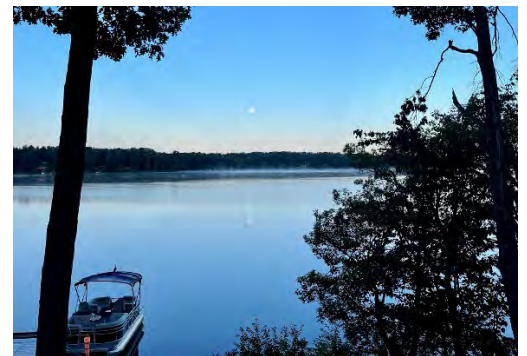


Half Moon Lake

2022 Eurasian Watermilfoil Management Results

Prepared for
Half Moon Lake Protection & Rehabilitation District

December 2022



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Abbreviations

AIS	Aquatic Invasive Species
APM	Aquatic Plant Management, LLC
ERS	Endangered Resource Services, LLC
EWM	Eurasian Watermilfoil
DASH	Diver Assisted Suction Harvesting
FQI	Floristic Quality Index
GPS	Global Positioning System
PI	Point Intercept
Sub PI	Sub Point Intercept
WDNR	Wisconsin Department of Natural Resources

1 Executive Summary

Eurasian watermilfoil (EWM) was first observed in Half Moon Lake at its boat landing on October 6th, 2021. A bed-mapping survey completed on October 30, 2021 indicated Eurasian watermilfoil (EWM) covered about 0.59 acres (0.24% of the plant inhabitable area). EWM spread rapidly during the spring of 2022. A spring pre-treatment plant survey was completed in which a pre-determined equally spaced grid of 119 sample points within the EWM areas documented by the fall 2021 plant survey were surveyed. The survey, termed a sub point intercept (sub PI) plant survey, documented all plant species within the surveyed area and their density. A spring bed-mapping survey was also completed to document EWM present in areas not included in the sub PI plant survey. The sub PI plant survey and EWM bed-mapping survey on June 8, 2022 documented 22.03 acres of EWM in Half Moon Lake. The Wisconsin Department of Natural Resources (WDNR) issued permits for the management of EWM in the lake on July 28. On August 1, the herbicide ProcellaCOR was applied to 13.71 acres and Diver Assisted Suction Harvesting (DASH) removed 158 cubic feet of EWM from an area of 8.32 acres in the lake during August 8 through 12, 2022.

A July 1 plant survey documented 0.82 acres of EWM not previously observed in the lake. Although a WDNR permit for DASH removal of the EWM was issued on July 28, the EWM was not removed in 2022.

A post-treatment bed-mapping survey on September 18 documented 0.95 acres of EWM in the lake. A bed-mapping survey on October 15 documented an additional 0.05 acres of EWM. The Half Moon Lake Protection and Rehabilitation District intends to treat the EWM with ProcellaCOR in spring of 2023. The proposed treatment areas include 15 individual treatment areas each ranging from 0.39 to 0.78 acres and totaling 7.01 acres.

Pre-treatment and post-treatment sub point intercept plant surveys were completed on June 8 and September 18 to assess the plant community within EWM managed areas. The data document several favorable changes to the plant community following EWM management, including increases in the number of species, increases in plant diversity measured by Simpson's Diversity Index, improved quality of the plant community as measured by the Floristic Quality Index (FQI), and increases in plant frequency and density. Factors likely causing the changes include seasonal changes in the plant community between June and September and removal of EWM from the monitored areas. A significant post-treatment frequency decrease for EWM documents the success of the EWM removal efforts. Significant post-treatment frequency increases occurred for filamentous algae and 7 native plant species. The increased frequency of the native plant species is a positive change for the lake.

A whole lake point intercept plant survey of Half Moon Lake was completed on July 1 to assess the lake's entire plant community. The survey results indicate the Half Moon Lake plant community was healthy and diverse.

Half Moon Lake aquatic plant data collected during July 16 through 17, 2007 by the WDNR and during June 21 through 23, 2018 and July 1, 2022 by the Half Moon Lake Protection and Rehabilitation District were compared to assess changes. Favorable changes in the plant community since 2018 include increases in plant frequency, average number of native plant species per sample location, average density,

and FQI, which indicates improved quality of the plant community. Six native plant species significantly increased in frequency between 2018 and 2022 while 2 native plant species significantly decreased in frequency. Both the maximum depth of plant growth and the mean depth of plant growth were lower in 2022 than 2007 and 2018.

While EWM is the Aquatic Invasive Species (AIS) of primary concern in Half Moon Lake for residents, two additional AIS were observed during 2022, hybrid cattail and curly-leaf pondweed. Hybrid cattail was found at the same location in the northwestern corner of the lake during 2018 and 2022. Because it is only found at one location and has not spread, it is not considered problematic. In 2022, curly-leaf pondweed was found at fewer locations (2 locations) than 2007 (3 locations) and 2018 (4 locations). In 2022, the plant surveyor commented that most curly-leaf pondweed plants were observed in 5 to 10 feet of water over organic muck and there was very little of this type of habitat in the lake.

2 Introduction

Half Moon Lake, located in the Town of Milltown in Central Polk County, Wisconsin, is a 550-acre stratified drainage lake. It reaches a maximum depth of 60 feet in the deep hole on the southeast end of the central basin and has an average depth of 25 feet (WDNR 2022).

Eurasian watermilfoil (EWM) was first observed in Half Moon Lake at its boat landing on October 6th, 2021. A bed mapping survey of the EWM on October 30th, 2021 indicated it covered about 0.59 acres (0.24% of the plant inhabitable area). EWM extent from the October 30th survey is shown in Figure 1. The Half Moon Lake Protection and Rehabilitation District, with assistance from Barr Engineering Co., applied for and was awarded a WDNR Rapid Response Grant to help fund EWM management efforts. This report presents the results of 2022 Half Moon Lake EWM management efforts and plant surveys completed for the project.



Figure 1 Fall 2021 EWM Extent in Half Moon Lake

3 2022 Plant Survey Methods

Multiple plant surveys were completed in 2022 to (1) determine EWM extent, (2) determine locations requiring EWM removal, (3) determine results of EWM removal efforts, (4) assess the plant community before and after EWM removal, (5) and determine locations requiring EWM removal in 2023. Pre-treatment plant surveys included a sub point intercept (sub PI) plant survey and EWM bed-mapping survey June 8 and a whole lake point intercept plant survey on July 1. The sub PI survey was a detailed survey of the areas in which EWM was documented during the fall of 2021. For the sub PI survey, a pre-determined equally spaced grid of 119 sample points was surveyed to document all plant species within the surveyed areas and their density. Post-treatment plant surveys include a sub PI plant survey and EWM bed-mapping survey on September 18 and a EWM bed-mapping survey on October 15. Plant survey methods are detailed in the following paragraphs.

3.1 2022 Pre-Treatment Plant Surveys on Half Moon Lake

3.1.1 June Sub Point Intercept (Sub PI) and Bed-Mapping Surveys

Endangered Resource Services (ERS), LLC, a subcontractor to Barr, completed a pre-treatment sub PI plant survey on June 8. For the survey, a total of 119 sample points were surveyed within the EWM beds and high density EWM areas identified in the fall 2021 plant survey (Figure 2). ERS located equally spaced preset points in the field with a global positioning system (GPS) and took measurements at each point. The measurements included the following:

1. Individual species present
2. The overall density of plants, as measured by the rake method
3. The density of individual species, as measured by the rake method
4. Water depth
5. Dominant sediment type

ERS also completed a EWM bed-mapping survey of Half Moon Lake in areas not included in the sub PI survey. ERS used transects to locate EWM, including beds, high density areas, multiple EWM plants that are not considered beds or high-density areas, and single EWM plants.

Following the pre-treatment plant surveys, ERS summarized the survey data in tabular format and prepared a map showing the boundaries of EWM beds, high density areas, and EWM areas of multiple plants, and locations of single EWM plants.



Figure 2 Sample Points for June 8, 2022 Sub PI Plant Survey

3.1.2 July 1 Whole Lake Aquatic Plant Survey

ERS performed a pre-treatment whole lake plant survey on July 1 to assess the distribution and growth density of all plants in the lake including EWM. ERS conducted the plant survey according to the methodologies used in the 2018 Point Intercept (PI) plant survey of Half Moon Lake and incorporated assessments at the same 734 GPS points surveyed in 2018 and shown in Figure 3 ERS located the equally spaced preset points in the field with a Global Positioning System (GPS) and took measurements at each point.

A rake was used to collect plant samples at each sample location and the overall quantity of plants on the rake was determined to evaluate plant density. Next, the individual species collected on the rake were identified. After identification of each species, the quantity of each individual species was determined to evaluate the plant density of each species at each sample location. Rake fullness was used to determine the overall quantity (density) of plants and the quantity (density) of individual species at each sample location. Rake fullness is measured on a scale of 1 to 3 where:




<u>Rating</u>	<u>Coverage</u>	<u>Description</u>
1		A few plants on rake head
2		Rake head is about ½ full Can easily see top of rake head
3		Overflowing Cannot see top of rake head

Figure 3 Rake fullness rating, rake coverage, and description of rake fullness rating (Source: Endangered Resource Services, LLC, 2021)

Water depth and dominant sediment type were determined and documented for each sample location.

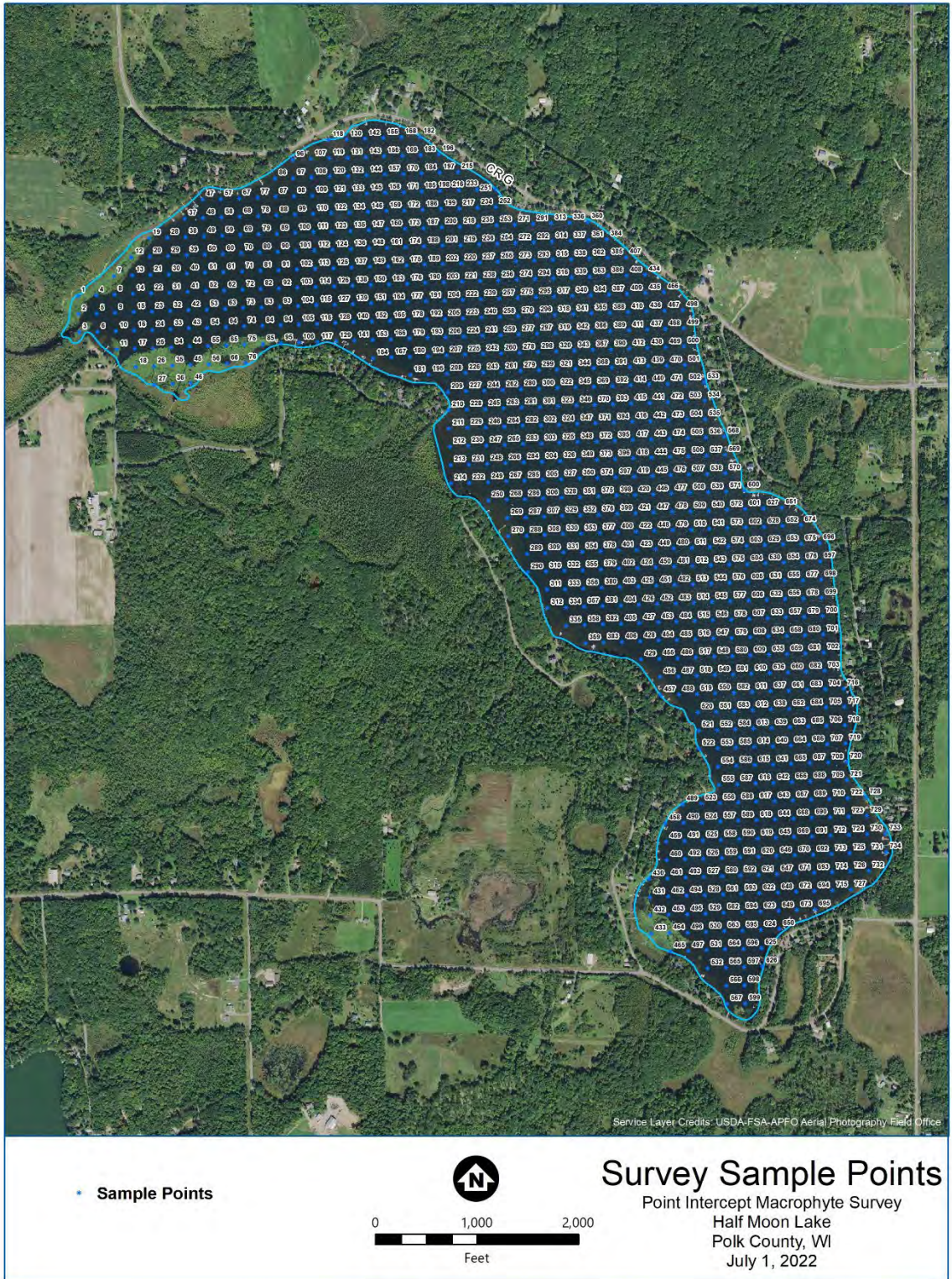


Figure 4 Sample Points for July 1, 2022 Point Intercept Plant Survey

3.2 2022 Post-Treatment Plant Surveys on Half Moon Lake

3.2.1 September Sub Point Intercept (Sub PI) and Bed-Mapping Surveys

ERS completed a post-treatment sub PI plant survey on September 18 at the sample points surveyed on June 8 (Figure 2) using the same sample methodology used for the June 8 survey.

ERS also completed a EWM bed-mapping survey of Half Moon Lake on September 18 in areas not included in the sub PI survey. ERS used transects to locate EWM, including beds, high density areas, multiple EWM plants that are not considered beds or high-density areas, and single EWM plants.

Following the post-treatment plant surveys, ERS summarized the survey data in tabular format and prepared a map showing the boundaries of EWM beds, high density areas, and EWM areas of multiple plants, and locations of single EWM plants.

3.2.2 October Bed-Mapping Survey

ERS completed a EWM bed-mapping survey of Half Moon Lake on October 15. ERS used transects throughout the lake's littoral area to locate EWM, including beds, high density areas, multiple EWM plants that are not considered beds or high-density areas, and single EWM plants. Following the bed-mapping survey, ERS created a map showing the boundaries of EWM beds, high density areas, and EWM areas of multiple plants, and locations of single EWM plants.

4 EWM Extents and EWM Management

4.1 June 8 EWM Extent and 2022 EWM Management

The June 8 sub PI plant survey and EWM bed-mapping survey documented 22.03 acres of EWM in Half Moon Lake (Figure 5). The plant surveyor commented, "Floating EWM fragments common throughout – plant appears to be spreading rapidly."

