Upper Kaubashine Lake
Oneida County, Wisconsin
Comprehensive Management Plan
February 2019

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Funded by: Town of Hazelhurst
Upper Kaubashine Property Owners Association
Wisconsin Dept. of Natural Resources
(AIRR20816)

Acknowledgements

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

Upper Kaubashine Lake Planning Committee

Mary Beckley	Jack Novotney
Renee Zahery	Ron Theis
-Name Omitted -	*-Name Omitted -*

Upper Kaubashine Lake Board of Directors

Mary Beckley	Harland Lee
Mike Fassbender	Renee Zahery
Bill Shepherd	

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1.0 INTRODUCTION

According to the 1969 recording sonar Wisconsin Department of Natural Resources (WDNR) Lake Survey Map, Upper Kaubashine Lake is 190 acres. The WDNR website list the lake as 181 acres. At the time of this planning project, the most current orthophoto (aerial photograph) was from the *National Agriculture Imagery Program (NAIP*) collected in Spring 2015. Based upon heads-up digitizing the water level from that photo, the lake was determined to be 191.3 acres.

According to a 2017 acoustic-based bathymetric modeling survey, this mesotrophic spring lake has a maximum depth of 57 feet. Upper Kaubashine Lake contains 25 native plant species, of which Eurasian watermilfoil and common waterweed are the most common plants. Two exotic plant species are known to exist in Upper Kaubashine Lake, Eurasian watermilfoil and purple loosestrife.

Field Survey Notes

Upper Kaubashine Lake is a deep lake with beautiful, clear water and mostly natural shoreline of cobble and boulders. Fieldcrews have observed numerous loons, eagles, and even otters on Upper Kaub.

Photograph 1.0-1. Upper Kaubashine Lake, Oneida County

Lake at a Glance - Upper Kaubashine Lake

Morphology	
Acreage	191.3
Maximum Depth (ft)	57
Mean Depth (ft)	26.6
Shoreline Complexity	3.4
Vegetation	
Most Recent Comprehensive Survey Date	August 17, 2017
Number of Native Species	25
Threatened/Special Concern Species	-
Exotic Plant Species	Eurasian watermilfoil, Purple loosestrife
Simpson's Diversity	0.88
Average Conservatism	6.7
Water Quality	
Trophic State	mesotrophic
Watershed to Lake Area Ratio	3:1

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 updates within the lake group's newsletter.

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

Kick-off Meeting

On July 16, 2016, a project kick-off meeting was held to introduce the project to the Upper Kaubashine Property Owners Association (UKPOA) and other riparians or interested citizens that wished to attend. The meeting was announced through a mailing and personal contact by UKPOA board members. The attendees observed a presentation given by Tim Hoyman, an aquatic ecologist with Onterra. Mr. Tim Hoyman's presentation included an educational component regarding general lake ecology and a detailed description of the project including opportunities for stakeholders to be involved. Additional topics such as Eurasian water milfoil (EWM) control strategies, hand-harvesting, herbicide treatment strategies and risks, and the WDNR's EWM Long-Term Trends Monitoring Program were discussed. The presentation was followed by a question and answer session.

Planning Committee Meeting I

On June 5, 2017, Tim Hoyman and Eddie Heath of Onterra met with five of the six members of the Upper Kaubashine Lake Planning Committee for nearly 4 hours. Also in attendance were two members of the UKPOA Board of Directors that were not on the Planning Committee as well as Kevin Gauthier from the WDNR. In advance of the meeting, attendees were provided an early draft of the study report sections (watershed, shoreland condition, and vegetation sections) to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions to the committee.

Planning Committee Meeting II

On June 28, 2017, Tim Hoyman and Eddie Heath met with the same attendees to begin developing management goals and actions for the Upper Kaubashine Lake management plan. The majority of the discussions at this 3-hour meeting were focused on the development of management goals and objectives for Eurasian watermilfoil.

Project Wrap-up Meeting

Scheduled for June 15, 2019

Management Plan Review and Adoption Process

On July 12, 2017, the UKPOA members received email two documents through email: 1) an outline of the Implementation Plan that had been prepared by Onterra based on the discussions from Planning Committee Meetings I and II; and 2) a *10 Eurasian Watermilfoil Myths and Facts* document prepared by the UKPOA Planning Committee with review from Onterra and WDNR that was meant to help Lake stakeholders gain a better understanding of the EWM issue (Appendix D).

Comments received from the Implementation Outline were integrated into a preliminary draft of the compiled management plan being sent to the UKPOA Planning Committee on October 24, 2017. On February 2, 2018, feedback and comments from the Planning Committee were closed and those received to date were integrated into the Official First Draft. One Planning Committee member did not have sufficient time to provide comments to this draft, but provided comments to the Official First Draft.

On February 9, 2018, an official first draft of the UKPOA's Comprehensive Management Plan was supplied for review to the Local WDNR Aquatic Specialists, WDNR Statewide Researchers, Local WDNR Fisheries Manager, Great Lakes Indian Fish & Wildlife Service, Oneida County, Town of Hazelhurst, and Oneida County Land and Water Conservation Committee.

Written review of the draft plan by WDNR (includes contracted staff from UW-Extension) were received on March 27, 2018 (46 days later). No other entity provided formal comment on the draft plan. Additional Planning Committee review comments and statements of opinions were received. Constructive comments were integrated. The WDNR comments and how they are addressed in the final plan are contained in Appendix F.

An official Second Draft was provided to WDNR on December 13, 2018. The WDNR provided final approval of UKPOA's Comprehensive Management Plan on February 18, 2019.

Stakeholder Survey

As a part of this project, a stakeholder survey was conducted to understand the perceptions of folks that own property on Upper Kaubashine Lake. The distribution list included all members of the association, regardless if they solely owned the property or jointly owned the property. Only three riparian properties do not have representation in the UKPOA, and they were provided one survey per property.

A base set of standard questions was provided to the UKPOA Planning Committee for initial review. Approximately one month after the survey was first sent to the UKPOA Planning Committee, Onterra advised that two additional questions (#28 and #29) about herbicide use in Upper Kaubashine Lake be added to the survey. These questions were forwarded on to the Planning committee the same day. These questions were accepted by the committee and added to the subsequent draft, along with other committee comments. This updated version was re-submitted to the Planning Committee for review. Once Onterra received approval, the survey was submitted to a WDNR social scientist by Onterra to assure integrity and objectivity. This is standard procedure required by the WDNR on all grant-funded projects. The social scientist asked that some additional text be added above question #28 and #29 for context. Onterra worked with the WDNR social scientist to rewrite the standard wording of the paragraph to make sure the words were as unbiased as possible. The WDNR-approved draft of the survey was then sent to the

UKPOA Planning Committee for final review before it was distributed. The addition of the paragraph before Questions 28 and 29 was not explicitly expressed as needing review, but the chair of the Planning Committee did request that the committee members review the survey one last time and send any additional changes to Onterra. Two members of the planning committee believe, after the WDNR review, that the text added before Questions 28 and 29 remained biased.

During October 2016, the eight-page, 37-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 UKPOA volunteer for analysis. Seventy-seven percent of the surveys were returned. With a response rate of 60% or higher, the responses to the following questions can be interpreted as being statistically representative of the population sampled. Therefore, when the following section discusses percent of stakeholders, it is reflective of the population that was provided surveys. It is not reflective of the percent of parcels, acreage, shoreline length, etc.

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. Please note that the final question of the survey allowed respondents to provide overall comments. These comments are included in their un-edited entirety unless they threatened the anonymity of the survey or used inappropriate language.

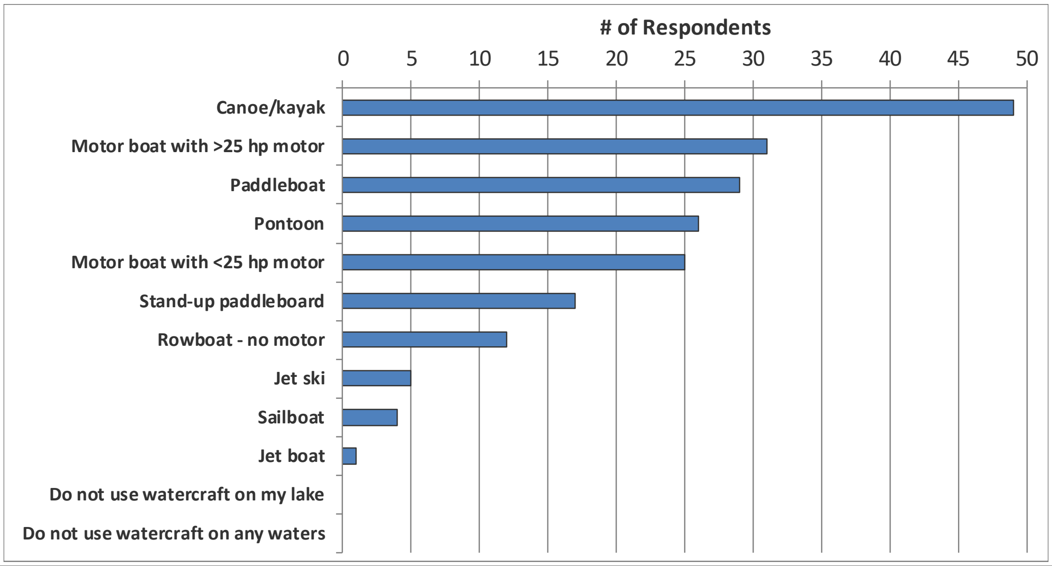
Based upon the results of the Stakeholder Survey, much was learned about the people that use and care for Upper Kaubashine Lake. The plurality of stakeholders (44%) visit on weekends throughout the year, while 26% live on the lake in the summer months only, and 17% are year-round residents (Question 1). 56% of stakeholders have owned their property for over 15 years, and 29% have owned their property for over 25 years (Question 2). Nine (14%) of the respondents answered *other* to this question, and their responses indicated that they use their lake property at various times throughout the year on an intermittent basis. Most stakeholder respondents (58%) indicated that their property is used 0 to 100 days per year, while 10 (15%) respondents noted using the property 301 to 365 days per year. Nearly half (47%) of the respondents have owned their property for 20 years or more, with 29% owning for more than 25 years.

The data also suggest that quiet motor sports (those involving the use of a non-motorized watercraft or boats operated with a low horsepower (hp) motor) are fairly typical on Upper Kaubashine (Figure 2.0-1, Question 13). For example, 74% of the respondents indicated they use a canoe or kayak; 38% use a low hp motor, 44% use a paddleboat; 26% use a stand-up paddleboard, 18% use a rowboat, and 6% use a sailboat. On the other hand, 47% of the respondents use a motorboat with a motor having more than 25 hp, 39% use a pontoon boat, and 8% of the respondents use a jet-ski.

When respondents were asked to indicate the top three reasons for owning property on Upper Kaubashine Lake (Figure 2.0-1, Question 17), relaxing/entertaining, and fishing in open water were the most frequent responses (39 and 40 responses, respectively). Swimming, nature viewing, and canoeing/kayaking (29, 25, and 23 responses, respectively) also were ranked highly. Motor boating, which could be at high speeds or low speeds, was indicated by 18 respondents among their top three choices.

A concern of stakeholders noted throughout the stakeholder survey (see Question 18 and survey comments – Appendix B) was aquatic invasive species and Eurasian watermilfoil expansion in Upper Kaubashine Lake. This topic is touched upon in the Summary & Conclusions section as well as within the Implementation Plan.

Question 13: What types of watercraft do you currently use on the lake?



Question 17: Please rank up to three activities that are important reasons for owning your property on or near the lake.

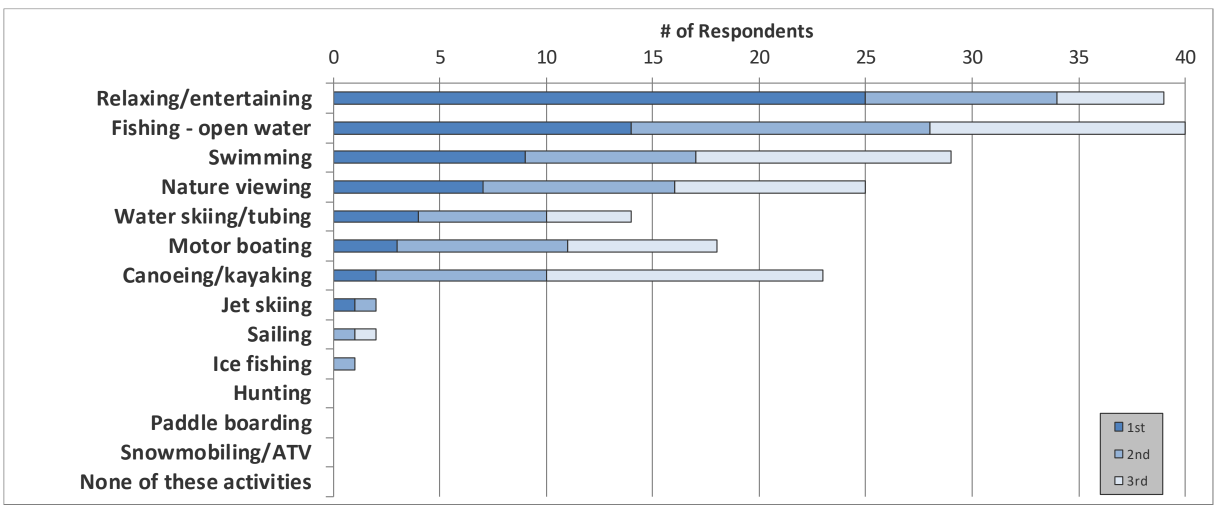
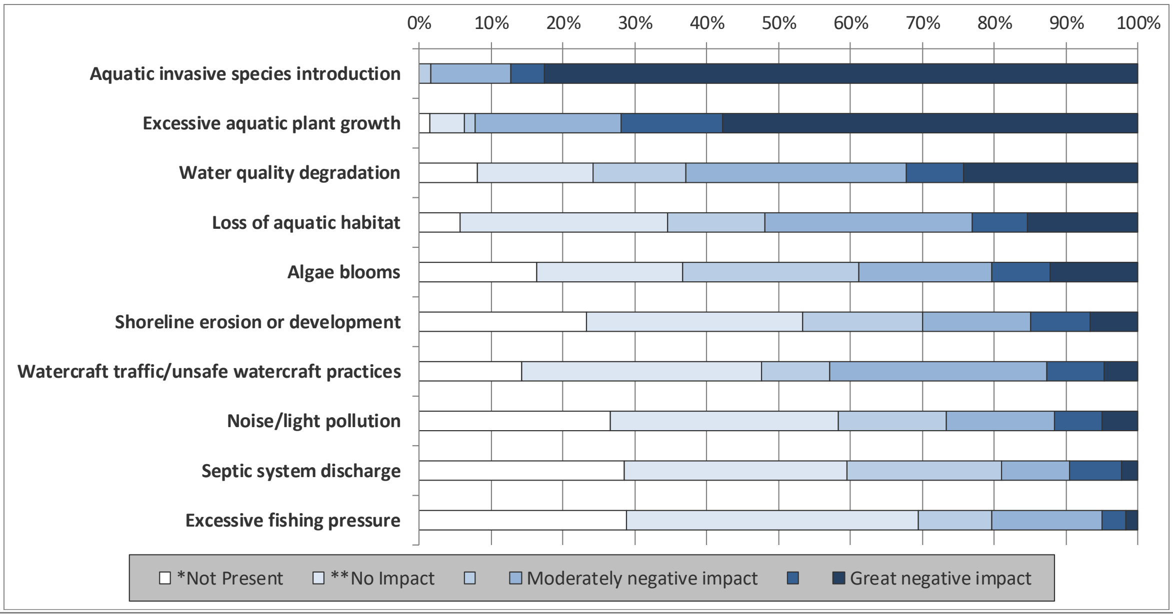


Figure 2.0-1. Select survey responses from the Upper Kaubashine Lake Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Question 23: To what level do you believe these factors may be negatively impacting Upper Kaubashine Lake?



Question 24: Please rank your top three concerns regarding Upper Kaubashine Lake.

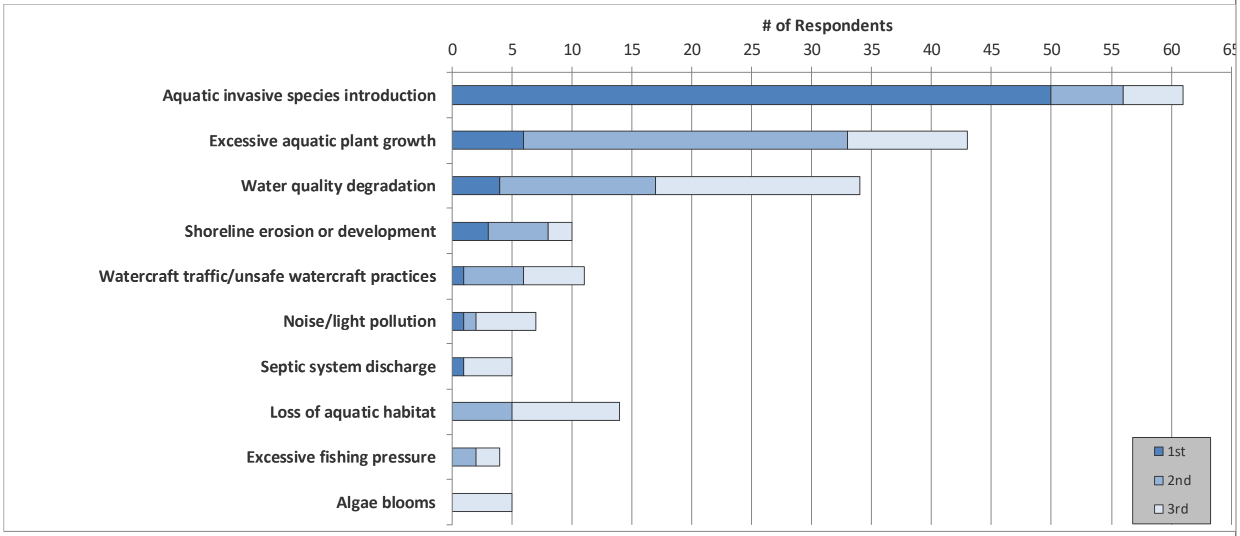


Figure 2.0-2. Select survey responses from the Upper Kaubashine Lake Stakeholder Survey, continued. Additional questions and response charts may be found in Appendix B.

3.0 RESULTS & DISCUSSION

3.1 Lake Water Quality

Primer on Water Quality Data Analysis and Interpretation

Reporting of water quality assessment results can often be a difficult and ambiguous task. Foremost is that the assessment inherently calls for a baseline knowledge of lake chemistry and ecology. Many of the parameters assessed are part of a complicated cycle and each element may occur in many different forms within a lake. Furthermore, 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 analysis are used to indicate not only the health of the lake, but also to provide a general understanding of the lake's ecology, which can then 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 Upper Kaubashine Lake is compared to other lakes in the state with similar characteristics as well as to lakes within the northern region. 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 Upper Kaubashine Lake's water quality analysis:

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

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

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

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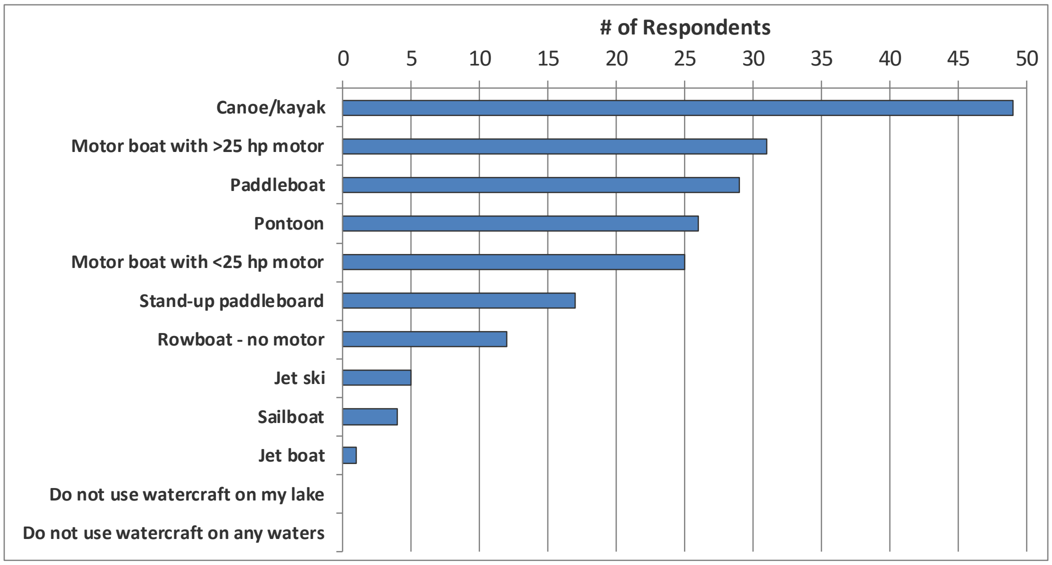

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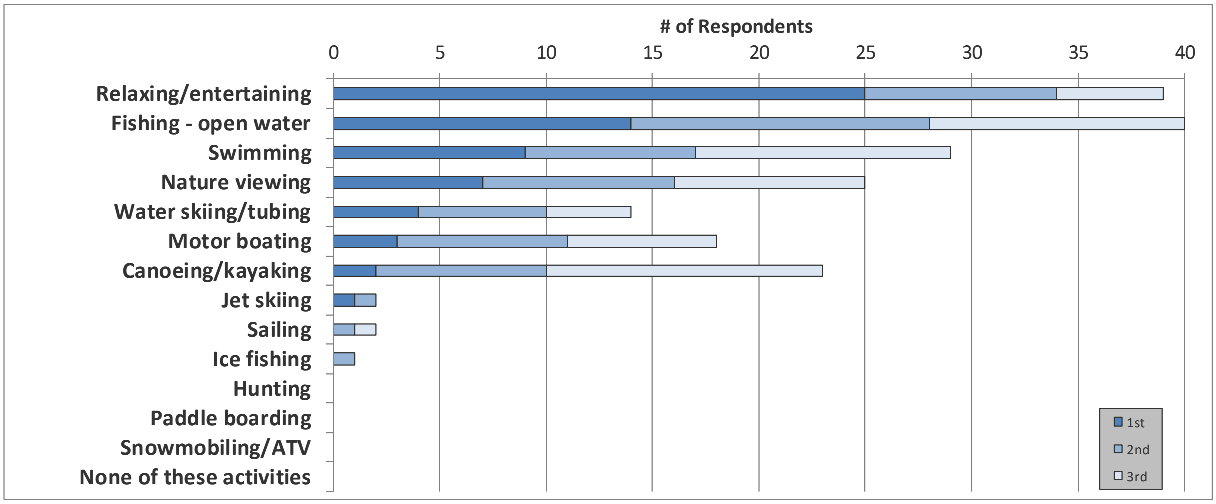

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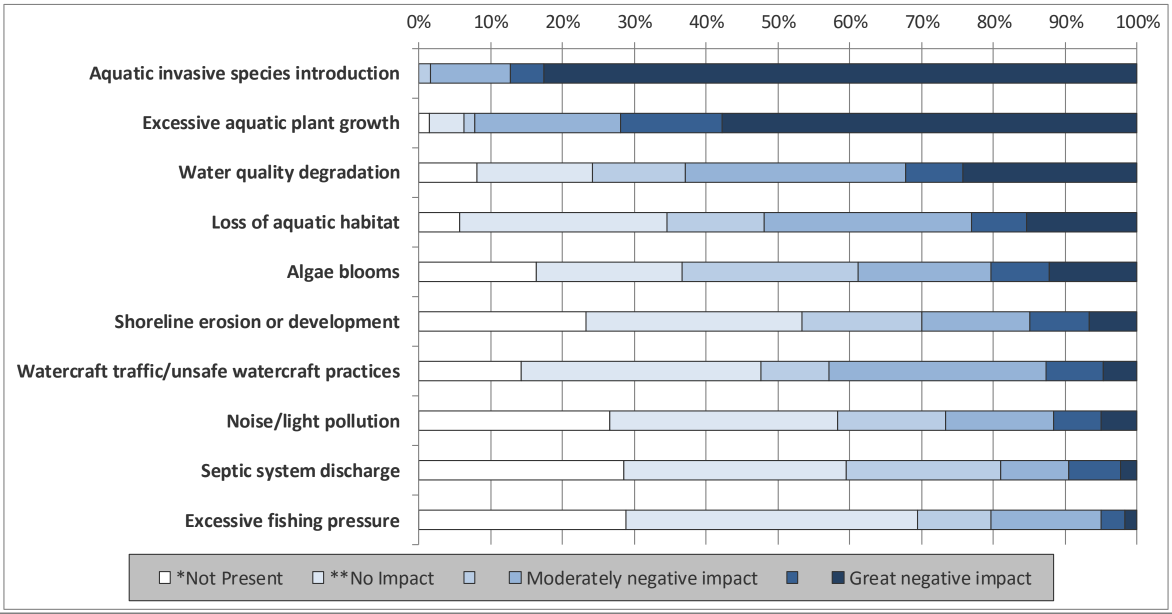

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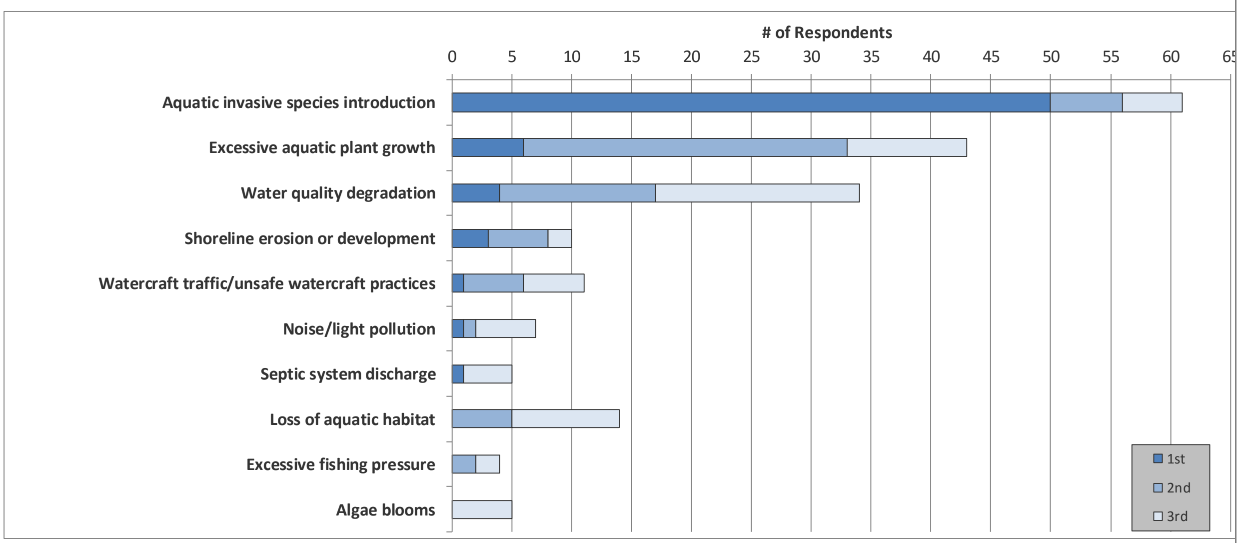

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The parameters described above are interrelated. Phosphorus controls algal abundance, which is measured by chlorophyll-*a* levels. Water clarity, as measured by Secchi disk transparency, is directly affected by the particulates that are suspended in 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). Water quality and water clarity have different meanings to professional limnologists.

