CLEARWATER LAKE
Crow Wing County
MINNESOTA

AQUATIC PLANT SURVEY 2024

Survey Dates:
August 12-15, 23, 2024

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Prepared for the Clearwater Lake Conservancy

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CLEARWATER LAKE AQUATIC PLANT SURVEY

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EXECUTIVE SUMMARY

An aquatic plant point intercept survey was conducted on Clearwater Lake in Crow Wing County, Minnesota during 2024. The survey began on August 12 and was completed on August 23. In total, 640 points were surveyed at a final resolution of 1 point per half acre. We found 77% of the surveyed area to be occupied with plants from 36 different species, which included Eurasian watermilfoil, the only invasive plant species identified. The most common types of submerged vegetation in the lake were muskgrass and variable-leaved pondweed, but there was a rich and healthy diversity of native plants overall. Eurasian watermilfoil was found at approximately 6% of sites or 21 acres and could be locally dense. While only genetic tests can rule out a hybrid type, it did not have hybrid characteristics and appeared to be a pure strain of Eurasian watermilfoil. The lake is also known to have populations of curlyleaf pondweed, but no evidence was found of it being present. Curlyleaf pondweed dies off naturally each year around the beginning of July and any new growth encountered during mid August would likely go overlooked. Compared to surveys performed by a different company in both 2018 and 2021, our results indicate similar plant community composition but higher overall coverage of native plants and greater overall diversity. Clearwater Lake is in a part of the state with starry stonewort nearby. In addition to professional surveys, educating lake users to recognize it and searching near high probability introduction areas such as boat launches, will be critical to finding invasive species early and containing them before they spread and management costs escalate. Full lake point intercept surveys should occur at a minimum of every three years or as often as budget allows to both search for new invasive species introductions and changes in native plant coverage. Overall, the plant community has desirable characteristics for both recreation and conservation relative to many other lakes in Minnesota.

INTRODUCTION

This report provides results of an aquatic plant survey that was conducted by Limnopro Aquatic Science on the Clearwater Lake during 2024 at the request of the Clearwater Lake Conservancy.

There are different ways that aquatic plant surveys can be done and each has different goals and methods. The main type of surveys done are the point intercept, meandering delineation, and hydroacoustic surveys (Fig. 1).

Point intercept surveys are the most complete and are best for knowing where in the lake different species of vegetation exist as well as the relative densities of each kind. These types of surveys are also good for finding new invasive plant species not previously known to exist in a lake. Standard point intercept surveys are conducted at a spatial resolution of 1 point per littoral acre but more information can be gathered with a more highly resolved point spacing such as 1 point per half acre or even 1 point per quarter acre.

Meandering delineation surveys are an invention of the MN DNR and are their preferred method of having boundaries

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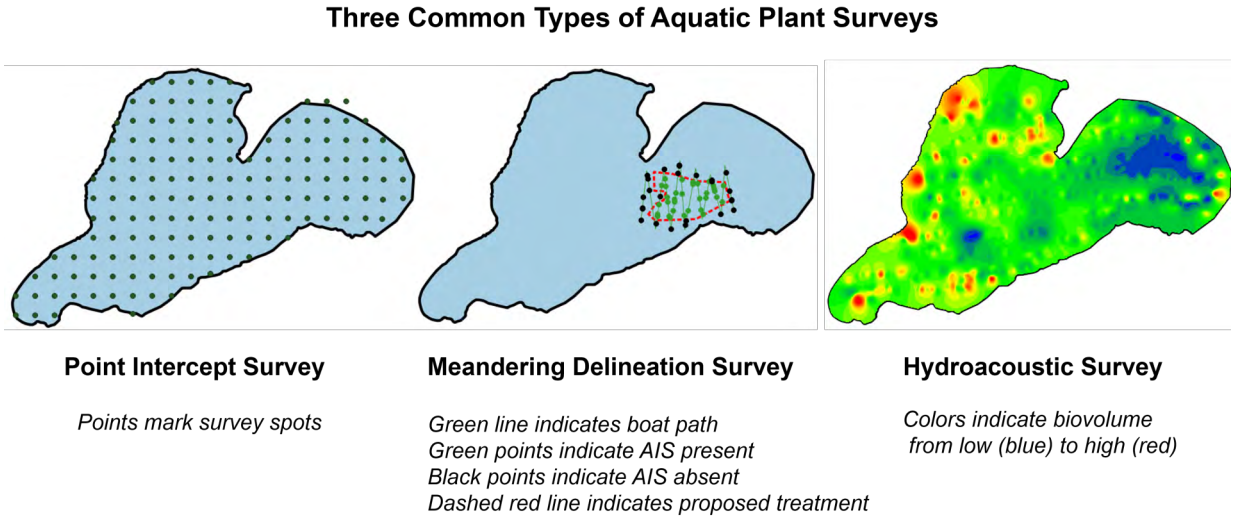

Fig. 1. Example of three types of aquatic plant surveys commonly done in Minnesota for a fictitious lake.

of invasive species mapped prior to chemical or mechanical treatments. These are not full lake surveys but typically use previous information or knowledge about where an invasive species is on the lake to reconfirm their presence and extent. Surveyors randomly zigzag through potential areas where the invasive species may exist and mark points where visual confirmation is made from the boat or where sonar and rake throws find the species.

Hydroacoustic surveys are derived directly from sonar, cover the entire lake and give an unbiased estimate of both coverage and density of plants, but unlike point intercept surveys, they do not tell you what *kind* of plants are being recorded. This type of survey simply provides information about where vegetation exists and how tall it grows from the bottom where it exists.

Aquatic plants are an important part of the functioning of a lake. They reduce wave impacts to shorelines as well as stabilize mud and sand at the bottom of the lake, keeping nutrients out of the water that might otherwise lead to poor water quality when wave disturbed bottom nutrients get stirred into the water and cause algal growth, making the water green and odorous. Aquatic plants also provide habitat and food for other organisms in a lake. These benefits might be referred to as the "conservation value" of plants.

Just because aquatic plants have conservation value, it does not follow that more plants equal greater value. In fact, it is well known that the highest conservation value for a plant community occurs at (1) intermediate coverage and densities, (2) the higher the number of different species, and (3) the higher mixes of broadleaf, narrow leaf, canopy forming and lower growth forms. In other words, not all kinds of plants are the same. The best plant communities have the right kinds in the right amount.

For a variety of reasons, lakes with excessive coverage and densities of plants with low species and functional diversity provide poor environmental conditions and thus have low conservation value.

Fig. 2. Curlyleaf pondweed form. Left Shows the characteristic lasagna noodle appearance with round tips while right shows a close up of the toothed leaf margin.

When lakes are developed and used for recreational purposes, there is an additional goal in plant management that allows for use of a lake by residents to boat, fish, and swim in a given lake. Sometimes conservation values and recreational values conflict with each other. Recreational lakes, which would include Clearwater Lake, are managed to best provide quality for both recreation and conservation.

A complicating factor in managing plant communities is the presence of an invasive plant species. Invasive plants are plants that are from states other than Minnesota or countries other than the USA that, because of their life history characteristics, outcompete native plants for sunlight and nutrients. Often when they are introduced, they cause problems that reduce both the recreational and conservation value of a lake because they grow densely and close to the surface or reduce native diversity. Clearwater Lake is known to have both curlyleaf pondweed and Eurasian watermilfoil, two invasive plant species that exhibits these characteristics.

Curlyleaf pondweed is easy to identify when mature, having a "lasagna noodle" like leaf appearance (Fig. 2). It is Minnesota's only pondweed with curly leaves that has serrated, or toothed, leaf margins and a rounded, rather than pointed, tip. It may be difficult to identify when immature because it does not have the characteristic curling and can be mistaken for other similar looking plants.

One life history characteristic that allows curlyleaf pondweed to flourish in Minnesota is its timing for growth and reproduction that differs from most native plants. Curlyleaf pondweed begins growing much earlier in the year than the vast majority of native plants in Minnesota. Because it grows so early, it can shade out native plants, which would require early season sunlight to begin their annual growth (Fig. 3). This can, and often does, lead to curlyleaf pondweed becoming a dominant plant in lakes it infests during early spring, particularly until the

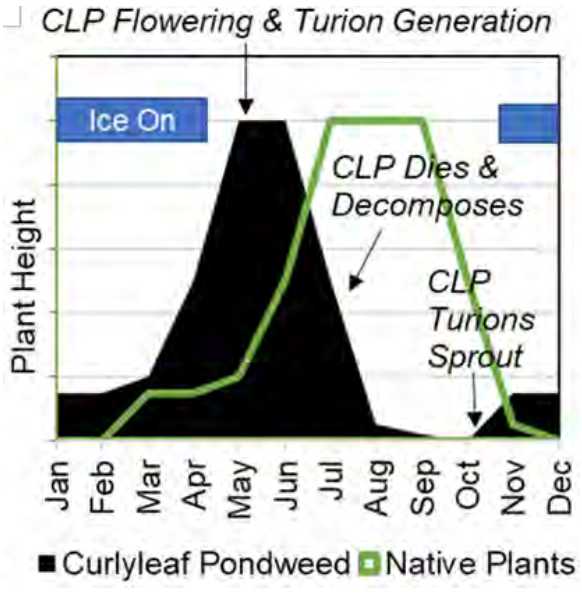

Fig. 3. Curlyleaf pondweed idealized life cycle (black solid area) interposed with "native" plants (hollow green area).

Fig. 4. Comparison of native to invasive watermilfoil species.

beginning of July when it will start its seasonal die off naturally.

Even though curlyleaf pondweed begins to disappear from the lake at the beginning of July, it can have impacts for extended periods of the summer after it has died off. As it dies off during the warmest part of the year, it releases nutrients, which can stimulate algae growth to make the water turbid or cloudy. Bacteria that decompose the dead plant use up oxygen in the water, which can lead to localized suffocation of fish and other organisms. The stimulated algae growth makes it hard for native plants to get the sunlight it needs for growth.

Eurasian watermilfoil is the other aquatic invasive plant species in Clearwater Lake. Eurasian watermilfoil is native to Europe and Asia and was introduced to the eastern United States in the early 1900's, first discovered in Minnesota in 1987 at Lake Minnetonka in central Minnesota.

The best way to identify Eurasian watermilfoil from the majority of native watermilfoils, of which approximately half a dozen exists in Minnesota with the most common being Northern watermilfoil, is the leaflet counts. All watermilfoils have four leaves coming off of a central axis. The extensions off of the leaves are called leaflets. If there are more than eleven pairs of "leaflets", it may be suspected of being Eurasian watermilfoil (Fig. 4).

In lakes with both curlyleaf pondweed and Eurasian watermilfoil, there can develop codominance of curlyleaf pondweed and Eurasian watermilfoil in the spring and Eurasian watermilfoil later in the summer. Unlike curlyleaf pondweed which dies off at the beginning of July, Eurasian watermilfoil remains a part of the plant community throughout the year (Fig. 5).

Most native plant species, as well as other invasive species such as Eurasian watermilfoil and starry stonewort, begin growing rapidly after early June when water temperatures exceed 60˚F and persist through the year until at least October or November. Prior to early June, even though they may be present, they can be difficult to detect. They become easiest to detect during the warmest months of the year from July to September. Subsequently, a common approach we employ for surveying the plant community is to divide it up into two periods, one that is good for surveying curlyleaf pondweed and the associated spring native plant community and the other for natives and other aquatic invasive species of concern.

This plant survey was done later in the year after curlyleaf pondweed would have died off. Given we missed the window to break the survey up in 2024, a follow up survey during spring of 2025 or in the future can supplement this one.

METHODS

Site Description. Clearwater Lake has a reported surface area of 905 acres with

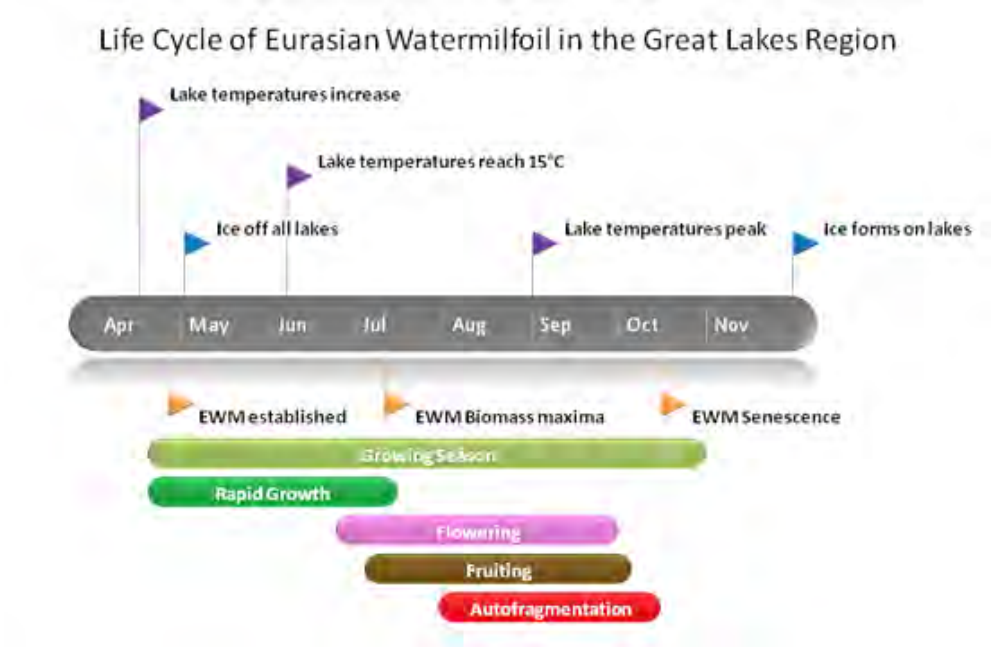

Fig. 5. Eurasian watermilfoil (EWM) generalized life cycle in the Upper Midwest. Source: Michigan Tech Research Institute.

