Curly-leaf pondweed (*Potamogeton crispus*) Point-Intercept and Bed Mapping Surveys, and Warm-Water Macrophyte Point-Intercept Survey Balsam Lake – WBIC: 2620600 Burnett County, Wisconsin

Balsam Lake Aerial Photo (2010)

Purple Loosestrife Near First Island (Berg 2014)

Project Initiated by:

Balsam Lake Protection and Rehabilitation District, Harmony Environmental, and the Wisconsin Department of Natural Resources – Grant AEPP – 430-14

Northern Wild Rice Bed at Rice Creek Inlet in Little Balsam (Berg 2014)

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TABLE OF CONTENTS

ABSTRACT

Balsam Lake (WBIC 2620600) is a 2,054 acre stratified mesotrophic drainage lake located in central Polk County, WI. In 2010, the Balsam Lake Protection and Rehabilitation District, under the direction of Harmony Environmental, developed an Aquatic Plant Management Plan that authorized chemical treatment of the lake's Curly-leaf pondweed (*Potamogeton crispus*) infestation. As a prerequisite to updating this plan in 2015 and to compare how the lake's vegetation had changed since the last point-intercept surveys in 2009, the BLPRD and the Wisconsin Department of Natural Resources authorized CLP density and bed mapping surveys from June 16-20, and a full point-intercept survey for all aquatic macrophytes from August 12-15, 2014. The cold-water survey found CLP at 37 points which extrapolated to 3.4% of the lake – a highly significant decrease since 2009 when we found it at 212 sites (19.4% of the lake). In 2014, 13 points (1.2% of the lake) had a significant infestation (rake fullness 2 or 3). This was also a highly significant decline (-89.7%) from 2009 when 126 points (11.5% of the lake) had a significant infestation. In 2014, we mapped 14 small CLP beds totaling 4.45 acres and covering 0.2% of the lake – an 89.2% reduction from the 80.58 acres mapped in 2009. During the August 2014 full point-intercept survey, we found macrophytes growing at 377 sites or 34.4% of the entire lake bottom and in 70.1% of the 15.5 littoral zone. This was also down significantly from 600 sites in 2009 (54.8% of the lake and 88.8% of the then 19.0ft littoral zone). Overall diversity was very high with a Simpson Diversity Index value of 0.92 – up slightly from 0.90 in 2009. Species richness was moderate with 46 species found growing in and immediately adjacent to the water – down slightly from 47 in 2009. There was an average of 3.41 native species/site with native veg. – up from 3.35 species/site in 2009. Coontail (*Ceratophyllum demersum*), Forked duckweed (*Lemna trisulca*), Flat-stem pondweed (*Potamogeton zosteriformis*), and Wild celery (*Vallisneria americana*) were the most common macrophyte species being found at 64.99%, 40.85%, 40.58%, and 27.85% of sites with vegetation and accounting for 49.95% of the total relative frequency. In 2009, Coontail, Forked duckweed, Small pondweed (*Potamogeton pusillus*), and Flat-stem pondweed were the most common native species being found at 57.33%, 55.17%, 48.00%, and 35.33% of survey points with vegetation respectively and accounting for 55.48% of the total relative frequency. Lakewide from 2009-2014, Forked duckweed, Small pondweed, CLP, Fern pondweed (*Potamogeton robbinsii*), White-stem pondweed (*Potamogeton praelongus*), and Coontail (only when considering East Balsam) demonstrated highly significant declines; while Northern water milfoil (*Myriophyllum sibiricum*) and White water crowfoot (*Ranunculus aquatilis*) experienced moderately significant declines. With the exception of crowfoot, these changes appeared to be almost entirely due to the loss of plants in East Balsam. Conversely, Water star grass (*Heteranthera dubia*) showed a highly significant increase; Fries' pondweed (*Potamogeton friesii*) a moderately significant increase; and Slender naiad (*Najas flexilis*), Spatterdock (*Nuphar variegata*), and Nitella (*Nitella* sp.) significant increases. Most of these increases appeared to also be primarily due to changes in East Balsam. Northern wild rice (*Zizania palustris*) was present at three points – up from one in 2009. Dense rice beds with human harvest potential occurred at the Rice Creek Inlet while rice at the Harder Creek Inlet was patchy and of poorer quality. We did not see rice anywhere else in the system. The 37 native index species found in the rake during the August 2014 survey (identical to 2009) produced an above average mean Coefficient of Conservatism of 6.3 (up from 6.1 in 2009), and a Floristic Quality Index of 38.1 (up from 37.2 in 2009) that was nearly double the median FQI for this part of the state. Other than CLP, we found two other exotic species growing adjacent to Balsam Lake: Reed canary grass (*Phalaris arundinacea*) which was present throughout, and Purple loosestrife (*Lythrum salicaria*) which was spreading north from Idlewild Bay and the Village Beach; fortunately, there were Galerucella beetles on most plants. Future management considerations include preserving the lake's native plants (especially the reed beds and floating-leaf species) and the important habitat they provide for the entire lake ecosystem including its excellent fishery; working to maintain CLP at its current low levels; continuing to monitor for and eliminate Purple loosestrife wherever it is found; and continuing both the Clean Boats/Clean Waters watercraft inspection and the landing/inlet monitoring program to prevent or quickly identify Eurasian water milfoil (*Myriophyllum spicatum*) should it be introduced to the lake.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION:

Balsam Lake (WBIC 2620600) 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 a 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 (WDNR 2014). Bottom substrate is variable with muck bottoms in most bays, and rock/sand bars in the Big and Little narrows and around the lake's many islands (Figure 1).

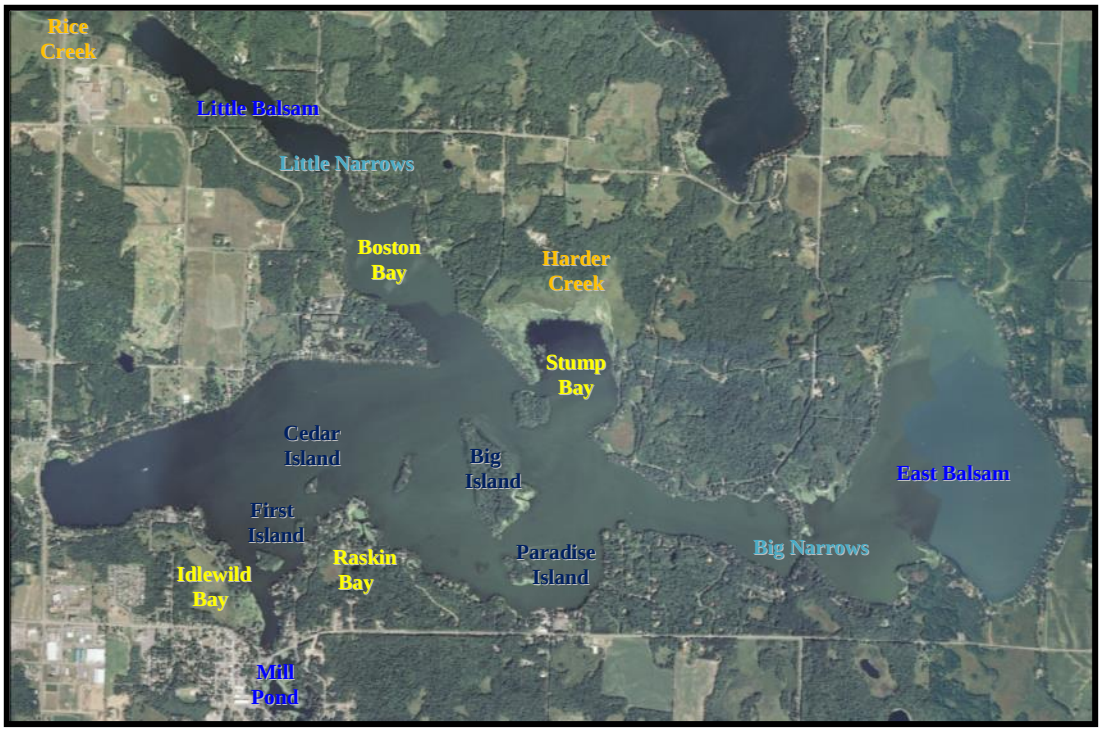


Figure 1: Aerial Photo of Balsam Lake

Curly-leaf pondweed (*Potamogeton crispus*) (CLP) is locally abundant in Balsam Lake, and the Balsam Lake Protection and Rehabilitation District (BLPRD) has been chemically and mechanically managing this exotic invasive species for decades. In 2009, as a prerequisite to continuing their active management, the Wisconsin Department of Natural Resources requested a series of full lake plant surveys prior to developing an Aquatic Plant Management Plan (APMP) in 2010. Per WDNR expectations, APMPs are normally updated every five years to remain current. In anticipation of updating their plan in 2015, the BLPRD, under the direction of Harmony Environmental, authorized three lakewide surveys in 2014. From June 16-20, we conducted early-season CLP point-intercept and bed mapping surveys. These were followed by a warm-water point-intercept survey of all macrophytes from August 12-15. The surveys' objectives were to document the current levels of CLP in the lake, determine if Eurasian water milfoil (*Myriophyllum spicatum*), or any other new exotic plants had invaded the lake, and to compare data from 2009 and 2014 to identify any significant changes in the lake's vegetation over this time. This report is the summary analysis of these field surveys.

METHODS:

Curly-leaf Pondweed Point-intercept Survey:

Using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth, and total acreage, Michelle Nault (WDNR) generated the original 1,083 point sampling grid for Balsam Lake with an additional 12 points added in the Mill Pond (Appendix I). Using this grid, we completed a density survey where we sampled for Curly-leaf pondweed at each point in and adjacent to the lake's littoral zone. We located each survey point using a handheld mapping GPS unit (Garmin 76CSx) and used a rake to sample an approximately 2.5ft section of the bottom. When found, CLP was assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also noted visual sightings of CLP within six feet of the sample point.

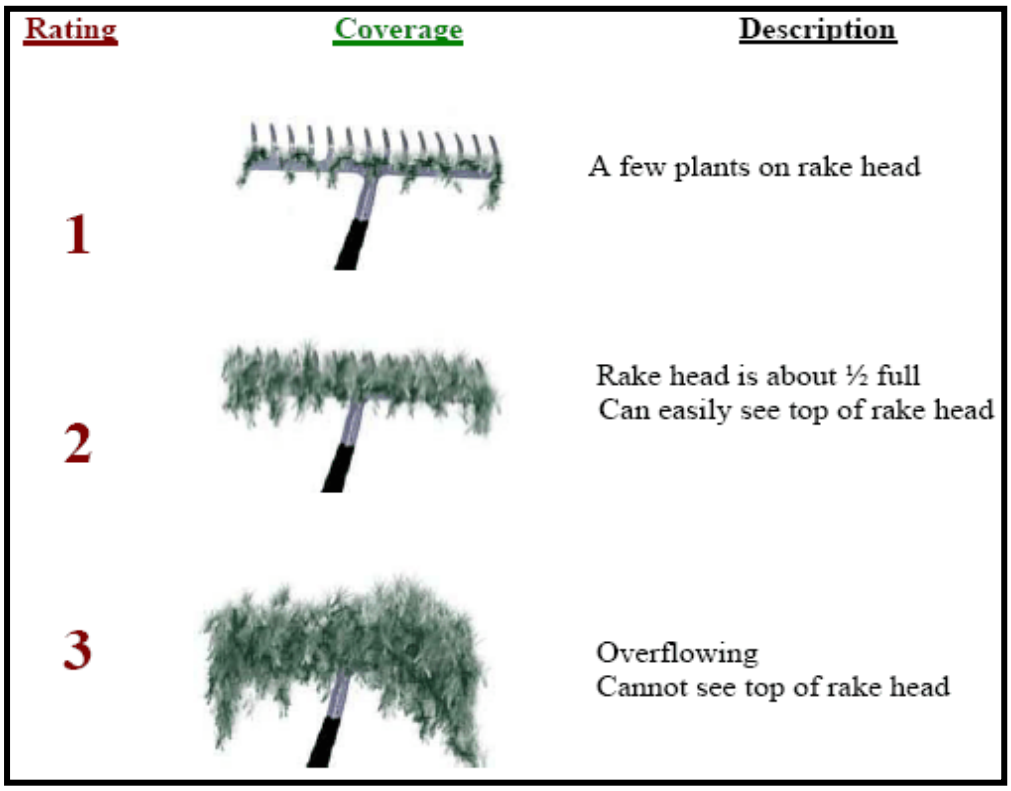


Figure 2: Rake Fullness Ratings (UWEX 2010)

Curly-leaf Pondweed Bed Mapping Survey:

By definition, a "bed" was determined to be any area where we visually estimated that CLP made up >50% of the area's plants, was generally continuous with clearly defined borders, and was canopied, or close enough to being canopied, that it would likely interfere with boat traffic.

During the bed mapping survey, we searched the lake's entire visible littoral zone. After we located a bed, we motored around the perimeter of the area, took GPS coordinates at regular intervals, and estimated the average rake fullness rating of CLP within the bed (Figure 2). These data were then mapped using ArcMap 9.3.1. We also used the WDNR's Forestry Tools Extension to determine the acreage of each bed to the nearest hundredth of an acre (Table 1).

Warm-water Full Point-intercept Macrophyte Survey:

Prior to beginning the August point-intercept survey, we conducted a general boat survey of the lake to regain familiarity with the species present (Appendix II). All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2009; Skawinski 2011), and a data sheet was built from the species present. We again located each survey point with a GPS, recorded a depth reading with a metered pole rake or hand held sonar (Vexilar LPS-1), and took a rake sample. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of all plants within six feet of the sample point not found in the rake. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

DATA ANALYSIS:

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

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

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

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

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

Frequency of occurrence example:

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

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

From these frequencies, we can estimate how common each species was at depths where plants were able to grow, and at points where plants actually were growing. Note the second value will be greater as not all the points (in this example, only ½) had plants growing at them.

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

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

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

Number of sites sampled using rope/pole rake: This indicates which rake type was used to take a sample. As is standard protocol, we use 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 at a sample point during the survey but not found in the rake, and those that were only seen during the initial boat survey or inter-point. **Note: Per DNR protocol, filamentous algae, freshwater sponges, aquatic moss and the aquatic liverworts *Riccia fluitans* and *Ricciocarpus natans* are excluded from these totals.**

Average rake fullness: This value is the average rake fullness of all species in the rake. It only takes into account those sites with vegetation (Table 2).

Relative frequency: This value shows a species' frequency relative to all other species. It is expressed as a percentage, and the total of all species' relative frequency will add up to 100%. Organizing species from highest to lowest relative frequency value gives us an idea of which species are most important within the macrophyte community (Tables 3 and 4).

Relative frequency example:

Suppose that we sample 100 points and found 5 species of plants with the following results:

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

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

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

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

Floristic Quality Index (FQI): This index measures the impact of human development on a lake's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each native index species found in the lake during the point-intercept survey**, and multiplying it by the square root of the total number of plant species (N) in the lake ($FQI=(\Sigma(c1+c2+c3+\ldots cn)/N)*\sqrt{N}$). Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, North Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Balsam Lake is in the North Central Hardwood Forests Ecoregion (Tables 5 and 6).

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

Comparison to Past Surveys: We compared data from our 2009 and 2014 CLP point-intercept surveys (Figures 3 and 4) and our 2009 and 2014 warm-water point-intercept surveys (Figure 10) (Tables 3 and 4) to see if there were any significant changes in the lake's vegetation. Using the WDNR Pre/Post Survey Sheet, we determined 2009-2014 differences to be significant at $p < .05$, moderately significant at $p < .01$ and highly significant at $p < .005$ (UWEX 2010). It should be noted that depths were not recorded during the June 2009 CLP survey, but, as we found CLP plants to 15.5ft, we were able to use the 2014 depth data to estimate there were 538 points in this depth range compared to 421 points in the 2014 13ft littoral zone. When comparing the warm-water point-intercept surveys, we again used the number of littoral points as the basis for "sample points" as 2014's 538 points was much reduced when compared to 2009's 676 points.

RESULTS:

Curly-leaf Pondweed Point-intercept Survey:

Following the establishment of the June littoral zone at approximately 13.0ft of water, we sampled for Curly-leaf pondweed at all points in and adjacent to this zone. CLP was present in the rake at 37 points which approximated to 3.4% of the entire lake. Of these, we recorded a rake fullness value of 3 at five points, a 2 at eight points, and a value of 1 at 24 points. This extrapolated to 1.2% of the lake having a significant infestation (rake fullness of 2 or 3). CLP was also a visual at seven points (Figure 3) (Appendix III).

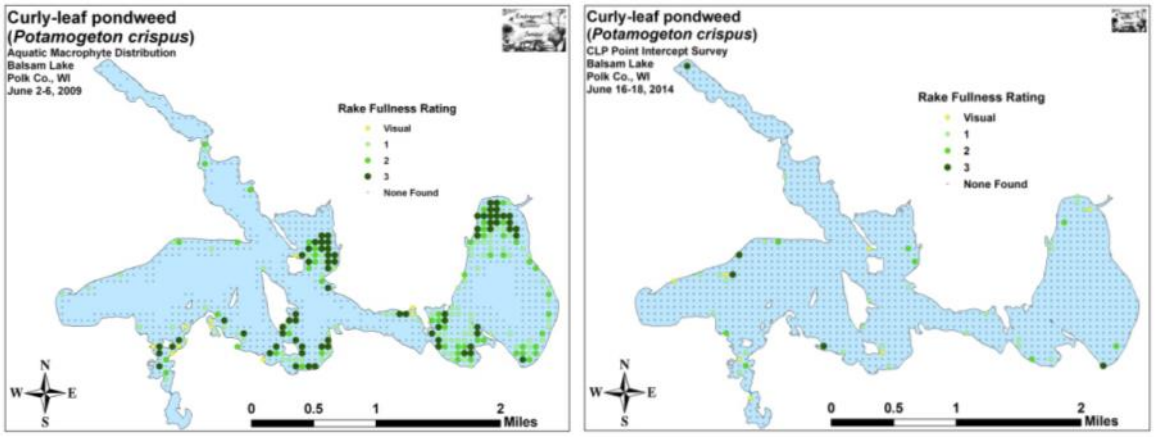
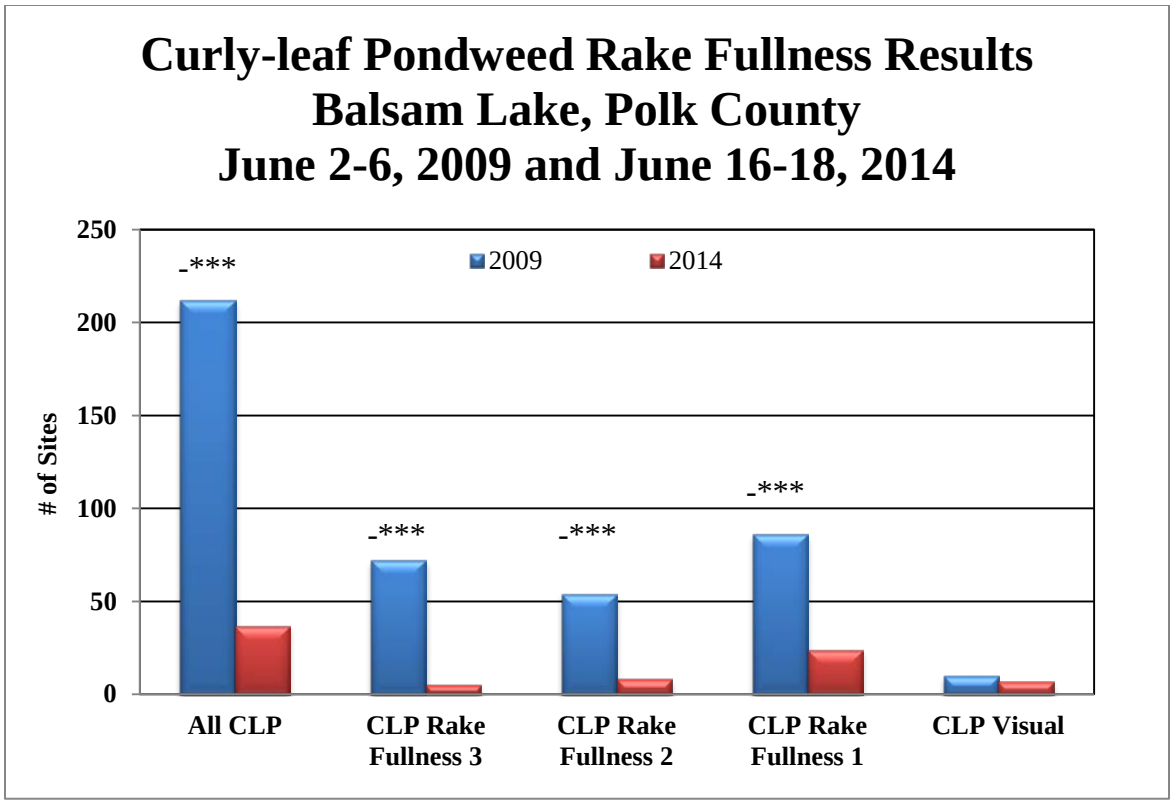


Figure 3: 2009 and 2014 June CLP Density and Distribution

Comparison of Curly-leaf Pondweed in 2009 and 2014:

The 2009 spring Curly-leaf pondweed survey found CLP at 212 sites which approximated to 19.4% of the entire lake. Of these, we recorded a rake fullness value of 3 at 72 points, a 2 at 54 points, and a value of 1 at 86 points. This extrapolated to 11.5% of the lake having a significant infestation (rake fullness of 2 or 3). We also recorded CLP as a visual at ten points (Figure 3) (Appendix III). Our results suggest a highly significant reduction in total CLP as well as rake fullness 3, 2, and 1 (Figure 4). Collectively, there was a greater than 82.5% reduction in total CLP coverage also well as an 89.7% reduction in areas where the infestation was significant enough to potentially be considered a nuisance. The reduction in East Balsam was especially dramatic as CLP was abundant and frequently canopied here in 2009, but almost completely absent following the 63 acre herbicide treatment in May 2014.



Significant differences = * $p < .05$, ** $p < .01$, *** $p < .005$

Figure 4: 2009 and 2014 Changes in June CLP Rake Fullness

CLP Bed Mapping Survey:

We located and mapped a total of 14 beds in 2014 that ranging in size from 0.04 acre (Bed 1A in Little Balsam) to 1.58 acres (Bed 20 east of Idlewild Bay/South and West of First Island) (Figure 5) (Appendix III). All combined, these beds covered a total of 4.45 acres or 0.2% of the lake's 2,054 total acres (Table 1). This represented a 76.13 acre (-94.5%) reduction from the 80.58 acres mapped in 2013, and a 36.76 acre (-89.2%) reduction from our original 2009 survey.

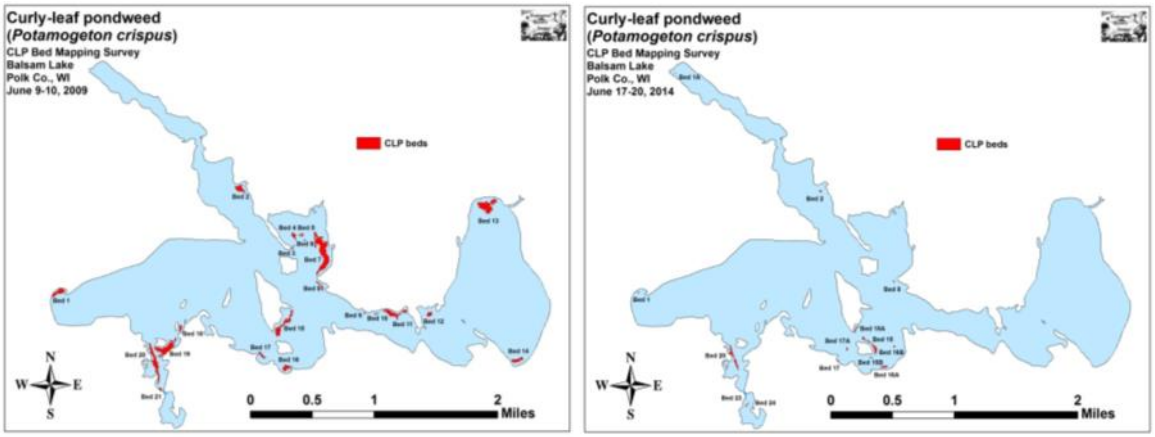


Figure 5: 2009 and 2014 June Curly-leaf Pondweed Beds

Table 1: CLP Bed Summary - Balsam Lake, Polk County - 2009 - 2014

Bed #	Location	2014 Area (Acres)	2013 Area	2012 Area	2011 Area	2009 Area	2013-14 Change in Area	Est. Range and Mean Rake-full	Years Treated	Acreage Treated
1	HWY 46 Landing	0.07	0.00	0.58	0.00	1.81	0.07	<1-2; 1	2011	1.81
1A	Balsam Branch Inlet	0.04	0.00	0.00	0.00	0.00	0.04	<<1-2; <1	-	-
2	Boston Bay	0.15	0.64	1.23	0.08	1.71	-0.49	<1-2; 1	-	-
3-6	Stump Bay	0.00	0.00	0.67	0.00	1.33	0.00	<<<1	-	-
7+8	East Shore Stump Bay/Outlet	0.08	3.08	4.91	0.00	10.64	-3.00	<1-3; 2	-	-
9	NW of Big Narrows	0.00	0.00	0.19	0.00	0.10	0.00	<<<1	2011	0.11
10	NW of Big Narrows	0.00	0.18	0.00	0.00	0.16	-0.18	<<<1	2011	0.22
11	Bay NW of Big Narrows	0.00	2.70	4.72	1.04	2.83	-2.7	<<1-1; <<1	2013, 11, '10	4.71, 2.80, 2.85
12	Bay NE of Big Narrows	0.00	10.34	0.00	5.91	0.73	-10.34	0	**2014**, 2012	10.37, 5.91
13	N. Bay of East Balsam	0.00	40.83	0.00	43.14	5.29	-40.83	0	**2014**, 2012	38.66, 43.14
14	SE Bay of East Balsam	0.00	4.37	0.00	6.95	1.29	-4.37	0	**2014**, 2012	4.37, 6.95
14B, 14C	Bay SE of Big Narrows	0.00	9.92	0.00	0.00	0.00	-9.92	0	**2014**, '11, '09	9.92, 3.07, 11.38
15, A, B	SE of Big Island	1.59	8.22	8.78	3.80	3.55	-6.63	<<1-3; 2	2013	8.70
16	Bay S. of Paradise Island	0.00	0.00	0.65	0.00	1.21	0.00	<<<1	2011	1.26
16A	N. of Paradise Landing	0.42	0.00	0.00	0.00	0.00	0.42	1-3; 3	-	-
16B	NE of Paradise Landing	0.11	0.00	0.00	0.00	0.00	0.11	1-3; 2	-	-
17	Bay SW of Paradise Island	0.08	0.00	0.00	0.00	0.66	0.08	1-2; 2	-	-
17A	West of Paradise Island	0.13	<0.01	1.86	0.00	0.00	0.12	<1-2; 2	-	-
17B	Raskin Bay	0.00	0.00	0.00	0.26	0.00	0.00	<<<1	-	-
17C	Raskin Bay Outlet	0.00	<0.01	1.04	0.00	0.00	-<0.01	<1-1; <1	-	-
18	Channel E. of Pine Island	0.00	0.00	0.00	0.00	0.55	0.00	<<<1	2011, '10	0.59, 0.57
19A , B	Channel E. of First Island	0.00	0.00	0.98	0.00	4.83	0.00	<<<1	2011, '10	4.87, 4.55
20, 20A	East of Idlewild Bay	1.58	0.30	0.10	0.00	4.19	1.28	<1-3; 3	2011	4.26
21	N. of Village Beach	0.00	0.00	0.00	0.00	0.29	0.00	<<<1	-	-
22	Northwest Mill Pond	0.00	0.00	0.40	0.00	0.00	0.00	<<<1	-	-
23	Northeast Mill Pond	0.05	0.00	0.43	0.00	0.00	0.05	1-2; 1	-	-
24	Mill Pond Point	0.15	0.00	1.37	0.00	0.00	0.15	1-2; 1	-	-
25	Southeast Mill Pond	0.00	0.00	0.30	0.00	0.00	0.00	<<<1	-	-
	Total	**4.45**	**80.58**	**28.21**	**61.18**	**41.21**	**-76.13**			

Descriptions of Past and Present CLP Beds:

Bed 1 – This bed near the western boat landing was characterized by low density, but continuously canopied Curly-leaf pondweed and Coontail.

Bed 1A – Located at the Balsam Branch Inlet adjacent the lake's largest Northern wild rice (*Zizania palustris*) bed, this area was more a collection of clusters than a true bed. We felt it deserved mapping, however, as it was the first time we have found CLP in Little Balsam.

Bed 2 – Scattered canopied CLP was present throughout the area. Plants were dense at the core before becoming fragmented along the edges.

Beds 3-6 – We found only very widely scattered CLP in Stump Bay.

Beds 7 and 8 – Located along the east shoreline of Stump Bay, this area was dominated by native vegetation in 2014. Although very low levels of CLP was scattered throughout the former large bed, it was never dominant and only canopied in the small mapped area on the south side at the drop off.

Beds 9, 10 and 11 – Located just northwest of the Big Narrows/East Balsam, these beds have been treated several times in the past with minimal success. Despite not being directly treated in 2014, we could find almost no CLP growing in the area. We feel it is possible and perhaps likely that "downstream residual control" from the major treatment in East Balsam may have knocked these beds down as well.

Beds 12, 13, 14, 14B, and 14C – None of East Balsam's CLP beds survived the 2014 treatment. Despite this, there likely continues to be a large CLP turion bank in the sediment, and we expect these beds will reestablish in 2015 without control. We feel this is especially likely as many of the former native plant beds in East Balsam have been eliminated by the 2012 and 2014 treatments that were, in effect, basin-wide.

Bed 15 and 15A – Although these beds were not treated in 2014, they acted as though they were with limited numbers of CLP plants reaching canopy. In the center and along the northern edge of Bed 15 where CLP has historically been dense, canopied, and nearly monotypic, we found almost no plants of any kind. As currents runs through these areas, we wondered if this bed had also been impacted by residual herbicide from East Balsam.

Bed 16 – We saw only a handful of CLP plants in this area in 2014, and none of them were canopied or bed forming.

Beds 16A, 16B, and 16C – Each of these beds was new in 2014, and, although dense and canopied at their cores, they were all <0.5 acre making them relatively easy to avoid. They were also surrounded by important native plant beds. This was especially true of 16B as this area has some of the best stands of Northern water milfoil (*Myriophyllum sibiricum*) in the lake. Because of this, and because the beds are located adjacent to deep water where treatment is often difficult, we hope efforts in 2015 will focus elsewhere.

Beds 17 and 17A – Neither of these beds were particularly dense, and, although canopied or near canopy, they did not appear likely to interfere with boat traffic. As in the past, 17A is situated next to a Hardstem bulrush (*Schoenoplectus acutus*) bed that provides important spawning habitat for the lake panfish (personal observation).

Beds 17B, and 17C – There were almost no CLP plants in Raskin Bay in 2014, and the bed at the bay entrance had only a handful of plants. Raskin Bay was again dominated by Coontail and water lilies while 17C had large numbers of Clasping-leaf pondweed (*Potamogeton richardsonii*).

Beds 18 and 19 – The areas around Pine Island and east of First Island continued to be almost completely CLP free.

Bed 20 – This bed stretched farther north (past Idlewild Bay and beyond the No Wake Zone) along the western shoreline than we have ever seen before. This area could be considered for control as most parts of the bed were canopied, and many plants were prop clipped or had been ripped out of the sediment by boat traffic.

Bed 21 – In 2014, CLP was rare and not bed forming north of the village beach.

Beds 23-24 – CLP was dense and canopied in the Mill Pond in 2012, nearly absent in 2013, and only moderately dense in 2014. Most areas around the beds were dominated by Coontail and Northern water milfoil.

Beds 22 and 25 – These Mill Pond beds had almost no CLP in them in 2014.

Warm-water Full Point-intercept Macrophyte Survey:

Depth readings taken at Balsam Lake's 1,095 point survey grid (Appendix I) revealed a varied underwater topography. 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 bowl that slopes gently from the north, west, and south, but sharply from the east before bottoming out in a giant 15-19ft flat (Figure 6) (Appendix IV).

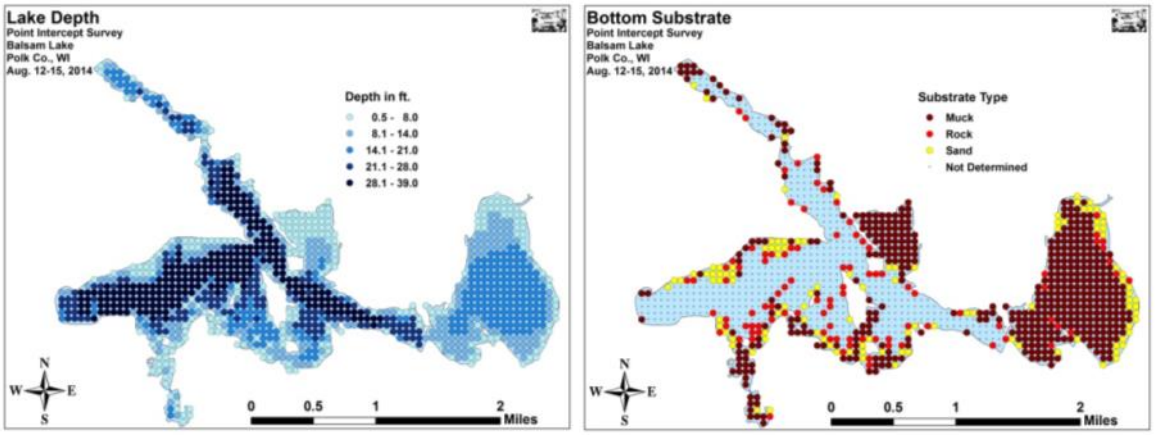


Figure 6: Lake Depth and Bottom Substrate

Of the 657 survey points where we could determine the substrate, 68.5% were muck and sandy muck, 16.9% were pure sand, and 14.9% were rock. Most pure sand substrate occurred around the main basin and along the eastern shoreline of East Balsam. Sandy muck dominated the rest of East Balsam while more nutrient-rich organic muck occupied the majority of the main lake's bays. Areas around the lake's many island and sunken islands, and many shorelines in Boston Bay and Little Balsam were dominated by rock and gravel (Figure 6) (Appendix IV).

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics
Balsam Lake, Polk County
July 17-22, 2009 and August 12-15, 2014

Summary Statistics:	2009	2014
Total number of points sampled	1,095	1,095
Total number of sites with vegetation	600	377
Total number of sites shallower than the maximum depth of plants	676	538
Frequency of occurrence at sites shallower than maximum depth of plants	88.76	70.07
Simpson Diversity Index	0.90	0.92
Maximum depth of plants (ft)	19.0	15.5
Mean depth of plants (ft)	10.0	7.3
Median depth of plants (ft)	10.0	7.0
Number of sites sampled using rake on Rope (R)	116	148
Number of sites sampled using rake on Pole (P)	537	509
Average number of all species per site (shallower than max depth)	3.13	2.44
Average number of all species per site (veg. sites only)	3.53	3.49
Average number of native species per site (shallower than max depth)	2.97	2.38
Average number of native species per site (sites with native veg. only)	3.35	3.41
Species richness	38	38
Species richness (including visuals)	39	38
Species richness (including visuals and boat survey)	47	46
Mean rake fullness (veg. sites only)	2.32	2.03

We found plants growing at 377 sites or on approximately 34.4% of the entire lake bottom and in 70.1% of the littoral zone. Despite an upper littoral limit of 15.5ft, most plant growth ended in 14.0ft of water. Because of this, growth was slightly skewed to deep water as the mean plant depth of 7.3ft was greater than the median depth of 7.0ft (Table 2) (Figure 7).

All of these values showed a dramatic decrease from 2009 when the mean and median depths were both 10.0ft, and plants were found at 600 points (54.8% of the total bottom and 88.8% in the 19ft littoral zone). Despite these overall declines, we noted that the changes were not even throughout the lake. In both 2009 and 2014, the littoral zone in the main lake was essentially unchanged at approximately 15ft. However, in East Balsam, rooted plants were consistently found to 18ft and occasionally to 19ft in 2009, but only 10ft in 2014 (Appendix V).

