Restorative Lake Sciences™

Lake Mitchell 2023 Aquatic Vegetation, Water Quality, and 2024 Management Recommendations Report

November, 2023

Lake Mitchell 2023 Aquatic Vegetation, Water Quality, and 2024 Management Recommendations Report (2009-2023)

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Section 1

Lake Mitchell 2023 Aquatic Vegetation, Water Quality, and 2024 Management Recommendations

The overall condition of Lake Mitchell in 2023 was excellent with favorable water clarity, reduced total phosphorus concentrations, and reduced EWM growth, except for a late-season germination which was promptly treated. The water clarity in 2023 averaged around 6.5 feet which is favorable. There was a slight increase in EWM growth in 2023 as there was a strong seedbank re-emergence. A result of rigorous whole-lake surveys, intermittent site visits, and rigorous applications of systemic herbicides for the target plants was effective in controlling this late-season growth. In 2023, RLS continued to utilized the systemic herbicide ProcellaCOR® along with diquat with excellent success and that is recommended for 2024. RLS is always present to oversee these herbicide treatments to assure that exact locations are addressed. Over the past decade, the LMIB has saved much needed funds due to these efforts. The EWM in Big Cove has continued to show sustained reduced growth in 2022-2023 after rigorous 2020 and 2021 ProcellaCOR® treatments. ProcellaCOR® has proven to require less frequent treatments.

Protection of the 34 native aquatic plant species is paramount for the health of the lake fishery and these plants should not be managed unless they are a nuisance to lakefront property owners and possess navigational and recreational hazards (i.e., lily pads or nuisance pondweeds in the coves).

Invasive species such as Eurasian Watermilfoil (EWM) are able to grow in moderate nutrient waters and thus are a challenge to the Lake Mitchell ecosystem. In 2023, approximately 184 acres of EWM were treated throughout the entire lake. RLS has recommended alternating use of different systemic herbicides to reduce the probability of herbicide tolerance which reduces efficacy. The treatment of Purple Loosestrife with triclopyr occurred in 2023 due to a lack of beetles. A thorough section on management recommendations for 2024 is offered at the end of this report.

Section 2

Lake Mitchell Water Quality Data (2009-2023)

Water Quality Parameters Measured

There are numerous water quality parameters one can measure on an inland lake, but several are the most critical indicators of lake health. These parameters include water temperature (measured in °C), dissolved oxygen (measured in mg/L), pH (measured in standard units-SU), conductivity (measured in micro-Siemens per centimeter-µS/cm), total alkalinity or hardness (measured in mg of calcium carbonate per liter-mg $CaCO_3$/L), total dissolved solids (mg/L), secchi transparency (feet), total phosphorus chlorophyll-*a* (in µg/L), and algal species composition. Water quality was measured in the deepest basins of Lake Mitchell on August 22, 2023 (Figure 1). Trend data was calculated using mean values for each parameter for each season. Lake Mitchell would be considered eutrophic (relatively productive) since it does contain ample phosphorus, nitrogen, and aquatic vegetation growth but also has good water clarity and moderate algal growth. General water quality classification criteria are defined in Table 1. 2023 water quality data for Lake Mitchell and its tributaries are shown below in Tables 2-4.

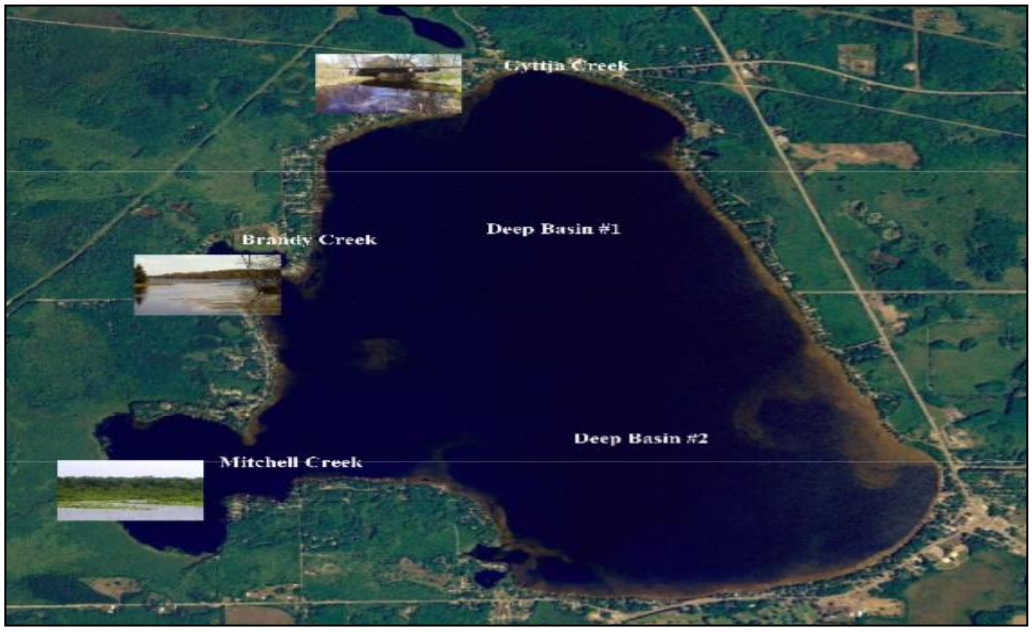


Figure 1. Water quality sampling locations for Lake Mitchell and its tributaries

Table 1. Lake trophic classification (MDNR).

Lake Trophic Status	*Total Phosphorus ($\mu g\ L^{-1}$)*	*Chlorophyll-a ($\mu g\ L^{-1}$)*	*Secchi Transparency (feet)*
Oligotrophic	< 10.0	< 2.2	> 15.0
Mesotrophic	10.0 – 20.0	2.2 – 6.0	7.5 – 15.0
Eutrophic	> 20.0	> 6.0	< 7.5

Table 2. Lake Mitchell water quality parameter data collected over the north deep basin on August 22, 2023.

Depth ft.	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. $\mu S\ cm^{-1}$*	*Turb. NTU*	*ORP mV*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*	*TKN mg L^{-1}*
0	20.86	8.52	8.35	150.5	0.5	126.7	96.3	45	0.020	0.84
10	20.94	8.59	8.29	151.2	0.7	117.5	96.7	45	0.016	0.8
17	20.49	1.78	7.22	222.2	1.6	106.8	142.0	47	0.021	0.78

Table 3. Lake Mitchell water quality parameter data collected over the south deep basin on August 22, 2023.