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 a 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 more clear understanding of the lake's trophic state while facilitating clearer long-term tracking. Carlson (1977) presented a trophic state index that gained great acceptance among lake managers.

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.

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 process that occur within a lake. Internal nutrient loading is an excellent example that is described below.

Lake stratification occurs when temperature gradients are developed with depth in a lake. During stratification the lake can be broken into three layers: The 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.

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 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 2014 Consolidated Assessment and Listing Methodology* (WDNR 2013) 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 land cover. For this reason, the water quality of Upper Kaubashine 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, 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, Upper Kaubashine Lake is classified as a deep, headwater drainage lake (category 3 on Figure 3.1-1). Spring lakes are a type of headwater drainage lakes where the primary source of water is from groundwater and the outlet is intermittent (not always flowing). Drained lakes are a type of headwater drainage lake with a continuously flowing outlet and the primary water source is from precipitation and overland runoff. The WDNR lists Upper Kaubashine as a spring lake.

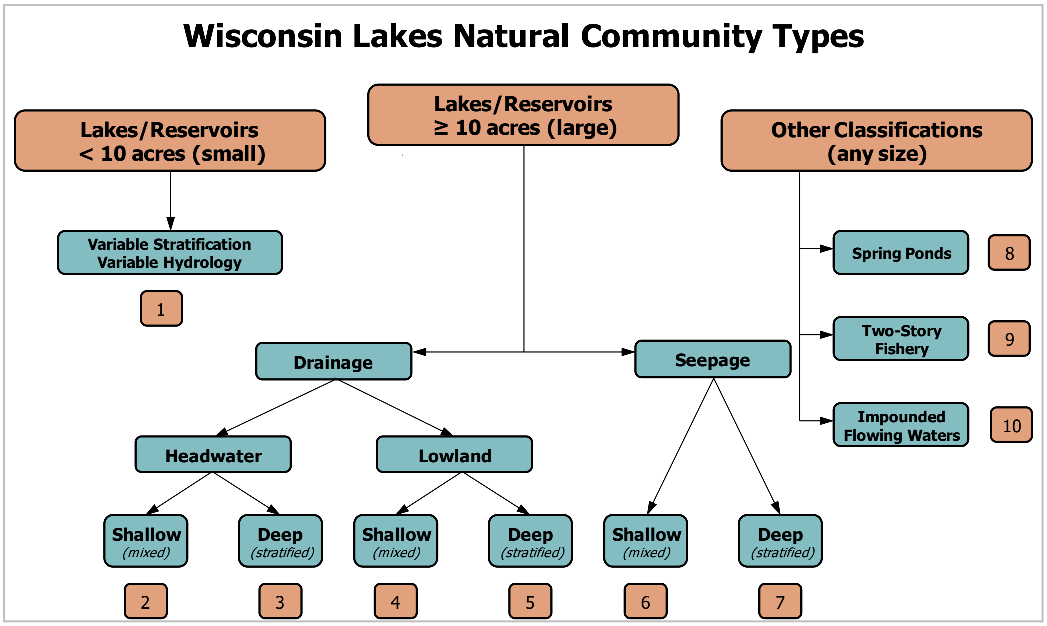


Figure 3.1-1. Wisconsin Lake Natural Communities. Adapted from WDNR 2013A.

Garrison, et. al (2008) developed state-wide 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. Upper Kaubashine Lake is within the Northern Lakes and Forests (NLF) ecoregion.

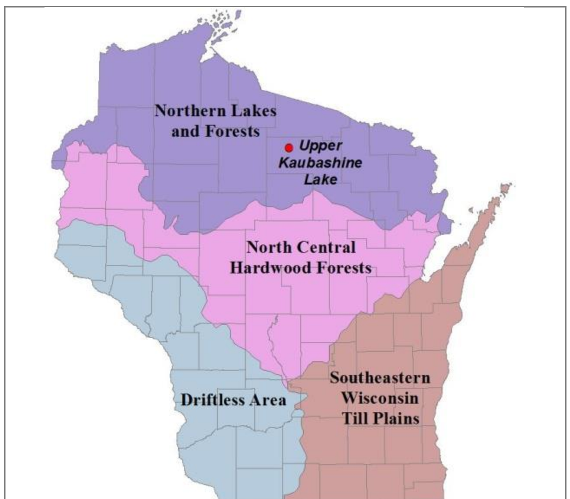


Figure 3.1-2. Location of Upper Kaubashine Lake within the ecoregions of Wisconsin. After Nichols 1999.

The Wisconsin 2014 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 Secchi depth data from Upper Kaubashine Lake is displayed in Figures 3.1-3 - 3.1-4. Please note that the data in these graphs represent 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.

Upper Kaubashine Lake Water Quality Analysis

Water Clarity

The only historical water quality data available from Upper Kaubashine Lake is Secchi disk depth, making long-term trends analysis of total phosphorus and chlorophyll-*a* impossible. Water clarity is measured using a Secchi disk and data is available from 1979 and from 2002-2007. Sporadic water clarity data was collected between 2007 to 2017, although not formally as part of the Citizens Lake Monitoring Network. These data may be included at a later date if they comply with the merits of this program (i.e. training, documentation, etc.). The average summer water clarity was 18.2 feet, well into the *excellent* category for deep, headwater drainage lakes in Wisconsin and exceeding the median value for lakes within the NLF ecoregion (Figure 3.1-3).

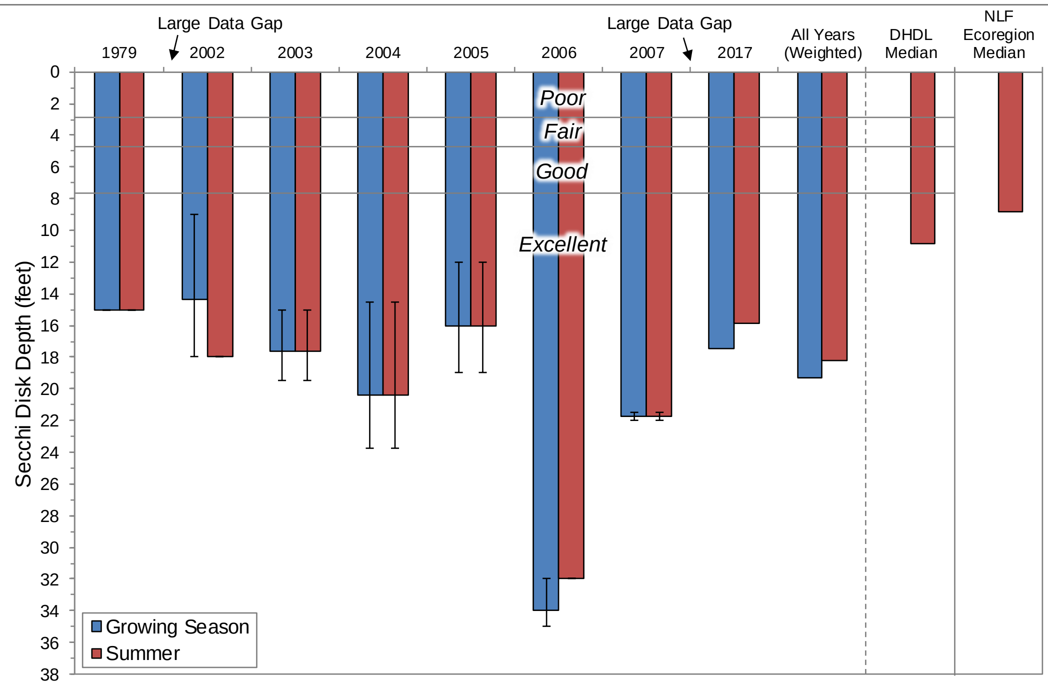


Figure 3.1-3. Upper Kaubashine Lake, state-wide class 3 lakes, and regional Secchi disk clarity values. Mean values calculated with summer month surface sample data. Water Quality Index values adapted from WDNR PUB WT-913.

Upper Kaubashine Lake Total Phosphorus and Chlorophyll-a

Total phosphorus and chlorophyll-a data are only available from the summer of 2017 following the UKPOA's entry into the advanced CLMN program. The mean summer total phosphorus concentration is 16.4 µg/L, falling into the *excellent* category for deep, headwater drainage lakes. The mean summer chlorophyll-a concentration was 4.7µg/L, also in the *excellent* category for lakes of the same classification.

Upper Kaubashine Lake Trophic State

Figure 3.1-4 contains the Trophic State Index (TSI) values for Upper Kaubashine Lake. These TSI values are calculated using available historical summer Secchi disk transparency data. In general, the best values to use in assessing a lake's trophic state are chlorophyll-*a* and total phosphorus, as water clarity can be influenced by factors other than phytoplankton such as dissolved organic compounds.

The weighted TSI values for Secchi disk depth in Upper Kaubashine Lake indicate the lake is at present in an oligotrophic state. However, a year's worth of biologically-related values like chlorophyll-*a* and total phosphorus suggest that Upper Kaubashine contains a moderate level of productivity and classified as mesotrophic (Figure 3.1-4). When determining the amount of productivity in a lake, limnologists give more weight to biological-driven parameters such as measured nutrients (total phosphorus) and measured free-floating algal abundance (chlorophyll-a) than surrogate parameters such as how clear the water is (Secchi disk) that are impacted by nonbiological factors (dissolved organic compounds, marl precipitates, etc.).

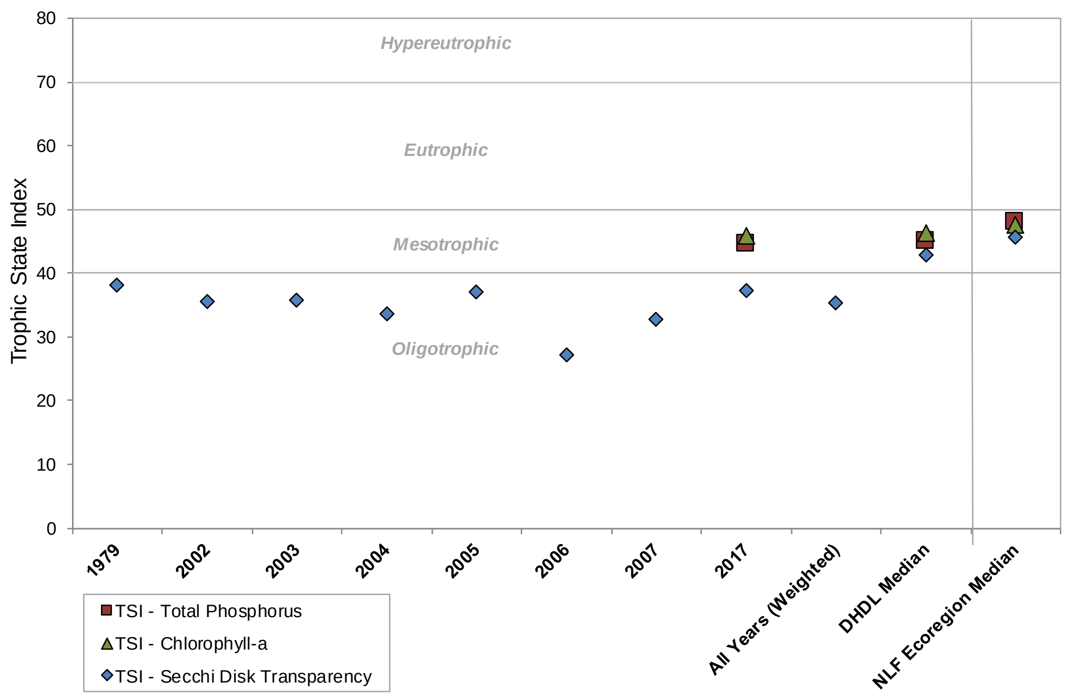


Figure 3.1-4. Upper Kaubashine Lake, state-wide class 3 lakes, and regional Trophic State Index values. Values calculated with summer month surface sample data using WDNR PUB-WT-193.

Additional Water Quality Data Collected at Upper Kaubashine Lake

Zebra mussels (*Dreissena polymorpha*) are a 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.

Researchers at the University of Wisconsin - Madison have developed an AIS suitability model called smart prevention (Vander Zanden and Olden 2008). In regards to zebra mussels, this model relies on measured or estimated dissolved calcium concentration to indicate whether a given lake in Wisconsin is suitable, borderline suitable, or unsuitable for sustaining zebra mussels. Within this model, suitability was estimated for approximately 13,000 Wisconsin waterbodies and is displayed as an interactive mapping tool (www.aissmartprevention.wisc.edu). Based upon this analysis, Upper Kaubashine Lake was considered borderline suitable for mussel establishment.

Zebra mussels and quagga mussels (both *Dreissena* spp.) have a free-floating planktonic larval stage to their lifecycle. Standard monitoring of zebra mussels looks for the larval stages within plankton net samples at specific times of the year. The plankton samples are then analyzed under a microscope for the presence of invasive mussels. To date, not larval zebra mussel samples have been collected on Upper Kaubashine Lake. No adult zebra mussels have been observed from Upper Kaubashine Lake, although no systematic surveys have been completed to date.

Stakeholder Survey Responses to Upper Kaubashine 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. Of the 86 surveys distributed, 66 (77%) were returned. With a response rate of 60% or higher, the responses to the following questions regarding water quality can be interpreted as being statistically representative of the population sampled.

Figure 3.1-5 displays the responses of Upper Kaubashine Lake riparian stakeholders to questions regarding water quality of Upper Kaubashine Lake. When asked how the they would describe the current water quality of Upper Kaubashine Lake, 34% of respondents indicated *excellent*, 28% indicated *good*, 23% indicated *fair*, 11% indicated *poor*, 3% indicated *very poor*, and 1% indicated that they were *unsure*.

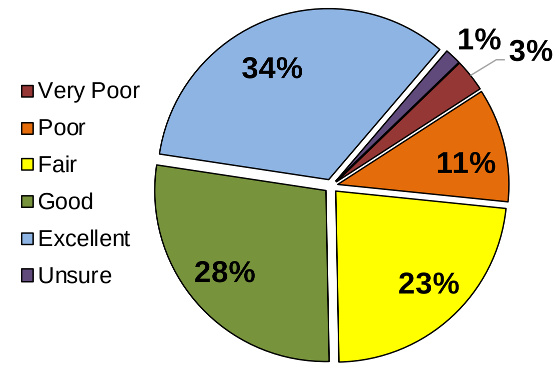


Figure 3.1-5. Stakeholder survey response Question #18. How would you describe the current water quality of Upper Kaubashine Lake?

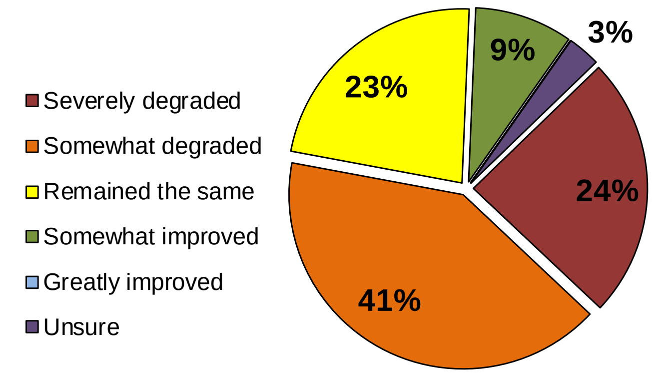


Figure 3.1-6. Stakeholder survey response Question #19. How as the water quality changed in Upper Kaubashine Lake since you first visited the lake?

When asked how they believe the water quality has changed since they first visited the lake, the majority, 41% indicated it has *somewhat degraded*, 24% indicated it has *severely degraded*, 23% indicated it has *remained the same*, 9% indicated it has *somewhat improved*, and 3% indicated that they were *unsure* (Figure 3.1-6). As discussed in the previous section, the lack of water quality data means the current state of Upper Kaubashine Lake's water quality cannot be discerned. The available historic water clarity data indicates that the lake had excellent water clarity; however, there are no data available to show how the current clarity has changed. The stakeholders who indicated that the lake's water clarity has somewhat or severely degraded may be taking into account Eurasian watermilfoil growth in the lake or may have observed increases in aquatic plant abundance within the lake. But again, the lack of historical data means no determination can be made if the lake's water quality has improved or degraded over time.

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

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

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

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

Regardless of the size of the watershed or the makeup of its land cover, it must be remembered that every lake is different and other factors, such as flushing rate, lake volume, sediment type, and many others, also influence how the lake will react to what is flowing into it. For instance, a deeper lake with a greater volume can dilute more phosphorus within its waters than a less voluminous lake and as a result, the production of a lake is kept low. However, in that same lake, because of its low flushing rate (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 land cover within the watershed to produce useful information about the lake ecosystem. This information includes an estimate of annual phosphorus load and the partitioning of those loads between the watershed's different land cover types and atmospheric fallout entering through the lake's water surface. WiLMS also calculates the lake's flushing rate and residence times using county-specific average precipitation/evaporation values or values entered by the user. Predictive models are also included within WiLMS that are valuable in validating modeled phosphorus loads to the lake in question and modeling alternate land cover scenarios within the watershed. Finally, if specific information is available, WiLMS will also estimate the significance of internal nutrient loading within a lake and the impact of shoreland septic systems.

Upper Kaubashine Lake Watershed Assessment

Upper Kaubashine Lake's total watershed encompasses an area of approximately 685 acres (1.1 square miles) in Oneida County, yielding a watershed to lake area ratio of 3:1 (Map 2). In other words, approximately three acres of land drain to every one acre of Upper Kaubashine Lake. According to WiLMS modeling, the lake's water is completely replaced approximately every 7.9 years (residence time) or 0.1 times per year (flushing rate).

Approximately 46% of Upper Kaubashine Lake's watershed is composed of forest, 27% is composed of Upper Kaubashine Lake's surface, 22% is composed of pasture/grass, 5% is composed of wetlands, and less than 1% is composed of rural residential areas (Figure 3.2-1).

Using the landcover described above, WiLMS was utilized to estimate the annual potential phosphorus load from Upper Kaubashine Lake's watershed. It was estimated that approximately 120 pounds of phosphorus is delivered to Upper Kaubashine Lake from its watershed on an annual basis (Figure 3.2-2). Phosphorus loading from septic systems was also estimated using data obtained from the 2016 stakeholder survey of riparian property owners, and indicates that approximately 6 pounds, or roughly 5% of the annual phosphorus load is attributed to septic systems.

Of the estimated 120 pounds being delivered annually to Upper Kaubashine Lake, 40% is estimated to originate from direct atmospheric deposition into the lake, 33% from pasture/grass, 20% from forest, 5% from septic systems, and 2% from wetlands (Figure 3.2-2).

Using predictive equations, it was estimated that based on the potential annual phosphorus load, Upper Kaubashine Lake should have a growing season mean total phosphorus concentration of approximately 16.2 µg/L. The 2017 summer mean total phosphorus concentration was 16.4 µg/L, indicating lake's watershed and phosphorus inputs were likely modeled accurately.

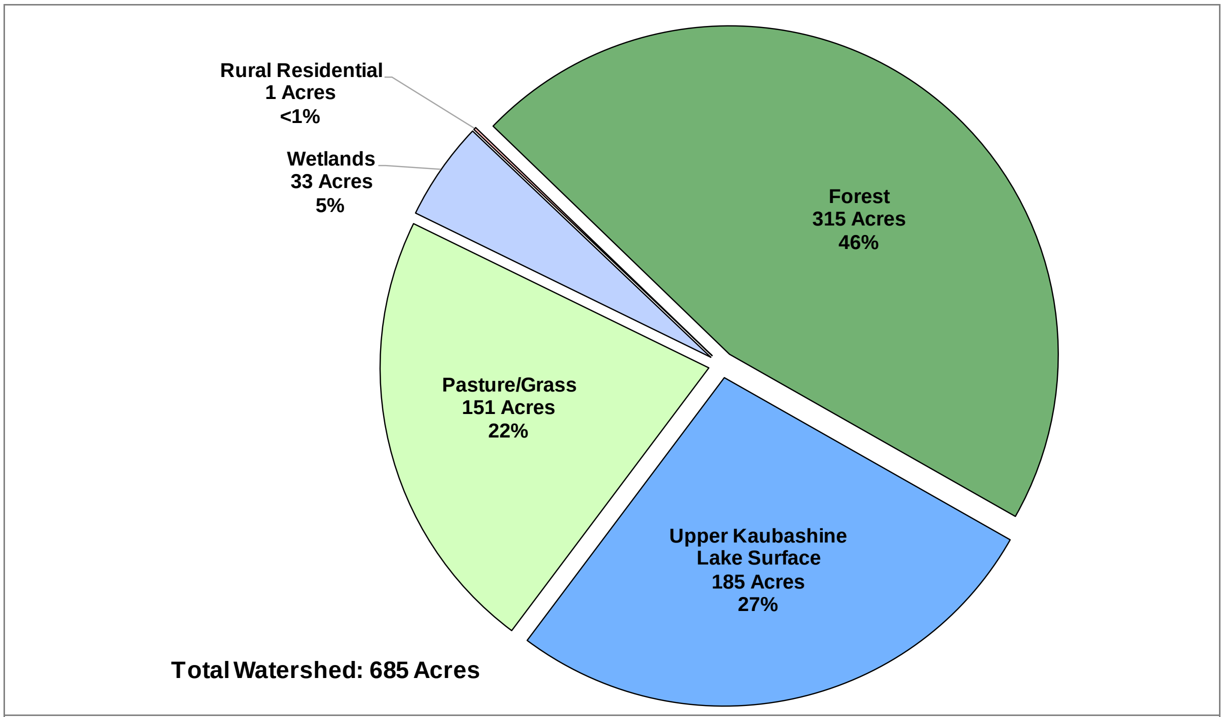


Figure 3.2-1. Upper Kaubashine Lake watershed land cover types in acres. Based upon National Land Cover Database (NLCD – Fry et. al 2011).

