Summary of Findings from LakeScan™
Surveys and Analysis of:

Cedar Lake South

Iosco County

2023 DATA AND ANALYSIS SUMMARY REPORT WITH MANAGEMENT RECOMMENDATIONS

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Executive Summary

Kieser & Associates, LLC (K&A) conducted vegetation monitoring on Cedar Lake (Iosco County, MI) during the summer of 2023 using LakeScan™ assessment methods. The purpose of these efforts was to assess aquatic vegetation during the summer recreational season in the context of nuisance conditions and management needs/outcomes. LakeScan™ methods combine detailed field data collection with mapping and whole-lake analyses based on established scientific metrics to score various lake conditions. This approach allows lake managers to readily and consistently identify successful lake management activities, highlight potential issues requiring intervention, and gather critical planning information necessary for improving the lake's ecological and recreational conditions.

The averaged scores from early and late-season LakeScan™ 2023 surveys for the southern portion of Cedar Lake (hereinafter, "Cedar Lake South") are summarized in Table ES - 1.[1] Survey results show that the average scores for each LakeScan™ analysis metric met all management goals in 2023. High Shannon Biodiversity and Morphology Indices indicate the lake supports a diverse plant community harboring good habitat for fish and macroinvertebrates. The high Floristic Quality Index score indicates a higher distribution of desirable, native plant species and a lower distribution of undesirable species, such as Eurasian watermilfoil (*Myriophyllum spicatum x sibiricum*; EWM). Recreational Nuisance Presence also met the management goal of <10%, suggesting that in 2023, few recreational hazards were present in Cedar Lake South. This was particularly relevant to early-season conditions, though late-season observations resulted in additional management efforts for nuisance natives. The Algal Bloom Risk rating for Cedar Lake South is "low" reflecting the very limited proportion of adjacent shorelines that drain to this portion of the lake.

Table ES-1 – Summary of lake analysis metrics.

LakeScan™ Metric	2023 Average	Management Goal
Species Richness	21	n/a
Shannon Biodiversity Index	9.9	> 8.8
Shannon Morphology Index	8.2	> 6.3
Floristic Quality Index	27.1	> 20
Recreational Nuisance Presence	5%	< 10%
Algal Bloom Risk	Low	Low

[1] See LakeScan™ Metrics section for a more detailed explanation of these management indices.

The Cedar Lake South early-season LakeScan™ vegetation survey was conducted on Tuesday, July 11, 2023. The common native species observed during the survey were *Chara* (*Chara sp.)*, Richardson's pondweed (*Potamogeton richardsonii*), broadleaf pondweed (*Potamogeton amplifolius Tuckerman*), naiad (*Najas sp.)*, sago pondweed (*Stuckenia pectinata*), wild celery (*Vallisneria americana Michaux*), and flat stem pondweed (*Potamogeton zosteriformis Fern)*. In addition, emergent plant species, such as white water-lily (Nymphaea odorata) and spadderdock (*Nuphar advena*) were regularly observed nearshore at high densities. Hybrid Eurasian watermilfoil (*Myriophyllum spicatum x sibiricum*; EWM) was the only submerged aquatic invasive species observed during the time of the survey and was found at very light coverages in three AROS (238, 280, and 281).

The late-season LakeScan™ vegetation survey was conducted on August 29, 2023. The most common native species observed throughout the survey included *Chara*, Richardson's pondweed, broadleaf pondweed, naiad, sago pondweed, wild celery and flat stem pondweed. In addition, emergent plant species, such as white water-lily and spadderdock were regularly observed nearshore at high densities. EWM was the only submerged aquatic invasive species observed during the time of the survey and was found at very light to light coverages in four AROS (238 & 280 - 282).

For this report, K&A also analyzed the past 5 years of LakeScan™ data for the average coverage of nuisance species (Figure ES -1). Cedar Lake South's coverage of Eurasian watermilfoil (*Myriophyllum spicatum x sibiricum*; EWM) and starry stonewort (*Nitellopsis obtusa*) have exhibited downward trends over the last five years. In 2023, starry stonewort was not observed during any summer survey. Native variable-leaf watermilfoil (*Myriophyllum heterophyllum*; VWM) coverage also decreased over the last five years, suggesting that the current management regime may be effective at suppressing growth of this invasive species.

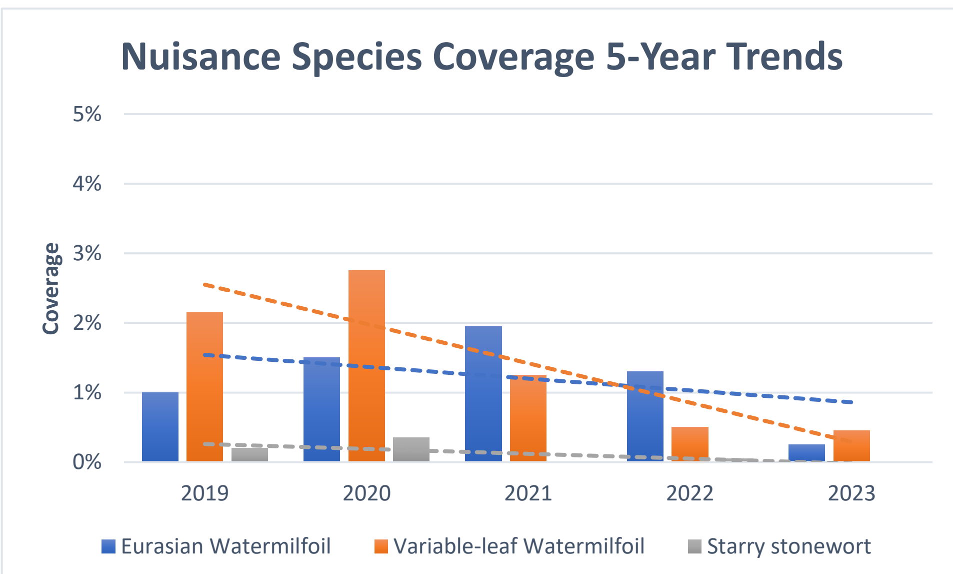

Figure ES-1 – nuisance species average coverage 5-year trends.

Based on 2023 findings, K&A recommends the following management considerations for 2024:

- **Continued Eurasian watermilfoil management.** Eurasian watermilfoil hybrid coverages have trended downward over the last five years with coverage in 2023 being 0.3%. A variety of nuisance mitigation interventions have been used successfully in Cedar Lake for several decades. Thus, the current management interventions appear to be effective at suppressing growth and reducing the cumulative coverage of EWM. Therefore, the Cedar Lake Improvement Board should continue exploring similar management options for treating EWM as necessary in the following years.

Table of Contents

1.0. Introduction

Inland lakes are complex systems, and managing them for both ecological health and recreational enjoyment involves balancing goals that are sometimes at odds with one another. Successful lake management requires a solid understanding of a lake's current ecological and recreational conditions, as well as how those conditions are changing over time. The LakeScan™ program combines a detailed data collection methodology with mapping capabilities and whole-lake analysis metrics backed by scientific literature. This analysis allows lake managers to identify successful lake management activities, as well as highlight potential issues requiring intervention. Appropriately targeted aquatic plant suppression can minimize weedy and nuisance species while allowing beneficial species to flourish at ecologically balanced levels supporting healthy lake conditions. This kind of adaptive management system provides a scientifically sound and consistent methodology to better manage a lake's ecological and recreational conditions.

The LakeScan™ analysis involves collecting data over two vegetation surveys during the critical summer recreational season. These surveys are based on a system where the lake is first divided into biological tiers (Table 1) and then further subdivided into Aquatic Resource Observation Sites (AROS; see Figure 1 for the southern portion of Cedar Lake). For each survey, field personnel record the density, distribution, and position in the water column of each aquatic plant species in each AROS, as well as noting any nuisance conditions. Dissolved oxygen profiles and temperature profiles as well as Secchi depth are additionally recorded. Other water quality sampling can be included with surveys when requested.

Aquatic plant communities change over the course of a year, so the surveys are split into early and late season observations. Early season surveys are scheduled with the goal of taking place within 10 days of early summer treatments to best observe treatment-targeted and non-targeted vegetation. However, this scheduling is subject to weather and times of increased boat activity.

Table 1 – Biological Tier Descriptions.

Tier*	Description
2	Emergent Wetland
3	Near Shore
4	Off Shore
5	Off Shore, Drop-Off
6	Canals
7	Around Islands and Sandbars
9	Off Shore Island Drop-Off

*Tiers 1 and 8 are reserved for future use.

