SAUK RIVER CHAIN OF LAKES
STEARNS COUNTY, MINNESOTA

AQUATIC PLANT SURVEYS
2022

Sauk River Chain of Lakes Aquatic Plant Survey

Prepared for Sauk River Chain of Lakes Association

2022

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SAUK RIVER CHAIN OF LAKES AQUATIC PLANT SURVEYS

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EXECUTIVE SUMMARY

Two aquatic plant surveys were done on the Sauk River Chain of Lakes (SRCL) during 2022. The first one occurred in mid-June over 997 points with a spacing of 1 point per acre in areas that had not previously been surveyed for plants. The primary purpose of that survey was to map previously unknown areas of curlyleaf pondweed for potential treatment in 2023. Curlyleaf pondweed was found in 38% of sampled sites that had previously not been surveyed. The second survey took place from September 27—October 7, 2022 over 1,941 points at a spacing of 1 point per half acre on Becker, Long, Horseshoe, and parts of Cedar Island in order to track the spread of hybrid watermilfoil, a new AIS listed in the system in 2021. This survey indicated that hybrid watermilfoil had spread from the site of origin along the northern shore of Horseshoe Lake throughout the rest of Horseshoe and into Cedar Island Lake. Combined between all surveys in 2022, a total of 28 different species were detected . Coontail, filamentous algae, and curlyleaf pondweed appear to be the dominant vegetation within the chain. Curlyleaf pondweed and hybrid watermilfoil were the only invasive aquatic plants detected. Water clarity, and subsequently nuisance plant growth/habitat will likely increase in the coming years as a consequence of a recent zebra mussel infestation and their spread through the chain. It is recommended continue management occur for curlyleaf pondweed where it causes interference with use of the lake for creation and monitoring for the spread of the hybrid watermilfoil and treat as budgets allow. Future surveys should also be vigilant about potential introduction of starry stonewort, which is not currently in SRCL but is within Stearns County.

INTRODUCTION

Aquatic plants are an important part of the ecological functioning of a lake. They reduce wave impacts to shorelines as well as stabilize sediments, keeping nutrients out of the water column that might otherwise lead to poor water quality due to stimulated algal growth. Aquatic plants provide habitat and food for other organisms in a lake. These benefits have been referred to as the "conservation value" of plants.

Just because aquatic plants have conservation value, it does not follow that more plants equal greater value. The highest conservation value for a plant community occurs at (1) intermediate coverage and densities, (2) high species diversity, and (3) high growth form diversity, meaning mixes of broad-leaf, narrow leaf, canopy forming and lower growth forms.

When lakes are developed and used for recreational purposes, such as fishing, swimming, and boating, there is an additional goal in plant management that allows for those activities to be enjoyed by users. Sometimes conservation values and recreational values conflict with each other.

Recreational lakes are usually managed to best make a trade-off between recreation and conservation. These lakes will have less coverage and density and less diversity than those that are not developed, but yet enough to ensure the ecological integrity of the lake.

A complicating factor in managing plant communities is the presence of invasive plant species. Invasive plants are those that are not native to Minnesota. Because of their life history characteristics, invasive plants outcompete native plants for sun-

Fig. 1. The most managed aquatic invasive species in Minnesota from left to right include curlyleaf pondweed, Eurasian watermilfoil, and starry stonewort. Top panel shows some identifying characteristics of each species and bottom panel is an example of these AIS growing to the surface where they may cause nuisance for recreational use of lakes. The Sauk River Chain of Lakes has both curlyleaf pondweed and Eurasian /hybrid watermilfoil.

light and nutrients. When they are introduced, they can reduce the recreational value of a lake given they often grow to the surface or reduce native plant diversity.

Common invasive species in Minnesota include curlyleaf pondweed (hereafter CLP), Eurasian watermilfoil (hereafter EWM), and starry stonewort. Any of these can mat at the surface of the lake and interfere with recreation (Fig. 1). The Sauk River Chain of Lakes (SRCL) is known to have populations of both CLP and hybrid watermilfoil (here after HWM), an invasive closely related to EWM.

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

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

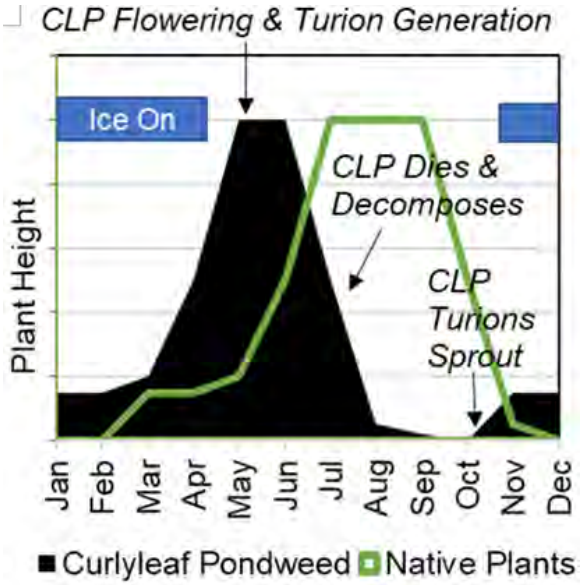

Fig. 3. Curly-leaf Pondweed idealized life cycle (black solid area) interposed with "native" plants (hollow green area).

One life history characteristic that allows CLP to become a problem in Minnesota is its timing for growth and reproduction that differs from most native plants and even other invasive plants. CLP begins growing much earlier in the year than most other plants. Because it grows so early, it can shade out native plants, which require early season sunlight to begin their annual growth (Fig. 3). This can, and often does, lead to CLP becoming a dominant plant in lakes it infests during late spring until about the first week in July in Minnesota.

EWM is native to Europe and Asia. It was introduced to the eastern United States in the early 1900's and first discovered in Minnesota in 1987 at Lake Minnetonka in central Minnesota. There are currently 471 water bodies in Minnesota known to have EWM.

Unlike CLP, rather than dying off in early summer, EWM persists through the growing season. In lakes with both CLP and EWM this can lead to codominance between the two species with CLP growing to nuisance levels in late spring and early summer and EWM becoming a nuisance during the summer months following CLP die-back.

EWM can be distinguished from the native watermilfoils by counting the leaflet pairs on each leaf. Native milfoils tend to have less than 11 pairs, while EWM has 12-24 leaflet pairs (Fig. 4).