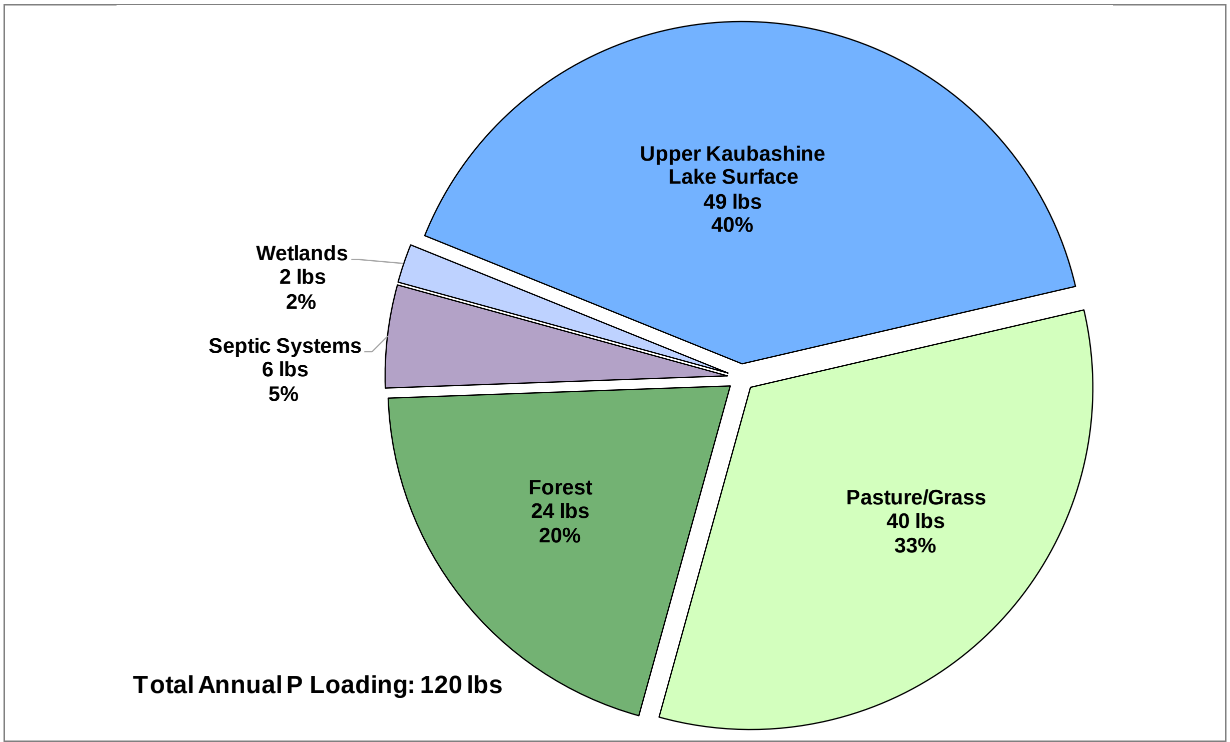


Figure 3.2-2. Upper Kaubashine Lake watershed phosphorus loading in pounds. Based upon Wisconsin Lake Modeling Suite (WiLMS) estimates.

3.3 Shoreland Condition

The Importance of a Lake's Shoreland Zone

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. Passed in February of 2010, the final 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. Please note that at the time of this writing, changes to NR 115 were last made in October of 2015 (Lutze 2015).

- 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: 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.

- 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 with the following caveats:
    - No expansion or complete reconstruction within 0-35 feet of shoreline
    - Re-construction may occur if the same type of structure is being built in the previous location with the same footprint. All construction needs to follow general zoning or floodplain zoning authority
    - Construction may occur if mitigation measures are included either within the existing footprint or beyond 75 feet.
    - Vertical expansion cannot exceed 35 feet

- 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.

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 ground water 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 et al. 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 et al 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 (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.

Cost

The cost of native, aquatic, and shoreland plant restorations is highly variable and depends on the size of the restoration area, the depth of buffer zone required to be restored, the existing plant density, the planting density required, the species planted, and the type of planting (e.g. seeds, bare-roots, plugs, live-stakes) being conducted. Other sites may require erosion control stabilization measures, which could be as simple as using erosion control blankets and plants and/or seeds or more extensive techniques such as geotextile bags (vegetated retaining walls), geogrids (vegetated soil lifts), or bio-logs (see above picture). Some of these erosion control techniques may reduce the need for rip-rap or seawalls which are sterile environments that do not allow for plant growth or natural shorelines. Questions about rip-rap or seawalls should be directed to the local Wisconsin DNR Water Resources Management Specialist. Other measures possibly required include protective measures used to guard newly planted area from wildlife predation, wave-action, and erosion, such as fencing, erosion control matting, and animal deterrent sprays. One of the most important aspects of planting is maintaining moisture levels. This is done by watering regularly for the first two years until plants establish themselves, using soil amendments (i.e., peat, compost) while planting, and using mulch to help retain moisture.

Most restoration work can be completed by the landowner themselves. To decrease costs further, bare-root form of trees and shrubs should be purchased in early spring. If additional assistance is needed, the lakefront property owner could contact an experienced landscaper. For properties with erosion issues, owners should contact their local county conservation office to discuss cost-share options.

In general, a restoration project with the characteristics described below would have an estimated materials and supplies cost of approximately $1,400. The more native vegetation a site has, the lower the cost. Owners should contact the county's regulations/zoning department for all minimum requirements. The single site used for the estimate indicated above has the following characteristics:

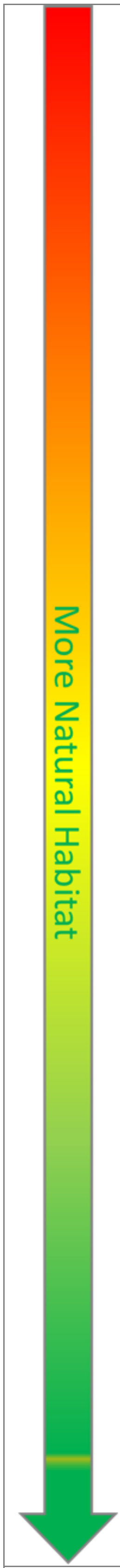
- Spring planting timeframe.
- 100' of shoreline.
- An upland buffer zone depth of 35'.
- An access and viewing corridor 30' x 35' free of planting (recreation area).
- Planting area of upland buffer zone 2- 35' x 35' areas
- Site is assumed to need little invasive species removal prior to restoration.
- Site has only turf grass (no existing trees or shrubs), a moderate slope, sandy-loam soils, and partial shade.
- Trees and shrubs planted at a density of 1 tree/100 sq. ft and 2 shrubs/100 sq. ft, therefore, 24 native trees and 48 native shrubs would need to be planted.
- Turf grass would be removed by hand.
- A native seed mix is used in bare areas of the upland buffer zone.
- An aquatic zone with shallow-water 2 - 5' x 35' areas.
- Plant spacing for the aquatic zone would be 3 feet.
- Each site would need 70' of erosion control fabric to protect plants and sediment near the shoreland (the remainder of the site would be mulched).
- Soil amendment (peat, compost) would be needed during planting.
- There is no hard-armor (rip-rap or seawall) that would need to be removed.
- The property owner would maintain the site for weed control and watering.

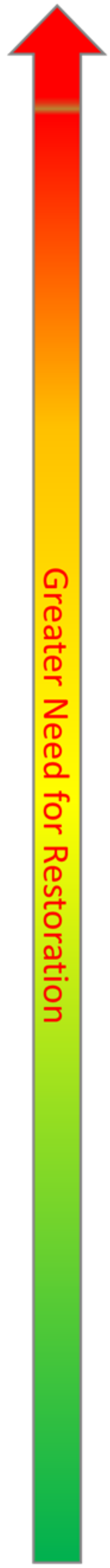
Advantages	*Disadvantages*
• Improves the aquatic ecosystem through species diversification and habitat enhancement. • Assists native plant populations to compete with exotic species. • Increases natural aesthetics sought by many lake users. • Decreases sediment and nutrient loads entering the lake from developed properties. • Reduces bottom sediment re-suspension and shoreland erosion. • Lower cost when compared to rip-rap and seawalls. • Restoration projects can be completed in phases to spread out costs. • Once native plants are established, they require less water, maintenance, no fertilizer; provide wildlife food and habitat, and natural aesthetics compared to ornamental (non-native) varieties. • Many educational and volunteer opportunities are available with each project.	• Property owners need to be educated on the benefits of native plant restoration before they are willing to participate. • Stakeholders must be willing to wait 3-4 years for restoration areas to mature and fill-in. • Monitoring and maintenance are required to assure that newly planted areas will thrive. • Harsh environmental conditions (e.g., drought, intense storms) may partially or completely destroy project plantings before they become well established.

Upper Kaubashine Lake Shoreland Zone Condition

Shoreland Development

Upper Kaubashine 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 3.3-1. Shoreland assessment category descriptions.

On Upper Kaubashine Lake, the development stage of the entire shoreland was surveyed during the Spring of 2017, 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 in Figure 3.3-2.

Upper Kaubashine Lake has stretches of shoreland that fit all of the five shoreland assessment categories. In all, 2.2 miles of natural/undeveloped and developed-natural shoreland were observed during the survey (Figure 3.3-2). These shoreland types provide the most benefit to the lake and should be left in their natural state if at all possible. During the survey, 0.9 miles of urbanized and developed–unnatural shoreland were observed. If restoration of the Upper Kaubashine Lake shoreland is to occur, primary focus should be placed on these shoreland areas as they currently provide little benefit to, and actually may harm, the lake ecosystem. Map 3 displays the location of these shoreland lengths around the entire lake.

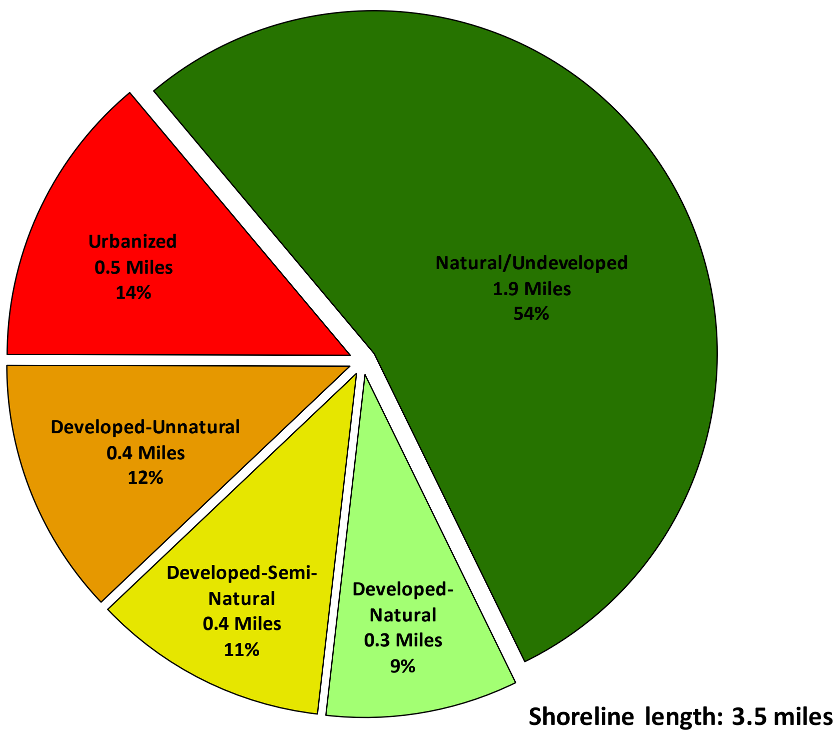


Figure 3.3-2. Upper Kaubashine Lake shoreland categories and total lengths. Based upon an Spring 2017 survey. Locations of these categorized shorelands can be found on Map 3.

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. And, 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, Upper Kaubashine 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, and cluster 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, 212 total pieces of coarse woody habitat were observed along 3.5 miles of shoreline (Map 4), which gives Upper Kaubashine Lake a coarse woody habitat to shoreline mile ratio of 61:1 (Figure 3.3-3). Only instances where emergent coarse woody habitat extended from shore into the water were recorded during the survey.

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 Upper Kaubashine 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.

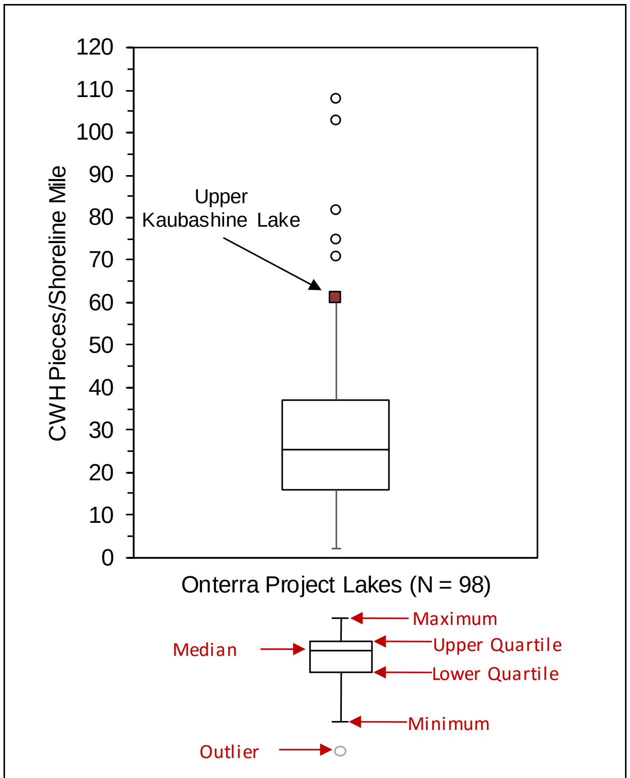


Figure 3.3-3. Upper Kaubashine Lake total number of coarse woody habitat (CWH) pieces per shoreline mile. State-wide comparative data available from 98 lakes surveyed by Onterra since 2012.

Onterra has completed coarse woody habitat surveys on 98 lakes throughout Wisconsin since 2012, with the majority occurring in the NLF ecoregion on lakes with public access. The number of coarse woody habitat pieces per shoreline mile in Upper Kaubashine Lake fall well above the 75th percentile of these 75 lakes and had the sixth highest coarse woody habitat pieces per shoreline mile recorded since these surveys began in 2012.

3.4 Aquatic Plants

Introduction

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

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

Diverse aquatic vegetation provides habitat and food for many kinds of aquatic life, including fish, insects, amphibians, waterfowl, and even terrestrial wildlife. For instance, wild celery (*Vallisneria americana)* and wild rice (*Zizania aquatica* and *Z. palustris*) both serve as excellent food sources for ducks and geese. Emergent stands of vegetation provide necessary spawning habitat for fish such as northern pike (*Esox lucius*) and yellow perch (*Perca flavescens*). In addition, many of the insects that are eaten by young fish rely heavily on aquatic plants and the periphyton attached to them as their primary food source. The plants also provide cover for feeder fish and zooplankton, stabilizing the predator-prey relationships within the system. Furthermore, rooted aquatic plants prevent 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 water-milfoil (*Myriophyllum spicatum*) and curly-leaf pondweed (*Potamogeton crispus*) can also upset the delicate balance of a lake ecosystem by out competing native plants and reducing species diversity. These 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 Upper Kaubashine 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 Upper Kaubashine 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. Removal of non-native plant species anywhere in the lake does not require a permit as long as a mechanical harvesting device is not used in the extraction process.

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 (Hand-Harvesting & DASH)

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.

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

Manual removal or hand-harvesting of aquatic invasive species has gained favor in recent years as an alternative to herbicide control programs. Professional hand-harvesting firms can be contracted for these efforts and can either use basic snorkeling or scuba divers, whereas others might employ the use of a Diver Assisted Suction Harvest (DASH) which involves divers removing plants and feeding them into a suctioned hose for delivery to the deck of the harvesting vessel. The DASH methodology is considered a form of mechanical harvesting and thus requires a WDNR approved permit. DASH is thought to be more efficient in removing target plants than divers alone and is believed to limit fragmentation during the harvesting process.

Cost

Contracting aquatic invasive species removal by third-party firm can cost approximately $1,000 per day for traditional hand-harvesting methods whereas the costs can be closer to $2,000 when DASH technology is used. Additional disposal, travel, and permitting fees may also apply.

Advantages	***Disadvantages***
• Very cost effective for clearing areas around docks, piers, and swimming areas. • Relatively environmentally safe if large-scale efforts are conducted after June 15th.to correspond with fish spawning • 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 water-milfoil for a few years. • Allows some loose sediment to consolidate, increasing water depth. • May enhance growth of desirable emergent species. • Other work, like dock and pier repair may be completed more easily and at a lower cost while water levels are down.	• May be cost prohibitive if pumping is required to lower water levels. • Has the potential to upset the lake ecosystem and have significant effects on fish and other aquatic wildlife. • Adjacent wetlands may be altered due to lower water levels. • Disrupts recreational, hydroelectric, irrigation and water supply uses. • May enhance the spread of certain undesirable species, like common reed 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. Granular herbicide application.

The use of herbicides to control aquatic plants and algae is a technique that is 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.

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; Eurasian water milfoil control when mixed with auxin herbicides
		Diquat	Inhibits photosynthesis & destroys cell membranes	Nusiance natives species including duckweeds, targeted AIS control when exposure times are low
Systemic	Auxin Mimics	2,4-D	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
		Triclopyr	auxin mimic, plant growth regulator	Submersed species, largely for Eurasian water milfoil
	In Water Use Only	Fluridone	Inhibits plant specific enzyme, new growth bleached	Submersed species, largely for Eurasian water milfoil
	Enzyme Specific (ALS)	Penoxsulam	Inhibits plant-specific enzyme (ALS), new growth stunted	New to WI, 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 control certain invasive species, such as Eurasian water-milfoil. • 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)	• 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; 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 water-milfoil and as a result has supported the experimentation and use of the milfoil weevil (*Euhrychiopsis lecontei*) within its lakes. The milfoil weevil is a native weevil that has shown promise in reducing Eurasian water-milfoil stands in Wisconsin, Washington, Vermont, and other states. Research is currently being conducted to discover the best situations for the use of the insect in battling Eurasian 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 water-milfoil density.

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

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

Cost

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

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

Analysis of Current Aquatic Plant Data

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

As described in more detail in the methods section, multiple aquatic plant surveys were completed on Upper Kaubashine 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 Upper Kaubashine 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 Upper Kaubashine 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 Upper Kaubashine 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 thought to be better suited to compete against exotic infestations than a lake with a lower diversity. However, in a recent study of 1,100 Minnesota lakes, researchers concluded that more diverse communities were not more resistant or resilient to invaders (Muthukrishnan et al. 2018).

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 Upper Kaubashine Lake is compared to data collected by Onterra and the WDNR Science Services on 77 lakes withn the Northern Lakes and Forest 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 Upper Kaubashine 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.

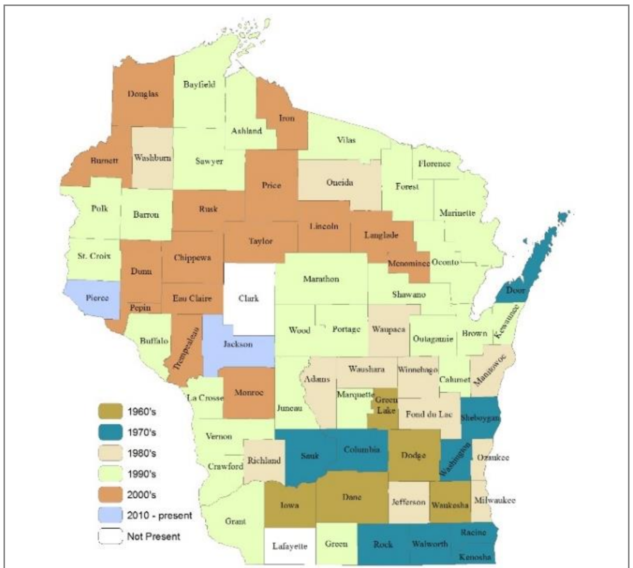


Figure 3.4-1. Spread of Eurasian watermilfoil within WI counties. WDNR Data 2015 mapped by Onterra.

Eurasian water-milfoil is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.4-1). Eurasian water-milfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, Eurasian water-milfoil has two other competitive advantages over native aquatic plants, 1) it starts growing very early in the spring when water temperatures are too cold for most native plants to grow, and 2) once its stems reach the water surface, it does not stop growing like most native plants, instead it continues to grow along the surface creating a canopy that blocks light from reaching native plants. Eurasian water-milfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating.

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

Because of its odd life-cycle, a special survey is conducted early in the growing season to inventory and map curly-leaf pondweed occurrence within the lake. Although Eurasian 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.

Aquatic Plant Survey Results

The whole-lake aquatic plant point-intercept survey and emergent/floating-leaf aquatic plant community mapping survey were conducted on Upper Kaubashine Lake on August 17, 2016 by Onterra. During the aquatic plant surveys completed on Upper Kaubashine Lake in 2016, a total of 27 species of plants were located in Upper Kaubashine Lake, two of which are considered non-native, invasive species: Eurasian watermilfoil and purple loosestrife (Table 3.4-1). The aquatic plant species list also contains species recorded during whole-lake point-intercept survey completed in 2013. An additional point-intercept plant survey was conducted in August 2017. Changes in species' abundance between these three surveys are discussed later in this section. On June 14, 2016, an Early-Season AIS Survey was completed on Upper Kaubashine Lake that focused on locating and mapping potential occurrences of curly-leaf pondweed. This meander-based visual survey did not locate any occurrences of this non-native plant. At present, curly-leaf pondweed either does not occur in Upper Kaubashine Lake or exists at an undetectable level. Because the non-native plants found in Upper Kaubashine Lake have the ability to negatively impact lake ecology, recreation, and aesthetics, the populations of these plants are discussed in detail within the Non-Native Aquatic Plants Section.

On September 27, 2017, Onterra ecologists completed an acoustic survey on Upper Kaubashine Lake. The sonar-based technology records aquatic plant bio-volume, or the percentage of the water column that is occupied by aquatic plants at a given location. Bathymetric information and data pertaining to Upper Kaubashine Lake's substrate composition were also recorded during this survey.

Acoustic data regarding substrate hardness reveals that Upper Kaubashine Lake's average substrate hardness ranges from hard to moderately hard with few areas containing soft, flocculent sediments (Figure 3.4-2). Substrate hardness is highest within the shallowest areas of Upper Kaubashine Lake. 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 areas, and some can be found growing in either. Lakes that have varying substrate types generally support a higher number of plant species because of the different habitat types that are available. Data from the 2016 point-intercept survey indicate that approximately 55% of the sampling locations located within the littoral zone contained sand, 23% contained fine organic sediment (muck), and 22% contained rock.

Table 3.4-1. Aquatic plant species located on Upper Kaubashine Lake during August point-intercept surveys.

Growth Form	Scientific Name	Common Name	Coefficient of Conservatism (C)	2013 WDNR	2016 Onterra	2017 Onterra
Emergent	*Bolboschoenus fluviatilis*	River bulrush	5		I	
	Carex aquatilis	Long-bracted tussock sedge	7		I	I
	Carex comosa	Bristly sedge	5		I	I
	Carex sp. (sterile)	Sedge sp. (sterile)	N/A		I	I
	Lythrum salicaria	Purple loosestrife	Exotic		I	I
	Scirpus cyperinus	Wool grass	4		I	I
FL	*Nymphaea odorata*	White water lily	6	X		
	Nuphar variegata	Spatterdock	6	X	X	X
	Persicaria amphibia	Water smartweed	5	X		I
Submergent	*Ceratophyllum demersum*	Coontail	3	X	X	X
	Chara spp.	Muskgrasses	7	X	X	X
	Elatine minima	Waterwort	9	X	X	X
	Elodea canadensis	Common waterweed	3	X	X	X
	Heteranthera dubia	Water stargrass	6	X	X	X
	Isoetes spp.	Quillwort spp.	8	X	X	X
	Myriophyllum sibiricum	Northern watermilfoil	7	X	X	X
	Myriophyllum spicatum	Eurasian watermilfoil	Exotic	I	X	X
	Myriophyllum tenellum	Dwarf watermilfoil	10	X	X	X
	Najas flexilis	Slender naiad	6	X	X	X
	Nitella spp.	Stoneworts	7		X	X
	Potamogeton amplifolius	Large-leaf pondweed	7		X	I
	Potamogeton epihydrus	Ribbon-leaf pondweed	8	X	X	X
	Potamogeton foliosus	Leafy pondweed	6	X	X	X
	Potamogeton friesii	Fries' pondweed	8	X	X	X
	Potamogeton gramineus	Variable-leaf pondweed	7	X	X	X
	Potamogeton pusillus	Small pondweed	7		X	X
	Potamogeton robbinsii	Fern-leaf pondweed	8	X	X	X
	Vallisneria americana	Wild celery	6	X	X	X
S/E	*Eleocharis acicularis*	Needle spikerush	5	X	X	X
FF	*Lemna minor*	Lesser duckweed	5			I

FL = Floating-leaf; S/E = Submergent and Emergent; FF = Free-Floating
X = Located on rake during point-intercept survey; I = Incidental Species

The acoustic survey also recorded aquatic plant bio-volume throughout the entire lake. As mentioned earlier, aquatic plant bio-volume is the percentage of the water column that is occupied by aquatic plants. The 2017 aquatic plant bio-volume data are displayed in Figure 3.4-3. Areas where aquatic plants occupy most or all of the water column are indicated in red while areas of little to no aquatic plant growth are displayed in blue. The densest areas of aquatic plant biovolume correspond with the EWM population.

