Shawano Lake

Shawano County, Wisconsin

2023 Aquatic Plant Monitoring Report

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Created by: Eddie Heath, Josephine Barlament, & Todd Hanke
Onterra, LLC
De Pere, WI

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1.0 INTRODUCTION

Shawano Lake, Shawano County, is a roughly 6,200-acre shallow lowland drainage lake with a mean depth of 9 feet. This eutrophic lake has a relatively small watershed when compared to the size of the lake.

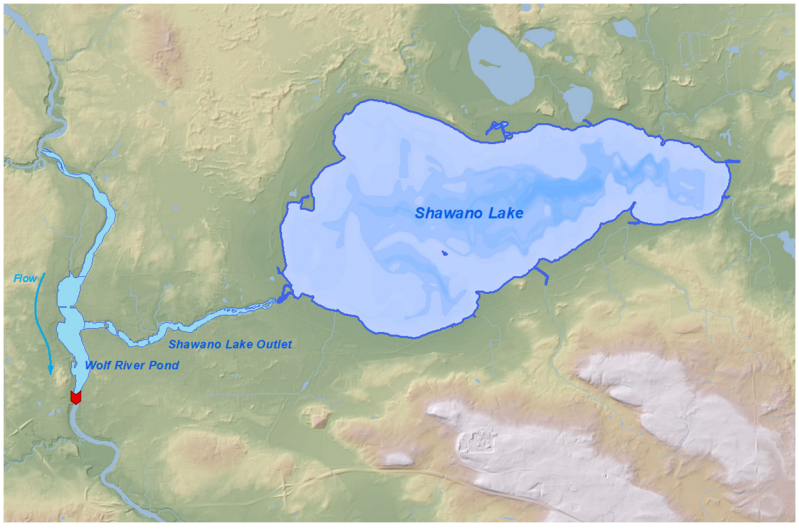


Figure 1.0-1. Shawano Lake, Shawano County

Shawano Lake is classified as an Area of Special Natural Resource Interest (ASNRI) by the WDNR. Several areas of the lake are listed as sensitive, Public Rights Features and a Sensitive Area Designation has been completed on the lake. The Natural Heritage Inventory (NHI) lists several endangered or threatened species from Shawano Lake, including fish, mussel, and turtle (Wood and Blanding's) species. Also present is square-stem spike-rush, which is listed by the NHI as endangered/critically imperiled, and American shoreweed, which is listed as a special concern due to rarity.

There is an abundance of public access to Shawano Lake with 8 public boat landings, 14 walk-in access sites, 19 resorts/rentals properties, and 5 campgrounds. Shawano Lake is a popular recreation and fishing lake, hosting a dozen permitted fishing tournaments during the ice and open-water seasons annually.

The Shawano Area Waterways Management (SAWM) has been a non-profit organization in existence for approximately 40 years. SAWM's areas of focus are; education, native and invasive plant management, water clarity and quality, fisheries, natural vegetation along shoreline, recreation / navigation.

1.1 Historic Management & Planning

EWM was officially documented in Shawano Lake in 1994, though studies conducted prior to 1994 indicated its presence in the lake. Genetic analysis has confirmed that Shawano Lake contains populations of both pure-strain EWM and populations of hybrid EWM (*Myriophyllum spicatum x sibiricum*, HWM). HWM can grow faster, become more invasive, and be less susceptible to chemical control strategies than pure-strain EWM. Unless specifically indicated, this report will use the term "EWM" to refer to the combined population of EWM and HWM within Shawano Lake.

Starting in 2013, management strategies targeting EWM were discussed within strategic planning sessions, with SAWM expressing their desire to attempt to manage the entire EWM population within Shawano Lake. EWM management is difficult on any lake, but numerous factors about the Shawano Lake ecosystem compound the difficulty of achieving management goals. In April 2014, SAWM updated its Aquatic Plant Management Plan, which outlined whole-lake 2,4-D amine treatment strategy to manage the entire EWM population on Shawano Lake. The goal was to reduce the EWM populations lake-wide for 3-5 years.

The whole-lake 2,4-D treatment on Shawano Lake was designed with a target lake-wide concentration of approximately 0.35 ppm acid equivalent (ae). The observed 1-7 day after treatment (DAT) average surface 2,4-D concentration during the 2016 treatment on Shawano Lake was 0.452 ppm ae, falling above the target lake-wide concentration. However, the herbicide exposure time was much shorter than was projected, degrading to just above detection limits by 14 days after treatment. This was one of the largest intentionally planned whole-lake 2,4-D treatment that has ever occurred, so there were uncertainties if the same principals of dissipation and mixing would scale up. Onterra believes the execution of the treatment plan went well, but the short exposure time limited the efficacy of the management action.

Following a few years of post treatment EWM and aquatic plant monitoring, SAWM completed a *Comprehensive Management Plan* for Shawano Lake in 2021. As outlined in this plan, SAWM intends to periodically conduct aquatic plant surveys to understand the aquatic plant community of Shawano Lake, with thresholds of EWM abundance that would warrant future herbicide management in select areas of the lake. But unlike the 2014 APM Plan, this plan would not attempt to conduct whole-lake population management of EWM, just nuisance relief to specific sites if warranted. With Onterra's assistance, SAWM was successful in receiving a series of WDNR grants to conduct a lake-wide point-intercept survey and EWM mapping survey on Shawano Lake in 2023. This report details those efforts and serves as the final written deliverable for AEPP-709-23 and AEPP-708-23.

2.0 2023 AQUATIC PLANT MONITORING RESULTS

It is important to note that two types of surveys are discussed in the subsequent materials: 1) point-intercept surveys and 2) EWM mapping surveys. Overall, each survey has its strengths and weaknesses, which is why both are utilized in different ways as part of this project.

The point-intercept survey provides a standardized way to gain quantitative information about a lake's aquatic plant population through visiting predetermined locations (Map 1) and using a rake sampler to identify all the plants at each location (Photograph 2.0-1). The survey methodology allows comparisons to be made over time, as well as between lakes. The point-intercept survey is most often applied at the whole-lake scale. The whole-lake point-intercept survey has been conducted on Shawano Lake in 2005, 2013, 2015-2019, and 2023. Please note the 2005 point-intercept survey was conducted by the US Army Corps of Engineers using slightly a different methodology than latter surveys. While these data are displayed on the following figures in this report, direct comparisons may not be appropriate.

Photograph 2.0-1. Point-intercept survey on a WI lake. Photo credit Onterra.

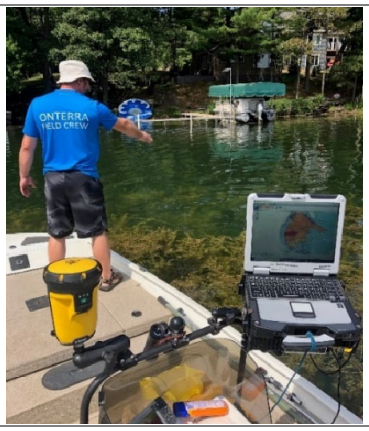


Photo 2.0-2. EWM mapping survey on a Wisconsin lake. Photo credit Onterra.

While the point-intercept survey is a valuable tool to understand the overall plant population of a lake, it does not offer a full account (census) of where a particular species exists in the lake. EWM grows high in the water column, which can cause recreation and navigation impediments. This factor allows it to typically be mapped through surface observation. During an EWM mapping survey, the entire littoral area of the lake is surveyed through visual observations from the boat (Photograph 2.0-2). Field crews may supplement the visual survey by deploying a submersible camera along with periodically doing rake tows. The EWM population is mapped using sub-meter GPS technology by using either 1) point-based or 2) area-based methodologies. Large colonies >40 feet in diameter are mapped using polygons (areas) and are qualitatively attributed a density rating based upon a five-tiered scale from *highly scattered* to *surface matting*. Point-based techniques were applied to AIS locations that were considered as *small plant colonies* (<40 feet in diameter), *clumps of plants*, or *single or few plants*.

2.1 Quantitative Monitoring: Whole-Lake Point-Intercept Survey

A whole-lake point-intercept aquatic plant survey was conducted as a key aspect of this project by Onterra on July 10-13, 2023. An important component of the point-intercept survey is defining the littoral zone, or the zone at which aquatic plants can grow. The maximum depth of plant growth is typically influenced by water clarity. In general, aquatic plants grow to a depth of two to three times the average Secchi disk depth. Shawano Lake's average summer Secchi disk depth is 7.1 feet, with maximum depth of aquatic plants being 18-22 feet (Figure 2.1-1). Subtle differences in water clarity at key points of the year make contribute to the variation between years.

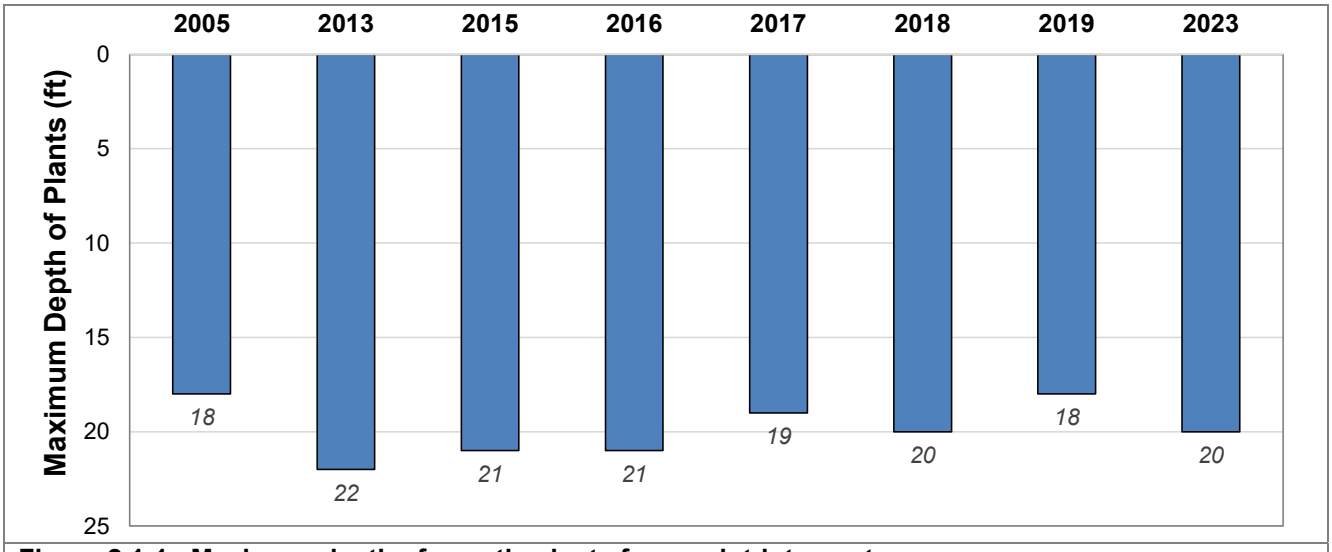


Figure 2.1-1. Maximum depth of aquatic plants from point-intercept surveys.

Species List

In total, 62 species have been recorded from Shawano Lake over the course of the point-intercept surveys (Table 2.1-1). The list also contains the growth-form of each plant found (e.g., submergent, emergent, etc.), its scientific name, common name, and its coefficient of conservatism. The latter is discussed in more detail below. Changes in this list over time, whether it is differences in total species present, gains and losses of individual species, or changes in growth forms that are present, can be an early indicator of changes in the ecosystem. Four non-native species have been documented during the aquatic plant monitoring surveys with two: EWM/HWM and curly-leaf pondweed, being submersed species while

giant reed (*phragmites*) and purple loosestrife are terrestrial/wetland plants growing around the fringes of the lake.

Table 2.1-1. Aquatic plant species located in Shawano Lake during 2005-2023 point-intercept surveys.

