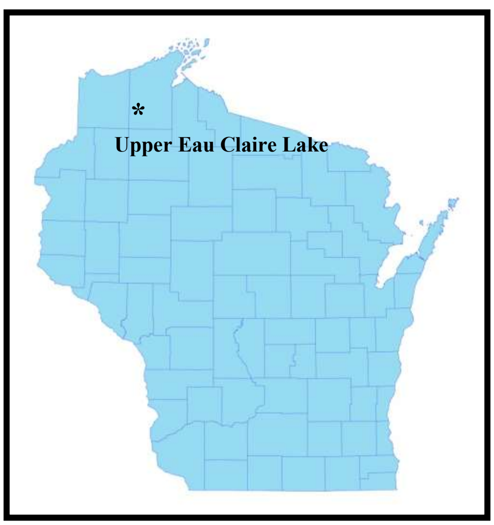
Curly-leaf pondweed (*Potamogeton crispus*) Point-intercept and Bed Mapping Surveys, and Warm-water Point-intercept Macrophyte Survey Upper Eau Claire Lake – WBIC: 2742700 Bayfield County, Wisconsin

Curly-leaf pondweed in the lake's southwest bay 7/27/21

Upper Eau Claire Lake Aerial Photo (2015)

Project Initiated by:

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



Expanding Hybrid cattail in the lake's northeast corner 7/28/21

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June 20-21 and July 27-28, 2021

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ABSTRACT

Upper Eau Claire Lake (WBIC 2742700) is a 1,024-acre 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 Upper 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 20-21st, and a full point-intercept survey for all aquatic macrophytes on July 27-28th. The 2021 cold-water survey found CLP at ten points (0.9% total lake coverage) with a mean rake fullness of 1.70. This was a non-significant increase in both distribution and density (p=0.16/p=0.21) when compared to the 2013 survey (five points with a mean rake of 1.40/0.4% lake coverage). The 2021 survey suggested 0.4% of the lake/0.9% of the littoral zone had a potentially significant infestation (five total points with a rake fullness of 2 or 3) – up only slightly from 2013 when just two points had a significant infestation (0.2% of the lake). In 2021, we mapped seven CLP beds totaling 0.69 acre (0.07% coverage). This was a +1,605% increase from the most recent survey in 2020 when we found two beds on 0.04 acre. In 2013, we mapped eight beds totaling 0.11 acre (0.01% coverage). During the July 2021 full point-intercept survey, we found macrophytes growing at 427 sites (38.3% of the lake bottom and 76.1% of the 20.5ft littoral zone). This was a non-significant decline (p=0.18) from 2013 when plants were present at 506 sites (44.4% of the entire lake bottom/83.5% of the then 23.5ft littoral zone). Overall diversity was exceptionally high with a Simpson Diversity Index value of 0.93 – up slightly from 0.92 in 2012. Total richness was also high with 58 species found growing in and immediately adjacent to the water – up from 57 in 2013. There was an average of 2.69 native species/site with native vegetation – a non-significant increase (p=0.11) from 2.56 native species/site in 2013. Mean total rake fullness was a moderate 1.69 – a highly significant increase **(p<0.001)** from a low/moderate 1.43 in 2013. Our 2013 survey identified Muskgrass (*Chara* sp.), Slender naiad (*Najas flexilis*), Variable pondweed (*Potamogeton gramineus*), and Clasping-leaf pondweed (*Potamogeton richardsonii*) as the most

common species. Present at 45.65%, 39.13%, 19.17%, and 15.81% of survey points with vegetation, they accounted for 46.80% of the total relative frequency. In 2021, we found Muskgrass (42.11% of points with vegetation), Slender naiad (30.89%), Variable pondweed (23.57%), and Southern naiad (*Najas guadalupensis*) (19.45%) were the most common species with a combined relative frequency of 43.15%. From 2013 to 2021, twelve species experienced significant changes in distribution. Slender naiad and Nitella (*Nitella* sp.) suffered highly significant declines **(p<0.001)**; Needle spikerush (*Eleocharis acicularis*) underwent a moderately significant decline **(p<0.01)**; and Muskgrass **(p=0.03)**, Stiff pondweed (*Potamogeton strictifolius*) **(p<0.05)**, and White-stem pondweed (*Potamogeton praelongus*) **(p<0.05)** all saw significant declines. Conversely, Northern water-milfoil (*Myriophyllum sibiricum*), Southern naiad, and filamentous algae enjoyed highly significant increases **(p<0.001)**; Fern pondweed (*Potamogeton robbinsii*) experienced a moderately significant increase **(p=0.004)**; and Common waterweed (*Elodea canadensis*) **(p=0.02)** and Curly-leaf pondweed **(p=0.04)** saw significant increases. The 38 native index species found in the rake during the July 2021 survey (down from 39 in 2013) produced a slightly above average mean Coefficient of Conservatism of 6.9 (down from 7.0 in 2013), and a Floristic Quality Index of 42.5 (down from 43.7 in 2013) that was nearly double the median FQI for this part of the state. Filamentous algae were present at 24 points with a mean rake of 1.00 – a highly significant increase **(p<0.001)** in distribution when compared to the single point (rake fullness of 1) with these algae found in 2013. By July 2021, CLP had almost completely senesced, but we still found it at four points with a mean rake fullness of 1.50 – this represented a significant increase **(p=0.04)** in distribution compared to 2013 when we didn't see CLP anywhere during the July survey. **We saw no evidence of EWM during any of our surveys.** Other than CLP, a small stand of Hybrid cattail (*Typha* X *glauca*) in the northeast bay was the only other exotic species found. 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; and continuing the established Clean Boats/Clean Waters landing monitoring program.

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INTRODUCTION:

Upper Eau Claire Lake (WBIC 2742700) is a 1,024-acre stratified drainage lake located in southwestern Bayfield County, Wisconsin in the Town of Barnes (T44N R9W S2-3, 9-11, and 15-16). It reaches a maximum depth of 92ft in the hole due west of Three-in-One Island and has an average depth of approximately 29ft (Figure 1). The lake is oligotrophic in nature with summer Secchi readings from 1986-2021 ranging from 13-25ft and averaging 18.1ft (WDNR 2021). This very good clarity produced a littoral zone that reached over 20ft in 2021. The bottom substrate is predominately sand and sandy muck, although areas of gravel are located throughout the lake – especially around exposed points and on shallow flats and sunken islands (Eaton et al. 1974).

Figure 1: Upper 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 Upper Eau Claire Lake, we conducted early-season point-intercept and CLP bed mapping surveys June 20-21st. These were followed by a warm-water point intercept survey of all macrophytes on July 27-28th. 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, islands, water clarity, depth, and total acreage, Jennifer Hauxwell (WDNR) generated the original 1,139-point sampling grid for Upper 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.

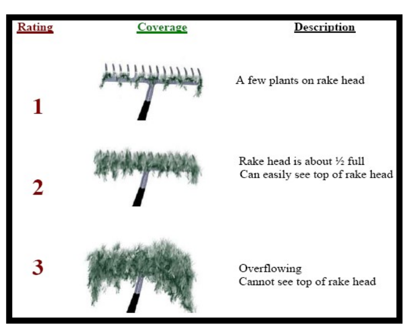


Figure 2: Rake Fullness Ratings (UWEX 2010)

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 CLP 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 maximum 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 (Table 1).

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 with a metered pole rake, 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 2).

<u>Relative frequency:</u> 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 3-4).

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. Upper Eau Claire Lake is in the Northern Lakes and Forests Ecoregion (Tables 5-6).

**** 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 13) 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 (606 in 2013/574 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 20.5ft of water, we sampled for Curly-leaf pondweed at all points in and adjacent to this zone. CLP was present in the rake at ten points with two additional visual sightings. This extrapolated to 0.9% of the entire lake and 1.7% of the 574-point littoral zone having at least some CLP present. Of these, two rated a rake fullness value of 3, three were a 2, and the remaining five were a 1 for a combined mean rake fullness of 1.70 (Figure 3) (Appendix III). The five points with a rake fullness of a 2 or a 3 suggested 0.4% of the entire lake and 0.9% of the spring littoral zone had a significant infestation.

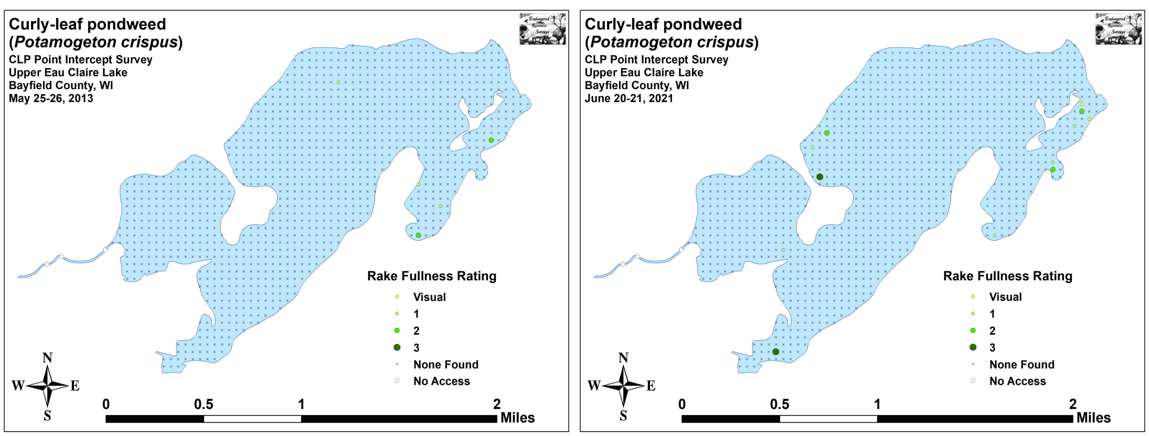
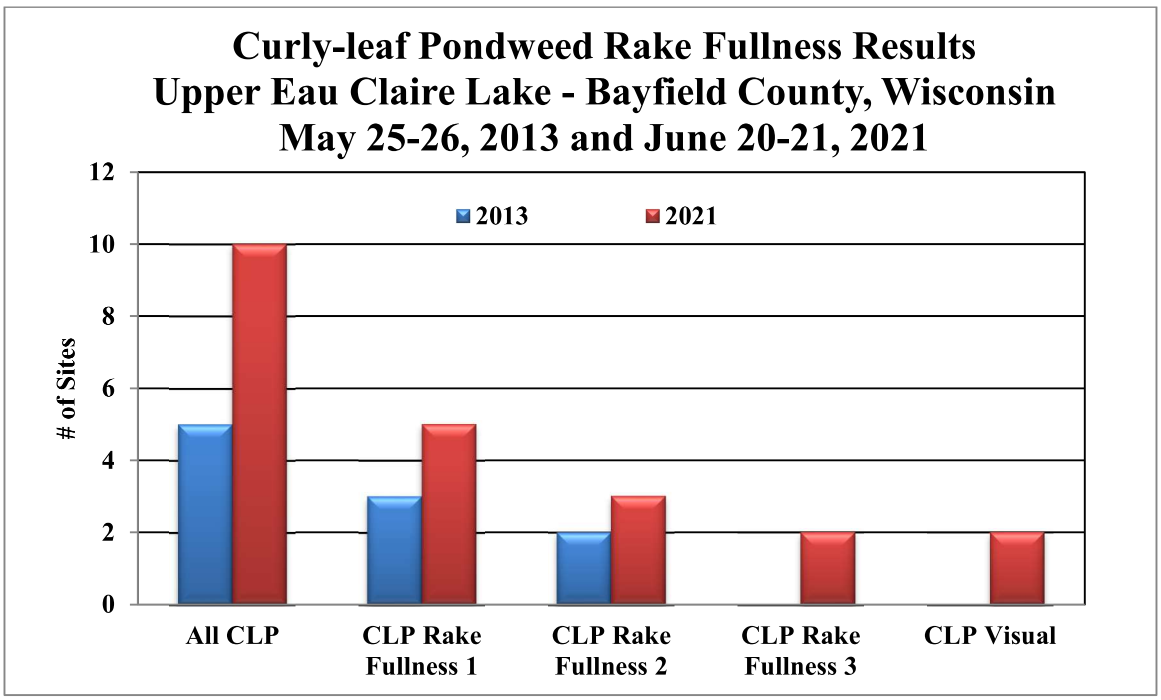


Figure 3: 2013 and 2021 Spring Curly-leaf Pondweed Density and Distribution

Comparison of Curly-leaf Pondweed in 2013 and 2021:

In 2013, Curly-leaf pondweed was present in the rake at five points which approximated to 0.4% of the entire lake. Of these, we recorded a rake fullness value of 2 at two points, and a value of 1 at the remaining three points for a mean rake fullness of 1.40. This extrapolated to 0.2% of the lake having a significant infestation (rake fullness of 2 or 3). We did not recorded CLP as a visual at any additional points, and, other than a single leaf fragment raked up on the flat projecting from the north shore, we did not find plants anywhere outside of Pease Bay and the channel east of the island (Appendix III).

Comparing the 2013 and 2021 early-season surveys found increases in all categories of Curly-leaf pondweed growth (Figure 4); however, none of these changes were significant. This may mean the non-significant increase (p=0.16) in coverage and the non-significant increase in density (p=0.21) were simply due to the later date of the 2021 survey, changes in season growing conditions, or a combination of the two. It could also mean that CLP is expanding on the lake, but that the suction harvesting program is slowing this expansion.



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, we mapped eight small beds totaling 0.11 acre (0.01% of the lake's 1,024 acres) in the channel/bays east of Three-in-One Island (Figure 5) and in Pease Bay (Figure 6) (Appendix III). The biggest was 0.03 acre (Beds 3 and 5) and the smallest was little more than a few 10's of plants covering <0.001 acre (Bed 8) (Table 1).

The 2015 survey found four beds that totaled 0.17 acre with the biggest (Bed 4) covering 0.11 acre and the smallest (7B) encompassing <0.01 acre (Table 1). Collectively, this was an increase of 0.06 acre from the 2013 survey; however, this amount was within the error range of the GPS. Each of these beds was canopied, had a low mean rake fullness of 1, and a rake range that varied from 1-2 (low to moderate). Although canopied, because these beds were so small, they were easily avoided, and it seemed unlikely that they would cause even minor navigation impairment.

East of Three-in-One Island, we noted that three of the beds we mapped in 2013 (Beds 1, 2, and 5) had completely disappeared after volunteers pulled plants in these areas during the 2014 growing season. We also saw no evidence of CLP in the deep-water areas bordering Pease Bay where we mapped Beds 6 and 8 in 2013. At these locations, it may be that CLP, which was never dense, just didn't canopy or even get close enough to the surface that we could see it. It may also be that localized conditions prevented turions from germinating in 2015.

Our 2020 survey found two "beds" totaling 0.04 acre – a 0.13-acre decline (-76.5%) from 2015 (Table 1). Bed 3A east of Three-in-One Island consisted of about 30 total plants most of which we were able to rake remove. Bed 5A also contained only about 20-30 plants, but they were in a tight cluster and covered a much smaller area. We were also able to rake remove most of them although some turions broke off as the plants were beginning to senesce. Other than a few floating plants that had broken free from the bottom, we saw no evidence of CLP anywhere else in the lake. Following the survey, we were informed that the BAISS boat had already been on the lake, and that may explain the sharp decline relative to the 2015 survey.

In 2021, we mapped seven areas totaling 0.69 acre. This was a 0.65-acre increase (+1,605%) compared to 2020, but still represented only 0.07% of the lake's total surface area (Table 1). The biggest was 0.37 acre (Bed 5B) while the smallest (Beds 5 and 5D) covered <0.01 acre. All three beds occurred in a nearly continuous low to moderate density line running down the channel east of Three-in-One Island in water from 5-13ft deep (Figure 5). In Pease Bay, the only CLP seen was a new bed (5AA) in the northeast side bay (Figure 6). Unfortunately, for the first time ever, we also found a small but very dense deepwater bed (Bed 9) in the lake's far southwest bay (Figure 7). Even with the 2021 increase in acreage, none of the lake's CLP beds were likely to cause more than moderate impairment, and even that was questionable as most beds were easily avoided.

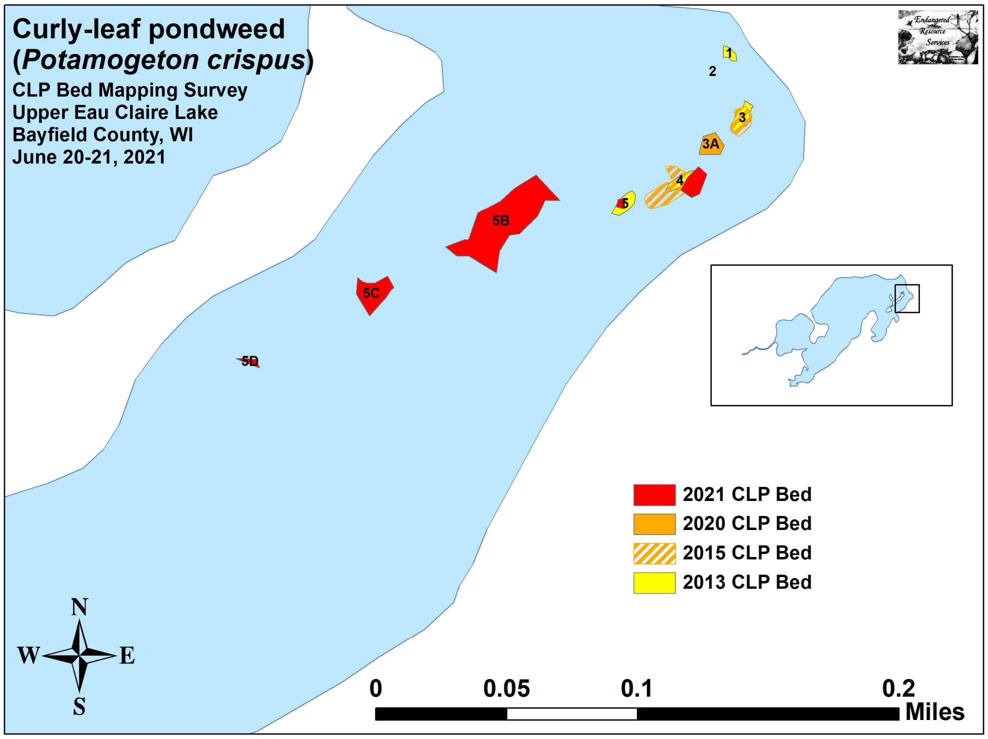


Figure 5: Curly-leaf Pondweed Beds –
East of Three-in-One Island – 2013, 2015, 2020, and 2021

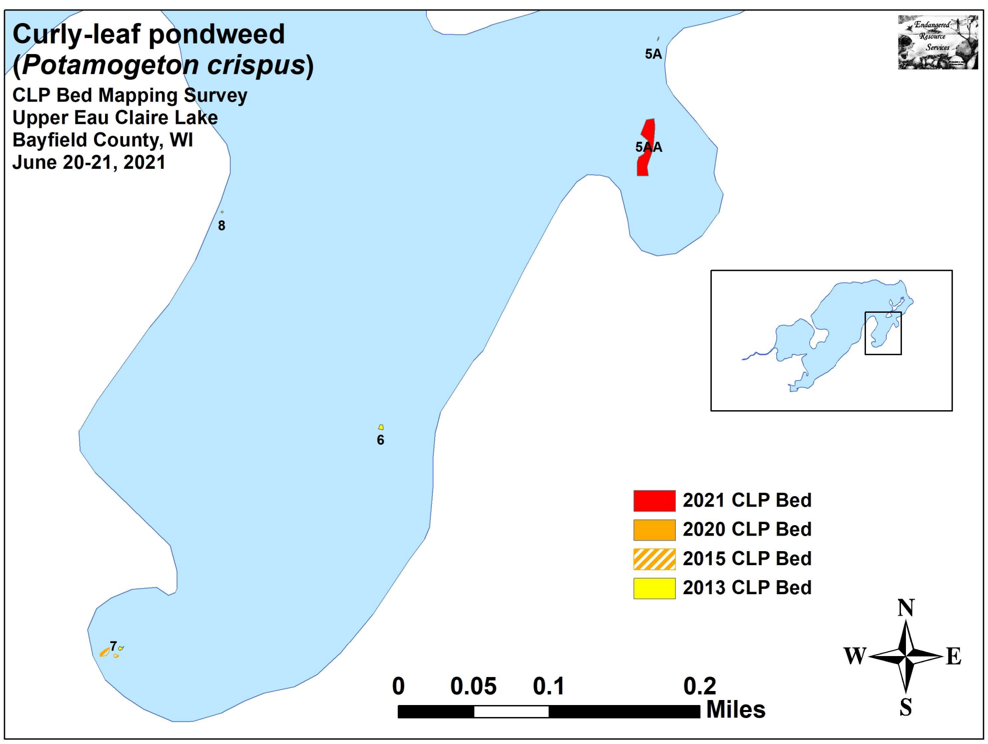


Figure 6: Curly-leaf Pondweed Beds –
Pease Bay – 2013, 2015, 2020, and 2021

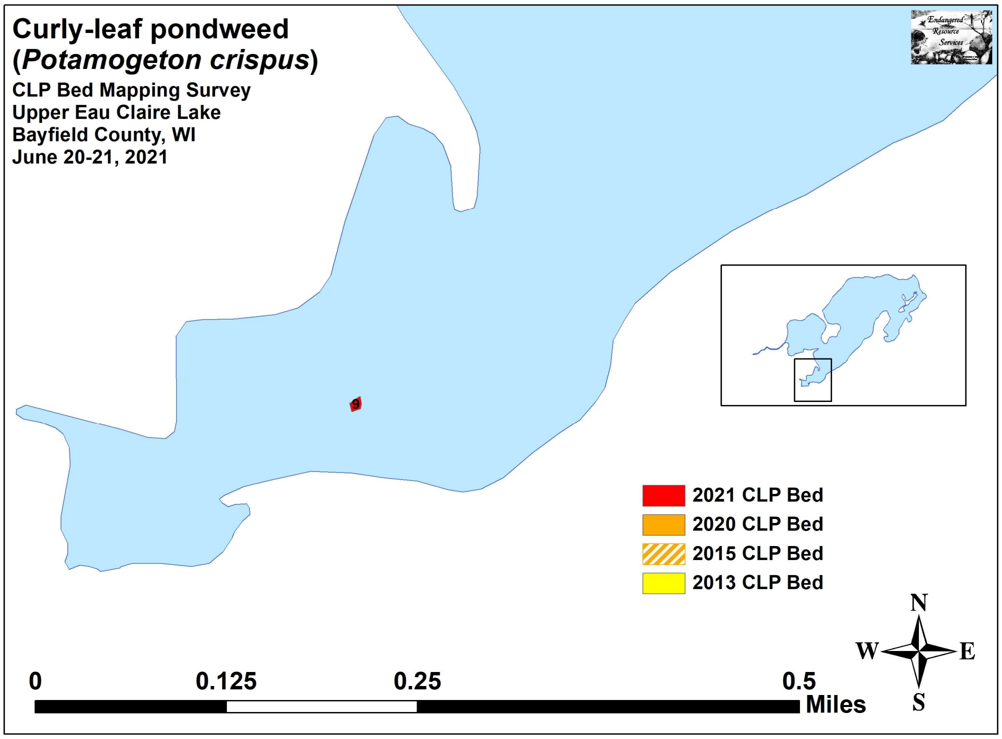


Figure 7: Curly-leaf Pondweed Beds – Southwest Bay – 2013, 2015, 2020, and 2021

Table 1: Curly-leaf Pondweed Bed Summary
Upper Eau Claire Lake – Bayfield County, Wisconsin
June 30, 2013, June 16, 2015, June 19, 2020, and June 20-21, 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	0.01	-	-	None	No CLP plants seen.
2	0	0	0	<<<0.01	-	-	None	No CLP plants seen.
3	0	0	0.04	0.03	-	-	None	No CLP plants seen.
3A	0	0.04	0	0	-	-	None	No CLP plants seen.
4	0.04	0	0.11	0.02	4-6; 5	<<<1-1; <<1	None	Widely scattered plants.
5	0.01	0	0	0.03	5-7; 6	1-2; 1	Minor	Small, open bed.
5A	0	<0.01	0	0	-	-	None	No CLP plants seen.
5AA	0.15	0	0	0	8-11; 10	<<1-2; 1	Minor	Open scattered bed.
5B	0.37	0	0	0	8-13; 10	<1-3; 2	Moderate	Deepwater bed
5C	0.08	0	0	0	8-13; 10	<1-3; 1	Minor	Deepwater bed
5D	0.01	0	0	0	9-12; 10	<1-3; 2	Moderate	Isolated microbed
6	0	0	0	<0.01	-	-	None	No CLP plants seen.
7 (A and B)	0	0	0.02	<<0.01	-	-	None	No CLP plants seen.
8	0	0	0	<<<0.01	-	-	None	No CLP plants seen.
9	0.03	0	0	0	13-15; 14	1-3; 3	None	Plants barely visible.
Total Acres	**0.69**	**0.04**	**0.17**	**0.11**				

Warm-Water Full Point-intercept Macrophyte Survey:

Depth soundings taken at Upper Eau Claire Lake's 1,139 survey points (three points were located in the river and were not accessible by boat) revealed the outlet bay is a shallow 5-10ft flat that slopes gently from the shoreline to the river channel. The main lake is dominated by a steep-sided 60ft+ trench running southwest to northeast with two separate deep holes that bottom out at 70ft+ in the south and 90ft+ in the north. The 30ft+ bay northwest of this trench contains several bars, flats, and sunken islands that top out at less than 10ft. Around Three-in-One Island, shallow flats extend to the north and west while the east side drops off sharply into a narrow 30ft+ groove that dominates Pease Bay (Figure 8) (Appendix IV).

Of the 620 survey points where we could determine the substrate, 27.3% were muck and sandy muck (169 points), 62.3% were pure sand (386 points), and 10.5% were rock (65 points). Sand and rock dominate the majority of the nearshore lake bottom as well as around Three-in-One Island, the flats and bars in the northwest bay, and the northeast end of the outlet bay. In the lake's bays and the channel east of Three-in-One Island, these sandy areas quickly transition to a nutrient-poor sandy muck at most depths over 7ft. In the outlet bay, this muck was a thick marl, while in the bog bay near the channel to Devil's Lake, it was a more nutrient-rich organic muck (Figure 8) (Appendix IV).

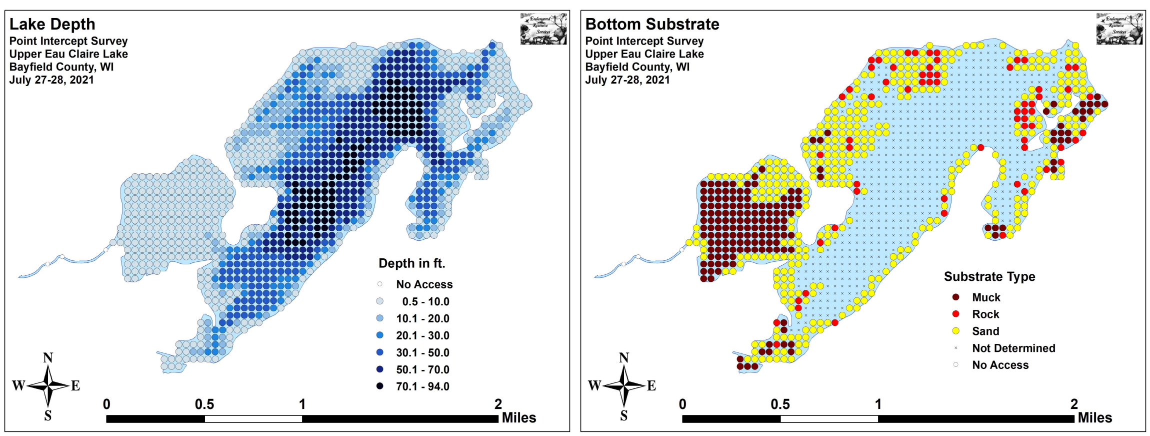


Figure 8: Lake Depth and Bottom Substrate

During the July 2021 survey, we found macrophytes at 437 sites (38.3% of the bottom and 76.1% of the 20.5ft littoral zone) (Figure 9). This was a non-significant decline (p=0.18) from 2013 when plants were present at 506 sites (44.4% of the entire lake bottom and in 83.5% of the then 23.5ft littoral zone). Plants were consistently found to 17ft, but they became much patchier beyond this depth (Figure 10).

Plant growth in 2021 was strongly skewed to deep water as the mean depth of 7.3ft was much greater than the median depth of 6.0ft (Table 2). This mean was identical to 2013, but the median was up sharply from 5.0ft during our original survey (Appendix V).

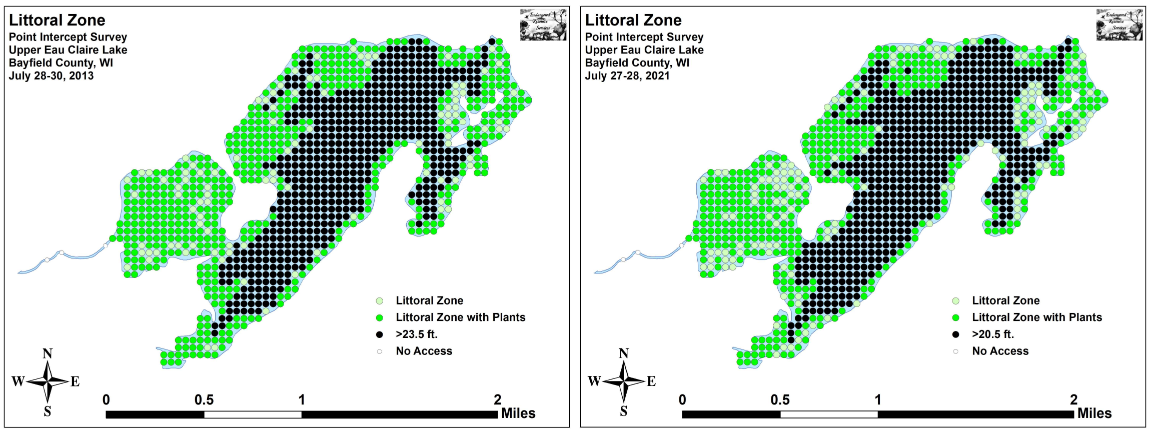


Figure 9: 2013 and 2021 Littoral Zone

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 28-30, 2013 and July 27-28, 2021

Summary Statistics:	2013	2021
Total number of points sampled	1,139	1,139
Total number of sites with vegetation	506	437
Total number of sites shallower than the max. depth of plants	606	574
Freq. of occurrence at sites shallower than max. depth of plants	83.5	76.1
Simpson Diversity Index	0.92	0.93
Maximum depth of plants (ft)	23.5	20.5
Mean depth of plants (ft)	7.3	7.3
Median depth of plants (ft)	5.0	6.0
Number of sites sampled using rake on Rope (R)	98	98
Number of sites sampled using rake on Pole (P)	520	520
Average # of all species per site (shallower than max depth)	2.14	2.05
Average # of all species per site (veg. sites only)	2.56	2.69
Average # of native species per site (shallower than max depth)	2.14	2.04
Average # of native species per site (veg. sites only)	2.56	2.69
Species richness	41	41
Species richness (including visuals)	46	43
Species richness (including visuals and boat survey)	57	58
Mean rake fullness (veg. sites only)	1.43	1.69

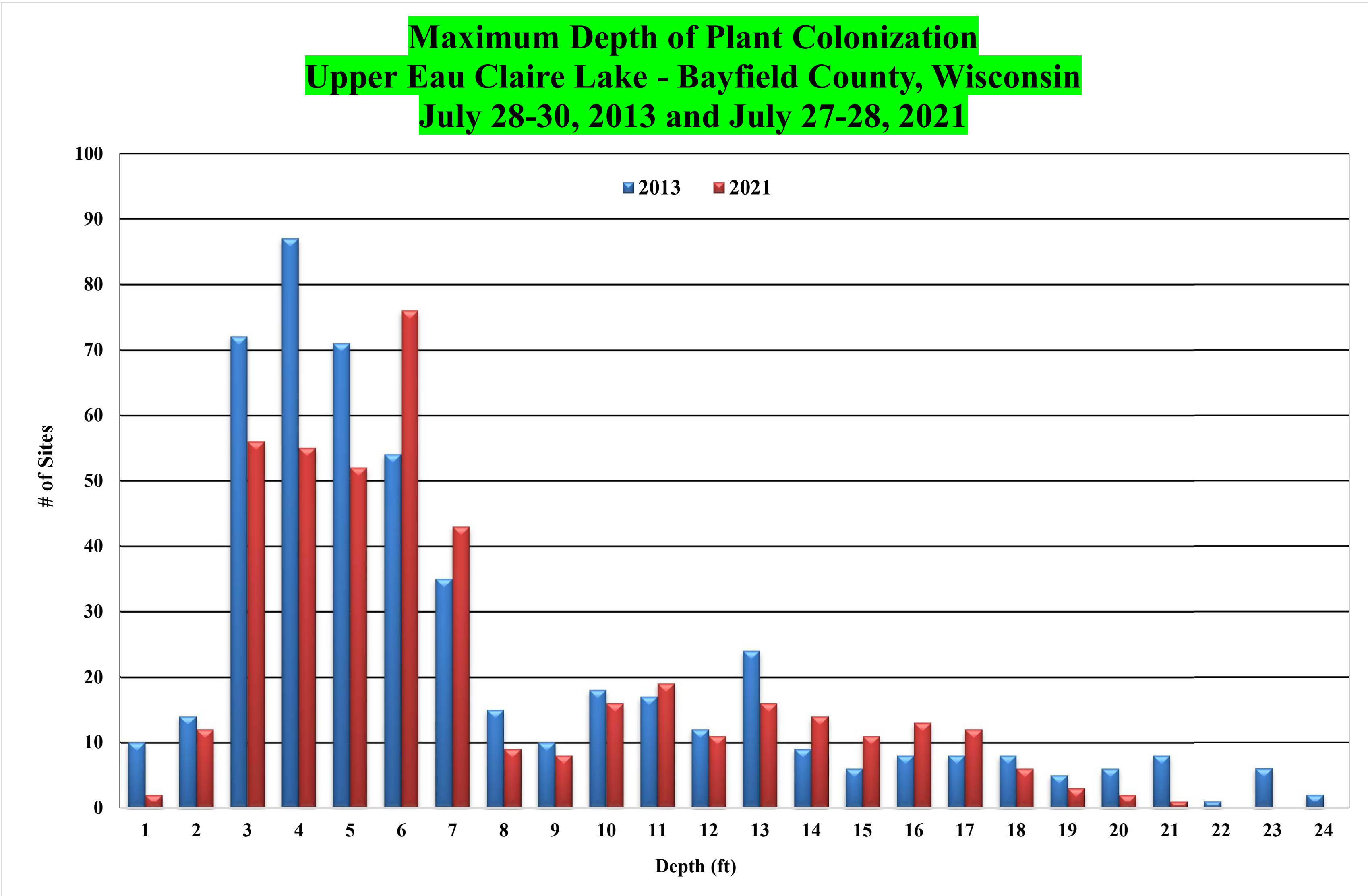


Figure 10: 2013 and 2021 Plant Colonization Depth Chart

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 high with 58 species found in and immediately adjacent to the lake in 2021 – up from 57 in 2013.

From 2013 to 2021, mean native species richness at sites with native vegetation saw a non-significant increase (p=0.11) from 2.56 species/site in 2013 to 2.69 species/site in 2021. Visual analysis of the map showed few changes in localized richness (Figure 11) (Appendix V).

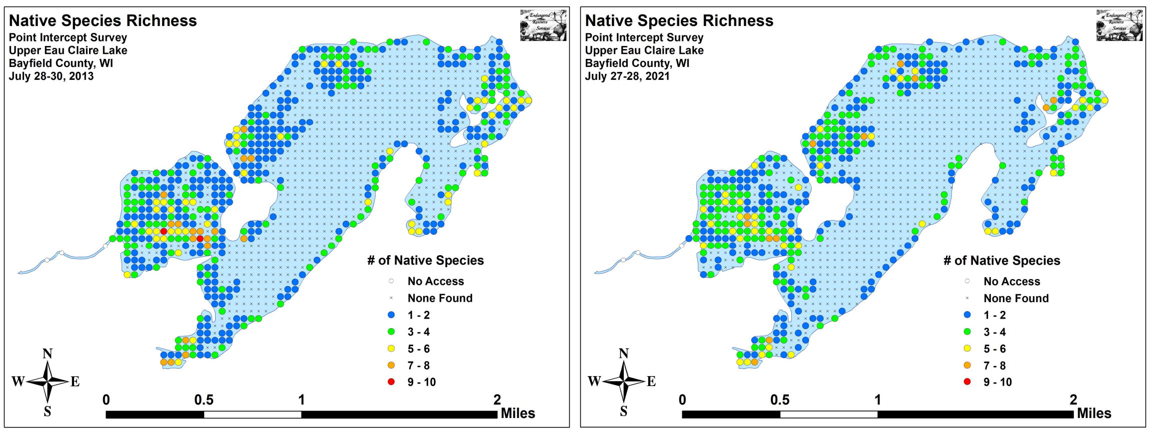


Figure 11: 2013 and 2021 Native Species Richness

Mean total rake fullness underwent a highly significant increase **(p<0.001)** from a low/moderate 1.43 in 2013 to a moderate 1.69 in 2021. Visual analysis of the maps showed these biomass increases were lakewide (Figure 12) (Appendix V).

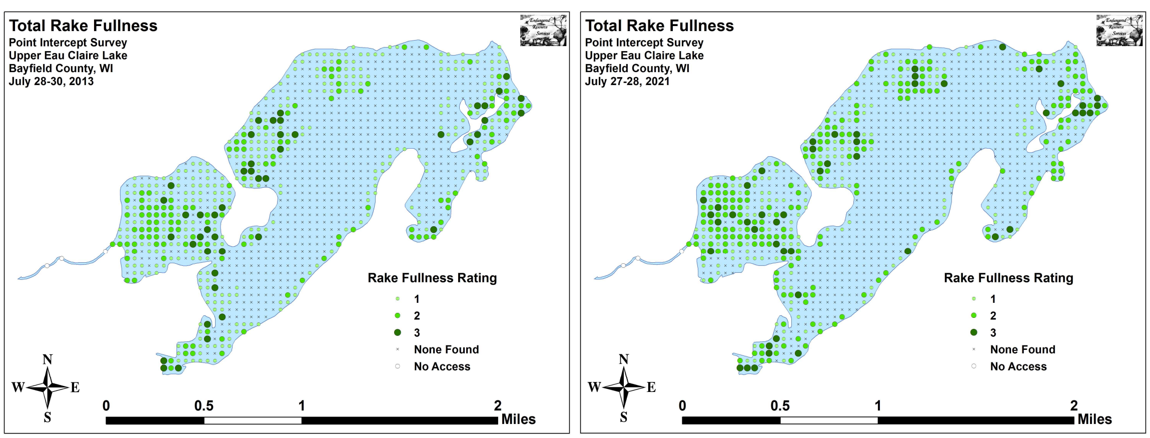


Figure 12: 2013 and 2021 Total Rake Fullness

Upper Eau Claire Lake Plant Community:

The Upper Eau Claire Lake ecosystem is home to a rich and diverse plant community that is typical of low-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. At the edge of the bog near the channel to Devil's Lake where the soil was a more nutrient-rich organic muck, we also documented limited numbers of Bottle brush sedge (*Carex comosa*) and Broad-leaved cattail (*Typha latifolia*).

Bluejoint (Routledge 2013)

Sweet gale (Devlin 2016)

Bottle-brush sedge (Penta 2010)

Broad-leaved cattail (Raymond 2011)

On shallow sand flats and gravel bars and around the lake’s islands, the emergent community was dominated by Narrow-leaved woolly sedge (*Carex lasiocarpa*), Smooth saw-grass (*Cladium mariscoides*), Creeping spikerush (*Eleocharis palustris*), Hardstem bulrush (*Schoenoplectus acutus*), Three-square bulrush (*Schoenoplectus pungens*), and Hybrid cattail (*Typha* X *glauca*).

Narrow-leaved wooly sedge (Navratil 2016)

Smooth saw-grass (Perlman 2011)

Creeping spikerush (Legler 2016)

Hardstem bulrush (Elliot 2007)

Three-square bulrush (Mittlhauser 2016)

Hybrid cattail (Berg 2020)

In sandy muck areas, these species were often replaced by Three-way sedge (*Dulichium arundinaceum*), Water horsetail (*Equisetum fluviatile*), and Pickerelweed (*Pontederia cordata*). On the muck bogs in the southwest bay, we also found Water bulrush (*Schoenoplectus subterminalis*).

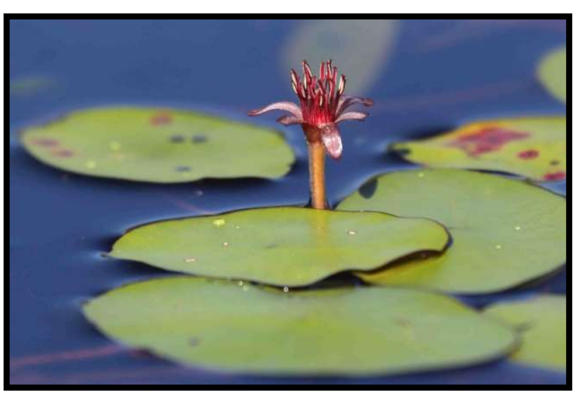
Three-way sedge (GMNRI 2016)

Water horsetail (Elliot 2007)

Pickerelweed (Texas A&M 2012)

Water bulrush (Haines 2013)

Shallow organic muck-bottomed areas were the rarest habitat in the lake. Because of this, floating-leaf species that require this nutrient-rich substrate were also relatively uncommon. In up to 5ft of water, we found 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)

Especially in the southwest bay near the channel to Devil's Lake, we also found lesser amounts of Large-leaf pondweed (*Potamogeton amplifolius*), Ribbon-leaf pondweed (*Potamogeton epihydrus*), Floating-leaf pondweed (*Potamogeton natans*), and Floating-leaf bur-reed (*Sparganium fluctuans*). The protective canopy cover these species provide is often utilized by panfish and bass.