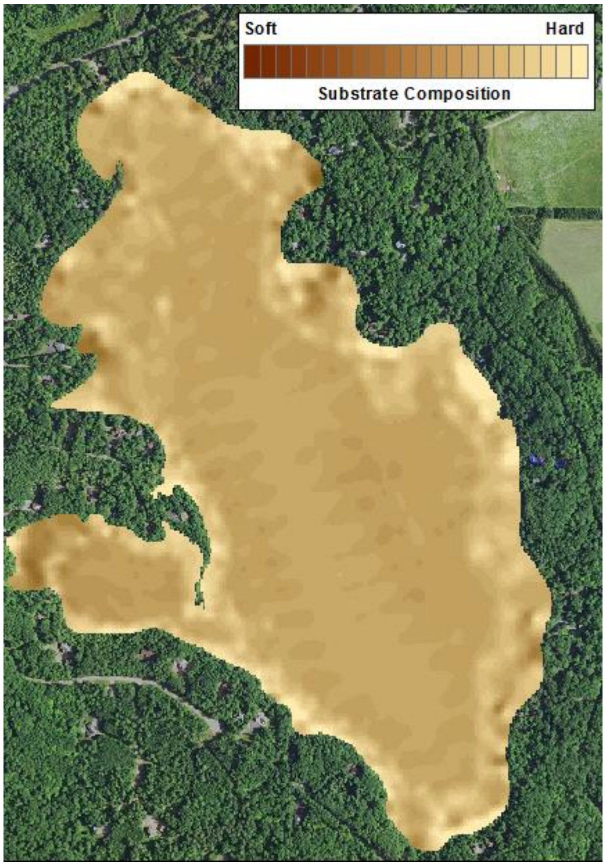


Figure 3.4-2. Upper Kaubashine Lake substrate hardness. Created using data from September 2017 acoustic survey.

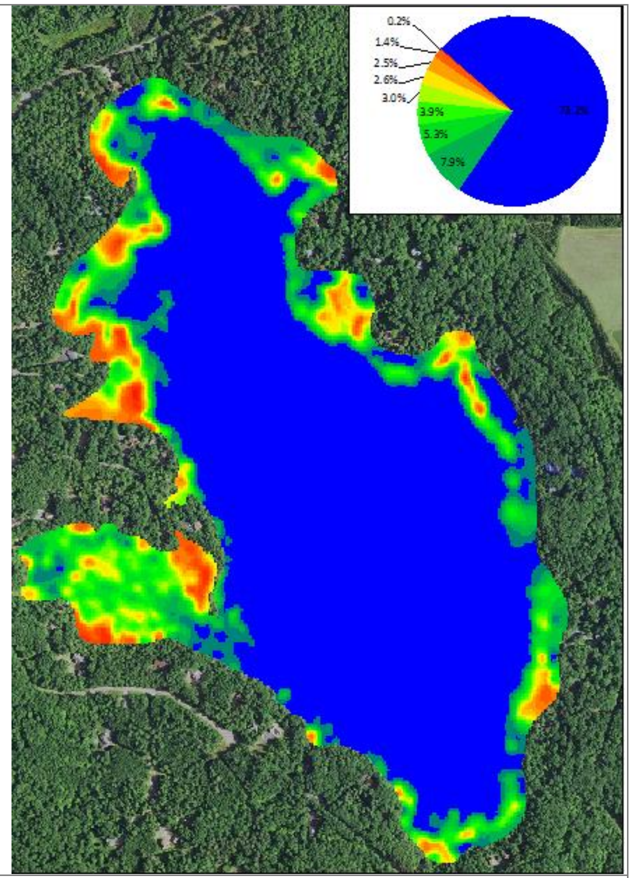


Figure 3.4-3. Upper Kaubashine Lake aquatic plant biovolume. Created using data from September 2017 acoustic survey.

In 2017, approximately 73% of point-intercept sampling locations that fell within the maximum depth of aquatic plant growth (19 feet), or the littoral zone, contained aquatic vegetation (Figure 3.4-3). This is slightly greater than 2013 and 2016. Aquatic plant rake fullness data indicates that plant densities are also slightly increasing (Figure 3.4-4).

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Lake Management Planning

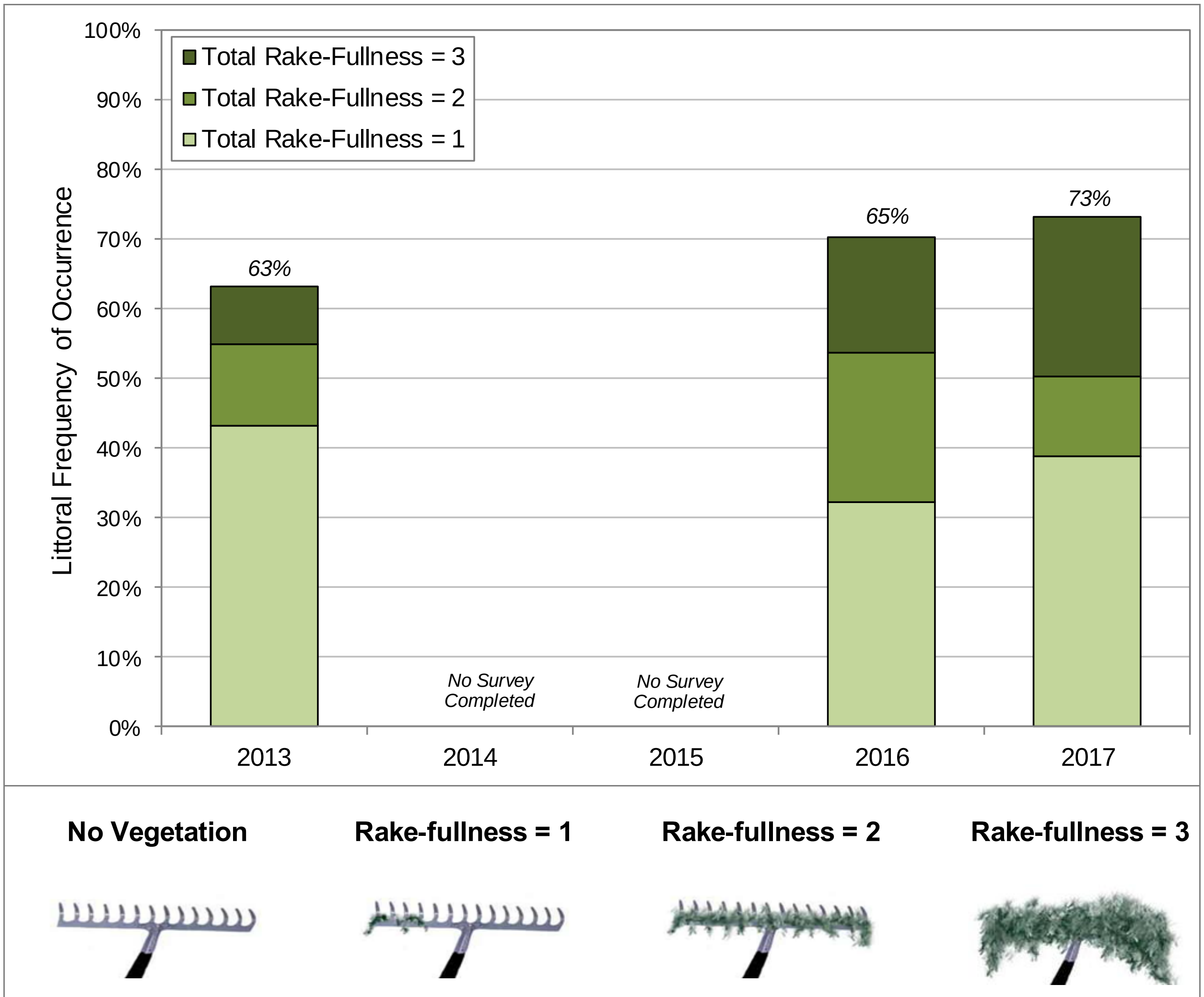


Figure 3.4-4. Upper Kaubashine Lake Total Rake Fullness Ratings. Created using data from WDNR (2013) and Onterra (2016,2017) point-intercept surveys.

Aquatic plants can be placed in one of two general groups, based upon their form of growth and habitat preferences. These groups include the isoetid growth form and the elodeid growth form. Upper Kaubashine Lake has both isoetid and elodeid species within its waters. Plants of the isoetid growth form are small, slow growing, and inconspicuous submerged plants. They often have evergreen leaves located in a rosette and are usually found growing in sandy soils within the near-shore areas of a lake (Boston and Adams 1987, Vestergaard and Sand-Jensen 2000). Some common isoetid species in Upper Kaubashine Lake include quillwort, needle spikerush, dwarf watermilfoil, and waterwort. Submersed species of the elodeid growth form have leaves on tall, erect stems which grow upwards into the water column. Examples of Upper Kaubashine Lake elodeid species include slender naiad, muskgrasses, wild celery, and small pondweed.

Alkalinity is the primary water chemistry factor determining whether a lake is dominated by plant species of the isoetid or elodeid growth form (Vestergaard and Sand-Jensen 2000). Most elodeids are restricted to lakes of relatively higher alkalinity, as their carbon demand for photosynthesis cannot be met solely by the dissolved carbon dioxide (CO_2) present in the water, and they must acquire additional carbon through bicarbonate (HCO_3^-). While isoetids are able to grow in lakes of higher alkalinity, their short stature makes them poor competitors for light, and they are usually outcompeted and displaced by the taller elodeids. Thus, isoetids are most prevalent in lakes of low alkalinity where they can avoid competition from elodeids. However, in lakes with intermediate alkalinity levels, like Upper Kaubashine Lake, we see a mixed community of both, with isoetids inhabiting the shallow, sandy/rocky areas and elodeids thriving in the deeper areas of softer sediment.

Of the 27 aquatic plants located in Upper Kaubashine Lake in 2016 and 2017, 21 species were encountered directly on the rake during the whole-lake point-intercept survey (Table 3.4-1, Figure 3.4-5, Figure 3.4-6). The remaining 6 species were located incidentally, meaning they were observed by Onterra ecologists while on the lake but they 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 relatively rare within the plant community.

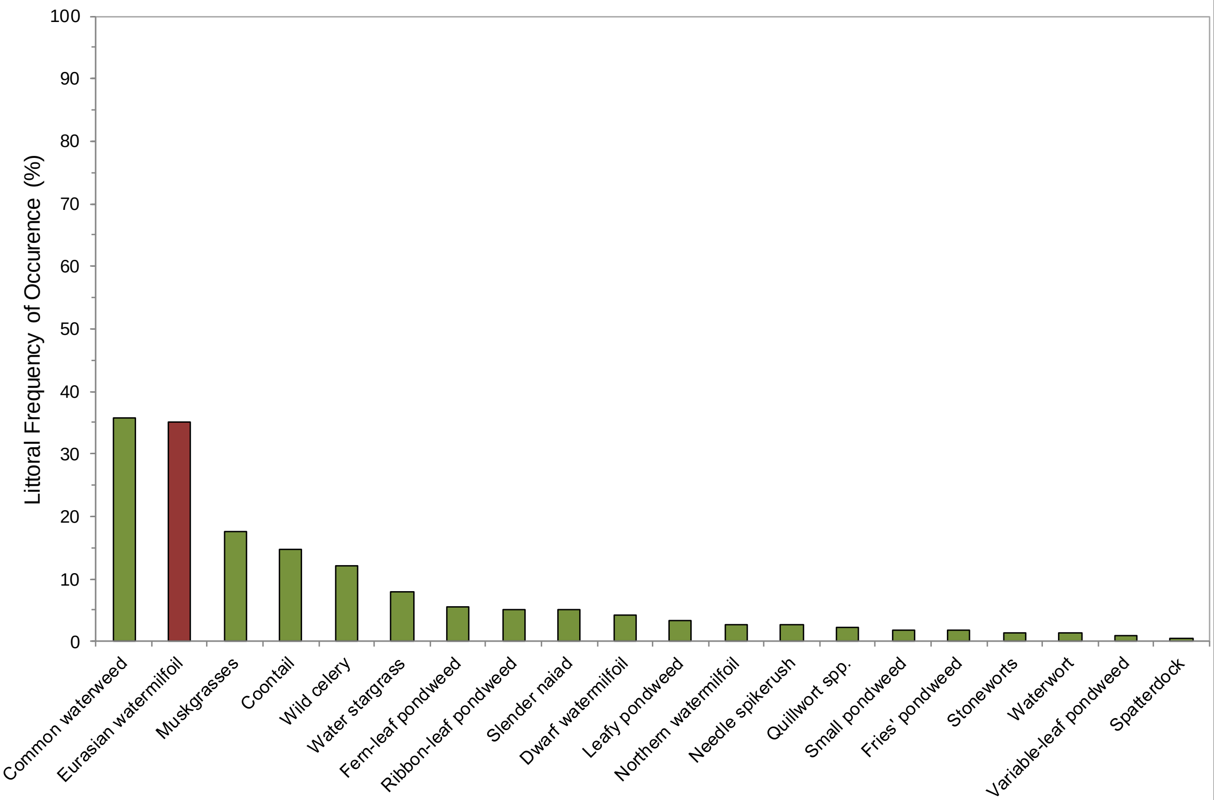


Figure 3.4-5. Upper Kaubashine Lake aquatic plant littoral frequency of occurrence. Created using data from the August 2017 point-intercept survey.

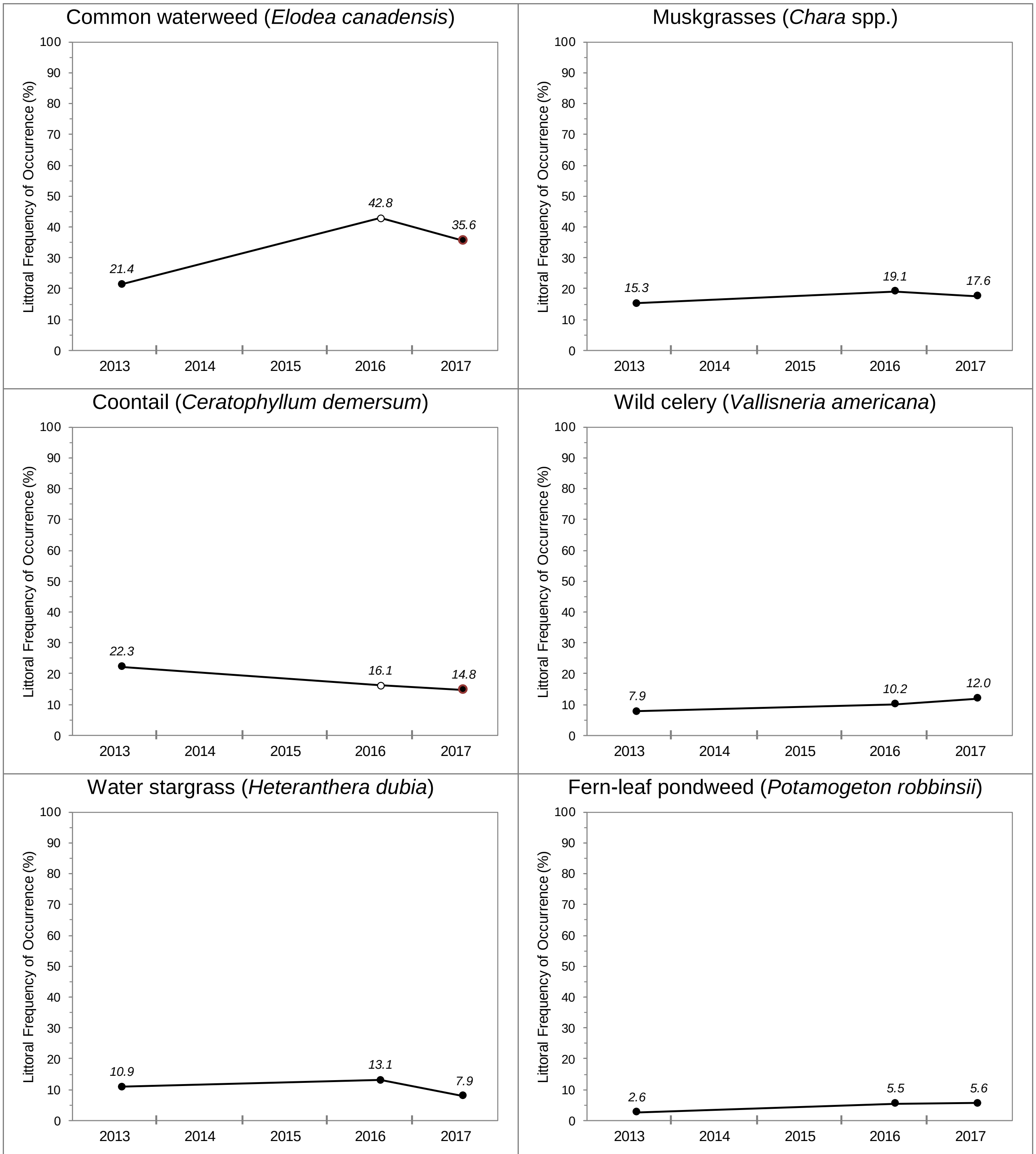


Figure 3.4-6. Littoral frequency of occurrence of select native aquatic plant species. Open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05). Circle outlined with red indicates 2017 littoral occurrence was statistically different from littoral occurrence in 2013 (Chi-Square α = 0.05).

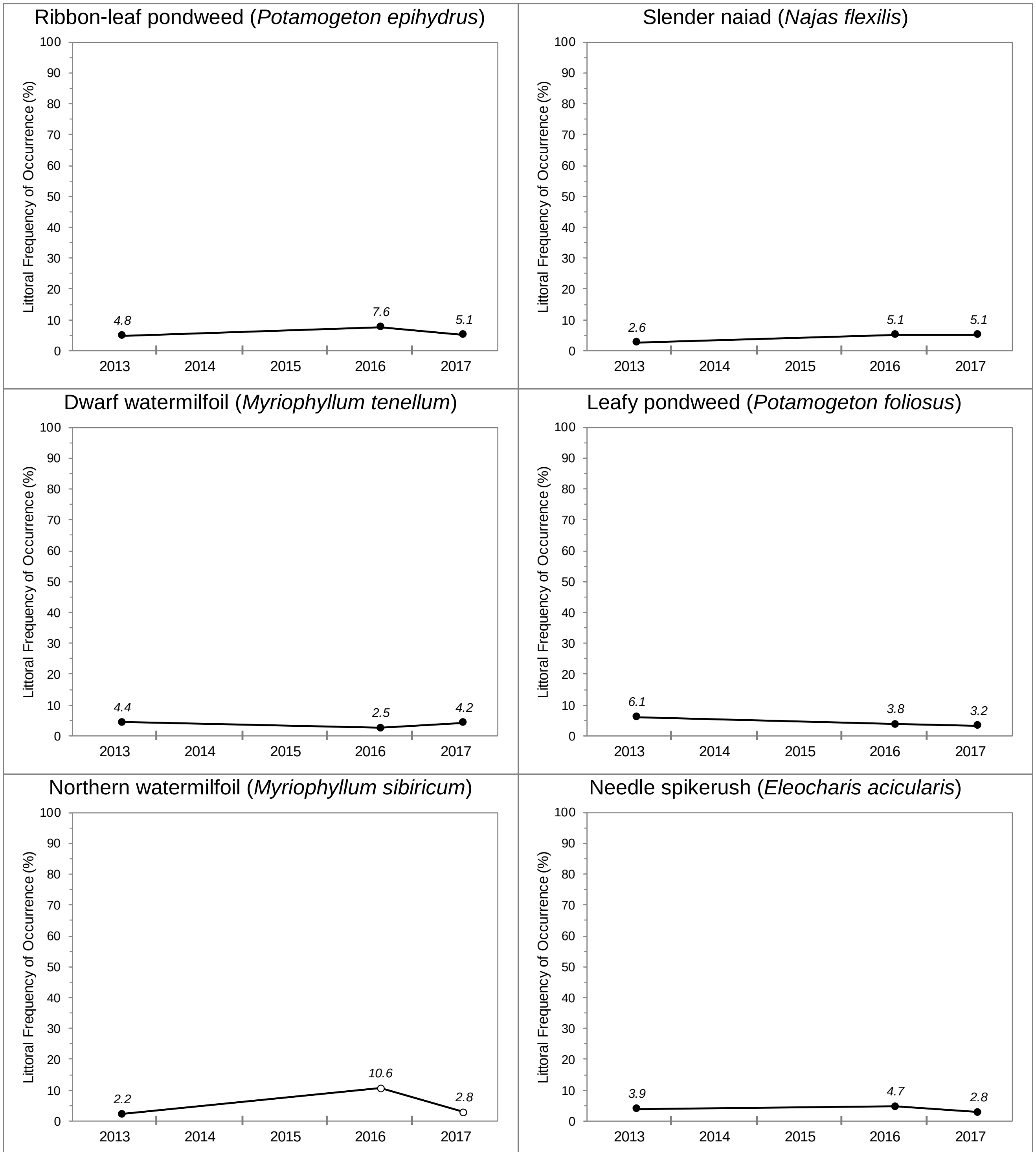


Figure 3.4-6 continued. Littoral frequency of occurrence of select native aquatic plant species. Open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05). Circle outlined with red indicates 2017 littoral occurrence was statistically different from littoral occurrence in 2013 (Chi-Square α = 0.05).

Of these 21 species, common waterweed and Eurasian watermilfoil were the most common (Figure 3.4-5). Eurasian watermilfoil will be discussed in detail the subsequent Non-Native Aquatic Plants Section. Common waterweed is often one of the more dominant aquatic plants in Wisconsin's lakes and can be found throughout North America. Common waterweed is able to tolerate low-light conditions and obtain the majority of its nutrients directly from the water, and can thrive in more productive lakes. Because of its prevalence in many of Wisconsin's lakes, common waterweed is an important component of many aquatic ecosystems where it provides structural habitat and absorbs nutrients that would otherwise be available to free-floating algae. In Upper Kaubashine Lake, common waterweed was most abundant between 9 and 15 feet of water. Common waterweed was more abundant in 2016 and 2017 compared to 2013 (Figure 3.4-6)

Coontail was the fourth-most frequently encountered aquatic plant in Upper Kaubashine Lake in 2017 with a littoral frequency of occurrence of approximately 15% (Figure 3.4-5). Arguably the most common aquatic plant in Wisconsin, coontail possesses whorls of stiff leaves. Lacking roots, coontail can grow entangled amongst rooted vegetation and obtain all of its nutrients directly from the water. For this reason, both coontail and common waterweed can become more abundant when invasive species populations increase. However, on Upper Kaubashine Lake, coontail populations have declined during the same timeframe as Eurasian watermilfoil increased (Figure 3.4-6). Similar to common waterweed, coontail is able to tolerate low-light conditions, it is often one of the most abundant aquatic plants in more productive lakes. Its dense foliage offers excellent habitat to aquatic organisms, especially in deeper water where many other plants are unable to grow. However, under certain conditions, most often in lakes with excessive nutrients, coontail can grow to levels which can interfere with recreation on the lake. In 2017, coontail was most abundant between 11 and 15 feet of water in Upper Kaubashine Lake.

Photograph 3.4-5. The aquatic macroalgae muskgrasses (*Chara* spp.). Photo credit Onterra.

Muskgrasses are a genus of macroalgae of which there are seven species in Wisconsin (Photograph 3.4-5). In 2017, muskgrasses, the third-most encountered species, had a littoral frequency of occurrence of approximately 18% (Figure 3.4-5). Dominance of the aquatic plant community by muskgrasses is common in lakes like Upper Kaubashine Lake, and these macroalgae have been found to 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 incrustations which from on these plants, aiding in improving water quality by making the phosphorus unavailable to phytoplankton (Coops 2002). In Upper Kaubashine Lake, muskgrasses were abundant across all littoral depths.

As discussed in the primer section, the calculations used for 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. Upper Kaubashine Lake's native aquatic plant species richness in 2016 and 2017 falls below the median value for lakes within the Northern Lake and Forests (NLFL) ecoregion and for lakes throughout Wisconsin (Figure 3.4-7). The average conservatism of the 20 native aquatic plants recorded on the rake in 2016 and 2017 was 6.7, falling at the median value (6.7) for lakes within the NLFL ecoregion and above the median value (6.3) for lakes throughout Wisconsin (Figure 3.4-8). This indicates that Upper Kaubashine Lake has the average number of native aquatic plant species with high conservatism values when compared to the majority of lakes within the NLFL ecoregion.