The Half Moon Lake Protection and Rehabilitation District contracted with Aquatic Plant Management, LLC (APM) to obtain WDNR permits and manage the EWM in the lake. After receiving WDNR permits on July 28, APM completed ProcellaCOR treatment of 13.71 acres of EWM on August 1 (Figure 6) and DASH removal of 158 cubic feet of EWM from 8.32 acres during August 8 through 12 (Figure 7).

The effectiveness of the ProcellaCOR and DASH EWM removal was documented by post-treatment plant surveys on September 18 and October 15. In fall 2022, EWM was visually observed at only 1 sample location within the 2022 EWM managed areas (Figure 8). However, spread of EWM to areas not managed in 2022 resulted in EWM beds with an extent of 1.0 acre and single EWM plants at two locations during fall 2022 (Figure 8).

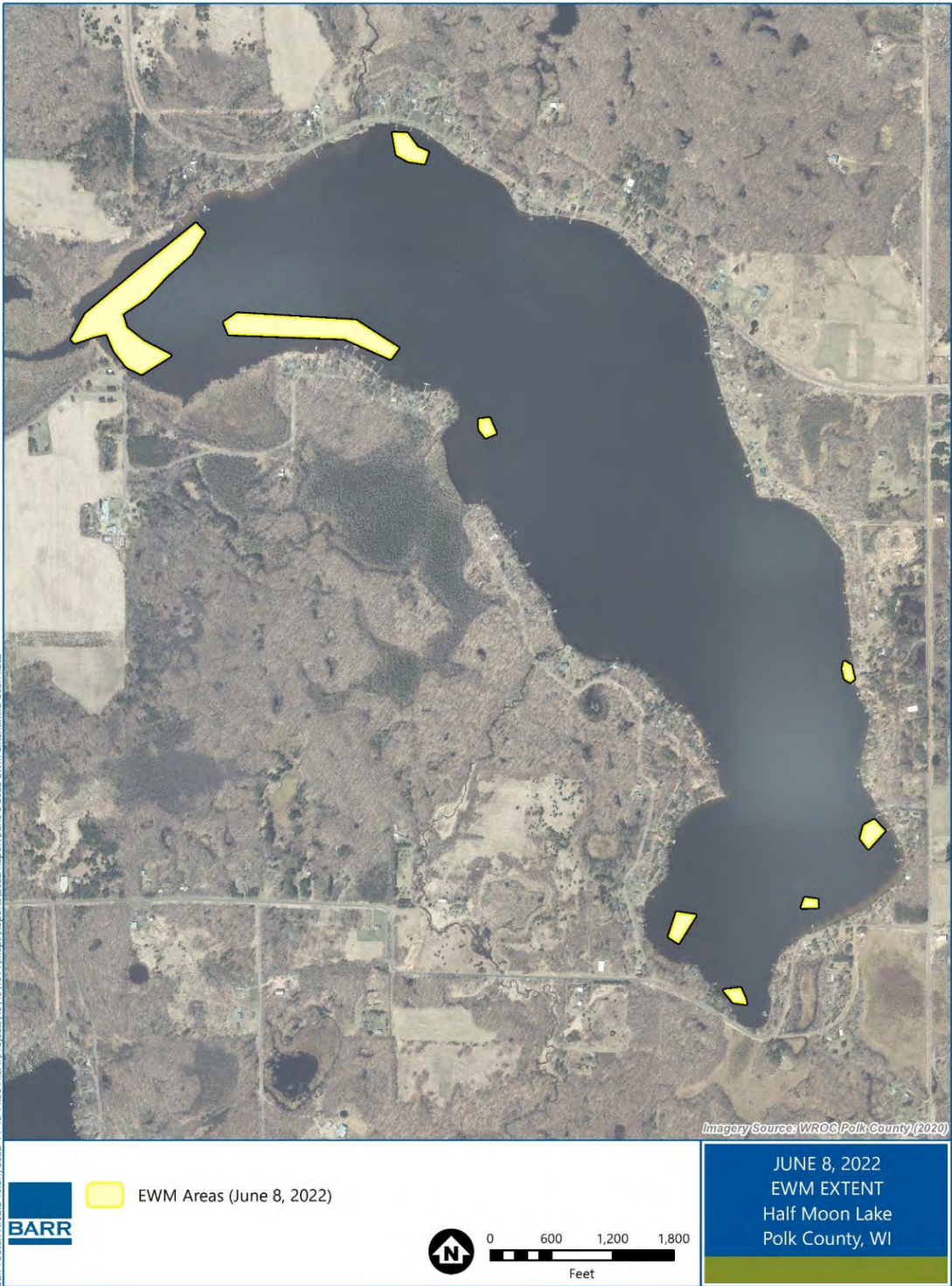


Figure 5 EWM Extent in Half Moon Lake on June 8, 2022

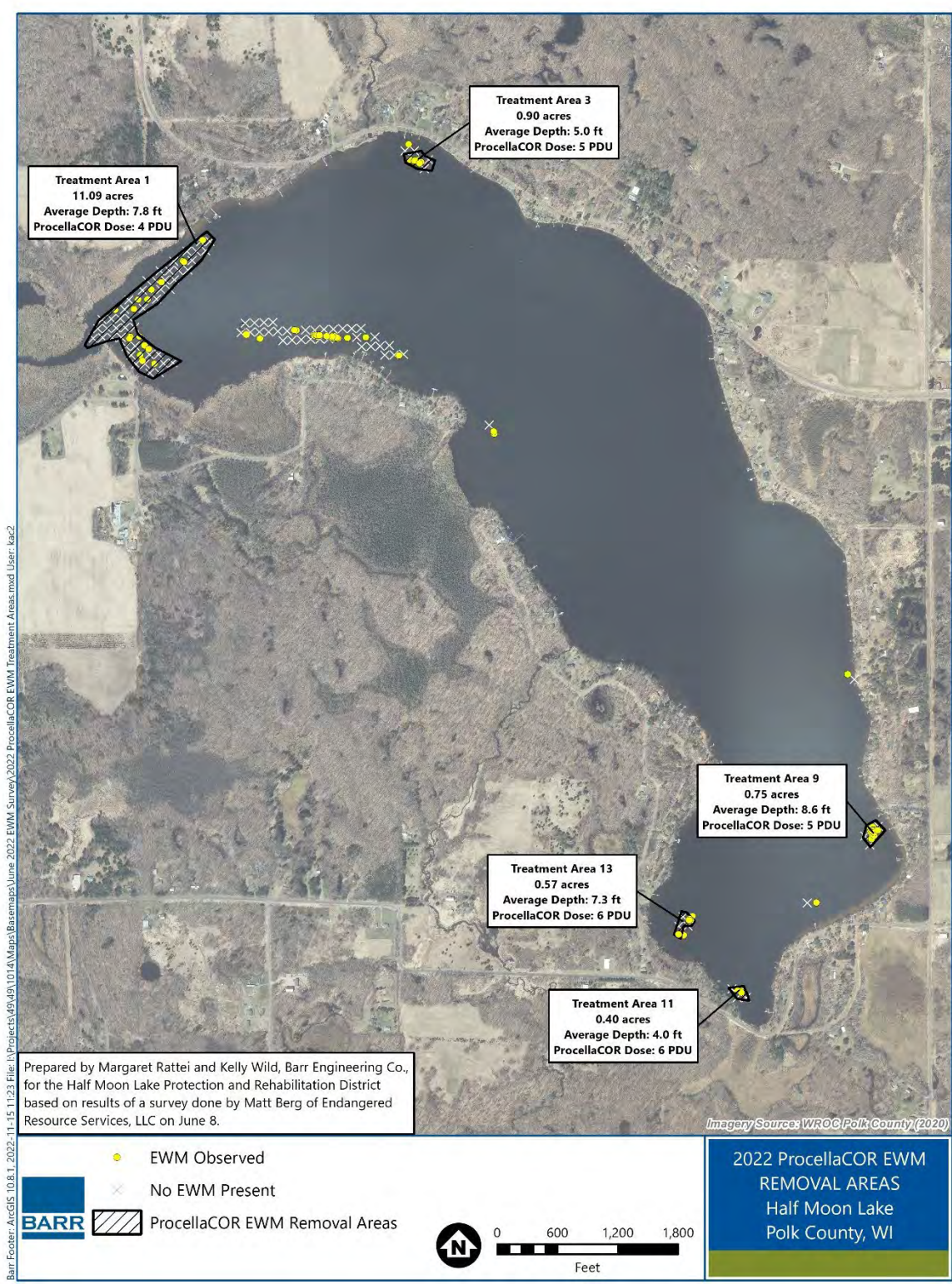


Figure 6 August 1, 2022 ProcellaCOR Treatment Areas in Half Moon Lake

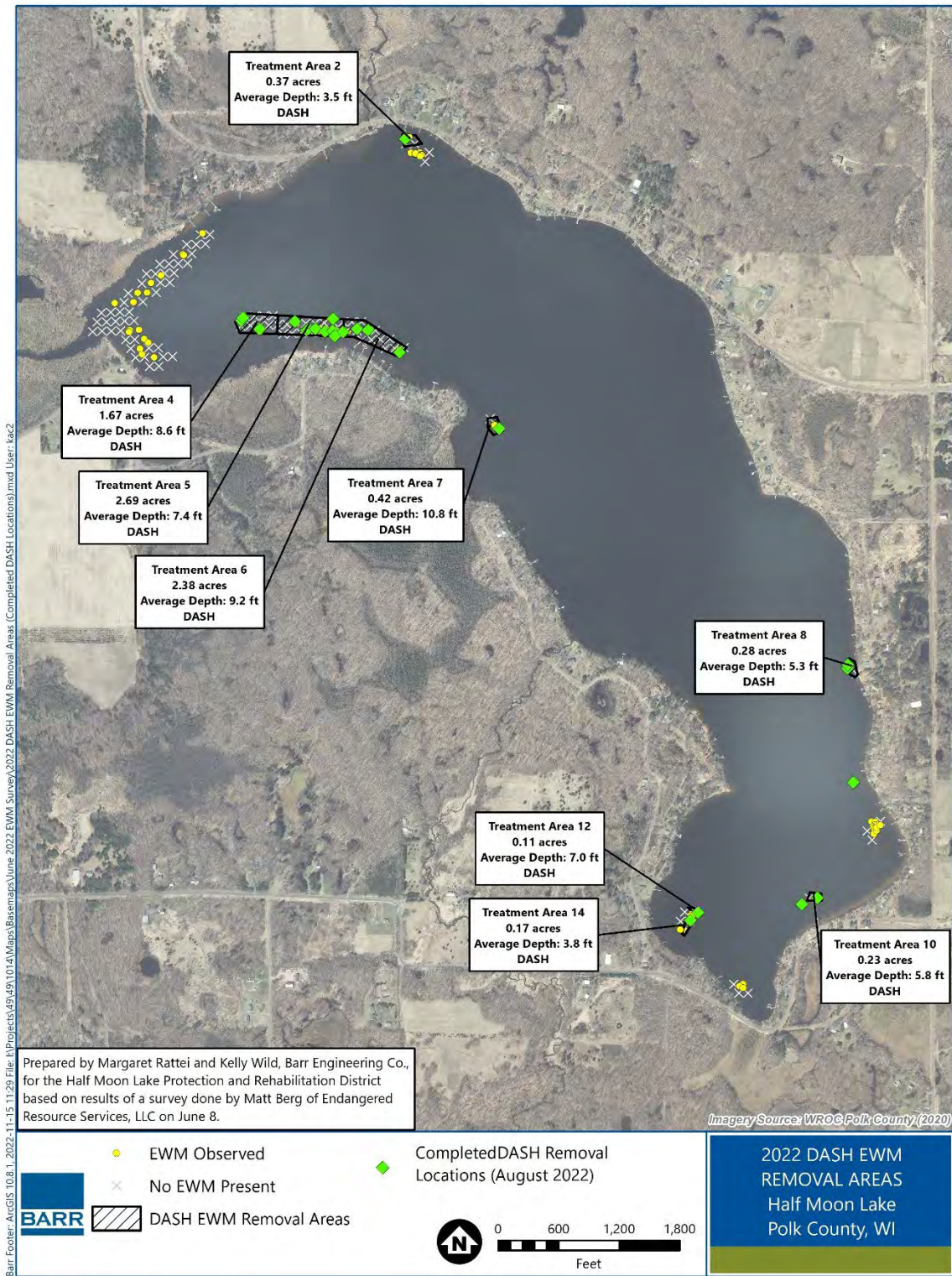


Figure 7 August 8-12, 2022 DASH EWM Removal Areas in Half Moon Lake

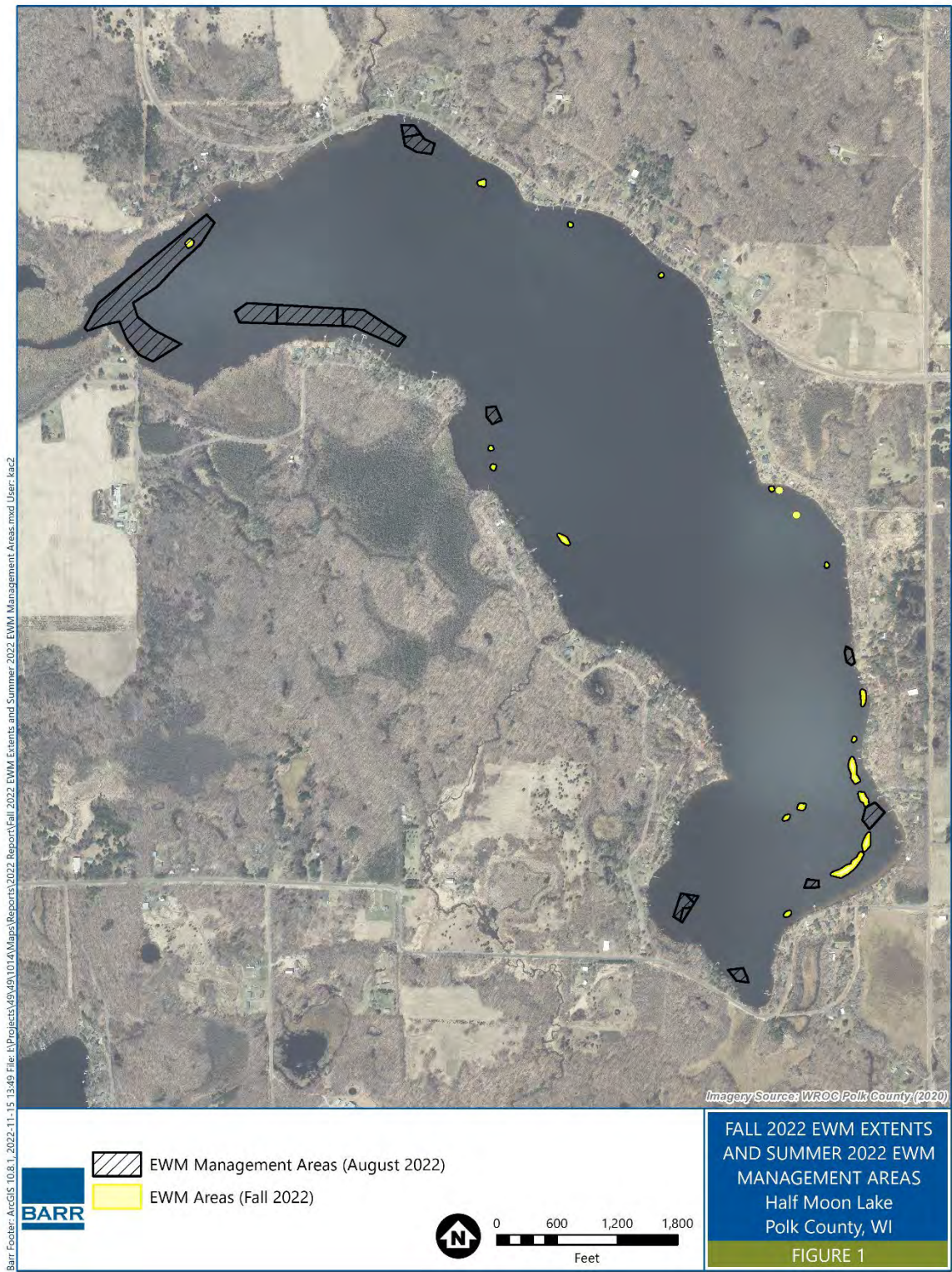


Figure 8 Comparison of Fall 2022 EWM Extents with Summer 2022 EWM Management Areas

4.2 July 1 EWM Extent

As shown in Figure 9, the July 1 whole lake point intercept plant survey documented the presence of 0.82 acres of EWM that had not previously been observed in the lake. The Half Moon Lake Protection and Rehabilitation District contracted with Aquatic Plant Management, LLC (APM) to obtain a WDNR permit and remove the EWM. A WDNR permit for DASH removal of the EWM shown in Figure 9 was received on July 28. However, the EWM was not removed in 2022.