252 classified as littoral zone with a maximum depth of 54 feet. The littoral zone is the area of the lake where sunlight penetrates deep enough to reach the bottom in sufficient amounts to allow for germination and plant growth. The MN DNR defines the littoral zone as any part of the lake that is less than 15 feet. While a good approximation, the true littoral zone will differ depending on a number of different factors, including water quality.

The Minnesota Pollution Control Agency (MPCA) assessed water quality for the lake for impairment in 2018 and determined that all standards were met for assessed parameters. In other words, the lake is not impaired for phosphorus, chlorophyll, or water clarity and has acceptable quality from the State's perspective.

The lake is broadly classified as mesotrophic, meaning it has moderate amounts of nutrients and water clarity compared to other lakes in the world generally. Water is clearest in the spring, and on average, will decline through the year, which is a typical pattern in Minnesota (Fig. 6).

EDDMapS (www.eddmaps.org) indicates the first record of curlyleaf pondweed was made in 1984, but records are not as well kept for curlyleaf pondweed as for other invasive species in Minnesota. The most recent infested waters list (October 15, 2024) by the MN DNR indicates Eurasian watermilfoil was listed present in Clearwater Lake in 2011.

The Clearwater Lake Conservancy has been actively managing Eurasian watermilfoil since it was listed, mostly with chemical herbicide applications of either 2,4D or ProcellaCOR (Table 1). Under normal rules and years, up to 37 acres could be chemically treated. Acreages

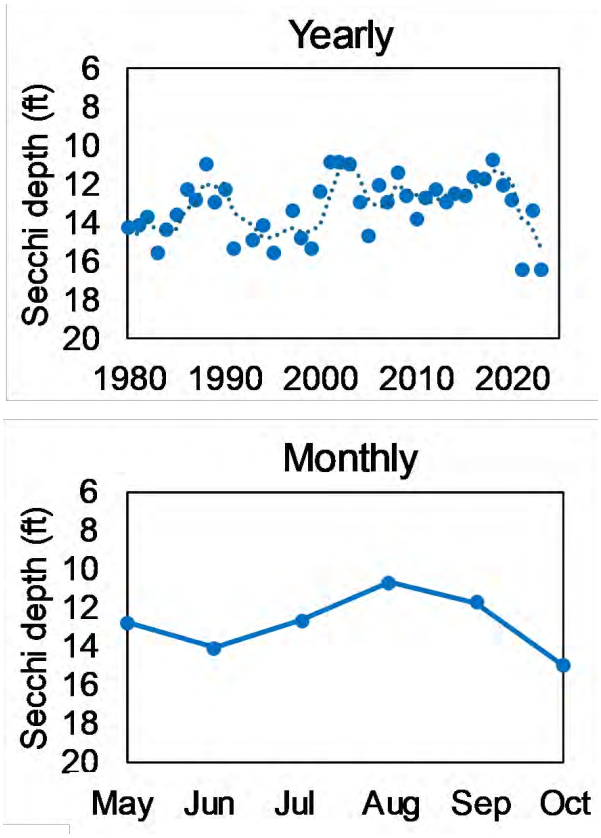

Fig. 6. Water clarity as measured by Secchi depth. Top panel shows seasonal averages. Bottom panel shows the average water clarity through a typical year on the lake from May through September. The MPCA impaired water threshold for Clearwater Lake is 6.6 ft.

treated each year have varied from as low as 1 to the maximum 37 but average area treated per year has been 19. We note that a treatment did occur in 2024 but areas treated were treated after our survey, so we report on pretreatment conditions in this document.

The most recent fisheries survey (8/5/2019) detected no presence of common carp, which is a species known to reduce plant coverage in lakes.

Aquatic Plant Point Intercept Survey. The survey on Clearwater Lake occurred between August 12-23, 2024 when most native species and invasives with the exception of curlyleaf pondweed were expected to be at or near their peak growth for the year.

Standard point intercept survey methodology was used. During the survey, point coordinates were loaded to an onboard GPS sonar with a spacing of 1 point per half acre (45 m spacing).

After navigating the boat to each point, a double-sided rake attached to a rope was tossed off the port side of the boat and dragged with four distinct pulling motions over an area of approximately three-meter (10 ft) length. All plants brought to the surface were identified to species and ranked on a density scale from 0 (no plant) to 3 (Fig. 7).

While navigating through the lake over points, sonar data were collected autonomously to a Lowrance HDS Gen 3 sonar unit as an *.sl2 file. An additional sonar mapping of the limnetic (i.e., >15 ft depth) zone was conducted where points were not surveyed in order to map the entire lake (Fig. 8) This would not only give an indication of the true depth of

Table 1. Eurasian watermilfoil control efforts on Clearwater Lake. In 2023 16.3 acres were treated with herbicide and remaining hand-pulled. Both herbicide treatments and hand pulling was also done in 2021Source: Clearwater Lake Conservancy webpage accessed 11/19/2024.

Year	Acres	Type	Cost Total	Cost/Acre
2012	5	2,4D	$4,000	$800
2013	10	2,4D	$8,000	$800
2014	37	2,4D	$26,400	$714
2015	37	2,4D	$30,000	$811
2016	23	2,4D	$20,600	$896
2017	19	2,4D	$20,940	$1,102
2018		No Treatments		
2019	17	2,4D	$24,000	$1,412
2020	37	ProcellaCOR	$36,000	$973
2021	1	ProcellaCOR*	$4,912	$4,912
2022	5	Mechanical	$3,150	$630
2023	18	ProcellaCOR*	$22,619	$1,257
2024	19	ProcellaCOR	$38,614	$2,032
MEAN	19		$19,936	$1,361

*Treatment included some hand-pulling

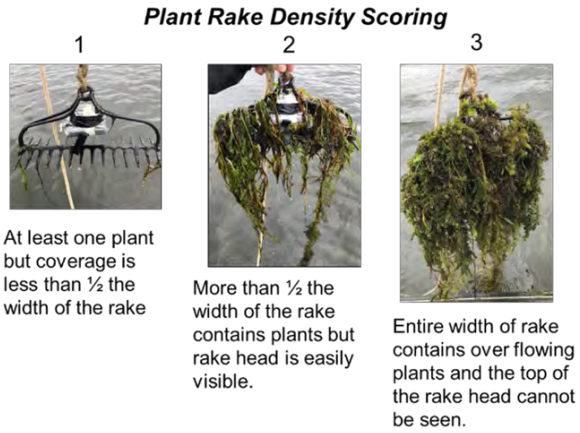

Fig. 7. Aquatic point intercept survey rake density method for density scoring.

plant growth but an updated depth map. Current data on depth and area for the lake come from a 1951 MN DNR mapping.

Sonar files were processed by EcoSound, a third-party software service owned by BioBase, a subsidiary of Navico. Some of the output from this service is spatial information describing biovolume percent and depth to top of the plant canopy.

Fig. 8. Boat path for whole lake sonar mapping with limnetic tracks spaced at 40 m grids.

We used this information to quantify nuisance and conservation conditions based on optimal depth of the canopy below the water surface (i.e., distance from surface of the water to the top of plants) and optimal plant coverage (i.e., the percentage of lake bottom that grows plants) to support both recreation and habitat for organisms that live in lakes.

Additional mapping and geostatistical analyses were performed using a geographic information system (QGIS 3.28). Generally, we assessed (1) frequency of occurrence for each species, (2) frequency by plant types, (3) relationship of plant growth to depth., and (4) in-depth additional assessment of any invasive species found to aid in future management strategies.

RESULTS

Plants were found at 77% of all sites sampled. Sonar mapping indicated that max depth vegetation could be detected was 20 ft. If we define the weed line as the point where 50% of sites surveyed had plants, then that point occurs at 15 ft (Fig. 9).

The whole lake sonar survey estimated the littoral zone, if set at the standard 15 ft depth, to be 328 acres rather than the MN DNR reported 252 acres. If we add in plant growth to 20ft, the true observable littoral zone is equal to 377 acres (Fig. 10).

A total of 36 vegetative species (plants or algae) were found during the survey (Fig. 11). This included 35 native plants and 1 invasive species. At any given point where vegetation was present there was

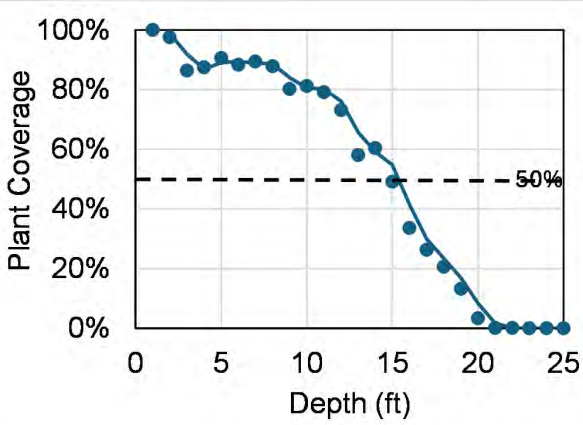

Fig. 9. Percentage of sites at a given depth where at least one plant based on sonar mapping of whole lake. No indication of plant growth occurred over 20 ft depth

up to 11 but on average three different species per rake (Fig. 12).

Four species dominated the vegetative community, accounting for 55% of all biomass collected. Those vegetation types included muskgrass, Nitella, variable-leaved pondweed and waterlily (Fig. 13).

Most of the native species detected, 28 of 36, might be classified as rare in that they were collected at less than 10% of the points. This is not unusual as plant communities in lakes tend to have a few dominant species but a higher number of species occurring at only a few spots. This is not to imply that these less common species are not important as often they serve important roles in the lake.

Eurasian watermilfoil was the only invasive plant species found during the survey (Fig. 14). Eurasian watermilfoil was found at 36/640 points visited, which represents approximately 5.6% of the area surveyed. Given the littoral zone is reported at 377 acres, our estimate is that Eurasian watermilfoil covered approximately 21 acres at time of survey. This was close to the estimate provided during a meandering survey done by Freshwater Scientific Services in July 2024, which found 19 acres.

Eurasian watermilfoil co-occurs with 25 of 35 native species on the lake. In over 75% of the points where Eurasian watermilfoil was found, muskgrass also occurred. Variable-leaved pondweed was found at nearly half of the sites where

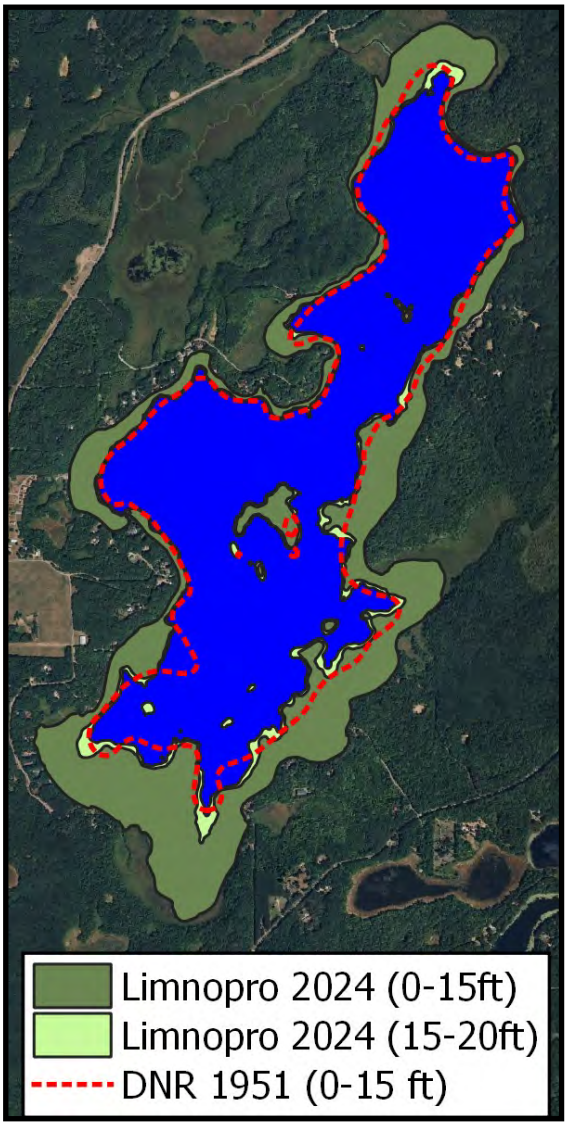

Fig. 10. Littoral zone redefinition based on 2024 whole lake sonar survey. Both 15 foot standard littoral zone and observed 20 ft littoral zone are shown as well as the MN DNR defined littoral zone currently in use.

