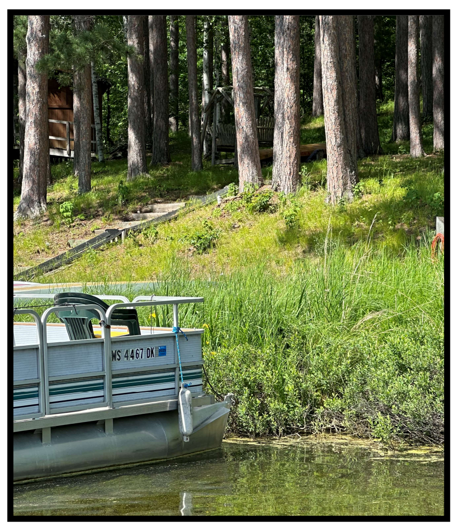
Curly-leaf pondweed (*Potamogeton crispus*) and Warm-water Point-intercept Macrophyte Surveys Shunenberg Lake - WBIC: 2743600 Bayfield County, Wisconsin

Thick mats of Muskgrass on Shunenberg Lake's west side – 7/22/24

Shunenberg Lake aerial photo (2015)

Project Initiated by:

The Town of Barnes – Aquatic Invasive Species Committee,
Lake Education and Planning Services, LLC, and the
Wisconsin Department of Natural Resources (Grant AIRR29724)



Yellow iris behind pontoon on east shoreline – 6/14/24

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June 14 and July 22, 2024

TABLE OF CONTENTS

	Page
ABSTRACT…………	ii
LIST OF FIGURES…………	iii
LIST OF TABLES…………	iv
INTRODUCTION…………	1
BACKGROUND AND STUDY RATIONALE…………	1
METHODS…………	2
DATA ANALYSIS…………	3
RESULTS…………	6
Curly-leaf Pondweed Point-intercept Survey…………	6
Warm-water Full Point-intercept Macrophyte Survey…………	7
Shunenberg Lake Plant Community…………	10
Plant Community Dominance…………	17
Floristic Quality Index…………	20
Filamentous Algae…………	21
Summer Curly-leaf Pondweed…………	22
Other Exotic Plant Species…………	22
DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT…………	24
LITERATURE CITED…………	26
APPENDIXES…………	27
I: Point-intercept Survey Sample Points Map…………	27
II: Boat and Vegetative Survey Datasheets…………	29
III: Early Season Curly-leaf Pondweed Density and Distribution Map…………	32
IV: Habitat Variable Maps…………	34
V: Littoral Zone, Native Species Richness, and Total Rake Fullness Maps…………	37
VI: Native Species Density and Distribution Maps…………	41
VII: Exotic Species Distribution Map and Aquatic Exotic Invasive Plant Species Information…………	73
VIII: Glossary of Biological Terms…………	82
IX: Raw Data Spreadsheets…………	86

ABSTRACT

Shunenberg Lake (WBIC 2743600) is a 43-acre drainage lake in southwest Bayfield County, WI. The 2020 and 2021 discovery of Curly-leaf pondweed (*Potamogeton crispus*) (CLP) in Smith and Shunenberg Lakes prompted members of the Town of Barnes Aquatic Invasive Species Committee (TOB) to apply for and receive a Wisconsin Department of Natural Resources (WDNR) Aquatic Invasives Early Detection and Response Grant (AIRR29724) to fund two plant surveys on the lake in 2024: an early-season CLP point-intercept survey on June 14, and a warm-water point-intercept survey of all aquatic plants on July 22. The goals of the surveys were to quantify the extent of the CLP infestation in the lake; determine if Eurasian water-milfoil (*Myriophyllum spicatum*) (EWM) or any other exotic plant species had invaded the lake; and to establish baseline data on the richness, diversity, abundance, and distribution of native aquatic plant populations. The June survey found CLP at a single point (rake fullness of 2) with five additional visual sightings. Several clusters of Yellow iris (*Iris pseudacorus*) were also present along the eastern shoreline. In July, we documented plants growing at 153 of 186 points (82.3% of the total lake bottom/83.2% of the lake's 184 point 10.5ft littoral zone). Overall diversity was very high with a Simpson Index value of 0.88. Richness was, however, only low/moderate with 24 species found in the rake. This total increased to 36 species when including visuals and plants found during the boat survey. Localized richness was also low/moderate as we calculated a mean native species at sites with native vegetation of 2.27 species/site. We found that biomass at sites with vegetation was a moderate mean total rake fullness of 1.90. Slender naiad (*Najas flexilis*), Muskgrass (*Chara* sp.), Common waterweed (*Elodea canadensis*), and Northern water-milfoil (*Myriophyllum sibiricum*) were the most widely-distributed macrophyte species. They were present at 49.02%, 34.64%, 34.64%, and 27.45% of survey points with vegetation; and, collectively, they accounted for 64.08% of the total relative frequency. The 22 native index species found in the rake during the point-intercept survey produced a mean Coefficient of Conservatism of 6.0 and a Floristic Quality Index of 28.1. When compared to other lakes in the Northern Lakes and Forest Ecoregion, Shunenberg Lake was below the average mean C of 6.7, but above the median FQI of 24.3. Filamentous algae were widely-distributed throughout the lake (42 points), and they were often so abundant that they formed floating blobs (mean rake fullness of 1.43). In addition to CLP and Yellow iris, we found two other exotic species: Common forget-me-not (*Myosotis scorpioides*) and Reed canary grass (*Phalaris arundinacea*). Both occurred in scattered shoreline locations. Future management considerations include preserving the lake's healthy native plant communities; working to maintain water clarity and limit nutrient inputs along the lakeshore by such things as establishing buffer strips of native vegetation, eliminating fertilizer applications, bagging grass clippings, removing pet waste, disposing of fire pit ash away from the lake, maintaining septic systems, and avoiding motor startups in shallow water; at least annually conducting water quality testing to track changes in the lake over time; continuing to manage CLP; and encouraging shoreline owners to annually look for and remove Yellow iris if they find it on their property.

LIST OF FIGURES

Page

Figure 1: Shunenberg Lake Aerial Photo…………………………………………………….. 1

Figure 2: Rake Fullness Ratings…………………………………………………………….. 2

Figure 3: June Curly-leaf Pondweed Density and Distribution.…………………………… 6

Figure 4: Survey Sample Points and Lake Depth…………………………………………… 7

Figure 5: Bottom Substrate and Littoral Zone……………………………………………….. 8

Figure 6: Plant Colonization Depth Chart……………………………………………….. 8

Figure 7: Native Species Richness and Total Rake Fullness………………………………. 10

Figure 8: Shunenberg Lake's Most Common Species..…………………………………….. 17

Figure 9: Filamentous Algae Density and Distribution and
Typical Algal Blobs on the North Shoreline……………………………………………. 21

Figure 10: July Curly-leaf Pondweed Density and Distribution and Typical Plant..……… 22

Figure 11: Yellow Iris on the East Shoreline – 6/14/24……………………………………. 23

Figure 12: Common Forget-me-not on the North Shoreline...…………………………….. 23

Figure 13: Reed Canary Grass on a Developed Shoreline…....…………………………… 23

Figure 14: Model Natural Shoreline on a Nearby Northwest Wisconsin Lake……………. 24

LIST OF TABLES

	Page
Table 1: Aquatic Macrophyte P/I Survey Summary Statistics – Shunenberg Lake – Bayfield County, Wisconsin – July 22, 2024………………………….	9
Table 2: Frequencies and Mean Rake Sample of Aquatic Macrophytes – Shunenberg Lake – Bayfield County, Wisconsin – July 22, 2024.……………………….....	18
Table 3: Floristic Quality Index of Aquatic Macrophytes – Shunenberg Lake – Bayfield County, Wisconsin – July 22, 2024.……………………..…..	20

INTRODUCTION:

Shunenberg Lake (WBIC 2743600) is a 43-acre drainage lake in southwest Bayfield County, Wisconsin in the Towns of Barnes (T44/45 R9W S2/35). It reaches a maximum depth of over 15ft in the north spring hole and has an average depth of approximately 4ft. Although only limited historical data exists (WDNR 2024), summer Secchi disc readings over the past 15 years have averaged over 14ft. This good clarity produced a littoral zone that extended to 10.5ft in 2024. The bottom is dominated by sandy muck with a ring of pure sand and scattered gravel along most of the immediate shoreline and in both the inlet from Sweet Lake and the outlet to Smith Lake (Figure 1).

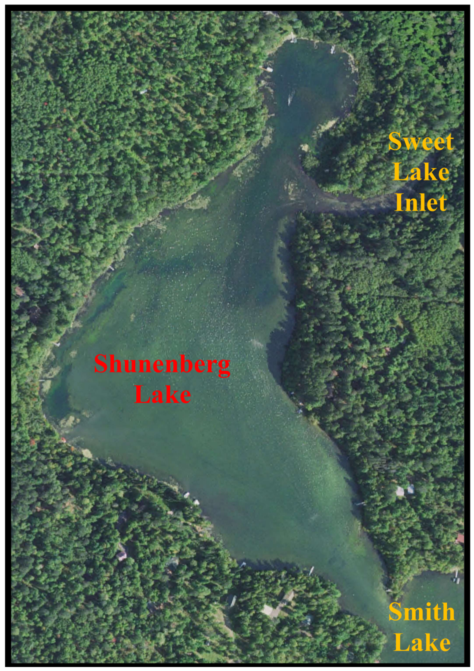


Figure 1: Shunenberg Lake Aerial Photo

BACKGROUND AND STUDY RATIONALE:

Curly-leaf pondweed (*Potamogeton crispus*) (CLP), an exotic invasive plant species, was discovered in Upper Eau Claire Lake in 2008, and the Town of Barnes Aquatic Invasive Species Committee (TOB) has annually managed the infestation with volunteer manual removal, and, more recently, diver assisted suction harvesting (DASH). In 2020 and 2021, CLP was found to have spread upstream into Smith and Shunenberg Lakes, and this prompted the TOB to apply for and receive a Wisconsin Department of Natural Resources (WDNR) Aquatic Invasives Early Detection and Response Grant (AIRR29724) which authorized CLP and warm-water point-intercept surveys on the lakes (the TOB asked us NOT to map CLP beds as the DASH crew was already doing this as part of their suction harvesting efforts on the lakes). The goals of these surveys were to determine if CLP was also present in Sweet Lake; to develop a WDNR approved aquatic management plan for CLP; to document any other exotic plant species in or around the lakes; and to gather baseline data on the richness, diversity, abundance, distribution, and density of the lakes' native vegetation. This report is the summary analysis of the Shunenberg Lake surveys conducted on June 14 and July 22, 2024.

METHODS:

Curly-leaf Pondweed Point-intercept Survey:

Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth, and total acreage, Michelle Nault (WDNR) generated a 186-point sampling grid for Shunenberg Lake (Appendix I). Using this grid, we completed a density survey where we sampled for Curly-leaf pondweed at each point in and adjacent to the lake's littoral zone. We located each survey point using a handheld mapping GPS unit (Garmin 76CSx) and used a rake to sample an approximately 2.5ft section of the bottom. When found, CLP was assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also noted visual sightings of CLP within six feet of the sample point.

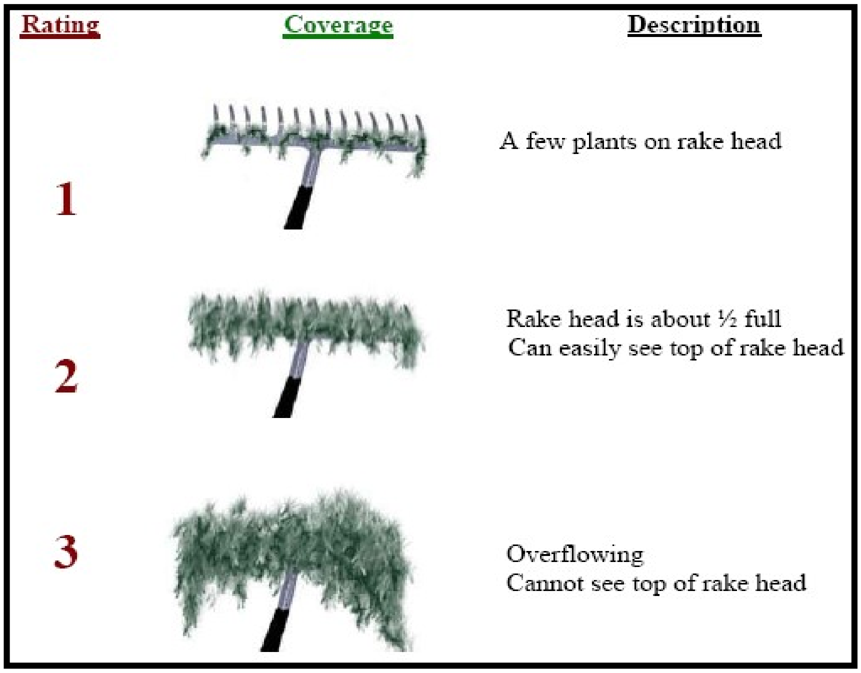


Figure 2: Rake Fullness Ratings (UWEX 2010)

Warm-water Full Point-intercept Macrophyte Survey:

Prior to beginning the July point-intercept survey, we conducted a general boat survey to gain familiarity with the lake's macrophytes. All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2012; Crow and Hellquist 2005; Skawinski 2019), a datasheet was built from the species present (Appendix II), and uncommon species were photo documented and uploaded to iNaturalist.

During the survey, we again located each survey point with a GPS, recorded a depth reading using a metered pole, and took a rake sample. All plants on the rake, as well as any that were dislodged by the rake were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of all plants within six feet of the sample point not found in the rake. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (bottom) type was assigned at each site where the bottom was visible, or it could be reliably determined using the rake.

DATA ANALYSIS:

We entered all data collected into the standard WDNR aquatic plant management spreadsheet (Appendix II) (UWEX 2010). From this, we calculated the following:

Total number of sites visited: This included the total number of points on the lake that were accessible to be surveyed by boat, kayak, or on foot.

Total number of sites with vegetation: These included all sites where we found vegetation after doing a rake sample. For example, if 20% of all sample sites have vegetation, it suggests that 20% of the lake has plant coverage.

Total number of sites shallower than the maximum depth of plants: This is the number of sites that are in the littoral zone. Because not all sites that are within the littoral zone actually have vegetation, we use this value to estimate how prevalent vegetation is throughout the littoral zone. For example, if 60% of the sites shallower than the maximum depth of plants have vegetation, then we estimate that 60% of the littoral zone has plants.

Frequency of occurrence: The frequency of all plants (or individual species) is generally reported as a percentage of occurrences within the littoral zone. It can also be reported as a percentage of occurrences at sample points with vegetation.

Frequency of occurrence example:

Plant A is sampled at 70 out of 700 total littoral points = 70/700 = .10 = 10%

This means that Plant A's frequency of occurrence = 10% when considering the entire littoral zone.

Plant A is sampled at 70 out of 350 total points with vegetation = 70/350 = .20 = 20%

This means that Plant A's frequency of occurrence = 20% when only considering the sites in the littoral zone that have vegetation.

From these frequencies, we can estimate how common each species was at depths where plants were able to grow, and at points where plants actually were growing.

Note the second value will be greater as not all the points (in this example, only ½) had plants growing at them.

Simpson's Diversity Index: A diversity index allows the entire plant community at one location to be compared to the entire plant community at another location. It also allows the plant community at a single location to be compared over time thus allowing a measure of community degradation or restoration at that site. With Simpson's Diversity Index, the index value represents the probability that two individual plants (randomly selected) will be different species. The index values range from 0 -1 where 0 indicates that all the plants sampled are the same species to 1 where none of the plants sampled are the same species. The greater the index value, the higher the diversity in a given location. Although many natural variables like lake size, depth, dissolved minerals, water clarity, mean temperature, etc. can affect diversity, in general, a more diverse lake indicates a healthier ecosystem. Perhaps most importantly, plant communities with high diversity also tend to be **more resistant** to invasion by exotic species.

Maximum depth of plants: This indicates the deepest point that vegetation was sampled. In clear lakes, plants may be found at depths of over 20ft, while in stained or turbid locations, they may only be found in a few feet of water. Although some species can tolerate very low light conditions, others are only found near the surface. In general, the diversity of the plant community decreases with increased depth.

Mean and median depth of plants: The mean depth of plants indicates the average depth in the water column where plants were sampled. Because a few samples in deep water can skew this data, median depth is also calculated. This tells us that half of the plants sampled were in water shallower than this value, and half were in water deeper than this value.

Number of sites sampled using rope/pole rake: This indicates which rake type was used to take a sample. We use a 20ft pole rake and a 35ft rope rake for sampling.

Average number of species per site: This value is reported using four different considerations. 1) **shallower than maximum depth of plants** indicates the average number of plant species at all sites in the littoral zone. 2) **vegetative sites only** indicate the average number of plants at all sites where plants were found. 3) **native species shallower than maximum depth of plants** and 4) **native species at vegetative sites only** excludes exotic species from consideration.

Species richness: This value indicates the number of different plant species found in and directly adjacent to (on the waterline) the lake. Species richness alone only counts those plants found in the rake survey. The other two values include those seen at a sample point during the survey but not found in the rake, and those that were only seen during the initial boat survey or inter-point. **Note: Per WDNR protocol, filamentous algae, freshwater sponges, aquatic moss and the aquatic liverworts *Riccia fluitans* and *Ricciocarpus natans* are excluded from these totals.**

Average rake fullness: This value is the average rake fullness of all species in the rake. It only takes into account those sites with vegetation (Table 1).

Relative frequency: This value shows a species' frequency relative to all other species. It is expressed as a percentage, and the total of all species' relative frequencies will add up to 100%. Organizing species from highest to lowest relative frequency value gives us an idea of which species are most important within the macrophyte community (Table 2).

Relative frequency example:

Suppose that we sample 100 points and found four species of plants with the following results:

Plant A was located at 70 sites. Its frequency of occurrence is thus 70/100 = 70%
Plant B was located at 50 sites. Its frequency of occurrence is thus 50/100 = 50%
Plant C was located at 20 sites. Its frequency of occurrence is thus 20/100 = 20%
Plant D was located at 10 sites. Its frequency of occurrence is thus 10/100 = 10%

To calculate an individual species' relative frequency, we divide the number of sites a plant is sampled at by the total number of times all plants were sampled. In our example that would be 150 samples (70+50+20+10).

Plant A = 70/150 = .4667 or 46.67%
Plant B = 50/150 = .3333 or 33.33%
Plant C = 20/150 = .1333 or 13.33%
Plant D = 10/150 = .0667 or 6.67%

This value tells us that 46.67% of all plants sampled were Plant A.

Floristic Quality Index (FQI): This index measures the impact of human development on a lake's aquatic plants. The species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each native index species found in the lake during the point-intercept survey**, and multiplying it by the square root of the total number of plant species (N) in the lake ($FQI=(\Sigma(c1+c2+c3+\ldots cn)/N)*\sqrt{N}$). Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, North Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Shunenberg Lake is in the Northern Lakes and Forests Ecoregion (Table 3).

**** Species that were only recorded as visuals or during the boat survey, and species found in the rake that are not included in the index are excluded from FQI analysis.**

RESULTS:
Curly-leaf Pondweed Point-intercept Survey:

On June 14th, we surveyed transects covering 6.7km (4.2 miles) throughout the lake and took a rake sample at all 186 points (Figure 3) (Appendix III). We found Curly-leaf pondweed in the rake at a single point (rake fullness of 2) and also recorded it as a visual at five points. We also found a few Yellow iris (*Iris pseudacorus*) clusters growing on the east shoreline (see report cover). Because of this, we immediately notified the Town of Barnes AIS Committee so they could dig them out.

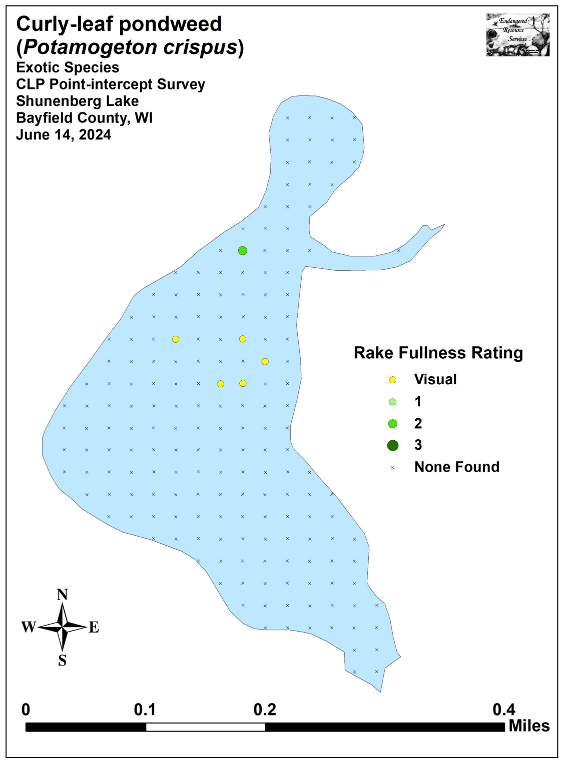


Figure 3: June Curly-leaf Pondweed Density and Distribution

Warm-water Full Point-intercept Macrophyte Survey:

Depth readings taken at Shunenberg Lake's 186 survey points (Appendix I) revealed that, other than the north and west spring holes, the lake is a more or less uniformly shallow oblong bowl that drops gradually from the shoreline into the central 3-6ft trough. The inlet channel from Sweet Lake and the outlet channel leading to Smith were especially shallow (Figure 4) (Appendix IV).

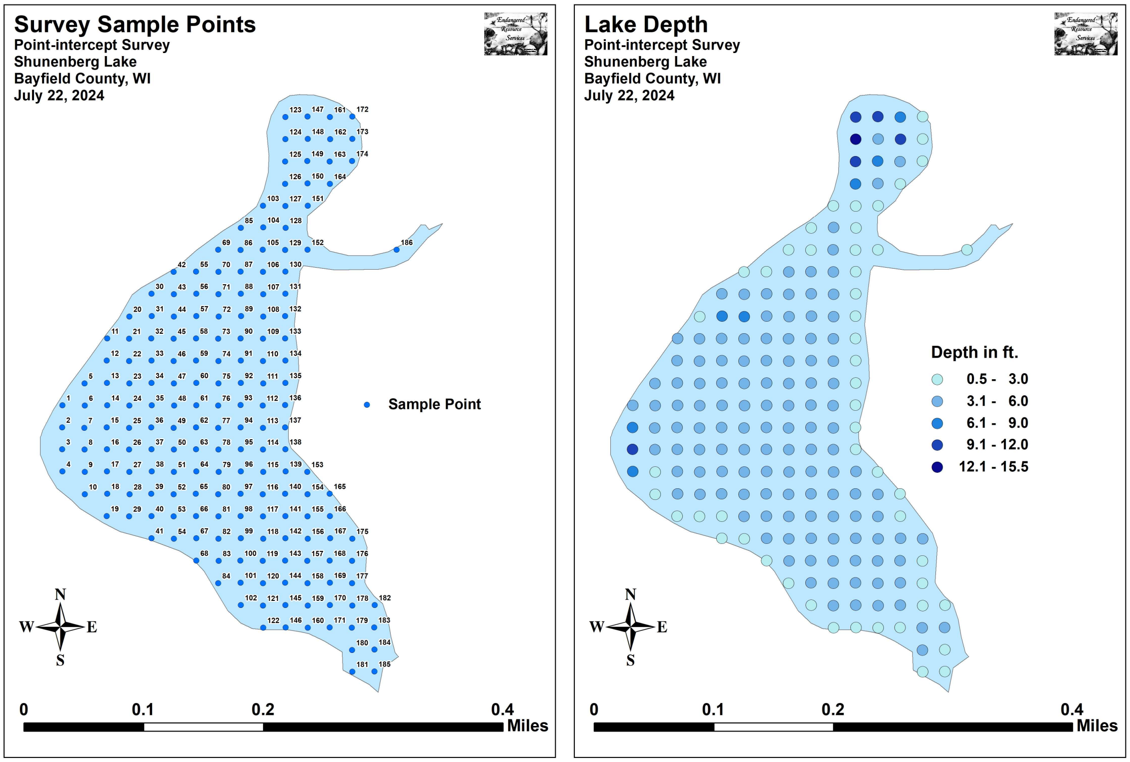


Figure 4: Survey Sample Points and Lake Depth

We categorized the bottom substrate as 85.5% sandy, marly, and organic muck (159 points), and 14.5% pure sand (27 points) (Figure 5) (Appendix IV). The majority of areas along the immediate shoreline were pure sand, although we also found some gravel areas inter-point in the lake inlet and outlet. With increasing depth, most areas with these firm substrates gradually transitioned to sandy muck. Pockets of nutrient-rich organic muck were scattered along the lake's western shoreline, while some nearshore areas on the lake's east sides also had nutrient-poor marly muck.

We found plants growing at 153 points (Table 1) or on approximately 82.3% of the total lake bottom and in 83.2% of the lake's 184 point - 10.5ft littoral zone (Figure 5) (Appendix V). Overall plant colonization was slightly skewed to shallow water as the mean depth of 3.8ft was less than than the median depth of 4.0ft (Figure 6).