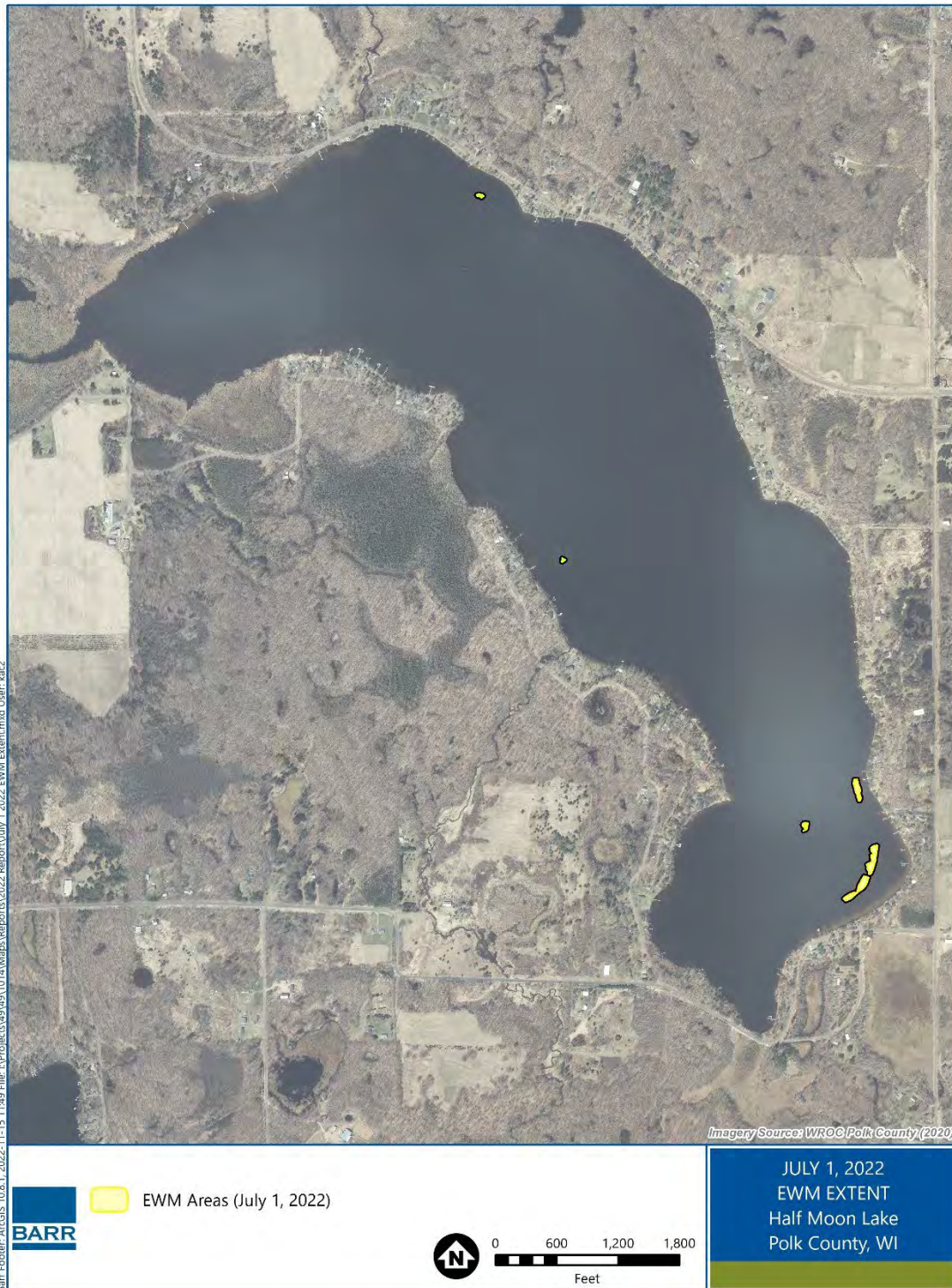


Figure 9 2022 EWM Areas Based on July 1 Survey Results

4.3 Fall EWM Extent and Proposed 2023 EWM Management

A post-treatment bed-mapping survey on September 18 documented 0.95 acres of EWM beds and single EWM plants at two locations (Figure 10). A bed-mapping survey on October 15 documented an additional 0.05 acres of EWM (Figure 11) that was not observed on September 18. The Half Moon Lake Protection and Rehabilitation District intends to treat the EWM with ProcellaCOR in spring of 2023. The proposed treatment areas include 15 individual treatment areas each ranging from 0.39 to 0.78 acres and totaling 7.01 acres (Figure 12).

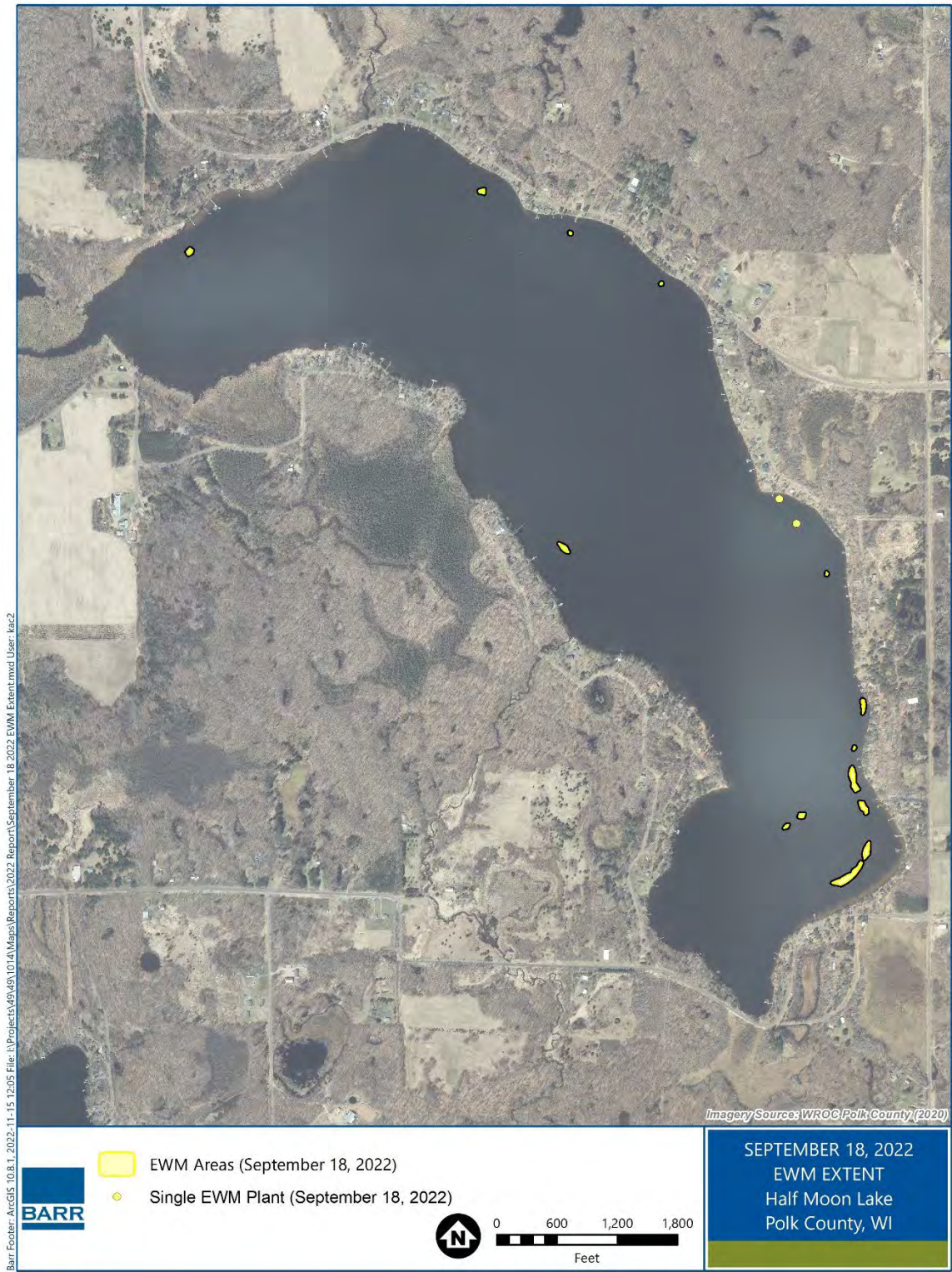


Figure 10 2022 EWM Areas Based on September 18 Survey Results



Barr Fochler ArcGIS 10.8.1, 2022-11-15 13:39 File: I:\Projects\491401\Map\Reports\2022 Report\October_15_2022 EWM_Extent.mxd User: jac2

Figure 11 2022 EWM Areas Based on October 15 Survey Results

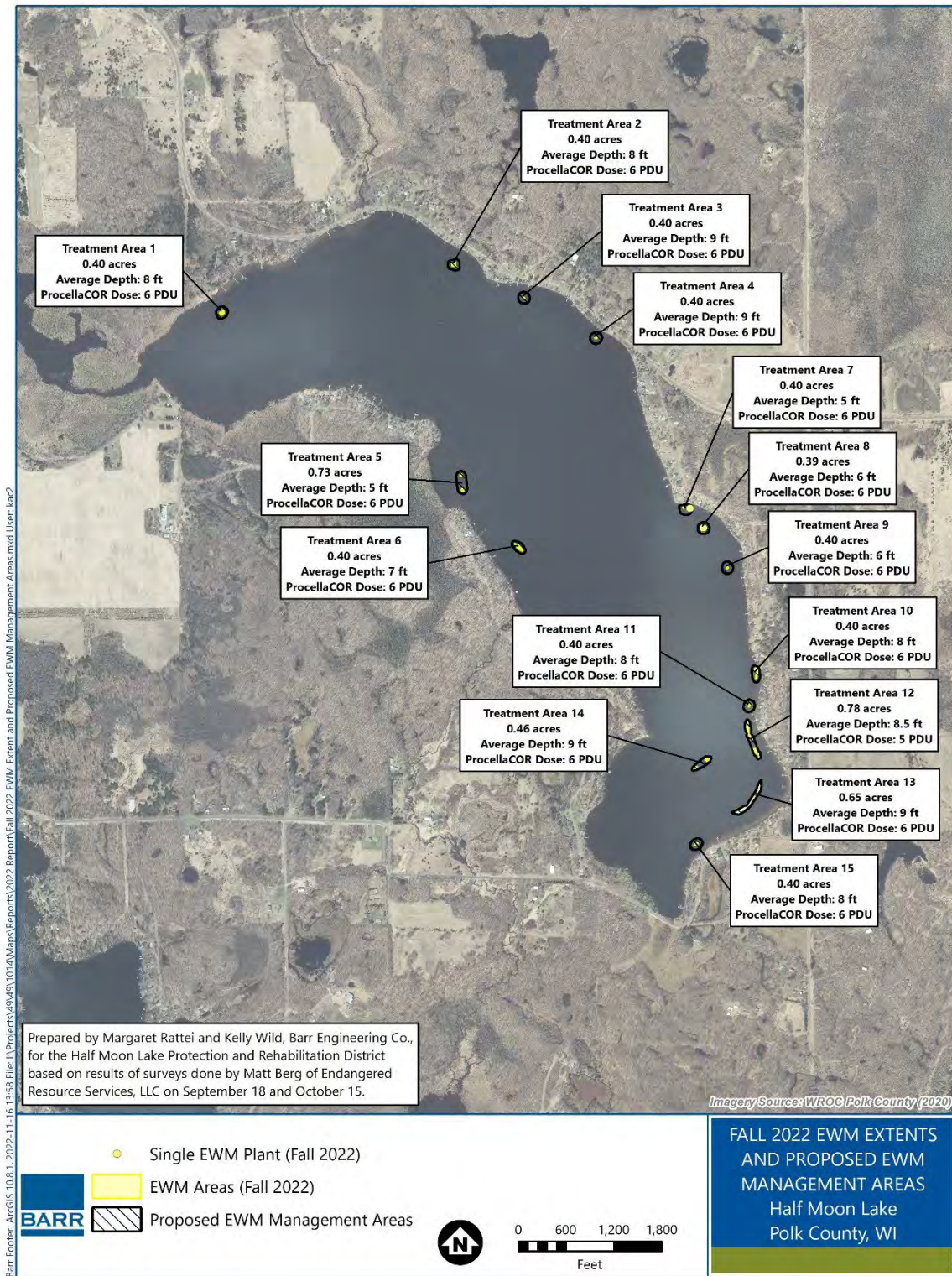


Figure 12 Proposed 2023 Half Moon Lake ProcellaCOR Treatment

5 Assessment of Half Moon Lake Plant Community

5.1 Comparison of June 8 and September 18 sub PI Survey Results

Pre-treatment and post-treatment sub PI plant surveys were completed on June 8 and September 18 to assess the plant community within EWM managed areas. Sample points are shown in Figure 2. The survey results are summarized in Table 1, Table 2, Figure 13, Appendix A, and Appendix B.

