Pike Chain of Lakes

Bayfield County, Wisconsin

Aquatic Plant Management Plan

November 2021

Sponsored by:

Iron River Pike Chain of Lakes Association, Inc.

WDNR Surface Water Grant Program

ACEI-180-16

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Onterra, LLC
Lake Management Planning

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Acknowledgements

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

IRPCLA Planning Committee (Expanded)

Al Bochler - Chair	Eddie Wangensteen
Jay Johnson	Joe Rapacz
Derek Ogle	Thomas Sandager
Howard Lehman	John Coffey

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1.0 INTRODUCTION

The Pike Chain of Lakes is comprised of 9 lake basins located near the Town of Iron River in Bayfield County, Wisconsin (Map 1, Figure 1.0-1). The chain includes over 1,000 acres of surface water, and forms the headwaters of a drainage system that leads to the White River which flows through the Bad River Indian Reservation on its way to Lake Superior (Table 1.0-1). Six of the lakes, sometimes referred to as the main lakes, area able to be boated between (colored blue on Figure 1.0-1). The other three lakes are hydrologically connected but cannot be reached by watercraft without portage.

Table 1.0-1. Pike Chain of Lake morphometry data. 6 main lakes data from 2016 acoustic surveys, McCarry data modeled from 2017 point-intercept survey, remaining two lakes from historic WDNR lake survey maps.

Lake	Acres	Volume (acre-ft)	Max Depth (ft)
BuskeyBay	93.4	1,541	50
Millicent	190.7	5,058	56
Hart	264.3	5,982	52
Twin Bear	162.0	3,916	60
Eagle	170.0	2,336	52
Flynn	31.3	121	8
McCarry	31.6	128	20
Muskellunge	43.0	753	35
Pike	17.1	131	23
Total	**1,003.4**	**19,966**	

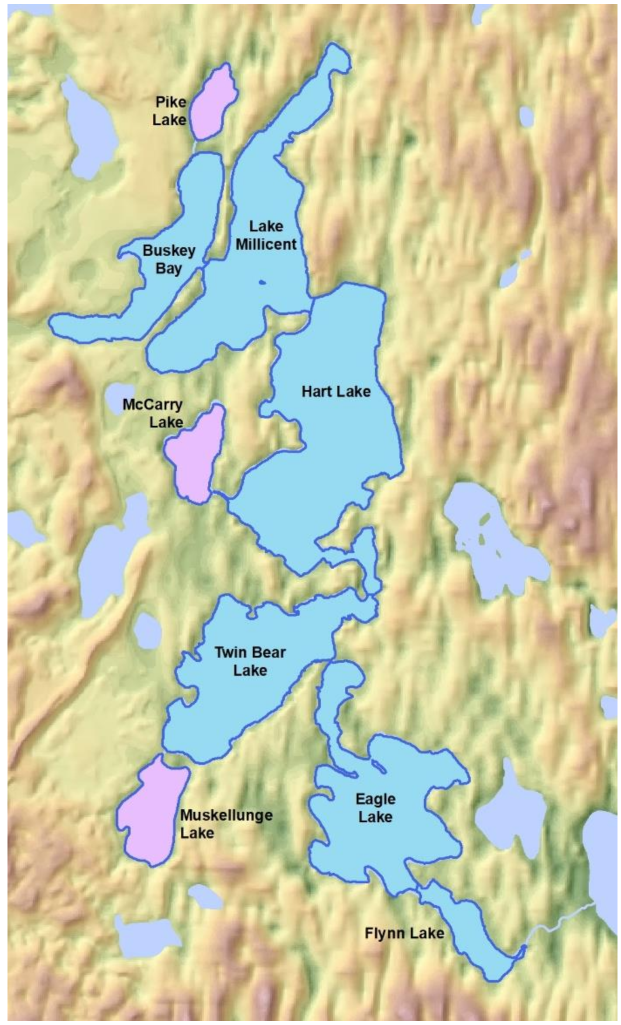


Figure 1.0-1 Pike Chain of Lakes, Bayfield County, WI.

All lakes within the chain are considered Priority Navigable Waterways by the Wisconsin Department of Natural Resources (WDNR), primarily for having waters with self-sustaining walleye and/or muskellunge populations. The six main lakes and Pike Lake are classified as Areas of Special Natural Resource Interest as outstanding or exceptional resource waters.

One non-native submergent plant species has been identified within the Pike Chain, Eurasian watermilfoil (*Myriophyllum spicatum*, EWM). EWM was first documented in the Twin Bear – Hart Channel in 2004. EWM populations were identified in Eagle Lake in 2005, Buskey Bay in 2007, and Millicent in 2008. Flynn Lake was the last lake for EWM to be identified within during surveys in 2014.

The Iron River Pike Chain of Lakes Association (IRPCLA) and partners have historically managed EWM with spatially targeted herbicide spot treatments, whole-lake herbicide treatments, and both volunteer- and professional-based hand-harvesting efforts.

Figure 1.0-2 Pike Chain of Lakes Association Logo. https://pikechain.org

The IRPCLA's *Comprehensive Management Plan* (Dec 2008) for the Pike Chain of lakes outlines an EWM management strategy that primarily uses herbicide spot treatments. An official addendum to the *Plan* was made in January 2016, following the completion of a 5-year AIS-Established Population Control Grant-funded project. The IRPCLA was awarded a proceeding WDNR AIS Established Population Control Grant in February 2016 (ACEI-180-16) that funded EWM management and monitoring from 2016-2018. Remaining funds from the grant allowed the project to extend to 2020. As a part of that project, the IRPCLA would revisit their aquatic plant management-related Implementation Plan to update its content based on the lessons learned during the project. This updated Aquatic Plant Management (APM) Plan provides an update to those management goals and actions.

The WDNR, Great Lakes Indian Fish and Wildlife Commission (GLIFWC), and Red Cliff Band of Lake Superior Chippewa are currently in the process of updating the fisheries management plan for the Pike Chain of Lakes. This APM Plan also contains a fisheries data integration section with updated data from available fisheries surveys, harvest information, and management perspective. Because of the overlap between fisheries and aquatic plant habitat/management, the IRPCLA is soliciting input from biologists/managers within the WDNR, GLIFWC, and Red Cliff Band during the development stages of the updated APM Plan.

The Summary and Conclusions Section (5.0) provide a succinct overview of the health of the Pike Chain of Lakes ecosystem (Click Here). The actual *plan* part of this documents is provided in the Implementation Plan Section (6.0) and is found immediately following the Summary and Conclusions Section.

2.0 STAKEHOLDER

The overarching goal of every Onterra-led planning project is to create a realistic and implementable plan that will meet the needs of the lake group while keeping the lake as healthy as possible. To meet this goal, Onterra ecologists complete specific ecosystem studies on the waterbody to develop a full understanding of the lake. Onterra shares those results and our conclusions with the lake group as a whole, but also with a project-specific group called the planning committee. The planning committee is comprised of lake group members and at times, people from outside of the lake group. The planning committee acts as a focus group for the development of the management plan and is Onterra's primary point-of-contact during the project. The members of the planning committee develop a deep understanding of their lake as a part of their involvement in the process, which allows them to make good management decisions during the development of the plan and extends the life of the plan due to the core group's enhanced knowledge of the ecosystem.

The planners educate the planning committee 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 planning committee educate the planners by describing how they and their constituents 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 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.

2.1 Strategic Planning Committee Meetings

Fisheries Committee Meeting

On September 1, 2020 GLIFWC hosted a teleconference between multiple GLIFWC staff, Red Cliff Band tribal staff, IRPCLA members, and Onterra staff. The goal of this meeting was to discuss concerns about the fisheries and find a path for developing a recovery plan. There was also positive discussion about the opportunity to dovetail the Aquatic Plant Management Plan with the Fisheries Management Plan.

Fisheries Committee Meeting

On January 28, 2021 GLIFWC hosted a teleconference between GLIFWC, Red Cliff Band, WDNR, IRPCLA, and Onterra. This meeting ensured all participating parties continued to be on the same page regarding the development of the Fisheries Management Plan as well as various fisheries management actions that need to be considered in a timely fashion.

Planning Committee Meeting I

On June 14, 2021, Eddie Heath of Onterra met virtually with four members of the IRPCLA Planning Committee, representatives from the WDNR lakes and fisheries programs, representatives for the Red Cliff Band, and a representative from GLIFWC. About 8 weeks prior to the meeting, attendees were provided an early draft of the *Aquatic Plant Management Plan* (sections 1.0, 2.0, 3.0, 4.0) to facilitate better discussion. The primary focus of this meeting was the delivery of the study results and conclusions, particularly as they overlap with fisheries management aspects.

Planning Committee Meeting I

Based upon the discussion from previous planning meeting, a draft Implementation Plan Section (60) was created by Onterra and sent to the planning committee. Written comments were provided back to Onterra. In addition, the IRPCLA Planning Committee met virtually on July 9, 2021 for over 1.5 hours methodically going through each management action contained within the draft Implementation Plan Section (6.0).

2.2 Management Plan Review and Adoption Process

On July 15, 2021, the Official First Draft of the IRPCLA's Comprehensive Management Plan for the Pike Chain of Lakes was supplied to WDNR (lakes and fisheries programs), Bayfield County, Great Lakes Indian Fish and Wildlife Commission, and Red Cliff Band of Lake Superior Chippewa to solicit comments. At that time the Official First Draft was posted to the IRPCLA website for public review, with outreach efforts requesting riparians to provide comments. The posting remained active until it was replaced with the finalized version.

No comments were received from the general public, although a Planning Committee member provided additional information on rusty crayfish that was integrated into the final draft. The WDNR officially approved the Plan on October 22, 2021, allowing specific plan recommendations to be eligible for funding under the Surface Water Grant Program (NR 193). At that time, *last-call for comments* reminder emails were sent to all agencies on the original distribution list, with Bayfield County providing recommendations for additional invasive species monitoring for shoreland and wetland species such as pale-yellow iris, narrow-leaved cattail, and knotweed (Appendix E).

2.3 IRPCLA and Pike Chain Riparian Stakeholder Survey

As a part of this project, a stakeholder survey was distributed to riparian property owners and the Iron River Pike Chain of Lake Association (IRPCLA) members around the Pike Chain of Lakes. The survey was designed by Onterra staff and the IRPCLA planning committee, with input on fisheries-related questions from the WDNR local fisheries biologist. The stakeholder survey design also considered questions asked during a June 2008 stakeholder survey effort, allowing for comparisons of response data over time. The final stakeholder survey was reviewed and approved by a WDNR social scientist to ensure that the questions were not misleading or biased.

During March 2021, the nine-page, 37-question survey was posted onto an online platform (Survey Monkey) for property owners to answer electronically. A postcard was sent to the sample population inviting their participation in the survey. The postcard included a unique code to ensure only one survey could be completed per household. The postcard also had an option for the stakeholder to request a paper copy to be sent directly to them, along with a self-addressed stamped envelope for returning the survey anonymously. A reminder postcard with much of the same information on the first postcard was sent out a few weeks later.

Of the 412 surveys distributed, 139 or 34% percent of the surveys were completed. In instances where stakeholder survey response rates are 60% or above, the results can generally be interpreted as being a statistical representation of the population. While the survey response rate may not be sufficient to be a statistical representation of the IRPCLA/Pike Chain Riparians, the IRPCLA believe the sentiments of the respondents is sufficient to provide an indication of riparian preferences and concerns. Said another way, these are the best quantitative data the IRPCLA has to help understand stakeholder's opinions and will couple the results with other communications to determine which management actions to pursue moving forward.

The data were analyzed and summarized by Onterra for use at the planning meetings and within the management plan. The full survey and results can be found in Appendix B, while discussion of those results is integrated within the appropriate sections of the management plan and a general summary is discussed below.

Based upon the results of the Stakeholder Survey, much was learned about the people who use and care for Pike Chain of Lakes. Approximately 90% of respondents owned property on the six-main lakes, while 8% were located on smaller connected waterways, and 2% of respondents were located in close proximity to the Chain, but did not own waterfront property (Figure 2.3-1).

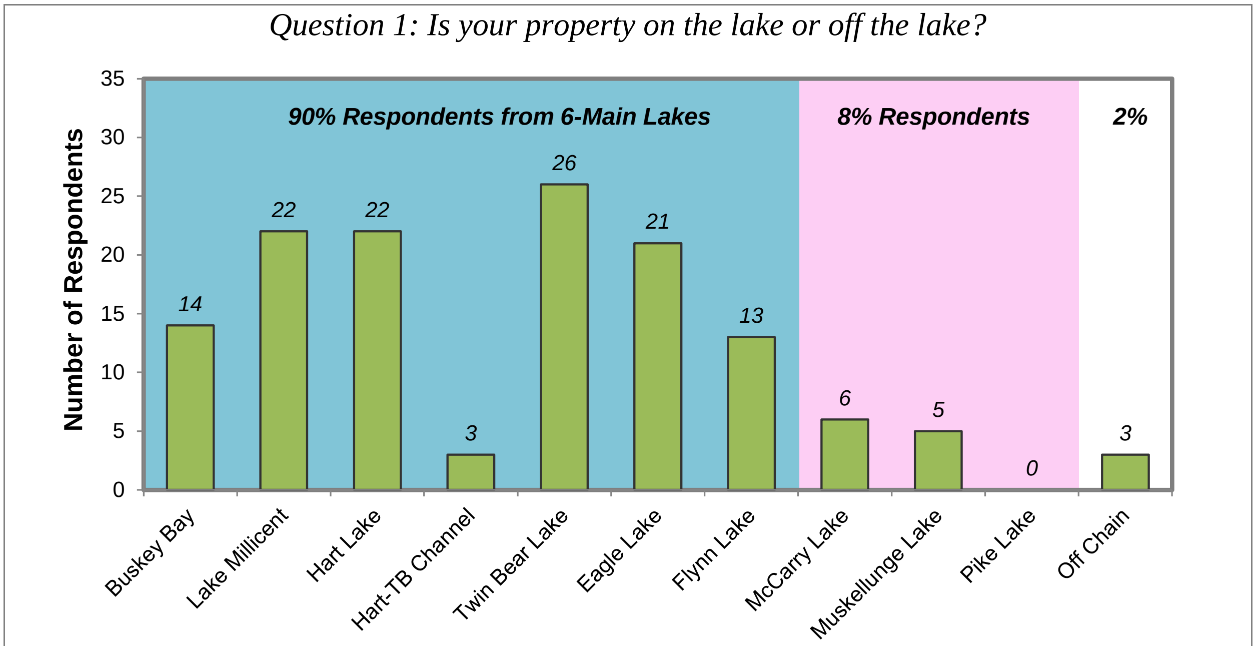
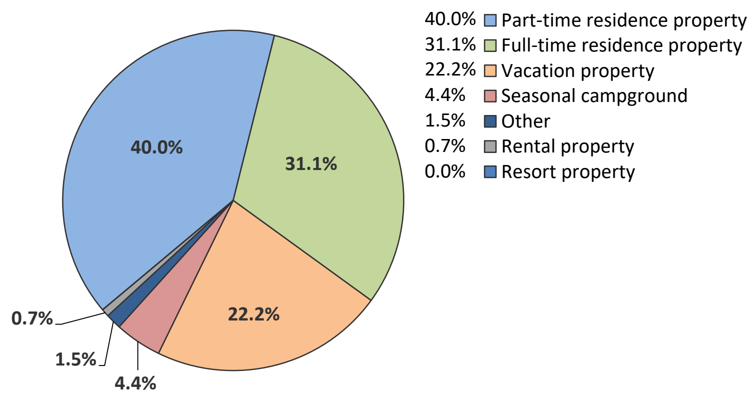


Figure 2.3-1. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Seventy-three percent of stakeholders have owned their property for over 10 years, and 53% have owned their property for over 25 years (Appendix B, Question #2). Thirty-one percent of stakeholder respondents live on the system year-round, while 40% use their property as a seasonal residence, 22% use it as a vacation home, and 4% utilize it as a seasonal campground (Figure 2.3-2, left). Approximately 72% of respondents us their property for 30 weeks (210 days) or less a year (Figure 2.3-2, right).

Question 2: How is your property on or near the Pike Chain utilized?



Question 3: How many days each year is your property used by you or others?

Category (# of days)	Responses	
0 to 30	13	10%
31 to 90	32	24%
91 to 120	23	17%
121 to 210	29	21%
211 to 300	7	5%
301 to 365	31	23%

Figure 2.3-2. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Relaxing/entertaining was the highest ranked activities when riparians were asked why the own property on the Pike Chain (Figure 2.3-3). Riparian respondents also ranked *pontoon-ing*, *open water fishing*, *swimming*, and *nature viewing* as top reasons they choose to be on or near the Pike Chain.

Question 8: Please rank up to three activities that are important reasons for owning or renting your property on or nera the Pike Chain.

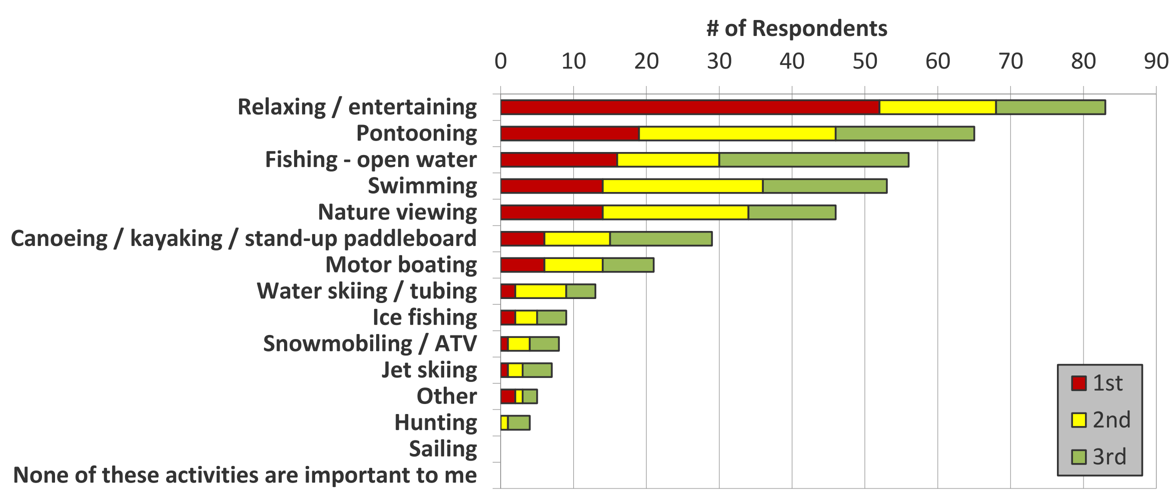


Figure 2.3-3. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Even though silent sports such as *canoeing/kayaking/paddle boarding* were ranked by respondents as the sixth highest activity on the Chain (Figure 2.3-3), almost 77% of respondents indicated they use that type of watercraft on the lake (Figure 2.3-4). Approximately 66% of respondents indicated they use a pontoon boat and almost 46% of survey respondents indicated that they use a motor boat with greater than 25 hp motor.

Question 12: What types of watercraft do you currently use on the Pike Chain?

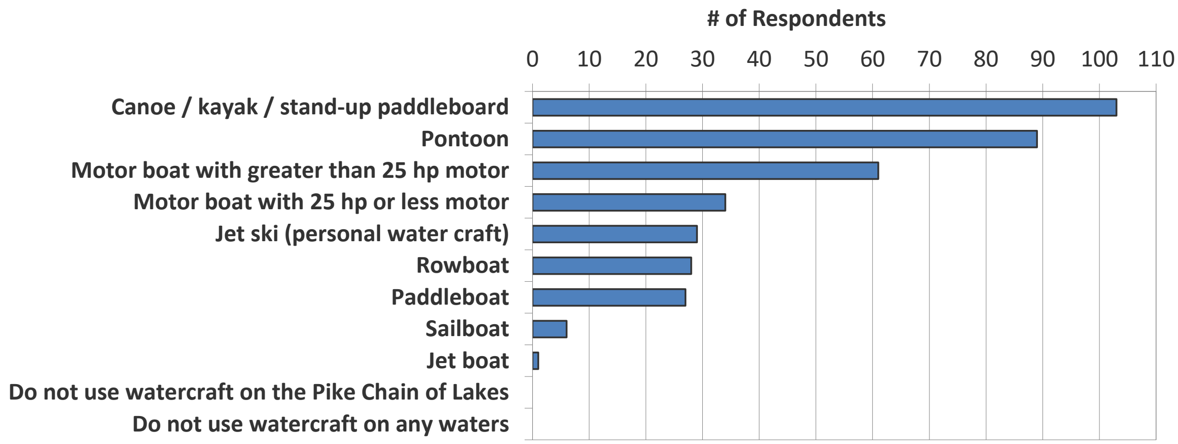


Figure 2.3-4. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Even though the Pike Chain is a big body of water, there are many back bays and narrow passages between basin that make boating safety concern. The need for responsible boating increases even more during weekends, holidays, and during times of nice weather or good fishing conditions as well, due to increased traffic on the system. Unsafe watercraft practices ranked 4th in the list of stakeholder respondents' top concerns, with the related shoreline erosion being ranked 3rd (Question #19, Appendix B). A concern of stakeholders noted throughout the stakeholder survey (Question #37, Appendix B) was wakeboard boats, their role in watercraft safety, and their impact in eroding shorelines.

The following sections, Aquatic Plants (3.0) and Fisheries Data Integration (4.0) will include stakeholder survey data with respect to these particular topics.

3.0 AQUATIC PLANTS

3.1 Primer on Aquatic Plant Data Analysis & Interpretation

Photograph 3.1-1. Native aquatic plants.

Native aquatic plants are an important element in every healthy aquatic ecosystem, providing food and habitat to wildlife, improving water quality, and stabilizing bottom sediments (Photograph 3.1-1). Because most aquatic plants are rooted in place and are unable to relocate in wake of environmental alterations, they are often the first community to indicate that changes may be occurring within the system. Aquatic plant communities can respond in a variety of ways; there may be increases or declines in the occurrences of some species, or a complete loss. Or, certain growth forms, such as emergent and floating-leaf communities may disappear from certain areas of the waterbody. With periodic monitoring and proper analysis, these changes are relatively easy to detect and provide relevant information for making management decisions.

The point-intercept method as described Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010 (Hauxwell et al. 2010) have been conducted on Hart and Twin Bear lakes in 2005, Buskey Bay, Lake Millicent, Eagle and Flynn lakes in 2007, all lakes in 2013, 2016, 2017, and 2018, and Eagle and Flynn lakes in 2020. At each point-intercept location within the *littoral zone*, information regarding the depth, substrate type (soft sediment, sand, or rock), and the plant species sampled along with their relative abundance on the sampling rake was recorded.

A pole-mounted rake was used to collect the plant samples, depth, and sediment information at point locations of 15 feet or less. A rake head tied to a rope (rope rake) was used at sites greater than 15 feet. Depth information was collected using graduated marks on the pole of the rake (at depths < 15 ft) or using an onboard sonar unit (at depths > 15 feet). Also, when a rope rake was used, information regarding substrate type was not collected due to the inability of the sampler to accurately "feel" the bottom with this sampling device. The point-intercept survey produces a great deal of information about a lake's aquatic vegetation and overall health. These data are analyzed and presented in numerous ways; each is discussed in more detail the following section.

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 Pike Chain of Lakes from 2005 to 2018. The list also contains each species' scientific name, common name, status in Wisconsin, and 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

> **Littoral Zone** is the area of a lake where sunlight is able to penetrate down to the sediment and support aquatic plant growth.

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 Pike Chain of Lakes, 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 Pike Chain of Lakes to be compared to other lakes within the region and state.

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

The Pike Chain of Lakes falls within the Northern Lakes and Forests (NLF) *ecoregion* (Figure 3.1-1), and the floristic quality of its aquatic plant community will be compared to other lakes within this ecoregion as well as the entire State of Wisconsin. Ecoregions are areas related by similar climate, physiography, hydrology, vegetation and wildlife potential. Comparing ecosystems within the same ecoregion is sounder than comparing systems within manmade boundaries such as counties, towns, or states. Ecoregional and state-wide medians were calculated from whole-lake point-intercept surveys conducted on 392 lakes throughout Wisconsin by Onterra and WDNR ecologists.

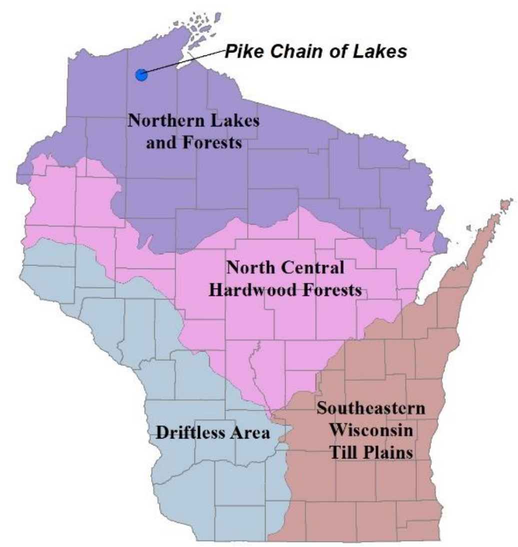


Figure 3.1-1. Location of Pike Chain of Lakes within the ecoregions of Wisconsin. After Nichols 1999.

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. Some managers believe a lake with a diverse plant community is also 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
D is a value between 0 and 1

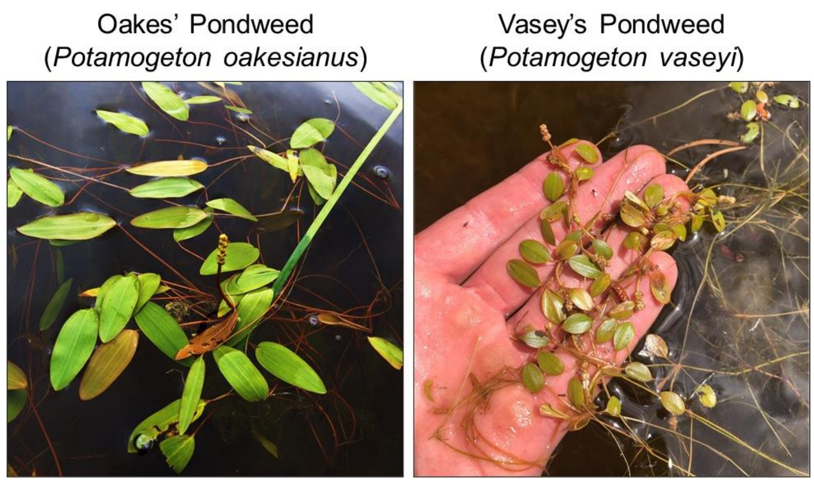
If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. The Simpson's Diversity Index value from Pike Chain of Lakes is compared to data collected by Onterra and the WDNR Science Services on 212 lakes within the Northern Lakes and Forests (lakes only, does not include flowages) Ecoregion and on 392 lakes throughout Wisconsin.

3.2 Pike Chain of Lakes Aquatic Plant Survey Results

Six Main Lakes

Whole-lake point-intercept surveys have been completed on the six main lakes of the Pike Chain in 2005/2007 (Twin Bear and Hart in 2005; Buskey Bay, Lake Millicent, Eagle Lake, and Flynn Lake in 2007), 2013, 2016, 2017, and 2018. Surveys were also completed on Eagle and Flynn lakes in 2020 as part of a Eurasian watermilfoil (EWM) herbicide control project. Over the course of these surveys, a total of 82 aquatic plant species have been located in the Pike Chain of Lakes (Table 3.2-1). Of these 82 species, two are considered to be non-native invasive species: Eurasian watermilfoil (EWM) and purple loosestrife. Because of their ecological, economical, and sociological significance, EWM occurrence and management in the Pike Chain of Lakes is discussed in the subsequent Eurasian Watermilfoil subsection (3.3). An additional non-native species, pale-yellow iris, was observed during a fall 2020 early detection survey, near the narrows connecting Buskey Bay and Millicent Lakes by Andrew Teal (Bayfield County AIS Coordinator) and Tyler Mesalk (WDNR lakes program). Additional invasive species monitoring for shoreland and wetland species such as pale-yellow iris, narrow-leaved cattail, and knotweed could be organized by Bayfield County and will aid in the understanding of the vegetation community around the Pike Chain.

Two native aquatic plant species located during these studies, Oakes' pondweed and Vasey's pondweed (Photograph 3.2-1), are listed as special concern by the WDNR Natural Heritage Inventory Program due to "a fairly restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors" (Wisconsin Natural Heritage Program 2016). Both of these plants require high-quality conditions to survive, and their presence in these lakes is indicative of high-quality environmental conditions.



Photograph 3.2-1. Oakes' and Vasey's pondweed, two native plant species listed as special concern in Wisconsin. Photograph credit Onterra.

Lakes in Wisconsin vary in their morphometry, water chemistry, water clarity, substrate composition, and management, all of which influence aquatic plant community composition. Like terrestrial plants, aquatic plants vary in their preference for a particular substrate type; some species are usually only found growing in soft sediments, others only course substrates like sand, while some are more generalists and can be found growing in either. Lakes with varying types of substrates generally support a higher number of aquatic plant species because of the different habitat types that are available. During the whole-lake point-intercept surveys completed on the Pike Chain of Lakes in 2018, substrate data were also recorded at each sampling location in one of three general categories: soft/organic sediments, sand, or rock/gravel.

Table 3.2-1. Aquatic plant species located in surveys completed in 2005/07, 2013, 2016, 2017, 2018, and 2020.

Scientific Name	Common Name	Status in Wisconsin	Coefficient of Conservatism	2005/07	2013	2016	2017	2018
Calla palustris	Water arum	Native	9	X	I	X		
Bidens beckii	Water marigold	Native	8	X	X	X	X	X
Brasenia schreberi	Watershield	Native	7	X	X	X	X	X
Carex comosa	Bristly sedge	Native	5	I	I			
Carex pellita	Broad-leaved woolly sedge	Native	4		I			
Carex pseudocyperus	Cypress-like sedge	Native	8		I			
Carex stricta	Common tussock sedge	Native	7		I			
Ceratophyllum demersum	Coontail	Native	3	X	X	X	X	X
Ceratophyllum echinatum	Spiny hornwort	Native	10	X	X	X	X	X
Chara spp.	Muskgrasses	Native	7	X	X	X	X	X
Dulichium arundinaceum	Three-way sedge	Native	9	X	X	X		
Eleocharis acicularis	Needle spikerush	Native	5	X	X	X	X	X
Eleocharis palustris	Creeping spikerush	Native	6	X	X			
Elodea canadensis	Common waterweed	Native	3	X	X	X	X	X
Equisetum fluviatile	Water horsetail	Native	7		I			
Heteranthera dubia	Water stargrass	Native	6	X	X	X	X	X
Iris versicolor	Northern blue flag	Native	5	X	I			
Isoetes spp.	Quillwort spp.	Native	8	X	X	X	X	X
Juncus effusus	Soft rush	Native	4	I				
Juncus pelocarpus	Brown-fruited rush	Native	8	X	X	X		
Lemna minor	Lesser duckweed	Native	5	X				
Lemna trisulca	Forked duckweed	Native	6	X	X	X	X	X
Lemna turionifera	Turion duckweed	Native	2				X	X
Lythrum salicaria	Purple loosestrife	Non-Native - Invasive	N/A	I	I			
Myriophyllum sibiricum	Northern watermilfoil	Native	7	X	X	X	X	X
Myriophyllum spicatum	Eurasian watermilfoil	Non-Native - Invasive	N/A	X	X	X	X	X
Myriophyllum tenellum	Dwarf watermilfoil	Native	10	X	X	X	X	X
Myriophyllum verticillatum	Whorled watermilfoil	Native	8		X			
Najas flexilis	Slender naiad	Native	6	X	X	X	X	X
Nitella spp.	Stoneworts	Native	7	X	X	X	X	X
Nuphar variegata	Spatterdock	Native	6	X	X	X	X	X
Nymphaea odorata	White water lily	Native	6	X	X	X	X	X
Persicaria amphibia	Water smartweed	Native	5	X	X	X	X	X
Phragmites australis subsp. *americanus*	Common reed	Native	5	I	I			
Pontederia cordata	Pickerelweed	Native	9	I				
Potamogeton amplifolius	Large-leaf pondweed	Native	7	X	X	X	X	X
Potamogeton amplifolius x *richardsonii* *	Large-leaf x Clasping-leaf pondweed	Native	N/A				X	
Potamogeton berchtoldii	Slender pondweed	Native	7		X	X	X	X
Potamogeton epihydrus	Ribbon-leaf pondweed	Native	8	X	X	X		X
Potamogeton foliosus	Leafy pondweed	Native	6	X	X	X	X	X
Potamogeton friesii	Fries' pondweed	Native	8		X	X	X	X
Potamogeton gramineus	Variable-leaf pondweed	Native	7	X	X	X	X	X
Potamogeton illinoensis	Illinois pondweed	Native	6	X	X	X	X	
Potamogeton natans	Floating-leaf pondweed	Native	5	X	X	X	X	X
Potamogeton oakesianus	Oakes' pondweed	Native - Special Concern	10	I				
Potamogeton praelongus	White-stem pondweed	Native	8	X	X	X	X	X
Potamogeton pusillus	Small pondweed	Native	7	X	X	X	X	X
Potamogeton richardsonii	Clasping-leaf pondweed	Native	5	X	X	X	X	X
Potamogeton robbinsii	Fern-leaf pondweed	Native	8	X	X	X	X	X
Potamogeton spirillus	Spiral-fruited pondweed	Native	8	X				
Potamogeton strictifolius	Stiff pondweed	Native	8	X	X	X	X	X
Potamogeton vaseyi	Vasey's pondweed	Native - Special Concern	10		X			
Potamogeton x *haynesii* *	Haynes' pondweed	Native	N/A				X	X
Potamogeton zosteriformis	Flat-stem pondweed	Native	6	X	X	X	X	X
Ranunculus aquatilis	White water crowfoot	Native	8	X	X	X	X	X
Ranunculus flabellaris	Yellow water crowfoot	Native	8		X			
Ranunculus flammula	Creeping spearwort	Native	9	X				X
Riccia fluitans	Slender riccia	Native	7	I	X			
Sagittaria graminea	Grass-leaved arrowhead	Native	9	X				
Sagittaria latifolia	Common arrowhead	Native	3	X	I			
Sagittaria sp. (rosette)	Arrowhead sp. (rosette)	Native	N/A	X	X	X	X	X
Schoenoplectus acutus	Hardstem bulrush	Native	5	X	X	X	X	X
Schoenoplectus pungens	Three-square rush	Native	5	X				
Schoenoplectus subterminalis	Water bulrush	Native	9	X	X	X	X	X
Schoenoplectus tabernaemontani	Softstem bulrush	Native	4	X	I	X		
Scirpus cyperinus	Wool grass	Native	4		I			
Sparganium americanum	American bur-reed	Native	8		X		X	
Sparganium angustifolium	Narrow-leaf bur-reed	Native	9	X	I			
Sparganium emersum var. *acaule*	Short-stemmed bur-reed	Native	8	X	I		X	
Sparganium eurycarpum	Common bur-reed	Native	5	I				
Sparganium fluctuans	Floating-leaf bur-reed	Native	10	I				
Sparganium glomeratum	Northern bur-reed	Native	8	X				
Sparganium natans	Little bur-reed	Native	9				I	
Spirodela polyrhiza	Greater duckweed	Native	5	X			X	X
Stuckenia pectinata	Sago pondweed	Native	3	X	X	X	X	X
Typha spp.	Cattail spp.	N/A	1	X	X			
Utricularia gibba	Creeping bladderwort	Native	9	X	X	X	X	X
Utricularia intermedia	Flat-leaf bladderwort	Native	9		X	X	X	X
Utricularia minor	Small bladderwort	Native	10	X	X	X	X	
Utricularia vulgaris	Common bladderwort	Native	7	X	X	X	X	X
Vallisneria americana	Wild celery	Native	6	X	X	X	X	X
Wolffia spp.	Watermeal spp.	Native	N/A		X			

X = Located on rake during point-intercept survey; I = Located incidentally
** = Verfied via genetic analysis*

The individual lakes within the chain vary somewhat in their proportion of these three substrate types. The littoral zones of Buskey Bay, Eagle and Flynn lakes are largely comprised of soft/organic sediments, while Lake Millicent, Hart and Twin Bear lakes have larger proportions of harder substrates of sand and rock (Figure 3.2-2). Like terrestrial plants, aquatic plants vary in their preference for a particular substrate type; some species are usually only found growing in soft sediments, others only course substrates like sand, while some are more generalists and can be found growing in either. Lakes with varying types of substrates generally support a higher number of aquatic plant species because of the different habitat types that are available.

