Warm Water Point/Intercept Macrophyte Survey
Balsam Lake
Polk County, Wisconsin
WBIC: 2620600

(Stump Bay - Courtesy Brian M. Collins)

Project Initiated by:
Balsam Lake Protection and Rehabilitation District, Harmony Environmental, and the Wisconsin Department of Natural Resources

(Common Loon Nest in Stump Bay - Courtesy Brian M. Collins, Unity Biology Instructor)

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ABSTRACT

Balsam Lake (WBIC 2620600) is a 2,054 acre stratified drainage lake in central Polk County. It is mesotrophic bordering on eutrophic in nature with Secchi readings averaging 6-8ft. and a littoral zone that extends to 19ft. A desire to develop an Aquatic Plant Management Plan prompted members of the Balsam Lake Protection and Rehabilitation District authorize a warm water full point intercept surveys of aquatic macrophytes in July 2009. We found macrophytes at 608 of 1,095 survey points or approximately 56% of the lake and 90% of the littoral zone. Coontail (*Ceratophyllum demersum*), Forked duckweed (*Lemna trisulca*), Small pondweed (*Potamogeton pusillus*), and Flat-stem pondweed (*Potamogeton zosteriformis*) were the most common macrophytes being found at 56.58%, 54.44%, 47.37%, and 34.87% of survey points with vegetation respectively. Overall diversity was very high with a Simpson Index value of 0.91. We identified a total of 49 plants in and immediately adjacent to the lake. Of these, the 38 native species found during the rake survey produced an above average mean Coefficient of Conservatism of 6.2 and a Floristic Quality Index of 38.4 that was nearly double the average for this part of the state. Future management should include preserving the lake's native plant communities. If controlling Curly-leaf pondweed (*Potamogeton crispus*) is adopted as part of the Aquatic Plant Management Plan, care should be taken to minimize the impact on native vegetation. We also recommend working to reduce algal and duckweed blooms by encouraging residents to reduce or eliminating fertilizer applications near the lake, and restore shorelines by adding buffer strips of native vegetation to prevent runoff. Finally, developing a proactive strategy to minimize the chances of a Eurasian water milfoil (*Myriophyllum spicatum*) introduction into the lake by continuing the established Clean Boats/Clean Water program, considering to require tournament directors provide boat inspectors during fishing tournaments and monitoring for EWM in transects parallel to the shore at the boat landings at least once a month during the summer are other management ideas for the BLPRD to consider.

ACKNOWLEDMENTS

We wish to thank the Wisconsin Department of Natural Resources' Michelle Nault and Alison Mikulyuk for technical assistance, and Brian M. Collins, and Rebecca, Mitchel and Noah Berg for assistance in conducting this survey.

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INTRODUCTION:

Balsam Lake (WBIC 2656200) is a 2,054 acre stratified drainage lake in central Polk County, Wisconsin in the Towns of Balsam Lake, Milltown, Georgetown, and Apple River (T34N R17W S10 NE NE). The lake reaches its maximum depth of 37ft north of Cedar Island in the western basin and has an average depth of 20ft (Hopke et al, 1964). Balsam Lake is mesotrophic bordering on eutrophic in nature and water clarity is fair with historical summer Secchi readings averaging 6ft in East Balsam, 7ft in Little Balsam, and 8ft in the deep hole north of Cedar Island. The July littoral zone reached approximately 15ft in Balsam, 14ft in Little Balsam and 19ft in East Balsam. Bottom substrate is variable with muck bottoms in most bays and rock/sand bars in the narrows and around the lake's many islands.

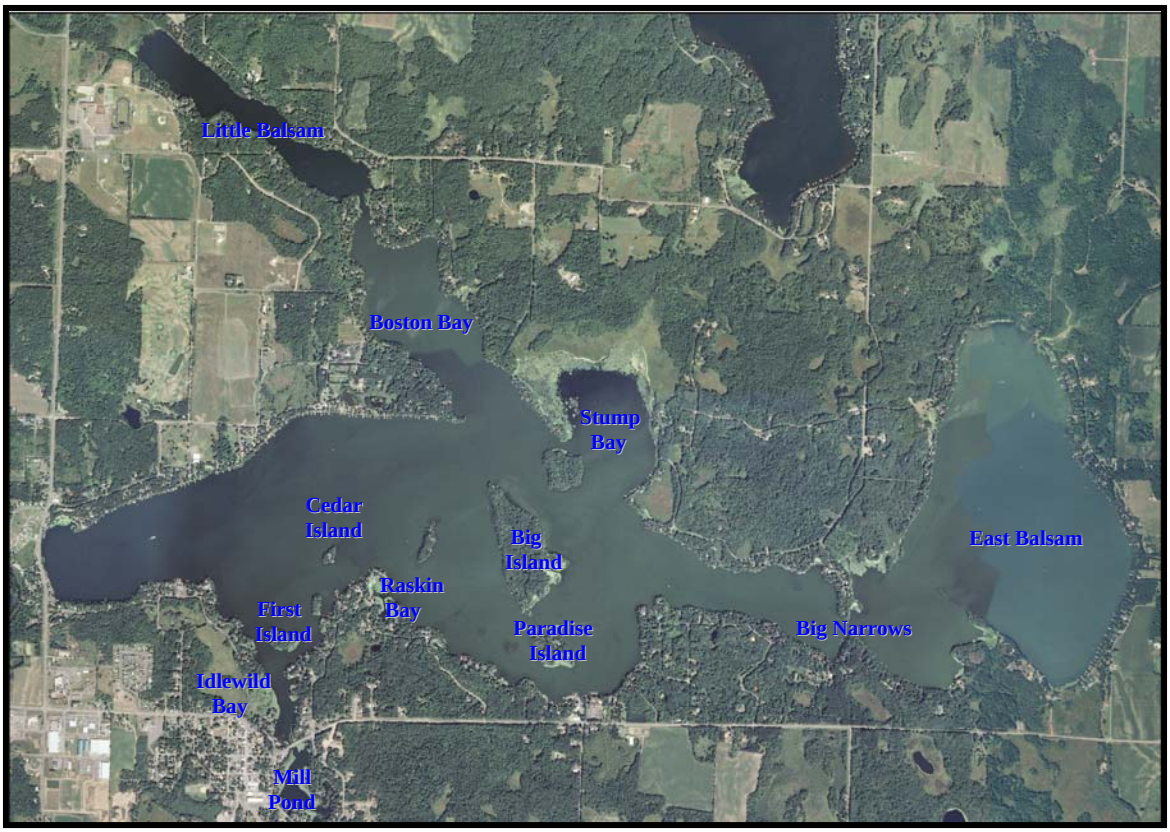


Figure 1: Aerial Photo of Balsam Lake

The Balsam Lake Protection and Rehabilitation District (BLPRD), Wisconsin Department of Natural Resources and Harmony Environmental authorized a series of full lake plant surveys as part of developing an Aquatic Plant Management Plan (APMP). Following the Curly-leaf pondweed (*Potamogeton crispus*) density and bed mapping surveys in June, 2009, we completed a warm water point/intercept survey of all aquatic macrophytes from July 19-23, 2009. The survey used the Wisconsin Department of Natural Resources statewide guidelines for conducting systematic point intercept macrophyte sampling. The guidelines ensure that all sampling in the state will be

conducted in the same manner, thus allowing data to be compared across time and space. This report represents the summary analysis of the data collected during this survey. The immediate goals of the project were to determine if Eurasian water milfoil (*Myriophyllum spicatum*) had invaded the lake and to establish baseline data on the diversity, abundance and distribution of native aquatic plant populations. These data provide a baseline for long-term monitoring of the lake's macrophyte community.

PLANT SURVEY METHODS:

Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth and total lake acres, Michelle Nault (WDNR) generated a 1,095 point sampling grid for Balsam Lake and the Mill Pond (Appendix I). Prior to beginning the July point intercept survey, we conducted a general boat survey of Balsam Lake to gain familiarity with the species present (Appendix II). All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2006), and two vouchers were pressed and mounted for herbarium specimens – one to be retained by the Balsam Lake Protection and Rehabilitation District, and one to be sent to the state herbarium in Stevens Point for identification confirmation. During the point intercept survey, we located each survey point using a handheld Garmin 76CSx mapping GPS unit. At each point, we recorded a depth reading with a Polar Vision hand held sonar unit. Following the establishment of the littoral zone at a maximum of 19ft., we sampled for plants within the depth range of plant growth. At each of these points, we used a rake (either on a pole or a throw line depending on depth) to sample an approximately 2.5ft. section of the bottom. 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 plants within six feet of the sample point. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (lake bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

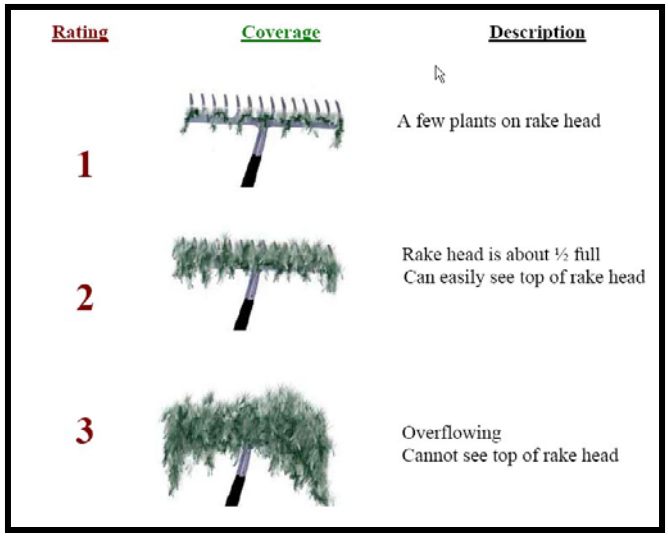


Figure 2: Rake Fullness Ratings (UWEX, 2009)

DATA ANALYSIS:

We entered all data collected into the standard APM spreadsheet (Appendix III) (UWEX, 2009). From this, we calculated the following:

Total number of points sampled: This included the total number of points on the lake coverage that were within the littoral zone (0-maximum depth where plants are found) Initially, we continued to sample points whose depth were several feet beyond the littoral zone, but once we established this maximum depth with confidence, most points beyond this depth were not rake sampled.

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 lake's littoral zone has plants.

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

Frequency of occurrence example:

Plant A is sampled at 70 out of 700 total points = 70/700 = .10 = 10%
This means that Plant A's frequency of occurrence = 10% considering the entire lake sample.

Plant A is sampled at 70 out of 350 total points in the littoral zone = 70/350 = .20 = 20%
This means that Plant A's frequency of occurrence = 20% when only considering the littoral zone.

From these frequencies, we can estimate how common each species was throughout the lake, and how common the species was at depths where plants were able to grow. Note the second value will be greater as not all the points (in this example, only ½) occur at depths shallow enough for plant growth.

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 individuals (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.

Number of sites sampled using rope/pole rake: This indicates which rake type was used to take a sample. We used a 15ft pole rake, and a 25ft 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 during the point intercept survey and the initial boat survey.

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.

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 (Table 2) gives us an idea of which species are most important within the macrophyte community.

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 (Table 3). 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 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 species found in the lake during the point intercept and boat surveys, 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, Northern 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. Balsam Lake is in the Northern Central Hardwood Forests Ecoregion.

RESULTS:

The Balsam Lake survey grid contained 1,095 points. Because the lake has many gravel bars (including some unmapped ones), we opted to take depth readings at all points (Figure 3) (Appendix IV). Little Balsam and Boston Bay are classic glacial "straight lakes" with steep sides and deep basins of 20-30ft. The main basins east and west of Big Island also have sharp drop offs into 30+ft. Stump Bay, Idlewild Bay and Raskin Bay are among the shallowest in the lake with water generally <10ft. East Balsam is a giant flat that slopes gently from the north, but sharply from all other sides into 15-18ft of water.

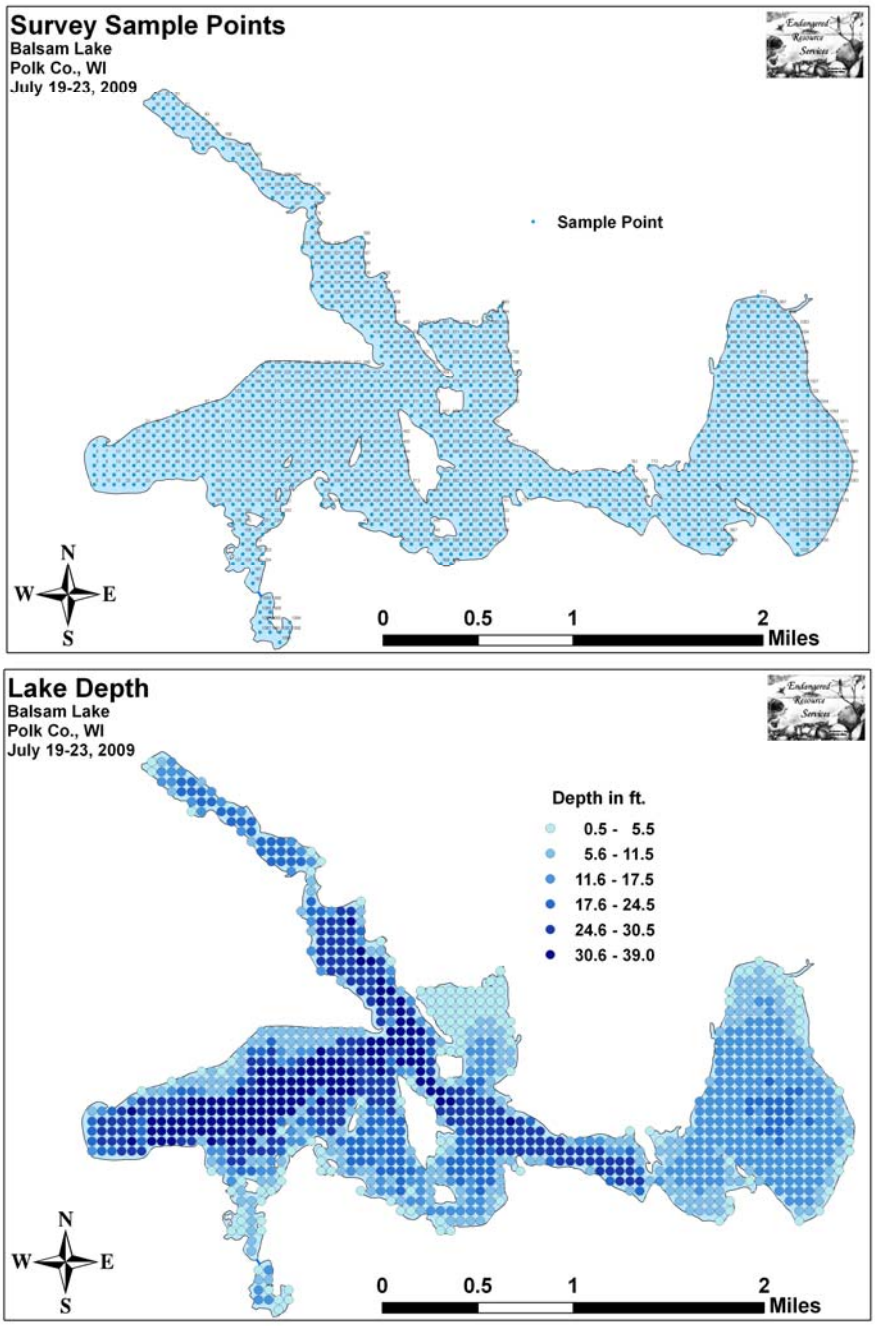


Figure 3: Balsam Lake Survey Sample Points and Lake Depth

Of the 653 points were we could determine the substrate, 69.1% were muck, 16.2% were rock, and 14.7% were sand. Little Balsam, Boston Bay, the areas around the lake's many islands, and most of the north shore of Balsam were generally rock and sand bottomed. East Balsam, Stump Bay, and Balsam's numerous small south bays tended to be filled with organic muck. We found plants growing on 55.5% of the entire lake bottom, and in 89.9% of the littoral zone (Figure 4) (Table 1) (Appendix IV).

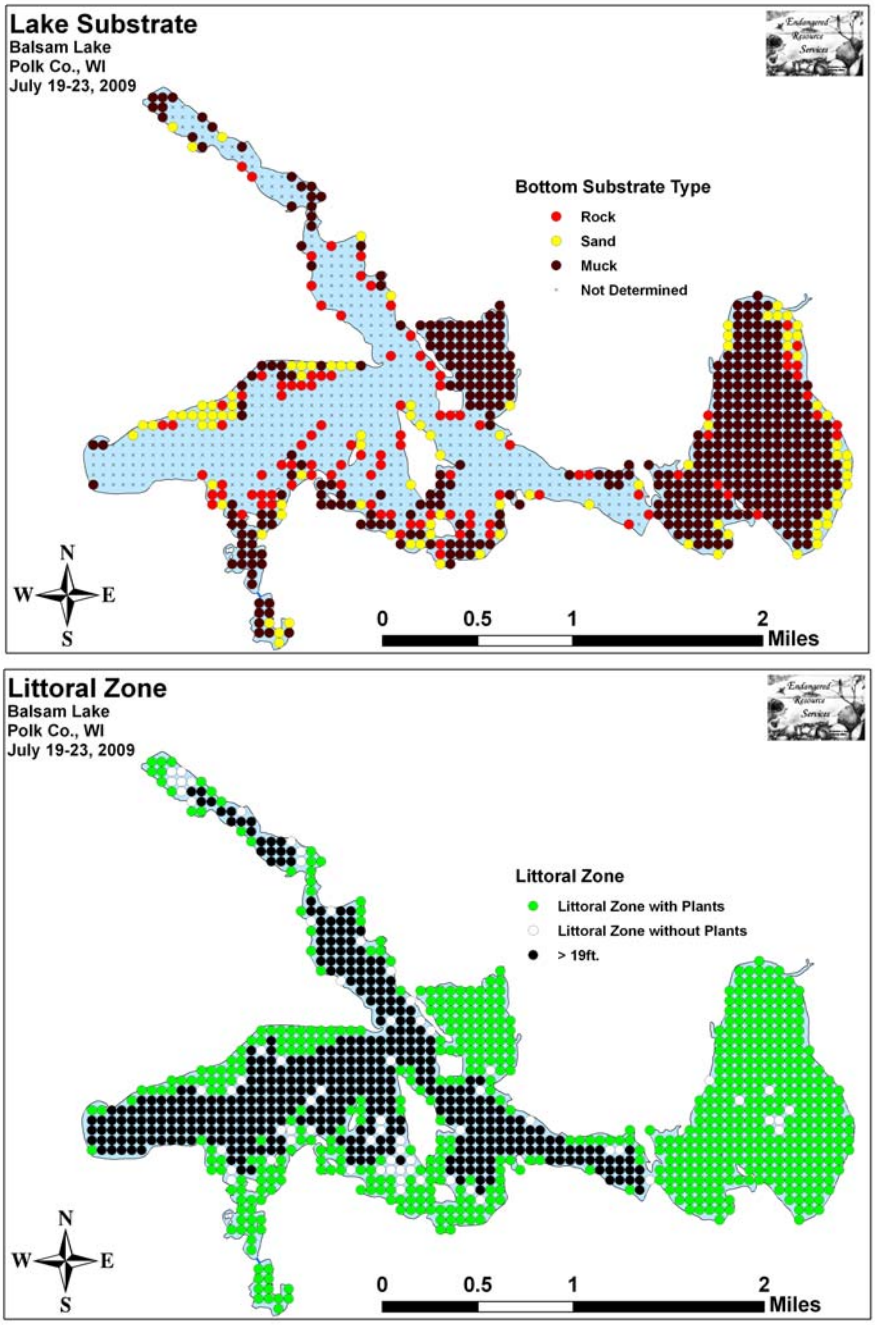


Figure 4: Balsam Lake Bottom Substrate and Littoral Zone

Table 1: Aquatic Macrophyte P/I Survey Summary Statistics
Balsam Lake, Polk County
July 19-23, 2009

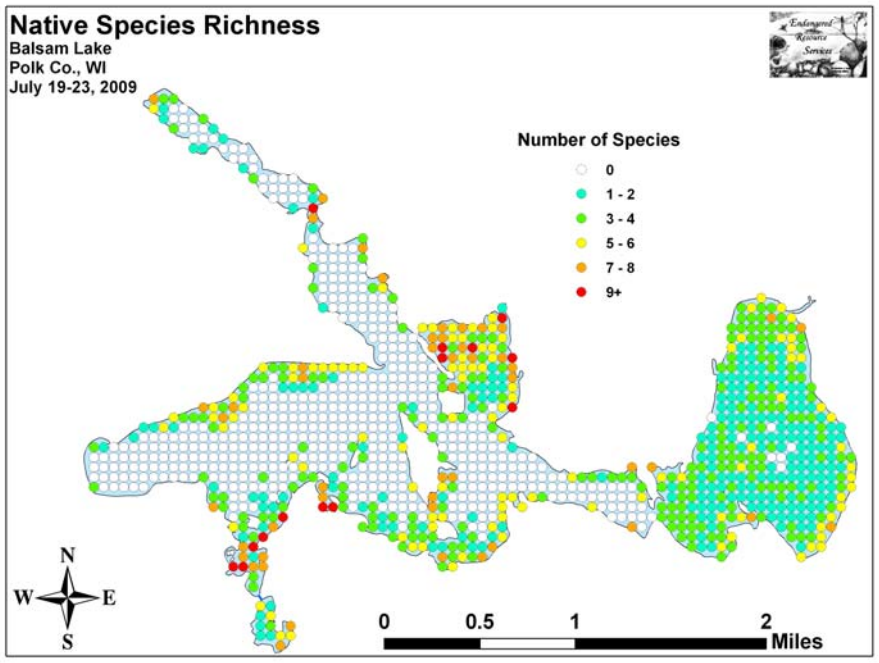
Summary Statistics:

Total number of points sampled	1095
Total number of sites with vegetation	608
Total number of sites shallower than the maximum depth of plants	676
Frequency of occurrence at sites shallower than maximum depth of plants	89.94
Simpson Diversity Index	0.91
Maximum depth of plants (ft)	19.00
Number of sites sampled using rope rake (R)	116
Number of sites sampled using pole rake (P)	537
Average number of all species per site (shallower than max depth)	3.41
Average number of all species per site (veg. sites only)	3.79
Average number of native species per site (shallower than max depth)	3.24
Average number of native species per site (veg. sites only)	3.61
Species Richness	41
Species Richness (including visuals)	42
Species Richness (including visuals and boat survey)	49
Mean depth of plants (ft)	10.05
Median depth of plants (ft)	10.00

Overall diversity was very high with a Simpson Diversity Index value of 0.91. Species richness was also very high with 49 total species found growing in and immediately adjacent to the lake. The majority of aquatic macrophytes were found growing in relatively deep water with both the mean and median depths near 10ft. Although we determined the littoral zone went to 19 feet, Coontail (*Ceratophyllum demersum*), Forked duckweed (*Lemna trisulca*), and Small pondweed (*Potamogeton pusillus*) were the only species that regularly occurred below 12ft. As the gradual drop offs in East Balsam and Stump Bay demonstrate, in general, species richness, diversity and total rake biomass decline with increasing depth (Figure 5) (Appendix V).

The lake's shallow bays (Stump Bay is pictured) supported expansive submergent, floating, and emergent plant beds. Their shallow water and thick organic muck promoted both plant density and species richness (Figure 6). Of these bays, Idlewild, Stump and Raskin were the most diverse. Each bay had unique species not found anywhere else on the lake. Idlewild in particular had several species more commonly associated with acidic lakes that had floating bogs on them.

The sandy/rocky bottom areas (Big Island is pictured) and relatively narrow littoral zone of Little Balsam, Boston Bay and most of Balsam north shore and island borders supported fewer species in lower densities albeit ones unique to these habitats (Figure 7).



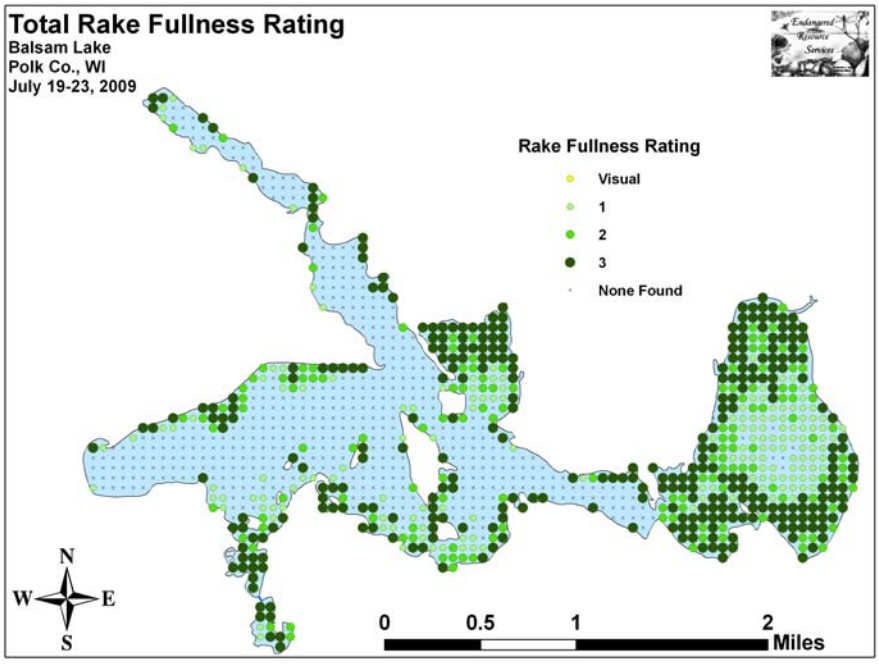


Figure 5: Native Species Richness and Total Rake Fullness Rating

The abundant plant beds in Idlewild Bay and most of Stump Bay are primarily bordered by undeveloped low areas. However, several high plant density areas of the lake appeared to be impacting lake access and general boat traffic. Specifically, we noted lakeshore owners were forced to motor through vegetation to access the lake on the east end of the Mill Pond, in the channel east of First Island, throughout Raskin Bay, in the two small bays on the east side of Boston Bay, on the southeast side of Stump Bay, in both north bays west and east of the Big Narrows and at some locations on the far north end of East Balsam. We also noted plants were prop clipped in the shallow submergent plant beds on the south side of Paradise Island. Most other areas of the lake offered adequate water to go over or around macrophytes.

Figure 6: Emergent and Floating Vegetation in Muck Bottom Bays

Figure 7: Submergent Vegetation in Sand/Rock Shoreline Areas

Table 2: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
July 19-23, 2009

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
Ceratophyllum demersum	Coontail	344	14.94	56.58	50.89	1.68
Lemna trisulca	Forked duckweed	331	14.37	54.44	48.96	1.49
Potamogeton pusillus	Small pondweed	288	12.51	47.37	42.60	1.90
Potamogeton zosteriformis	Flat-stem pondweed	212	9.21	34.87	31.36	1.55
	Filamentous algae	184	7.99	30.26	27.22	1.59
Vallisneria americana	Wild celery	127	5.51	20.89	18.79	1.74
Myriophyllum sibiricum	Northern water milfoil	123	5.34	20.23	18.20	1.79
Potamogeton crispus	Curly-leaf pondweed	113	4.91	18.59	16.72	1.14
Potamogeton robbinsii	Robbins pondweed	93	4.04	15.30	13.76	1.69
Elodea canadensis	Common waterweed	77	3.34	12.66	11.39	1.44
Potamogeton richardsonii	Clasping-leaf pondweed	65	2.82	10.69	9.62	1.35
Potamogeton praelongus	White-stem pondweed	46	2.00	7.57	6.80	1.33
Nymphaea odorata	White water lily	40	1.74	6.58	5.92	1.75
Ranunculus aquatilis	Stiff water crowfoot	37	1.61	6.09	5.47	1.46
Lemna minor	Small duckweed	30	1.30	4.93	4.44	1.40
Spirodela polyrhiza	Large duckweed	29	1.26	4.77	4.29	1.66
Potamogeton illinoensis	Illinois pondweed	26	1.13	4.28	3.85	1.35
Najas flexilis	Bushy pondweed	18	0.78	2.96	2.66	1.56
Potamogeton amplifolius	Large-leaf pondweed	14	0.61	2.30	2.07	1.86
Wolffia columbiana	Common watermeal	14	0.61	2.30	2.07	1.43
Megalodonta beckii	Water marigold	13	0.56	2.14	1.92	1.00

Table 2 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
July 19-23, 2009

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
Nuphar variegata	Spatterdock	13	0.56	2.14	1.92	1.85
Stuckenia pectinata	Sago pondweed	10	0.43	1.64	1.48	1.70
Chara sp.	Muskgrass	9	0.39	1.48	1.33	1.33
Heteranthera dubia	Water star-grass	9	0.39	1.48	1.33	1.11
Potamogeton natans	Floating-leaf pondweed	7	0.30	1.15	1.04	1.14
Nitella sp.	Nitella	4	0.17	0.66	0.59	1.50
Sagittaria cristata	Crested arrowhead	4	0.17	0.66	0.59	1.25
Eleocharis acicularis	Needle spikerush	3	0.13	0.49	0.44	2.00
Pontederia cordata	Pickerelweed	3	0.13	0.49	0.44	3.00
Potamogeton friesii	Fries' pondweed	3	0.13	0.49	0.44	1.33
Utricularia gibba	Creeping bladderwort	3	0.13	0.49	0.44	1.00
Brasenia schreberi	Watershield	2	0.09	0.33	0.30	2.00
Utricularia vulgaris	Common bladderwort	2	0.09	0.33	0.30	1.00
	Aquatic moss	1	0.04	0.16	0.15	1.00
Myriophyllum verticillatum	Whorled water milfoil	1	0.04	0.16	0.15	1.00
Sagittaria rigida	Sessile-fruited arrowhead	1	0.04	0.16	0.15	1.00
Schoenoplectus acutus	Hardstem bulrush	1	0.04	0.16	0.15	1.00
Sparganium eurycarpum	Common bur-reed	1	0.04	0.16	0.15	1.00
Typha latifolia	Broad-leaved cattail	1	0.04	0.16	0.15	3.00
Zizania palustris	Northern wild rice	1	0.04	0.16	0.15	2.00
Calla palustris	Water arum	**	**	**	**	**
Eleocharis intermedia	Matted spikerush	***	***	***	***	***
Eleocharis palustris	Creeping spikerush	***	***	***	***	***

Table 2 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
July 19-23, 2009

Lythrum salicaria	Purple loosestrife	***	***	***	***	***
Phalaris arundinacea	Reed canary grass	***	***	***	***	***
Potamogeton epihydrus	Ribbon-leaf pondweed	***	***	***	***	***
Sagittaria latifolia	Common arrowhead	***	***	***	***	***
Schoenoplectus tabernaemontani	Softstem bulrush	***	***	***	***	***

** Visual Only

*** Boat Survey Only

Coontail, Forked duckweed, Small pondweed and Flat-stem pondweed (*Potamogeton zosteriformis*) were the most common macrophyte species (Table 2). We found them at 56.58%, 54.44%, 47.37%, and 34.87% of survey points with vegetation respectively (Figure 8). Together, they combined for almost 51% of the total relative frequency. Coontail, Forked duckweed and Flat-stem pondweed were common and widely distributed throughout over muck bottom areas. Small pondweed was also found scattered throughout, but it became dominant in East Balsam where it formed expansive nearly monotypic beds in 10-18ft. of water.

Although many other species were common and widely distributed, no other species had relative frequencies over 8%. This indicates there was high evenness among species in most areas of the lake with no one species dominating at the expense of others (Appendix VI and VII).