Growth Form	Scientific Name	Common Name	Status in Wisconsin	Coefficient of Conservatism	2005	2013	2015	2016	2017	2018	2019	2023
Emergent	*Decodon verticillatus*	Water-willow	Native	7		I						
	Eleocharis palustris	Creeping spikerush	Native	6		X	X	X		X	X	X
	Eleocharis quadrangulata	Square-stem spikerush	Native - Endangered	10		X						
	Lythrum salicaria	Purple loosestrife	Non-Native - Invasive	N/A	X	I						
	Phragmites australis subsp. americanus	Common reed	Native	5		I						X
	Phragmites australis subsp. australis	Giant reed	Non-Native - Invasive	N/A		X				X		
	Pontederia cordata	Pickerelweed	Native	9		X				X		X
	Sagittaria latifolia	Common arrowhead	Native	3		I						
	Sagittaria rigida	Stiff arrowhead	Native	8		I						
	Schoenoplectus acutus	Hardstem bulrush	Native	5		X	X	X		X	X	X
	Schoenoplectus pungens	Three-square rush	Native	5		X		X		X	X	X
	Schoenoplectus tabernaemontani	Softstem bulrush	Native	4		I			X			
	Sparganium eurycarpum	Common bur-reed	Native	5		I						
	Typha spp.	Cattail spp.	Unknown (Sterile)	N/A		I						
	Zizania spp.	Wild rice sp.	Native	8		X	X		X			X
FL	*Brasenia schreberi*	Watershield	Native	7		X	X					
	Nuphar variegata	Spatterdock	Native	6	X	X	X	X		X	X	
	Nymphaea odorata	White water lily	Native	6	X	X	X	X	X	X	X	X
	Persicaria amphibia	Water smartweed	Native	5		I						
	Sparganium angustifolium	Narrow-leaf bur-reed	Native	9							X	
FL/E	*Sparganium sp.*	Bur-reed sp.	Native	N/A					X			
Submergent	*Bidens beckii*	Water marigold	Native	8		X	X	X	X	X	X	X
	Ceratophyllum demersum	Coontail	Native	3	X	X	X	X	X	X	X	X
	Ceratophyllum echinatum	Spiny hornwort	Native	10						X	X	X
	Chara spp.	Muskgrasses	Native	7	X	X	X	X	X	X	X	X
	Charophytes	Muskgrasses & Stoneworts	Native	N/A	X	X	X	X	X	X	X	X
	Elodea canadensis	Common waterweed	Native	3	X	X	X	X	X	X	X	X
	Heteranthera dubia	Water stargrass	Native	6		X	X	X	X	X	X	X
	Littorella uniflora	American shoreweed	Native - Special Concern	10						X		
	Myriophyllum sibiricum	Northern watermilfoil	Native	7	X	X	X	X	X	X	X	X
	Myriophyllum spicatum	Eurasian watermilfoil	Non-Native - Invasive	N/A	X	X	X	X	X	X	X	X
	Myriophyllum tenellum	Dwarf watermilfoil	Native	10		X	X	X			X	
	Najas flexilis	Slender naiad	Native	6	X	X	X	X	X	X	X	X
	Najas flexilis & N. gracillima & N. guadalupensis	Slender naiad & Northern naiad & Southern naiad	Native	N/A	X	X	X	X	X	X	X	X
	Najas guadalupensis	Southern naiad	Native	7		X	X	X	X	X	X	X
	Nitella spp.	Stoneworts	Native	7		X		X		X	X	X
	Potamogeton amplifolius	Large-leaf pondweed	Native	7	X	X	X	X	X	X	X	X
	Potamogeton amplifolius X Potamogeton praelongus	Large-leaf X White-stem pondweed	0	N/A								X
	Potamogeton berchtoldii	Slender pondweed	Native	7		X					X	X
	Potamogeton crispus	Curly-leaf pondweed	Non-Native - Invasive	N/A	X	X	X	X	X	X	X	X
	Potamogeton epihydrus	Ribbon-leaf pondweed	Native	8		X	X					
	Potamogeton foliosus	Leafy pondweed	Native	6	X			X	X		X	X
	Potamogeton friesii	Fries' pondweed	Native	8		X	X	X	X	X	X	X
	Potamogeton gramineus	Variable-leaf pondweed	Native	7	X	X	X	X	X	X	X	X
	Potamogeton hybrid 1	2015 Unknown Pondweed Hybrid	N/A	N/A			X					
	Potamogeton hybrid 2	2016 Unknown Pondweed Hybrid	N/A	N/A				X				
	Potamogeton hybrid 3	2019 Unknown Pondweed Hybrid	N/A	N/A							X	
	Potamogeton illinoensis	Illinois pondweed	Native	6	X	X	X	X	X	X	X	X
	Potamogeton praelongus	White-stem pondweed	Native	8		X	X	X	X	X	X	X
	Potamogeton pusillus	Small pondweed	Native	7			X	X	X	X	X	X
	Potamogeton richardsonii	Clasping-leaf pondweed	Native	5		X	X	X	X	X	X	X
	Potamogeton robbinsii	Fern-leaf pondweed	Native	8	X	X	X	X	X	X	X	X
	Potamogeton spirillus	Spiral-fruited pondweed	Native	8								X
	Potamogeton strictifolius	Stiff pondweed	Native	8	X	X	X		X	X	X	X
	Potamogeton X scoliophyllus	Large-leaf X Illinois pondweed	Native	N/A								
	Potamogeton zosteriformis	Flat-stem pondweed	Native	6	X	X	X	X	X	X	X	X
	Ranunculus aquatilis	White water crowfoot	Native	8		X	X				X	X
	Sagittaria sp. (rosette)	Arrowhead sp. (rosette)	Native	N/A	X	X	X		X	X	X	X
	Stuckenia pectinata	Sago pondweed	Native	3		X	X	X	X	X	X	X
	Utricularia vulgaris	Common bladderwort	Native	7	X	X		X			X	X
S/E	*Eleocharis acicularis*	Needle spikerush	Native	5		X		X	X	X		
FF	*Lemna trisulca*	Forked duckweed	Native	6		X	X	X	X	X	X	X
	Spirodela polyrhiza	Greater duckweed	Native	5		X					X	X
	Wolffia spp.	Watermeal spp.	Native	N/A								X

X = Located on rake during point-intercept survey; I = Incidentally located; not located on rake during point-intercept survey
FL = Floating-leaf; F/L = Floating-leaf & Emergent; S/E = Submergent and/or Emergent; FF = Free-floating

Map 2 shows the native plant richness from the 2023 point-intercept survey, where an average of 2.4 native species were found at each sampling location (Figure 2.1-2). The most recent survey in 2019 indicated that 3.5 native species were found at each point, with the current survey being reduced by approximately 1 species per point.

Figure 2.1-2. Shawano Lake Number of Native Aquatic Plant Species per Sampling Site. Red-hatched line indicates spring 2016 whole-lake 2,4-D treatment.

Total rake fullness values from the 2023 point-intercept survey are displayed on Map 3. These data represent the aquatic plant biomass at each sampling location and does not differentiate between native or non-native vegetation. Some of the greatest amount of plant biomass in the 2023 survey was found in the western part of the lake in waters greater than 5 feet. The proportional distribution of aquatic plants has been relatively stable over time (Figure 2.1-3)

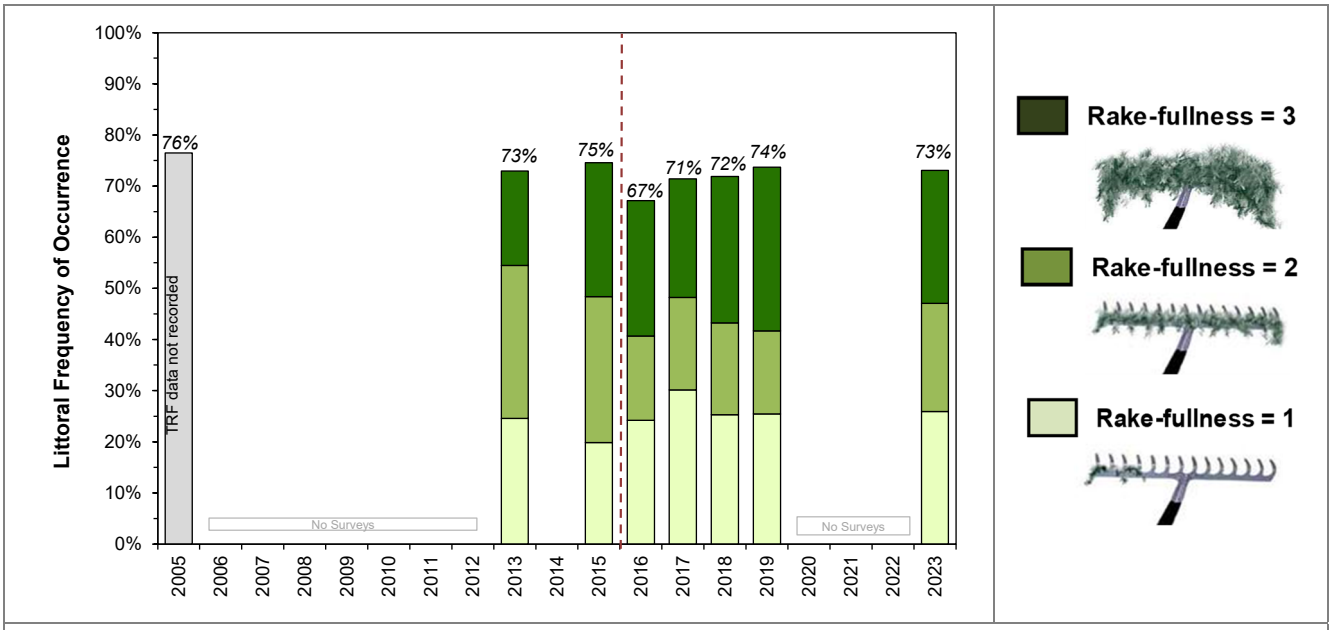


Figure 2.1-3. Shawano Lake aquatic vegetation total rake fullness ratings. Red-hatched line indicates spring 2016 whole-lake 2,4-D treatment.

Frequency of Occurrence

Littoral Frequency of Occurrence (LFOO) is one of the most common metrics used from point-intercept data, as it relays how often aquatic plants are found within the zone of the lake that can support aquatic plants (littoral zone). This metric is calculated by taking the number of sampling points with a given species, divided by the number of sampling points that season that were found to be less than or equal to the maximum depth of plants.

A total of 43 aquatic plant species were encountered directly on the rake during the 2023 whole-lake point-intercept survey with charophytes, forked duckweed, naiad species, wild celery, and coontail comprising the top 5 most frequently encountered species (Figure 2.1-4).

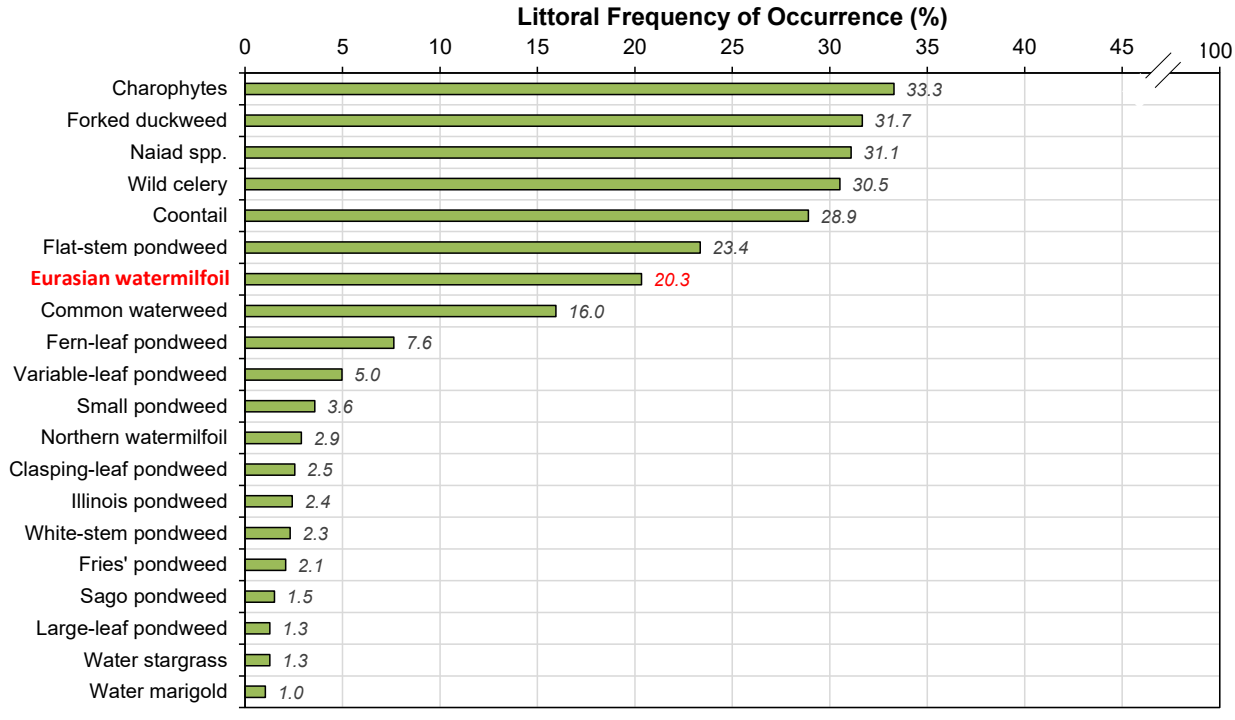


Figure 2.1-4. 2023 littoral frequency of occurrence of aquatic plant species. Species with greater than 1.0% LFOO shown.