Large-leaf pondweed (Dziuk 2018)

Ribbon-leaf pondweed (Petroglyph 2007)

Floating-leaf pondweed (Petroglyph 2007)

Floating-leaf bur-reed (Sullman 2009)

In boggy areas of the southwest bay, growing among the lilypads, we also occasionally encountered Leafy pondweed (*Potamogeton foliosus*) and Common bladderwort (*Utricularia vulgaris*). Rather than drawing nutrients up through roots like other plants, the carnivorous bladderworts trap zooplankton and minute insects in their bladders, digest their prey, and use the nutrients to further their growth.

Leafy pondweed (Kleinman 2009)

Common bladderwort flowers among lilypads (Hunt 2010)

Sand, sandy muck, and marly muck areas in water less than 4ft deep supported fewer and narrower-leaved floating-leaf species than organic muck areas. Near the Devil's Lake Channel, we found patches of Common water-starwort (*Callitriche palustris*) and Narrow-leaved bur-reed (*Sparganium angustifolium*). Several pondweeds in this habitat also occasionally produced floating leaves. They included Variable pondweed (*Potamogeton gramineus*), Illinois pondweed (*Potamogeton illinoensis*), and Spiral-fruited pondweed (*Potamogeton spirillus*).

Common water-starwort (Cameron 2014)

Narrow-leaved bur-reed (Schouh 2006)

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

Illinois pondweed (Dziuk 2017)

Spiral-fruited pondweed (Cameron 2019)

Close-up of Spiral-fruited pondweed seeds (Dziuk 2019)

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 like Rough stonewort – a Muskgrass (*Chara aspera*), Needle spikerush (*Eleocharis acicularis*), Spiny-spored quillwort (*Isoetes echinospora*), Dwarf water milfoil (*Myriophyllum tenellum*), Slender naiad (*Najas flexilis*), and Crested arrowhead (*Sagittaria cristata*).

Rough Stonewort – a Muskgrass (Gibbons 2012)

Needle spikerush (Fewless 2005)

Spiny-spored quillwort (Fewless 2005)

Dwarf water milfoil (Koshere 2002)

Slender naiad (Apipp 2009)

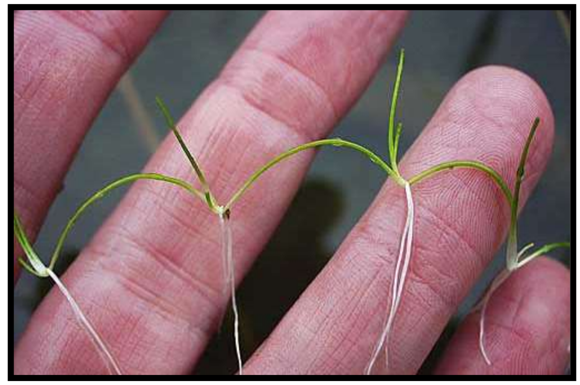
Crested arrowhead (Fewless 2004)

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*), Pipewort (*Eriocaulon aquaticum*), Brown-fruited rush (*Juncus pelocarpus*), and Creeping spearwort (*Ranunculus flammula*). All of these "turf" species, along with the emergents, stabilize the bottom and prevent wave action erosion.

Waterwort (Fewless 2005)

Pipewort (Fewless 2005)

Brown-fruited rush (Koshere 2002)



Creeping spearwort with arching “stolons” (Fewless 2005)

Shallow sandy and marly 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*), Southern naiad (*Najas guadalupensis*), Large-leaf pondweed, Curly-leaf pondweed, 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)

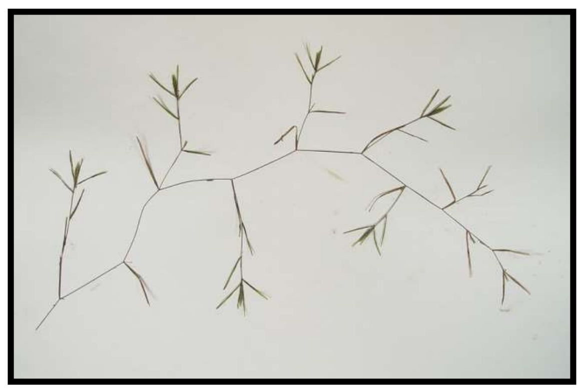
Common waterweed (Fischer 2005)

Southern naiad (Fewless 2004)

Large-leaf and Illinois pondweeds (Dziuk 2018)

Curly-leaf pondweed (USGS 2019)

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.) and Nitella (*Nitella* sp.) 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)

Comparison of Native Species in 2013 and 2021:

Our 2013 survey identified Muskgrass, Slender naiad, Variable pondweed, and Clasping-leaf pondweed as the most common species (Table 3). They were found at 45.65%, 39.13%, 19.17%, and 15.81% of sites with vegetation and encompassed 46.80% of the total relative frequency. Needle spikerush (4.79%), Nitella (4.40%), Fern pondweed (4.40%), and Wild celery (4.02%) were the only other species with relative frequencies over 4.00% (Species accounts and maps for all plants found in July 2013 can be found in the project folder).

The 2021 survey documented Muskgrass (42.11% of points with vegetation), Slender naiad (30.89%), Variable pondweed (23.57%), and Southern naiad (19.45%) as the most common species with a combined relative frequency of 43.15% (Table 4). Fern pondweed (7.23%), Northern water-milfoil (7.06%), Clasping-leaf pondweed (5.53%), Common waterweed (5.19), Flat-stem pondweed (4.68), and Wild celery (4.60%) 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, twelve species experienced significant changes in distribution (Figure 13). Slender naiad and Nitella suffered highly significant declines **($p<0.001$)**; Needle spikerush underwent a moderately significant decline **($p<0.01$)**; and Muskgrass **($p=0.03$)**, Stiff pondweed **($p<0.05$)**, and White-stem pondweed **($p<0.05$)** all saw significant declines. Conversely, Northern water-milfoil, Southern naiad, and filamentous algae enjoyed highly significant increases **($p<0.001$)**; Fern pondweed experienced a moderately significant increase **($p=0.004$)**; and Common waterweed **($p=0.02$)** and Curly-leaf pondweed **($p=0.04$)** saw significant increases.

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 28-30, 2013

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Chara sp.	Muskgrass	231	17.84	45.65	38.12	1.14	1
Najas flexilis	Slender naiad	198	15.29	39.13	32.67	1.05	1
Potamogeton gramineus	Variable pondweed	97	7.49	19.17	16.01	1.06	9
Potamogeton richardsonii	Clasping-leaf pondweed	80	6.18	15.81	13.20	1.24	21
Eleocharis acicularis	Needle spikerush	62	4.79	12.25	10.23	1.13	0
Nitella sp.	Nitella	57	4.40	11.26	9.41	1.84	0
Potamogeton robbinsii	Fern pondweed	57	4.40	11.26	9.41	1.39	3
Vallisneria americana	Wild celery	52	4.02	10.28	8.58	1.04	5
Myriophyllum sibiricum	Northern water-milfoil	48	3.71	9.49	7.92	1.31	5
Potamogeton zosteriformis	Flat-stem pondweed	46	3.55	9.09	7.59	1.26	2
Potamogeton pusillus	Small pondweed	45	3.47	8.89	7.43	1.20	0
Elodea canadensis	Common waterweed	42	3.24	8.30	6.93	1.07	0
Najas guadalupensis	Southern naiad	42	3.24	8.30	6.93	1.24	0
Ceratophyllum demersum	Coontail	31	2.39	6.13	5.12	1.32	0
Potamogeton amplifolius	Large-leaf pondweed	25	1.93	4.94	4.13	1.08	13
Potamogeton friesii	Fries' pondweed	20	1.54	3.95	3.30	1.10	2
Potamogeton strictifolius	Stiff pondweed	19	1.47	3.75	3.14	1.00	0
Myriophyllum tenellum	Dwarf water-milfoil	17	1.31	3.36	2.81	1.35	0
Bidens beckii	Water marigold	16	1.24	3.16	2.64	1.06	1
Potamogeton praelongus	White-stem pondweed	14	1.08	2.77	2.31	1.29	4
Isoetes echinospora	Spiny spored-quillwort	12	0.93	2.37	1.98	1.25	1
Potamogeton illinoensis	Illinois pondweed	12	0.93	2.37	1.98	1.08	2
Schoenoplectus acutus	Hardstem bulrush	9	0.69	1.78	1.49	1.56	4
Heteranthera dubia	Water star-grass	7	0.54	1.38	1.16	1.00	1
Sagittaria cristata	Crested arrowhead	7	0.54	1.38	1.16	1.00	1

Table 3 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 28-30, 2013

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Brasenia schreberi	Watershield	6	0.46	1.19	0.99	1.67	3
Elatine minima	Waterwort	5	0.39	0.99	0.83	1.20	3
Ranunculus aquatilis	White water crowfoot	5	0.39	0.99	0.83	1.00	0
Stuckenia pectinata	Sago pondweed	5	0.39	0.99	0.83	1.00	1
Cladium mariscoides	Smooth sawgrass	3	0.23	0.59	0.50	1.67	0
Eleocharis palustris	Creeping spikerush	3	0.23	0.59	0.50	2.00	0
Juncus pelocarpus f. submersus	Brown-fruited rush	3	0.23	0.59	0.50	1.00	0
Nymphaea odorata	White water lily	3	0.23	0.59	0.50	2.00	4
Potamogeton natans	Floating-leaf pondweed	3	0.23	0.59	0.50	1.00	2
Schoenoplectus subterminalis	Water bulrush	3	0.23	0.59	0.50	2.00	0
Eriocaulon aquaticum	Pipewort	2	0.15	0.40	0.33	1.50	1
Ranunculus flammula	Creeping spearwort	2	0.15	0.40	0.33	1.50	2
Utricularia minor	Small bladderwort	2	0.15	0.40	0.33	1.00	0
Utricularia vulgaris	Common bladderwort	2	0.15	0.40	0.33	1.50	1
Carex lasiocarpa	Narrow-leaved wooly sedge	1	0.08	0.20	0.17	2.00	0
Sparganium fluctuans	Floating-leaf bur-reed	1	0.08	0.20	0.17	2.00	1
	Aquatic moss	1	*	0.20	0.17	1.00	0
	Filamentous algae	1	*	0.20	0.17	1.00	0
Nuphar variegata	Spatterdock	**	**	**	**	**	1
Pontederia cordata	Pickerelweed	**	**	**	**	**	1
Potamogeton epihydrus	Ribbon-leaf pondweed	**	**	**	**	**	1
Schoenoplectus pungens	Three-square bulrush	**	**	**	**	**	1
Utricularia gibba	Creeping bladderwort	**	**	**	**	**	1

* Excluded from the relative frequency calculation   ** Visual only   **Exotic species in bold**

Table 3 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 28-30, 2013

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Calamagrostis canadensis	Bluejoint	***	***	***	***	***	***
Carex comosa	Bottle-brush sedge	***	***	***	***	***	***
Carex lacustris	Lake sedge	***	***	***	***	***	***
Lemna minor	Small duckweed	***	***	***	***	***	***
Myosotis scorpioides	**Common forget-me-not**	***	***	***	***	***	***
Myrica gale	Sweet gale	***	***	***	***	***	***
Polygonum amphibium	Water smartweed	***	***	***	***	***	***
Potamogeton X *haynesii*	Hayne's pondweed	***	***	***	***	***	***
Sparganium angustifolium	Narrow-leaved bur-reed	***	***	***	***	***	***
Typha latifolia	Broad-leaved cattail	***	***	***	***	***	***
Utricularia intermedia	Flat-leaf bladderwort	***	***	***	***	***	***
Potamogeton crispus	**Curly-leaf pondweed**	****	****	****	****	****	****

*** Boat survey only ****June CLP Survey only **Exotic species in bold**

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 27-28, 2021

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Chara sp.	Muskgrass	184	15.66	42.11	32.06	1.33	0
Najas flexilis	Slender naiad	135	11.49	30.89	23.52	1.23	4
Potamogeton gramineus	Variable pondweed	103	8.77	23.57	17.94	1.15	4
Najas guadalupensis	Southern naiad	85	7.23	19.45	14.81	1.40	0
Potamogeton robbinsii	Fern pondweed	85	7.23	19.45	14.81	1.59	1
Myriophyllum sibiricum	Northern water-milfoil	83	7.06	18.99	14.46	1.84	9
Potamogeton richardsonii	Clasping-leaf pondweed	65	5.53	14.87	11.32	1.29	9
Elodea canadensis	Common waterweed	61	5.19	13.96	10.63	1.28	0
Potamogeton zosteriformis	Flat-stem pondweed	55	4.68	12.59	9.58	1.51	2
Vallisneria americana	Wild celery	54	4.60	12.36	9.41	1.17	2
Potamogeton pusillus	Small pondweed	42	3.57	9.61	7.32	1.21	0
Eleocharis acicularis	Needle spikerush	35	2.98	8.01	6.10	1.46	1
	Filamentous algae	24	*	5.49	4.18	1.00	0
Ceratophyllum demersum	Coontail	23	1.96	5.26	4.01	1.22	0
Myriophyllum tenellum	Dwarf water-milfoil	22	1.87	5.03	3.83	1.50	0
Bidens beckii	Water marigold	19	1.62	4.35	3.31	1.00	1
Potamogeton amplifolius	Large-leaf pondweed	16	1.36	3.66	2.79	1.25	3
Nitella sp.	Nitella	9	0.77	2.06	1.57	1.11	0
Potamogeton friesii	Fries' pondweed	9	0.77	2.06	1.57	1.22	0
Sagittaria cristata	Crested arrowhead	9	0.77	2.06	1.57	1.33	0
Isoetes echinospora	Spiny spored-quillwort	8	0.68	1.83	1.39	1.25	0
Potamogeton strictifolius	Stiff pondweed	8	0.68	1.83	1.39	1.00	1
Heteranthera dubia	Water star-grass	7	0.60	1.60	1.22	1.43	1
Potamogeton illinoensis	Illinois pondweed	7	0.60	1.60	1.22	1.29	0

* Excluded from the relative frequency calculation

Table 4 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 27-28, 2021

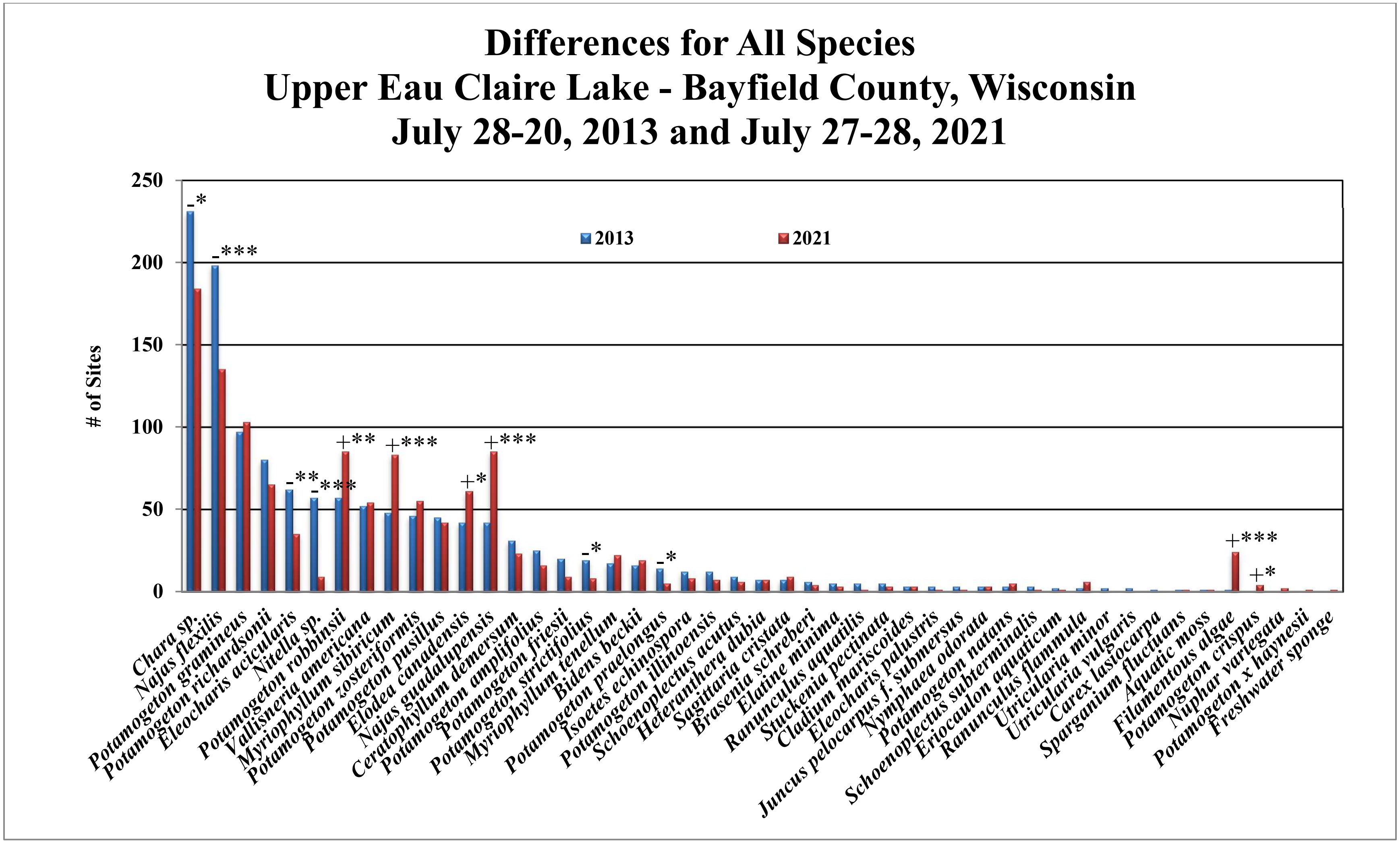
Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Ranunculus flammula	Creeping spearwort	6	0.51	1.37	1.05	1.67	1
Schoenoplectus acutus	Hardstem bulrush	6	0.51	1.37	1.05	1.33	2
Potamogeton natans	Floating-leaf pondweed	5	0.43	1.14	0.87	1.00	2
Potamogeton praelongus	White-stem pondweed	5	0.43	1.14	0.87	1.00	0
Brasenia schreberi	Watershield	4	0.34	0.92	0.70	1.50	0
Potamogeton crispus	**Curly-leaf pondweed**	**4**	**0.34**	**0.92**	**0.70**	**1.50**	**0**
Cladium mariscoides	Smooth sawgrass	3	0.26	0.69	0.52	1.67	0
Elatine minima	Waterwort	3	0.26	0.69	0.52	1.00	2
Nymphaea odorata	White water lily	3	0.26	0.69	0.52	2.00	6
Stuckenia pectinata	Sago pondweed	3	0.26	0.69	0.52	1.00	1
Nuphar variegata	Spatterdock	2	0.17	0.46	0.35	2.50	0
Eleocharis palustris	Creeping spikerush	1	0.09	0.23	0.17	1.00	0
Eriocaulon aquaticum	Pipewort	1	0.09	0.23	0.17	2.00	0
Juncus pelocarpus f. submersus	Brown-fruited rush	1	0.09	0.23	0.17	1.00	0
Potamogeton X *haynesii*	Hayne's pondweed	1	0.09	0.23	0.17	2.00	0
Ranunculus aquatilis	White water crowfoot	1	0.09	0.23	0.17	1.00	1
Schoenoplectus subterminalis	Water bulrush	1	0.09	0.23	0.17	2.00	1
Sparganium fluctuans	Floating-leaf bur-reed	1	0.09	0.23	0.17	2.00	1
	Aquatic moss	1	*	0.23	0.17	1.00	0
	Freshwater sponge	1	*	0.23	0.17	1.00	0
Myrica gale	Sweet gale	**	**	**	**	**	1
Polygonum amphibium	Water smartweed	**	**	**	**	**	1

* Excluded from the relative frequency calculation   ** Visual only   **Exotic species in bold**

Table 4 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 27-28, 2021

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Calamagrostis canadensis	Bluejoint	***	***	***	***	***	***
Callitriche palustris	Common water-starwort	***	***	***	***	***	***
Carex comosa	Bottle brush sedge	***	***	***	***	***	***
Carex lasiocarpa	Narrow-leaved wooly sedge	***	***	***	***	***	***
Dulichium arundinaceum	Three-way sedge	***	***	***	***	***	***
Equisetum fluviatile	Water horsetail	***	***	***	***	***	***
Pontederia cordata	Pickerelweed	***	***	***	***	***	***
Potamogeton epihydrus	Ribbon-leaf pondweed	***	***	***	***	***	***
Potamogeton foliosus	Leafy pondweed	***	***	***	***	***	***
Potamogeton spirillus	Spiral-fruited pondweed	***	***	***	***	***	***
Schoenoplectus pungens	Three-square bulrush	***	***	***	***	***	***
Sparganium angustifolium	Narrow-leaved bur-reed	***	***	***	***	***	***
Typha latifolia	Broad-leaved cattail	***	***	***	***	***	***
Typha X glauca	**Hybrid cattail**	***	***	***	***	***	***
Utricularia vulgaris	Common bladderwort	***	***	***	***	***	***

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



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

Figure 13: 2013-2021 Macrophyte Differences for All Species

Muskgrass, the most common species during each of the surveys, was found throughout the lake (Figure 14). In 2013, it was present at 231 sites with a mean rake fullness of 1.14. The 2021 survey documented a significant decrease **(p=0.03)** in distribution (184 sites), but a highly significant increase **(p<0.001)** in mean density (mean rake fullness of 1.33).

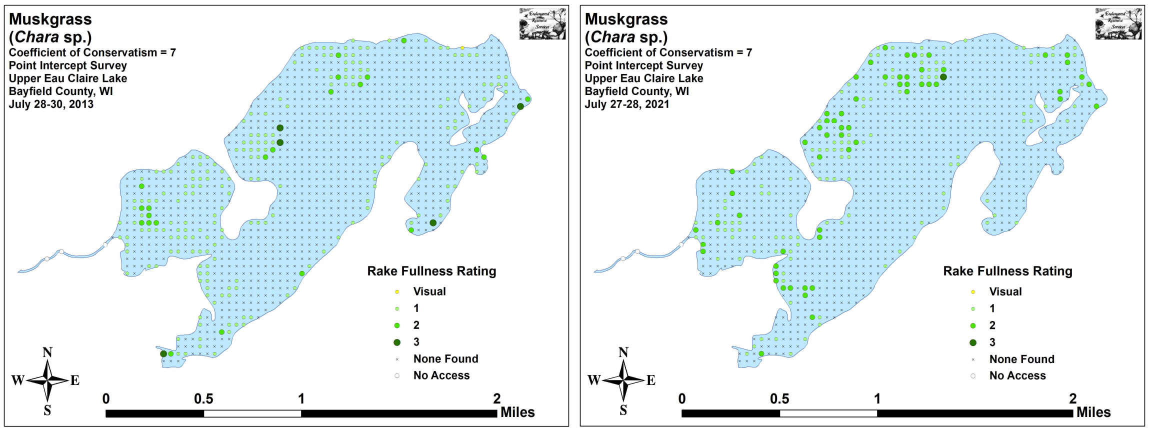


Figure 14: 2013 and 2021 Muskgrass Density and Distribution

Slender naiad, the second most widely-distributed species during each survey, was also widespread (Figure 15). Like Muskgrass, we documented a highly significant decline **(p<0.001)** in distribution from 198 points in 2013 to 135 points in 2021. Conversely, its density underwent a highly significant increase **(p<0.001)** from a mean rake of 1.05 in 2013 to 1.23 in 2021.

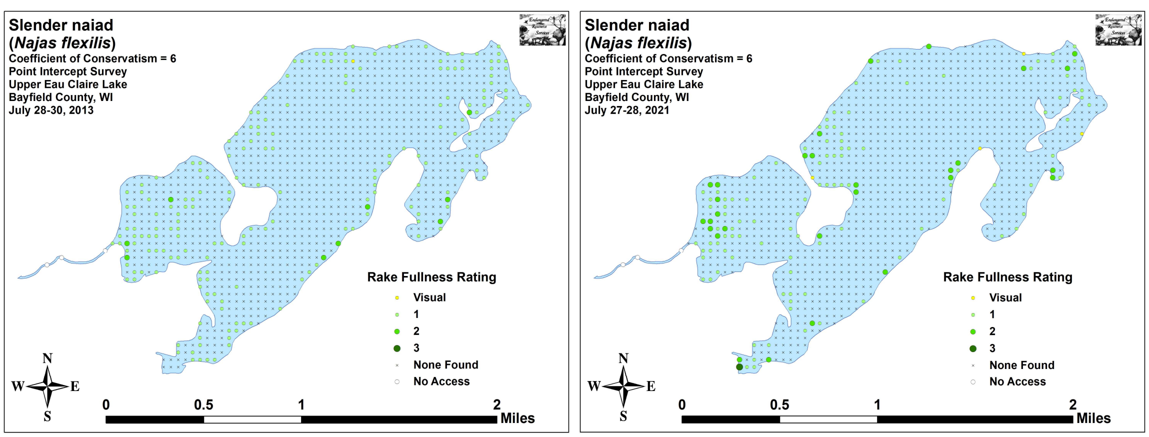


Figure 15: 2013 and 2021 Slender Naiad Density and Distribution

We identified Variable pondweed as the third most widely-distributed species in 2013 when it was present at 97 sites with a mean rake fullness of 1.06 (Figure 16). In 2021, despite a non-significant increase (p=0.38) in distribution (103 sites), it remained the third-ranked species in the plant community. Although little changed in distribution, it underwent a significant increase **(p=0.03)** in density (mean rake 1.15) with much of this expansion occurring in the bays north and east of Three-in-One Island.

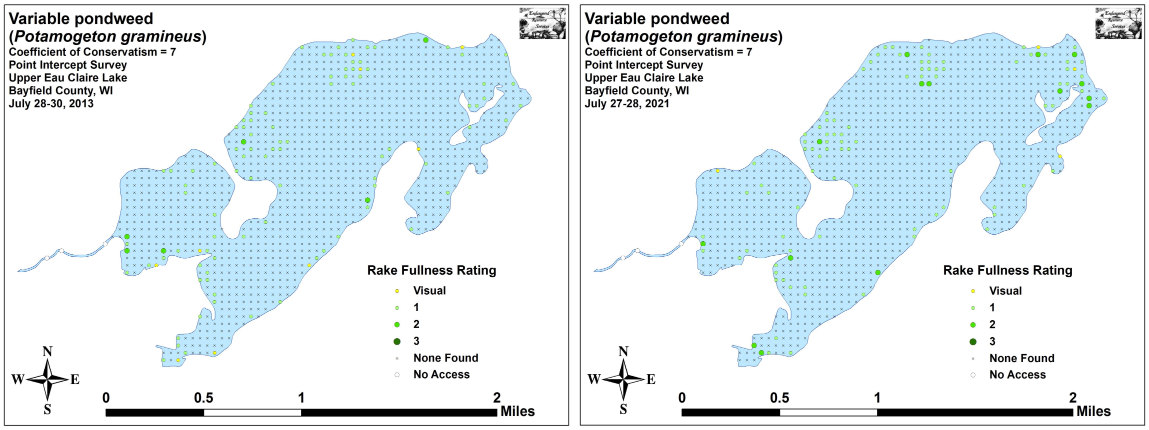


Figure 16: 2013 and 2021 Variable Pondweed Density and Distribution

Clasping-leaf pondweed was the fourth-ranked species in 2013 when it was present at 80 sites with a mean rake fullness of 1.24 (Figure 17). In 2021, following a non-significant decline (p=0.33) in distribution (65 sites) and a non-significant increase (p=0.23) in density (mean rake of 1.23), it fell to the seventh-ranked species in the plant community.

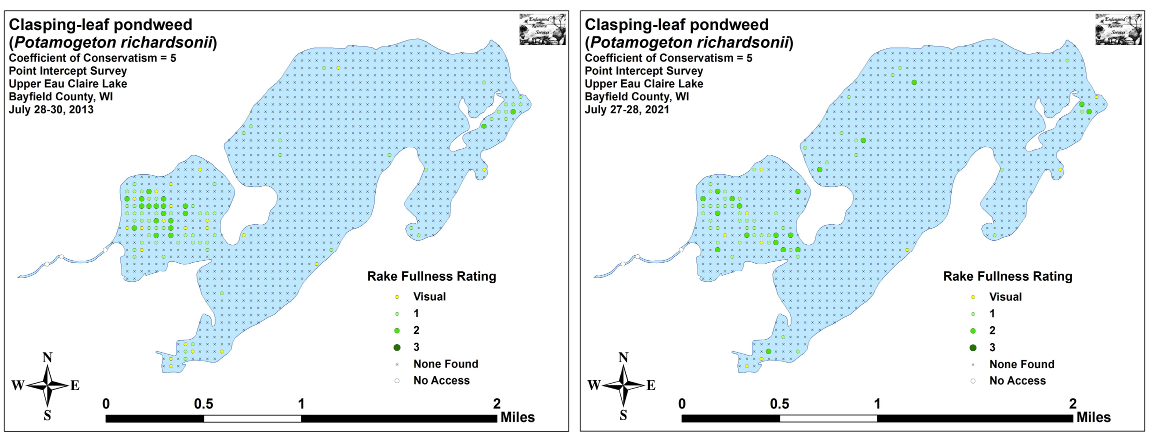


Figure 17: 2013 and 2021 Clasping-leaf Pondweed Density and Distribution

Needle spikerush was the fifth most widely-distributed species in 2013 when it was present at 62 sites with a mean rake fullness of 1.13 (Figure 18). In 2021, following a moderately significant decline **(p<0.01)** in distribution (35 sites), but a highly significant increase **(p<0.001)** in density (mean rake 1.46), it was just the twelfth most common species in the plant community.

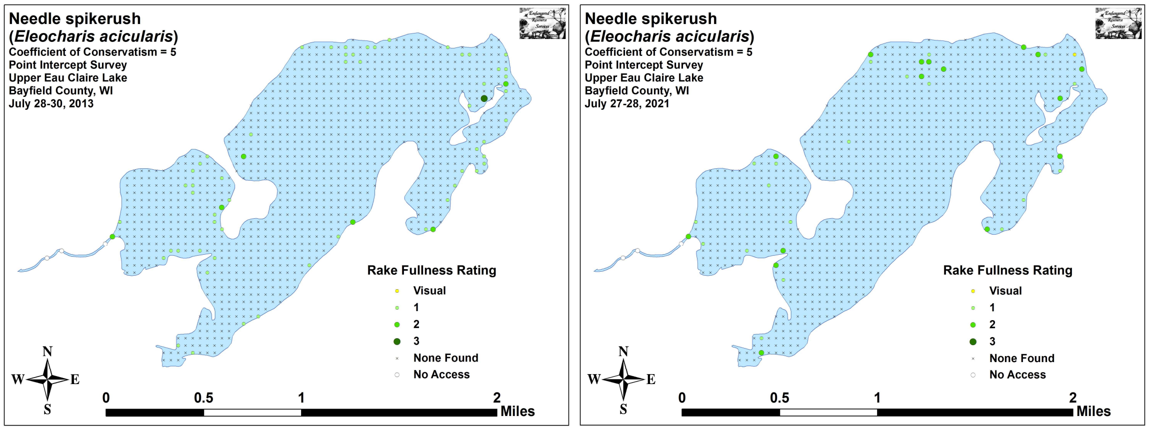


Figure 18: 2013 and 2021 Needle Spikerush Density and Distribution

In 2013, we raked up giant mats of Nitella on the outer edge of the littoral zone in 20+ft of water (Figure 19). At that time, it was tied for sixth most widely-distributed species (57 sites) and had a moderate mean density (rake fullness of 1.84). The 2021 survey documented highly significant declines **(p<0.001)** in both distribution (nine sites) and density (mean rake 1.11) as it fell to just the seventeenth-ranked species in the plant community.

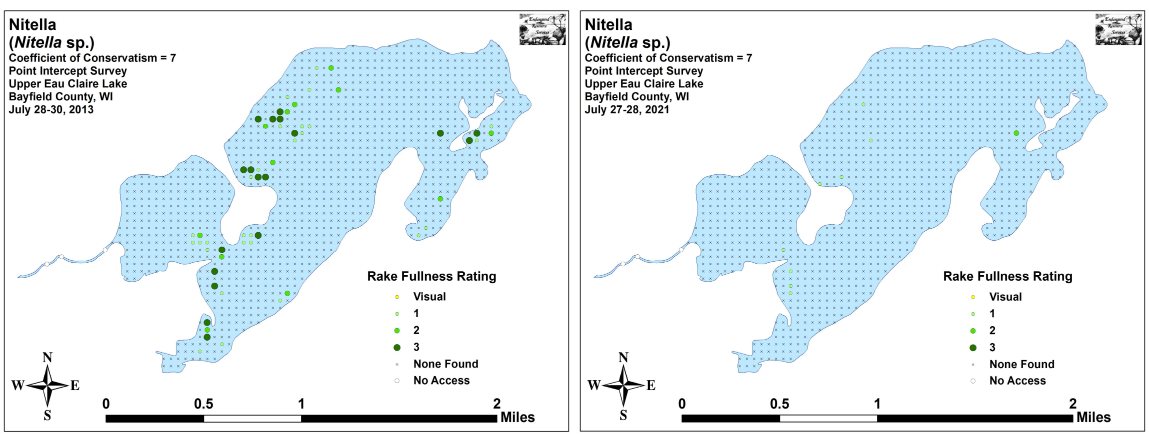


Figure 19: 2013 and 2021 Nitella Density and Distribution

Fern pondweed was tied with Nitella as the sixth most common species in 2013 (57 points/mean rake of 1.39) (Figure 20). Although still largely restricted to the sandy and organic muck habitats of the outlet bay, the southwest bay, and the bay northeast of Three-in-One Island during the 2021 survey, we documented a moderately significant increase **(*p*=0.004)** in distribution (85 sites) and a significant increase **(*p*=0.03)** in density (mean rake of 1.59).

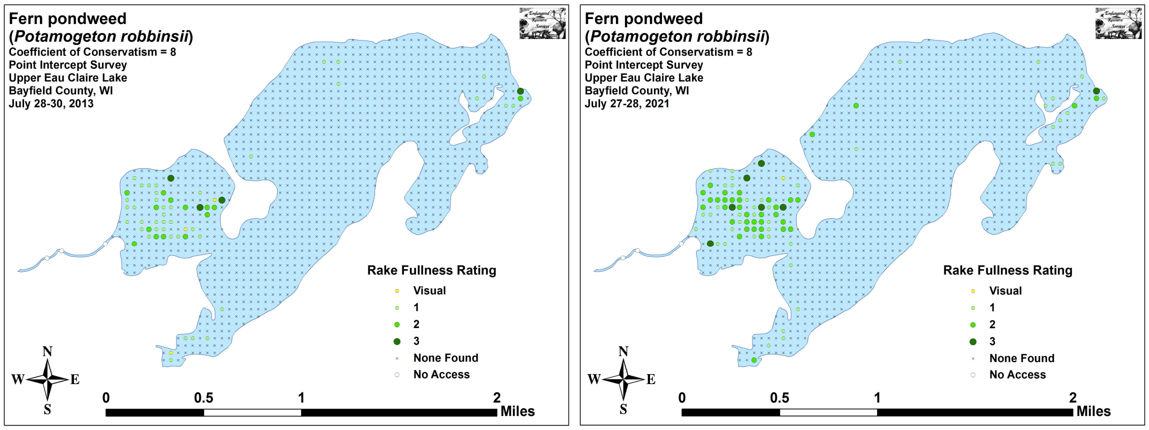


Figure 20: 2013 and 2021 Fern Pondweed Density and Distribution

Perhaps no species showed a more dramatic increase than Northern water-milfoil - a species known for significant boom/bust population cycles. Present at 48 points with a mean rake fullness of 1.31, it was the ninth-ranked species in 2013. Following highly significant increases **(*p*<0.001)** in both distribution (83 sites) and density (mean rake of 1.84), it jumped to the sixth-ranked species in 2021. Visual analysis of the maps showed these increases were a lakewide event (Figure 21).

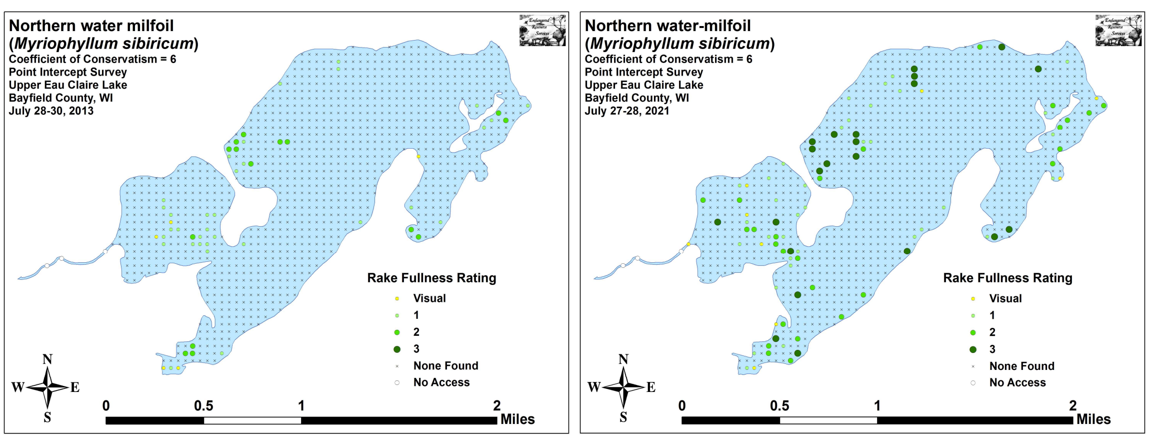


Figure 21: 2013 and 2021 Northern Water-milfoil Density and Distribution

Southern naiad was tied for the twelfth most widely-distributed species in 2013 when it was present at 42 sites with a mean rake fullness of 1.24 (Figure 22). In 2021, following a highly significant increase **(p<0.001)** in distribution (85 sites) and a significant increase **(p=0.03)** in density (mean rake 1.40), it jumped to the fourth-ranked species in the plant community. Despite these increases, we didn't see it anywhere outside the outlet bay during the 2021 survey where it was often the dominant species over marly muck.

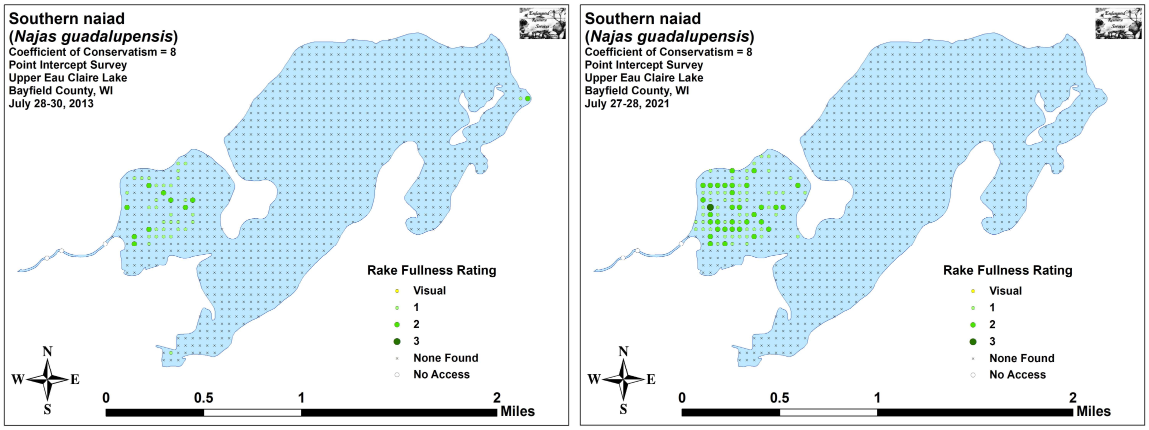


Figure 22: 2013 and 2021 Southern Naiad Density and Distribution

Common waterweed was tied with Southern naiad as the twelfth most widely-distributed species in 2013 (42 sites/mean rake 1.07) (Figure 23). The 2021 survey documented a significant increase **(p=0.02)** in distribution (61 sites) and a moderately significant increase **(p=0.03)** in density (mean rake 1.28) as it rose to the eighth-most common species in the plant community. Although these increases were relatively widespread, it's possible that this species was exploiting open substrate created by the suction harvest program as it was especially abundant northeast of Three-in-One Island.