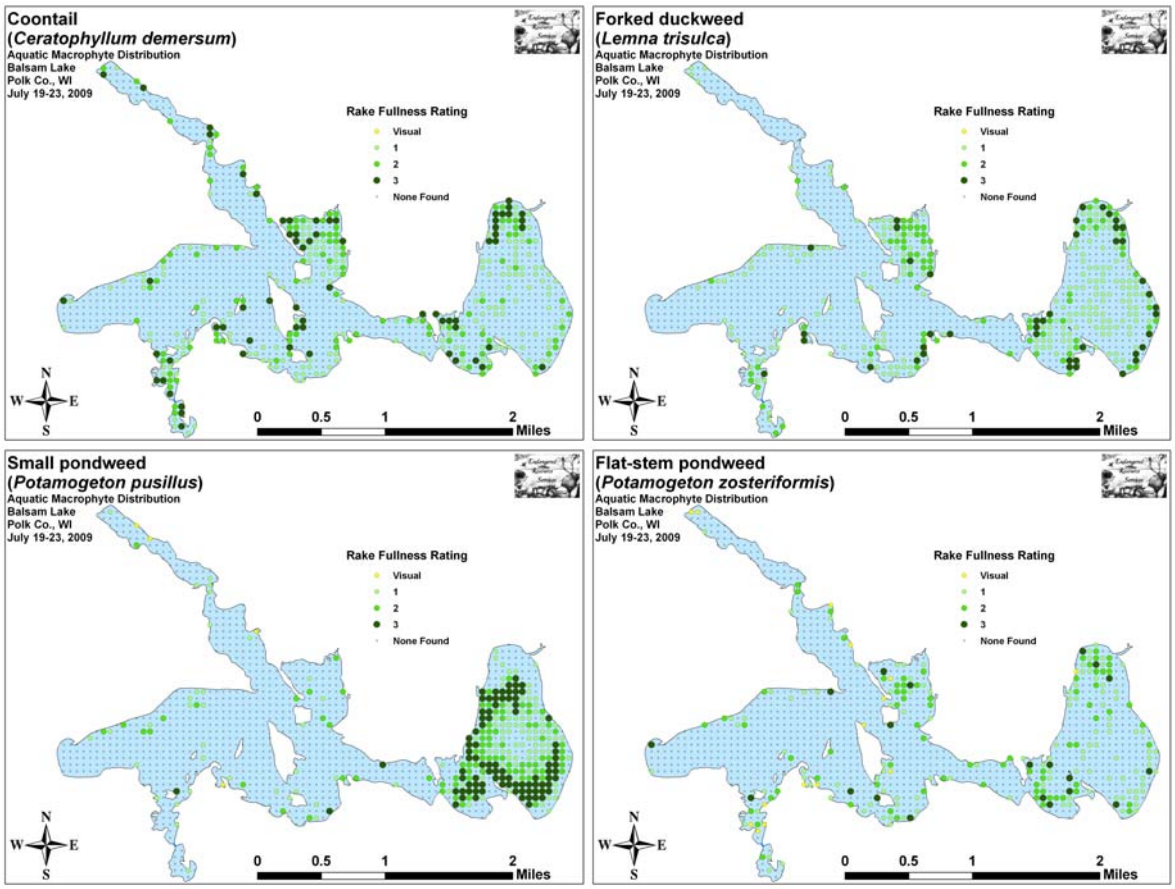


Figure 8: Balsam Lake's Most Common Species

Table 3: Floristic Quality Index of Aquatic Macrophytes
Balsam Lake, Polk County
July 19-23, 2009

Species	Common Name	C
Brasenia schreberi	Watershield	7
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	5
Lemna trisulca	Forked duckweed	6
Megalodonta beckii	Water marigold	8
Myriophyllum sibiricum	Northern water milfoil	7
Myriophyllum verticillatum	Whorled water milfoil	8
Najas flexilis	Bushy pondweed	6
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	9
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton friesii	Fries' pondweed	8
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton natans	Floating-leaf pondweed	5
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Robbins (fern) pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	Stiff water crowfoot	7
Sagittaria cristata	Crested arrowhead	9
Sagittaria rigida	Sessile-fruited arrowhead	8
Schoenoplectus acutus	Hardstem bulrush	5
Sparganium eurycarpum	Common bur-reed	5
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Typha latifolia	Broad-leaved cattail	1
Utricularia gibba	Creeping bladderwort	9
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
Wolffia columbiana	Common watermeal	5
Zizania palustris	Northern wild rice	8
N		38
mean C		6.2
FQI		38.4

We identified a total of 38 native plants to species during the point intercept survey. They produced a mean Coefficient of Conservatism of 6.2 and a Floristic Quality Index of 38.4 (Table 3). Nichols (1999) reported an Average mean C for the Northern Central Hardwood Forests Region of 5.6 putting Balsam Lake well above average for this part of the state. The FQI was also nearly double the mean FQI of 20.9 for the Northern Central Hardwood Forests Region (Nichols 1999).

We did NOT find any evidence of Eurasian water milfoil in Balsam Lake. However, several large clusters of Purple loosestrife (*Lythrum salicaria*), another invasive species, were noted along the west Mill Street Boat Landing shoreline (Figure 9). Plants were few in number and could/should be hand removed before they spread to other areas of the lake shore. Reed canary grass (also pictured below) is widely distributed in undeveloped shoreline areas of the lake. Curly-leaf pondweed, which was so prevalent in June, had largely senesced by the time of the July survey (Figure 10) (For more information on exotic invasive species, see Appendix IX).

Figure 9: Reed Canary Grass and Purple Loosestrife

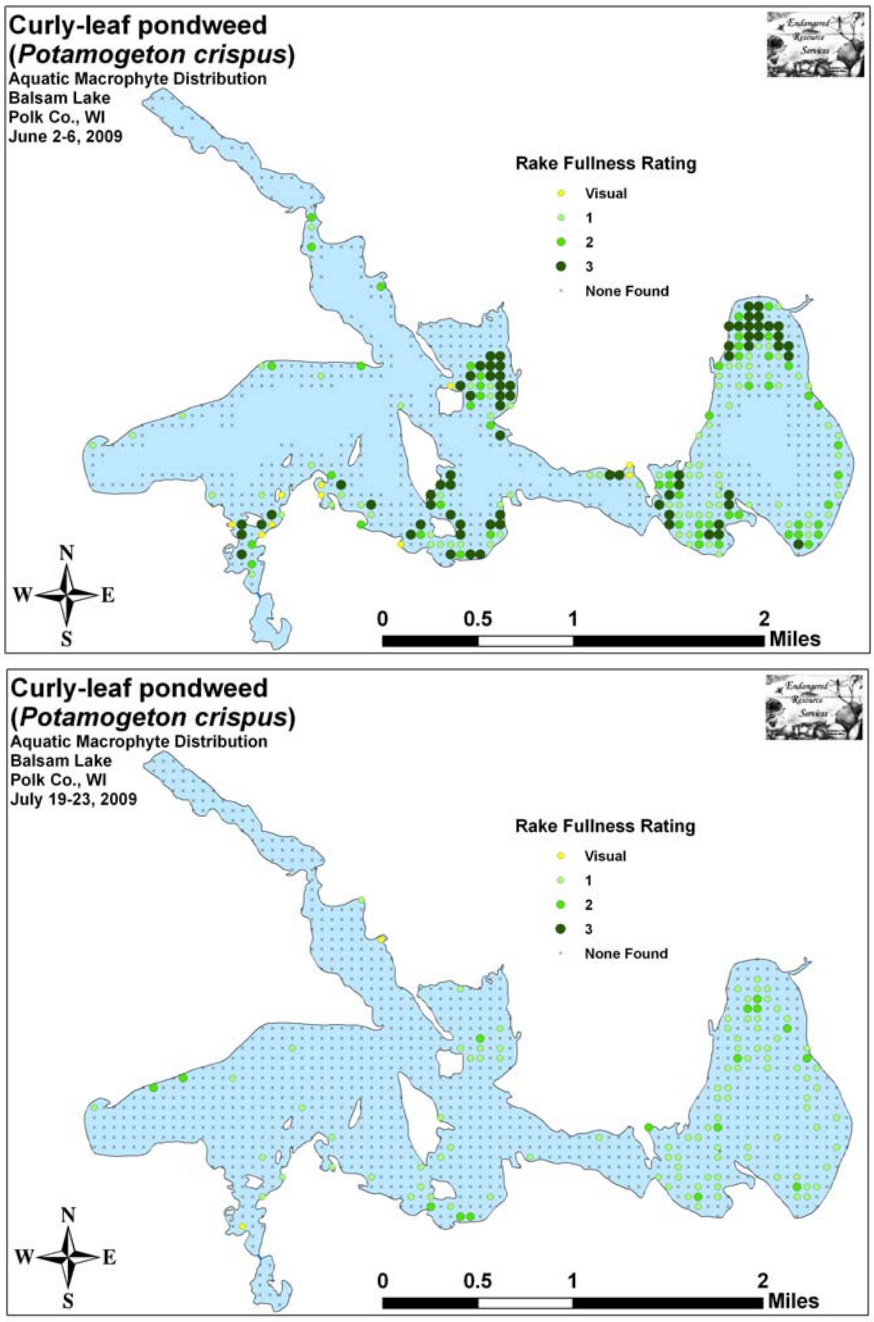


Figure 10: Curly-leaf Pondweed June and July Distribution

We noted large amounts of filamentous algae (relative frequency of 7.99), other floating algae, and Common watermeal, Forked, Large and Small duckweeds at many locations throughout Balsam Lake. These species tend to proliferate in areas that have excessive nutrients. Filamentous algae was especially common in stagnant bays, in front of managed lawns where fertilizer application was evident, and in areas where property owners cut the native vegetation down to the lakeshore (Figure 11).

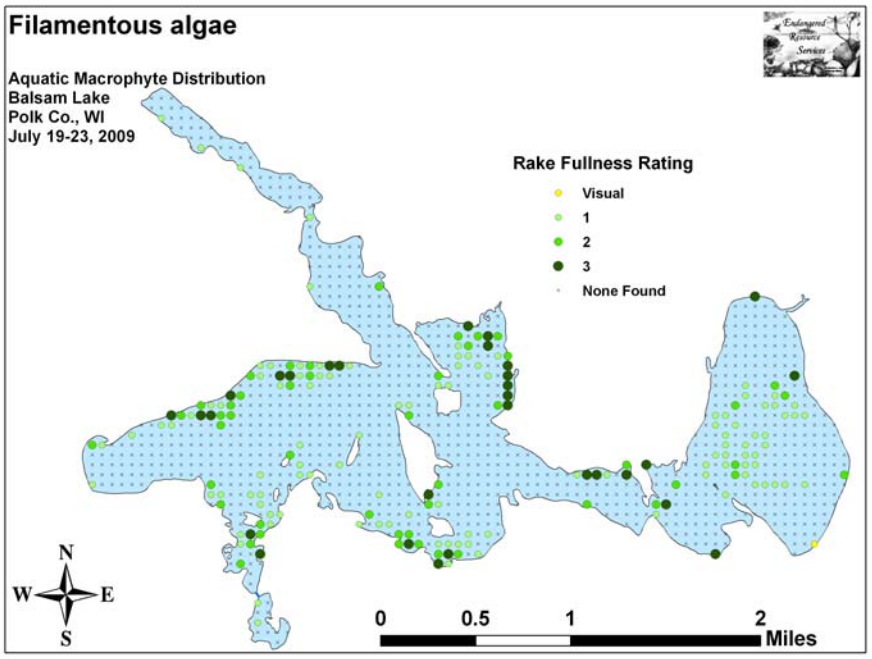


Figure 11: Filamentous Algae Distribution

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Balsam Lake has an abundant and diverse plant community. This is likely a result of Balsam Lake's large size, variable substrate, and fair water clarity. All of these factors create a mosaic of microhabitats which offer a wide variety of plants suitable growing conditions.

Curly-leaf pondweed:

Based on the June 2009 CLP surveys, we believe that Curly-leaf pondweed has overtaken all suitable habitat in the lake. Despite CLP's dominance in many areas in June, native plants such as Coontail, Small pondweed, Flat-stem pondweed, and water lilies seemed to successfully fill in areas once CLP died back. This is encouraging as it means native plants have been able to survive alongside CLP. They may be at reduced levels, but at least the important and varied habitat they provide for a variety of young and mature fish and the food those fish depend on are being maintained at some level.

Because Curly-leaf pondweed is so common and so widespread in the lake, elimination is not feasible. In the past, the BLPRD has dealt with CLP in one of three ways: Do nothing if the bed is not an issue; mechanically remove CLP beds with weed cutters in the spring when growth is the densest and native plants will be least affected; and chemical application to beds in a manner prescribed by the DNR to maximize control of CLP while minimizing impact on native vegetation.

If mechanical and/or chemical removal of CLP or other macrophytes are adopted as part of the APMP, the Board should be mindful that plants in general are the base of the aquatic food pyramid, provide habitat for other aquatic organisms, are important food sources for waterfowl and other wildlife, stabilize the shoreline, and work to improve water clarity by absorbing excess nutrients from the water. The reed/rush beds around the lake's islands are especially important as they provide "nursery" habitat for baitfish and juvenile gamefish. In essence, a lake's plants are as critical to the aquatic environment as trees are to a forest. Any plant control should be the minimum required to meet management goals while minimizing damage to native vegetation.

Water Clarity:

The high levels of filamentous and floating algae, duckweeds and watermeal in the lake are anecdotal evidence that there are excessive nutrients in the water (Boedeltje et al. 2005). Such things as internal loading from sediments, failed septic systems, and lawn and field fertilizer runoff are common causes of excess nutrients in surface water (Barko and Smart 1980, Carignan and Kalff 1982, Moeller et al. 1988)

The breakdown of CLP in June is may also be a contributing factor to the algal blooms we observed in July (Wetzel, 2001). Regardless of the cause, these algal blooms decrease light penetration into the lake which leads to increased die back of plants at the edge of the littoral zone resulting in even more nutrients being released into the water. The elimination of shoreline vegetation can also increase the lake's nutrient load by increasing runoff and adding "grass clipping" vegetation to the water. The dense areas of filamentous algae that occurred in front of some residences where there is no obvious visual reason for it may indicate septic systems are leaching nutrients into the lake. In other instances, obviously fertilized lawns may be the most likely explanation for these high levels of localized algae growth. The lake's planned multi-year assessment of water quality within the watershed will likely shed light on the specifics of nutrients within the system, as well as provide more specific suggestions on how to decrease nutrient inflow.

Educating lake residents about reducing nutrient input directly along the lake is the least expensive way to decrease algal growth and improve water clarity. Not mowing down to the lakeshore, switching to a phosphorus-free fertilizer or eliminating fertilizer altogether would all be positive steps to this end. Where possible, shoreline restoration and buffer strips of native vegetation would enhance water quality by preventing erosion and runoff as well as improve the aesthetic value of the lake's highly developed shorelines.

Aquatic Invasive Species Prevention:

Finally, aquatic invasive species (AIS) such as Eurasian water milfoil are an increasing problem in the lakes of northern Wisconsin in general, and several neighboring lakes in Polk County in particular. Preventing their introduction into Balsam Lake with proactive measures is strongly encouraged. Especially around the boat landing, lakeshore owners should refrain from removing native plants from the lake unless absolutely necessary as these patches of barren substrate can provide an easy place for invasive plants to take root and become established. The established "Clean Boats/Clean Water" program and noticeable signage at the boat landing offer a layer of protection against AIS by providing

education, reeducation, and continual reminders of the dangers/impacts of aquatic invasive species to lake owners and visitors alike. We were impressed by the diligence and knowledge of the people the Board hired to work your landings in the summer of 2009. One point of potential concern we noticed may be the numerous "bass fishing tournaments" that are held on Balsam Lake. Tournaments by nature tend to involve individuals moving from lake to lake. Requiring tournament directors to hire someone to inspect incoming boats on tournament days could decrease the chances of AIS getting into the lake. Finally, conducting monthly or bimonthly transect surveys parallel to the shore near the lake's boat landings could result in immediate detection if AIS are introduced into the lake. The sooner an infestation is detected, the greater the chances it can be successfully controlled or even eliminated.

Management Considerations Summary:

- Preserve and maintain Balsam Lake's native plant communities.
- If controlling Curly-leaf pondweed or other macrophytes is adopted as part of the Aquatic Plant Management Plan, care should be taken to minimize the impact on native vegetation.
- Reduce and, wherever possible, eliminate fertilizer applications and other sources of nutrients near the lakeshore.
- Encourage shoreline restoration and the establishment of native vegetation buffer strips along the lakeshore to prevent runoff.
- Encourage owners to refrain from removing native plants from the lake as these areas provide Aquatic Invasive Species an ideal place to become established.
- Continue the lake's established Clean Boats/Clean Water campaign to prevent the introduction of Aquatic Invasive Species like Eurasian water milfoil.
- Consider requiring fishing tournament directors to provide an inspector for all boats coming into the lake on tournament days.
- Consider transect monitoring for invasive species at the lake's boat landings at least once a month during the summer.

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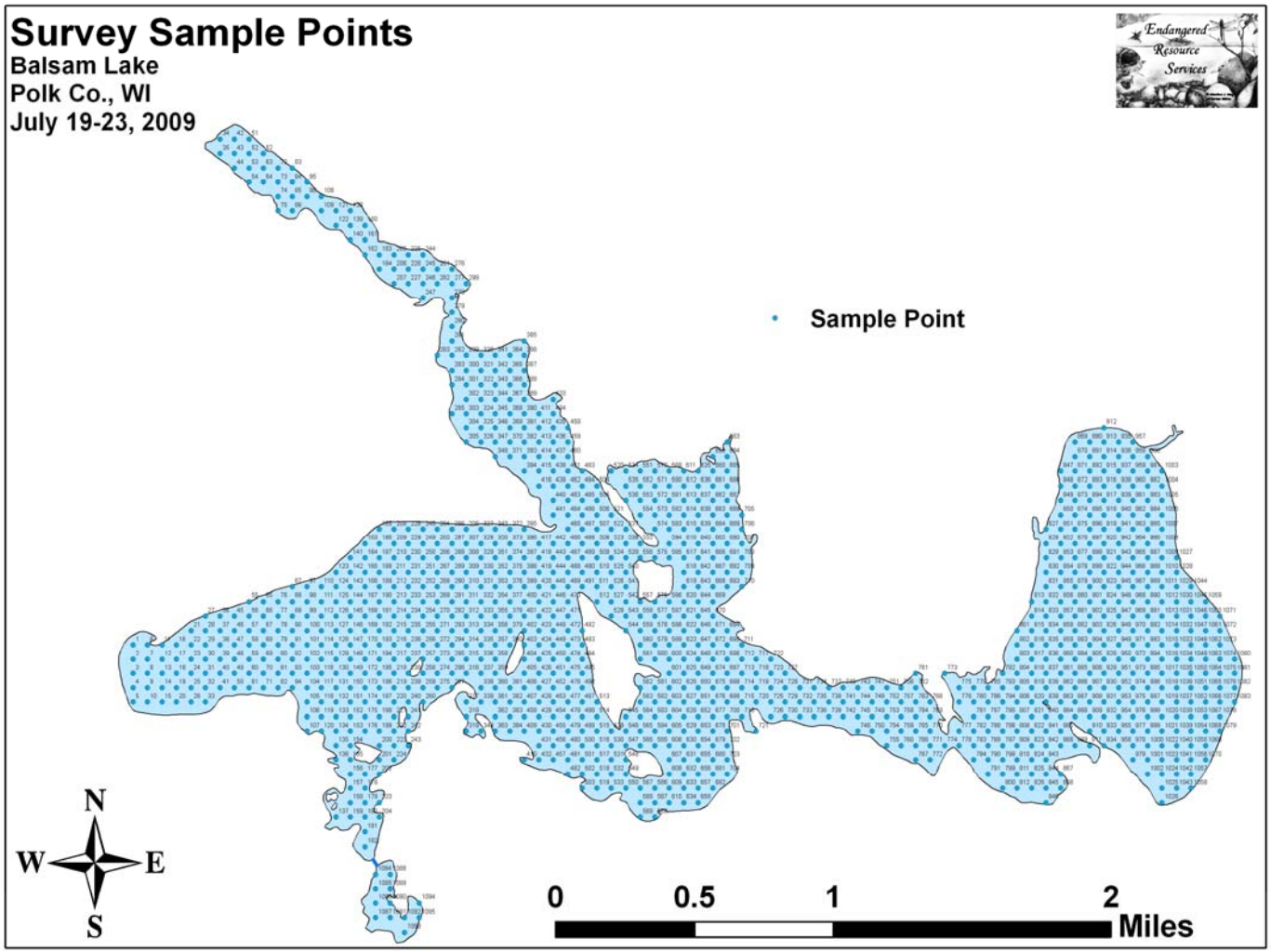
Appendix I: Balsam Lake Map with Sample Points


Survey Sample Points
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Sample Point
N
W
E
S
0
0.5
1
2
Miles

Appendix II: Boat Survey Data Sheet

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

Appendix III: Vegetative Survey Data Sheet

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																									
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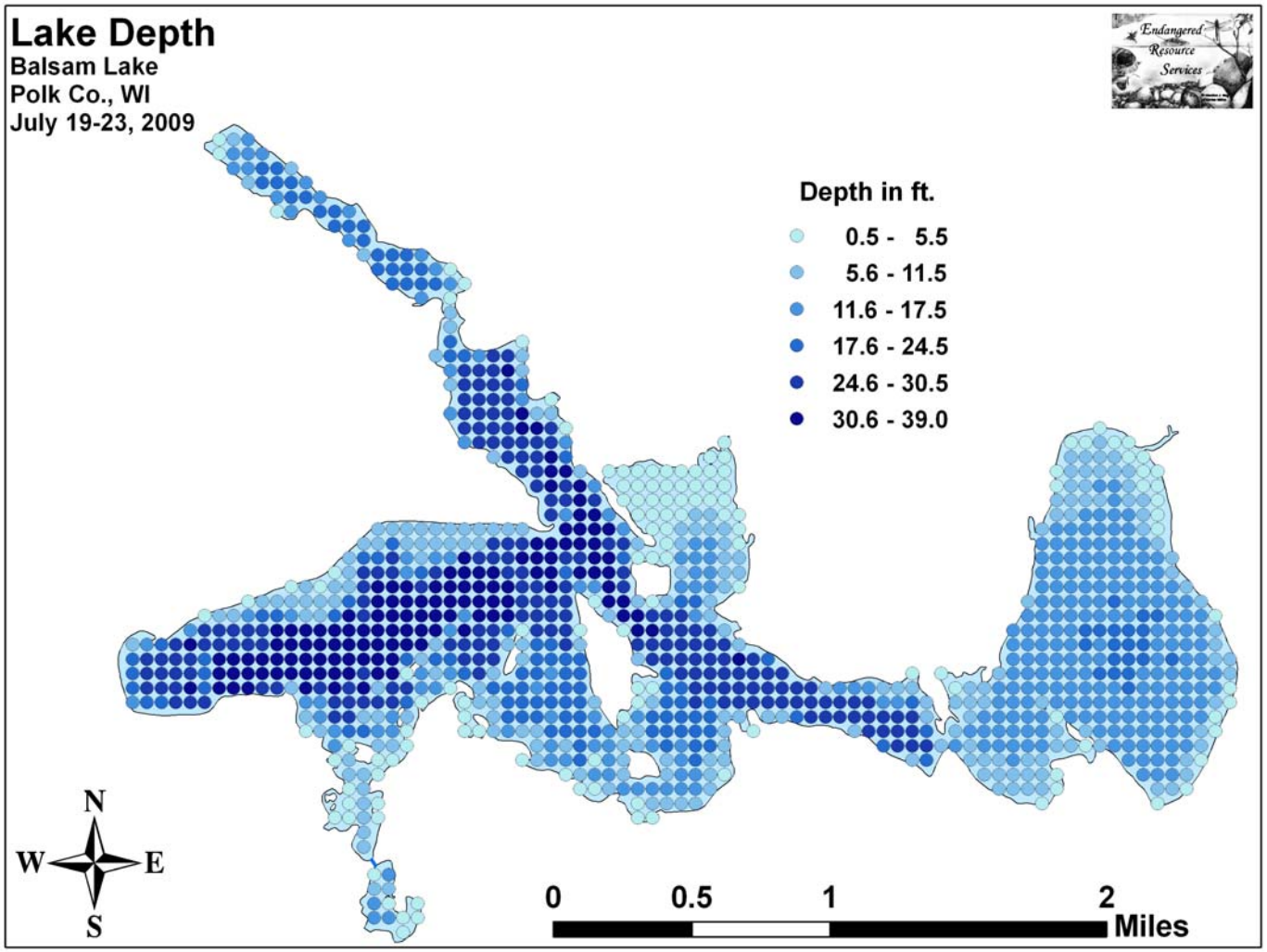
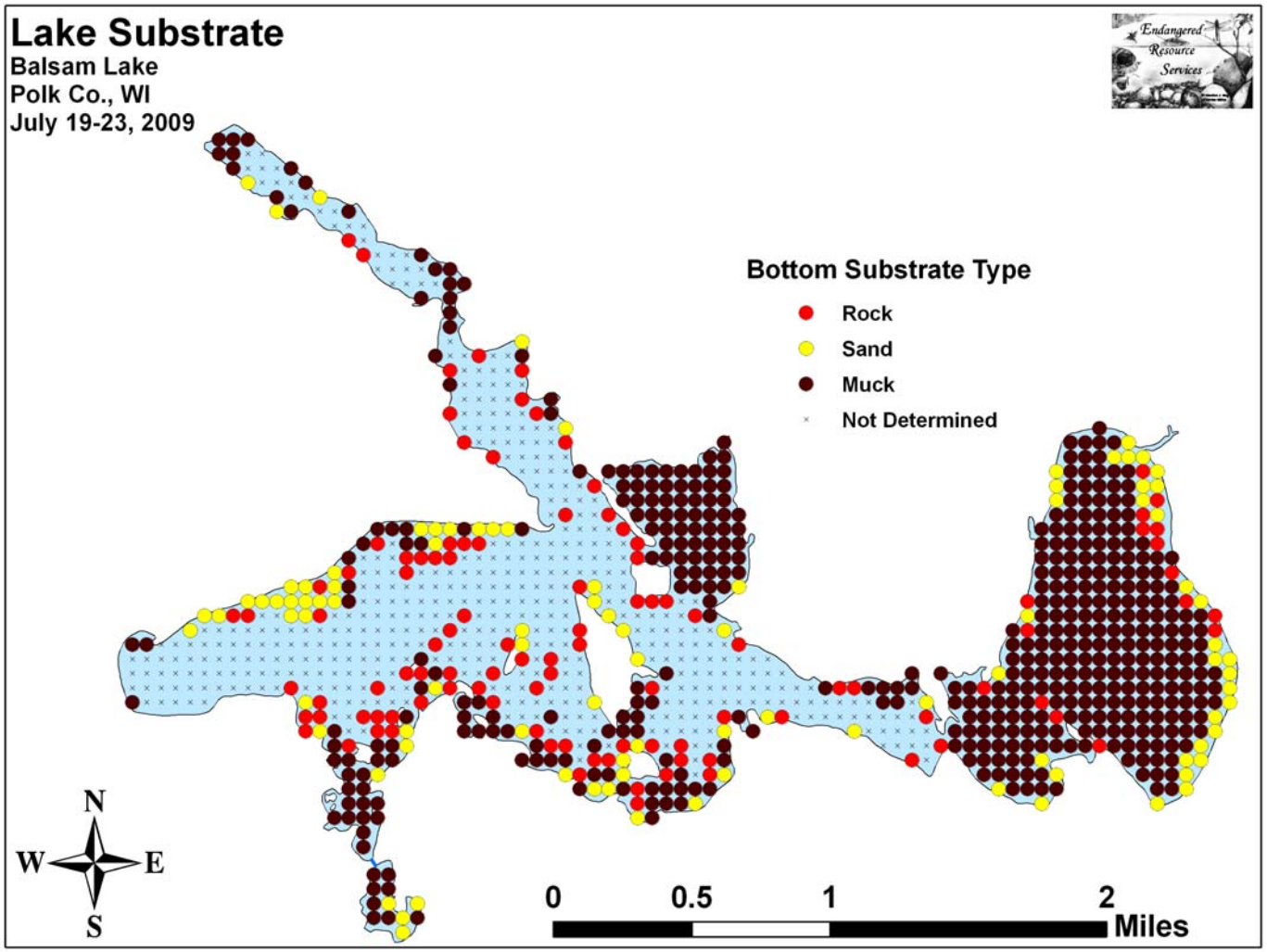
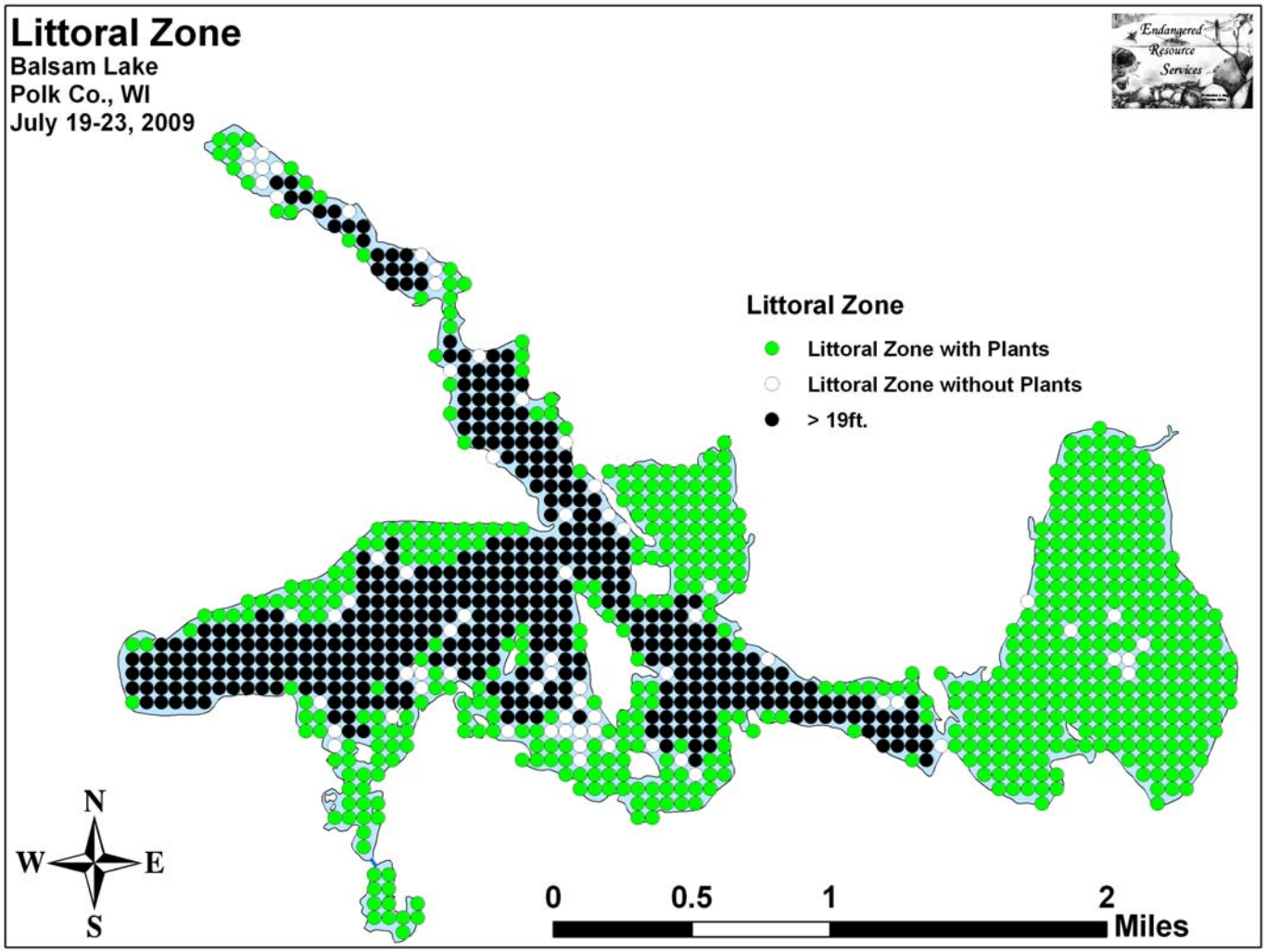
16																									
17																									
18																									
19																									
20																									