Figures 2.1-5 -2.1-9 will investigate the population dynamics of a few select species from Shawano Lake. The red-hatched line indicates the year in which a spring whole-lake 2,4-D treatment occurred.

Muskgrasses were the most abundant macrophyte located in the 2023 point-intercept surveys. Muskgrasses are actually not true "plants," but represent a genus of macroalgae, of which there are ten documented species that occur in Wisconsin (Figure 2.1-5). Dominance of the aquatic plant community by muskgrasses is common in hardwater lakes and these macroalgae have been found to be more competitive against vascular plants (e.g., pondweeds, milfoils, etc.) in lakes with higher concentrations of calcium carbonate in the sediment (Kufel and Kufel 2002); (Wetzel 2001). Muskgrasses require lakes with good water clarity, and their large beds stabilize bottom sediments. Studies have also shown that muskgrasses sequester phosphorus in the calcium carbonate encrustations which form on these plants, aiding in improving water quality by making the phosphorus unavailable to phytoplankton (Coops 2002). Muskgrasses can be easily identified by their strong skunk-like odor. As well as providing a food source for waterfowl, muskgrasses often serves as a sanctuary for small fish and other aquatic organisms. Muskgrasses populations have been relatively stable from 2013-2023.

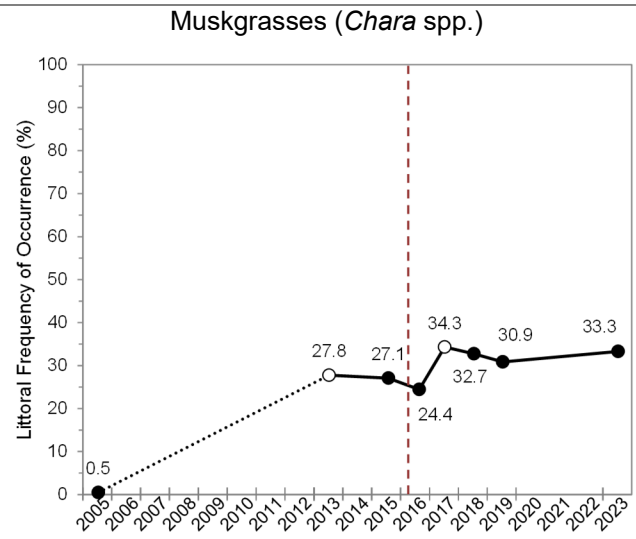


Figure 2.1-5. Littoral frequency of occurrence of muskgrasses. Open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05).

Photograph 2.1-1. The aquatic macroalgae muskgrasses (*Chara* spp.). Photo credit Onterra.

Forked duckweed was the second-most frequently encountered species in Shawano Lake during the 2023 point-intercept survey. Like the other six species of duckweed found in Wisconsin, forked duckweed is rootless and is found free-floating within the water; however, forked duckweed is found growing below the surface along the bottom or entangled among other plants as opposed to floating on the surface like the other duckweed species. Forked duckweed obtains all of its nutrients directly from the water and is found in waters with sufficient nutrients to sustain its growth. But because it grows beneath the surface, it also requires water with adequate light transparency. Forked duckweed was found growing at depths from 1-20 feet with a littoral frequency of occurrence of 31.7% in 2023.

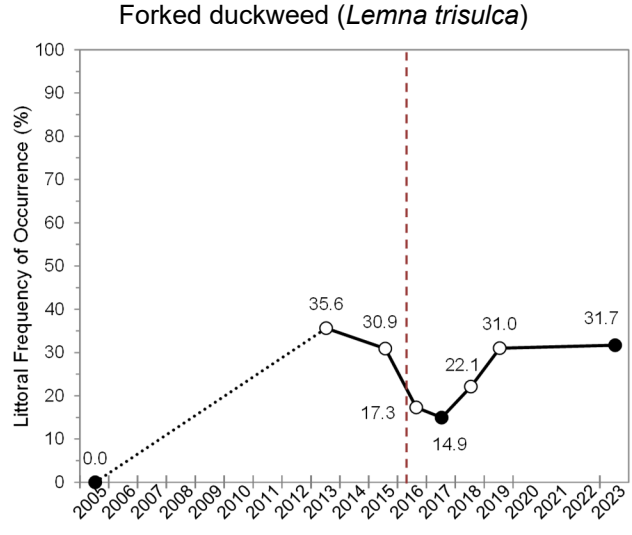


Figure 2.1-6. Littoral frequency of occurrence of forked duckweed. Open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05).

Photograph 2.1-2. Free-floating forked duckweed (*Lemna trisulca*). Photo credit Onterra.

Naiad species were there third-most common species in the 2023 point-intercept survey. Slender naiad and southern naiad are morphologically similar species (Photograph 2.1-3), with field crews distinguishing between these species in more recent years (Figure 2.1-7). Slender naiad is an annual, reproducing from seed each year, while southern naiad is a perennial, growing out of the previous year's stems. Onterra's experience is that slender naiad is particularly susceptible to whole-lake 2,4-D treatments whereas southern naiad is more tolerant. Although southern naiad is native to North America, in some lakes it has been observed exhibiting aggressive growth in recent years. While southern naiad provides shelter for smaller fish and invertebrates and is a food source for some duck species, it can dislodge from sediments and form surface mats that interfere with navigation, recreation, and aesthetics

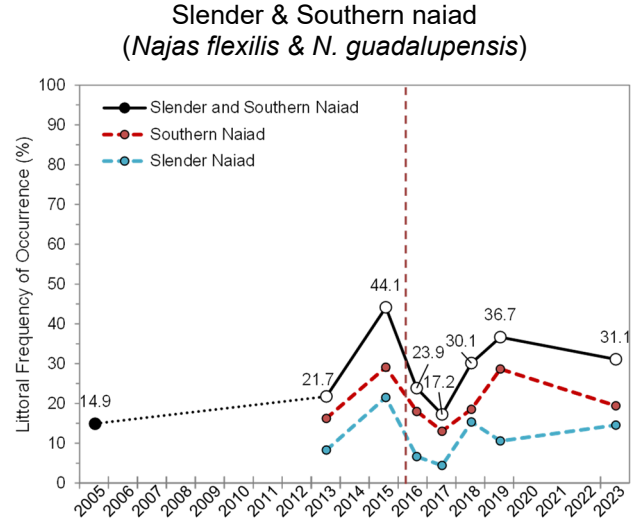


Figure 2.1-7. Littoral frequency of occurrence of naiad species. Open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05).

Photograph 2.1-3. Slender naiad (*Najas flexilis*; left) and southern naiad (*N. guadalupensis*; right). Photo credit Onterra.

The fourth most common species in 2023 and one of the most commonly encountered species in Shawano Lake when considering all surveys is wild celery. Wild celery contains a basal rosette, which means that the long, grass-like leaves extend in a circular fashion from the base of the plant located at the sediment-water interface (Photograph 2.1-4). To keep the leaves standing in the water column, lacunar cells in the leaves trap air and gasses making them more buoyant. Towards the late-summer when water celery is at its peak growth stage, it is easily uprooted by wind and wave activity. The wild celery can then pile up on shorelines depending on the predominant wind direction (Photograph 2.1-5). This occurs periodically on Shawano Lake, and is common on other large waterbodies around the state. In 2016, SAWM utilized their mechanical harvester to mitigate the recreation and navigation impacts. The leaves, fruits, and winter buds of wild celery are food sources for numerous species of waterfowl and other wildlife and are an important

Photograph 2.1-5. Floating wild celery mats in 2016 (right) on Shawano Lake. 2016 photo courtesy of SAWM.

component of the Shawano Lake ecosystem. Wild celery emerges a little later than many native plant species and perhaps is dormant during the herbicide treatment and thus less susceptible to impacts from this herbicide. Wild celery populations were highest during the year of the whole-lake 2,4-D treatment but exhibited relatively stable populations between 2015 and 2023 (Figure 2.1-8).

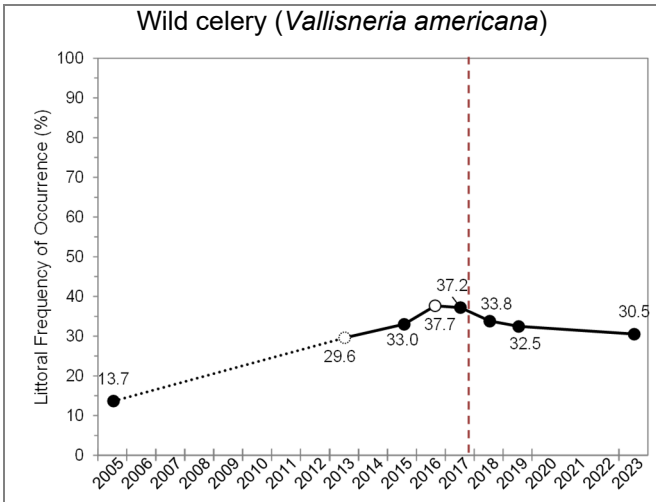


Figure 2.1-8. Littoral frequency of occurrence of wild celery. Open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05).

Photograph 2.1-4. Wild celery (*Vallisneria americana).* Photo credit Onterra.

Coontail was the fifth most common species in Shawano Lake during 2023; common waterweed was the eight most common species. Coontail populations have been very stable over time in Shawano Lake, whereas common waterweed populations have fluctuated. Common waterweed populations expanded following the whole-lake 2,4-D treatment, although it is unsure if this inverse correlation is causation or driven by another factor. Common waterweed has trended lower since 2017 to 16% in 2023.

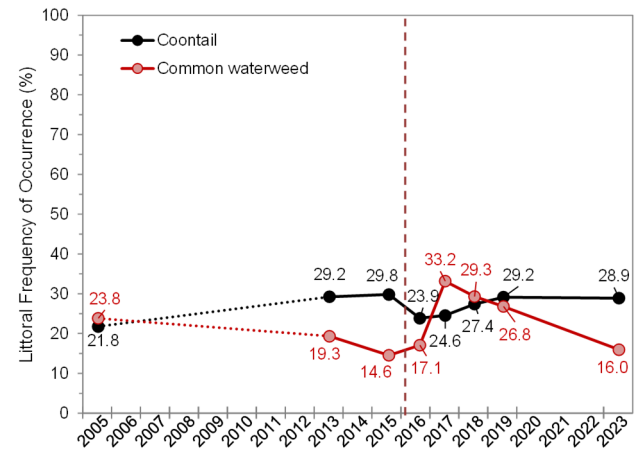


Figure 2.1-9. Littoral frequency of occurrence of naiad species.

