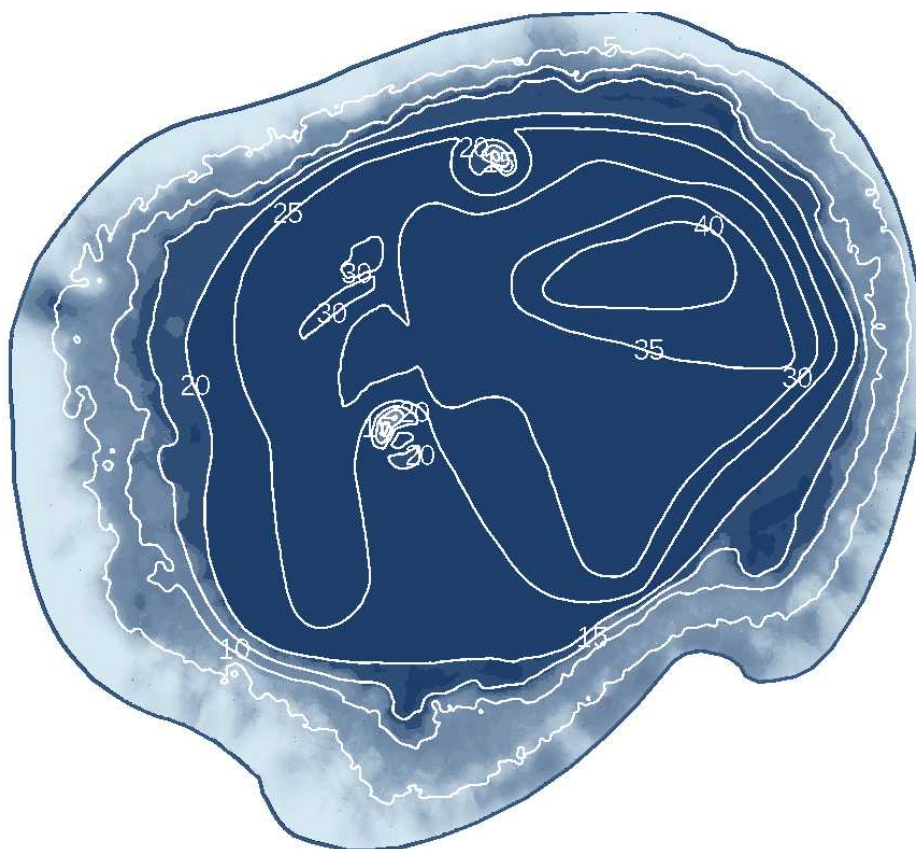




Grace Lake

Aquatic Plant Survey 2025–2026

Hubbard County, Minnesota

Prepared for the Grace Lake Watershed Improvement Association
Prepared by Limnopro Aquatic Science, Inc.



Grace Lake Aquatic Plant Survey 2025–2026

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- *Spring Point Intercept Survey 6/17-7/6/2026*
- *Curlyleaf Pondweed Meandering Survey 7/7/2026*
- *Summer Point Intercept Survey 8/25 – 9/9/2025*

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GRACE LAKE AQUATIC PLANT SURVEY 2025–2026

Prepared for the Grace Lake Watershed Improvement Association by Limnopro Aquatic Science, Inc.

EXECUTIVE SUMMARY

Grace Lake supports a widespread, diverse community of native aquatic plants and generally clear water. Curlyleaf pondweed, an invasive plant first found in 2025, is now established in several localized beds but is not a lakewide problem. Current conditions favor monitoring curlyleaf pondweed and protecting the native plant community rather than lakewide plant control. Where plants cause nuisance problems locally, property owners can manage them along their own shoreline using mechanical or chemical methods allowed under Minnesota DNR rules.

Native plant community

Across two lakewide surveys in August 2025 and June 2026, crews sampled 681 points with a rake. Plants were present at about 92% of points, and 25 kinds of plants were recorded. Flexuous naiad, a low-growing native plant, was the most common, found at about 60% of points. Flat-stemmed pondweed, Canadian waterweed, coontail, and northern watermilfoil were also widespread. Most of these were also the dominant plants in the 2006 DNR survey, so the community has changed little in two decades. Plants grow to depths of about 15 ft, where light becomes limiting.

Sonar mapping showed plants growing within 2 ft of the surface across about 15% of the lake, or a little over a third of the area where plants grow, mostly in shallow water near shore. That growth can interfere with boating and swimming in places, but it is also important fish and wildlife habitat.

Curlyleaf pondweed

The June 2026 survey found curlyleaf pondweed at only 3 of 341 points. A follow-up search on July 7 mapped five beds totaling near 21 acres, plus four isolated plants or small patches. The beds cover about 6% of the 340 acres of the lake shallow enough for rooted plants. Curlyleaf grows early and dies back by midsummer, which is why the August 2025 survey missed it. Given its limited extent, the Association's plan to monitor the beds in 2027 rather than treat them is reasonable. Treatment can be reconsidered if the beds spread or become denser. No Eurasian watermilfoil or starry stonewort, two other regionally present aquatic invasive species of concern, were found.

Water quality

Summer water clarity has averaged about 14 ft since 2004, near the clear end of the range typical for lakes in this region. Clarity is greatest in June, at about 19 ft, and drops to about 9 ft in August and September as algae increase. Phosphorus, the nutrient that most controls algae growth, averages just under the state standard, while algae levels average slightly above it. The state ranks Grace among its highest-priority lakes for phosphorus protection. This means that even modest increases in phosphorus could noticeably reduce water clarity, and because Grace is already near the state standard, it is at greater risk of future impairment than most lakes.

Recommendations

- Conduct meandering survey of the curlyleaf pondweed beds each spring during peak growth.
- Search for Eurasian watermilfoil and starry stonewort each late summer by meandering survey and/or SCUBA focusing on the public access.
- Repeat the full lakewide plant survey about every three years.
- Continue monthly water sampling from June through September.
- Protect native plants and keep any plant control small and properly permitted.

INTRODUCTION

Purpose and objectives

Grace Lake is an approximately 860-acre lake on the Beltrami-Hubbard county boundary southeast of Bemidji. It has about 340 acres of littoral habitat, a maximum depth of 42 ft, and a mean depth of about 17 ft. The littoral zone is the shallow portion of the lake where enough light reaches the bottom for rooted aquatic plants to grow. Grace Lake lies within the Mississippi River Headwaters Watershed.

The Grace Lake Watershed Improvement Association has been active since 1954. Current protection work includes funding boat-access inspections, tracking aquatic invasive species, commissioning independent lake studies, maintaining a resource library, and supporting water-quality monitoring. Recent work has focused particularly on aquatic invasive species prevention and the first confirmed curlyleaf pondweed (CLP) finding. These activities provide useful context for the plant surveys because lake vegetation, water quality, shoreline condition, and invasive species management are closely linked (Grace Lake Watershed Improvement Association 2026).

The Association commissioned Limnopro Aquatic Science to update the lake's aquatic plant information following the first confirmed CLP finding during the 2025 Minnesota DNR fisheries survey. The work had four main objectives: (1) document the early-season aquatic plant community while CLP was detectable, (2) compare early-season conditions with the existing late-summer 2025 survey, (3) delineate CLP beds for management planning, and (4) integrate the plant results with hydroacoustic vegetation mapping and available long-term water-quality information.

Ecological role of aquatic plants

Aquatic plants are a central part of lake habitat. They reduce wave energy, stabilize bottom sediments, take up nutrients, provide spawning and nursery habitat for fish, and supply food and cover for wildlife. At the same time, more vegetation is not automatically better for every

lake use or ecological function. Dense, continuous surface canopies can reduce open-water habitat, restrict movement within plant beds, and contribute to low dissolved oxygen under some conditions, while patchier or lower-growing communities can provide habitat without the same degree of recreational interference (Bunch et al. 2015; Radomski et al. 2019; Verhofstad and Bakker 2019). Plant identity, density, canopy position, spatial pattern, and recreational use therefore all matter when interpreting an aquatic plant community. Aquatic plant surveys provide a way to weigh the ecological benefits of the existing community against potential recreational or ecological drawbacks.

Historical plant community

The primary historical vegetation benchmark for Grace Lake is a Minnesota DNR survey completed in 2006 and reported in 2007. That survey documented 20 native aquatic plant taxa, vegetation at 96% of sample sites from shore to 15 ft, submerged plants to 26 ft, and approximately 8 acres of bulrush. The dominant submerged community included flexuous naiad, coontail, flat-stemmed pondweed, Canadian waterweed, muskgrass, and Northern watermilfoil.

Historical surveys are valuable context but are not exact replicates of the current work. Observed taxa richness can vary with survey effort, timing, taxonomic resolution, and field method, so long-term comparisons are interpreted primarily in terms of broad community continuity and major changes rather than simple differences in raw species counts (Perleberg and Radomski 2021).

Curlyleaf pondweed context

The management context changed in 2025 when Minnesota DNR fisheries staff recovered fragments of curlyleaf pondweed (*Potamogeton crispus*; CLP) in gill nets at a single location in the southeast bay during a standard fish survey (Fig. 1). That original detection is represented as Point 0 in the Grace Lake plant dataset. This was the first known occurrence of CLP in Grace Lake. The August

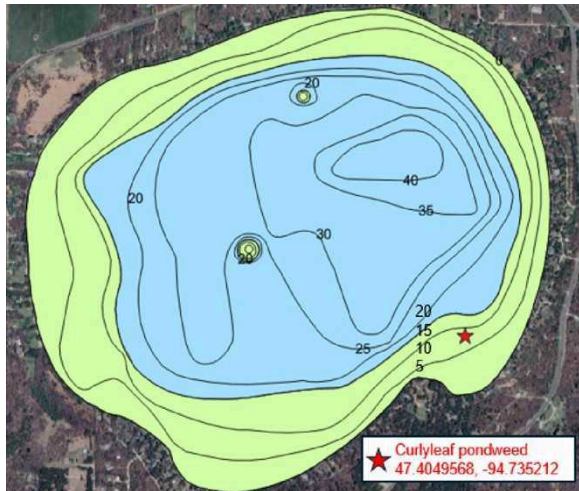


Fig. 1. Location of the original curlyleaf pondweed detection by Minnesota DNR fisheries staff in 2025.

2025 Limnopro plant survey did not detect CLP, but late summer occurs after the species' normal early-summer dieback period and therefore could not rule out an established spring population. That uncertainty was one reason for conducting an early-season survey in 2026.

Curlyleaf pondweed is a non-native, rooted submerged plant that is usually distinctive when mature. Leaves are strongly wavy or "lasagna-like," with blunt or rounded tips and finely toothed margins (Fig. 2). Immature plants may show less pronounced curling and can be more difficult to distinguish from native pondweeds (Minnesota DNR 2026a).



Fig. 2. Curlyleaf pondweed identification features. Mature plants have distinctly wavy or "lasagna-noodle" leaves with rounded tips and finely toothed margins. Inset is a turion, a reproductive structure of the plant.

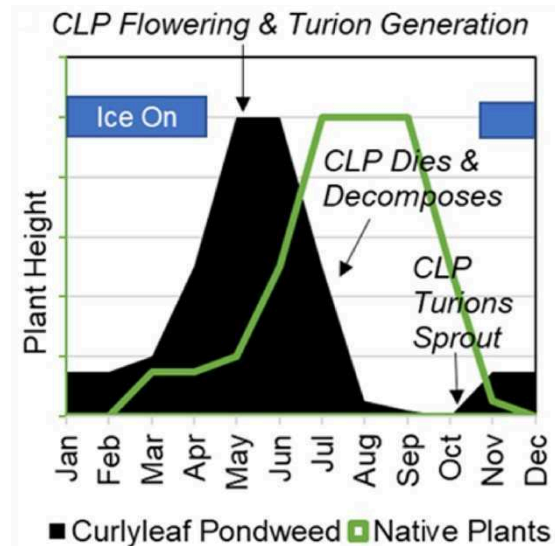


Fig. 3. Idealized seasonal growth cycle of curlyleaf pondweed compared with the general seasonal development of native aquatic plants. Curlyleaf pondweed can begin growth in fall, remain active under ice, grow rapidly in spring, form turions, and senesce in early summer before many native plants reach peak biomass.

CLP also has an unusual seasonal cycle compared with most native Minnesota lake plants (Fig. 3). Turions typically sprout in fall, plants can continue growing beneath the ice, and rapid growth resumes early in spring before many native species are well developed. New turions are produced in late spring or early summer before the plant typically senesces in midsummer. This seasonal pattern explains why CLP may be missed during a late-summer plant survey even when an established population is present earlier in the year. Dense CLP can interfere with boating, fishing, and swimming, and accumulated plant material can also influence nutrient cycling during rapid senescence and decomposition (Minnesota DNR 2026a; Wang et al. 2018).

