Curly-leaf pondweed (*Potamogeton crispus*) Point-intercept and Bed Mapping Surveys, and Warm-water Point-intercept Macrophyte Survey Middle Eau Claire Lake – WBIC: 2742100 Bayfield County, Wisconsin



Bird's nest stonewort – a rare Charophyte and Arrow arum in Hole-in-the-Wall Bay 7/29/21 Middle Eau Claire Lake Aerial Photo

Project Initiated by:

The Town of Barnes – Aquatic Invasive Species Committee and the Wisconsin Department of Natural Resources (Grant ACEI24521)

Water smartweed in bloom near the southeast public landing 7/29/21

Surveys Conducted by and Report Prepared by:

Endangered Resource Services, LLC
Matthew S. Berg, Research Biologist
St. Croix Falls, Wisconsin
June 18-19 and July 29-30, 2021

TABLE OF CONTENTS

ABSTRACT

Middle Eau Claire Lake (WBIC 2742100) is an 880-acre meso/oligotrophic stratified drainage lake located in southwestern Bayfield County, Wisconsin. Following the discovery of Curly-leaf pondweed (*Potamogeton crispus*) (CLP) on both Upper and Middle Eau Claire Lakes in 2012, the Town of Barnes Aquatic Invasive Species Committee (TOB) and the Eau Claire Lakes Area Property Owners Association used a Wisconsin Department of Natural Resources (WDNR) rapid response grant to fund three plant surveys on each lake in 2013. Data from these surveys were used to develop an Aquatic Plant Management Plan that outlined manual removal and suction harvesting to control the lakes' relatively small CLP infestations. To compare how Middle Eau Claire Lake's vegetation had changed since the last point-intercept surveys, in 2021, the TOB and WDNR authorized CLP density and bed mapping surveys on June 18-19th, and a full point-intercept survey for all aquatic macrophytes on July 29-30th. The 2021 cold-water survey found CLP at 15 points (1.9% total lake coverage) with a mean rake fullness of 1.27. This was a highly significant increase **(p<0.001)** in total CLP coverage, mean density, and rake fullness 1; and a significant increase in rake fullness 2 **(p<0.05)** when compared to 2013 when we didn't find CLP in the rake at any point (single visual sighting near the boat landing). The 2021 survey suggested 0.5% of the lake/0.9% of the spring littoral zone had a significant infestation (four total points with a rake fullness of 2 or 3). In 2021, we mapped 17 CLP beds totaling 0.58 acre (0.07% coverage). This was a +729% increase from the most recent survey in 2020 when we found 12 beds on 0.07 acre. In 2013, we mapped 14 beds totaling 0.11 acre (0.01% coverage). During the July 2021 full point-intercept survey, we found macrophytes growing at 391 sites (49.4% of the bottom and 88.7% of the 19.5ft littoral zone). This was a non-significant increase (p=0.69) from 2013 when plants were present at 359 sites (45.4% of the entire lake bottom and in 82.9% of the then 19.0ft littoral zone). Overall diversity was exceptionally high with a Simpson Diversity Index value of 0.93 – up slightly from 0.92 in 2013. Total richness was also high with 64 species found growing in and immediately adjacent to the water – up from 56 in 2013. There was an average of 3.75 native species/site with native vegetation – a highly significant increase **(p<0.001)** from 2.96 native species/site in 2013. Mean total rake fullness was a moderately high 2.22 – a highly significant increase **(p<0.001)** from a moderate 1.79 in 2013. Our 2013 survey identified Slender naiad (*Najas flexilis*), Coontail (*Ceratophyllum demersum*), Flat-stem pondweed (*Potamogeton zosteriformis*), and Small pondweed (*Potamogeton pusillus*) as the most common species. Present at 46.80%, 31.75%, 30.64%, and 28.13% of survey points with vegetation, they accounted for 46.42% of the total relative frequency. In 2021, we found Coontail (38.36% of points with vegetation), Northern water-milfoil (*Myriophyllum sibiricum*)

(38.36%), Small pondweed (38.11%), and Common waterweed (*Elodea canadensis*) (32.23%) were the most common species with a combined relative frequency of 39.14%. From 2013 to 2021, sixteen species experienced significant changes in distribution. Slender naiad suffered a highly significant decline **(p<0.001)** and Leafy pondweed (*Potamogeton foliosus*) underwent a significant decline **(p=0.01)**. Conversely, Small pondweed, Northern water-milfoil, Fern pondweed (*Potamogeton robbinsii*), Clasping-leaf pondweed (*Potamogeton richardsonii*), filamentous algae, Variable pondweed (*Potamogeton gramineus*), Large-leaf pondweed (*Potamogeton amplifolius*), Wild celery (*Vallisneria americana*), Forked duckweed (*Lemna trisulca*), and White water crowfoot (*Ranunculus aquatilis*) enjoyed highly significant increases **(p<0.001)**; Common waterweed showed a moderately significant increase **(p=0.001)**; and Coontail **(p=0.02)**, Fries' pondweed (*Potamogeton friesii*) **(p=0.03)**, and Bird's nest stonewort (*Tolypella intricata*) **(p<0.05)** saw significant increases. The 43 native index species found in the rake during the July 2021 survey (up from 42 in 2013) produced a slightly above average mean Coefficient of Conservatism of 6.8 (identical to 2013), and a Floristic Quality Index of 44.8 (up from 43.8 in 2013) that was nearly double the median FQI for this part of the state. Filamentous algae were present at 96 points with a mean rake fullness of 1.51 – a highly significant increase **(p<0.001)** in distribution, but a non-significant increase (p=0.22) in density when compared to 2013 survey that found these algae at 21 points with a mean rake fullness of 1.42. By July 2021, CLP had almost completely senesced, but we still found it at two points – both with a rake fullness of 1. This was similar to 2013 when we recorded CLP as a visual at a single point during the July survey. **We saw no evidence of EWM during any of our surveys.** In addition to CLP, we found five other exotic species. A few clusters of Horseradish (*Armoracia rusticana*) were located on the immediate shoreline southwest of the Crosswinds Resort and Campground; Common forget-me-not (*Myosotis scorpioides*) and Reed canary grass (*Phalaris arundinacea*) were scattered in disturbed shoreline areas at the public boat landing in the lake's southeast bay; and Arrow arum (*Peltandra virginicum*) and Hybrid cattail (*Typha* X *glauca*) were growing in shallow water along the shoreline in Hole-in-the-Wall Bay on the lake's southwest side. Future management considerations include preserving the lake's native plants and the important habitat they provide for the entire lake ecosystem including its excellent fishery; continuing to harvest CLP using manual removal and suction harvesting as is likely the most environmentally friendly method of managing the current infestation; working to prevent the spread of CLP by refraining from removing native plants which can expose the substrate making it easy for CLP to establish and spread; removing the Horseradish and Arrow arum plants and monitoring for them in the future; and continuing the established Clean Boats/Clean Waters landing monitoring program.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION:

Middle Eau Claire Lake (WBIC 2742100) is an 880-acre stratified drainage lake located in southwestern Bayfield County, Wisconsin in the Town of Barnes (T44N R9W S7-9 and 16-21). It reaches a maximum depth of 66ft in the hole north/northwest of the Eau Claire River Inlet and has an average depth of approximately 17ft (Figure 1). The lake is mesotrophic bordering on oligotrophic in nature with mean summer Secchi readings from 1987-2021 ranging from 12-21ft and averaging 17.7ft (WDNR 2021). This very good clarity produced a littoral zone that reached 19.5ft in 2021. The bottom is predominately sand and gravel along the shoreline and around the many sunken islands, while muck dominates the deeper basins and bays (Hopke et al. 1964).

Figure 1: Middle Eau Claire Lake Aerial Photo

BACKGROUND AND STUDY RATIONALE:

In 2005, concern over the spread of Eurasian water-milfoil (*Myriophyllum spicatum*) (EWM) into nearby Tomahawk and Sand Bar Lakes prompted members of the Town of Barnes Aquatic Invasive Species Committee (then the Eurasian water-milfoil Committee) and the Eau Claire Lakes Area Property Owners Association (ECLAPOA) to authorize an initial point-intercept survey to look for exotic plant species in the lakes. This survey did not find EWM, Curly-leaf pondweed (*Potamogeton crispus*) (CLP), or any other exotic species in either Upper or Middle Eau Claire Lakes (Kudlas et al. – pers. comm.).

Along with the original 2005 point-intercept survey, the TOB/ECLAPOA initiated a Clean Boats/Clean Waters monitoring program at the lakes' landings, and trained volunteers as shoreline spotters to look for exotic invasive species. These spotters ultimately discovered CLP in Pease Bay on Upper Eau Claire Lake and in the south bays of Middle Eau Claire Lake during the summer of 2012. In an effort to determine how to deal with the newly found infestation, the TOB applied for and received a rapid response grant that authorized three plant surveys on each lake in 2013: May CLP point-intercept surveys, June CLP bed mapping surveys with a SCUBA habitat assessment, and late July warm-water point-intercept macrophyte surveys.

As these surveys found only small amounts of CLP that were generally minor components within expansive beds of beneficial habitat-forming native vegetation, it was decided to limit control of CLP to manual removal by volunteers. However, when a follow-up CLP bed mapping survey in 2015 found expanding numbers of small beds on both lakes, it was determined that suction harvesting using the "Barnes Aquatic Invasive Species Sucker" or BAISS would be employed to increase capacity. Following efforts to this end from 2015-2020, the TOB/ECLAPOA again authorized lakewide surveys in 2021 so they could update their Aquatic Plant Management Plan in 2022. On Middle Eau Claire Lake, we conducted early-season point-intercept and CLP bed mapping surveys on June 18-19th. These were followed by a warm-water point intercept survey of all macrophytes on July 29-30th. The surveys' objectives were to document the levels of CLP in the lake, determine if EWM or any other new exotic plants had invaded the lake, and to compare the 2013 and 2021 data to determine if the lake's vegetation had changed significantly over this time. This report is the summary analysis of these three field surveys.

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, Jennifer Hauxwell (WDNR) generated the original 791-point sampling grid for Middle Eau Claire Lake that has been used for each survey since 2005 (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.

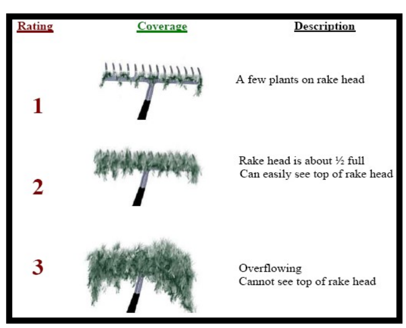


Figure 2: Rake Fullness Ratings (UWEX 2010)

Curly-leaf Pondweed Bed Mapping Survey:

During the bed mapping survey, we searched the lake's visible littoral zone. By definition, a "bed" was determined to be any area where we visually estimated that Curly-leaf pondweed made up >50% of the area's plants, was generally continuous with clearly defined borders, and was canopied, or close enough to being canopied that it would likely interfere with boat traffic. After we located a bed, we motored around the perimeter of the area taking GPS coordinates at regular intervals. We also estimated the rake density range and mean rake fullness of the bed (Figure 2), the range and mean depth of the bed, whether it was canopied, and the impact it was likely to have on navigation (**none** – easily avoidable with a natural channel around or narrow enough to motor through/**minor** – one prop clear to get through or access open water/**moderate** – several prop clears needed to navigate through/**severe** – multiple prop clears and difficult to impossible to row through). These data were then mapped using ArcMap 9.3.1, and we used the WDNR's Forestry Tools Extension to determine the acreage of each bed to the nearest hundredth of an acre (Tables 1 and 2).

Warm Water Full Point-intercept Macrophyte Survey:

Prior to beginning the July point-intercept survey, we conducted a general boat survey of the lake to regain familiarity with the species present (Appendix II). All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2005; Skawinski 2019), and a datasheet was built from the species present.

During the survey, we again located each survey point with a GPS, recorded a depth reading using a metered pole or handheld sonar, 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:

In an effort to visualize the changes on the lake since our last point-intercept survey in 2013, we included summary statistics and maps from the 2013 survey in the 2021 report and linked folders (UWEX 2010) (Appendix II). Using the standard aquatic plant management spreadsheet, we entered all data collected in the field and 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 or kayak.

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. While 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 3).

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 (Tables 4-5).

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. Middle Eau Claire Lake is in the Northern Lakes and Forests Ecoregion (Tables 6-7).

**** 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.**

Comparison to Past Surveys: We compared data from our 2013 and 2021 Curly-leaf pondweed point-intercept surveys (Figure 4), and the 2013 and 2021 warm-water point-intercept surveys (Figure 12) to see if there were any significant changes in the lake's vegetation. For individual plant species as well as count data, we used the Chi-square analysis on the WDNR pre/posttreatment survey worksheet. For comparing averages (mean species/point and mean rake fullness/point), we used t-tests. Differences were considered significant at $p<0.05$, moderately significant at $p<0.01$ and highly significant at $p<0.001$ (UWEX 2010). It should be noted that we used the number of July littoral points (433 in 2013/441 in 2021) as the basis for "sample points" in the statistical calculations.

RESULTS:

Curly-leaf Pondweed Point-intercept Survey:

Following the establishment of the June 2021 littoral zone at approximately 19.5ft of water, we sampled for Curly-leaf pondweed at all points in and adjacent to this zone. CLP was present in the rake at 15 points with three additional visual sightings. This extrapolated to 1.9% of the entire lake and 3.4% of the 441-point littoral zone having at least some CLP present. Of these, none rated a rake fullness value of 3, four were a 2, and the remaining 11 were a 1 for a combined mean rake fullness of 1.27 (Figure 3) (Appendix III). The four points with a rake fullness of a 2 or a 3 suggested 0.5% of the entire lake and 0.9% of the spring littoral zone had a significant infestation.

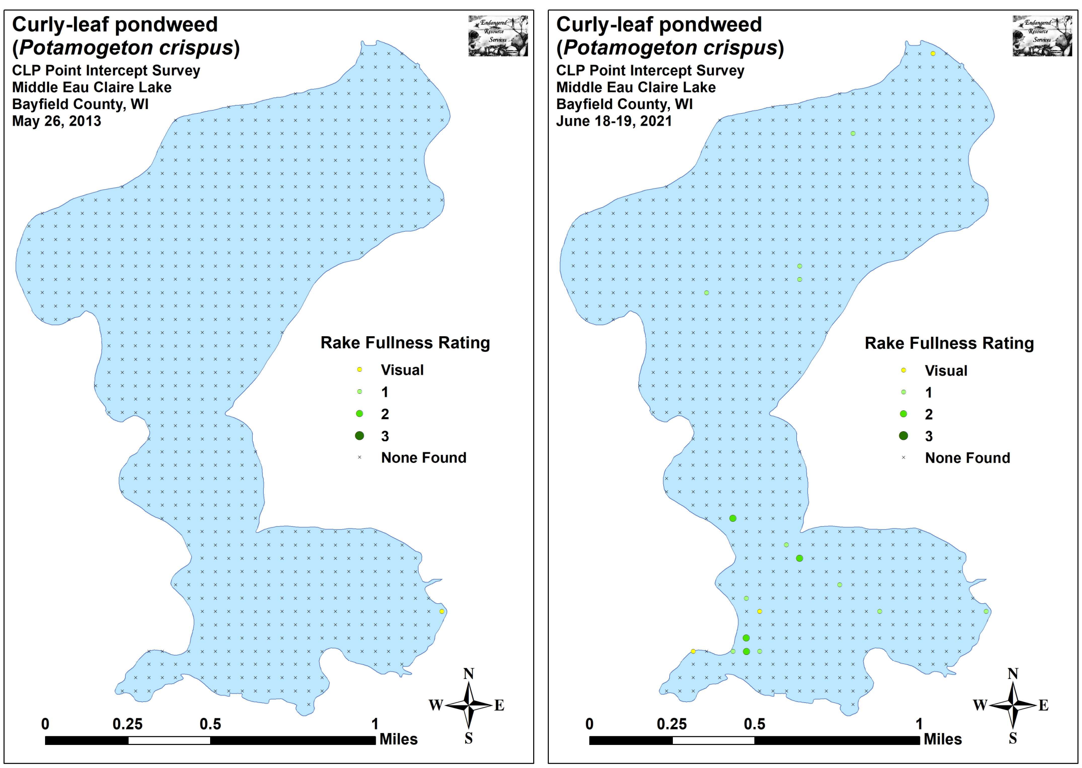
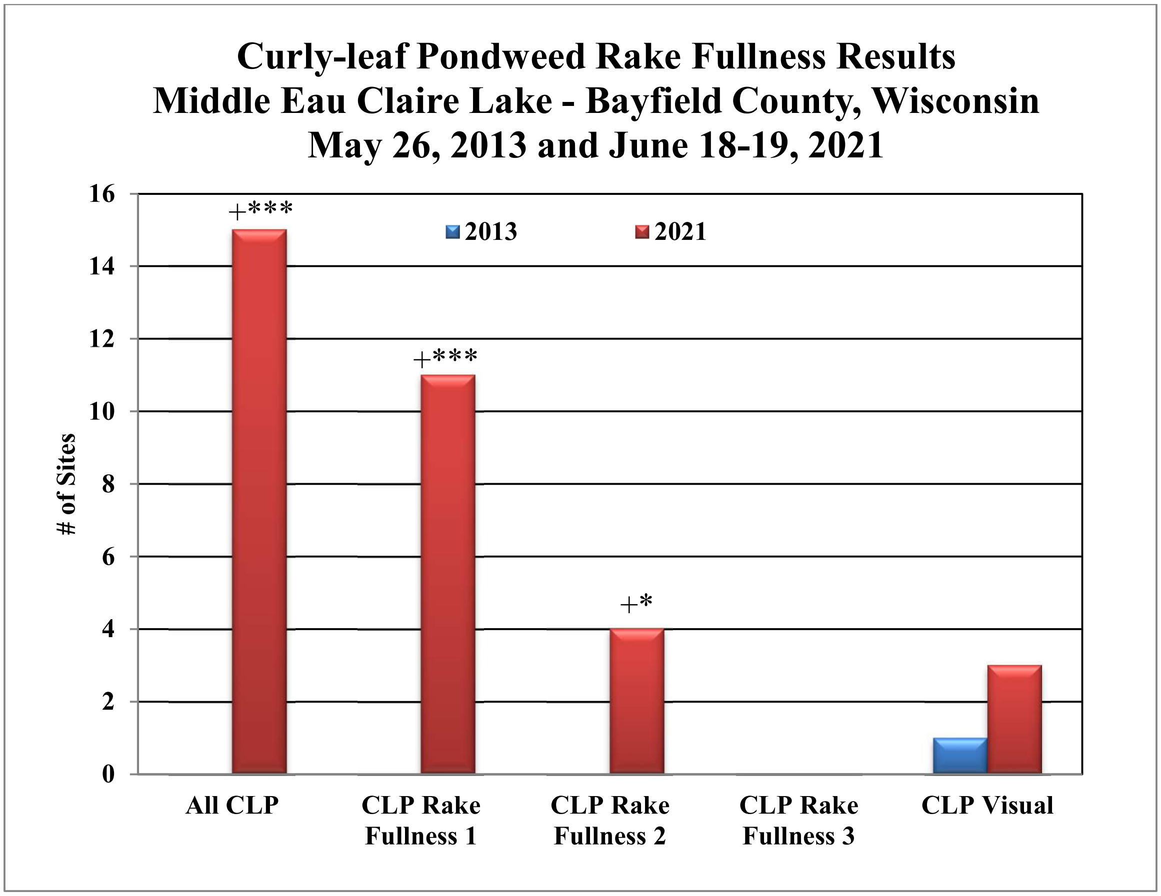


Figure 3: 2013 and 2021 Spring Curly-leaf Pondweed Density and Distribution

Comparison of Curly-leaf Pondweed in 2013 and 2021:

In 2013, we did not find Curly-leaf pondweed in the rake at any location. In fact, the only evidence we saw of CLP anywhere in the lake during the May survey was at the point nearest the boat landing where we recorded it as a visual (Figure 3) (Appendix III).

Compared to 2013, our 2021 results suggested a highly significant increase **(p<0.001)** in total CLP coverage, mean density, and rake fullness 1; and a significant increase in rake fullness 2 **(p<0.05)** (Figure 4).



Significant differences = * p<0.05, ** p<0.01, *** p<0.001

Figure 4: 2013 and 2021 Changes in Early-season CLP Rake Fullness

Curly-leaf Pondweed Bed Mapping Survey:

During our original 2013 survey, despite searching over 21km (13 miles) of transects throughout the lake's visible littoral zone, the only beds found were in the southern third of the lake (Figure 5) (Appendix III). Even in this area, Curly-leaf pondweed was very limited in distribution as the 14 mapped beds totaled just 0.11 acre (0.01% of the lake's 880 acres) with the biggest being 0.03 acre (Beds 1 and 11) and the smallest being nothing more than a few 10's of plants covering <0.001 acre (Bed 12) (Table 1).

The 2015 survey documented a general uptick in CLP distribution and density on Middle Eau Claire Lake. In total, we located 41 microbeds covering 0.53 acre (0.06% of the lake's surface area) (Figure 5). Most of these "beds" were nothing more than a few clusters of plants, but, as the goal of the suction harvest program is to reduce the species as much as possible, we marked every single CLP plant we found and drew a polygon around it. Because of this, the "real" acreage of CLP beds on the lake was likely significantly less than the stated total. The largest true beds were Bed 7 (0.11 acre) and Bed N (0.05 acre). All other mapped areas were <0.04 acre, and most marked areas covered <0.001 acre and consisted of a few 10's of plants.

Although we revisited all 14 beds found in 2013, eight of them did not appear to have any CLP in 2015 (Table 1). Of the six beds that still had CLP present, only Bed 1 where SCUBA divers from Grantsburg High School had removed large numbers of plants in 2014 showed a decrease in size. In total, the beds in these areas had increase from 0.11 acre to 0.20 acre. Despite this, only the beds that occurred directly out from the boat landing (Beds 11 and 13) could have been considered even a minor navigation impairment, and, in reality, they were easily avoided because of their overall small size.

The 35 new "beds" in 2015 added 0.33 acre for a total delineated acreage of 0.53 acre (Table 2). Twenty-two of them were <0.005 acres meaning they were little more than a few clusters with a handful of plants in each. Perhaps the most noteworthy part of the survey was that we found two beds (A and B) that were north of the "neck" suggesting CLP had broken out of the southern bays (Figure 6).

In 2020, we searched along 27.6km (16.6 miles) of transects, and this included revisiting all former CLP areas. Despite this, we had difficulty finding any CLP to map. Although we delineated 12 areas with CLP totaling 0.07 acre (<0.01% coverage), almost all of these "beds" had less than 10-20 plants in them, and none of them were bigger than 0.01 acre (Figure 5). We also didn't locate any beds outside the southern bays (Figure 6). Collectively, this represented a 0.46-acre decline (-86.8%) compared to 2015.

Of the original 14 beds found in 2013, only Beds 7 and 13 had any visible CLP in them in 2020. In each case, we saw just a few handfuls of plants, and the total acreage with any plants present was 0.02 acre (Table 1).

We also found surviving CLP in just three out of the 35 beds first delineated in 2015. Each was little more than a handful of plants, but we mapped them as there wasn't anything else present to map. The seven new "beds" found in 2020 were little more than a few scattered plants growing among beds of native pondweeds (Table 2).

The 2021 Curly-leaf pondweed point-intercept and bed mapping surveys covered 42.0km (26.1 miles) of transects. Collectively, we mapped 17 areas totaling 0.58 acre (0.07% of the lake's surface area). Although this was a sharp increase (+729%) over 2020 levels, it was almost identical to the acreage we mapped in 2015.

The original beds found in the southern bays during the 2013 survey continued to have almost no CLP present (Figure 5). In total, our 2021 survey noted less than 50 plants in three areas (Beds 7, 11, and 13) that covered <0.01 acre (Table 1).

Similarly, the majority of beds delineated in 2015 and 2020 had no remaining CLP. Only nine of the 35 new areas mapped in 2015 had any plants, and only Beds J and R covered more than 0.01 acre. Even here, CLP was patchy and never an impairment to navigation. Of the seven beds first documented in 2020, Bed NN was the lone area where we still found CLP growing in 2021 (Table 2).

Although beds in 2021 continued to be widely-scattered and plants within the beds generally occurred at low-densities, we again discovered evidence of CLP's continued expansion. Along the southeastern shoreline midlake, we again rake removed a few individual plants from Bed A. We also documented a collection of microbeds (Bed TT) near the Bony Lake Inlet that covered 0.08 acre (Figure 6).

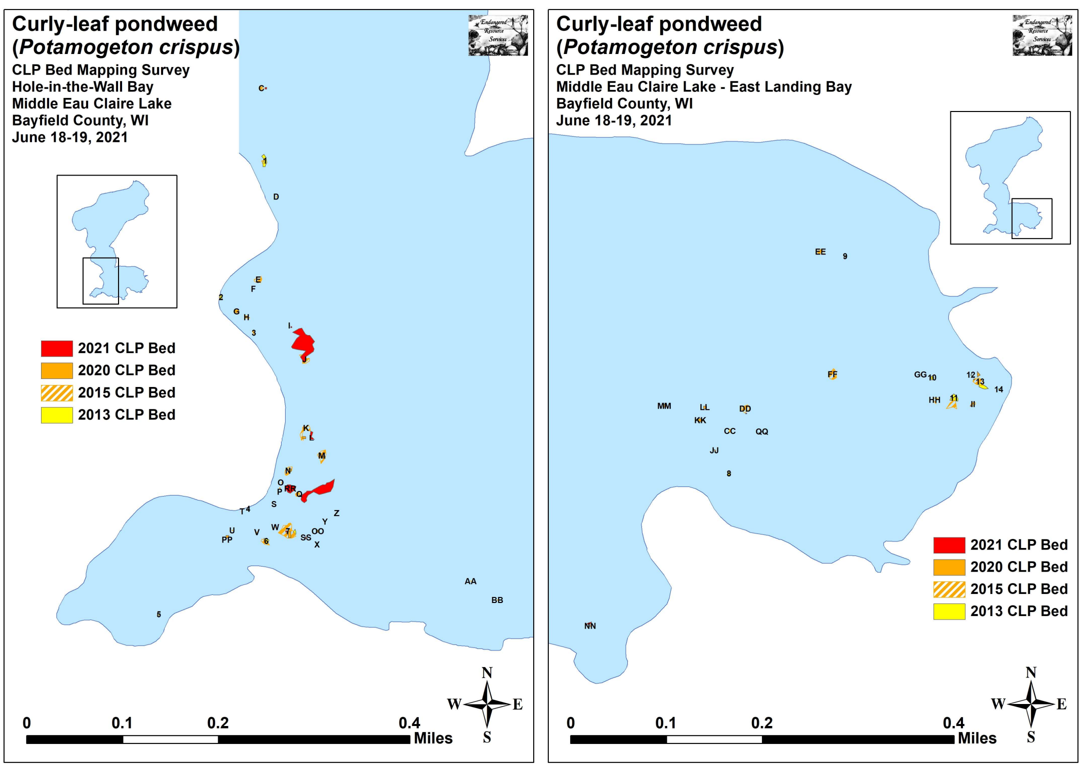


**Figure 5: Curly-leaf Pondweed Beds –
Hole-in-the-Wall and Boat Landing Bays – 2013, 2015, 2020, and 2021**

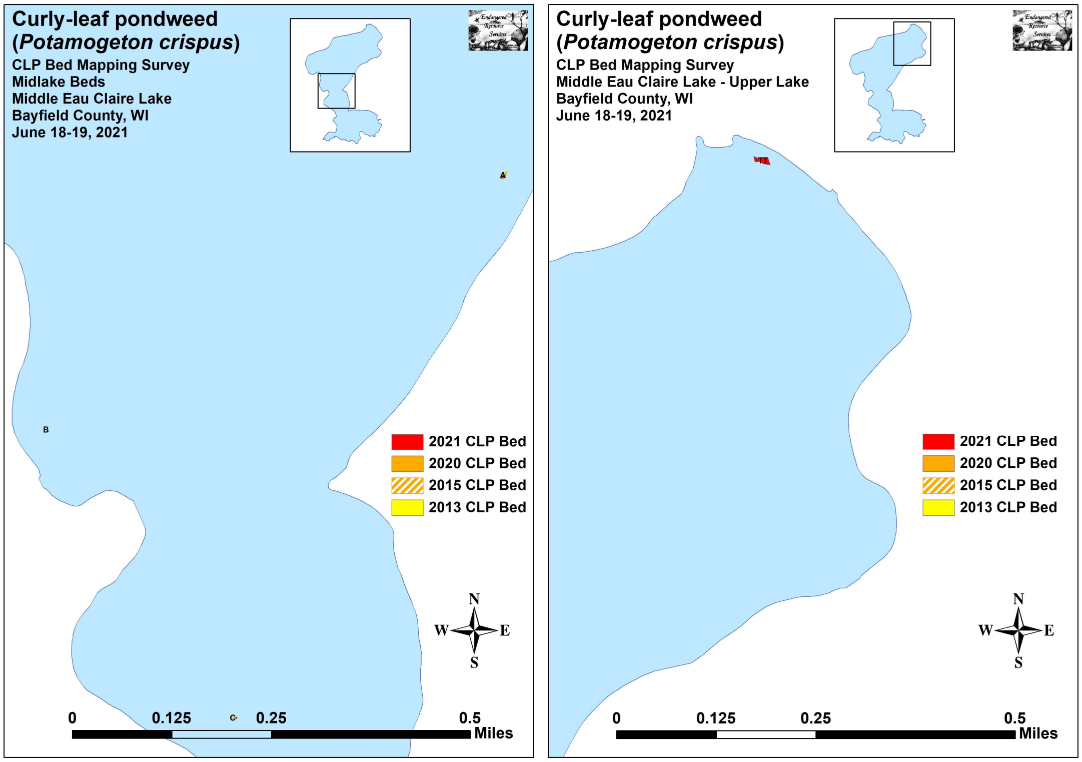


Figure 6: Curly-leaf Pondweed Beds –
Midlake and Upper Lake – 2013, 2015, 2020, and 2021

Table 1: Summary of Curly-leaf Pondweed Beds First Identified in 2013
Middle Eau Claire Lake – Bayfield County, Wisconsin
June 30, 2013, June 16, 18, 2015, June 19, 2020, and June 18-19, 2021

Bed Number	2021 Acreage	2020 Acreage	2015 Acreage	2013 Acreage	Depth Range and Mean Depth	Range and Mean Rake Fullness	Navigation Impairment	2021 Field Notes
1	0	0	0.01	0.03	-	-	None	No CLP plants seen.
2	0	0	0	0.01	-	-	None	No CLP plants seen.
3	0	0	<<0.01	<<0.01	-	-	None	No CLP plants seen.
4	0	0	0	<<0.01	-	-	None	No CLP plants seen.
5	0	0	0	<<0.01	-	-	None	No CLP plants seen.
6	0	0	0.02	0.01	-	-	None	No CLP plants seen.
7	<0.01	0.01	0.11	<0.01	7-8; 7	<<<1-1; <<1	None	Few dozen plants.
8	0	0	0	0.01	-	-	None	No CLP plants seen.
9	0	0	0	<<0.01	-	-	None	No CLP plants seen.
10	0	0	0	0.01	-	-	None	No CLP plants seen.
11	<0.01	0	0.03	0.03	4-5; 5	<1-1; 1	None	12+ plants.
12	0	0	0	<<<0.01	-	-	None	No CLP plants seen.
13	<0.01	<0.01	0.04	0.02	3-4; 3	<<<1-1; <1	None	10+ scattered plants.
14	0	0	0	<<<0.01	-	-	None	No CLP plants seen.
Total Acres	**<0.01**	**0.02**	**0.20**	**0.11**				

Table 2: Summary of Curly-leaf Pondweed Beds First Identified in 2015, 2020, and 2021
Middle Eau Claire Lake – Bayfield County, Wisconsin
June 16, 18, 2015, June 19, 2020, and June 18-19, 2021

Bed Number	2021 Acreage	2020 Acreage	2015 Acreage	Depth Range and Mean Depth	Range and Mean Rake Fullness	Navigation Impairment	2021 Field Notes
A	<0.01	0	0.03	8-9; 8	<<<1-1; <<<1	None	Handful of plants.
B	0	0	<<0.01	-	-	None	No CLP plants seen.
C	<0.01	0	<0.01	9-11; 10	<<<1-2; <<<1	None	Scattered plants.
D	0	0	<<0.01	-	-	None	No CLP plants seen.
E	<0.01	0	0.02	6-7; 6	<<<1-1; <1	None	Handful of plants.
F	0	0	<<0.01	-	-	None	No CLP plants seen.
G	0	0	<0.01	-	-	None	No CLP plants seen.
H	0	0	0.01	-	-	None	No CLP plants seen.
I	<0.01	0	<<0.01	6-7; 6	<1-2; 1	None	Handful of plants.
J	0.27	0	0.03	5-11; 8	<<<1-2; <1	None	Open scattered bed.
K	0	<<0.01	0.03	-	-	None	No CLP plants seen.
L	0.01	0	<<0.01	7-11; 9	<<1-2; 1	None	Open true bed.
M	0	<<0.01	0.05	-	-	None	No CLP plants seen.
N	0	<<0.01	0.03	-	-	None	No CLP plants seen.
O	0	0	<<0.01	-	-	None	No CLP plants seen.
P	0	0	<<0.01	-	-	None	No CLP plants seen.
Q	0	0	0.01	-	-	None	No CLP plants seen.
R	0.16	0	<<0.01	8-11; 9	<1-3; 1	None	Open patchy bed.
S	0	0	<<0.01	-	-	None	No CLP plants seen.
T	0	0	<<0.01	-	-	None	No CLP plants seen.
U	0	0	<<0.01	-	-	None	No CLP plants seen.
V	0	0	<<0.01	-	-	None	No CLP plants seen.
W	0	0	<<0.01	-	-	None	No CLP plants seen.
X	0	0	<<0.01	-	-	None	No CLP plants seen.
Y	0	0	<<0.01	-	-	None	No CLP plants seen.
Z	0	0	<<0.01	-	-	None	No CLP plants seen.

Table 2 (continued): Summary of Curly-leaf Pondweed Beds First Identified in 2015, 2020, and 2021
Middle Eau Claire Lake – Bayfield County, Wisconsin
June 16, 18, 2015, June 19, 2020, and June 18-19, 2021

Bed Number	2021 Acreage	2020 Acreage	2015 Acreage	Depth Range and Mean Depth	Range and Mean Rake Fullness	Navigation Impairment	2021 Field Notes
AA	0	0	<<0.01	-	-	None	No CLP plants seen.
BB	0	0	<<0.01	-	-	None	No CLP plants seen.
CC	0	0	<0.01	-	-	None	No CLP plants seen.
DD	<0.01	0	0.03	5-7; 6	<<<1-1; <1	None	15+ plants.
EE	0	0	0.16	-	-	None	No CLP plants seen.
FF	0	0	0.04	-	-	None	No CLP plants seen.
GG	0	0	<<0.01	-	-	None	No CLP plants seen.
HH	0	0	0.01	-	-	None	No CLP plants seen.
II	<0.01	0	0.01	3-5; 4	<<<1-1; <1	None	15+ plants.
JJ	0	<<0.01	0	-	-	None	No CLP plants seen.
KK	0	<0.01	0	-	-	None	No CLP plants seen.
LL	0	<<0.01	0	-	-	None	No CLP plants seen.
MM	0	<<0.01	0	-	-	None	No CLP plants seen.
NN	<0.01	<<0.01	0	4-6; 5	<1-3; 3	None	Microbed in Chara.
OO	0	<<0.01	0	-	-	None	No CLP plants seen.
PP	0	<<0.01	0	-	-	None	No CLP plants seen.
QQ	<0.01	0	0	4-6; 5	<<<1-1; <1	None	15+ plants.
RR	0.04	0	0	6-8; 7	<<1-2; 1	None	Open bed.
SS	<0.01	0	0	7-9; 8	<<<1-2; 1	None	Open microbed.
TT	0.08	0	0	5-9; 8	<<1-3; 1	None	Patchy microbeds.
Total Acres	**0.58**	**0.05**	**0.33**				

Warm-Water Full Point-intercept Macrophyte Survey:

Depth soundings taken at Middle Eau Claire Lake's 791 survey points revealed an extremely varied underwater topography with flats, bars, and sunken islands scattered throughout the lake. While the lake's southern bays tended to slope gradually to 15ft+, the central neck and northern shorelines tended to drop off sharply into 30ft+ with the deepest areas occurring in the 60ft+ hole on the northeast end (Figure 7) (Appendix IV).

Of the 453 survey points where we could determine the substrate, 33.8% were muck and sandy muck (153 points), 13.9% were pure sand (63 points), and 52.3% were rock (237 points). Sand and rock dominated the majority of the nearshore lake bottom as well as around the numerous sunken islands and bars in the northern two-thirds of the lake. Away from the shoreline in the southern third of the lake, the majority of these areas quickly transitioned to a nutrient-poor sandy muck with the only organic-rich muck occurring in the far northeast bay, the east end of the boat landing bay, and throughout Hole-in-the-Wall Bay (Figure 7) (Appendix IV).

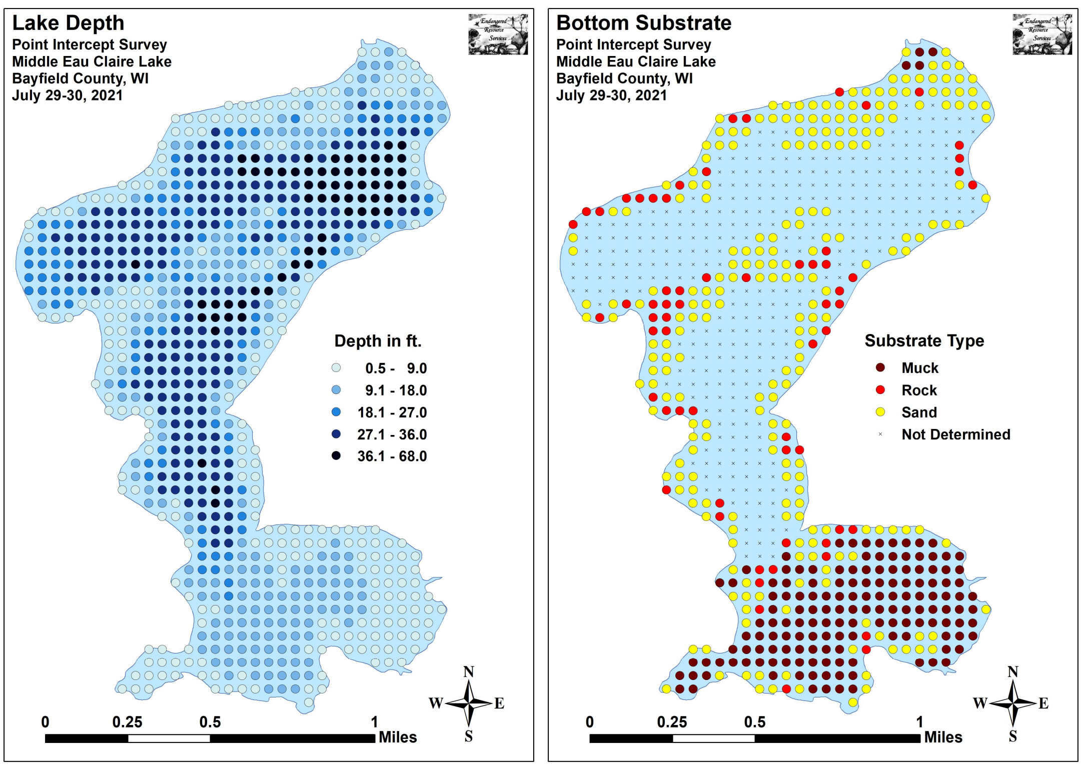


Figure 7: Lake Depth and Bottom Substrate

During the July 2021 survey, we found macrophytes at 391 sites (49.4% of the bottom and 88.7% of the 19.5ft littoral zone) (Figure 8). This was a non-significant increase (p=0.69) from 2013 when plants were present at 359 sites (45.4% of the entire lake bottom and in 82.9% of the then 19.0ft littoral zone). Plants were consistently found to 17ft, but they became much patchier beyond this depth (Figure 9).

Plant growth in 2021 was slightly skewed to deep water as the mean depth of 8.6ft was greater than the median depth of 8.0ft (Table 3). These values were almost identical to 2013 when the mean and median depths were 8.2ft and 8.0ft respectively (Appendix V).

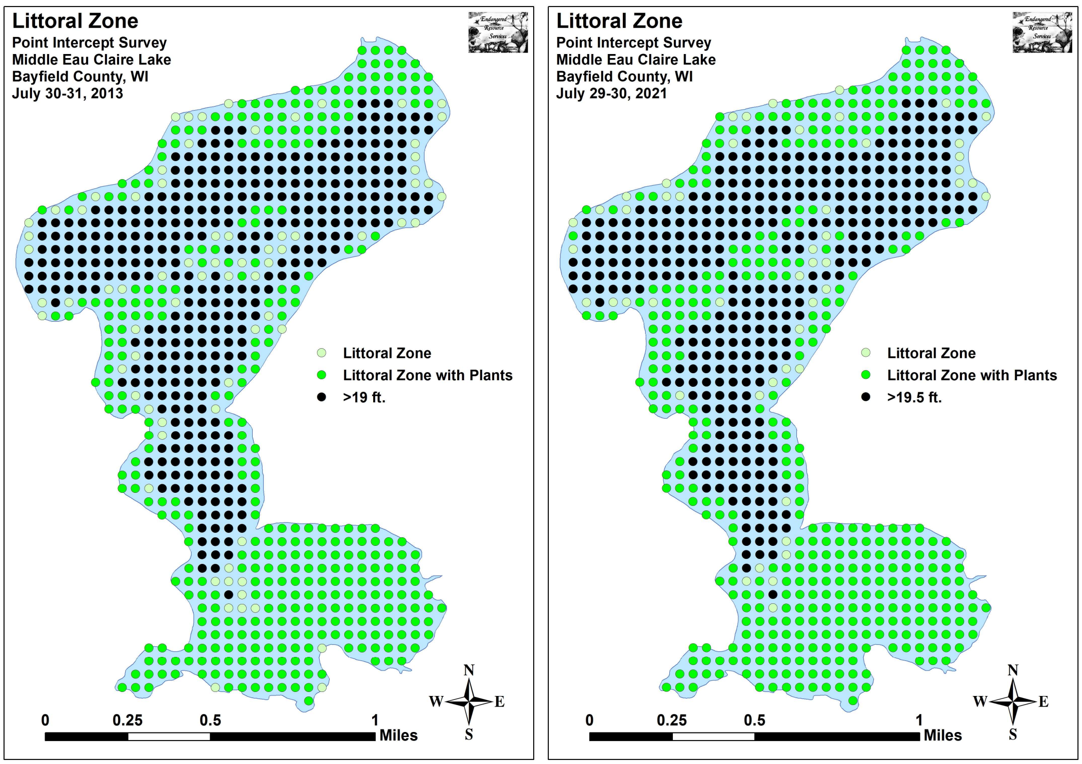


Figure 8: 2013 and 2021 Littoral Zone

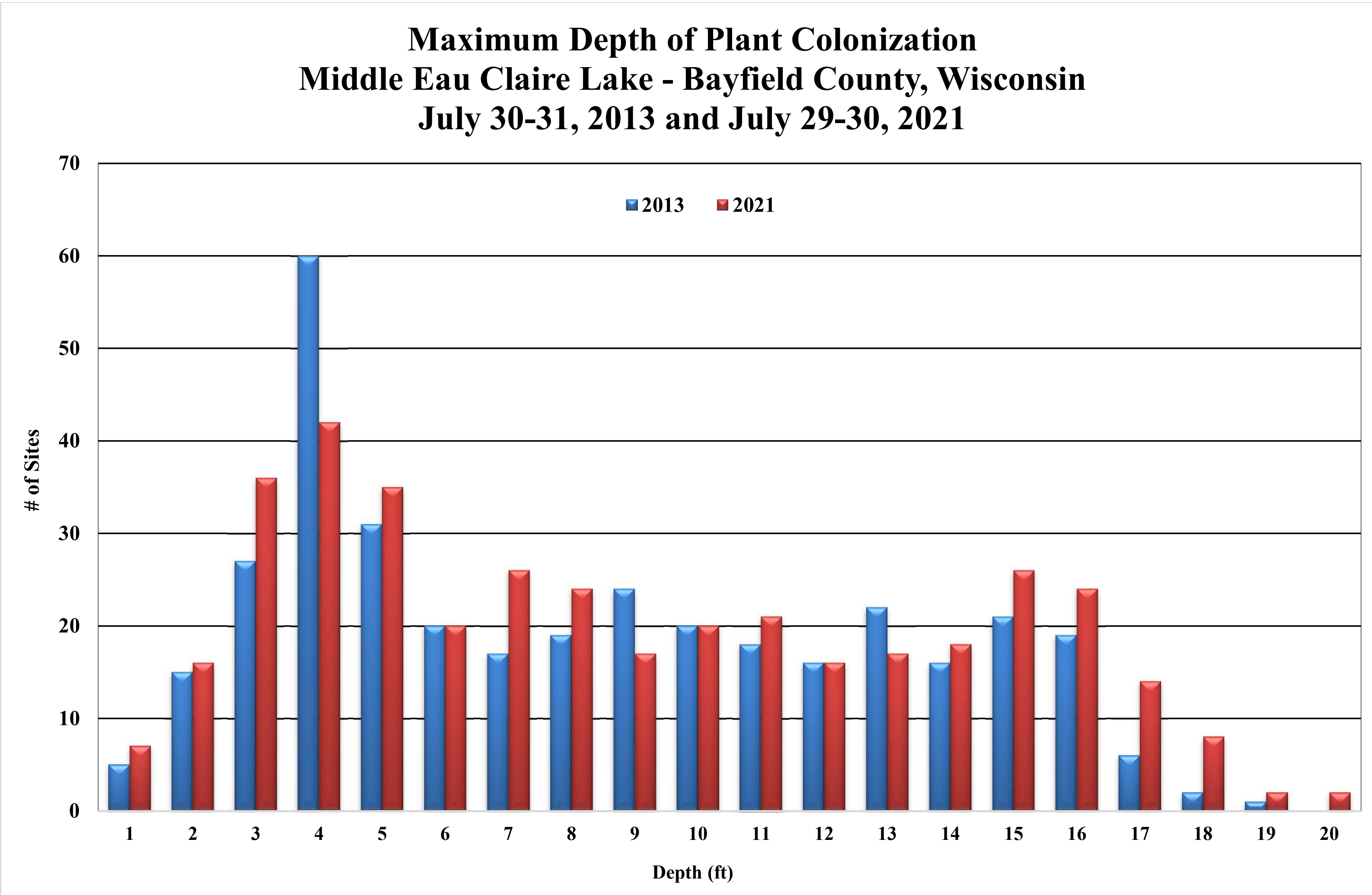


Figure 9: 2013 and 2021 Plant Colonization Depth Chart

Table 3: Aquatic Macrophyte P/I Survey Summary Statistics
Middle Eau Claire Lake – Bayfield County, Wisconsin
July 30-31, 2013 and July 29-30, 2021

Summary Statistics:	2013	2021
Total number of points sampled	791	791
Total number of sites with vegetation	359	391
Total number of sites shallower than the max. depth of plants	433	441
Freq. of occurrence at sites shallower than max. depth of plants	82.9	88.7
Simpson Diversity Index	0.92	0.93
Maximum depth of plants (ft)	19.0	19.5
Mean depth of plants (ft)	8.2	8.6
Median depth of plants (ft)	8.0	8.0
Number of sites sampled using rake on Rope (R)	66	66
Number of sites sampled using rake on Pole (P)	375	375
Average # of all species per site (shallower than max depth)	2.45	3.33
Average # of all species per site (veg. sites only)	2.96	3.76
Average # of native species per site (shallower than max depth)	2.45	3.33
Average # of native species per site (veg. sites only)	2.96	3.75
Species richness	42	48
Species richness (including visuals)	45	57
Species richness (including visuals and boat survey)	56	64
Mean rake fullness (veg. sites only)	1.79	2.22

Plant diversity was exceptionally high in 2021 with a Simpson Index value of 0.93 – up slightly from 0.92 in 2013. Total species richness was also exceptionally high with 64 species found in and immediately adjacent to the lake in 2021 – up from 56 in 2013.

From 2013 to 2021, mean native species richness at sites with native vegetation saw a highly significant increase **(p<0.001)** from 2.96 species/site in 2013 to 3.75 species/site in 2021. Most of these increases occurred in the south bays and near the inlet from Bony Lake (Figure 10) (Appendix V).

Total rake fullness underwent a highly significant increase **(p<0.001)** from a moderate 1.79 in 2013 to a moderately high 2.22 in 2021. Visual analysis of the maps showed these increases in biomass were widespread in the south bays and along the sunken islands of the upper lake (Figure 11) (Appendix V).

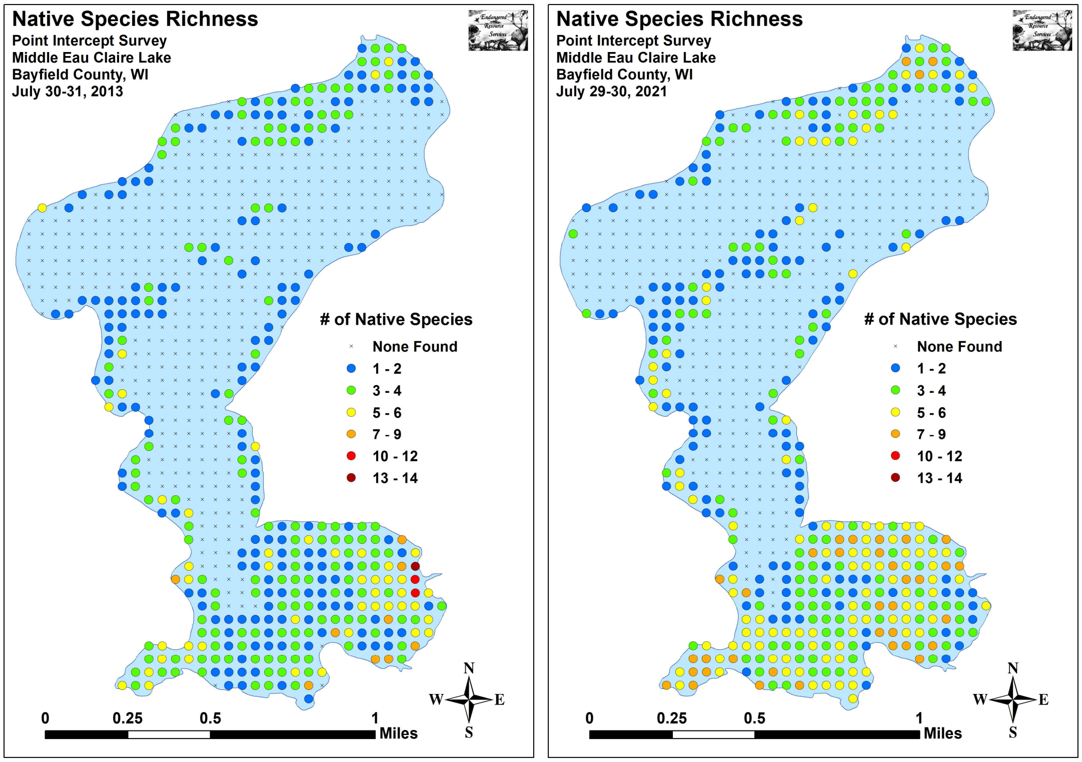


Figure 10: 2013 and 2021 Native Species Richness

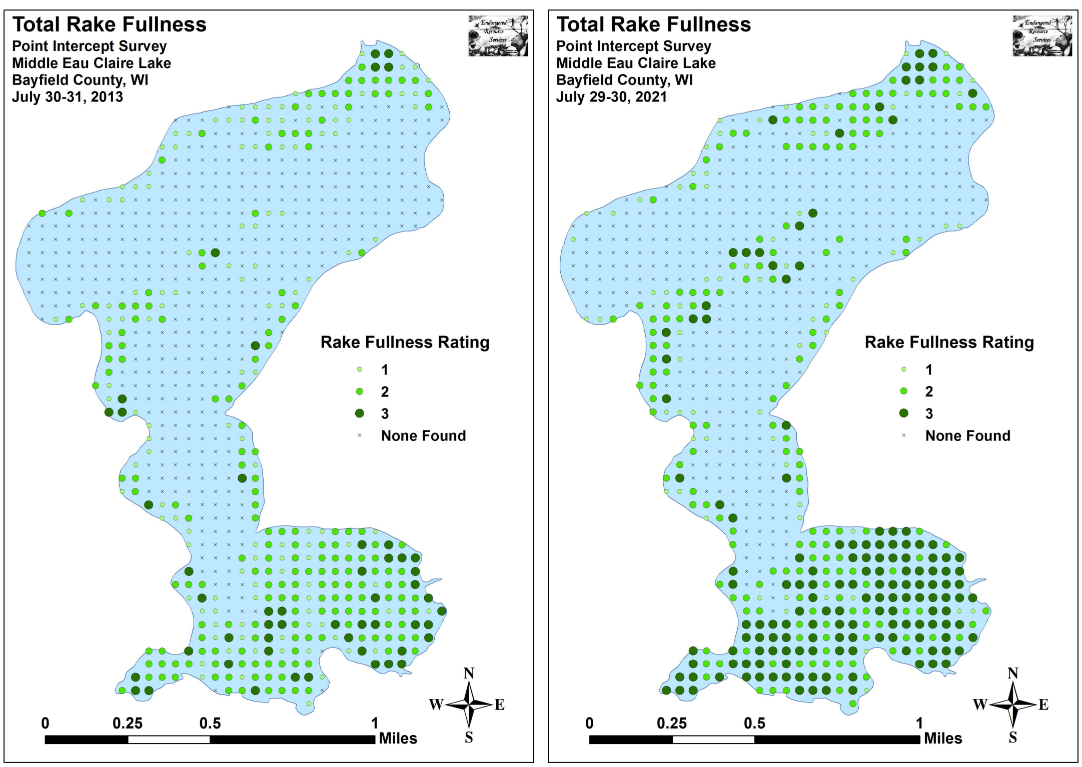


Figure 11: 2013 and 2021 Total Rake Fullness

Middle Eau Claire Lake Plant Community:

The Middle Eau Claire Lake ecosystem is home to a rich and 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 (sand, rock, 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 lakeshore, 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.

Bluejoint (*Calamagrostis canadensis*) and Sweet gale (*Myrica gale*) were common at the waterline on undeveloped sandy lakeshores throughout the system. In disturbed soil at the public boat landing, we also found the exotic species Common forget-me-not (*Myosotis scorpioides*) and Reed canary grass (*Phalaris arundinacea*)

Bluejoint (Routledge 2013)

Sweet gale (Devlin 2016)

Common forget-me-not (Raymond 2011)

Reed canary grass (Berg 2019)

At the edge of the bogs near the public boat landing and in Hole-in-the-Wall Bay where the soil was a more nutrient-rich organic muck, we also documented limited numbers of Bottle brush sedge (*Carex comosa*), Narrow-leaved woolly sedge (*Carex lasiocarpa*), Marsh cinquefoil (*Comarum palustre*), Northern blue flag (*Iris versicolor*), Common arrowhead (*Sagittaria latifolia*), and Broad-leaved cattail (*Typha latifolia*).