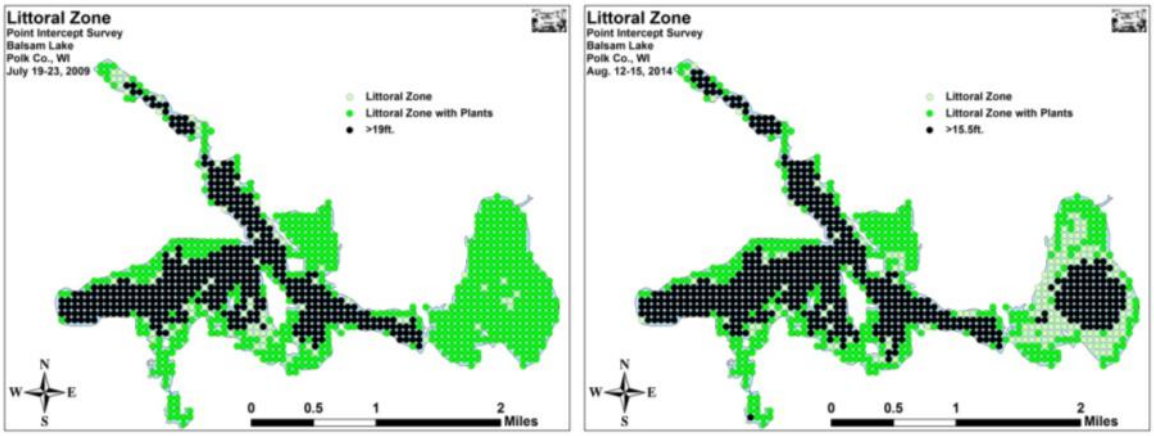


Figure 7: 2009 and 2014 Littoral Zone

Plant diversity was exceptionally high in 2014 with a Simpson Index value of 0.92 - up slightly from 0.90 in 2009. Species richness was also moderately high with 46 species found in and adjacent to the lake in 2014 – down from 47 in 2009. Mean native species richness at sites with vegetation was, however, up from 3.35/site in 2009 to 3.41/site in 2014 (Figure 8). Total rake fullness declined from a moderately high 2.32 in 2009 to a moderate 2.03 in 2014. This decline was most evident in East Balsam (Figure 9) (Appendix V).

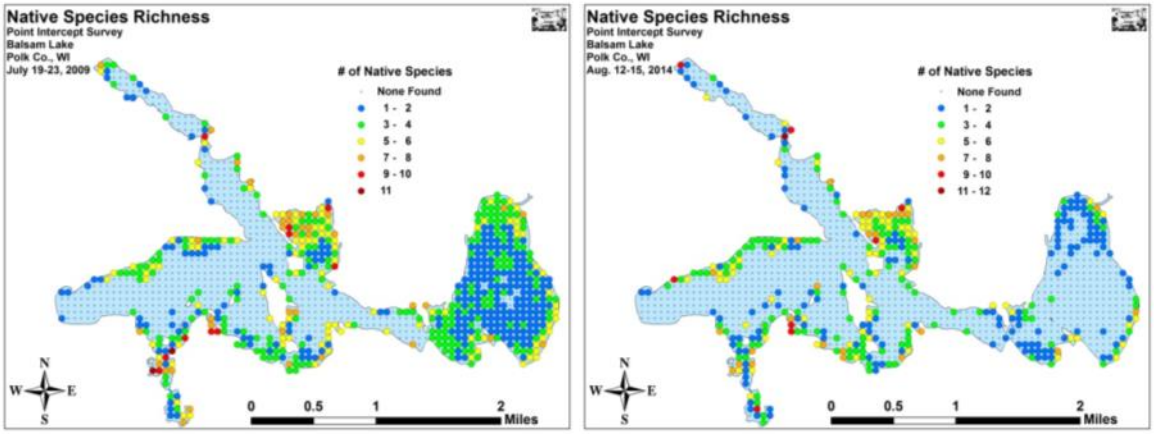


Figure 8: 2009 and 2014 Native Species Richness

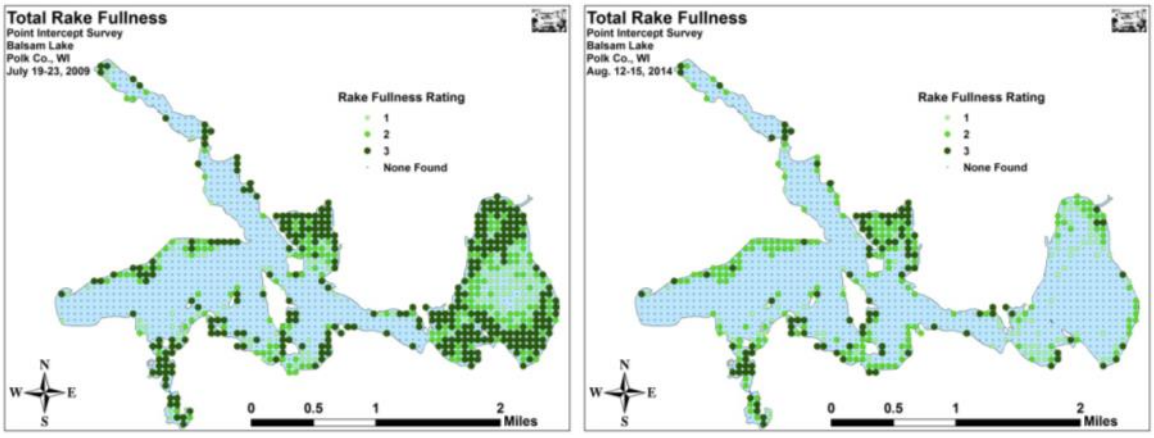


Figure 9: 2009 and 2014 Total Rake Fullness

Balsam Lake Plant Community:

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

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

Along sandy and rocky shorelines, the emergent community was dominated by Creeping spikerush (*Eleocharis palustris*) and Hardstem bulrush, while sandy muck areas supported beds of Pickerelweed (*Pontederia cordata*), Sessile-fruited arrowhead (*Sagittaria rigida*), Common bur-reed (*Sparganium eurycarpum*), and Softstem bulrush (*Schoenoplectus tabernaemontani*). At the edge of wetlands adjacent to the Rice and Harder Creek Inlets where the soil was a more nutrient rich organic muck, we documented Common arrowhead (*Sagittaria latifolia*) and Broad-leaved cattails (*Typha latifolia*). These areas also supported patches of Reed canary grass (*Phalaris arundinacea*) and sizable beds of Northern wild rice.

Creeping spikerush (Cremlin 2009)

Pickerelweed and Hardstem bulrush (Berg 2011)

Softstem bulrush (Schwarz 2011)

Common bur-reed (Raymond 2011)

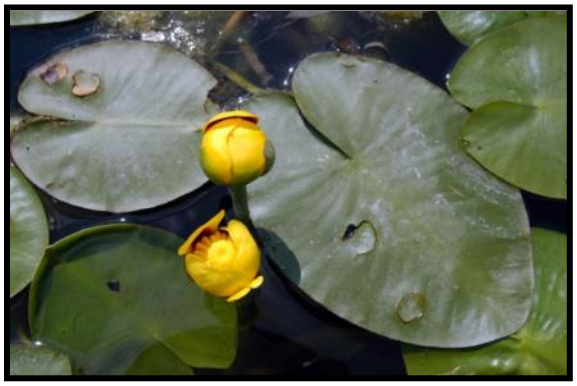
Common arrowhead (Young 2009)

Broad-leaved cattail (Raymond 2011)

Northern wild rice bed at the Rice Creek Inlet (Berg 2014)

Northern wild rice (Pippen 2009)

Just beyond the emergents, in muck-bottomed areas in up to 5ft of water, the floating-leaf species Spatterdock (*Nuphar variegata*) and White-water lily (*Nymphaea odorata*) were common throughout the lake, while Watershield (*Brasenia schreberi*), Ribbon-leaf pondweed (*Potamogeton epihydrus*), and Floating-leaf pondweed (*Potamogeton natans*), tended to be rarer and local. Large-leaf pondweed (*Potamogeton amplifolius*) and Illinois pondweed (*Potamogeton illinoensis*), two species that occasionally produce floating leaves when in shallow water, were common throughout the lake, but seldom had floating leaves. The canopy cover this community provides is often utilized by panfish and bass for protection.



Spatterdock (CBG 2014)

White water lily (Falkner 2009)

Watershield (Gmelin, 2009)

Ribbon-leaf pondweed (Petroglyph 2007)

Floating-leaf pondweed (Sein 2014)

Large-leaf pondweed (Fewless 2010)

Growing amongst these floating-leaf species, we also frequently encountered the submergent species Water marigold (*Bidens beckii*), Coontail (*Ceratophyllum demersum*), Common waterweed (*Elodea canadensis*), Whorled water milfoil (*Myriophyllum verticillatum*), Small pondweed (*Potamogeton pusillus berchtoldii*), and Fern pondweed (*Potamogeton robbinsii*). In addition to these plants, a large number of "duckweeds" were found floating among both the lilypads and the emergents. Forked duckweed (*Lemna trisulca*) was the most common of this group, and we documented it throughout the lake. Large duckweed (*Spirodela polyrhiza*), Small duckweed (*Lemna minor*), and Common watermeal (*Wolffia columbiana*) were also common, but they tended to be more restricted to shallow sheltered areas like Idlewild, Raskin, and Stump Bays as well as among the wild rice in Little Balsam.

Whorled water milfoil (Hill 2007)

Water marigold (Curtis 2010)

Along with the duckweeds, we also documented a limited number of Creeping bladderwort (*Utricularia gibba*) entangled among the submergents, and Common bladderwort (*Utricularia vulgaris*) floating among the lilypads. Rather than drawing nutrients up through roots like other macrophytes, these carnivorous plants trap zooplankton and minute insects in their bladders, digest their prey, and use the nutrients to further their growth.

Forked duckweed (Curtis 2010)

Large duckweed (Thomas 2014)

Small duckweed and Common watermeal (Kieron 2010)

Creeping bladderwort (Martins 2011)

Common bladderwort flowers among lilypads (Hunt 2010)

Bladders for catching plankton and insect larvae (Wontolla 2009)

Sand and sandy muck bottomed habitats supported few floating-leaf species. In pure sand areas, in water up to 5ft deep, we noted the plant community was dominated by generally finer leaved submergent plants like Muskgrass (*Chara* sp.), Needle spikerush (*Eleocharis acicularis*), Slender naiad (*Najas flexilis*), White water crowfoot (*Ranunculus aquatilis*, and Sago pondweed (*Stuckenia pectinata*). These species tend to form a carpet that stabilizes the bottom.

Shallow sand community on Balsam Lake (Collins 2009)

Muskgrass (Penuh 2009)

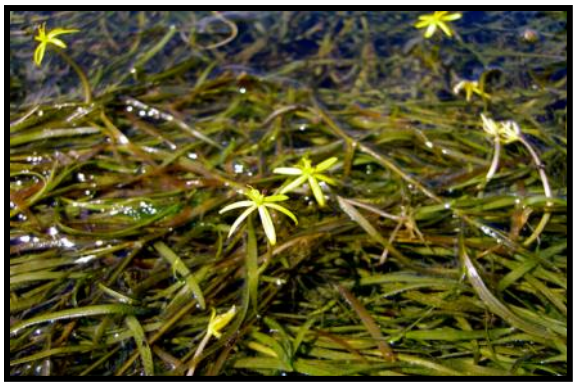
Needle spikerush (Fewless 2005)

Slender naiad (Apipp 2009)

White water crowfoot (Wasser 2014)

Sago pondweed (Hilty 2012)

Shallow sandy muck areas tended to support slightly broader-leaved species like Water star-grass (*Heteranthera dubia*), Northern water milfoil, Fries' pondweed (*Potamogeton friesii*), Illinois pondweed, Clasping-leaf pondweed, and Wild celery (*Vallisneria americana*). The roots, shoots, and seeds of these species are heavily utilized by both resident and migratory waterfowl for food. They also provide important habitat for the lake's fish throughout their lifecycles, as well as a myriad of invertebrates like scuds, dragonfly and mayfly nymphs, and snails.



Water star-grass (Mueller 2010)

Northern water milfoil (Berg 2007)

Fries pondweed (Koshere 2002)

Illinois pondweed (Cameron 2012)

Clasping-leaf pondweed (Cameron 2014)

Wild celery (Dalvi 2009)

Floating-leaf and many shallow submergent species disappeared on Balsam Lake in water over 5ft. These deeper areas were dominated by Coontail, Common waterweed, Curly-leaf pondweed, Large-leaf pondweed, Small pondweed, White-stem pondweed (*Potamogeton praelongus*), and Flat-stem pondweed (*Potamogeton zosteriformis*). Predatory fish like the lake's pike are often found along the edges of these beds waiting in ambush.

Coontail (Hassler 2011)

Common waterweed (Fischer 2009)

Small pondweed (Villa 2011)

Large-leaf pondweed (Martin 2002)

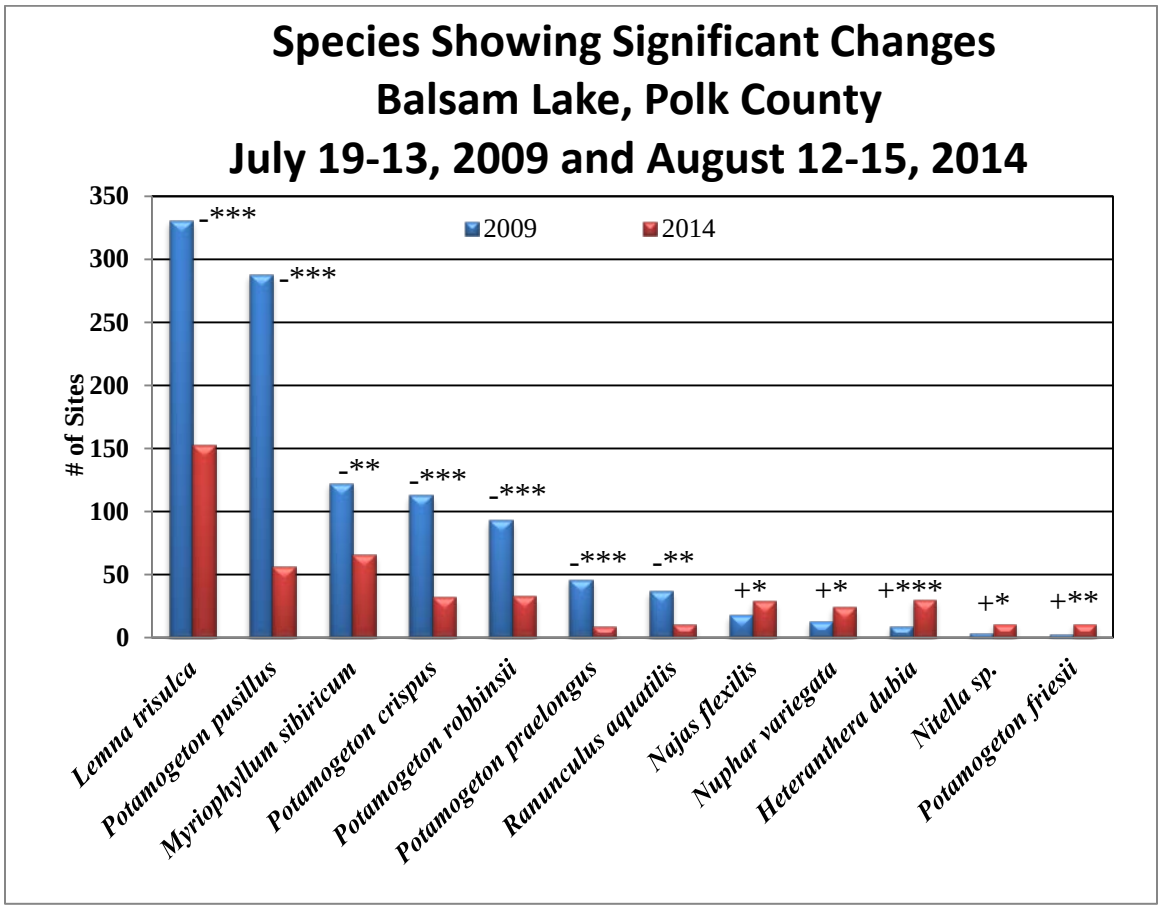
White-stem pondweed (Fewless 2005)

Flat-stem pondweed (Fewless 2004)

Comparison of Native Macrophyte Species in 2009 and 2014:

In 2009, Coontail, Forked duckweed, Small pondweed, and Flat-stem pondweed were the most common native species during the July survey (Table 3). They were present at 57.33%, 55.17%, 48.00%, and 35.33% of survey points with vegetation respectively and accounted for 55.48% of the total relative frequency (Maps for all species found at 10 or more points in July 2009 are located in Appendix VI). In 2014, Coontail and Forked duckweed were again the most common species, with Flat-stem pondweed, and Wild celery (the fifth most common species in 2009) the third and fourth most common. They were found at 64.99%, 40.85%, 40.58%, and 27.85% of sites with vegetation (Table 4) and accounted for 49.95% of the total relative frequency (Species accounts and maps for all plants found in August 2014 can be found in Appendix VII and VIII). These results suggest a slightly more diverse and even plant community existed in 2014 than in 2009.

Lakewide, 12 species showed significant changes from 2009 to 2014 (Figure 10). Forked duckweed, Small pondweed, Curly-leaf pondweed, Fern pondweed, and White-stem pondweed demonstrated highly significant declines; while Northern water milfoil and White water crowfoot experienced moderately significant declines. Conversely, Water star grass showed a highly significant increase; Fries' pondweed a moderately significant increase; and Slender naiad, Spatterdock, and Nitella significant increases.



Significant differences = * $p < .05$, ** $p < .01$, *** $p < .005$

Figure 10: Macrophytes Showing Significant Changes from 2009-2014

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
July 17-22, 2009

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Ceratophyllum demersum	Coontail	344	16.24	57.33	50.89	1.68	0
Lemna trisulca	Forked duckweed	331	15.63	55.17	48.96	1.49	0
Potamogeton pusillus	Small pondweed	288	13.60	48.00	42.60	1.90	4
Potamogeton zosteriformis	Flat-stem pondweed	212	10.01	35.33	31.36	1.55	15
	Filamentous algae	184	*	30.67	27.22	1.59	1
Vallisneria americana	Wild celery	127	6.00	21.17	18.79	1.74	5
Myriophyllum sibiricum	Northern water-milfoil	123	5.81	20.50	18.20	1.79	11
Potamogeton crispus	Curly-leaf pondweed	113	5.34	18.83	16.72	1.14	2
Potamogeton robbinsii	Fern pondweed	93	4.39	15.50	13.76	1.69	2
Elodea canadensis	Common waterweed	77	3.64	12.83	11.39	1.44	5
Potamogeton richardsonii	Clasping-leaf pondweed	65	3.07	10.83	9.62	1.35	25
Potamogeton praelongus	White-stem pondweed	46	2.17	7.67	6.80	1.33	7
Nymphaea odorata	White water lily	40	1.89	6.67	5.92	1.75	11
Ranunculus aquatilis	White water crowfoot	37	1.75	6.17	5.47	1.46	2
Lemna minor	Small duckweed	30	1.42	5.00	4.44	1.40	0
Spirodela polyrhiza	Large duckweed	29	1.37	4.83	4.29	1.66	1
Potamogeton illinoensis	Illinois pondweed	26	1.23	4.33	3.85	1.35	7
Najas flexilis	Slender naiad	18	0.85	3.00	2.66	1.56	0
Potamogeton amplifolius	Large-leaf pondweed	14	0.66	2.33	2.07	1.86	8
Wolffia columbiana	Common watermeal	14	0.66	2.33	2.07	1.43	0
Bidens beckii	Water marigold	13	0.61	2.17	1.92	1.00	1
Nuphar variegata	Spatterdock	13	0.61	2.17	1.92	1.85	10
Stuckenia pectinata	Sago pondweed	10	0.47	1.67	1.48	1.70	2
Chara sp.	Muskgrass	9	0.42	1.50	1.33	1.33	1
Heteranthera dubia	Water star-grass	9	0.42	1.50	1.33	1.11	7

* Excluded from the Relative Frequency Calculation

Table 3 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
July 17-22, 2009

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton natans	Floating-leaf pondweed	7	0.33	1.17	1.04	1.14	1
Sagittaria rigida	Sessile-fruited arrowhead	5	0.24	0.83	0.74	1.20	5
Nitella sp.	Nitella	4	0.19	0.67	0.59	1.50	0
Eleocharis acicularis	Needle spikerush	3	0.14	0.50	0.44	2.00	1
Pontederia cordata	Pickerelweed	3	0.14	0.50	0.44	3.00	4
Potamogeton friesii	Fries' pondweed	3	0.14	0.50	0.44	1.33	0
Utricularia gibba	Creeping bladderwort	3	0.14	0.50	0.44	1.00	1
Brasenia schreberi	Watershield	2	0.09	0.33	0.30	2.00	1
Utricularia vulgaris	Common bladderwort	2	0.09	0.33	0.30	1.00	0
Myriophyllum verticillatum	Whorled water-milfoil	1	0.05	0.17	0.15	1.00	0
Schoenoplectus acutus	Hardstem bulrush	1	0.05	0.17	0.15	1.00	0
Sparganium eurycarpum	Common bur-reed	1	0.05	0.17	0.15	1.00	2
Typha latifolia	Broad-leaved cattail	1	0.05	0.17	0.15	3.00	2
Zizania palustris	Northern wild rice	1	0.05	0.17	0.15	2.00	0
	Aquatic moss	1	*	0.17	0.15	1.00	0
Calla palustris	Wild calla	**	**	**	**	**	1
Eleocharis intermedia	Matted spikerush	***	***	***	***	***	***
Eleocharis palustris	Creeping spikerush	***	***	***	***	***	***
Lythrum salicaria	Purple loosestrife	***	***	***	***	***	***
Phalaris arundinacea	Reed canary grass	***	***	***	***	***	***
Potamogeton X *scolyophyllus*	Large-leaf X Illinois pondweed hybrid	***	***	***	***	***	***
Potamogeton epihydrus	Ribbon-leaf pondweed	***	***	***	***	***	***
Sagittaria latifolia	Common arrowhead	***	***	***	***	***	***
Schoenoplectus tabernaemontani	Softstem bulrush	***	***	***	***	***	***

** Visual Only *** Boat Survey Only

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
August 12-15, 2014

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Ceratophyllum demersum	Coontail	245	18.63	64.99	45.54	1.64	1
Lemna trisulca	Forked duckweed	154	11.71	40.85	28.62	1.21	1
Potamogeton zosteriformis	Flat-stem pondweed	153	11.63	40.58	28.44	1.61	18
	Filamentous algae	145	*	38.46	26.95	1.61	0
Vallisneria americana	Wild celery	105	7.98	27.85	19.52	1.58	4
Elodea canadensis	Common waterweed	69	5.25	18.30	12.83	1.41	8
Myriophyllum sibiricum	Northern water-milfoil	66	5.02	17.51	12.27	1.36	27
Potamogeton richardsonii	Clasping-leaf pondweed	60	4.56	15.92	11.15	1.43	25
Potamogeton pusillus	Small pondweed	57	4.33	15.12	10.59	1.33	8
Nymphaea odorata	White water lily	47	3.57	12.47	8.74	1.57	11
Potamogeton robbinsii	Fern pondweed	33	2.51	8.75	6.13	1.39	6
Potamogeton crispus	Curly-leaf pondweed	32	2.43	8.49	5.95	1.09	1
Heteranthera dubia	Water star-grass	30	2.28	7.96	5.58	1.20	9
Spirodela polyrhiza	Large duckweed	30	2.28	7.96	5.58	1.43	1
Lemna minor	Small duckweed	29	2.21	7.69	5.39	1.34	1
Najas flexilis	Slender naiad	29	2.21	7.69	5.39	1.28	4
Nuphar variegata	Spatterdock	24	1.83	6.37	4.46	2.25	9
Potamogeton illinoensis	Illinois pondweed	21	1.60	5.57	3.90	1.71	7
Wolffia columbiana	Common watermeal	18	1.37	4.77	3.35	1.67	1
Potamogeton amplifolius	Large-leaf pondweed	14	1.06	3.71	2.60	1.57	8
Nitella sp.	Nitella	11	0.84	2.92	2.04	1.36	0
Potamogeton friesii	Fries' pondweed	11	0.84	2.92	2.04	1.27	1
Ranunculus aquatilis	White water crowfoot	11	0.84	2.92	2.04	1.36	1
Stuckenia pectinata	Sago pondweed	10	0.76	2.65	1.86	1.80	2

* Excluded from the Relative Frequency Calculation

Table 4 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
August 12-15, 2014

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton praelongus	White-stem pondweed	9	0.68	2.39	1.67	1.56	7
Chara sp.	Muskgrass	6	0.46	1.59	1.12	1.17	1
Sagittaria rigida	Sessile-fruited arrowhead	6	0.46	1.59	1.12	1.33	2
Utricularia gibba	Creeping bladderwort	6	0.46	1.59	1.12	1.33	0
Bidens beckii	Water marigold	5	0.38	1.33	0.93	1.20	1
Pontederia cordata	Pickerelweed	5	0.38	1.33	0.93	1.80	3
Brasenia schreberi	Watershield	3	0.23	0.80	0.56	1.67	1
Myriophyllum verticillatum	Whorled water-milfoil	3	0.23	0.80	0.56	1.67	0
Sparganium eurycarpum	Common bur-reed	3	0.23	0.80	0.56	2.33	6
Utricularia vulgaris	Common bladderwort	3	0.23	0.80	0.56	1.00	1
Zizania palustris	Northern wild rice	3	0.23	0.80	0.56	1.33	1
	Aquatic moss	2	*	0.53	0.37	1.00	0
Calla palustris	Wild calla	1	0.08	0.27	0.19	1.00	0
Potamogeton epihydrus	Ribbon-leaf pondweed	1	0.08	0.27	0.19	2.00	0
Potamogeton natans	Floating-leaf pondweed	1	0.08	0.27	0.19	1.00	0
Typha latifolia	Broad-leaved cattail	1	0.08	0.27	0.19	3.00	0
Eleocharis acicularis	Needle spikerush	***	***	***	***	***	***
Eleocharis intermedia	Matted spikerush	***	***	***	***	***	***
Eleocharis palustris	Creeping spikerush	***	***	***	***	***	***
Lythrum salicaria	Purple loosestrife	***	***	***	***	***	***
Phalaris arundinacea	Reed canary grass	***	***	***	***	***	***
Sagittaria latifolia	Common arrowhead	***	***	***	***	***	***
Schoenoplectus acutus	Hardstem bulrush	***	***	***	***	***	***
Schoenoplectus tabernaemontani	Softstem bulrush	***	***	***	***	***	***

** Visual Only *** Boat Survey Only

Coontail, the most common species in both 2009 and 2014, continues to be abundant throughout the main lake, but disappeared from most areas that it had formerly inhabited in East Balsam. This was especially true in the north bay (Figure 11). Found at 344 sites in 2009, it demonstrated a nearly significant decline in distribution to 245 sites in 2014; although its mean rake fullness value was almost unchanged from 1.68 in 2009 to 1.64 in 2014.

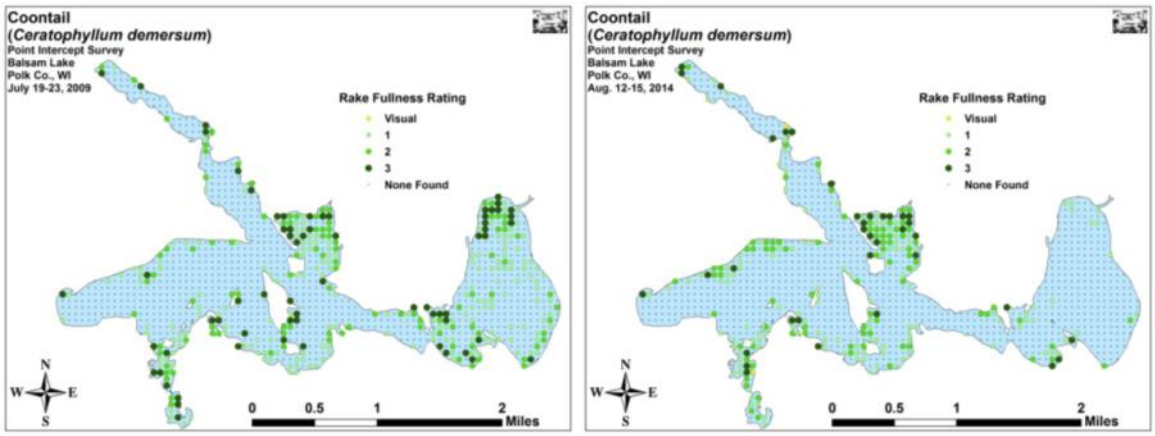


Figure 11: 2009 and 2014 Coontail Density and Distribution

Forked duckweed's highly significant decline in distribution (331 sites in 2009 to 154 sites in 2014) and density (mean rake fullness of 1.49 in 2009 to 1.21 in 2014) appears to have been lakewide (Figure 12). The second most common species in each year, we have historically found it growing in areas that had significant Curly-leaf pondweed stands in June as the nutrient release from CLP's early summer senescence seems to fuel its growth and expansion. In 2014, the large scale herbicide treatment to control CLP in East Balsam coupled with generally low levels of CLP in the main basin may explain Forked duckweed's relative scarcity.

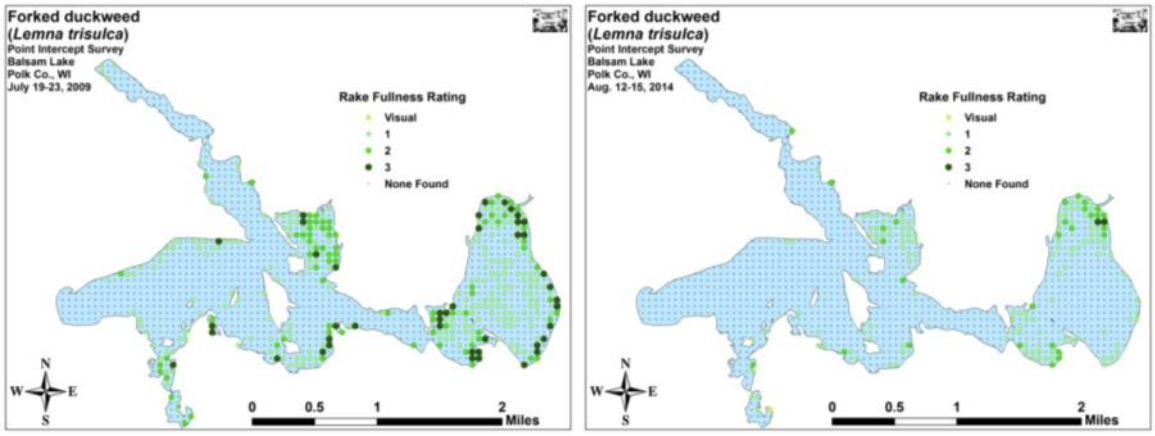


Figure 12: 2009 and 2014 Forked Duckweed Density and Distribution

Small pondweed was the third most common macrophyte species in 2009, but only the eighth most common in 2014. Its highly significant decline in numbers (288 sites in 2009 to 57 in 2014) was accompanied by a significant decline in density (mean rake fullness of 1.90 in 2009 to 1.33 in 2014). In 2009, this species formed a dense, nearly monotypic carpet that covered the majority of the deep flat in East Balsam. At this time, we found plants dominated the 10-18ft bathymetric ring and grew from 8-10ft in height producing a dense "forest" of habitat throughout much of the area. The maps for this species show that, while it was all but eliminated from East Balsam, it remained relatively unchanged in the main lake (Figure 13). This was also the case for Flat-stem pondweed which we found to be the fourth most common species in 2009 (212 sites and a mean rake fullness of 1.55) and the third most common in 2014 (153 sites and a mean rake fullness of 1.61) (Figure 14).

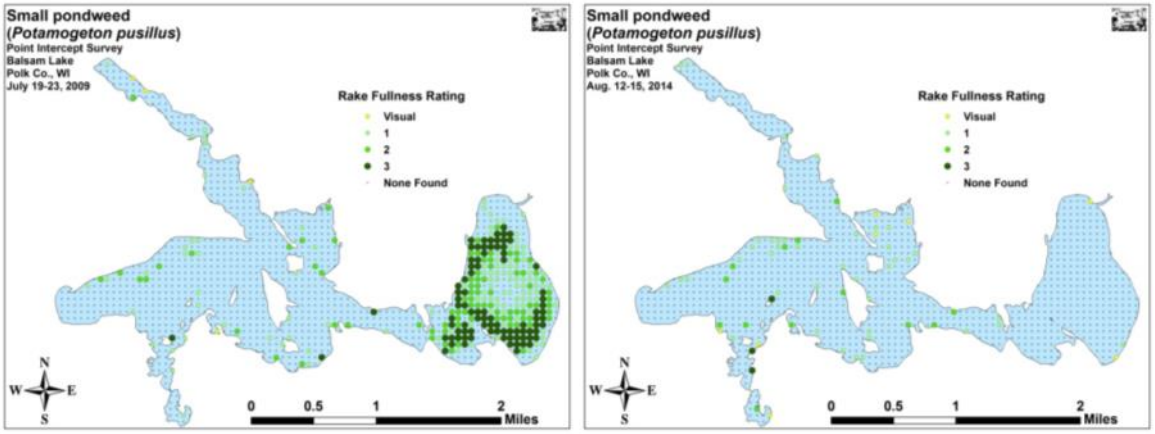


Figure 13: 2009 and 2014 Small Pondweed Density and Distribution

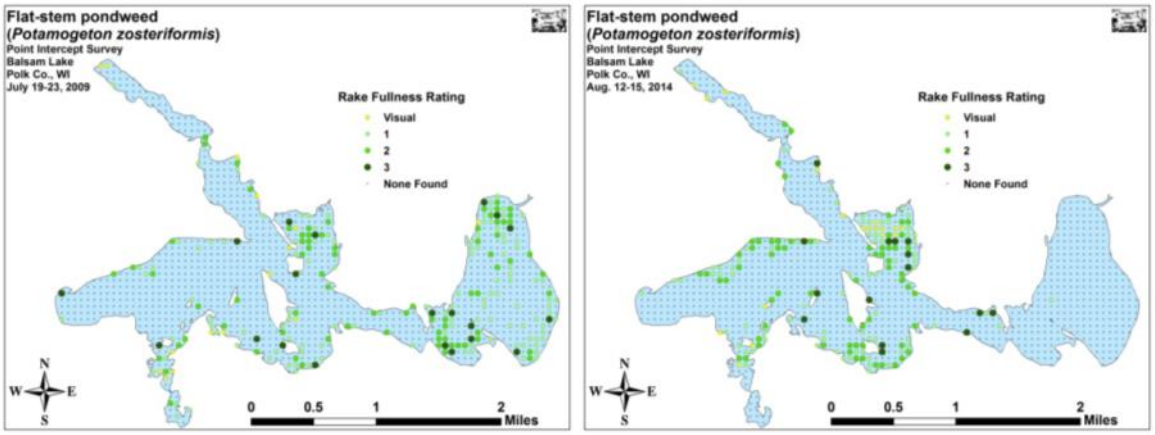


Figure 14: 2009 and 2014 Flat-stem Pondweed Density and Distribution

Comparison of Northern Wild Rice in 2009 and 2014:

Wild rice, a plant of significant wildlife and cultural value, showed an insignificant increase from 2009 to 2014 (Figure 15). In 2009, we found it in the rake at a single point which had a rake fullness of 2. In 2014, it was present in the rake at three points with a mean rake fullness of 1.33.

All significant rice stands were established in the far ends of Little Balsam and Stump Bay at the Rice and Harder Creek Inlets, and, outside these two areas, we did not find rice anywhere in the system (Figure 16). These bays have filled in with plants over time to the point that there is now just a few inches to a foot of water over many feet of muck and detritus. Despite the single rice plant at our survey point on the far downstream edge of the bed in Little Balsam, we estimated an overall mean rake fullness of 3 along the creek inlet as far upstream as we could see. This high density bed would have been profitable for human harvest; although shallow water in the bed would have made navigation difficult. At the Harder Creek Inlet, the water was even shallower, and the many stumps and floating muck bogs coupled with a low overall rice density that varied from <1-2 with an estimated mean rake fullness of 1 likely meant that human harvest in these beds would not have been profitable. Despite this, we noted large numbers of waterfowl and other wildlife utilizing this important habitat area during each of our trips to the lake.