Water-quality and phosphorus-protection context

Water quality is an important influence on the amount and distribution of aquatic vegetation. Aquatic plants need light to grow, so clearer water generally allows plants to grow deeper and can expand the portion of a lake that supports vegetation.

Grace Lake is relatively clear. Water clarity is commonly measured with a Secchi disk, a black-and-white disk that is lowered into the water until it can no longer be seen. In most Minnesota lakes, water clarity is strongly influenced by the amount of suspended algae in the water. Algal growth, in turn, is strongly influenced by nutrients, particularly phosphorus. In general, increasing phosphorus supports more algae, which reduces water clarity and limits the depth to which enough light reaches the lake bottom for rooted aquatic plants.

One useful way to evaluate Grace Lake is to compare it with other lakes in the same ecological region. Northern Lakes and Forests reference lakes have central summer ranges of approximately 14 to 27 $\mu\text{g/L}$ total phosphorus and 8 to 15 ft Secchi transparency (Heiskary and Wilson 2008). These ranges provide a useful benchmark for asking whether Grace Lake is typical of relatively minimally disturbed lakes in this part of Minnesota.

For comparison, across years with complete monitoring, Grace Lake averaged 27.3 $\mu\text{g/L}$ total phosphorus and 14.1 ft Secchi transparency through 2025. This places Grace near the upper end of the regional phosphorus range but near the clear end of the regional water-clarity range.

Minnesota also has water-quality standards for both phosphorus and Secchi transparency that provide another useful comparison. For lakes like Grace, total phosphorus should generally remain below 30 $\mu\text{g/L}$, while Secchi transparency should generally remain at least 6.6 ft. Grace Lake's long-term averages of 27.3 $\mu\text{g/L}$ phosphorus and 14.1 ft Secchi transparency are within those benchmarks.

Grace Lake has also been identified as a lake where phosphorus protection is particularly important. In its 2017 Mississippi River Headwaters assessment, the MPCA noted that Grace Lake's water-quality data appeared near an impairment threshold: chlorophyll-*a* (a measure of suspended algae) exceeded the standard, phosphorus was near the standard, and Secchi transparency met the standard.

Because those indicators gave mixed results, the assessment concluded that there was insufficient information to classify the lake as impaired. The same report placed Grace Lake in the highest Lake Phosphorus Sensitivity Significance priority group, meaning that preventing additional phosphorus loading was considered especially important for protecting the lake's existing condition.

These water-quality conditions are also directly connected to Grace Lake's aquatic plants. Clear water allows sunlight to reach deeper portions of the lake and supports vegetation over a larger area of the lake bottom. If phosphorus increases and algal growth reduces water clarity, the depth and area available for rooted plants would be expected to decrease. Changes in light conditions can also change which species are most successful, potentially favoring plants that grow rapidly toward the surface or form dense canopies. Protecting Grace Lake's water clarity therefore helps protect not only water quality, but also the extent and character of its aquatic plant community.

METHODS

Survey framework

This report integrates three complementary survey approaches. Point-intercept surveys describe lakewide species occurrence and relative density, meandering delineation surveys trace the boundaries of targeted invasive-plant beds, and hydroacoustic surveys map vegetation structure such as biovolume and canopy depth but do not identify species (Fig. 4). The methods answer different questions and are treated as complementary rather than interchangeable.

Point-intercept surveys

This report uses two complementary point-intercept datasets. The spring 2026 survey was started on June 17, 2026 and completed on July 6, 2026. Between those dates surveyors were on the lake for a total of four days and sampled 341 points. The summer portion of

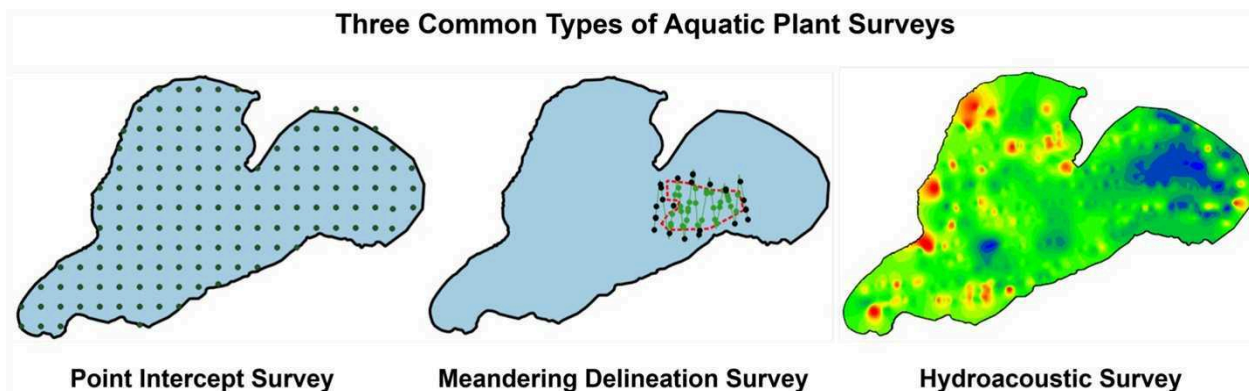


Fig. 4. Three aquatic plant survey approaches commonly used in Minnesota. Point-intercept surveys describe lakewide species occurrence and relative density. Meandering delineation surveys trace the boundaries of targeted invasive plant beds. Hydroacoustic surveys map vegetation structure such as biovolume and canopy depth but do not identify species.

the survey was reported on separately in 2025 but portions were reused in this document to give an overall annual picture of how the vegetation community changed between early and late year after the discovery of CLP. The summer portion of the survey occurred between August 25, 2025 and September 9, 2025 and included 340 sampled points. The early-season survey was selected to capture CLP while it was still actively growing. The late-summer survey represents the most recent full-lake assessment of the mature native plant community.

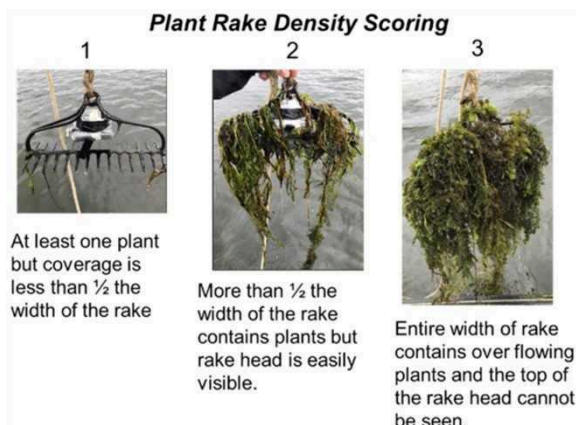


Fig. 5. Aquatic plant point-intercept rake-density method used for field scoring. Total vegetation and individual taxa are scored from 0 for absent to 3 for maximum rake density after a standardized rake toss and retrieval.

At each point, field staff collected vegetation with a double-sided rake and identified plants to the lowest practical taxonomic level. Total vegetation density was scored from 0 to 3, and each taxon on the rake was assigned its species-level rake score (Fig. 5). Occupancy is the proportion of sampled point-visits where a taxon was present. Relative rake density is the taxon's summed rake score divided by the grand total rake score for all taxa in the applicable survey or reporting window. Point-intercept data are well suited to describing local occupancy and relative commonness when survey designs are comparable (Verhoeven et al. 2026; Larkin et al. 2026).

Curlyleaf pondweed survey timing and field recognition

The spring survey was timed to improve detection of CLP before its typical early-summer senescence. These seasonal characteristics distinguished the purpose of the spring CLP-focused work from the late-summer native-community survey.

Plant-community benchmark calculations

Two published Minnesota plant-community measures were also calculated to help answer a basic question: *Is Grace Lake's aquatic plant*

community relatively good, poor, or typical compared with other Minnesota lakes?

The first, the Floristic Quality Index (FQI), considers both the number and types of plants present. In general, lakes with more native species, particularly species associated with less-disturbed conditions, receive higher scores. The second, a Minnesota macrophyte Index of Biotic Integrity (IBI), combines several characteristics of the plant community, including species richness, how much of the littoral zone supports vegetation, the depth of plant growth, and the occurrence of different groups of plants.

Neither index should be interpreted as a regulatory grade or a simple pass/fail test. Lake depth, water chemistry, geography, season, and survey methods can all influence the scores. They are used here only as additional benchmarks for comparing Grace Lake with similar Minnesota lakes. The calculations followed the published methods of Beck et al. (2010) and Radomski and Perleberg (2012).

Hydroacoustic vegetation mapping

Sonar data were collected while the survey boat moved between field locations and were processed through EcoSound and Limnopro's standardized spatial workflow. Hydroacoustic data describe vegetation structure but do not identify plant species. Biovolume is the percentage of the water column occupied by vegetation at a location. A biovolume of 50% means the modeled plant canopy fills about half of the water column. For summary statistics in this report, modeled values at or below 5% biovolume are treated as no modeled vegetation, consistent with the accepted vegetation-presence threshold. Mean biovolume is therefore calculated only for locations where modeled vegetation exceeds 5%.

Final vegetation surfaces were generated from the sonar observations using Limnopro's standardized interpolation workflow and accepted bathymetry. The resulting surfaces were independently benchmarked against the commercial BioBase vegetation grid.

Depth to canopy is the vertical distance from the water surface to the top of the plants. Areas where the canopy was within 2 ft of the surface were used as a practical indicator of where dense vegetation may interfere with recreation. Canopy depth and plant cover are descriptors of recreational interference rather than direct measures of ecological condition; the point at which vegetation becomes a nuisance depends on the activity and user (Verhofstad and Bakker 2019; Thiemer et al. 2023).

Curlyleaf pondweed delineation

After the early-season point-intercept survey, Limnopro conducted a dedicated meandering CLP delineation on July 7, 2026 along an approximately 8.3-mile survey path. The survey revisited positive areas and meandered through surrounding habitat to trace the distribution of CLP more completely than a fixed point grid can. Closely spaced detections were used to define bed boundaries within the littoral zone. Isolated detections were retained separately rather than assigning them arbitrary bed acreage.

Water quality

The water-quality dataset used for this report contains observations from MPCA station 29-0071-00-201 from 2004 through 2025. Sampling frequency was not the same every year. Secchi transparency, total phosphorus, chlorophyll-a, and surface temperature were collected during portions of the open-water season, with some years having much more complete coverage than others.

Annual Secchi transparency, total phosphorus, chlorophyll-a, and surface-temperature values were summarized for June through September only when at least one valid observation was available in each month. This complete-season rule reduces bias from years sampled only during the clearest or most algae-rich part of summer. The resulting Grace Lake values were compared with Northern Lakes and Forests reference ranges and Minnesota eutrophication criteria described above.

Table 1. Summary comparison of the Spring 2026 and Summer 2025 whole-lake surveys. The surveys represent complementary seasonal snapshots rather than a simple before-and-after comparison.

Metric	Spring 2026	Summer 2025
Survey date	June 15, 2026	August 20, 2025
Points sampled	341	340
Vegetated points	314 (92.1%)	310 (91.2%)
Taxa recorded	23	23
Macrophyte taxa	22	22
Native macrophyte taxa	21	22
Floristic Quality Index (FQI)	25.8	26.4
Macrophyte IBI (supplemental)	56	55
Modeled vegetated area	357 acres	352 acres
Mean biovolume in vegetated areas	40.3%	45.7%
Vegetation within 2 ft of surface	129 acres	138 acres
Curlyleaf pondweed occupancy	0.9%	0%

RESULTS

Overall plant coverage and depth distribution

Aquatic vegetation was widespread during both survey periods, with very little difference in overall plant occurrence or species richness between summer 2025 and spring 2026 (Table

1). Vegetation occurred at 310 of 340 points (91.2%) in summer 2025 and 314 of 341 points (92.1%) in spring 2026, and 23 taxa were recorded during each survey. The larger differences between surveys were in vegetation density and species composition, reflecting the different seasons and growth stages sampled.