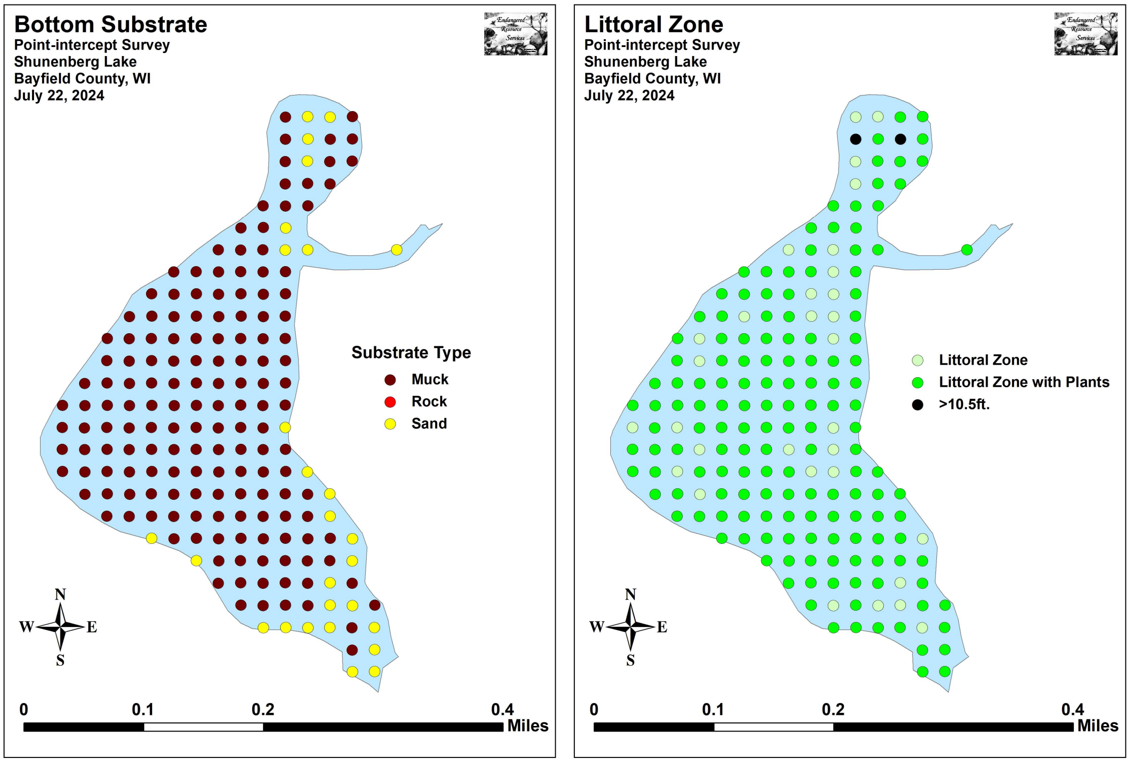


Figure 5: Bottom Substrate and Littoral Zone

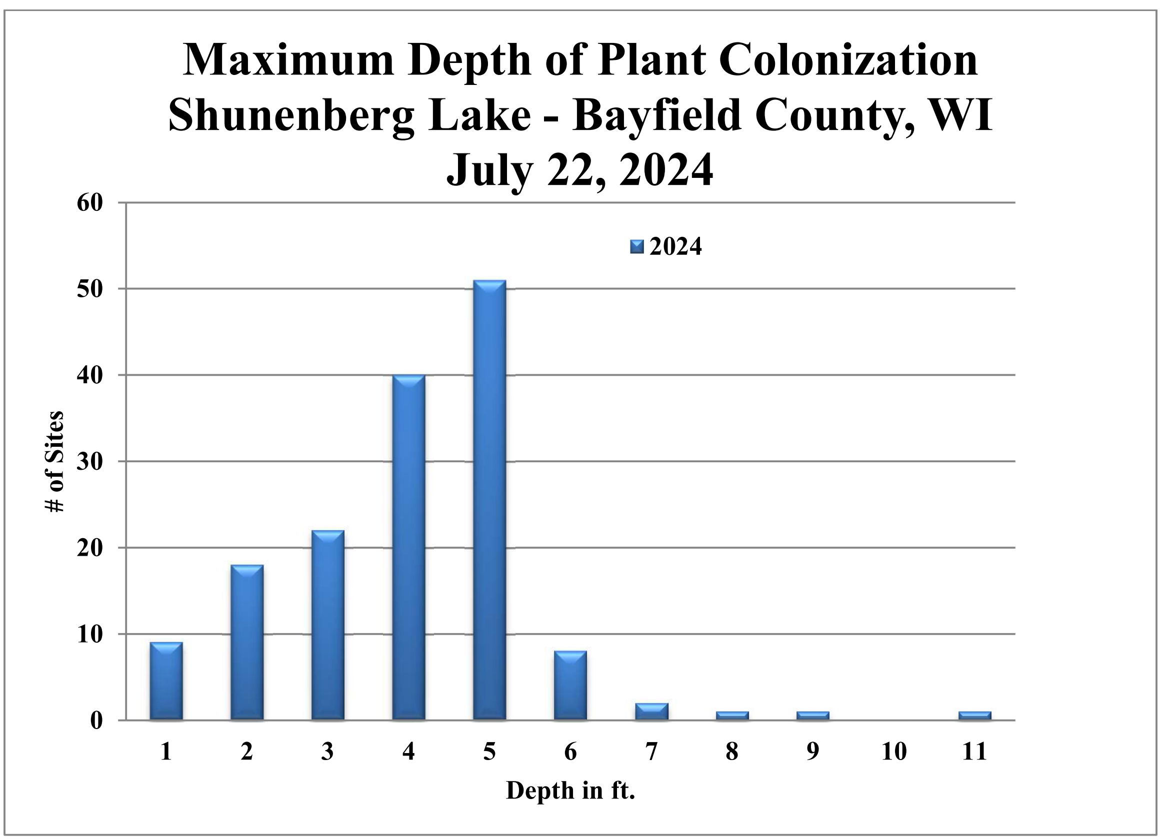


Figure 6: Plant Colonization Depth Chart

Table 1: Aquatic Macrophyte P/I Survey Summary Statistics
Shunenberg Lake – Bayfield, Wisconsin
July 22, 2024

Summary Statistics:

Total number of points sampled	186
Total number of sites with vegetation	153
Total number of sites shallower than the maximum depth of plants	184
Frequency of occurrence at sites shallower than maximum depth of plants	83.2
Simpson Diversity Index	0.88
Number of sites sampled using rake on Rope (R)	0
Number of sites sampled using rake on Pole (P)	186
Maximum depth of plants (ft)	10.5
Mean depth of plants (ft)	3.8
Median depth of plants (ft)	4.0
Average number of all species per site (shallower than max depth)	1.89
Average number of all species per site (veg. sites only)	2.27
Average number of native species per site (shallower than max depth)	1.89
Average number of native species per site (sites with native veg. only)	2.27
Species richness	24
Species richness (including visuals)	30
Species richness (including visuals and boat survey)	36
Mean total rake fullness (veg. sites only)	1.90

Plant diversity was very high with a Simpson Index value of 0.88. Richness was, however, only low/moderate with 24 species found in the rake. This total increased to 36 species when including visuals and plants seen during the boat survey. Localized richness was also low/moderate as we calculated a mean native species at sites with native vegetation of 2.27 species/site. We noted that most high richness points occurred along the southwest and northeast shorelines and immediately south of the inlet in areas with more nutrient-rich organic muck. On the low-nutrient sand and sandy muck substrates that dominated the majority of the rest of the lake, we found few sites had more than two species present (Figure 7) (Appendix V).

Biomass at sites with vegetation was a moderate mean total rake fullness of 1.90. Similar to localized richness, visual analysis of the map showed most nearshore areas over organic muck had dense plant growth, while most areas over sand and nutrient-poor muck had low to moderate plant densities (Figure 7) (Appendix V).

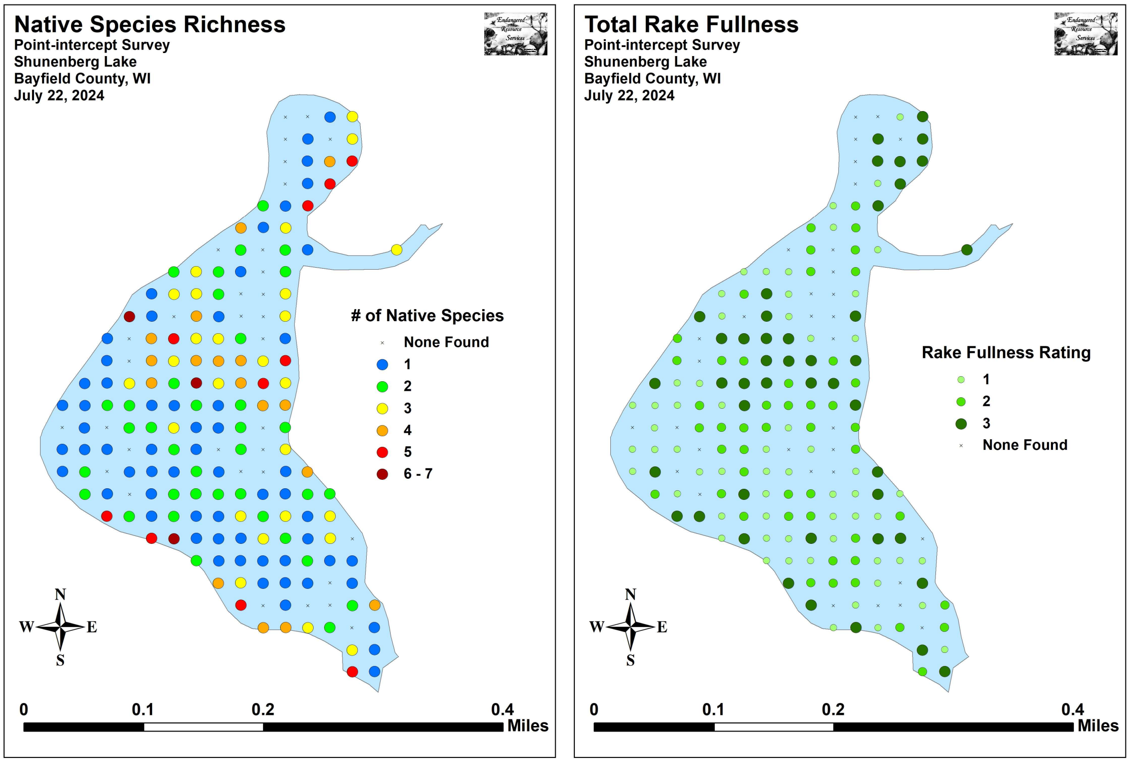


Figure 7: Native Species Richness and Total Rake Fullness

Shunenberg Lake Plant Community:

The Shunenberg Lake ecosystem is home to a relatively diverse plant community that is typical of low to moderate-nutrient lakes with good water quality. This community can be subdivided into four distinct zones (emergent, floating-leaf, shallow submergent, and deep submergent) with each zone having its own characteristic functions in the aquatic ecosystem. Depending on the local bottom type (rock, sand, nutrient-poor sandy muck, marly muck, or nutrient-rich organic muck), these zones often had somewhat different species present.

In shallow areas, beds of emergent plants prevent erosion by stabilizing the shoreline, break up wave action, provide a nursery for baitfish and juvenile gamefish, offer shelter for amphibians, and give waterfowl and predatory wading birds like herons a place to hunt. These areas also provide important habitat for invertebrates like dragonflies and mayflies.

At the immediate shoreline, Bluejoint (*Calamagrostis canadensis*) and Sweet gale (*Myrica gale*) were common at the waterline on undeveloped sandy lakeshores. On margins where the soil was a more nutrient-rich sandy or organic muck, we also found Marsh cinquefoil (*Comarum palustre*), Northern blue flag (*Iris versicolor*), Softstem bulrush (*Schoenoplectus tabernaemontani*), and Broad-leaved cattail (*Typha latifolia*).

Bluejoint (Routledge 2013)

Sweet gale (Devlin 2016)

Marsh cinquefoil (Myrhatt 2012)

Northern blue flag (Tracey 2007)

Softstem bulrush (Schwarz 2011)

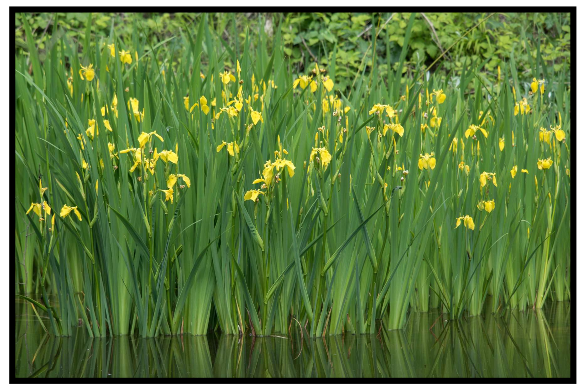
Broad-leaved cattail (Raymond 2011)

In areas with cold-water seeps at the shoreline, we often found these species were joined by the exotic species Common forget-me-not (*Myosotis scorpioides*). We also occasionally found the exotic species Reed canary grass (*Phalaris arundinacea*) and Yellow iris, but usually only on highly developed and disturbed shorelines.

Common forget-me-not (Raymond 2011)

Reed canary grass (Berg 2019)

Yellow iris (Devlin 2016)



Yellow iris clusters – showing invasion potential (Alsake 2024)

Extending away from the immediate shoreline on shallow areas over firm sand and gravel, we found scattered beds of Common yellow lake sedge (*Carex utriculata*) and Hardstem bulrush (*Schoenoplectus acutus*). These species were especially common near the lake inlet and outlet.

Common yellow lake sedge (Lavin 2011)

Hardstem bulrush (Elliot 2007)

Just beyond the emergents, pure sand areas seldom provided enough nutrients for floating-leaf species. In areas with sandy muck, we found Variable pondweed (*Potamogeton gramineus*) and Large-leaf pondweed (*Potamogeton amplifolius*) occasionally produced floating leaves. Areas with thicker sandy muck and nutrient-rich organic muck supported somewhat limited number of species with broader leaves like White water lily (*Nymphaea odorata*) and Water smartweed (*Polygonum amphibium*).

Variable pondweed with and without floating leaves (Koshere 2002)

Large-leaf pondweed (Dziuk 2018)

White water lily (Falkner 2009)

Water smartweed (Someya 2009)

In calm areas primarily immediately adjacent to the western shoreline, we also documented a few scattered Small duckweed (*Lemna minor*) and Large duckweed (*Spirodela polyrhiza*). More typical of nutrient-rich systems, the "duckweeds" were predictably rare in Shunenberg Lake.

Small duckweed (Kramer 2013)

Large duckweed (Thomas 2014)

Growing among the emergents and in water up to 6ft deep, shallow sugar sand areas tended to have low total biomass as these nutrient-poor substrates provide habitat most suited to fine-leaved "isoetid" turf-forming species. In this environment, we documented carpets of Muskgrass (*Chara* sp.) with scattered patches of Slender naiad (*Najas flexilis*), Variable pondweed, Stiff pondweed (*Potamogeton strictifolius*), White water crowfoot (*Ranunculus aquatilis*), Crested arrowhead (*Sagittaria cristata*), and Sago pondweed (*Stuckenia pectinata*) mixed in. All of these "turf" species, along with the emergents, stabilize the bottom and prevent wave action erosion.

Muskgrass (Gibbons 2012)

Slender naiad (Cameron 2013)

Stiff pondweed (Andrews 2012)

White water crowfoot (Wasser 2014)

Crested arrowhead (Fewless 2004)

Sago pondweed (Hilty 2012)

In areas with sandy muck in up to 10.5ft of water, we often noted additional, slightly broader-leaved species like Water star-grass (*Heteranthera dubia*), Northern water-milfoil (*Myriophyllum sibiricum*), Nitella (*Nitella* sp.), Fries' pondweed (*Potamogeton friesii*), Clasping-leaf pondweed (*Potamogeton richardsonii*), and Wild celery (*Vallisneria americana*). The roots, shoots, and seeds of these submergent species are heavily utilized by both resident and migratory waterfowl for food. They also provide important habitat for the lake's fish throughout their lifecycles, as well as a myriad of invertebrates like scuds, dragonfly and mayfly nymphs, and snails.

Water star-grass (Mueller 2010)

Northern Water-milfoil (Berg 2007)

Smooth stonewort – a Nitella (Schou 2003)

Fries' pondweed (End 2012)

Clasping-leaf pondweed (Cameron 2016)

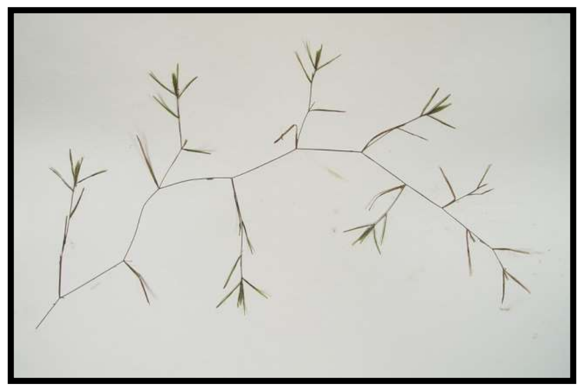
Wild celery (Dalvi 2009)

Deepwater areas where the substate was a more nutrient-rich organic muck provided habitat for Coontail (*Ceratophyllum demersum*), Common waterweed (*Elodea canadensis*), Large-leaf pondweed, Curly-leaf pondweed, Leafy pondweed (*Potamogeton foliosus*), Small pondweed (*Potamogeton pusillus*), Fern pondweed (*Potamogeton robbinsii*), and Flat-stem pondweed (*Potamogeton zosteriformis*). Predatory fish like the lake's Musky (*Esox masquinongy*) and Northern pike (*Esox lucius*) are often found on these habitat edges waiting in ambush.

Coontail (Hassler 2011)

Common waterweed (Pinkka 2013)

Leafy pondweed (Kleinman 2009)



Small pondweed (Cameron 2013)

Fern pondweed (Apipp 2011)

Flat-stem pondweed (Dziuk 2019)

Plant Community Dominance:

When considering the lake as a whole, Slender naiad, Muskgrass, Common waterweed, and Northern water-milfoil were the most widely-distributed macrophyte species (Figure 8). They were present at 49.02%, 34.64%, 34.64%, and 27.45% of survey points with vegetation respectively; and, collectively, they accounted for 64.08% of the total relative frequency (Table 2). Fries' pondweed (5.17%), Sago pondweed (4.31%), and Clasping-leaf pondweed (4.02%) also had relative frequencies over 4.00% (Maps for all native plant species are located in Appendix VI).

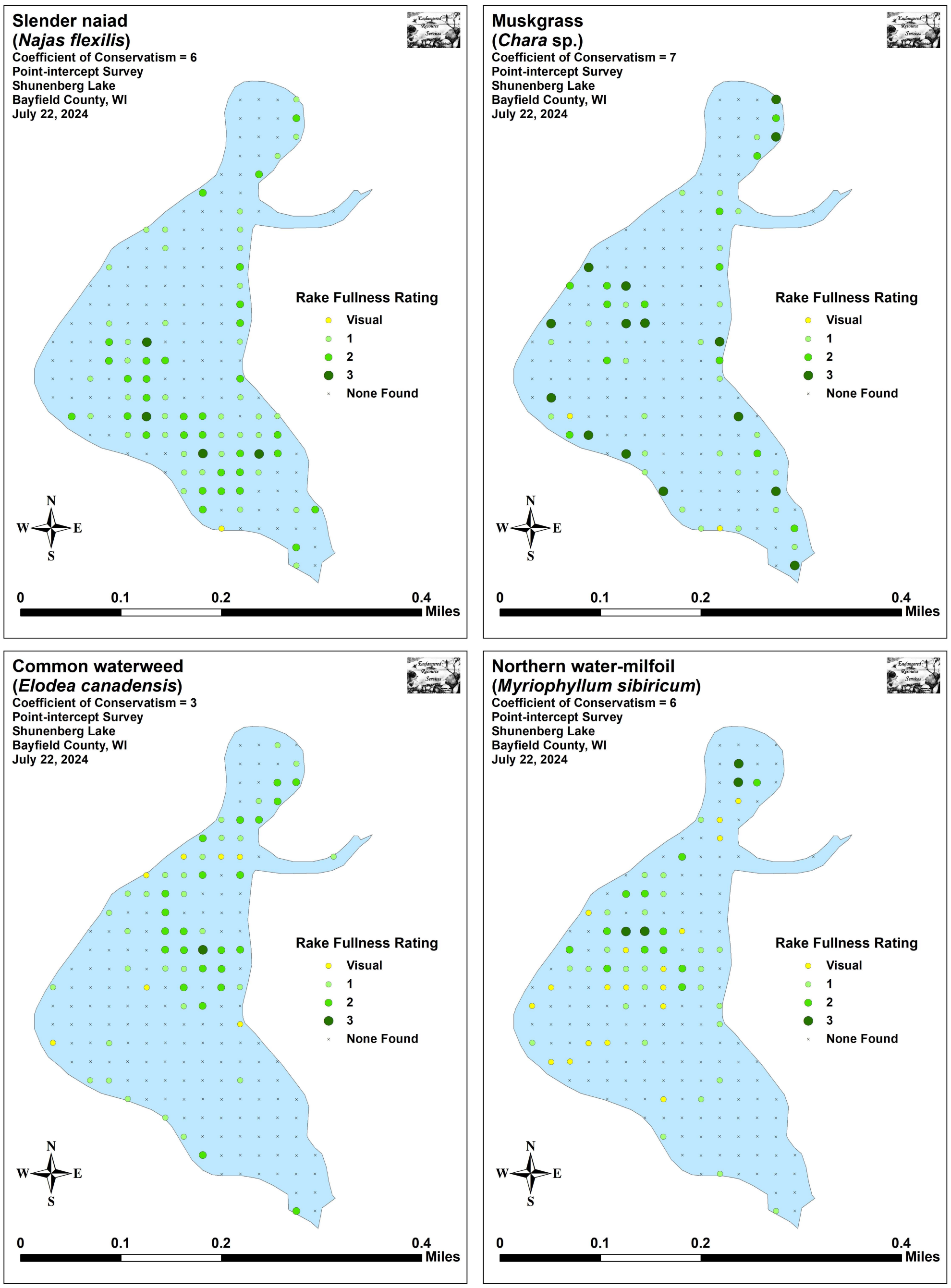


Figure 8: Shunenberg Lake's Most Common Species

Table 2: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Shunenberg Lake – Bayfield County, Wisconsin
July 22, 2024

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Najas flexilis	Slender naiad	75	21.55	49.02	40.76	1.53	1
Chara sp.	Muskgrass	53	15.23	34.64	28.80	1.81	2
Elodea canadensis	Common waterweed	53	15.23	34.64	28.80	1.47	7
Myriophyllum sibiricum	Northern water-milfoil	42	12.07	27.45	22.83	1.48	18
	Filamentous algae	42	*	27.45	22.83	1.43	0
Potamogeton friesii	Fries' pondweed	18	5.17	11.76	9.78	1.28	9
Stuckenia pectinata	Sago pondweed	15	4.31	9.80	8.15	1.33	5
Potamogeton richardsonii	Clasping-leaf pondweed	14	4.02	9.15	7.61	1.21	13
Potamogeton amplifolius	Large-leaf pondweed	12	3.45	7.84	6.52	1.08	8
Potamogeton zosteriformis	Flat-stem pondweed	12	3.45	7.84	6.52	1.33	10
Lemna minor	Small duckweed	8	2.30	5.23	4.35	1.25	0
Nymphaea odorata	White water lily	7	2.01	4.58	3.80	1.14	8
Heteranthera dubia	Water star-grass	6	1.72	3.92	3.26	1.17	2
Potamogeton robbinsii	Fern pondweed	5	1.44	3.27	2.72	1.00	6
Spirodela polyrhiza	Large duckweed	5	1.44	3.27	2.72	1.00	0
Myrica gale	Sweet gale	5	1.44	3.27	2.72	1.80	2
Potamogeton strictifolius	Stiff pondweed	4	1.15	2.61	2.17	1.00	2
Schoenoplectus acutus	Hardstem bulrush	4	1.15	2.61	2.17	1.75	3
Ceratophyllum demersum	Coontail	2	0.57	1.31	1.09	1.00	0
Potamogeton pusillus	Small pondweed	2	0.57	1.31	1.09	1.00	0
Vallisneria americana	Wild celery	2	0.57	1.31	1.09	1.00	1
	Freshwater sponge	2	*	1.31	1.09	1.50	0

*Excluded from relative frequency analysis

Table 2 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Shunenberg Lake – Bayfield County, Wisconsin
July 22, 2024

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Comarum palustre	Marsh cinquefoil	1	0.29	0.65	0.54	1.00	0
Nitella sp.	Nitella	1	0.29	0.65	0.54	1.00	0
Potamogeton foliosus	Leafy pondweed	1	0.29	0.65	0.54	1.00	2
Sagittaria cristata	Crested arrowhead	1	0.29	0.65	0.54	1.00	1
Potamogeton crispus	**Curly-leaf pondweed**	**	**	**	**	**	**2**
Ranunculus aquatilis	White water crowfoot	**	**	**	**	**	2
Calamagrostis canadensis	Bluejoint	**	**	**	**	**	1
Carex utriculata	Common yellow lake sedge	**	**	**	**	**	1
Iris versicolor	Northern blue flag	**	**	**	**	**	1
Potamogeton gramineus	Variable pondweed	**	**	**	**	**	1
Myosotis scorpioides	**Common forget-me-not**	***	***	***	***	***	***
Phalaris arundinacea	**Reed canary grass**	***	***	***	***	***	***
Polygonum amphibium	Water smartweed	***	***	***	***	***	***
Schoenoplectus tabernaemontani	Softstem bulrush	***	***	***	***	***	***
Typha latifolia	Broad-leaved cattail	***	***	***	***	***	***
Iris pseudacorus	**Yellow iris**	****	****	****	****	****	****

Visual only   * Boat survey only   *** Only seen during the June survey   **Exotic species in bold**

Floristic Quality Index:

We identified a total of 22 **native index plants** in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 6.0 and a Floristic Quality Index of 28.1 (Table 3). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Shunenberg Lake below average for this part of the state. The FQI was, however, slightly above the region's median FQI of 24.3 (Nichols 1999). Crested arrowhead (C = 9) was the only highly sensitive index plant of note. One other high-value species – Sweet gale (C = 9) – is not included in the index.

Table 3: Floristic Quality Index of Aquatic Macrophytes
Shunenberg Lake – Bayfield County, Wisconsin
July 22, 2024

Species	Common Name	C
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton foliosus	Leafy pondweed	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Fern pondweed	8
Potamogeton strictifolius	Stiff pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Sagittaria cristata	**Crested arrowhead**	**9**
Schoenoplectus acutus	Hardstem bulrush	6
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Vallisneria americana	Wild celery	6
Ceratophyllum demersum	Coontail	3
N		**22**
Mean C		**6.0**
FQI		**28.1**

Filamentous Algae:

Filamentous algae are normally associated with excessive nutrients in the water column from such things as runoff, internal nutrient recycling, and failed septic systems. We found these algae were widely-distributed throughout the lake (42 points), and they were often so abundant that they formed floating blobs (mean rake fullness of 1.43) (Figure 9).

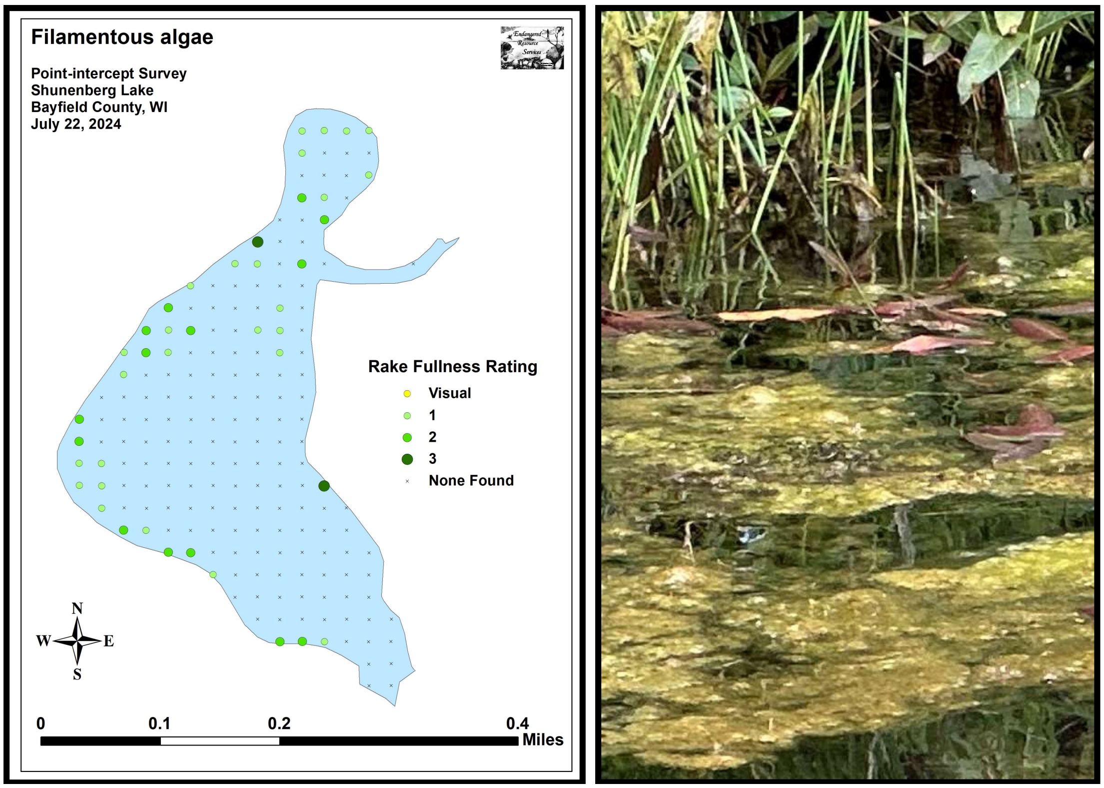


Figure 9: Filamentous Algae Density and Distribution and Typical Algal Blobs on the North Shoreline

Summer Curly-leaf Pondweed:

Curly-leaf pondweed normally completes its annual life cycle by late June, and most plants have set turions and senesced by early July. After seeing CLP in the rake at one point in June with five additional visual sightings, we didn't find it in the rake anywhere in July, but did have two points where it was a visual. We noted almost all plants seen during both surveys were concentrated in more nutrient-rich areas downstream from the inlet and stretching across the majority of the lake. July CLP plants were sparse, but they were almost universally canopied and were a bright rusty color which made them relatively easy to locate and rake remove (Figure 10) (Appendix VII).

