Paddock Lake

Aquatic Plant Management Plan

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INTRODUCTION

Paddock Lake is located within the Village of Paddock Lake in the western region of Kenosha County, Wisconsin. It is a 132-acre lake with a maximum depth of 32 feet (**Figure 1**) and 3.4 miles of shoreline. Paddock Lake is classified as a drainage lake that contains one outlet on the southeast corner of the lake. Most of the shoreline is developed by single-family homes. The proposed lake study for Paddock Lake has been designed at the request of the operators of Paddock Lake Protection and Rehabilitation District to further the knowledge base about its' aquatic plant community and to recreate their aquatic plant management plan. This plan will address many of the concerns regarding Paddock Lake's aquatic plant community and recommend the best course of action for future lake management.

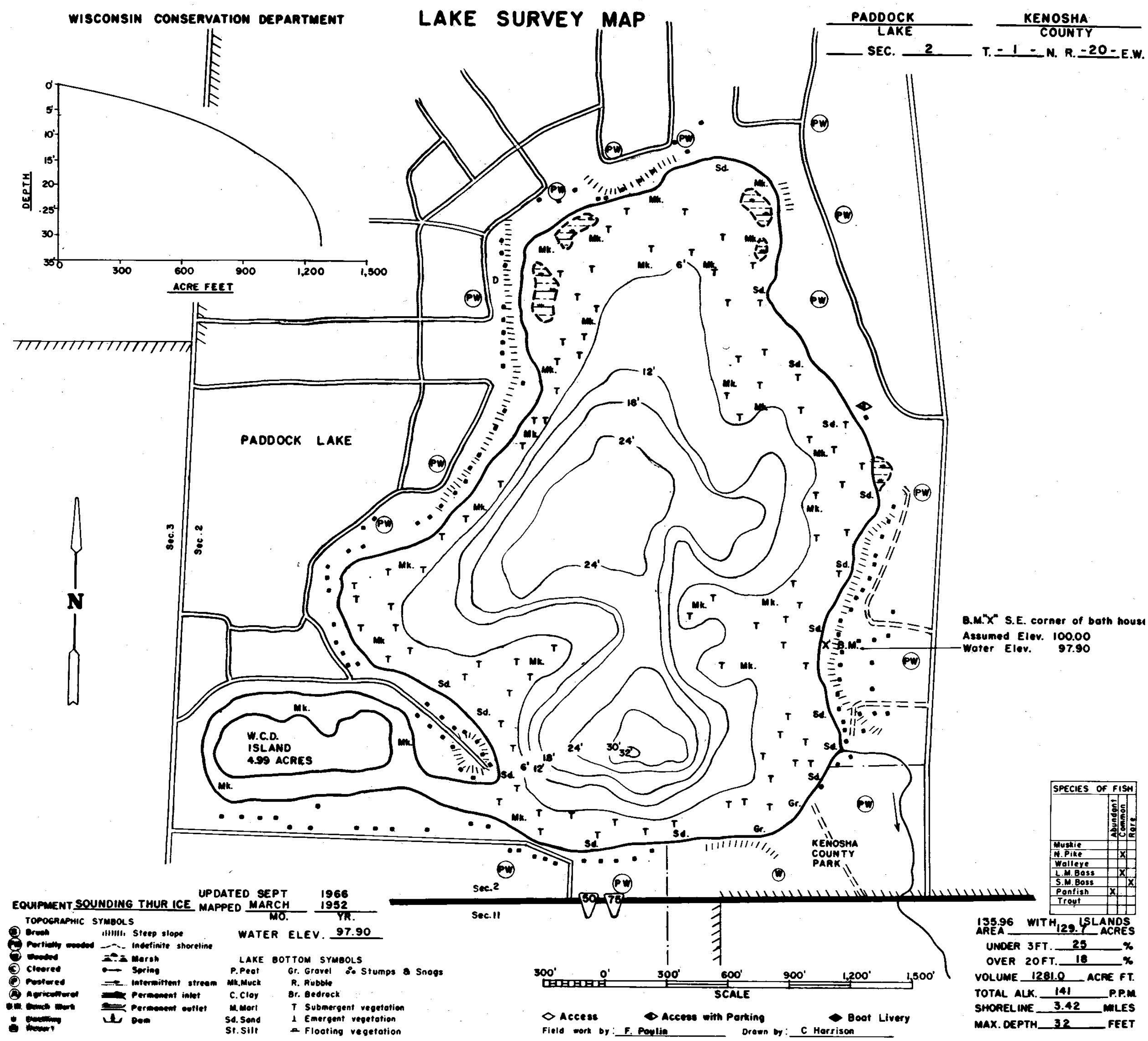


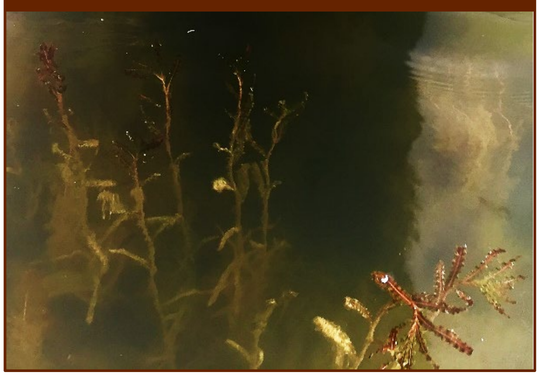
Figure 1. Paddock Lake Contour map provided by the WDNR.

Photo 1: Eurasian Watermilfoil (Invasive Species)

HISTORICAL AQUATIC PLANT CONDITIONS

Paddock Lake has had aquatic plant surveys done throughout the decades. In 1951 and 1971 the survey was done by the Office of Inland Lake Renewal. Another survey was conducted in 1978 by the Environmental Resource Assessments (ERA). During the survey in 1951, 18 species of aquatic plants were observed in the lake. By the 1970 survey the number of species had decreased to 12. In 1979 The Office of Inland Lake Renewal noted that there had been a trend of milfoil dominance in Paddock Lake between 1951 and 1970. During these times a few pondweed species had disappeared from Paddock Lake. The 1978 ERA survey observed 16 plant species while conducting a line-intercept survey. ERA identified two different milfoil species during their survey: Eurasian watermilfoil (invasive species) and whorled watermilfoil (native species). Muskgrass, Eurasian watermilfoil (**Photo 1**), and curly-leaf pondweed (**Photo 2**) were reported as being the dominant species at that time.

Photo 2: Curly-Leaf Pondweed (Invasive Species)



An aquatic plant survey was conducted in 1993 with a plant management plan to follow. Another aquatic plant survey was conducted in 2003 to guide the development of this aquatic plant management plan. The 2003 survey observed many more plant species than the survey of 1969.

Wisconsin Department of Natural Resources conducted a detailed aquatic plant survey on Paddock Lake in 2005. Aron & Associates conducted general surveys in 2008 and 2014.

Cason & Associates conducted a point-intercept survey as well as an aquatic invasive species meandering survey in 2021.

HISTORICAL PLANT MANAGEMENT

- **Chemical Treatment**

According to the 2015 Aquatic Plant Management Plan, Paddock Lake P&R District has not used chemical treatments in the past to control plants and algae. The residents of the district have instead previously preferred to manage invasive and nuisance plants using mechanical and manual harvesting methods.

- **Mechanical Harvesting**

Paddock Lake has been using a harvester to remove nuisance plants since 1981. In 1993 The District received a cost-sharing grant from the Wisconsin Waterways Commission. The grant was used to purchase the equipment. The district also purchased a harvester in 2004 with the assistance of the

Waterways Commission. In 2015 the Waterway Commission assisted PLPRD with the purchase of the current harvester, trailer, and shore conveyor.

Paddock Lake harvests aquatic plants throughout the summer. The district currently owns an Aquarius Model harvester, as well as a shore conveyer and a transport trailer. Homeowners also regularly raked and pulled plants along their shoreline.

GOALS

PLPRD's goal is to preserve and enhance the lake, including its water quality, fisheries, and wildlife while minimizing aquatic nuisance species and to preserve and maintain safe recreational uses of Paddock Lake. To achieve these goals, the district has commissioned this update to their previous 2015 Aquatic Plant Management Plan in addition to continuing their participation in the Citizen Lake Monitoring program, having updated aquatic vegetation surveys performed.

The District desires to:

- Control exotic and nuisance species by:
  - Continuing harvesting
  - Using herbicides to reduce invasive species
  - Encourage homeowners to restore native shoreline

- Preserve and enhance the natural lake environment by:
  - Educate landowners and lake users about healthy lake ecology
  - Working with Village and County governments to develop and enforce ordinances to protect Paddock Lake
  - Continuing to improve the watershed to protect Paddock Lake.

- Identify and expand local educational efforts to improve the public's understanding of lake issues by:
  - Distributing at least 1 newsletter per year and maintaining public tv and website information
  - Encouraging community participation in lake management activities

- Conduct in-lake management activities with the long-range goal of minimizing management to the extent possible by:
  - Conduct annual AIS surveys to track changes in distribution.
  - Conduct point-intercept surveys every few years to track plant community diversity.
  - Track progress of treatments to reduce invasive species.
  - Continue water quality monitoring to assist in the documentation of results.

METHODS

Point-Intercept Aquatic Plant Survey

In July of 2021, a submergent aquatic plant survey was conducted on Paddock Lake utilizing methods developed by the WDNR. The WDNR develops point-intercept plant survey for Aquatic Plant Management Plans with a series of grid points mapped across the lake (**Figure 2**). At each point on the map, a single rake tow will be used to collect aquatic plants. The rake head will consist of two standard bow rakes welded together. At depths of 15 feet or less, a double rake head attached to a pole was used to collect a sample; a double rake head on a rope was used for depths greater than 15 feet. An overall rake fullness rating was recorded that best estimates the total coverage of plants on the rake using the criteria established by the WDNR: 1 - few, 2 - moderate, 3 – abundant (**Figure 3**). All plants collected were identified to genus and species whenever possible and recorded. An abundance rating was given for each species collected as well (**Figure 3**). Plant species adjacent to the boat (within six feet), but not found on the rake were recorded as *visual* observations. In addition, water depth and dominant sediment type was recorded at each site. Data collected was then used to determine species composition and diversity, percent frequency and floristic quality. Distribution maps were also developed from this data for Eurasian Watermilfoil and the top seven native aquatic plants found in the lake.

Aquatic Invasive Species Distribution Mapping (Meandering)

Eurasian watermilfoil (*Myriophyllum spicatum,* EWM) has been verified and vouchered in Paddock Lake since 1977 and is still present currently. In order to best manage aquatic invasive species in Paddock Lake, current detailed mapping surveys were needed. To effectively identify and map invasive species, such as EWM a fall AIS meandering survey was conducted as a part of this study. It is important to annually survey for invasive species which can cause harm to the lake ecosystem. Eurasian watermilfoil continues to grow throughout the mid-late season. Late summer/fall (2021) surveys are the best time to locate and map this species. Another invasive species, Curly-leaf pondweed (*Potagometon crispus*, CLP) has been verified in Paddock Lake since 2004. CLP grows early in the spring and dies off during the summer before other species do. As a result, it will be important to conduct an invasive species mapping survey in the spring (April/May 2022) for CLP. Once found during the survey, the locations, plant densities and water depths of invasive plant beds were recorded. This data was then used to generate a map of EWM bed distribution and density in ArcGIS Pro (**Appendix B**).

Water Quality Monitoring

Citizen Lake Monitoring Network volunteers sampled Paddock Lake water quality at the deep hole ten times in 2021: May 24, June 1, June 11, June 16, July 7, July 21, July 26, August 16, September 2, and September 12. Water clarity (Secchi depth), dissolved oxygen and temperature data were collected during each sampling event. Readings were collected by Robert Leick, Chris Leick, and Liz Biever.