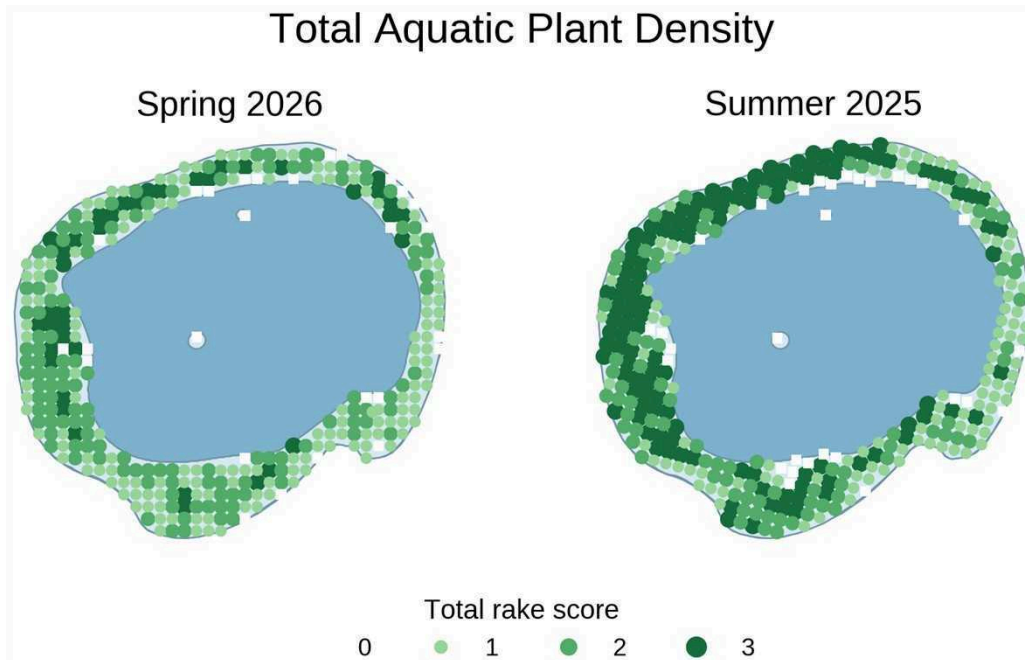


Fig. 6. Total aquatic plant density at sampled points during Spring 2026 and Summer 2025. Point symbols show total rake score from 0 to 3 and illustrate the widespread distribution of aquatic vegetation around the littoral zone.

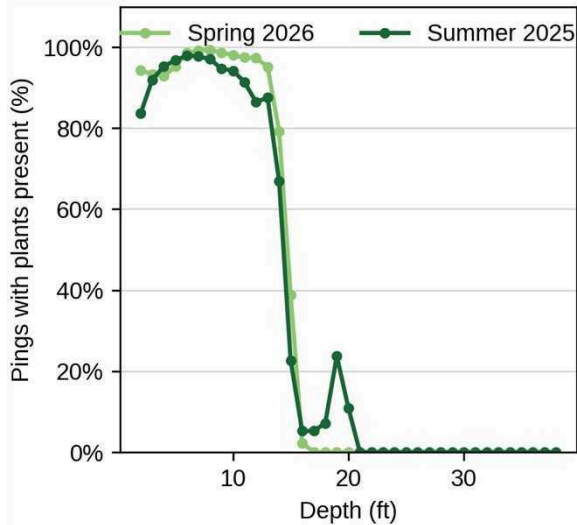


Fig. 7. Percentage of surveyed locations containing aquatic vegetation by water depth for Spring 2026 and Summer 2025. Plant occurrence remains high through approximately 14 ft and declines sharply near the current lakewide weedline at about 15 ft.

Vegetation was also broadly distributed throughout the littoral zone (Fig. 6). Unvegetated points were relatively uncommon and scattered rather than concentrated in a particular portion of the lake.

The hydroacoustic depth analysis showed a relatively sharp outer edge to the main plant community. In spring 2026, modeled plant presence remained above 79% through 14 ft, dropped to about 39% at 15 ft, and to about 2% at 16 ft. Summer 2025 showed a similar pattern, with plant presence about 67% at 14 ft, 23% at 15 ft, and about 5% at 16 to 17 ft. The main lakewide decline in vegetation occurrence therefore occurred near 15 ft, although individual plants occurred deeper (Fig. 7).

Biovolume and near-surface vegetation

Using the 5% biovolume threshold to distinguish modeled vegetation from no modeled vegetation, vegetation covered approximately 357 acres in spring 2026 and 352 acres in summer 2025. Although total vegetated area was nearly unchanged, vegetation was somewhat denser in summer: mean biovolume at vegetated locations increased from 40.3% in spring to 45.7% in

summer, and the area with biovolume of at least 50% increased from about 117 to 141 acres.

Near-surface vegetation showed a similar seasonal difference. Approximately 129 acres had plants within 2 ft of the surface in spring 2026, compared with 138 acres in summer 2025. These areas were concentrated around the shallow perimeter of the lake rather than in the deep central basin, showing that the main seasonal change was greater vegetation development within already vegetated portions of the littoral zone rather than expansion into new areas (Fig. 8).

Species richness and composition

Spring 2026 contained 23 reporting taxa, including the CLP detection, and summer 2025 contained 23 reporting taxa. Across both surveys, 25 reporting taxa were documented. Point-level richness averaged 4.1 taxa per vegetated point in spring and 4.0 in summer. These reporting totals include filamentous algae, which is useful for lake management but represents a mixed algal category rather than one biological macrophyte taxon. Formal FQI and IBI calculations therefore used 22 biological macrophyte taxa in each survey. Summer contained 22 native biological taxa, while spring contained 21 native biological taxa plus CLP.

In spring 2026, the most widespread taxa were flexuous naiad at 55%, flat-stemmed pondweed at 50%, Canadian waterweed at 49%, coontail at 35%, and Northern watermilfoil at 30%. In summer 2025, the most widespread taxa were flexuous naiad at 66%, flat-stemmed pondweed at 44%, Canadian waterweed at 41%, Northern watermilfoil at 36%, and coontail at 34%.

Flexuous naiad was the dominant taxon in both surveys, occurring at 55% of spring points and 66% of summer points and contributing 19% and 23% of total rake density, respectively. Across the pooled reporting set, flexuous naiad, Canadian waterweed, and flat-stemmed pondweed were the three largest contributors to relative rake density, accounting for 21.1%,

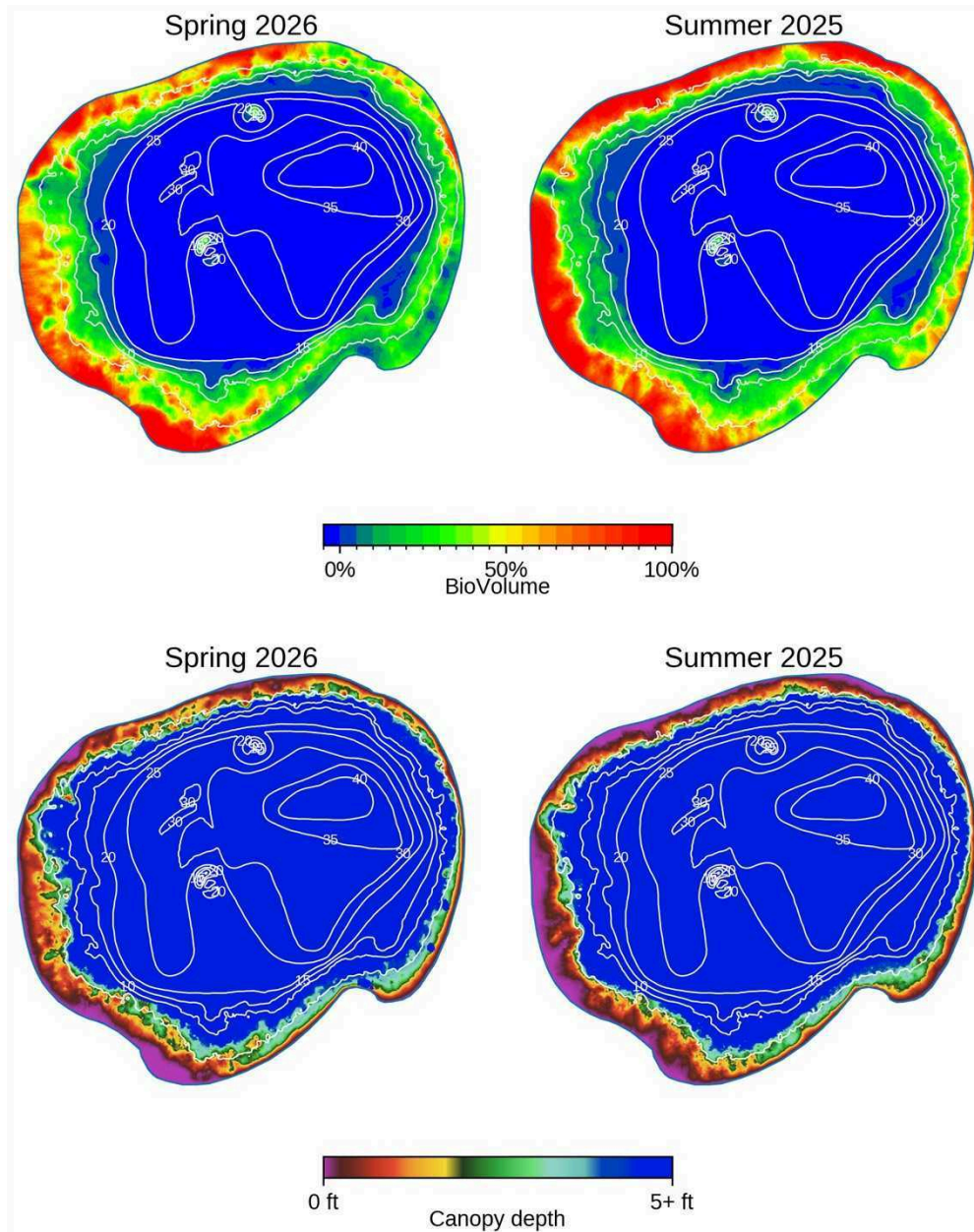


Fig. 8. Hydroacoustic vegetation structure during Spring 2026 and Summer 2025. Biovolume maps show the percentage of the water column occupied by vegetation. Canopy-depth maps show the distance from the water surface to the top of the modeled plant canopy. Areas with canopy within 2 ft of the surface identify locations with greater potential for recreational interference.

14.1%, and 11.1%, respectively (Table 2). Several taxa also shifted in relative importance between seasons: sago pondweed and Northern watermilfoil were more prominent in summer, whereas muskgrass, filamentous algae, and Fries' pondweed contributed proportionally more in spring.

Viewed across the full plant community, the taxa contributing the greatest share of rake density were generally also among the most widely distributed, with flexuous naiad standing out as both the most widespread and the largest contributor to pooled rake density (Fig. 9). The three leading taxa together accounted for about 46% of all rake density

Table 2. Aquatic plant taxa recorded on Grace Lake with pooled and survey-specific occupancy and relative rake density. Inaccessible and unsampled locations are excluded and are not treated as zero vegetation.

Common Name	Scientific Name	Combined		Spring		Summer	
		Density	Occupancy	Density	Occupancy	Density	Occupancy
Flexuous naiad	<i>Najas flexilis</i>	21%	61%	19%	55%	23%	66%
Flatstemmed pondweed	<i>Potamogeton zosteriformis</i>	11%	47%	12%	50%	10%	44%
Canadian waterweed	<i>Elodea canadensis</i>	14%	45%	15%	49%	13%	41%
Coontail	<i>Ceratophyllum demersum</i>	9%	35%	9%	35%	9%	34%
Northern watermilfoil	<i>Myriophyllum sibiricum</i>	9%	33%	8%	30%	9%	36%
Sago	<i>Stuckenia pectinata</i>	8%	26%	5%	21%	11%	32%
Star duckweed	<i>Lemna trisulca</i>	6%	26%	5%	24%	6%	28%
Claspingleaf pondweed	<i>Potamogeton richardsonii</i>	5%	23%	5%	23%	6%	23%
Whitestemmed pondweed	<i>Potamogeton praelongus</i>	3%	14%	2%	10%	4%	18%
Muskgrass	<i>Chara spp.</i>	3%	14%	5%	20%	2%	7%
Filamentous algae	<i>Various</i>	2%	10%	5%	18%	0.3%	1%
Fries' pondweed	<i>Potamogeton friesii</i>	2%	8%	3%	14%	0.4%	2%
Variable-leaved pondweed	<i>Potamogeton gramineus</i>	1%	6%	0.7%	3%	2%	10%
Water stargrass	<i>Heteranthera dubia</i>	1%	5%	0.9%	4%	1%	5%
Small pondweed	<i>Potamogeton pusillus</i>	1%	4%	2%	6%	0.5%	2%
White waterscrowsfoot	<i>Ranunculus aquatilis</i>	0.8%	4%	0.9%	4%	0.7%	3%
Hard Stem Bulrush	<i>Schoenoplectus acutus</i>	0.7%	3%	0.7%	3%	0.7%	3%
Illinois pondweed	<i>Potamogeton illinoensis</i>	0.6%	2%	0.3%	1%	0.9%	4%
Needle spikerush	<i>Eleocharis acicularis</i>	0.5%	2%	0.8%	3%	0.2%	0.9%
Cattail	<i>Typha spp.</i>	0.2%	0.9%	0.3%	1%	0.1%	0.3%
Arrowhead	<i>Sagittaria spp.</i>	0.2%	0.7%	0.1%	0.3%	0.3%	1%
Straight-leaved pondweed	<i>Potamogeton strictifolius</i>	0.2%	0.7%	0.0%	0.0%	0.3%	1%
Curlyleaf pondweed	<i>Potamogeton crispus</i>	0.1%	0.4%	0.2%	0.9%	0.0%	0.0%
Brown-fruited rush	<i>Juncus pelocarpus</i>	0.0%	0.1%	0.1%	0.3%	0.0%	0.0%
Wild Celery	<i>Vallisneria americana</i>	0.0%	0.1%	0.0%	0.0%	0.1%	0.3%

collected, indicating a community dominated by several common native species rather than by a single overwhelmingly dominant taxon (Fig. 10).