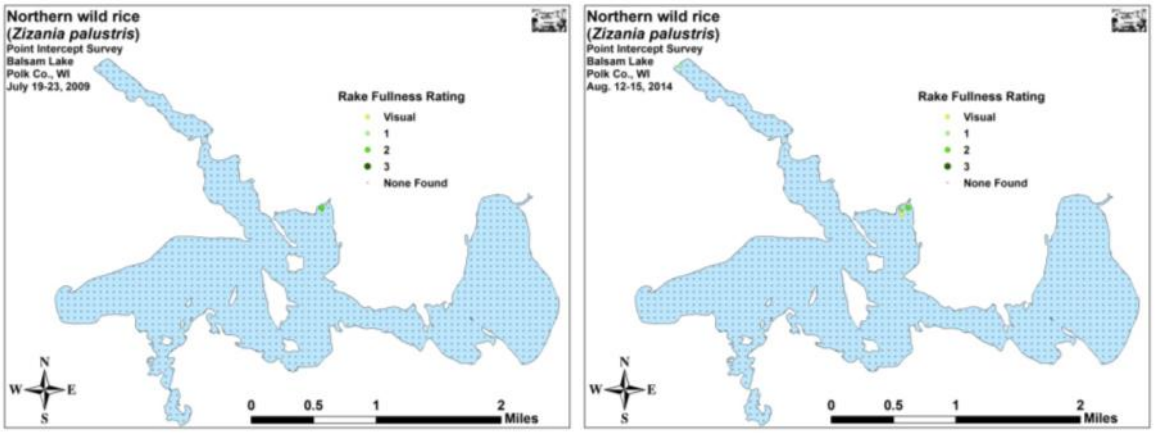


Figure 15: 2009 and 2014 Northern Wild Rice Density and Distribution

Figure 16: Dense Wild Rice Beds at the Rice Creek Inlet and Patchy Rice at the Harder Creek Inlet - August 2014

Comparison of Filamentous Algae in 2009 an 2014:

Filamentous algae, normally associated with excessive nutrients in the water column, was located at 145 survey points – a 21% decrease from the 184 points we found it at in 2009 (Figure 17). Most of the highest density algae areas were located in shallow muck-bottomed bays; especially Stump Bay, the bays located on either side of the Big Narrows, and in the north bay of East Balsam.

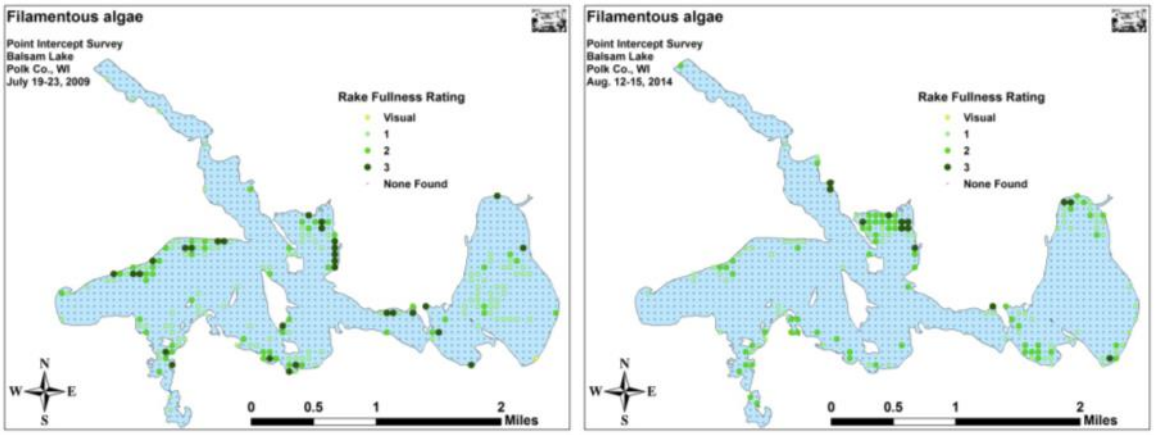


Figure 17: 2009 and 2014 Filamentous Algae Density and Distribution

Comparison of Floristic Quality Indexes in 2009 and 2014:

In 2009, we identified a total of 37 **native index species** in the rake during the point-intercept survey (Table 5). They produced a mean Coefficient of Conservatism of 6.1 and a Floristic Quality Index of 37.2.

Table 5: Floristic Quality Index of Aquatic Macrophytes
Balsam Lake, Polk County
July 17-22, 2009

Species	Common Name	C
Bidens beckii	Water marigold	8
Brasenia schreberi	Watershield	6
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	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum verticillatum	Whorled water-milfoil	8
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	8
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	Fern pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8
Sagittaria rigida	Sessile-fruited arrowhead	8
Schoenoplectus acutus	Hardstem bulrush	6
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		**37**
Mean C		**6.1**
FQI		**37.2**

In 2014, we again identified a total of 37 **native index plants** on the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 6.3 and a Floristic Quality Index of 38.1 (Table 6). Nichols (1999) reported an average mean C for the North Central Hardwood Forests Region of 5.6 putting Balsam Lake above average for this part of the state. The FQI was also nearly double the median FQI of 20.9 for the North Central Hardwood Forests (Nichols 1999). Twelve high value index plants of note included Water marigold (C = 8), Wild calla (C = 9), Whorled water milfoil (C = 8), Pickerelweed (C = 8), Ribbon-leaf pondweed (C = 8), Fries' pondweed (C = 8), White-stem pondweed (C = 8), Fern pondweed (C = 8), White water crowfoot (C = 8), Sessile-fruited arrowhead (C = 8), Creeping bladderwort (C = 9), and Northern wild rice (C = 8). Both the mean C and the total FQI were fractionally higher than in 2009. This may indicate a slight change in annual growing conditions or the lake's habitat, improvements in the detection and identification abilities of the surveyors, or a combination of these factors.

Table 6: Floristic Quality Index of Aquatic Macrophytes
Balsam Lake, Polk County
August 12-15, 2014

Species	Common Name	C
Bidens beckii	Water marigold	8
Brasenia schreberi	Watershield	6
Calla palustris	Wild calla	9
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum verticillatum	Whorled water-milfoil	8
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	8
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton epihydrus	Ribbon-leaf pondweed	8
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	Fern pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8

Table 6 (cont'): Floristic Quality Index of Aquatic Macrophytes
Balsam Lake, Polk County
August 12-15, 2014

Species	Common Name	C
Sagittaria rigida	Sessile-fruited arrowhead	8
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		**37**
Mean C		**6.3**
FQI		**38.1**

Other Exotic Plant Species:

In addition to Curly-leaf pondweed, we found two other exotic species growing adjacent to Balsam Lake: Reed canary grass and Purple loosestrife (*Lythrum salicaria*).

Despite only being reported from the boat survey, Reed canary grass was often a dominant plant just beyond the lakeshore (Figure 18). We noticed patches in wetlands adjacent to the lake and next to mowed and otherwise disturbed shorelines. A ubiquitous plant in the state, there's likely little that can be done about it.

Figure 18: Reed Canary Grass Near the City Beach

Purple loosestrife was scattered and local along muck bottomed shorelines in the bays south of First Island (Figure 19). We first noted loosestrife on the lake near the Village Beach in 2009 during the original point-intercept survey. In 2013, we found it had expanded and formed several large beds in Idlewild Bay among the shoreline/nearshore vegetation directly down the hill from (north of) the Holiday station/store. At this time, we contacted the Polk County Land and Water Resources Dept. (PCLWRD), notified them of the infestations, and clarified that plans were in place to release Galerucella beetles (a natural biocontrol that specializes in eating loosestrife) during the 2014 growing season. During the August 2014 survey, we noted extensive damage from beetles on loosestrife plants in Idlewild Bay and in the bay near the Village Beach (Figure 20). A follow-up call to PCLWRD confirmed that they were in fact able to raise and release beetles on the lake; however, they only released them in Idlewild Bay. This suggests that the beetles are spreading on their own (Eric Wojchik pers. comm). Unfortunately, we found no evidence of beetles on the most northerly plants in and around First Island (For more information on select aquatic exotic species, see Appendix IX).

Figure 19: Purple Loosestrife East of First Island - August 17, 2014

Figure 20: Loosestrife Near the Village Beach with Heavy Beetle Damage

Comparison of East Balsam in 2009 and 2014:

Visual analysis of both species maps and community data suggested the majority of changes observed from 2009 to 2014 occurred in East Balsam. Because of this, and because the majority of herbicide use to control Curly-leaf pondweed over that time has occurred here, we separated out the data from East Balsam for further analysis (Table 7).

Table 7: Aquatic Macrophyte P/I Survey Summary Statistics East Balsam Lake, Polk County July 21-22, 2009 and August 15, 2014

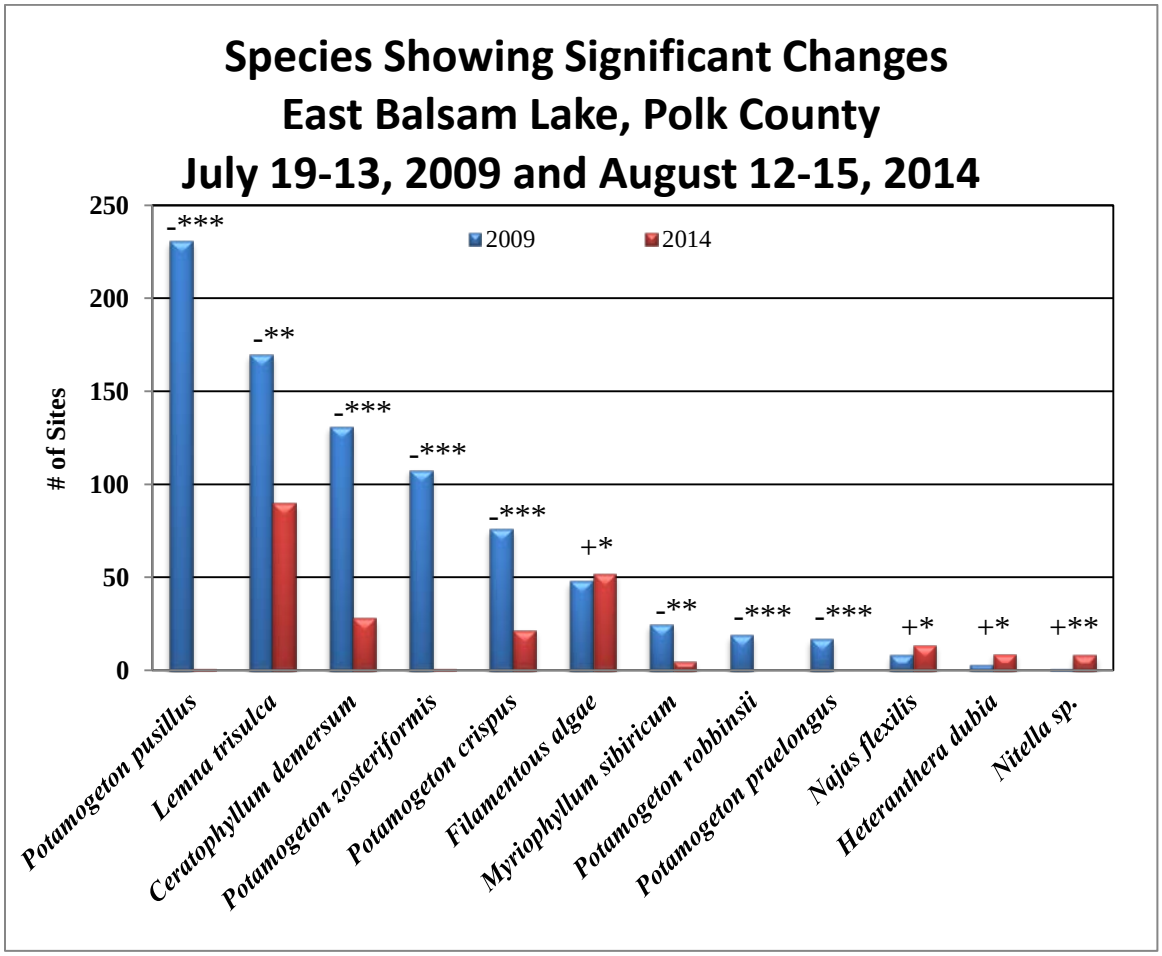
Summary Statistics:	2009	2014
Total number of points sampled	309	309
Total number of sites with vegetation	301	102
Total number of sites shallower than the maximum depth of plants	309	214
Frequency of occurrence at sites shallower than maximum depth of plants	97.41	47.66
Simpson Diversity Index	0.84	0.83
Number of Floristic Quality Index Species (N)	28	22
Mean Coefficient of Conservatism (C)	6.0	5.8
Floristic Quality Index (FQI)	31.7	27.1
Maximum depth of plants (ft)	19.0	15.5
Mean depth of plants (ft)	12.5	8.0
Median depth of plants (ft)	14.0	7.5
Average number of all species per site (shallower than max depth)	2.82	1.18
Average number of all species per site (veg. sites only)	2.89	2.47
Average number of native species per site (shallower than max depth)	2.57	1.07
Average number of native species per site (sites with native veg. only)	2.64	2.28
Species richness	29	23
Species richness (including visuals)	29	23
Mean rake fullness (veg. sites only)	2.31	1.59

After finding plants growing at almost every survey point in 2009 (all of East Balsam fell within the 19ft littoral zone and plants were present at 97.4% of survey points), in 2014, we found plants at just 33.0% of survey points and in 47.7% of the 15.5ft littoral zone. Mean and median depths both showed significant declines with the mean dropping 3.5ft from 12.5 to 8.0ft and the median dropping 6.5ft from 14.0 to 7.5ft. Average native species at sites with native species also declined from 2.64 species/site to 2.28 species/site. Mean rake fullness showed a highly significant decline from a moderately high 2.31 to a low moderate 1.59. This was not surprising as the majority of sites over 10ft that had been dominated by dense Small pondweed beds in 2009 often produced little more than a single Forked duckweed plant in 2014.

In 2009, Small pondweed, Forked duckweed, Coontail, and Flat-stem pondweed were the most common species (Table 8). They were present at 76.74%, 56.48%, 43.52%, and 35.88% of survey points with vegetation respectively and accounted for a very high 73.48% of the total relative frequency. In 2014, Forked duckweed and Coontail were again the most common species, with Wild celery and Curly-leaf pondweed being the

third and fourth most common. They were found at 88.24%, 27.45%, 23.53%, and 21.57% of sites with vegetation (Table 9) and accounted for 65.08% of the total relative frequency. These results suggest a slightly more even plant community existed in 2014 than in 2009; however, the Simpson's Diversity Index, Total N, Mean C, FQI, and Species Richness values all showed slight to moderate declines.

In East Balsam, 11 macrophytes and Filamentous algae showed significant changes from 2009 to 2014 (Figure 21). Small pondweed, Coontail, Flat-stem pondweed, Curly-leaf pondweed, Fern pondweed, and White-stem pondweed all demonstrated highly significant declines; while Forked duckweed and Northern water milfoil experienced moderately significant declines. Conversely, Nitella showed a moderately significant increase; and Filamentous algae, Slender naiad, and Water star grass significant increases. These results suggest that species that over winter (Coontail, Fern pondweed, and White-stem pondweed) as well as those that start growing early in the spring prior to herbicide application (Small pondweed, Flat-stem pondweed, Curly-leaf pondweed, and Northern water milfoil) suffered the biggest declines; while species that reproduce from seeds/oogonia (Slender naiad and Nitella) or start growing later in the spring (Water star-grass) expanded – presumably into habitat vacated by other species.



Significant differences = * $p < .05$, ** $p < .01$, *** $p < .005$

Figure 21: Significant Macrophyte Changes – East Balsam - 2009-2014

Table 8: Frequencies and Mean Rake Sample of Aquatic Macrophytes
East Balsam Lake, Polk County
July 21-22, 2009

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton pusillus	Small pondweed	231	26.52	76.74	74.76	2.01	0
Lemna trisulca	Forked duckweed	170	19.52	56.48	55.02	1.52	0
Ceratophyllum demersum	Coontail	131	15.04	43.52	42.39	1.60	0
Potamogeton zosteriformis	Flat-stem pondweed	108	12.40	35.88	34.95	1.53	1
Potamogeton crispus	Curly-leaf pondweed	76	8.73	25.25	24.60	1.12	0
	Filamentous algae	48	*	15.95	15.53	1.33	1
Myriophyllum sibiricum	Northern water-milfoil	25	2.87	8.31	8.09	1.84	2
Vallisneria americana	Wild celery	23	2.64	7.64	7.44	1.83	2
Potamogeton robbinsii	Fern pondweed	19	2.18	6.31	6.15	1.68	1
Potamogeton praelongus	White-stem pondweed	17	1.95	5.65	5.50	1.29	2
Potamogeton richardsonii	Clasping-leaf pondweed	9	1.03	2.99	2.91	1.44	1
Elodea canadensis	Common waterweed	8	0.92	2.66	2.59	1.38	0
Najas flexilis	Slender naiad	8	0.92	2.66	2.59	1.75	0
Ranunculus aquatilis	White water crowfoot	7	0.80	2.33	2.27	1.57	0
Stuckenia pectinata	Sago pondweed	6	0.69	1.99	1.94	1.83	0
Potamogeton illinoensis	Illinois pondweed	5	0.57	1.66	1.62	1.80	1
Bidens beckii	Water marigold	4	0.46	1.33	1.29	1.00	0
Nuphar variegata	Spatterdock	4	0.46	1.33	1.29	1.75	1
Heteranthera dubia	Water star-grass	3	0.34	1.00	0.97	1.33	2
Nymphaea odorata	White water lily	3	0.34	1.00	0.97	2.00	2
Lemna minor	Small duckweed	2	0.23	0.66	0.65	1.00	0
Pontederia cordata	Pickerelweed	2	0.23	0.66	0.65	3.00	0
Sagittaria rigida	Sessile-fruited arrowhead	2	0.23	0.66	0.65	1.00	1
Spirodela polyrhiza	Large duckweed	2	0.23	0.66	0.65	1.50	0
Chara sp.	Muskgrass	1	0.11	0.33	0.32	1.00	0

* Excluded from the Relative Frequency Calculation

Table 8 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
East Balsam Lake, Polk County
July 17-22, 2009

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Eleocharis acicularis	Needle spikerush	1	0.11	0.33	0.32	1.00	0
Nitella sp.	Nitella	1	0.11	0.33	0.32	1.00	0
Potamogeton amplifolius	Large-leaf pondweed	1	0.11	0.33	0.32	3.00	0
Sparganium eurycarpum	Common bur-reed	1	0.11	0.33	0.32	1.00	1
Wolffia columbiana	Common watermeal	1	0.11	0.33	0.32	1.00	0

Table 9: Frequencies and Mean Rake Sample of Aquatic Macrophytes
East Balsam Lake, Polk County
August 15, 2014

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Lemna trisulca	Forked duckweed	90	35.71	88.24	42.06	1.26	0
	Filamentous algae	52	*	50.98	24.30	1.44	0
Ceratophyllum demersum	Coontail	28	11.11	27.45	13.08	1.43	0
Vallisneria americana	Wild celery	24	9.52	23.53	11.21	1.63	3
Potamogeton crispus	Curly-leaf pondweed	22	8.73	21.57	10.28	1.14	1
Najas flexilis	Slender naiad	14	5.56	13.73	6.54	1.36	2
Elodea canadensis	Common waterweed	11	4.37	10.78	5.14	1.09	1
Heteranthera dubia	Water star-grass	9	3.57	8.82	4.21	1.11	2
Nitella sp.	Nitella	8	3.17	7.84	3.74	1.50	0
Lemna minor	Small duckweed	5	1.98	4.90	2.34	1.00	0
Myriophyllum sibiricum	Northern water-milfoil	5	1.98	4.90	2.34	1.00	4
Nymphaea odorata	White water lily	5	1.98	4.90	2.34	1.60	3
Spirodela polyrhiza	Large duckweed	5	1.98	4.90	2.34	1.00	0
Stuckenia pectinata	Sago pondweed	5	1.98	4.90	2.34	2.20	1
Nuphar variegata	Spatterdock	4	1.59	3.92	1.87	2.25	1
Ranunculus aquatilis	White water crowfoot	4	1.59	3.92	1.87	1.25	0
Chara sp.	Muskgrass	3	1.19	2.94	1.40	1.00	0
Potamogeton richardsonii	Clasping-leaf pondweed	3	1.19	2.94	1.40	1.33	4
Pontederia cordata	Pickerelweed	2	0.79	1.96	0.93	3.00	0
	Aquatic moss	2	*	1.96	0.93	1.00	0
Potamogeton illinoensis	Illinois pondweed	1	0.40	0.98	0.47	2.00	2
Potamogeton pusillus	Small pondweed	1	0.40	0.98	0.47	1.00	2
Potamogeton zosteriformis	Flat-stem pondweed	1	0.40	0.98	0.47	1.00	0
Sagittaria rigida	Sessile-fruited arrowhead	1	0.40	0.98	0.47	1.00	0
Sparganium eurycarpum	Common bur-reed	1	0.40	0.98	0.47	2.00	2

* Excluded from the Relative Frequency Calculation

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Native Aquatic Macrophytes:

Aquatic plants are the basis of a lake's ecosystem and are as important to the aquatic environment as trees are to a forest. They provide habitat for fish and other aquatic organisms, serve as food sources for waterfowl and other wildlife, stabilize the shoreline, and work to improve clarity by absorbing nutrients from the water. On the main lake, sharp drop-offs into deep water often produced a narrow littoral zone, and, in East Balsam, the loss of most broad-leaved habitat producing plants resulted in a much more limited plant community than what existed in 2009. Because of this, preserving the plants that are there, especially the floating-leaf beds of lilypads and the emergent beds of rushes which provide critical habitat for the lake's fish, should be a top priority for all lake residents.

Curly-leaf pondweed:

The aggressive management of Curly-leaf pondweed over the past five years has significantly reduced the overall area and density of this exotic invasive species in the lake, and working to maintain these low levels seems advisable. As CLP thrives on disturbance, residents can help prevent its spread by maintaining the lake's native vegetation. Such things as motor start ups in shallow water, boating through native plant beds, and excessive removal of plants in front of their shoreline all create barren patches of substrate that can give CLP a competitive advantage where it can reestablish and start to spread again.

Purple Loosestrife:

Purple loosestrife continues to expand north and east away from the source populations near the Village Beach and in Idlewild Bay. Although most plants in the source area had beetles on them, the most northerly plants showed no evidence of beetle herbivory. Because of this, we believe an additional release in 2015 is warranted if the beetles don't colonize the area on their own. Perhaps more troubling, we noted several shoreline owners had removed all the vegetation down to the lakeshore, but mowed around loosestrife plants. Although their blooms are beautiful, putting a note in the summer 2015 edition of the "Dockside" to remind people how rapidly this species can expand, and why they should remove any PL that shows up on their property might also be an idea worth considering.

To prevent further spread, residents should watch for and remove loosestrife plants in August/September when the bright fuchsia candle-shaped flower spikes are easily seen. Plants should be bagged and disposed of well away from any wetland. Also, because the plants have an extensive root system, care should be taken to remove the entire plant as even small root fragments can survive and produce new plants the following year.

Eurasian Water Milfoil:

Eurasian water milfoil has now expanded into four lakes in Polk County all of which have public landings and in/out boat traffic. Because of this, we recommend the lake continues its Clean Boats/Clean Waters program to inspect watercraft, and its monthly transect surveys near the lake's boat landings throughout the growing season. These practices decrease the likelihood EWM will be introduced into the lake, and could allow for early detection if EWM or another Aquatic Invasive Species is introduced. The sooner an AIS is detected, the greater the chances it can be successfully and economically controlled.

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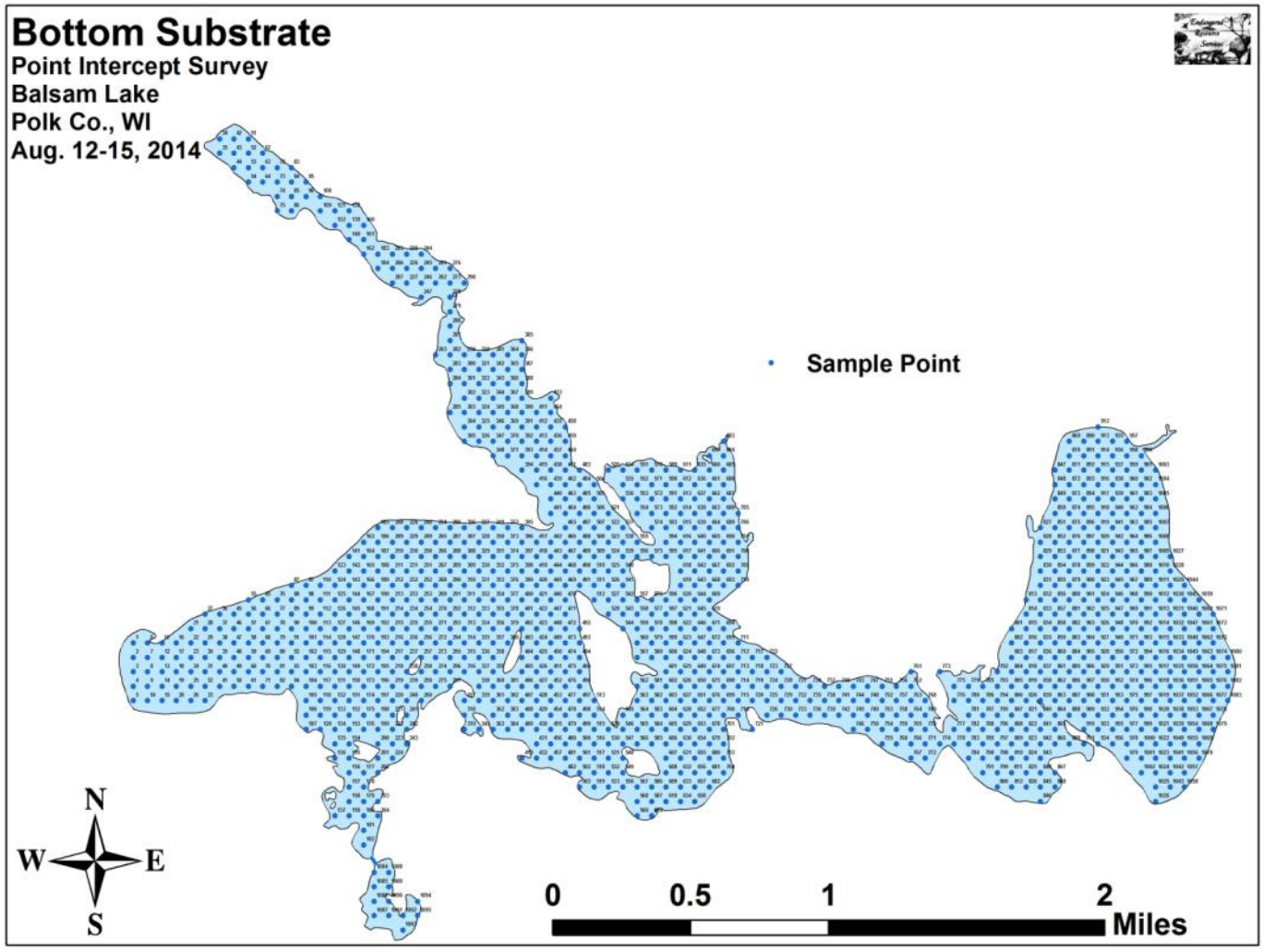
WDNR. [online]. 2010. Eurasian water milfoil fact sheet. http://dnr.wi.gov/invasives/fact/milfoil.htm (2010, August).

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

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

Appendix I: Survey Sample Points Map

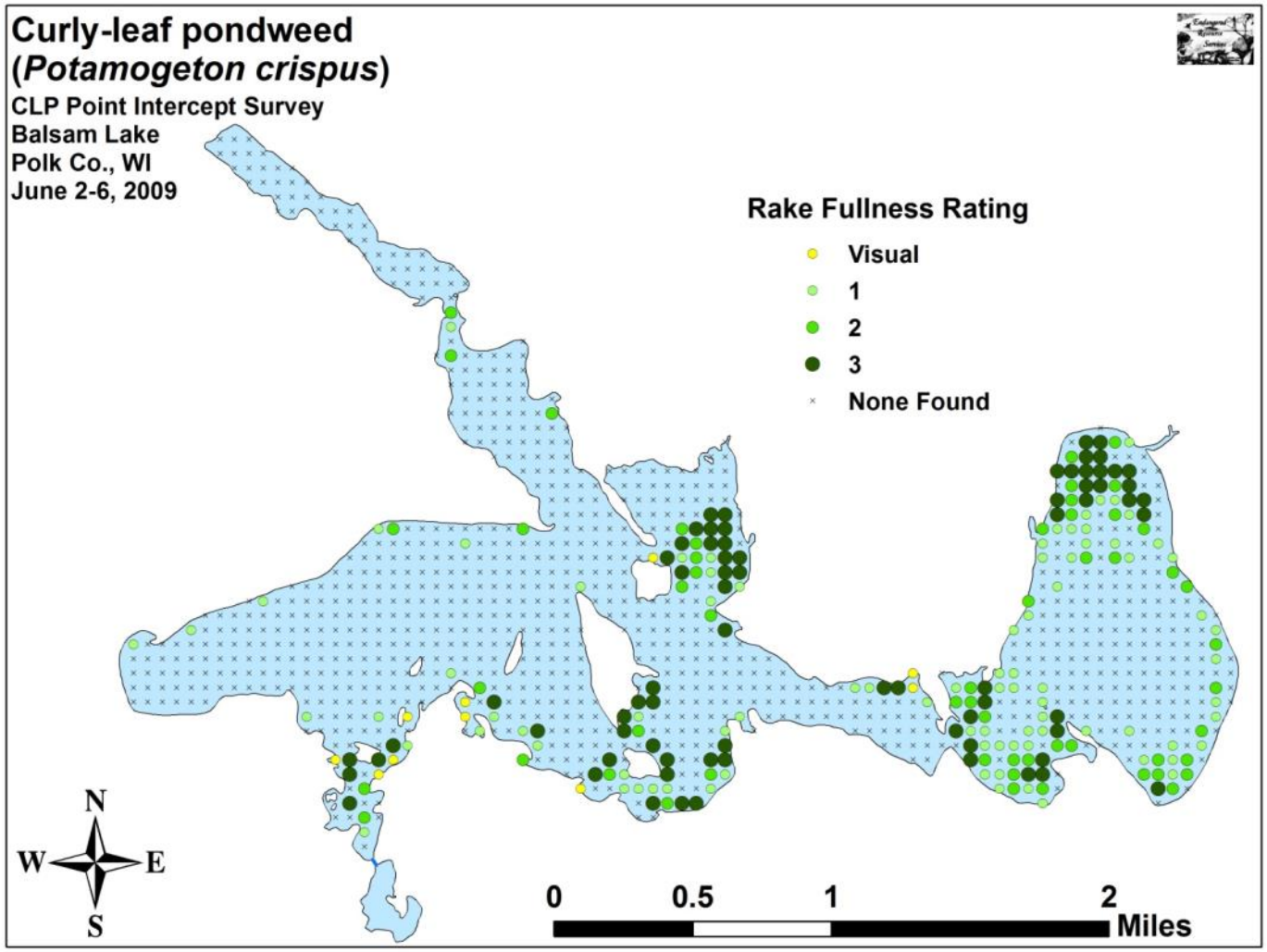

Bottom Substrate
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Sample Point
N
W
E
S
0
0.5
1
2
Miles

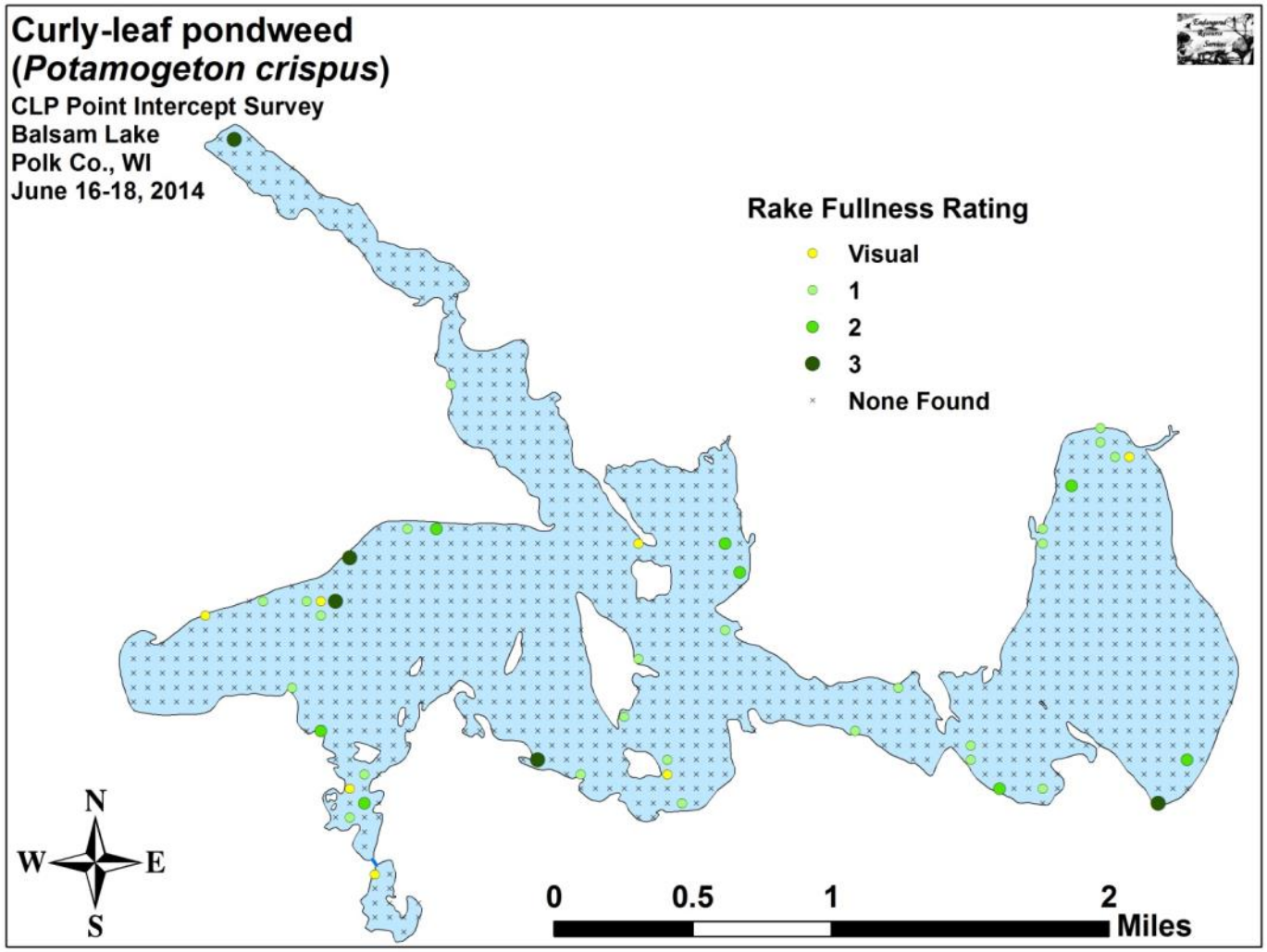
Appendix II: Boat and Vegetative Survey Data Sheets

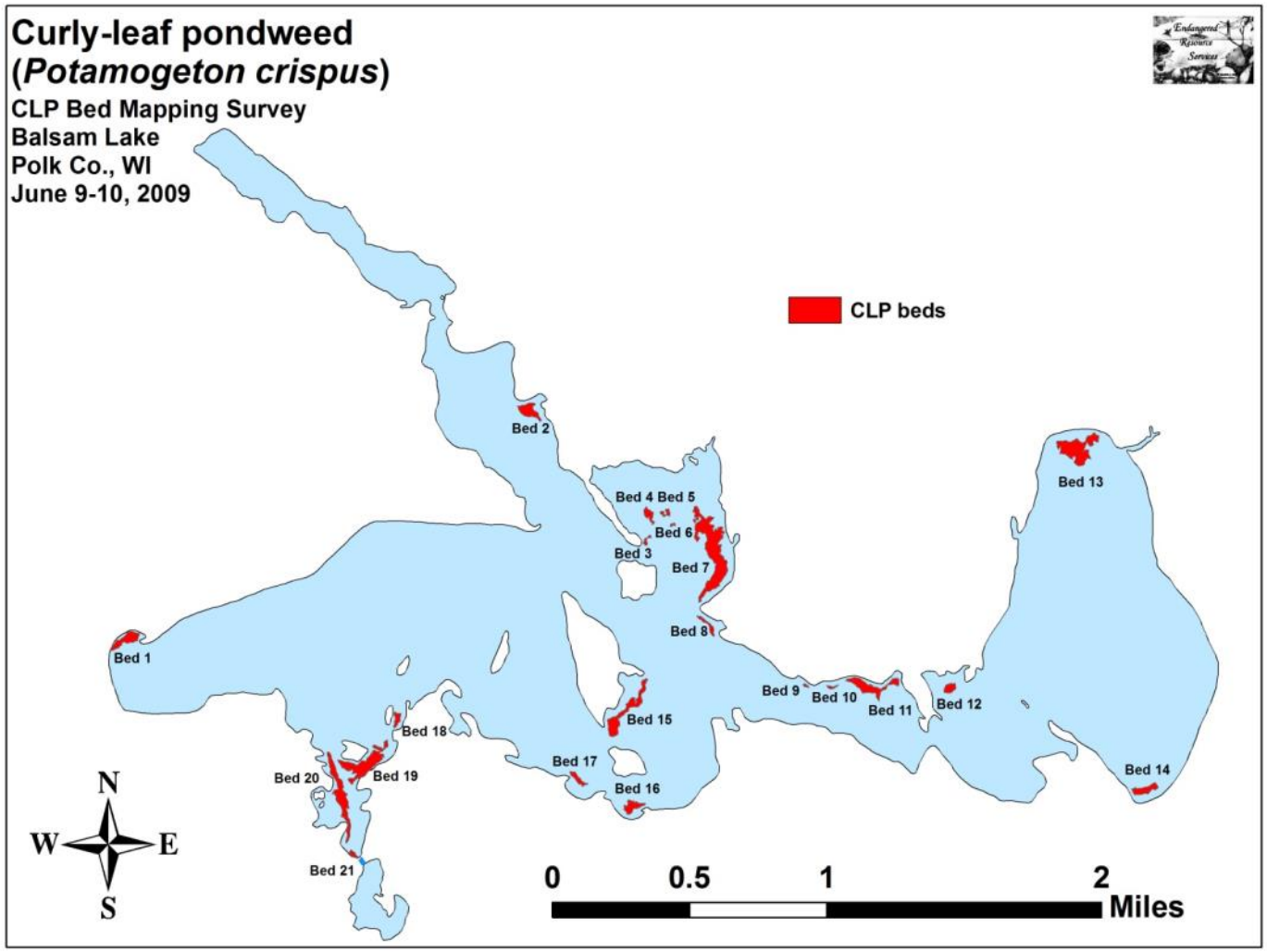
Boat Survey	
Lake Name	
County	
WBIC	
Date of Survey	
(mm/dd/yy)	
workers	
Nearest Point	**Species seen, habitat information**