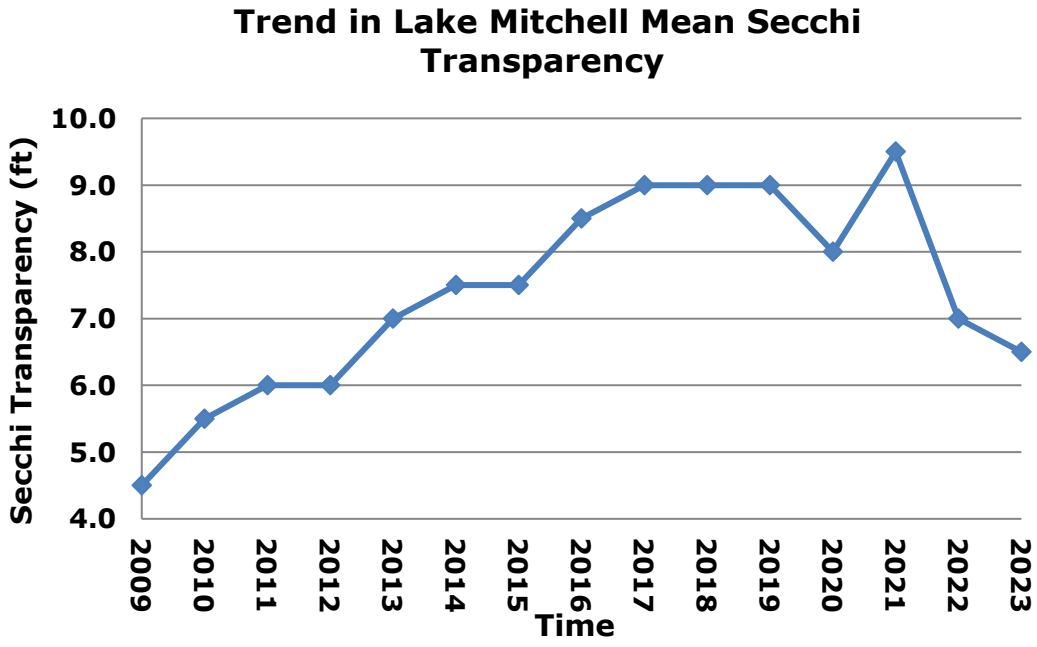
Depth ft.	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. $\mu S\ cm^{-1}$*	*Turb. NTU*	*ORP mV*	*Total Dissolved Solids mg L^{-1}*	*Total Alk. mg L^{-1} $CaCO_3$*	*Total Phos. mg L^{-1}*	*TKN mg L^{-1}*
0	21.55	8.64	8.37	151.0	0.5	119.5	96.6	45	0.018	0.81
10	21.56	8.74	8.36	151.0	1.1	105.6	96.6	46	0.014	0.76
20	20.60	6.23	7.73	152.5	2.3	99.2	97.6	47	0.015	0.9

Table 4. Lake Mitchell Tributary water quality parameter data collected on October 5, 2023.

Tributary	*Water Temp ºC*	*DO mg L^{-1}*	*pH S.U.*	*Cond. µS cm^{-1}*	*TDS mg L^{-1}*	*Total Phos. mg L^{-1}*	*TKN mg L^{-1}*
Mitchell	16.9	1.10	7.49	329.0	210.7	0.010	0.65
Brandy	17.19	3.62	7.79	297.1	190.0	0.065	1.3
Gyttja	19.24	7.15	7.88	226.3	144.9	<0.010	0.7

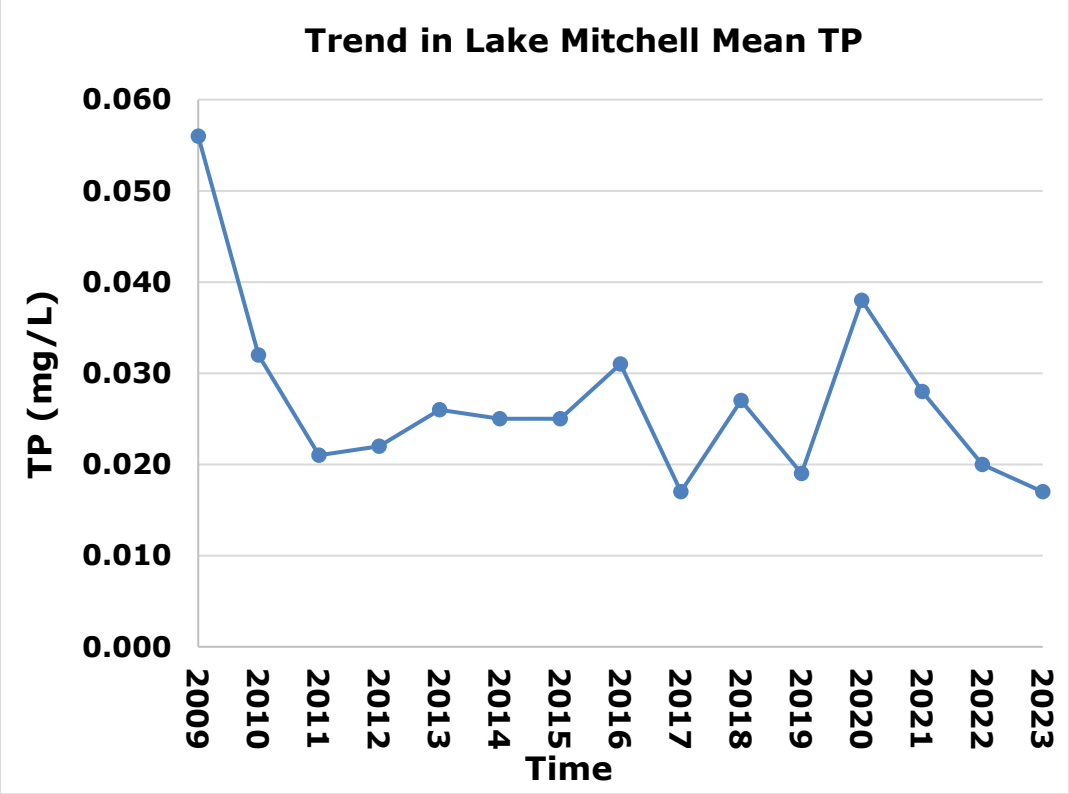
Water Clarity (Transparency) Data

Elevated Secchi transparency readings allow for more aquatic plant and algae growth. The transparency in Lake Mitchell during the 2023 August sampling event averaged around 6.5 feet which was slightly lower than observed in 2022. Secchi transparency is variable and depends on the number of suspended particles in the water (often due to windy conditions of lake water mixing) and the amount of sunlight present at the time of measurement. Other parameters such as turbidity (measured in NTU's) and total dissolved solids (measured in mg/L) are correlated with water clarity and show an increase as clarity decreases. The turbidity and total dissolved solids in Lake Mitchell were low to moderate in 2023 at ≤2.3 NTU's and ≤170 mg/L, respectively. The graph below shows the trend in mean Secchi transparency over time for Lake Mitchell.