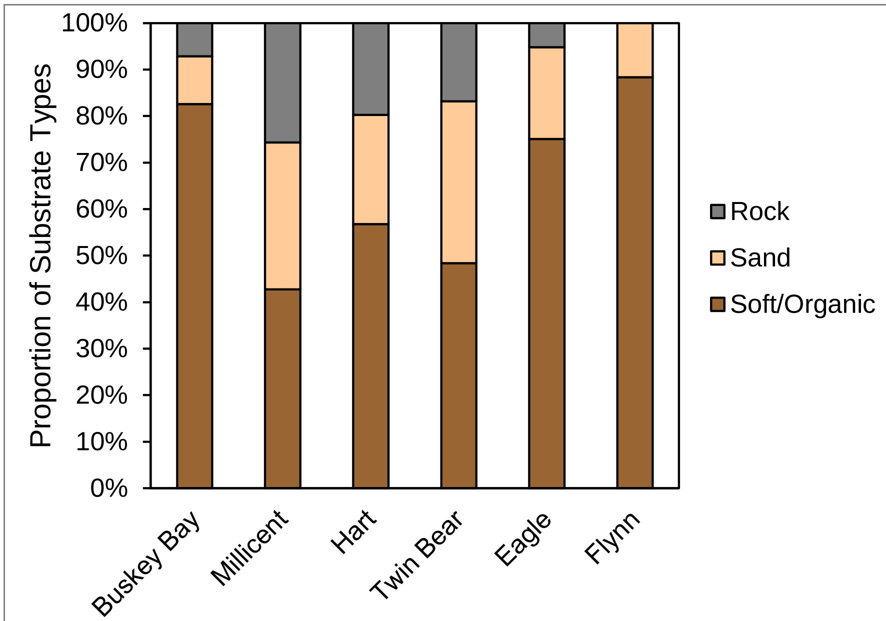


Figure 3.2-2. Pike Chain of Lakes proportion of substrate types. Represents proportion of substrate types in water ≤ 15 feet deep. Created using data collected during the 2018 whole-lake point-intercept surveys.

Given the high water clarity in the Pike Chain of Lakes, aquatic plants grow to maximum depths of greater than 30 feet in some lakes (Figure 3.2-3). In Flynn Lake, aquatic plants grow to the maximum depth of the lake of 8.0 feet. While there appears to be a decreasing trend in the maximum depth of recorded plants in Buskey Bay from 2013-2018, this is due to vegetation being very sparse at depths deeper than 25 feet. In 2013, plants were recorded at just a few points at depths between 25 and 32 feet, resulting in a maximum recorded depth of 32 feet. Secchi disk transparency data collected by Citizen Lake Monitoring Network volunteers shows that there has not been a decreasing trend in water clarity over this period, and the perceived decline in maximum depth of plant growth is believed to be due to the low probability of encountering vegetation beyond 25 feet in Buskey Bay.

The chain-wide littoral frequency of occurrence of all aquatic vegetation has ranged from 67% in 2018 to 76% in 2017, with an average of 72% (Figure 3.2-4). The littoral occurrence of vegetation has declined in Buskey Bay and Lake Millicent from 2007-2018, increased in Hart and Twin Bear lakes, and remained relatively consistent in Eagle and Flynn lakes. As is discussed later in this section, the localized and whole-lake herbicide treatments that took place in these lakes to manage EWM have resulted in impacts to non-target native plant populations, most notably northern watermilfoil. Declines in these native plant populations have contributed to the overall reduction in aquatic plant occurrence observed in Buskey Bay and Lake Millicent.

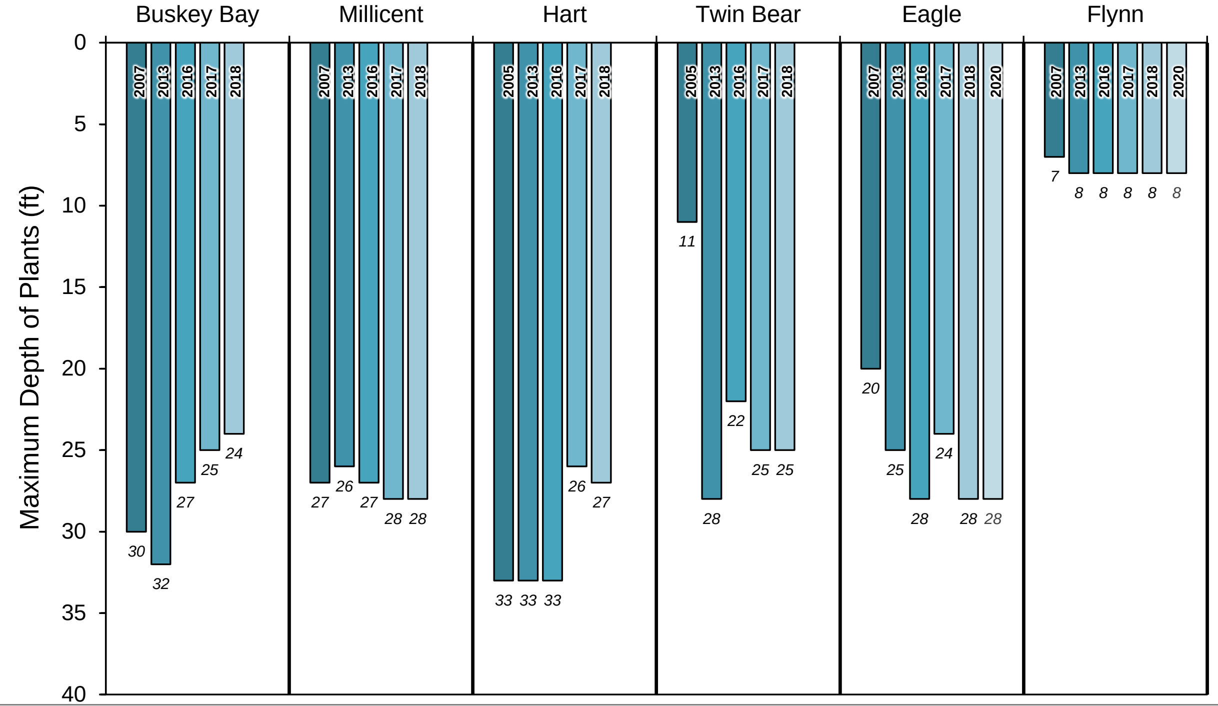


Figure 3.2-3. Pike Chain of Lakes recorded maximum depth of aquatic plant growth. Created using data from whole-lake point-intercept surveys. Please note that the maximum depth of Flynn Lake is 8.0 feet.

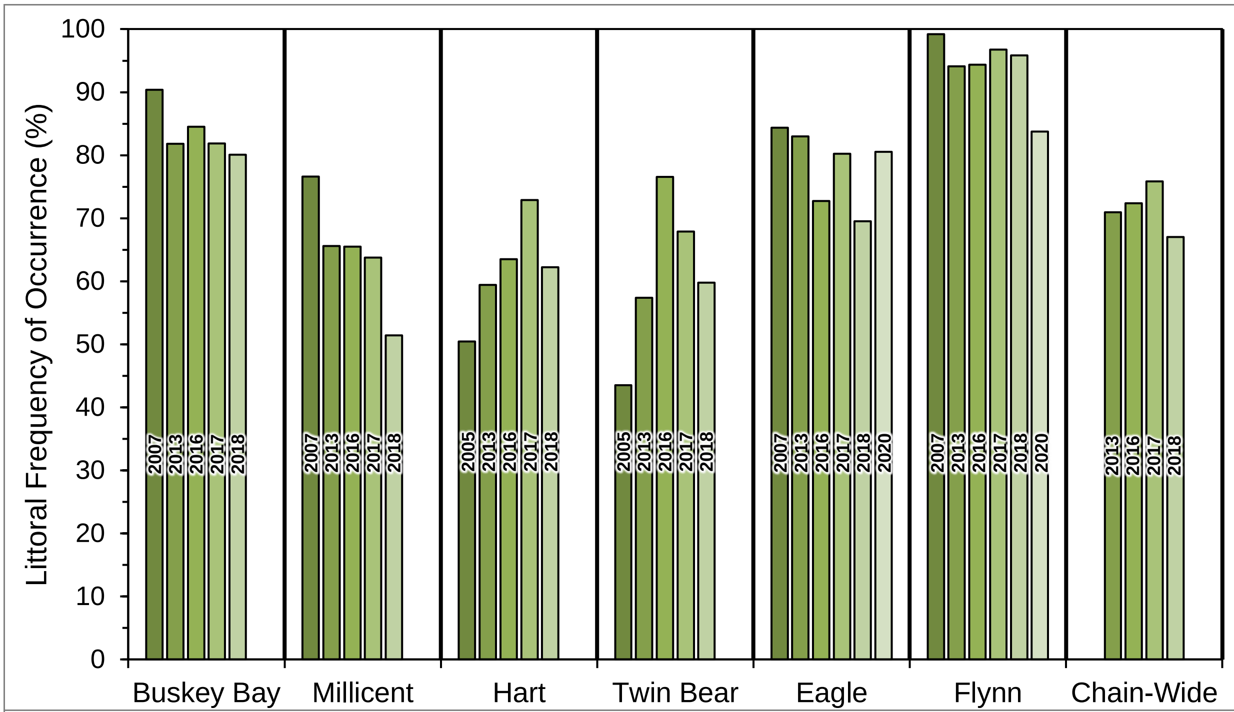


Figure 3.2-4. Pike Chain of Lakes aquatic plant littoral frequency of occurrence. Includes all aquatic plant species, both native and non-native. Created using data from whole-lake point-intercept surveys.

Of the 82 species that have been recorded in the Pike Chain of Lakes since 2005, 45 were physically encountered on the rake during the 2018 point-intercept surveys (Figure 3.2-5). Of these 45 species, fern-leaf pondweed, muskgrasses, coontail, common waterweed, wild celery, and variable-leaf pondweed were the most frequently encountered, all having a littoral occurrence of greater than 10%.

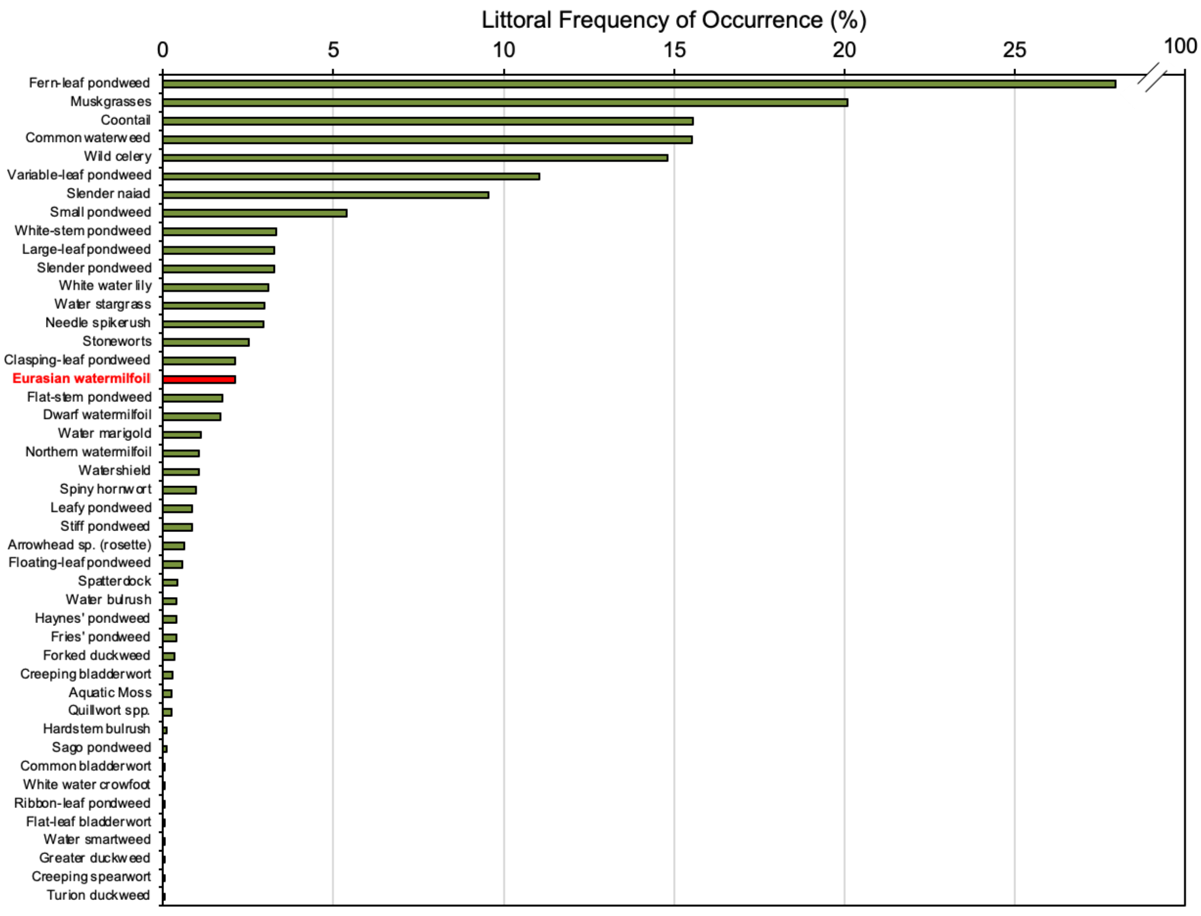


Figure 3.2-5. Chain-wide littoral frequency of occurrence of aquatic plant species in the Pike Chain of Lakes in 2018. Non-native species indicated with red. Created using data from whole-lake point-intercept surveys. N = 2,075

Fern-leaf pondweed was the most abundant aquatic plant in the Pike Chain of Lakes in 2018. As its name indicates, this plant resembles a terrestrial fern frond in appearance (Figure 3.2-5) and is often a dominant species in plant communities of northern Wisconsin lakes. Fern pondweed is generally found growing in thick beds over soft substrates where it stabilizes bottom sediments and provides a dense network of structural habitat for aquatic wildlife. While the occurrence of fern-leaf pondweed has been somewhat variable over time in each individual lake, at a chain-wide level fern-leaf pondweed has increased from a littoral occurrence of 23% in 2005/07 to 28% in 2018 (Figure 3.2-6).

Muskgrasses, a group of native macroalgae, were the second-most frequently encountered aquatic plants in the Pike Chain of Lakes in 2018 (Figure 3.2-7). Muskgrasses require lakes with good water clarity, and their large beds stabilize bottom sediments. Studies have also shown that muskgrasses sequester phosphorus in the calcium carbonate encrustations which form on these plants, aiding in improving water quality by making the phosphorus unavailable to phytoplankton (Coops 2002). To compare the occurrence of muskgrasses over time, their occurrence was combined with the stoneworts, another group of macroalgae that are morphologically similar. Chain-wide, the occurrence of these two groups of macroalgae, or charophytes, have not seen any trends (positive or negative) over the period from 2005/07-2018 (Figure 3.2.7).

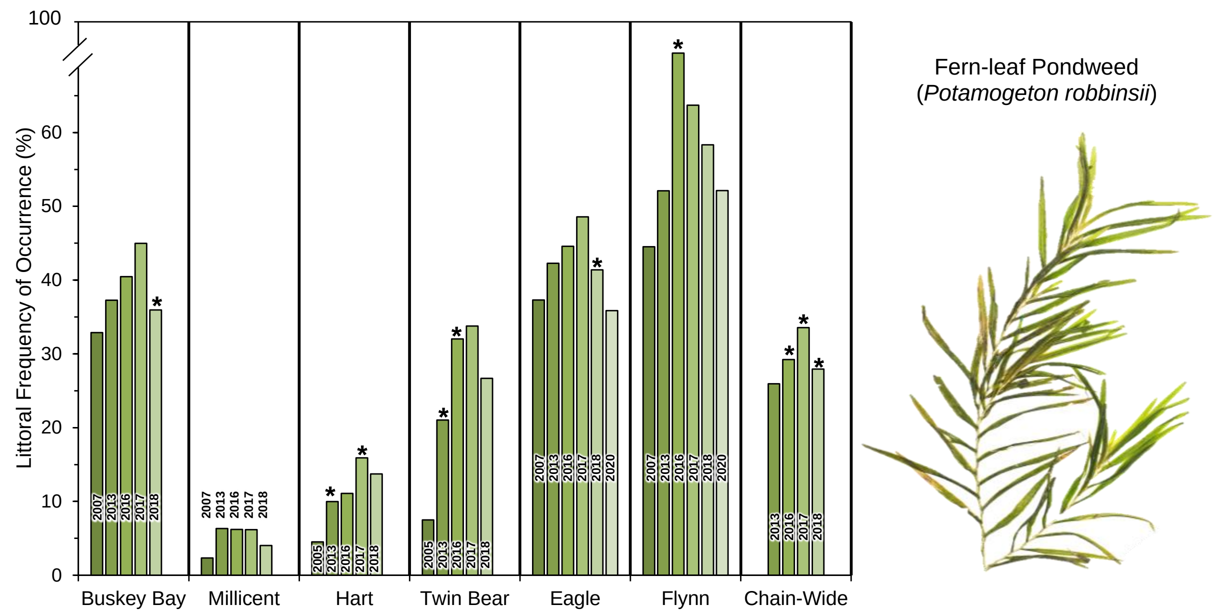


Figure 3.2-6. Littoral frequency of occurrence of fern-leaf pondweed in the Pike Chain of Lakes. Asterisk denotes statistically valid change in occurrence from previous survey (Chi-square α = 0.05).

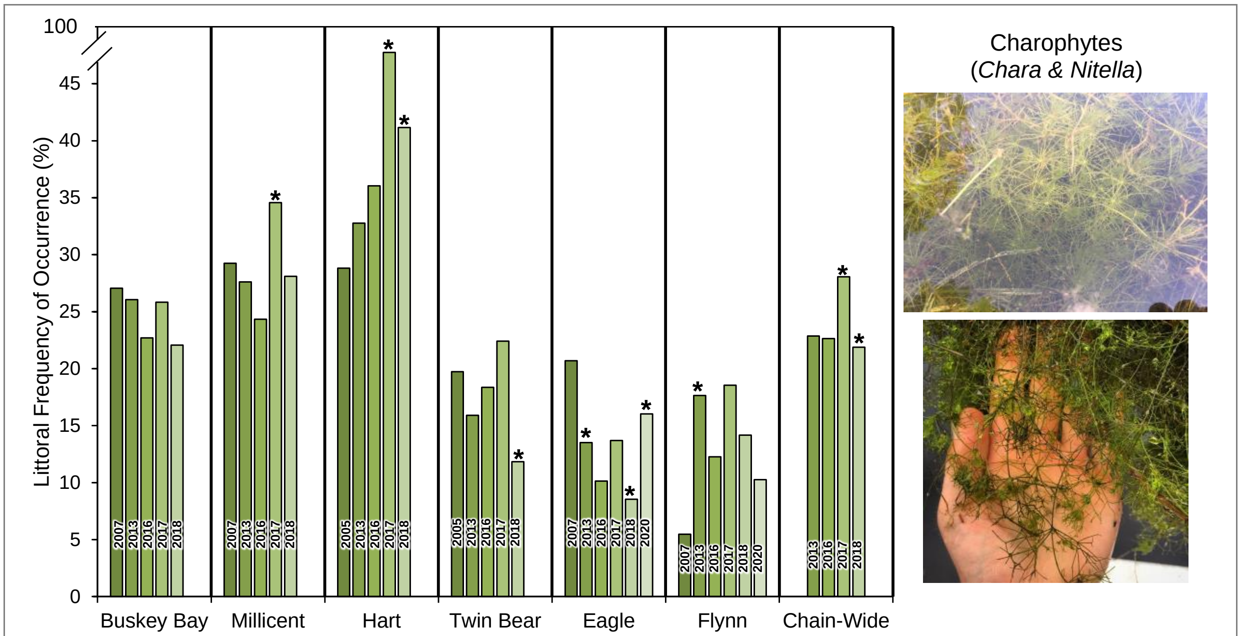


Figure 3.2-7. Littoral frequency of occurrence of charophytes in the Pike Chain of Lakes. Asterisk denotes statistically valid change in occurrence from previous survey (Chi-square α = 0.05).

Coontail was the third-most frequently encountered aquatic plant in the Pike Chain of Lakes in 2018 (Figure 3.2-8). Coontail is arguably one of the most common aquatic plants that can be found in Wisconsin's waterbodies, and possesses whorls of divided leaves which provide excellent structural habitat for aquatic organisms. Like charophytes, coontail derives most of its nutrients directly from the water, helping to maintain water quality. Coontail has exhibited a slight increasing trend in chain-wide occurrence from 2005/07-2018 (Figure 3.2-8).

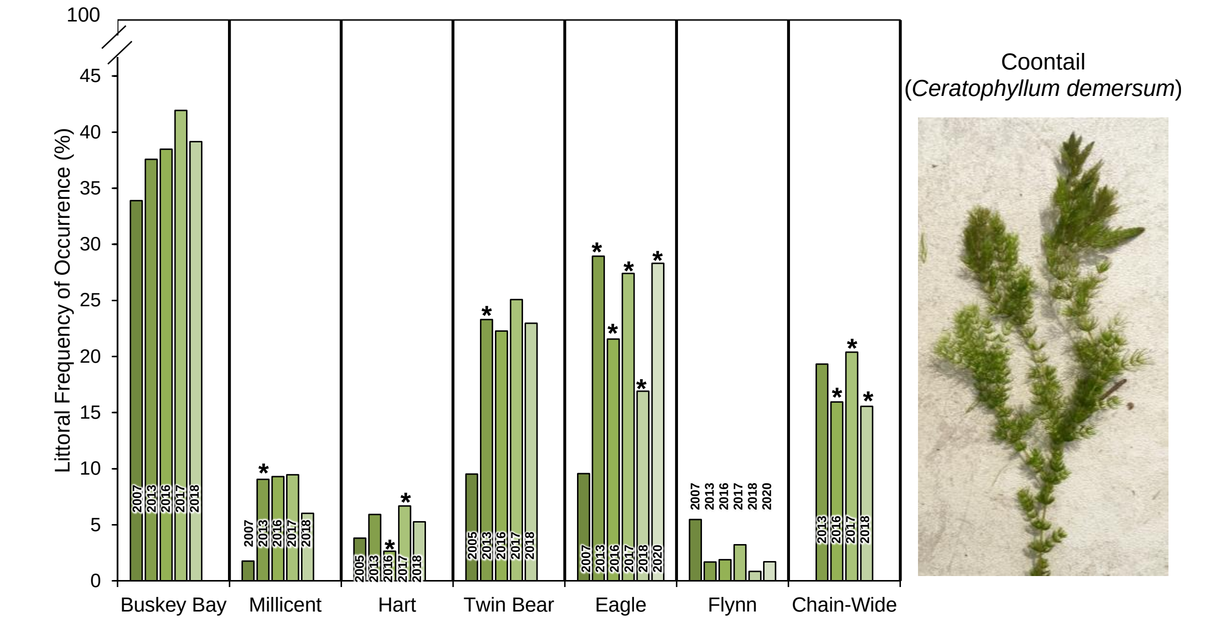


Figure 3.2-8. Littoral frequency of occurrence of coontail in the Pike Chain of Lakes. Asterisk denotes statistically valid change in occurrence from previous survey (Chi-square α = 0.05).

Common waterweed was the fourth-most frequently encountered aquatic plant in the Pike Chain of Lakes in 2018 (Figure 3.2-9). Like coontail, common waterweed can be found in waterbodies across Wisconsin, obtains much of its nutrients directly from the water, and provides valuable structural habitat. The chain-wide occurrence of common waterweed remained constant between 2005/07-2017 before seeing a statistically valid reduction between 2017 and 2018 (Figure 3.2-9). The largest declines occurred in Buskey Bay and Twin Bear lakes which had small spot treatments using the combination of diquat and endothall, but common waterweed also declined to a lesser extent in Lake Millicent and Hart Lake which did not receive any herbicide applications during this time period.

Wild celery was the fifth-most frequently encountered aquatic plant species in the Pike Chain of Lakes in 2018 (Figure 3.2-10). Wild celery, or tape grass, produces long linear leaves which originate from a basal rosette. Later in summer, numerous seeds are produced which serve as an important source of food for migratory waterfowl and other wildlife. The plants extensive network of rhizomes stabilizes bottom sediments. The chain-wide occurrence of wild celery has fluctuated somewhat between 2005/07-2018, but no overall trends in occurrence have occurred over this time period (Figure 3.2-10).

Variable-leaf pondweed was the sixth-most frequently encountered aquatic plant species in the Pike Chain of Lakes in 2018 (Figure 3.2-11). Variable-leaf pondweed is one of several broad-leaf pondweed species that can be found in Wisconsin, and as its name indicates, can be quite variable in terms of size and shape from lake to lake. Variable-leaf pondweed is considered sensitive to water quality degradation.

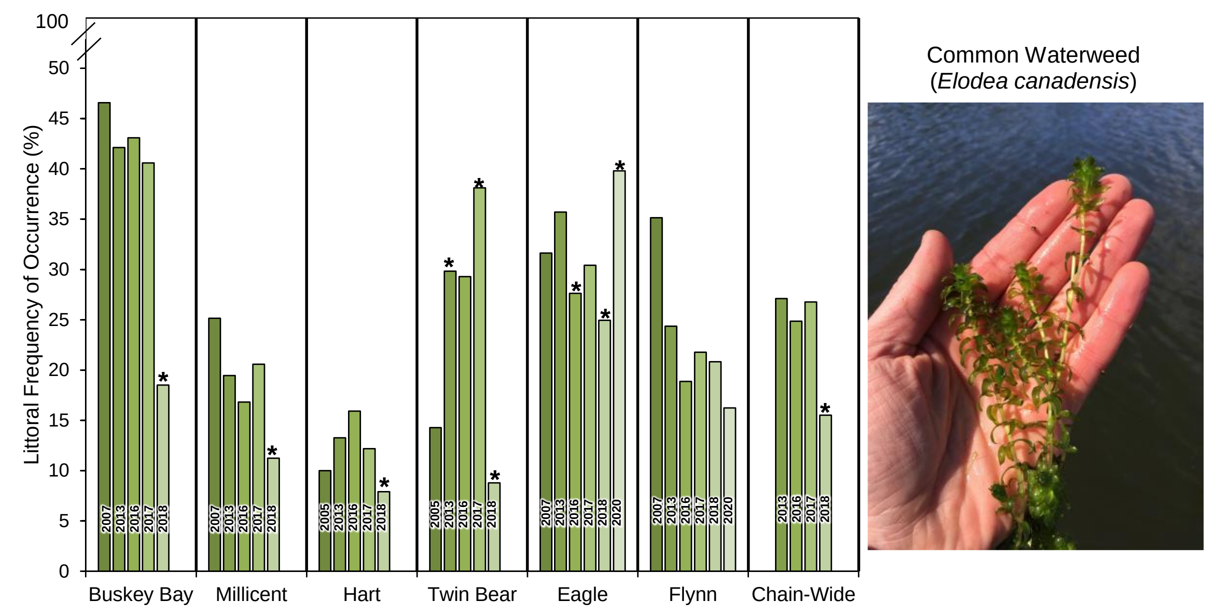


Figure 3.2-9. Littoral frequency of occurrence of common waterweed in the Pike Chain of Lakes. Asterisk denotes statistically valid change in occurrence from previous survey (Chi-square $\alpha = 0.05$).

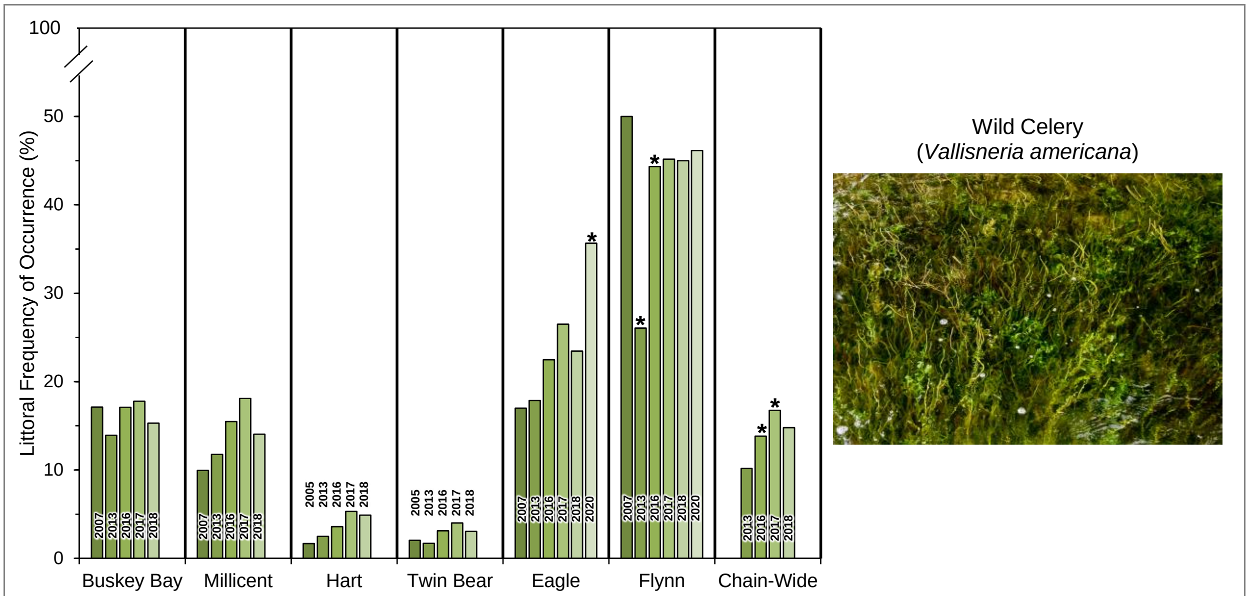


Figure 3.2-10. Littoral frequency of occurrence of wild celery in the Pike Chain of Lakes. Asterisk denotes statistically valid change in occurrence from previous survey (Chi-square $\alpha = 0.05$).

For comparison purposes, the occurrence of variable-leaf pondweed was combined with the occurrence of Illinois pondweed, a species that is morphologically very similar to variable-leaf pondweed and often difficult to separate in all instances. The chain-wide occurrence of variable-leaf/Illinois pondweed in the Pike Chain of Lakes was relatively consistent until 2018 where it reached its lowest occurrence (Figure 3.2-11). Reductions from 2017-2018 occurred in Buskey

Bay and Twin Bear lakes which saw combined diquat and endothall spot treatments, but reductions also occurred in Lake Millicent and Hart Lake which did not receive herbicide treatments. Their occurrence in Eagle Lake increased while it remained unchanged in Flynn Lake.

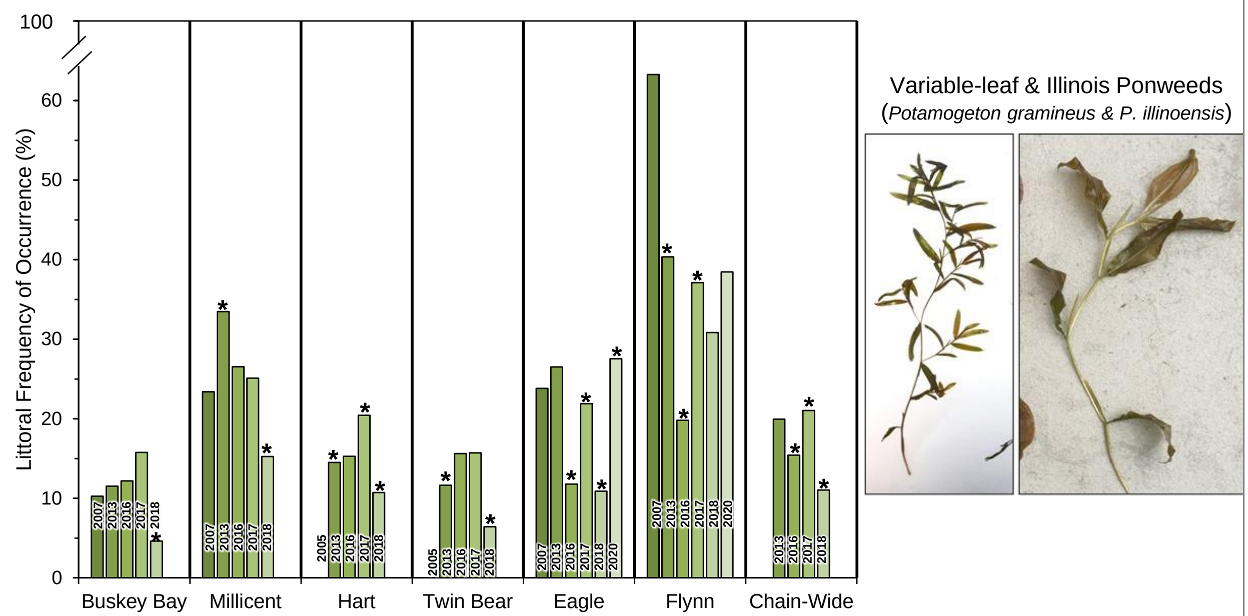


Figure 3.2-11. Littoral frequency of occurrence of the combined occurrence of variable-leaf and Illinois pondweeds in the Pike Chain of Lakes. Asterisk denotes statistically valid change in occurrence from previous survey (Chi-square $\alpha = 0.05$).

Small pondweed (*Potamogeton pusillus*) and slender pondweed (*P. berchtoldii*), common narrow-leaf pondweed species in the Pike Chain of Lakes, are morphologically similar and their occurrences were combined for comparison purposes. These species were actually lumped as a single species up until recently that cannot be teased a part in the analysis. Despite being monocots, both of these species have been shown to be sensitive to the more-dicot targeted herbicide 2,4-D that has been used in the Pike Chain of Lakes. On a chain-wide basis, the occurrence of these two species have increased over the period from 2005/07 to 2018 (Figure 3.2-12). These plants saw declines in 2018 in Buskey Bay and Twin Bear lakes following the combination diquat and endothall spot treatments. In Eagle Lake, small/slender pondweeds declined initially following the whole-lake 2,4-D treatment, but rebounded one year following the treatment.

Another narrow-leaf pondweed species that has been shown to be sensitive to 2,4-D, flat-stem pondweed, has exhibited decline in the Pike Chain of Lakes from 2005/07-2018 (Figure 3.2-13). This species has seen declines in its occurrence within all six lakes. Similarly, large-leaf pondweed, has also exhibited a decline in occurrence chain-wide over the course of this time period (Figure 3.2-12). In Buskey Bay, the largest decline occurred in 2018 following the combined diquat and endothall spot treatments. Large-leaf pondweed also declined in Flynn Lake which has not seen any herbicide treatments, so the chain-wide decline may also be due in part to natural factors. Large-leaf pondweed has not been shown to be particularly sensitive to 2,4-D.

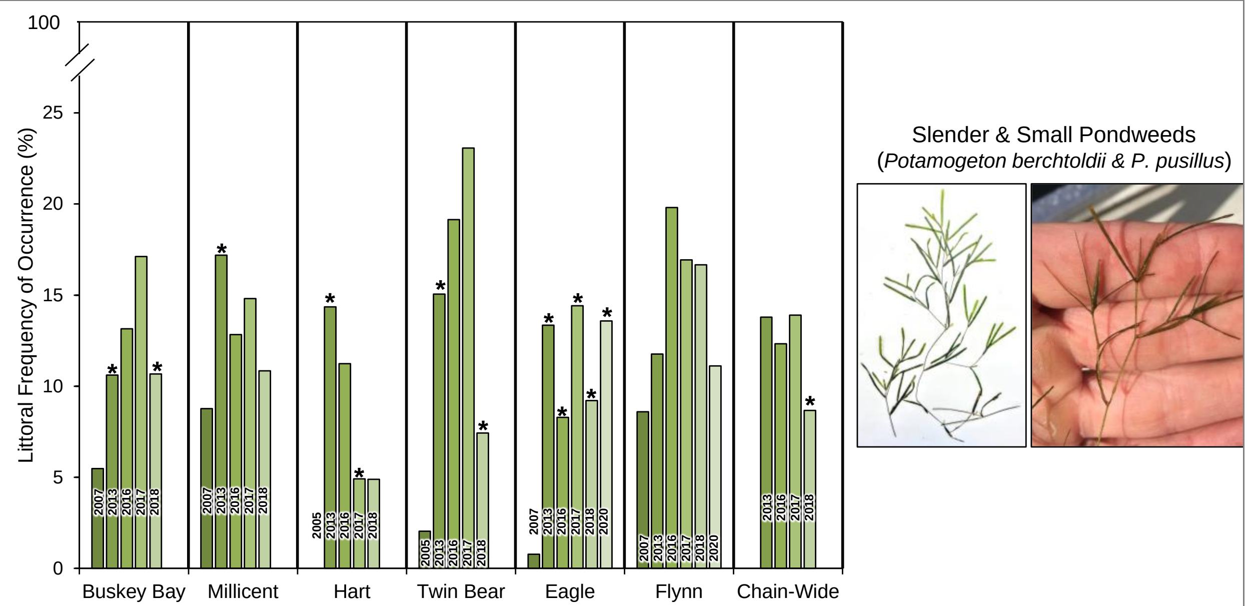


Figure 3.2-12. Littoral frequency of occurrence of the combined occurrence of slender and small pondweeds in the Pike Chain of Lakes. Asterisk denotes statistically valid change in occurrence from previous survey (Chi-square α = 0.05).