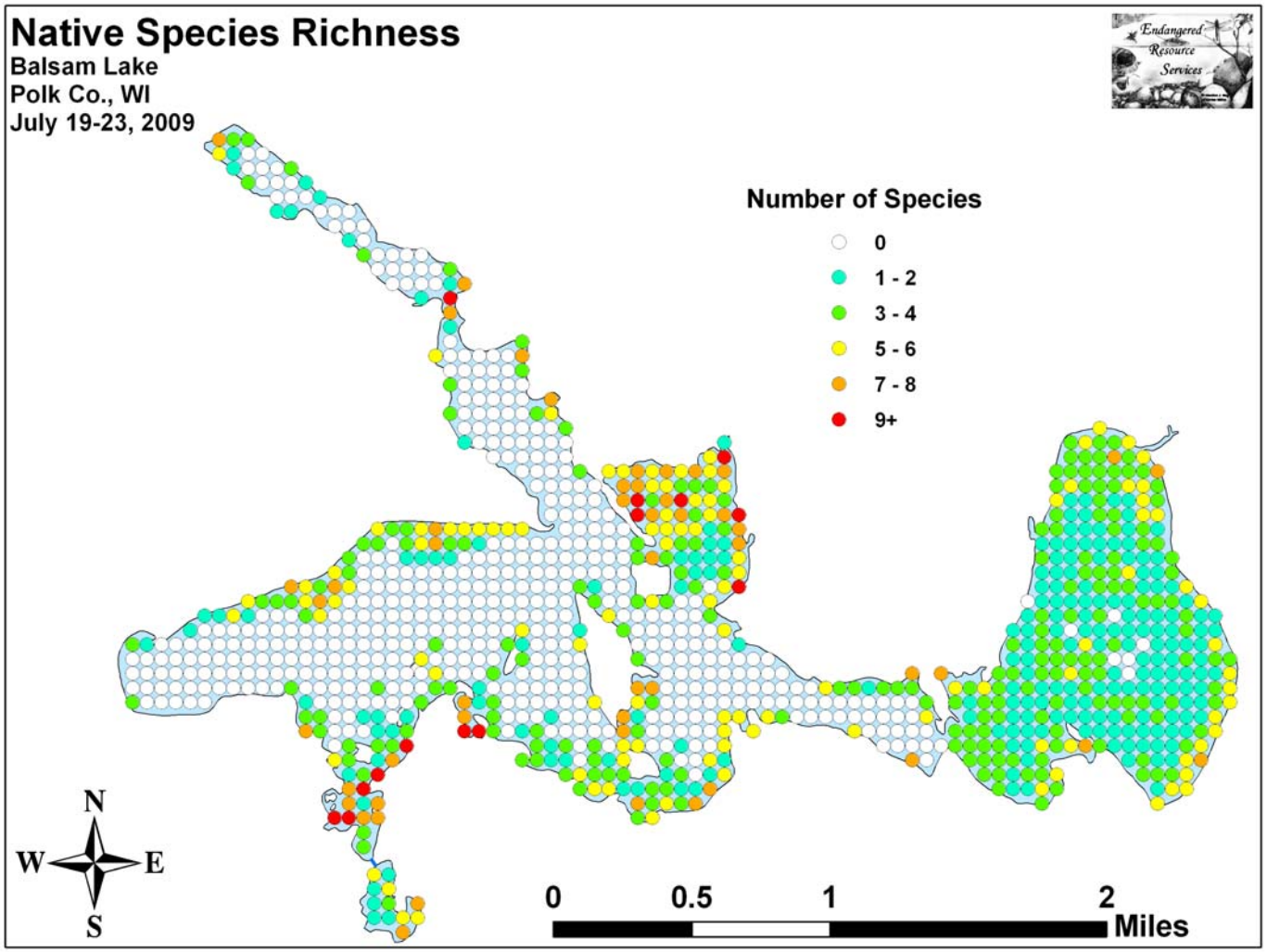
Appendix IV: Habitat Variable Maps

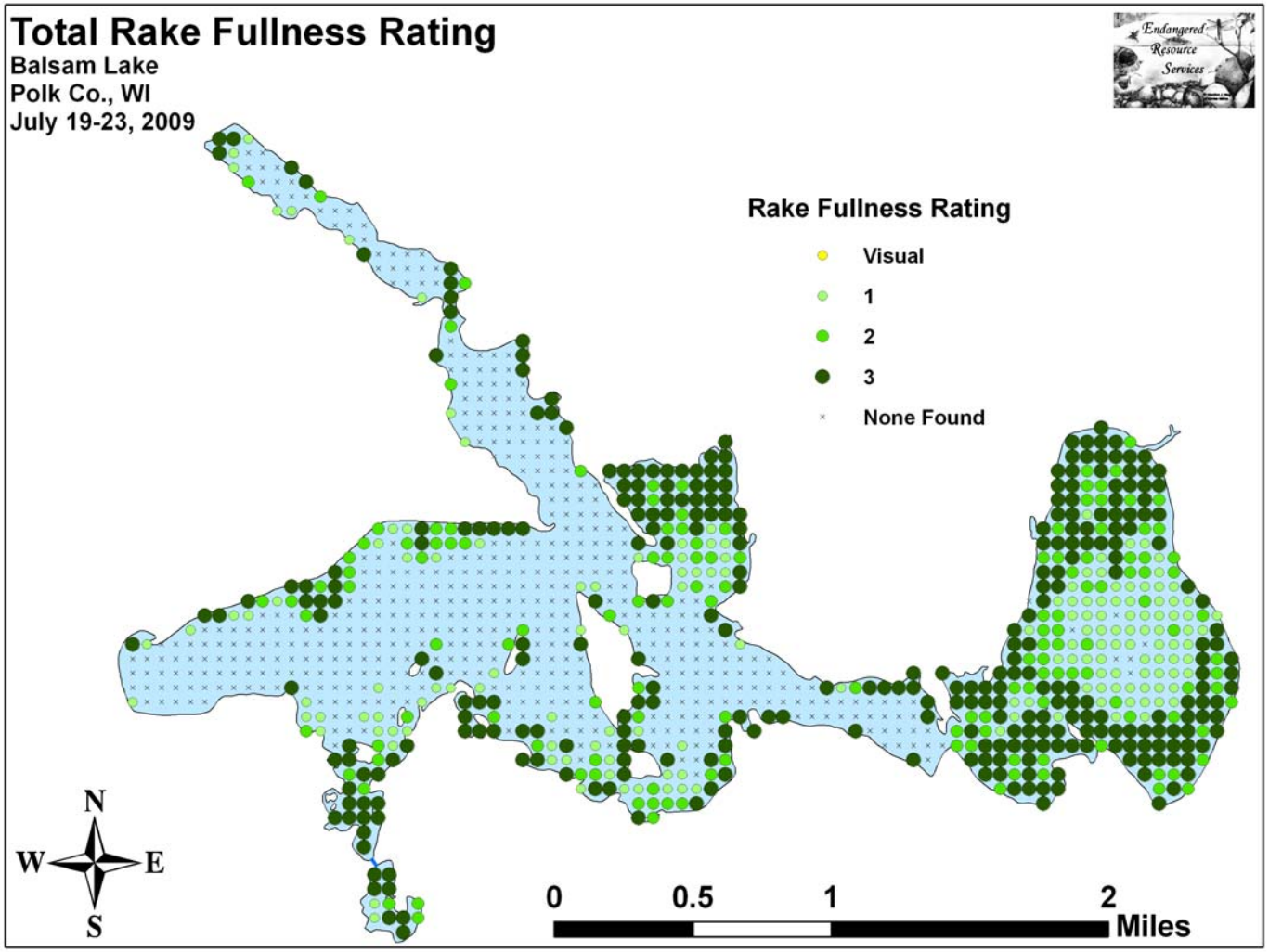

Lake Depth
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Depth in ft.
0.5 - 5.5
5.6 - 11.5
11.6 - 17.5
17.6 - 24.5
24.6 - 30.5
30.6 - 39.0
N
W
E
S
0
0.5
1
2
Miles


Lake Substrate
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Bottom Substrate Type
Rock
Sand
Muck
Not Determined
N
W
E
S
0
0.5
1
2
Miles


Littoral Zone
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Littoral Zone
Littoral Zone with Plants
Littoral Zone without Plants
> 19ft.
N
W
E
S
0
0.5
1
2
Miles

Appendix V: Native Species Richness and Total Rake Fullness Maps


Native Species Richness
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Number of Species
0
1 - 2
3 - 4
5 - 6
7 - 8
9+
N
W
E
S
0
0.5
1
2
Miles


Total Rake Fullness Rating
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

Appendix VI: Plant Species Accounts

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: Aquatic moss
Specimen Location: Balsam Lake; N45.45406°, W92.45270°
Collected/Identified by: Matthew S. Berg
Habitat/Distribution: Mucky bottom in 1m of water. A single decaying specimen was found in Idlewild Bay. We never found another specimen and thus have no voucher for this species.
Common Associates: (*Nuphar variegata)* Spatterdock, (*Nymphaea odorata*) White water lily, (*Pontederia cordata*) Pickerelweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Brasenia schreberi*) **Watershield**
Specimen Location: Balsam Lake; N45.45406°, W92.45270°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-075
Habitat/Distribution: Muck and mucky sand bottom in 0.5-1.5 meters. Uncommon – a couple of large patches were located in Idlewild Bay and on the east end of the Mill Pond.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Nymphaea odorata*) White water lily, (*Potamogeton natans*) Floating-leaf pondweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Calla palustris*) **Water arum**
Specimen Location: Balsam Lake; N45.46134°, W92.43045°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-076
Habitat/Distribution: Muck soil at the shoreline in 0 – 0.25m of water. Rare with only a few scattered individuals located along shore in the southwest corner of the bay on the east side of Big Island.
Common Associates: (*Sagittaria latifolia*) Common arrowhead, (*Typha latifolia*) Broad-leaved cattail, (*Sparganium eurycarpum*) Common bur-reed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Ceratophyllum demersum*) **Coontail**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-077
Habitat/Distribution: Muck bottom in 0-5 meters. Abundant in muck bottom areas like Raskin, Stump and Idlewild Bays and throughout East Balsam. Along with small pondweed and forked duckweed, it was the deepest growing macrophyte.
Common Associates: (*Potamogeton crispus*) Curly-leaf pondweed**,** (*Potamogeton pusillus*) Small pondweed, (*Nuphar variegata*) Spatterdock, (*Nymphaea odorata*) White water lily, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Chara* sp.) **Muskgrass**
Specimen Location: Balsam Lake; N45.45640°, W92.44958°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-078
Habitat/Distribution: Most common in sand/silt/rock bottom areas (especially on exposed points) in water from 0 – 1 meter deep. Scattered locations throughout.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Najas flexilis*) Bushy pondweed, (*Schoenoplectus acutus*) Hardstem bulrush

County/State: Polk County, Wisconsin **Date:** 7/21/09
Species: (*Eleocharis acicularis*) **Needle spikerush**
Specimen Location: Balsam Lake; N45.47027°, W92.43729°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-079
Habitat/Distribution: Found in firm sand/rock bottom areas in water from 0 – 1 meter deep. Fairly common around islands and on exposed rocky points; especially in Boston Bay.
Common Associates: (*Chara* sp.) Muskgrass, (*Najas flexilis*) Bushy pondweed

County/State: Polk County, Wisconsin **Date:** 7/22/09
Species: (*Eleocharis intermedia*) **Matted spikerush**
Specimen Location: Balsam Lake; N45.45232°, W92.45083°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-080
Habitat/Distribution: Mucky to firm bottoms in 0-0.5 meters of water. A dense patch of plants was located at the Mill St. boat landing and along the swim beach. Achene analysis was used to determine species.
Common Associates: None. Plants grew in a monotypic stand.

County/State: Polk County, Wisconsin **Date:** 7/21/09
Species: (*Eleocharis palustris*) **Creeping spikerush**
Specimen Location: Balsam Lake; N45.48453°, W92.45007°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-081
Habitat/Distribution: Firm sandy to rocky bottoms in 0-0.5 meters of water. Scattered nearly monotypic beds were located in Little Balsam and along Big and Paradise Islands.
Common Associates: (*Schoenoplectus acutus*) Hardstem bulrush, (*Chara* sp.) Muskgrass, (*Najas flexilis*) Bushy pondweed, (*Eleocharis acicularis*) Needle spikerush

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Elodea canadensis*) **Common waterweed**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-082
Habitat/Distribution: Muck bottom in 0-5 meters of water.
Abundant in Stump and Idlewild Bays; widely distributed, but not common elsewhere.
Common Associates: (*Potamogeton crispus*) Curly-leaf pondweed**,** (*Potamogeton robbinsii*) Robbins (Fern) pondweed, (*Ceratophyllum demersum*) Coontail, (*Potamogeton amplifolius*) Large-leaf pondweed, (*Potamogeton pusillus*) Small pondweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Heteranthera dubia*) **Water star-grass**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-083
Habitat/Distribution: Firm muck bottoms usually in water < 2m. Scattered individuals throughout; widespread but never abundant.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Elodea canadensis*) Common waterweed, (*Ceratophyllum demersum*) Coontail, (*Lemna trisulca*) Forked duckweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Ranunculus aquatilis*) Stiff water crowfoot

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Lemna minor*) **Small duckweed**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-084
Habitat/Distribution: Located floating at or just under the surface in sheltered bays. Especially common in Raskin Bay and among the cattails and wild rice areas of Stump Bay.
Common Associates: (*Wolffia columbiana*) Common watermeal, (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Nuphar variegata*) Spatterdock, (*Spirodela polyrhiza*) Large duckweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Lemna trisulca*) **Forked duckweed**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-085
Habitat/Distribution: Located entangled in other plants and along the bottom. Abundant like we have never seen in any other lake. Some places had feet of *trisulca* covering the bottom. In herbicided areas, it was the only species left.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton praelongus*) White-stem pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Ceratophyllum demersum*) Coontail, (*Elodea canadensis*) Common waterweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Lythrum salicaria*) **Purple loosestrife**
Specimen Location: Balsam Lake; N45.45406°, W92.45270°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-086
Habitat/Distribution: Rare. About 10-15 plants were located just west of the Mill St. boat landing. Prefers thick muck soil in and out of water <0.5 meters.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass**,** (*Sagittaria latifolia*) Common arrowhead

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Megalodonta beckii*) **Water marigold**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-087
Habitat/Distribution: Muck bottom in 0-4 meters of water. Widespread throughout, but never abundant.
Common Associates: (*Nymphaea odorata*) White water lily**,** (*Potamogeton robbinsii*) Robbins (Fern) pondweed, (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Myriophyllum sibiricum*) **Northern water milfoil**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-088
Habitat/Distribution: Muck to sand bottom in water up to 4 meters; widespread and common throughout.
Common Associates: (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Potamogeton praelongus*) White-stem pondweed, (*Ceratophyllum demersum*) Coontail, (*Ranunculus aquatilis*) Stiff water crowfoot, (*Lemna trisulca*) Forked duckweed, (*Vallisneria americana*) Wild celery

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Myriophyllum verticillatum*) **Whorled water milfoil**
Specimen Location: Balsam Lake; N45.45406°, W92.45270°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-089
Habitat/Distribution: A single small population was located in Idlewild Bay.
Common Associates: (*Nymphaea odorata*) White water lily, (*Potamogeton natans*) Floating-leaf pondweed, (*Pontederia cordata*) Pickerelweed, (*Brasenia schreberi*) Watershield, (*Utricularia vulgaris*) Common bladderwort

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Najas flexilis*) **Bushy pondweed**
Specimen Location: Balsam Lake; N45.45640°, W92.44958°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-090
Habitat/Distribution: Found in almost any bottom conditions, but grows best in rock/ sand bottoms in 0.5-1.5 meters of water. Widely distributed, but not very common. Most individuals were located in sandy shoreline areas; especially along the islands and on the east end of East Balsam.
Common Associates: (*Chara* sp.) Muskgrass, (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Vallisneria americana*) Wild celery, (*Eleocharis acicularis*) Needle spikerush

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Nitella* sp.) **Nitella**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-091
Habitat/Distribution: Muck bottom area in water generally less than 3 meters deep. Abundant in Idlewild Bay, but only found in one other location in East Balsam.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Potamogeton robbinsii*) Robbins (Fern) pondweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Nuphar variegata)* **Spatterdock**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-092
Habitat/Distribution: Muck bottom in 0-1.5 meters of water where it often forms dense canopies. Relatively common in muck bays and sheltered shoreline area. It prefers a firmer bottom than (*Nymphaea odorata*) and is often found growing on the outside edge of lily beds.
Common Associates: (*Nymphaea odorata*) White water lily, (*Potamogeton natans*) Floating-leaf pondweed, (*Pontederia cordata*) Pickerelweed, (*Brasenia schreberi*) Watershield, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Nymphaea odorata*) **White water lily**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-093
Habitat/Distribution: Muck bottom in 0-1.5 meters where it forms dense canopies with other floating leaf species. Common in all calm water bays.
Common Associates: (*Nuphar variegata)* Spatterdock, (*Elodea canadensis*) Common waterweed, (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Phalaris arundinacea*) **Reed canary grass**
Specimen Location: Balsam Lake; N45.46134°, W92.43045°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-094
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 scattered throughout.
Common Associates: (*Lythrum salicaria*) Purple loosestrife**,** (*Typha latifolia*) Broad-leaved cattail, (*Calla palustris*) Water arum

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Pontederia cordata*) **Pickerelweed**
Specimen Location: Balsam Lake; N45.46134°, W92.43045°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-095
Habitat/Distribution: Silt to muck bottom over firm substrate in 0-1.5 meters of water. Scattered emergent beds in sheltered bays throughout.
Common Associates: (*Brasenia schreberi*) Watershield, (*Nymphaea odorata*) White water lily, (*Nuphar variegata)* Spatterdock, (*Ceratophyllum demersum*) Coontail

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton amplifolius*) **Large-leaf pondweed**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-096
Habitat/Distribution: Found in most muck/firm muck bottom areas in water from 1-2m deep. Widely distributed but seldom abundant.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Potamogeton praelongus*) White-stem pondweed, (*Ceratophyllum demersum*) Coontail, (*Myriophyllum sibiricum*) Northern water milfoil

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton crispus*) **Curly-leaf pondweed**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-097
Habitat/Distribution: Found in most mucky bottom areas in water from 1-3.5m deep. Common and widely distributed throughout Balsam Lake and East Balsam, absent in Little Balsam.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Elodea canadensis*) Common waterweed, (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/20/09
Species: (*Potamogeton epihydrus*) **Ribbon-leaf pondweed**
Specimen Location: Balsam Lake; N45.45882°, W92.44216°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-098
Habitat/Distribution: Found in mucky bottom conditions in shallow water 0.5-1.5 meter deep. A single tiny population was found at the point in Raskin Bay.
Common Associates: (*Myriophyllum sibiricum*) Northern water milfoil, (*Elodea canadensis*) Common waterweed, (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton friesii*) **Fries' pondweed**
Specimen Location: Balsam Lake; N45.45406°, W92.45270°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-099
Habitat/Distribution: Very rare. We found three small populations; the biggest was in Idlewild Bay. Told from the similar looking small pondweed by having 5 leaf veins and a fan shaped winter bud. Nodal glands were also especially big in these specimens.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Vallisneria americana*) Wild celery, (*Myriophyllum sibiricum*) Northern water milfoil

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton natans*) **Floating-leaf pondweed**
Specimen Location: Balsam Lake; N45.45406°, W92.45270°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-100
Habitat/Distribution: Muck bottom in 1meter of water. Common in Stump and Idlewild Bay, but rare elsewhere.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton amplifolius*) Large-leaf pondweed, (*Elodea canadensis*) Common waterweed, (*Nymphaea odorata*) White water lily

County/State: Polk County, Wisconsin **Date:** 7/20/09
Species: (*Potamogeton illinoensis*) **Illinois pondweed**
Specimen Location: Balsam Lake; N45.46173°, W92.44766°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-101
Habitat/Distribution: Muck and sand bottom in 1-3 meters of water. Relatively common and widespread though seldom abundant in deeper water with a thin layer of muck over firm substrate.
Common Associates: (*Vallisneria americana*) Wild celery, (*Ceratophyllum demersum*) Coontail, (*Potamogeton amplifolius*) Large-leaf pondweed, (*Elodea canadensis*) Common waterweed, (*Myriophyllum sibiricum*) Northern water milfoil, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton praelongus*) **White-stem pondweed**
Specimen Location: Balsam Lake; N45.47123°, W92.42766°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-102
Habitat/Distribution: Widely distributed but seldom abundant over sandy muck in 2-3 meters of water.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Ceratophyllum demersum*) Coontail, (*Myriophyllum sibiricum*) Northern water milfoil, (*Lemna trisulca*) Forked duckweed, (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Potamogeton robbinsii*) Robbins (Fern) pondweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton pusillus*) **Small pondweed**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-103
Habitat/Distribution: Found in almost any bottom conditions, but formed dense monotypic stands over muck in 1-5.5 meters of water. Normally it, Coontail and Flat-stem pondweed were the deepest growing vascular plant. It is widely distributed on the edge of the drop off. East Balsam is a giant underwater forest of this plant.
Common Associates: (*Potamogeton crispus*) Curly-leaf pondweed, (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton richardsonii*) **Clasping-leaf pondweed**
Specimen Location: Balsam Lake; N45.47123°, W92.42766°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-104
Habitat/Distribution: Found in sandy/sandy muck bottom conditions in shallow water 0.5-3 meters deep. Common and widespread throughout.
Common Associates: (*Myriophyllum sibiricum*) Northern water milfoil, (*Vallisneria americana*) Wild celery, (*Najas flexilis*) Bushy pondweed, (*Lemna trisulca*) Forked duckweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Ceratophyllum demersum*) Coontail

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton robbinsii*) **Robbins (Fern) pondweed**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-105
Habitat/Distribution: Common and widespread over its preferred substrate of organic muck. Especially common to the point of being dominant in Stump Bay. Grows in 0-4m of water, but prefers 2.5-3.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Ceratophyllum demersum*) Coontail, (*Ranunculus aquatilis*) Stiff water crowfoot, (*Myriophyllum sibiricum*) Northern water milfoil, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton zosteriformis*) **Flat-stem pondweed**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-106
Habitat/Distribution: It prefers substrate of thick organic muck. Widely distributed and abundant in muck bottom bays throughout where it grows in 0-5 meters of water. Especially common in East Balsam and Stump Bay.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton pusillus*) Small pondweed, (*Lemna trisulca*) Forked duckweed, (*Myriophyllum sibiricum*) Northern water milfoil, (*Potamogeton crispus*) Curly-leaf pondweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Ranunculus aquatilis*) **Stiff water crowfoot**
Specimen Location: Balsam Lake; N45.47047°, W92.42762°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-107
Habitat/Distribution: Widely distributed and fairly common throughout over variable substrate in 0-2.5 meters of water.
Common Associates: (*Myriophyllum sibiricum*) Northern water milfoil, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Potamogeton robbinsii*) Robbins (Fern) pondweed, (*Ceratophyllum demersum*) Coontail, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/21/09
Species: (*Sagittaria cristata*) **Crested arrowhead**
Specimen Location: Balsam Lake; N45.47482°, W92.43641°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-108
Habitat/Distribution: Rare in shallow water 0-1.5 meters over firm sand bottom. Scattered individuals throughout, but mostly on rocky points, around islands, and in Boston Bay. No fertile plants were located making identification tentative based on submersed rosettes, and habitat.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Najas flexilis*) Bushy pondweed, (*Chara* sp.) Muskgrass

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Sagittaria latifolia*) **Common arrowhead**
Specimen Location: Balsam Lake; N45.46134°, W92.43045°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-122
Habitat/Distribution: Thick muck soil in and out of water <0.5 meters. Found in undeveloped shoreline areas throughout.
Common Associates: (*Phalaris arundinacea*) Reed canary grass, (*Calla palustris*) Water arum, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Sparganium eurycarpum*) Common bur-reed, (*Typha latifolia*) Broad-leaved cattail

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Sagittaria rigida*) **Sessile-fruited arrowhead**
Specimen Location: Balsam Lake; N45.46134°, W92.43045°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-109
Habitat/Distribution: Emergent plants were scattered in undeveloped mucky shoreline areas.
Common Associates: (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Typha latifolia*) Broad-leaved cattail, (*Calla palustris*) Water arum

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Schoenoplectus acutus*) **Hardstem bulrush**
Specimen Location: Balsam Lake; N45.46134°, W92.43045°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-110
Habitat/Distribution: More common than the survey map indicates. Monotypic stands of Hardstem were found throughout on firm sand and gravel bars in water 0-1m deep. They were especially common around the islands of the main lake.
Common Associates: (*Chara* sp.) Muskgrass, (*Eleocharis palustris*) Creeping spikerush, (*Najas flexilis*) Bushy pondweed, (*Myriophyllum sibiricum*) Northern water milfoil

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Schoenoplectus tabernaemontani*) **Softstem bulrush**
Specimen Location: Balsam Lake; N45.45179°, W92.44951°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-111
Habitat/Distribution: Firm muck bottoms in 0-1 meter of water. A few patches of plants were located at the tunnel entrance of the Mill Pond and along CTH I.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata)* Spatterdock, (*Myriophyllum sibiricum*) Northern water milfoil

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Sparganium eurycarpum*) **Common bur-reed**
Specimen Location: Balsam Lake; N45.46134°, W92.43045°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-112
Habitat/Distribution: Uncommon in scattered mucky shoreline locations.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass, (*Calla palustris*) Water arum, (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Spirodela polyrhiza*) **Large duckweed**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-113
Habitat/Distribution: Located floating at or just under the surface in sheltered bays. Especially common in Raskin Bay and among the cattails and wild rice areas of Stump Bay.
Common Associates: (*Wolffia columbiana*) Common watermeal, (*Lemna minor*) Small duckweed, (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Nuphar variegata*) Spatterdock, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Stuckenia pectinata*) **Sago pondweed**
Specimen Location: Balsam Lake; N45.45792°, W92.42930°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-114
Habitat/Distribution: Uncommon to rare. Scattered plants were located in sandy/rocky areas along the lake's islands, in Boston Bay, and on the eastern shoreline of East Balsam.
Common Associates: (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Vallisneria americana*) Wild celery, (*Eleocharis acicularis*) Needle spikerush, (*Najas flexilis*) Bushy pondweed, (*Chara* sp.) Muskgrass

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Typha latifolia*) **Broad-leaved cattail**
Specimen Location: Balsam Lake; N45.46134°, W92.43045°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-115
Habitat/Distribution: Thick muck soil in and out of water <0.5 meters. Found in undeveloped shoreline areas throughout.
Common Associates: (*Phalaris arundinacea*) Reed canary grass, (*Calla palustris*) Water arum, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Sparganium eurycarpum*) Common bur-reed

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Utricularia gibba*) **Creeping bladderwort**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-116
Habitat/Distribution: Scattered individuals and clusters were floating among the lilypads in Idlewild Bay. Not found anywhere else.
Common Associates: (*Utricularia vulgaris*) Common bladderwort, (*Brasenia schreberi*) Watershield, (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Nuphar variegata*) Spatterdock

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Utricularia vulgaris*) **Common bladderwort**
Specimen Location: Balsam Lake; N45.45406°, W92.45270°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-117
Habitat/Distribution: Thick muck bottom in shallow water 0-1.5 meters deep. Relatively common in Idlewild Bay; rare elsewhere with a few individuals found in Stump Bay.
Common Associates: (*Utricularia vulgaris*) Common bladderwort, (*Brasenia schreberi*) Watershield, (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Nuphar variegata*) Spatterdock

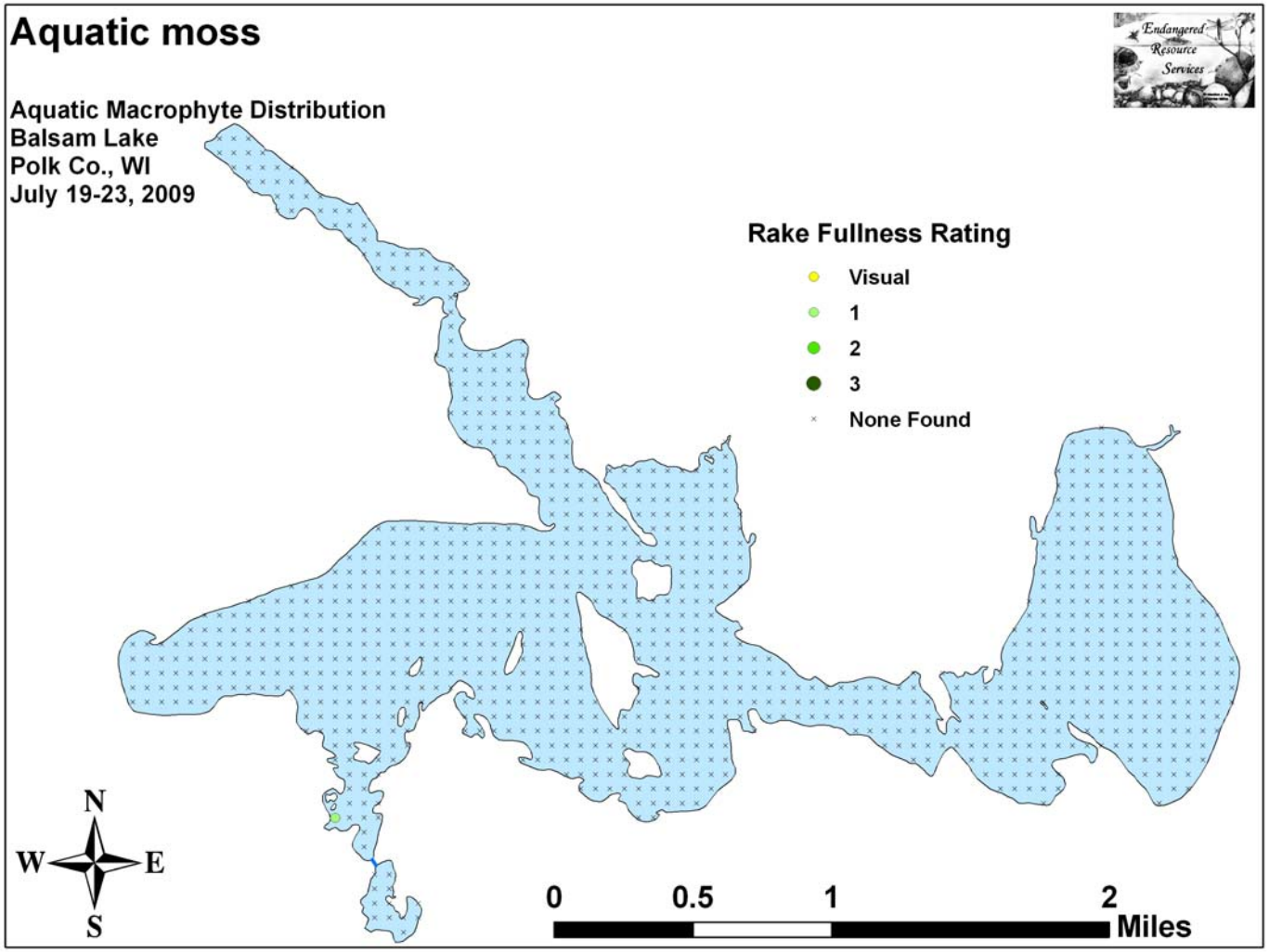
County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Vallisneria americana*) **Wild celery**
Specimen Location: Balsam Lake; N45.47047°, W92.42762°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-118
Habitat/Distribution: Found in almost any bottom conditions, but grows best in sandy to sand/muck bottoms in 0.5-2 meters of water. Common and widely distributed throughout; especially on the north shore of the west end of Balsam and on the east shore of East Balsam.
Common Associates: (*Potamogeton richardsonii*) Clasping-leaf pondweed, (*Chara* sp.) Muskgrass, (*Najas flexilis*) Bushy pondweed, (*Myriophyllum sibiricum*) Northern water milfoil