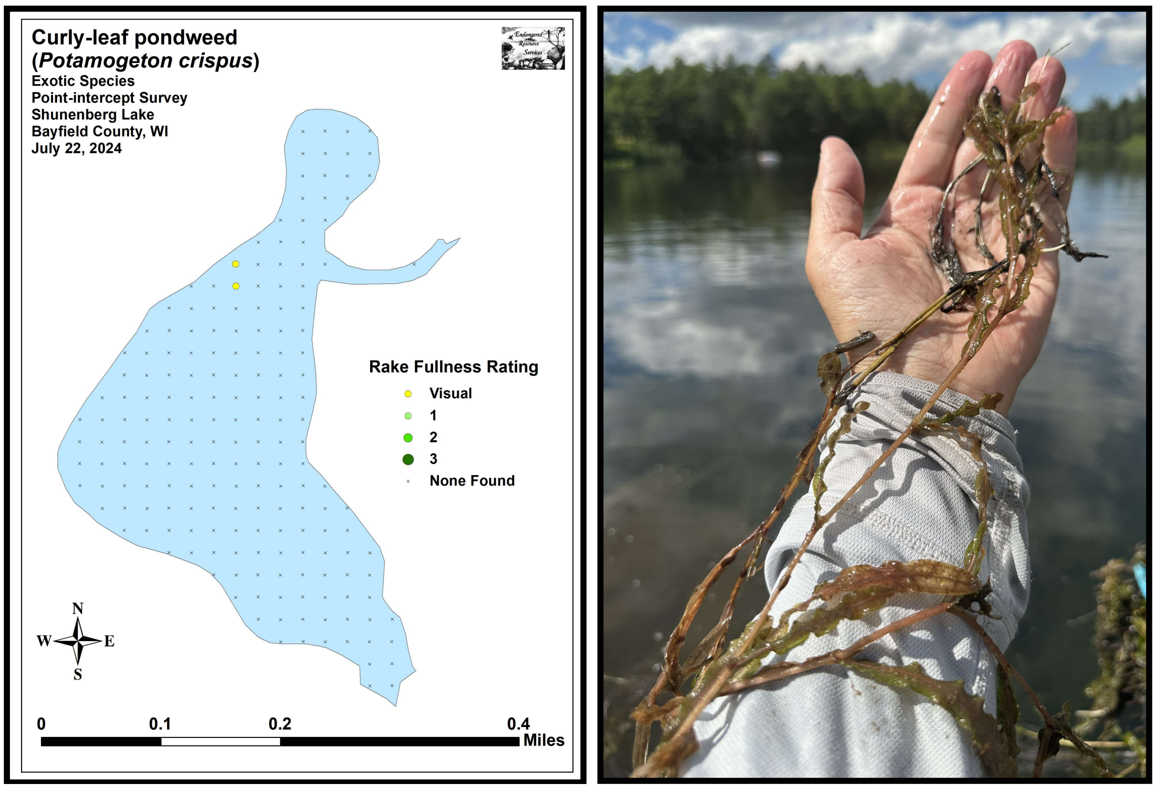


Figure 10: July Curly-leaf Pondweed Density and Distribution and Typical Plant

Other Exotic Plant Species:

In addition to Curly-leaf pondweed, we found three other exotic species during the boat survey: Yellow iris was only seen on the east shoreline in front of one residence during the June survey (Figure 11). We found Common forget-me-not clusters were scattered around much of the lake; especially in areas where cold-water springs were trickling in at the shoreline (Figure 12). Reed canary grass was rare on natural shorelines, but we found several especially dense patches along developed margins (Figure 13) (Exotic species maps and additional information on a sampling of aquatic exotic invasive plant species can be found in Appendix VII).

Figure 11: Yellow Iris on the East Shoreline – 6/14/24

Figure 12: Common Forget-me-not on the North Shoreline

Figure 13: Reed Canary Grass on a Developed Shoreline

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Water Clarity, Nutrient Inputs, and the Role of Native Macrophytes:

Shunenberg Lake is home to a healthy native plant community. Like trees in a forest, these plants are the basis of the aquatic ecosystem. They capture the sun's energy and turn it into usable food, "clean" the water of excess nutrients, and provide habitat for other organisms like aquatic invertebrates and the lake's fish populations. Because of this, preserving them is critical to maintaining the lake's overall health.

When phosphorus and nitrogen in a lake's water column increase to levels beyond what macrophytes can absorb, filamentous and floating algae tend to proliferate leading to declines in both water clarity and quality. During our surveys, we noted that most residents have native vegetation buffers along much of the lake's shoreline. This helps cut down on soil erosion and nutrient runoff into the lake which would otherwise promote algae growth and decrease clarity. Despite this positive news, the lake's relatively small size means even a slight increase in nutrient inputs could negatively impact clarity. Because of this, residents should continually evaluate how their shoreline practices may be impacting the lake. Simple things like establishing a buffer strip of native vegetation along the lakeshore if one isn't already present (Figure 14), bagging grass clippings, eliminating fertilizer near the lake, collecting pet waste, disposing of ash from fire pits away from the lakeshore, maintaining septic systems, and avoiding stirring up sediments with motor start-ups in shallow water can all significantly reduce the amount of nutrients entering the lake's water column. Hopefully, a greater understanding of how even individual property owners can have lake-wide impacts will result in even more people taking appropriate conservation actions and thus ensure continued water clarity and quality for all.

During our background research on the lake, we noted water quality monitoring has been inconsistent. Committing to an at least annual monitoring program would allow residents to track changes in their lake over time, address declines if clarity or quality decreases, or celebrate improvements if they occur.

Figure 14: Model Natural Shoreline on a Nearby Northwest Wisconsin Lake

Curly-leaf Pondweed Management:

Curly-leaf pondweed is widespread in the lake which likely makes eradication an unrealistic expectation. Despite this, we found mature CLP plants were easy to locate and remove, and it is possible that, following the 2024 suction harvesting removal of the majority of plants, volunteers might be able to maintain the infestation at a low level by rake removing the plants that are present each spring. If further suction harvesting is needed, manual removal by volunteers might still be an effective way to eliminate isolated plants that harvesting missed.

Yellow Iris Management:

After our June discovery of Yellow iris and subsequent conversation with the Town of Barnes AIS Committee, we believe all plants were removed as we saw no evidence of this species in July. Because iris flowers are beautiful, it is common for uninformed residents to mow around plants on their shoreline. To educate shoreline owners about how invasive this species can be and to encourage them to monitor for and, if possible, remove plants on their property, we encourage the TOB to consider placing a "wanted poster" with further information on their website. Sending out a reminder email to residents about how to remove plants along their shoreline if they find them in June when they are easy to identify is another idea worth considering.

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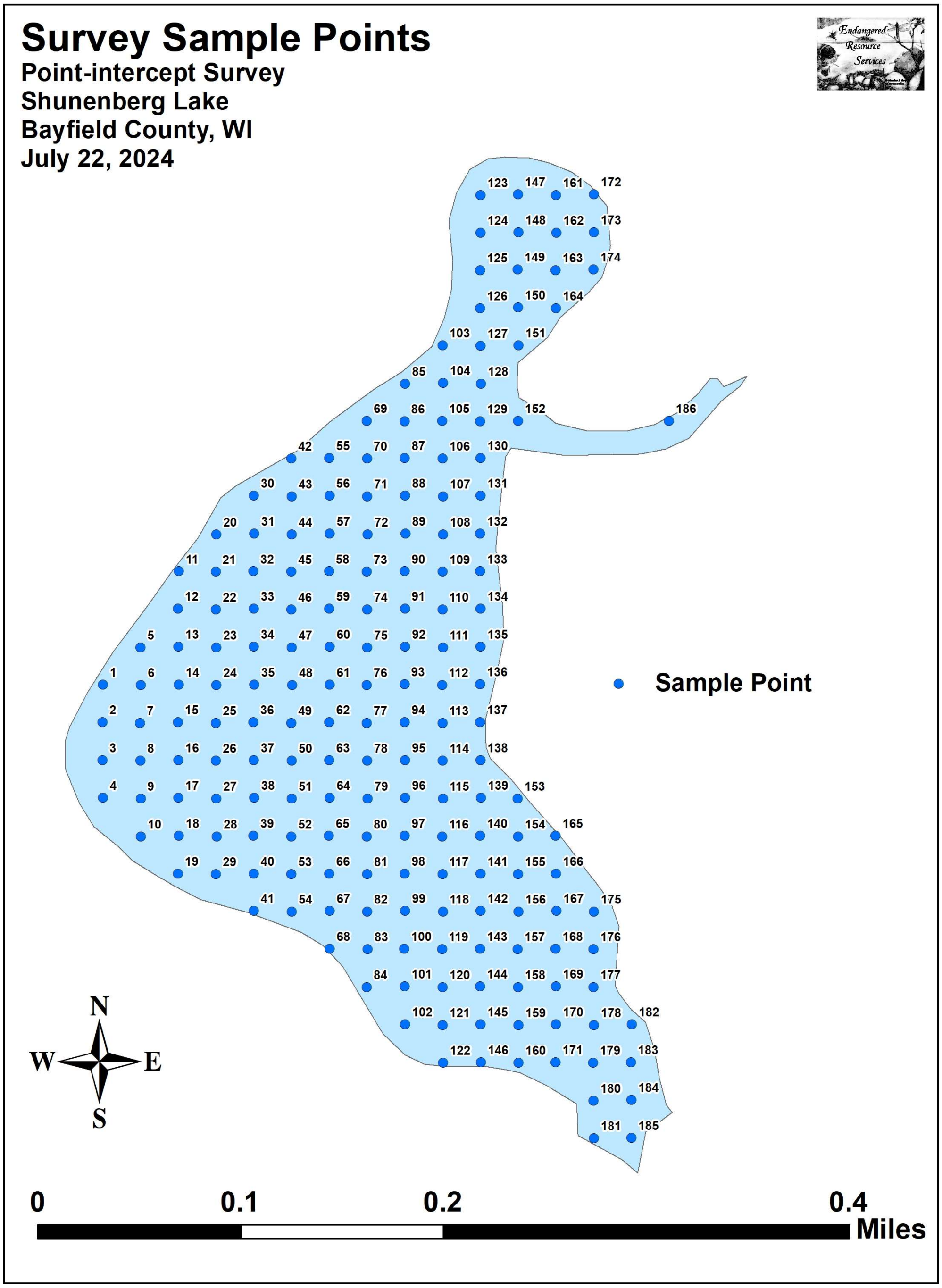
Appendix I: Point-intercept Survey Sample Points Map

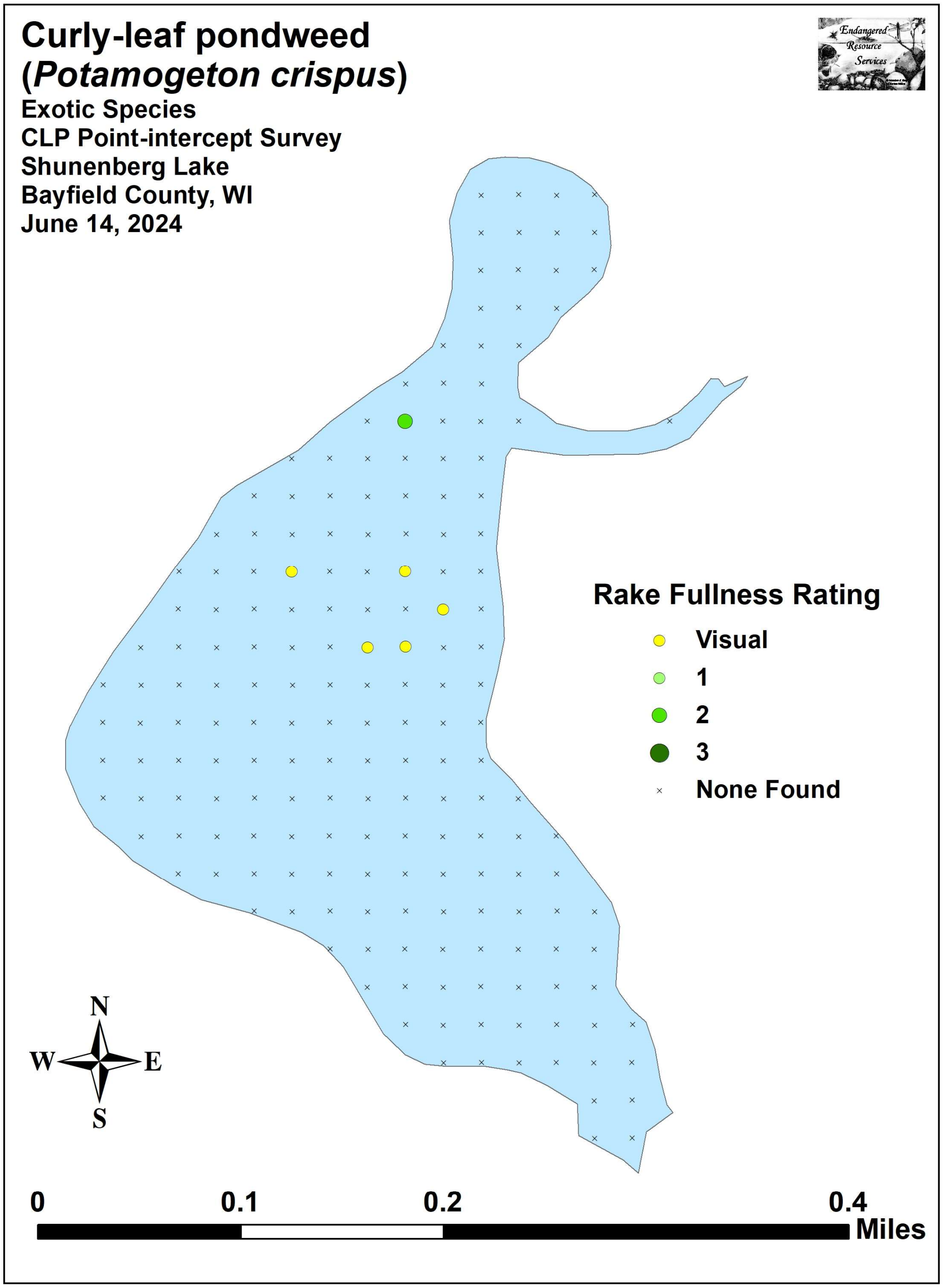

Survey Sample Points
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Sample Point
N
W
E
S
0
0.1
0.2
0.4
Miles

Appendix II: Boat and Vegetative Survey Datasheets

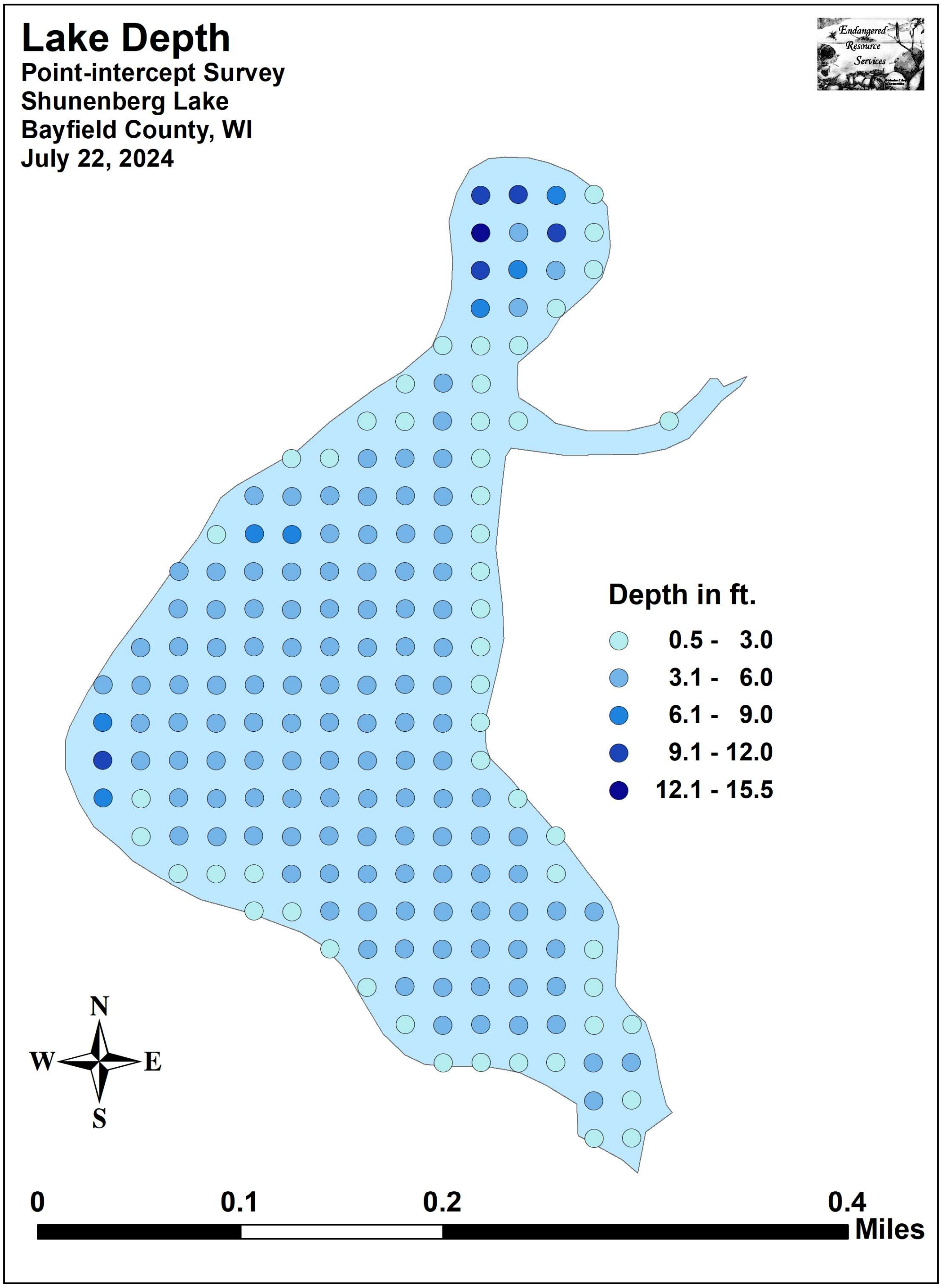
Boat Survey	
Lake Name	
Counties	
WBIC	
Date of Survey	
(mm/dd/yy)	
workers	
Nearest Point	**Species seen, habitat information**

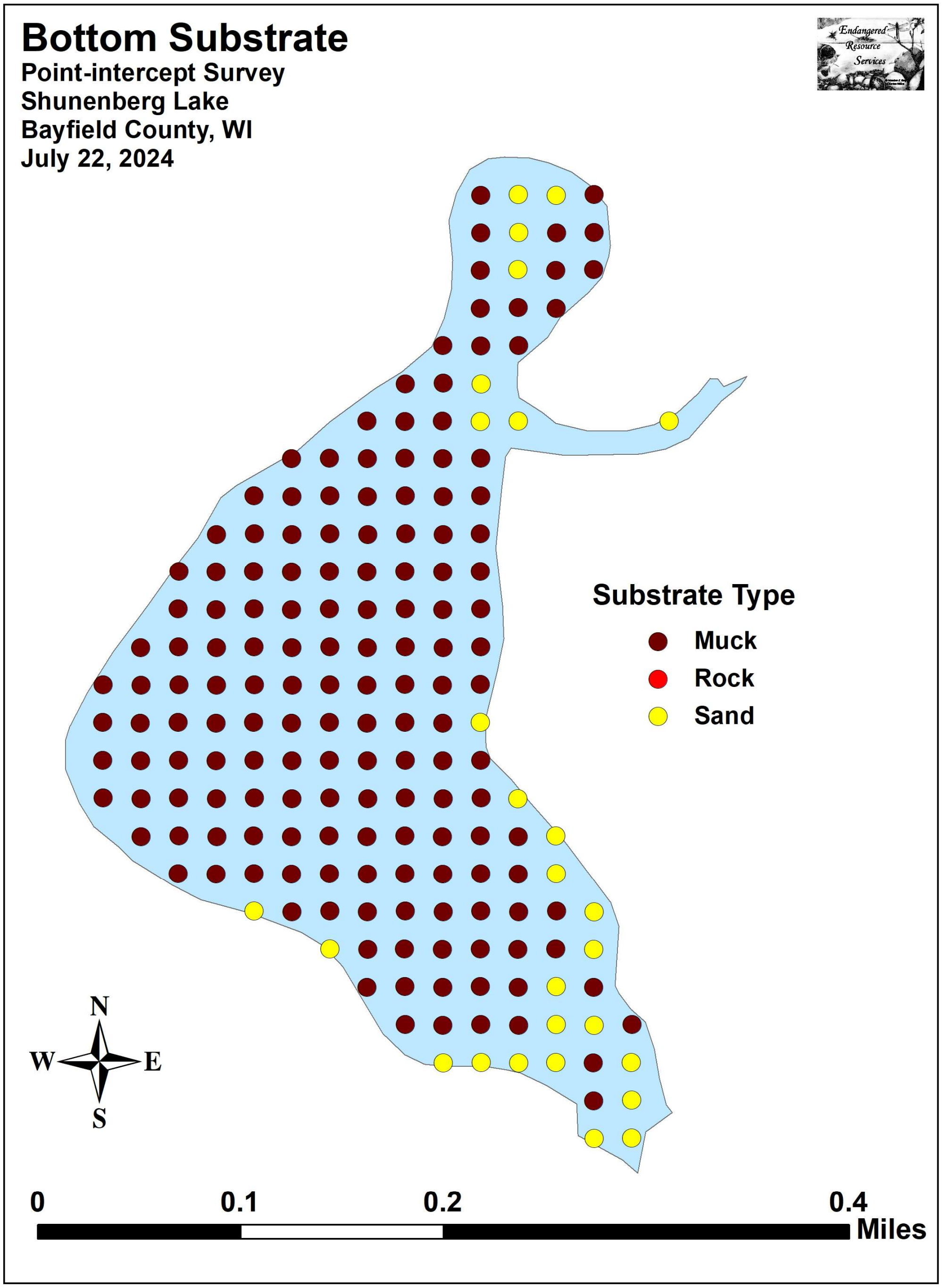
Observers for this lake: names and hours worked by each:																									
Lake:									**WBIC**									**Counties**						**Date:**	
Site #	**Depth (ft)**	**Muck (M), Sand (S), Rock (R)**	**Rake pole (P) or rake rope (R)**	**Total Rake Fullness**	**EWM**	**CLP**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
1																									
2																									
3																									
4																									
5																									
6																									
7																									
8																									
9																									
10																									
11																									
12																									
13																									
14																									
15																									
16																									
17																									
18																									
19																									
20																									

Appendix III: Early Season Curly-leaf Pondweed Density and Distribution Map

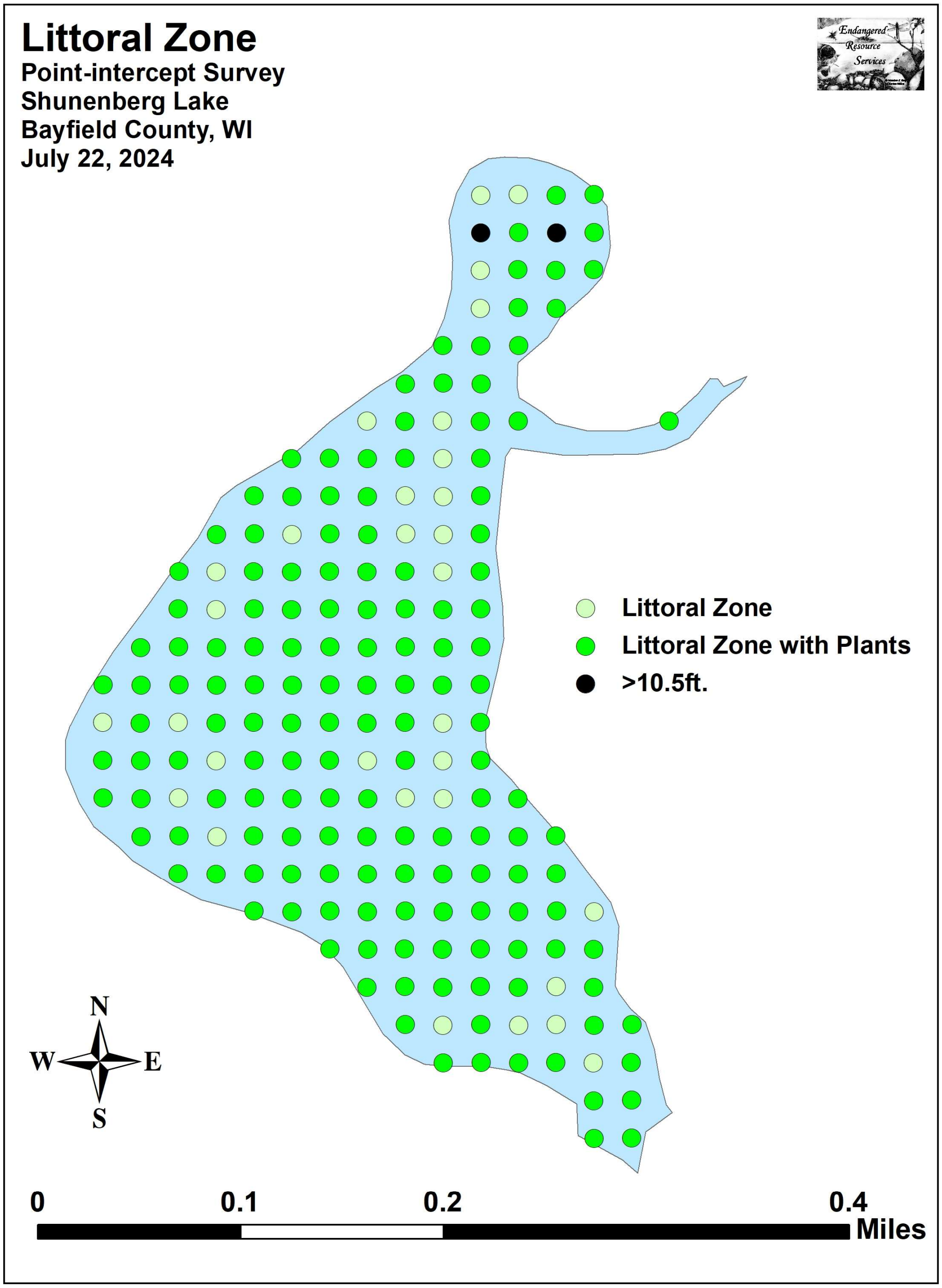

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
June 14, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles

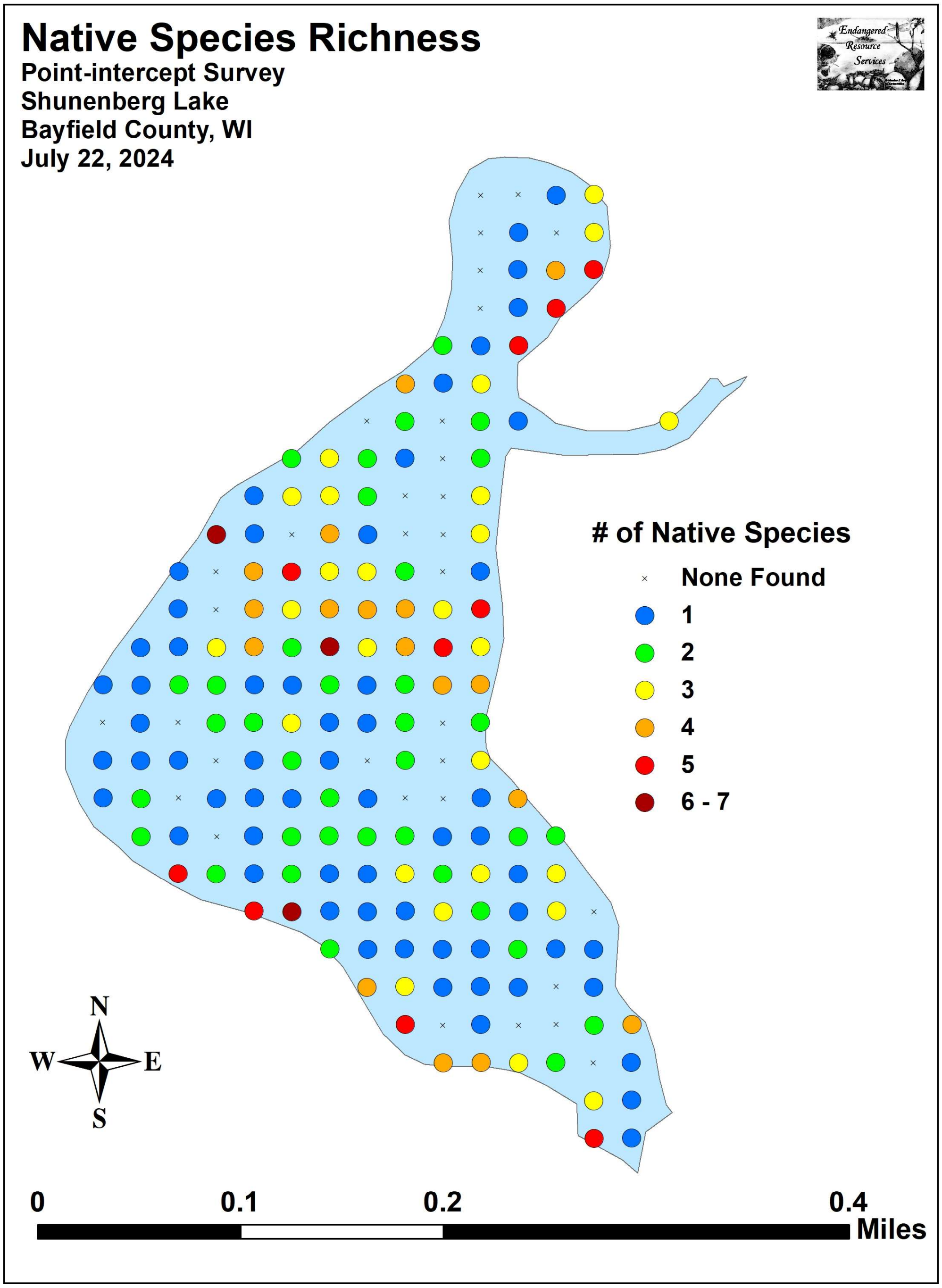
Appendix IV: Habitat Variable Maps


Lake Depth
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Depth in ft.
0.5 - 3.0
3.1 - 6.0
6.1 - 9.0
9.1 - 12.0
12.1 - 15.5
N
W
E
S
0
0.1
0.2
0.4
Miles