Photograph 2.1-6. Coontail (*Ceratophyllum demersum*; left) and common waterweed (*Elodea canadensis*; right). Photo credit Onterra.

These species are often discussed together due to the unique fact that coontail and common waterweed do not produce true roots (Photograph 2.1-6). While they sometimes form root-like structures and appear anchored to the sediment, these species are most often found growing entangled amongst other aquatic plants or matted at the surface. Because they lacks true roots, these species derive all of their nutrients directly from the water (Gross, Erhard and Ivanyi 2003). This ability in combination with a tolerance for low-light conditions allows these species to become more abundant in productive waterbodies with higher nutrients and lower water clarity. These species provide excellent structural habitat for aquatic invertebrates and fish, especially in winter as they remain green under the ice. In addition, they compete for nutrients that would otherwise be available for free-floating algae and helps to improve water clarity. However, in some lakes such as Shawano Lake, coontail can form dense surface mats that interfere with recreation and navigation.

Plant species from the family Potamogetonaceae are referred to as the pondweeds. Shawano Lake is known to contain 15-20 different pondweed species and hybrid varieties. The top ten most frequent pondweeds are investigated in Figure 2.1-10 and shown in Photograph 2.1-7. Some of these species were particularly impacted by the whole-lake 2,4-D treatment, whereas others were more resilient.

Flat-stem pondweed was the most abundant pondweed in 2023 at 23% littoral frequency of occurrence. This pondweed is often more abundant in productive lakes with soft sediments like Shawano Lake. Flat-stem pondweed, as its name implies, can be distinguished from other thin-leaved pondweeds by its conspicuously flattened stem. Flat-stem pondweed can attain heights of 10 feet or greater in the water column, and provides excellent structural habitat for aquatic wildlife.

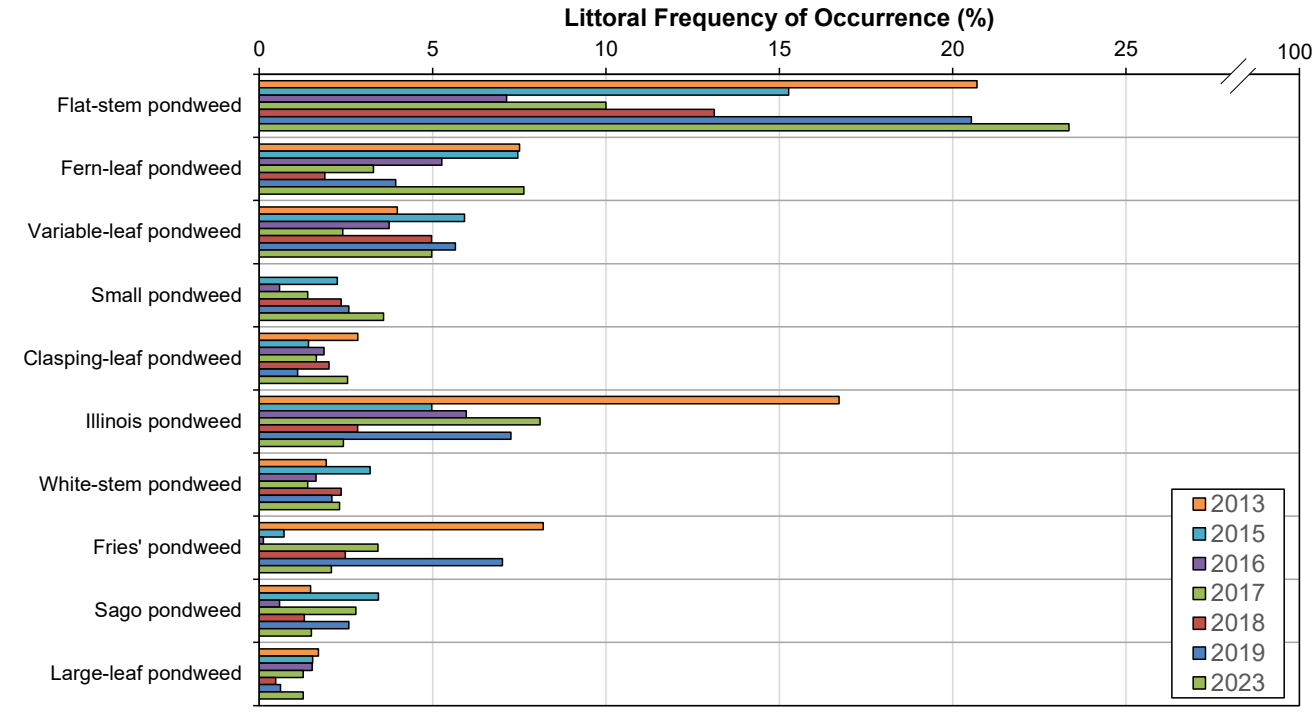
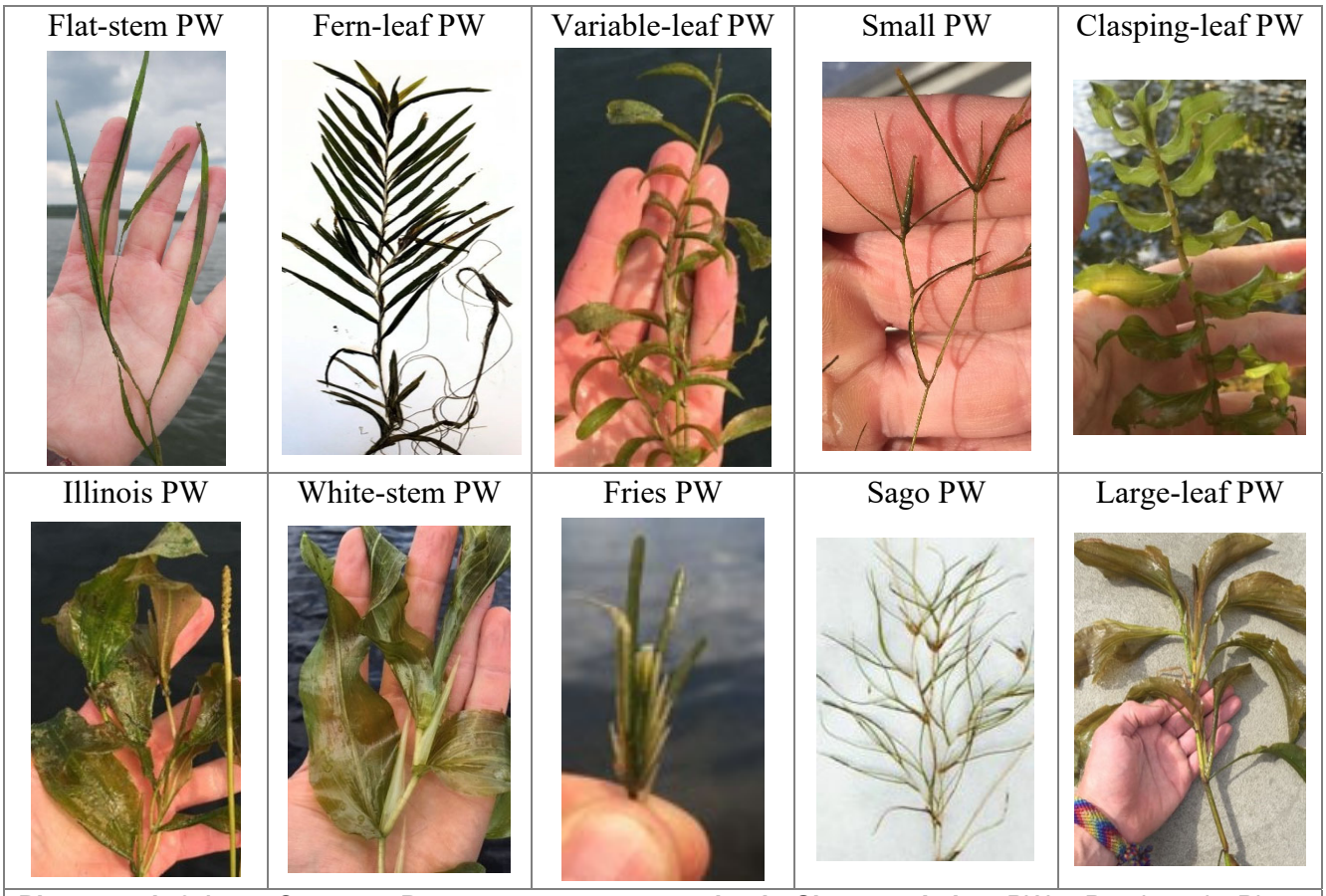


Figure 2.1-10. Littoral frequency of occurrence of pondweed aquatic plant species. (Chi-Square α = 0.05)

Fern pondweed was the second most abundant pondweed in Shawano Lake in 2023 with a littoral frequency of occurrence of approximately 8%. As its name indicates, this plant resembles a terrestrial

fern frond in appearance, and is often a dominant species in plant communities of northern Wisconsin lakes. Fern pondweed is generally found growing in thick beds over soft substrates, where it stabilizes bottom sediments and provides a dense network of structural habitat for aquatic wildlife. This plant remains green under the ice, being extremely important to the aquatic ecosystem.

Many anglers are most familiar with large-leaf pondweed, sometimes called cabbage, musky cabbage, tobacco cabbage, etc. because it has big, broad leaves, often have a brown color, and are great habitat for ambush predatory fish like muskellunge. Large-leaf pondweed was the tenth most common pondweed species in 2023 at 1.3% of sampling locations. This species has slight reductions in 2018-2019 but approximately rebounded to historical levels in 2023. Large-leaf pondweed looks very similar to other large-leaved pondweeds like Illinois pondweed and white-stem pondweed, often hybridizing between these species.



Photograph 2.1-7. Common Potamogetonaceae species in Shawano Lake. PW = Pondweed. Photo credit Onterra.

Floristic Quality Assessment

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

undisturbed environment. Species which are more specialized and require undisturbed habitat are given higher coefficients, while species which are more tolerant of environmental disturbance have lower coefficients. Higher average conservatism values generally indicate a healthier lake as it is able to support a greater number of environmentally-sensitive aquatic plant species. Low average conservatism values indicate a degraded environment, one that is only able to support disturbance-tolerant species.

On their own, the species richness and average conservatism values for a lake are useful in assessing a lake's plant community; however, the best assessment of the lake's plant community health is determined when the two values are used to calculate the lake's floristic quality. The floristic quality is calculated using the species richness and average conservatism value of the aquatic plant species that were solely encountered on the rake during the point-intercept surveys (equation shown below). This assessment allows the aquatic plant community of Shawano Lake to be compared to other lakes within the region and state.

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

Figure 2.1-11 displays the species richness, average conservatism, and floristic quality of Shawano Lake along with ecoregion and state median values. Shawano Lake's native plant species richness value has averaged 32.5 over the course of all eight point-intercept surveys which all falls well above the median values for the ecoregion (16) and state (19). Shawano Lake's average species conservatism of 6.4 over all surveys falls above ecoregion (5.8) and state (6.3) medians as well. This indicates that Shawano Lake has a higher number of environmentally sensitive species (higher C-values) when compared to most lakes within the North Central Hardwood Forests (NCHF) ecoregion and in Wisconsin. Using the species richness and average conservatism values, Shawano Lake's Floristic Quality Index was 41.6 in 2023, and averaged 36.4 over all surveys which again falls well above the median value for lakes in the NCHF ecoregion (23.6) and for lakes statewide (27.2).

