Photo Credit: Teresa Skog (top left, top right); Luke Davis (bottom)

2023-27 AQUATIC PLANT MANAGEMENT PLAN

11/28/2022 DRAFT

Sand Lake

Sand Lake Management District

November 2022

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Acknowledgements:

Members of the Sand Lake Management District who helped collect data, and contributed to discussions and recommendations presented in this plan.

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Executive Summary

Sand Lake is an exceptionally beautiful, clear-water lake home to many species of birds, game fish, and a diverse aquatic plant community. Unfortunately, invasive Eurasian watermilfoil (*Myriophyllum spicatum,* EWM) was discovered in the lake in 2002, threatening its biodiversity, recreational opportunities, and overall health as a functioning ecosystem. As such, management of EWM is necessary to protect this valuable resource and maintain its status as a high-quality waterbody. An integrated management approach that relies on a combination of manual and chemical control methods is recommended to continue for Sand Lake.

The Sand Lake Management District (SLMD) takes an active role in managing the lake, and the purpose of this Aquatic Plant Management Plan (APM Plan) is to outline a strategy meant to control EWM, protect native plant communities, and prevent the introduction of additional aquatic invasive species. Therefore, the primary goal of this plan is to protect Sand Lake's ecosystem and native plant community through management efforts to control EWM.

This goal will be accomplished through the following objectives:

1. **EWM Management.** Limit the spread of EWM through environmentally responsible methods to benefit the native plant community while maintaining EWM at manageable levels.

2. **Education and Awareness.** Continue to educate property owners and lake users on aquatic invasive species through public outreach and education programs to help contain EWM within the lake and prevent its spread further in the lake, as well as to other waterbodies.

3. **Research and Monitoring.** Develop a better understanding of the lake and the factors affecting lake water quality through continued and expanded monitoring efforts.

4. **Adaptive Management.** Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modify the management plan as necessary to meet goals and objectives.

Aquatic Plant Management (APM) Strategy

We recommend the continuation of a combination of chemical and manual control methods to curb the spread of EWM in Sand Lake and to prevent it from dominating areas of the lake. The overall goal of this plan is to protect this outstanding resource from degradation by maximizing prevention of new invasions and through the containment and control of existing aquatic invasive species while maintaining the health and recreational use of the lake.

This plan supports sustainable practices to protect, maintain and improve the native aquatic plant community, the fishery, and the recreational and aesthetic values of the lake. This plan is intended to be a living document that will be evaluated annually to determine if it is meeting stated goals and community expectations, and can it be revised if necessary. The SLMD sponsored the development of this APM Plan, funded through a WDNR Aquatic Invasive Species Education, Prevention, and Planning Grant and in-kind donations by SLMD volunteers.

APM Plans developed for northern Wisconsin lakes are evaluated according to Northern Region APM Strategy goals developed by the Wisconsin Department of Natural Resources (WDNR). APM Plans and the associated management permits (chemical or harvesting) are reviewed by the WDNR. Additional review may be completed by the Voigt Intertribal Task Force (VITF) in cooperation with the Great Lakes Indian Fish and Wildlife Commission (GLIFWC). WDNR aquatic plant management planning guidelines, the Northern Region Aquatic Plant Management Strategy, and the goals of the SLMD in conjunction with the current state of the lake formed the framework for the development of this APM Plan. This plan is designed to be implemented over the course of 5 years with goals and objectives to be met throughout that time frame.

Sand Lake Management District

The SLMD was created in 2004 to address primarily three issues:

- EWM, which was discovered in Sand Lake in 2002.
- Overall water quality, based on experiencing spikes in phosphorus levels.
- Maintaining the overall integrity of Sand Lake through time, based on the increased pressure from continued development.

The first Sand Lake Management Plan was completed in 2005 and was focused on EWM management. Another APM Plan was completed in 2010 and continued to focus on EWM, but added other AIS management and recommendations for reducing shoreland runoff that may help improve water quality. In 2014, a Comprehensive Lake Management Plan was completed guiding additional management actions to improve water quality in the lake. In 2016, the 2010 APM Plan was updated again. This document updates the 2017-21 APM Plan.

Since its formation, the SLMD has been using Lake District funds to support education and management efforts both with the assistance of WDNR grant funds and on their own. The following committees are supported by the SLMD: EWM Management, Water Quality, Clean Boats, Clean Waters, EWM Buoys, and the Sand Lake Soundings Newsletter and Webpage. The SLMD Board consists of seven members including a Town of Maple Plain and Barron County representative and five commissioners. The Board meets at least six times during the year, usually on a Saturday morning at 9:00am.

Public Participation and Public Input

Lake Information

Background

Sand Lake (WBIC: 2661100) is a mesotrophic drainage lake located in the town of Maple Plain in the northwest corner of Barron County (Figure 1). Sand Lake is approximately 322 acres with a maximum depth of 57 feet and an average depth of 28 feet (Figure 2). The lake has steeply sloping sides that flatten to a relatively consistent depth, with the exception of the southern end that quickly deepens to more than 50 feet (Figure 2). The bottom substrate is composed of a mix of sand and muck throughout the narrow littoral zone with a few mucky, shallow bays (Figure 2). Water quality data collected by Citizen Lake Monitoring Network (CLMN) volunteers from 1988 to 2021 has shown that the lake is consistently mesotrophic (relatively clear water and mid-range nutrient levels; Figure 3). Aquatic vegetation is surprisingly diverse considering the narrow littoral zone that extends to approximately 18 feet in the clear water of the lake (Figure 4). Sand Lake supports a fishery of musky, northern pike, walleye, largemouth bass, and panfish.

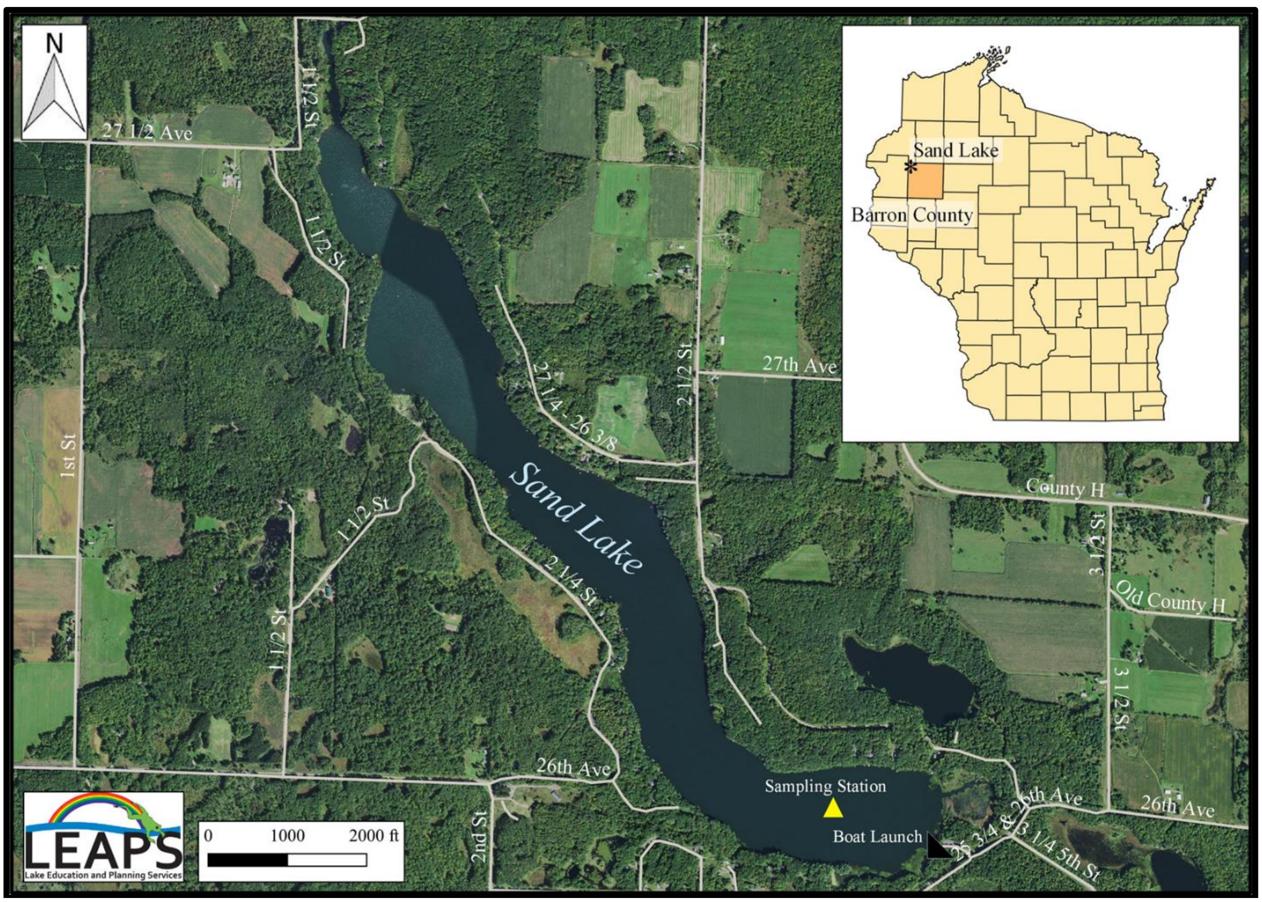


Figure 1: Location of Sand Lake, Barron County, Wisconsin

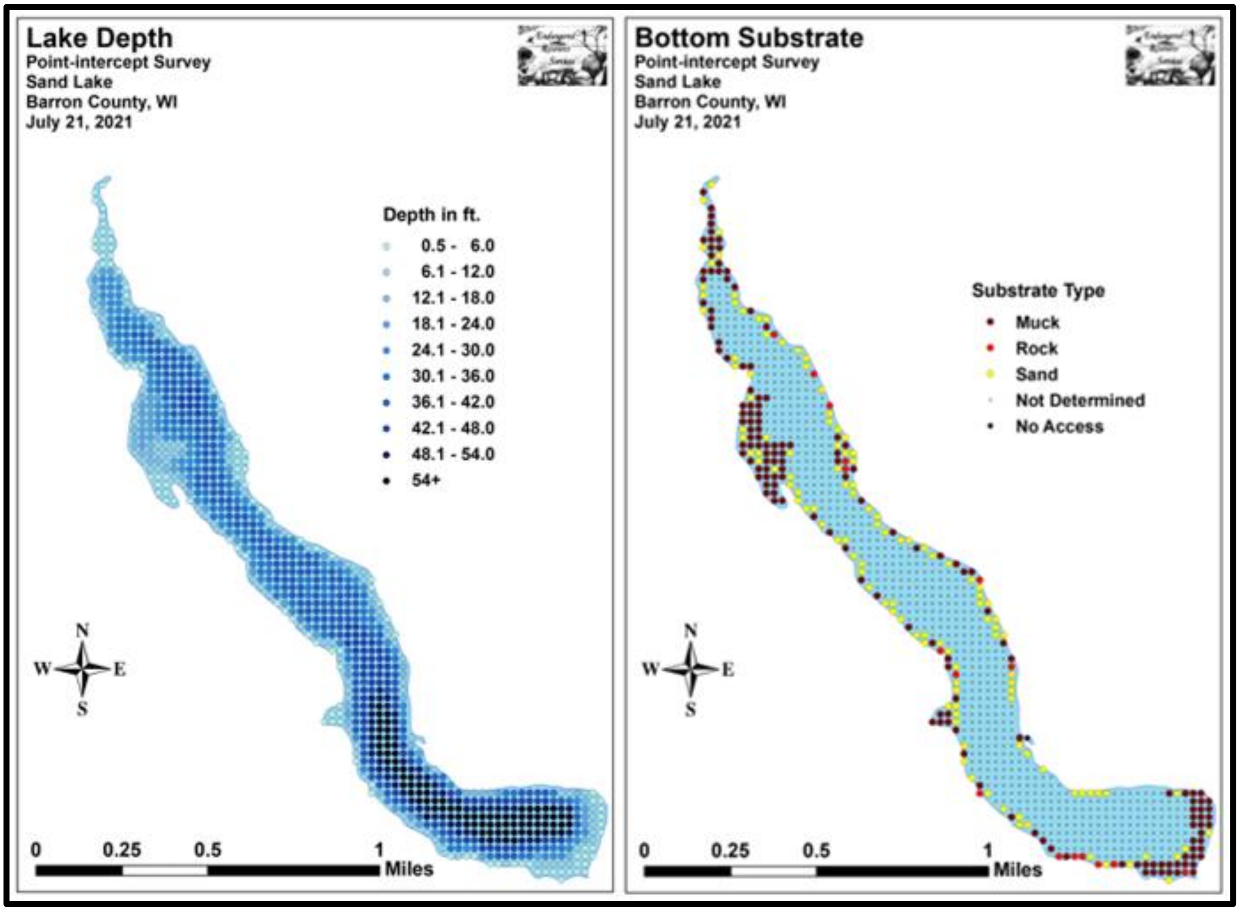


Figure 2: Sand Lake depth and bottom substrate (Berg, 2021)

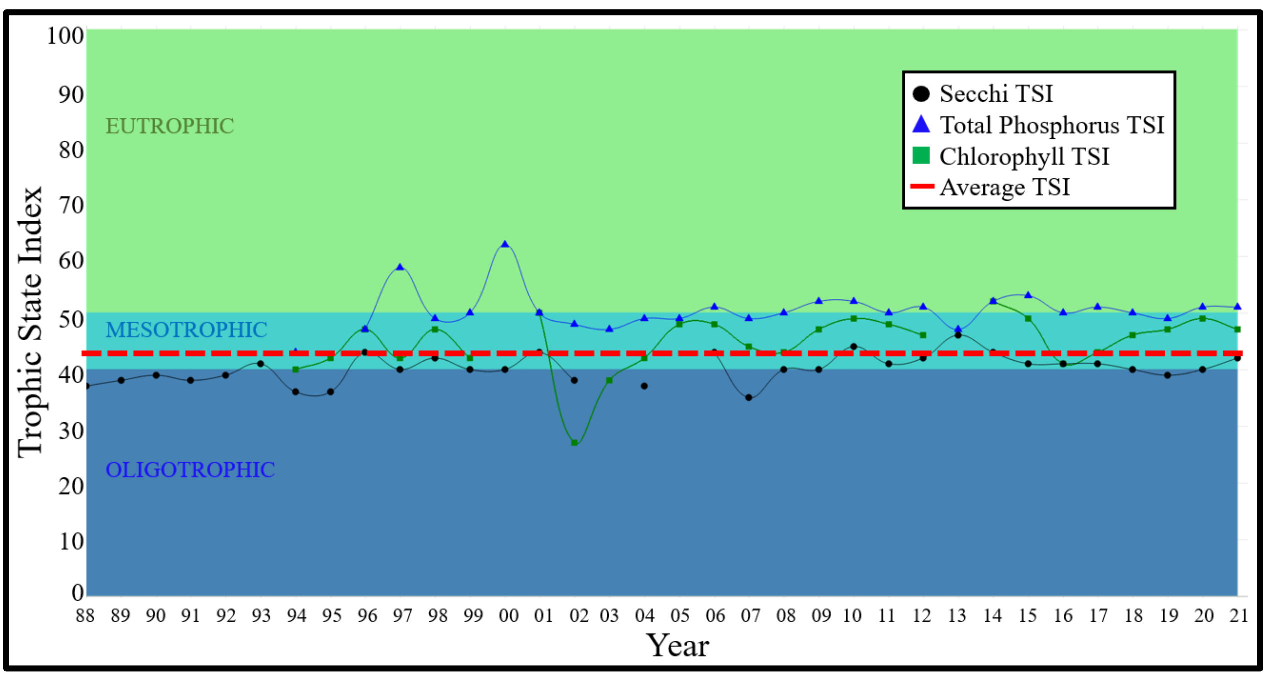


Figure 3: Water quality summary from 1988-2021

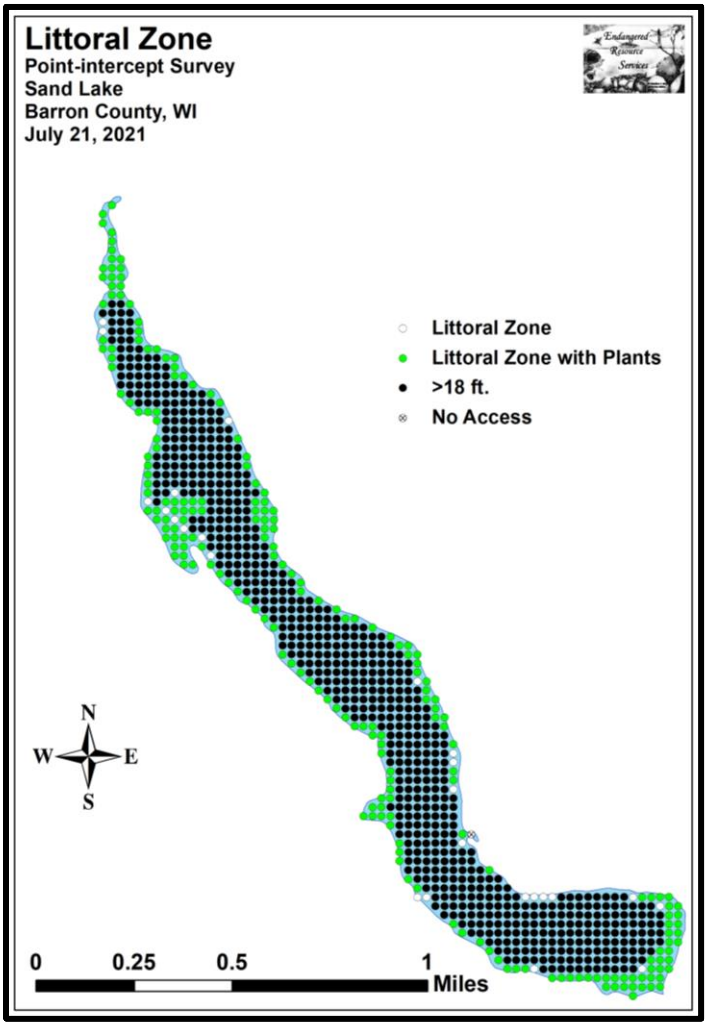


Figure 4: Sand Lake 2021 Littoral Zone (Berg, 2021)

Watershed Land Cover

A watershed is an area of land from which water drains to a common surface water feature such as a stream, lake, or wetland. Sand Lake is located near the headwaters of the North Fork of the Clam River Watershed (173.51 mi^2) that covers the intersecting corners of Burnett, Washburn, Polk, and Barron counties (Figure 5). There are approximately 232 miles of streams and rivers – 64.5 miles are trout waters and 61.2 miles are classified as Outstanding/Exceptional. There are 2,180.4 acres of lakes, and 12,749 acres of wetlands, and there are no impaired streams or lakes. The North Fork of the Clam River is classified as an outstanding resource water. The watershed is ranked low in nonpoint source issues that affect waterbodies despite containing 25,718.5 acres of agriculture. The North Fork of the Clam River Watershed is part of the larger St. Croix River Watershed that eventually flows to the Mississippi River. Additionally, within 300 feet of Sand Lake is fairly developed with several roads and many homes and cabins, although the majority of the area contains mixed forest cover (Figure 6). The larger watershed is mostly forested (58.0%) with some large wetland complexes (12.0%) and a larger portion of land used for agriculture (24.2%; Figure 5).