EWM has been shown to hybridize with native watermilfoil and exist as "hybrid watermilfoil" (HWM). As sometimes occurs, this HWM can take the best traits of it's parents, EWM and native watermilfoil creating an organism that has "hybrid vigor", meaning it can be better at growing and spreading than either of it's parents. SRCL

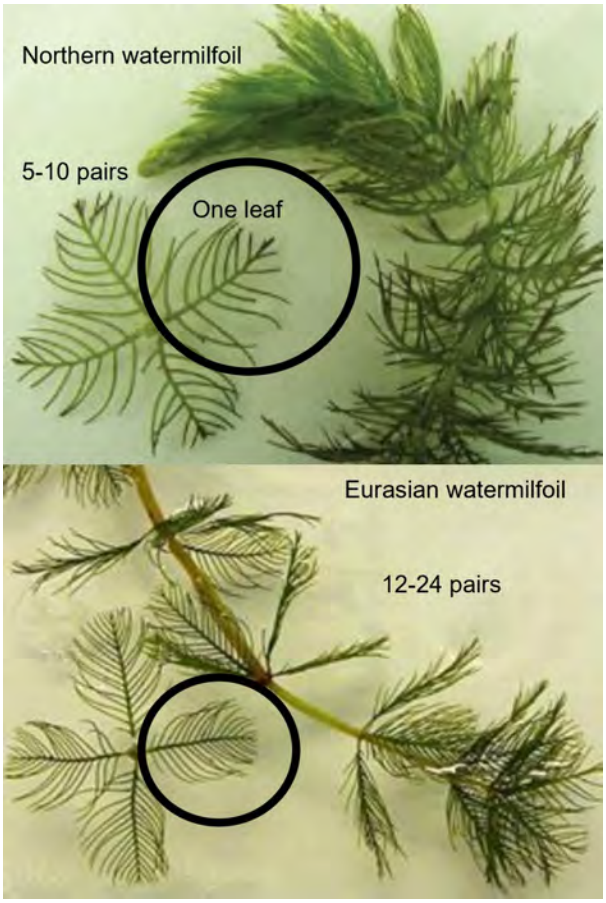

Fig. 4 EWM morphology as compared to native northern watermilfoil.

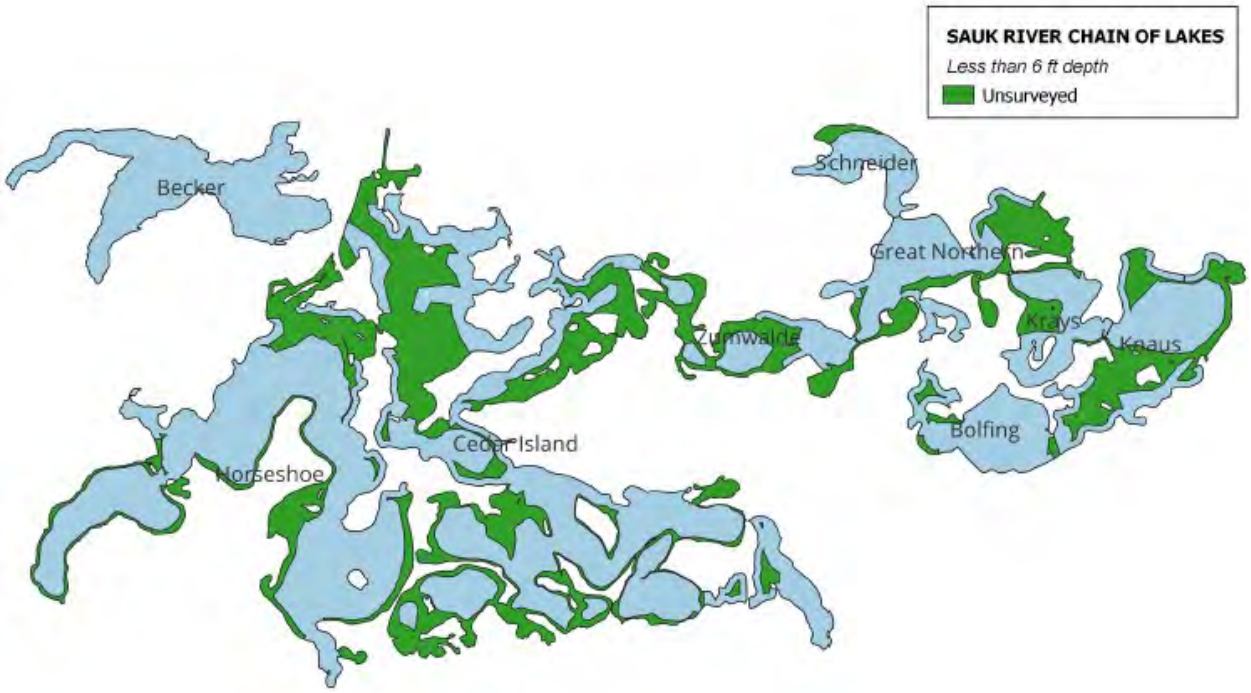

Fig. 5. Areas surveyed in June 2022 (green) for curlyleaf pondweed that had not been previously surveyed.

has putative HWM, which is currently being verified using genetic techniques. HWM looks intermediate to EWM and native watermilfoil and often has leaflets counted at 11-13.

The primary goals of the plant surveys on SRCL in 2022 was to determine the extent of CLP in areas not previously mapped and determine the extent of HWM/EWM. While these surveys were being completed, data were collected on the rest of the plant community and described.

METHODS

Site Description. The SRCL is a reservoir consisting of 10 individual water bodies (i.e., "lakes"): Becker (73015600), Bolfing (73008800), Cedar Island (73013300), Great Northern (73008300), Horseshoe, (73015700), Knaus (73008600), Krays (73008700), Long (73013900), Schneider (73008200), Zumwalde (73008900). Together these lakes total 3,114 acres with 2,333 classified as littoral.

The littoral zone is the area of the lake where sunlight can penetrate deep enough to reach the bottom in sufficient amounts to allow for germination and plant growth. The MN DNR delineates littoral zones as any part of the lake less than 15 feet. While a good approximation, the true littoral zone will differ depending on several factors.

Nine of the ten lakes are impaired in regards to the MPCA North Central Hardwood Forest Ecoregion standards for total phosphorus, chlorophyll *a*, and Secchi depth. The only one without an impairment designation is Becker Lake.