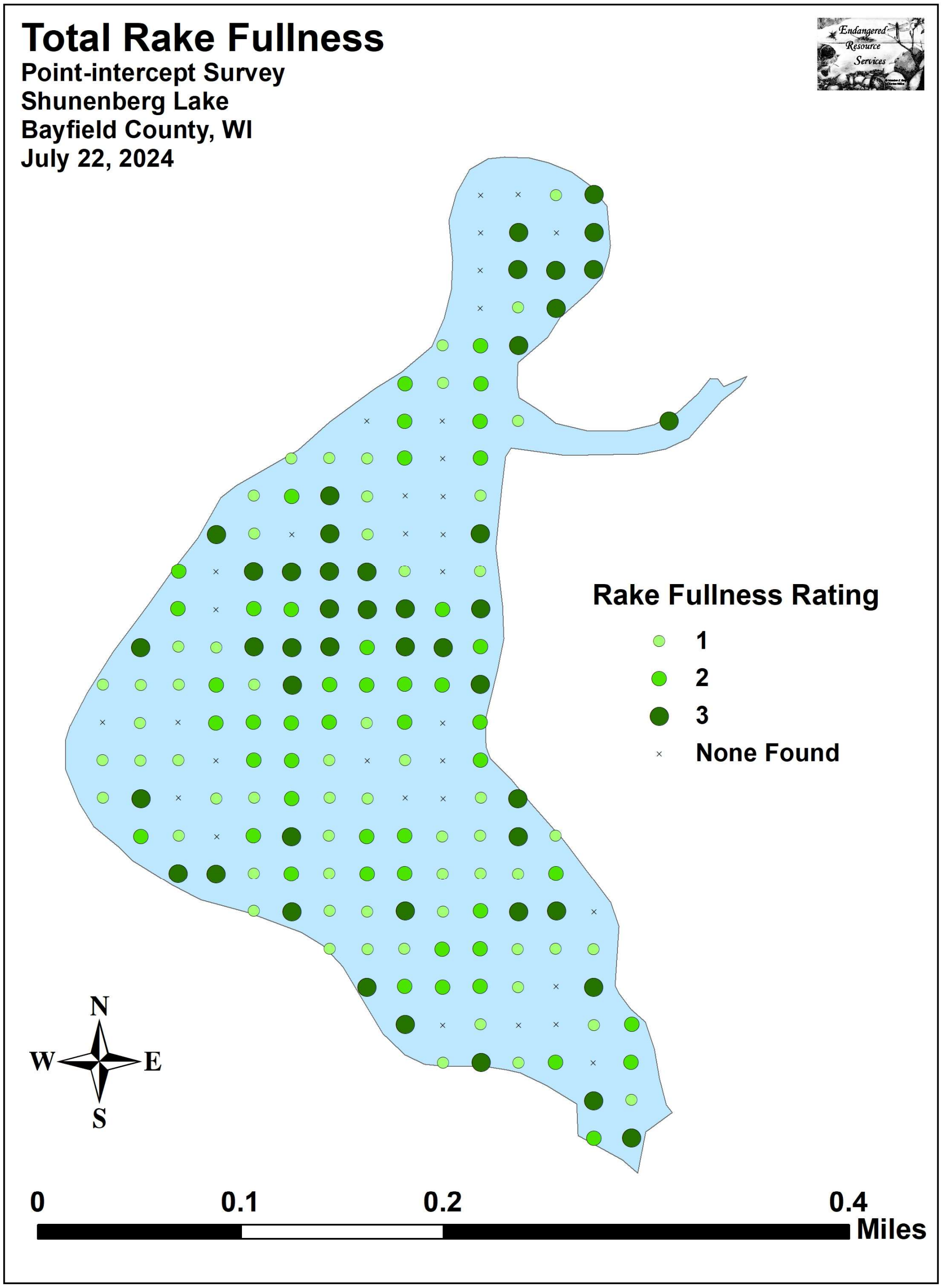

Bottom Substrate
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Substrate Type
Muck
Rock
Sand
N
W
E
S
0
0.1
0.2
0.4
Miles

Appendix V: Littoral Zone, Native Species Richness, and Total Rake Fullness Maps

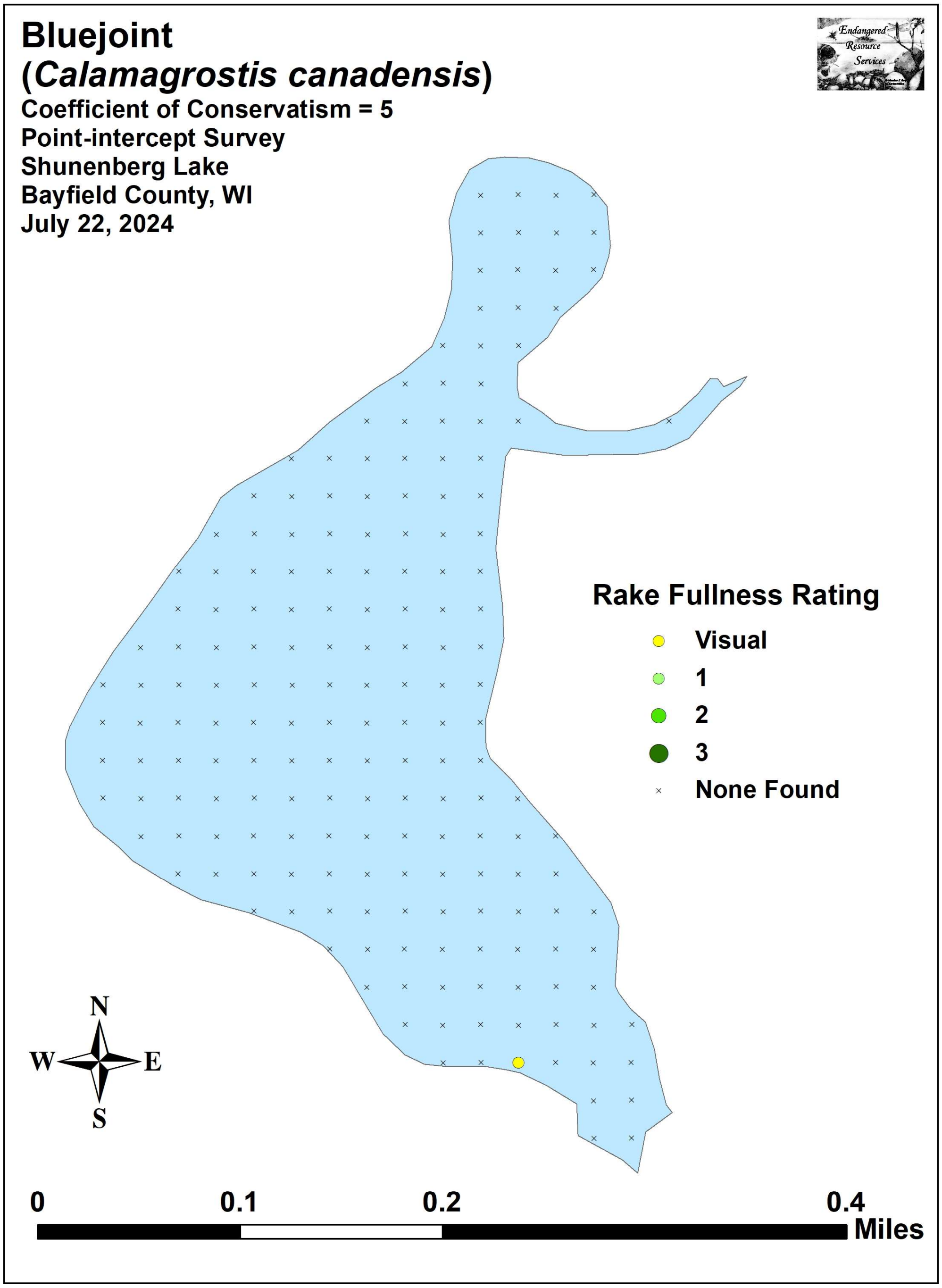

Littoral Zone
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Littoral Zone
Littoral Zone with Plants
>10.5ft.
N
W
E
S
0
0.1
0.2
0.4
Miles



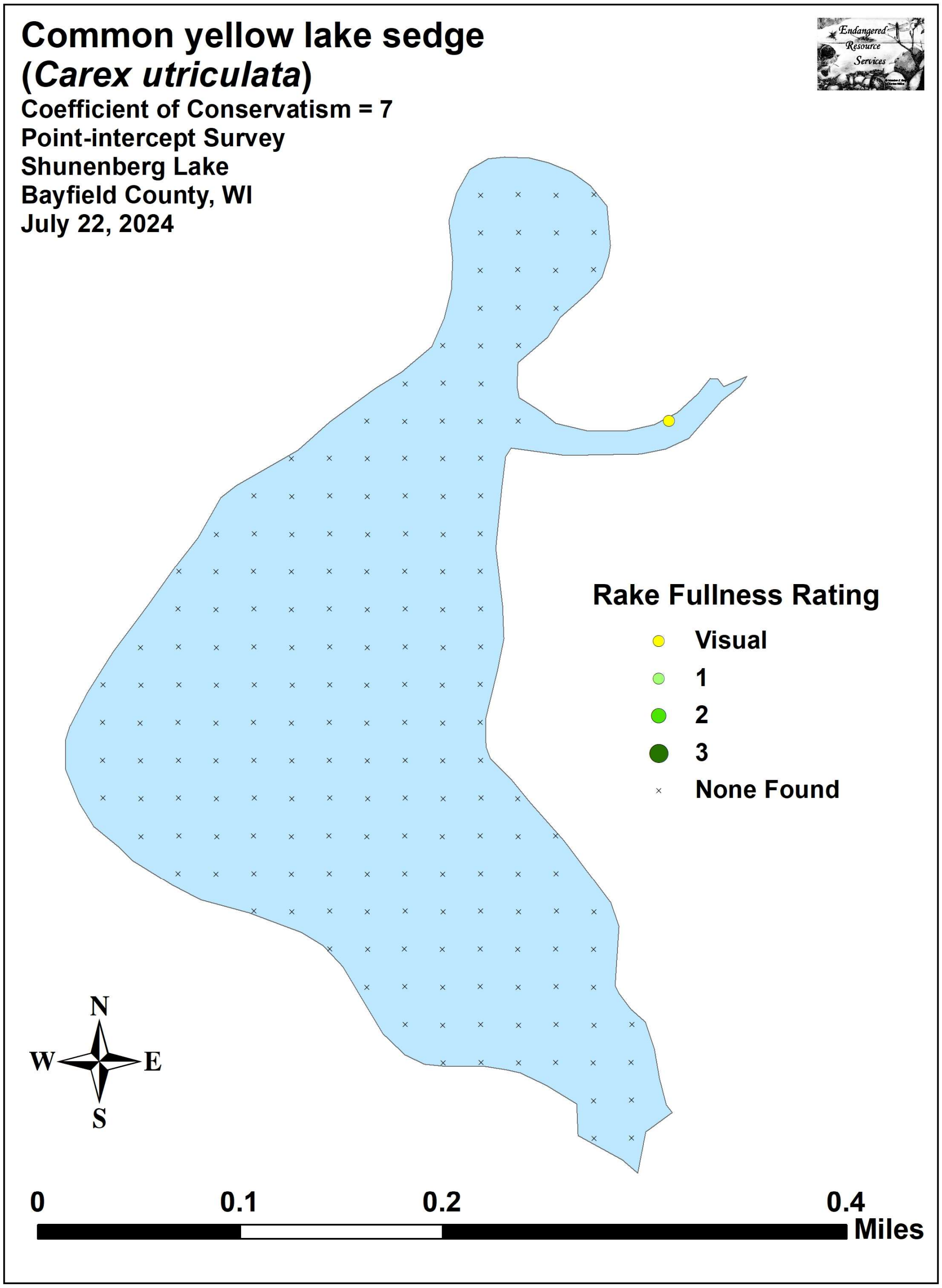
Native Species Richness
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
# of Native Species
None Found
1
2
3
4
5
6 - 7
N
W
E
S
0
0.1
0.2
0.4
Miles

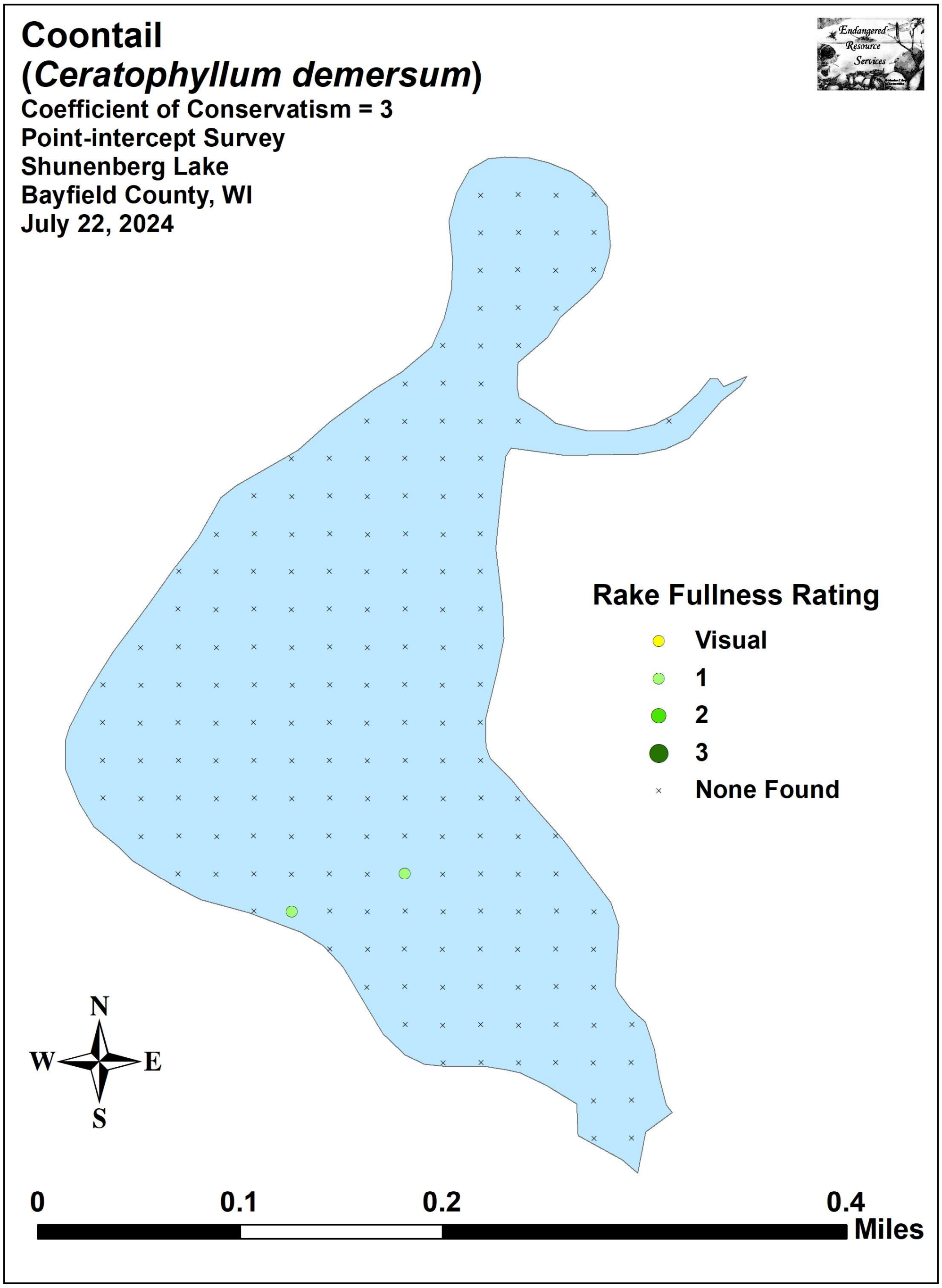

Total Rake Fullness
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles

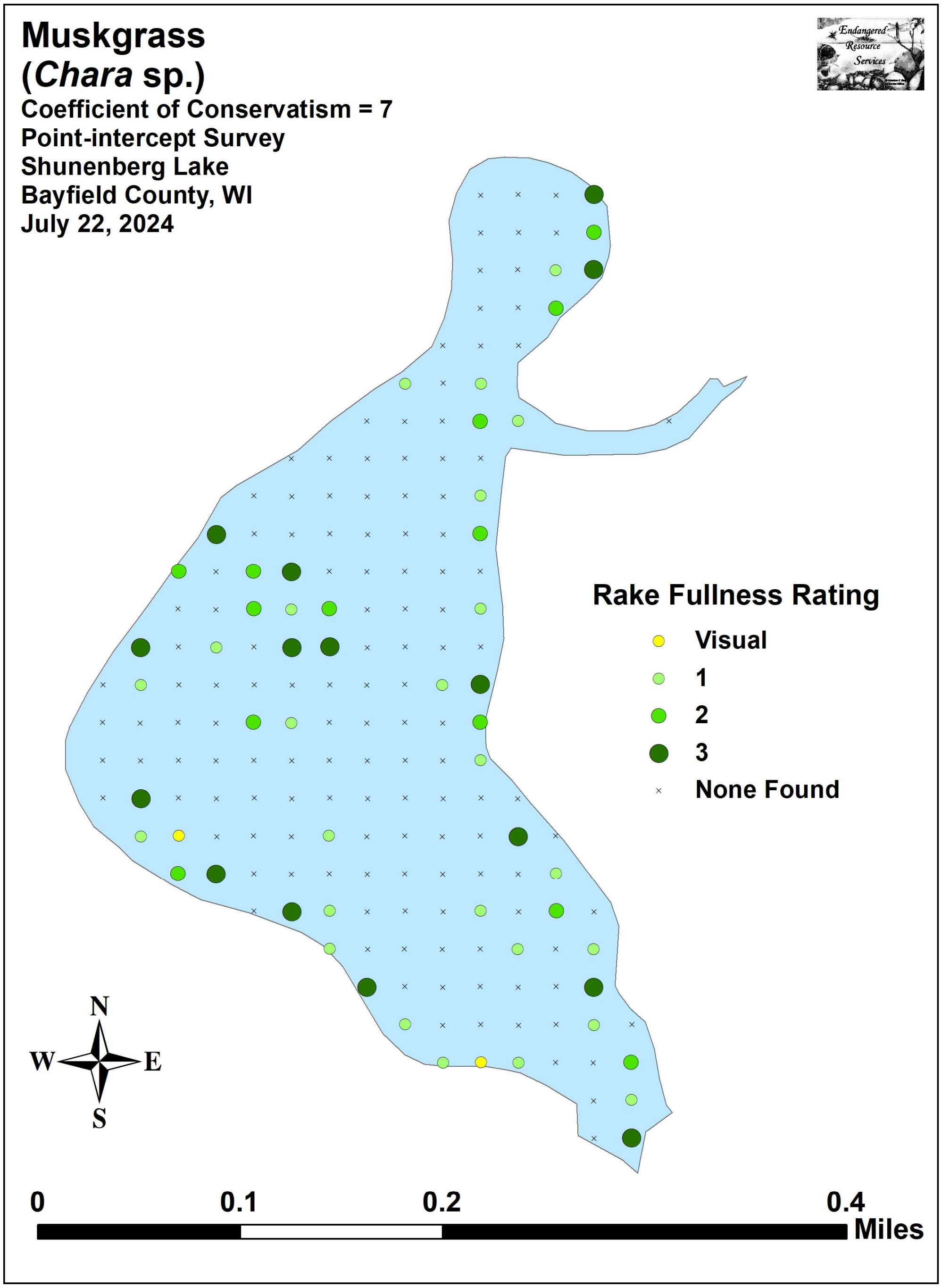
Appendix VI: Native Species Density and Distribution Maps

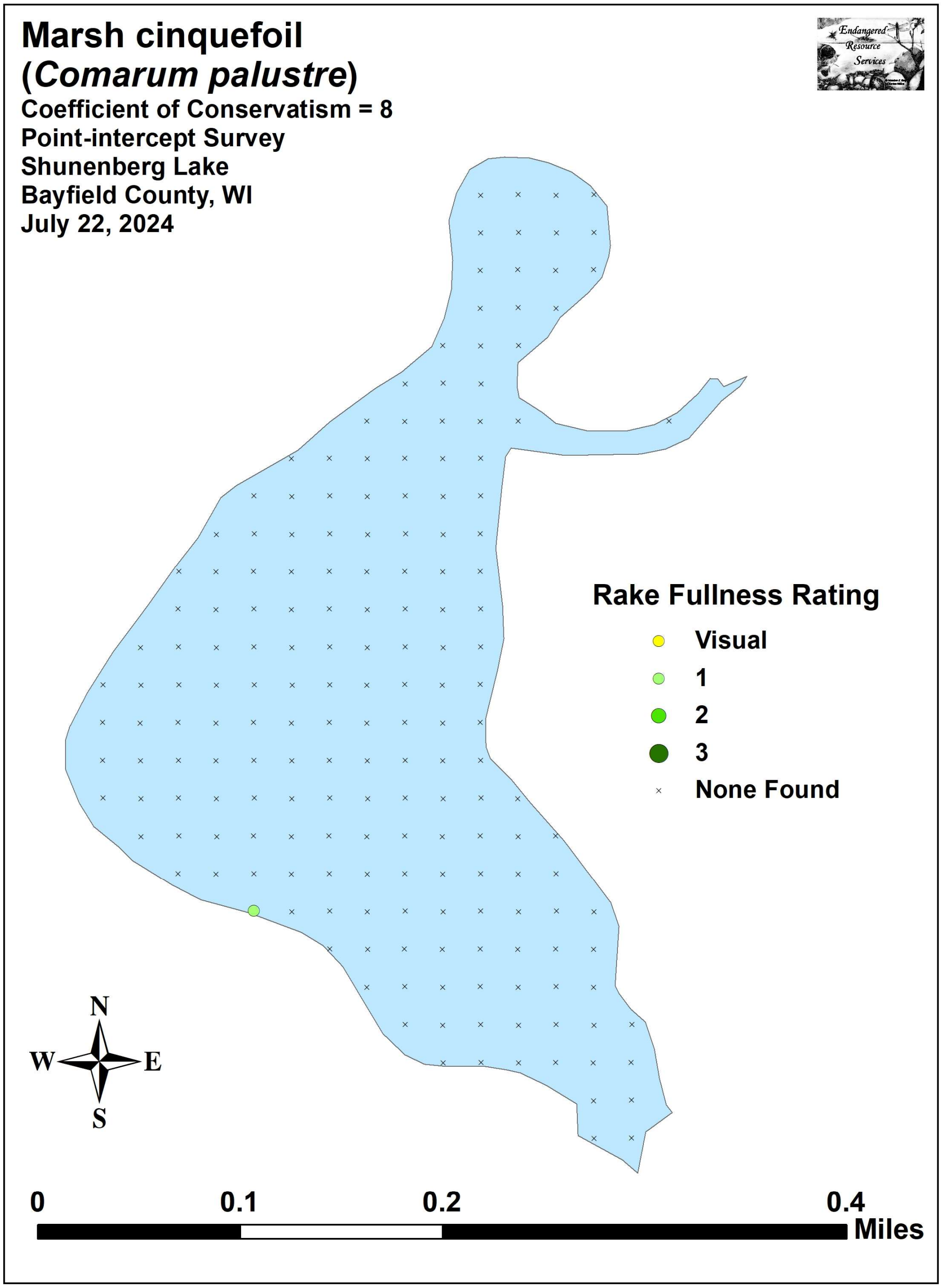


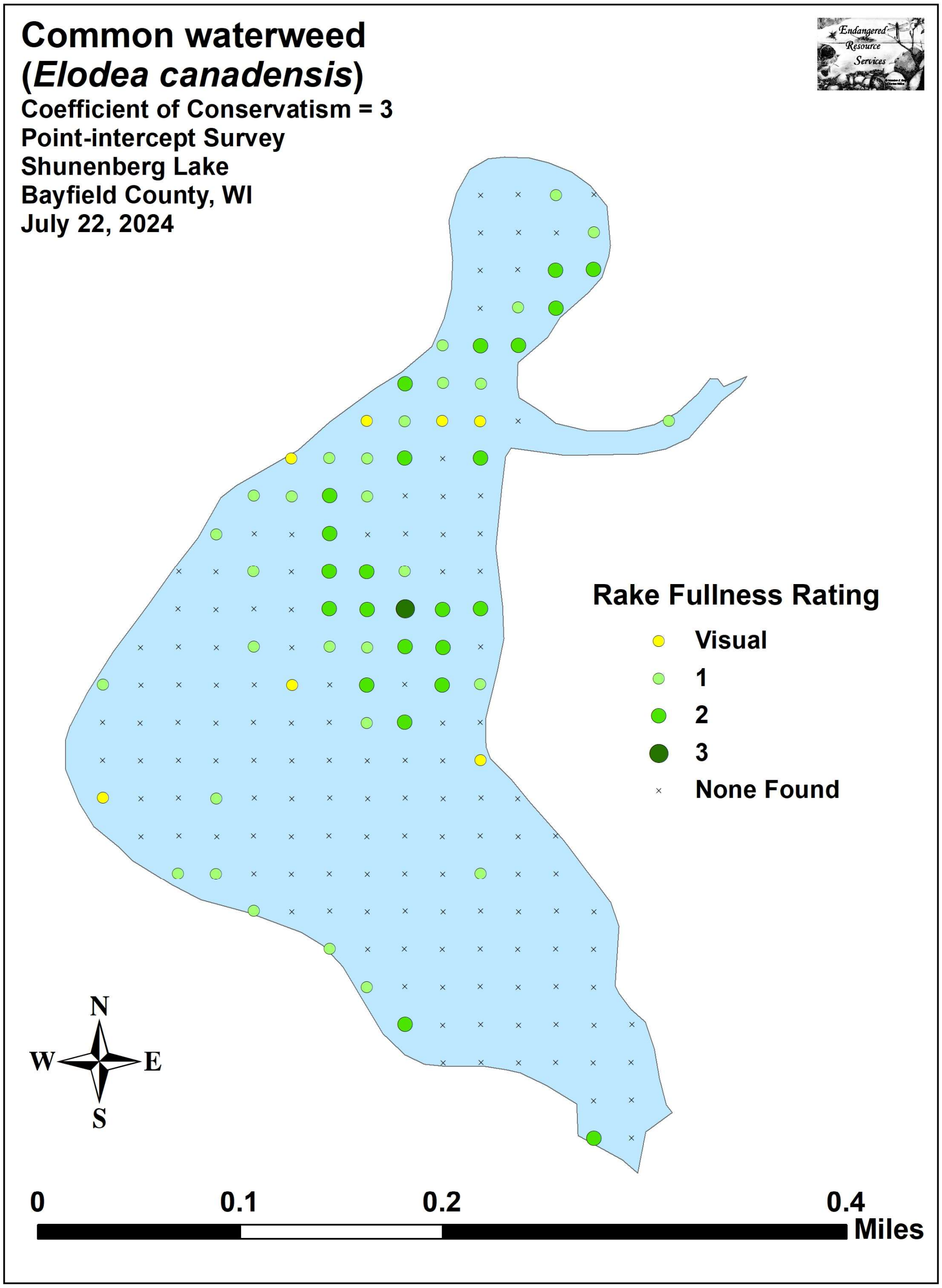
Bluejoint
(*Calamagrostis canadensis*)
Coefficient of Conservatism = 5
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles