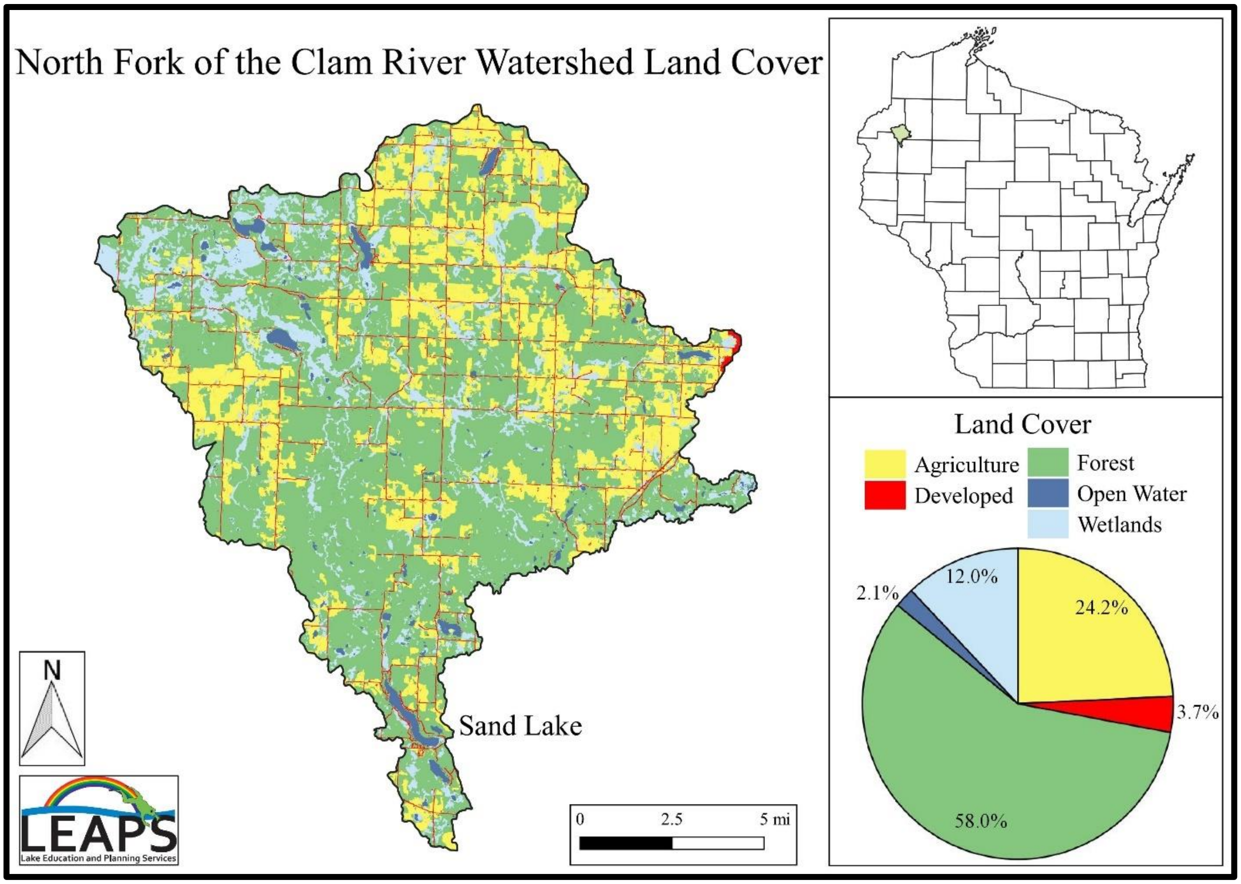


Figure 5: North Fork of the Clam River Watershed location and land cover (Dewitz, 2019)

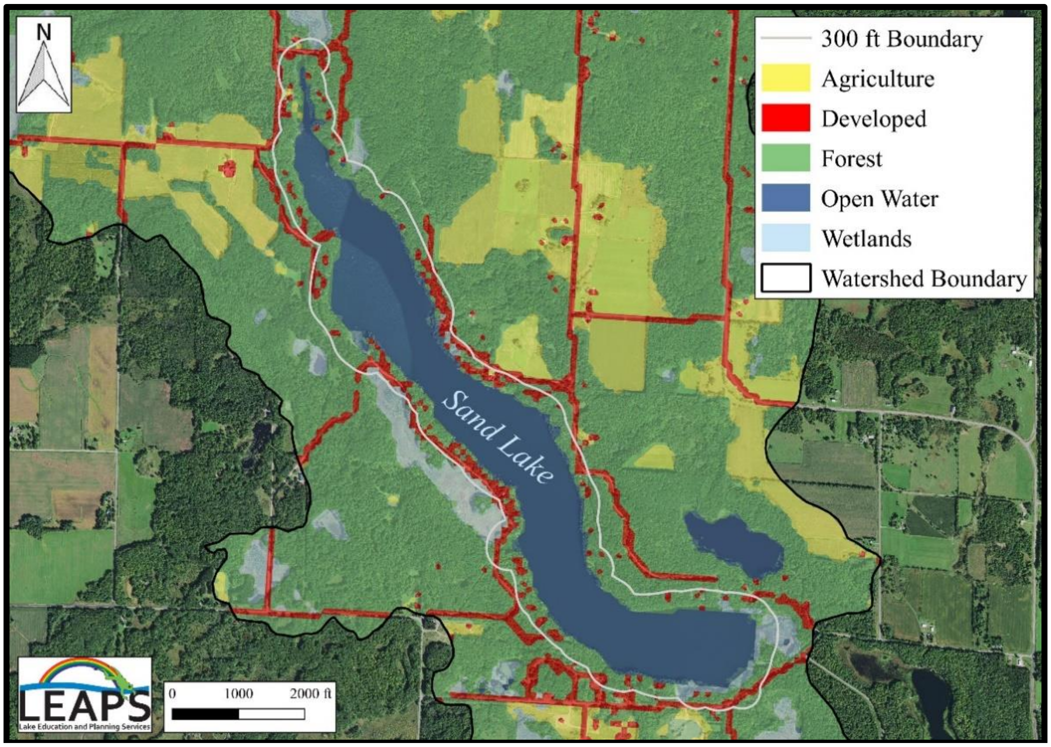


Figure 6: Sand Lake land cover and buffer (Dewitz, 2019)

Trophic State and Water Quality

Trophic state and water quality are often used synonymously; however, they are not the same. Water quality is typically based on a perception of the lake, which may be subjective for different lake users. People who use the lake for primarily swimming usually classify lakes with clear water as having better water quality while the same lake might be classified as having poor water quality by a fisherman because the low productivity limits fish growth. Trophic state describes the biological condition of a lake using a scale that is based on water clarity, total phosphorus, and chlorophyll-*a* (Carlson, 1977).

Sand Lake has been a part of the CLMN water quality monitoring program since 1988. From 1988 to 1993 only Secchi disk readings of water clarity were collected. From 1994 to the present, Sand lake has been a part of the CLMN Expanded water quality monitoring program that includes Secchi disk readings of water clarity and water sampling and analysis for chlorophyll-*a* (CHL) and total phosphorus (TP). In addition, temperature and dissolved oxygen profiles are collected.

Water Quality

Every time a CLMN volunteer collects a Secchi disk reading of water clarity, that volunteer also rates their perception of the lake on a 1-5 scale: 1-beautiful could not be nicer; 2-very minor aesthetic problems, excellent for swimming and boating enjoyment; 3-swimming and aesthetic enjoyment of the lake slightly impaired because of high algae levels; 4-Desire to swim and levels of enjoyment lf lake substantially reduced because of algae, would not swim but boating is OK; and 5-swimming and aesthetic enjoyment of lake substantially reduced because of algae levels.

From 1988 to 2022, CLMN volunteers collected 267 Secchi disk reading of water clarity that also provided a lake perception ranking. Of all the rankings 67 were 1, 121 were 2, 76 were 3, and 1 was 4. There were no rankings of 5. The average of all the perception rankings from 1988 to 2022 is 2-very minor aesthetic problems, excellent for swimming and boating enjoyment.

Trophic State

By combining data for water clarity, TP, and CHL in Sand Lake, the trophic state as determined by Carlson's Trophic Status Index (1977) is able to be determined (Figure 3). Eutrophic lakes typically have large amounts of aquatic plant growth, higher nutrient concentrations, low water clarity due to algae blooms, and oxygen-depleted bottom waters. On the other end of the spectrum, oligotrophic lakes are nutrient-poor, have clear and cold water, and oxygen throughout the water column continually. Mesotrophic lakes fall in the middle and have intermediate nutrient levels, occasional algal blooms, and may experience bottom water oxygen depletion in the summer (Red circles in Figure 7 represent Sand Lake's ranges).

TSI	Chlorophyll-a (ug/L)	Secchi Depth (ft)	Total Phosphorus (ug/L)	Classification	Attributes	Fisheries and Recreation
<30	<0.95	>26	<6	ULTRAOLIOGOTROPHIC	clear water, many algal species, oxygen throughout the year in bottom water, cold water	oxygen-sensitive, cold water fish species in deep lakes
30-40	0.95 - 2.6	13 - 26	6 - 12	OLIGOTROPHIC	clear water, many algal species, oxygen throughout the year in bottom water except possibly in shallow lakes, cold water	oxygen-sensitive, cold water fish species in deep lakes only
40-50	2.6 - 7.3	6.5 - 13	12 - 24	MESOTROPHIC	water moderately clear, but increasing chance of low dissolved oxygen in deep water during the summer	walleye may dominate
50-60	7.3 - 20	3 - 6.5	24 - 48	EUTROPHIC	decreased clarity, fewer algal species, oxygen-depleted bottom waters during the summer, plant overgrowth evident	warm-water fisheries (pike, perch, bass, etc.)
60-70	20 - 56	1.5 - 3	48 - 96	EUTROPHIC	blue-green algae become dominant and algal scums are possible, extensive plant overgrowth problems possible	thick aquatic vegetation and algal scums may discourage swimming and boating
70-80	56 - 155	0.75 - 1.5	96 - 192	HYPEREUTROPHIC	heavy algal blooms possible throughout summer, dense plant beds, but extent limited by light penetration (blue-green algae block sunlight)	summer fish kills possible, rough fish dominant
>80	>155	<0.75	192 - 384	HYPEREUTROPHIC	Algal scums, few plants	

Figure 7: Sand Lake trophic state summary

Circled values indicate the values and corresponding TSI scores for Sand Lake from data collected by citizen volunteers. This figure is adapted from Carlson and Simpson 1996, information from the WDNR and publicly available CLMN water quality data.

The specific measurements of water quality and trophic status in Sand Lake have remained relatively constant over time as measured by volunteers. Secchi depth readings (a measure of water clarity) in Sand Lake average 13.1 feet, which is consistent with oligotrophic readings (Figure 7; Figure 8). Chlorophyll-*a* in those same years ranged from 0.35 to 15.00µg/L, averaging 4.61µg/L (trophic state value 44.7), which classifies Sand as a mesotrophic lake (Figure 7). TP ranged from 7.00 to 82.00µg/L, averaging 20.25µg/L (trophic state value 50.8). Overall, Sand Lake is a mesotrophic lake with high water clarity and high water quality (Figure 7; Figure 8). Sand Lake is considered an Outstanding Resource Water in WI.[1]

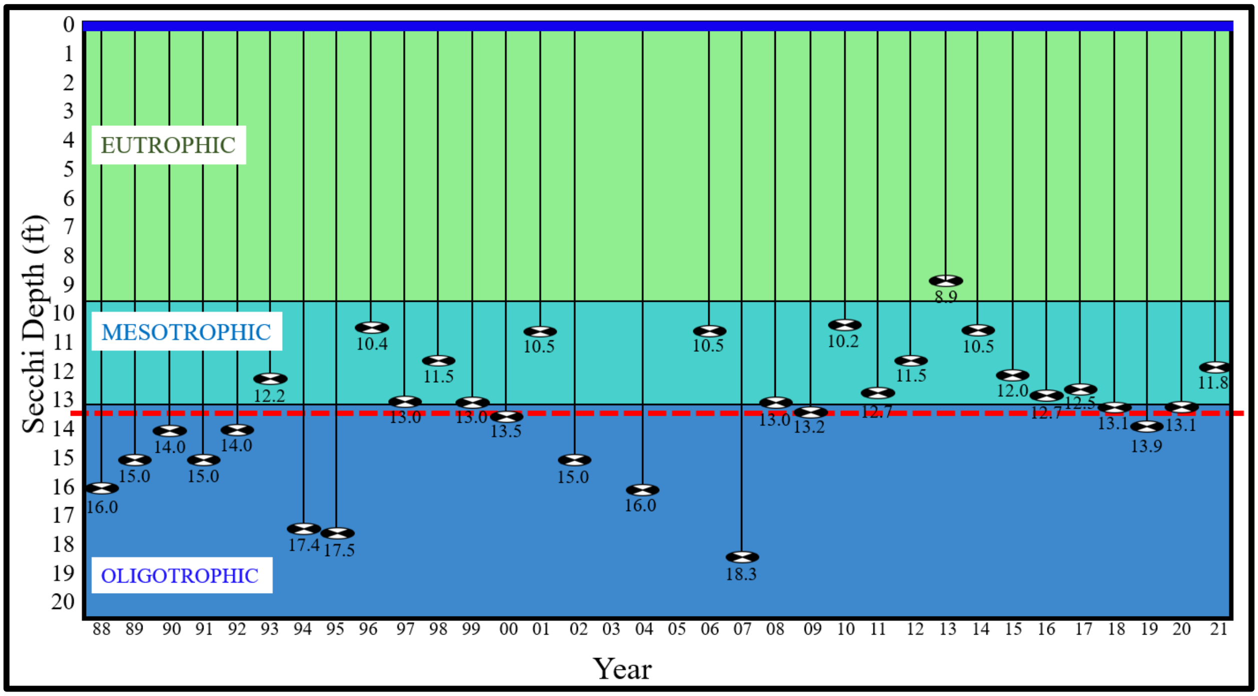


Figure 8: Secchi depth readings 1988-2021 Sand Lake

Long-term trends in Secchi disk readings of water clarity suggest that water clarity in Sand Lake has declined since measurements began in 1988. Figure 9 reflects all Secchi disk readings taken in each year of data collection, the mean annual Secchi disk reading, and a linear trend line.

[1] More information can be found at: https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=033143.

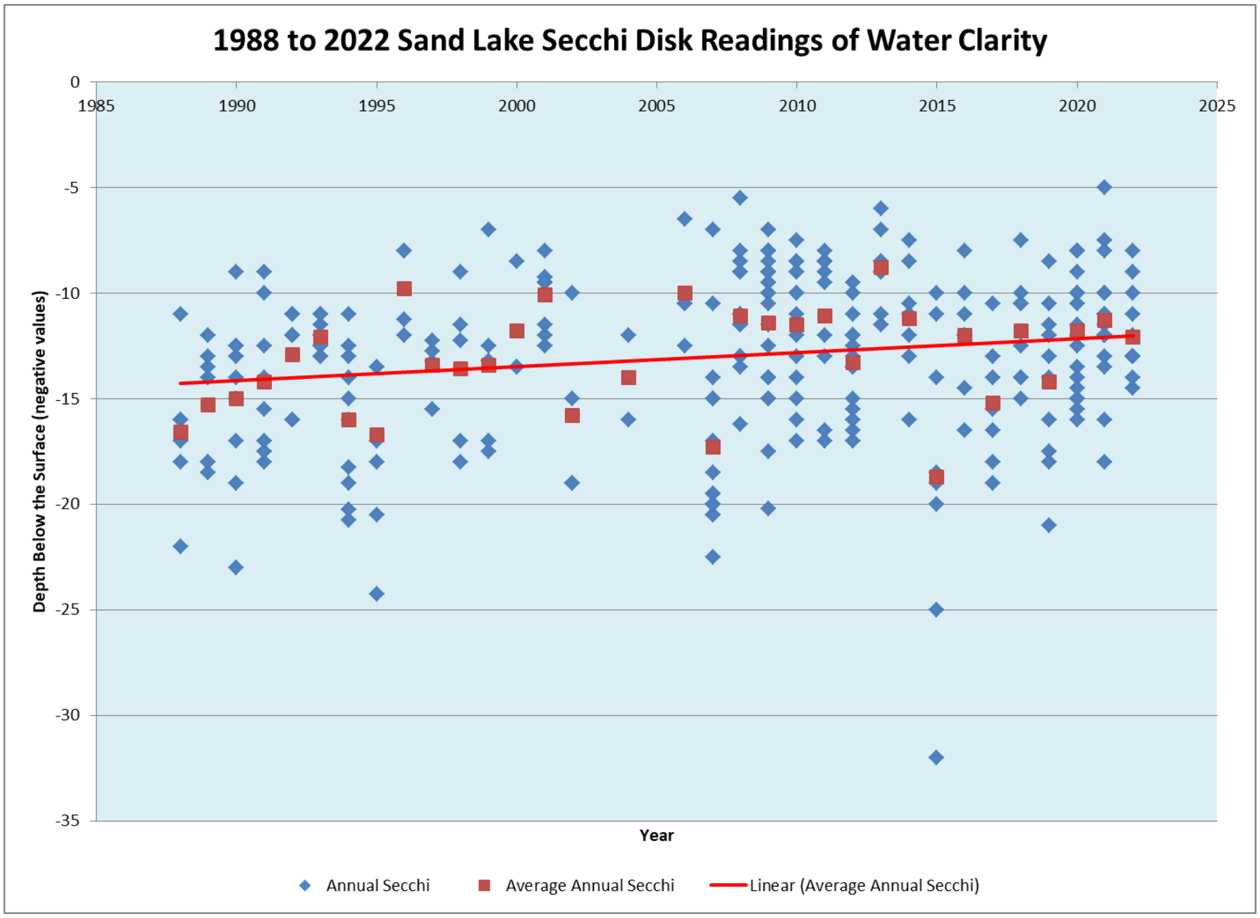


Figure 9: Annual Secchi disk readings of water clarity, average annual water clarity, and linear trend line for Sand Lake 1988 to 2022

Oxygen

Dissolved oxygen is essential for the survival of most aquatic animals, just like atmospheric oxygen is essential for most terrestrial animals. Surface waters (also called the epilimnion) exchange oxygen with the atmosphere and are usually oxygen-rich. In deeper lakes, or smaller lakes that are generally sheltered from prevailing winds, the water in the lake stratifies (or separates) into distinct zones during the summer months, impacting water quality and affecting biota. These zones are the epilimnion (usually oxygen-rich surface waters), the thermocline (the layer separating the surface and bottom waters), and the hypolimnion (oxygen-depleted bottom waters; Figure 10).

CLMN dissolved oxygen and temperature profile data has been collected over many years, and there is evidence that Sand thermally stratifies in the summer months between 10-15 feet. The lake may experience hypolimnetic hypoxia (oxygen depletion). Any stratification that does occur is likely to be reversed during fall turnover as the warmer surface waters cool and mix with the colder bottom waters. Additionally, heavy boat traffic and large storm/wind events can re-mix the lakes at any point.

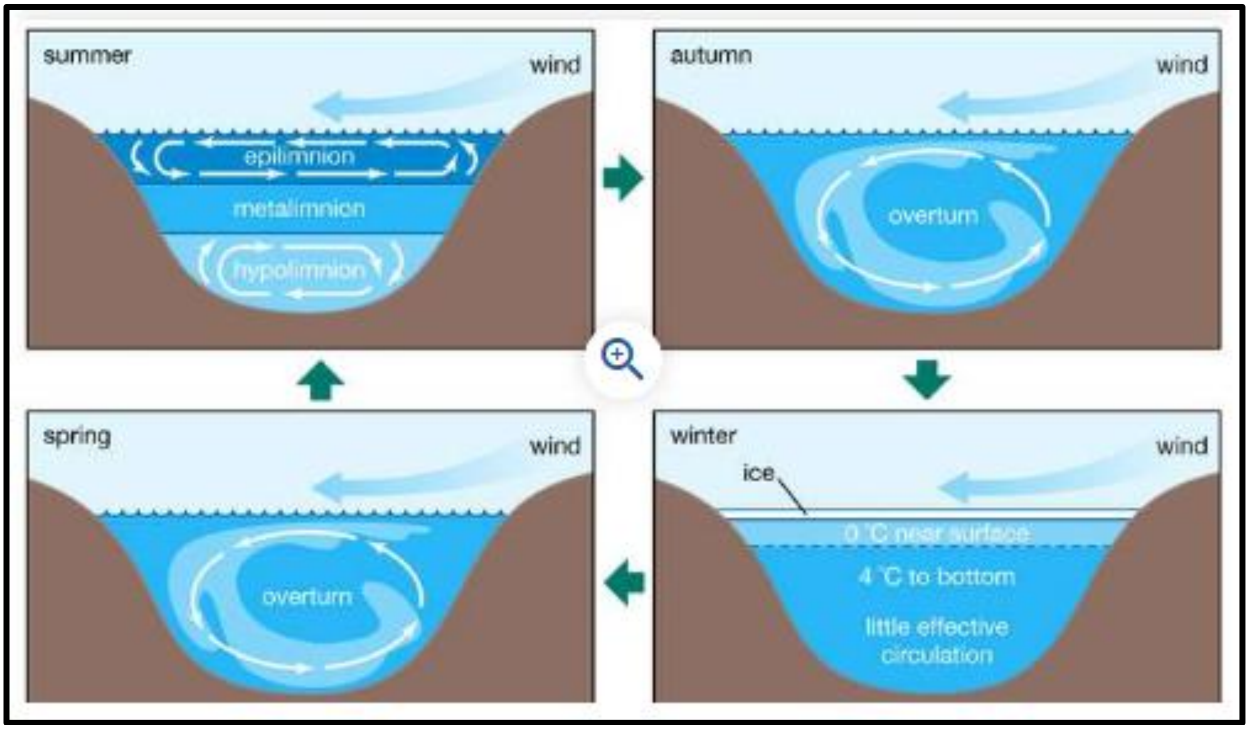


Figure 10: Seasonal thermal stratification in lakes (Encyclopedia Britannica)

Lake Level

Sand Lake is a drainage lake, meaning water flows in and flows out continuously. The outlet of the lake is on the north end and is the headwaters of Sand Creek which ultimately joins the Clam River and the St. Croix River. An inlet stream from Little Sand Lake and several intermittent gullies bring in a lot of water particularly during spring snowmelt or large rain events. Under these situations, the water level in Sand Lake can fluctuate as much as a foot or more. In addition, beavers frequently plug up the outlet of Sand Lake causing lake level to rise. High water levels exacerbate shoreland erosion. Water from the gullies carries sediment and nutrients into the lake.

The ability to spread rapidly by fragmentation allows EWM quickly colonize new habitat whenever it is made available such as by sediment deposition, water level changes, or declines/removal of populations of other species (Smith & Barko, 1990). Characteristics of EWM that make it an effective competitor for light with other aquatic plants increases it potential to persist once established (Smith & Barko, 1990).