EDDMapS (www.eddmaps.org) indicates the first records of CLP occurred in 1980 in Long and Zumwalde Lakes. The first rec-

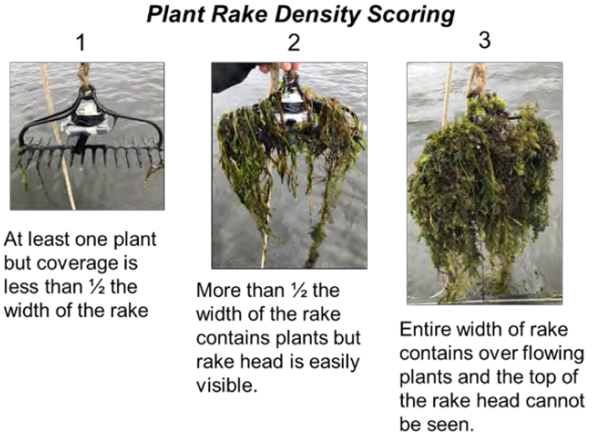

Fig. 6. Aquatic point intercept survey rake density method for density scoring.

ord of zebra mussels was on Knaus Lake in 2017 and the first record of HWM was in 2021 on Horseshoe Lake. The most recent infested waters list (September 16, 2022) by the MN DNR indicates no other invasive species within the chain. (www.dnr.state.mn.us/invasives/ais/infested.html).

Aquatic Plant Point Intercept Surveys. Two separate point intercept surveys were conducted on the chain of lakes during 2022, the first of which targeted CLP and the second targeted EWM/HWM.

Spring Curlyleaf Pondweed Survey — During 2020–2021, Limnopro conducted surveys on the chain of lakes in specific areas of interest where CLP had previously been reported by SRCL Association (Fig. 5). The survey in 2022 was meant to fill in some gaps of areas that had not previously been surveyed but were suspected to have CLP. Without verification of CLP, it is difficult to get permits from the MN DNR for treatments. In mid-June 2022, 997 points were surveyed in areas not previously surveyed. In order to hold costs down, the survey only looked at areas not previously surveyed that were less than 6 ft in depth. Even if CLP were in areas greater than 6 ft in depth, the likelihood that it would grow to nuisance levels in those deeper areas was low.

After navigating the boat to each point, a double-sided rake attached to a rope was tossed off the port side of the boat and dragged with four distinct pulling motions over an area of approximately three-meter (10 ft) length. If plants were brought to the surface they were identified to species and ranked on a density scale from 0 (no plant) to 3 (Fig. 6). The point resolution for the CLP survey was 1 point per acre.

Fall Hybrid Watermilfoil Survey — The second survey was conducted between late September and early October 2022. Hybrid watermilfoil was first identified on Horseshoe Lake in 2020 at a single location and mapped in October 2021 as it was determined to have spread. The mapping from October 2021 was used as a basis for chemically treating the area by *Clarke* using ProcellaCOR. Limnopro performed a meandering survey after they treated for three purposes: (1) to determine the initial success of the chemical treatment, (2) determine the spread of HWM to additional nearshore areas, and (3) collect samples for genetic analysis.

The meandering survey assessed seven miles of the 13.8 mile shoreline on Horseshoe Lake where clarity was high enough for plants to be visible. When HWM was detected, the location was stored on an onboard GPS. At the same time, 20 different HWM plants were collected around the lake for genetic analysis to verify that the plants were HWM and to determine if a genotype could be determined to help inform management decisions. As treated areas were meandered, the presence and

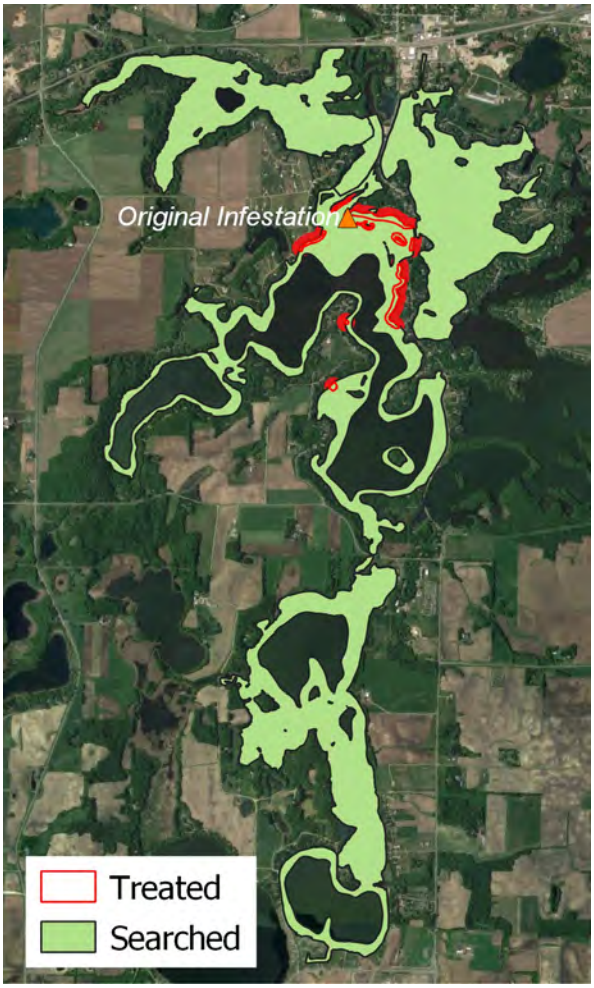

Fig. 7. Areas searched using point intercept survey and/or meandering survey for hybrid watermilfoil are shown in green. Red boxes are locations where HWM was found in 2021 and treated by Clarke in 2022. The orange triangle shows the approximately location of the original plant found in Horseshoe in summer of 2020.

health of HWM was noted as to determine the success of chemical treatment.

The meandering survey was supplemented with a point intercept survey in September—October 2022 (Fig. 7). During this sampling bout, 1,941 points were loaded to an onboard GPS/sonar unit with a spacing of 1 point per 0.5 acres over Becker, Long, Horseshoe, and part of Cedar Island Lakes for the primary purpose of determining the potential of the HWM infestation in areas not covered by the meandering survey or in areas not amenable to a meandering type survey.

Mapping and geostatistical analyses were performed using a geographic information system (QGIS 3.22.11). Interpolation methods used a multilevel b-spline algorithm in QGIS.

In summary of the plant community, we also designated plants into management categories based on their desirability to have on the lake relative to their propensity to cause a nuisance. "Desirable" plants are lower canopy growers that are less likely (though not impossible) to grow to the surface. "Nondesirables" are plant species that do tend to grow to near the surface and become a problem.

For the remaining plant community we calculated (1) frequency of occurrence for each species, (2) density of individual species as a function of the total density (3) the observed maximum depth of submersed plants, and (4) in-depth additional assessment of CLP to aid in future management strategies.

The report ends with discussion and suggestions for potential management and future monitoring.