Plant-community benchmark results

The FQI was 26.4 in summer 2025 and 25.8 in spring 2026. Radomski and Perleberg (2012)

reported lower-tail thresholds of 11 taxa and an FQI of 20.2 for deep western Northern Lakes and Forests lakes surveyed by point-intercept or transect methods. Grace Lake had 22 biological macrophyte taxa in each survey.

Using the seven-metric Beck et al. (2010) macrophyte IBI, Grace Lake scored approximately 55 in summer 2025 and 56 in

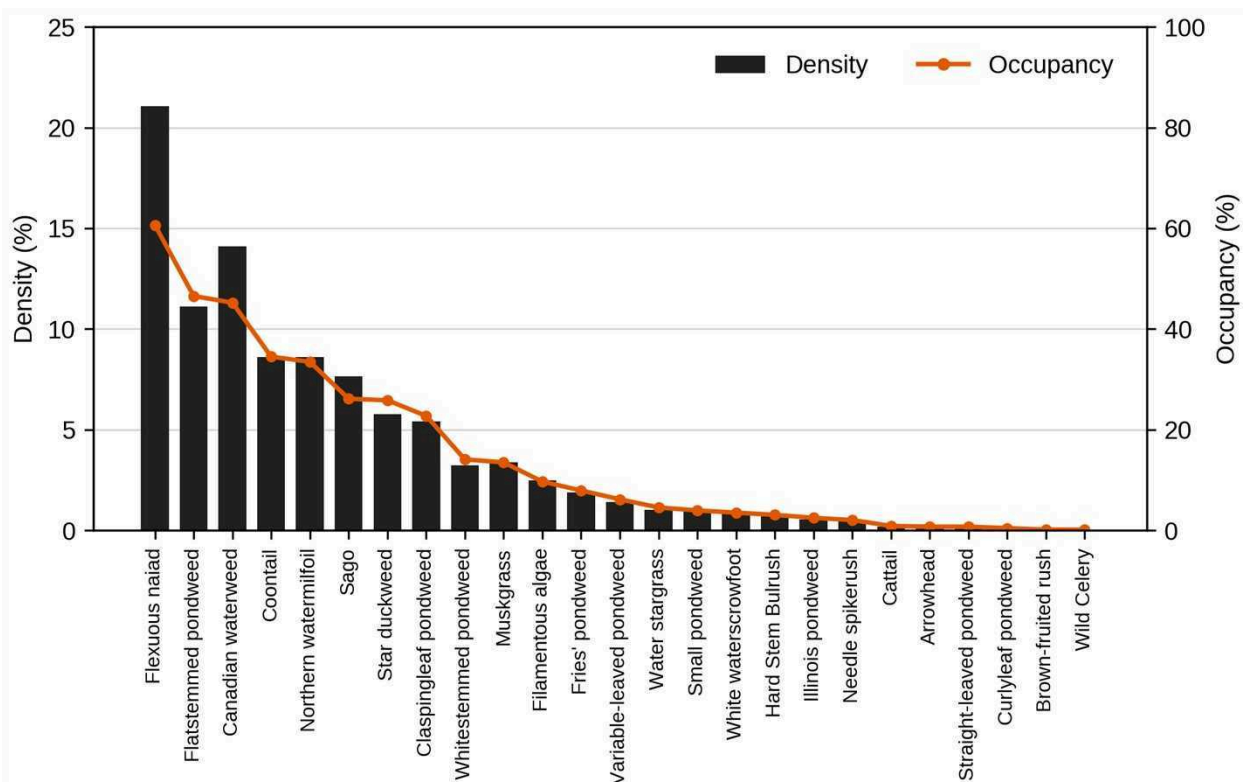


Fig. 9. Aquatic plant occupancy and relative rake density on Grace Lake pooled across the Spring 2026 and Summer 2025 surveys. Bars show the proportion of all rake density contributed by each reporting taxon. The line shows pooled occupancy, defined as the percentage of valid sampled point-visits where each taxon was present.

spring 2026. Northern Lakes and Forests lakes in the original development dataset averaged 66.9 and ranged from 46.4 to 80.1. No condition class was assigned to the Grace Lake scores.

Curlyleaf pondweed

CLP was confirmed in the spring 2026 point-intercept survey at 3 points, corresponding to 0.9% occupancy and approximately 0.2% of



Flexuous naiad

Najas flexilis
21.1% pooled rake density



Canadian waterweed

Elodea canadensis
14.1% pooled rake density



Flatstemmed pondweed

Potamogeton zosteriformis
11.1% pooled rake density

Fig. 10. The three taxa contributing the greatest pooled relative rake density were flexuous naiad, Canadian waterweed, and flat-stemmed pondweed.

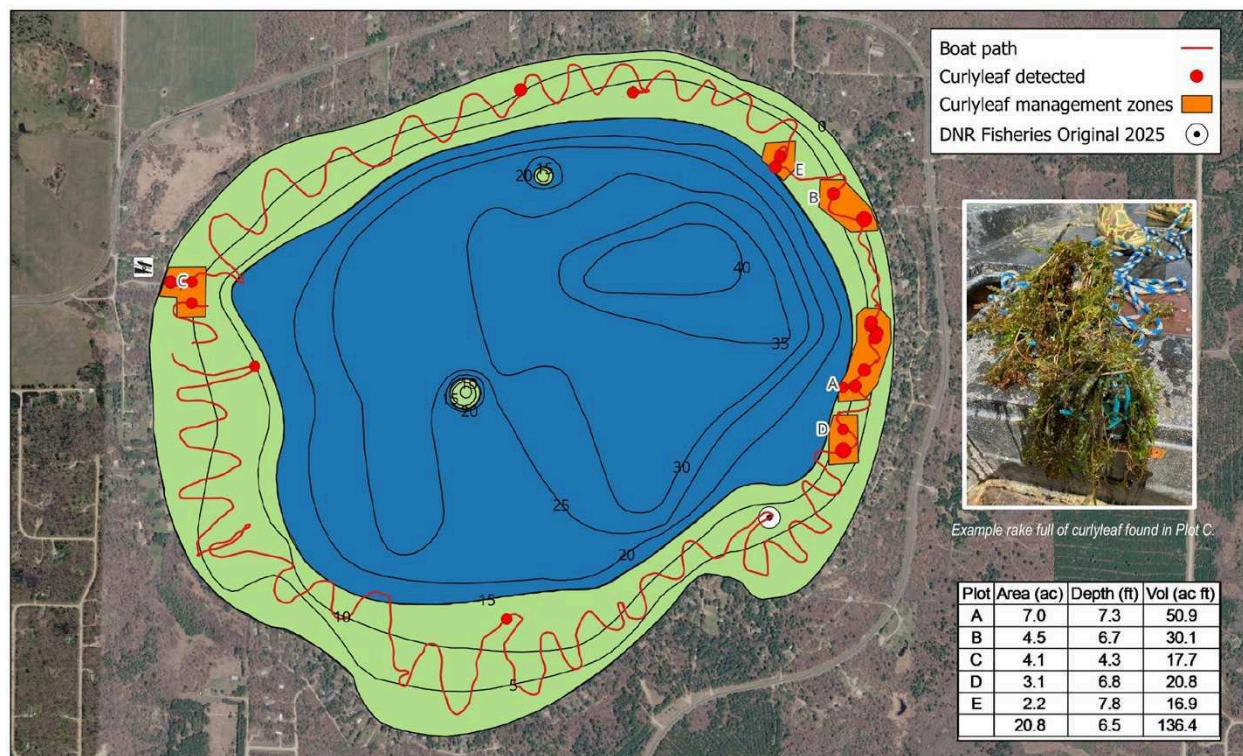


Fig. 11. Curlyleaf pondweed meandering delineation completed July 7, 2026.

total rake density. It was not detected in summer 2025.

The dedicated July 7 delineation identified five beds totaling 20.8 acres. Their approximate areas were 7.0, 4.5, 4.1, 3.0, and 2.2 acres. Four additional isolated detections were documented separately and were not assigned arbitrary bed acreage. The five mapped beds represent approximately 6.1% of the 340-acre littoral zone. The original 2025 DNR detection location was also revisited during the meandering survey, but no growing CLP was found there (Fig. 11).

Water quality

Among years meeting the complete June through September rule, mean Secchi transparency was 14.1 ft, mean total phosphorus was 27.3 $\mu\text{g/L}$, and mean chlorophyll-a was 11.3 $\mu\text{g/L}$. Northern Lakes and Forests reference lakes have a central summer range of about 14 to 27 $\mu\text{g/L}$ total phosphorus, 4 to 10 $\mu\text{g/L}$ mean chlorophyll-a, and 8 to 15 ft Secchi transparency (Heiskary

and Wilson 2008). Grace Lake's long-term Secchi mean was therefore near the clear end of that reference range, while the long-term phosphorus mean was just above and

Table 3. Grace Lake water quality in regional context. The table compares the long-term complete June-through-September mean and the 2025 complete-season mean with Northern Lakes and Forests reference-lake ranges and current Minnesota eutrophication criteria for total phosphorus, chlorophyll-a, and Secchi transparency. Reference values describe the central range among minimally impacted lakes, while criteria are regulatory thresholds used together rather than lake averages or grades.

Measure	Long-term	2025	NLF	MN
Total phosphorus ($\mu\text{g/L}$)	27.3	24.3	14-27	30
Chlorophyll-a ($\mu\text{g/L}$)	11.3	8.5	4-10	9
Secchi transparency (ft)	14.1	15.7	8-15	≥ 6.6

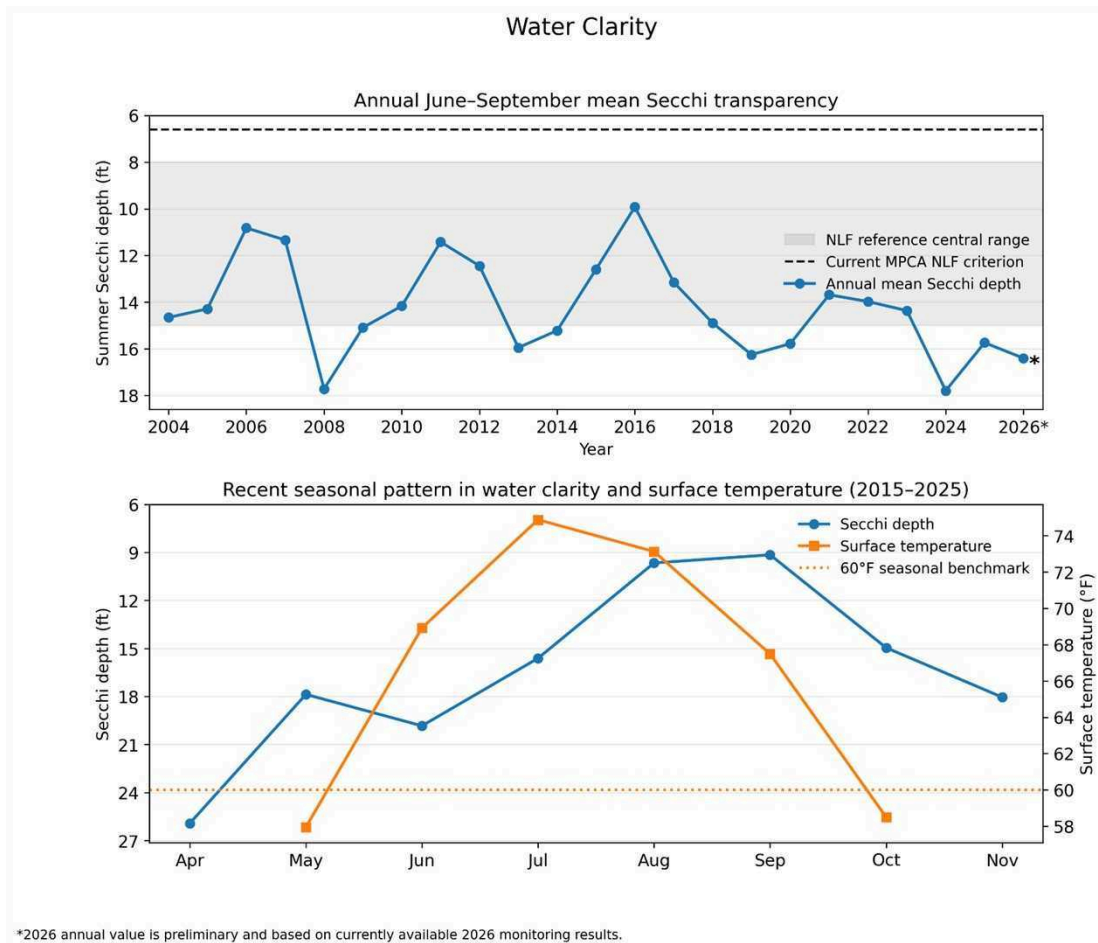


Fig. 12. Water clarity on Grace Lake. The upper panel shows annual June-through-September mean Secchi transparency for years with at least one valid observation in each of those four months. The lower panel shows the recent seasonal pattern in Secchi transparency and surface water temperature. Greater (i.e., lower positions on graph) Secchi depth indicates clearer water.

chlorophyll-a was modestly above the upper end of the central reference ranges.