Post-treatment data document increases in the number of plant species (from 26 to 30), average number of native species per sites shallower than the maximum depth of plant growth (from 2.6 to 3.4), plant diversity as measured by the Simpson Diversity Index (from 0.89 to 0.92), the quality of the plant community as measured by the Floristic Quality Index (FQI) (from 32 to 35), plant frequency (from 92 percent to 97 percent), and plant density as measured by mean rake fullness (from 2.1 to 2.2) (Table 1). The increases are favorable changes for the lake’s plant community. Factors likely causing the increases include seasonal changes in the plant community between June and September and removal of EWM from the monitored areas.

Significant frequency changes of species before and after EWM removal from the managed areas were documented by a Chi Squared analysis of June 8 and September 18 data. A significant post-treatment frequency decrease for EWM documents the success of the EWM removal efforts (Figure 13 and Table 2). Significant post-treatment frequency increases occurred for filamentous algae and 7 native plant species—small duckweed (*Lemna minor*), slender naiad (*Najas flexilis*), nitella (*Nitella sp.*), variable pondweed (*Potamogeton gramineus*), floating-leaf pondweed (*Potamogeton natans*), wild celery (*Vallisneria americana*), and common watermeal (*Wolffia columbiana*) (Figure 13 and Table 2). Factors likely causing the increases include seasonal changes in the plant community between June and September and removal of EWM from the monitored area. The increased frequency of the native species is a positive change for the lake.

Table 1 Half Moon Lake 2022 Sub PI Summary Statistics

SUMMARY STATS:	6/8/2022	9/18/2022
Total number of points sampled	119	119
Total number of sites with vegetation	109	112
Total number of sites shallower than maximum depth of plants	118	115
Frequency of occurrence of all species at sites shallower than maximum depth of plants	92.4	97.4
Simpson Diversity Index	0.89	0.92
Maximum depth of plants (ft)	17.5	16.5
Average number of all species per site (shallower than max depth)	2.7	3.4
Average number of all species per site (veg. sites only)	2.9	3.5
Average number of native species per site (shallower than max depth)	2.6	3.4
Average number of native species per site (veg. sites only)	2.8	3.5
Species Richness	26	29

SUMMARY STATS:	6/8/2022	9/18/2022
Species Richness (including visuals)	26	30
Species Richness (including visuals and boat survey)	26	30
Mean depth of plants (ft)	6.8	6.9
Median depth of plants (ft)	6.0	6.0
Mean rake fullness (veg. sites only)	2.1	2.2
Mean C	6.5	6.4
FQI	31.8	34.7

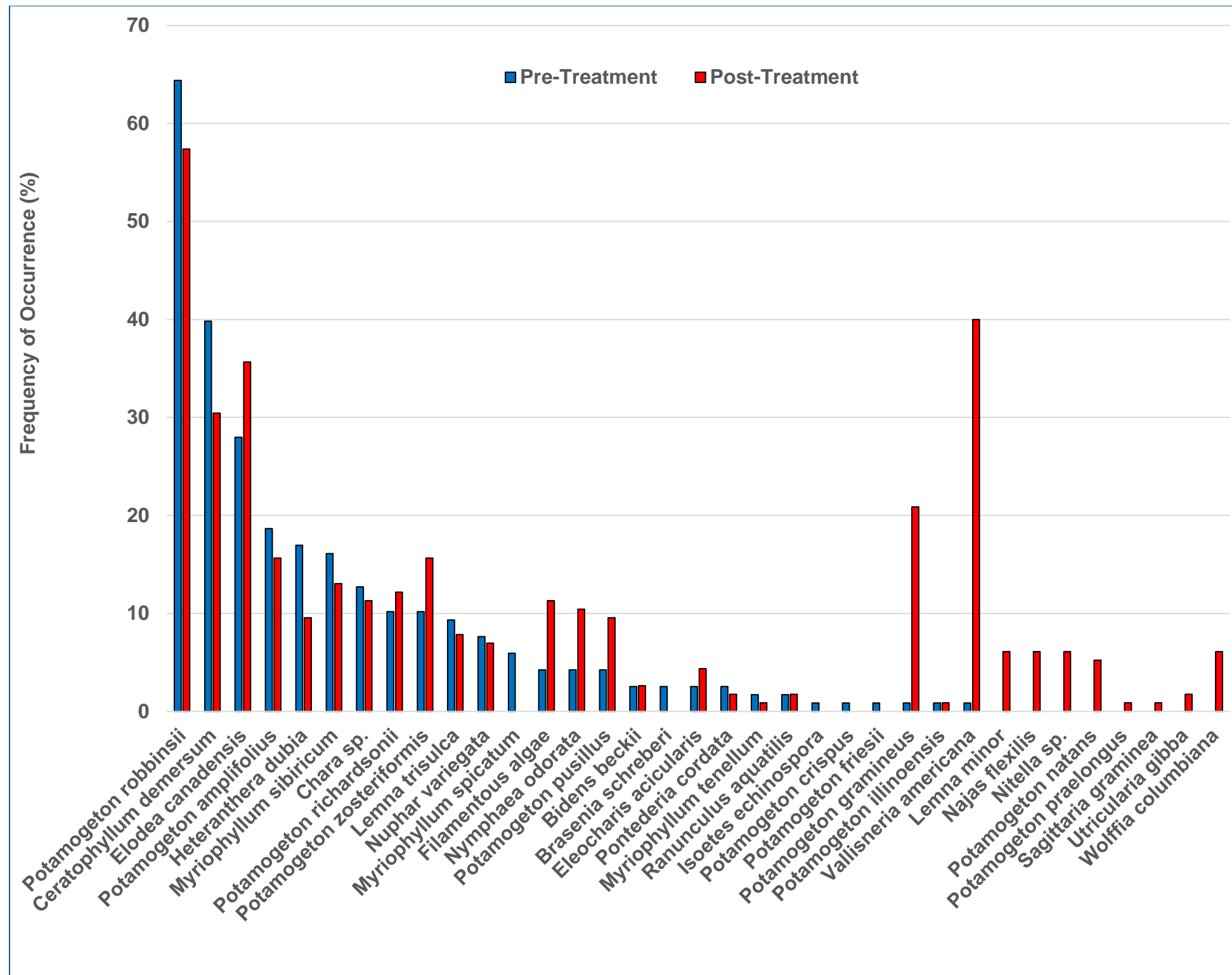


Figure 13 Comparison of Half Moon Lake Pre-Treatment (June 8) and Post-Treatment (September 18) Frequency of Occurrence (% of Sites Shallower than Maximum Depth of Plants)

Table 2 Half Moon Lake 2022 Sub PI Survey Results: Frequency of Occurrence at Sites Shallower Than Maximum Depth of Plant and Significant Change Between June 8 and September 18

Scientific Name	Common Name	Frequency of occurrence at sites shallower than maximum depth of plants		Significant Changes 6/8/2022 to 9/18/2022	Significant Increase/Decrease
		06/08/22	09/18/22		
<i>Bidens beckii</i>	Water marigold	2.54	2.61	--	--
<i>Brasenia schreberi</i>	Watershield	2.54	0.00	--	--
<i>Ceratophyllum demersum</i>	Coontail	39.83	30.43	--	--
<i>Chara sp.</i>	Muskgrass	12.71	11.30	--	--
<i>Eleocharis acicularis</i>	Needle spikerush	2.54	4.35	--	--
<i>Elodea canadensis</i>	Common waterweed	27.97	35.65	--	--
Filamentous algae	Filamentous algae	4.24	11.30	*	Increase
<i>Heteranthera dubia</i>	Water star-grass	16.95	9.57	--	--
<i>Isoetes echinospora</i>	Spiny-spored quillwort	0.85	0.00	--	--
<i>Lemna minor</i>	Small duckweed	0.00	6.09	**	Increase
<i>Lemna trisulca</i>	Forked duckweed	9.32	7.83	--	--
<i>Myriophyllum sibiricum</i>	Northern watermilfoil	16.10	13.04	--	--
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	5.93	0.00	**	Decrease
<i>Myriophyllum tenellum</i>	Dwarf watermilfoil	1.69	0.87	--	--
<i>Najas flexilis</i>	Slender naiad	0.00	6.09	**	Increase
<i>Nitella sp.</i>	Nitella	0.00	6.09	**	Increase
<i>Nuphar variegata</i>	Spatterdock	7.63	6.96	--	--
<i>Nymphaea odorata</i>	White water lily	4.24	10.43	--	--
<i>Pontederia cordata</i>	Pickeralweed	2.54	1.74	--	--
<i>Potamogeton amplifolius</i>	Large-leaf pondweed	18.64	15.65	--	--
<i>Potamogeton crispus</i>	Curly-leaf pondweed	0.85	0.00	--	--
<i>Potamogeton friesii</i>	Fries' pondweed	0.85	0.00	--	--
<i>Potamogeton gramineus</i>	Variable pondweed	0.85	20.87	***	Increase
<i>Potamogeton illinoensis</i>	Illinois pondweed	0.85	0.87	--	--
<i>Potamogeton natans</i>	Floating-leaf pondweed	0.00	5.22	*	Increase
<i>Potamogeton praelongus</i>	White-stem pondweed	0.00	0.87	--	--
<i>Potamogeton pusillus</i>	Small pondweed	4.24	9.57	--	--
<i>Potamogeton richardsonii</i>	Clasping-leaf pondweed	10.17	12.17	--	--
<i>Potamogeton robbinsii</i>	Fern pondweed	64.41	57.39	--	--
<i>Potamogeton zosteriformis</i>	Flat-stem pondweed	10.17	15.65	--	--
<i>Ranunculus aquatilis</i>	White water crowfoot	1.69	1.74	--	--
<i>Sagittaria graminea</i>	Grass-leaved arrowhead	0.00	0.87	--	--
<i>Utricularia gibba</i>	Creeping bladderwort	0.00	1.74	--	--
<i>Vallisneria americana</i>	Wild celery	0.85	40.00	***	Increase
<i>Wolffia columbiana</i>	Common watermeal	0.00	6.09	**	Increase

A p value, or probability value, describes how likely it is that the differences are due to random chance and, hence, are not statistically significant differences.

* means $p \leq 0.05$ and there is less than a 5% probability; ** means $p \leq 0.01$ and indicates there is less than a 1 percent probability; *** means $p \leq 0.001$ and indicates there is less than a 0.1 percent probability.

5.2 Results of July 1 Whole Lake Point Intercept Plant Survey

A whole lake point intercept plant survey of Half Moon Lake was completed on July 1 to assess the lake’s entire plant community. The survey results indicate the Half Moon Lake plant community was healthy and diverse. A total of 55 species were observed, 52 native species and 3 non-native species (EWM; curly-leaf pondweed, *Potamogeton crispus*; and hybrid cattail, *Typha X glauca*) (Table 3 and Figure 14). The number of species in Half Moon Lake was nearly 4 times greater than the median value for lakes in the same ecoregion (median value of North Central Hardwood Forests is 14) (Nichols 1999). The maximum water depth plants were found growing in was 18 feet (Table 3). The area of the lake up to the 18-foot depth is called the littoral area of the lake because this is the area of the lake in which plants were found growing. A total of 235 sample points were found in the littoral area of the lake and 205 sample points had vegetation. Hence, plants were found in 87 percent of the sample sites in the littoral area. Plant species abundance was balanced between many types and 79 percent of the lake’s plant species had a frequency of less than 10 percent (i.e., were found at less than 10 percent of the sample locations within the littoral area of the lake). The 12 most prevalent species in Half Moon Lake, ranging in frequency from 11 percent to 39 percent, were muskgrass (*Chara sp.*), variable pondweed (*Potamogeton gramineus*), fern pondweed (*Potamogeton robbinsii*), coontail (*Ceratophyllum demersum*), common waterweed (*Elodea canadensis*), northern watermilfoil (*Myriophyllum sibiricum*), flat-stem pondweed (*Potamogeton zosteriformis*), needle spikerush (*Eleocharis acicularis*), small pondweed (*Potamogeton pusillus*), wild celery (*Vallisneria americana*), dwarf watermilfoil (*Myriophyllum tenellum*), and large-leaf pondweed (*Potamogeton amplifolius*) (Figure 14).

Plant density in Half Moon Lake was measured by rake fullness on a scale of 1 (low) to 3 (high) (Figure 3). In 2022, plant density ranged from low to high (Figure 15). The average rake fullness in the lake’s vegetated sample sites was 2.1 indicating, on average, the rake was about half full (Table 3). The most densely growing plant species in Half Moon Lake during 2022, ranging in average rake fullness from 2.0 to 2.1, were watershield (*Brasenia schreberi*), whorled watermilfoil (*Myriophyllum verticillatum*), white-stem pondweed (*Potamogeton praelongus*), water bulrush (*Schoenplectus subterminalis*), common bur-reed (*Sparganium eurycarpum*), and sago pondweed (*Stuckenia pectinata*) (Figure 16).