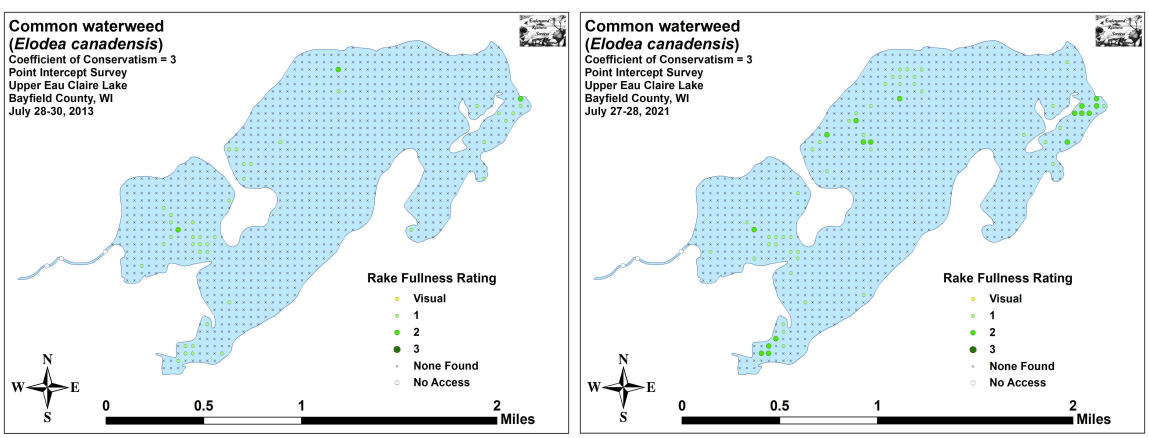


Figure 23: 2013 and 2021 Common Waterweed Density and Distribution

Comparison of Floristic Quality Indexes in 2013 and 2021:

The 2013 point-intercept survey identified a total of 39 **native index plants** in the rake. They produced a mean Coefficient of Conservatism of 7.0 and a Floristic Quality Index of 43.7 (Table 5).

Table 5: Floristic Quality Index of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 28-30, 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
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Eriocaulon aquaticum	Pipewort	9
Heteranthera dubia	Water star-grass	6
Isoetes echinospora	Spiny-spored quillwort	8
Juncus pelocarpus	Brown-fruited rush	8
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Najas guadalupensis	Southern naiad	8
Nitella sp.	Nitella	7
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
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
Schoenoplectus subterminalis	Water bulrush	9
Sparganium fluctuans	Floating-leaf bur-reed	10
Stuckenia pectinata	Sago pondweed	3

Table 5 (continued): Floristic Quality Index of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 28-30, 2013

Species	Common Name	C
Utricularia minor	Small bladderwort	10
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		**39**
Mean C		**7.0**
FQI		**43.7**

Our 2021 point-intercept survey found 38 **native index plants** in the rake. They produced a mean Coefficient of Conservatism of 6.9 and a Floristic Quality Index of 42.5 (Table 6). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Upper 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). Seven exceptionally high-value index plants of note included Waterwort (C = 9), Pipewort (C = 9), Dwarf water-milfoil (C = 10), Creeping spearwort (C = 9), Crested arrowhead (C = 9), Water bulrush (C = 9), and Floating-leaf bur-reed (C = 10).

Table 6: Floristic Quality Index of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 27-28, 2021

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
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Eriocaulon aquaticum	Pipewort	9
Heteranthera dubia	Water star-grass	6
Isoetes echinospora	Spiny-spored quillwort	8
Juncus pelocarpus f. submersus	Brown-fruited rush	8
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Najas guadalupensis	Southern naiad	8
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6

Table 6 (continued): Floristic Quality Index of Aquatic Macrophytes
Upper Eau Claire Lake – Bayfield County, Wisconsin
July 27-28, 2021

Species	Common Name	C
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
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
Schoenoplectus subterminalis	Water bulrush	9
Sparganium fluctuans	Floating-leaf bur-reed	10
Stuckenia pectinata	Sago pondweed	3
Vallisneria americana	Wild celery	6
N		**38**
Mean C		**6.9**
FQI		**42.5**

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 a single point with a rake fullness of 1 (Figure 24). The 2021 survey documented a highly significant increase **(p<0.001)** in distribution, but all 24 points again had a rake fullness of 1. These points were scattered throughout the entire lake suggesting the nutrients feeding this growth are not from a single source.

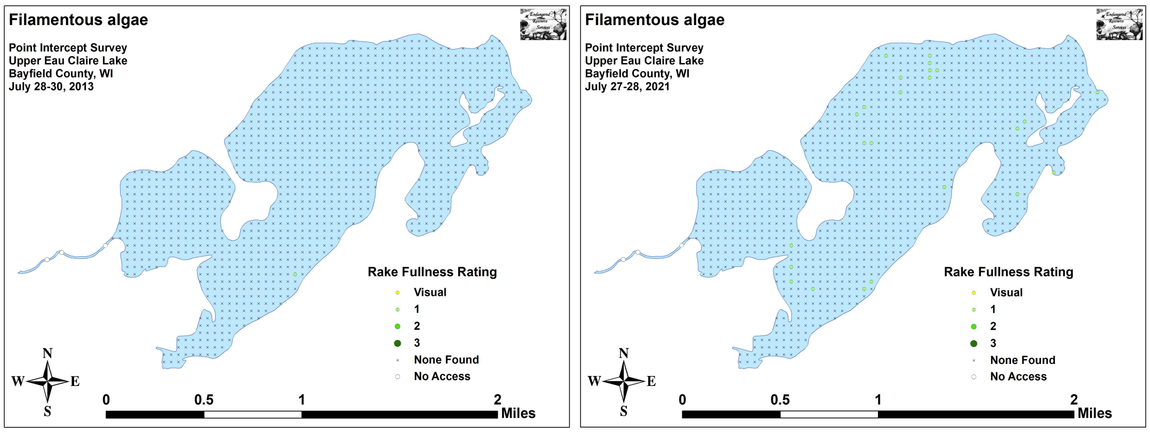


Figure 24: 2013 and 2021 Filamentous Algae Density and Distribution

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 July 2013 survey, we saw no evidence of CLP anywhere in the lake. In July 2021, CLP was still present in the rake at four points with a mean rake fullness of 1.50 – this included several areas in the northwest bay where we hadn't found it previously (Figure 25) (Appendix VII). Compared to 2021, this was a significant increase **(p=0.04)** in distribution.

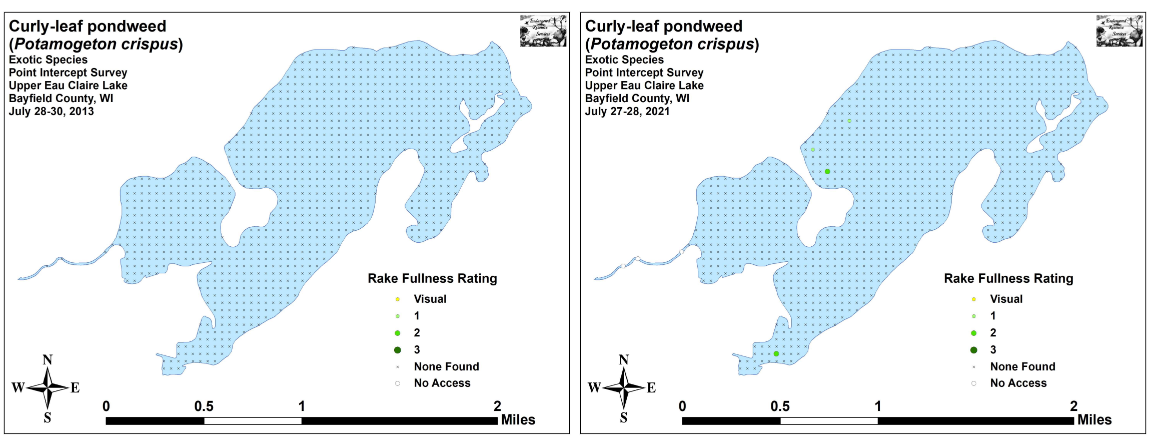


Figure 25: 2013 and 2021 Late Summer CLP Density and Distribution

Other Exotic Plant Species:

We did NOT find any evidence or Eurasian water-milfoil in Upper Eau Claire Lake during any of our surveys. However, in addition to Curly-leaf pondweed, we documented a stand of Hybrid cattail growing in the bay northeast of Three-in-One Island (Figure 26) (Appendix VII).

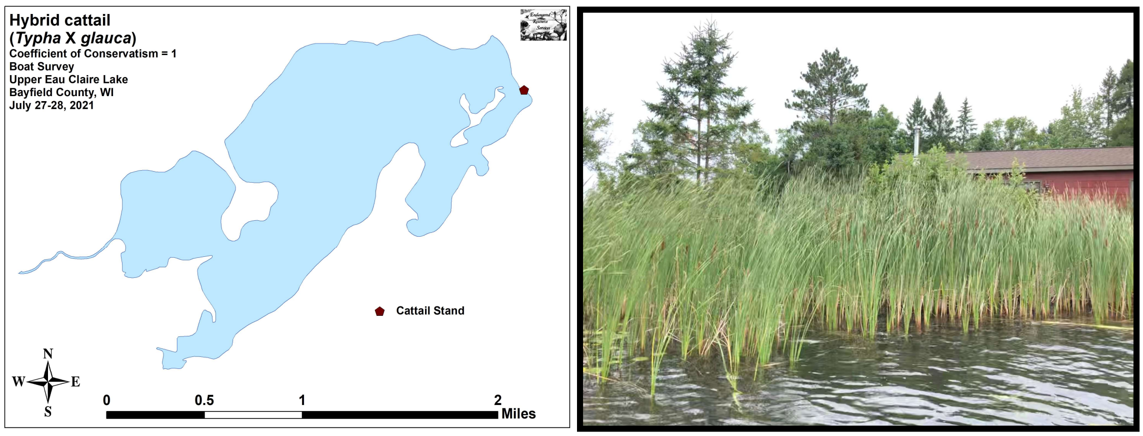


Figure 26: 2021 Hybrid Cattail Distribution and Stand in Northeast Bay

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).

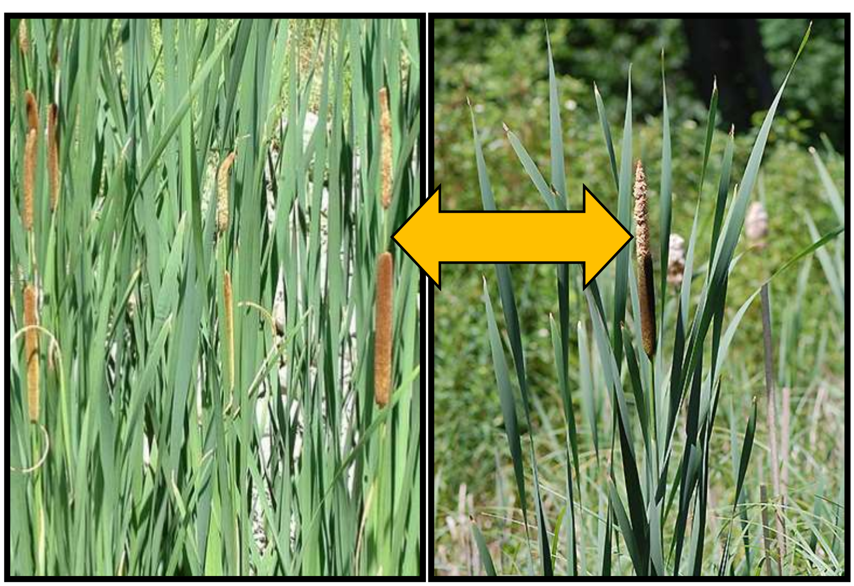


Figure 27: Exotic Hybrid and Native Broad-leaved Cattail Identification

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Native Aquatic Macrophytes:

Upper 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.

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 Upper 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 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.

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.

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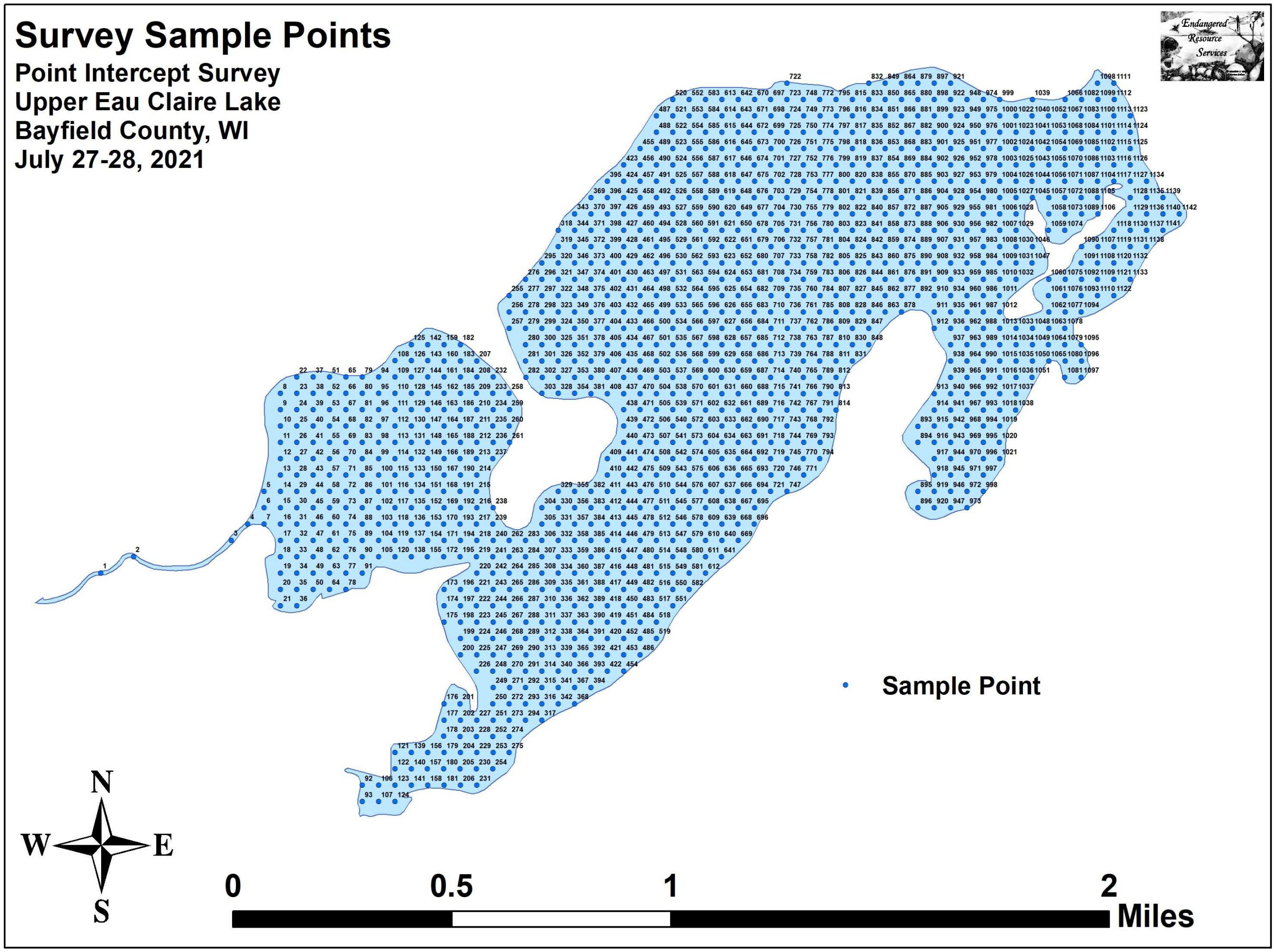
WDNR. [online]. 2010. Reed canary grass fact sheet. http://dnr.wi.gov/invasives/fact/reed_canary.htm (2010, August).

WDNR. [online]. 2021. Wisconsin Lake Citizen Monitoring Data for Upper Eau Claire Lake Bayfield County. Available from http://dnr.wi.gov/lakes/waterquality/Station.aspx?id=043129 (2021, November).

WDNR. [online]. 2021. Wisconsin Lakes Information – Upper Eau Claire Lake. http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2742700 (2021, November).

Appendix I: Survey Sample Points Map

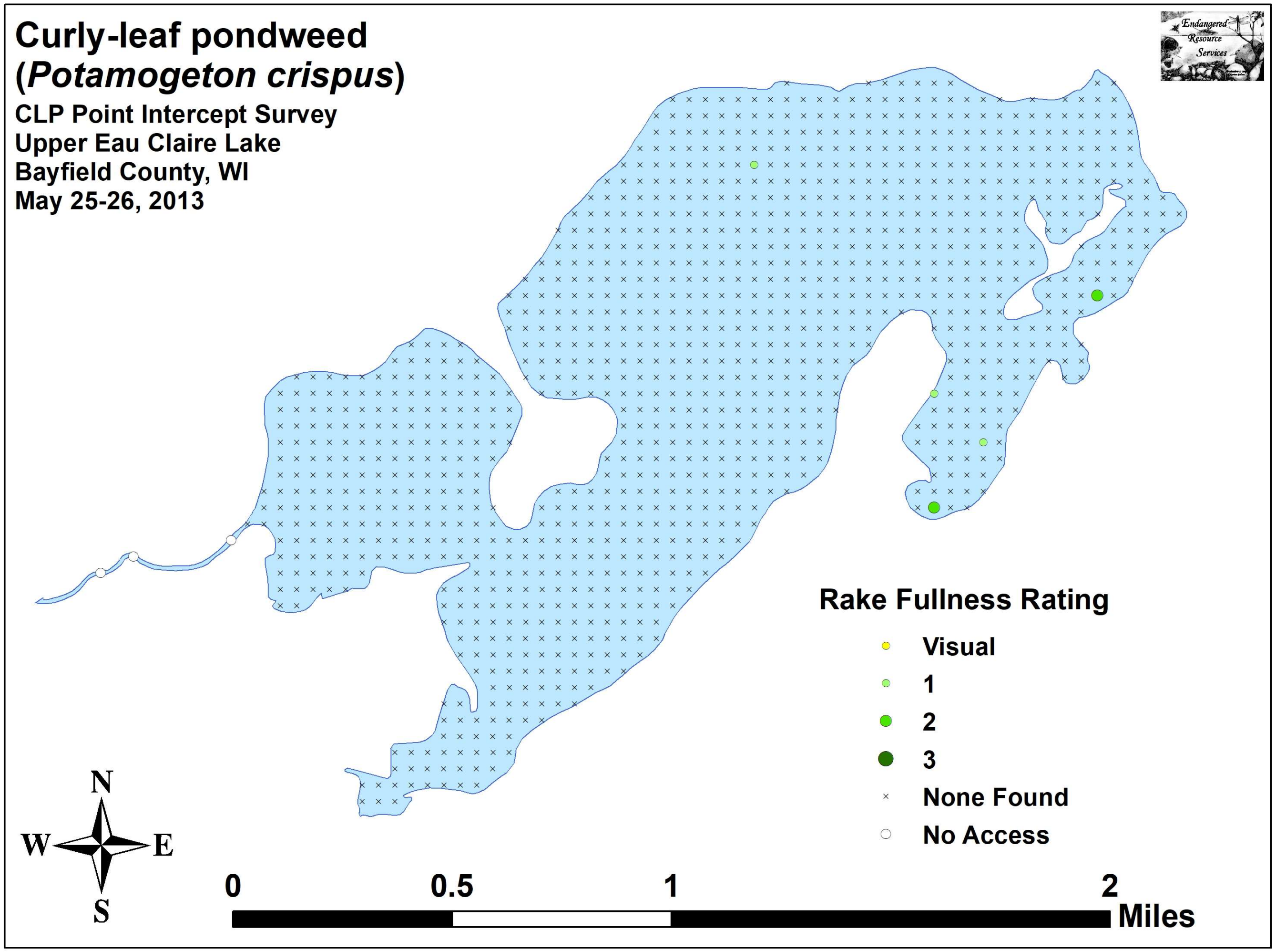

Survey Sample Points
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Sample Point
N
W
E
S
0
0.5
1
2
Miles

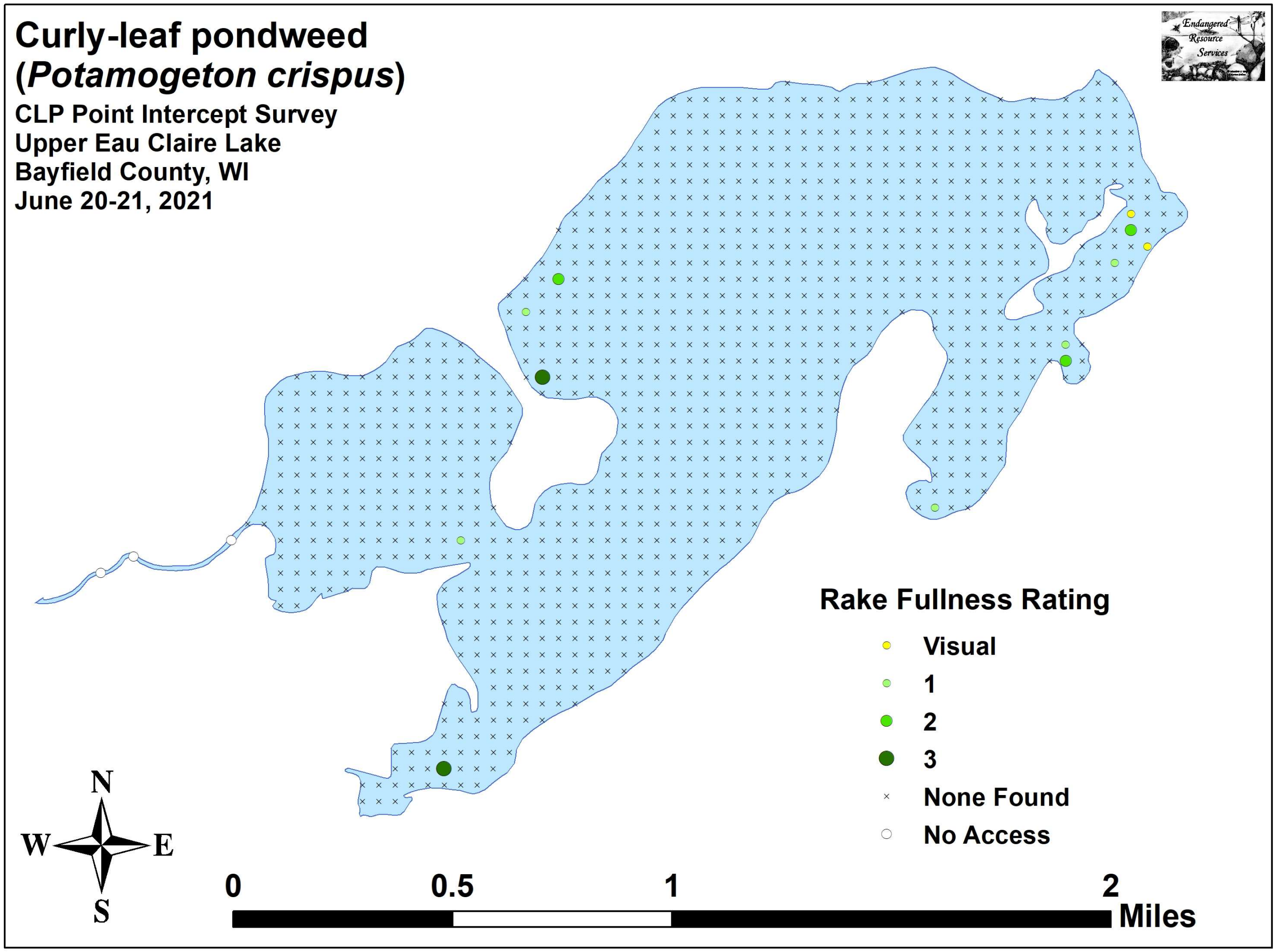
Appendix II: Boat and Vegetative Survey Datasheets

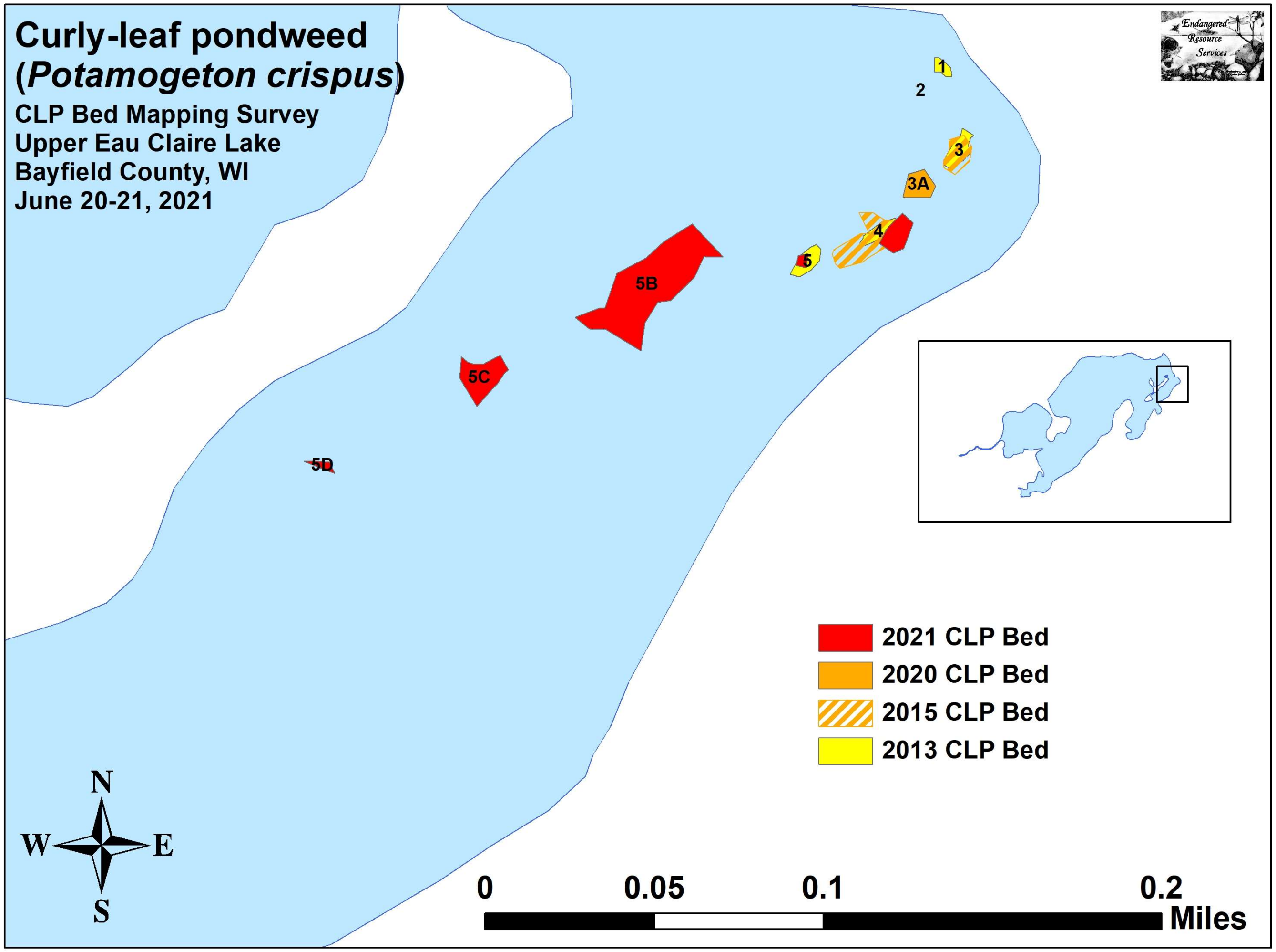
Boat Survey	
Lake Name	
County	
WBIC	
Date of Survey	
(mm/dd/yy)	
workers	
Nearest Point	**Species seen, habitat information**

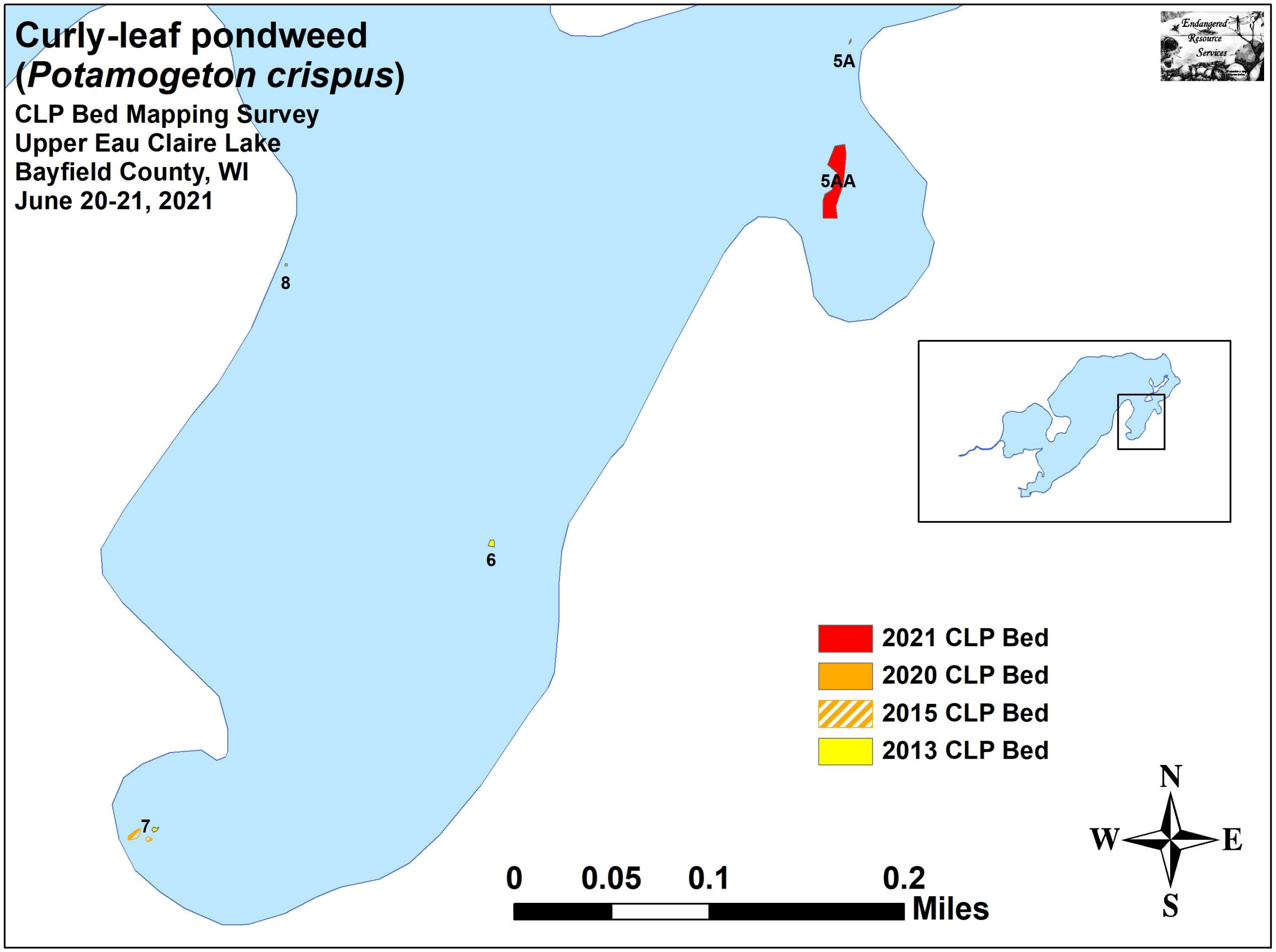
Observers for this lake: names and hours worked by each:																									
Lake:									**WBIC**									**County**						**Date:**	
Site #	**Depth (ft)**	**Muck (M), Sand (S), Rock (R)**	**Rake pole (P) or rake rope (R)**	**Total Rake Fullness**	**EWM**	**CLP**	**1**	**2**	**3**	**4**	**5**	**6**	**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																									

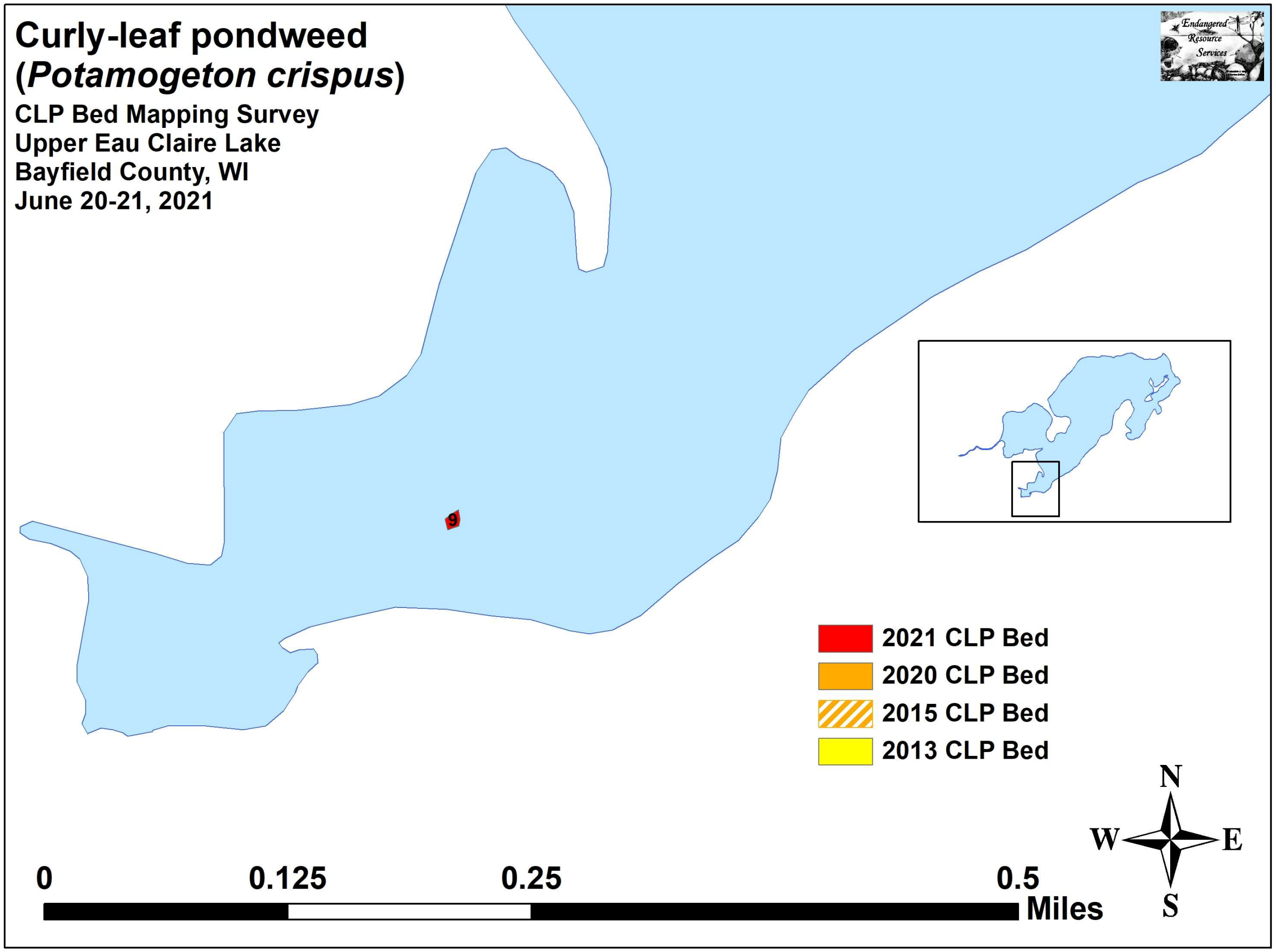
Appendix III: 2013 and 2021 Early Season Curly-leaf Pondweed Density and Distribution, and 2013, 2015, 2020, and 2021 CLP Bed Maps


Curly-leaf pondweed
(*Potamogeton crispus*)
CLP Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
May 25-26, 2013
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

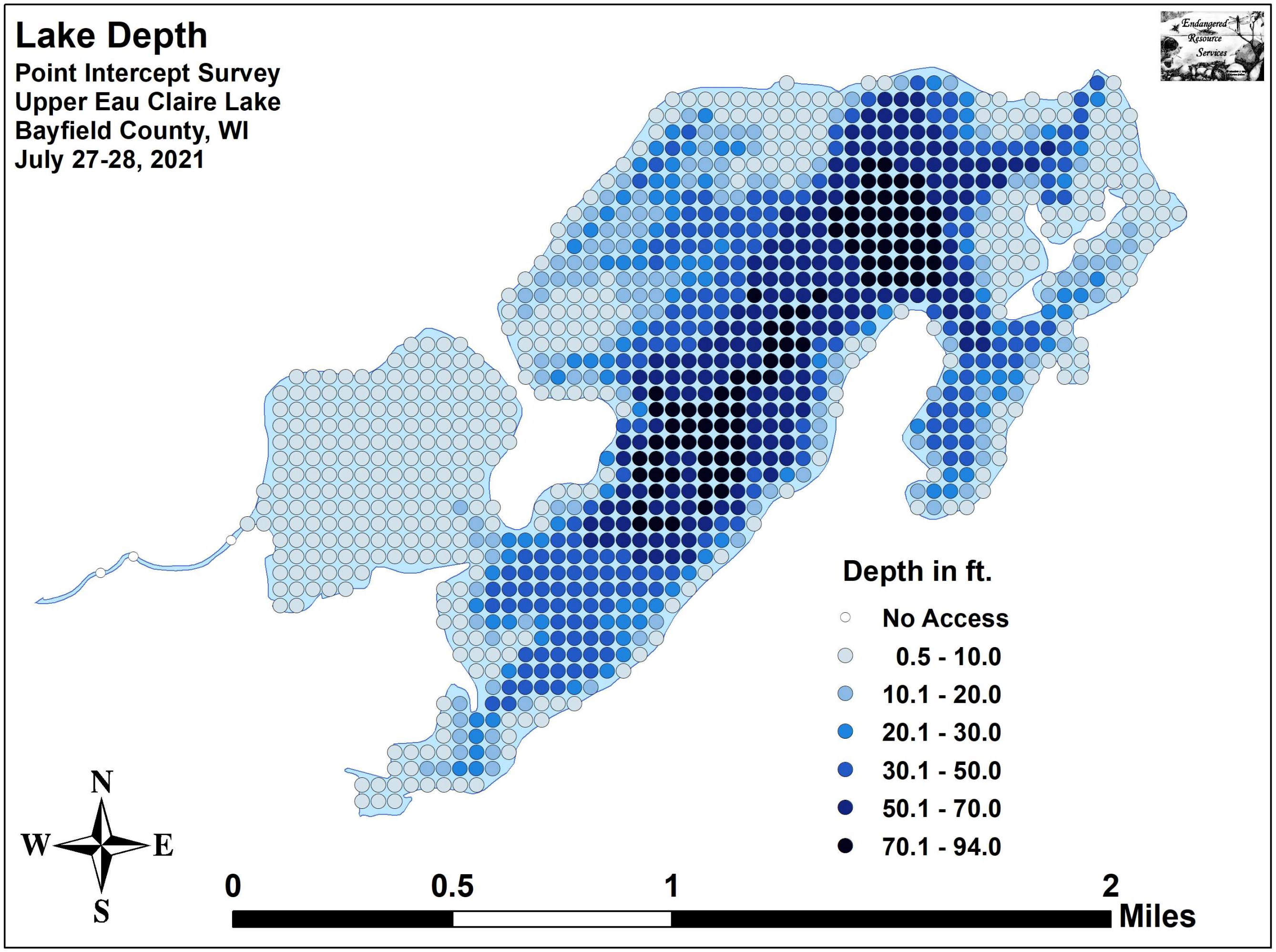

Curly-leaf pondweed
(Potamogeton crispus)
CLP Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
June 20-21, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles


Curly-leaf pondweed
(*Potamogeton crispus*)
CLP Bed Mapping Survey
Upper Eau Claire Lake
Bayfield County, WI
June 20-21, 2021
Endangered Resource Services
1
2
3
3A
4
5
5B
5C
5D
2021 CLP Bed
2020 CLP Bed
2015 CLP Bed
2013 CLP Bed
N
W
E
S
0
0.05
0.1
0.2
Miles

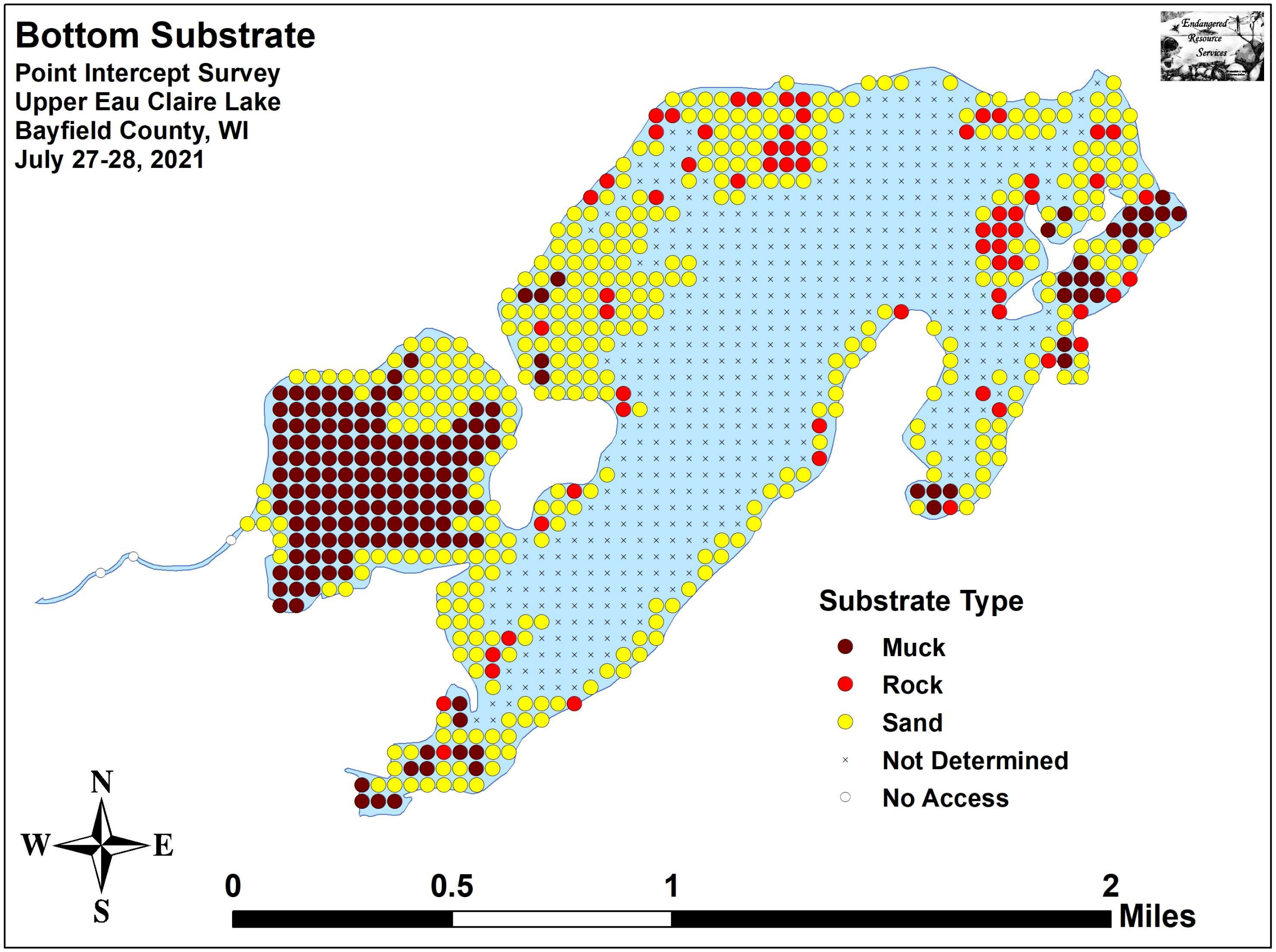

Curly-leaf pondweed
(*Potamogeton crispus*)
CLP Bed Mapping Survey
Upper Eau Claire Lake
Bayfield County, WI
June 20-21, 2021
5A
5AA
8
6
7
2021 CLP Bed
2020 CLP Bed
2015 CLP Bed
2013 CLP Bed
N
W
E
S
0
0.05
0.1
0.2
Miles