Composite environmental changes simultaneously alter several facets of the environment. In drought years, lower runoff typically results in reduced sediment and nutrient loading, temperatures are higher than normal, turbidity is reduced and water levels may drop. The resulting conditions are ideal for the expansion of EWM populations (Smith & Barko, 1990). Past mapping and management actions show that this is particularly true for Sand Lake, with EWM expanding into deeper water in those years with better water clarity. Changes in water level also make it more difficult to find EWM during mapping surveys.

The SLMD addressed one of the problem gullies and encourages property owners to make improvements to their shoreline to protect it from high water. Additionally, the SLMD passed an ordinance specifically focusing on large wakes created by boats. During the year a SLMD volunteer works to physically remove beaver dams and other debris from the outlet. To date, no official water level monitoring has been completed on Sand Lake. Monitoring water level is a recommended action to implement over the next five years.

Fish and Wildlife

Fisheries

The most recent fish surveys were conducted in 2012 to monitor walleye, bass, and panfish populations in Sand Lake. Walleye were estimated to be 0.2 fish/acre but this estimate is based on a low sample size and is therefore indefinite. The walleye were classified as having high size structure (20-28 inches long) and low recruitment. Historically, the WDNR stocked small fingerling (~2”) walleye into Sand Lake, but the 2012 survey results reveal a lack of recruitment. It should be noted that low stocking success with small fingerlings is not something unique to Sand Lake, as small fingerlings have been unsuccessful at producing walleye year classes in many of the lakes in the area that are better-suited for bass, bluegill, crappie, and northern pike. In 2013 the WDNR began stocking large fingerling (6-8”) walleye into Sand Lake at a rate of 15 fish/acre during odd-numbered years.

Of the other fish species surveyed in 2012, largemouth bass had moderate abundance (35 fish/mile during electrofishing survey) and bluegill were the most abundant panfish species at 308 fish/mile and their size structure was low. No crappies were collected but that is likely due to the timing of the electrofishing survey and not representative of their populations.

Although the 2012 survey was not targeting musky, 20 were found and measured 23-45 inches with 30% of them >40 inches. A different survey conducted by WDNR Research in 2009-10 revealed an estimated 0.33 fish/acre of musky that were ≥30 inches in Sand Lake, which is an average density for muskellunge. Musky are currently stocked in “even-numbered” years at a rate of 1 fish/acre.

WDNR records reveal the earliest record of stocking musky in 1938. In the last ten years, more than 27,000 six inch walleyes and 1,232 twelve inch muskies have been stocked in Sand Lake (Table 1).[2]

[2] https://dnr.wi.gov/fisheriesmanagement/Public/Summary/Index

Table 1: WDNR Musky and Walleye stocking from 2012-2021

Stocking Year	Stocked Waterbody Name	Location	Species	Strain(Stock)	Age Class	Number Fish Stocked	Avg Fish Length(IN)
2021	SAND LAKE	36N-14W-17	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	4766	6.1
2019	SAND LAKE	36N-14W-17	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	4771	6.3
2018	SAND LAKE	36N-14W-17	MUSKELLUNGE	UPPER CHIPPEWA RIVER	LARGE FINGERLING	360	12.1
2017	SAND LAKE	36N-14W-17	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	7989	5.4
2016	SAND LAKE	36N-14W-17	MUSKELLUNGE	UPPER CHIPPEWA RIVER	LARGE FINGERLING	228	12
2015	SAND LAKE	36N-14W-17	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	4760	7.1
2014	SAND LAKE	36N-14W-17	MUSKELLUNGE	UPPER CHIPPEWA RIVER	LARGE FINGERLING	322	10.9
2013	SAND LAKE	36N-14W-17	WALLEYE	MISSISSIPPI HEADWATERS	LARGE FINGERLING	4830	6.3
2012	SAND LAKE	36N-14W-17	MUSKELLUNGE	UPPER CHIPPEWA RIVER	LARGE FINGERLING	322	12.7

1991 WDNR Sensitive Areas Survey

Lake sensitive area survey results from 1991 identified nine areas in Sand Lake that merit special protection of the aquatic habitat (Figure 11). These areas of aquatic vegetation offer critical or unique fish and wildlife habitat. This habitat provides the necessary seasonal or life stage requirements of the associated fisheries while offering water quality or erosion control benefits to the body of water. The WDNR also documented six areas which provide the necessary habitat for the spawning success of walleyes. Walleyes require a cobble substrate with little or no fine sediment usually along a sharp drop-off from shore.

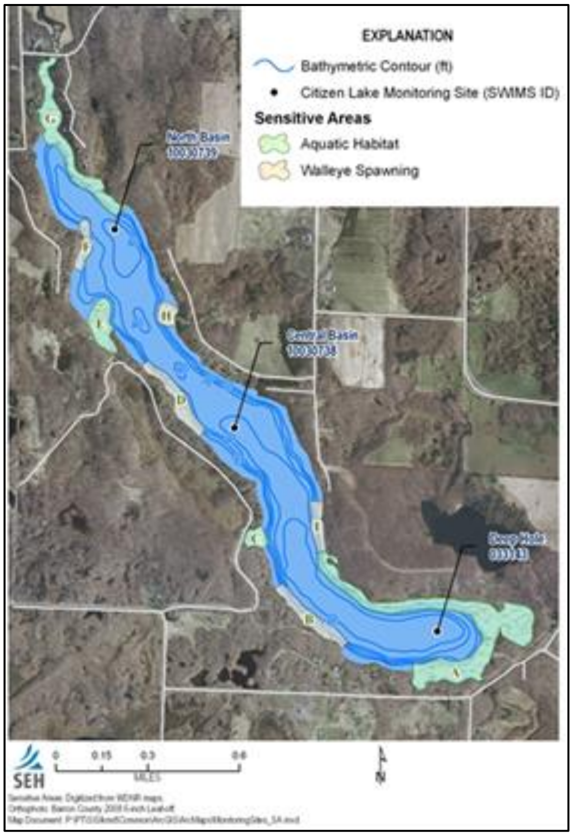


Figure 11: 1991 Sand Lake sensitive area survey of critical habitat results

Wildlife

Many waterfowl, including common mergansers, mallards, Canada geese, and common loons have been observed nesting on the lake and using it during migrations. Great blue herons, green herons, sand hill cranes, and many other bird species have been observed around the lake. Muskrats, beavers, and otters are also common visitors. Painted turtles, snapping turtles, and several snake species can also be found in the lakes. It is common to hear spring peepers in the spring and green frogs, American toads, and other frog species throughout the summer. Whitetail deer are common in the area and have been observed browsing near the lakes.

The Natural Heritage Inventory (NHI) database contains recent and historic observations of rare species and plant communities. Each species has a state status including Special Concern (SC), Threatened (THR) or Endangered (END). There is one fish species (least darter, [SC]), one bird species (trumpeter swan, [SC]) and two ecological communities (shallow-soft-seepage lake and fast,-soft-warm stream) that have been documented in the same township and range as Sand Lake (T36N R14W).[3]

Coarse Woody Habitat

Coarse woody habitat (CWH) in lakes is classified as trees, limbs, branches, roots, and wood fragments at least 4 inches in diameter that enter a lake by natural (beaver activity, toppling from ice, wind, or wave scouring) or human means (logging, intentional habitat improvement, flooding following dam

[3]https://dnr.wisconsin.gov/topic/erreview/PublicPortal.html#:~:text=The%20Natural%20Heritage%20Inventory%20(NHI,endangered%20resources%20(endangered%2C%20threatened%20and

construction). CWH in the littoral or near-shore zone serves many functions within a lake ecosystem including erosion control, as a carbon source, and as a surface for algal growth which is an important food base for aquatic macro invertebrates. Presence of CWH has also been shown to prevent suspension of sediments, thereby improving water clarity. CWH serves as important refuge, foraging, and spawning habitat for fish, aquatic invertebrates, turtles, birds, and other animals. The amount of littoral CWH occurring naturally in lakes is related to characteristics of riparian forests and likelihood of toppling. However, humans have also had a large impact on amounts of littoral CWH present in lakes through time. During the 1800's the amount of CWH in northern lakes was increased beyond natural levels as a result of logging practices. But time changes in the logging industry and forest composition along with increasing shoreline development have led to reductions in CWH present in many northern Wisconsin lakes (Wolter, 2012).

CWH is often removed by shoreline residents to improve aesthetics or select recreational opportunities (swimming and boating). One study found a negative relationship between lakeshore development and the amount of CWH in northern Wisconsin lakes Jennings, et al. (2003). Another found a negative correlation between density of cabins and CWH present in Wisconsin and Michigan lakes Christensen, et al. (1996). While it is difficult to make precise determinations of natural densities of CWH in lakes it is believed that the value is likely on the scale of hundreds of logs per mile. The positive impact of CWH on fish communities have been well documented by researchers, making the loss of these habitats a critical concern. One study determined that black crappie selected nesting sites that were usually associated with woody debris, silty substrate, warmer water, and protected from wind and waves (Pope & Willis, 1997). Crappie fishing is one aspect of the fishery in Sand Lake that many lake residents would like to improve.

Fortunately, remediation of this habitat type is attainable on many waterbodies, particularly where private landowners and lake associations are willing to partner with county, state, and federal agencies. Large-scale CWH projects are currently being conducted by lake associations and local governments with assistance from the WDNR where hundreds of whole trees are added to the near-shore areas of lakes. For more information on this process visit: http://dnr.wi.gov/topic/fishing/outreach/fishsticks.html (last accessed on 4-27-2016).

Since 2016, the SLMD has supported the installation of a dozen "Fishsticks" projects along the shore of Sand Lake. A thirteenth is planned for installation in either 2023 or 2024.

Public Use

There is one public boat landing located on the south end of the lake (Figure 1). The landing is used by shoreland owners who launch and take out their boats, as well as visitors to the lake. Sand Lake is enjoyed by many throughout spring, summer, fall, and winter. Sand Lake is used for a wide range of recreational activities, including:

- Fishing for panfish species, bass, northern pike, musky, and walleye
- Using non-motorized boats while photographing or viewing nature
- Using motorized boats for recreational enjoyment of the lake (pontoon rides)
- High power watercraft for skiing, tubing, and wake boarding/surfing
- Swimming
- Ice fishing

Enjoying Sand Lake. Photo credit: Pat Heaney (left); Teresa Skog (top right, bottom right)

In 2021, the SLMD passed an “Enhanced Wake Ordinance” designed to limit, but not eliminate, the use of wake enhancing watercraft to set hours. Before and after those hours, wakes from any boat are limited to no more than 18” in height.

Aquatic Plant Community

The following sections are summarized from Endangered Resource Services Warm-water Point-intercept Macrophyte Survey Sand Lake (WBIC: 2661100) Barron County, Wisconsin 2021.

2010, 2015, and 2021 Whole-lake, Point-Intercept Native Aquatic Plant Surveys

The 2021 littoral zone extended to 18.0ft (down from 24.0ft in 2015 but identical to 2010). Aquatic plants were found at 216 points (23.2% of the bottom/89.6% of the littoral zone). This was identical to 2015 (76.0% littoral coverage); but down slightly from 221 points (23.7% coverage/93.6% littoral coverage) in 2010 (Table 2). Diversity was exceptionally high with a Simpson Index Value of 0.93 (identical to 2015/up slightly from 0.92 in 2010; Table 2). Species richness was also high as 50 species were found growing in and immediately adjacent to the lake (up from 47 in 2015 and 45 in 2010; Table 2). In 2010, a moderately high mean of 3.44 native species per site with native vegetation was documented. This underwent a non-significant decline in 2015 to 3.40 native species/site. In 2021, localized richness increased significantly to a high 3.78 native species/site (Table 2). From 2010 to 2015, total rake fullness declined significantly from a moderately high mean rake fullness of 2.42 to a moderate 2.04 (Table 2). In 2021, this trend was reversed as rake fullness significantly increased to a mean rake fullness of 2.30 (Table 2).

Coontail (*Ceratophyllum demersum*), Flat-stem pondweed (*Potamogeton zosteriformis*), Northern water-milfoil (*Myriophyllum sibiricum*), and Small pondweed (*Potamogeton pusillus*) were identified as the most common species in 2010. They were found at 56.56%, 47.96%, 38.46%, and 28.05% of survey points with vegetation and accounted for 49.41% of the total relative frequency. During the 2015 survey, these same four species were again the most common with Coontail at 42.59% of sites with vegetation, Flat-stem pondweed at 36.11%, Small pondweed at 33.33%, and Northern water-milfoil at 32.87%. Collectively, they accounted for 42.35% of the total relative frequency. The 2021 survey identified Coontail (52.78% of vegetative sites), Flat-stem pondweed (45.37%), Small pondweed (27.31%), and Forked duckweed (*Lemna trisulca*) (24.54%) as the most common species with a combined relative frequency of 39.80% (Table 3).

From 2010 to 2015, eleven species showed significant changes in distribution. White-stem pondweed (*Potamogeton praelongus*); Coontail; and Flat-stem pondweed, Leafy pondweed (*Potamogeton foliosus*), Common waterweed (*Elodea canadensis*), and Sago pondweed (*Stuckenia pectinata*) significantly declined. Conversely, significant increases in filamentous algae, Forked duckweed, Large-leaf pondweed (*Potamogeton amplifolius*), Clasping-leaf pondweed (*Potamogeton richardsonii*), and Fern pondweed (*Potamogeton robbinsii*) were found.

Comparing the 2015 and 2021 surveys found nine significant changes in distribution. Northern water-milfoil, Illinois pondweed (*Potamogeton illinoensis*), and EWM saw a significant decline (Table 3; Figure 12). However, Clasping-leaf pondweed, Fern pondweed, and Variable pondweed (*Potamogeton gramineus*) significantly expanded; and Coontail, Forked duckweed, and Sago pondweed saw significant increases in distribution (Table 3).

A total of 36 native index species (up from 33 in 2015/29 in 2010) produced a slightly above average mean Coefficient of Conservatism of 6.0 (down from 6.1 in 2015/up from 5.9 in 2010), and an above average Floristic Quality Index of 36.0 (up from 34.8 in 2015/31.8 in 2010) (Table 2).

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics Sand Lake – Barron County, Wisconsin July 21-22, 2010, July 20-21, 2015, and July 21, 2021

Summary Statistics:	2010	2015	2021
Total number of points sampled	931	931	931
Total number of sites with vegetation	221	216	216
Total number of sites shallower than the maximum depth of plants	236	284	241
Frequency of occurrence at sites shallower than maximum depth of plants	93.6	76.1	89.6
Simpson Diversity Index	0.92	0.93	0.93
Maximum depth of plants (ft)	18.0	24.0	18.0
Mean depth of plants (ft)	6.7	6.6	6.5
Median depth of plants (ft)	6.5	6.0	6.0
Average number of all species per site (shallower than max depth)	3.24	2.60	3.38
Average number of all species per site (veg. sites only)	3.46	3.42	3.77
Average number of native species per site (shallower than max depth)	3.22	2.57	3.37
Average number of native species per site (veg. sites only)	3.44	3.40	3.78
Species richness	31	35	38
Species richness (including visuals)	35	40	40
Species richness (including visuals and boat survey)	45	47	50
Mean rake fullness (veg. sites only)	2.42	2.04	2.30

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes Sand Lake, Barron County July 21, 2021

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Ceratophyllum demersum	Coontail	114	14.00	52.78	47.30	1.59	2
Potamogeton zosteriformis	Flat-stem pondweed	98	12.04	45.37	40.66	1.67	7
Potamogeton pusillus	Small pondweed	59	7.25	27.31	24.48	1.56	3
Lemna trisulca	Forked duckweed	53	6.51	24.54	21.99	1.40	0
Potamogeton richardsonii	Clasping-leaf pondweed	52	6.39	24.07	21.58	1.73	5
Potamogeton robbinsii	Fern pondweed	50	6.14	23.15	20.75	1.38	0
	Filamentous algae	47	*	21.76	19.50	1.40	0
Najas flexilis	Slender naiad	39	4.79	18.06	16.18	1.41	2
Potamogeton gramineus	Variable pondweed	39	4.79	18.06	16.18	1.46	3
Potamogeton friesii	Fries' pondweed	33	4.05	15.28	13.69	1.30	0
Chara sp.	Muskgrass	32	3.93	14.81	13.28	1.72	2
Nuphar variegata	Spatterdock	29	3.56	13.43	12.03	2.52	6
Elodea canadensis	Common waterweed	27	3.32	12.50	11.20	1.33	1
Stuckenia pectinata	Sago pondweed	27	3.32	12.50	11.20	1.48	5
Vallisneria americana	Wild celery	26	3.19	12.04	10.79	1.31	2
Potamogeton amplifolius	Large-leaf pondweed	20	2.46	9.26	8.30	1.50	2
Nymphaea odorata	White water lily	18	2.21	8.33	7.47	1.83	4
Heteranthera dubia	Water star-grass	13	1.60	6.02	5.39	1.15	0
Spirodela polyrhiza	Large duckweed	13	1.60	6.02	5.39	1.62	0
Lemna minor	Small duckweed	10	1.23	4.63	4.15	1.20	0
Wolffia columbiana	Common watermeal	10	1.23	4.63	4.15	1.40	0
Potamogeton illinoensis	Illinois pondweed	8	0.98	3.70	3.32	1.38	0
Ranunculus aquatilis	White water crowfoot	8	0.98	3.70	3.32	1.38	0
Myriophyllum sibiricum	Northern water-milfoil	5	0.61	2.31	2.07	1.00	3
Potamogeton nodosus	Long-leaf pondweed	5	0.61	2.31	2.07	1.60	1
Potamogeton natans	Floating-leaf pondweed	3	0.37	1.39	1.24	1.33	2
Sagittaria rigida	Sessile-fruited arrowhead	3	0.37	1.39	1.24	1.00	1
Sparganium eurycarpum	Common bur-reed	3	0.37	1.39	1.24	2.00	0
Utricularia vulgaris	Common bladderwort	3	0.37	1.39	1.24	1.00	0
Bidens beckii	Water marigold	2	0.25	0.93	0.83	1.50	0
Nitella sp.	Nitella	2	0.25	0.93	0.83	1.00	0
Schoenoplectus tabernaemontani	Softstem bulrush	2	0.25	0.93	0.83	3.00	0
Typha latifolia	Broad-leaved cattail	2	0.25	0.93	0.83	1.00	0
Eleocharis acicularis	Needle spikerush	1	0.12	0.46	0.41	2.00	0
Myriophyllum spicatum	**Eurasian water-milfoil**	**1**	**0.12**	**0.46**	**0.41**	**1.00**	**0**
Phalaris arundinacea	**Reed canary grass**	**1**	**0.12**	**0.46**	**0.41**	**3.00**	**2**
Potamogeton epihydrus	Ribbon-leaf pondweed	1	0.12	0.46	0.41	1.00	0
Potamogeton praelongus	White-stem pondweed	1	0.12	0.46	0.41	1.00	0
Sagittaria cristata	Crested arrowhead	1	0.12	0.46	0.41	1.00	0
	Freshwater sponge	1	*	0.46	0.41	2.00	0
Carex comosa	Bottle brush sedge	**	**	**	**	**	1
Scirpus atrovirens	Black bulrush	**	**	**	**	**	1
Brasenia schreberi	Watershield	***	***	***	***	***	***
Calla palustris	Wild calla	***	***	***	***	***	***
Eleocharis erythropoda	Bald spikerush	***	***	***	***	***	***
Equisetum fluviatile	Water horsetail	***	***	***	***	***	***
Leersia oryzoides	Rice-cut grass	***	***	***	***	***	***
Lythrum salicaria	**Purple loosestrife**	***	***	***	***	***	***
Polygonum amphibium	Water smartweed	***	***	***	***	***	***
Sagittaria latifolia	Common arrowhead	***	***	***	***	***	***
Schoenoplectus acutus	Hardstem bulrush	***	***	***	***	***	***
Scirpus cyperinus	Woolgrass	***	***	***	***	***	***

* Excluded from relative frequency analysis ** Visual only *** Boat survey only **Exotic species in bold**

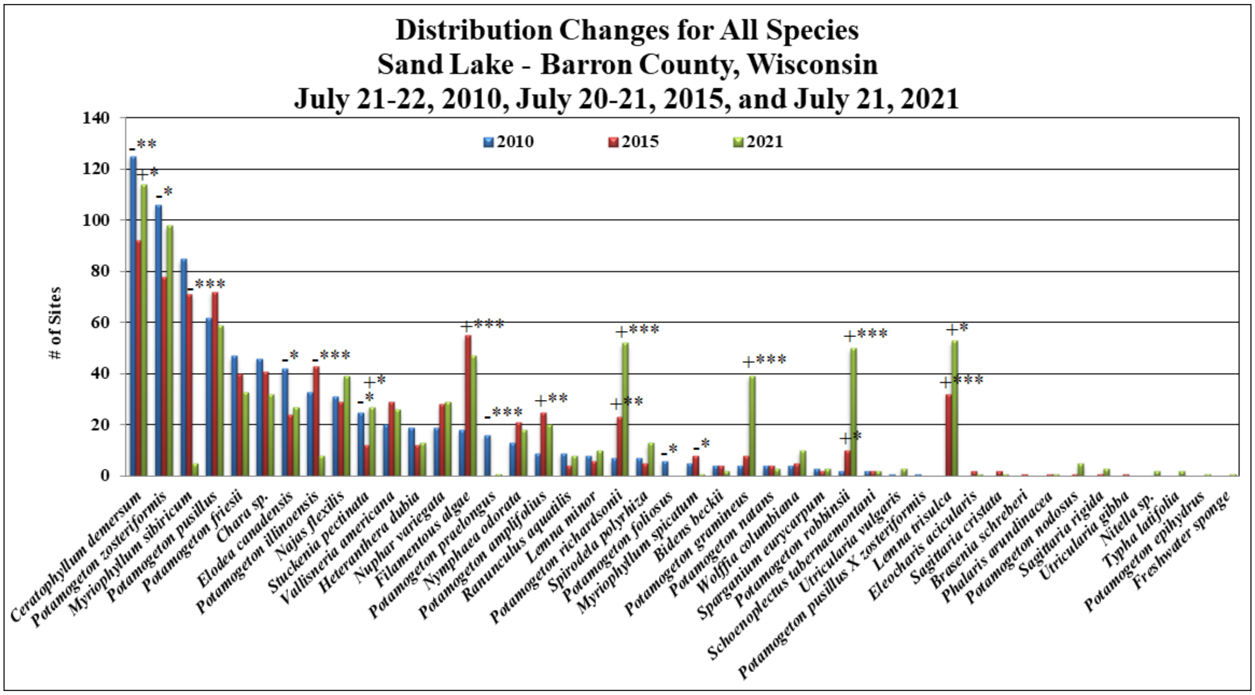


Figure 12: 2010, 2015, and 2021 survey differences for all plant species (Significant differences = * p<0.05, ** p<0.01, *** p<0.001)

Results from the three whole-lake PI surveys completed as a part of the preparation of APM Plans (2010, 2015, & 2021) show that Northern watermilfoil, Fries' pondweed, Illinois pondweed, muskgrass (*Chara* sp.), White-stem pondweed (*Potamogeton praelongus*), and Leafy pondweed (*Potamogeton foliosus*) all show significant declines from 2010 to 2021. Under the treatment regime from 2016 to 2019, Northern watermilfoil declined but rebounded. After the 2021 ProcellaCOR treatment, Northern watermilfoil was nearly gone from the lake, as recorded by the 2021 PI survey. Another whole-lake PI survey should be completed in 2023 to see on what level Northern watermilfoil returns to the lake. If it does not rebound, it will have to be recognized that thought management of EWM with ProcellaCOR may be beneficial overall, Northern watermilfoil will likely continue to suffer the same fate as EWM.