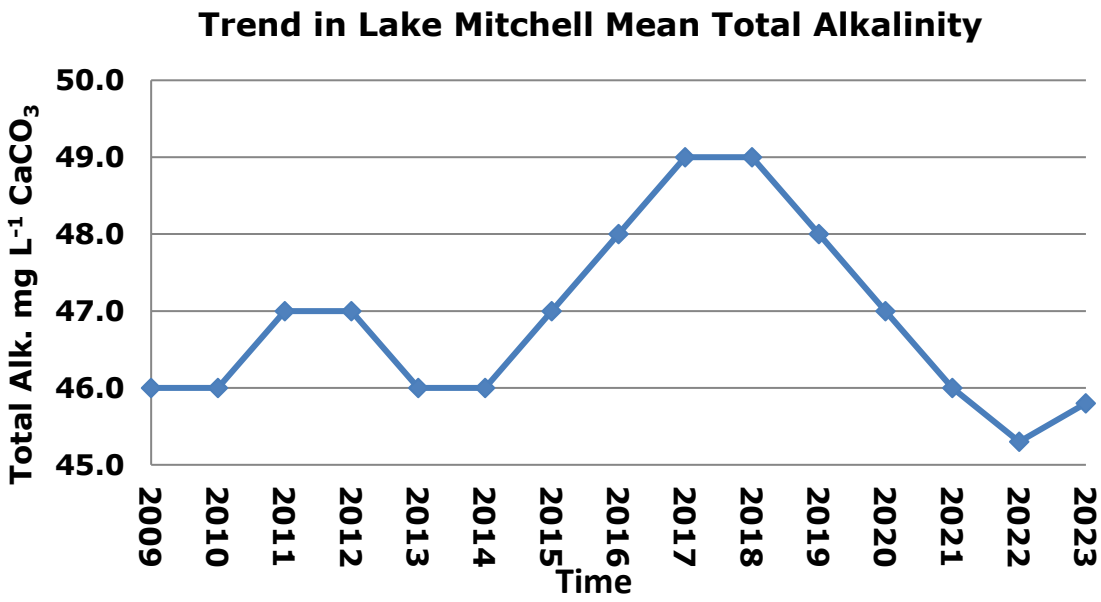
Total Phosphorus

Total phosphorus (TP) is a measure of the amount of phosphorus (P) present in the water column. Phosphorus is the primary nutrient necessary for abundant algae and aquatic plant growth. TP concentrations are usually higher at increased depths due to higher release rates of P from lake sediments under low oxygen (anoxic) conditions. Phosphorus may also be released from sediments as pH increases. Fortunately, even though the TP levels in Lake Mitchell are moderate, the dissolved oxygen levels are good enough at the bottom to not cause release of phosphorus from the bottom. TP concentrations during the 2023 sampling event averaged 0.017 mg L^{-1}, with the highest concentration at the bottom of the north basin (below figure). This is a favorable concentration and is well below the eutrophic threshold. The mean concentrations of TP have been declining in recent years.



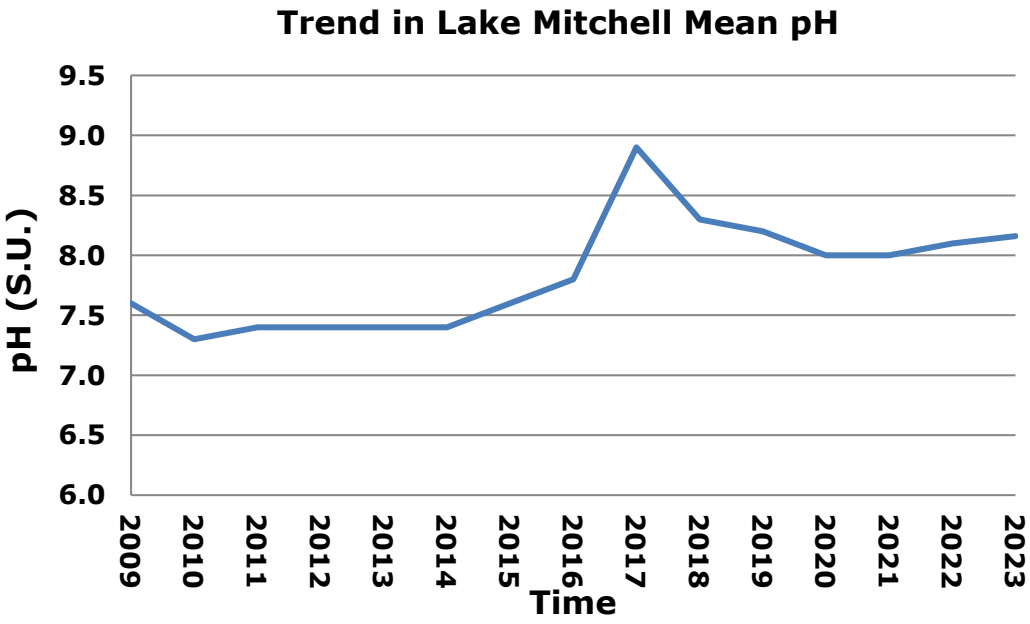
Total Alkalinity

Lakes with high alkalinity (> 150 mg L^{-1} of $CaCO_3$) are able to tolerate larger acid inputs with less change in water column pH. Many Michigan lakes contain high concentrations of $CaCO_3$ and are categorized as having "hard" water. Total alkalinity may change on a daily basis due to the re-suspension of sedimentary deposits in the water and respond to seasonal changes due to the cyclic turnover of the lake water. The alkalinity of Lake Mitchell is quite low and is indicative of a "soft water" aquatic ecosystem. The total alkalinity during the sampling event in 2023 averaged 45.8 mg L^{-1} of $CaCO_3$ which is similar to recent years (below figure).