Table 3 Half Moon Lake 2007, 2018, and 2022 Summary Statistics

SUMMARY STATS:	7/16-7/18/2007	6/21/2018	7/1/2022
Total number of points sampled	372	734	734
Total number of sites with vegetation	197	213	205
Total number of sites shallower than maximum depth of plants	285	335	235
Frequency of occurrence of all species at sites shallower than maximum depth of plants	69.1	63.6	87.2
Simpson Diversity Index	0.93	0.95	0.95
Maximum depth of plants (ft)	25.0	25.0	18.0
Average number of all species per site (shallower than max depth)	2.8	2.7	3.0
Average number of all species per site (veg. sites only)	4.0	4.3	3.5

SUMMARY STATS:	7/16- 7/18/2007	6/21/2018	7/1/2022
Average number of native species per site (shallower than max depth)	2.8	2.7	3.0
Average number of native species per site (veg. sites only)	4.0	4.2	3.5
Species Richness	32	44	46
Species Richness (including visuals)	35	50	48
Species Richness (including visuals and boat survey)	37	58	55
Mean depth of plants (ft)	7.0	6.1	5.6
Median depth of plants (ft)	4.5	4.5	4.0
Mean rake fullness (veg. sites only)	1.8	1.8	2.1
Mean C	6.0	6.3	6.6
FQI	32.5	41.5	43.0

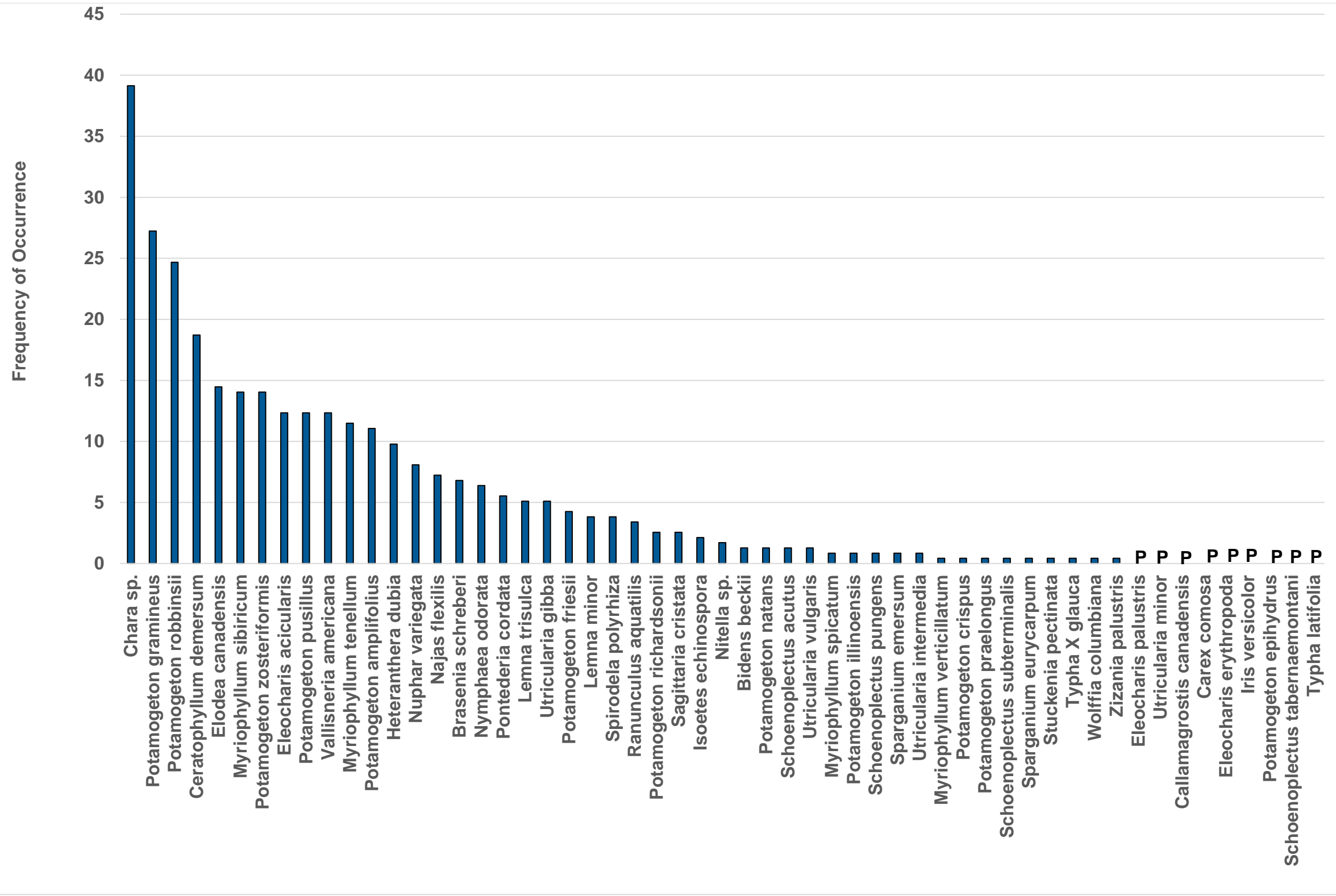


Figure 14 Frequency of Occurrence of Half Moon Lake Plants During July 1, 2022 Plant Survey

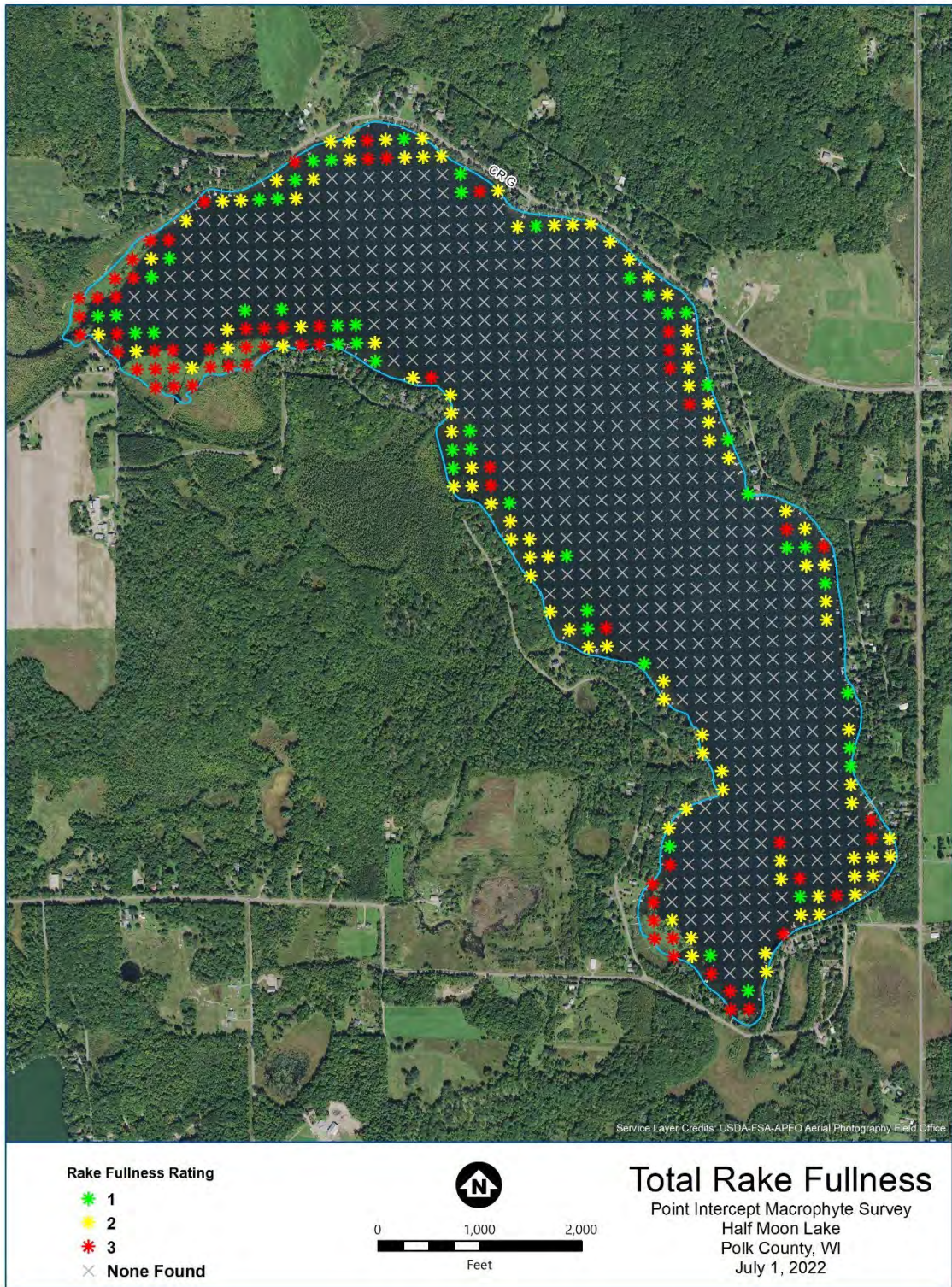


Figure 15 Total Rake Fullness at Half Moon Lake Vegetated Sites During July 1, 2022 Plant Survey

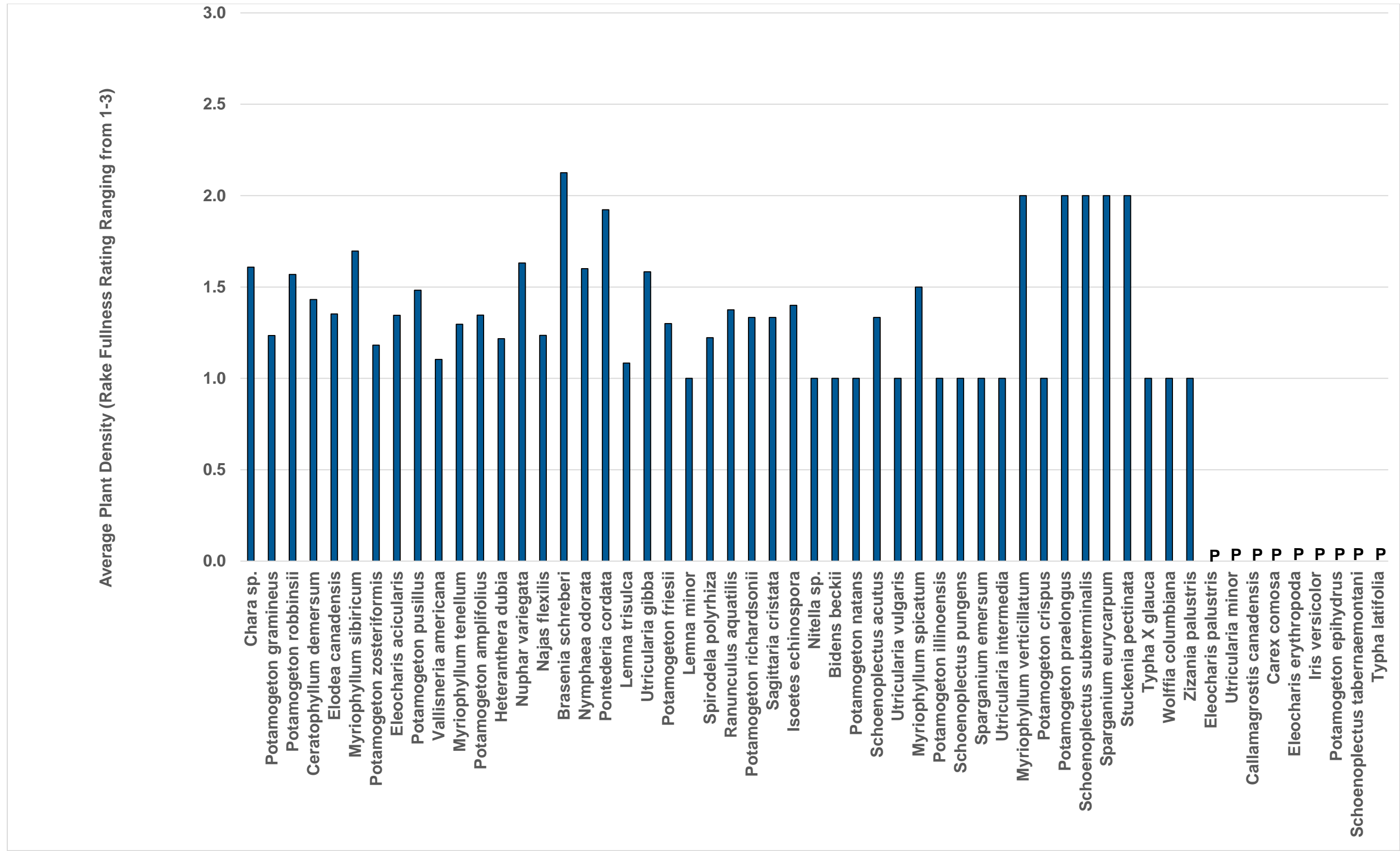


Figure 16 Average Density of Half Moon Lake Plants During July 1, 2022 Plant Survey

Simpson Diversity Index was used to measure the diversity of the 2022 Half Moon Lake plant community. The index, with scores ranging from 0 to 1, considers both the number of species present and the evenness of species distribution. The scores represent the probability that two individual plants randomly selected from the lake will belong to different species. A high score indicates a more diverse plant community—a higher probability that two randomly selected plants will represent different species. Half Moon Lake had a score of 0.95 which indicates the probability that two randomly selected plants will belong to different species is 95 percent (Table 3). Hence, plant diversity in Half Moon Lake in 2022 was high.

The diversity in the Half Moon Lake plant community was also indicated by the number of plant species found at each sample site. The average number of individual species collected from vegetated sample sites was 3.5 and the range was 1 to 10 (Table 3 and Figure 17). The average number of individual native species collected from vegetated sample sites was 3.5. The presence of more than 3 species per sample site on average indicates high plant diversity in Half Moon Lake. The high diversity in Half Moon Lake indicates the plant community is very healthy.

The quality of the Half Moon Lake aquatic plant community was measured by the Floristic Quality Index (FQI). The number of native species collected on the rake during the aquatic plant survey and the average tolerance of the plant community to degraded conditions are used to compute FQI. The average tolerance of the plant community to degraded conditions is measured by a value called the C value. Plant species are assigned C values on a scale of 0 to 10, with increasing values indicating plants are less tolerant of degraded conditions and of better quality. An average of the C values for individual species within a lake's plant community indicates the average tolerance of the community to degraded conditions. The average C value for the Half Moon Lake plant community in 2022 was 6.6 (Table 3). A total of 46 plant species were collected on the rake during the plant survey (Table 3). The FQI value for Half Moon Lake in 2022 was 43. This value is approximately double the median FQI value for lakes in the same ecoregion (20.9) (Nichols 1999). The high FQI indicates (1) the plant community is intolerant to development and other human disturbances; (2) the plant community has not been degraded by human impacts; and (3) the lake has high water quality.