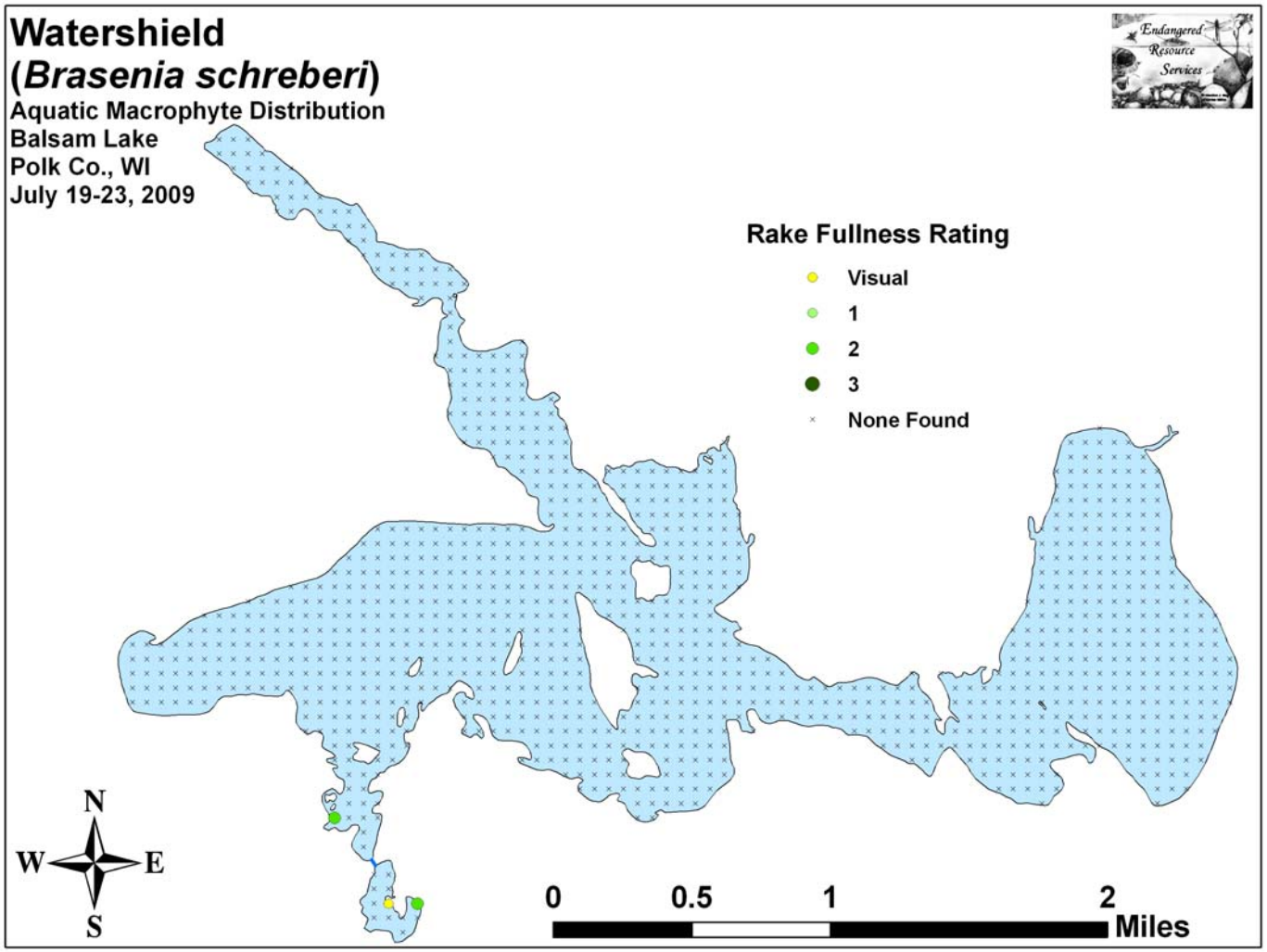
County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Wolffia columbiana*) **Common watermeal**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-119
Habitat/Distribution: Located floating at or just under the surface in sheltered bays. Especially common in Raskin Bay and among the cattails and wild rice areas of Stump Bay.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata)* Spatterdock, (*Spirodela polyrhiza*) Large duckweed, (*Lemna minor*) Small duckweed, (*Lemna trisulca*) Forked duckweed

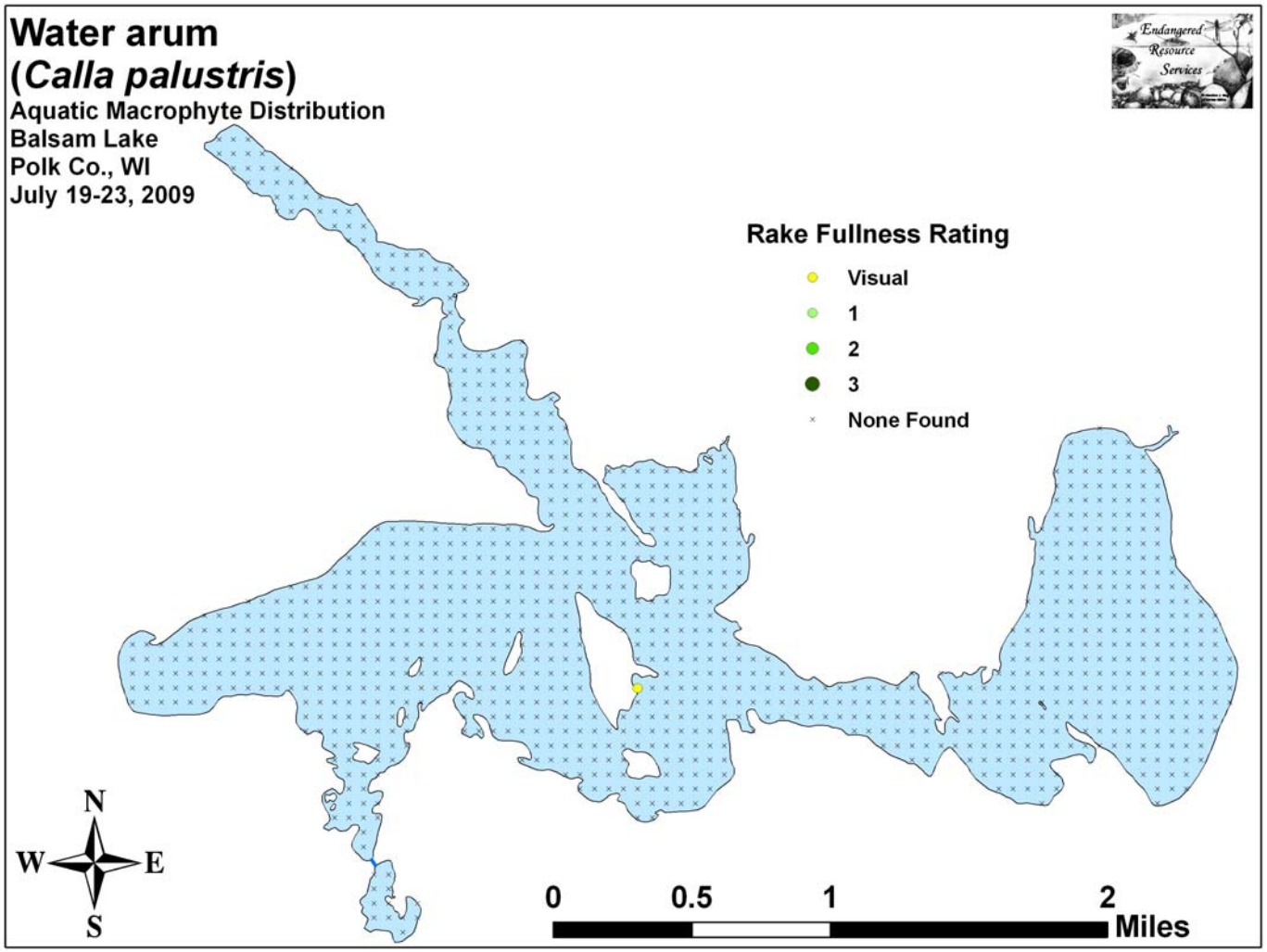
County/State: Polk County, Wisconsin **Date:** 7/21/09
Species: (*Zizania palustris*) **Northern wild rice**
Specimen Location: Balsam Lake; N45.48938°, W92.46284°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-120
Habitat/Distribution: Found in muck bottom areas that have water flow. The rice beds were located at the entrance of Rice Creek and where the unnamed stream flows into Stump Bay.
Common Associates: (*Typha latifolia*) Broad-leaved cattail

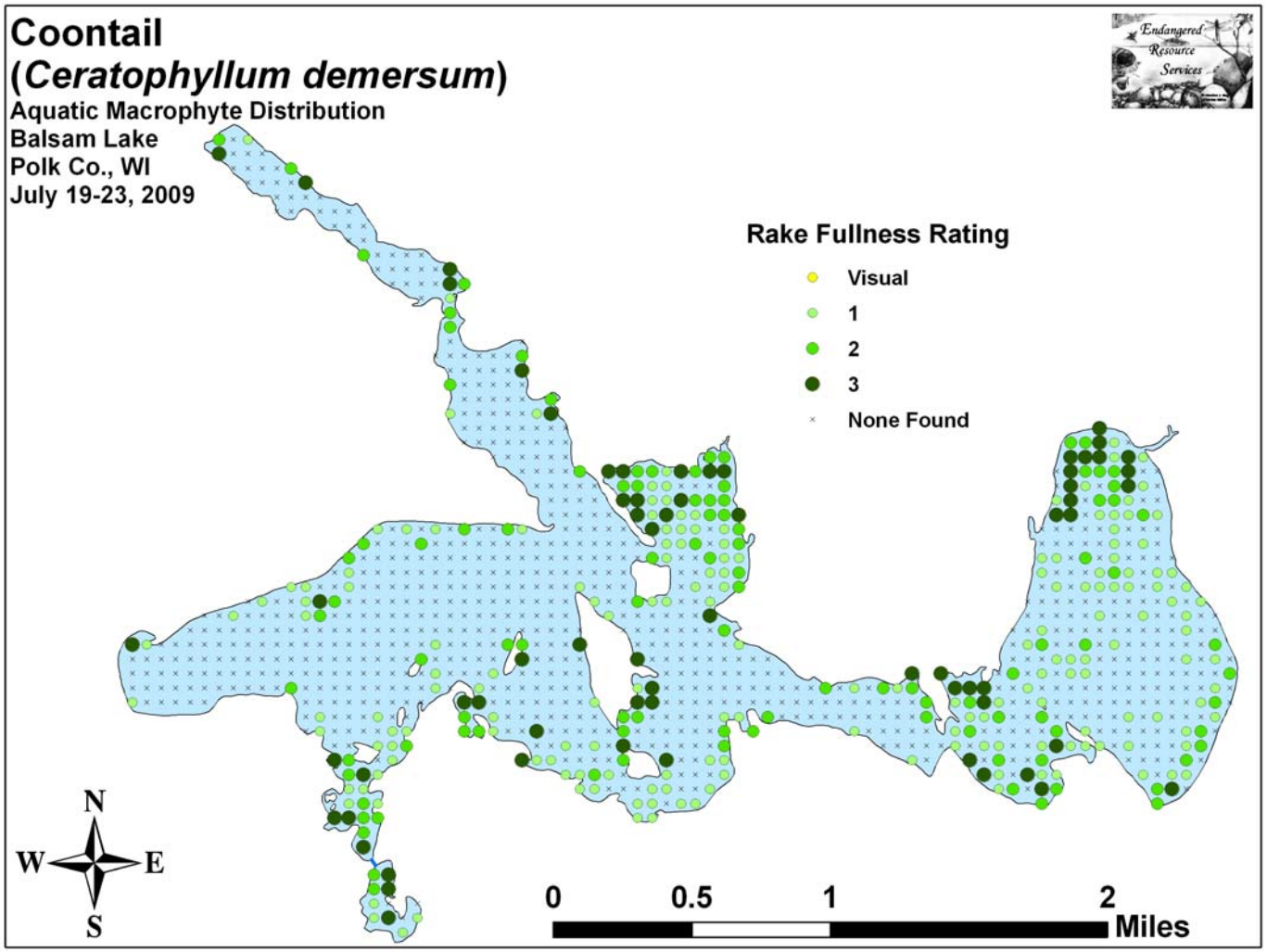
County/State: Polk County, Wisconsin **Date:** 7/20/09
Species: (*Potamogeton amplifolius* X *illinoensis*)
Large-leaf X Illinois pondweed Hybrid?
Specimen Location: Balsam Lake; N45.46173°, W92.44766°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-121
Habitat/Distribution: Located on the south end of Cedar Island, a dense bed of plants that had the crescent moon shaped leaves of Large-leaf, the awl tip and stipule length more characteristic of Illinois and a leaf vein count (22) intermittent between the highest number for Illinois (19) and the lowest number for Large-leaf (25) given by Voss. If I had to choose between the two species, I would call it *Illinoensis*.

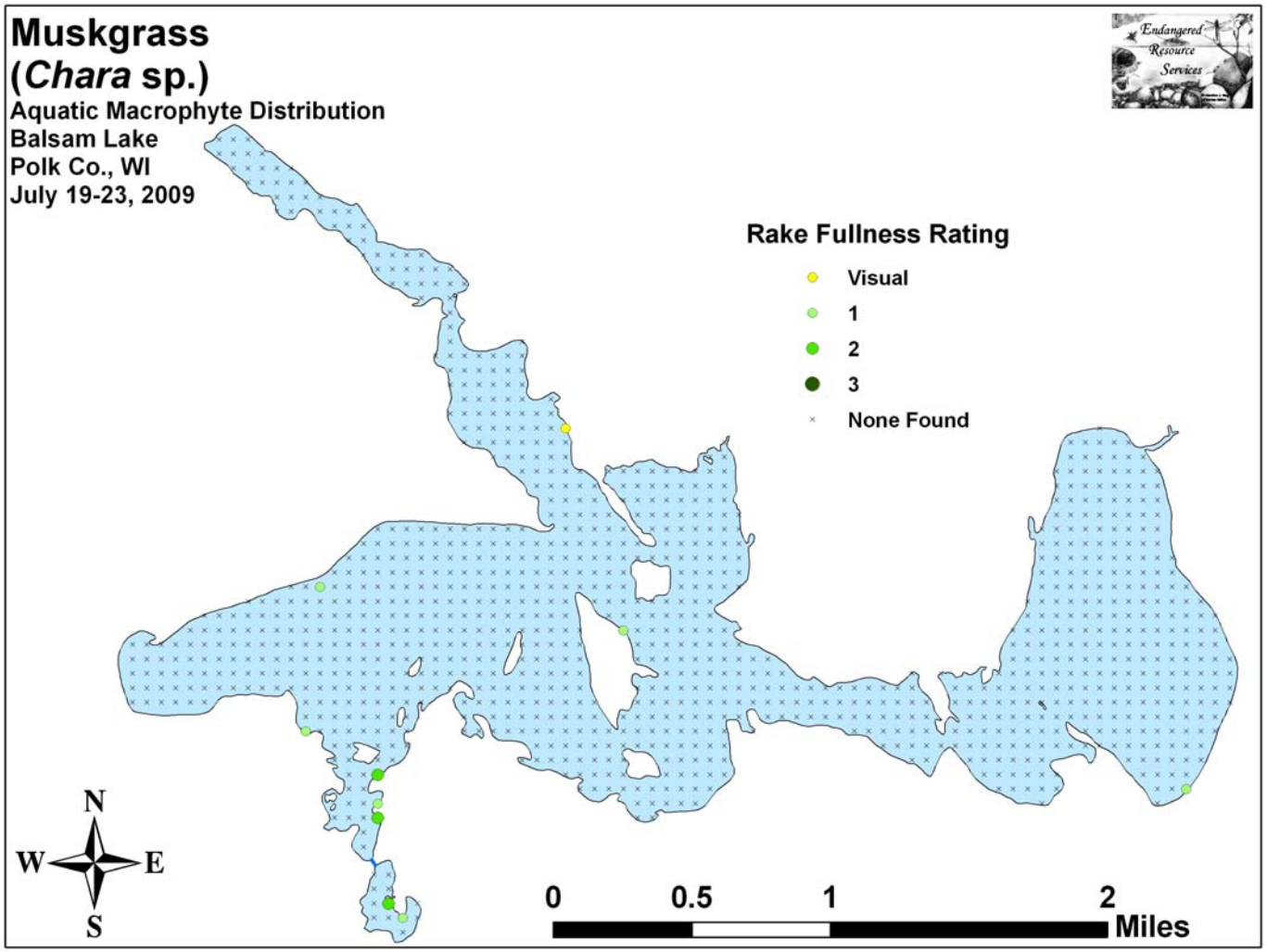
Appendix VII: Point Intercept Plant Species Distribution Maps

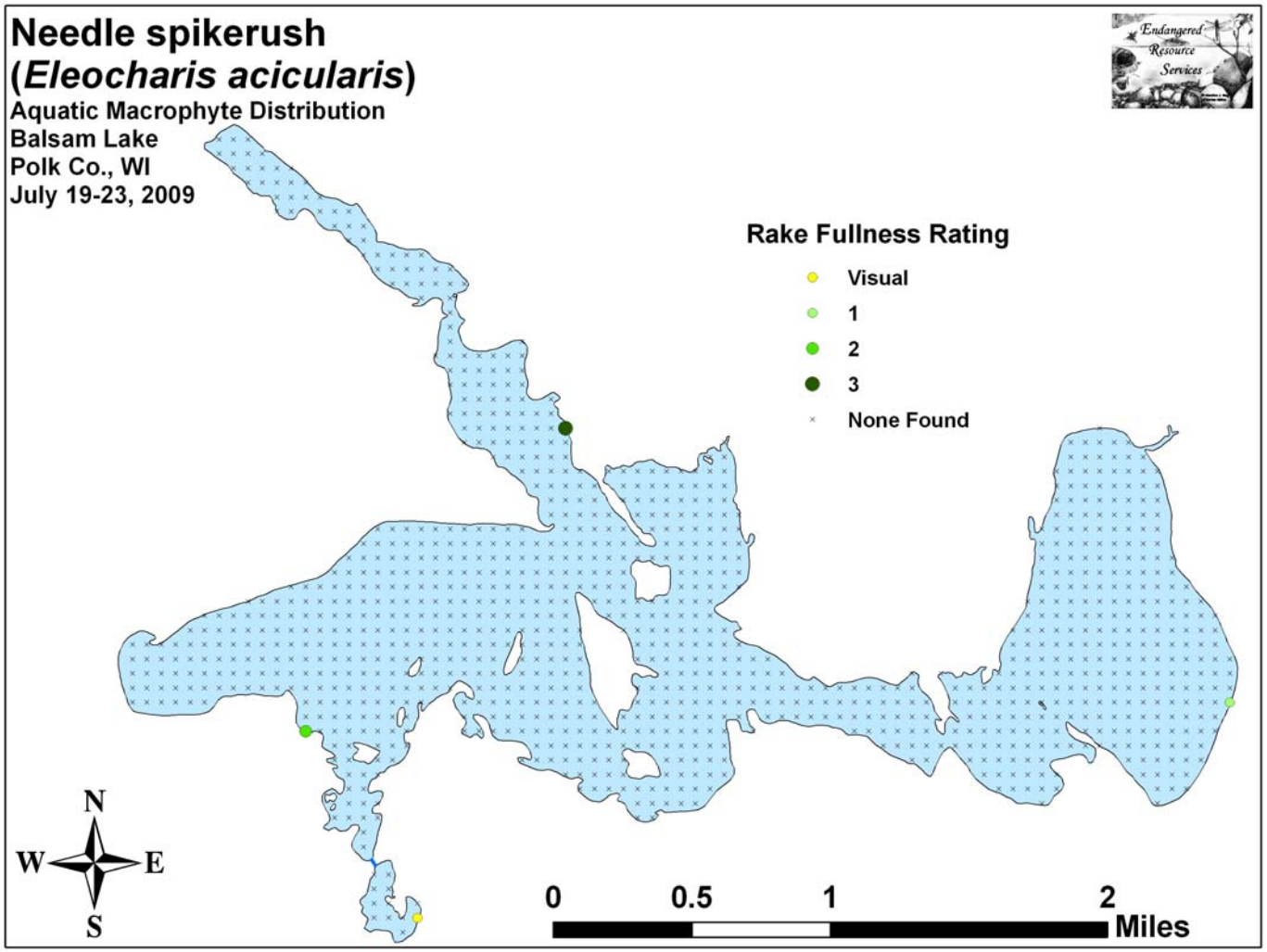

Aquatic moss
Endangered Resource Services
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

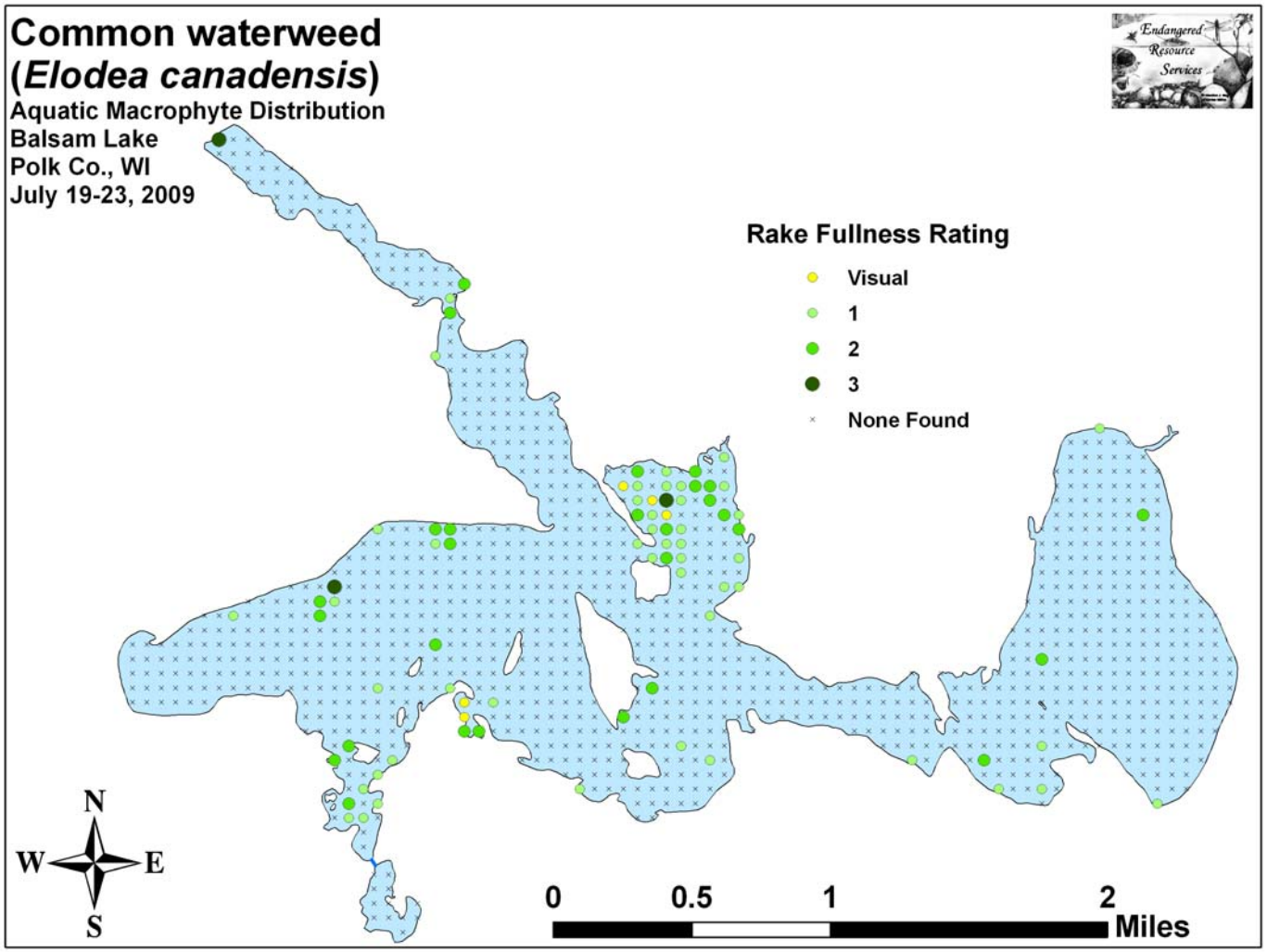

Watershield
(Brasenia schreberi)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

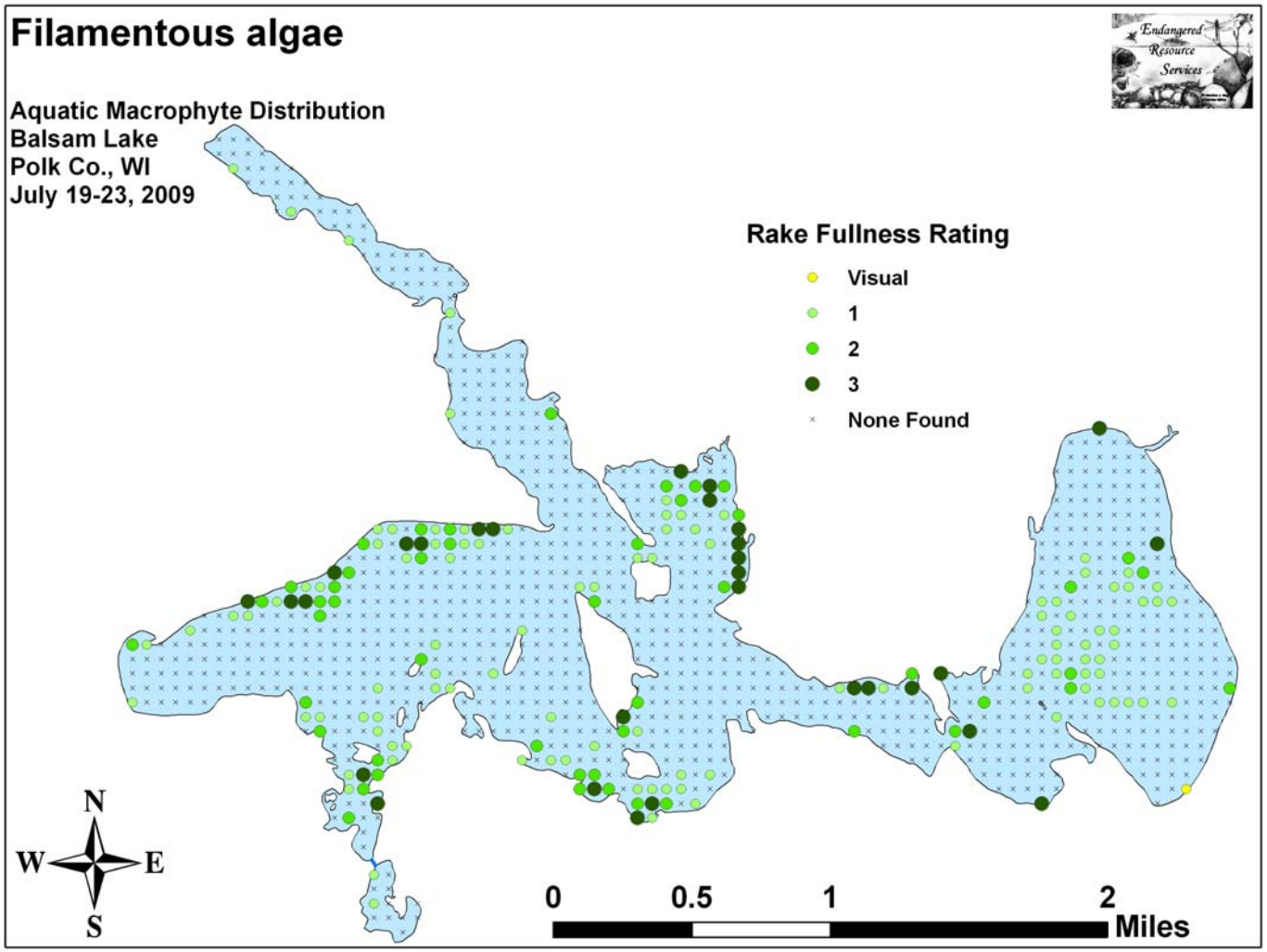

Water arum
(Calla palustris)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

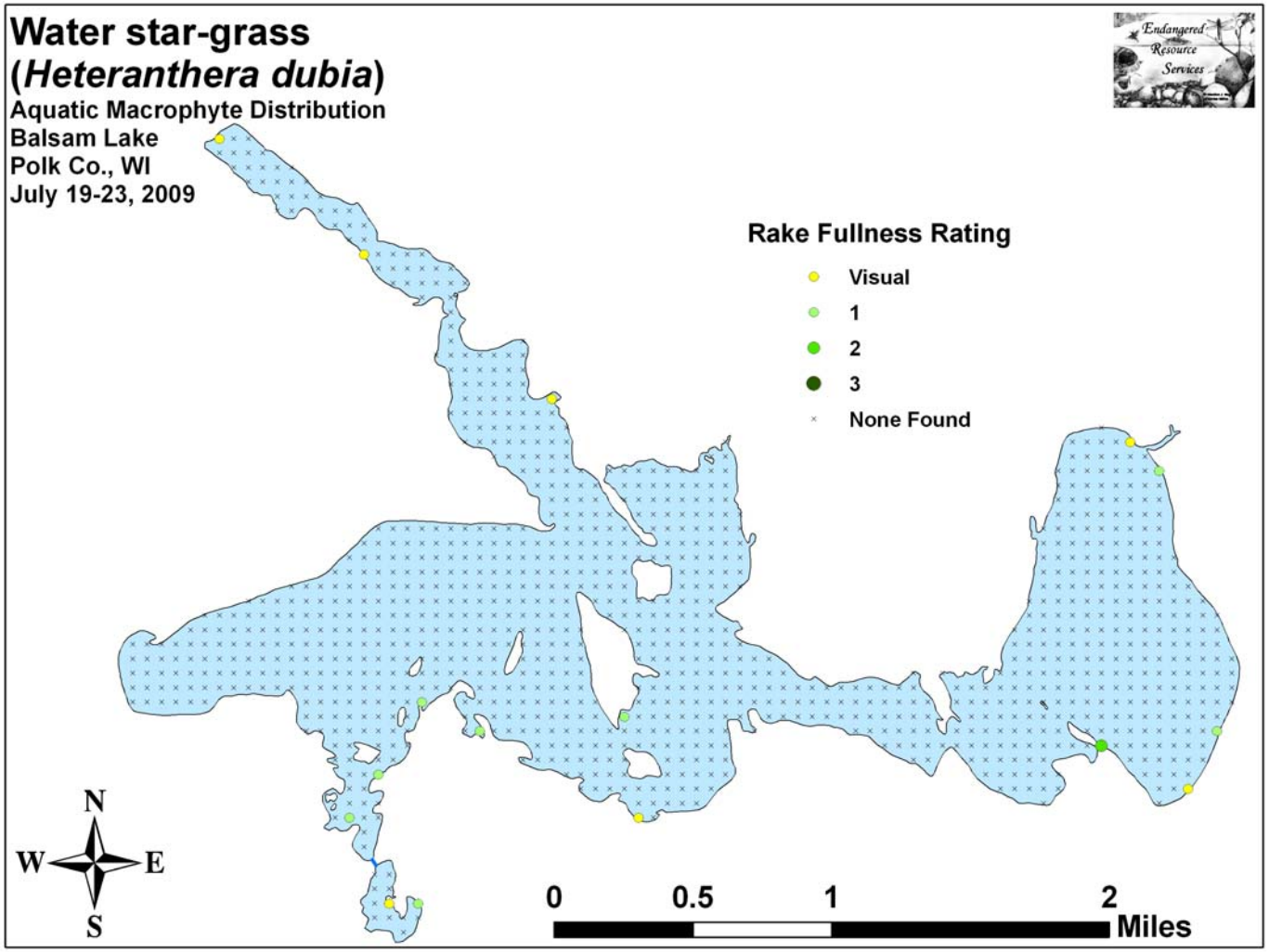

Coontail
(Ceratophyllum demersum)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