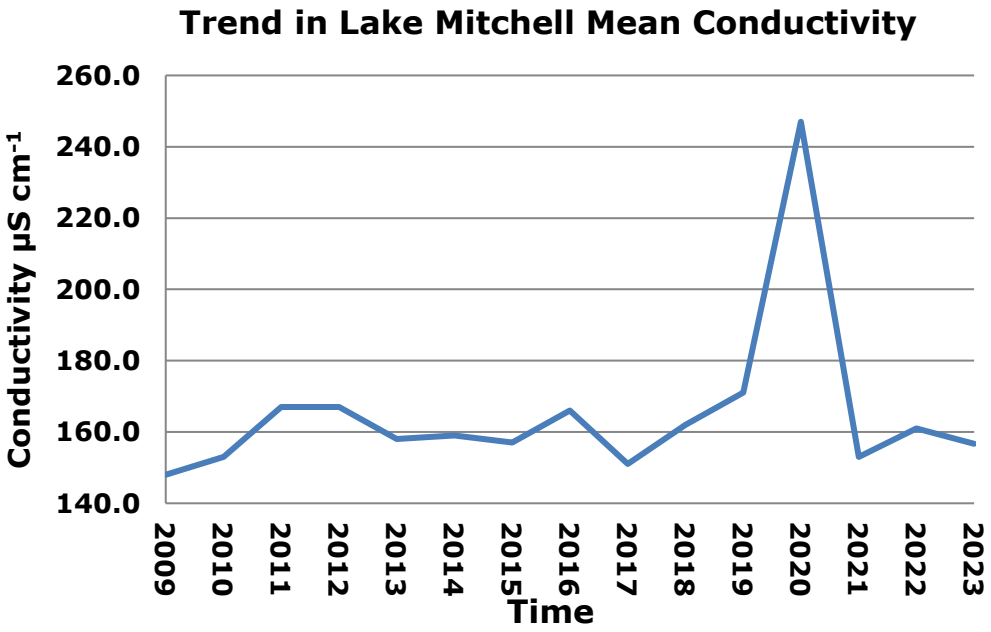
pH

Most Michigan lakes have pH values that range from 6.5 to 9.5. Acidic lakes (pH < 7) are rare in Michigan and are most sensitive to inputs of acidic substances due to a low acid neutralizing capacity (ANC). Lake Mitchell is considered "neutral" on the pH scale. The pH of Lake Mitchell in 2023 was similar to previous years with a mean of 8.2 S.U. (below figure).



Conductivity

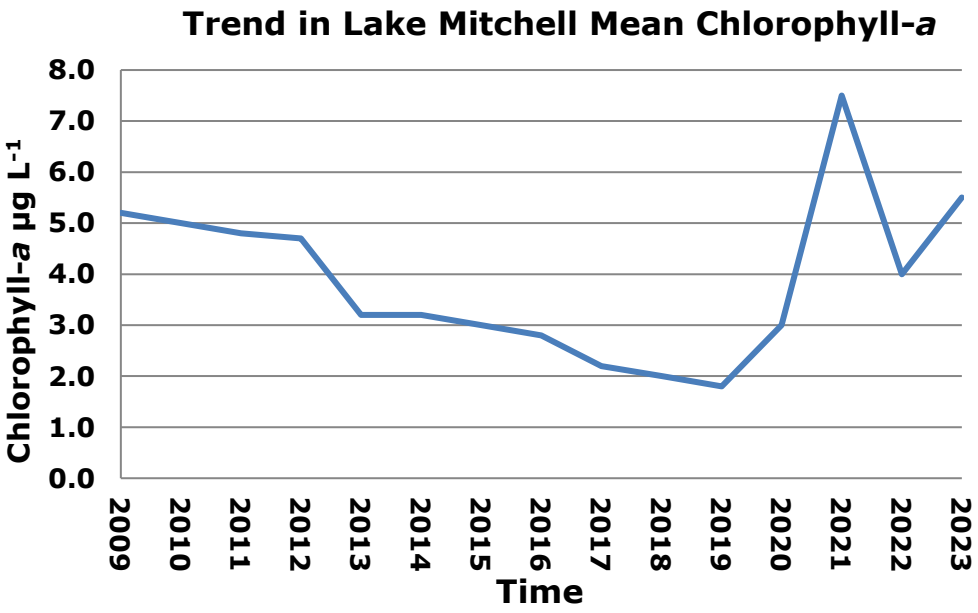
Conductivity is a measure of the number of mineral ions present in the water, especially those of salts and other dissolved inorganic substances. Conductivity generally increases as the amount of dissolved minerals and salts in a lake increases, and also increases as water temperature increases**.** The conductivity values for Lake Mitchell are moderately low for a large, shallow inland lake and the mean was 156.7 µS/cm during the 2023 sampling event which is lower than previous years (below figure). Severe water quality impairments do not occur until values exceed 800 µS/cm and are toxic to aquatic life around 1,000 µS/cm. Conductivity may be increasing due to more road salt applications during recent harsh winters.



Chlorophyll-*a* and Algal Species Composition

Chlorophyll-*a* is a measure of the amount of green plant pigment present in the water, often in the form of planktonic algae. High chlorophyll-*a* concentrations are indicative of nutrient-enriched lakes. Chlorophyll-*a* concentrations greater than 6 µg L^{-1} are found in eutrophic or nutrient-enriched aquatic systems, whereas chlorophyll-*a* concentrations less than 2.2 µg/L are found in nutrient-poor or oligotrophic lakes**.** The mean chlorophyll-*a* concentrations on August 22, 2023 in Lake Mitchell was 5.5 µg/L which was slightly higher than last year but still below the 6 µg L^{-1} which is characteristic of eutrophic lakes. (below figure).

The algal genera were determined from composite water samples collected over the deep basins of Lake Mitchell in 2023 were analyzed with a compound bright field microscope. The genera present included the Chlorophyta: *Chlorella* sp., *Mougeotia* sp., *Haematococcus* sp., *Spirogyra* sp., *Ulothrix* sp., and *Gloeocystis* sp. The Cyanophyta (blue-green algae): *Microcystis* sp.; The Bascillariophyta (diatoms): *Synedra* sp., *Cymbella* sp., and *Navicula* sp. The aforementioned species indicate a diverse algal flora and represent a good diversity of alga with an abundance of diatoms that are indicative of good water quality.


Trend in Lake Mitchell Mean Chlorophyll-a
Chlorophyll-a µg L-1
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
Time

Section 3

Aquatic Vegetation Data (2023)

Status of Native Aquatic Vegetation in Lake Mitchell

The native aquatic vegetation present in Lake Mitchell is essential for the overall health of the lake and the support of the lake fishery. The August 8, 2023 all-species inventory survey determined that there were a total of 34 native aquatic plant species in Lake Mitchell. These include 22 submersed species, 6 floating-leaved species, and 6 emergent species which is similar to recent years and means that the lake is maintaining its biodiversity. This indicates a very high biodiversity of aquatic vegetation in Lake Mitchell and is likely a significant reason for the great fishery in the lake. The overall % cover of the lake by native aquatic plants is moderate relative to the lake size and thus these plants should be protected and not treated unless they become a nuisance in shallow coves or the Torenta Canal. In these cases, RLS may recommend the use of mechanical harvesting in some areas of Big Cove and/or Little Cove along with the Torenta Canal. A list of all native aquatic plants and their relative abundance can be found in Table 5 below.

The most common aquatic plants found during the 2023 surveys included: 1) Largeleaf Pondweed, which is a very favorable pondweed for fish foraging and macro-invertebrate communities, 2) Variable leaf Pondweed, this plant also creates very favorable fish and maco-invertebrate habitat without creating extremely dense beds, and 3) Chara, which creates a grass like community across the bottom, filtering the water, increasing clarity and increasing sediment stabilization. All of these species are favorable when in moderate amounts and help to reduce sediment suspension from the lake bottom during turbulent events to result in clearer waters.