Curly-leaf pondweed
(*Potamogeton crispus*)
CLP Bed Mapping Survey
Upper Eau Claire Lake
Bayfield County, WI
June 20-21, 2021
9
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

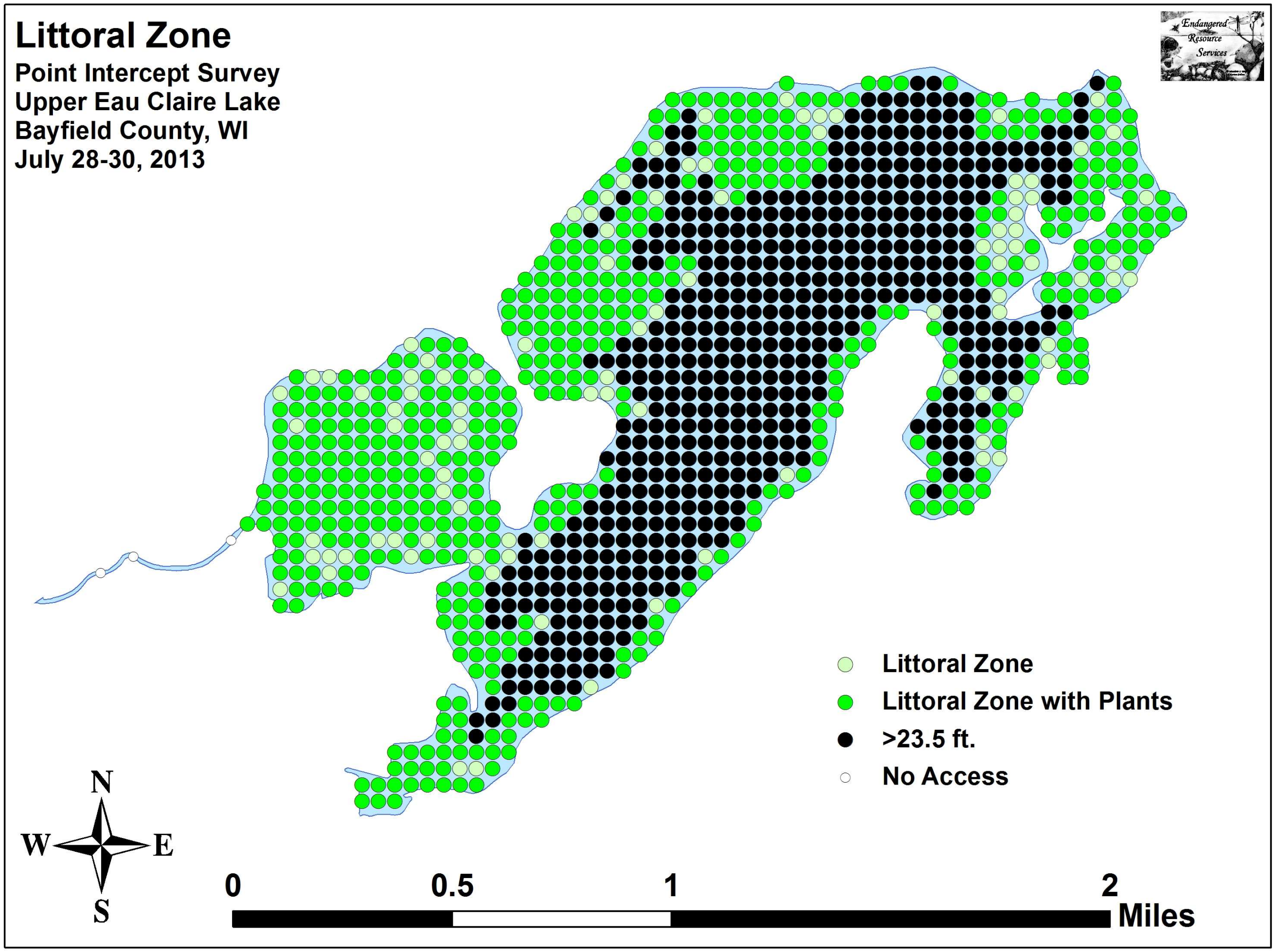


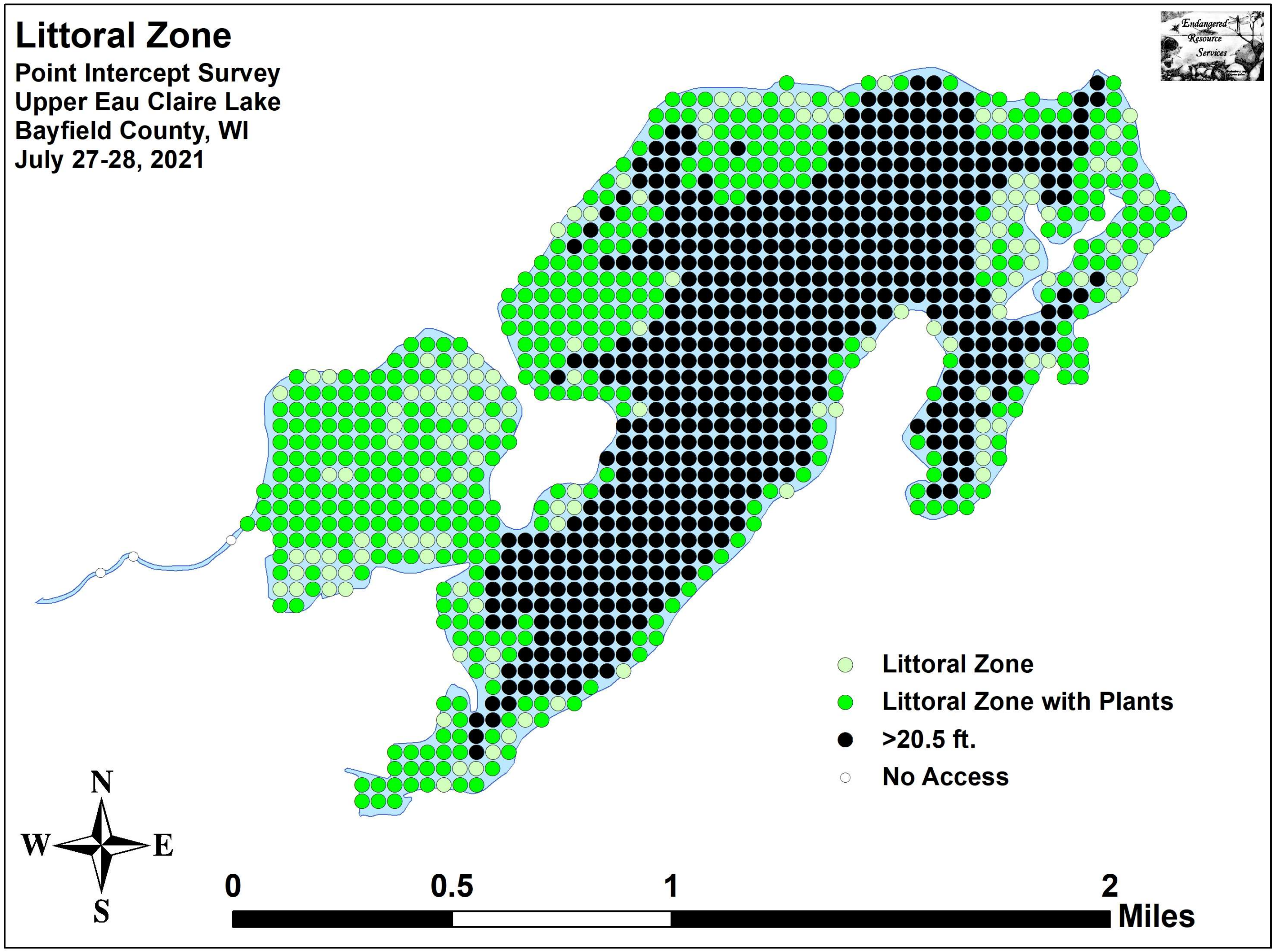
Lake Depth
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Depth in ft.
No Access
0.5 - 10.0
10.1 - 20.0
20.1 - 30.0
30.1 - 50.0
50.1 - 70.0
70.1 - 94.0
N
W
E
S
0
0.5
1
2
Miles

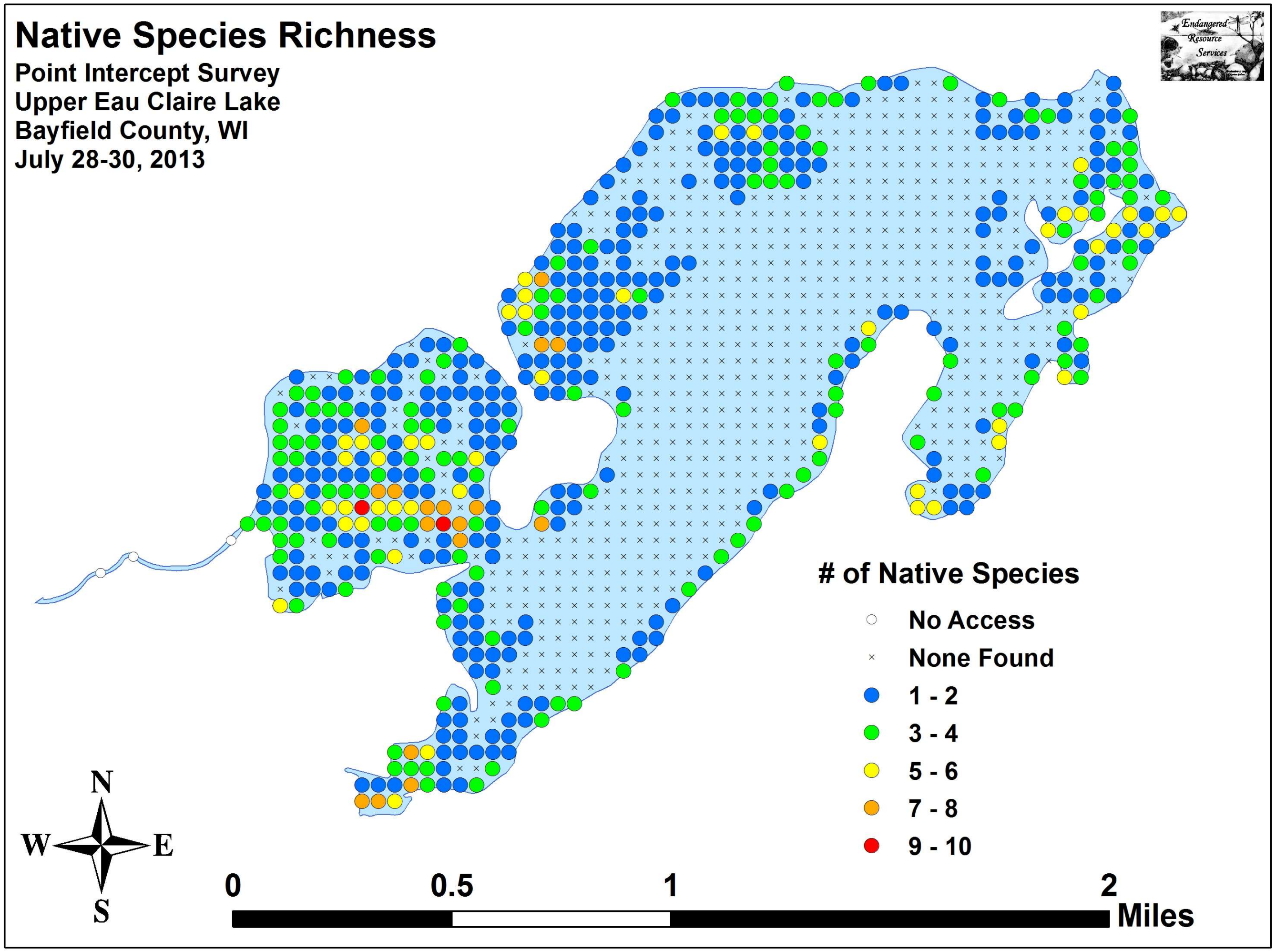


Bottom Substrate
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Substrate Type
Muck
Rock
Sand
Not Determined
No Access
N
W
E
S
0
0.5
1
2
Miles

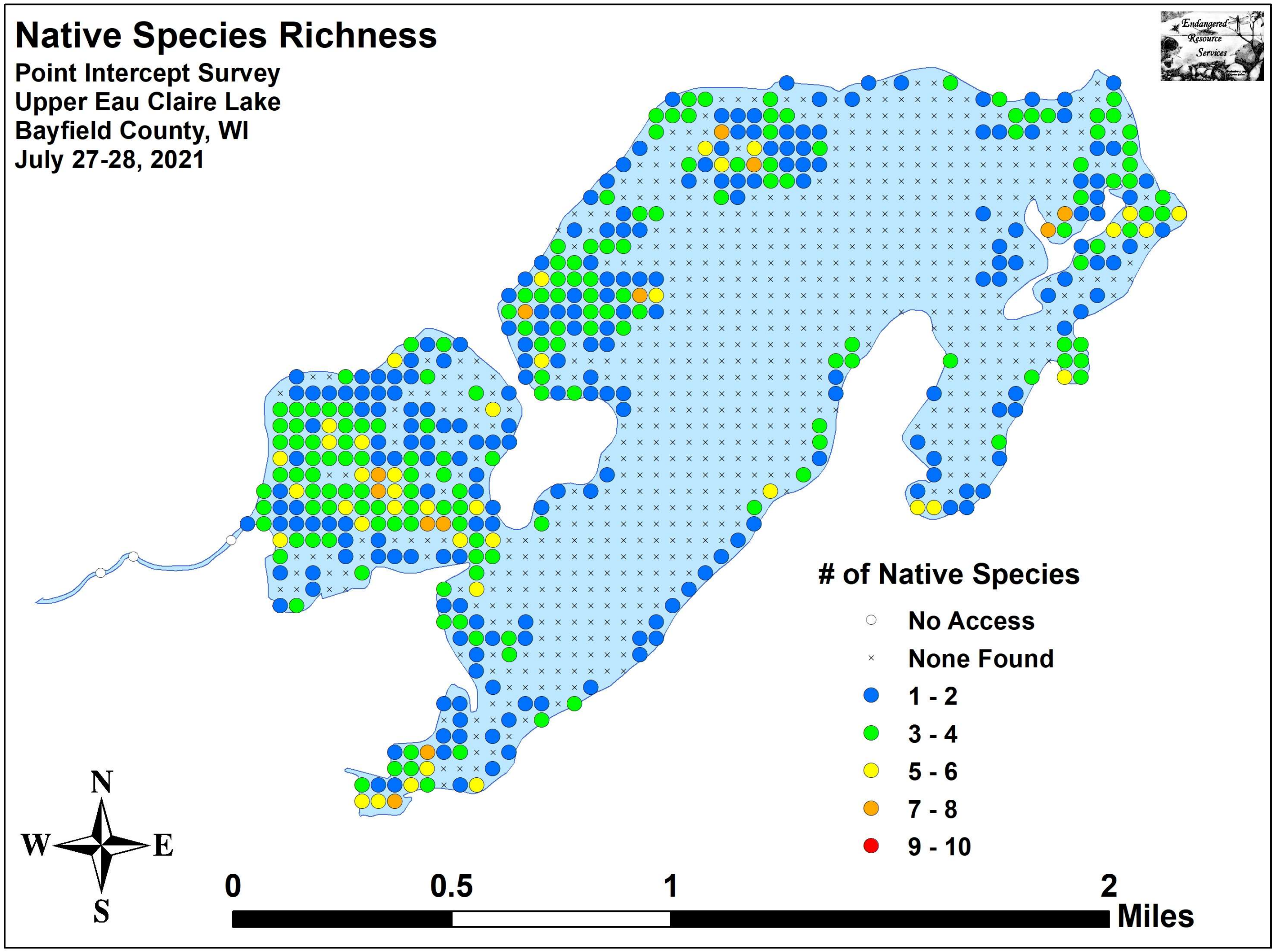
Appendix V: 2013 and 2021 Littoral Zone, Native Species Richness, and Total Rake Fullness Maps


Littoral Zone
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 28-30, 2013
Littoral Zone
Littoral Zone with Plants
>23.5 ft.
No Access
N
W
E
S
0
0.5
1
2
Miles

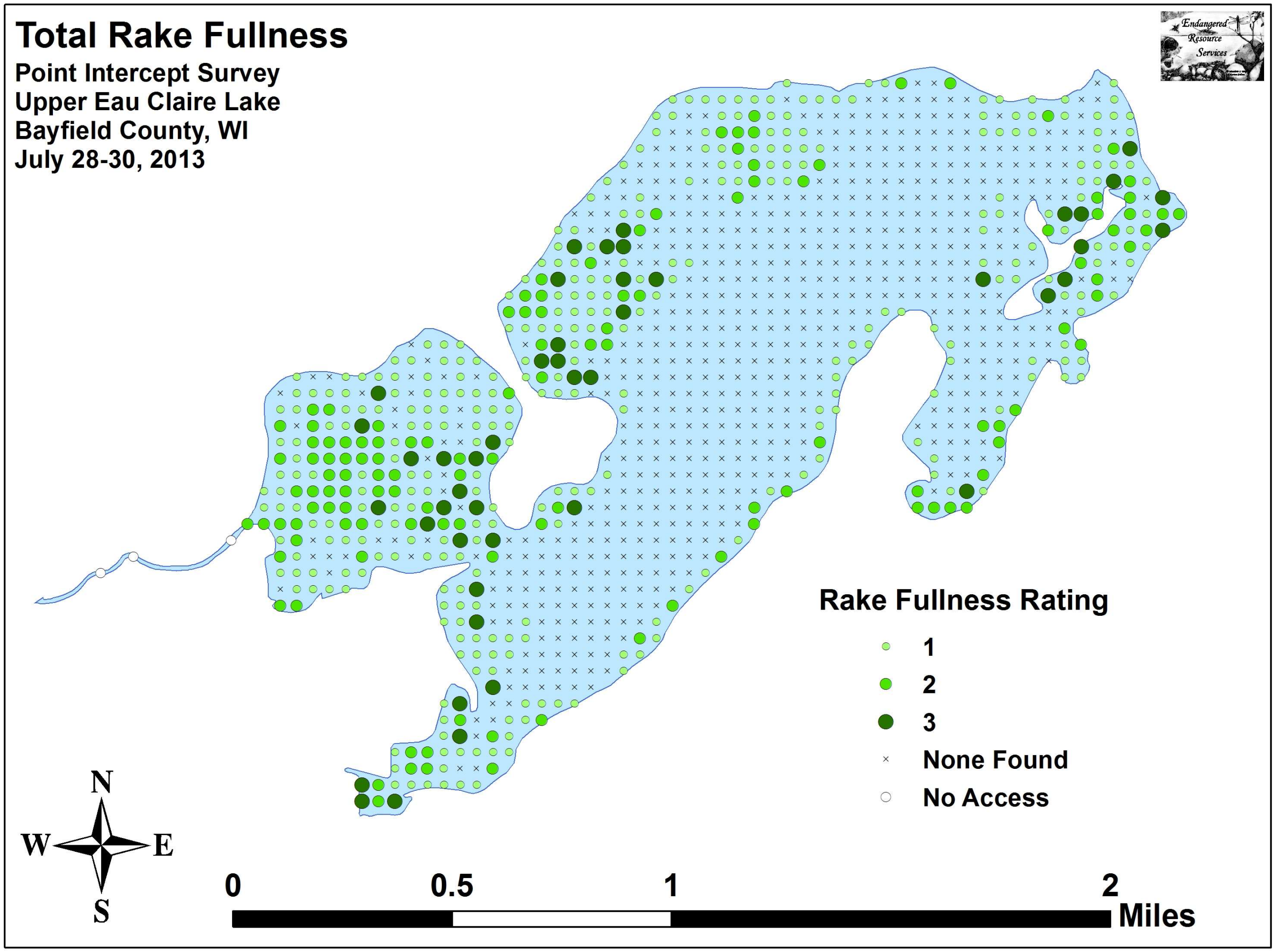

Littoral Zone
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Littoral Zone
Littoral Zone with Plants
>20.5 ft.
No Access
N
W
E
S
0
0.5
1
2
Miles

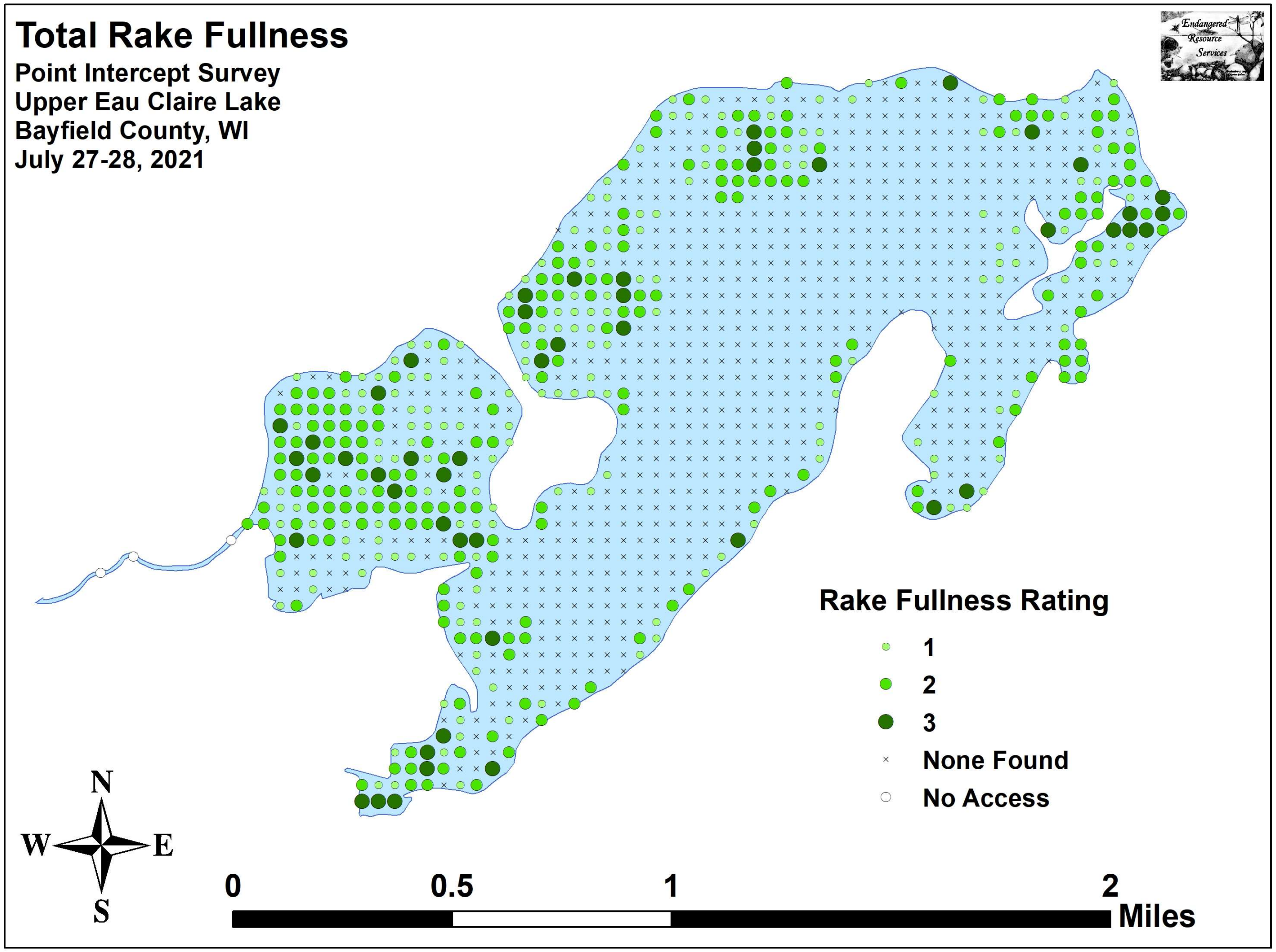


Native Species Richness
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 28-30, 2013
# of Native Species
No Access
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
N
W
E
S
0
0.5
1
2
Miles

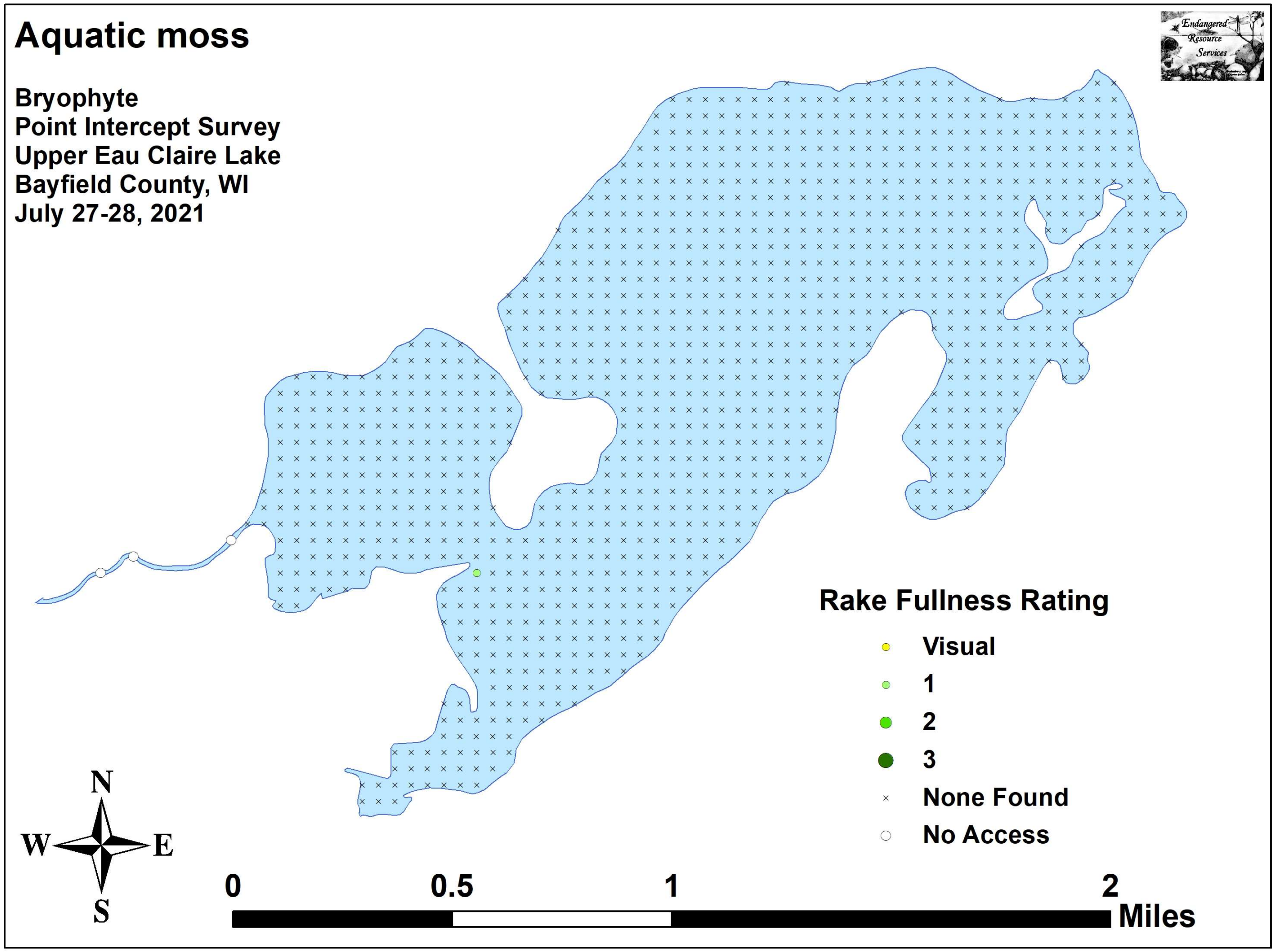


Native Species Richness
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
# of Native Species
No Access
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
N
W
E
S
0
0.5
1
2
Miles

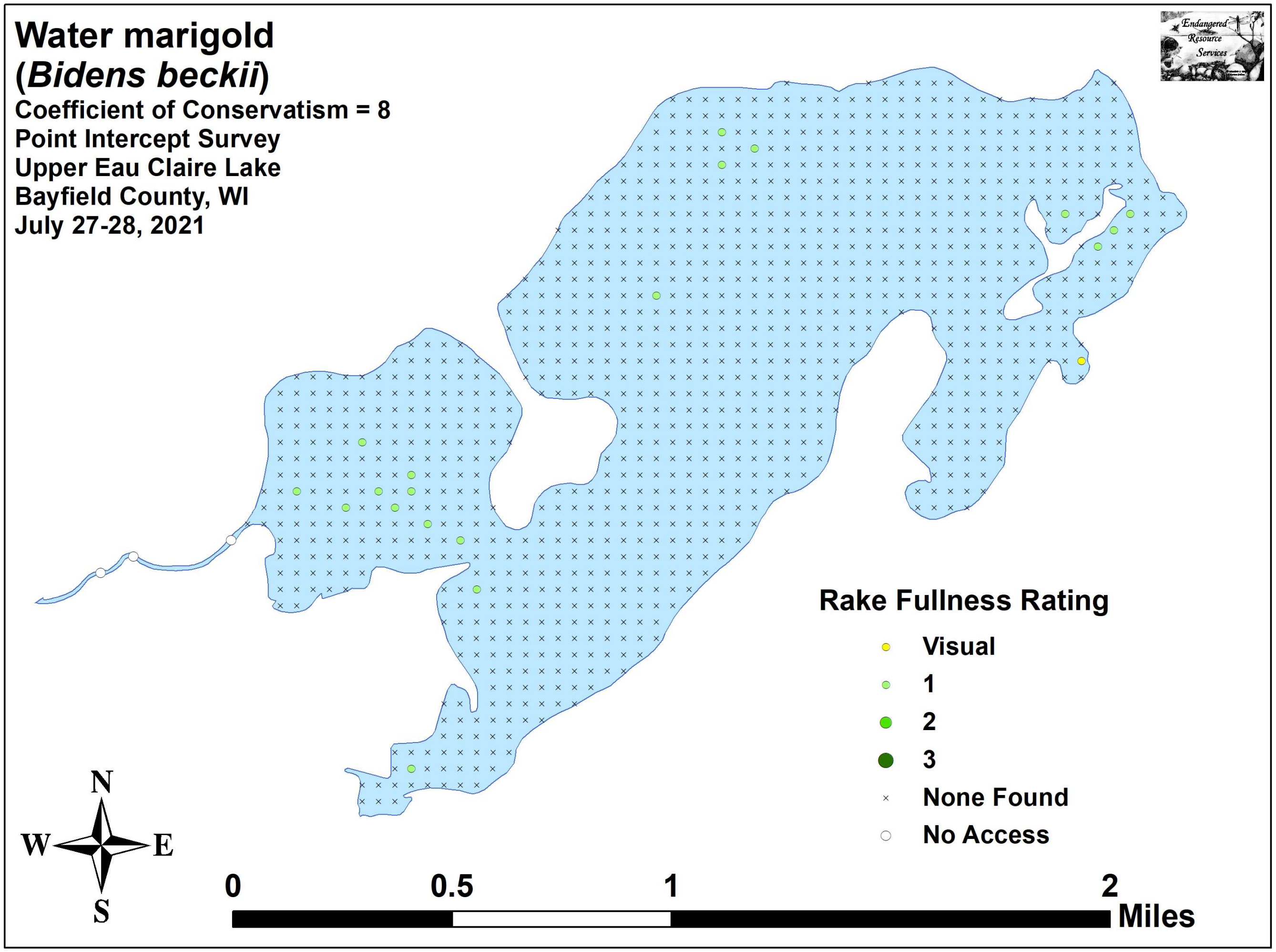

Total Rake Fullness
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 28-30, 2013
Rake Fullness Rating
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

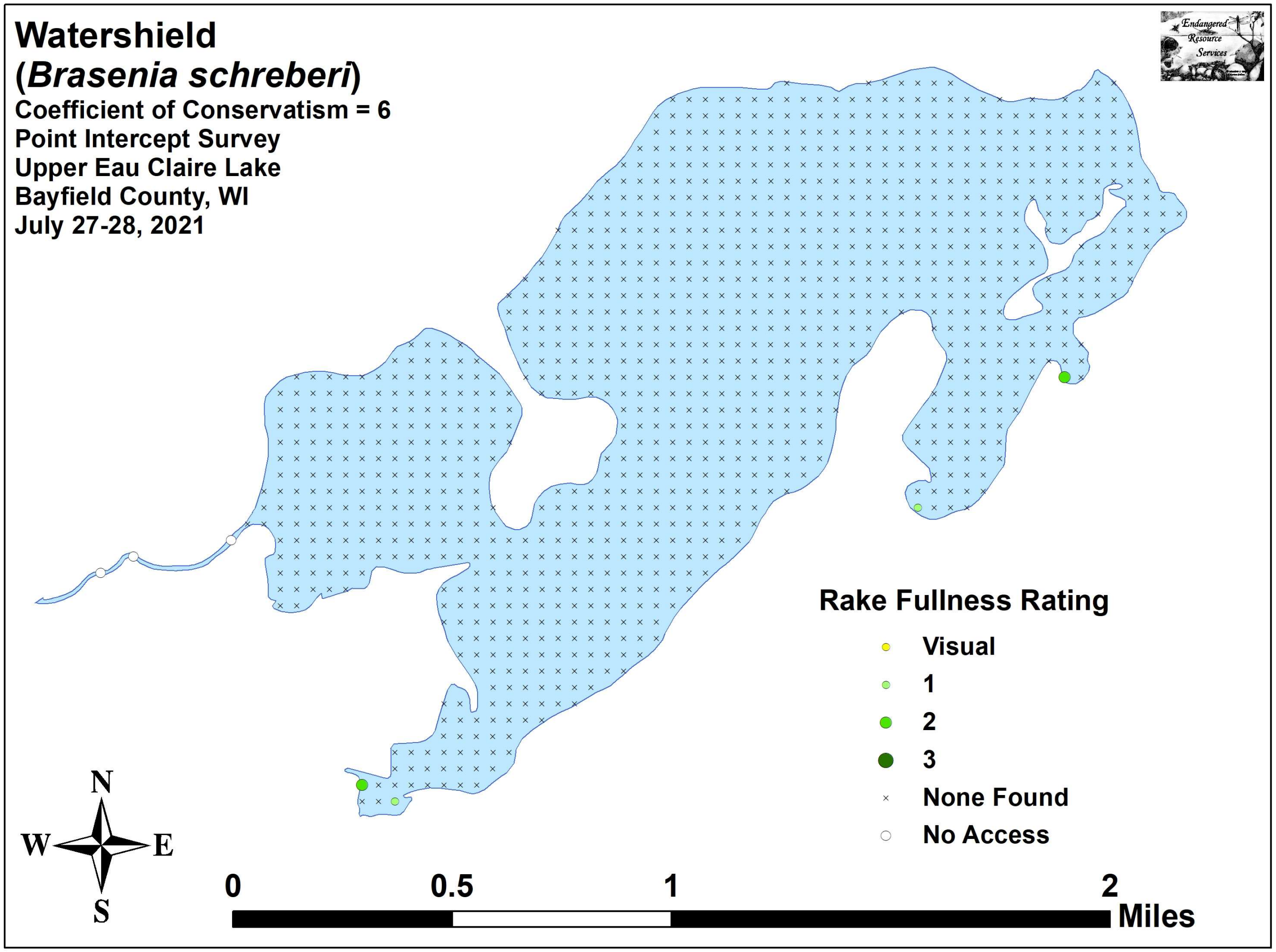

Total Rake Fullness
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

Appendix VI: July 2021 Native Species Density and Distribution Maps

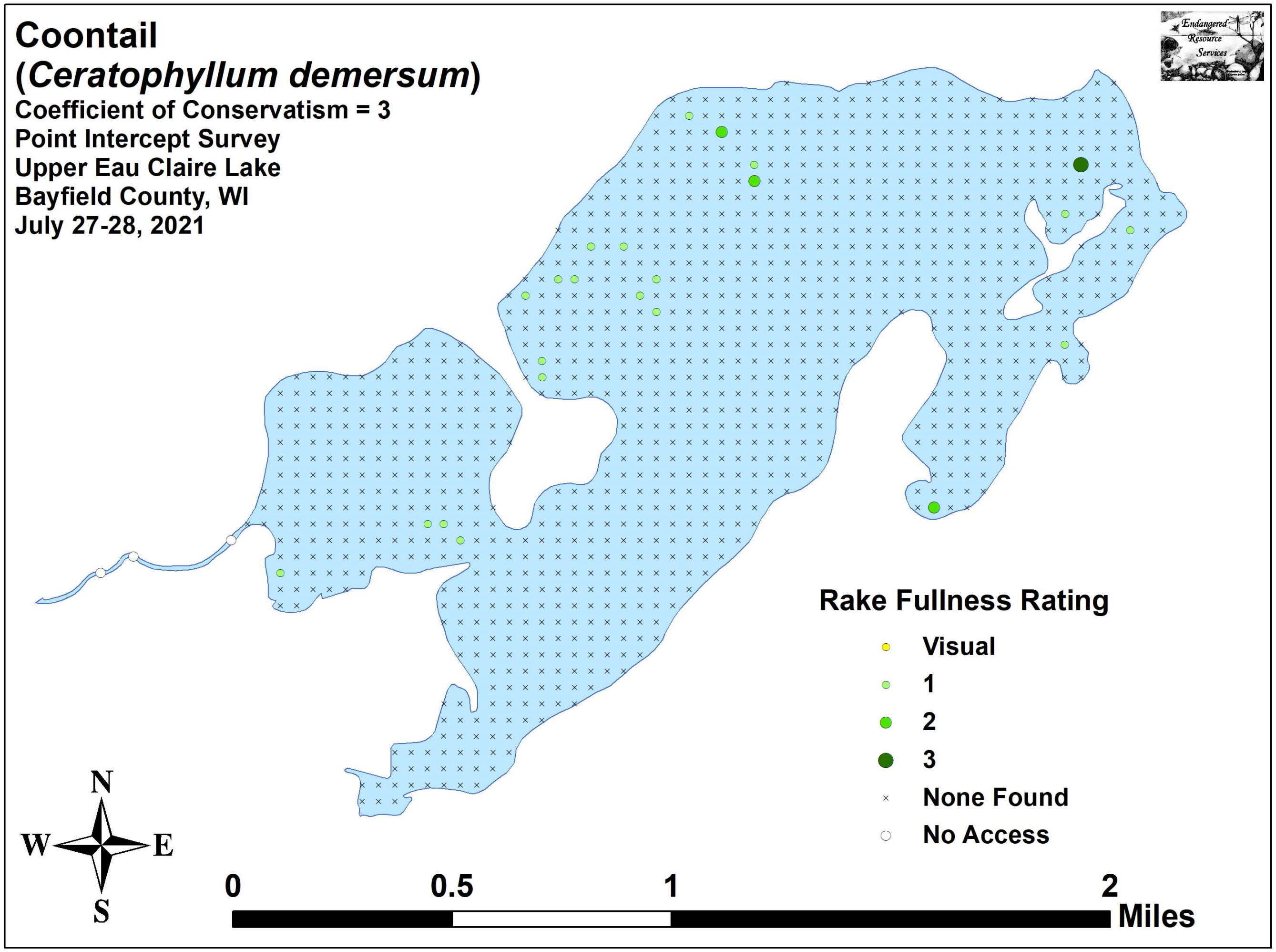


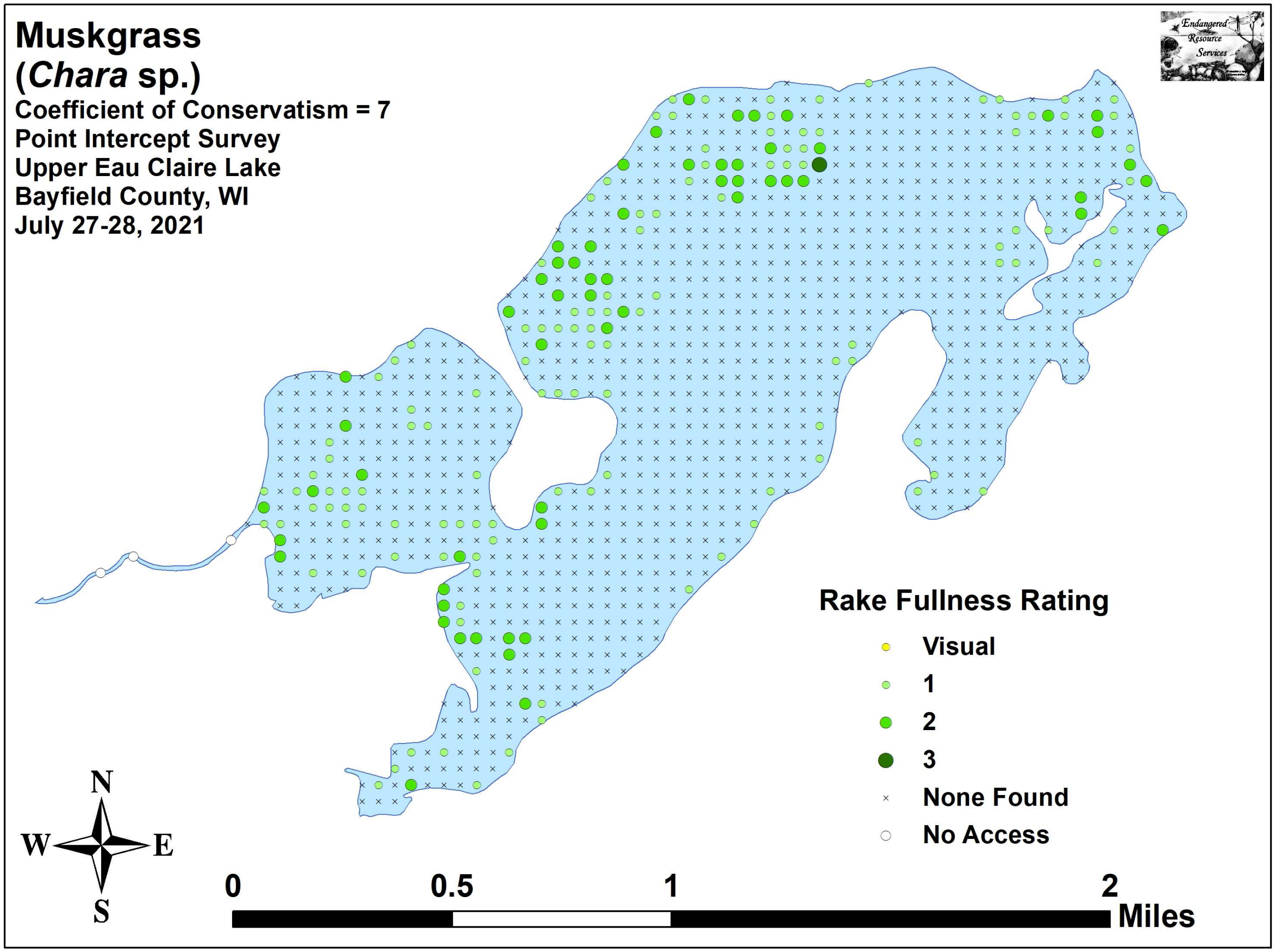
Aquatic moss
Bryophyte
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles