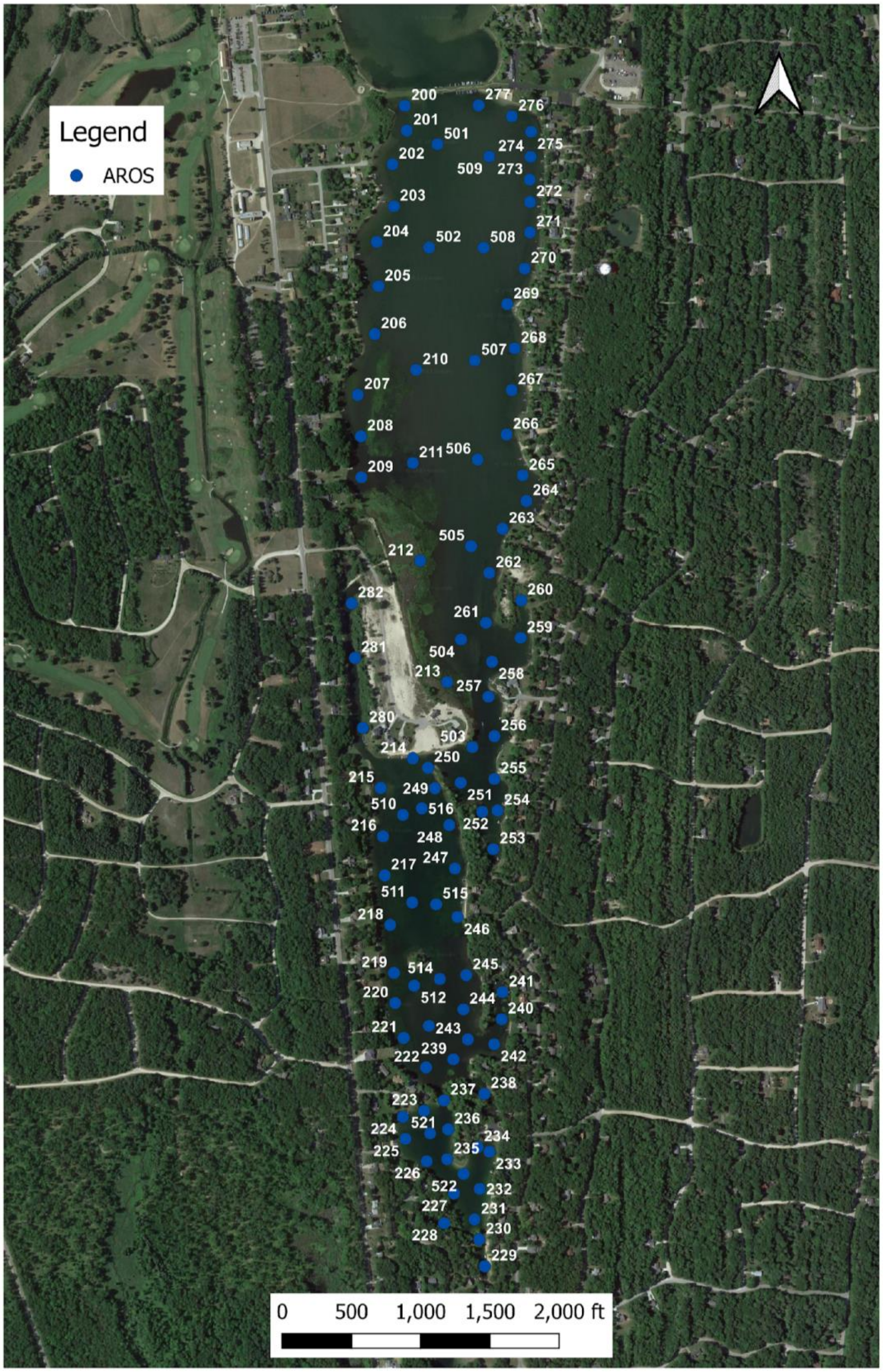

Figure 1 - Map of Aquatic Resource Observation Sites (AROS) for the southern portion of Cedar Lake.

The following sections describe the lake and watershed *Chara*cteristics, field water quality measurements, results of the aquatic vegetation surveys, and aquatic vegetation management activities and recommendations for Cedar Lake South using LakeScan™ methods.

2.0. Lake and Watershed *Chara*cteristics

This section provides a brief overview of physical and geopolitical *Chara*cteristics of the lake and its watershed.

Location

County: Iosco

Township: Oscoda

Township/Range/Section(s): T24N, R9E Sections: 3 & 10

GPS Coordinates: N 44°29.79996' W 83°20.04684

Morphometry

Total Area: 78 acres

Shoreline Length: 20,583 feet

Maximum Depth: 12 feet

Administrative Management

Management Authority: Cedar Lake Improvement Board

Years in LakeScan™ Program: 2003 to Present

2.1. Algal Bloom Risk Level

K&A calculates an algal bloom risk level for each LakeScan™ lake based on the *Chara*cteristics of its watershed. Agricultural and urban land uses contribute more phosphorus to receiving waters than grasslands or forested land uses; phosphorus being the limiting nutrient that drives algal blooms. Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms. Not all algal blooms contain cyanobacteria and their associated toxins (Harmful Algal Blooms or HABs). It is important to note that the risk factors reported here are based on a watershed analysis from the Cedar Lake Watershed Management Plan.[2] For Cedar Lake, there is limited adjacent shoreline runoff, while groundwater flows away from the lake. Therefore, the algal bloom risk for Cedar Lake South is: **Low**

3.0. Water Quality

Secchi depth, dissolved oxygen, and temperature data were collected during the late season vegetation survey (Figure 2). Secchi disk transparency is the depth at which a Secchi disk (a flat white or black and

[2] See: https://img1.wsimg.com/blobby/go/a080ee0a-11db-41bd-8830-a064f9457faa/downloads/final_cedar_lake_wmp_9_15_11.pdf?ver=1704727444770.

white platter, approximately 20 centimeters in diameter) suspended into a lake disappears from the investigator's sight. In general, the greater depth at which the Secchi disk can be viewed, the lower the productivity of the water body. Secchi depth readings of greater than 15 feet can be indicative of low productivity or oligotrophic conditions.[3] Some variation in Secchi disk reporting may be a result of cloud cover, time of day, recent rain events, and recreational lake usage.

A sufficient supply of dissolved oxygen (DO) in lake water is necessary for most forms of desirable aquatic life. Colder waters contain more dissolved oxygen than warmer waters. Oxygen depletion can occur in deeper, unmixed bottom waters during warmer summer months in highly productive lakes. Increased algal growth associated with additional nutrients in the lake can lead to severe decreases in DO in lake bottom waters. This decrease in oxygen is due in part to dead algae and other organic matter, such as leaves, grass and other plant debris washed in from shoreline lawns and storm drains settling to the bottom of the lake. This organic matter is then consumed along with oxygen by organisms in the sediment. DO depletion is most often observed in lake bottom waters during periods of temperature stratification in warmer summer months and, to a lesser degree, under winter ice cover conditions.

Dissolved oxygen levels and temperature were measured at a 12 feet deep portion of the lake near AROS 214. These parameters were measured using a YSI ProSolo dissolved oxygen meter, calibrated prior to use. A DO and temperature profile was only recorded during the late-season survey on August 29, due to equipment limitations in the early-season. During the late-season survey, temperature and DO concentrations were relatively uniform through the water column (Figure 2). The uniform DO and temperature profile is to be expected due to the shallow depths of the lake, and the lack of lake stratification. Both DO and temperature parameters fell within the range of desirable conditions for fish and aquatic life.[4]

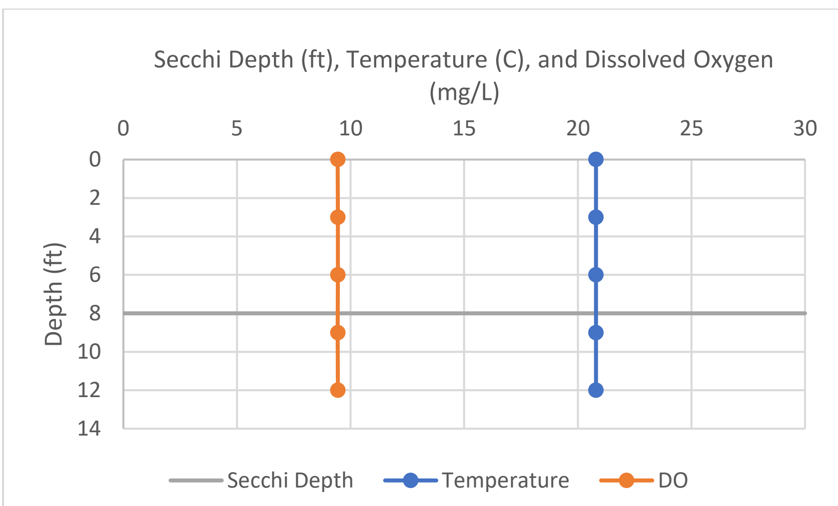

Figure 2 - Late season survey (August 28, 2023) dissolved oxygen and temperature profiles with Secchi depth, taken near AROS 214.

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[3] US Geological Survey. 2012. "Water Quality *Chara*cteristics of Michigan's Inland Lakes, 2001-10." Scientific Investigations Report 2011–5233. Available online at: https://pubs.usgs.gov/sir/2011/5233/.

[4] Michigan Department of Environmental Quality. 2006. "Part 4-Water Quality Standards." Water Bureau, Water Resources Protection. Available online at: https://www.michigan.gov/documents/deq/wrd-rules-part4_521508_7.pdf.

4.0. Aquatic Vegetation

This section details findings from the two vegetation surveys that were conducted on the lake in 2023. This includes observations, aquatic vegetation mapping, and LakeScan™ analysis metrics.