Bottle-brush sedge (Penta 2010)

Narrow-leaved wooly sedge (Navratil 2016)

Marsh cinquefoil (Myrhatt 2012)

Northern blue flag (Tracey 2007)

Common arrowhead (Young 2010)

Broad-leaved cattail (Raymond 2011)

The emergent community on shallow sand flats and gravel bars was dominated by Hardstem bulrush (*Schoenoplectus acutus*) with a few widely scattered patches of Creeping spikerush (*Eleocharis palustris*) and Grass-leaved arrowhead (*Sagittaria graminea*). We also found isolated patches of the exotic species Horseradish (*Armoracia rusticana*), Arrow arum (*Peltandra virginicum*), and Hybrid cattail (*Typha* X *glauca*) growing near the immediate shoreline in this environment.

Hardstem bulrush (Elliot 2007)

Creeping spikerush (Legler 2016)

Grass-leaved arrowhead (Flaigg 2003)

Horseradish along the northwest shoreline of MEC – 7/30/21

Arrow arum in Hole-in-the-Wall Bay – MEC – 7/29/21

Hybrid cattail (Berg 2020)

Sandy muck areas near the bogs in the southern bays supported beds of Pickerelweed (*Pontederia cordata*) and scattered Water bulrush (*Schoenoplectus subterminalis*).


Pickerelweed (Texas A&M 2012)

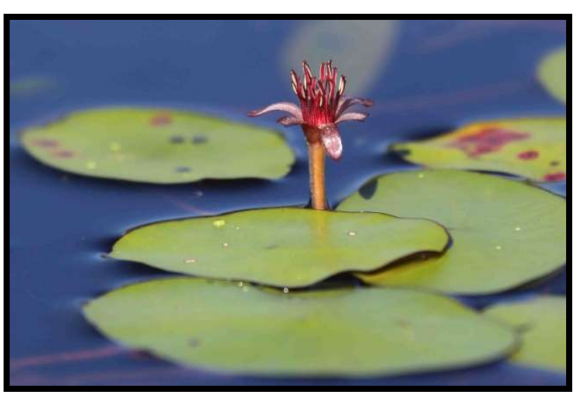

Water bulrush (Haines 2013)

Just beyond the emergents, pure sand areas seldom provided enough nutrients for floating-leaf species. In this environment, we found a few scattered beds of Variable pondweed (*Potamogeton gramineus*) and Illinois pondweed (*Potamogeton illinoensis*) – two other species that only occasionally produce floating leaves.


Variable pondweed – with and without floating leaves (Koshere 2002)


Illinois pondweed (Dziuk 2017)

Most beds of floating-leaf species occurred in sheltered muck-bottomed areas of the southern bays in up to 5ft of water. This habitat was dominated by beds of Watershield (*Brasenia schreberi*), Spatterdock, (*Nuphar variegata*), White-water lily (*Nymphaea odorata*), and Water smartweed (*Polygonum amphibium*).


Watershield (WED 2019)


Spatterdock (CBG 2014)

White water lily (Falkner 2009)

Water smartweed (Someya 2009)

Near the bogs in the southern bays, we also found lesser amounts of Alpine pondweed (*Potamogeton alpinus*), Large-leaf pondweed (*Potamogeton amplifolius*), Floating-leaf pondweed (*Potamogeton natans*), and Short-stemmed bur-reed (*Sparganium emersum*). The protective canopy cover all these species provide is often utilized by panfish and bass.

Alpine pondweed (Holm 2016)

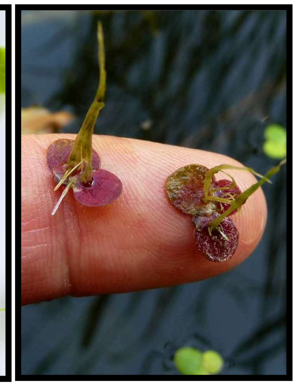
Large-leaf pondweed (Dziuk 2018)

Floating-leaf pondweed (Petroglyph 2007)

Short-stemmed bur-reed (Cameron 2016)

Growing among these floating-leaf species, especially in the far corners of the southern bays next to the bogs, we found scattered "duckweeds". They included Small duckweed (*Lemna minor*), Forked duckweed (*Lemna trisulca*), and Large duckweed (*Spirodela polyrhiza*).

Small duckweed (Kramer 2013)



Forked duckweed (Curtis 2010) and Large duckweed (Thomas 2016)

This environment also supported the submergent species Spiny hornwort (*Ceratophyllum echinatum*) and Whorled water-milfoil (*Myriophyllum verticillatum*) as well as a variety of carnivorous plants including Creeping bladderwort (*Utricularia gibba*), Flat-leaf bladderwort (*Utricularia intermedia*), Small bladderwort (*Utricularia minor*), and Common bladderwort (*Utricularia vulgaris*). Rather than drawing nutrients up through roots like other plants, bladderworts trap zooplankton and minute insects in their bladders, digest their prey, and use the nutrients to further their growth.

Spiny hornwort (Chayka 2019)

Whorled water-milfoil (Cameron 2018)

Creeping bladderwort showing bladders for catching prey (Eyewed 2010)

Flat-leaf bladderwort (Woods 2012)

Small bladderwort (Cameron 2019)

Common bladderwort flowers among lilypads (Hunt 2010)

Just beyond the emergents, in water up to 5ft deep, shallow sugar sand and gravel 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 Rough stonewort – a Muskgrass (*Chara aspera*), Needle spikerush (*Eleocharis acicularis*), Slender naiad (*Najas flexilis*), and Variable pondweed.

Rough Stonewort – a Muskgrass (Gibbons 2012)

Needle spikerush (Fewless 2005)

Slender naiad (Apipp 2009)

Variable pondweed – submergent leaves (Cameron 2018)

In the most pristine shoreline areas on the lake, these shallow sandy habitats also supported an often limited number of uncommon to rare species. These plants, which are extremely sensitive to human disturbance, included Waterwort (*Elatine minima*), Brown-fruited rush (*Juncus pelocarpus*), Dwarf water milfoil (*Myriophyllum tenellum*), and Grass-leaved arrowhead. All of these "turf" species, along with the emergents, stabilize the bottom and prevent wave action erosion.

Waterwort (Fewless 2005)

Brown-fruited rush (Koshere 2002)

Dwarf water milfoil (Koshere 2002)

Grass-leaved arrowhead (Cameron 2019)

Shallow sandy muck tended to support slightly broader-leaved species like Water star-grass (*Heteranthera dubia*), Northern water-milfoil (*Myriophyllum sibiricum*), Slender naiad, Fries' pondweed (*Potamogeton friesii*), Variable pondweed, Clasping-leaf pondweed (*Potamogeton richardsonii*), Stiff pondweed (*Potamogeton strictifolius*), White water crowfoot (*Ranunculus aquatilis*), Sago pondweed (*Stuckenia pectinata*), and Wild celery (*Vallisneria americana*). The roots, shoots, and seeds of these 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)

Fries' pondweed (End 2012)

Clasping-leaf pondweed (Cameron 2014)

Stiff pondweed (Andrews 2012)

White water crowfoot (Wasser 2014)

Sago pondweed (Hilty 2012)

Wild celery (Dalvi 2009)

In water from 6-18ft over sandy and organic muck, the plant community was dominated by Water marigold (*Bidens beckii*), Coontail (*Ceratophyllum demersum*), Common waterweed (*Elodea canadensis*), Large-leaf pondweed, Curly-leaf pondweed, Leafy pondweed (*Potamogeton foliosus*), Illinois pondweed, White-stem pondweed (*Potamogeton praelongus*), Small pondweed (*Potamogeton pusillus*), Fern pondweed (*Potamogeton robbinsii*), and Flat-stem pondweed (*Potamogeton zosteriformis*). Predatory fish like the lake's Musky and Northern pike are often found along the edges of these rich underwater forests waiting in ambush.

Water marigold (Dziuk 2012)

Coontail (Hassler 2011)

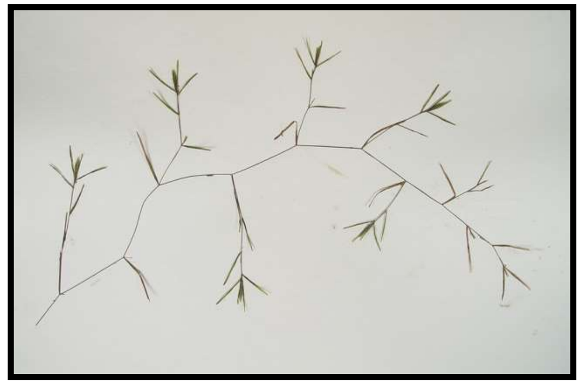
Common waterweed (Fischer 2005)

Large-leaf and Illinois pondweeds (Dziuk 2018)

Curly-leaf pondweed (USGS 2019)

Leafy pondweed (Kleinman 2009)

White-stem pondweed (Fewless 2005)



Small pondweed (Cameron 2013)

Fern pondweed (Apipp 2011)

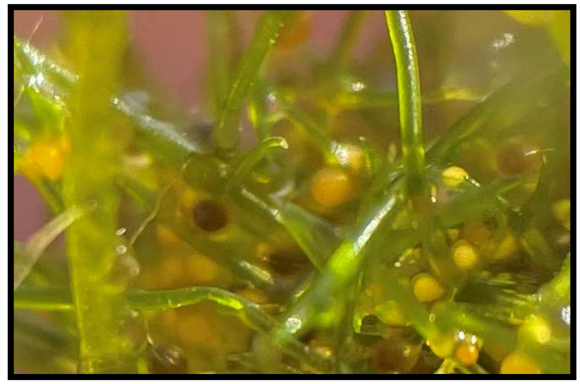
Flat-stem pondweed (Dziuk 2019)

Growing on the outer edge of the littoral zone, the colonial charophytes Muskgrass (*Chara* sp.), Nitella (*Nitella* sp.), and Bird's nest stonewort (*Tolypella intricata*) were widely-distributed and occasionally abundant. Able to survive in low-light conditions, these species combined to provide significant deepwater habitat.

Muskgrass (Skawinski 2018)

Smooth stonewort – a Nitella (Schou 2003)

Bird's nest stonewort – Middle Eau Claire Lake – 7/30/21



Close-up of Oogonia from Bird's nest stonewort – MEC Lake – 7/30/21

Comparison of Native Species in 2013 and 2021:

Our 2013 survey identified Slender naiad, Coontail, Flat-stem pondweed, and Small pondweed as the most common species (Table 4). They were found at 46.80%, 31.75%, 30.64%, and 28.13% of sites with vegetation and encompassed 46.42% of the total relative frequency. Muskgrass (8.10%), Common waterweed (7.82%), Northern water-milfoil (7.53%), Fern pondweed (4.71%), and Nitella (4.43%) were the only other species with relative frequencies over 4.00% (Maps for all plants found in July 2013 can be found in the project folder).

The 2021 survey documented Coontail (38.36% of points with vegetation), Northern water-milfoil (38.36%), Small pondweed (38.11%), and Common waterweed (32.23%) as the most common species with a combined relative frequency of 39.14% (Table 5). Slender naiad (7.90%), Flat-stem pondweed (7.90%), Muskgrass (6.19%), Fern pondweed (6.13%), and Clasping-leaf pondweed (5.85%) also had relative frequencies over 4.00% (Density and distribution maps for all native plant species found in 2021 are located in Appendix VI).

From 2013 to 2021, sixteen species experienced significant changes in distribution (Figure 12). Slender naiad suffered a highly significant decline **($p<0.001$)**, and Leafy pondweed underwent a significant decline **($p=0.01$)**. Conversely, Small pondweed, Northern water-milfoil, Fern pondweed, Clasping-leaf pondweed, filamentous algae, Variable pondweed, Large-leaf pondweed, Wild celery, Forked duckweed, and White water crowfoot all enjoyed highly significant increases **($p<0.001$)**; Common waterweed showed a moderately significant increase **($p=0.001$)**; and Coontail **($p=0.02$)**, Fries' pondweed **($p=0.03$)**, and Bird's nest stonewort **($p<0.05$)** saw significant increases.

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Middle Eau Claire Lake – Bayfield County, Wisconsin
July 30-31, 2013

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Najas flexilis	Slender naiad	168	15.82	46.80	38.80	1.35	1
Ceratophyllum demersum	Coontail	114	10.73	31.75	26.33	1.49	1
Potamogeton zosteriformis	Flat-stem pondweed	110	10.36	30.64	25.40	1.35	7
Potamogeton pusillus	Small pondweed	101	9.51	28.13	23.33	1.21	0
Chara sp.	Muskgrass	86	8.10	23.96	19.86	1.33	3
Elodea canadensis	Common waterweed	83	7.82	23.12	19.17	1.17	0
Myriophyllum sibiricum	Northern water-milfoil	80	7.53	22.28	18.48	1.33	8
Potamogeton robbinsii	Fern pondweed	50	4.71	13.93	11.55	1.36	3
Nitella sp.	Nitella	47	4.43	13.09	10.85	1.15	0
Potamogeton richardsonii	Clasping-leaf pondweed	32	3.01	8.91	7.39	1.31	7
	Filamentous algae	31	*	8.64	7.16	1.42	0
Potamogeton friesii	Fries' pondweed	28	2.64	7.80	6.47	1.18	0
Heteranthera dubia	Water star-grass	17	1.60	4.74	3.93	1.00	0
Potamogeton gramineus	Variable pondweed	16	1.51	4.46	3.70	1.44	1
Potamogeton amplifolius	Large-leaf pondweed	15	1.41	4.18	3.46	1.40	9
Vallisneria americana	Wild celery	15	1.41	4.18	3.46	1.00	1
Eleocharis acicularis	Needle spikerush	12	1.13	3.34	2.77	1.25	0
Bidens beckii	Water marigold	9	0.85	2.51	2.08	1.00	1
Potamogeton foliosus	Leafy pondweed	9	0.85	2.51	2.08	1.22	0
Potamogeton strictifolius	Stiff pondweed	7	0.66	1.95	1.62	1.00	2
Stuckenia pectinata	Sago pondweed	7	0.66	1.95	1.62	1.00	1
Schoenoplectus acutus	Hardstem bulrush	6	0.56	1.67	1.39	1.83	0
Utricularia vulgaris	Common bladderwort	6	0.56	1.67	1.39	1.17	0
Nuphar variegata	Spatterdock	5	0.47	1.39	1.15	2.60	3
Nymphaea odorata	White water lily	5	0.47	1.39	1.15	1.60	2

* Excluded from relative frequency

Table 4 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Middle Eau Claire Lake – Bayfield County, Wisconsin
July 30-31, 2013

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton illinoensis	Illinois pondweed	4	0.38	1.11	0.92	1.50	1
Potamogeton praelongus	White-stem pondweed	4	0.38	1.11	0.92	1.25	3
Brasenia schreberi	Watershield	3	0.28	0.84	0.69	1.33	0
Potamogeton alpinus	Alpine pondweed	3	0.28	0.84	0.69	1.00	0
Utricularia minor	Small bladderwort	3	0.28	0.84	0.69	1.00	0
Elatine minima	Waterwort	2	0.19	0.56	0.46	1.50	0
Isoetes echinospora	Spiny spored-quillwort	2	0.19	0.56	0.46	1.00	0
Potamogeton natans	Floating-leaf pondweed	2	0.19	0.56	0.46	1.00	1
Sagittaria cristata	Crested arrowhead	2	0.19	0.56	0.46	1.00	1
Juncus pelocarpus f. submersus	Brown-fruited rush	1	0.09	0.28	0.23	2.00	0
Lemna trisulca	Forked duckweed	1	0.09	0.28	0.23	1.00	0
Myriophyllum tenellum	Dwarf water-milfoil	1	0.09	0.28	0.23	1.00	0
Pontederia cordata	Pickerelweed	1	0.09	0.28	0.23	3.00	0
Ranunculus aquatilis	White water crowfoot	1	0.09	0.28	0.23	1.00	0
Ranunculus flammula	Creeping spearwort	1	0.09	0.28	0.23	1.00	1
Sparganium emersum	Short-stemmed bur-reed	1	0.09	0.28	0.23	1.00	0
Typha latifolia	Broad-leaved cattail	1	0.09	0.28	0.23	1.00	1
Utricularia intermedia	Flat-leaf bladderwort	1	0.09	0.28	0.23	1.00	0
Carex comosa	Bottle brush sedge	**	**	**	**	**	1
Potamogeton crispus	**Curly-leaf pondweed**	**	**	**	**	**	**1**
Schoenoplectus subterminalis	Water bulrush	**	**	**	**	**	1
Carex aquatilis	Long-bract tussock sedge	***	***	***	***	***	***
Carex lacustris	Lake sedge	***	***	***	***	***	***
Carex utriculata	Common yellow lake sedge	***	***	***	***	***	***

** Visual only *** Boat survey only **Exotic species in bold**

Table 4 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Middle Eau Claire Lake – Bayfield County, Wisconsin
July 30-31, 2013

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Iris pseudacoris	**Yellow iris**	***	***	***	***	***	***
Iris versicolor	Northern blue flag	***	***	***	***	***	***
Myosotis scorpioides	**Common forget-me-not**	***	***	***	***	***	***
Myrica gale	Sweet gale	***	***	***	***	***	***
Phalaris arundinacea	**Reed canary grass**	***	***	***	***	***	***
Potamogeton epihydrus	Ribbon-leaf pondweed	***	***	***	***	***	***
Potamogeton spathuliformis	Illinois X Variable Hybrid	***	***	***	***	***	***
Potamogeton X *haynesi*	Haynes' pondweed	***	***	***	***	***	***

*** Boat survey only **Exotic species in bold**

Table 5: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Middle Eau Claire Lake – Bayfield County, Wisconsin
July 29-30, 2021

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Ceratophyllum demersum	Coontail	150	10.21	38.36	34.01	1.48	0
Myriophyllum sibiricum	Northern water-milfoil	150	10.21	38.36	34.01	1.73	8
Potamogeton pusillus	Small pondweed	149	10.14	38.11	33.79	1.40	1
Elodea canadensis	Common waterweed	126	8.58	32.23	28.57	1.34	0
Najas flexilis	Slender naiad	116	7.90	29.67	26.30	1.56	3
Potamogeton zosteriformis	Flat-stem pondweed	116	7.90	29.67	26.30	1.92	1
	Filamentous algae	96	*	24.55	21.77	1.51	0
Chara sp.	Muskgrass	91	6.19	23.27	20.63	1.44	0
Potamogeton robbinsii	Fern pondweed	90	6.13	23.02	20.41	1.60	0
Potamogeton richardsonii	Clasping-leaf pondweed	86	5.85	21.99	19.50	1.45	8
Potamogeton friesii	Fries' pondweed	47	3.20	12.02	10.66	1.28	0
Vallisneria americana	Wild celery	44	3.00	11.25	9.98	1.20	2
Potamogeton gramineus	Variable pondweed	41	2.79	10.49	9.30	1.27	5
Potamogeton amplifolius	Large-leaf pondweed	39	2.65	9.97	8.84	1.46	7
Nitella sp.	Nitella	34	2.31	8.70	7.71	1.38	0
Lemna trisulca	Forked duckweed	33	2.25	8.44	7.48	1.15	0
Heteranthera dubia	Water star-grass	27	1.84	6.91	6.12	1.19	3
Ranunculus aquatilis	White water crowfoot	14	0.95	3.58	3.17	1.21	0
Eleocharis acicularis	Needle spikerush	13	0.88	3.32	2.95	1.46	0
Potamogeton strictifolius	Stiff pondweed	11	0.75	2.81	2.49	1.27	0
Nymphaea odorata	White water lily	9	0.61	2.30	2.04	2.11	2
Potamogeton praelongus	White-stem pondweed	9	0.61	2.30	2.04	1.56	1
Stuckenia pectinata	Sago pondweed	8	0.54	2.05	1.81	1.13	3

* Excluded from relative frequency

Table 5 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Middle Eau Claire Lake – Bayfield County, Wisconsin
July 29-30, 2021

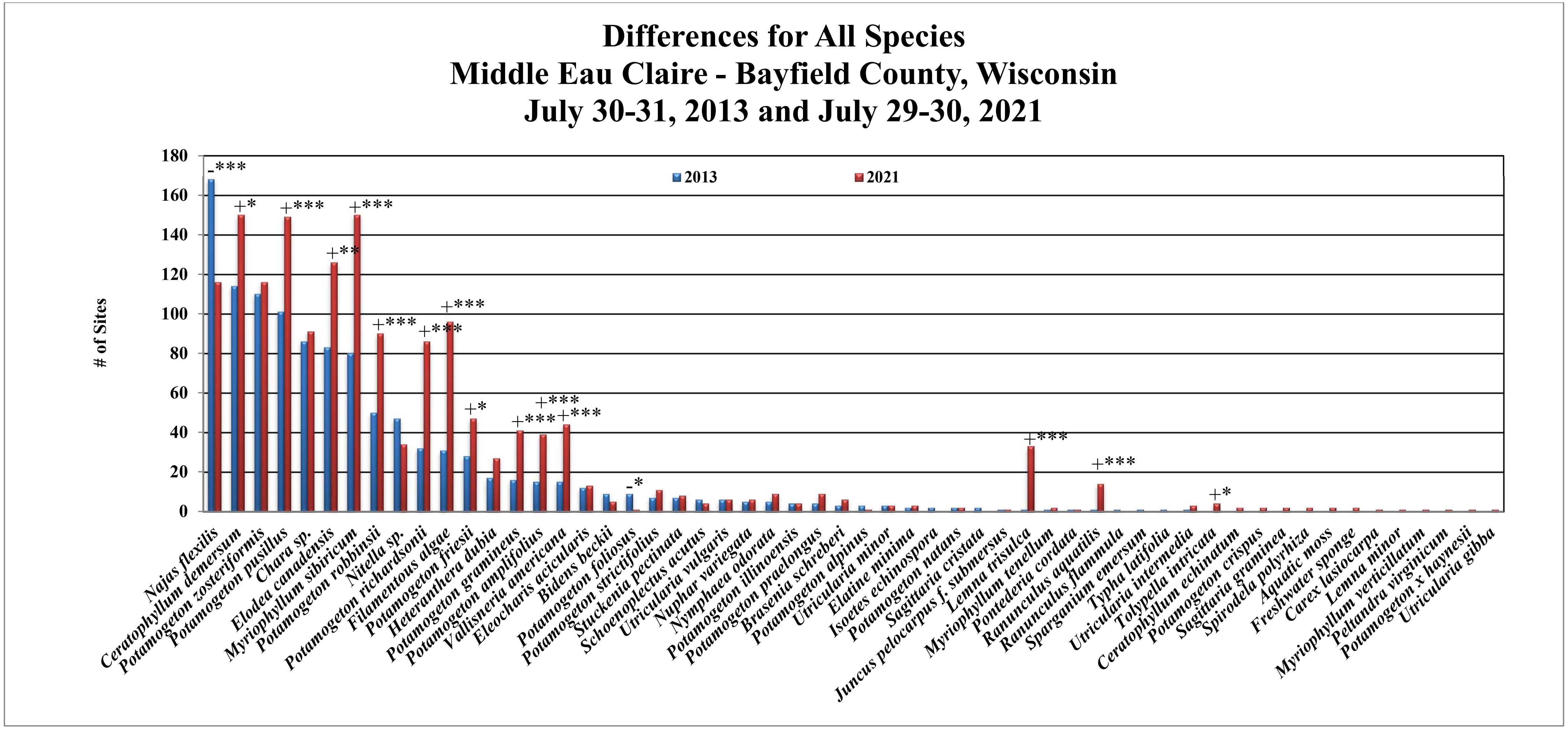
Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Brasenia schreberi	Watershield	6	0.41	1.53	1.36	1.17	1
Nuphar variegata	Spatterdock	6	0.41	1.53	1.36	2.17	3
Utricularia vulgaris	Common bladderwort	6	0.41	1.53	1.36	1.17	0
Bidens beckii	Water marigold	5	0.34	1.28	1.13	1.00	0
Potamogeton illinoensis	Illinois pondweed	4	0.27	1.02	0.91	1.50	0
Schoenoplectus acutus	Hardstem bulrush	4	0.27	1.02	0.91	2.00	1
Tolypella intricata	Bird’s nest stonewort	4	0.27	1.02	0.91	1.25	0
Elatine minima	Waterwort	3	0.20	0.77	0.68	1.33	1
Utricularia intermedia	Flat-leaf bladderwort	3	0.20	0.77	0.68	1.00	0
Utricularia minor	Small bladderwort	3	0.20	0.77	0.68	1.33	0
Ceratophyllum echinatum	Spiny hornwort	2	0.14	0.51	0.45	1.00	1
Myriophyllum tenellum	Dwarf water-milfoil	2	0.14	0.51	0.45	1.50	0
Potamogeton crispus	**Curly-leaf pondweed**	**2**	**0.14**	**0.51**	**0.45**	**1.00**	**1**
Potamogeton natans	Floating-leaf pondweed	2	0.14	0.51	0.45	1.50	0
Sagittaria graminea	Grass-leaved arrowhead	2	0.14	0.51	0.45	1.00	1
Spirodela polyrhiza	Large duckweed	2	0.14	0.51	0.45	1.00	0
	Aquatic moss	2	*	0.51	0.45	1.00	0
	Freshwater sponge	2	*	0.51	0.45	1.00	0
Carex lasiocarpa	Narrow-leaved wooly sedge	1	0.07	0.26	0.23	3.00	0
Juncus pelocarpus f. submersus	Brown-fruited rush	1	0.07	0.26	0.23	2.00	0
Lemna minor	Small duckweed	1	0.07	0.26	0.23	1.00	0
Myriophyllum verticillatum	Whorled water-milfoil	1	0.07	0.26	0.23	1.00	0
Pontederia cordata	Pickerelweed	1	0.07	0.26	0.23	3.00	0
Potamogeton alpinus	Alpine pondweed	1	0.07	0.26	0.23	1.00	2
Potamogeton foliosus	Leafy pondweed	1	0.07	0.26	0.23	1.00	0

* Excluded from relative frequency **Exotic species in bold**

Table 5 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Middle Eau Claire Lake – Bayfield County, Wisconsin
July 29-30, 2021

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton x haynesii	Hayne's pondweed	1	0.07	0.26	0.23	1.00	0
Peltandra virginicum	**Arrow arum**	**1**	**0.07**	**0.26**	**0.23**	**3.00**	**0**
Utricularia gibba	Creeping bladderwort	1	0.07	0.26	0.23	1.00	1
Calamagrostis canadensis	Bluejoint	**	**	**	**	**	1
Carex comosa	Bottle brush sedge	**	**	**	**	**	1
Comarum palustre	Marsh cinquefoil	**	**	**	**	**	1
Iris versicolor	Northern blue flag	**	**	**	**	**	1
Myrica gale	Sweet gale	**	**	**	**	**	2
Sagittaria latifolia	Common arrowhead	**	**	**	**	**	1
Schoenoplectus subterminalis	Water bulrush	**	**	**	**	**	1
Sparganium emersum	Short-stemmed bur-reed	**	**	**	**	**	1
Typha latifolia	Broad-leaved cattail	**	**	**	**	**	2
Armoracia rusticana	**Horseradish**	***	***	***	***	***	***
Eleocharis palustris	Creeping spikerush	***	***	***	***	***	***
Myosotis scorpioides	**Common forget-me-not**	***	***	***	***	***	***
Phalaris arundinacea	**Reed canary grass**	***	***	***	***	***	***
Polygonum amphibium	Water smartweed	***	***	***	***	***	***
Typha* X *glauca	**Hybrid cattail**	***	***	***	***	***	***

** Visual only   *** Boat survey only   **Exotic species in bold**



Significant differences = * $p<0.05$, ** $p<0.01$, *** $p<0.001$

Figure 12: Macrophytes Showing Significant Changes from 2013-2021

Slender naiad was common over sand and gravel areas throughout the lake (Figure 13). In 2013, it was the most widely-distributed species on the lake (168 sites with a mean rake fullness of 1.35). Following a highly significant decline **(*p*<0.001)** in distribution (116 sites), it fell into a tie for the fifth most common species in 2021. Despite these loses, its mean rake fullness underwent a highly significant increase **(*p*<0.001)** in density (mean rake fullness of 1.56).

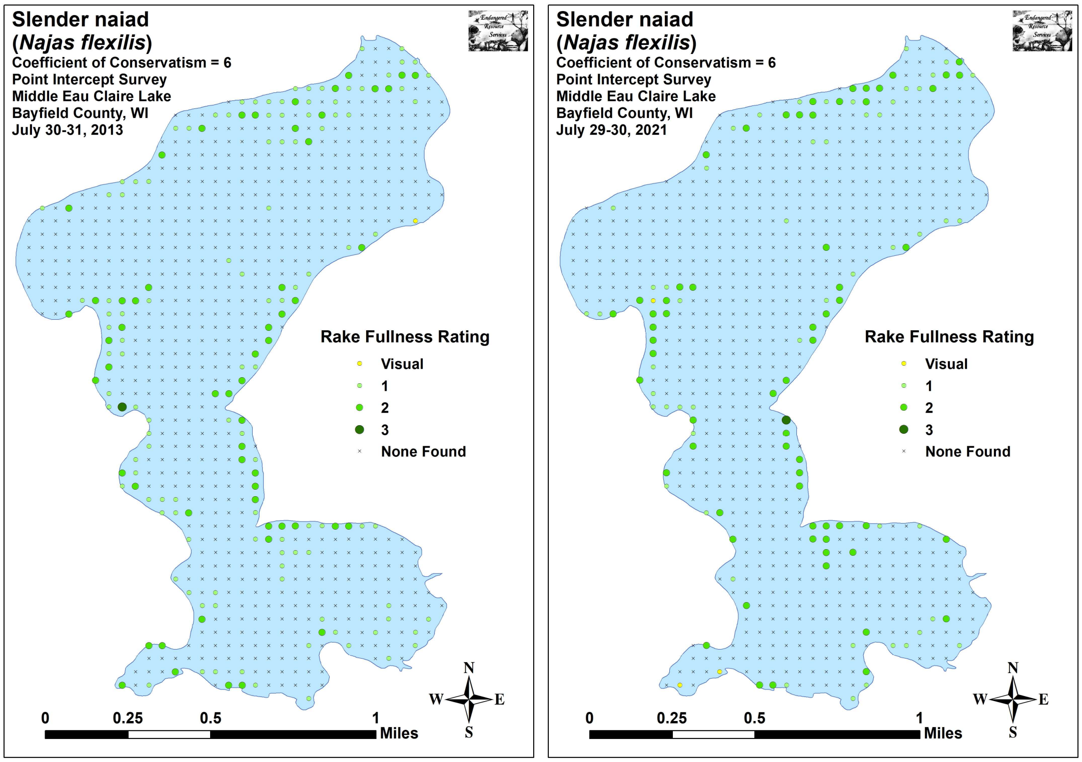


Figure 13: 2013 and 2021 Slender Naiad Density and Distribution

Coontail was the second most common species in 2013 and tied for the most common in 2021 (Figure 14). Found at 114 sites with a mean rake fullness of 1.49 in 2013, it underwent a significant increase **(*p*=0.01)** in distribution to 150 sites in 2021. Although it expanded in coverage, its density was almost unchanged at a mean rake fullness of 1.48.

We identified Flat-stem pondweed as the third most widely-distributed species in 2013 (110 sites with a mean rake fullness of 1.35) (Figure 15). In 2021, we documented a non-significant increase (*p*=0.76) in distribution to 116 points; however, the accompanying increase in density (mean rake of 1.92) was highly significant **(*p*<0.001)**. Despite these increases, it fell into a tie for the fifth-ranked species in the overall community.

Small pondweed was the fourth-ranked species in 2013 when it was present at 101 sites with a mean rake fullness of 1.21 (Figure 16). Following a highly significant increase **(*p*<0.001)** in distribution (149 sites) and a moderately significant increase **(*p*=0.002)** in density (mean rake of 1.40), it rose to the third-ranked species in 2021.

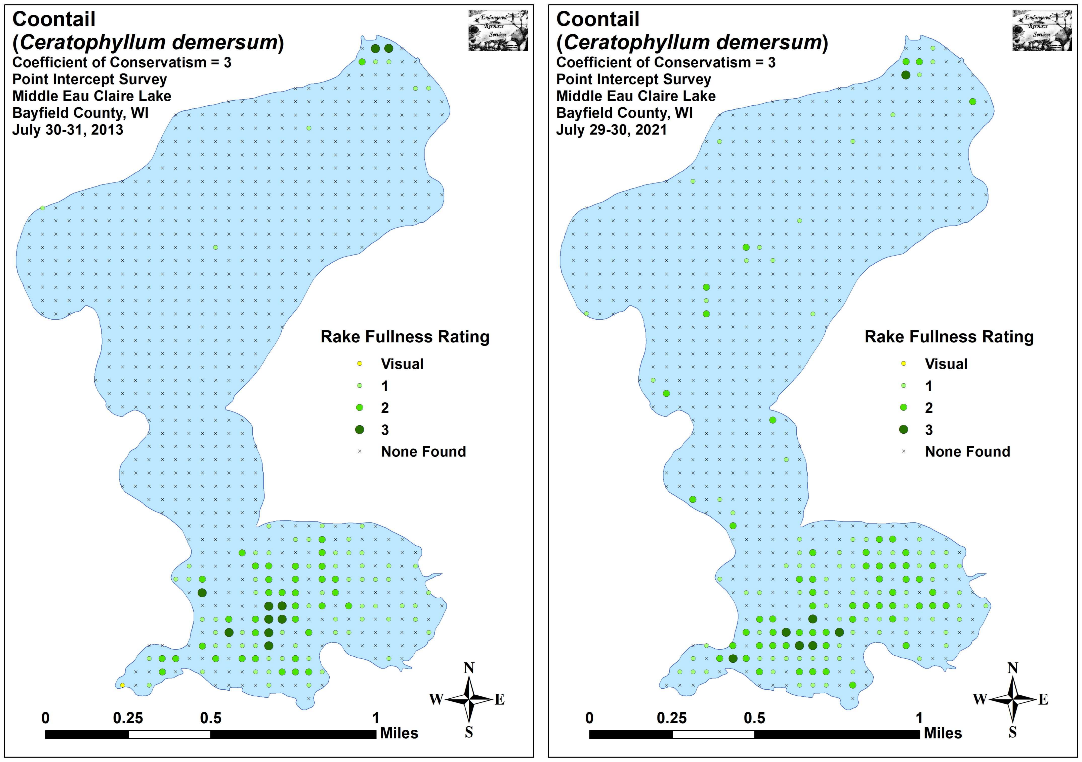


Figure 14: 2013 and 2021 Coontail Density and Distribution

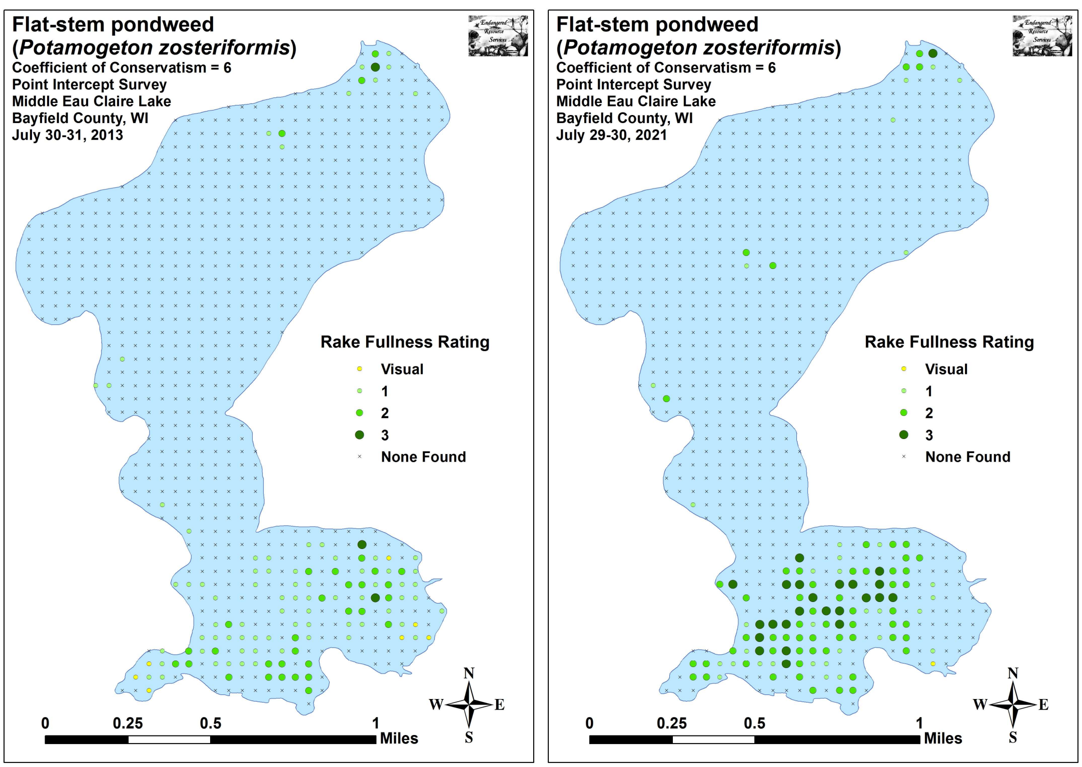


Figure 15: 2013 and 2021 Flat-stem Pondweed Density and Distribution

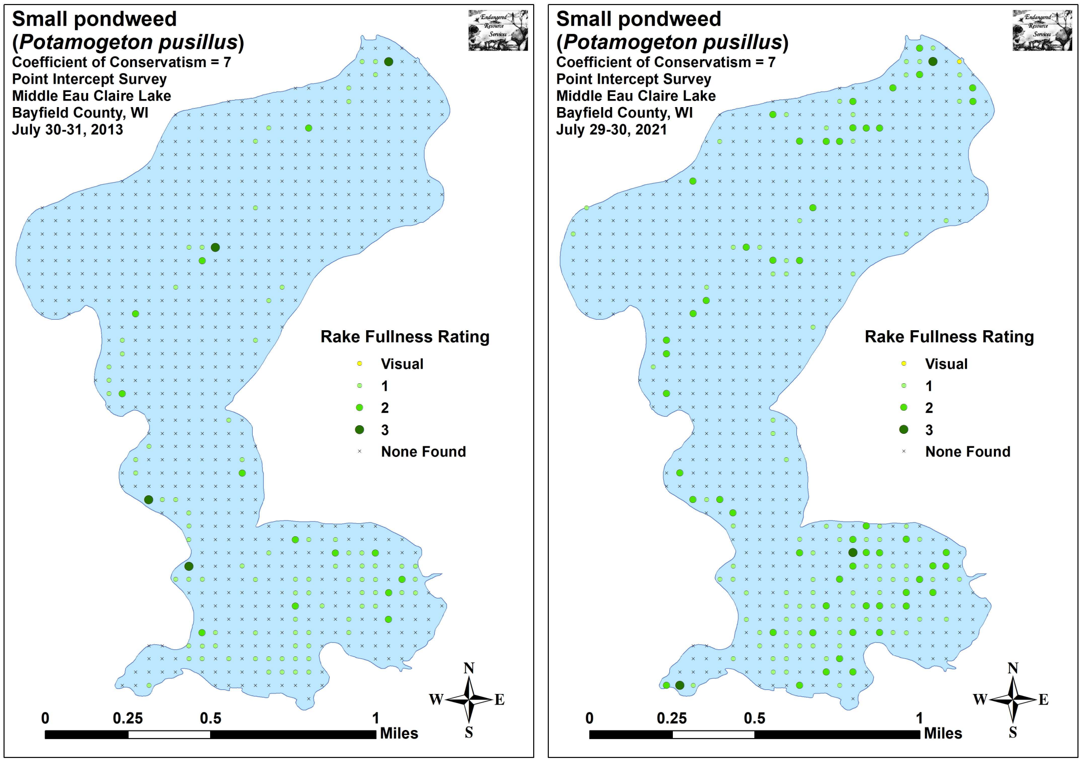
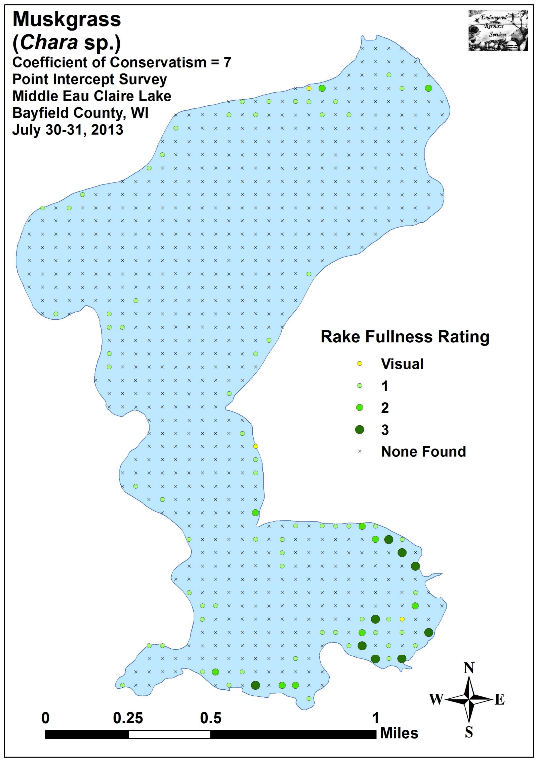


Figure 16: 2013 and 2021 Small Pondweed Density and Distribution

From 2013 to 2021, Muskgrass was little changed in the southern bays, but it saw a significant expansion on the sunken islands of the upper lake (Figure 17). In 2013, we found it at 86 sites with a mean rake fullness of 1.33. Although it increased in both distribution (91 sites) and density (mean rake of 1.44), neither of these changes were significant (p=0.78/p=0.13). Despite these increases, it declined in community rank from the fifth most common species in 2013 to the seventh most common in 2021.

Common waterweed was the sixth-ranked species in 2013 when it was present at 83 sites with a mean rake fullness of 1.17 (Figure 18). In 2021, following moderately significant increases **(p=0.001)/(p=0.003)** in both distribution (126 sites) and density (mean rake of 1.34), it rose to the fourth most common species in the plant community. Visual analysis of the maps showed these increases were lakewide.



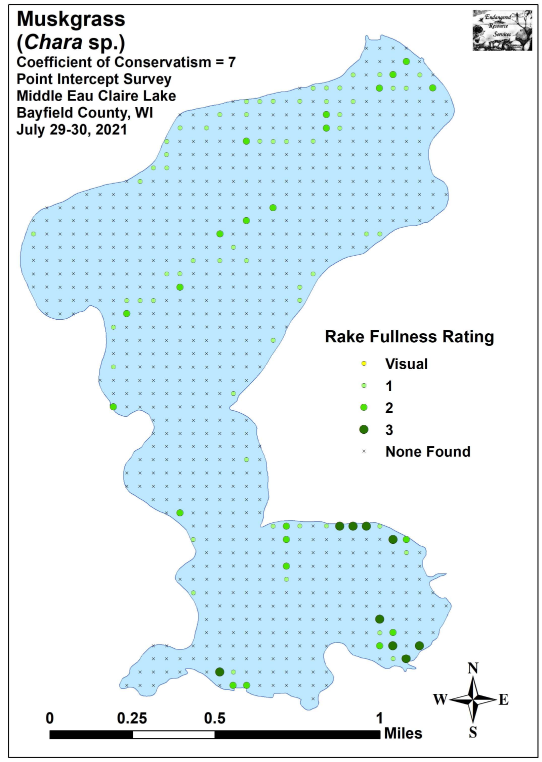
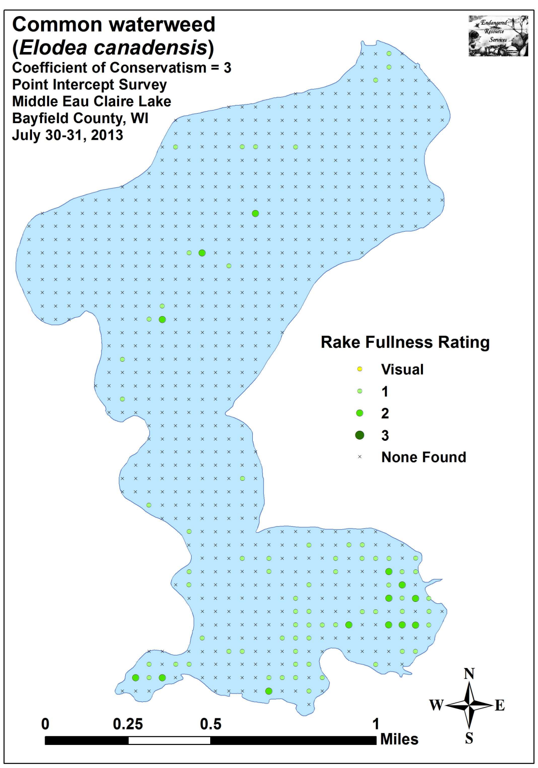


Figure 17: 2013 and 2021 Muskgrass Density and Distribution



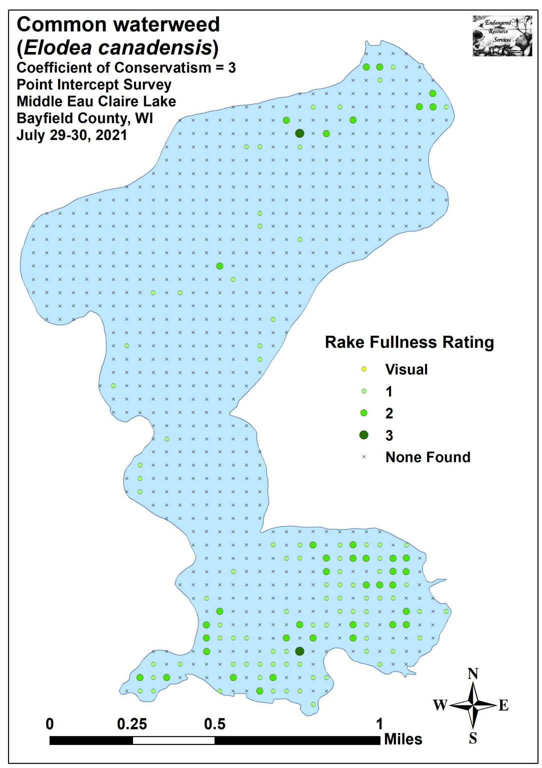


Figure 18: 2013 and 2021 Common Waterweed Density and Distribution

Northern water-milfoil is known to experience dramatic boom/bust population cycles. We identified it as the seventh most widely-distributed species in 2013 when it was present at 80 sites with a mean rake fullness of 1.33 (Figure 19). In 2021, following highly significant increases **(p<0.001)** in both distribution (150 sites) and density (mean rake 1.73), it jumped into a tie with Coontail as the most common species in the plant community. This increase was most pronounced on the midlake bars where milfoil was nearly absent in 2013 but formed significant beds in 2021.

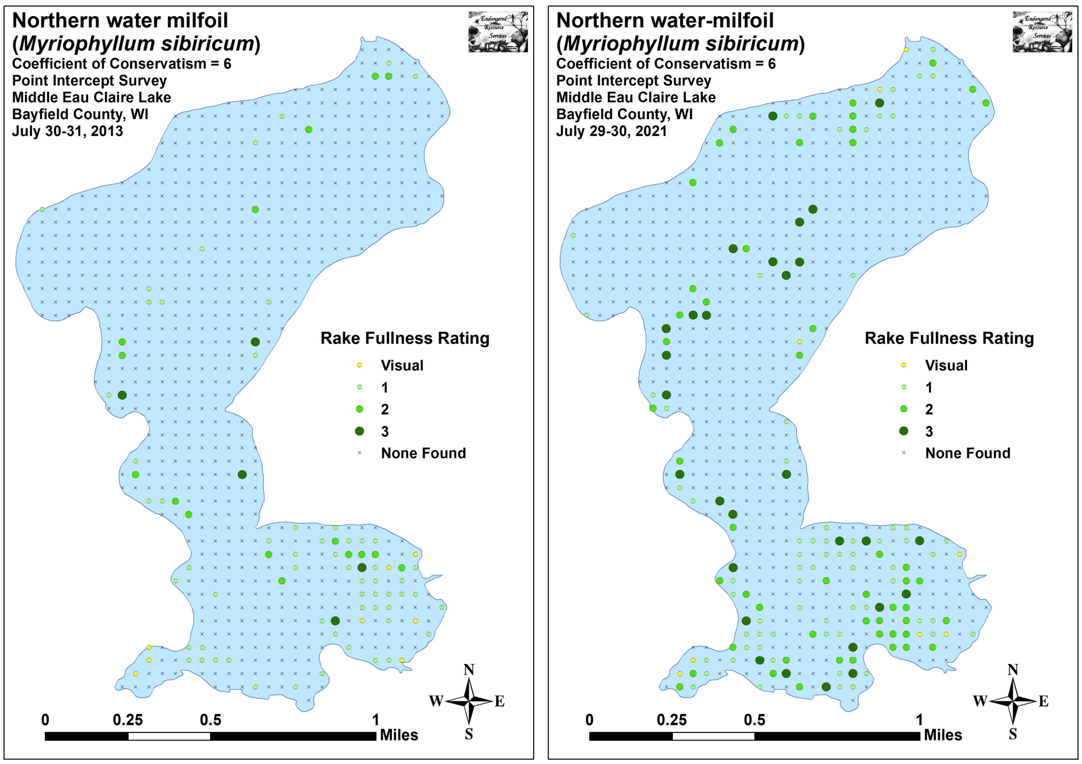


Figure 19: 2013 and 2021 Northern Water-milfoil Density and Distribution

Fern pondweed also saw a highly significant increase **(p<0.001)** in distribution (50 sites in 2013/90 sites in 2021). Despite nearly doubling its coverage, its community rank was almost unchanged as it went from the eight most common species in 2013 to the seventh most common in 2021 (Figure 20). Its density also underwent a significant increase **(p=0.02)** from a mean rake of 1.36 in 2013 to a mean rake of 1.60 in 2021. Almost the entirety of these increases occurred in the southern bays where it often carpeted the bottom.

Although not significant (p=0.11), Nitella was one of the few dominant species that showed any decline in distribution as it fell from the ninth-ranked species in 2013 (47 sites) to just the fourteenth-ranked in 2021 (34 sites) (Figure 21). Its density did, however, significantly increase **(p=0.02)** from a mean rake of 1.15 in 2013 to a mean rake of 1.38 in 2021.

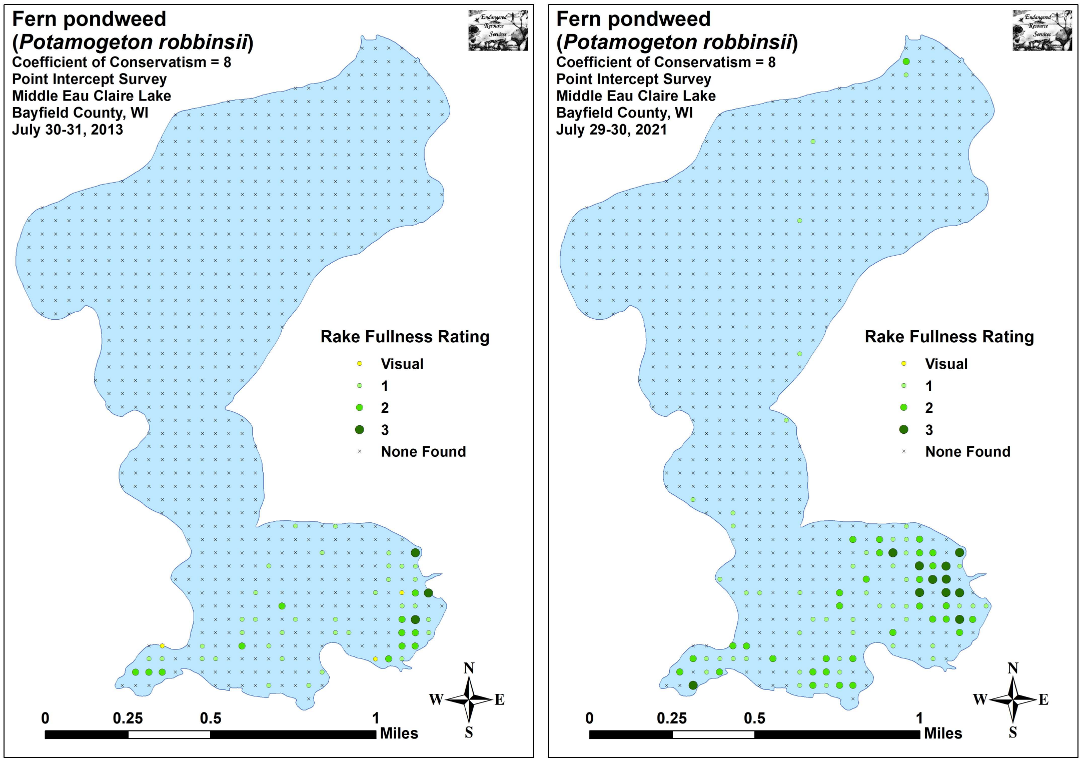


Figure 20: 2013 and 2021 Fern Pondweed Density and Distribution

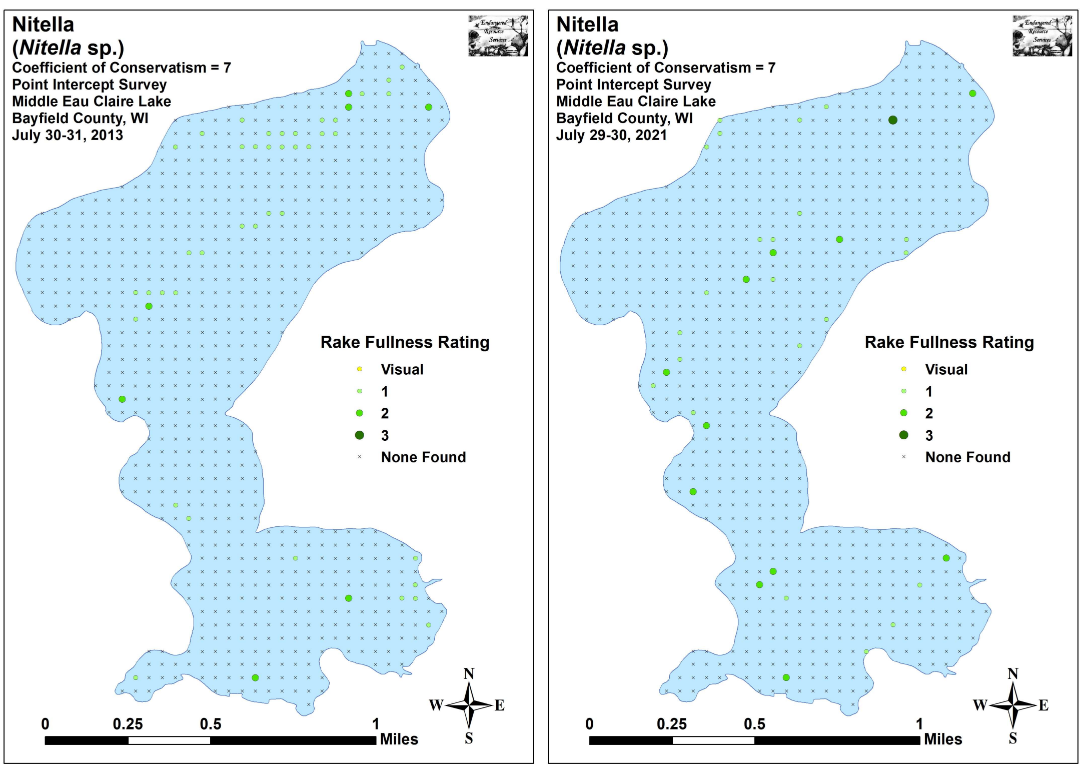


Figure 21: 2013 and 2021 Nitella Density and Distribution

Comparison of Floristic Quality Indexes in 2013 and 2021:

The 2013 point-intercept survey identified a total of 42 **native index plants** in the rake. They produced a mean Coefficient of Conservatism of 6.8 and a Floristic Quality Index of 43.8 (Table 6).