The most recent complete year in the supplied file, 2025, had a June through September mean Secchi transparency of 15.7 ft, total phosphorus of 24.3 µg/L, and chlorophyll-a of 8.5 µg/L. Table 3 compares the long-term and 2025 Grace Lake values with regional reference ranges and current Minnesota criteria.

During 2015 through 2025, mean Secchi transparency declined from about 19.3 ft in June to 9.8 ft in August and 8.8 ft in September. Over the same months, both phosphorus and suspended algae as measured by chlorophyll-a generally followed the same pattern. Annual and seasonal Secchi transparency patterns are

shown in Fig. 12.

Other aquatic invasive species

No Eurasian watermilfoil or starry stonewort was detected during the 2026 survey work.

DISCUSSION

Native plant community condition and historical comparison

Grace Lake continues to support a widespread and diverse native plant community. Minnesota surveys average about 16 aquatic plant taxa per lake (Radomski and Perleberg 2012). The 2006/2007 DNR survey of Grace

Table 4. Occupancy of five historically common submerged aquatic plant taxa in the 2007 DNR survey, Summer 2025, and Spring 2026. Survey timing and methods differ, so the comparison is descriptive rather than an exact trend estimate.

Taxon	2007 DNR	Summer 2025	Spring 2026
Flexuous naiad	54%	66%	55%
Canadian waterweed	34%	41%	49%
Sago pondweed	19%	32%	21%
Northern watermilfoil	20%	36%	30%
Coontail	40%	34%	35%

Lake documented 20 native taxa and vegetation at 96% of sites sampled from shore to 15 ft. In the current surveys, 23 taxa were identified and vegetation occurred at about 92% of sampled points, and many of the same species remain among the most common plants in the lake (Table 4).

The most important long-term finding is therefore continuity rather than major change. Grace Lake remains heavily vegetated and supports a diverse native community. Exact comparisons of species numbers among years should be made cautiously because survey timing, sampling effort, and methods have changed, and more intensive modern surveys are more likely to detect uncommon species (Perleberg and Radomski 2021).

Other plant-community measures tell a similar but more nuanced story. Grace scores well for the amount of vegetated habitat and the number of common species. Some components of the Minnesota macrophyte IBI are lower, including maximum depth of plant growth and the relative occurrence of sensitive species. These measures describe different features of the plant community and should not be interpreted as a single grade of lake health.

Flexuous naiad is the dominant plant in Grace Lake, occurring at 55% of spring points and 66% of summer points and contributing about one-fifth of total rake density. That dominance is not, by itself, a sign of excessive or undesirable vegetation. Recent analysis of thousands of Midwestern aquatic-plant

surveys identified flexuous naiad as a potential “workhorse” native species because it is widespread among lakes, can become abundant within individual lakes, and appears capable of establishing across a relatively broad range of conditions (Larkin et al. 2026). Its relatively low-growing form also means that high lakewide abundance is less likely to produce the surface-matting problems associated with taller canopy-forming species.

Its abundance may nevertheless be useful to track over time. Flexuous naiad is an annual plant that must regenerate from seed each year rather than overwintering as an established perennial. Research outside Minnesota has shown that it can decline when nutrient enrichment changes the competitive environment—particularly when increased plant or algal growth reduces light or favors taller, earlier-growing perennial species (Wingfield et al. 2006; Bishop et al. 2019).

In Europe, flexuous naiad is treated as a high-conservation-priority species. Bishop et al. (2019) describe it as a “rare and declining” aquatic plant and note that it is listed as a Priority Species under the EU Habitats Directive. They also describe European sites that were formally protected specifically because they supported their populations.

Those European results should not be treated as direct thresholds for Grace Lake, where flexuous naiad is common and successful. They do, however, reinforce the importance of the lake's phosphorus sensitivity. A future decline in flexuous naiad accompanied by increasing

Table 5. Property-scale aquatic plant management options under current Minnesota DNR Aquatic Plant Management rules

Property-scale aquatic plant management	DNR APM permit?
Cut or pull submerged plants Up to 2,500 sq ft; up to 50 ft along shore or half the frontage; a 15-ft boat channel is also allowed.	No
Cut or pull submerged plants beyond those limits	Yes
Remove emergent plants Cattails, bulrushes, wild rice, and similar emergent vegetation.	Yes
Remove floating-leaf plants beyond a 15-ft channel Water lilies, watershield, and similar floating-leaf vegetation.	Yes
Use herbicides/algacides or an automated control device Aquatic herbicides, algacides, weed rollers, and similar devices.	Yes
Excavation, hydraulic jets, bottom barriers, or prohibited-area removal Includes undeveloped shoreline and posted fish-spawning areas.	Not allowed

algae, reduced water clarity, and greater dominance by nutrient-tolerant or canopy-forming plants would be more informative than a change in naiad abundance by itself.

Vegetation depth, canopy, and recreation

Aquatic plants remain common through much of the shallow portion of Grace Lake but decline sharply near 15 ft of water depth. This pattern is consistent with light becoming increasingly limiting as depth increases (Chambers and Kalff 1985; Middelboe and Markager 1997).

More than 100 acres had modeled plant growth within 2 ft of the water surface during each survey period. Dense growth in these shallow areas can interfere with boating, swimming, or shoreline access even though the same vegetation provides valuable habitat for fish and other aquatic organisms.

Native plants stabilize sediments, provide habitat, compete with algae for nutrients, and are an important part of a clear-water lake ecosystem. Localized vegetation that substantially interferes with recreation can reasonably be managed, but the current survey does not indicate a lakewide ecological problem caused by excessive native vegetation (Bunch et al. 2015; Radomski et al. 2019; Verhofstad and Bakker 2019). Minnesota does allow limited aquatic-plant control at an

individual property under their Aquatic Plant Management (APM) program, and larger or more intensive work may be authorized through the DNR aquatic plant management permitting process (Table 5).

Curlyleaf pondweed is established but still localized

The 2026 surveys confirm that CLP is now established in Grace Lake rather than represented by only an isolated historical detection. Five beds totaling 20.8 acres were mapped, along with four additional isolated plants or small patches. Those beds represent



Fig. 13. Example of nuisance-level surface matting by curlyleaf pondweed on a boat paddle. Dense surface growth can interfere with boating, fishing, and swimming even though the present Grace Lake infestation is much more localized.

about 6.1% of the approximately 340-acre littoral zone.

Dense CLP can eventually form surface mats that interfere with boating, fishing, and swimming (Fig. 13). Grace Lake is not currently experiencing that level of lakewide infestation. The more useful questions are whether these beds expand, become denser, begin producing nuisance surface growth, or begin affecting water quality.

CLP may also become important to nutrient cycling. The plant takes up phosphorus while growing and can release some of that phosphorus back into the water when it dies rapidly in early summer (Wang et al. 2018). There is currently no evidence that CLP is responsible for Grace Lake's late-summer water-quality pattern, particularly at its present limited acreage. However, because Grace Lake is considered sensitive to additional phosphorus, this interaction is worth watching. Continued monitoring can help determine whether phosphorus concentrations increase during or shortly after CLP dieback as the infestation expands.

Minnesota allows both chemical and mechanical control of CLP under the Invasive Aquatic Plant Management program. Under current state rules, pesticide treatment is generally limited to 15% of the littoral area, while mechanical control may extend to as much as 50%; the combined area managed mechanically and chemically may not exceed 50% of the littoral zone. CLP control is generally intended to suppress nuisance growth rather than eradicate the plant because it reproduces from persistent turions. Chemical treatments are typically conducted early in spring, often soon after ice-out and before substantial turion production; the exact timing is established through the permit.

For planning purposes, chemical control commonly costs on the order of \$250–\$450 per acre depending on treatment depth, product, and permitted application rate, while mechanical harvesting may exceed \$1,000 per acre. These figures should be treated as

approximate project-cost estimates rather than DNR-established rates.

Water quality is clear, but phosphorus remains important

Grace Lake is generally a clear lake, but conditions change substantially through the summer. Its long-term June-through-September Secchi transparency averages 14.1 ft, near the clear end of the 8–15 ft range typical of Northern Lakes and Forests reference lakes. Long-term total phosphorus averages 27.3 µg/L and chlorophyll-a averages 11.3 µg/L, both near or somewhat above the upper end of typical reference-lake conditions.

There is also a consistent seasonal pattern. Grace is generally clearest during early summer. By August and September, algal biomass tends to increase and water clarity declines. This does not necessarily mean that water quality is poor; rather, it shows that phosphorus, algae, and transparency respond differently through the season and need to be considered together.

More important for Grace Lake is its sensitivity to additional phosphorus. The state's Lake Phosphorus Sensitivity Significance analysis placed Grace in its highest protection-priority group (Minnesota Pollution Control Agency 2017; Radomski and Carlson 2018). In practical terms, this means that protecting the lake from additional phosphorus is particularly worthwhile because further nutrient enrichment could produce a meaningful ecological response.

Increasing phosphorus can ultimately change the aquatic plant community as well. More phosphorus can support greater algal growth, reducing the amount of light reaching the lake bottom. If water clarity declines enough, submerged plants can no longer grow as deeply, sensitive species may decline, and the community can shift toward plants better able to tolerate nutrient-rich and lower-light conditions. Because Grace currently supports extensive native vegetation and relatively clear water, preventing additional phosphorus

loading is preferable to trying to restore those conditions after they have been lost.

The present data do not indicate that such a shift has occurred. Instead, they identify a reason for protecting the lake's current condition. Maintaining shoreline vegetation, limiting runoff and erosion, maintaining septic systems, and avoiding unnecessary phosphorus inputs will help protect both water clarity and the native plant community.

Low water in 2026

The Association reported that Grace Lake reached its lowest recorded water level on July 27, 2026, approximately 39 inches below the 2019 record high. Low water changes shoreline habitat, recreational access, and the amount of shallow lake bottom available for plant growth.

The current survey does not demonstrate that any particular vegetation change was caused by the low water level. It should nevertheless be documented because lake level is an important factor when future plant surveys are compared with 2026.

MANAGEMENT RECOMMENDATIONS

Minnesota aquatic plant management process

Minnesota uses two related permit pathways for most lake-plant management. The Aquatic Plant Management program, or APM, addresses access and nuisance control for riparian property owners while balancing conservation of the plant community. The Invasive Aquatic Plant Management program, or IAPM, addresses selective control of listed invasive aquatic plants such as curlyleaf pondweed. Permit rules, fees, treatment areas, and allowable products can change, so the current DNR guidance and MPARS permit conditions should be checked before any work begins.

The five mapped CLP beds on Grace Lake total 20.8 acres, or about 6.1% of the approximately

340-acre littoral zone. That mapped acreage by itself is below the standard IAPM herbicide ceiling of 15% of littoral area. The DNR applies the limit cumulatively across permitted aquatic plant management on a lake, however, and final permitted acreage depends on the current delineation, other permitted control, landowner authorization, field review, and the selectivity of the proposed treatment.

1. Monitor the mapped CLP beds each spring

Revisit the five mapped beds during peak CLP growth in late May or early June 2027 and document bed boundaries, density, and recreational interference. Continue targeted spring monitoring annually while the infestation is changing. The Association's current decision to monitor rather than chemically treat in 2027 is reasonable given the localized footprint and strong native community. Treatment can be reconsidered if beds expand materially, become denser, or create nuisance conditions. If treatment is reconsidered, update the spring delineation and obtain the appropriate IAPM permit before final treatment acreage, chemistry, or rate is selected.