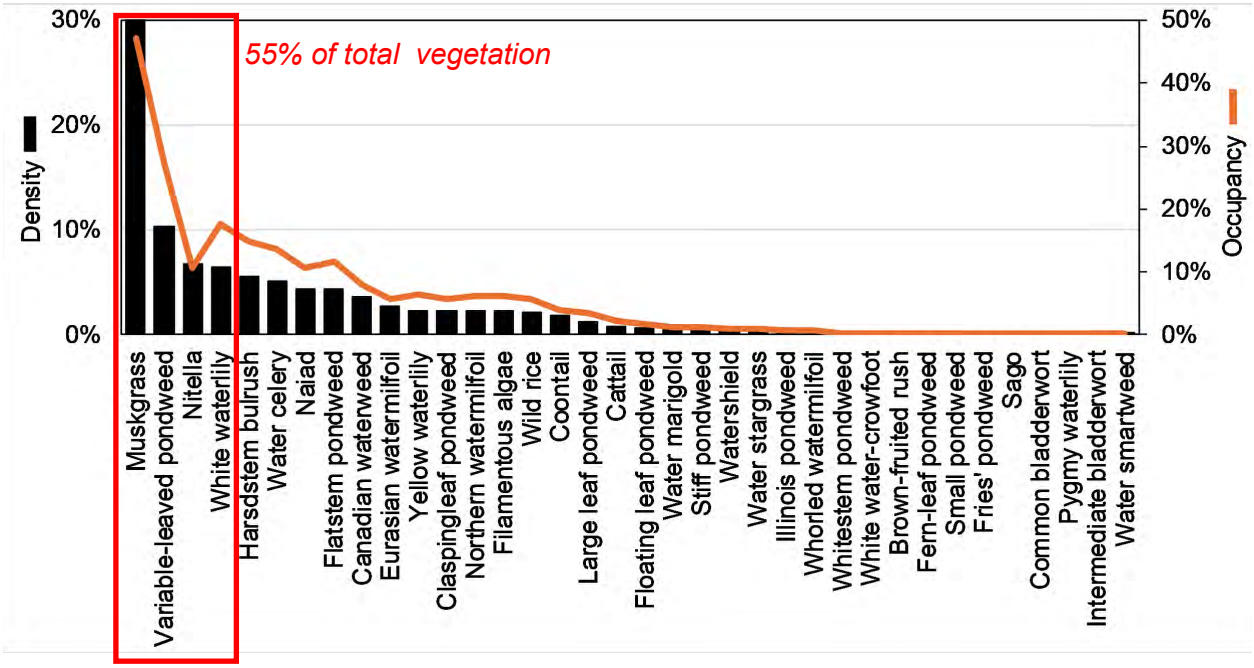

Fig. 11. Types and species of vegetation collected on Clearwater Lake during August 2024. Density (black bars) is the total amount of plant material collected during the two surveys belonging to the listed type while occurrence (orange line) indicates the proportion of sites surveyed out of 640 where at least one individuals of a given species was identified and counted.

Eurasian watermilfoil was found. It also commonly overlapped with naiad (34%), bulrush (22%), waterweed (19%), and water celery (19%). All other species overlapped at rates of less than 10%.

Biovolume was highest and canopy depth lowest in six bays of the lake (Fig. 15). Dense plant growth also showed up along the eastern shoreline of the lake. The growth was primarily coontail, muskgrass, Eurasian watermilfoil and variable-leaved pondweed.

Sonar indicated 85% coverage, which was slightly higher than the 77% over littoral zone indicated by direct measurements at points. Over areas with vegetation present, the average canopy depth was 5.8 ft. Overall, this indicates minimal nuisance growth over the lake and slightly more coverage than may be beneficial to fisheries (Fig. 16).

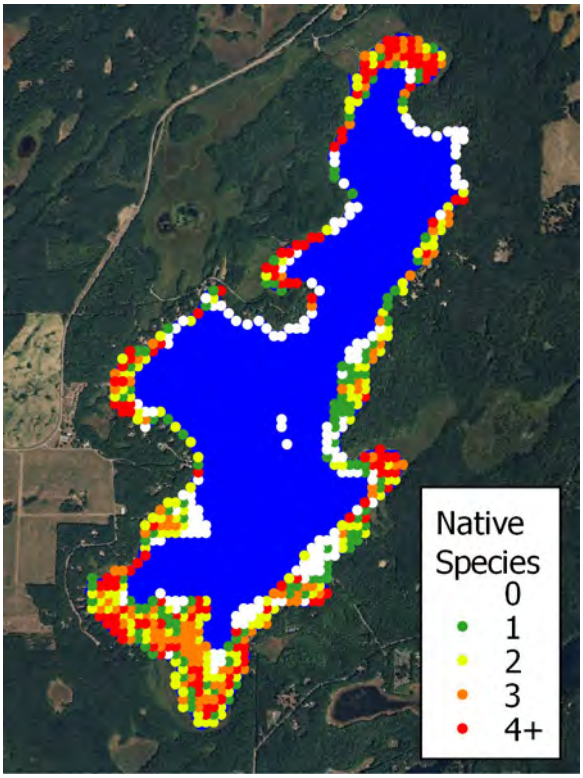

Fig. 12. Number of different species per point for combined data from surveys in spring and summer.

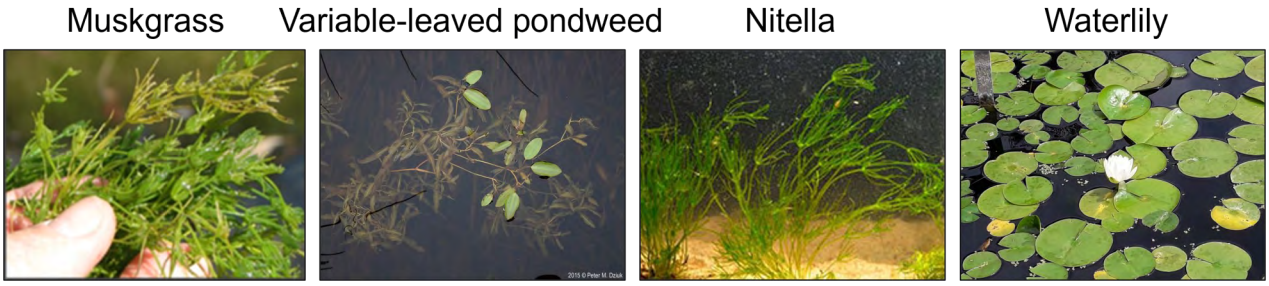

Fig. 13. Most commonly sampled submerged vegetation on Clearwater lake in 2024 included muskgrass, variable-leaved pondweed, Nitella, and white waterlily.

A table and spatial density plots for all species found is included in the appendix of the report.

DISCUSSION

The aquatic plant survey done on Clearwater Lake in 2024 revealed the following key points: (1) the lake has extraordinary native plant diversity compared to similar lakes in Minnesota; (2) macroalgae, variable-leaved pondweed, and waterlilies dominate the native plant community; (3) Eurasian watermilfoil was the only invasive species detected in the lake and while coverage was not high it was locally dense sometimes where it occurred; (4) curlyleaf pondweed is known to exist but was not found and not expected to be found given the late date of the survey, and (5) water quality on the lake was excellent.

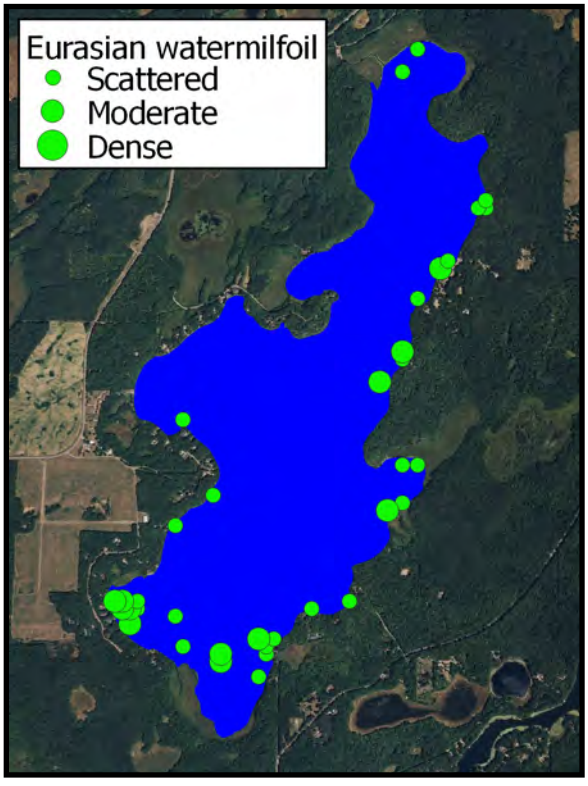

Fig. 14. Eurasian watermilfoil identified during 2024 surveys on Clearwater Lake. . .

The last full lake aquatic plant point intercept survey for Clearwater Lake was done in 2021 by RMB Environmental. The only other full survey known was done in 2018 also by them. By all summary metrics, including overall vegetation coverage, density at each point, number of native species, the maximum number of species per point and the maximum depth of plant growth, the plant community has improved (Table 2). All vegetation species found in 2024 increased in coverage compared to prior years' surveys with the exception of yellow waterlily and perfoliate pondweed (Table 3). Perfoliate pondweed, which is rare in Minnesota, is the only species found by RMB that was not also found by Limnopro.

The general pattern of muskgrass being the most common vegetation type also remained unchanged. RMB also found a

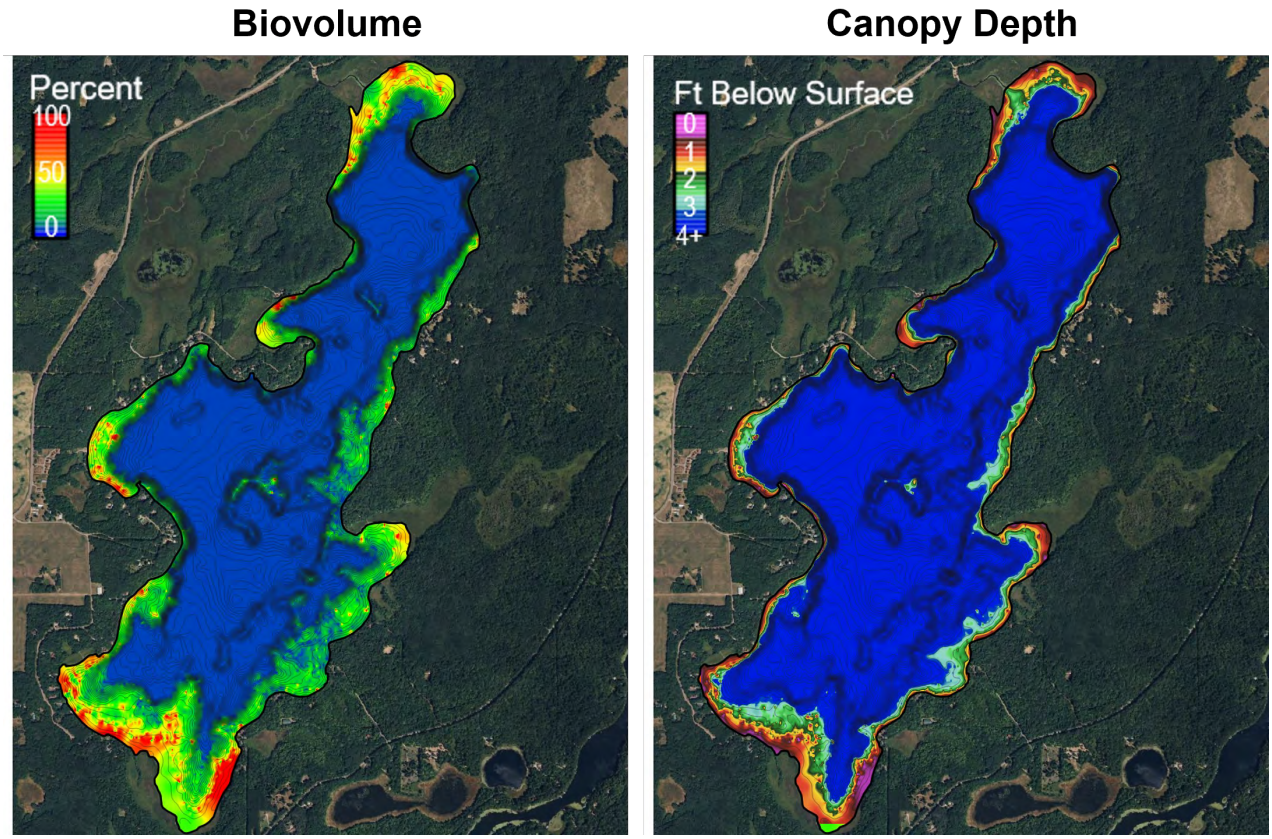

Fig. 15. Sonar derived biovolume and canopy depth as measured during August 2024. Biovolume is the percentage of the water column occupied by vegetation at any given point while canopy depth is the distance between the top of the plant and surface of the water at a given point.

high occurrence of both bulrush and waterlilies as did we, but they did not find a lot of variable-leaved pondweed. In fact, they found none in 2018. Whether variable-leaved pondweed is expanding or it was previously mixed up with other pondweeds is not known. Variable-leaved pondweed is not as common as some other pondweeds in Minnesota lake and it can sometimes be confused for Illinois pondweed, whitestem, or clasping-leaf pondweeds among others.

All of the dominant vegetative species are desirable in lakes. Muskgrass and *Nitella*, which are macroalgae and not true plants, grow as a "carpet" along the bottom. They do not tend to grow to the near surface and provide a cover to keep phosphorus and sediment from suspending.

While pondweeds in general are common in Minnesota lakes, dominance by variable-leaved pondweed is not. The name of this species comes from its variable sized leaves on the plant. It can include both submerged and floating leaves, but it does not commonly reach the surface. This species, along with other large leaved pondweeds in the lake such as clasping leaf, large-leaf, Illinois and whitestem pondweed are often referred to as "cabbage" by anglers and associated with good fish habitat.