4.1. Early-Season Survey

The Cedar Lake South early-season LakeScan™ vegetation survey was conducted on Tuesday, July 11, 2023. The survey took place 14 days after the scheduled herbicide treatment on Tuesday, June 27, 2023. The weather was overcast with scattered showers and a brief thunderstorm. The temperature was around 70°F with 6 to 10 mph winds out of the north. Overcast skies combined with rain disrupting the surface created challenging visibility conditions throughout most of the survey. Figure 3 depicts data on all combined species using three-dimensional density, which reflects a combination of vegetation density, distribution, and height observations of all species observed on Cedar Lake South during the early-season survey. Color-coding is provided for each AROS to spatially depict observed vegetation data.

Common native species observed throughout the survey included *Chara*, Richardson's pondweed, broadleaf pondweed, naiad, sago pondweed, wild celery, and flat stem pondweed. In addition, emergent plant species such as white water-lily and spadderdock were regularly observed nearshore at high densities which could cause some navigation concerns, especially in the shallow lobes and channels. The dense lilypad island in AROS 209-213 also caused heavy navigation concerns. Similar to the northern portion of the lake, *Chara* and the pondweed species were regularly found throughout most AROS zones with *Chara* being present at the bottom in almost all of this southern portion of Cedar Lake. Hybrid variable-leaf watermilfoil was sparsely scattered throughout five AROS locations, not displaying sufficient densities or nuisance concerns to recommend treatment at the time of the survey (Figure 4).

The only submerged aquatic invasive species observed during the time of the survey was hybrid Eurasian watermilfoil (*Myriophyllum spicatum x sibiricum*; EWM) which was found in scattered patches in AROS 281, 280, and 238 (Figure 5). During the time of the survey, these small patches did not appear dense or continuous enough to warrant treatment.

Starry stonewort (*Nitellopsis obtusa*; SSW) has historically been observed in south Cedar Lake, however, the species was not observed during the early-season survey. It is likely that *Chara* and native pondweed growth in this area had increased since SSW was last observed. Increased native plant growth may be outcompeting and suppressing the growth of starry stonewort. Based on these observations, treatment for starry stonewort in Cedar Lake South was not recommended.

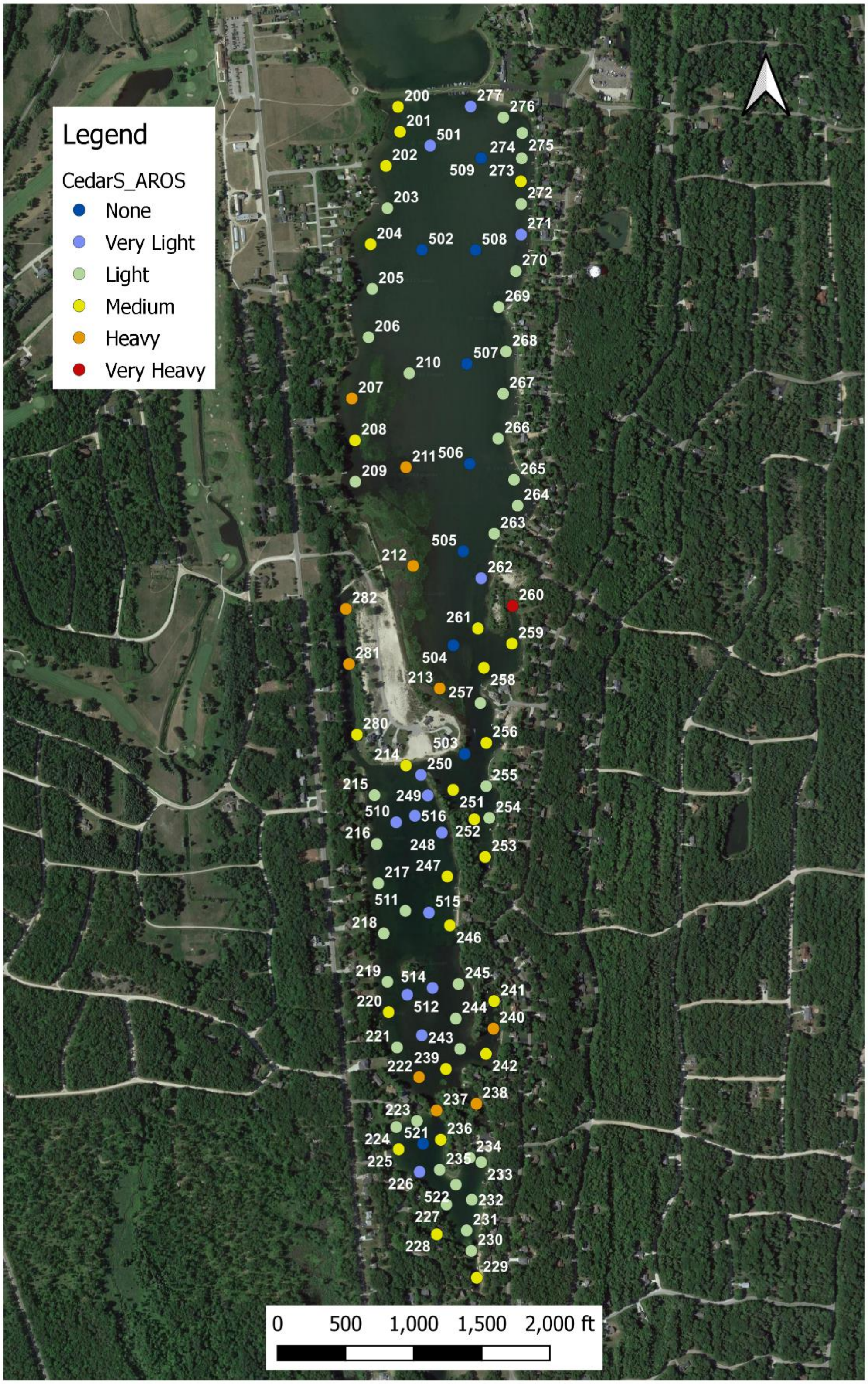

Figure 3 – Early-season survey (July 11, 2023) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

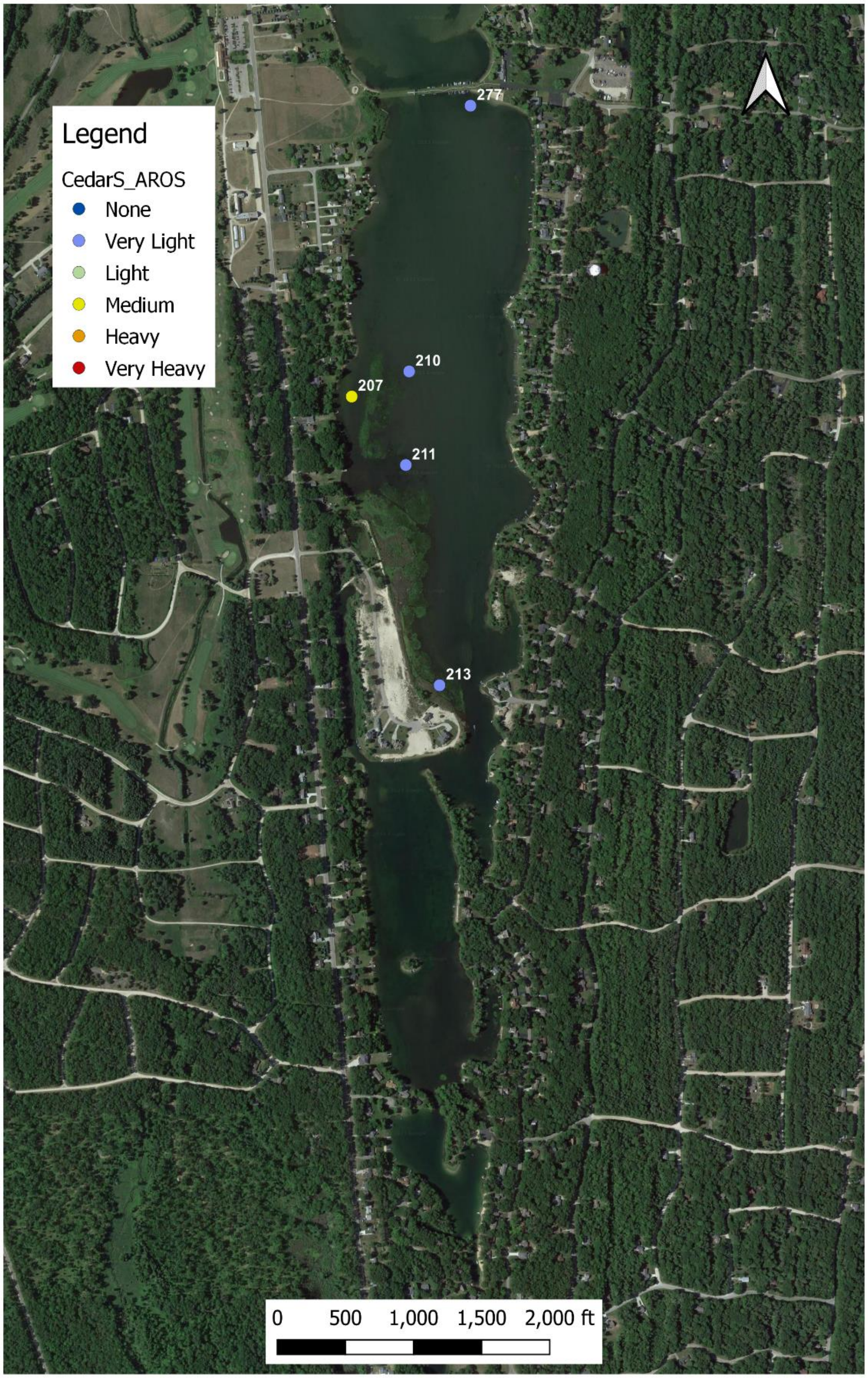

Figure 4 – Early-season (July 11, 2023) Variable-leaf Watermilfoil and hybrids coverage.