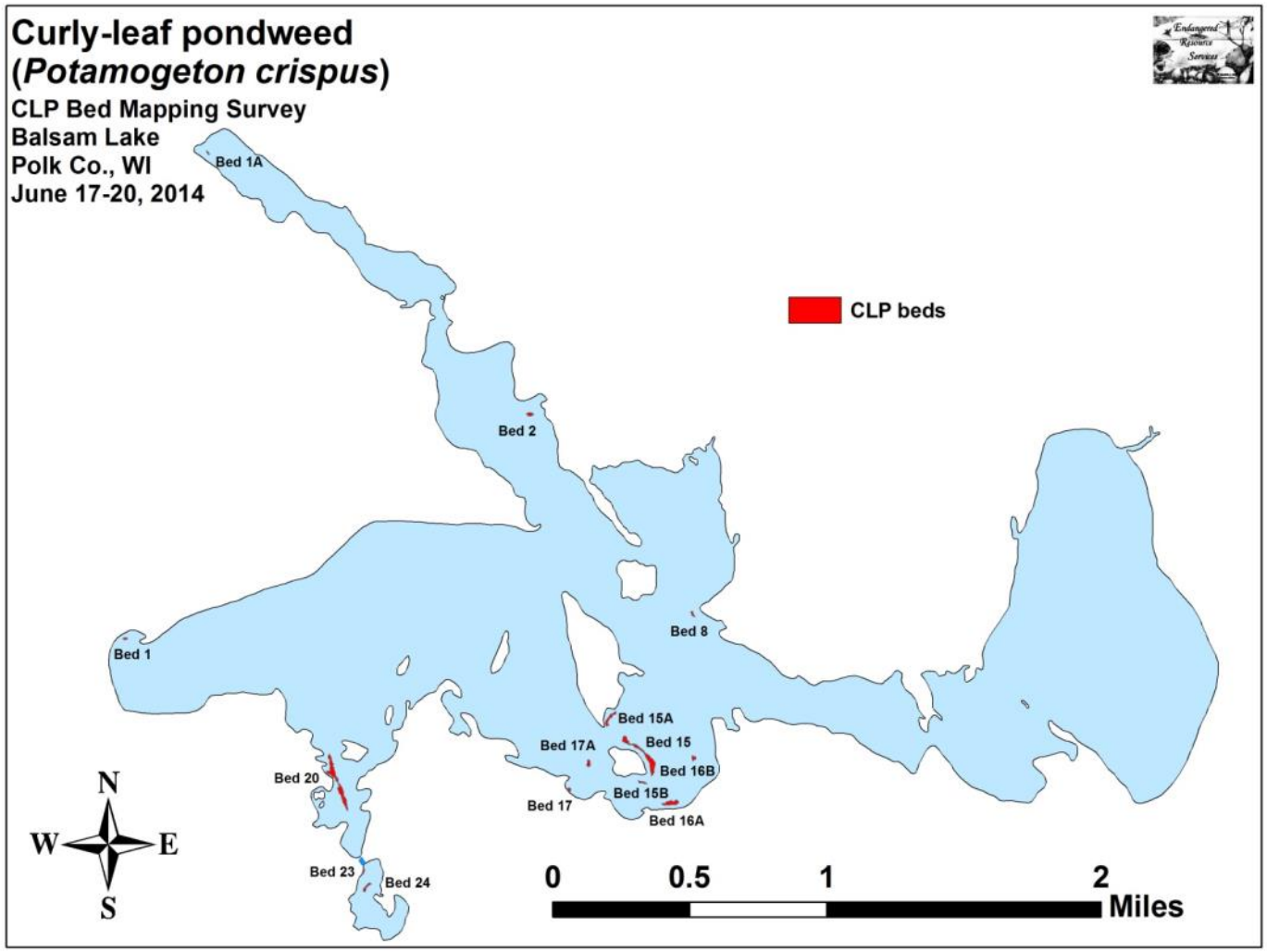
Observers for this lake: names and hours worked by each:																										
Lake:									WBIC									County						Date:	
Site #	Depth (ft)	Muck (M), Sand (S), Rock (R)	Rake pole (P) or rake rope (R)	Total Rake Fullness	EWM	CLP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1																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

Appendix III: 2009 and 2014 Early Season CLP Density and Distribution and CLP Bed Maps

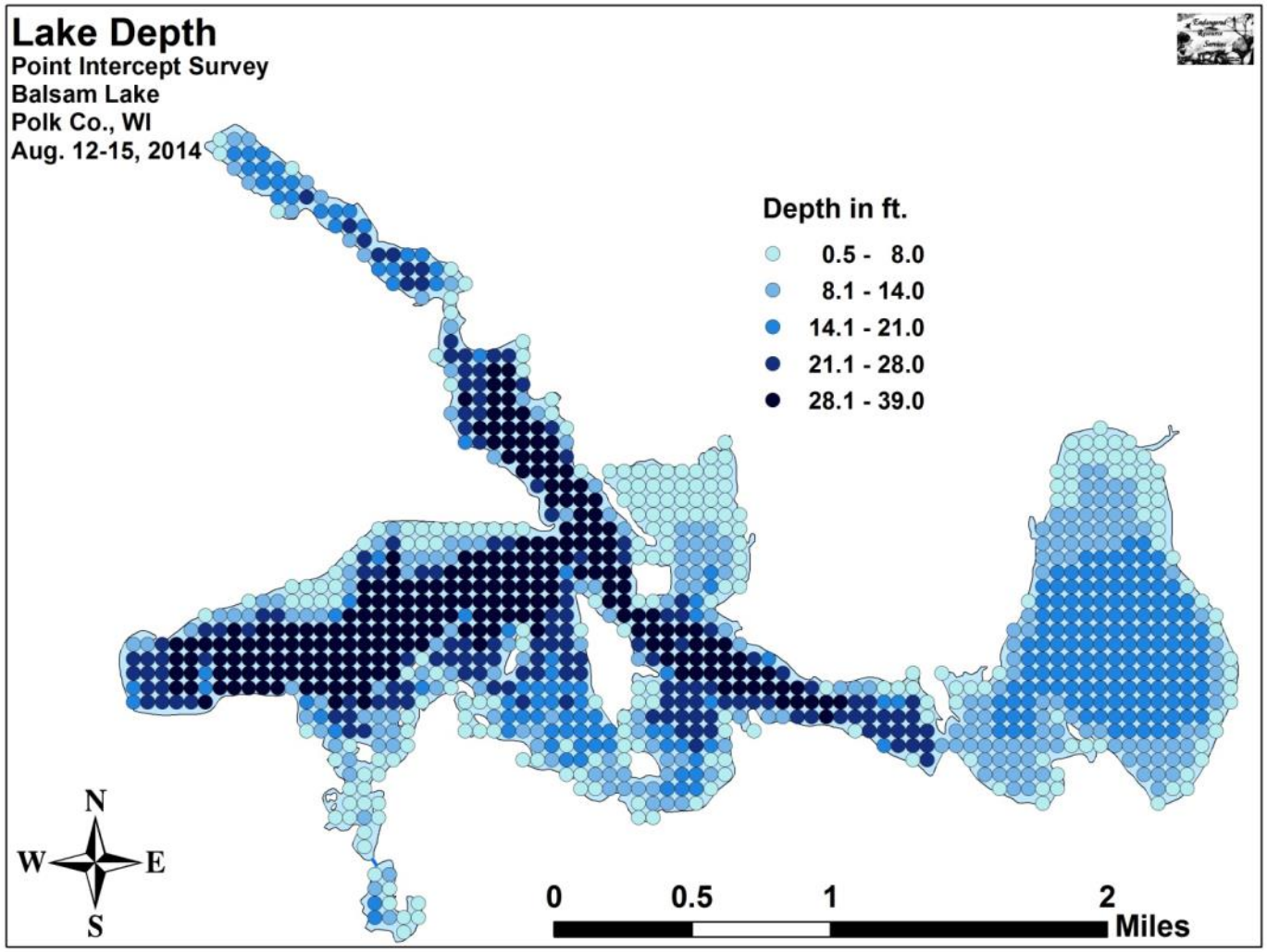

Curly-leaf pondweed
(Potamogeton crispus)
CLP Point Intercept Survey
Balsam Lake
Polk Co., WI
June 2-6, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

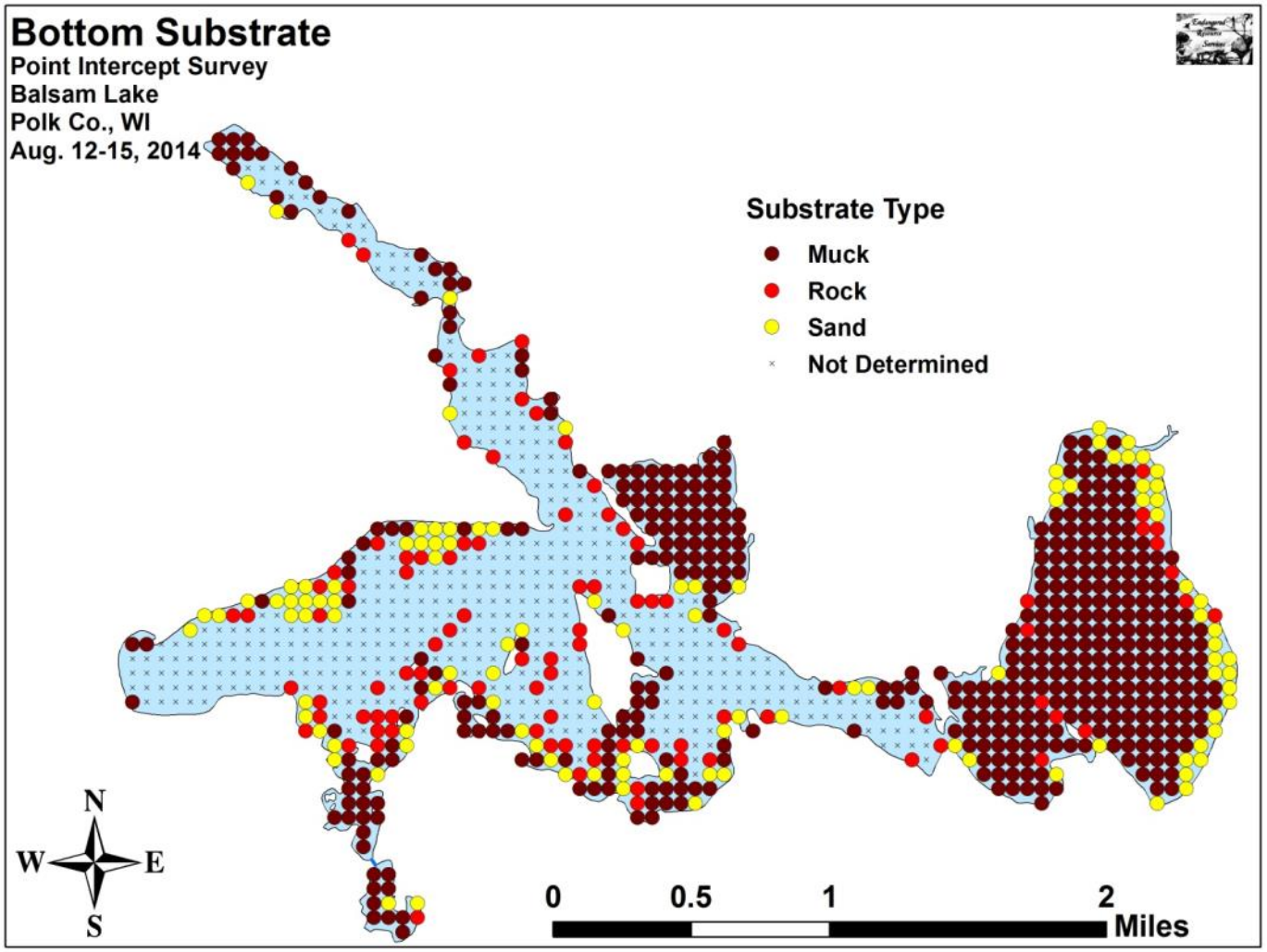

Curly-leaf pondweed
(Potamogeton crispus)
CLP Point Intercept Survey
Balsam Lake
Polk Co., WI
June 16-18, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Curly-leaf pondweed
(Potamogeton crispus)
CLP Bed Mapping Survey
Balsam Lake
Polk Co., WI
June 9-10, 2009
CLP beds
Bed 1
Bed 2
Bed 3
Bed 4 Bed 5
Bed 6
Bed 7
Bed 8
Bed 9
Bed 10
Bed 11
Bed 12
Bed 13
Bed 14
Bed 15
Bed 16
Bed 17
Bed 18
Bed 19
Bed 20
Bed 21
N
W
E
S
0
0.5
1
2
Miles

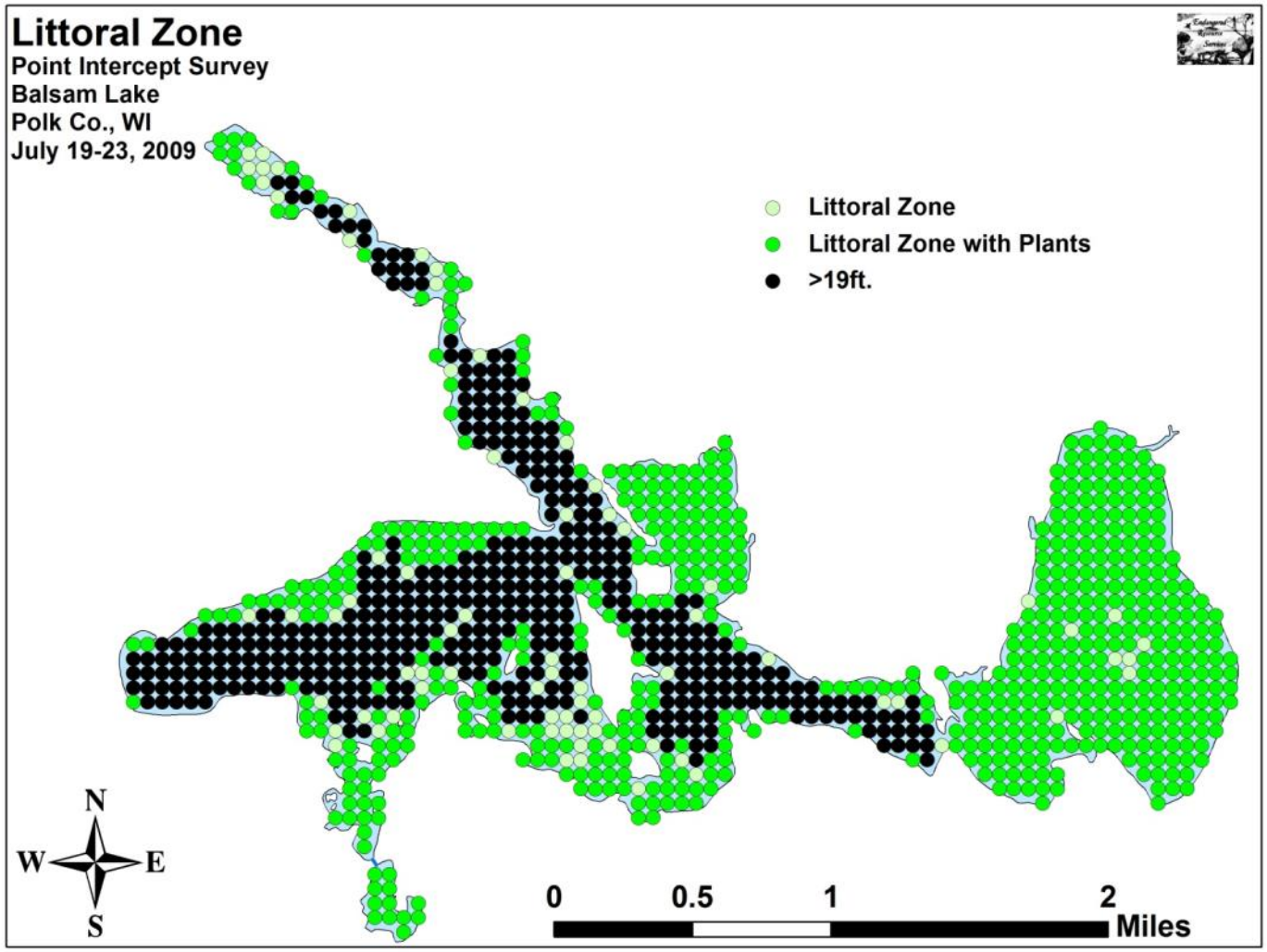

Curly-leaf pondweed
(Potamogeton crispus)
CLP Bed Mapping Survey
Balsam Lake
Polk Co., WI
June 17-20, 2014
CLP beds
Bed 1A
Bed 2
Bed 8
Bed 1
Bed 15A
Bed 17A
Bed 15
Bed 16B
Bed 20
Bed 15B
Bed 17
Bed 16A
Bed 23
Bed 24
N
W
E
S
0
0.5
1
2
Miles

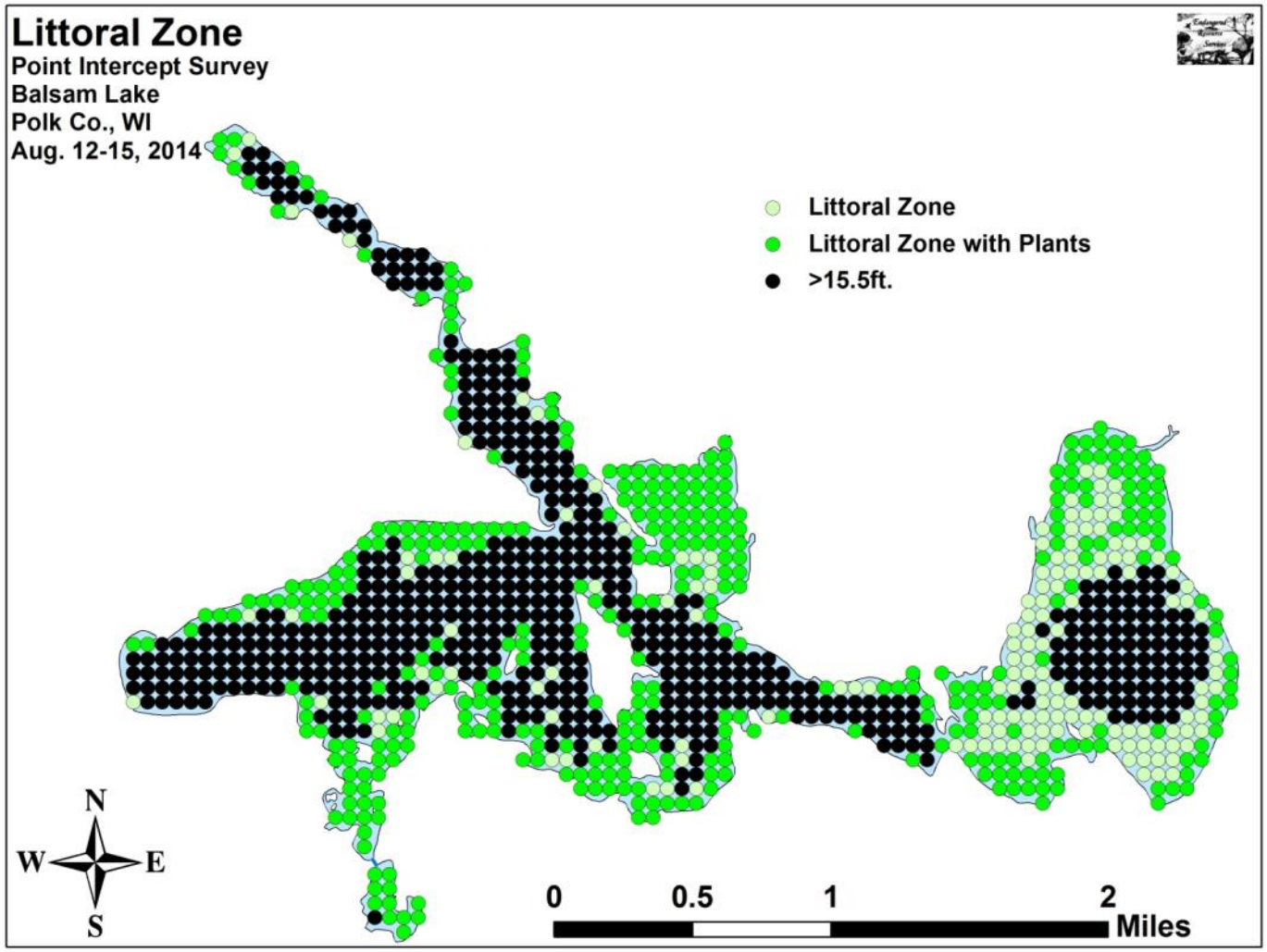
Appendix IV: Habitat Variable Maps

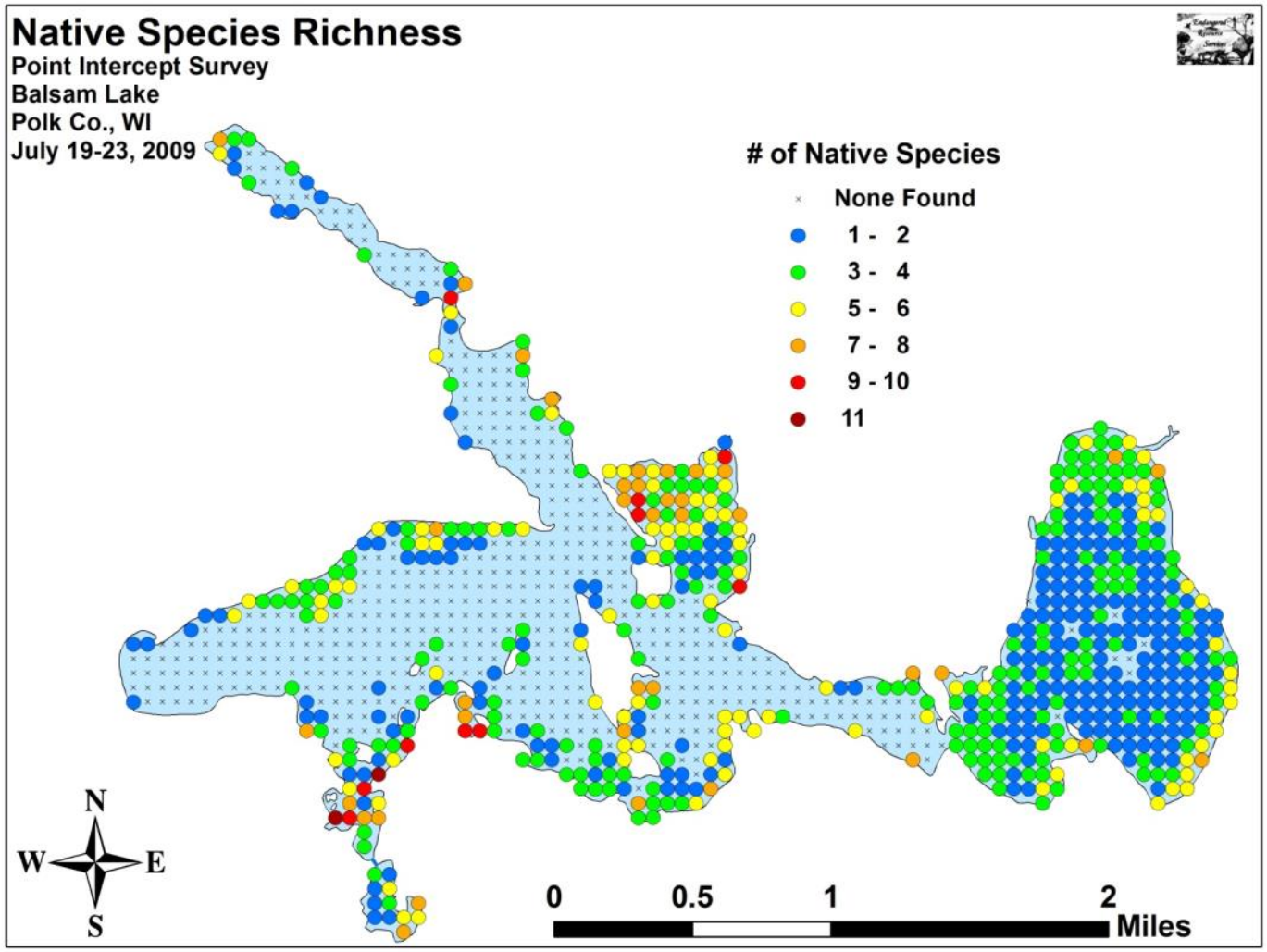

Lake Depth
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Depth in ft.
0.5 - 8.0
8.1 - 14.0
14.1 - 21.0
21.1 - 28.0
28.1 - 39.0
N
W
E
S
0
0.5
1
2
Miles

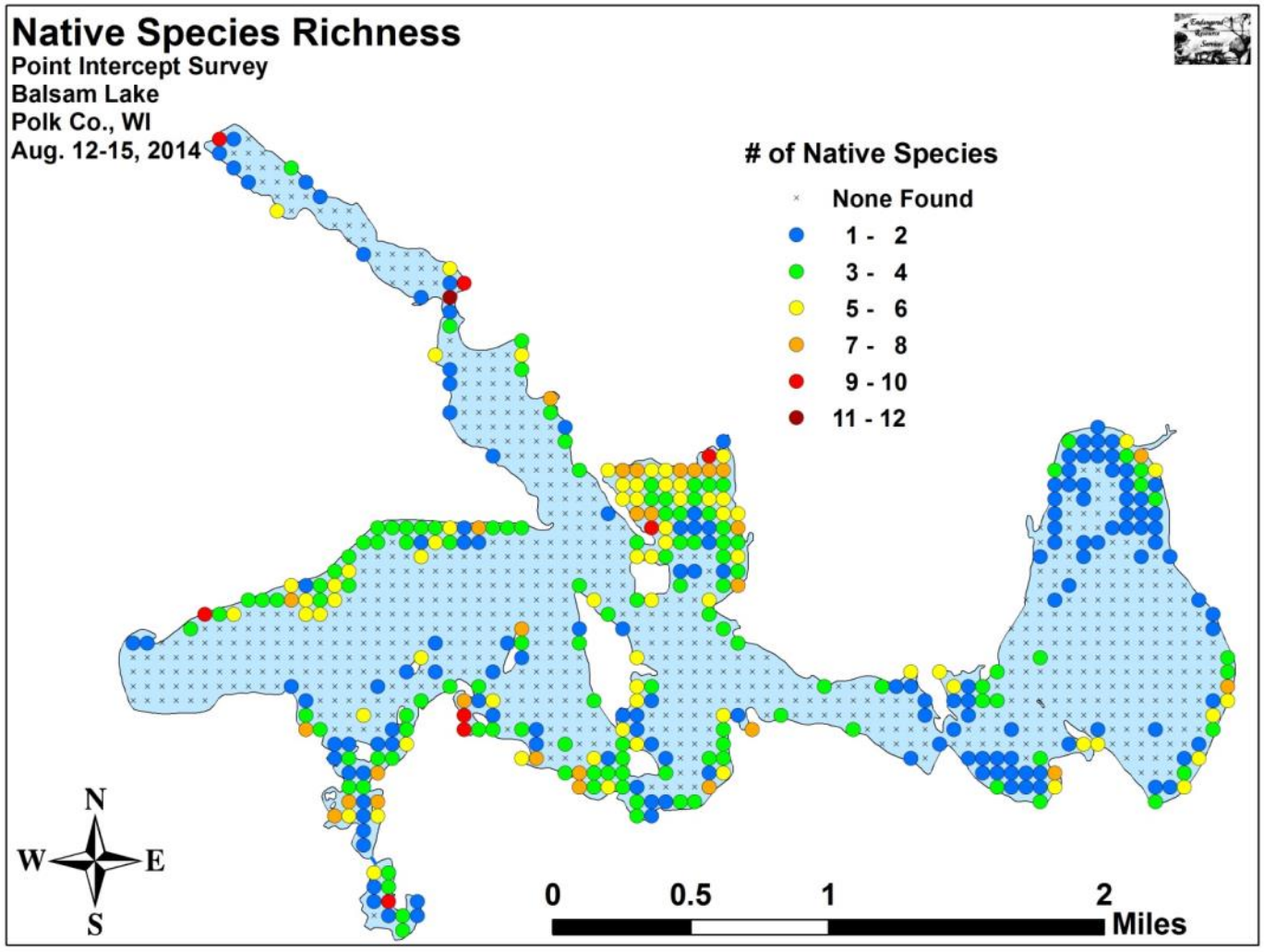

Bottom Substrate
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Substrate Type
Muck
Rock
Sand
Not Determined
N
W
E
S
0
0.5
1
2
Miles

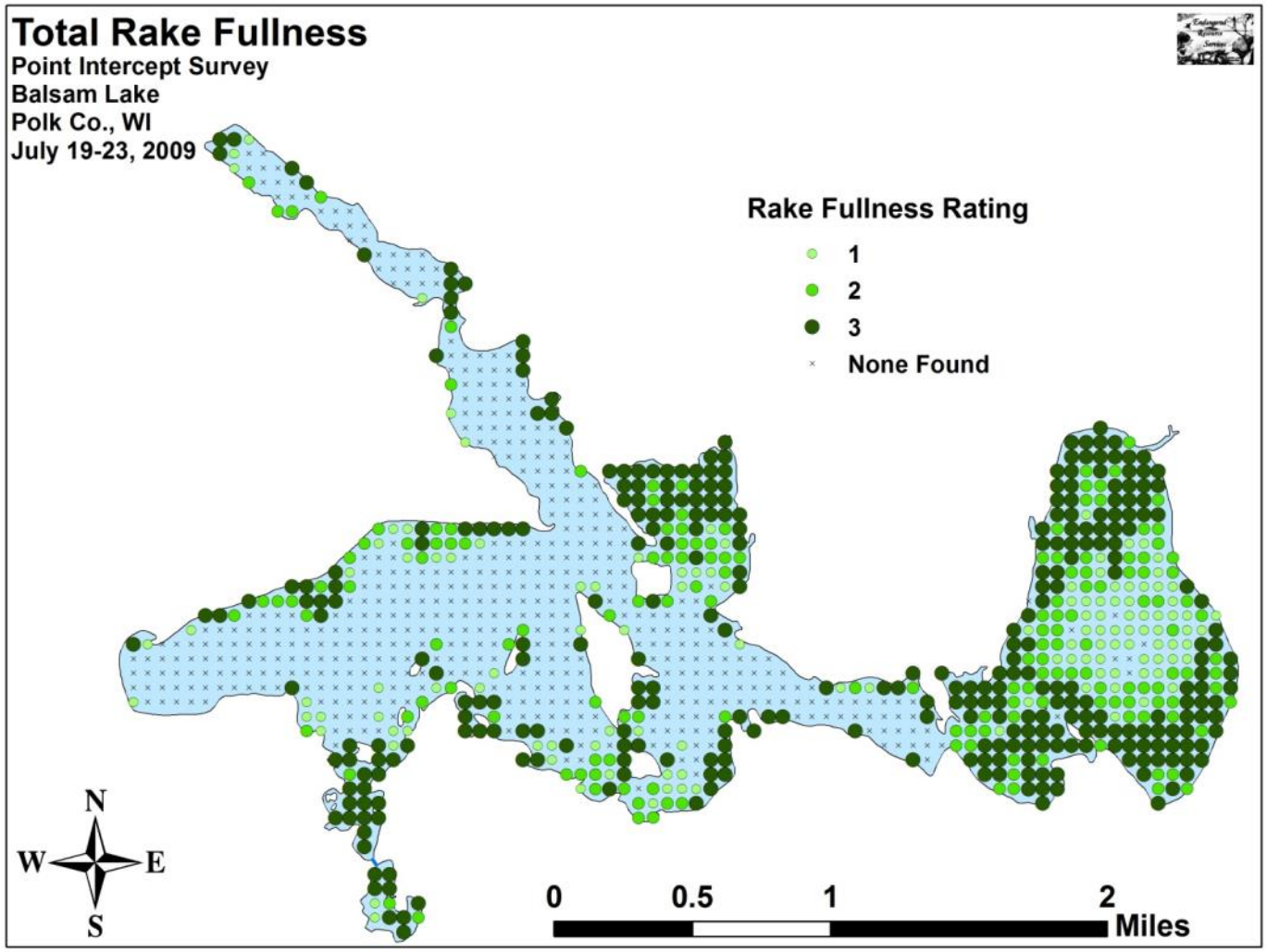
Appendix V: 2009 and 2014 Littoral Zone, Native Species Richness and Total Rake Fullness Maps

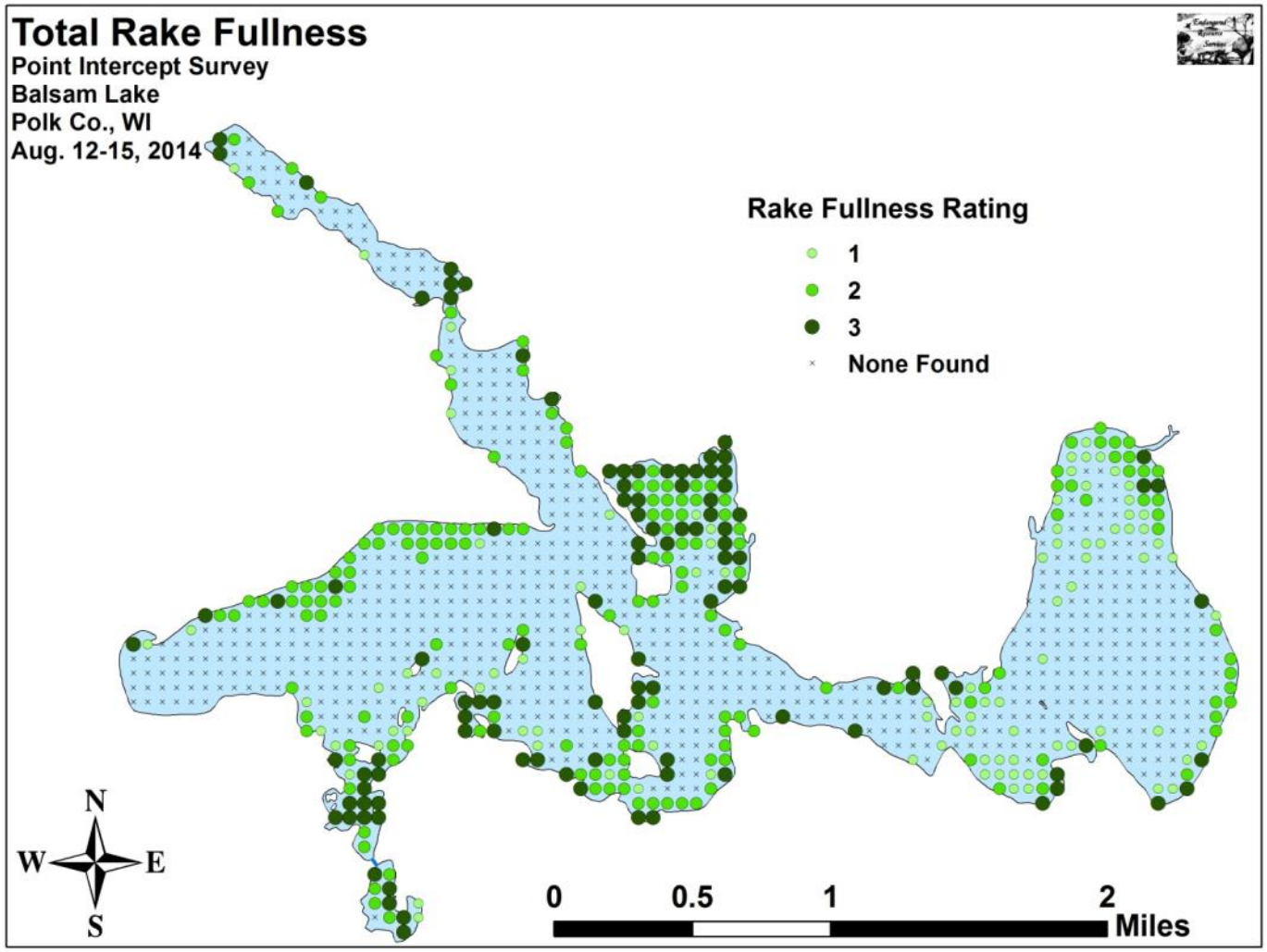

Littoral Zone
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Littoral Zone
Littoral Zone with Plants
>19ft.
N
W
E
S
0
0.5
1
2
Miles