Wild Rice

Wild rice is an aquatic grass which grows in shallow water in lakes and slow flowing streams. This grass produces a seed which is a nutritious source of food for wildlife and people. The seed matures in August and September with the ripe seed dropping into the sediment, unless harvested by wildlife or people. It is a highly protected and valued natural resource in Wisconsin. Only Wisconsin residents may harvest wild rice in the state. According to the WDNR Surface Water Data Viewer, Sand Lake is not wild rice water. All three of the whole-lake point-intercept, aquatic plant surveys confirm this designation, as no wild rice was found in either survey, and it has never been found in any of the other survey work (pre, post, summer, and fall) completed on the lake.

Eurasian Watermilfoil

In 2010, EWM was present at five points (0.54% coverage/2.26% of points with vegetation) with a mean rake fullness of 1.60 (Figure 13). Following non-significant increases in density and distribution, the 2015 survey found EWM at eight points (0.86% coverage/3.70% of points with vegetation) with a mean rake fullness of 1.63 (Figure 13). After the June 2021 herbicide treatment, the only evidence of EWM in the lake during the July point-intercept survey was a single surviving leaflet on a severely burned stem. This plant was growing on the “reef” northeast of Silo Bay in the only area that was treated with 2, 4-D. Statistically, the 2021 results suggested a significant decline in mean rake fullness; and a significant decline in total EWM and visual sightings (Figure 13).

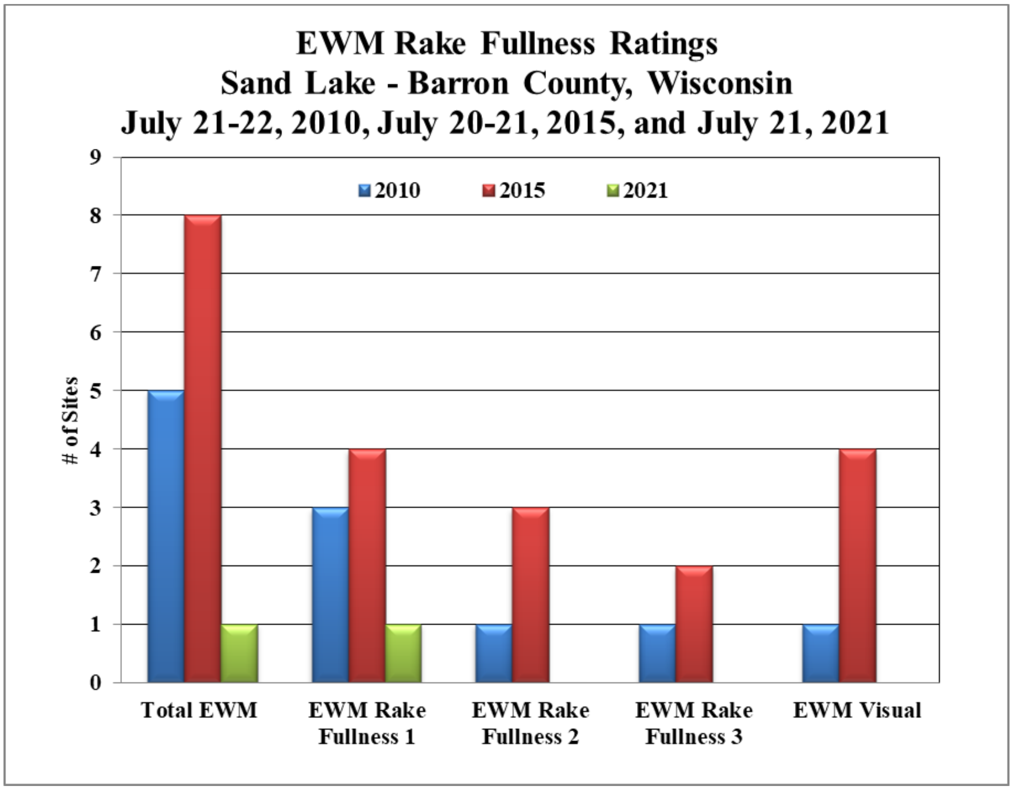


Figure 13: 2010, 2015, and 2021 Changes in EWM rake fullness (ERS, 2021)

Other Non-native Aquatic Plants

In addition to EWM, two other exotic plant species were found growing directly adjacent to the lake. Purple loosestrife (*Lythrum salicaria*) continues to survive in scattered locations around the lakeshore, and Reed canary grass (*Phalaris arundinacea*) was common in disturbed shoreline areas.

2016-2019 Summer Littoral Zone Point-intercept Surveys

From 2016 to 2019, summer sub-basin littoral zone point-intercept (PI) surveys were used to document annual changes in EWM instead of bed mapping.

In 2016 a 518 regular offset point survey grid at 25m resolution, double the approximately 250 littoral points in the original WDNR 932 point-intercept survey grid at 37m resolution, was created (Figure 14). Using this survey grid, summer (July) littoral PI surveys were completed from 2016 to 2019.

Before each survey, the surveyor conducted a general boat survey of the lake to regain familiarity with the species present. All plants found were identified and a field datasheet was developed. During the survey, the surveyor located each point with a handheld mapping GPS unit, recorded a depth reading, and used a rake to sample an approximately 2.5ft section of the bottom. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance. Visual sightings of all plants within six feet of the sample point but not found in the rake were also recorded. In addition to a rake rating for each species, a total rake fullness rating was noted. Substrate (bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake. To further assist with management, the location of any visible Eurasian water-milfoil beds surrounding or between survey points was documented. The perimeters/areas of these beds were not delineated, but they were mapped from the point-intercept data for ease in locating them.

Over the course of the four years when the summer littoral PI survey was completed, each year was compared to the other years. Table 4 reflects the statistics from the four surveys done. Table 5 reflects the minimal changes in the Floristic Quality Index and Mean Coefficient of Conservatism.

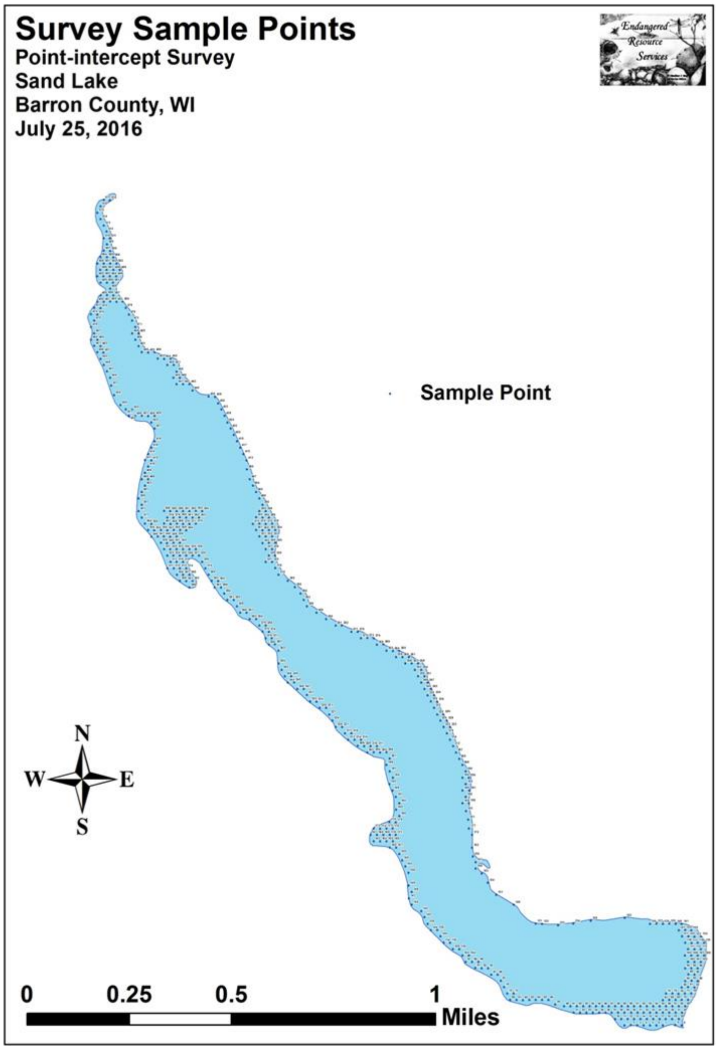


Figure 14: Summer littoral zone sub-basin point-intercept survey points

Table 4: Summer Littoral Zone PI survey statistics 2016-2019

Summary Statistics:	2016	2017	2018	2019
Total number of points sampled	518	518	518	518
Total number of sites with vegetation	470	474	474	472
Total number of sites shallower than the max. depth of plants	517	516	492	497
Freq. of occurrence at sites shallower than max. depth of plants	90.9	91.9	96.3	95.0
Simpson Diversity Index	0.94	0.94	0.93	0.94
Maximum depth of plants (ft)	18.5	19.0	16.0	17.0
Mean depth of plants (ft)	6.3	6.6	6.2	6.5
Median depth of plants (ft)	6.0	6.0	6.0	6.5
Ave. number of all species per site (shallower than max depth)	3.32	3.71	3.80	3.80
Ave. number of all species per site (veg. sites only)	3.65	4.03	3.95	4.00
Ave. number of native species per site (shallower than max depth)	3.29	3.67	3.78	3.77
Ave. number of native species per site (veg. sites only)	3.62	4.01	3.93	3.99
Species richness	43	44	43	45
Species richness (including visuals)	47	49	46	45
Species richness (including visuals and boat survey)	51	52	48	49
Mean rake fullness (veg. sites only)	2.16	2.19	2.18	2.37

Table 5: 2016 to 2019 Changes in the Floristic Quality Index (FQI) and Mean Coefficient of Conservatism (C)

Year	# of Species	Mean C	FQI
2016	41	6.0	38.3
2017	43	6.1	39.8
2018	42	6.0	38.7
2019	43	5.9	38.6

Figure 15 reflects the changes in native aquatic vegetation from 2016 to 2019 based on the summer littoral PI surveys. Only Fries' pondweed (*Potamogeton friesii*), Illinois pondweed (*Potamogeton illinoensis*), and White-water crowfoot (*Ranunculus aquatilis*) saw large declines in distribution from 2016 to 2019. Only white-water crowfoot is likely to have been negatively impacted by the 2,4D treatments over that time. Another native plant species that is very sensitive to 2,4D-based herbicides, Northern watermilfoil (*Myriophyllum sibiricum*) only saw a slight decline over that period.

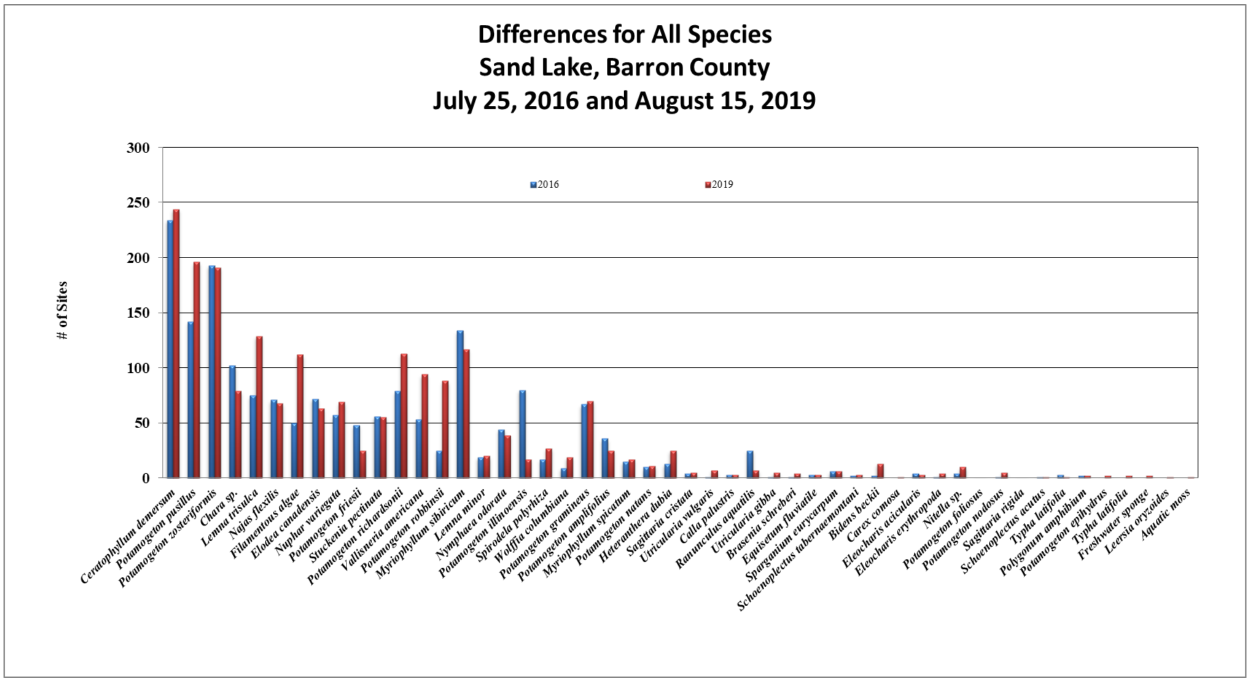


Figure 15: Changes in all aquatic vegetation in Sand Lake from 2016 to 2019

Changes in EWM from 2016-2019

Figure 16 reflects the changes in EWM from 2016 to 2019 as documented by the annual summer littoral zone surveys. Essentially, saw little reduction from 2016 to 2019; however it did not expand in the lake.

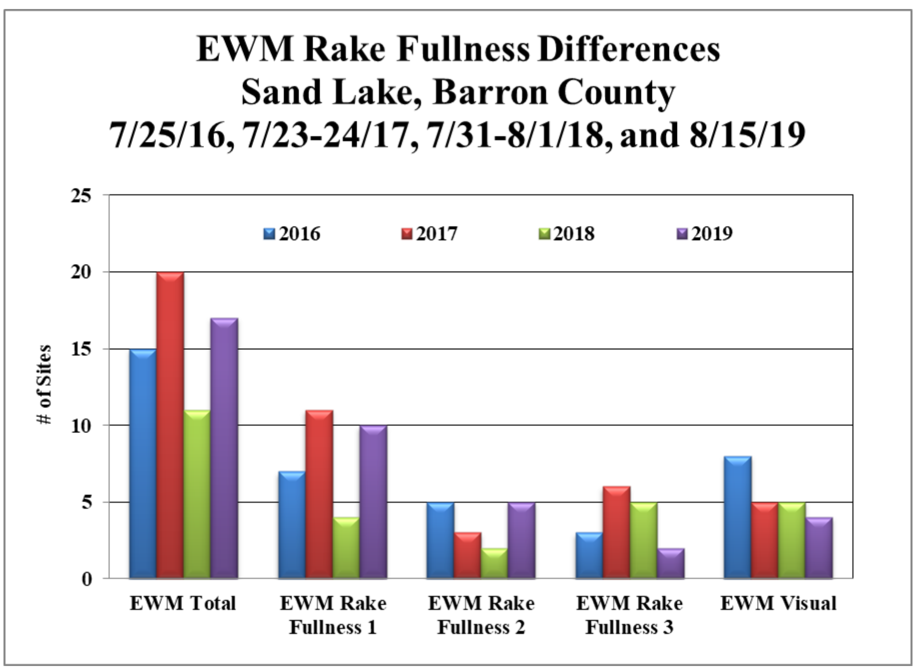


Figure 16: 2016 - 2019 Changes in EWM rake fullness (ERS, 2019)

Thoughts about the Summer Littoral Zone PI Surveys

In general there were not a lot of significant changes detected in EWM or native aquatic plants from 2016 to 2019. The aquatic plant surveyor had this to say about the four years of intensive, summer, littoral zone survey work.

"*After four years of intensively monitoring the lake's summer littoral zone, a review of the value of the data these surveys have produced is likely needed prior to determining monitoring strategies for the future. On the positive side and as intended, the surveys are detecting EWM in deep water at a higher rate than traditional fall bed monitoring. They are also providing annual lakewide data on native plants which would ultimately allow long term trends to be established. On the negative side, the survey is labor intensive, and, consequently, costly. Ultimately, it will be up to the SLMD, LEAPS, and the WDNR to decide if the positives of these intensive summer survey continue to outweigh the negatives. If these intensive surveys are discontinued, it will likely mean returning to pre/post treatment surveys with fall EWM bed mapping, or simply doing fall bed mapping.*"

Another problem with the summer littoral PI surveys was that they did not provide enough detail about EWM in the fall of the year – where it was located, how big the beds were, and the depth and density of the beds. Because of this, it was more difficult to determine subsequent year targeted chemical treatment proposals.

In 2020, after grant support for the summer, littoral zone surveys ran out, fall EWM bed mapping was again used to determine changes in EWM. The information gleaned from the summer littoral survey was valuable and informative, but not enough so to warrant its continued use.

EWM Management History

EWM was first discovered near the boat landing on Sand Lake in 2002. Since that time, management of EWM has been active and consistent. What was discovered in Sand Lake was considered "regular" EWM, not hybrid EWM. This assumption was confirmed in 2014 when the WDNR collected EWM samples from Sand Lake and had it analyzed for hybridization. Table 6 provides a quick breakdown of all EWM management since 2002. Prior to 2009, AIS management planning was provided by BARR Engineering. Since 2009, it has been provided by SEH Inc. and Lake Education and Planning Services (LEAPS) (by the same management planner in both cases). Plant survey work prior to 2008 was completed by BARR, but since then plant survey support has been provided by Endangered Resource Services (ERS).

The majority of EWM in Sand Lake over this time period has been managed using early season/spring small and large-scale herbicide application and from 2006-16, adding mid-season individual and small clump (SWITER) treatments. Physical removal by property owners has been encouraged over all this time, but the amount completed has not been documented. From 2010 to 2012, EWM management implementation was supported by an AIS Established Infestation Control grant, but from 2009 to 2020, all herbicide application has been paid for directly by the SLMD, with support for management planning and aquatic plant surveying provided via AIS Education, Planning and Prevention grant funds.

Through this time period, EWM was consistently treated using 24D-based herbicides either in granular or liquid form. Chemical treatments using 2,4D-based herbicides have been successful at reducing the amount of EWM in treated areas; however, EWM usually reappears after one or two seasons and has needed to be retreated. Figure 17 reflects overlapping chemical treatments from 2006 to 2020 and shows that EWM growth is supported lake-wide. EWM is found in water from 2-13 feet in depth throughout the littoral zone, but is most concentrated in 6-9 feet of water.