RESULTS

Spring CLP Survey. A total of 23 species (plants or algae) were found with the dominant members of the community being coontail, filamentous algae, and curlyleaf pondweed. Those three species accounted for 55% of all vegetation pulled up on rakes. All three are capable of causing nuisance conditions.CLP was found over an estimated 379 acres for 38% of sites surveyed. A full sized map is provided in the

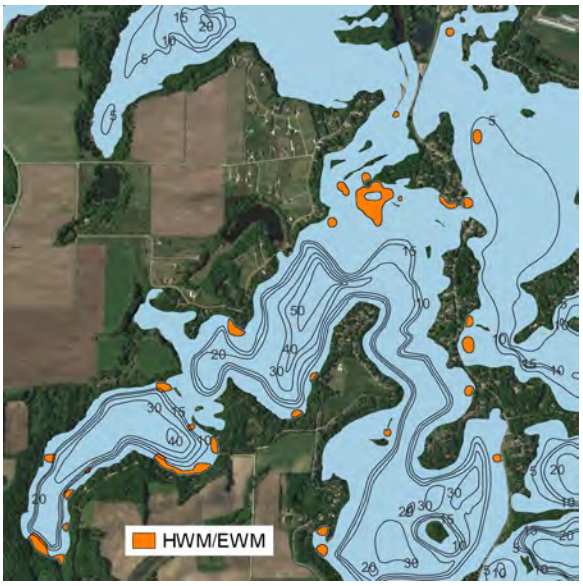

Fig. 8. HWM location found during surveys in 2022.

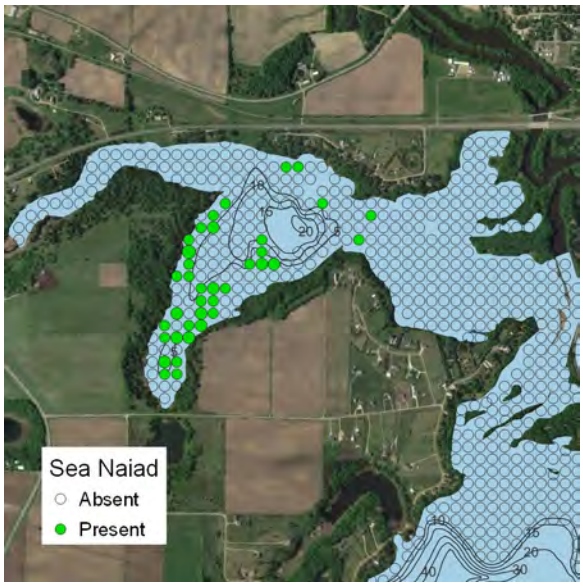

Fig. 9. Sea naiad locations on Becker Lake.

appendix that shows all CLP that has been mapped to date by Limnopro.

Fall HWM Survey. During the meandering survey, plants suspected of being HWM were found at 29 sites. Of the nine treated areas of the lake, evidence of remaining HWM were only found in two. Most of the plants found in treated areas were showing signs of damage, but not all of it.

During the point intercept portion of the survey, plants were found at 1,181/1,941 (61%) of all sites sampled. A total of 24 different species were detected (plants or algae) with the plant community dominated again by coontail, filamentous algae, and CLP. Those three species accounted for 55% of all plants found. Coontail was the dominant species, accounting for an estimated 38% of all plants. We found HWM had spread to new areas within Horseshoe Lake since the last survey in October of 2021. In total, HWM covered approximately 24 acres, primarily on Horseshoe and a few locations on Cedar Island (Fig. 8).

Somewhat surprisingly, CLP covered roughly 124 acres during the late survey. Generally, we expect CLP to be mostly dormant during later parts of the summer. Chinese mystery snails and zebra mussels were also detected.

Sea naiad, a species listed as special concern status in MN was found at 37 of the 342 sites on Becker Lake during the late season sampling (Fig. 9). Its distribution is worldwide but considered to the rare in MN.

A full map set, including a list of plant species identified in SRCL along with their occurrences and densities are given in the appendix.

DISCUSSION

The set of surveys on SRCL revealed the following key points: (1) there is an abundance of CLP in the lake; (2) an initial evaluation of HWM using ProcellaCOR seems successful, and (3) HWM is spreading in

Horseshoe Lake and into connected lakes (Cedar Island).

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

Control of the current invasives, HWM and CLP, best done with herbicidal treatment. Mechanical harvesting of plants may lead to greater spread as both of these species can grow from discharged fragments. EWM and CLP require different approaches for control as their biology is different enough that different chemicals ought be used for each species.

Currently two herbicides are commonly used to treat CLP, endothall and diquat. The best chance of control for small or open plots is to apply as high concentration as possible. The maximum labeled rate for endothall is 5.0 ppm. The SRCL has historically treated with a concentration of 2.0 ppm. The maximum labeled rate of diquat is 0.37 ppm. We prefer diquat as the cost is much lower than endothall, and it requires less contact time to be effective. Endothall treatment costs are 4-12 times that of diquat depending on the concentrations used.

The MN DNR Fisheries Division has a list of diquat restricted lakes, which includes all the SRCL lakes with the exception of Knaus and Zumwalde. It's possible that this was an oversight. Being on the list means that the only chemical that can be used on the lake for control of CLP is endothall. The diquat restriction is from a controversial belief the MN DNR has that diquat is harmful to young of the year walleye but not endothall. Lake groups can petition the DNR to be removed from the list.

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

Two systematic herbicides are commonly used for HWM/EWM. Compared with the contact herbicides, systematic herbicides target the entirety of the plant, including the below ground and reproductive structures which make the likelihood of the plant returning in the following year low. The traditional product used to control EWM is 2,4-D while a newer formula has been growing in usage called ProcellaCOR. Both have been shown to be effective under the right conditions. The company that produces ProcellaCOR guarantees control for three years after treatment if plots are larger than 10 acres.

It is important to remember that Becker Lake is classified as an "Environmental Lake" in the MN Shoreland Management Program, which means that chemicals, under any circumstance, are not allowed to be used in the lake. There is a petition process with the County to have the designation changed if HWM turns up on the lake. Resolving a plan for managing in Becker should be a priority given its proximity to Horseshoe Lake.

Even though the chain currently has zebra mussels, CLP, and EWM, vigilance for starry stonewort (SSW), a relatively new comer to Minnesota is important. SSW was first de-

Fig. 10. Locations of starry stonewort in Minnesota in relation to Sauk River Chain of Lakes. The bullseye is centered on the SRCL. The center ring is 50 miles, the second ring is 100 miles, and the third ring is 150 miles wide.

tected in Lake Koronis in Stearns County in 2015. Presently, it is currently in 22 different lakes in the state, the closest of which is Grand in Stearns County, only 6 miles from the landing in Cold Spring (Fig. 10).