Table 6: Floristic Quality Index of Aquatic Macrophytes Middle Eau Claire Lake – Bayfield County, Wisconsin July 30-31, 2013

Species	Common Name	C
Bidens beckii	Water marigold	8
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elatine minima	Waterwort	9
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Isoetes echinospora	Spiny-spored quillwort	8
Juncus pelocarpus	Brown-fruited rush	8
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	8
Potamogeton alpinus	Alpine pondweed	9
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton foliosus	Leafy pondweed	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton gramineus	Variable pondweed	7
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton natans	Floating-leaf pondweed	5
Potamogeton praelongus	White-stem 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
Ranunculus aquatilis	White water crowfoot	8
Ranunculus flammula	Creeping spearwort	9
Sagittaria cristata	Crested arrowhead	9
Schoenoplectus acutus	Hardstem bulrush	6
Sparganium emersum	Short-stemmed bur-reed	8
Stuckenia pectinata	Sago pondweed	3
Typha latifolia	Broad-leaved cattail	1

Table 6 (continued): Floristic Quality Index of Aquatic Macrophytes Middle Eau Claire Lake – Bayfield County, Wisconsin July 30-31, 2013

Species	Common Name	C
Utricularia intermedia	Flat-leaf bladderwort	9
Utricularia minor	Small bladderwort	10
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		**42**
Mean C		**6.8**
FQI		**43.8**

Our 2021 point-intercept survey found 43 **native index plants** in the rake. They produced a mean Coefficient of Conservatism of 6.8 and a Floristic Quality Index of 44.8 (Table 7). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Middle Eau Claire Lake slightly above average for this part of the state. The FQI was, however, nearly double the median FQI of 24.3 for the Northern Lakes and Forest Region (Nichols 1999). Eight exceptionally high-value index plants of note included Spiny hornwort (C = 10), Waterwort (C = 9), Dwarf water-milfoil (C = 10), Alpine pondweed (C = 9), Grass-leaved arrowhead (C = 9), Creeping bladderwort (C = 9), Flat-leaf bladderwort (C = 9), and Small bladderwort (C = 10). Two other high-value species found were either not part of the index – Narrow-leaved wooly sedge (C = 9) – or they were only seen as a visual – Water bulrush (C = 9).

Table 7: Floristic Quality Index of Aquatic Macrophytes Middle Eau Claire Lake – Bayfield County, Wisconsin July 29-30, 2021

Species	Common Name	C
Bidens beckii	Water marigold	8
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Ceratophyllum echinatum	Spiny hornwort	10
Chara sp.	Muskgrass	7
Elatine minima	Waterwort	9
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Juncus pelocarpus f. submersus	Brown-fruited rush	8
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum tenellum	Dwarf water-milfoil	10
Myriophyllum verticillatum	Whorled water-milfoil	8
Najas flexilis	Slender naiad	6

Table 7 (continued): Floristic Quality Index of Aquatic Macrophytes
Middle Eau Claire Lake – Bayfield County, Wisconsin
July 29-30, 2021

Species	Common Name	C
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	8
Potamogeton alpinus	Alpine pondweed	9
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton foliosus	Leafy pondweed	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton gramineus	Variable pondweed	7
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton natans	Floating-leaf pondweed	5
Potamogeton praelongus	White-stem 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
Ranunculus aquatilis	White water crowfoot	8
Sagittaria graminea	Grass-leaved arrowhead	9
Schoenoplectus acutus	Hardstem bulrush	6
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Utricularia gibba	Creeping bladderwort	9
Utricularia intermedia	Flat-leaf bladderwort	9
Utricularia minor	Small bladderwort	10
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		**43**
Mean C		**6.8**
FQI		**44.8**

Comparison of Filamentous Algae in 2013 and 2021:

Filamentous algae are normally associated with excessive nutrients in the water column from such things as runoff, internal nutrient recycling, and failed septic systems. In 2013, these algae were located at 31 points with a mean rake fullness of 1.42 (Figure 22). The 2021 survey documented a highly significant increase **(p<0.001)** in distribution (96 points), but a non-significant increase (p=0.22) in density (mean rake fullness of 1.51). These points were scattered throughout the entire lake suggesting the nutrients feeding this growth are not from a single source.

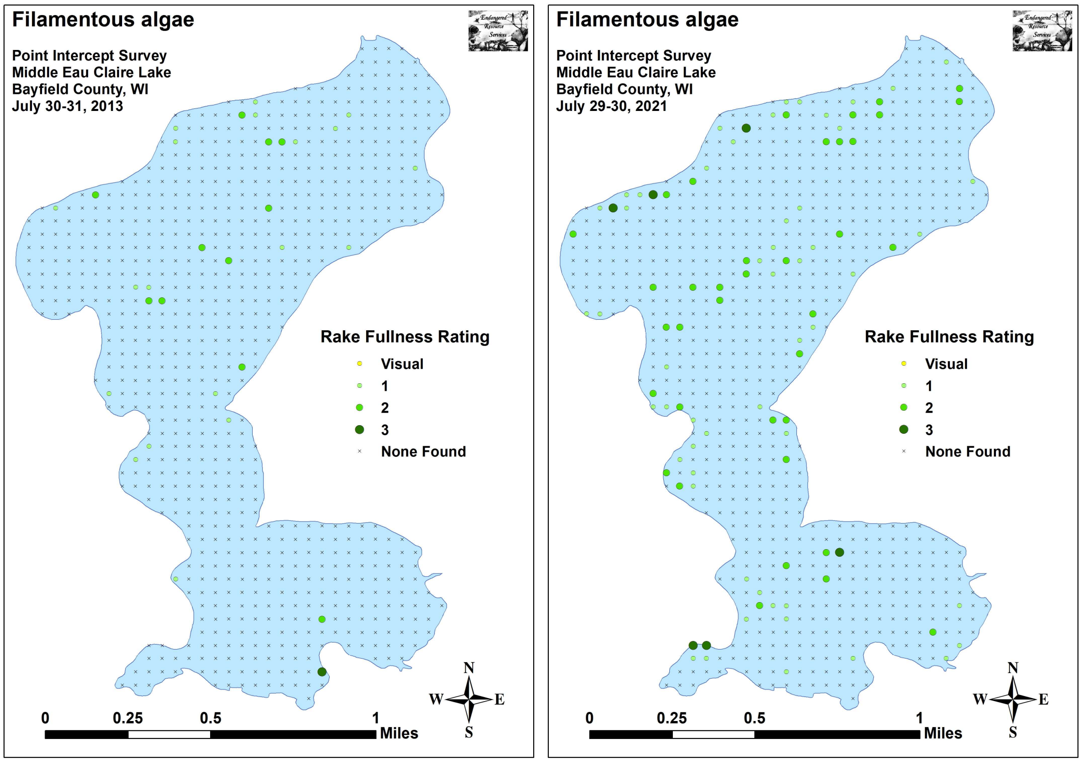


Figure 22: 2013 and 2021 Filamentous Algae Density and Distribution

Comparison of Late Summer Curly-leaf Pondweed in 2013 and 2021:

Curly-leaf pondweed normally completes its annual life cycle by late June, and most plants have set turions and senesced by early July. During our 2013 survey, we only recorded CLP as a visual at a single point. In 2021, CLP was present at two points (both with a rake fullness of 1) with one additional visual sighting (Figure 23) (Appendix VII).

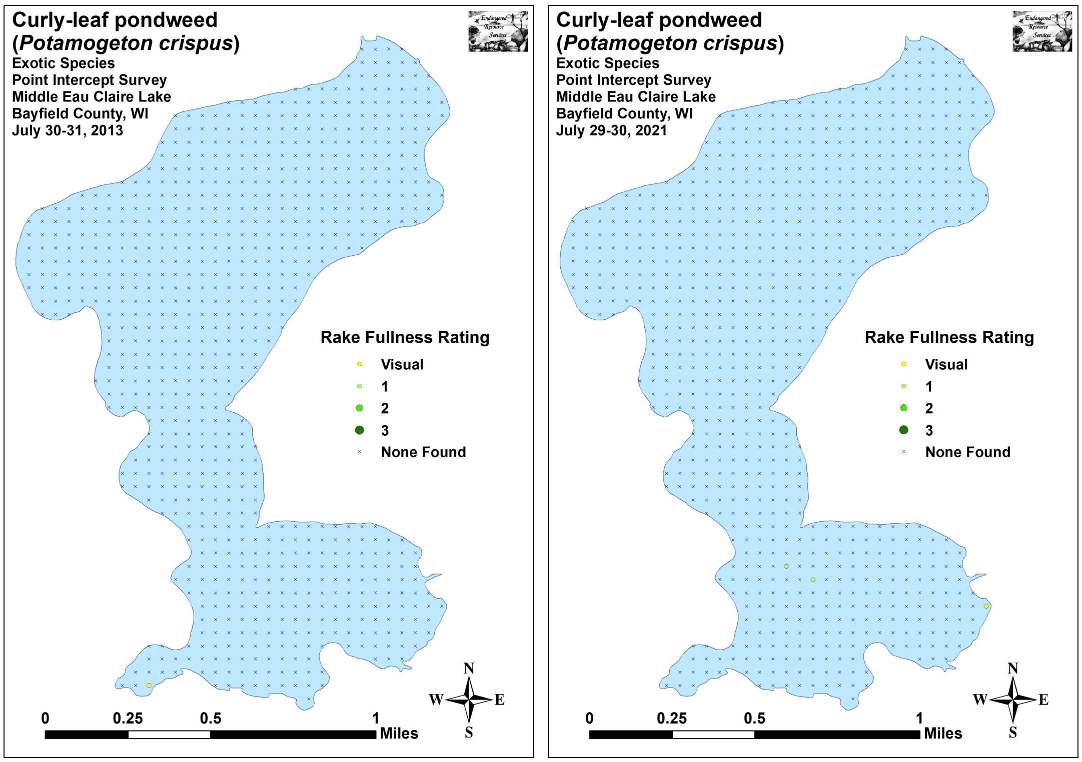


Figure 23: 2013 and 2021 Late Summer CLP Density and Distribution

Other Exotic Plant Species:

We did NOT find any evidence or Eurasian water-milfoil in Middle Eau Claire Lake during any of our surveys. However, in addition to Curly-leaf pondweed, we documented five other exotic species growing in or immediately adjacent to the lake: Horseradish, Common forget-me-not, Arrow arum, Reed canary grass, and Hybrid cattail.

A few clusters of Horseradish were located on the immediate shoreline southwest of the Crosswinds Resort and Campground. We also noted several clusters growing away from the lake that were in bloom (Figure 24) (Appendix VII).

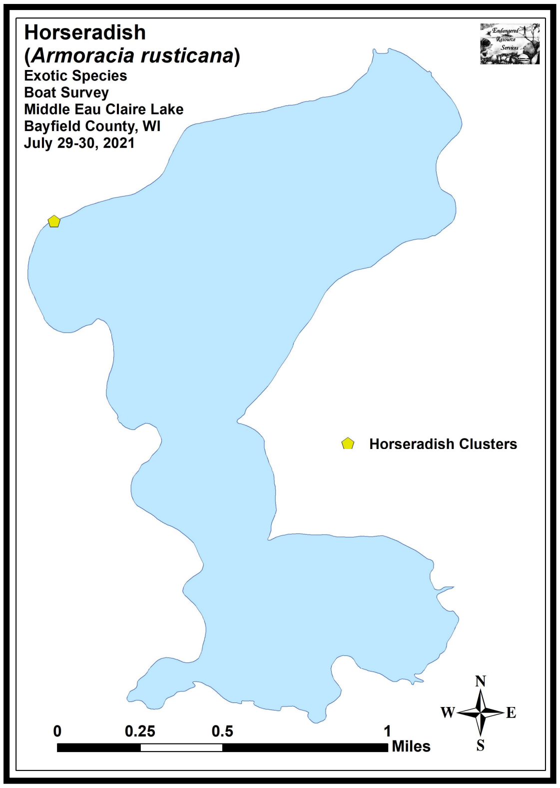


Figure 24: Horseradish Distribution and Inflorescence

Along the shoreline at the public boat landing in the lake's southeast bay, we found several patches of Common forget-me-not and Reed canary grass (Figure 25) (Appendix VII). Forget-me-nots were present in a small, shaded area where a cold-water spring was trickling in at the shoreline. As this type of preferred habitat appears to be rare on the lake, it is unlikely this species will ever be common or a cause for concern.

Despite only being found at the boat landing, Reed canary grass is capable of being highly invasive (Figure 25) (Appendix VII). A ubiquitous plant in the state, there's likely little that can be done about it beyond maintaining native vegetation and minimizing shoreline disturbance.

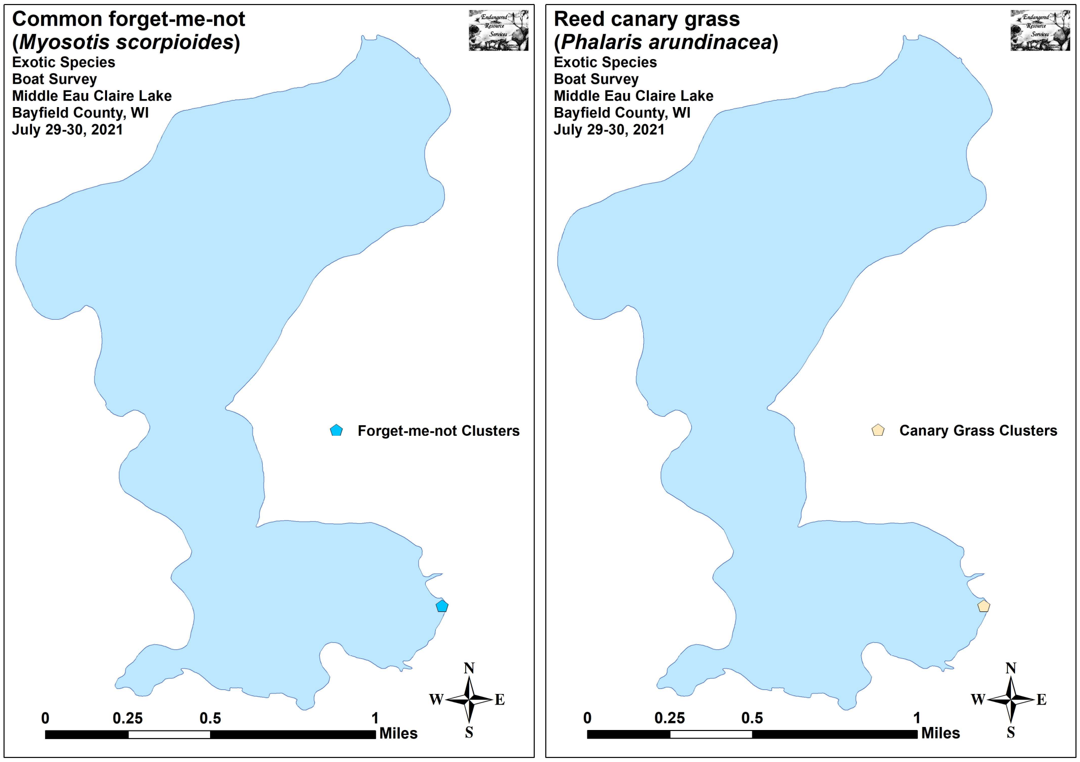


Figure 25: Common Forget-me-not and Reed Canary Grass Distribution

In Hole-in-the-Wall Bay on the lake's southwest side, we found a large cluster of Arrow arum with a few satellite plants growing at the immediate shoreline on the bay's north side. On the bay's south side, we documented a small patch of Hybrid cattail (Figure 26) (Appendix VII).

Native to southern but not northern Wisconsin, Narrow-leaved cattail and its hybrids with Broad-leaved cattail are becoming increasingly common in Bayfield County where they also tend to be invasive. Besides having narrower leaves, the exotics can be told from our native cattails by having a relatively narrower and longer "hotdog-shaped" tan female cattail flower, whereas our native species tends to produce a fatter and shorter "bratwurst-shaped" dark chocolate colored female flower. Narrow-leaved cattail and its hybrids also have a male flower that is separated from the female flower by a thin green stem while the native Broad-leaved cattail has its male and female flowers connected (Figure 27) (For more information on a sampling of aquatic exotic plant species, see Appendix VIII).

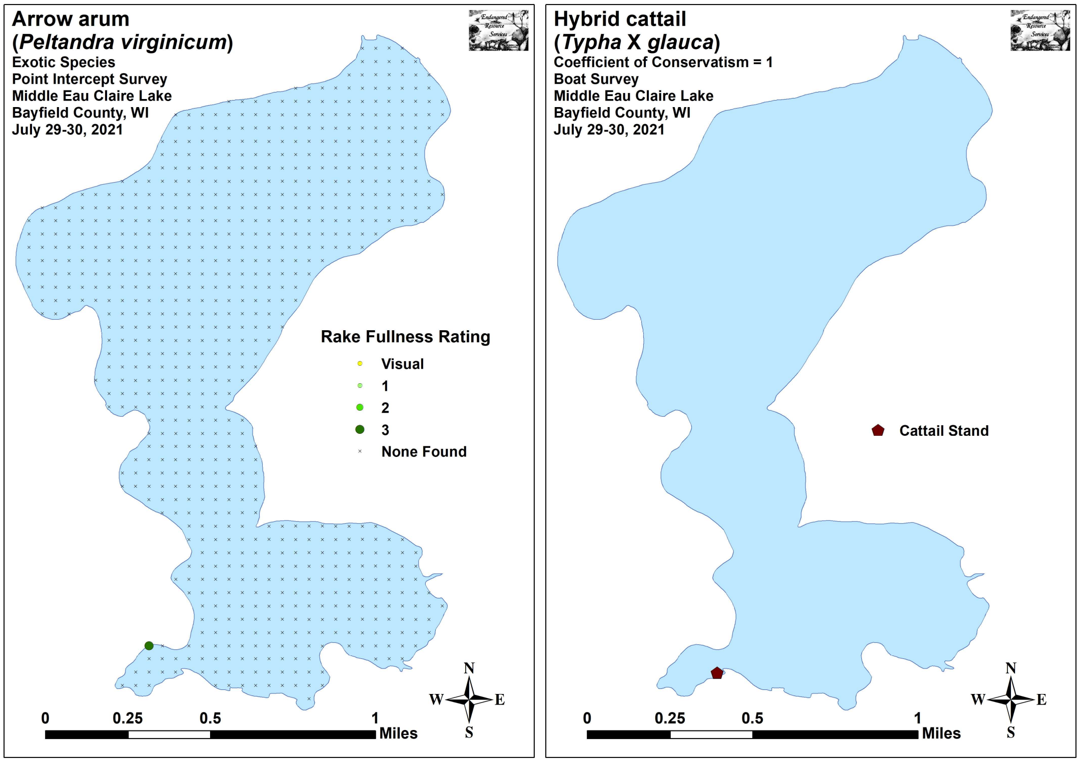


Figure 26: Arrow Arum and Hybrid Cattail Distribution

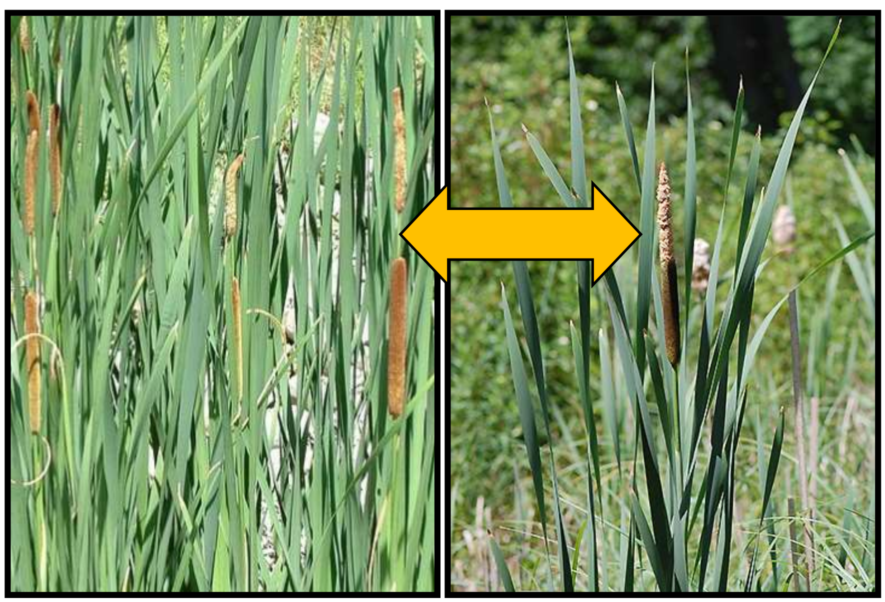


Figure 27: Exotic Hybrid and Native Broad-leaved Cattail Identification

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Native Aquatic Macrophytes:

Middle Eau Claire Lake is home to a healthy native plant community that is dominated by many high-value species that are sensitive to human disturbance. 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. Over the past 50 years, water quality data collected by volunteers shows a history of consistently good clarity. This is probably not a coincidence. Rather, it is likely at least partially tied to the work done by conservation-minded people. Their native vegetation buffers along much of the lake's shoreline 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, even a small 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 28), 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 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.

Figure 28: Model Natural Shoreline on a Nearby Northwest Wisconsin Lake

Curly-leaf pondweed Management:

Curly-leaf pondweed continues to play only a minor role in the Middle Eau Claire Lake ecosystem, and, even when present, it is seldom dense enough to cause even minor navigation impairment. Currently, the "BAISS" harvesting program appears to be mostly keeping the CLP population in check while simultaneously having minimal impact on the lake's rich and diverse native plant community. As long as running the harvester remains a viable management option, it will likely continue to be the most environmentally friendly method of controlling CLP.

In the future, if suction harvesting is discontinued or if isn't possible to get to all of the CLP beds with the time available and the TOB again considers chemical control, we strongly encourage a measured approach that is closely evaluated. CLP is an opportunistic species that can rapidly exploit disturbed areas. As herbicides eliminate native vegetation as well as the target species, it is possible that CLP could rapidly reestablish in the treatment areas and ultimately become worse rather than better.

Regardless of what, if any, future active management occurs on the lake, we remind lakeshore residents that they can help minimize CLP's opportunities to spread by maintaining the lake's native plants. To accomplish this, residents should refrain from removing rooted plants from the lake unless absolutely necessary as these barren patches of substrate not only release nutrients into the water column, but also give CLP a place to establish where it has a competitive advantage. Avoiding motor start-ups in water <5ft deep would also help limit CLP's spread by not clipping or uprooting vegetation. This would also work to keep nutrients out of the water column as the lake's soft sediments are easily stirred up by prop wash.

Horseradish and Arrow Arum Management:

Although generally not considered invasive, the small patch of Horseradish should likely be removed before it spreads. The plants were quite large at the time of the survey, and they were already in bloom.

Following a discussion with shareholders, it seems that the potential concern of Arrow Arum being invasive likely outweighs the fact that is a native plant in the United States. Based on our experience with this species in other lakes where it has completely taken over shorelines, removing the clusters present and monitoring for it in the future are likely prudent management decisions.

Exotic Cattail Management:

All of Wisconsin's cattails have wildlife value as many bird species nest in them, and muskrats and a variety of insects use them as food. Because Narrow-leaved cattail and its hybrids can be invasive along the shoreline to the point that they interfere with lake access, property owners may want to remove pioneering individuals before they become a bed. However, unless they are interfering with human activity, removing previously established stands is probably unnecessary and unlikely to be ecologically beneficial. Because cattail seeds are transported by the wind, the continued expansion of this species in northern Wisconsin is likely inevitable.

Aquatic Invasive Species Prevention:

The lake's active Clean Boats/Clean Water Program appears to be a model as there were diligent workers on duty every time we launched on the lake. In addition to the education and reeducation they offer to residents and visitors alike, the physical checking of incoming/outgoing boats provides an important safeguard for the lake. Because of this, continuing the program is strongly encouraged.

LITERATURE CITED

Borman, S., R. Korth, and J. Temte 1997. Through the Looking Glass…A Field Guide to Aquatic Plants. Wisconsin Lakes Partnership. DNR publication FH-207-97.

Chadde, Steve W. 2002. A Great Lakes Wetland Flora: A complete guide to the aquatic and wetland plants of the Upper Midwest. Pocketflora Press; 2nd edition

Crow, G. E., C. B. Hellquist. 2005. Aquatic and Wetland Plants of Northeastern North America, Volume I + II: A Revised and Enlarged Edition of Norman C. Fassett's A Manual of Aquatic Plants. University of Wisconsin Press.

Hopke, R., M. Perkin, L. Sather, and C. Holt. [online]. 1964. Middle Eau Claire Lake Map. Available from: http://dnr.wi.gov/lakes/maps/DNR/2742100a.pdf (2021, November).

Nichols, Stanley A. 1999. Floristic Quality Assessment of Wisconsin Lake Plant communities with Example Applications. Journal of Lake and Reservoir Management 15 (2): 133-141.

Skawinski, Paul. 2019. Aquatic Plants of the Upper Midwest: A photographic field guide to our underwater forests. 4th Edition, Wausau, WI.

Sullman, Josh. [online] 2010. Sparganium of Wisconsin Identification Key and Description. Available from University of Wisconsin-Madison http://www.botany.wisc.edu/jsulman/Sparganium%20identification%20key%20and%20description.htm (2012, August).

UWEX Lakes Program. [online]. 2010. Aquatic Plant Management in Wisconsin. Available from http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/aquaticplants/default.aspx (2021, November).

UWEX Lakes Program. [online]. 2010. Pre/Post Herbicide Comparison. Available from http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic%20Plants/Appendix-D.pdf (2021, November).

Voss, Edward G. 1996. Michigan Flora Vol I-III. Cranbrook Institute of Science and University of Michigan Herbarium.

WDNR. [online]. 2010. Curly-leaf pondweed fact sheet. http://dnr.wi.gov/invasives/fact/curlyleaf_pondweed.htm (2010, August).

WDNR. [online]. 2010. Eurasian Water-milfoil fact sheet. http://dnr.wi.gov/invasives/fact/milfoil.htm (2010, August).

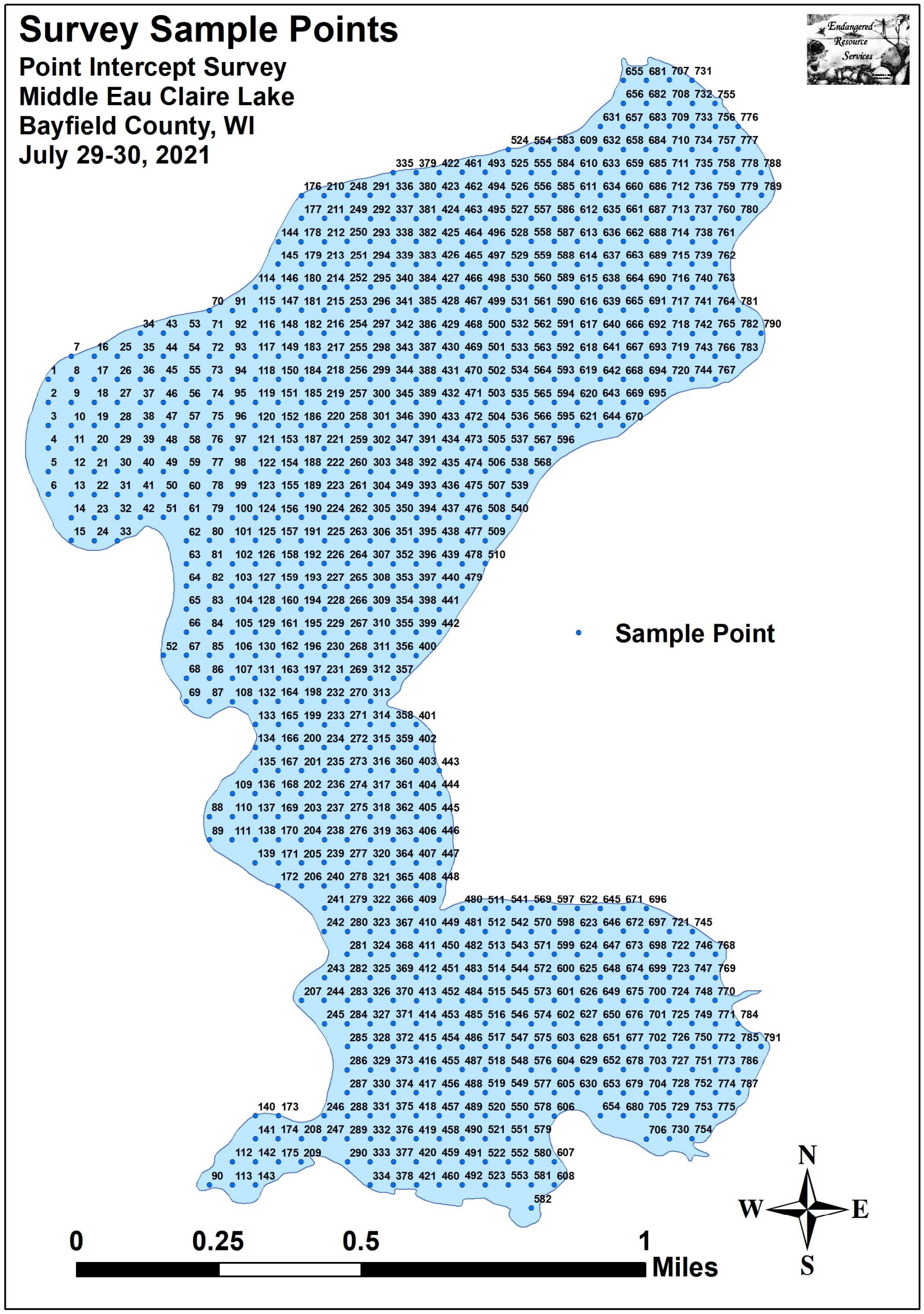
WDNR. [online]. 2010. Purple loosestrife fact sheet. http://dnr.wi.gov/invasives/fact/loosestrife.htm (2010, August).

WDNR. [online]. 2010. Reed canary grass fact sheet. http://dnr.wi.gov/invasives/fact/reed_canary.htm (2010, August).

WDNR. [online]. 2021. Wisconsin Lake Citizen Monitoring Data for Middle Eau Claire Lake Bayfield County. Available from https://dnr.wi.gov/lakes/waterquality/Station.aspx?id=043035 (2021, November).

WDNR. [online]. 2021. Wisconsin Lakes Information – Middle Eau Claire Lake. https://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2742100 (2021, November).

Appendix I: Survey Sample Points Map

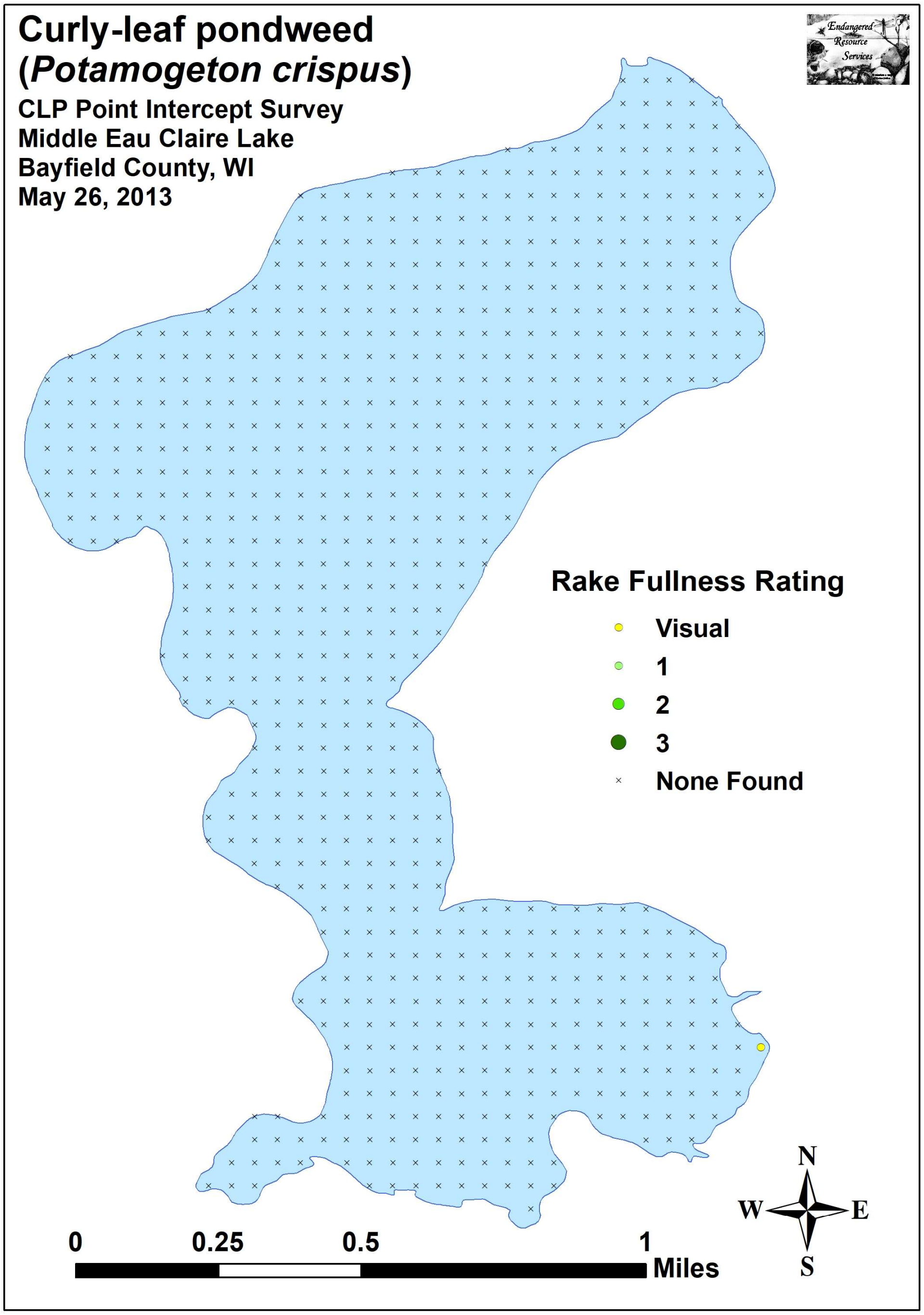

Survey Sample Points
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Sample Point
0
0.25
0.5
1
Miles
N
S
W
E

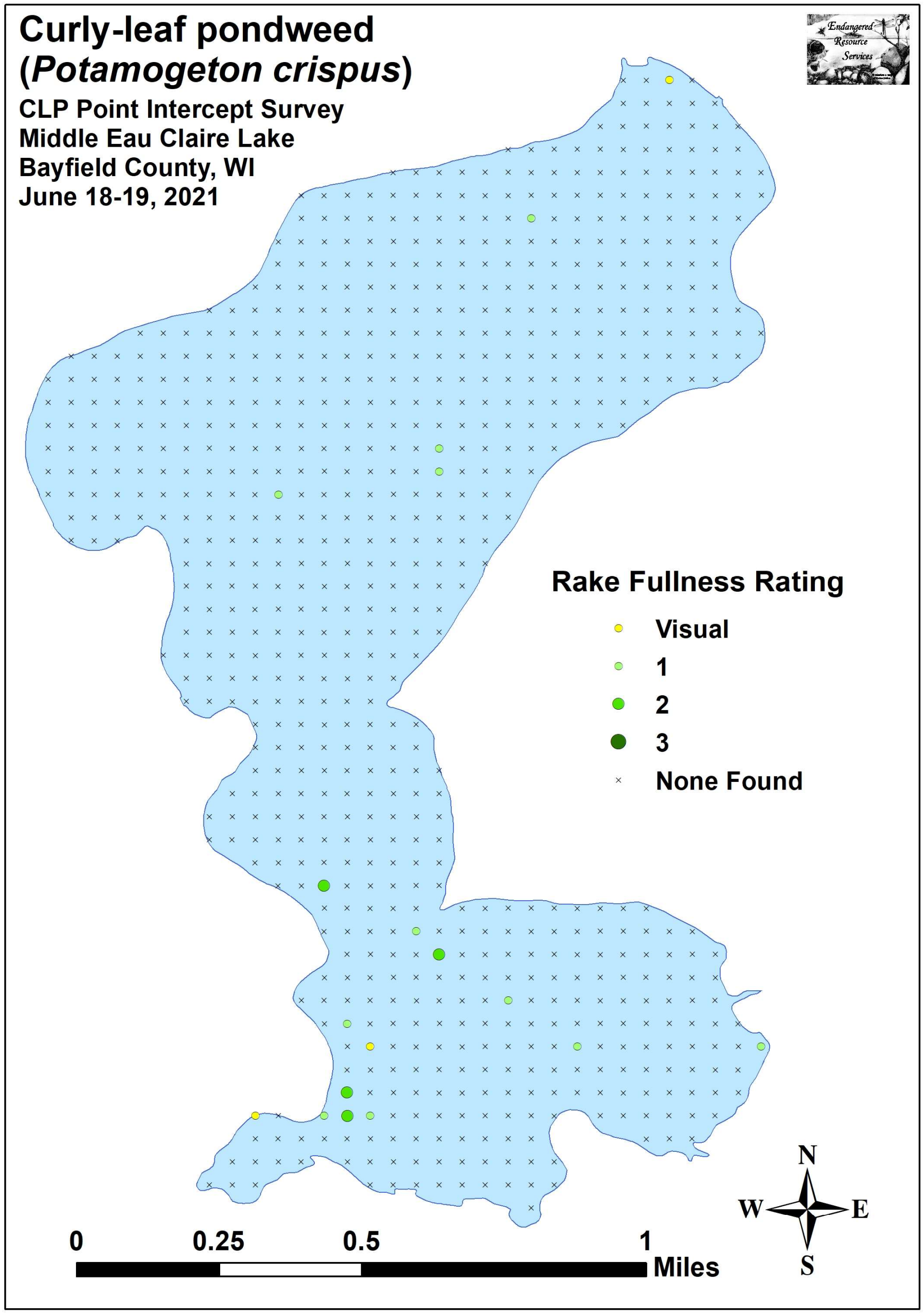
Appendix II: Boat and Vegetative Survey Datasheets

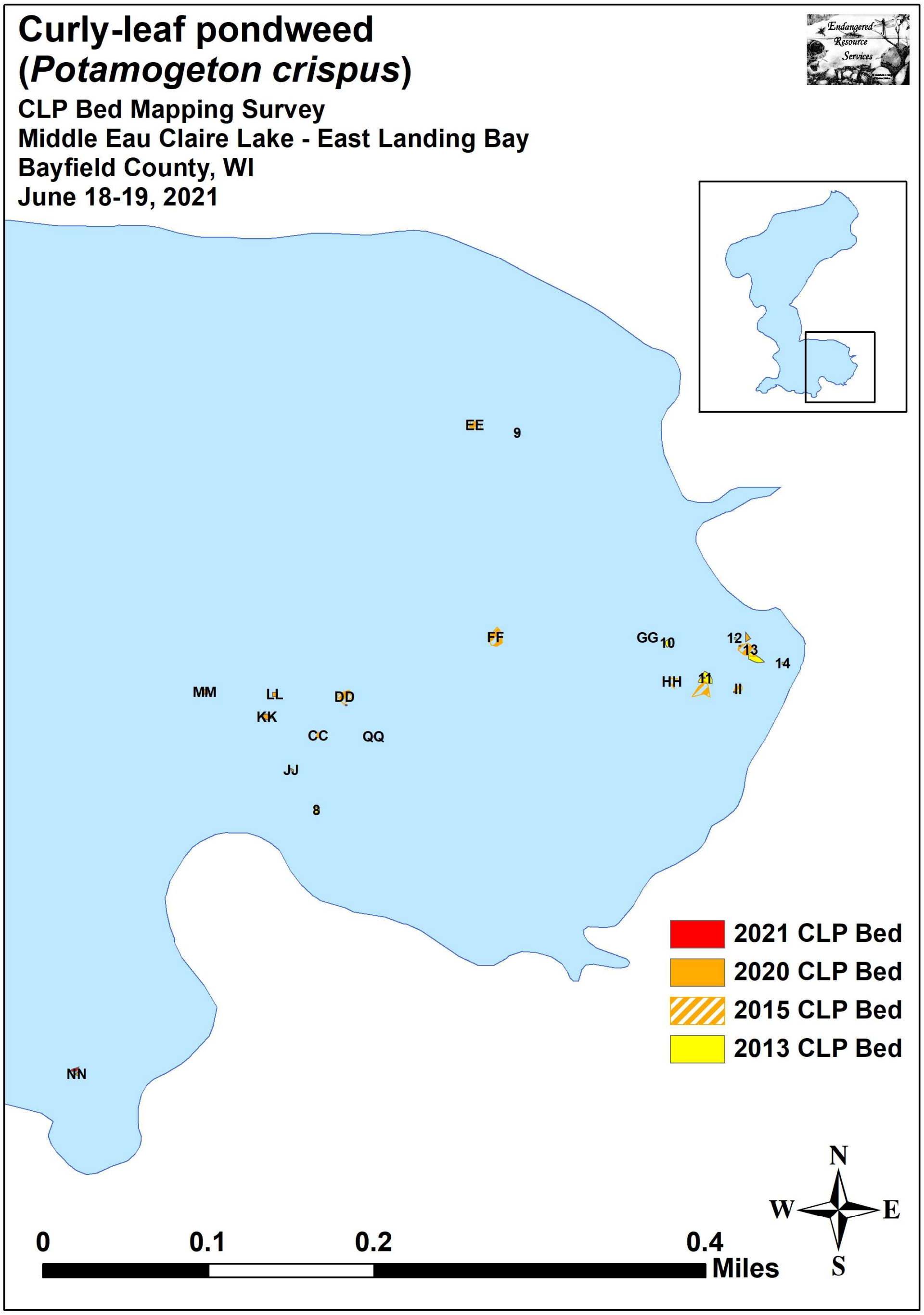
Boat Survey	
Lake Name	
County	
WBIC	
Date of Survey	
(mm/dd/yy)	
workers	
Nearest Point	Species seen, habitat information

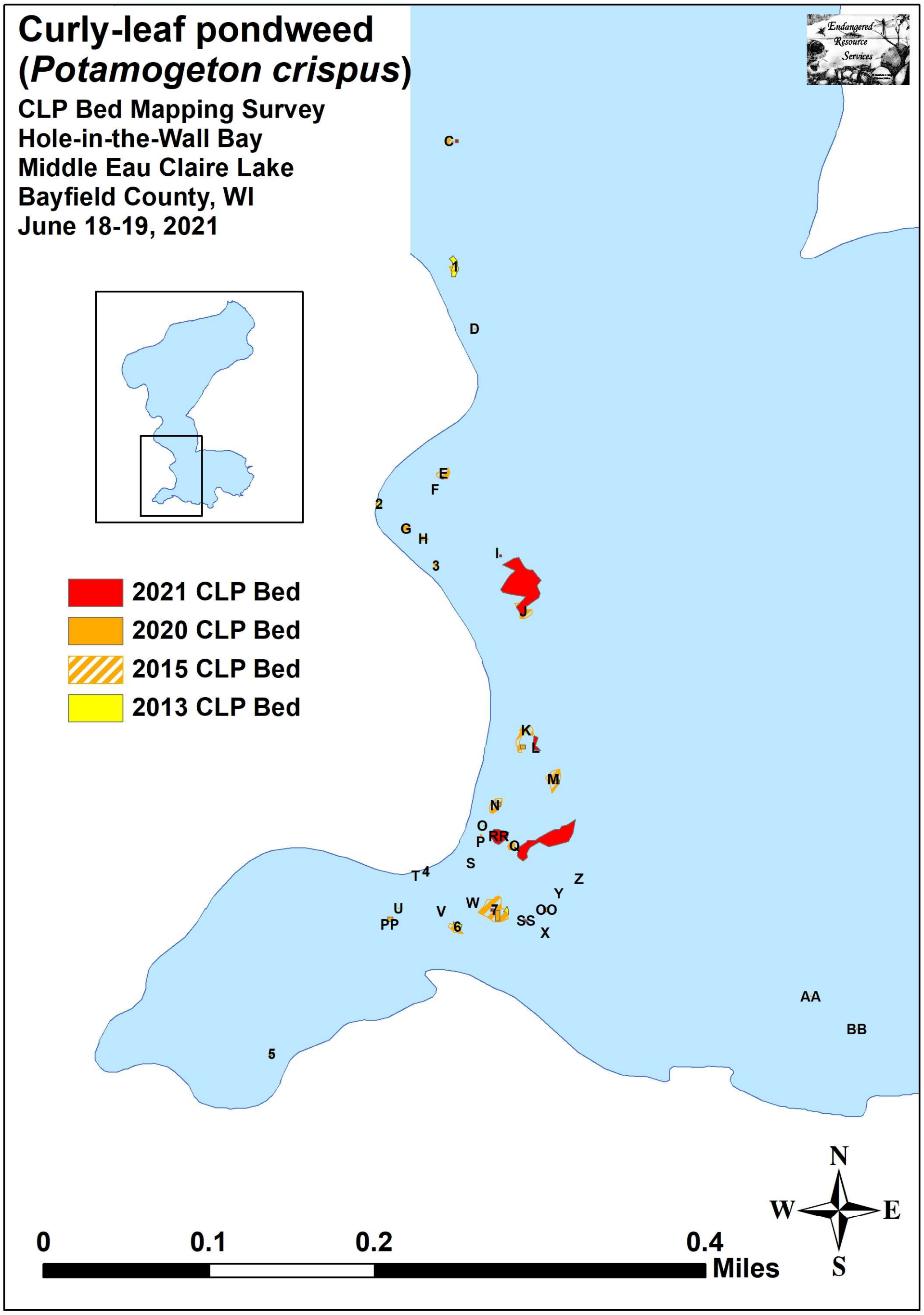
Observers for this lake: names and hours worked by each:																									
Lake:									WBIC									County						Date:	
Site #	Depth (ft)	Muck (M), Sand (S), Rock (R)	Rake pole (P) or rake rope (R)	Total Rake Fullness	EWM	CLP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1																	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

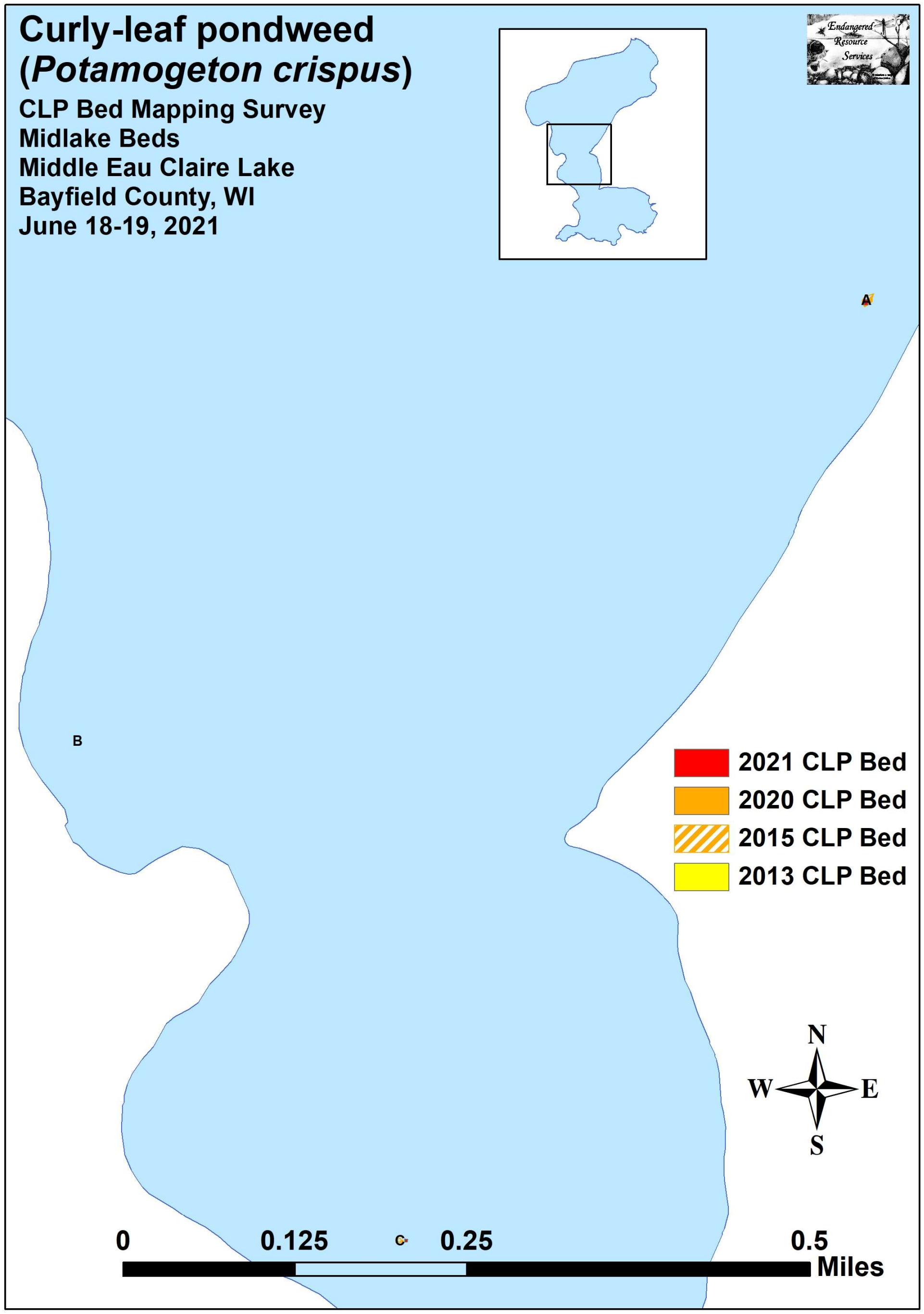
Appendix III: 2013 and 2021 Early Season Curly-leaf Pondweed Density and Distribution, and 2013, 2015, 2020, and 2021 CLP Bed Maps

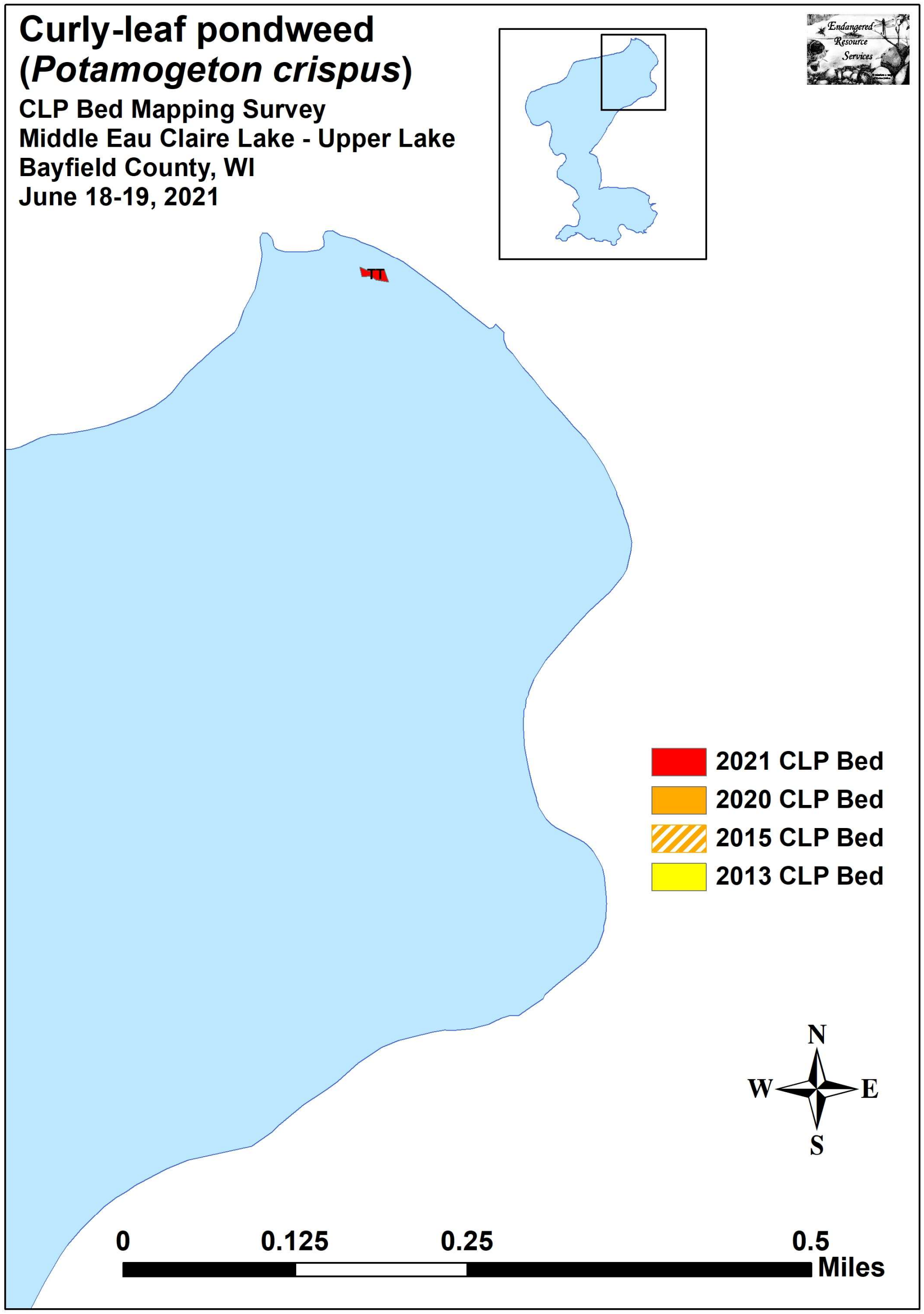

Curly-leaf pondweed
(Potamogeton crispus)
CLP Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
May 26, 2013
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Curly-leaf pondweed
(Potamogeton crispus)
CLP Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
June 18-19, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S


Curly-leaf pondweed
(*Potamogeton crispus*)
CLP Bed Mapping Survey
Middle Eau Claire Lake - East Landing Bay
Bayfield County, WI
June 18-19, 2021
EE
9
FF
GG
10
12
13
14
HH
11
II
MM
LL
DD
KK
CC
QQ
JJ
8
NN
2021 CLP Bed
2020 CLP Bed
2015 CLP Bed
2013 CLP Bed
N
W
E
S
0
0.1
0.2
0.4
Miles