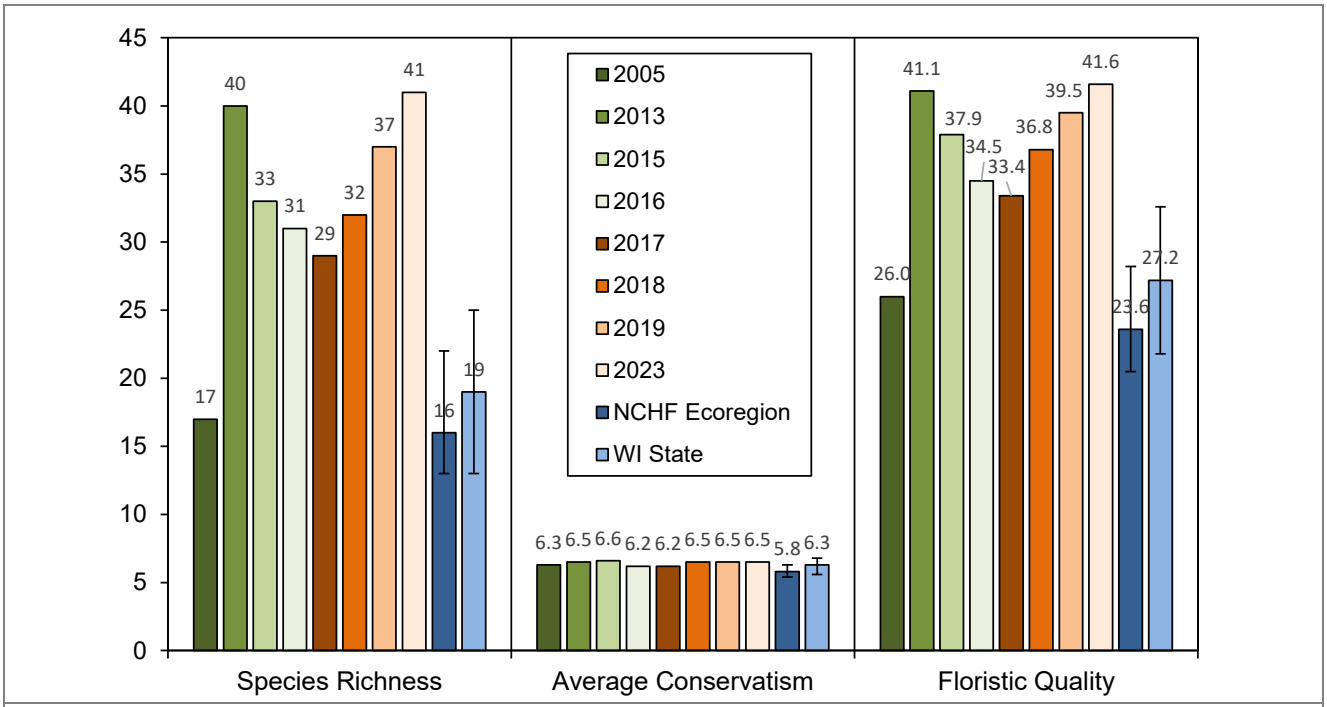


Figure 2.1-11. Shawano Lake Floristic Quality Assessment. Created using data from point-intercept surveys. Analysis following Nichols (1999) where NCHF = North Central Hardwood Forests Ecoregion.

Species Diversity

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

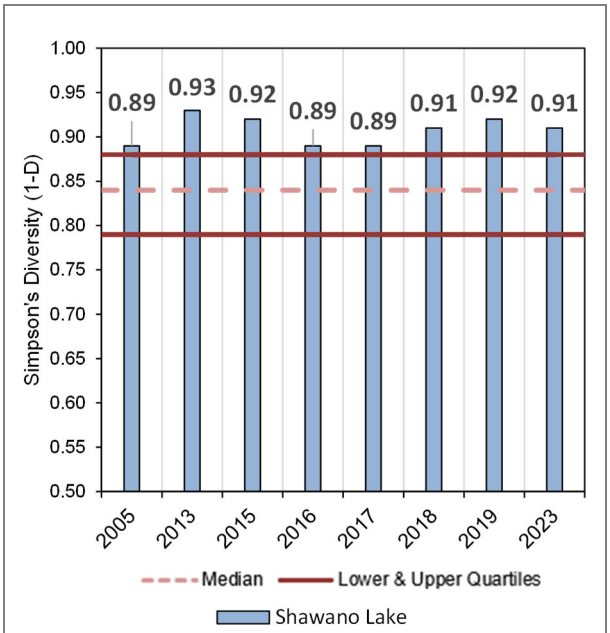


Figure 2.1-12. Shawano Lake Simpson's Diversity Index. Created using data from point-intercept surveys.

If a lake has a diversity index value of 0.90, it means that if two plants were randomly sampled from the lake there is a 90% probability that the two individuals would be of a different species. The Simpson's Diversity Index value from Shawano Lake is compared to data collected by Onterra and the WDNR Science Services on lakes within the North Central Hardwood Forests ecoregion and on lakes throughout Wisconsin (Figure 2.1-12). While a method for characterizing diversity values of fair, poor, etc. does not exist, lakes within the same ecoregion may be compared to provide an idea of how Shawano Lake's diversity values rank. Shawano Lake's Simpson's Diversity Index value has been stable at 0.89-0.93 over the course of the point-intercept surveys spanning 2005-2023, which is above the ecoregion upper quartile.

Eurasian watermilfoil

Eurasian watermilfoil was the target of the spring 2016 whole-lake 2,4-D treatment. As discussed in the Introduction Section (1.1), this treatment slightly exceeded whole-lake target concentrations, but the herbicide degraded much faster than anticipated. The EWM population just before the treatment in 2015 was 16.6%, declining to 1.2% during the late-summer following the treatment in 2016 (Figure 2.1-13). The EWM population rebounded and at four summers following treatment, was greater than pretreatment levels at 22.3% in 2019. The 2023 survey was eight summers post treatment, and the EWM population has been relatively similar at 20.3%

A closer analysis was taken comparing the EWM rake fullness ratings for the most recent six point-intercept surveys on Map 4. Interestingly, different areas of the lake seem to contain more EWM in different years, likely as a result of small changes in water clarity, water temperatures, days of sunlight, competition from native plants, etc.

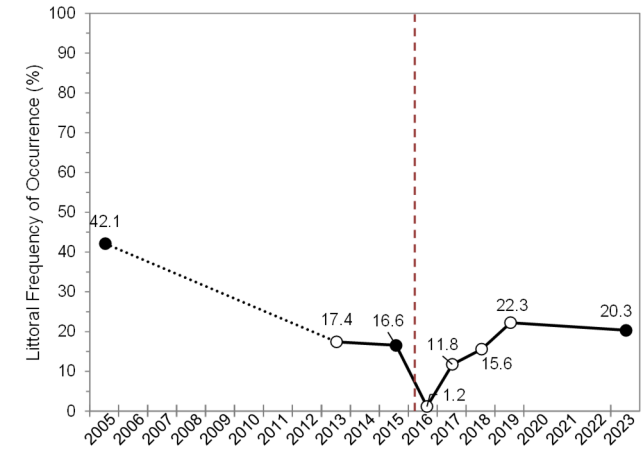


Figure 2.1-13. Littoral frequency of occurrence of invasive watermilfoil. Open circle indicates a statistically valid change in occurrence from the previous survey (Chi-Square α = 0.05).

Photograph 2.1-8. Eurasian watermilfoil, a non-native, invasive aquatic plant. Photo credit Onterra.

2.2 Qualitative Monitoring: EWM Mapping Surveys

Starting in 2013, late-season EWM mapping surveys began on Shawano Lake using a consistent density rating system (Figure 2.2-1). These survey approximate a census of all the EWM that can be observed through surface viewing. These surveys take place at the end of the growing season when EWM is presumably at its maximum growth for a given year. On Shawano Lake, these surveys have consistently occurred the last week of September through the first week of October. The most recent mapping survey occurred on October 4-9, 2023.

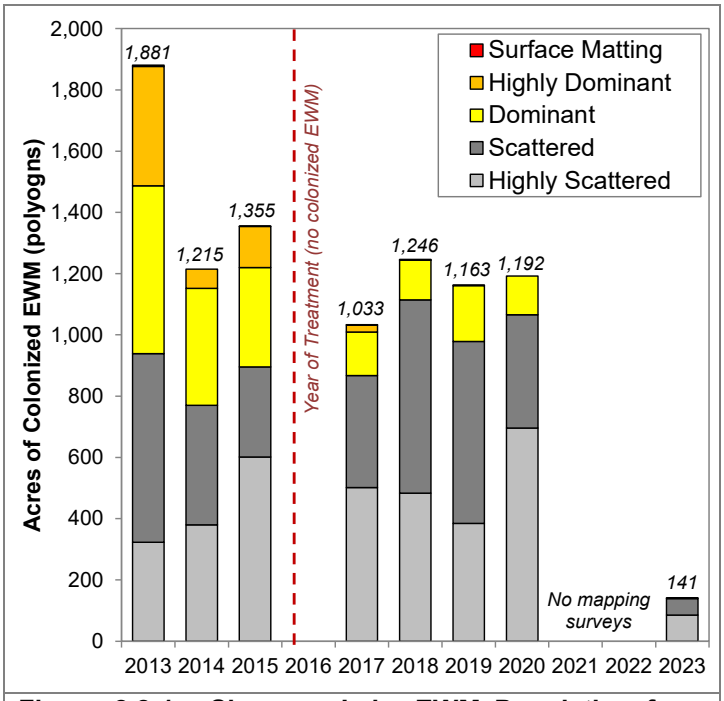


Figure 2.2-1. Shawano Lake EWM Population from 2021-2023. Data from Late-Summer EWM Mapping Surveys.

During the 2023 survey, the crew marked numerous *single or few plant* EWM plants around the lake as well as *highly scattered* and *scattered* colonies (Map 5). The largest concentrations of EWM in the lake were found near shore. Water clarity and conditions were not the limiting factor, as field crews could easily observe other plant species. The crews deployed submersible camera transects in previously dominant EWM areas, noting very little EWM and what was present was short-statured and impossible to view from the surface.

Map 6 explores both the point-intercept survey and the EWM mapping survey from Shawano Lake. Almost all the EWM observed during the 2023 point-intercept survey had a rake fullness rating of 1, meaning that the rake only contained a sprig or two of EWM where present. The EWM population in 2023 occupied a similar overall footprint as in past years, but was sparse and low growing to the point it was not able to be mapped using the standard methodologies.

3.0 CONCLUSIONS AND DISCUSSION

Based upon the analysis of the point-intercept data over time, the native aquatic plant community of Shawano Lake remains in a healthy condition. While some plants responded negatively to the 2016 whole-lake 2,4-D treatment, these species have essentially all rebounded. Some plant species have been extremely stable since over the past decade, whereas others have naturally fluctuated.

The assessment of the EWM population through both the point-intercept survey and late-season EWM mapping survey yielded somewhat contrasting results. The point-intercept survey showed EWM was at a littoral frequency of occurrence of 20.3% which is similar to the 2019 results of 22.3%. Crews expected to map a comparable extent of EWM as in 2019 (1,192 acres), however, only 141 acres were visible from the surface and were mapped in 2023. At these levels, it is not causing impacts to navigation or recreation within the lake, nor is it impacting the ecological function of the lake.

Based on the 2023 findings, no EWM-targeted management actives are warranted. Since the 2016 whole-lake herbicide treatment, EWM has rebounded to pretreatment frequencies, but continues to be found growing below levels that are negatively impacting Shawano Lake.

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

In many Wisconsin Lake, EWM has integrated into the aquatic plant community of a lake. Like other aquatic plants, EWM populations are dynamic and annual changes in EWM frequency of occurrence have been documented in many lakes, including those that are not being actively managed for EWM control (no herbicide treatment or hand-harvesting program). The data are clearest for unmanaged lakes in the Northern Lakes and Forests Ecoregion (NLF) and the North Central Hardwood Forests Ecoregion (NCHF) (Figure 3.0-1).

Following initial infestation, EWM expansion was rapid on some lakes, but overall was variable and unpredictable (Nault 2016). On some lakes, the EWM populations reached a relatively stable equilibrium whereas other lakes had more moderate year-to-year variation. Regional climatic factors also seem to be a driver in EWM populations, as many EWM populations declined in 2015 even though the lakes were at vastly different points in time following initial detection within the lake. 2019 also experienced record rainfall which may have had an impact on the EWM population indirectly through a decrease in water clarity on some systems.