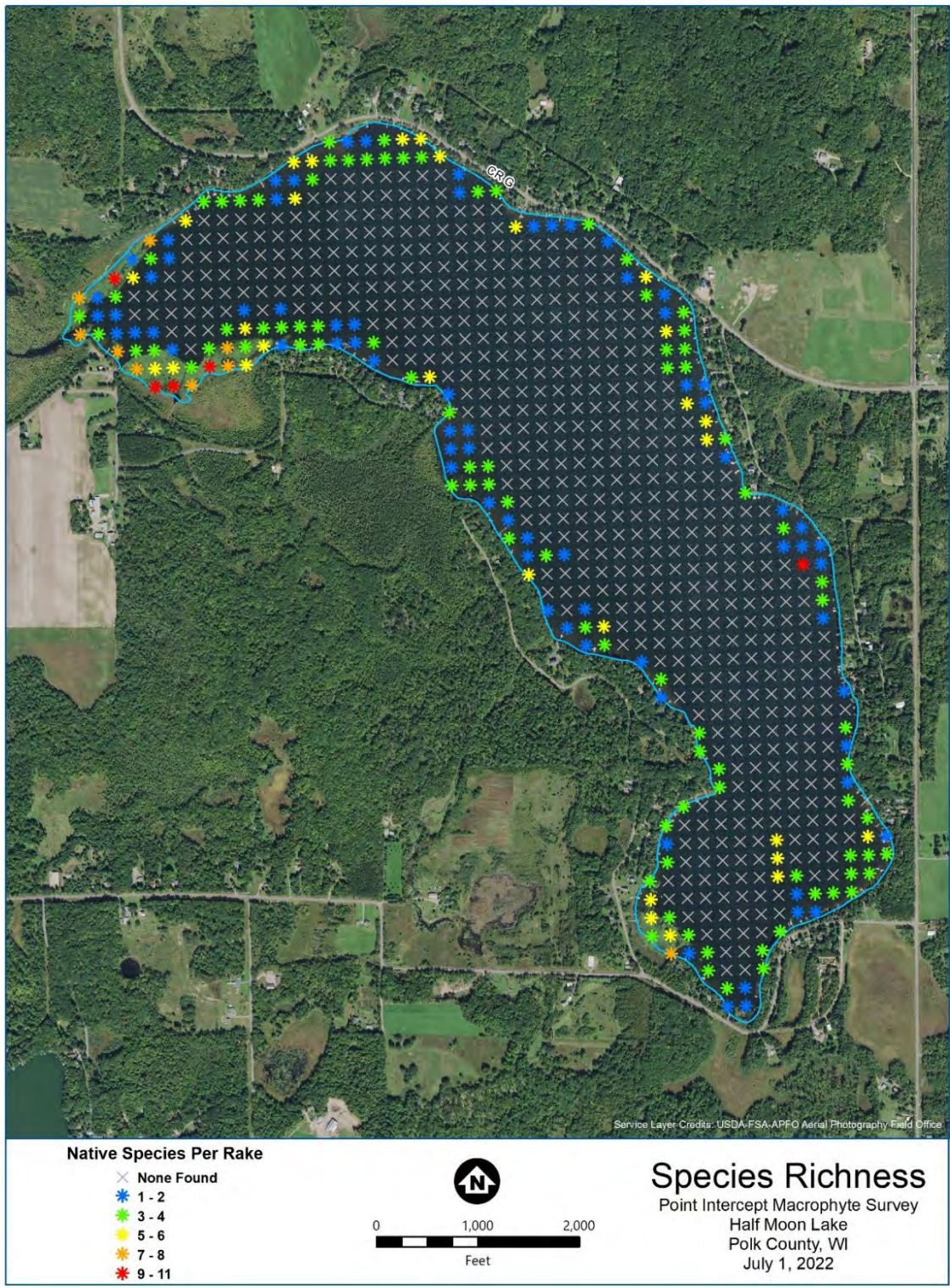


Figure 17 July 1, 2022 Half Moon Lake Native Species Richness

5.3 Comparison of 2007, 2018, and 2022 Point Intercept Plant Survey Results

Half Moon Lake aquatic plant data collected during July 16 through 17, 2007 by the Wisconsin Department of Natural Resources and during June 21 through 23, 2018 and July 1, 2022 by the Half Moon Lake Protection and Rehabilitation District were compared to assess changes.

In 2022, the maximum and mean depths of plant growth were lower than previous years. The maximum depth of plant growth was 25 feet in 2007 and 2018 compared with 18 feet in 2022 (Table 3). The mean depth of plant growth was 7.0 in 2007, 6.1 in 2018, and was 5.6 in 2022 (Table 3).

The 2022 plant survey results indicated the plant community in Half Moon Lake was very healthy and of high quality. The number of species (including visuals and boat surveys) in Half Moon Lake in 2021 was within the range of previous years—55 in 2022 compared with 37 in 2007 and 58 in 2018 (Table 3). In 2022, the number of species in Half Moon Lake was nearly 4 times greater than the median value for lakes in the same eco-region (median value of North Central Hardwood Forests is 14) (Nichols, 1999). In 2022, the quality of the plant community, measured by FQI, was higher than previous years—43.0 in 2022 compared with 32.5 in 2007 and 41.5 in 2018 (Table 3). Half Moon Lake FQI has been consistently higher than the median value for lakes in the same eco-region (i.e., 20.9) (Nichols, 1999). In 2022, diversity, measured by Simpson Diversity Index, was the same as 2018 (0.95) and higher than 2007 (0.93) (Table 3).

In 2022, plant frequency and the average number of native plant species per sample location were higher than previous years. During 2007 and 2018, the plant frequency of occurrence at sites shallower than the maximum depth of plants was 69 percent and 64 percent, respectively, and compared with 87 percent in 2022 (Table 3). The average number of native plant species at each littoral sample location was 2.8 in 2007 and 2.7 in 2018, increasing to 3.0 in 2022 (Table 3).

The average density of the plant community remained stable during 2007 through 2018 documented by an average rake fullness of 1.8 during both years and then increased to 2.1 in 2022 (Table 3). The data indicate the plant sample rake, on average, was slightly less than half full during 2007 and 2018 and was slightly more than half full in 2022.

A statistical tool, Chi Squared Analysis, was used to identify significant frequency changes of individual species in Half Moon Lake. Significant frequency changes have occurred in nearly half of the native species since 2007 (Figure 18 and Table 4).

- 23 of the 49 native species collected on the sampling rake have significantly changed in frequency on at least one occasion since 2007.
- 2 native species have both significantly declined and significantly increased in frequency since 2007.
- 13 native species have significantly increased in frequency since 2007.
- 8 native species have significantly decreased in frequency since 2007.

Filamentous algae and 8 native species significantly changed in frequency between 2018 and 2022 (Figure 18 and Table 4).

- 6 native species significantly increased in frequency—muskgrass (*Chara sp.*), variable pondweed (*Potamogeton gramineus*), large-leaf pondweed (*Potamogeton amplifolius*), spatterdock (*Nuphar variegata*), watershield (*Brasenia schreberi*), and creeping bladderwort (*Utricularia gibba*).
- 2 native species significantly decreased in frequency—flat-stem pondweed (*Potamogeton zosteriformis*) and Fries' pondweed (*Potamogeton friesii*).

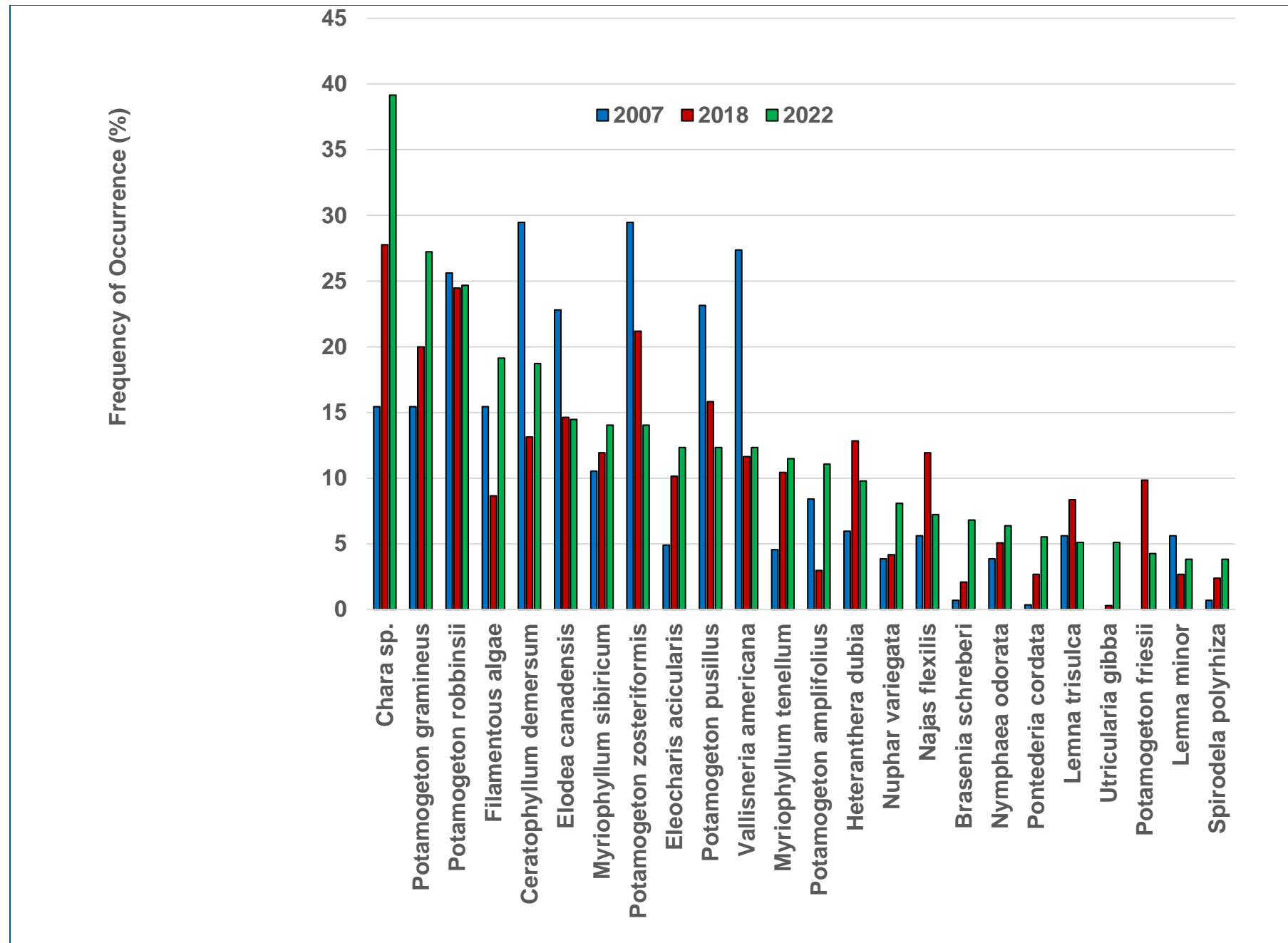


Figure 18 Frequency of Occurrence of Half Moon Lake Plants During 2007, 2018, and 2022

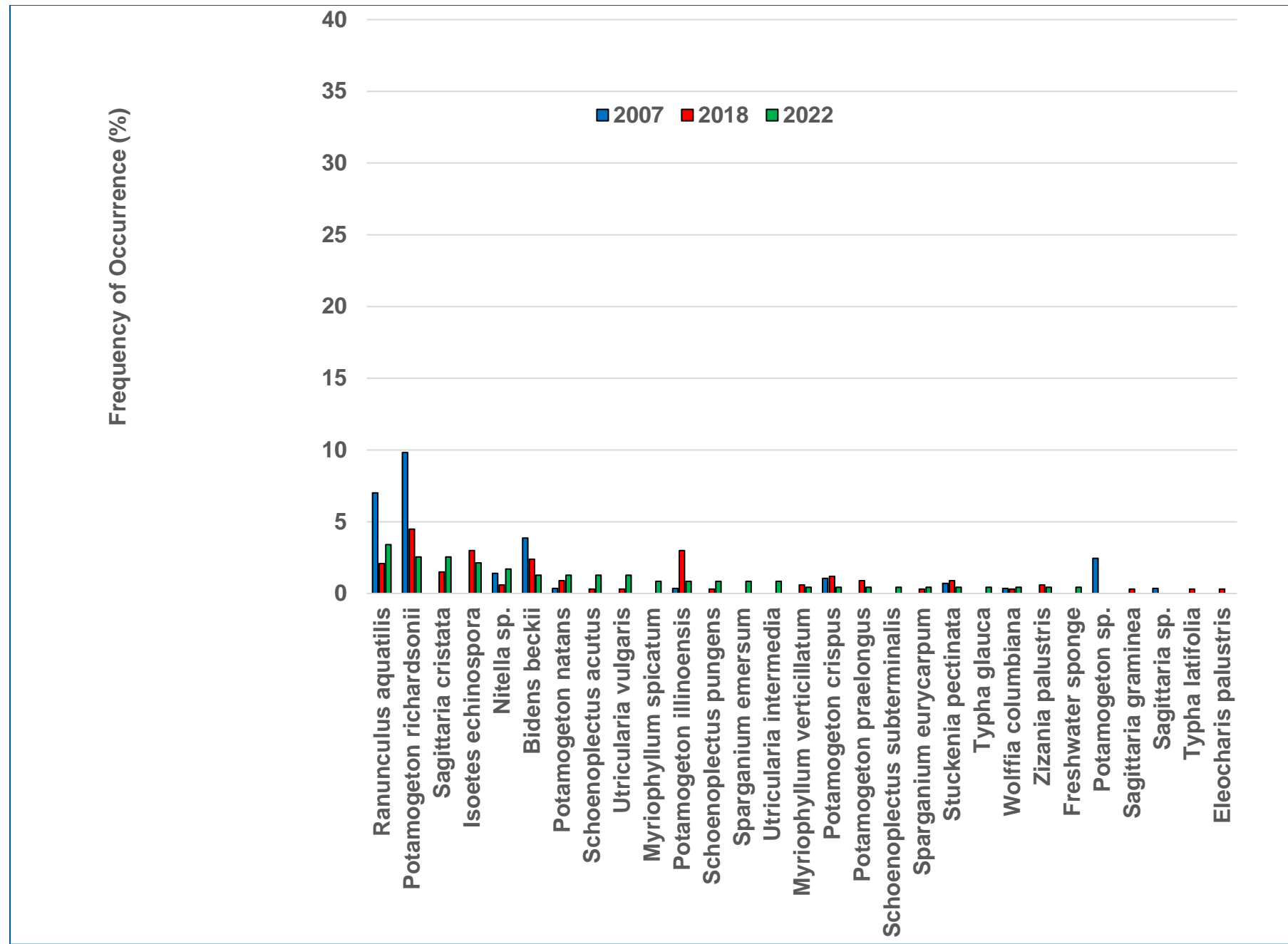


Figure 18 (Continued) Frequency of Occurrence of Half Moon Lake Plants During 2007, 2018, and 2022

Table 4 2007-2022 Half Moon Lake Frequency of Occurrence at Sites Shallower Than Maximum Depth of Plants and Significant Change Between Years