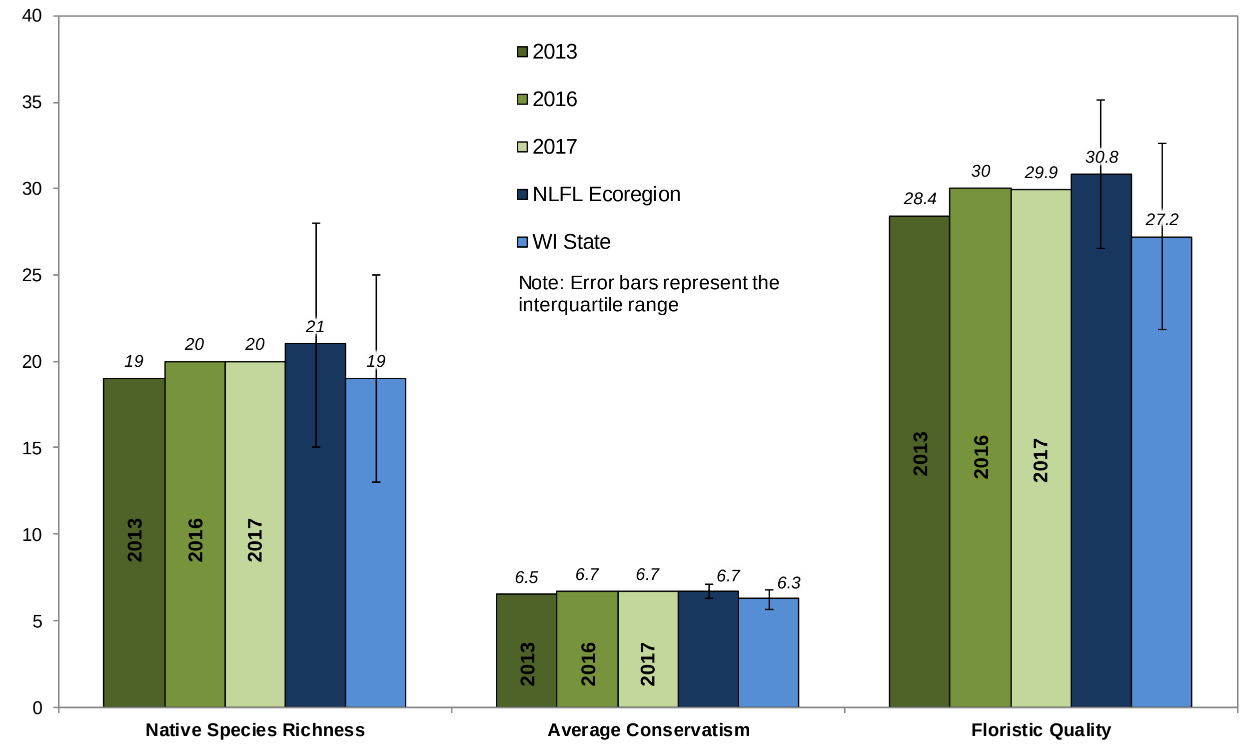


Figure 3.4-7. Upper Kaubashine Lake Floristic Quality Analysis. Created using data from WDNR (2013) and Onterra (2016,2017) point-intercept surveys.

Onterra ecologists also conducted an aquatic plant community mapping survey in 2016 and 2017 aimed at mapping communities of emergent and floating-leaf vegetation. During this survey, 5 emergent and floating-leaf aquatic plant species were located (Table 3.4-1). This survey also revealed that Upper Kaubashine Lake contains less than an acre (0.73 acres) of emergent and floating-leaf aquatic plant communities (Map 5). The native emergent and floating-leaf plant communities provide valuable fish and wildlife habitat that is important to the ecosystem of the lake.

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 Upper Kaubashine 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.

Non-native Plants in Upper Kaubashine Lake

Eurasian watermilfoil

Eurasian watermilfoil was first discovered in the lake in July of 2013 along the lake's northwest side. Genetic analysis has indicated that of the few samples tested to date, all are were confirmed as pure-strain EWM, not a hybrid. Early efforts to control the pioneering population were made through coordinated professional hand-harvesting. In 2014, a professional firm completed over 67 diver-hours removing approximately 700 gallons of EWM. A similar amount of hand-harvesting was conducted in 2015 with approximately 600 gallons of EWM being removed. These efforts ultimately proved to be insufficient to reduce the EWM population, as population increases continued to occur.

During a July 7, 2015 UKPA annual meeting, Onterra and the UKPOA representatives discussed the increasing concerns regarding the EWM population in the lake. Control strategies were discussed, including addition of a Diver Assisted Suction Harvest (DASH) component to the hand-harvesting. The use of spot and large-scale herbicide treatments was also discussed. Concerns were voiced about the lack of a WDNR-approved lake management plan and an understanding of the support of herbicide use by riparians. At a later date however, the UKPOA Board of Directors did provide a vote in support of the use of an herbicide spot treatment in the lake as part of a 2016 strategic approach.

A teleconference was held in October of 2015 with Kevin Gauthier, local WDNR Water Resources Management Specialist, the UKPOA, and Onterra. During the call, Mr. Gauthier expressed concern over the use of herbicides in the lake. Onterra submitted a map for discussion where roughly 6.2 acres of the densest EWM in the lake was proposed to be targeted with an herbicide spot treatment (2,4-D amine at 4.0 ppm ae) in addition to coordinated hand-harvesting in other parts of the lake. The local WDNR's opinion was that this control strategy would result in only temporary nuisance relief and would not address EWM throughout the lake, as the grant funded project had initially been designed to do.

While not all agreed on the 2016 management strategy, it was mutually agreed upon by all parties that the UKPOA would benefit from completing a management planning process to better understand the lake's aquatic plant community and develop a long-term plan to address EWM. Mr. Gauthier offered that this process could be partially funded through the state by completing a Phase II AIS-EDR grant application.

A grant proposal and budget was assembled by Onterra in December 2015 and was sent to Mr. Gauthier on January 13, 2016. The proposal outlined lake management planning components as well as a plan to utilize DASH on the lake's densest EWM colonies. Mr. Gauthier sent the grant proposal to other WDNR staff for review. In late January, Onterra and WDNR staff discussed the proposal and its components in terms of eligibility for the AIS-EDR grant category. The AIS-EDR grant category is intended to provide funding for lake groups to "*provide early identification and control of pioneer populations of AIS*". In the WDNR's review, it was determined that an action such as the use of DASH, while providing a nice visual to lake residents, an examination of the tool's effectiveness on the lake, and a navigation aid, would not be in line with the AIS-EDR's intended goal and was disallowed from the project. No professional based hand-harvesting occurred in 2016.

While the point-intercept survey is a valuable tool to understand the overall plant population of a lake, it does not offer a full account (census) of where a particular species exists in the lake. As the name implies, the EWM Peak-Biomass Survey is a meander-based mapping survey conducted when the plant is at its peak growth stage (late-summer), allowing for a true assessment of the amount of this exotic within the lake. EWM occurrences would be mapped using either 1) point-based or 2) area-based methodologies. Large colonies >40 feet in diameter would be mapped using polygons (areas) and would be qualitatively assigned a density rating based upon a five-tiered scale from *highly scattered* to *surface matting*. Point-based techniques would be applied to locations considered as *small plant colonies* (<40 feet in diameter), *clumps of plants*, or *single or few plants*. The method for mapping EWM used by Onterra was discussed at the Kick-Off Meeting (Appendix A, pages 5-6) as well as the Planning Committee Meeting I (Appendix A, page 8). While the methods are consistent over time, decisions on how populations get mapped and assigned density designations are subjective.

Please note that Figure 3.4-8 represents the acreage of mapped EWM polygons, not EWM mapped within point-based methodologies (*Single or Few Plants*, *Clumps of Plants*, or *Small Plant Colonies*). Taken out of context, this figure can be misleading as large changes in EWM colonial acreage may be the results of differences in EWM populations fluctuating from point-based data to areas best delineated with polygons. For example, less than a half-acre of colonized EWM was mapped in 2013 and 2014, but Map 6 shows that a number of point-based EWM occurrences were confirmed during these years. As these populations increased and individual colonies became greater than 40 feet in diameter, the populations were mapped by delineating the extents of the colony and assigning a density rating. The acreage of these colonies increased to approximately 7 acres in 2015 and then to 25-26 acres in 2016 and 2017.

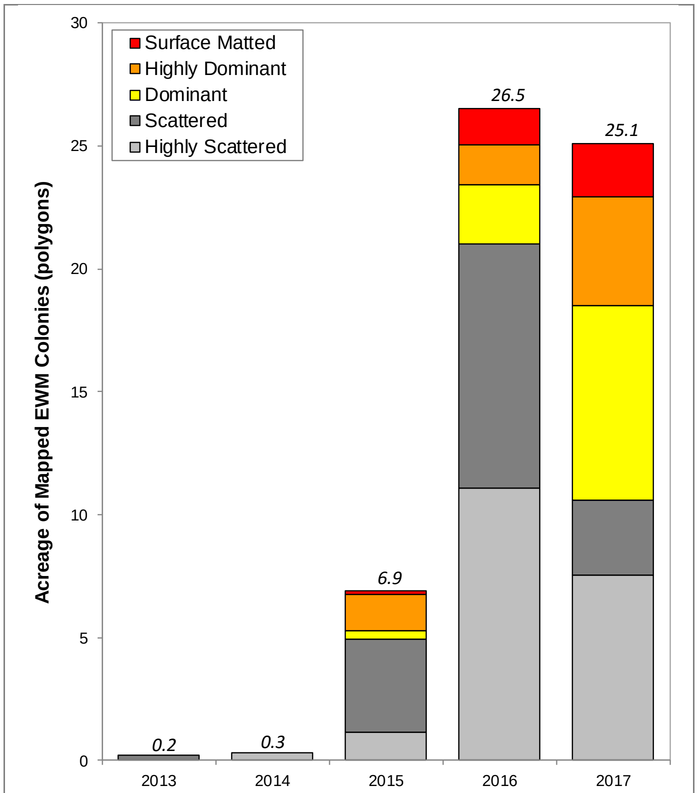


Figure 3.4-8. Acreage of Eurasian watermilfoil found in Upper Kaubashine Lake from 2013 to 2016. Created using data from Onterra 2013-2016 peak biomass surveys.

The EWM population occupied roughly the same footprint in 2017 as it had in 2016, but the densities increased (Figure 3.4-8). This may suggest the EWM population may be reaching its maximum capacity in Upper Kaubashine Lake. As is discussed in the following section, understanding the trajectory of an EWM population in any lake is difficult.

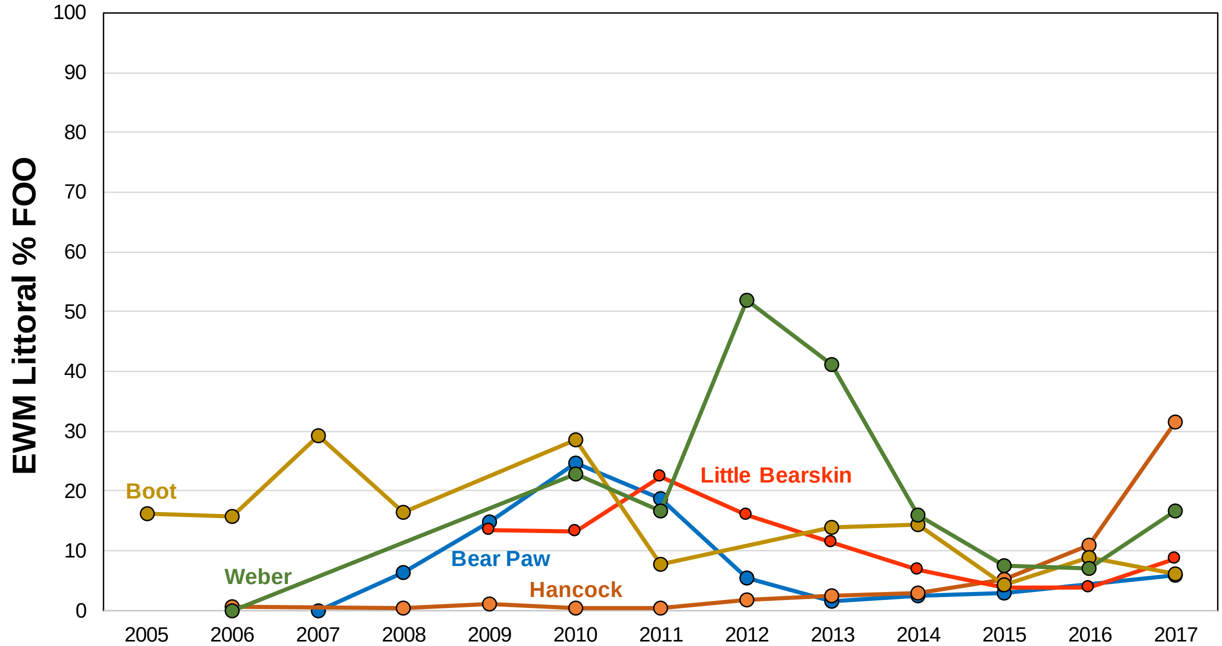
WDNR Long-Term EWM Trends Monitoring Research Project

Starting in 2005, WDNR Science Services began conducting annual point-intercept aquatic plant surveys on a set of 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. As outlined in *The Science Behind the "So-Called" Super Weed* (Nault 2016), EWM population dynamics on lakes are not that simplistic.

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). The point-intercept data are most clear for unmanaged lakes in the Northern Lakes and Forests Ecoregion (Figure 3.4-9). The upper frame of Figure 3.4-9 shows the EWM littoral frequency of occurrence for these unmanaged systems by year, and the lower frame shows the same data based on the number years the survey was conducted following the year of initial detection of EWM listed on the WDNR website. During this study, six of the originally selected "unmanaged lakes" were moved into the "managed" category as the EWM populations were targeted for control by the local lake organization.

The results of the study clearly indicate that EWM populations in unmanaged lakes can fluctuate greatly between years. Following initial infestation, EWM expansion was rapid on some lakes, but overall was variable and unpredictable (Nault 2016). On some lakes, the EWM populations reached a relatively stable equilibrium whereas other lakes had more moderate year-to-year variation. Regional climatic factors also seem to be a driver in EWM populations, as many EWM populations declined in 2015 even though the lakes were at vastly different points in time following initial detection within the lake.

As reported by the Milwaukee Journal Sentinel, January 1 through July 31, 2017 was Wisconsin's wettest period on record (records date back 123 years). These conditions can reduce water clarity by increasing nutrient run-off that fuels algal growth but also by delivering an increase amount of staining organic compounds from the watershed. With a smaller watershed, these potential impacts may have been muted on Upper Kaubashine Lake as late-May and early-June Secchi disk values were 25 and 28 feet, respectively. Some have suggested that this increase precipitation may contributed to increased EWM populations on Upper Kaubashine Lake in 2017. That potential is possible, as EWM increases were noted on a majority of the Northern Lakes and Forests Ecoregion unmanaged lakes within the long-term trends study (Figure 3.4-9). A corresponding increase in other plant species was not noted on Upper Kaubashine Lake in 2017.



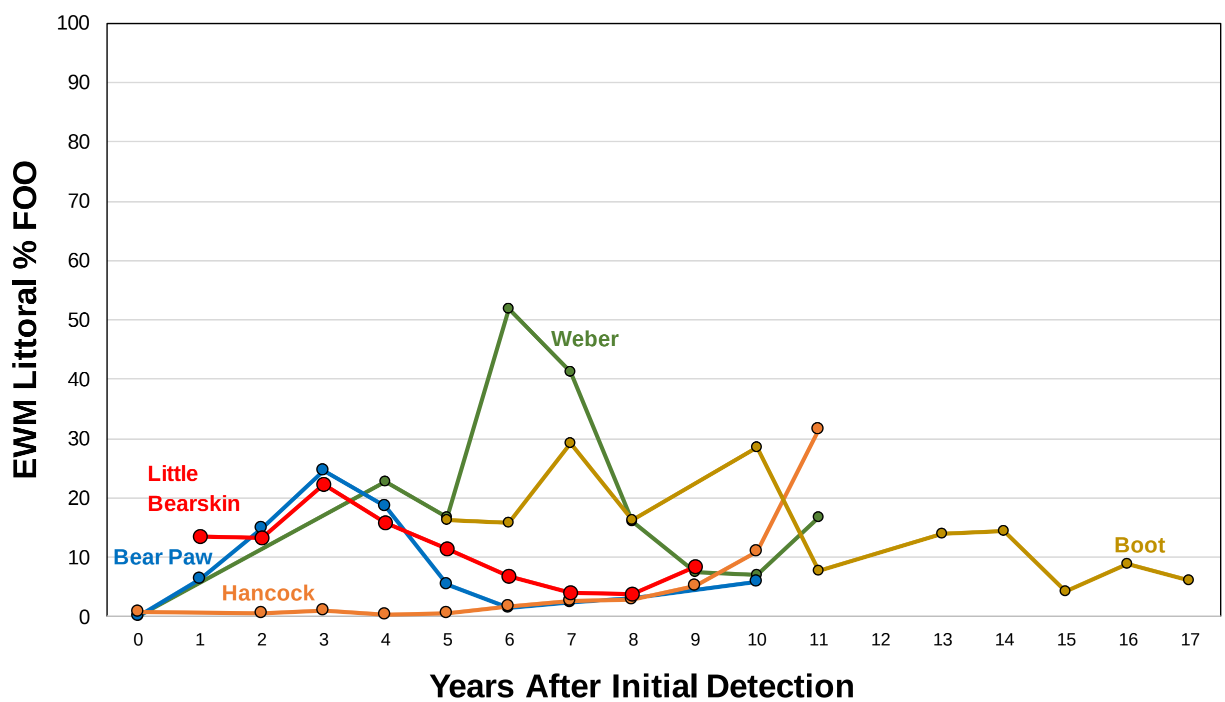


Figure 3.4-9. Littoral frequency of occurrence of EWM in the Northern Lakes and Forests Ecoregion without management. Data provided by and used with permission from the WDNR Bureau of Science Services.

Within the long-term EWM monitoring study, eight lakes were in the managed category (Figure 3.4-10). As discussed above, the number of lakes included within this category was initially less, but some lakes that were originally in the unmanaged category had lake groups that opted to conduct herbicide treatment strategies to reduce the EWM population within the lake. Some of the lakes within the study conducted large-scale (whole-lake) herbicide treatments and had large reductions of EWM. Sandbar Lake conducted a follow-up large-scale treatment a few years after large-scale management, whereas Kathan Lake and Silver Lake conducted a second large-scale treatment after 6 and 9 years following the first, respectively.

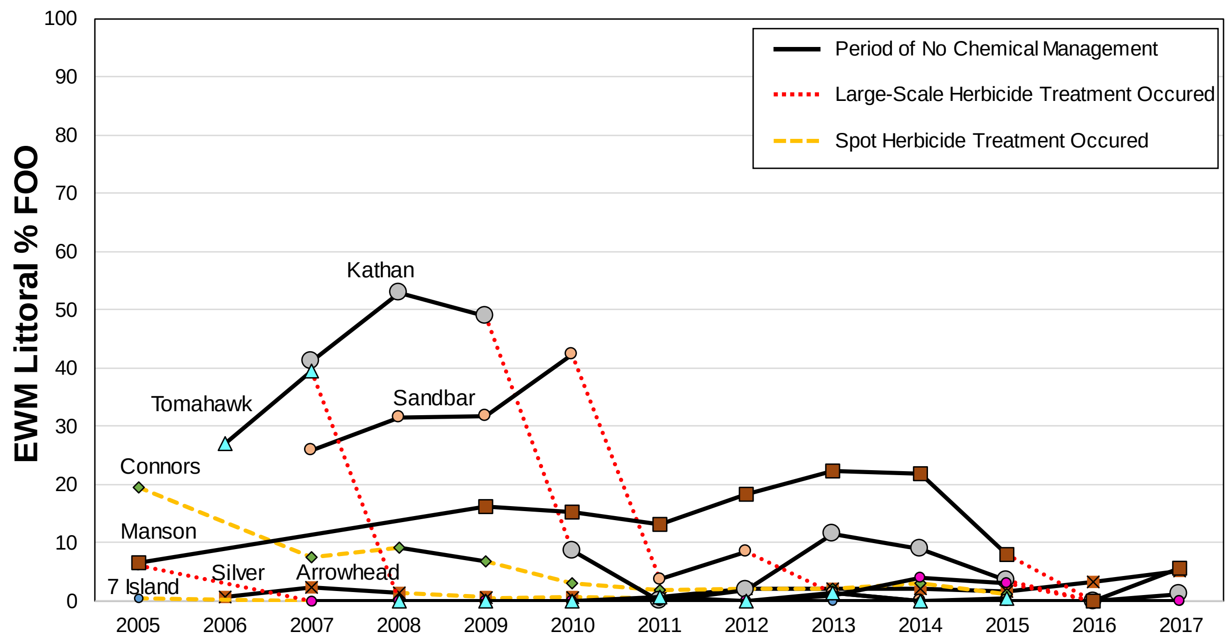


Figure 3.4-10. Littoral frequency of occurrence of EWM in the Northern Lakes and Forests Ecoregion with management. Data provided by and used with permission from the WDNR Bureau of Science Services.

Other lakes conducted more frequent spot treatments to reduce or maintain a low EWM population within the lake. The 2005 spot treatment on Connors Lake may have been close to approaching a large-scale treatment, as almost 8% of the lake was targeted for control. Seven Island Lake conducted a large spot treatment in a bay of the lake in 2005 and has not conducted additional herbicide management to date. After a few largely unsuccessful herbicide treatments from 2008 to 2010 on Arrowhead Lake, herbicide management was abandoned and the population has slowly increased to just over 5% after 6 years.

The study results clearly show that management can be effective to reduce and maintain lowered EWM populations. The data also show that continued management is often required to maintain a low population.

While EWM mapping surveys have been completed on Upper Kaubashine every year since 2013, only three point-intercept surveys have been conducted on the lake. The WDNR conducted the first survey in 2013 following the verification of EWM from the system. At that time, no EWM was directly sampled on the rake, however EWM was visually noted as occurring near the sampling point in six locations (Figure 3.4-11). Only EWM sampled on the rake are used within the frequency analysis. Onterra conducted EWM surveys in 2016 and 2017 as part of the lake management planning project. Approximately 23% of sampling locations with the littoral zone (plant growing zone) contained EWM in 2016, and just over 35% contained EWM in 2017 (Figure 3.4-11). This increase made EWM approximately tied for the most encountered plant in 2017. While the data suggest some slight reductions in native plant occurrences over this timeframe, an insufficient timeframe has passed to allow an understanding if these changes are in response to the increased EWM population or other factors.

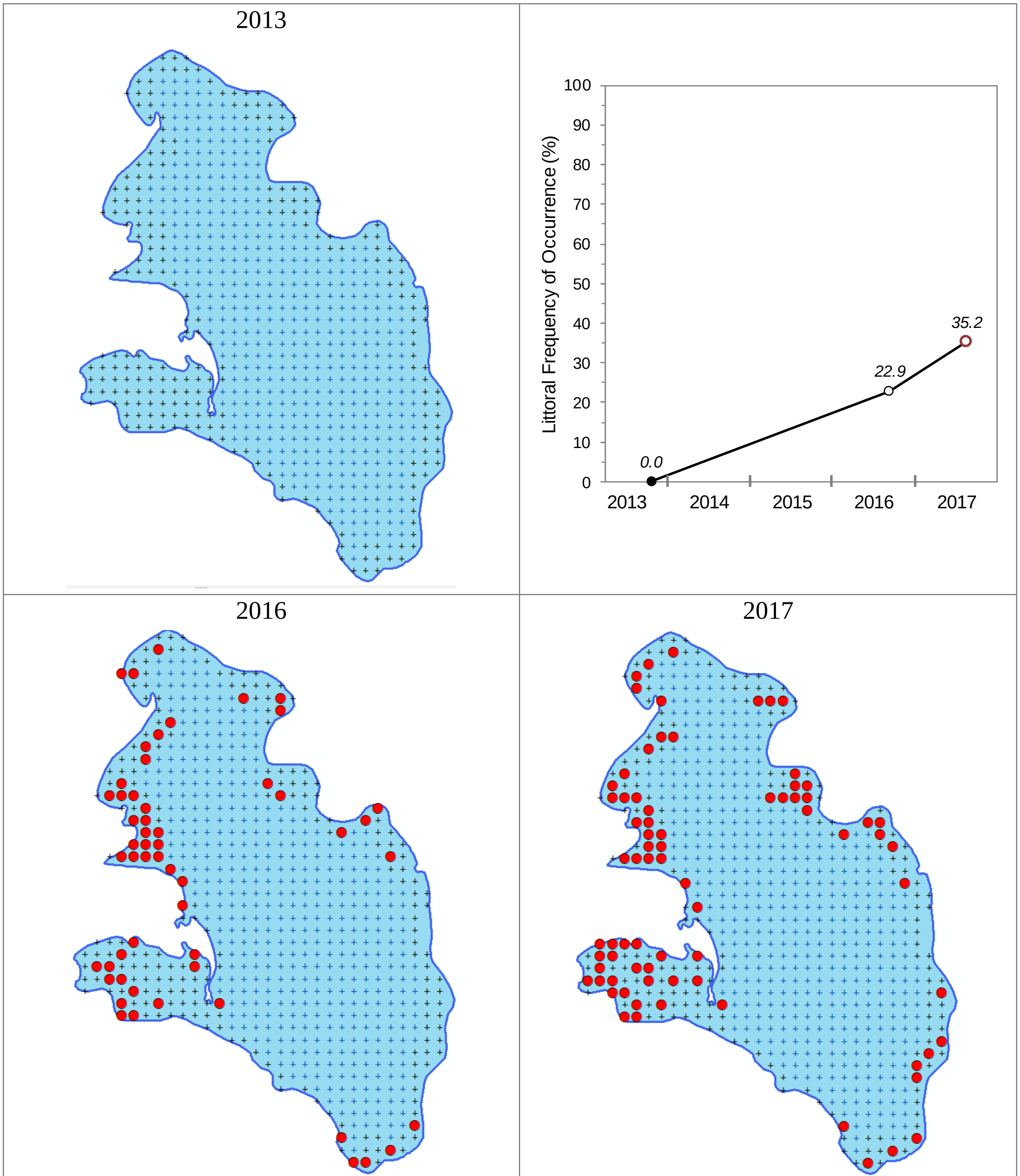


Figure 3.4-11. Littoral frequency of occurrence of EWM in Upper Kaubashine Lake. Red circle on map indicates EWM occurrence at the point-intercept sampling location. On the figure, open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05). Circle outlined with red indicates 2017 littoral occurrence was statistically different from littoral occurrence in 2013 (Chi-Square α = 0.05).