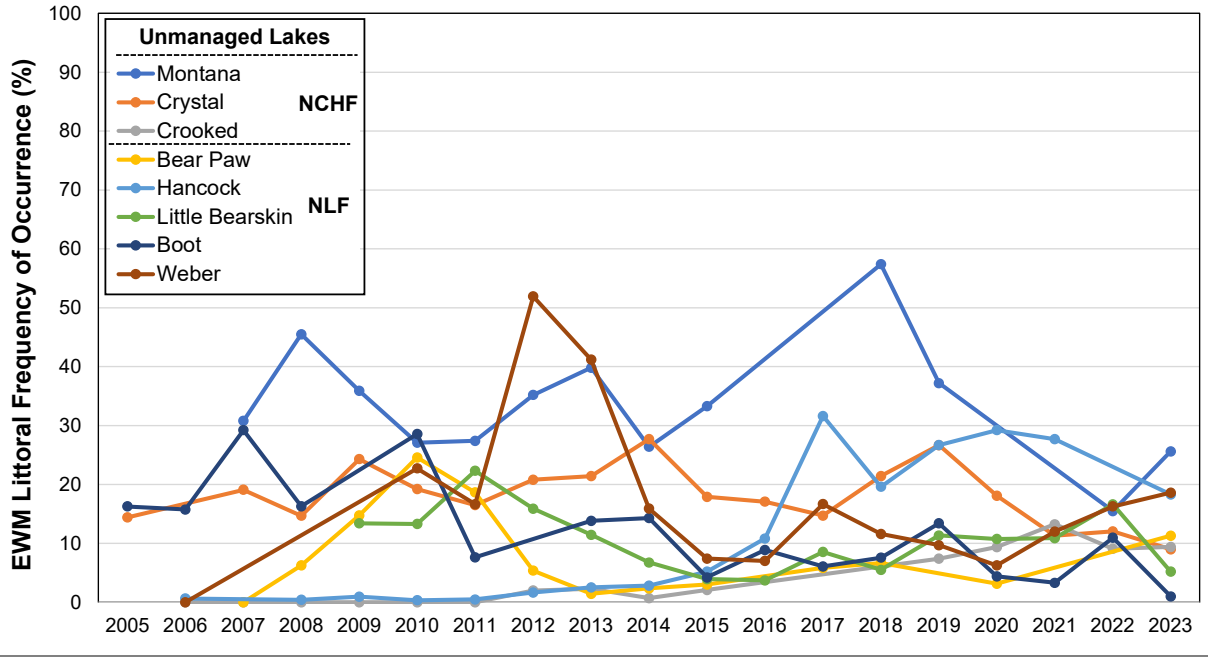
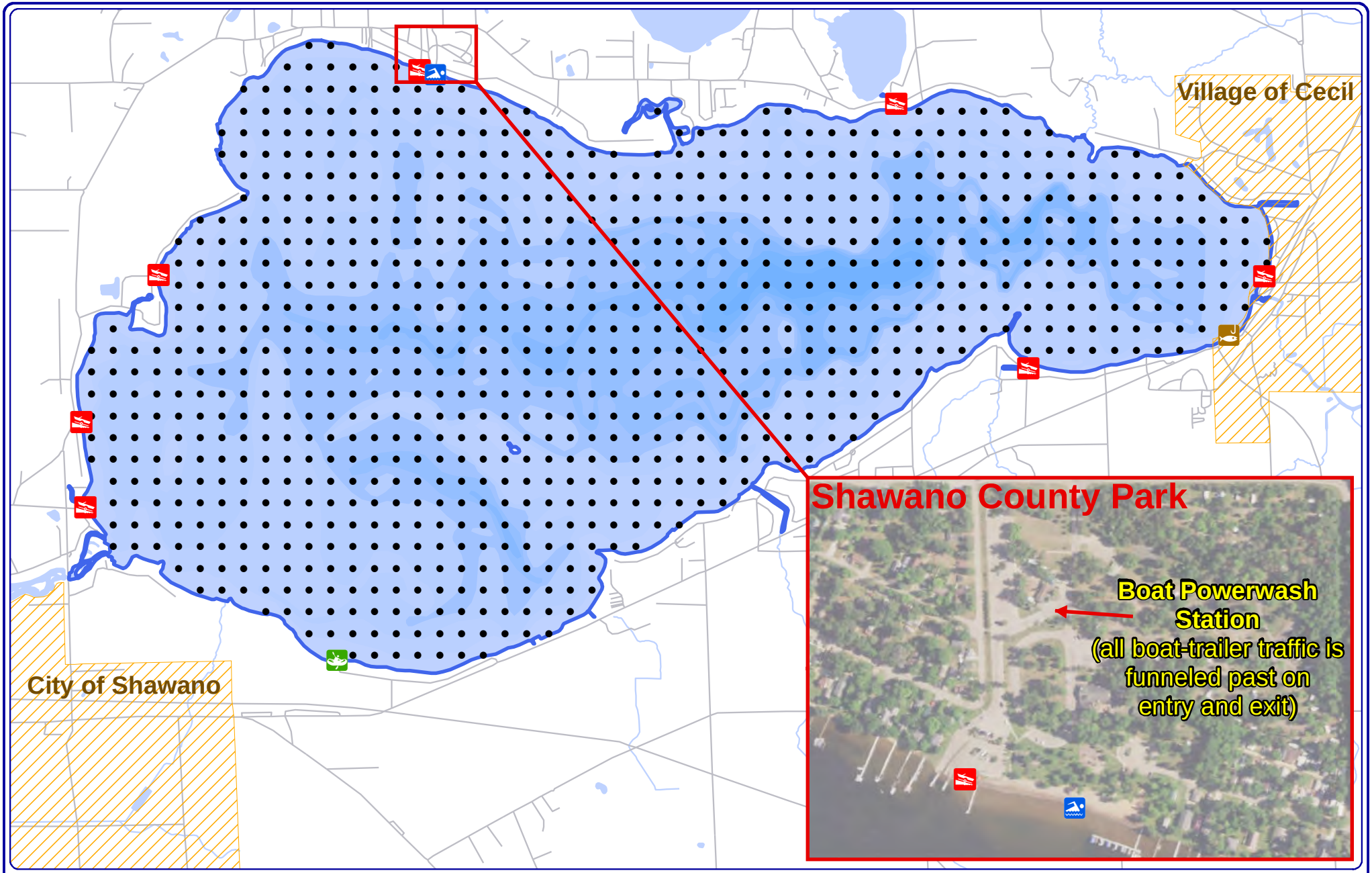


Figure 3.0-1. LFOO of EWM in northern ecoregions without management. Data provided by and used with permission from WDNR.

The SAWM *Comprehensive Management Plan* (2021) states that late-season EWM mapping surveys would continue to occur every 2-3 years and the point-intercept survey would occur every 3-5 years. If EWM continues to be below thresholds where directed management are considered, replicating these surveys in roughly 2026 would be consistent with the management plan. Pairing these surveys together into a single project increases the likelihood of receiving WDNR grant assistance.



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

Sources:
Roads and Hydro: WDNR
Bathymetry: Onterra, 2017
Map Date: March 8th, 2024 KLW
Filename: Map1_Shawano_Location_2023.mxd

Project Location in Wisconsin

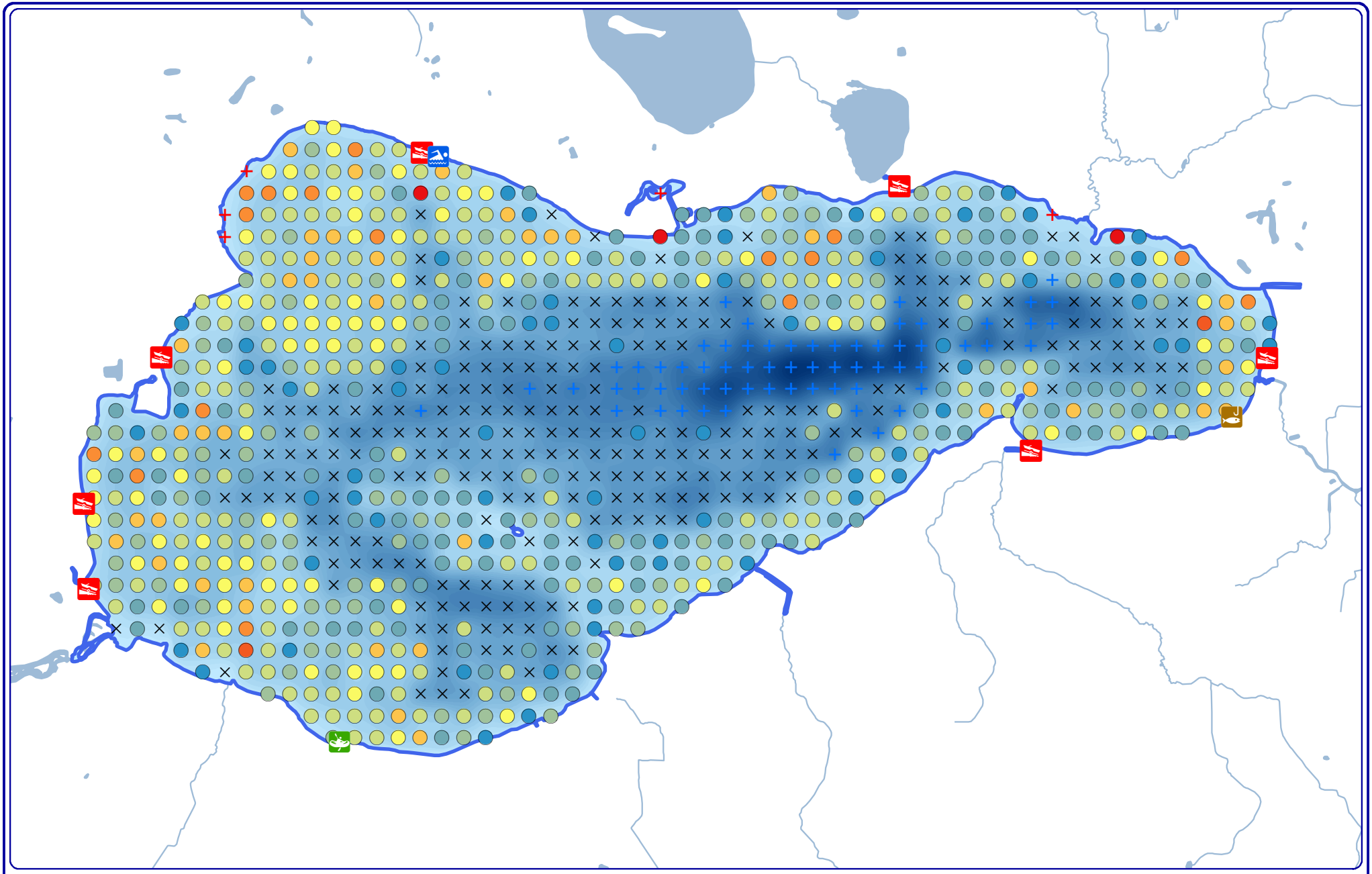
Legend

Shawano Lake ~6,258 acres
Ortho-corrected Definition

Point-Intercept Survey Location
165-meter spacing, 925 total points

Map 1
Shawano Lake
Shawano County, Wisconsin

Project Location & Lake Boundaries



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Lake Management Planning
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De Pere, WI 54115
920.338.8860
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Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2023
Map Date: March 8th, 2024 KLW