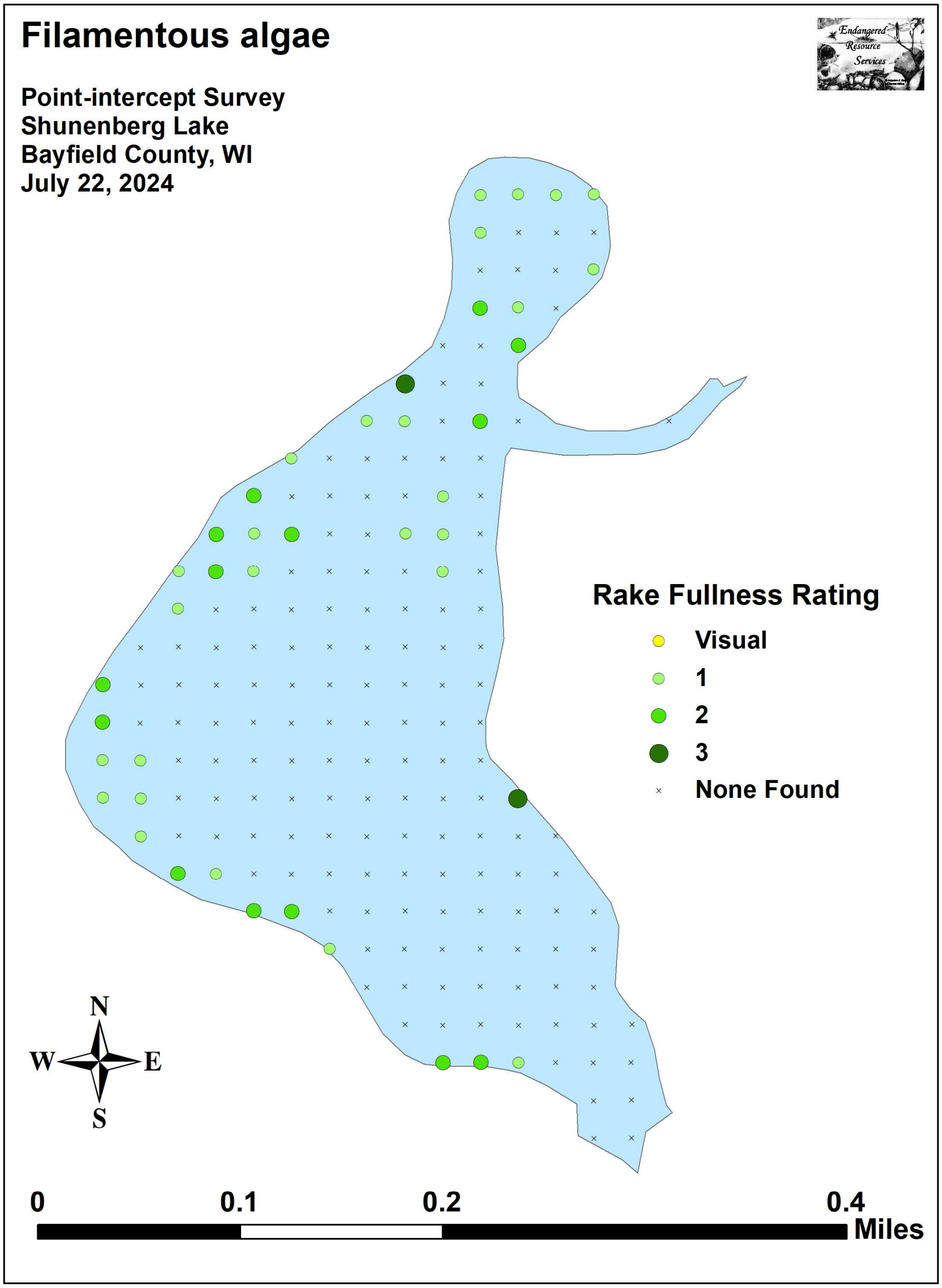

Common yellow lake sedge
(Carex utriculata)
Coefficient of Conservatism = 7
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles

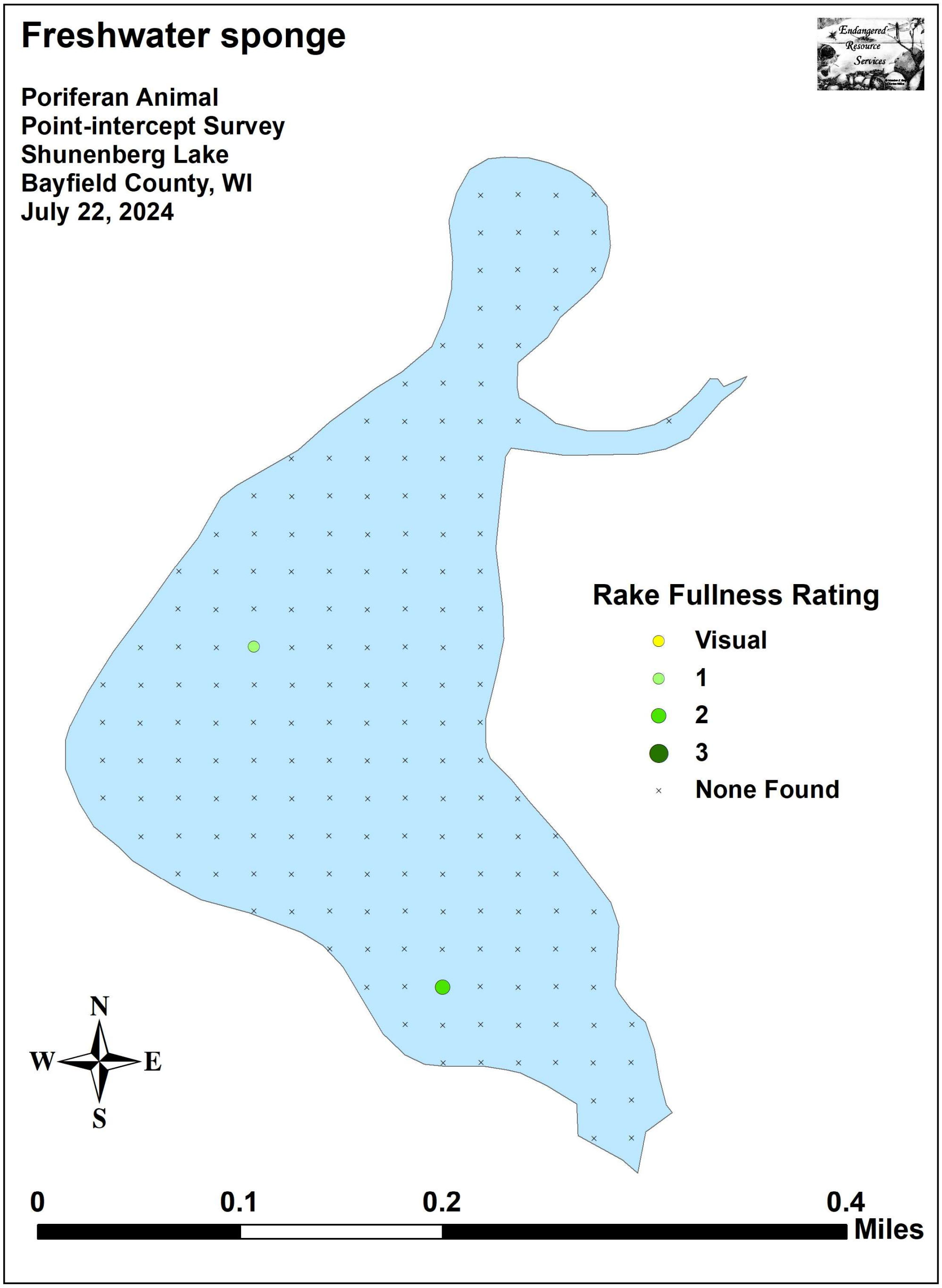

Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles


Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles

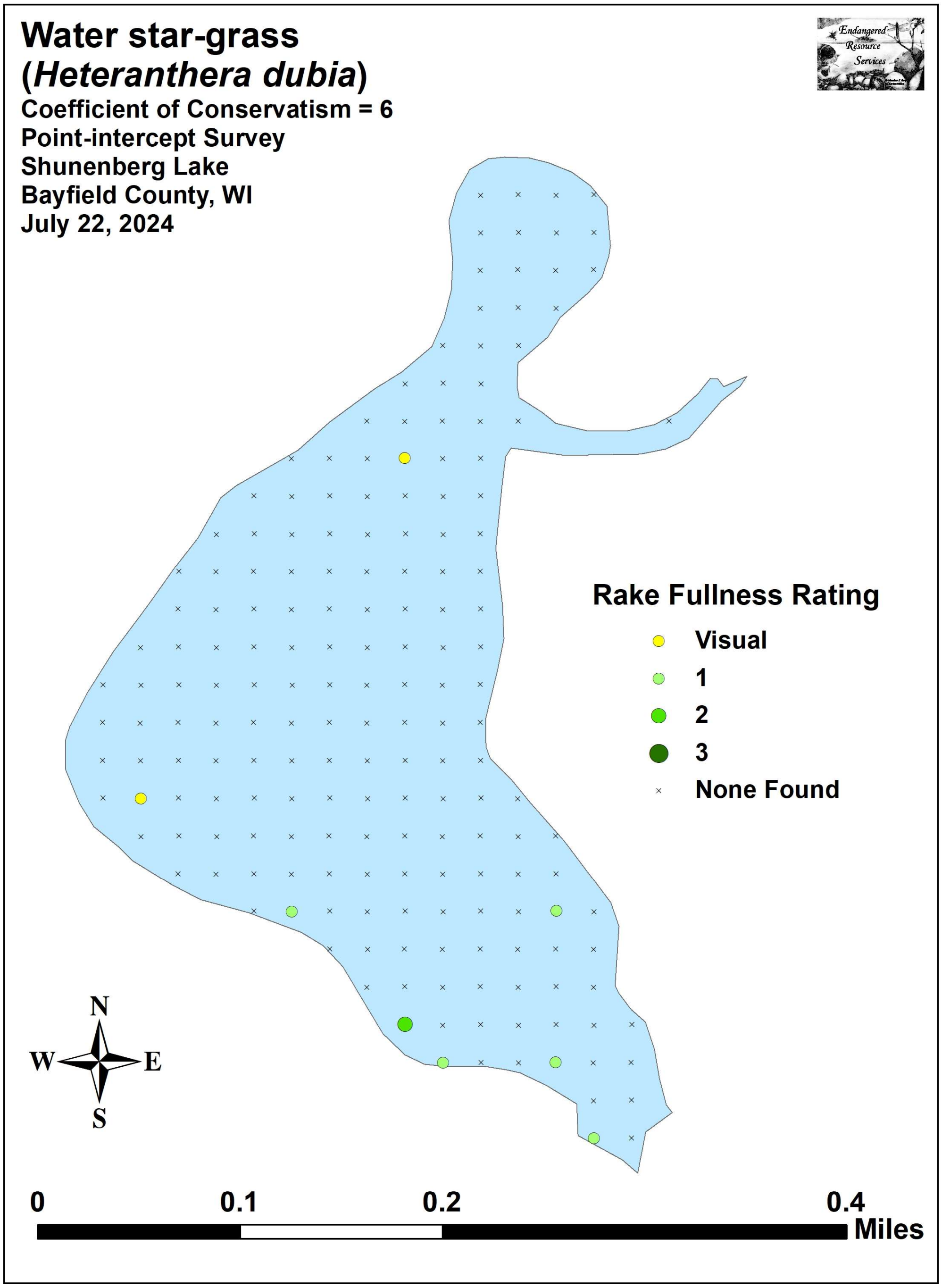

Marsh cinquefoil
(Comarum palustre)
Coefficient of Conservatism = 8
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles

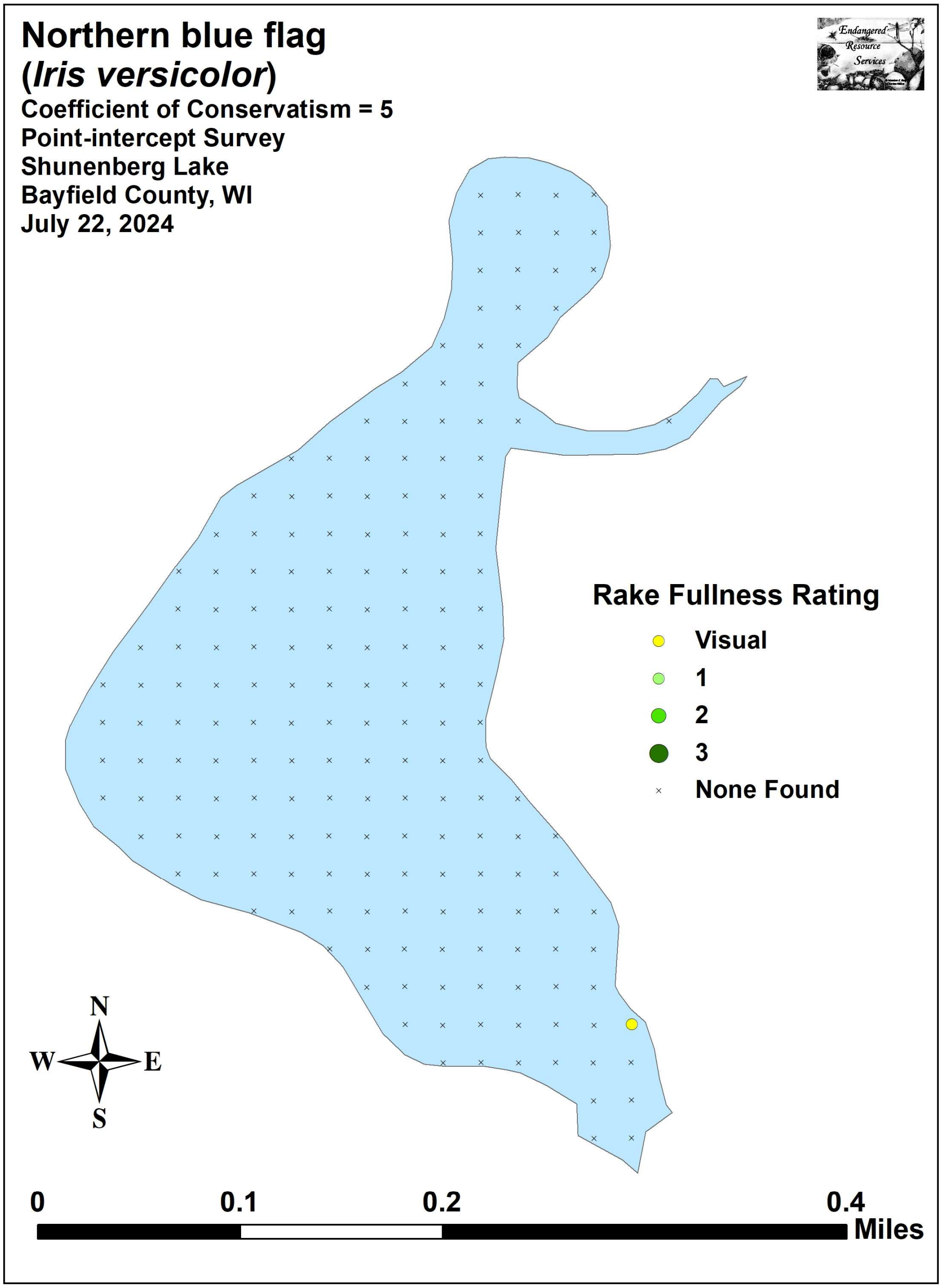

Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles


Filamentous algae
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles



Freshwater sponge
Endangered Resource Services
Poriferan Animal
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles


Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.1
0.2
0.4
Miles


Northern blue flag
(*Iris versicolor*)
Coefficient of Conservatism = 5
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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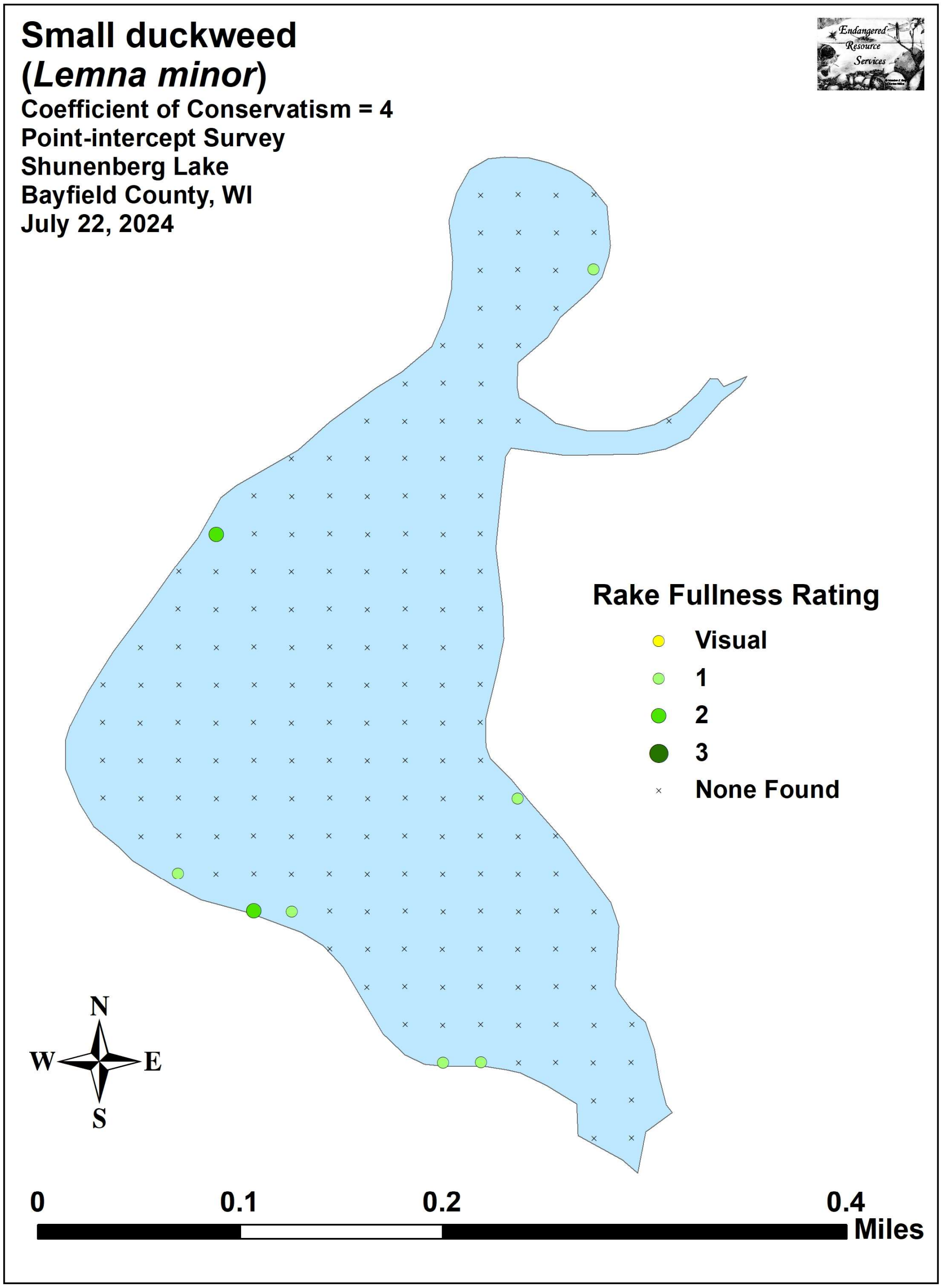

Small duckweed
(Lemna minor)
Coefficient of Conservatism = 4
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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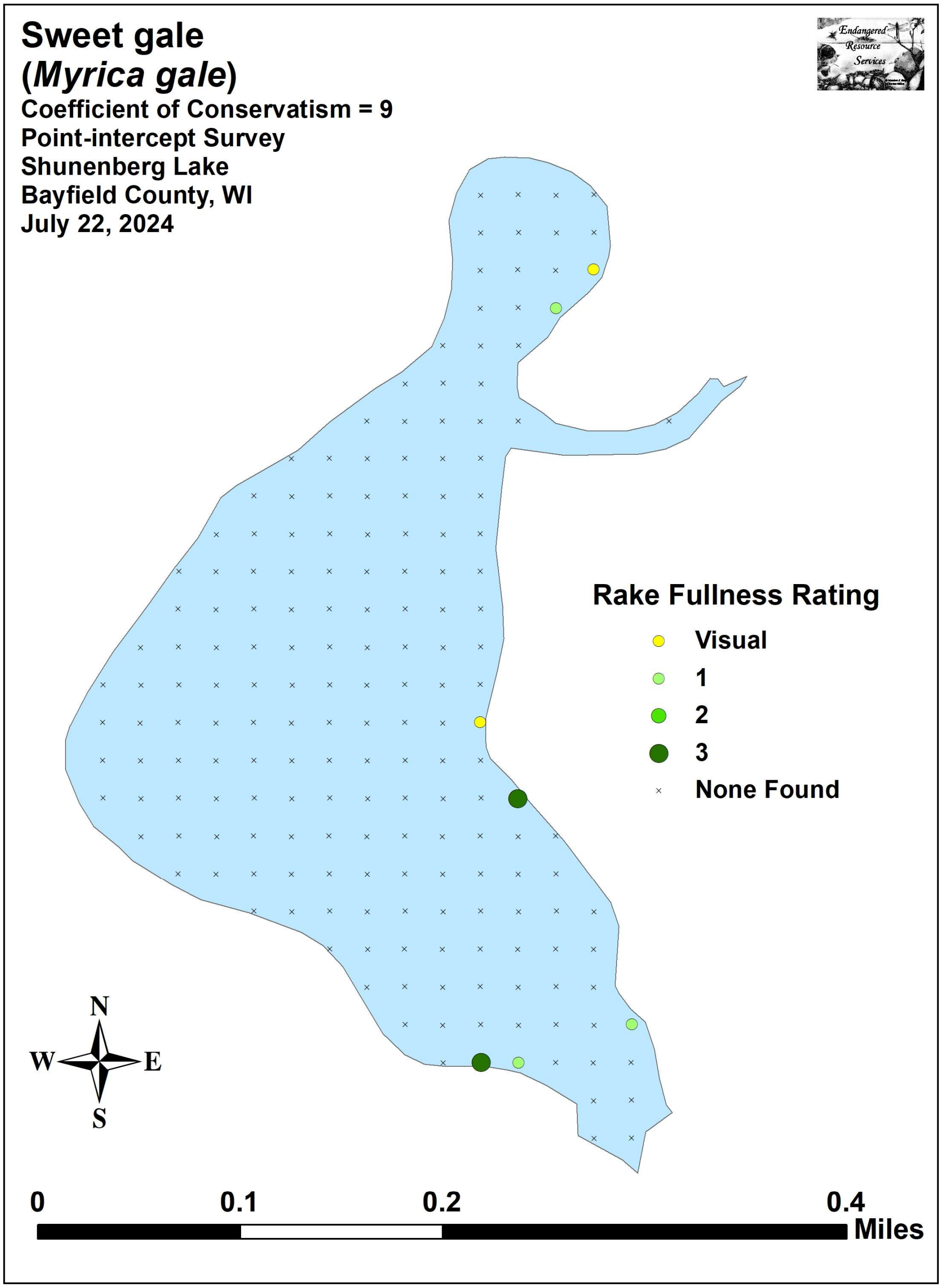
Sweet gale
(*Myrica gale*)
Coefficient of Conservatism = 9
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Rake Fullness Rating
Visual
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None Found
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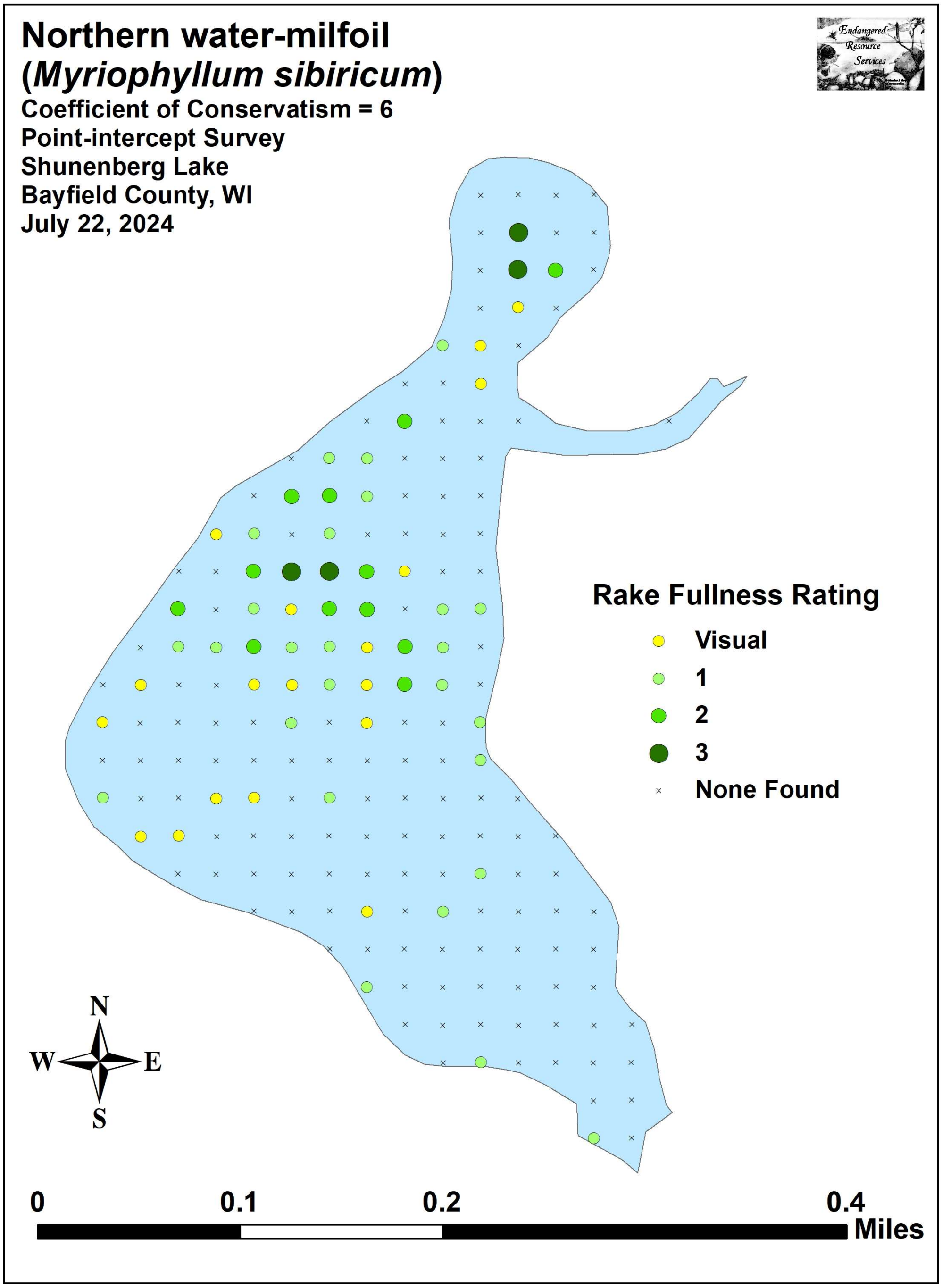
Miles


Northern water-milfoil
(Myriophyllum sibiricum)
Coefficient of Conservatism = 6
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Rake Fullness Rating
Visual
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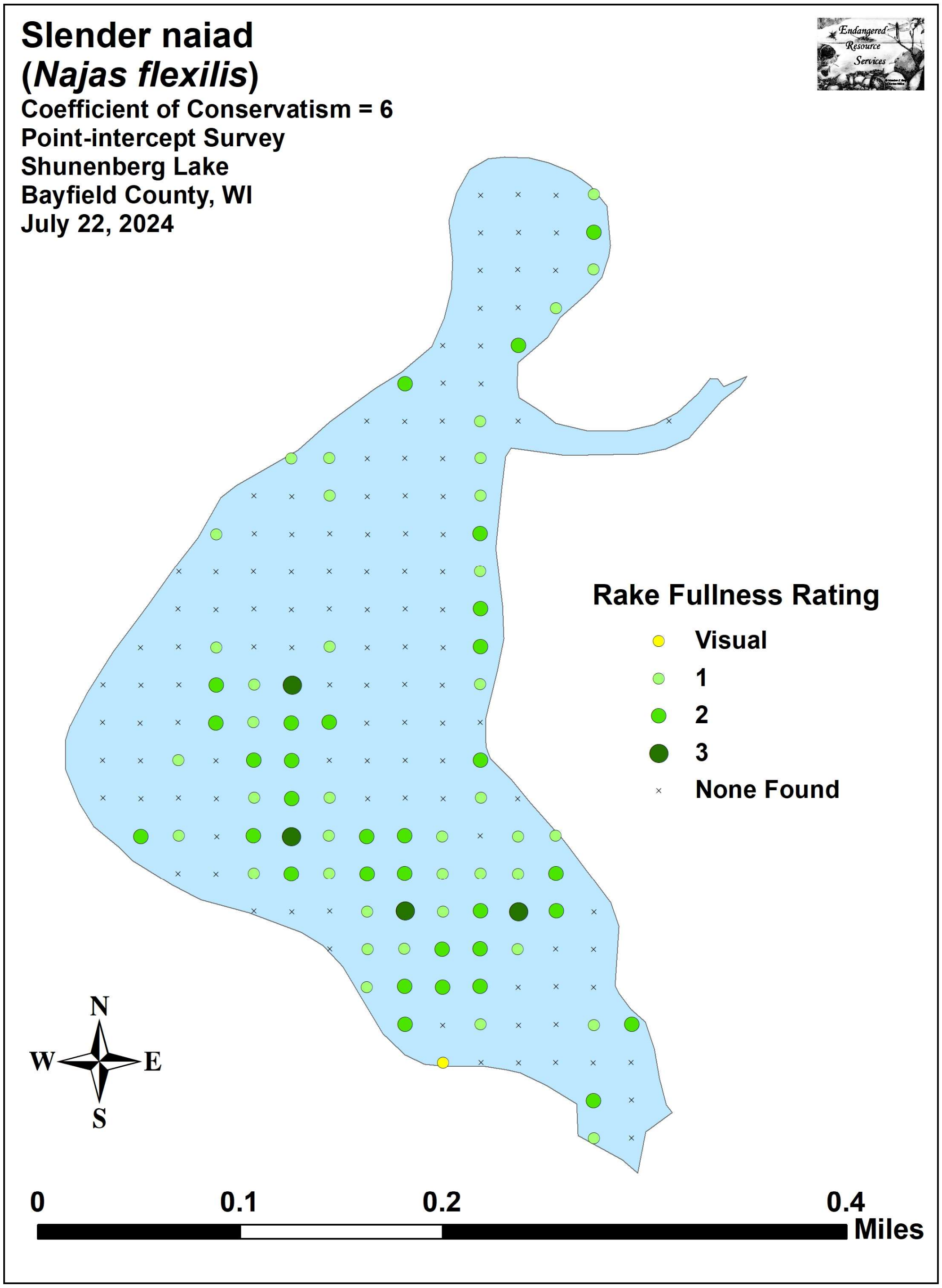
Miles