Littoral Zone
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Littoral Zone
Littoral Zone with Plants
>15.5ft.
N
W
E
S
0
0.5
1
2
Miles

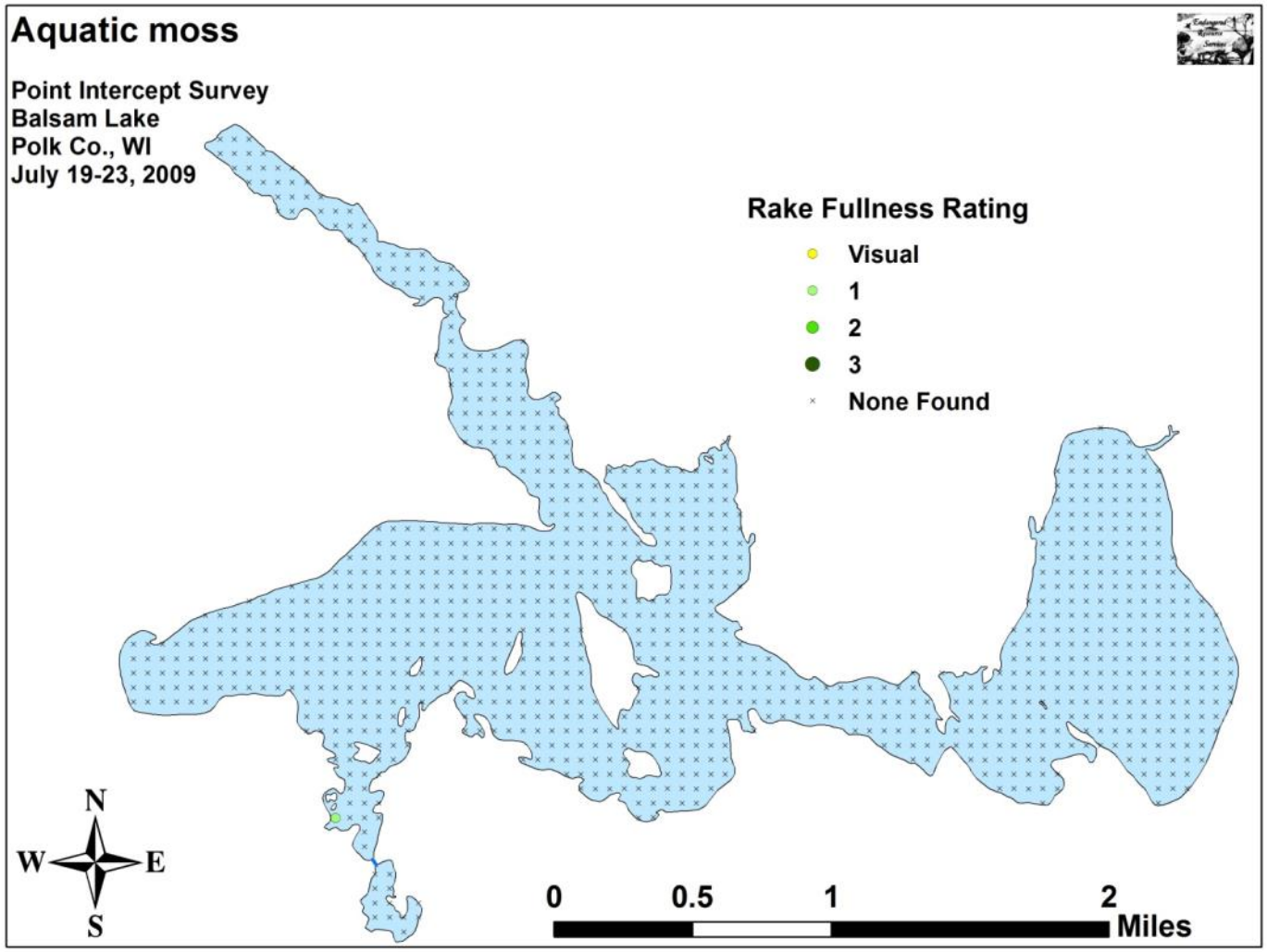

Native Species Richness
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
11
N
W
E
S
0
0.5
1
2
Miles

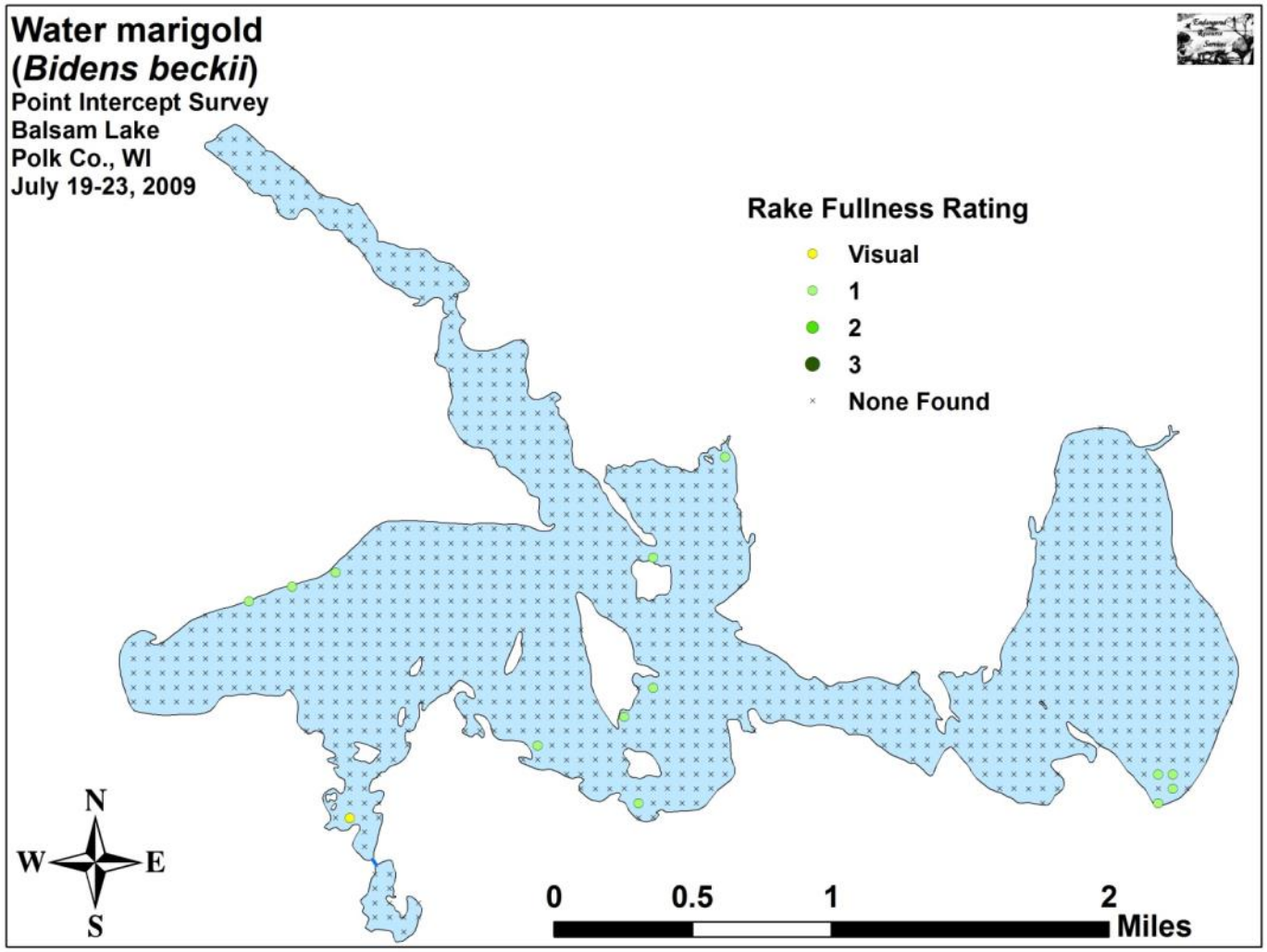

Native Species Richness
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
11 - 12
N
W
E
S
0
0.5
1
2
Miles

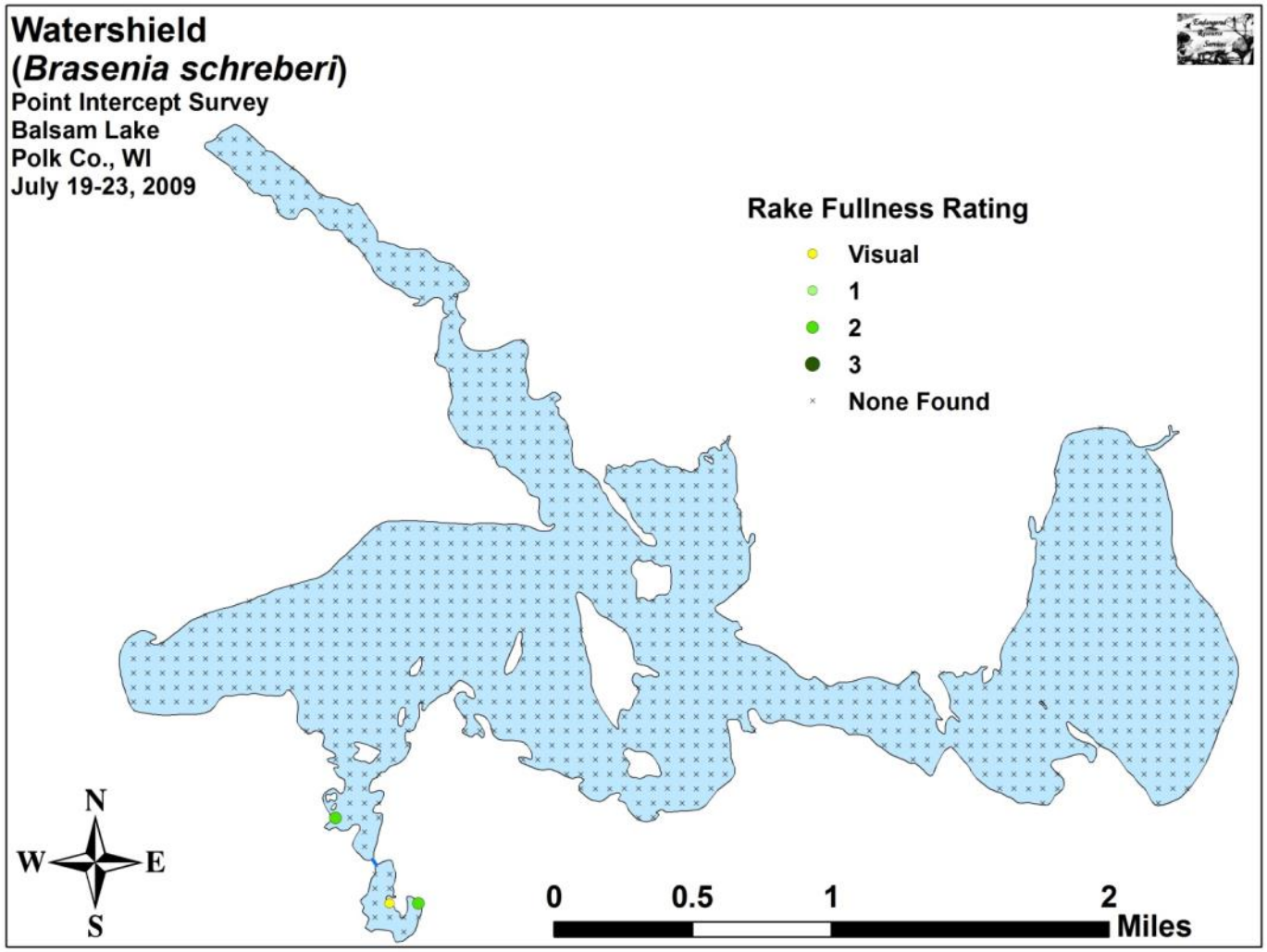

Total Rake Fullness
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

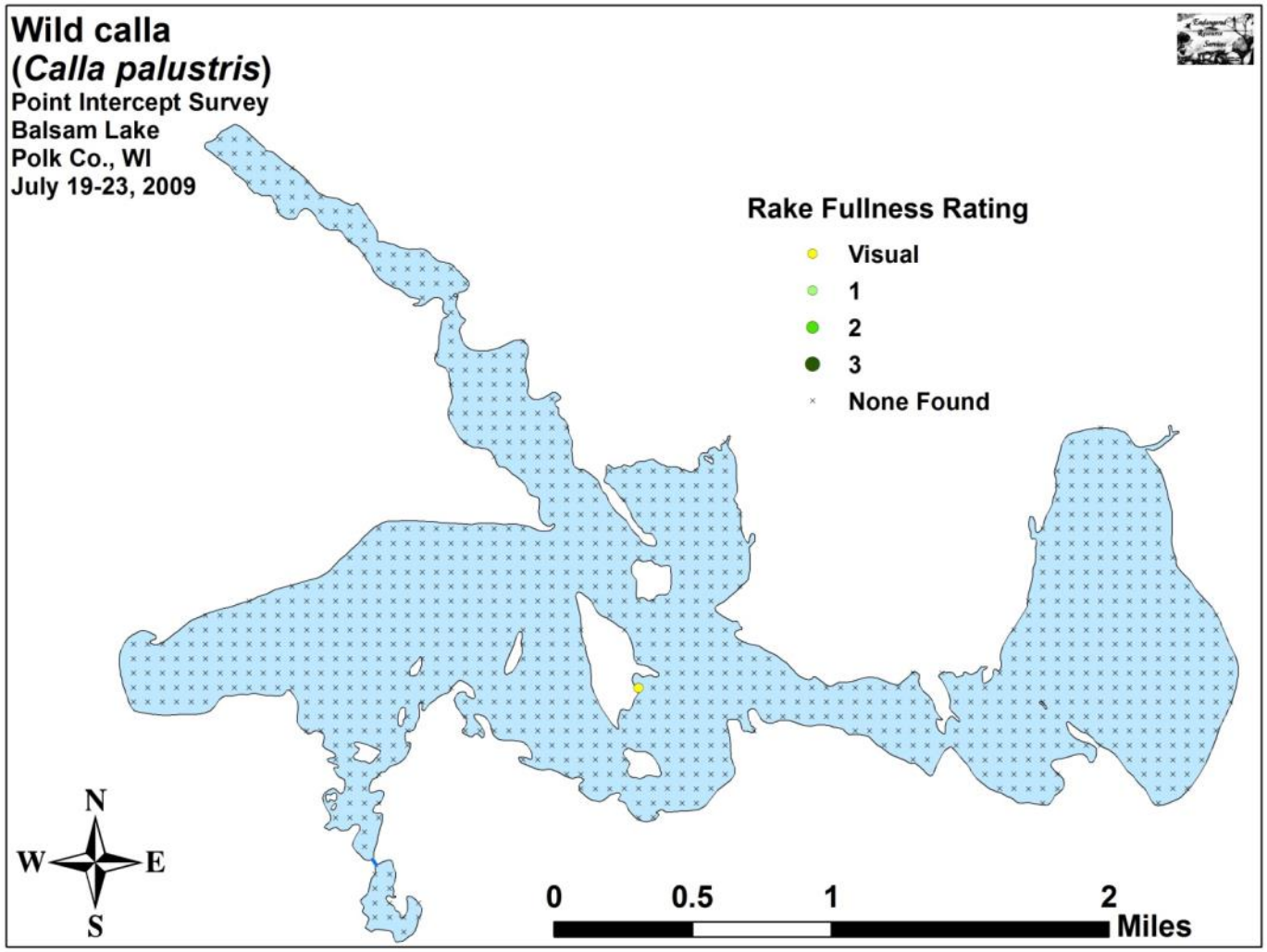

Total Rake Fullness
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

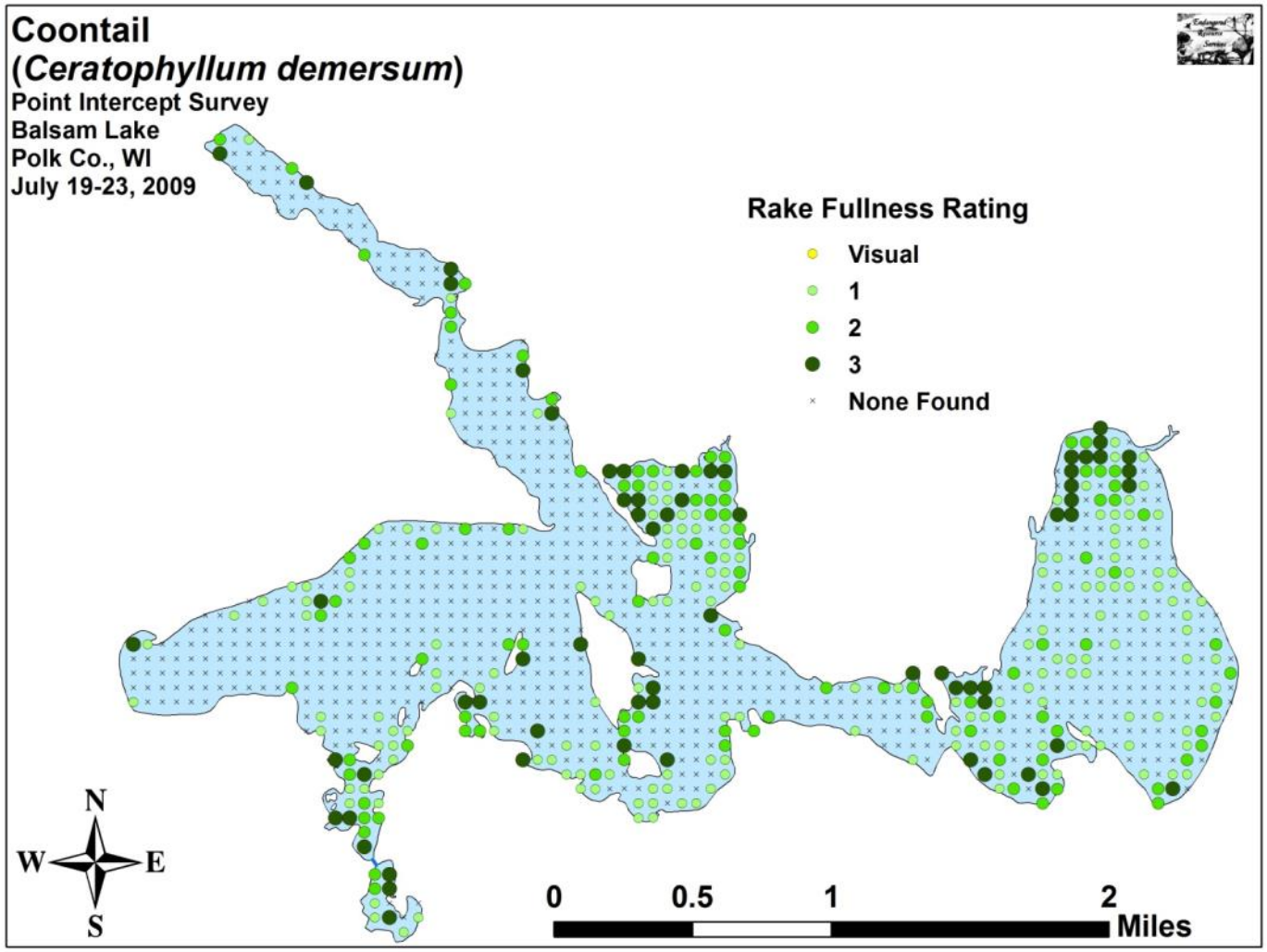
Appendix VI: July 2009 Species Density and Distribution Maps

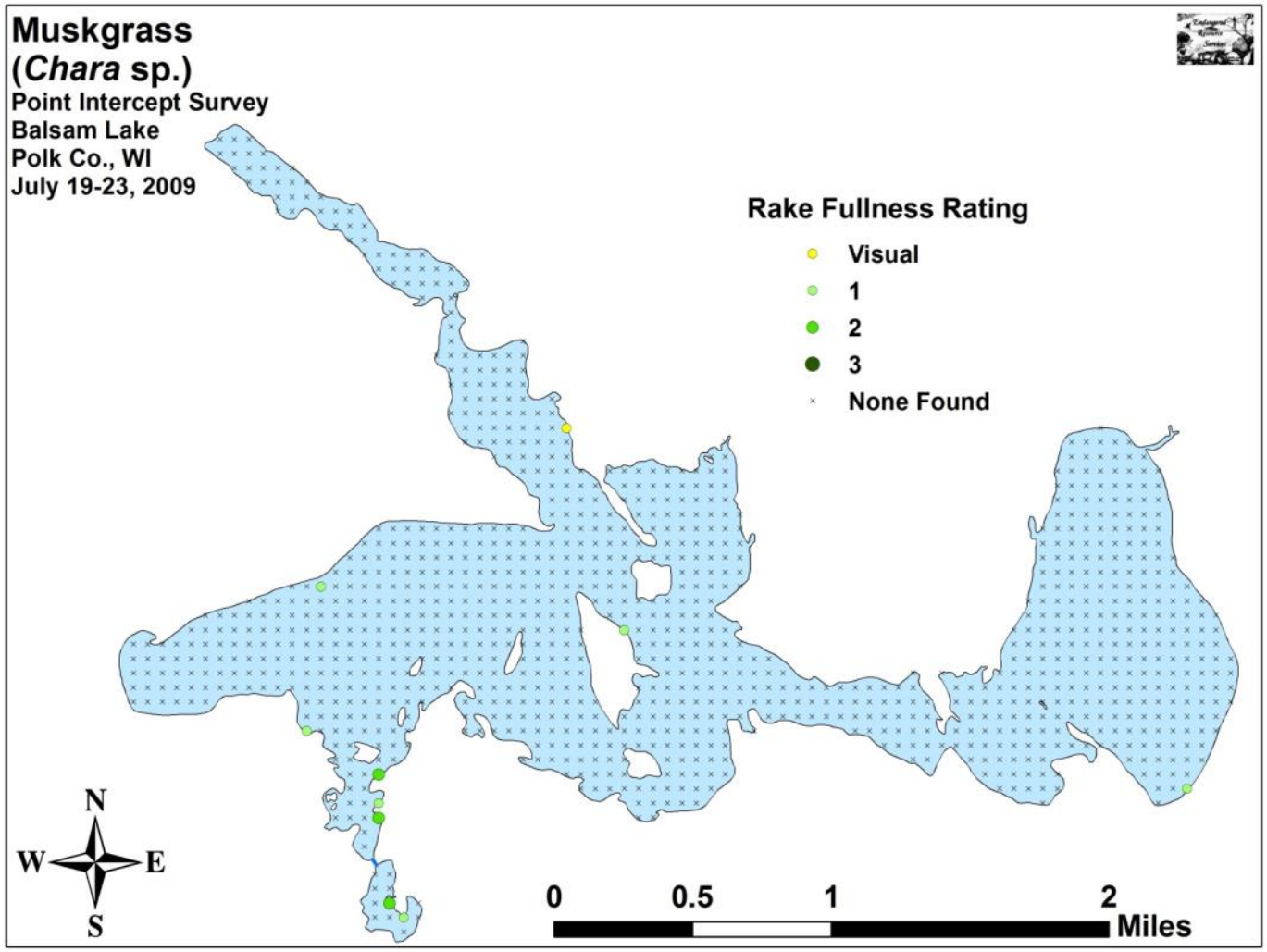

Aquatic moss
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

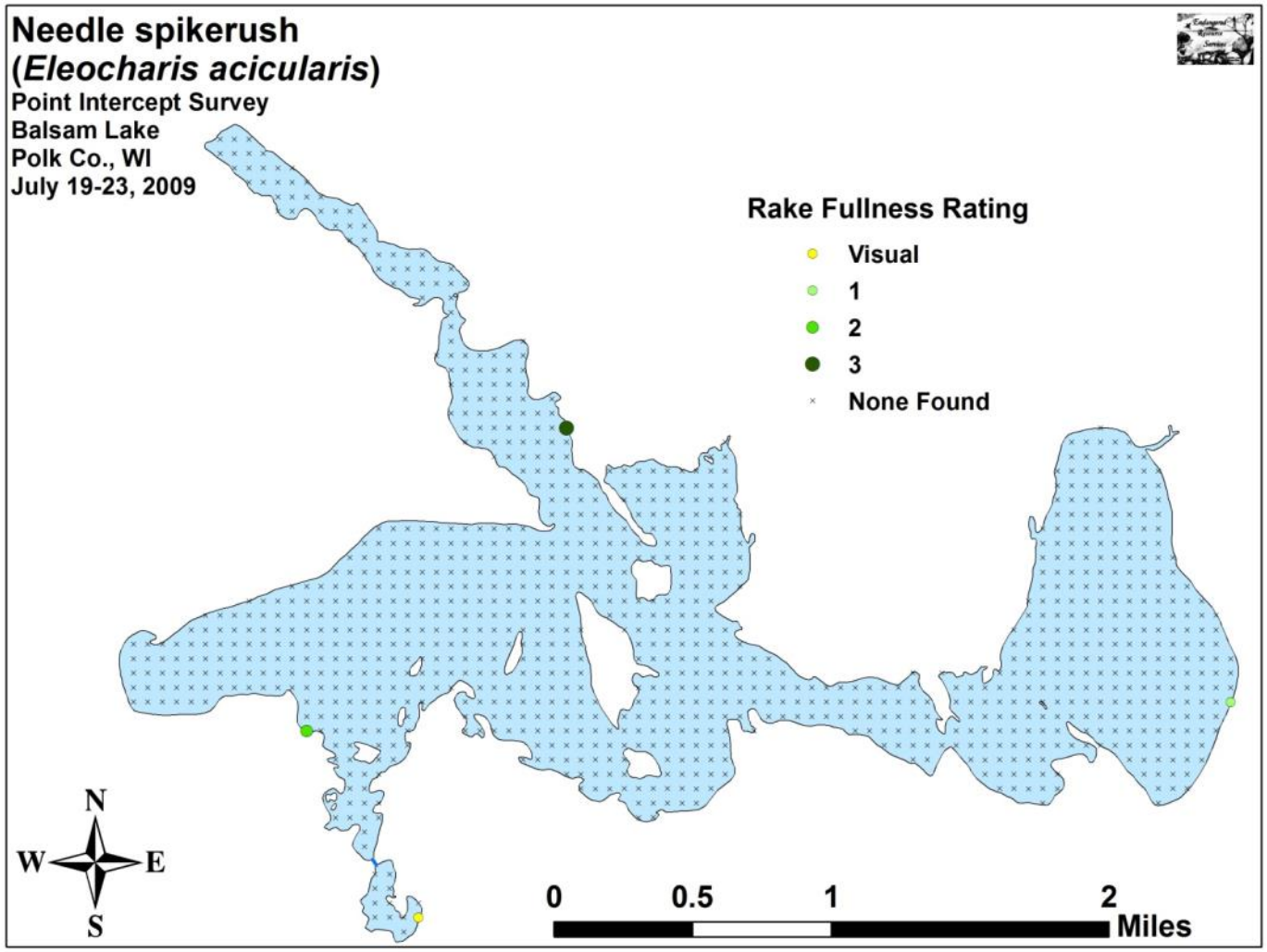

Water marigold
(Bidens beckii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

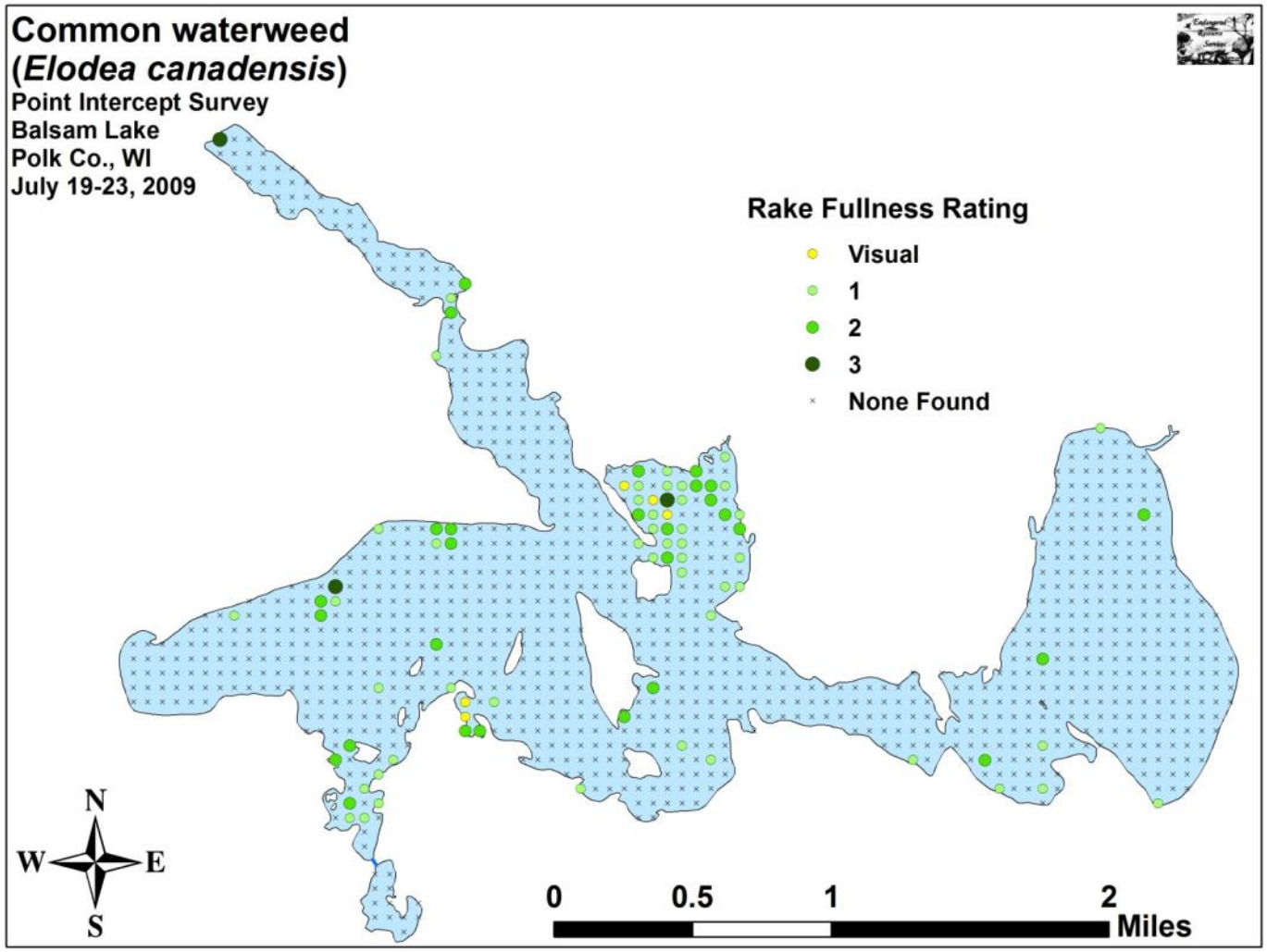

Watershield
(Brasenia schreberi)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

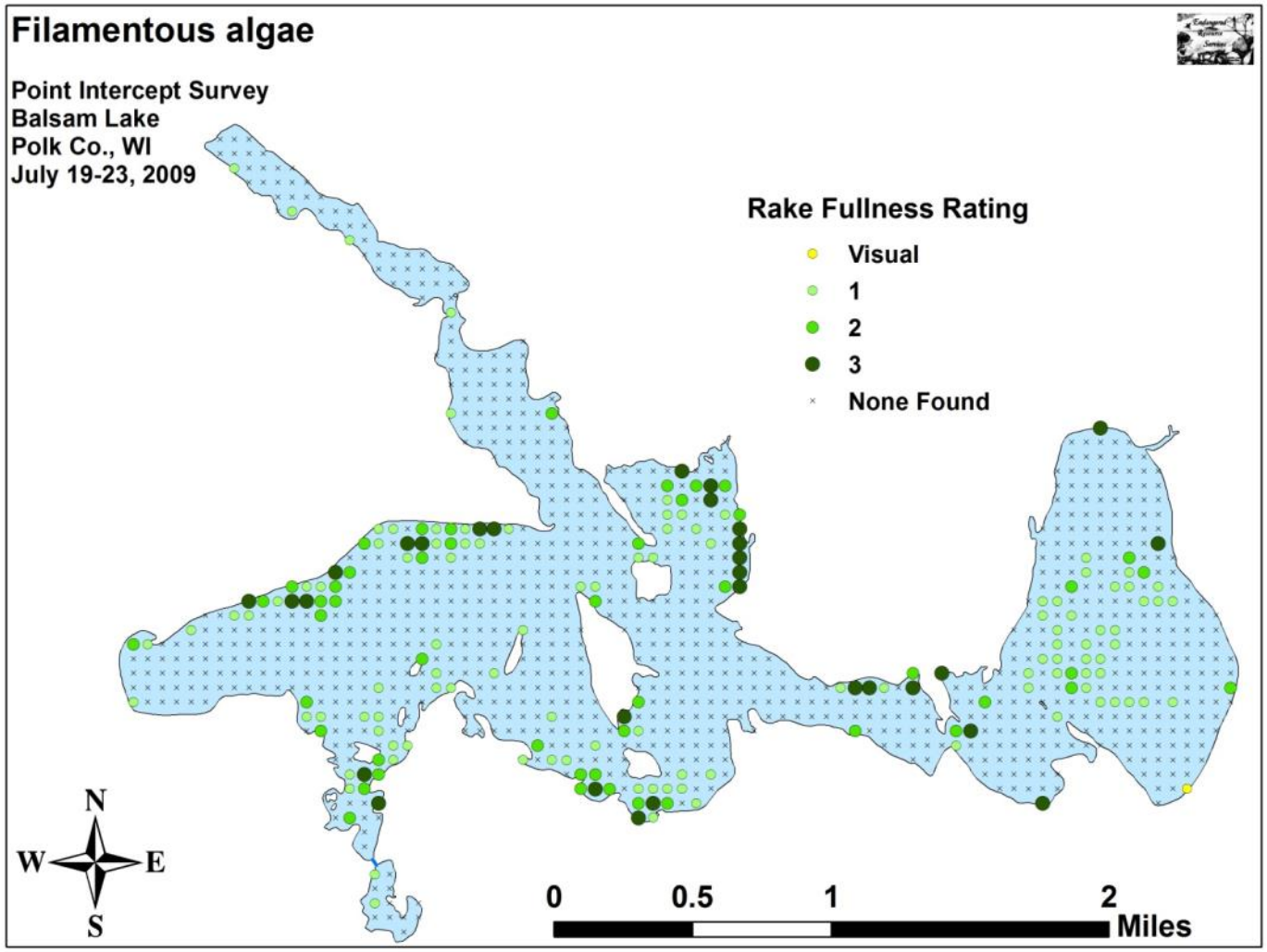

Wild calla
(Calla palustris)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