Additionally, water samples were collected three times in 2021: June 16, July 26, and August 23. Samples were collected by Robert and Chris Leick and sent to the State Lab of Hygiene in Madison for analysis of the following parameters: total phosphorus and chlorophyll *a*.

Water clarity, measured with a Secchi disc, is not a chemical property of water. However, it is used as an indicator of water quality. Secchi disc readings were taken on the downwind, shaded side of the boat. The disc was lowered until it disappeared, then raised until it was just visible. This process was repeated three times, and the average deepest visible depth of the Secchi disk was then recorded. As depth readings can be affected by waves, angle of the sun and cloud cover, an effort was made to take readings only on calm sunny days.

All water quality data available for Paddock Lake were accessed via the WDNR's Surface Water Data Viewer. Water quality data were organized and tabulated using Microsoft Excel. Software available from the WDNR entitled Wisconsin Lake Modeling Suite (WiLMS) was used to predict the trophic state of Paddock Lake given its area, the watershed area, mean depth and eco-region. WiLMS was also used to predict the average total phosphorus concentration in the lake.

RESULTS & DISCUSSION

2021 SUBMERGENT PLANT POINT-INTERCEPT SURVEY

Cason & Associates completed the 2021 Point Intercept Aquatic plant survey on Paddock Lake on August 12, & 17/18, 2021. At 347 of the 374 grid points (**Figure 2**) aquatic plant samples were collected from a boat with a single rake pull or throw.

Plants were observed up to a depth of 26 feet (**Table 1**). All plant samples collected were identified to genus and species whenever possible, and the information was recorded. Sixteen different aquatic plant species were observed during the survey (**Table 2**). An abundance rating was also given for each species collected using criteria established by the WDNR. Rake fullness (**Figure 3**) is a criterion developed to determine density of submergent plants. In addition to the plant data, water depths were also recorded for each location. Data collected was used to determine species composition, percent relative frequency of occurrence and relative abundance.

Eurasian Watermilfoil was the most prevalent submergent plant species in Paddock Lake based on the point-intercept survey. Eurasian watermilfoil was found at most of the point-intercept survey points located in water 12 feet or less **(Appendix A, Figure 4**).

Point-Intercept survey result maps of the seven most abundant native plant species found in Paddock Lake are also provided. (**Appendix A, Figures 5-11**).

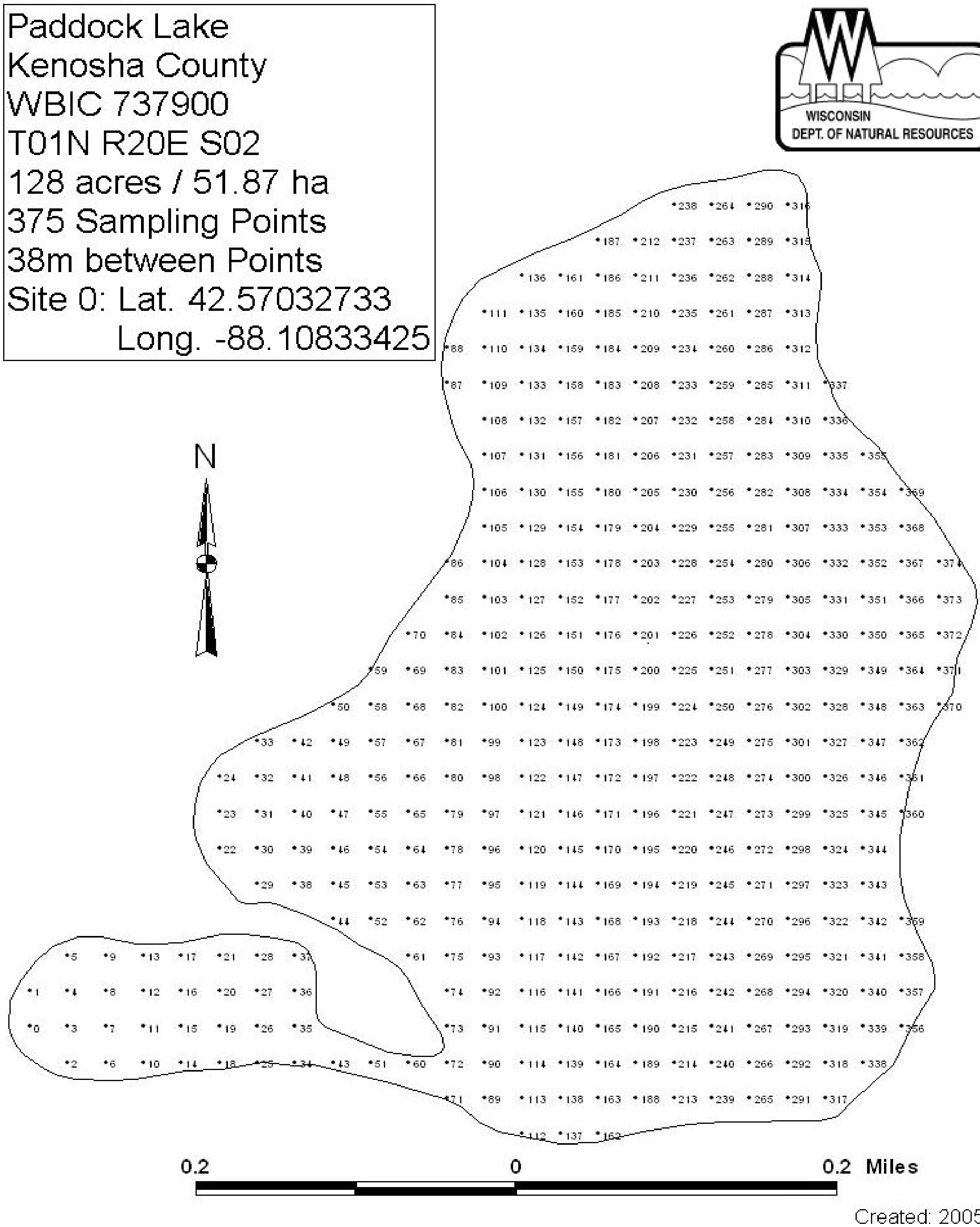


Figure 2. Point-Intercept survey grid provided by WDNR.

Table 1. Maximum rooting depths of plants in previous and current survey years.

2003	2005	2008	2014	2021
15 ft	24 ft	19 ft	20 ft	26 ft

Rake Fullness Rating	Coverage	Description
1		Only few plants. There are not enough plants to entirely cover the length of the rake head in a single layer.
2		There are enough plants to cover the length of the rake head in a single layer, but not enough to fully cover the tines.
3		The rake is completely covered, and tines are not visible.

Figure 3. Plant abundance rating criteria used in submergent aquatic plant point-intercept surveys developed by the Wisconsin Department of Natural Resources.

Table 2. Paddock Lake Aquatic Plant Species Present.

Species	Scientific Name	Plant type: floating leaf, free floating, submergent, emergent	% Relative Frequency of Occurrence	Sites Found
Eurasian water milfoil	*Myriophyllum spicatum*	Submergent	23.4	174
Water star-grass	*Heteranthera dubia*	Submergent	19.9	148
Coontail	*Ceratophyllum demersum*	Submergent	16.8	125
Variable pondweed	*Potamogeton gramineus*	Submergent	13.6	101
Muskgrasses (Chara)	*Chara sp.*	Submergent	9.3	69
Wild celery	*Vallisneria americana*	Submergent	4.8	36
Large-leaf pondweed	*Potamogeton amplifolius*	Submergent	3.8	28
Sago pondweed	*Stuckenia pectinata*	Submergent	2.7	20
Illinois pondweed	*Potamogeton illinoensis*	Submergent	2.2	16
White-stem pondweed	*Potamogeton praelongus*	Submergent	2.0	15
Slender Naiad	*Najas flexilis*	Submergent	0.5	4
White water lily	*Nymphaea odorata*	Floating Leaf	0.3	2
Forked Duckweed	*Lamna triscula*	Free Floating	0.3	2
Fern pondweed	*Potamogeton robbinsii*	Submergent	0.1	1
Small pondweed	*Potamogeton pusillus*	Submergent	0.1	1
Common bladderwort	*Utricularia vulgaris*	Free Floating	0.1	1

Table 3. Comparison of Aquatic Plant Species Found, Paddock Lake, 2005, 2008, 2014, 2021.

Scientific Name	Common Name	2005	2008	2014	2021
Ceratophyllum demersum	Coontail	X	X	X	X
Chara sp.	Muskgrasses	X	X	X	X
Elodea canadensis	Elodea	X	X	X	–
Lemna minor	Small Duckweed	–	–	X	–
Lemna triscula	Forked Duckweed	X	–	–	X
Myriophyllum sibericum	Northern Watermilfoil	X	–	X	–
M. Spicatum	Eurasian Watermilfoil	X	X	X	X
Najas flexilis	Slender Naiad	X	X	X	X
Najas marina	Spiny Naiad	–	–	X	–
Nitella sp.	Nitella	–	–	X	–
Nuphar sp.	Bullhead water lily	X	X	X	–
Nyphaea sp.	White water lily	X	X	X	X
Potamogeton amplifolius	Large-leaf pondweed	X	X	X	X
P. crispus	Curly-leaf pondweed	X	X	–	–
P. friesii	Fries pondweed	X	X	X	–
P. gramineus	Variable pondweed	X	X	X	X
P. illinoensis	Illinois pondweed	X	X	X	X
P. praelongus	White-stem pondweed	X	X	X	X
P. pusillus	Small pondweed	X	–	–	X
P. richardsonii	Richardson's pondweed	–	–	–	–
P. robbinsii	Fern pondweed	–	–	–	X
P. zosterformis	Flat-stem pondweed	–	X	*	–
Ranunculus aquatilis	Stiff water crowfoot	X	–	–	–
Sagittaria sp.	Arrowhead	–	X	X	–
Scirpus sp.	Bulrush	–	X	X	–
Spirodela polyrhiza	Large duckweed	X	–	–	–
Stuckenia pectinatus	Sago pondweed	X	X	X	X
Typha sp.	Cattail	–	X	*	–
Utricularia vulgaris	Great Bladderwort	X	X	X	X
Vallisneria americana	Water celery	X	X	X	X
Zannichellia palustris	Horned pondweed	–	–	–	–
Zosterella dubia	Water star grass	–	X	X	X
*found in general survey					

2021 FALL AQUATIC INVASIVE SPECIES SURVEY

On September 8-9, 2021, Cason & Associates, LLC conducted an Aquatic Invasive Species survey on Paddock Lake. During the survey, Eurasian Watermilfoil and its' hybrids (hereafter referred to just as EWM) were the only aquatic invasive species observed. In the table below, EWM acreages are listed by density:

Table 4. Eurasian Watermilfoil acreage by density (2021 Fall AIS Survey).

Densities	EWM Surveyed (Acres)
Highly Scattered	3.66
Scattered	19.7
Moderately Dense	16.2
Dense	38.4
Total Acreage:	**77.96**

A high percentage of Paddock Lake is relatively shallow and clear, this provides ample habitat for aquatic plants to grow, especially EWM (**Table 4**). We observed EWM in 60.9% of Paddock Lake (**Appendix B, Figure 12**). The highest densities of EWM were usually the areas furthest from shore where there was less competition for growing space. Some areas on the northern end of the lake were too shallow to navigate effectively during the survey however EWM was omnipresent. The aquatic plant mower working to remove plants from navigation areas likely contributes to the continual fragmentation and aides in the spread of EWM throughout the lake; this process can also affect the density observed at any given time.