During the whole-lake scan, an aquatic vegetation biovolume map (Figure 4) was developed which shows the areas where aquatic vegetation is absent (blue color), sparse (green color), or high-growing (red color). The red colors usually represent milfoil growth in Lake Mitchell which has declined over the past few years. Most of the biomass is located in Big Cove, Little Cove, and the northwest region of the lake. In Big Cove, the red areas represent tall pondweeds and lily pads. This scan also kicked out a sediment composition map that shows the sediment hardness of the bottom of the lake. The darker shaded colors are harder compared to the lighter shades. (Figure 5)

Table 5. Native aquatic plants found in Lake Mitchell on August 8, 2023.

Aquatic Plant Species Name	*Aquatic Plant Common Name*	*Aquatic Plant Growth Form*	*% Coverage of Lake (2022)*
Chara vulgaris (macroalga)	Muskgrass	Submersed; Rooted	6.97
Potamogeton pectinatus	Sago Pondweed	Submersed; Rooted	6.82
Potamogeton robbinsii	Fern-leaf Pondweed	Submersed; Rooted	4.27
Potamogeton gramineus	Variable-leaf Pondweed	Submersed; Rooted	8.74
Potamogeton praelongus	White-stem Pondweed	Submersed; Rooted	3.69
Potamogeton richardsonii	Clasping-leaf Pondweed	Submersed; Rooted	4.83
Potamogeton illinoensis	Illinois Pondweed	Submersed; Rooted	3.23
Potamogeton amplifolius	Large-leaf Pondweed	Submersed; Rooted	11.57
Myriophyllum sibiricum	Northern Watermilfoil	Submersed; Rooted	0.1
Ceratophyllum demersum	Coontail	Submersed; Non-rooted	2.0
Elodea canadensis	Common Waterweed	Submersed: Rooted	6.8
Utricularia vulgaris	Common Bladderwort	Submersed; Non-rooted	0.83
Najas guadalupensis	Southern Naiad	Submersed; Rooted	6.52
Najas flexilis	Slender Naiad	Submersed; Rooted	1.04
Myriophyllum tenellum	Leafless Watermilfoil	Submersed; Rooted	0.15
Potamogeton zosteriformis	Flat-stem Pondweed	Submersed; Rooted	2.40
Nitella flexilis	Nitella	Submersed; Rooted	0.03
Tolypella sp.	Tolypella	Submersed; Rooted	1.26
Potamogeton pusillus	Small-leaf Pondweed	Submersed; Rooted	0.2
Vallisneria americana	Wild Celery	Submersed; Rooted	2.17
Najas minor	Brittle Naiad	Submersed; Rooted	0.03
Megalodonta beckii	Water Marigold	Submersed; Rooted	0.13
Nymphaea odorata	White Waterlily	Floating-leaved; Rooted	0.66
Potamogeton nodosus	American Pondweed	Floating-leaved; Rooted	0.28
Potamogeton natans	Floating Pondweed	Floating-leaved; Rooted	0.08
Nuphar variegata	Yellow Waterlily	Floating-leaved; Rooted	0.38
Brasenia schreberi	Watershield	Floating-leaved; Rooted	0.03
Lemna trisulca	Star Duckweed	Floating-Leaved; Non-rooted	0.3
Pontedaria cordata	Pickerelweed	Emergent	0.3
Typha latifolia	Cattails	Emergent	0.51
Peltandra virginica	Arrow arum	Emergent	0.13
Schoenoplectus acutus	Bulrushes	Emergent	0.86
Decodon verticillatus	Swamp Loosestrife	Emergent	0.23
Iris spp.	Iris	Emergent	0.1

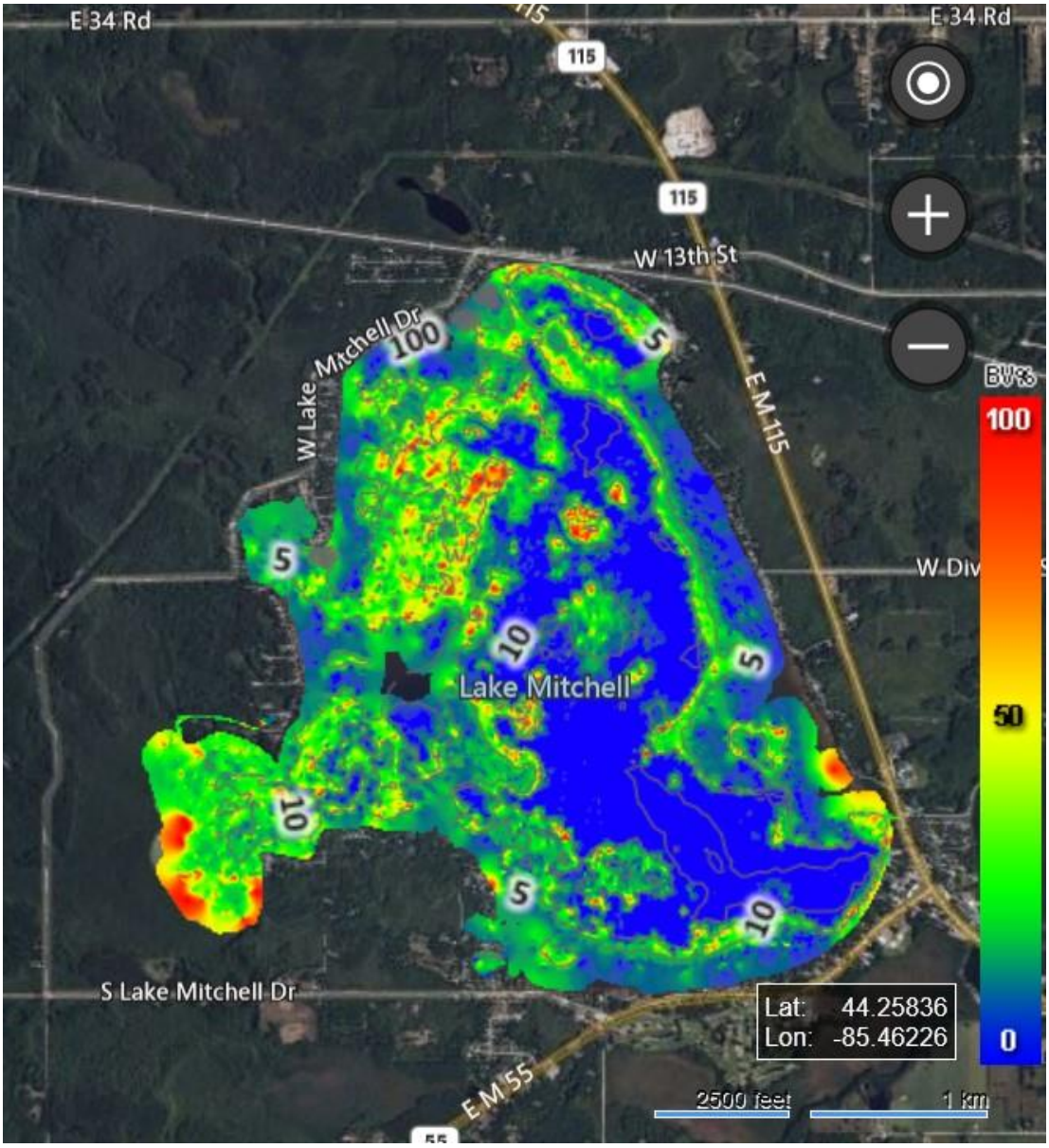


Figure 4. Aquatic Vegetation Biovolume in Lake Mitchell (August 8, 2023).