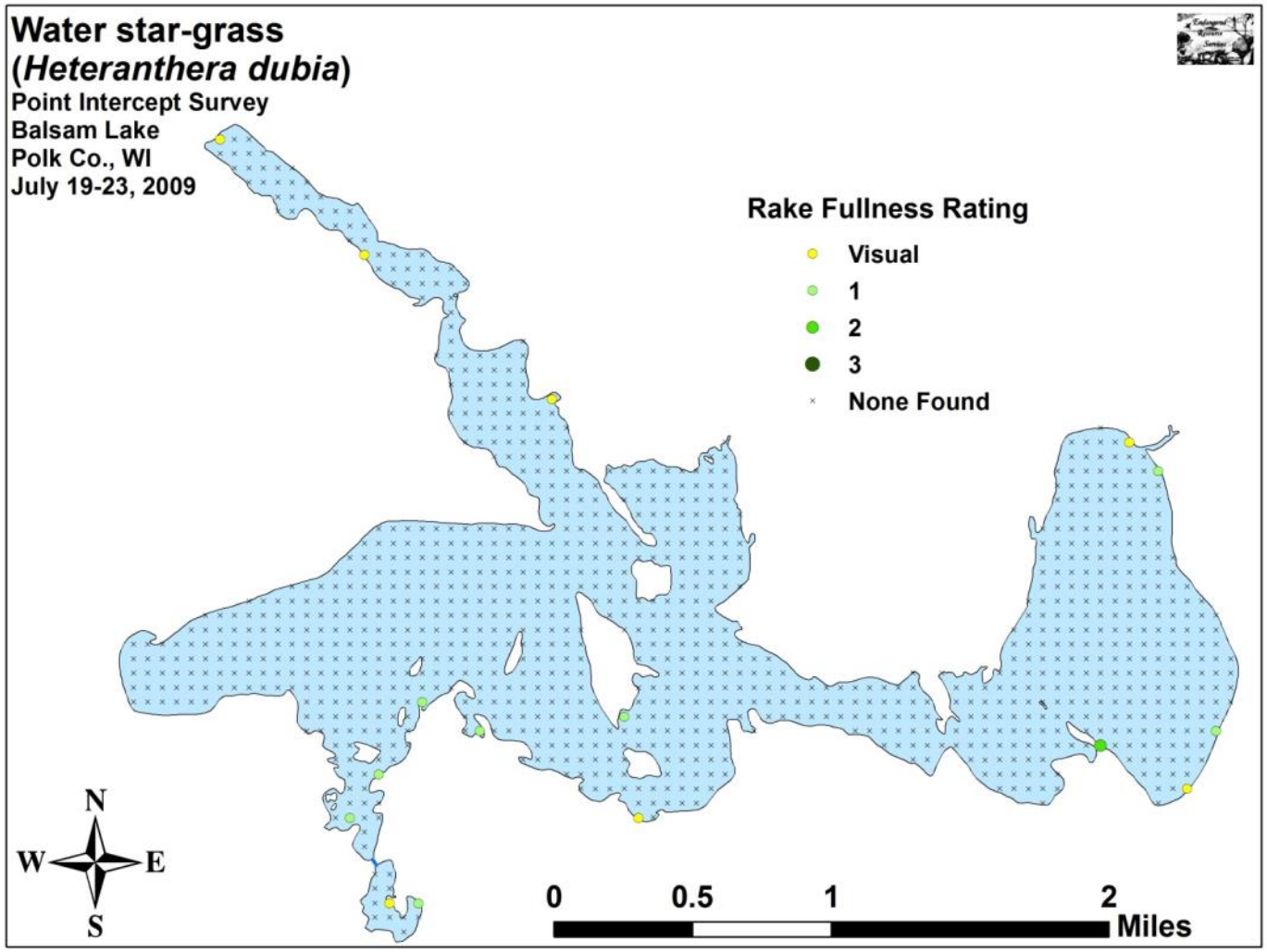

Coontail
(Ceratophyllum demersum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

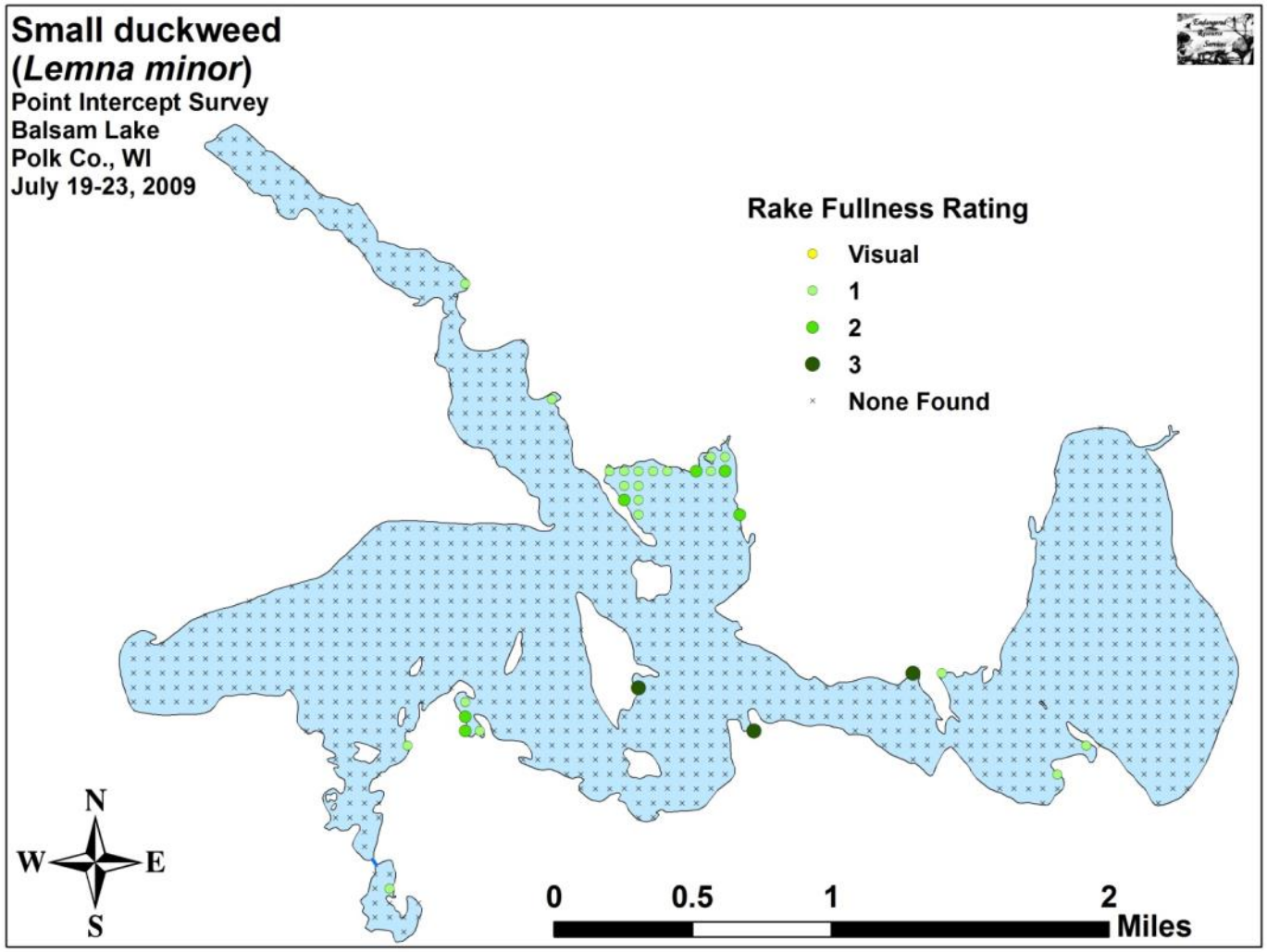

Muskgrass
(Chara sp.)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

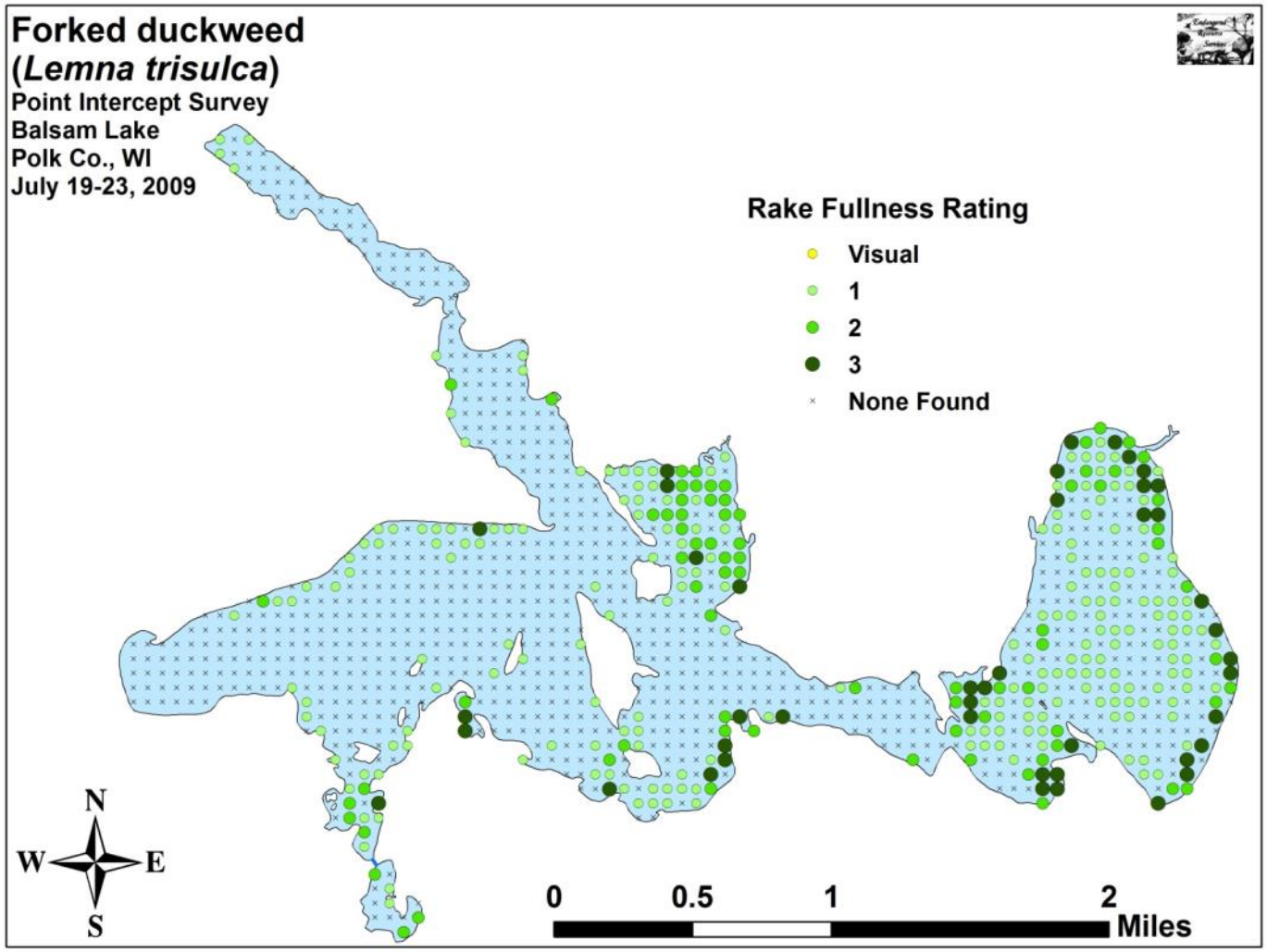

Needle spikerush
(Eleocharis acicularis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

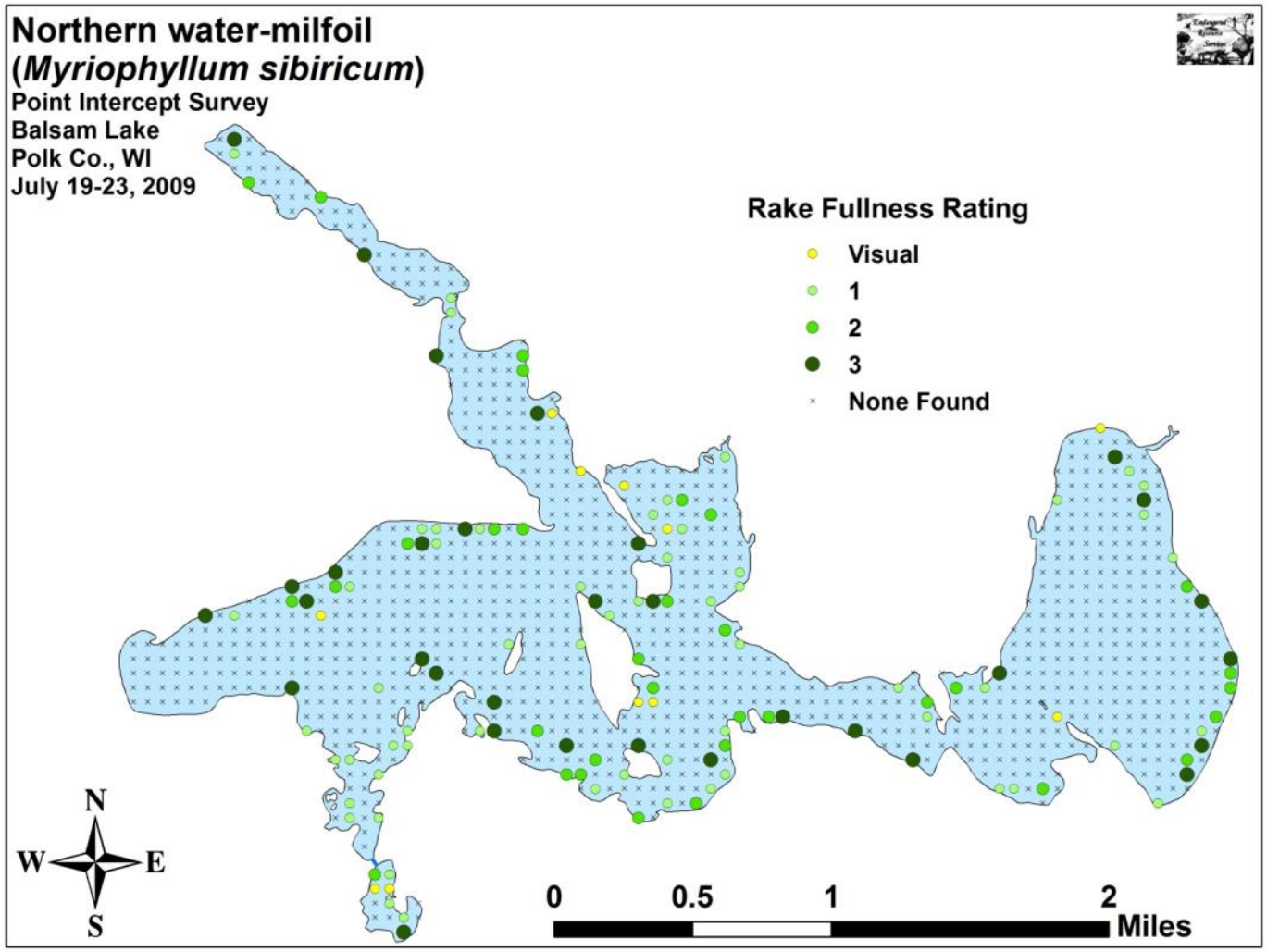

Common waterweed
(Elodea canadensis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

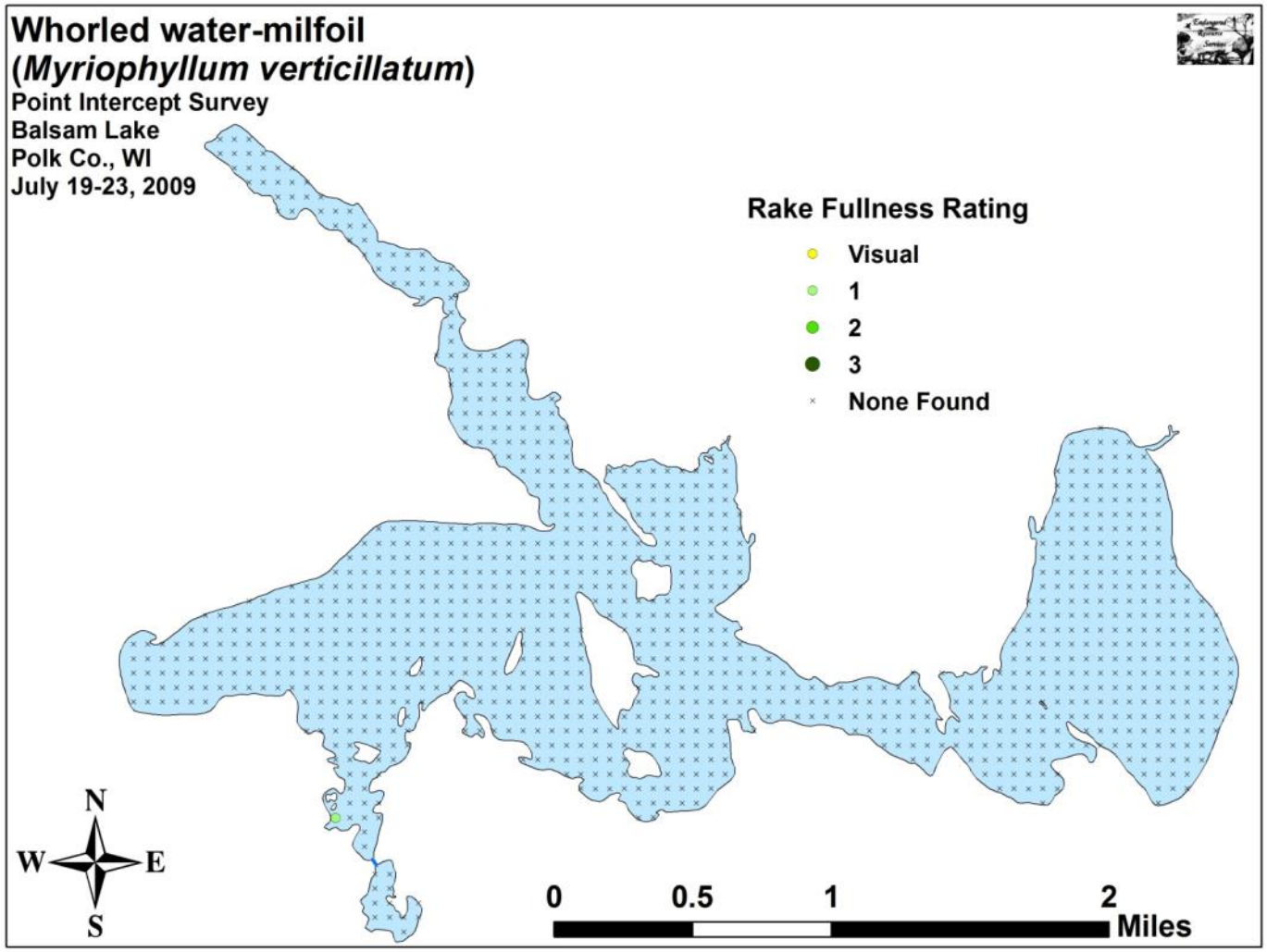

Filamentous algae
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

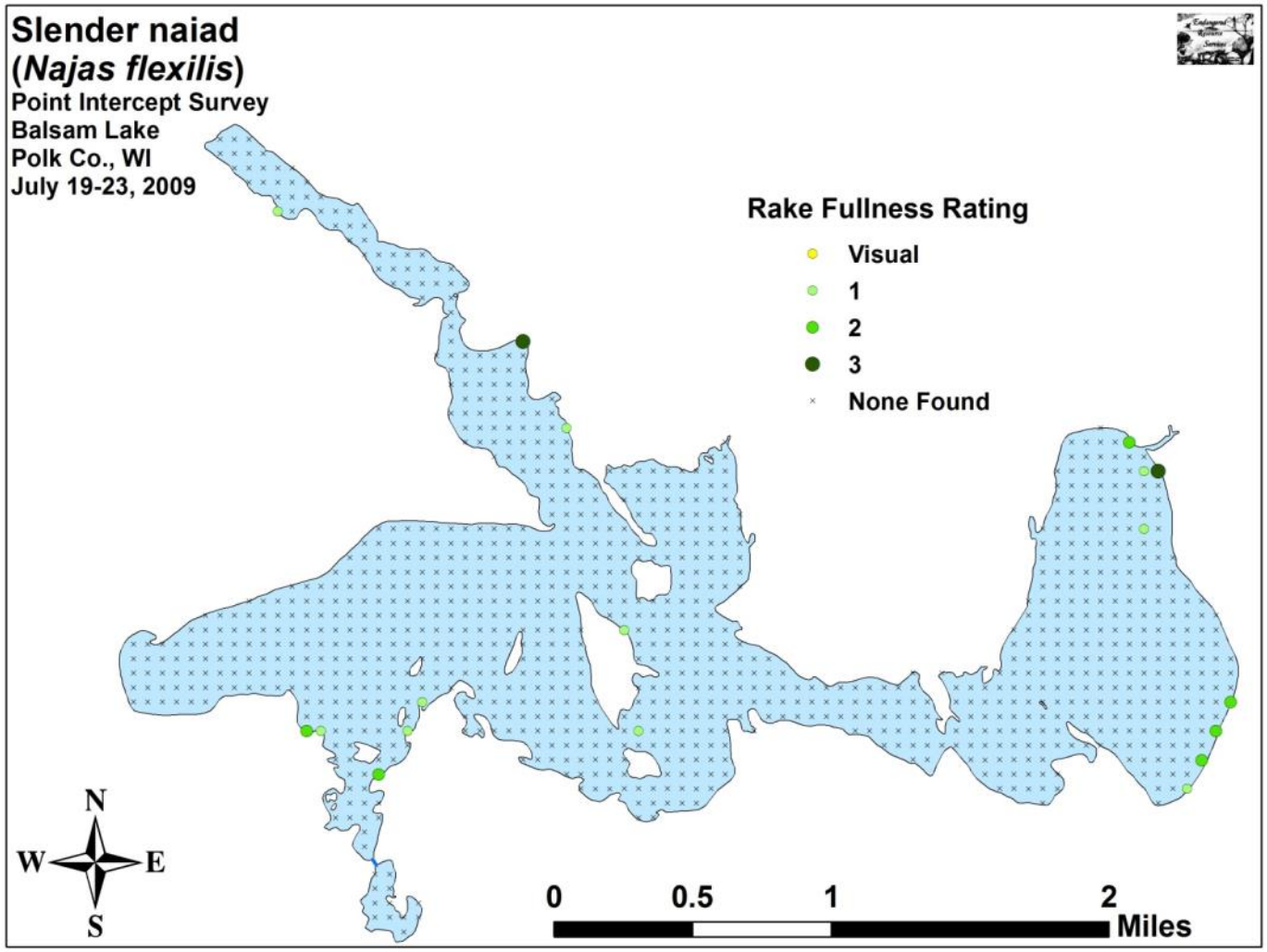

Water star-grass
(Heteranthera dubia)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

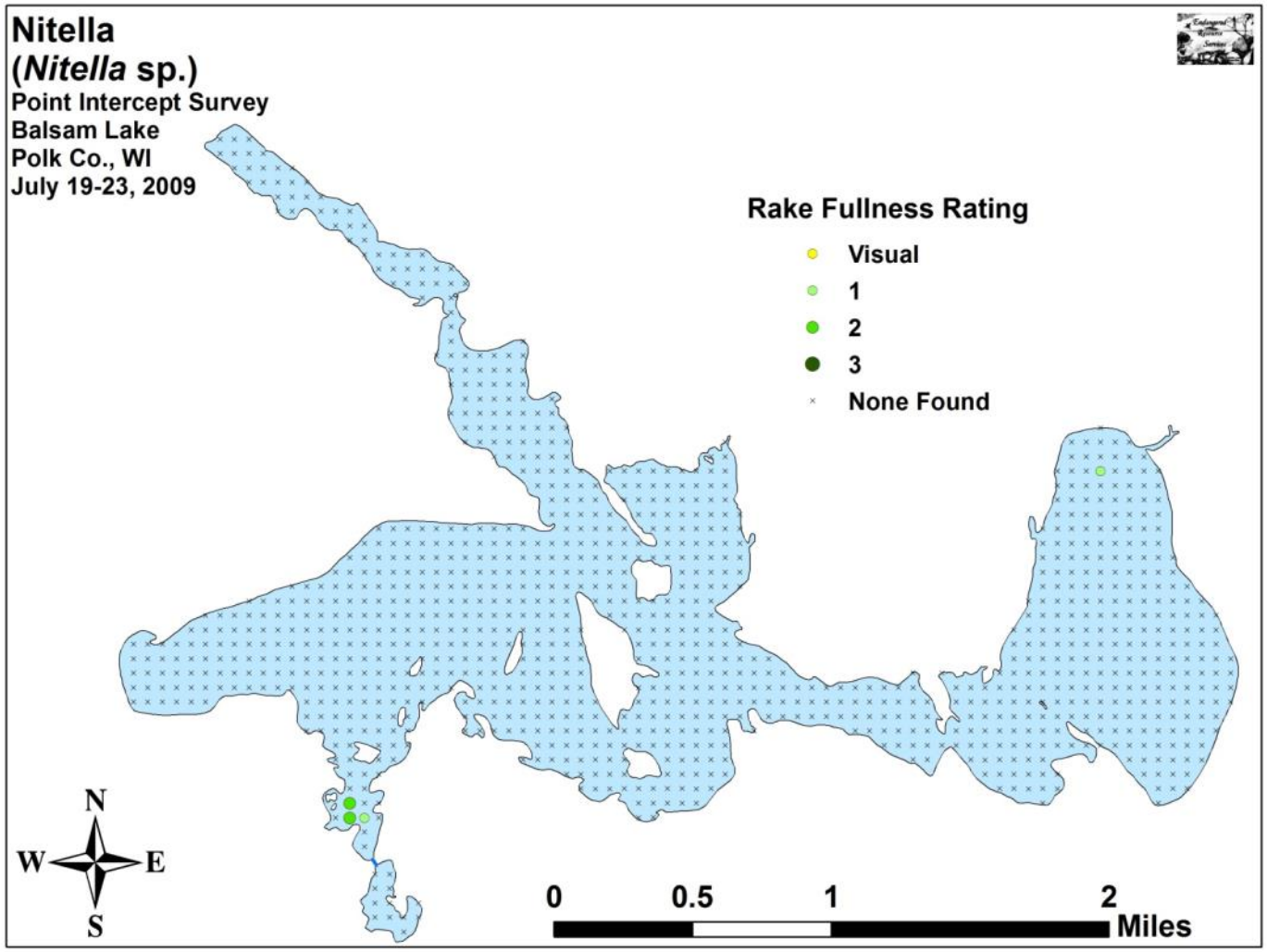

Small duckweed
(Lemna minor)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

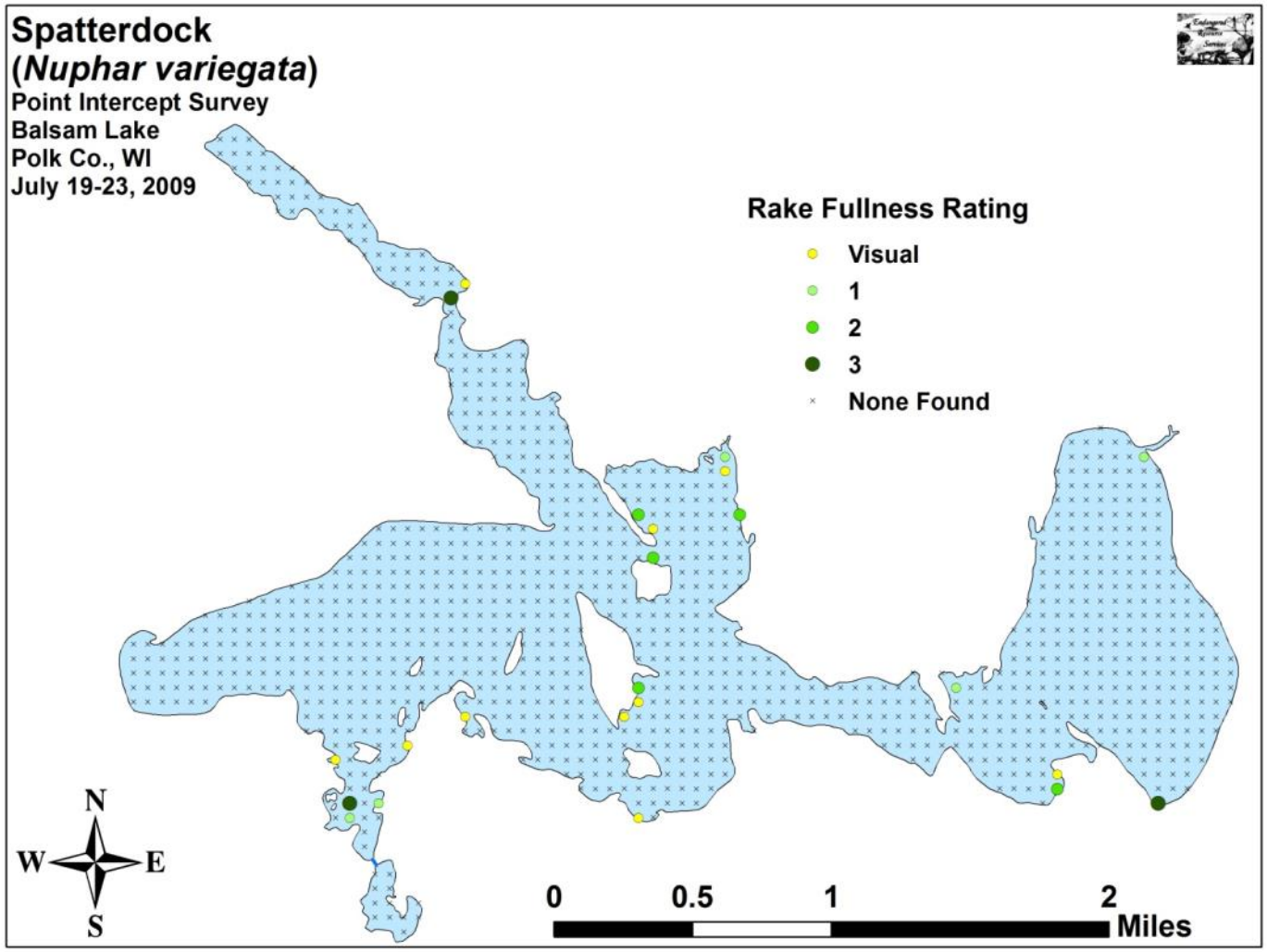

Forked duckweed
(Lemna trisulca)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

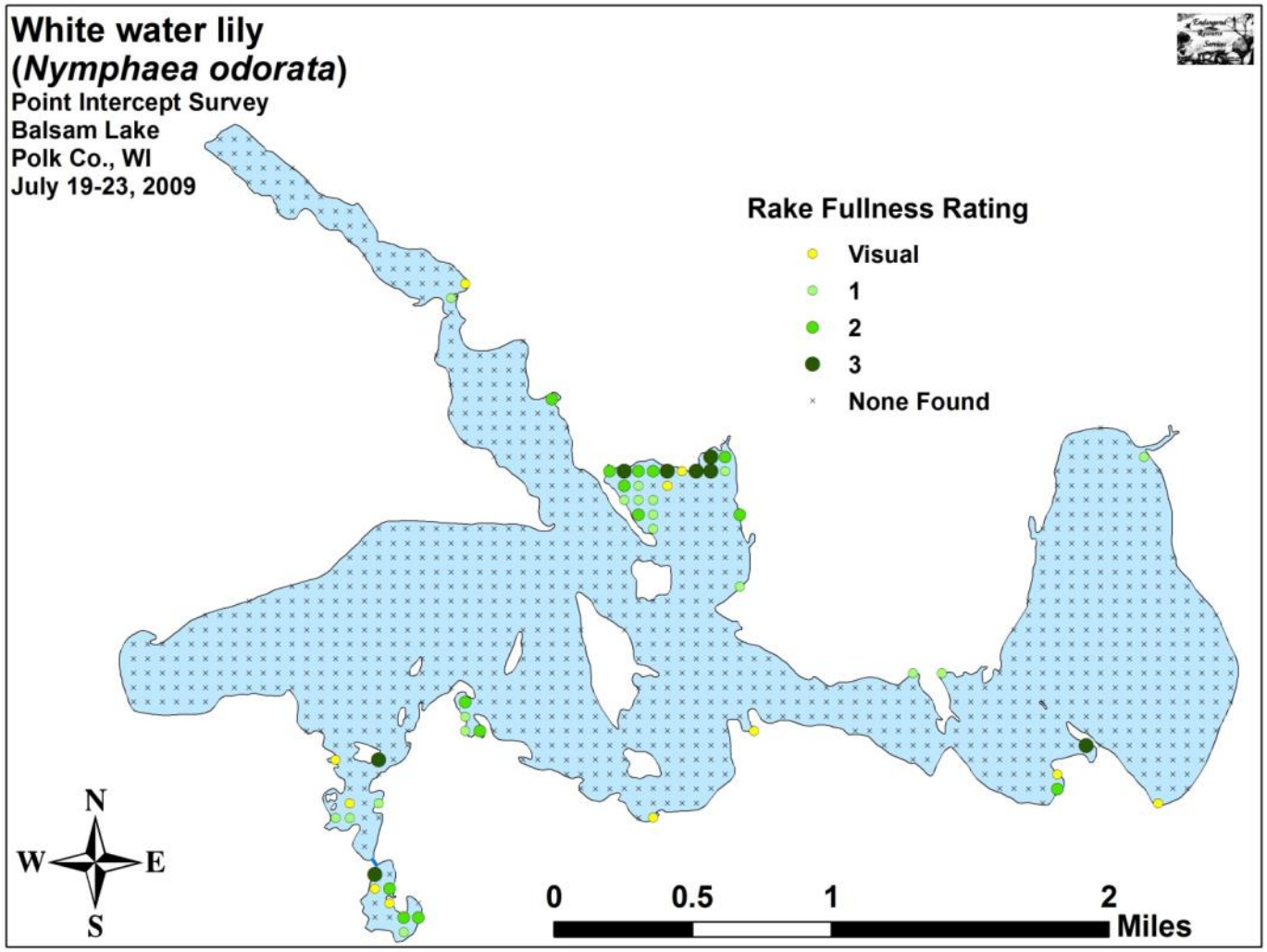

Northern water-milfoil
(Myriophyllum sibiricum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

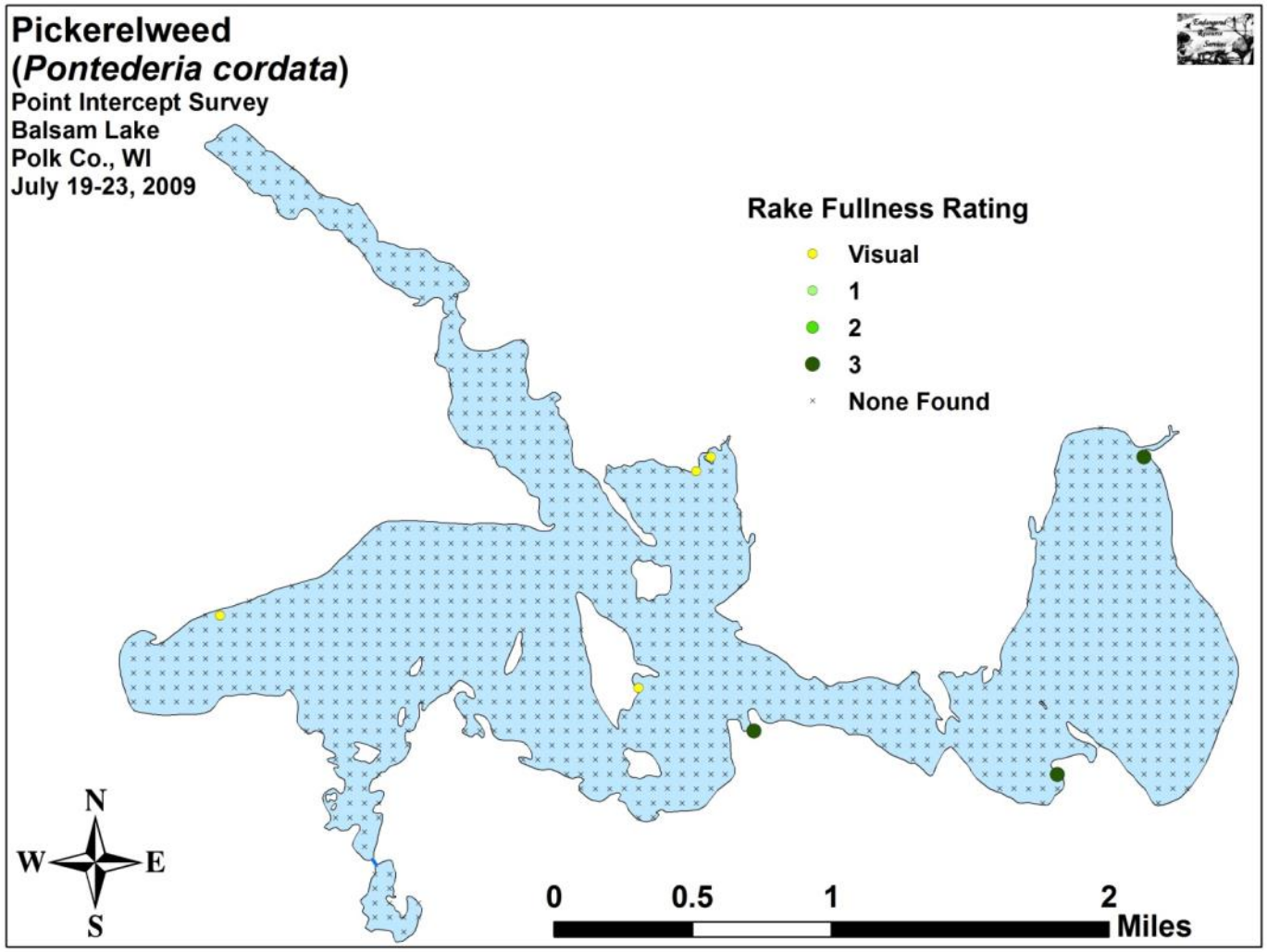

Whorled water-milfoil
(Myriophyllum verticillatum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

