Curly-leaf pondweed (*Potamogeton crispus*) Point-intercept and Bed Mapping Surveys, and Warm-water Macrophyte Point-intercept Survey Upper Turtle Lake - WBIC: 2079800 Barron County, Wisconsin

Upper Turtle Lake Aerial Photo (2015)

Piles of dead Curly-leaf pondweed washing up on shore 6/20/17

Project Initiated by:

The Upper Turtle Lake Association, the Wisconsin Department of Natural Resources, and Lake Education and Planning Services, LLC

Typical 10ft tall CLP plants from the North Bay 6/20/17

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June 20-21, and July 17, 2017

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ABSTRACT

Upper Turtle Lake (WBIC 2079800) is a 427 acre drainage lake located in west-central Barron County, WI. Following our original point-intercept surveys in 2010, the Upper Turtle Lake Association (UTLA), under the direction of Dave Blumer (Lake Education and Planning Services, LLC) developed an initial Aquatic Plant Management Plan at which time they decided against actively managing Curly-leaf pondweed (*Potamogeton crispus*) (CLP). Increases in CLP levels since that time prompted the UTLA to again consider active management. As a prerequisite to updating their plan in 2018 and to compare how the lake's vegetation had changed since the last point-intercept surveys, the UTLA and the Wisconsin Department of Natural Resources authorized CLP density and bed mapping surveys on June 20-21, and a full point-intercept survey for all aquatic macrophytes on July 17, 2017. During the initial 2010 early-season survey, we found CLP at 52 sites (8.7% coverage with a mean rake fullness of 1.87) of which 35 had a rake fullness of 2 or 3 suggesting 5.9% of the lake had a significant infestation. In 2017, we found CLP at 216 points (36.3% coverage with a mean rake fullness of 1.97) with 140 of these having a rake fullness of 2 or 3 (23.5% of the lake had a significant infestation). This represented a 315% increase in total CLP coverage as well as a 300% increase in areas with significant CLP. Although the increase in CLP density was not significant (p=0.19), the increases in total CLP distribution, and in points with a rake fullness of 3, 2, and 1 were all highly significant **(p<0.001)**. In 2017, we found Curly-leaf pondweed formed a nearly continuous canopied mat that ringed the entire lake and covered the north bay. We divided the bed into 11 different areas based on their mean density and potential for navigation impairment. Totaling 132.4 acres (31.0% coverage), it represented a 124.57 acre increase (+1,590%) over the 33 small beds mapped in 2010 that totaled 7.83 acres (1.83% of the lake). During the July 2017 full point-intercept survey, we found macrophytes growing at 163 sites which approximated to 27.4% of the entire lake bottom and 59.7% of the 14.0ft littoral zone. This was down slightly from 166 sites in 2010 (27.9% of the lake and 62.6% of the then 13.5ft littoral zone). Overall diversity was moderately high with a Simpson Index value of 0.88 – nearly identical to 0.89 in 2010. Species richness was low/moderate with 38 species found growing in and immediately adjacent to the water (also down slightly from 40 species in 2010). There was an average of 2.97 native species/site with native vegetation – a non-significant decline (p=0.18) from 3.01/site in 2010. Total rake fullness experienced a highly significant decline **(p<0.001)** from a high/moderate 2.33 in 2010 to a low/moderate 1.79 in 2017. Coontail (*Ceratophyllum demersum*), Flat-stem pondweed (*Potamogeton zosteriformis*), Small duckweed (*Lemna minor*), and Large duckweed (*Spirodela polyrhiza*)/Common watermeal (*Wolffia columbiana*) (4th place tie) were the most common macrophyte species in 2017. Found at 70.55%, 42.94%, 25.15%, and 24.54% of sites with vegetation, the top four accounted for 57.45% of the total relative frequency. In 2010, Coontail, Flat-stem pondweed, Fries' pondweed (*Potamogeton friesii*), and Small duckweed were the most common species (67.47%, 51.81%, 33.13%, and 20.48% of survey points with vegetation/56.27% of the total relative frequency). Lakewide, from 2010-2017, ten species showed significant changes in distribution: Fries' pondweed, Northern water-milfoil (*Myriophyllum sibiricum*), and Muskgrass (*Chara* sp.) suffered highly significant declines; Illinois pondweed (*Potamogeton illinoensis*) and Wild celery (*Vallisneria americana*) experienced moderately significant declines; and Slender naiad (*Najas flexilis*) saw a significant decline. Conversely, filamentous algae demonstrated a highly significant increase; White water lily (*Nymphaea odorata*) had a moderately significant increase, and Curly-leaf pondweed and Forked duckweed (*Lemna trisulca*) experienced significant increases. In addition to these changes in distribution, several important habitat-producing species suffered moderately significant declines in density (Flat-stem pondweed mean rake fullness of 1.60 in 2010 to 1.34 in 2017 **(p=0.005)**); or highly significant declines (Fries' pondweed mean rake fullness of 1.91 in 2010 to 1.11 in 2017 and Muskgrass 1.93 in 2010 to 1.00 in 2017 – both **(p<0.001)**). The 25 native index species found in the rake during the July 2017 survey (down from 29 in 2010) produced a slightly above average mean Coefficient of Conservatism of 5.8 (down from 5.9 in 2010). The Floristic Quality Index of 29.0 (also down from 31.6 in 2010) was, however, well above the median FQI for this part of the state. Although filamentous algae showed a highly significant increase in distribution **(p<0.001)** from 132 points in 2010 to 163 points in 2017; it also showed a moderately significant decline in density **(p=0.002)** from a mean rake fullness of 1.89 in 2010 to 1.65 in 2017. Curly-leaf pondweed was still present at 28 points in July (up from 14 in 2010), and we recorded viable turions in the rake at 25 additional points. Other than CLP, we found two other exotic species growing adjacent to Upper Turtle Lake: Reed canary grass (*Phalaris arundinacea*) was present along shorelines throughout, and Hybrid cattail (*Typha* X *glauca*) was scattered along the western shoreline. Rather than simply trying to manage CLP, we encourage the UTLA to proactively work to limit nutrients coming into the system as they feed both excessive algal and CLP growth. Educating lakeshore residents on ways to control erosion and nutrient runoff, and completing a watershed study to identify and address nutrient sources are both future management considerations worth exploring.

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INTRODUCTION:

Upper Turtle Lake (WBIC 2079800) is a 427 acre, stratified, drainage lake located in the Town of Almena in west-central Barron County (T34N R14W S27 NE NW). It reaches a maximum depth of 25ft in the central basin and has an average depth of 14ft (WDNR 2017). The lake is eutrophic in nature with Secchi readings from 1994-2017 averaging 5.8ft; however, in 2017 the summer average was only 2.8 – the lowest value during this span (WDNR 2017). This poor water clarity produced a littoral zone that reached approximately 14.0ft throughout the 2017 growing season. The lake's bottom substrate is predominantly organic muck in the north, south, and western bays as well as the majority of the main basin with a narrow ring of sand/rock occurring along most of the eastern shore and on scattered exposed points (Figure 1) (Bush et al. 1966).

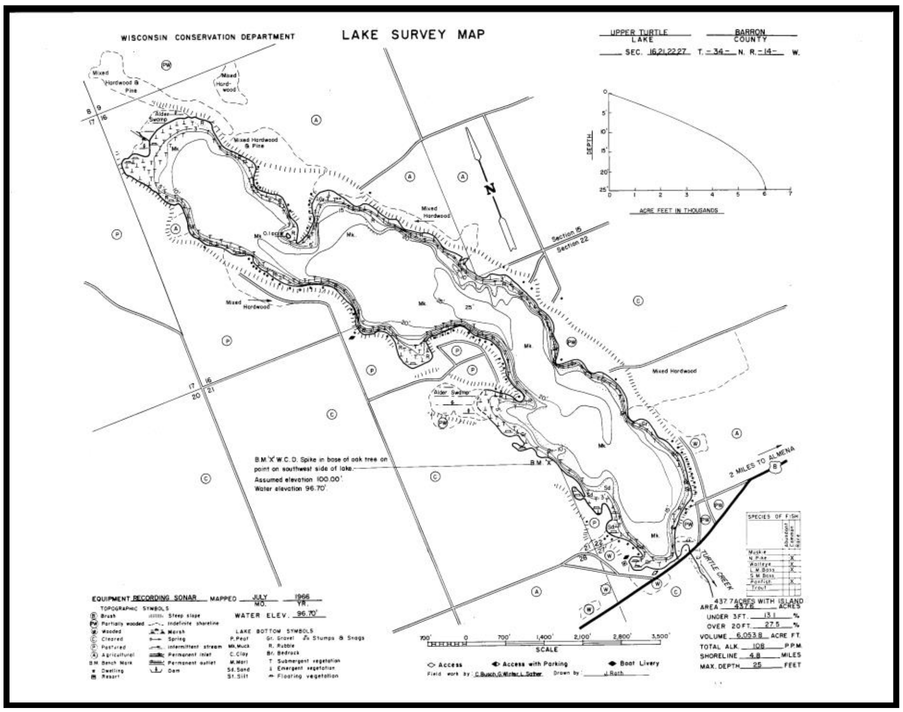


Figure 1: Upper Turtle Lake Bathymetric Map

BACKGROUND AND STUDY RATIONALE:

In 2010, the Upper Turtle Lake Association (UTLA) and the Wisconsin Department of Natural Resources (WDNR) authorized a series of full lake plant surveys as a prerequisite to developing the lake's initial Aquatic Plant Management Plan (APMP). Although those surveys found that the exotic invasive species Curly-leaf pondweed (*Potamogeton crispus*) (CLP) occurred throughout the lake, it was decided that the generally low growth levels did not justify active management at that time. However, following several years of high CLP density on the lake that resulted in severe navigation impairment for many residents, mats of rotting vegetation, and poor summer water quality (UTLA board, pers. comm), the UTLA decided to revisit active management. Per WDNR expectations, plant surveys are normally repeated every five to seven years to remain current (Pamela Toshner/Alex Smith, WDNR – pers. comm.). Because of this, the UTLA was informed they needed to have the lake resurveyed so they could update their APMP prior to initiating any active management.

Normally, Curly-leaf pondweed surveys are conducted in late-May or early June before the plant begins its annual senescence. Although this timeframe had already passed by the time we were contacted in 2017, the board felt strongly about not waiting an additional year. Because of this, our early-season CLP point-intercept survey on June 20th, and our CLP bed mapping survey on June 21st were later than we would normally conduct them. Our warm-water point-intercept survey of all macrophytes on July 17th also occurred at a later date than the original 2010 survey as we had not anticipated doing this work in 2017 and had to make room in our schedule. The surveys' objectives were to document the current levels of CLP; determine if Eurasian water-milfoil (*Myriophyllum spicatum*) or any other new exotic plants had invaded the lake; and to compare data from the original 2010 surveys with the 2017 data to identify any significant changes in the lake's vegetation over this time. This report is the summary analysis of these three field surveys.

METHODS:

Curly-leaf Pondweed Point-intercept Survey:

Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth, and total acreage, Michelle Nault (WDNR) generated the original 595 point sampling grid for Upper Turtle Lake (Appendix I) in 2010. Using this same grid in 2017, we completed a density survey where we sampled for Curly-leaf pondweed at each littoral point in the lake. 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.

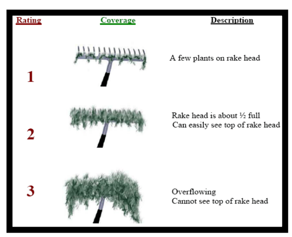


Figure 2: Rake Fullness Ratings (UWEX 2010)

Curly-leaf Pondweed Bed Mapping Survey:

During the bed mapping survey, we searched the lake's entire 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 to regain familiarity with the lake's macrophytes (Appendix II). All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2010; Skawinski 2014), and a datasheet was built from the species present. We again located each survey point with a GPS, recorded a depth reading with a metered pole rake or handheld sonar (Vexilar LPS-1), and took a rake sample. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of all plants within six feet of the sample point not found in the rake. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

DATA ANALYSIS:

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

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

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 DNR 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).

Relative frequency: This value shows a species' frequency relative to all other species. It is expressed as a percentage, and the total of all species' relative frequency 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 and 4).

Relative frequency example:

Suppose that we sample 100 points and found 5 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 124 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 Turtle Lake is in the North Central Hardwood Forests Ecoregion (Tables 5 and 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 2010 and 2017 CLP point-intercept surveys (Figure 4) and warm-water point-intercept surveys (Figure 10) (Tables 3 and 4) 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/Post 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 when comparing the CLP point-intercept surveys we used the number of littoral points (256 in 2010/290 in 2017); however, for the warm-water point-intercept surveys, we used the number of littoral points with plants (166 in 2010/163 in 2017) as the basis for "sample points".

RESULTS:

Curly-leaf Pondweed Point-intercept Survey:

Because Curly-leaf pondweed was found growing to 15.0ft in 2017 (up from 13.0ft in 2010), we rake sampled every point in the lake <17ft. during the early-season point-intercept survey. CLP was present at 216 points which approximated to 36.3% of the entire lake and 74.5% of the spring littoral zone. Of these, we recorded a rake fullness value of 3 at 69 points, a 2 at 71 points, and a 1 at 76 points for a combined mean rake fullness of 1.97. We also noted CLP as a visual at 8 points (Figure 3) (Appendix III). The combined 140 points with a rake fullness of a 2 or a 3 extrapolated to 23.5% of the entire lake and 48.3% of the spring littoral zone having a significant infestation.

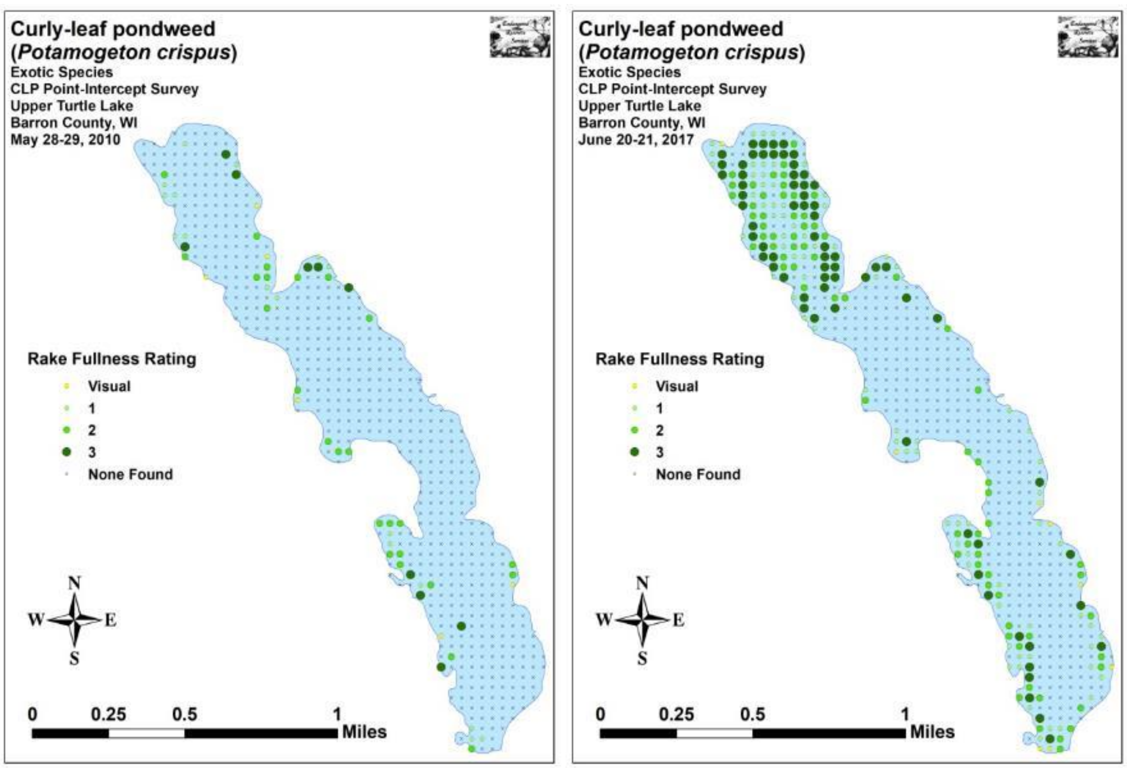
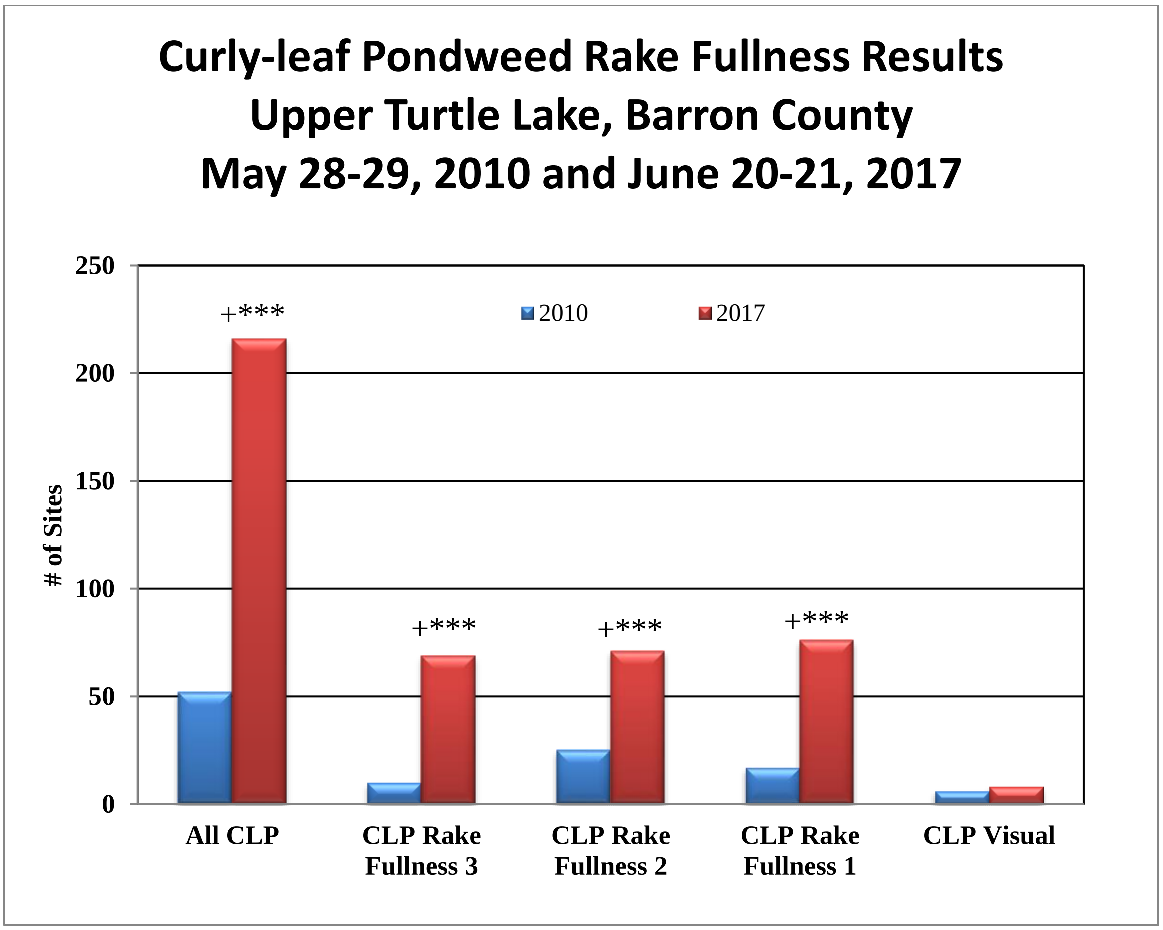


Figure 3: 2010 and 2017 Early-season Curly-leaf Pondweed Density and Distribution

Comparison of Curly-leaf Pondweed in 2010 and 2017:

The 2010 spring Curly-leaf pondweed survey found CLP at 52 sites which approximated to 8.7% of the entire lake and 20.3% of the then 13.0ft spring littoral zone. Of these, we recorded a rake fullness value of 3 at 10 points, a 2 at 25 points, and a value of 1 at 17 points for a mean rake fullness of 1.87. We also recorded CLP as a visual at 6 points (Figure 3) (Appendix III). The combined 35 points with a rake fullness of 2 or 3 extrapolated to 5.9% of the entire lake and 13.7% of the littoral zone having a significant infestation. Our results suggest a highly significant increase **(*p*<0.001)** in total CLP as well as rake fullness 3, 2, and 1; however, the increase in combined mean rake fullness was not significant (*p*=0.19) (Figure 4). Collectively, from 2010-2017, there was a 315% increase in total CLP coverage as well as an even 300% increase in areas where the infestation was significant enough to likely be considered a nuisance.



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

Figure 4: 2010 and 2017 Changes in Early-season CLP Rake Fullness

Curly-leaf Pondweed Bed Mapping Survey:

In 2010, we mapped 33 Curly-leaf pondweed beds scattered throughout the lake's littoral zone (Figure 5). Only four were greater than 0.5 acre, and, collectively, they covered 7.83 acres (1.83% of the lake's 427 acres). The 2017 survey showed a dramatic increase in coverage as CLP now dominated the entire littoral zone with the exception of sandy and rocky areas next to the immediate shoreline and areas that were dominated by lilypads. Although the lake essentially contained one continuous bed, we chose to divide it into 11 separate areas based on density and potential navigation impairment. In total, canopied CLP covered 132.40 acres (31.0% of the lake's surface area) (Table 1). This represented a 124.57 acre increase (+1,590%) over our 2010 bed mapping survey (Figure 5) (Appendix III).

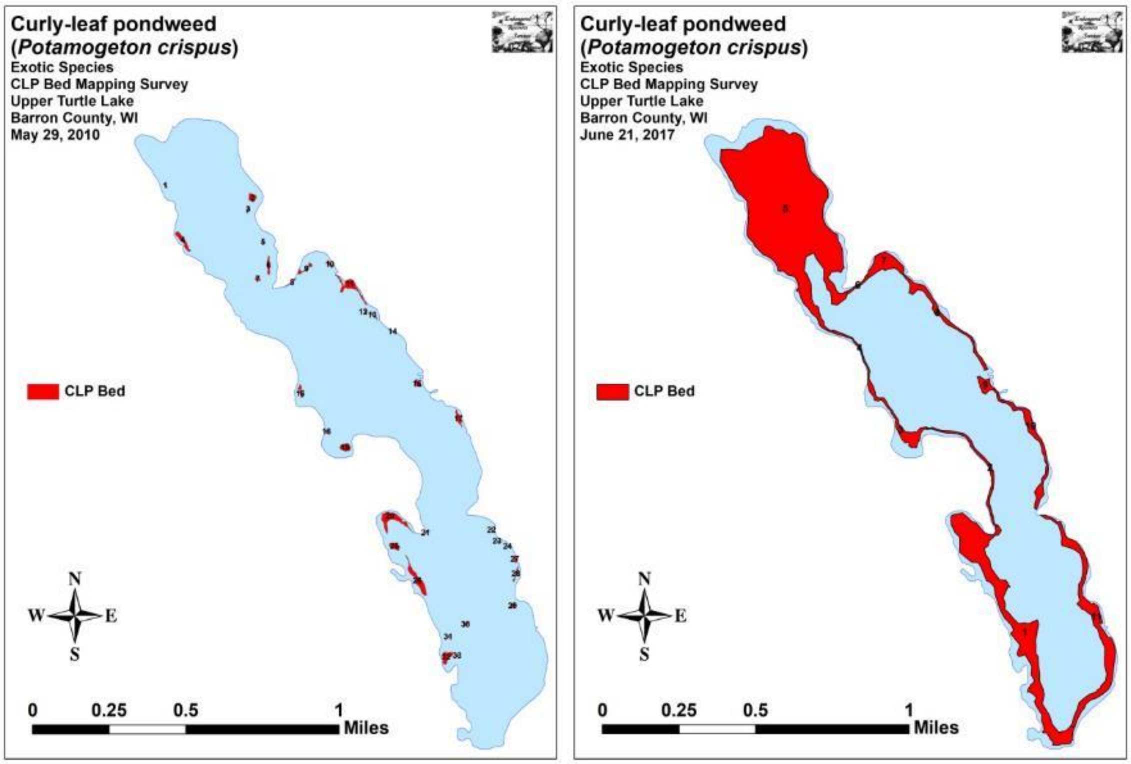


Figure 5: 2010 and 2017 Early-season Curly-leaf Pondweed Beds

Descriptions of Past and Present CLP Beds:

Bed 1 – The southwestern shoreline was ringed by native vegetation dominated by floating-leaf species. In areas beyond 3ft of water, Curly-leaf pondweed thickened into a bed that, due to its width, likely resulted in at least moderate navigation impairment. In the northwest "thumb" bay, that impairment potentially bordered on severe although regular in and out boat traffic was keeping a channel open.

Beds 2, 3, and 4 – Although CLP was occasionally dense along the central-western shoreline, the narrowness of the bed due to sharp drop-offs into 20ft+ likely meant the beds were just a minor impairment. The exception to this was on the outer edges of the bays in Beds 3 and 4 where residents were cutting visible trails through the plants to gain access. Even here, beds were still narrow enough that the impairment probably wasn't severe.

Bed 5: The majority of the north bay would likely have been almost impassible in early June. By the time we surveyed, most plants in water over 11ft were dying, and we had to rake to find the outer edge of the bed in 13ft+ of water. Giant mats of dead CLP, some more than an acre in size, were everywhere, and the prevailing southerly winds had created a ring of plant debris on the north end of the bay that was making it almost impossible for residents to get through our around to open water.

Beds 6 and 8: Similar to the midlake western shoreline, CLP in these areas was patchy as the sharp drop-offs from a shoreline that was mostly sand and rock created poor growing conditions. Because of this, for most residents, CLP was likely only a minor inconvenience.

Bed 7: CLP in the northeast bay midlake was moderately dense, although we noted there were significant numbers of submerged native plants mixed in. Because of this, we found the bed was difficult to navigation, but patchy enough that it wasn't impassible. However, similar to the north bay, residents were forced to rake out "haystacks" of dead CLP that the winds were blowing into shore (see report cover).

Bed 9: Further to the southeast, we found the bed thickened as the substrate transitioned to muck. This area had the potentially to be a moderate impairment to navigation, but, with no residences along this piece of shoreline, it is likely not a management priority.

Beds 10 and 11: The beds along the southeast shoreline weren't especially wide, but they likely posed at least a moderate impairment to navigation. At the time of the survey, we estimated they averaged a mean rake of 2, but this was likely higher earlier in the growing season based on the volume of boat traffic to and from this heavily developed shoreline.

Table 1: Curly-leaf Pondweed Bed Summary
Upper Turtle Lake, Barron County – June 21, 2017

Bed Number	Acreage	Rake Range	Mean Rake Fullness	Depth Range of CLP	Mean Depth of CLP	Potential Navigation Impairment Level
1	24.62	<1-3	2	3-13	10	Moderate
2	2.12	<1-3	3	2-13	10	Minor
3	3.24	<1-3	2	5-13	10	Minor
4	0.69	<1-2	1	4-12	9	Minor
5	79.13	<1-3	3	4-14	11	Severe
6	0.40	<1-3	2	5-13	11	Minor
7	3.17	<1-3	2	3-13	10	Moderate
8	3.12	<<1-3	1	4-13	10	Minor
9	1.06	1-3	3	4-13	9	Moderate
10	3.81	<<1-3	2	4-13	9	Moderate
11	11.00	<1-3	2	3-13	10	Moderate
Total Acres	**132.40**					

Warm-water Full Point-intercept Macrophyte Survey:

Depth readings taken at Upper Turtle Lake's 595 survey points (Appendix I) revealed the north bay is a fairly uniform bowl that slopes gradually from all sides into 13ft of water. The lower 2/3rds of the lake forms an elongate bowl that bottoms out from 20-26ft in the central basin, but only 15-20ft in the southern basin. In general, the eastern shoreline along this bowl drops off sharply, while the western side contains numerous shallow side bays and flats that are usually <10ft and tend to drop-off more gradually into deep water (Figure 6) (Appendix IV).

Of the 381 points that were shallow enough to take a rake sample, we characterized the lake's substrate as 79.5% organic and sandy muck (303 points), 12.1% pure sand (46 points), and 8.4% rock (32 points). Thick nutrient-rich organic muck dominated the north bay and western side bays, while thinner sandy muck covered the south basin. Most of the pure sand areas were found around the "neck" leading into the north bay and along the southeastern shoreline. The majority of the gravel and cobble substrates occurred along the steep slopes of the central basin; especially around exposed points (Figure 6) (Appendix IV).

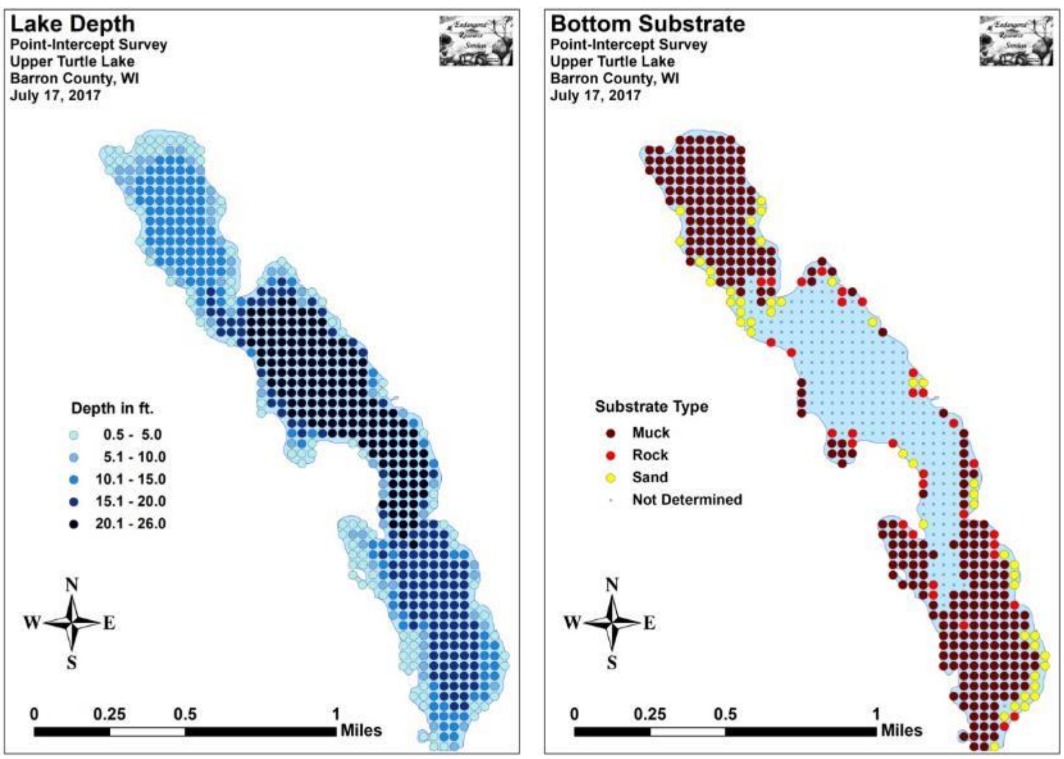


Figure 6: Lake Depth and Bottom Substrate

In July 2017, we found plants growing to 14.0ft (similar to 13.5ft in 2010) (Table 2) (Figure 7). The 163 points with vegetation (approximately 27.4% of the entire lake bottom and 59.7% of the littoral zone) were also nearly identical to the 2010 survey when we found plants growing at 166 points (27.9% of the bottom and 62.6% of the littoral zone). Growth in 2017 was slightly skewed to deep water as the mean plant depth of 5.5ft was more than the median depth of 4.5ft. In 2010, fewer deep water points with plants resulted in a mean (5.2ft) and a median (4.0ft) that were both lower than in 2017 (Appendix V).

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics
Upper Turtle Lake, Barron County
July 8-9, 2010 and July 17, 2017

Summary Statistics:	2010	2017
Total number of points sampled	595	595
Total number of sites with vegetation	166	163
Total number of sites shallower than the maximum depth of plants	265	273
Frequency of occurrence at sites shallower than maximum depth of plants	62.6	59.7
Simpson Diversity Index	0.89	0.88
Maximum depth of plants (ft)	13.5	14.0
Mean depth of plants (ft)	5.2	5.5
Median depth of plants (ft)	4.0	4.5
Average number of all species per site (shallower than max depth)	1.92	1.70
Average number of all species per site (veg. sites only)	3.07	2.84
Average number of native species per site (shallower than max depth)	1.87	1.59
Average number of native species per site (sites with native veg. only)	3.01	2.97
Species richness	31	28
Species richness (including visuals)	35	29
Species richness (including visuals and boat survey)	40	38
Mean rake fullness (veg. sites only)	2.33	1.79

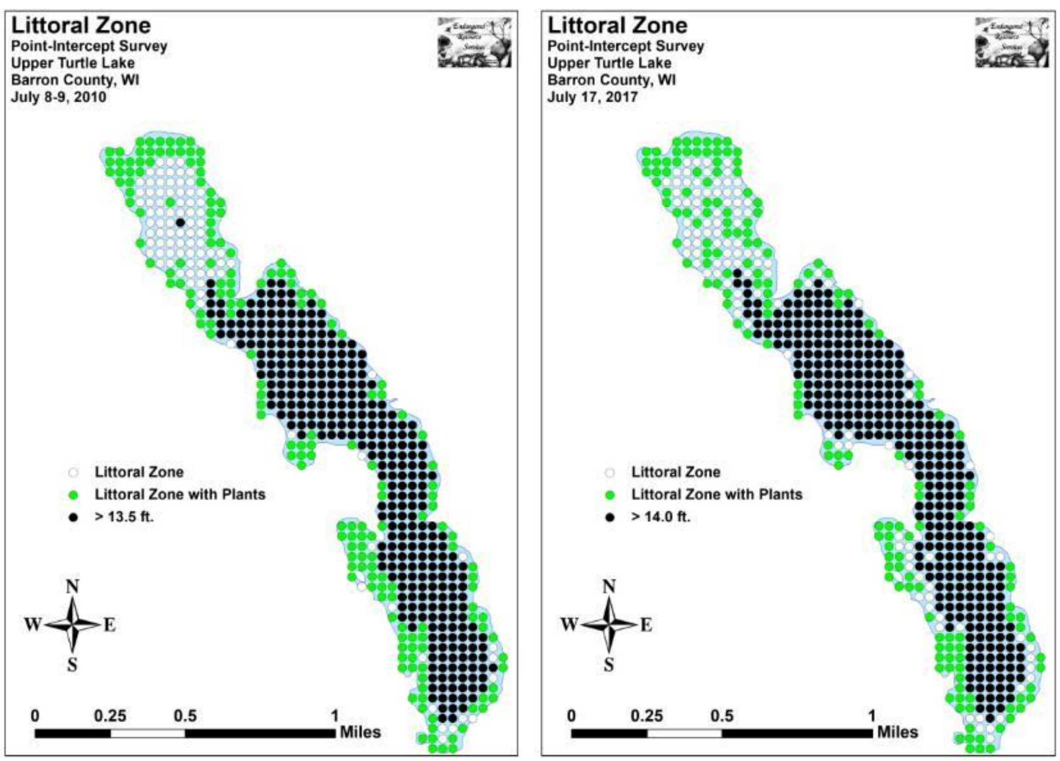


Figure 7: 2010 and 2017 Littoral Zone

Plant diversity was moderately high in 2017 with a Simpson Index value of 0.88 – down slightly from 0.89 in 2010. Species richness was low/moderate with 28 species found in the rake (down from 31 in 2010); however, this total increased to 38 species when including visuals and plants seen during the boat survey. This number was also down slightly from the 40 total species we documented in 2010. Mean native species richness at sites with native vegetation also experienced a non-significant decline (p=0.18) from 3.01/site in 2010 to 2.97/site in 2017. Visual analysis of the maps suggested the north bay experienced a widespread increase in localized richness, while the southern 1/3rd of the lake showed an almost equal decline (Figure 8) (Appendix V).

Total rake fullness experienced a highly significant decline **(p<0.001)** from a high/moderate 2.33 in 2010 to a low/moderate 1.79 in 2017. We noted this decline was a lakewide event, and, with few exceptions, the only sizable remaining high density beds occurred near the creek inlet and in shallow water near shore in the most nutrient-rich bays (Figure 9) (Appendix V).

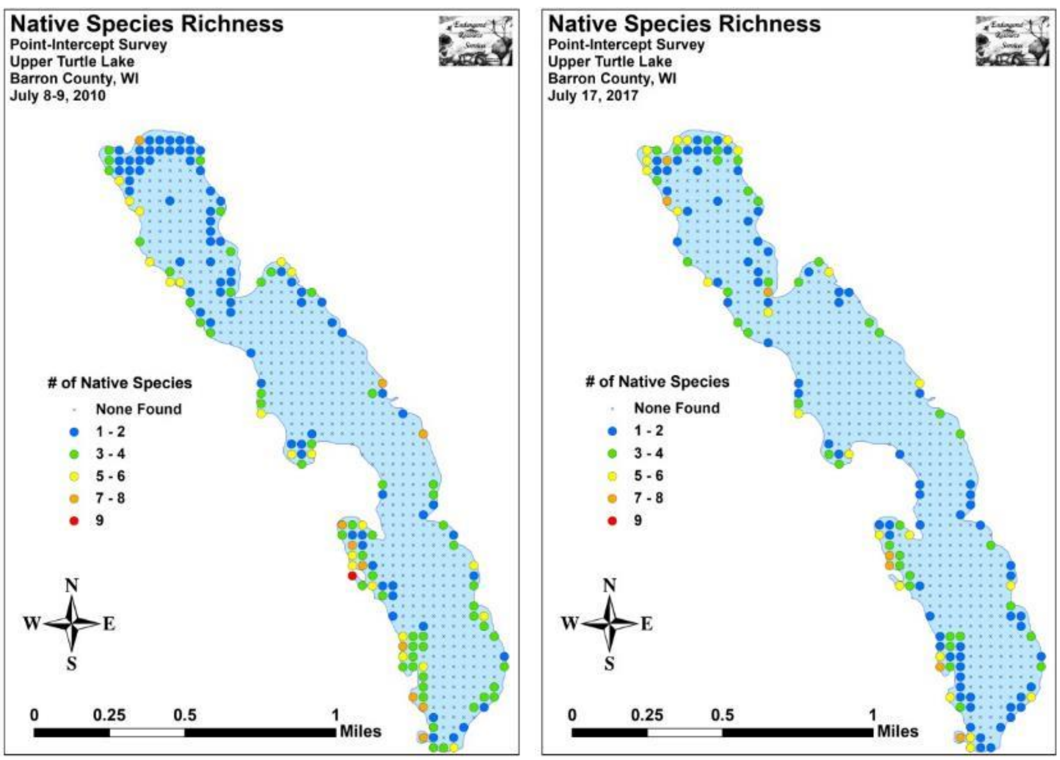


Figure 8: 2010 and 2017 Native Species Richness

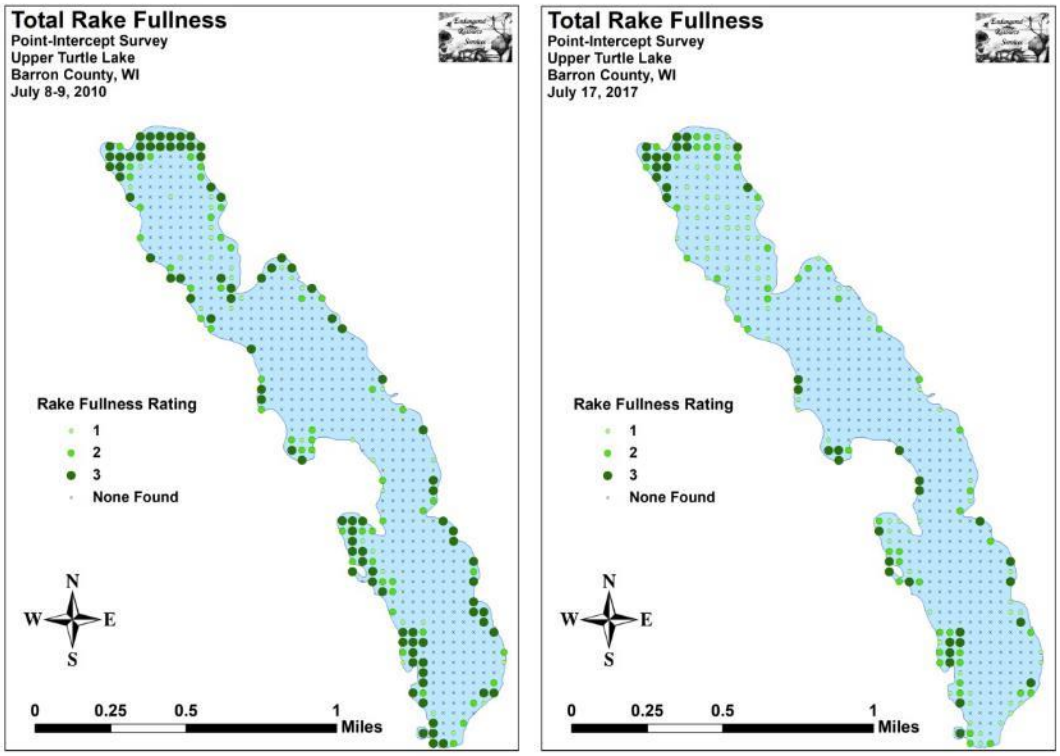


Figure 9: 2010 and 2017 Total Rake Fullness

Upper Turtle Lake Plant Community:

The Upper Turtle Lake ecosystem is home to a somewhat limited plant community that is typical of high-nutrient lakes with fair to poor water quality. This community can be subdivided into four distinct zones (emergent, shallow submergent, floating-leaf, 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 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.

Exposed sandy and rocky areas at the shoreline had few emergents other than Reed canary grass (*Phalaris arundinacea*) and a couple of widely scattered patches of River bulrush (*Bolboschoenus fluviatilis*). Away from the immediate shore, shallow gravel and sandy areas supported beds of Hardstem bulrush (*Schoenoplectus acutus*) and Common bur-reed (*Sparganium eurycarpum*). Around the organic muck margins of the lake's bays, these species were replaced by Sweet-flag (*Acorus americanus*), Wild calla (*Calla palustris*), Bottle brush sedge (*Carex comosa*), Porcupine sedge (*Carex hystericina*), Swamp loosestrife (*Decodon verticillatus*), Bald spikerush (*Eleocharis erythropoda*), Common arrowhead (*Sagittaria latifolia*), Softstem bulrush (*Schoenoplectus acutus*), and both Broad-leaved cattail (*Typha latifolia*) and Narrow-leaved cattail (*Typha angustifolia*).

River bulrush (Ratzlaff 2008)

Common bur-reed (Raymond 2011)

Sweet-flag (Hough 2014)

Wild calla (Pierce 2001)

Bottle-brush sedge (Penta 2010)

Swamp loosestrife (Wigney 2005)

Common arrowhead (Young 2006)

Softstem bulrush (Schwarz 2011)

Just beyond the emergents, in sheltered muck-bottomed areas in up to 4ft of water, the floating-leaf species White-water lily (*Nymphaea odorata*) and Spatterdock (*Nuphar variegata*) were common throughout the lake. The canopy cover these species provides is often utilized by panfish and bass for protection.

White water lily (Falkner 2010)

Spatterdock (CBG 2014)

Growing amongst the lilypads, we also frequently encountered the submergent species Coontail (*Ceratophyllum demersum*), Common waterweed (*Elodea canadensis*), and Curly-leaf pondweed. In addition to these plants, a large number of "duckweeds" including Large duckweed (*Spirodela polyrhiza*), Small duckweed (*Lemna minor*), Forked duckweed (*Lemna trisulca*), and Common watermeal (*Wolffia columbiana*) were often found floating among the lilypads and emergents.

Small duckweed and Common watermeal (Kieron 2010)

Large duckweed (Thomas 2017)

Shallow rocky areas were almost entirely devoid of plants, and many pure sand areas were covered with a thick mat of filamentous algae making exposed sand flats one of the rarest habitats on the lake. These nutrient-poor substrates tended to have low total biomass as they provide habitat most suited to fine-leaved "isoetid" turf forming species. Near the creek inlet in the north bay and scattered along the southeastern shoreline, we found very limited numbers of Muskgrass (*Chara* sp.), Waterwort (*Elatine minima*), Spiny-spored quillwort (*Isoetes echinospora*), and Crested arrowhead (*Sagittaria cristata*).

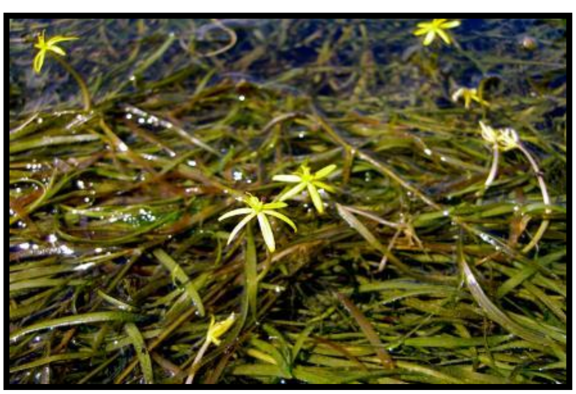
Muskgrass (Penuh 2007)

Waterwort (Fewless 2005)

Spiny-spored quillwort (Fewless 2005)

Crested arrowhead (Fewless 2004)

Sandy muck areas in water from 2-5ft deep generally supported fine to moderate-leaved species such as Water star-grass (*Heteranthera dubia*), Northern water-milfoil (*Myriophyllum sibiricum*), Slender naiad (*Najas flexilis*), Fries' pondweed (*Potamogeton friesii*), Illinois pondweed (*Potamogeton illinoensis*), Clasping-leaf pondweed (*Potamogeton richardsonii*), White water crowfoot (*Ranunculus aquatilis*), Sago pondweed (*Stuckenia pectinata*), and Wild celery (*Vallisneria americana*). The roots, shoots, and seeds of these plants are heavily utilized by 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)


Slender naiad (Apipp 2009)


Fries pondweed (Koshere 2002)


Illinois pondweed (Koshere 2002)


Clasping-leaf pondweed (Cameron 2013)


Sago pondweed (Hilty 2012)

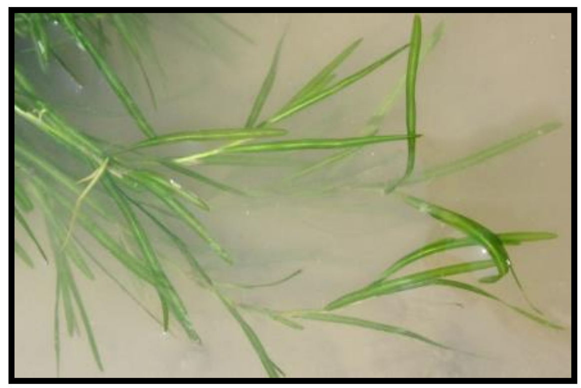

Wild celery (Dalvi 2010)

Organic muck areas in water greater than 5ft were dominated by Coontail, Common waterweed, White-stem pondweed (*Potamogeton praelongus*), Small pondweed (*Potamogeton pusillus*), Flat-stem pondweed (*Potamogeton zosteriformis*), and, in the early spring, Curly-leaf pondweed. Predatory fish like the lake's pike are often found along the edges of these deep beds waiting in ambush.

Coontail (Hassler 2011)

Common waterweed (Fischer 2010)

White-stem pondweed (Fewless 2005)



Small pondweed (Villa 2011)

Flat-stem pondweed (Fewless 2004)

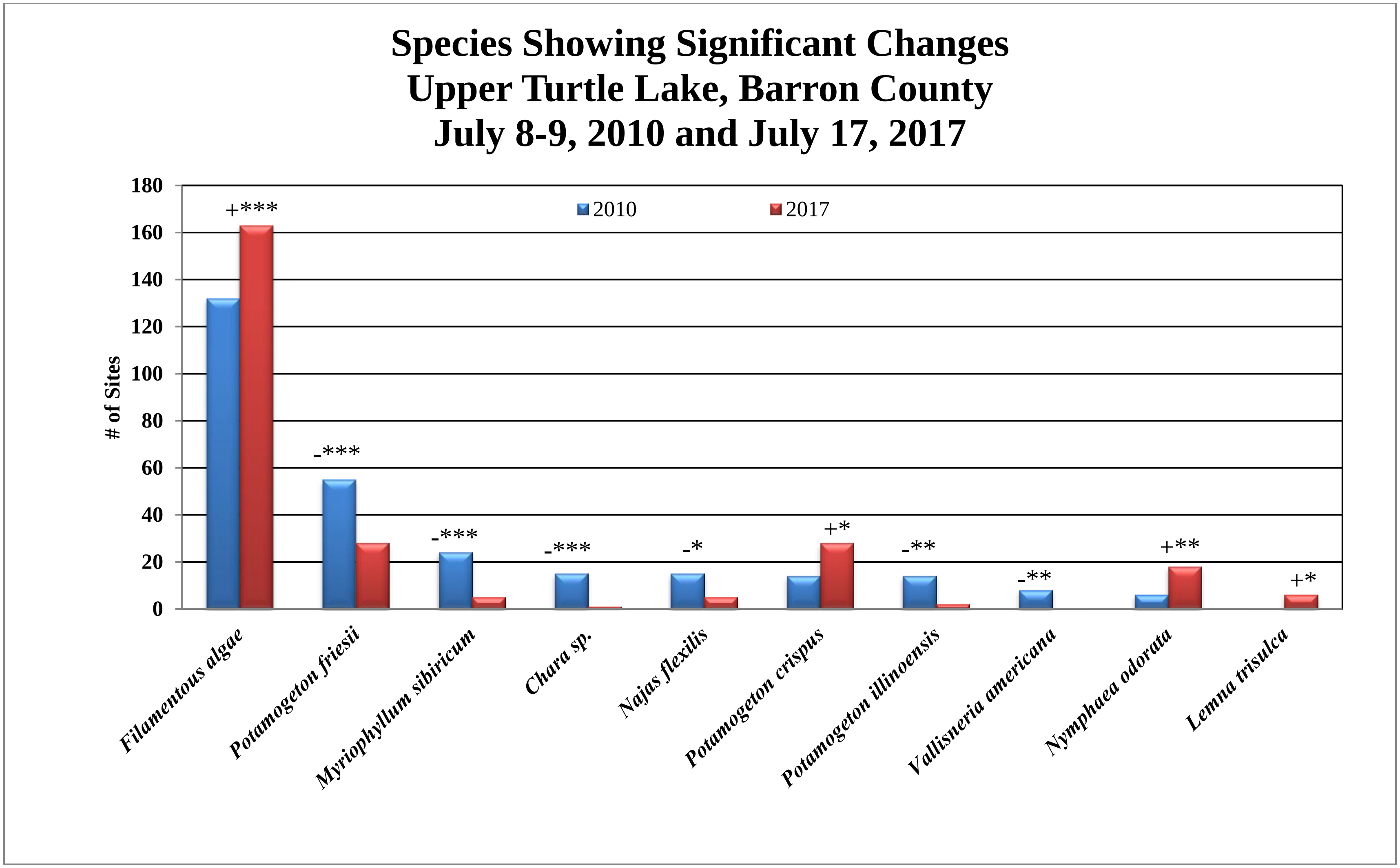
Curly-leaf pondweed (USGS 2017)

Comparison of Native Macrophyte Species in 2010 and 2017:

In July 2010, Coontail, Flat-stem pondweed, Fries' pondweed, and Small duckweed were the most common macrophyte species (Table 3). They were present at 67.47%, 51.81%, 33.13%, and 20.48% of survey points with vegetation respectively and accounted for 56.27% of the total relative frequency. Large duckweed (5.69), Common watermeal (5.69), Northern water-milfoil (4.71), and Small pondweed (4.31) also had relative frequencies over 3.0 (Maps for all species found in July 2010 are located in Appendix VI).