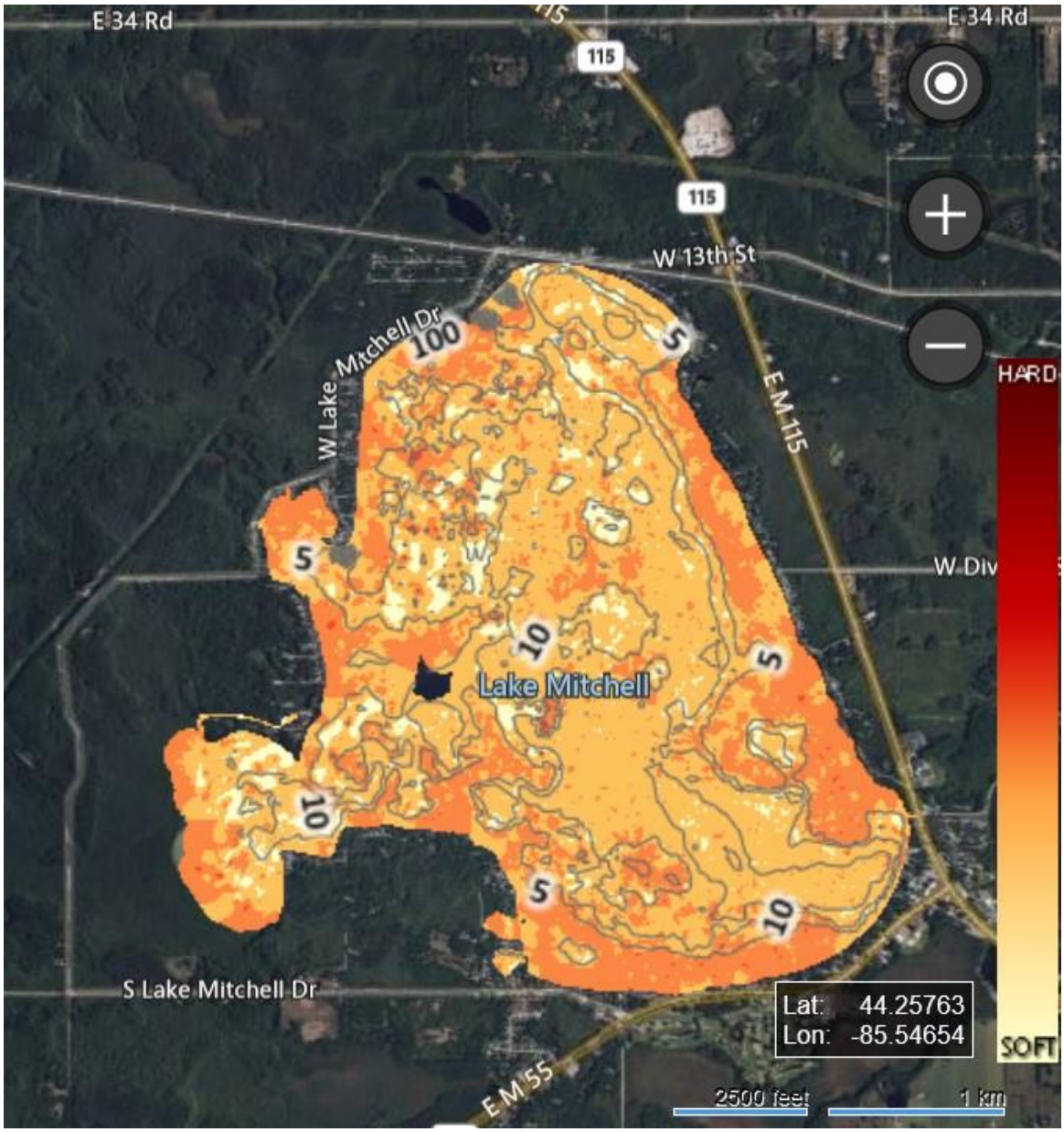


Figure 5. Bottom hardness map (composition) of Lake Mitchell from the August 8th, 2023 scan.

Status of Invasive (Exotic) Aquatic Plant Species in Lake Mitchell

The amount of Eurasian Watermilfoil (Figure 6) present in Lake Mitchell varies each year and is dependent upon climatic conditions, especially runoff-associated nutrients. A whole-lake survey of the main lake was conducted on May 23, 2023 and revealed that approximately 58.5 acres of milfoil were found throughout the entire lake. This survey also revealed 13 acres of CLP within little cove on June 1, 2023, those acres of EWM and an additional 1 acre of new growth were treated throughout the lake and coves with ProcellaCOR® at 6 PDU and diquat at 1 gal/acre. Additionally, an Aquathol K® and flumioxazin spot treatment was needed in Little Cove along with Frankie North and South coves due to excessive growth of dense nuisance vegetation bringing a total of 15 additional acres of treatment on June 1, 2023. There was a treatment on July 11th of little cove along with the frankie coves for nuisance native vegetation using a combination of Diquat, Aquathol K, and Flumioxazin. An additional survey on August 8, 2023 determined a significant late season growth of approximately 125 acres of EWM which were treated on August 28, 2023 with ProcellaCOR® at 6 PDU with diquat at 1 gal/acre. On August 28, 2023, nuisance Purple Loosestrife was treated with triclopyr since the beetles have not been available. The new Phragmites infestation was also treated during this date. Table 6 below shows the total acres of milfoil and nuisance weeds found in each region of the lake that was treated on various dates. Also noted are the effective products and doses used. The treatments were very successful with little viable milfoil remaining at the end of 2023. A spring 2024 survey is needed, however, to determine the 2023 treatment efficacy as EWM plants were senesced by late September 2023 but may re-germinate in the same locations in 2024. Treatment maps for each of these invasive species are shown in the maps below (Figures 8-9). Also noted are the effective products and doses used.

Figure 6. Eurasian Watermilfoil (*Myriophyllum spicatum*)

Figure 7. Curly-leaf Pondweed (*Potamogeton crispus*)

Table 6. Number of acres of nuisance aquatic vegetation managed in various regions of Lake Mitchell (June-August 2023).