Waterlilies also provide structural habitat forming sediment stabilizing rhizomes

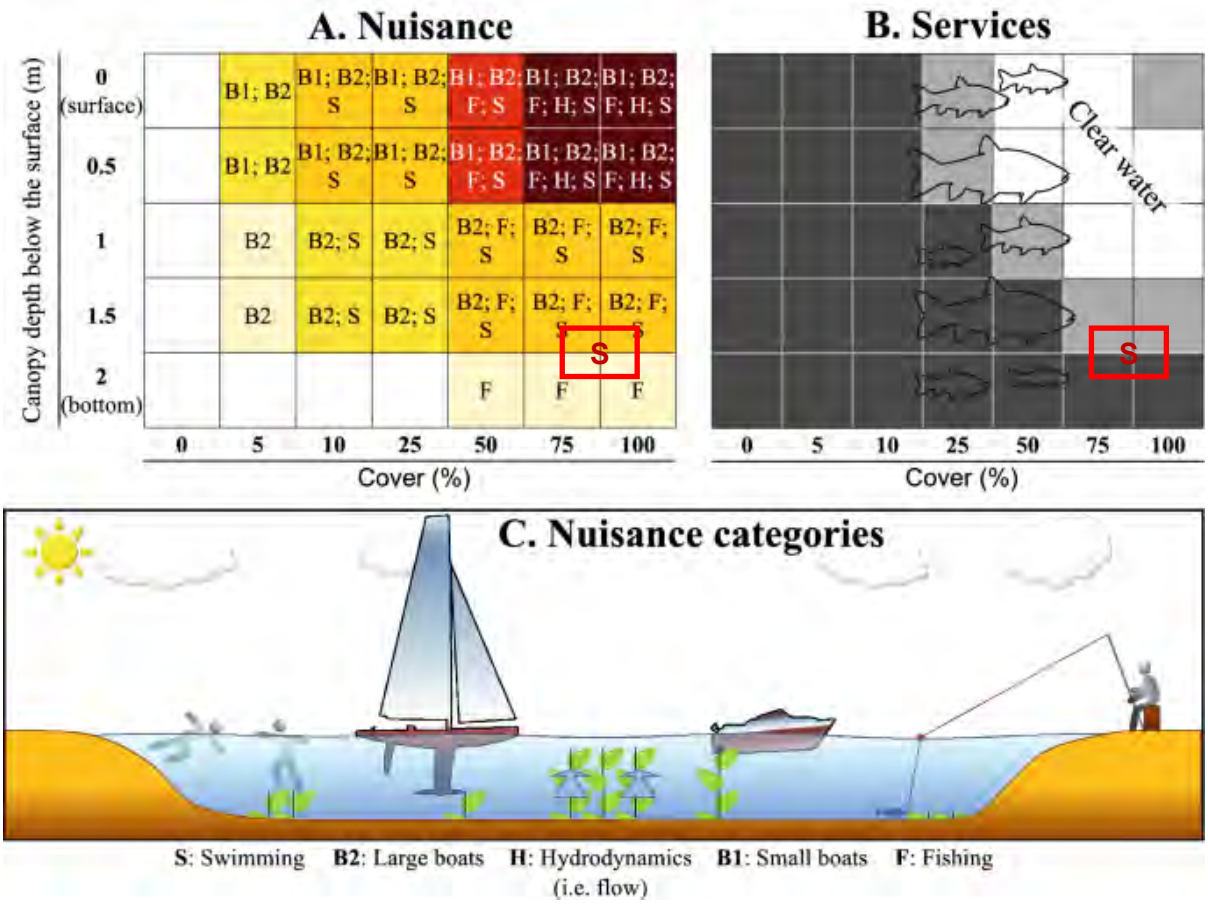

*Fig. 16. **A** Case study (water depth = 2 m) classification of nuisance macrophyte vegetation by plant canopy depth and plant cover depending on ecosystem services provided by the aquatic system. Letters indicate that macrophytes are classified as nuisance for each anthropogenic function: B1 = small recreational boats; B2=large recreational boats; F= fishing; S= swimming; H=hydrodynamics, i.e. water flow in this case. For a graphical representation, see **C**. Darker (red) fills indicate more services are impaired by macrophytes. **B** Probability of maintaining two important ecosystem services (i.e. clear water and fish populations) in shallow aquatic systems considering the total area of the ecosystem. Lighter fills are generally considered more desirable for the stability of the clear water state. The school of fish indicates the plant cover that is suggested as optimal for fish populations. Fish size has no informative meaning. **C** Graphical representation of the ecosystem services impaired by submerged plant growth, as reported in **A**. Red labels indicate positions as determined by analysis presented. Modified from Verhofstad and Bakker 2019.*

under the lake bottom and plant coverage that can create open spaces that sometimes do not occur with more complex submerged plants.

Since Eurasian watermilfoil was found in 2011 on the lake, near annual herbicide treatments have been done that ranged from 1 to 37 total acres. From 2012-2019, treatments have been done with 2,4D and from 2022-2024 it has been ProcellaCOR. Both herbicides are known to be effective in the control of Eurasian watermilfoil with some selectivity.

With any herbicide application there can be concern of nontarget impacts to vegetative species that are deemed desirable for the lake. Literature has not shown largescale negative impacts on nontarget vegetation from small scale spot treatments of plants, similar to what is being

Table 2. Comparison of summary metrics from point intercept surveys done by RMB Environmental in 2018/2021 and Limnopro 2024. Source: Clearwater Lake Conservancy webpage accessed 11/19/2024.

Metric	2018	2021	2024
Plant Coverage	63%	67%	77%
Mean Rake Density (0-3)	1.2	2.0	2.2
Native Species	17	23	36
Invasive Species	1	1	1
Max Species/Point	4	6	11
Max Plant Growth Depth (ft)	18	18	20

done on Clearwater Lake. On the other hand, there is scientific support for the growth of Eurasian watermilfoil to negatively impact native plants it grows with. There does not seem to be evidence from the series of surveys done from 2018 to present that there is widespread decline in native plants in general or specifically in connection to herbicide treatments done on this lake. Nonetheless, without doing a designed experiment it's impossible to make any causative statement on the matter. If there continues to be concern about herbicide treatments creating negative nontarget impacts, we would suggest experiments to test associated hypotheses.

At standard application rates, 2,4-D (4 ppm) has an estimated cost of $350 per acre while ProcellaCOR costs upwards of $1,000 per acre. ProcellaCOR is a recently approved herbicide with some data suggesting it may be more effective on hybrid watermilfoil and anecdotal information suggesting it is more selective than 2,4-D which may support its higher price. Independent data, however, are lacking to make such definitive statements. Typically, the MN DNR will allow up to two treatments per year of Eurasian watermilfoil with the last expiration date at the start of September no matter what herbicide is used.

Contrasted with Eurasian watermilfoil, there has not been active chemical management of curlyleaf pondweed on the lake. Generally, when lakes are chemically treated for curlyleaf pondweed, three herbicides are used including endothall, diquat, and flumioxazin. All can be effective but their costs can be dramatically different. At standard application rates, diquat (0.37 ppm) has an estimated cost of $200 per acre, flumioxazin (200 ppb) an estimated cost of $350 per acre, and endothall (1.5 ppm) an estimated cost of $500 per acre.

In some cases, the MN DNR does not allow lakes to use the least expensive diquat because of their belief that diquat reduces survivorship of newly hatched walleye and that the other chemicals do not. Generally in those cases, the much more expensive endothall has been the only other option, but the mid-priceed flumioxazin has been being approved for curlyleaf pondweed more in recent years. Currently, Clearwater Lake does appear on the diquat-restriction list. MN DNR mandated deadlines for curlyleaf pondweed treatment have recently changed from May 31 to April 30. It is currently unclear what the deadline will be for 2025.

Whether using diquat, endothall, or flumioxazin, chemicals currently used on curlyleaf pondweed do not target the entire plant but only the part of the plant the chemical touches. These are known as contact herbicides. As such, the plant can and will grow back the following year, so annual maintenance should be expected. The goal for management of curlyleaf pondweed should be not to eradicate the plant but to manage it so that it does not surface mat and create hinderances for recreating on the lake.

Table 3. Comparison of coverage for individual species done by RMB Environmental in 2018/2021 and Limnopro 2024. Values indicate percentage of points where at least one individual of a given taxon was identified during the survey. The field Δ (i.e., "delta) shows change during 2024 relative to 2018 and 2021. Values indicated as "++" mean 2024 showed greater coverage than both 2018 and 2021 while "+" indicates coverage greater than only one of the 2018 or 2021. Blank records indicate that coverage in 2024 was less than both 2018 and 2024. Source: Clearwater Lake Conservancy webpage accessed 11/19/2024.

Habit	Common Name	Scientific Name	2018	2021	2024	Δ
Invasive	Eurasian watermilfoil	*Myriophyllum spicatum*	2.0%	1.0%	5.6%	++
		Maximum invasive	**2.0%**	**1.0%**	**5.6%**	
Submerged	Muskgrass	*Chara* spp.	25.0%	38.0%	47.0%	++
	Variable-leaved pondweed	*Potamogeton gramineus*	0.0%	6.0%	27.3%	++
	Water celery	*Vallisneria americana*	17.0%	13.0%	13.8%	+
	Flatstem pondweed	*Potamogeton zosterformis*	6.0%	9.0%	11.6%	++
	Nitella	*Nitella* spp.	0.0%	1.0%	10.8%	++
	Naiad	*Najas flexilis*	5.0%	10.0%	10.6%	++
	Canadian waterweed	*Elodea canadensis*	4.0%	7.0%	8.0%	++
	Northern watermilfoil	*Myriophyllum sibiricum*	3.0%	2.0%	6.3%	++
	Claspingleaf pondweed	*Potamogeton richardsonii*	2.0%	1.0%	5.8%	++
	Coontail	*Ceratophyllum demersum*	6.0%	3.0%	3.9%	+
	Large leaf pondweed	*Potamogeton ampifolius*	0.0%	7.0%	3.4%	+
	Water marigold	*Bidens beckii*	1.0%	1.0%	1.3%	++
	Stiff pondweed	*Potamogeton strictifolius*	0.0%	0.0%	1.3%	++
	Water stargrass	*Heteranthera dubia*	0.0%	0.0%	1.1%	++
	Whorled watermilfoil	*Myriophyllum verticillatum*	0.0%	0.0%	0.6%	++
	Illinois pondweed	*Potamogeton illinoensis*	5.0%	0.0%	0.6%	+
	Brown-fruited rush	*Juncus pelocarpus*	0.0%	0.0%	0.3%	++
	Fern-leaf pondweed	*Potamogeton robinsii*	0.0%	0.0%	0.3%	++
	Whitestem pondweed	*Potamogeton praelongus*	0.0%	0.0%	0.3%	++
	Small pondweed	*Potamogeton pusillus*	0.0%	0.0%	0.3%	++
	White water-crowfoot	*Ranunculus aquatilis*	0.0%	1.0%	0.3%	+
	Common bladderwort	*Utricularia macrorhiza*	0.0%	1.0%	0.2%	+
	Fries' pondweed	*Potamogeton friesii*	0.0%	3.0%	0.2%	+
	Sago	*Stuckenia pectinata*	0.0%	1.0%	0.2%	+
	Intermediate bladderwort	*Utricularia intermedia*	0.0%	0.0%	0.2%	++
	Perfoliate pondweed	*Potamogeton perfoliatus*	0.0%	3.0%	0.0%	-
		Maximum submerged	**25.0%**	**38.0%**	**47.0%**	
Floating	White waterlily	*Nymphaea odonata*	13.0%	12.0%	17.7%	++
	Yellow waterlily	*Nuphar variegata*	11.0%	12.0%	6.4%	-
	Filamentous algae	Various	0.0%	0.0%	6.1%	++
	Floating leaf pondweed	*Potamogeton natans*	1.0%	0.0%	1.7%	++
	Watershield	*Brasenia schreberi*	0.0%	0.0%	1.1%	++
	Pygmy waterlily	*Nymphaea leibergii*	0.0%	0.0%	0.2%	++
	Water smartweed	*Persicaria amphibia*	0.0%	0.0%	0.2%	++
		Maximum floating	**13.0%**	**12.0%**	**17.7%**	
Emergent	Harsdstem bulrush	*Schoenoplectus acutus*	11.0%	11.0%	15.0%	++
	Wild rice	*Zizania palustris*	1.0%	0.0%	5.8%	++
	Cattail	*Typha* spp.	0.0%	1.0%	2.2%	++
		Maximum emergent	**11.0%**	**11.0%**	**15.0%**	
		Maximum overall	**25.0%**	**38.0%**	**47.0%**	

Note that these three contact herbicides (i.e., diquat, endothall, and flumioxazin) can all also control Eurasian watermilfoil but the chemicals that control Eurasian watermilfoil (i.e., 2,4-D and ProcellaCOR) do not provide any control of curlyleaf pondweed given differences in biology of the two species.

Chemical treatment of offshore areas requires an Invasive Aquatic Plant Management (IAPM) permit, which is approved by the regional MN DNR AIS Specialist within Ecological and Water Resources.

As a general rule, the maximum amount of lake that can be treated by permit is 15% of the littoral zone. Historically, this has been set at 37 acres, which is 15% of 252, which is the number of acres reported on MN DNR LakeFinder. It is unclear where the 252 acre number comes from as the MN DNR Geographic Information System Shapefiles measure to 338 acres. Using this number the allowed area for treatment would be 50 acres rather than 37 acres.

No evidence was found for starry stonewort, another invasive species of concern in Minnesota, but it is close. Two lakes were identified this year in Crow Wing County with starry stonewort, including Middle Cullen (2024) and Rush (2024).

The best chance of getting control of starry stonewort, which if it became established, would drastically change the ecology and management strategy of the lake, is early detection and remediation. Early detection searches for starry stonewort ought to be a priority every year and efforts should be made to educate lake shore property owners to be able to recognize these two species and report any plants that look suspicious to the MN DNR and/or Limnopro immediately.

Where aquatic plants are creating nuisance that can be attributed to native rather than invasive species (e.g., coontail, filamentous algae, duckweeds, and etc.), allowed methods of control are limited to either individuals managing their own shorelines, or at a larger scale, controlling over navigational channels. By law, large acreages of offshore treatments are allowed only for invasive species.