2. Maintain targeted late-summer or fall AIS early detection

Conduct a targeted late-summer or fall search for Eurasian watermilfoil and starry stonewort at the public access and other high-risk shoreline areas. A meandering shoreline search can cover broader habitat, while SCUBA at the public access provides a more intensive early-detection check where feasible. This complements the spring CLP survey because the highest-detection periods differ among invasive species.

3. Repeat the full point-intercept survey about every three years

Repeat the paired whole-lake point-intercept and hydroacoustic survey approximately every three years or as frequently as budget allows, or sooner if a major management action or obvious lakewide change occurs. This interval

should be frequent enough to detect meaningful shifts while avoiding the cost of repeating the full survey annually. Use the same point grid, rake-scoring method, and reporting definitions so future comparisons remain valid.

4. Protect the native littoral plant community

Avoid broad-scale vegetation removal. Native plants occupy more than 90% of sampled points and form the habitat structure of much of the littoral zone. Where homeowners experience nuisance growth, management should remain localized and follow the pathways summarized in Table 5. For permitted nearshore nuisance control, a granular contact herbicide such as Hydrothol 191 may be an option where the target vegetation, water depth, product label, and permit conditions make it appropriate. The DNR permit, not this report, determines the authorized area, product, and rate. If the specific target is CLP or another listed invasive plant, homeowners should also confirm the appropriate IAPM pathway with the DNR because invasive-plant management is administered separately. Low-growing native species such as flexuous naiad should generally be protected where they do not interfere with recreation.

5. Continue water-quality monitoring through the full June through September season

Maintain monthly Secchi transparency, total phosphorus, and chlorophyll-a monitoring through at least June, July, August, and September. Late August and September are particularly important because the existing record shows lower clarity and higher algal and nutrient concentrations during this period. Consistent seasonal monitoring will also provide the best way to determine whether future expansion and senescence of CLP is associated with any measurable water-quality change.

6. Maintain AIS early-detection outreach

Continue asking residents to report unusual plants and inspect docks, lifts, trailers, and shoreline equipment. Grace Lake now has CLP but remains free of confirmed Eurasian watermilfoil and starry stonewort based on the 2026 survey information. Early detection remains much less expensive and more effective than managing a large established infestation.

CONCLUSIONS

Grace Lake continues to support a widespread and relatively species-rich native aquatic plant community. Vegetation occupied about 92% of sampled points in both the spring 2026 and summer 2025 surveys. Formal plant-community benchmarks place Grace above the lower-tail Minnesota richness and FQI thresholds for comparable deep western Northern Lakes and Forests surveys. Its supplemental macrophyte IBI scores fall within the range reported for Northern Lakes and Forests lakes in the original development dataset, although below that dataset's mean. These indices are best viewed as supporting context rather than grades. Many of the same common native species documented about two decades ago remain prominent. Flexuous naiad remains the most widespread species and is best interpreted as a successful native component of the community rather than a sensitive indicator by itself.

The principal management change is CLP. The species is now confirmed as established in localized beds, with 20.8 acres mapped in five beds plus four isolated detections. At current abundance, the issue is important but still spatially limited. The appropriate near-term strategy is annual spring monitoring of the mapped beds, targeted late-summer or fall early detection for other AIS, and protection of the native community rather than broad plant control.

Long-term water-quality data reinforce the value of that conservative approach. Grace Lake is generally clear compared with Northern Lakes and Forests reference lakes. Its long-term Secchi transparency is near the clear end of the

regional reference range, while total phosphorus and chlorophyll-a are just above the upper end of central reference conditions. The pattern is strongly seasonal, with clearer water early in summer and greater algal biomass later in the season. State phosphorus-prioritization work provides an additional reason to protect this condition because Grace ranks highly for preventive phosphorus protection rather than restoration after impairment. Protecting water clarity, shoreline habitat, and native vegetation while watching the newly established CLP population provides the strongest foundation for maintaining the lake's ecological and recreational value.

REFERENCES

- Bachmann, R.W., Horsburgh, C.A., Hoyer, M.V., Mataraza, L.K., and Canfield, D.E. Jr. 2002. Relations between trophic state indicators and plant biomass in Florida lakes. *Hydrobiologia* 470, 219-234.
- Beck, M.W., Hatch, L.K., Vondracek, B., and Valley, R.D. 2010. Development of a macrophyte-based index of biotic integrity for Minnesota lakes. *Ecological Indicators* 10, 968-979. <https://doi.org/10.1016/j.ecolind.2010.02.006>
- Bishop, I.J., Bennion, H., Sayer, C.D., Patmore, I.R., and Yang, H. 2019. Filling the data gap. Using paleoecology to investigate the decline of *Najas flexilis*, a rare aquatic plant. *Geo: Geography and Environment* 6, e00081. <https://doi.org/10.1002/geo2.81>
- Bunch, A.J., Allen, M.S., and Gwinn, D.C. 2015. Influence of macrophyte-induced hypoxia on fish communities in lakes with altered hydrology. *Lake and Reservoir Management* 31, 11-19.
- Chambers, P.A., and Kalff, J. 1985. Depth distribution and biomass of submersed aquatic macrophyte communities in relation to Secchi depth. *Canadian Journal of Fisheries and Aquatic Sciences* 42, 701-709.
- Grace Lake Watershed Improvement Association. 2026. Grace Lake website, 2026 curlyleaf pondweed update, and resource library. <https://www.gracelakebemidji.com/>
- Heiskary, S.A., and Wilson, C.B. 1989. The regional nature of lake water quality across Minnesota. An analysis for improving resource management. *Journal of the Minnesota Academy of Science* 55, 71-77.
- Heiskary, S.A., and Wilson, C.B. 2008. Minnesota's approach to lake nutrient criteria development. *Lake and Reservoir Management* 24, 282-297. <https://doi.org/10.1080/07438140809354068>
- Heiskary, S.A., Wilson, C.B., and Larsen, D.P. 1987. Analysis of regional patterns in lake water quality using ecoregions for lake management in Minnesota. *Lake and Reservoir Management* 3, 337-344. <https://doi.org/10.1080/07438148709354789>
- Larkin, D.J., Verhoeven, M.R., Walsh, J.R., and Johnson, J.A. 2026. Quantifying aquatic plant commonness and co-occurrence across scales to support ecological understanding and management. *Journal of Ecology* 114, e70268. <https://doi.org/10.1111/1365-2745.70268>
- Limnopro Aquatic Science, Inc. 2025. Grace Lake Aquatic Plant Survey 2025. Prepared for the Grace Lake Watershed Improvement Association.
- Limnopro Aquatic Science, Inc. 2026. Grace Lake Curlyleaf Pondweed Meandering Delineation Survey Report. July 7, 2026.
- Middelboe, A.L., and Markager, S. 1997. Depth limits and minimum light requirements of freshwater macrophytes. *Freshwater Biology* 37, 553-568.
- Milburn, S.A., Bourdaghs, M., and Husveth, J.J. 2007. Floristic Quality Assessment for Minnesota Wetlands. Minnesota Pollution Control Agency.
- Minnesota Department of Natural Resources. 2006/2007. Aquatic Vegetation of Grace Lake, DOW 29-0071-00, Hubbard County, Minnesota. Surveyed July 24-25, 2006.
- Minnesota Department of Natural Resources. 2025. Fisheries Management Lake Survey

Report: Grace Lake, DOW 29-0071-00. Standard survey dated July 28, 2025.

Minnesota Department of Natural Resources. 2026a. Curly-leaf pondweed (*Potamogeton crispus*): identification, life history, and management guidance. Minnesota DNR website.

Minnesota Department of Natural Resources. 2026b. Aquatic Plant Management Program, aquatic plant regulations, permit guidance, and Aquatic Plant Management permit fees. Accessed October 2026. <https://www.dnr.state.mn.us/apm/index.html>

Minnesota Department of Natural Resources. 2026c. Bushy Pondweeds and Naiads, *Najas* spp., and aquatic plant management guidance. Minnesota DNR website.

Minnesota Department of Natural Resources. 2026d. Invasive Aquatic Plant Management permit guidance and cumulative treatment-area limits. Accessed October 2026. <https://www.dnr.state.mn.us/invasives/iapm.html>

Minnesota Department of Natural Resources. 2026e. Permits issued with a variance for aquatic invasive plant management. Accessed October 2026. <https://www.dnr.state.mn.us/invasives/variance.html>

Minnesota Pollution Control Agency. 2005. Minnesota Lake Water Quality Assessment Report. Developing Nutrient Criteria. Third Edition.

Minnesota Pollution Control Agency. 2017. Mississippi River-Headwaters Watershed Stressor Identification Report.

Minnesota Rules 7050.0222. Lake eutrophication standards for Northern Lakes and Forests. Total phosphorus 30 µg/L, chlorophyll-a 9 µg/L, and Secchi transparency not less than 2.0 m. Impairment determination requires phosphorus plus a response variable.

Moeller, R.E., Burkholder, J.M., and Wetzel, R.G. 1988. Significance of sedimentary phosphorus to a rooted submersed macrophyte, *Najas flexilis*, and its algal epiphytes. *Aquatic Botany* 32, 261-281. [https://doi.org/10.1016/0304-3770\(88\)90120-9](https://doi.org/10.1016/0304-3770(88)90120-9)

Olmanson, L.G., Bauer, M.E., and Brezonik, P.L. 2008. A 20-year Landsat water clarity census of Minnesota's 10,000 lakes. *Remote Sensing of Environment* 112, 4086-4097. <https://doi.org/10.1016/j.rse.2007.12.013>

Perleberg, D.J., and Radomski, P.J. 2021. A century of change in Minnesota's lake plant communities. *Aquatic Botany* 173, 103401. <https://doi.org/10.1016/j.aquabot.2021.103401>

Radomski, P., and Carlson, K. 2018. Prioritizing lakes for conservation in lake-rich areas. *Lake and Reservoir Management* 34, 401-416. <https://doi.org/10.1080/10402381.2018.1471110>

Radomski, P., and Perleberg, D. 2012. Application of a versatile aquatic macrophyte integrity index for Minnesota lakes. *Ecological Indicators* 20, 252-268.

Radomski, P., Carlson, K., and Perleberg, D. 2019. Advancing aquatic vegetation management for fish in north temperate lakes. *Lake and Reservoir Management* 35, 355-363.

Thiemer, K., Immerzeel, B., Schneider, S., Sebola, K., Coetzee, J., Baldo, M., Thiebaut, G., Hilt, S., Köhler, J., Harpenslager, S.F., and Vermaat, J.E. 2023. Drivers of perceived nuisance growth by aquatic plants. *Environmental Management* 71, 1024-1036. <https://doi.org/10.1007/s00267-022-01781-x>

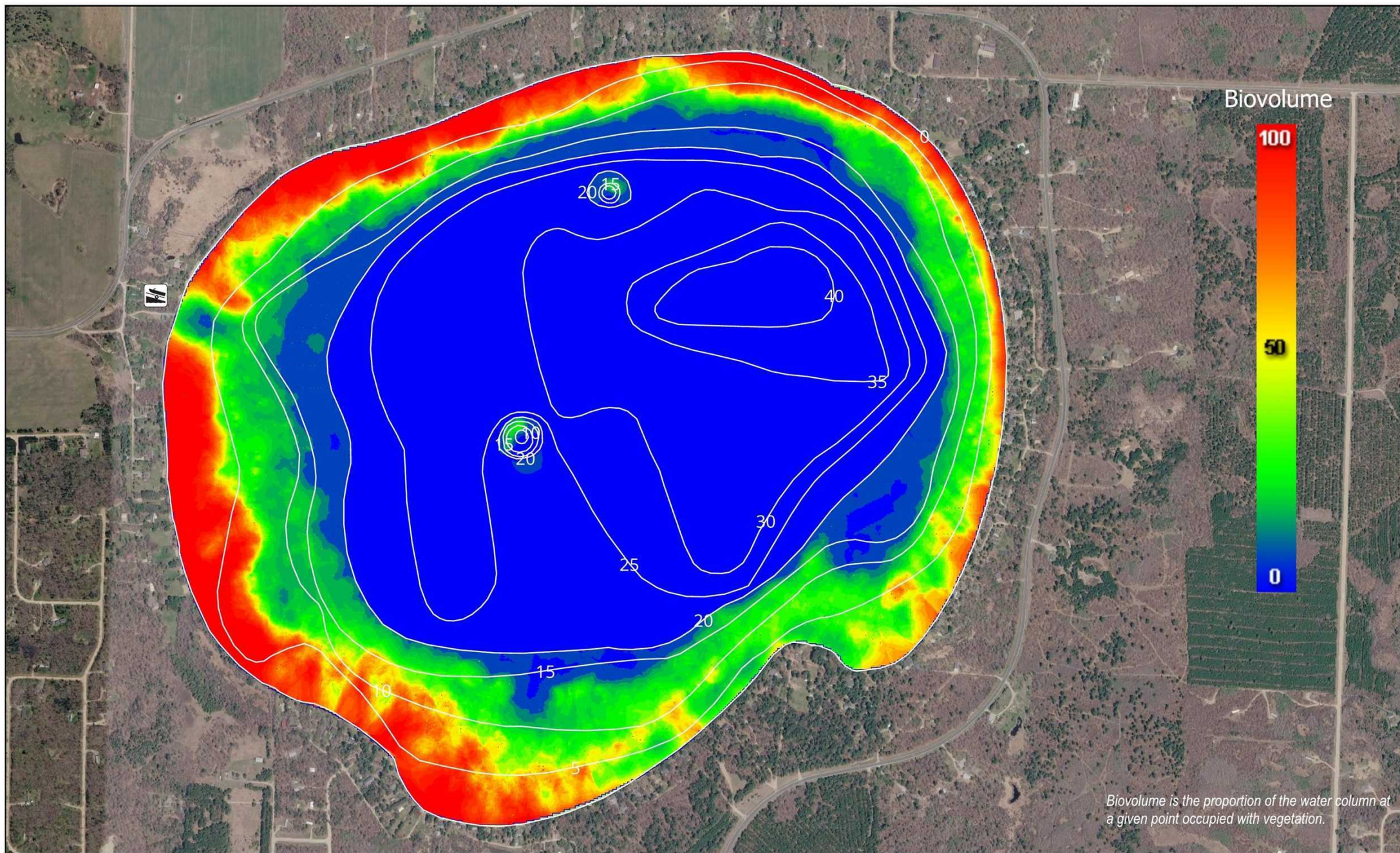
Verhoeven, M.R., Bartodziej, W.L., Berg, M.S., et al. 2026. Occurrence and environmental data descriptor for aquatic plants of Minnesota from 1999-2018. *Scientific Data* 13, 650. <https://doi.org/10.1038/s41597-026-07027-3>