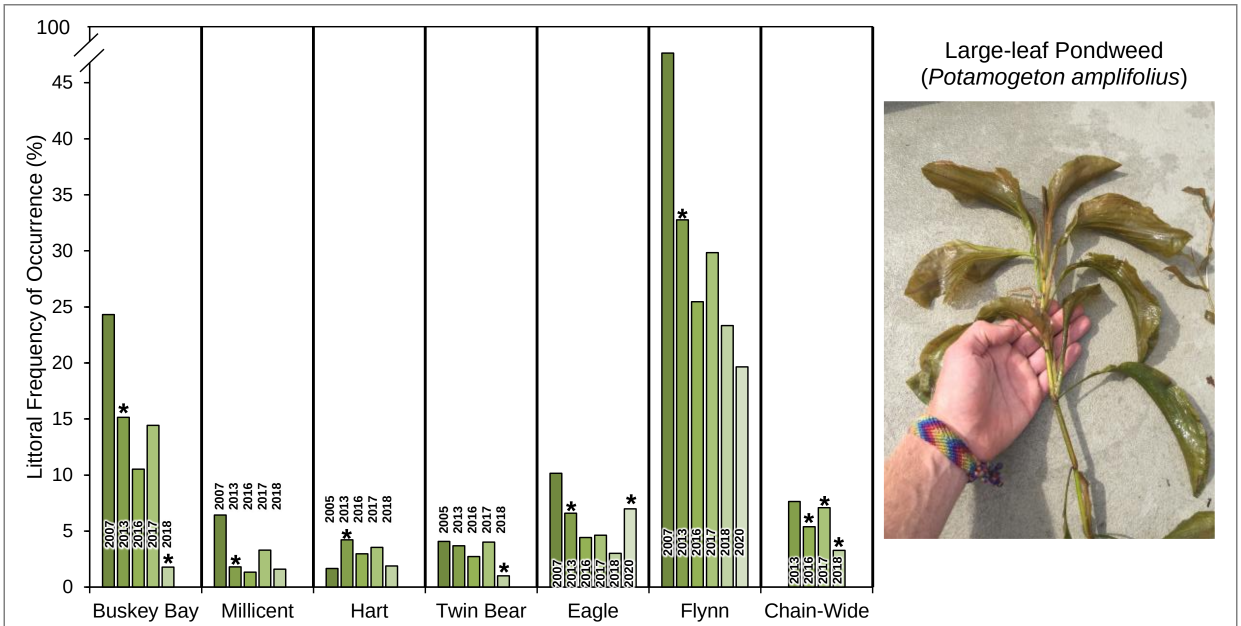


Figure 3.2-13. Littoral frequency of occurrence of large-leaf pondweed in the Pike Chain of Lakes. Asterisk denotes statistically valid change in occurrence from previous survey (Chi-square α = 0.05).

Northern watermilfoil, a native dicot that is closely related to Eurasian watermilfoil and has been shown to be particularly sensitive to 2,4-D herbicide treatments, has also exhibited statistically valid reductions in occurrence chain-wide from 2005/07-2018 (Figure 3.2-14). In Buskey Bay, the occurrence of northern watermilfoil declined from 28% in 2007 to 0.4% in 2018. Similarly, in Lake Millicent, northern watermilfoil declined from an occurrence of 26% in 2007 to undetectable (0%) in 2017 and 2018. While northern watermilfoil had a relatively low occurrence in Hart Lake from 2005 to 2016 between 2 and 4%, it declined to undetectable levels in 2017 and 2018.

Following an increase in occurrence from 2005-2016 in Twin Bear Lake, northern watermilfoil declined in occurrence to near 0% in 2018. In Eagle Lake, northern watermilfoil declined an occurrence of 7% in 2007 to undetectable in 2020 following the 2019 whole-lake 2,4-D treatment. On a chain-wide level, northern watermilfoil has declined from an occurrence of 11.4% in 2005/07 to 1.1% in 2018.

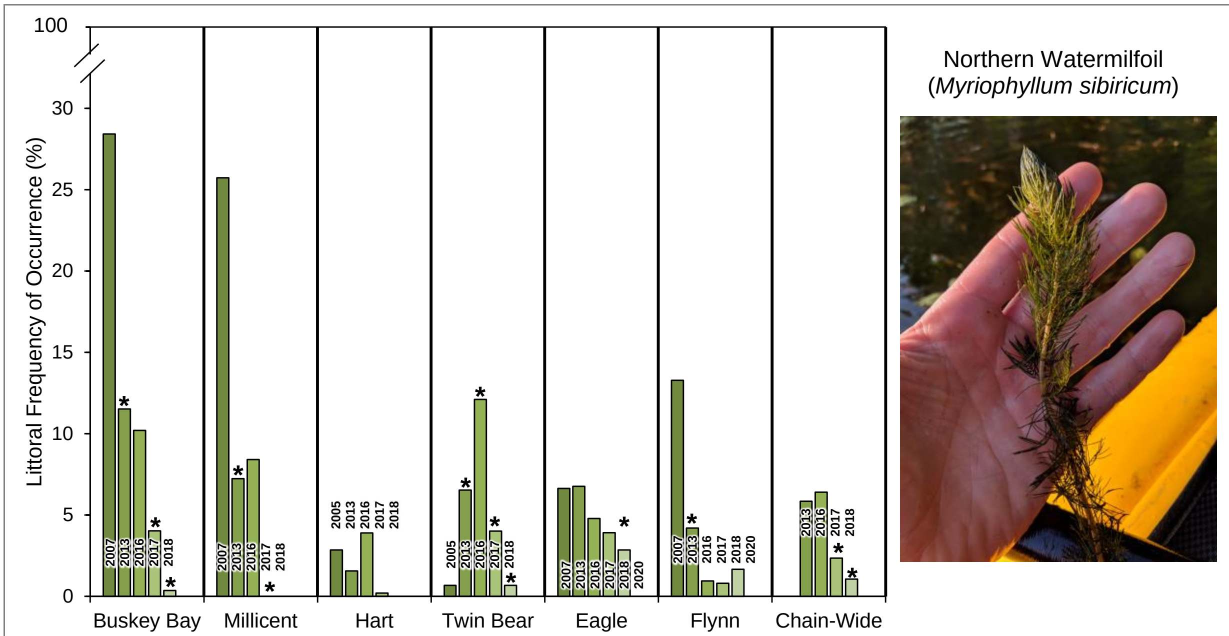


Figure 3.2-14. Littoral frequency of occurrence of northern watermilfoil in the Pike Chain of Lakes. Asterisk denotes statistically valid change in occurrence from previous survey (Chi-square α = 0.05).

The decline of the northern watermilfoil population in the Pike Chain of Lakes over the period from 2005/07-2018 is concerning, and is likely the result of its susceptibility to the herbicides utilized over this period to control EWM. In fact, the combined occurrence of all dicotyledon species in the Pike Chain of Lake shows they have had a disproportionate decline in occurrence over this time period when compared to most monocotyledon species. Northern watermilfoil was the most abundant dicotyledon species in the Pike Chain of Lakes in 2005/07, but other dicotyledon species which have exhibited declines include: white water lily, watershield, water marigold, spatterdock, and common bladderwort.

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. The native aquatic plant species located on the rake during the point-intercept surveys from 2005/07 to 2018 and their conservatism values were used to calculate the FQI for each year. While chain-wide species richness is well above the median species richness for lakes in the NLF ecoregion and lakes throughout Wisconsin, it has declined over the period from 2005/07-2018 from 54 to 43, respectively (Figure 3.2-15).

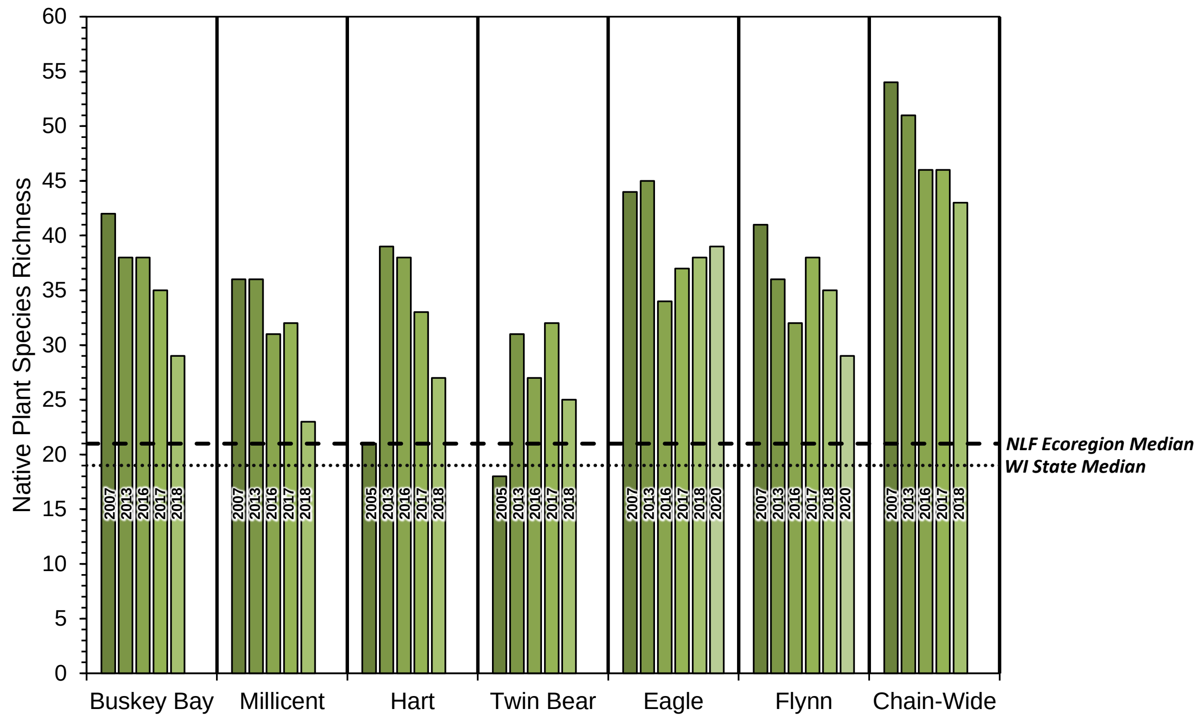


Figure 3.2-15. Pike Chain of Lakes native aquatic plant species richness. Includes native aquatic plant species physically encountered on the rake during the point-intercept survey and does not include incidentally-located species.

Average species conservatism in the Pike Chain of Lakes has remained relatively consistent with little variability over the period from 2005/07-2018 (Figure 3.2-16). The average conservatism in Buskey Bay fell below the Wisconsin state median value in 2018 following the combined diquat and endothall spot treatments. Similarly, average conservatism in Hart Lake fell to the WI state median value in 2018 despite no treatment occurring in that year. The average conservatism in the other four lakes have remained relatively similar, falling near or above the NLF ecoregion median.

Using the species richness and average conservatism to calculate the Floristic Quality Index for the Pike Chain of Lakes reveals exceptionally high values for all lakes (Figure 3.2-17). Given the decline in chain-wide species richness, chain-wide Floristic Quality Index values have also declined. Floristic Quality Index values have declined from around 49 in 2005/07 and 2013 to 43.5 in 2018. The largest declines in floristic quality have occurred in Buskey Bay, Lake Millicent, and Hart Lake.

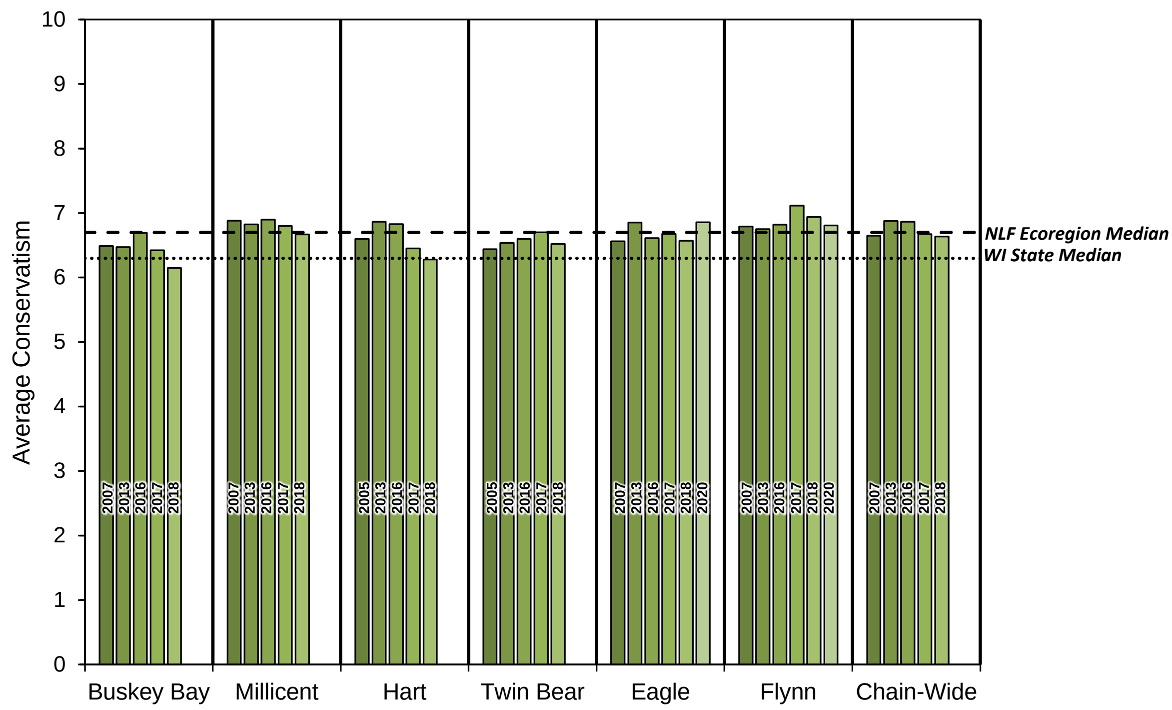


Figure 3.2-16. Pike Chain of lakes average conservatism values. Calculated using c-values for native aquatic plant species physically encountered on the rake during the point-intercept survey and does not include incidentally-located species.

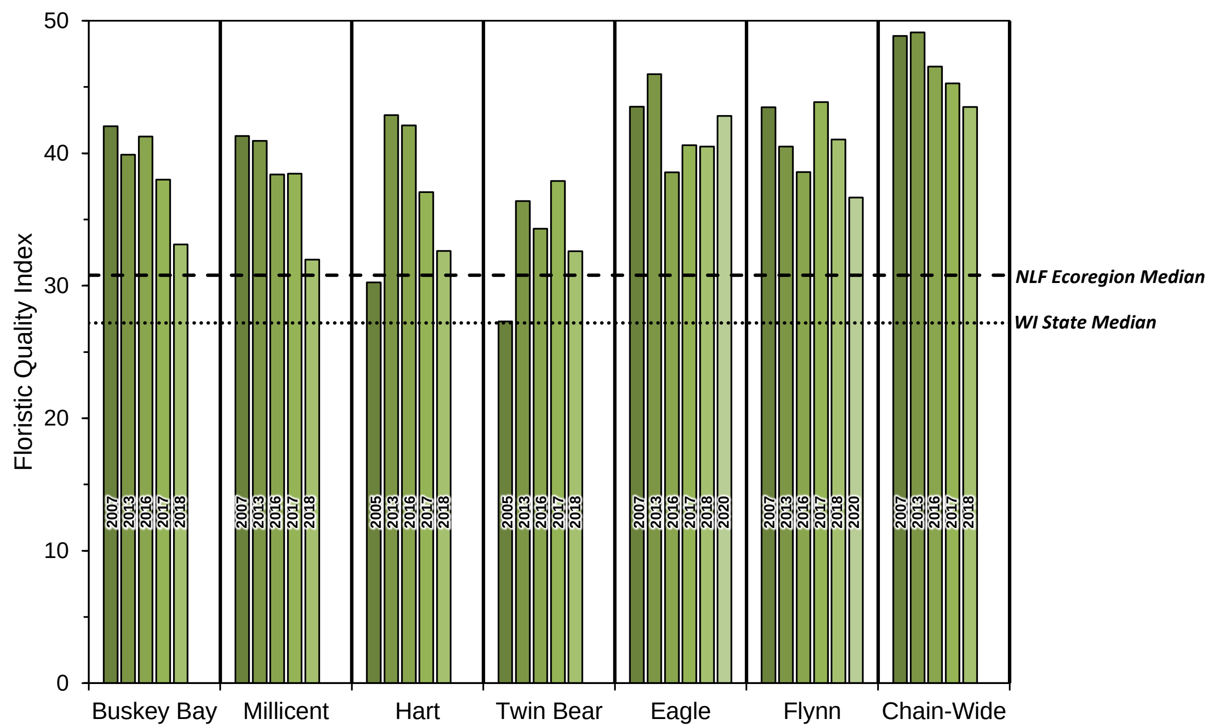


Figure 3.2-17. Pike Chain of lakes Floristic Quality Index. Analysis follows (Nichols 1999).

While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Pike Chain of Lakes' diversity values rank. Using data collected by Onterra and WDNR Science Services, quartiles were calculated for 212 lakes within the NLFL Ecoregion (Figure 3.2-18). Using the data collected from the whole-lake point-intercept surveys, the Pike Chain of Lakes' aquatic plant species diversity has declined slightly from 0.94 in 2005/07 to 0.91 in 2018. These values are all above the 75th percentile for lakes in the NLF ecoregion.

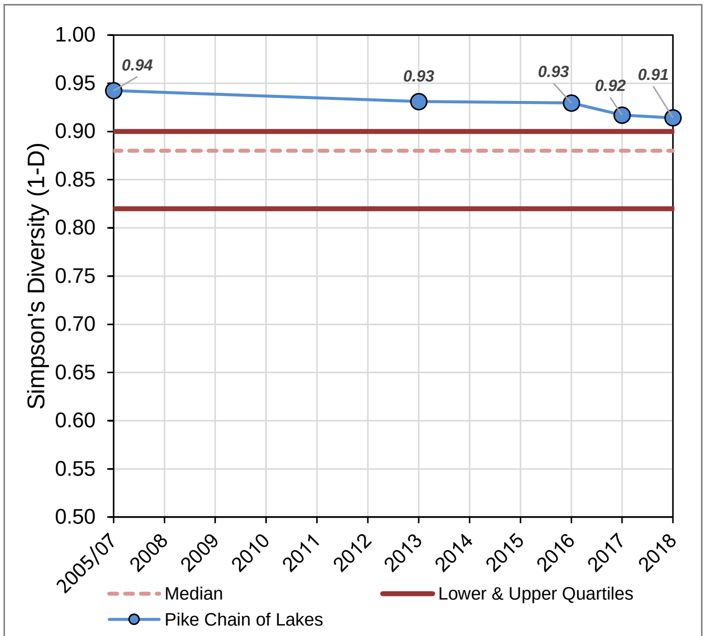


Figure 3.2-18. Pike Chain of Lakes Simpson's Diversity Index. Created using data from whole lake-lake point intercept surveys.

McCarry Lake

As discussed in the Introduction Section (1.0), the Pike Chain of Lakes as defined by the IRPCLA includes 6 main lakes, and 3 small hydrologically connected lakes where watercraft traffic is disconnected from the main lakes. The six main lakes have been the focus of past aquatic plant studies. During the summer of 2017, IRPCLA members discovered EWM within McCarry Lake. This lake has been surveyed through various EWM mapping surveys and point-intercept surveys since. IRPCLA members located a suspicious and abundant watermilfoil plant from Muskellunge, prompting a cursory site visit by Onterra in the late-summer of 2019. The crew identified a large population of native watermilfoils, but did not locate EWM. No formal aquatic plant surveys have been completed on Muskellunge or Pike Lakes to date.

Photograph 3.2-2. Flower of northeastern bladderwort (U. resupinata). Photograph credit: Onterra.

As will be discussed in the Eurasian Watermilfoil Section (3.3), a whole-lake 2,4-D treatment was conducted in 2019 in an effort to reduce the lake's EWM population. A pre-treatment whole-lake point-intercept survey was completed in 2018, while a post-treatment whole-lake point-intercept survey was completed in 2020. This sub-section will explore these data in the context of the EWM management activities.

During these two surveys, a total of 26 native and one non-native (EWM) plant species were located (Table 3.2-2). One aquatic plant species located in 2015, northeastern bladderwort (*Utricularia resupinata* – Photograph 3.2-2), is listed as special concern in Wisconsin by the Natural Heritage Inventory due to uncertainty regarding its population and rarity in the state (WDNR PUBL-ER-001 2016). Northeastern bladderwort is one of nine bladderwort species found in Wisconsin, and one of three species found in McCarry Lake.

Bladderworts are *insectivorous*, meaning they supplement their nutrient demand by trapping and digesting small insects and crustaceans. These plants possess small sac-like bladders containing small hairs, which when touched by unsuspecting prey trigger a door on the trap to open rapidly drawing in water and the insect. Trapped within the bladder, the insect is slowly digested. Northeastern bladderwort is often difficult to locate, as the majority of the plant is buried within the substrate. In McCarry Lake, this plant was found in sandy, shallow water in the northeastern portion of the lake.

Table 3.2-2. Aquatic plant species located in McCarry Lake during 2018 and 2020 point-intercept surveys.

Scientific Name	Common Name	Status in Wisconsin	Coefficient of Conservatism	2018	2020
Bidens beckii	Water marigold	Native	8	X	
Brasenia schreberi	Watershield	Native	7	X	X
Ceratophyllum echinatum	Spiny hornwort	Native	10	X	X
Chara spp.	Muskgrasses	Native	7	X	X
Dulichium arundinaceum	Three-way sedge	Native	9		X
Eleocharis acicularis	Needle spikerush	Native	5	X	
Elodea canadensis	Common waterweed	Native	3	X	X
Eriocaulon aquaticum	Pipewort	Native	9	I	I
Isoetes spp.	Quillwort spp.	Native	8		I
Myriophyllum spicatum	Eurasian watermilfoil	Non-Native - Invasive	N/A	X	
Najas flexilis	Slender naiad	Native	6	X	X
Nuphar variegata	Spatterdock	Native	6	X	X
Nymphaea odorata	White water lily	Native	6	X	X
Potamogeton amplifolius	Large-leaf pondweed	Native	7	X	I
Potamogeton epihydrus	Ribbon-leaf pondweed	Native	8	X	X
Potamogeton gramineus	Variable-leaf pondweed	Native	7	X	X
Potamogeton natans	Floating-leaf pondweed	Native	5	X	X
Potamogeton praelongus	White-stem pondweed	Native	8	X	X
Potamogeton pusillus	Small pondweed	Native	7	X	X
Potamogeton robbinsii	Fern-leaf pondweed	Native	8	X	X
Potamogeton zosteriformis	Flat-stem pondweed	Native	6	X	
Sagittaria sp. (rosette)	Arrowhead sp. (rosette)	Native	N/A	X	
Schoenoplectus subterminalis	Water bulrush	Native	9	X	X
Utricularia gibba	Creeping bladderwort	Native	9	X	
Utricularia resupinata	Northeastern bladderwort	Native - Special Concern	9	X	
Utricularia vulgaris	Common bladderwort	Native	7	X	X
Vallisneria americana	Wild celery	Native	6	X	X

X = Located on rake during point-intercept survey; I = Incidentally located; not located on rake during point-intercept survey

The point-intercept surveys revealed that the majority (97%) of McCarry Lake's littoral substrate is comprised of soft, organic sediments, while a small proportion (3%) is comprised of sand in shallow, near-shore areas (Figure 3.2-19). Aquatic plants were recorded growing to a maximum depth of 9.0 and 12.0 feet in 2018 and 2020, respectively. The littoral frequency of aquatic vegetation increased from 54% in 2018 to 63% in 2020 (Figure 3.2-20). However, total rake fullness (TRF) ratings suggest a slight reduction in aquatic plant biomass as in 2020 as there was a lower proportion of the TRF ratings of 2 and 3.

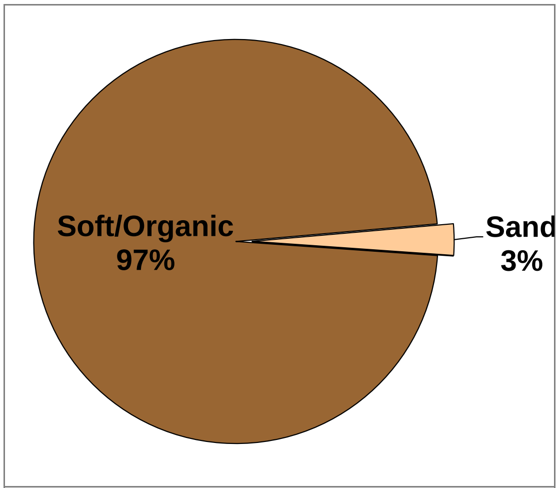


Figure 3.2-19. McCarry Lake proportion of substrate types. Created using data from 2020 point-intercept survey.

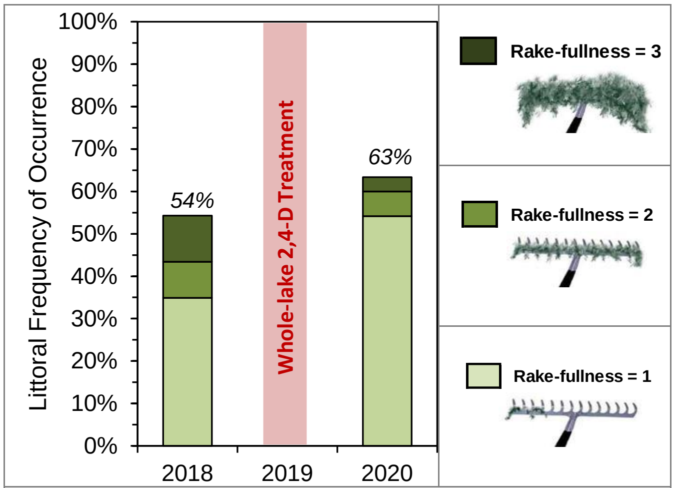


Figure 3.2-20. McCarry Lake aquatic plant littoral frequency of occurrence and total rake fullness (TRF) ratings from pre- and post-treatment. Created using data from 2018 and 2020 point-intercept survey. 2018 N = 129; 2020 N = 120.

The pre- and post-treatment point-intercept surveys revealed that the treatment was highly effective at reducing the occurrence of EWM (Figure 3.2-21). The occurrence of EWM declined from 6% in 2018 to 0% (undetectable) in 2020, a statistically valid reduction of 100% (Chi-Square $\alpha = 0.05$). Three native aquatic plant species also exhibited statistically valid reductions in their occurrence from pre- and post-treatment, and include: common waterweed (93% reduction), fern-leaf pondweed (81% reduction), and flat-stem pondweed (100% reduction).

Both common waterweed and flat-stem pondweed have been shown to decline following whole-lake 2,4-D treatments. However, fern-leaf pondweed has not been shown to be particularly sensitive to these types of treatments. It's not known if the reduction in fern-leaf pondweed is attributable to the treatment or some other environmental factor. One species, watershield, exhibited a statistically valid increase in occurrence of 130% between 2018 and 2020. The occurrences of the remaining 20 native species encountered on the rake during the point-intercept surveys were not statistically different between 2018 and 2020.

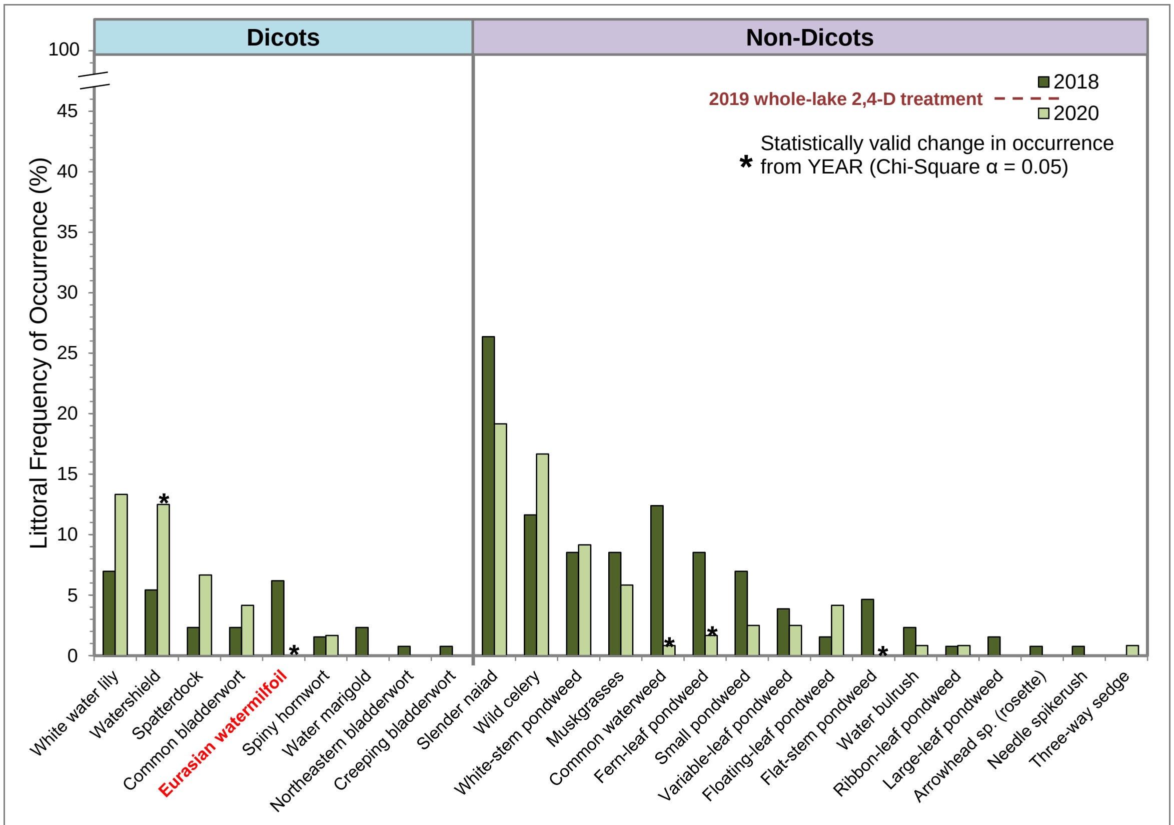


Figure 3.2-21. McCarry Lake aquatic plant species littoral frequency of occurrence from pre- and post-treatment. Non-native species indicated with red. Created using data from 2018 and 2020 point-intercept survey. 2018 N = 129; 2020 N = 120.

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. The native aquatic plant species located on the rake during the point-intercept surveys in 2018 and 2020 and their conservatism values were used to calculate the FQI for each year. Aquatic plant species richness in McCarry Lake declined from 23 in 2018 to 17 in 2020 (Figure 3.2-22). This decline was the result of not re-recording water marigold, needle spikerush, arrowhead rosette, creeping bladderwort, northeastern bladderwort, large-leaf pondweed, and flat-stem pondweed in 2020. However, the occurrences of the former six species in 2018 prior to treatment were low, and the fact they were not recorded again in 2020 is likely due to the low probability of encountering these species and not the treatment. Large-leaf pondweed was observed in 2020 despite not being recorded on the rake.

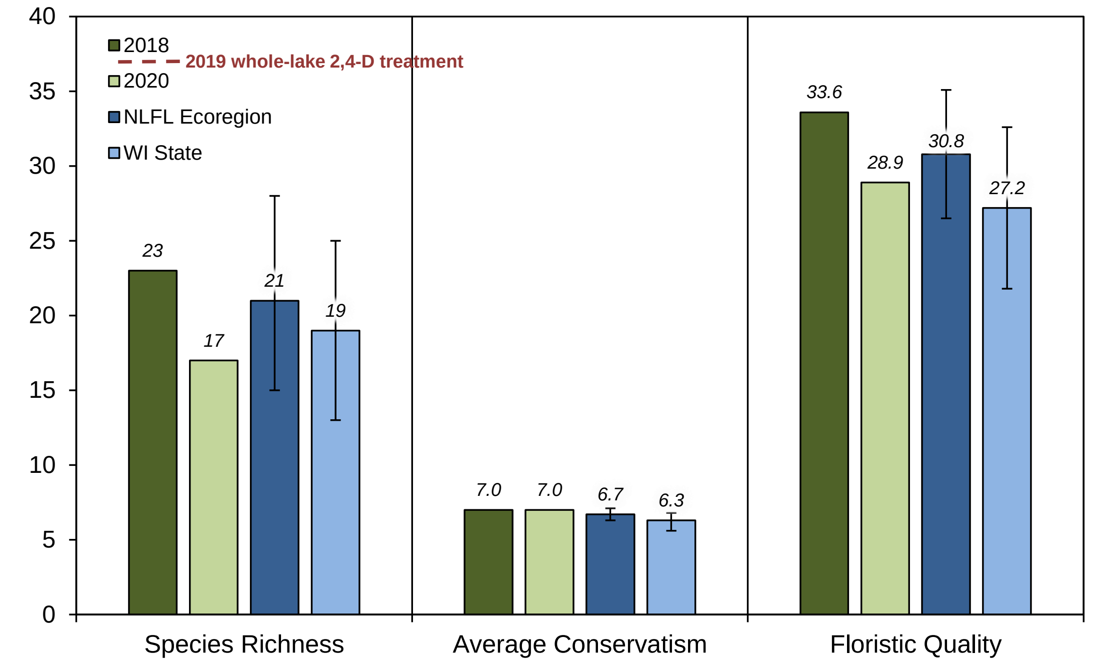


Figure 3.2-22. McCarry Lake Floristic Quality Analysis. NLFL = Northern Lakes and Forests Lakes ecoregion. Analysis follows (Nichols 1999).

The average species conservatism remained high at 7.0 following the 2019 whole-lake treatment (Figure 3.2-22). This indicates that McCarry Lake supports a higher number of environmentally sensitive aquatic plant species when compared to the majority of lakes within the ecoregion and the state. Using the species richness and average conservatism to calculate the Floristic Quality Index shows that floristic quality declined from 33.6 in 2018 to 28.9 in 2020 (Figure 3.2-22). This decline was the result of the lower number of species recorded in 2020.

The diversity of McCarry Lake's aquatic plant community declined slightly from 0.91 in 2018 to 0.89 in 2020 (Figure 3.2-22). This slight decline in species diversity is likely the result of the reduced number of native species recorded in 2020 as discussed previously. Overall, McCarry Lake's diversity remains high, above the median for lakes in the NLF ecoregion.

The data collected from McCarry Lake indicates that the 2019 whole-lake 2,4-D treatment was largely successful in terms of controlling EWM and causing minimal impacts to the native aquatic plant community. Continued monitoring will determine how the native aquatic plants which saw reductions following the treatment will recover.

3.3 Eurasian Watermilfoil

Because of their potential to upset the natural balance of an aquatic ecosystem, non-native species are paid particular attention to during the aquatic plant surveys. One submersed non-native aquatic plant is known from the Pike Chain – Eurasian watermilfoil (*Myriophyllum spicatum*).

Eurasian watermilfoil (EWM) is an invasive species, native to Europe, Asia and North Africa, that has spread to most Wisconsin counties (Figure 3.3-1). Eurasian watermilfoil is unique in that its primary mode of propagation is not by seed. It actually spreads by shoot fragmentation, which has supported its transport between lakes via boats and other equipment. In addition to its propagation method, EWM 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 sometimes does not stop growing like most native plants and instead continues to grow along the surface creating a canopy that blocks light from reaching native plants.

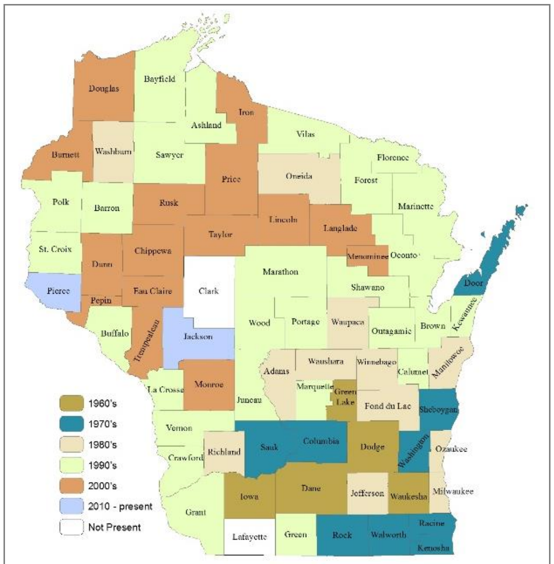


Figure 3.3-1. Spread of Eurasian watermilfoil within WI counties. WDNR Data 2015 mapped by Onterra.