Scientific Name	Common Name	Frequency of occurrence at sites shallower than maximum depth of plants			2007-2022 Significant Changes		Increase/Decrease/Both
		7/16/2007-7/18/2007	06/21/18	7/1/2022	2007-2018	2018-2022	
<i>Chara</i> sp.	Muskgrass	15.44	27.76	39.15	***	**	Increase
<i>Potamogeton gramineus</i>	Variable pondweed	15.44	20.00	27.23	--	*	Increase
<i>Potamogeton robbinsii</i>	Fern pondweed	25.61	24.48	24.68	--	--	--
Filamentous algae	Filamentous algae	15.44	8.66	19.15	**	***	--
<i>Ceratophyllum demersum</i>	Coontail	29.47	13.13	18.72	***	--	Decrease
<i>Elodea canadensis</i>	Common waterweed	22.81	14.63	14.47	**	--	Decrease
<i>Myriophyllum sibiricum</i>	Northern watermilfoil	10.53	11.94	14.04	--	--	--
<i>Potamogeton zosteriformis</i>	Flat-stem pondweed	29.47	21.19	14.04	*	*	Decrease
<i>Eleocharis acicularis</i>	Needle spikerush	4.91	10.15	12.34	*	--	Increase
<i>Potamogeton pusillus</i>	Small pondweed	23.16	15.82	12.34	*	--	Decrease
<i>Vallisneria americana</i>	Wild celery	27.37	11.64	12.34	***	--	Decrease
<i>Myriophyllum tenellum</i>	Dwarf watermilfoil	4.56	10.45	11.49	**	--	Increase
<i>Potamogeton amplifolius</i>	Large-leaf pondweed	8.42	2.99	11.06	**	***	Both
<i>Heteranthera dubia</i>	Water star-grass	5.96	12.84	9.79	**	--	Increase
<i>Nuphar variegata</i>	Spatterdock	3.86	4.18	8.09	--	*	Increase
<i>Najas flexilis</i>	Slender naiad	5.61	11.94	7.23	**	--	Increase
<i>Brasenia schreberi</i>	Watershield	0.70	2.09	6.81	--	**	Increase
<i>Nymphaea odorata</i>	White water lily	3.86	5.07	6.38	--	--	--
<i>Pontederia cordata</i>	Pickerelweed	0.35	2.69	5.53	**	--	Increase
<i>Lemna trisulca</i>	Forked duckweed	5.61	8.36	5.11	--	--	--
<i>Utricularia gibba</i>	Creeping bladderwort	0.00	0.30	5.11	--	***	Increase
<i>Potamogeton friesii</i>	Fries' pondweed	0.00	9.85	4.26	***	*	Both
<i>Lemna minor</i>	Small duckweed	5.61	2.69	3.83	--	--	--
<i>Spirodela polyrhiza</i>	Large duckweed	0.70	2.39	3.83	--	--	--
<i>Ranunculus aquatilis</i>	White water crowfoot	7.02	2.09	3.40	**	--	Decrease
<i>Potamogeton richardsonii</i>	Clasping-leaf pondweed	9.82	4.48	2.55	**	--	Decrease
<i>Sagittaria cristata</i>	Crested arrowhead	0.00	1.49	2.55	*	--	Increase
<i>Isoetes echinospora</i>	Spiny-spored quillwort	0.00	2.99	2.13	**	--	Increase
<i>Nitella</i> sp.	Nitella	1.40	0.60	1.70	--	--	--
<i>Bidens beckii</i>	Water marigold	3.86	2.39	1.28	--	--	--
<i>Potamogeton natans</i>	Floating-leaf pondweed	0.35	0.90	1.28	--	--	--
<i>Schoenoplectus acutus</i>	Hardstem bulrush	0.00	0.30	1.28	--	--	--
<i>Utricularia vulgaris</i>	Common bladderwort	0.00	0.30	1.28	--	--	--
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	0.00	0.00	0.85	--	--	--
<i>Potamogeton illinoensis</i>	Illinois pondweed	0.35	2.99	0.85	*	--	Increase

Table 4 (Continued) 2007-2022 Half Moon Lake Frequency of Occurrence at Sites Shallower Than Maximum Depth of Plants and Significant Change Between Years

Scientific Name	Common Name	Frequency of occurrence at sites shallower than maximum depth of plants			2007-2022 Significant Changes		Increase/Decrease/Both
		7/16/2007-7/18/2007	06/21/18	7/1/2022	2007-2018	2018-2022	
<i>Schoenoplectus pungens</i>	Three-square bulrush	0.00	0.30	0.85	--	--	--
<i>Sparganium emersum</i>	Short-stemmed bur-reed	0.00	P	0.85	--	--	--
<i>Utricularia intermedia</i>	Flat-leaf bladderwort	0.00	P	0.85	--	--	--
Freshwater sponge	Freshwater sponge	0.00	0.00	0.43	--	--	--
<i>Myriophyllum verticillatum</i>	Whorled watermilfoil	0.00	0.60	0.43	--	--	--
<i>Potamogeton crispus</i>	Curly-leaf pondweed	1.05	1.19	0.43	--	--	--
<i>Potamogeton praelongus</i>	White-stem pondweed	0.00	0.90	0.43	--	--	--
<i>Schoenoplectus subterminalis</i>	Water bulrush	0.00	P	0.43	--	--	--
<i>Sparganium eurycarpum</i>	Common bur-reed	P	0.30	0.43	--	--	--
<i>Stuckenia pectinata</i>	Sago pondweed	0.70	0.90	0.43	--	--	--
<i>Typha glauca</i>	Hybrid Cattail	0.00	P	0.43	--	--	--
<i>Wolffia columbiana</i>	Common watermeal	0.35	0.30	0.43	--	--	--
<i>Zizania palustris</i>	Northern wild rice	0.00	0.60	0.43	--	--	--
<i>Potamogeton</i> sp.	Narrow-leaved pondweed	2.46	0.00	0.00	**	--	Decrease
<i>Sagittaria graminea</i>	Grass-leaved arrowhead	0.00	0.30	0.00	--	--	--
<i>Sagittaria</i> sp.	Arrowhead	0.35	0.00	0.00	--	--	--
<i>Typha</i> sp.	Cattail	P	0.00	0.00	--	--	--
<i>Eleocharis palustris</i>	Creeping spikerush	P	0.30	P	--	--	--
<i>Typha latifolia</i>	Broad-leaved cattail	0.00	0.30	P	--	--	--

A p value, or probability value, describes how likely it is that the differences are due to random chance and, hence, are not statistically significant differences.

* means $p \leq 0.05$ and there is less than a 5% probability; ** means $p \leq 0.01$ and indicates there is less than a 1 percent probability; *** means $p \leq 0.001$ and indicates there is less than a 0.1 percent probability.

6 Aquatic Invasive Species (AIS)

AIS are nonnative species that have the potential to cause serious problems. Because they are not native, they lack predators and can rapidly spread, displacing native species and dominating the community.

One AIS was observed during the 2007 plant survey (curly-leaf pondweed) (Barr, 2018). Five AIS were observed during the 2018 aquatic plant survey (curly-leaf pondweed, yellow iris, common forget-me-not, hybrid cattail, and reed canary grass) (Barr, 2018). Three AIS were observed during the 2022 plant survey (EWM, curly-leaf pondweed, and hybrid cattail) (Appendix C). The EWM in Half Moon Lake was discussed in Section 1 and Section 4 of this report.

In 2007, curly-leaf pondweed (*Potamogeton crispus*) was collected on the rake at three sample locations in the northern end of the lake (Barr, 2018). In 2018, curly-leaf pondweed was collected on the rake at four sample locations and observed near two additional locations in the northern end of the lake (Barr, 2018). In 2022, curly-leaf pondweed was found at fewer locations than 2007 and 2018. It was collected on the rake at one location in the northwestern corner of the lake and visually observed at one location near the east side of the lake (Figure 19). The plant surveyor commented that most curly-leaf pondweed plants were observed in 5 to 10 feet of water over organic muck and there was very little of this type of habitat in the lake.

Hybrid cattail was found at the same location in the northwestern corner of the lake during 2018 (Barr, 2018) and 2022 (Figure 20). Because it is only found at one location and has not spread, it is not considered problematic.

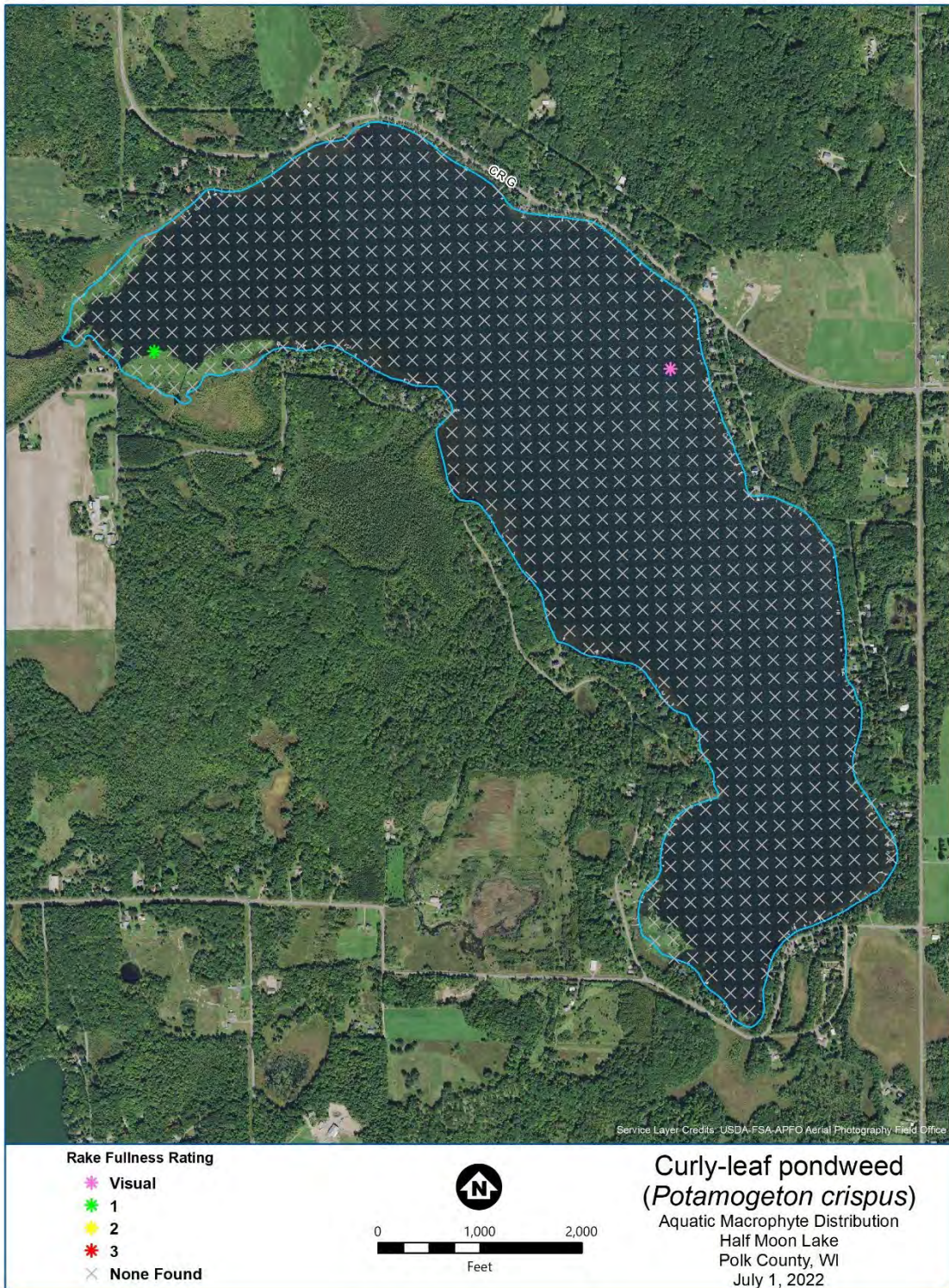


Figure 19 Curly-leaf pondweed Locations in Half Moon Lake on July 1, 2022

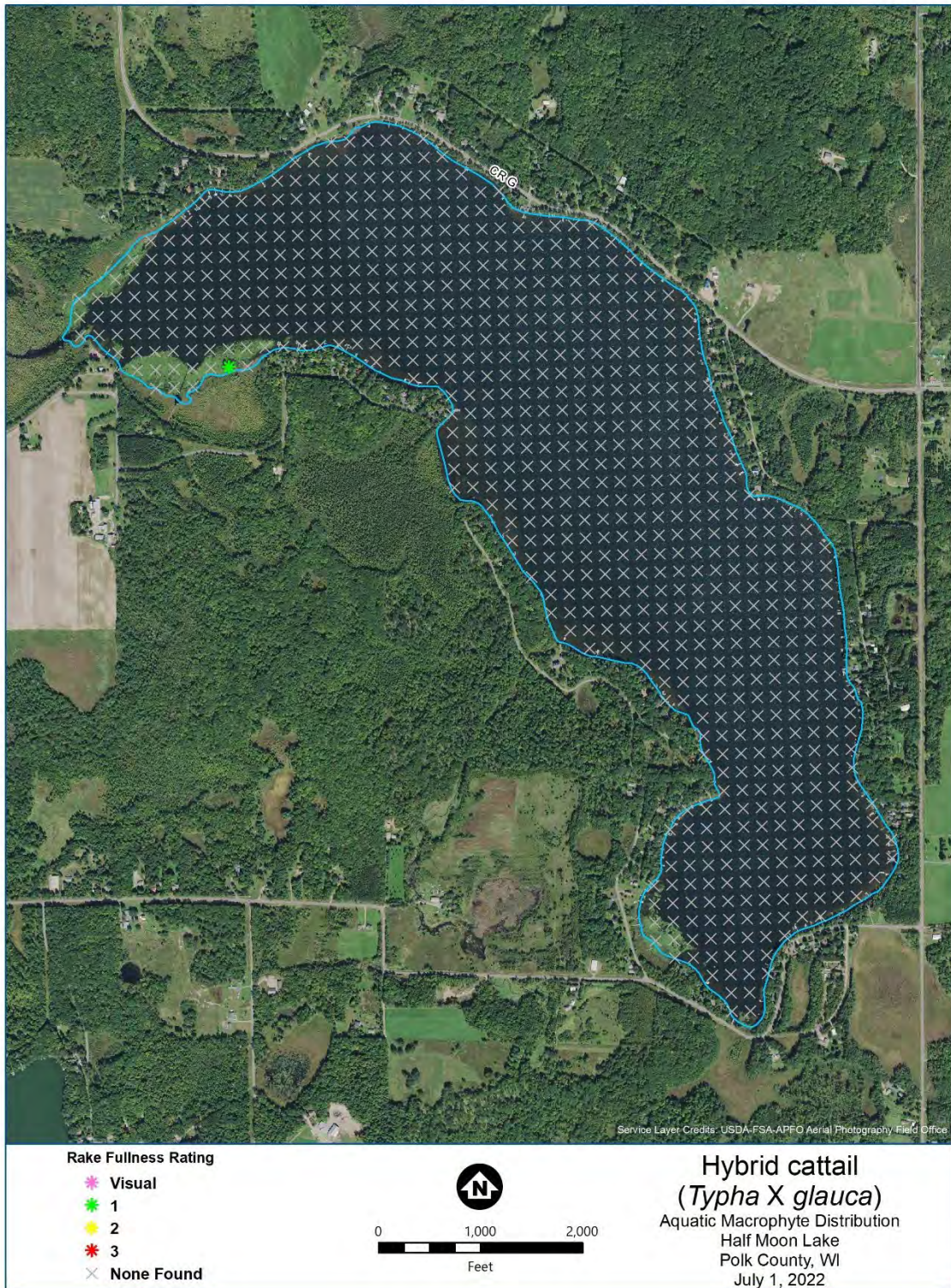


Figure 20 Hybrid Cattail Location in Half Moon Lake on July 1, 2022

7 References

- Barr Engineering, Co. 2018. 2018 Half Moon Lake Aquatic Plant Survey. [Half+Moon+Lake+Report.pdf \(squarespace.com\)](#) (2022, November).
- Endangered Resource Services, LLC. 2021. Eurasian Watermilfoil (*Myriophyllum spicatum*) Fall Bed-mapping Survey Half Moon Lake – WBIC: 2621100 Polk County Wisconsin. 13 pages.
- Nichols, S.A. 1999. "Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications." *Journal of Lake and Reservoir Management* 15 (2): 133-141.
- Wisconsin Department of Natural Resources (WDNR). [online], 2022. Wisconsin Lakes Information - Half Moon Lake - Polk County. [Half Moon Lake \(wi.gov\)](#) (2022, October).