Another invasive wetland species, Purple Loosestrife, was observed at a few locations around the lake however we did not map them during this survey. Purple Loosestrife spreads through fragmentation, rhizomes, and seeds and can quickly create a monoculture that is low in diversity.

WATER QUALITY MONITORING -

From May 24 - September 12, volunteers collected water quality data as a part of the Citizen Lake Monitoring Network. The table below (**Table 5**) lists the individual Secchi depth readings as well as the Trophic State Index values determined for Secchi Depth, Chlorophyll *a*, and Total Phosphorus.

Table 5. Eurasian Watermilfoil acreage by density (2021 Fall AIS Survey).

Sample Date	Secchi Depth (ft)	TSI (SD)	TSI (CHL)	TSI (TP)
5/24/2021	15	38		
6/1/2021	16	37		
6/11/2021	23	32		
6/16/2021	23	32	31	50
7/7/2021	15	38		
7/21/2021	15	38		
7/26/2021	15	38	32	50
8/16/2021	18	35		
8/23/2021	11	43	46	52
9/2/2021	8	47		
9/12/2021	8	47		

TROPHIC STATE INDEX

Trophic State Index (TSI) is a measure of a lake's productivity **(Figure 4)**. Trophic state takes into consideration water quality parameters such as total phosphorus, chlorophyll α, and water clarity. A high TSI value means a highly productive lake and poor water quality, whereas a low TSI value is characteristic of a lake with low productivity and good water quality. A desired TSI value for good water quality in lakes is below 50. Overall, Paddock Lake had a TSI value was 41 in 2021. The TSI suggests that Paddock Lake was mesotrophic. Mesotrophic lakes are characterized by moderately clear water but have an increased chance of low dissolved oxygen in deep water during the summer.

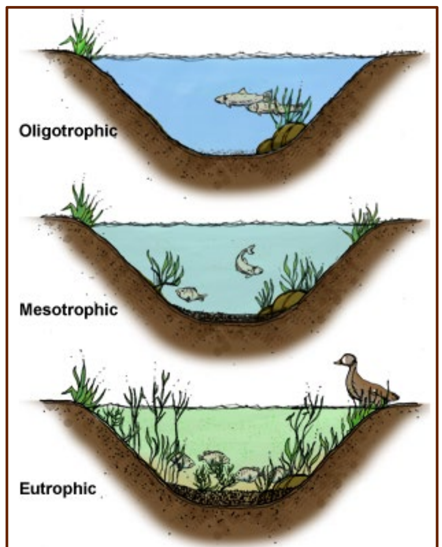


Figure 4: Lake Productivity Classifications

Credit: Michigan Lake Info
http://www.michiganlakeinfo.com/lake-water-quality.html

The calculated TSI values for average summer total phosphorous was 19.2 µg/l, and chlorophyll *α* was 2.4 µg/l. Lakes that have more than 20 µg/l of total phosphorus may experience noticeable algae blooms.

SUMMARY

- Paddock Lake has good diversity of native aquatic plants.
- EWM has become very widespread throughout most of the littoral zone of the lake.
- EWM could become a threat to the native plant community and to the general health of the ecosystem.
- Yearly surveys should be conducted to monitor spreading of aquatic invasive species and to quickly identify any possible new invasive species.
- Shoreline invasive species such as purple loosestrife should be removed to prevent further spread around the lake.

AQUATIC PLANT MANAGEMENT OPTIONS

Herbicide Control

Herbicides have been the one of the most widely used and often successful tools for controlling aquatic macrophytes. Herbicide treatments require WDNR permitting, and herbicides must be applied by a licensed applicator (Cason & Associates). The efficacy of herbicides is contingent upon timing, formulations and application rates, water flow, lake type and target and non-target species.[1] The two most important variables to consider in determining herbicide effectiveness are the concentration and exposure time. Product can dissipate throughout the waterbody due to water flow, water depth, wind and volume. The herbicide also degrades, or breaks down, over time and from microbial processes. Sunlight can also degrade herbicide into its components. There is a broad spectrum of herbicide formulations available to target invasive aquatic plants such as Eurasian watermilfoil and curly-leaf pondweed. These include 2, 4-D products (Navigate®, Sculpin G®, and Weedar®); diquat and endothall products (Aquastrike®, Aquathol K®, and Tribune®); fluridone products (Sonar®); and triclopyr products (Renovate®).

Eurasian water milfoil and curly-leaf pondweed are not the only plant species sensitive to herbicide applications. Some non-target species may experience statistically significant declines following an herbicide treatment.[2] As a result of the potential for all herbicides to impact non-target species, herbicide treatment effectiveness can be bolstered if applied in early spring. Exotic species typically emerge prior to native vegetation. At earlier stages of growth, plants are more actively absorbing nutrients, and therefore, are more vulnerable to herbicide. Since most native plants are still dormant, native plants are less likely to be affected by the treatment. Since water temperatures are cooler, microbial degradation is slower and exposure time is extended. In the spring, plant biomass is also lower, which mitigates the possibility of detrimental effects from the decomposition of large amounts of organic matter, namely, low dissolved oxygen, release of nutrients and subsequent algae blooms.

[1] Nault, Michelle, A. Mikulyuk, J. Hauxwell, J. Skogerboe, T. Asplund, M. Barton, K. Wagner, T. Hoyman, E. Heath. 2012. Herbicide treatments in Wisconsin lakes: building a framework for scientific evaluation of large-scale herbicide treatments in Wisconsin lakes. Lakeline 32: 21-26.

[2] Nault, Michelle E., Michael D. Netherland, Alison Mikulyuk , John G. Skogerboe , Tim Asplund , Jennifer Hauxwell & Pamela Toshner. 2014. Efficacy, selectivity, and herbicide concentrations following a whole-lake 2,4-D application targeting Eurasian/hybrid watermilfoil in two adjacent northern Wisconsin lakes. Lake and Reservoir Management 30:1, 1-10.

Manual Vegetation Removal

Manual removal options include raking, hand-pulling, harvester and Diver Assisted Suction Harvesting (DASH). Individuals can remove aquatic vegetation in front of their homes, however, there are limitations as to where plants can be hand-pulled and how much can be removed. In most instances, control of native aquatic plants is discouraged and is limited to areas next to piers and docks and in navigational lanes. When aquatic vegetation is manually removed, it is restricted to an area that is 30 feet or less in width along the shore. Invasive species (Eurasian watermilfoil, curly-leaf pondweed, etc.) may be manually removed beyond 30 feet without a permit if native plants are not harmed. Manual removal of native plants beyond the 30-foot area would require an NR 109 permit. Manual removal is low cost compared to other control methods. However, raking or hand-pulling aquatic plants is labor intensive and fragmentation may lead to further spread.

DASH involves a diver or snorkeler removing plants from the sediment and using a suction device to feed the plant into a harvester or other container. As with other similar activities, removal of the entire plant, including the stems and roots, is critical to eliminate the possibility of further spread and regrowth. There are firms in the state that specialize in DASH. As an alternative, some lake organizations have built their own DASH units and operate the units throughout the season. Variables to consider when planning DASH activities and selecting areas to harvest include plant bed size and density, water clarity, sediment type, native plant abundance, obstructions such as docks or fallen trees, financial resources and time restraints. These variables determine the speed at which progress is made. DASH is a small-scale tool and should not be expected to greatly reduce Eurasian watermilfoil densities in areas of widespread growth. DASH operations should primarily focus on areas of scattered Eurasian watermilfoil not slated for chemical treatment or as a touch-up for regrowth in previously treated areas. However, DASH can be highly effective in managing and reducing curly-leaf pondweed as the plant is much more robust and does not reproduce via fragmentation, but through turions. If the curly-leaf pondweed can be removed prior to turion development and release, populations can achieve long-term controlled.

CONCLUSIONS AND RECOMMENDATIONS

Aquatic Invasive Species

Paddock Lake is a shallow, productive lake that creates ideal conditions for aquatic plant growth. Paddock Lake currently contains an above-average diversity of submergent vegetation for the Southeastern Wisconsin region. Eurasian watermilfoil beds identified during the September 2021 AIS survey (**Appendix B**) are recommended for herbicide treatment and/or harvesting.

If beds of curly-leaf pondweed are found in further surveys, herbicide use may be appropriate. For areas with small clusters or individuals, manual removal (such as DASH or hand-pulling) is a viable option. However, before deciding on a curly-leaf pondweed management option, it would be best to conduct a spring meandering, visual AIS survey to determine the true extent of curly-leaf pondweed in Paddock Lake.

Continuing to selectively treat aquatic plants for navigation purposes is recommended in areas of high traffic and waterfront access. Annual meandering, visual AIS surveys should continue to be performed for the foreseeable future to monitor Eurasian watermilfoil and curly-leaf pondweed locations, densities and extents. Point-intercept surveys for quantitative analyses should be conducted each year before and after large-scale management activities. Point-intercept survey should remain current, with no more than five years between surveys to monitor management efficacy and the plant communities.

Annual stakeholder meetings should take place to assess the results of the previous year's AIS management activities. Attendees should include representatives from the WDNR, the Paddock Lake Management District Board, Cason & Associates, LLC and the Kenosha County AIS specialist. These meetings should provide consensus on annual invasive species management activities.

Clean Boats, Clean Waters

Paddock Lake Protection and Rehabilitation District should implement a Clean Boats, Clean Water (CBCW) program. The WDNR, in cooperation with the UW-Extension Lakes Program, has developed this volunteer watercraft inspection program designed to educate motivated lake organizations in preventing the spread of exotic plant and animal species among Wisconsin lakes. This program would be particularly useful to Paddock Lake during the summer months when lake usage increases. Paddock Lake Protection and Rehabilitation District should train volunteers to monitor and stop the spread of invasive plants and animals. Not only does this program help reduce the likelihood of new invasive species being introduced to Paddock Lake, it also helps prevent the spread of invasive species from this lake to other waterbodies.

Education plays a big part in the CBCW program. PLPRD should make it a priority to include exotic species education during all normally scheduled meetings whenever possible. In addition, special meetings should be sponsored to train volunteers for this program.

Native northern watermilfoil is also present in Paddock Lake. Since it superficially appears to share characteristics with Eurasian watermilfoil, care should be taken to specifically learn to differentiate between the two species. Native northern watermilfoil has been known to hybridize with Eurasian watermilfoil; being aware of hybrid watermilfoil characteristics is necessary to properly differentiate between species. In addition to Eurasian watermilfoil and curly-leaf pondweed, it would benefit District members to become familiar with the identification of other exotic species that pose a threat to Wisconsin lakes. Additional information and education materials are available through the WDNR and the local UW-Extension office.

Water Quality Management

Paddock Lake is impacted by non-point source pollution from nearby agricultural and urban land use practices in the watershed. The first step in managing nutrients in a lake is to control external sources of nutrients. Individual property owners should be encouraged by Paddock Lake Protection and Rehabilitation District to utilize shoreline improvement and nutrient management practices through presentations at meeting and in newsletters.

Several water quality parameters discussed in this management plan had only small data sets available. To make valid long-term interpretations of water quality data, it is recommended Paddock Lake Protection and Rehabilitation District collect regular water samples to be analyzed at the State Lab of Hygiene for chlorophyll *a*, total phosphorus, total nitrogen, nitrate, nitrite, ammonia and Kjeldahl nitrogen. Additionally, sampling for chloride, sulfates, sodium and potassium on a regular basis would be prudent to detect significant changes. Monitoring pH and hardness values may be required if changes in related data sets suggest acidity concerns in Paddock Lake. In the field, continuing to take dissolved oxygen, temperature and conductivity profiles is critical, as data indicated that Paddock Lake experiences low dissolved oxygen in the summer months.