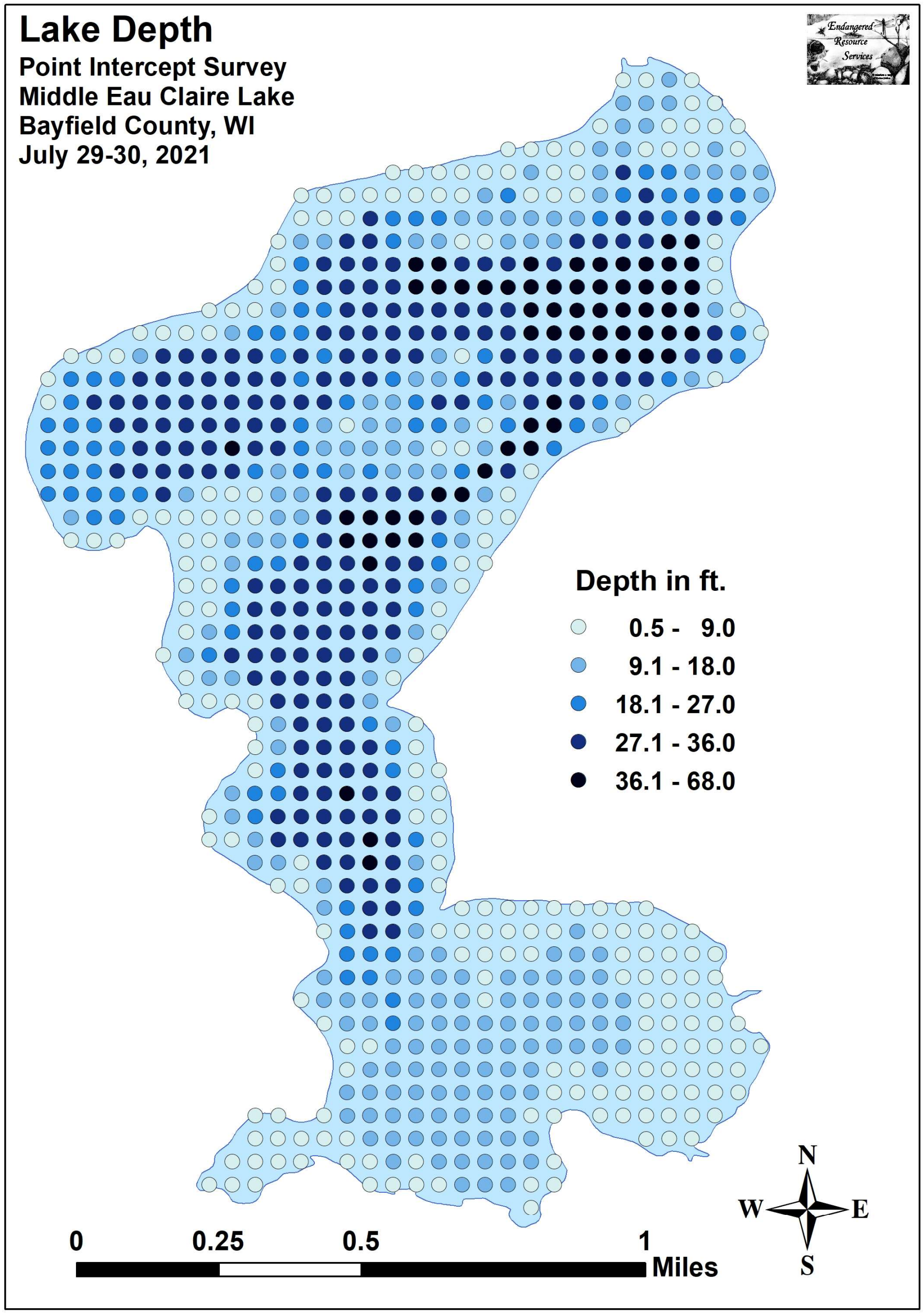

Curly-leaf pondweed
(Potamogeton crispus)
CLP Bed Mapping Survey
Hole-in-the-Wall Bay
Middle Eau Claire Lake
Bayfield County, WI
June 18-19, 2021
Endangered Resource Services
2021 CLP Bed
2020 CLP Bed
2015 CLP Bed
2013 CLP Bed
C
1
D
E
F
2
G
H
3
I
J
K
L
M
N
O
P
RR
Q
S
T
4
U
PP
V
6
W
7
SS
OO
X
Y
Z
AA
BB
5
N
W
E
S
0
0.1
0.2
0.4
Miles

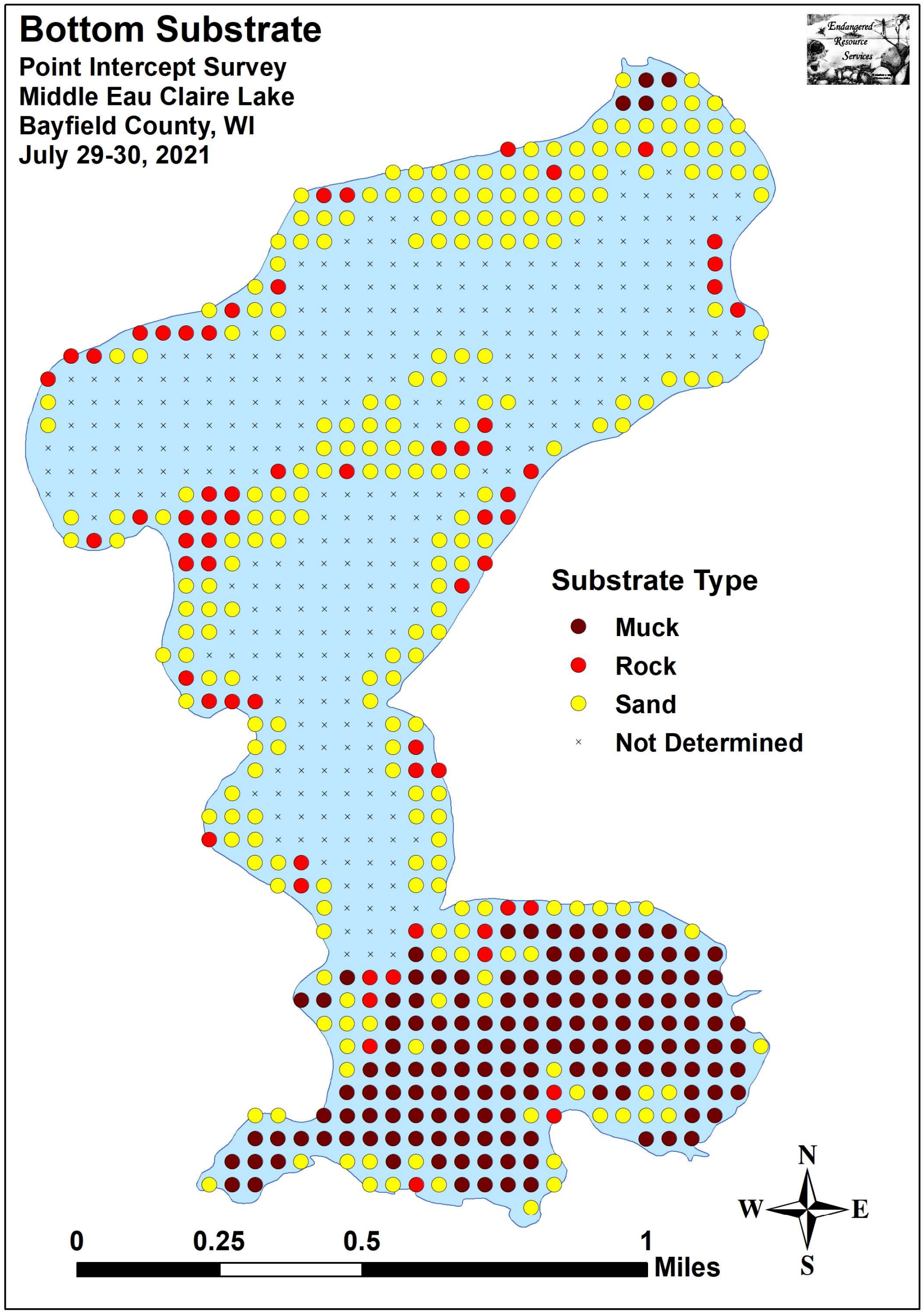

Curly-leaf pondweed
(Potamogeton crispus)
CLP Bed Mapping Survey
Midlake Beds
Middle Eau Claire Lake
Bayfield County, WI
June 18-19, 2021
A
B
C
2021 CLP Bed
2020 CLP Bed
2015 CLP Bed
2013 CLP Bed
N
W
E
S
0
0.125
0.25
0.5
Miles



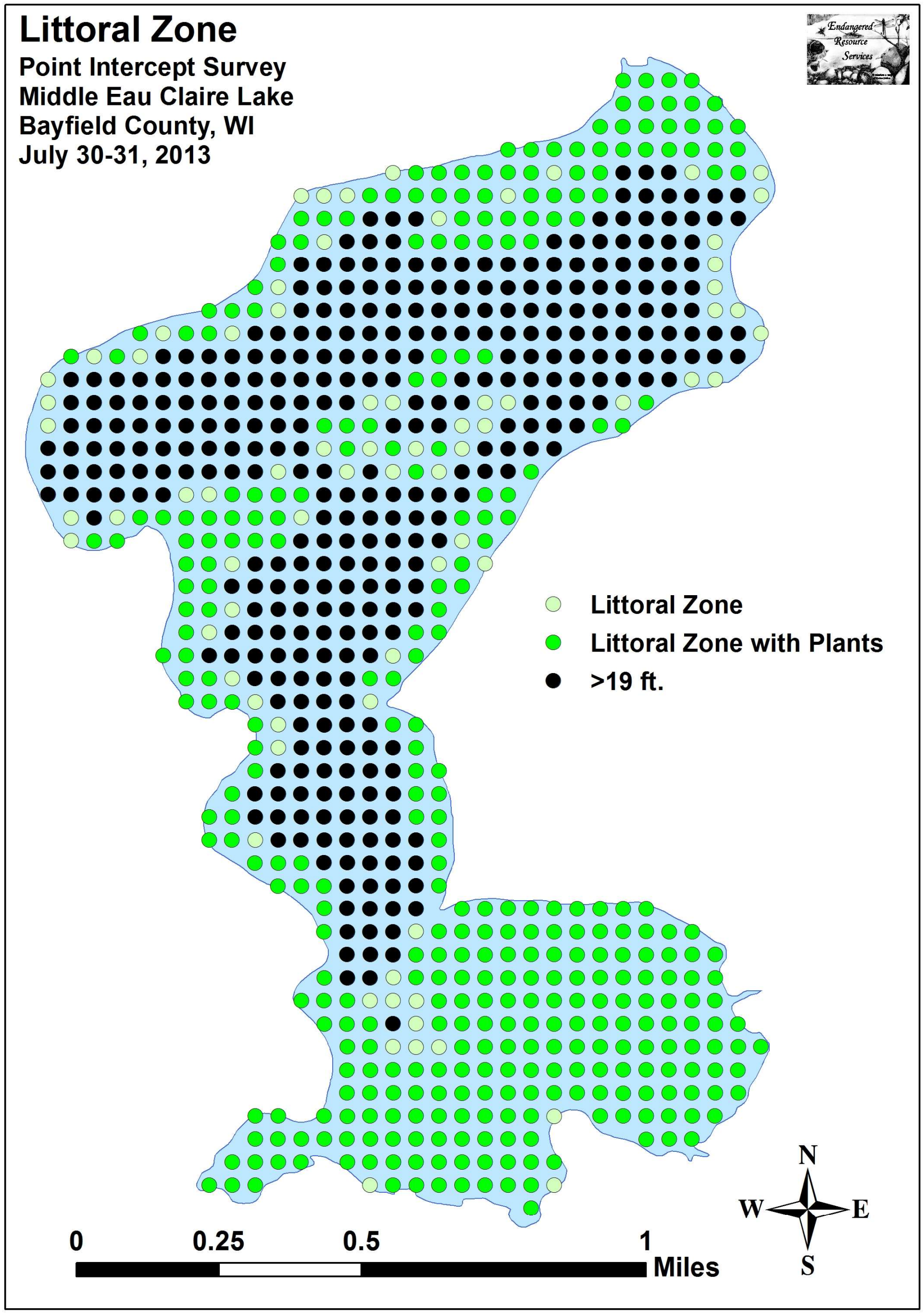
Curly-leaf pondweed
(Potamogeton crispus)
CLP Bed Mapping Survey
Middle Eau Claire Lake - Upper Lake
Bayfield County, WI
June 18-19, 2021
Endangered Resource Services
2021 CLP Bed
2020 CLP Bed
2015 CLP Bed
2013 CLP Bed
N
W
E
S
0
0.125
0.25
0.5
Miles

Appendix IV: Habitat Variable Maps

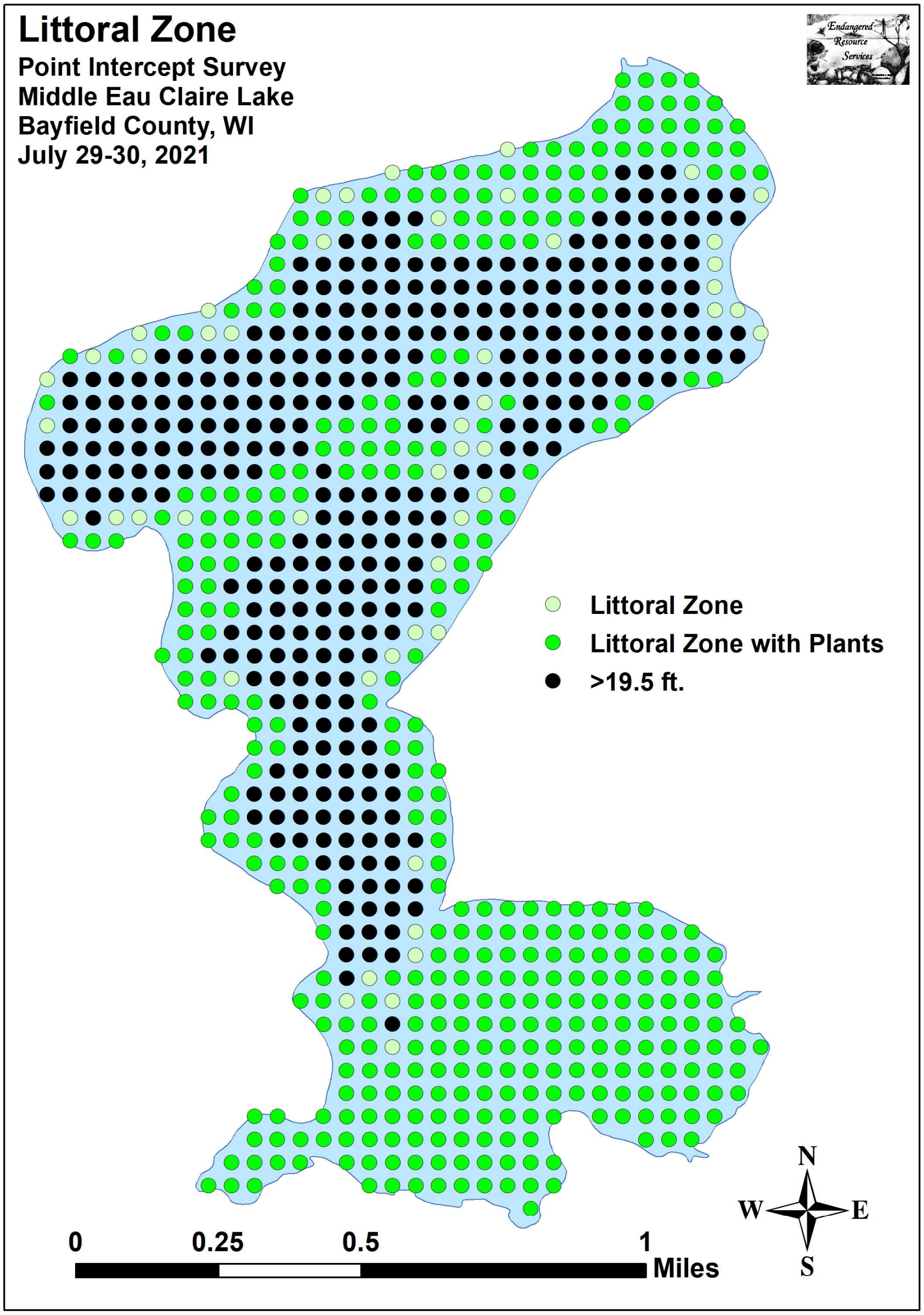

Lake Depth
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Depth in ft.
0.5 - 9.0
9.1 - 18.0
18.1 - 27.0
27.1 - 36.0
36.1 - 68.0
0
0.25
0.5
1
Miles
N
W
E
S

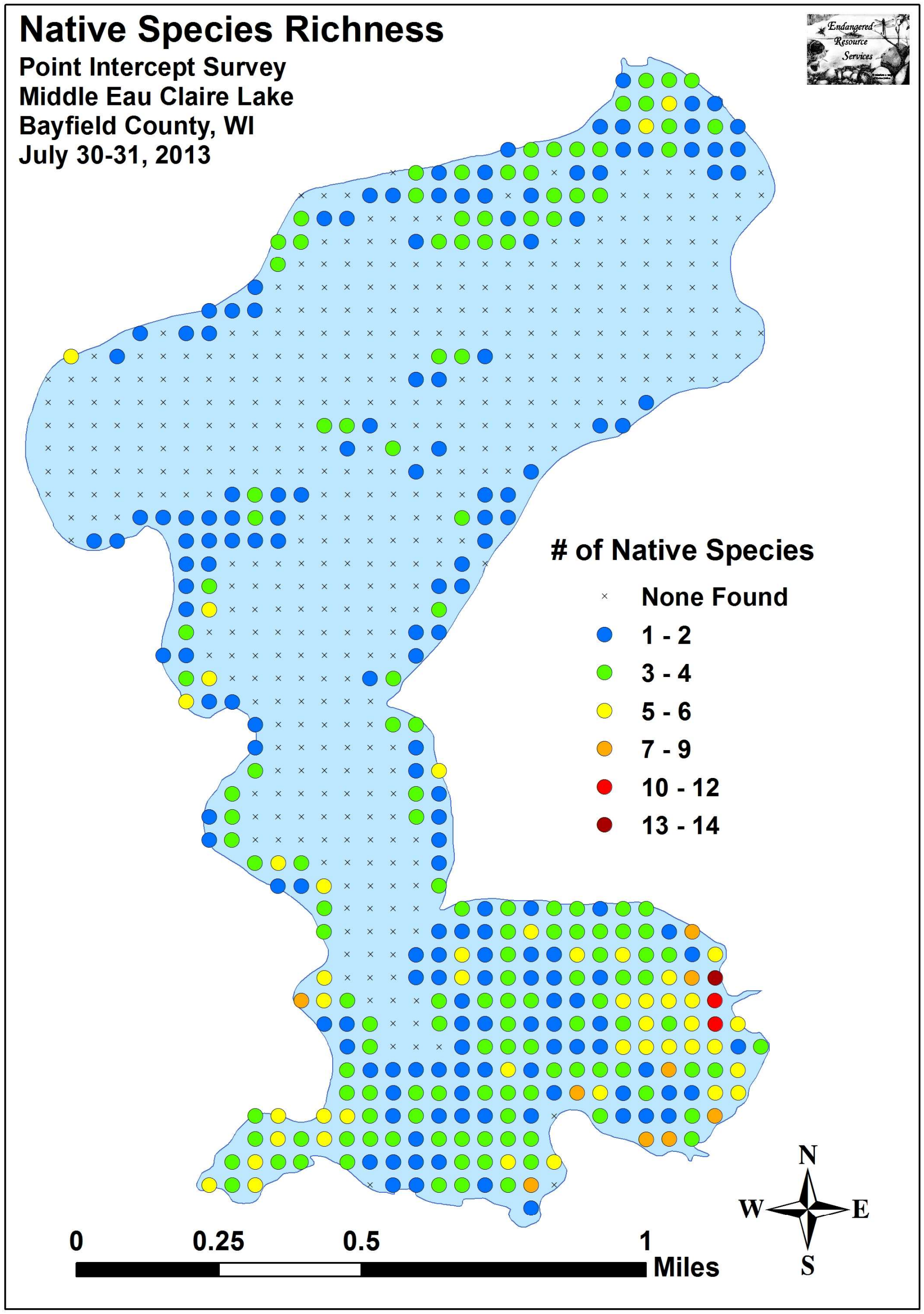

Bottom Substrate
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Substrate Type
Muck
Rock
Sand
Not Determined
0
0.25
0.5
1
Miles
N
W
E
S

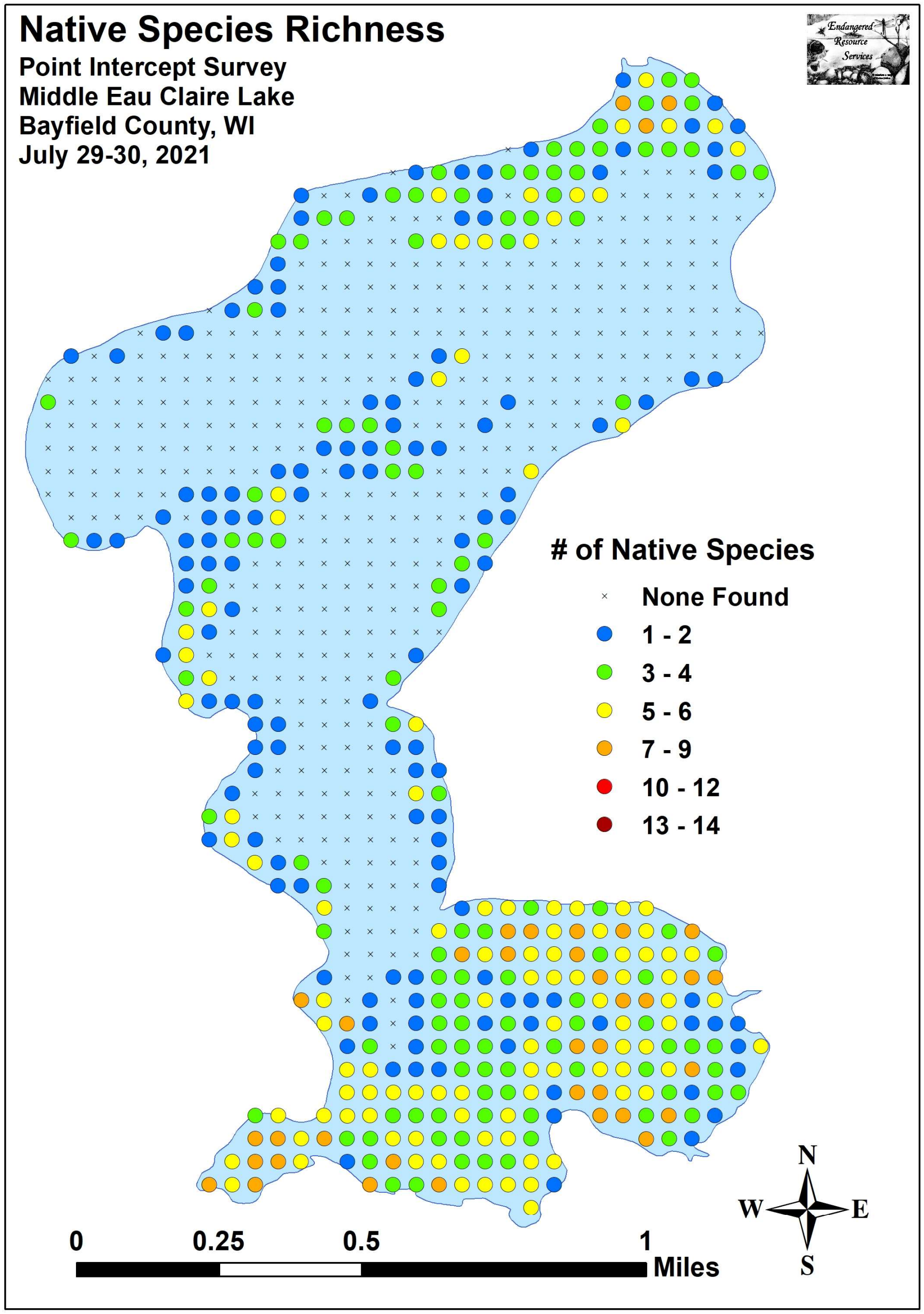
Appendix V: 2013 and 2021 Littoral Zone, Native Species Richness, and Total Rake Fullness Maps



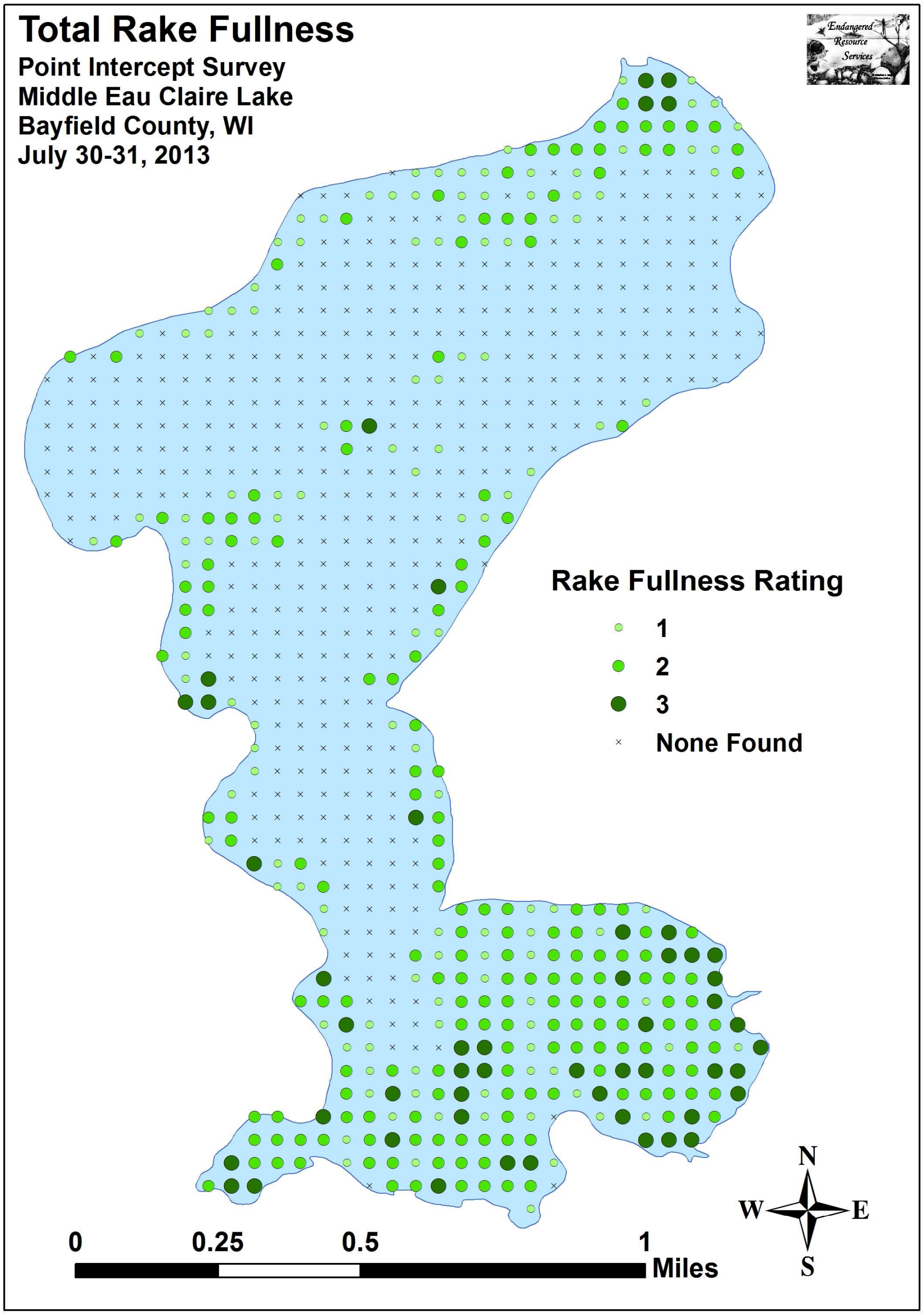
Littoral Zone
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 30-31, 2013
Endangered Resource Services
Littoral Zone
Littoral Zone with Plants
>19 ft.
0
0.25
0.5
1
Miles
N
W
E
S

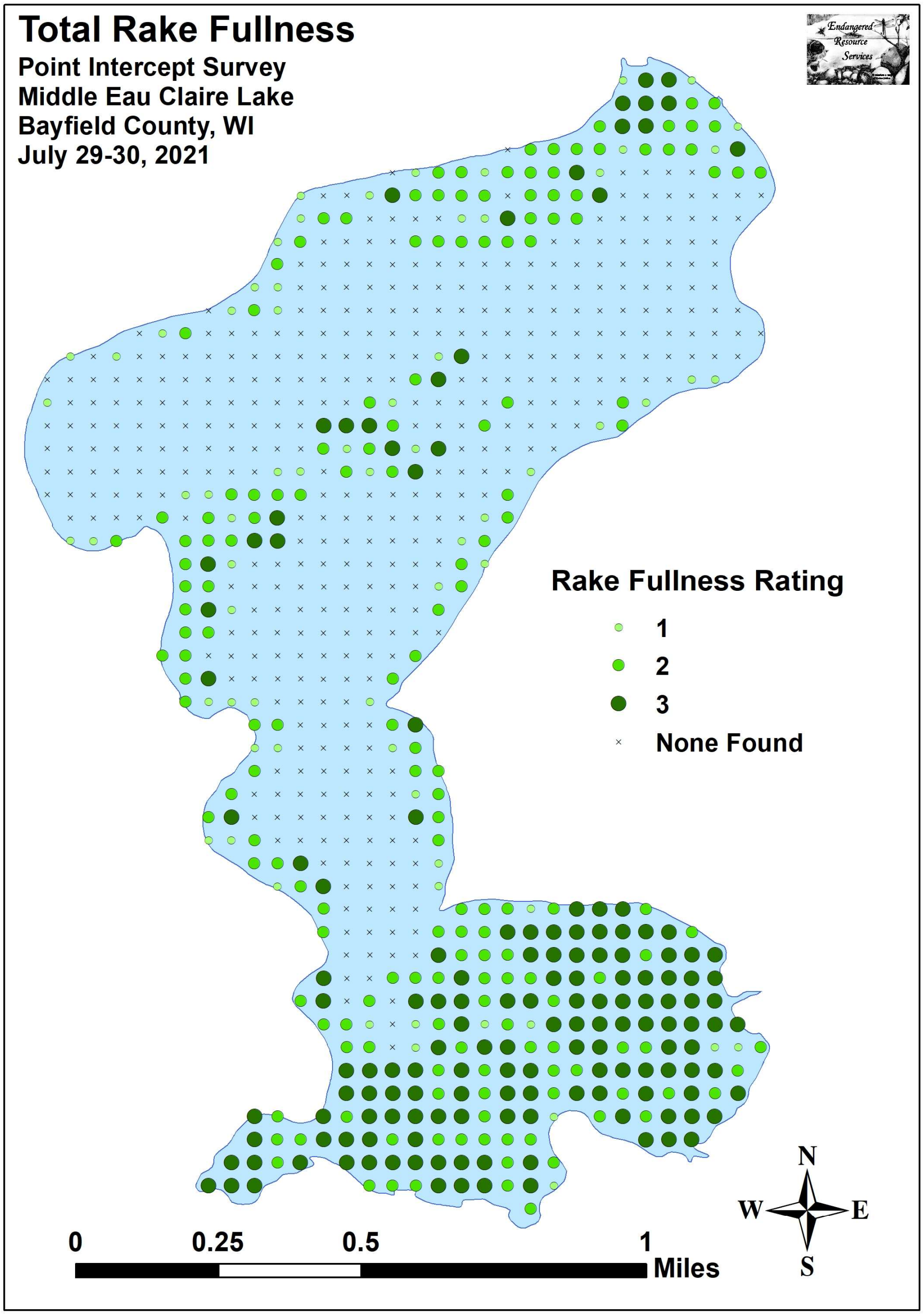

Littoral Zone
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Littoral Zone
Littoral Zone with Plants
>19.5 ft.
N
W
E
S
0
0.25
0.5
1
Miles


Native Species Richness
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 30-31, 2013
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 9
10 - 12
13 - 14
0
0.25
0.5
1
Miles
N
S
E
W

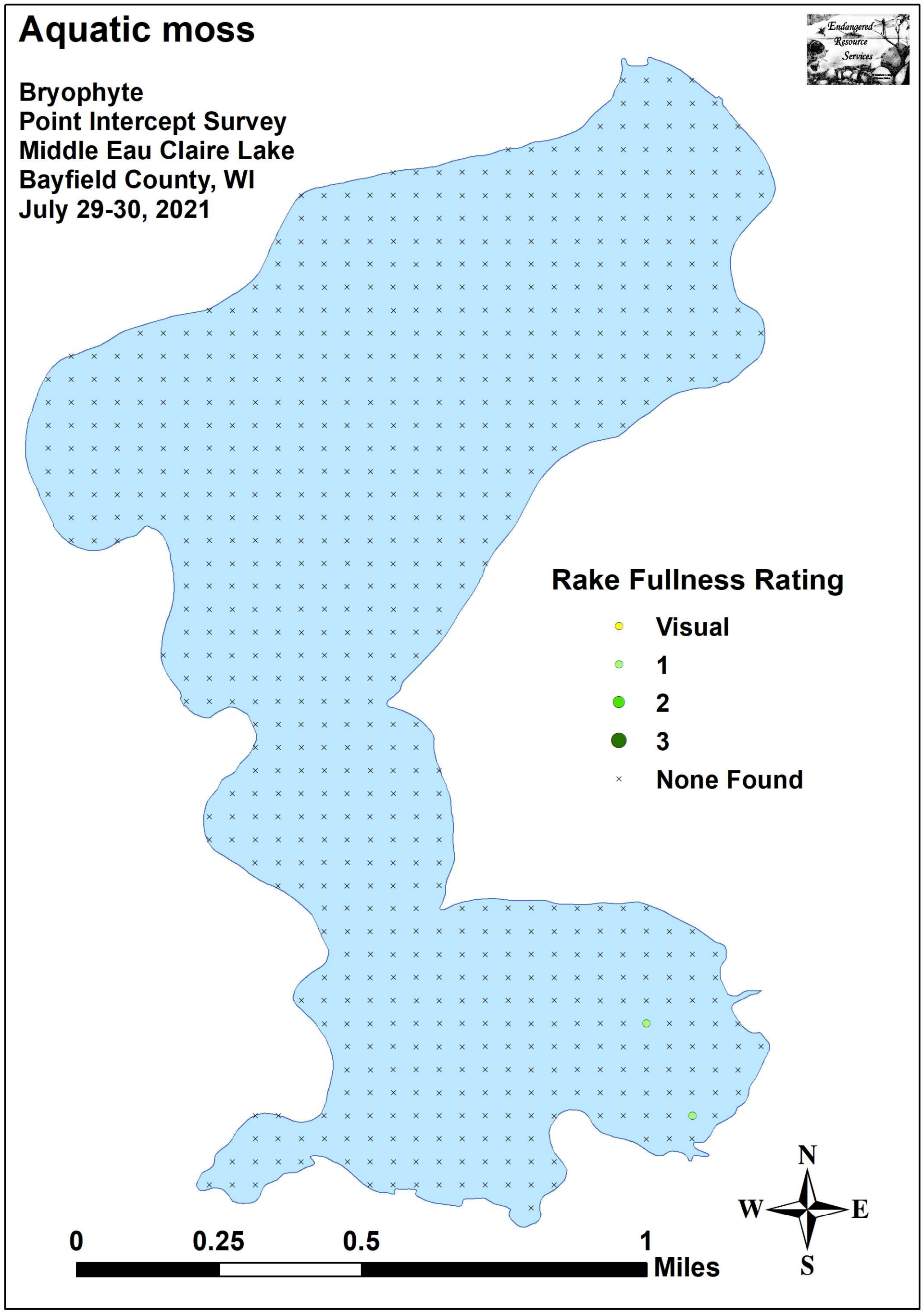


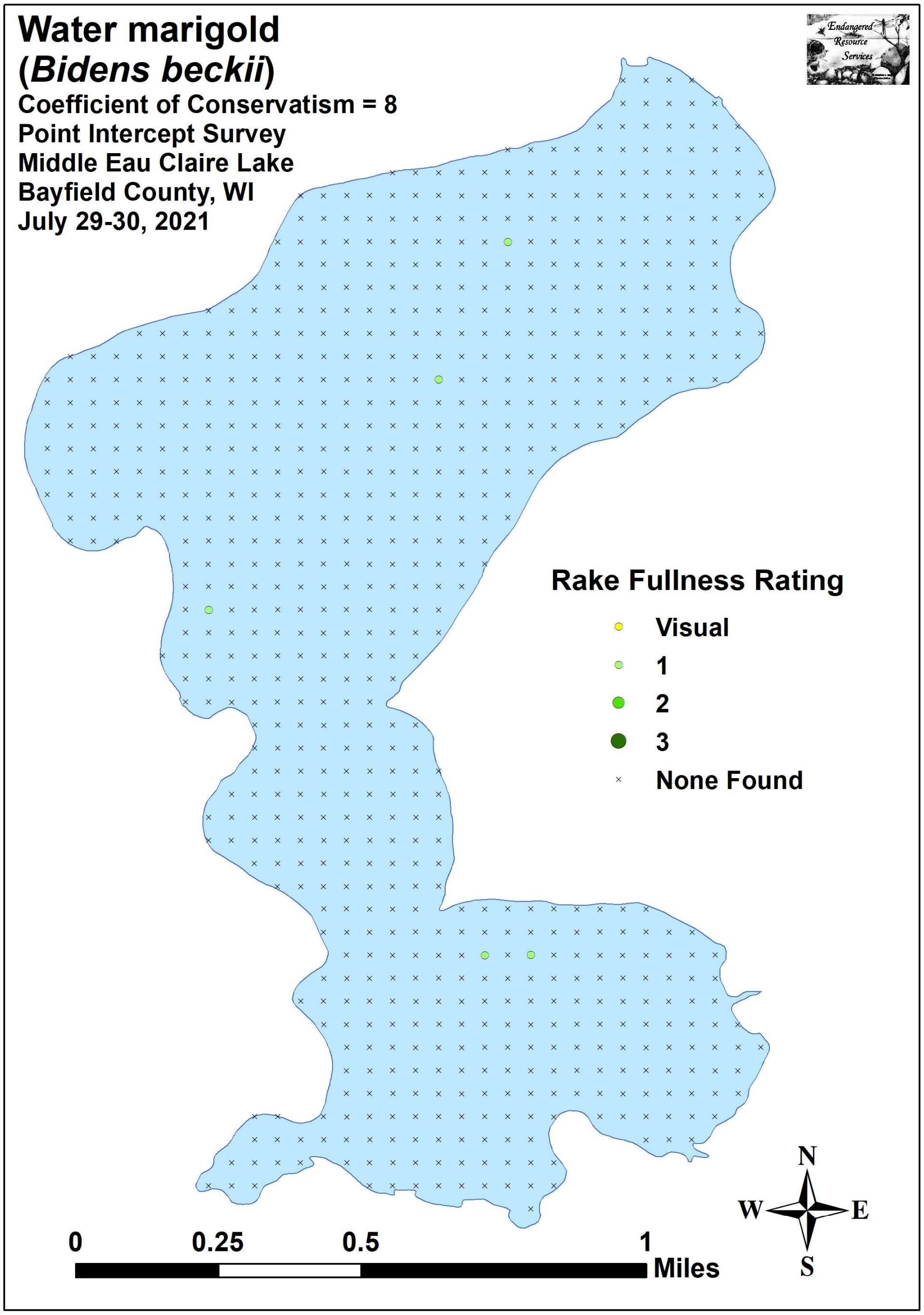
Native Species Richness
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 9
10 - 12
13 - 14
N
W
E
S
0
0.25
0.5
1
Miles


Total Rake Fullness
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 30-31, 2013
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

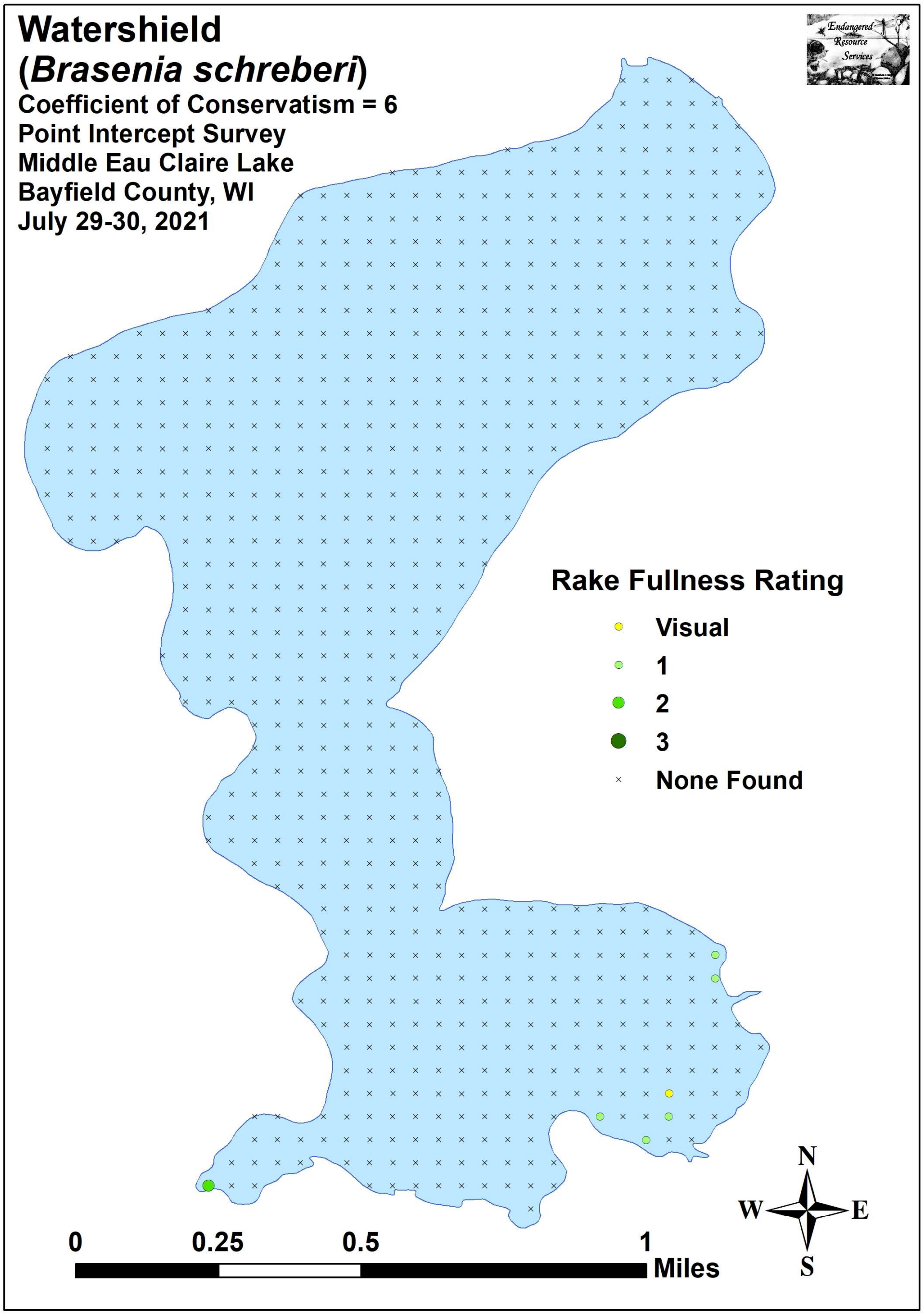

Total Rake Fullness
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

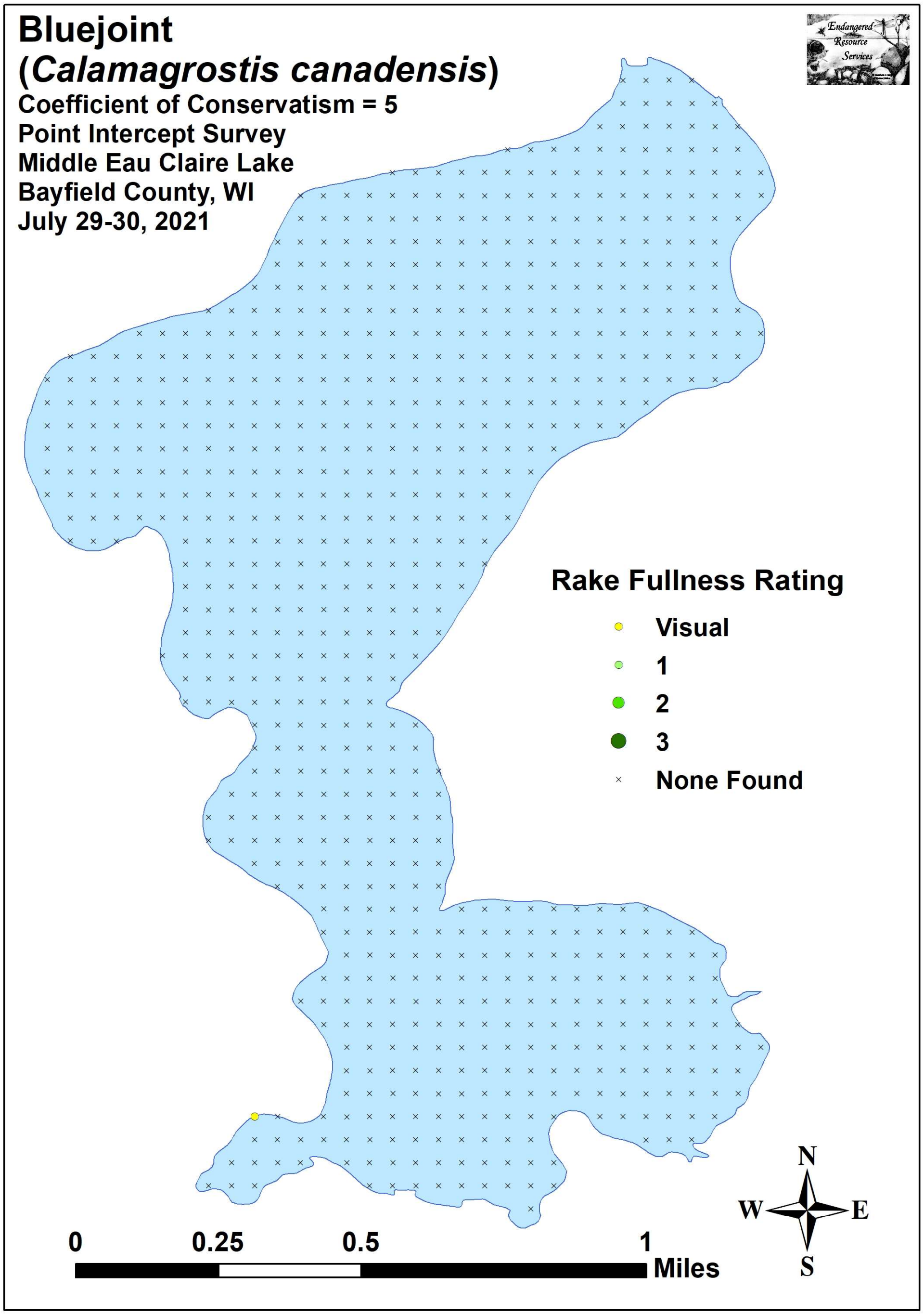
Appendix VI: July 2021 Native Species Density and Distribution Maps

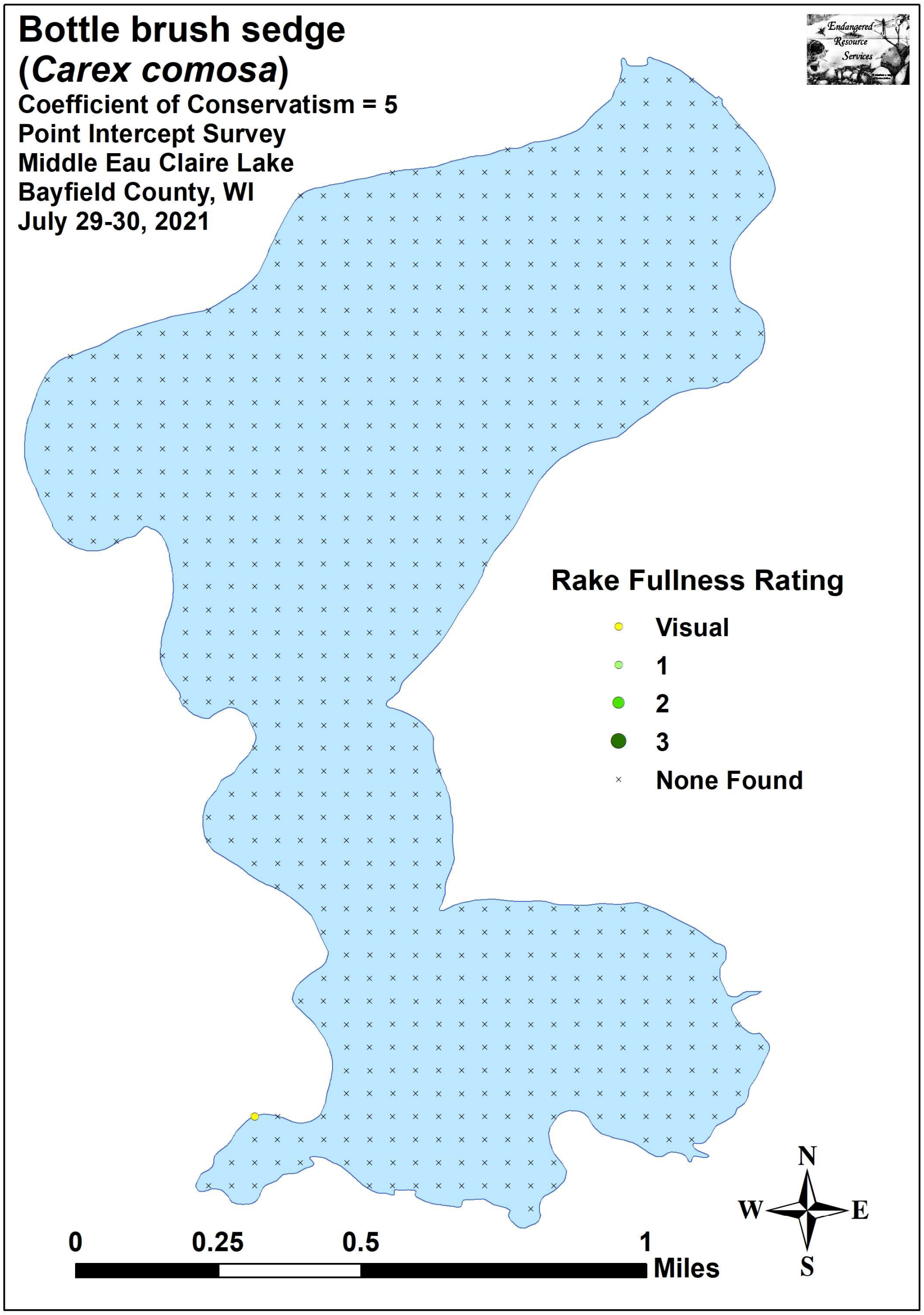

Aquatic moss
Bryophyte
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



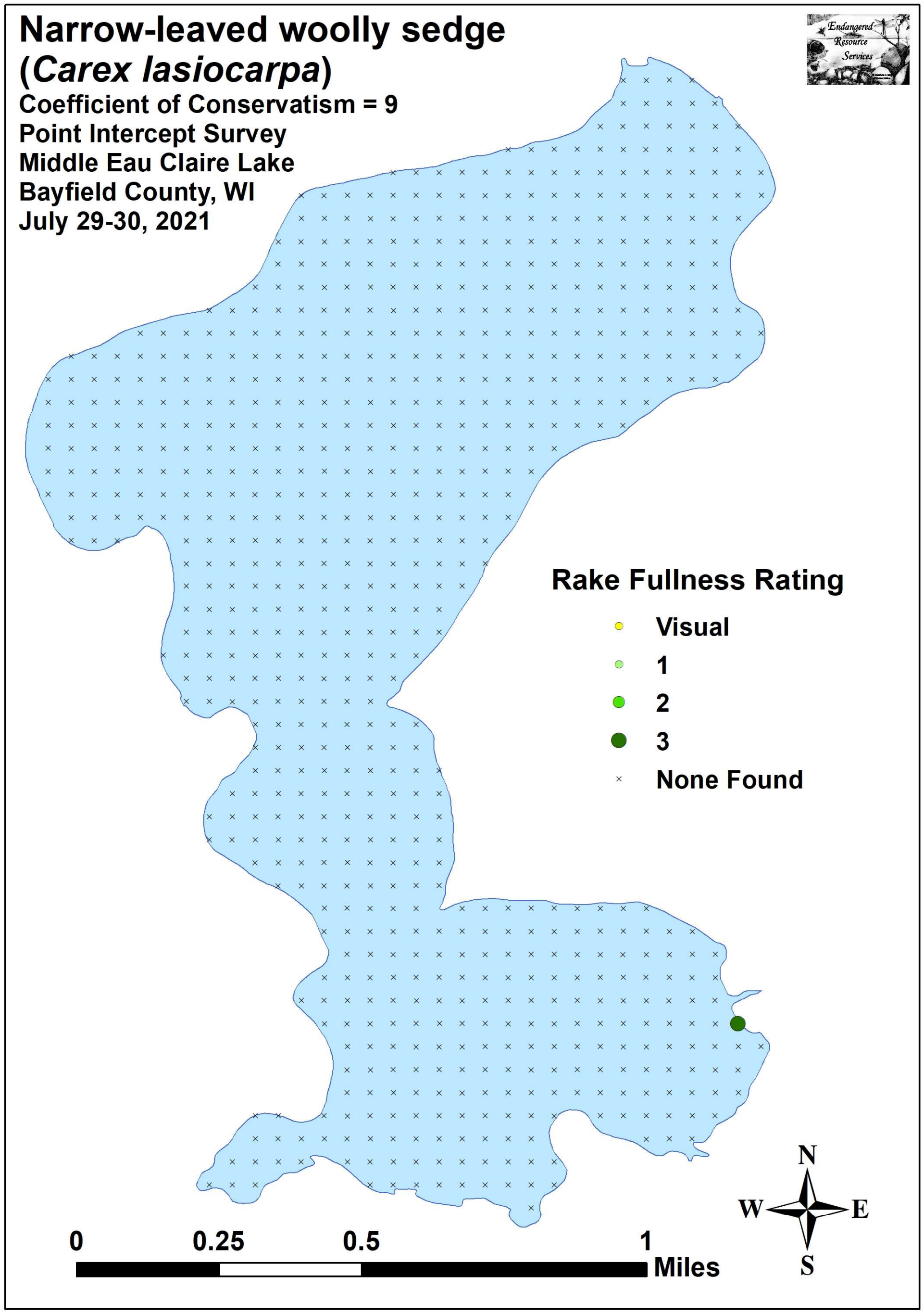
Water marigold
(Bidens beckii)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