Figure 5 – Early-season (July 11, 2023) Eurasian Watermilfoil and Hybrids coverage.

4.2. Late-Season Survey

The Cedar Lake South late-season LakeScan™ vegetation survey was conducted on Tuesday, August 29, 2023. The weather during the survey was overcast with showers throughout the day. Temperatures were around 65°F with 6 to 10 mph winds out of the north. Visibility through the water column was good with a secchi disk reading of 8 ft. Figure 6 depicts data on all combined species using three-dimensional density during the late-season survey.

The most common late-season native species observed throughout Cedar Lake South were *Chara*, Richardson's pondweed, broadleaf pondweed, naiad, sago pondweed, wild celery, and flat stem pondweed. In addition, emergent plant species, such as white water-lily and spadderdock were regularly observed nearshore in high densities which could cause some navigation concerns, especially in the shallow bays/lobes and channels. The lilypad island in AROS zones 209-213 appeared less dense than in the early-season survey, but still caused navigation concerns. *Chara* and the four noted pondweed species were regularly found throughout most AROS with *Chara* being present at the bottom in almost all of the this section of the lake. Broadleaf pondweed was observed flowering in multiple locations around resident's docks and near swimming areas, also causing some recreational nuisance concerns. The coverage and distribution of hybrid variable-leaf watermilfoil remained low throughout the late-season survey, and was only found in three AROS locations (Figure 7).

The only observed submerged aquatic invasive species during the time of the survey was hybrid Eurasian watermilfoil which was found in scattered patches in AROS 280 - 282 and 238 (Figure 8). The distribution of EWM was similar to what was observed during the early-season survey, although it had spread further up the western channel and was in higher coverage in AROS 238. Despite the slightly higher density and distribution of the species in the late-season survey, the relatively consistent distribution of the species throughout both surveys suggests that EWM is not aggressively spreading throughout this southern section of the lake, or growing in dense patches. While EWM coverage was light, the canal where the EWM was located was also noted for potential recreational nuisance concerns caused by the floating leaf pondweed (*Potamogeton natans*) and the other flowering pondweed species. This area was therefore included in a late-season herbicide treatment (Appendix C). The terrestrial invasive species purple loosestrife (*Lythrum salicaria L.*) was found in isolated clusters across 16 AROS in the Late-season survey. The coverage of purple loosestrife mirrors the conditions observed previously in 2020, suggesting that the species is not rapidly spreading across the shoreline from year-to-year.

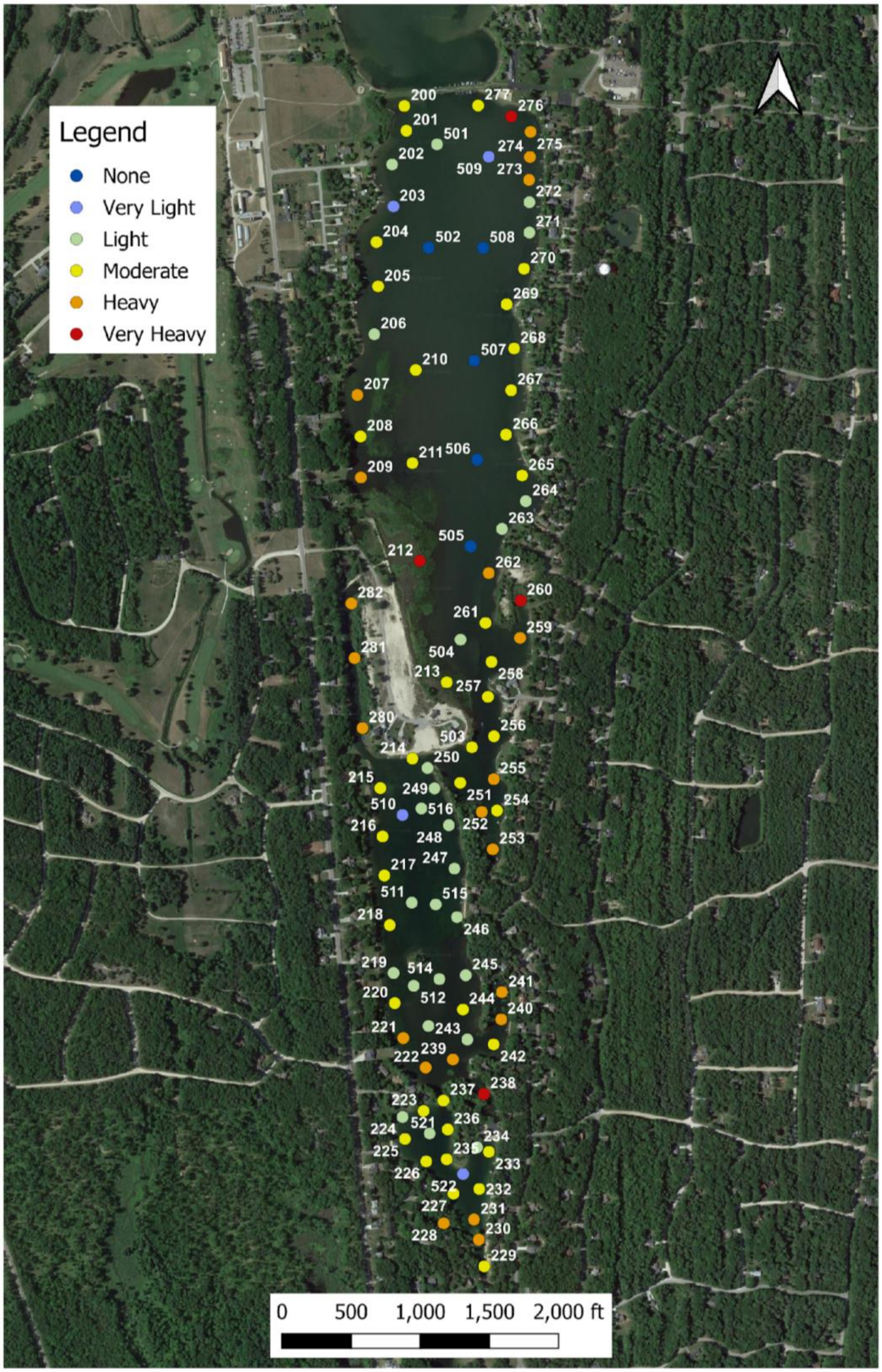

Figure 6 - Late season survey (August 29, 2023) vegetation 3D Density (a function of observed vegetation coverage, and height of all vegetation species).

