lily	Misc. Wetland Species	0.14
O	White water lily	Spatterdock	Watershield	Robbins' spikerush	Water bulrush			0.14
O	White water lily	Spatterdock	Watershield	Robbins' spikerush	Water bulrush			12.17
P	White water lily	Hardstem bulrush	Broad-leaved cattail					0.07
R	Robbins' spikerush	Hardstem bulrush	Spatterdock	White water lily	Broad-lea cattail			0.15
S	White water lily	Hardstem bulrush						0.08
S	White water lily	Hardstem bulrush						0.04
								58.23

Small Plant Community (Points)							
Emergent	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**
1	Hardstem bulrush						
2	Robbins' spikerush						
3	Purple loosestrife						
4	Robbins' spikerush	Hardstem bulrush					
5	Broad-leaf cattail	Purple loosestrife	Hardstem bulrush	Common arrowhead	Misc. Wetland Species		
6	Hardstem bulrush	Purple loosestrife					
7	Broad-leaf cattail	Robbins' spikerush	Common arrowhead	Softstem bulrush			
8	Broad-leaf cattail						
9	Hardstem bulrush						
12	Northern blue-flag iris						
Floating-leaf	**Species 1**	**Species 2**	**Species 3**	**Species 4**	**Species 5**	**Species 6**	**Species 7**
10	Spatterdock						
11	White water lily						

Species are listed in order of dominance within the community; Scientifc names can be found in the species list in Table 3.4-2



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- Highly Scattered
- Scattered *(none found)*
- Dominant *(none found)*
- Highly Dominant *(none found)*
- Surface Matting *(none found)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony *(none found)*

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Sources
Roads and Hydro: WDNR
Bathymetry: Onterra, 2020
Aquatic Plants: Onterra, 2020
Orthophotography: NAIP, 2020
Map Date: June 9, 2020 JMB
Filename: *Hatch_CLP_June20.mxd*

Map 6
Hatch Lake
Waupaca County, Wisconsin

June 2020 CLP Survey Results