Area of Lake Treated	Date Treated	# Acres of EWM	# Acres of CLP or Nuisance Pondweeds	Products Used and Associated Doses
Franke South Cove	6-1	--	1.0	Aquathol-K® (1 gal/acre)
	7-11	--	3	Aquathol-K® (1 gal/acre) + Diquat (1gal /ac) + Flumioxazin @ 100 ppb
Main Lake	6-1	22.5	--	ProcellaCOR®/diquat (6 PDU + 1 gal/acre)
	8-28	123.8	--	ProcellaCOR®/diquat (6 PDU + 1 gal/acre)
Big Cove	6-1	36	--	ProcellaCOR®/diquat (6 PDU + 1 gal/acre)
Little Cove	6-1	--	13.0	Aquathol K® (1 gal/acre)
	7-11	--	0.5	Aquathol K® (1 gal/acre)
	7-11		10	Flumioxazin @ 100 ppb + Diquat (1gal/ac)
Franke North Cove	6-1	--	1.0	Flumioxazin @ 100 ppb
	7-11	--	1	Aquastrike @ 2.5 gal / ac
Torenta Canal	8-28	1.28		ProcellaCOR®/diquat (6 PDU + 1 gal/acre)

NOTE: Purple loosestrife was treated with triclopyr on August 28, 2023 in Franke North, Little Cove, and Big Cove.

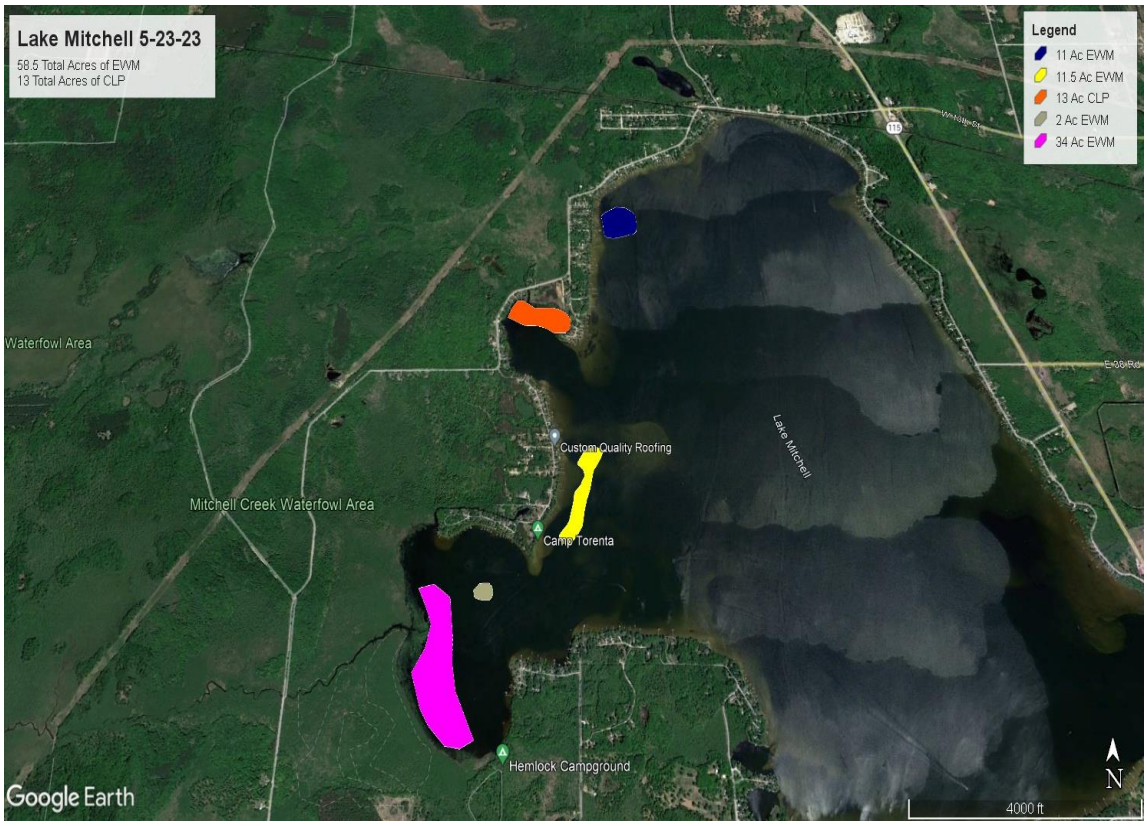


Figure 8. Distribution of EWM and CLP in Lake Mitchell (May 23, 2023). A marked reduction in EWM in the main lake occurred relative to previous years due to intense treatment efforts and surveys.

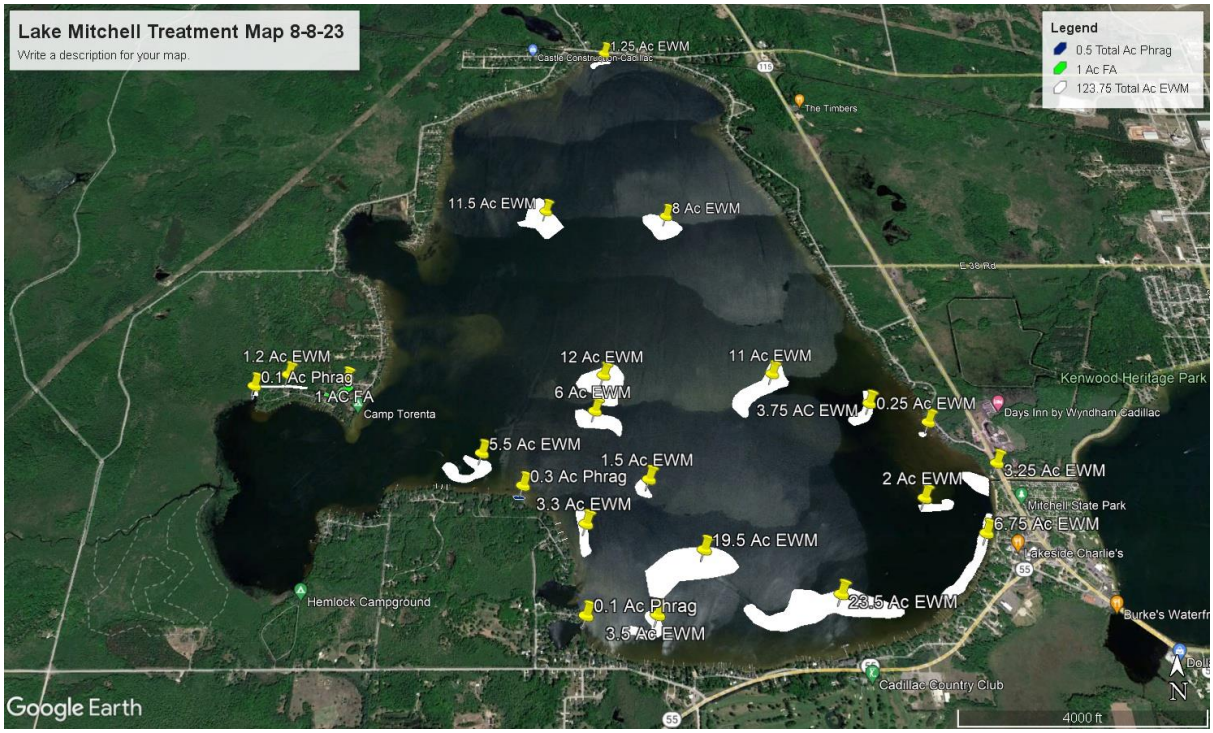


Figure 9. Late-season Distribution of EWM in the main lake and coves (August 8, 2023)