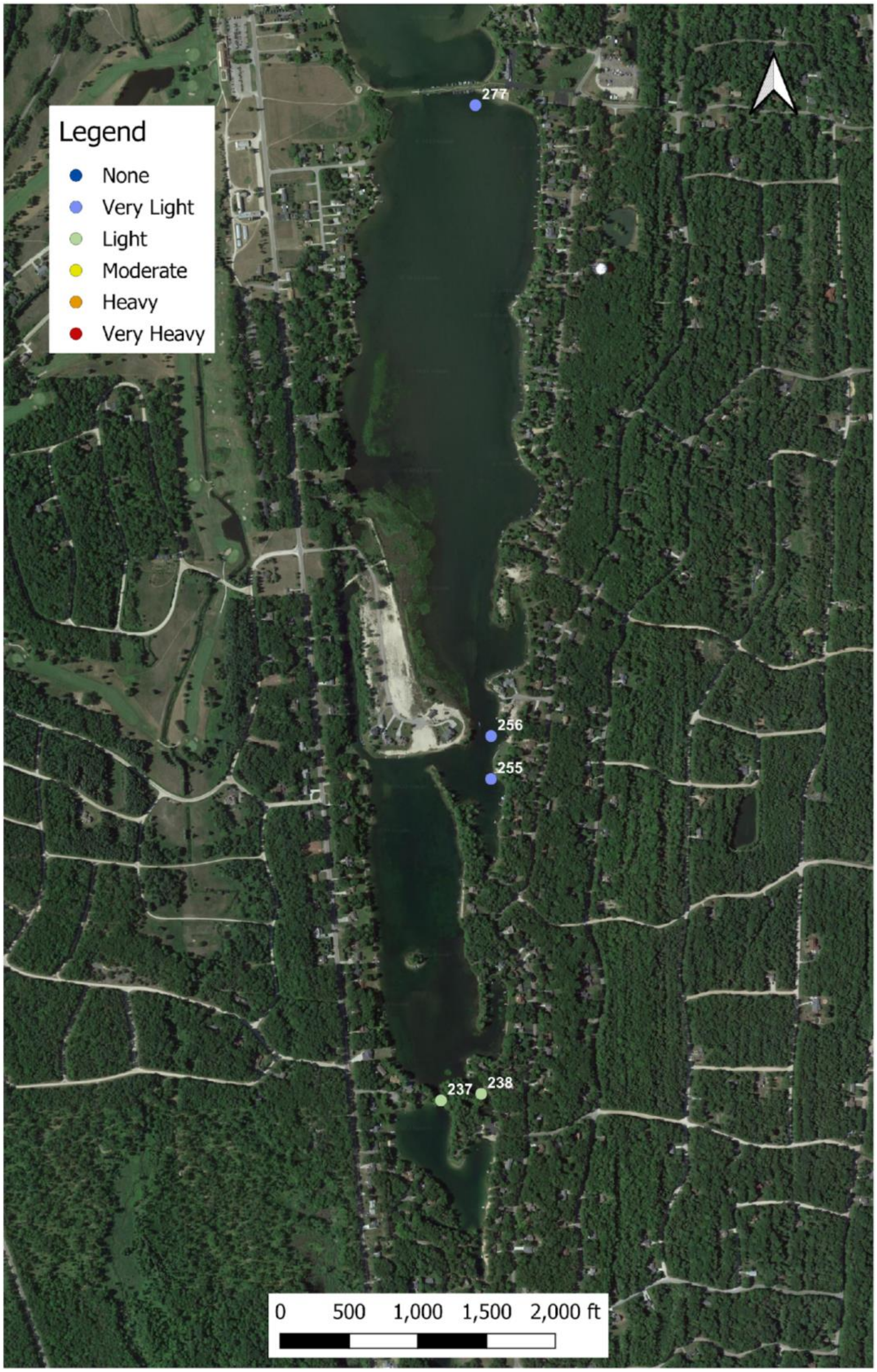

Figure 7 – Late season (August 29, 2023) Variable-leaf Watermilfoil coverage.

Figure 8 - Late season (August 29, 2023) Eurasian Watermilfoil coverage.

4.3. Summary Observations for Early & Late Surveys

Aquatic plant species observed during the 2022 vegetation surveys are identified in Table 2. The 'T Value' in this table is a qualitative value ranging from 1 to 4 that is assigned to each species, where 1 represents an undesirable species highly likely to require treatment and 4 represents a desirable species highly unlikely to require treatment (thus, 1 is 'bad'; 4 is 'good'). 'Frequency' represents the percentage of survey sites (AROS) where a given species was found. 'Coverage' represents the lake bottom spatial cover observed for each species, represented as a percentage of available area. 'Dominance' represents the degree to which a species is more numerous than its competitors. Figure 9 illustrates dominance by T Value categories for early and late-season surveys over the last few years in Cedar Lake South.

Table 2- Aquatic Plant Species Observed in 2023.

Common Name	T Value	Frequency		Coverage		Dominance	
		Early '23	Late '23	Early '23	Late '23	Early '23	Late '23
Eurasian Watermilfoil Hybrid	1	3.0%	4.0%	0.2%	0.3%	0.4%	0.5%
Green/Variable Watermilfoil	2	5.1%	5.1%	0.5%	0.4%	1.1%	0.7%
Common Bladderwort	3	9.1%	0.0%	0.6%	0.0%	1.3%	0.0%
Coontail	3	0.0%	1.0%	0.0%	0.1%	0.0%	0.2%
Elodea	3	2.0%	4.0%	0.1%	0.3%	0.3%	0.4%
Naiad	2	29.3%	41.4%	4.5%	6.3%	9.5%	10.0%
Chara	4	86.9%	80.8%	16.5%	14.1%	34.9%	22.4%
Curly Leaf Pondweed	1	0.0%	1.0%	0.0%	0.1%	0.0%	0.2%
Flat Stem Pondweed	3	11.1%	10.1%	1.0%	1.5%	2.1%	2.4%
Water Star Grass	2	3.0%	0.0%	0.3%	0.0%	0.5%	0.0%
Purple Loosestrife	1	0.0%	17.2%	0.0%	1.1%	0.0%	1.7%
Swamp Loosestrife	4	0.0%	13.1%	0.0%	0.8%	0.0%	1.3%
Clasping Leaved Pondweed	3	17.2%	0.0%	1.4%	0.0%	2.9%	0.0%
Richardson's Pondweed	2	0.0%	47.5%	0.0%	5.7%	0.0%	9.0%
Variable Pondweed	2	0.0%	1.0%	0.0%	0.1%	0.0%	0.1%
Broadleaf Pondweed	3	27.3%	71.7%	2.7%	8.1%	5.7%	12.9%
Hybrid Pondweed	2	60.6%	0.0%	5.5%	0.0%	11.6%	0.0%
Sago Pondweed	2	19.2%	24.2%	2.6%	2.6%	5.5%	4.1%
Thin Leaf Pondweed	4	0.0%	4.0%	0.0%	0.5%	0.0%	0.8%
Horned Pondweed	3	2.0%	0.0%	0.1%	0.0%	0.3%	0.0%
Wild Celery	2	12.1%	26.3%	1.1%	3.3%	2.3%	5.2%
Rush	4	0.0%	49.5%	0.0%	3.7%	0.0%	5.9%
Waterlily	2	63.6%	71.7%	8.6%	9.2%	18.2%	14.6%
Spadderdock	2	5.1%	12.1%	0.6%	1.3%	1.2%	2.0%
Water Shield	3	4.0%	1.0%	0.5%	0.1%	1.1%	0.2%
Floating Leaf Pondweed	3	4.0%	6.1%	0.6%	0.6%	1.2%	0.9%
Smartweed	3	0.0%	3.0%	0.0%	0.2%	0.0%	0.3%
Arrow Arum	3	0.0%	4.0%	0.0%	0.5%	0.00%	0.8%
Cattail	3	0.0%	27.3%	0.0%	2.0%	0.00%	3.2%

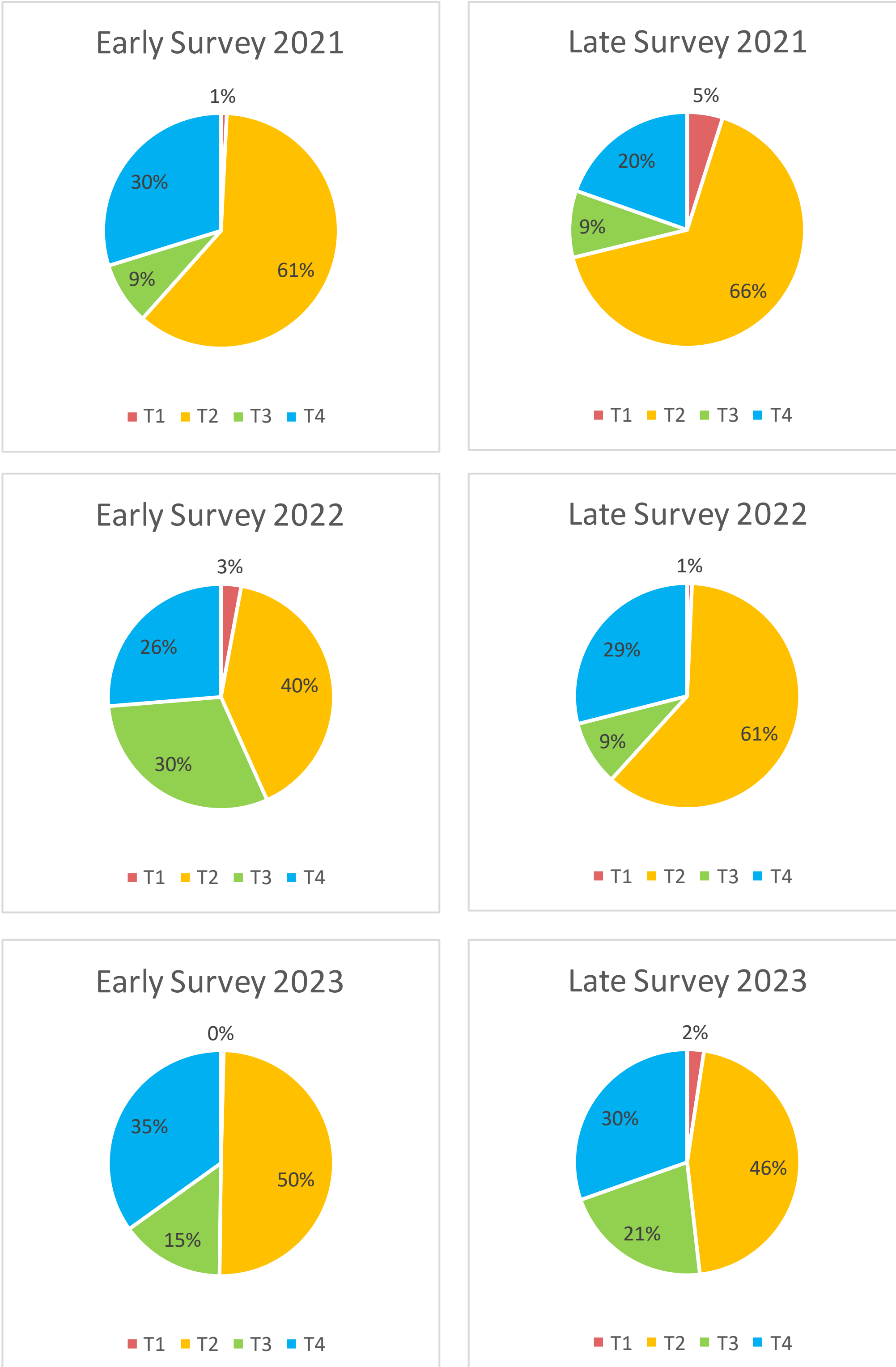

Figure 9 - Distribution of aquatic plant coverage by T Value comparing early-season and late-season surveys from 2021 – 2023.