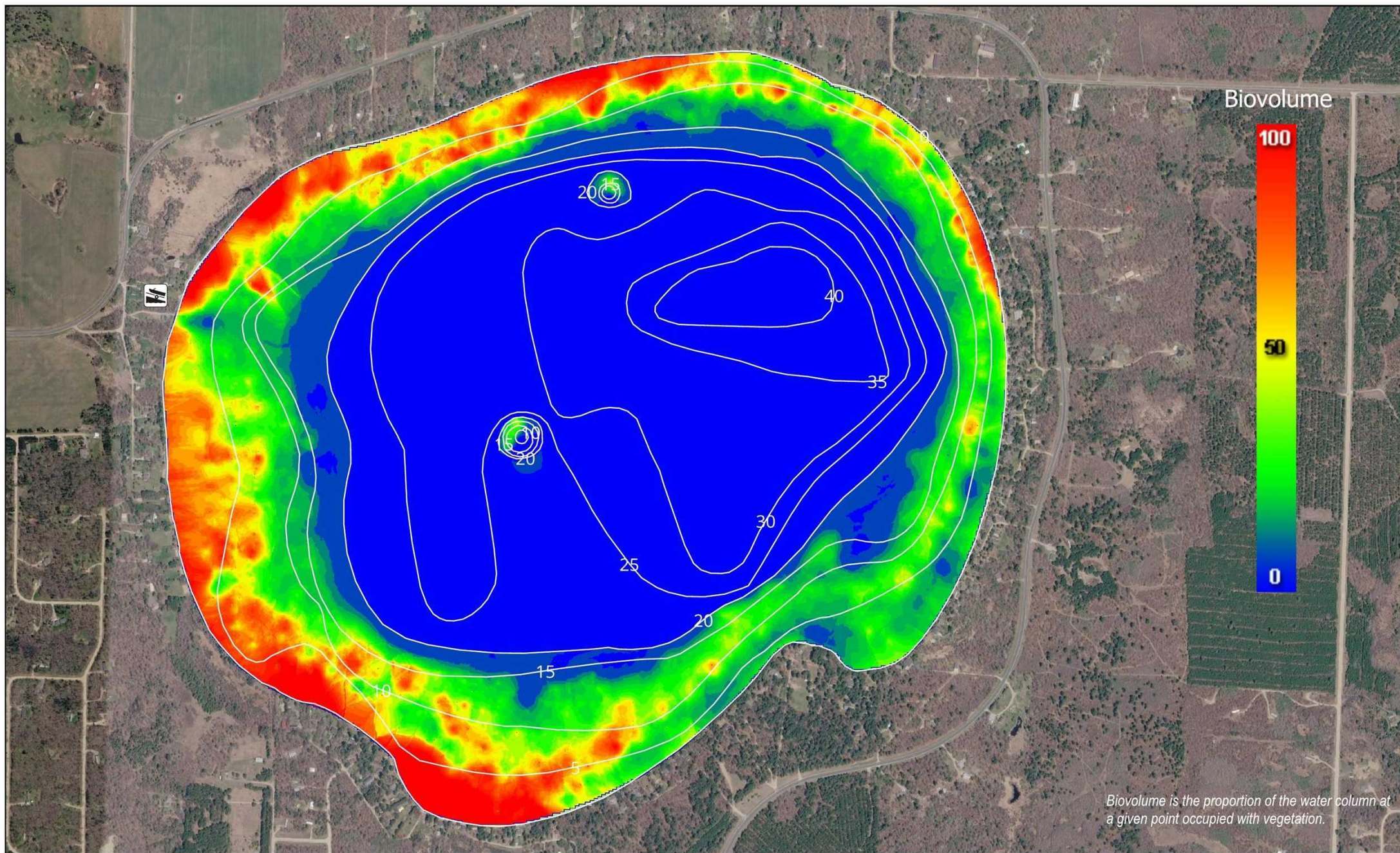
Verhofstad, M.J.J.M., and Bakker, E.S. 2019. Classifying nuisance submerged vegetation depending on ecosystem services. *Limnology* 20, 55-68. <https://doi.org/10.1007/s10201-017-0525-z>

Wang, L., Liu, Q., Hu, C., Liang, R., Qiu, J., and Wang, Y. 2018. Phosphorus release during decomposition of the submerged macrophyte *Potamogeton crispus*. *Limnology* 19, 355-366. <https://doi.org/10.1007/s10201-018-0538-2>

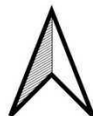
Weaver, M.E., and Newman, R.M. 2026. A multi-index macrophyte-based assessment approach for lakes in the metropolitan region of Minnesota. *Ecological Indicators* 182, 114451. <https://doi.org/10.1016/j.ecolind.2025.114451>

Wingfield, R., Murphy, K.J., and Gaywood, M. 2006. Assessing and predicting the success of *Najas flexilis* in relation to lake environmental conditions. *Hydrobiologia* 570, 79-86. <https://doi.org/10.1007/s10750-0>





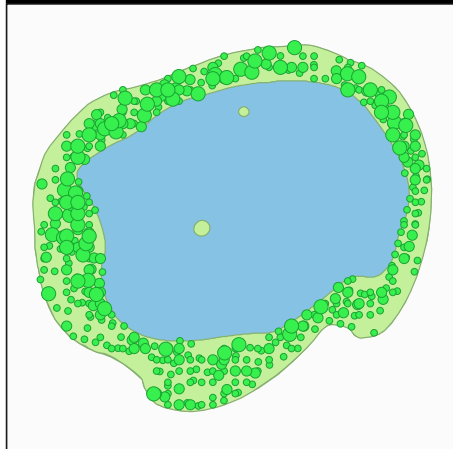
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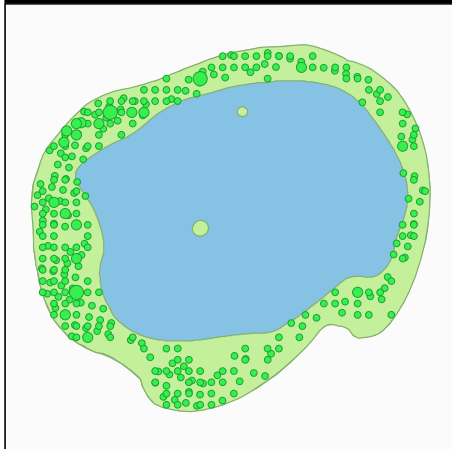
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Summer Biovolume
8/25/2025 - 9/9/2025

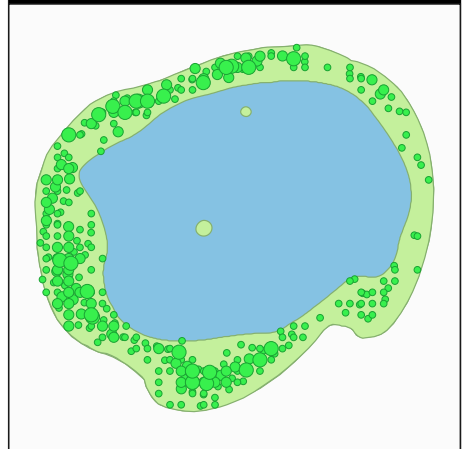
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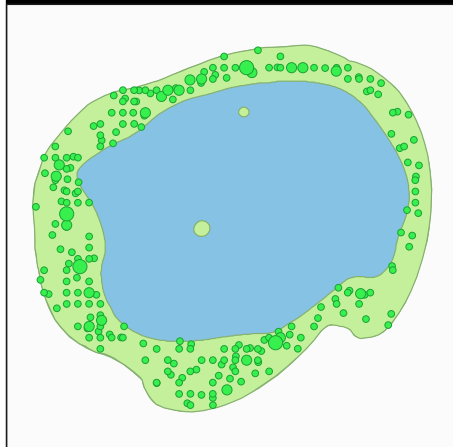
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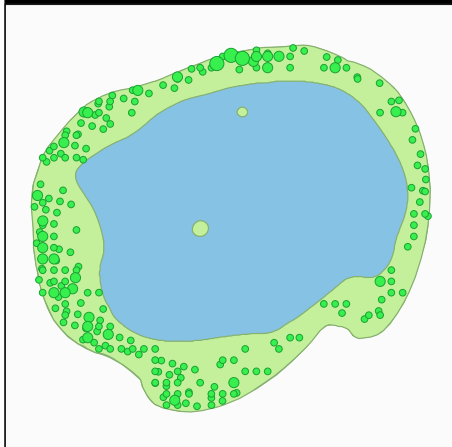
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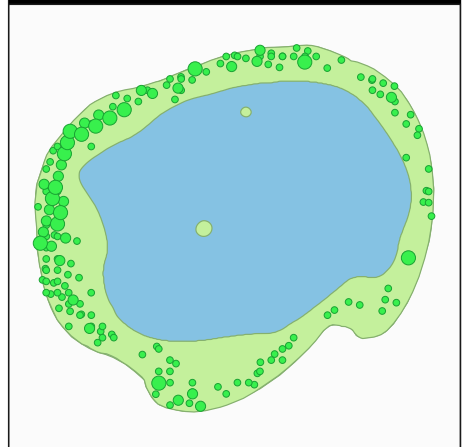
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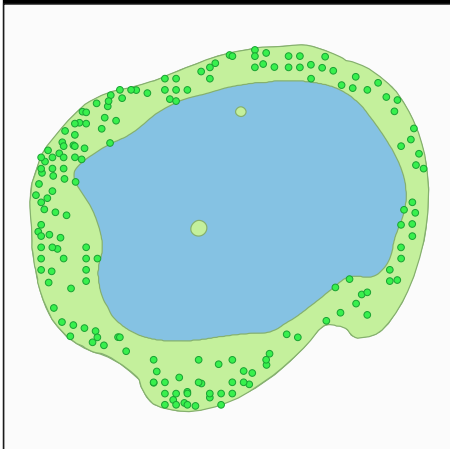
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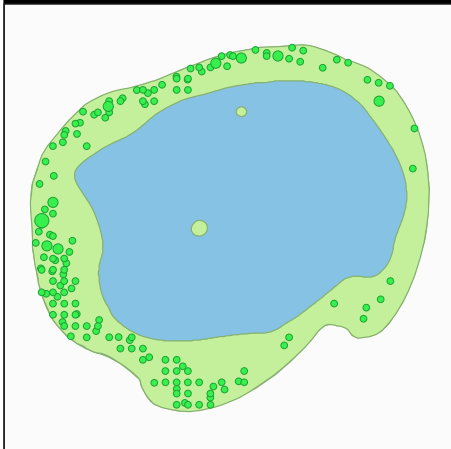
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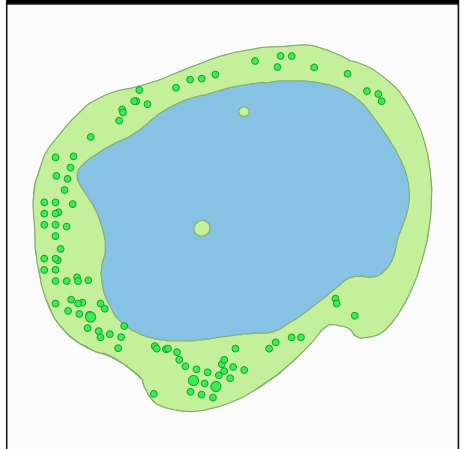
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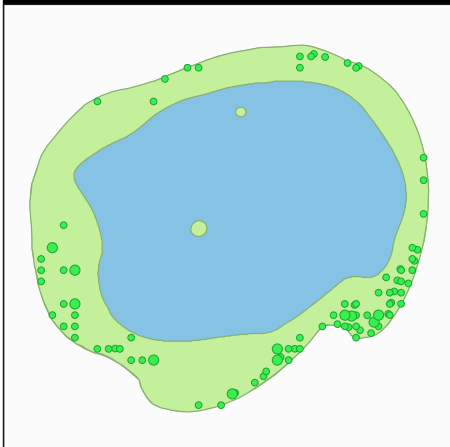
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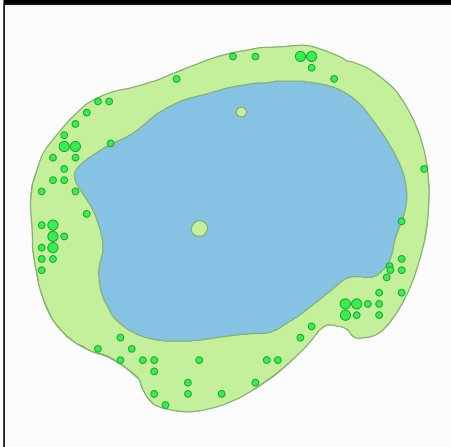
Whitestemmed Pondweed