Individual property owners can apply for an Aquatic Plant Management (APM) permits that if approved either allow greater areas or types of plants to be mechanically removed or that may allow up to two seasonal chemical treatments of aquatic plants along property owner shoreline. Generally, the MN DNR will allow treatment up to a width of half of the shoreline property owned out to 100 feet lakeward. They may also allow a 15-foot width channel to reach the main lake if there are still abundant plants out that far.

While commercial companies can provide a shoreline herbicide application service, property owners can apply chemical themselves with a permit. For homeowners who go the DIY path, purchasing and using a product named Hydrothol 191 is a good general purpose herbicide that can control most plants and algae, including coontail and filamentous algae, which can become a nuisance.

The majority of individual shoreline vegetation management requires a MN DNR

treatment permit. The only exception to this rule is if you are mechanically removing submerged plant in an area less than 2500 square feet in front of your property. By mechanical removal, it is meant to pull or cut and physically remove plants. By submerged plants, it is meant any plant whose whole body is under the water (e.g., water lilies, cattails, and bulrush cannot be removed without a permit).

It's important to recognize that if aquatic plants are growing and not presenting problems and control is initiated, whether by mechanical or chemical ways, it may create problems that do not currently exist. This is because most of types of vegetation that do create problems are those that are favored by disturbed conditions. If healthy, diverse native plant communities that are sensitive to disturbance are removed, they may be replaced by monocultures of either invasive plants or even native plants that are less desirable. Vegetation in lakes plays a central role in maintaining good environmental quality.

MANAGEMENT RECOMMENDATIONS

1. Continued management of Eurasian watermilfoil as required necessary.
2. Experimental study of herbicide non-target impacts when treating Eurasian watermilfoil to allay concerns of detrimental impacts.
3. Aquatic invasive species early detection efforts for starry stonewort during September at public boat launch annually.
4. Repeat aquatic point intercept surveys as basic monitoring program at a minimum of once per three years or as often as budget allows.

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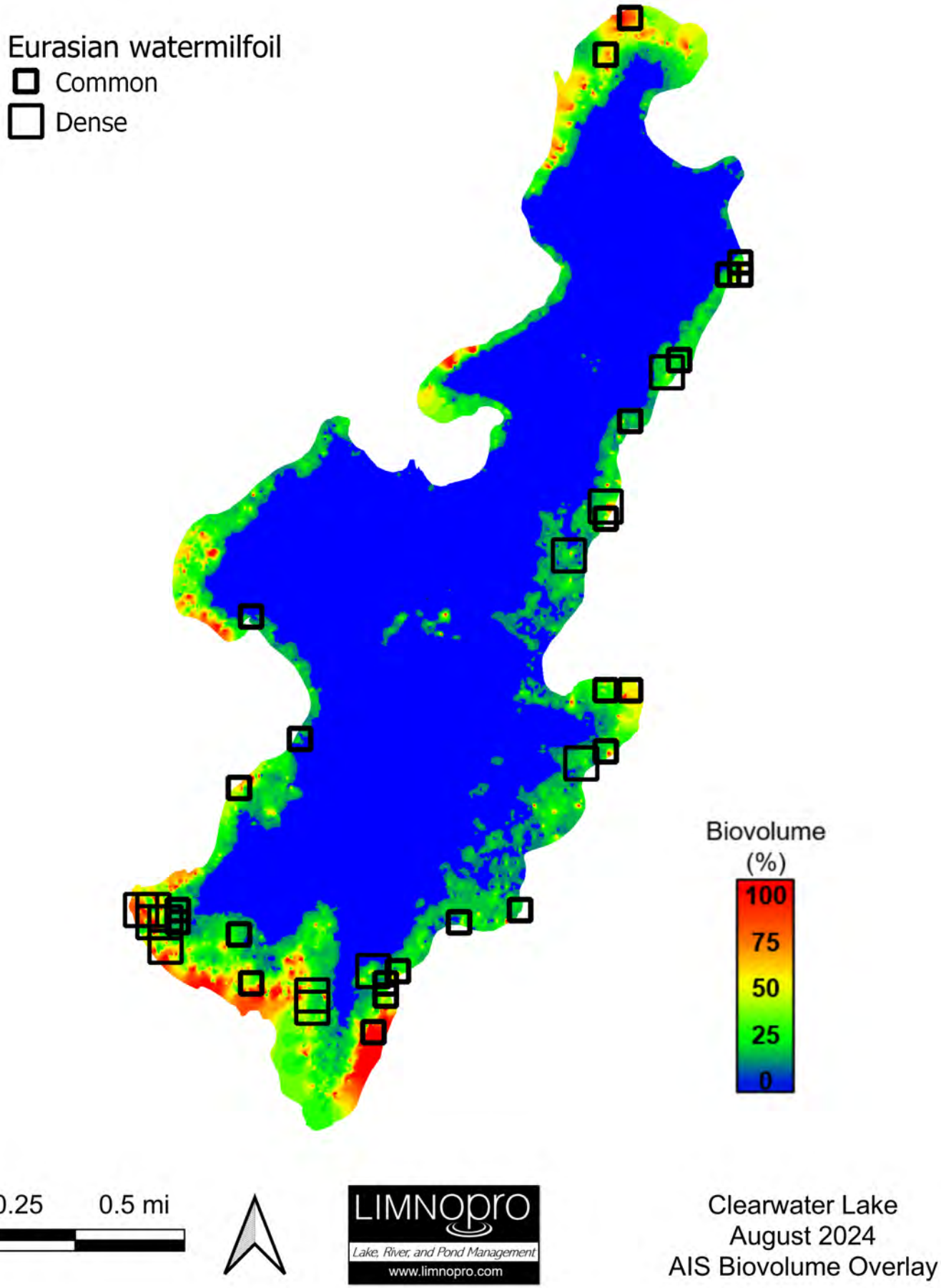
Appendix

Vegetation community summary from a point intercept aquatic point intercept survey in 2024. Occupancy is defined as the percentage of total sites during the survey that the plant was found at least once and density is the percentage of rake scores attributed to a given species (i.e., how much of the plant exists given it does exist). Bolded summaries for density are for total within category and for the occupancy the maximum within category.

Habitat	Common Name	Scientific Name	Density	Occupancy
Invasive	Eurasian watermilfoil	*Myriophyllum spicatum*	2.8%	5.6%
		Invasive subtotal	**2.8%**	**5.6%**
Submerged	Muskgrass	*Chara* spp.	31.2%	47.0%
	Variable-leaved pondweed	*Potamogeton gramineus*	10.3%	27.3%
	Nitella	*Nitella* spp.	6.8%	10.8%
	Water celery	*Vallisneria americana*	5.2%	13.8%
	Naiad	*Najas flexilis*	4.5%	10.6%
	Flatstem pondweed	*Potamogeton zosterformis*	4.5%	11.6%
	Canadian waterweed	*Elodea canadensis*	3.6%	8.0%
	Claspingleaf pondweed	*Potamogeton richardsonii*	2.4%	5.8%
	Northern watermilfoil	*Myriophyllum sibiricum*	2.3%	6.3%
	Coontail	*Ceratophyllum demersum*	1.8%	3.9%
	Large leaf pondweed	*Potamogeton ampifolius*	1.3%	3.4%
	Water marigold	*Bidens beckii*	0.5%	1.3%
	Stiff pondweed	*Potamogeton strictifolius*	0.5%	1.3%
	Water stargrass	*Heteranthera dubia*	0.4%	1.1%
	Slender watermilfoil	*Myriophyllum tenellum*	0.2%	0.6%
	Illinois pondweed	*Potamogeton illinoensis*	0.2%	0.6%
	Brown-fruited rush	*Juncus pelocarpus*	0.1%	0.3%
	Whitestem pondweed	*Potamogeton praelongus*	0.1%	0.3%
	Small pondweed	*Potamogeton pusillus*	0.1%	0.3%
	Fern-leaf pondweed	*Potamogeton robinsii*	0.1%	0.3%
	White water-crowfoot	*Ranunculus aquatilis*	0.1%	0.3%
	Fries' pondweed	*Potamogeton friesii*	0.1%	0.2%
	Sago	*Stuckenia pectinata*	0.1%	0.2%
	Intermediate bladderwort	*Utricularia intermedia*	0.1%	0.2%
	Common bladderwort	*Utricularia macrorhiza*	0.1%	0.2%
		Submerged subtotal	**76.4%**	**47.0%**
Floating	White waterlily	*Nymphaea odonata*	6.5%	17.7%
	Yellow waterlily	*Nuphar variegata*	2.4%	6.4%
	Filamentous algae	Various	2.3%	6.1%
	Floating leaf pondweed	*Potamogeton natans*	0.6%	1.7%
	Watershield	*Brasenia schreberi*	0.4%	1.1%
	Pygmy waterlily	*Nymphaea leibergii*	0.1%	0.2%
		Floating subtotal	**12.3%**	**17.7%**
Emergent	Harsdstem bulrush	*Schoenoplectus acutus*	5.6%	15.0%
	Wild rice	*Zizania palustris*	2.1%	5.8%
	Cattail	*Typha* spp.	0.8%	2.2%
	Water smartweed	*Persicaria amphibia*	0.1%	0.2%
		Emergent subtotal	8.6%	15.0%
		Vegetation community total	**100.0%**	**47.0%**


Eurasian watermilfoil
Common
Dense
Biovolume
(%)
100
75
50
25
0
0.25
0.5 mi
LIMNOpro
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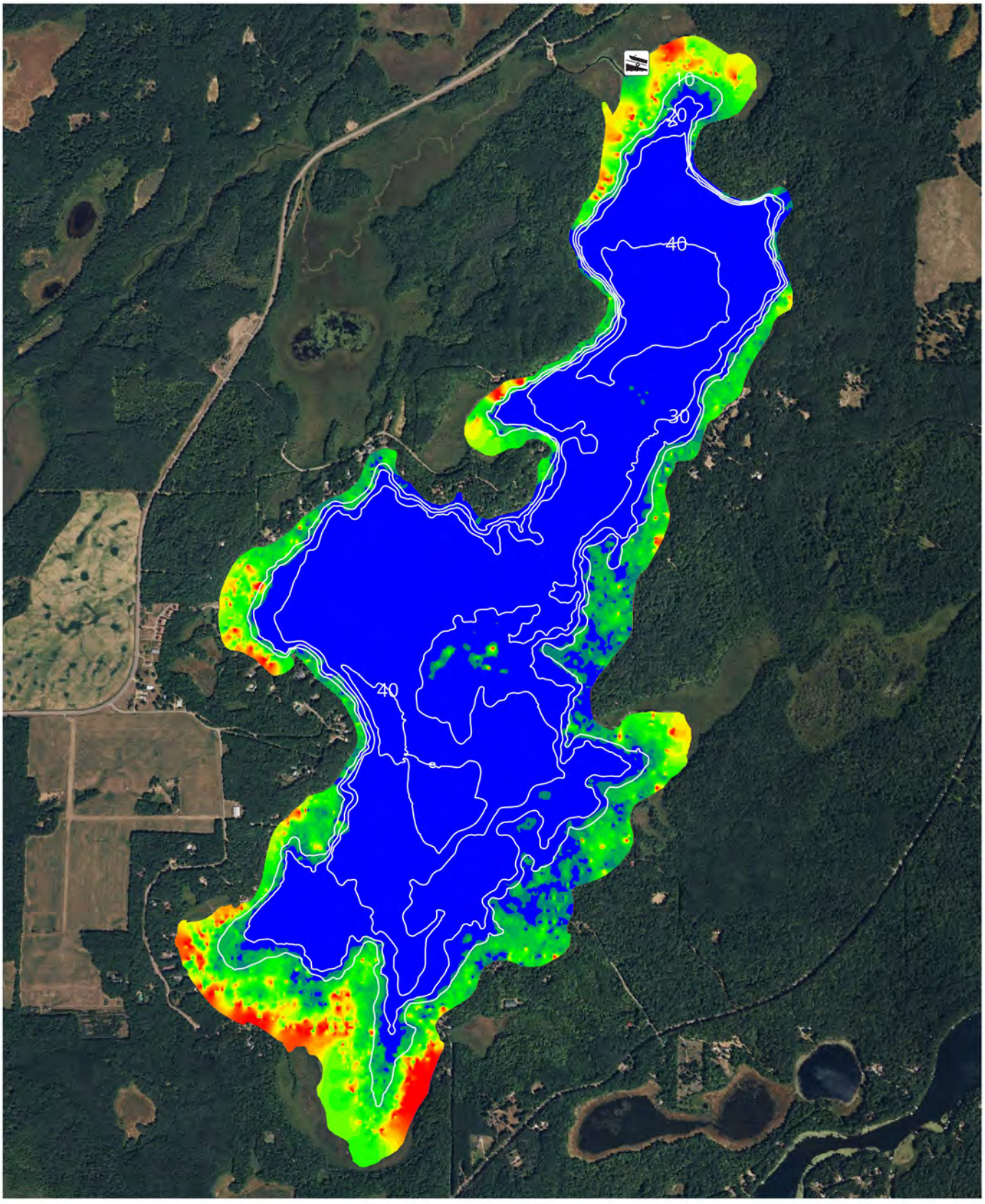
Clearwater Lake
August 2024
AIS Biovolume Overlay