While Koronis had a populations that was found after it was well established and has cost the state and their lake association hundreds of thousands of dollars in control efforts, most of the newly infested lakes where it was found early have been successful at controlling at a far lower price point.

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

For all surveys combined in 2022, there was a total of 28 different species found that covered 65% of the littoral zone. Only two invasive species were found. The plant community was dominated by coontail, curlyleaf pondweed, an filamentous algae, three types of vegetation that often cause nuisance plant growth conditions (Fig. 11). Nuisance vegetation as well as the size of the littoral zone will both potentially increase in the coming years due to the presence of zebra mussels due to their impact on water clarity. Plants are light limited, meaning the maximum abundance and coverage that occurs in a lake can be directly correlated with the amount of light penetrating the water column to the lake bottom surface. Zebra mussels likely have, and will continue to have significant impacts on the ecology of the Sauk River Chain of Lakes.

In conclusion management ought to focus on managing invasive species and nuisance growth to improve recreational opportunities, preventing new infestations, and improving water quality.

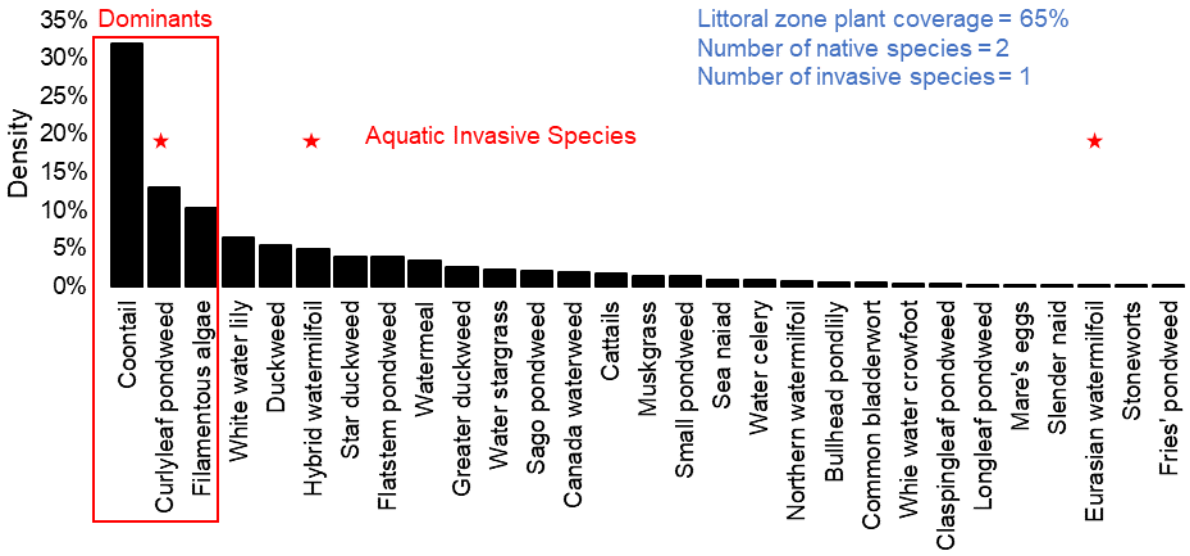

Fig. 44. Rank abundance of plants identified in the SRCL in 2022. Density indicates the percentage of all plant mass collected that belongs to a specific group. For example, 32% of all vegetative mass collected was coontail. Three species made up 50% ofall plants collected.

MANAGEMENT RECOMMENDATIONS

1. Spring meandering survey (annually) over areas where CLP was found to determine location and extent and chemical herbicide treatment in areas it impedes recreational use on the lake.
2. Surveys as budget allows to determine locations and extent of EWM/HWM for treatment recommendations with the goal to reduce probability of spread and/or eradicate it.
3. AIS Early Detection Survey at the public boat launch late summer to rule out new infestation of starry stonewort.

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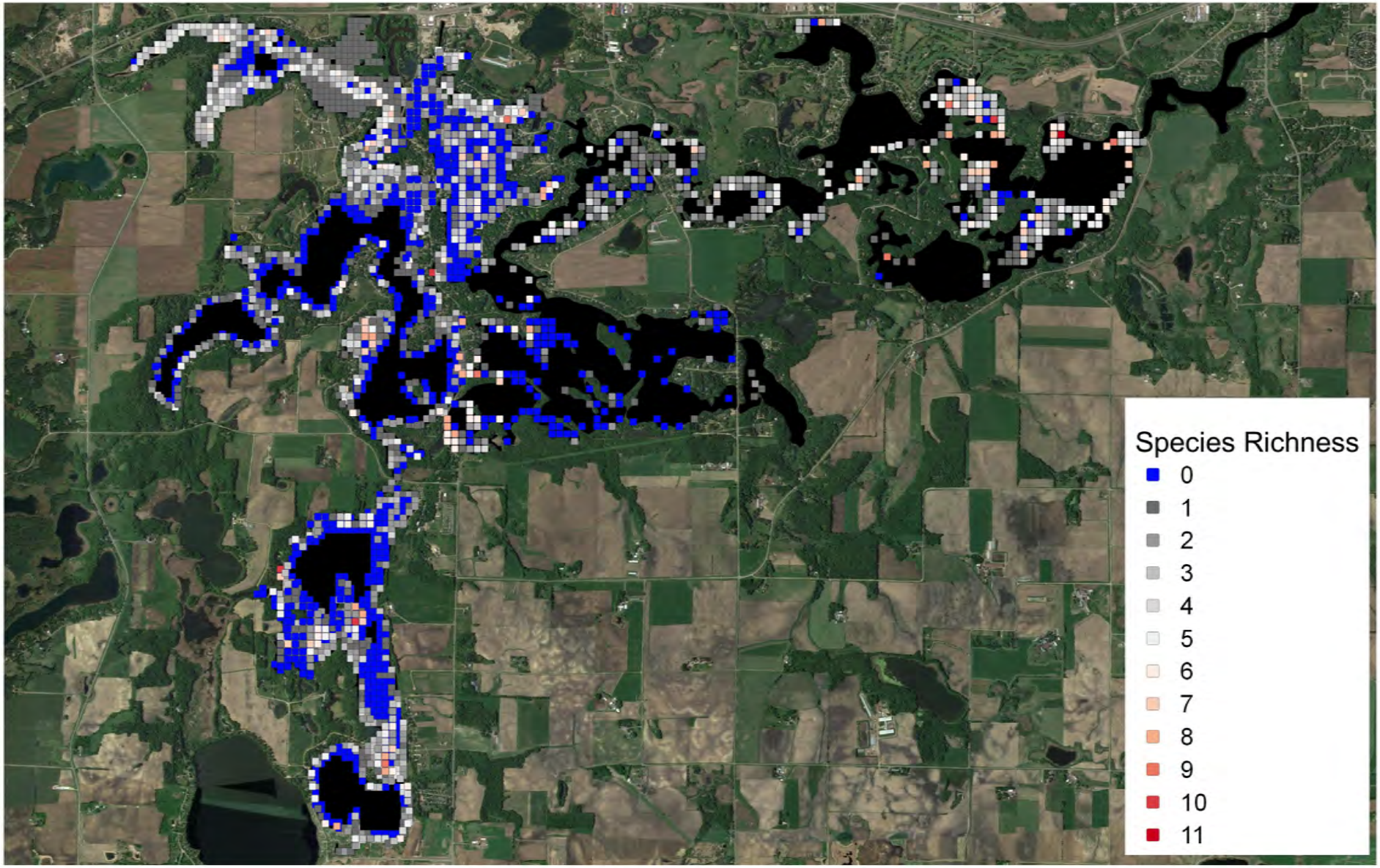
APPENDIX