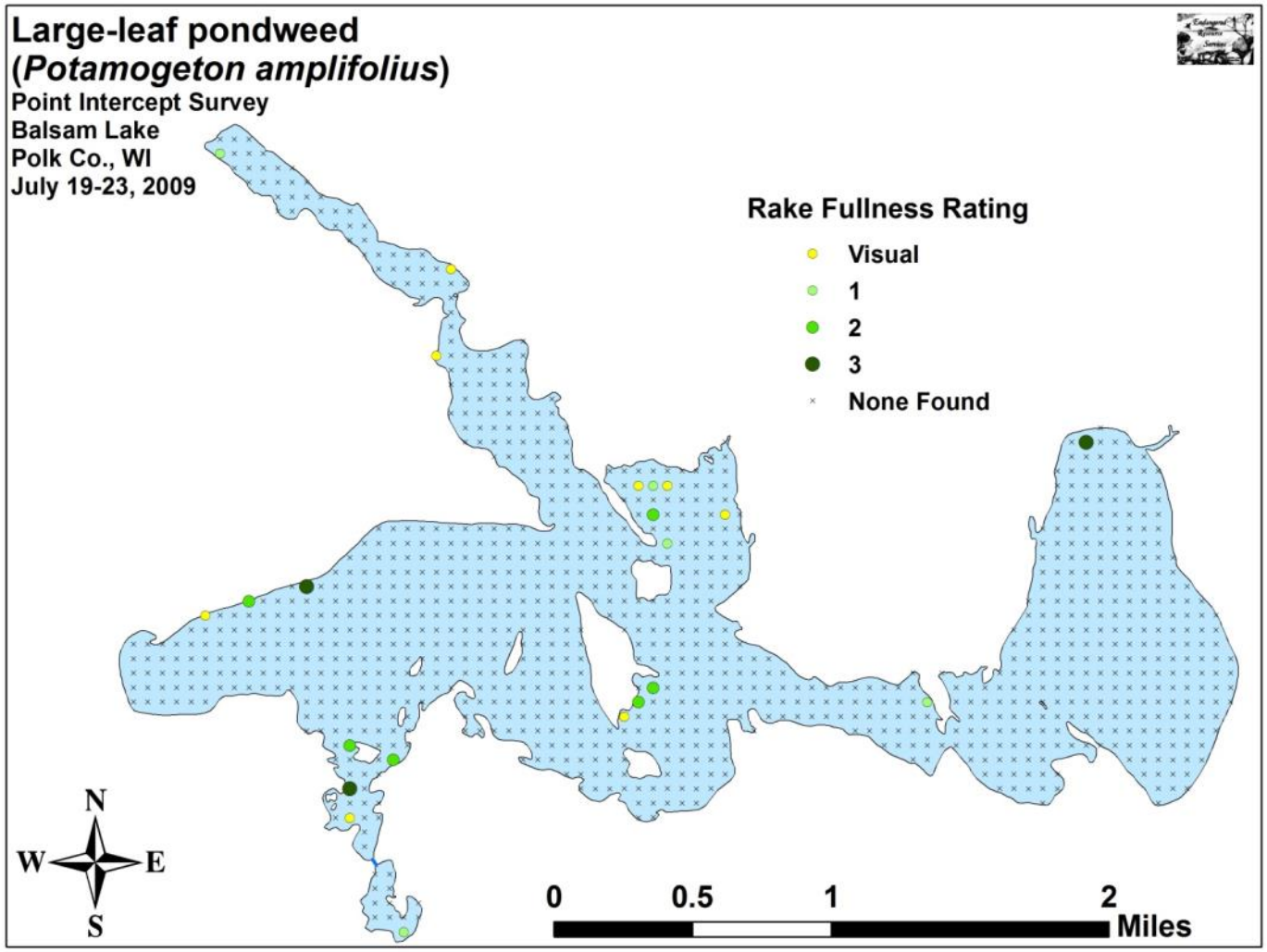

Slender naiad
(Najas flexilis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Nitella
(*Nitella* sp.)
Point Intercept Survey
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


Spatterdock
(Nuphar variegata)
Point Intercept Survey
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


White water lily
(*Nymphaea odorata*)
Point Intercept Survey
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


Pickerelweed
(Pontederia cordata)
Point Intercept Survey
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


Large-leaf pondweed
(Potamogeton amplifolius)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
1
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None Found
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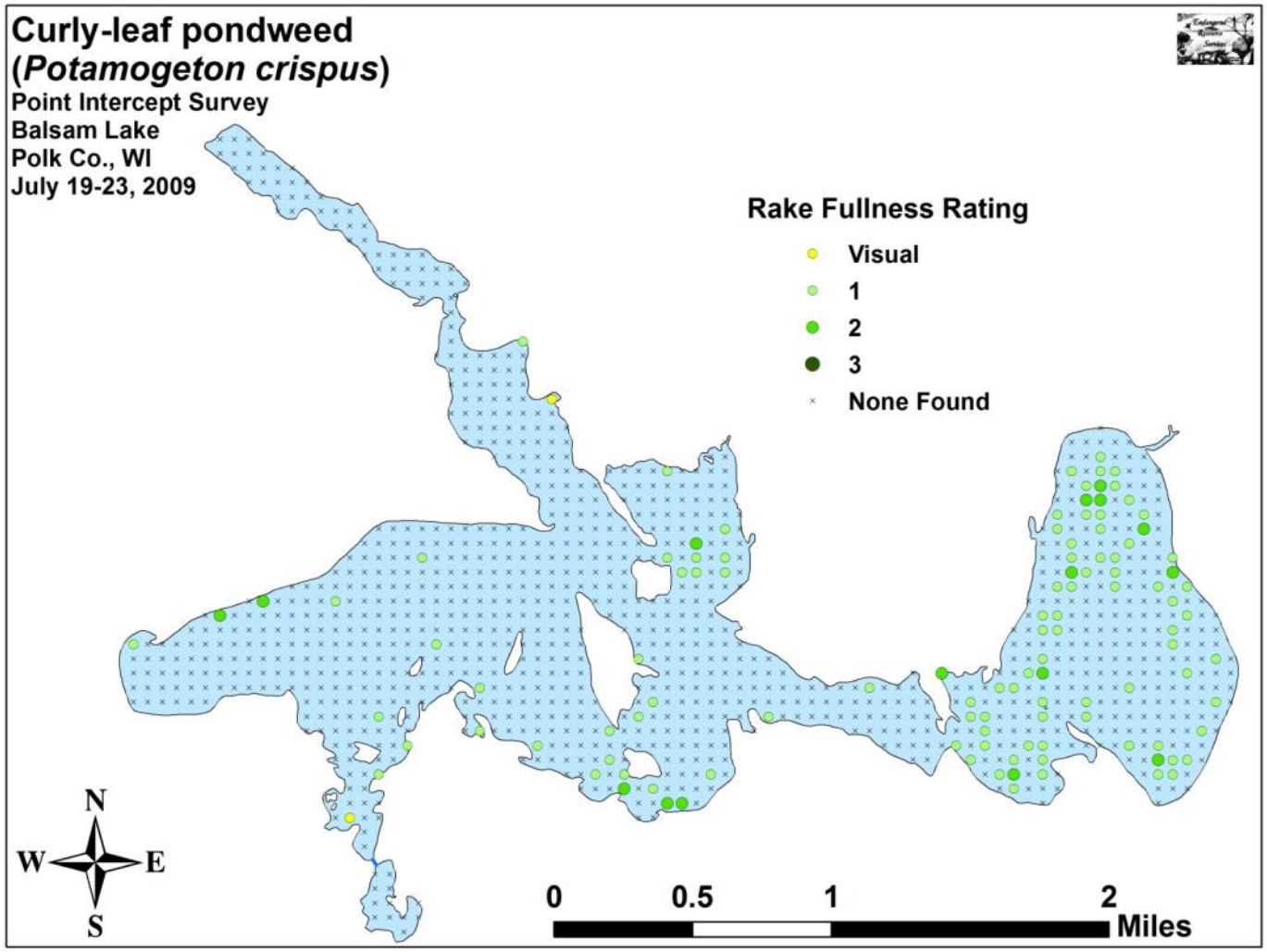
Miles


Curly-leaf pondweed
(Potamogeton crispus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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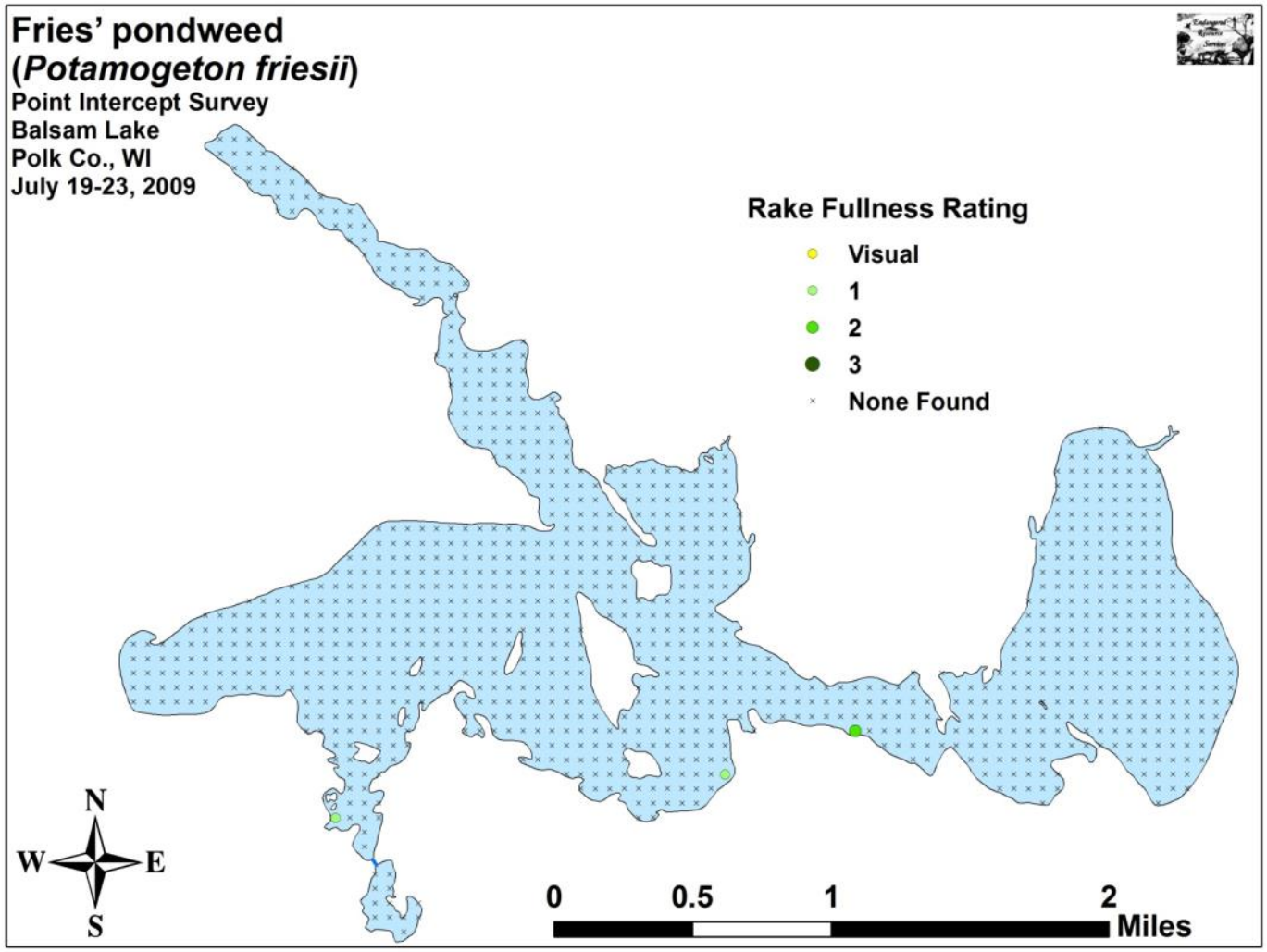
Miles


Fries' pondweed
(Potamogeton friesii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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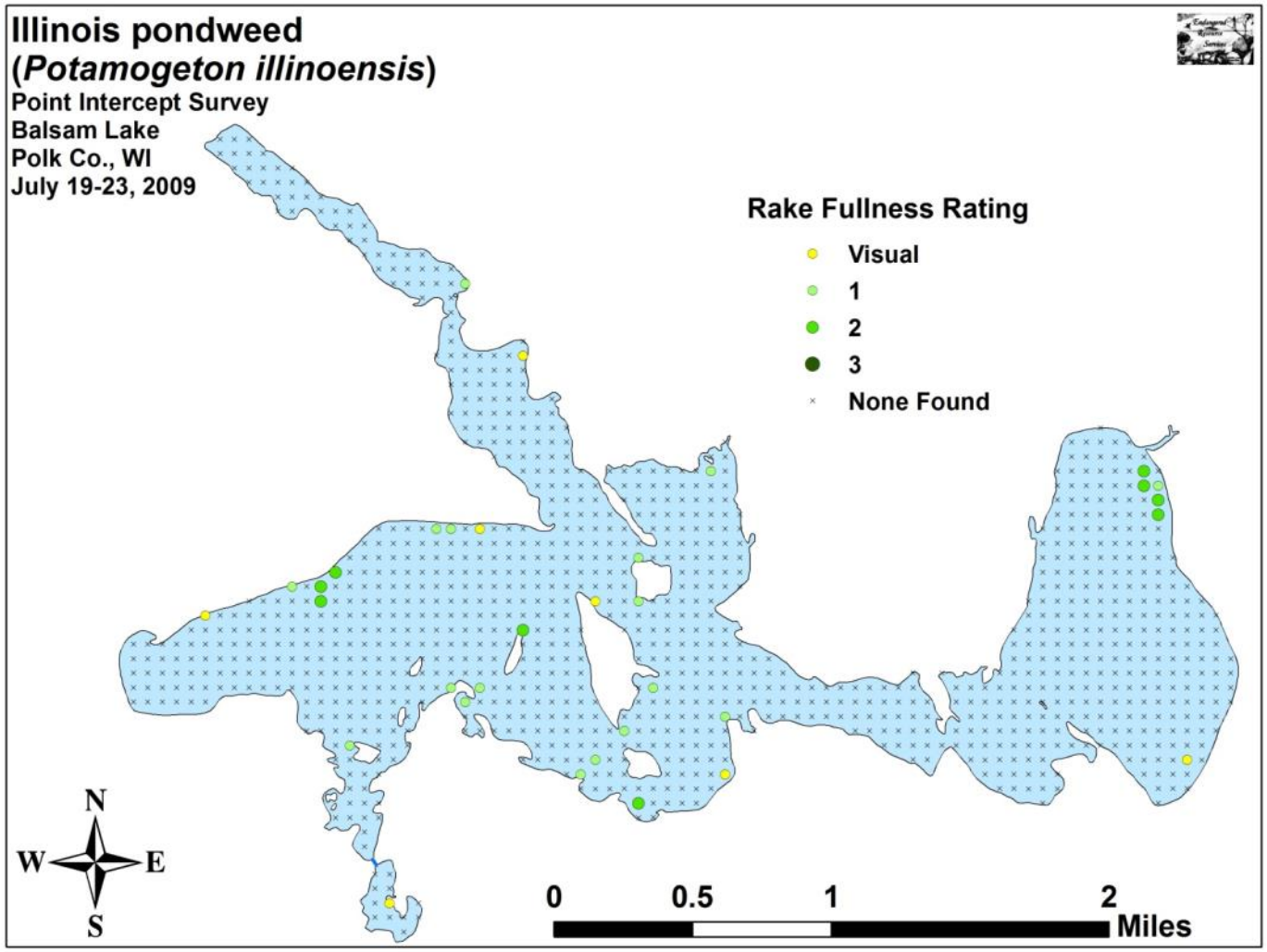
Miles


Illinois pondweed
(Potamogeton illinoensis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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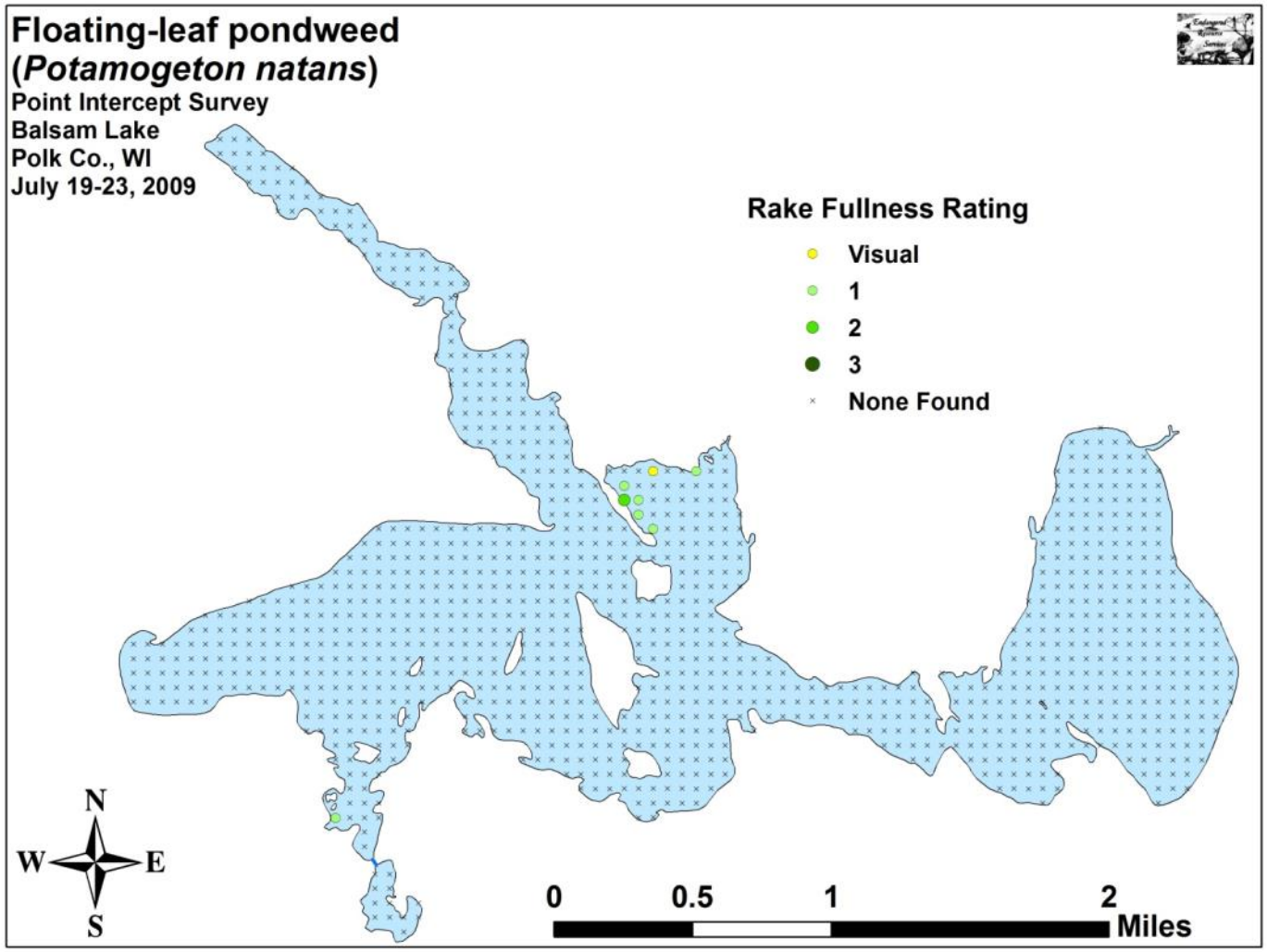
Miles


Floating-leaf pondweed
(Potamogeton natans)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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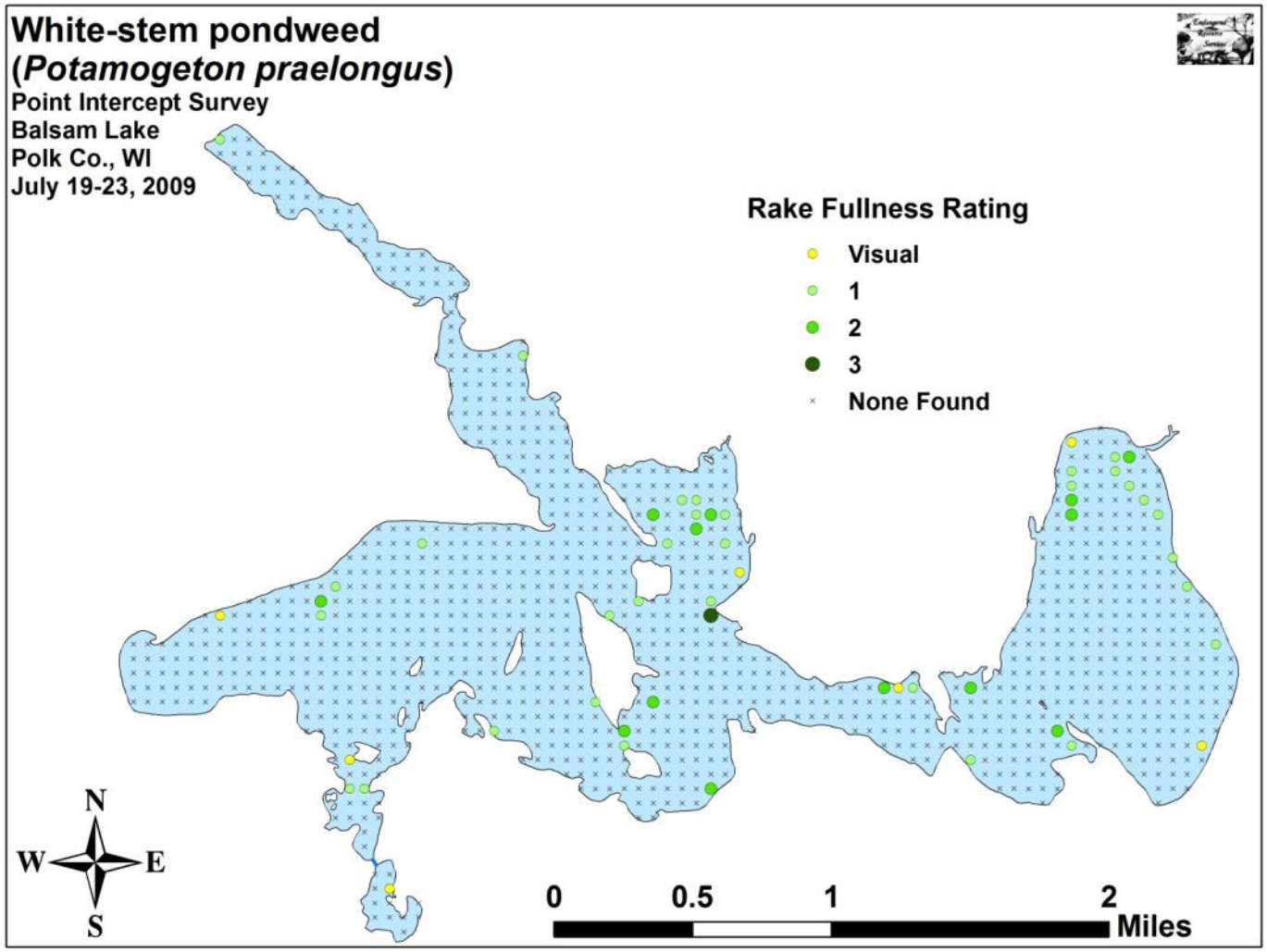
Miles


White-stem pondweed
(Potamogeton praelongus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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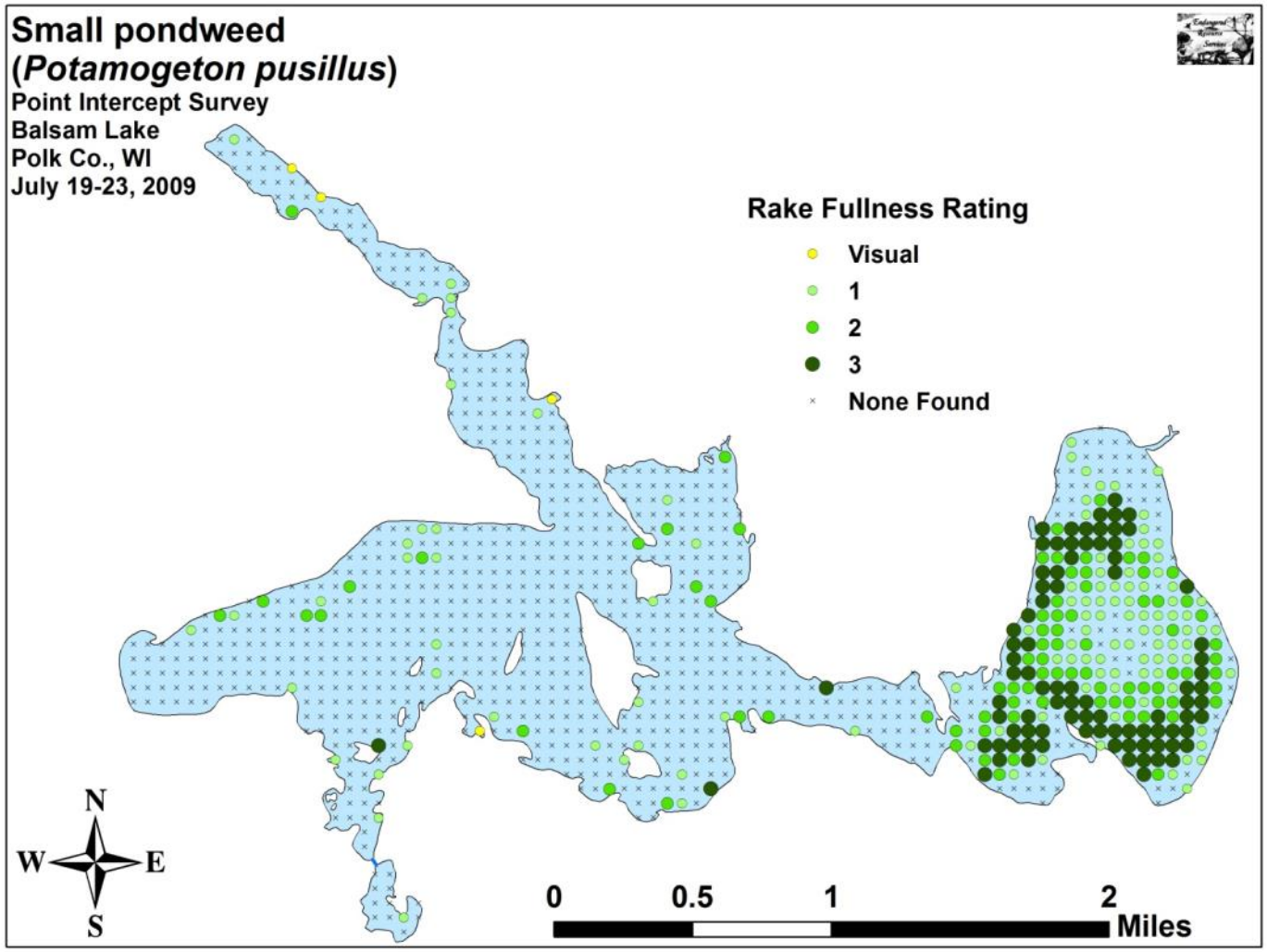
Miles


Small pondweed
(Potamogeton pusillus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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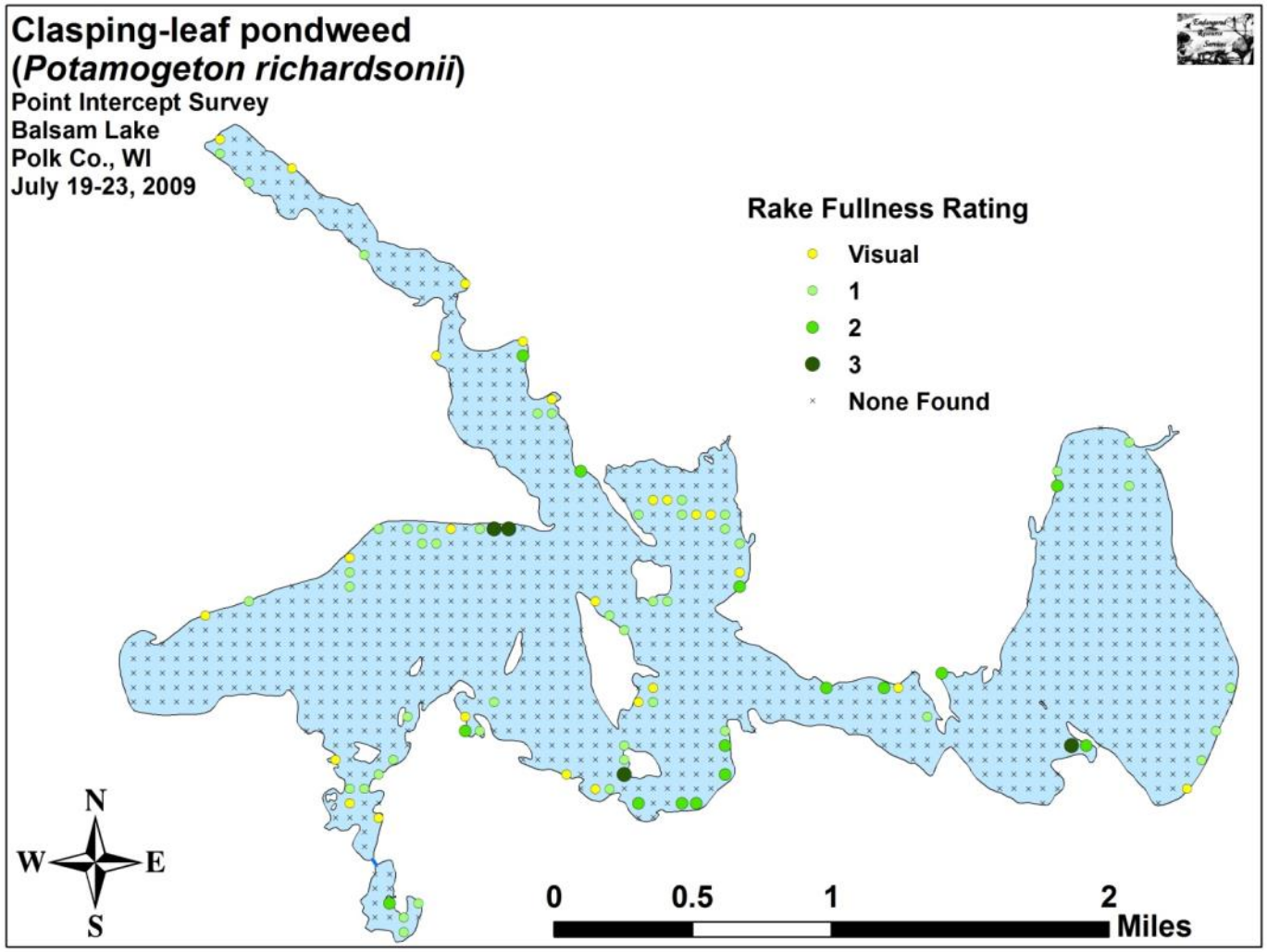
Miles


Clasping-leaf pondweed
(Potamogeton richardsonii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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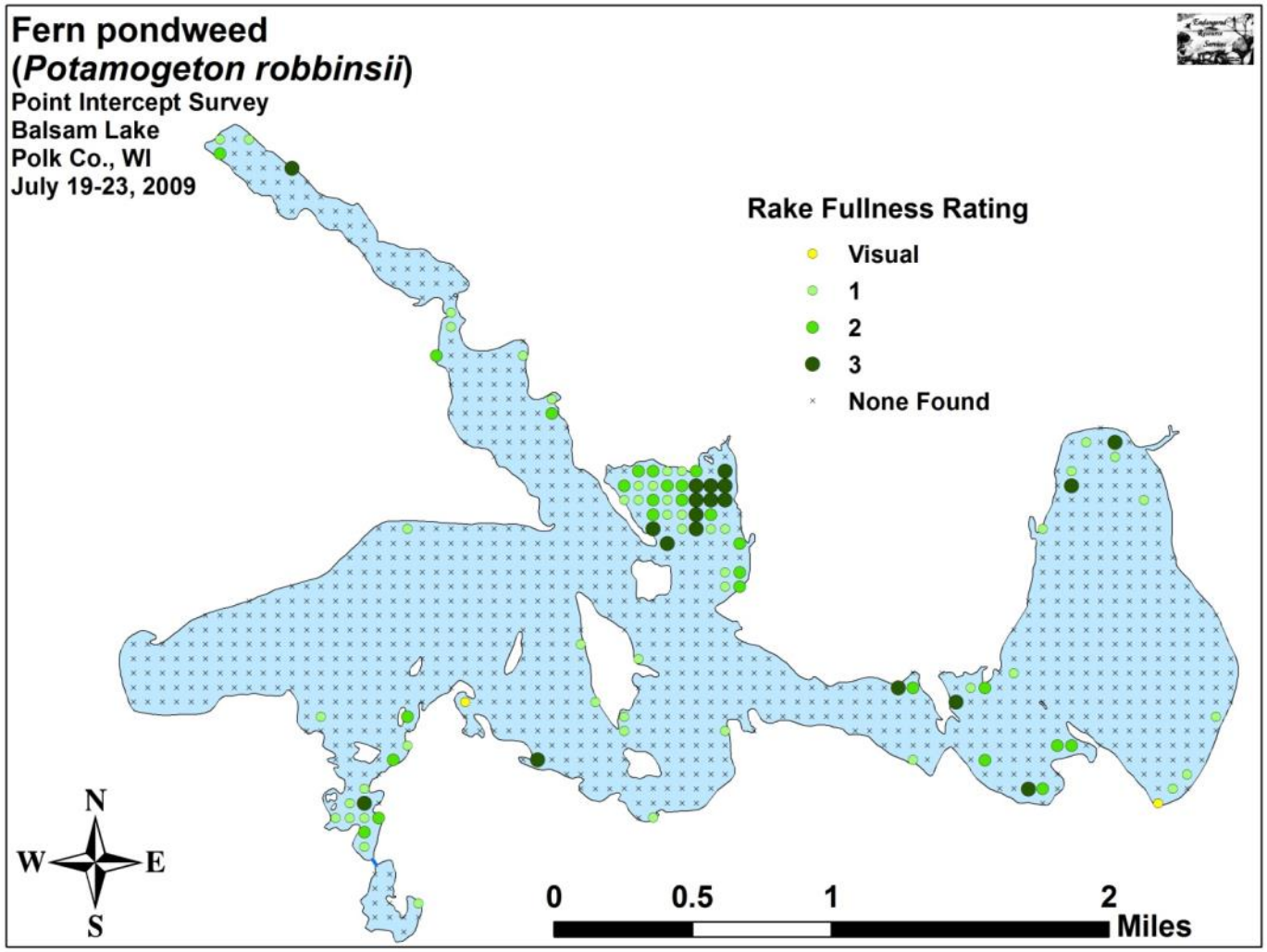
Miles