Slender naiad
(*Najas flexilis*)
Coefficient of Conservatism = 6
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Rake Fullness Rating
Visual
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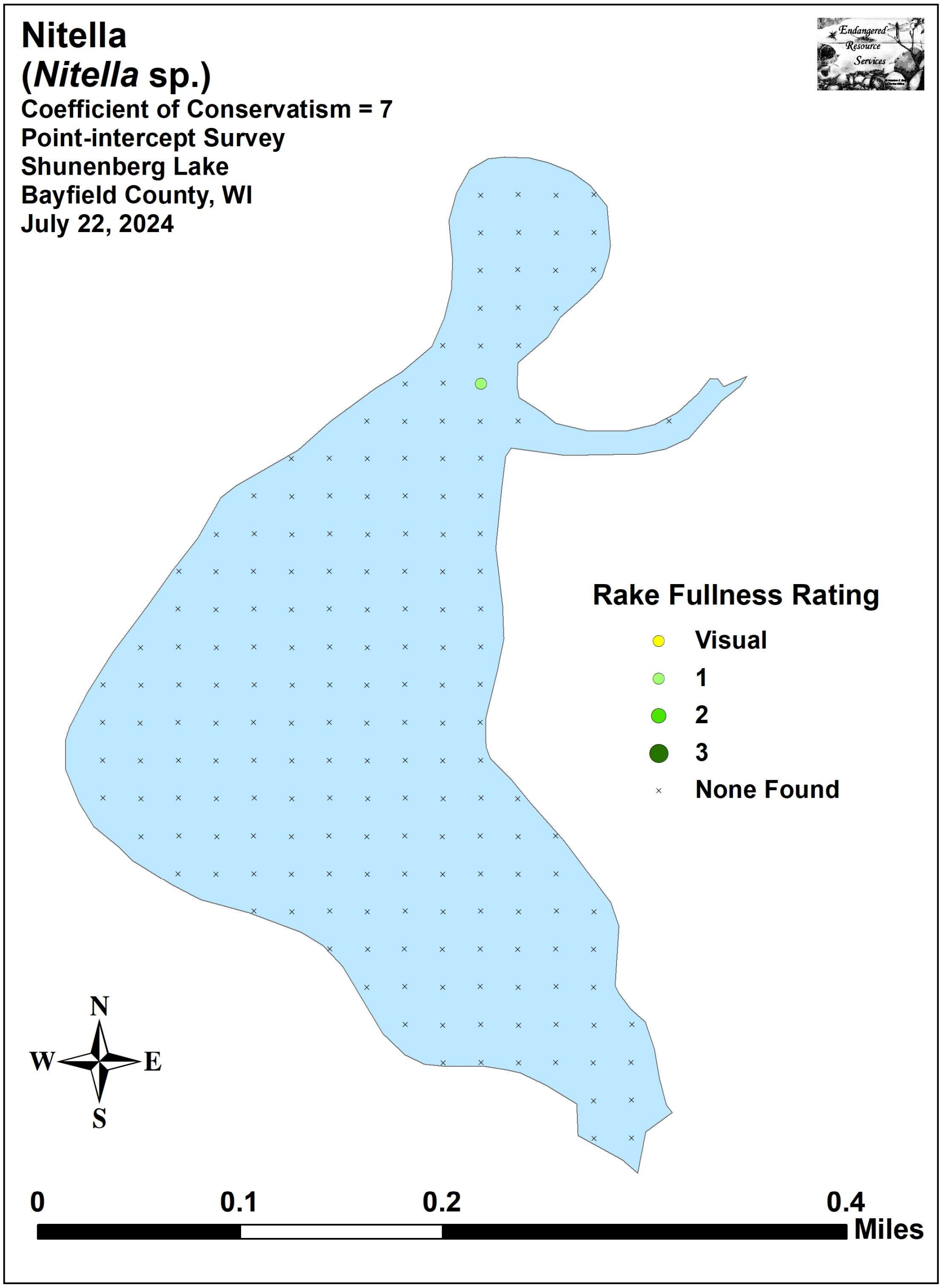
Miles


Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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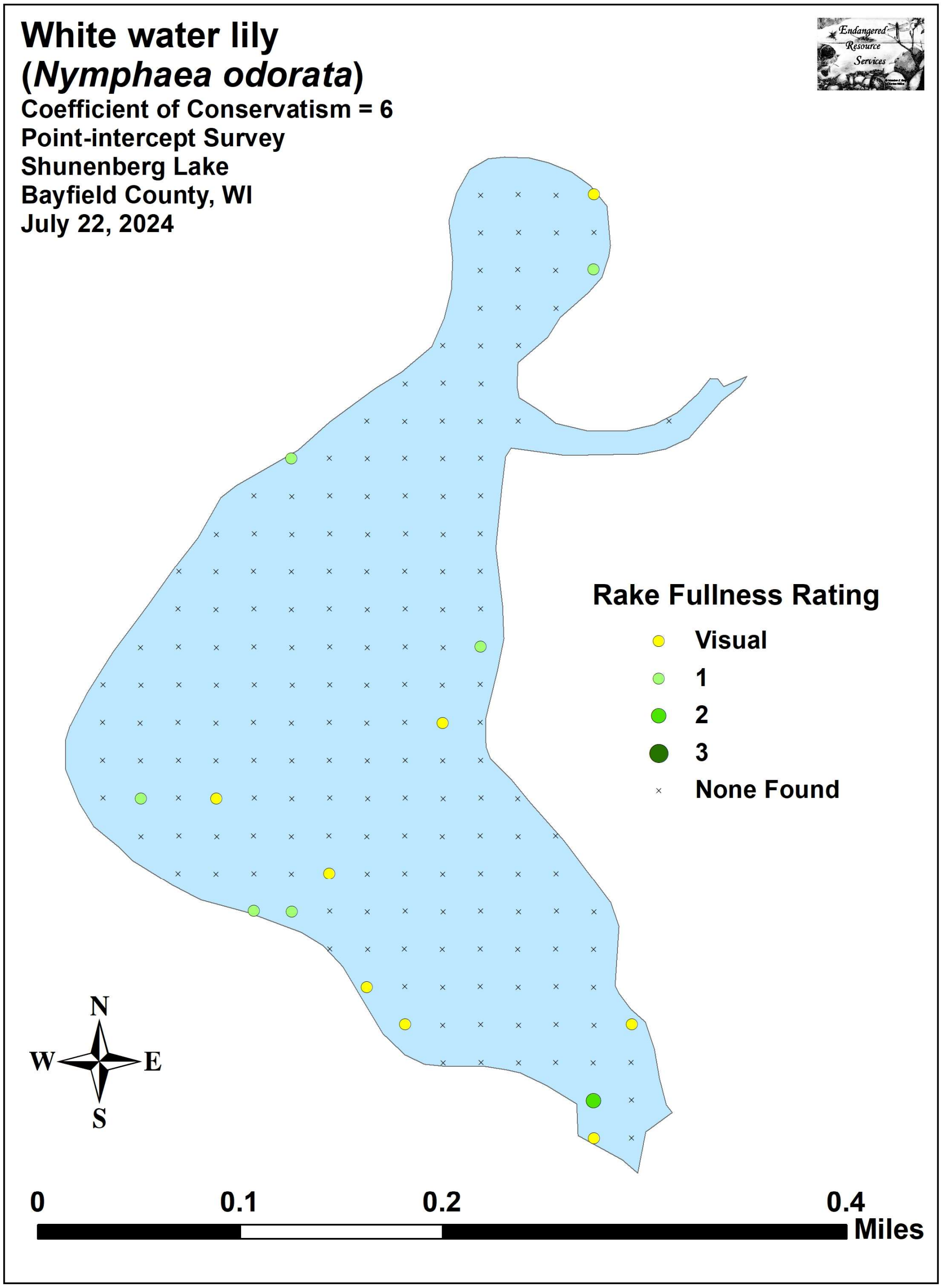
White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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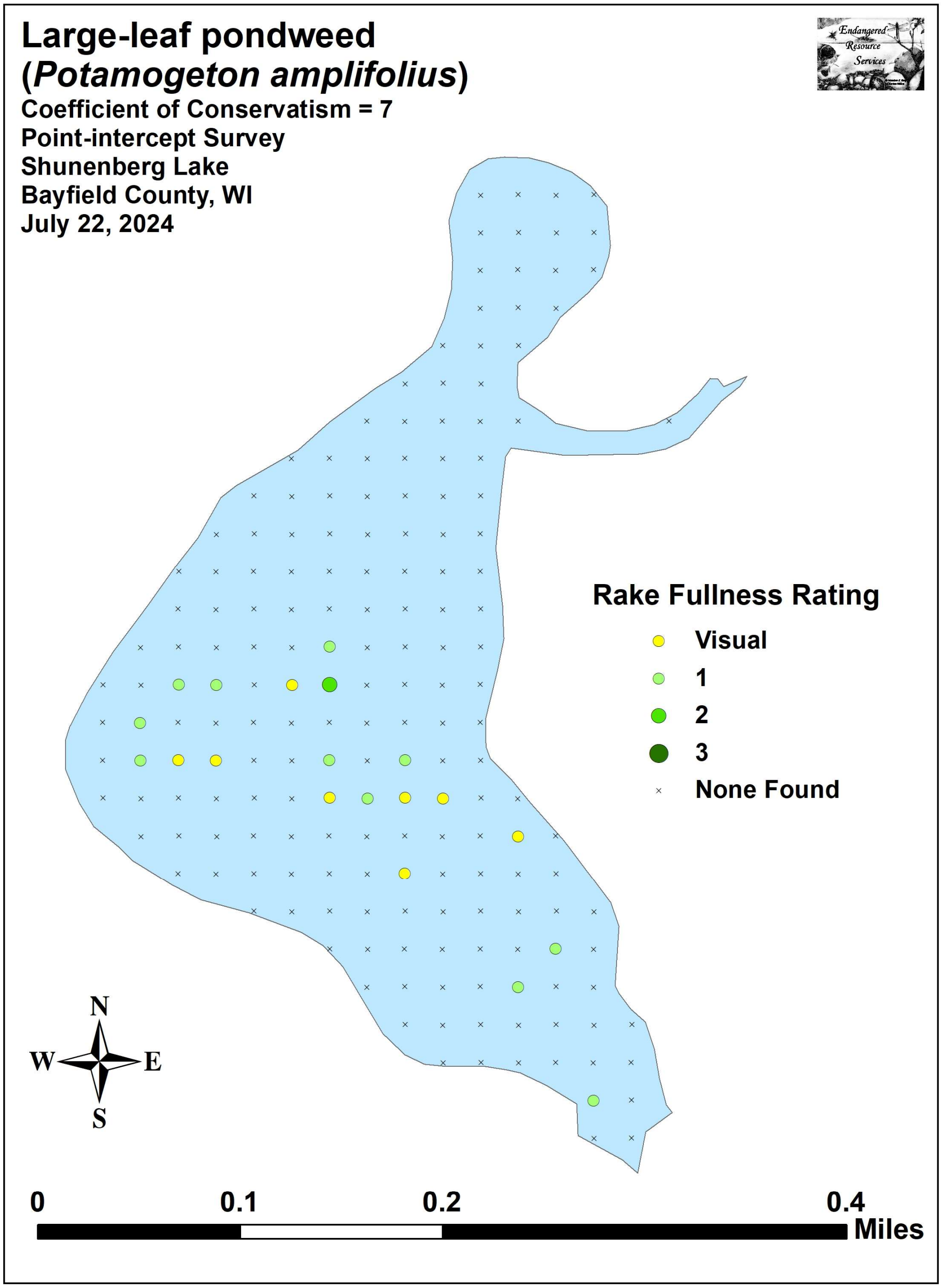
Large-leaf pondweed
(*Potamogeton amplifolius*)
Coefficient of Conservatism = 7
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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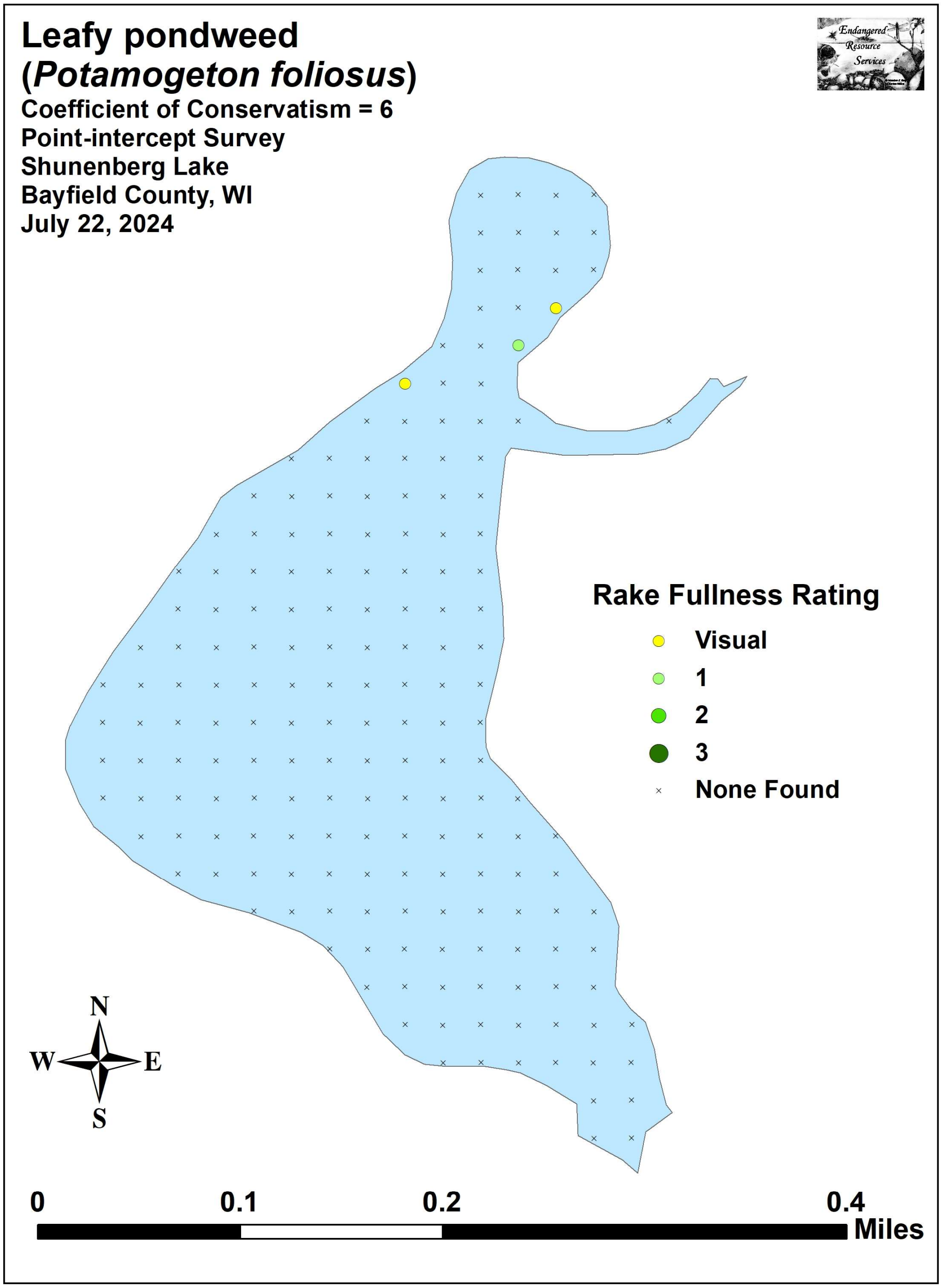
Leafy pondweed
(*Potamogeton foliosus*)
Coefficient of Conservatism = 6
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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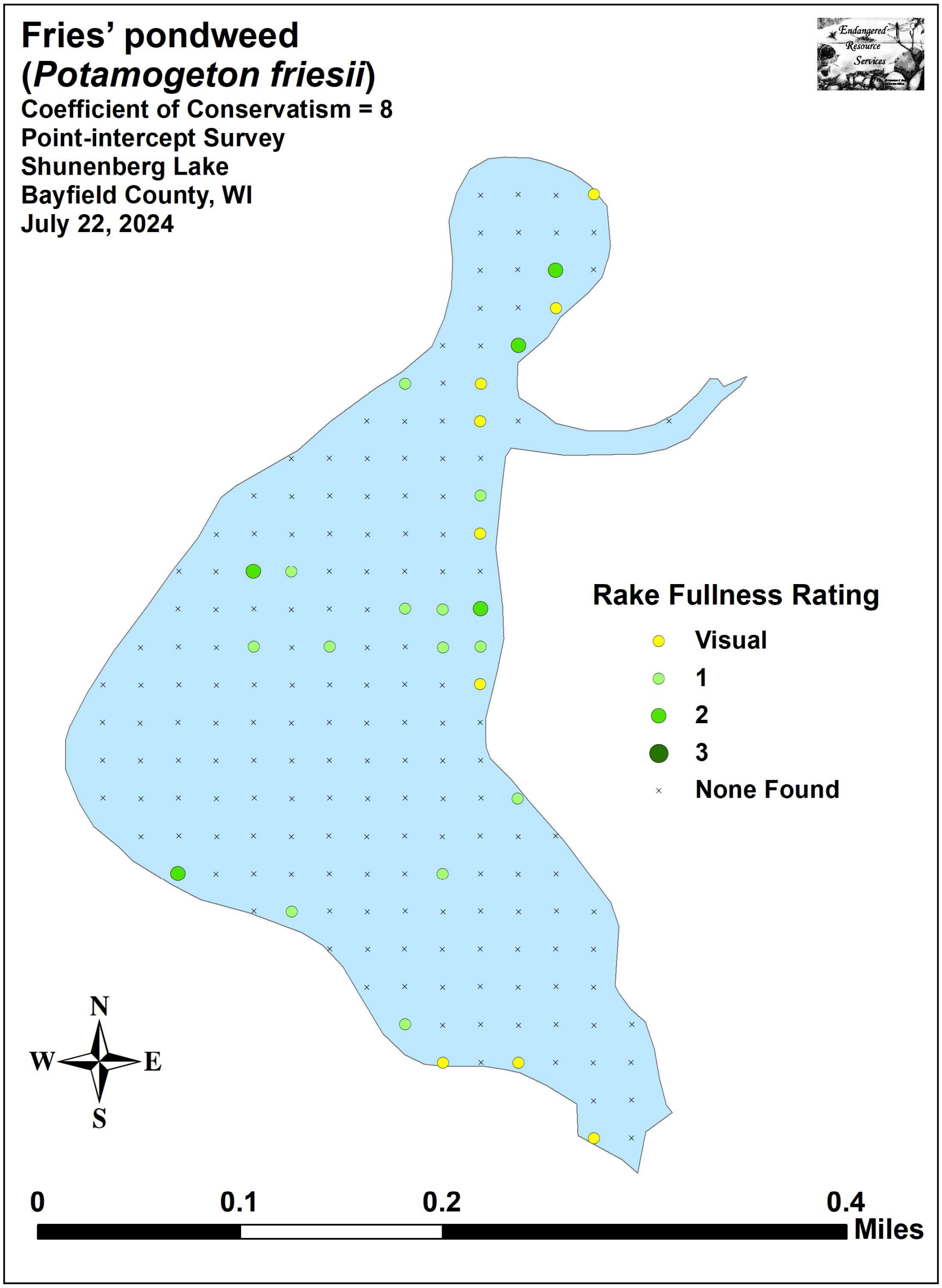
Fries' pondweed
(*Potamogeton friesii*)
Coefficient of Conservatism = 8
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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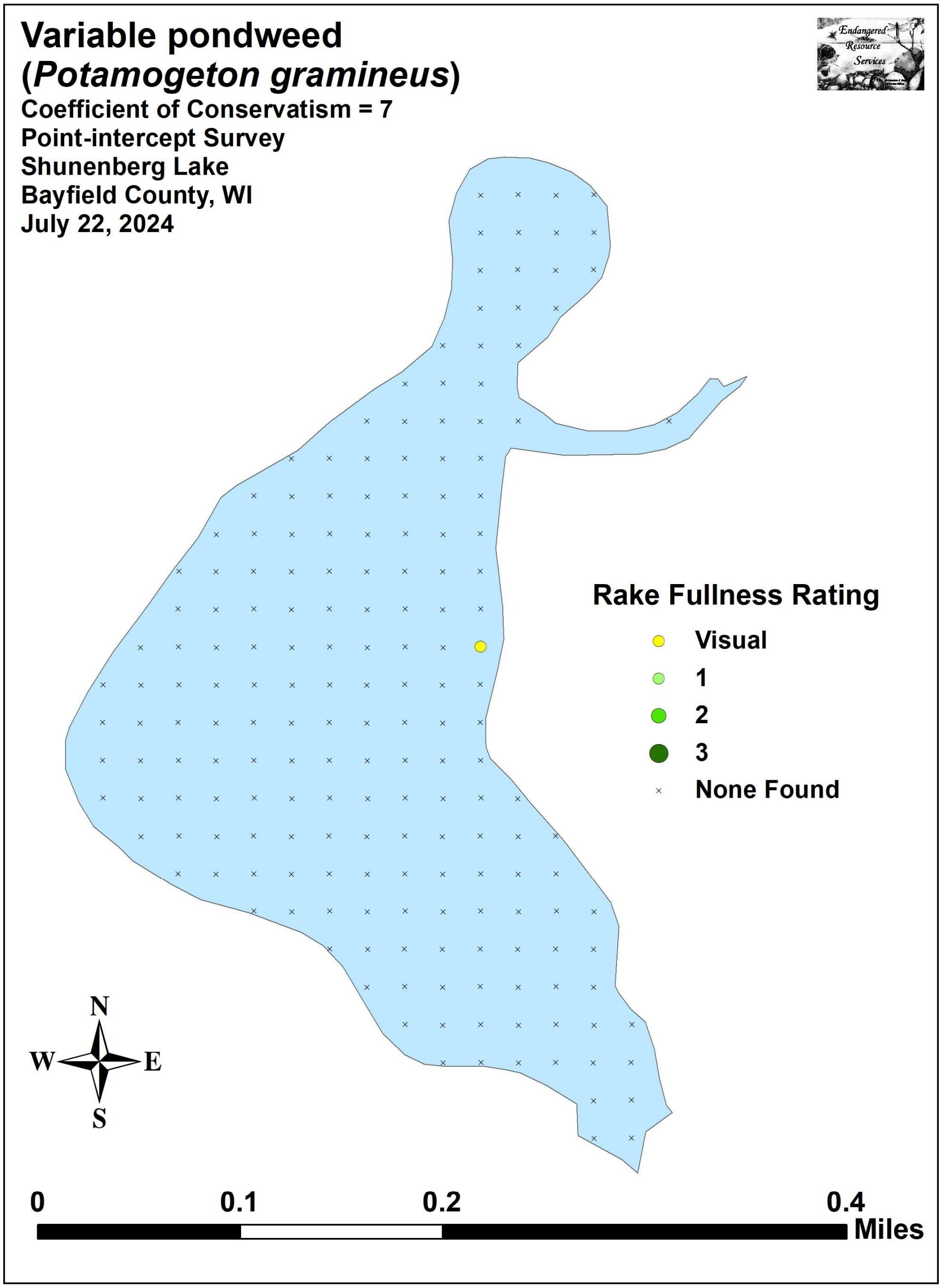
Variable pondweed
(*Potamogeton gramineus*)
Coefficient of Conservatism = 7
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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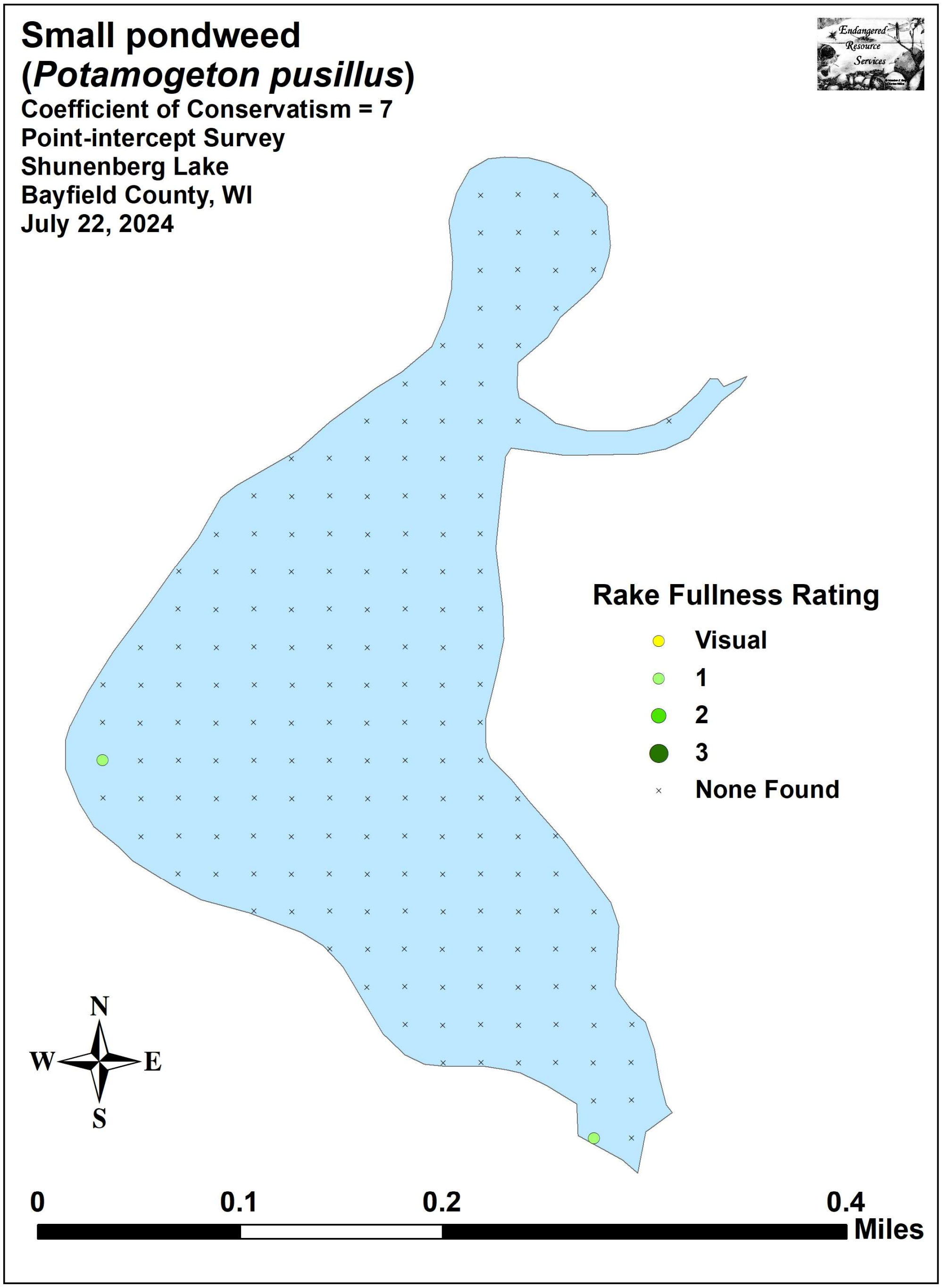
Miles


Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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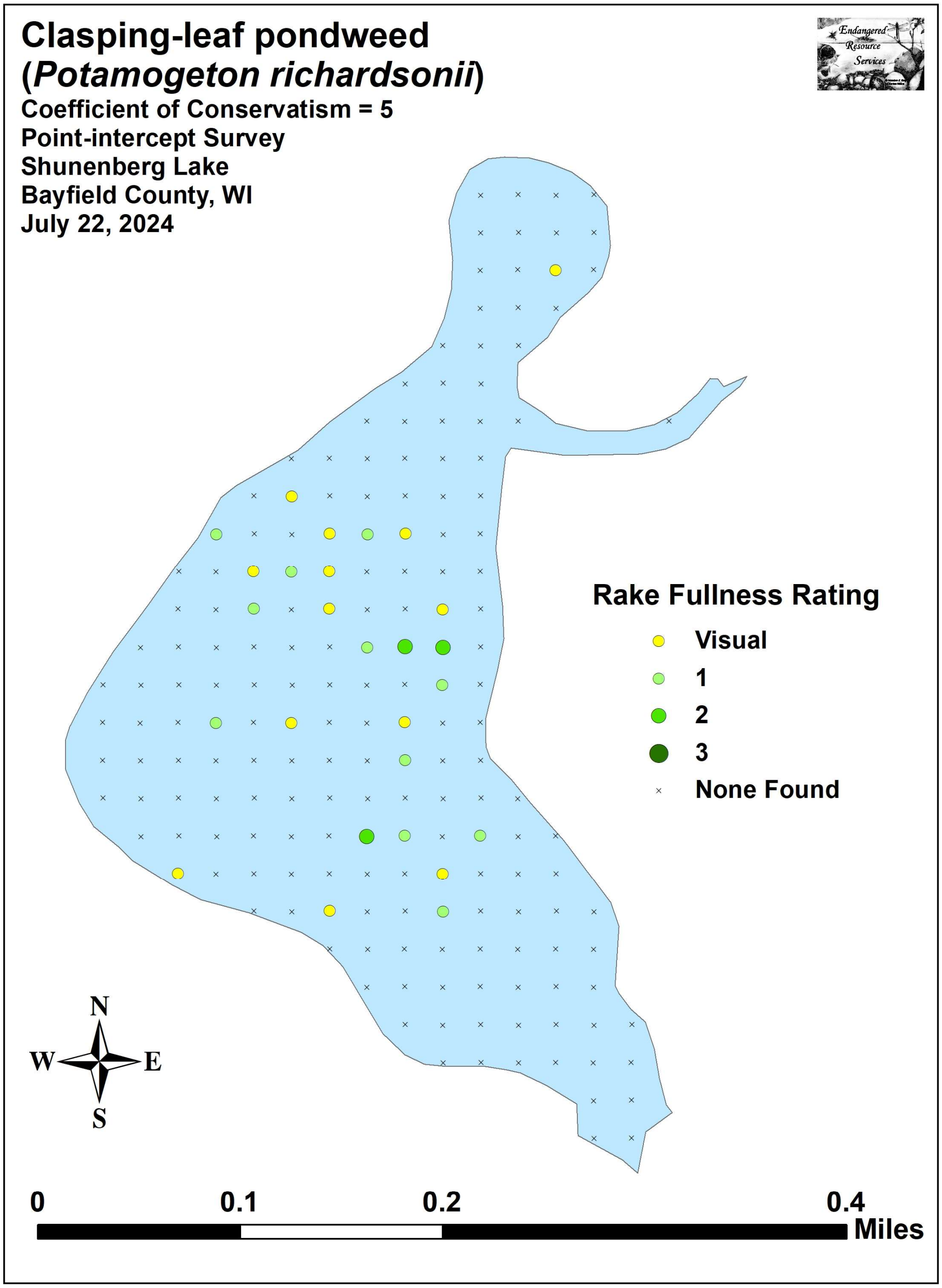
Clasping-leaf pondweed
(*Potamogeton richardsonii*)
Coefficient of Conservatism = 5
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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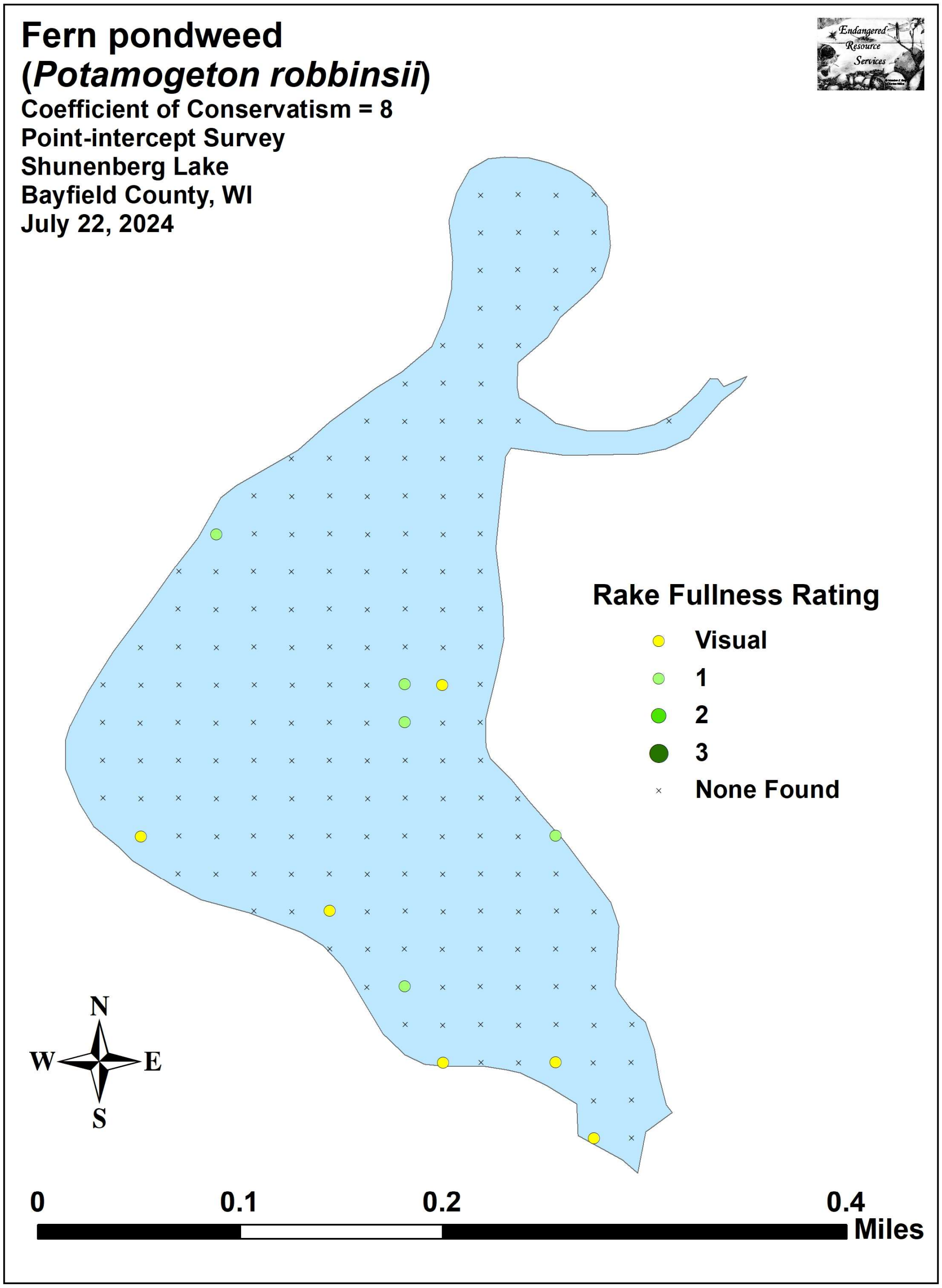
Fern pondweed
(*Potamogeton robbinsii*)
Coefficient of Conservatism = 8
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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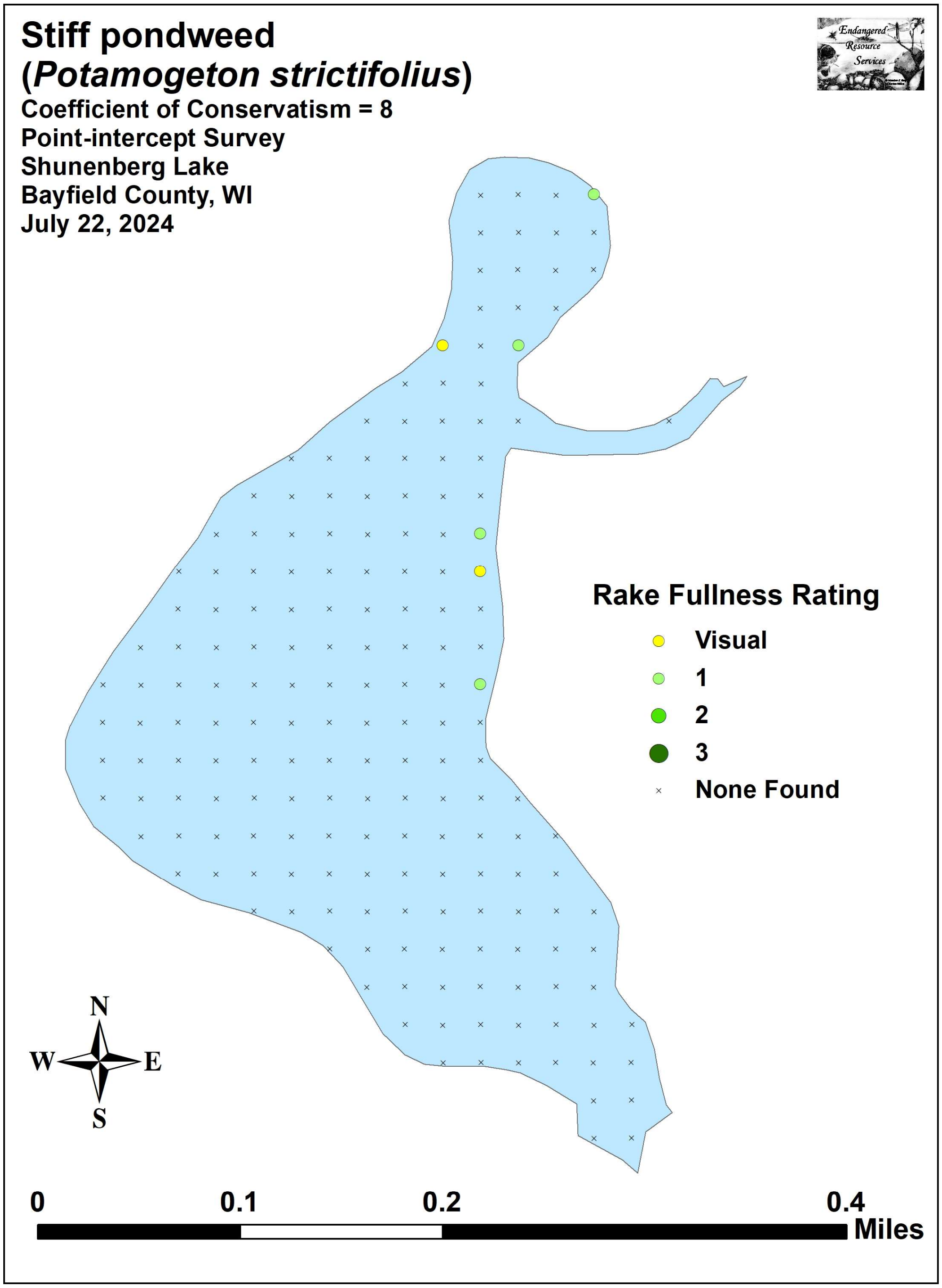

Stiff pondweed
(*Potamogeton strictifolius*)
Coefficient of Conservatism = 8
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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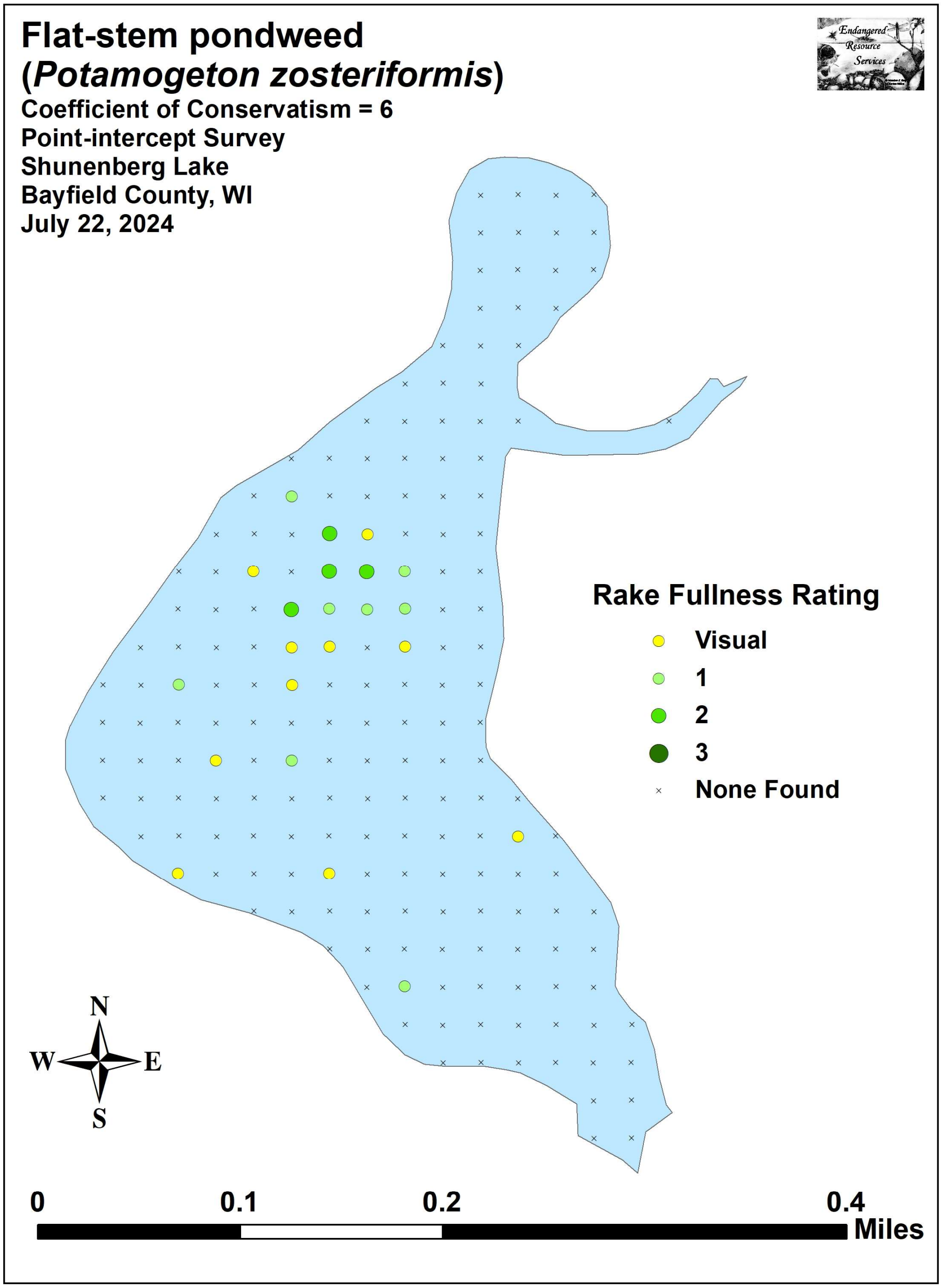
Miles


Flat-stem pondweed
(*Potamogeton zosteriformis*)
Coefficient of Conservatism = 6
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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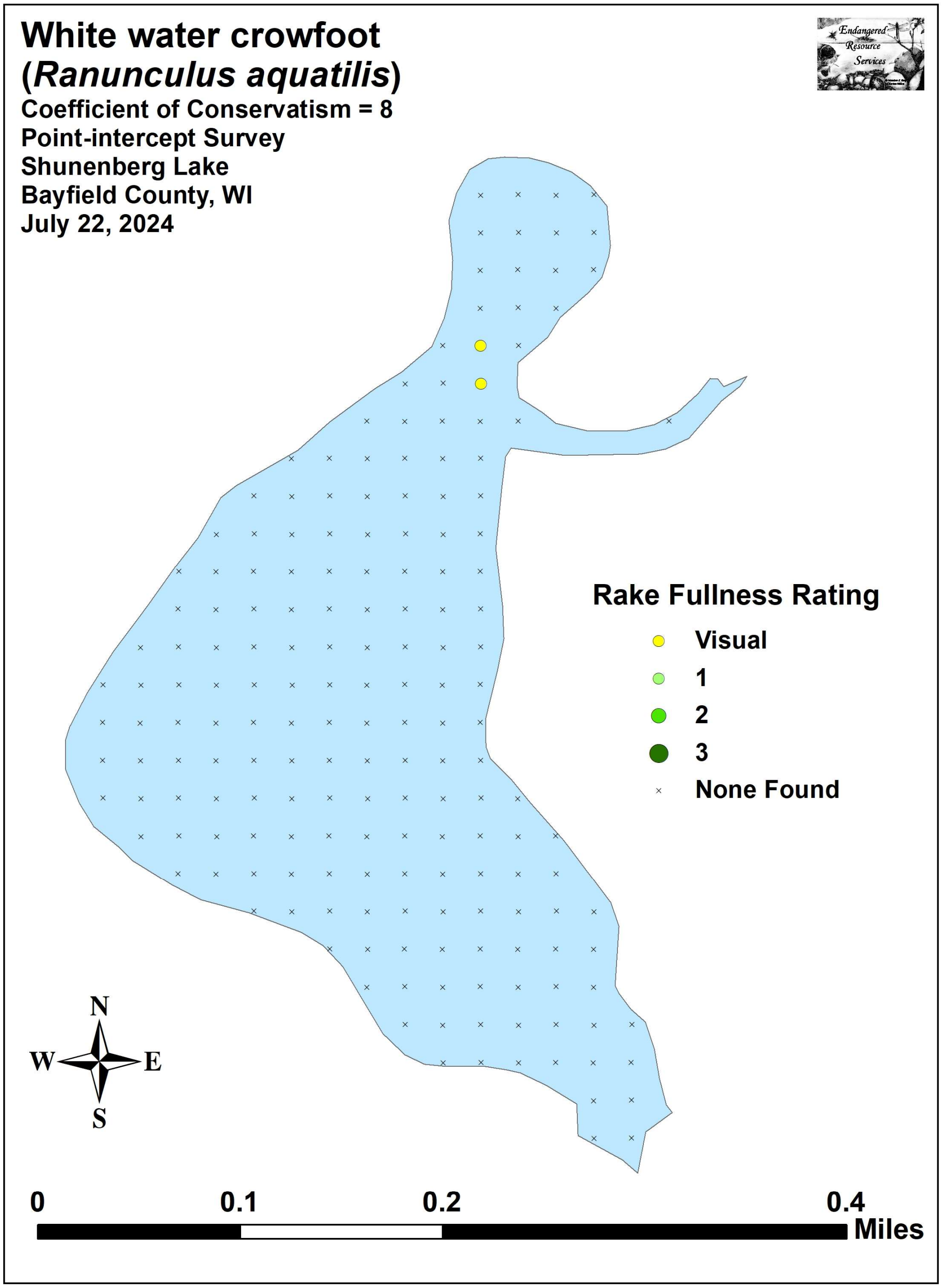
White water crowfoot
(*Ranunculus aquatilis*)
Coefficient of Conservatism = 8
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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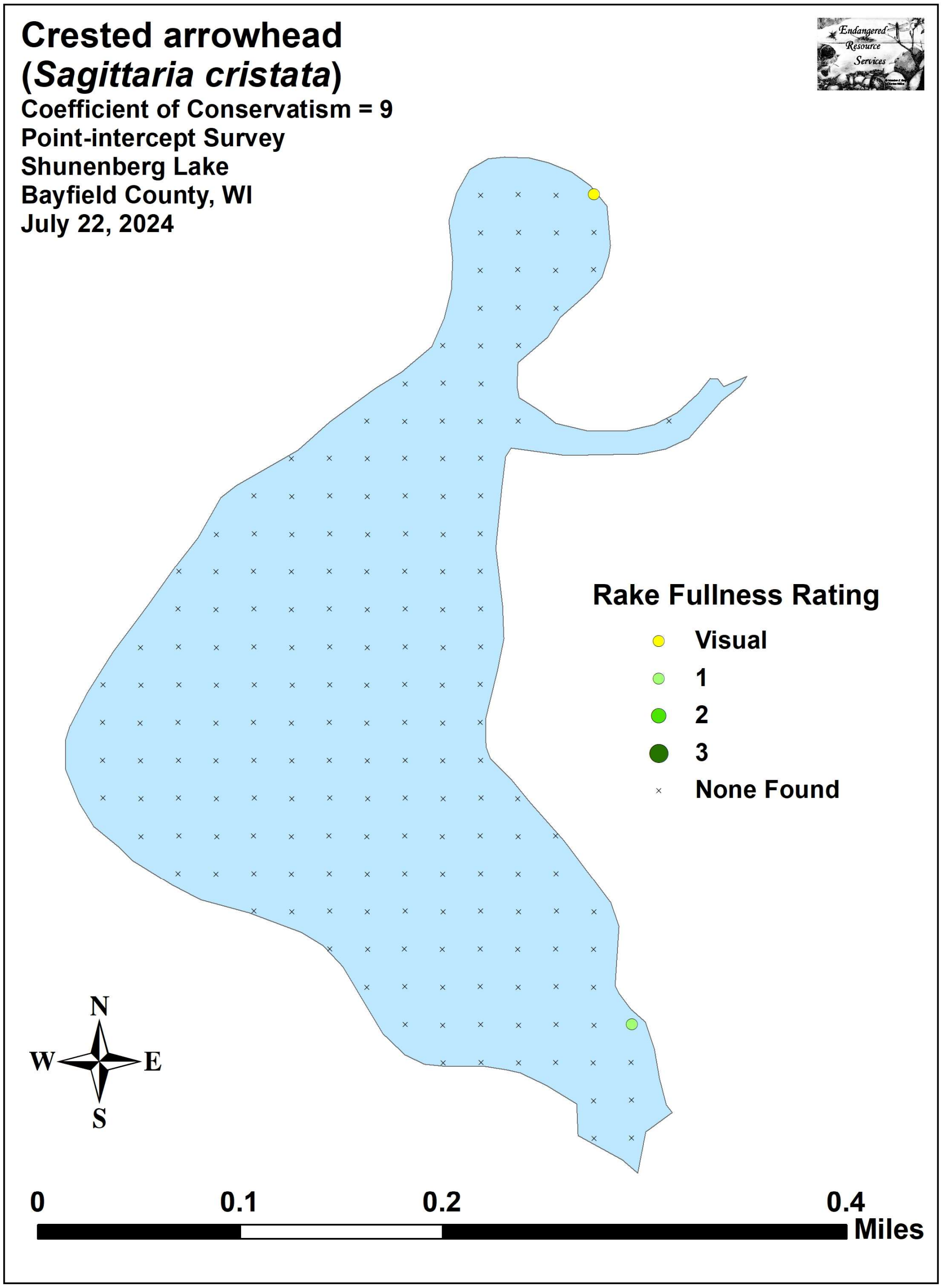

Crested arrowhead
(*Sagittaria cristata*)
Coefficient of Conservatism = 9
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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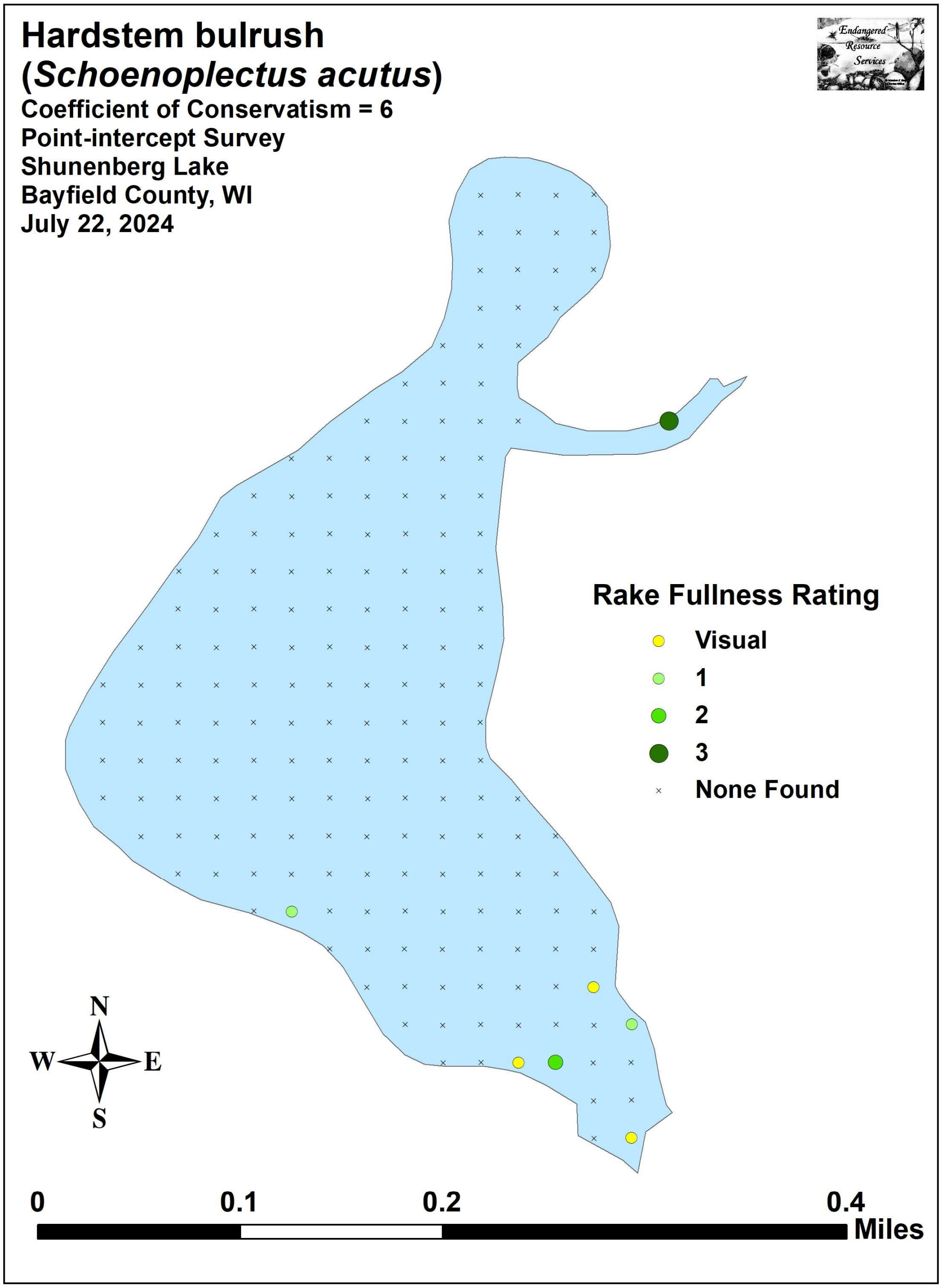
Hardstem bulrush
(Schoenoplectus acutus)
Coefficient of Conservatism = 6
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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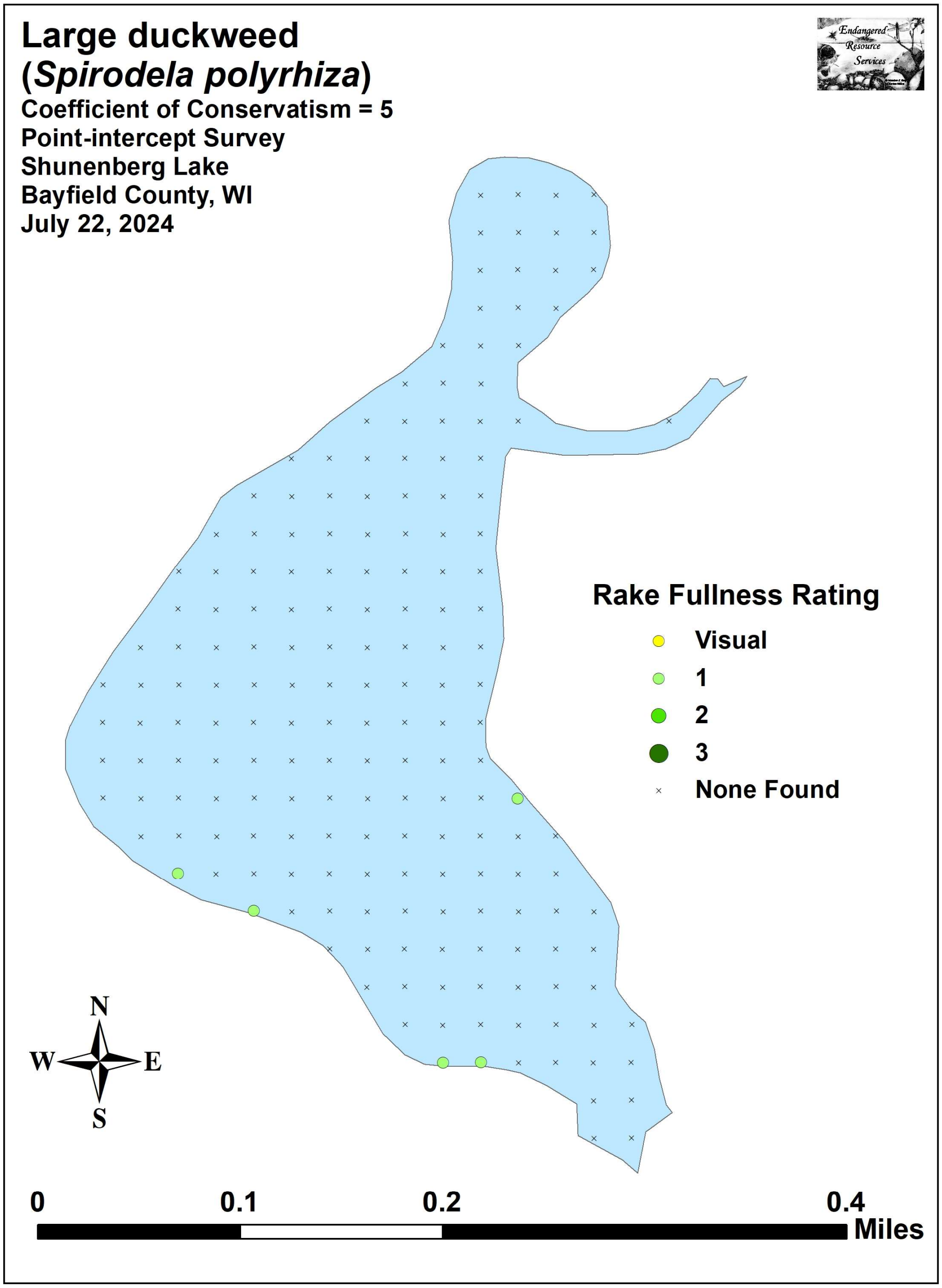
Miles