0.25 0.5 mi

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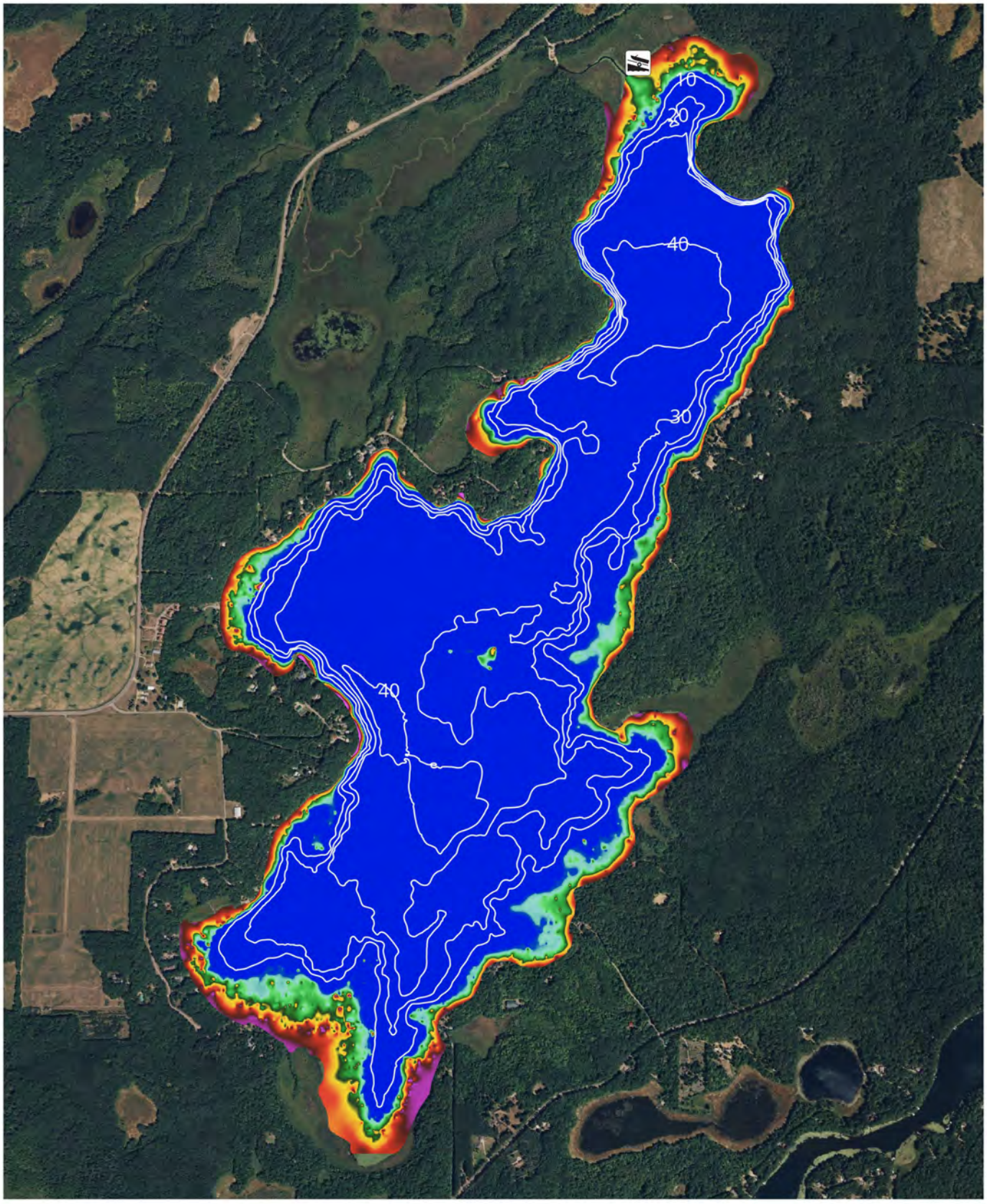
Clearwater Lake
8/5/2024
Biovolume



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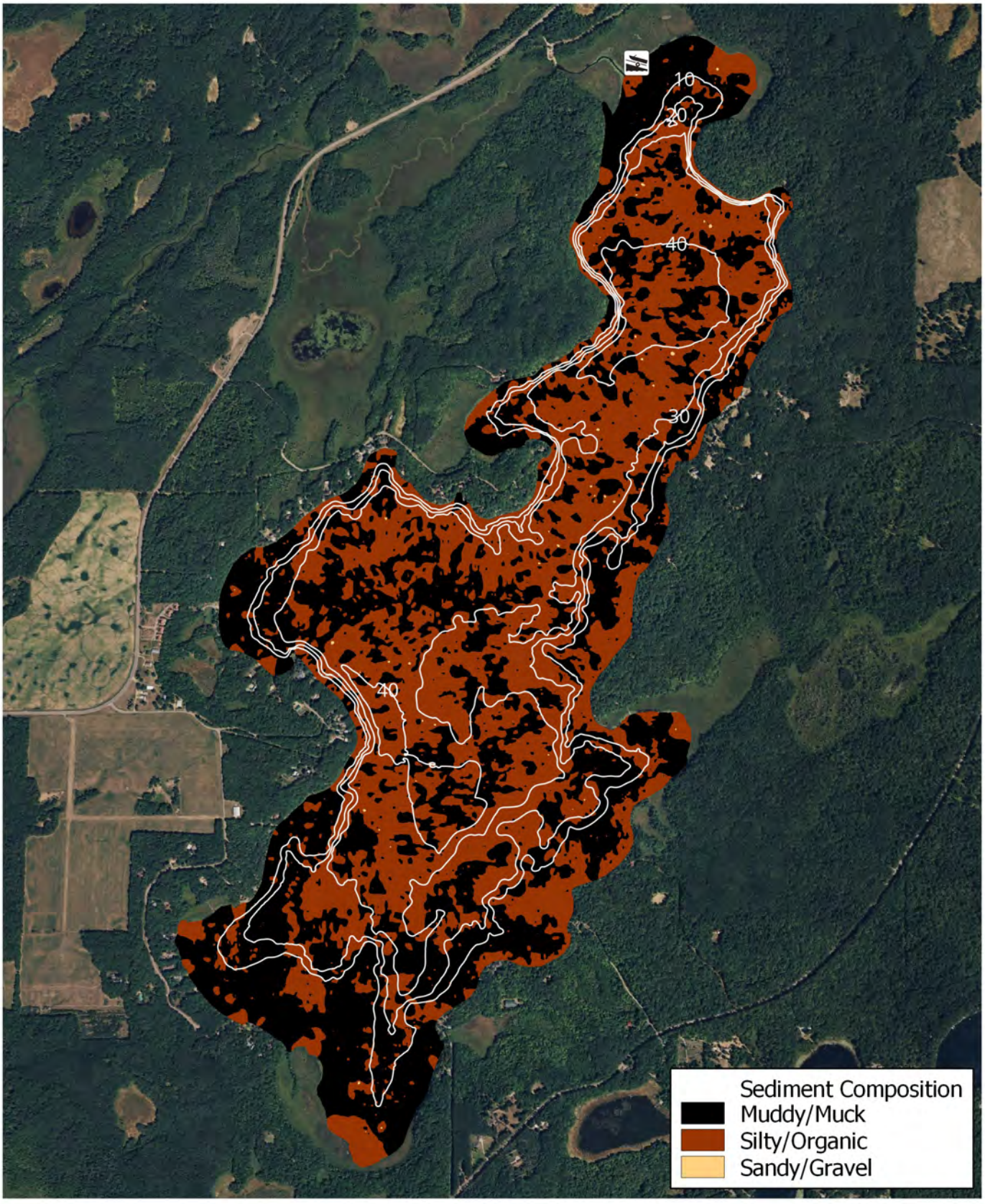
Clearwater Lake
8/5/2024
Canopy Depth



0.25 0.5 mi

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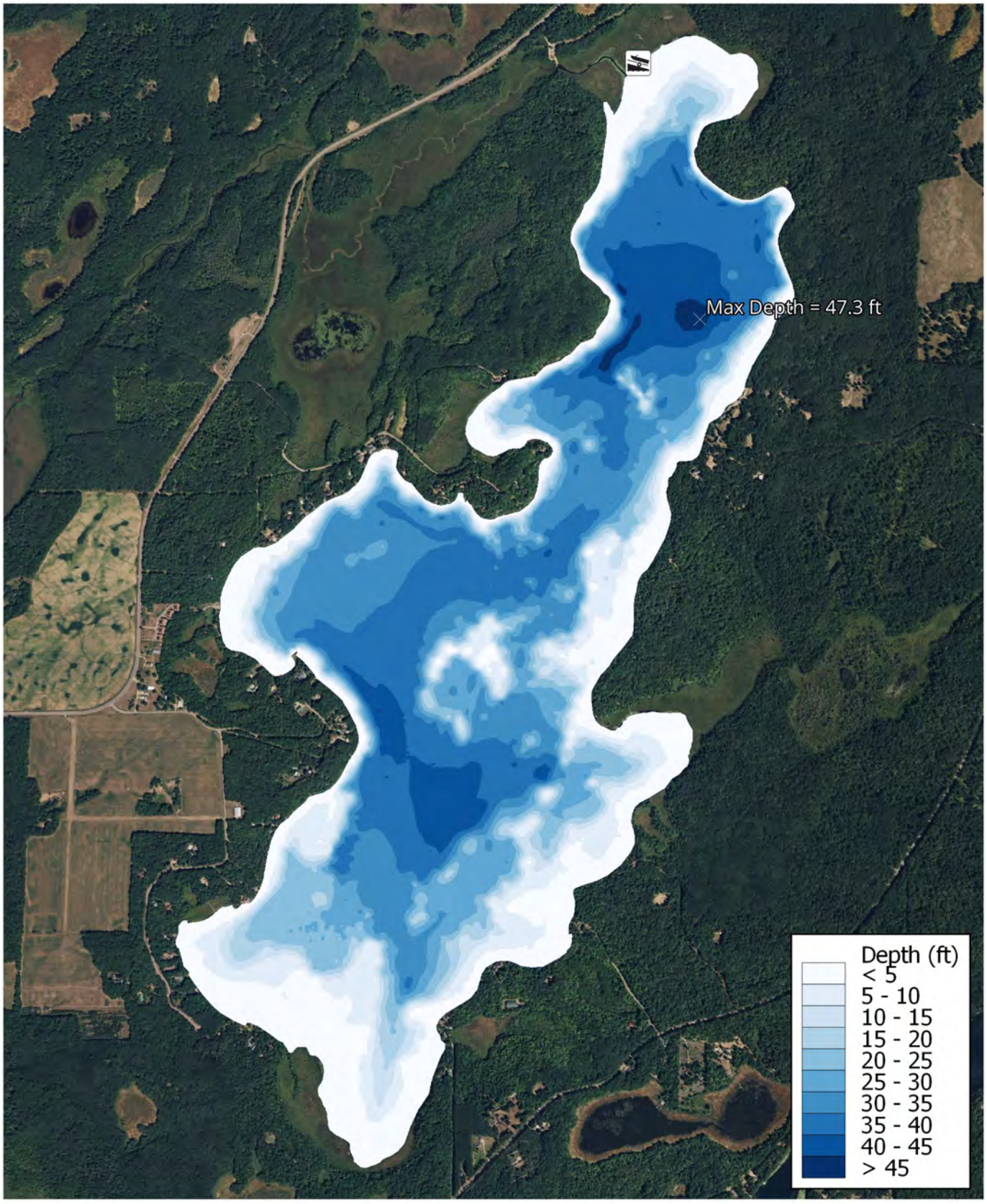
Clearwater Lake
8/5/2024
Sediment Hardness



0.25 0.5 mi

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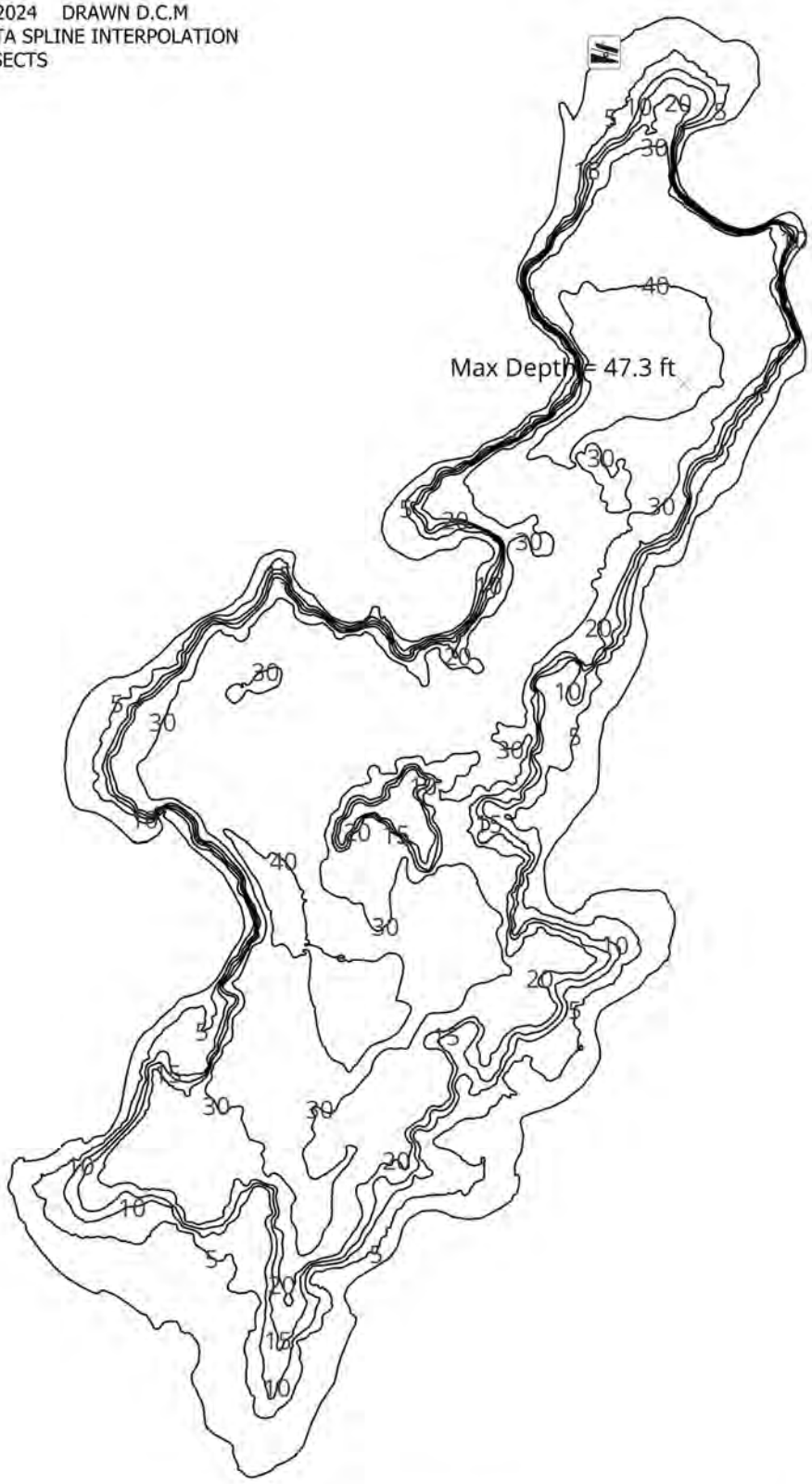
Clearwater Lake
8/5/2024
Bathymetry (Depth)