Photo 4: Shoreline Examples from Paddock Lake

The district should consider adding an aeration system to Paddock Lake. Adding an aeration system would combat the low dissolved oxygen levels, algal blooms, organic sediment (muck) accumulation, noxious odors, reduced water clarity and fish kills. Any proposed aeration system should be designed specifically for Paddock Lake using the documented water quality parameters and lake geomorphology.

Lawn Care Practices

Individuals are important in reducing sedimentation and nutrient inputs from local sources. Mowed grass up to the water's edge is detrimental for the well-being of a lake **(Photo 4)**. A mowed lawn can cause seven times the amount of phosphorus and 18 times the amount of sediment to enter a waterbody than a natural shoreline.[3] Lawn grasses also tend to have shallow root systems that cannot protect the shoreline from erosion as well as deeper-rooted native vegetation.[4] Property owners should take care to keep leaves and grass clippings out of the lake whenever possible, as they contain nitrogen and phosphorus. The best disposal for organic matter, such as leaves and grass clippings, is composting.

Fertilizers that enter the lake will encourage an increase in plant and algae biomass. Fertilizers contain nutrients that can wash directly into the lake. While elevated levels of phosphorus can cause unsightly algal blooms, nitrogen inputs have been shown to increase plant growth. Increases in plant biomass will lead to further sedimentation and navigational issues. Landowners are encouraged to

[3] Korth, Robert and Tamara Dudiak. 2003. The Shoreland Stewardship Series #1. University of Wisconsin-Extension, Wisconsin Department of Natural Resources, The Wisconsin Lakes Partnership, Wisconsin Association of Lakes, River Alliance of Wisconsin.

[4] Henderson, C.L., C.J. Dindorf, and F. J. Rozumalski. 1998. Lakescaping for Wildlife and Water Quality. State of Minnesota, Department of Natural Resources.

perform a soil test before fertilizing. A soil test will help determine if a yard needs to be fertilized. For assistance in having soil tested, contact the local county UW-Extension office. Most lawns in Wisconsin do not need additional phosphorus. The numbers on a bag of fertilizer are the percentages of available nitrogen, phosphorus and potassium found in the bag. Phosphorus-free fertilizers will have a 0 for the middle number (e.g. 10-0-3). Since April 1, 2010, fertilizers containing phosphorus cannot be applied to lawns or turf in Wisconsin. This change in the state's statutes is intended to provide protection to Wisconsin's water resources from phosphorus run-off.

Vegetated Buffer Zones

There are beneficial alternatives to the traditional mowed lawn. When possible, it is best to leave the natural shoreline undisturbed, but if clearing is necessary to access or view the lake, consider selective vegetation removal. If the natural shoreline has been disturbed or removed, restoring the natural areas to the greatest extent practical would have a positive impact on the lake's overall health.

Shoreline vegetation serves as an important filter against nutrient loading, traps loose sediment and plays a key role in bank stabilization. Additionally, a vegetated buffer zone provides excellent fish and wildlife habitat, including nesting sites for birds, and spawning habitat for fish.[5] A buffer zone consists of a mixture of native trees, shrubs and other upland and aquatic plants that may extend from 25 to 100 feet or more from the water's edge onto land, and 25 to 50 feet into the water. Often a buffer to this extent is not feasible, either physically or economically. In these cases, a smaller or narrower buffer can still provide the same benefits of a more extensive buffer on a smaller scale. The goal for a buffer zone should be to cover between 50% and 75% of the shoreline frontage. In most cases, this 50% and 75% would leave space for a dock, swimming area and lawn. Providing complex shoreline habitats can result in significant increases in fish diversity and numbers, as well as increasing lake health.

Several resources are available to assist property owners in creating beneficial buffer zones. These include the WDNR, local UW-Extension office and the County Land and Water Conservation Department. These organizations can provide descriptions of beneficial native plant species and listings of aquatic nurseries in the state. Kenosha County and the WDNR have grant programs that can be utilized for funding sources. Cason & Associates provides native plantings as one of our many services. Contact us for quotes.

The WDNR offers grant funds through the Healthy Lakes Program. Healthy Lakes practices focus on simple ways to improve fish habitat, integrate native plantings, divert and clean runoff water and promote natural beauty. Options include fish sticks, native plantings, diversion, rain garden, and rock infiltration practices. Fish sticks and native plantings help create habitat for fish and wildlife and provide pleasing aesthetics. Diversion, rain garden and rock infiltration practices capture and redirect runoff and reduce soil erosion. A total of one thousand dollars can be awarded per practice. A recognized lake district or association can sponsor the grant for participating individual property owners.

5 Jennings, M., M.A. Bozek, G. Hatzenbeler, E. Emmons, and M. Staggs. 1999. Cumulative effects of incremental shoreline habitat. North American Journal of Fisheries Management 19(1): 18-27.

The Paddock Lake Protection and Rehabilitation District should encourage all lakefront residents to improve their shorelines by installing vegetated buffers (**photos 5 & 6),** rain gardens and water diversions to improve the water quality of Paddock Lake.

Photo 5: Blue Flag Iris, A Native Shoreline Plant.

Photo 6: *Liatris spicata*, A Native Wildlfower.

Erosion Control

Although erosion is a natural process, erosion should be controlled and slowed as much as possible, both for the health of the lake and benefit of the landowner. Sediment transport into the lake causes nutrient pollution, turbid water conditions, degrades fish spawning habitat and increases eutrophication. Shoreline owners are encouraged to leave existing vegetation undisturbed to stabilize the shore. The placement of logs, brush mats and rock riprap are also options against erosion. Desirable shrubs and aquatic plants should be planted within riprap, which will serve as nutrient filters and habitat. Before any shoreline stabilization project is initiated, property owners need to contact the local WDNR office for project approval and to obtain any necessary permits.

Reduced Impacts from Boating

Boat traffic can increase suspended solids, especially in shallow areas of lakes.[6] Maximum turbidity occurs between 2 and 24 hours following boating activities. Effects of boating depend upon propeller size, boat speed, draft, and sediment characteristics.[7] Silty sediments have the highest susceptibility to resuspension and the highest potential for the reintroduction of nutrients into the water column. No significant changes in algae (chlorophyll *a*) concentrations have been reported following boating activity. This is due primarily to an indeterminate time lag which occurs between the release of nutrients and the subsequent increase in algal growth.[8]

Disturbances to the native plant communities from watercrafts can accelerate the spread of opportunistic exotic plant species. Wisconsin statutes require boaters to maintain no-wake speeds within 100 feet of shorelines, other boats or fixed structures, including boat docks and swimming platforms. However, it is difficult to enforce such regulations, and even slow boat traffic can have a negative impact on sediments and plant communities in shallow areas. Operating in shallow areas not only has a negative impact on the lake, but shallow conditions can also damage boat propellers and motors. Education is vital to reducing impacts from boat traffic.

Septic System Maintenance

Septic systems are known to contribute nutrients to a lake. It is the responsibility of lakeshore property owners to ensure that septic systems are properly functioning. A failing septic system can contaminate both surface and ground water. Many counties in Wisconsin are currently taking inventory of septic systems and enrolling the systems in a three-year maintenance program. Property owners should avoid flushing toxic chemicals into septic systems, which can harm important bacteria that live in the tank and naturally break down wastes. Owners should also avoid planting trees, compacting soil or directing additional surface runoff on top of the drain field.

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6 Hill, David F. 2004. Physical impacts of boating on lakes. Lakeline. Fall 2004. pp. 15-18.

7 Asplund, T. R., and C. M. Cook. 1999. Effects of motorboats on submerged aquatic macrophytes. Lake and Reservoir Management 13(1):1-12.

8 Asplund, T. R. 1996. Impacts of motorized watercraft on water quality in Wisconsin Lakes. Wis. Dept. Nat. Res. Bur. Research, Madison, WI. PUBL-RS-920-96. 46 pp.

Wisconsin Citizen Lake Monitoring Network

Paddock Lake Protection and Rehabilitation District has an active Citizen Lake Monitoring Network group. In addition to collecting Secchi depth data, it would be useful to sample for chlorophyll *a* and phosphorus and measure dissolved oxygen and temperature profiles three times during the summer.

Supplementary information and resources to continue or begin monitoring activities are available through the Wisconsin Citizen Lake Monitoring Network. The Citizen Lake Monitoring Network program provides an opportunity for volunteers from lake organizations to assist in state-wide water quality monitoring. Through a database managed by the WDNR, information gathered is shared by volunteers and archived. The importance of long-term data is crucial in assessing changes to the lake environment. In addition, participating in projects of this type can help Paddock Lake Protection and Rehabilitation District secure additional grant money from the WDNR. Funds are awarded to organizations that demonstrate a commitment to the health and wellbeing of their lakes.

Fish and Habitat

To gather data on the fish community and assess population dynamics, an electrofishing and/or fyke netting survey is recommended for Paddock Lake. Since a fish survey has not been conducted in the past, there is no baseline fishery data, which is necessary to make assessments.

MANAGEMENT ACTIVITES IMPLEMENTATION PLAN

The following management activities are recommended for implementation in 2022.

Treatment

- Eurasian/hybrid watermilfoil (EWM/HWM) treatment cost estimate can be developed and provided upon request from the PLPRD

Aquatic Plant Surveys

- System-Wide AIS Mapping Surveys
    - A system-wide AIS survey for EWM/HWM should be conducted again in 2022 to identify and map areas of EWM/HWM growth. The results of this survey will be used to guide 2023 management activities.
        - *Timeline for implementation:* end of July 2022 - September 2022 (We recommend scheduling this survey later in the season so more accurate EWM/HWM acreages and densities are observed due to continued growth of EWM/HWM into the fall.)

Mechanical Harvesting

- The PLPRD will continue to use mechanical harvesters to remove vegetation from areas of dense plant growth that impede navigation and recreational activities, which includes both rooted and floating nuisance plants. Areas of dense invasive plant growth should be prioritized to decrease the amount of fragmentation caused by boat traffic.

Water Quality Monitoring

- The PLPRD and volunteers will continue collecting and recording data for water clarity (Secchi disk depth), dissolved oxygen, and temperature Paddock Lake.