Eurasian watermilfoil can create dense stands and dominate submergent communities, reducing important natural habitat for fish and other wildlife, and impeding recreational activities such as swimming, fishing, and boating. However, in some lakes, EWM appears to integrate itself within the community without becoming a nuisance or having a measurable impact to the ecological function of the lake.

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.

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 data are clearest for unmanaged lakes in the Northern Lakes and Forests Ecoregion (Figure 3.3-2). The upper frame of Figure 3.3-12 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 as populations increased.

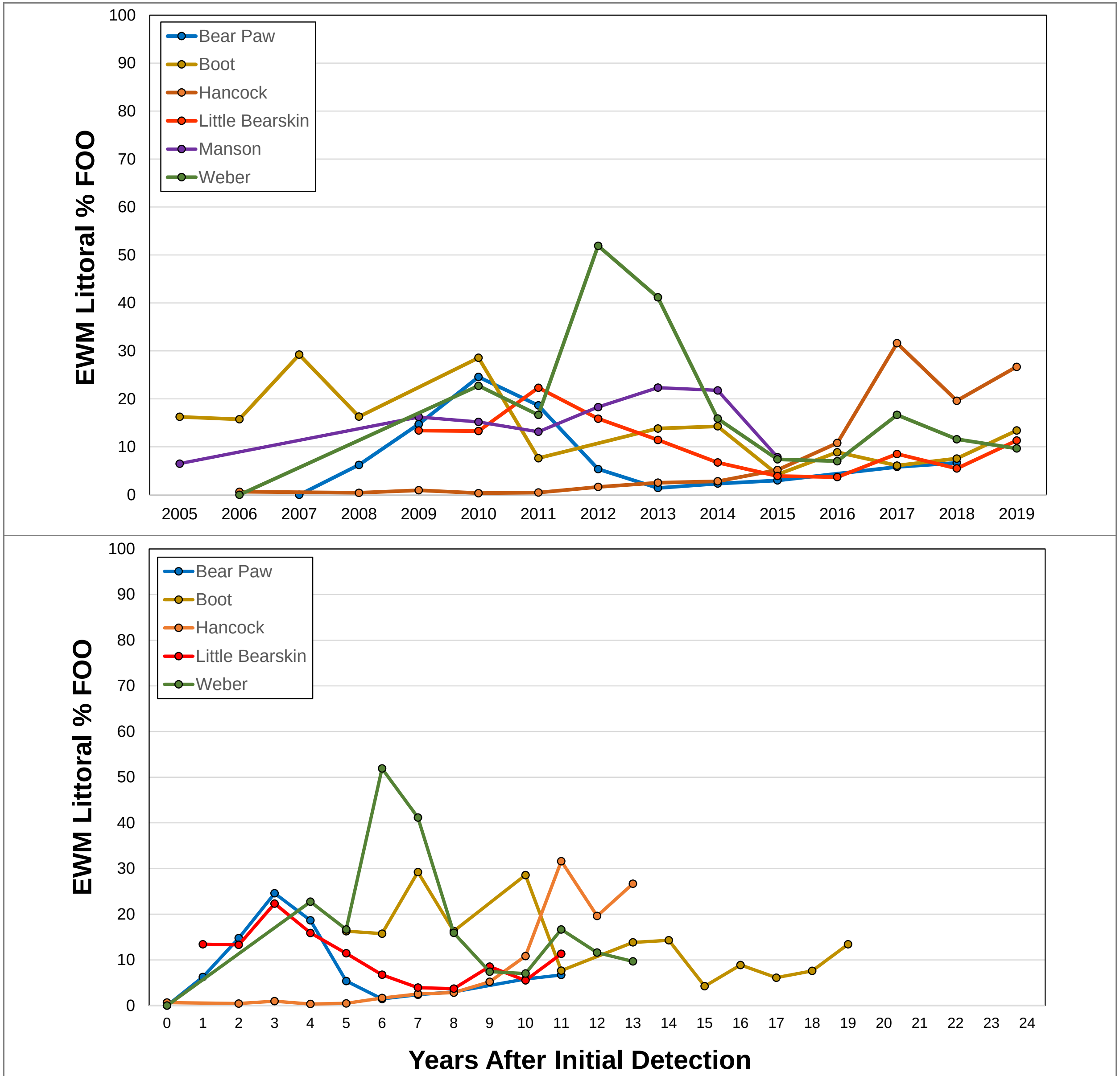


Figure 3.3-2. Littoral frequency of occurrence of EWM in the Northern Lakes and Forests Ecoregion without management. Data provided by and used with permission from WDNR.

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.

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

In 2015, the WDNR investigated the most recent point-intercept data from almost 400 Wisconsin Lakes that had confirmed EWM populations. These data show that approximately 65% of these lakes had EWM populations of 10% or less (Figure 3.3-1). At these low population levels, there may not be impacts to recreation and navigation, nor changes in ecological function. Table 3.3-1 shows the EWM population within the Pike Chain over time, with Millicent and Hart lakes reaching or exceeding 10% only in 2016.

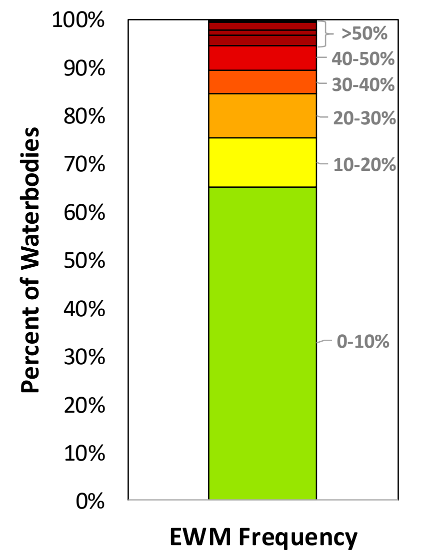


Figure 3.3-3. EWM littoral frequency of occurrence in 397 WI lakes with EWM populations. Data provided by and used with permission from WDNR.

Table 3.3-1. Littoral Frequency of EWM during point-intercept surveys.

	Eurasian Watermilfoil LFOO%					
	2005/07	**2013**	**2016**	**2017**	**2018**	**2020**
Buskey Bay	0.0	0.6	6.3	2.3	1.4	*N/A*
Millicent	0.0	0.9	13.7	0.0	0.0	*N/A*
Hart	0.0	0.9	10.0	0.0	1.9	*N/A*
Twin Bear	2.0	0.3	9.4	2.0	0.3	*N/A*
Eagle	0.0	0.0	0.9	0.5	4.5	0.8
Flynn	0.0	0.0	0.9	0.0	1.7	0.0
McCarry	*N/A*	*N/A*	*N/A*	*N/A*	6.2	0.0

Project Monitoring Methodologies

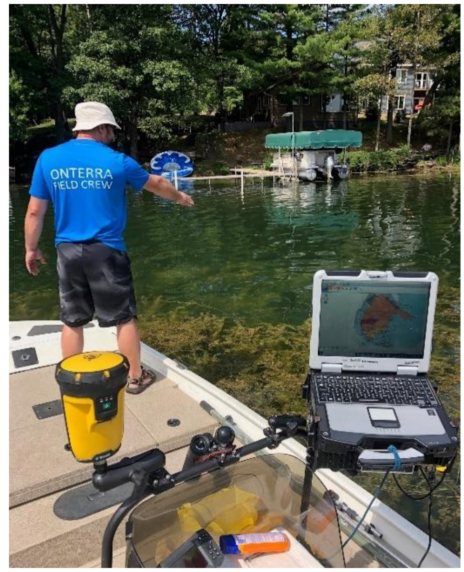
Almost all of the aquatic plant data discussed so far within this report were collected as part of point-intercept surveys. The subsequent materials will also incorporate data from EWM mapping surveys.

Point-Intercept Surveys

The point-intercept survey provides a standardized way to gain quantitative information about a lake's aquatic plant population through visiting predetermined locations and using a rake sampler to identify all the plants at each location. The point-intercept survey can be applied at various scales. The point-intercept survey is most often applied at the whole-lake scale. These data from the Pike Chain were discussed as part of the previous sub-section (Section 3.2). If a smaller area is being studied, a modified and finer-scale point-intercept sampling grid may be needed to produce a sufficient number of sampling points for comparison purposes. This sub-sample point-intercept survey methodology is often applied over management areas such as herbicide application sites. This type of sampling has been conducted in association with the Pike Chain's herbicide spot treatments prior to the 2017 whole-lake 2,4-D treatments.

EWM Mapping Surveys

While completing the point-intercept survey, it is common to see a particularly plant species, such as EWM, very near the point-intercept sampling location but not yield it on the rake sampler. Particularly in low-density colonies such as those designated by Onterra as *highly scattered* and *scattered*, large gaps between EWM plants may exist resulting in EWM not being present at a particular pre-determined point-intercept sampling location in that area. While the point-intercept survey is a valuable tool to understand the overall plant population of a lake or a target area, it does not offer a full account (census) of where a particular species exists in the lake. A species-specific mapping survey, such as an EWM mapping survey, approximates a census of where that species exists in the surveyed boundaries.



Photograph 3.3-1. EWM mapping survey on a Waushara County, WI lake. Photograph credit Onterra.

During an EWM mapping survey, the entire littoral area of the lake is surveyed through visual observations from the boat (Photograph 3.3-1). Field crews supplement the visual survey by deploying a submersible camera along with periodically doing rake tows. The EWM population is mapped using sub-meter GPS technology by using either 1) point-based or 2) area-based methodologies. Large colonies greater than 40 feet in diameter are mapped using polygons (areas) and are qualitatively attributed a density rating based upon a five-tiered scale from *highly scattered* to *surface matting*. Point-based techniques were applied to AIS locations that were considered as *small plant colonies* (less than 40 feet in diameter), *clumps of plants*, or *single or few plants*.

Overall, each survey has its strengths and weaknesses, which is why both are utilized in different ways as part of this overall project.

EWM population of the Pike Chain

Eurasian watermilfoil was first discovered in 2004 within the Twin Bear-Hart Lake channel, and it has since spread to all six lakes within the chain that are traversable by boat. Eurasian watermilfoil has also been found in McCarry Lake which flows into Hart Lake, but is not yet known to exist in Muskellunge or Pike lakes.

Genetic analysis of single plant samples from each of the six main lakes (2013) and McCarry Lake (2017) has confirmed that the populations are pure-strain EWM and not hybrid watermilfoil (HWM), a cross between EWM and the native northern watermilfoil (*Myriophyllum sibiricum*)As is discussed further in this report, hybrid watermilfoil typically has thicker stems, is a prolific flowerer, and grows much faster than pure-strain EWM (LaRue et al. 2012). These conditions likely contribute to this plant being particularly less susceptible to chemical control strategies (Glomski and Nehterland 2010), (Poovey, Slade and Netherland 2007), (Nault et al. 2018).

Field identification between EWM, HWM, and certain native watermilfoil species can be difficult. Photograph 3.3-2 shows a cross-section of a whorl of four EWM leaves. One of the primary ways to distinguish between different species of watermilfoils is to count the number of leaflets on each leaf. As shown on Figure 3.3-4, northern watermilfoil (green triangles) typically has leaflet counts under 23, whereas EWM typically has leaflet counts over 25. Hybrid watermilfoil leaflet counts overlap with both these ranges, making field identification difficult. While leaflet counts can be a relatively definitive way to differentiate between EWM and northern watermilfoil, this method is less definitive in distinguishing HWM from EWM and northern watermilfoil. Genetic analysis in some cases, can be the only method for accurate determination of watermilfoil species.

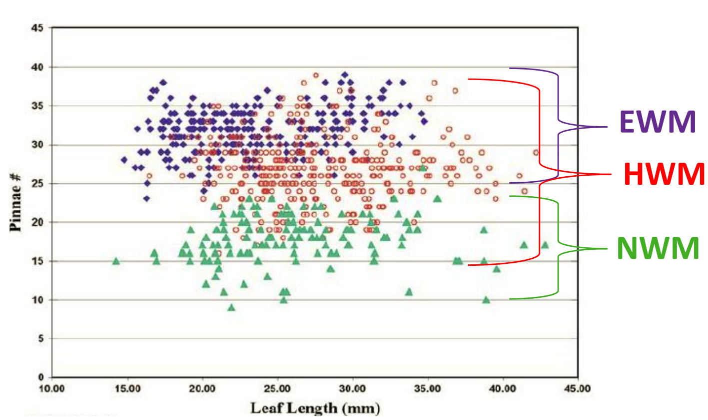


Figure 3.3-4. Pinnae (leaflet) counts from three watermilfoil species-types. Extracted and modified from (Moody and Les 2007).

Photograph 3.3-2. EWM leaflet.

Late-season EWM mapping surveys have been completed on the Pike Chain of Lakes annually since 2007 using a consistent density rating system (Figure 3.3-5). Please note that this figure only represents only the acreage of mapped EWM polygons, not EWM mapped with point-based methodologies (*Single or Few Plants*, *Clumps of Plants*, or *Small Plant Colonies*). Said another way, EWM marked with point-based mapping methods do not contribute to colonized acreage as shown on Figure 3.3-5 or Figure 3.3-6. Map 2 shows the entire EWM footprint from 2007-2020, including the point-based EWM occurrences. Maps 3-8 show the latest EWM mapping data (2020).

As shown on Figures 3.3-5 and 3.3-6, the colonized EWM population of the Pike Chain did not exceed one acre until 2014. The majority of the EWM occurrences until that time consisted of point-based occurrences. Herbicide spot treatments using granular 2,4-D occurred during this timeframe (Table 3.3-2), as did volunteer-based hand-harvesting activities (increased effort in 2009-2013). This herbicide use pattern was considered the best management practice at that time. The term best management practice (BMP) is often used in environmental management fields to represent the management option that is currently supported by the latest science and policy. When used in an action plan, the term can be thought of as a placeholder with anticipation of having an evolving definition over time.

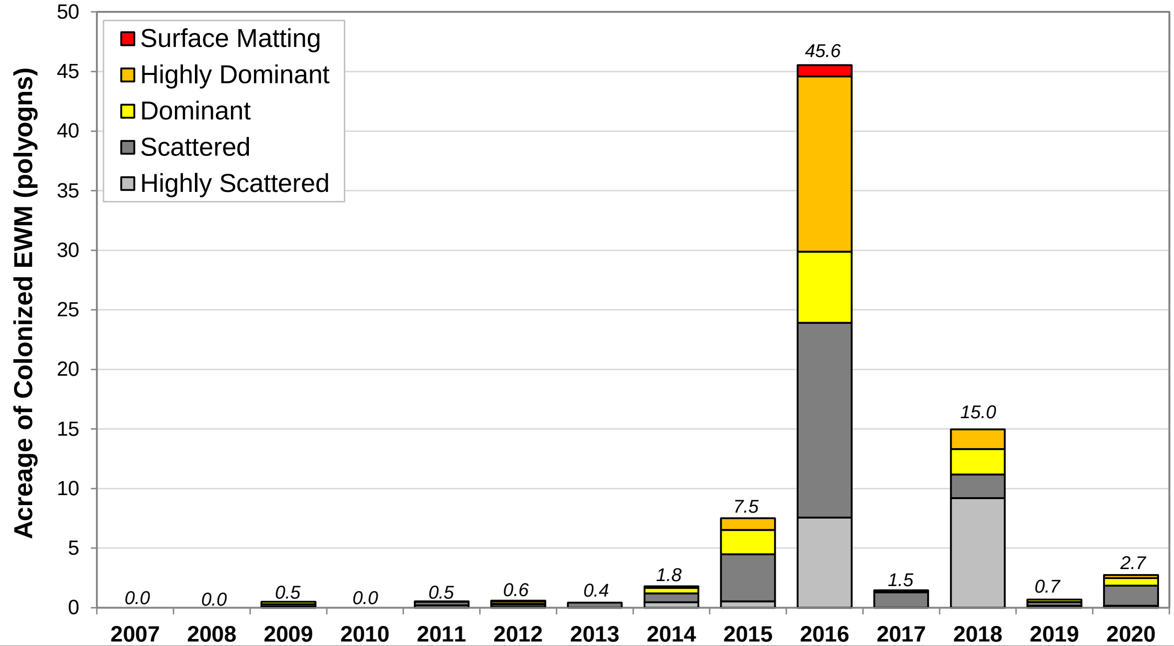


Figure 3.3-5. Chain-wide acreage of mapped EWM colonies on the Pike Chain of Lakes from 2007-2020. From six main lakes only.

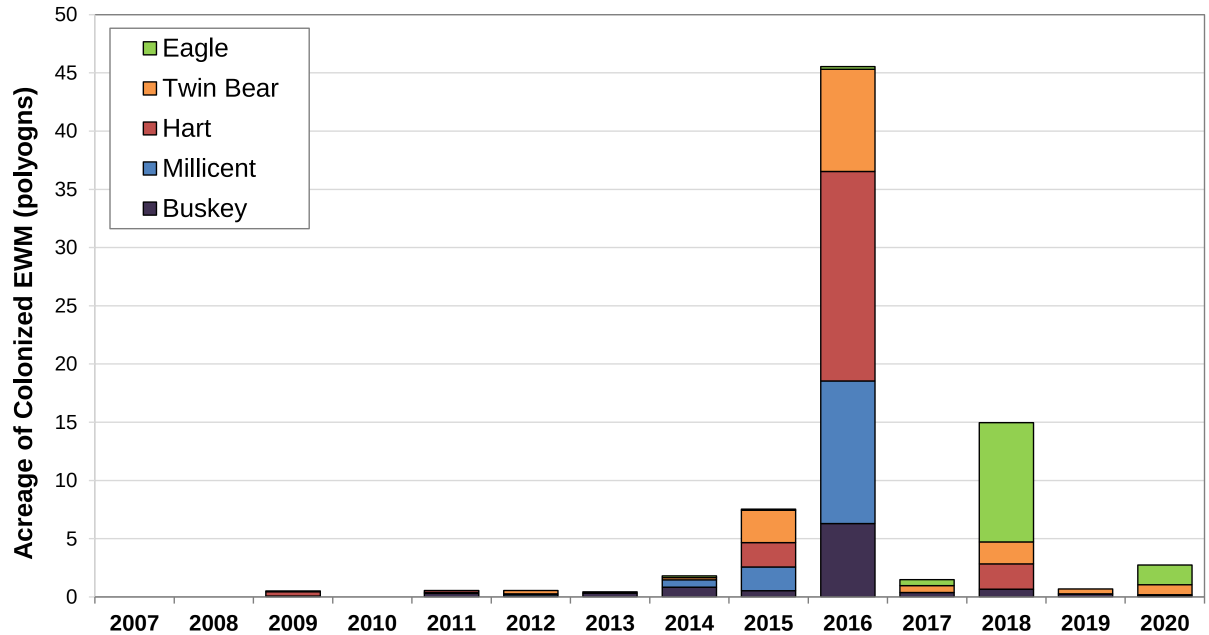


Figure 3.3-6. Distribution of acreage of mapped EWM colonies by lake from 2007-2020. From six main lakes only.

Onterra LLC
Lake Management Planning

Table 3.3-2. Historical aquatic plant management activities on the Pike Chain.

	Buskey Bay	Millicent	Hart	Twin Bear	Eagle	Flynn	McCarry
2005		6.0					
2006		10.0					
2007			10.0	17.2			
2008	0.4	0.7	8.7	10.4			
2009		0.8	10.6	13.2	0.1		
2010	0.5	4.7	3.8	6.1			
2011	0.2	2.0	8.2	5.7			
2012	2.8	2.9	3.1	3.0	0.2		
2013	1.6	9.3	2.2	8.8	0.6		
2014	3.9		4.2	0.5			
2015	1.5	0.8		1.3			
2016					3.8		
2017	15.3	33.0	41.5	26.7	3.9		
2018	2.0			2.2 2.0	0.9	0.2	
2019	3.9		18.8	10.9	28.1		4.2
2020	3.9		6.9	10.0			

- Granular 2,4-D ester Spot Treatments
- Granular 2,4-D amine Spot Treatments
- Liquid 2,4-D amine Spot Treatments
- Liquid 2,4-D amine Whole-Lake Treatments
- Diquat + endothall (Aquastrike) Spot Treatments
- Contracted Hand-Harvesting/DASH

While short-term EWM suppression was observed in many of the spot treatment sites between 2005 and 2015, EWM population rebound was often observed occurring as soon as the *year after treatment*. Areas were requiring treatment on an every-other-year basis as new areas were emerging around the chain. This program was analogous to playing the Whac-A-Mole™ arcade game, constantly responding to the same areas over time. This *seasonal control* being achieved did not meet Onterra's expectations of longevity following treatment and Onterra questioned the sustainability of the strategy in regards to financial and ecological costs. Ceasing treatment for a year in 2016 result in all areas returning to pretreatment levels.

Figures 3.3-5 and 3.3-6 illustrate that the colonized EWM population increased to 45 acres and was almost exclusively contained within the four lakes upstream of the County HWY H bridge. Downstream Eagle and Flynn Lakes contained EWM in many areas, but was confined to low-density EWM marked within point-based mapping methodologies.

Developed over the winter of 2016-2017, the final deliverable report for a multi-year WDNR grant-funded control project (ACEI-169-15) discussed a new BMP for EWM management in the Pike Chain of Lakes. This included the adoption of whole-lake treatment strategies for lakes that contained large footprints of EWM. The strategy immediately applied to the four upstream lakes with the possibility that Eagle Lake could be considered for whole-lake treatment in future years. The whole-lake treatment strategy discussion was formally tied into the *Pike Chain*

Comprehensive Management Plan (Dec. 2018) as a WDNR-approved addendum. A whole-lake treatment strategy was adopted for Eagle and McCarry lakes in 2019.

From an ecological perspective, whole-lake 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 lake-wide low-concentration equilibriums were reached within the first few days after application."

The target lake-wide 2,4-D concentration was between 0.300 ppm and 0.375 ppm acid equivalent (ae) for all Pike Chain of Lakes treatments, which is consistent with the BMP for whole-lake 2,4-D treatments in Wisconsin (0.275-0.400 ppm ae). In association with the whole-lake 2,4-D treatments, water samples were collected by IRPCLA volunteers at multiple sites and at specific time intervals. Figure 3.3-7 shows the mean lake-wide 2,4-D concentrations that resulted from the whole-lake treatments.

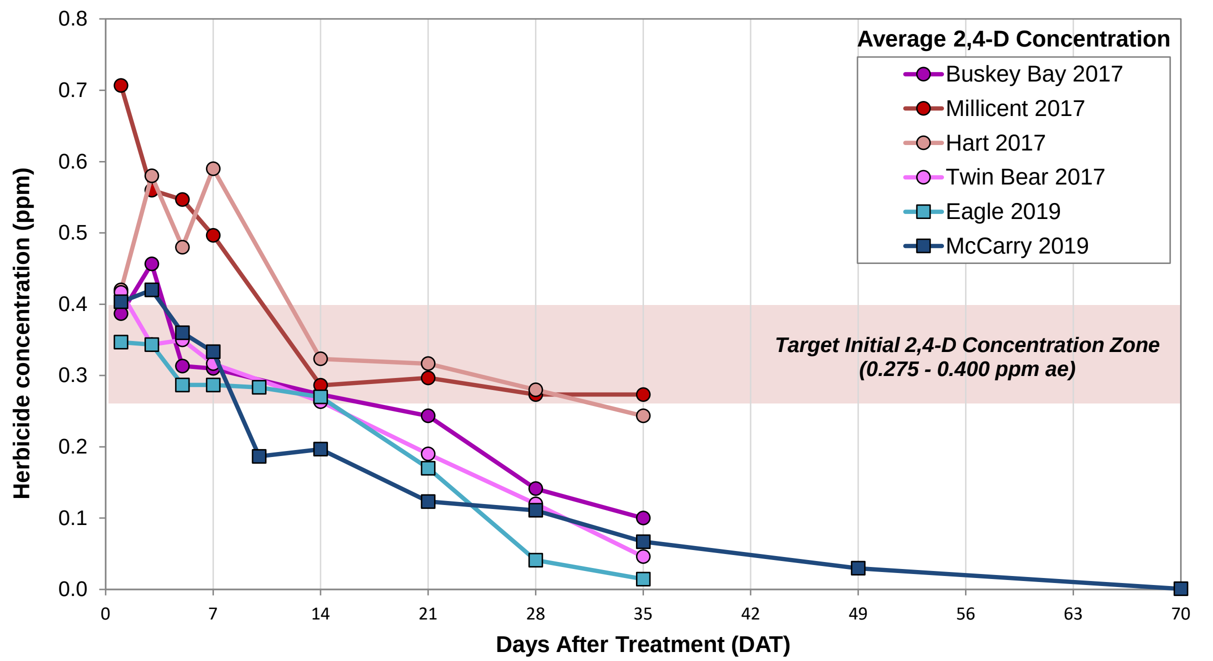


Figure 3.3-7. Mean 2,4-D Concentration Results following whole-lake herbicide treatments. Treatments occurred concurrently in Buskey Bay, Millicent, Hart, and Twin Bear in 2016 and with impacts from upstream treatments likely.

All whole-lake treatments had initial concentrations that met or exceeded targets. Lake managers' ability to predict whole-lake herbicide concentrations has improved, but understanding the degradation rate of the herbicide 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." The targeted Pike Chain Lakes are considered spring lakes, a type of drainage lake where groundwater influence is high, with relatively low amounts of nutrients or low primary productivity. This factor likely resulted in the longer than anticipated herbicide exposure times observed. During 2017, sampling did not occur long enough afterwards to determine when 2,4-D concentrations degraded or dissipated below detection. Sampling out to 70 days after treatment in McCarry Lake during 2019 detected 2,4-D at extremely low levels (< 0.001 ppm), but still above detection limits.

Predicting the level of EWM control and native plant impacts from whole-lake treatments is also better understood than for spot treatments. Based upon the concentrations and exposure times observed on the Pike Chain of Lakes, EWM control should be high with a higher potential of native plant impacts. Although much of the scientific literature focuses on comparing plant populations from the *year before treatment* to the *year of treatment* populations, this project compared plant populations from the *year before treatment* to the *year after treatment.* Many native plant populations are impacted during the *year of treatment*, but understanding how that population rebounds and stabilizes during the *year after treatment* is often more important information to lake managers and regulators.

Table 3.3-3 shows a summary of the plant populations that responded negatively or positively from the whole-lake treatment as measured by the point-intercept survey method. While some impacts to the native aquatic plant community were noted, the magnitude of decline was near levels anticipated by Onterra. Northern watermilfoil was negatively impacted the greatest, being reduced to an occurrence of near 0% during the *year after treatment* in all lakes. Some narrow-leaved pondweed and naiad species were reduced, but continue to have a moderate presence in the system.

Table 3.3-3. Statistically valid changes in aquatic plant populations following whole-lake treatments.

	Year Before Treatment* to *Year After Treatment*					
	Buskey	Lake	Hart	Twin Bear	Eagle	McCarry
Number of Statistcally-Valid Species Decreases	10	5	5	7	3	3
Number of Statistcally-Valid Species Increases	0	0	1	0	11	1
Net increas/decrease	**-10**	**-5**	**-4**	**-7**	**+8**	**-2**

** Native species with > 2.0 Littoral Frequency of Occurrence in one of compared surveys*

EWM was not located during the *year of treatment* (2017) late-summer point-intercept or meander-based mapping surveys in Lake Millicent or Hart Lakes and large EWM decreases documented in Buskey Bay and Twin Bear Lakes (Figure 3.3-8). *Year of treatment* point-intercept nor meander-based mapping surveys did not occur in association with the spring 2019 whole-lake treatments on Eagle and McCarry lakes. Map 10 shows that the treatment on McCarry Lake was extremely effective, with no EWM being located during the *year of treatment* survey. No EWM was located during the point-intercept survey either (Figure 3.3-8). While a reduction of EWM was observed during both Eagle Lake surveys of the *year after treatment*, the magnitude of reduction fell short of expectations (Map 9).

Consistent with the January 2016 addendum to the *Pike Chain Comprehensive Management Plan*, the IRPCLA continued an active EWM management program that targets the remaining EWM population in the system following whole-lake treatments as part of an Integrated Pest Management (IPM) program. This includes herbicide spot treatments and hand-harvesting.

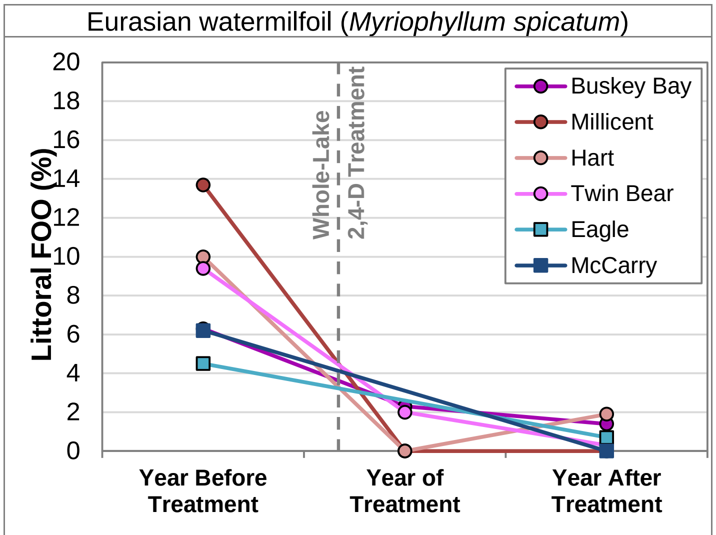


Figure 3.3-8. Littoral frequency of occurrence of EWM surrounding whole-lake treatments. Year of treatment point-intercept data not collected on Eagle or McCarry.

While herbicides like 2,4-D are relatively economically priced, they require a longer herbicide exposure time than can be obtained in most spot treatment scenarios and therefore are rarely used in this capacity any longer. Current BMPs for herbicide spot treatments rely on herbicides or herbicide combinations thought to be more effective under short exposure situations. At the time of this writing, florpyrauxifen-benzyl (ProcellaCOR™), a combination of 2,4-D/endothall (Chinook®), and a combination of diquat/endothall (Aquastrike™) are examples of herbicides with reported short exposure time requirements. These herbicides can be 3-4 times as expensive as 2,4-D alone.

The left frames on Map 11 show the EWM population of select areas of Buskey Bay and Twin Bear Lake prior to the whole-lake treatment. Moving to the right, the *year of treatment*, a site each in Buskey Bay and Twin Bear Lake contained surviving/rebounding EWM that was targeted for herbicide treatment. Following discussion with the IRPCLA, WDNR, and Onterra, the spring 2018 treatment utilized a combination of diquat and endothall sold under the trade name Aquastrike™ (UPL). These treatments failed to meet expectations, with relatively minimal results in Buskey Bay and increases in EWM occurrence observed in Twin Bear Lake. It is theorized that the sites targeted were too small and too exposed for this herbicide, or potentially any herbicide at that time, to be effective.

With EWM expansion in these areas, larger herbicide spot treatment designs occurred. Because of the large size of the treatment areas, the IRPCLA decided to move forward with the most economical treatment strategy which includes application of liquid 2,4-D amine at its maximum concentration on these two sites as well as another area in southern Hart Lake. Some EWM reductions were observed during the *year of treatment* in all sites, but continued to contain EWM populations at levels warranting management.

The IRPCLA initially favored the option of utilizing florpyrauxifen-benzyl (ProcellaCOR™) for EWM management in 2020 and presented a proposed treatment strategy to the local WDNR. The WDNR expressed concerns that the strategy was not in-line with the IRPCLA's existing aquatic plant management plan and communicated that such a strategy was not likely to be permitted in 2020. The IRPCLA worked with Onterra in developing an updated EWM management strategy for 2020 using a strategy of a similar nature as was conducted in 2019 with 2,4-D spot treatments.

EWM populations were slightly reduced again following the 2020 treatment, but concerns about only reaching seasonal EWM control are expressed by Onterra. The level of EWM population rebound during 2021 without herbicide treatment will help understand the longevity of control from these management actions.

Pike Chain of Lakes Future EWM Management Discussions

Broad Management Perspectives

During the upcoming Planning Committee meetings, Onterra will outline three broad EWM population management perspectives for consideration, including a generic potential action plan for each (Figure 3.3-9). Onterra has extracted relevant chapters from the WDNR's *APM Strategic Analysis Document* to serve as an objective baseline for the IRPCLA to weigh the benefits of the management strategy with the collateral impacts each management action may have on the Pike Chain of Lakes ecosystem. These chapters are included as Appendix C. The IRPCLA Planning Committee will also review these management perspectives in the context of perceived riparian stakeholder support, which is discussed in the subsequent sub-section.

1. **No Coordinated Active Management**
   (Let Nature Take its Course)
   - Focus on education of manual removal methods for property owners
2. **Reduce EWM Population on a lake-wide level**
   (Lake-Wide Population Management)
   - Would likely rely on herbicide treatment strategies (risk assessment)
   - Will not eradicate EWM
   - Set triggers (thresholds) of implementation and tolerance
3. **Minimize navigation and recreation impediment**
   (Nuisance Control)
   - May be accomplished through professional hand-harvesting of areas or lanes
   - Hand-harvesting may not be able to accomplish this goal and herbicides or a mechanical harvester may be required

Figure 3.3-9. Potential EWM Management Perspectives

<u>Let Nature Take its Course:</u> In some instances, the EWM population of a lake may plateau or reduce without conducting active management, as shown in the WDNR Long-Term EWM Trends Monitoring Research Project on Figure 3.-2. Some lake groups decide to periodically monitor the EWM population, typically through a semi-annual point-intercept survey, but do not coordinate active management (e.g., hand-harvesting or herbicide treatments). This requires that the riparians tolerate the conditions caused by the EWM, acknowledging that some years may be problematic to recreation, navigation, and aesthetics. Individual riparians may choose to hand-remove the EWM within their recreational footprint, but most often the lake group chooses not to assist financially or with securing permits (only necessary if Diver Assisted Suction Harvest [DASH] is used). In some instances, the lake group may select this management goal, but also set an EWM population threshold or management *trigger* where they would revisit their management strategy if the population reached that level. Said another way, the lake group would let nature take its course up until populations reached a certain lake-wide level or site-specific density threshold. At that time, the lake group would investigate whether active management measures may be justified.

Lake-Wide Population Management: 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. It must also be acknowledged that some lake managers and natural resource regulators question whether that is an achievable goal as management actions have unintended collateral impacts.

In early EWM populations, the entire population may be targeted through hand-harvesting or spot treatments. 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. Few lakes in Bayfield County contain EWM, and the local WDNR historically supported aggressive management of existing populations assuming this may lessen the chance of EWM spreading to other waterbodies. In other areas of the state that contain much higher and more prevalent EWM populations, lake-wide population management is often considered too aggressive by local WDNR regulators.

Nuisance Control: 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 the EWM population on their lake 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 these cultural ecosystem services.

There has been a change in preferred strategy amongst many lake managers and regulators when it comes to established EWM population in recent years. Instead of chasing the entire EWM population with management, perhaps focusing on the areas that are causing the largest impacts can be more economical and cause less ecological stress. The majority of EWM management in Wisconsin would be considered nuisance management, where dense areas that are causing navigation or recreation issues are prioritized for management and dense areas not meeting these criteria being left unmanaged. Mechanical harvesting and herbicide spot treatments are most typically employed to reach nuisance management goals, although hand-harvesting is sometimes employed to target small footprints.

Herbicide Resistance

While understood in terrestrial herbicide applications for years, tolerance evolution is an emerging topic amongst aquatic herbicide applicators, lake management planners, regulators, and researchers. Herbicide resistance is when a population of a given species develops reduced susceptibility to an herbicide over time, such that an herbicide use pattern that once was effective no longer produces the same level of effect. This occurs in a population when some of the targeted plants have an innate tolerance to the herbicide and some do not. Following an herbicide treatment, the more tolerant strains will rebound whereas the more sensitive strains will be controlled. Thus, the plants that re-populate the lake will be those that are more tolerant to that herbicide resulting in a more tolerant population over time.

If genetic variation in the target population exists, particularly the presence of hybrid watermilfoils, repetitive treatments with the same herbicide may cause a shift towards increased herbicide tolerance in the population. Rotating herbicide use-patterns can help avoid population-level herbicide tolerance evolution from occurring. Onterra maintains concern for future use of 2,4-D in the Pike Chain of Lakes; the extensive use of this product may have created herbicide resistance and therefore herbicide rotation away from this herbicide is recommended.

Stakeholder Survey Responses to Eurasian Watermilfoil Management

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. The return rate of the 2021 survey was 34% and the response rate of an earlier survey in 2008 survey was 47%. Because the response rate was below 60% in both instances, it is important to reiterate that the stakeholder survey results need to be understood in the context of the respondents to the survey, not to the overall population sampled.