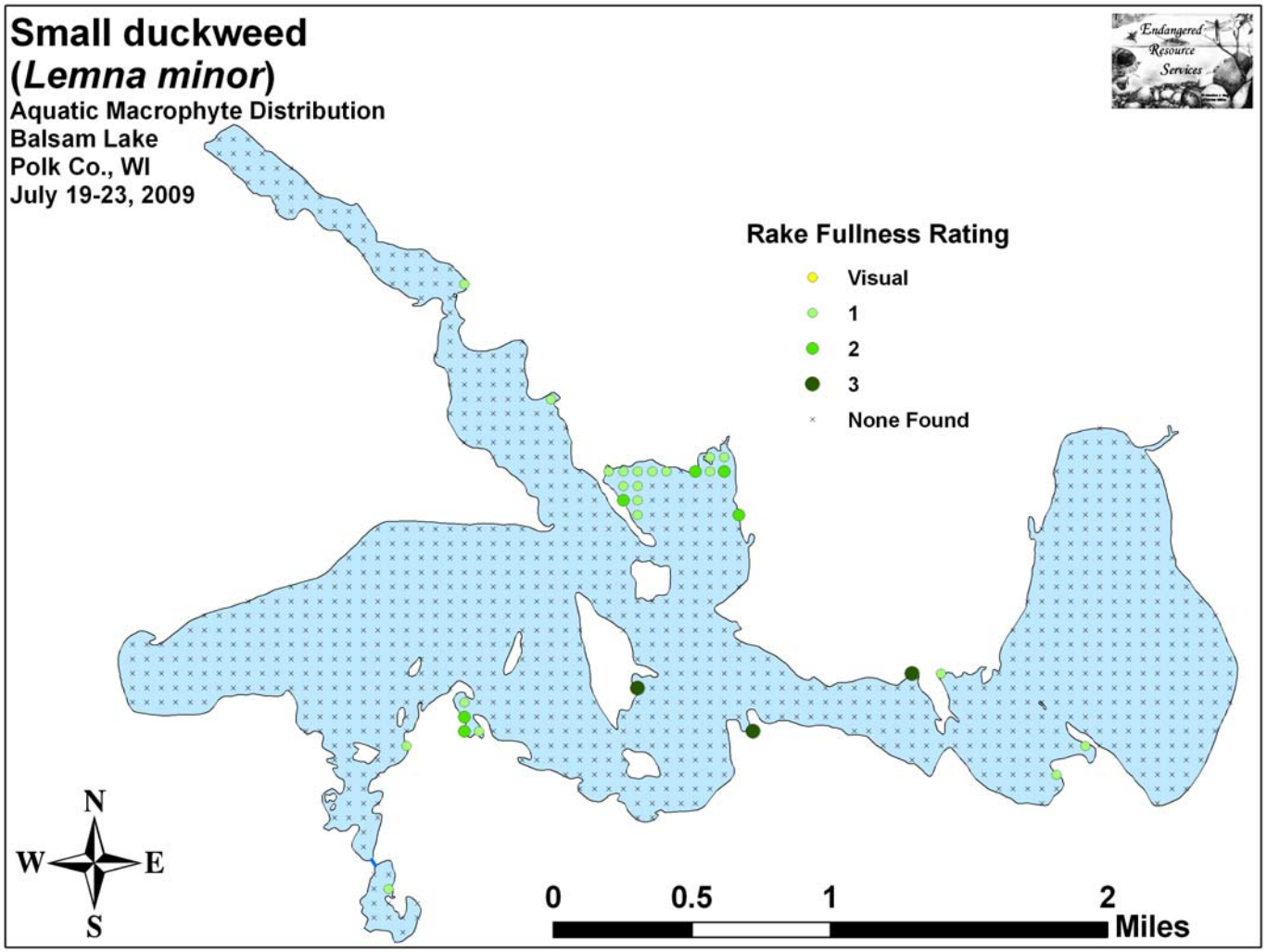

Muskgrass
(Chara sp.)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Needle spikerush
(Eleocharis acicularis)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Common waterweed
(Elodea canadensis)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Filamentous algae
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Water star-grass
(Heteranthera dubia)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Small duckweed
(Lemna minor)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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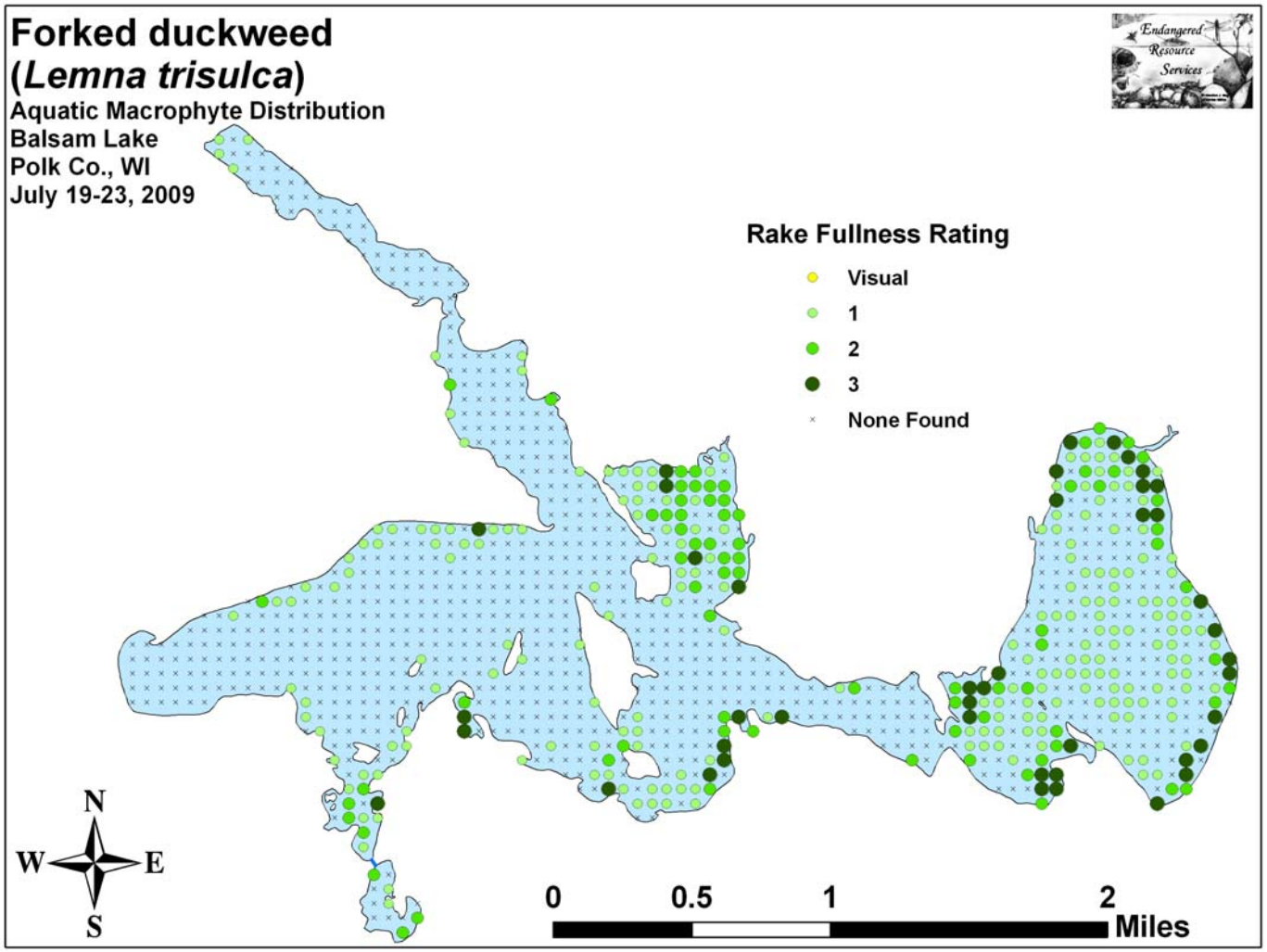
Forked duckweed
(Lemna trisulca)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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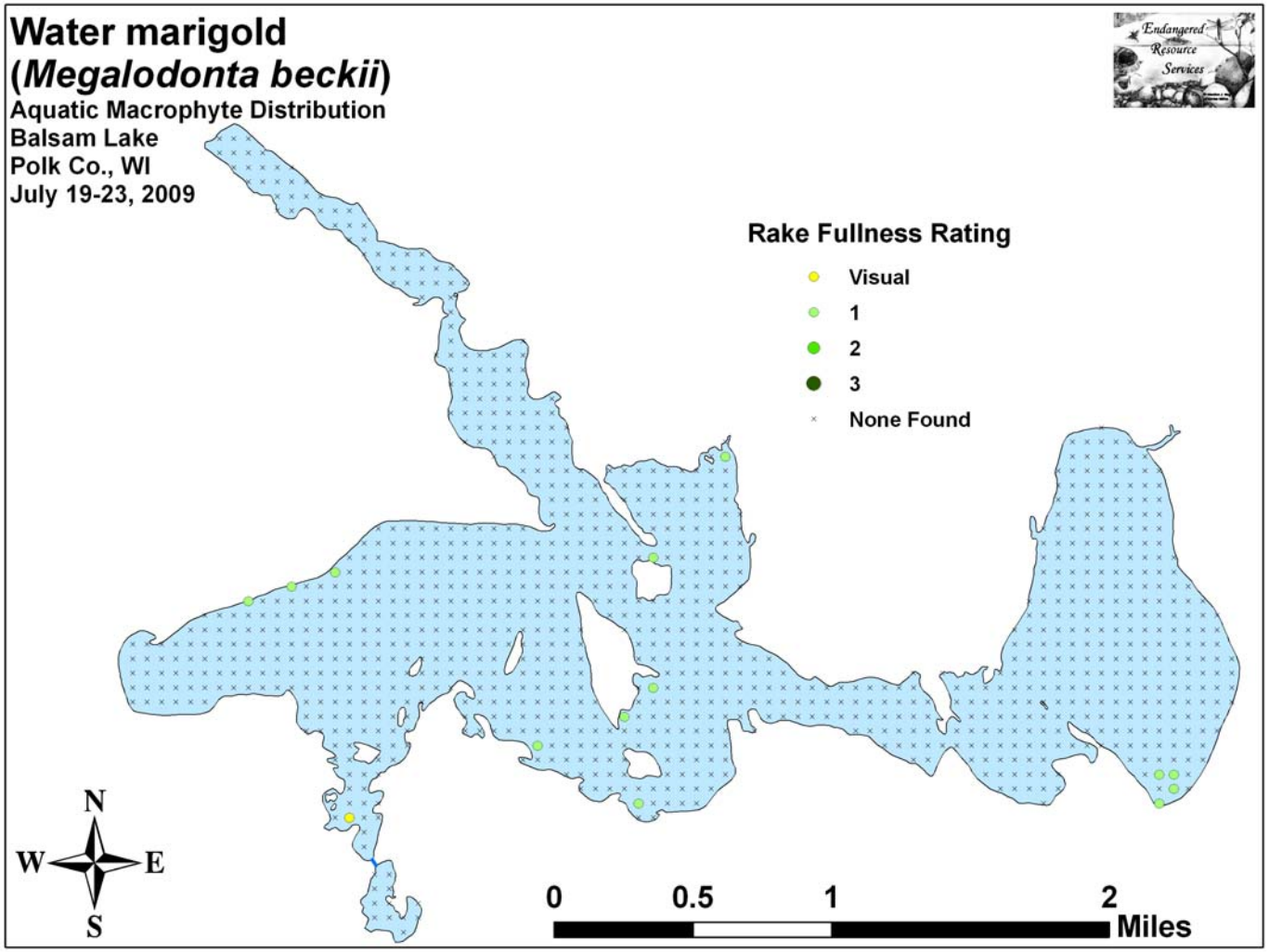
Water marigold
(Megalodonta beckii)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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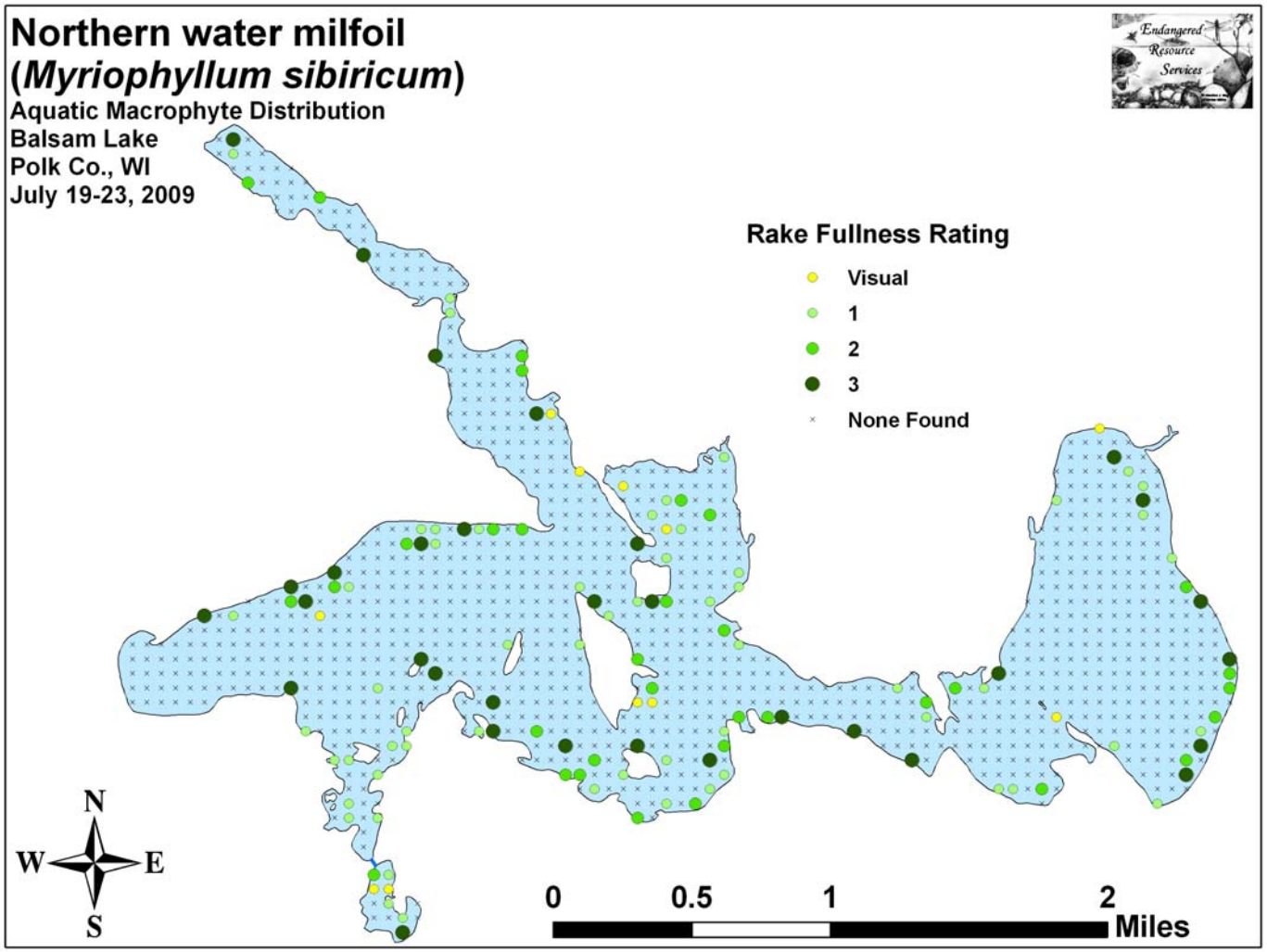
Northern water milfoil
(Myriophyllum sibiricum)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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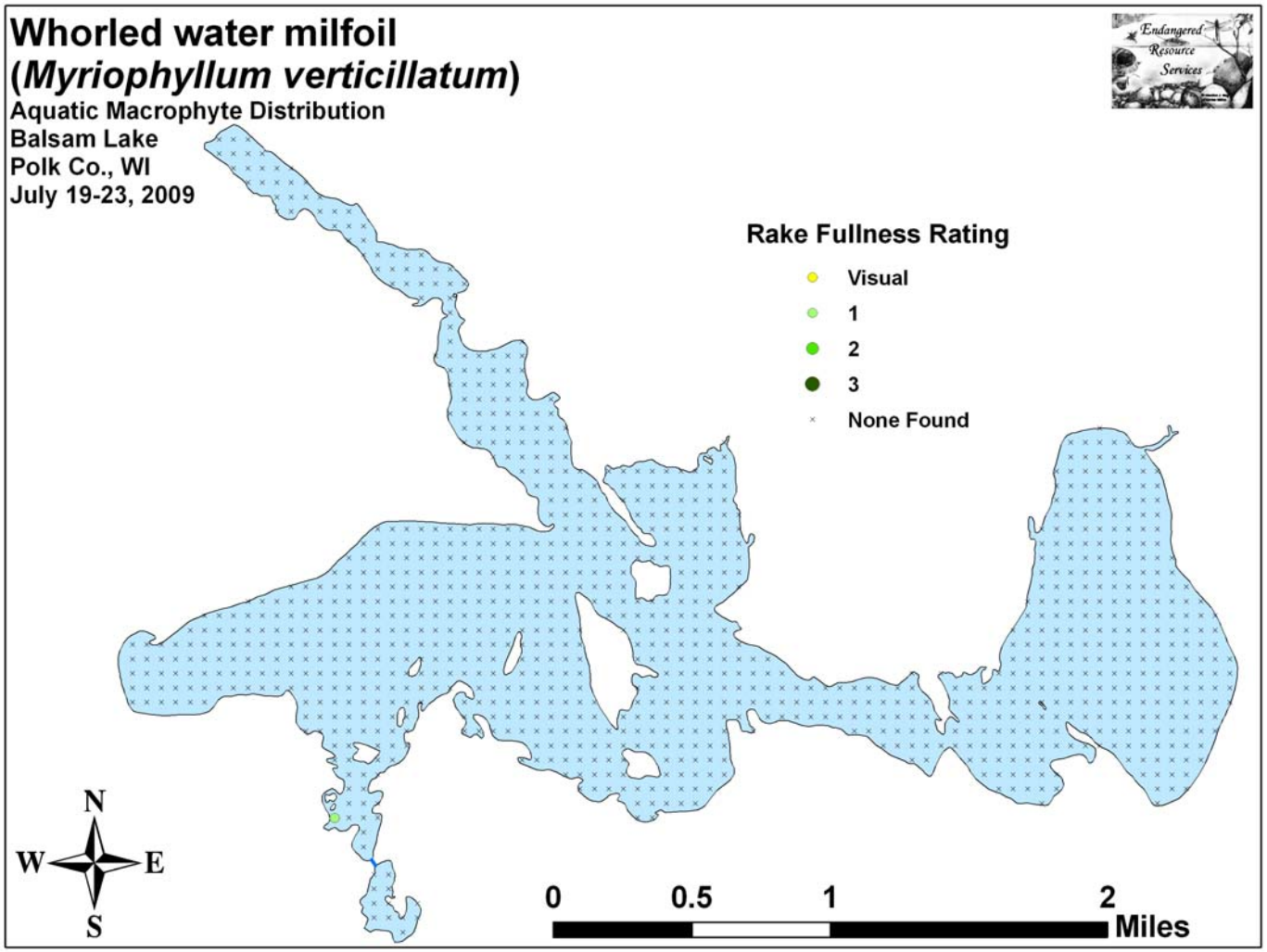
Whorled water milfoil
(Myriophyllum verticillatum)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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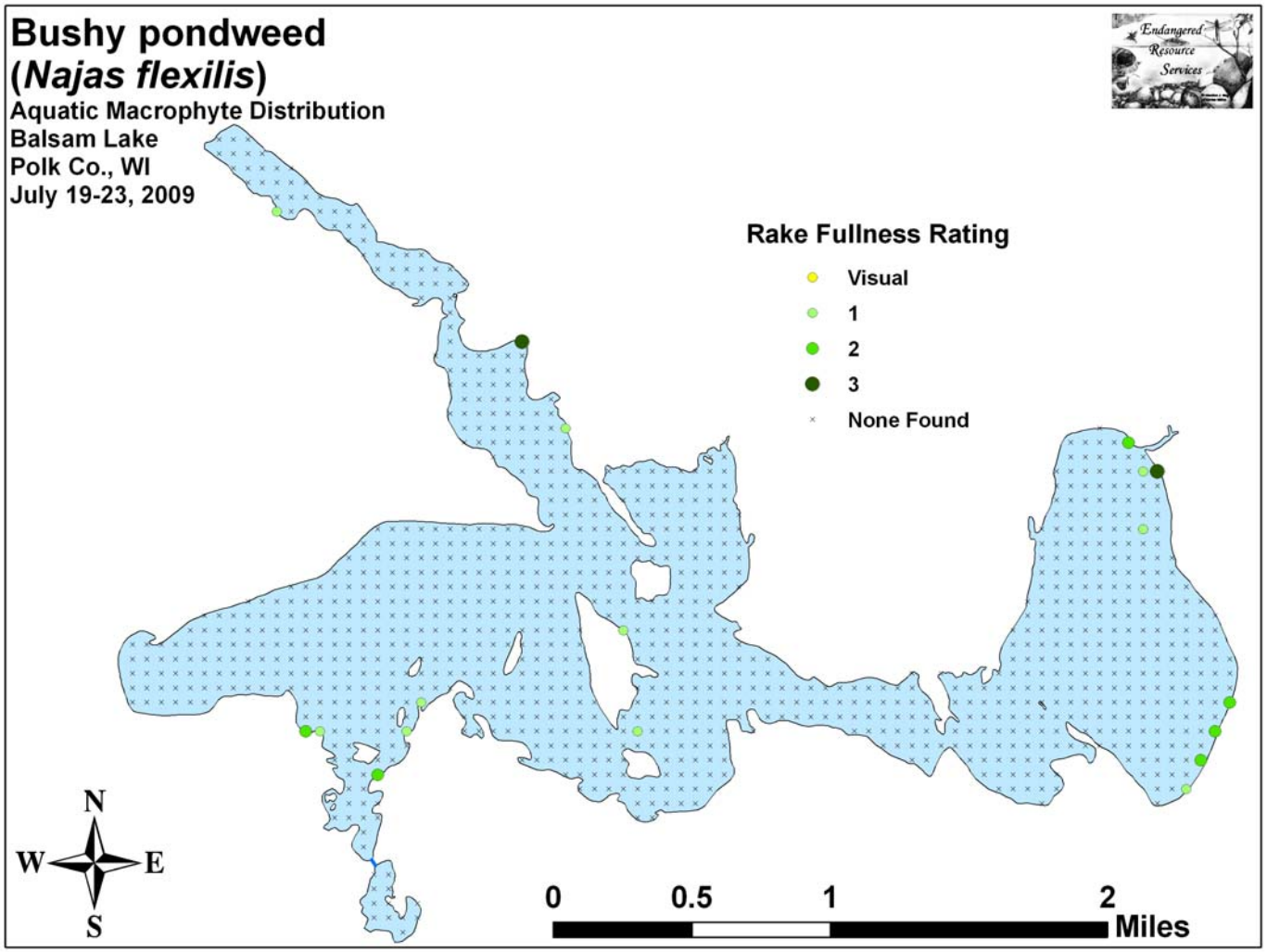
Bushy pondweed
(Najas flexilis)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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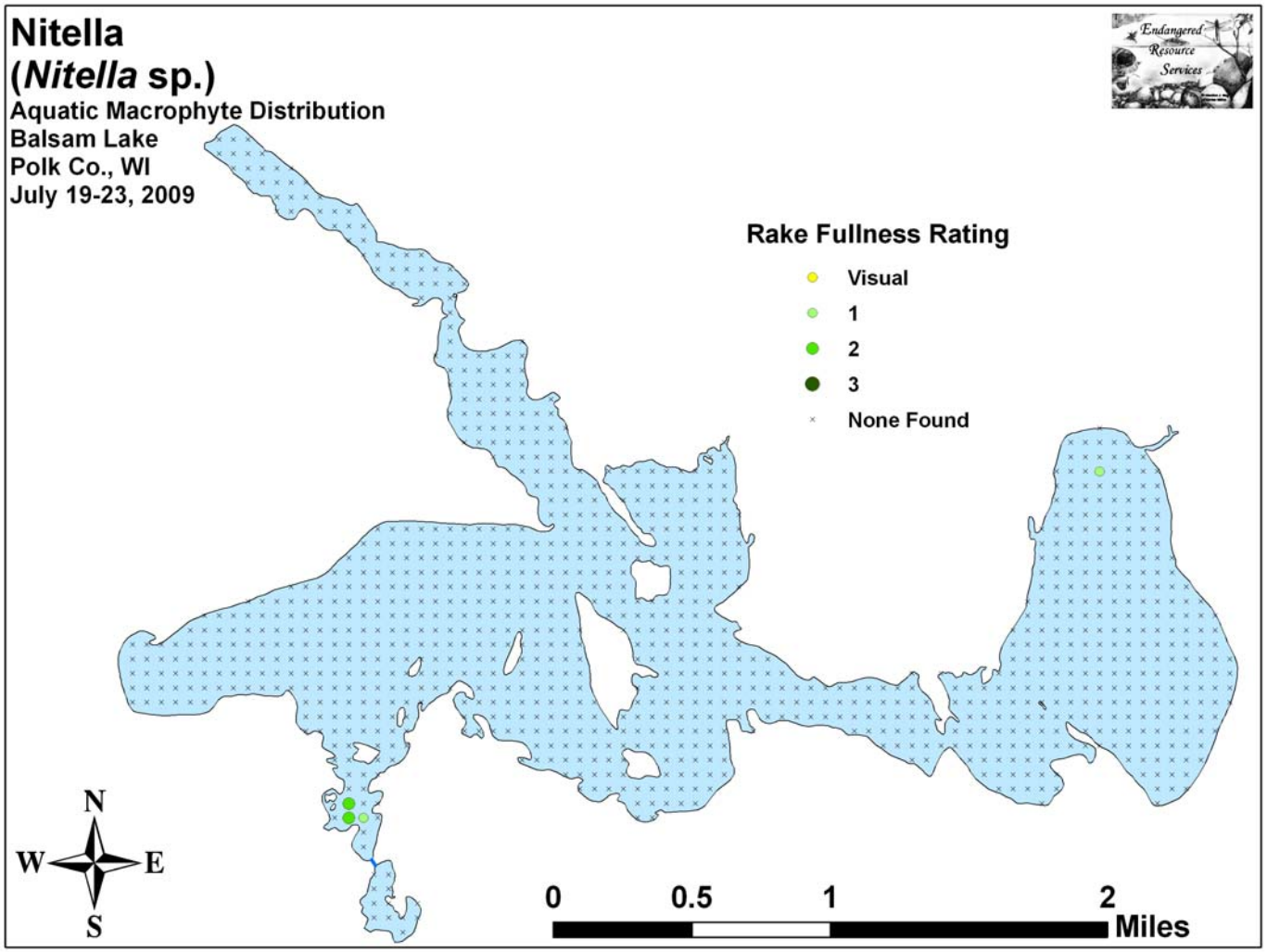
Nitella
(*Nitella* sp.)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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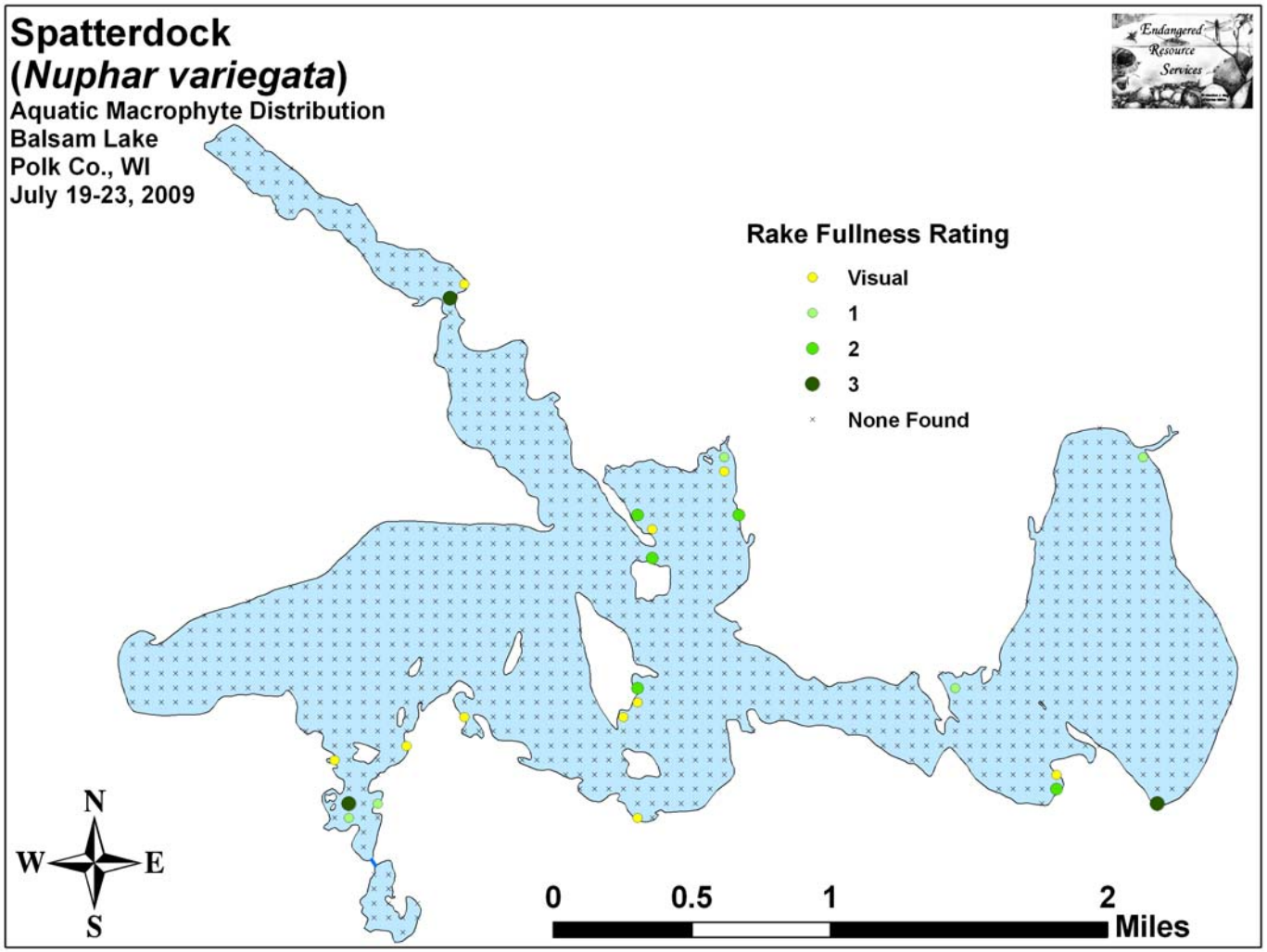
Spatterdock
(Nuphar variegata)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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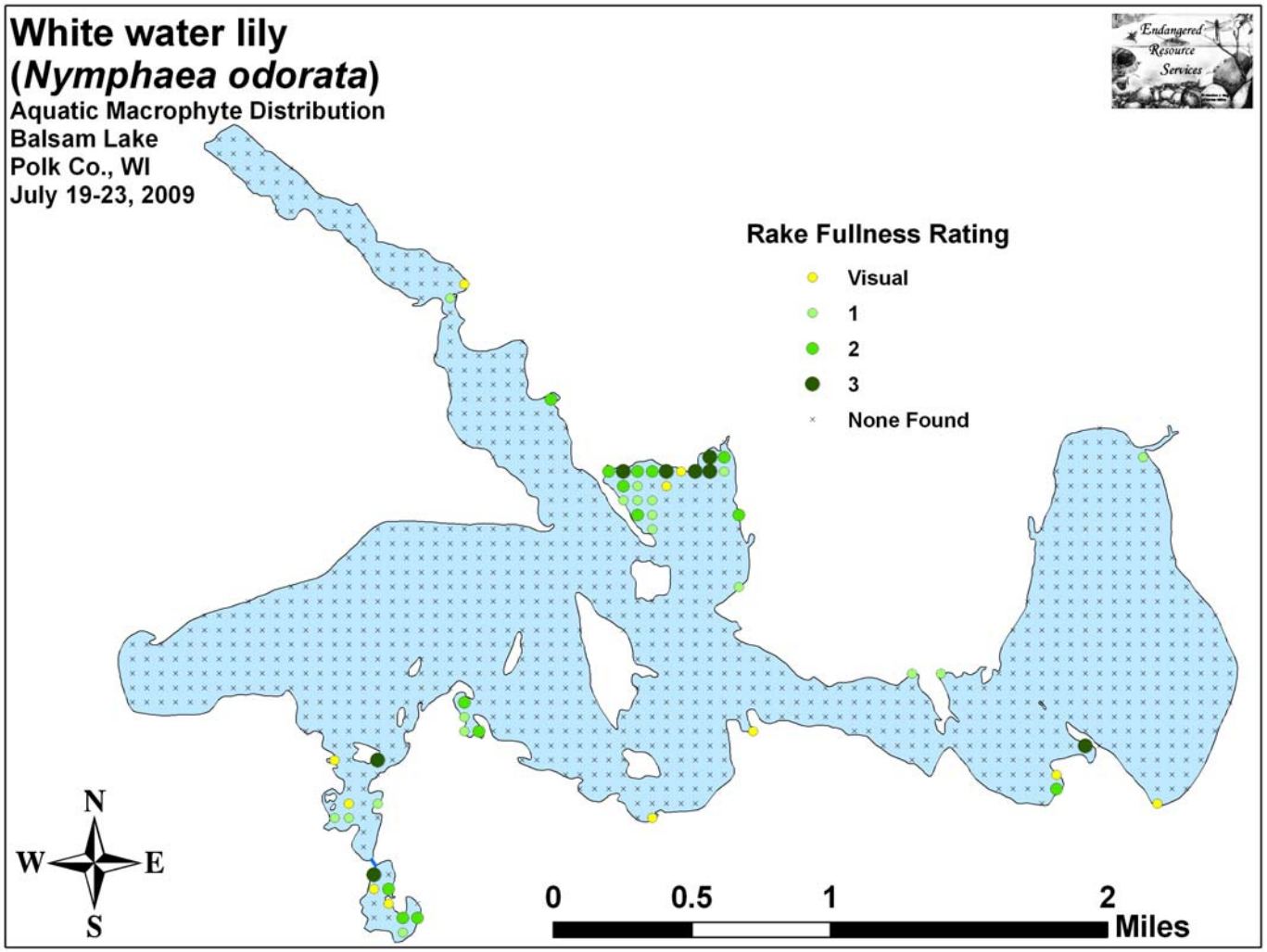
White water lily
(Nymphaea odorata)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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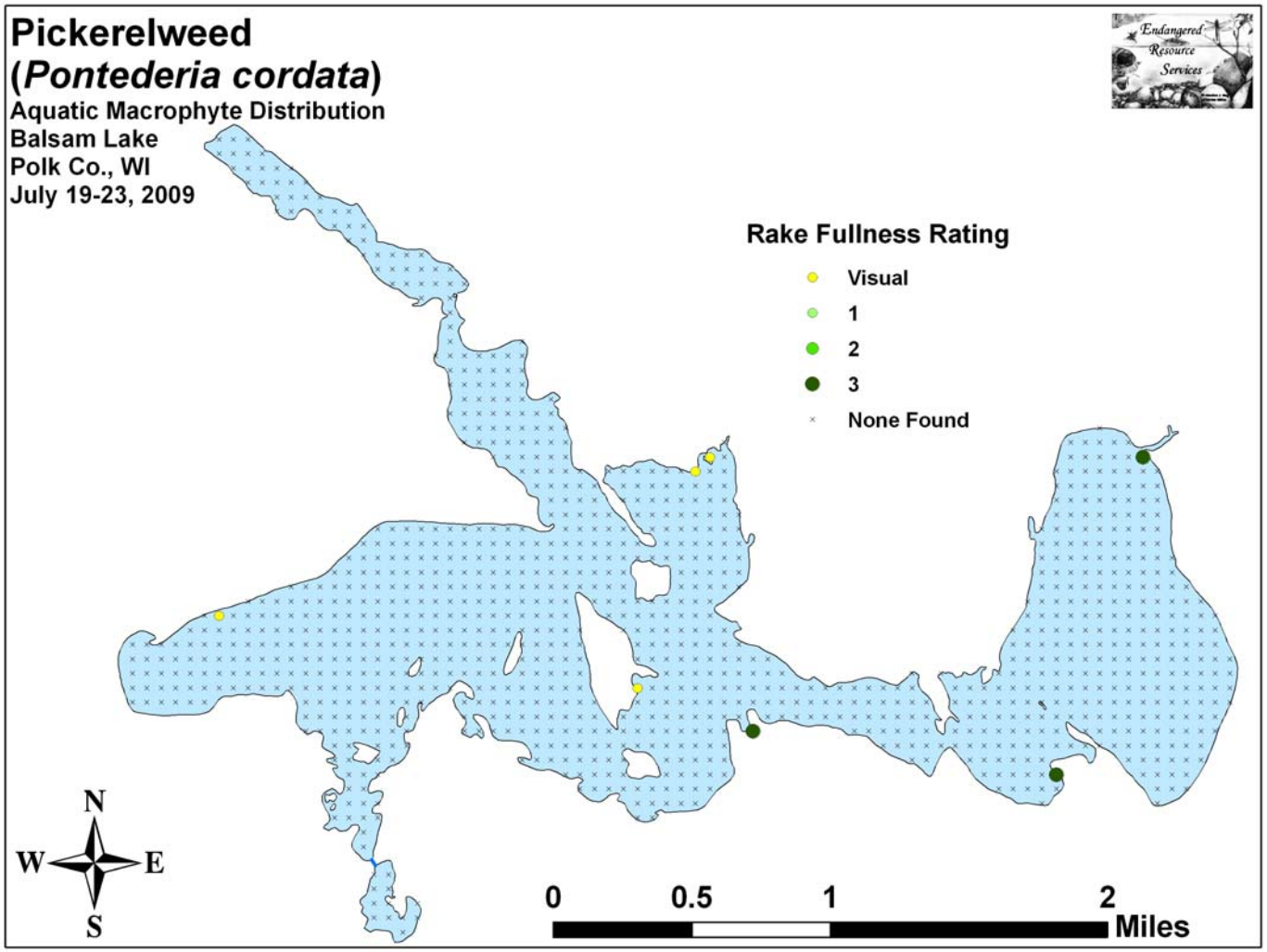
Pickerelweed
(Pontederia cordata)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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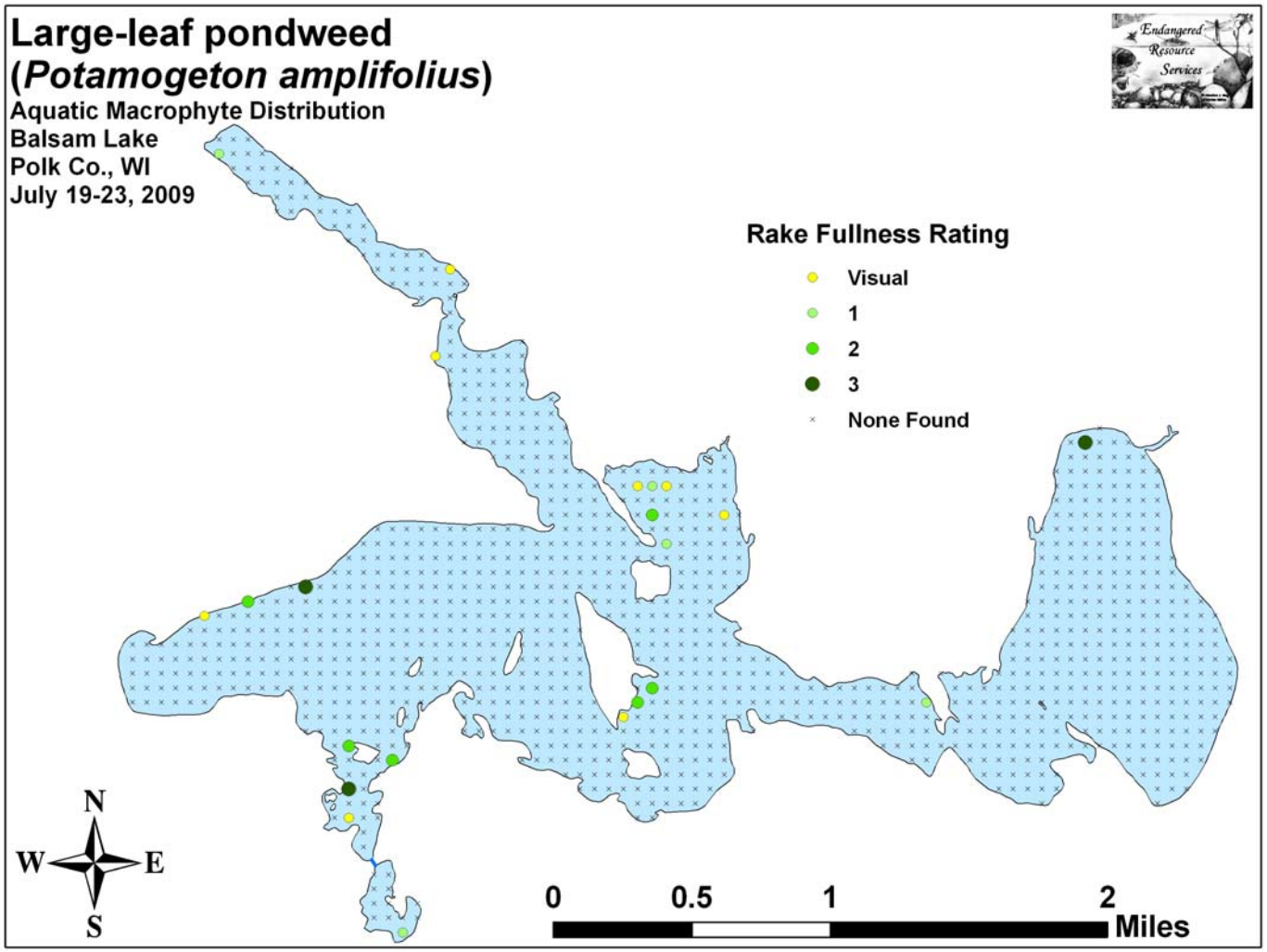
Large-leaf pondweed
(Potamogeton amplifolius)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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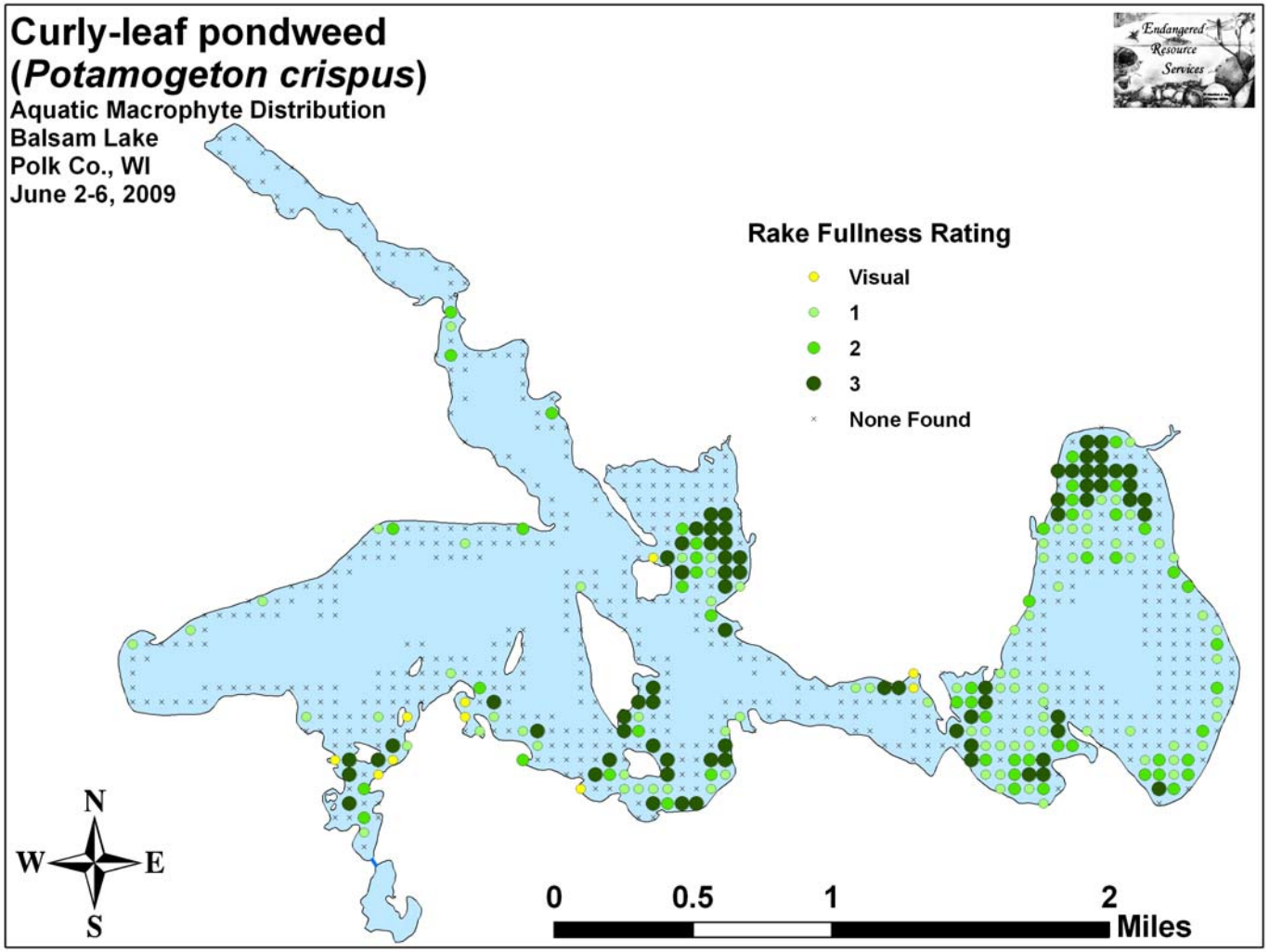