APPENDIX A

2021 Point-Intercept Survey Maps

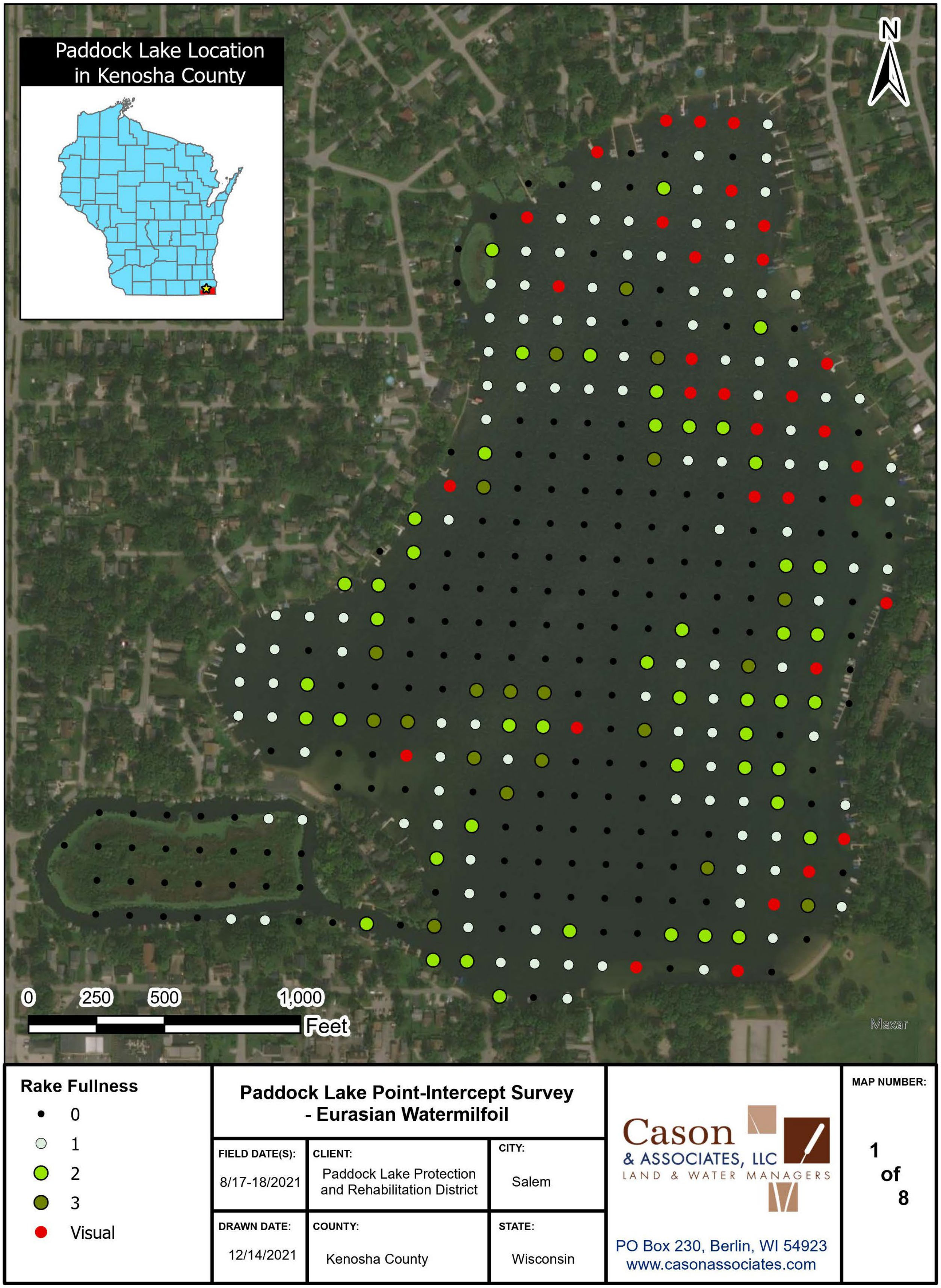


Figure 4. Distribution of Eurasian Watermilfoil in Paddock Lake.

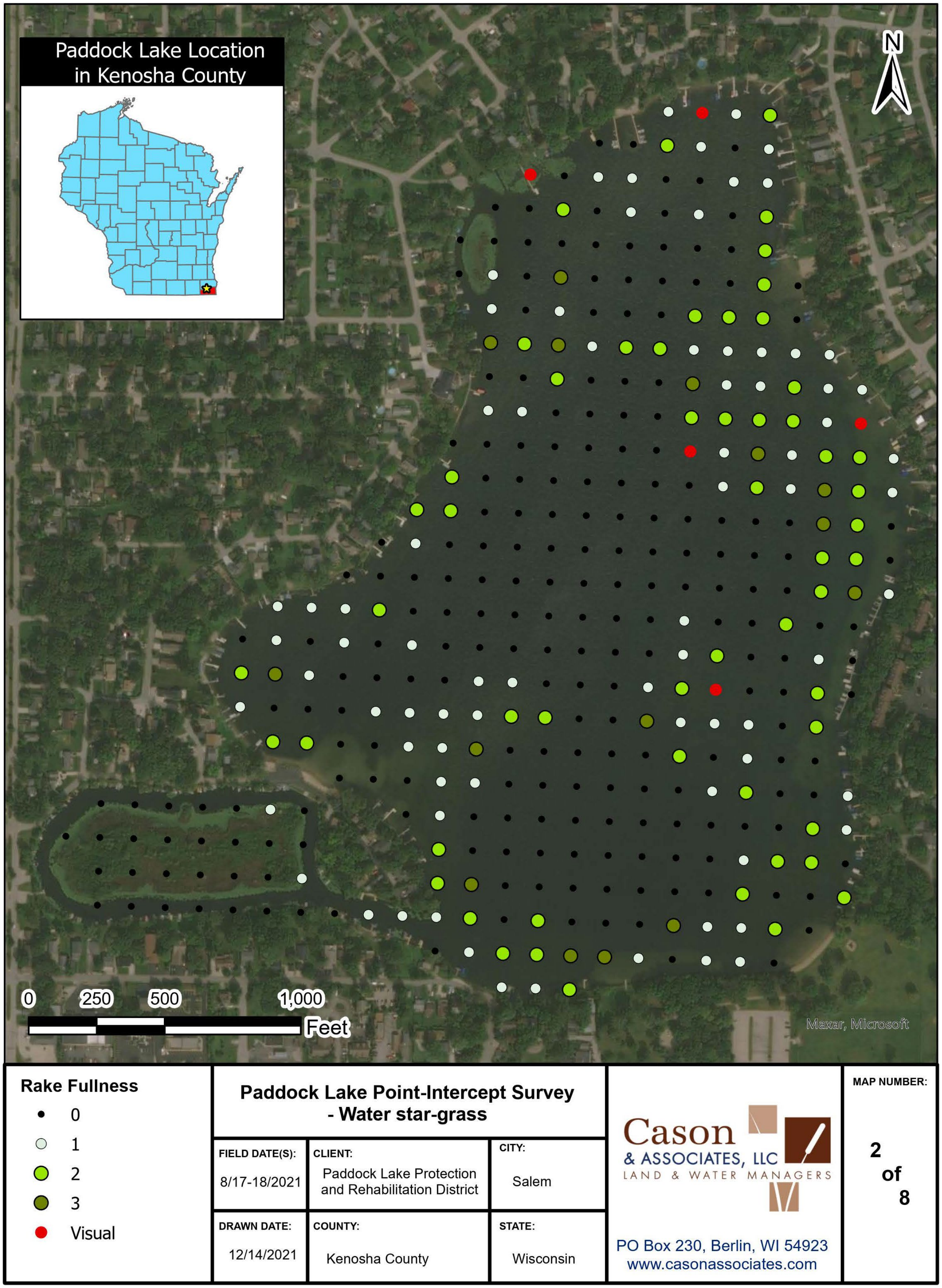


Figure 5. Distribution of Water Star-grass in Paddock Lake.

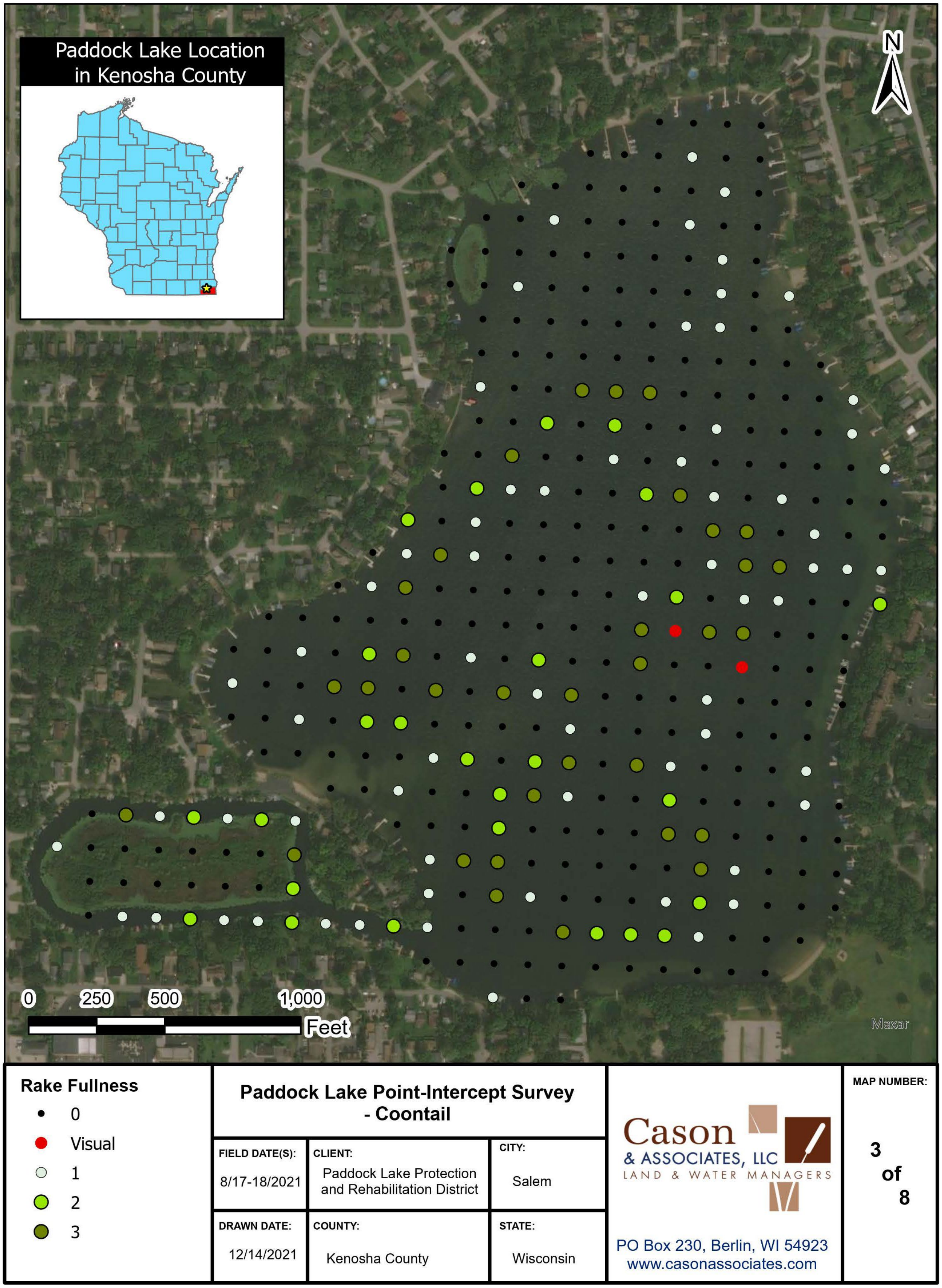


Figure 6. Distribution of Coontail in Paddock Lake.