In 2017, Coontail, Flat-stem pondweed, Small duckweed, and Large duckweed/Common watermeal (tied for 4th place) were the most common macrophyte species. We found them at 70.55%, 42.94%, 25.15%, and 24.54% of sites with vegetation (Table 4), and the top four accounted for 57.45% of the total relative frequency. Common watermeal (8.64), CLP (6.05), Fries' pondweed (6.05), White water lily (3.89), Small pondweed (3.46), and Water star-grass (3.02) also had relative frequencies over 3.0 (Species accounts for all species found in 2010 and 2017, and maps for all plants found in July 2017 can be found in Appendixes VII and VIII).

Lakewide, ten species showed significant changes in distribution from 2010 to 2017 (Figure 10). Fries' pondweed, Northern water-milfoil, and Muskgrass suffered highly significant declines; Illinois pondweed and Wild celery experienced moderately significant declines; and Slender naiad saw a significant decline. Conversely, filamentous algae demonstrated a highly significant increase; White water lily had a moderately significant increase; and Curly-leaf pondweed and Forked duckweed experienced significant increases. Taken as a whole, these results suggest a habitat shift away from rooted species that need at least fair water clarity towards species that can tolerate poor clarity (White water lily), favor high suspended nutrient levels (duckweeds and filamentous algae), and disturbance (Curly-leaf pondweed).



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

Figure 10: Macrophytes Showing Significant Changes from 2010-2017

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Turtle Lake, Barron County
July 8-9, 2010

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
	Filamentous algae	132	*	79.52	49.81	1.89	1
Ceratophyllum demersum	Coontail	112	21.96	67.47	42.26	1.73	1
Potamogeton zosteriformis	Flat-stem pondweed	86	16.86	51.81	32.45	1.60	13
Potamogeton friesii	Fries' pondweed	55	10.78	33.13	20.75	1.91	3
Lemna minor	Small duckweed	34	6.67	20.48	12.83	1.94	0
Spirodela polyrhiza	Large duckweed	29	5.69	17.47	10.94	1.55	0
Wolffia columbiana	Common watermeal	29	5.69	17.47	10.94	1.69	1
Myriophyllum sibiricum	Northern water-milfoil	24	4.71	14.46	9.06	1.25	12
Potamogeton pusillus	Small pondweed	22	4.31	13.25	8.30	1.23	0
Chara sp.	Muskgrass	15	2.94	9.04	5.66	1.93	0
Najas flexilis	Slender naiad	15	2.94	9.04	5.66	1.53	3
Potamogeton crispus	Curly-leaf pondweed	14	2.75	8.43	5.28	1.14	5
Potamogeton illinoensis	Illinois pondweed	14	2.75	8.43	5.28	1.50	11
Stuckenia pectinata	Sago pondweed	12	2.35	7.23	4.53	1.75	5
Potamogeton richardsonii	Clasping-leaf pondweed	8	1.57	4.82	3.02	1.75	7
Vallisneria americana	Wild celery	8	1.57	4.82	3.02	1.38	1
Heteranthera dubia	Water star-grass	7	1.37	4.22	2.64	1.71	3
Nymphaea odorata	White water lily	6	1.18	3.61	2.26	1.50	5
Nuphar variegata	Spatterdock	4	0.78	2.41	1.51	3.00	0
Elodea canadensis	Common waterweed	2	0.39	1.20	0.75	2.00	0
Potamogeton obtusifolius	Blunt-leaf pondweed	2	0.39	1.20	0.75	1.00	0
Schoenoplectus tabernaemontani	Softstem bulrush	2	0.39	1.20	0.75	2.00	1
Acorus americanus	Sweet-flag	1	0.20	0.60	0.38	3.00	0
Decodon verticillatus	Swamp loosestrife	1	0.20	0.60	0.38	3.00	1

* Excluded from relative frequency analysis

Table 3 (cont): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Turtle Lake, Barron County
July 8-9, 2010

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Elatine minima	Waterwort	1	0.20	0.60	0.38	1.00	1
Eleocharis acicularis	Needle spikerush	1	0.20	0.60	0.38	1.00	0
Eleocharis erythropoda	Bald spikerush	1	0.20	0.60	0.38	3.00	1
Isoetes echinospora	Spiny spored-quillwort	1	0.20	0.60	0.38	2.00	1
Potamogeton praelongus	White-stem pondweed	1	0.20	0.60	0.38	1.00	1
Ranunculus aquatilis	White water crowfoot	1	0.20	0.60	0.38	2.00	0
Sagittaria latifolia	Common arrowhead	1	0.20	0.60	0.38	1.00	0
Sagittaria rigida	Sessile-fruited arrowhead	1	0.20	0.60	0.38	3.00	1
Carex comosa	Bottle brush sedge	**	**	**	**	**	2
Phalaris arundinacea	Reed canary grass	**	**	**	**	**	2
Sparganium eurycarpum	Common bur-reed	**	**	**	**	**	2
Typha angustifolia	Narrow-leaved cattail	**	**	**	**	**	1
Bolboschoenus fluviatilis	River bulrush	***	***	***	***	***	***
Carex hystericina	Porcupine sedge	***	***	***	***	***	***
Sagittaria cristata	Crested arrowhead	***	***	***	***	***	***
Schoenoplectus acutus	Hardstem bulrush	***	***	***	***	***	***
Typha latifolia	Broad-leaved cattail	***	***	***	***	***	***

* Excluded from relative frequency analysis ** Visual only *** Boat survey only

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Turtle Lake, Barron County
July 17, 2017

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
	Filamentous algae	163	*	100.00	59.71	1.65	0
Ceratophyllum demersum	Coontail	115	24.84	70.55	42.12	1.71	4
Potamogeton zosteriformis	Flat-stem pondweed	70	15.12	42.94	25.64	1.34	7
Lemna minor	Small duckweed	41	8.86	25.15	15.02	2.20	0
Spirodela polyrhiza	Large duckweed	40	8.64	24.54	14.65	1.15	0
Wolffia columbiana	Common watermeal	40	8.64	24.54	14.65	1.33	0
Potamogeton crispus	Curly-leaf pondweed	28	6.05	17.18	10.26	1.00	1
Potamogeton friesii	Fries' pondweed	28	6.05	17.18	10.26	1.11	1
Nymphaea odorata	White water lily	18	3.89	11.04	6.59	2.06	4
Potamogeton pusillus	Small pondweed	16	3.46	9.82	5.86	1.00	0
Heteranthera dubia	Water star-grass	14	3.02	8.59	5.13	1.21	1
Stuckenia pectinata	Sago pondweed	11	2.38	6.75	4.03	1.09	3
Lemna trisulca	Forked duckweed	6	1.30	3.68	2.20	1.00	0
Nuphar variegata	Spatterdock	6	1.30	3.68	2.20	2.67	2
Myriophyllum sibiricum	Northern water-milfoil	5	1.08	3.07	1.83	1.40	0
Najas flexilis	Slender naiad	5	1.08	3.07	1.83	1.00	1
Elodea canadensis	Common waterweed	4	0.86	2.45	1.47	1.00	0
Phalaris arundinacea	Reed canary grass	2	0.43	1.23	0.73	1.00	2
Potamogeton illinoensis	Illinois pondweed	2	0.43	1.23	0.73	1.00	1
Potamogeton praelongus	White-stem pondweed	2	0.43	1.23	0.73	1.00	1

*Excluded from relative frequency analysis

Table 4 (cont): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Turtle Lake, Barron County
July 17, 2017

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton richardsonii	Clasping-leaf pondweed	2	0.43	1.23	0.73	1.00	1
Carex comosa	Bottle brush sedge	1	0.22	0.61	0.37	1.00	0
Chara sp.	Muskgrass	1	0.22	0.61	0.37	1.00	0
Decodon verticillatus	Swamp loosestrife	1	0.22	0.61	0.37	3.00	1
Elatine minima	Waterwort	1	0.22	0.61	0.37	1.00	0
Eleocharis erythropoda	Bald spikerush	1	0.22	0.61	0.37	3.00	0
Isoetes echinospora	Spiny spored-quillwort	1	0.22	0.61	0.37	1.00	0
Ranunculus aquatilis	White water crowfoot	1	0.22	0.61	0.37	1.00	0
Schoenoplectus acutus	Hardstem bulrush	1	0.22	0.61	0.37	1.00	0
Sparganium eurycarpum	Common bur-reed	**	**	**	**	**	1
Bolboschoenus fluviatilis	River bulrush	***	***	***	***	***	***
Calla palustris	Wild calla	***	***	***	***	***	***
Carex hystericina	Porcupine Sedge	***	***	***	***	***	***
Sagittaria cristata	Crested arrowhead	***	***	***	***	***	***
Sagittaria latifolia	Common arrowhead	***	***	***	***	***	***
Schoenoplectus tabernaemontani	Softstem bulrush	***	***	***	***	***	***
Typha angustifolia	Narrow-leaved cattail	***	***	***	***	***	***
Typha latifolia	Broad-leaved cattail	***	***	***	***	***	***
Vallisneria americana	Wild celery	***	***	***	***	***	***

** Visual only *** Boat survey only

Found throughout the lake's organic muck bottom bays, Coontail was the most common species in both 2010 and 2017. We noted that both its overall distribution (112 points in 2010/115 in 2017) and density (mean rake fullness of 1.73 in 2010/1.71 in 2017) were essentially unchanged; however, visual analysis of the maps showed it was greatly reduced in the north bay (presumably in response to competition from CLP and mats of filamentous algae shading it out) but expanded throughout the southern 2/3rds of the lake (likely at the expense of more sensitive species) (Figure 11).

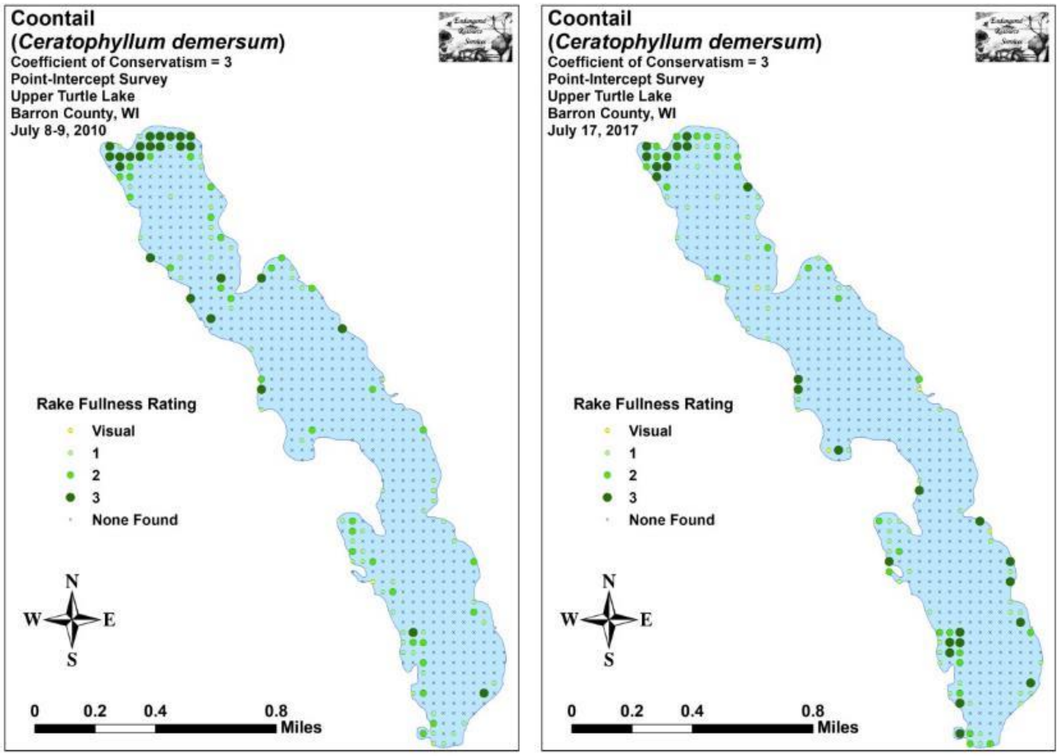


Figure 11: 2010 and 2017 Coontail Density and Distribution

We found Flat-stem pondweed was the second most common native macrophyte species in both 2010 and 2017. Although its decline in distribution (86 sites in 2010/70 sites in 2017) was not significant (p=0.11), it did suffer a moderately significant decline **(p=0.005)** in density from a mean rake fullness of 1.60 in 2010 to a mean rake of 1.34 in 2017 (Figure 12).

Significant lakewide declines were seen in many other important habitat producing species. Fries' pondweed (the third most common species in 2010, but just the sixth most common in 2017) exhibited highly significant declines **(p<0.001)** in both distribution (55 sites 2010/28 sites 2017) and density (mean rake 1.91 in 2010/mean rake 1.11 in 2017) (Figure 13). Likewise, Northern water-milfoil (24 sites/mean rake 1.25 in 2010 and 5 sites/mean rake 1.40) (Figure 14) and Muskgrass (15 sites/mean rake 1.93 in 2010 and 1 site/mean rake 1.00 in 2017) (Figure 15) suffered highly significant declines in distribution **(p<0.001)** and nearly disappeared from the lake.

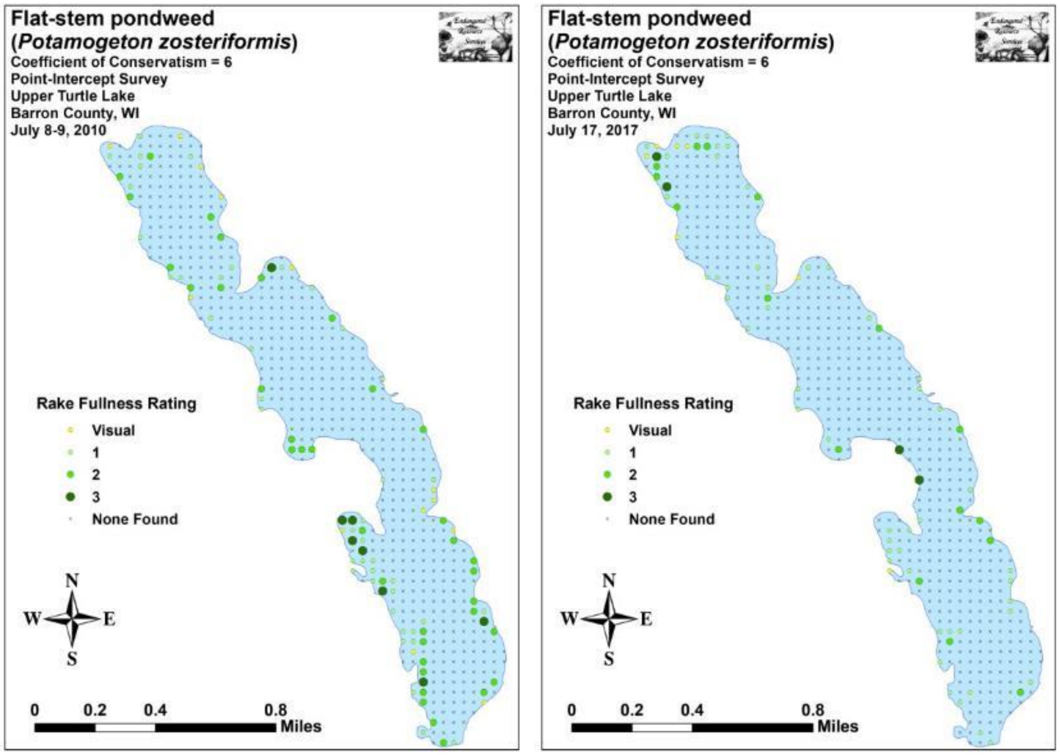


Figure 12: 2010 and 2017 Flat-stem Pondweed Density and Distribution

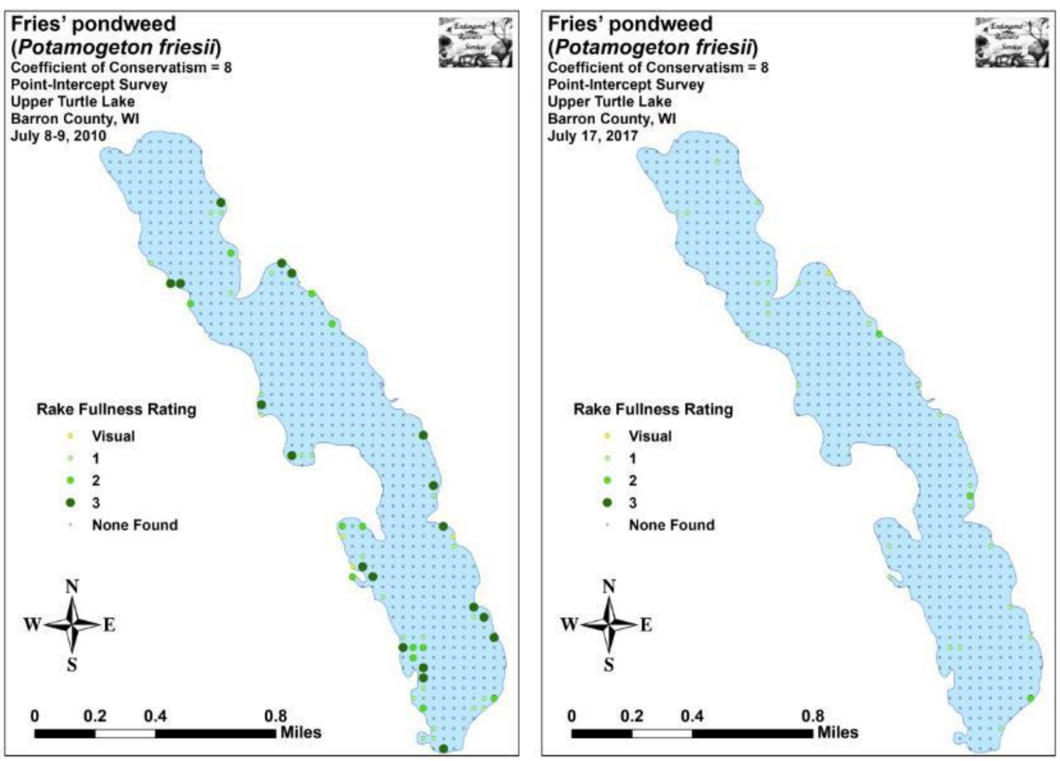


Figure 13: 2010 and 2017 Fries' Pondweed Density and Distribution

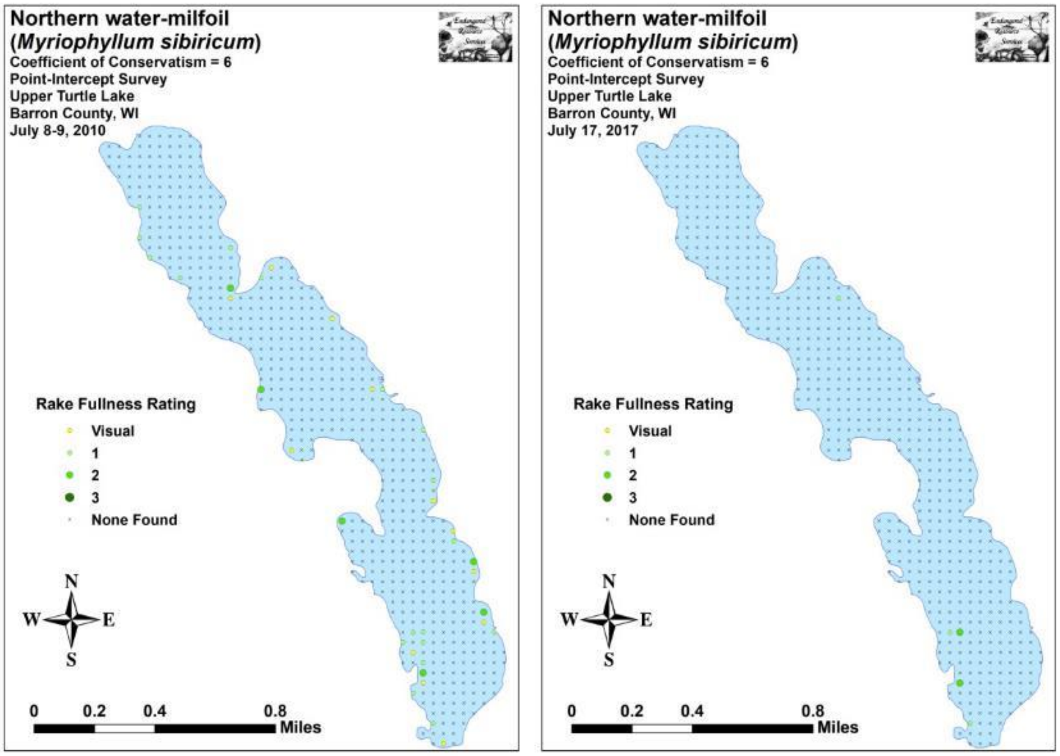


Figure 14: 2010 and 2017 Northern Water-milfoil Density and Distribution

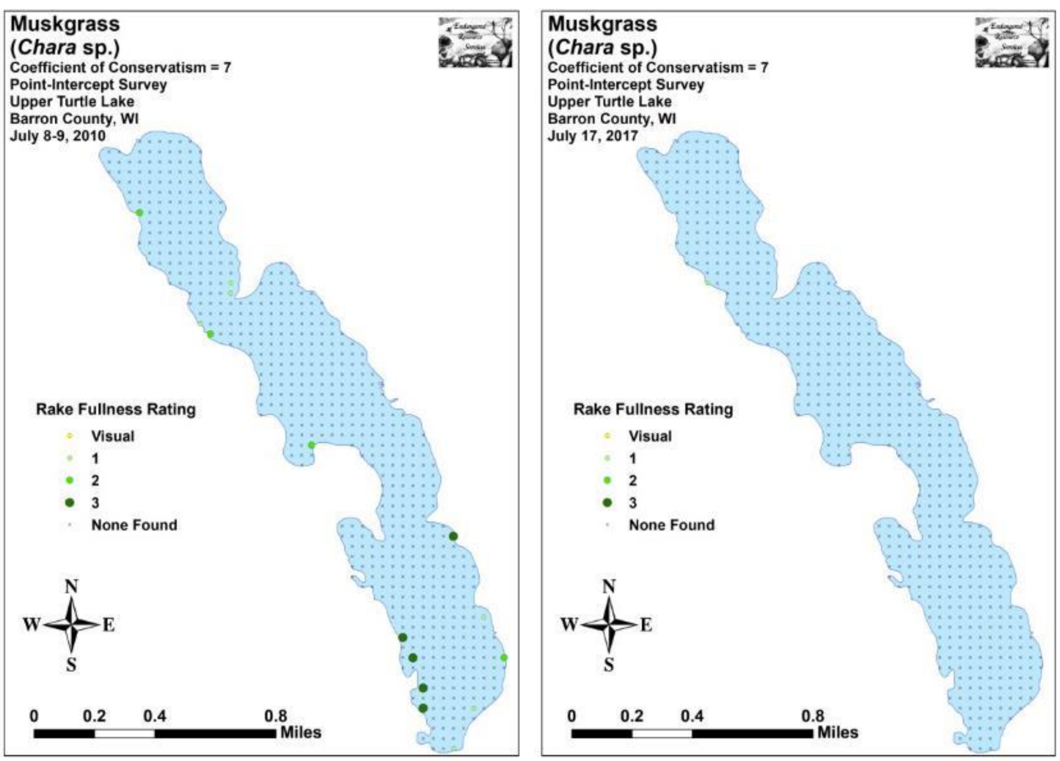


Figure 15: 2010 and 2017 Muskgrass Density and Distribution

Comparison of Floristic Quality Indexes in 2010 and 2017:

In 2010, we identified a total of 29 **native index species** in the rake during the point-intercept survey (Table 5). They produced a mean Coefficient of Conservatism of 5.9 and a Floristic Quality Index of 31.6.

Table 5: Floristic Quality Index of Aquatic Macrophytes
Upper Turtle Lake, Barron County
July 8-9, 2010

Species	Common Name	C
Acorus americanus	Sweet-flag	7
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elatine minima	Waterwort	9
Eleocharis acicularis	Needle spikerush	5
Eleocharis erythropoda	Bald spikerush	3
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Isoetes echinospora	Spiny-spored quillwort	8
Lemna minor	Small duckweed	4
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton obtusifolius	Blunt-leaf pondweed	9
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	8
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8
Sagittaria latifolia	Common arrowhead	3
Sagittaria rigida	Sessile-fruited arrowhead	8
Schoenoplectus tabernaemontani	Softstem bulrush	4
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Vallisneria americana	Wild celery	6
Wolffia columbiana	Common watermeal	5
N		**29**
Mean C		**5.9**
FQI		**31.6**

In 2017, we identified a total of 25 **native index plants** in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 5.8 and a Floristic Quality Index of 29.0 (Table 6). Nichols (1999) reported an average mean C for the North Central Hardwood Forests Region of 5.6 putting Upper Turtle Lake slightly above average for this part of the state. The FQI was, however, well above the median FQI of 20.9 for the North Central Hardwood Forests (Nichols 1999).

Table 6: Floristic Quality Index of Aquatic Macrophytes Upper Turtle Lake, Barron County July 17, 2017

Species	Common Name	C
Carex comosa	Bottle brush sedge	5
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elatine minima	Waterwort	9
Eleocharis erythropoda	Bald spikerush	3
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Isoetes echinospora	Spiny-spored quillwort	8
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Potamogeton friesii	Fries' pondweed	8
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8
Schoenoplectus acutus	Hardstem bulrush	6
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Wolffia columbiana	Common watermeal	5
N		**25**
Mean C		**5.8**
FQI		**29.0**

Comparison of Filamentous Algae in 2010 and 2017:

Filamentous algae, normally associated with excessive nutrients in the water column, were located at 163 survey points in 2017. Although this was a highly significant increase **(p<0.001)** in distribution from the 132 points they were found at in 2010, algal density experienced a moderately significant **(p=0.002)** decline in mean rake fullness from 1.89 in 2010 to 1.65 in 2017 (Figure 16).

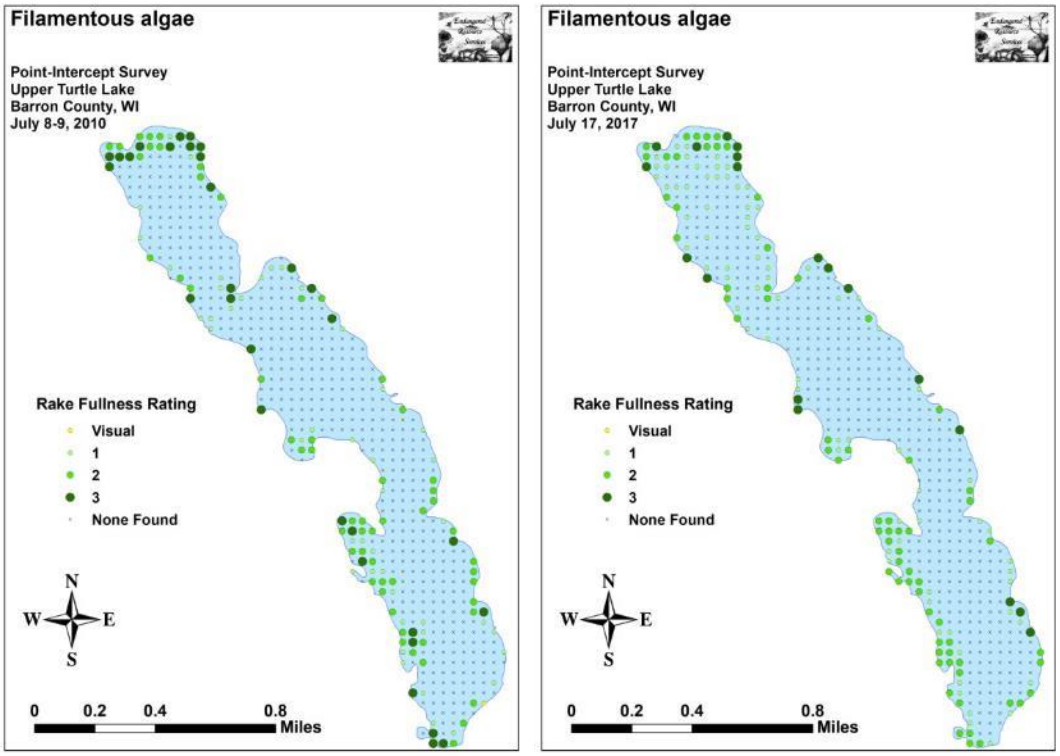


Figure 16: 2010 and 2017 Filamentous Algae Density and Distribution

Comparison of Midsummer Curly-leaf Pondweed in 2010 and 2017:

Curly-leaf pondweed normally completes its annual life cycle by late June, and most plants have set turions and senesced by early July. In 2010, CLP was still present at 14 points (mean rake fullness 1.14) and was a visual at five additional points. Despite being a week later than the July 2010 survey, in 2017 we documented a significant increase **(*p*=0.02)** in distribution to 28 points (mean rake fullness of 1.00) with one additional point where it was a visual. We also raked up viable turions at 25 locations (Figure 17).

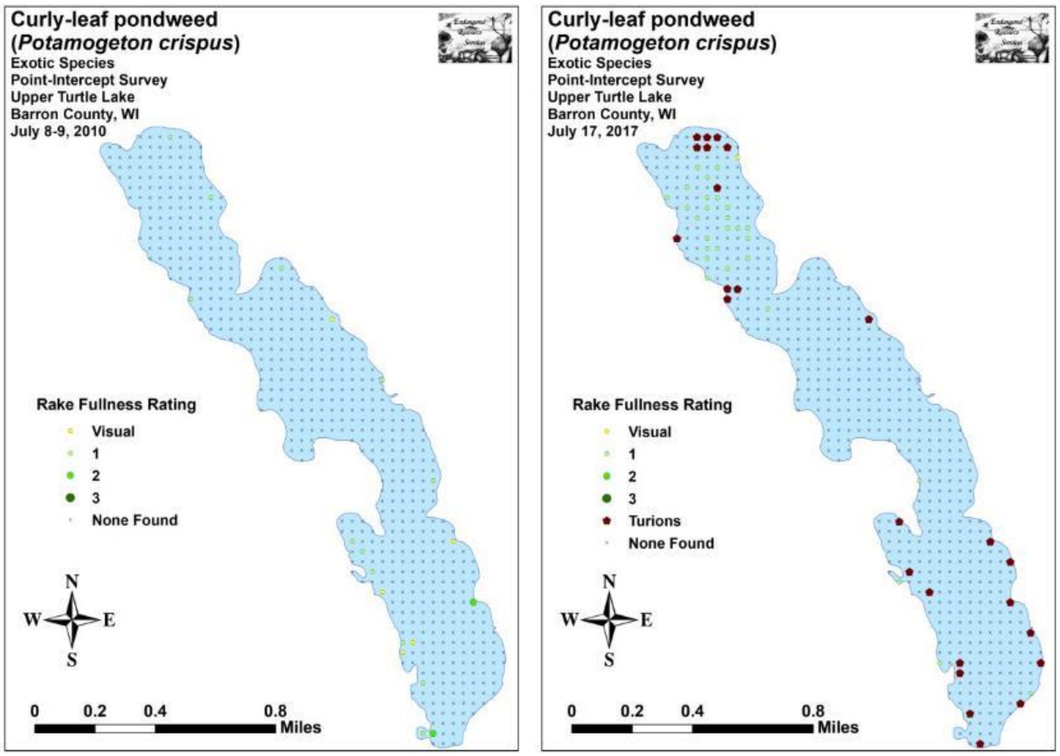


Figure 17: 2010 and 2017 Midsummer CLP Density and Distribution

Other Exotic Plant Species:

We did NOT find any evidence or Eurasian water-milfoil in Upper Turtle Lake during any of our surveys. However, in addition to Curly-leaf pondweed, we documented two other exotic species growing around the lake: Reed canary grass and Narrow-leaved cattail. Despite only being recorded in the rake at two points and as a visual at two additional points (Figure 18), Reed canary grass was often a dominant plant just beyond the lakeshore in adjacent wetlands and next to mowed or otherwise disturbed shoreline areas. A ubiquitous plant in the state, there's likely little that can be done about it.

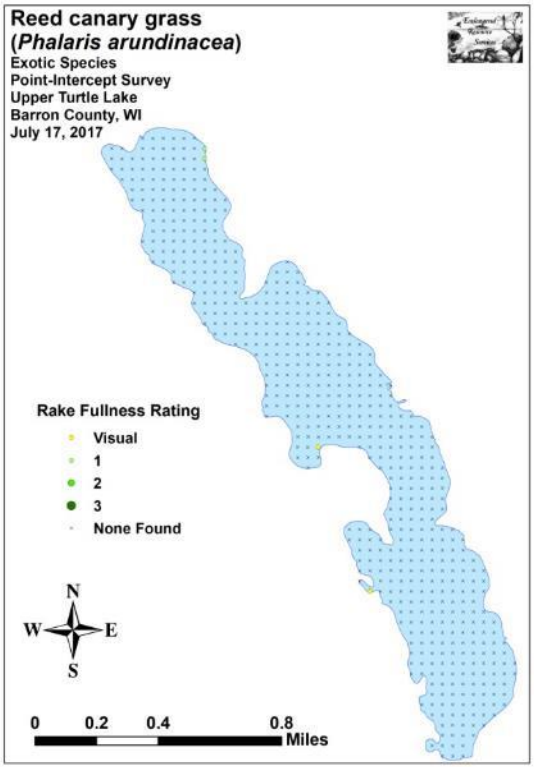


Figure 18: Reed Canary Grass Density and Distribution

Native to southern but not northern Wisconsin, Narrow-leaved cattail and its hybrids with Broad-leaved cattail are becoming increasingly common in northern Wisconsin where they also tend to be invasive. We found a few small stands of Narrow-leaved cattail/Hybrid cattail scattered along the western shoreline where they appeared to be expanding in shallow water and crowding out other emergent species.

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 19) (For more information on a sampling of aquatic exotic invasive plant species, see Appendix IX).

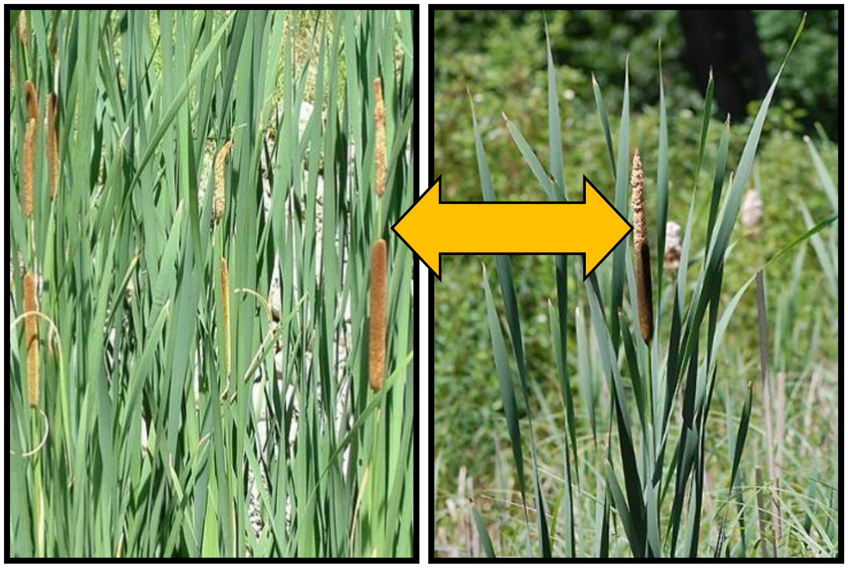


Figure 19: Exotic Hybrid and Native Broad-leaved Cattail Identification

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

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

Like trees in a forest, a lake's native 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. Unfortunately, when phosphorus and nitrogen levels exceed what the lake's macrophytes can utilize, it tends to promote algae blooms which impact these sensitive species as well as general lake esthetics.

Although upstream agricultural runoff can be a major contributor to a lake's overall nutrient load, soil erosion and nutrient inputs from along the immediate lakeshore can also have significant impacts. Because of this, all lake residents have the opportunity to help reduce runoff by evaluating how their shoreline practices may be affecting the lake. Simple things like establishing or maintaining their own buffer strip of native vegetation along the lake shore to prevent erosion, building rain gardens, bagging grass clippings, switching to a phosphorus-free fertilizer or preferably eliminating fertilizer near the lake altogether, collecting pet waste, and disposing of the ash from fire pits away from the lakeshore can all significantly reduce the amount of nutrients entering the ecosystem. Hopefully, a greater understanding of how all property owners can have lakewide impacts will result in more people taking appropriate conservation actions to not only help improve water clarity and quality, but also to benefit the lake's important habitat producing native plant species.

Curly-leaf Pondweed Management:

During our 2010 early-season Curly-leaf pondweed surveys, we found that CLP was present throughout the lake, but it was not acting overly invasive and appeared to be "just another plant species" in the lake's macrophyte community. In July 2010, we also noted that native species had recolonized most of the areas CLP occupied earlier in the growing season. In 2017, this was not the case as water clarity was so poor that there was almost no regrowth on the outer edge of the littoral zone following CLP's late June senescence. This poor clarity appeared to be creating a negative feedback loop as most plants in water >6ft deep were dying and turning black. Ultimately, as they rotted, they were contributing more nutrients to the water column and thus producing even more algae leading to even poorer clarity.

Exotic species tend to proliferate in these types of disturbed environments, and their expansion in an ecosystem can potentially be symptomatic rather than causative. The explosion in Curly-leaf pondweed density and distribution since 2010 suggests there has been a fundamental change in the Upper Turtle Lake ecosystem. That such an incredible biomass has grown up in the north bay could mean that a new source of nutrients is feeding into the lake. Ultimately, a phosphorus/nitrogen study within the lake's watershed would be needed to pinpoint if this is the case. Although that study would likely be expensive, the results could shed light on what has happened to the lake; and, more importantly, be used to help guide a path to restoration rather than simply trying to manage the CLP infestation as it currently is.

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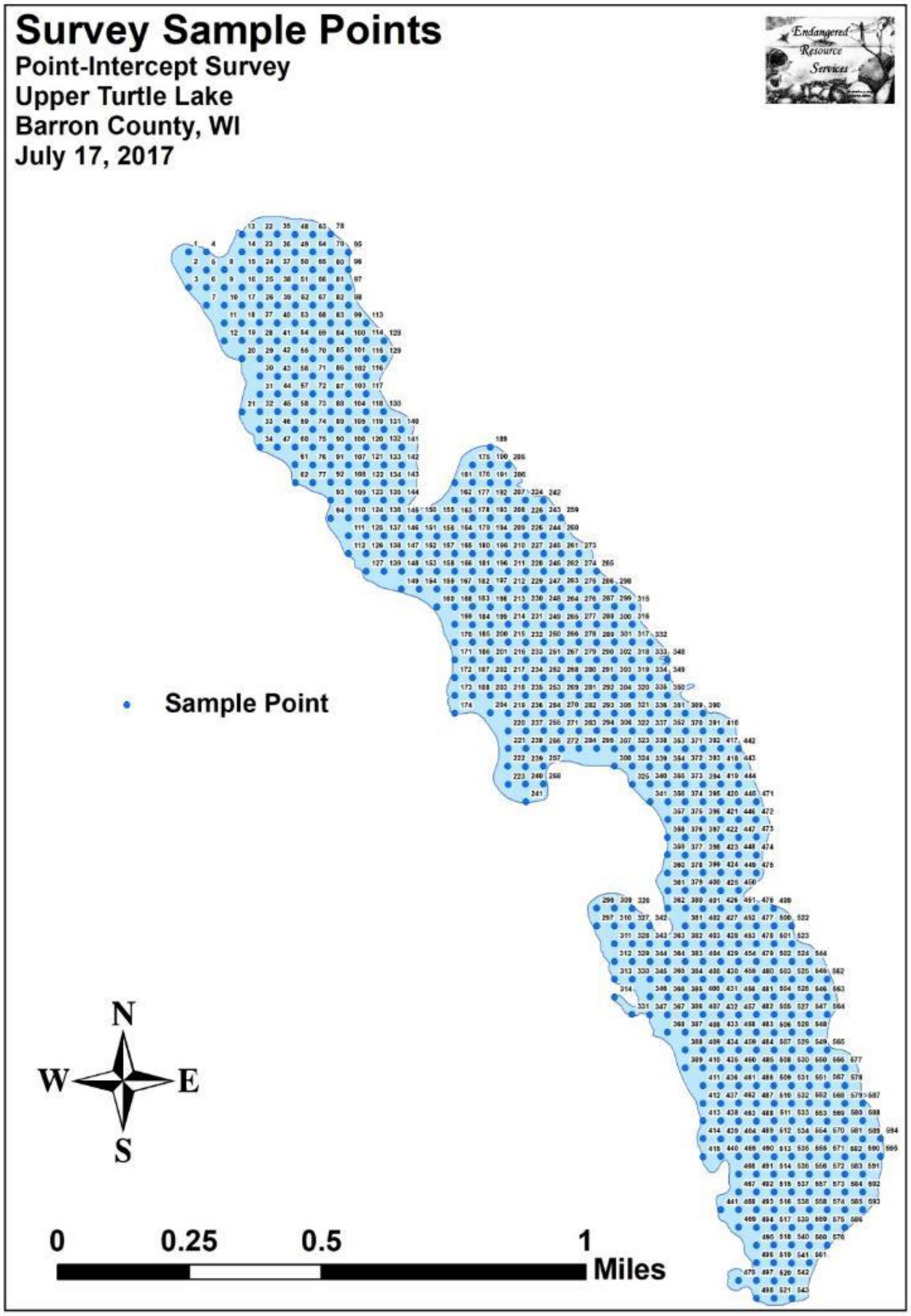
WDNR. [online]. 2010. Reed canary grass fact sheet. http://dnr.wi.gov/invasives/fact/reed_canary.htm (2010, August).

Appendix I: Survey Sample Points Map

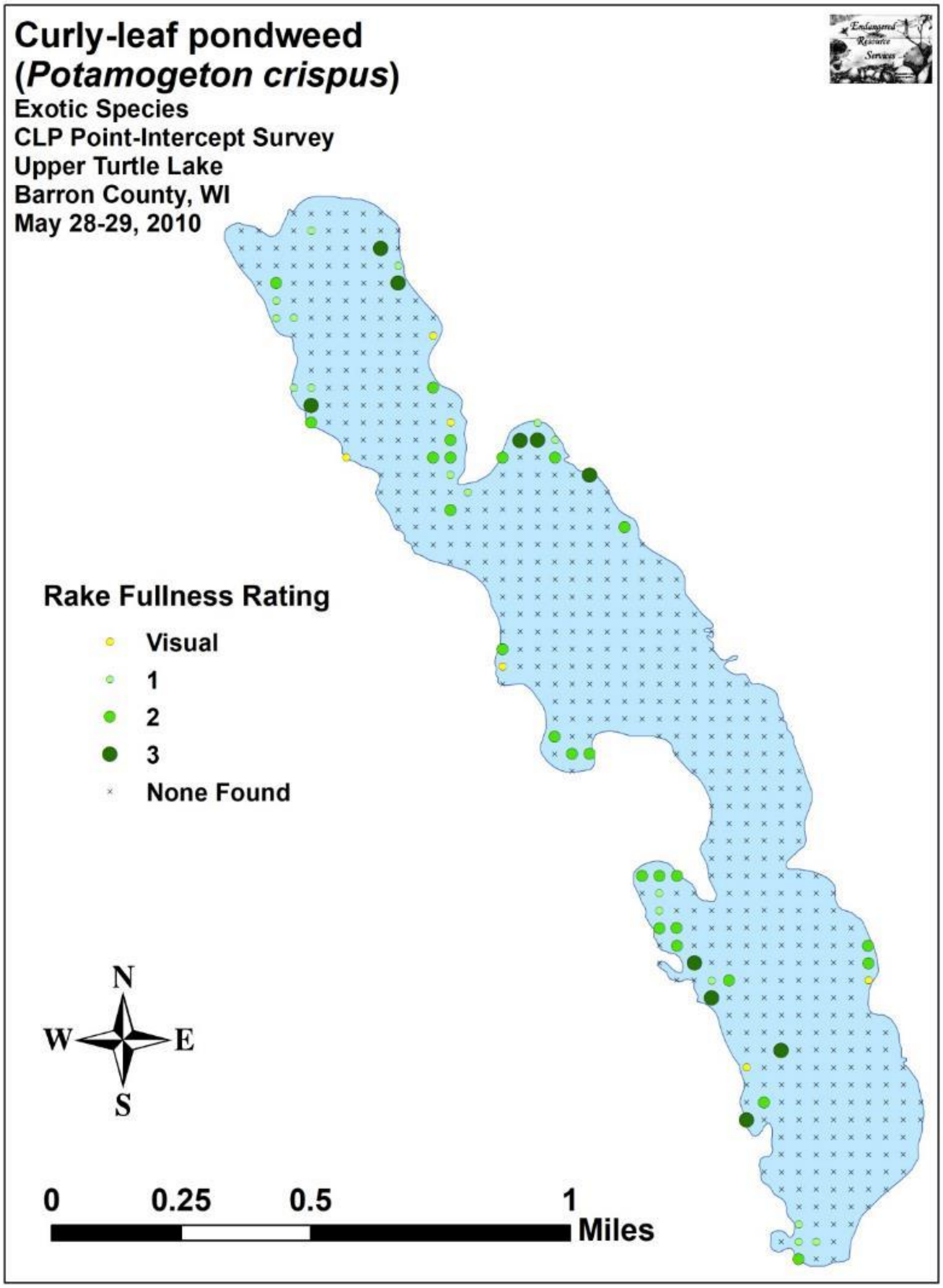

Survey Sample Points
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Sample Point
N
W
E
S
0
0.25
0.5
1
Miles

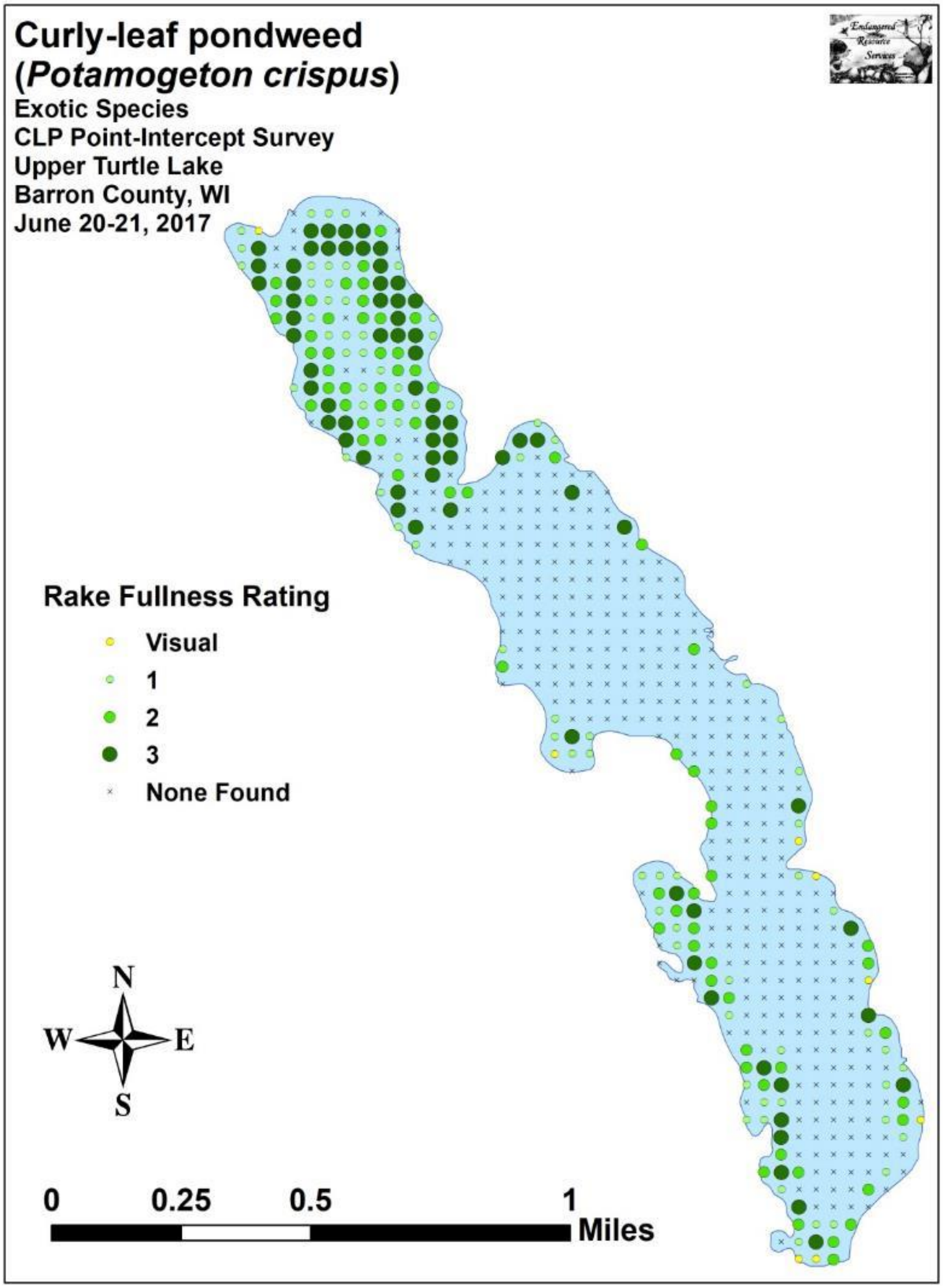
Appendix II: Boat and Vegetative Survey Datasheets