Large duckweed
(Spirodela polyrhiza)
Coefficient of Conservatism = 5
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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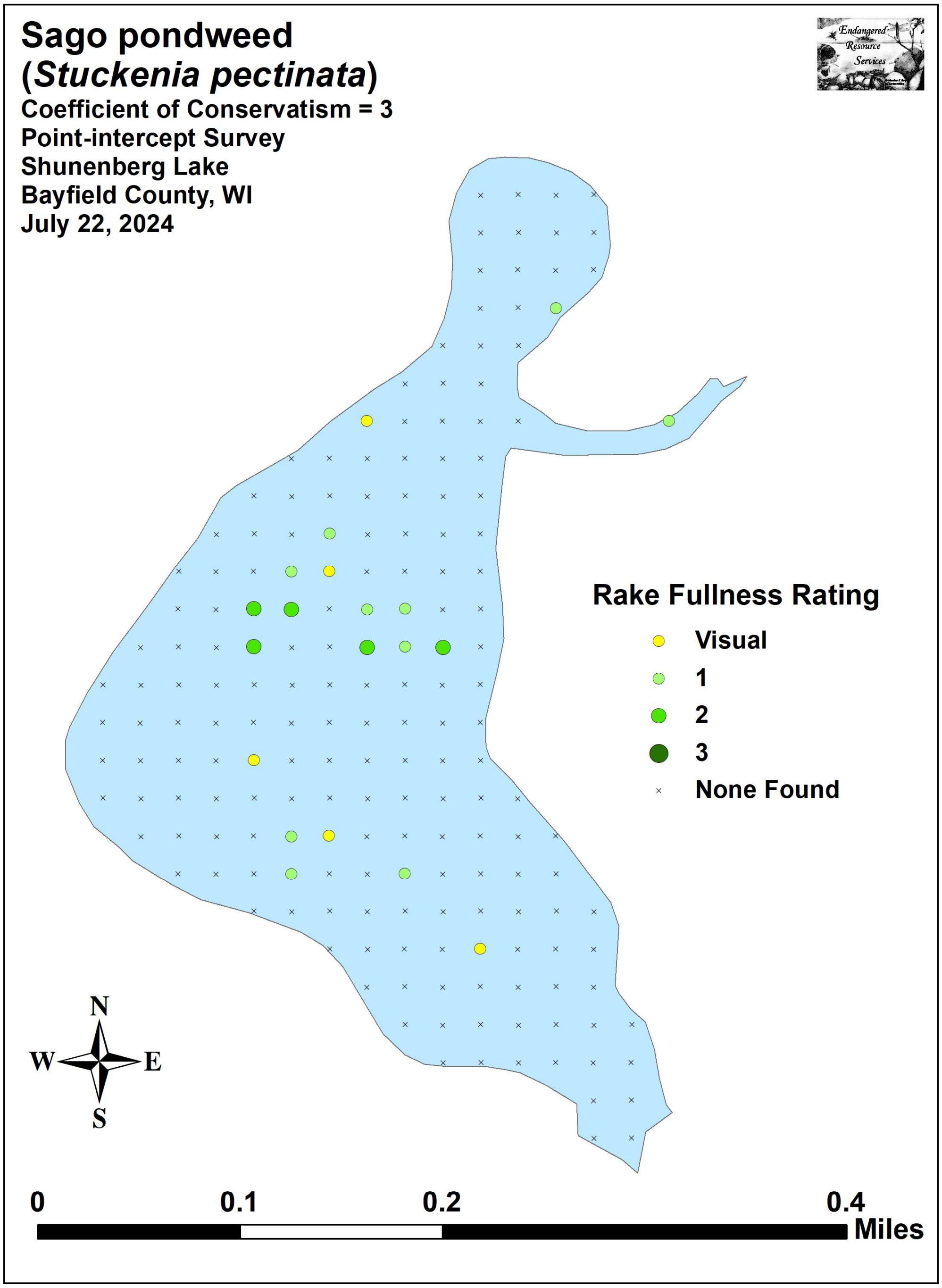

Sago pondweed
(*Stuckenia pectinata*)
Coefficient of Conservatism = 3
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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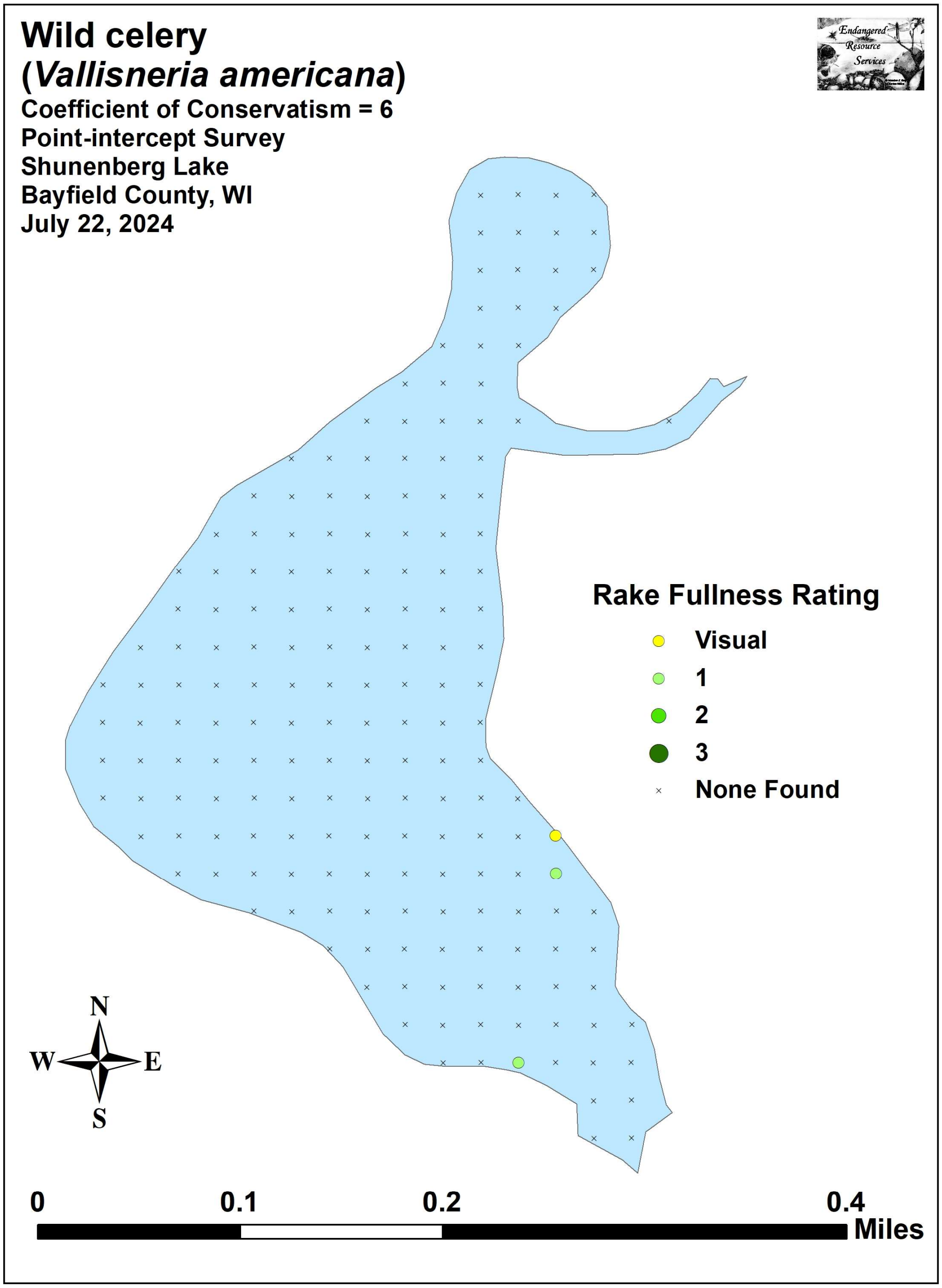
Miles


Wild celery
(Vallisneria americana)
Coefficient of Conservatism = 6
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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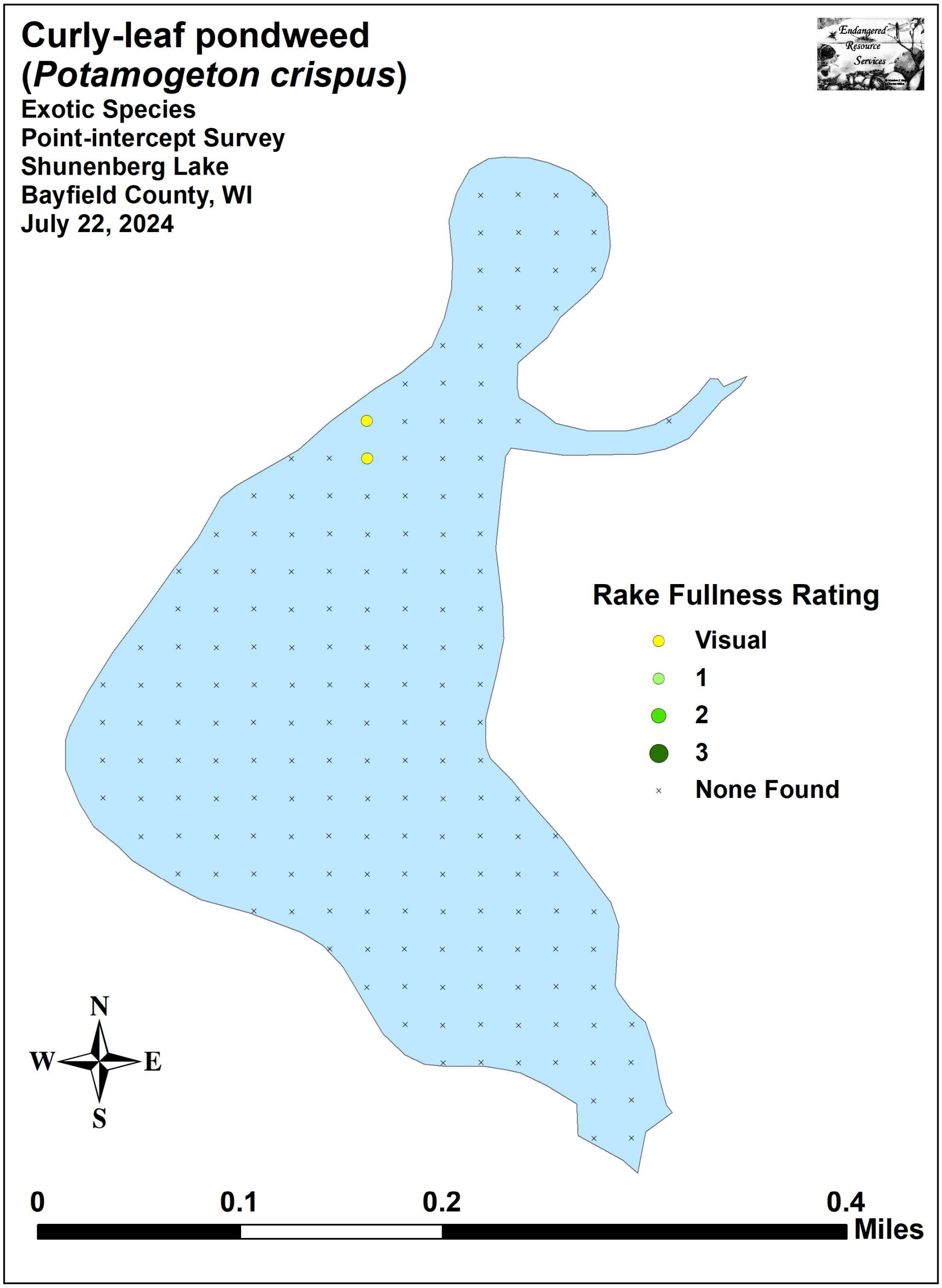
Appendix VII: Exotic Species Distribution Maps and Aquatic Exotic Invasive Plant Species Information


Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Point-intercept Survey
Shunenberg Lake
Bayfield County, WI
July 22, 2024
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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Eurasian Water-milfoil

DESCRIPTION: Eurasian water-milfoil is a submersed aquatic plant native to Europe, Asia, and northern Africa. It is the only non-native milfoil in Wisconsin. Like the native milfoils, the Eurasian variety has slender stems whorled by submersed feathery leaves and tiny flowers produced above the water surface. The flowers are located in the axils of the floral bracts, and are either four-petaled or without petals. The leaves are threadlike, typically uniform in diameter, and aggregated into a submersed terminal spike. The stem thickens below the inflorescence and doubles its width further down, often curving to lie parallel with the water surface. The fruits are four-jointed nut-like bodies. Without flowers or fruits, Eurasian water-milfoil is nearly impossible to distinguish from Northern water-milfoil. Eurasian water-milfoil has 9-21 pairs of leaflets per leaf, while Northern milfoil typically has 7-11 pairs of leaflets. Coontail is often mistaken for the milfoils, but does not have individual leaflets.

DISTRIBUTION AND HABITAT: Eurasian milfoil first arrived in Wisconsin in the 1960's. During the 1980's, it began to move from several counties in southern Wisconsin to lakes and waterways in the northern half of the state. As of 1993, Eurasian water-milfoil was common in 39 Wisconsin counties (54%) and at least 75 of its lakes, including shallow bays in Lakes Michigan and Superior and Mississippi River pools.

Eurasian water-milfoil grows best in fertile, fine-textured, inorganic sediments. In less productive lakes, it is restricted to areas of nutrient-rich sediments. It has a history of becoming dominant in eutrophic, nutrient-rich lakes, although this pattern is not universal. It is an opportunistic species that prefers highly disturbed lake beds, lakes receiving nitrogen and phosphorous-laden runoff, and heavily used lakes. Optimal growth occurs in alkaline systems with a high concentration of dissolved inorganic carbon. High water temperatures promote multiple periods of flowering and fragmentation.

LIFE HISTORY AND EFFECTS OF INVASION: Unlike many other plants, Eurasian water-milfoil does not rely on seed for reproduction. Its seeds germinate poorly under natural conditions. It reproduces vegetatively by fragmentation, allowing it to disperse over long distances. The plant produces fragments after fruiting once or twice during the summer. These shoots may then be carried downstream by water currents or inadvertently picked up by boaters. Milfoil is readily dispersed by boats, motors, trailers, bilges, live wells, or bait buckets, and can stay alive for weeks if kept moist.

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, Eurasian water-milfoil is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of Eurasian water-milfoil provide only a single habitat, and threaten the integrity of aquatic communities in a number of ways; for example, dense stands disrupt predator-prey relationships by fencing out larger fish, and reducing the number of nutrient-rich native plants available for waterfowl.

Dense stands of Eurasian water-milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by Eurasian water-milfoil may lead to deteriorating water quality and algae blooms of infested lakes. (Taken in its entirety from WDNR, 2010 http://www.dnr.state.wi.us/invasives/fact/milfoil.htm)

Curly-leaf pondweed

DESCRIPTION: Curly-leaf pondweed is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. The plant usually drops to the lake bottom by early July.

DISTRIBUTION AND HABITAT: Curly-leaf pondweed is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures. It has been reported in all states but Maine.

LIFE HISTORY AND EFFECTS OF INVASION: Curly-leaf pondweed spreads through burr-like winter buds (turions), which are moved among waterways. These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf pondweed one of the first nuisance aquatic plants to emerge in the spring.

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out compete native plants in the spring. In mid-summer, when most aquatic plants are growing, curly-leaf pondweed plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. Curly-leaf pondweed forms surface mats that interfere with aquatic recreation. (Taken in its entirety from WDNR, 2010 http://www.dnr.state.wi.us/invasives/fact/curlyleaf_pondweed.htm)

Reed canary grass

DESCRIPTION: Reed canary grass is a large, coarse grass that reaches 2 to 9 feet in height. It has an erect, hairless stem with gradually tapering leaf blades 3 1/2 to 10 inches long and 1/4 to 3/4 inch in width. Blades are flat and have a rough texture on both surfaces. The lead ligule is membranous and long. The compact panicles are erect or slightly spreading (depending on the plant's reproductive stage), and range from 3 to 16 inches long with branches 2 to 12 inches in length. Single flowers occur in dense clusters in May to mid-June. They are green to purple at first and change to beige over time. This grass is one of the first to sprout in spring, and forms a thick rhizome system that dominates the subsurface soil. Seeds are shiny brown in color.

Both Eurasian and native ecotypes of reed canary grass are thought to exist in the U.S. The Eurasian variety is considered more aggressive, but no reliable method exists to tell the ecotypes apart. It is believed that the vast majority of our reed canary grass is derived from the Eurasian ecotype. Agricultural cultivars of the grass are widely planted.

Reed canary grass also resembles non-native orchard grass (*Dactylis glomerata*), but can be distinguished by its wider blades, narrower, more pointed inflorescence, and the lack of hairs on glumes and lemmas (the spikelet scales). Additionally, blue-joint grass (*Calamagrostis canadensis*) may be mistaken for reed canary in areas where orchard grass is rare, especially in the spring. The highly transparent ligule on reed canary grass is helpful in distinguishing it from the others. Ensure positive identification before attempting control.

DISTRIBUTION AND HABITAT: Reed canary grass is a cool-season, sod-forming, perennial wetland grass native to temperate regions of Europe, Asia, and North America. The Eurasian ecotype has been selected for its vigor and has been planted throughout the U.S. since the 1800's for forage and erosion control. It has become naturalized in much of the northern half of the U.S., and is still being planted on steep slopes and banks of ponds and created wetlands.

Reed canary grass can grow on dry soils in upland habitats and in the partial shade of oak woodlands, but does best on fertile, moist organic soils in full sun. This species can invade most types of wetlands, including marshes, wet prairies, sedge meadows, fens, stream banks, and seasonally wet areas; it also grows in disturbed areas such as berms and spoil piles.

LIFE HISTORY AND EFFECTS OF INVASION: Reed canary grass reproduces by seed or creeping rhizomes. It spreads aggressively. The plant produces leaves and flower stalks for 5 to 7 weeks after germination in early spring, then spreads laterally. Growth peaks in mid-June and declines in mid-August. A second growth spurt occurs in the fall. The shoots collapse in mid to late summer, forming a dense, impenetrable mat of stems and leaves. The seeds ripen in late June and shatter when ripe. Seeds may be dispersed from one wetland to another by waterways, animals, humans, or machines.

This species prefers disturbed areas, but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in less than twelve years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, deforestation of swamp forests, sedimentation, and intentional planting. The difficulty of selective control makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites. (Taken in its entirety from WDNR, 2010 http://www.dnr.state.wi.us/invasives/fact/reed_canary.htm)

Purple loosestrife
(Photo Courtesy Brian M. Collins)

DESCRIPTION: Purple loosestrife is a perennial herb 3-7 feet tall with a dense bushy growth of 1-50 stems. The stems, which range from green to purple, die back each year. Showy flowers vary from purple to magenta, possess 5-6 petals aggregated into numerous long spikes, and bloom from August to September. Leaves are opposite, nearly linear, and attached to four-sided stems without stalks. It has a large, woody taproot with fibrous rhizomes that form a dense mat.

This species may be confused with the native wing-angled loosestrife (*Lythrum alatum*) found in moist prairies or wet meadows. The latter has a winged, square stem and solitary paired flowers in the leaf axils. It is generally a smaller plant than the Eurasian loosestrife.

By law, purple loosestrife is a nuisance species in Wisconsin. It is illegal to sell, distribute, or cultivate the plants or seeds, including any of its cultivars.

DISTRIBUTION AND HABITAT: Purple loosestrife is a wetland herb that was introduced as a garden perennial from Europe during the 1800's. It is still promoted by some horticulturists for its beauty as a landscape plant, and by beekeepers for its nectar-producing capability. Currently, about 24 states have laws prohibiting its importation or distribution because of its aggressively invasive characteristics. It has since extended its range to include most temperate parts of the United States and Canada. The plant's reproductive success across North America can be attributed to its wide tolerance of physical and chemical conditions characteristic of disturbed habitats, and its ability to reproduce prolifically by both seed dispersal and vegetative propagation. The absence of natural predators, like European species of herbivorous beetles that feed on the plant's roots and leaves, also contributes to its proliferation in North America

LIFE HISTORY AND EFFECTS OF INVASION: Purple loosestrife can germinate successfully on substrates with a wide range of pH. Optimum substrates for growth are moist soils of neutral to slightly acidic pH, but it can exist in a wide range of soil types. Most seedling establishment occurs in late spring and early summer when temperatures are high.

Purple loosestrife spreads mainly by seed, but it can also spread vegetatively from root or stem segments. A single stalk can produce from 100,000 to 300,000 seeds per year. Seed survival is up to 60-70%, resulting in an extensive seed bank. Mature plants with up to 50 shoots grow over 2 meters high and produce more than two million seeds a year. Germination is restricted to open, wet soils and requires high temperatures, but seeds remain viable in the soil for many years. Even seeds submerged in water can live for approximately 20 months. Most of the seeds fall near the parent plant, but water, animals, boats, and humans can transport the seeds long distances. Vegetative spread through local perturbation is also characteristic of loosestrife; clipped, trampled, or buried stems of established plants may produce shoots and roots. Plants may be quite large and several years old before they begin flowering. It is often very difficult to locate non-flowering plants, so monitoring for new invasions should be done at the beginning of the flowering period in mid-summer.

Any sunny or partly shaded wetland is susceptible to purple loosestrife invasion. Vegetative disturbances such as water drawdown or exposed soil accelerate the process by providing ideal conditions for seed germination. Invasion usually begins with a few pioneering plants that build up a large seed bank in the soil for several years. When the right disturbance occurs, loosestrife can spread rapidly, eventually taking over the entire wetland. The plant can also make morphological adjustments to accommodate changes in the immediate environment; for example, a decrease in light level will trigger a change in leaf morphology. The plant's ability to adjust to a wide range of environmental conditions gives it a competitive advantage; coupled with its reproductive strategy, purple loosestrife tends to create monotypic stands that reduce biotic diversity.

Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways. (Taken in its entirety from WDNR, 2010 http://www.dnr.state.wi.us/invasives/fact/loosestrife.htm)

Appendix VIII: Glossary of Biological Terms
(Adapted from UWEX 2010)

Aquatic:
organisms that live in or frequent water.

Cultural Eutrophication:
accelerated eutrophication that occurs as a result of human activities in the watershed that increase nutrient loads in runoff water that drains into lakes.

Dissolved Oxygen (DO):
the amount of free oxygen absorbed by the water and available to aquatic organisms for respiration; amount of oxygen dissolved in a certain amount of water at a particular temperature and pressure, often expressed as a concentration in parts of oxygen per million parts of water.

Diversity:
number and evenness of species in a particular community or habitat.

Drainage lakes:
Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems but generally have shorter residence times than seepage lakes. Watershed protection is usually needed to manage lake water quality.

Ecosystem:
a system formed by the interaction of a community of organisms with each other and with the chemical and physical factors making up their environment.

Eutrophication:
the process by which lakes and streams are enriched by nutrients, and the resulting increase in plant and algae growth. This process includes physical, chemical, and biological changes that take place after a lake receives inputs for plant nutrients--mostly nitrates and phosphates--from natural erosion and runoff from the surrounding land basin. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

Exotic:
a non-native species of plant or animal that has been introduced.

Habitat:
the place where an organism lives that provides an organism's needs for water, food, and shelter. It includes all living and non-living components with which the organism interacts.

Limnology:
the study of inland lakes and waters.

Littoral:

the near shore shallow water zone of a lake, where aquatic plants grow.

Macrophytes:

Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

Nutrients:

elements or substances such as nitrogen and phosphorus that are necessary for plant growth. Large amounts of these substances can become a nuisance by promoting excessive aquatic plant growth.

Organic Matter:

elements or material containing carbon, a basic component of all living matter.

Photosynthesis:

the process by which green plants convert carbon dioxide (CO2) dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base, and is an important source of oxygen for many lakes.

Phytoplankton:

microscopic plants found in the water. Algae or one-celled (phytoplankton) or multicellular plants either suspended in water (Plankton) or attached to rocks and other substrates (periphyton). Their abundance, as measured by the amount of chlorophyll a (green pigment) in an open water sample, is commonly used to classify the trophic status of a lake. Numerous species occur. Algae are an essential part of the lake ecosystem and provides the food base for most lake organisms, including fish. Phytoplankton populations vary widely from day to day, as life cycles are short.

Plankton:

small plant organisms (phytoplankton and nanoplankton) and animal organisms (zooplankton) that float or swim weakly though the water.

ppm:

parts per million; units per equivalent million units; equal to milligrams per liter (mg/l)

Richness:
number of species in a particular community or habitat.

Rooted Aquatic Plants:
(macrophytes) Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

Runoff:
water that flows over the surface of the land because the ground surface is impermeable or unable to absorb the water.

Secchi Disc:
An 8-inch diameter plate with alternating quadrants painted black and white that is used to measure water clarity (light penetration). The disc is lowered into water until it disappears from view. It is then raised until just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. For best results, the readings should be taken on sunny, calm days.

Seepage lakes:
Lakes without a significant inlet or outlet, fed by rainfall and groundwater. Seepage lakes lose water through evaporation and groundwater moving on a down gradient. Lakes with little groundwater inflow tend to be naturally acidic and most susceptible to the effects of acid rain. Seepage lakes often have long, residence times. and lake levels fluctuate with local groundwater levels. Water quality is affected by groundwater quality and the use of land on the shoreline.

Turbidity:
degree to which light is blocked because water is muddy or cloudy.

Watershed:
the land area draining into a specific stream, river, lake or other body of water. These areas are divided by ridges of high land.

Zooplankton:
Microscopic or barely visible animals that eat algae. These suspended plankton are an important component of the lake food chain and ecosystem. For many fish, they are the primary source of food.

Appendix IX: Raw Data Spreadsheets

ShunenbergLakeBayfieldCoWBIC2743600CLPPISurvey614,2024MBergERSLLC.xlsx

ShunenbergLakeBayfieldCoWBIC2743600PISurvey722,2024MBergERSLLC.xlsx