4.4. LakeScan™ Metrics

Six important metrics for defining lake conditions are presented here for the 2023 vegetation surveys (Table 3). Early and late-season scores are averaged for a yearly score and compared against a management goal for each metric. Management goals are based on median Michigan lake values (Shannon Biodiversity Index and Shannon Morphology Index), scientific literature (Floristic Quality Index), and professional judgment (Recreational Nuisance Presence and Algal Bloom Risk). Green shading in Table 3 highlights scores meeting management goals, while yellow highlights represent scores needing improvement. A total lake score[5] is presented with 1 being poor and 10 being excellent. Descriptions of each metric are as follows:

- **Species Richness** – the number of aquatic plant species present in the lake. (More species are generally indicative of a healthier ecosystem, but not all species are desirable).
- **Shannon Biodiversity Index** – a measure of aquatic plant species diversity and distribution evenness, indicative of the plant community's stability and diversity. (Also known as the Shannon Expected Number of Species).[6]
- **Shannon Morphology Index** – a measure of aquatic plant morphology type diversity and distribution evenness, indicative of fish and macroinvertebrate habitat quality. (This is calculated using morphology types instead of species).
- **Floristic Quality Index[7]** – a measure of the distribution of desirable aquatic plants. This index is used by Midwestern states for aquatic habitats, with higher scores indicative of increased biodiversity and a positive ratio of desirable versus undesirable aquatic plant species.
- **Recreational Nuisance Presence** – the percentage of survey sites that identified aquatic plants inhibiting recreational activities. (Areas where any vegetation is growing densely enough to inhibit boating and/or swimming).
- **Algal Bloom Risk** – a calculated algal bloom risk level based on the *Chara*cteristics of the lake's watershed. Lakes with watersheds that have high proportions of land in agricultural and urban land uses are more likely to be at risk of algal blooms because these land uses contribute more phosphorus to receiving waters than grasslands or forests.

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[5] A total lake score is a summary of the category scores where: "red" scores receive 0 points, "yellow" scores receive 1 point, and "green" scores receive 2 points. The Floristic Quality Index is double-weighted, and the total is then refit to a 1 to 10 scale for more simplified scaling and interpretation of the overall lake condition.

[6] Hill, M. O. (1973). Diversity and evenness: a unifying notation and its consequences. *Ecology*, 54(2), 427-432.

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

Table 3 – 2022 LakeScan™ Metric Results.

LakeScan Metric	Score Range	2023 Early Season	2023 Late Season	2023 Average	Management Goal
Species Richness	5 - 30	18	24	21	n/a
Shannon Biodiversity Index	1 -15	8.1	11.6	9.9	> 8.8
Shannon Morphology Index	1 - 10	7.1	9.2	8.2	> 6.3
Floristic Quality Index	1 - 40	25.6	28.6	27.1	> 20
Recreational Nuisance Presence	0 - 100%	0%	10%	5%	< 10%
Algal Bloom Risk	Low - High	n/a	n/a	Low	Low
Total Lake Score	1 - 10	n/a	n/a	10.0	n/a

*n/a = not applicable

Cedar Lake South average metric scores met all the management goals in 2023. The scores were similar between both surveys, although the early-season survey had consistently lower scores than the late-season. The high Shannon morphology and biodiversity scores across both surveys indicate a diverse plant community contributing to desirable habitat for fish and macroinvertebrates. The late-season increases in Shannon Biodiversity and Shannon Morphology scores reflect the higher number of species observed and the variation in plant growth commonly noted in the late season. The consistently high Floristic Quality Index on Cedar Lake South indicates a high distribution of native plant species and a low distribution of undesirable species, such as Eurasian watermilfoil.

Recreational Nuisance Presence met optimal management goals of less than 10% during both the early and late-season surveys. The spike in nuisance conditions in the late-season survey can likely be attributed to the presence of floating-leaf pondweed, Richardson's pondweed, and broadleaf pondweed flowering at the surface which were not as abundant in the early season survey. While the flowering species caused aesthetic and recreational concerns, flowering is a natural stage in the late lifecycle of many native pondweeds, therefore nuisance conditions are typically more common in the late-season. The Algal Bloom Risk rating for Cedar Lake South is "low" reflecting the limited proportion of surrounding shoreline lands that drain to the lake. The overall total lake score for Cedar Lake South is 10 out of 10.

The 5-year historical trends for Floristic Quality Index (FQI) scores and the average nuisance species coverage values are presented in (Figures 10 and 11), respectively. Trendlines shown are calculated using Microsoft Excel's linear trendline function. Positive trends for the FQI scores indicate increases in desirable plant species and/or decreases in undesirable plant species. Negative trends for the nuisance species coverage values suggest herbicide treatment and other lake management activities are showing success.

Over the last five years, the FQI score for Cedar Lake South has exhibited a linear trend, which indicates an equilibrium between desirable, native plant species and undesirable, non-native plant species (Figure 10). For the last five years, Cedar Lake South's FQI score has exceeded the management goal of 20. Furthermore, Cedar Lake South's average invasive species coverage of Eurasian watermilfoil and starry stonewort have exhibited a decreasing 5-year trend, with no starry stonewort observed during the 2023 surveys. These observations suggest management activities are likely contributing to reducing invasive species populations and suppressing population expansion. Additionally, the average coverage of the native species, variable-leaf watermilfoil, has decreased over the last five years (Figure 11), suggesting that management activities have contributed to the suppressed growth of the species. Prior to 2020, variable-leaf watermilfoil coverage was increasing year-over-year, prompting treatment during September of 2020 to relieve nuisance conditions. Since treatment, variable-leaf watermilfoil coverage has consistently been the lowest observed over the last five years. These observations suggest that management actions targeting variable-leaf watermilfoil have successfully contributed to the reduced growth of the species over multiple years.

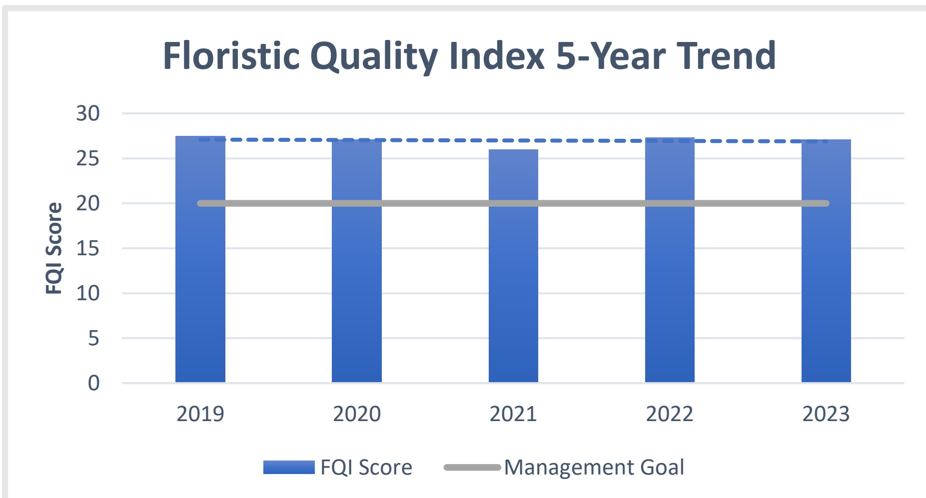

Figure 10 – Floristic Quality Index 5-Year Trend.

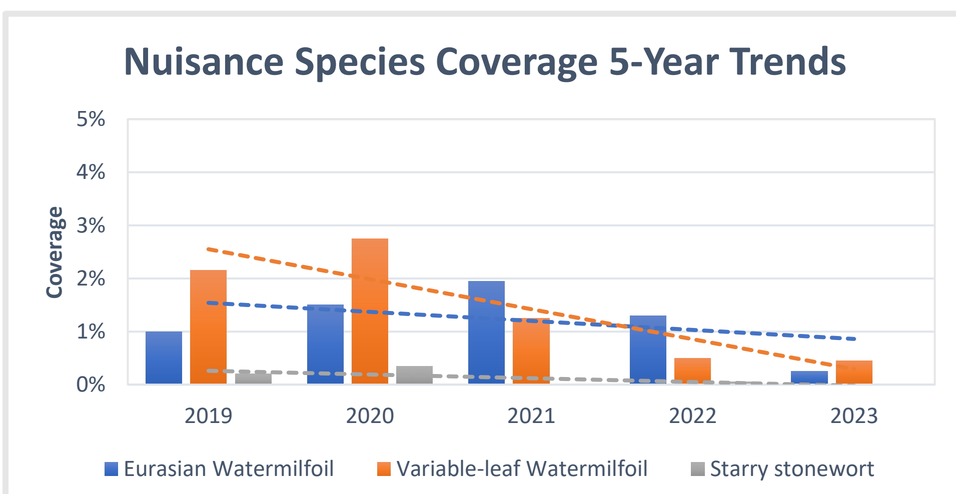

Figure 11 – Nuisance species average coverage 5-year trends.