Water marigold
(Bidens beckii)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

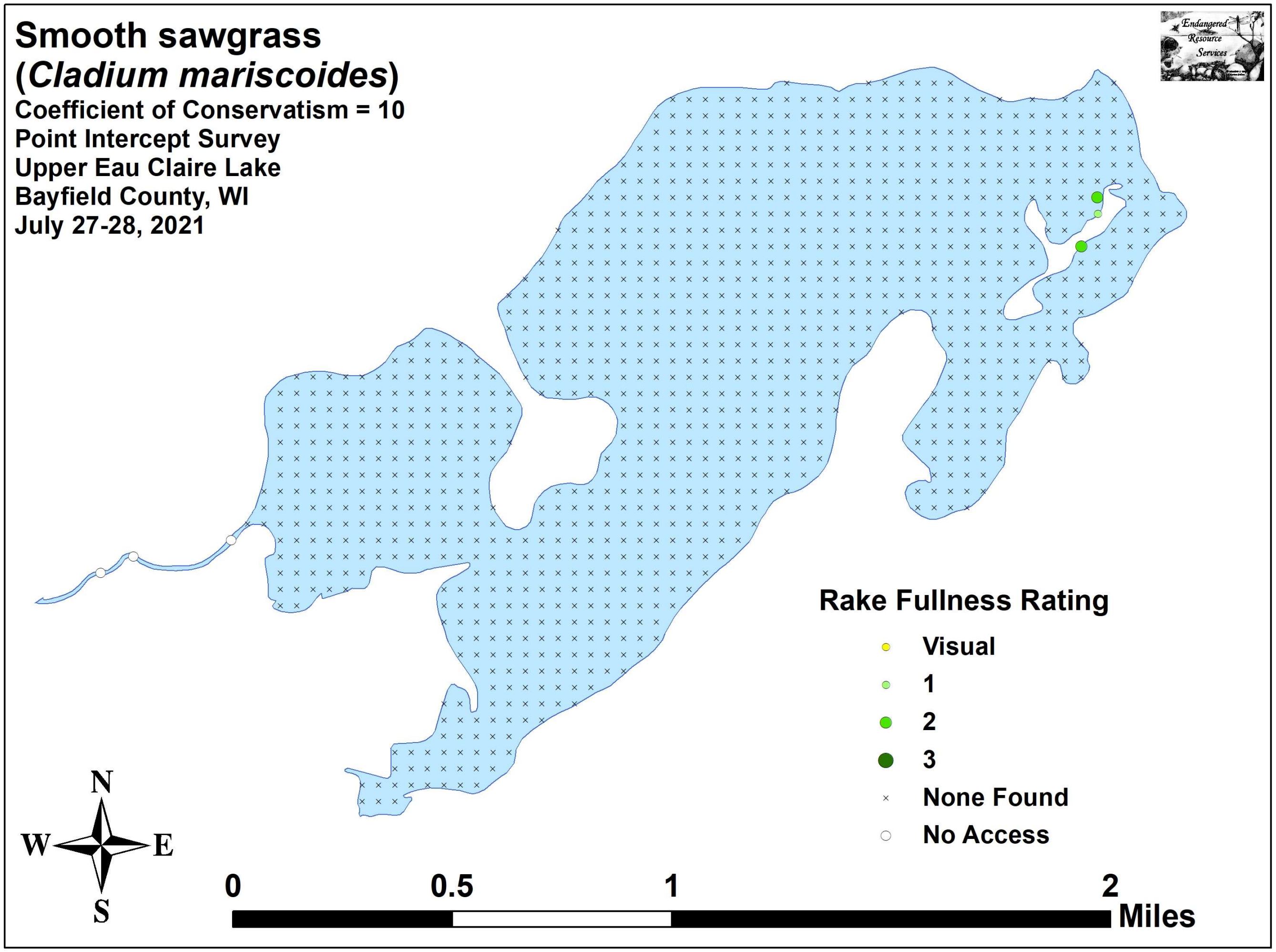


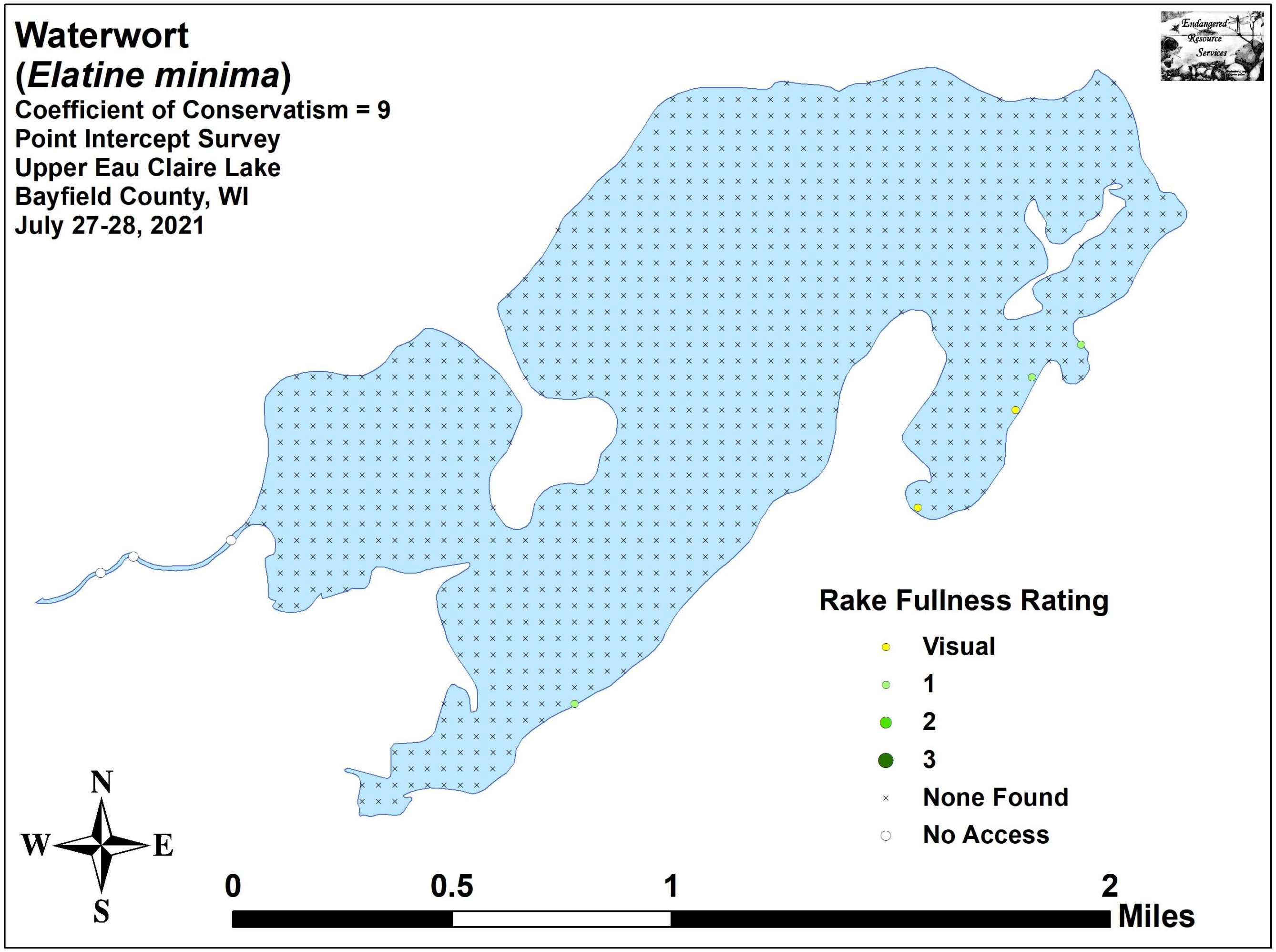
Watershield
(*Brasenia schreberi*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles


Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

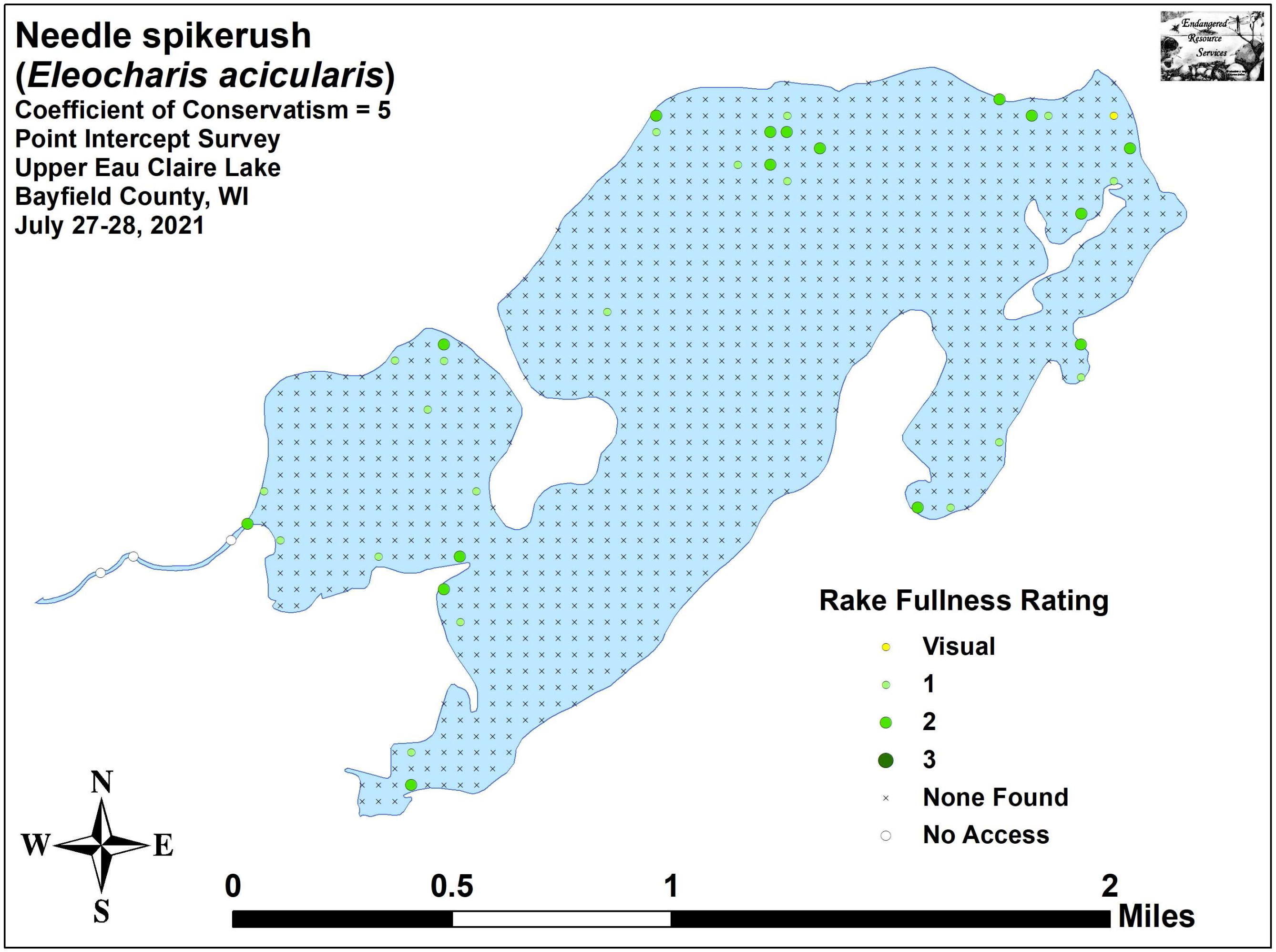


Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

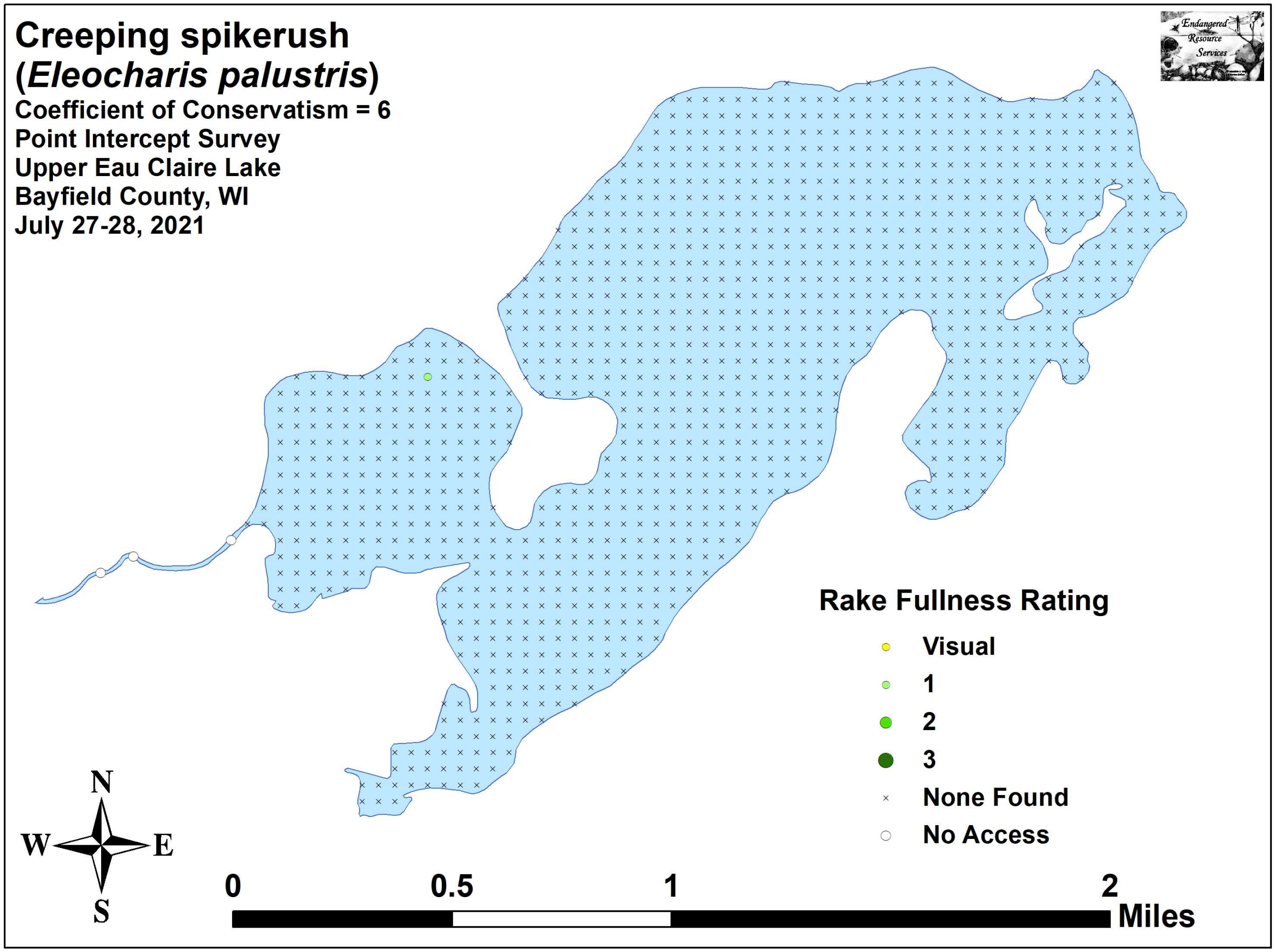

Smooth sawgrass
(*Cladium mariscoides*)
Coefficient of Conservatism = 10
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles



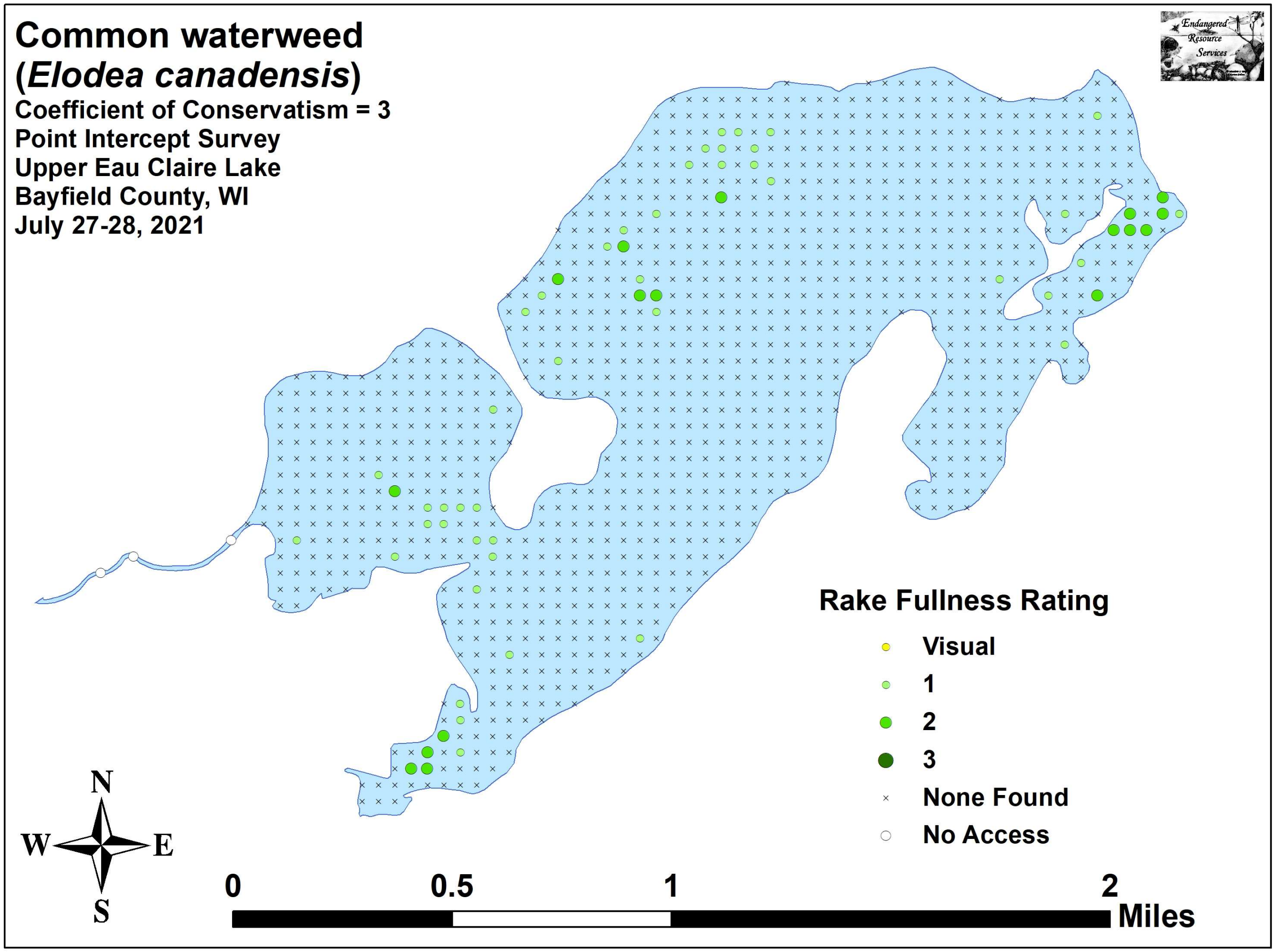
Waterwort
(*Elatine minima*)
Coefficient of Conservatism = 9
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles



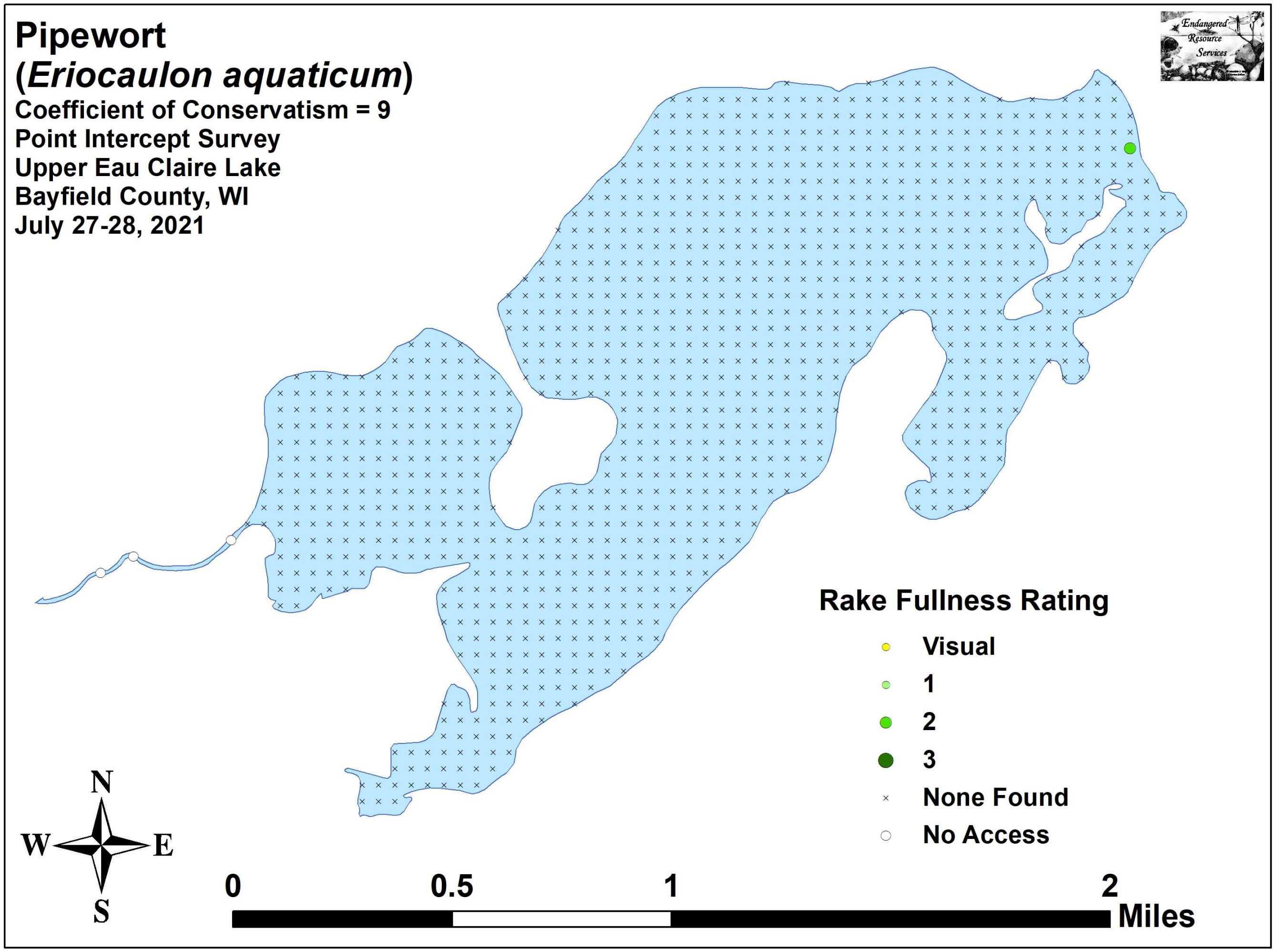
Needle spikerush
(*Eleocharis acicularis*)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

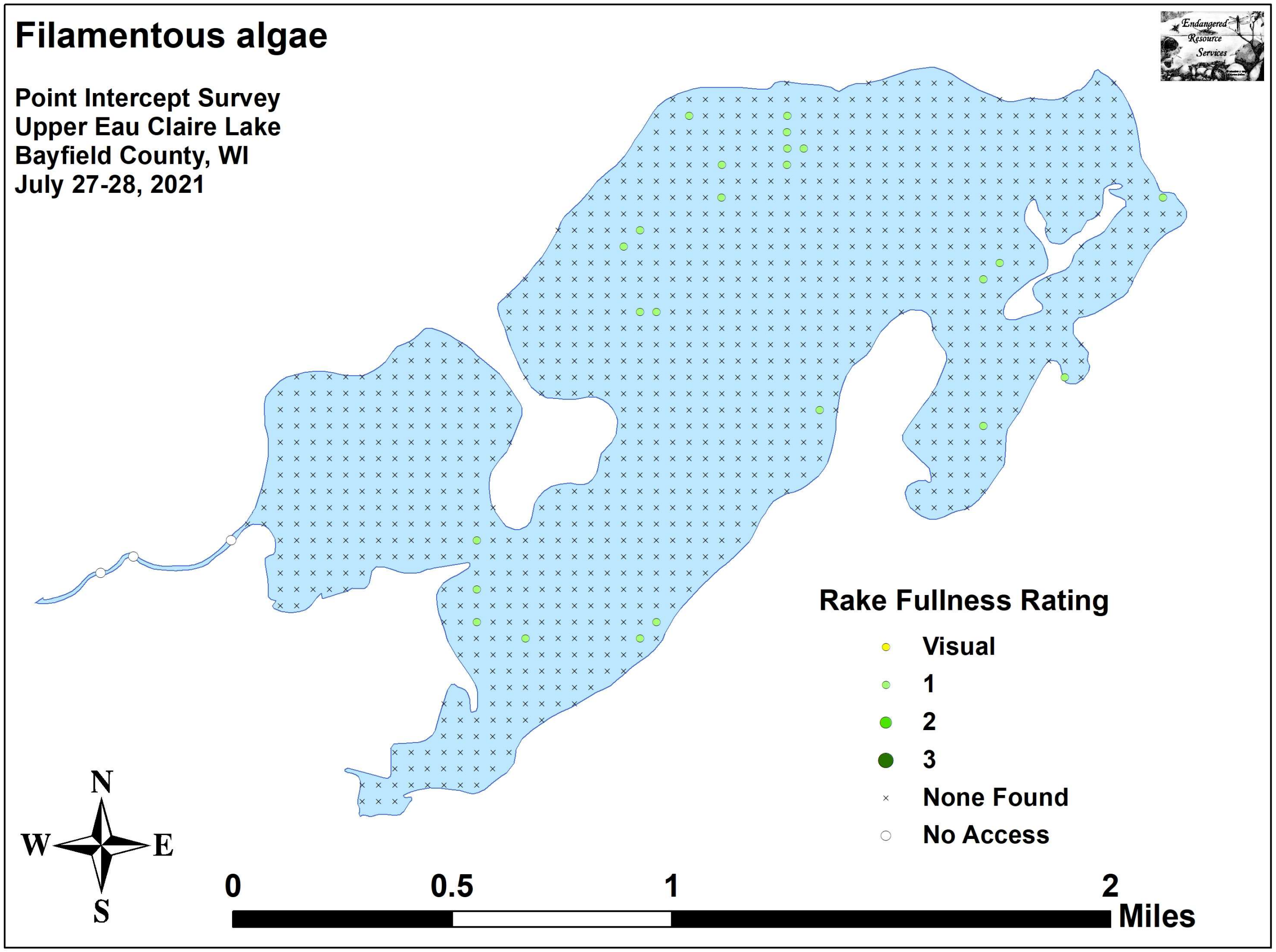


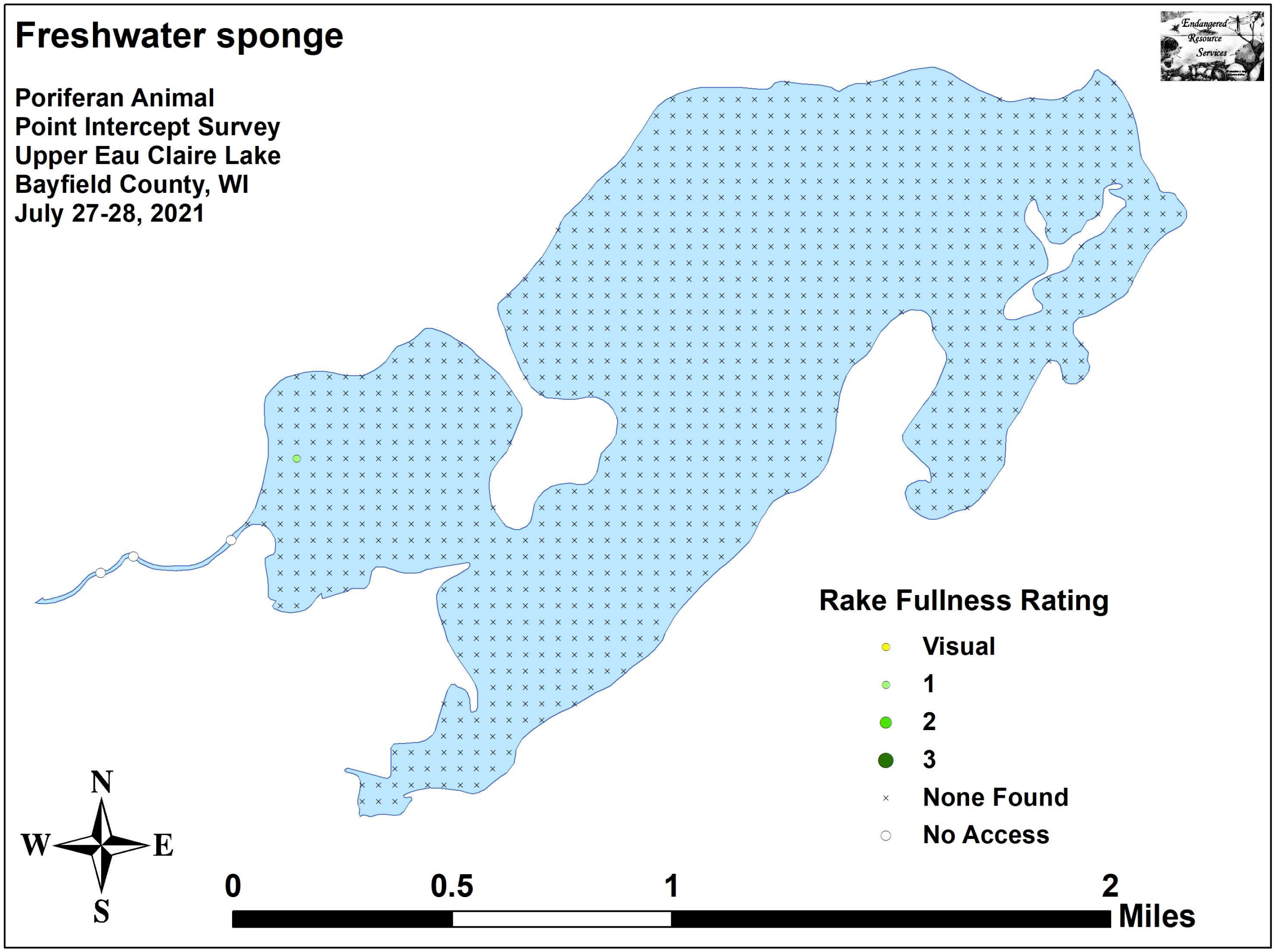
Creeping spikerush
(Eleocharis palustris)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

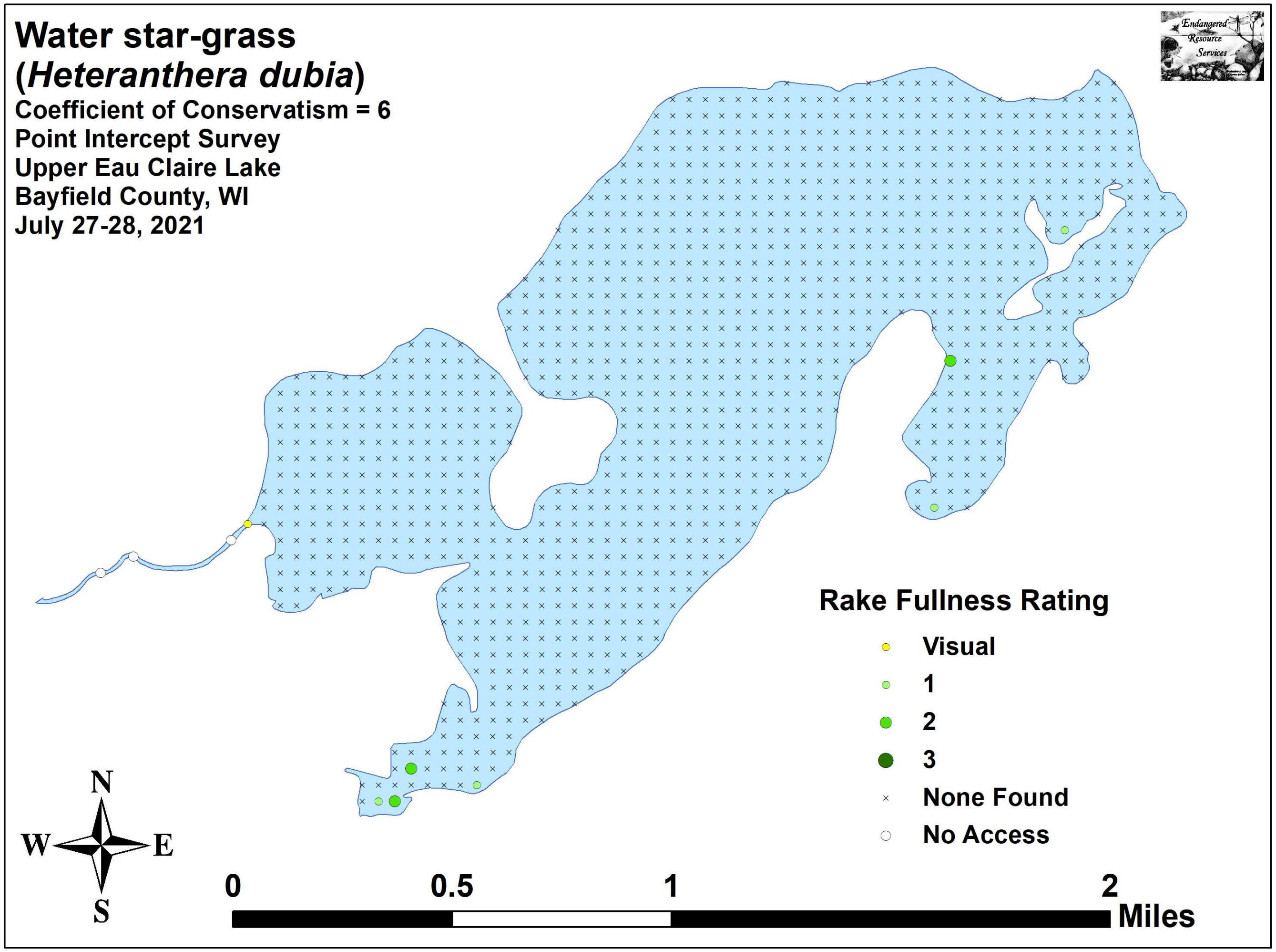


Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

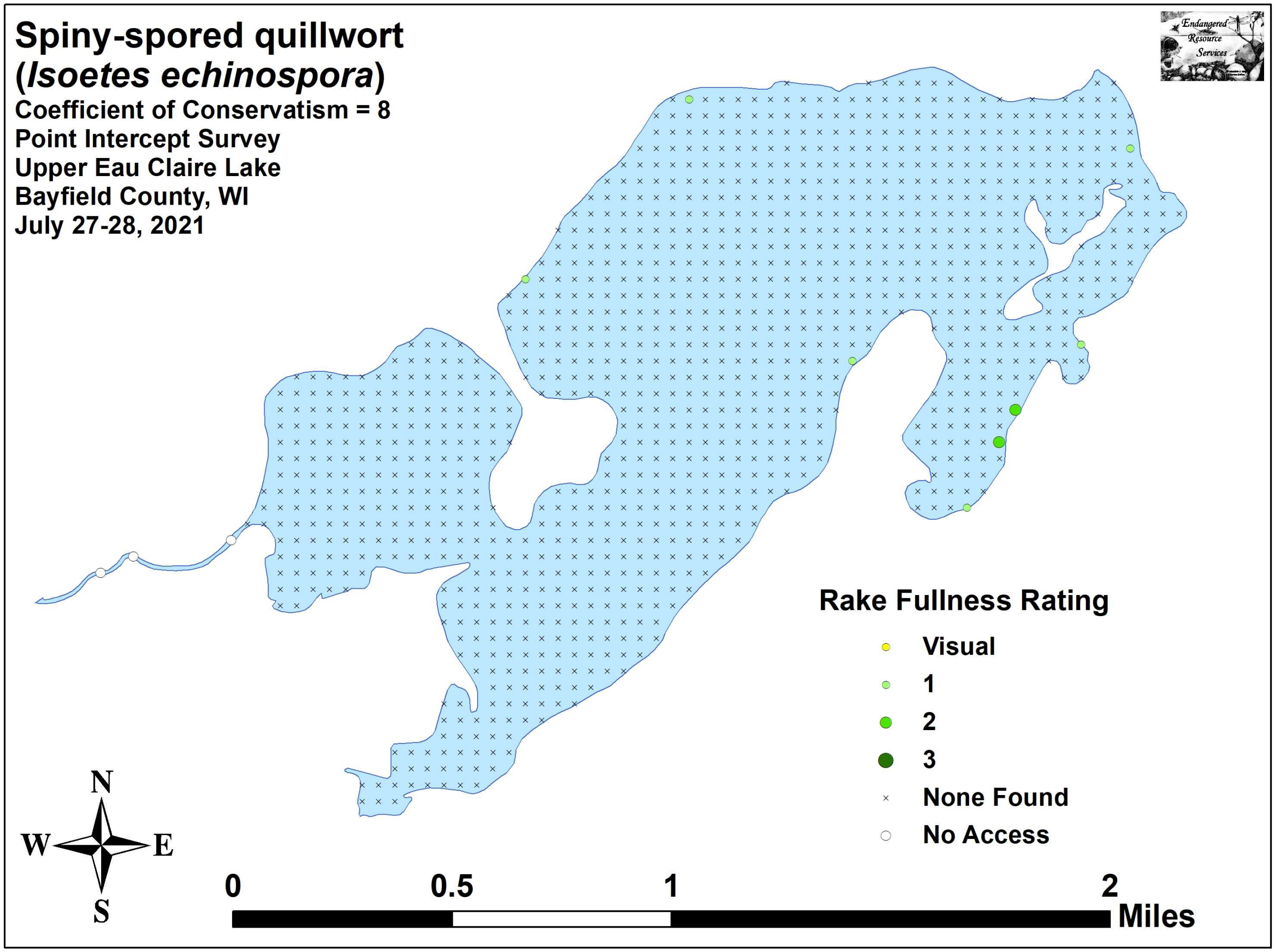

Pipewort
(Eriocaulon aquaticum)
Coefficient of Conservatism = 9
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