FIELD WORK 8/5/2024 DRAWN D.C.M
SONAR MULTI-BETA SPLINE INTERPOLATION
50 M WIDE TRANSECTS



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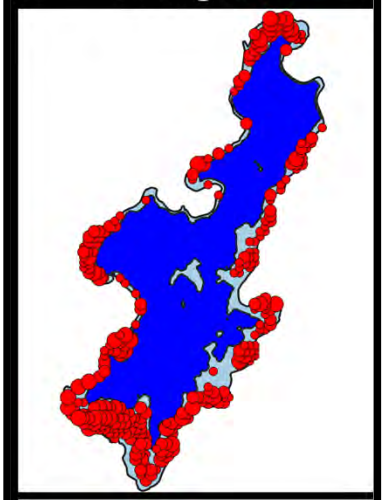
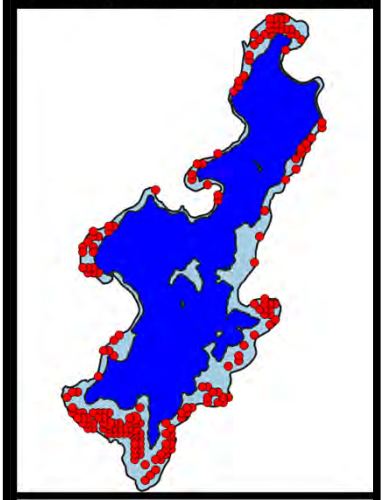
Clearwater Lake
8/5/2024
Bathymetry (Depth)

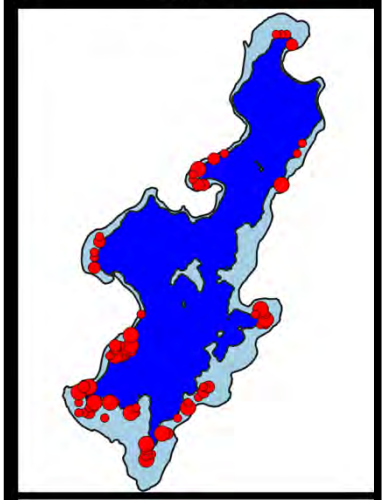
Muskgrass



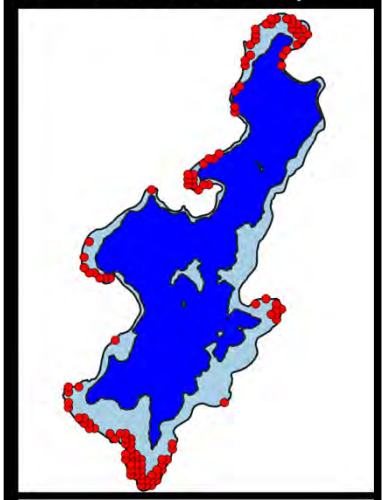
Variable-leaved pondweed



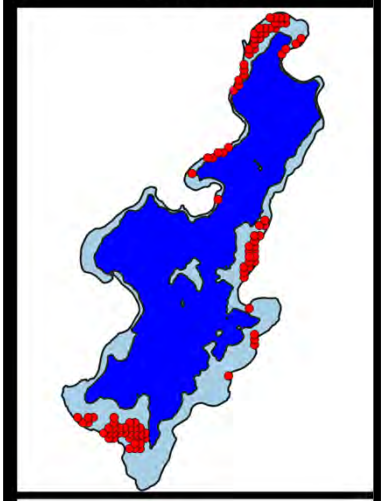
Nitella



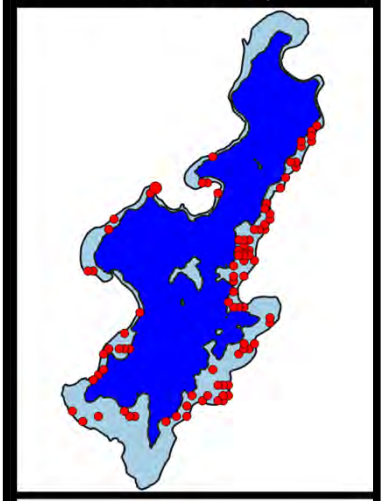
White waterlily



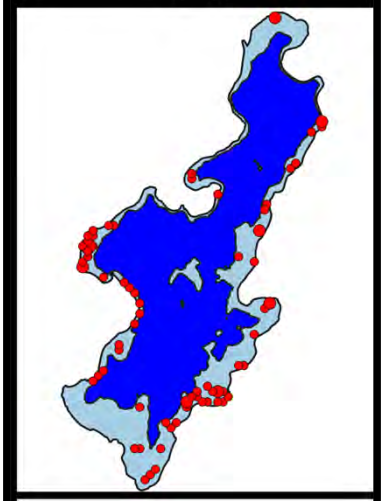
Bulrush

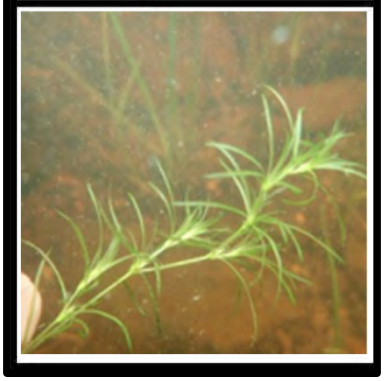


Wild celery

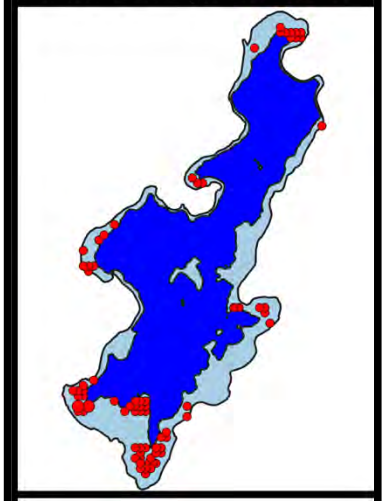


Naiad

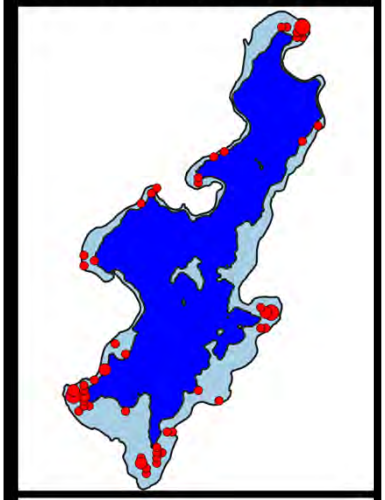




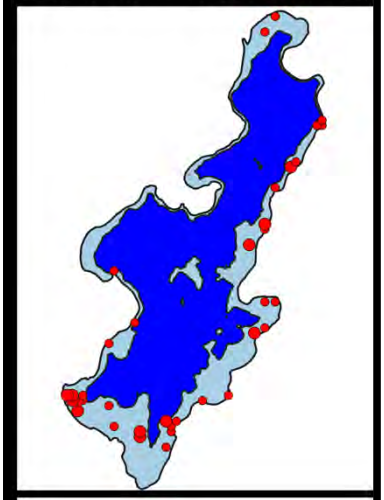
Flatstem pondweed



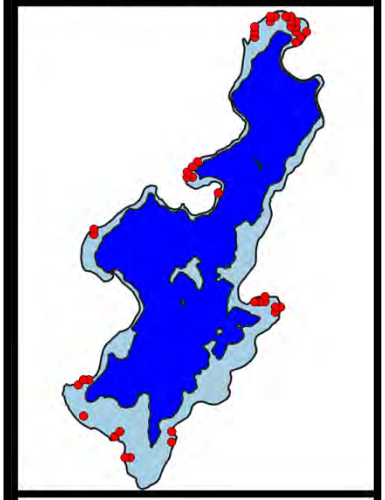
Canadian waterweed



Eurasian watermilfoil



Yellow waterlily



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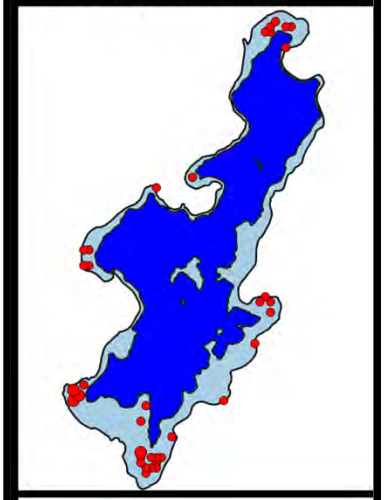
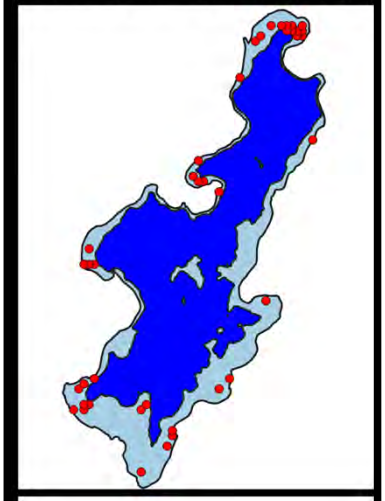
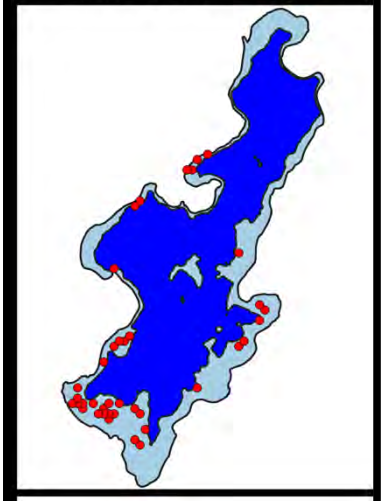