Project Location in Wisconsin

Legend

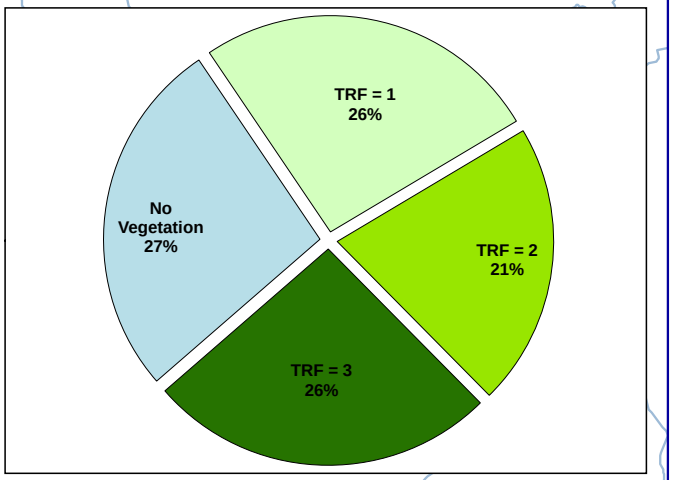
Number of Native Species per Site

0 1 2 3 4 5 6 7 8 9

\+ Too Deep

\+ Non-navigable/Temporary Obstacle

Map 2
Shawano Lake
Shawano County, Wisconsin
2023 PI Survey: Native Species Richness



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De Pere, WI 54115
920.338.8860
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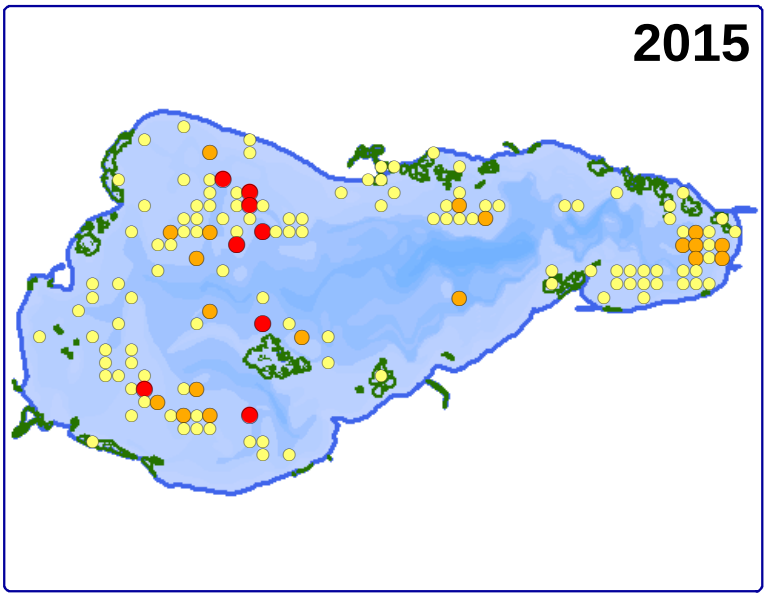
Sources:
Roads and Hydro: WDNR
Aquatic Plants: Onterra, 2023
Map Date: March 8th, 2024 KLW

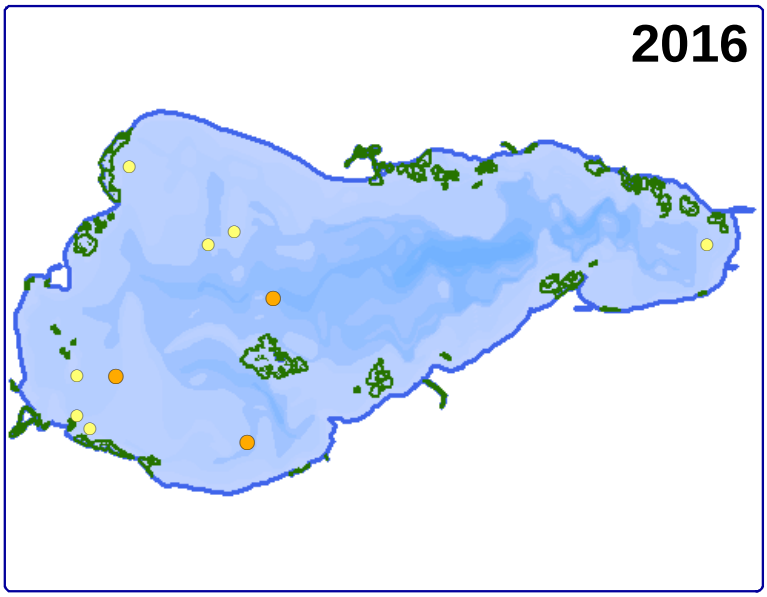
Project Location in Wisconsin

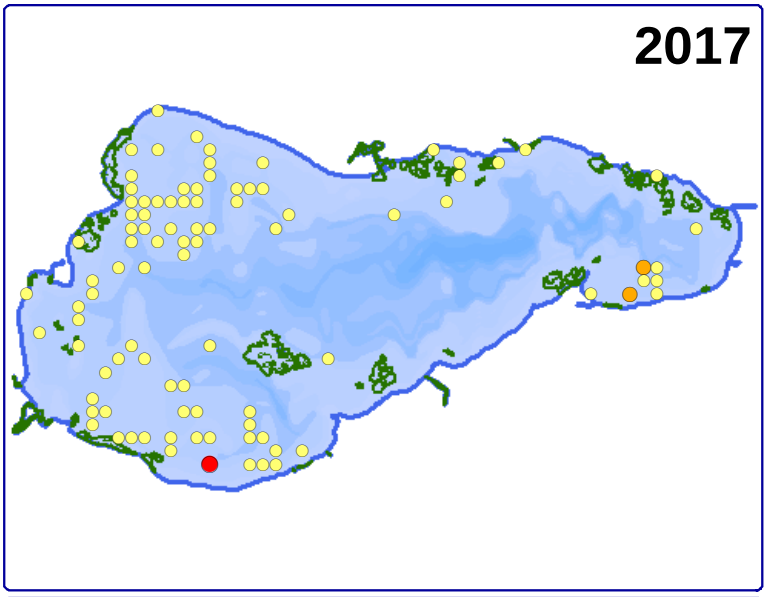
Legend

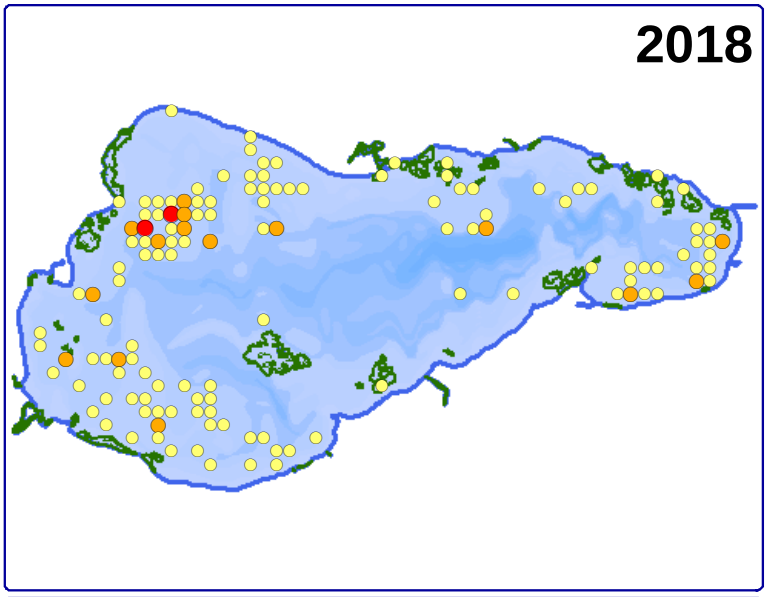
- Total Rake Fullness = 1
- Total Rake Fullness = 2
- Total Rake Fullness = 3
- No Vegetation
- Too Deep
- Non-Navigable, Obstacle, etc.

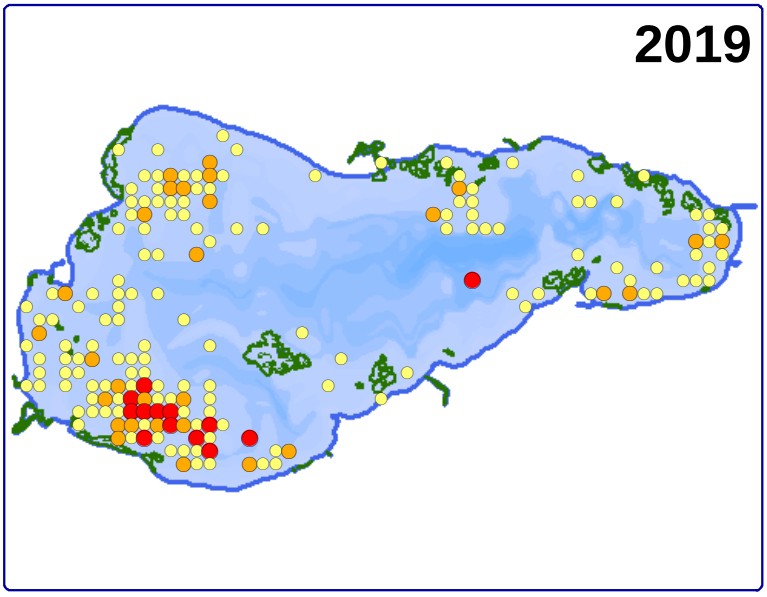
Map 3
Shawano Lake
Shawano County, Wisconsin
2023 PI Survey:
Total Rake Fullness

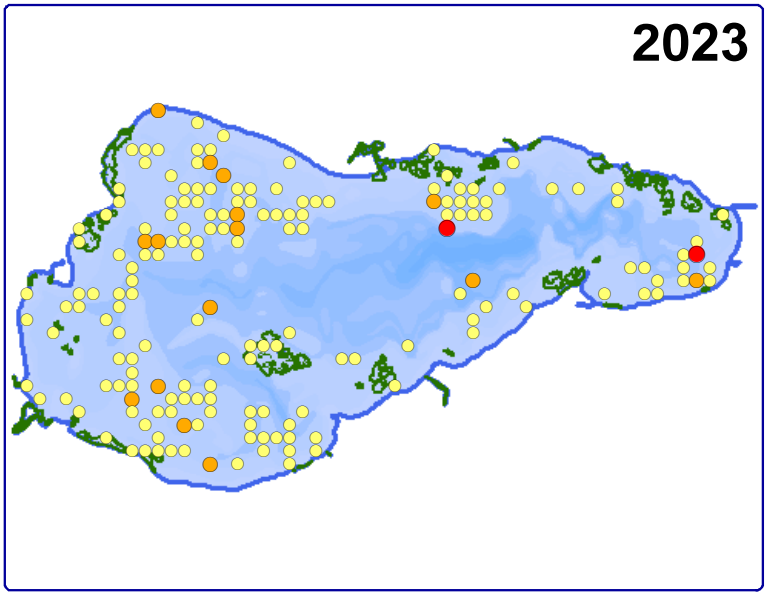












Onterra LLC
Lake Management Planning
815 Prosper Rd
De Pere, WI 54115
920.338.8860
www.onterra-eco.com

Sources
Roads and Hydro: WDNR
Bathymetry: Digitzed by Onterra
Aquatic Plants: Onterra, 2023