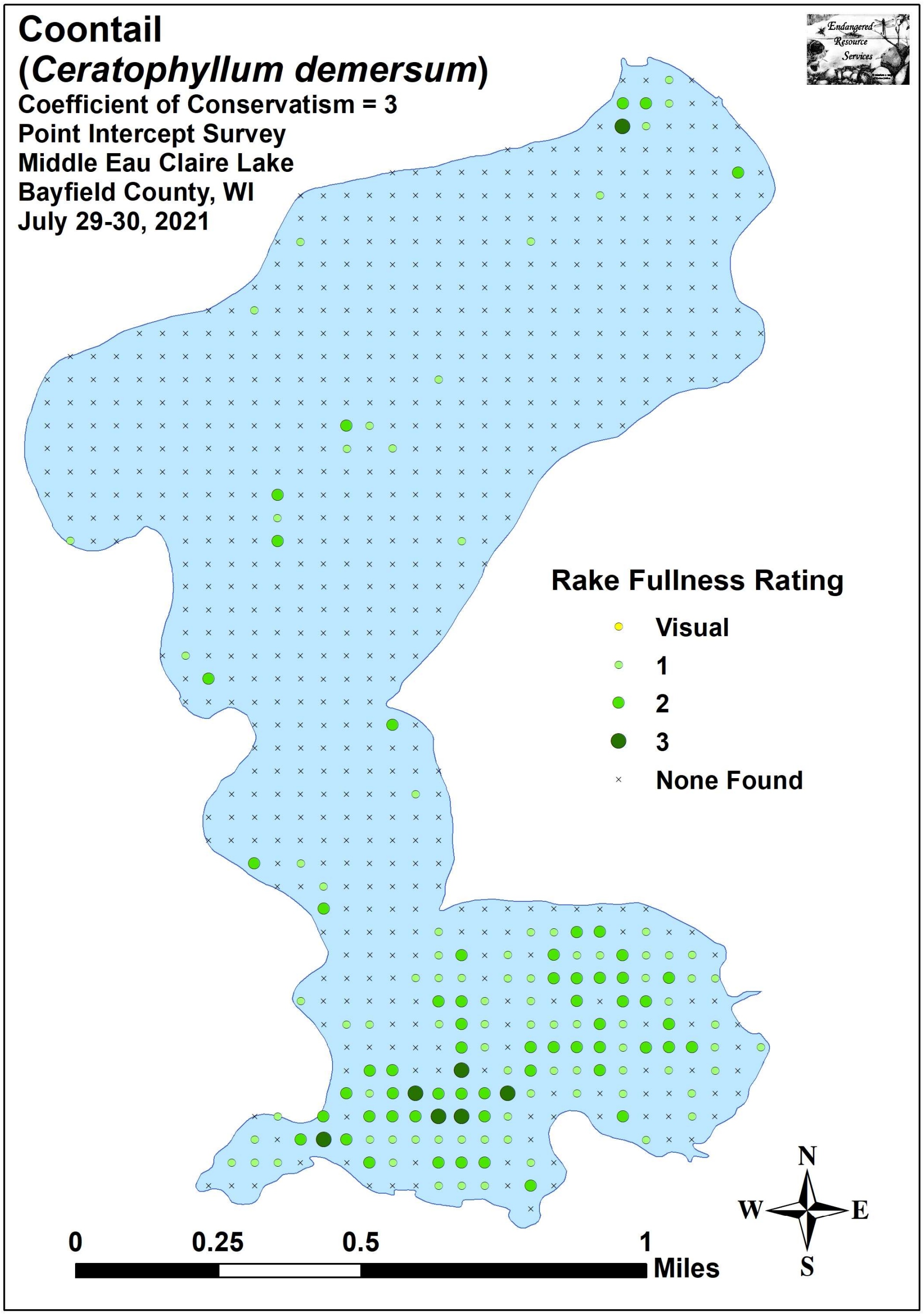

Watershield
(Brasenia schreberi)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

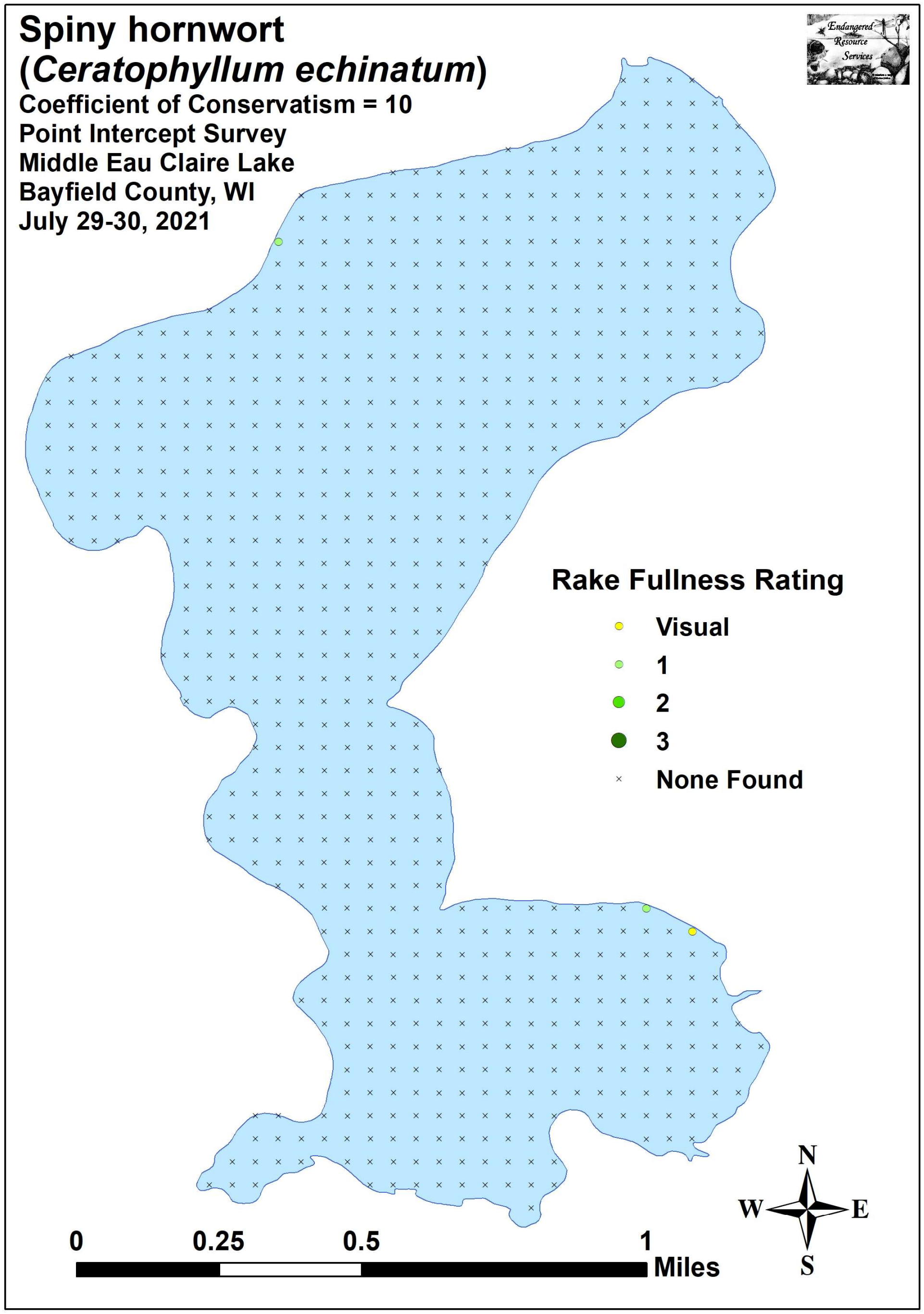

Bluejoint
(Calamagrostis canadensis)
Coefficient of Conservatism = 5
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

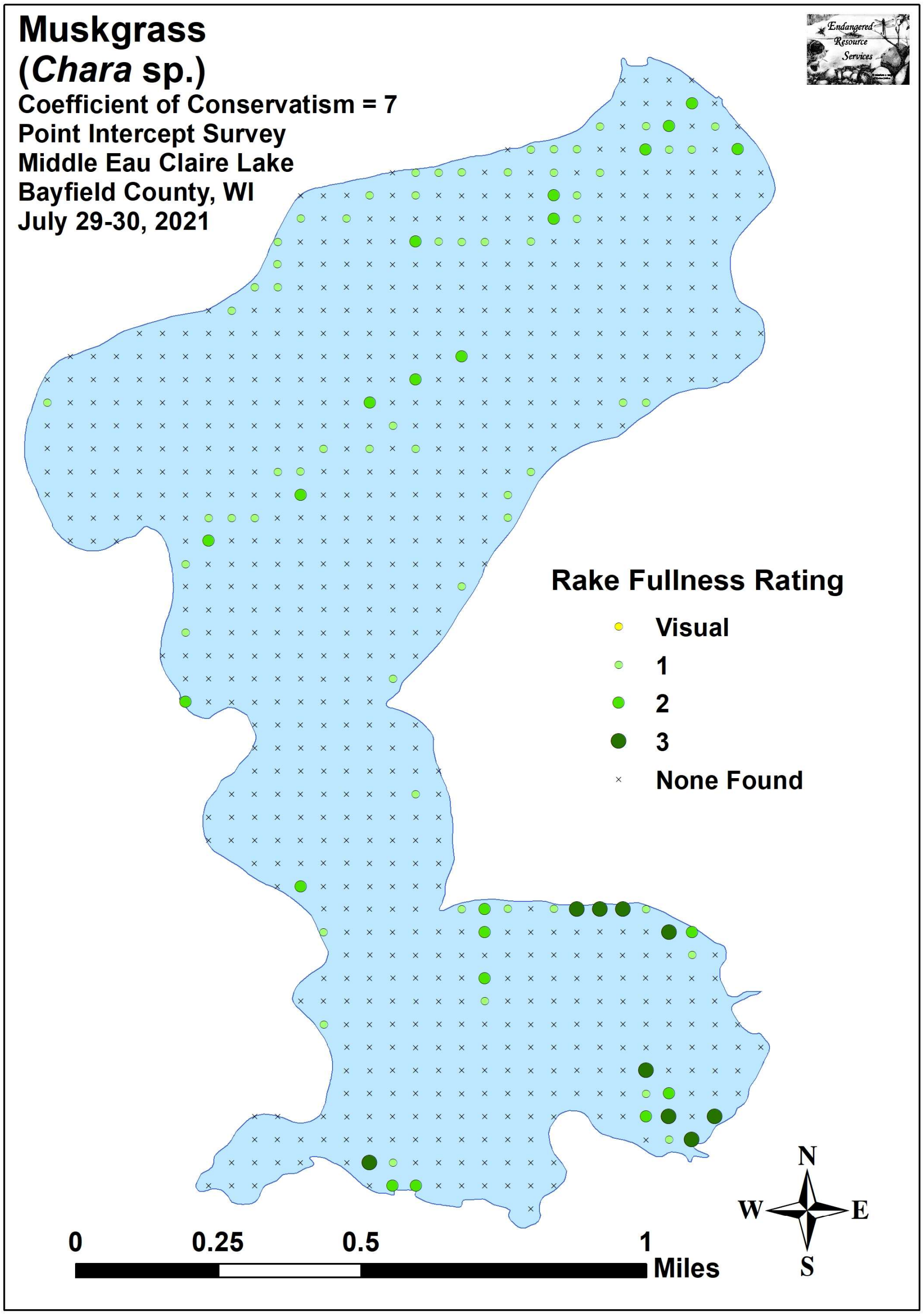


Bottle brush sedge
(*Carex comosa*)
Coefficient of Conservatism = 5
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

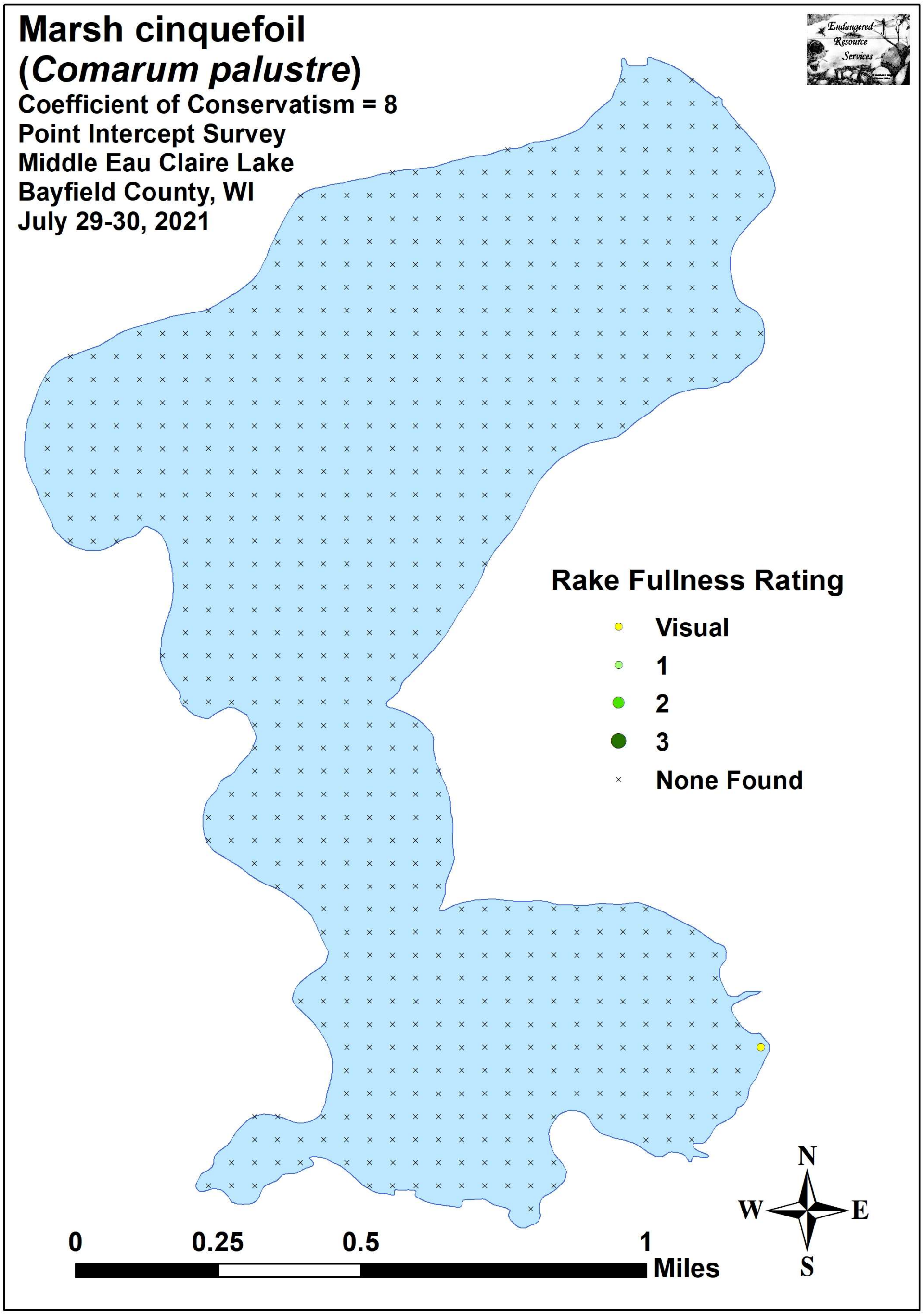

Narrow-leaved woolly sedge
(*Carex lasiocarpa*)
Coefficient of Conservatism = 9
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Coontail
(*Ceratophyllum demersum*)
Coefficient of Conservatism = 3
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

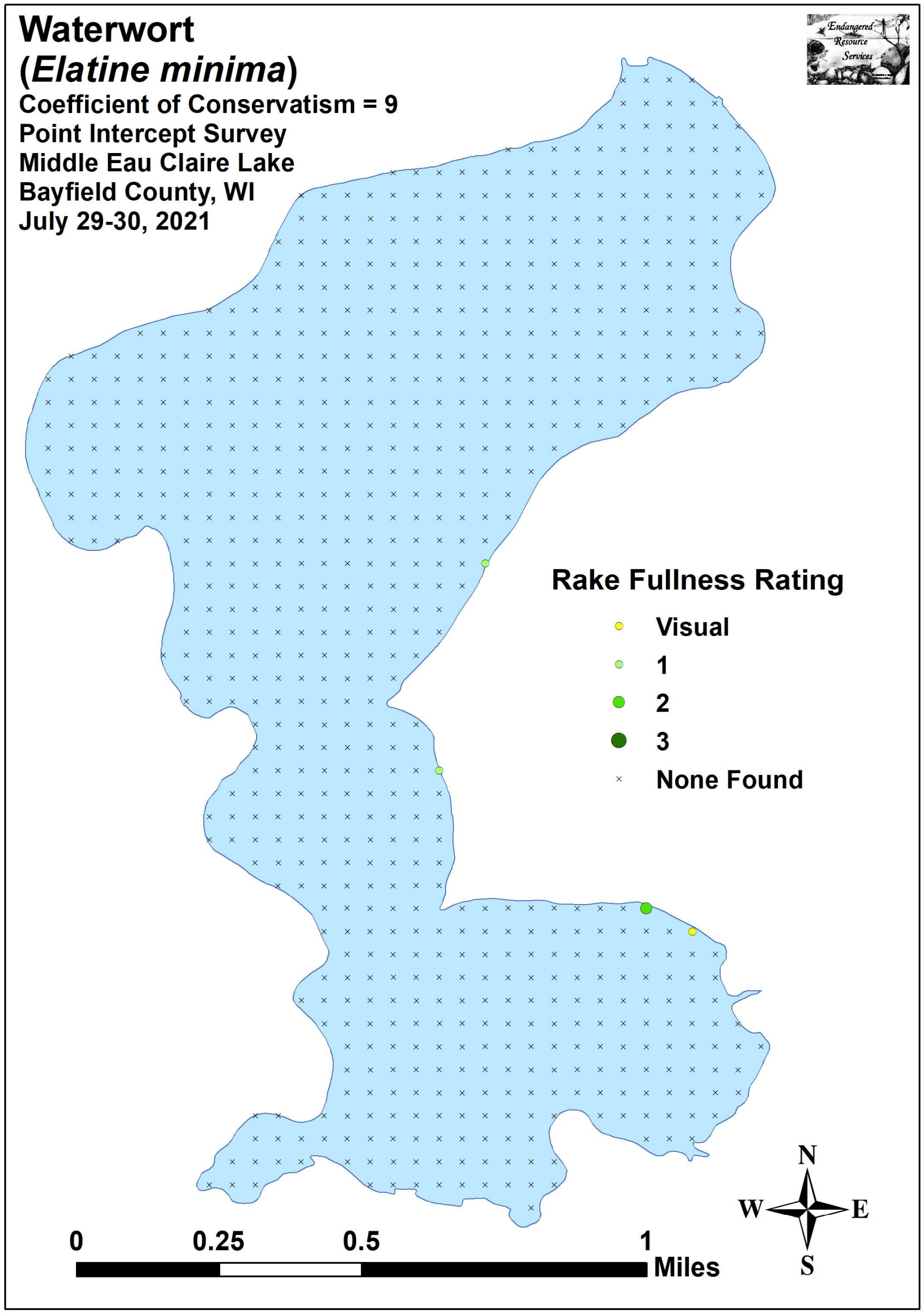

Spiny hornwort
(*Ceratophyllum echinatum*)
Coefficient of Conservatism = 10
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

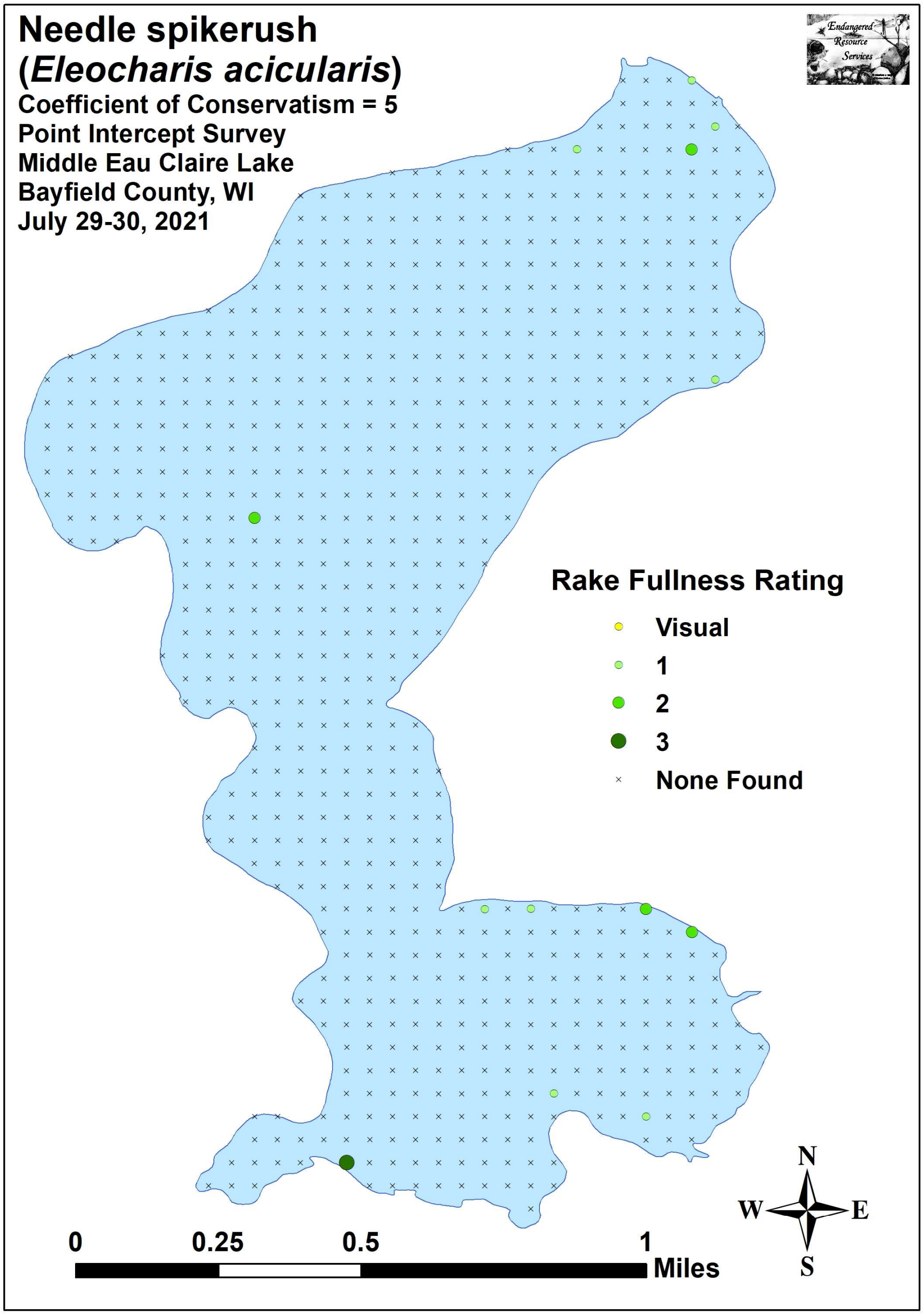


Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

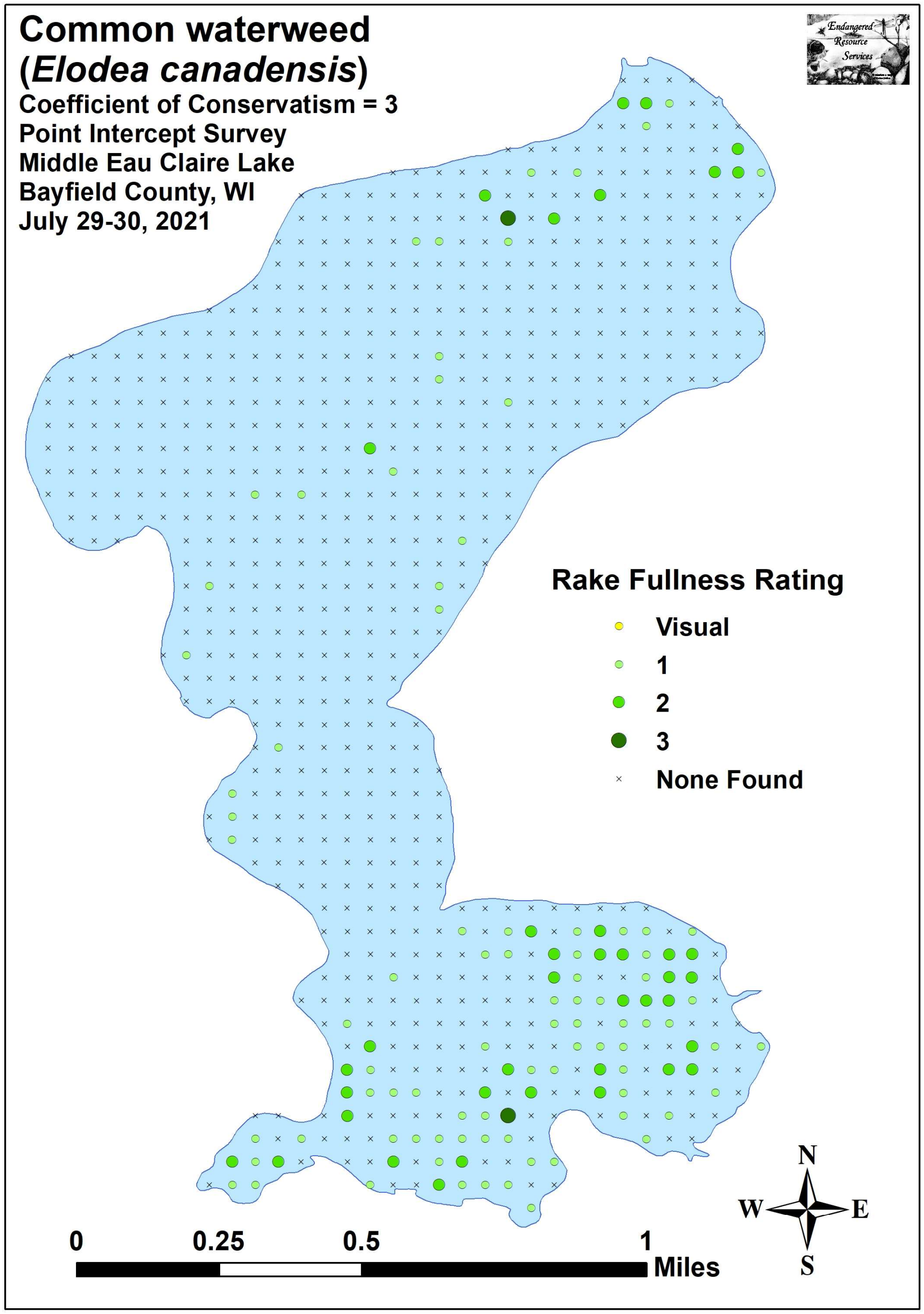


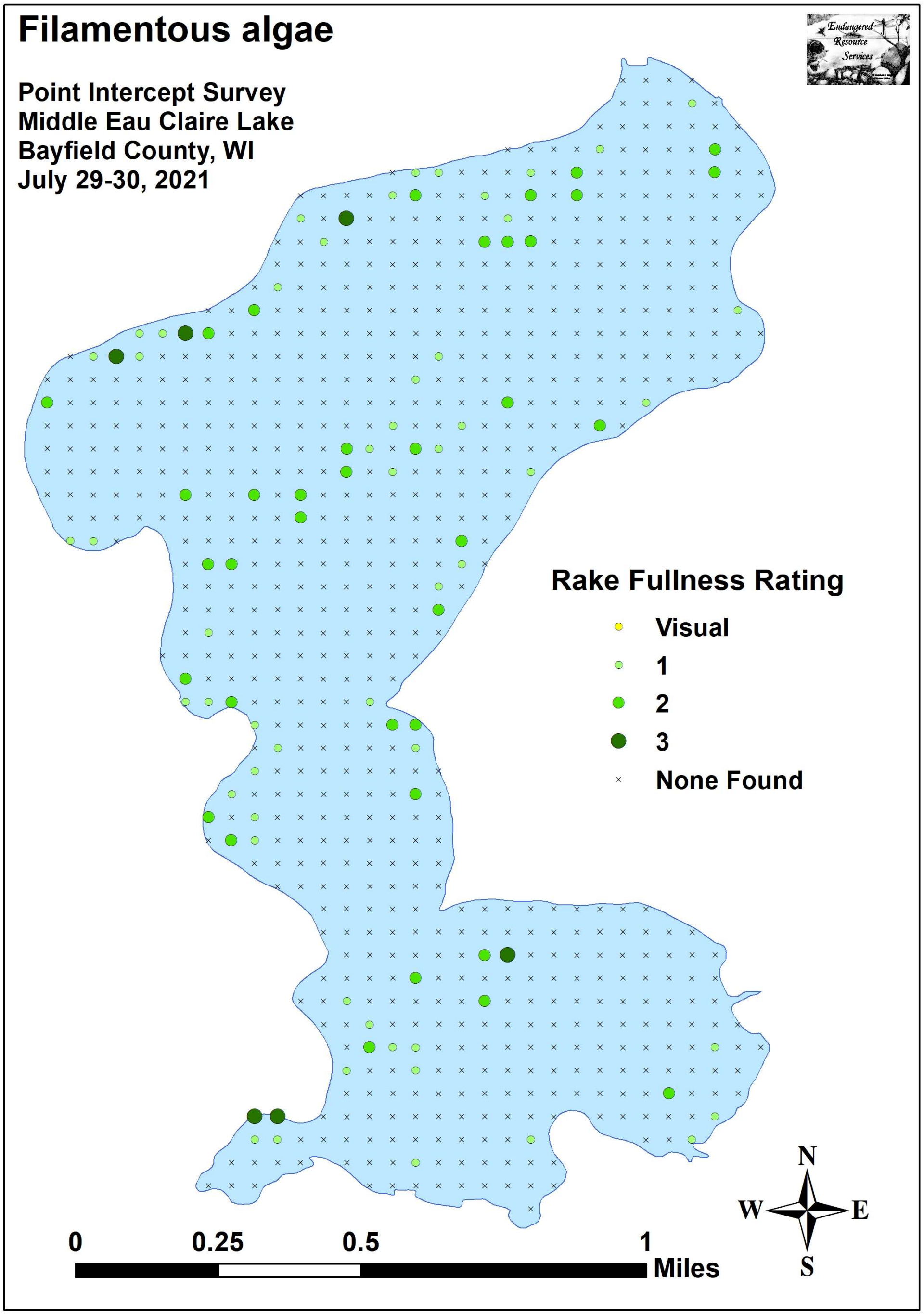
Marsh cinquefoil
(*Comarum palustre*)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

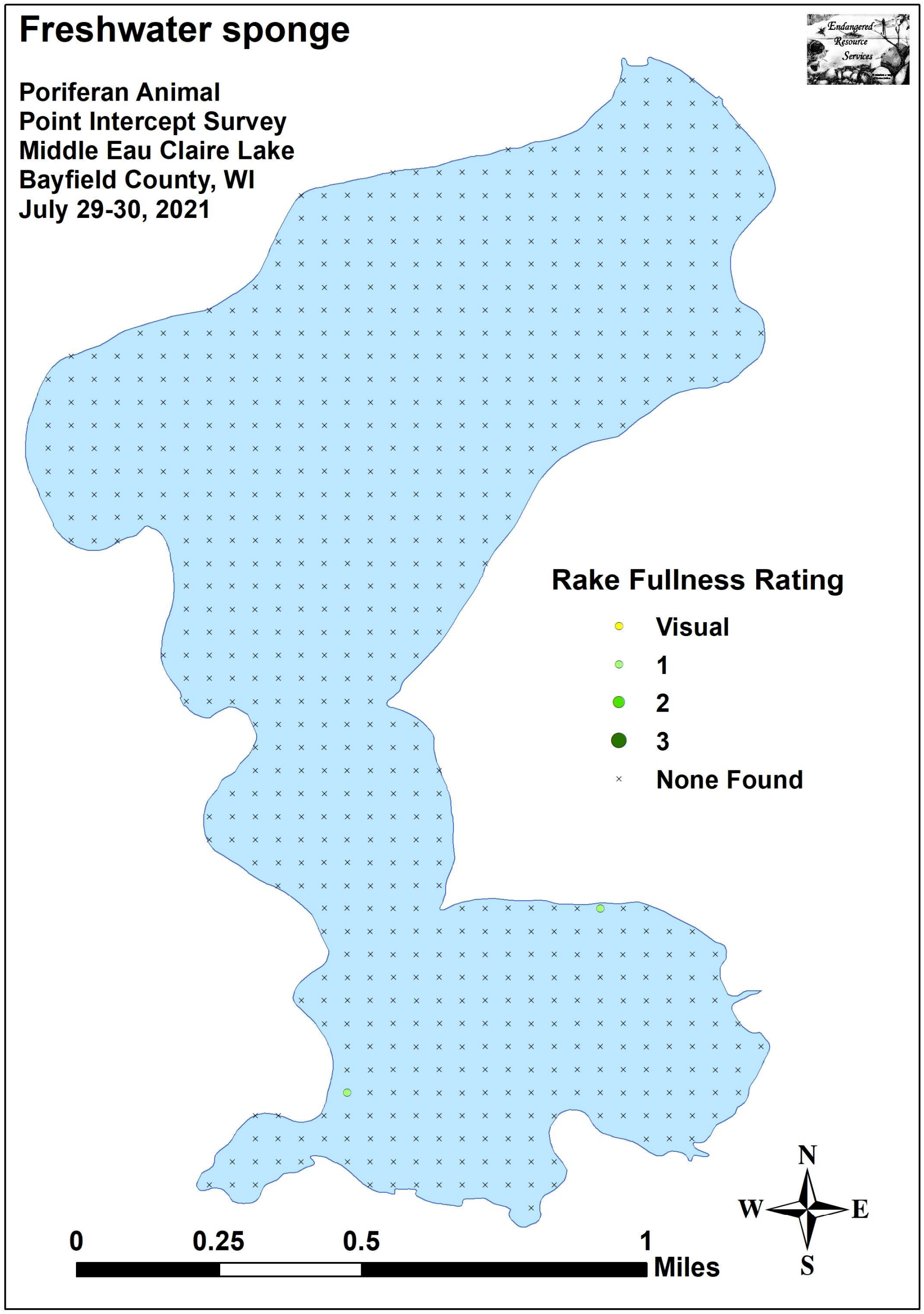

Waterwort
(*Elatine minima*)
Coefficient of Conservatism = 9
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



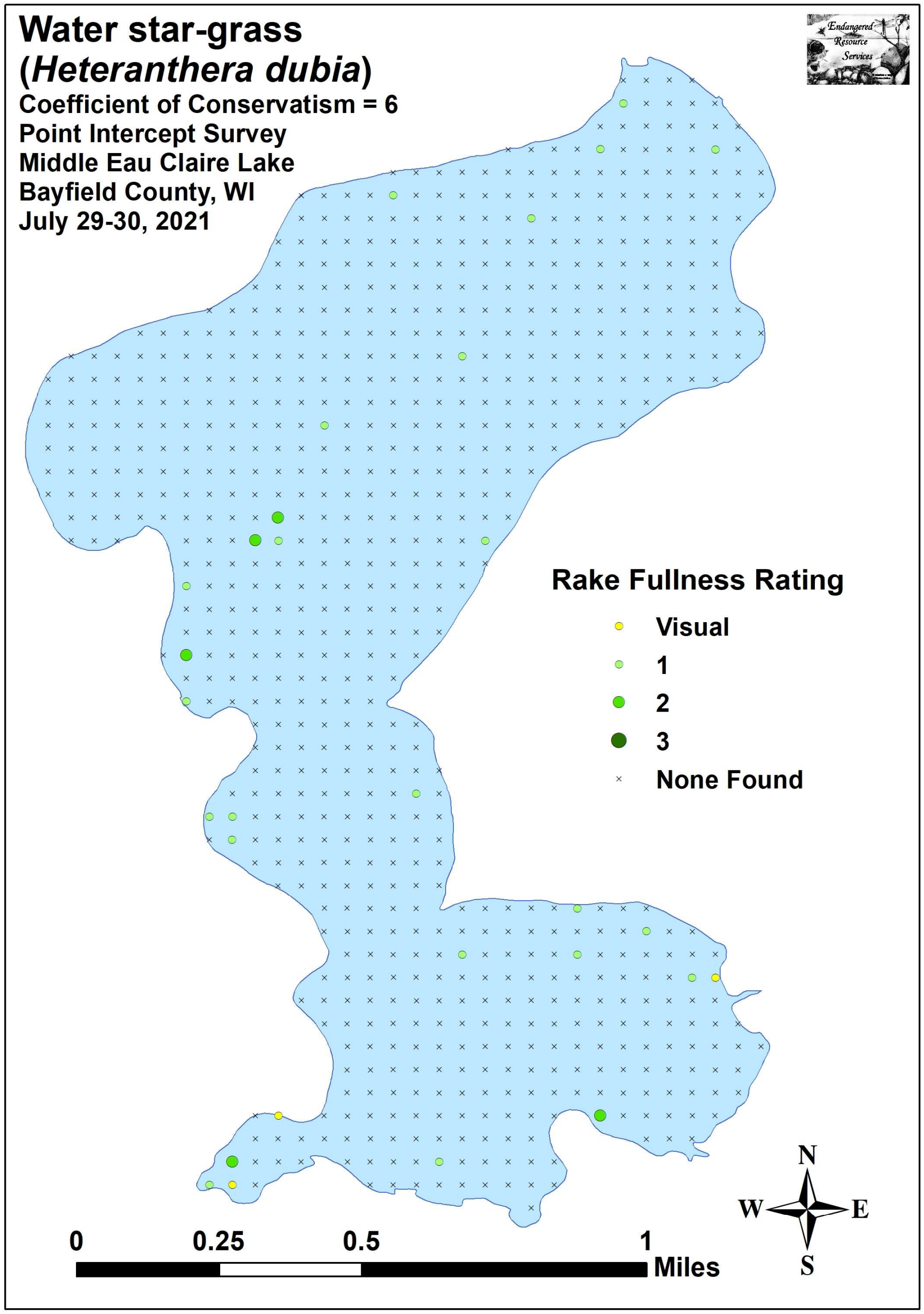
Needle spikerush
(*Eleocharis acicularis*)
Coefficient of Conservatism = 5
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S


Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

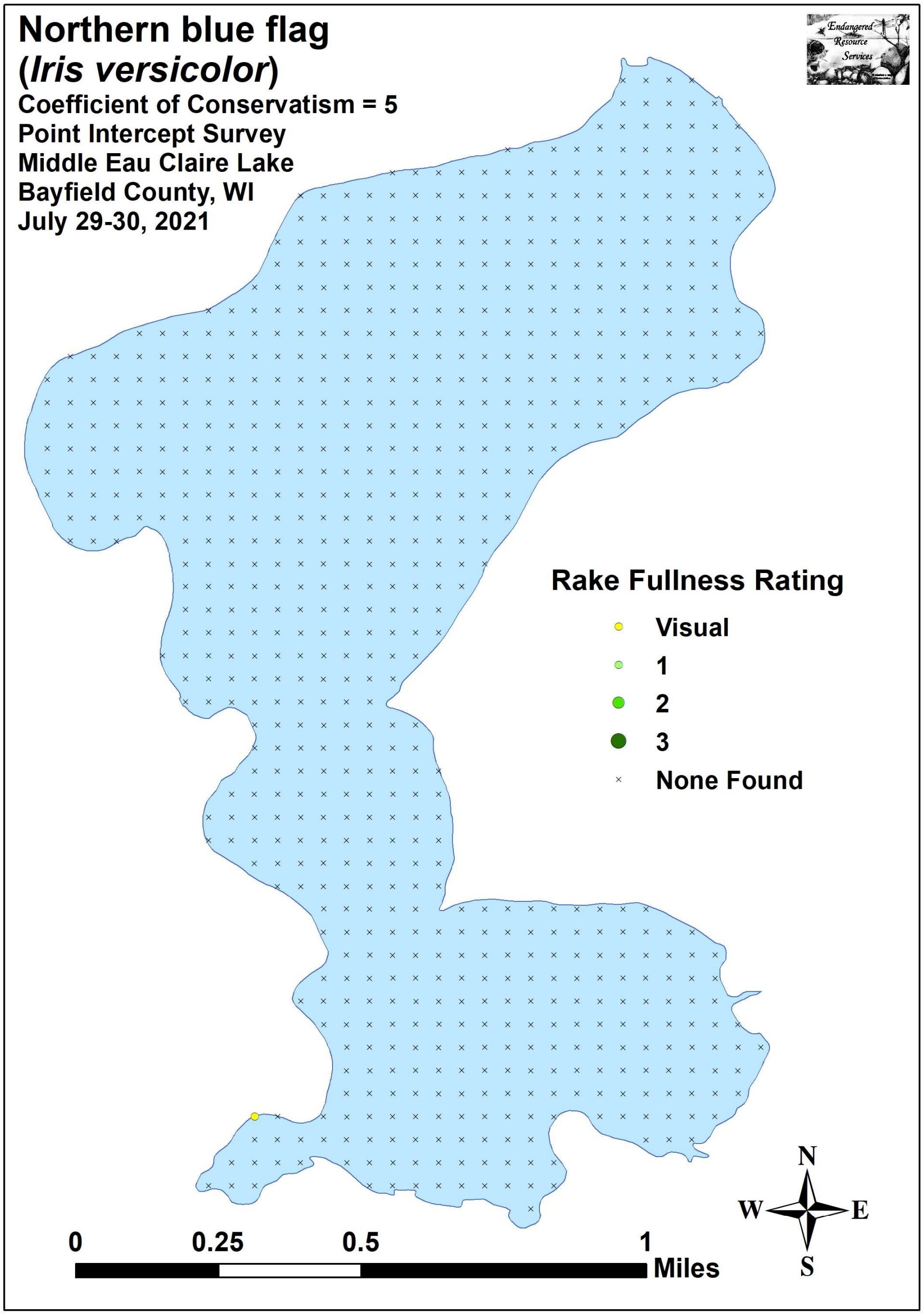

Filamentous algae
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

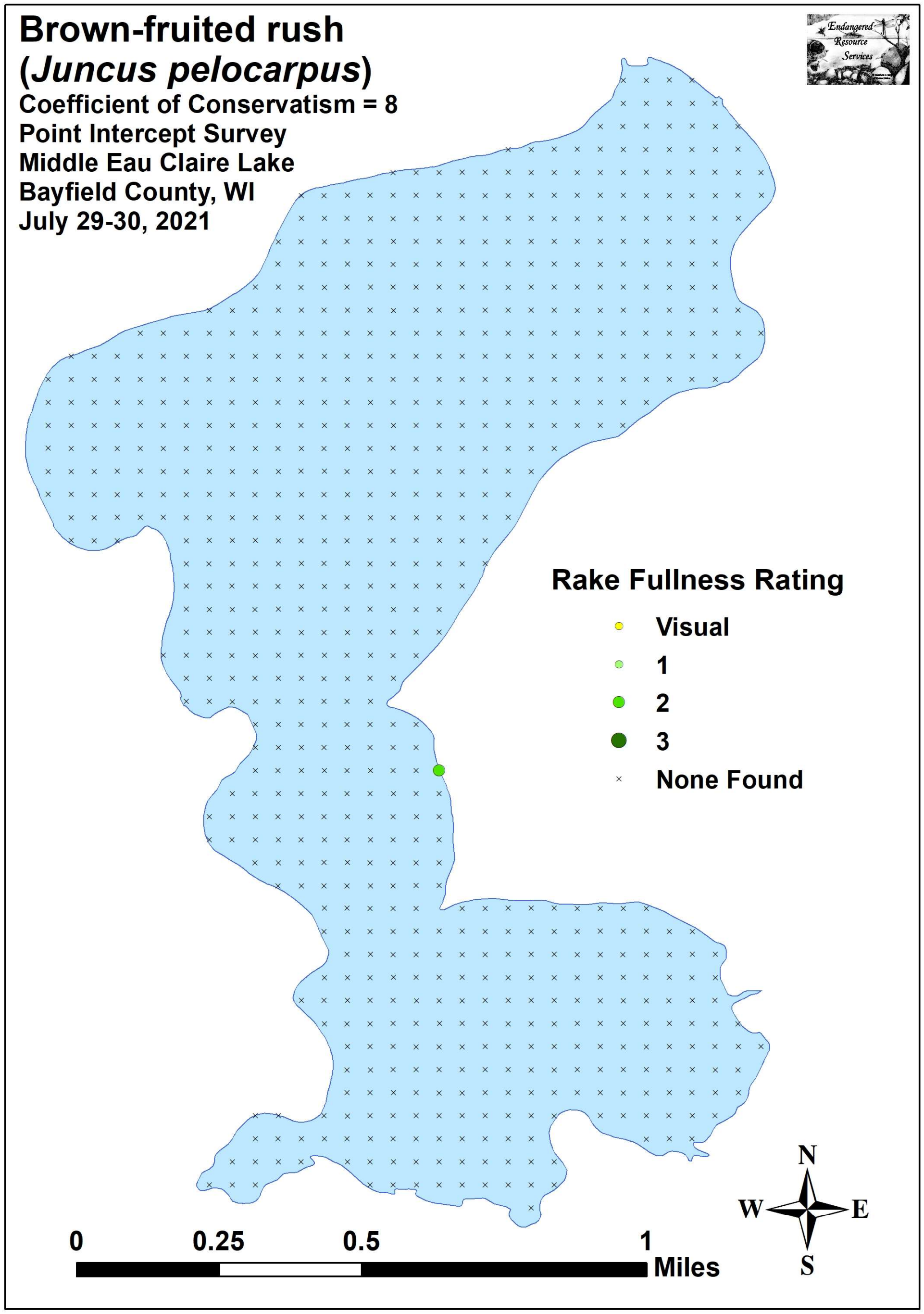


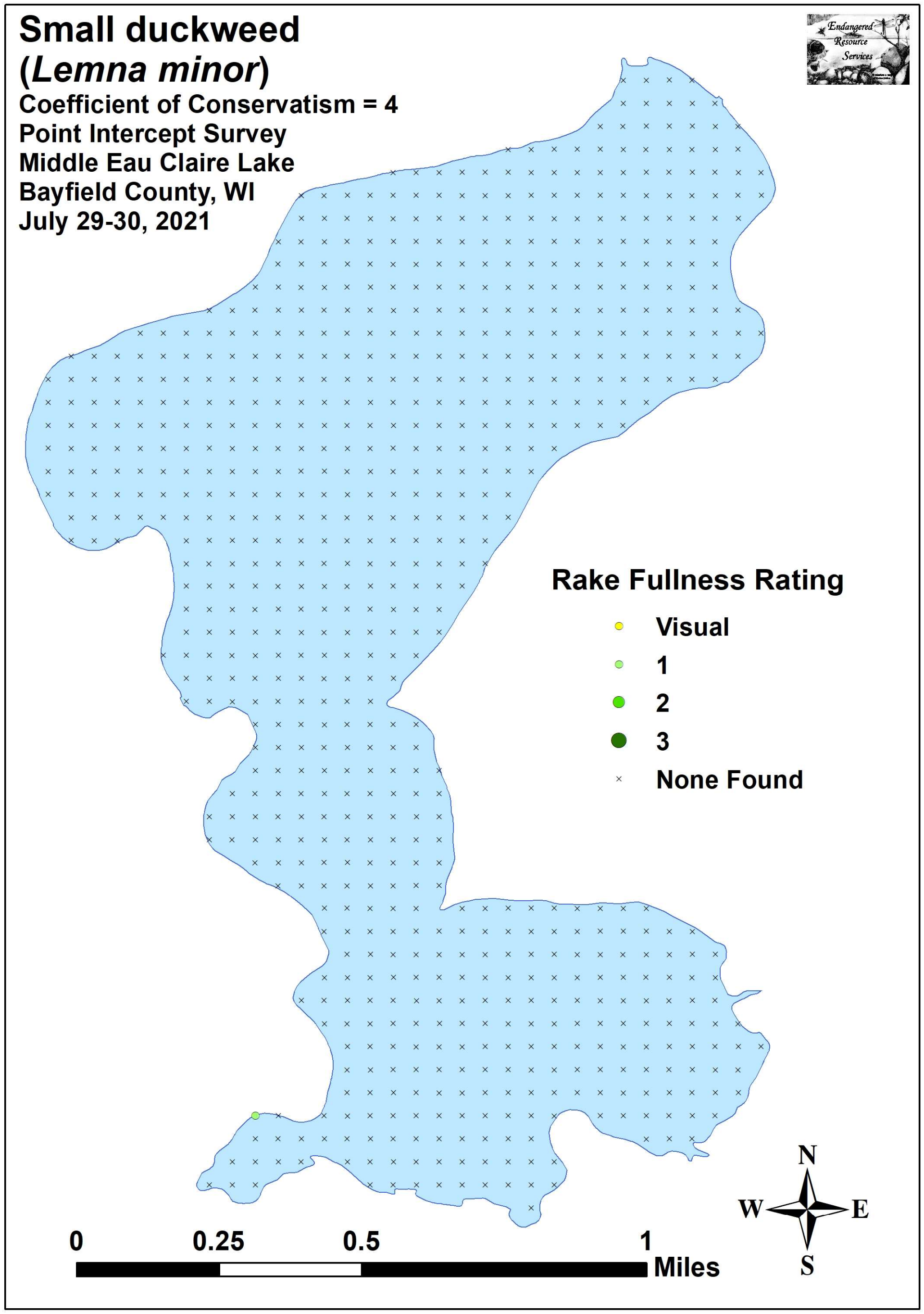
Freshwater sponge
Poriferan Animal
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

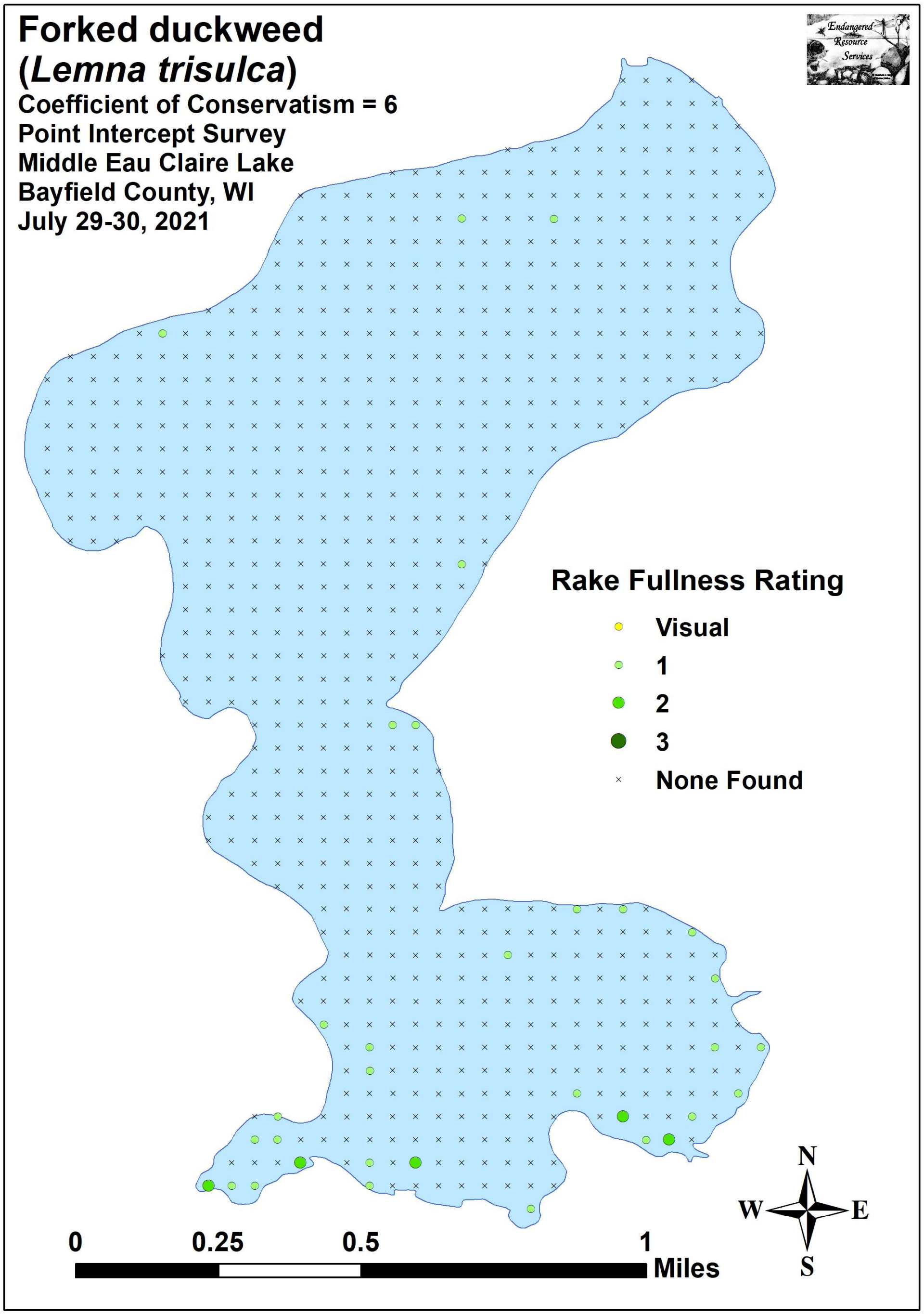


Water star-grass
(*Heteranthera dubia*)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

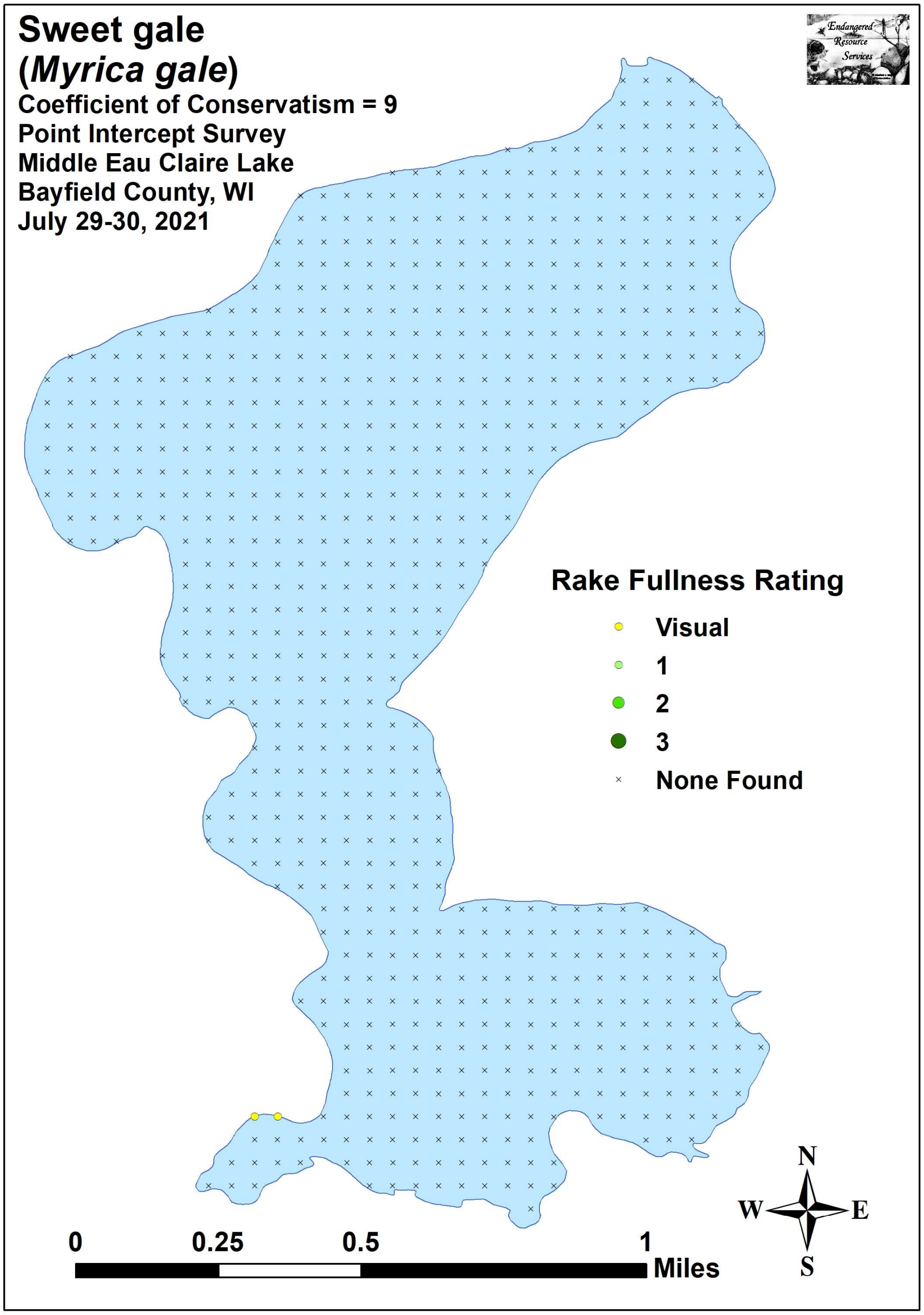

Northern blue flag
(*Iris versicolor*)
Coefficient of Conservatism = 5
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
S
E
W