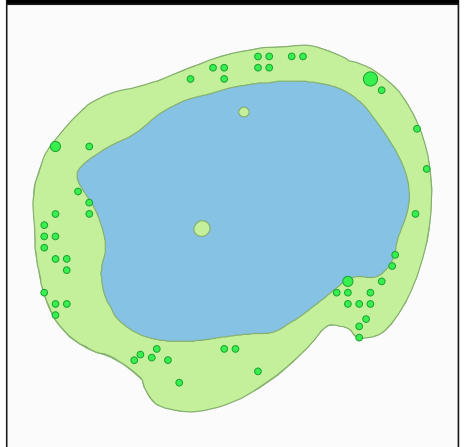
Muskgrass



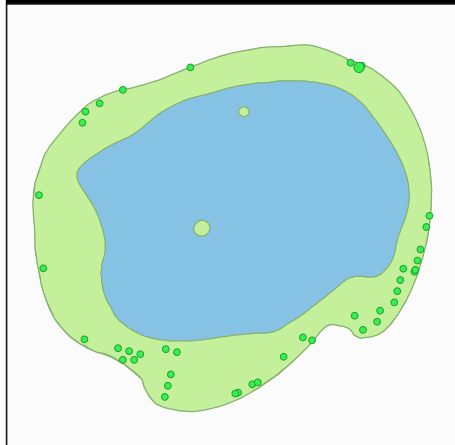
Filamentous Algae



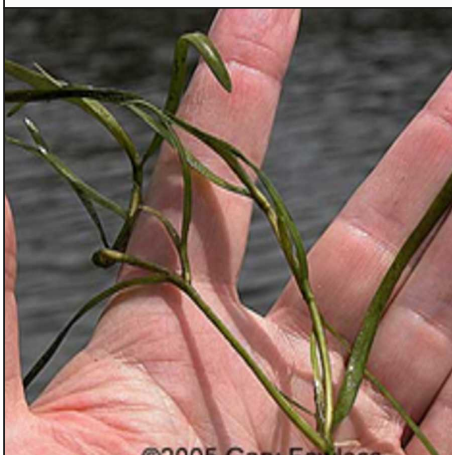
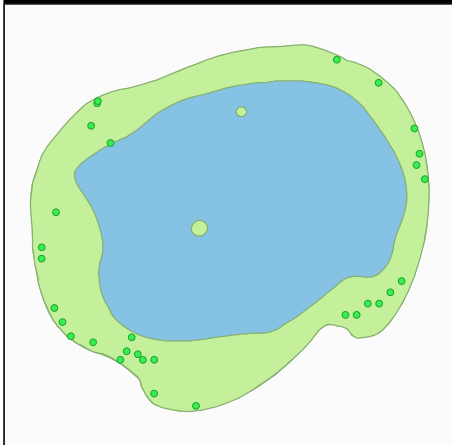
Fries' Pondweed



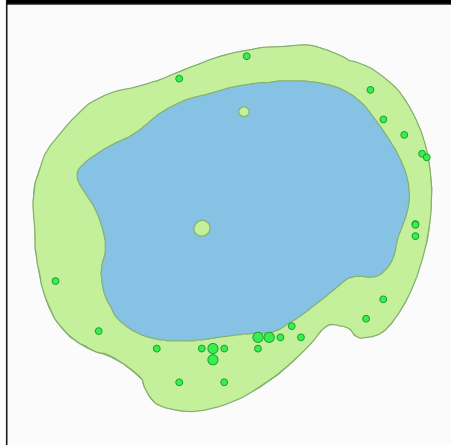
Variable-Leaved Pondweed



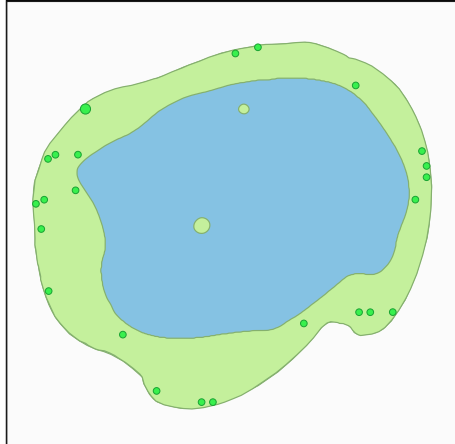
Water Stargrass



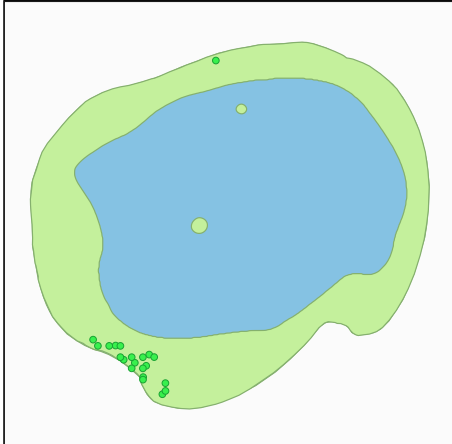
Small Pondweed



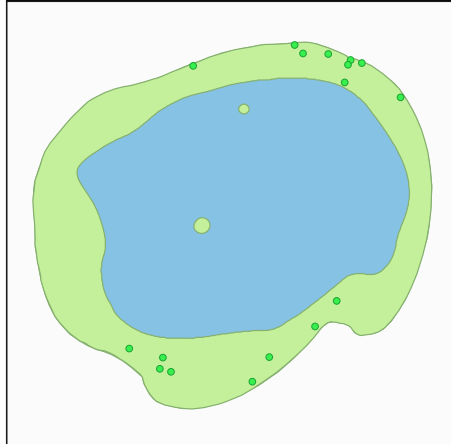
White Waterscrowfoot



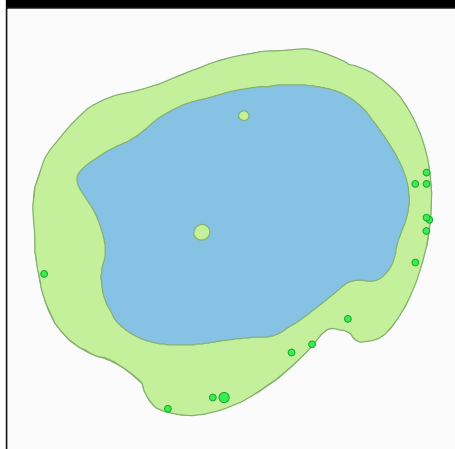
Hard Stem Bulrush



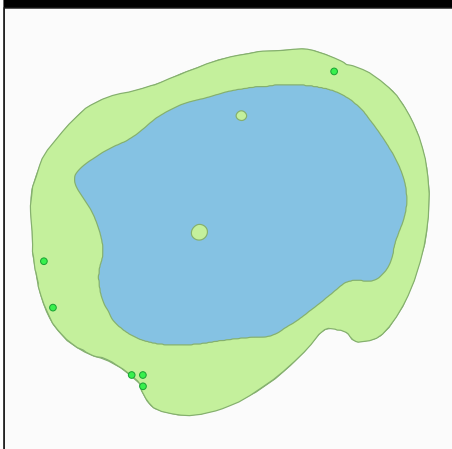
Illinois Pondweed



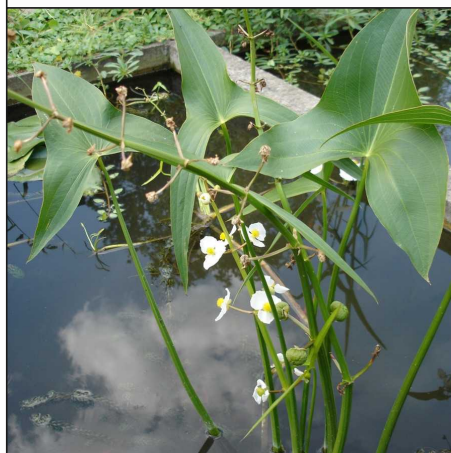
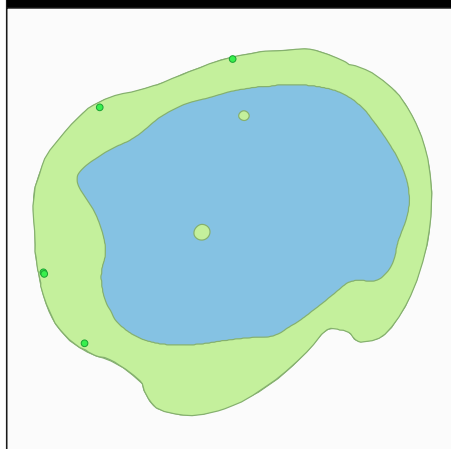
Needle Spikerush



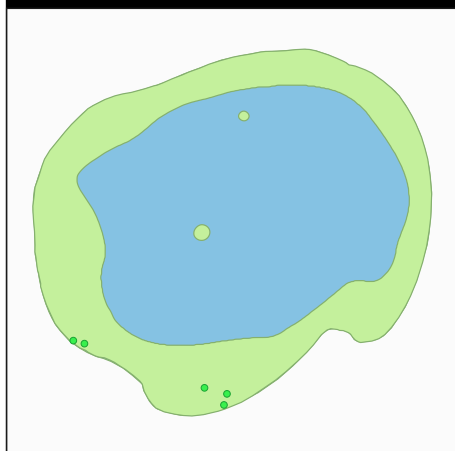
Cattail



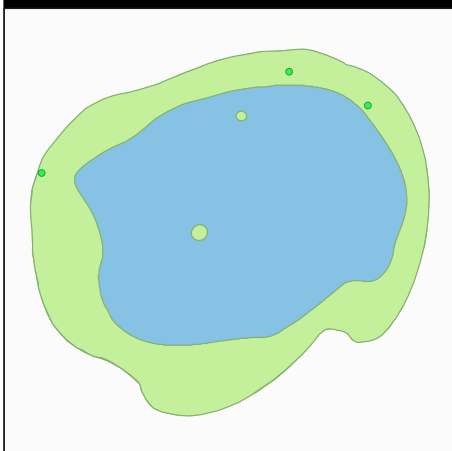
Arrowhead



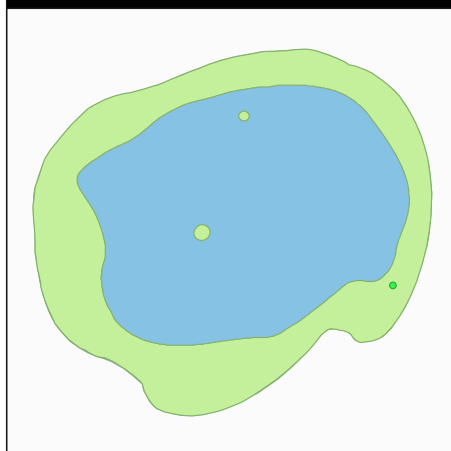
Straight-Leaved Pondweed



Curlyleaf Pondweed



Brown-Fruited Rush



Wild Celery