In an effort to understand how EWM impacts Pike Chain stakeholders, the 2021 stakeholder survey asked if the Eurasian watermilfoil population ever had a negative impact on your enjoyment of the Pike Chain of Lakes. The category with the highest number of respondents indicating *Yes* was aesthetics followed by motor boating and swimming (Figure 3.3-10).

Queston 27 (2021): Has the EWM population ever had a negative impact on your enjoyment of the Pike Chain of Lakes?

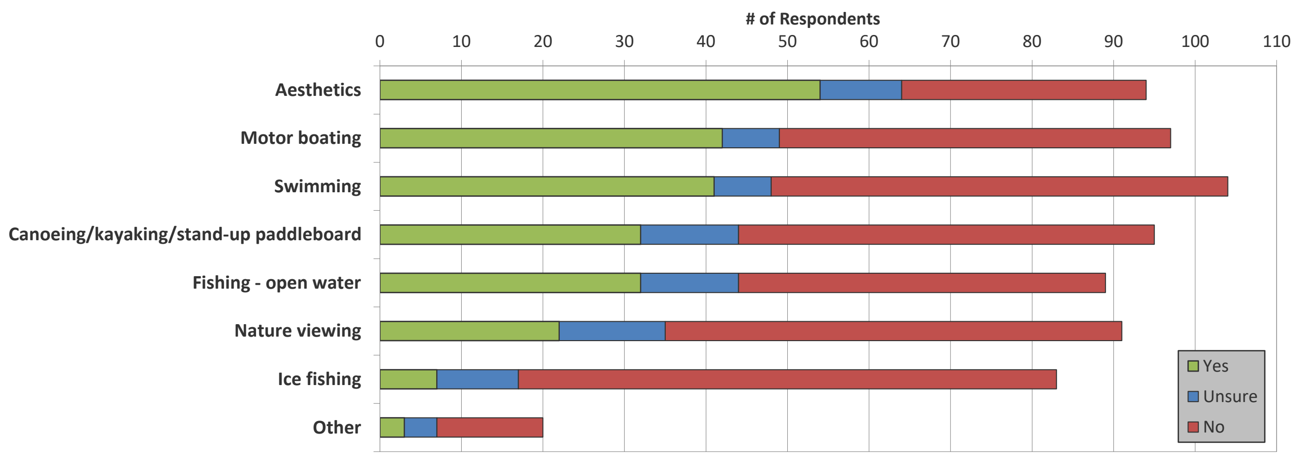
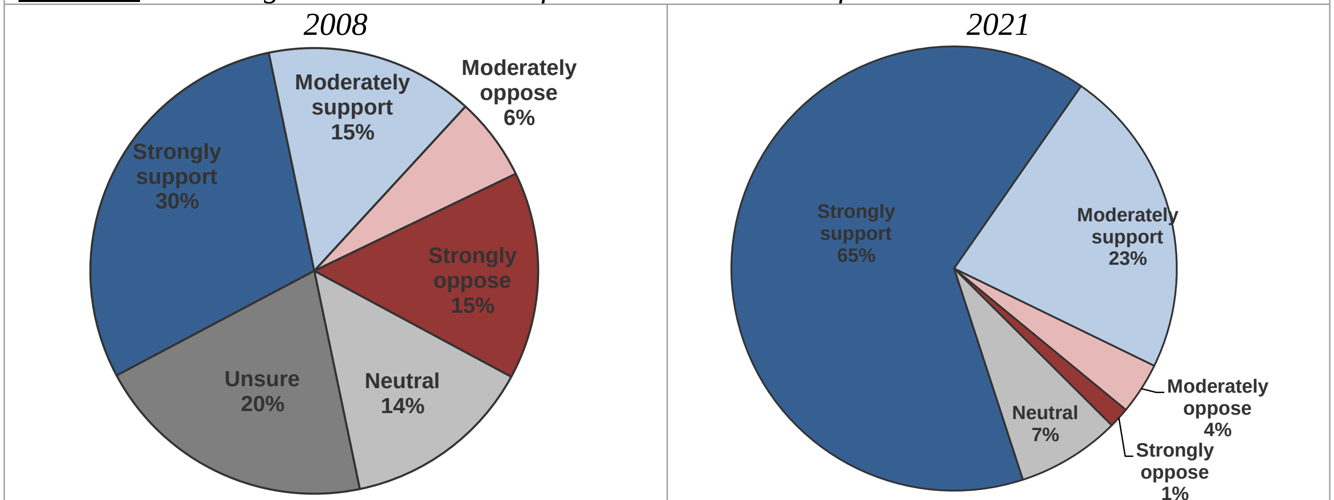


Figure 3.3-10. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

In both 2008 and 2020, riparian and IRPCLA members were asked about a number of management techniques for managing non-native aquatic plants. Figure 3.3-11 highlights the responses for herbicide treatment. Its important to note that these questions were worded a little differently. The level of support amongst stakeholder respondents has shifted, with stronger support for herbicide management in 2021 compared to 2008. There are also less respondents indicating unsure or neutral level of support.

Question 21 (2008): What is your level of support for the responsible use of herbicide treatment on the Pike Chain of Lakes?

Queston 30 (2021): What is your level of support or opposition for the future use of aquatic herbicides to manage Eurasian watermilfoil in the Pike Chain of Lakes



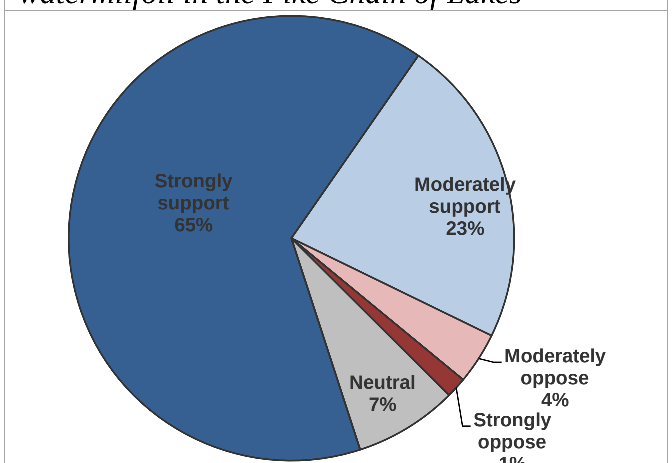
Support	45%
Oppose	21%
Unsure/Neutral	34%

Support	88%
Oppose	5%
Unsure/Neutral	8%

Figure 3.3-11. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Within the 2021 survey, stakeholders were also asked about their level of support for hand-harvesting using Diver Assisted Suction Harvesting (Figure 3.3-12). Respondents had similar favorability ratings for herbicide and DASH to manage EWM. Respondents largely indicated concern for DASH hand-harvesting due to high cost and ineffectiveness of the technique (Appendix B, Question # 31). Concern for herbicide treatment included potential impacts to non-plant species, potential impacts to human health, potential impacts to native aquatic plant species, and future impacts are unknown (Appendix B, Question # 31).

Queston 30 (2021): What is your level of support or opposition for the future use of Diver Assisted Suction Harvesting to manage Eurasian watermilfoil in the Pike Chain of Lakes



Support	85%
Oppose	3%
Unsure/Neutral	12%

Figure 3.3-12. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B

4.0 FISHERIES DATA INTEGRATION

Fishery management is an important aspect in the overall 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 Pike Chain of Lakes. The goal of this section is to provide an overview of some of the historical and most current data that exists. The following information was compiled based upon data available from the Wisconsin Department of Natural Resources (WDNR) the Great Lakes Indian Fish and Wildlife Commission (GLIFWC) and personal communications with DNR Fisheries Biologist Zach Lawson (WDNR 2021).

4.1 Pike Chain of Lakes Fishery

There are nine total lakes within the Pike Chain. Three of those lakes, Pike Lake, Muskellunge Lake and McCarry Lake, have limited access for fisheries biologists and technicians to deploy their equipment. For this reason, there is limited data provided on these lakes and majority of the data presented below will be on Buskey Bay, Lake Millicent, Hart Lake, Twin Bear Lake, Eagle Lake, and Flynn Lake unless specified.

Classification of the Pike Chain of Lakes

When discussing the management of a lake, it is important to examine its classification and where is lies when compared with other systems. Lake classifications assist managers in making well informed decisions by simplifying the high complexity of various attributes associated with lakes and make easier comparisons. In 2019, the WDNR released a publication which places all lakes greater than 8 ha (19.7 acres) into one of 15 lake classes based on the fish community, physical characteristics, lake temperature, and clarity data (Rypel et al. 2019). Classifications can be reassessed over time to determine if the lake is undergoing a change and should be updated to a different class. Table 3.6-1 displays all lakes within the Pike Chain of Lakes, their classes as well as the description of their current classification.

Table 4.1-1. Pike Chain of Lakes and their lake classifications.

Lake	*Classification*	*Description*
Buskey Bay Eagle Lake Hart Lake Lake Millicent Muskellunge Lake Pike Lake Twin Bear Lake	Complex-Cool-Clear	≥4 sportfish species, low DD, high secchi, low in landscape, these lakes are found primarily in the north, Walleye are an indicator species, Smallmouth Bass can be in high abundance.
McCarry Lake	Complex-Cool-Dark	≥4 sportfish species, low DD, low secchi, low in landscape, these lakes are found primarily in the north, Walleye are an indicator species, Yellow Perch can be in abundance, can develop quality Northern Pike and/or Muskellunge size structure.
Flynn Lake	Complex-Riverine	≥4 sportfish species, <15 d hydrologic retention time, large watershed areas, often a low secchi, Walleye and other riverine taxa are indicator species, common carp often present.

With the exception of McCarry and Flynn Lake, all lakes fall within the Complex-Cool-Clear class. Out of the 5,950 lakes assessed in Wisconsin, 232 (4%) lakes also fall within the Complex-Cool-Clear class. Interquartile ranges for fish populations were calculated for each of the 15 classes as well. Fisheries managers can utilize these classes to determine if a fish species in their study lake falls within the interquartile range of its specific class.

Table 3.6-2 lists fish species found within the Pike Chain of Lakes. Although not an exhaustive list of fish species in the lake, additional species documented in past WDNR surveys of Pike Chain of Lakes include white sucker (*Catostomus commersonii*), log perch (*Percina caprodes*), johnny darter (*Etheostoma nigrum*), bluntnose minnow (*Pimephales notatus*), golden shiner (*Notemigonus crysoleucas*), blacknose shiner (*Notemigonus heterolepis*), spottail shiner (*Notemigonus hudsonius*) mimic shiner (*Notemigonus volucellous*), and the central mudminnow (*Umbra limi*).

Table 4.1-2. Gamefish present in Pike Chain of Lakes with corresponding biological information (Becker 1983).

Common Name (*Scientific Name*)	Max Age (yrs)	Spawning Period	Spawning Habitat Requirements
Black Crappie (*Pomoxis nigromaculatus*)	7	May - June	Near *Chara* or other vegetation, over sand or fine gravel
Bluegill (*Lepomis macrochirus*)	11	Late May - Early August	Shallow water with sand or gravel bottom
Largemouth Bass (*Micropterus salmoides*)	13	Late April - Early July	Shallow, quiet bays with emergent vegetation
Muskellunge (*Esox masquinongy*)	30	Mid April - Mid May	Shallow bays over muck bottom with dead vegetation, 6 - 30 in.
Northern Pike (*Esox lucius*)	25	Late March - Early April	Shallow, flooded marshes with emergent vegetation with fine leaves
Pumpkinseed (*Lepomis gibbosus*)	12	Early May - August	Shallow warm bays 0.3 - 0.8 m, with sand or gravel bottom
Rock Bass (*Ambloplites rupestris*)	13	Late May - Early June	Bottom of course sand or gravel, 1 cm - 1 m deep
Smallmouth Bass (*Micropterus dolomieu*)	13	Mid May - June	Nests more common on north and west shorelines over gravel
Walleye (*Sander vitreus*)	18	Mid April - Early May	Rocky, wavewashed shallows, inlet streams on gravel bottoms
Warmouth (*Lepomis gulosus*)	13	Mid May - Early July	Shallow water 0.6 - 0.8 m, with rubble slightly covered with silt
Yellow Bullhead (*Ameiurus natalis*)	7	May - July	Heavy weeded banks, beneath logs or tree roots
Yellow Perch (*Perca flavescens*)	13	April - Early May	Sheltered areas, emergent and submergent veg

Pike Chain of Lakes Fish Habitat

Substrate Composition

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

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

Fish Habitat Structures

The presence of coarse woody habitat is important for many stages of a fish's life cycle, including nesting or spawning, escaping predation as a juvenile, and hunting insects or smaller fish as an adult. Unfortunately, as development has increased on Wisconsin lake shorelines in the past century, this beneficial habitat has often been the first to be removed from the natural shoreland zone. Leaving these shoreland zones barren of coarse woody habitat can lead to decreased abundances and slower growth rates in fish (Sass 2009).

Some fisheries managers may consider incorporating fish habitat structures on the lakebed or littoral areas extending to shore for the purpose of improving fish habitats and spawning areas. These projects are typically conducted on lakes lacking significant coarse woody habitat in the shoreland zone. The "Fish sticks" program, outlined in the WDNR best practices manual, adds trees to the shoreland zone restoring fish habitat to critical near shore areas. Typically, every site has 3 – 5 trees which are partially or fully submerged in the water and anchored to shore (Photograph 4.1-1). 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.

Photograph 4.1-1. Examples of fish sticks on the Pike Chain. (Photograph by Onterra).

Starting in 2014, a program was enacted by the WDNR and UW-Extension to promote riparian landowners to implement relatively straight-forward shoreland restoration activities. This program, no called the Healthy Lake and River program, provides education, guidance, and grant funding to promote installation of best management practices aimed to protect and restore lakes and rivers in Wisconsin. The program has identified five best practices aimed at improving habitat and water quality, including the installation of Fish Sticks. These in-lake best practices (not eligible for rivers) are woody habitat structures that provide feeding, breeding, and nesting areas for wildlife. Fish sticks consist of multiple whole trees grouped together and anchored to the shore. Trees are not felled from the shoreline, as existing trees are valuable in place, but brought from a short distance or dragged across the ice. In order for this practice to be eligible, an existing vegetated buffer or pledge to install one is required. More information on this program can be found here:

https://healthylakeswi.com/

The WDNR partnered with Bayfield County in 2010 to complete a woody habitat restoration project in which several trees were placed at the Twin Bear Campground in Twin Bear Lake. A similar project was also completed in 2011 on a private land owner's property on Eagle Lake.

Fish cribs are a type of fish habitat structure placed on the lakebed. These structures are more commonly utilized when there is not a suitable shoreline location for fish sticks. Installing fish cribs may also be cheaper than fish sticks; however, some concern exists that fish cribs can concentrate fish, which in turn leads to increased predation and angler pressure. Having multiple locations of fish cribs can help alleviate that issue. In 1997 and 1998 the WDNR added 130 fish cribs to the Pike Chain of Lakes to increase structural complexity.

Half-logs are another form of fish spawning habitat placed on the bottom of the lakebed (Photograph 4.1-2). Smallmouth bass specifically have shown an affinity for overhead cover when creating spawning nests, which half-logs provide (Wills, Bremigan and Haynes 2004). If the waterbody is exempt from a permit or a permit has been received, information related to the construction, placement and maintenance of half-log structures are available online. The WDNR was involved in placing 35 half-log structures in 1991 to improve smallmouth bass spawning habitat.

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

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

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

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

Photograph 4.1-2. Example of a half-log structure and a smallmouth bass utilizing a half-log on the Pike Chain of Lakes Right photo by WDNR, left photo by Onterra.

If interested, the Iron River Pike Chain of Lakes Association, may work with the local WDNR fisheries biologist to determine if the installation of fish habitat structures should be considered in aiding fisheries management goals for the Pike Chain of Lakes.

Rusty Crayfish

Photograph 4.1-3. Rusty crayfish. Photograph credit: GLIFWC

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 (Photograph 4.1-3). Along with impacts to the aquatic plant community, rusty crayfish can provide a food source for smallmouth bass that may impact overall populations and size structure of this fish species. This could be in opposition of fisheries management goals, particularly in the case of the Pike Chain of Lakes.

Rusty crayfish have been present in the Pike Chain for decades, first being noticed in the early- to mid-1980s. Anecdotal, but reliable accounts indicate that almost all of the aquatic plant biomass was decimated in parts of the Pike Chain following the establishment of rusty crayfish. In an effort to reduce the rusty crayfish in an economically beneficial fashion, members of the IRPCLA would trap and ship hundreds of pounds of crayfish to Pick Fisheries in Chicago from 1984 to 1987. The size of the crayfish were large at the beginning of the effort, yielding 16 per pound. At the end of this period, the size of the crayfish were smaller at 25-30 per pound and the population was reduced to levels that were no longer profitable to ship to market. The aquatic plant population of the Pike

Chain began to recover around 2010. The current rusty crayfish population is thought to be low based upon scuba accounts of diving the rock bars (Al Bochler personal comm.).

Fishing Activity

Based on data collected from the 2021 riparian stakeholder survey fishing (open-water) was the third most important reason for owning property on or near the Pike Chain of Lakes (Question #8, Appendix B). Figure 4.1-1 displays the fish that Pike Chain stakeholder respondents enjoy catching the most, with bluegill/sunfish being the most popular followed closely by largemouth bass, smallmouth bass, walleye, and crappie.

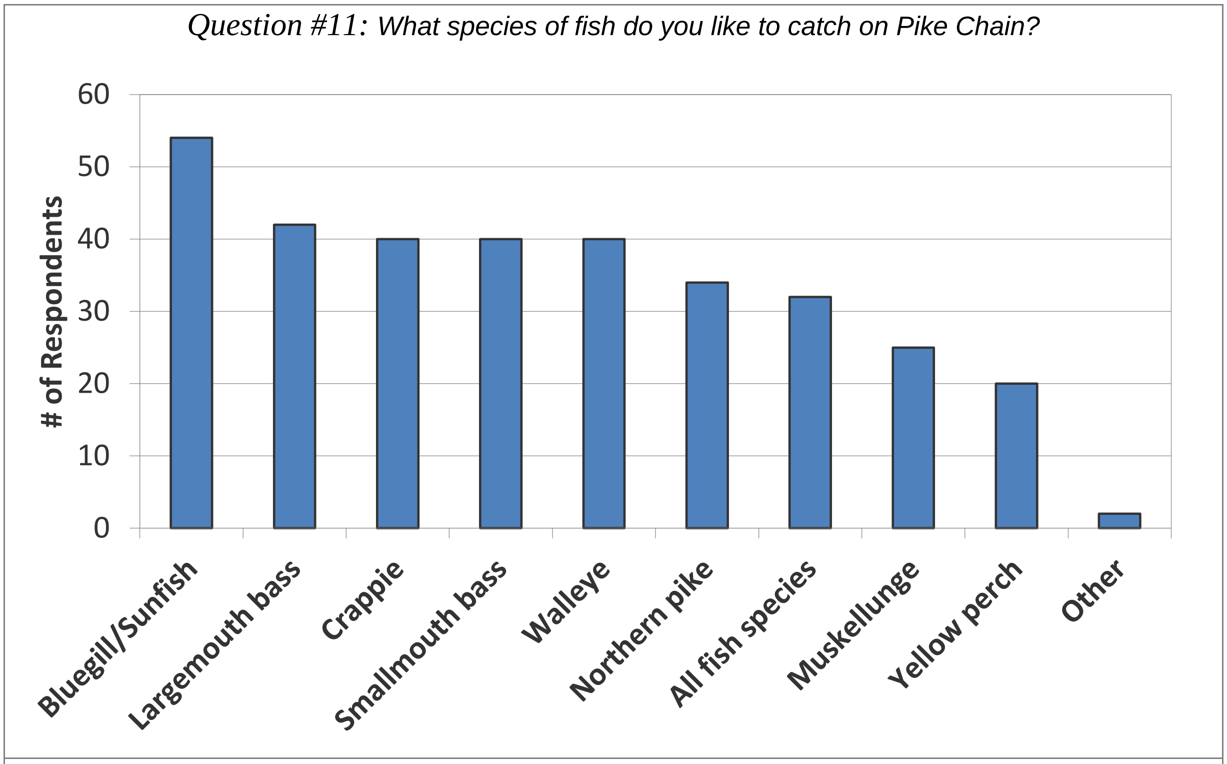


Figure 4.1-1. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

While few respondents perceived the quality of panfish or bass fishing as *poor* or *very poor*, almost 80% provided that perception of the quality of walleye fishing (Figure 4.1-12). Approximately 60% of respondents perceived the yellow perch fishing as *poor* or *very poor*.

Question #12: How would you describe the current quality of fishing on Pike Chain of Lakes?

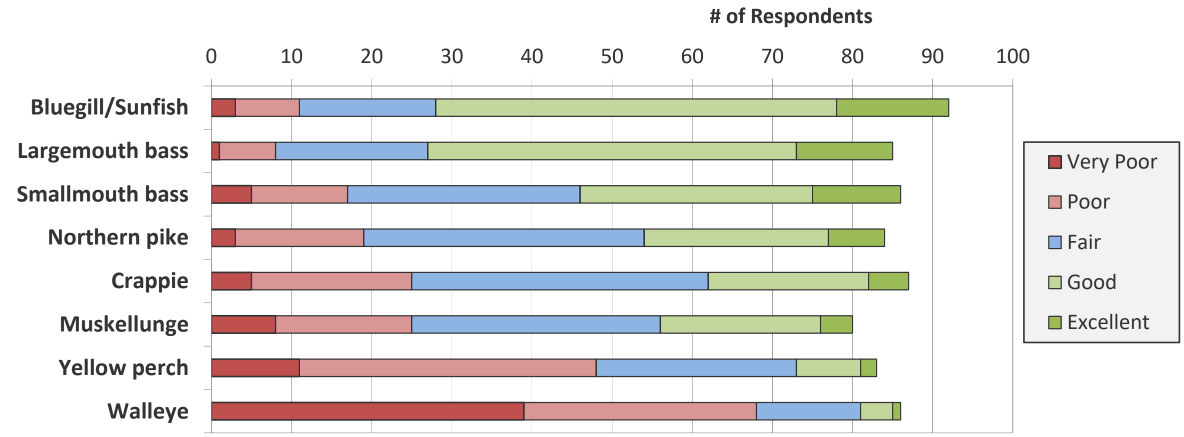


Figure 4.1-2. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Respondents indicated quality of walleye and yellow perch fishing have gotten *somewhat worse* or *much worse* compared with other species (Figure 4.1-3). About a third (33%) of respondents indicated the largemouth bass fishing has become *somewhat better* or *much better*, and 28% believe the fishing improved for smallmouth bass.

Question #13: How has the quality of fishing changed on Pike Chain of Lakes since you have started fishing the lake?

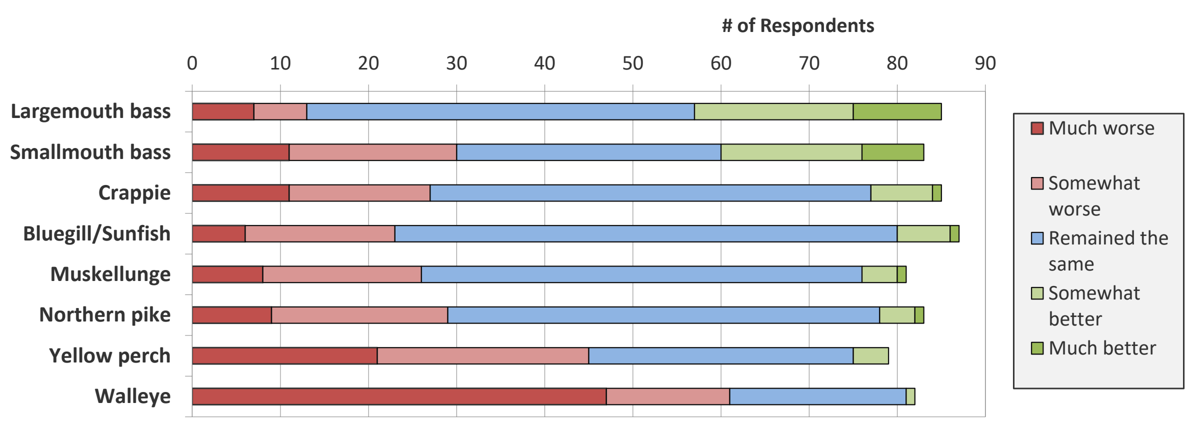


Figure 4.1-3. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

4.2 Pike Chain Fisheries Management

Fisheries Survey Methods

In order to keep the fishery of a lake healthy and stable, WDNR fisheries biologists must assess the current fish populations and trends. To begin this process, the correct sampling technique(s) must be selected to efficiently capture the desired fish species. A commonly used method is a fyke net (Photograph 4.2-2). Fish swimming towards this net along the shore or bottom will encounter the lead of the net, be diverted into the trap and through a series of funnels which direct the fish further into the net. Once reaching the end, the fisheries technicians can open the net, record biological characteristics, mark (usually with a fin clip), and then release the captured fish.

Photograph 4.2-1. Fyke net positioned in the littoral zone of a Wisconsin Lake (left) and an electroshocking boat (right).

The other commonly used sampling method is electrofishing (Photograph 4.2-1). This is done, often at night, by using a specialized boat fit with a generator and two electrodes installed on the front touching the water. Once a fish comes in contact with the electrical current produced, the fish involuntarily swims toward the electrodes. When the fish is in the vicinity of the electrodes, they become stunned making them easier to net and place into a livewell to recover. Contrary to what some may believe, electrofishing does not kill the fish and after being placed in the livewell fish generally recover within minutes. As with a fyke net survey, biological characteristics are recorded and any fish that has a mark (considered a recapture from the earlier fyke net survey) are also documented before the fish is released.

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

Fish Stocking

To assist in meeting fisheries management goals, the WDNR may permit the stocking of fingerling or adult fish in a waterbody that were raised in permitted hatcheries (Photograph 4.2-2). Stocking a lake may be done to assist the population of a species due to a lack of natural reproduction in the system, or to otherwise enhance angling opportunities. Pike Chain of Lakes has been stocked from 1972 to 2018 with muskellunge and walleye (Figure 4.2-2). Stocking efforts of walleye discontinued after 1978 because natural reproduction was occurring at the time. A walleye stocking event did occur in 2016 by the Bad River Tribe. This would ordinarily void the Pike Chain of Lakes from being a reference lake for the walleye and bass study, however, the stocked fish were fin clipped so WDNR Biologists were able to separate out stocked vs non-stocked walleye and create an abundance estimate to continue the study. Muskellunge stocking continues to occur every even year. Detailed stocking information is attached to this report as Appendix D.

Photograph 4.2-2. Muskellunge fingerling.

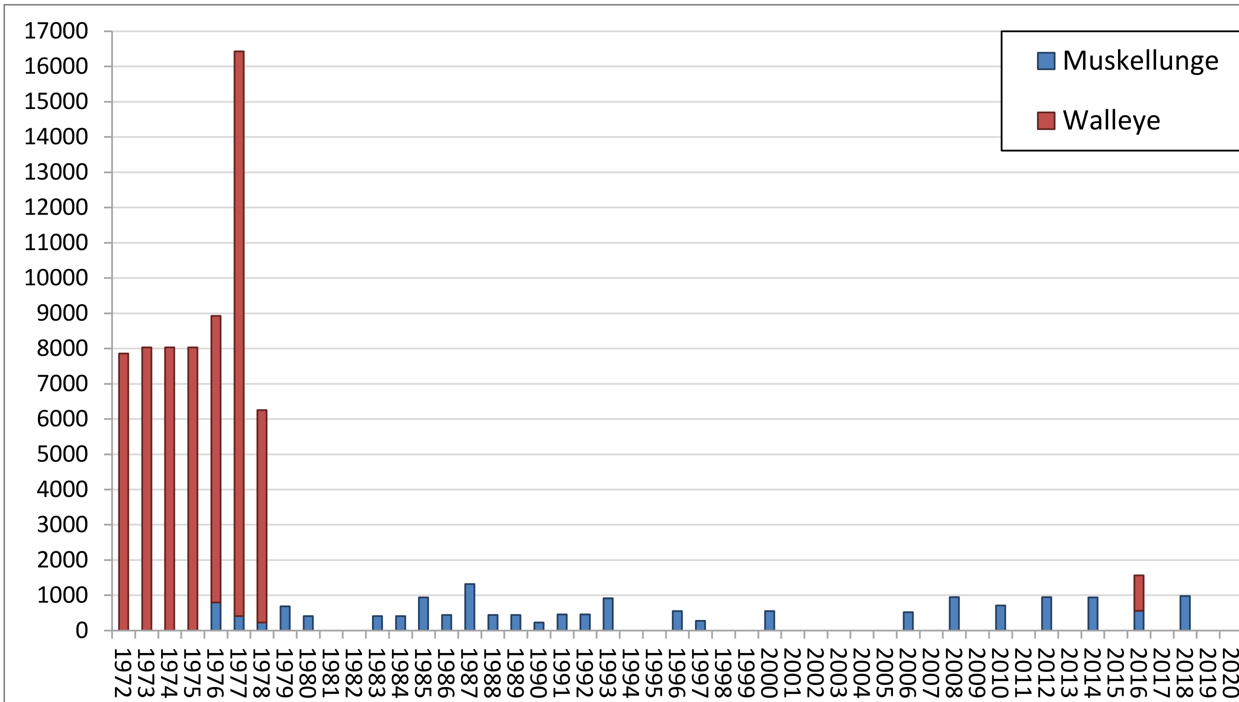


Figure 4.2-1. Muskellunge and walleye fingerling stocking in the Pike Chain. Additional stocking data found in Appendix D.

Fish Populations and Trends

Utilizing the above-mentioned fish sampling techniques and specialized formulas, WDNR fisheries biologists can estimate populations and determine trends of captured fish species. These numbers provide a standardized way to compare fish caught in different sampling years depending on gear used (fyke net or electrofishing). Data is analyzed in many ways by fisheries biologists to better understand the fishery and how it should be managed.

Gamefish

The gamefish present on Pike Chain of Lakes represent different population dynamics depending on the species. Brief summaries of gamefish with fishable populations in Pike Chain of Lakes are provided based off of the report submitted by the WDNR following the fisheries survey completed in 2012 and subsequent surveys through 2020.

Walleyes are a valued sportfish in Wisconsin and the Pike Chain of Lakes has historically been known for its excellent walleye fishery. The 2012 WDNR survey results indicated the walleye were declining amongst an increasing bass population (WDNR 2012). GLIFWC has also participated in fishery surveys estimating the populations of walleye and bass within the Chain. The July 2020 GLIFWC report (Appendix D) indicates the walleye population has the capability to increase through natural reproduction if harvest is reduced. The report suggests modifying the walleye regulation to a more protective stance on juvenile walleye while also relaxing the regulations on largemouth bass to allow for more angler and tribal harvest of the species (Luehring 2020).

Following the conclusion of two WDNR surveys associated with the bass and walleye project in 2021, the WDNR, with possible assistance from Redcliff band, will make an effort to stock the entire Chain with 10 large fingerling walleye per acre in 2021. While stocking the walleye population will assist in raising abundance, the rehabilitating population will likely need to be protected as well. The WDNR may decide to also modify fishing regulations of the walleye and bass populations to support the rehabilitation process.

Largemouth bass and smallmouth bass have followed similar population dynamics over time in the Pike Chain of Lakes. Between 2001 and 2010 the bass population increased substantially. This population was found to have decreased in the 2016 WDNR survey. Following the 2020 fishery surveys, GLIFWC noted only a small percentage of the bass population were over the angling minimum size limit of 14 inches. This may be due to larger bass, particularly smallmouth, nesting in deeper waters unreachable for the electrical current to stun them (Luehring 2020).

Bass and Walleye project

In many Wisconsin lakes, fishery biologists have observed a warming trend coinciding with changing fish communities. To best understand this ongoing phenomenon, the WDNR began a study in 2014 in which specific lakes are selected to part-take in a study of walleye and bass populations. Lakes chosen were placed into either a reference lake category, where no walleye management is taken, or a treatment lake category, which if a walleye decline was observed, stocking would likely occur. The Pike Chain of Lakes role was to be a reference lake in which no walleye stocking is done to observe what occurs when a lake receives no supplemental stocking of walleye. During the study which began in 2014, the Chain also received an annual fall electrofishing survey for young of the year walleye, a spring electrofishing to estimate bass abundance, and two walleye population estimates for each lake in the chain. The study was set to conclude in 2022, however, encouragement from the IRPCLA and Redcliff band has resulted in a

WDNR-led plan for the project to conclude in 2021. A 2021 spring bass survey and fall walleye recruitment survey will mark the conclusion of the Pike Chain of Lakes involvement with the bass and walleye project.

Creel Survey and Angling Effort

Historically creel surveys have occurred on the Pike Chain of Lakes in 1991, 2001, and 2010. During the 2010-2011 season, anglers fished an estimated 34,867 hours (38.2 hours/acre) which is above the Bayfield and Douglas County averages (22.1 hours/acre). The estimated angler effort on the Pike Chain of Lake is also higher than the Northern Region (20 counties) average of 32.9 hours/acre. During the 2010-2011 survey, open water anglers accounted for 87% of all fishing effort. Directed effort (effort targeted toward a specific fish species) was largemouth bass (20.6%), smallmouth bass (16.2%), and northern pike (11.6%). In comparison to previous creel surveys on the Pike Chain of Lakes, walleye directed effort has declined by more than half from 1991 to 2010.

Pike Chain of Lakes 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 (Figure 4.2-2). Pike Chain of Lakes 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. Determining how many fish are able to be taken from a lake by tribal harvest is a highly regimented and dictated process. This highly structured procedure begins with bi-annual meetings between tribal and state management authorities. Reviews of population estimates are made for ceded territory lakes, and then a "total allowable catch" (TAC) is established, based upon estimates of a sustainable harvest of the fishing stock. The TAC is the number of adult walleye or muskellunge that can be harvested from a lake by tribal and recreational anglers without endangering the population. A "safe harvest" value is calculated as a percentage of the TAC each year for all walleye lakes in the ceded territory. The safe harvest represents the number of fish that can be harvested by tribal members through the use of high efficiency gear such as spearing or netting without influencing the sustainability of the population. This does not apply to angling harvest which is considered a low-efficiency harvest regulated statewide by season length, size and bag limits. The safe harvest limits are set through either recent population estimates or a statistical model that ensure there is less than a 1 in 40 chance that more than 35% of the adult walleye population will be harvested in a lake through high efficiency methods. By March 15th of each year the relevant Native American communities may declare a proportion of the total safe harvest on each lake; this declaration represents the maximum number of fish that can be harvested by tribal members annually. Prior to 2015, annual walleye bag limits for anglers were adjusted in all Ceded Territory lakes based

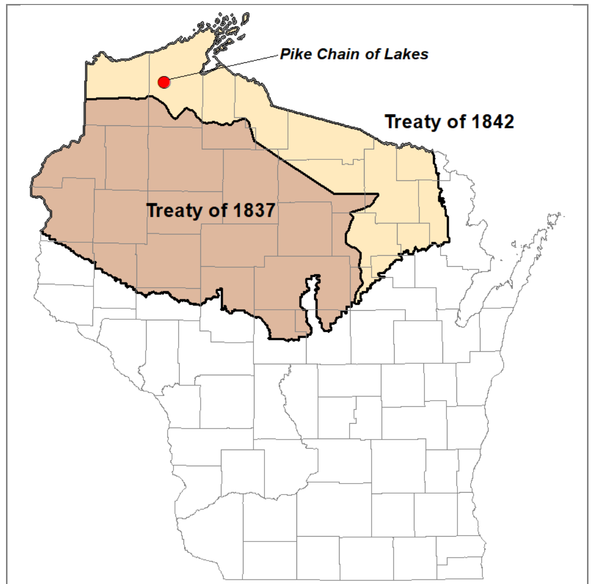


Figure 4.2-2. Location of Pike Chain of Lakes within the Native American Ceded Territory (GLIFWC 2020). This map was digitized by Onterra; therefore, it is a representation and not legally binding.

upon the percent of the safe harvest levels determined for the Native American spearfishing season. Beginning in 2015, new regulations for walleye were created to stabilize regional walleye angler bag limits. The daily bag limits for walleye in lakes located partially or wholly within the ceded territory is three. The statewide bag limit for walleye is five. Anglers may only remove three walleye from any individual lake in the ceded territory but may fish other waters to full-fill the state bag limit (WDNR 2017).