Evaluation of Purple Loosestrife Beetles on Lake Mitchell Purple Loosestrife Reduction:

The beetle, *Galerucella* sp. had been previously stocked around areas of Lake Mitchell infested with Purple Loosestrife. The goal was to introduce enough beetles each season to create a sustainable population around the lake to naturally take over management of the invasive Purple Loosestrife. Previously, beetle counts were performed on the plants each year to evaluate the number of beetles found along with damage of the inflorescences (flower portions of the plants). Due to lack of beetle availability, the beetle population began declining in 2020-2021. Due to this issue, RLS recommended the application of the herbicide triclopyr to the Purple Loosestrife still present in Franke North, Big Cove, and Little Cove. These areas were treated on August 28, 2023. They will need to be evaluated in the summer of 2024 to determine efficacy since they required a late season treatment for best results. RLS will provide those results in the 2024 annual report.

ection 4

Management Recommendations for 2024

Detailed whole-lake aquatic vegetation surveys will be done in 2024 to determine locations of EWM, CLP, and any other nuisance invasive species or natives that may be a threat to the Lake Mitchell ecosystem. Along with the surveys, bottom scans will be conducted to determine changes in aquatic biovolume and distribution of aquatic vegetation. These surveys will occur during the summer or early fall depending on weather patterns that correspond with growth patterns. A post-treatment survey will also be scheduled after each treatment, along with intermittent post-treatment surveys if small-scale treatments are conducted. RLS scientists will oversee all treatments as in previous years. RLS will notify the LMIB of the 2024 survey and treatment dates and update the LMIB on all management activities. Treatments may need to be rescheduled dependent upon wind and other weather conditions.

In 2024, RLS is recommending treatment of large offshore areas with a combination of the systemic herbicide ProcellaCOR® along with the contact herbicide diquat, which resulted in sustained control on EWM in 2022-2023. Diquat and/or flumioxazin will continue to be used in the cove areas for nuisance natives. An additional triclopyr treatment may be needed in Franke North, Little Cove, and Big Cove for the treatment of Purple Loosestrife later in the season. Phragmites will also continue to be monitored and recommended for treatment when infestations are present. Maintaining EWM at existing low levels will be the top priority to keeping a healthy aquatic plant balance and continuing to maintain a low assessment for the lakefront owners in the special assessment district. RLS is aware that mid to late season seedbank germination can occur and is prepared to address those with lake surveys and mapping. The canal will be assessed for the need for a possible harvest and scheduled if necessary although those harvests have lasted for a few years at a time. Lastly, the coves will be surveyed earlier in the season as they require early treatments due to early vegetation growth.

Water quality will continue to be monitored in the lake and tributaries. The water quality of the tributaries in 2023 was improved relative to reduced nutrients, likely due to less rainfall and runoff. New water quality data from 2024 will be compared to historic data to continue evaluation of long-term trends. Lake Mitchell is a healthy lake with excellent aquatic plant diversity. In 2023, there was a community shift in some of the native plant densities but this is normal due to environmental factors such as icepack and the amount of rainfall in the early season. Nutrients in the lake deep basins are at acceptable levels below the eutrophic threshold and there is a robust fishery indicated by the many fishing tournaments held on the lake. Temporary algal blooms occur during hot windless periods or after intense rainfall events. RLS will continue to monitor the lake for any problematic algal blooms. If there are intense algae blooms or you suspect there to be an HAB (harmful algae -bloom) from blue-green algae, please report this by emailing: algaebloom@michigan.gov or calling the Environmental Assistance Center @ 800-662-9278.

Lake Mitchell Improvement Board meetings will be attended by an RLS scientist as in previous years and RLS will develop a comprehensive annual report during the year that will be presented to the LMIB in the fall or winter of 2024. The graph below shows the results of the successful EWM reduction plan for Lake Mitchell which has resulted in substantial savings to the LMIB over the years. In 2023, there was a late season germination which can occur at any time. The quick response resulted in ample time for the treatment to be effective for late season decay of treated milfoil plants. Even though the graph has trended up in the past couple years, we are still well below the max density of when the program was first established.

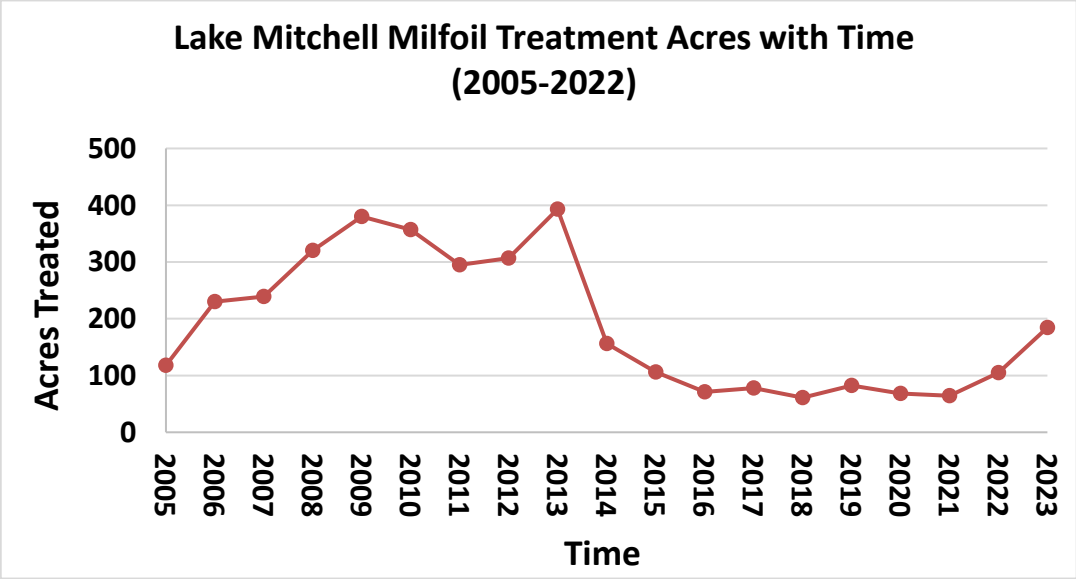


Figure 10. Trendline of EWM acreage treated over time in Lake Mitchell.