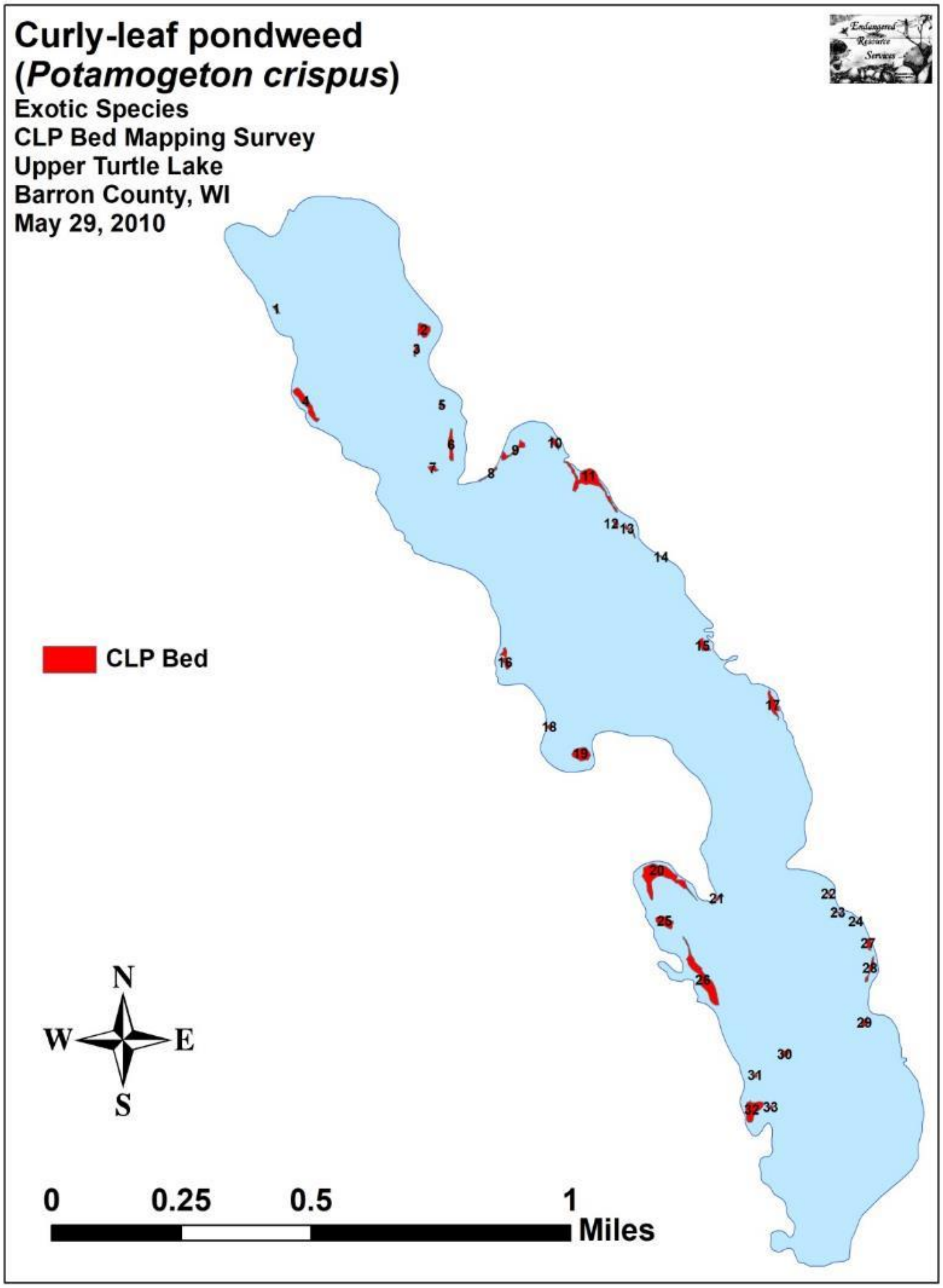
Boat Survey	
Lake Name	
County	
WBIC	
Date of Survey	
(mm/dd/yy)	
workers	
Nearest Point	**Species seen, habitat information**

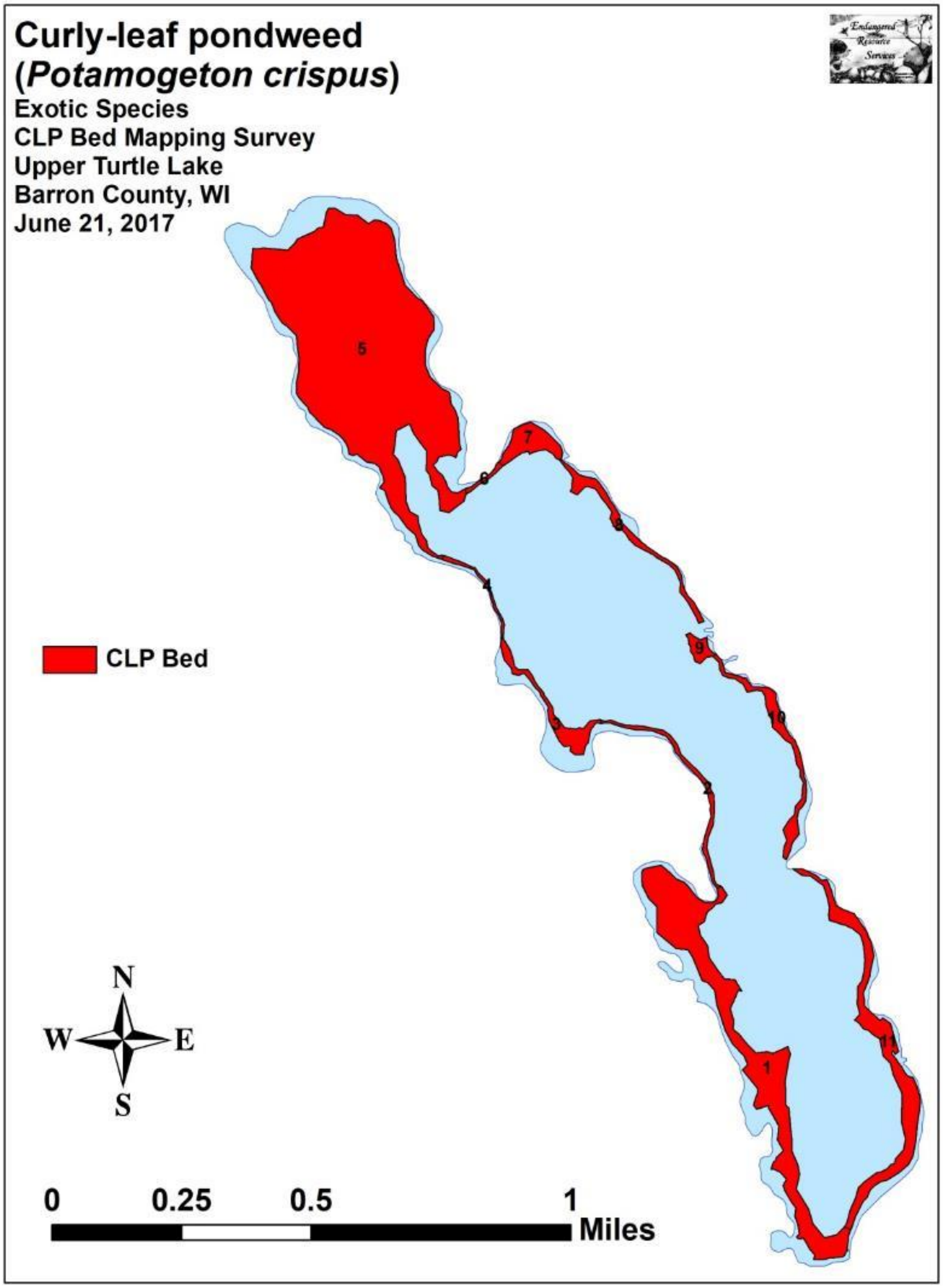
Observers for this lake: names and hours worked by each:																									
Lake:									**WBIC**									**County**						**Date:**	
Site #	**Depth (ft)**	**Muck (M), Sand (S), Rock (R)**	**Rake pole (P) or rake rope (R)**	**Total Rake Fullness**	**EWM**	**CLP**	**1**	**2**	**3**	**4**	**5**	**6**	**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: 2010 and 2017 Early-season CLP Density and Distribution and CLP Bed Maps

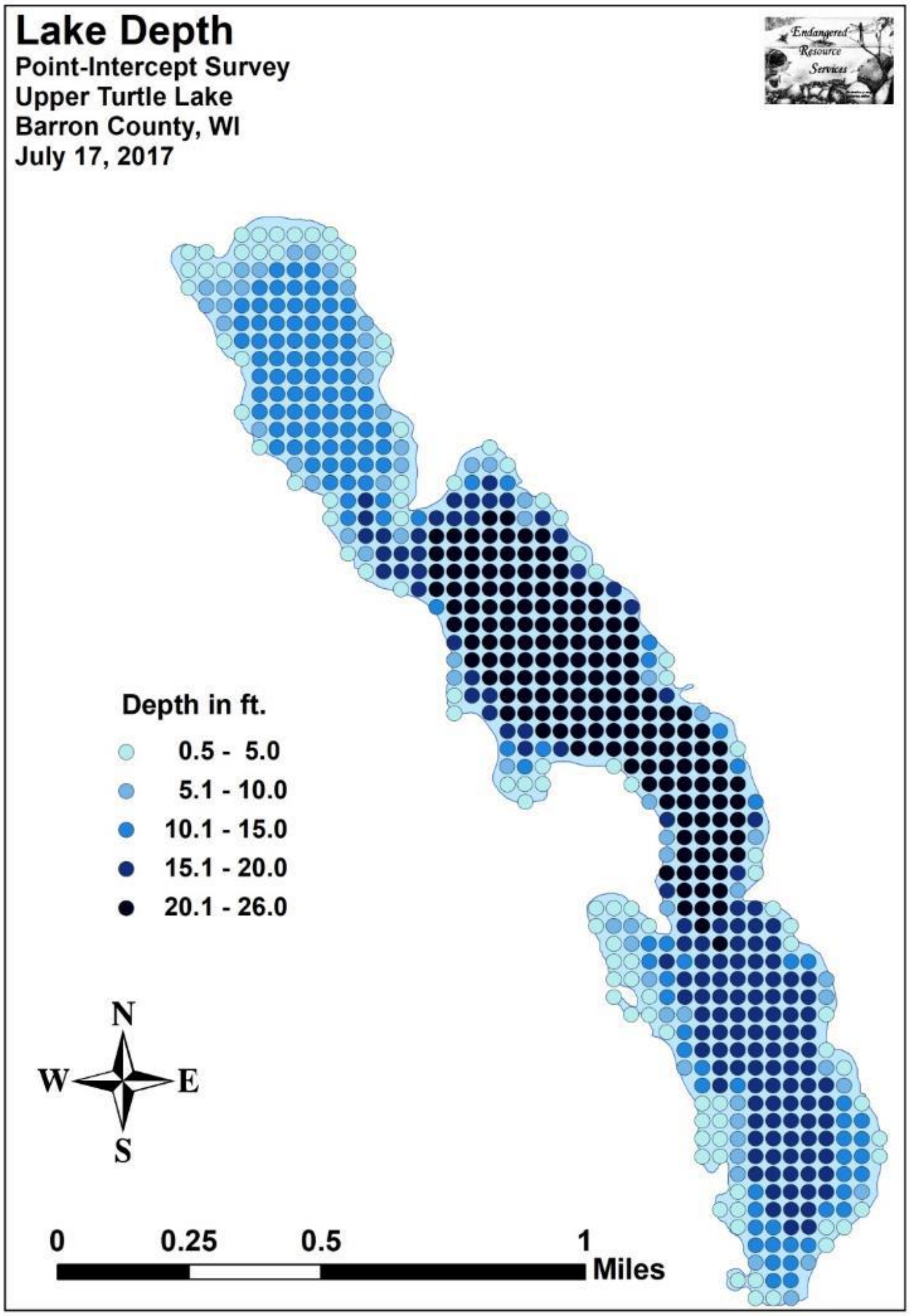

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
May 28-29, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

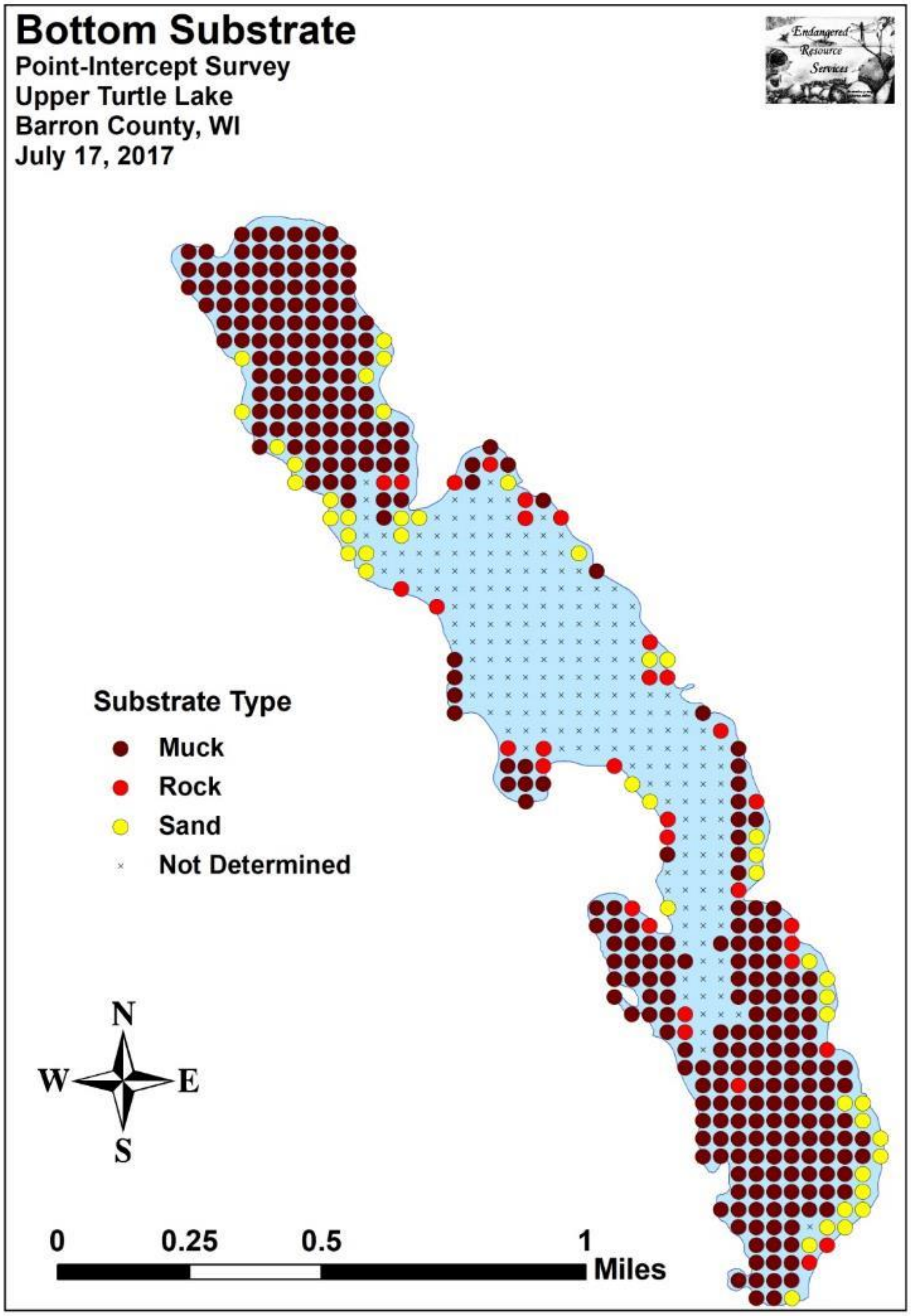

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
June 20-21, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Bed Mapping Survey
Upper Turtle Lake
Barron County, WI
May 29, 2010
CLP Bed
N
W
E
S
0
0.25
0.5
1
Miles

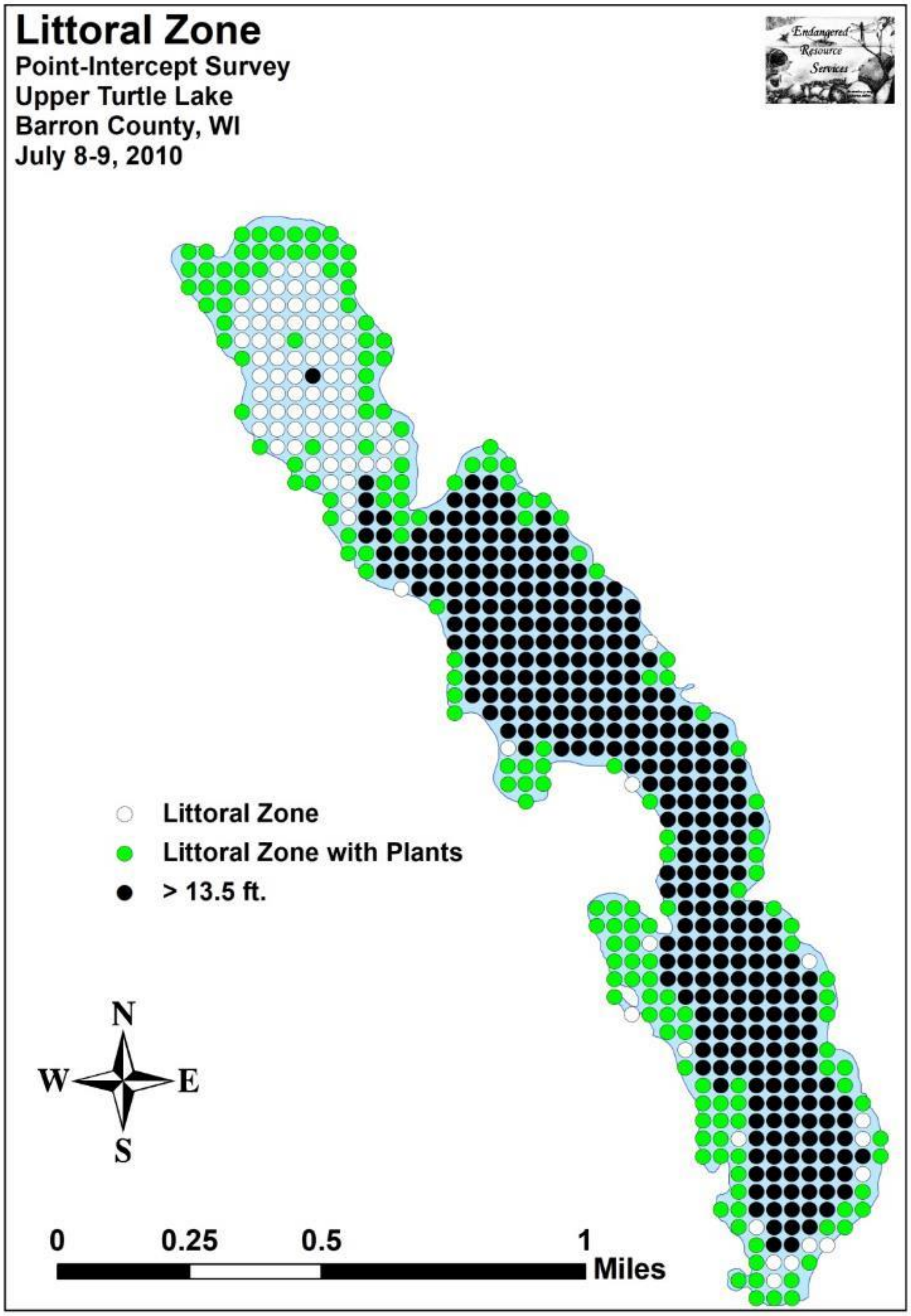

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Bed Mapping Survey
Upper Turtle Lake
Barron County, WI
June 21, 2017
CLP Bed
N
W
E
S
0
0.25
0.5
1
Miles
5
7
6
8
4
9
3
10
2
1
11

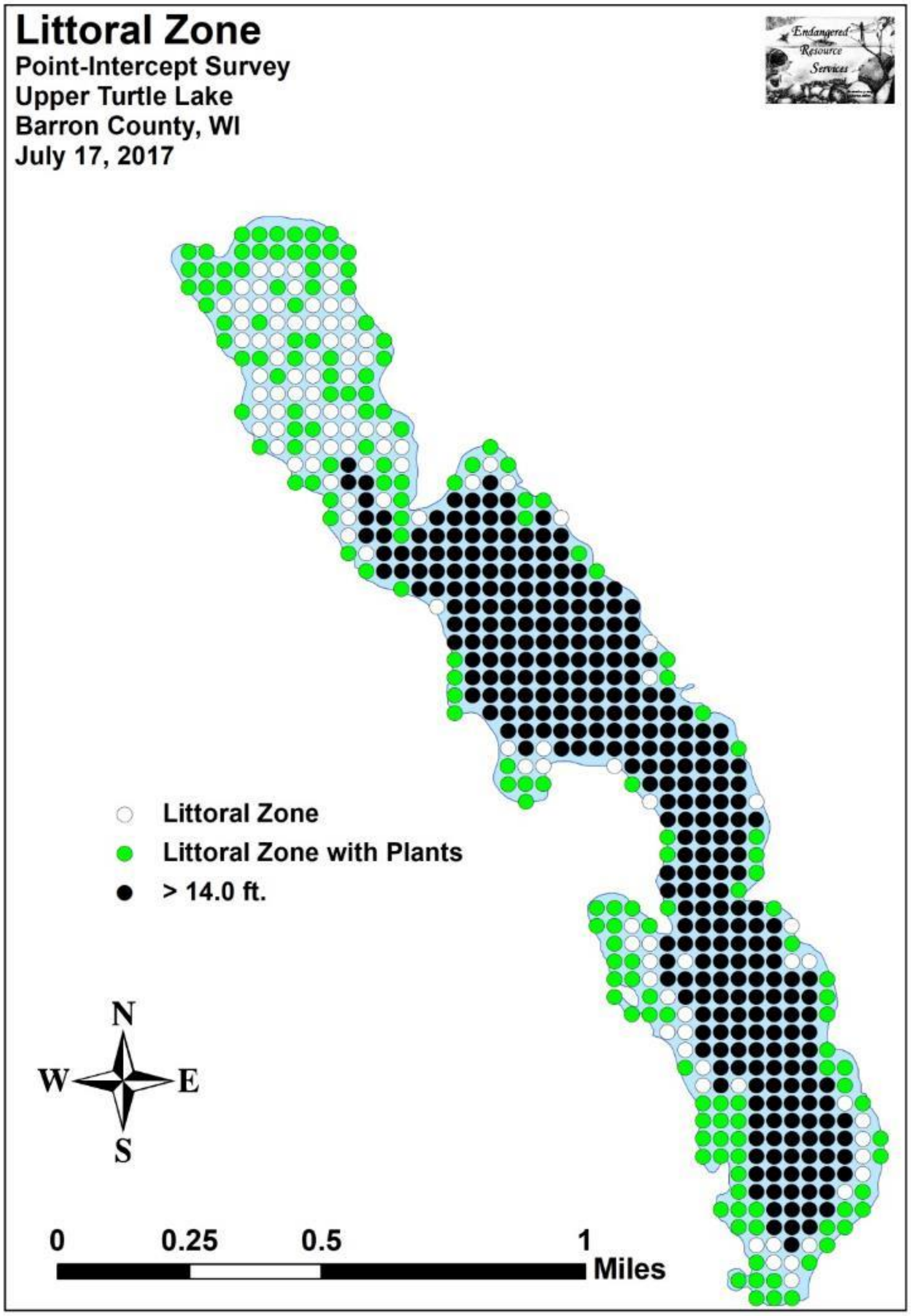
Appendix IV: Habitat Variable Maps


Lake Depth
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Depth in ft.
0.5 - 5.0
5.1 - 10.0
10.1 - 15.0
15.1 - 20.0
20.1 - 26.0
N
W
E
S
0
0.25
0.5
1
Miles

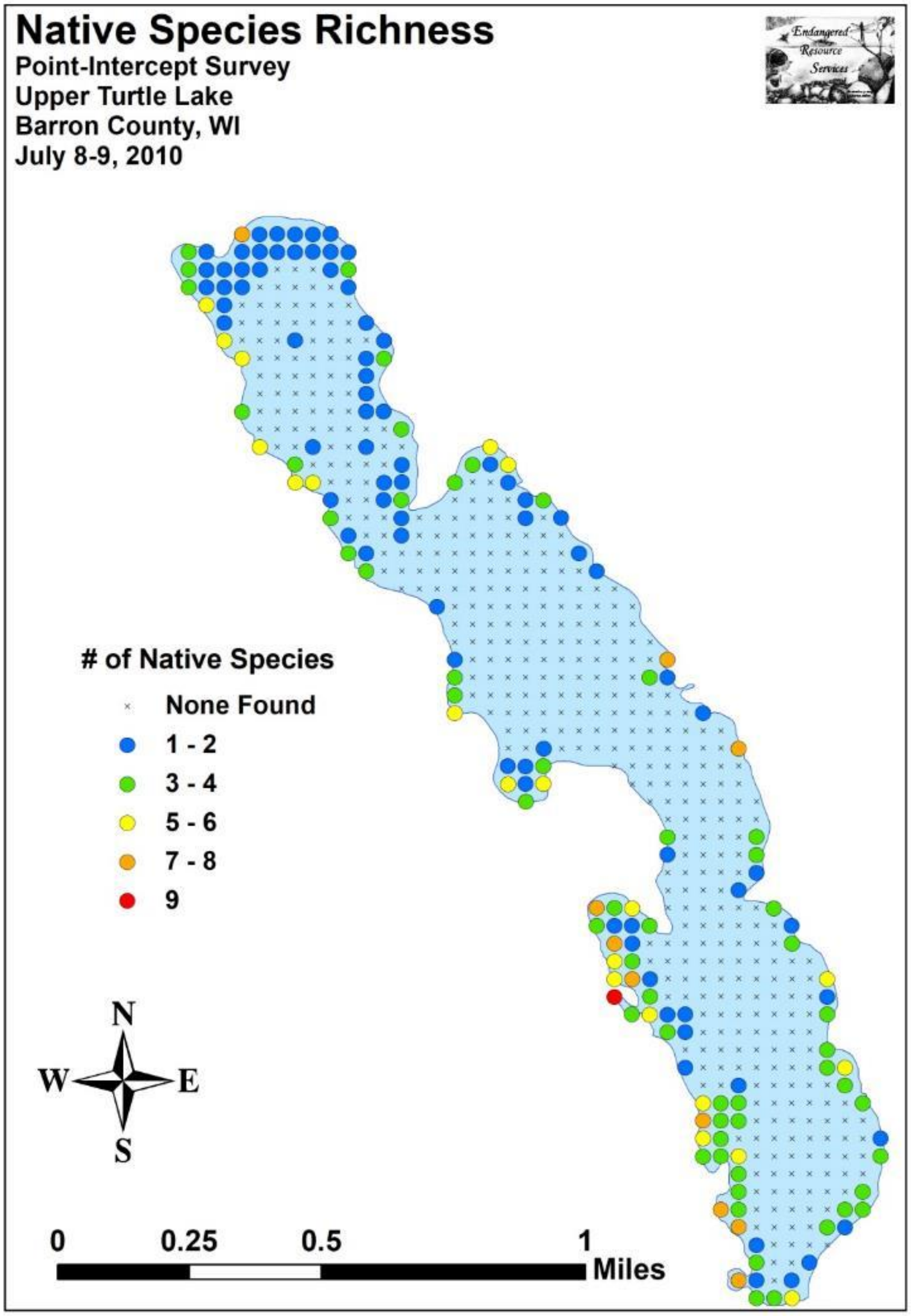

Bottom Substrate
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Substrate Type
Muck
Rock
Sand
Not Determined
N
W
E
S
0
0.25
0.5
1
Miles

Appendix V: 2010 and 2017 Littoral Zone, Native Species Richness and Total Rake Fullness Maps

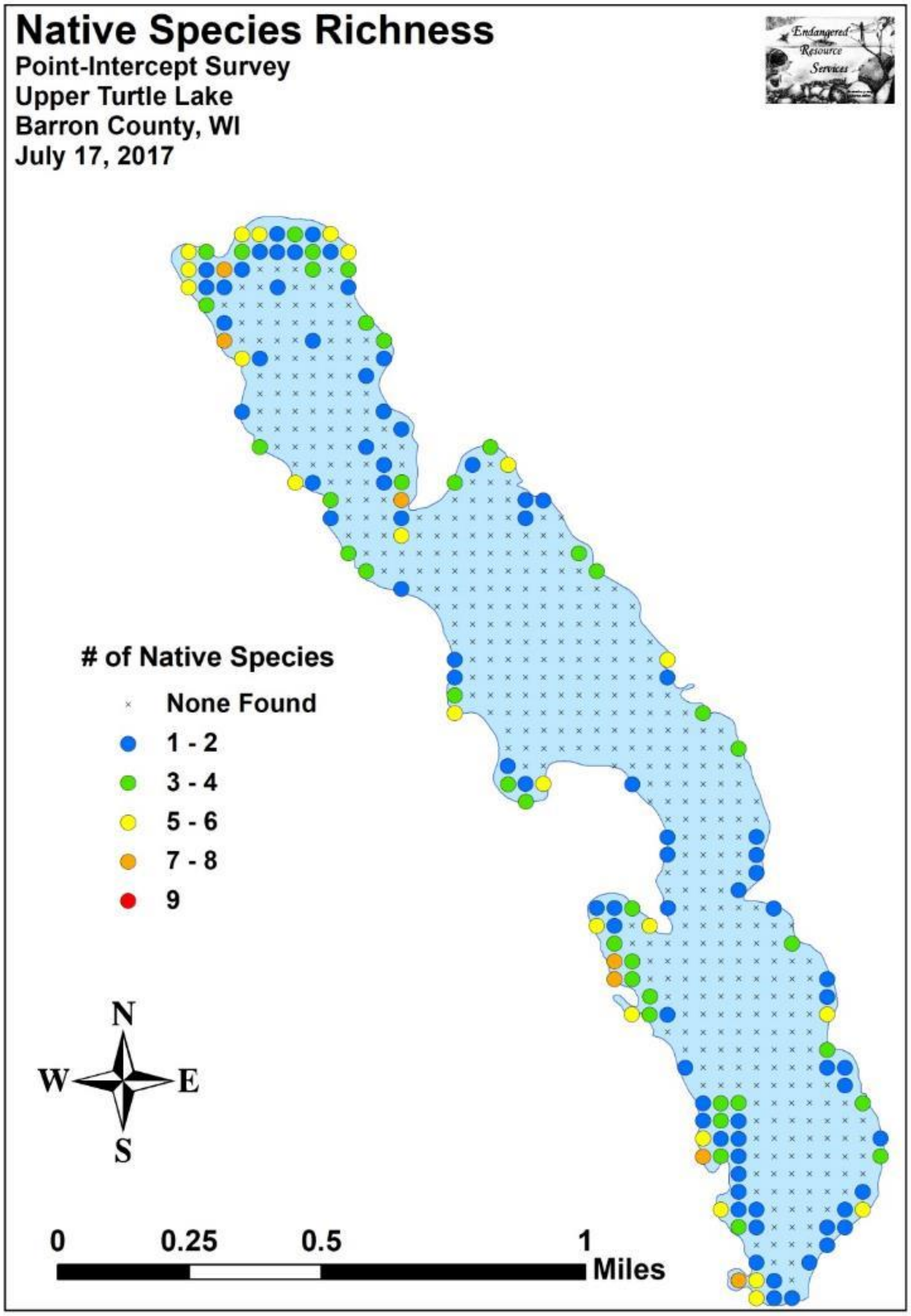

Littoral Zone
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Littoral Zone
Littoral Zone with Plants
> 13.5 ft.
N
W
E
S
0
0.25
0.5
1
Miles

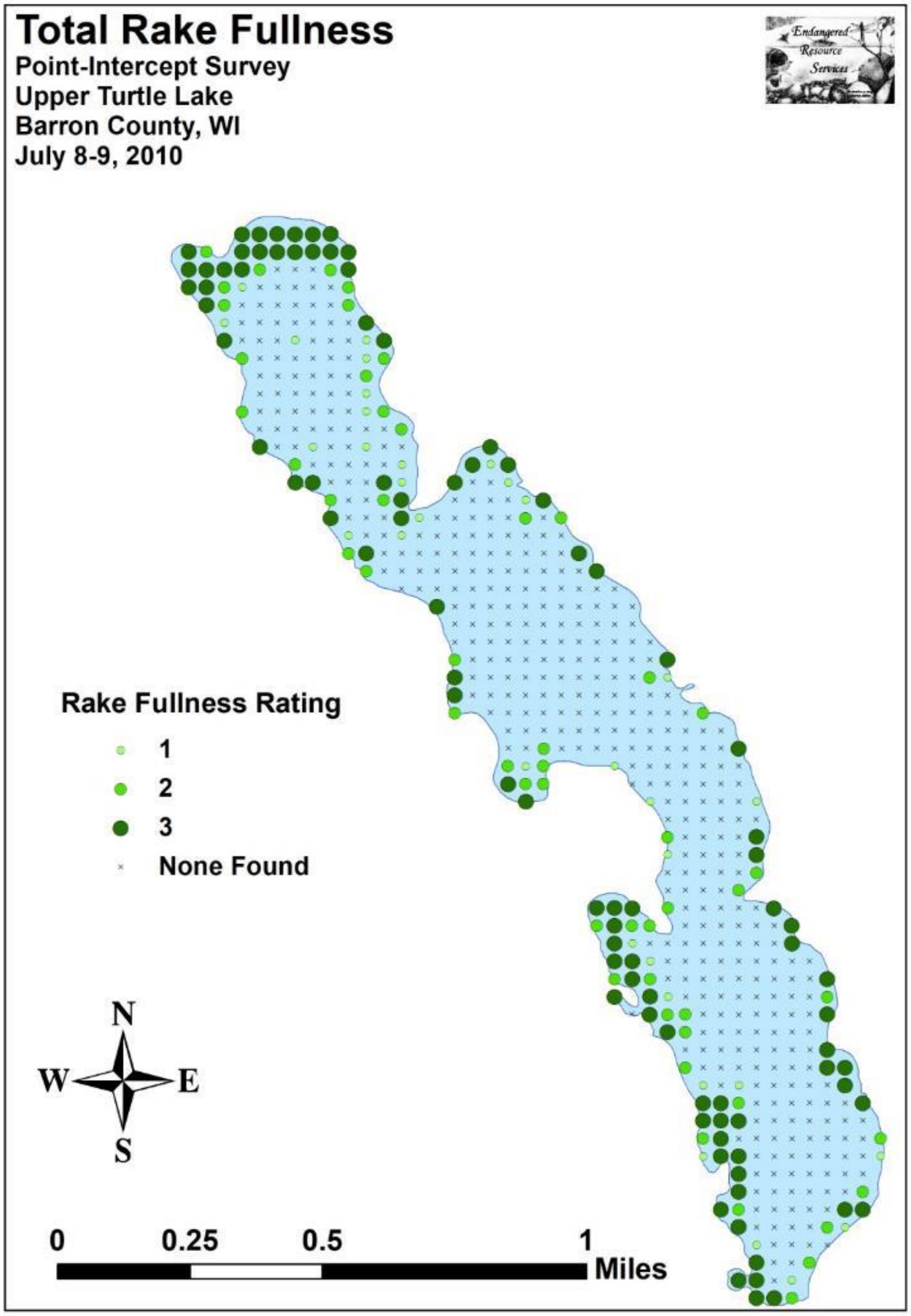


Littoral Zone
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Littoral Zone
Littoral Zone with Plants
> 14.0 ft.
N
W
E
S
0
0.25
0.5
1
Miles

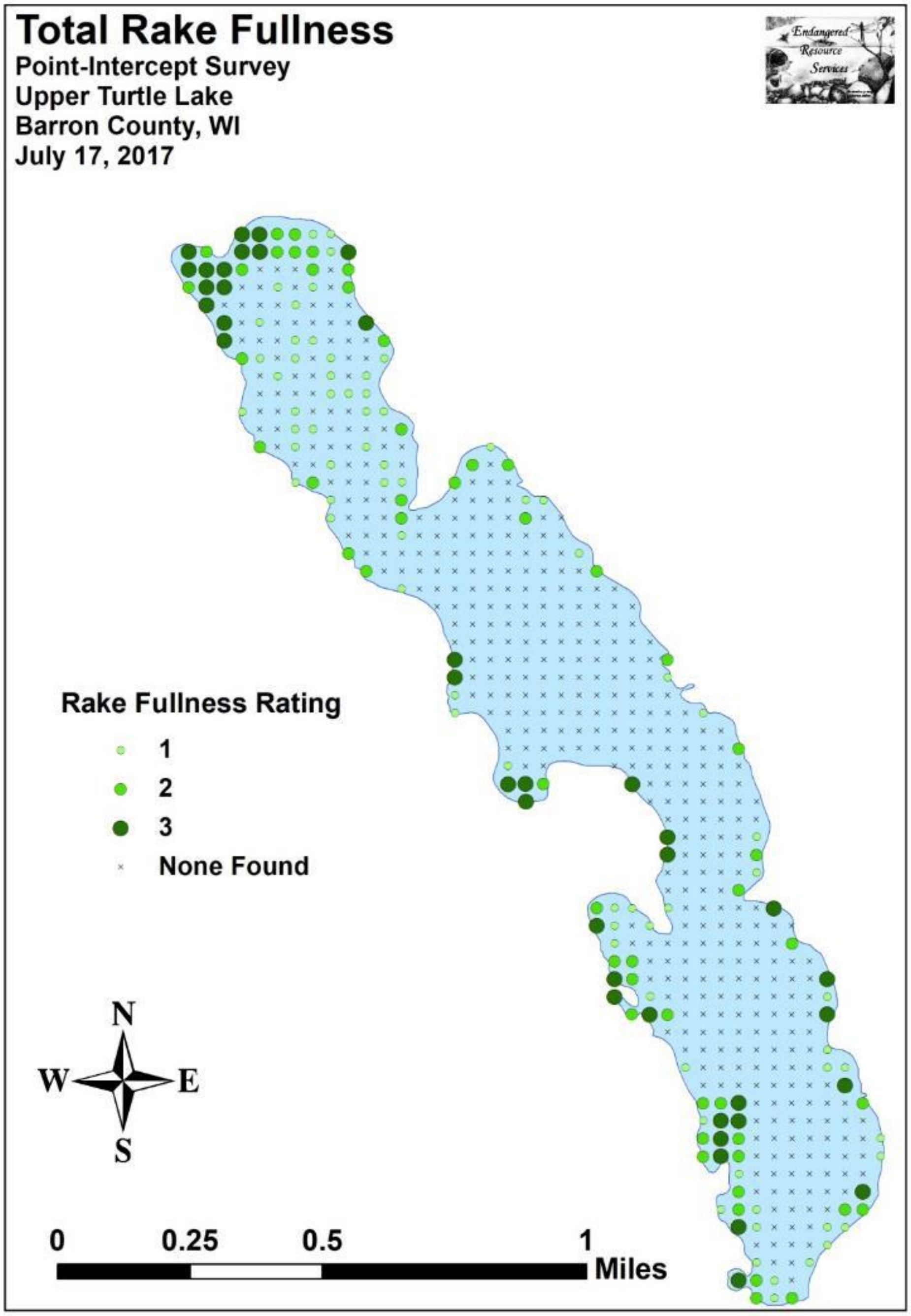


Native Species Richness
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9
N
W
E
S
0
0.25
0.5
1
Miles

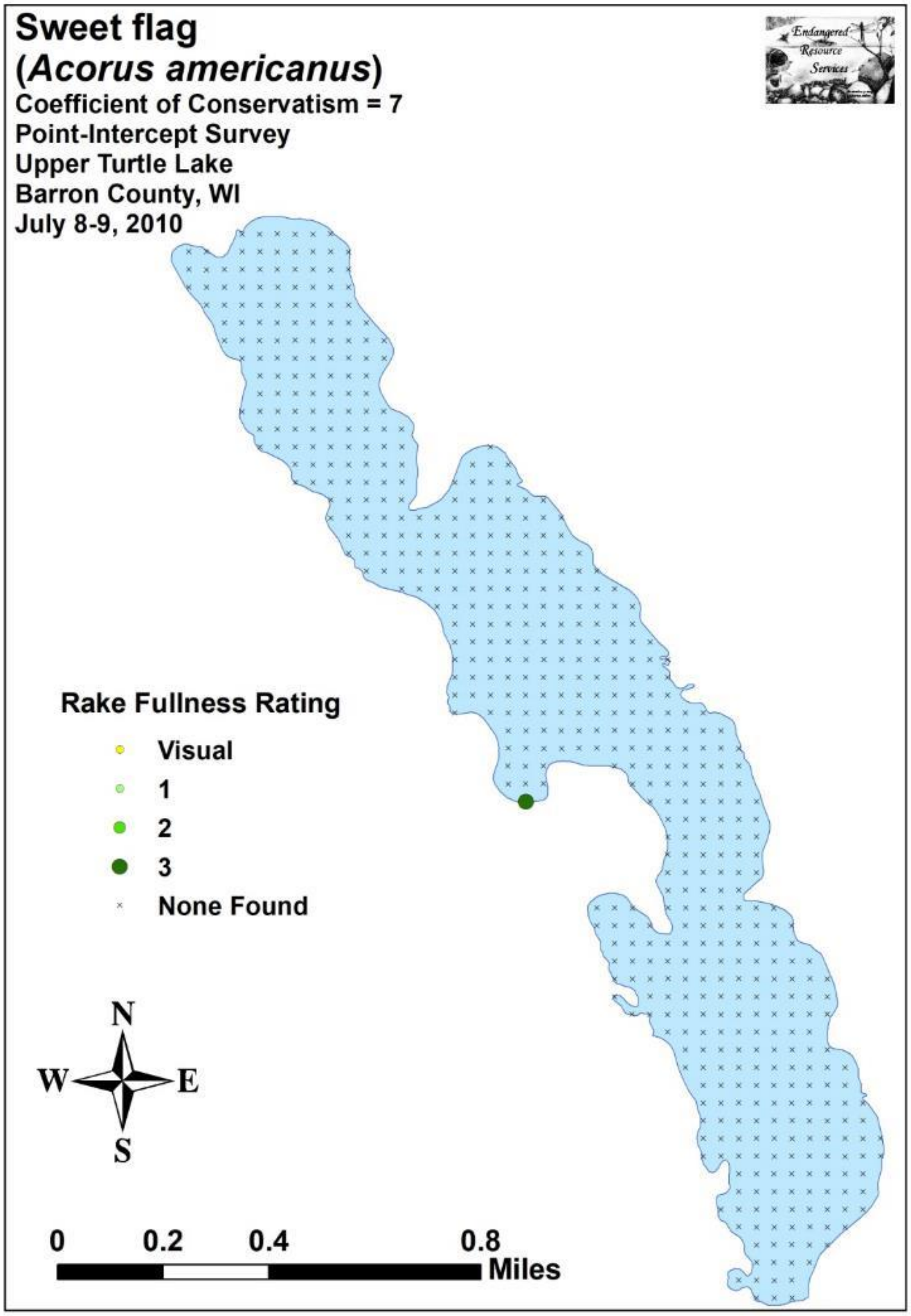

Native Species Richness
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9
N
W
E
S
0
0.25
0.5
1
Miles

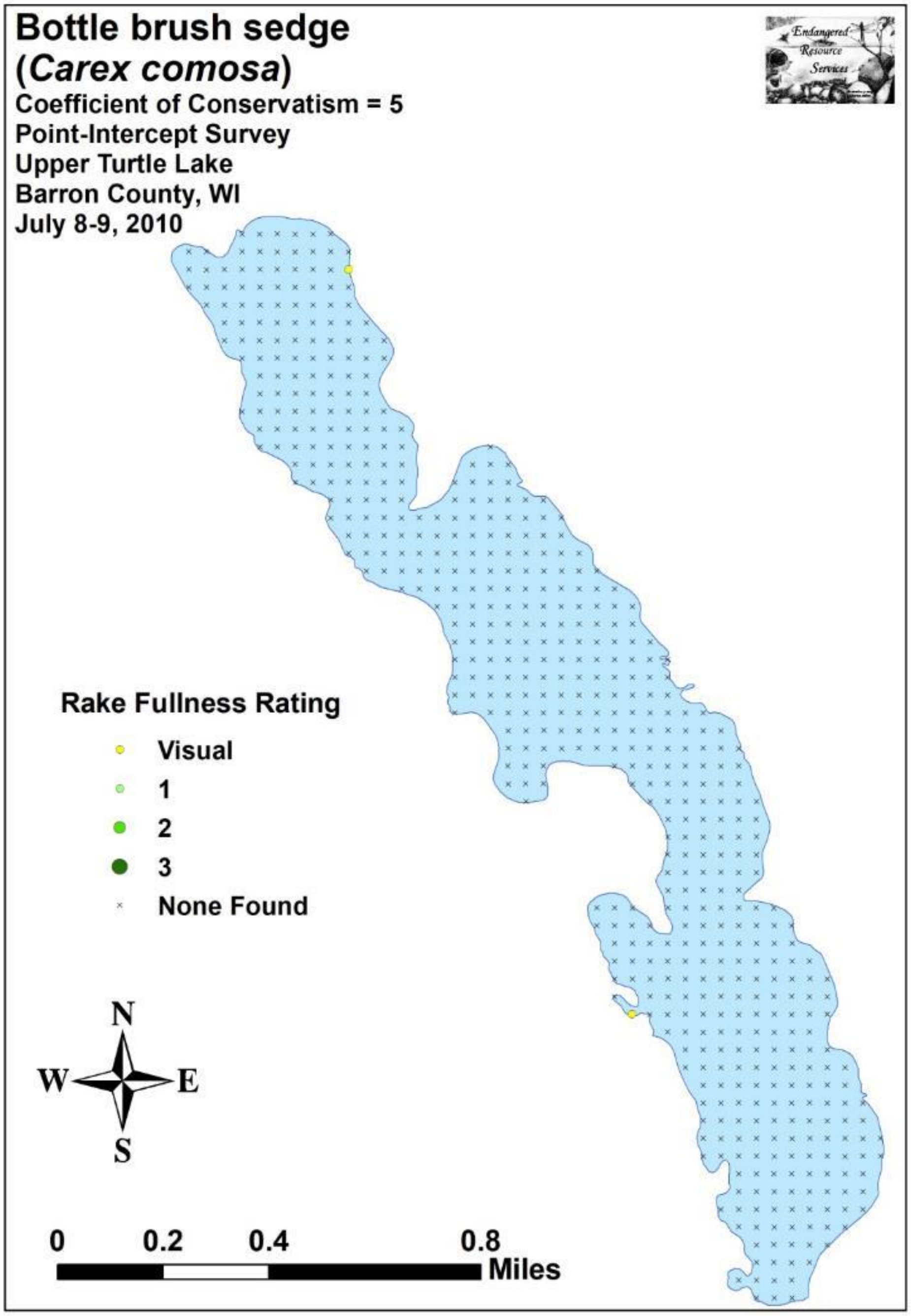


Total Rake Fullness
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

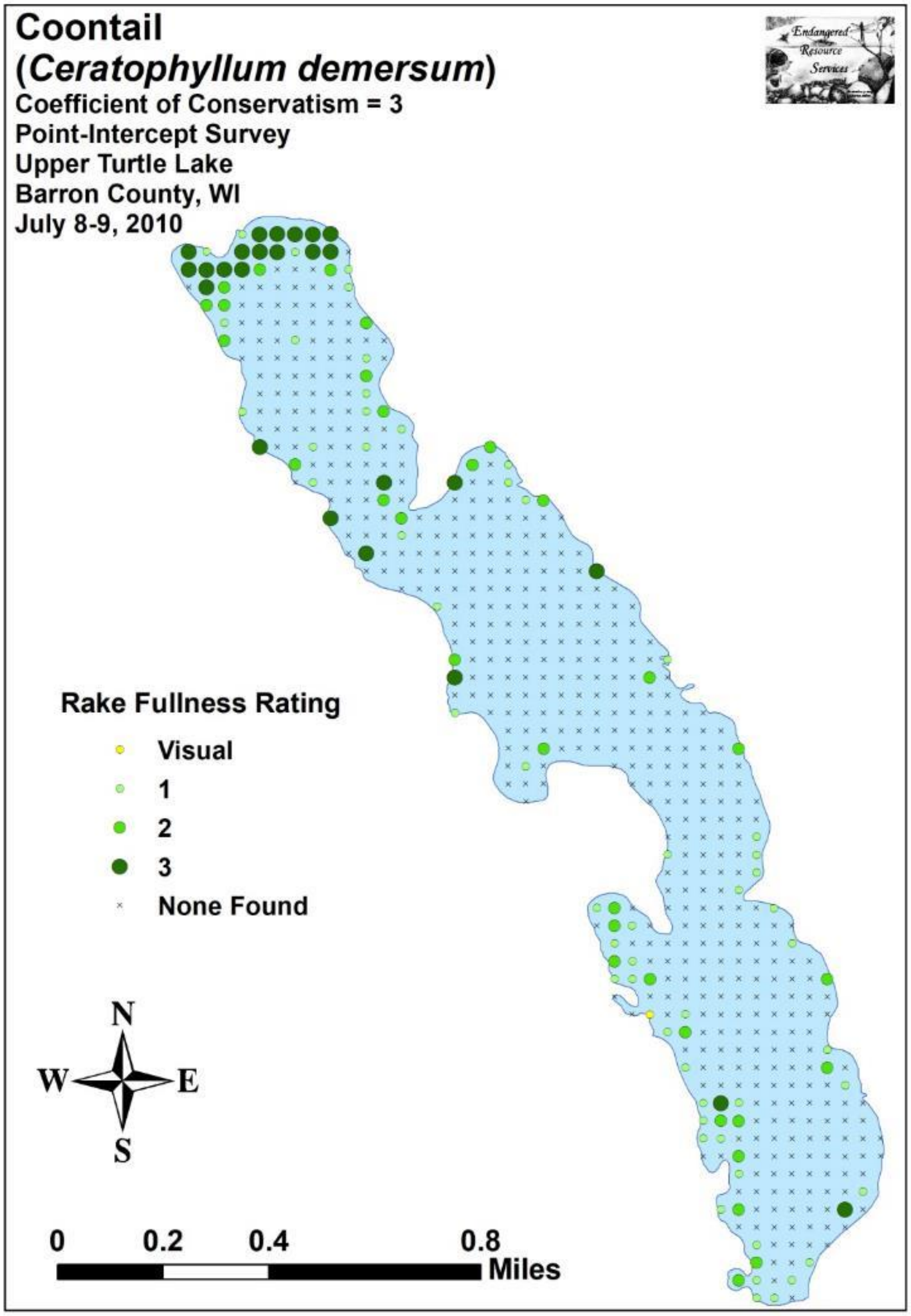

Total Rake Fullness
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

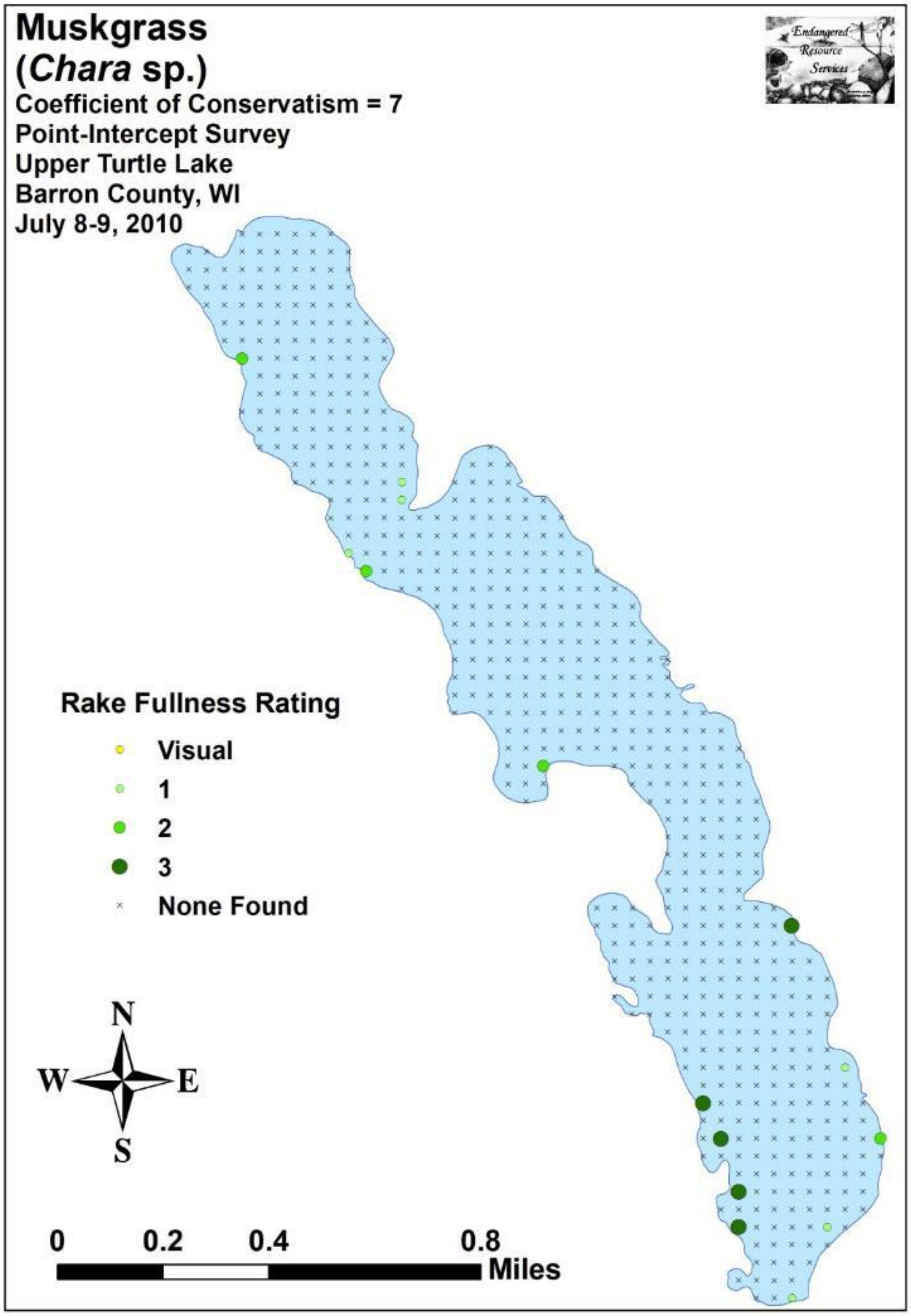
Appendix VI: July 2010 Species Density and Distribution Maps