Tribal members may harvest muskellunge, walleye, northern pike, and bass during the open water season; however, in practice walleye and muskellunge are the only species harvested in significant numbers, so conservative quotas are set for other species. The spear harvest is monitored through a nightly permit system and a complete monitoring of the harvest (GLIFWC 2017). Creel clerks and tribal wardens are assigned to each lake at the designated boat landing. A catch report is completed for each boating party upon return to the boat landing. In addition to counting every fish harvested, the first 100 walleye (plus all those in the last boat) are measured and sexed. Tribal spearers may only take two walleyes over twenty inches per nightly permit; one between 20 and 24 inches and one of any size over 20 inches (GLIFWC 2017). This regulation limits the harvest of the larger, spawning female walleye. An updated nightly declaration is determined each morning by 9 a.m. based on the data collected from the successful spearers. Spearfishing of a particular species ends once the declared harvest is reached in a given lake. In 2011, a new reporting requirement went into effect on lakes with smaller declarations.

The Red Cliff Band of Lake Superior Chippewa are the primary entity that exercise their spear harvest rights on the Pike Chain of Lakes. Walleye open water spear harvest records are provided in Figure 4.2-3 from 2010-2020. As many as 283 walleye have been harvested from the lake in the past (2016), but the average harvest is 161 fish in a given year. Spear harvesters on average have taken 99% of the declared quota.

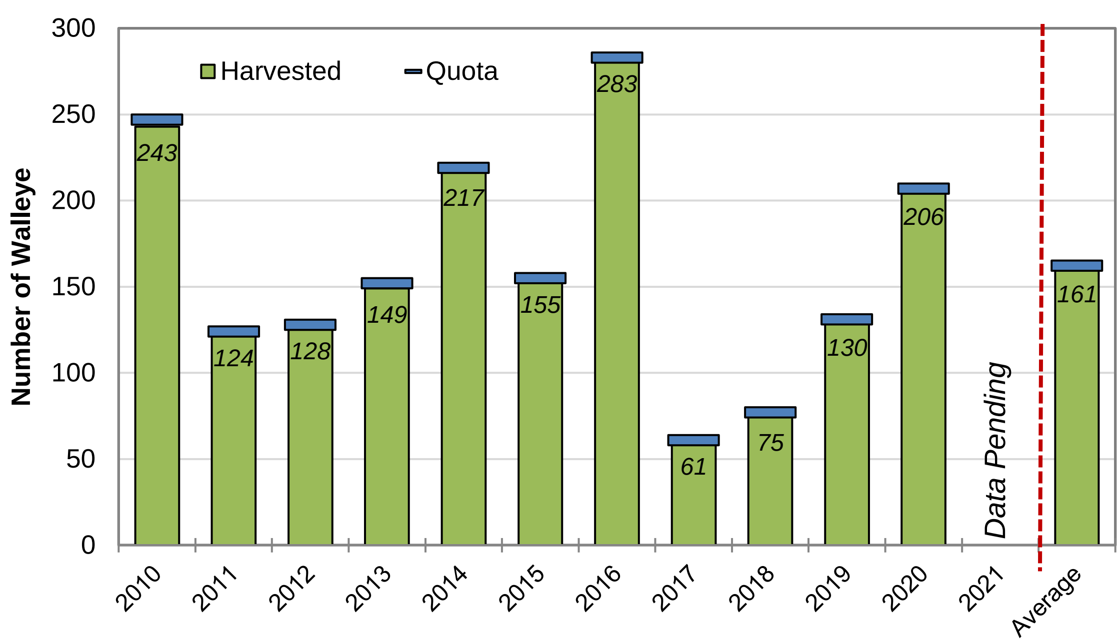


Figure 4.2-3. Pike Chain of Lakes walleye spear harvest data. (GLIFWC 2010-2020).

Muskellunge open water spear harvest records are provided in Figure 4.2-4 from 2010-2020. As many as five muskellunge have been harvested from the chain in the past (2016), however the average harvest is one fish in a given year. Spear harvesters on average have taken 18% of the declared quota.

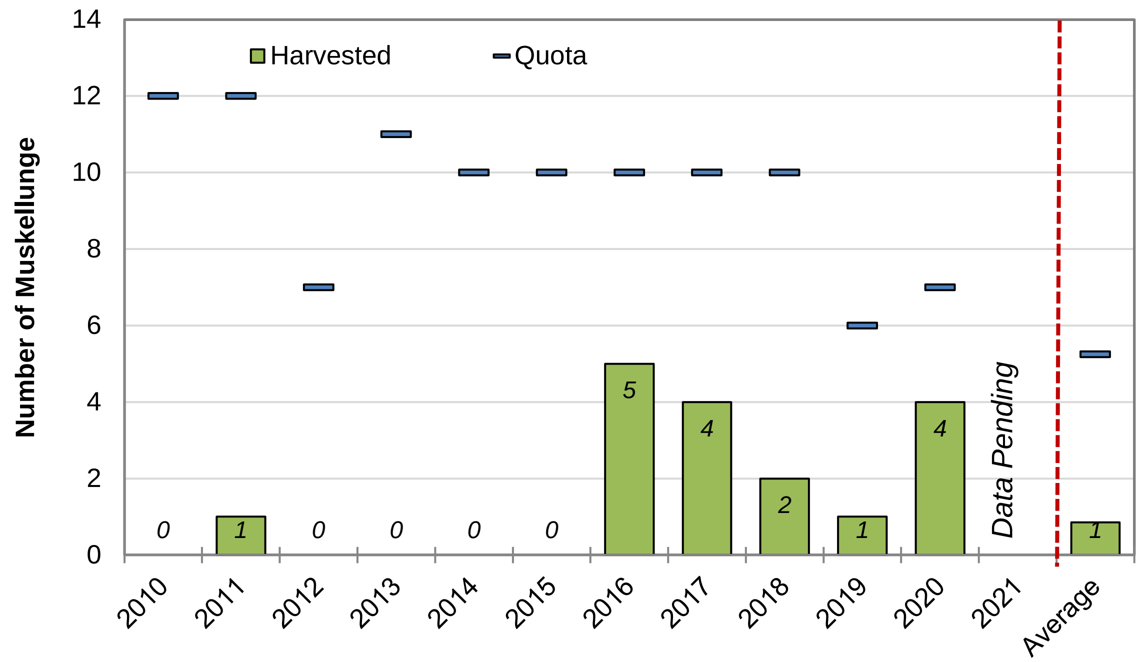


Figure 4.2-4. Pike Chain of Lakes muskellunge spear harvest data. (GLIFWC 2010-2020).

Fishing Regulations

Angling regulations for Pike Chain of Lakes fish species as of February 2021 are displayed in Table 4.2-1. The WDNR may consider changing regulations to walleye and bass if deemed appropriate to further support the walleye rehabilitation process. 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 4.2-1. WDNR fishing regulations for Pike Chain of Lakes (As of April 2021).

Species	Daily bag limit	Length Restrictions	Season
Panfish (bluegill, pumpkinseed, sunfish, crappie and yellow perch)	25	None	Open All Year
Largemouth bass and smallmouth bass	5	14"	June 19, 2021 to March 6, 2022
Smallmouth bass	Catch and Release Only		May 1, 2021 to June 18, 2021
Largemouth bass	5	14"	May 1, 2021 to June 18, 2021
Muskellunge and hybrids	1	40"	May 29, 2021 to December 31, 2021
Northern pike	5	None	May 1, 2021 to March 6, 2022
Walleye, sauger, and hybrids	3	No minimum length, walleye sauger, and hybrids from 14" to 18" may not be kept, only 1 fish over 18 is allowed	May 2, 2020 to March 7, 2021
Bullheads	Unlimited	None	Open All Year

Mercury Contamination and Fish Consumption Advisories

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

General fish consumption guidelines for Wisconsin inland waterways are presented in Figure 4.2-5. 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.

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	-

Figure 4.2-5. Wisconsin statewide safe fish consumption guidelines. Graphic displays consumption guidance for most Wisconsin waterways. Figure adapted from WDNR: http://dnr.wi.gov/topic/fishing/consumption/

**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.*

4.3 Herbicide Use for EWM Management and Fisheries Impacts

As is discussed in the Eurasian Watermilfoil Section (3.3), several aquatic herbicides have been historically applied on the Pike Chain of Lakes to target Eurasian watermilfoil. Future herbicide strategies are also likely to be employed. 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 spot-treatment use patterns (high concentrations, short exposure times). The use of aquatic herbicides includes regulatory oversight and must comply with the following list. Additional information from the WDNR on aquatic herbicide risk assessment is included within Appendix C.

- 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)
- Applied by a DATCP-certified and licensed applicator

Diquat-dibromide is a fast-acting non-selective contact herbicide that does not completely breakdown (degrade), but rather binds with organic matter indefinitely. At approved label rates, diquat does not have any short-term effects on most aquatic organisms that were tested, except for certain zooplankton (*Daphnia* spp.) and benthic insects (*Amphipoda* spp.) (Appendix C). Sublethal effects including respiratory stress or reduced swimming abilities have been documented in laboratory tests of certain fishes, with young walleye being more sensitive than other species. Diquat was used as part of a trial short concentration and exposure time spot treatment during the spring of 2018 on Buskey Bay and Twin Bear Lake.

Endothall is an aquatic herbicide that is applied as either a dipotassium salt or an amine salt. These active ingredients break down following application to endothall acid, the form that acts as an herbicide (Netherland 2009). Amine salt forms of endothall (Hydrothol®) can be highly toxic to aquatic invertebrate and fish so it is recommended that they not be used in areas where fish are considered an important resource (e.g., agriculture irrigation channels). The dipotassium salt form of endothall (Aquathol® K) has been shown to have a very low to no toxicity to fish and other invertebrates (Appendix C). Along with diquat, endothall (dipotassium salt) was used as part of a trial short concentration and exposure time spot treatment during the spring of 2018 on Buskey Bay and Twin Bear Lake.

2,4-D is an auxin mimic herbicide that gets translocated throughout the plant (acts systemically) and suppresses growth regulation hormones. While the ester formulations of 2,4-D have been shown to be toxic to some fish and important invertebrates, the amine formulations of 2,4-D are considered non-toxic at spot treatment use rates (Appendix C). The granular 2,4-D spot treatments from 2005-2010 on the Pike Chain utilized the ester 2,4-D formulation (Navigate ®), whereas all 2,4-D treatments since 2011 used the amine form.

It is important to note that only limited organismal toxicity data is available for concentrations and exposure times consistent with whole-lake treatment use patterns (low concentrations, long exposure times) of many herbicides. This includes 2,4-D amine, which has been used on the Pike Chain within a whole-lake treatment use pattern.

With the assistance of a series of WDNR AIS-Research Grants, Dr. William Karasov from the University of Wisconsin has been leading a series of studies attempting to understand the impacts of 2,4-D on early life stages of Fish. The initial research investigated the impacts on fathead minnow of 2,4-D amine concentrations more relevant to what would be observed in large-scale treatments (Dequattro and Karasov 2015). 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); however, a large-scale treatment would expose the fish to the herbicide for much longer than 96 hours.

Since the mode of action of 2,4-D involves growth regulating hormone mimicry, the focus of DeQuattro and Karasov 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 facial 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 first paper also demonstrated a statistically valid reduction in fathead minnow larval survivability when 2,4-D is exposed throughout the totality of the embryo (eggs) and larval (hatched) period (Dequattro and Karasov 2015).

Dr. Gavin Dehnert broadened this research by determining that the first 14 days post hatch (dph) is the most critical period for fathead minnow and potentially other fishes (G. K. Dehnert et al. 2018). A recent paper available electronically and soon to be in print, investigated a chronic 2,4-D exposure (>30 days) to multiple freshwater gamefish from Wisconsin that included the critical 14 dph larval period (G. K. Dehnert et al. 2020). These data confirm that walleye embryos when exposed to differing concentrations of 2,4-D had a statically higher probability of having deformities present. Larval walleye exposed to a static exposure of 2,4-D at 0.05 ppm ae for 30 days did not indicate statically reduced survivability, although 30-day exposure to both 0.5 ppm ae and 2.0 ppm ae were found to reduce larval survivability. Most whole-lake 2,4-D treatments would fall between the 0.05 ppm and 0.5 ppm ae thresholds. A static exposure of 2.0 ppm ae for

30 days is not a relevant concentration observed in association with permitted 2,4-D treatments in Wisconsin.

The whole-lake 2,4-D treatments produced concentrations of 0.4-0.7 ppm ae for 10-14 days. Based upon the laboratory studies conducted by Dehnert et al. 2021, these would have resulted in reduced survivability of larval walleye if the herbicide was present at the proper period in the larval development – especially if exposure during the embryo to 14 days post hatch (dph). Figure 4.3-1 investigates the herbicide treatment history of the Pike Chain in relation to the probably life stage of walleyes. The figure was constructed by Onterra based upon the assumptions discussed below and then provided to Dr. Gavin Dehnert for discussion.

- The Great Lakes Indian Fish and Wildlife Commission (GLIFWC) uses peak tribal spear harvest as proxy for peak walleye spawning activity. The historic peak walleye tribal spear harvest for the Pike Chain was used in Figure 4.3-1 as the approximate fertilization date and beginning of the embryo period.
- Walleye eggs hatch roughly 7 days (warm water) to 21 days (cold water). Within the UW research, warmer water temperatures were used but cold water is more representative of field conditions. Figure 4.3-1 adds 21 days to the fertilization date to arrive at a conservatively late hatch date. This represents the embryo period.
- 14 days post hatch is the most vulnerable period for exposure to 2,4-D amine.

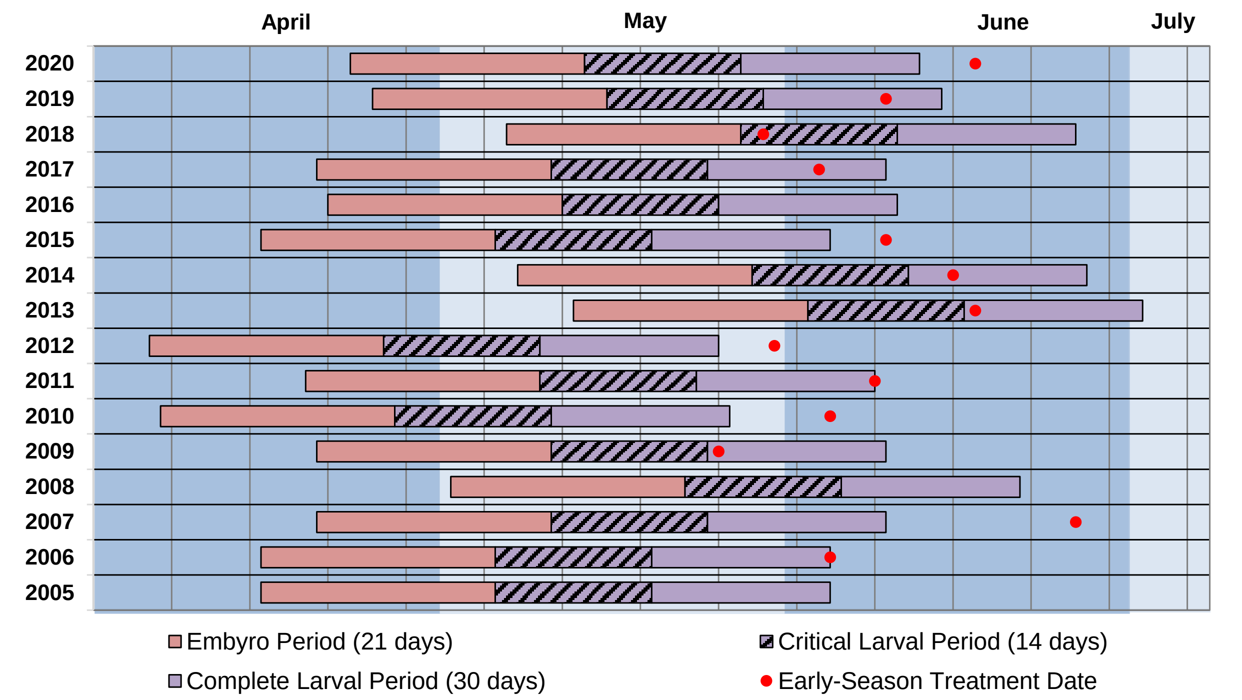


Figure 4.3-1. Walleye life stage exposure to historic Pike Chain herbicide treatments. Whole-lake 2,4-D treatments occurred on Buskey Bay, Millicent, Hart, & Twin Bear in 2017 and on Eagle & McCarry in 2019. Refer to Table 3.3-1 for more specific herbicide treatment information.

Since the mid-2000s, an early season treatment window has been adopted as a BMP for aquatic invasive plant management in Wisconsin. The theory is that the herbicide treatments can take place while the target plants, such as EWM, are actively growing, but before many of the native plants have emerged from winter dormancy. Therefore, EWM treatments often occur as early in the growing season as possible. For whole-lake treatments, the lakes need to exhibit stable stratification prior to treatment, so this can delay implementation later than spot treatments.

Figure 4.3-1 overlays the walleye life stage data and the historic herbicide treatment dates from the Pike Chain. All herbicide treatments on the Pike Chain occurred after walleye were presumably out of the embryo period. One year, 2018, was the only year where herbicide treatment occurred during the 14 dph critical larval period, but that treatment did not include 2,4-D amine. This treatment included a combination of diquat and endothall, which was purposefully timed early as endothall has increased systemic activity on aquatic plants at lower water temperatures. The herbicide treatments most likely to produce concentrations and exposure times consistent with the laboratory research are the whole-lake 2,4-D treatments that occurred on Buskey Bay, Lake Millicent, Hart, and Twin Bear lakes in 2017 and on Eagle and McCarry lakes in 2019. Both of these treatments occurred towards the end of the complete larval period and after the embryo and critical larval period.

Fish species that spawn after walleye may be more likely to encounter herbicide concentrations during embryonic or larval growth stages. Different species have different sensitivities to 2,4-D that are not related to phylogenetic relationship. For instance, walleye and yellow perch are closely related, with walleye being sensitive to 2,4-D in the embryo stage and yellow perch not being sensitive. Similarly, northern pike are sensitive at higher concentrations during the embryo stage, but muskellunge are not sensitive to any of the concentrations tested. Both northern pike and muskellunge are not sensitive to the 2,4-D concentrations tested during their larval stages.

Future herbicide treatments, particularly whole-lake treatments, that utilize 2,4-D or other herbicides with endocrine disruption potential, should consider treatment timing after particularly fish species have passed life stages where they may be more vulnerable.

4.4 Pike Chain Fishery Management Plan and Development

The fisheries of the Pike Chain of Lakes are of particular interest to many stakeholders. The management of a system fisheries is conducted by state and tribal entities with input from stakeholder groups such as the IRPCLA. As the Pike Chain emerges from being a control lake within the Bass and Walleye Project, in which no walleye stocking or regulation modifications occurred, there is concern that the walleye fishery is underperforming. There is also concern that bass populations, primarily smallmouth bass, are increasing and competing for resources. Reasons for the fishery change may be increased water temperatures from global climate change, increases in overall walleye harvest, changes in the habitat of the chain as invasive species like rusty crayfish and Eurasian watermilfoil have established, and the direct or indirect impacts of aquatic plant management activities such as herbicide treatments

The WDNR, Great Lakes Indian Fish and Wildlife Commission (GLIFWC), and Red Cliff Band of Lake Superior Chippewa, with input from the IRPCLA are currently in the process of updating the fisheries management plan for the Pike Chain of Lakes. A series of meetings has occurred to start this project Figure 4.3-1 shows a general timeline for completion of the Fisheries Management Plan. As of current, the IRPCLA, WDNR, GLIFWC, and Red Cliff Band are in agreement the fishery management plan will likely include stocking of walleye and regulation changes to walleye and bass species.

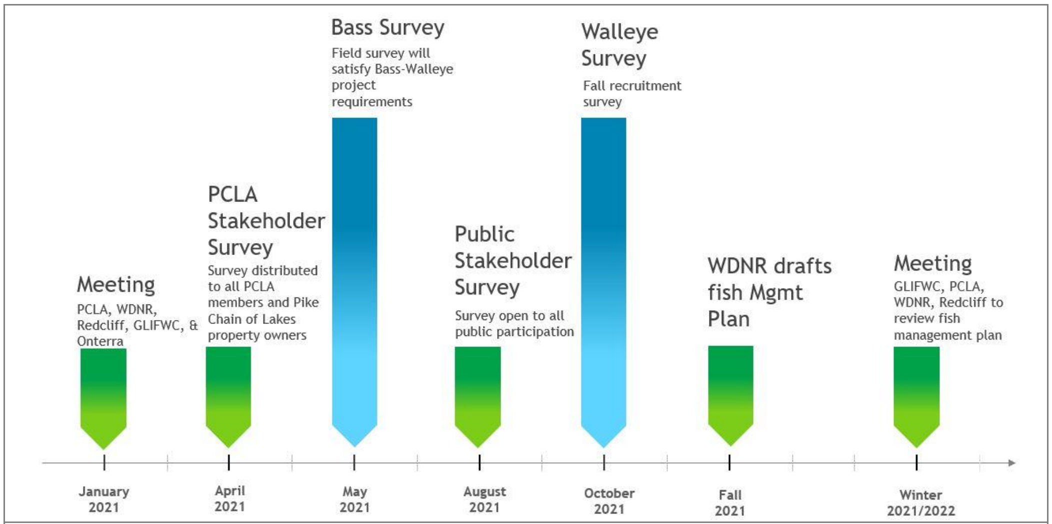


Figure 4.4-1. General fisheries management plan timeline.

In addition to using the 2021 riparian stakeholder survey to understand perceptions about anglers preferred species, the condition of the fishery, and how that fishery has changed over time, questions related to future fisheries management were included. These surveys were developed with assistance from Zachary Lawson, WDNR fisheries biologist.

Approximately 83% of stakeholder respondents indicated they will likely practice catch and release on muskellunge in the future (Figure 4.4-2). Approximately two-thirds (66%) of respondents indicated future plants to catch and release bass species. Only 27% indicated exclusive plans to catch and release walleye, with 44% indicating a combination of catch and release and catching for harvest. This combination strategy for walleye is common, with anglers returning larger fish in thoughts of helping the population but still keeping some fish for consumption.

Question #14: When fishing the Pike Chain of Lakes in the future, would you like to practice catch and release, harvest your catch, or both?

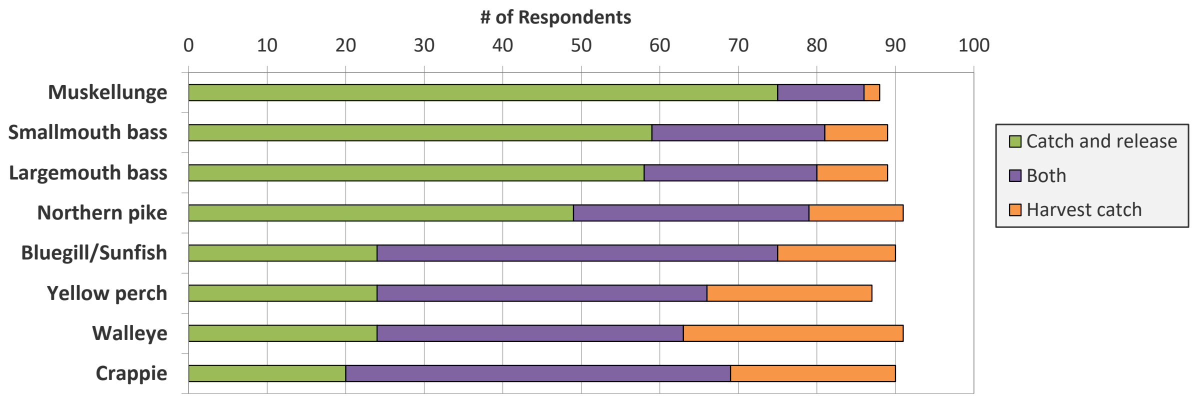


Figure 4.4-2. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

Survey respondents perceptions were split on how they wanted future fishing opportunities for muskellunge, with approximately 40% preferring trophy fish with a low abundance and 60% wanting a balance between size and abundance (Figure 4.4-3). No respondents indicated they preferred a fishery with small-sized muskellunge or pike, but high abundance. Approximately 90% of respondents preferred walleye populations be managed for a balance between size and number, with approximately 5% of respondents indicating trophy fish/low abundance and 5% indicating small fish/high abundance.

Question #15: When fishing the Pike Chain of Lakes in the future, what kind of fishing opportunities would you like to experience?

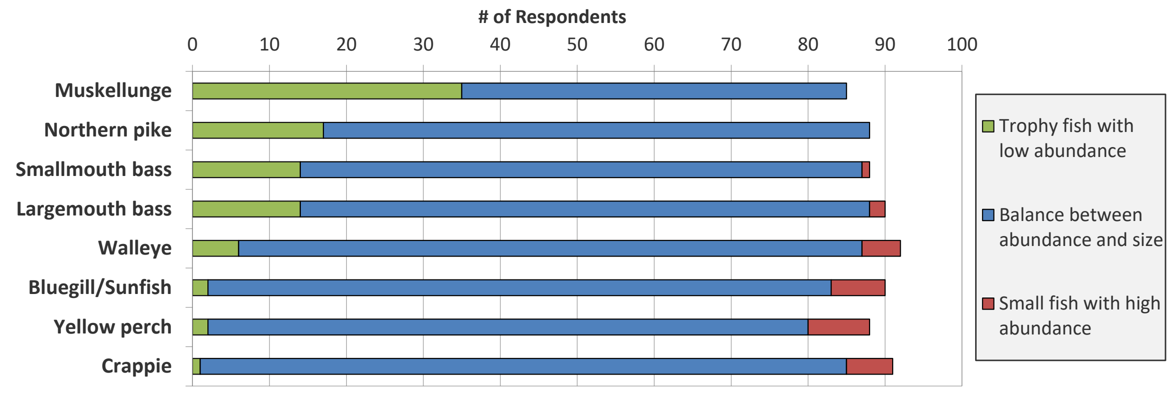


Figure 4.4-3. Select survey responses from the IRPCLA Stakeholder Survey. Additional questions and response charts may be found in Appendix B.

5.0 SUMMARY & CONCLUSIONS

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

1) Collect detailed information regarding invasive plant species within the chain, with the primary emphasis being on Eurasian watermilfoil.
2) Collect sociological information from Pike Chain riparian stakeholders regarding their use of the lake and their thoughts pertaining to the past and current condition of the lake and its management.
3) Solicit input from biologists/managers within the WDNR, GLIFWC, and Red Cliff Band to ensure the aquatic plant management goals and actions outlined within this plan are consistent with the fisheries goals currently being developed by these entities as a part of the forthcoming *Comprehensive Fisheries Management Plan.*

The three objectives were fulfilled during the project and have led to a good understanding of the Pike Chain of Lakes aquatic plant community, the folks that care about the lakes, and what steps can be taken by the IRPCLA to protect and enhance the system.

As discussed in the IRPCLA's *Comprehensive Management Plan* (Dec 2008), the Pike Chain watershed is largely covered with forested areas, which export the least amount of nutrients to the lake compared with other land cover types. The low phosphorus loads lead to the outstanding water quality apparent within the lakes. Degradation of water quality continues to be a concern among Pike Chain stakeholders, being ranked as the second highest concern by stakeholder respondents (Appendix B, Questions #19).

The Pike Chain experiences very good water clarity because of its low nutrient levels supporting low algal growth. With high light penetration, aquatic plants grow to maximum depths of greater than 30 feet in some lakes. The most dominant macrophyte species within the Pike Chain are fern pondweed and muskgrasses. These are both low-growing species that provide valuable sediment stabilization and year-round habitat for aquatic life. The next two most dominant species, coontail and common waterweed, are both largely non-rooted species that can shift around the lake as they become entangled on taller vegetation. Wild celery and slender naiad are also valuable parts of the aquatic plant community, growing largely in sandy near-shore areas. Pondweed species are less common in the Pike Chain of lakes, with variable-leaf and small pondweed being the seventh and eight most common native species, respectively. These species, along with other wider-leaved pondweeds like large-leaf pondweed (aka musky cabbage), provide valuable habitat for apex fish predators to hide and await their prey. The upper part of the water column has traditionally been only sparsely occupied with aquatic plant biomass. However, the establishment of Eurasian watermilfoil has greatly altered the aquatic plant aquascape of the Pike Chain as this species contains large amounts of biomass high in the water column. This change in habitat type is thought to be preferred by some fish species (largemouth bass) and disfavored by others (walleye).

The IRPCLA, in conjunction within WDNR grants, have invested a large amount of money managing the EWM population of the Pike Chain primarily with herbicides but also through strategic hand-removal operations. The herbicide strategies employed during this time period were considered the *Best Management Practices (BMPs*) of the time. However, some of these management actions have gone out of favor as new research and information has become available. At the start of this timeframe, the IRPCLA initiated small granular 2,4-D spot treatments.

Emerging research demonstrated that liquid 2,4-D treatments provided more consistent results at a fraction of the cost of granular products, which prompted the IRPCLA to move towards liquid herbicides. While short-term control was observed in many of the spot treatment sites over the years, EWM population rebound was observed occurring as soon as one year after treatment. Areas were requiring treatment on an every-year or every-other-year basis as new areas were emerging around the chain. This *seasonal control* being achieved did not meet lake manager's expectations of longevity following treatment and questioned the sustainability of the strategy in regards to financial and ecological costs. Ceasing treatment for a year in 2016 result in all areas shortly returning to pretreatment levels.

At that time, the IRPCLA pivoted towards an emerging concept of whole-lake 2,4-D treatments. While the herbicide is applied to specific sites of dense EWM, there was the understanding that the herbicide would dissipate offsite and reach an equilibrium within the entire mixing volume of the lake in a few days. The whole-lake herbicide dose became the target and dictated how much would be applied at each location. These treatments offered high level of EWM control with more longevity than previous spot treatments.

The IRPCLA continues to investigate newer technologies and herbicide use-patterns to reach their EWM management goals. Aspects the IRPCLA continues to consider are herbicide resistance requiring likely rotation towards alternative herbicide modes of action, as well as obtaining multi-year control through spot treatments. It was important to the IRPCLA to create a management plan that provides the framework for employing new and existing management tools, with the specifics of each year's control and monitoring plan being outlined during the months prior to implementation as a part of annual reporting. This ensures the most current BMPs are employed integrating the latest understanding of the technology. The IRPCLA intends to pursue new herbicide chemistries (ProcellaCOR™) and new use-patterns (barrier curtains and basin-wide approaches) in 2022.

The Pike Chain of Lakes contains an important regional fishery that is currently not meeting the expectations of fisheries managers, especially in regards to the walleye population. Approximately 75% of Pike Chain riparian stakeholder survey respondents indicated the quality of walleye fishing has gotten *somewhat worse* or *much worse* since they had started fishing the system. The WDNR, Great Lakes Indian Fish and Wildlife Commission (GLIFWC), and Red Cliff Band of Lake Superior Chippewa, with input from the IRPCLA, are currently in the process of updating the *Comprehensive Fisheries Management Plan* for the Pike Chain of Lakes to recover the population of walleye in the chain. To ensure the *Comprehensive Fisheries Management Plan* dovetails well with the IRPCLA's *Aquatic Plant Management Plan* for the Pike Chain of Lakes, the IRPCLA has been working closely with these entities in the construction of both plans. It is the intention of the IRPCLA to continue to conduct EWM management with the goal of reducing recreational impediments the plant is causing and manage for a diverse and native aquatic plant population. It is also important to ensure the management actions are consistent with improving the fishery and not a detriment to that goal.

6.0 AQUATIC PLANT IMPLEMENTATION PLAN SECTION

The IRPCLA's *Comprehensive Management Plan* for the Pike Chain was finalized and approved by the WDNR in December 2008. This *Plan* can be found on the WDNR website located here:

https://dnrx.wisconsin.gov/swims/downloadDocument.do?id=29842799

The Implementation Plan Section of the *2008 Plan* includes the following management goals along with specific management actions developed to help reach those goals.

1. Promote Lake Protection and Enjoyment through Education
   - Support an Education & Communication Committee to promote clean boating, water quality, public safety, and quality of life on the Pike Chain of Lakes
2. Maintain Current Water Quality Conditions
   - Monitor water quality through WDNR Citizens Lake Monitoring Network
   - Reduce phosphorus and sediment loads from immediate watershed
   - Complete Shoreland Restoration Demonstration Sites on Pike Chain
   - Gain an understanding of filamentous algae and periphytic algae
   - Assist Bayfield County in private septic pumping and inspection tracking system
3. Improve Fishery Resource and Fishing, While Striving to Control Rusty Crayfish
   - Work with WDNR fisheries managers to promote development of special fishing regulations for the Pike Chain of Lakes
   - Develop and distribute appropriate information of the value of catch and release fishing and fishing etiquette to promote quality fish populations, fishing, and Pike Chain for Lakes ecosystem stability
4. Control Aquatic Invasive Species within Pike Chain of Lakes
   - Reduce occurrence of purple loosestrife on Pike Chain shorelands
   - Maintain and expand boater education, boat inspection and boat cleaning operations at boat landings
   - Coordinate annual volunteer monitoring of Aquatic Invasive Species
   - Control established Eurasian water milfoil infestations within the Pike Chain
   - Prevent Eurasian water milfoil establishment in Eagle Lake, Flynn Lake, Lake Millicent, Buskey Bay Lake, and the White River

Figure 6.0-1. IRPCLA management goals (numbered) and actions developed to assist in reaching the goal. From *Pike Chain Comprehensive Management Plan* (December 2008)

An official addendum to the specifics within Management Goal 4, *Control Established EWM Infestations* was made in January 2016, following the completion of a 5-year AIS-Established Population Control Grant-funded project. This included discussion details for adopting whole-lake 2,4-D use patterns. The final deliverable for this project, with the addendum starting on the bottom of page 9, can be found here:

https://dnrx.wisconsin.gov/swims/downloadDocument.do?id=163246868

The following Implementation plan updates Management Goal 4 of the IRPCLA's *Comprehensive Management Plan* for the Pike Chain. During this process, the IRPCLA revisits their Aquatic Plant Management Plan based on the lessons learned during the project and current best management practices (BMPs) for aquatic plant management.

The Implementation Plan presented below was created through the collaborative efforts of the IRPCLA Planning Committee and ecologist/planners from Onterra. Prior to the development of the Implementation Plan, the IRPCLA Planning Committee and Onterra met with members of the WDNR (Lakes and Fisheries Programs), GLIFWC, and Red Cliff Tribe for perspective and information

The Implementation Plan represents the path IRPCLA will follow in order to meet their lake management goals. The goals detailed within the plan are realistic and based upon the findings of the studies completed in conjunction with this planning project and the needs of the Pike Chain of Lake's stakeholders as portrayed by the members of the Planning Committee, the returned stakeholder surveys, and numerous communications between Planning Committee members and the lake stakeholders. The Implementation Plan is a living document in that it will be under constant review and adjustment depending on the condition of the lake, the availability of funds, level of volunteer involvement, and the needs of the stakeholders.

While the IRPCLA 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/coordinator. The IRPCLA Board of Directors will be responsible for determining whether the formation of sub-committees and or directors is needed to achieve the various management goals.

Management Goal 1: Ensuring the IRPCLA has a Functioning and Up-to-Date Management Plan

Management Action:	Periodically update lake management plan
Timeframe:	Periodic
Facilitator:	Board of Directors
Description:	The term *Best Management Practice (BMP)* is often used in environmental management fields to represent the management option that is currently supported by that latest science and policy. When used in an action plan, the term can be thought of as a placeholder with anticipation of having an evolving definition over time. The WDNR recommends *Comprehensive Lake Management Plans* generally get updated every 10 years. Implementation projects require a completion data of "no more than 10 years prior to the year in which an implementation grant application is submitted. The department may determine a longer lifespan is appropriate if the applicant can demonstrate a plan has been actively implemented and updated during its lifespan." This allows a review of the available data from the lake, as well as to consider changing BMPs for water quality, watershed, and shoreland management. The IRPCLA's previous *Comprehensive Lake Management Plan* was completed in December 2008.

	BMPs for aquatic plant management change rapidly, as new information about effectiveness, non-target impacts, and risk assessment emerges. To be eligible to apply for grants that provide cost share for AIS control and monitoring, "a current plan has a completion date of no more than 5 years prior to submittal of the recommendation for approval. The department may determine that a longer lifespan is appropriate for a given management plan if the applicant can demonstrate it has been actively implemented and updated during its lifespan. However, a [whole-lake] point-intercept survey of the aquatic plant community conducted within 5 years of the year an applicant applies for a grant is required. The department may also determine a survey more recent than 5 years is necessary." It is important to work with the regional WDNR Lakes Biologist to understand what is required at this time, as it is more subjective in comparison to the requirements of a *Comprehensive Lake Management Plan* as it relates to the specific management actions being considered. The IRPCLA conducted an official update to their aquatic plant management plan in January 2016. It is important to note that the management plan provides a framework to guide the management action, but does not include the specific control plan for a given year. A written control plan, consistent with the *Management Plan*, would be produced prior to the action outlining the management and monitoring strategy. The control plan is useful for WDNR and tribal regulators when considering approval of the action, as well as to convey the control plan to IRPCLA members for their understanding. Historically, the IRPCLA has conveyed their control plan within annual reporting, which are distributed in late winter of each year.
Action Steps:	
	See description above.