Curly-leaf pondweed
(Potamogeton crispus)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
June 2-6, 2009
Endangered Resource Services
Rake Fullness Rating
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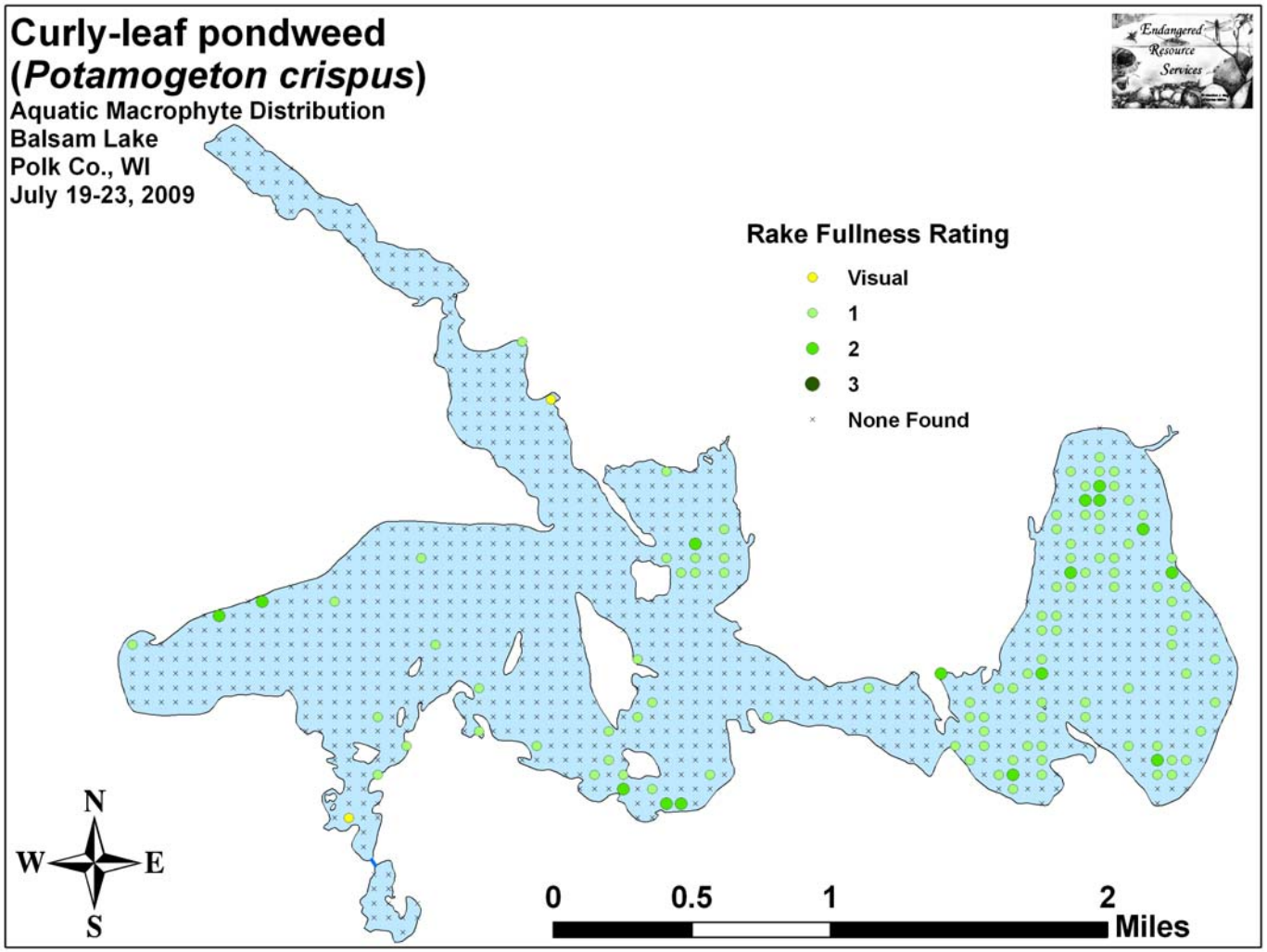
Curly-leaf pondweed
(Potamogeton crispus)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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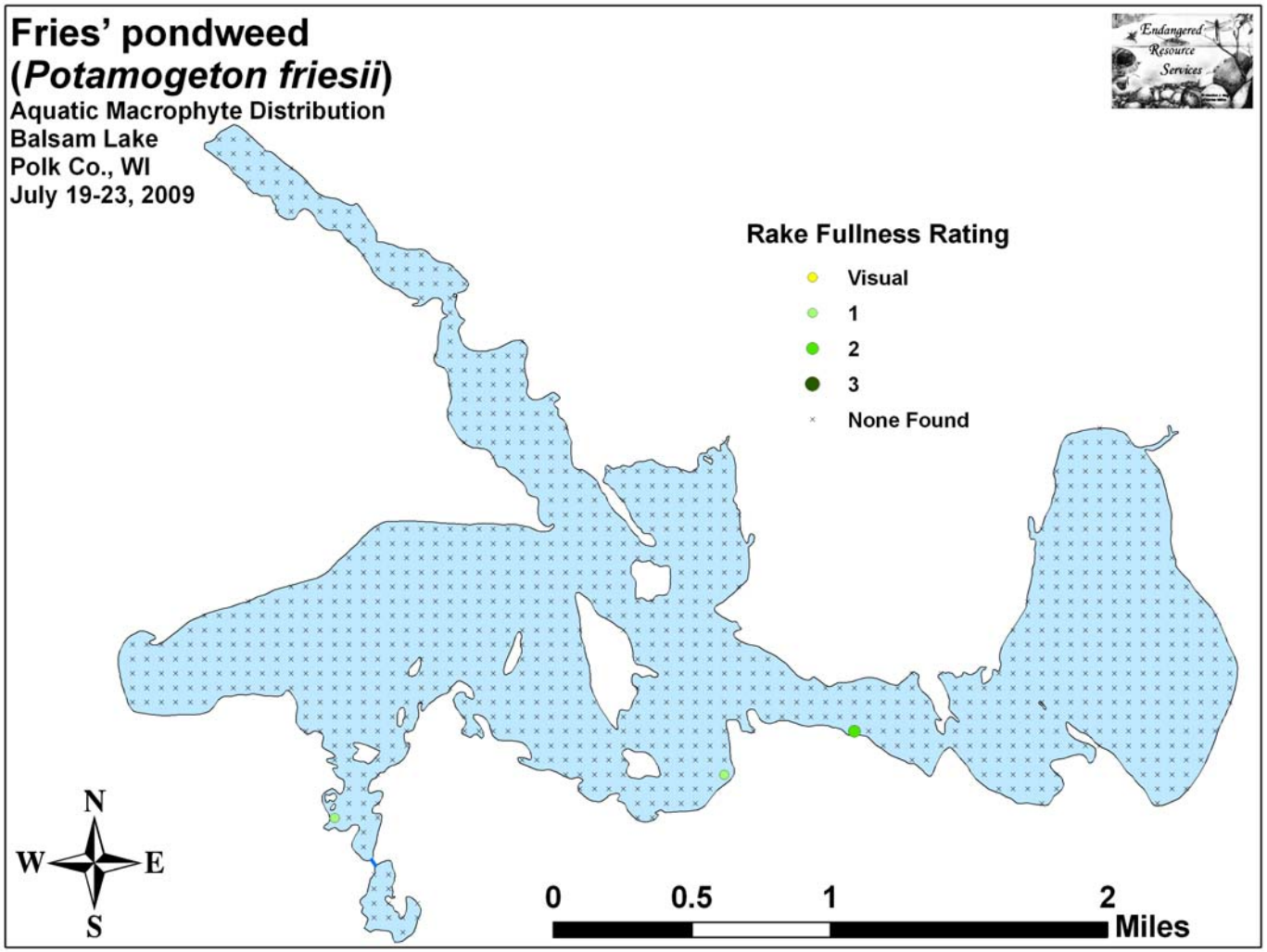
Fries' pondweed
(Potamogeton friesii)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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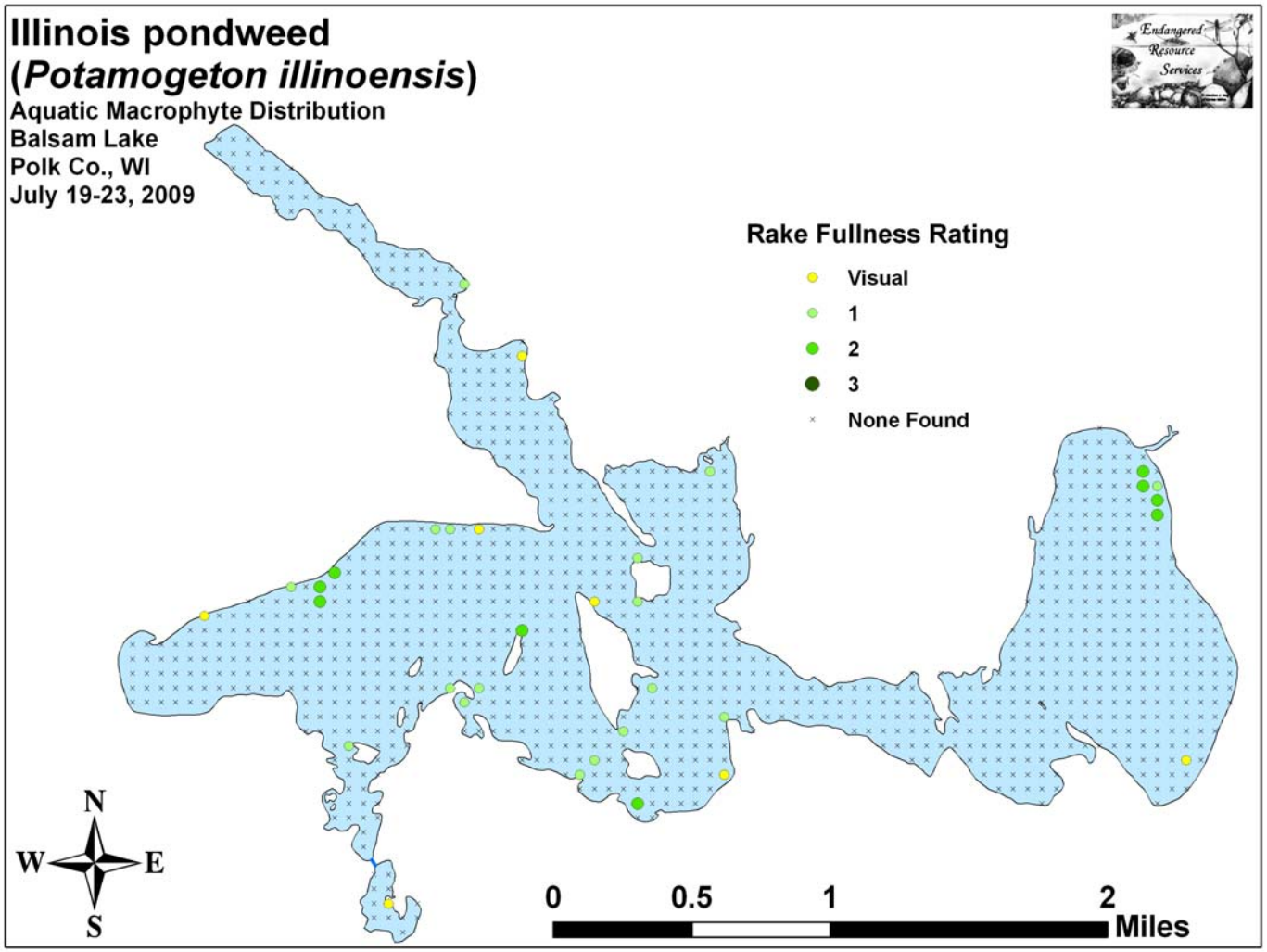
Illinois pondweed
(Potamogeton illinoensis)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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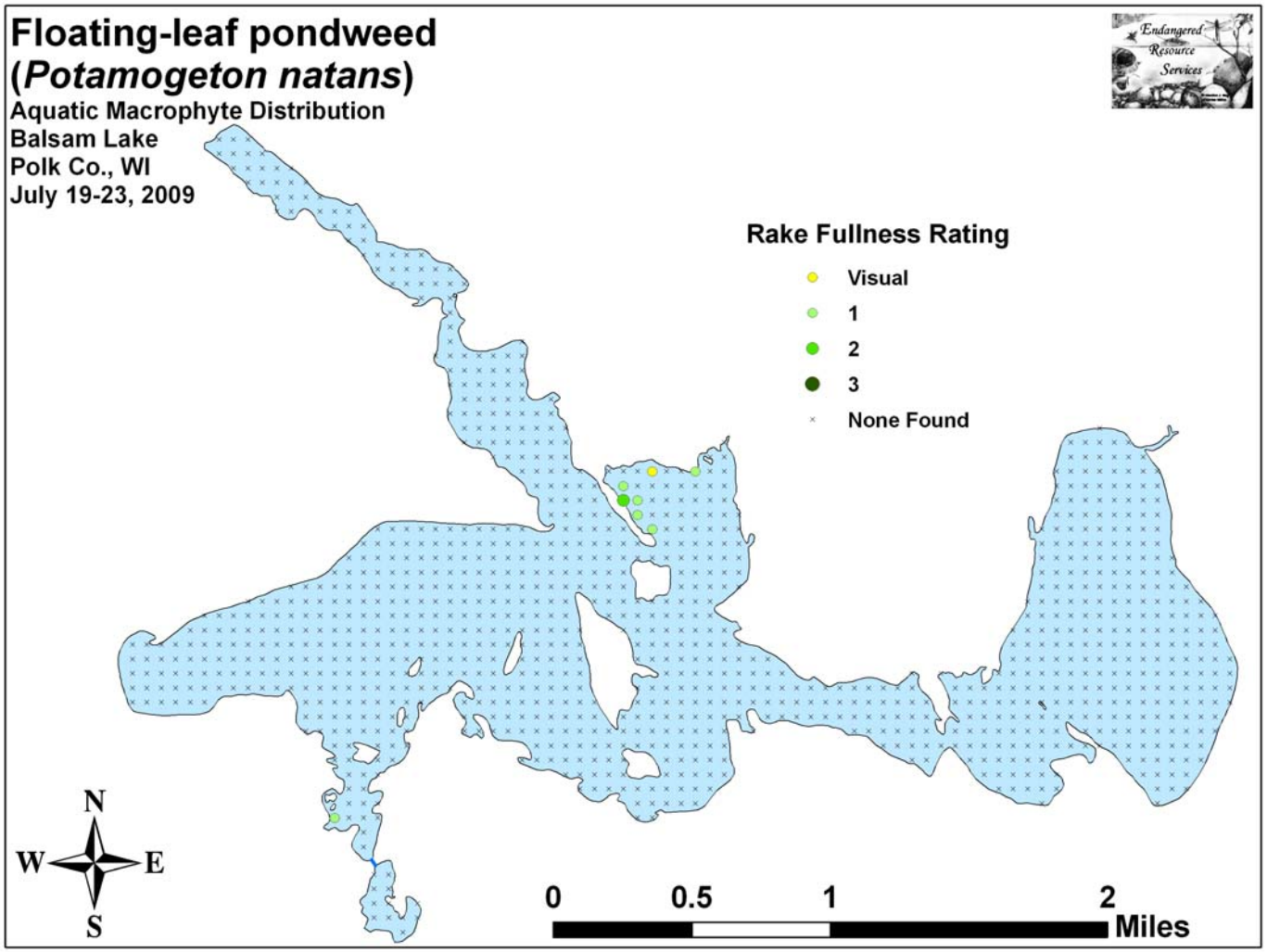
Floating-leaf pondweed
(Potamogeton natans)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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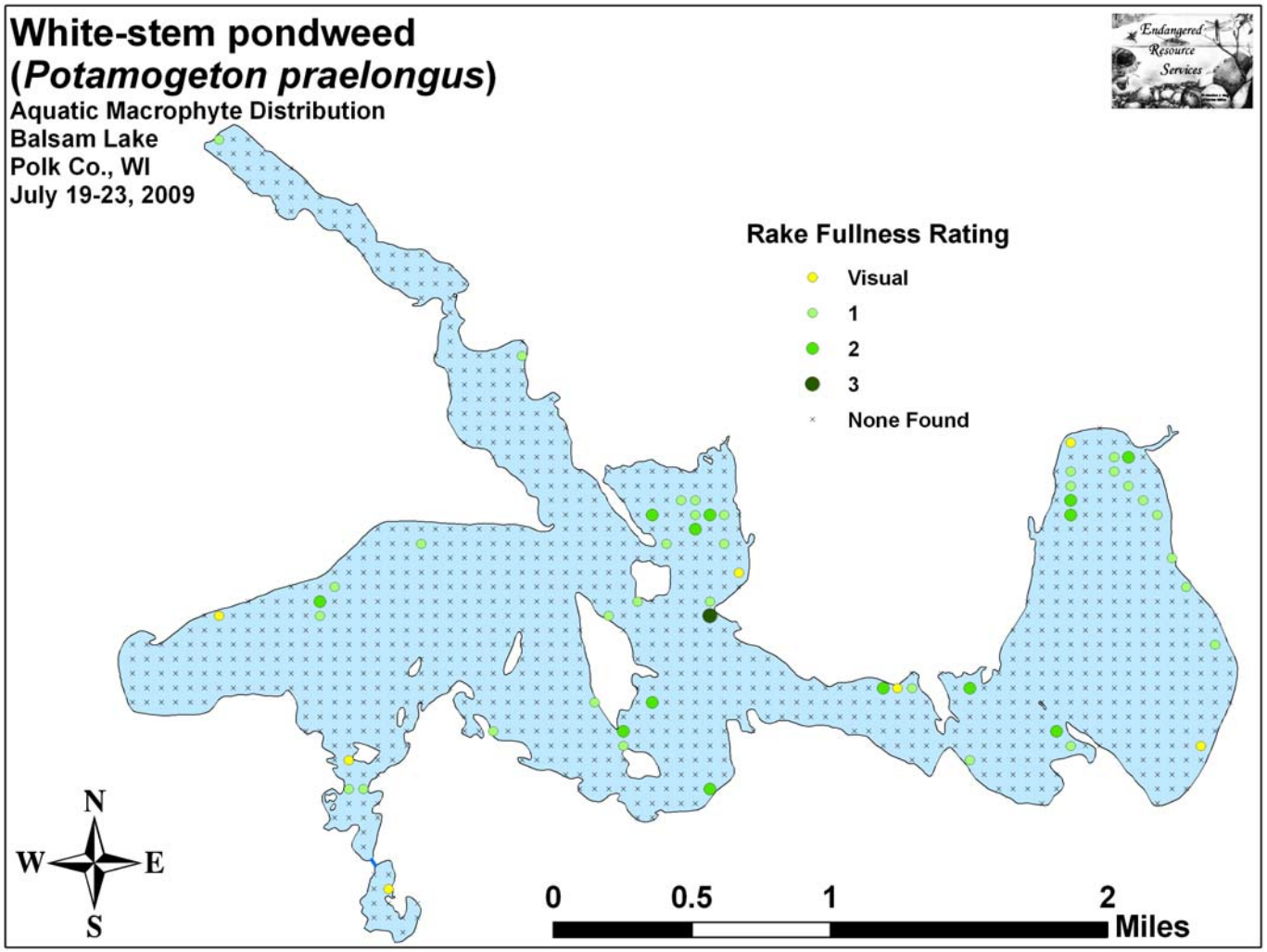
White-stem pondweed
(Potamogeton praelongus)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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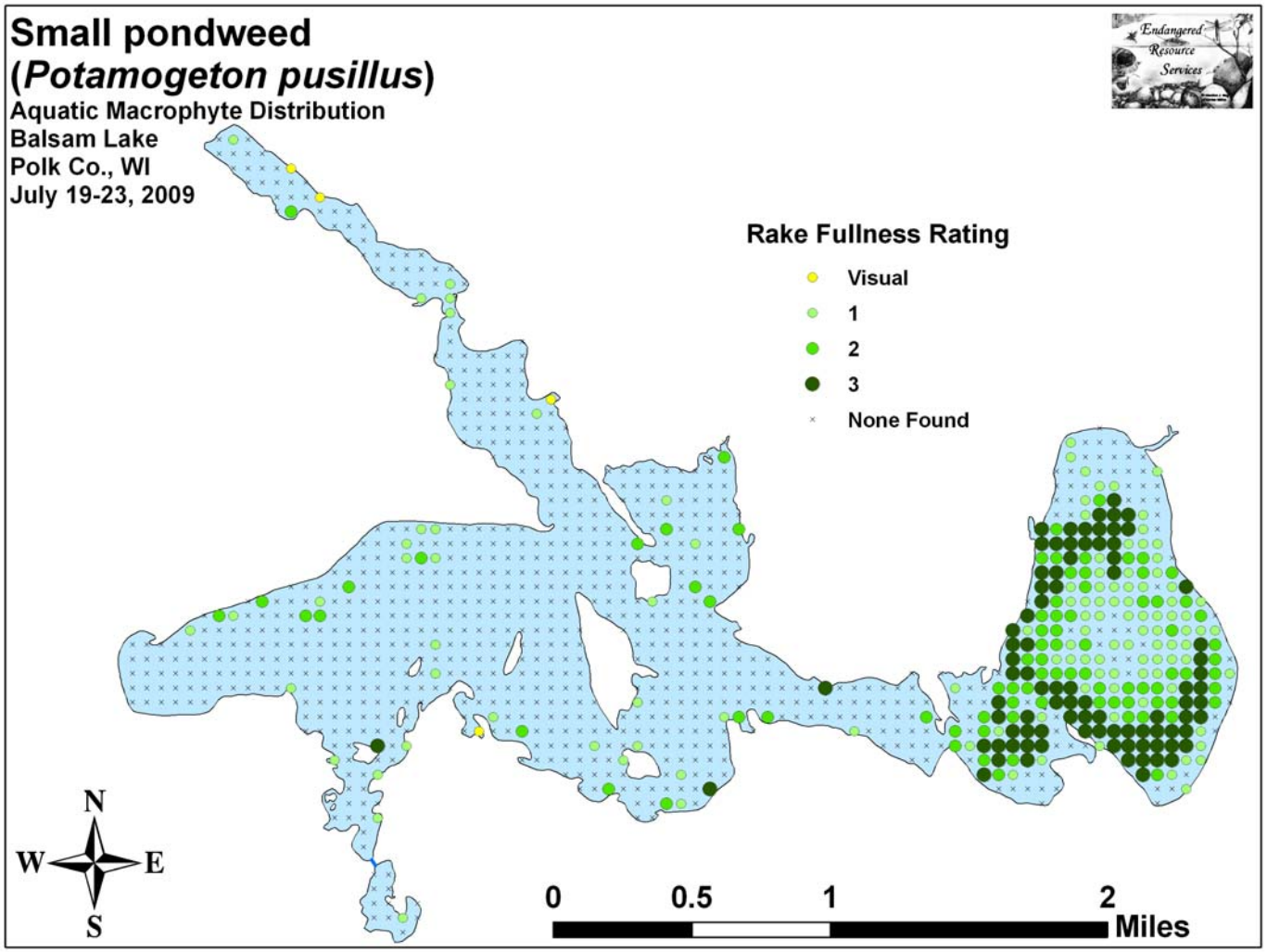
Small pondweed
(Potamogeton pusillus)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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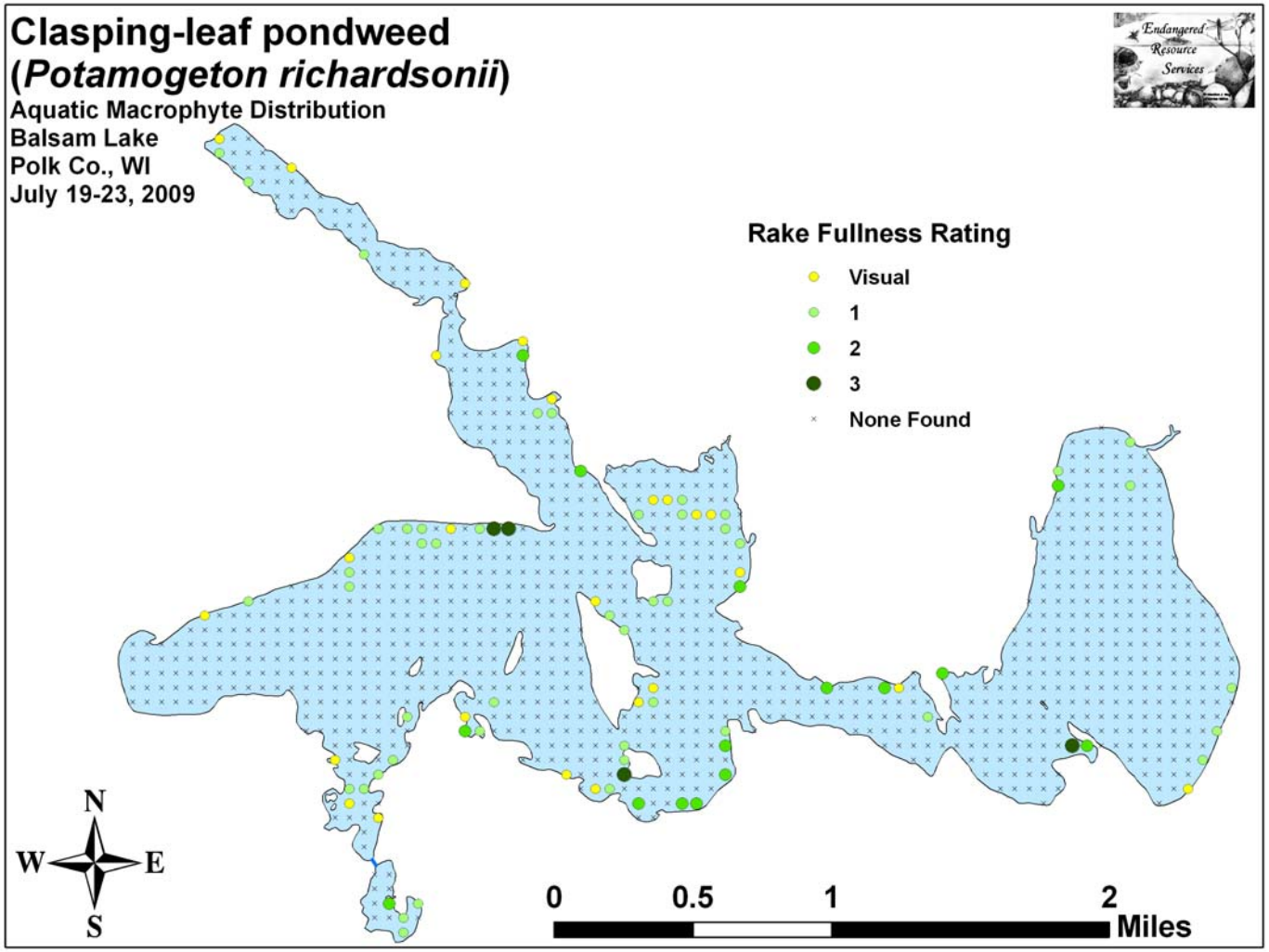
Clasping-leaf pondweed
(Potamogeton richardsonii)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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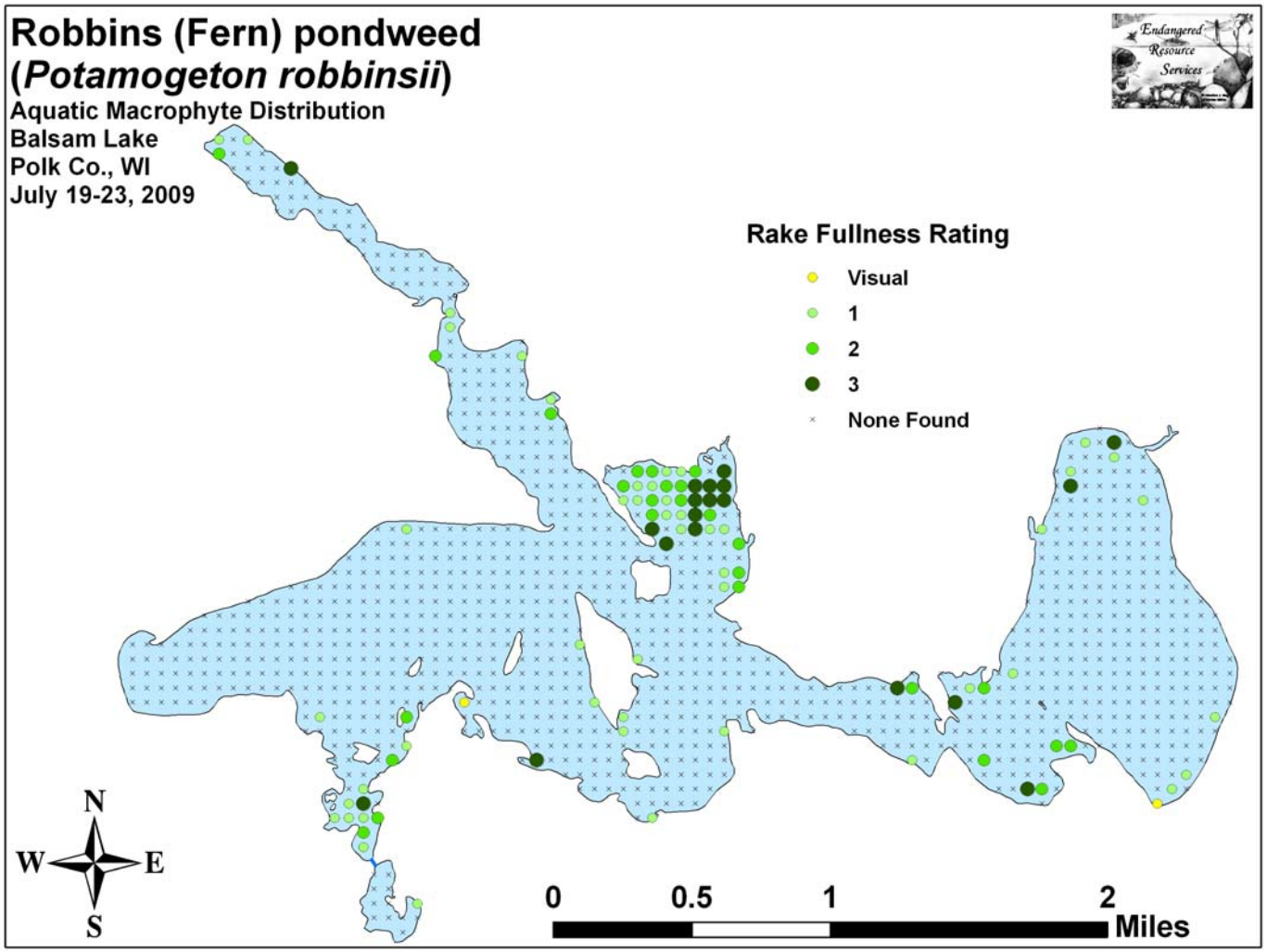
Robbins (Fern) pondweed
(Potamogeton robbinsii)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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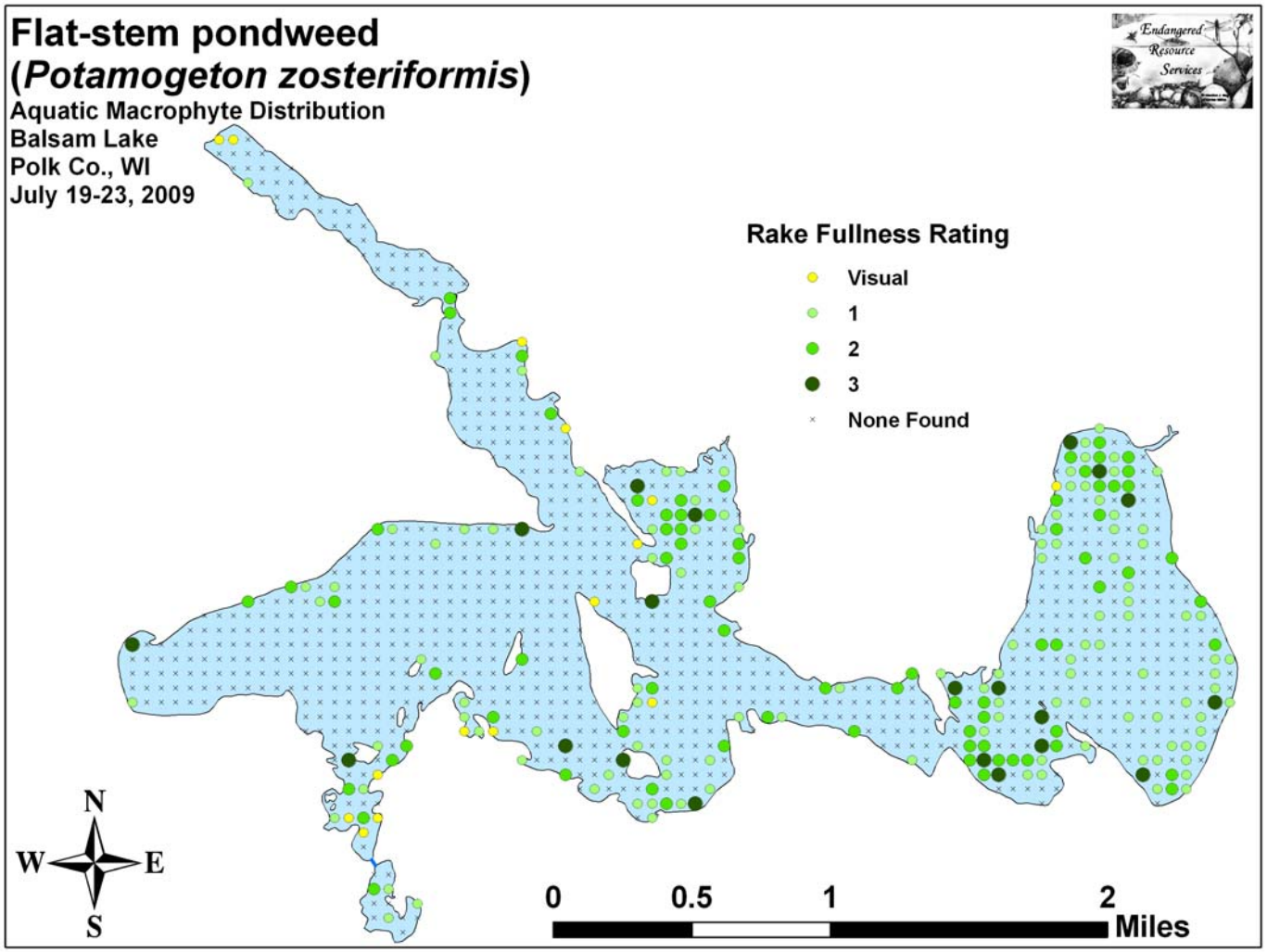
Flat-stem pondweed
(Potamogeton zosteriformis)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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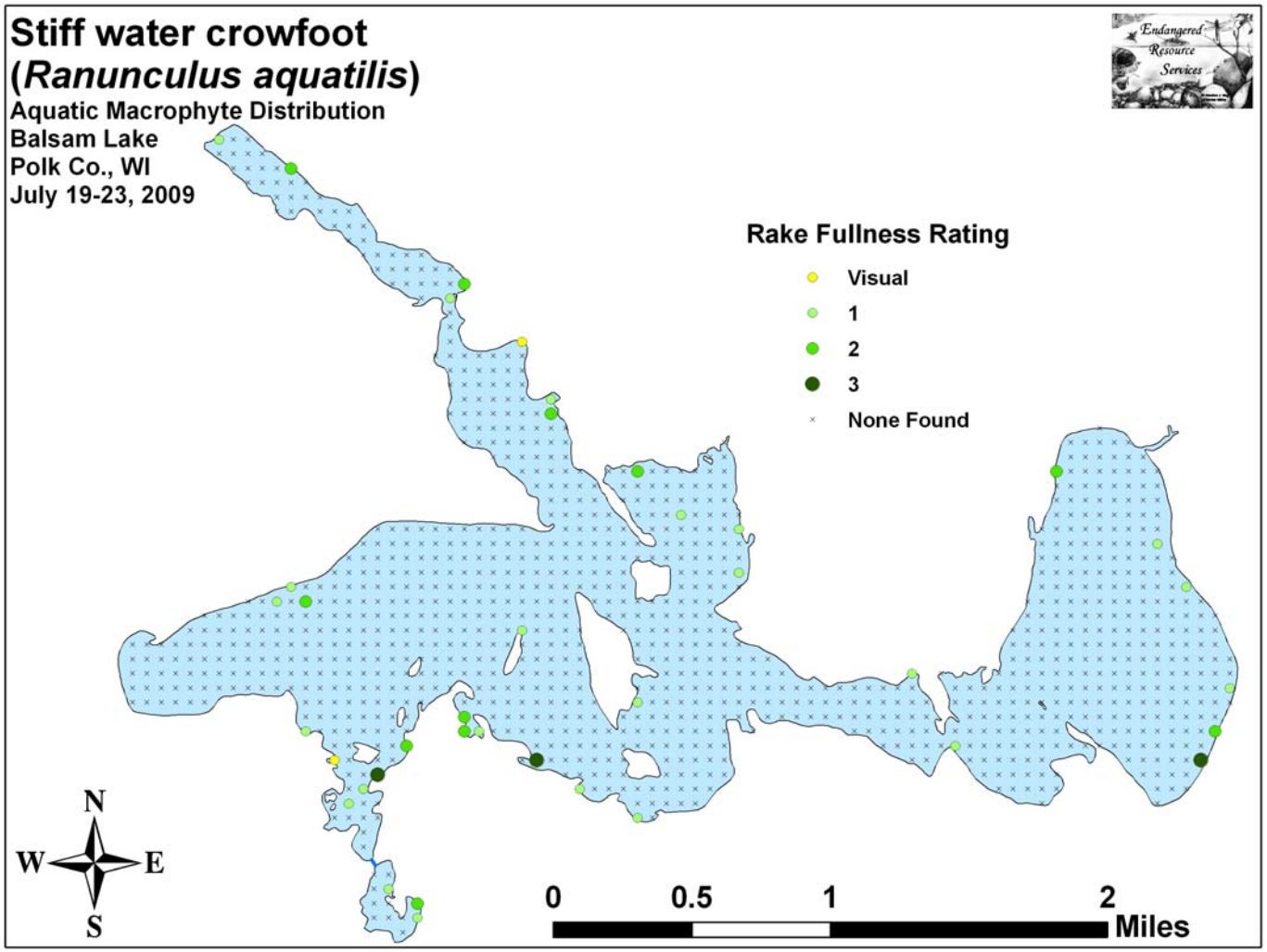
Stiff water crowfoot
(Ranunculus aquatilis)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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None Found
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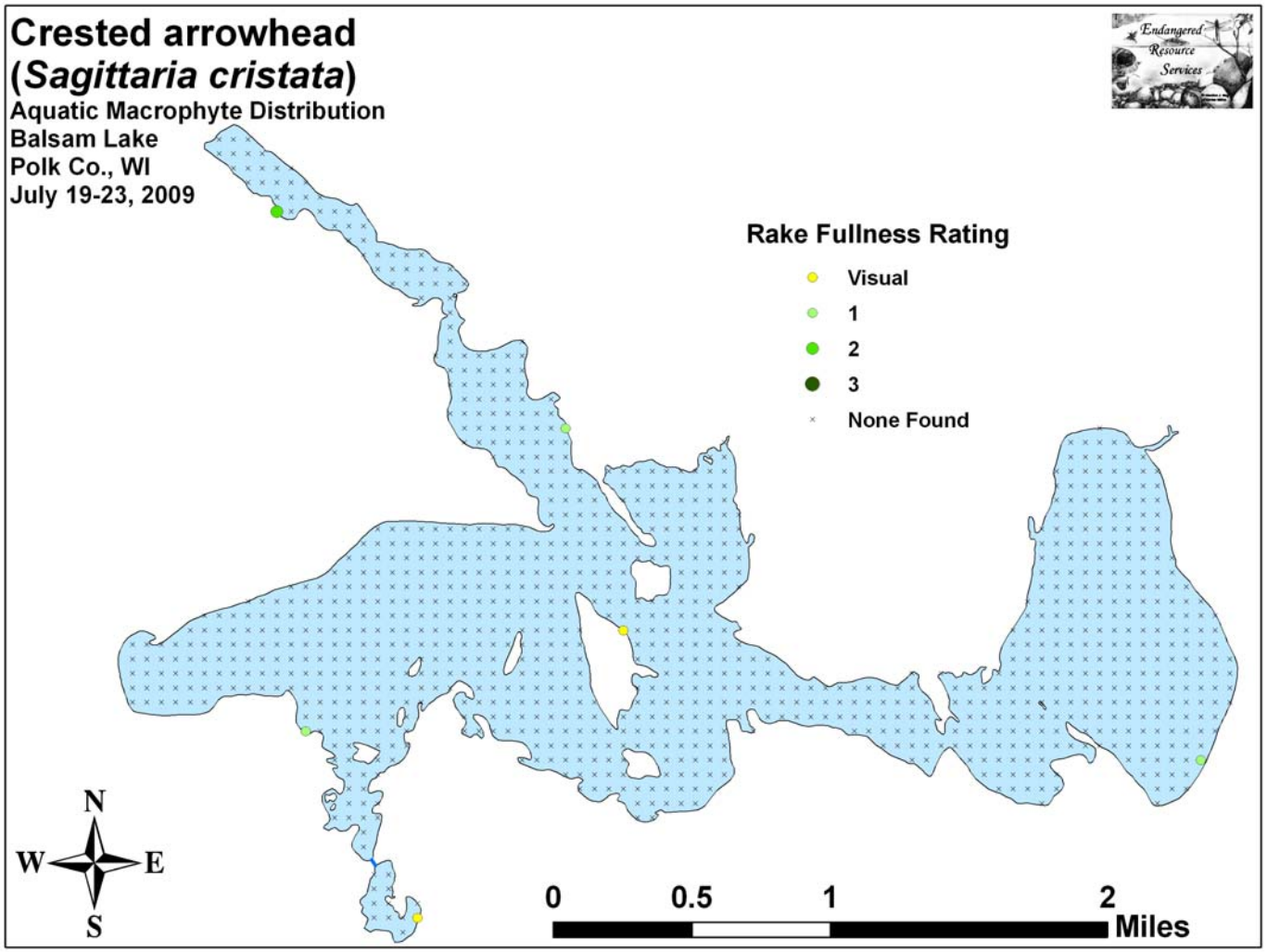
Crested arrowhead
(Sagittaria cristata)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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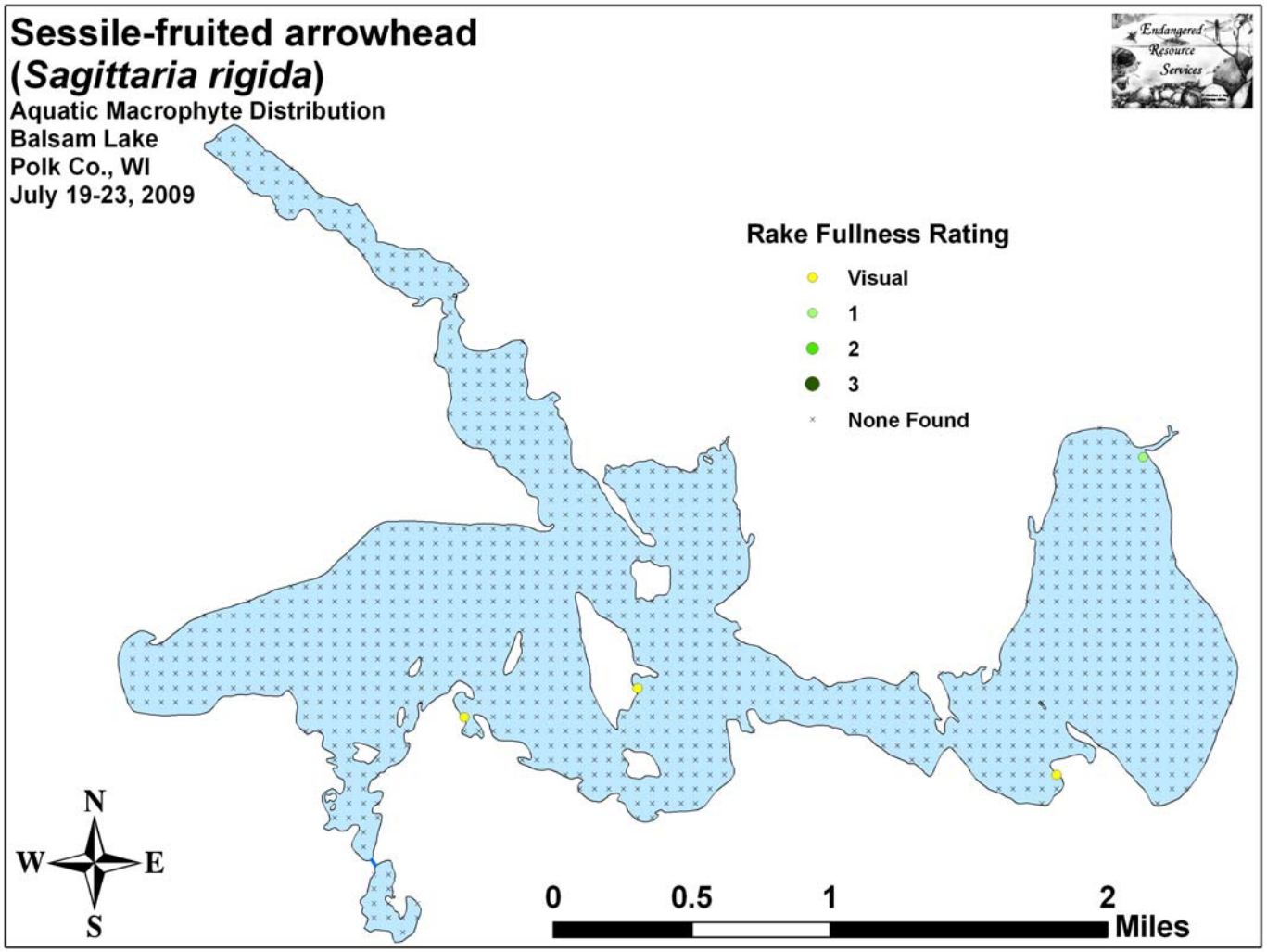