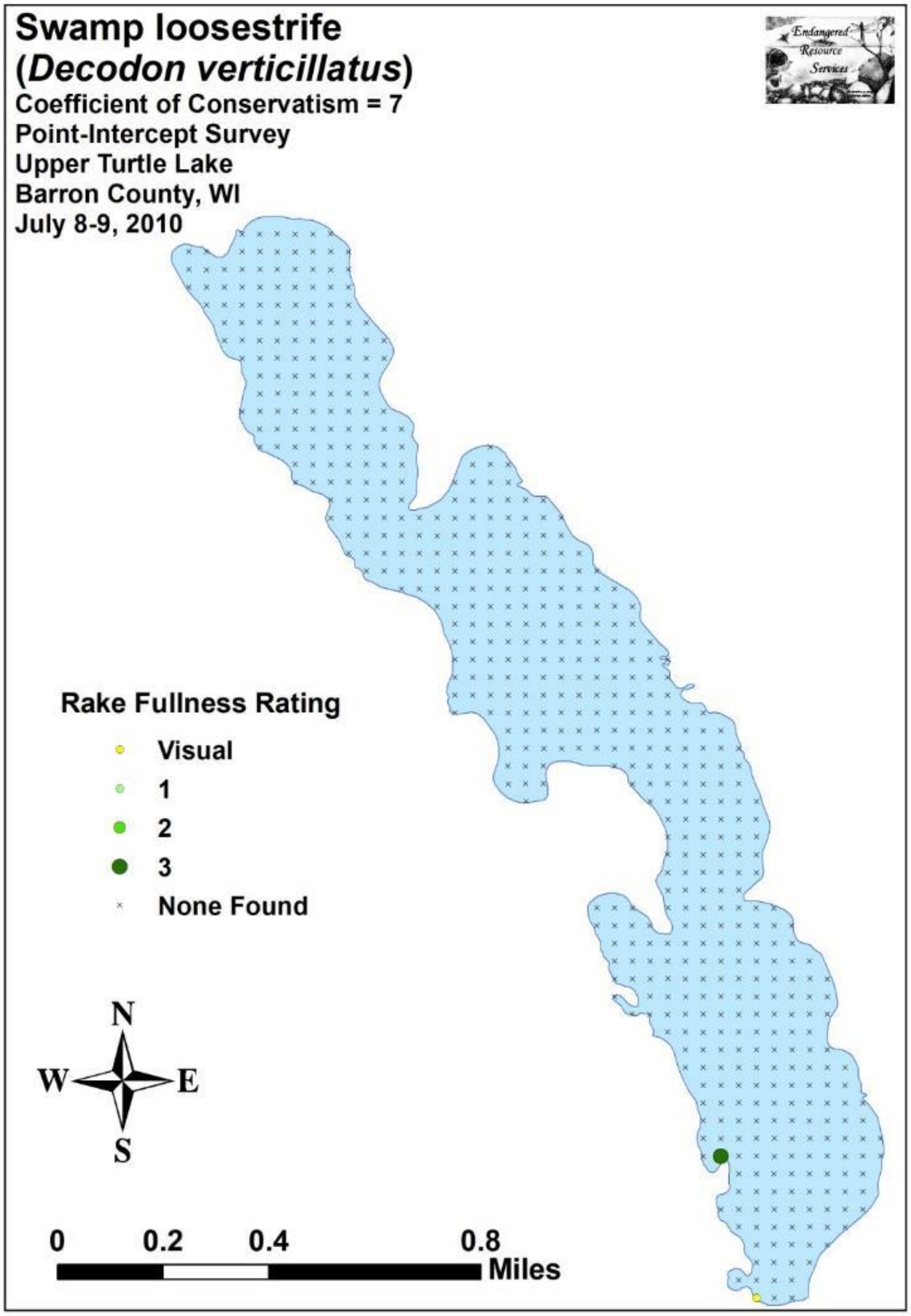

Sweet flag
(Acorus americanus)
Coefficient of Conservatism = 7
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

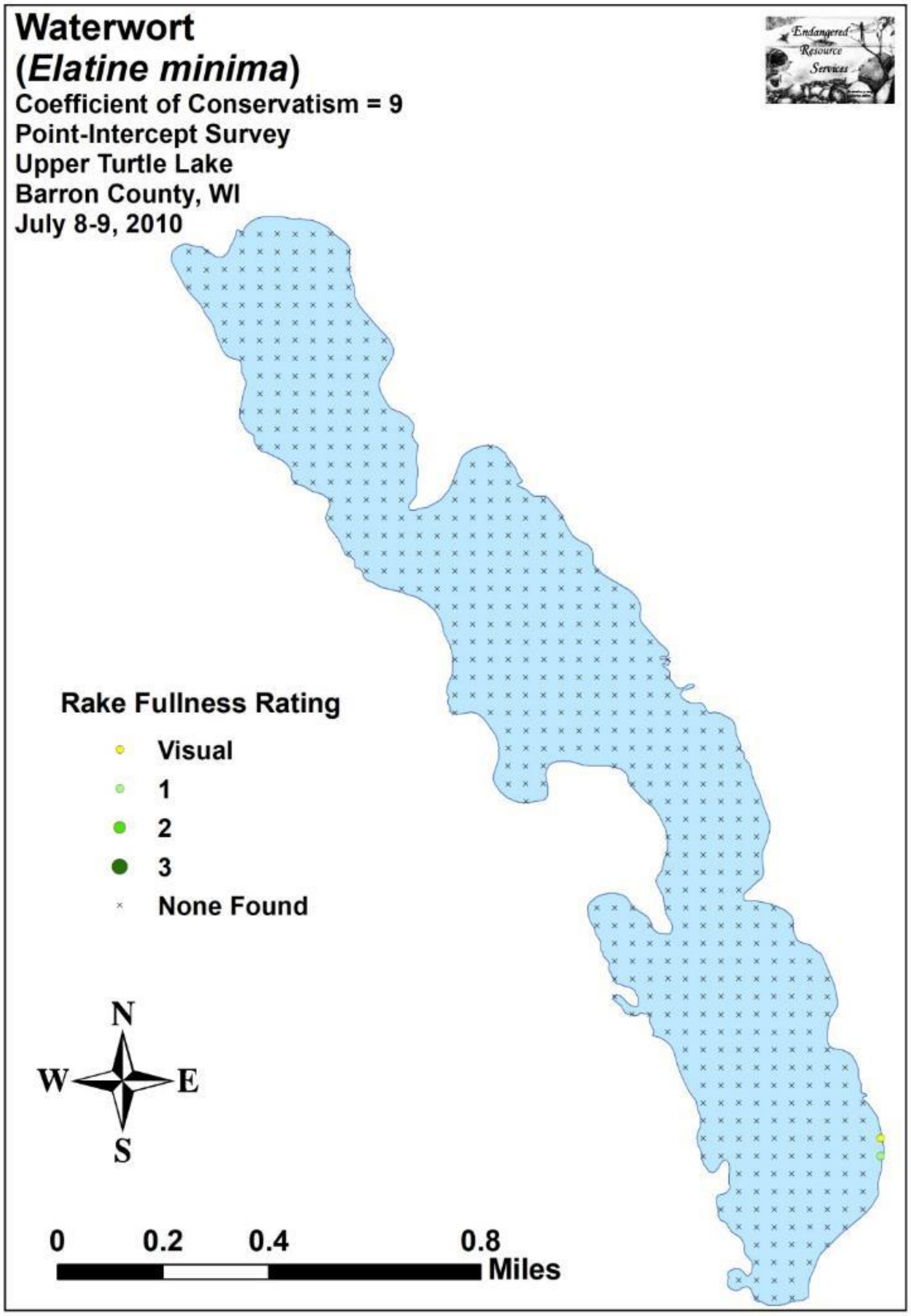


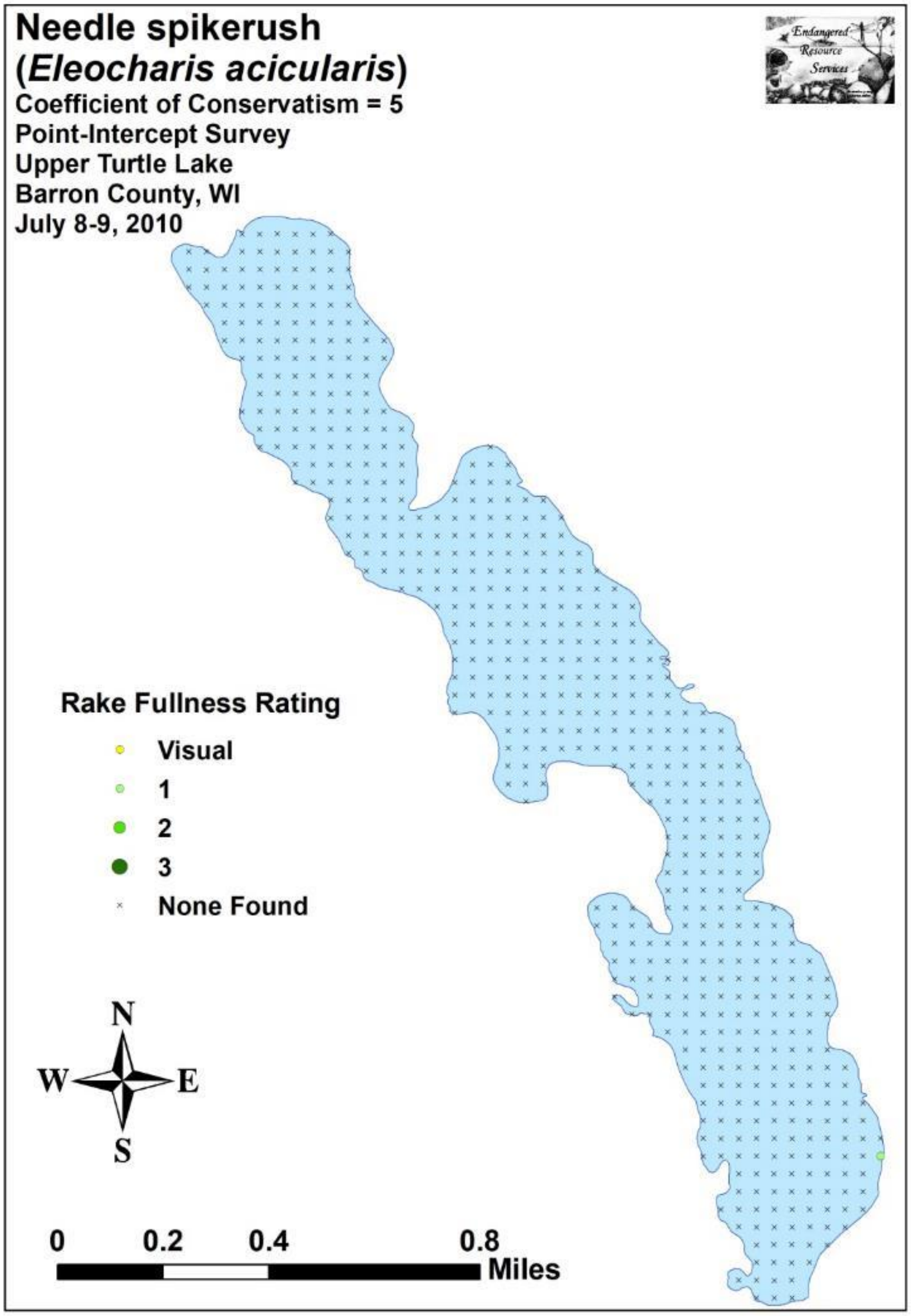
Bottle brush sedge
(*Carex comosa*)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

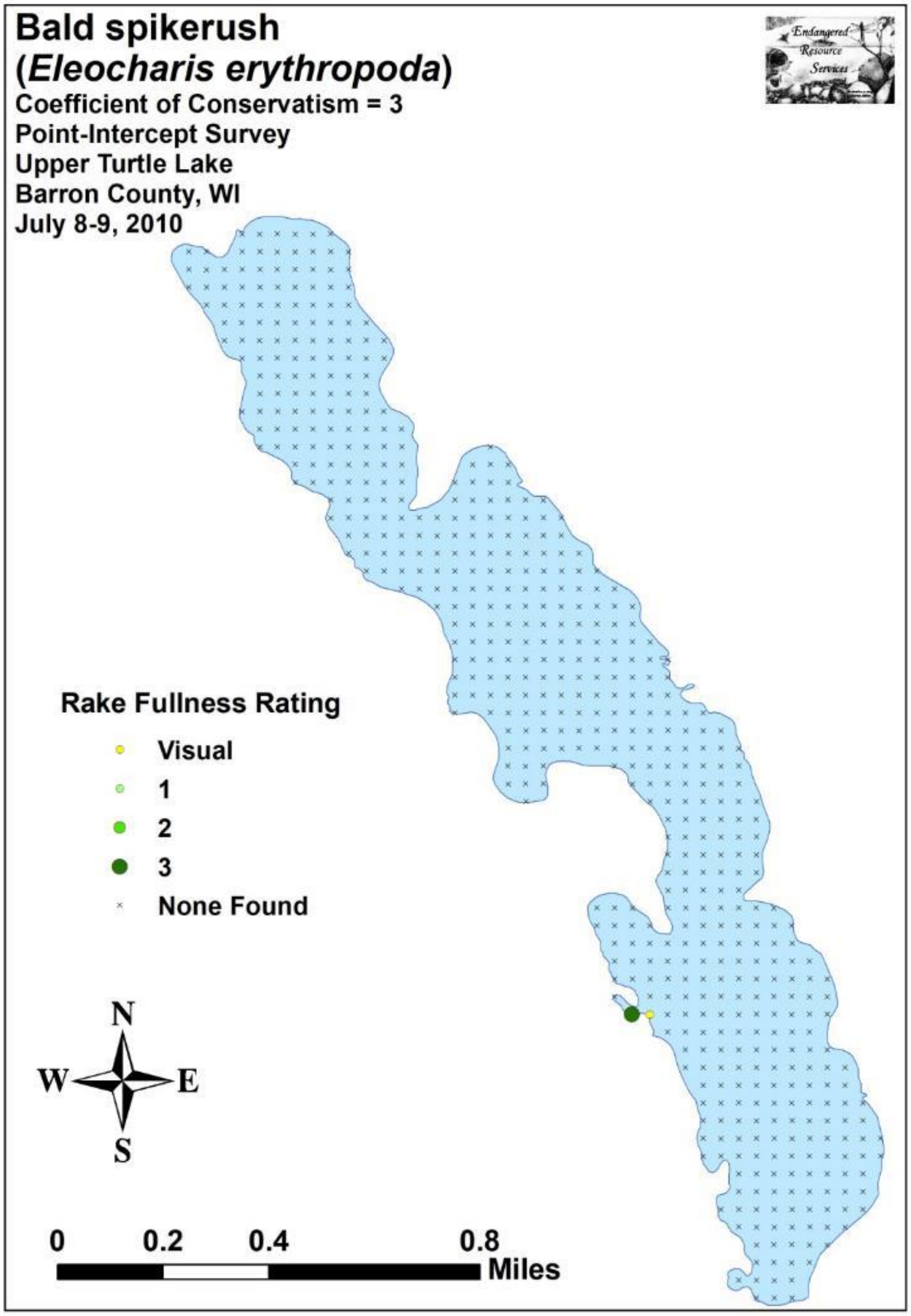

Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

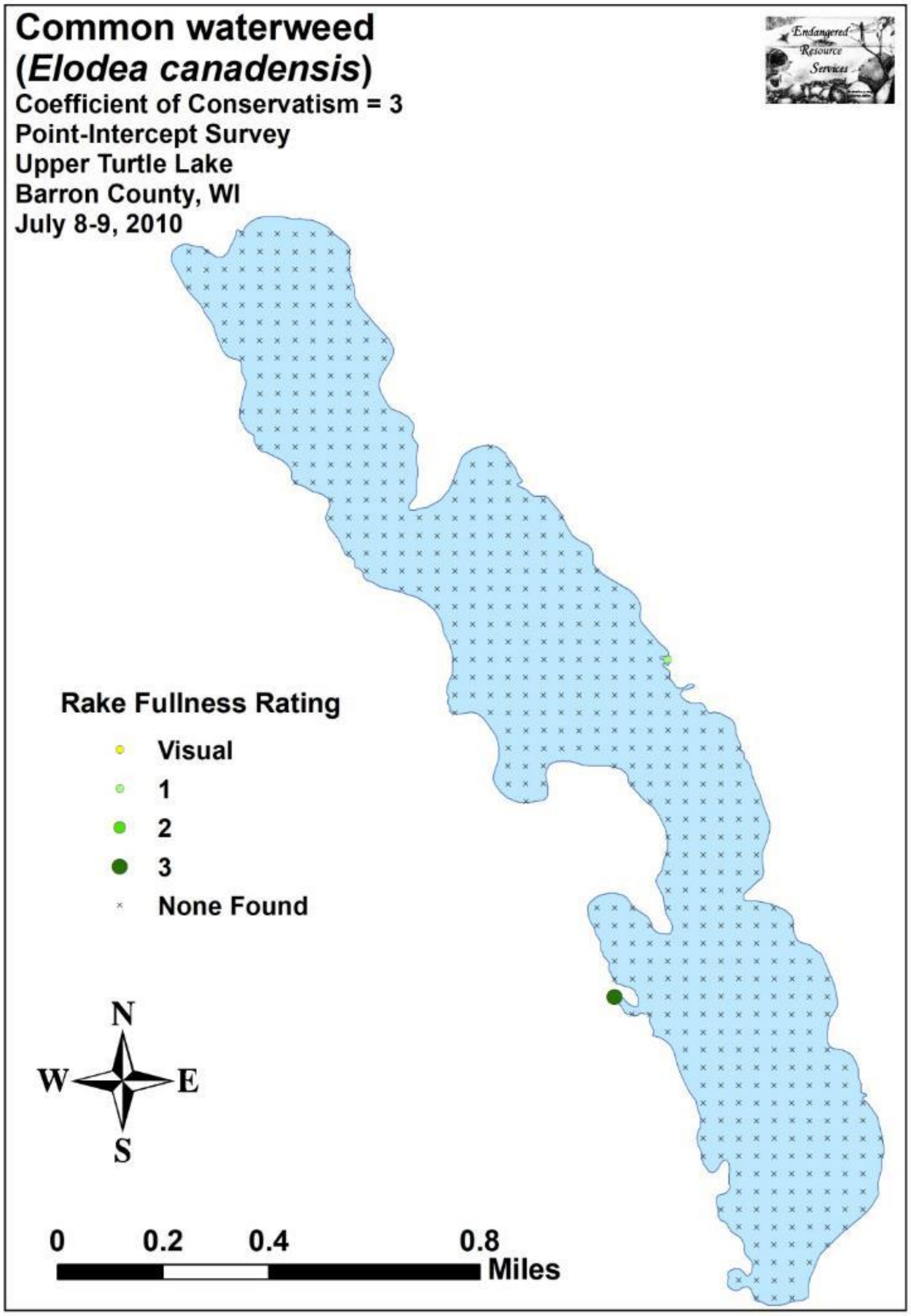

Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Swamp loosestrife
(Decodon verticillatus)
Coefficient of Conservatism = 7
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

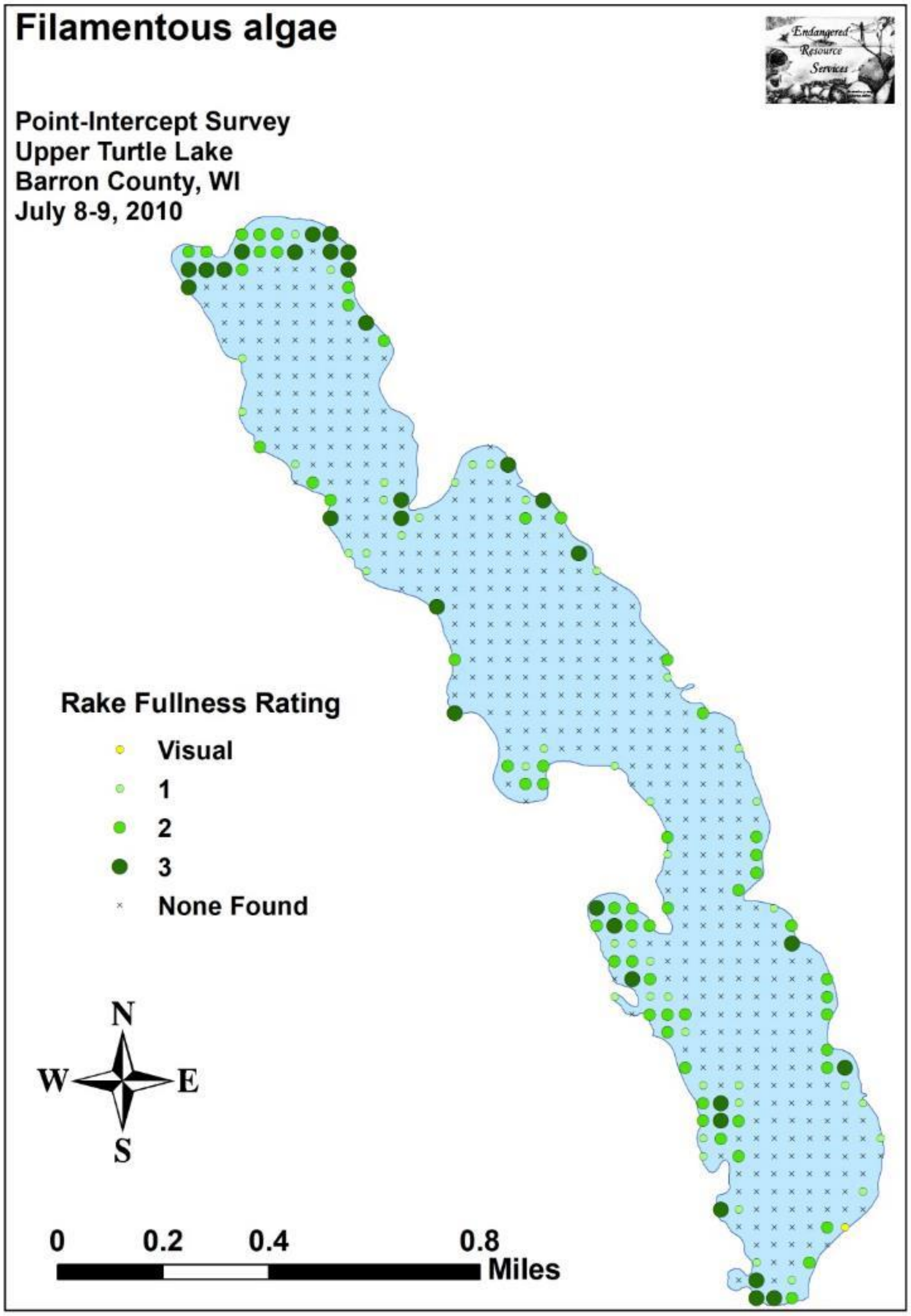

Waterwort
(Elatine minima)
Coefficient of Conservatism = 9
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

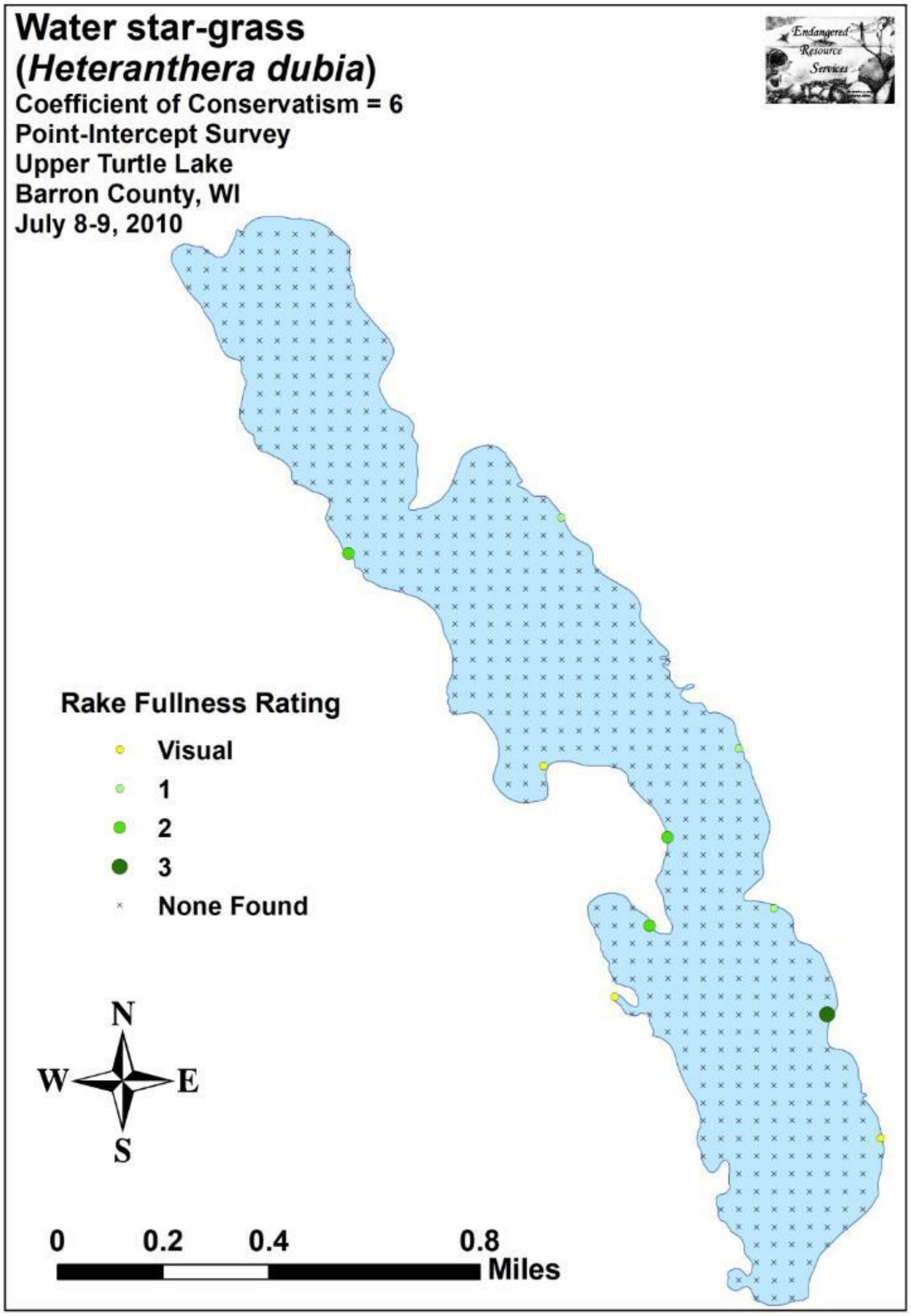

Needle spikerush
(Eleocharis acicularis)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

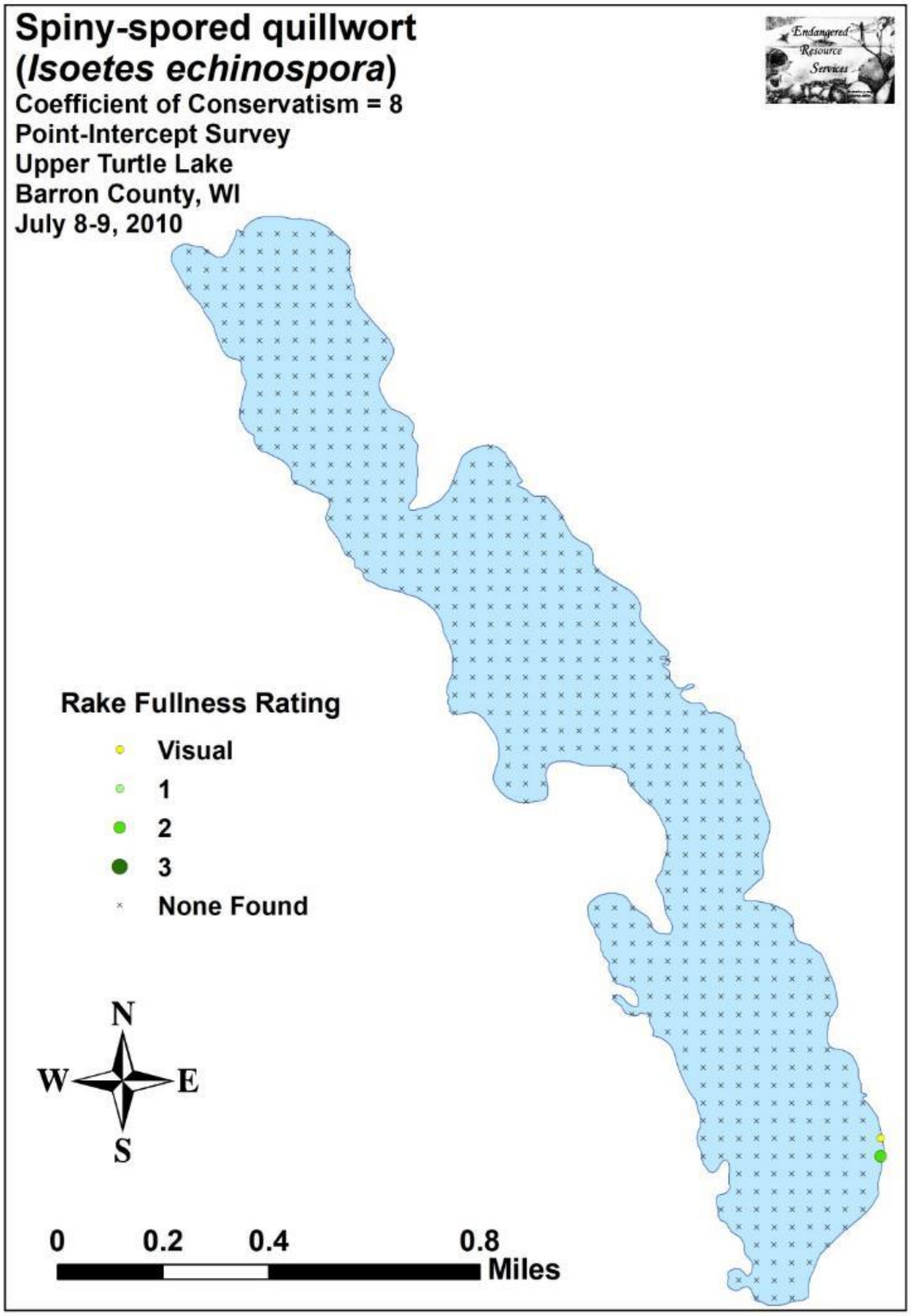

Bald spikerush
(*Eleocharis erythropoda*)
Coefficient of Conservatism = 3
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

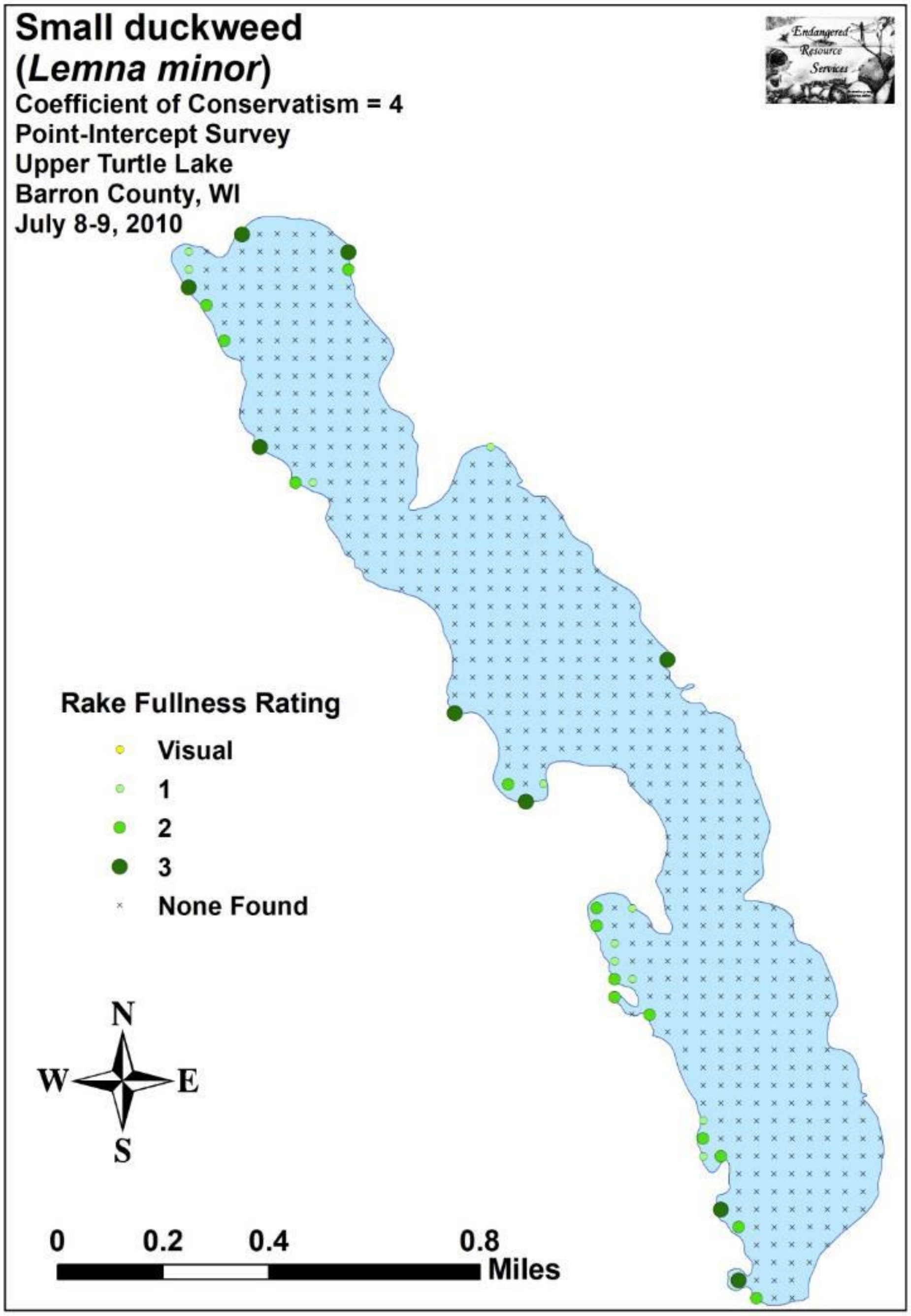


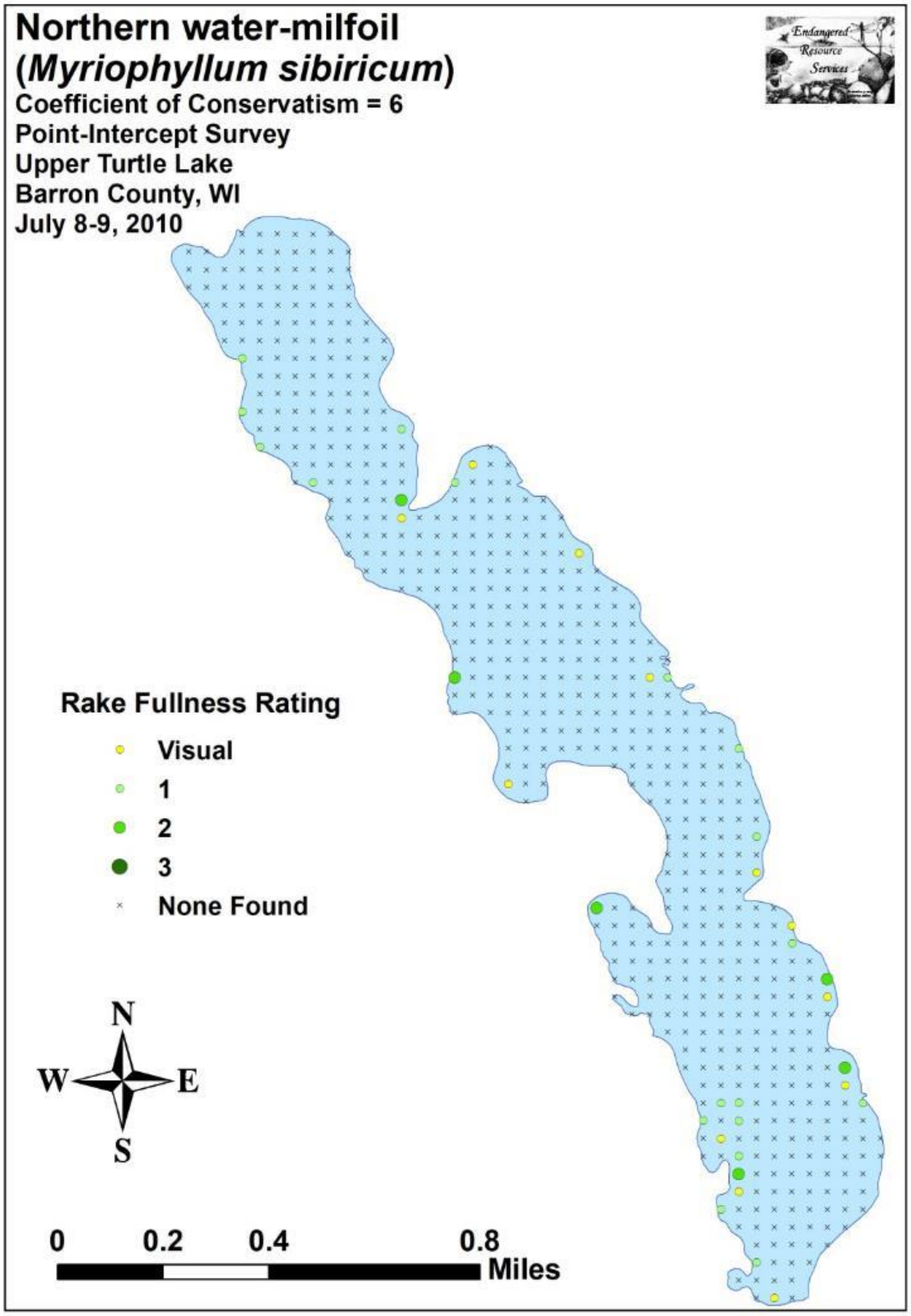
Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

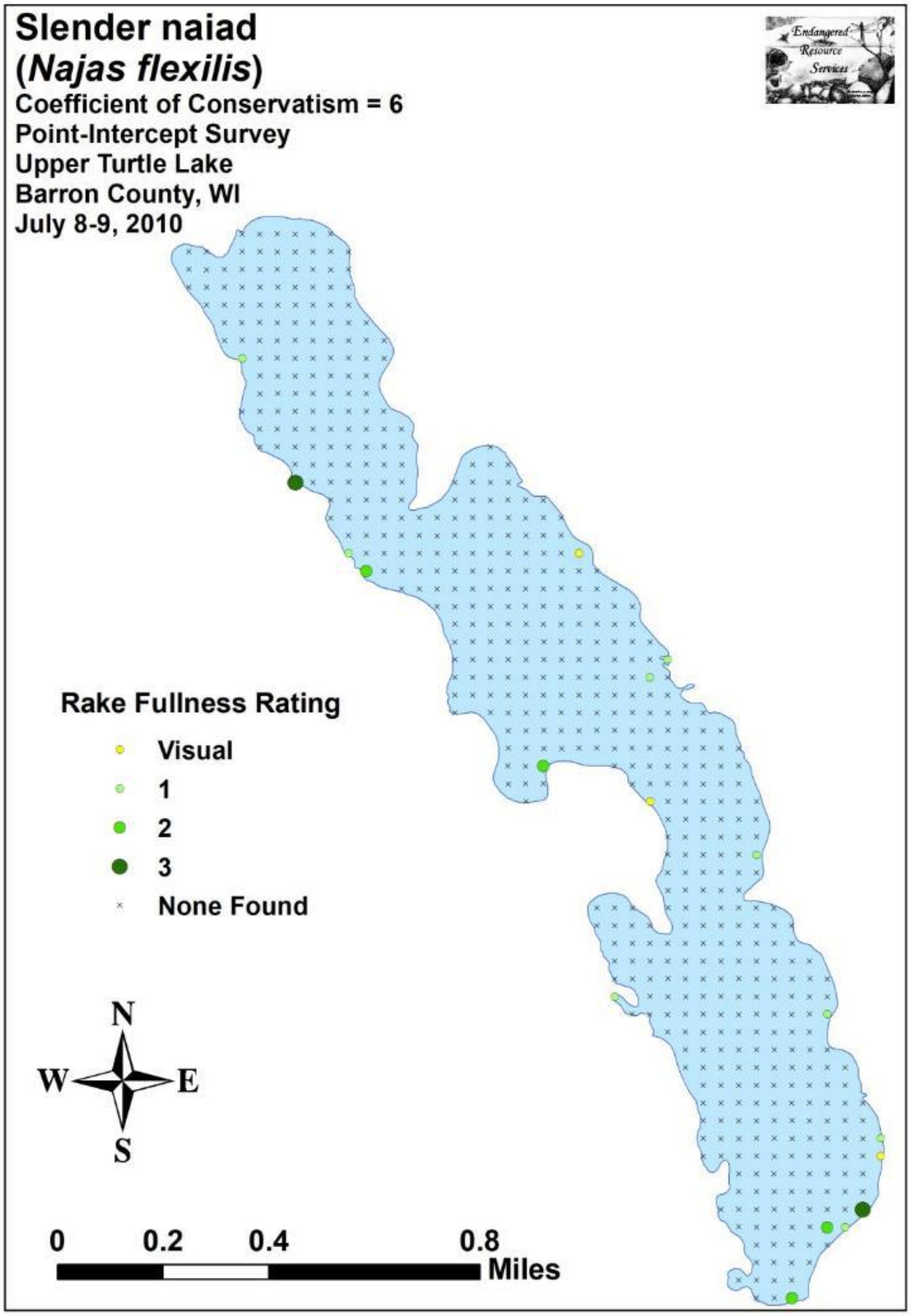

Filamentous algae
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

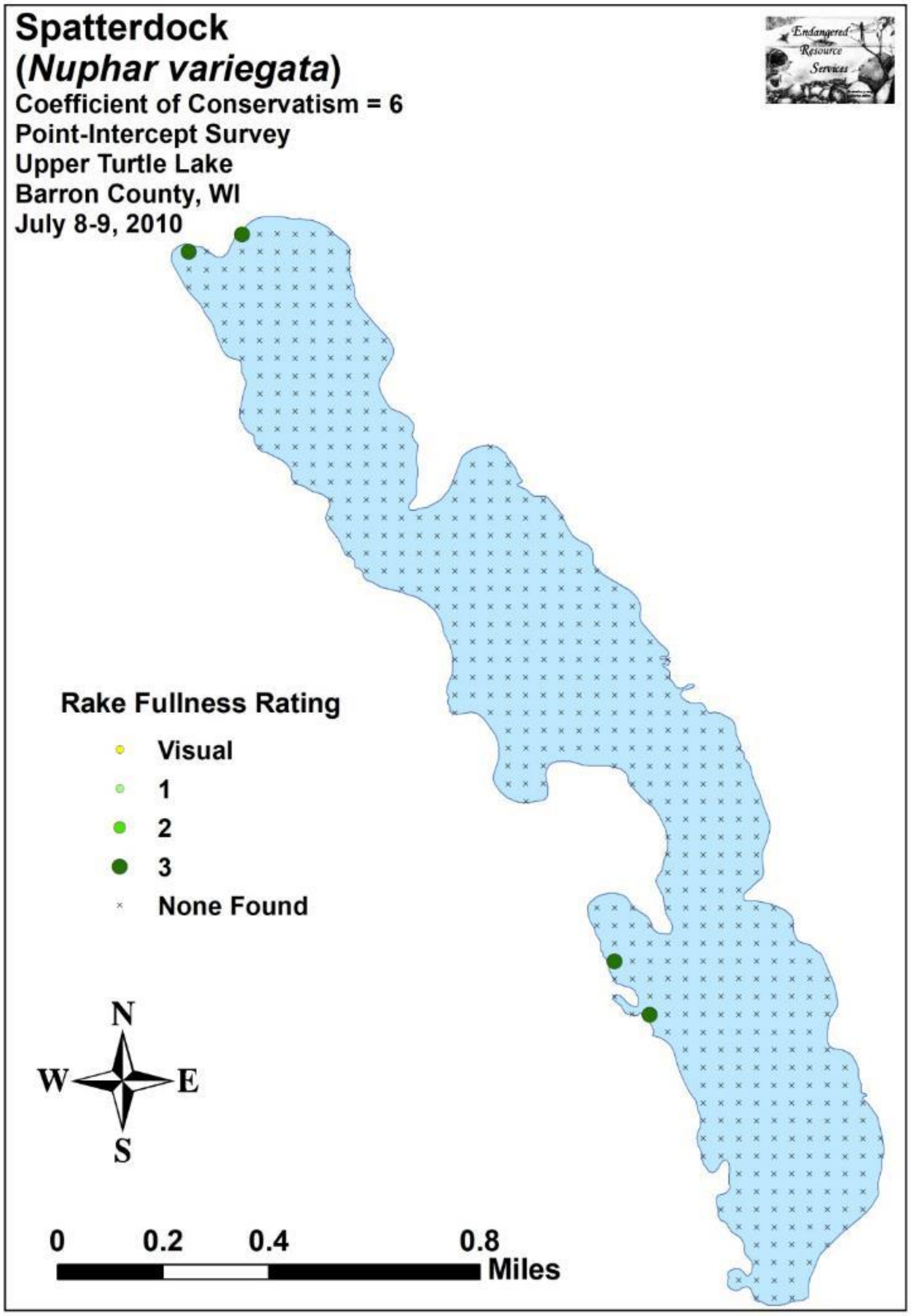

Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

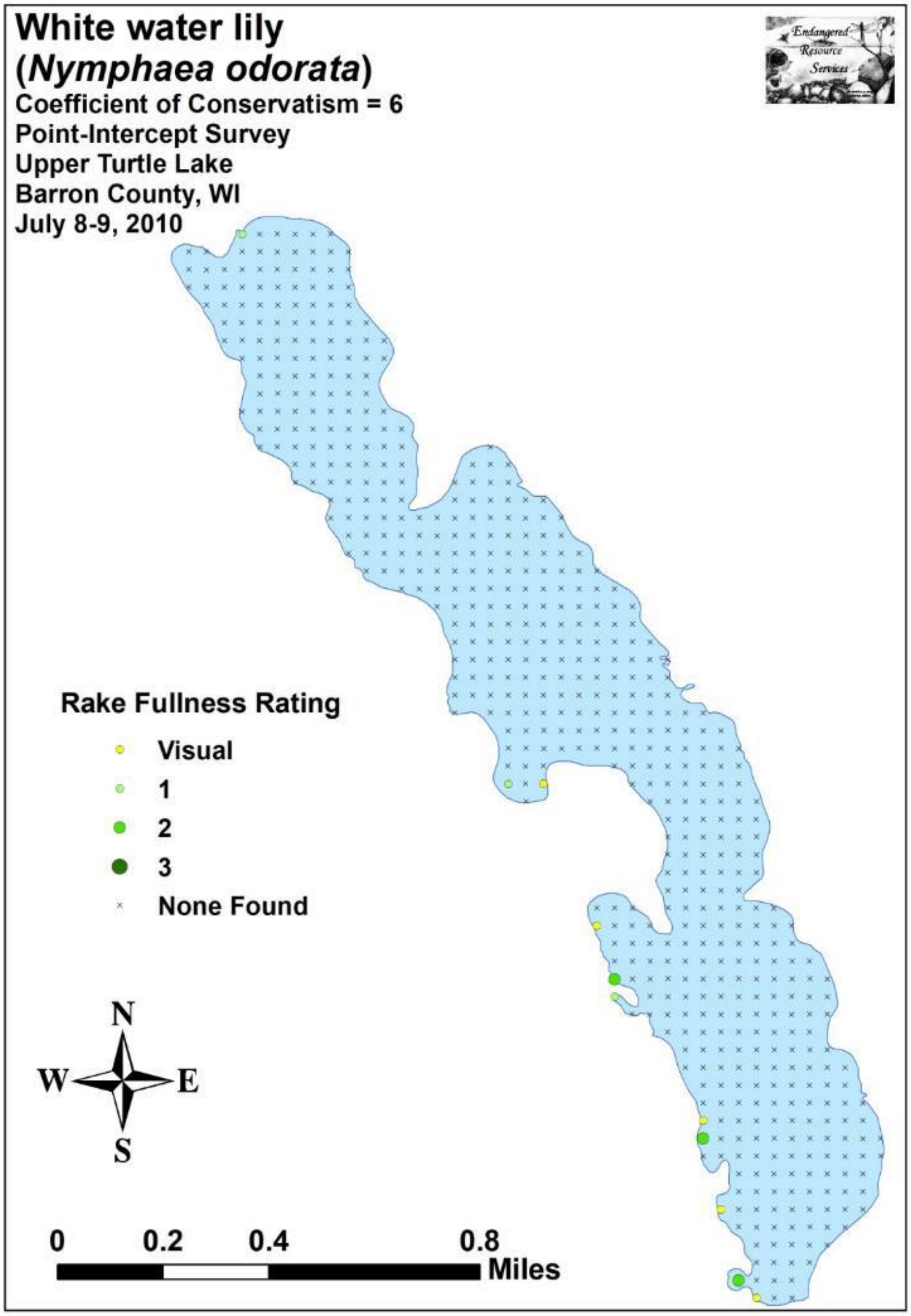

Spiny-spored quillwort
(*Isoetes echinospora*)
Coefficient of Conservatism = 8
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