EWM Impacts in Upper Kaubashine Lake

Following EWM population establishment in Upper Kaubashine Lake, the UKPOA took a rapid and proactive approach to management by implementing strategic paid hand-harvesting services. Many lake managers believe that there are benefits in early intervention of an invasive species. As part of a 28-lake study in Wisconsin, Kujawa et al (2017) indicate that management "appears to be particularly effective in recently invaded lakes, where it can be used with lower frequency and overall magnitude to maintain low [EWM] abundance." That being said, this study looks at the findings over a broad-scale, whereas, "the specific effects of individual treatments can be unpredictable." And some of the case studies of early intervention contained relatively high EWM populations (18-49% LFOO), above what some would consider an early intervention.

Particularly in regards to an established EWM population, some lake groups have adopted a strategy where they postpone active management until an EWM population reaches a certain threshold. This threshold may be set at a level where the EWM population is 1) suspected to cause change in the lake's historic ecologic function and/or 2) a level that reduced the lake's ability to be enjoyed by riparians prior to the EWM population. Within strategic planning meetings, the UKLPOA Planning Committee discussed these two concepts and some of the information that surrounds them.

Impact Riparian Use

While riparians would claim they know it when they see it, it is subjective to define the population level when navigation, recreation, aesthetics, property values, etc. are impacted by EWM populations. Upper Kaubashine is utilized by recreationalists for varying uses. It is an exceptional water resource for water skiing, fishing, swimming, nature viewing, and more. While almost impossible to quantitatively document, most riparians agree that navigation, recreation, and aesthetic impairment has occurred in specific areas on Upper Kaubashine in recent years. As EWM populations fluctuate in the future, these impairments may be reduced or exacerbated. Studies have documented decreases in lakefront property values when EWM inhibits water-based recreational activities on lakes (Eiswerth et al. 2000, Horsch and Lewis 2009, Zhang and Boyle 2010).

Impact Historic Ecosystem Function

The scientific literature has a number of specific examples of declining native vegetation in communities dominated by EWM (Madsen et al. 1991; Boylen et al. 1999, Madsen 1999). These examples are largely based upon aquatic plant population changes within dense EWM colonies. More recent multi-lake studies suggest that "[EWM] invasion does not correlate with decreased native macrophyte abundance at a landscape scale" (Mikulyuk 2017). This could be interpreted as suggesting that EWM populations may not be outcompeting native plants as often as traditionally thought; displacement of native species by EWM is likely occurring in localized areas and the impact may be undetectable at a lake-wide scale or across the landscape.

In a recent study of 1,100 Minnesota lakes, researchers concluded that more diverse communities were not more resistant or resilient to invaders (Muthukrishnan et al. 2018). The authors of the study contend that invasive species like EWM are able to initially take advantage of marginal habitats where native plants are not as well established, and then expand from those locations. Examining Figure 3.4-12, there are some instances where EWM was found in 2016 and 2017 that did not contain native vegetation in 2013. However, there are more instances where EWM occurrences occurred in areas that contained native vegetation in 2013.

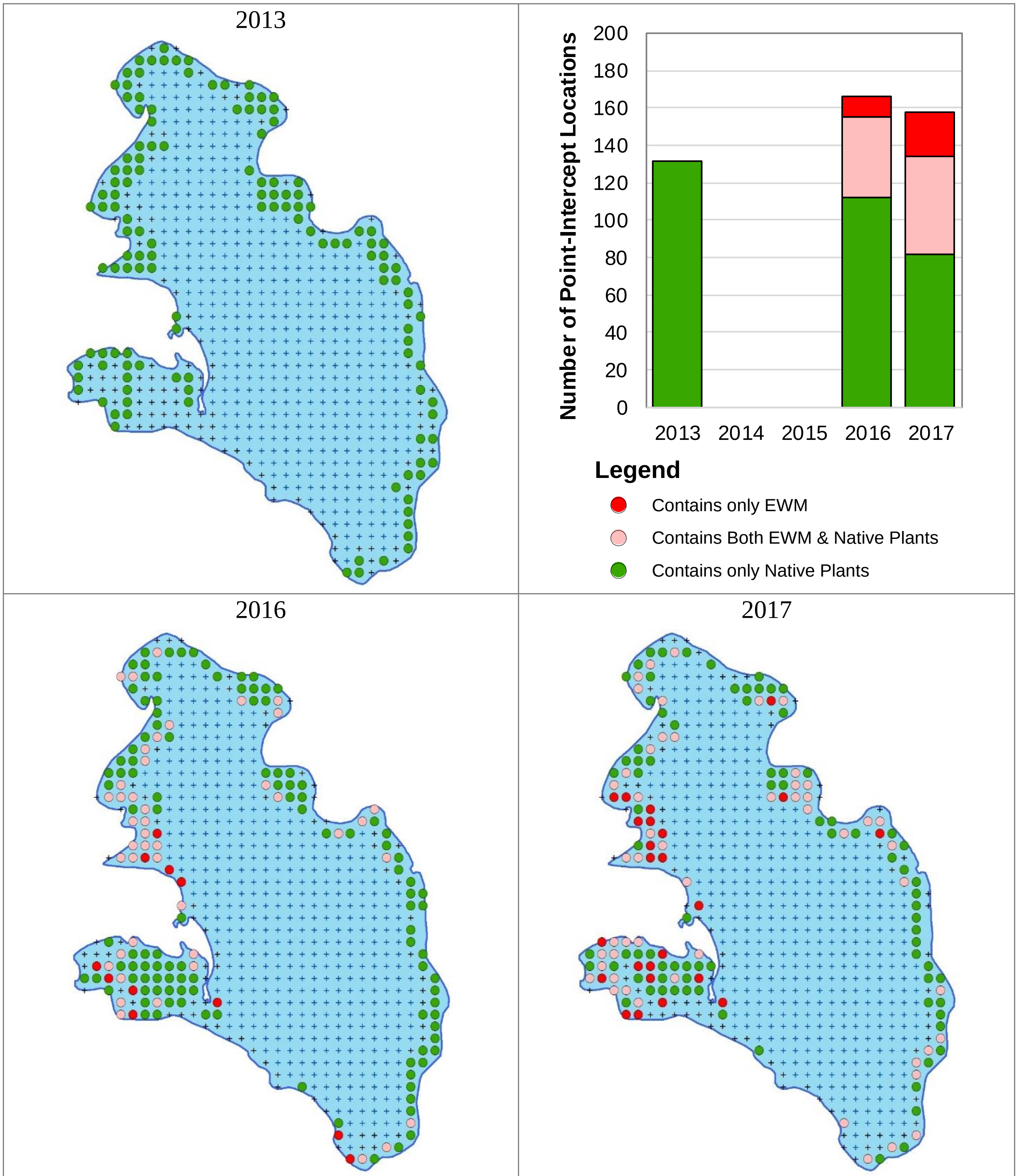


Figure 3.4-12. Native and EWM locations from point-intercept surveys.

If the native plant communities stay at relatively the same population levels in a lake, but the increased EWM adds a large amount of additional biomass to the lake, one may contend that lake

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Lake Management Planning

now has a different habitat architecture (i.e. lakescape). Depending on the perspective, this may be negative or positive. EWM has a concentration of biomass in the top of the water column, which may be different from existing habitat structure of the lake. While not only exacerbating human use, this increase of biomass in the upper part of the water column can impact refugia for zooplankton and fish species. This is especially important for shallow and heavily vegetated lakes that are dominated by panfish and other planktivores and insectivores. It is less clear how the addition of large amounts of plant biomass impact lakes like Upper Kaubashine that have fisheries driven by predator fish (piscivores).

Figure 3.4-13 shows the 2017 acoustic-based bio-volume study results of where dense and near-surface vegetation exists in the lake (yellow/orange/red colors), as well as an overlap of the mapped EWM colonies (hatched polygons). This confirms that almost all of the dense aquatic plant biomass in Upper Kaubashine Lake is EWM. It is important to note that in 2013, Upper Kaubashine contained low populations of species that grow high in the water column, as over half the native vegetation consisted of low-growing plants such as coontail, common waterweed, and muskgrasses (Figure 3.4-14).

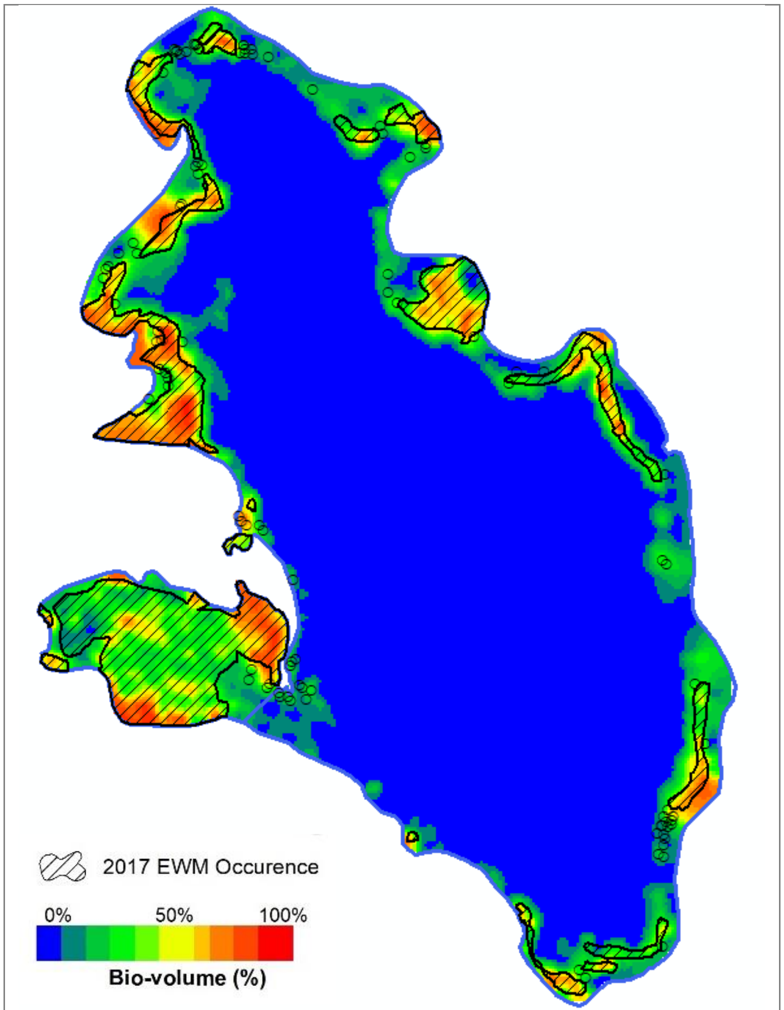

Figure 3.4-13. Upper Kaubashine Lake 2017 bio-volume & EWM colonies.

This also confirms that the current EWM footprint is almost the entirety of where plants grow within the lake. Any potentially increases in the EWM population may be from increases in density, but not likely from an increase in spatial distribution.

One way to look at the aquatic plant community composition is through the relative frequency of occurrence analysis. Because each sampling location may contain numerous plant species, relative frequency of occurrence is one tool to evaluate how often each plant species is found in relation to all other species found (composition of population). For instance, while muskgrasses had a littoral frequency of occurrence of 18% in 2017, their relatively frequency of occurrence was 11%. Explained another way, if 100 plants were sampled from Upper Kaubashine Lake in 2017, 11 would be muskgrasses. Figure 3.4-14 illustrates that approximately one out of every five or approximately 20% of Upper Kaubashine Lake's 2017 plant population was EWM compared with 0% in 2013.

The Simpson's Diversity index is influenced by how evenly the plant species are distributed within the community. The plant species listed in the "other species" category on Figure 3.4-14 are comprising a lower proportion of the entire plant population as Upper Kaubashine Lake becomes more dominated by a small number of species. That being said, the magnitude of the change has not had much influence on the diversity metric, as the Simpson's Diversity in 2017 (0.87) is not much different than in 2013 (0.88) or 2016 (0.88).

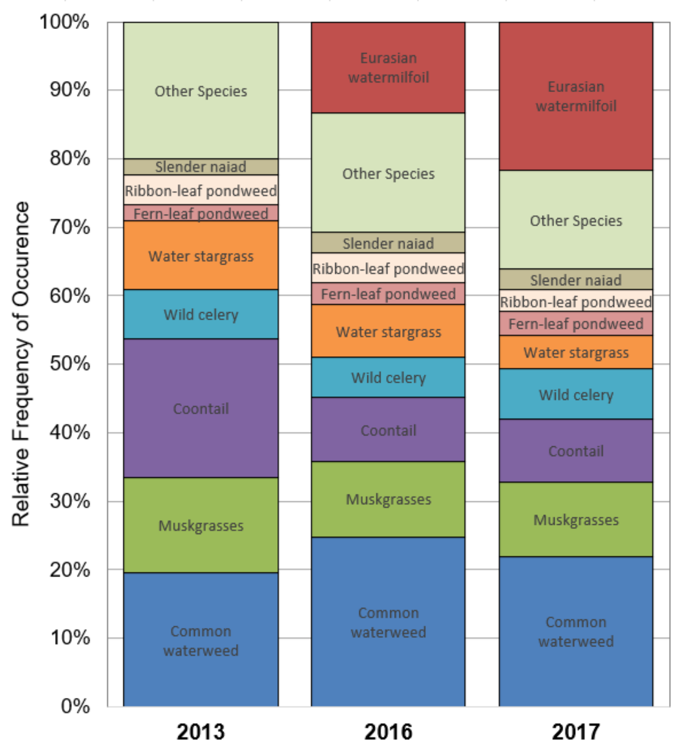

Figure 3.4-14. Relative frequency of occurrence analysis of Upper Kaubashine Lake.

Management Strategies for Upper Kaubashine Lake

During the Planning Committee meetings, Onterra outlined three potential EWM population goals for consideration including a recommended action plan to help reach each of the goals (Figure 3.4-15). Please note that WDNR has expressed concern about using the term *ecosystem restoration* in cases where the only metric of impairment is the increased population of the EWM (i.e. no documented changes in native plants, water quality, etc).

1. **Let Nature Take its Course - No Coordinated Active Management by UKPOA**
    - Onterra recommends considering a trigger when goal would be reconsidered
    - Onterra recommends UKPOA provide education on manual removal by property owners
2. **Improve ability for some riparians to navigate to deeper waters – Improve Cultural Ecosystem Services**
    - Onterra recommends professional hand-harvesting of areas or lanes
    - Hand-harvesting may not be able to reach this goal and herbicides or small mechanical harvester may be alternatives worth considering
    - Onterra does not recommend benthic barriers past individual riparian use
3. **Reduce EWM Population on a lake-wide level - Ecosystem Restoration Approach**
    - Extensive monitoring before and after
    - Onterra recommends a large-scale herbicide treatment (most likely using liquid 2,4-D amine at a target of 0.3 ppm ae) followed by contingency strategy

Figure 3.4-15. Potential EWM Management Goals. Presented by Onterra at Planning Committee meetings.

Let Nature Take its Course: As discussed above, unmanaged EWM populations on some lakes may increase rapidly following detection, as occurred on Upper Kaubashine Lake. In some instances, the EWM population plateaus or reduces without active management. Some lake groups decide to periodically monitor the EWM population, typically through an annual or semi-annual point-intercept survey, but do not coordinate active management (e.g. hand-harvesting or herbicide treatments). Individual riparians could choose to hand-remove the EWM within their recreational footprint, but the lake group would not assist financially or by securing permits if necessary. In most instances, the lake group may select an EWM population threshold or "trigger" where they would revisit their management goal if the population reached that level.

In 2017, a few riparians contracted hand-harvesting services by a local party to remove EWM in front of their properties. Because these efforts did not include a mechanized assistance component (i.e. DASH), WDNR permits were not required for these activities. Riparians noted that EWM populations grew back in these removal areas by the end of the summer, but were not as dense as prior to the removal effort.

Improve Cultural Ecosystem Services: The concept of ecosystem services is that the natural world provides a multitude of services to humans, such as the production of food and water (provisioning), control of climate and disease (regulating), nutrient cycles and pollination (supporting), and spiritual and recreational benefits (cultural). Some lake groups acknowledge that the most pressing issues with their EWM population is the reduced recreation, navigation, and aesthetics compared to before EWM became established in their lake. Particularly on lakes with large EWM populations that may be impractical or unpopular to target on a lake-wide basis, the lake group would coordinate (secure permits and financially support the effort) a strategy to improve the navigability within the lake. This is typically accomplished by designing common-use navigation lanes through EWM colonies that would be managed through herbicide spot treatments or mechanical harvesting, but the use of professional hand-harvesting to provide common use lanes is being explored on some lakes. Control efforts near individual properties would be the responsibility of the riparian.

Ecosystem Restoration Approach: Some believe that there is an intrinsic responsibility to correct for changes in the environment that are caused by humans. For lakes with EWM populations, that may be to manage the EWM population at a reduced level with the perceived goal to allow the lake to function as it had prior to EWM establishment. As discussed above, it must also be acknowledged that some lake managers and natural resource regulators question whether that is an achievable goal. The WDNR also questions the use of *ecosystem restoration* when impairment is not documented or defined.

In early EWM populations, the entire population may be targeted through hand-harvesting or spot treatments. This was the response strategy of the UKPOA after EWM was first located within the lake.

On more advanced or established populations, this may be accomplished through large-scale control efforts such as water-level drawdowns or whole-lake herbicide treatment strategies. If conducted properly, large-scale management can reduce EWM populations for several years, but will not eradicate it from the lake. Subsequent smaller scale management (e.g. hand-harvesting or spot treatments) is typically employed to slow the rebound of the population until another large-scale effort is likely required again. Typically, complete rebound of an EWM population following a large-scale control action is 4-6 years, with quicker rebound on some lakes and longer control observed on others. Large-scale control efforts, especially using herbicide treatments, can be impactful of some native plant species as well as carry a risk of environmental toxicity. Some argue that the impacts of the control actions may have greater negative impacts to the ecology of the system than if the EWM population was not managed.

Stakeholder Survey Responses to Aquatic Vegetation within Upper Kaubashine 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. Of the 86 possible Upper Kaubashine Lake riparians, 66 completed the 36-question survey yielding a 77% response rate. In instances where stakeholder survey response rates are 60% or above, the results can be interpreted as being a statistical representation of the population.

When asked if stakeholders believe aquatic plant control is needed on Upper Kaubashine Lake, 68% indicated *definitely yes,* 20% indicated *probably yes,* 9% indicated they were *unsure,* and 3% indicated *probably no* (Figure 3.4-16).

Question 26: Do you believe aquatic plant control is needed on Upper Kaubashine Lake?

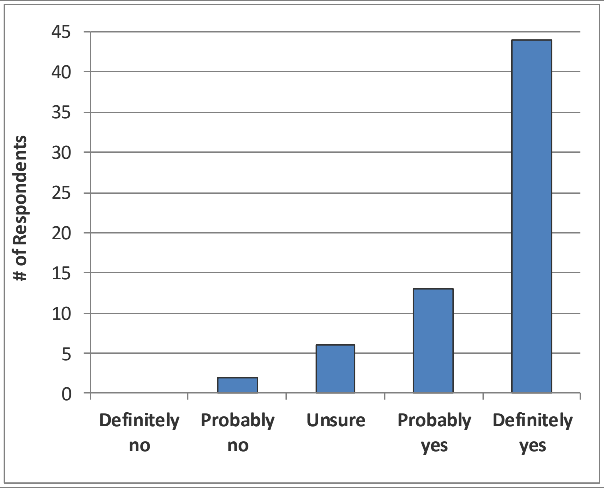

Figure 3.4-16. Select survey responses from the UKPOA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

The UKPOA Planning Committee also wanted to understand the stakeholders' perceptions on the use of various active management techniques (Figure 3.4-17). 75% of stakeholder respondents indicated they were supportive (pooled *highly supportive* and *moderately supportive* responses) of responsibly using herbicides in Upper Kaubashine Lake, whereas 13% were unsupportive (pooled *not supportive* and *moderately un-supportive* responses). Similarly, 73% of stakeholder respondents indicated they were supportive (pooled *highly supportive* and *moderately supportive* responses) of responsibly conducting hand-harvesting with divers in Upper Kaubashine Lake, whereas only 6% were unsupportive (pooled *not supportive* and *moderately un-supportive* responses). Only 6% of the stakeholders were supportive of not managing the aquatic plants and monitoring their populations

More specifically, stakeholders were asked about their level of support or opposition to aquatic herbicide use to target Eurasian watermilfoil in Upper Kaubashine Lake. 85% of stakeholders indicated they were supportive (pooled *highly supportive* and *moderately supportive* responses), whereas 12% were unsupportive (pooled *not supportive* and *moderately un-supportive* responses), and only 3% were *unsure* (Figure 3.4-17). It is important to note that the stakeholder survey response period occurred in October, 2016, after association members and other riparians were given an opportunity to participate in Onterra presentations at the 2014, 2015, and 2016 annual meetings. At these meetings, Tim Hoyman discussed the EWM population progression, EWM management strategies (including herbicide use pros and cons), and the WDNR's EWM Long-Term Trend Monitoring results.

Question 27: What is your level of support for the responsible use of the following techiniques on Upper Kaubashine Lake?

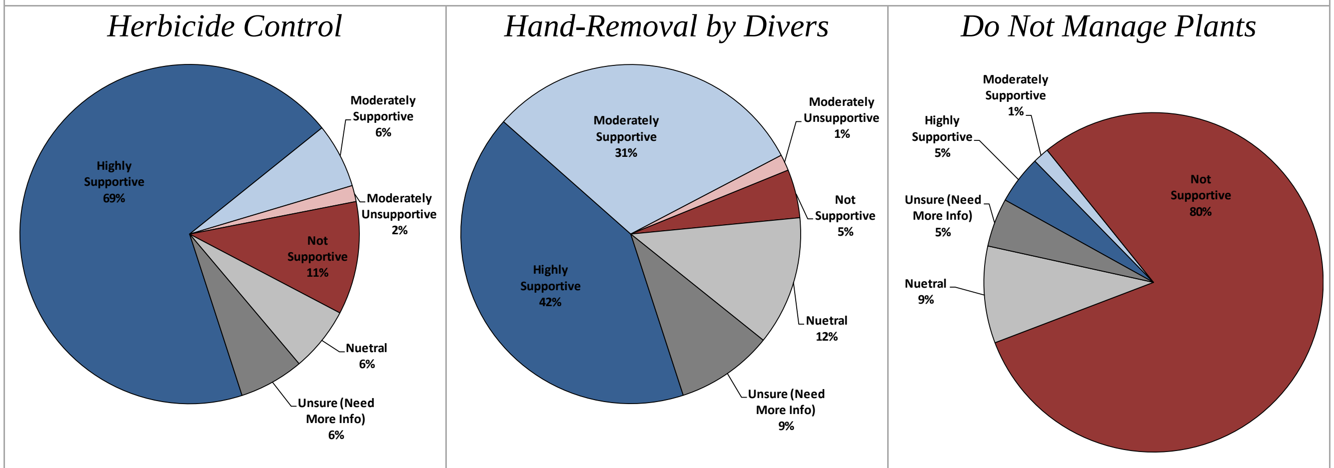

Figure 3.4-17. Select survey responses from the UKPOA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Upper Kaubashine Lake Management Goal Adoption Process

On June 28, 2017 the UKPOA Planning Committee voted 4 (in favor) to 2 (against) pursuing large-scale herbicide treatment strategy to present to the membership for consideration. The two Planning Committee Members asked that their names not be included in the list of Planning Committee Members on the title page of this document.

Prior to the 2017 UKPOA annual meeting, the Planning Committee with review from Onterra and the WDNR, distributed a *10 Eurasian Watermilfoil Myths and Facts* factsheet (Appendix D). At the meeting, both dissenting Planning Committee members were given an opportunity to explain to the attendees why they were not in favor of a large-scale herbicide control strategy. Some other UKPOA members then voiced their opinion, either for or against herbicide use. The UKPOA membership voted 72 *for* and 18 *against* to give the Board of Directors permission to make the decision on how to proceed. The Board of Directors will vote on the strategy following review of the draft Comprehensive Lake Management Plan.

Developing a Large-Scale Herbicide Control and Monitoring Strategy

From an ecological perspective, large-scale treatments are those where the herbicide may be applied to specific sites, but when the herbicide dissipates from where it was applied and reaches equilibrium within the entire mixing volume of water (of the 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 treated volume. A recent article by Nault et al. 2018 investigated 28 large-scale herbicide treatments in Wisconsin and found that "herbicide dissipation from the treatment sites into surrounding untreated waters was rapid (within 1 day) and lakewide low-concentration equilibriums were reached within the first few days after application." WDNR administrative code defines large-scale treatments as those that exceed 10% of the littoral zone (NR 107.04[3]). As spot treatments approach 10% of a lake's area, they are more likely to have large-scale impacts, which is why the WDNR has this check mechanism within the permitting process.