5.0. Lake Management

There are several species that typically become a nuisance in Michigan's inland lakes (Appendix B). These species are usually targeted for very selective control to prevent them from becoming an aesthetic or recreational nuisance and to protect desirable plants that are part of healthy lake ecosystems. This section includes an analysis of nuisance conditions in the lake, as well as a description of any management actions that were taken in 2023. Figure 12 shows the coverage changes of targeted species over both surveys. Copies of the herbicide applicator treatment maps are included in Appendix C.

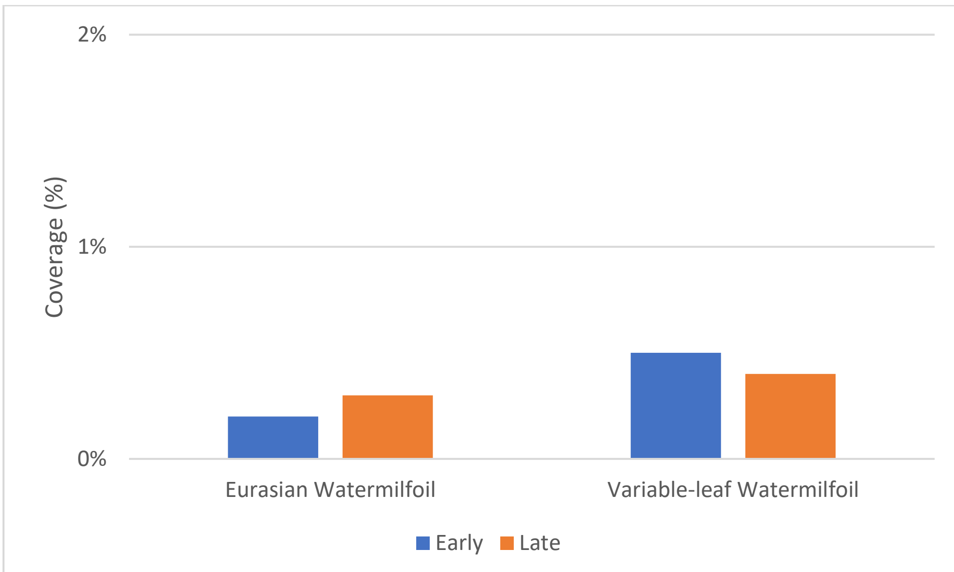

Figure 12 – Changes in coverage across both surveys for targeted species.

Variable-leaf watermilfoil and native pondweeds have been some of the most dominant species observed on Cedar Lake South. Eurasian watermilfoil, variable-leaf watermilfoil, elodea, wild celery, Richardson's pondweed, and other native pondweeds commonly grow to nuisance levels in the shallow lobes/bays, around resident's docks, and in swimming areas causing nuisance concerns.

On September 18, 2023, 1.48 acres of Cedar Lake South was treated by SOLitude Lake Management, targeting lilypads, and other plants causing nuisance conditions. The goal of the treatment was to alleviate the shallow bays of the lake from the nuisance conditions observed in the late-season survey.

Despite the lack of an early summer treatment in Cedar Lake South, the coverage of variable-leaf watermilfoil still declined between the early to the lake-season surveys; EWM increased only slightly. Average coverage for both remained below 1%. These trends are indicative of treatment efficacy and expected ecological responses in Cedar Lake South.

Despite the coverage declines, it remains important to monitor the growth of variable-leaf watermilfoil since the species has been known to cause nuisance conditions in Cedar Lake South. In the future it might be necessary to submit permit amendments to allow for selective treatment of variable-leaf watermilfoil (considered a native species in Michigan); however, there is no assurance that these efforts will be successful as treatment restrictions tighten.

Low to no coverage of starry stonewort, Eurasian watermilfoil, and variable-leaf watermilfoil in 2023 combined with their decrease in coverage over the last five years suggest that previous lake management activities have successfully contributed to suppressing the growth and expansion of target species.

5.1. Future Management Recommendations

LakeScan™ vegetation monitoring will continue with two surveys per growing season under the current K&A contract (once during the spring-early summer and another during the late summer). Information collected during these surveys allows lake managers to readily and consistently identify successful lake management activities, highlight potential issues requiring intervention, and gather critical information necessary to improve the lake's ecological and recreational conditions.

Continued Eurasian watermilfoil management is recommended. Eurasian watermilfoil's 5-year trend shows coverage in Cedar Lake South has decreased, suggesting that current management activities are likely suppressing the growth and expansion of Eurasian watermilfoil. Pre-season observations in May of 2024 will dictate whether some chemical applications may be warranted in 2024.

6.0. Appendices

Appendix A: Blue-green Algae

Blue-green algal blooms are becoming increasingly common in Michigan. Blooms can appear as though green latex paint has been spilled on the water, or resemble an oil slick in enclosed bays or along leeward shores. Blue-green algal blooms are usually temporal events and may disappear as rapidly as they appear. Such blooms have become more common for a variety of potential reasons; however, the spread and impact of zebra mussels has been closely associated with blooms of blue-green algae.

Figure A1: Example blue-green algae images from the 2019 LakeScan™ field crew.

Blue-green algae are really a form of bacteria known as cyanobacteria. They are becoming an important issue for lake managers, riparian property owners and lake users because studies have revealed that substances made and released into the water by some of these nuisance algae can be toxic. They are known to have negative impacts on aquatic ecosystems and can potentially poison and sicken pets, livestock, and wildlife. Blue-green algae can have both direct and indirect negative impacts on fisheries. Persons can be exposed to the phytotoxins by ingestion or dermal absorption (through the skin). They can also be exposed to toxins by inhalation of aerosols created by overhead irrigation, strong winds, and boating activity.

Approximately one-half of blue-green algae blooms contain phytotoxins, and this is determined through lab testing. It is recommended that persons not swim in waters where blue-green algal blooms are conspicuously present. Specifically, persons should avoid contact with water where blooms appear as though green latex paint has been spilled on the water, or where the water in enclosed bays appears to be covered by an "oil slick". Pets should be prevented from drinking from tainted water. Since blue-green algal toxins can enter the human body through the lungs as aerosols, it is suggested that water containing obvious blue-green algae blooms not be used for irrigation in areas where persons may be exposed to it.

Blue-green algae typically bloom and become a nuisance when resources are limiting to other plant and algae or when biotic conditions reach certain extremes, particularly warm water conditions. Some of the reasons that blue-green algae can bloom and become noxious are listed below:

TP and TN: The total phosphorus (TP) concentration in a water resource is usually positively correlated with the production of suspended algae (but not rooted plants). Very small amounts of phosphorus may result in large algal blooms. If the ratio of total nitrogen (TN) to total phosphorus is low (<20), suspended algae production may become nitrogen limited and noxious blue-green algae may dominate a system because they are able to “fix” their own nitrogen from atmospheric sources. Other common and desirable algae are not able to do this.

Biotic Factors: Zebra mussels and zooplankton (microscopic, free-floating animals) are filter feeding organisms that strain algae and other substances out of the lake water for food. Studies have shown that filter-feeding organisms often reject cyanobacteria and feed selectively on other more desirable algae. Over time, and given enough filter feeding organisms, a lake will experience a net loss in “good” algae and a gain in “bad” blue-green algae as the “good” algae are consumed and the “bad” algae are rejected back into the water column. This is one of the most disturbing factors associated with the invasion and proliferation of zebra mussel.

Management: Treatment methods for blue-green algae are generally preventative rather than reactionary. One of the most common forms of algae treatment is limiting nutrients, namely phosphorus, from entering the lake ecosystem through several sources. Phosphorus mainly enters lake systems through surface water inputs such as rivers, creeks, or overland runoff. In some inland lakes that experience late-summer stratification, sediment-bound phosphorus at the lake bottom becomes mobilized due to low-oxygen conditions which, under high sustained wind conditions, can mix surface and bottom waters. This is particularly problematic in the late summer. Phosphorus-reducing practices include: implementing Best Management Practices (BMPs) in upstream agricultural and urban areas, limiting nutrient (fertilizer) applications on lawns, planting vegetative buffer strips between nutrient-producing areas and surface water, reducing septic system leaching (if riparian homes are not sewered), binding lake-bottom phosphorus using alum or other adsorbent materials (e.g., Phoslock®), and treating/infiltrating stormwater prior discharge into upstream surface waters of the lake.

Research has shown that water circulation devices such as bubblers or aeration systems may limit the viability of blue-green algae over native algae species.[8] Blue-green algae are more buoyant than native algae species and often float to the water’s surface during quiescent conditions to increase the amount of sunlight needed for photosynthesis. Circulation systems disturb the water column and eliminate this evolutionary advantage portrayed by blue-green algae. The intended result is a shift from a blue-green algae dominated community to a mix of green algae species. When nuisance conditions occur, contact algaecides or hydrogen peroxide may be used as a reactionary treatment to destroy algae cells present in the water column. However, chemicals should be applied with caution due to concerns of bioaccumulation and toxicity to other forms of aquatic life. Moreover, chemical applications will often need to ‘chase’ blooms that can be pushed to different areas of the lake with prevailing winds.