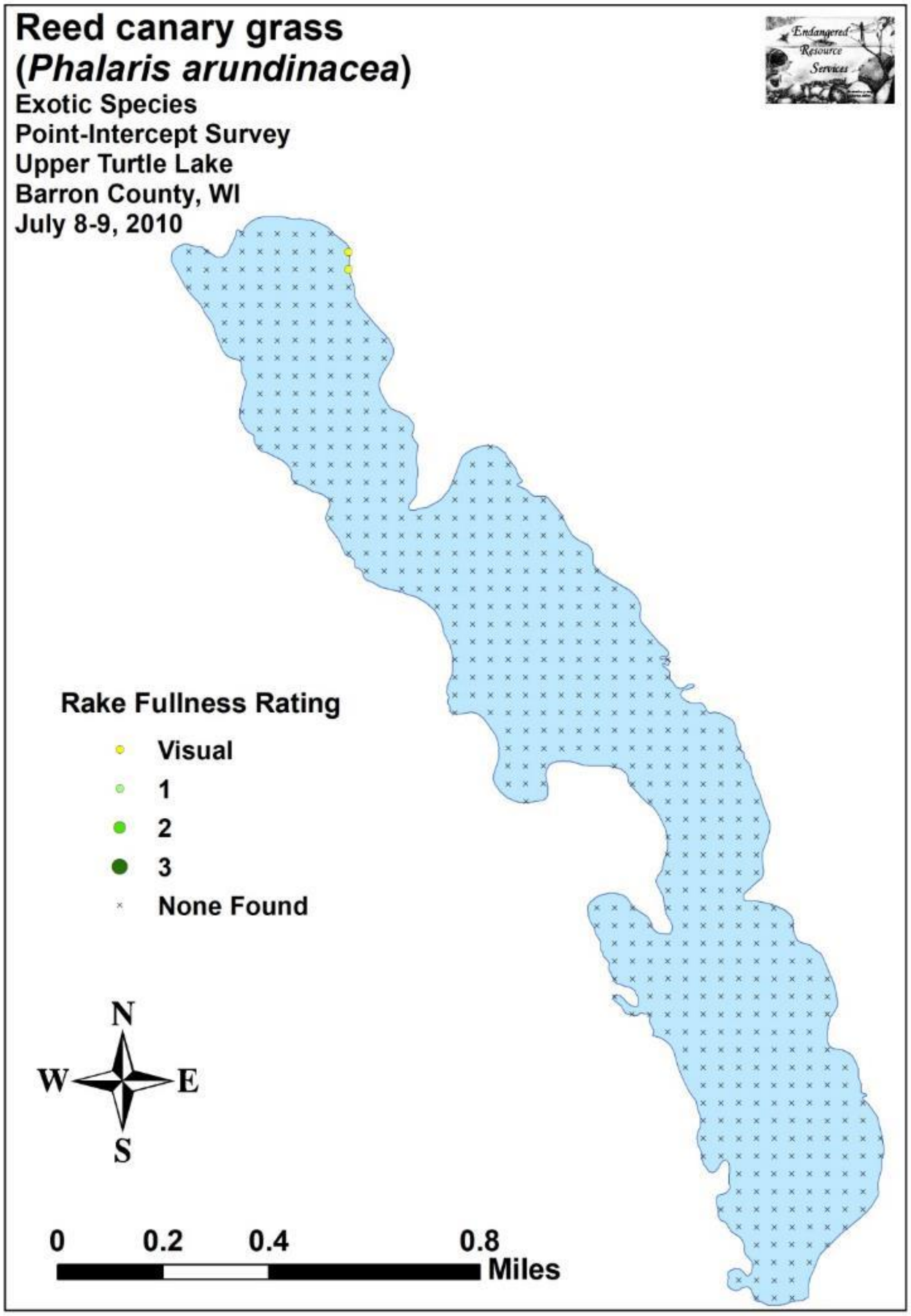

Small duckweed
(Lemna minor)
Coefficient of Conservatism = 4
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

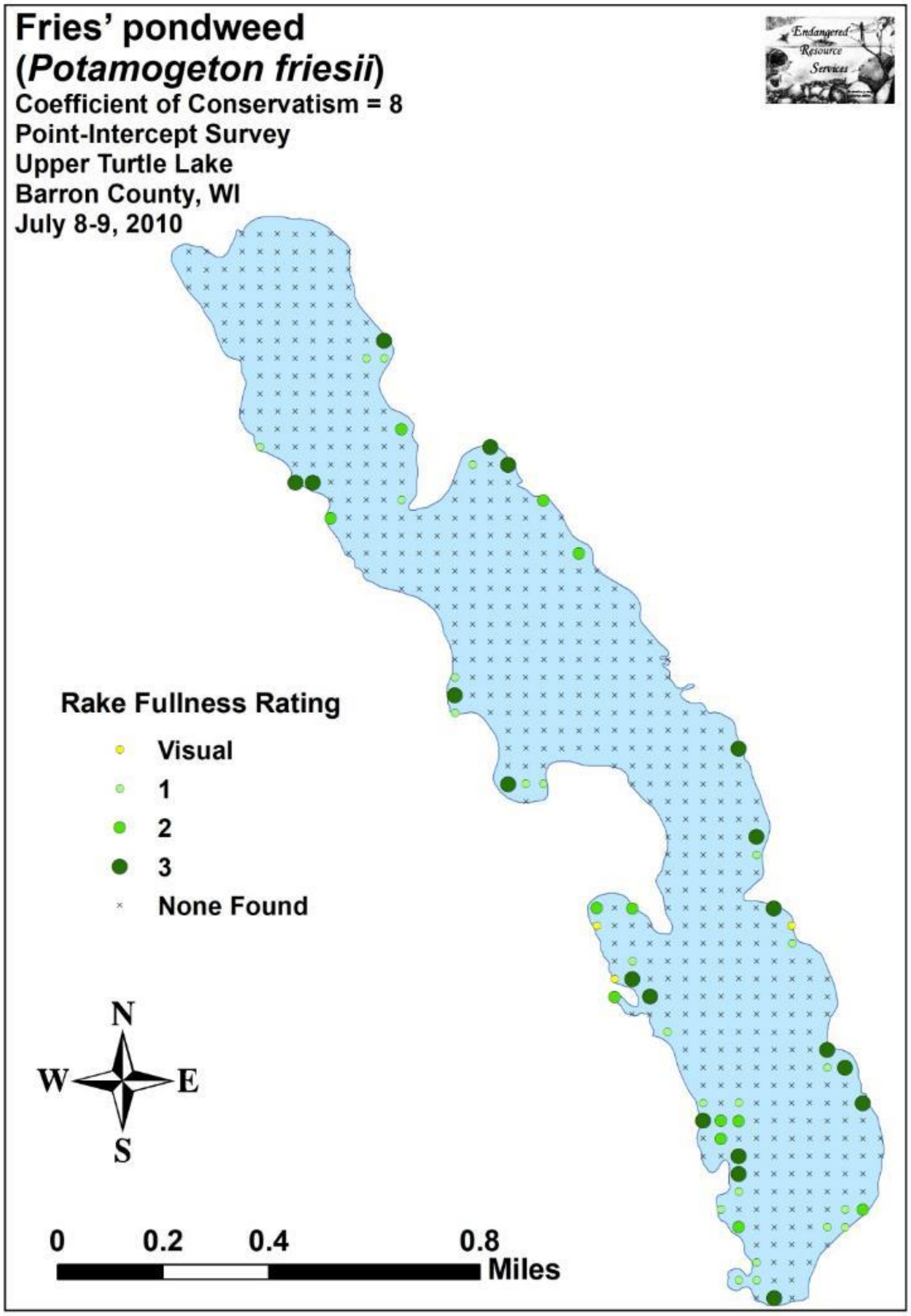

Northern water-milfoil
(Myriophyllum sibiricum)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

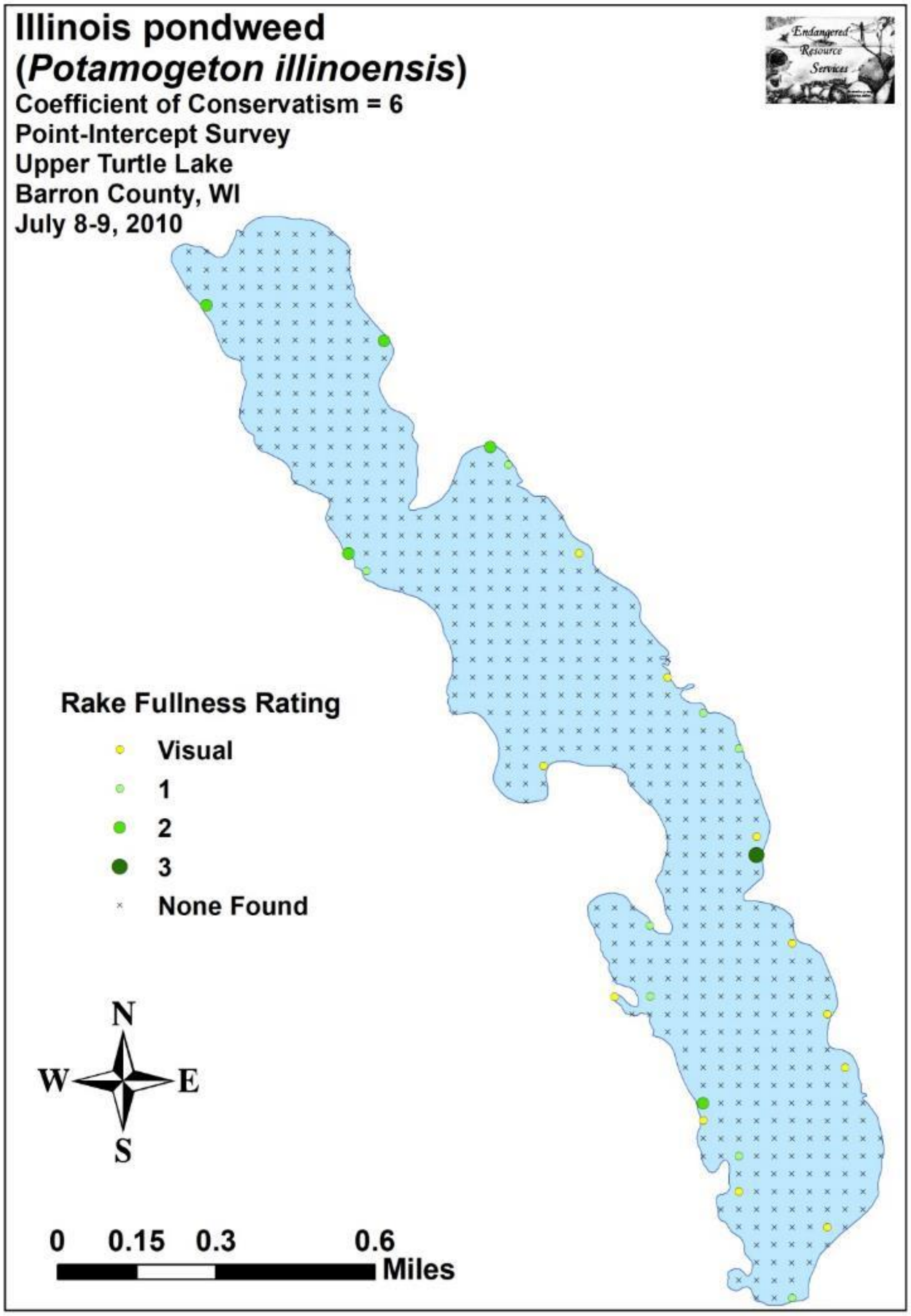

Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

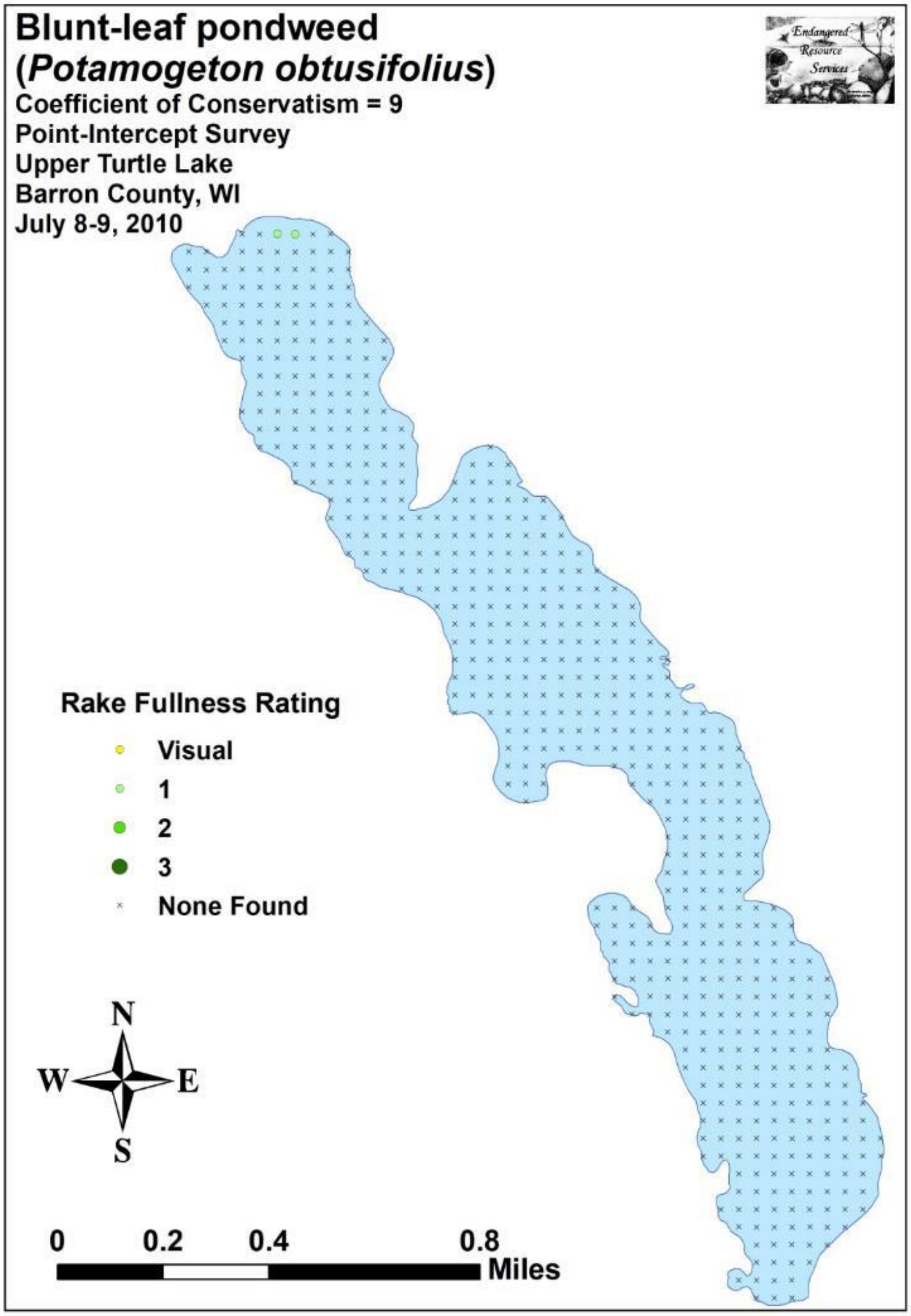

White water lily
(*Nymphaea odorata*)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

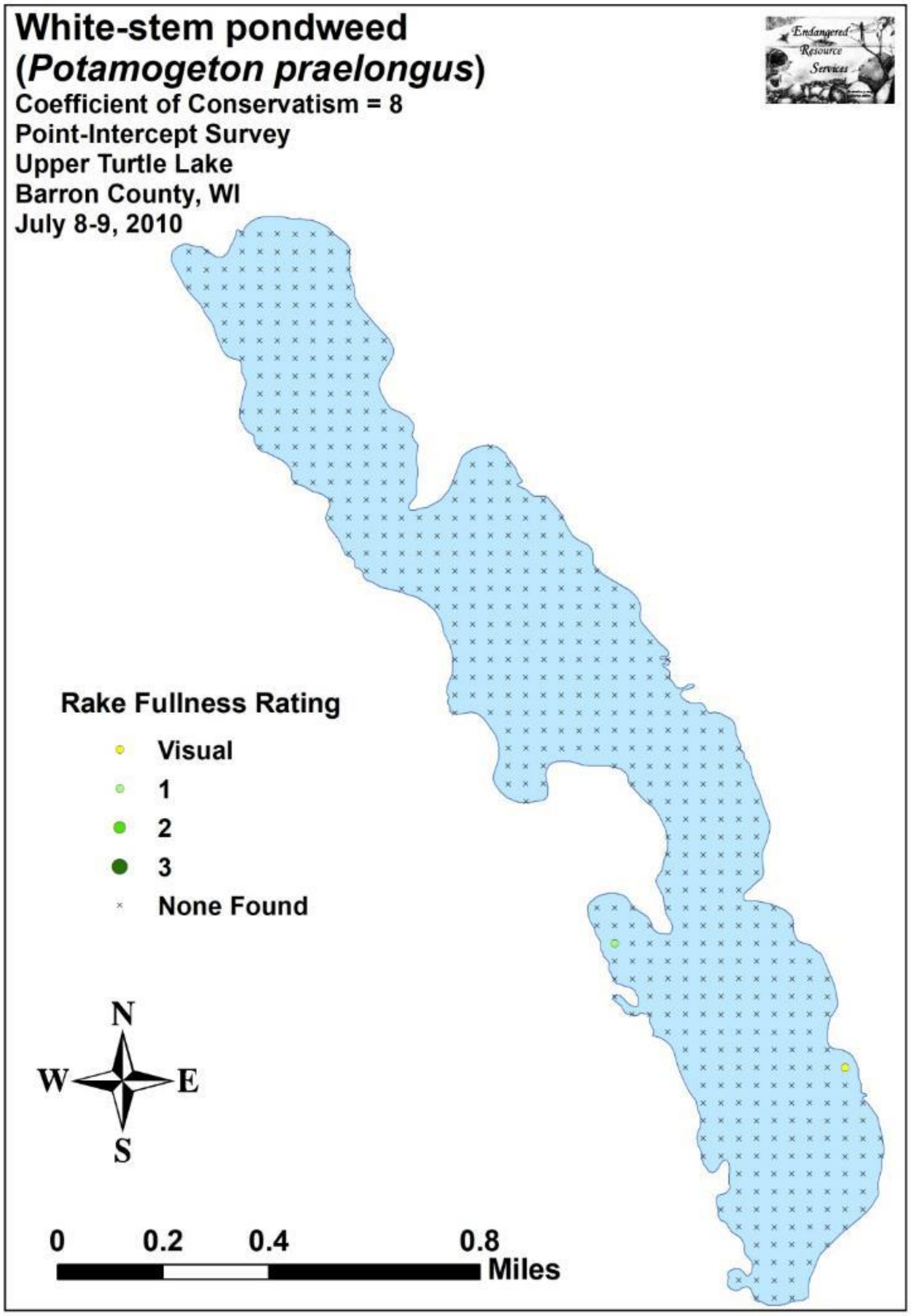

Reed canary grass
(Phalaris arundinacea)
Exotic Species
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

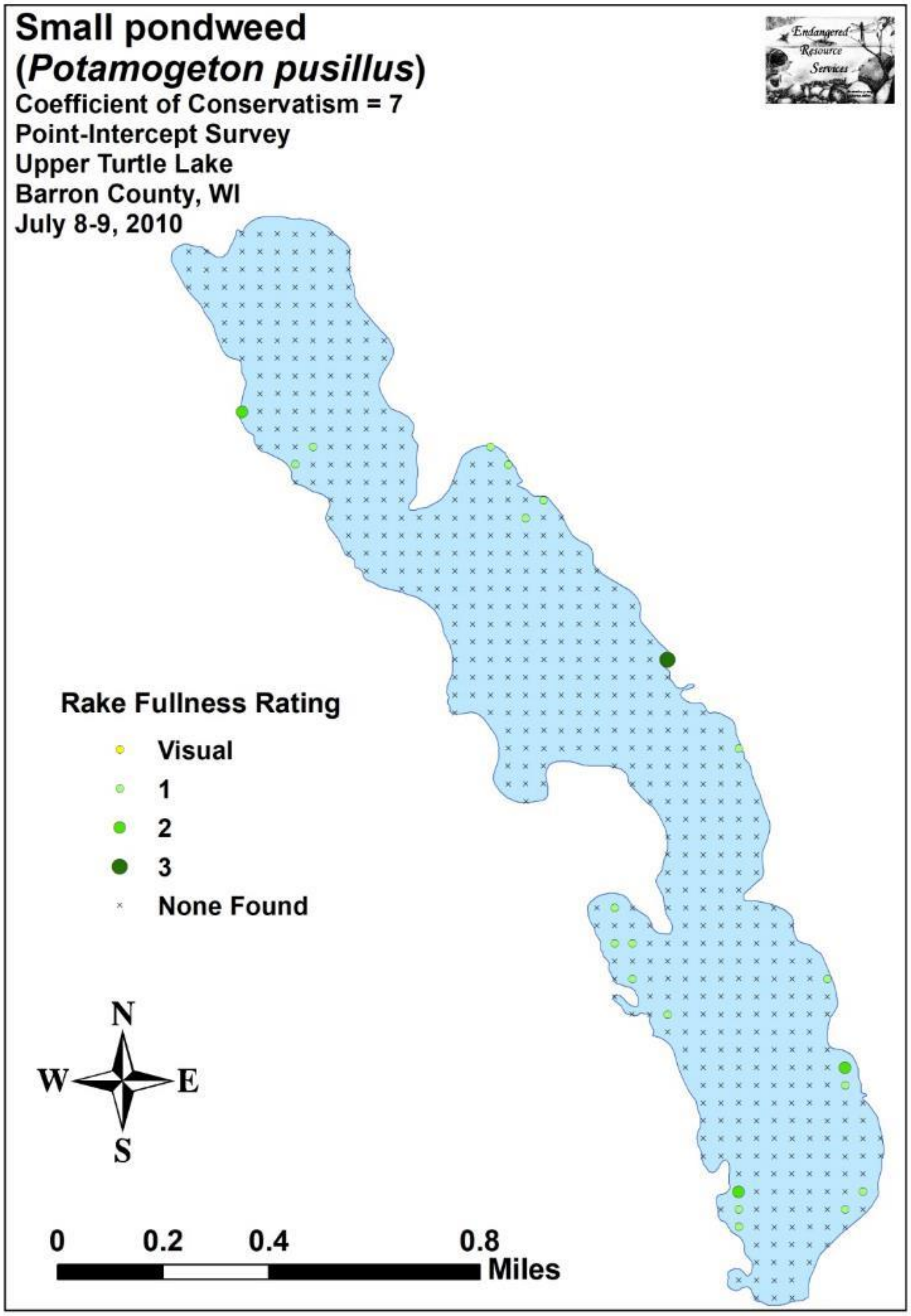

Fries' pondweed
(Potamogeton friesii)
Coefficient of Conservatism = 8
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles



Illinois pondweed
(Potamogeton illinoensis)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.15
0.3
0.6
Miles


Blunt-leaf pondweed
(*Potamogeton obtusifolius*)
Coefficient of Conservatism = 9
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
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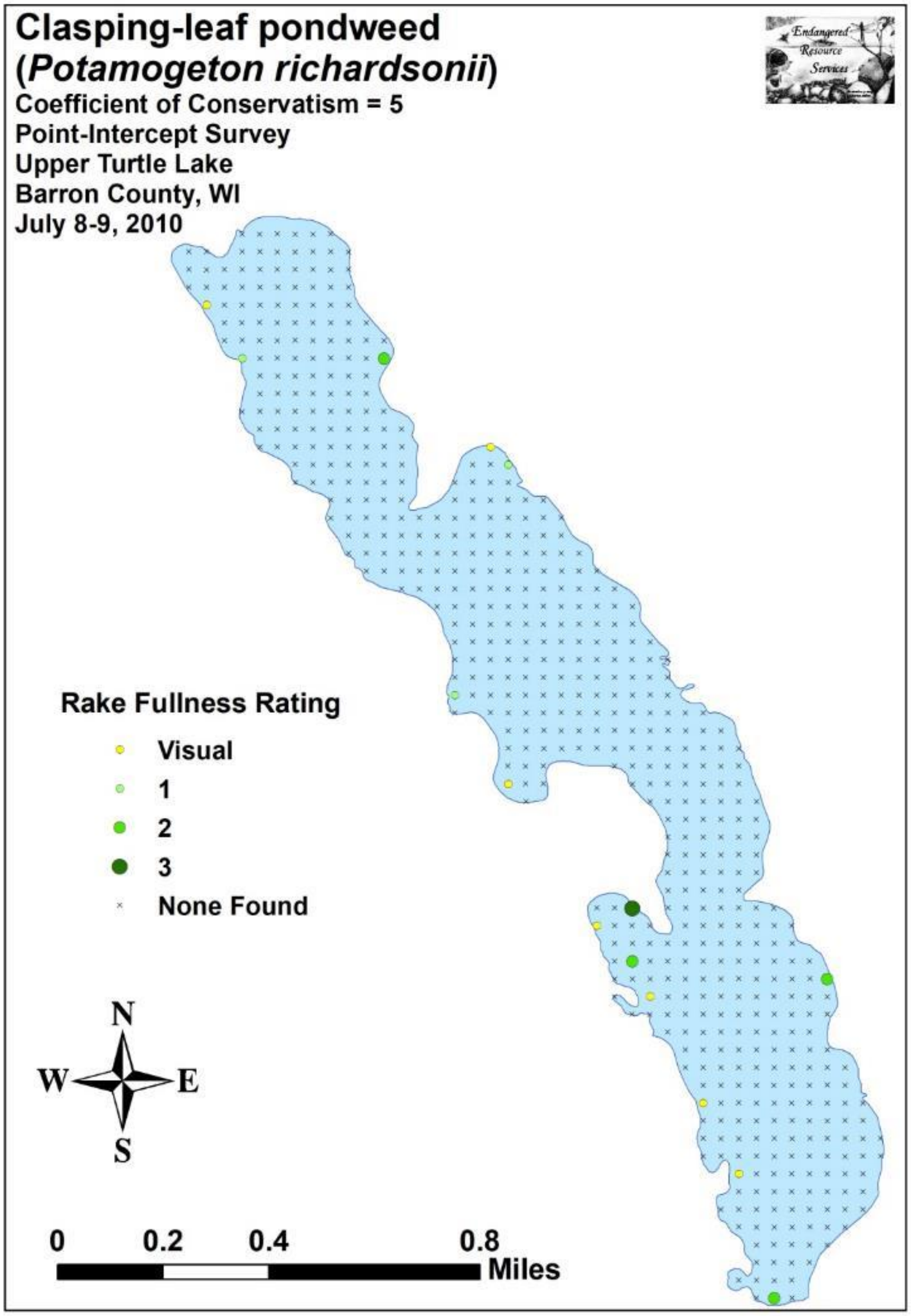
S
0
0.2
0.4
0.8
Miles



Clasping-leaf pondweed
(*Potamogeton richardsonii*)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
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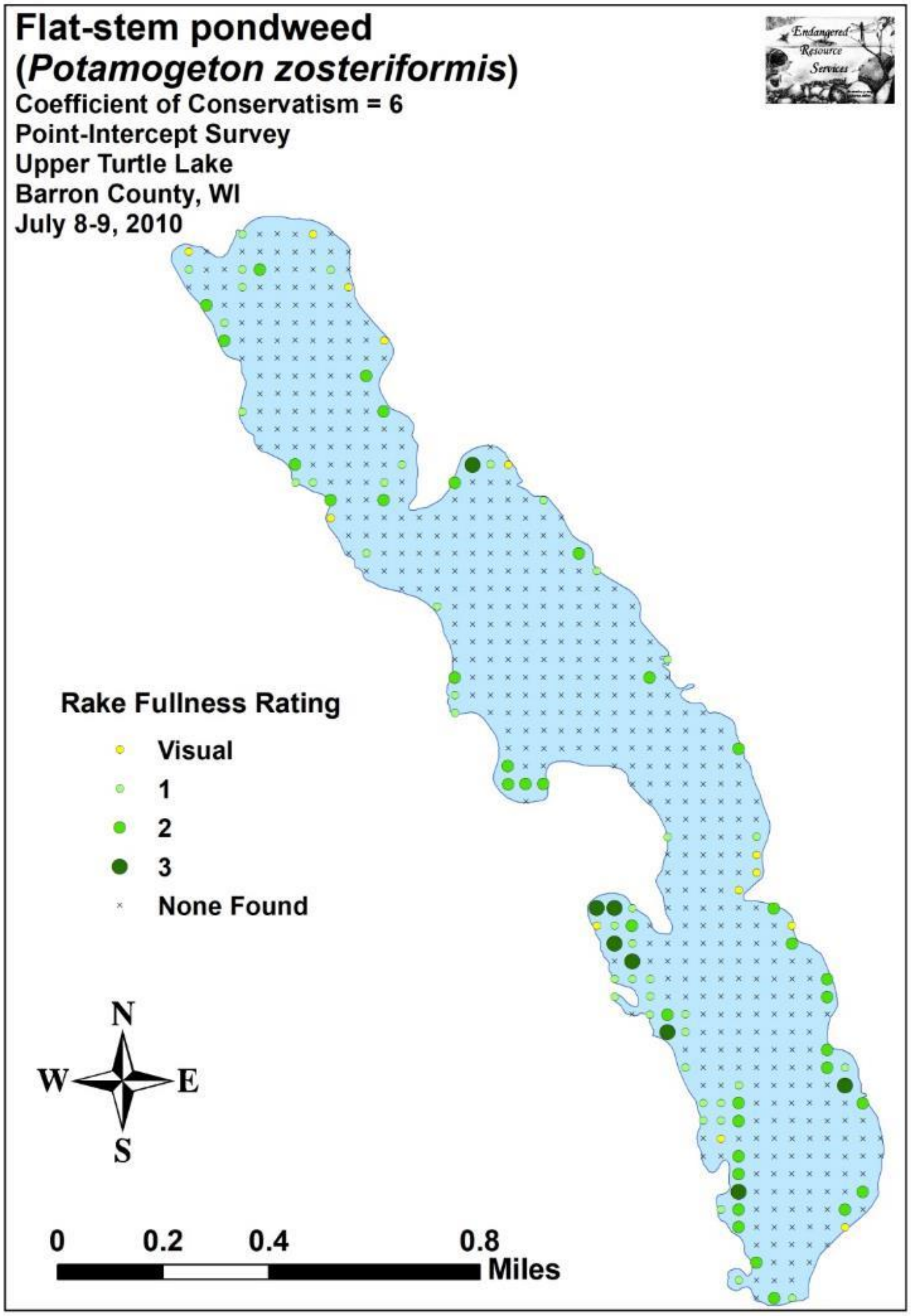
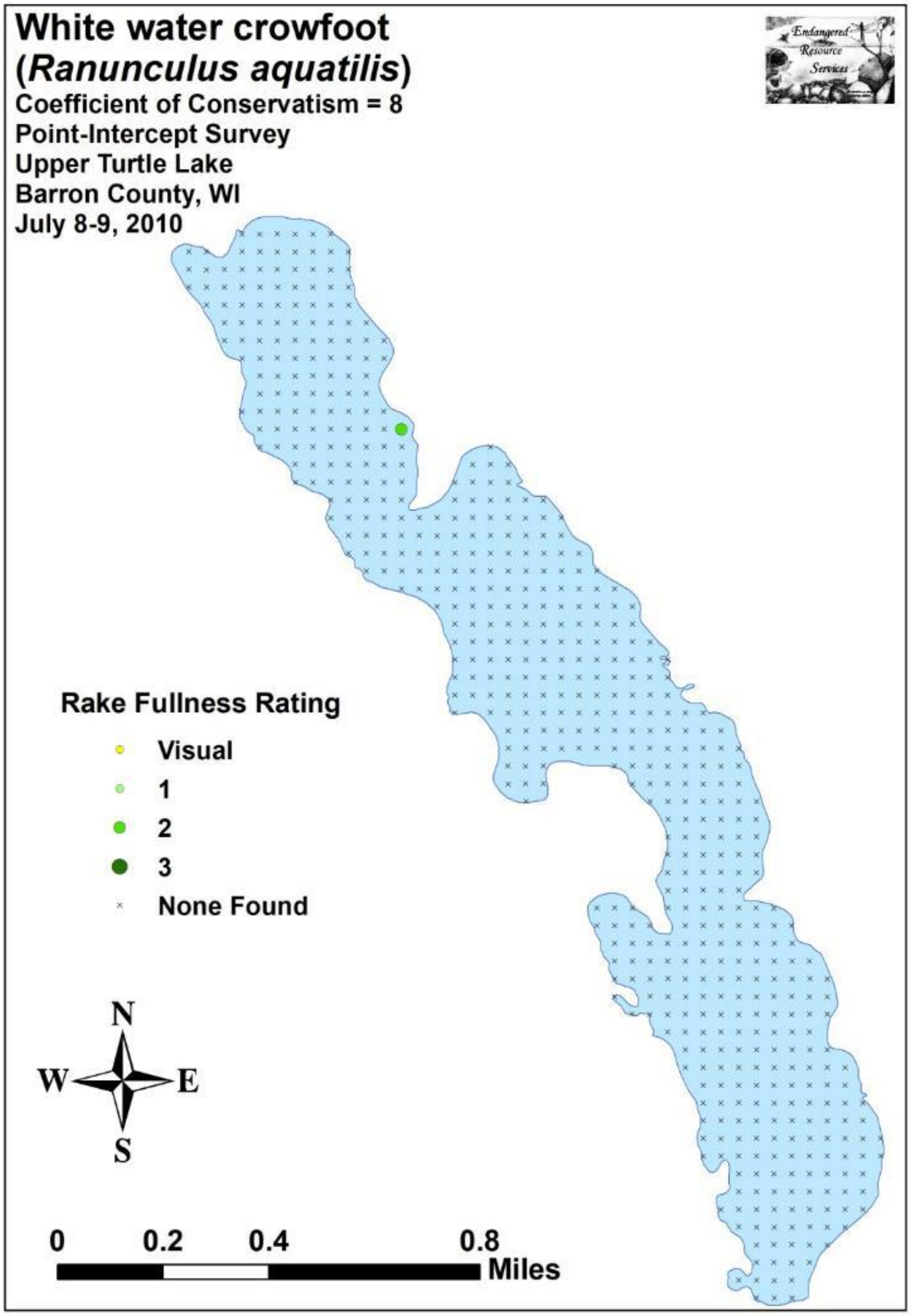
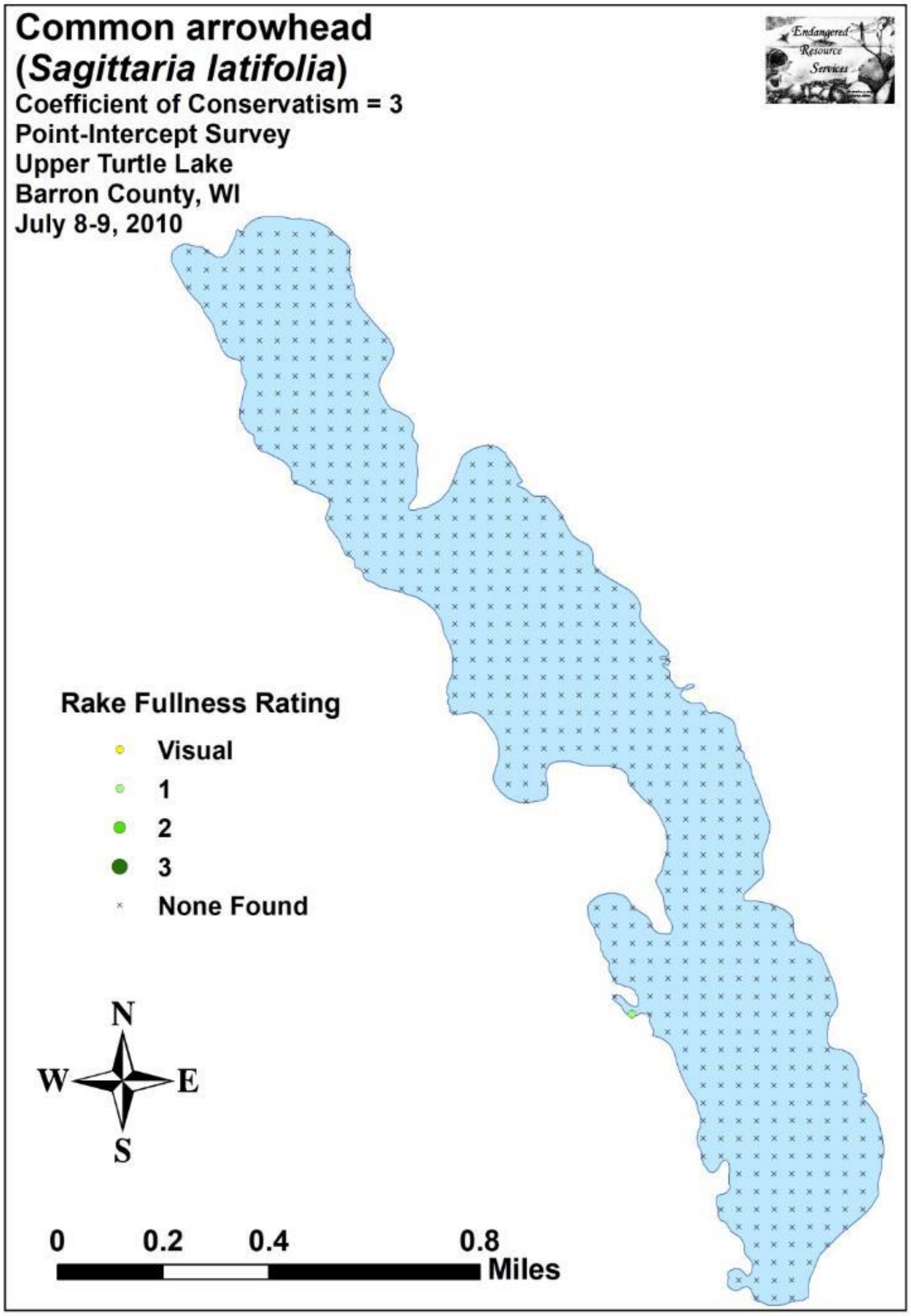
S
0
0.2
0.4
0.8
Miles


Flat-stem pondweed
(Potamogeton zosteriformis)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


White water crowfoot
(Ranunculus aquatilis)
Coefficient of Conservatism = 8
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Common arrowhead
(Sagittaria latifolia)
Coefficient of Conservatism = 3
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
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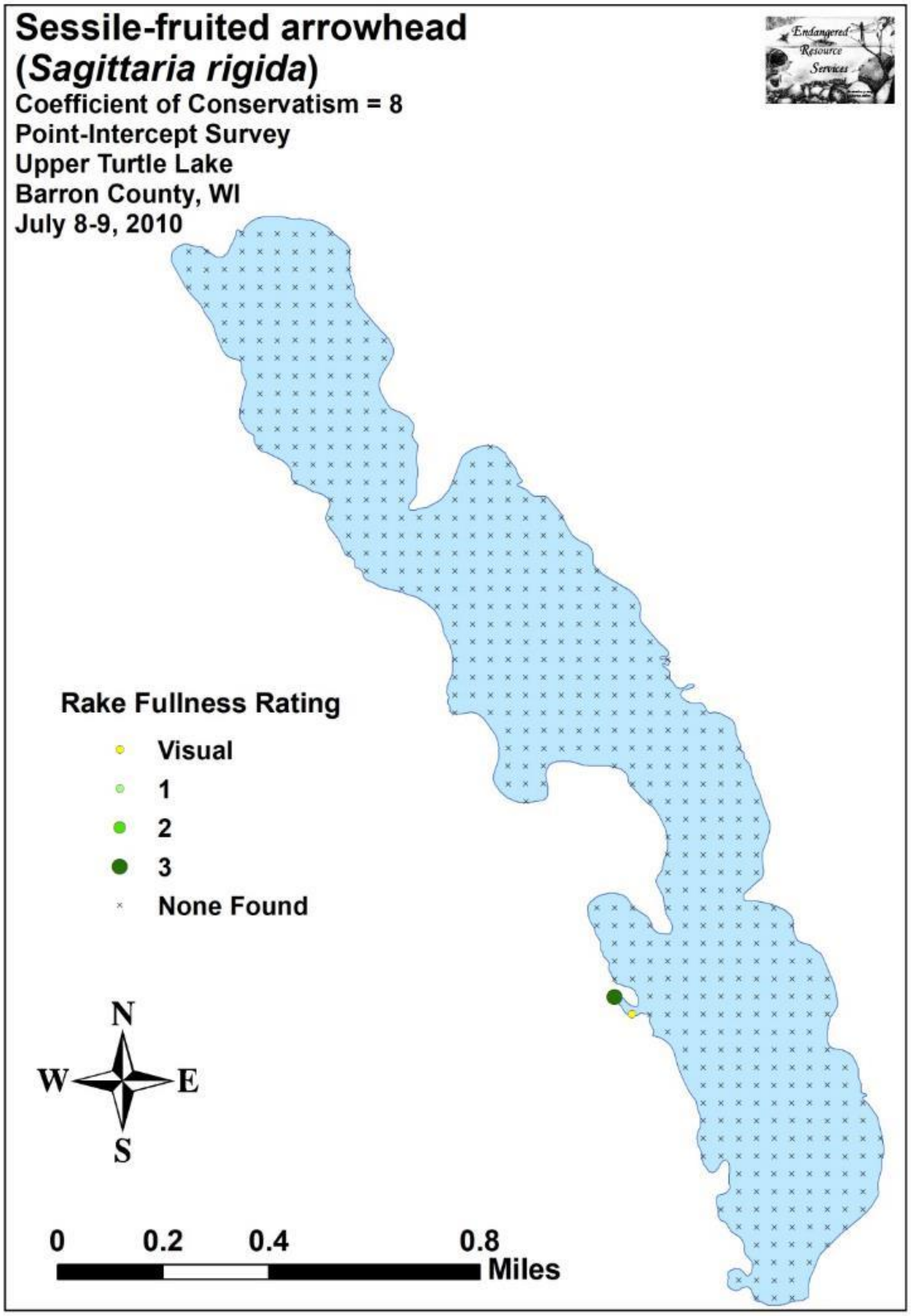
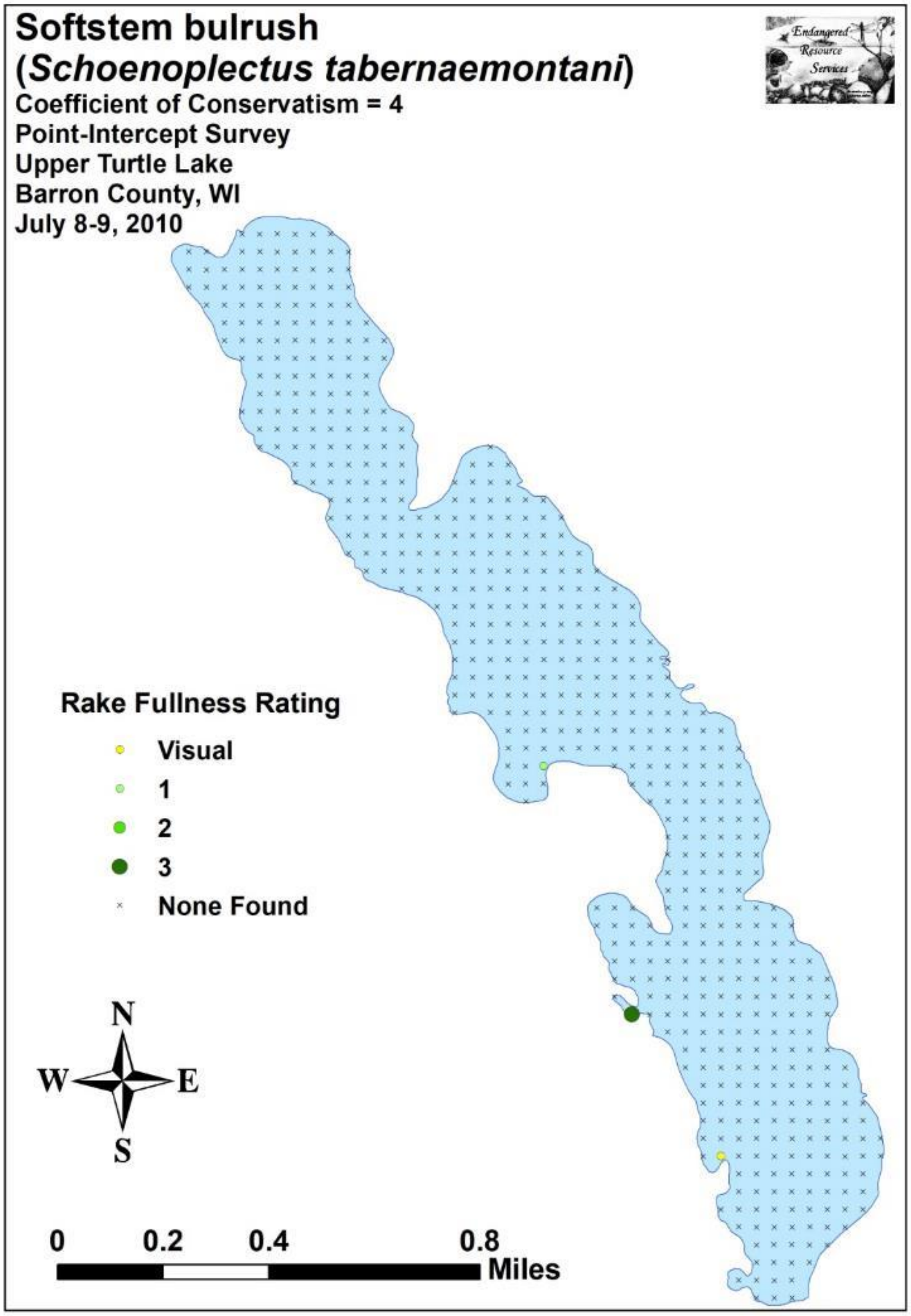
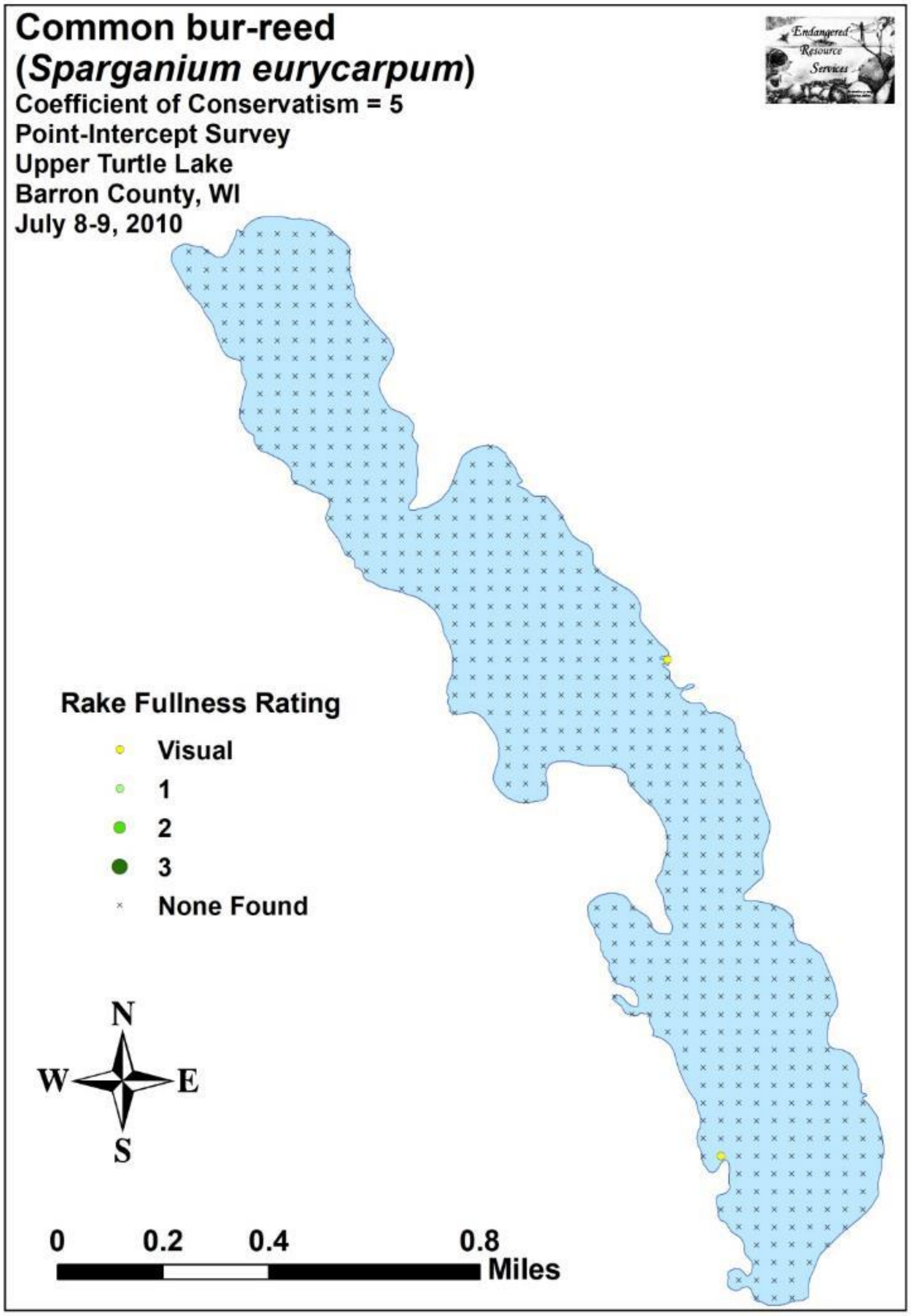
S
0
0.2
0.4
0.8
Miles