Sessile-fruited arrowhead
(Sagittaria rigida)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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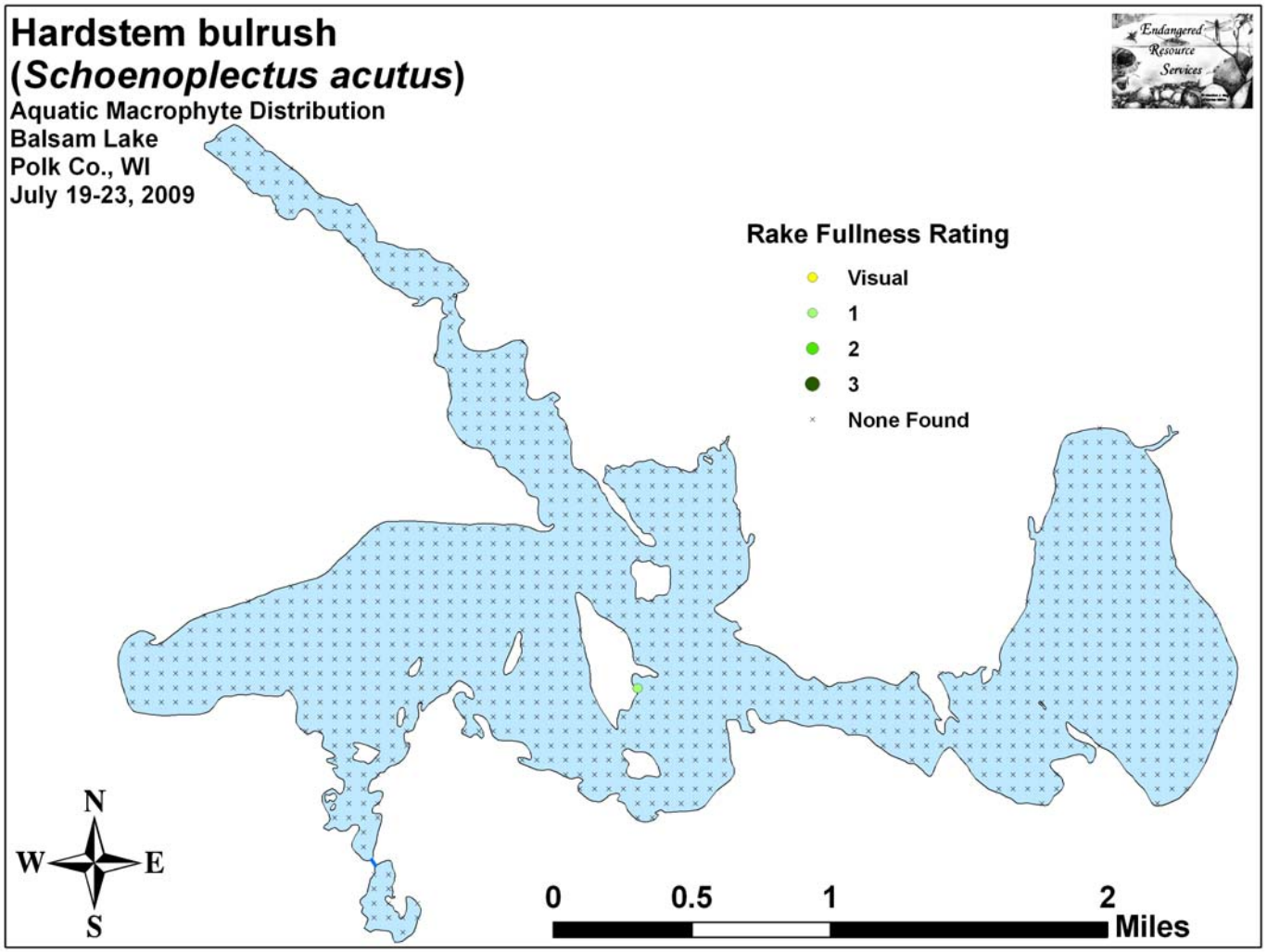
Hardstem bulrush
(Schoenoplectus acutus)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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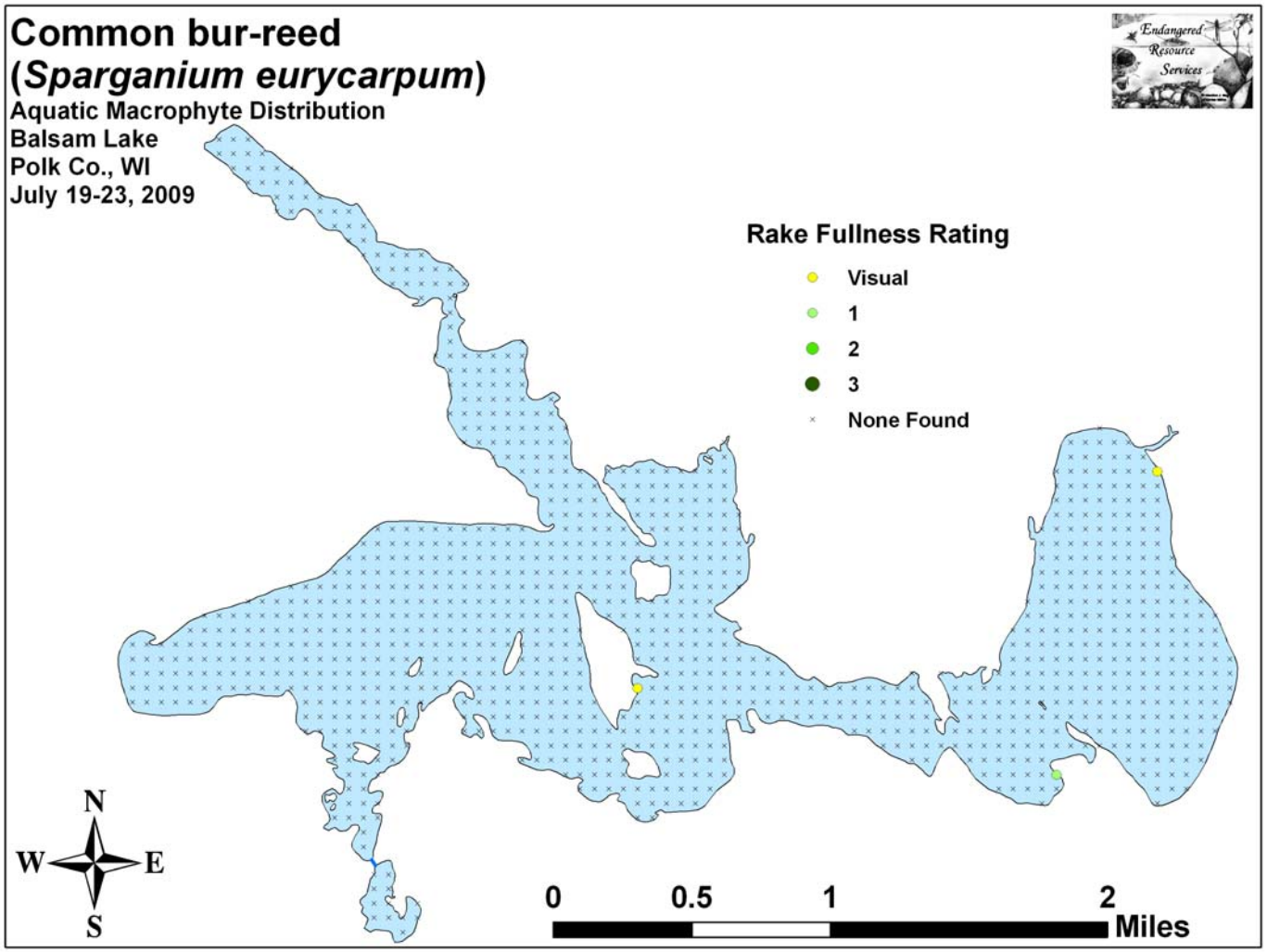
Common bur-reed
(Sparganium eurycarpum)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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None Found
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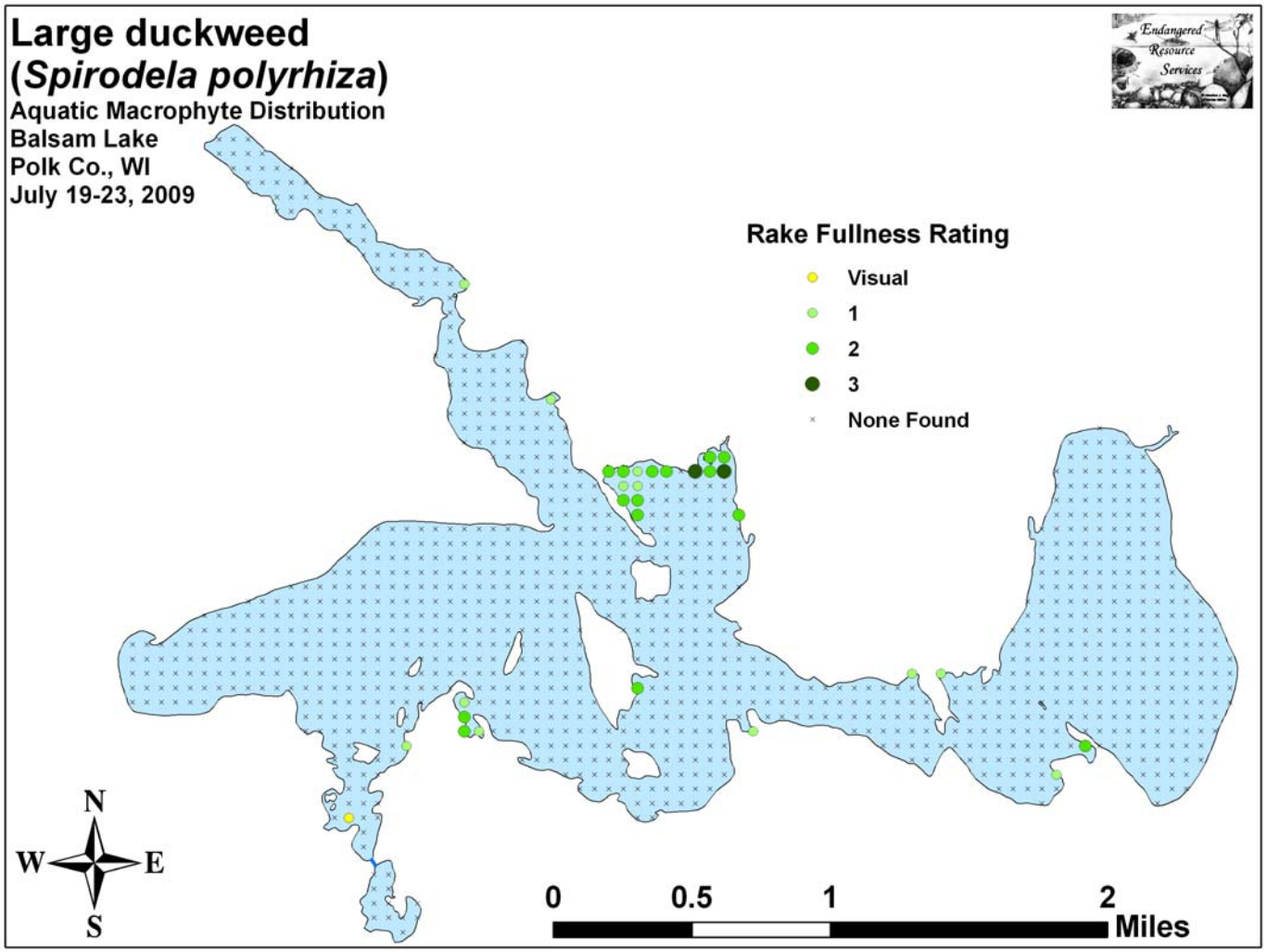
Large duckweed
(Spirodela polyrhiza)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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None Found
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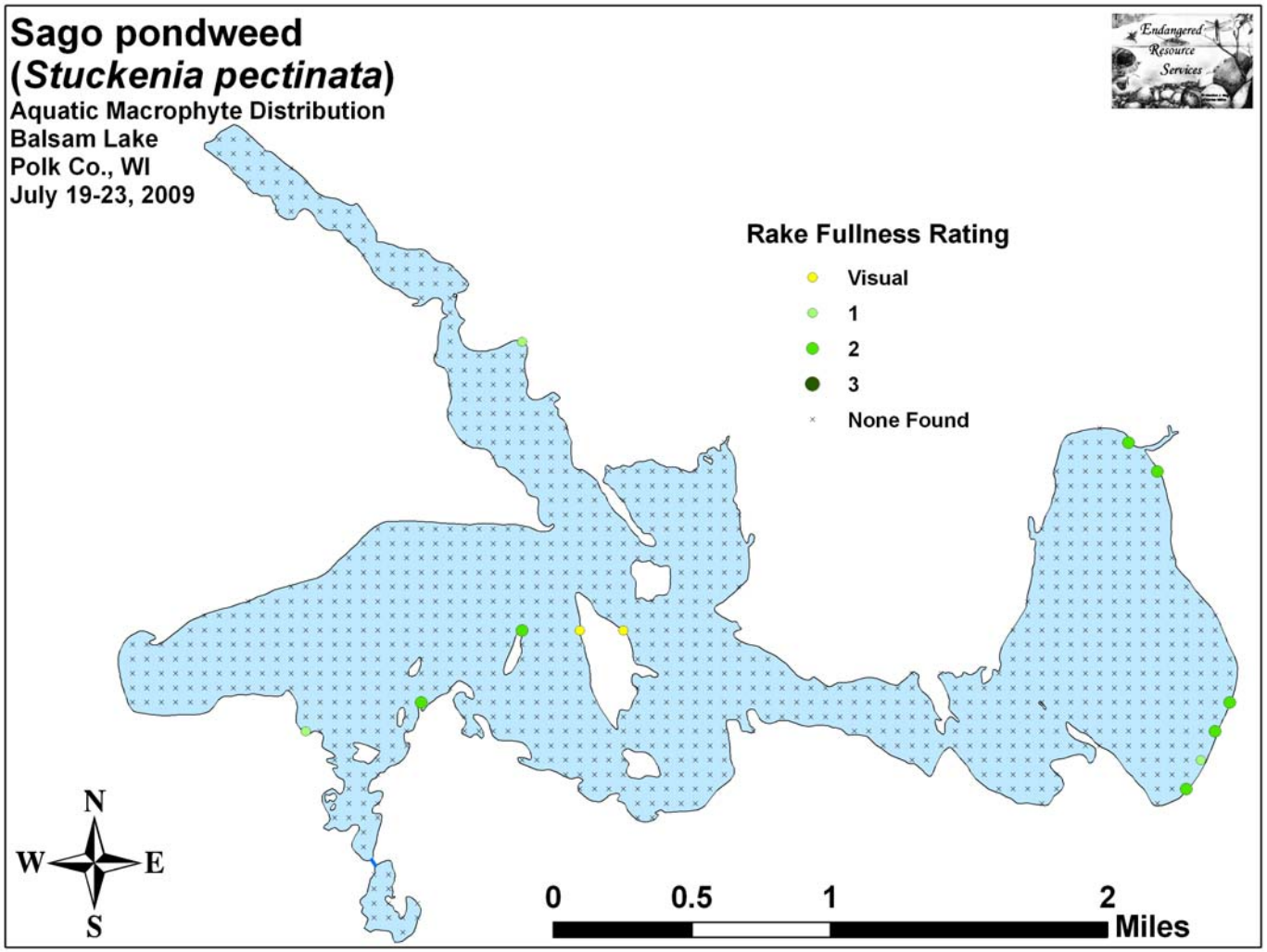
Sago pondweed
(Stuckenia pectinata)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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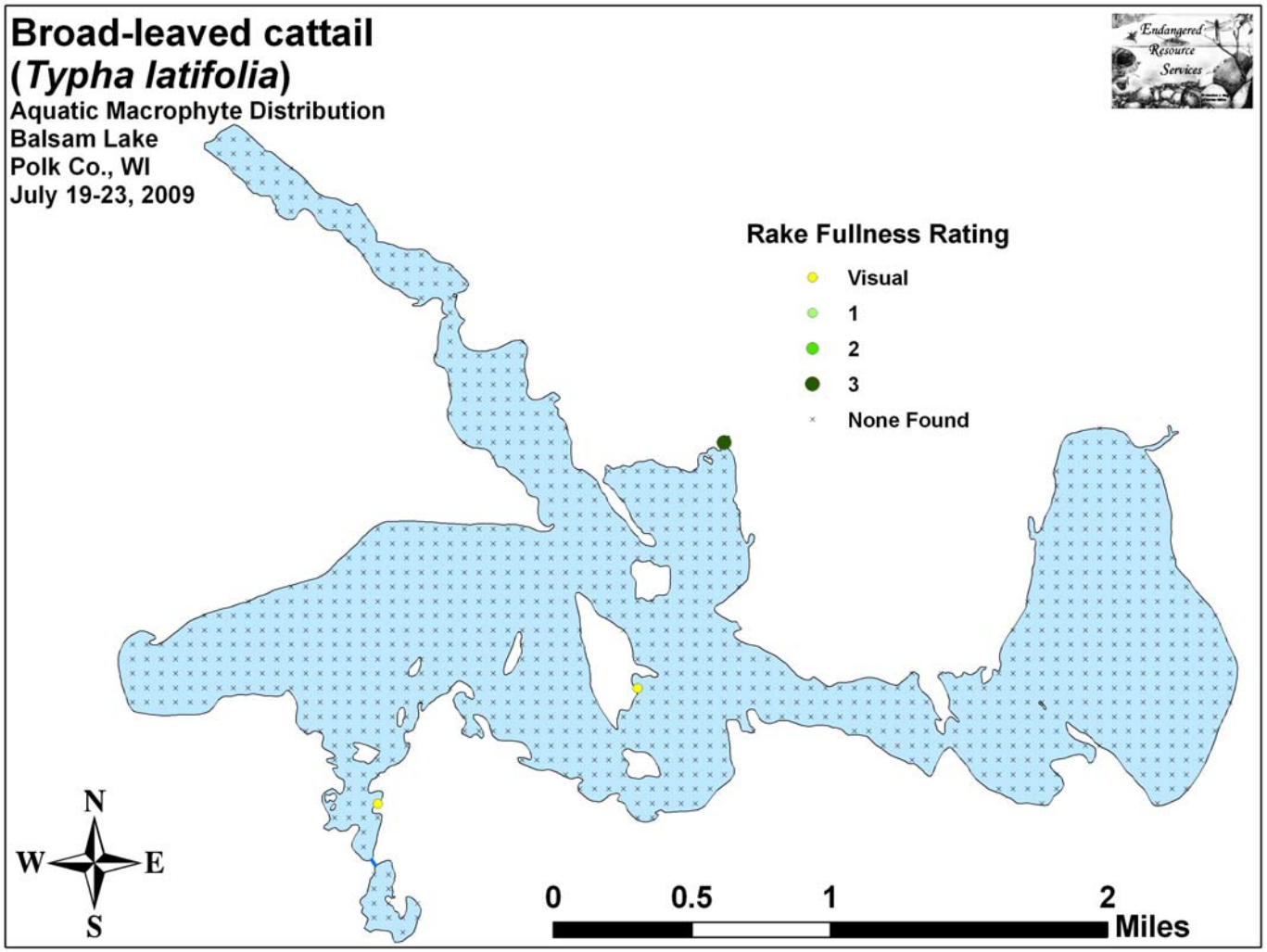
Broad-leaved cattail
(Typha latifolia)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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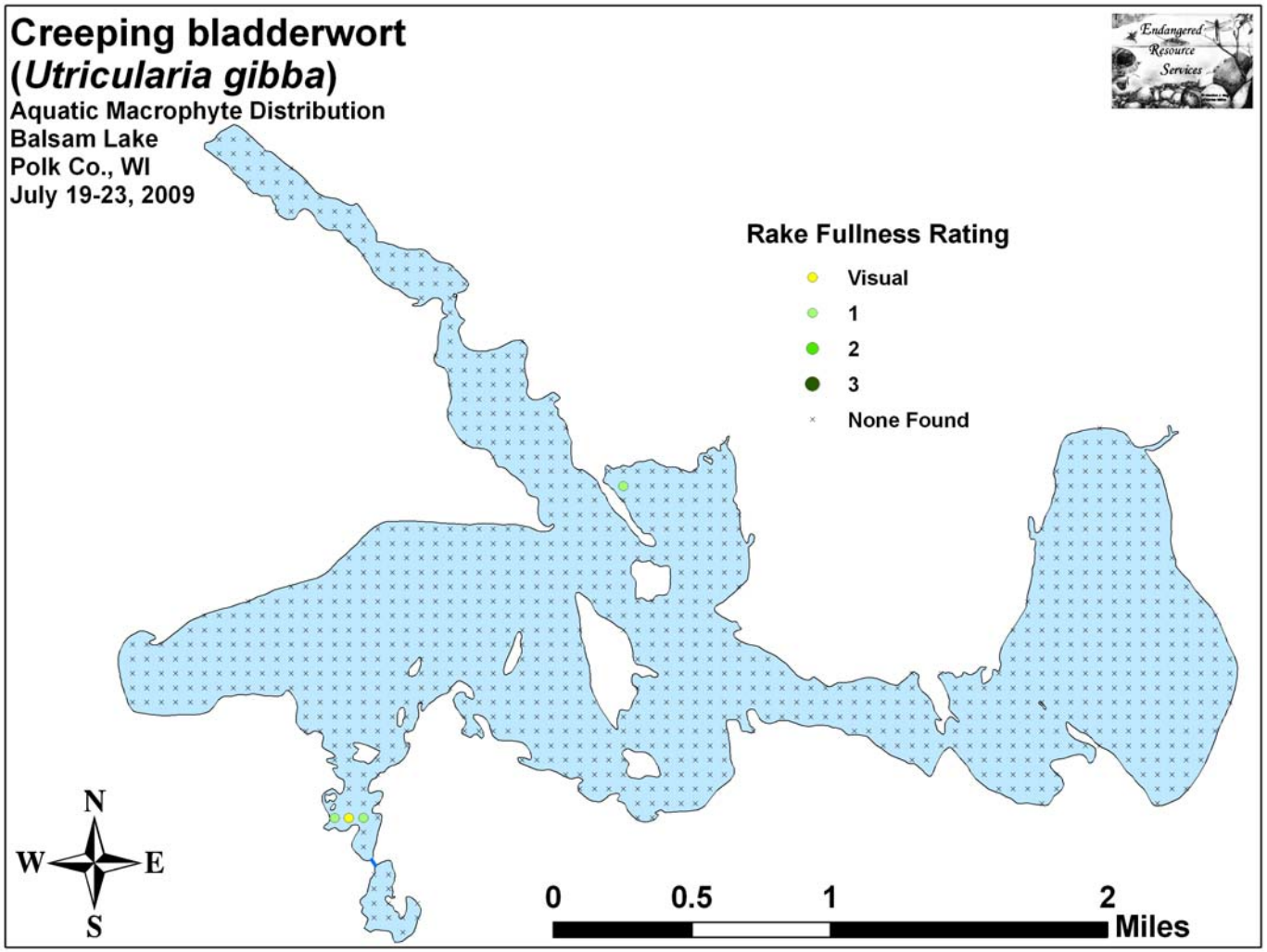
Creeping bladderwort
(Utricularia gibba)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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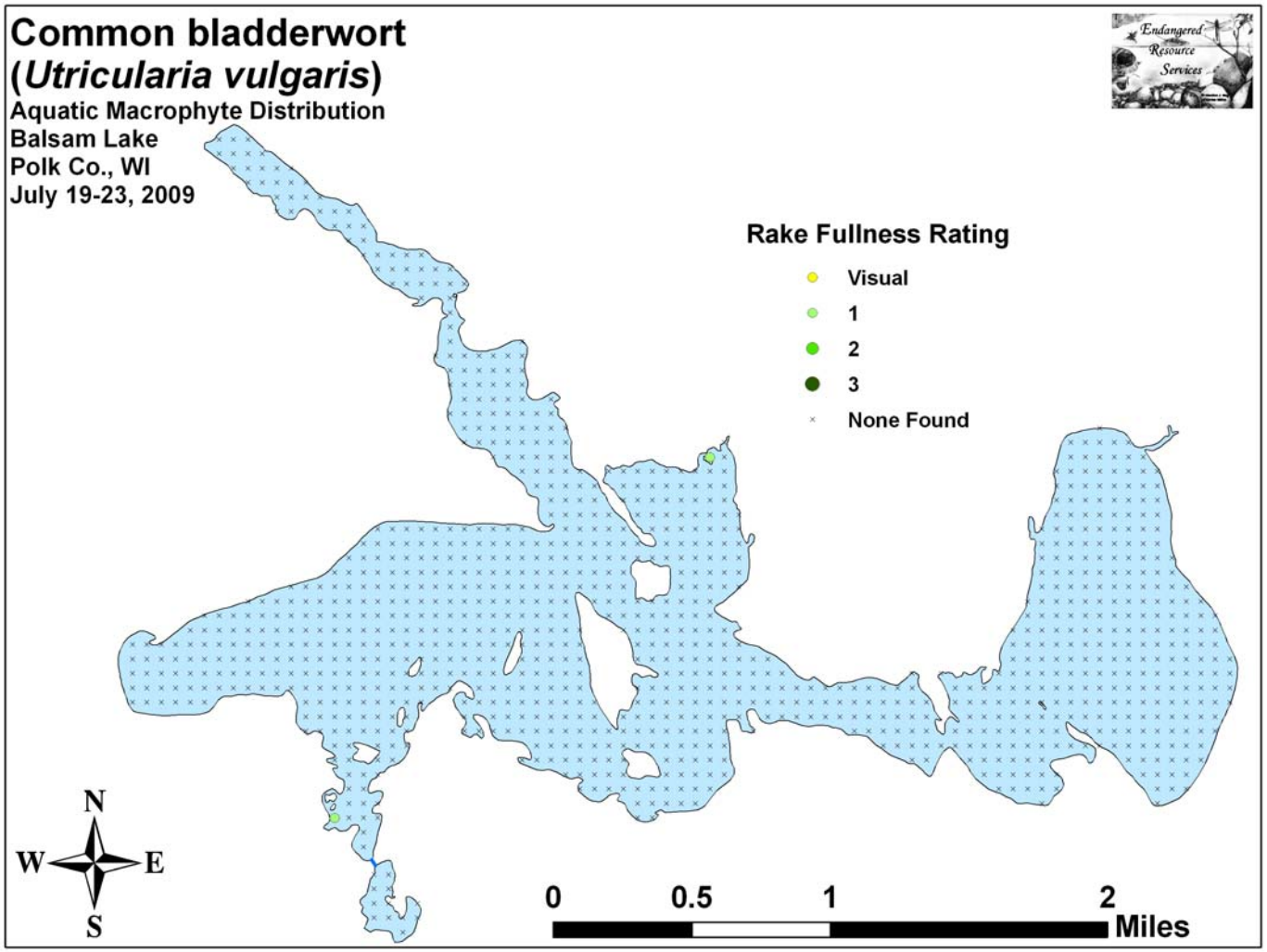
Common bladderwort
(Utricularia vulgaris)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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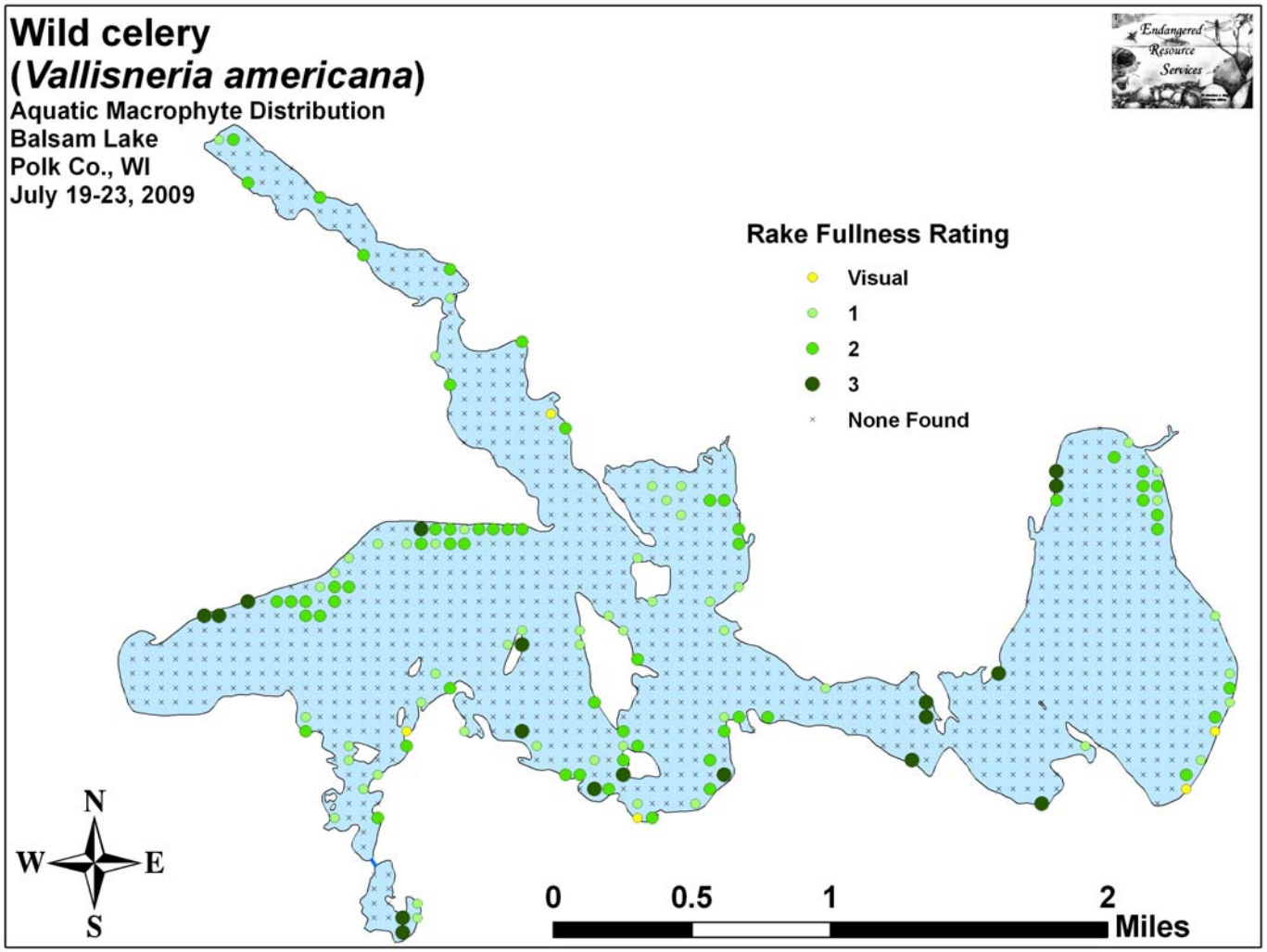
Wild celery
(Vallisneria americana)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
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None Found
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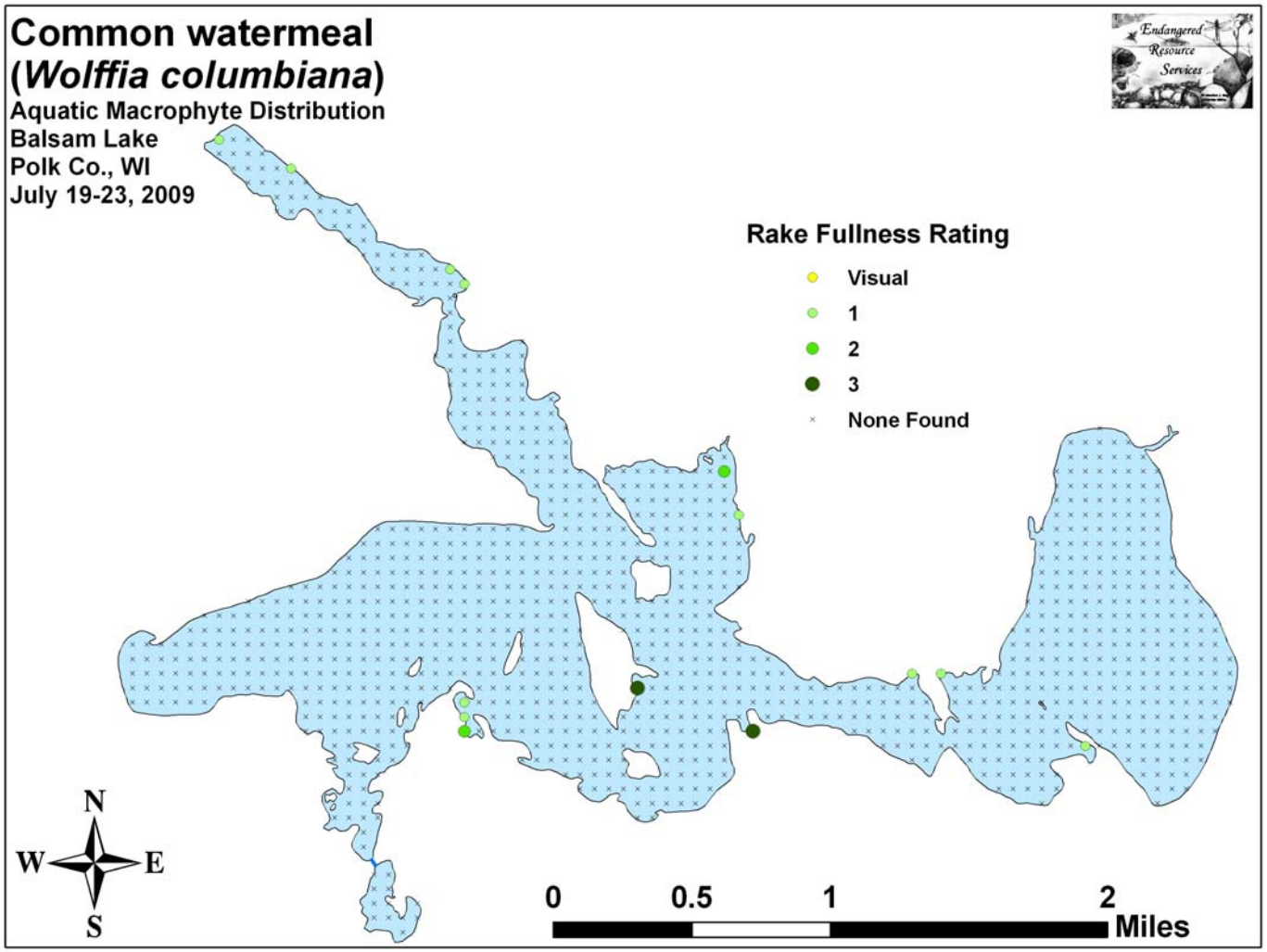
Common watermeal
(Wolffia columbiana)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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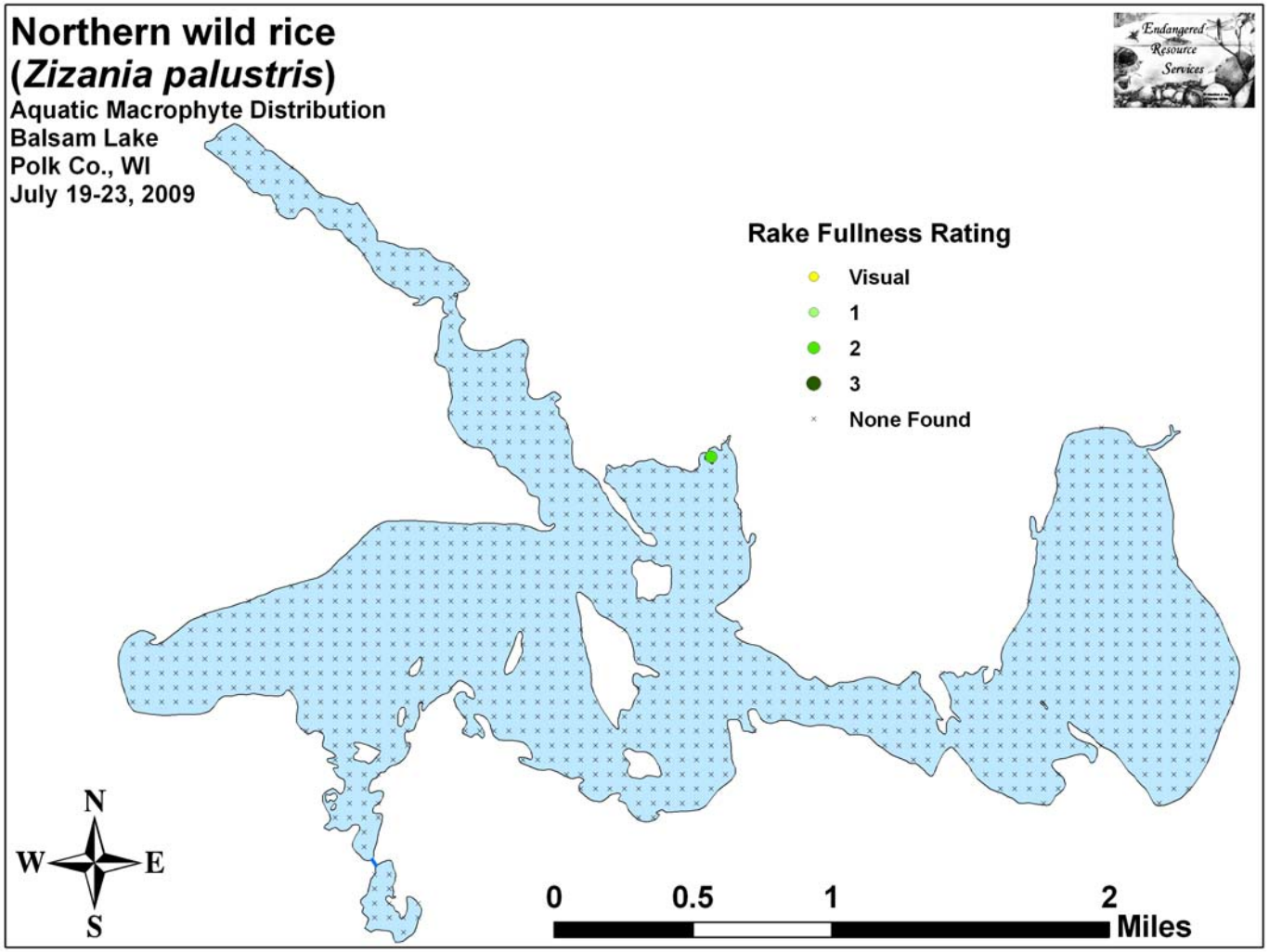
Northern wild rice
(Zizania palustris)
Aquatic Macrophyte Distribution
Balsam Lake
Polk Co., WI
July 19-23, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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Appendix VIII: Glossary of Biological Terms
(Adapted from UWEX 2009)

Aquatic:
organisms that live in or frequent water.

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

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

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

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

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

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

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

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

Limnology:
the study of inland lakes and waters.

Littoral:

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

Macrophytes:

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

Nutrients:

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

Organic Matter:

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

Photosynthesis:

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

Phytoplankton:

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

Plankton:

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

ppm:

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

Richness:

number of species in a particular community or habitat.

Rooted Aquatic Plants:

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

Runoff:

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

Secchi Disc:

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

Seepage lakes:

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

Turbidity:

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

Watershed:

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

Zooplankton:

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

Appendix IX: Aquatic Exotic Invasive Species Information

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, 2009 http://www.dnr.state.wi.us/invasives/fact/curlyleaf_pondweed.htm)

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, 2009 http://www.dnr.state.wi.us/invasives/fact/milfoil.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, 2009 http://www.dnr.state.wi.us/invasives/fact/reed_canary.htm)

Purple loosestrife near Mill St. Boat Landing
(Photo Courtesy Brian M. Collins – Unity Biology Instructor)

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 July 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, 2009 http://www.dnr.state.wi.us/invasives/fact/loosestrife.htm)

Appendix X: Raw Data Spreadsheets