<u>Management Action:</u>	Conduct Periodic Riparian Stakeholder Surveys
Timeframe:	Every 5-6 years, corresponding with management plan updates
Facilitator:	Board of Directors
Description:	Formal riparian stakeholder user surveys have been performed by the association in 2008 and 2021. Approximately once every 5-6 years, an updated stakeholder survey would be distributed to the Pike Chain of Lakes riparians and IRPCLA members. Periodically conducting an anonymous stakeholder survey would gather comments and opinions from lake stakeholders to gain important information regarding their understanding of the chain and thoughts on how it should be managed. This information would be critical to the development of a realistic plan

	by supplying an indication of the needs of the stakeholders and their perspective on the management of the lake. The stakeholder survey could partially replicate the design and administration methodology conducted during 2021, with modified or additional questions as appropriate. The survey would again receive approval from a WDNR Research Social Scientist, particularly if WDNR grant funds are used to offset the cost of the effort.
Action Steps:	
	See description above

Management Goal 2: Monitor Aquatic Vegetation on Pike Chain of Lakes

Management Action:	Periodically monitor the Eurasian watermilfoil population
Timeframe:	Periodic (annual for some areas, every 5 years for entire system)
Facilitator:	Board of Directors
Description:	As the name implies, the Late-Season EWM Mapping Survey is a professionally contracted survey completed towards the end of the growing season when the plant is at its anticipated peak growth stage, allowing for a true assessment of the amount of this exotic within the lake. For the Pike Chain of Lakes, this survey would likely take place in mid-August to the end of September, dependent on the growing conditions of the particular year. This survey would include a complete meander survey of the system's littoral zone by professional ecologists and mapping using GPS technology (sub-meter accuracy is preferred). Late Season EWM Mapping Surveys have been conducted annually on the six main lakes since 2007, allowing for lake stakeholders to understand annual EWM populations in response to natural variation and directed management activities. These surveys are also used as the trigger within a subsequent management goal for management. The IRPCLA would like to continue annual EWM mapping surveys on the six main chain lakes, with supplemental assistance from volunteer monitors. The IRPCLA would identify citizen surveillance monitors to focus on the EWM population in particularly areas of the lake. The volunteers would informally survey the lake and talk to riparians about their perceived level of concerns. The volunteer monitors would periodically convey their findings and conversations to the Board, as well as to the consultant prior to the Late Season EWM Mapping Survey.

	Approximately every five years, EWM mapping survey would be conducted to the full extent of the IRPCLA's boundaries by professionals. Professional Late-Season EWM Mapping Surveys have occurred on McCarry lake in 2018 and 2020. An informal professional survey occurred in 2018 on Muskellunge Lake. No surveys have occurred on Pike Lake. The difficulty of getting a professional survey boat and corresponding technology into these lakes has been a challenge that the IRPCLA will continue to work through. IRPCLA will also investigate grant funding opportunities to help fund this survey in the future. This will likely consist of a Surface Water AIS Control Grant, which have an application deadline of November 1 of each year, with intent materials being due 60 days prior (September 2).
Action Steps:	
	See description above.

Management Action:	Coordinate periodic point-intercept surveys
Timeframe:	Periodic: every 5 years
Facilitator:	Board of Directors
Description:	The point-intercept method as described Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1068 2010 (Hauxwell et al. 2010) has been conducted periodically on the six main lakes and McCarry Lake. Point-intercept surveys have not occurred on Muskellunge or Pike lakes. At each point-intercept location within the *littoral zone*, information regarding the depth, substrate type (soft sediment, sand, or rock), and the plant species sampled along with their relative abundance (rake fullness) on the sampling rake is recorded. The WDNR generally indicates that repeating a point-intercept survey every five years will generally suffice to meet WDNR planning requirements unless large-scale aquatic plant management is taking place and more frequent monitoring is requested for the specifically targeted areas. This increased sampling intensity surrounded the whole-lake 2,4-D treatments in 2017 and 2019. The IRPCLA will ensure point-intercept surveys on the six main lakes occur at least once every five years. If whole-lake scale management is occurring, consideration of conducting pre- and post-point-intercept surveys would occur. In addition, the IRPCLA will consider initiating the first ever point-intercept surveys on Muskellunge and Pike lakes

	during the next cycle of point-intercept surveys, likely around 2024-2025.
Action Steps:	
	See description above.

Management Action:	Coordinate periodic community mapping surveys (floating-leaf and emergent colonies)
Timeframe:	Period: every 10 years or when prompted
Facilitator:	Board of Directors
Description:	This survey would delineate the margins of floating-leaf (e.g., water lilies) and emergent (e.g., cattails, bulrushes) plant species using GPS technology (preferably sub-meter accuracy) as well as document the primary species present within each community. Changes in the footprint of these communities can be strong and early indicators of environmental perturbation as well as provide information regarding various habitat types within the system. This survey has been conducted on the six main lakes in 2007 and 2013, but not on other area lakes within the IRPCLA. To continue understanding the dynamics of the emergent and floating-leaf aquatic plant communities in Pike Chain of Lakes, a community mapping survey would be conducted approximately every 10 years unless a specific rationale prompts a shorter interval.
Action Steps:	
	See description above.

Management Goal 3: Manage Aquatic Invasive Species and Prevent Establishment of New Aquatic Invasive Species

Management Action:	Monitor Pike Chain of Lakes entry points for aquatic invasive species
Timeframe:	Ongoing
Facilitator:	Board of Directors - Karen Austin
Description:	The intent of this program is not only be to prevent additional invasive species from entering the Pike Chain of Lakes through its public access locations, but also to prevent the infestation of other waterways with invasive species that originated in the Pike Chain. The IRPCLA continues to support watercraft inspections occurring on local waters. It would be most helpful to have watercraft monitors at

	the landings during the busiest times in order to maximize contact with lake users, spreading the word about the negative impacts of AIS on lakes and educating people about how they are the primary vector of its spread. A Clean Boat Clean Waters (CBCW) volunteer-based watercraft inspection program has been in place on the Pike Chain since at least 2005. In recent years, the following five area public boat landings have been included within a Bayfield County-lead watercraft monitoring project: Twin Bear County Bark Landing, Buskey Bay Town Landing, Buskey Bay Hyde's Landing, Long Lake Landing, and Delta County Park Landing. Paid watercraft inspectors are used as part of this project with cost share assistance through the WDNR's streamline Clean Boats Clean Waters (CBCW) program. The Northlakes Community Clinic has volunteered to conduct the payroll obligations as part of this project. The IRPCLA has consistently provided volunteer watercraft inspection hours that serve as the local share match of this WDNR grant. Based upon modeling by the University of Wisconsin Center for Limnology, Twin Bear Lake and Buskey Bay are on the list of the state's top 300 AIS Prevention Priority Waterbodies. This means that these lakes have a high number of boats arriving from lakes that have AIS (receiving) and a high number of boats moving from the Pike Chain to uninvaded waters (sending). Therefore, the WDNR encourages additional supplemental prevention efforts above just watercraft inspections, offering additional grant funds for these activities for applicable lakes. Supplemental prevention efforts such as decontamination stations (e.g., pressure washer) and remote video surveillance (e.g., I-Lids™) could be funded through this program. The IRPCLA will strive to have updated signage at all landings promoting CBCW messaging. They will also consider supplemental prevention efforts as described above.
Action Steps:	
	See description above.

Management Action:	Reduce occurrence of purple loosestrife on Pike Chain shorelands
Timeframe:	Annually as volunteerism allows
Facilitator:	Board of Directors – Al Bochler
Description:	In 2009, purple loosestrife was largely confined to the upstream (northern) portion of the Pike Chain of Lakes. Led by Al and John Bochler, purple loosestrife monitoring and control has taken place on the chain annually since 2009. During approximately the third week in August, the volunteers search

	the system for purple loosestrife. Plants found are tagged with ribbon and their flower heads are removed, bagged, and properly disposed of. Follow-up herbicide applications are conducted using aquatic-approved glyphosate products. GLIFWC initially conducted the herbicide management activities, but that role has switched to the IRPCLA. The PCLA volunteers have noted a large and constant reduction in the purple loosestrife population on the chain, from typically targeting about 400 plants a year to now only dealing with a handful. The IRPCLA will continue to support this program and encourage volunteerism to be sufficient to carry forth this action.
Action Steps:	
	See description above as this is an established program

Management Action:	Conduct management actions towards Eurasian watermilfoil
Timeframe:	Ongoing
Facilitator:	Board of Directors
Description:	As discussed within the Eurasian Watermilfoil sub-section (3.3), there are differing management philosophies and approaches to invasive aquatic plant species. Few lakes in Bayfield County contain EWM, and the local WDNR historically supported aggressive management of existing populations assuming this may lessen the chance of EWM spreading within the lake and to other nearby waterbodies. In other areas of the state that contain much higher and more prevalent EWM populations, lake-wide population management is often considered too aggressive by local WDNR regulators. Where EWM populations already have an established footprint in the lake and are already present in most nearby waterbodies, such as in the southeast part of Wisconsin, most populations are no-longer managed for containment purposes. In these instances, the nuisance conditions are targeted for management and other areas are tolerated or avoided. The IRPCLA understands that EWM is established within at least the six main lakes of the Pike Chain, but wants to continue managing with the goal of maintaining a low lake-wide population within the system. The IRPCLA wants to minimize areas of dense vegetation that are preferred by largemouth bass species and promote more habitat for walleye and smallmouth bass. Even though hand-harvesting using DASH was supported by 85% of stakeholder survey respondents, the IRPCLA planning committee feels this technique is costly and ineffectual to target EWM at the scale of the population that exists in the Chain. The IRPCLA intends to use

herbicide application as the primary tool for EWM population management, with hand-harvesting actions potentially employed as part of a follow-up Integrated Pest Management (IPM) program. As a part of this management planning process, IRPCLA would like to set the following management trigger:

Herbicide treatment would be considered when the following criteria are met:

1) *colonized areas of EWM with a density of dominant or greater*
2) *prioritize high use or riparian frontage*
3) *consider basin-wide or whole-lake concentrations and approaches when appropriate*

If IRPCLA's trigger is reached, they would start understanding what is considered the current best management practice (BMP) for EWM herbicide management. Herbicide spot treatment techniques would only be considered if the colonies have a size/shape/location where management is anticipated to be effective. In general, this would be areas confined to bays (not exposed), broad in shape (not narrow bands), and of sufficient size to hold core concentrations and exposure times (likely at least 5 acres or larger). Protected areas would consider additive impacts within an Area of Potential Impact (AOPI), such that if levels reach whole-basin concentrations, they are accounted for in the treatment and monitoring strategy.

While some herbicide spot treatments show promise, the unpredictability of spot treatments state-wide has resulted in less favorability of this strategy with some WDNR regulators and lake managers. This is particularly true in areas of increased water exchange via flow, exposed and offshore EWM colonies, or when traditional weak-acid herbicides like 2,4-D are used. Future spot herbicide treatments would consider herbicides thought to be effective under short exposure situations. At the time of this writing, florpyrauxifen-benzyl (ProcellaCOR™), a combination of 2,4-D/endothall (Chinook®), and a combination of diquat/endothall (Aquastrike™) are examples of herbicides with reported short exposure time requirements that are employed for invasive watermilfoil control in Wisconsin. Advancements in research into new herbicides and use patterns will need to be integrated into future management strategies, including effectiveness, native plant selectivity, and environmental risk profile.

The IRPCLA and current lake management consultant have been investigating the potential for herbicide treatments with barrier curtains to target smaller areas of EWM (i.e. less than 5 acres). Although these treatments commonly take place with an economical-priced herbicide like 2,4-D, the Pike Chain's historic use with this chemistry suggests

	potentially switching away from this mode of action. The IRPCLA have investigated construction of barrier curtains and regulatory requirements of temporarily placement of this structure. Along with a few other stipulations, a WDNR permit is not required so long as access is not denied to any part of the system and the curtain is in place for no more than 96 hours.
	
	If IRPCLA decides to pursue future herbicide management towards EWM, the following set of bullet points would occur:
	• Early consultation with WDNR would occur.
	• The preceding annual AIS monitoring report would outline the precise control and monitoring strategy.
	    • Give consideration to pretreatment invasive watermilfoil genetic testing (i.e., fingerprinting)
	    • Monitoring for EWM efficacy at the scale of likely impact. If the treatment is a true spot treatment, the application area should be monitored. If the Area of Potential Impact (AOPI) is larger, such as a basin or an entire lake, that AOPI should be monitored.
	    • EWM efficacy would occur by comparing annual late-summer EWM mapping surveys
	    • If grant funds are being used or new-to-the-region herbicide strategies are being considered, the WDNR may request a quantitative evaluation monitoring plan be constructed that is consistent with the *Draft Aquatic Plant Treatment Evaluation Protocol (October 1, 2016) – Click Here*
	    This generally consist of collecting quantitative point-intercept before the treatment (pre) and the summer following the treatment (post) at the scale of AOPI.
	    • Herbicide concentration monitoring may also occur surrounding the treatment if grant funds are being used or the IRPCLA believes important information would be gained from the effort.
	• An herbicide applicator firm would be selected in late-winter and a permit application would be applied to the WDNR as early in the calendar year as possible, allowing interested parties sufficient time to review the control plan outlined within the annual report as well as review the permit application.
	• Unless specified otherwise by the manufacturer of the herbicide, an early-season use-pattern would likely occur. This would consist of the herbicide treatment occurring towards the beginning of the growing season (typically in June), active growth tissue is confirmed on the target plants, and is after Native American open-water spear harvest has concluded. A focused pretreatment survey

	would take place approximately a week or so prior to treatment. This site visit would evaluate the growth stage of the EWM (and native plants) as well as to confirm the proposed treatment area extents and water depths. This information would be used to finalize the permit, potentially with adjustments and dictate approximate ideal treatment timing. Additional aspects of the treatment may also be investigated, depending on the use pattern being considered, such as the role of stratification. *Short-Term EWM Control Plan:* Following the management plan outlined above, the IRPCLA aims to conduct a set of trial herbicide treatments in 2022 and seek grant funding to offset the costs of the management and monitoring. Initial discussions include targeting areas in Eagle Lake with florpyrauxifen-benzyl (ProcellaCOR™), understanding the AOPI would likely be greater in scale than just the application site. The IRPCLA is also considering this chemistry in other areas of the Chain, as well as the potential for using barrier curtains with ProcellaCOR™ or another chemical like 2,4-D in applicable smaller sites.
Action Steps:	
	See description above.

Management Goal 4: Improve Lake and Fishery Resource

Management Action:	Facilitate connecting Pike Chain of Lakes Riparians with Healthy Lakes & River Grants
Timeframe:	Ongoing
Facilitator:	Board of Directors
Description:	As discussed in the Fisheries Data Integration Section (4.0), the Healthy Lakes & Rivers Grant program provides cost share for implementing the following best shoreland practices: • Rain Garden • Rock Infiltration • Diversion • Native Plantings • Fish Sticks The cost share allows $1,000 per practice, up to $25,000 per annual grant application. More details and resources for the program can be found at: https://healthylakeswi.com

	The IRPCLA would focus specific education on the importance of shoreland condition and the resources that are available (planning and funding). Partial funding for shoreland restoration activities is available through the WDNR Healthy Lakes Initiative but needs to be applied for by a qualified lake group such as the IRPCLA, not an individual riparian. The IRPCLA would assist with the grant application, but all direct and indirect costs would be the responsibility of the benefiting riparian. The above Healthy Lakes practices are important and applicable to all riparian properties except the addition of fish sticks. Fish stick projects need to be implemented in accordance to approved technical requirements from the local WDNR fisheries biologist and complies with local shoreland zoning ordinances. It's important to reiterated the importance of working with the local WDNR fisheries biologist (Zachary Lawson) prior to implementing fish stick projects to ensure the activity will be beneficial for the fish species being managed for.
Action Steps:	
	See description above

<u>Management Action:</u>	Work with fisheries managers to promote development of special fishing regulations for the Pike Chain of Lakes
Timeframe:	Ongoing
Facilitator:	Board of Directors
Description:	As the Pike Chain emerges from being a control lake within the Bass and Walleye Project, in which no walleye stocking or regulation modifications occurred, there is concern that the walleye fishery is underperforming. There is also concern that largemouth bass populations are increasing and competing for resources. As discussed in the Fisheries Data Integration Section (4.0), the WDNR, Great Lakes Indian Fish and Wildlife Commission (GLIFWC), and Red Cliff Band of Lake Superior Chippewa, with input from the IRPCLA are currently in the process of updating the *Comprehensive Fisheries Management Plan* for the Pike Chain of Lakes. The IRPCLA will participate in the development of a *Comprehensive Fisheries Management Plan* to its full capacity. To ensure the *Comprehensive Fisheries Management Plan* dovetails well with the IRPCLA's *Aquatic Plant Management Plan* for the Pike Chain of Lakes, the IRPCLA Planning Committee will have the same core composition of representatives for both projects. Further public input will be solicited through angler preference surveys conducted during summer of 2021 by WDNR which will help refine

	more specific management goals and construction of a *Comprehensive Fisheries Management Plan*. Process for the fisheries management plan will include: 1) An online angler preference survey to understand desired opportunities provided by the fishery 2) Determining measurable objectives for the fishery (balancing public desires with realistic population characteristics based on standardized fisheries field and creel metrics of similar fisheries) 3) Compiling recent field survey data to understand present status of fish populations 4) Engage stakeholders in refining measurable objectives and identifying key management efforts for moving fish populations towards management objectives (i.e. regulation changes, stocking efforts, and habitat work). While the aforementioned steps have not been completed, preliminary overarching themes of angler interest for directing the future of the fishery include: 1) Restoring a self-sustaining walleye population 2) Increasing panfish size structure 3) Continuing management of a low density, trophy muskellunge fishery 4) Preventing excessive aquatic vegetation growth 5) Promoting a native plant community 6) Preventing colonization of additional aquatic invasive species
Action Steps:	
	See description above

7.0 LITERATURE CITED

Becker, G.C. 1983. *Fishes of Wisconsin.* London, England: The University of Wisconsin Press, 1983.

Coops, H. 2002. Ecology of charophytes; an introduction. *Aquatic Botany*, 2002: 72(3-4): 205-208.

Dehnert, G. K., M. B. Freitas, Z. A. DeQuattro, T. Barry, and W. H. Karasov. 2018. Effects of Low, Subchronic Exposure of 2,4-Dichlorophenoxyacetic Acid (2,4-D) and Commercial 2,4-D Formulations of Early Life Stages of Fathead minnows (Pimephales promelas). *Environmental Toxicology and Chemistry*, 2018: 37(10):25502559.

Dehnert, Gavin K., Mariella B. Freitas, Prashant P. Sharma, Terence P. Barry, and William H. Karasov. 2020. Impacts of subchronic exposure to a commercial 2,4-D herbicide on developmental stages of multiple freshwater fish species. Edited by Jim Lazorchak. *Chemosphere*, 2020: 11.

Dequattro, Z. A., and W. H. Karasov. 2015. Impacts of 2,4-dichlorophenoxyacetic acid aquatic herbicide formulations on reproduction and development of the fathead minnow (pimephales promelas). *Environmental Toxicology and Chemistry*, 2015: 35(6):153-169.

GLIFWC. 2017. *Great Lakes Indian Fish and Wildlife Service Interactive Mapping Website.* 2017. http://maps.glifwc.org.

Glomski, L M, and M D Nehterland. 2010. Response of Eurasian and Hybrid Watermilfoil to Low Use Rates and Extended Exposures of 2,4-D and Tricoplyr. *Journal of Aquatic Plant Management* (Journal of Aquatic plant Management), 2010: 48:12-14.

Hauxwell, J., et al. 2010. *Recommended baseline monitoring of Aquatic Plants in Wisconsin: Sampling Design, Field and Laboratory Procedures, Data Entry and Analysis, and Applications.* PUB-SS-1068, Madison, WI: Wisconsin Department of Natural Resources, 2010.

Luehring, Mark. Pike L Chain Walleye and Bass Population Estimate Summary. 2020.

Moody, M L, and D H Les. 2007. Geographic distribution and genotypic composition of invasive hybrid watermilfoil (Myriophyllum spicatum x M. sibiricum) populations in North America. *Biological Invasions*, 2007: 9:559-570.

Muthukrishnan, R., A. S. Davis, N. R. Jordan, and J. D. Forester. 2018. Invasion complexity at large spatial scales is an emergent property of interactions among landscape characteristics and invader traits. *PLOS ONE.* 2018. https://doi.org/10.1371/journal.pone.0195892 (accessed 2018).

Nault, M. E., et al. 2018. Evolution of large-scale low-concentration 2,4-D treatments for Eurasian and hybrid watermilfoil control across multiple Wisconsin lakes. *Lake and Reservoir Management*, 2018: 34(2):115-129.

Nault, M. 2016. The science behind the "so-called" super weed. *Wisconsin Natural Resources*, 2016: 10-12.

Netherland, M.D. 2009. Chapter 11, “Chemical Control of Aquatic Weeds.”. In *Biology and Control of Aquatic Plants: A Best Management Handbook*, by W.T. Haller, & M. Bellaud (eds.) L.A. Gettys, 65-77. Marietta, GA.: Aquatic Ecosystem Restoration Foundation, 2009.

Neuswanger, D., and M. A. Bozek. 2004. *Preliminary assessment of Effects of Rock Habitat Projects on Walleye Reproduction in 20 Northern Wisconsin Lakes.* A Summary of Case Histories, Wisconsin Department of Natural Resources, 2004.

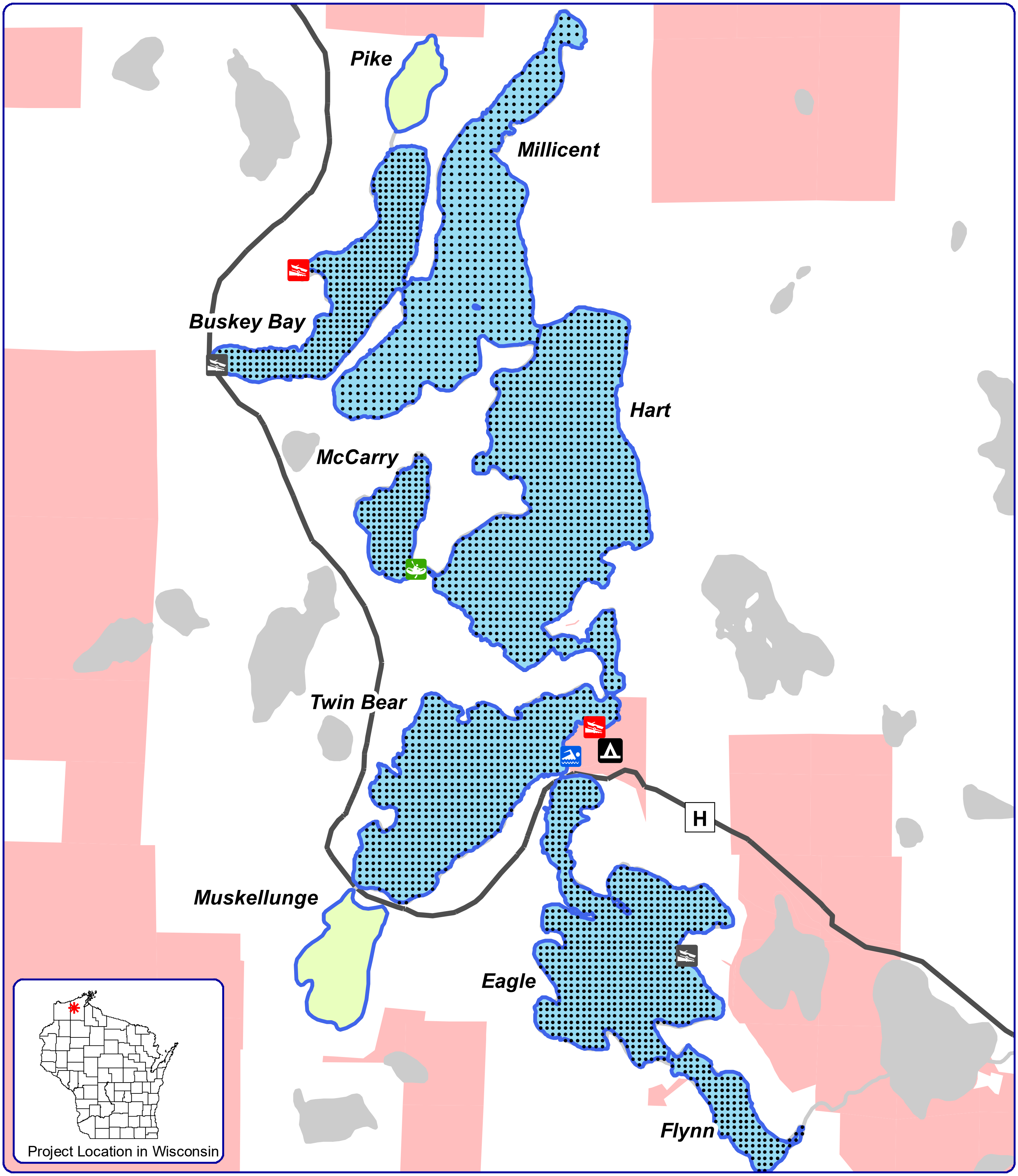
Nichols, S.A. 1999. Floristic quality assessment of Wisconsin lake plant communities with example applications. *Journal of Lake and Reservoir Management*, 1999: 15(2): 133-141.

Poovey, A G, J G Slade, and M D Netherland. 2007. Susceptibility of Eurasian Watermilfoil (Myriophyllum spicatum) and a Milfoil Hybrid (M. spicatum x M. sibiricum) to Tricoplyr and 2,4-D Amine. *Journal of Aquatic Plant Management*, 2007: 45:111-115.

Rypel, Andrew, et al. 2019. Flexible Classification of Wisconsin Lakes for Improved Fisheries Conservation and Management. *Fisheries Magazine* 44, no. 5 (2019): 225-238.

Sass, G.G. 2009. Coarse Woody Debris in Lakes and Streams. In *Encyclopedia of Inland Waters*, by Gene E. Likens, 1: 60-69. Oxford: Elsevier, 2009.

Wills, T. C., M. T. Bremigan, and D. B. Haynes. 2004. Variable Effects of Habitat Enhancement Structures across Species Habitats in Michigan Reservoirs. *American Fisheries Society*, 2004: 133:399-411.



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Sources:
Roads and Hydro: WDNR
Bathymetry: WDNR; digitized by Onterra
Map Date: January 23, 2016
Filename: Map1_PikeChain_Location,mxd

Legend

Pike Chain of Lakes

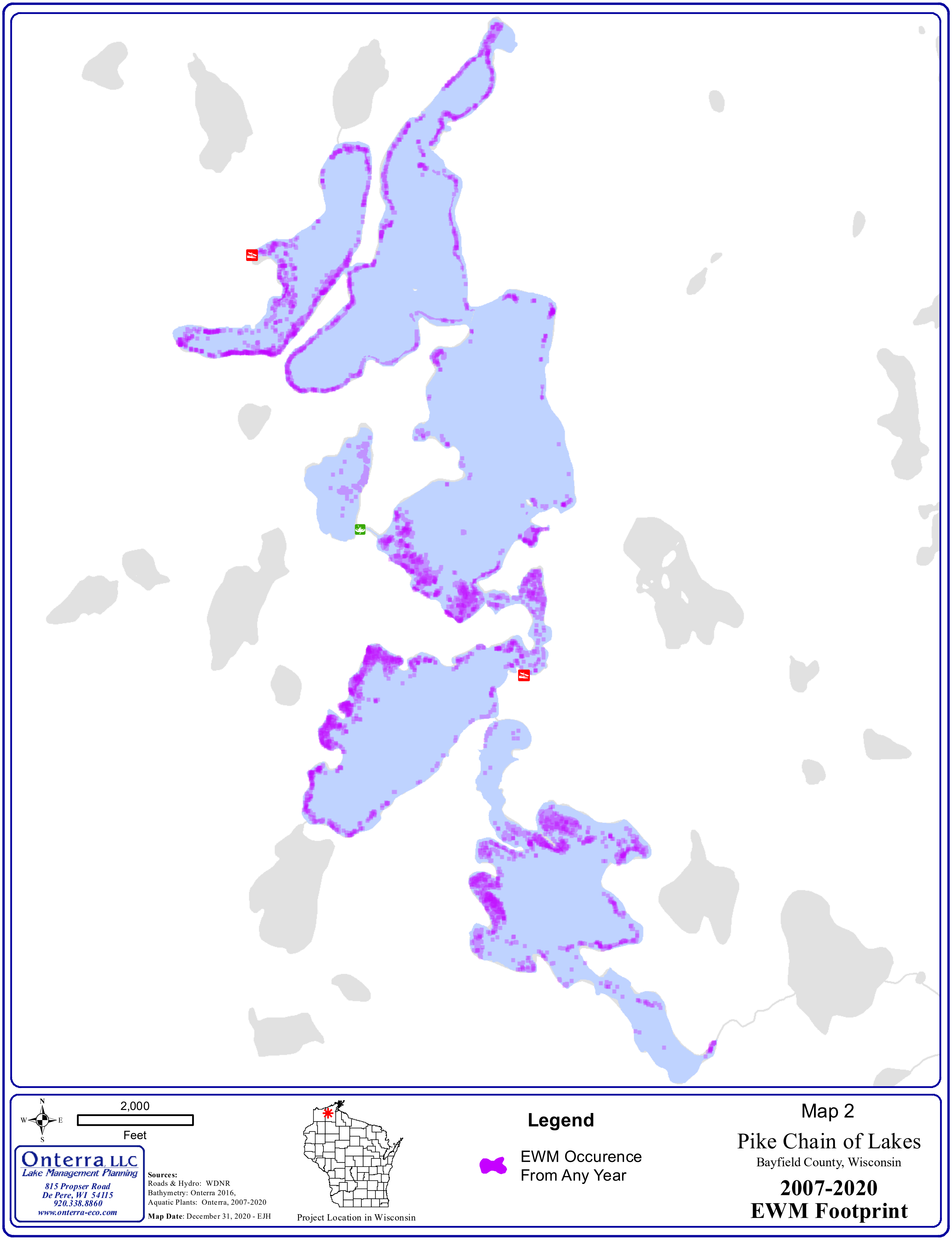
Project Lake

Outside of Project Lake

Point-Intercept Survey Location

Public Lands

Map 1
Pike Chain of Lakes
Bayfield County, Wisconsin
Project Location & Lake Boundaries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EWM Occurence From Any Year
Project Location in Wisconsin
Map 2
Pike Chain of Lakes
Bayfield County, Wisconsin
2007-2020
EWM Footprint
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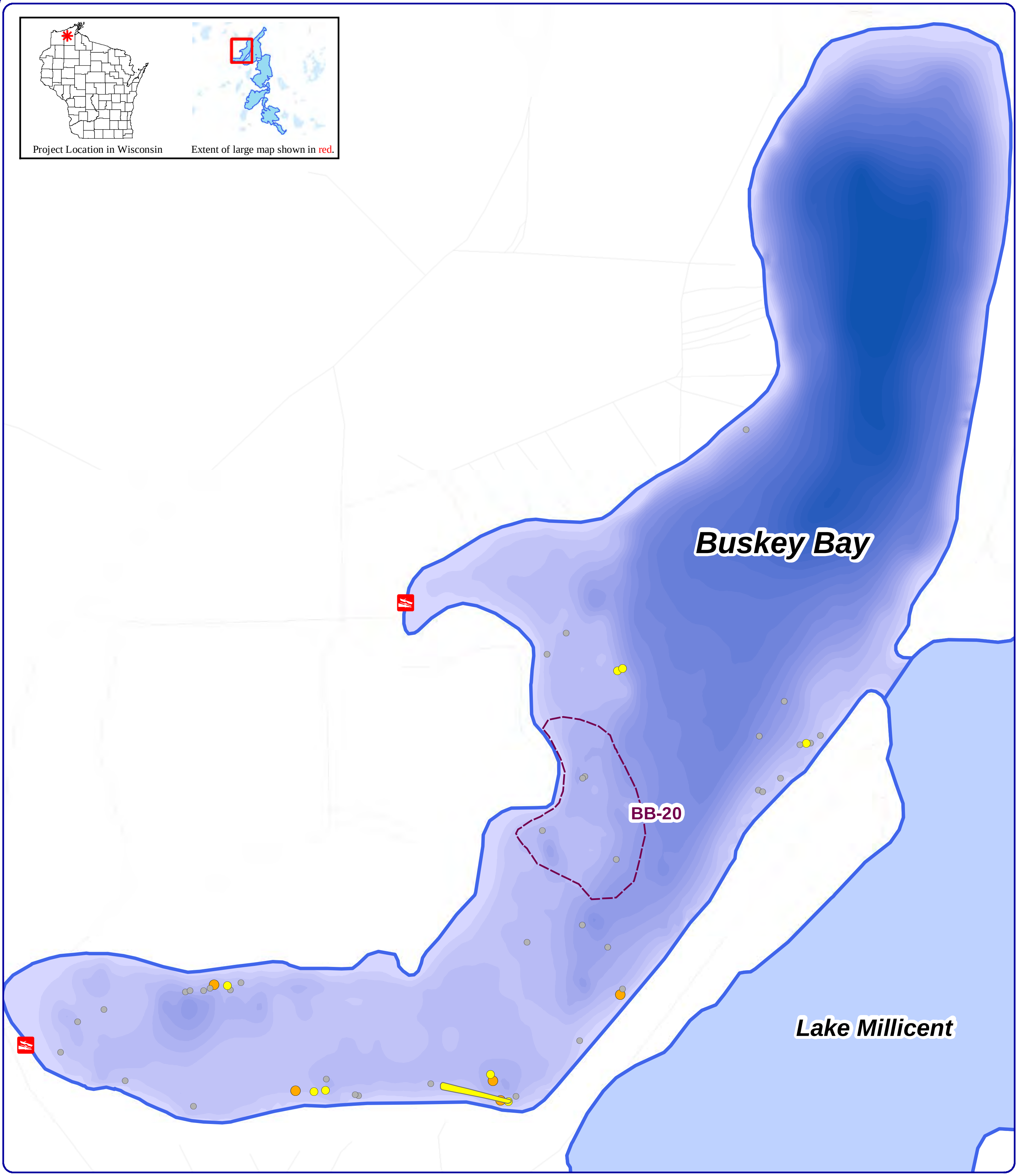
Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra 2016,
Aquatic Plants: Onterra, 2007-2020
Map Date: December 31, 2020 - EJH



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EWM ***(September 22, 2020)***

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clump of Plants
- Small Plant Colony
- 2020 Herbicide Treatment Site

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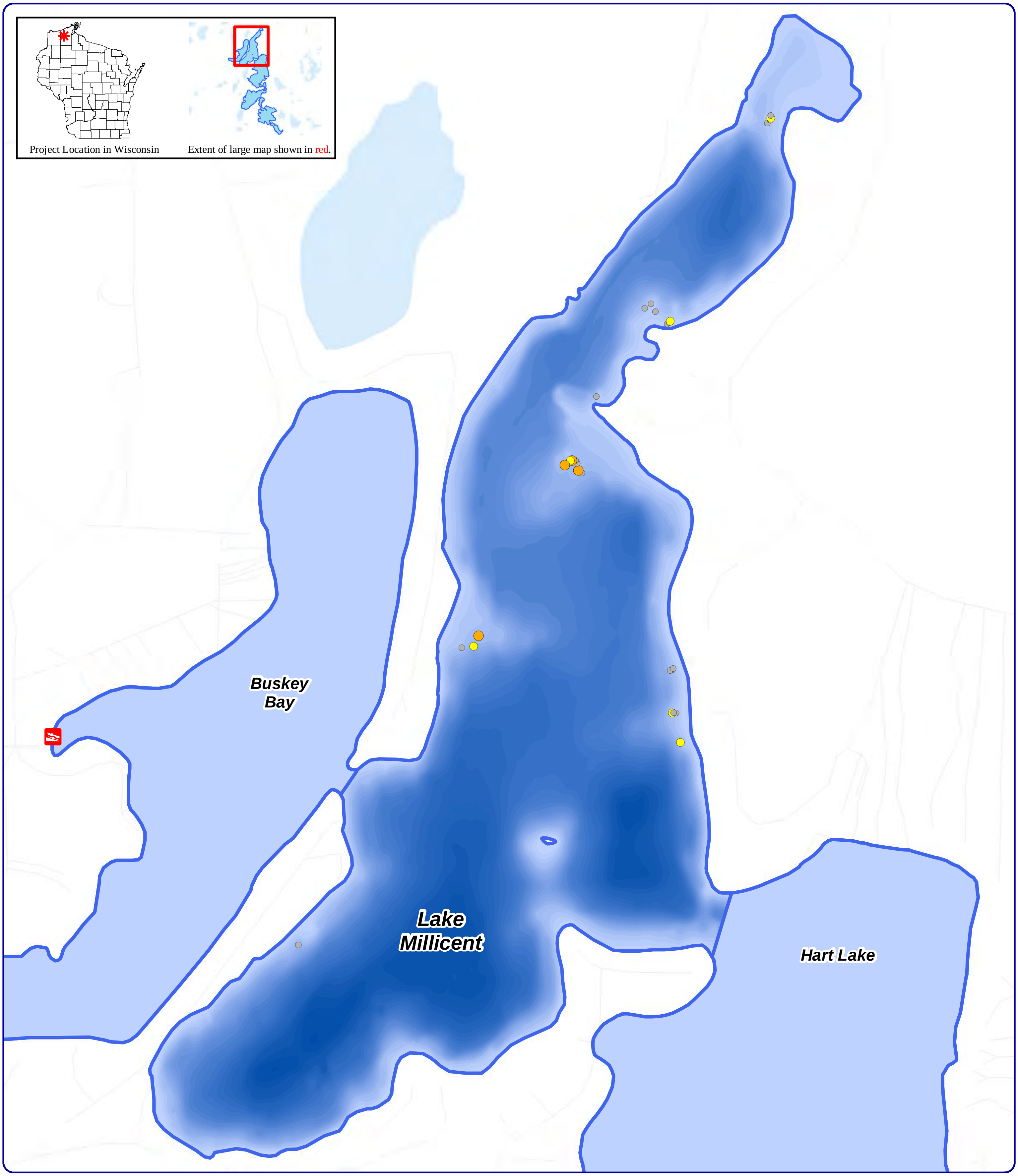
Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra 2016, processed by C-Map USA
Aquatic Plants: Onterra, 2020
Map Date: October 14, 2020 AMS