Predicting success and native plant impacts from large-scale treatments is also better understood than for spot treatments. However, with any large-scale chemical treatment, both the positive and negative effects of this type of treatment strategy are anticipated to occur at a lakewide scale, whereas the impacts from spot treatments are mostly contained within and around the application sites.

Efficacy

Figure 3.4-18 includes the entirety of Onterra-monitored 2,4-D large-scale treatments in the Northern Lakes and Forests Ecoregion that have progressed to at least 1 year after treatment (YAT). Also included on this figure are two lakes that received large-scale 2,4-D treatments that were monitored by WDNR as part of the EWM Long-Term Trends project discussed above. Properly implemented large-scale herbicide treatments can be highly effective, with minimal EWM, often zero, being detected for a year or two following the treatment (Figure 3.4-18). Some large-scale treatments have been effective at reducing EWM populations for 5 or more years following the application, whereas others have rebounded sooner (i.e. South Twin '16, Sandbar '11).

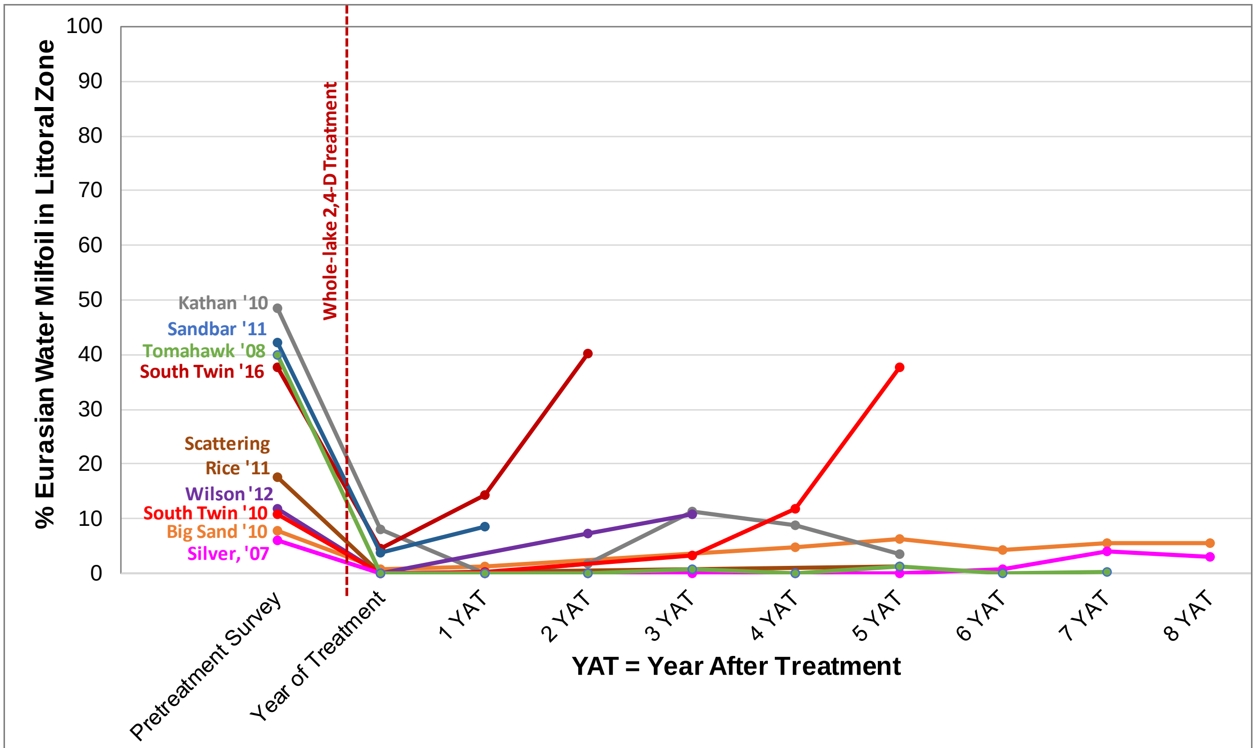

Figure 3.4-18. Littoral frequency of occurrence of EWM in lakes managed with large-scale 2,4-D treatments. South Twin '10 had treatment at 6 YAT, Kathan '10 had treatment at 6 YAT, Sandbar '11 had treatment at 2 YAT & 6 YAT, Silver '07 had treatment at 9 YAT, Tomahawk had a treatment at 9 YAT. All others are ongoing. Data collection is a mix of Onterra and WDNR.

Lake manager's ability to predict whole-lake herbicide concentrations has improved, but understanding the degradation period has not. In some cases, the biological breakdown of 2,4-D through microbial activity has been slower than typically observed. Nault et al. 2018 indicated the 2,4-D half-life was shown to range from 4-76 days within the 28 lakes studies, with the "rate of herbicide degradation to be slower in lower-nutrient seepage lakes." While Upper Kaubashine is often classified as a spring lake, the practical distinction in regards to herbicide breakdown is minimal. Upper Kaubashine Lake has minimal water leaving it making dissipation likely a negligible factor in the 2,4-D half-life with the lake. The primary function of lowering 2,4-D levels over time will be driven by biological degradation. Biologically-related water quality samples collected during the summer of 2017 indicate that Upper Kaubashine Lake is of moderate productivity (mesotrophic). That being said, an adjusted dosing strategy accounting for a potential long half-life is suggested.

Selectivity

Some native plants are quite resilient to large-scale 2,4-D treatments, either because they are inherently tolerant of the herbicide's mode of action or they emerge later in the year than when the herbicide is active in the lake. Other species, particularly dicots, some thin-leaved pondweeds, and naiad species, can be impacted and take a number of years to recover. Often during the year of treatment, overall native plant biomass can be lessened but typically (not always) rebounds the following year. However, the preceding statements are a bit of a generalization because some case studies have had varying levels of EWM control even at high concentration and exposure times and others case studies had collateral native plant impacts greater than would be assumed considering the concentrations and exposure times achieved.

An analysis of the anticipated native plant impacts of a large-scale 2,4-D treatment in Upper Kaubashine Lake was presented at Planning Meeting I and is contained within Appendix A (PDF pg 16-17). In 2016 when this analysis was conducted, common waterweed, muskgrasses, coontail, northern watermilfoil, and wild celery were the most dominant native plants. The analysis indicates that with the exception of northern watermilfoil, these species are generally resilient to large-scale 2,4-D treatments. Northern watermilfoil is highly impacted by this form of management and would be anticipated to take large collateral impact.

Toxicity

The use of any aquatic herbicide poses environmental risks to non-target plants and aquatic organisms. The majority of available toxicity data has been conducted as part of the EPA product registration process. These laboratory studies are attempted to mimic field settings, but can underestimate or overestimate the actual risk (Fairbrother and Kapustka 1996). Federal and state pesticide regulations and strict application guidelines are in place to minimize impacts to non-target organisms based on the organismal studies. The use of aquatic herbicides includes regulatory oversight and must comply with the following list. Additional information from the WDNR on aquatic herbicide regulation is included within Appendix E.

- Labeled and registered with U.S. EPA's office of Pesticide Programs;
- Registered for sale and use by the Department of Agriculture, Trade, and Consumer Protection (DATCP);
- Permitted by the Wisconsin Department of Natural Resources (WDNR); and
- Applied by a DATCP-certified and licensed applicator,

The EPA-approved maximum application rate for liquid 2,4-D amine is 4.0 ppm acid equivalent (ae). At these rates, there are no restrictions on swimming, fish consumption, human drinking water, or pet/livestock drinking water. There are irrigation restrictions such that specific plants, particularly dicot species, should not be watered with concentrations above 70 ppb for concerns of herbicidal impacts. The 2,4-D amine use pattern being considered for Upper Kaubashine Lake is to target specific areas at a dose of up to 2.68 ppm ae to achieve a lake-wide concentration of 0.3 ppm ae (Map 7). This concentration is above 0.07 ppm ae, the EPA's maximum contaminant level of public drinking water.

As outlined within the WDNR's 2,4-D chemical fact sheet (Appendix E), there are human risks of being exposed to 2,4-D, especially for high-exposure populations (herbicide applicators and farmers). These include lymphoma and endocrine disruption (tier 1 screening by EPA). 2,4-D is currently classified by EPA as a Group D herbicide, which indicates that the inability to prove or disprove that there is human carcinogenicity (USDA FS 2006). The World Health Organization classifies 2,4-D as being "possibly carcinogenic to humans."

It is important to note that US EPA registration of aquatic herbicides requires organismal toxicity studies to be conducted using concentrations and exposure times consistent with their intended use. For herbicides like 2,4-D, the historic registration was aimed at spot-treatment use patterns (high concentrations, short exposure times). Therefore, only limited organismal toxicity data is available for concentrations and exposure times consistent with whole-lake treatment use patterns (low concentrations, long exposure times). Highlighted below is a recent and relevant research project from Wisconsin consistent with large-scale 2,4-D use patterns.

Because of their durability as a laboratory species, fathead minnows are often the subject of organismal toxicity studies. The LC50 (lethal concentration when half die) for fathead minnow exposure to 2,4-D (amine salt) has been determined to be 263 ppm ae sustained for 96 hours, a thousand times higher than fish would be exposed to in a large-scale treatment (target of approximately 0.3 ppm ae). With the assistance of a WDNR AIS-Research Grant, DeQuattro and Karasov (2015) investigated the impacts on fathead minnow of 2,4-D concentrations more relevant to what would be observed in large-scale treatments. The focus of their investigations was on reproductive toxicity and/or possible endocrine disruption potential from the herbicide. The study revealed morphological changes in reproducing male fathead minnows, such that they had lower tubercle scores (analogous to smaller antlers on a male white-tail deer) with some 2,4-D products/use-rates and not with others. This may suggest that the "inert" carrier may be the cause, not the 2,4-D itself. At a static exposure of 0.05 ppm ae for 58 days (adult fish exposed for 28 days then larval fish from eggs they laid were continued to be exposed for 30 more days post fertilization) uncovered a reduction in larval fathead survival from 97% to 83% at the lowest dose of the 2,4-D (amine salt) formulation was tested (no reduction at higher doses).

Dehnert et al. 2018 continued this line of investigation were able to identify a particularly vulnerable window of exposure of fathead minnow. The study also indicate that pure 2,4-D and two commercially available herbicides had relatively similar outcomes, indicating that the cause of the 10-20% reduced larval survivability is likely related directly to the active ingredient and not the inert ingredients.

A cooperative UW-Steven's Point and WDNR research project entitled *Effects of 2, 4-D Herbicide Treatments Used to Control Eurasian Watermilfoil on Fish and Zooplankton in Northern Wisconsin Lakes* was conducted in response to this laboratory work to see if changes could be observed in a series of field trials (Rydell 2018). Three lakes were given large-scale 2,4-D amine treatments and a paired set of three lakes served as untreated reference lakes. The limnological, zooplankton, fisheries, and aquatic plant communities of these lakes were thoroughly sampled during the year prior to treatment, the year of treatment, and the year after treatment. A plethora of important data came from the study; however, measurable impacts from the herbicide treatments on the zooplankton and fisheries were not documented. A one-page summary report from the UWSP/WDNR study is included as part of Appendix E to this report.

Purple loosestrife

Purple loosestrife (Photograph 3.4-6) is a perennial herbaceous plant native to Europe and was likely brought over to North America as a garden ornamental. This plant escaped from its garden landscape into wetland environments where it is able to out-compete our native plants for space and resources. First detected in Wisconsin in the 1930's, it has now spread to 70 of the state's 72 counties. Purple loosestrife largely spreads by seed, but also can vegetatively spread from root or stem fragments.

Photograph 3.4-6. Purple loosestrife, a non-native, invasive wetland plant. Photo credit Onterra.

Purple loosestrife occurrences were located growing along the northeastern side of Upper Kaubashine Lake's shoreline (Map 5). All of these occurrences were comprised of a single or few plants, and no large monotypic colonies were observed. There are a number of effective control strategies for combating this aggressive plant, including herbicide application, biological control by native beetles, and manual hand removal.

3.5 Aquatic Invasive Species in Upper Kaubashine Lake

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

Table 3.5-1. AIS present within Upper Kaubashine Lake

Type	Common name	Scientific name	Location within the report
Plants	Eurasian watermilfoil	*Myriophyllum spicatum*	Section 3.4 – Aquatic Plants
	Purple loosestrife	*Lythrum salicaria*	Section 3.4 – Aquatic Plants
Invertebrates	Chinese mystery snail	*Cipangopaludina chinensis*	Section 3.5 - Aquatic Invasive Species
	Rusty crayfish	*Orconectes rusticus*	Section 3.5 - Aquatic Invasive Species

Figure 3.5-1 displays the eight aquatic invasive species that Upper Kaubashine Lake stakeholders believe are in Upper Kaubashine Lake. Only the species present in Upper Kaubashine 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

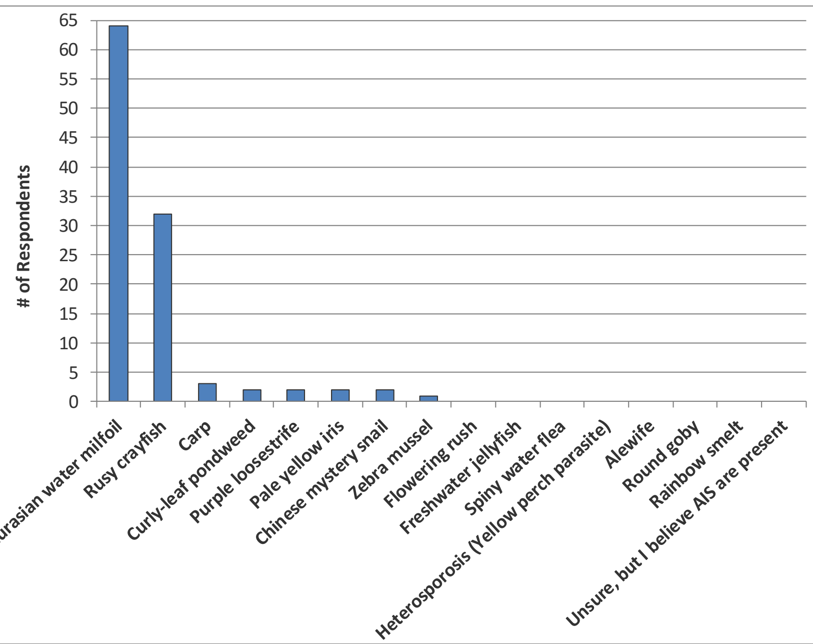

Figure 3.5-1. Stakeholder survey response Question #22. Which aquatic invasive species do you believe are in Upper Kaubashine Lake?

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 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).

Rusty Crayfish

Rusty crayfish (*Orconectes rusticus*) are originally from the Ohio River basin and are thought to have been transferred to Wisconsin through bait buckets. These crayfish displace native crayfish and reduce aquatic plant abundance and diversity. Rusty crayfish can be identified by their large, smooth claws, varying in color from grayish-green to reddish-brown, and sometimes visible rusty spots on the sides of their shell. They are considered more aggressive than the native crayfish, which may make them less attractive as a food source for some fish species. Rusty crayfish reproduce quickly but with intensive harvesting their populations can be reduced impacted within a lake.

Since the 1980s, Upper Kaubashine Lake has contained a known population of rusty crayfish. In many lakes, introduction of rusty crayfish can reduce aquatic plant abundance and diversity. Anecdotally, Upper Kaubashine Lake has had a low aquatic plant population and great concerns existed that the rusty crayfish population could decimate the aquatic plant community of the system. Since 1989, professional trappers were hired to remove rusty crayfish from Upper Kaubashine Lake (Figure 3.5-2). The UKPOA had difficulty finding a trapper to hire in 1997 and 1998, therefore no trapping was done those years. In the early 2000s and after 2005, there was a low population of crayfish and therefor no trapping was conducted.

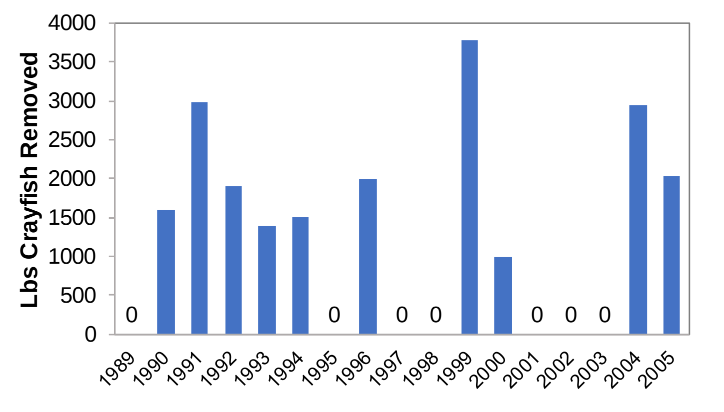

Figure 3.5-2. Pounds of rusty crayfish removed from Upper Kaubashine Lake.

3.6 Fisheries Data Integration

Fishery management is an important aspect in the comprehensive management of a lake ecosystem; therefore, a 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 Upper Kaubashine Lake. The goal of this section is to provide an overview 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) (WDNR 2017).

Upper Kaubashine Lake Fishery

Upper Kaubashine Lake Fishing Activity

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 Upper Kaubashine 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.

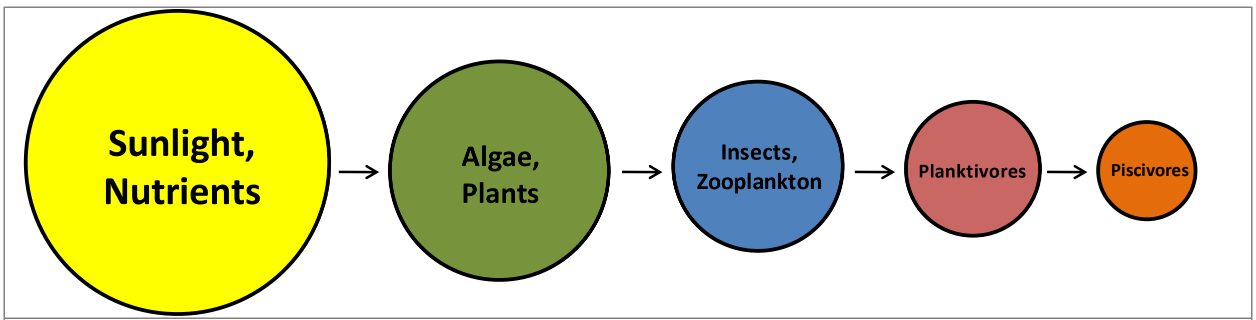

Figure 3.6-1. Aquatic food chain. Adapted from Carpenter et. al 1985.

As discussed in the Water Quality section, based on the minimal amount of historical water quality data, Upper Kaubashine Lake is a mesotrophic system, meaning it has a moderate nutrient content and thus a moderate amount of primary productivity. This is relative to a eutrophic system, which contains more nutrients (more productive). Simply put, this means Upper Kaubashine Lake should be able to support a modest sized population of predatory fish (piscivores) when compared to eutrophic system. Table 3.6-1 shows the popular game fish present in the system. Although not an exhaustive list of species, historical data also lists perch, bluegill, crappie, rock bass, pumpkinseed, and suckers as present in the lake (WDNR).

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

Common Name (*Scientific Name*)	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements	Food Source
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation	Fish, amphipods, algae, crayfish and other invertebrates
Muskellunge (*Esox masquinongy*)	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.	Fish including other muskies, small mammals, shore birds, frogs
Northern Pike (*Esox lucius*)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves	Fish including other pike, crayfish, small mammals, water fowl, frogs
Smallmouth Bass (*Micropterus dolomieu*)	13	Mid May - June	Nests more common on north and west shorelines over gravel	Small fish including other bass, crayfish, insects (aquatic and terrestrial)
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms	Fish, fly and other insect larvae, crayfish

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 common passive trap used 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 and 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) then release the captured fish.

The other commonly used sampling method is electroshocking (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 easy for fisheries technicians to net and place into a livewell to recover. Contrary to what some may believe, electroshocking 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.

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

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.

Fish Stocking

To assist in meeting fisheries management goals, the WDNR may stock fry, fingerling or adult fish in a waterbody that were raised in nearby permitted hatcheries (Photograph 3.6-2). Stocking of 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. Upper Kaubashine does not have adequate public access, so DNR does not perform Natural Resource Enhancement Services like fish stocking. Upper Kaubashine Lake has been privately stocked since at least 1955 with a variety of fish species and the available stocking records are displayed on Table 3.6-2. Additional private stocking efforts may have occurred, however details of these efforts were not available within WDNR records.

Photograph 3.6-2 Walleye Fingerling.

Table 3.6-2. Stocking data available for Upper Kaubashine Lake (1956-2016).

Lake	Year	Species	Stock Source Group	Age Class	# Fish Stocked	Avg Fish Length (in)
Upper Kaubashine	2001	Black Crappie	Non-DNR	Large Fingerling	525	3
Upper Kaubashine	2000	Bluegill	Non-DNR	Yearling	200	4
Upper Kaubashine	2001	Bluegill	Non-DNR	Unspecified	525	3
Upper Kaubashine	2002	Bluegill	Non-DNR	Large Fingerling	400	5
Upper Kaubashine	1990	German Brown Trout	-	-	2,000	5
Upper Kaubashine	1990	Largemouth Bass	-	-	1,000	4
Upper Kaubashine	1955	Muskellunge	-	Fingerling	183	-
Upper Kaubashine	1956	Walleye	-	Fingerling	2,000	-
Upper Kaubashine	1959	Walleye	-	Fingerling	11,100	-
Upper Kaubashine	2000	Walleye	Non-DNR	Large Fingerling	800	4
Upper Kaubashine	2001	Walleye	Non-DNR	Large Fingerling	525	5
Upper Kaubashine	2002	Walleye	Non-DNR	Large Fingerling	700	6
Upper Kaubashine	2015	Walleye	Non-DNR	Large Fingerling	1899	8
Upper Kaubashine	2001	Yellow Perch	Non-DNR	Large Fingerling	525	3

Fishing Activity

Based on data collected from the stakeholder survey (Appendix B), fishing was the second most important reason for owning property on or near Upper Kaubashine Lake (Question #17). Figure 3.6-2 displays the fish species that Upper Kaubashine Lake stakeholders enjoy catching the most. Approximately 80% of these same respondents believed that the quality of fishing on the lake either remained the same or had gotten worse since they first began fishing on the lake (Figure 3.6-3). Approximately 70% of survey respondents who fish Upper Kaubashine Lake believe the current quality of fishing is fair or good (Figure 3.6-4).

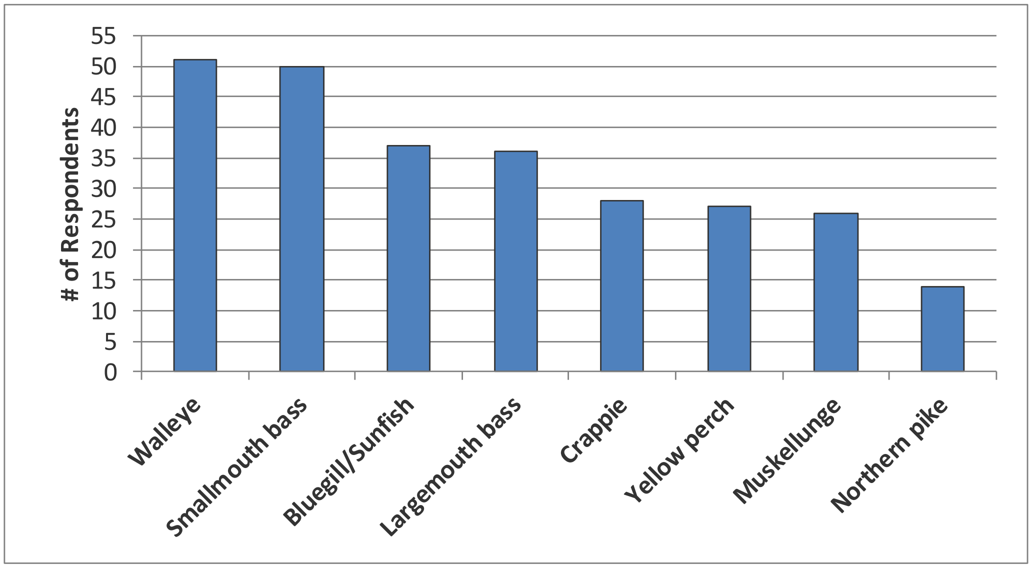

Figure 3.6-2. Stakeholder survey response Question #9. What species of fish do you like to catch on Upper Kaubashine Lake?