Map Date: March 11th, 2024 KLW
Filename: *Map4_Shawano_2023_EWM.mxd*

Project Location in Wisconsin

Legend

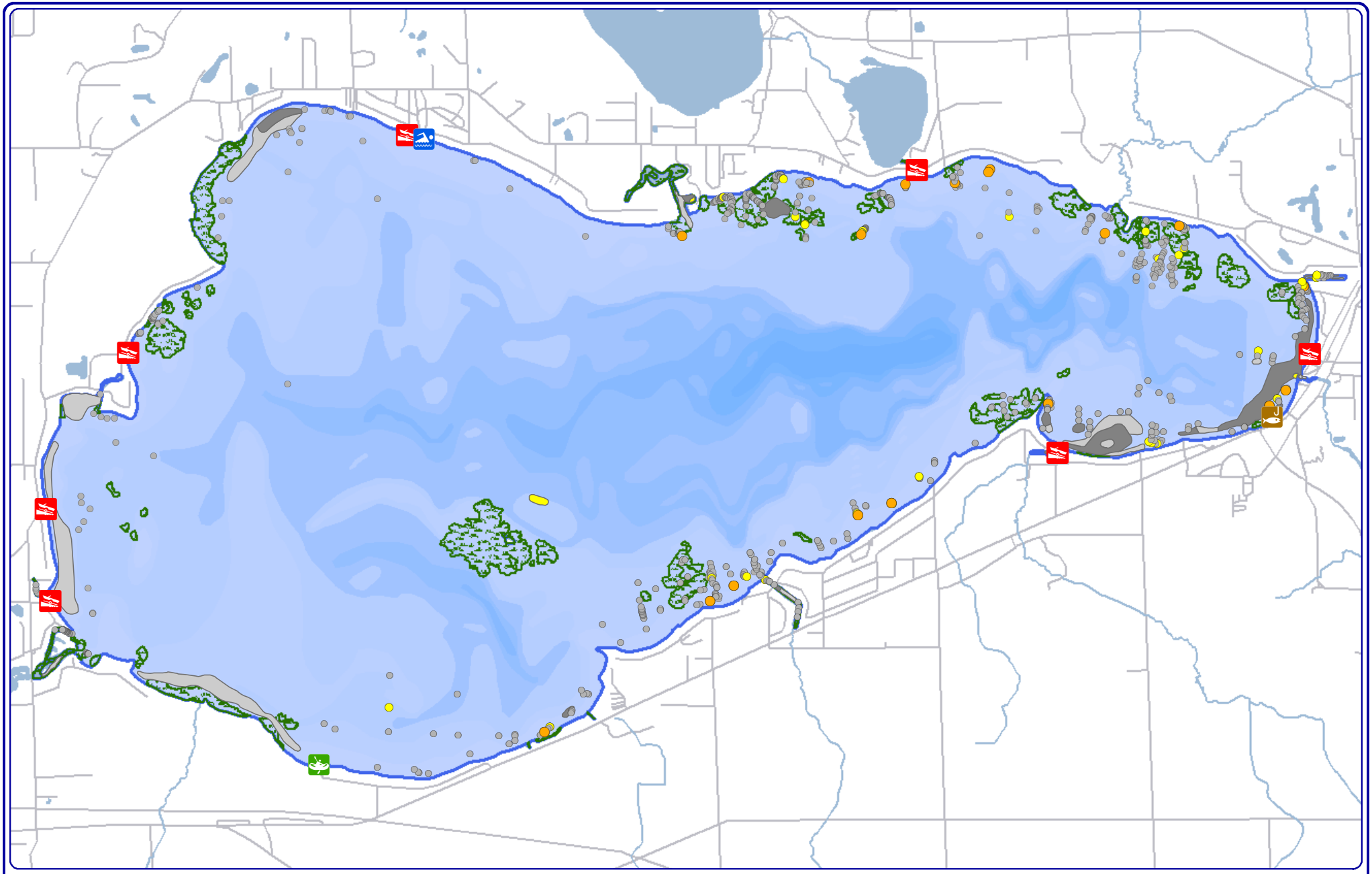
- EWM Rake Fullness = 1
- EWM Rake Fullness = 2
- EWM Rake Fullness = 3

Map 4

Shawano Lake

Shawano County, Wisconsin

Point-Intercept EWM Survey Locations



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De Pere, WI 54115
920.338.8860
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Sources:
Roads and Hydro: WDNR
Bathymetry: Onterra, digitized by Onterra
Aquatic Plants: Onterra, 2023
Orthophtography: NAIP, 2022
Map Date: October 18th, 2023 KLW
Filename:Shawano_EWM_PB_Oct23.mxd

Project Location in Wisconsin

Legend

Eurasian watermilfoil (October 4-9, 2023)

- Highly Scattered
- Scattered
- Dominant
- Highly Dominant *(None)*
- Surface Matting *(None)*
- Single or Few Plants
- Clumps of Plants
- Small Plant Colony
- Floating-leaf and/or Emergent Plant Community *(Mapped 2013)*

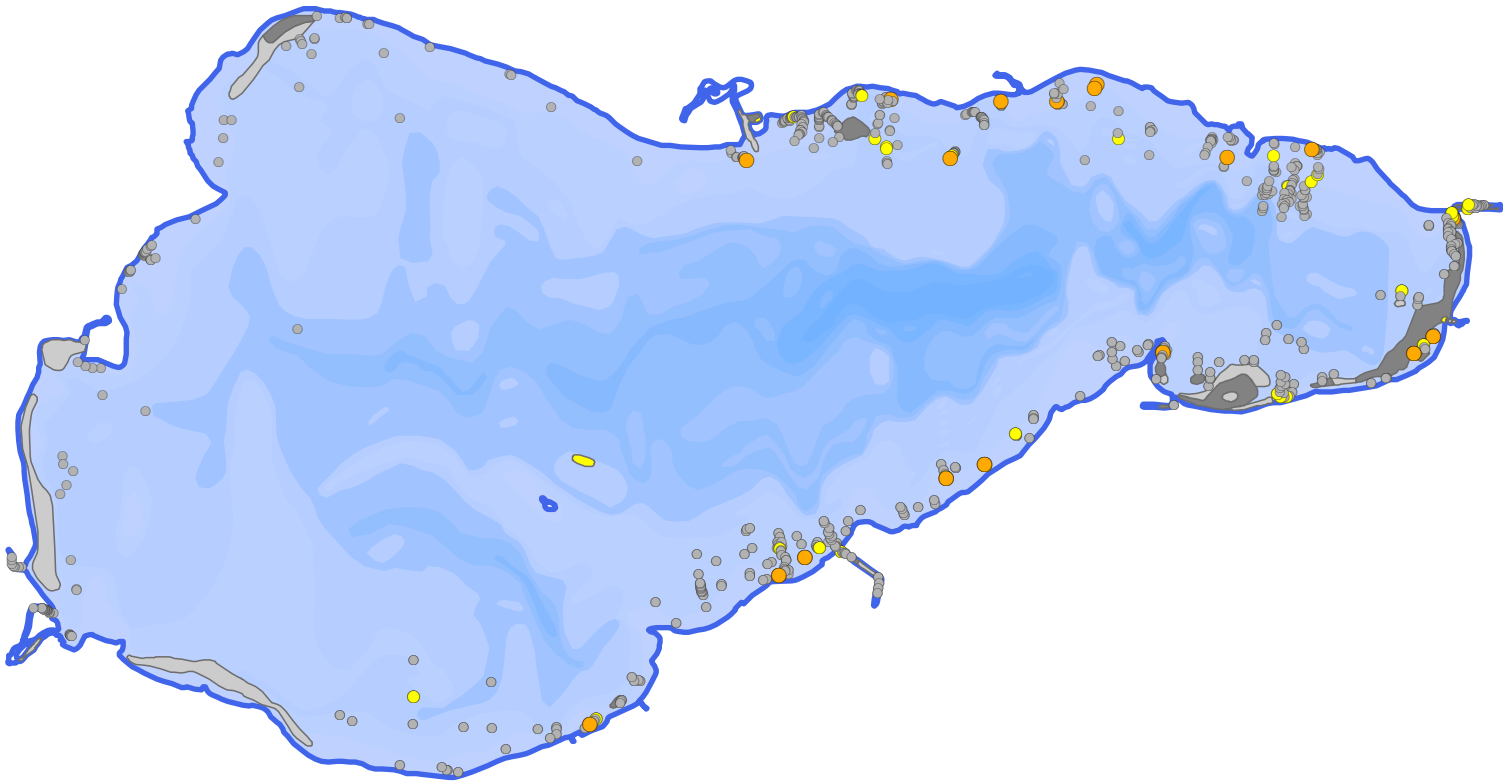
Map 5

Shawano Lake

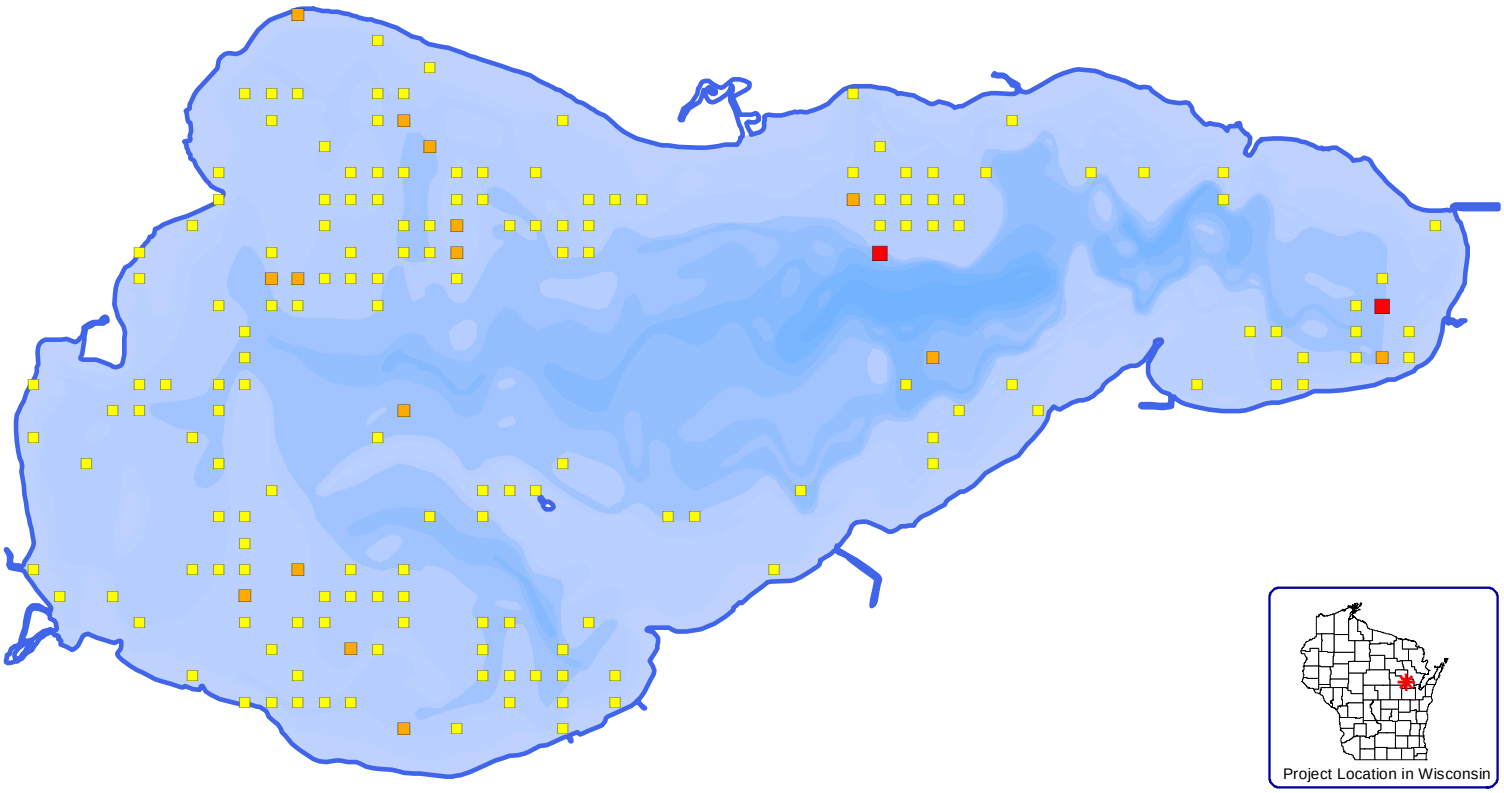
Shawano County, Wisconsin

Late-Season EWM 2023 Survey Results

2023 EWM Mapping Survey



2023 Point-Intercept Survey



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Sources
Roads and Hydro: WDNR
Bathymetry: Digitzed by Onterra
Aquatic Plants: Onterra, 2023

Map Date: March 11th, 2024 KLW
Filename: *Map4_Shawano_2023_EWM.mxd*

Legend

Top Frame

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

Bottom Frame

- EWM Rake Fullness = 1
- EWM Rake Fullness = 2
- EWM Rake Fullness = 3

Map 6
Shawano Lake
Shawano County, Wisconsin

2023 Comparison EWM Mapping vs PI Survey