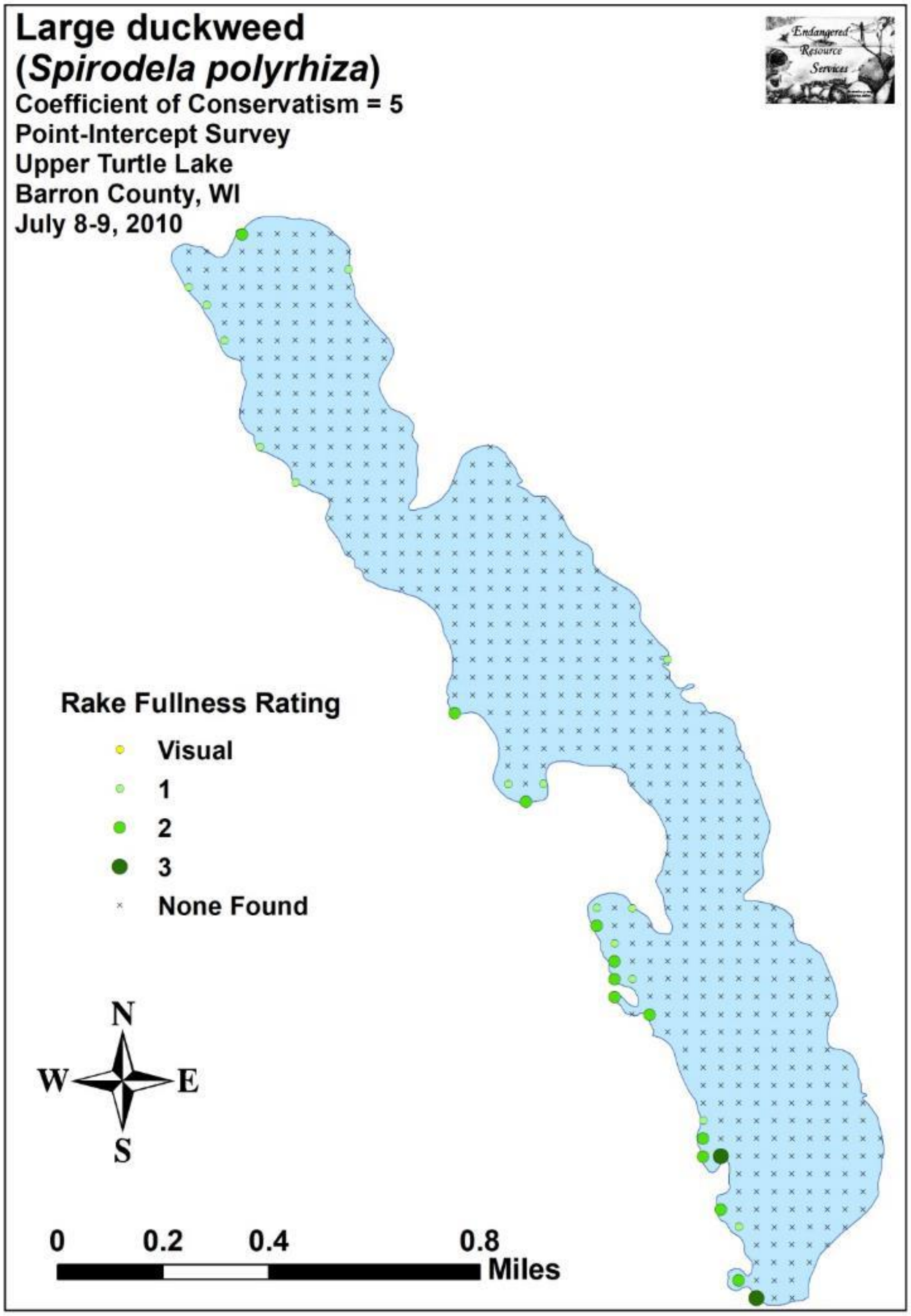


Sessile-fruited arrowhead
(Sagittaria rigida)
Coefficient of Conservatism = 8
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

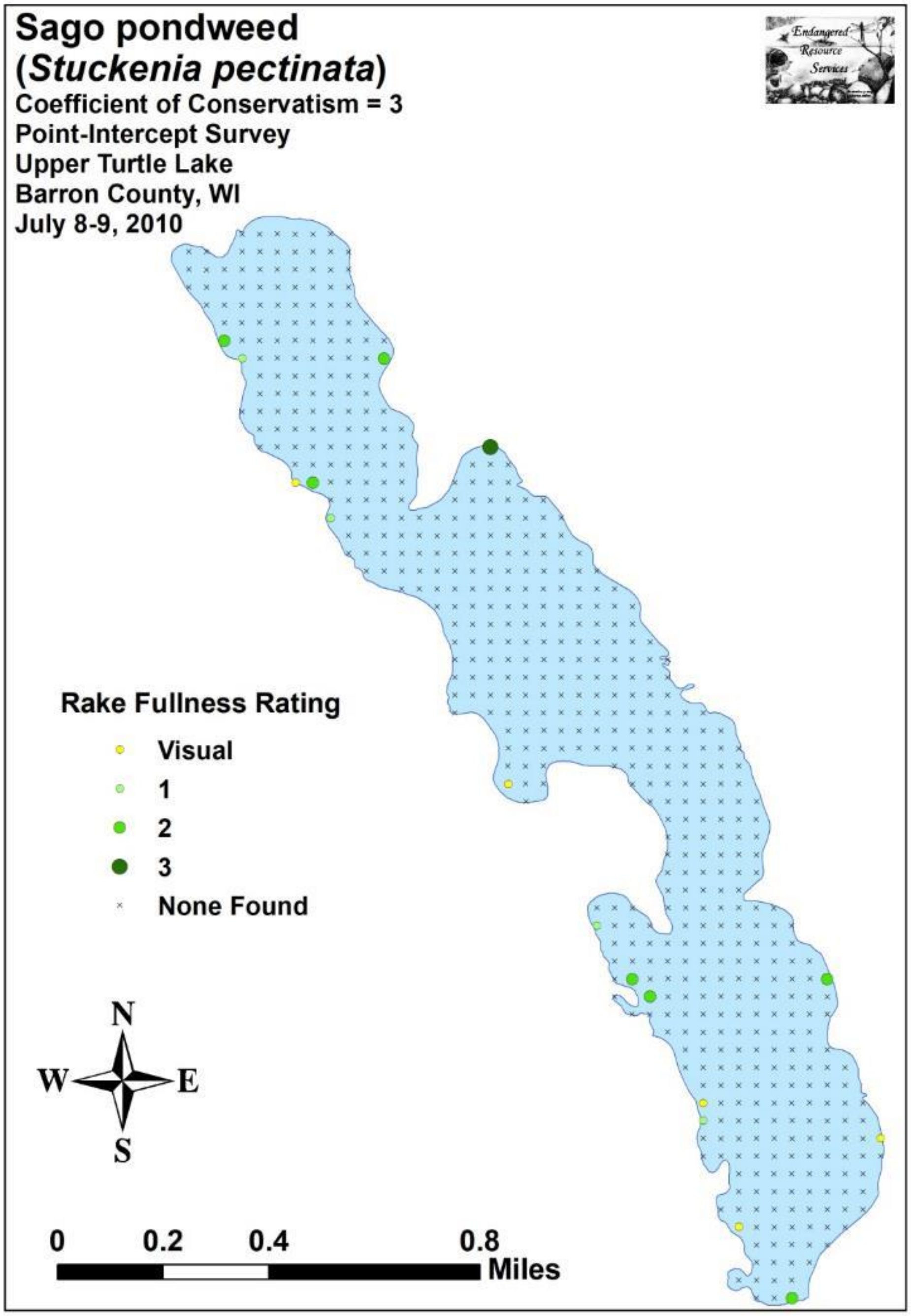


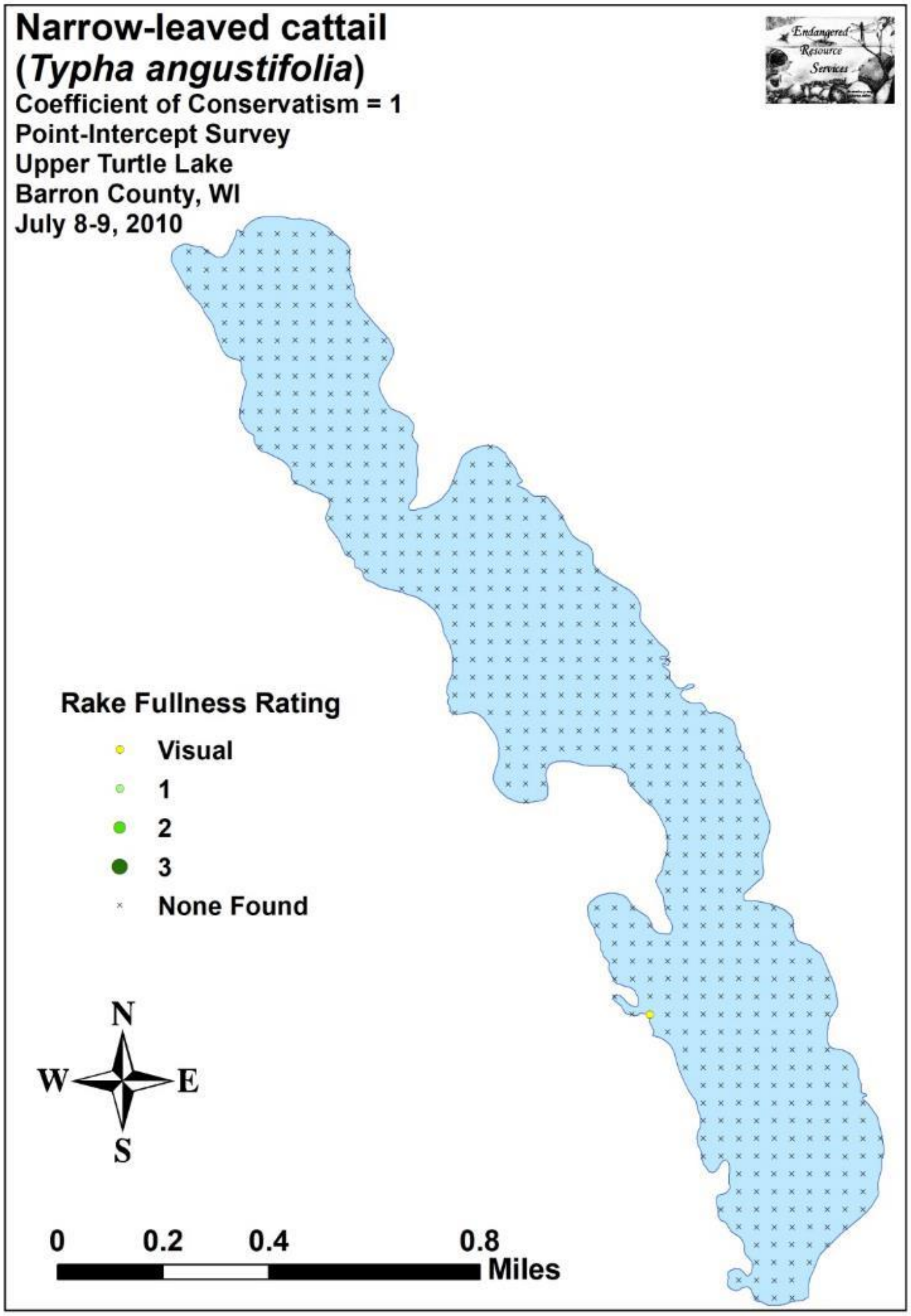
Softstem bulrush
(*Schoenoplectus tabernaemontani*)
Coefficient of Conservatism = 4
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

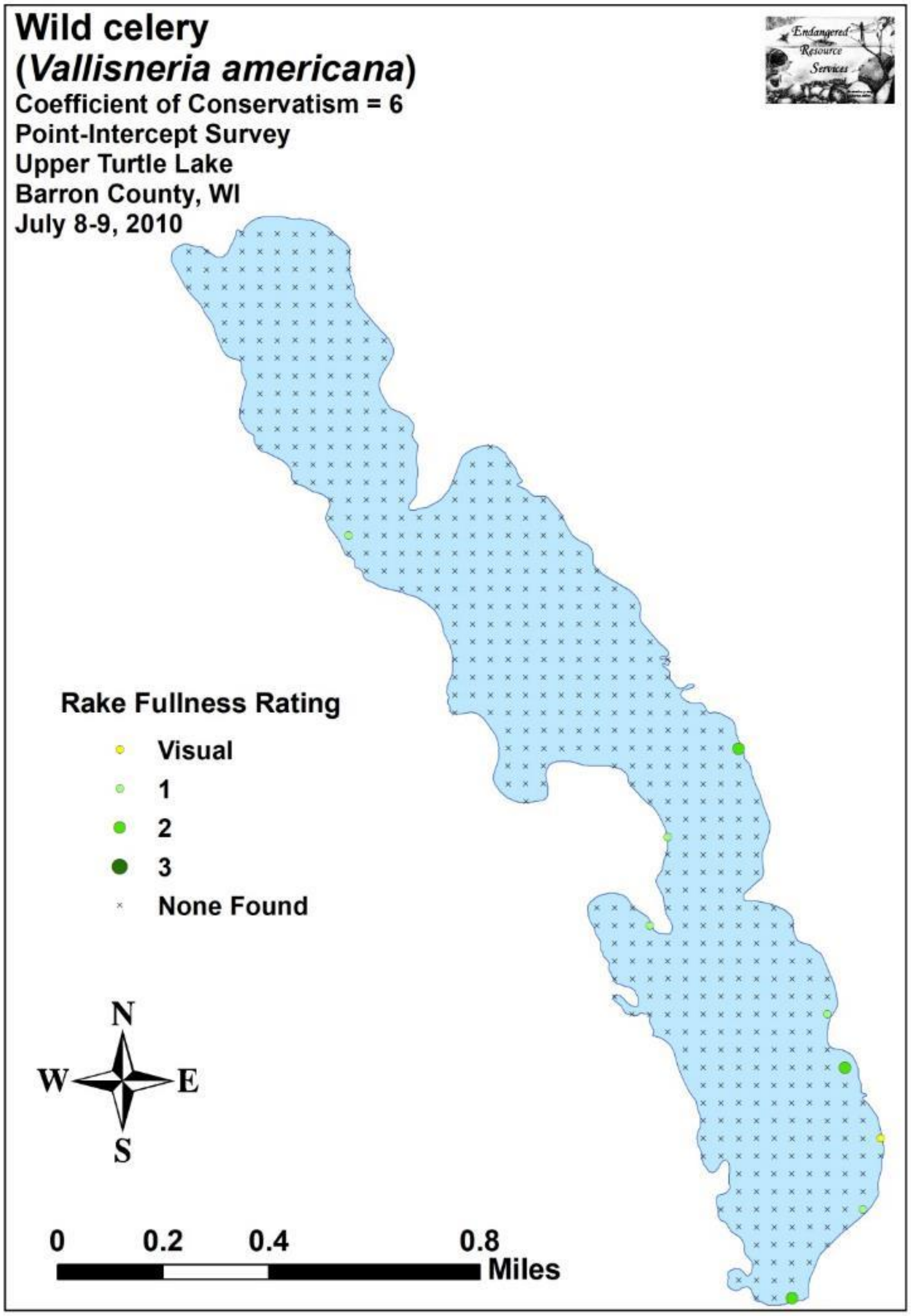

Common bur-reed
(Sparganium eurycarpum)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

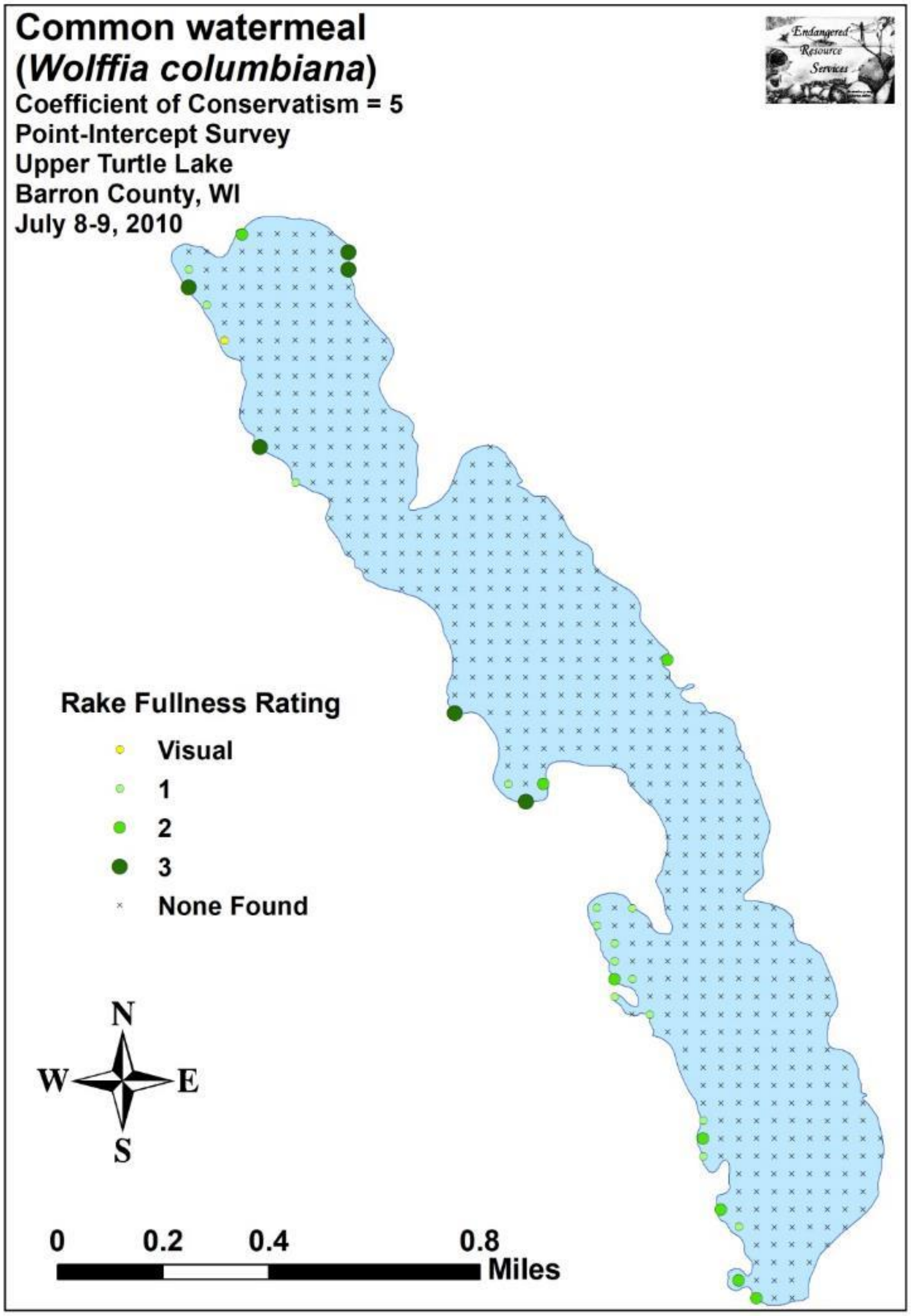


Large duckweed
(Spirodela polyrhiza)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered
Resource
Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Sago pondweed
(Stuckenia pectinata)
Coefficient of Conservatism = 3
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Narrow-leaved cattail
(Typha angustifolia)
Coefficient of Conservatism = 1
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Wild celery
(Vallisneria americana)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Common watermeal
(Wolffia columbiana)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 8-9, 2010
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

Appendix VII: Upper Turtle Lake Plant Species Accounts

County/State: Barron County, Wisconsin **Date:** 7/9/10
Species: (*Acorus americanus*) **Sweet-flag**
Specimen Location: Upper Turtle Lake; N45.42187°, W92.09966°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-353
Habitat/Distribution: Muck bottom at the shoreline in 0 – 0.5 meters of water. Rare with only a few scattered monotypic clusters in the bay around the point.
Common Associates: (*Sagittaria latifolia*) Common arrowhead, (*Typha latifolia*) Broad-leaved cattail

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Bolboschoenus fluviatilis*) **River bulrush**
Specimen Location: Upper Turtle Lake; N45.42487°, W92.09494°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-354
Habitat/Distribution: Muck bottom along the shoreline. A few individuals were found at the point.
Common Associates: (*Sagittaria latifolia*) Common arrowhead, (*Eleocharis erythropoda*) Bald spikerush, (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Carex comosa*) **Bottle-brush sedge**
Specimen Location: Upper Turtle Lake; N45.41513°, W92.09596°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-355
Habitat/Distribution: Muck bottom along the shoreline. A few individuals were scattered throughout in undeveloped low areas.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Carex hystericina*) Porcupine sedge, (*Typha angustifolia*) Narrow-leaved cattail, (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Carex hystericina*) **Porcupine sedge**
Specimen Location: Upper Turtle Lake; N45.41513°, W92.09596°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-356
Habitat/Distribution: Muck bottom along the shoreline. A few individuals were scattered near the point.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Carex comosa*) Bottle-brush sedge, (*Typha angustifolia*) Narrow-leaved cattail, (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Ceratophyllum demersum*) **Coontail**
Specimen Location: Upper Turtle Lake; N45.40994°, W92.08748°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-357
Habitat/Distribution: Muck bottom in 0-4.5 meters. Abundant throughout – it was the deepest growing macrophyte.
Common Associates: (*Potamogeton crispus*) Curly-leaf pondweed**,** (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Nuphar variegata*) Spatterdock, (*Nymphaea odorata*) White water lily, (*Myriophyllum sibiricum*) Northern water milfoil

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Chara* sp.) **Muskgrass**
Specimen Location: Upper Turtle Lake; N45.41191°, W92.08617°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-358
Habitat/Distribution: Most common in sand/silt/rock bottom areas (especially on exposed points) in water from 0 – 1.5 meters deep. Most plants were located on the east side of the lake.
Common Associates: (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton illinoensis*) *Illinois* pondweed, (*Najas flexilis*) Slender naiad

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Decodon verticillatus*) **Swamp loosestrife**
Specimen Location: Upper Turtle Lake; N45.40745°, W92.09084°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-359
Habitat/Distribution: Muck bottom at the shoreline in 0 – 0.25 meters of water. Abundant in scattered shoreline locations where it forms dense, nearly monotypic stands. Most plants were located on the west side of the lake where it ringed several muck bottomed bays.
Common Associates: (*Sagittaria latifolia*) Common arrowhead**,** (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Eleocharis erythropoda*) Bald spikerush

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Elatine minima*) **Waterwort**
Specimen Location: Upper Turtle Lake; N45.41142°, W92.08616°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-360
Habitat/Distribution: Rocky to sandy bottoms in <1 meter of water. Rare; a few scattered colonies were located on the eastern shoreline.
Common Associates: (*Chara* sp.) Muskgrass, (*Eleocharis acicularis*) Needle spikerush**,** (*Isoetes echinospora*) Spiny-spored quillwort, (*Najas flexilis*) Slender naiad

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Eleocharis acicularis*) **Needle spikerush**
Specimen Location: Upper Turtle Lake; N45.41142°, W92.08616°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-361
Habitat/Distribution: A single patch was found at the point in sand/rock bottom areas in water from 0 – 1 meter deep.
Common Associates: (*Chara* sp.) Muskgrass, (*Elatine minima*) Waterwort, (*Isoetes echinospora*) Spiny-spored quillwort, (*Najas flexilis*) Slender naiad

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Eleocharis erythropoda*) **Bald spikerush**
Specimen Location: Upper Turtle Lake; N45.42487°, W92.09494°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-362
Habitat/Distribution: Mucky to firm bottoms in 0-0.5 meters of water. Scattered individuals found growing among cattails, swamp loosestrife, and arrowheads and bulrushes in undeveloped low areas.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Sagittaria latifolia*) Common arrowhead, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Decodon verticillatus*) Swamp loosestrife

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Elodea canadensis*) **Common waterweed**
Specimen Location: Upper Turtle Lake; N45.40793°, W92.09086°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-363
Habitat/Distribution: Muck bottom in 0-4 meters of water.
Rare; only a few individuals of this normally abundant plant were found at a couple of points in muck bottom bays on the west side of the lake.
Common Associates: (*Potamogeton zosteriformis*) Flat-stem, (*Potamogeton friesii*) Fries' pondweed, (*Najas flexilis*) Slender naiad, (*Ceratophyllum demersum*) Coontail

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Heteranthera dubia*) **Water star-grass**
Specimen Location: Upper Turtle Lake; N45.41191°, W92.08617°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-364
Habitat/Distribution: Firm muck, sand and rock bottoms usually in water < 2 meter deep. Scattered individuals primarily on the east side of the lake.
Common Associates: (*Chara* sp.) Muskgrass, (*Potamogeton illinoensis*) Illinois pondweed, (*Vallisneria americana*) Wild celery, (*Najas flexilis*) Slender naiad

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Isoetes echinospora*) **Spiny-spored quillwort**
Specimen Location: Upper Turtle Lake; N45.41142°, W92.08616°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-365
Habitat/Distribution: Rare; found at the point in sand/rock bottom areas in water from 0 – 1 meter deep.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Chara* sp.) Muskgrass, (*Elatine minima*) Waterwort, (*Najas flexilis*) Slender naiad

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Lemna minor*) **Small duckweed**
Specimen Location: Upper Turtle Lake; N45.40745°, W92.09084°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-366
Habitat/Distribution: Located floating at or just under the surface in sheltered areas. Common to abundant in stagnant bays; primarily on the western side of the lake.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Spirodela polyrhiza*) Large duckweed, (*Wolffia columbiana*) Common watermeal

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Myriophyllum sibiricum*) **Northern water milfoil**
Specimen Location: Upper Turtle Lake; N45.41382°, W92.08763°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-367
Habitat/Distribution: Variable substrate in water up 0.5-3 meters. Widespread and relatively common throughout.
Common Associates: (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Ceratophyllum demersum*) Coontail

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Najas flexilis*) **Slender naiad**
Specimen Location: Upper Turtle Lake; N45.41142°, W92.08616°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-368
Habitat/Distribution: Found in almost any bottom conditions, but grows best in rock/ sand bottoms in 0.5-1.5 meters of water. Uncommon, but widely distributed along the lake's eastern shoreline.
Common Associates: (*Chara* sp.) Muskgrass, (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton illinoensis*) Illinois pondweed, (*Vallisneria americana*) Wild celery

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Nuphar variegata*) **Spatterdock**
Specimen Location: Upper Turtle Lake; N45.41514°, W92.09527°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-369
Habitat/Distribution: Firm muck bottom in 0-2 meters of water where it often formed dense canopies. Widely scattered in muck bays and sheltered shoreline areas
Common Associates: (*Nymphaea odorata*) White water lily, (*Spirodela polyrhiza*) Large duckweed, (*Wolffia columbiana*) Common watermeal, (*Ceratophyllum demersum*) Coontail

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Nymphaea odorata*) **White water lily**
Specimen Location: Upper Turtle Lake; N45.40745°, W92.09084°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-370
Habitat/Distribution: Muck bottom in 0-2 meters where it forms dense canopies with other floating leaf species. Relatively common bays and sheltered shoreline areas.
Common Associates: (*Nuphar variegata*) Spatterdock, (*Spirodela polyrhiza*) Large duckweed, (*Wolffia columbiana*) Common watermeal, (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Phalaris arundinacea*) **Reed canary grass**
Specimen Location: Upper Turtle Lake; N45.40745°, W92.09084°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-371
Habitat/Distribution: Common but not abundant. Prefers thick muck soil in and out of water <0.5 meters. Primarily found on shore in undeveloped low areas. Present throughout.
Common Associates: (*Typha latifolia*) Broad-leaved cattail**,** (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Eleocharis erythropoda*) Bald spikerush, (*Sagittaria latifolia*) Common arrowhead

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Potamogeton crispus*) **Curly-leaf pondweed**
Specimen Location: Upper Turtle Lake; N45.41430°, W92.08833°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-372
Habitat/Distribution: Found in most mucky bottom areas in water from 0.5-3.5m deep. Common and widely distributed, but seldom monotypic and invasive.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Potamogeton friesii*) Fries' pondweed

County/State: Barron County, Wisconsin **Date:** 7/21/10
Species: (*Potamogeton friesii*) **Fries' pondweed**
Specimen Location: Upper Turtle Lake; N45.40994°, W92.08748°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-373
Habitat/Distribution: Variable substrate in 1-3 meters of water. Widespread and often abundant throughout.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Potamogeton illinoensis*) Illinois pondweed, (*Vallisneria americana*) Wild celery, (*Myriophyllum sibiricum*) Northern water milfoil, (*Chara* sp.) Muskgrass

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Potamogeton illinoensis*) **Illinois pondweed**
Specimen Location: Upper Turtle Lake; N45.41382°, W92.08763°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-374
Habitat/Distribution: Variable substrate in 1-2.5 meters of water. Scattered individuals throughout with the majority of plants being found at the outer half of the littoral zone on the east side of the lake. A few small plant near shore were ambiguous and may have been gramineus, but the lack of any morphologically pure individuals caused us to classify all specimens as illinoensis.
Common Associates: (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Myriophyllum sibiricum*) Northern water milfoil

County/State: Barron County, Wisconsin **Date:** 7/9/10
Species: (*Potamogeton obtusifolius*) **Blunt-leaf pondweed**
Specimen Location: Upper Turtle Lake N45.43626°, W92.10986°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-375
Habitat/Distribution: A few individual plants were found at two points in the northeast corner of the north bay over thick organic muck in <1.5 meters of water.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Nymphaea odorata*) White water lily

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Potamogeton praelongus*) **White-stem pondweed**
Specimen Location: Upper Turtle Lake; N45.41382°, W92.08763°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-376
Habitat/Distribution: Variable substrate in 1-2 meters of water. Rare with only a few plants seen throughout the entire lake.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Potamogeton pusillus*) **Small pondweed**
Specimen Location: Upper Turtle Lake; N45.40994°, W92.08748°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-377
Habitat/Distribution: Found in almost any bottom conditions, but grows best in muck bottoms in 1-4 meters of water. Plants were found scattered throughout the lake and throughout the littoral zone.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Potamogeton illinoensis*) Illinois pondweed

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Potamogeton richardsonii*) **Clasping-leaf pondweed**
Specimen Location: Upper Turtle Lake; N45.41624°, W92.08841°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-378
Habitat/Distribution: Found in sandy/muck bottom conditions in shallow water 0.5-1.5 meter deep. Uncommon in scattered locations on the eastern shoreline.
Common Associates: (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Potamogeton illinoensis*) Illinois pondweed, (*Stuckenia pectinata*) Sago pondweed

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Potamogeton zosteriformis*) **Flat-stem pondweed**
Specimen Location: Upper Turtle Lake; N45.40994°, W92.08748°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-379
Habitat/Distribution: Prefers thick organic muck. Widely distributed and common throughout in 0-3.5 meters of water. Along with Coontail, it was one of the deepest growing macrophytes.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton pusillus*) Small pondweed, (*Potamogeton friesii*) Fries' pondweed, (*Myriophyllum sibiricum*) Northern water milfoil, (*Potamogeton illinoensis*) Illinois pondweed

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Ranunculus aquatilis*) **White water crowfoot**
Specimen Location: Upper Turtle Lake; N45.43099°, W92.10552°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-380
Habitat/Distribution: Rare; a single cluster of plants was found at the point in 1.5 meters of water over in.
Common Associates: (*Potamogeton friesii*) Fries' pondweed, (*Myriophyllum sibiricum*) Northern water milfoil

County/State: Barron County, Wisconsin **Date:** 7/9/10
Species: (*Sagittaria cristata*) **Crested arrowhead**
Specimen Location: Upper Turtle Lake; N45.43282°, W92.11180°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-381
Habitat/Distribution: A single bed of both submergent and emergent plants was found at the point in shallow water 0-1.5 meters over firm sand.
Common Associates: (*Myriophyllum sibiricum*) Northern water milfoil, (*Chara* sp.) Muskgrass, (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Najas flexilis*) Slender naiad, (*Stuckenia pectinata*) Sago pondweed

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Sagittaria latifolia*) **Common arrowhead**
Specimen Location: Upper Turtle Lake; N45.42487°, W92.09494°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-382
Habitat/Distribution: Scattered mucky shoreline locations in undeveloped areas throughout.
Common Associates: (*Typha latifolia*) Broad-leaved cattail**,** (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Eleocharis erythropoda*) Bald spikerush, (*Sparganium eurycarpum*) Common bur-reed, (*Phalaris arundinacea*) Reed canary grass

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Sagittaria rigida*) **Sessile-fruited arrowhead**
Specimen Location: Upper Turtle Lake; N45.40745°, W92.09084°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-383
Habitat/Distribution: Several small emergent beds were found on the west side of the lake. Plants were growing over muck in <1 meter of water.
Common Associates: (*Elodea canadensis*) Common waterweed, (*Nymphaea odorata*) White water lily

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Schoenoplectus acutus*) **Hardstem bulrush**
Specimen Location: Upper Turtle Lake; N45.41757°, W92.09536°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-384
Habitat/Distribution: Single cluster of plants on a rocky exposed peninsula at the point in water <0.5 meters deep.
Common Associates: (*Heteranthera dubia*) Water star-grass, (*Vallisneria americana*) Wild celery

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Schoenoplectus tabernaemontani*) **Softstem bulrush**
Specimen Location: Upper Turtle Lake; N45.41131°, W92.09236°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-385
Habitat/Distribution: Firm muck bottoms in 0-0.5 meter of water. Relatively common with scattered clusters located in undeveloped low areas throughout.
Common Associates: (*Eleocharis erythropoda*) Bald spikerush, (*Typha latifolia*) Broad-leaved cattail, (*Sparganium eurycarpum*) Common bur-reed, (*Phalaris arundinacea*) Reed canary grass, (*Sagittaria latifolia*) Common arrowhead

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Sparganium eurycarpum*) **Common bur-reed**
Specimen Location: Upper Turtle Lake; N45.41131°, W92.09236°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-386
Habitat/Distribution: Uncommon in scattered mucky shoreline locations.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Sparganium eurycarpum*) Common bur-reed, (*Phalaris arundinacea*) Reed canary grass

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Spirodela polyrhiza*) **Large duckweed**
Specimen Location: Upper Turtle Lake; N45.40745°, W92.09084°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-387
Habitat/Distribution: Located floating at or just under the surface in sheltered areas. Common in stagnant bays; primarily on the western side of the lake.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Wolffia columbiana*) Common watermeal, (*Lemna minor*) Small duckweed

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Stuckenia pectinata*) **Sago pondweed**
Specimen Location: Upper Turtle Lake; N45.41191°, W92.08617°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-388
Habitat/Distribution: Uncommon to rare. Scattered plants were located in sand/muck over firm bottom in water <1.5 meters deep.
Common Associates: (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Potamogeton illinoensis*) Illinois pondweed, (*Potamogeton richardsonii*) Clasping-leaf pondweed

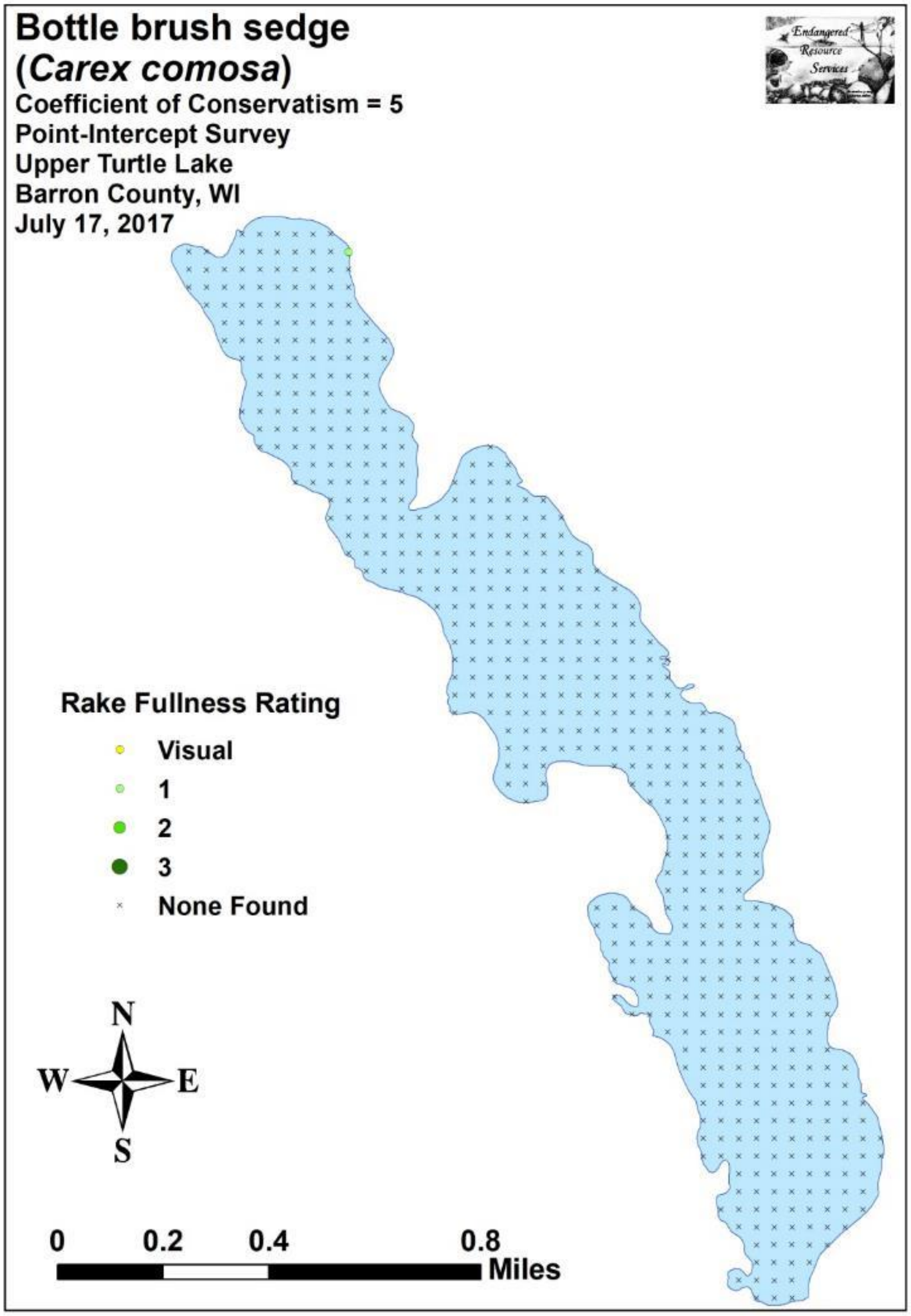
County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Typha angustifolia*) **Narrow-leaved cattail**
Specimen Location: Upper Turtle Lake; N45.41513°, W92.09596°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-389
Habitat/Distribution: Thick muck soil in and out of water <0.5 meters. Uncommon – found in a few undeveloped shoreline areas throughout.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Sagittaria latifolia*) Common arrowhead**,** (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Eleocharis erythropoda*) Bald spikerush

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Typha latifolia*) **Broad-leaved cattail**
Specimen Location: Upper Turtle Lake; N45.41513°, W92.09596°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-390
Habitat/Distribution: Thick muck soil in and out of water <0.5 meters. Uncommon – found in a few undeveloped shoreline areas throughout.
Common Associates: (*Typha angustifolia*) Narrow-leaved cattail, (*Sagittaria latifolia*) Common arrowhead**,** (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Eleocharis erythropoda*) Bald spikerush

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Vallisneria americana*) **Wild celery**
Specimen Location: Upper Turtle Lake; N45.41191°, W92.08617°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-391
Habitat/Distribution: Found in sandy/rock to sand/muck bottoms in 0.5-2.5 meters of water. Uncommon and almost exclusively restricted to the eastern shoreline in the southern half of the lake.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Heteranthera dubia*) Water star-grass, (*Chara* sp.) Muskgrass, (*Potamogeton friesii*) Fries' pondweed

County/State: Barron County, Wisconsin **Date:** 7/8/10
Species: (*Wolffia columbiana*) **Common watermeal**
Specimen Location: Upper Turtle Lake; N45.40745°, W92.09084°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-392
Habitat/Distribution: Located floating at or just under the surface in sheltered areas. Common in stagnant bays; primarily on the western side of the lake.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Spirodela polyrhiza*) Large duckweed, (*Lemna minor*) Small duckweed

Appendix VIII: July 2017 Species Density and Distribution Maps


Bottle brush sedge
(Carex comosa)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Rake Fullness Rating
Visual
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None Found
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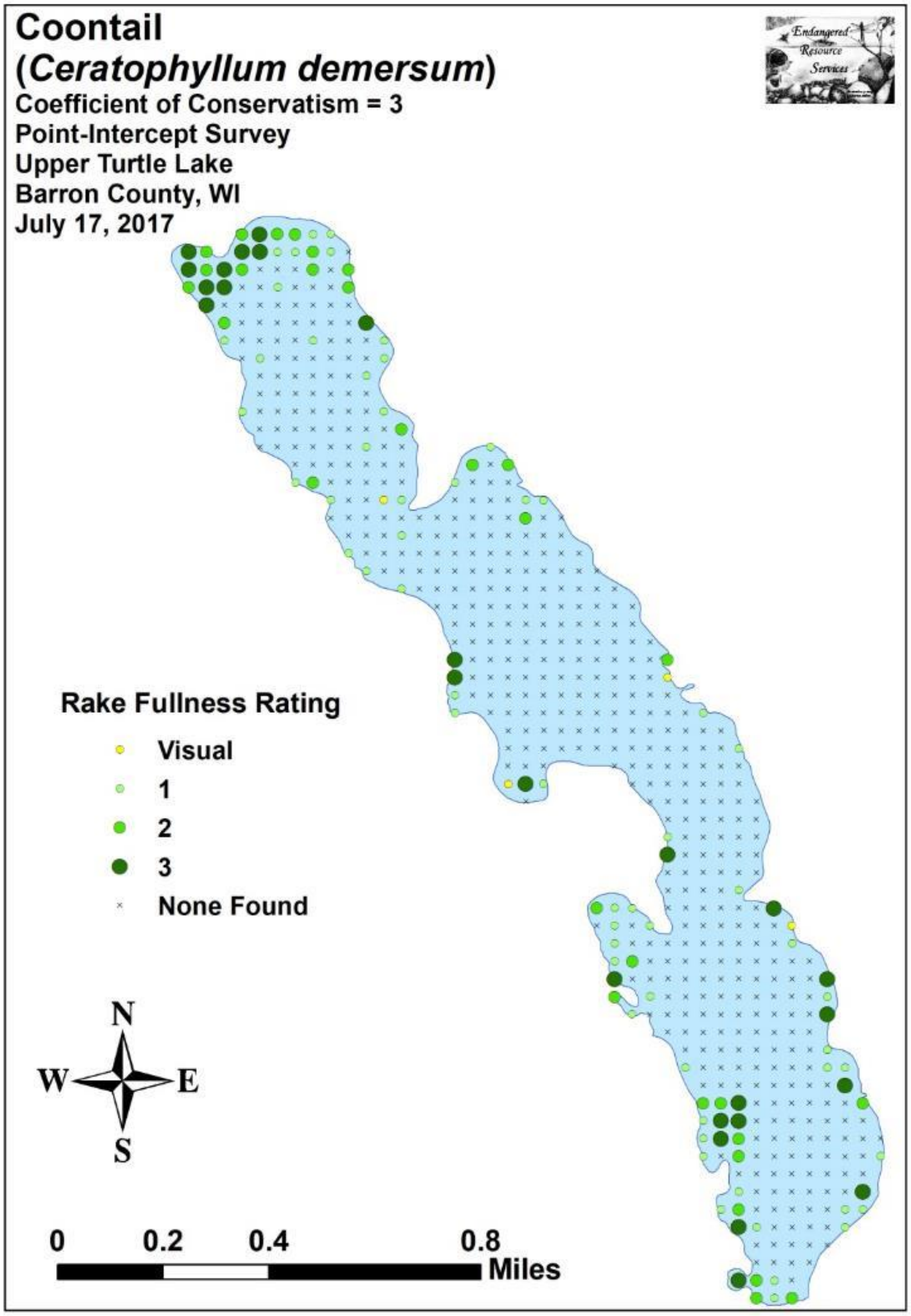
Miles



Coontail
(*Ceratophyllum demersum*)
Coefficient of Conservatism = 3
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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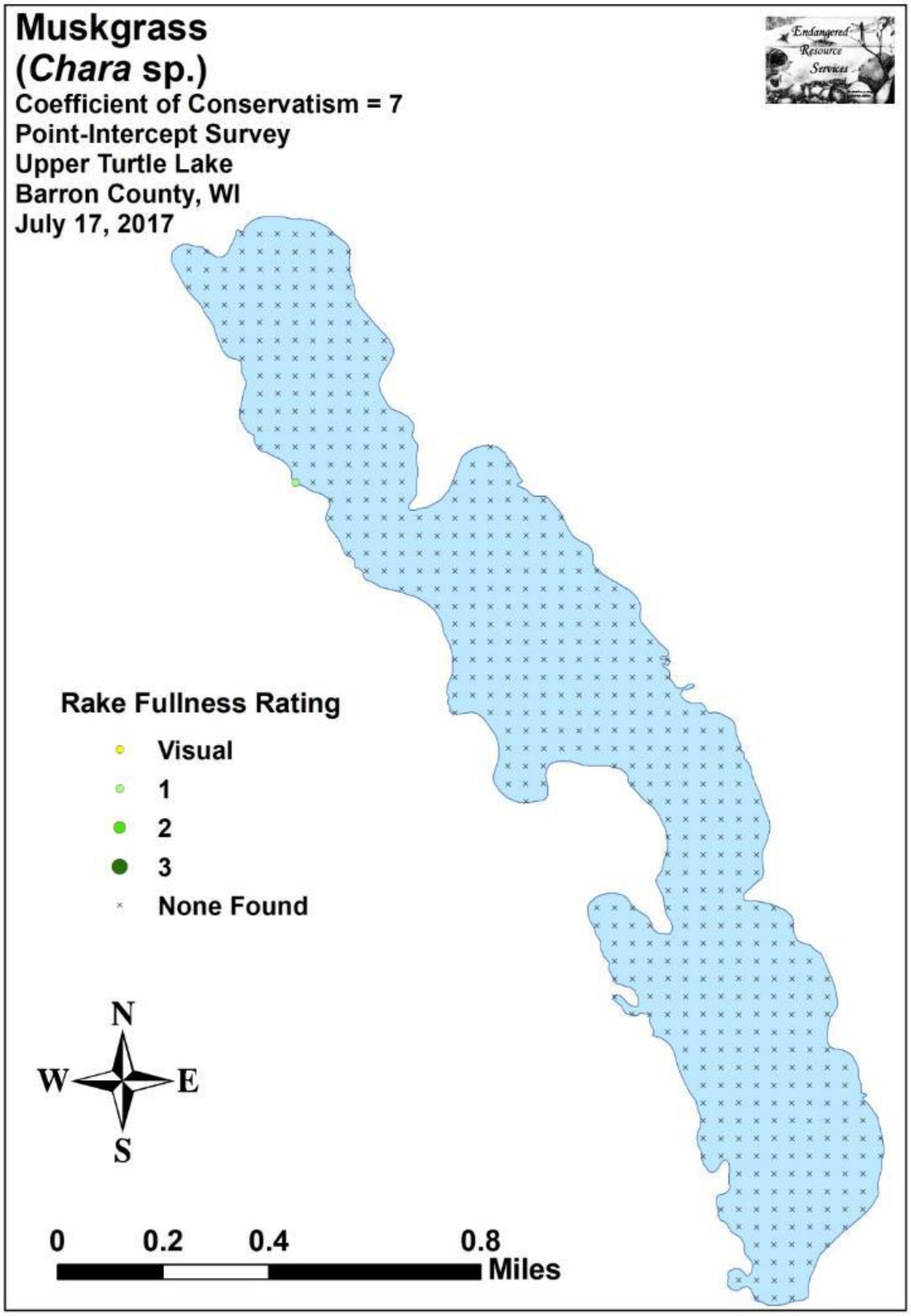
Miles