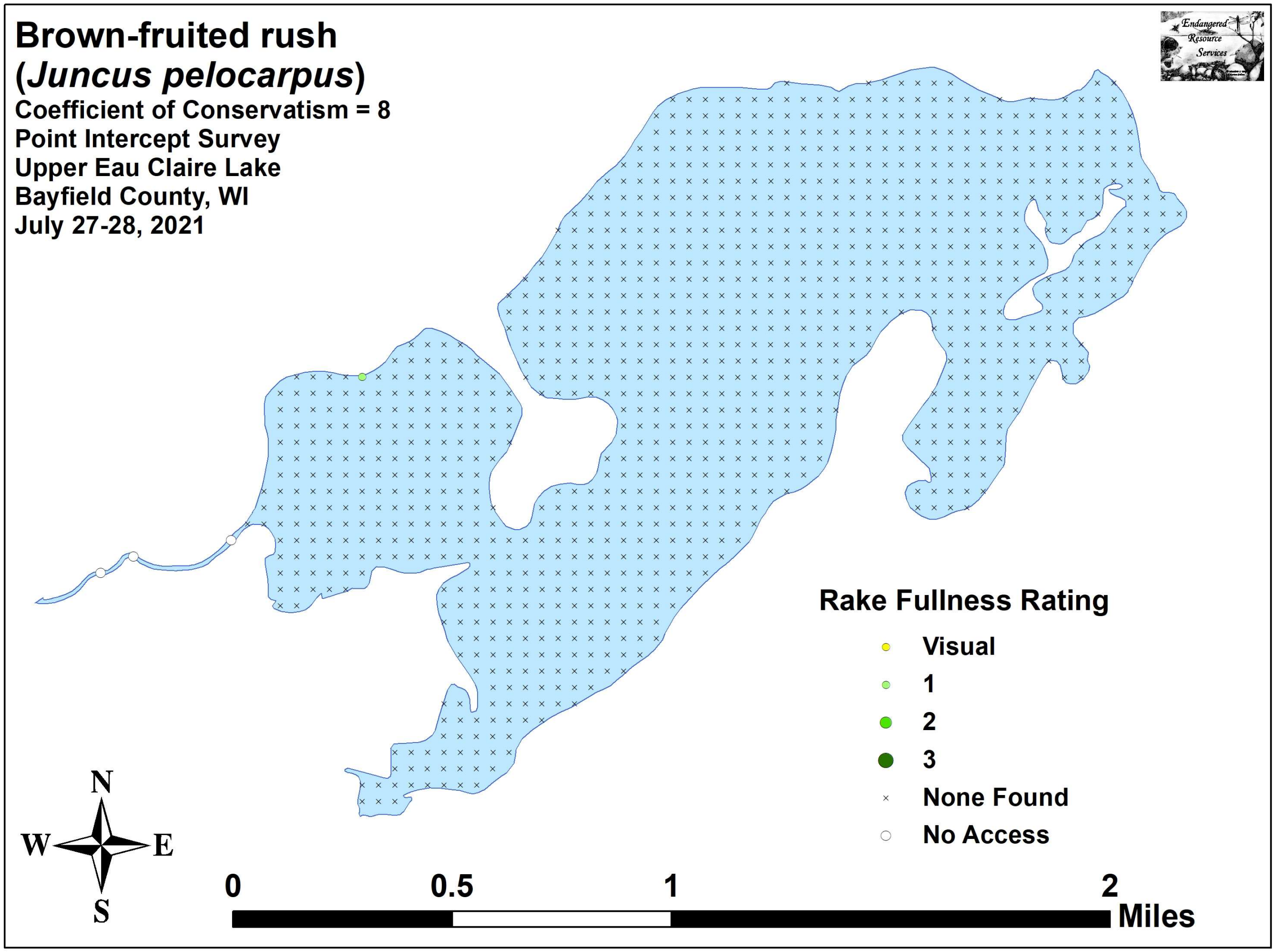

Filamentous algae
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

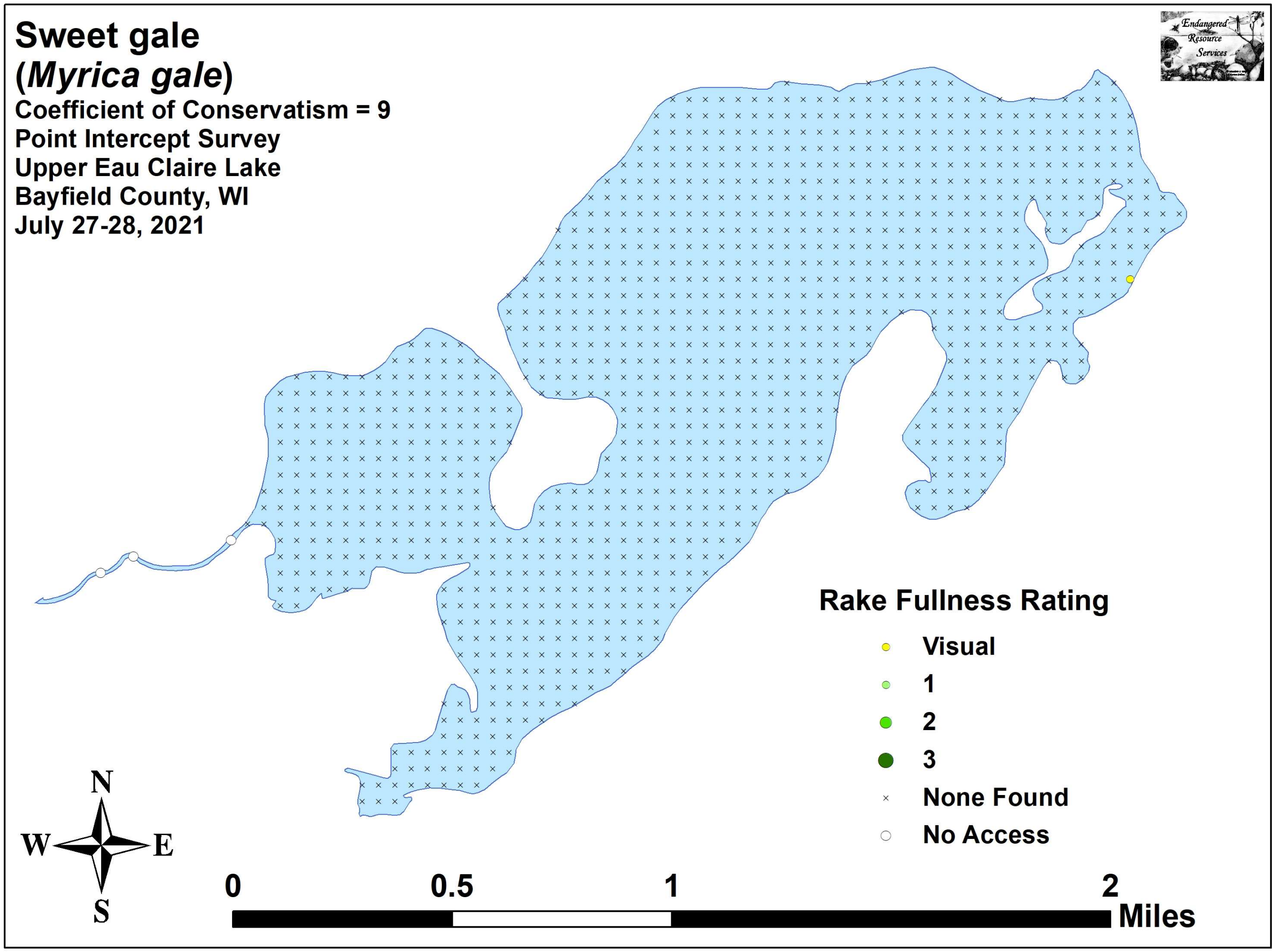

Freshwater sponge
Poriferan Animal
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

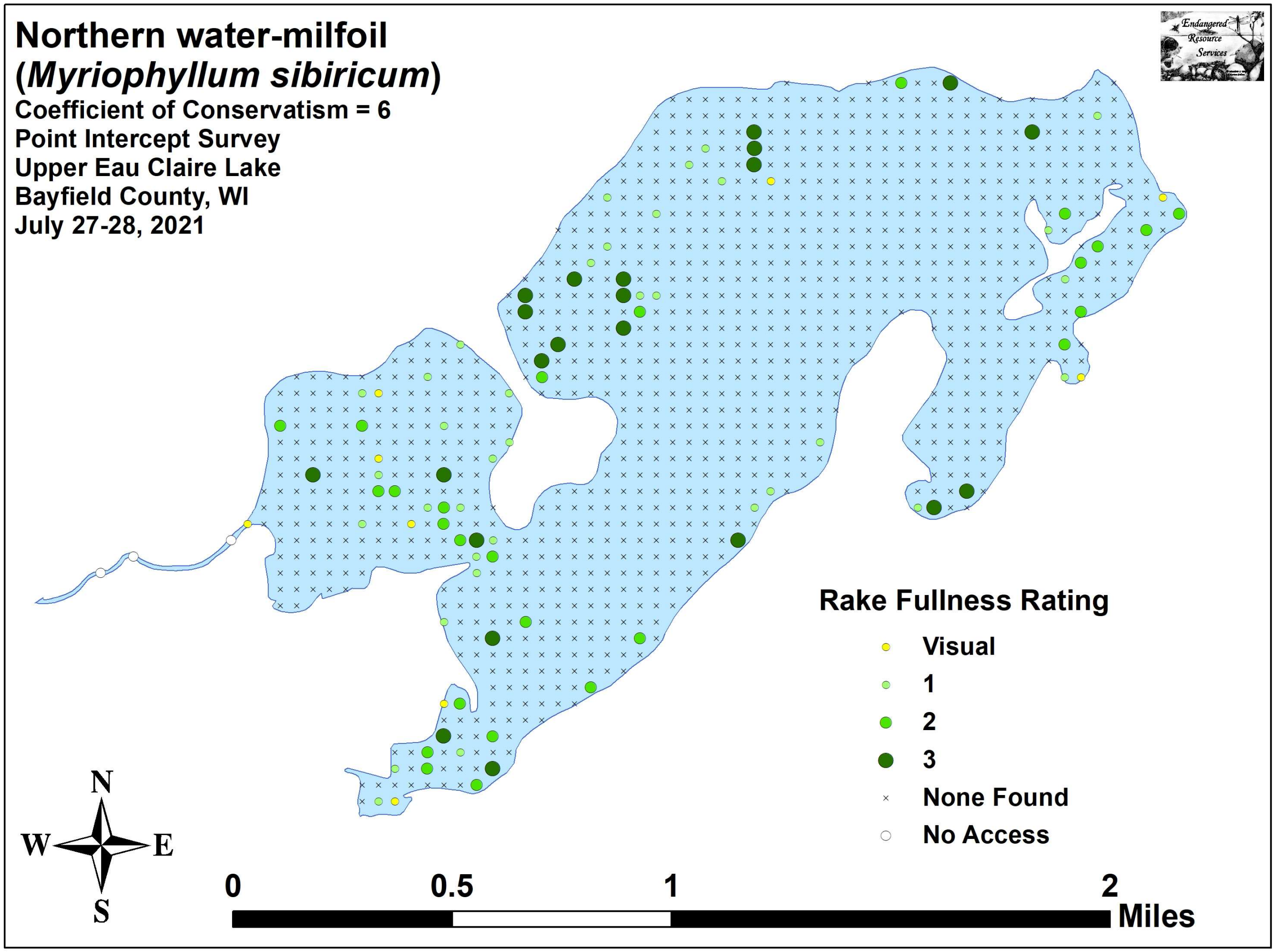


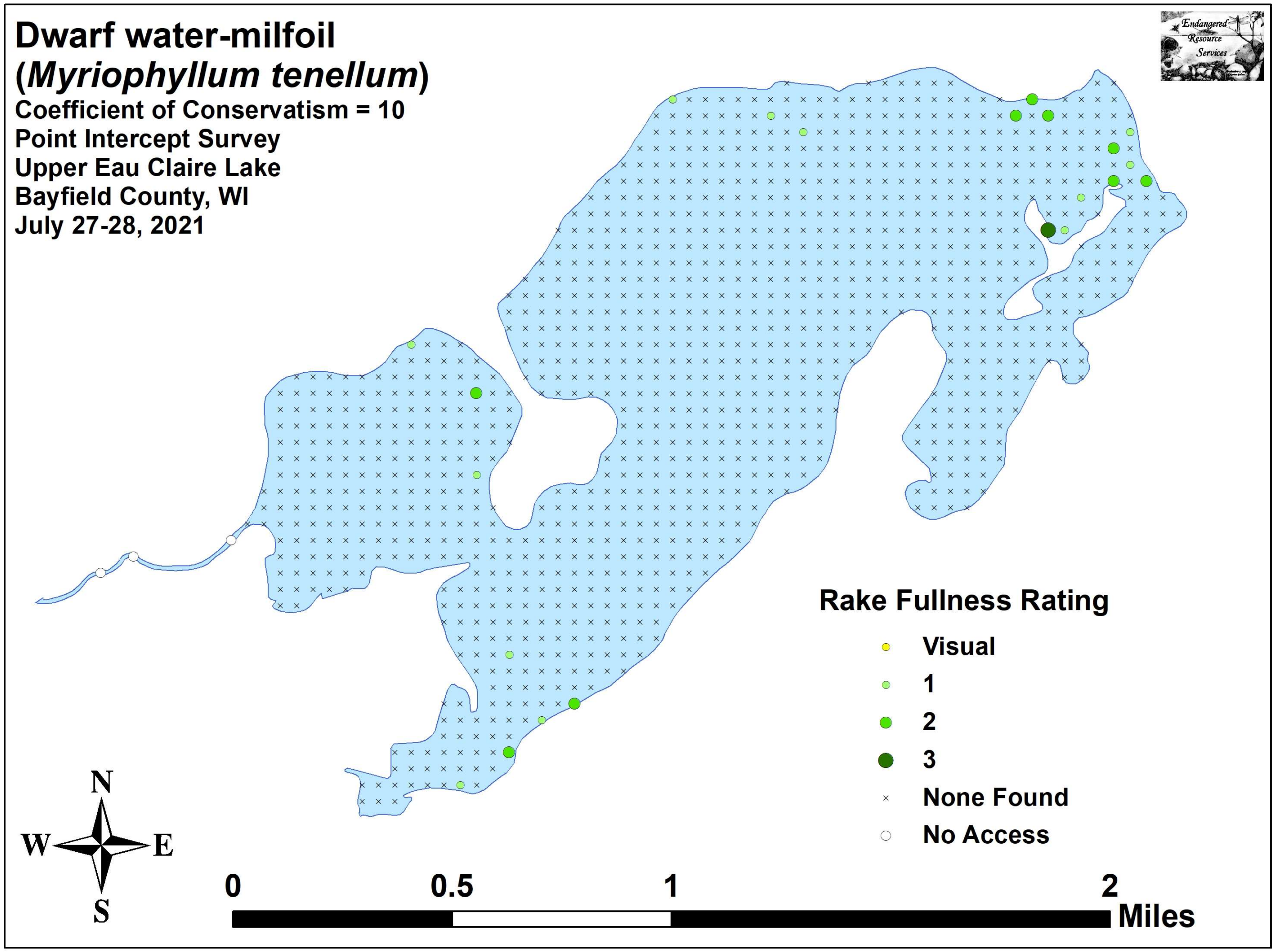
Water star-grass
(*Heteranthera dubia*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

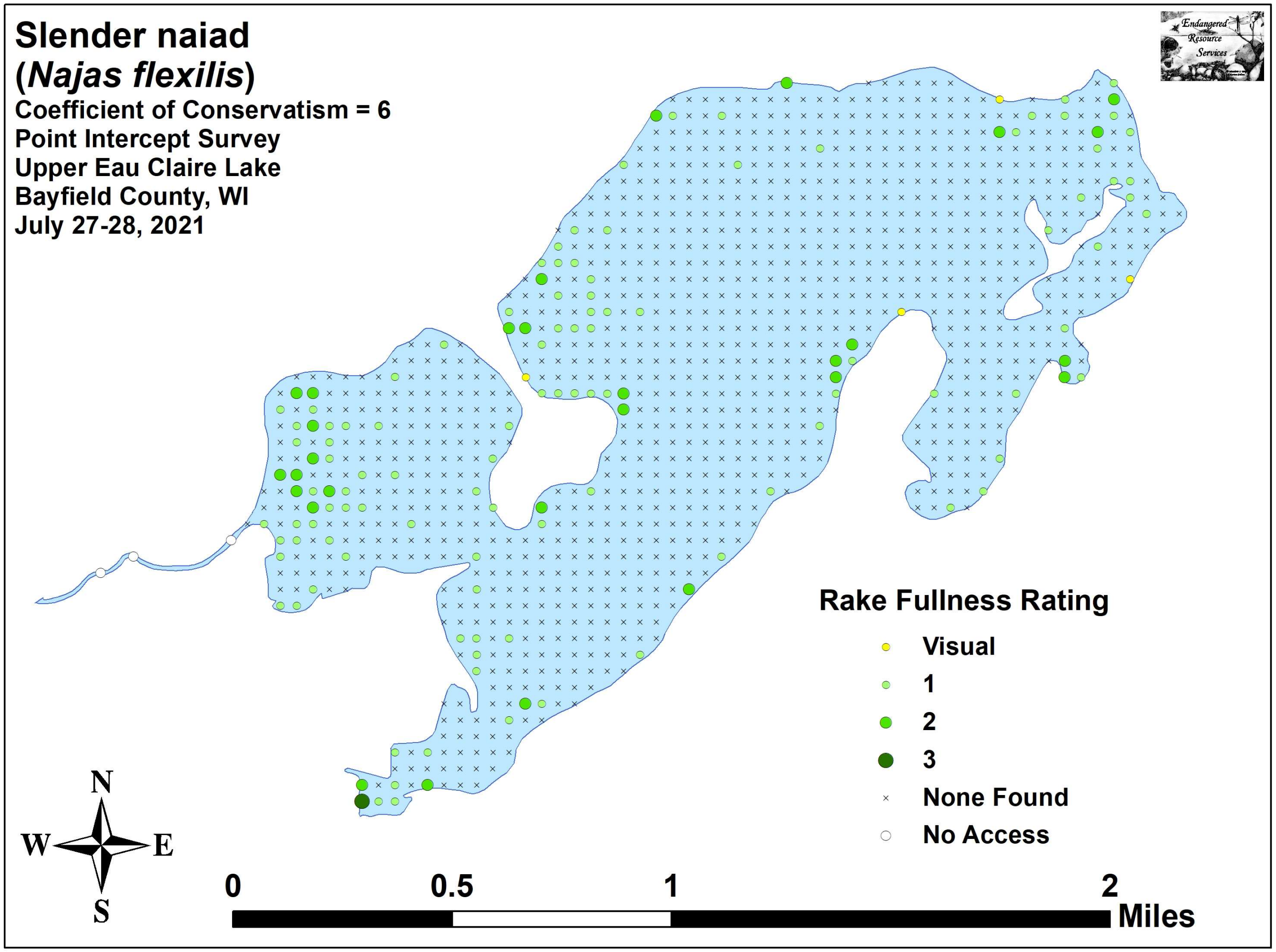

Spiny-spored quillwort
(*Isoetes echinospora*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles


Brown-fruited rush
(*Juncus pelocarpus*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

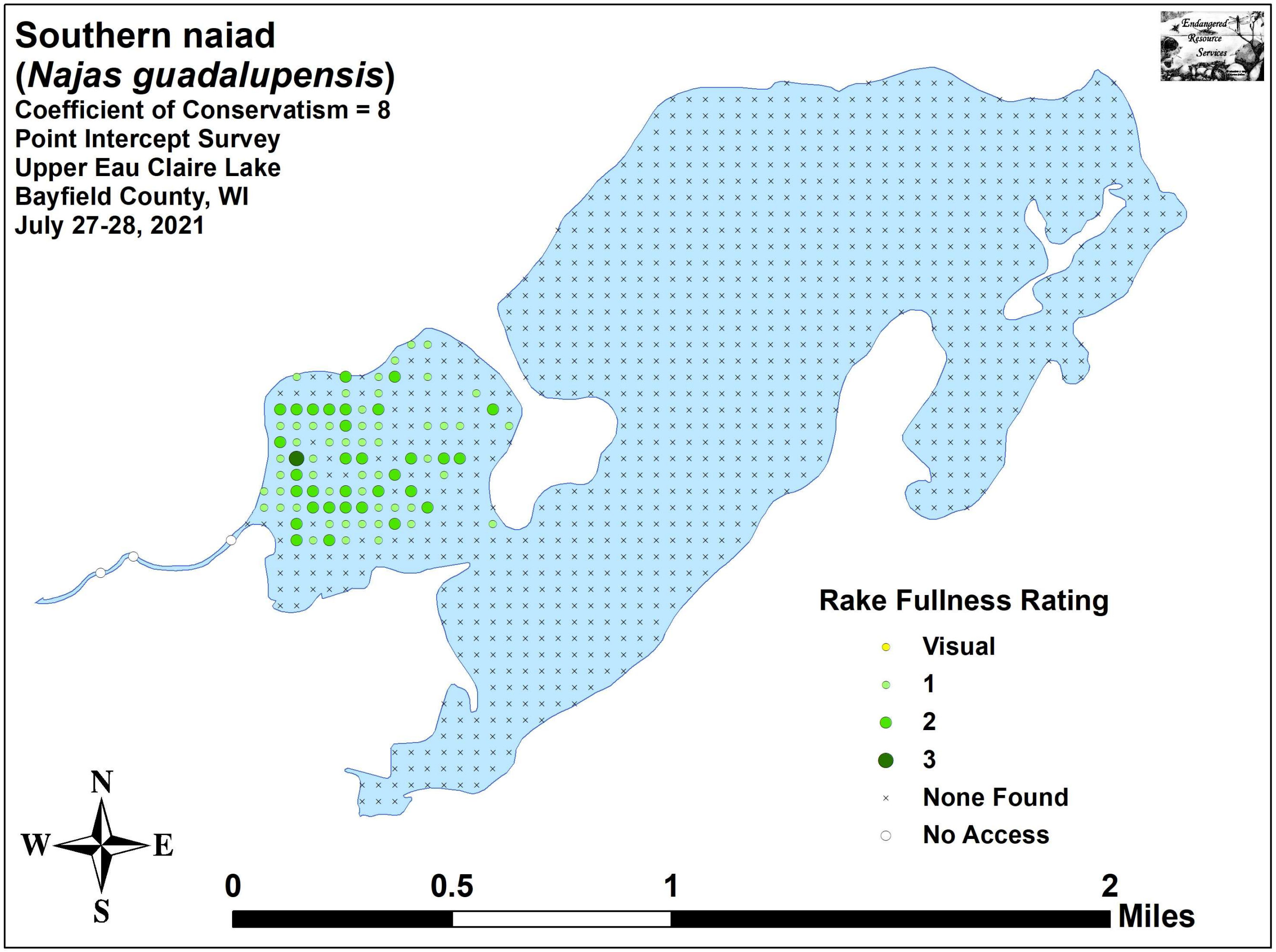

Sweet gale
(Myrica gale)
Coefficient of Conservatism = 9
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles

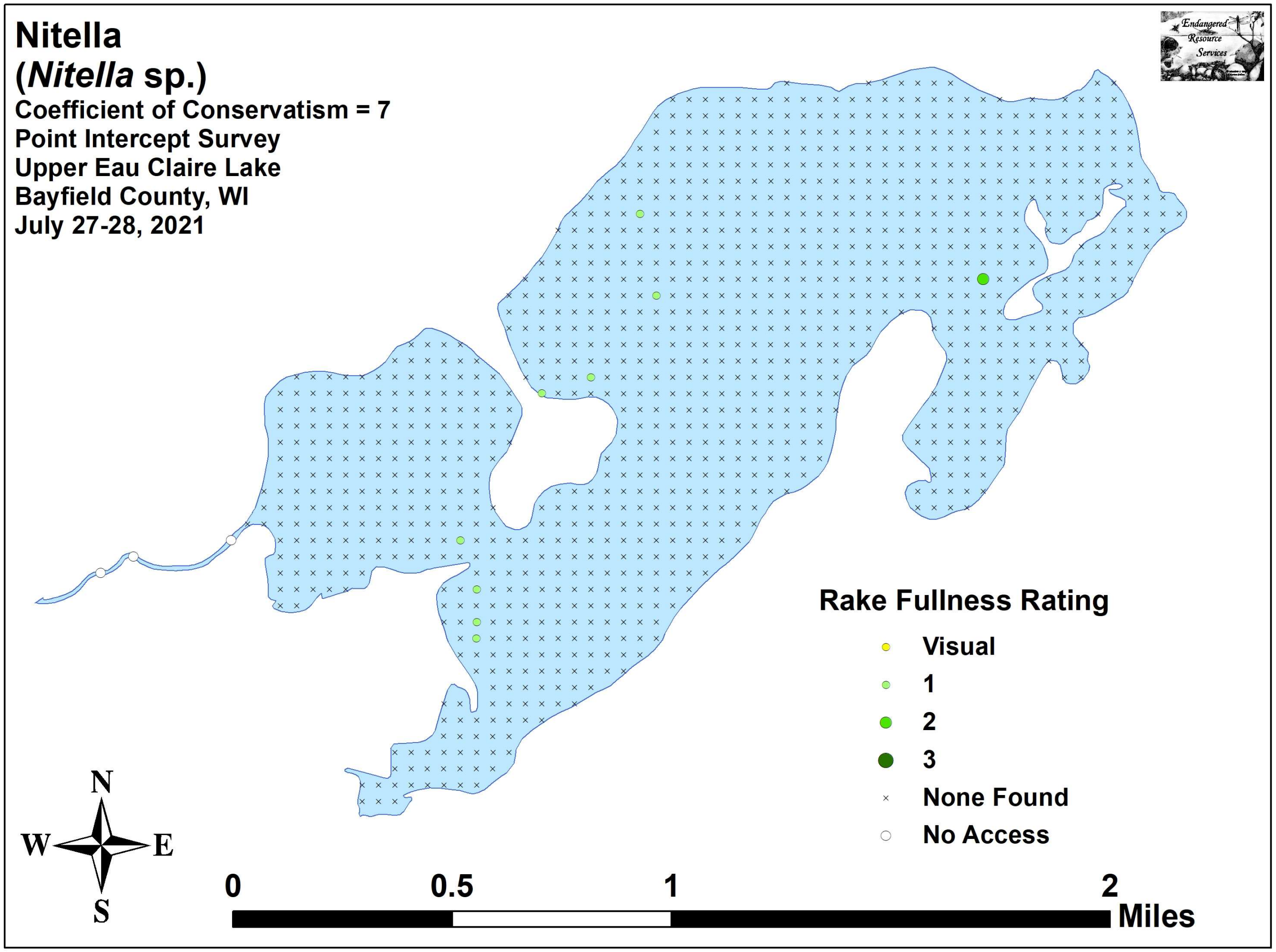

Northern water-milfoil
(*Myriophyllum sibiricum*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles


Dwarf water-milfoil
(*Myriophyllum tenellum*)
Coefficient of Conservatism = 10
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles



Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles


Southern naiad
(Najas guadalupensis)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
No Access
N
W
E
S
0
0.5
1
2
Miles


Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
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No Access
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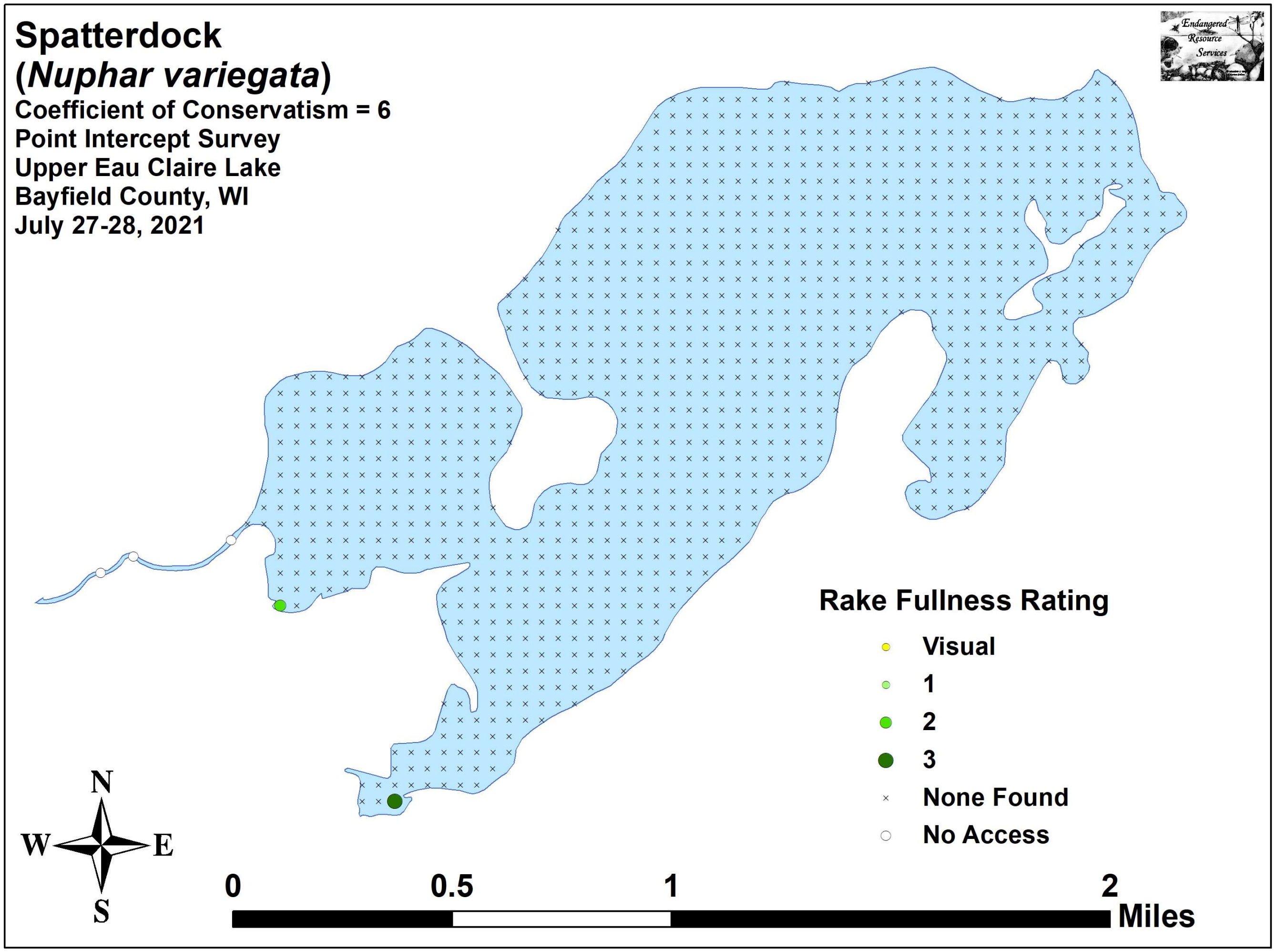