Table 6: EWM management history in Sand Lake

Task	2002	2003	2004	2005	2006	2007	2008
APM Plan					X		
AIS Control Grant							
AIS Education Grant							
AIS Early Detection Grant					X		
Spring EWM Treatment (acres)(liquid 24D)							
Spring EWM Treatment (acres)(granular 24D)			1.12	3	31.1	11.2	20
SWITER Treatments (#)					12	23	95
EWM Physical Removal	X	X					
Pre Treatment Plant Survey							
Post Treatment Plant Survey					X		
Fall EWM Bed Mapping							X
Summer EWM Survey					X	X	X
Summer Littoral PI Survey							
Summer Whole-lake, PI Survey							
Residual Testing					X		
Weevil Monitoring					X		

Task	2009	2010	2011	2012	2013	2014	2015
APM Plan		X					
AIS Control Grant			X				
AIS Education Grant						X	
AIS Early Detection Grant							
Spring EWM Treatment (acres)(liquid 24D)			NA	15.31	4.02	8.67	11.1
Spring EWM Treatment (acres)(granular 24D)	10.59	8.11	NA	2.95	3	6.96	5.46
SWITER Treatments (#)	171	57	355	283	136	227	29
EWM Physical Removal							
Pre Treatment Plant Survey		X	X	X	X	X	X
Post Treatment Plant Survey		X		X	X	X	X
Fall EWM Bed Mapping	X	X	X	X	X	X	X
Summer EWM Survey					X		
Summer Littoral PI Survey							
Summer Whole-lake, PI Survey	X						X
Residual Testing				X			
Weevil Monitoring						X	

Task	2016	2017	2018	2019	2020	2021	2022
APM Plan	X						X
AIS Control Grant						X	
AIS Education Grant	X	X					
AIS Early Detection Grant							
Spring EWM Treatment (acres)(liquid 24D)	5.72	13.6	13.9	NA	1.92	3.12	NA
Spring EWM Treatment (acres)(granular 24D)	4.33	NA	0.75	2.54	0.41	NA	NA
Spring EWM Treatment (acres)(ProcellaCOR)	NA	NA	NA	NA	NA	6.4	NA
SWITER Treatments (#)	86	NA	NA	NA	NA	NA	NA
EWM Physical Removal							Diver
Pre Treatment Plant Survey	X					X	
Post Treatment Plant Survey						X	
Fall EWM Bed Mapping					X	X	X
Summer EWM Survey	X						X
Summer Littoral PI Survey	X	X	X	X			
Summer Whole-lake, PI Survey	X					X	
Residual Testing						X	
Weevil Monitoring							
X - Completed							

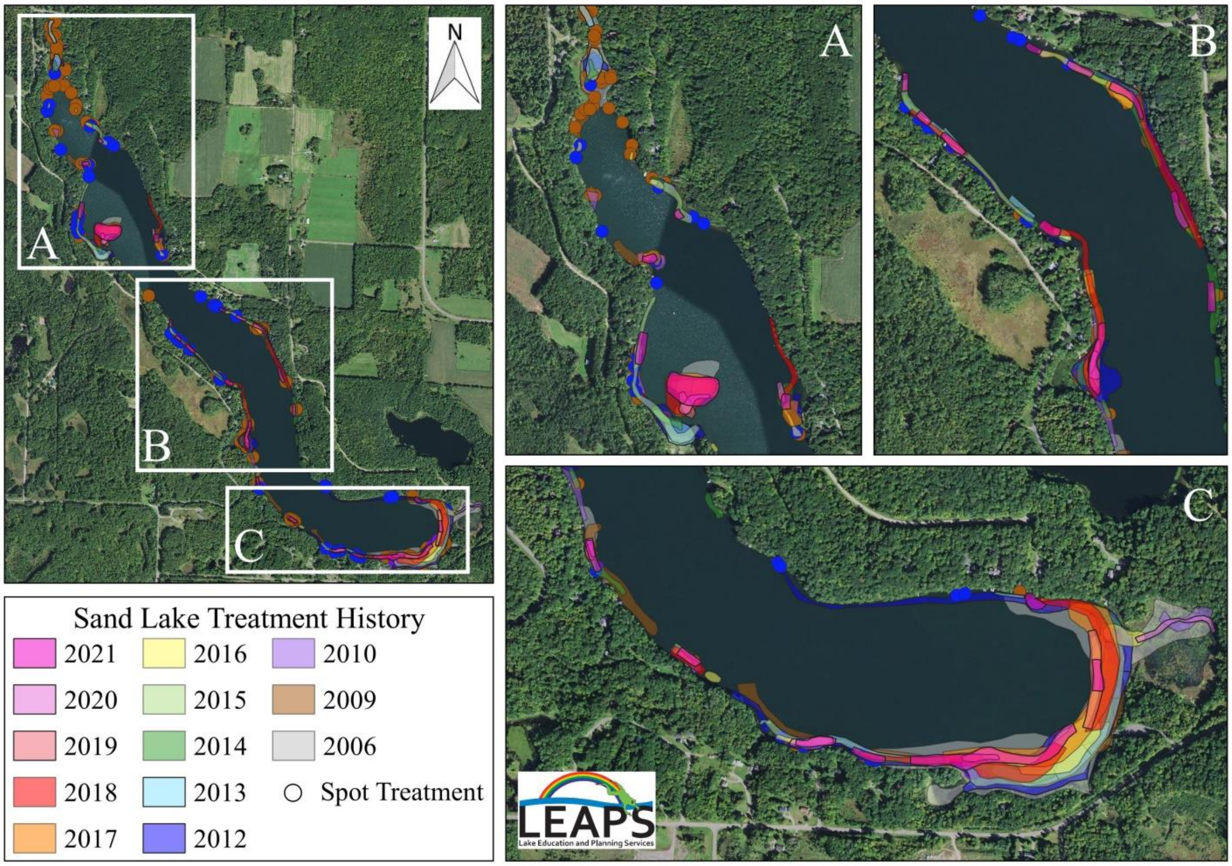


Figure 17: 2006-21 Overlapping EWM chemical treatments

Application of ProcellaCOR

Based on the results from more than 20 years of EWM management using 2,4D-based herbicides, a switch to ProcellaCOR was made in 2021. Fall bed mapping in 2020 identified 27 beds of EWM ranging in size from <0.01 to >1.0 acres totaling 3.18 acres, this despite treating more than two acres in the spring using 2,4D. According to the aquatic plant surveyor, “In general, it appeared the 2020 treatment provided only limited relief as almost all of the treatment areas still had plants present to varying degrees.”

ProcellaCOR is a relatively new aquatic herbicide being used for EWM control. It needs only 2-4 hours of contact time to kill the target species, is applied in ounces not gallons, has been shown to work well on small areas in deep water, and has shown it can prevent regrowth for two or more years. Its only drawback is that it is 3-4 times the cost of using a liquid formulation of a 2,4D- based herbicide.

An AIS control grant was applied for and received in 2021 to support a chemical treatment using both ProcellaCOR and liquid 2,4D to control EWM. ProcellaCOR was used on 20 small treatment areas ranging from 0.15 to0.85 acres. Liquid 2,4D was used on one large bed of 3.12 acres. One area of EWM, known to be one of the hardest to effectively treat with liquid 2,4D was left untreated to act as a control bed. This bed was near several ProcellaCOR treatment areas, but not specifically treated. Pre and post-treatment aquatic plant survey work in 2021 showed that EWM in the control area was “killed” by the ProcellaCOR applied in adjacent beds. In fact, the post-treatment survey showed that all treatment areas, ProcellaCOR and 2,4D, successfully eliminated EWM so that none was found in the 2021 fall bed mapping survey. However, in the summer of 2022, EWM came back in the area treated with 2,4D, but did not return to the areas treated with ProcellaCOR.

Fall Bed Mapping Surveys to Document Changes in EWM

From 2009 to 2015, annual changes in EWM due to management or natural change were documented using fall bed mapping surveys. This method was again used starting in 2020 and will continue in each year of this plan. These surveys search the visible littoral zone of the lake by boat. A bed is determined to be any area where it can be visually estimated that EWM makes up >50% of the area's plants, is generally continuous with clearly defined borders, and is canopied or close enough to being canopied that it would likely interfere with boat traffic. Once a bed is located, the surveyor motors around the perimeter taking GPS coordinates at regular intervals. Rake density range and mean rake fullness of the bed, the range and mean depth of the bed, whether it is canopied, and the impact it was likely to have on navigation (none – easily avoidable with a natural channel around or narrow enough to motor through/minor – one prop clear to get through or access open water/moderate – several prop clears needed to navigate through/severe – multiple prop clears and difficult to impossible to row through) is also determined. The problem with these surveys on Sand Lake is that they tended to miss the deep water EWM beds that were not visible from the surface.

Management and Monitoring of Purple Loosestrife

EWM causes the greatest issues in Sand Lake. Purple loosestrife is common, though not abundant along its shores. The SLMD in cooperation with Barron County released several thousand Galerucella beetles used for biological control back in the early 2000's. In the last several years, the SLMD has set up its own beetle rearing station. Volunteers and property owners remove flower heads and complete physical removal when possible. Both rusty crayfish and Chinese mystery snails are present in the lake, but no active management of these species is completed.

Aquatic Invasive Species (AIS)

Past invasive species monitoring efforts have identified several different plant and animal non-native, invasive species in Sand Lake. Most of these species are considered aquatic, although some are also considered shoreland or wetland type invasive species.

Non-native, Aquatic Invasive Plant Species

EWM is the most problematic non-native, AIS in the lake. In addition, purple loosestrife, Japanese knotweed, and reed canary grass have been identified along the shores of Sand Lake. Purple loosestrife and reed canary grass are shoreland or wetland plants not generally problematic within the lake, but can be very problematic on the shores and in the wetlands adjacent to the lake. Curly-leaf pondweed, another submerged AIS has not been identified in Sand Lake. More information is given for each non-native species in the following sections.

EWM

EWM is a submersed aquatic plant native to Europe, Asia, and northern Africa (Figure 18). It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, EWM is difficult to distinguish from Northern water milfoil. EWM has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

EWM grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

Unlike many other plants, EWM does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. EWM is readily dispersed by boats, motors, trailers, bilges, live wells, and bait buckets; and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, EWM is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of EWM provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of EWM also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by EWM may lead to deteriorating water quality and algae blooms in infested lakes.

Figure 18: EWM

Purple Loosestrife

Purple loosestrife (Figure 19) is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers that vary from purple to magenta possess 5-6 petals aggregated into numerous long spikes, and bloom from August to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat. By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

Purple loosestrife is a wetland herb that was introduced as a garden perennial from Europe during the 1800's. It is still promoted by some horticulturists for its beauty as a landscape plant, and by beekeepers for its nectar-producing capability. Currently, more than 20 states, including Wisconsin have laws prohibiting its importation or distribution because of its aggressively invasive characteristics. It has since extended its range to include most temperate parts of the United States and Canada. The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America.

Purple loosestrife was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the state, and has been recorded in 70 of Wisconsin's 72 counties. Low densities in most areas of the state suggest that the plant is still in the pioneering stage of establishment. Areas of heaviest infestation are sections of the Wisconsin River, the extreme southeastern part of the state, and the Wolf and Fox River drainage systems.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes, and rivers.

Purple loosestrife can germinate successfully on substrates with a wide range of pH. Optimum substrates for growth are moist soils of neutral to slightly acidic pH, but it can exist in a wide range of soil types. Most seedling establishment occurs in late spring and early summer when temperatures are high.

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local perturbation is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Plants may be quite large and several years old before they begin flowering. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. Invasion usually begins with a few pioneering plants that build up a large seed bank in the soil for several years. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland. The plant can also make morphological adjustments to accommodate changes in the immediate environment; for example, a decrease in light level will trigger a change in leaf morphology. The plant's ability to adjust to a wide range of environmental conditions gives it a competitive advantage; coupled with its reproductive strategy, purple loosestrife tends to create monotypic stands that reduce biotic diversity.

Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways.

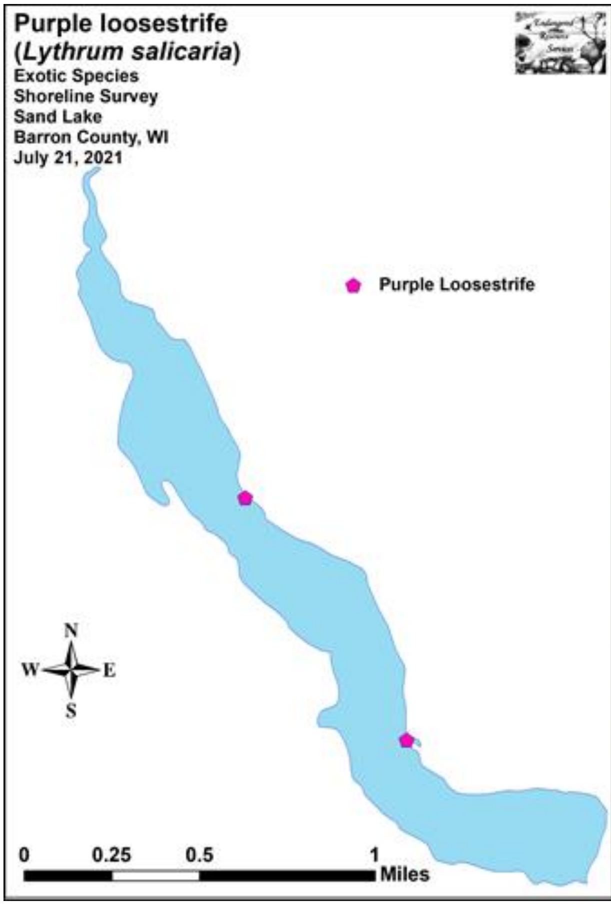


Figure 19: 2021 Purple Loosestrife Distribution – Loosestrife in Bloom among Reed Canary Grass on Sand Lake's Southeast Shoreline – 7/21/21

Japanese Knotweed

Knotweeds are robust, bamboo-like perennials introduced from Asia that are spreading throughout the Great Lakes states. The main species is Japanese Knotweed. Knotweed grows in dense stands 6-12-ft tall. Its stems are hollow, green to reddish in color and bamboo-like. Its leaves are bright green, broad, egg or heart shaped, with a pointed tip. Small white flowers in branched spray appear July through August. Dormant in winter, the dead reddish brown stems often remain standing. It emerges from root crowns in April and reaches full height in June. The heaviest concentrations of knotweed are usually along rivers and roads, but are also found in parks, backyards, along lake shore, in forests and on farms. Japanese knotweed reproduces occasionally by seed, but spreads primarily by extensive networks of underground rhizomes, which can reach 6 feet deep, 60 feet long, and become strong enough to damage pavement and penetrate building foundations. Controlling Japanese knotweed is difficult and requires persistence and diligence. It can be dug, cut, covered, chemically sprayed, or have herbicide injected into individual stems.

It has only been identified at one location in Sand Lake, along the northwest shoreline (Figure 20). In a recent discussion with the property owner, it was discovered that this one location was planted many years ago by a family member. It has since been removed.

Figure 20: Japanese Knotweed in Sand Lake – Photo and Location

Reed Canary Grass

Reed canary grass (Figure 21) is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades 3 1/2 to 10 inches long and 1/4 to 3/4 inch in width. Blades are flat and have a rough texture on both surfaces. The lead ligule is membranous and long. The compact panicles are erect or slightly spreading (depending on the plant's reproductive stage), and range from 3 to 16 inches long with branches 2 to 12 inches in length. Single flowers occur in dense clusters in May to mid-June. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Both Eurasian and native ecotypes of reed canary grass are thought to exist in the U.S. The Eurasian variety is considered more aggressive, but no reliable method exists to tell the ecotypes apart. It is believed that the vast majority of our reed canary grass is derived from the Eurasian ecotype. Agricultural cultivars of the grass are widely planted.

Reed canary grass is a cool-season, sod-forming, perennial wetland grass native to temperate regions of Europe, Asia, and North America. The Eurasian ecotype has been selected for its vigor and has been planted throughout the U.S. since the 1800's for forage and erosion control. It has become naturalized in much of the northern half of the U.S., and is still being planted on steep slopes and banks of ponds and created wetlands.

Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas such as bergs and spoil piles.

Reed canary grass reproduces by seed or creeping rhizomes. It spreads aggressively. The plant produces leaves and flower stalks for 5 to 7 weeks after germination in early spring and then spreads laterally. Growth peaks in mid-June and declines in mid-August. A second growth spurt occurs in the fall. The shoots collapse in mid to late summer, forming a dense, impenetrable mat of stems and leaves. The seeds ripen in late June and shatter when ripe. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.

This species prefers disturbed areas, but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in just a few years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, and deforestation of swamp forests, sedimentation, and intentional planting. The difficulty of selective control makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites.

Reed canary grass is located in many locations along the shoreland of Sand Lake.

Figure 21: Reed Canary Grass

Curly-leaf Pondweed

Curly-leaf pondweed (CLP) is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia (Figure 22). It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. CLP is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures. It has been reported in all states but Maine.

CLP spreads through burr-like winter buds (turions) (Figure 24), which are moved among waterways. These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf pondweed one of the first nuisance aquatic plants to emerge in the spring. It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out-compete native plants in the spring. In mid-summer, when most aquatic plants are growing, CLP plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. CLP forms surface mats that interfere with aquatic recreation.

CLP has not been found in any aquatic plant survey completed on Sand Lake.

Figure 22: CLP Plants and turions

Non-native Aquatic Invasive Animal Species

Several non-vegetative, aquatic, invasive species are in nearby lakes, but have not been identified in Sand Lake. One species, Chinese mystery snails have been. It is important for lake property owners and users to be knowledgeable of these species in order to identify them if and when they show up in Sand Lake.

Chinese Mystery Snails

The Chinese mystery snails and the banded mystery snails (Figure 23) are non-native snails that have been found in a number of Wisconsin lakes including Sand Lake (2003). There is not a lot yet known about these species, however, it appears that they have a negative effect on native snail populations. The mystery snail's large size and hard operculum (a trap door cover which protects the soft flesh inside), and their thick hard shell make them less edible by predators.

The female mystery snail gives birth to live crawling young. This may be an important factor in their spread as it only takes one impregnated snail to start a new population. Mystery snails thrive in silt and mud areas although they can be found in lesser numbers in areas with sand or rock substrates. They are found in lakes, ponds, irrigation ditches, and slower portions of streams and rivers. They are tolerant of pollution and often thrive in stagnant water areas. Mystery snails can be found in water depths of 0.5 to 5 meters (1.5 to 15 feet). They tend to reach their maximum population densities around 1-2 meters (3-6 feet) of water depth. Mystery snails do not eat plants. Instead, they feed on detritus and in lesser amounts on algae and phytoplankton. Thus removal of plants along the shoreline area will not reduce the abundance of mystery snails.

Lakes with high densities of mystery snails often see large die-offs of the snails. These die-offs are related to the lake's warming coupled with low oxygen (related to algal blooms). Mystery snails cannot tolerate low oxygen levels. High temperatures by themselves seem insufficient to kill the snails as the snails could move into deeper water.

Many lake residents are worried about mystery snails being carriers of the swimmer's itch parasite. In theory they are potential carriers, however, because they are an introduced species and did not evolve as part of the lake ecosystem, they are less likely to harbor the swimmer's itch parasites.

Figure 23: Chinese Mystery Snails (not from Sand Lake)

Rusty Crayfish

Rusty crayfish (Figure 24) live in lakes, ponds and streams, preferring areas with rocks, logs and other debris in water bodies with clay, silt, sand or rocky bottoms. They typically inhabit permanent pools and fast moving streams of fresh, nutrient-rich water. Adults reach a maximum length of 4 inches. Males are larger than females upon maturity and both sexes have larger, heartier, claws than most native crayfish. Dark “rusty” spots are usually apparent on either side of the carapace, but are not always present in all populations. Claws are generally smooth, with grayish-green to reddish-brown coloration. Adults are opportunistic feeders, feeding upon aquatic plants, benthic invertebrates, detritus, juvenile fish and fish eggs.

The native range of the rusty crayfish includes Ohio, Tennessee, Kentucky, Indiana, Illinois and the entire Ohio River basin. However, this species may now be found in Michigan, Massachusetts, Missouri, Iowa, Minnesota, New York, New Jersey, Pennsylvania, Wisconsin, New Mexico and the entire New England state area (except Rhode Island). The Rusty crayfish has been a reported invader since at least the 1930’s. Its further spread is of great concern since the prior areas of invasion have led to severe impacts on native flora and fauna. It is thought to have spread by means of released game fish bait and/or from aquarium release. Rusty crayfish are also raised for commercial and biological harvest.

Rusty crayfish reduce the amount and types of aquatic plants, invertebrate populations, and some fish populations--especially bluegill, smallmouth and largemouth bass, lake trout and walleye. They deprive native fish of their prey and cover and out-compete native crayfish. Rusty crayfish will also attack the feet of swimmers. On the positive side, rusty crayfish can be a food source for larger game fish and are commercially harvested for human consumption.

Rusty crayfish may be controlled by restoring predators like bass and sunfish populations. Preventing further introduction is important and may be accomplished by educating anglers, trappers, bait dealers and science teachers of their hazards. Use of chemical pesticides is an option, but does not target this species and will kill other aquatic organisms.

It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except the Mississippi River). It is also illegal to release crayfish into a water of the state without a permit.

Rusty crayfish were first identified in Sand Lake in 2009.