Muskgrass
(Chara sp.)
Coefficient of Conservatism = 7
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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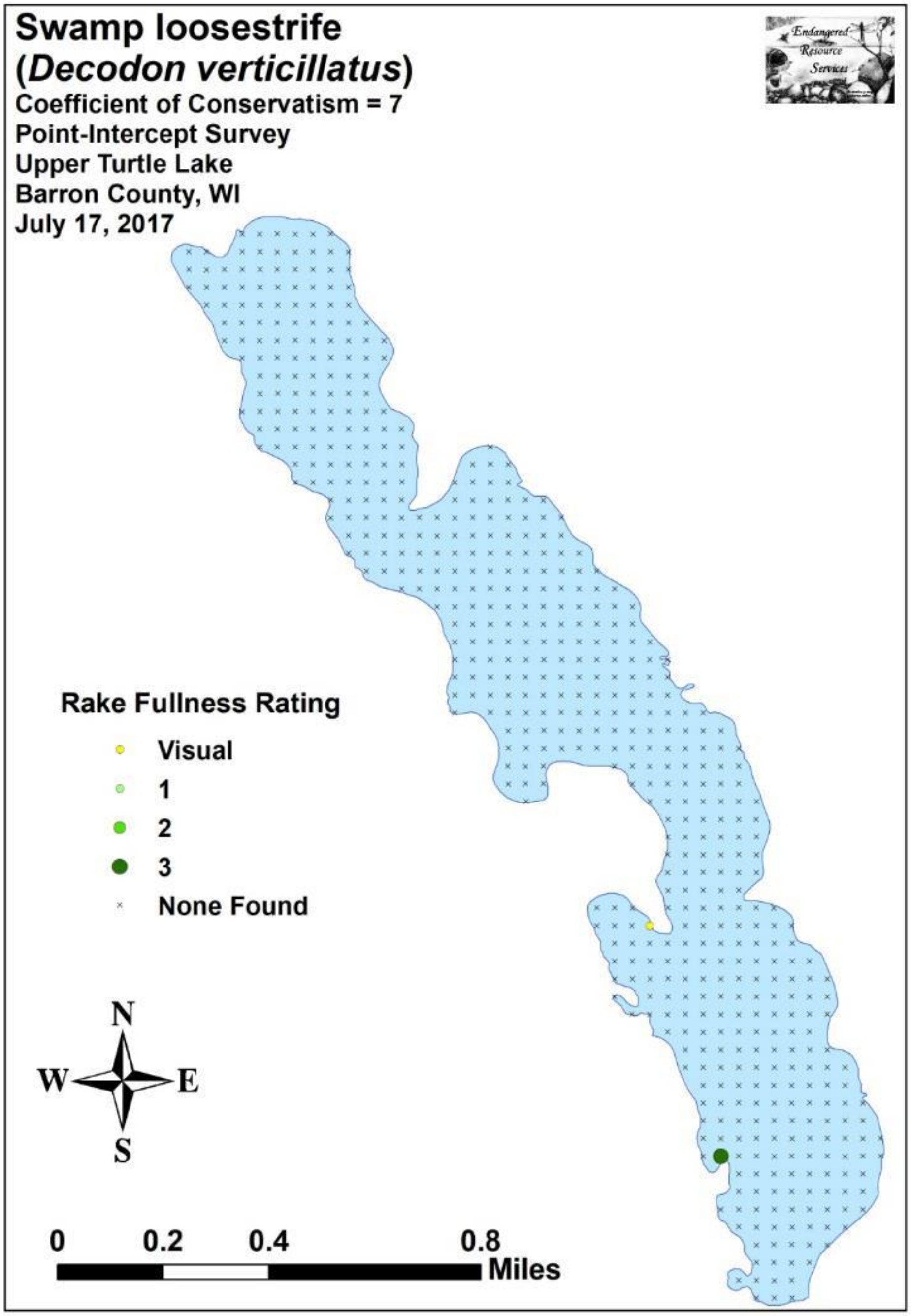
Miles


Swamp loosestrife
(*Decodon verticillatus*)
Coefficient of Conservatism = 7
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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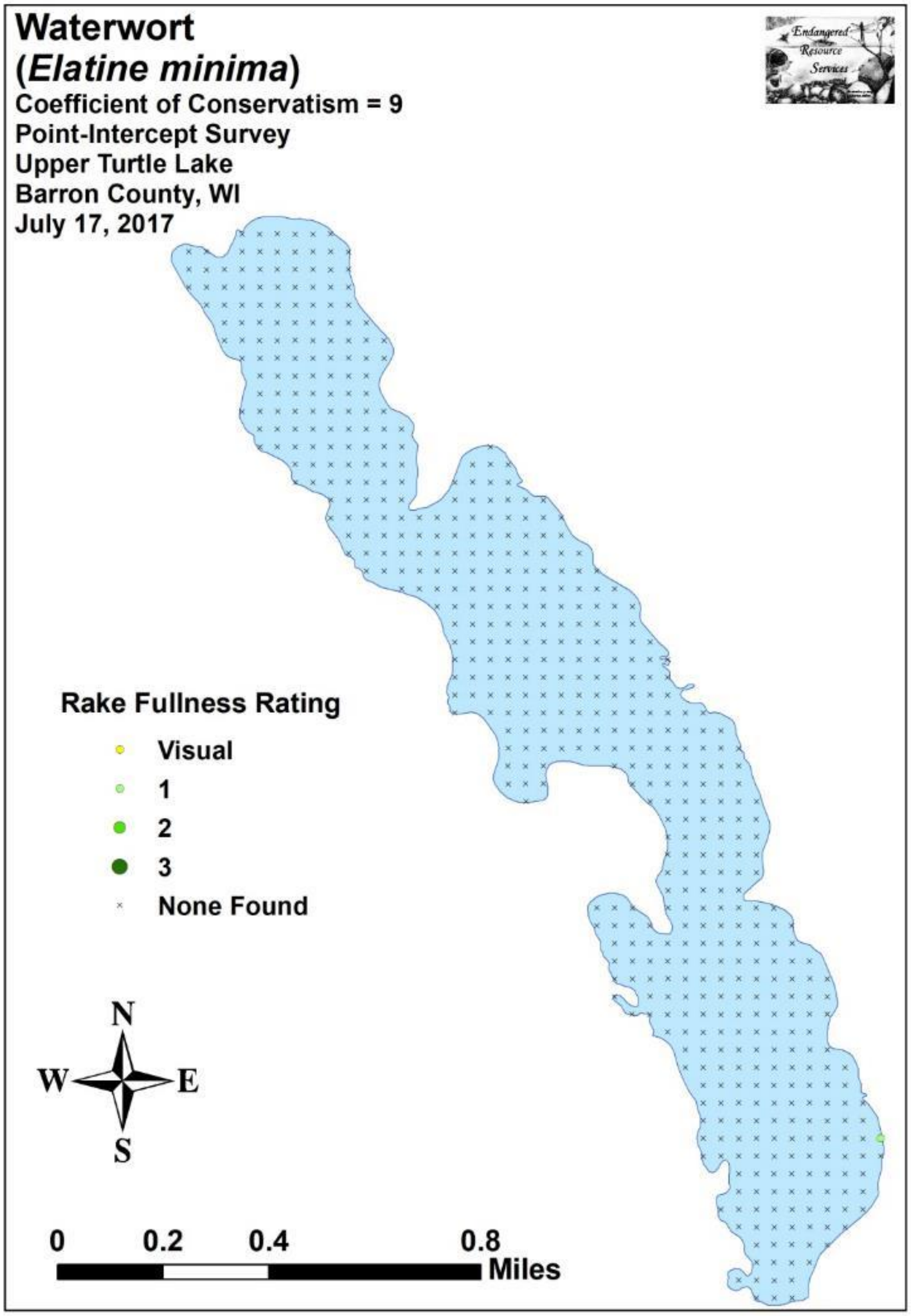
Miles



Waterwort
(Elatine minima)
Coefficient of Conservatism = 9
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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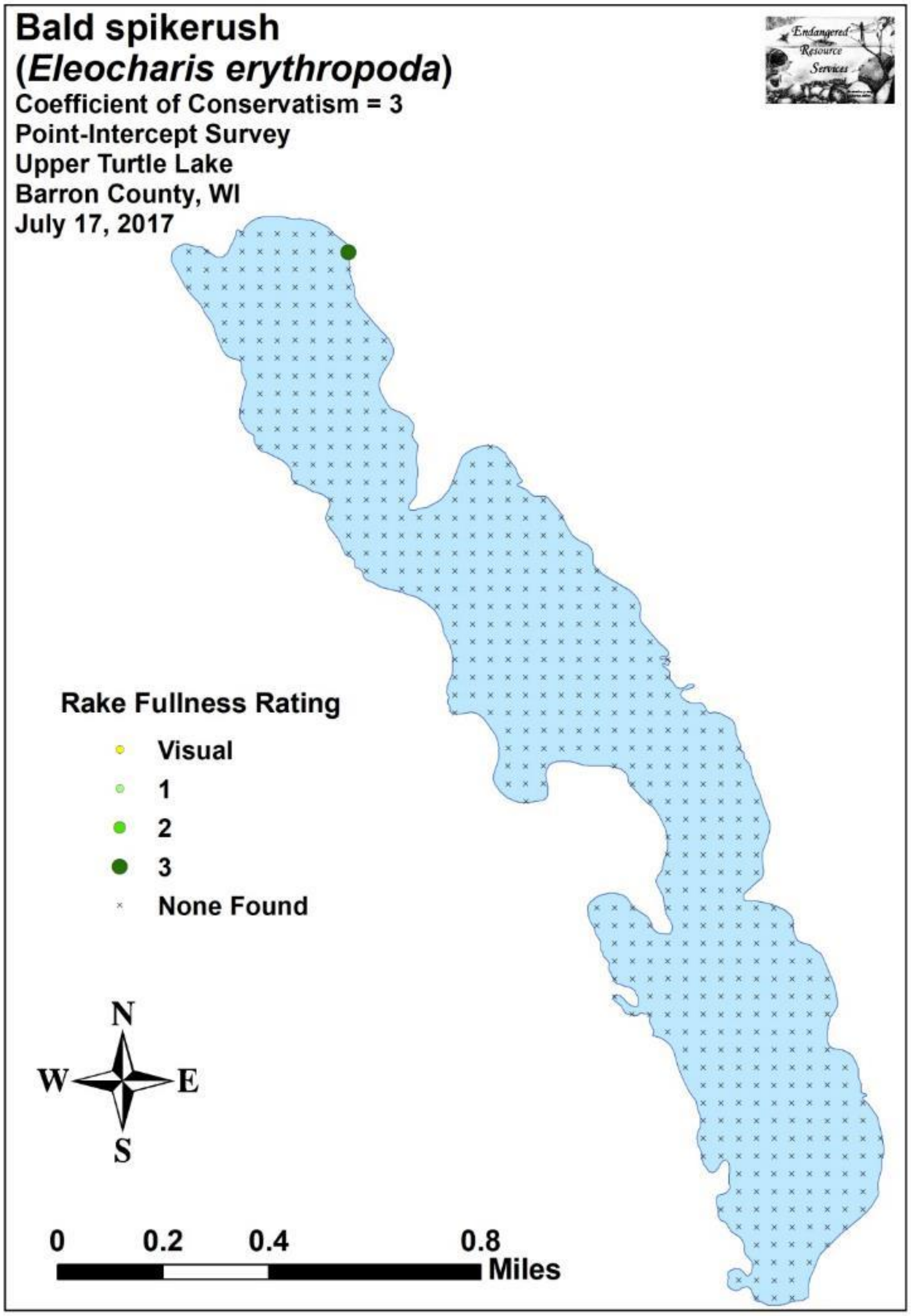
Miles


Bald spikerush
(*Eleocharis erythropoda*)
Coefficient of Conservatism = 3
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Rake Fullness Rating
Visual
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None Found
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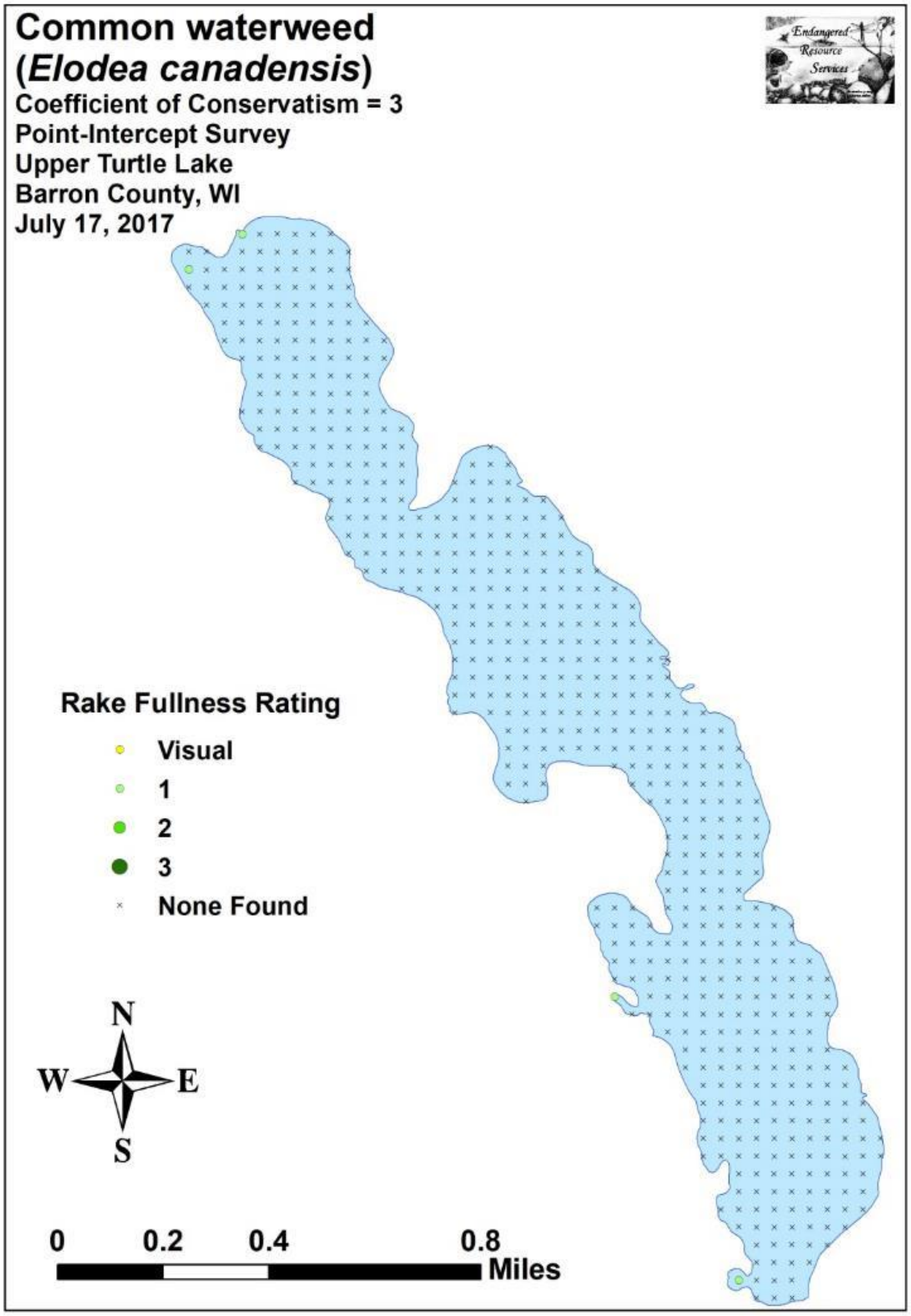
Miles


Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Rake Fullness Rating
Visual
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None Found
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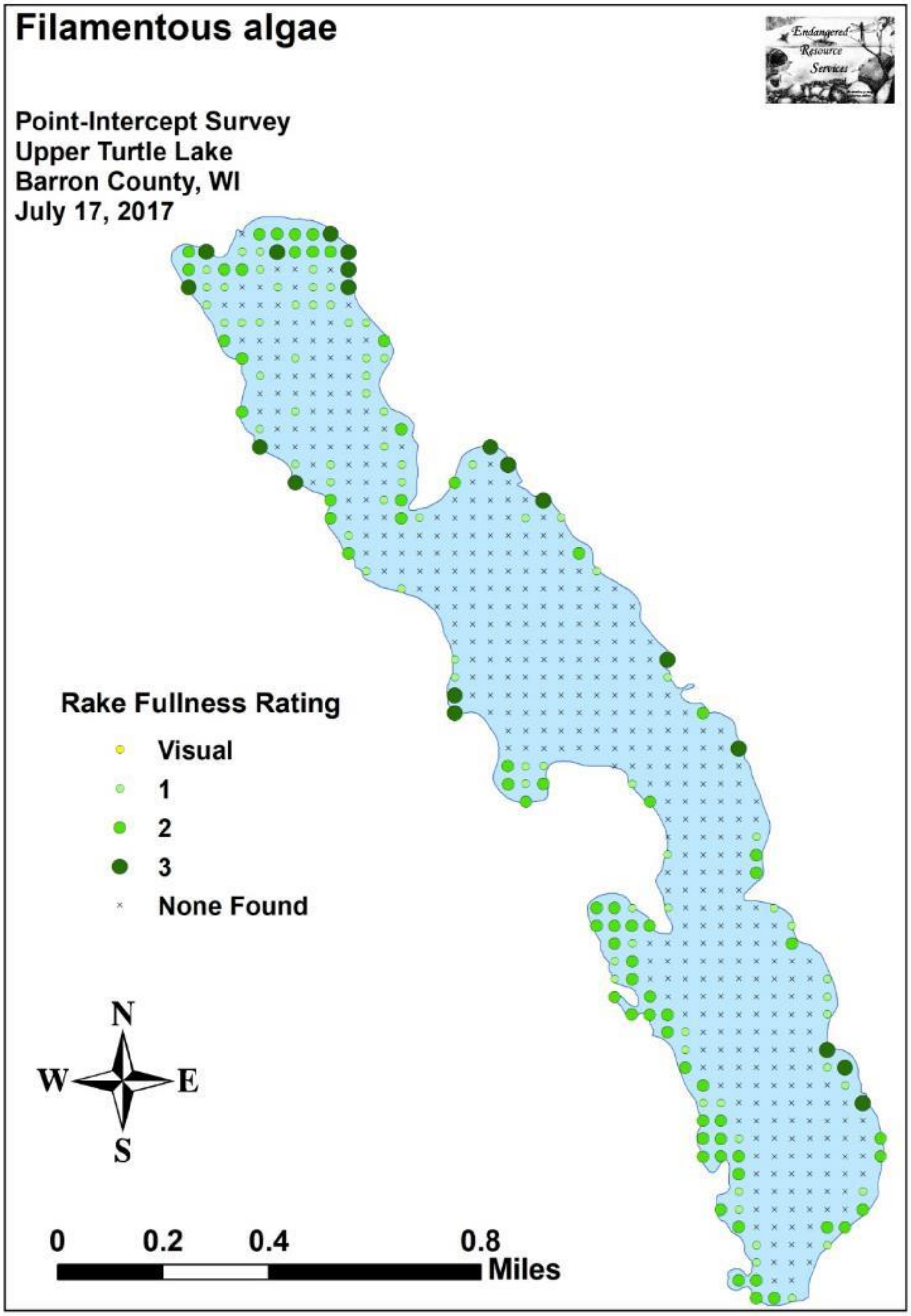
Miles


Filamentous algae
Endangered Resource Services
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Rake Fullness Rating
Visual
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None Found
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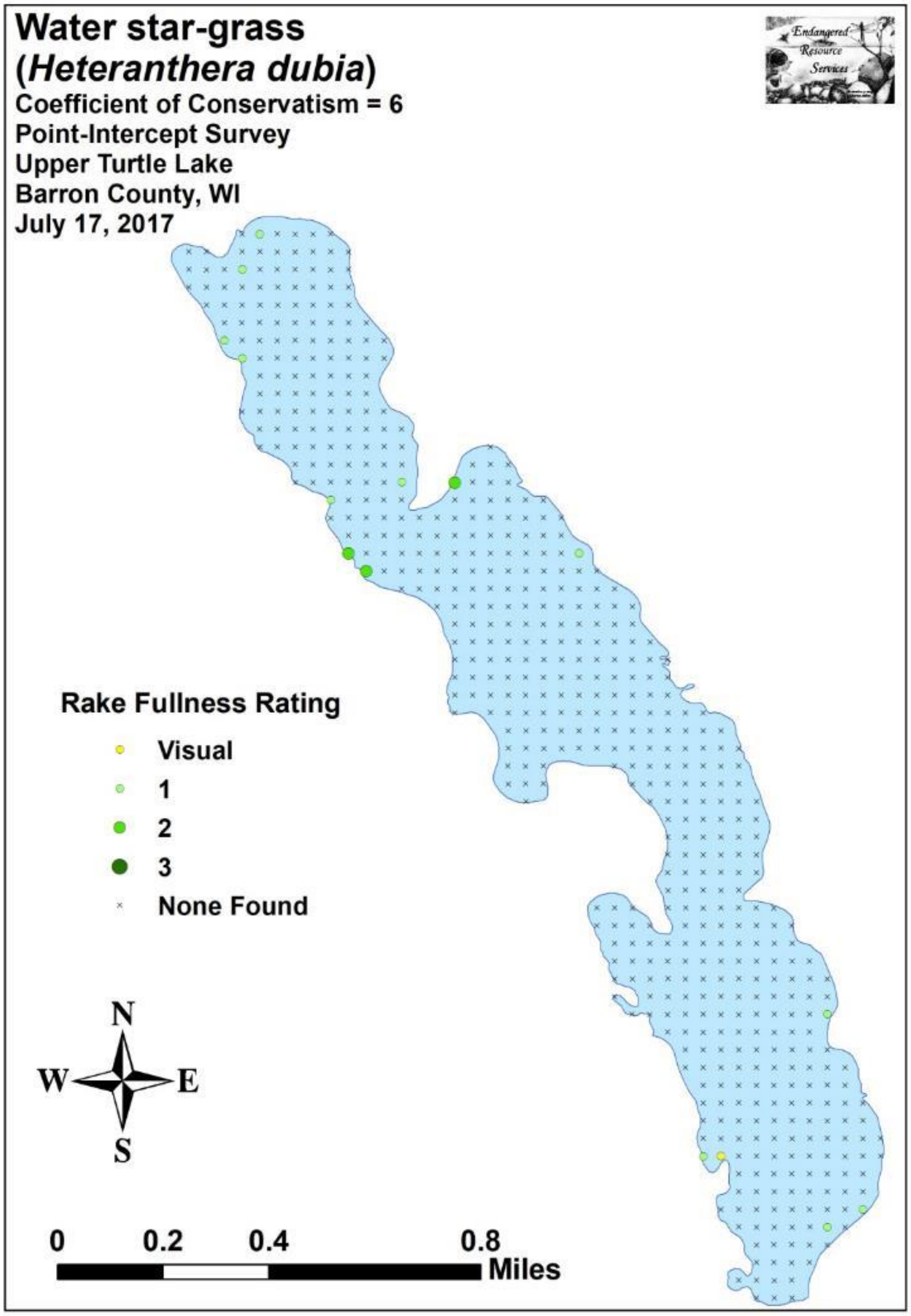
Miles


Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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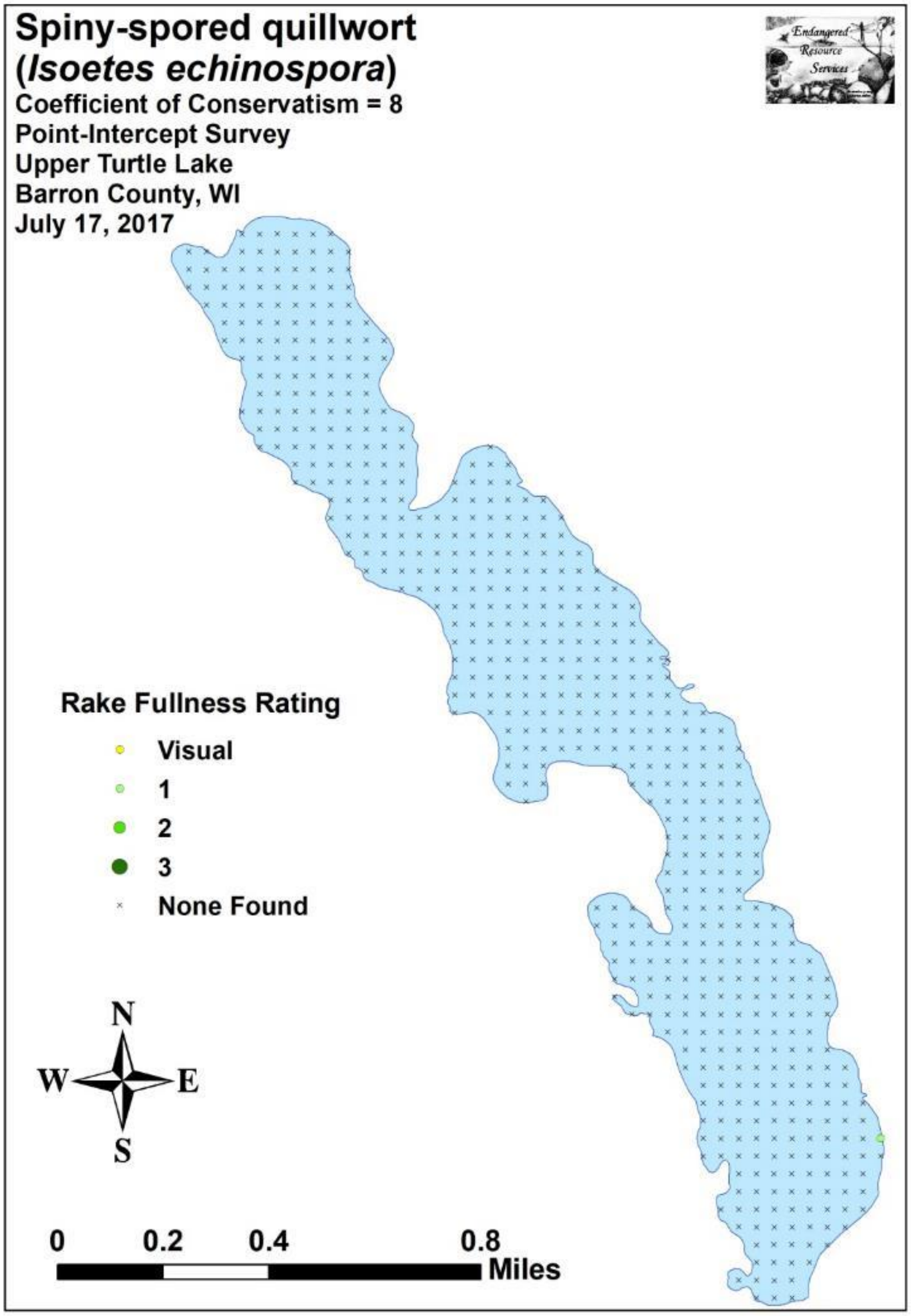
Miles


Spiny-spored quillwort
(*Isoetes echinospora*)
Coefficient of Conservatism = 8
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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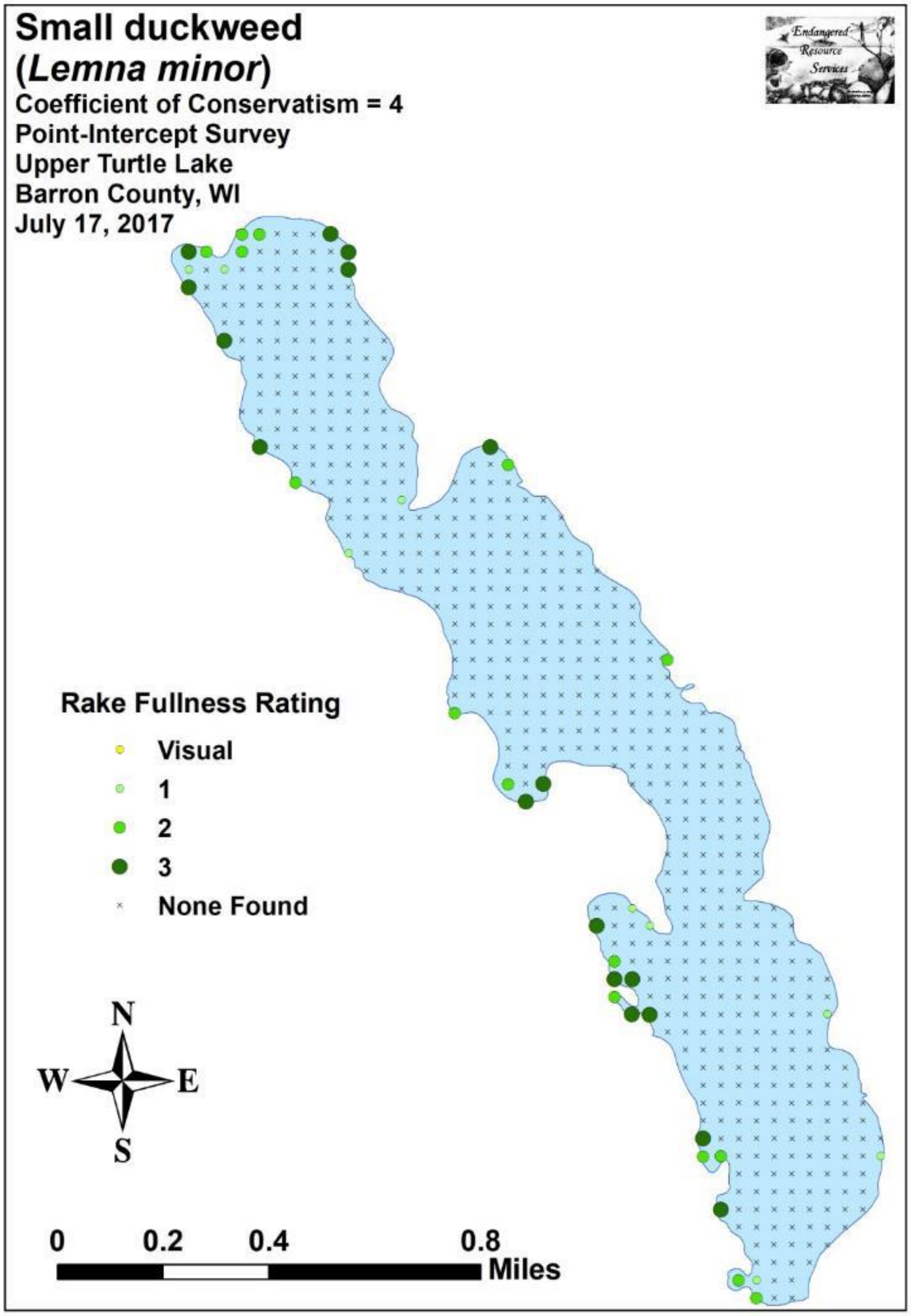
Miles



Small duckweed
(Lemna minor)
Coefficient of Conservatism = 4
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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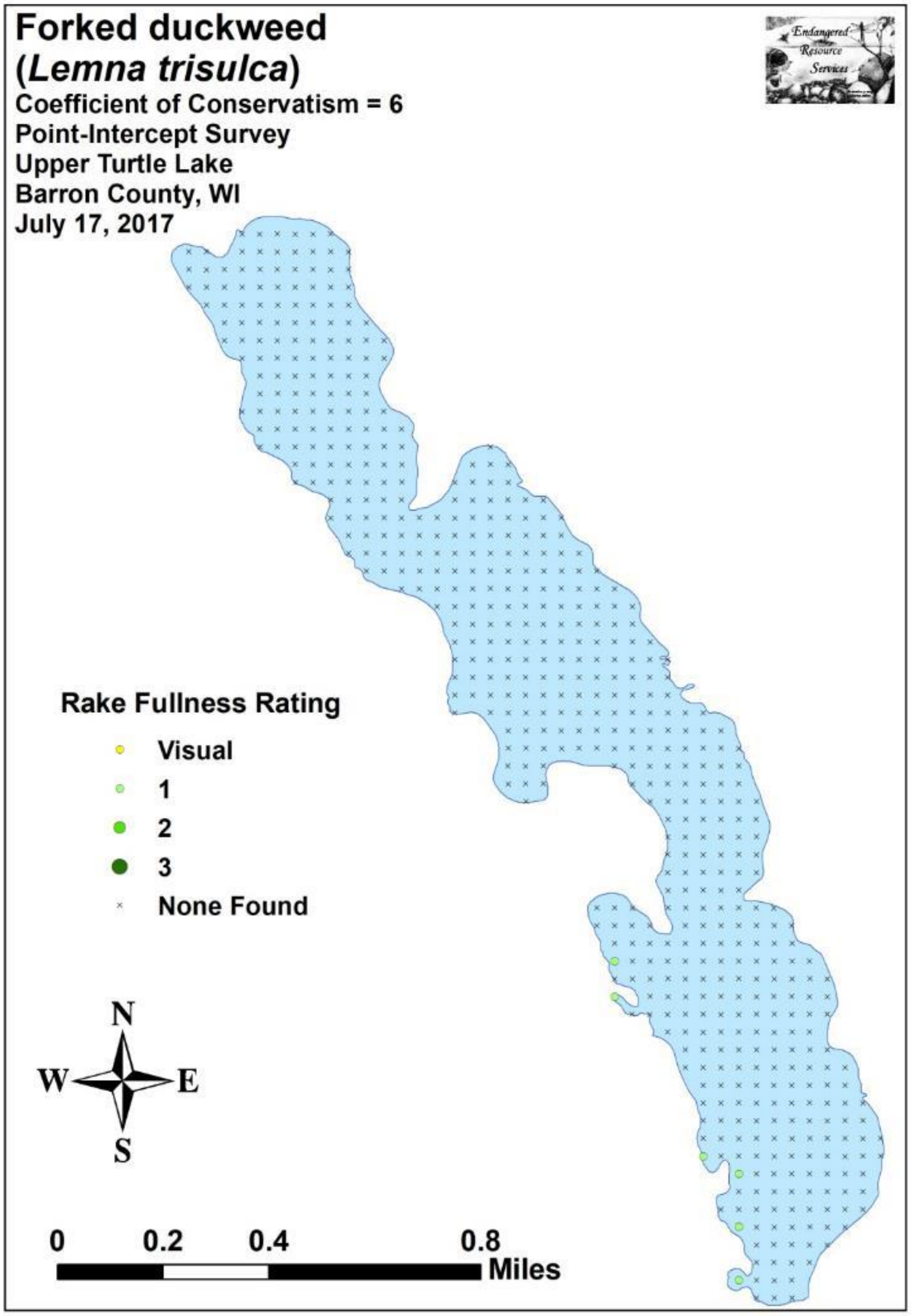
Miles


Forked duckweed
(Lemna trisulca)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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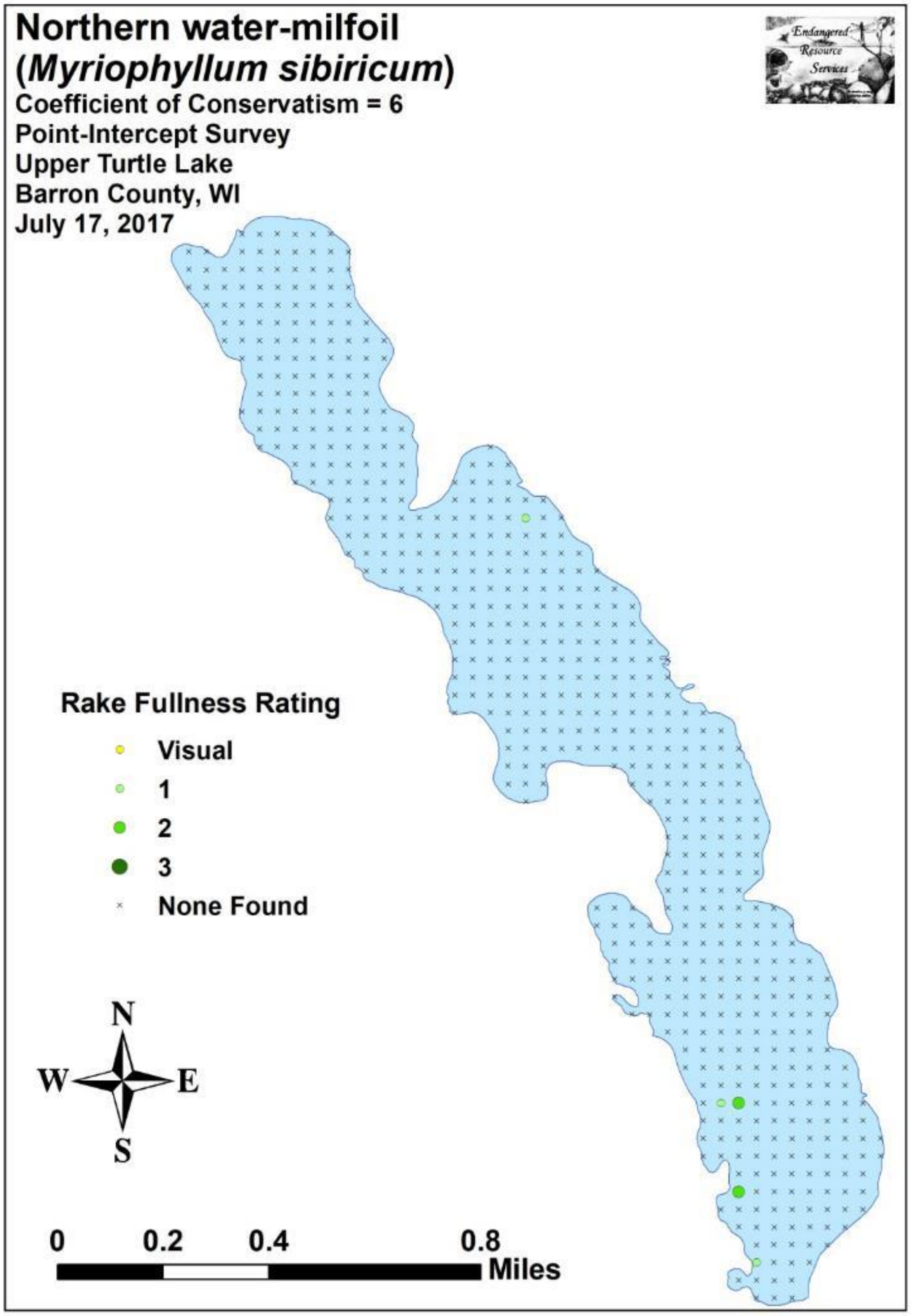
Miles


Northern water-milfoil
(*Myriophyllum sibiricum*)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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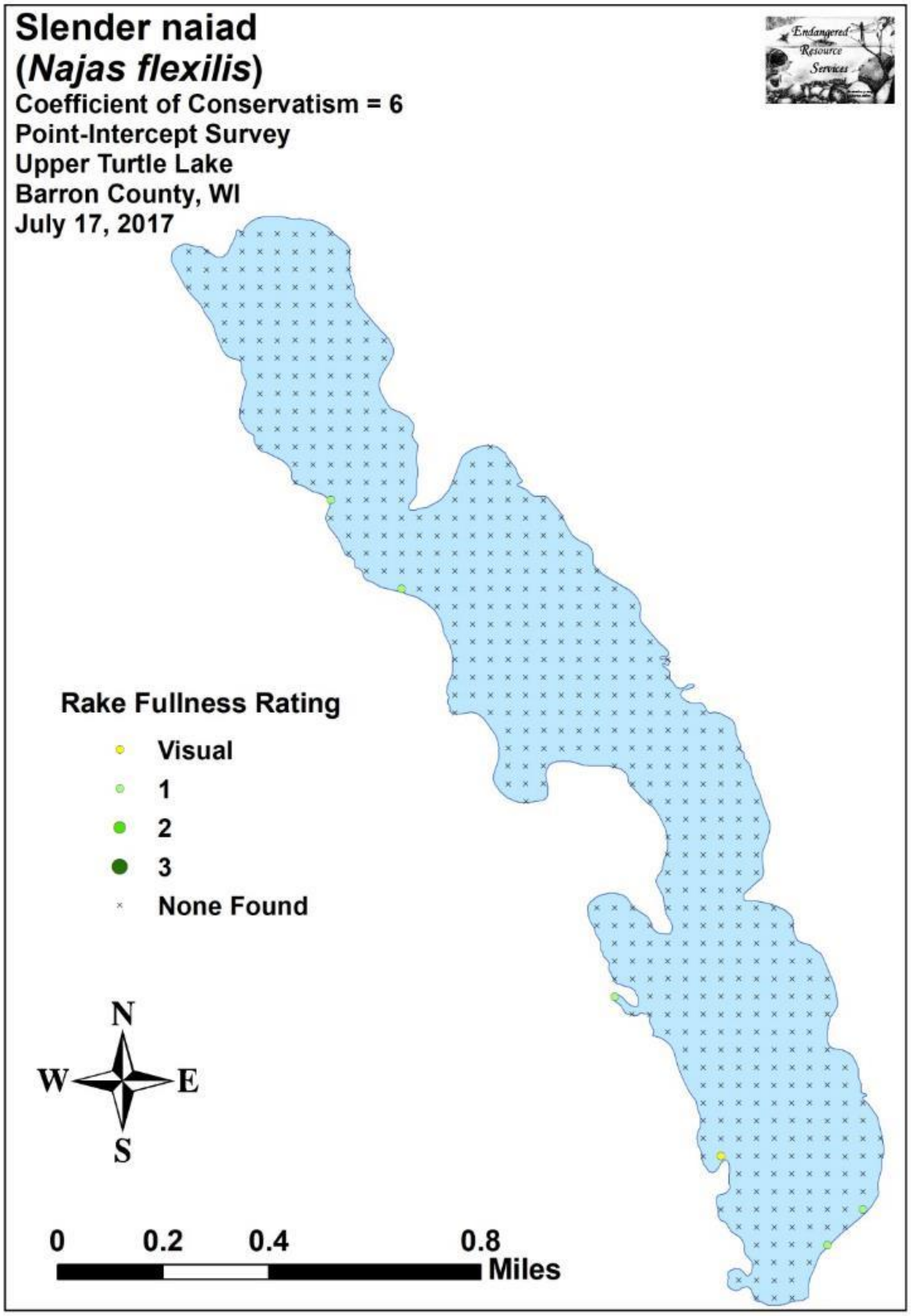
Miles


Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Rake Fullness Rating
Visual
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None Found
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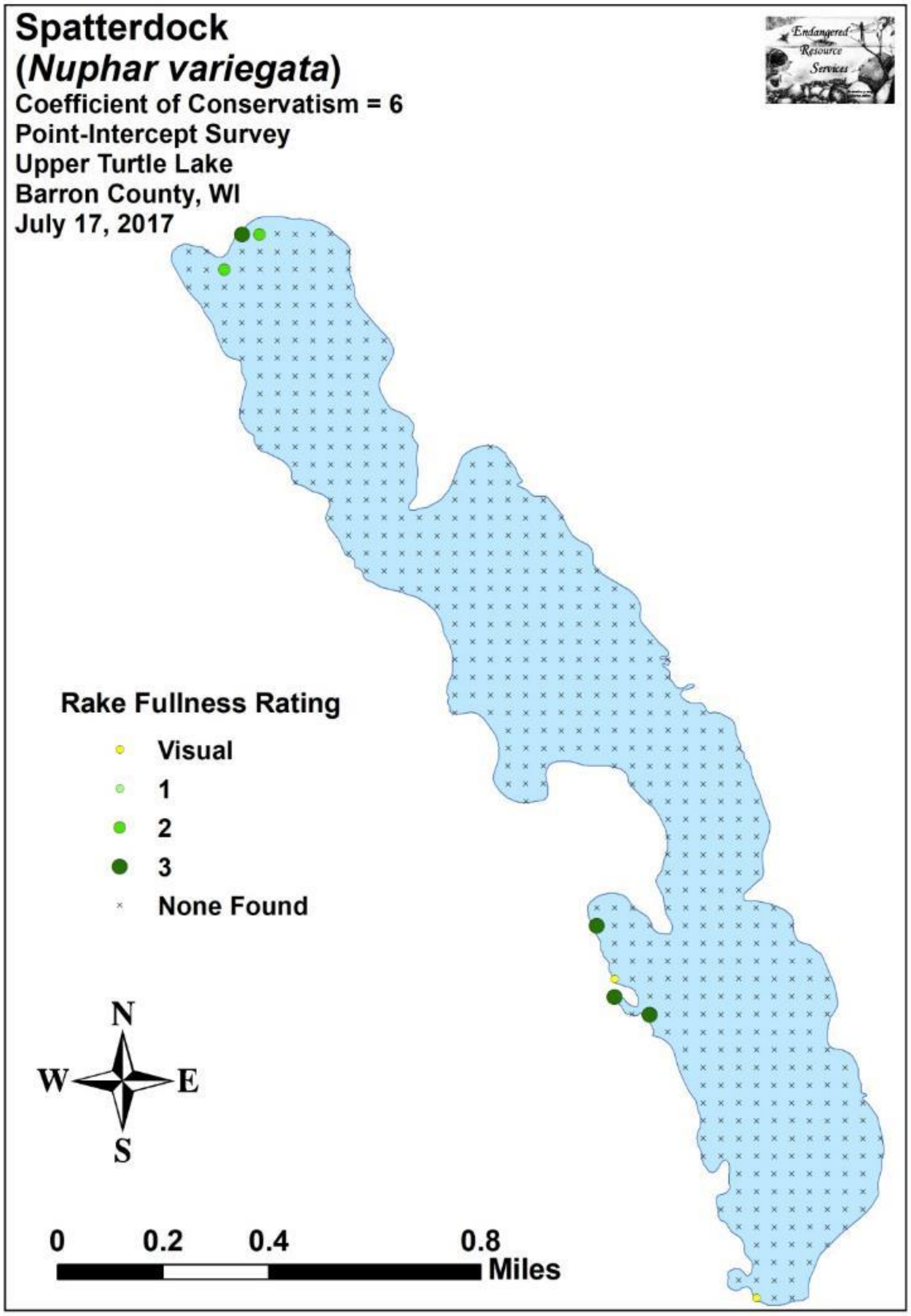
Miles


Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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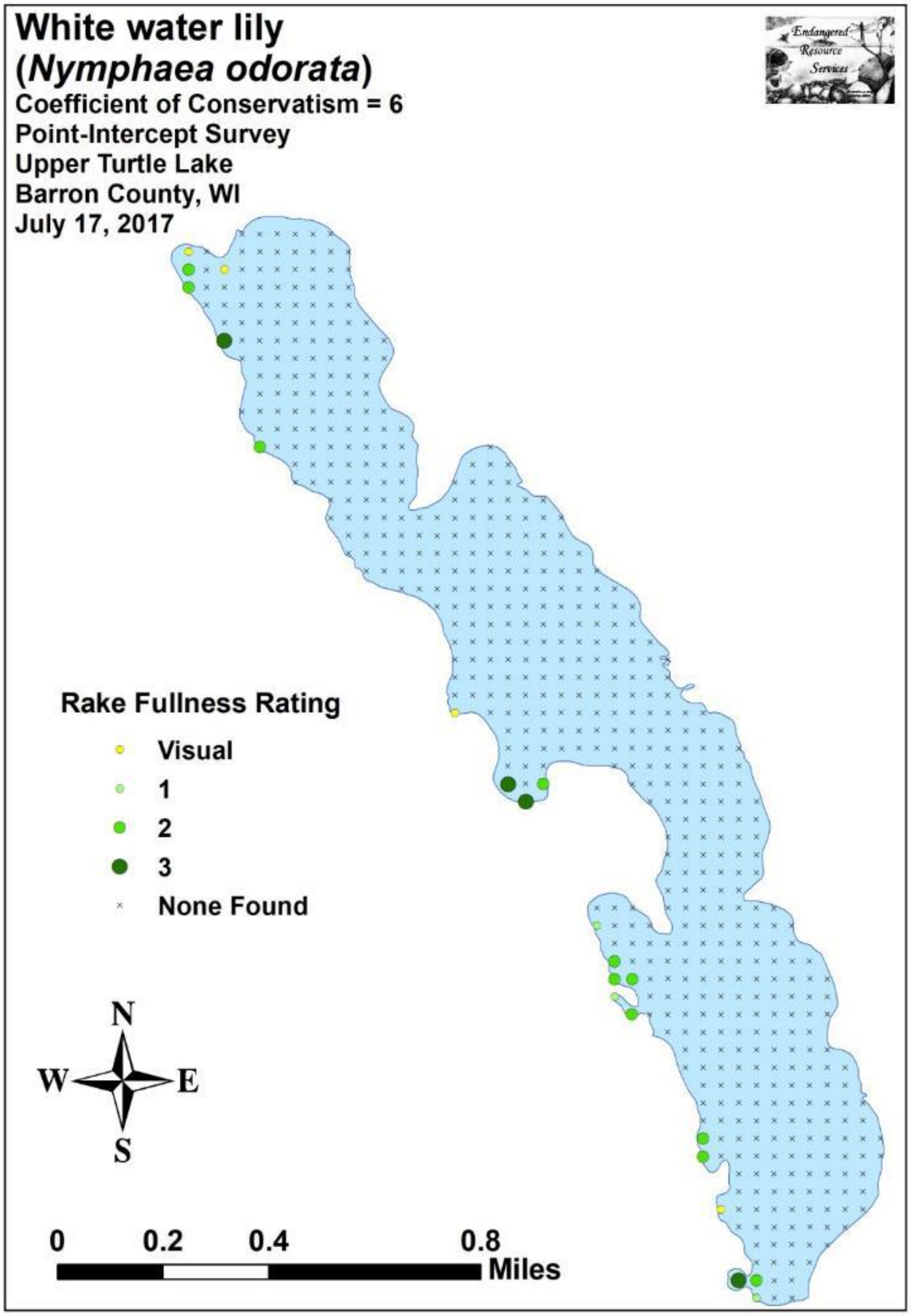
Miles