Spatterdock
(*Nuphar variegata*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
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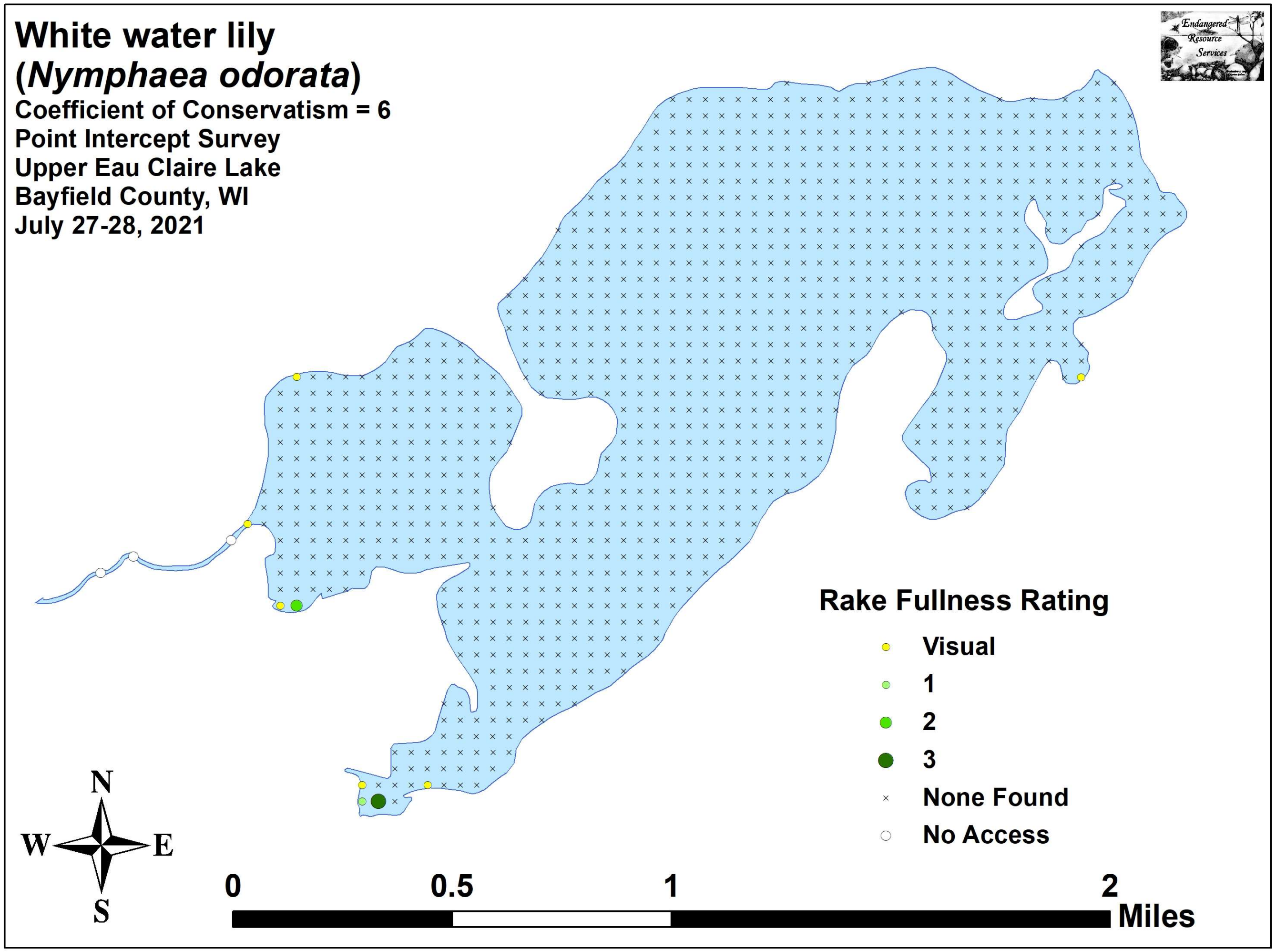
White water lily
(*Nymphaea odorata*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
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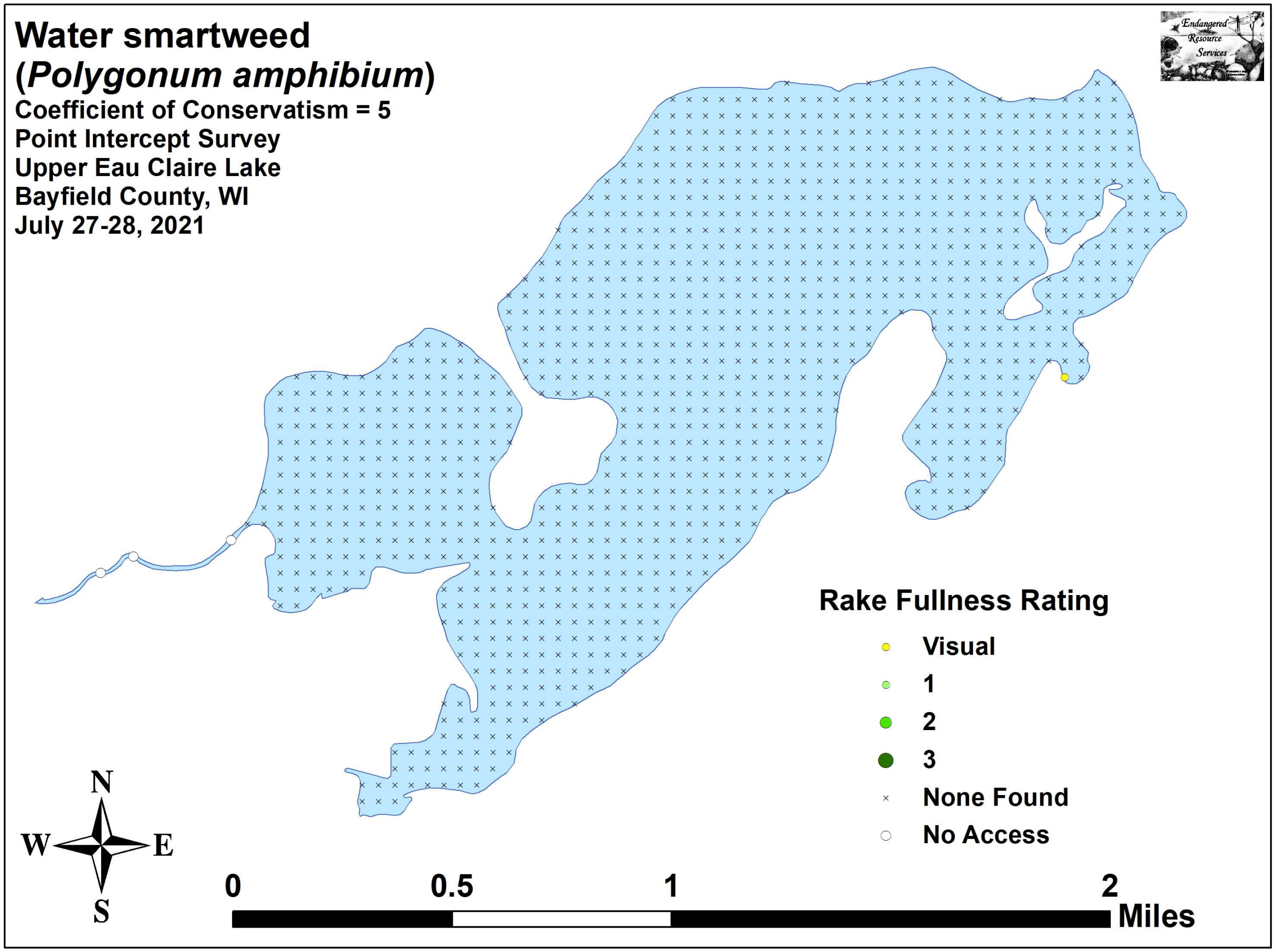
Water smartweed
(*Polygonum amphibium*)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
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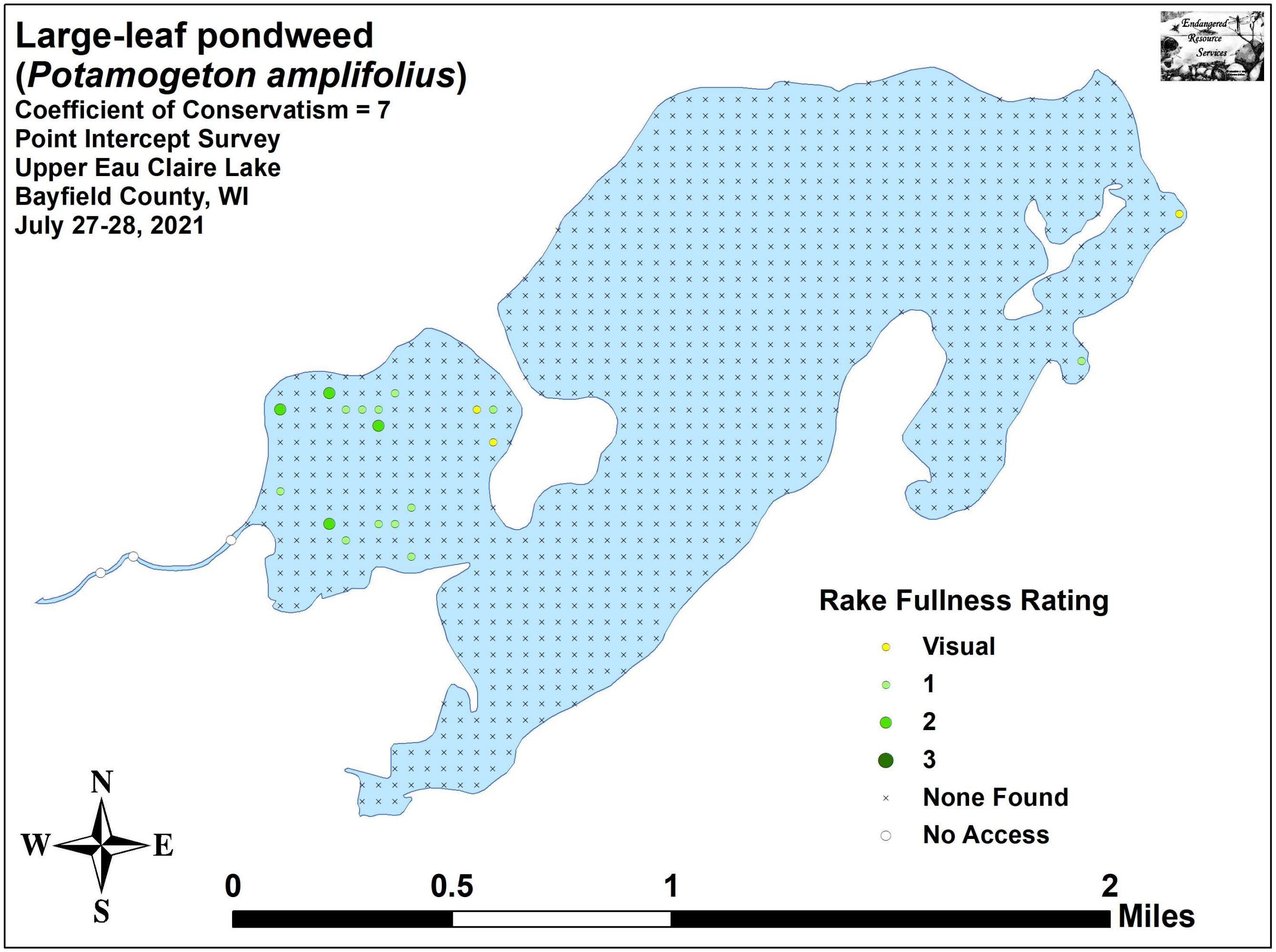
Large-leaf pondweed
(Potamogeton amplifolius)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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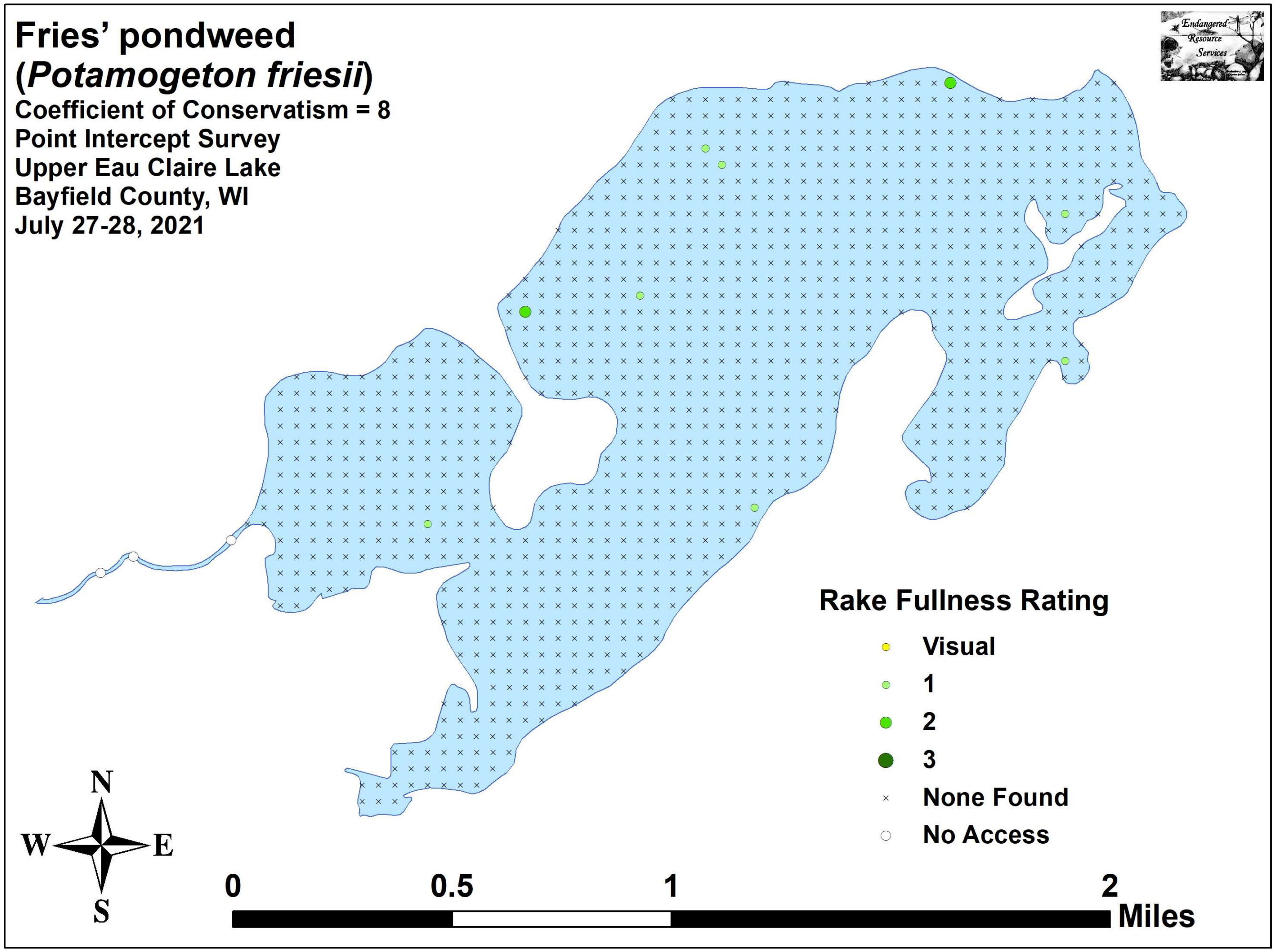
Fries' pondweed
(Potamogeton friesii)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
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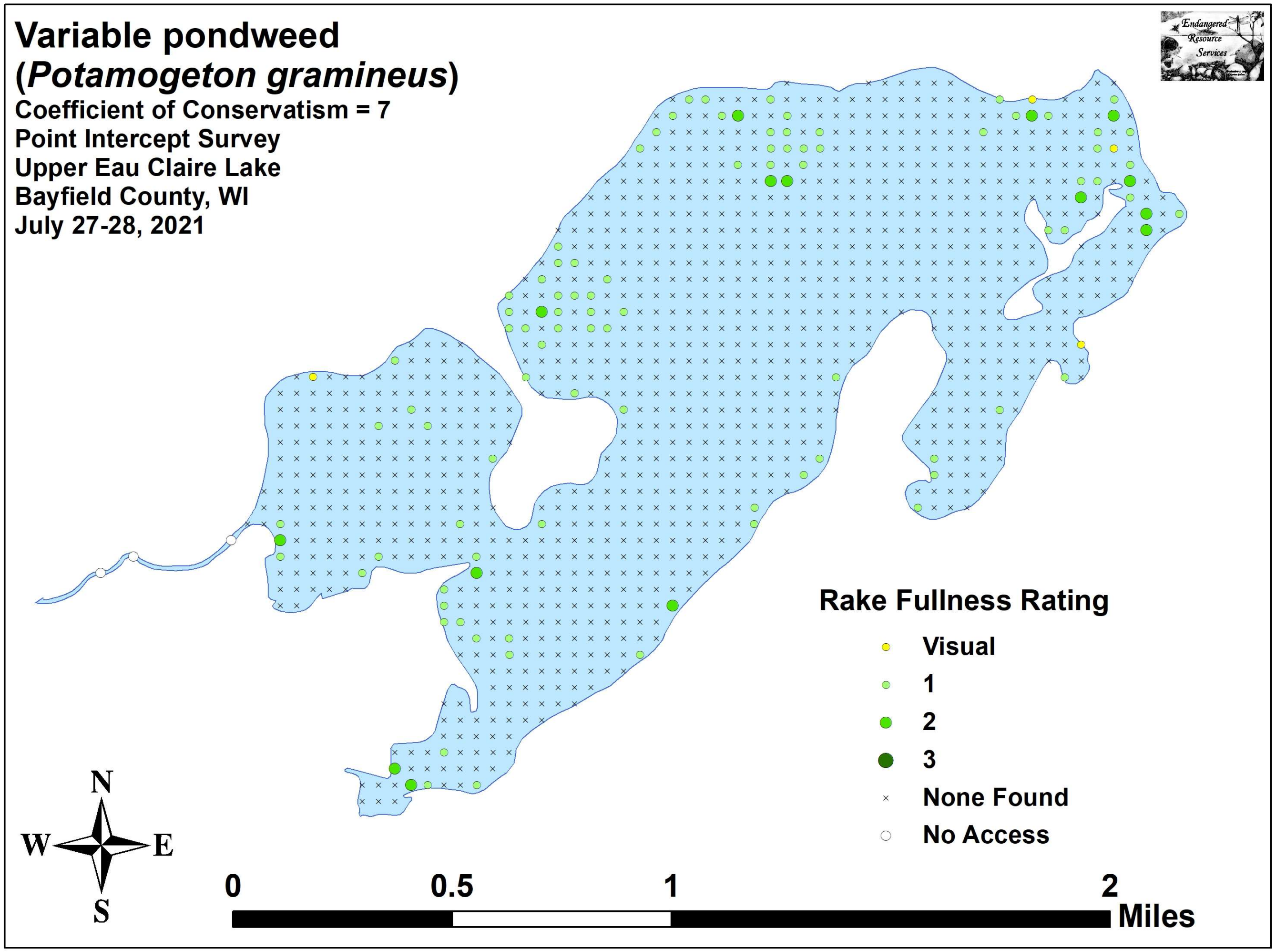
Variable pondweed
(Potamogeton gramineus)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
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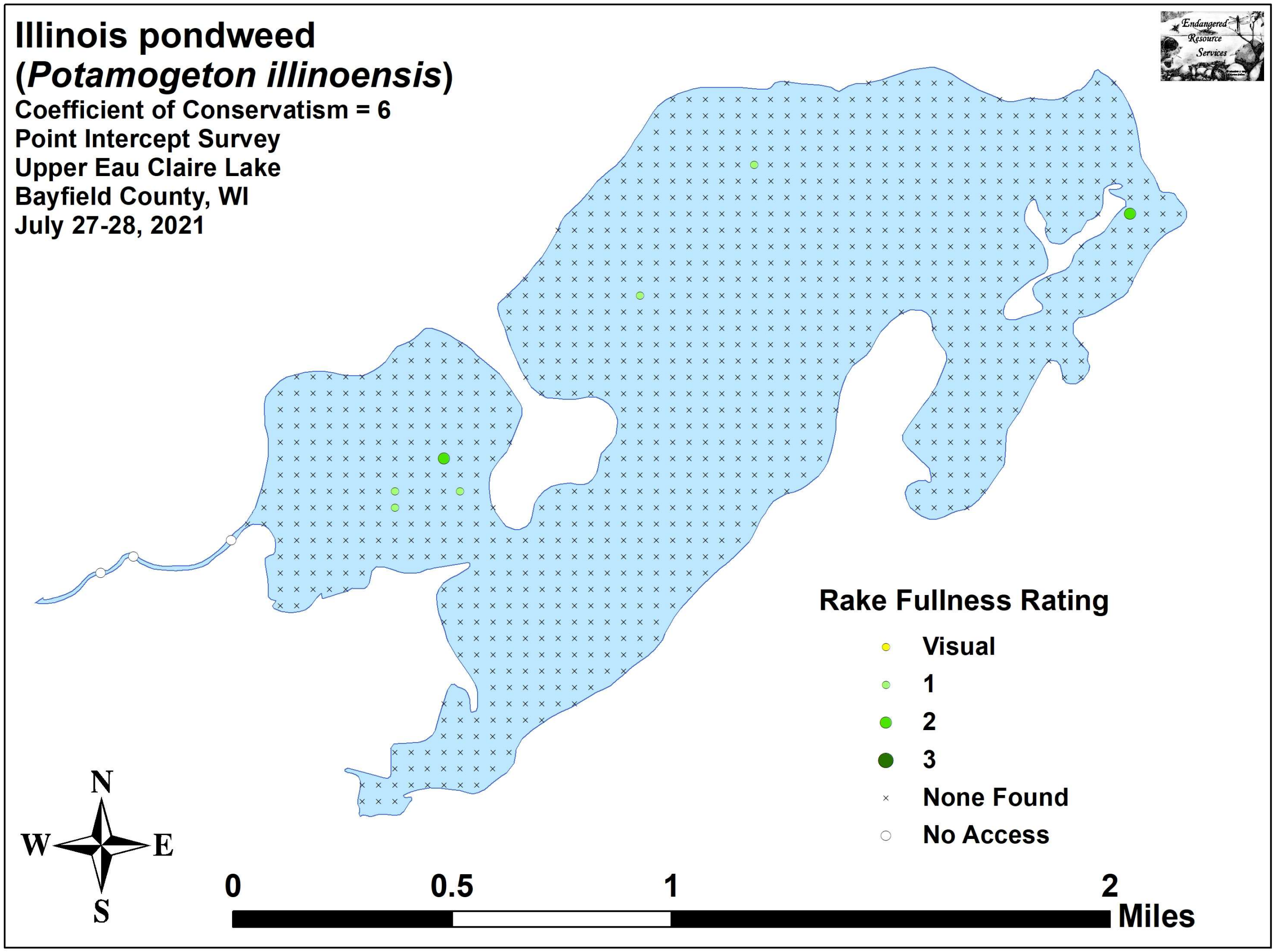
Illinois pondweed
(*Potamogeton illinoensis*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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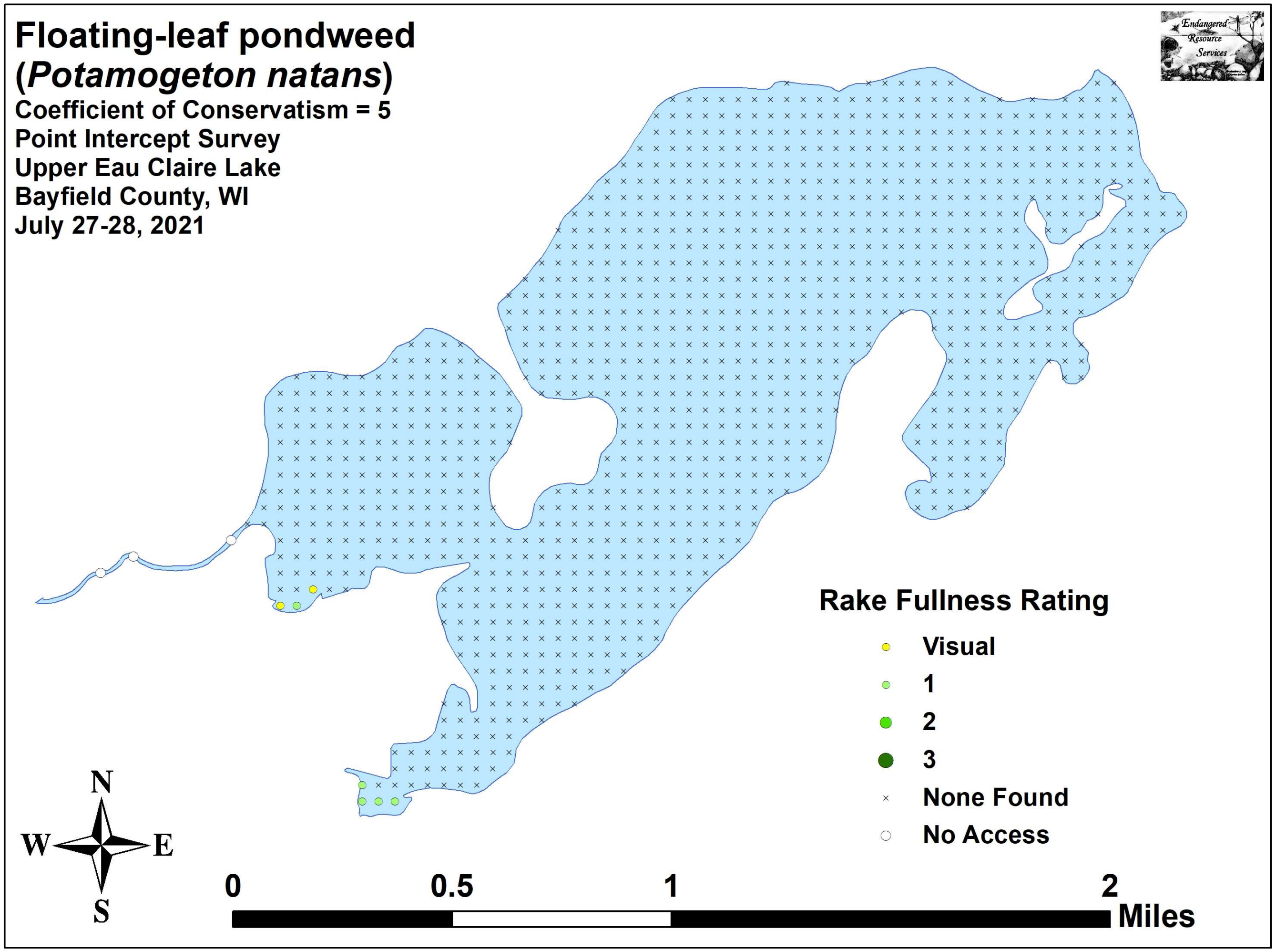

Floating-leaf pondweed
(Potamogeton natans)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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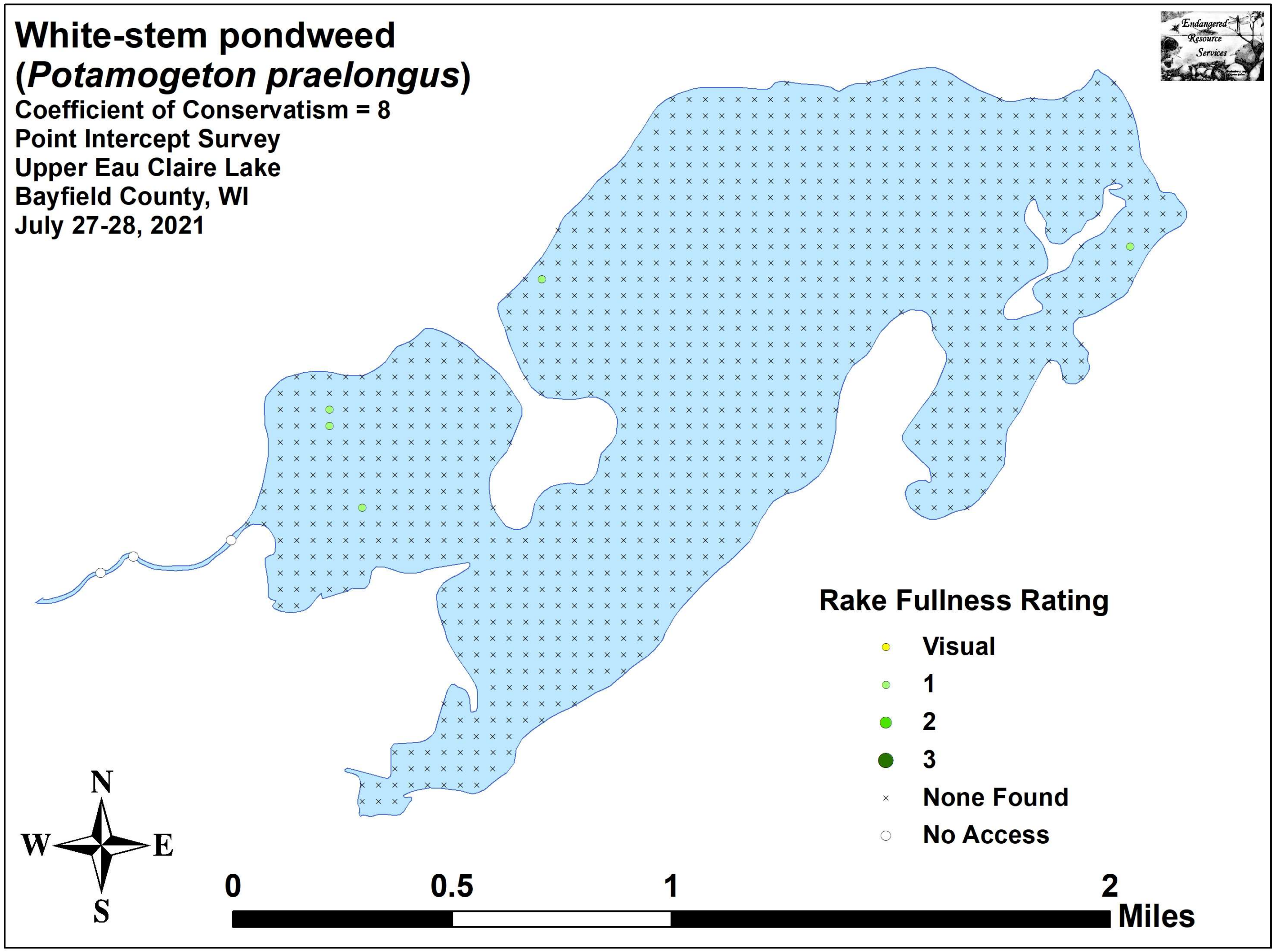
White-stem pondweed
(*Potamogeton praelongus*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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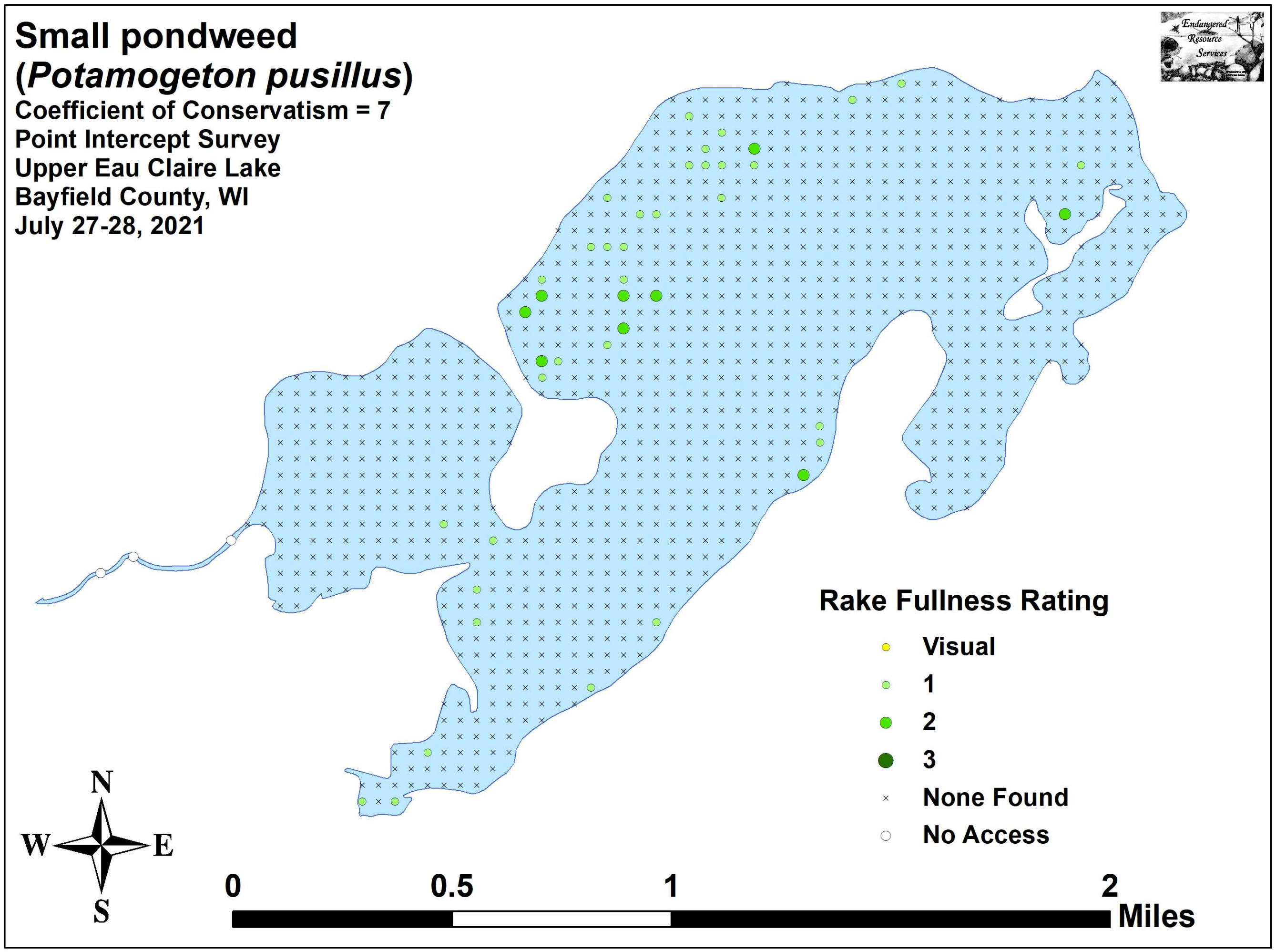
Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
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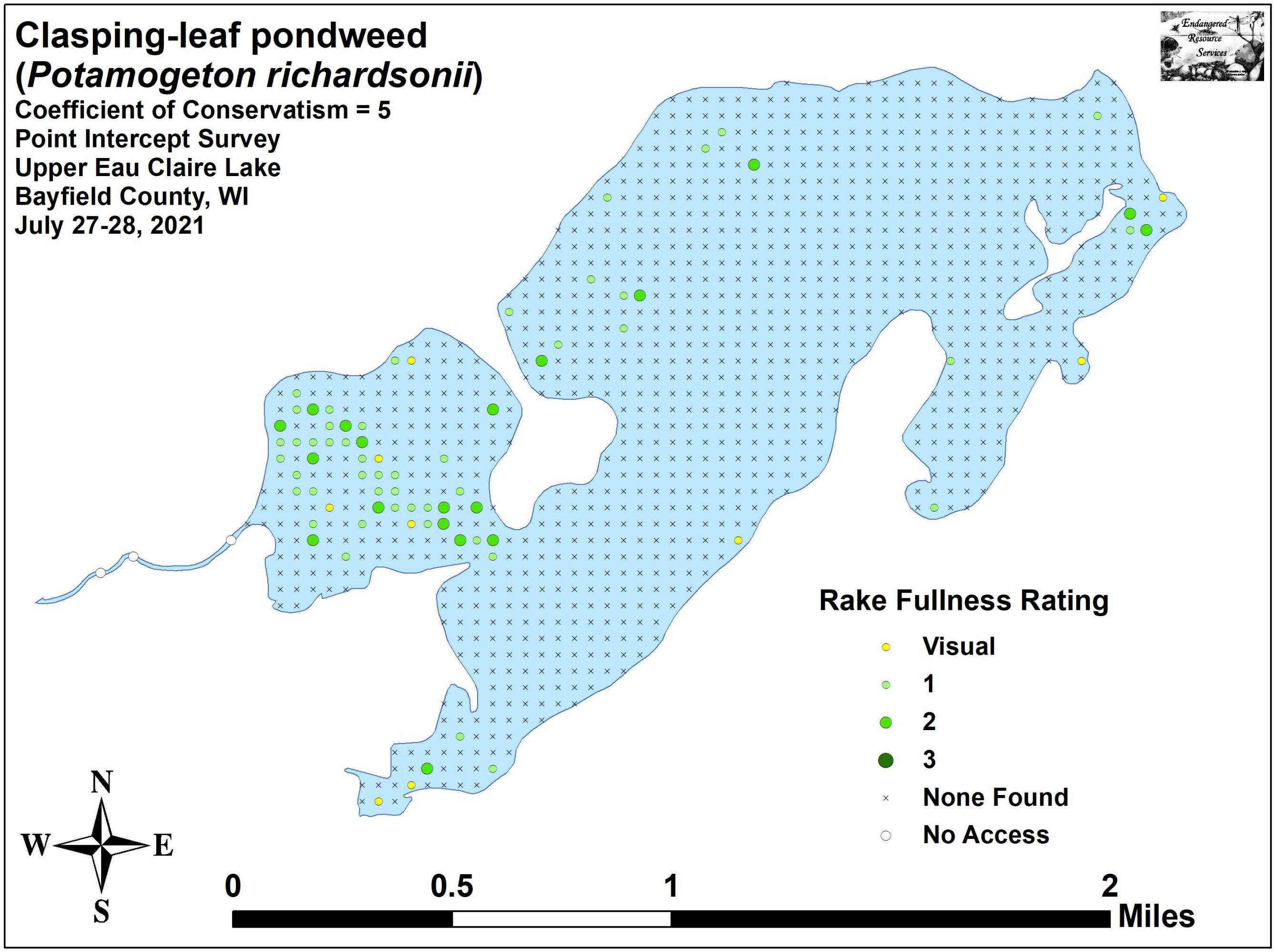
Clasping-leaf pondweed
(Potamogeton richardsonii)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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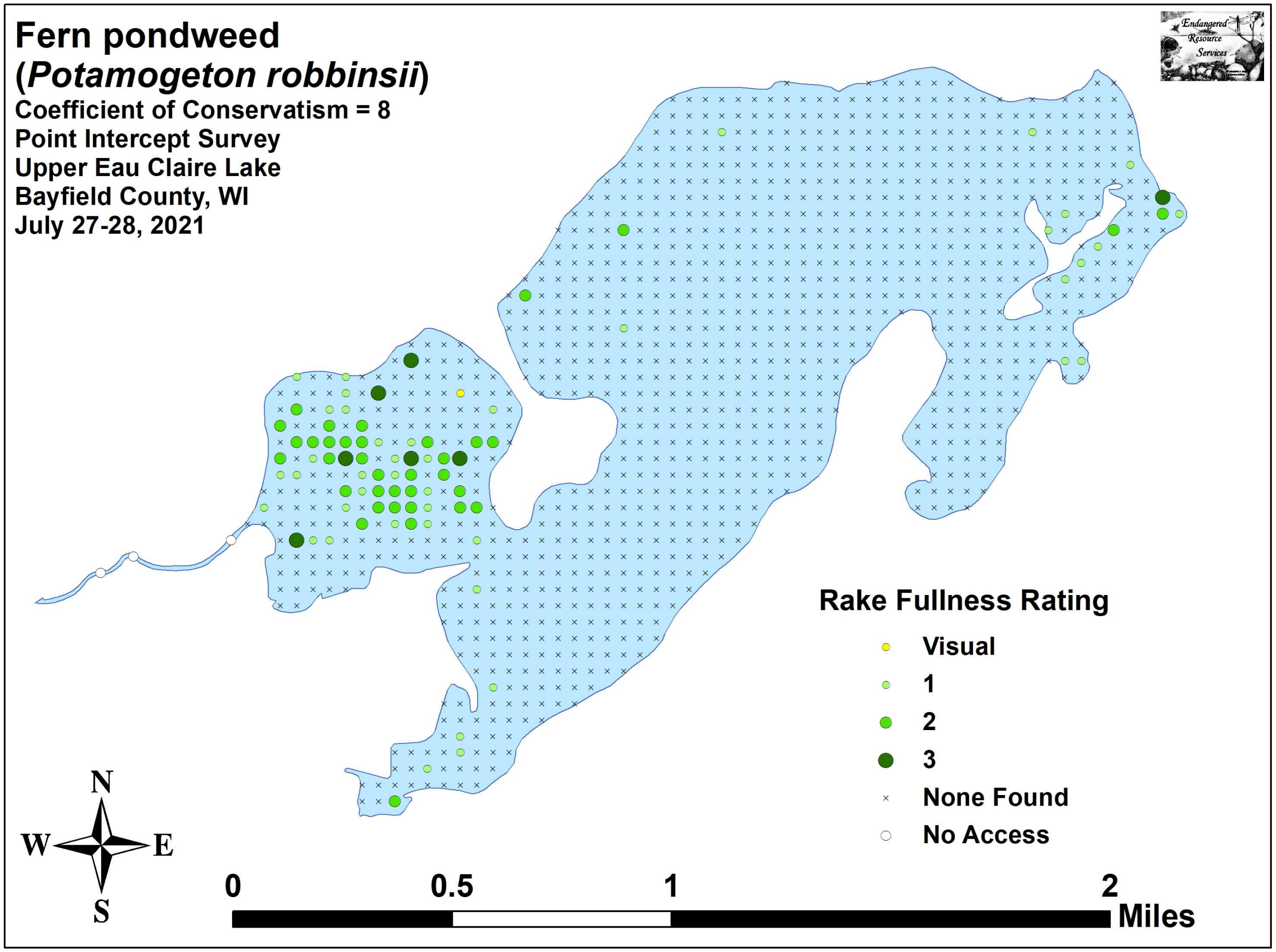
Fern pondweed
(Potamogeton robbinsii)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
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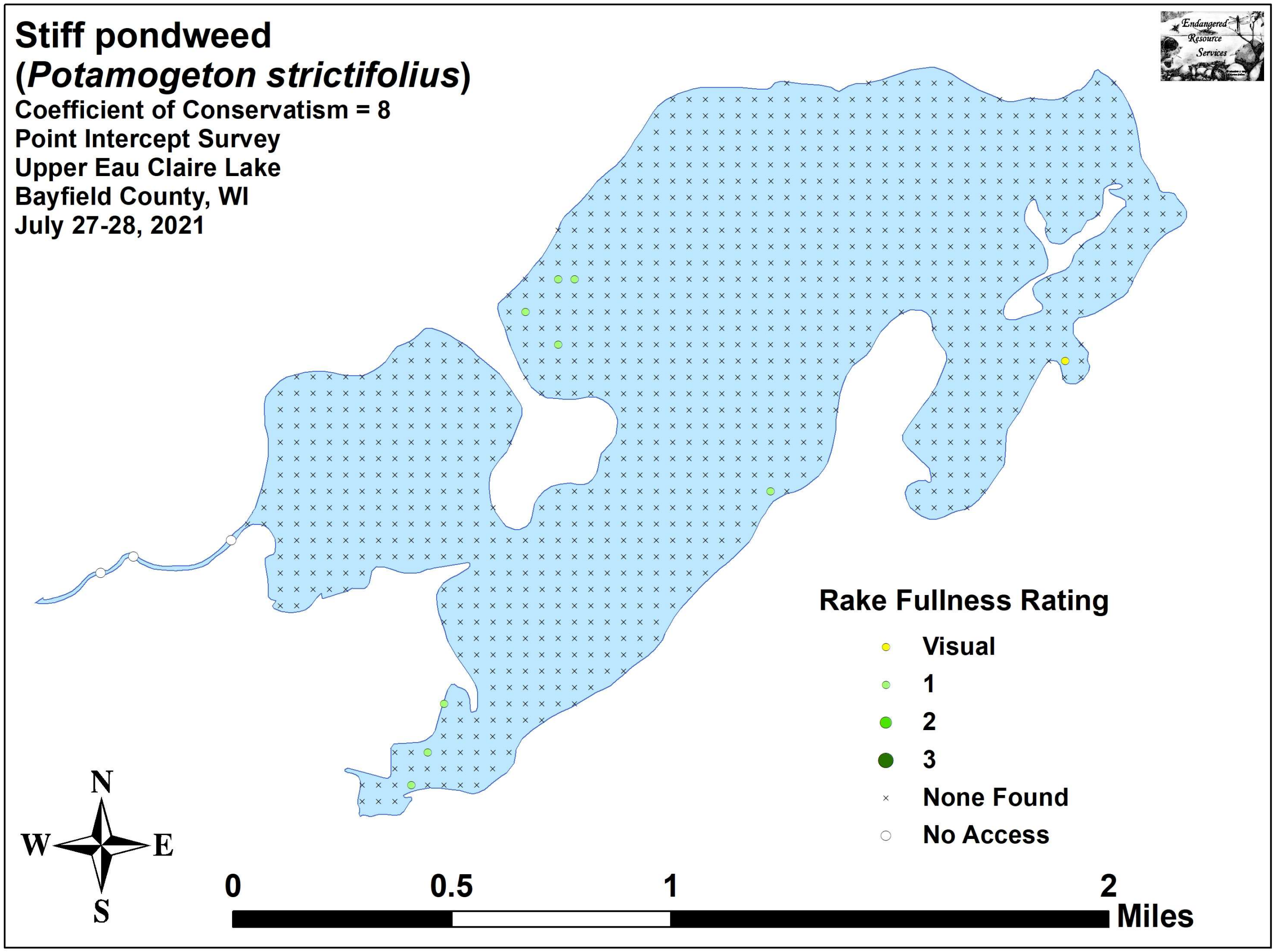
Stiff pondweed
(Potamogeton strictifolius)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
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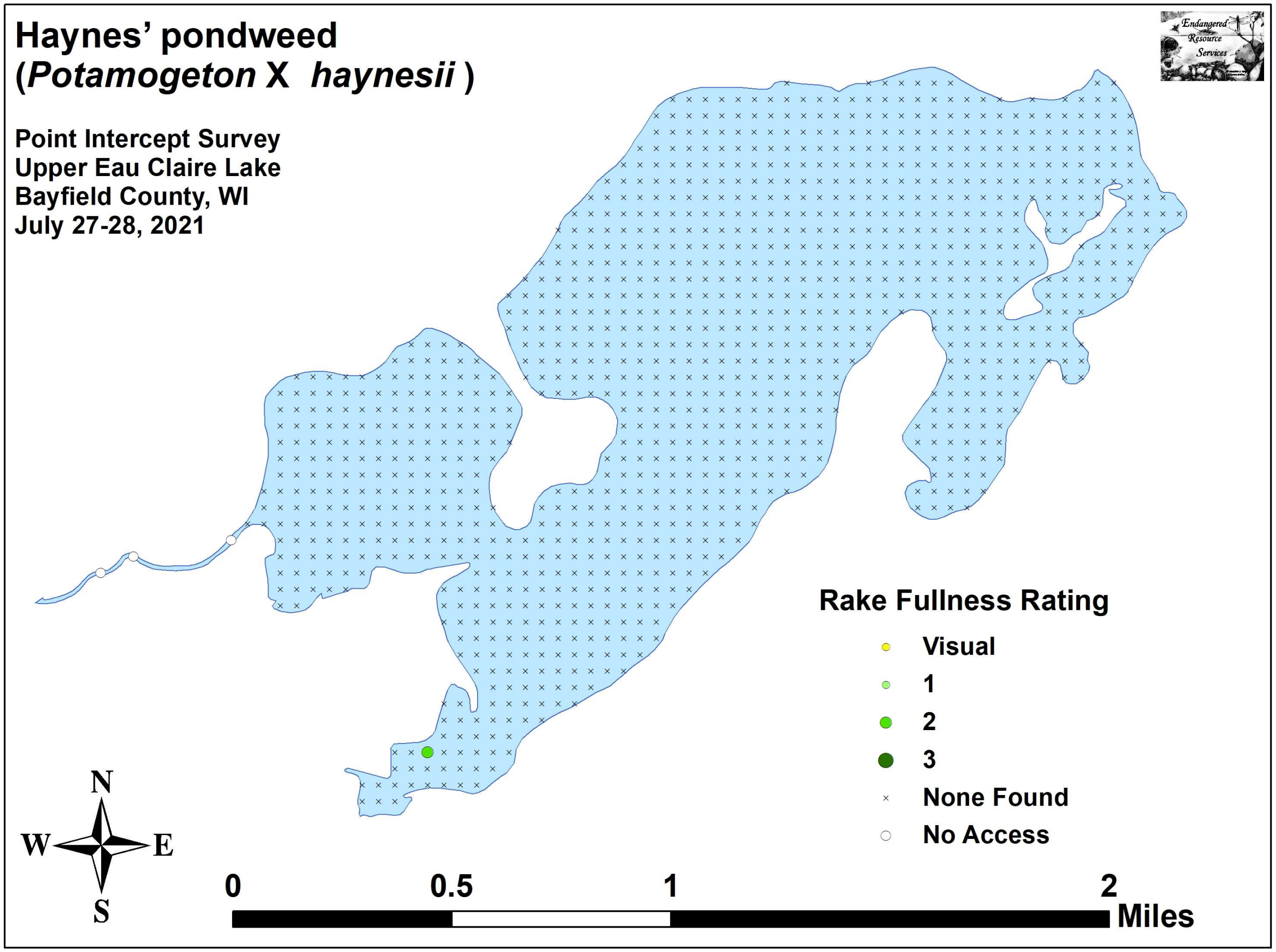
Haynes' pondweed
(Potamogeton X haynesii)
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
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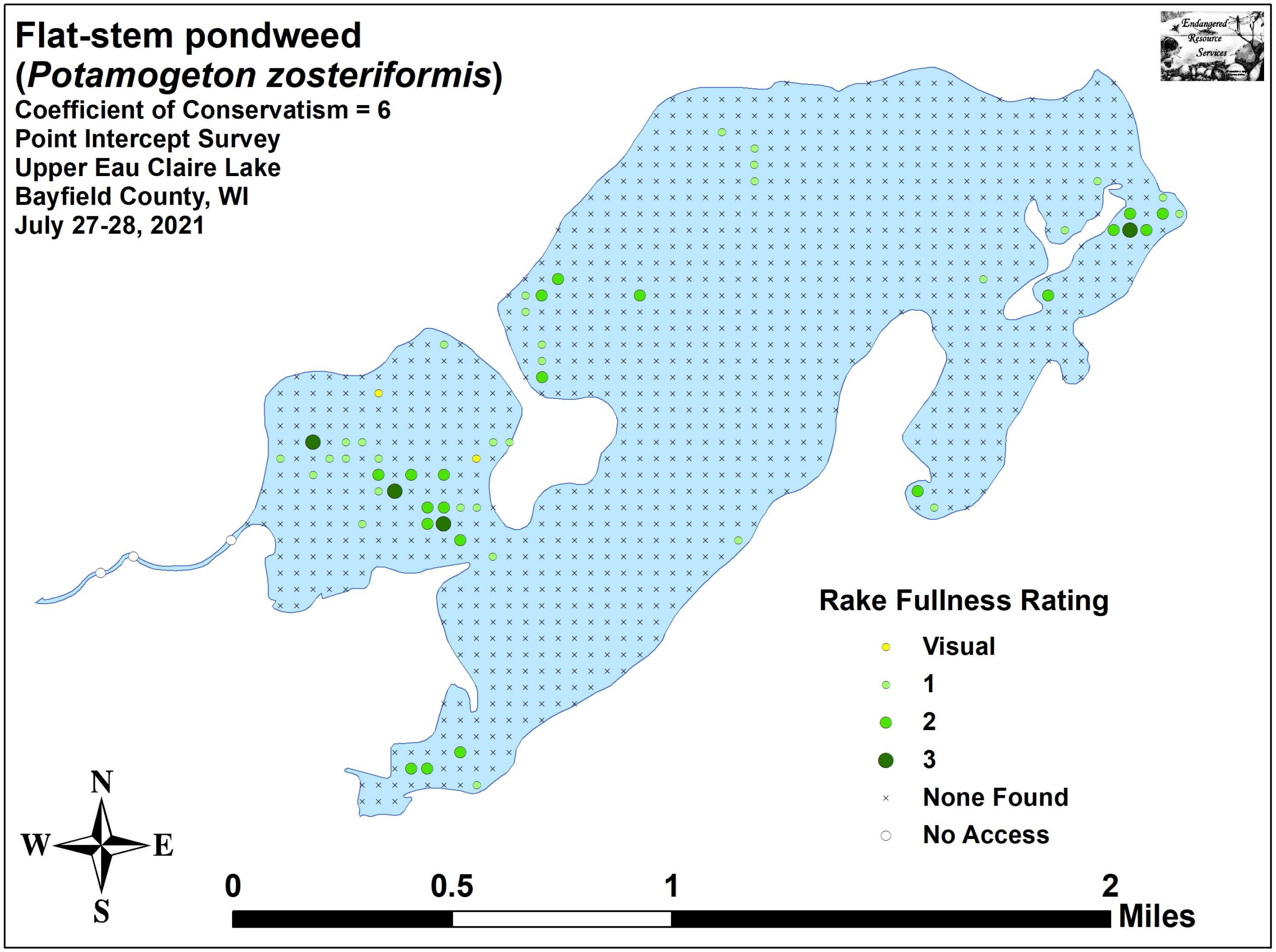
Flat-stem pondweed
(Potamogeton zosteriformis)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
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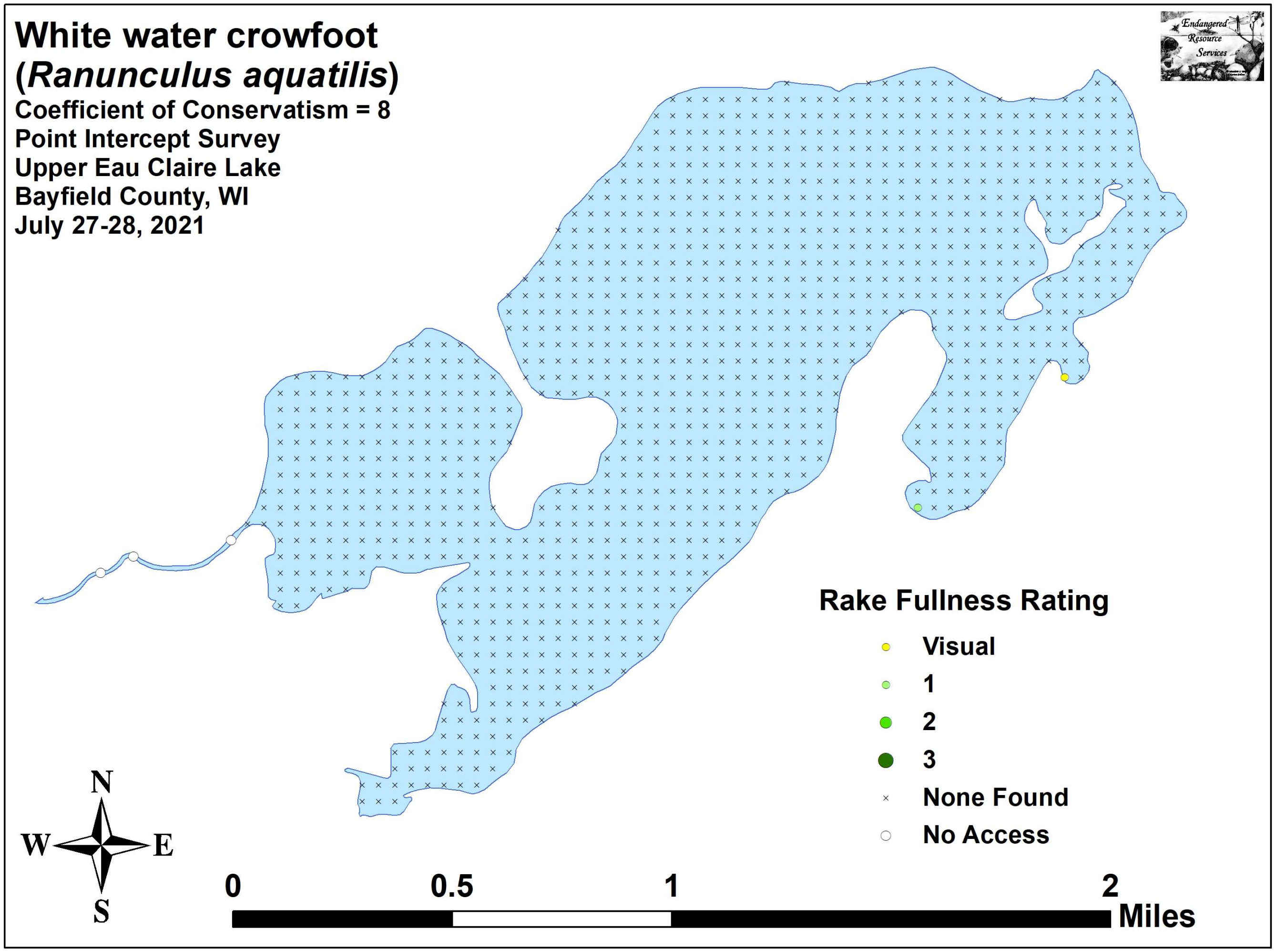
White water crowfoot
(*Ranunculus aquatilis*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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No Access
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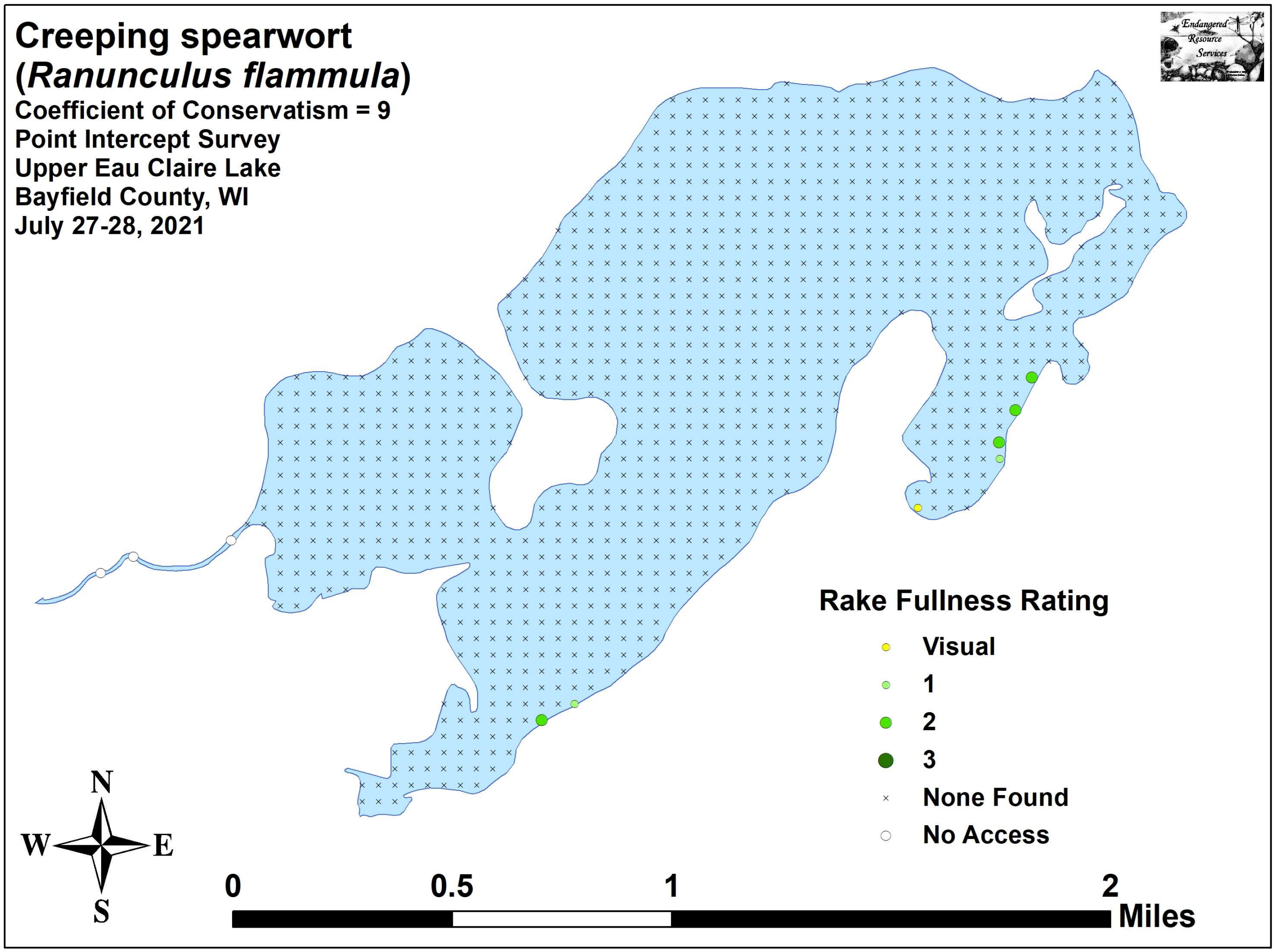
Creeping spearwort
(*Ranunculus flammula*)
Coefficient of Conservatism = 9
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
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None Found
No Access
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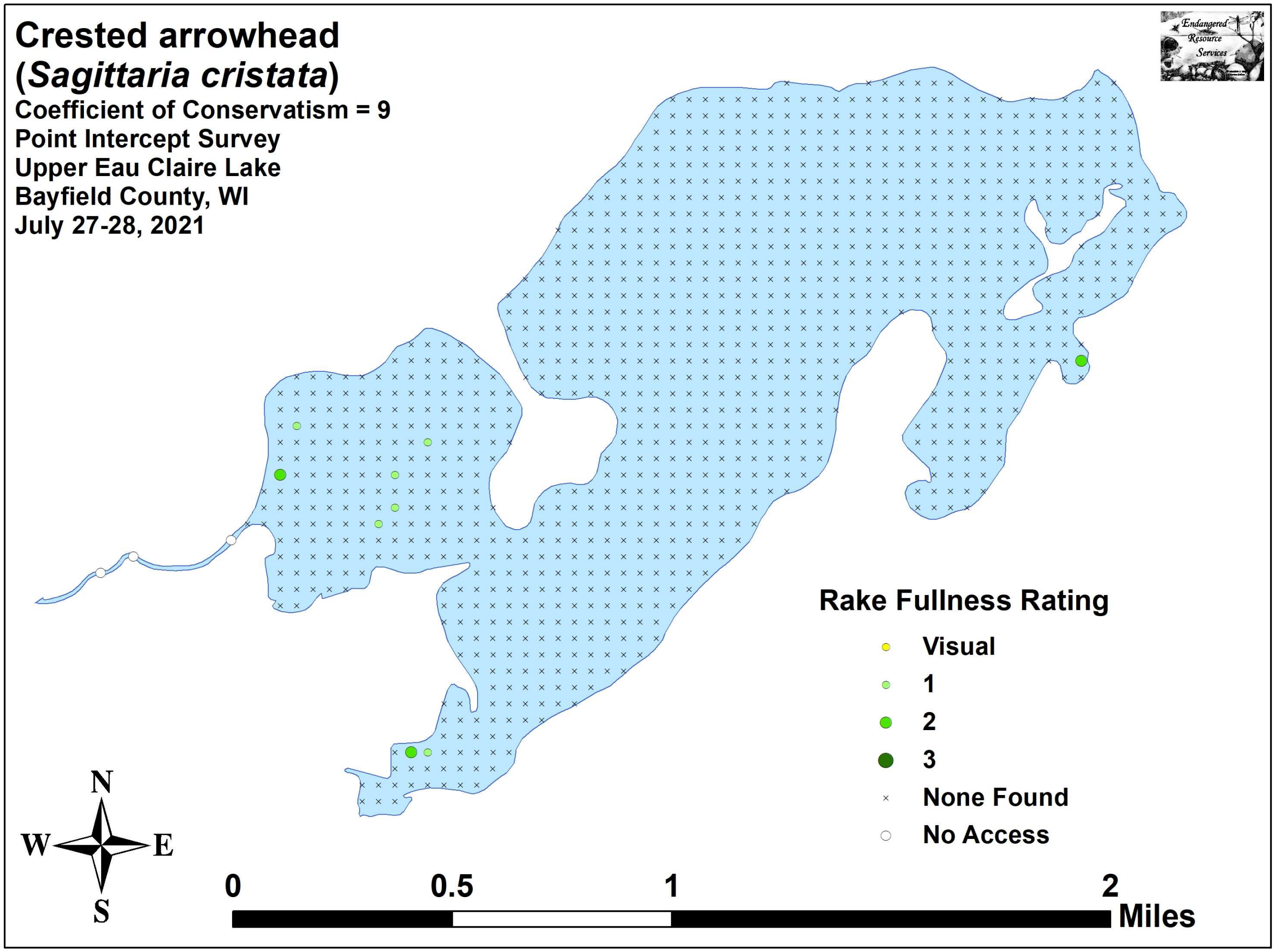
Crested arrowhead
(*Sagittaria cristata*)
Coefficient of Conservatism = 9
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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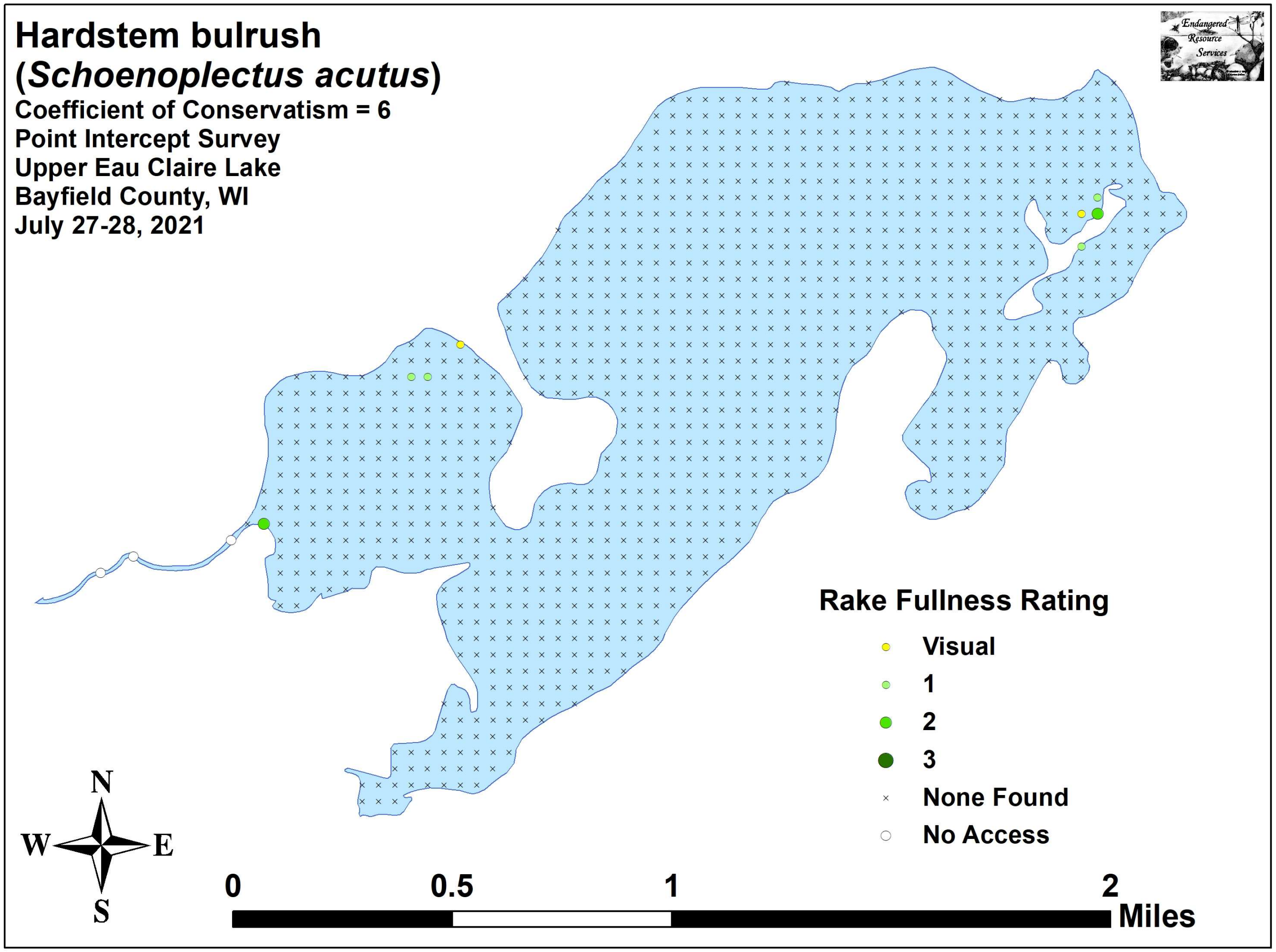