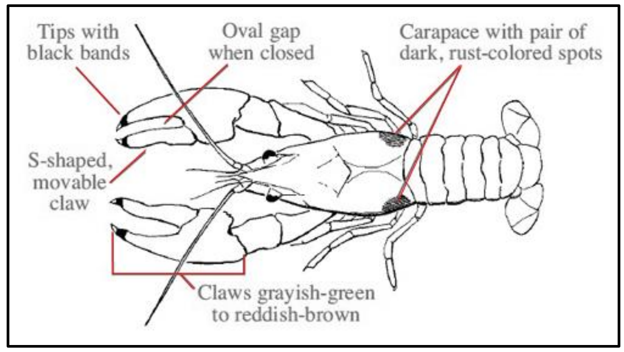


Figure 24: Rusty crayfish and identifying characteristics

Zebra Mussels

Zebra mussels (Figure 25) are an invasive species that have inhabited Wisconsin waters and are displacing native species, disrupting ecosystems, and affecting citizens' livelihoods and quality of life. They hamper boating, swimming, fishing, hunting, hiking, and other recreation, and take an economic toll on commercial, agricultural, forestry, and aquacultural resources. The zebra mussel is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986, and have been spreading throughout them since that time. They were most likely brought to North America as larvae in ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes. Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.

Zebra mussels feed by drawing water into their bodies and filtering out most of the suspended microscopic plants, animals and debris for food. This process can lead to increased water clarity and a depleted food supply for other aquatic organisms, including fish. The higher light penetration fosters growth of rooted aquatic plants which, although creating more habitat for small fish, may inhibit the larger, predatory fish from finding their food. This thicker plant growth can also interfere with boaters, anglers and swimmers. Zebra mussel infestations may also promote the growth of blue-green algae, since they avoid consuming this type of algae but not others.

Zebra mussels attach to the shells of native mussels in great masses, effectively smothering them. A survey by the Army Corps of Engineers in the East Channel of the Mississippi River at Prairie du Chien revealed a substantial reduction in the diversity and density of native mussels due to Zebra Mussel infestations. The East Channel provides habitat for one of the best mussel beds in the Upper Mississippi River. Future efforts are being considered to relocate such native mussel beds to waters that are less likely to be impacted by zebra mussels.

Once zebra mussels are established in a water body, very little can be done to control them. It is therefore crucial to take all possible measures to prevent their introduction in the first place. Some of the preventative and physical control measures include physical removal, industrial vacuums, and back flushing.

Chemical applications include solutions of chlorine, bromine, potassium permanganate and even oxygen deprivation. An ozonation process is under investigation (patented by Bollyky Associates Inc.) which involves the pumping of high concentrations of dissolved ozone into the intake of raw water pipes. This method only works in controlling veligers, and supposedly has little negative impacts on the ecosystem.

Further research on effective industrial control measures that minimize negative impacts on ecosystem health is needed.

Zebra mussels have not been found in Sand Lake, but are in several nearby lakes including Big and Middle McKenzie Lakes in Burnett County, and in Deer Lake in Polk County.

Figure 25: Zebra mussels from Big McKenzie Lake in Burnett County (2019)

AIS Prevention Strategy

Sand Lake already has several established AIS. However there are many more that could be introduced to the lake. The SLMD has and will continue to implement a watercraft inspection and AIS Signage program at the public access point on the lake. Information will be shared with lake residents and users in an effort to expand the watercraft inspection message. In addition to the watercraft inspection program, an in-lake and shoreland AIS monitoring program will be implemented. Both of these programs will follow UW-Extension Lakes and WDNR protocol through the Clean Boats, Clean Waters program and the CLMN AIS Monitoring program.

Additionally, having an educated and informed lake constituency is the best way to keep non-native AIS at bay in Sand Lake. To foster this, the SLMD will host and/or sponsor lake community events including AIS identification and management workshops; distribute education and information materials to lake property owners and lake users through the newsletter, webpage, and general mailings.

Integrated Pest Management

Integrated Pest Management (IPM) is an ecosystem-based management strategy that focuses on long-term prevention and/or control of a species of concern. IPM considers all the available control practices such as: prevention, biological control, biomanipulation, nutrient management, habitat manipulation, substantial modification of cultural practices, pesticide application, water level manipulation, mechanical removal and population monitoring (Figure 26). In addition to monitoring and considering information about the target species' life cycle and environmental factors, groups can decide whether the species' impacts can be tolerated or whether those impacts warrant control. Then, an IPM-based plan informed by current, comprehensive information on pest life cycles and the interactions among pests and the environment can be formed.

After monitoring and considering information about the target species' life cycle and environmental factors, groups can decide whether the species' impacts can be tolerated or whether those impacts warrant control. If control is needed, data collected on the species and the waterbody will help groups select the most effective management methods and the best time to use them.

The most effective, long-term approach to managing a species of concern is to use a combination of methods. Approaches for managing pests are often grouped in the following categories:

- **Assessment** – is the use of learning tools and protocols to determine a waterbodies' biological, chemical, physical and social properties and potential impacts. Examples include: point-intercept (PI) surveys, water chemistry tests and boater usage surveys. This is the most important management strategy on every single waterbody.
- **Biological Control –** is the use of natural predators, parasites, pathogens and competitors to control target species and their impacts. An example would be beetles for purple loosestrife control.
- **Cultural controls** – are practices that reduce target species establishment, reproduction, dispersal, and survival. For example, a Clean Boats, Clean Waters program at boat launches can reduce the likelihood of the spread of species of concern.
- **Mechanical and physical controls –** can kill a target species directly, block them out, or make the environment unsuitable for it. Mechanical harvesting, hand pulling, and diver assisted suction harvesting are all examples.
- **Chemical control** – is the use of pesticides. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Groups should use the most selective pesticide that will do the job and be the safest for other organisms and for air, soil, and water quality.

(Additional information on each method is outlined in the following section).

IPM is a process that combines informed methods and practices to provide long-term, economic pest control. A quality IPM program should adapt when new information pertaining to the target species is provided or monitoring shows changes in control effectiveness, habitat composition and/or water quality.

While each situation is different, eight major components should be established in an IPM program:

1. Identify and understand the species of concern

2. Prevent the spread and introduction of the species of concern
3. Continually monitor and assess the species' impacts on the waterbody
4. Prevent species of concern impacts
5. Set guidelines for when management action is needed
6. Use a combination of biological, cultural, physical/mechanical and chemical management tools
7. Assess the effects of target species' management
8. Change the management strategy when the outcomes of a control strategy create long-term impacts that outweigh the value of target species control.

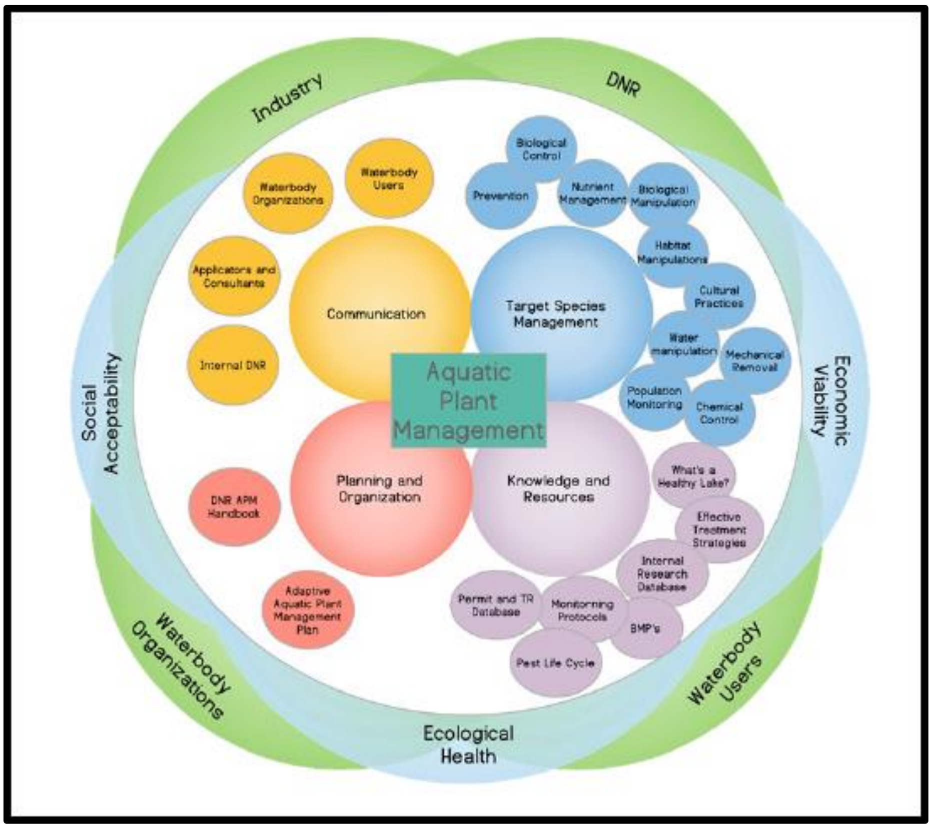


Figure 26: Wisconsin Department of Natural Resources: Wisconsin Waterbodies – Integrated Pest Management March 2020

Aquatic Plant Management Alternatives

Protecting native plants and limiting EWM through IPM is a primary focus of plant management in Sand due to its diverse plant community and the benefits it offers. Generally, control methods for nuisance aquatic plants can be grouped into four broad categories:

- Chemical control: use of herbicides
- Mechanical/physical control: pulling, cutting, raking and harvesting

- Biological control: the use of species that compete successfully with the nuisance species for resources
- Aquatic plant habitat manipulation: dredging, flooding, and drawdowns

In many cases, an IPM approach to aquatic plant management is the best way to protect and enhance the native plant community while maintaining functional use of the lake.

Physical/Manual Removal: Recommended

Physical removal will be completed by educated landowners who monitor their own shorelines or by a trained EWM Management Team sponsored by the SLMD. There is no limit as to how far out into the lake this management activity can occur, provided the area cleared is no more than 30-ft wide. It limits disturbance to the lake bottom, is inexpensive, and can be practiced by many lake residents. Landowners should also continually monitor near their docks and swimming areas in the open water season and remove rooted plants as well as floating fragments that wash into their shoreline.

Pulling EWM while snorkeling or scuba diving in deeper water is also allowable without a permit and can be effective at slowing the spread of a new aquatic invasive species infestation within a waterbody when done properly. Diver removal will be completed by SLMD volunteers and/or resource professionals retained by the SLMD. These efforts will focus on smaller beds not treated with chemical herbicides in areas not directly adjacent to any landowner’s property.

Diver Assisted Suction Harvesting

Diver assisted suction harvesting or DASH is a fairly recent aquatic plant removal technique. It is called "harvesting" rather than "dredging" because, although a specialized small-scale dredge is used, bottom sediment is not removed from the system. The operation involves hand-pulling of weeds from the lake bed by a scuba diver and inserting them into an underwater vacuum system that sucks up plants and their root systems taking them to the surface. It requires water pumps on the surface (generally on a pontoon system) to move a large volume of water to maintain adequate suction of materials that the divers are processing. Only clean water goes through the pump.

The material placed by the divers into the suction hose along with the water is deposited into mesh bags on the surface with the water leaving through the holes in the bag. The bags have a large enough 'mesh' size so that silts, clay, leaves and other plant material being collected do not immediately clog them and block water movement. If a fish or other living marine life is sucked into the suction hose it comes out the discharge unharmed and is returned to the body of water.

DASH can have some negative impacts to other nearby non-target plants if not done carefully, particularly those plants that are perennials and expand their populations by sub-sediment runners Eichler et al. (1993).

The cost to implement DASH is more expensive than employing a diver alone. A DASH boat consists of a pontoon boat equipped with the necessary water pump, catch basin, suction hose, and other apparatus (Figure 27). Estimates made to build a custom DASH boat range from $15,000.00 to $20,000.00. Contracted DASH services usually run in the $2,000.00 to $3,000.00 per day range. Contracted large-scale removal of EWM through DASH at around $2,500.00 per day is relatively expensive.

DASH could be an effective way to manage small areas of EWM in Sand Lake, provided the conditions for harvest are conducive to it. How successful DASH operations can be is dependent on the type of bottom substrate, the density of the EWM in the areas where DASH is used, water clarity, and the amount of other vegetation present. DASH also requires a Mechanical Harvesting permit from the WDNR.

Figure 27: DASH – Feeding EWM into the underwater Suction Hose (Marinette Co.); and a sample DASH Pontoon Boat (Beaver Dam Lake Management District)

Chemical Herbicide Treatments: Recommended

Herbicides will be used to manage existing EWM and any existing or new areas with moderate to severe growth density and deemed too large for effective physical removal. Determining which herbicide to use (as approved by the state of Wisconsin) and at what concentration will be determined on a yearly basis during the treatment planning phase. Spring application of herbicides is preferred to reduce negative effects on native plants.

There are several chemical herbicide options currently available in the State of Wisconsin (as approved by the Environmental Protection Agency). There are two classes of aquatic chemical herbicides currently in use:

1) Systemic: moves through the entire plant. It is absorbed through the leaves or stem and moves through the entire plant and usually results in the death of the plant within two or more weeks
2) Contact: kills the plant at the point of contact. The entire plant may not be damaged, and the roots may still be viable for regrowth. Mostly used when an immediate removal of a plant is required.

Available aquatic herbicides for EWM include:

ProcellaCOR®

ProcellaCOR® is a relatively new systemic, selective herbicide that can be used to target EWM with limited impact to most native species. It is also very fast acting, making it an effective control measure on smaller beds, especially ones in high boat traffic areas and/or deeper water. In addition, applications rates are measured in ounces, not gallons as is common with almost all other liquid herbicides. And while it is more expensive to use than 2,4D equivalents, it has been shown to provide two or more years of control without re-application.

Triclopyr

Triclopyr is a selective, systemic herbicide used to control broadleaf plants like EWM by mimicking plant hormones. Liquid triclopyr (Renovate®) or granular triclopyr combined with granular 2,4-D (Renovate Max G®) may be an option in the lakes.

2,4D (liquid)

2,4D is a commonly used systemic herbicide that targets dicot plants (or broad-leaved plants) like EWM. Monocots (like pondweed species and water celery) are generally not affected by 2,4D. Shredder Amine 4®, also referred to as 2,4D Amine 4® is a liquid formulation of 2,4D. The use of liquid 2,4D products is supported by the WDNR, however, at the present time; Regional WDNR Aquatic Plant Management Personnel recommend that a treatment area be at least 5 acres in size to use liquid 2,4D.

Both liquid 2,4D and ProcellaCOR have been used to control EWM in Sand Lake. Both can effectively control EWM, but so far only ProcellaCOR has been able to provide two or more years of control without regrowth in treated areas, although there is only one year of data to support this claim about ProcellaCOR. It is recommended that ProcellaCOR be used for future EWM management implementation, particularly in any treatment area less than 5 acres in size. Larger areas could be treated with liquid 2,4D if financial resources are limited.

Chemical Herbicide Treatments: Not Recommended

The following herbicides and/or herbicide formulations have also been used effectively for control of EWM but are not recommended for use in Sand Lake.

2,4-D (granular)

Granular 2,4-D, under the trade name Navigate® or Sculpin G® has been effectively used in Sand Lake to treat EWM in the past, and its use may be warranted again in the future. Granular 2,4D products are more expensive than their liquid counterparts and recent research has shown that it does not work any better than a liquid formulation. As such, the WDNR will generally not fund EWM management (through grants) that incorporates small-scale treatment with 2,4D-based herbicides, granular or liquid. The WDNR will often not approve chemical application permits using 2,4D herbicides if the areas treated are not at least 5 acres in size. If a treatment area is at least 5 acres in size, liquid 2,4D would likely be used. So in general, granular 2,4D herbicides are not recommended.

Fluridone (liquid)

Fluridone is also a non-selective, systemic herbicide often used for whole-lake treatment. It is slow-acting and can be selective to EWM at low concentrations; however, the contact time must be very long in order for this to be effective, which may not be practical in the lakes depending on water movement, wind and weather during and after applications. At the present time, whole-lake management of EWM is not a recommendation in this plan. As such, Fluridone is not appropriate for use in Sand Lake.

Diquat (liquid)

Diquat is non-selective contact herbicide that is commonly used to control emergent and submersed aquatic vegetation. It is fast-acting and has no restrictions for swimming, fish, or wildlife, but there may be irrigation and drinking water restrictions for up to 5 days. Diquat-based herbicides are often used as a low-cost alternative for EWM control when the goal is only to provide immediate relief, without any expectations of long-term results. As a non-selective contact herbicide, it is generally not going to be an option in lakes where the native plant community is so valuable and the risk of stressing the native plants and allowing EWM to re-grow would be detrimental to the lake.

Endothall (liquid)

Endothall is a non-selective contact herbicide most often used for the control of curly-leaf pondweed. IT can be effective at killing EWM if the concentration is high enough. As a contact, herbicide, it would likely provide one season's worth of relief, but would not be expected to be a long-term solution. Endothall requires an herbicide/target species contact time similar to 2,4D based products and is as or more expensive than them. As such it is not recommended for use in Sand Lake.

Mechanical Harvesting: Not Recommended

Harvesters can remove thousands of pounds of vegetation in a relatively short time period. They are not, however, species specific. Everything in the path of the harvester will be removed, including the target species, other plants, macro-invertebrates, semi-aquatic vertebrates, forage fishes, young-of-the-year fishes, and even adult game fish found in the littoral zone (Booms, 1999). Plants are cut at a designated depth, but the roots of the plants are often not disturbed. Cut plants will usually grow back after time, and re-cutting several times a season is often required to provide adequate annual control (Madsen, 2000).

Harvesting activities in shallow water can re-suspend bottom sediments into the water column releasing nutrients and other accumulated compounds (Madsen, 2000). Even the best aquatic plant harvesters leave some cutting debris in the water to wash up on the shoreline or create loose mats of floating vegetation on the surface of the lake. This "missed" cut vegetation can potentially increase the amount of EWM in a lake by creating more fragments that can go on to establish new sites elsewhere. A major benefit, however, of aquatic plant harvesting is the removal of large amounts of plant biomass from a water body. Mechanical harvesting is not recommended in Sand Lake as the goal of EWM management is to reduce the overall distribution and density of EWM to a low level, not just to get it out of the lake.

Biological Control: Not Recommended

Biological control uses one or more living organisms to control, or suppress, another living organism. Milfoil weevils (*Euhychiopsis lecontei)* are one method used to manage EWM. Weevils are an alternative to chemical treatments and potentially damaging mechanical harvesting. However, they are expensive to rear, easily predated on by sunfish, and only suppress – not eliminate – EWM.

The milfoil weevil is native to North America is likely present at some level in the lake, naturally. A milfoil weevil survey was completed in Sand Lake several years ago. Weevils were present, but in very low numbers. However, attempting to artificially increase their population as a biological control method is not recommended.

Habitat Manipulation: Not Recommended

Habitat manipulation can take the form of flooding, dredging and drawdowns. None of these options are recommended or viable in Sand Lake. Flooding and drawdowns are not possible because there is no dam at the outlet capable of manipulating water levels. Dredging is not recommended because the high-water quality and valuable habitat of the lakes would be jeopardized by removing large quantities of substrate and bottom materials.

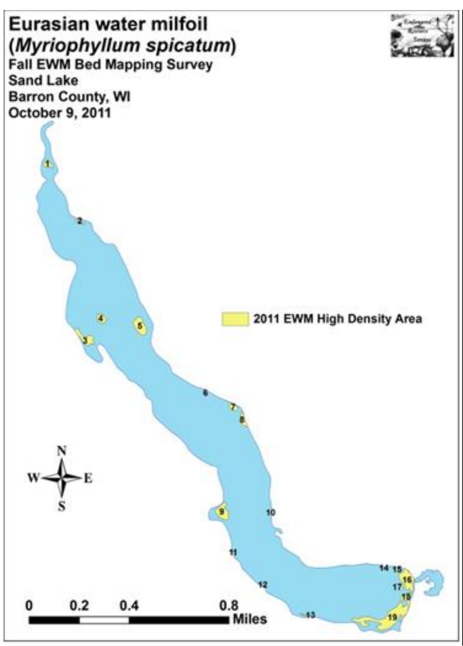
No Management: Not Recommended

Regardless of the target plant species, native or non-native, sometimes no management is the best management option. Plant management activities can be disruptive to areas identified as critical habitat for fish and wildlife and should not be done unless it can occur without ecological impacts. This management alternative is not recommended for Sand Lake due to EWM's proven ability to overtake large areas of the lake if left unmanaged for two or more years. Additionally, limiting the spread of EWM within the lake through management protects the ecological integrity of the lake long-term.

Aquatic Plant Management Discussion

In 16 of the last 18 years (2004-2022) aquatic herbicides have been used to manage EWM. The greatest acreage managed was in the early years of the infestation (2006-08) when an average of nearly 21 acres a year was chemically treated. Since those treatments, the total acreage of EWM managed in a single year has only gotten close to that average in one year (2012 – 18.25 acres) following a year when no EWM management was completed (2011). After 2012, it took another five years of chemical management treating more than 10 acres annually to finally bring the amount of EWM back down to a low level. Since 2018 (the last time >10 acres of EWM was chemically treated in a single year) only an average of 2.66 acres of EWM has been chemically managed. In 2022, no EWM was chemically managed. The year 2022 followed the first year (2021) ProcellaCOR was used to control EWM. The expectation was that the ProcellaCOR used in 2021 would provide better control for a longer period of time. This appears to be the case, as almost no EWM was found in 2022 in the areas treated with ProcellaCOR in 2021. This was not that case in 2011, the year after a "successful" 2,4D-based herbicide application in 2010.