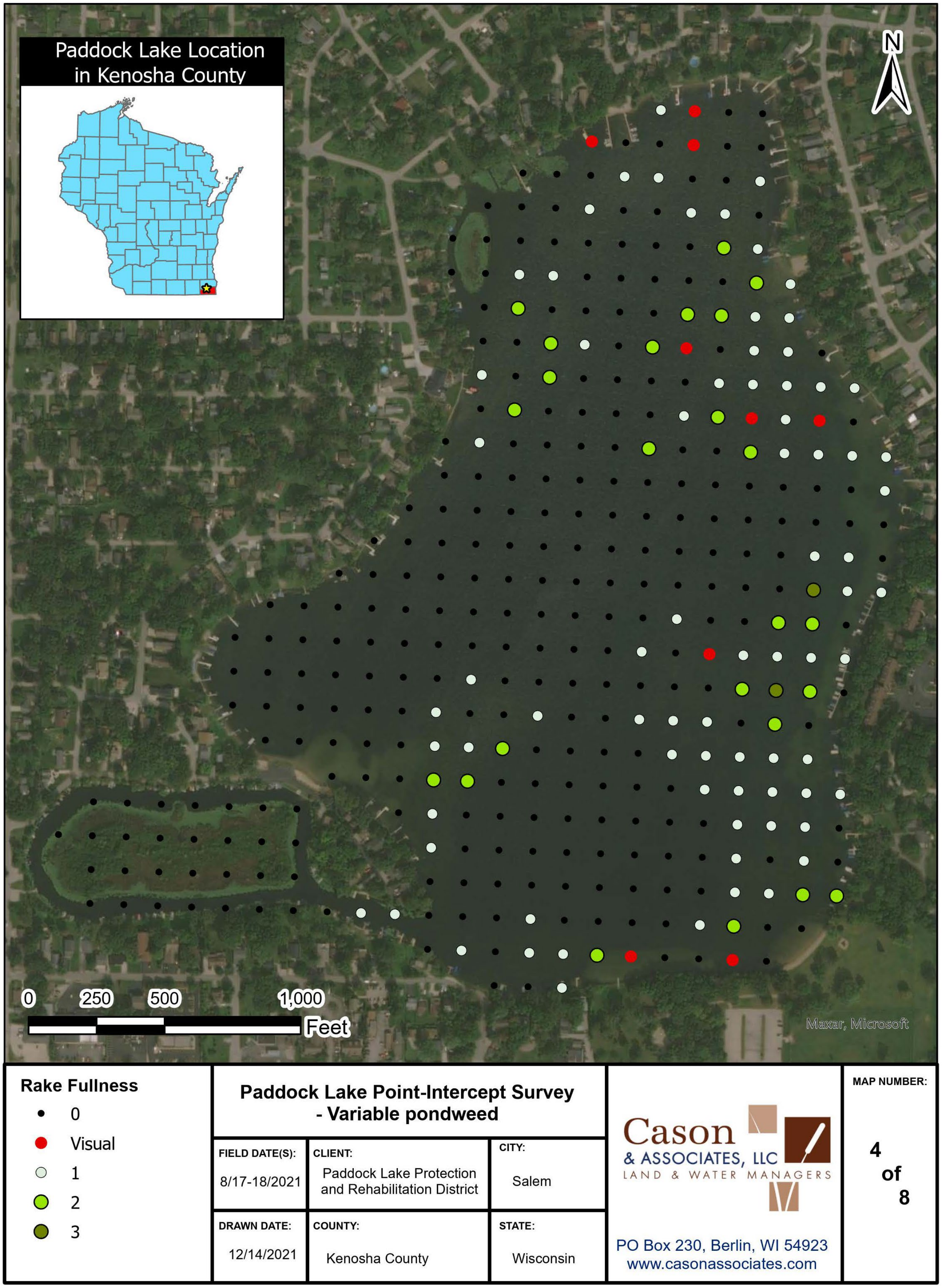


Figure 7. Distribution of Variable Pondweed in Paddock Lake.

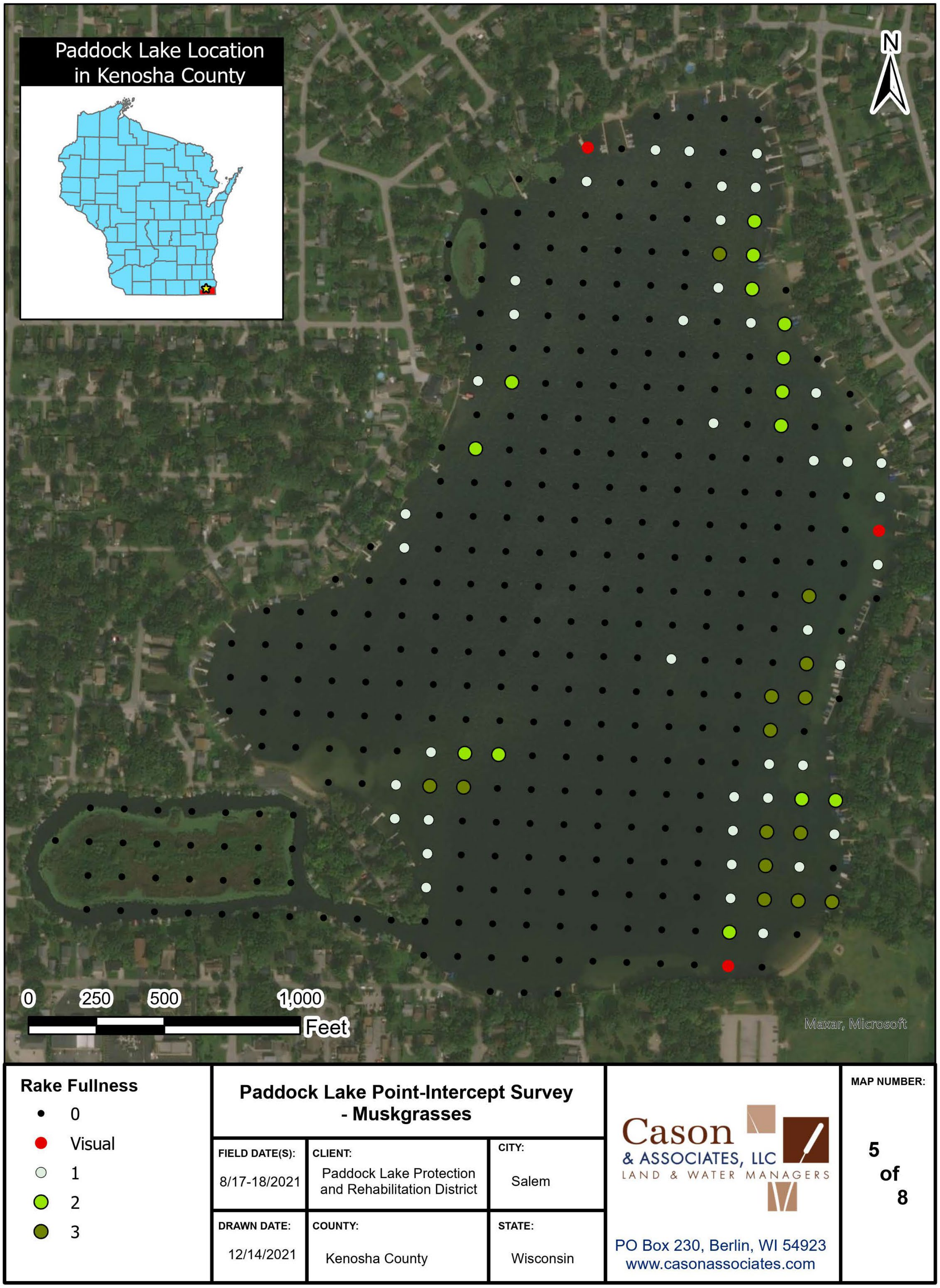


Figure 8. Distribution of Muskgrass (Chara) in Paddock Lake.

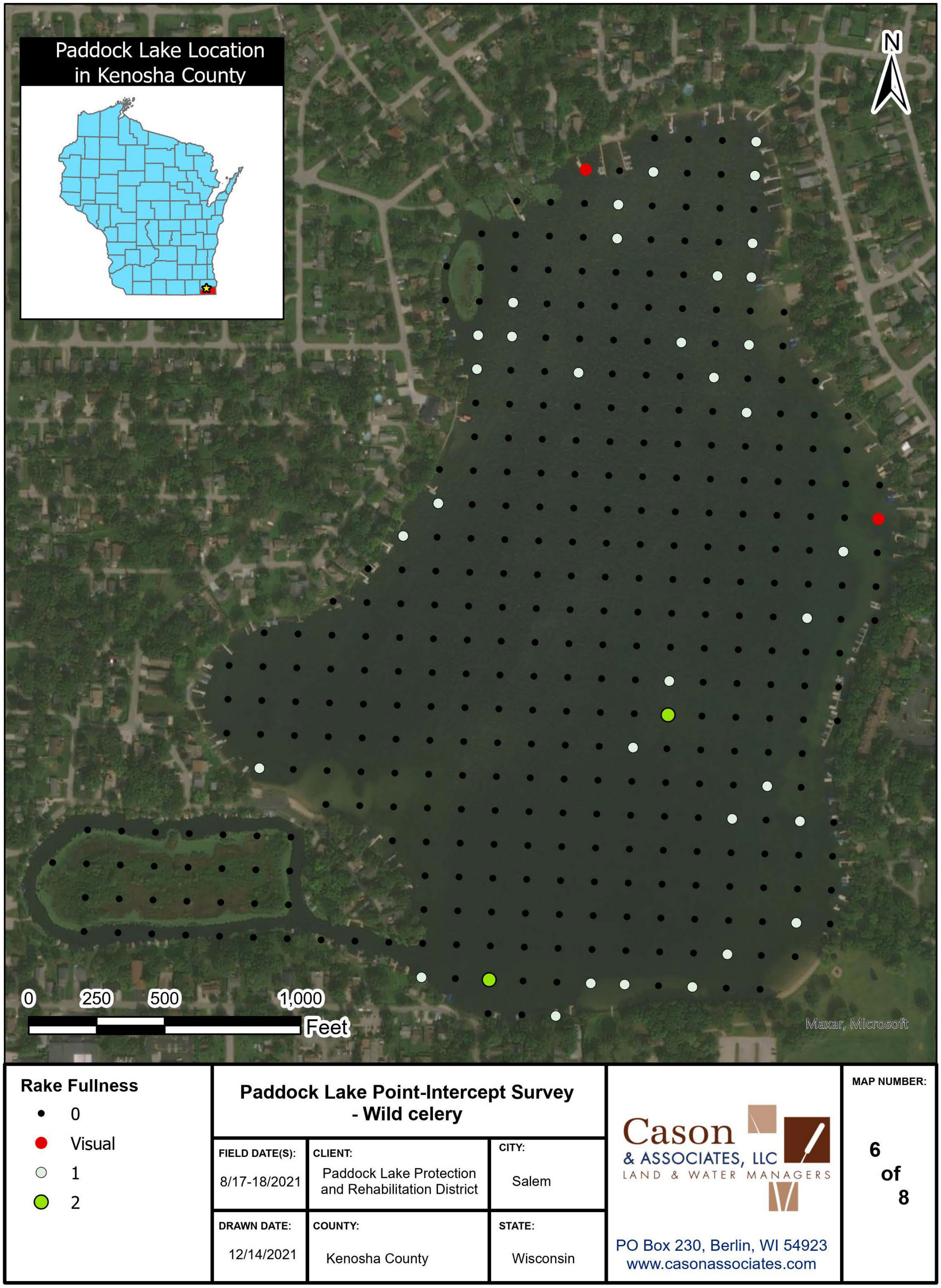
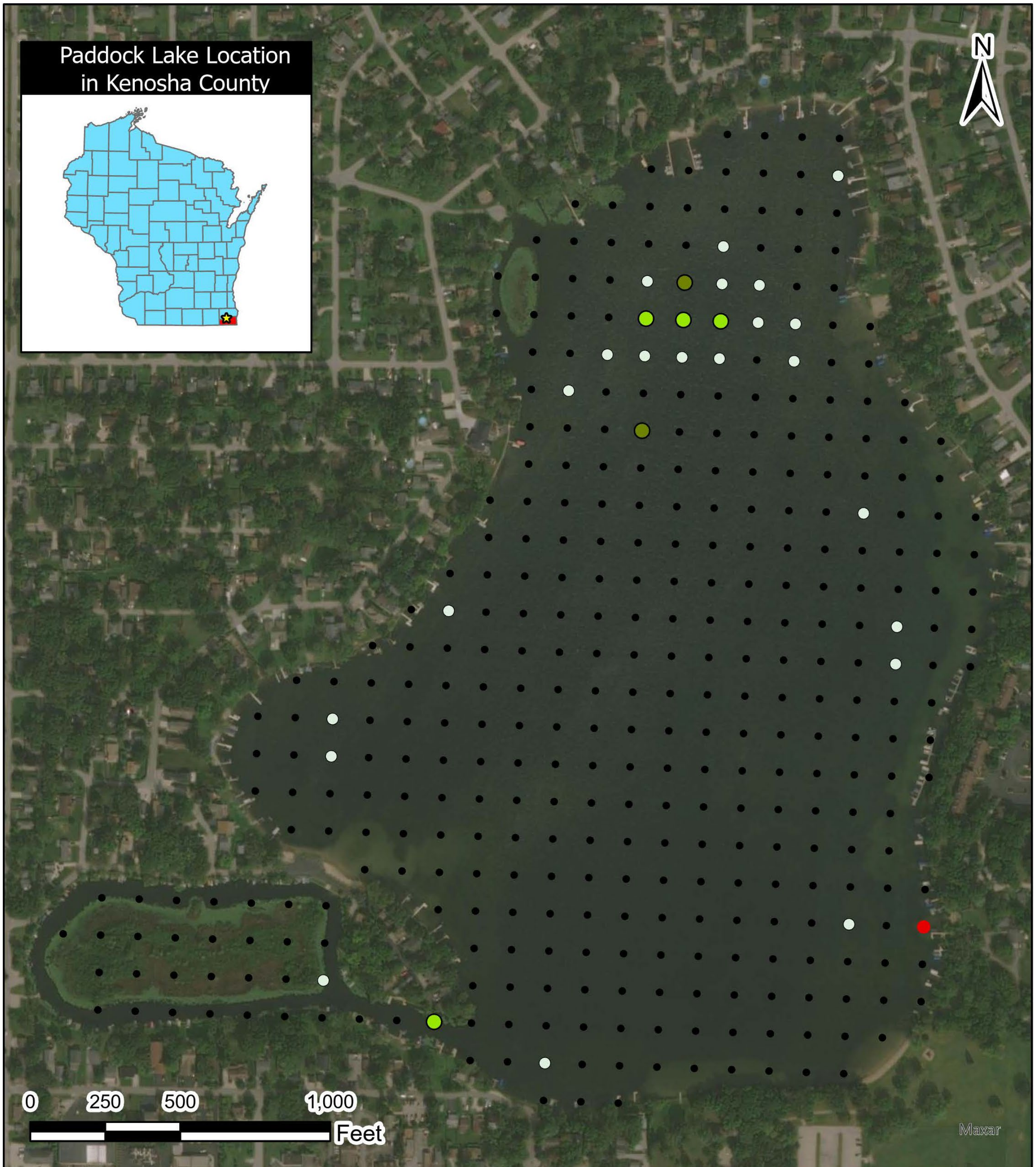