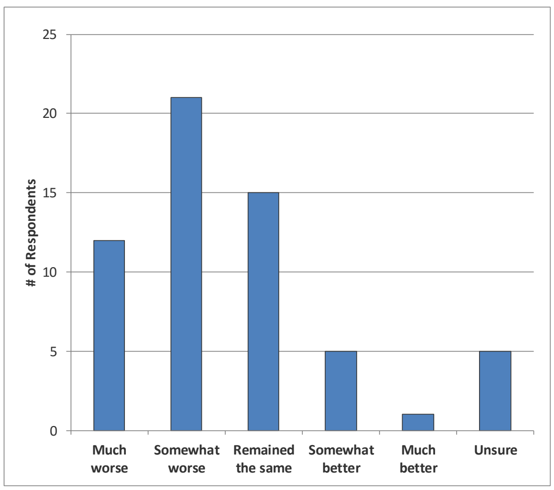

Figure 3.6-3. Stakeholder survey response Question #12. How has the quality of fishing changed on Upper Kaubashine Lake since you started fishing the lake?

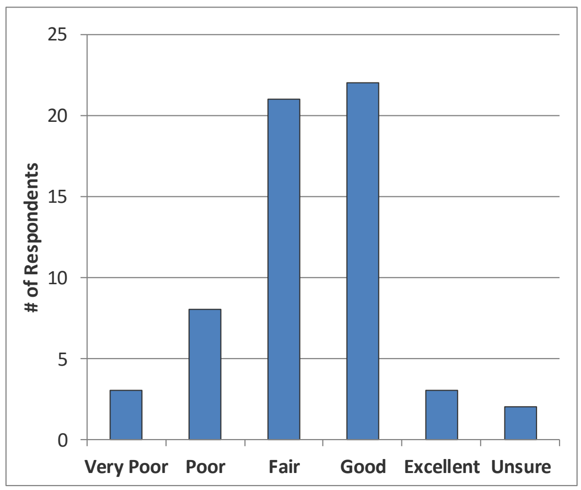

Figure 3.6-4. Stakeholder survey response Question #11. Given your fishing preference, how would you describe the current quality of fishing on Upper Kaubashine Lake?

Ceded Territory Spear Harvest Records

Approximately 22,400 square miles of northern Wisconsin was ceded to the United States by the Lake Superior Chippewa tribes in 1837 and 1842. Upper Kaubashine Lake falls within the ceded territory based on the Treaty of 1842. This allows for a regulated open water spear fishery by Native Americans on lakes located within the Ceded Territory. While within the ceded territory, Upper Kaubashine Lake has not experienced a spearfishing harvest. A declaration for walleye and muskellunge harvest has been listed for Upper Kaubashine Lake in recent years; however no spearing efforts have been undertaken.

Upper Kaubashine 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 is 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 2016, 55% of the substrate sampled in the littoral zone of Upper Kaubashine Lake was sand sediments, 23% was soft with the remaining 22% composed of rock substrate. The makeup of substrate types is corroborated by the acoustic-based sediment composition survey (Figure 3.4-2).

Coarse Woody Habitat and Fish Sticks Program

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 2006).

Photograph 3.6-3. Fish Stick Example.
(Photo courtesy of WDNR 2014)

The "Fish sticks" program, outlined in the WDNR best practices manual, adds trees to the shoreland zone by restoring fish habitat to critical near shore areas (WDNR 2014). 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.

These projects are typically conducted on lakes lacking significant coarse woody habitat in the shoreland zone. During Onterra's 2017 coarse woody habitat survey, 61 coarse woody pieces per mile of shoreline were documented on the lake. To further improve the available fish habitat in Upper Kaubashine Lake, installing fish sticks in the lake may be considered.

Regulations and Management

Fishing regulations as of December 2017 for Upper Kaubashine Lake gamefish species are displayed in Table 3.6-3. 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 3.6-3. WDNR fishing regulations for Upper Kaubashine Lake (2017-2018).

Species	Daily bag limit	Length Restrictions	Season
Panfish	25	None	Open All Year
Largemouth bass and smallmouth bass	5	14"	June 17, 2017 to March 4, 2018
Smallmouth bass	Catch and release only	None	May 6, 2017 to June 16, 2017
Largemouth bass	5	14"	May 6, 2017 to June 16, 2017
Muskellunge and hybrids	1	40"	May 27, 2017 to November 30, 2017
Northern pike	5	None	May 6, 2017 to March 4, 2018
Walleye, sauger, and hybrids	3	The minimum length is 15", but 20" to 24" may not be kept, and only 1 fish over 24" is allowed.	May 6, 2017 to March 4, 2018

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 3.6-5. 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.

Section 303(d) of the Clean Water Act requires states, every two years, to make a list of all waterbodies not meeting water quality standards. In 1988, Upper Kaubashine was listed as an impaired waterbody due to elevated mercury concentrations via atmospheric deposition (WDNR 2016). This requires anglers to give careful observation to fish consumption guidelines when fishing in Upper Kaubashine Lake.

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 3.6-5. 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/)

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 Upper Kaubashine 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 Upper Kaubashine Lake stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.

These objectives were fulfilled during the project and have led to a better understanding of the Upper Kaubashine Lake ecosystem, the people who care about the lake, and what needs to be completed to protect, monitor, and enhance the lake. Overall, the results of the studies that were conducted on Upper Kaubashine are indicative of a relatively healthy ecosystem.

Analysis of limited current water quality data indicates that Upper Kaubashine Lake's water quality overall falls within the *excellent* category for deep, headwater drainage lakes (which includes the classification of spring lakes) in Wisconsin. The biological parameters (total phosphorus and chlorophyll-a) indicates the lake is of moderate productivity (mesotrophic). The UKPOA's enrollment within the advanced CLMN program will ensure additional data will be collected in the future to understand if changes in water quality parameters are occurring in the system.

Being a spring lake, groundwater and the land use around the immediate shoreline areas are going to have a large influence over the lake's water quality. About 26% of Upper Kaubashine Lake's shoreline consisted of the two most impactful categories (*urbanize*d and *developed–unnatural* shoreland, whereas 63% consisted of shorelines in the two most ecologically beneficial categories (*developed–natural* and *undeveloped*). It is fundamental to the health of Upper Kaubashine Lake to preserve natural shorelands and take considerable steps towards shifting the proportion of developed shorelines into less impactful categories.

By all standard metrics, the vegetation surveys revealed that the aquatic plant community of Upper Kaubashine Lake is of moderate quality compared to other lakes within the ecoregion and throughout the state. The lake contains a slightly lower number of native species and slightly lower diversity than others in its ecoregion. The latter is influenced by how even the species populations are within the lake, which have been altered following the establishment of EWM within the system. Many of the native aquatic plant species have not shown practically significant changes (some statistically valid changes noted) in their population during the 5 years since EWM has been detected from Upper Kaubashine Lake

Exotic species, particularly EWM have been a focus of management for the UKPOA. EWM was first discovered in 2013 (4 years ago) and the association has been able to watch the population increase quickly throughout the lake. During this time, the UKPOA was proactive and conducted professional hand-harvesting efforts in 2014 and 2015 only to learn the amount of effort was nowhere near what would be needed to keep the population in check or reduce it. This was not a fault of the UKPOA, simply the understanding of this control method continues to be in its infancy and Upper Kaubashine Lake became a field trial to understand its applicability.

The development of a management plan, specifically in response to the growing EWM population, has been a contentious issue within the UKPOA. The Planning Committee was developed with that in mind, getting participation from differing perspectives. Ultimately, a decision on whether or not to use aquatic herbicides to target the EWM population needed to be made. It is known that the use of herbicides is not without impact or risk. Some folks believe the benefits justify the risks, and others do not.

Anecdotal accounts indicate that Upper Kaubashine Lake historically had a low aquatic plant population. The high biomass of aquatic plants, especially EWM, observed in 2016-2017 was alarming to many riparians. Comments provided by the WDNR are clear that they do not believe a large-scale herbicide treatment on Upper Kaubashine can be justified for ecosystem restoration, as they believe there is no evidence to show impairment (Appendix F).

With a split decision, the Planning Committee voted to move forward developing a strategy to target the EWM population on a lake-wide basis. The reduction of EWM would attempt to set the aquatic vegetation community (lakescape) back closer to what it looked like in 2013 while also acknowledging that some native plant impacts are anticipated. The reduction of EWM would also alleviate some of the human use issues (recreation, navigation, etc.) that are at the forefront of many Upper Kaubashine Lake property owner's concerns.

The UKPOA understand that entering into this type of a management strategy does not end after a large-scale management event (whole-lake herbicide treatment), but continues through monitoring and follow-up small-scale management events (hand-harvesting) to extend the benefits and allow any collateral impacts to adjust.

5.0 IMPLEMENTATION PLAN

The Implementation Plan presented below was created through the collaborative efforts of the UKPOA Planning Committee and ecologist/planners from Onterra. It represents the path the UKPOA intends to 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 Upper Kaubashine Lake stakeholders as portrayed by the members of the Planning Committee, 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.

While the UKPOA Board of Directors is listed as the facilitator of the majority of management actions listed below, many of the actions may be better facilitated by a sub-committee or an individual director (e.g. Education and Communication Committee, Water Quality Director/Committee, Invasive Species Committee, Shoreland Improvement Director/Committee). The UKPOA will be responsible for deciding whether the formation of sub-committees and or directors is needed to achieve the various management goals.

Management Goal 1: Increase UKPOA's Capacity to Communicate with Lake Stakeholders and Facilitate Partnerships with Other Management Entities

Management Action:	Use education to promote lake protection and enjoyment through stakeholder education
Timeframe:	Continuation of current efforts
Facilitator:	UKPOA Board of Directors – possibly formation of an Education and Communication Committee
Description:	Education represents an effective tool to address many lake issues. The UKPOA regularly distributes (2 times per year) its newsletter and frequent email communications. These mediums allow for exceptional communication with association members. This level of communication is important within a management group because it facilitates the spread of important association news, educational topics, and even social happenings. The UKPOA will also give consideration to periodic expansion of its communication strategy past those that belong to the association and include all property owners around Upper Kaubashine Lake. The UKPOA will continue to make the education of lake-related issues a priority. These may include educational materials, awareness events, and demonstrations for lake users as well as activities which solicit local and state government support. *Example Educational Topics* • Specific topics brought forth in other management actions • Aquatic invasive species identification and spread

	• Basic lake ecology • Sedimentation • Boating safety (promote existing guidelines) • Noise, air, and light pollution • Shoreline habitat restoration and protection • Preserving and enhancing coarse woody habitat • Fishing regulations and overfishing • Fireworks • Minimizing disturbance to spawning fish • Septic system maintenance (i.e. list of questions for septic pumper professionals to ask)
Action Steps:	
	See description above as this is an established program.

<u>Management Action:</u>	Continue UKPOA's involvement with other entities that have responsibilities in managing (management units) Upper Kaubashine Lake
Timeframe:	Continuation of current efforts
Facilitator:	UKPOA Board of Directors – possibly formation of an Education and Communication Committee
Description:	The waters of Wisconsin belong to everyone and therefore this goal of protecting and enhancing these shared resources is also held by other entities. Some of these entities are governmental while other organizations rely on voluntary participation. It is important that the UKPOA 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 on the next page:
Action Steps:	
	See table guidelines on the next pages.

Partner	Contact Person	Role	Contact Frequency	Contact Basis
Town of Hazelhurst	(715) 356-5800	Provides information and networking related to the advancement of the community.	Once a year, or more as needed. Unified Lake Group regularly scheduled meetings are the last Monday of the month	The Township serves a valuable role in promoting local businesses, tourism, and community within the area.
Oneida County Land and Water Conservation Committee	Committee Chair (Bob Mott)	Serve as the County-appointed citizen advisory committee.	Once a year, or more as needed	The committee oversees County decisions as it applies to zoning and lake organization formation.
Oneida County Land and Water Conservation Department	Conservationist (Michele Sadauskas– president@vclra.us)	Oversees conservation efforts for land and water projects.	Twice a year or more as needed.	Can provide assistance with shoreland restorations and habitat improvements.
Oneida County AIS Coordinator	Invasive Species Coordinator (Stephanie Boismenue – 715.479.3738)	Oversees AIS monitoring and prevention activities locally.	Twice a year or more as issues arise.	Spring: AIS training and ID, AIS monitoring techniques Summer: Report activities to Coordinator
Oneida County Lakes & Rivers Association	Secretary (Connie Anderson – 715.282.5798)	Protects Oneida Co. waters through facilitating discussion and education.	Twice a year or as needed.	Become aware of training or education opportunities, partnering in special projects, or networking on other topics pertaining to Oneida Co. waterways.
Wisconsin Department of Natural Resources	Fisheries Biologist (Zachariah Woiak – (715.369.8848)	Manages the fishery in Oneida County.	Once a year, or more as issues arise.	Stocking activities, scheduled surveys, survey results, volunteer opportunities for improving fishery.
	Lakes Coordinator (Kevin Gauthier – 715.365.5211)	Oversees management plans, grants, all lake activities.	Once a year, or more as necessary.	Information on updating a lake management plans, submitting grants or to seek advice on other lake issues.
	Conservation Warden (Tim Ebert – (715.892.7490)	Oversees regulations handed down by the state.	As needed. May contact WDNR Tip Line (1.800.847.9367) as needed also.	Suspected violations pertaining to recreational activity, including fishing, boating safety, ordinance violations, etc.
	CLMN Director (Sandra Wickman – 715.365.8951)	Training and assistance on CLMN activities.	Twice a year or more as needed.	Contact to arrange for training as needed, in addition to planning out monitoring and reporting of data.
Wisconsin Lakes	General staff (800.542.5253)	Facilitates education, networking and assistance on all matters involving WI lakes.	As needed. May check website (www.wisconsinlakes.org) often for updates.	UKPOA members may attend WL’s annual conference to keep up-to-date on lake issues. WL reps can assist on grant issues, AIS training, habitat enhancement techniques, etc.

Management Goal 2: Maintain Current Water Quality Conditions

Management Action:	Monitor water quality through WDNR Citizens Lake Monitoring Network.
Timeframe:	Continuation of current effort.
Facilitator:	UKPOA Board of Directors – possibly formation of a Water Quality Director or Committee
Description:	Monitoring water quality is an important aspect of every lake management planning activity. Collection of water quality data at regular intervals aids in the management of the lake by building a database that can be used for long-term trend analysis. Early discovery of negative trends may lead to the reason of why the trend is occurring. Volunteer water quality monitoring has been completed annually by Upper Kaubashine Lake riparians through the Citizen Lake Monitoring Network (CLMN). Prior to 2017, the lake was monitored only by collecting Secchi disk readings and now has transitioned in to the advanced CLMN program. Under this program, Secchi disk readings and water chemistry samples are collected three times during the summer and once during the spring. It is the responsibility of the current CLMN volunteer in conjunction with the UKPOA Board of Directors to coordinate new volunteers as needed. When a change in the collection volunteer occurs, Sandra Wickman (715.365.8951) or the appropriate WDNR/UW Extension staff should be contacted to ensure the proper training occurs and the necessary sampling materials are received by the new volunteer. It is also important to note that as a part of this program, the data collected are automatically added to the WDNR database and available through their Surface Water Integrated Monitoring System (SWIMS) by the volunteer.
Action Steps:	
1.	Trained CLMN volunteer(s) collects data and report results to WDNR and to association members during annual meeting.
2.	CLMN volunteer and/or UKPOA Board of Directors would facilitate new volunteer(s) as needed
3.	Coordinator contacts Sandra Wickman (715.365.8951) to acquire necessary materials and training for new volunteer (s)

Management Goal 3: Reduce EWM Population on a Lake-Wide Level in Upper Kaubashine Lake

Management Action:	Conduct Large-Scale Herbicide Treatment
Timeframe:	Spring 2018
Facilitator:	AIS Committee
Description:	One method of controlling EWM on a lake-wide basis is through the use of a large-scale herbicide applications - specifically, early-spring treatments. These concepts and the UKPOA's rationale for pursuing this strategy are outlined within the *Non-native Plants in Upper Kaubashine Lake* subsection of the Aquatic Plant Section (3.4). The UKPOA has initiated the planning and pretreatment steps necessary to conduct a large-scale (aka whole-lake treatment) on Upper Kaubashine using 2,4-D amine at an epilimnetic dosing strategy of 0.300 ppm ae. Onterra typically recommends between 0.300 ppm ae and 0.375 ppm ae for pure-strain EWM large-scale 2,4-D treatments. The target concentration being recommended for Upper Kaubashine is toward the lower range of Onterra's current dosing strategies to account for a potentially extended exposure time due to the moderate productivity (mesotrophic biological parameters) of the system. The preliminary strategy accounts for the western basin being targeted in a manner that would aid in even herbicide concentration in this protected part of the lake that might not experience the water exchange patterns as the main body of the lake (Map 7). <u>Active Management Monitoring Strategy</u>: A cyclic series of steps will be used to plan and implement the control efforts. The series includes conducting the following surveys during the *year prior to the treatment (2017)*, *year of the treatment (2018)*, and *year following the treatment (2019)*: • A lake-wide mapping assessment of EWM completed while the plant is at peak growth stage (peak biomass). • A detailed assessment of bathymetric (depth contours) data from the lake, potentially augmenting with an acoustic survey of the lake. • Quantitative assessments of the native and non-native aquatic plant community of the lake utilizing point-intercept survey methodology. • Give consideration to conducting acoustic-based biovolume studies to quantify aquatic plant biomass (i.e. lakescape) changes at a finer scale that can occur with the point-intercept method. During the *year of the treatment*, the project would include verification and refinement of the treatment plan immediately before control strategies are implemented. This potentially would include refinements of herbicide

	application areas, assessments of growth stage of aquatic plants, and documentation of thermal stratification parameters that influence the final dosing strategy. Volunteer-based monitoring of temperature profiles would also be coordinated surrounding the treatment, as well as collection of post treatment herbicide concentration sample at multiple locations and sampling intervals. The UKPOA will give consideration to monitoring groundwater wells, as riparians concerns emerged as part of this project.t The success criteria of a large-scale treatment would be a 70% reduction in EWM littoral frequency of occurrence comparing point-intercept surveys from the *year prior to the treatment* to the *year after the treatment.* This means if the treatment occurs in 2018, the *year before treatment* would be 2017 and the *year after treatment* would be 2019. Regardless of treatment efficacy, a whole-lake treatment would not be conducted during the *year following the treatment*. In 2018, the UKPOA initiated this action. Information relating to the monitoring and planning of the 2018 large-scale treatment are contained within the *Upper Kaubashine 2018 EWM Control & Monitoring Report* (Appendix G)
Action Steps:	
1.	Retain qualified professional assistance to develop a specific project design utilizing the methods discussed above.
2.	Conduct fundraising efforts, particularly since WDNR funds are not eligible for costs-share due to the lake not having sufficient public access.
3.	Initiate control and monitoring plan.

Management Action:	Develop Long-Term Contingency Strategy for Rebounding EWM Populations
Timeframe:	2018 and beyond
Facilitator:	AIS Committee
Description:	As shown in Figure 3.4-17 the EWM population is often greatly impacted the year of large-scale treatment and low EWM levels are maintained for 4-5 years following the control action. Many lake groups initiate a whole-lake herbicide strategy with the intention of implementing smaller-scale control measures (herbicide spot treatments, hand-removal) when EWM begins rebounding. The UKPOA would give preference to non-herbicide control measures between large-scale treatments. Occasionally, the EWM rebounds in a fashion that does not lend well to these methods. If the rebounded EWM population exceeds a level that can be controlled using best management practices, the UKPOA will transition to a

	management goal to "Let Nature Take its Course" and not conduct coordinated active management. The UKPOA will tolerate the EWM to until it again exceeds a predefined threshold to trigger another whole-lake treatment. Based on the data collected over the three-year project, the UKPOA would revisit their management plan as it applies to EWM control and monitoring. Based upon the information gained during the multi-year control project, the UKPOA would update their management plan as appropriate. This would include how the UKPOA will target the rebound EWM populations as well as the trigger of when to consider future large-scale management (likely as an addendum to this plan).
Action Steps:	
1.	Retain qualified professional assistance to develop a specific project design utilizing the methods discussed above.
2.	Conduct fundraising efforts, particularly since WDNR funds are not eligible for costs-share due to the lake not having sufficient public access.
3.	Initiate control and monitoring plan.
4.	Update management plan to reflect changes in control needs and those of the lake ecosystem.

Management Goal 4: Improve Lake and Fishery Resource by protecting and restoring the shoreland condition of Upper Kaubashine Lake

Management Action:	Investigate restoring highly developed shoreland areas around Upper Kaubashine Lake
Timeframe:	Initiate 2017
Facilitator:	UKPOA Board of Directors – possibly formation of a Shoreland Improvement Director or Committee
Description:	As discussed in the Shoreland Condition Section (3.3), the shoreland zone of a lake is highly important to the ecology of a lake. When shorelands are developed, the resulting impacts on a lake range from a loss of biological diversity to impaired water quality. Because of its proximity to the waters of the lake, even small disturbances to a natural shoreland area can produce ill effects. Approximately 26% of Upper Kaubashine Lake's shoreline are either urbanized or developed-unnatural and could be the focus of early restoration efforts. Because property owners may have little experience with or are uncertain about restoring a shoreland to its natural state, the UKPOA has decided to take the following steps to increase shoreland restoration on Upper Kaubashine Lake:

	1. Educate riparians about the importance of healthy and natural shorelands, highlighting restoration projects that occur when possible. 2. Set a goal to solicit 3 riparians to implement shoreland restorations. Project funding would partially be available through the WDNR's Healthy Lakes Implementation Plan (see below). 3. The UKPOA work with Oneida County (Michele Sadauskas) or private entity to create design work. Small-scale WDNR grants may be sought to offset design costs. 4. Shoreland restoration sites will serve as demonstrations sites to encourage other riparians to follow same path of shoreland restoration. The WDNR's Healthy Lakes Implementation Plan allows partial cost coverage for native plantings in transition areas. This reimbursable grant program is intended for relatively straightforward and simple projects. More advanced projects that require advanced engineering design may seek alternative funding opportunities, potentially through Vilas County. • 75% state share grant with maximum award of $25,000; up to 10% state share for technical assistance • Maximum of $1,000 per 350 ft^2 of native plantings (best practice cap) • Implemented according to approved technical requirements (WDNR, County, Municipal, etc.) and complies with local shoreland zoning ordinances • Must be at least 350 ft^2 of contiguous lakeshore; 10 feet wide • Landowner must sign Conservation Commitment pledge to leave project in place and provide continued maintenance for 10 years • Additional funding opportunities for water diversion projects and rain gardens (maximum of $1,000 per practice) also available
Action Steps:	
1.	Recruit facilitator from Planning Committee
2.	Facilitator contacts the Oneida County Land and Water Conservation department to gather information on initiating and conducting shoreland restoration projects. If able, the County Conservationist would be asked to speak to UKPOA members about shoreland restoration at their annual meeting.
3.	The UKPOA would encourage property owners that have restored their shorelines to serve as demonstration sites.

Management Action:	Protect natural shoreland zones around Upper Kaubashine Lake
Timeframe:	Initiate 2017
Facilitator:	UKPOA Board of Directors – possibly formation of a Shoreland Improvement Director or Committee
Description:	Approximately 63% of Upper Kaubashine Lake's shoreline was found to be in either a *natural* or *developed-natural* state. It is therefore very important that owners of these properties become educated on the benefits their shoreland is providing to Upper Kaubashine Lake, and that these shorelands remain in a natural state. This indicates that over 2.2 miles of private shorelands are in either a *natural* or *developed-natural state* that should be prioritized for education initiatives and physical preservation. Members of the UKPOA Planning Committee believe that the majority of the lands that are held in this condition are by non-UKPOA members. A Planning Committee appointed person will work with appropriate entities to research grant programs and other pertinent information that will aid the UKPOA in preserving the Upper Kaubashine Lake shoreland. This would be accomplished through education of property owners, or direct preservation of land through implementation of conservation easements or land trusts that the property owner would approve of. Valuable resources for this type of conservation work include the WDNR, UW-Extension, and Oneida County Land and Water Conservation Department. Several websites of interest include: • Wisconsin Lakes website: (www.wisconsinlakes.org/shorelands) • Conservation easements or land trusts: (http://www.northwoodslandtrusts.org/) • UW-Extension Shoreland Restoration: (www.uwex.edu/ces/shoreland/Why1/whyres.htm) • WDNR Shoreland Zoning website: (http://dnr.wi.gov/topic/ShorelandZoning/)
Action Steps:	
1.	Recruit facilitator (potentially same facilitator as previous management action).

6.0 METHODS

Watershed Analysis

The watershed analysis began with an accurate delineation of Upper Kaubashine Lake's drainage area using U.S.G.S. topographic survey maps and base GIS data from the WDNR. The watershed delineation was then transferred to a Geographic Information System (GIS). These data, along with land cover data from the National Land Cover Database (NLCD – Fry et. al 2011) were then combined to determine the watershed land cover classifications. These data were modeled using the WDNR's Wisconsin Lake Modeling Suite (WiLMS) (Panuska and Kreider 2003)

Aquatic Vegetation

Comprehensive Macrophyte Surveys

Comprehensive surveys of aquatic macrophytes were conducted on Upper Kaubashine 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. A point spacing of 33 meters was used resulting in approximately 704 points.

Community Mapping

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

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