White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Rake Fullness Rating
Visual
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None Found
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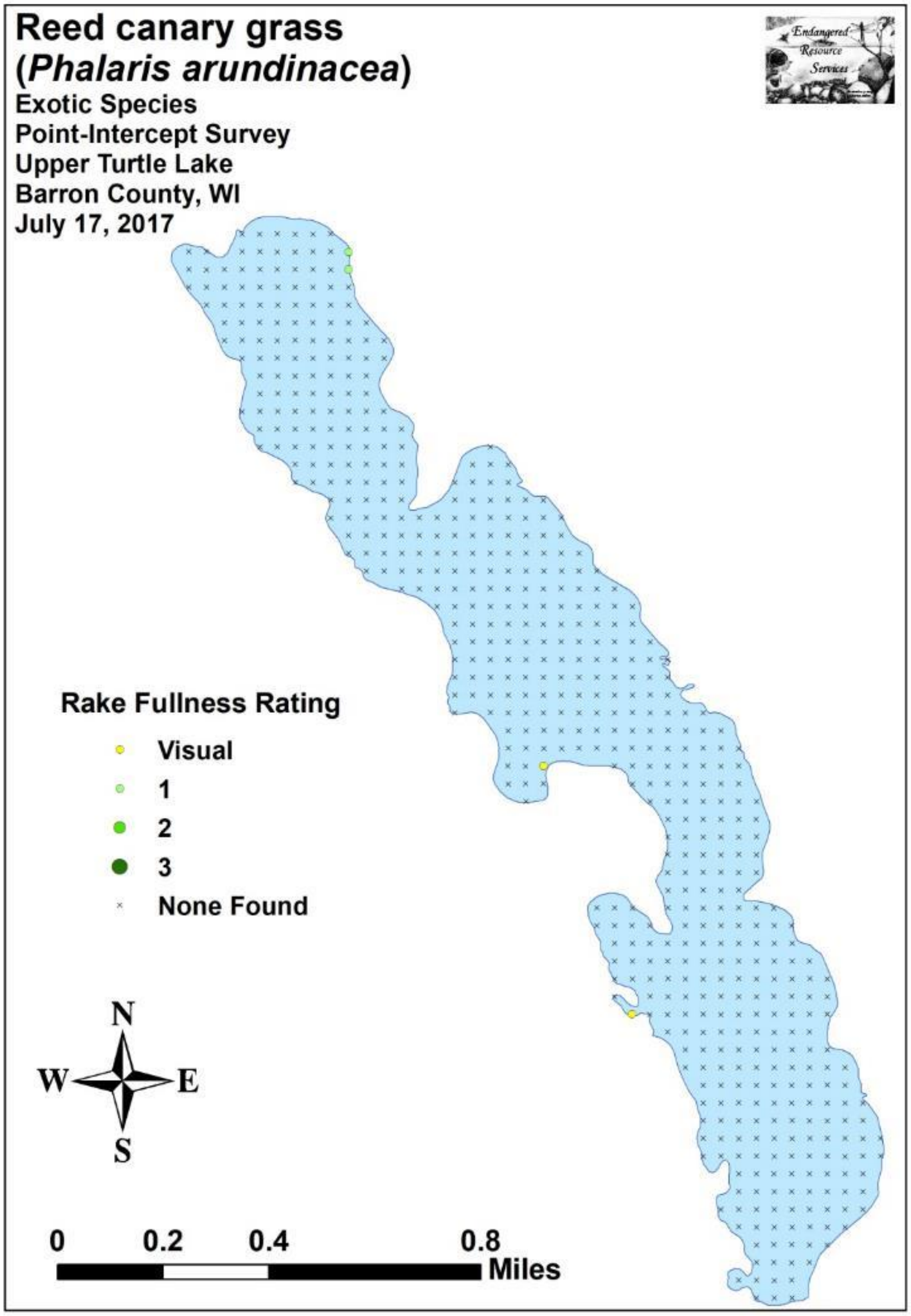
Miles


Reed canary grass
(*Phalaris arundinacea*)
Exotic Species
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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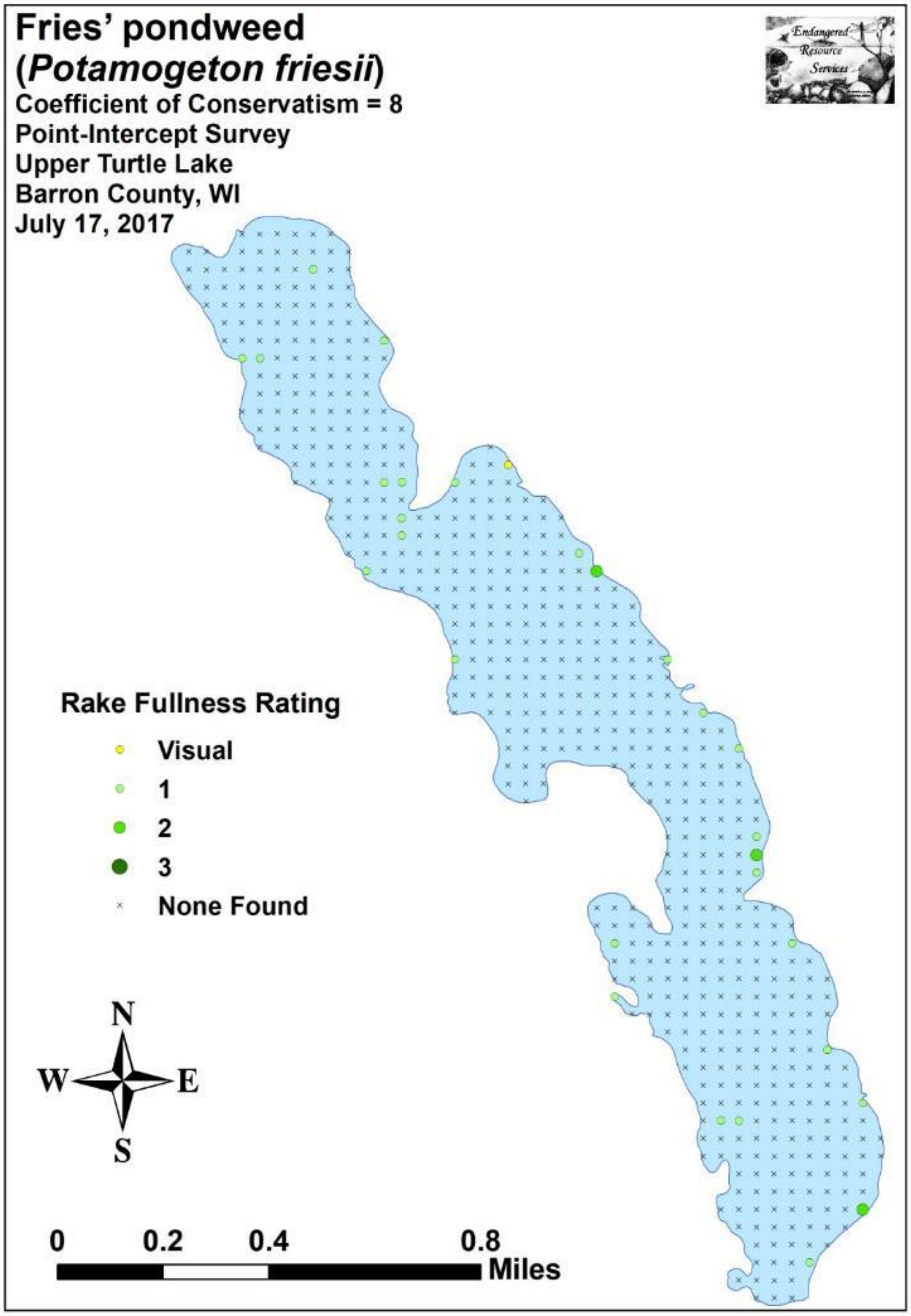
Miles


Fries' pondweed
(*Potamogeton friesii*)
Coefficient of Conservatism = 8
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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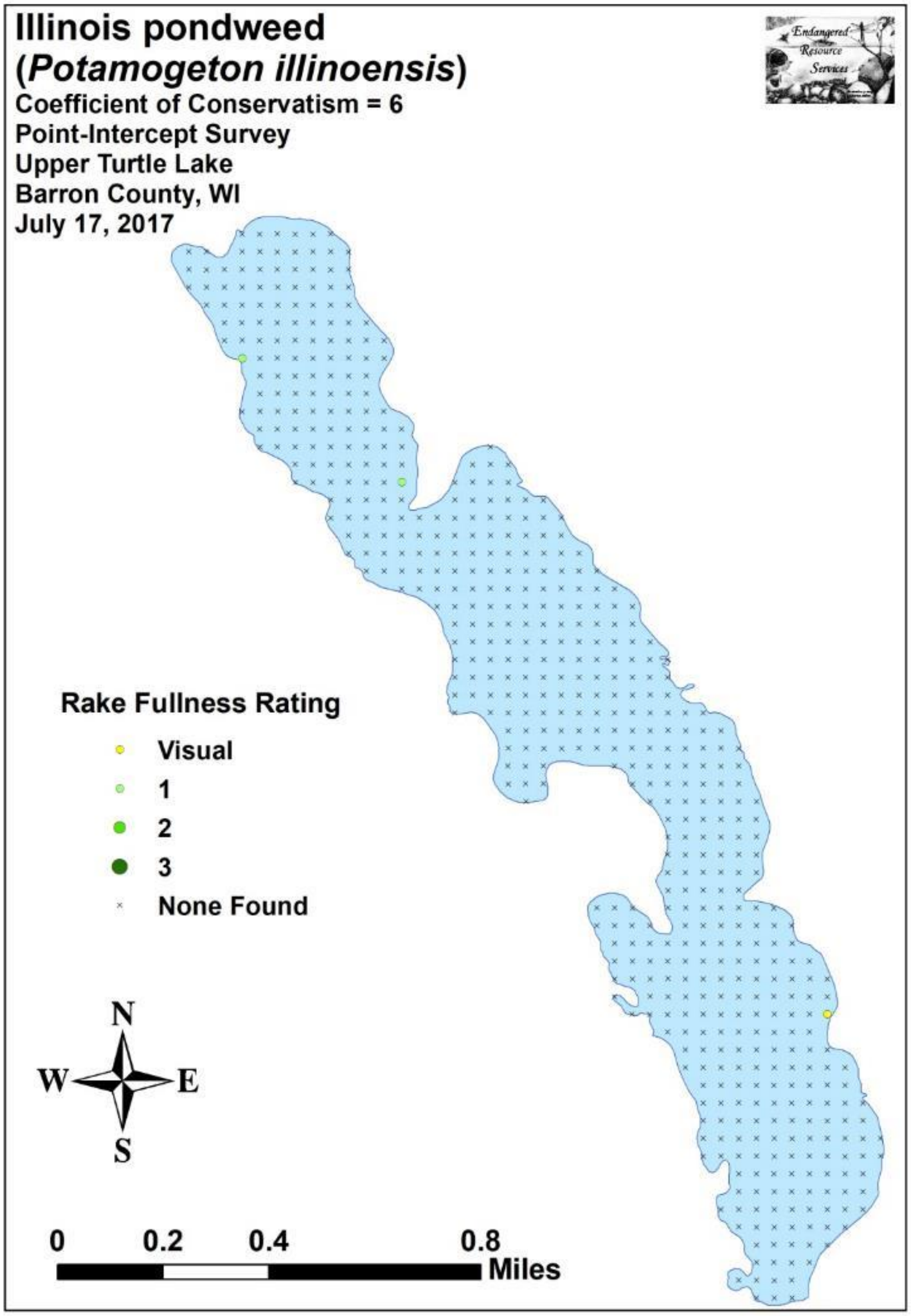
0.8
Miles


Illinois pondweed
(*Potamogeton illinoensis*)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Rake Fullness Rating
Visual
1
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None Found
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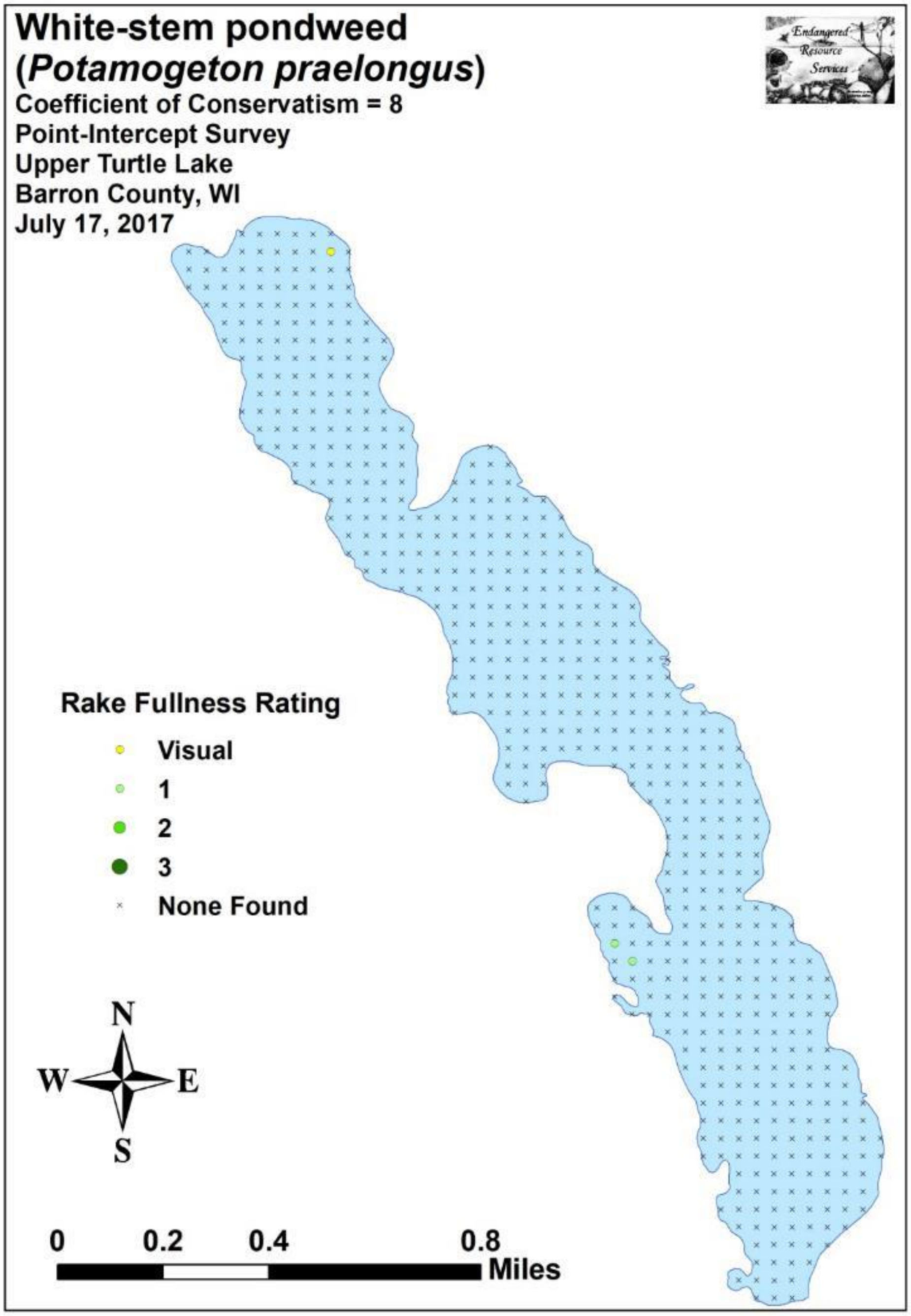
Miles


White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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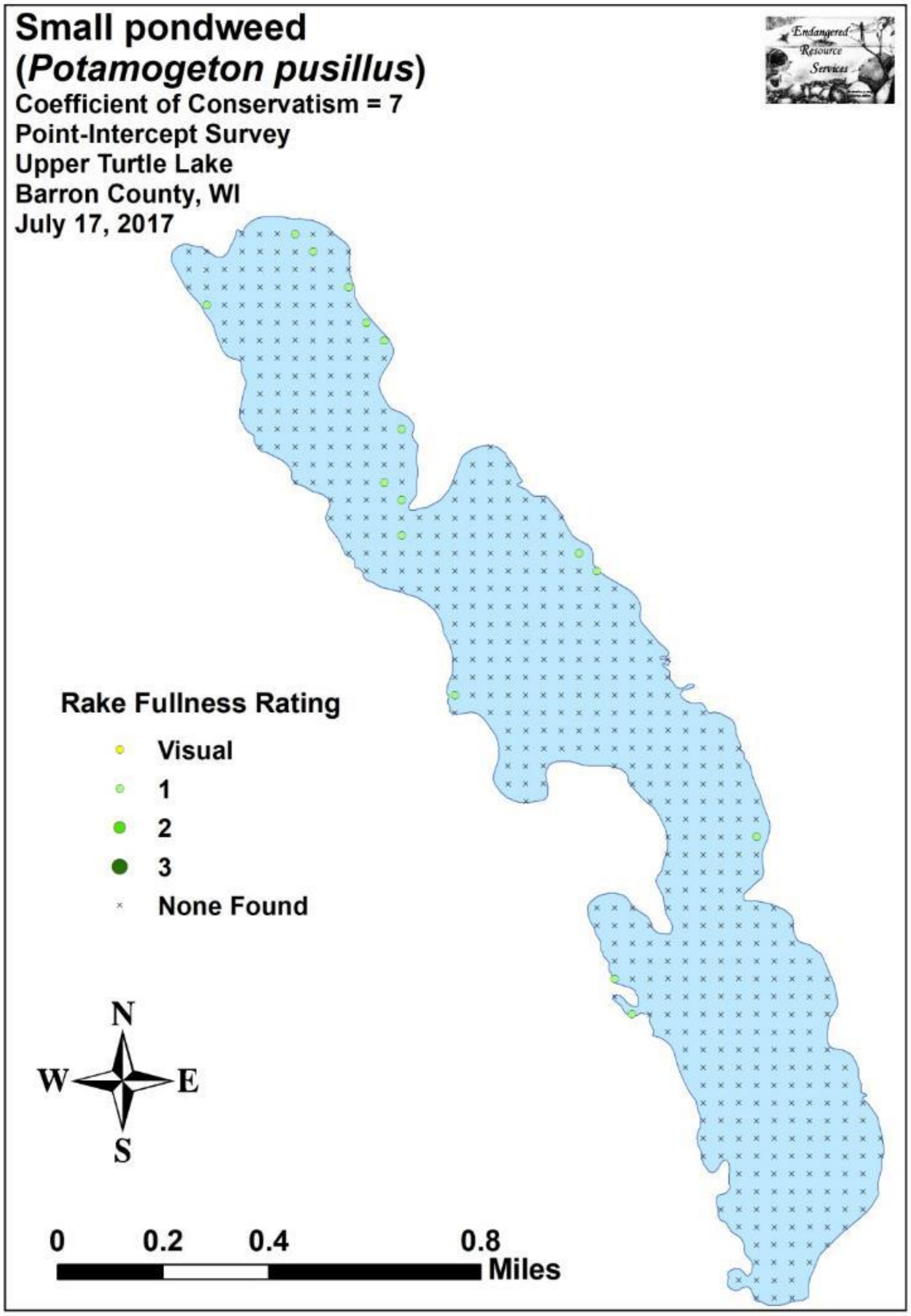
Miles


Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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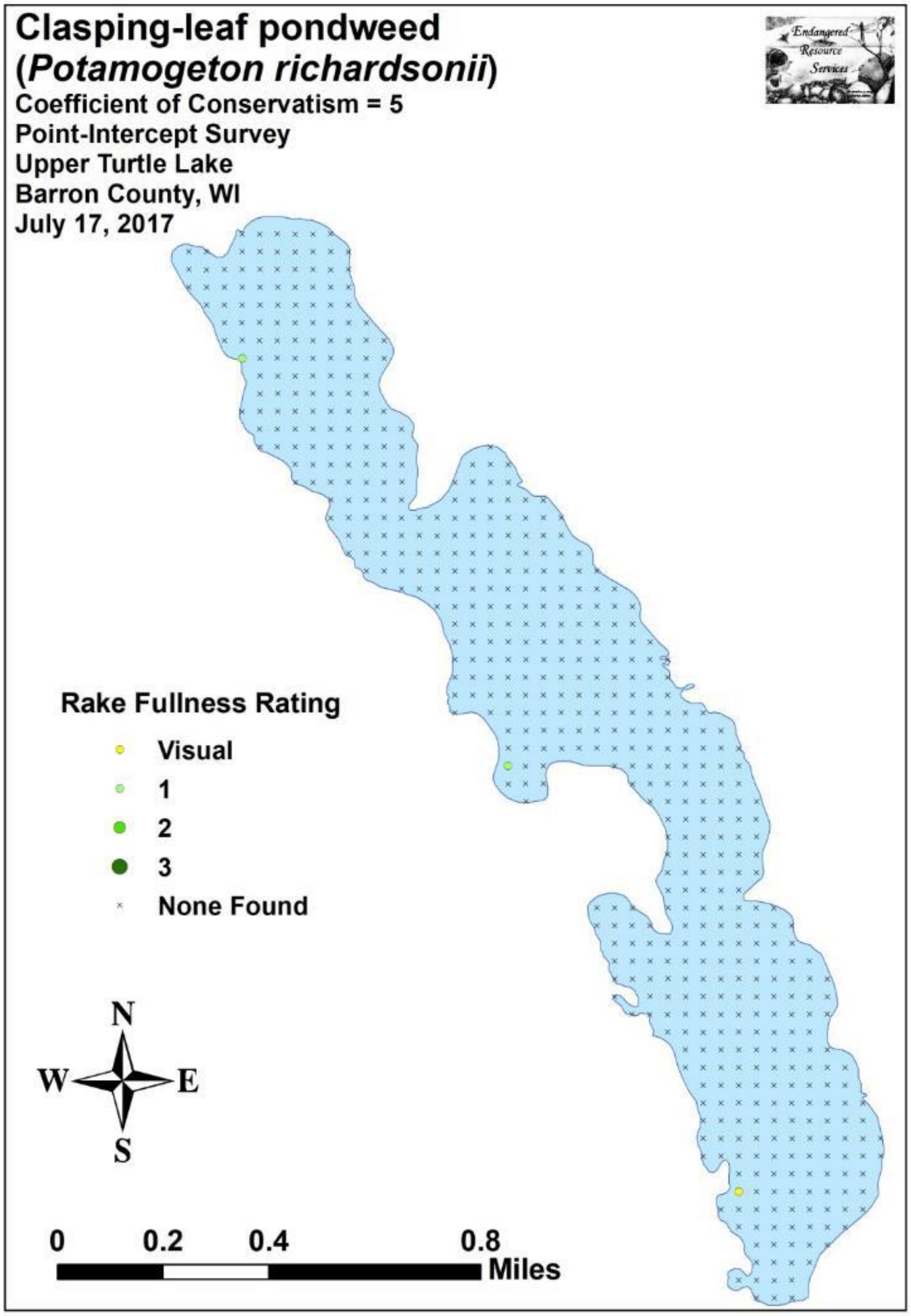
Miles


Clasping-leaf pondweed
(Potamogeton richardsonii)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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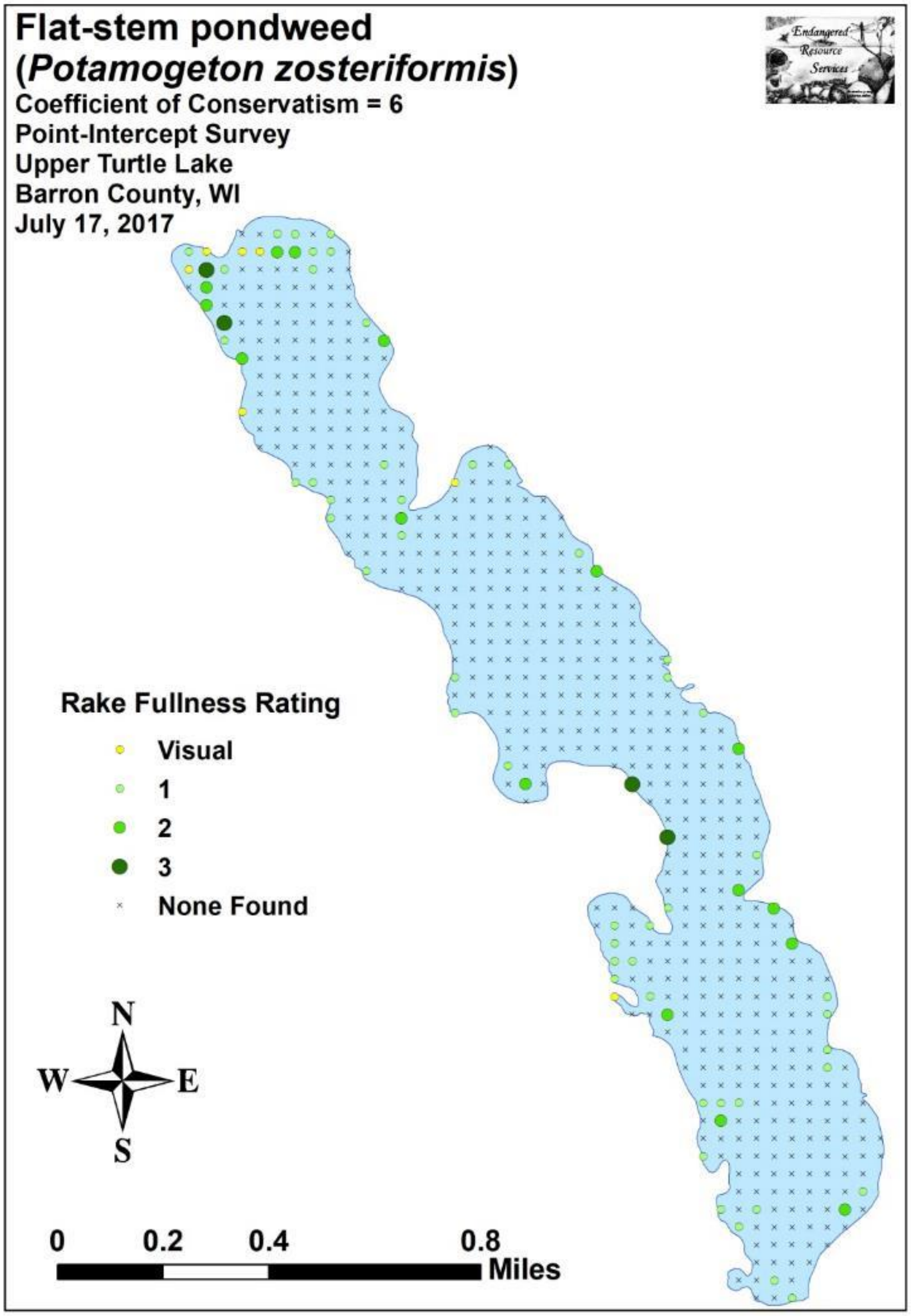
Miles


Flat-stem pondweed
(Potamogeton zosteriformis)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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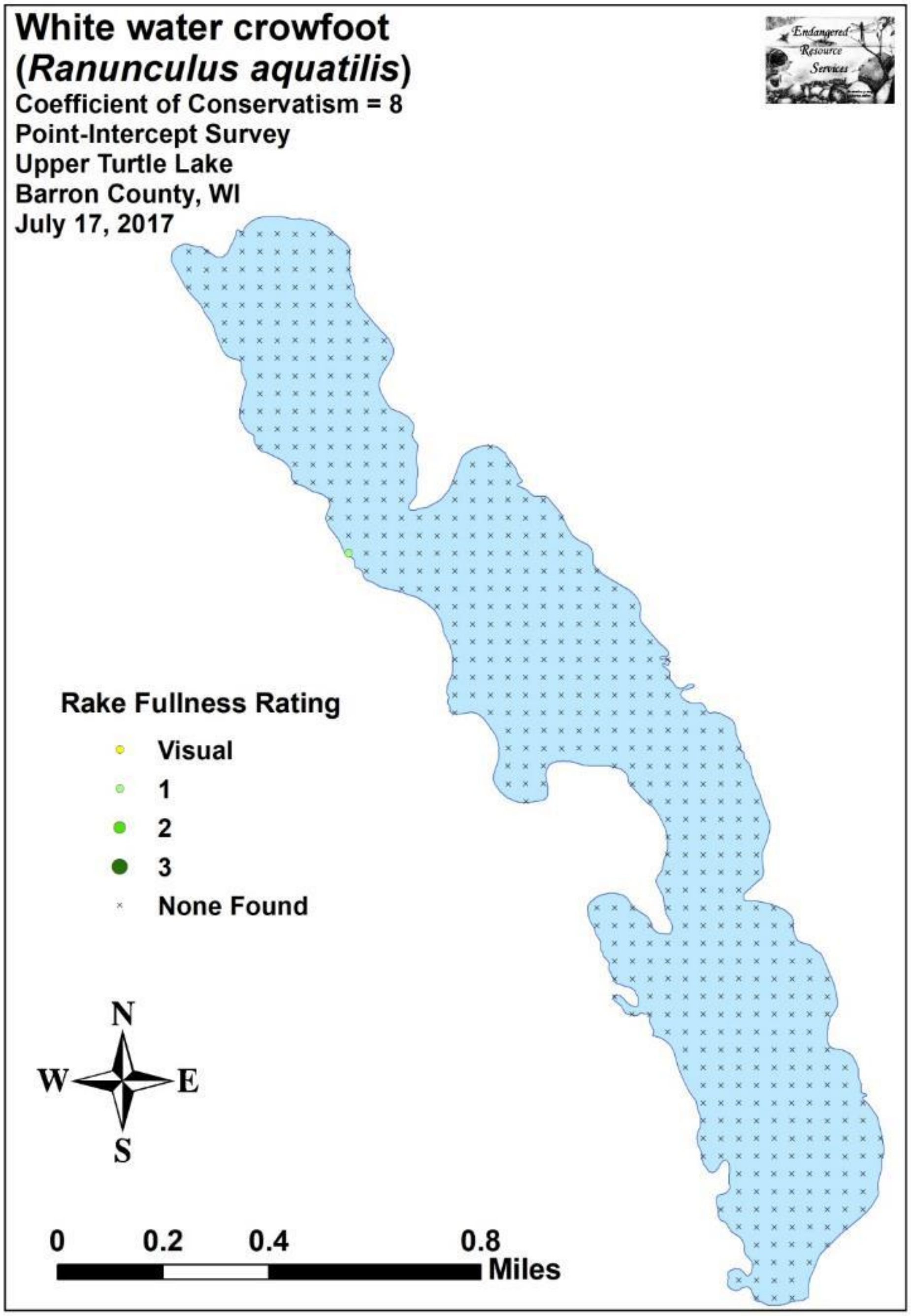
Miles


White water crowfoot
(Ranunculus aquatilis)
Coefficient of Conservatism = 8
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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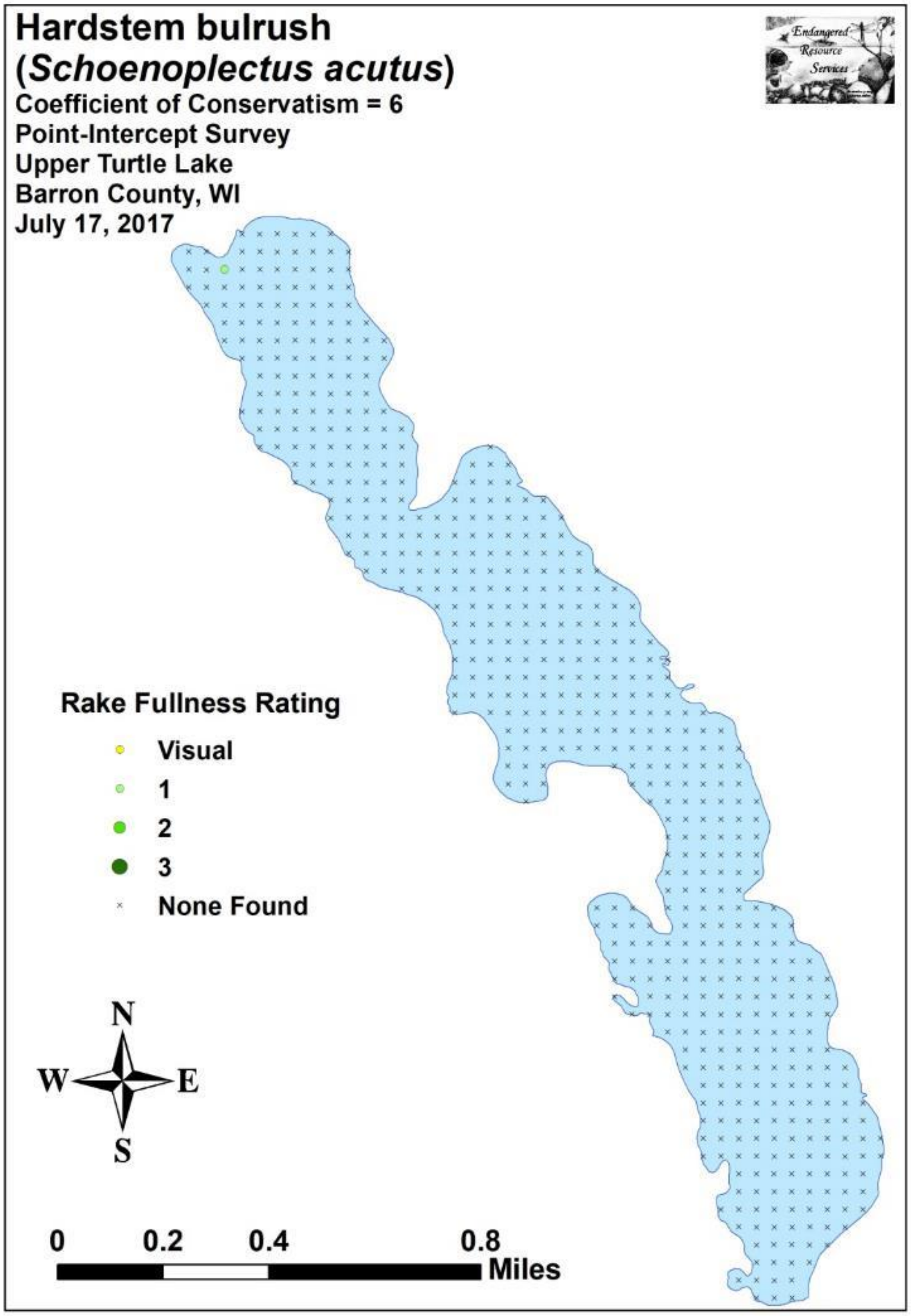
Miles


Hardstem bulrush
(Schoenoplectus acutus)
Coefficient of Conservatism = 6
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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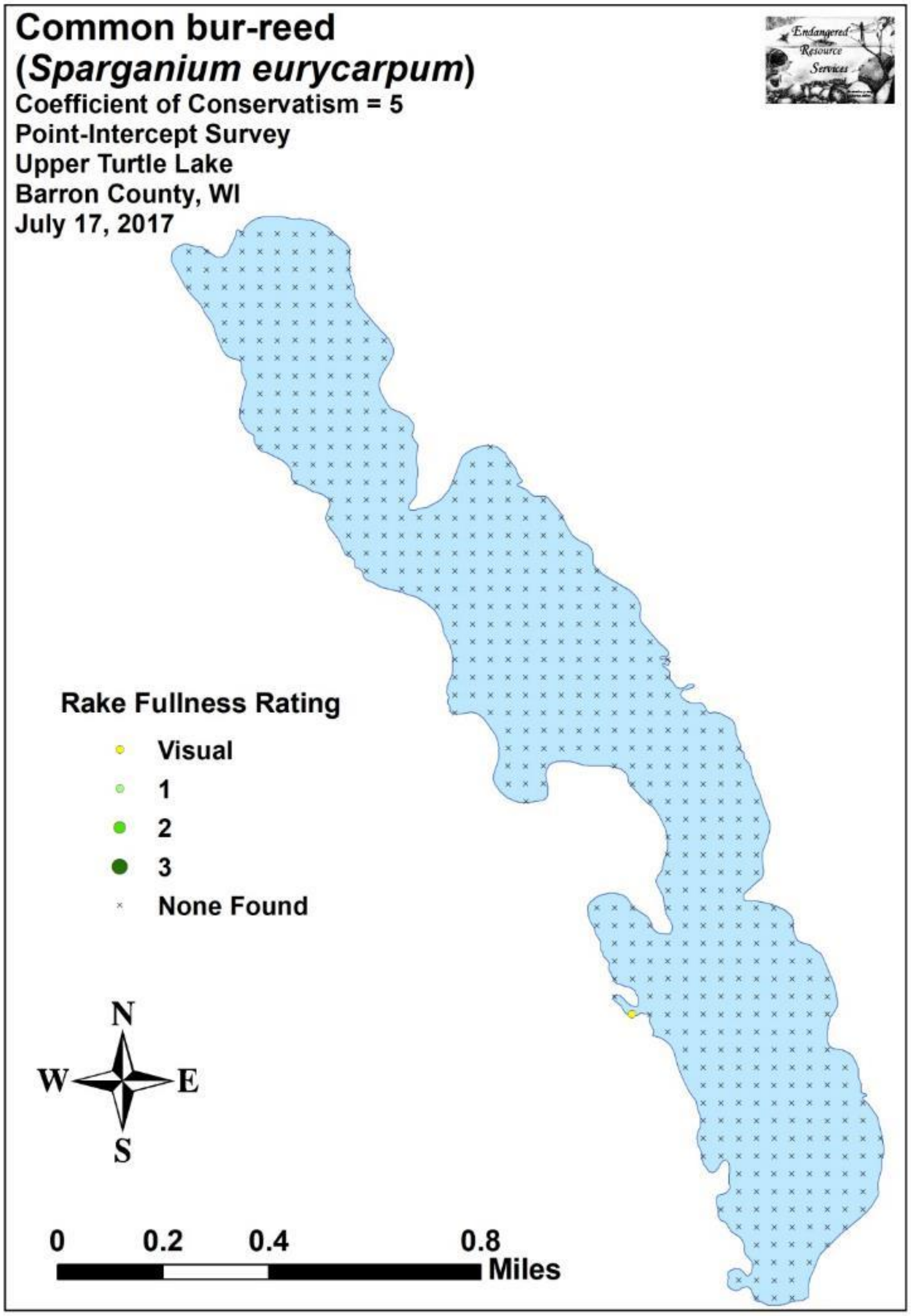
Miles


Common bur-reed
(*Sparganium eurycarpum*)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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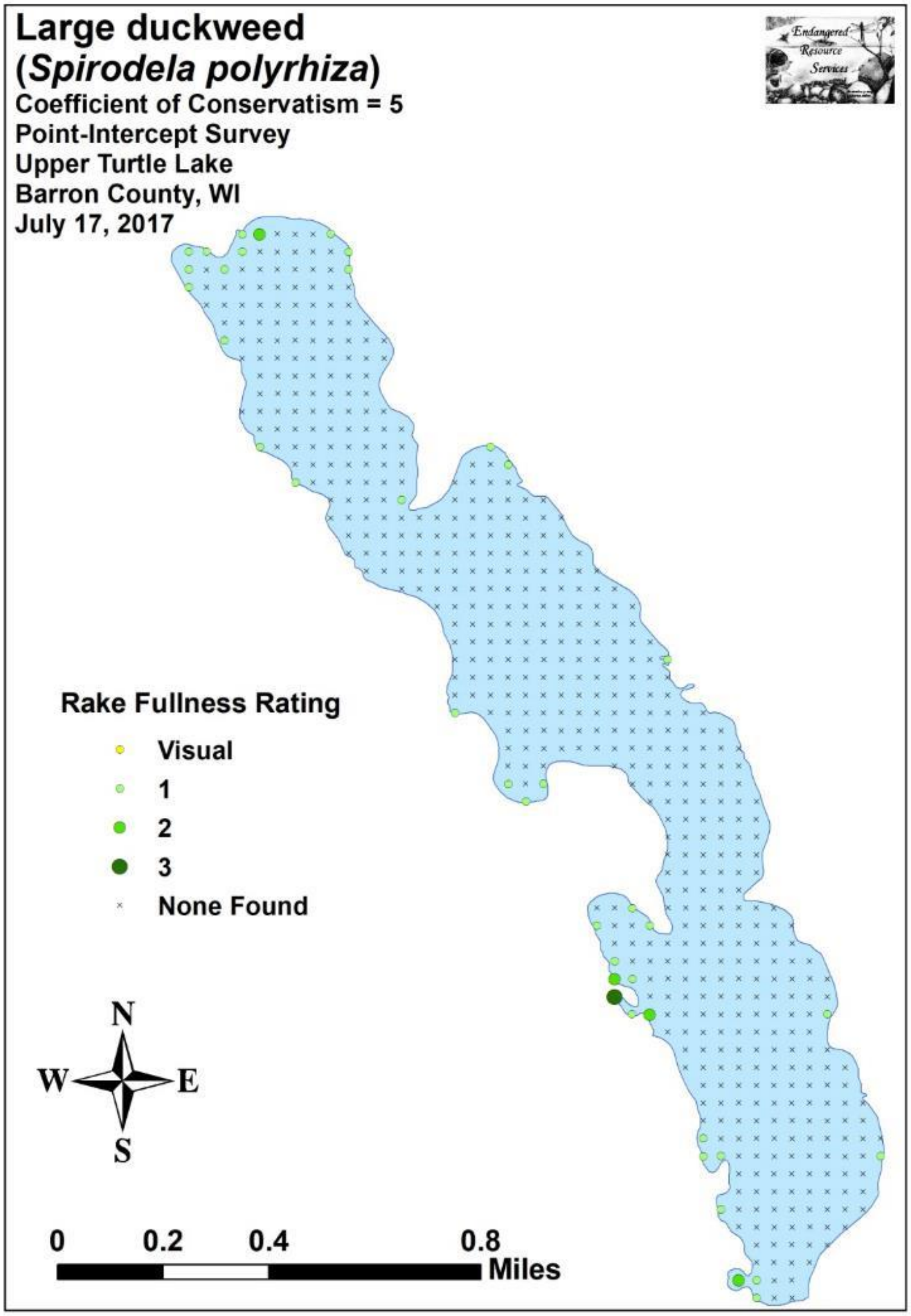
Miles


Large duckweed
(Spirodela polyrhiza)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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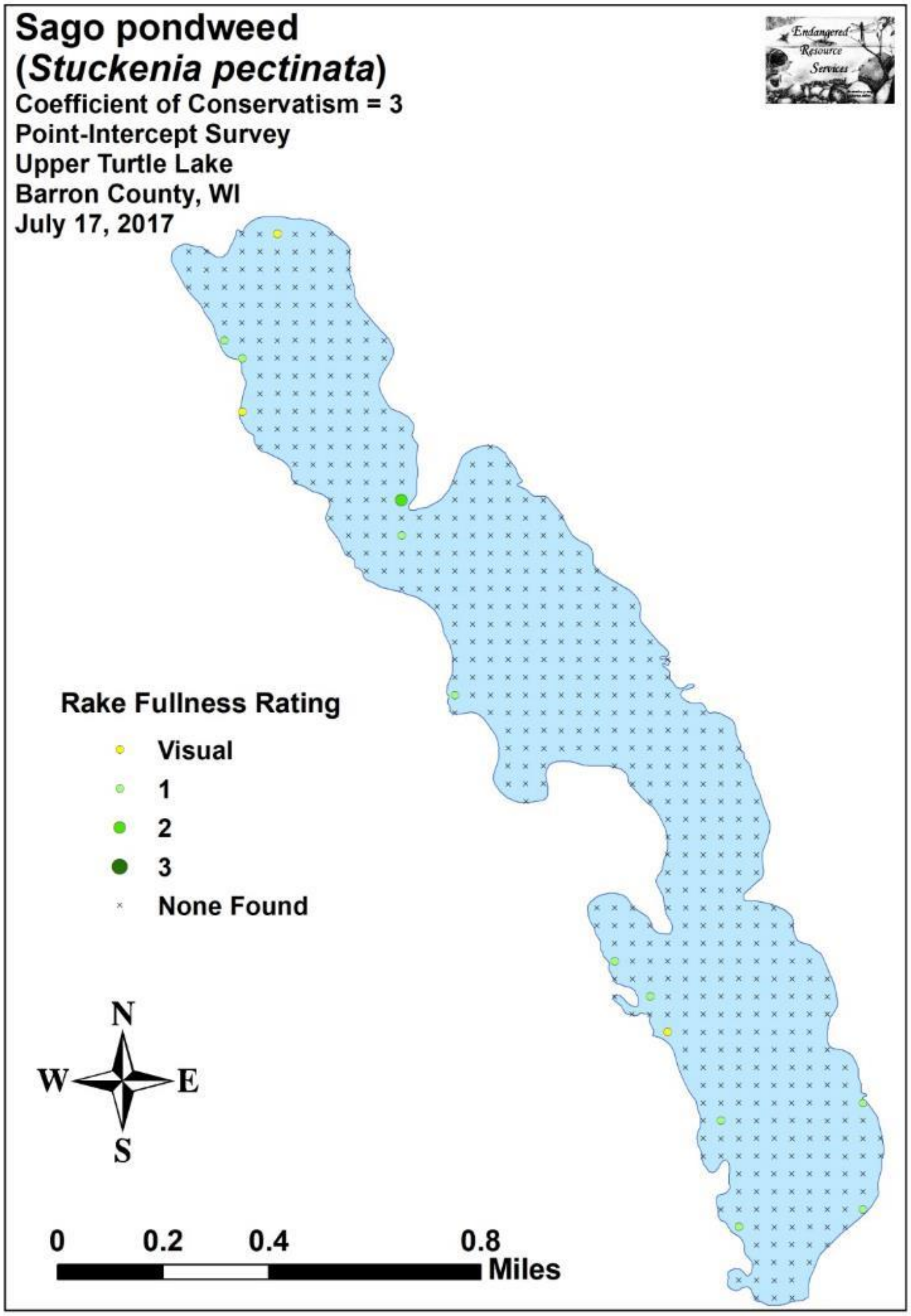
Miles


Sago pondweed
(Stuckenia pectinata)
Coefficient of Conservatism = 3
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
1
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None Found
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0.2
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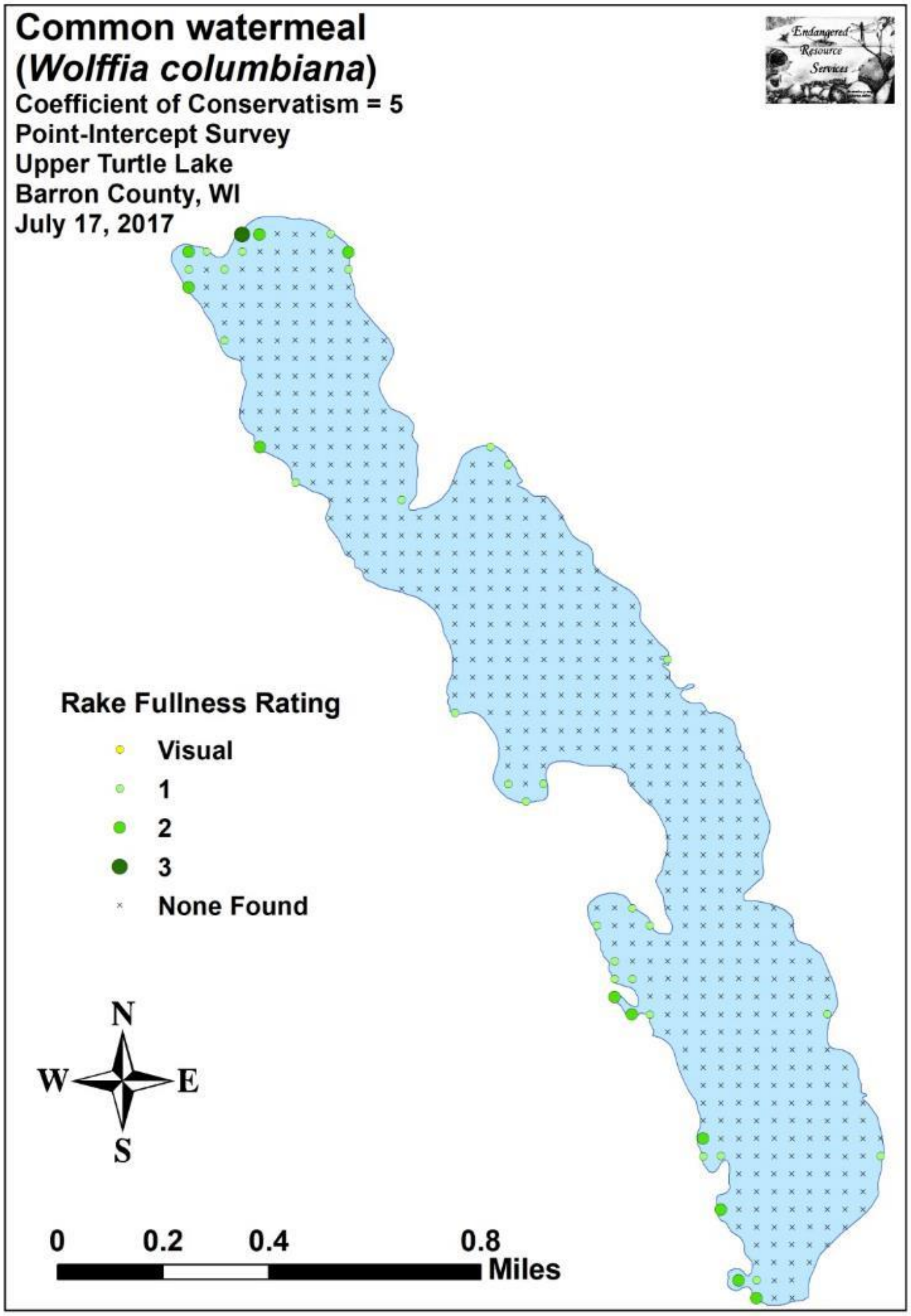
Miles


Common watermeal
(*Wolffia columbiana*)
Coefficient of Conservatism = 5
Point-Intercept Survey
Upper Turtle Lake
Barron County, WI
July 17, 2017
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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Appendix IX: 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 milfoil was common in 39 Wisconsin counties (54%) and at least 75 of its lakes, including shallow bays in Lakes Michigan and Superior and Mississippi River pools.

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

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

Once established in an aquatic community, milfoil reproduces from shoot fragments and stolons (runners that creep along the lake bed). As an opportunistic species, Eurasian Water-milfoil is adapted for rapid growth early in spring. Stolons, lower stems, and roots persist over winter and store the carbohydrates that help milfoil claim the water column early in spring, photosynthesize, divide, and form a dense leaf canopy that shades out native aquatic plants. Its ability to spread rapidly by fragmentation and effectively block out sunlight needed for native plant growth often results in monotypic stands. Monotypic stands of Eurasian 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, bluejoint 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 bergs 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.

Purple loosestrife was first detected in Wisconsin in the early 1930's, but remained uncommon until the 1970's. It is now widely dispersed in the state, and has been recorded in 70 of Wisconsin's 72 counties. Low densities in most areas of the state suggest that the plant is still in the pioneering stage of establishment. Areas of heaviest infestation are sections of the Wisconsin River, the extreme southeastern part of the state, and the Wolf and Fox River drainage systems.

This plant's optimal habitat includes marshes, stream margins, alluvial flood plains, sedge meadows, and wet prairies. It is tolerant of moist soil and shallow water sites such as pastures and meadows, although established plants can tolerate drier conditions. Purple loosestrife has also been planted in lawns and gardens, which is often how it has been introduced to many of our wetlands, lakes, and rivers.

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 X: 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 XI: 2017 Raw Data Spreadsheets