Appendix A

Half Moon Lake Pre-Treatment Plant Survey Data Summary

June 8, 2022

Half Moon Lake Pre-Treatment Data Summary: June 8, 2022

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	#Visual sightings
<i>Potamogeton robbinsii</i>	Fern pondweed	76	24.13	69.72	64.41	1.99	0
<i>Ceratophyllum demersum</i>	Coontail	47	14.92	43.12	39.83	1.13	0
<i>Elodea canadensis</i>	Common waterweed	33	10.48	30.28	27.97	1.55	0
<i>Potamogeton amplifolius</i>	Large-leaf pondweed	22	6.98	20.18	18.64	1.23	0
<i>Heteranthera dubia</i>	Water star-grass	20	6.35	18.35	16.95	1.15	0
<i>Myriophyllum sibiricum</i>	Northern watermilfoil	19	6.03	17.43	16.10	1.68	0
<i>Chara sp.</i>	Muskgrass	15	4.76	13.76	12.71	1.40	0
<i>Potamogeton richardsonii</i>	Clasping-leaf pondweed	12	3.81	11.01	10.17	1.08	0
<i>Potamogeton zosteriformis</i>	Flat-stem pondweed	12	3.81	11.01	10.17	1.08	0
<i>Lemna trisulca</i>	Forked duckweed	11	3.49	10.09	9.32	1.09	0
<i>Nuphar variegata</i>	Spatterdock	9	2.86	8.26	7.63	1.33	0
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	7	2.22	6.42	5.93	2.14	18
<i>Nymphaea odorata</i>	White water lily	5	1.59	4.59	4.24	1.00	0
<i>Potamogeton pusillus</i>	Small pondweed	5	1.59	4.59	4.24	1.00	0
--	Filamentous algae	5	*	4.59	4.24	1.80	0
<i>Bidens beckii</i>	Water marigold	3	0.95	2.75	2.54	1.00	0
<i>Brasenia schreberi</i>	Watershield	3	0.95	2.75	2.54	1.00	0
<i>Eleocharis acicularis</i>	Needle spikerush	3	0.95	2.75	2.54	1.33	0
<i>Pontederia cordata</i>	Pickerelweed	3	0.95	2.75	2.54	1.33	0
<i>Myriophyllum tenellum</i>	Dwarf watermilfoil	2	0.63	1.83	1.69	1.00	0
<i>Ranunculus aquatilis</i>	White water crowfoot	2	0.63	1.83	1.69	1.00	0

Half Moon Lake Pre-Treatment Data Summary: June 8, 2022 (Continued)

Scientific Name	Common Name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
<i>Isoetes echinospora</i>	Spiny-spored quillwort	1	0.32	0.92	0.85	1.00	0
<i>Potamogeton crispus</i>	Curly-leaf pondweed	1	0.32	0.92	0.85	2.00	0
<i>Potamogeton friesii</i>	Fries' pondweed	1	0.32	0.92	0.85	1.00	0
<i>Potamogeton gramineus</i>	Variable pondweed	1	0.32	0.92	0.85	1.00	0
<i>Potamogeton illinoensis</i>	Illinois pondweed	1	0.32	0.92	0.85	1.00	0
<i>Vallisneria americana</i>	Wild celery	1	0.32	0.92	0.85	1.00	0

*Excluded from relative frequency analysis

Appendix B

Half Moon Lake Post-Treatment Plant Survey Data Summary

September 18, 2022

Half Moon Lake Post-Treatment Data Summary: September 18, 2022

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
<i>Potamogeton robbinsii</i>	Fern pondweed	66	16.79	58.93	57.39	1.83	0
<i>Vallisneria americana</i>	Wild celery	46	11.70	41.07	40.00	1.22	0
<i>Elodea canadensis</i>	Common waterweed	41	10.43	36.61	35.65	1.59	0
<i>Ceratophyllum demersum</i>	Coontail	35	8.91	31.25	30.43	1.34	0
<i>Potamogeton gramineus</i>	Variable pondweed	24	6.11	21.43	20.87	1.46	0
<i>Potamogeton amplifolius</i>	Large-leaf pondweed	18	4.58	16.07	15.65	1.17	0
<i>Potamogeton zosteriformis</i>	Flat-stem pondweed	18	4.58	16.07	15.65	1.17	0
<i>Myriophyllum sibiricum</i>	Northern watermilfoil	15	3.82	13.39	13.04	1.20	0
<i>Potamogeton richardsonii</i>	Clasping-leaf pondweed	14	3.56	12.50	12.17	1.57	0
<i>Chara</i> sp.	Muskgrass	13	3.31	11.61	11.30	1.54	0
--	Filamentous algae	13	*	11.61	11.30	1.31	0
<i>Nymphaea odorata</i>	White water lily	12	3.05	10.71	10.43	1.75	0
<i>Heteranthera dubia</i>	Water star-grass	11	2.80	9.82	9.57	1.64	0
<i>Potamogeton pusillus</i>	Small pondweed	11	2.80	9.82	9.57	1.18	0
<i>Lemna trisulca</i>	Forked duckweed	9	2.29	8.04	7.83	1.00	0
<i>Nuphar variegata</i>	Spatterdock	8	2.04	7.14	6.96	1.88	0
<i>Lemna minor</i>	Small duckweed	7	1.78	6.25	6.09	1.00	0
<i>Najas flexilis</i>	Slender naiad	7	1.78	6.25	6.09	1.29	0
<i>Nitella</i> sp.	Nitella	7	1.78	6.25	6.09	1.86	0
<i>Wolffia columbiana</i>	Common watermeal	7	1.78	6.25	6.09	1.00	0
<i>Potamogeton natans</i>	Floating-leaf pondweed	6	1.53	5.36	5.22	1.50	0

Half Moon Lake Post-Treatment Data Summary: September 18, 2022 (Continued)

Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
<i>Eleocharis acicularis</i>	Needle spikerush	5	1.27	4.46	4.35	1.80	0
<i>Bidens beckii</i>	Water marigold	3	0.76	2.68	2.61	1.00	0
<i>Pontederia cordata</i>	Pickerelweed	2	0.51	1.79	1.74	2.00	0
<i>Ranunculus aquatilis</i>	White water crowfoot	2	0.51	1.79	1.74	1.00	0
<i>Utricularia gibba</i>	Creeping bladderwort	2	0.51	1.79	1.74	1.00	0
<i>Myriophyllum tenellum</i>	Dwarf watermilfoil	1	0.25	0.89	0.87	1.00	0
<i>Potamogeton illinoensis</i>	Illinois pondweed	1	0.25	0.89	0.87	1.00	0
<i>Potamogeton praelongus</i>	White-stem pondweed	1	0.25	0.89	0.87	1.00	0
<i>Sagittaria graminea</i>	Grass-leaved arrowhead	1	0.25	0.89	0.87	1.00	0
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	*	*	*	*	*	2

*Excluded from relative frequency analysis

Appendix C

Half Moon Lake Whole Lake Point Intercept Plant Survey Data Summary

July 1, 2022

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Scientific name	Common name	Number of sites where species found	Relative Frequency (%)	Frequency of occurrence within vegetated areas (%)	Frequency of occurrence at sites shallower than maximum depth of plants	Average rake fullness	# Visual sightings
<i>Chara</i> sp.	Muskgrass	92	12.90	44.88	39.15	1.61	0
<i>Potamogeton gramineus</i>	Variable pondweed	64	8.98	31.22	27.23	1.23	15
<i>Potamogeton robbinsii</i>	Fern pondweed	58	8.13	28.29	24.68	1.57	4
--	Filamentous algae	45	*	21.95	19.15	1.24	0
<i>Ceratophyllum demersum</i>	Coontail	44	6.17	21.46	18.72	1.43	1
<i>Elodea canadensis</i>	Common waterweed	34	4.77	16.59	14.47	1.35	0
<i>Myriophyllum sibiricum</i>	Northern watermilfoil	33	4.63	16.10	14.04	1.70	5
<i>Potamogeton zosteriformis</i>	Flat-stem pondweed	33	4.63	16.10	14.04	1.18	7
<i>Eleocharis acicularis</i>	Needle spikerush	29	4.07	14.15	12.34	1.34	0
<i>Potamogeton pusillus</i>	Small pondweed	29	4.07	14.15	12.34	1.48	5
<i>Vallisneria americana</i>	Wild celery	29	4.07	14.15	12.34	1.10	4
<i>Myriophyllum tenellum</i>	Dwarf watermilfoil	27	3.79	13.17	11.49	1.30	0
<i>Potamogeton amplifolius</i>	Large-leaf pondweed	26	3.65	12.68	11.06	1.35	6
<i>Heteranthera dubia</i>	Water star-grass	23	3.23	11.22	9.79	1.22	1
<i>Nuphar variegata</i>	Spatterdock	19	2.66	9.27	8.09	1.63	5
<i>Najas flexilis</i>	Slender naiad	17	2.38	8.29	7.23	1.24	0
<i>Brasenia schreberi</i>	Watershield	16	2.24	7.80	6.81	2.13	3
<i>Nymphaea odorata</i>	White water lily	15	2.10	7.32	6.38	1.60	3
<i>Pontederia cordata</i>	Pickerelweed	13	1.82	6.34	5.53	1.92	2
<i>Lemna trisulca</i>	Forked duckweed	12	1.68	5.85	5.11	1.08	0
<i>Utricularia gibba</i>	Creeping bladderwort	12	1.68	5.85	5.11	1.58	0
<i>Potamogeton friesii</i>	Fries' pondweed	10	1.40	4.88	4.26	1.30	1
<i>Lemna minor</i>	Small duckweed	9	1.26	4.39	3.83	1.00	0
<i>Spirodela polyrhiza</i>	Large duckweed	9	1.26	4.39	3.83	1.22	0

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<i>Ranunculus aquatilis</i>	White water crowfoot	8	1.12	3.90	3.40	1.38	1
<i>Potamogeton richardsonii</i>	Clasping-leaf pondweed	6	0.84	2.93	2.55	1.33	4
<i>Sagittaria cristata</i>	Crested arrowhead	6	0.84	2.93	2.55	1.33	1
<i>Isoetes echinospora</i>	Spiny-spored quillwort	5	0.70	2.44	2.13	1.40	0
<i>Nitella</i> sp.	Nitella	4	0.56	1.95	1.70	1.00	0
<i>Bidens beckii</i>	Water marigold	3	0.42	1.46	1.28	1.00	
<i>Potamogeton natans</i>	Floating-leaf pondweed	3	0.42	1.46	1.28	1.00	2
<i>Schoenoplectus acutus</i>	Hardstem bulrush	3	0.42	1.46	1.28	1.33	2
<i>Utricularia vulgaris</i>	Common bladderwort	3	0.42	1.46	1.28	1.00	1
<i>Myriophyllum spicatum</i>	Eurasian watermilfoil	2	0.28	0.98	0.85	1.50	7
<i>Potamogeton illinoensis</i>	Illinois pondweed	2	0.28	0.98	0.85	1.00	1
<i>Schoenoplectus pungens</i>	Three-square bulrush	2	0.28	0.98	0.85	1.00	0
<i>Sparganium emersum</i>	Short-stemmed bur-reed	2	0.28	0.98	0.85	1.00	0
<i>Utricularia intermedia</i>	Flat-leaf bladderwort	2	0.28	0.98	0.85	1.00	0
<i>Myriophyllum verticillatum</i>	Whorled watermilfoil	1	0.14	0.49	0.43	2.00	0
<i>Potamogeton crispus</i>	Curly-leaf pondweed	1	0.14	0.49	0.43	1.00	1
<i>Potamogeton praelongus</i>	White-stem pondweed	1	0.14	0.49	0.43	2.00	0
<i>Schoenoplectus subterminalis</i>	Water bulrush	1	0.14	0.49	0.43	2.00	0
<i>Sparganium eurycarpum</i>	Common bur-reed	1	0.14	0.49	0.43	2.00	0
<i>Stuckenia pectinata</i>	Sago pondweed	1	0.14	0.49	0.43	2.00	0
<i>Typha X glauca</i>	Hybrid cattail	1	0.14	0.49	0.43	1.00	0
<i>Wolffia columbiana</i>	Common watermeal	1	0.14	0.49	0.43	1.00	0
<i>Zizania palustris</i>	Northern wild rice	1	0.14	0.49	0.43	1.00	0
--	Freshwater sponge	1	*	0.49	0.43	1.00	0

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<i>Eleocharis palustris</i>	Creeping spikerush	**	**	**	**	**	4
<i>Utricularia minor</i>	Small bladderwort	**	**	**	**	**	1
<i>Callamagrostis canadensis</i>	Bluejoint	***	***	***	***	***	***
<i>Carex comosa</i>	Bottlebrush sedge	***	***	***	***	***	***
<i>Eleocharis erythropoda</i>	Bald spikerush	***	***	***	***	***	***
<i>Iris versicolor</i>	Northern blue flag	***	***	***	***	***	***
<i>Potamogeton epihydrus</i>	Ribbon-leaf pondweed	***	***	***	***	***	***
<i>Schoenoplectus tabernaemontani</i>	Softstem bulrush	***	***	***	***	***	***
<i>Typha latifolia</i>	Broad-leaved cattail	***	***	***	***	***	***

*Excluded from relative frequency analysis

**Visual Only

***Boat Survey