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[8] Pastorok, R., T. Ginn, AND M. Lorenzen. Evaluation of Aeration/Circulation as a Lake Restoration Technique. U.S. Environmental Protection Agency, Washington, D.C., EPA/600/3-81/014 (NTIS PB81191884), 1981.

Appendix B: Common Aquatic Invasive Species

Eurasian Watermilfoil and Hybrids:

Background: Anecdotal evidence suggests that hybrid milfoil has been found in Michigan inland lakes for a long time (since the late 1980's). University of Connecticut professor Dr. Don Les was the first to determine that there were indeed, Eurasian watermilfoil and northern watermilfoil hybrids in Michigan based on samples sent to his Connecticut lab by Dr. Douglas Pullman, Aquest Corp. in 2003. Experience has proven that it is usually not possible to determine whether the milfoil observed is either Eurasian or hybrid genotype. However, because they play such similar roles in lake ecology, they are simply "lumped together" and referred to collectively as Eurasian watermilfoil hybrids. Eurasian watermilfoil hybrids are a very common nuisance in many Michigan inland lakes.

Management: Lake disturbance, such as weed control, unusual weather, and heavy lake use can destabilize the lake ecosystem and encourage the sudden nuisance bloom of weeds, like Eurasian watermilfoil. Eurasian watermilfoil is an ever-present threat to the stable biological diversity of the lake ecosystem. Species selective, systemic herbicide combinations have been used to suppress the nuisance production of Eurasian watermilfoil and support the production of a more desirable flora. However, it is becoming much more resistant to herbicidal treatments. Herbicide resistant Eurasian watermilfoil and hybrid watermilfoil have been observed in many lakes throughout the Midwest.[9,10] Continued chemical applications can select for herbicide resistant plants, resulting in hybrid watermilfoil.[11] Some research suggests this resistance can be defeated with the use of microbiological system treatments. Eurasian watermilfoil community genetics are dynamic and careful monitoring is needed to adapt to the expected changes in the dominance of distinct Eurasian watermilfoil genotypes. Some of these genotypes may be more herbicide resistant than others and treatment strategies must be adjusted to remain effective in different parts of the lake.



[9] Berger, S. T., Netherland, M. D., & MacDonald, G. E. (2015). Laboratory documentation of multiple-herbicide tolerance to fluridone, norflurazon, and topramazone in a hybrid watermilfoil (*Myriophyllum spicatum× M. sibiricum)* population. Weed Science, 63(1), 235-241.

[10] Netherland, M. D., & Willey, L. (2017). Mesocosm evaluation of three herbicides on Eurasian watermilfoil (*Myriophyllum spicatum*) and hybrid watermilfoil (*Myriophyllum spicatum x Myriophyllum sibiricum*): Developing a predictive assay. J. Aquat. Plant Manage, 55, 39-41.

[11] Netherland and Wiley, 2017.

Figure B1: Example Eurasian Watermilfoil and Hybrids images from the 2019 LakeScan™ field crew.

Starry Stonewort:

Background: Starry stonewort, a macroalgae native to northern Eurasia, invaded North American inland lakes after becoming established in the St. Lawrence Seaway/Great Lakes system. Though not positively identified in a Michigan inland lake until 2006, by Aquest Corporation in Lobdell Lake, Genesee County, starry stonewort has likely been present in Michigan's inland lakes since the late 1990's. Since then, this invasive species has spread throughout Michigan. Able to spread by both fragmentation and asexual reproduction, starry stonewort has thrived in Michigan's high-quality oligotrophic and mesotrophic lakes, particularly those with marl sediments. Once established, this opportunistic species will bloom and crash and impose a very significant and deleterious impact on many ecosystem functions. Bloom and crash events are unpredictable and can happen at any time of the year. In some years starry stonewort can become a horrendous nuisance while it can be inconspicuous in others. It can comingle with other similar species and be very difficult to find when it is not blooming.

Figure B2: Example starry stonewort images from the 2019 LakeScan™ field crew.

Management: Starry stonewort is capable of growing to extreme nuisance levels and can significantly impact important ecosystem functions. This species is difficult to control due to its asexual reproductive structures (bulbils) which embed in lake sediments.[12] While many strategies have been employed to manage starry stonewort, no single strategy has emerged as a panacea for controlling infestations.

Diver-assisted suction harvesting (DASH) or diver-assisted hand-pulling of small starry stonewort infestations could reduce populations over time.[13] While these methods can be effective and have high specificity, they are expensive, labor-intensive strategies that require long-term commitment.[14] These strategies may not be viable for large-scale infestations, however, due to their labor-intensive nature

[12] Glisson, W. J., Wagner, C. K., McComas, S. R., Farnum, K., Verhoeven, M. R., Muthukrishnan, R., & Larkin, D. J. (2018). Response of the invasive alga starry stonewort (*Nitellopsis obtusa*) to control efforts in a Minnesota lake. Lake and Reservoir Management, 34(3), 283-295.

[13] Glisson et al., 2018.

[14] Larkin, D.J., Monfils, A.K., Boissezon, A., Sleithd, R.S., Skawinski, P.M., Welling, C.H., Cahill, B.C., and Karold, K.G. 2018. Biology, ecology, and management of starry stonewort (*Nitellopsis obtusa*; *Chara*ceae): A Red-listed Eurasian green alga invasive in North America. https://doi.org/10.1016/j.aquabot.2018.04.003

and their potential for increasing distribution of the target plant species through fragmentation during removal.

Starry stonewort chemical treatments using copper-, diquat- and endothall-based algaecides have produced mixed results and long-term management has yet to be achieved using chemical biocides alone.[15] While starry stonewort is susceptible to most selective algaecides, the dense mats of vegetation are very difficult to penetrate and provide reasonable biocide exposure. Consequently, multiple algaecide applications may be required to "whittle down" dense starry stonewort growth if the mats reach sufficient height.

Curly-leaf Pondweed:

Background: Curly-leaf pondweed (CLP) is one of the world's most widespread aquatic plant species. Although it is found worldwide, CLP is native to only Eurasia. The earliest verifiable records of the plant are from Pennsylvania in the 1840s, and has been found in Michigan since 1910. Curly-leaf pondweed is currently found in inland lakes of 34 counties in Michigan, distributed both in the upper and lower peninsulas.[16] Scientific literature suggests that curly-leaf pondweed is an aggressively growing species that often expands to nuisance levels when native plants are damaged.

Curly-leaf pondweed can create problems such as recreational nuisances, ecological nuisances (by outcompeting native species and reducing light availability to other plants), and degraded fish spawning habitat. Curly-leaf pondweed is easily detectable in early spring as it will be one of the few plants readily growing and the first submersed plant to reach the surface. This gives it a competitive advantage and can grow 4 to 5 feet tall before other plants begin germinating from the bottom sediments. As water temperatures rise in late June and early July, curly-leaf pondweed stems begin to die, break down, and can be completely gone by mid-July.[17]

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[15] Pokrzywinski, K. L., Getsinger, K. D., Steckart, B., & Midwood, J. D. (2020). Aligning research and management priorities for *Nitellopsis obtusa* (starry stonewort).

[16] MDEQ. (2018). "State of Michigan's Status and Strategy for Curly-leafed Pondweed (*Potamogeton crispus L*.)." Accessed online: <https://www.michigan.gov/documents/invasives/egle-ais-potamogeton-crispus_708948_7.pdf>.

[17] Hart, Steven, M. Klepinger, H. Wandell, D. Garling, L. Wolfson. (2000). "Integrated Pest Management for Nuisance Exotics in Michigan Inland Lakes." Accessed online: <https://www.michigan.gov/documents/invasives/egle-great-lakes-aquatics-IPM-manual_708904_7.pdf>.

Figure B3: Example curly-leaf pondweed image from the 2021 LakeScan™ field crew.

Management: Like other invasive species, CLP is difficult to control once established and is considered widespread in Michigan. Therefore, prevention of new populations in uninfected waters is the most economical management approach. Several herbicides have been shown to be effective at long-term control of CLP, but eradication is difficult after establishment. Bottom barriers have shown effectiveness at combating CLP in small areas, and mechanical harvesting of CLP can be effective if timed and managed correctly.[18]

The most viable ways to control CLP is through chemical and physical means after developing an integrated pest management plan. Early infestations may best be controlled by manual removal, diver-assisted suction harvesting (DASH), or benthic barrier use during spring before turions are produced. Aquatic herbicides including endothall, diquat, and imazamox are the most effective for general applications. Aquatic herbicides including flumioxazin and imazamox are effective for specific types of application and in specific environments. Chemical treatments are a part of a long-term integrated management plan as the turions are viable for at least 5 years and only diquat, fluridone, and some hormone treatments have shown a reduction of turion development in the laboratory.[19]

[18] MDEQ, 2018.
[19] MDEQ, 2018.

Appendix C: Herbicide Applicator Map