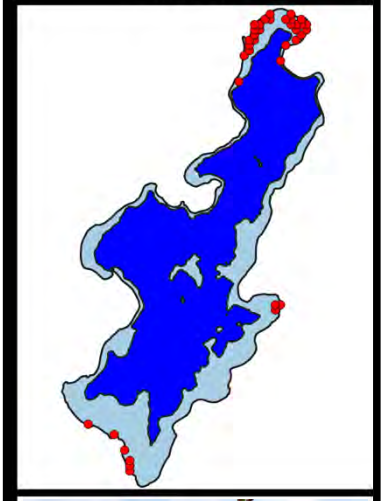
Northern watermilfoil



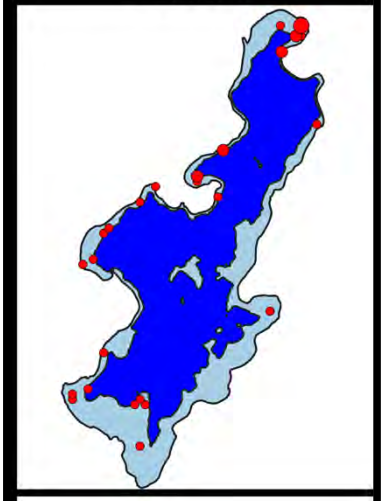
Filamentous algae



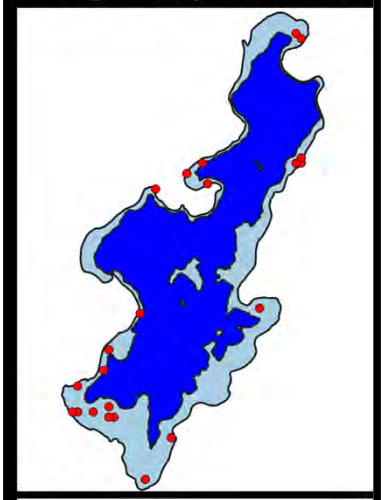
Wild Rice



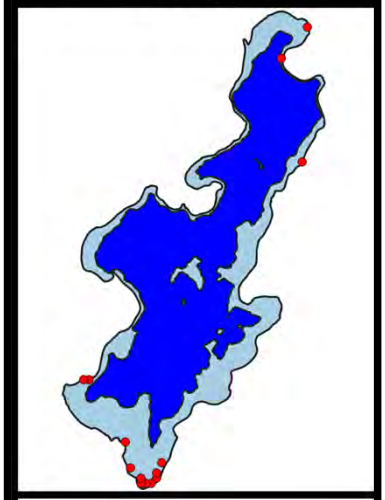
Coontail



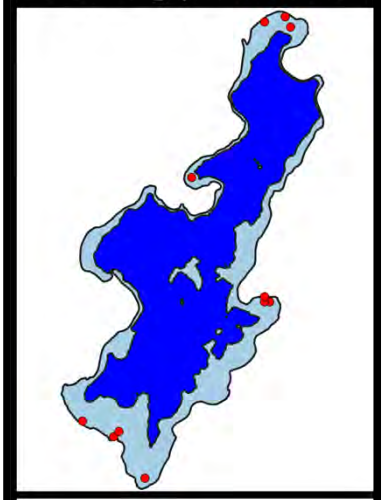
Largeleaf pondweed

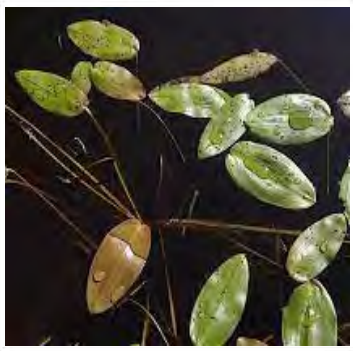


Cattail

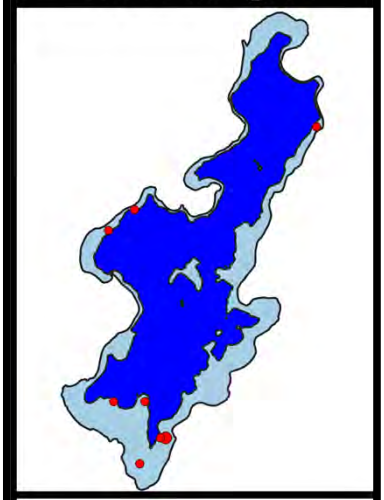


Floating pondweed

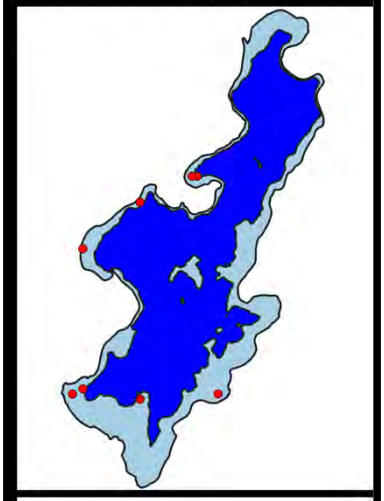




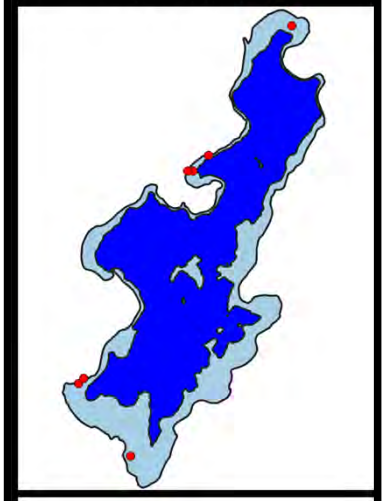
Water marigold



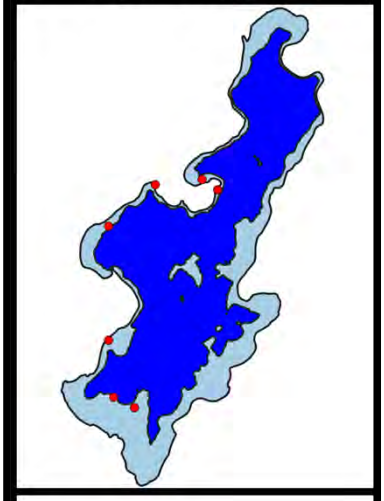
Stiff-leaved pondweed



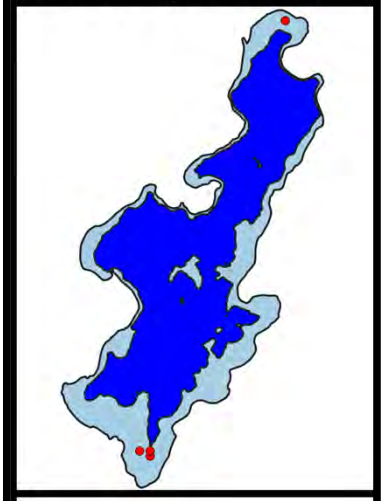
Watershield



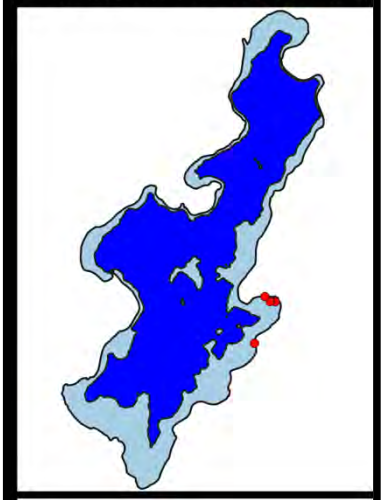
Water stargrass



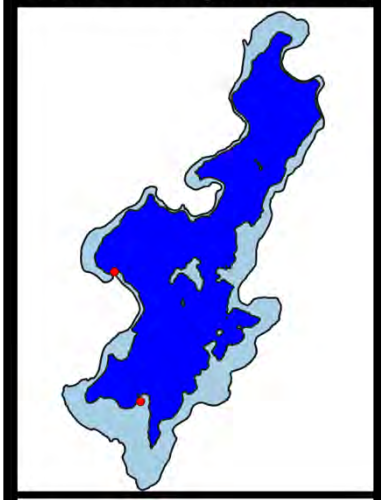
Illinois pondweed



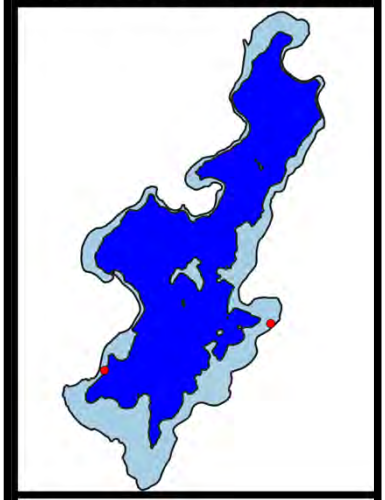
Slender watermilfoil

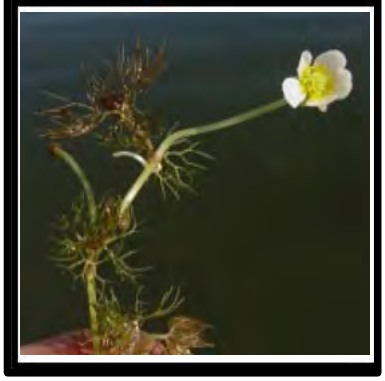


Whitestem pondweed

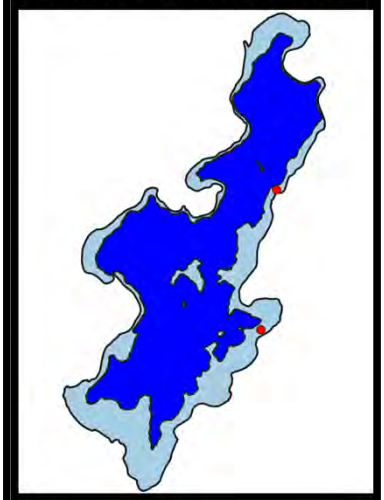


White water-crowfoot

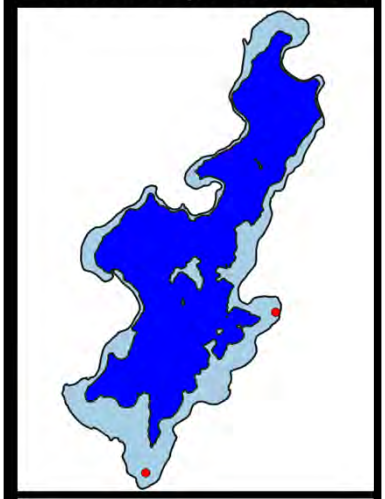




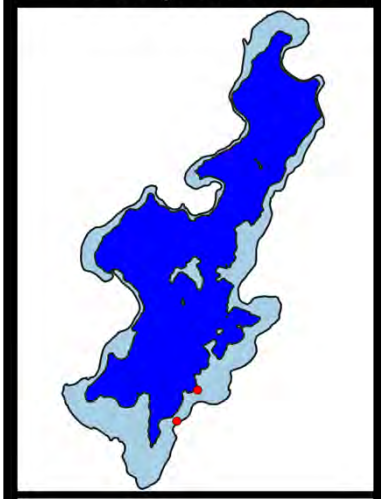
Brown-fruited rush

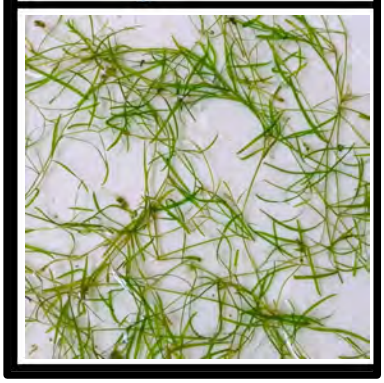


Robbins' pondweed

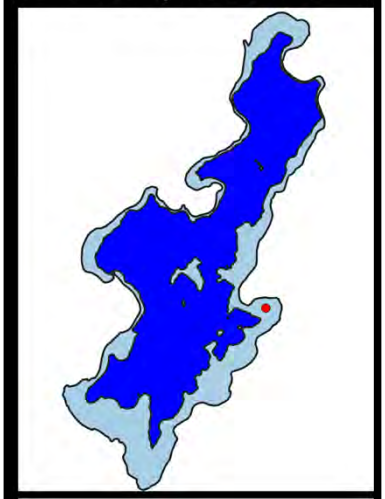


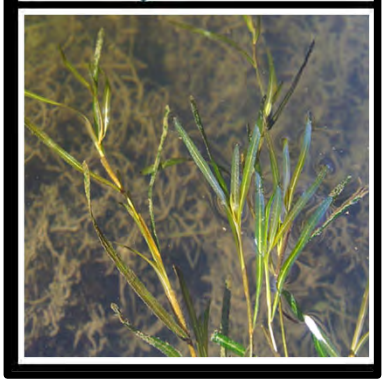
Small pondweed



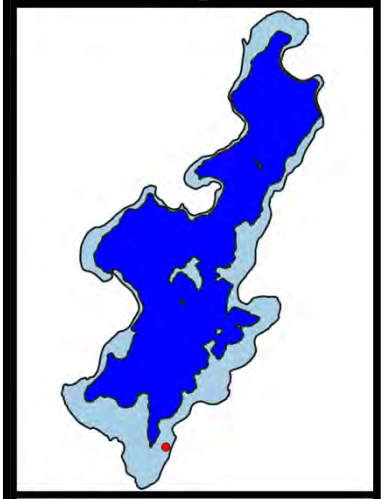


Fries' pondweed

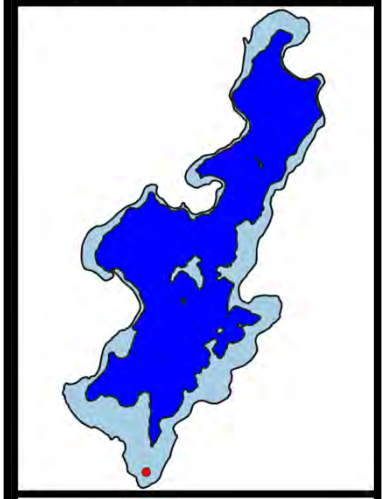




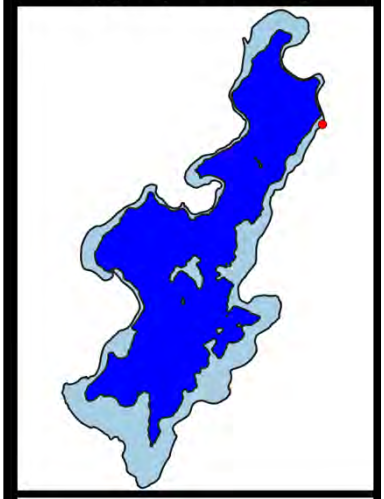
Sago

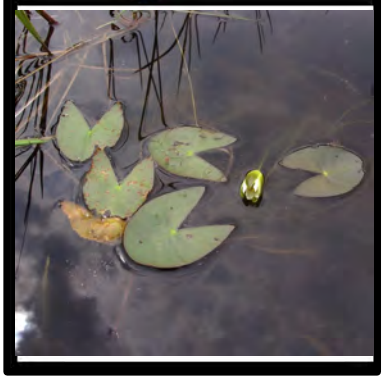


Common Bladderwort

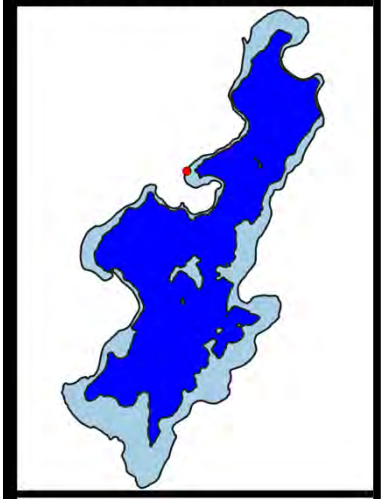


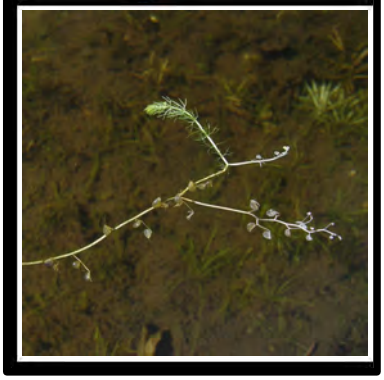
Pygmy waterlily





Intermediate bladderwort





Water smartweed