Summary of plant survey data on the Sauk River Chain of Lakes in Stearns County, MN. Management is our judgement of species that have qualities that are desirable, undesirable, or neutral. Density is an estimate, based on rake densities, of the proportion of mass for a given species during the survey. Occupancy is the proportion of sites sampled that had at least one instance of the species.

			June		September		Overall	
Common Name	Scientific Name	Management	Occupancy	Density	Occupancy	Density	Occupancy	Density
Coontail	*Ceratophyllum demersum*	Undesirable	52%	26%	41%	38%	44%	32%
Curlyleaf pondweed	*Potamogeton crispus*	Undesirable	38%	19%	13%	8%	21%	13%
Filamentous algae	Various	Undesirable	25%	11%	15%	10%	19%	10%
White water lily	*Nymphaea odorata*	Neutral	20%	7%	10%	6%	13%	6%
Duckweed	*Lemna* spp.	Neutral	11%	4%	11%	7%	11%	5%
Hybrid watermilfoil	*Myriophyllum spicatum x Myriophyllum sibiricum*	Undesirable	9%	4%	9%	6%	9%	5%
Star duckweed	*Lemna triscula*	Desirable	12%	4%	6%	4%	8%	4%
Flatstem pondweed	*Potamogeton zosterformis*	Desirable	16%	8%	1%	1%	6%	4%
Watermeal	*Wolffia* spp.	Neutral	9%	3%	6%	4%	7%	3%
Greater duckweed	*Spirodela polyhriza*	Neutral	15%	5%	0%	0%	5%	2%
Water stargrass	*Heteranthera dubia*	Desirable	3%	1%	5%	3%	4%	2%
Sago pondweed	*Stuckenia pectinata*	Desirable	6%	2%	3%	2%	4%	2%
Canada waterweed	*Elodea canadensis*	Desirable	3%	1%	4%	3%	4%	2%
Cattails	*Typha* spp.	Neutral	4%	1%	3%	2%	4%	2%
Muskgrass	*Chara* spp.	Desirable	1%	0.4%	3%	2%	2%	1%
Small pondweed	*Potamogeton pusillus*	Desirable	5%	3%	0%	0%	2%	1%
Sea naiad	*Najas Marina*	Desirable	0%	0%	2%	2%	1%	1%
Water celery	*Valisneria americana*	Desirable	0%	0%	2%	1%	2%	1%
Northern watermilfoil	*Myriophyllum sibiricum*	Desirable	0%	0%	2%	1%	1%	1%
Bullhead pondlily	*Nuphar variegata*	Neutral	2%	1%	0.4%	0.3%	1%	1%
Common bladderwort	*Utricularia macrorhiza*	Desirable	1%	0.18%	1%	1%	1%	0.4%
White water crowfoot	*Ranunculus aquatillis*	Desirable	1%	0.21%	1%	0.5%	1%	0.3%
Claspingleaf pondweed	*Potamogeton richardsonii*	Desirable	0%	0%	1%	0.5%	1%	0.2%
Longleaf pondweed	*Potamogeton nodosus*	Desirable	0.5%	0.2%	0.3%	0.2%	0.4%	0.2%
Slender naid	*Najas flexillis*	Desirable	0%	0%	0.2%	0.1%	0.1%	0.05%
Eurasian watermilfoil	*Myriophyllym spicatum*	Undesirable	0%	0%	0.1%	0.03%	0.03%	0.02%
Stoneworts	*Nitella spp.*	Desirable	0.1%	0.04%	0%	0%	0.03%	0.02%
Fries' pondweed	*Potamogeton friesii*	Desirable	0.1%	0.04%	0%	0%	0.03%	0.02%