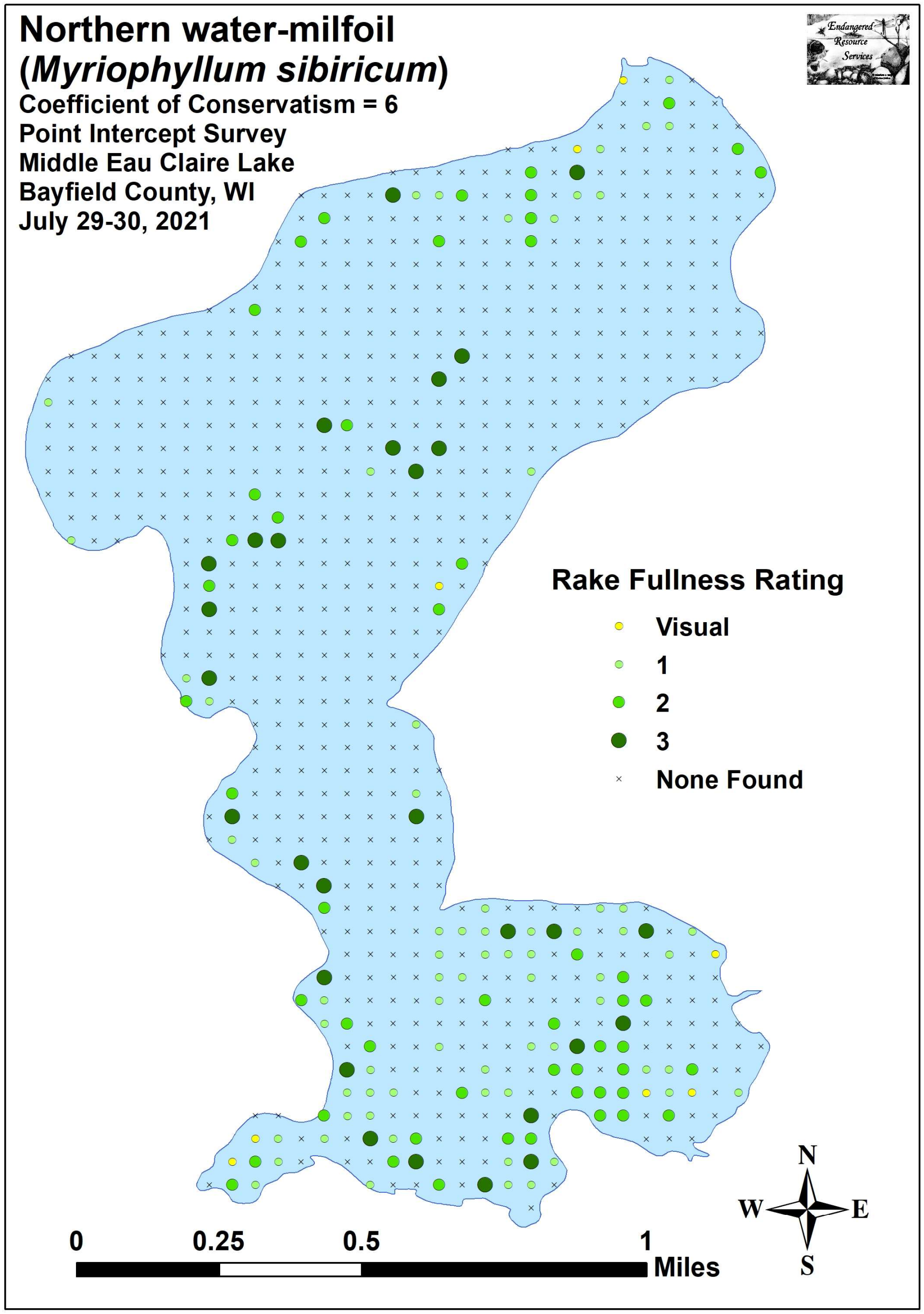

Brown-fruited rush
(Juncus pelocarpus)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

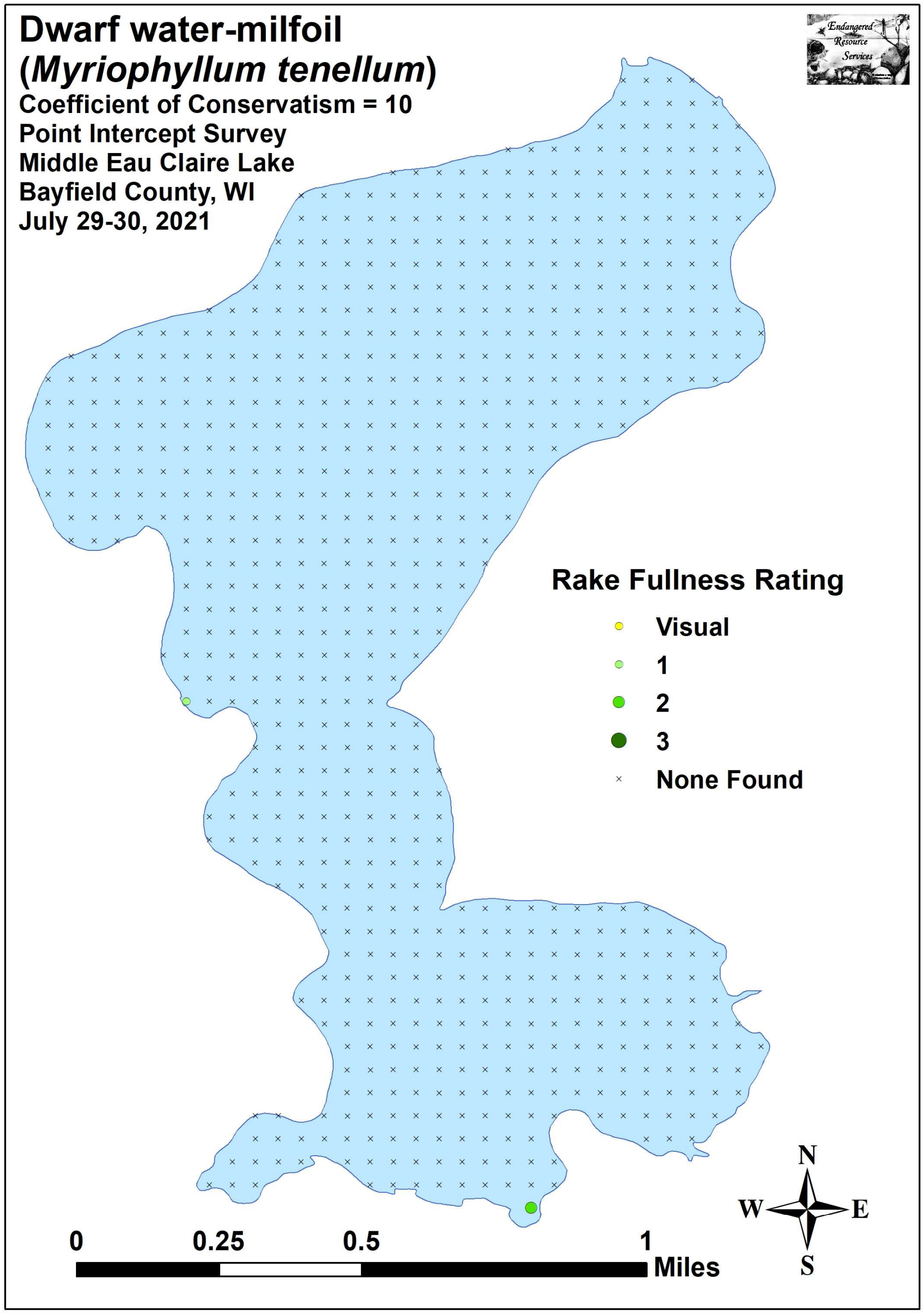

Small duckweed
(Lemna minor)
Coefficient of Conservatism = 4
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



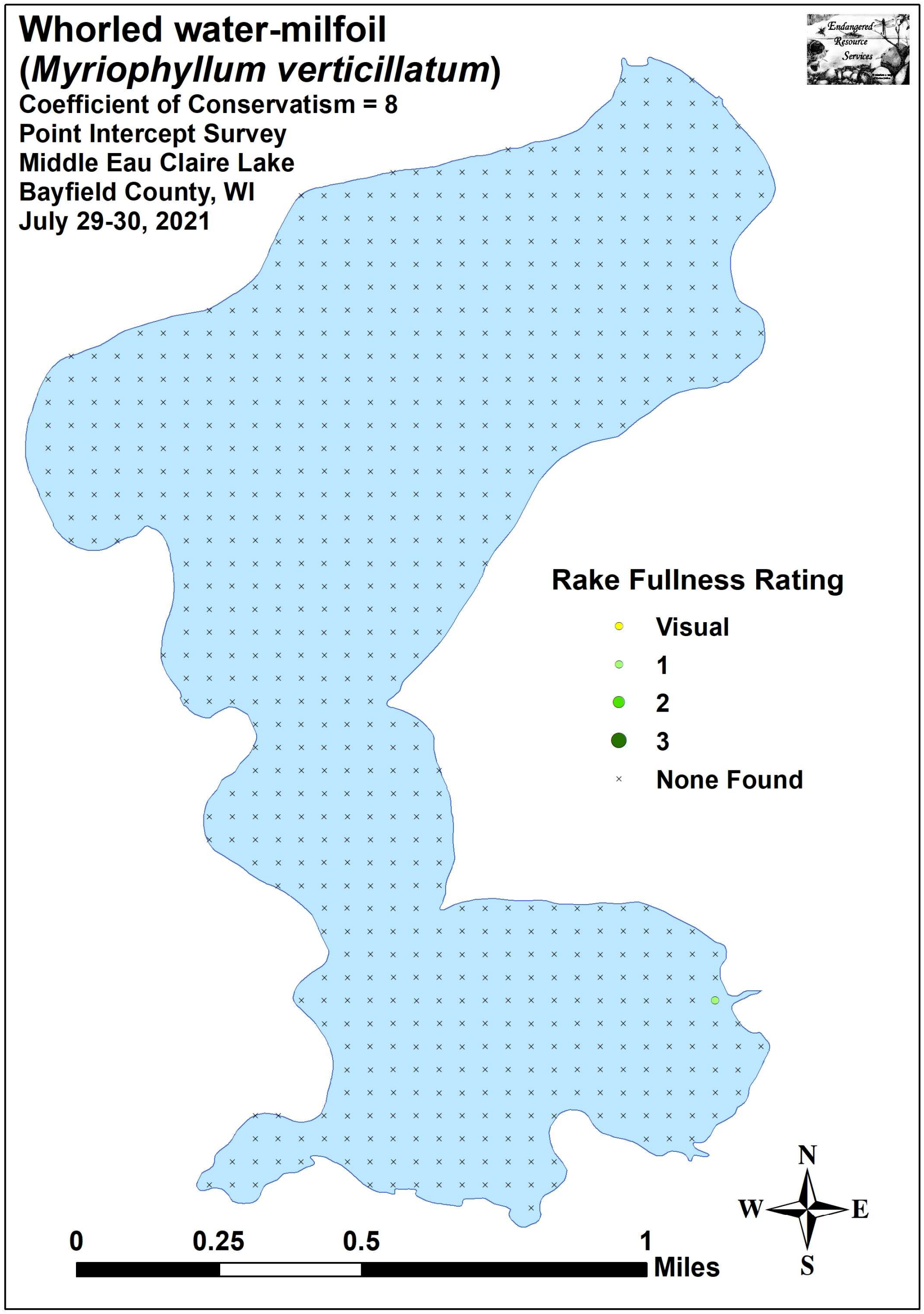
Forked duckweed
(*Lemna trisulca*)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S


Sweet gale
(Myrica gale)
Coefficient of Conservatism = 9
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

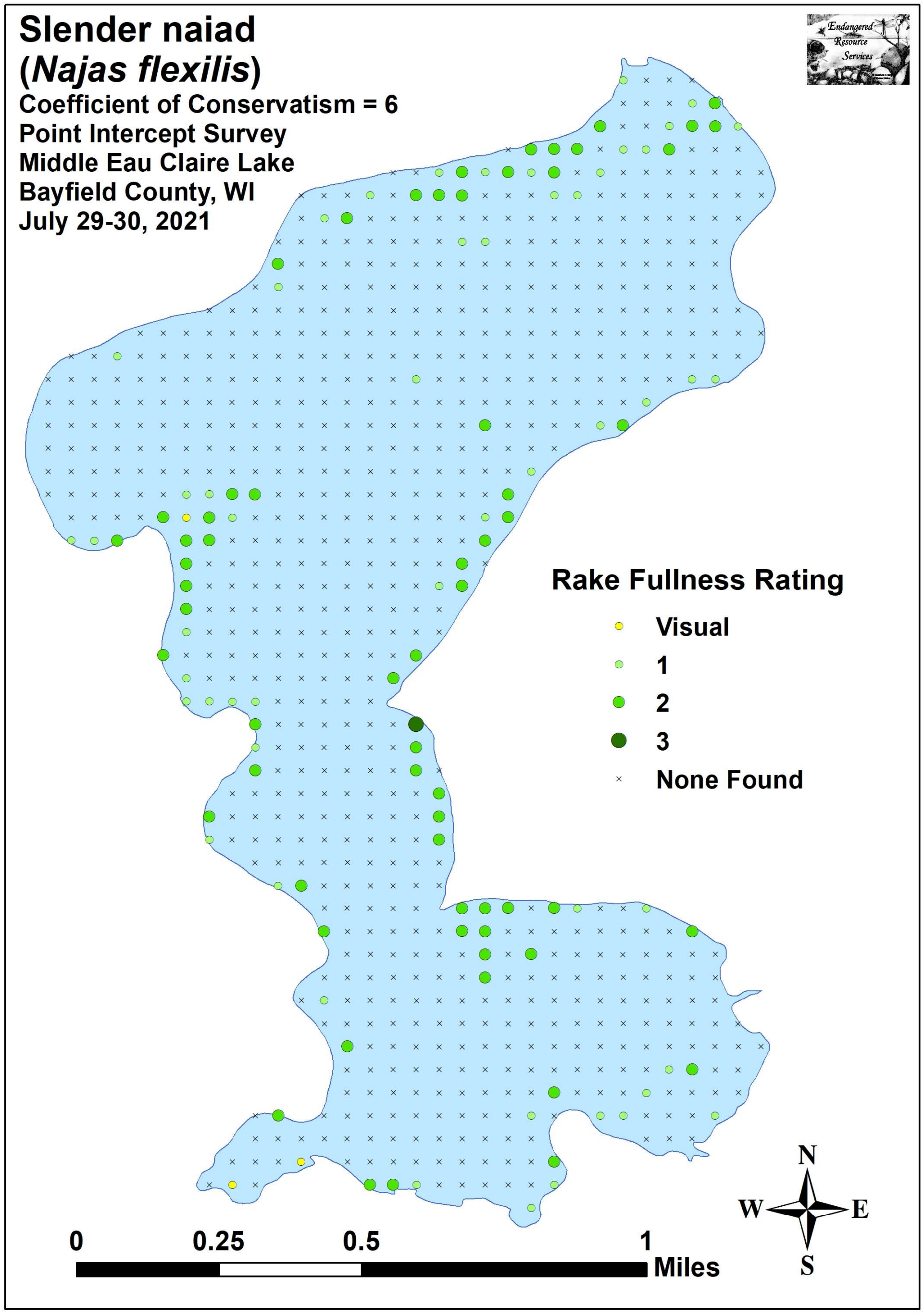

Northern water-milfoil
(Myriophyllum sibiricum)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

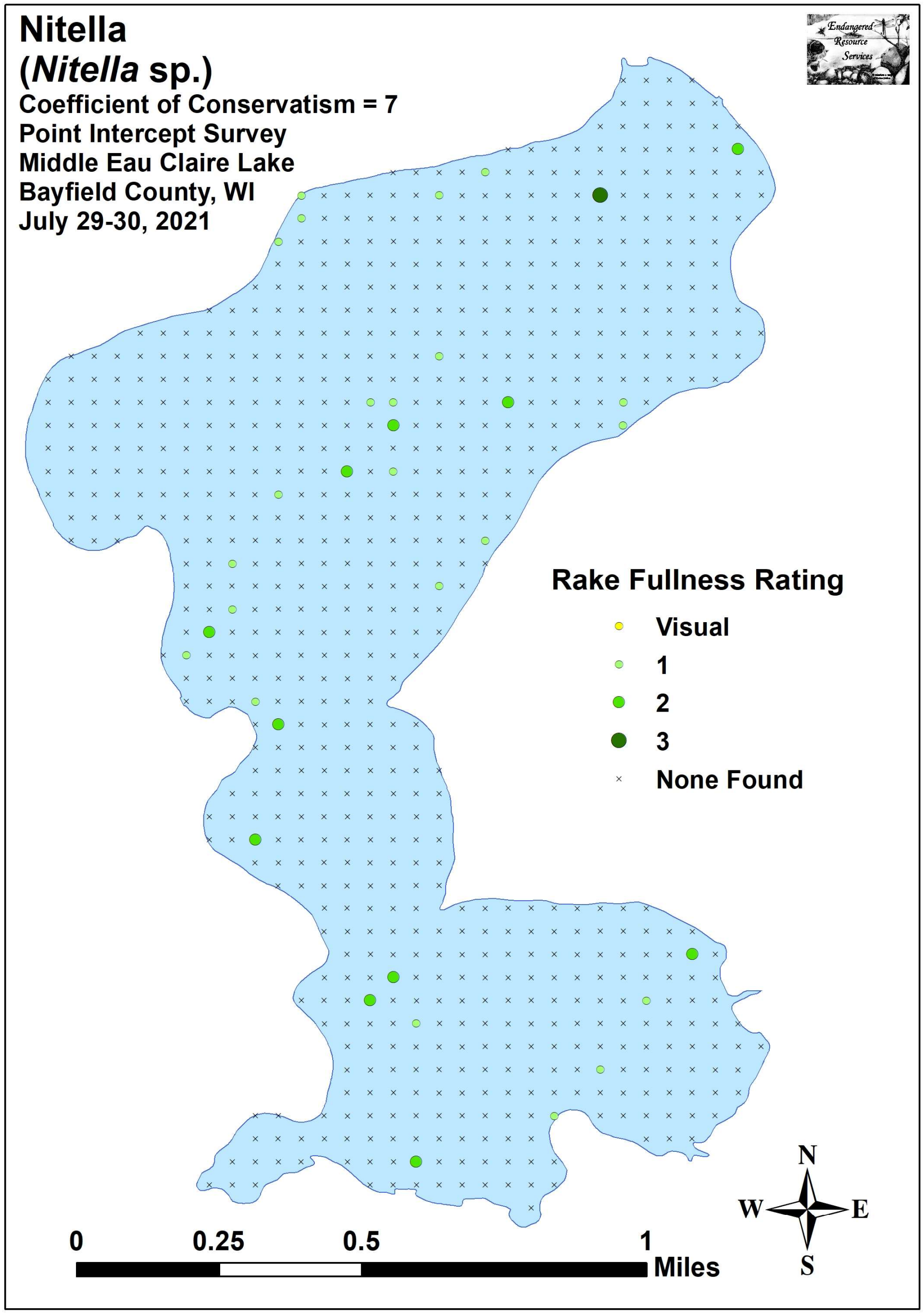


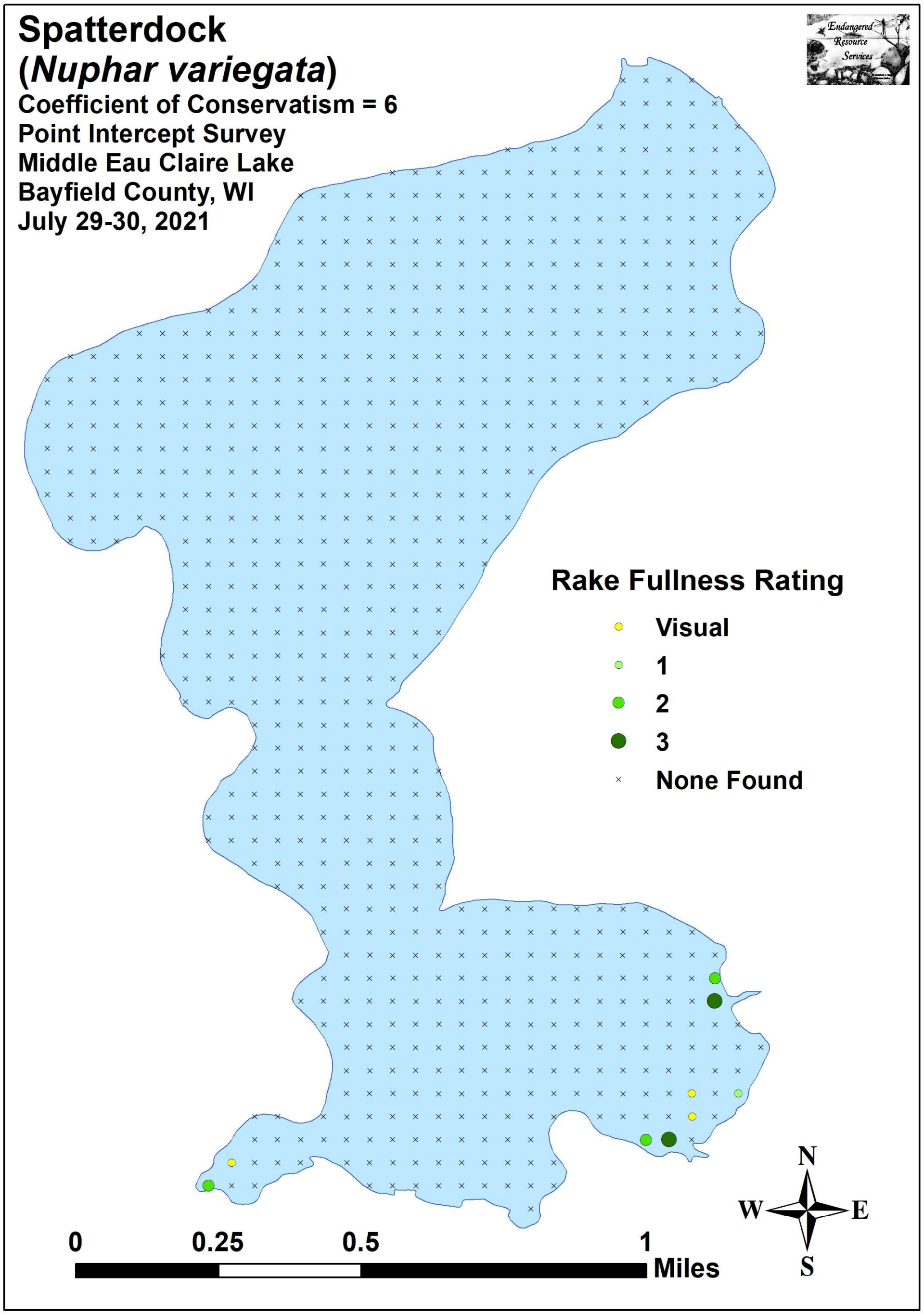
Dwarf water-milfoil
(*Myriophyllum tenellum*)
Coefficient of Conservatism = 10
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

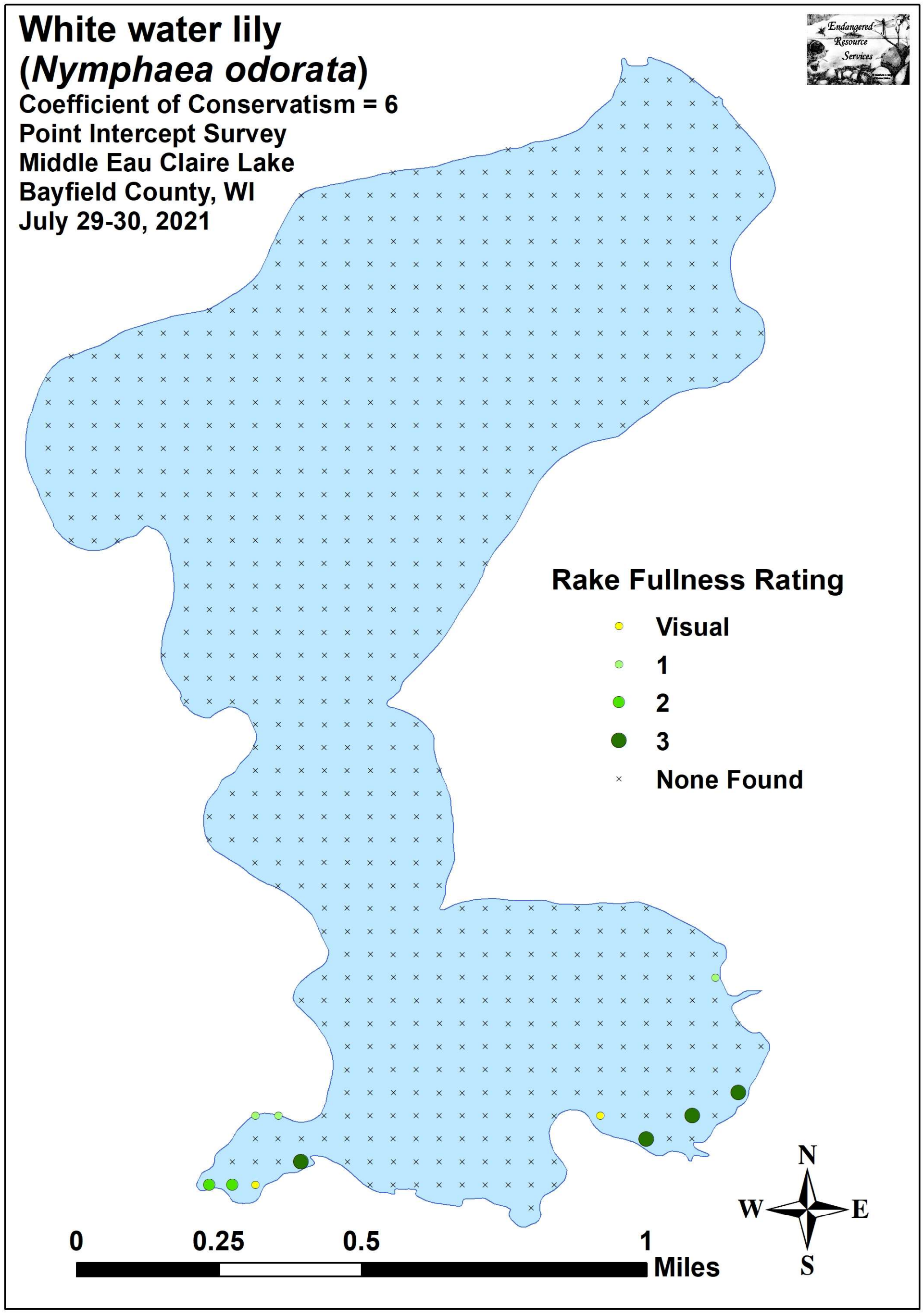


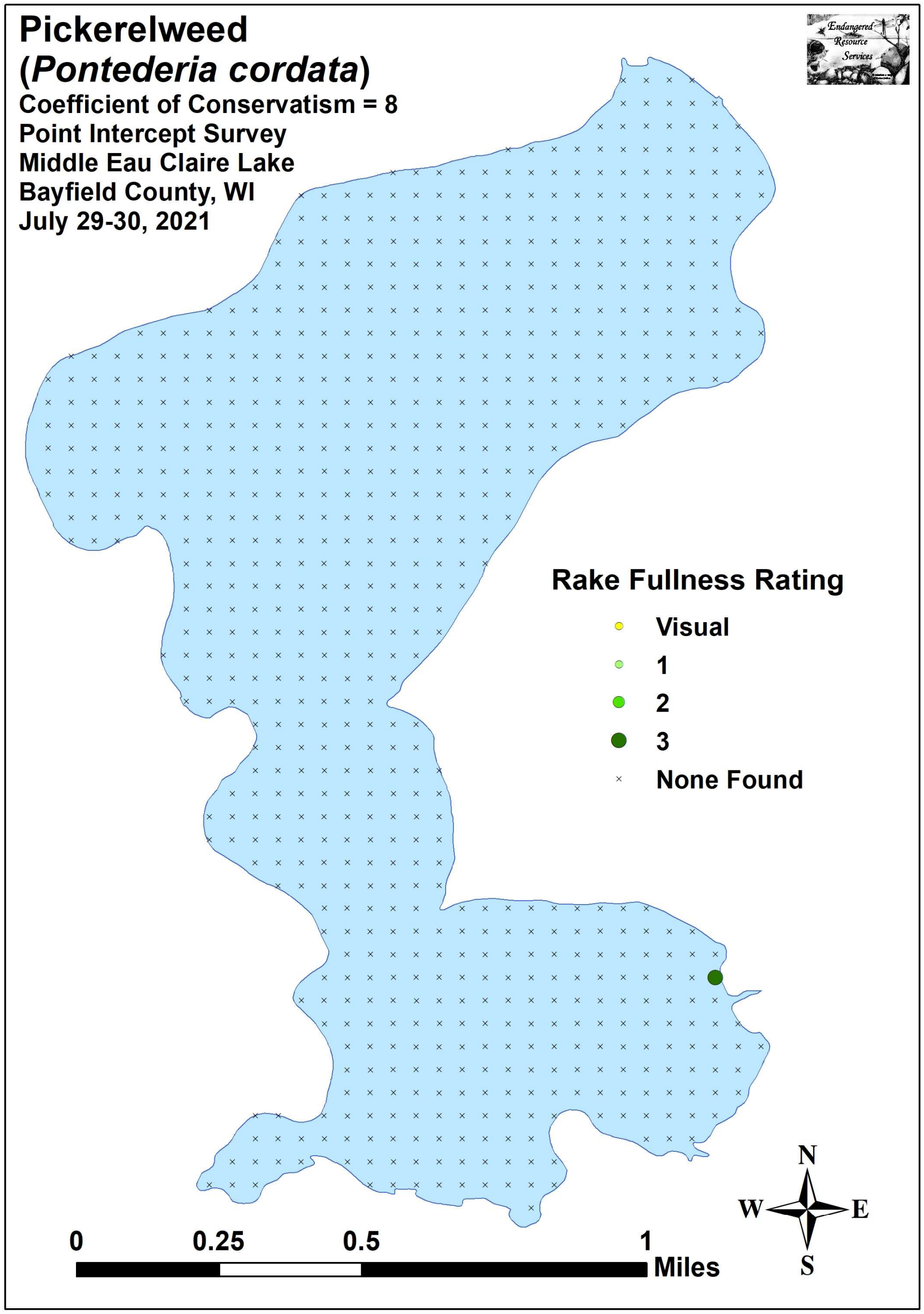
Whorled water-milfoil
(*Myriophyllum verticillatum*)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

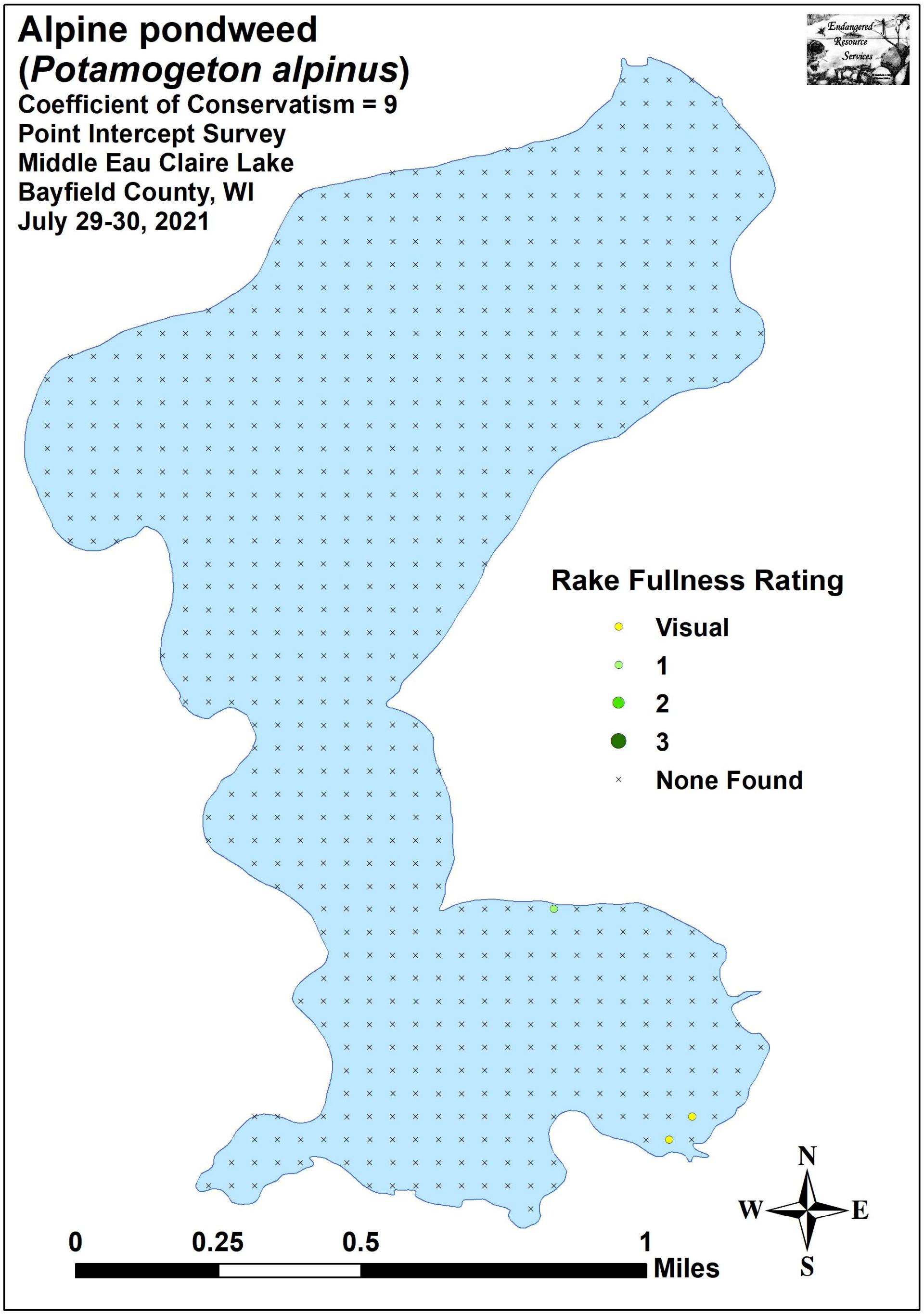

Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

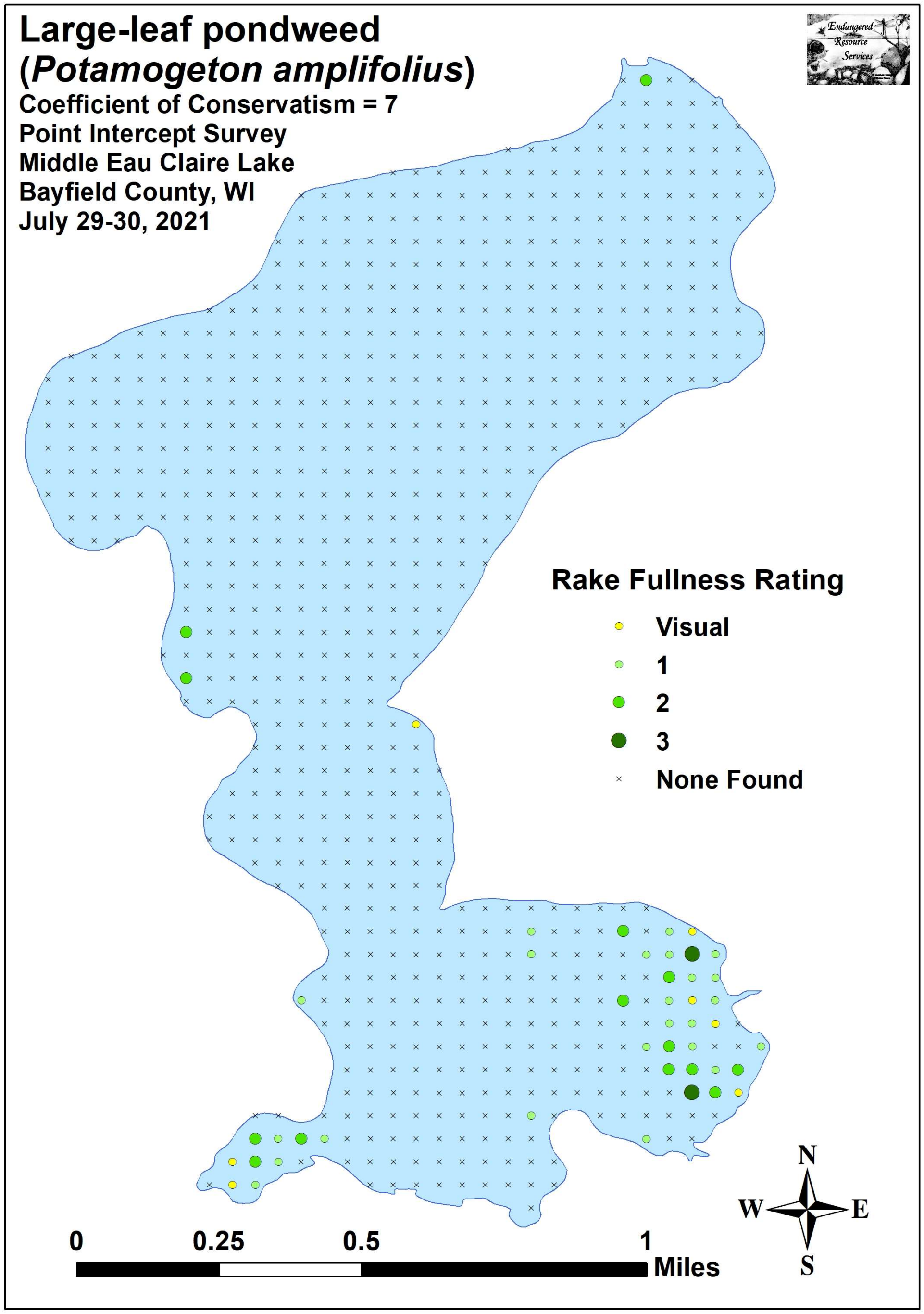

Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

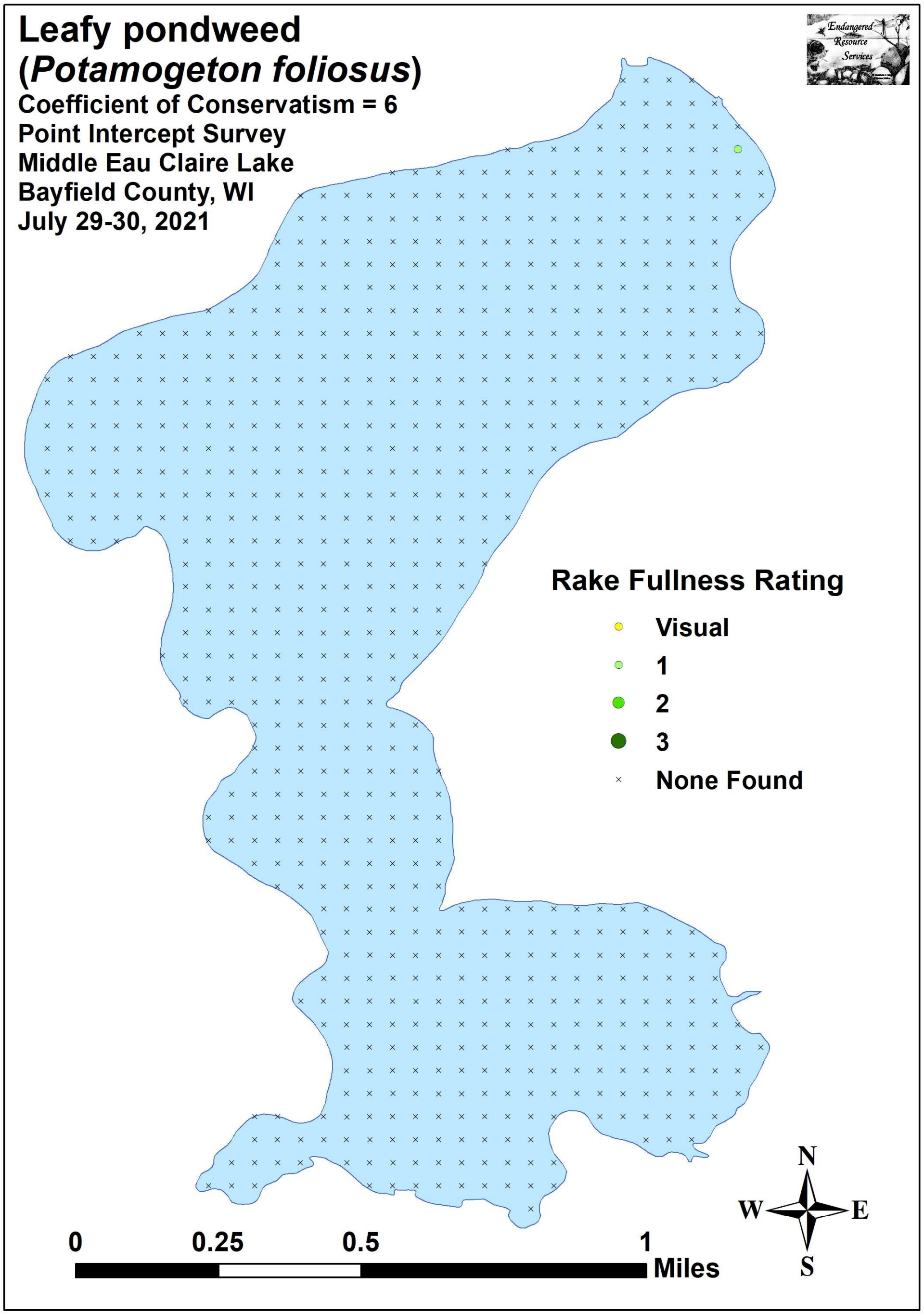

White water lily
(*Nymphaea odorata*)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

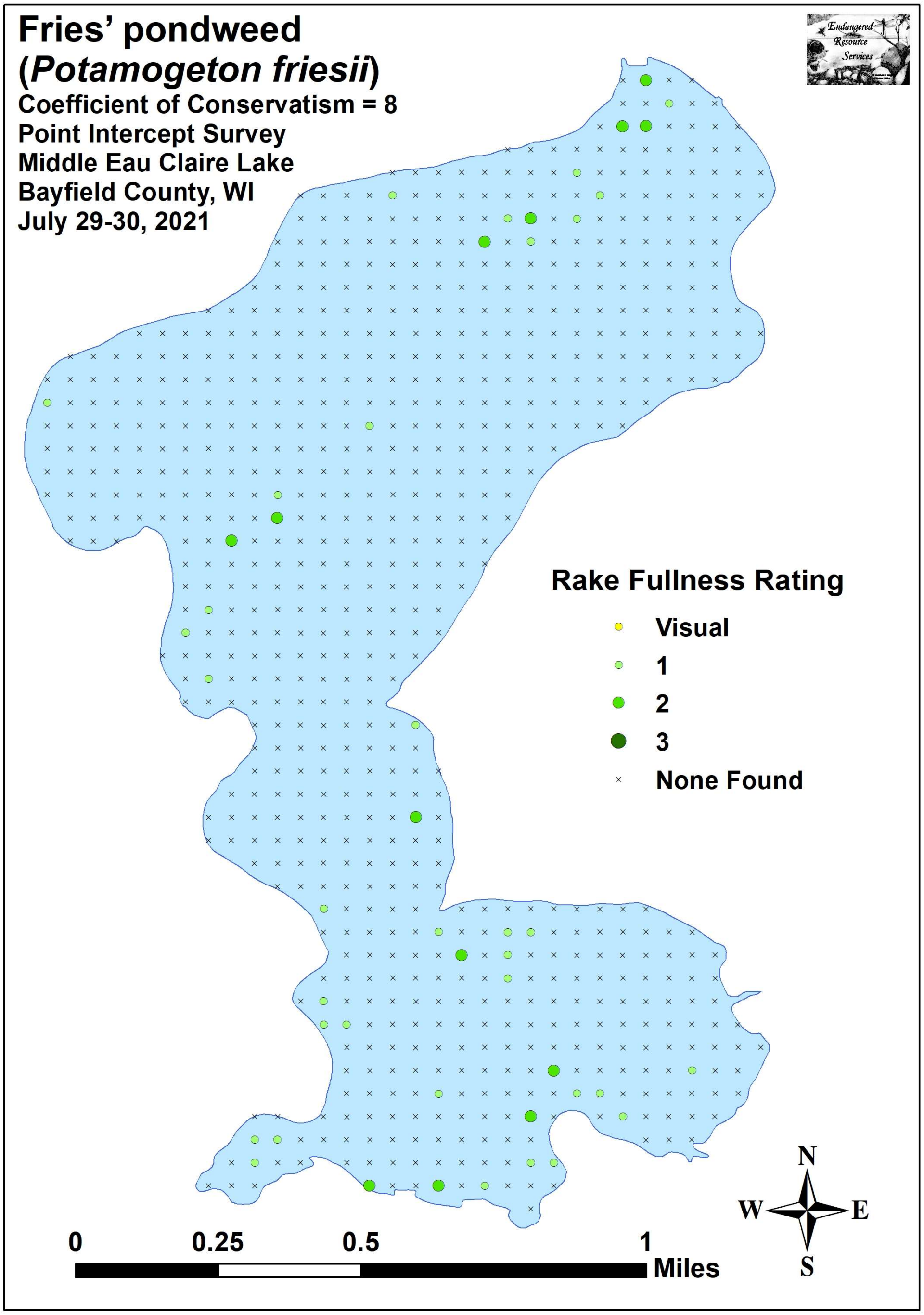

Pickerelweed
(Pontederia cordata)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

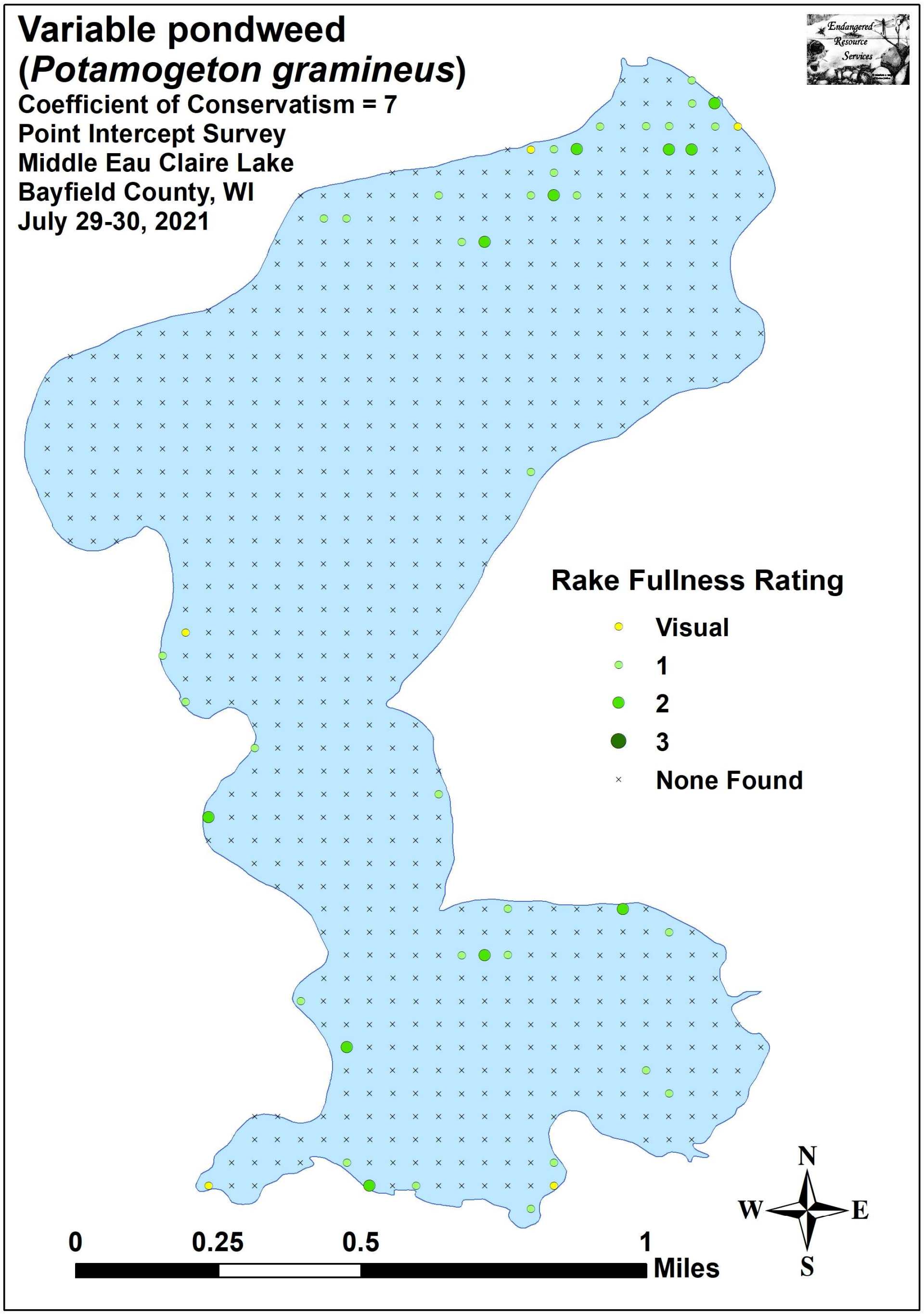

Alpine pondweed
(*Potamogeton alpinus*)
Coefficient of Conservatism = 9
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

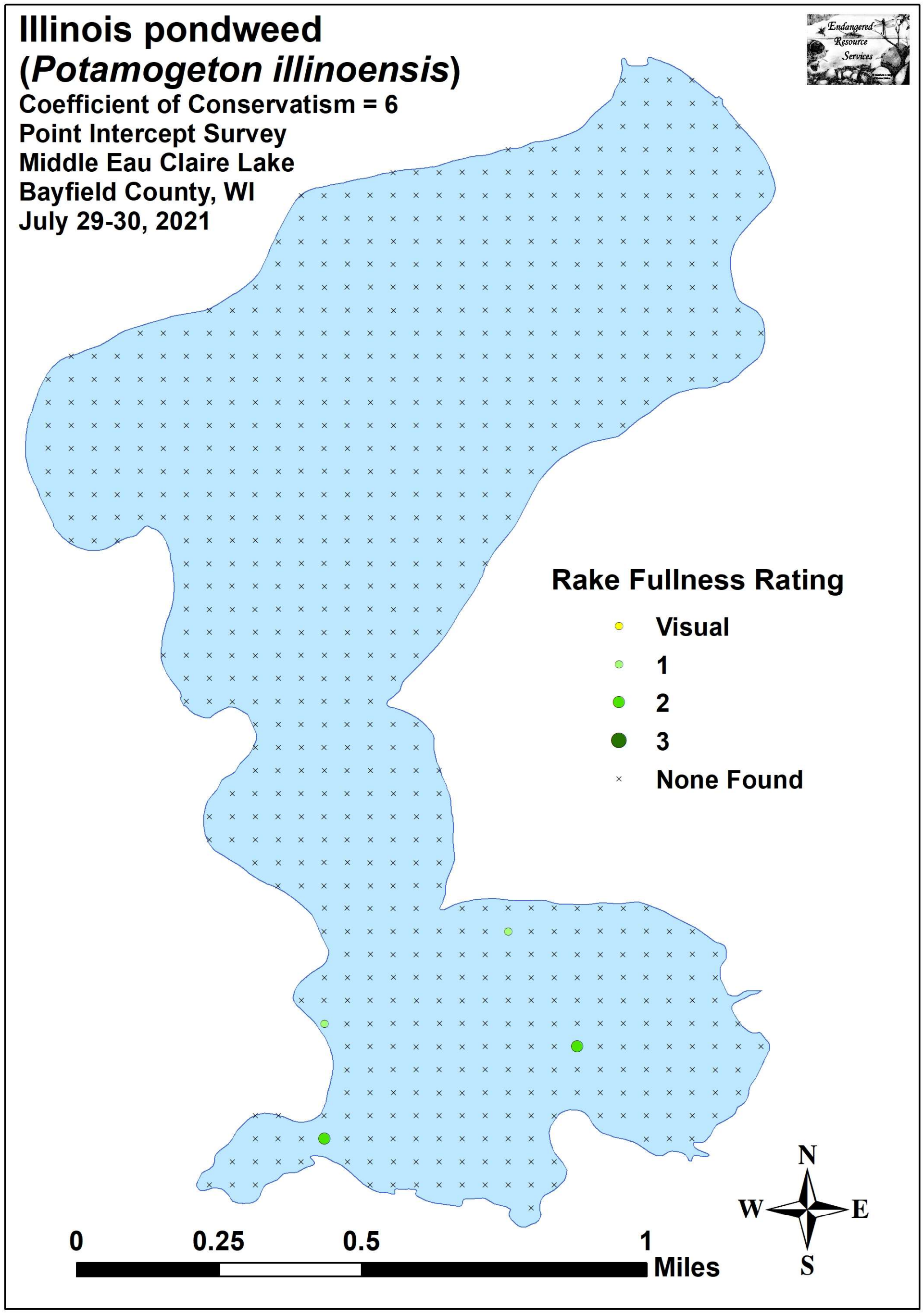


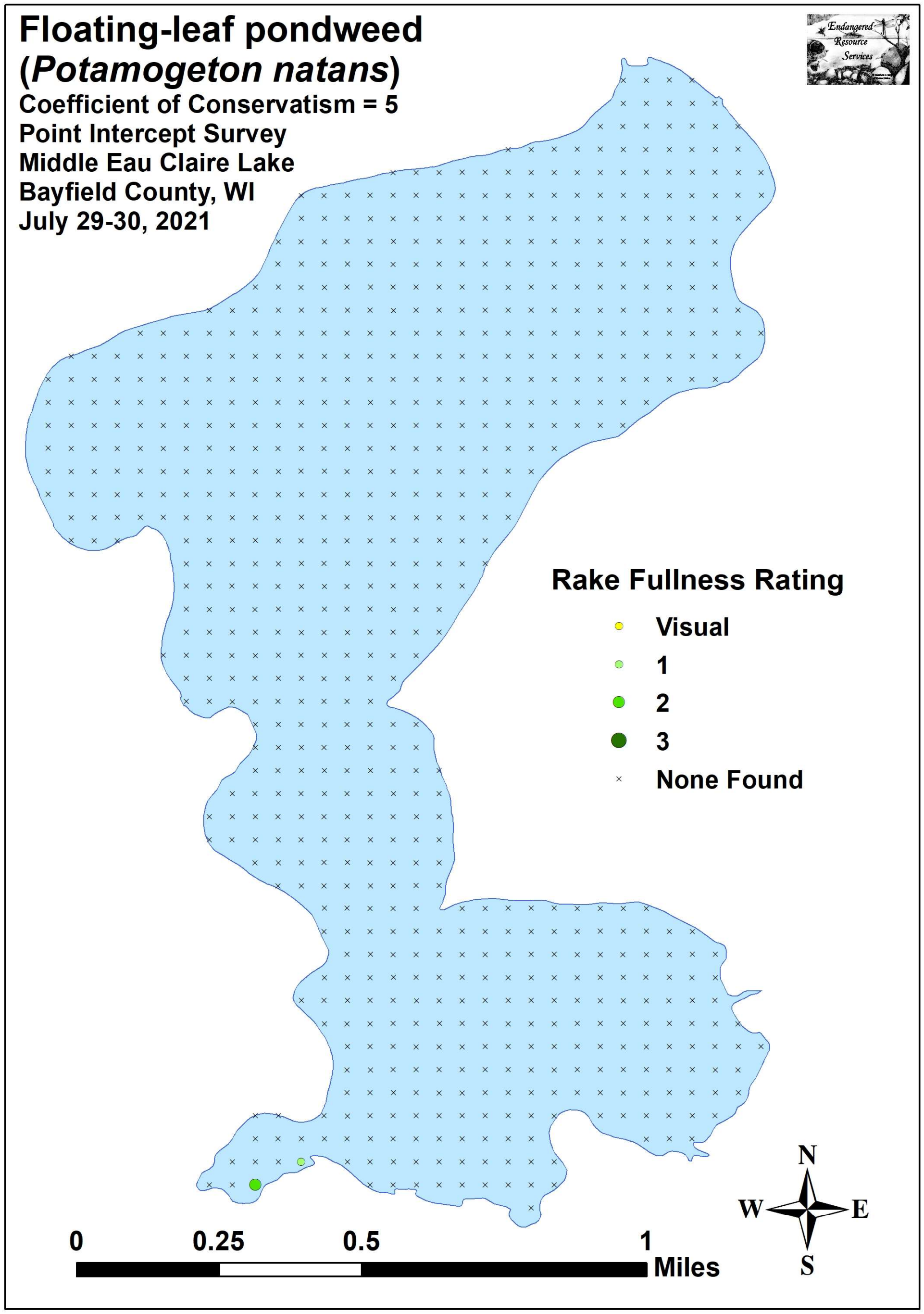
Large-leaf pondweed
(*Potamogeton amplifolius*)
Coefficient of Conservatism = 7
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S