Figure 9. Distribution of Wild Celery in Paddock Lake.



Rake Fullness
- 0
- Visual
- 1
- 2
- 3

Paddock Lake Point-Intercept Survey - Large-leaf pondweed

FIELD DATE(S): 8/17-18/2021	CLIENT: Paddock Lake Protection and Rehabilitation District	CITY: Salem
DRAWN DATE: 12/14/2021	COUNTY: Kenosha County	STATE: Wisconsin

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LAND & WATER MANAGERS
PO Box 230, Berlin, WI 54923
www.casonassociates.com

MAP NUMBER: 7 of 8

Figure 10. Distribution of Large-Leaf Pondweed in Paddock Lake.

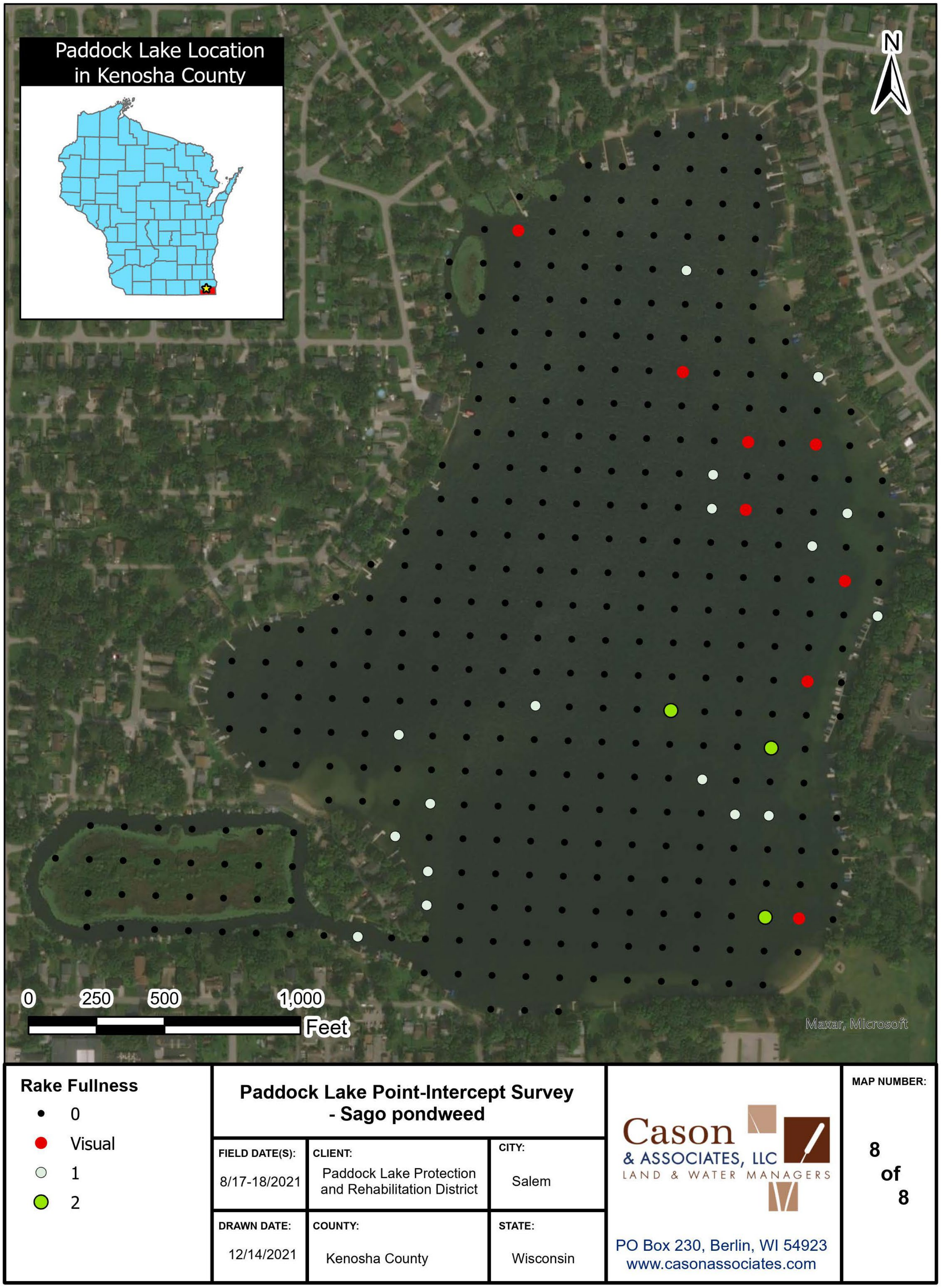


Figure 11. Distribution of Sago Pondweed in Paddock Lake.

APPENDIX B

2021 Fall AIS Meandering Survey Map

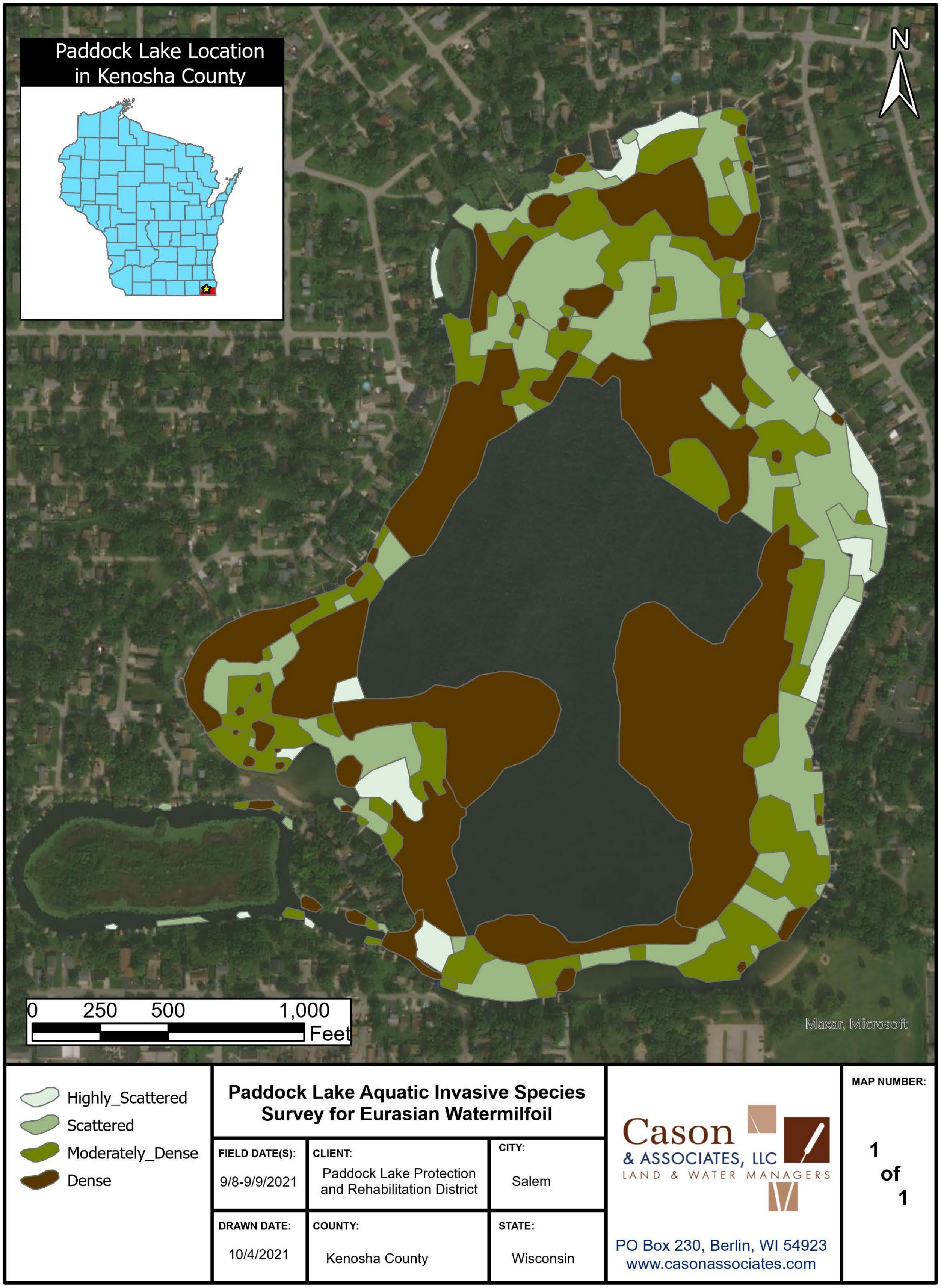


Figure 12. Survey map of Eurasian Watermilfoil density on Paddock Lake.