In the fall of 2010, the aquatic plant surveyor only found 5 true beds of EWM totaling just 0.22 acres with a handful of additional plants scattered around the lake. In fall of 2011, after a year with no management, the surveyor identified 94 beds ranging in size from $5m^2$ to approximately $30m^2$. Between the beds, there were usually large gaps, but most of these areas had EWM plants as well. In addition to these numerous small beds, an additional 478 plants were marked. After mapping all plants and beds, the surveyor identified 19 "High Density Areas" that had large numbers of EWM plants that ranged in size from 0.02 acres to 5.29 acres and produced a combined total of 15.27 acres (Figure 28). A note made by the surveyor in his 2011 Summary Report stated that, "although these were not true beds with "continuous areas of > 50% EWM and clearly defined borders", the EWM was obviously expanding and deserves consideration for treatment in 2012."



Number	2011 Fall Acreage	2011 Fall Perimeter	Mean Rake Fullness
1	0.48	192	<1-1
2	0.17	162	1-2
3	1.27	415	<1-1
4	0.66	194	<1-1
5	1.61	323	<1-3
6	0.03	38	2
7	0.44	169	<1-2
8	0.60	240	<1-2
9	1.49	340	<1-3
10	0.02	35	2-3
11	0.06	90	<1-2
12	0.02	48	<1-1
13	0.10	171	<1-2
14	0.08	112	<1-3
15	0.16	110	<1-3
16	2.12	422	<1-1
17	0.09	71	1-3
18	0.56	206	<1-3
19	5.29	1,305	<1-3
Total Acres	15.25		

Figure 28: Fall 2011 EWM bed mapping results (Berg, 2011)

From this history, it is clear that when EWM is left unmanaged in the lake, it tends to expand its distribution and density rapidly. So completing no EWM management in any given year is not recommended. And, at least anecdotally it appears that using ProcellaCOR provides a longer time period of control than did liquid 2,4D herbicides.

Sand Lake supports a valuable aquatic plant community and a quality fishery valued by the lake community and the general public. EWM is the only known fully aquatic invasive species in the lake, and is widespread throughout most of the littoral zone. The main goal of the APM Plan is to control EWM in a sound, ecological manner to minimize the effect on native plants while keeping EWM at as low a level as resources allow. To do this, a new scenario-based approach to EWM management will be implemented with this APM Plan.

Scenario Based Management

In a scenario-based approach to EWM management, there is no set minimum or maximum amount of EWM that is "OK" in the lake, or a "trigger" for management. Any amount of EWM at any time can and should be managed in the lake, albeit using different management alternatives. When to use what management alternative is the basis of a scenario-based approach to control EWM while at the same time, minimizing issues that might be caused to native aquatic vegetation, either by greater amounts of EWM or from the management used to control EWM.

This plan recognizes that the financial and/or human resources necessary to implement any given management action may exceed the ability of the lake organization to implement it. If the resources available to manage EWM are limited, Figure 29 provides a method to determine priority. Referred to as FLIPS, it involves evaluating each areas of EWM in the lake in any given year based on when it was first discovered and managed (Formation), where it is located (Location), whether it causing issues (Impairment), whether it was mapped in a previous year (Prior Year), and whether it is negatively impacting the native aquatic plant community (Sensitive Area).

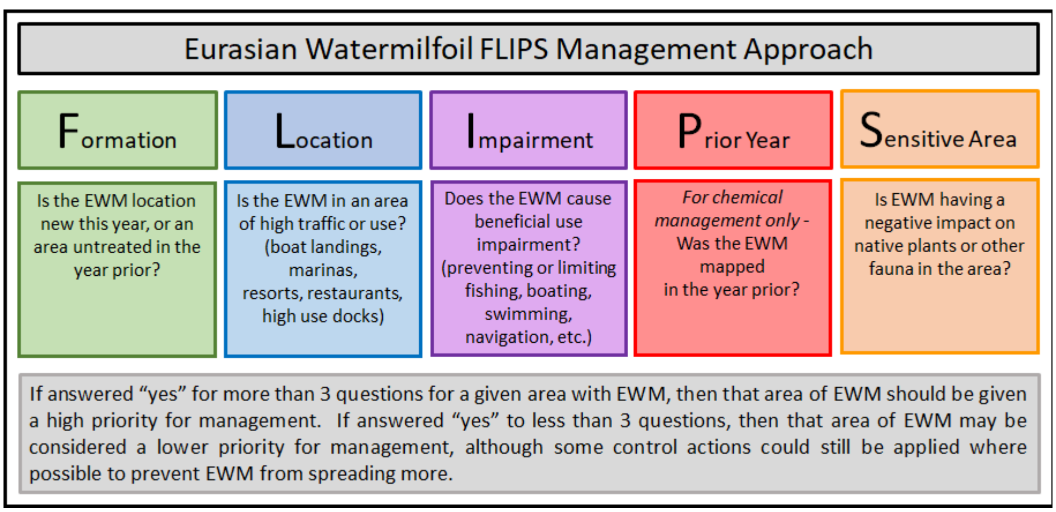


Figure 29: FLIPS Management Priority Matrix

A combination of chemical and manual/physical removal control methods are recommended for Sand Lake. Mechanical harvesting (except for DASH), artificially enhanced biological control (for EWM), habitat manipulation, and zero management are not recommended at this time.

Given the goal of the SLMD is to control EWM in a sound, ecological manner, the following monitoring and control activities have been outlined:

1) EWM will be monitored by volunteers throughout the growing season.
2) Fall bedmapping will be completed annually by a Resource Professional or trained SLMD volunteers.
3) Areas of EWM with sparse, isolated plants will be hand pulled or raked by volunteers in shallow water (≈ 5 feet) around docks and along shorelines.
    a. These services can be completed at any time during the open-water season and do not require a WDNR permit.
4) Snorkel, rake, and/or scuba diver removal of EWM will take place in areas with isolated plants, small clumps, or small beds of plants where practical and if resources are available.
    a. These services would likely be contracted by the SLMD, can be completed at any time during the open-water season, and do not require a WDNR permit.
5) Diver-assisted Suction Harvest or DASH can be used in place of or in combination with snorkel, rake, and/or scuba diver removal of EWM where practical and if resources are available.
    a. These services would likely be contracted by the SLMD, can be completed at any time during the open-water season, and require a WDNR Mechanical Harvesting permit.
    b. DASH may allow larger areas of EWM to be managed without the use of herbicides.
6) Aquatic herbicides can be used in any area if its application can be justified under the following guidelines
    a. The SLMD can show that other management methods have been tried and did not work
    b. Conditions exist that are likely to make other management alternatives less effective
        i. Bed size and density of EWM in the area
        ii. Location of the area in relation to lake access and usability
        iii. Water depth and clarity
        iv. Limited or unavailable access to contracted diver or DASH services
        v. Limited financial resources
        vi. Less than a majority constituent support for a proposed management action.
    c. Areas that are <5.00 acres should be treated with ProcellaCOR
    d. Areas ≥5.0 acres may be treated with ProcellaCOR, 2,4D-based herbicides, or 2,4D/triclopyr blends, depending on available resources.
        i. Treatments larger than 9 acres (10% of the littoral zone) will be considered large-scale
            1. Pre (prior year) and post (year of and/or year after) treatment aquatic plant surveys should be considered.
            2. Herbicide concentration testing should be considered.
    e. The same area will not be chemically treated two years in a row with the same herbicide.

Figure 30 further delineates when to do EWM management, what management actions to consider, and the parameters involved in making management decisions. It is not to be considered a concrete and unyielding approach to management, but rather a guide to lead management discussion. Actual management decisions will be based on the resources available, what is acceptable to the constituency, and what the WDNR will approve.

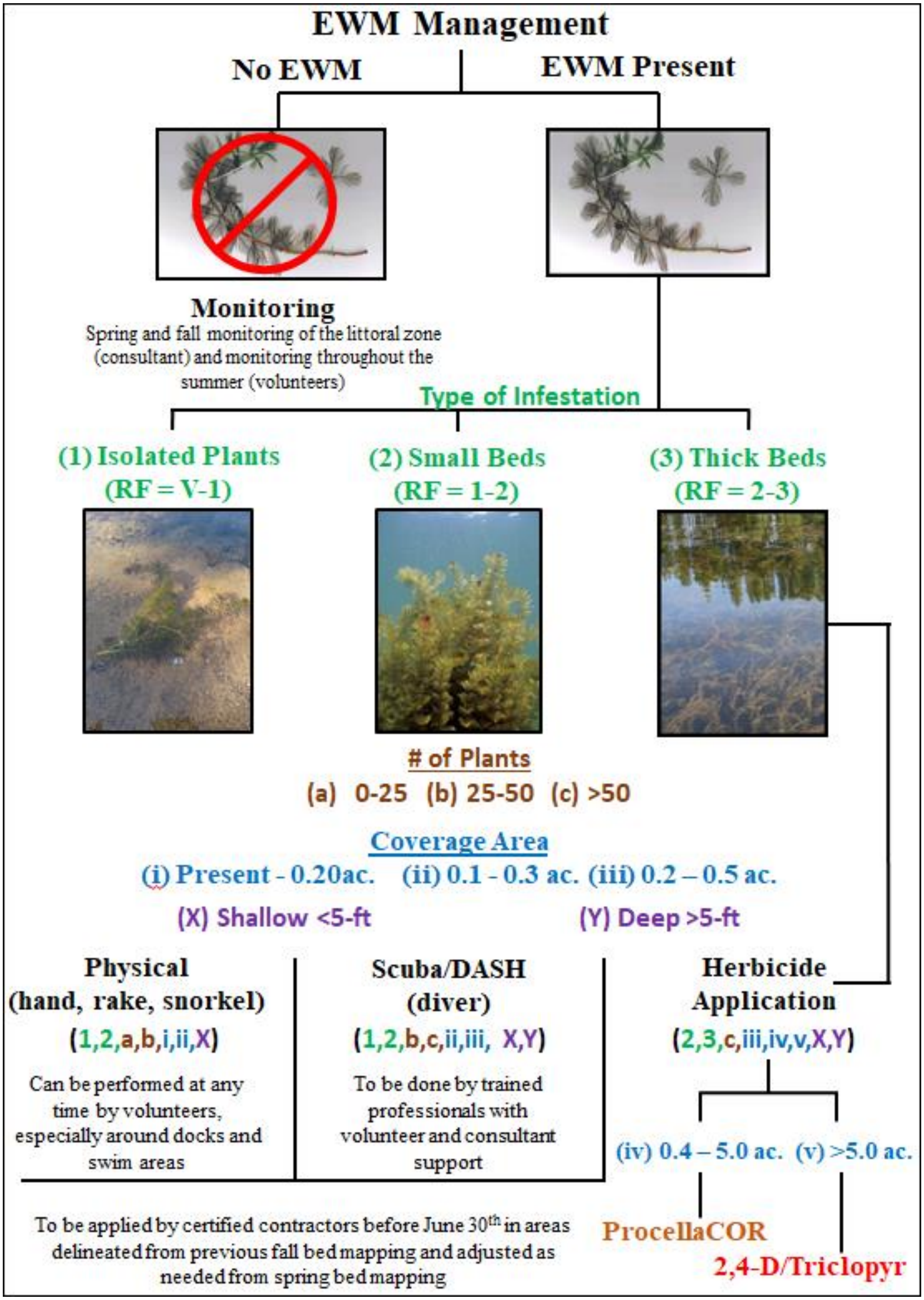


Figure 30: Flow chart guide to appropriate EWM control methods

Overuse of Aquatic Herbicides

Concerns exist when herbicide treatments using the same herbicide are done over multiple and subsequent years. Target plant species may build up a tolerance to a given herbicide making it less effective, susceptible plant species may be damaged and/or disappear from the lake (ex. water lilies), concerns over fish and other wildlife might occur, and concern over recreational use in chemically treated water may be voiced. By using several different aquatic herbicides interspersed with physical removal efforts between treatments, many of these concerns are minimized. Given the treatment history on the lakes and the recent plant surveys, the chemical treatments that are occurring are not likely to be causing great environmental harm. If there are any negative impacts to native plants in treated areas, plants would be available from other areas of the lake to re-colonize that location. It is also likely that an extensive seed bank of native plants throughout the lake would aide in the recovery of any area impacted by management actions.

Aquatic Plant Management Plan

This Aquatic Plant Management Plan establishes the following goals for aquatic plant management in Sand Lake:

1. **EWM Management.** Limit the spread of EWM through environmentally responsible methods to benefit the native plant community while maintaining EWM at manageable levels.

2. **Education and Awareness.** Continue to educate property owners and lake users on aquatic invasive species through public outreach and education programs to help contain EWM within the lake and prevent its spread further in the lake, as well as to other water bodies.

3. **Research and Monitoring.** Develop a better understanding of the lake and the factors affecting lake water quality through continued and expanded monitoring efforts.

4. **Adaptive Management.** Follow an adaptive management approach that measures and analyzes the effectiveness of control activities and modify the management plan as necessary to meet goals and objectives.

Goal 1. EWM and other AIS Management

Despite years of treatment, EWM continues to be a nuisance in Sand Lake. A combination of management alternatives will be used to help minimize the negative impacts of EWM on native plants and water quality, and to provide relief for navigation impairment caused by EWM. EWM management options will be scenario-based and include small-scale physical removal, diver removal, DASH, and targeted use of aquatic herbicides. While EWM is the main focus of management, purple loosestrife is actively managed as well. Other AIS will continue to be monitored for, but no specific management is recommended at this time.

Pre and Post Treatment Survey and Fall Bed Mapping

Management of EWM will be updated regularly based on annual fall bed mapping surveys, and under certain conditions, pre-treatment surveys, and post-treatment surveys performed by either trained SLMD volunteers or resource professionals retained by the SLMD. Pre-treatment surveys should be completed in the year prior to a planned larger EWM chemical management. Post-treatment surveys should be included in the year of treatment, and at least one year after if the resources are available. Post-treatment surveys could be completed even two or three years after the year of treatment to determine longevity of the completed application. Pre and post treatment surveys are not required by the WDNR unless the chemically treated area covers more than 10% of the littoral zone (9 acres in Sand Lake). However, completing these tasks is highly recommended in any treatment program as they provide a means to measure success.

Herbicide Concentration Testing

During the last herbicide application in 2021 that included the first application of ProcellaCOR in the lake, herbicide concentration testing was completed. Concentration testing helps determine if the amount of herbicide applied reached the expected concentrations, how fast it dissipates, and if it is transported to other parts of the lake that were not intended for treatment. If a chemical treatment is not very effective, concentration testing can help determine why.

Goal 2. AIS Education and Awareness

Aquatic invasive species can be transported via a number of vectors, but most invasions are associated with human activity. Maintaining signs and continuing watercraft inspection at the public boat landing should be done to educate lake users about what they can do to prevent the spread of AIS.

Early detection and rapid response efforts increase the likelihood that a new aquatic invasive species will be addressed successfully while the population is still localized and levels are not beyond that which can be contained and eradicated. Once an aquatic invasive species becomes widely established in a lake, complete eradication becomes extremely difficult, so attempting to partially mitigate negative impacts becomes the goal. The costs of early detection and rapid response efforts are typically far less than those of long-term invasive species management programs needed when an AIS becomes established.

It is recommended that the SLMD continue to implement a proactive and consistent AIS monitoring program. At least three times during the open water season, trained volunteers should patrol the shoreline and littoral zone looking for EWM and other species like curly-leaf pondweed, purple loosestrife, Japanese knotweed, giant reed grass, zebra mussels. Free support for this kind of monitoring program is provided as part of the UW-Extension Lakes/WDNR CLMN AIS Monitoring Program. Any monitoring data collected should be recorded annually and submitted to the WDNR SWIMS database.

Providing education, outreach opportunities, and materials to the lake community will improve general knowledge and likely increase participation in lake protection and restoration activities. It is further recommended that the SLMD continue to cultivate an awareness of the problems associated with AIS and enough community knowledge about certain species to aid in detection, planning, and implementation of management alternatives within their lake community. It is also recommended that the SLMD continue to strive to foster greater understanding and appreciation of the entire aquatic ecosystem including the important role plants, animals, and people play in that system.

Understanding how their activities impact the aquatic plants and water quality of the lakes is crucial in fostering a responsible community of lakeshore property owners. To accomplish this, the SLMD should distribute, or redistribute informational materials and provide educational opportunities on aquatic invasive species and other factors that affect the lakes. At least one annual activity (picnic at the lake, public workshop, guest speakers, etc.) should be sponsored and promoted by the SLMD that is focused on AIS. Results of water quality monitoring should be shared with the lake community at the annual meeting, or another event, to promote a greater understanding of the lake ecosystem and potentially increase participation in planning and management.

Goal 3. Research and Monitoring

Long-term data can be used to identify the factors leading to changes to water quality, such as aquatic plant management activities, changes in the watershed land use, and the response of the lakes to environmental changes. The CLMN Water Quality Monitoring Program supports volunteer water quality monitors across the state following a clearly defined schedule. In the first level of the program, Secchi disk readings are encouraged 2-3 times a month from ice out to ice on. In the CLMN expanded monitoring program, water samples are collected for analysis of TP two weeks after ice out, and once each in June, July and August. Water samples are collected and processed for chlorophyll-*a* once each in June, July, and August. Temperature profiles are encouraged anytime a Secchi reading is taken, but recommended to be done at the same time water samples for TP and chlorophyll-*a*. If the necessary equipment is available to collect dissolved oxygen profiles these are encouraged at least monthly as well.

The intensity/success of water quality monitoring efforts should be evaluated at least every three years. The background information and trends provided by these data are invaluable for current and future lake and aquatic plant management planning.

To monitor changes in lake level through the season and annually, it is recommended that the SLMD participate in the CLMN lake level monitoring program. To do this, the SLMD would partner with Barron County to have a staff gauge installed at the outlet of the lake. Then, SLMD volunteers would record lake level at least weekly throughout the open water season.

To monitor any changes in the plant community, it is recommended that whole-lake point intercept aquatic plant surveys be completed at three to five-year intervals. This will allow managers to adjust the APM Plan as needed in response to how the plant community changes as a result of management and natural factors like water level. The next whole-lake point-intercept survey should be planned for 2026 with an update of this plan completed in 2027.

To monitor changes in the amount of EWM in the system, late season bed mapping surveys should be completed annually.

Goal 4. Adaptive Management

This APM Plan is a working document guiding management actions on Sand Lake for the next five years. This plan will follow a scenario-based, adaptive management approach by adjusting actions as the results of management and data obtained deem fit following IPM strategy. This plan is therefore a living document, progressively evolving and improving to meet environmental, social, and economic goals, to increase scientific knowledge, and to foster good relations among stakeholders. Annual and end of project assessment reports are necessary to monitor progress and justify changes to the management strategy, with or without state grant funding. Project reporting will meet the requirements of all stakeholders, gain proper approval, allow for timely reimbursement of expenses, and provide the appropriate data for continued management success. Success will be measured by the efficiency and ease in which these actions are completed.

The SLMD and their retainers will compile, analyze, and summarize management operations, public education efforts, and other pertinent data into an annual report each year. The information will be presented to members of the SLMD, Barron County, and the WDNR and made available in hardcopy and digital format on the internet. These reports will serve as a vehicle to propose future management recommendations and will therefore be completed prior to implementing following year management actions (approximately March 31st annually). At the end of this five-year project, all management efforts (including successes and failures) and related activities will be summarized in a report to be used for revising the APM Plan.

Timeline of Implementation

The activities in this APM Plan are designed to be implemented over a 5-year period beginning in 2023. The plan is intended to be flexible to accommodate future changes in the needs of the lake and its watershed, as well as those of the SLMD. Some activities in the timeline (Appendix D) are eligible for grant support to complete.

The following are the objectives and actions are associated with the goals included in this management plan. They are intended to be implemented over a 5-yr period beginning in 2023 and extending through 2027. Appendix A lays out a recommended Timeline of Implementation for these objectives and actions.

EWM and other AIS Management

An integrated approach to management including physical removal, diver removal, DASH, and the use of herbicides will be implemented between 2023 and 2027 to keep the amount of EWM growth as low as possible with minimal impacts to native aquatic vegetation. Management of EWM will be scenario-based; meaning any amount of EWM can be managed at any time provided chemical application is not used. Criteria are set for the use of aquatic herbicides generally with herbicide use being considered if dense beds of EWM ≥0.40 acres are mapped, with preferences to treat larger areas for more effective herbicide results. ProcellaCOR should be used for all herbicide applications <5.0 acres. In treatment areas ≥5.0 acres, ProcellaCOR or liquid 2,4D-based herbicides could be used. The same treatment area will not be chemically treated in two or more consecutive years with the same herbicide. All herbicide applications will take place in the early season generally expected to be before June 30 annually.

Purple loosestrife has been identified in several locations along the shoreline of Sand Lake. Monitoring for purple loosestrife will be completed by District volunteers every year and removal of flower heads will be completed where accessible. The SLMD will also rear and release Galerucella beetles for control of purple loosestrife. Chinese mystery snails and Rusty crayfish are also present, but no management is planned.

Objective 1 - Determine how much EWM is present in the lake each year.

Action Item: EWM bedmapping will be completed annually in the late summer by a hired contractor or trained SLMD volunteer to identify potential areas for management consideration.

Objective 2 - Implement EWM management actions to keep EWM as low as possible each year.