Leafy pondweed
(*Potamogeton foliosus*)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

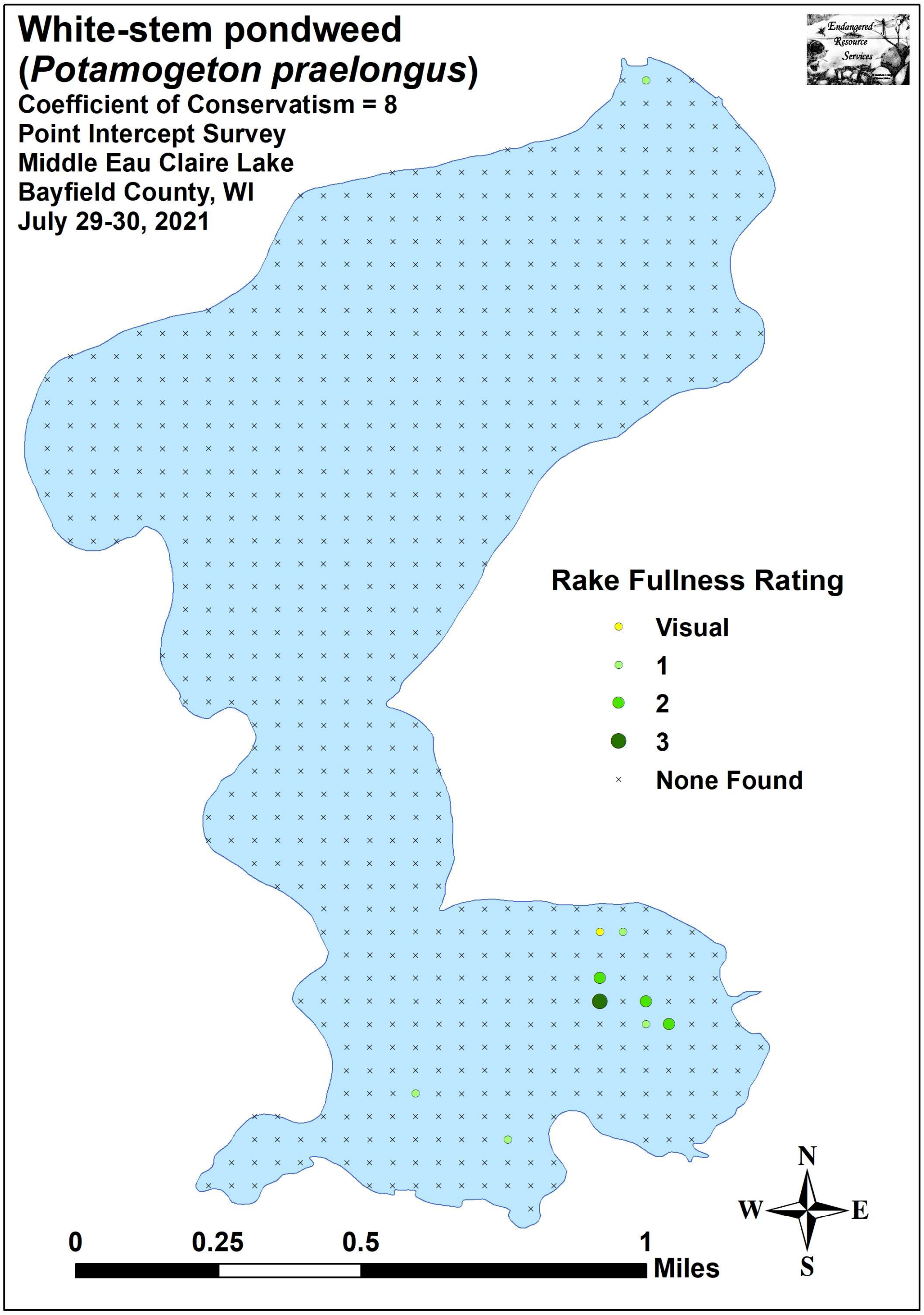

Fries' pondweed
(*Potamogeton friesii*)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

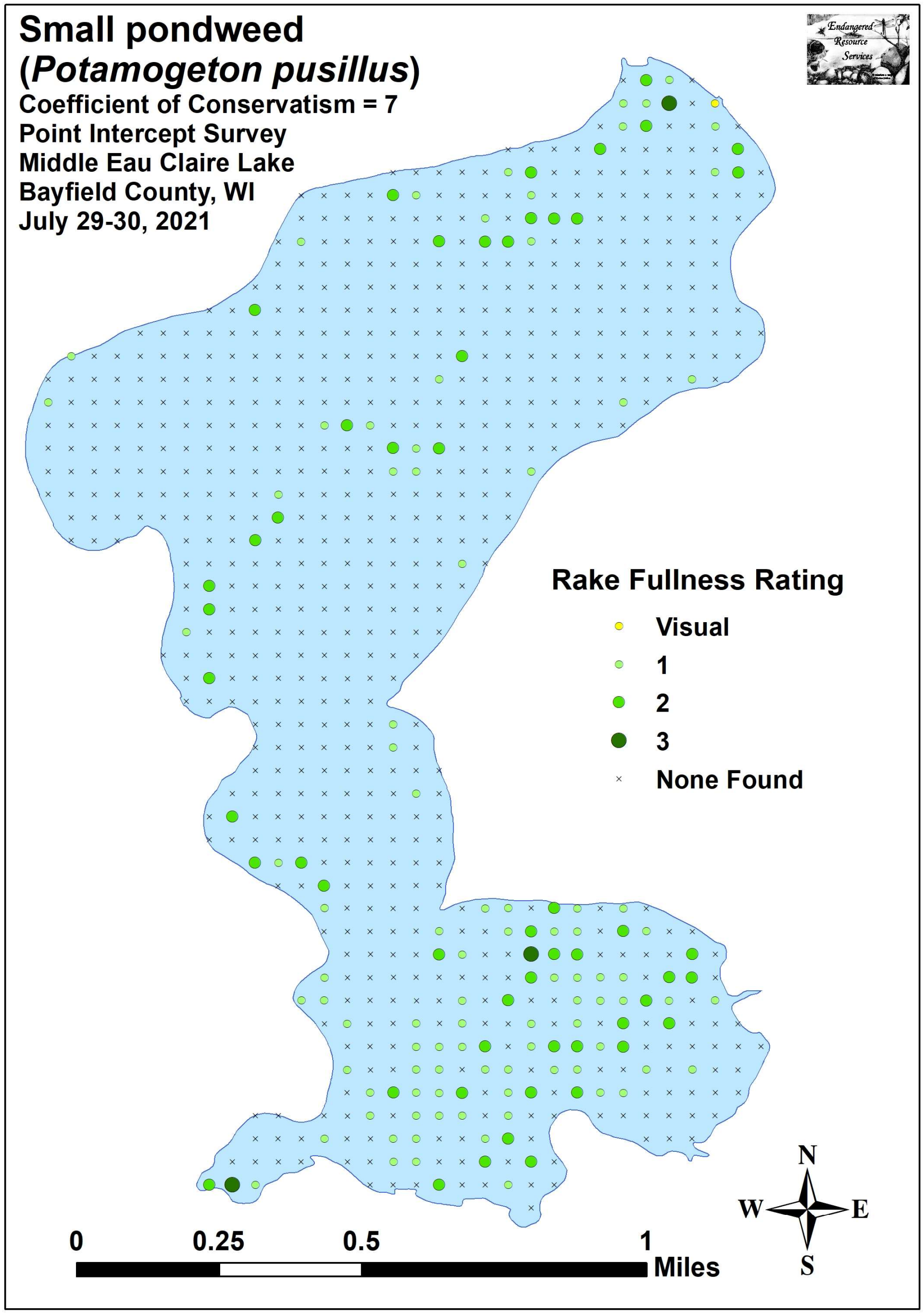

Variable pondweed
(*Potamogeton gramineus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Illinois pondweed
(*Potamogeton illinoensis*)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
S
E
W

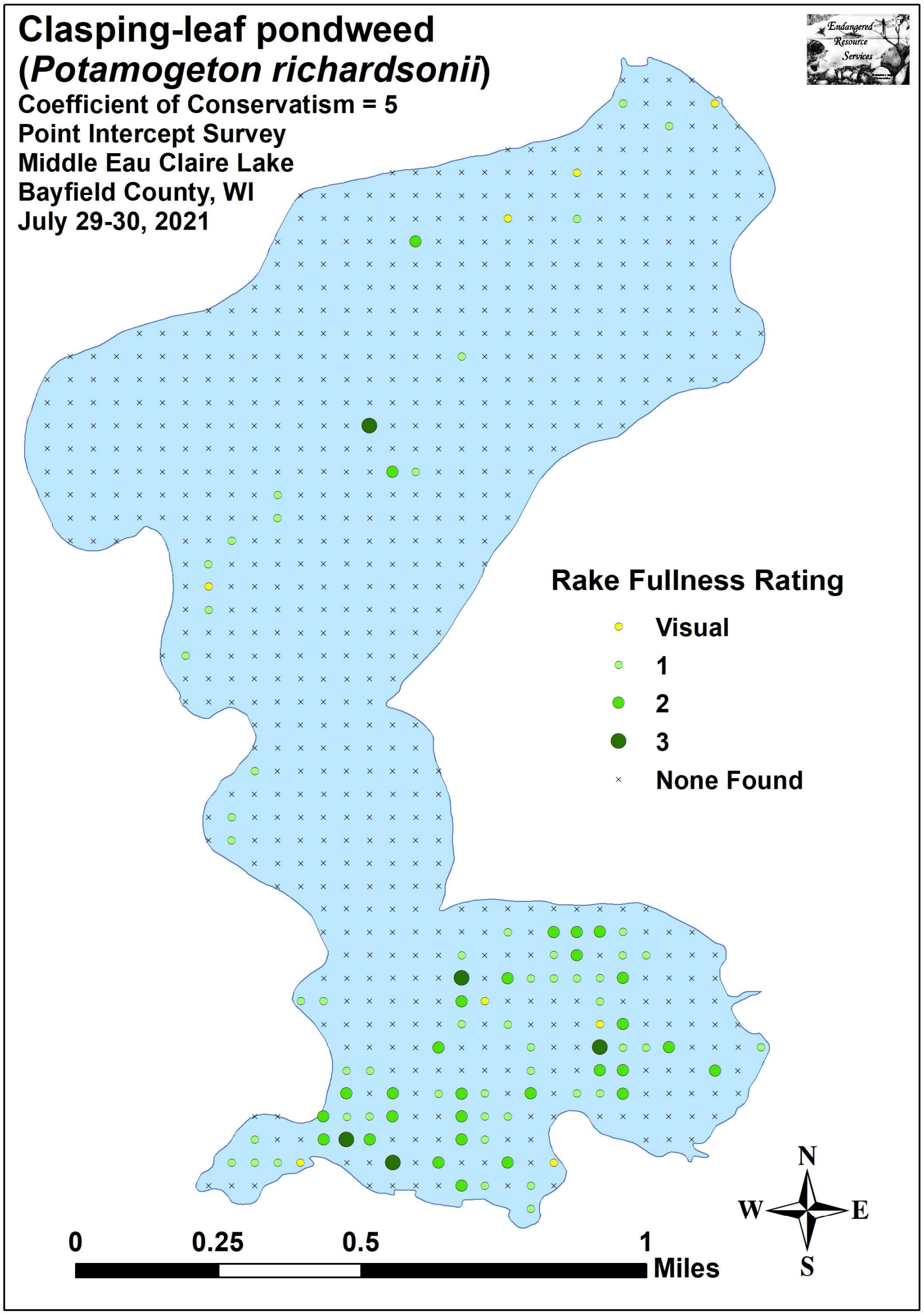


Floating-leaf pondweed
(Potamogeton natans)
Coefficient of Conservatism = 5
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
S
E
W

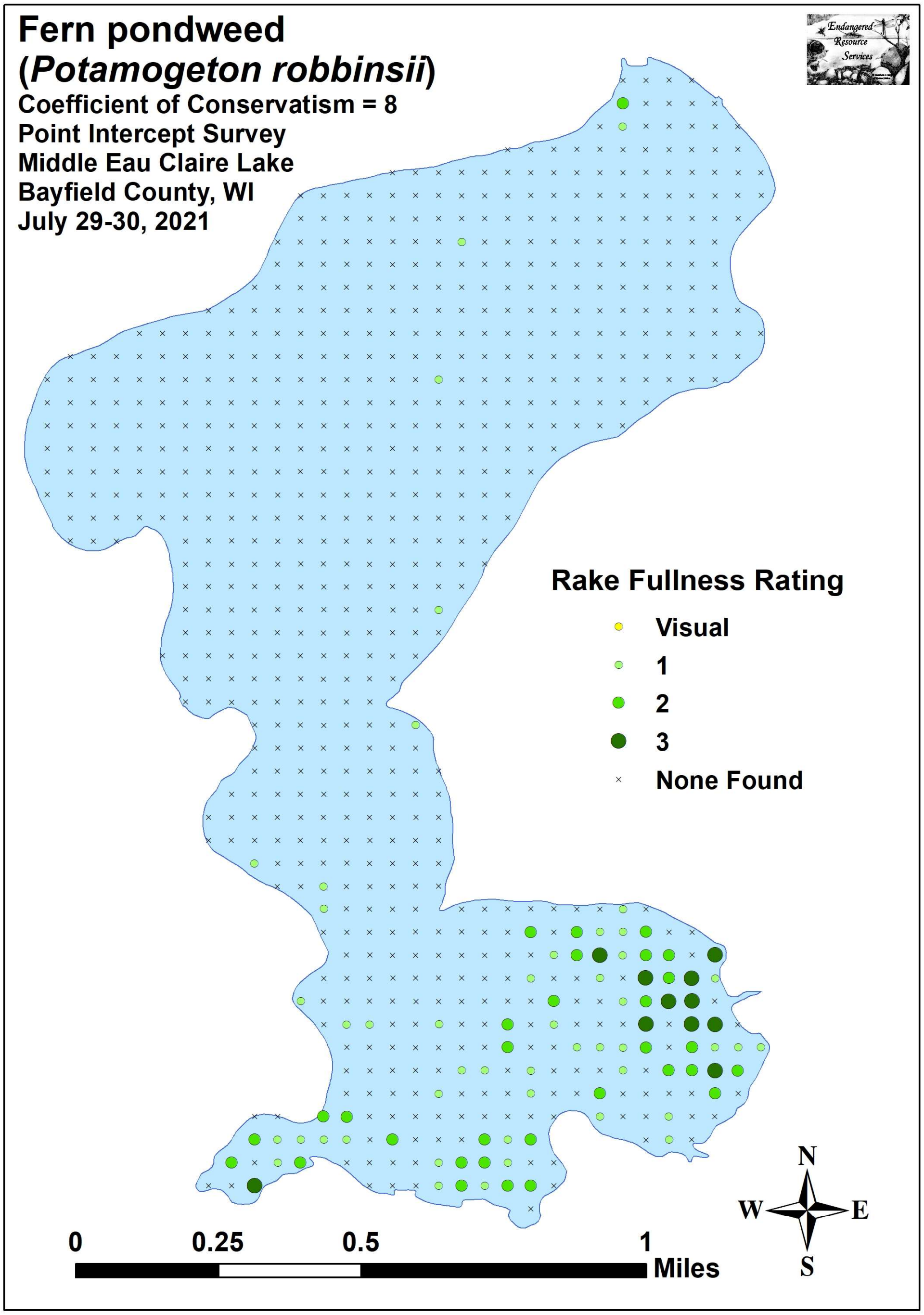

White-stem pondweed
(*Potamogeton praelongus*)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



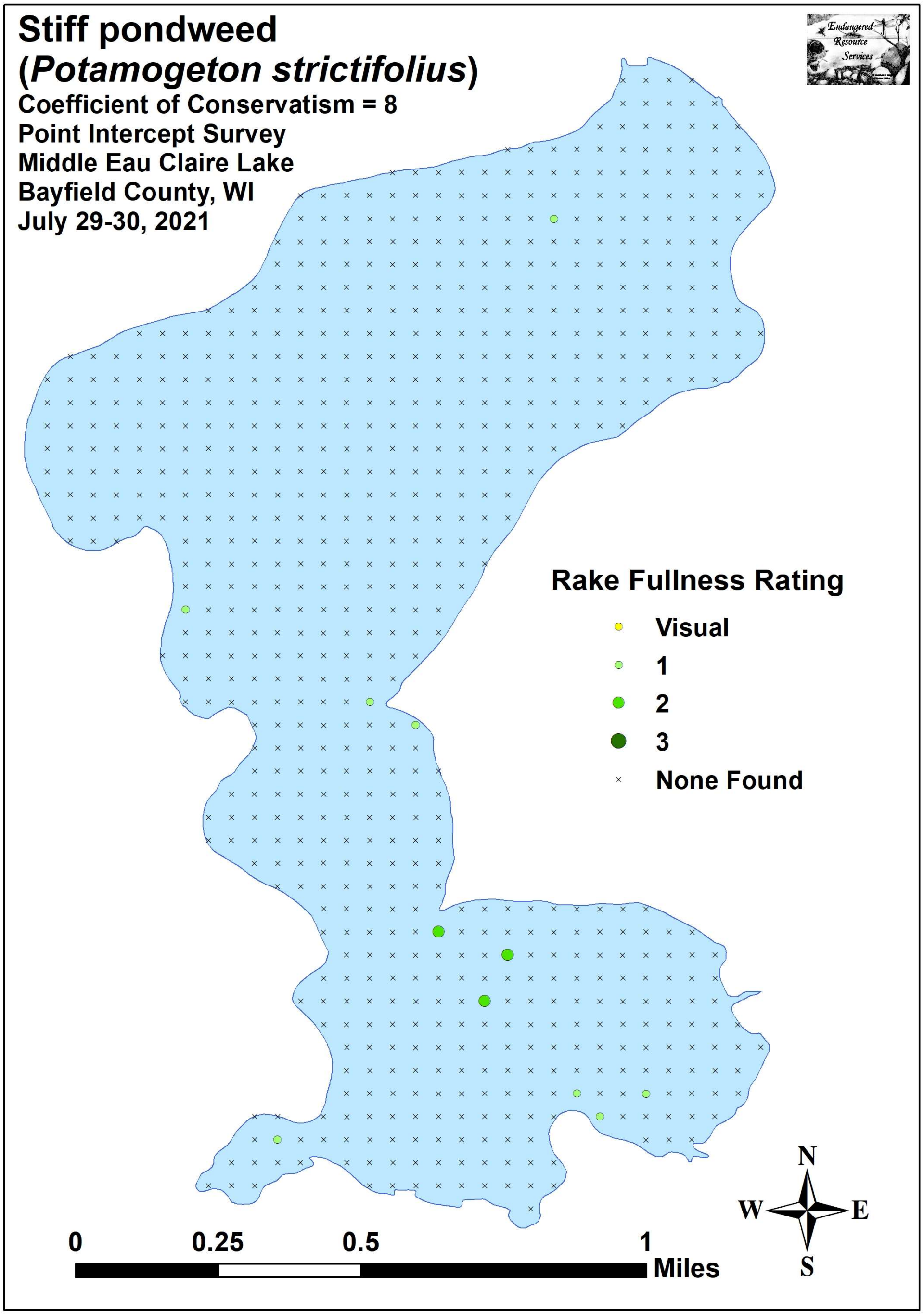
Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S



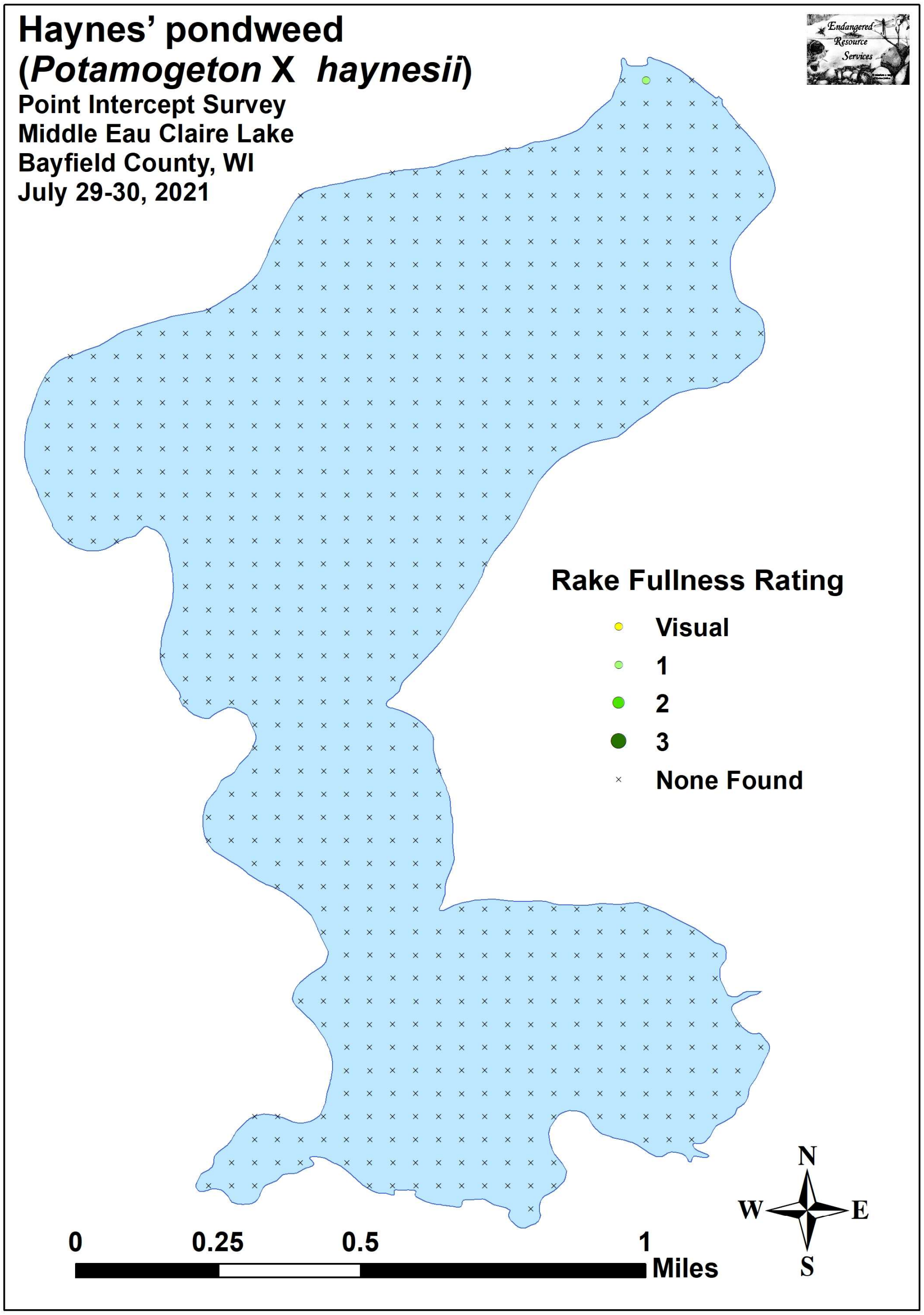
Clasping-leaf pondweed
(Potamogeton richardsonii)
Coefficient of Conservatism = 5
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



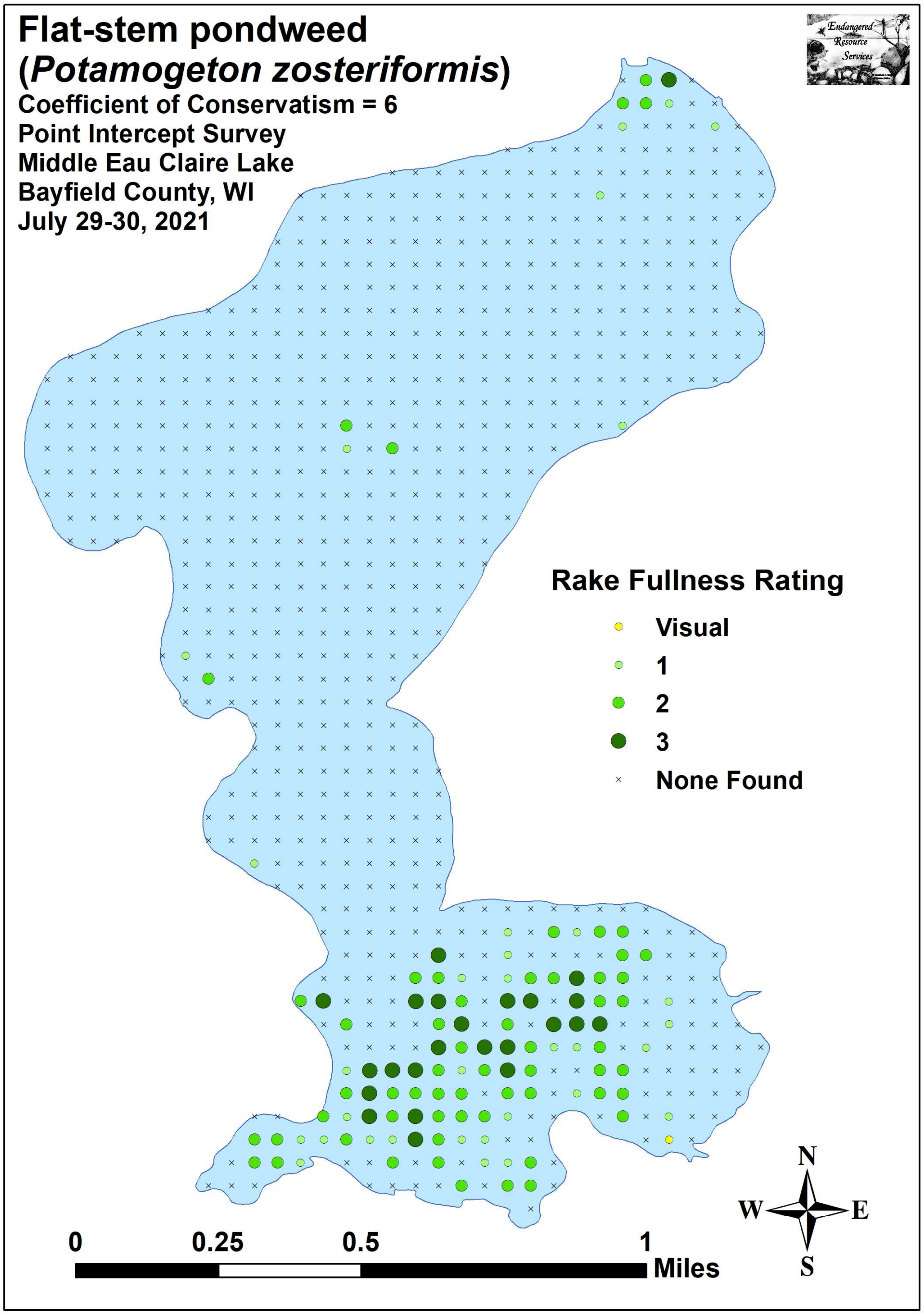
Fern pondweed
(*Potamogeton robbinsii*)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

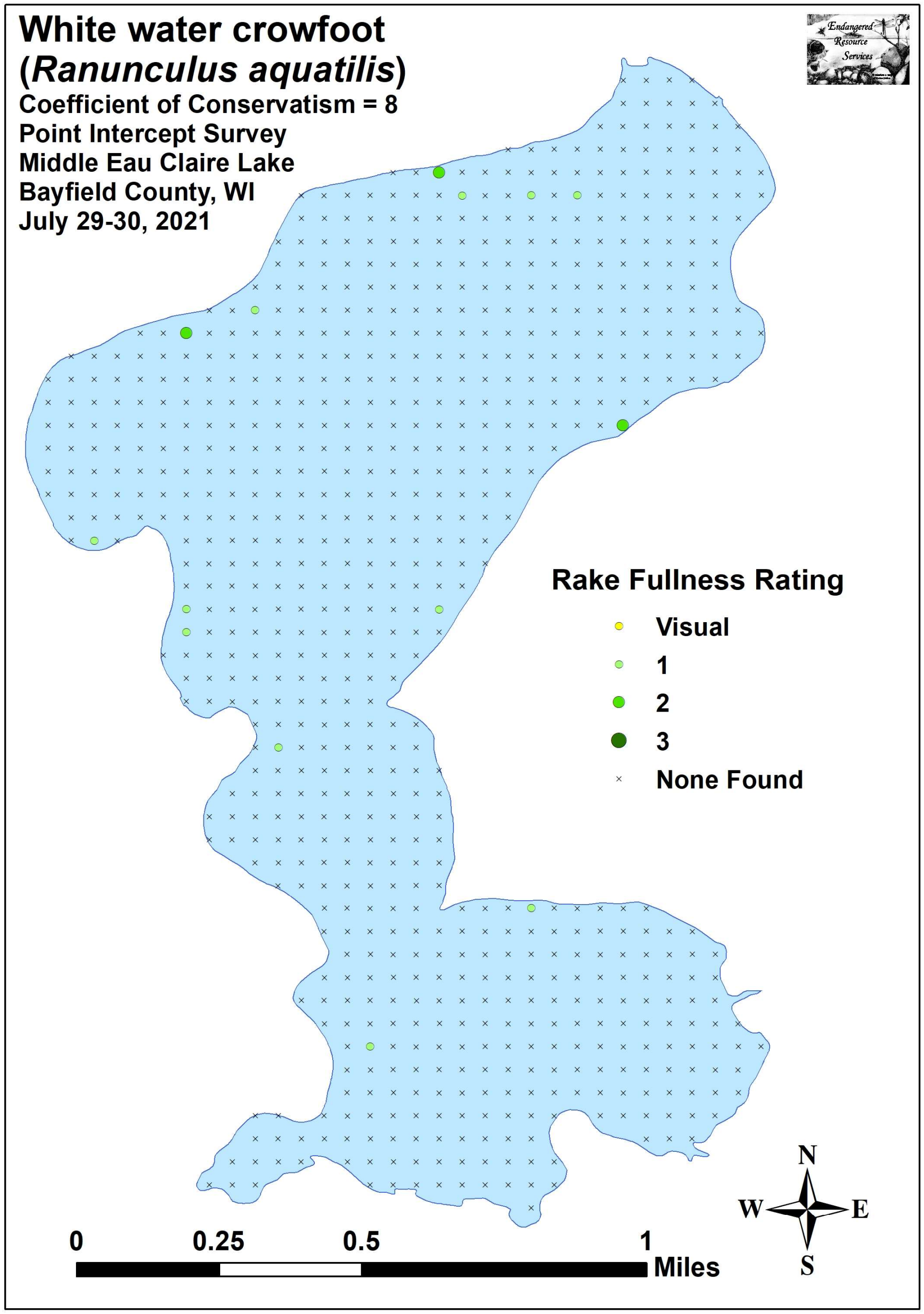


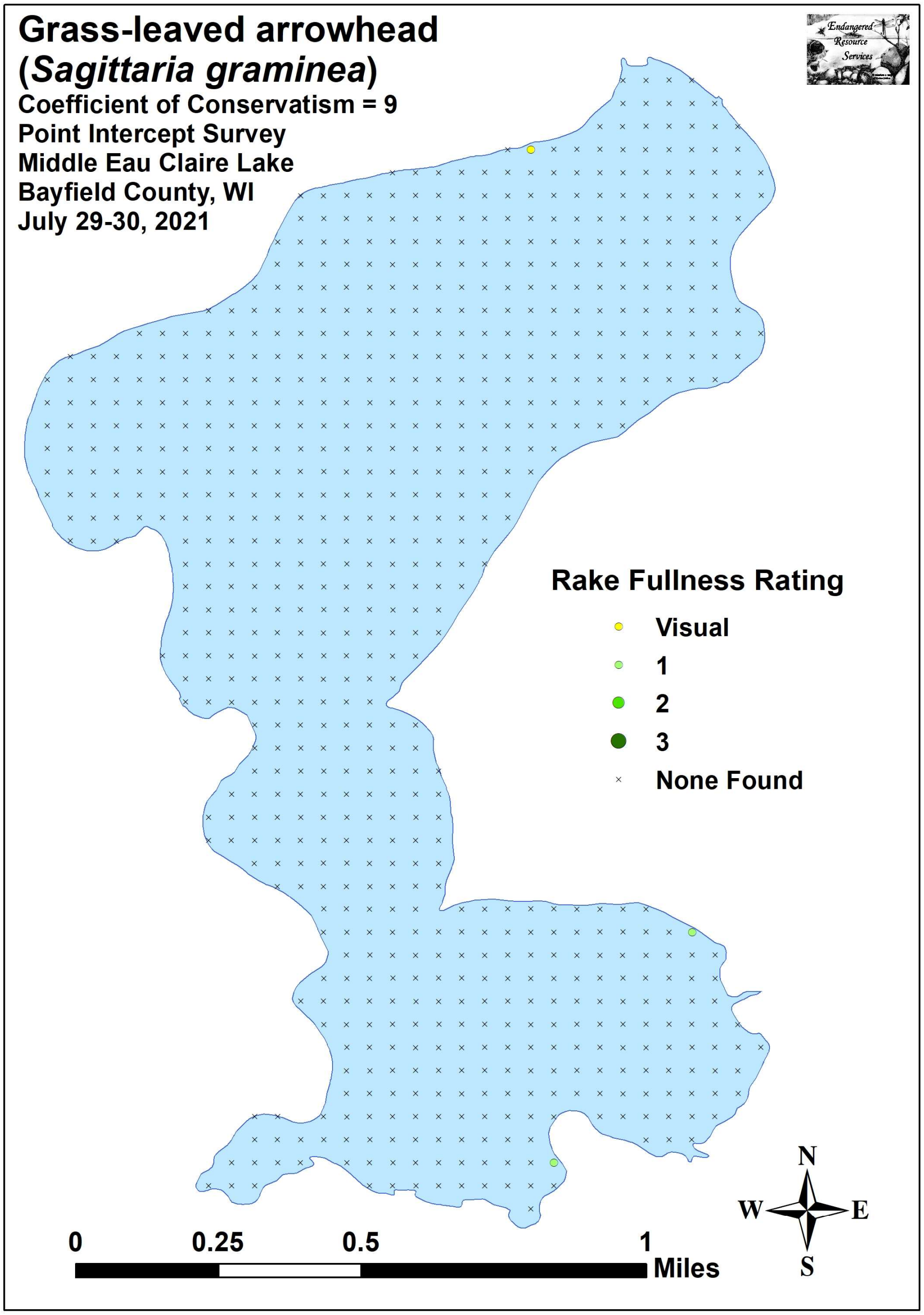
Stiff pondweed
(*Potamogeton strictifolius*)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

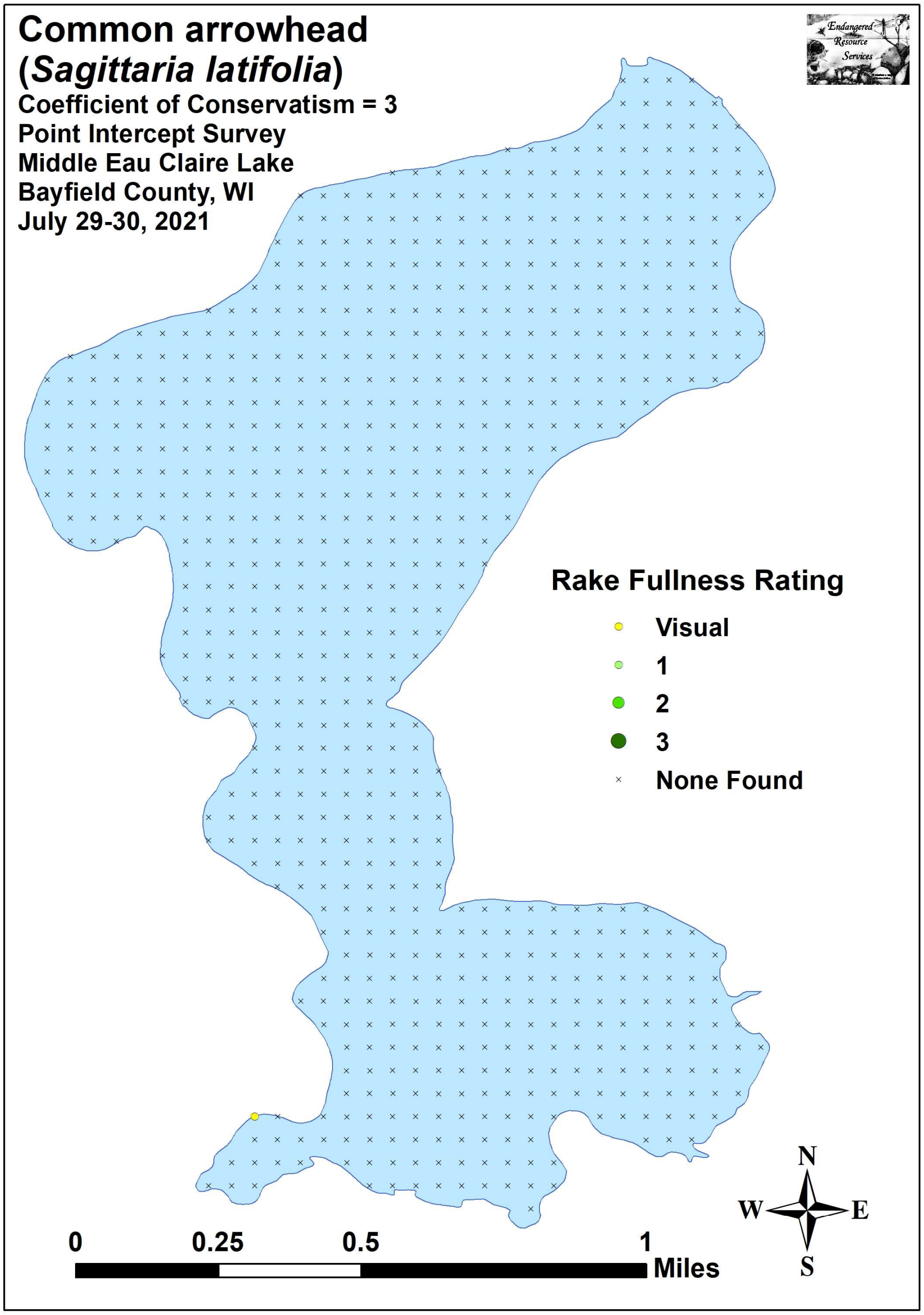


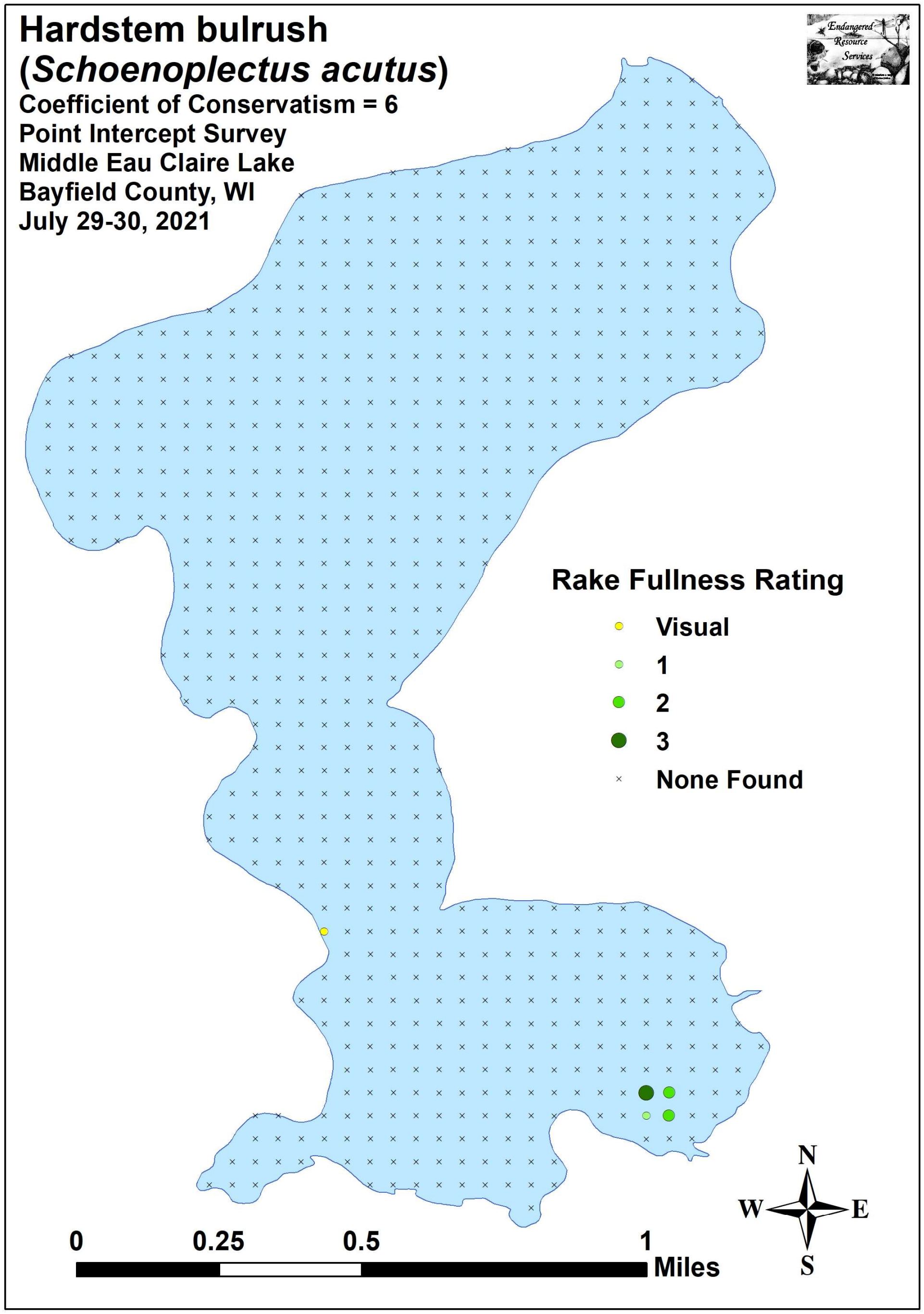
Haynes' pondweed
(*Potamogeton* X *haynesii*)
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S


Flat-stem pondweed
(*Potamogeton zosteriformis*)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

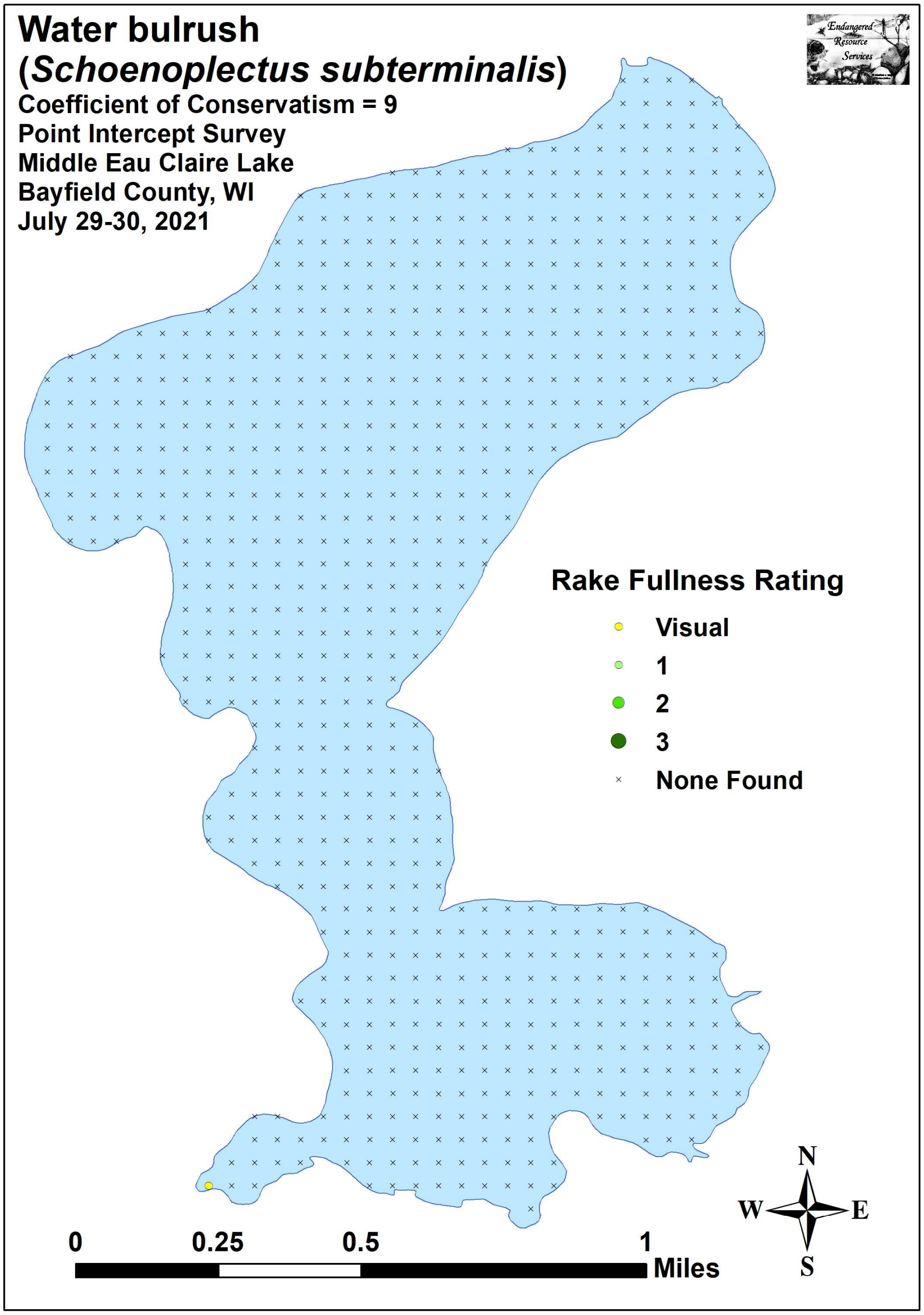

White water crowfoot
(*Ranunculus aquatilis*)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

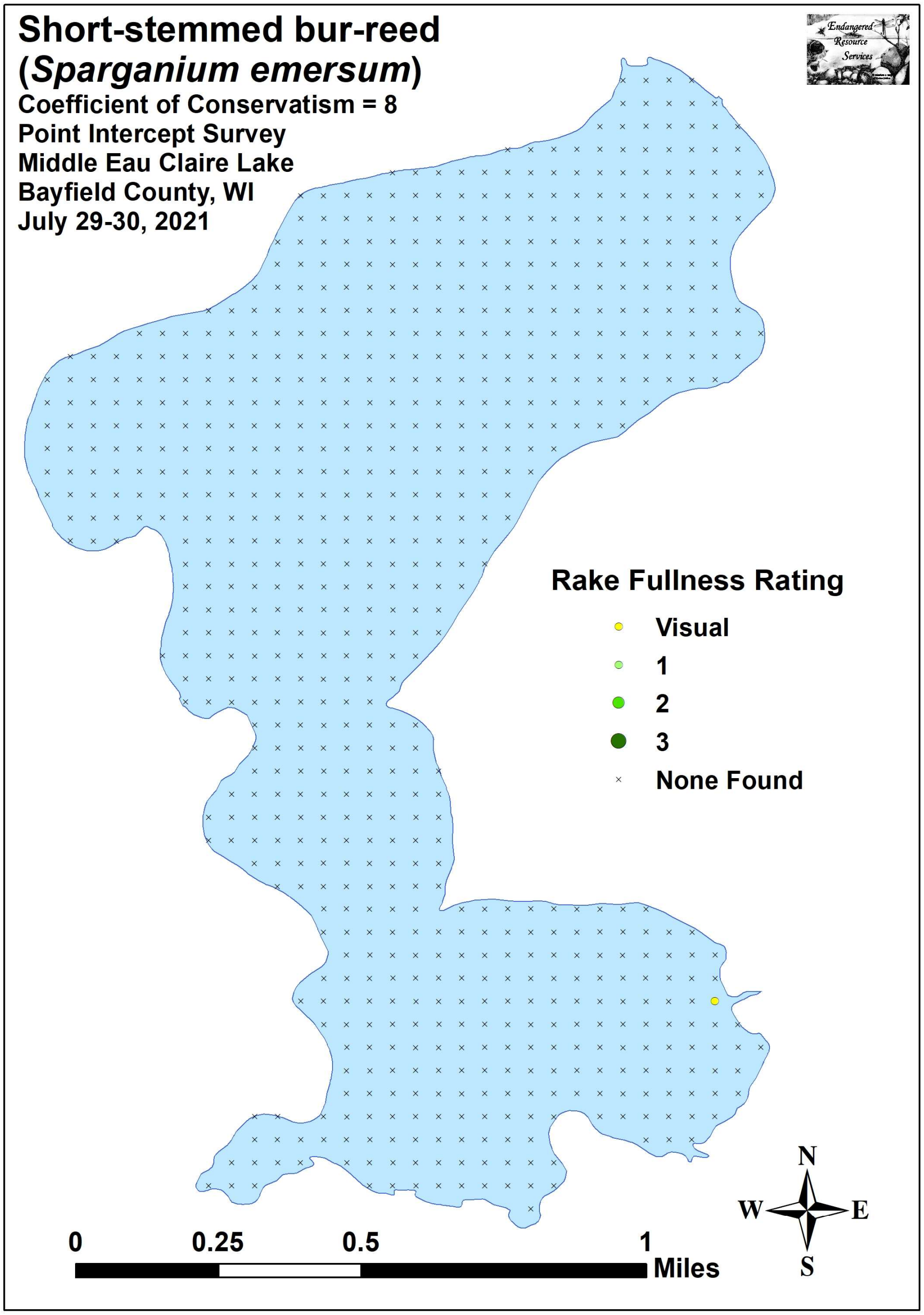

Grass-leaved arrowhead
(*Sagittaria graminea*)
Coefficient of Conservatism = 9
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

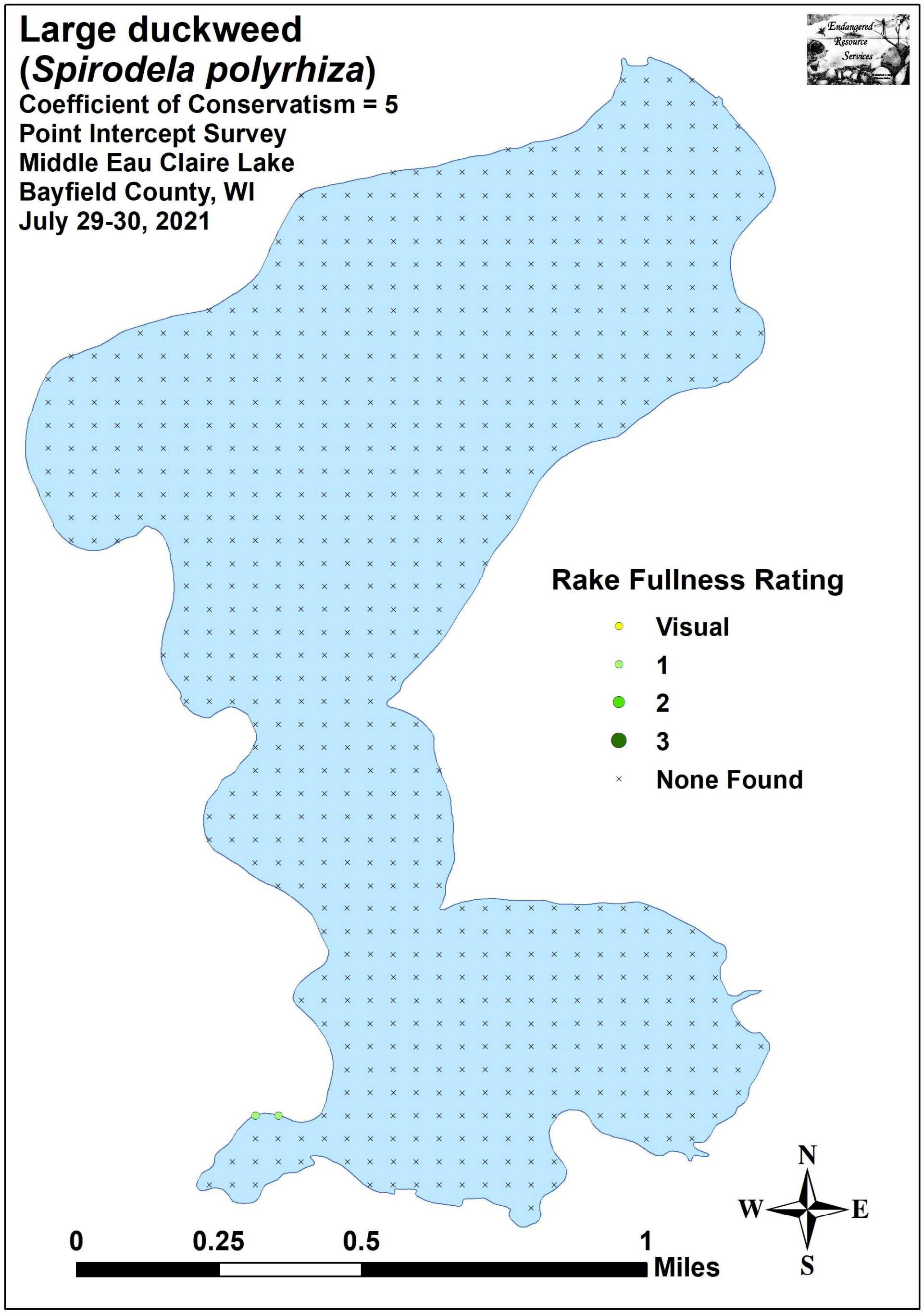

Common arrowhead
(Sagittaria latifolia)
Coefficient of Conservatism = 3
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