Map 3 - Buskey Bay
Pike Chain of Lakes
Bayfield County, Wisconsin

September 2020 EWM Survey Results



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Legend

EWM ***(September 22, 2020)***

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting

- Single or Few Plants
- Clump of Plants
- Small Plant Colony

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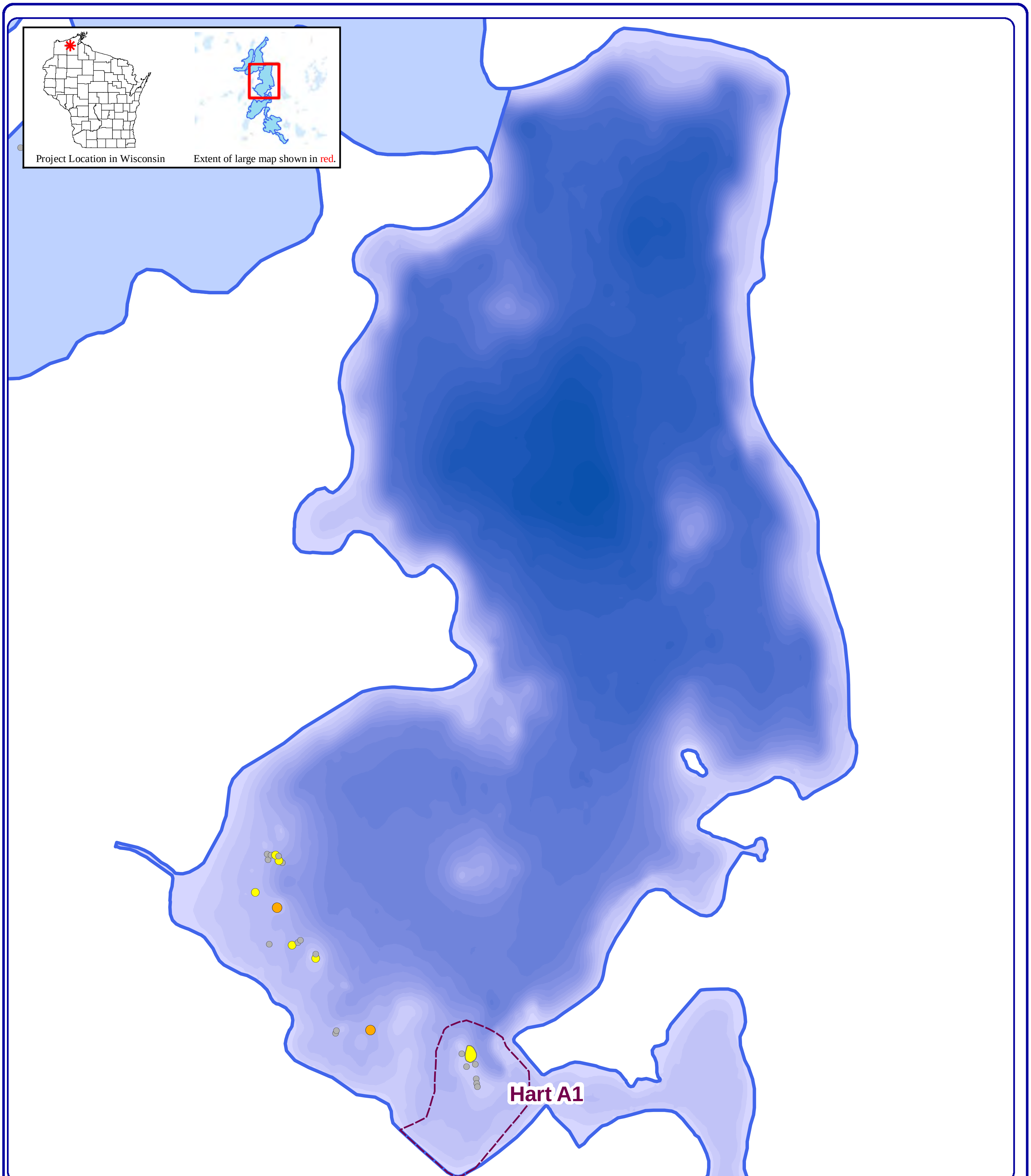
Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra 2016, processed by C-Map USA
Aquatic Plants: Onterra, 2020
Map Date: October 15, 2020 AMS

Map 4 - Lake Millicent
Pike Chain of Lakes
Bayfield County, Wisconsin

September 2020 EWM Survey Results



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Feet

Onterra LLC
Lake Management Planning
815 Propser Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

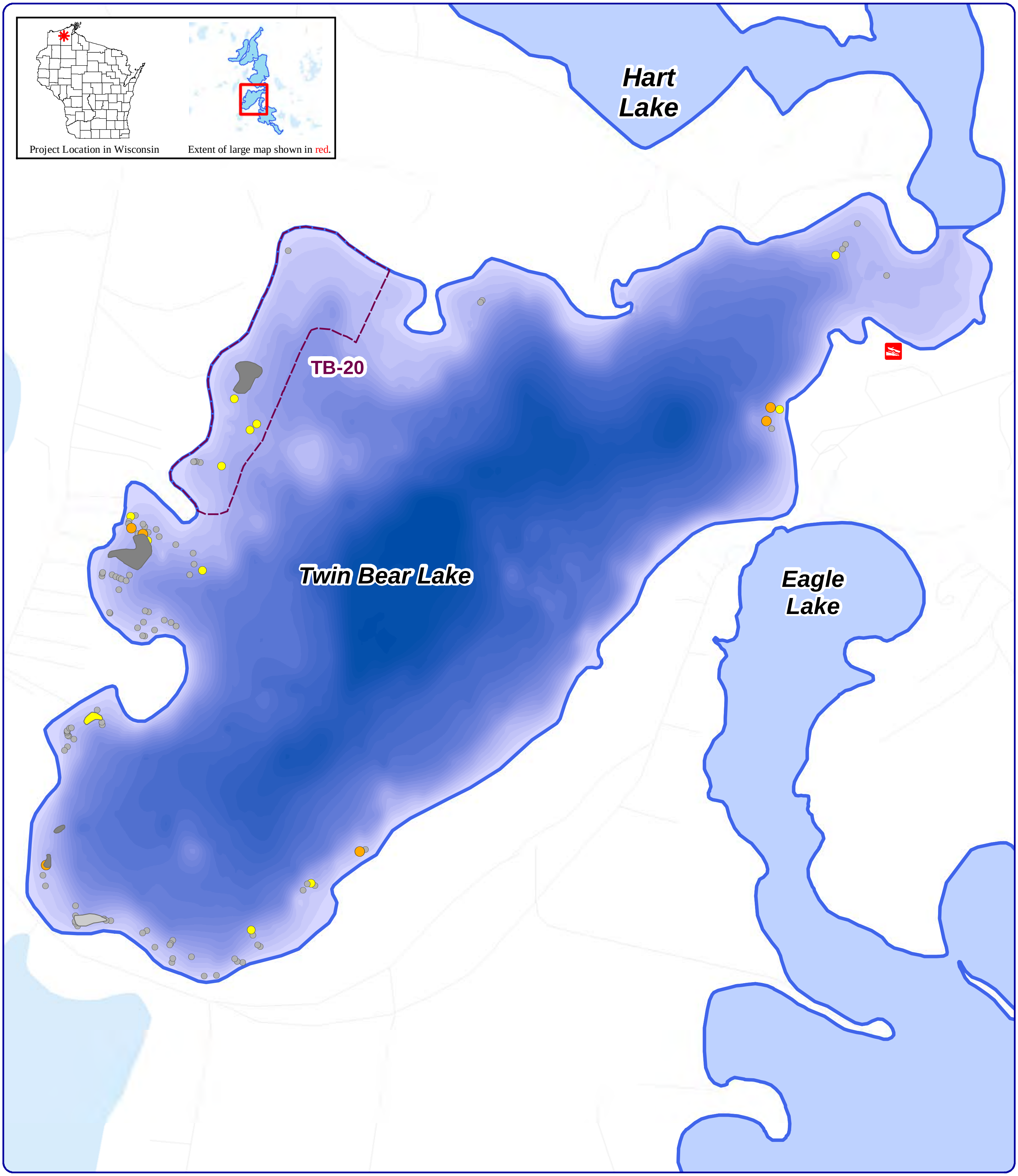
Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra 2016, processed by C-Map USA
Aquatic Plants: Onterra, 2020
Map Date: October 14, 2020 AMS

Legend

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clump of Plants
- Small Plant Colony
- 2020 Herbicide Treatment Site

Map 5 - Hart Lake
Pike Chain of Lakes
Bayfield County, Wisconsin

September 2020 EWM Survey Results



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Onterra LLC
Lake Management Planning
815 Propser Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra 2016, processed by C-Map USA
Aquatic Plants: Onterra, 2020
Map Date: October 14, 2020 AMS

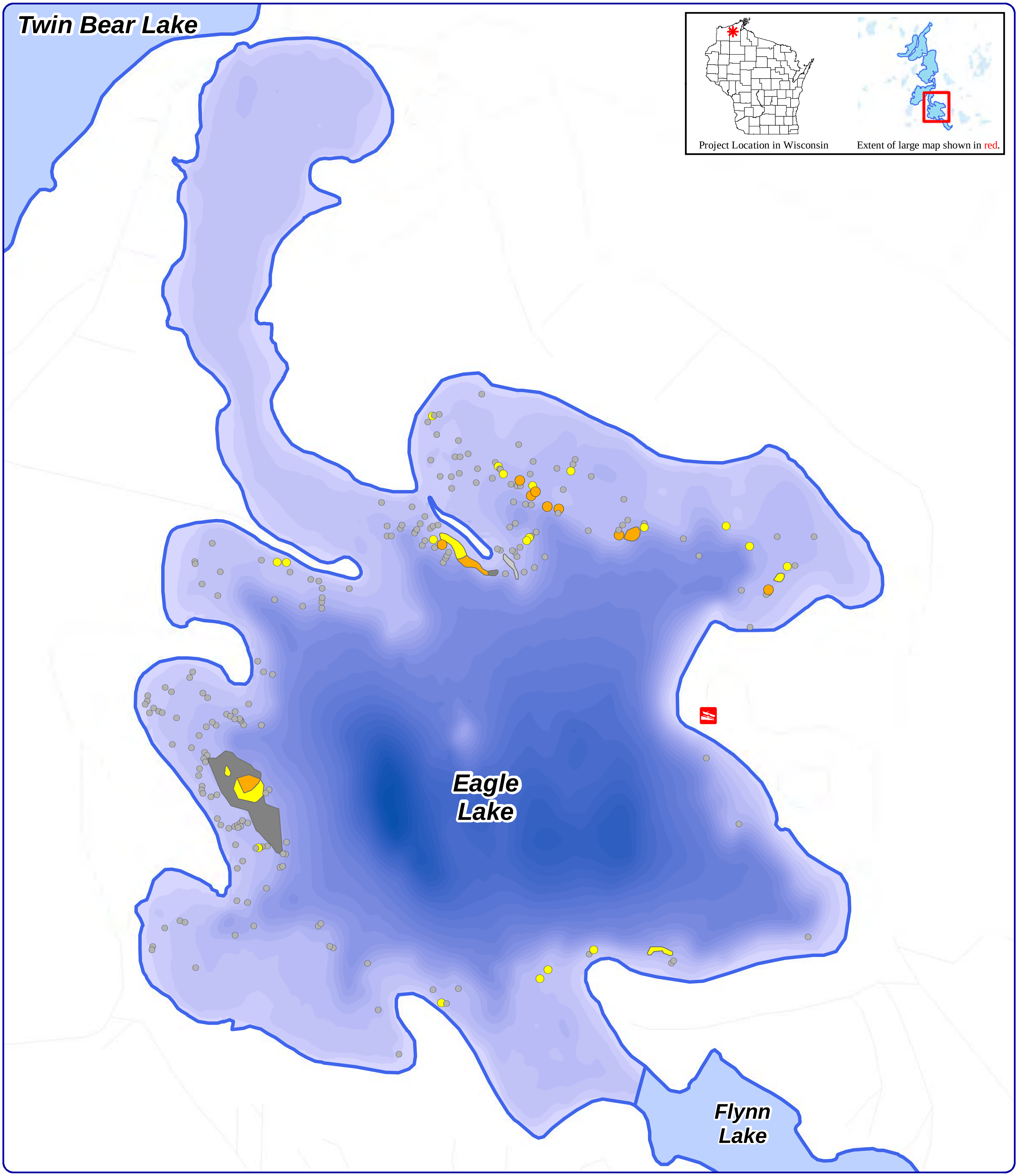
Legend

EWM *(September 22, 2020)*

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clump of Plants
- Small Plant Colony
- 2020 HerbicideTreatment Site

Map 6 - Twin Bear Lake
Pike Chain of Lakes
Bayfield County, Wisconsin

September 2020 EWM Survey Results



530
Feet

Legend

EWM ***(September 22, 2020)***

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clump of Plants
- Small Plant Colony

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920.338.8860
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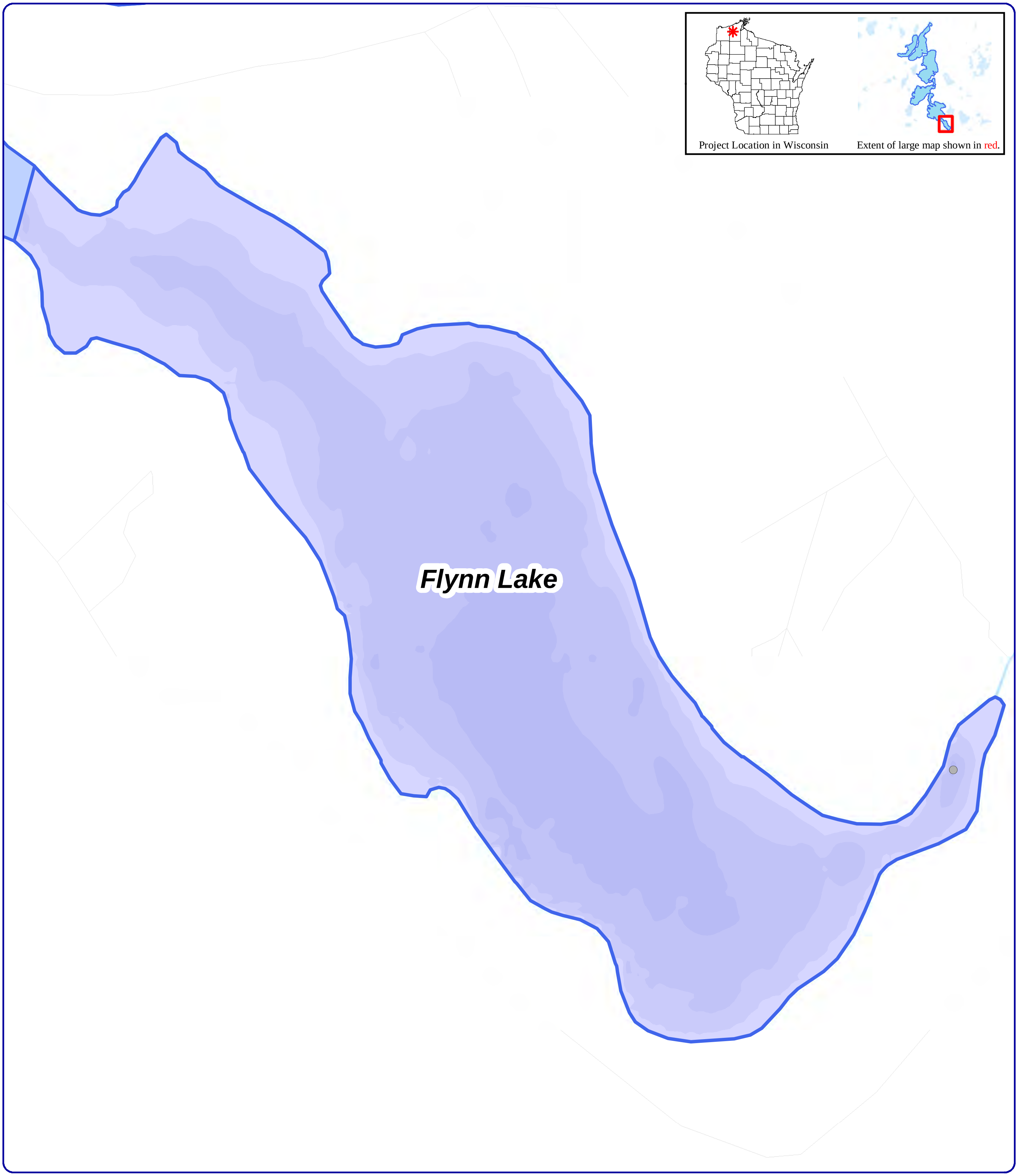
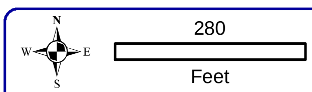
Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra 2016, processed by C-Map USA
Aquatic Plants: Onterra, 2020
Map Date: October 15, 2020 AMS

Map 7 - Eagle Lake
Pike Chain of Lakes
Bayfield County, Wisconsin

September 2020 EWM Survey Results





Legend

EWM ***(August 12, 2020)***

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface Matting
- Single or Few Plants
- Clump of Plants
- Small Plant Colony

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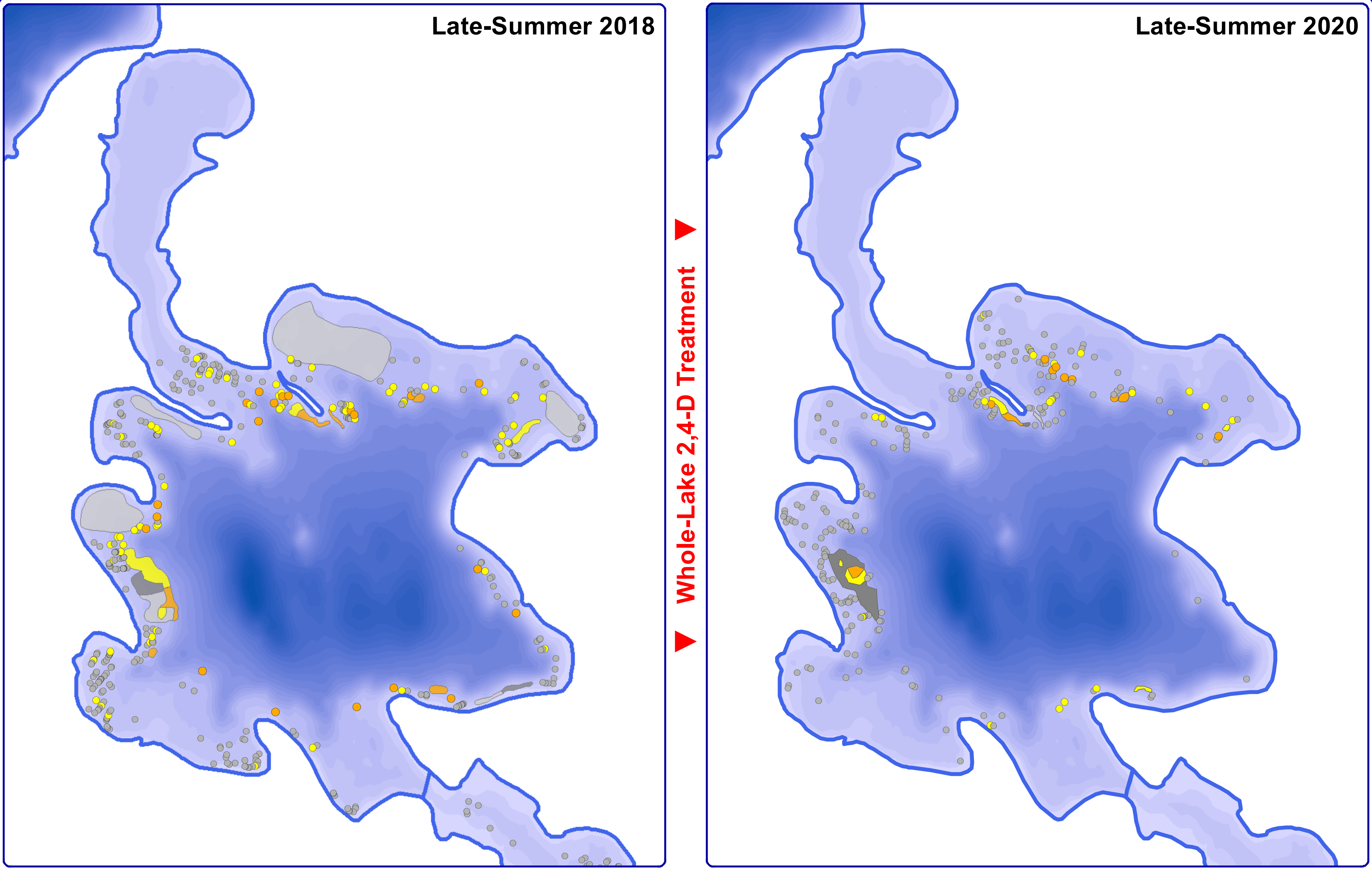
Sources:
Roads & Hydro: WDNR
Bathymetry: Onterra 2016, processed by C-Map USA
Aquatic Plants: Onterra, 2020
Map Date: October 15, 2020 AMS

Map 8 - Flynn Lake
Pike Chain of Lakes
Bayfield County, Wisconsin

August 2020 EWM Survey Results



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Onterra, LLC
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
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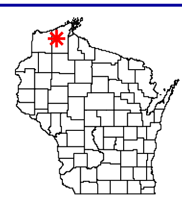
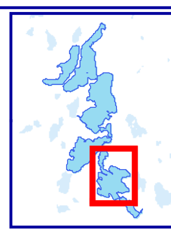
Sources:
Roads and Hydro: WDNR
Bathymetry: Onterra, 2016
Aquatic Plants: Onterra, 2018-2020
Map Date: April 6, 2021 - EJH



Project Location in Wisconsin



Legend

EWM Mapping Survey

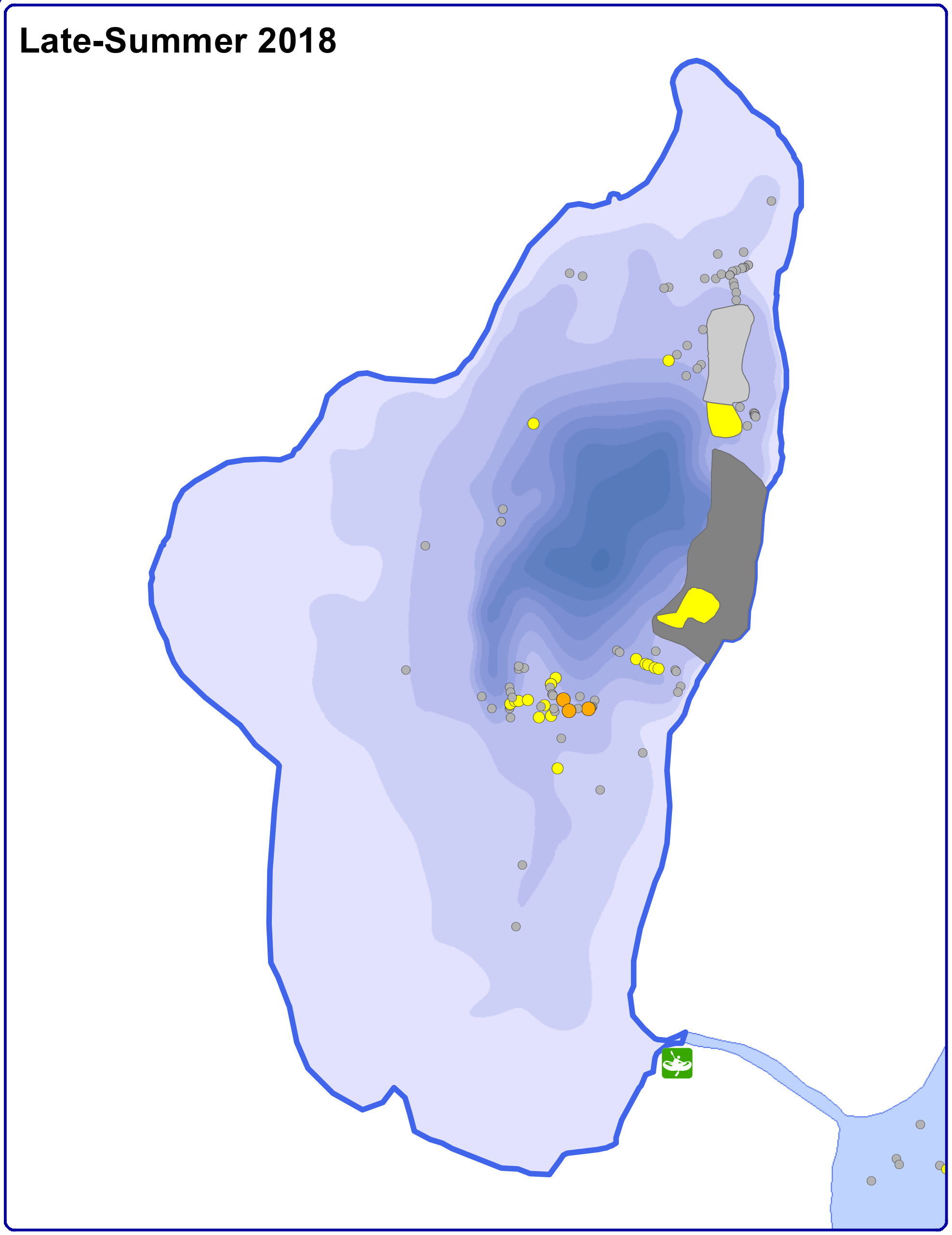
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface MattinG
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

Map 9

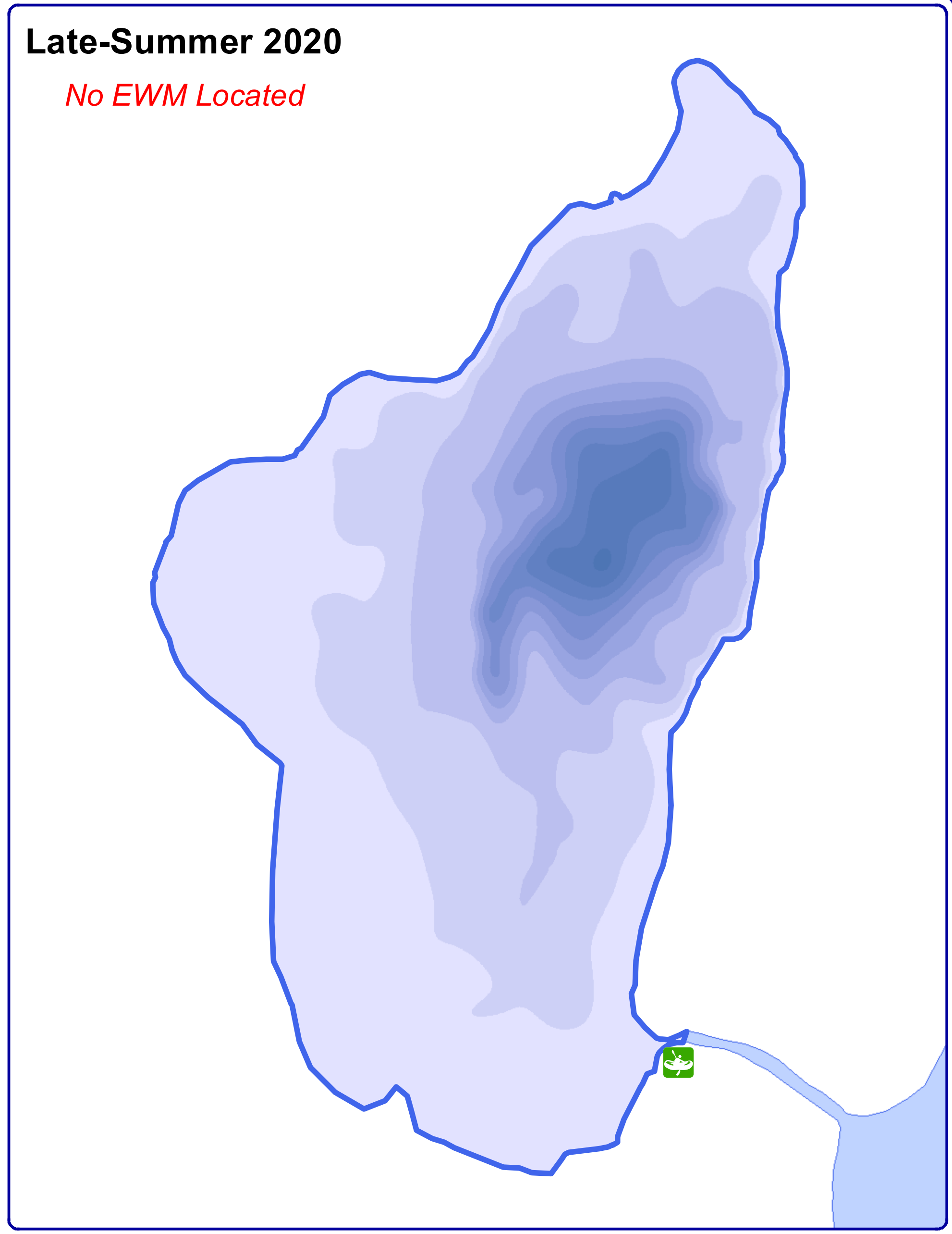
Eagle Lake

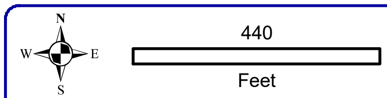
Bayfield County, Wisconsin

EWM Population Pre/Post Treatment



Whole-Lake 2,4-D Treatment





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920.338.8860
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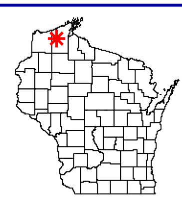
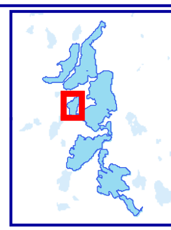
Sources:
Roads and Hydro: WDNR
Bathymetry: Onterra, 2016
Aquatic Plants: Onterra, 2018-2020
Map Date: April 6, 2021 - EJH



Project Location in Wisconsin



Legend

EWM Mapping Survey

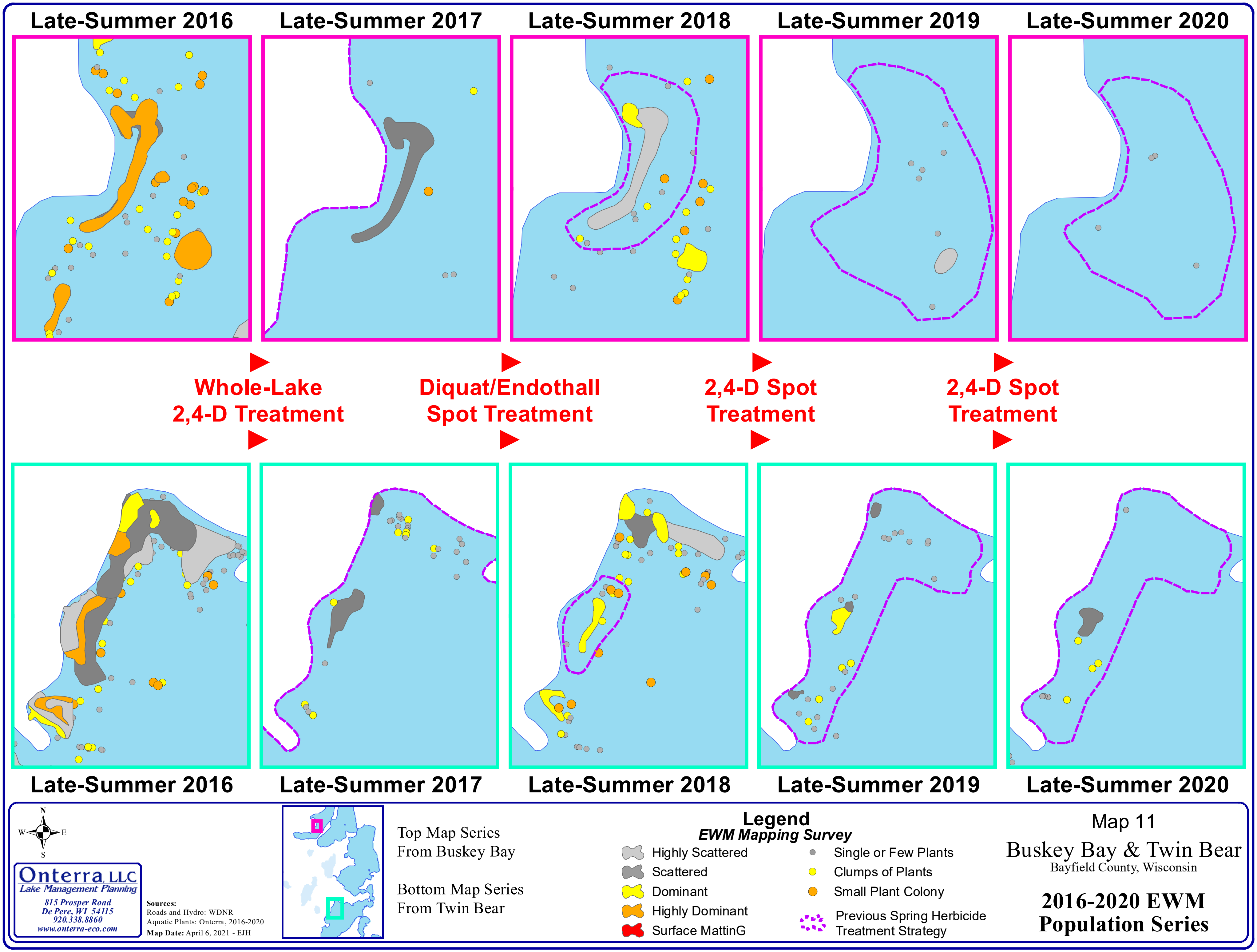
- Highly Scattered
- Scattered
- Dominant
- Highly Dominant
- Surface MattinG
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony

Map 10

McCarry Lake

Bayfield County, Wisconsin

EWM Population Pre/Post Treatment



Late-Summer 2016
Late-Summer 2017
Late-Summer 2018
Late-Summer 2019
Late-Summer 2020
Whole-Lake 2,4-D Treatment
Diquat/Endothall Spot Treatment
2,4-D Spot Treatment
2,4-D Spot Treatment
Late-Summer 2016
Late-Summer 2017
Late-Summer 2018
Late-Summer 2019
Late-Summer 2020
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Onterra, LLC
Lake Management Planning
815 Prosper Road
De Pere, WI 54115
920.338.8860
www.onterra-eco.com
Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2016-2020
Map Date: April 6, 2021 - EJH
Top Map Series
From Buskey Bay
Bottom Map Series
From Twin Bear
Legend
EWM Mapping Survey
Highly Scattered
Scattered
Dominant
Highly Dominant
Surface MattinG
Single or Few Plants
Clumps of Plants
Small Plant Colony
Previous Spring Herbicide Treatment Strategy
Map 11
Buskey Bay & Twin Bear
Bayfield County, Wisconsin
2016-2020 EWM Population Series