Action Item: Using a scenario-based approach to management, any amount of EWM can be managed at any time. Depending on criteria like bed size, density, and depth of water, an integrated approach to management that includes physical removal by property owners, rake removal, snorkel, scuba diver, DASH, and application of aquatic herbicides will be implemented. See the Aquatic Plant Management Discussion beginning on p.53 of this APM Plan.

Objective 3 - Measure the effectiveness and impacts of herbicide treatments on target and non-target plants within the treated areas on an annual basis.

Action Item: If aquatic plant herbicides are used for management, consider implementing a pre-treatment sub-PI survey within a proposed treatment area in the year prior to treatment, and a post-treatment sub-PI survey either in the year of treatment or the year following treatment. This action must be done if the expected treatment area(s) reaches or exceeds 9 acres (10%) of the littoral zone of the lake.

Action Item: Complete a pre-chemical treatment readiness survey in the year of proposed management to assess the readiness of the proposed treatment area and make modifications to the proposed treatment area if necessary.

Action Item: If aquatic plant herbicides are used for management, consider implementing an herbicide concentration testing program in the year of management. This action must be done if the expected treatment area(s) reaches or exceeds 9 acres (10%) of the littoral zone of the lake.

Objective 4 - Track the distribution and density of purple loosestrife along the shores of Sand Lake and implement management actions annually.

Action Item: Complete a visual inspection of the entire shoreland in late July or early August and record the location of any purple loosestrife found on a map. Remove flower heads from any purple loosestrife that is accessible.

Action Item: Rear and release Galerucella beetles on Sand Lake in an effort to establish active biocontrol of purple loosestrife on the lake.

Education and Awareness

Sand Lake is already a source lake for EWM being carried out attached to boats and/or trailers and taken to other lakes. Appropriate AIS signage will be maintained at the public access on Horseshoe Lake to improve the AIS awareness of many lake users. The SLMD will continue to implement a watercraft inspection program according to WDNR/UW-Extension Lakes protocol. This program will either be paid for by the SLMD or through a CBCW grant. Watercraft inspection data will be entered into the WDNR SWIMS database annually.

AIS monitoring to track the AIS already present in Sand Lake and to monitor for possible new AIS will be completed following WDNR/UW-Extension Lakes protocol through the CLMN AIS Monitoring Program. Zebra mussels, spiny waterflea, hydrilla, banded mystery snails, and other species will be watched for and survey data entered into the WDNR SWIMS database annually.

The SLMD will continue efforts to educate and inform property owners and lake users about AIS already in Sand Lake and AIS not already in Sand Lake. Efforts will include annual education events; distribution of AIS publications, placement of EWM marker buoys in the lake, and discussion forums of various types related to management actions and alternatives.

Objective 1 - Maintain current and complete AIS Signage at the public access on Sand Lake annually.

Action Item: Inspect the public access for appropriate AIS signage annually.

Action Item: Repair, replace, and/or install current WDNR AIS signs at the public access.

Objective 2 - Implement a Clean Boats Clean Waters water craft inspection program annually.

Action Item: Attempt to get 200 hours of paid watercraft inspection at the public access.

Action Item: Apply for CBCW grants annually to support watercraft inspection efforts.

Objective 3 - Reduce the likelihood that new AIS go undetected in Sand Lake and track existing AIS for additional spread.

Action Item: Participate in CLMN AIS Monitoring at least monthly between May and October each year.

Objective 4 - Plan, coordinate, and implement an annual AIS education event(s) alone or in cooperation with other Stakeholders.

Action Item: Seek out other stakeholders including but not limited to the other lake associations and Districts, Barron and Washburn Counties, and Tribal Resources (specifically Maple Plain Tribal entities) to explore cooperative education and information events.

Objective 5 - Distribute information and education materials to property owners and lake users.

Action Item: Research AIS and lake stewardship materials with little or no cost to attain and make available at events including but not limited to Annual Meetings, Lake Fairs, Summer Picnic, etc.

Objective 6 - Solicit public input and review of annual AIS management planning efforts.

Action Item: Complete preliminary AIS management planning by January 31 each year and post on the SLMD webpage for public comment.

Action Item: Provide a summary of coming year AIS management plans in a spring newsletter to be published and distributed prior to April 30 each year.

Action Item: Present current year AIS management actions at the Annual Meeting held in August each year.

Research and Monitoring

Long-term data can be used to identify the factors leading to changes to water quality, such as aquatic plant management activities, changes in the watershed land use, and the response of the lakes to environmental changes. Changes in lake level also impacts EWM management and water quality. To monitor any changes in the plant community, it is recommended that whole-lake point intercept aquatic plant surveys be completed at least every five years. This will allow managers to adjust the APM Plan as needed in response to how the plant community changes as a result of management and natural factors like water level.

Objective 1 - Collect long-term trend water quality data in Sand Lake.

Action Item: Collect CLMN water quality data (water clarity, total phosphorus, chlorophyll a, and dissolved oxygen and temperature) in the Deep Hole.

Objective 2 - Collect regular lake-level data in Sand Lake.

Action Item: SLMD volunteers will monitor lake level at the outlet of SL using a staff gauge installed by Barron Co. and according to guidelines provided by the CLMN program.

Objective 3 - Measure the five year impact of AIS management actions on the native aquatic plant community in Sand Lake.

Action Item: Repeat a whole lake, point-intercept, aquatic plant survey in 2026.

Action Item: Compare 2026 plant survey results to previous survey results to determine success or failure of management actions over a five year period.

Adaptive Management

This APM Plan is a working document guiding management actions on Sand Lake for the next five years. This plan follows a scenario-based, adaptive management approach by adjusting actions as the results of management and data obtained deem fit following IPM strategy. This plan is therefore a living document, progressively evolving and improving to meet environmental, social, and economic goals, to increase scientific knowledge, and to foster good relations among stakeholders.

Management actions implemented in each year of this plan will be evaluated for how well they helped meet the goals and objectives included in this APM Plan. Small changes will be made automatically if it is determined they will improve outcomes. Larger management changes will be presented to the SLMD and other Stakeholders for approval before implementation.

Objective 1 - Prepare annual summary reports for aquatic plant surveys, management planning and implementation, and management evaluation.

Action Item: Annual aquatic plant survey summary reports will be completed by the aquatic plant surveyor contracted by the SLMD.

Action Item: End-of -year management summary reports will be completed by the Primary Consultant contracted by the SLMD.

Action Item: All report documents will be posted on the SLMD webpage for public review.

Objective 2: At the end of this five-year project, all management efforts (including successes and failures) and related activities will be summarized in a report to be used for revising the APM Plan.

Action Item: Review the goals, objectives, and actions from the 2023-27 APM Plan for successful implementation.

Action Item: Revise/update the 2023-27 APM Plan.

Potential Funding

There are several WDNR grant programs that may be able to assist the SLMD in implementing its new APM Plan. AIS grants are specific to actions that involve education, prevention, planning, and in some cases, implementation of AIS management actions. Lake Management Planning grants can be used to support a broad range of management planning and education actions. Lake Protection grants can be used to help implement approved management actions that would help to improve water quality.

The cost of the last EWM management actions completed in 2022, and those to be completed through at least 2023 will have to be covered by the SLMD. The SLMD has applied for AIS planning grant funds to cover 2023. If larger-scale management actions are expected to be needed in 2024, additional WDNR population control grant funding will be applied for.

More information about WDNR grant programs can be found at: https://dnr.wisconsin.gov/aid/SurfaceWater.html

Outside Resources to help with Future Planning

Many of the actions recommended in this plan cannot be completed solely by the VLA. They will continue to need the help of an outside consultant or other outside resource. Multiple outside resources and expertise exist to help guide implementation. The following is a list of outside resources that the VLA will need to partner with to implement the actions in this plan.

Barron County

Soil and Water Conservation

In most cases, the Soil and Water Conservation Department for a given county has a mission is to administer land and water conservation projects to meet local priorities, conditions, and the needs of county land users. County management plans and often state-funded, cost-share programs are administered for the purpose of implementing conservation practices. Conservation Departments are responsible for administering programs such as: Aquatic Invasive Species Program; Environmental Reserve Fund; short-term, grant-funded programs; providing technical assistance for all types of conservation practices; implementing information and education programs; updating various soil and water resource inventories; and nurturing partnerships with other county, state, and federal agencies.

https://www.barroncountywi.gov/index.asp?SEC=89D075CD-5873-4056-8599-65155CFB943F

Cooperative Extension

County-based Extension educators are University of Wisconsin (UW) faculty and staff who are experts in agriculture and agribusiness, community and economic development, natural resources, family living, and youth development. Extension county-based faculty and staff live and work with the people they serve in communities across the State. Extension specialists work on UW System campuses where they access current research and knowledge. Collaboration between county and campus faculty is the hallmark of Cooperative Extension in Wisconsin.
https://www.barroncountywi.gov/index.asp?SEC=50C303EF-0521-438F-B290-5C0373F46D27

University and Collegiate

Lake Superior Research Institute – UW-Superior

The Lake Superior Research Institute (LSRI) at UW-Superior was created in 1967 and formally recognized by the UW Board of Regents in 1969. LSRI's mission is to conduct environmental research and provide services that directly benefit the people, industries, and natural resources of the Upper Midwest, the Great Lakes Region, and beyond; provide non-traditional learning and applied research opportunities for undergraduate students; and foster environmental education and outreach in the Twin Ports and surrounding communities.

Areas of expertise include: analytical chemistry; aquatic invasive species monitoring and outreach; benthic and zooplankton taxonomy; habitat restoration; microbiology; sediment and aquatic toxicology; quality assurance and data management; watershed management and planning; and wetland assessment and monitoring. Current research includes: aquatic and sediment toxicity testing, aquatic invasive species ecology, ballast water management system testing, beach monitoring and microbial source testing, biological monitoring and inventory of aquatic and terrestrial communities, endangered species management planning, habitat restoration, and mercury analysis in biota.

https://www.uwsuper.edu/lsri/index.cfm

Mary Griggs Burke Center for Freshwater Innovation

The Mary Griggs Burke Center for Freshwater Innovation (Burke Center) at Northland College in Ashland, WI focuses on scientific research, communication, and thought leadership on water issues in the Great Lakes region and beyond. The Burke Center specializes in "translating" science to the general public, government agencies, NGOs, agriculture, and the private sector, helping to edify water policy in a wide variety of geographies and subject areas. Two such areas are Integrated Ecosystem Management and Environmental Monitoring and Assessment.

Effective management of freshwater ecosystems is dependent on an understanding of how human activities and value sets intersect with the environmental processes that sustain water resource integrity. Their work focuses on integrating approaches from the natural and social sciences to conduct and develop integrated assessments and management plans for freshwater ecosystems.

Public decision-making surrounding water resources is dependent on a range of data that describe the condition of freshwater ecosystems and the current—and potential future—stressors that may impact their integrity. Their work focuses on the use of environmental monitoring and analytical technologies to develop long-term data sets to support public decision-making for freshwater resources. The Burke Center is involved in multiple projects that collect and analyze a variety of data including bacteria, e-coli, zooplankton, aquatic plants, wild rice, water quality, etc.

https://www.northland.edu/centers/mgbc/

Center for Land Use Education

The Center for Land Use Education (CLUE) is a joint venture of the College of Natural Resources at the UW-Stevens Point and the UW-Madison Division of Extension. It is a focal point for land-use planning and management education. Through applied research, teaching and outreach, CLUE specialists and faculty support students, local government officials, communities and K-12 audiences on a variety of land and water topics including planning and zoning, land divisions, fragmentation, sustainability, bio- and renewable energy, food systems, shorelands and wetlands. By providing up-to-date and comprehensive training on planning and zoning tailored to address specific local needs, CLUE specialists are able to assist towns, villages, cities and counties in making sound land use decisions.

https://erc.cals.wisc.edu/programs/center-for-land-use-education/

Center for Watershed Science and Education

The Center for Watershed Science and Education (CWSE) at UW-Stevens Point supports watershed understanding and stewardship across and beyond the state of Wisconsin. The center includes specialists with expertise in groundwater, lakes, streams, water chemistry and analysis, and data science. The center helps individuals, organizations and private and public water resources professionals understand water quality and quantity in private wells, groundwater, lakes and rivers. Through their programming, center staff provides guidance on sampling and data collection, education on water quantity and quality, and interpretation and evaluation of monitoring results. The center also performs applied research and creates data visualization tools to improve watershed understanding.

Current research explores the movement of nitrate-nitrogen in soil and groundwater, the quantity and chemistry of groundwater, changes in lake water quality and the occurrence of pharmaceuticals and new pesticides in the water.

https://erc.cals.wisc.edu/programs/center-for-watershed-science-and-education/

Center for Limnological Research and Rehabilitation

The Center for Limnological Research and Rehabilitation (CLRR) at UW-STOUT focuses on eutrophication issues and management solutions for freshwater systems. They provide limnological research services to the surrounding community, including: diagnosing eutrophication-related problems in lakes and reservoirs; conducting comprehensive hydrologic and limnological monitoring programs; identifying and quantifying important phosphorus sources that drive cyanobacterial blooms; and developing and implementing management plans to sustainably rehabilitate degraded aquatic systems.

Their laboratory facilities provide an array of analytical capabilities for the examination of nutrients (primarily phosphorus species) and algae in water and sediment. They have a variety of field monitoring equipment for quantifying tributary flow and phosphorus loads discharging into lakes, boats and sampling equipment for monitoring lake chemistry and biology, and coring capabilities for the examination of aquatic sediment. In particular, they have unique expertise for determining important mobile phosphorus fractions in aquatic sediments and nutrient exchanges between sediments and the overlying water.

https://www.uwstout.edu/directory/center-limnological-research-and-rehabilitation

Natural Resources Education Program

NRE Water Programming

Natural Resource Educators (NRE) are providing leadership on nutrient reduction and water quality projects across the state. Key efforts include outreach to increase local capacity to reduce nonpoint source pollution in the Lower Fox, Wisconsin, St. Croix, Red Cedar and Rock River watersheds and the Lower Fox River Demo Farm Network initiative. Projects are carried out in collaboration with federal, state and local partners as well as producer-led watershed initiatives. The Demo Farm initiative works with farmers and their advisers to conduct on-farm demonstrations that measure and share the effectiveness of conservation practices to reduce erosion and sediment runoff, control phosphorus runoff and address other nonpoint sources of pollution.

NRE Forestry Programming

ERC-based Natural Resources Educators and key partners are leading classes (Learn About Your Land and Your Land, Your Legacy) and other efforts to engage landowners in the sustainable management of Wisconsin’s privately-owned forests. NREs create content for landowners on a variety of topics in publication, video, and website formats.

https://erc.cals.wisc.edu/programs/regional-natural-resources-education-program/

Aquatic Invasive Species Outreach

Wisconsin’s aquatic invasive species (AIS) program focuses on preventing the introduction of new invasive species to Wisconsin, containing the spread of invasives that are already in the state, and managing established populations when possible. In close cooperation with the Wisconsin Department of Natural Resources and Extension Lakes program, UW– Madison Division of Extension education efforts focus on working with resource professionals and citizens statewide to teach boaters, anglers and other water users the steps they should take to prevent transporting aquatic invasives to new waters. Efforts also address other potential mechanisms of introduction, including aquarium pet release and water gardening.

https://erc.cals.wisc.edu/programs/aquatic-invasive-species-outreach/

UW-Extension Lakes Program

Based at UW-Stevens Point, the Extension Lakes Program seeks to preserve Wisconsin's legacy of lakes through education, communication and collaboration. The program works with over 800 local lake associations and lake districts in Wisconsin, assisting them through education and capacity building. Lakes also partners with the Wisconsin DNR to coordinate a number of programs and projects to assist those concerned with the future of our lakes, including the Citizen Lake Monitoring Network, the Clean Boats, Clean Waters program and the Lake Leaders Institute. The *Lake Tides* newsletter reaches thousands of readers throughout the region.

https://erc.cals.wisc.edu/programs/extension-lakes-program/

Works Cited

Berg, M. (2011). *Eurasian water milfoil (Myriophyllum spicatum) Pretreatment and Fall Bed Mapping Surveys.* St. Croix Falls, WI: ERS.

Berg, M. (2021). *Warm-water Point-intercept Survey* . St. Croix Falls, WI: Endangered Resource Services, LLC.

Booms, T. (1999). Vertebrates removed by mechanical weed harvesting in Lake Keesus, Wisconsin. *Journal of Aquatic Plant Management*, 34-36.

Carlson, R. (1977). A trophic state index for lakes. *Limnology and Oceanography*, 361-369.

Christensen, D., Hewig, B., Schindler, D. E., & and Carpenter, S. (1996). Impacts of lakeshore residential development on coarse woody debris in north temperate lakes. *Ecological Applications 6 (4),* 1143-1149.

Dewitz, J. (2019). National Land Cover Database (NLCD) 2016 Products: U.S. Geologiocal Survey data release. Retrieved from https://doi.org/10.5066/P96HHBIE

Eichler, L., Bombard, R., Sutherland, J., & and Boylen, C. (1993). Suction harvesting of Eurasian watermilfoil and its effect on native plant communities. *Journal of Aquatic Plant Management 31*, 144-148.

Jennings, M., Emmons, E., Hatzenbeler, G., Edwards, C., & and Bozek, M. (2003). Is littoral habitat affected by residential development and land use in watersheds of Wisconsin lakes? *Lake Reservoir Management, 19 (3)*, 272-279.

Madsen, J. (2000). *Advantages and disadvantages of aquatic plant management techniques.* Vicksburg, MS: US Army Corps of Engineers Aquatic Plant Control Research Program.

Pope, K., & Willis, D. (1997). Environmental characteristics of black crappie (Pomoxis nigromaculatus) nesting sites in two South Dakota waters. *Ecology of Freshwater Fish*, 7:56-68.

Smith, C. S., & Barko, J. (1990). Ecology of Eurasian Water Milfoil. *Journal of Aquatic Plant Management: Vol. 28,* 55-64.

Wolter, M. (2012). *Lakeshore Woody Habitat in Review.* Hayward, WI: Wisconsin Department of Natural Resources.

APPENDIX A

Five Year Timeline of Implementation

Appendix A - 5-year Timeline of Implementation for the 2023-27 Sand Lake Aquatic Plant Management Plan. Pg. 1									
Goal	**Objective**	**Recommendation**	**Grant Eligible**	**Facilitator**	**2023**	**2024**	**2025**	**2026**	**2027**
Management of Eurasian Milfoil and Other AIS	Keep the level of EWM in Sand Lake as low as possible in any give year.	Monitoring and mapping	yes	SLMD, Consultant, WDNR, Outside Resources	x	x	x	x	x
		Physical removal	yes		x	x	x	x	x
		Diver/snorkel removal	yes		x	x	x	x	x
		DASH removal	yes		?	?	?	?	?
		Herbicide application	yes		?	?	?	?	?
		Pre and post-treatment PI/readiness surveys	yes		?	?	?	?	?
		Herbicide concentration testing	yes		?	?	?	?	?
	Prevent purple loosestrife from claiming more of the shoreland along Sand Lake	Monitoring and mapping	yes		x	x	x	x	x
		Physical removal	yes		x	x	x	x	x
		Biological control	yes		x	x	x	?	?
Education and Awareness	AIS signage	Inspection, improvement, and maintenance of AIS signage	yes	SLMD, Consultant, WDNR, Outside Resources	?	?	?	?	?
	Watercraft inspection	CBCW through grants and the SLMD	yes		x	x	x	x	x
	AIS monitoring	Implement and maintain an in-lake and shoreline AIS monitoring program (CLMN)	yes		x	x	x	x	x
		Train landowners to monitor their own lake front for AIS	yes		x	x	x	x	x
	AIS education event	Annual public event planning and implementation	yes		x	x	x	x	x
	Public particpartion and communication program	Publish a newsletter at least once annually	yes		x	x	x	x	x
		Provide information and education materials	yes		x	x	x	x	x
	Public participation and input	Solicit public input and review of annual AIS management planning efforts.	yes		x	x	x	x	x
Research and Monitoring	CLMN expanded monitoring at the Deep Hole	Complete Secchi, Temp, DO, TP, CHL	yes	SLMD, Consultant, WDNR, Outside Resources	x	x	x	x	x
	CLMN lake level monitoring	Install a staff gauge at the outlet (Barron Co)	yes		x	x	x	x	x
		Weekly monitoring of lake level	yes		x	x	x	x	x
	Monitor and measure changes in the aquatic plant community	Redo the whole-lake, PI survey	yes					x	
Adaptive Management	Annual Project Activity and Assessment Reports	Complete annual plant management planning	yes	SLMD, Consultant, WDNR, Outside Resources	x	x	x	x	x
		Provide for document sharing	yes		x	x	x	x	x
	End-of-project Summary Report	Overall review of project successes and failures	yes						x
		Revise/rewrite APM Plan	yes						x
		Provide for document sharing	yes						x

SLMD-Sand Lake Management District; WDNR, Wisconsin Department of Natural Resources; EWM, Eurasianwatermilfoil; PI, Point-intercept; DASH, Diver assisted suction harvest; CBCW, Clean Boats Clean Waters; AIS, Aquatic Invasive Species; CLMN, Citizen Lake Monitoring Network; DO, dissolved oxygen; TP, total phosphorus; CHL, chlorophyll-a; APM, Aquatic plant management.