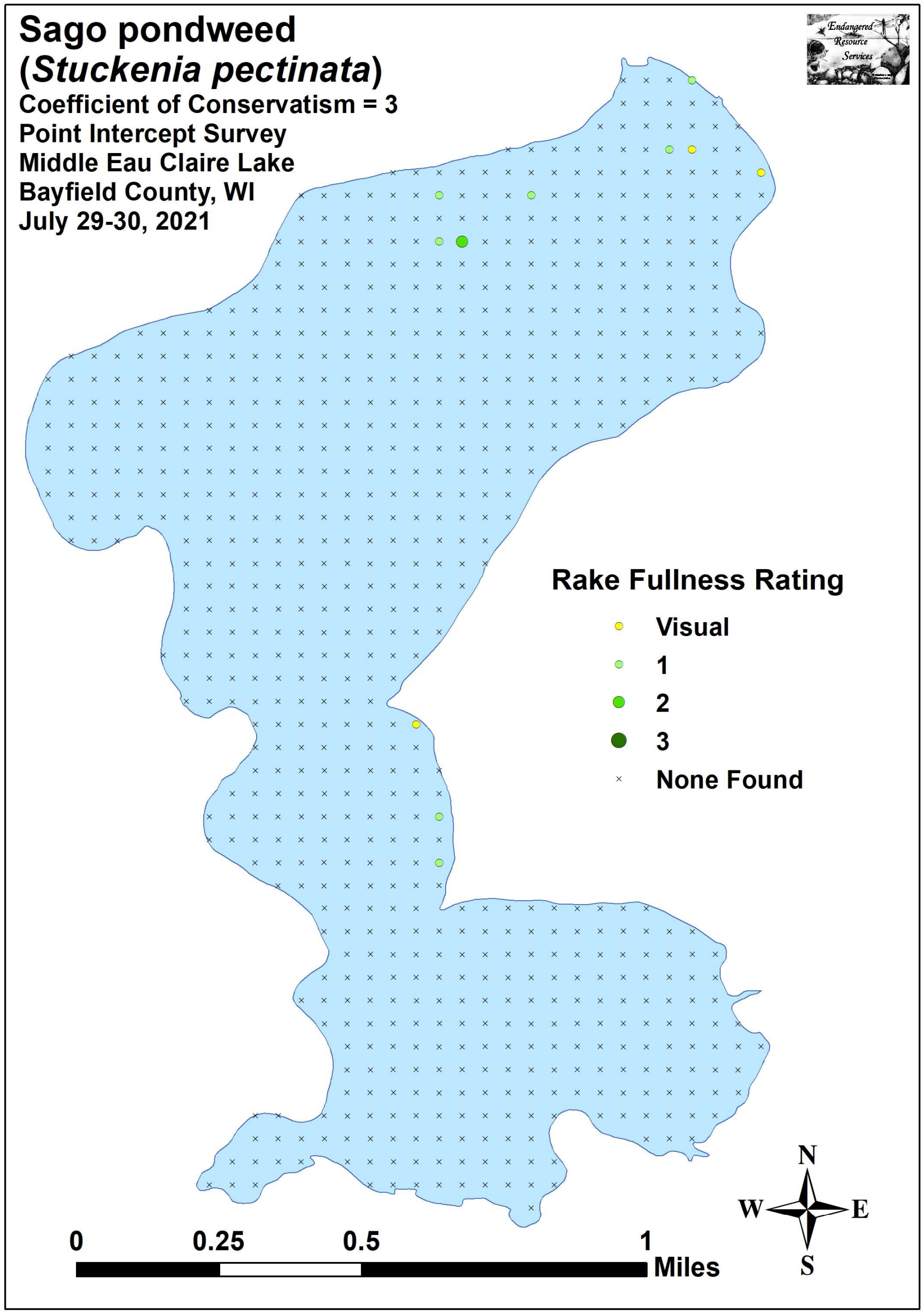


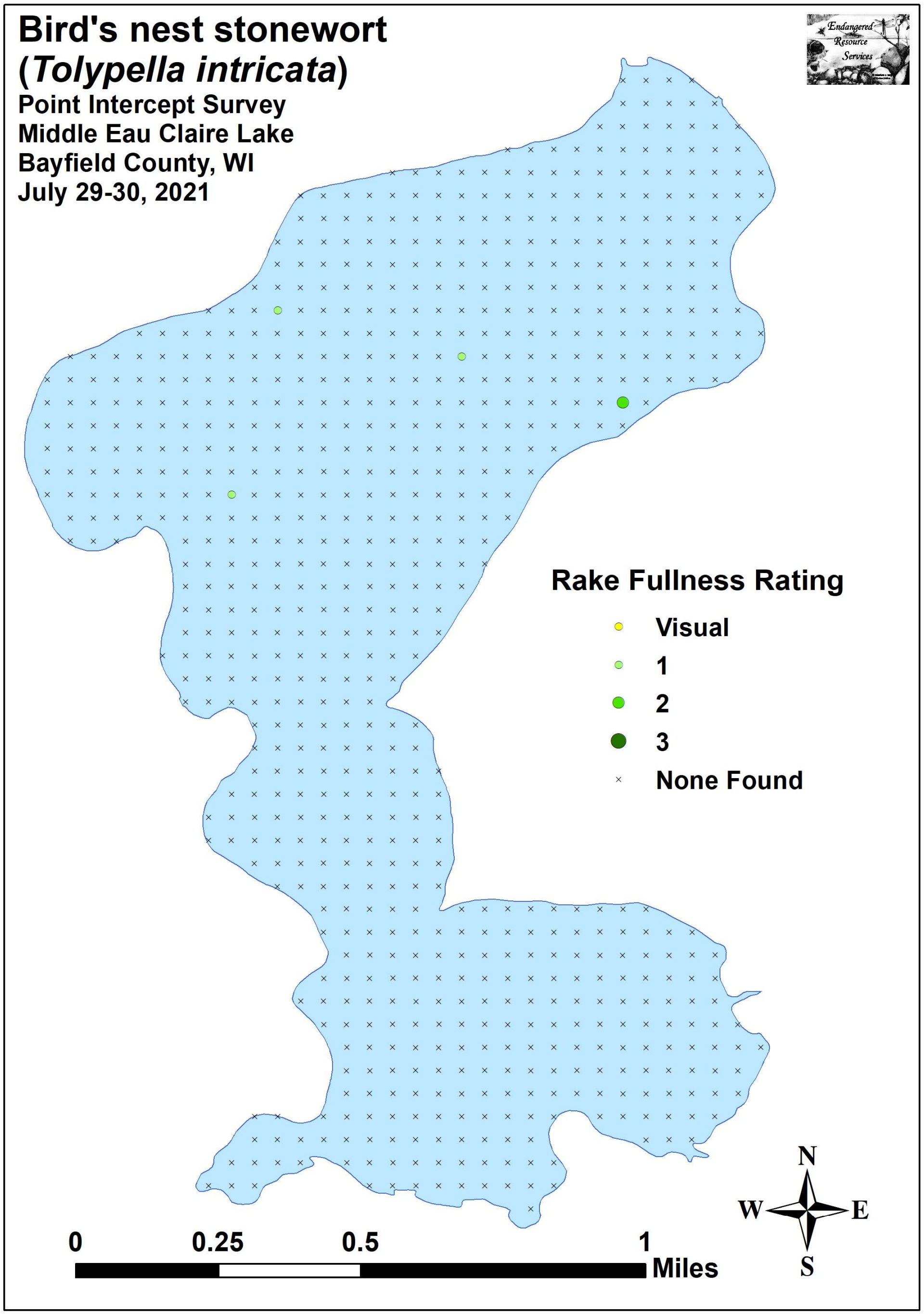
Hardstem bulrush
(*Schoenoplectus acutus*)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

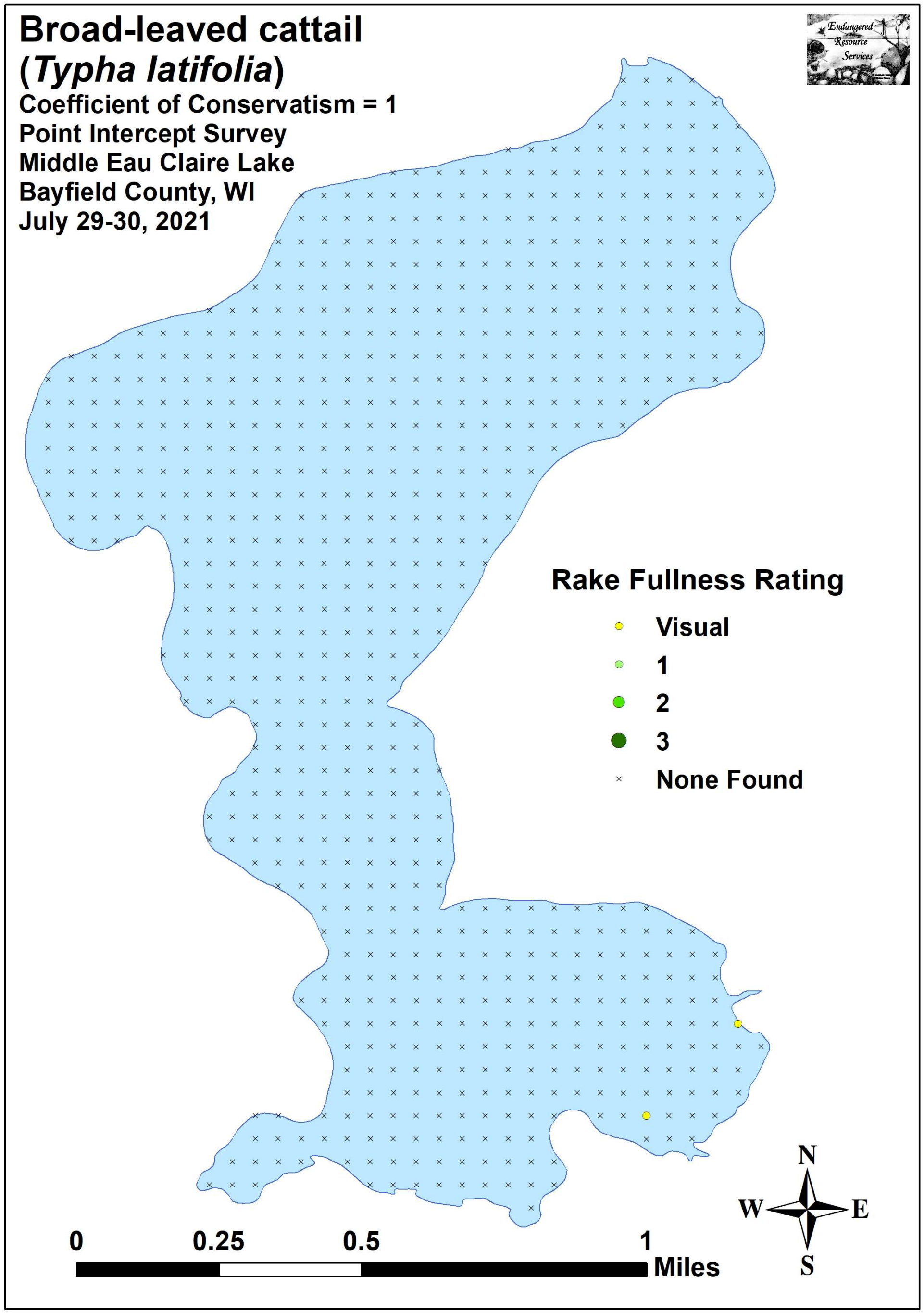

Water bulrush
(*Schoenoplectus subterminalis*)
Coefficient of Conservatism = 9
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

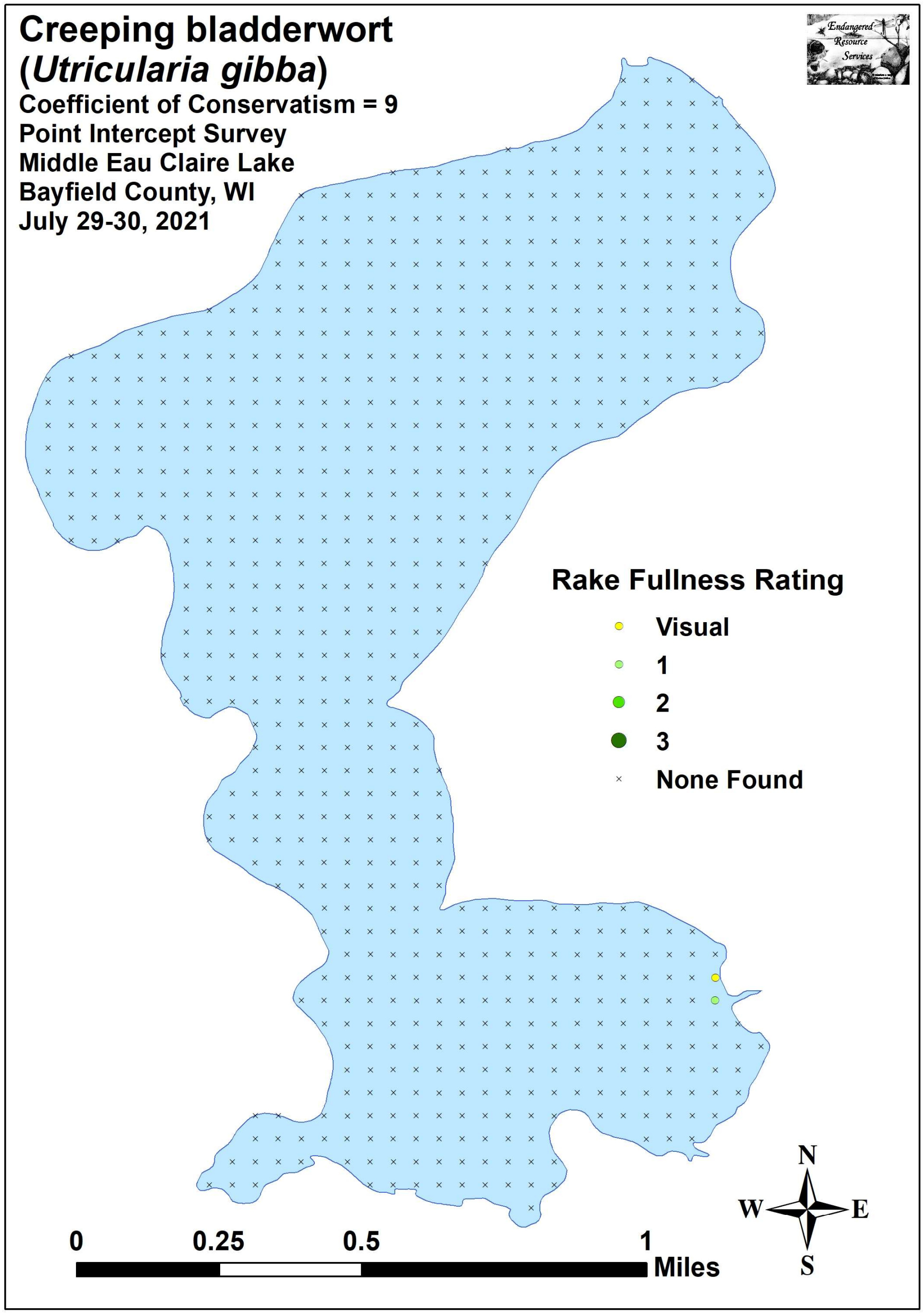

Short-stemmed bur-reed
(Sparganium emersum)
Coefficient of Conservatism = 8
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

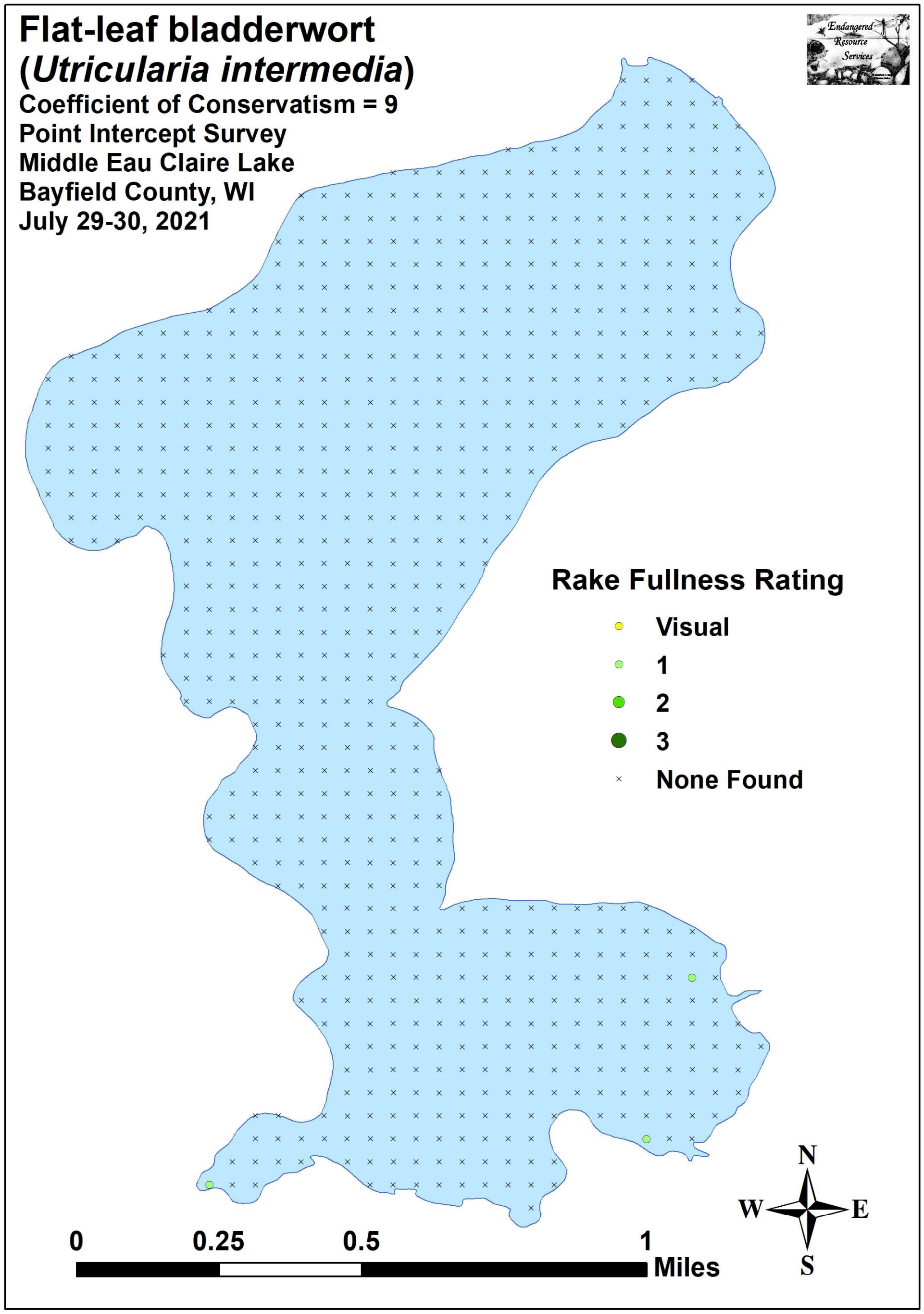

Large duckweed
(Spirodela polyrhiza)
Coefficient of Conservatism = 5
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S


Sago pondweed
(*Stuckenia pectinata*)
Coefficient of Conservatism = 3
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

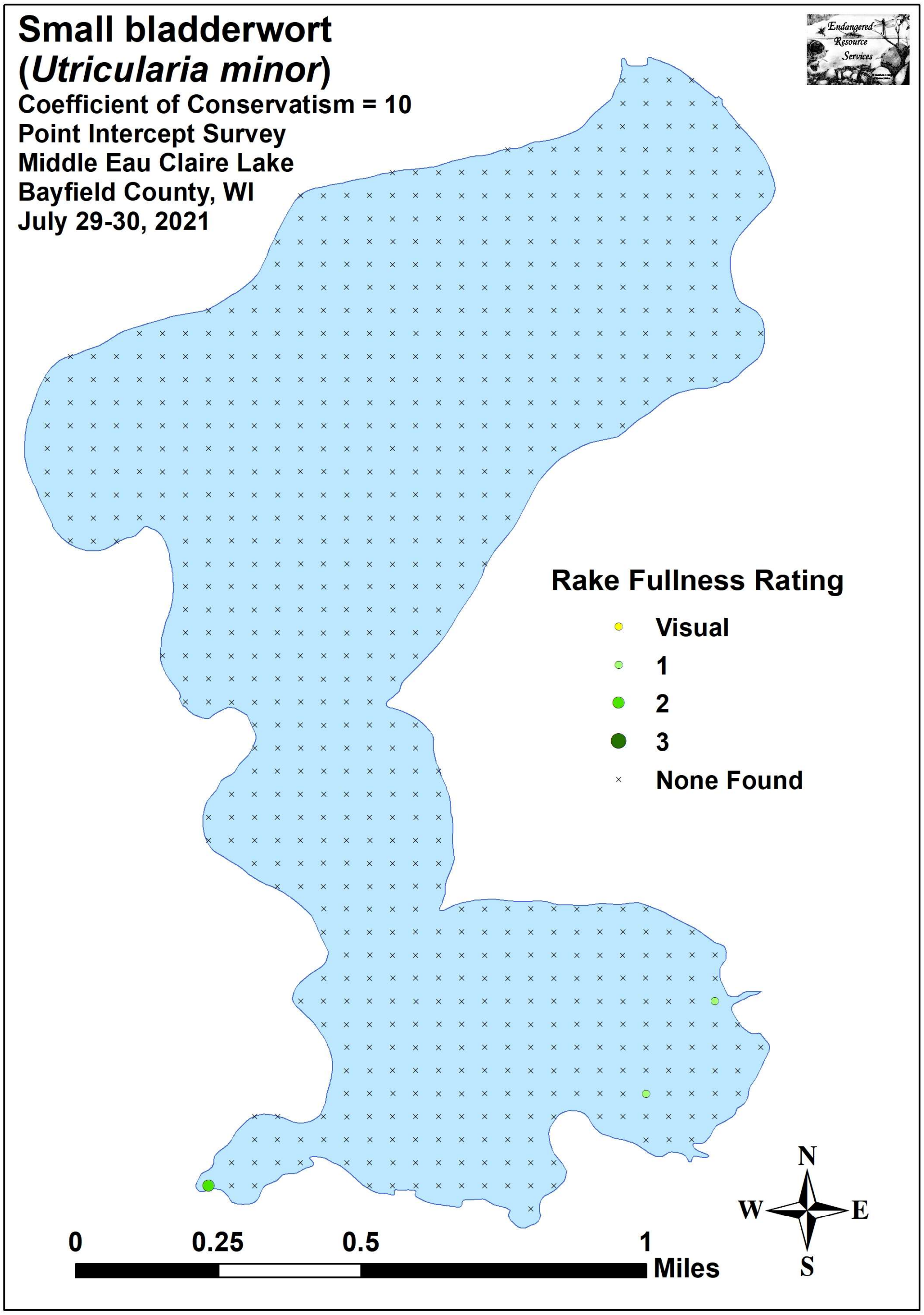

Bird's nest stonewort
(Tolypella intricata)
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

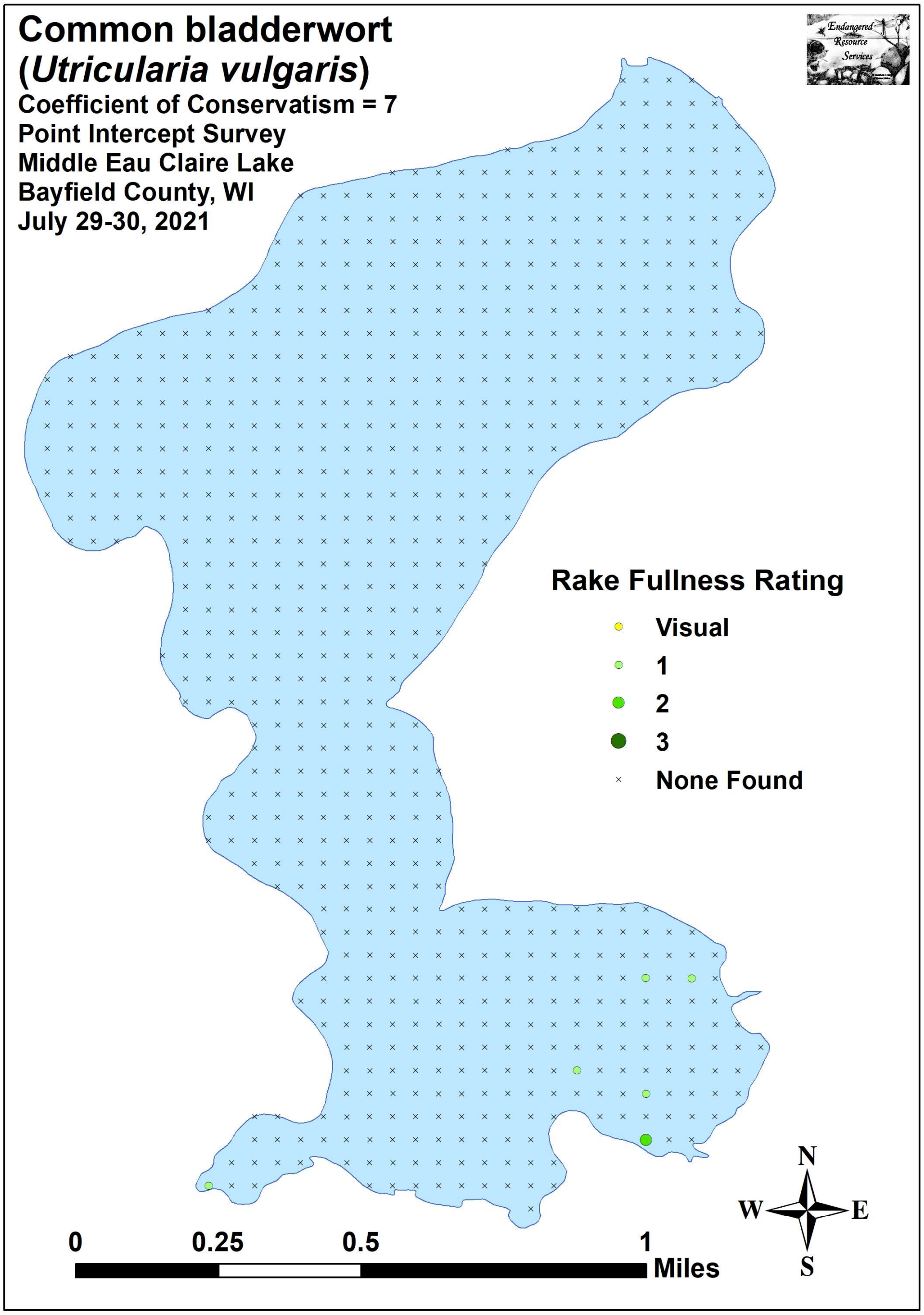

Broad-leaved cattail
(Typha latifolia)
Coefficient of Conservatism = 1
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S


Creeping bladderwort
(*Utricularia gibba*)
Coefficient of Conservatism = 9
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

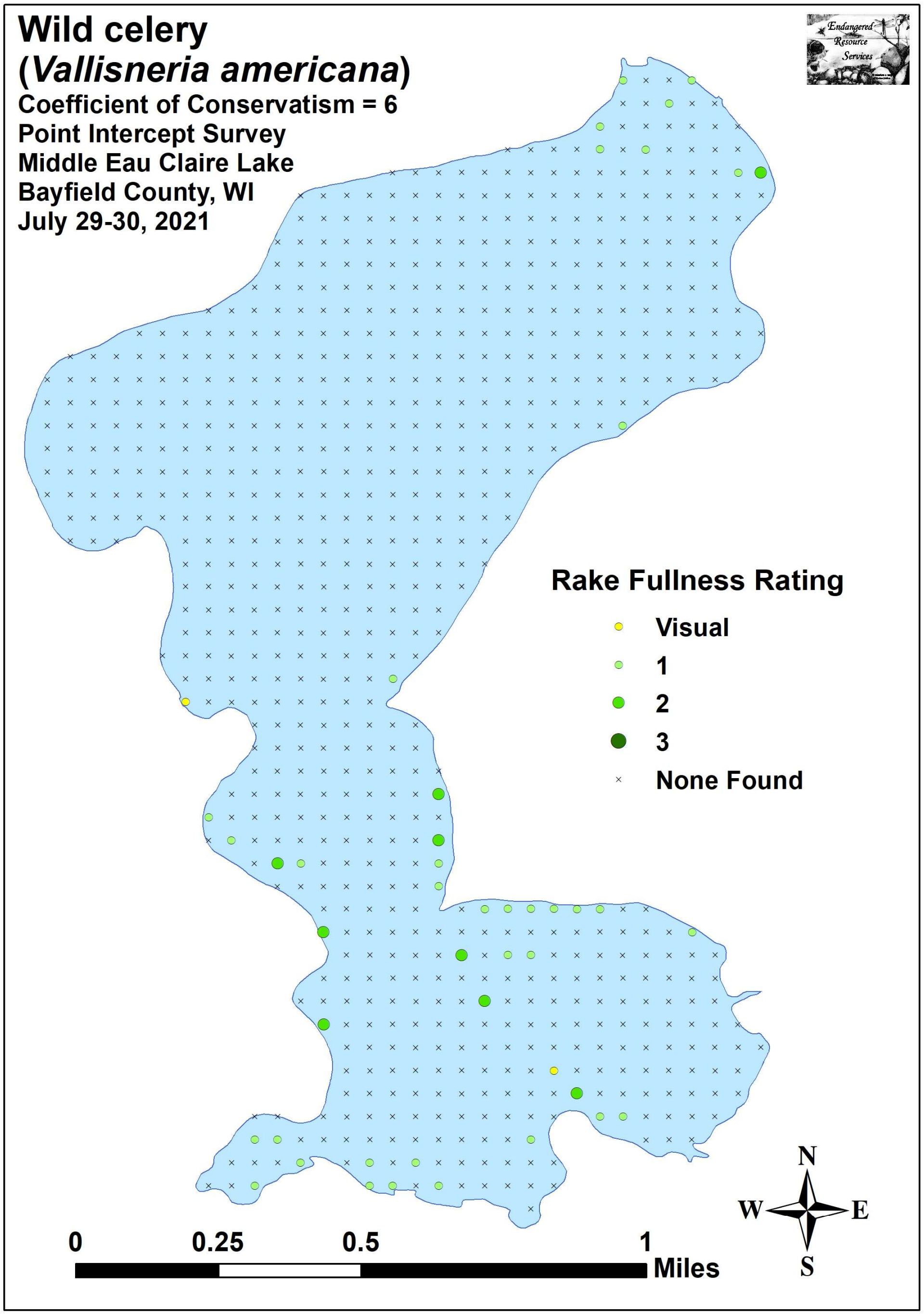


Flat-leaf bladderwort
(Utricularia intermedia)
Coefficient of Conservatism = 9
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S


Small bladderwort
(*Utricularia minor*)
Coefficient of Conservatism = 10
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

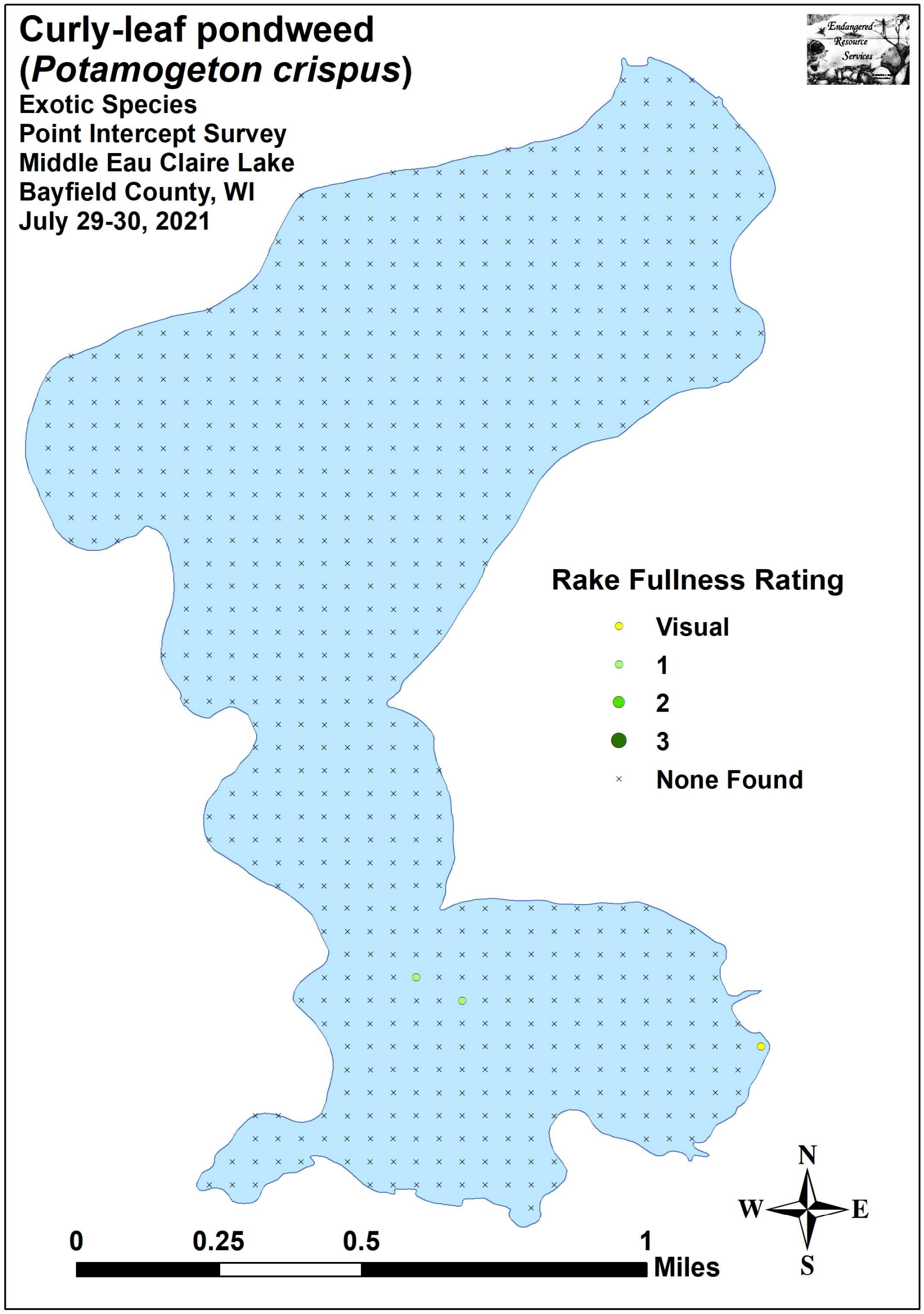


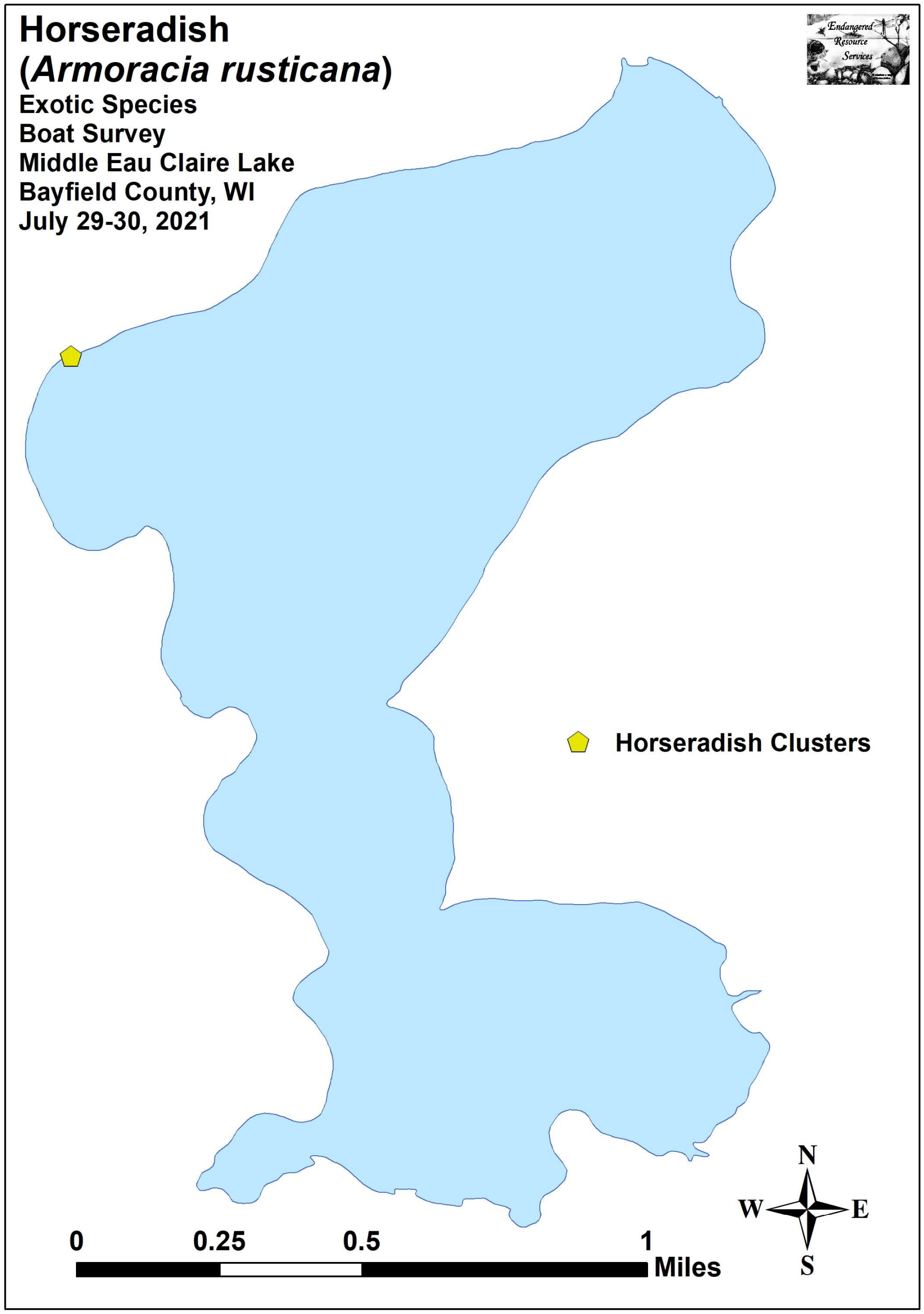
Common bladderwort
(*Utricularia vulgaris*)
Coefficient of Conservatism = 7
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

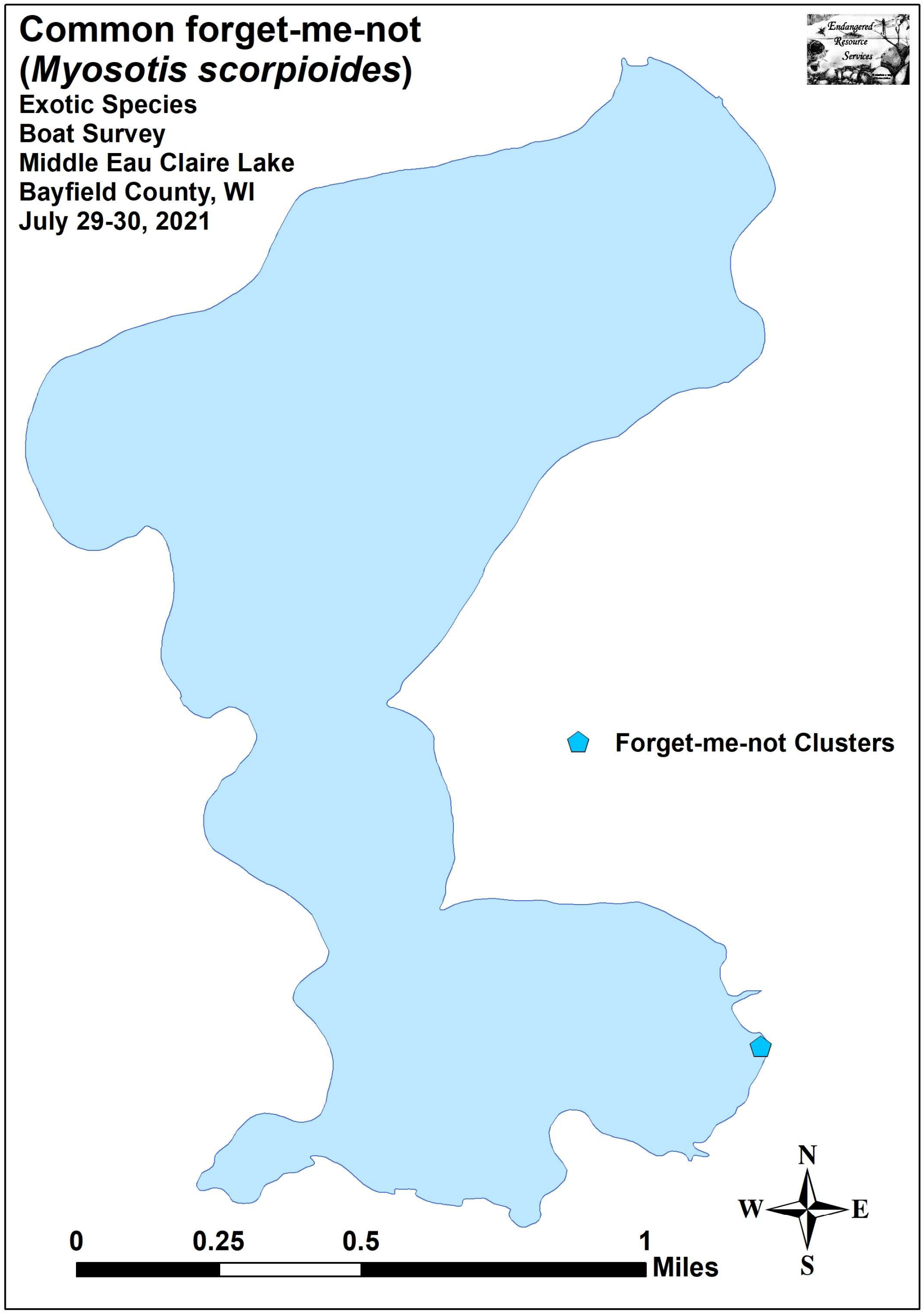


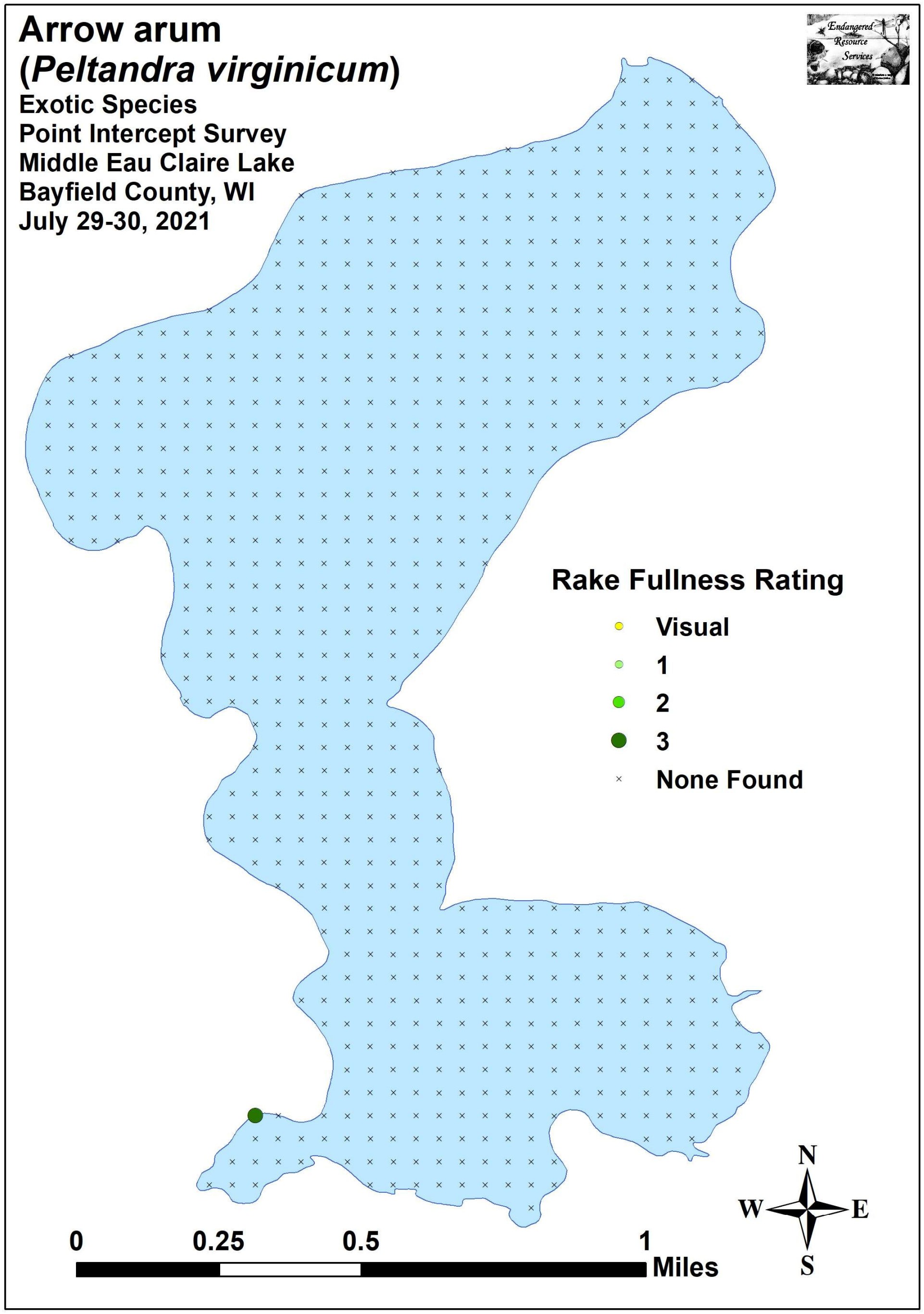
Wild celery
(*Vallisneria americana*)
Coefficient of Conservatism = 6
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

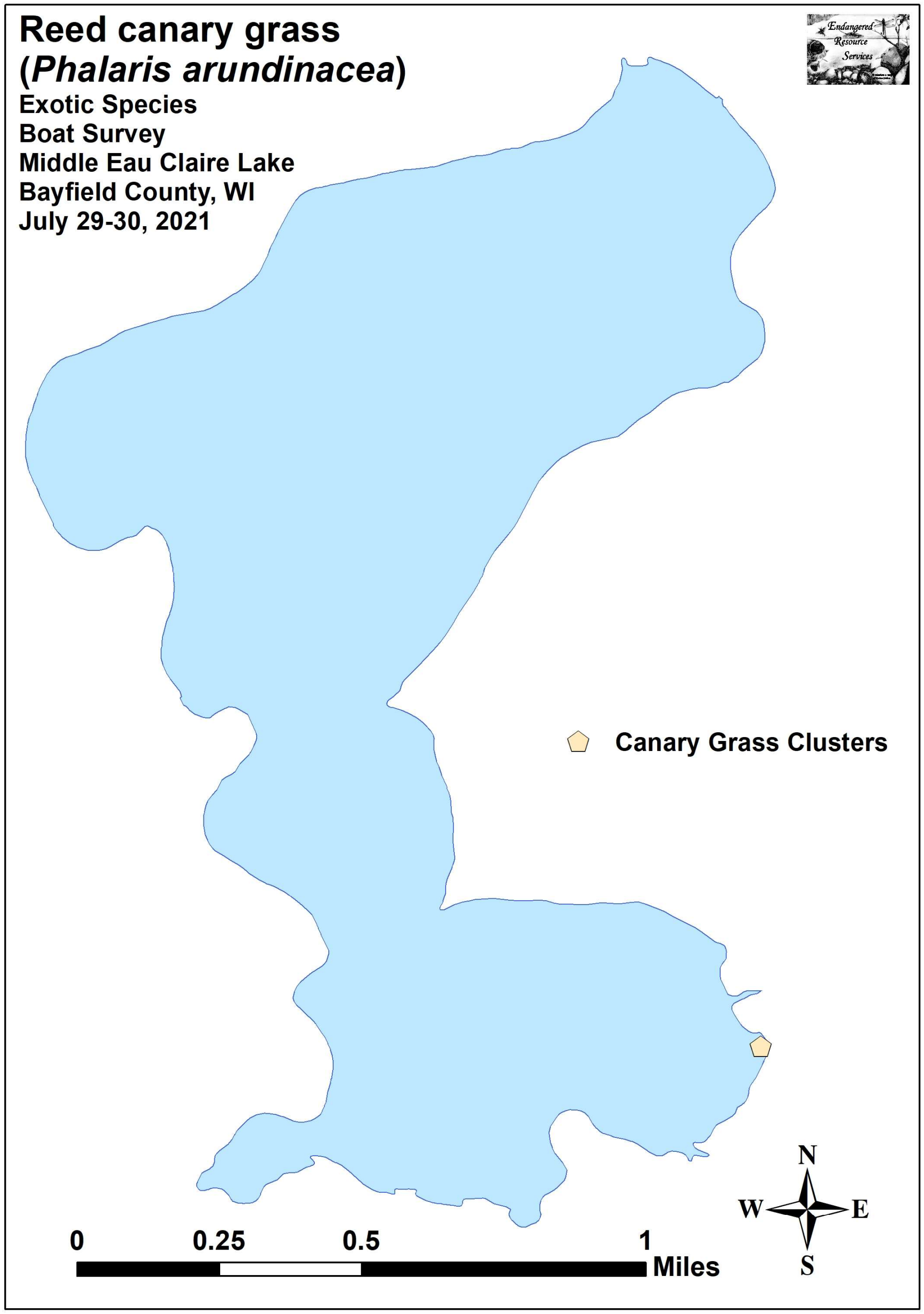
Appendix VII: July 2021 Curly-leaf Pondweed and Other Exotic Species Density and Distribution Maps

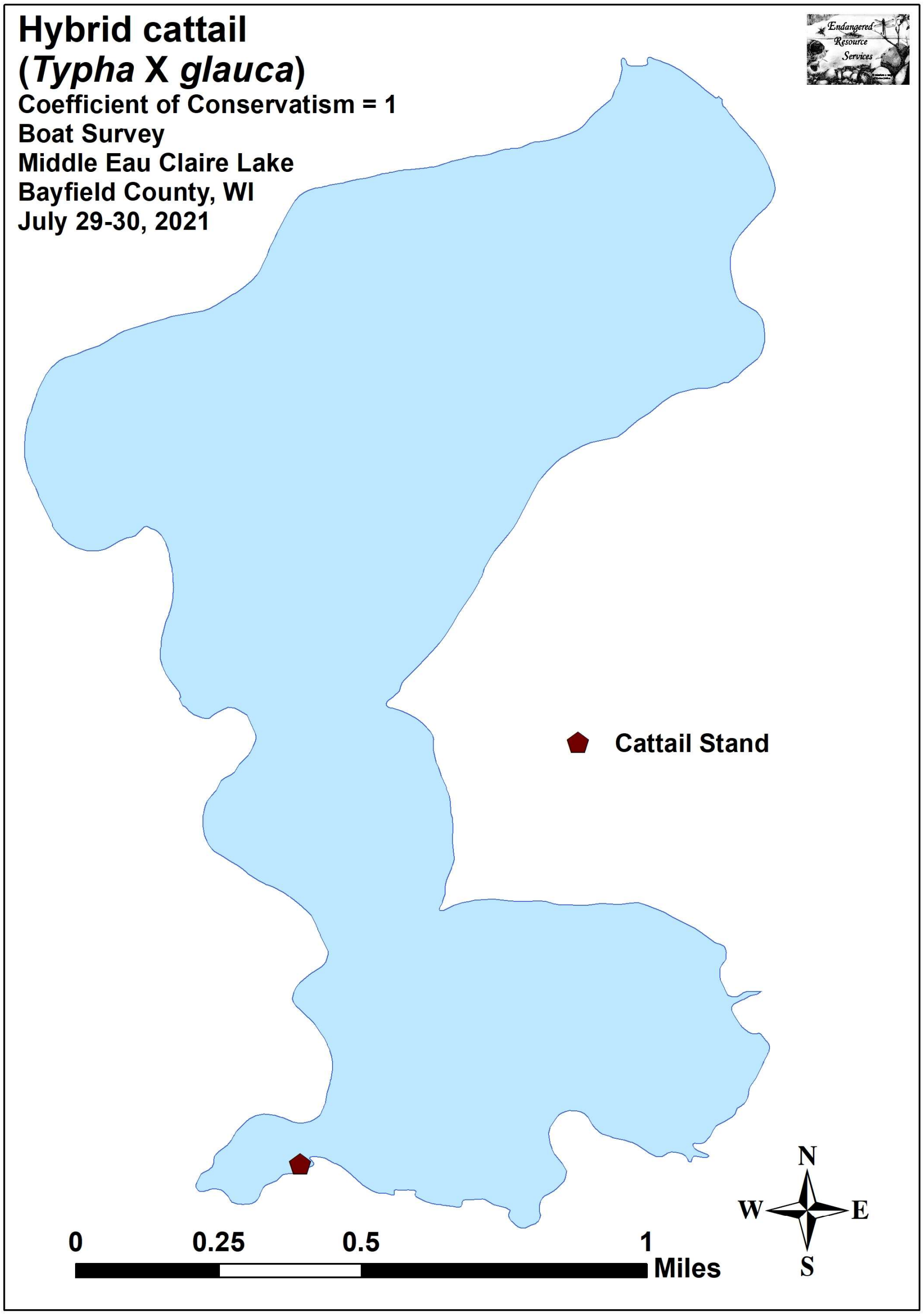

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S


Horseradish
(*Armoracia rusticana*)
Exotic Species
Boat Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Horseradish Clusters
0
0.25
0.5
1
Miles
N
W
E
S


Common forget-me-not
(*Myosotis scorpioides*)
Exotic Species
Boat Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Forget-me-not Clusters
0
0.25
0.5
1
Miles
N
W
E
S


Arrow arum
(Peltandra virginicum)
Exotic Species
Point Intercept Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Reed canary grass
(Phalaris arundinacea)
Exotic Species
Boat Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Canary Grass Clusters
0
0.25
0.5
1
Miles
N
W
E
S



Hybrid cattail
(*Typha* X *glauca*)
Coefficient of Conservatism = 1
Boat Survey
Middle Eau Claire Lake
Bayfield County, WI
July 29-30, 2021
Endangered Resource Services
Cattail Stand
0
0.25
0.5
1
Miles
N
W
E
S

Appendix VIII: Aquatic Exotic Invasive Plant Species Information

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 lakebed). 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 IX: 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 (CO_2) 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 X: 2021 Raw Data Spreadsheets

MiddleEauCaireLakeBayfieldCountyWBIC2742100CLPPISurvey618-19,2021MBergERSLLC.xlsx

MiddleEauCaireLakeBayfieldCountyWBIC2742100PISurvey728-30,2021MBergERSLLC.xlsx