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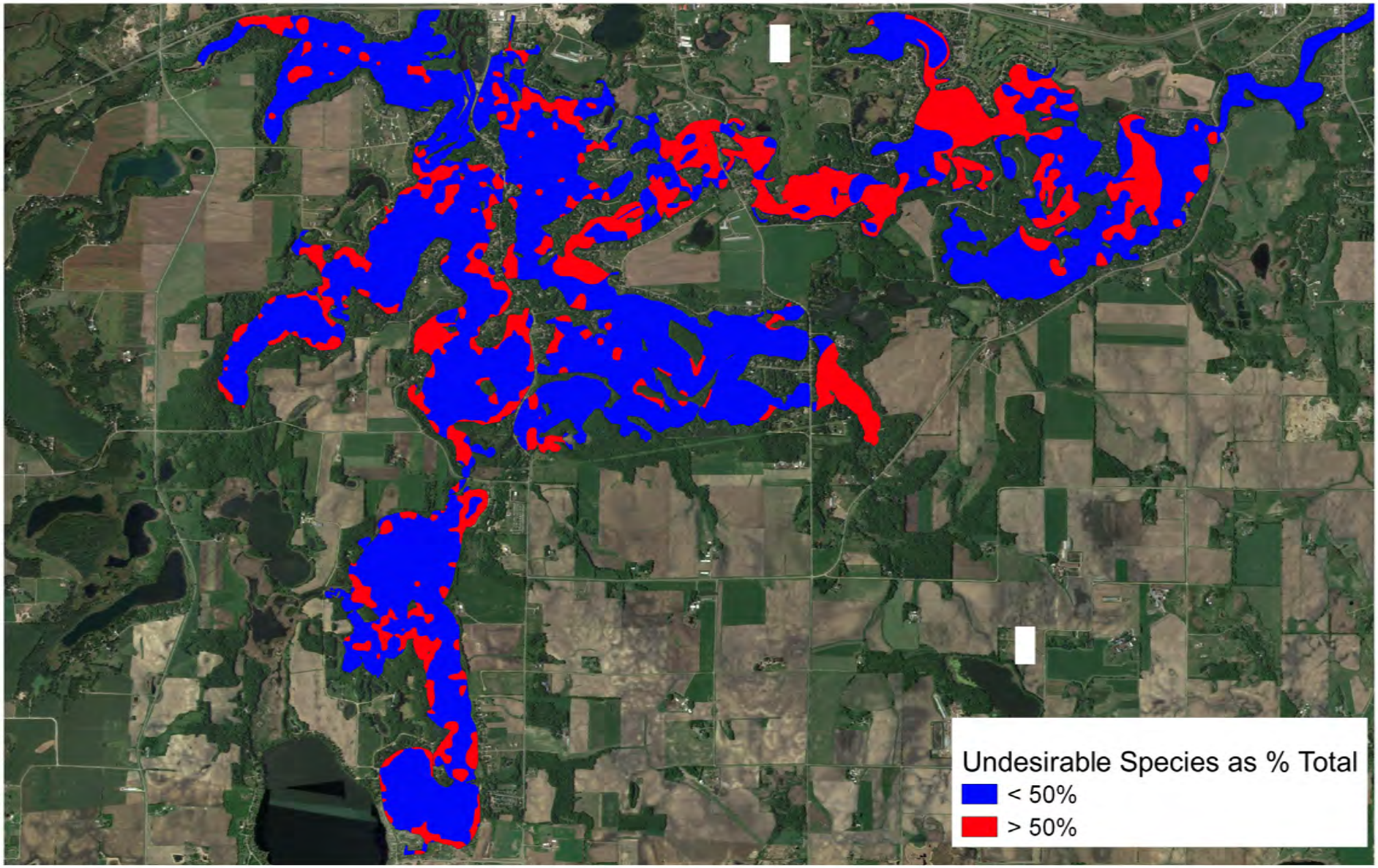
Sauk River Chain of Lakes
Hybrid/Eurasian Watermilfoil
2022



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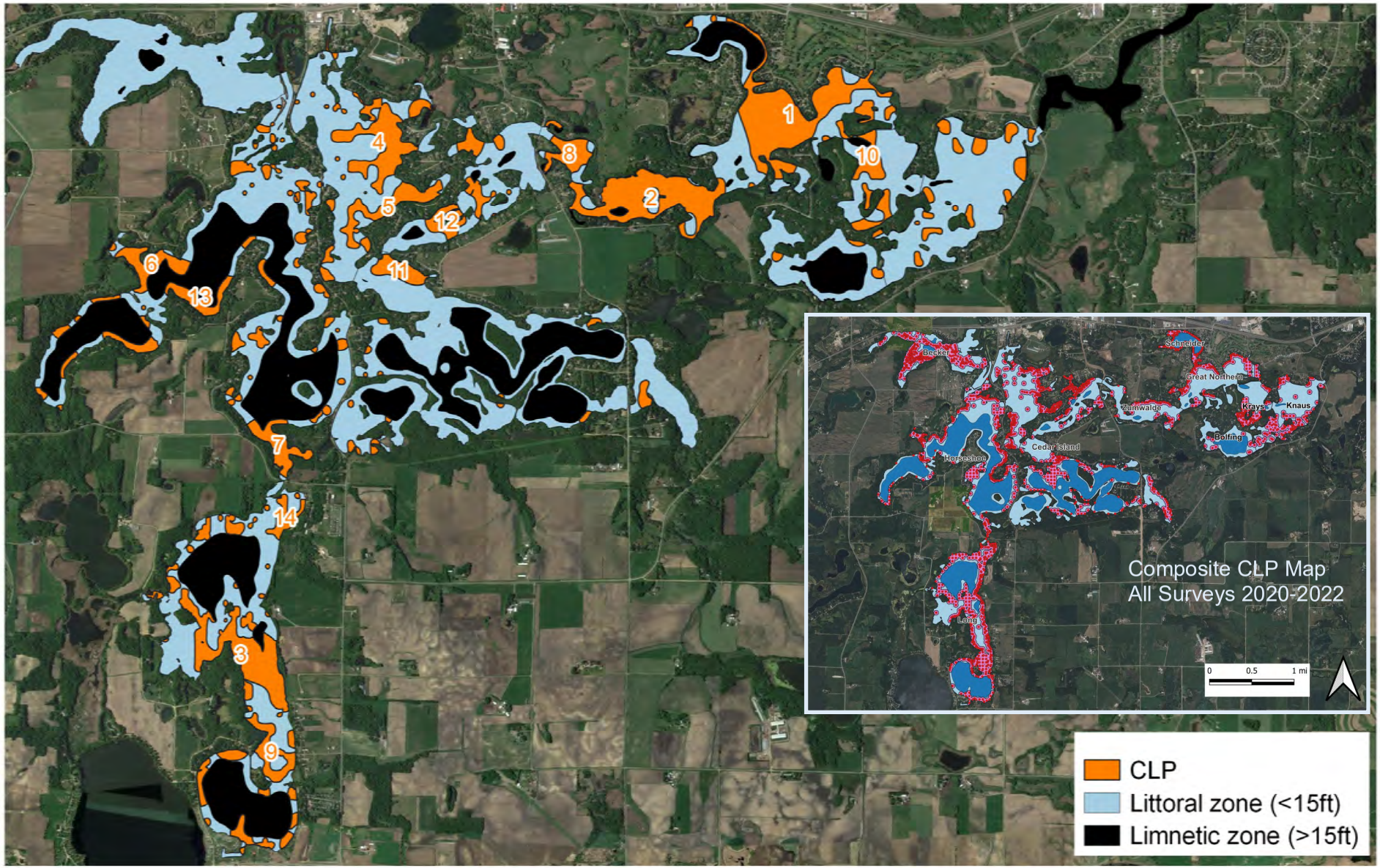