APPENDIX C

2022 Aquatic Plant Harvesting Plan Map

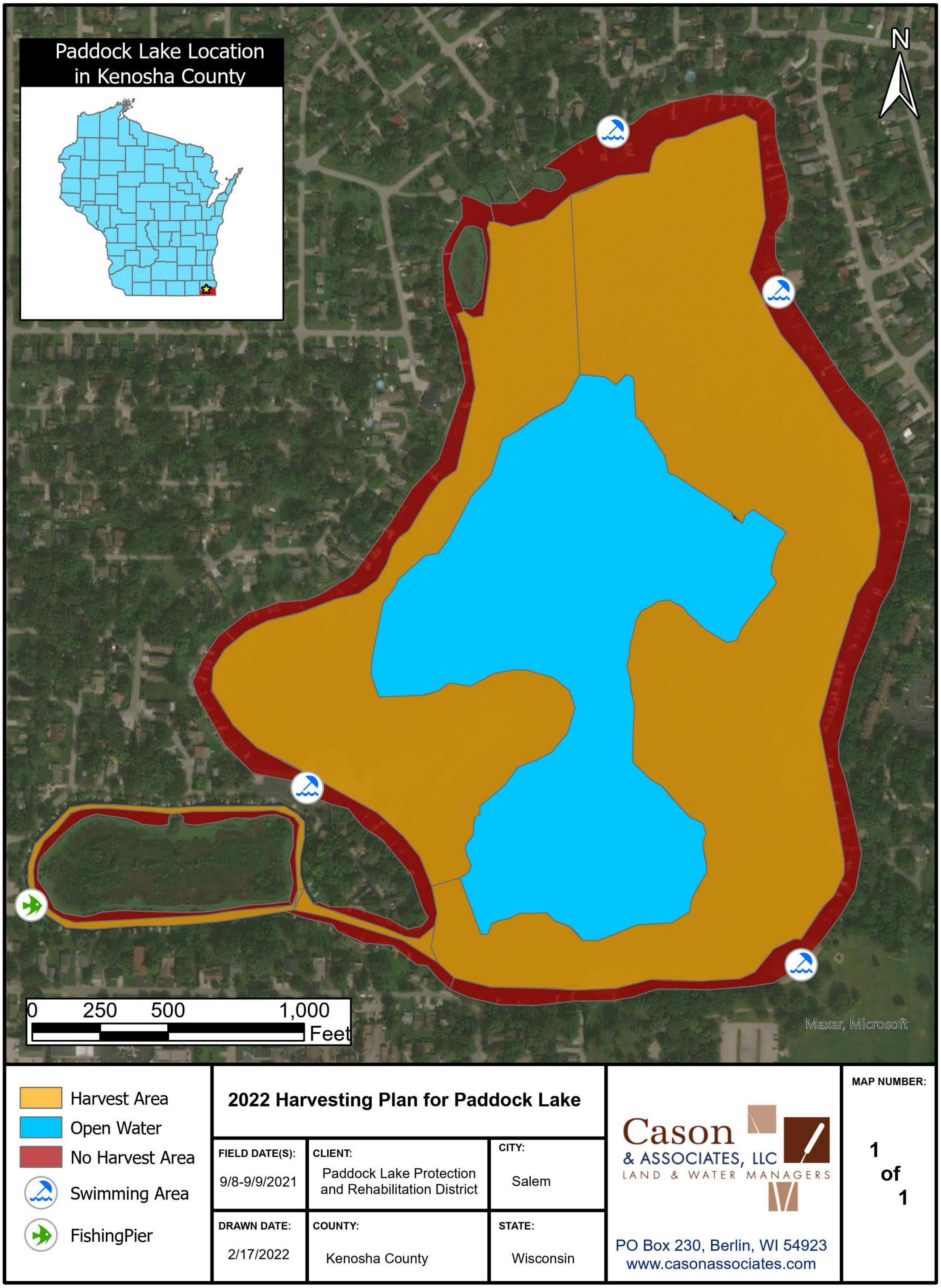


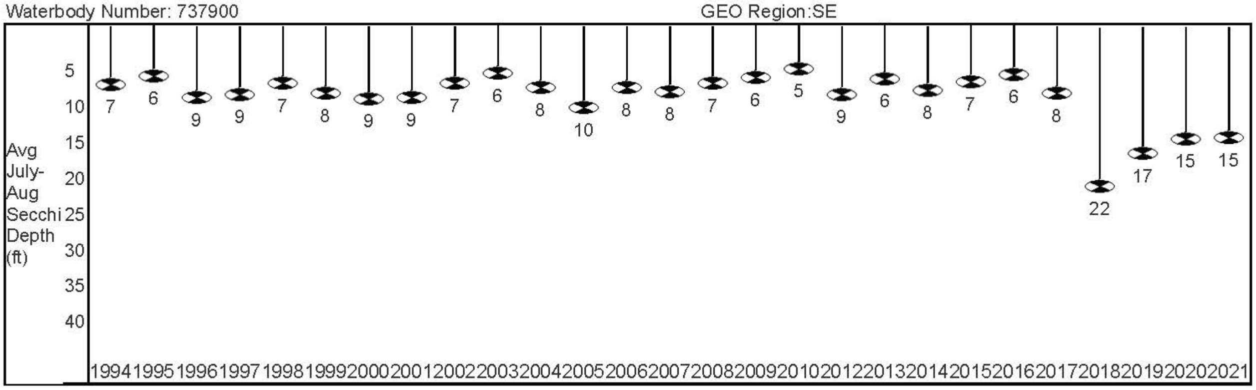
Figure 13. 2022 Aquatic plant harvesting map for Paddock Lake.

APPENDIX D

2021 Citizen Lake Monitoring Network - Water Quality Data

Wisconsin Department of Natural Resources

Paddock Lake Lake Type: DRAINED
Kenosha County DNR Region: SE
Waterbody Number: 737900 GEO Region:SE



Past secchi averages in feet (July and August only).

Year	Secchi Mean	Secchi Min	Secchi Max	Secchi Count
1994	7.4	6	9	5
1995	6.25	4.75	10	6
1996	9.17	8	10.5	6
1997	8.79	7.5	10.5	7
1998	7.1	7	7.5	5
1999	8.5	8	9	4
2000	9.33	7.5	11.5	6
2001	9.29	8	11	6
2002	7.25	7	8	4
2003	5.83	4.5	8	3
2004	7.83	7.5	8	6
2005	10.56	8.5	12.5	9
2006	7.81	6.5	9.5	8
2007	8.3	7	9.5	10
2008	7.23	3.5	10	11
2009	6.41	5	8.5	16
2010	5.25	5	5.5	2
2012	8.72	7	11	9
2013	6.5	3.5	10	6
2014	8.29	7	10	7
2015	6.92	6.5	7.5	6
2016	6.06	4	9	8
2017	8.5	7	11	9
2018	21.5	17	25	6
2019	17	16	18	6
2020	15	15	15	3
2021	14.8	11	18	5

Report Generated: 02/17/2022

The Official Internet site for the Wisconsin Department of Natural Resources
101 S. Webster Street . PO Box 7921 . Madison, Wisconsin 53707-7921 . 608.266.2621

Figure 14. Secchi depth readings for Paddock Lake from 1994-2021.

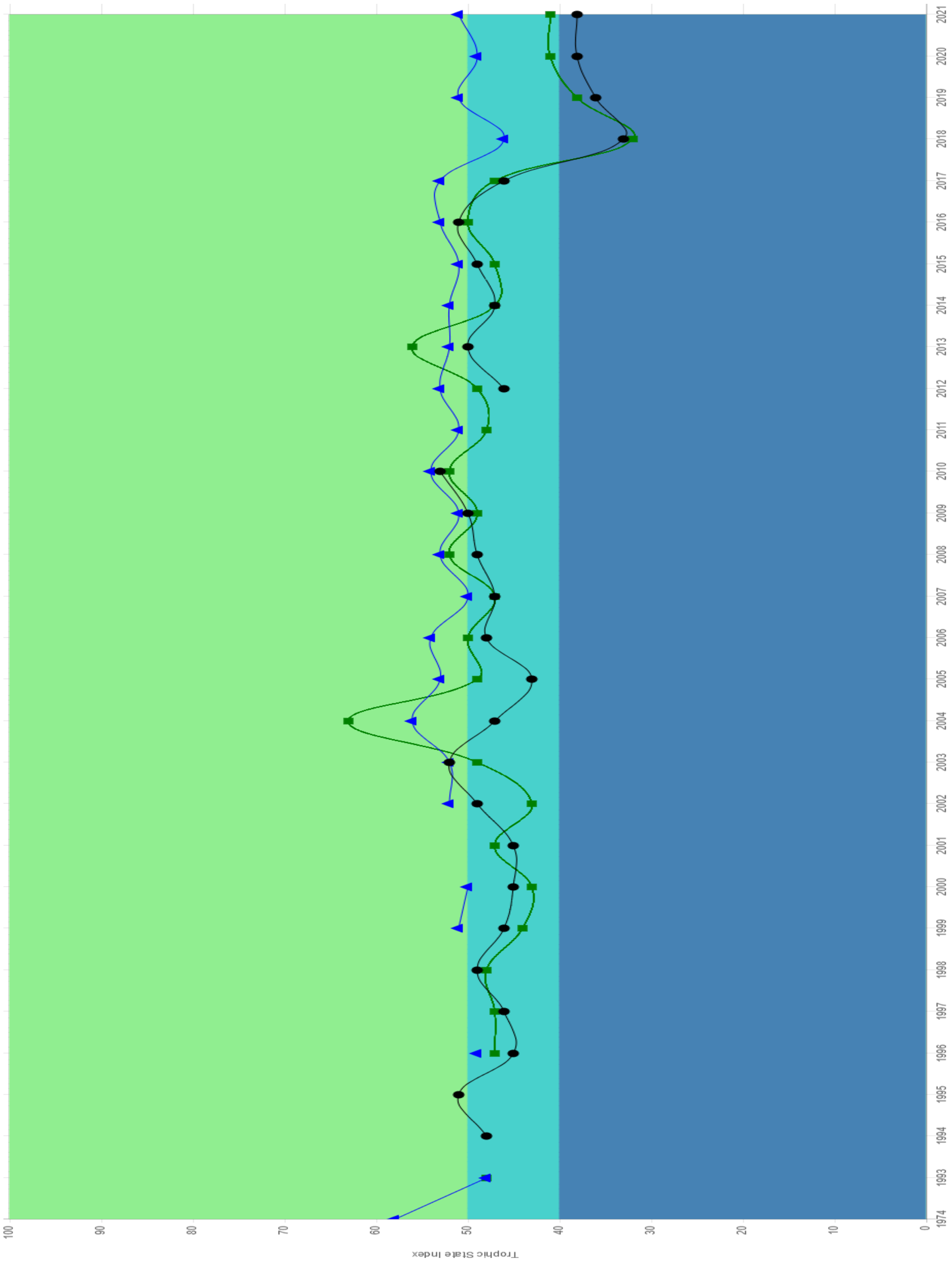


Figure 15. Trophic State Index graph for Paddock Lake from 1974-2021.

● Secchi TSI ▲ Total Phosphorus TSI ■ Chlorophyll TSI

GLOSSARY

Fragmentation: a form of asexual reproduction or cloning, where an organism is split into fragments. Each of these fragments develop into mature, fully grown individuals that are clones of the original organism.

Macrophytes: Aquatic plants.

Rhizomes: horizontal underground plant stem capable of producing the shoot and root systems of a new plant.

Secchi Disc: an opaque disk, typically white, used to gauge the transparency of water by measuring the depth (Secchi depth) at which the disk ceases to be visible from the surface.

Turbidity: caused by particles suspended or dissolved in water that scatter light making the water appear cloudy or murky.

Turions: Vegetative, dormant storage organs formed by aquatic plants.