Hardstem bulrush
(*Schoenoplectus acutus*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered
Resource
Services
Rake Fullness Rating
Visual
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No Access
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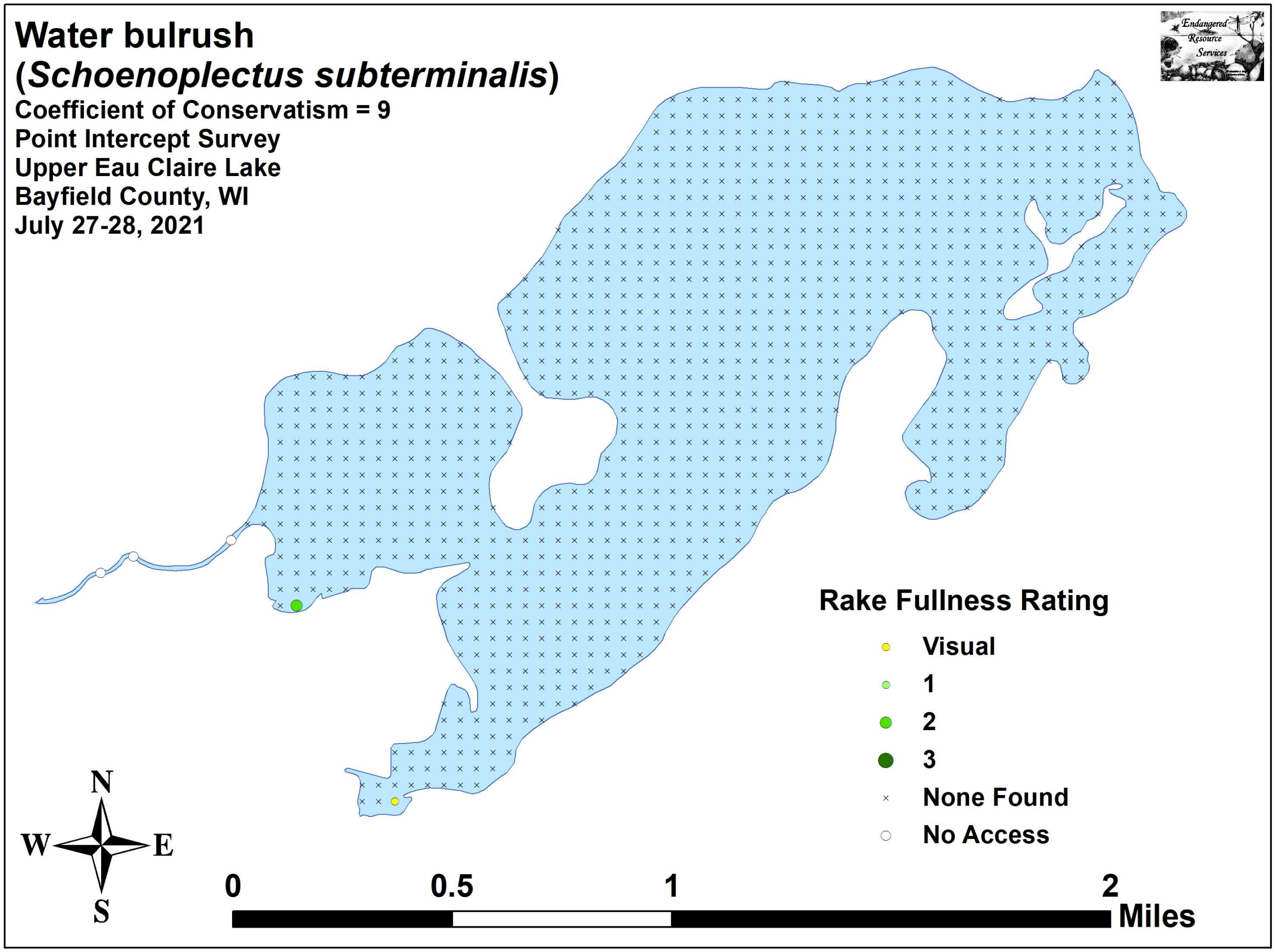
Water bulrush
(*Schoenoplectus subterminalis*)
Coefficient of Conservatism = 9
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
No Access
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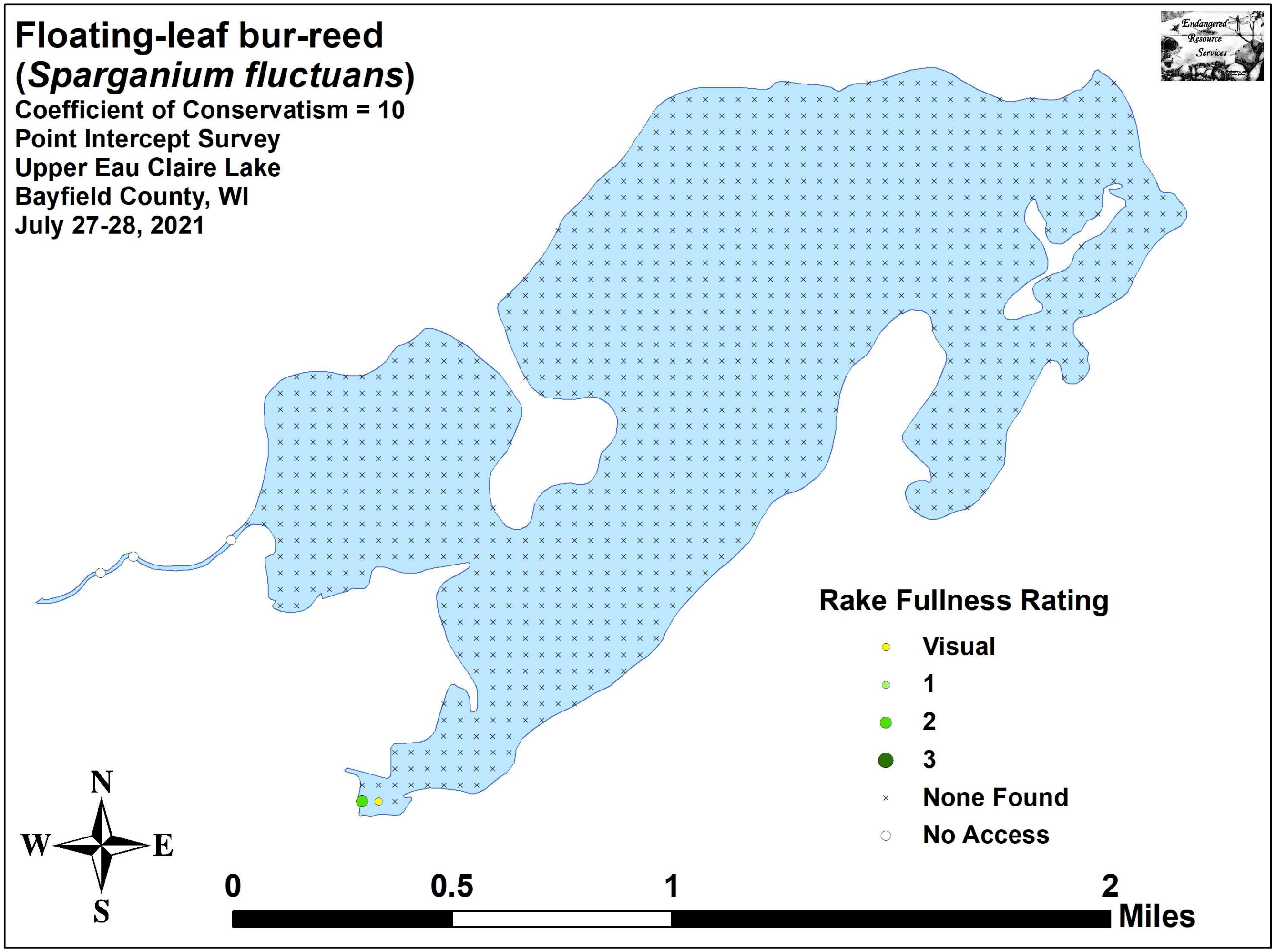
Floating-leaf bur-reed
(*Sparganium fluctuans*)
Coefficient of Conservatism = 10
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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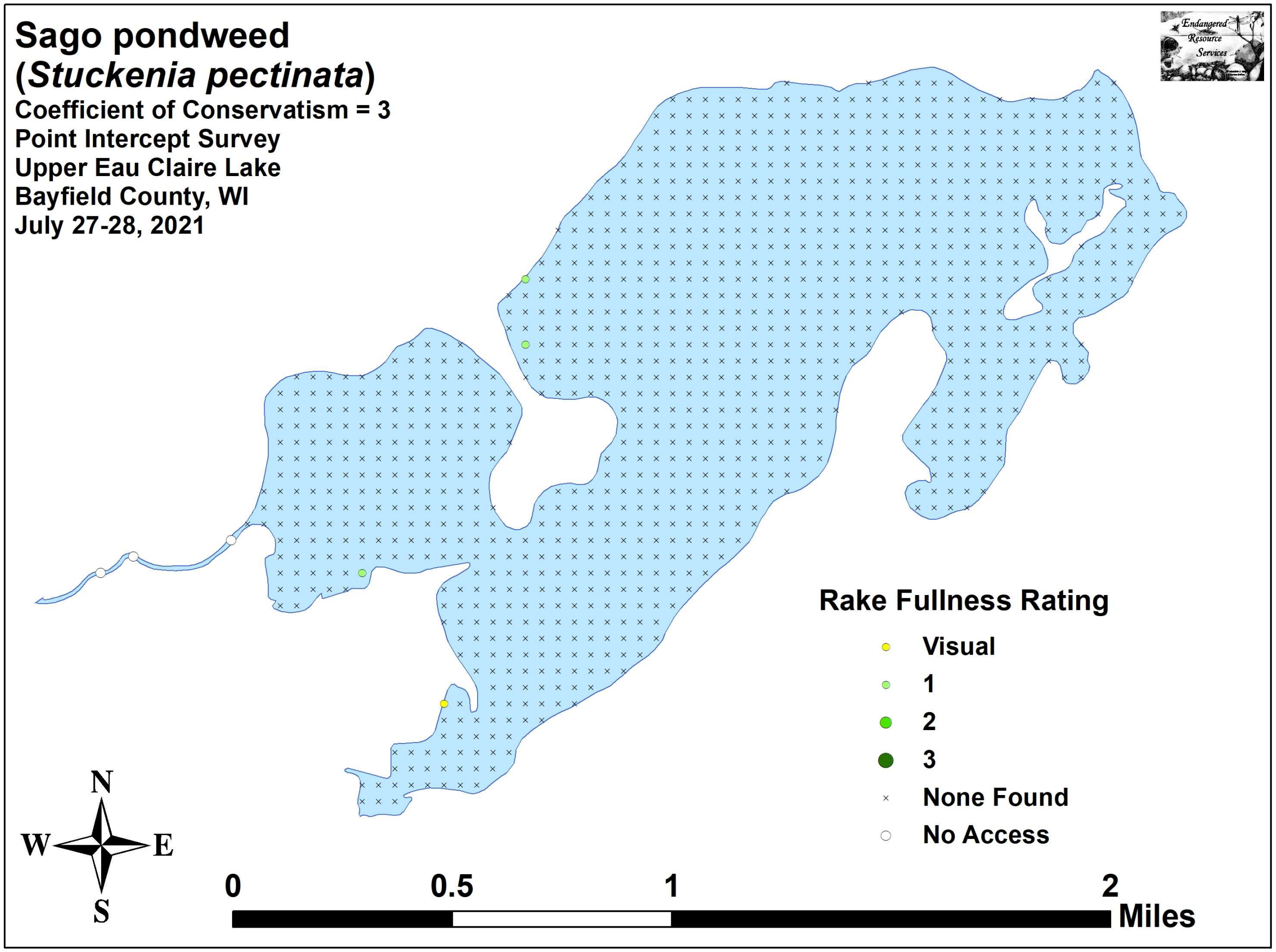
Sago pondweed
(*Stuckenia pectinata*)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
No Access
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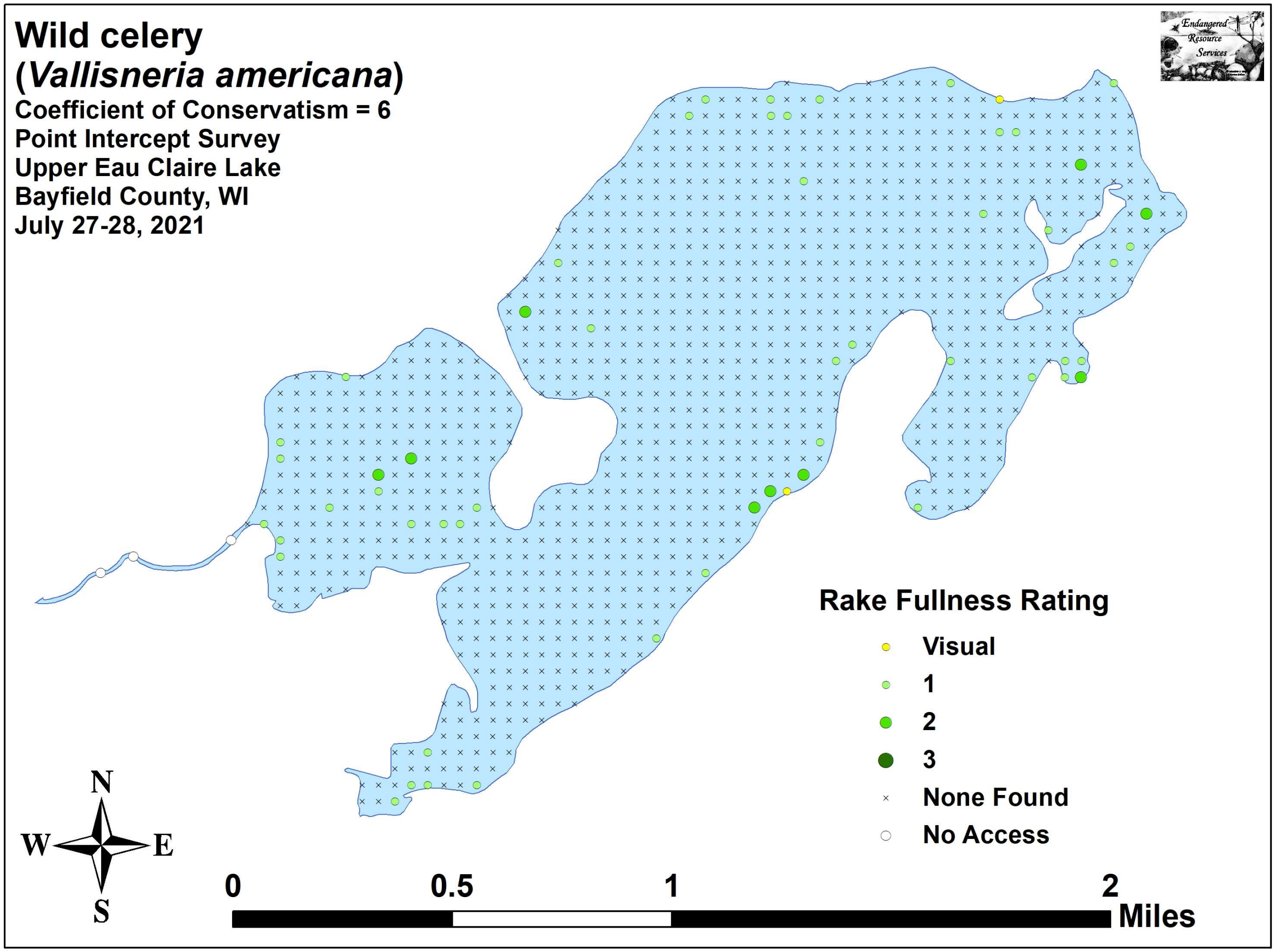

Wild celery
(*Vallisneria americana*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Rake Fullness Rating
Visual
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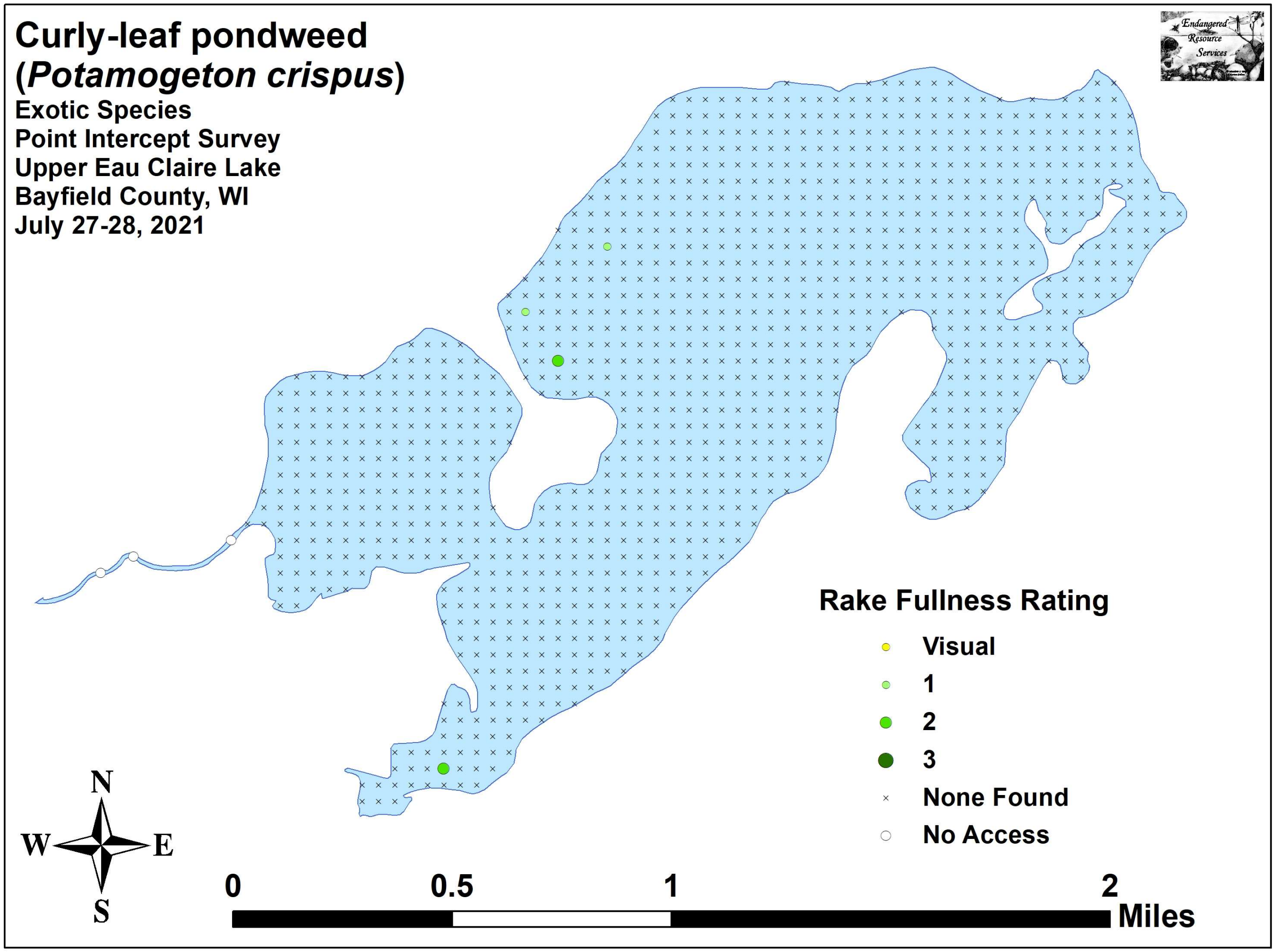
Appendix VII: July 2021 Curly-leaf Pondweed and Hybrid Cattail Density and Distribution Maps



Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Point Intercept Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Rake Fullness Rating
Visual
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None Found
No Access
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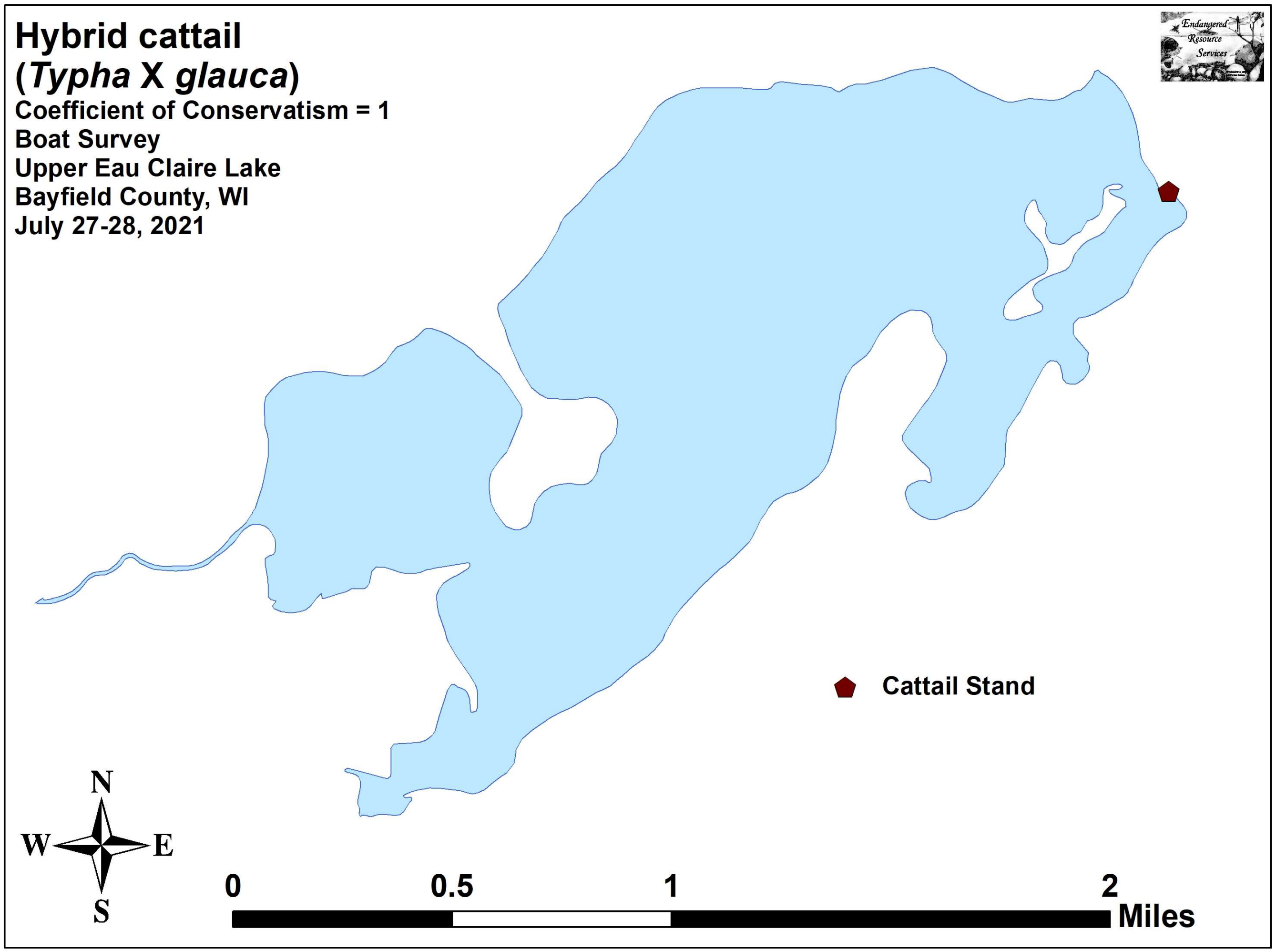
Hybrid cattail
(*Typha* X *glauca*)
Coefficient of Conservatism = 1
Boat Survey
Upper Eau Claire Lake
Bayfield County, WI
July 27-28, 2021
Endangered Resource Services
Cattail Stand
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Appendix VIII: Aquatic Exotic Invasive Plant Species Information

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 (CO2) dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base, and is an important source of oxygen for many lakes.

Phytoplankton:

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

Plankton:

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

ppm:

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

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

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

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

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

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

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

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

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

Appendix X: 2021 Raw Data Spreadsheets

UpperEauCaireLakeBayfieldCountyWBIC2742700CLPPISurvey620-21,2021MBergERSLLC.xlsx

UpperEauCaireBayfieldCountyWBIC2742700PISurvey727-28,2021MBergERSLLC.xlsx