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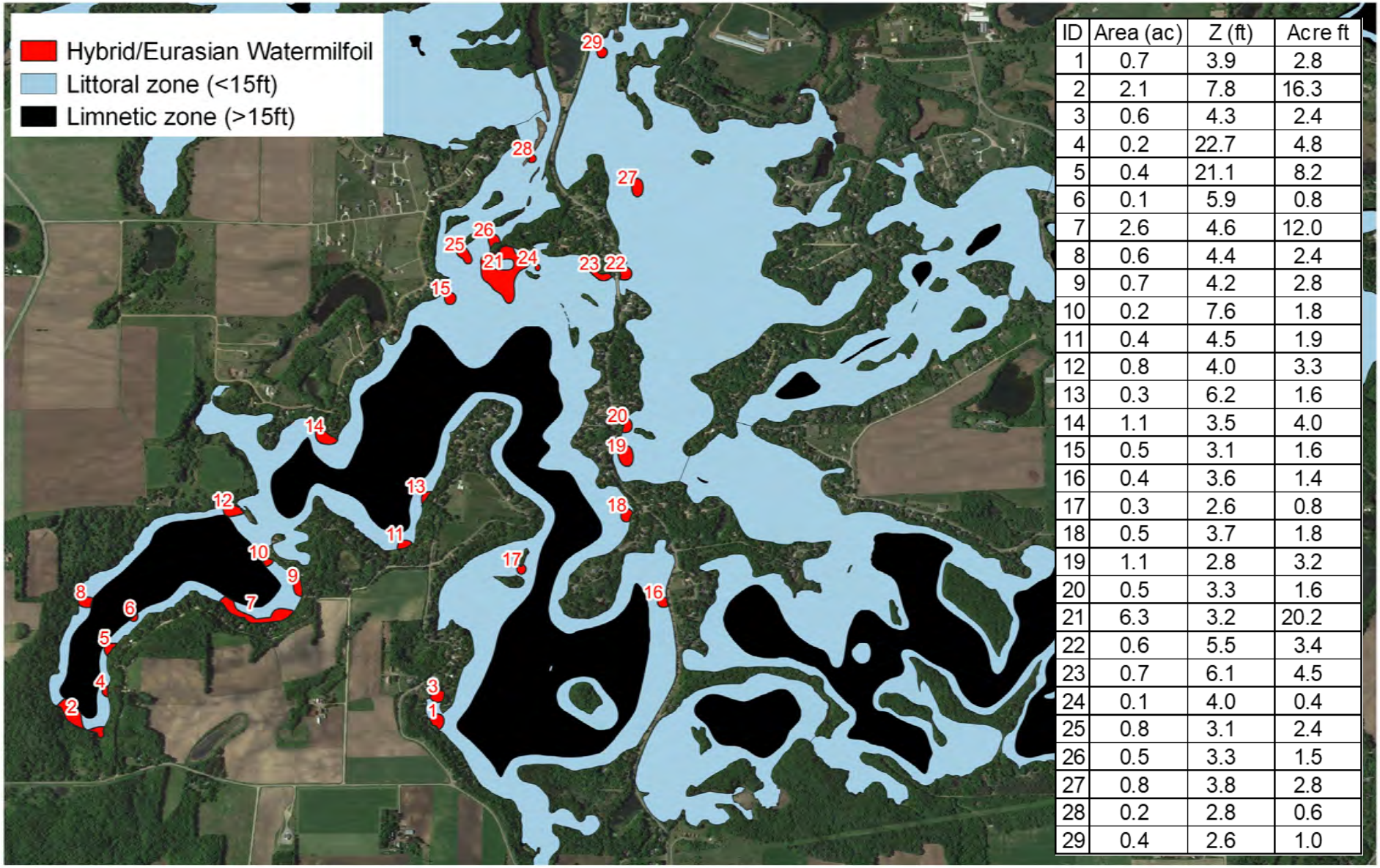
Sauk River Chain of Lakes
Curly leaf Pondweed
2022



ID	Area (ac)	Z (ft)	Acre ft
1	0.7	3.9	2.8
2	2.1	7.8	16.3
3	0.6	4.3	2.4
4	0.2	22.7	4.8
5	0.4	21.1	8.2
6	0.1	5.9	0.8
7	2.6	4.6	12.0
8	0.6	4.4	2.4
9	0.7	4.2	2.8
10	0.2	7.6	1.8
11	0.4	4.5	1.9
12	0.8	4.0	3.3
13	0.3	6.2	1.6
14	1.1	3.5	4.0
15	0.5	3.1	1.6
16	0.4	3.6	1.4
17	0.3	2.6	0.8
18	0.5	3.7	1.8
19	1.1	2.8	3.2
20	0.5	3.3	1.6
21	6.3	3.2	20.2
22	0.6	5.5	3.4
23	0.7	6.1	4.5
24	0.1	4.0	0.4
25	0.8	3.1	2.4
26	0.5	3.3	1.5
27	0.8	3.8	2.8
28	0.2	2.8	0.6
29	0.4	2.6	1.0

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Sauk River Chain of Lakes
Hybrid/Eurasian Watermilfoil
2022

Coontail

Curlyleaf Pondweed

Filamentous Algae

White Water Lily

Duckweeds

Hybrid Watermilfoil

Star Duckweed

Flatstem Pondweed

Watermeal

Greater Duckweed

Water Stargrass

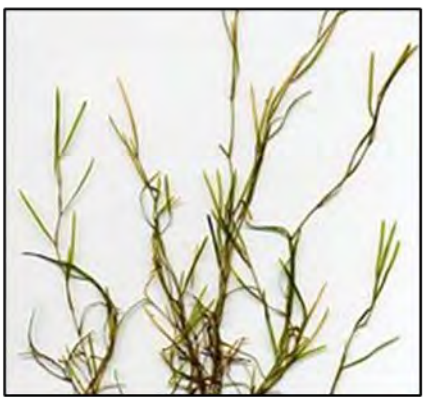
Sago Pondweed

Canada Waterweed

Cattails

Muskgrass

Small Pondweed



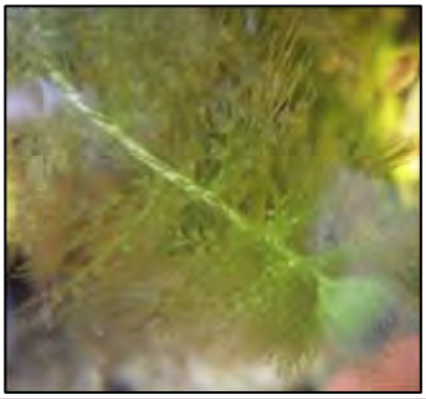
Sea Naiad

Water Celery

Northern Watermilfoil

Bullhead Pond Lily

Common Bladderwort



White Water Crowfoot

Claspingleaf Pondweed

Longleaf Pondweed

Mare's Eggs

Slender Naiad

Eurasian Watermilfoil

Stoneworts

Fries' Pondweed

Chinese Mystery Snail