Fern pondweed
(Potamogeton robbinsii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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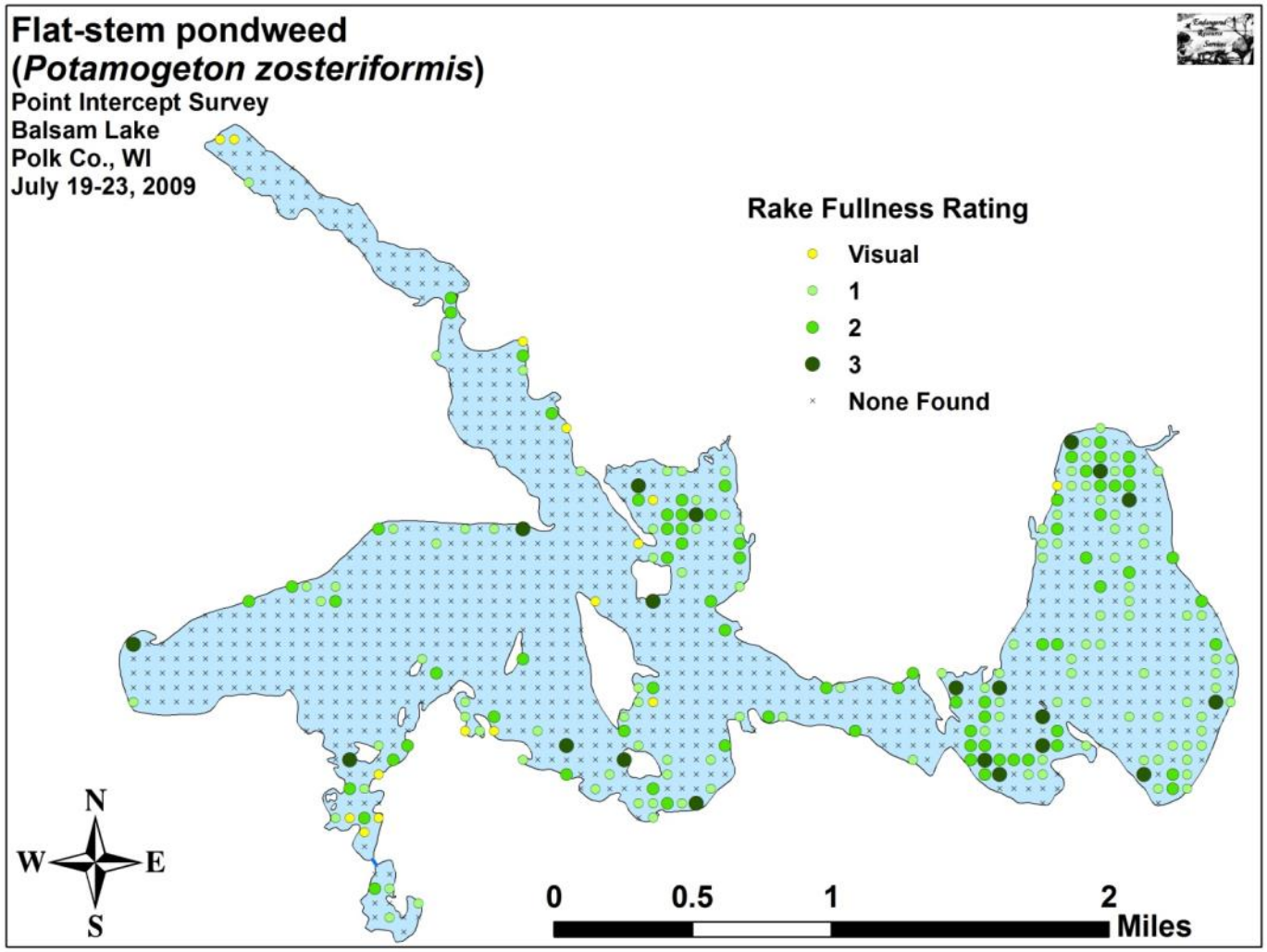
Miles


Flat-stem pondweed
(Potamogeton zosteriformis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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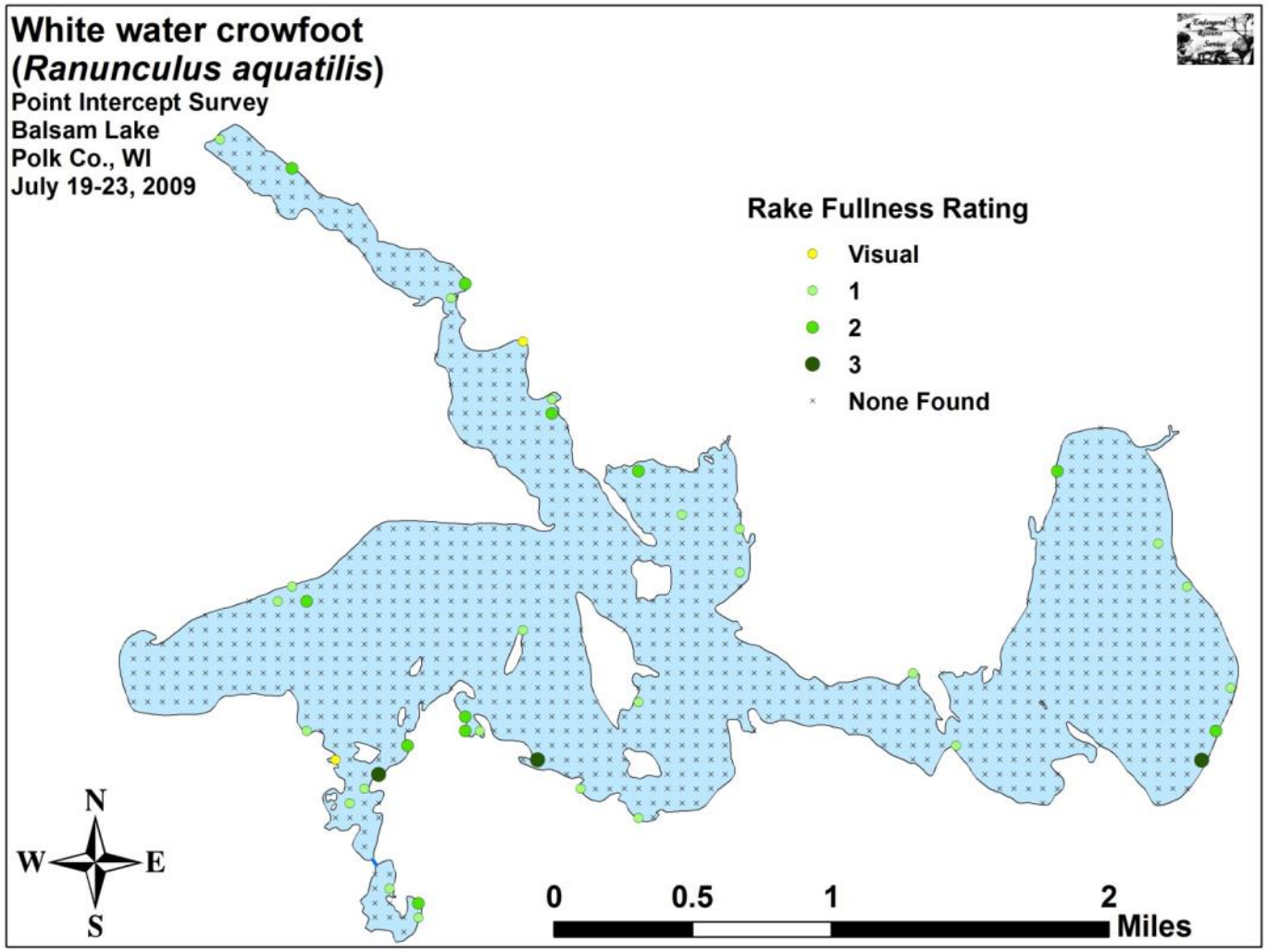
Miles


White water crowfoot
(Ranunculus aquatilis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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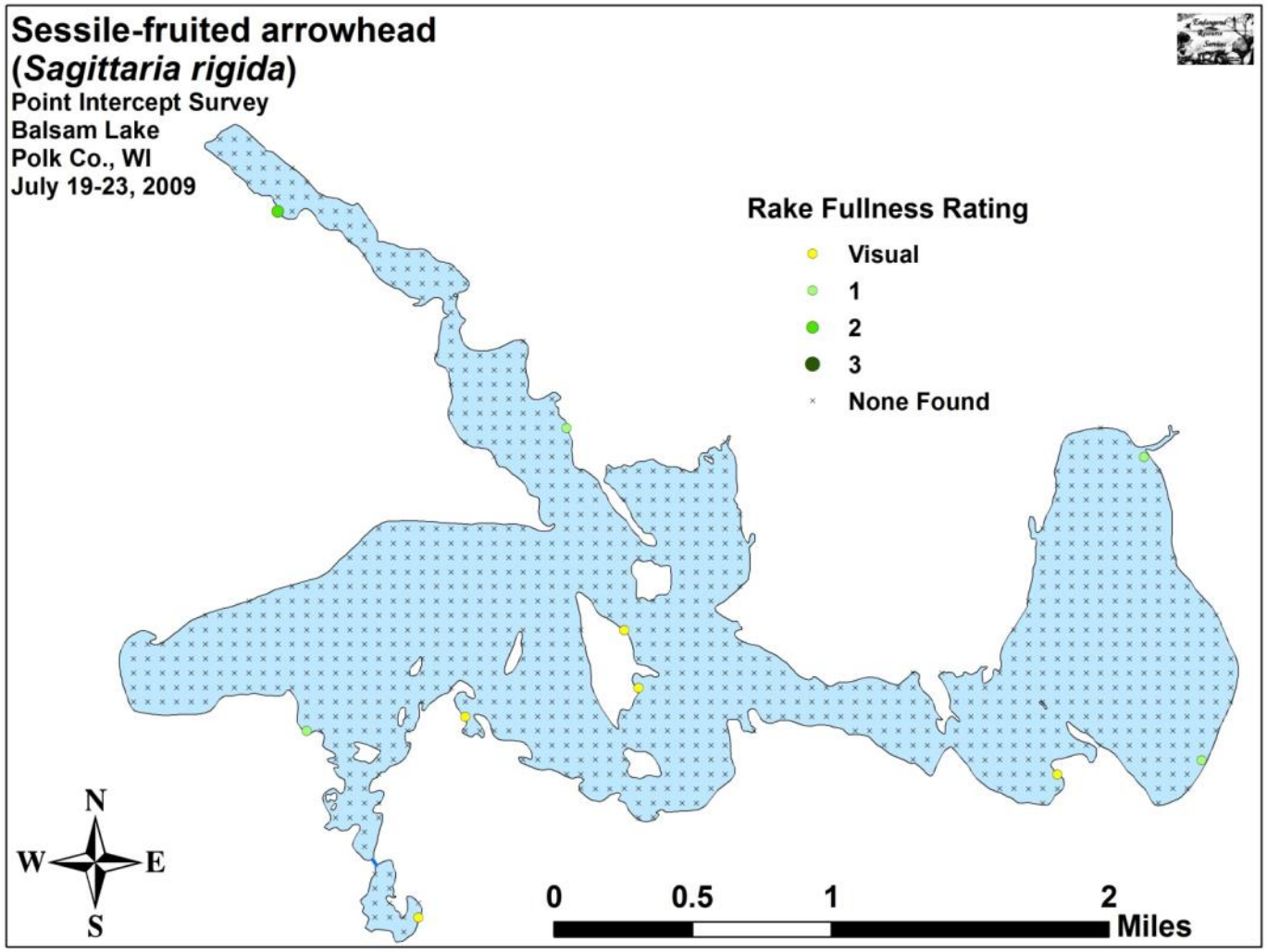
Miles


Sessile-fruited arrowhead
(Sagittaria rigida)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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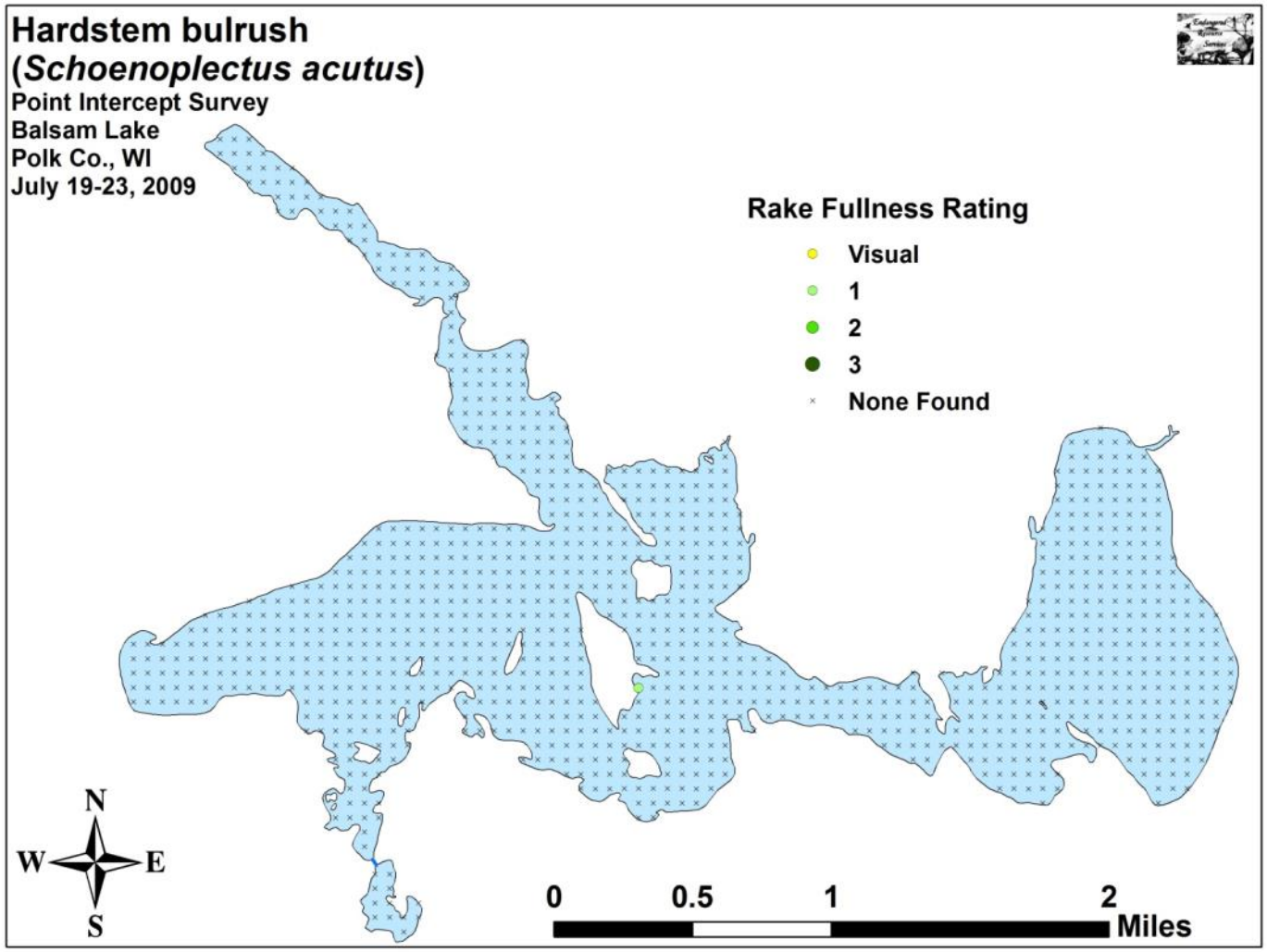
Miles


Hardstem bulrush
(Schoenoplectus acutus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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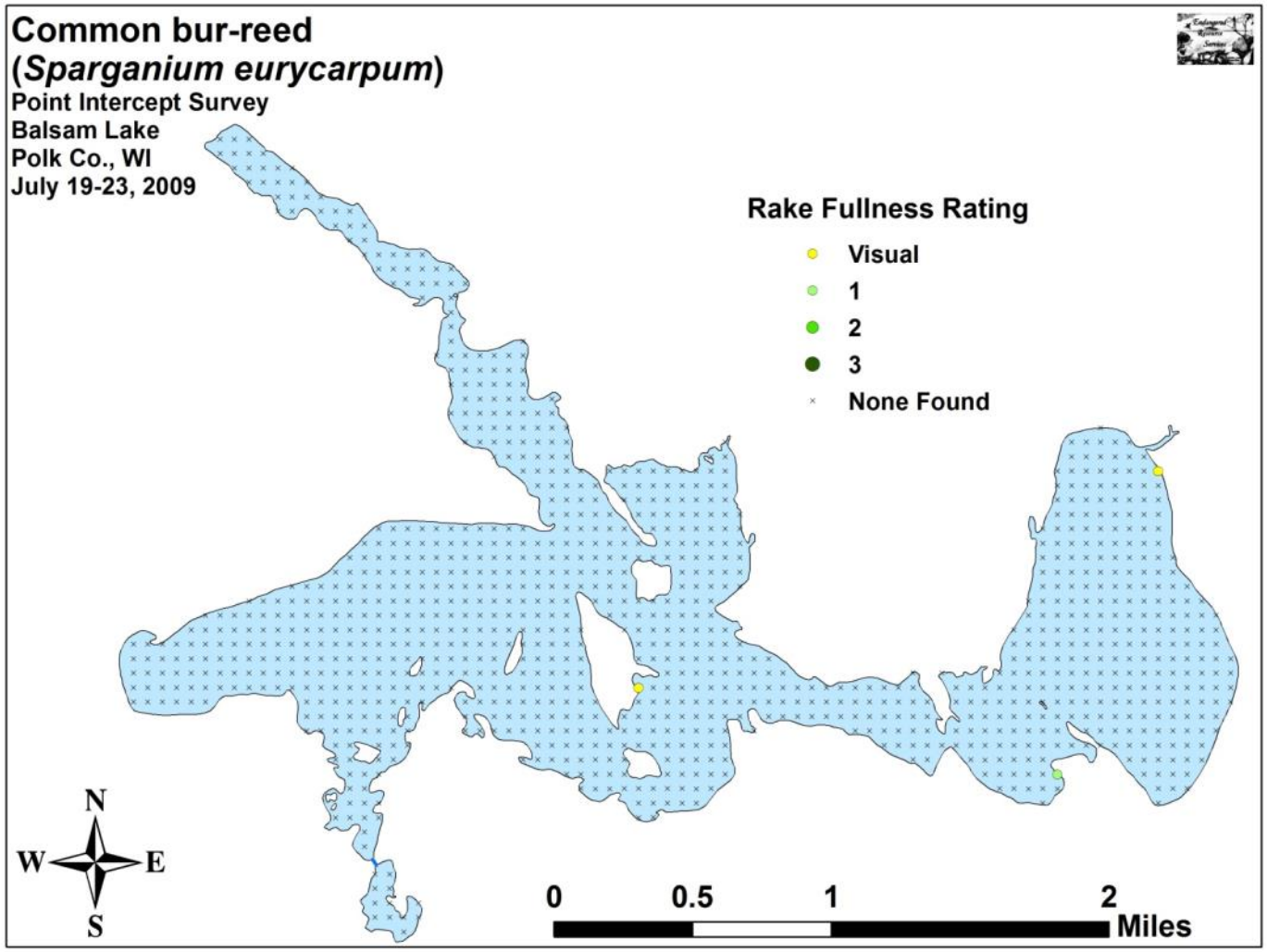
Miles


Common bur-reed
(Sparganium eurycarpum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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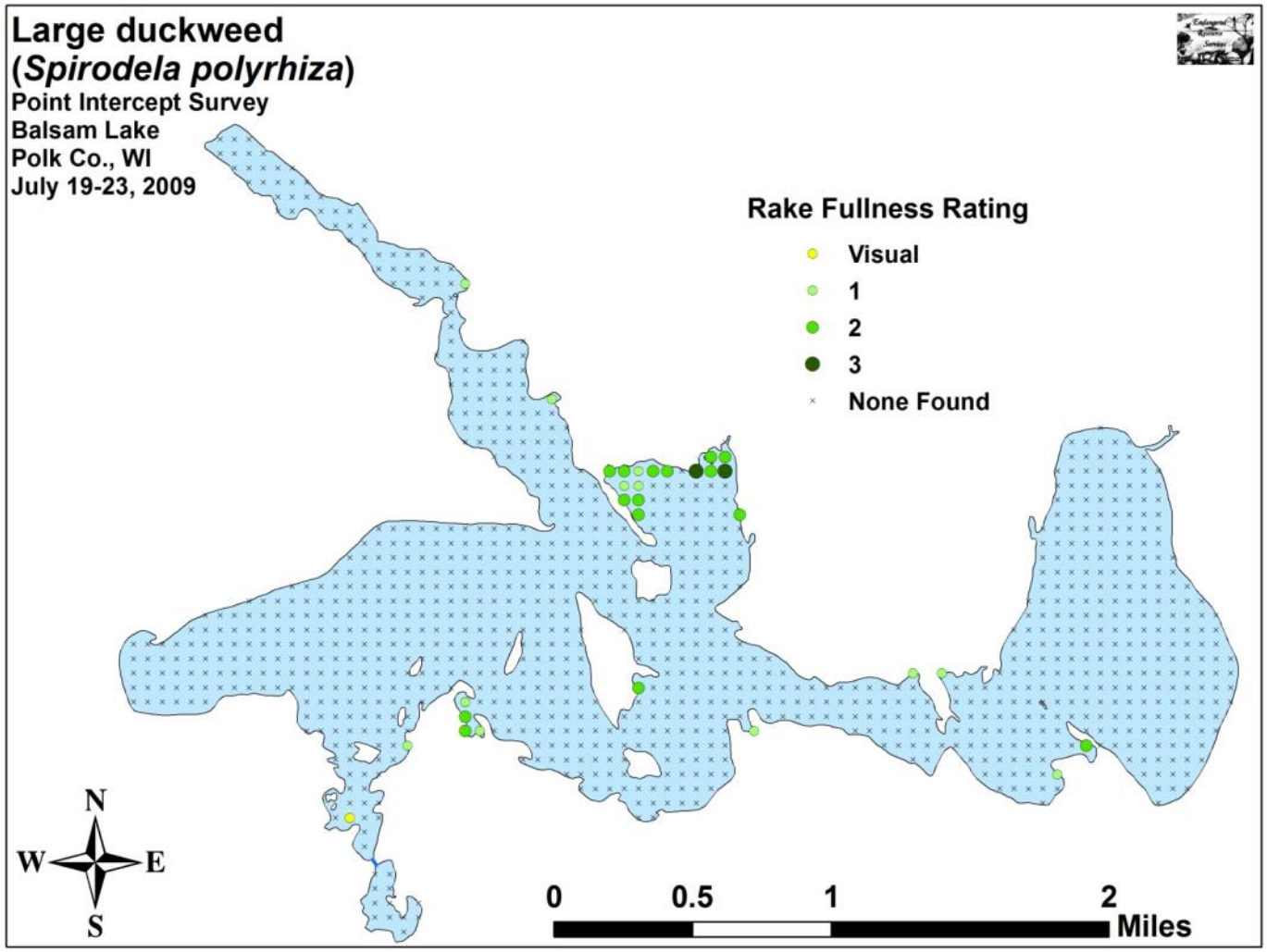
Miles


Large duckweed
(Spirodela polyrhiza)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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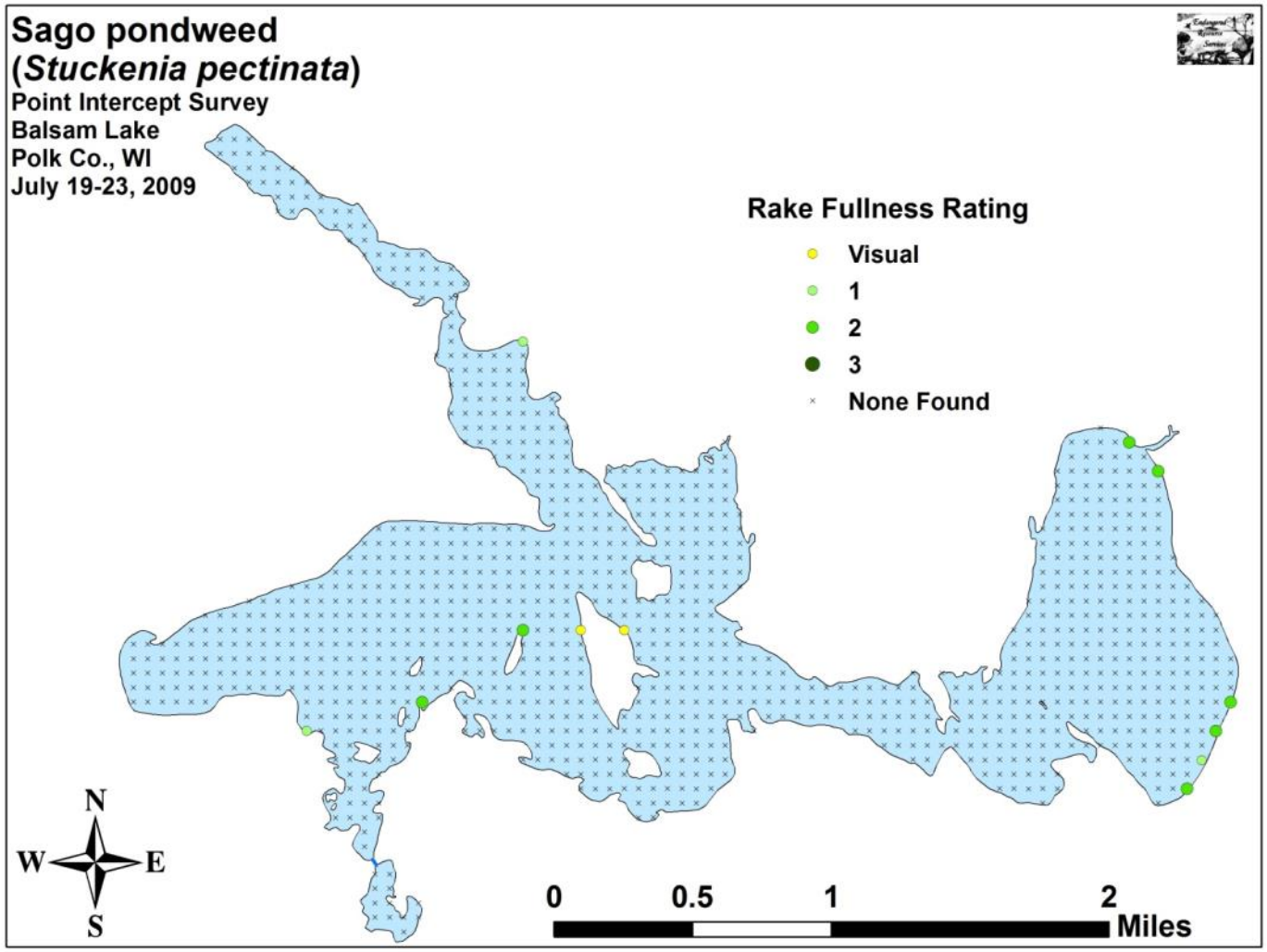
Miles


Sago pondweed
(Stuckenia pectinata)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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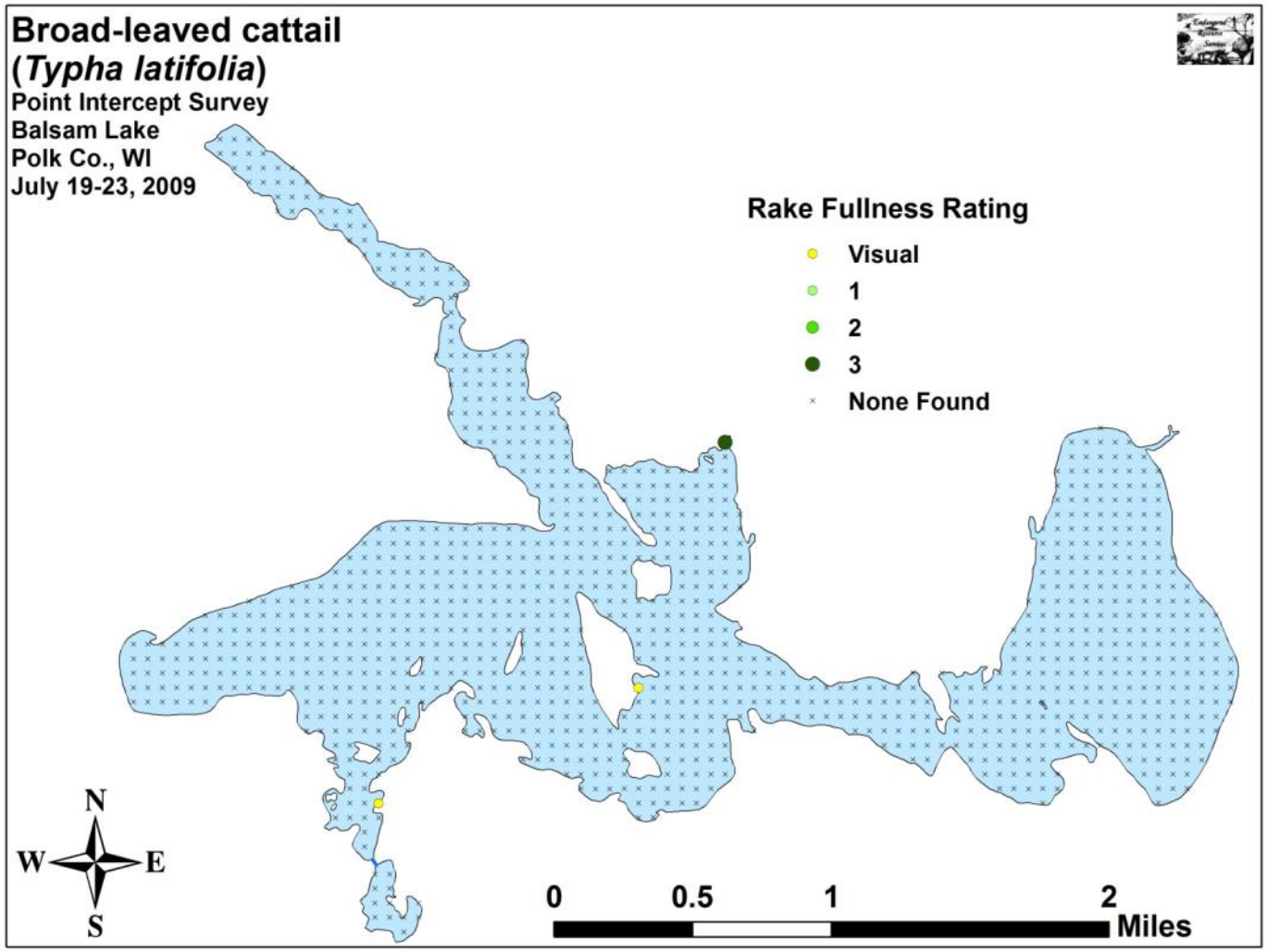
Miles


Broad-leaved cattail
(Typha latifolia)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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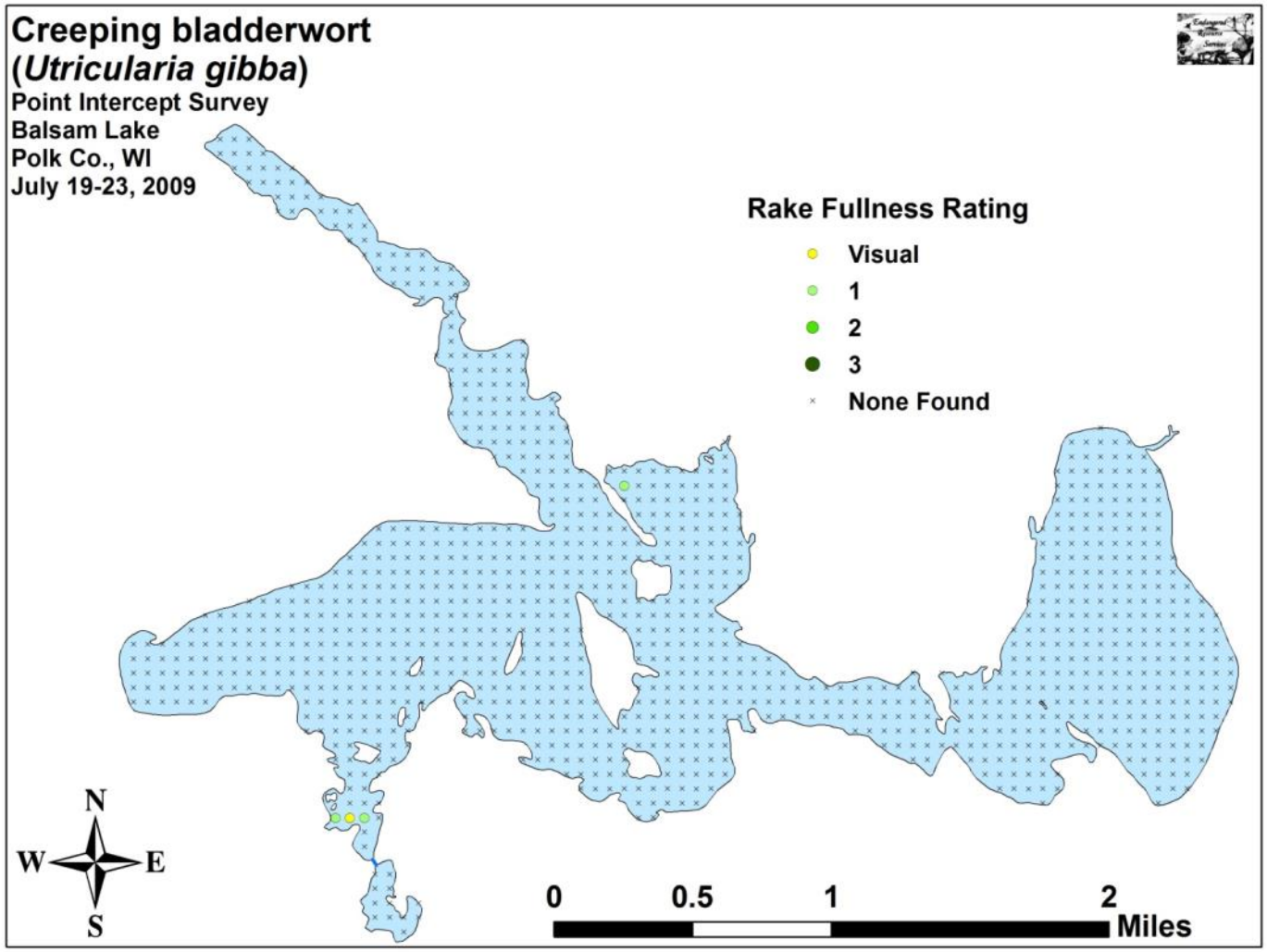
Miles


Creeping bladderwort
(Utricularia gibba)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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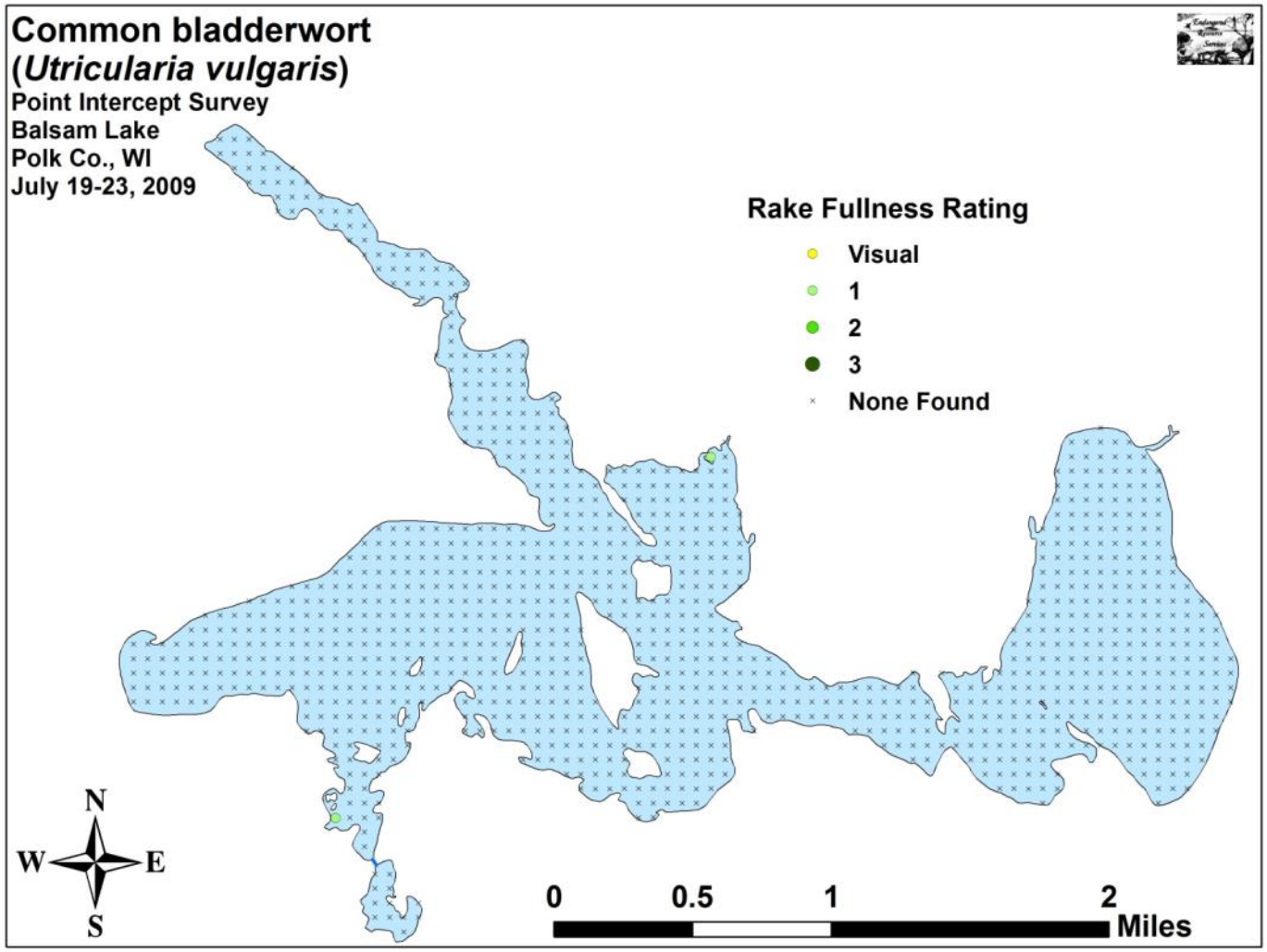
Miles


Common bladderwort
(Utricularia vulgaris)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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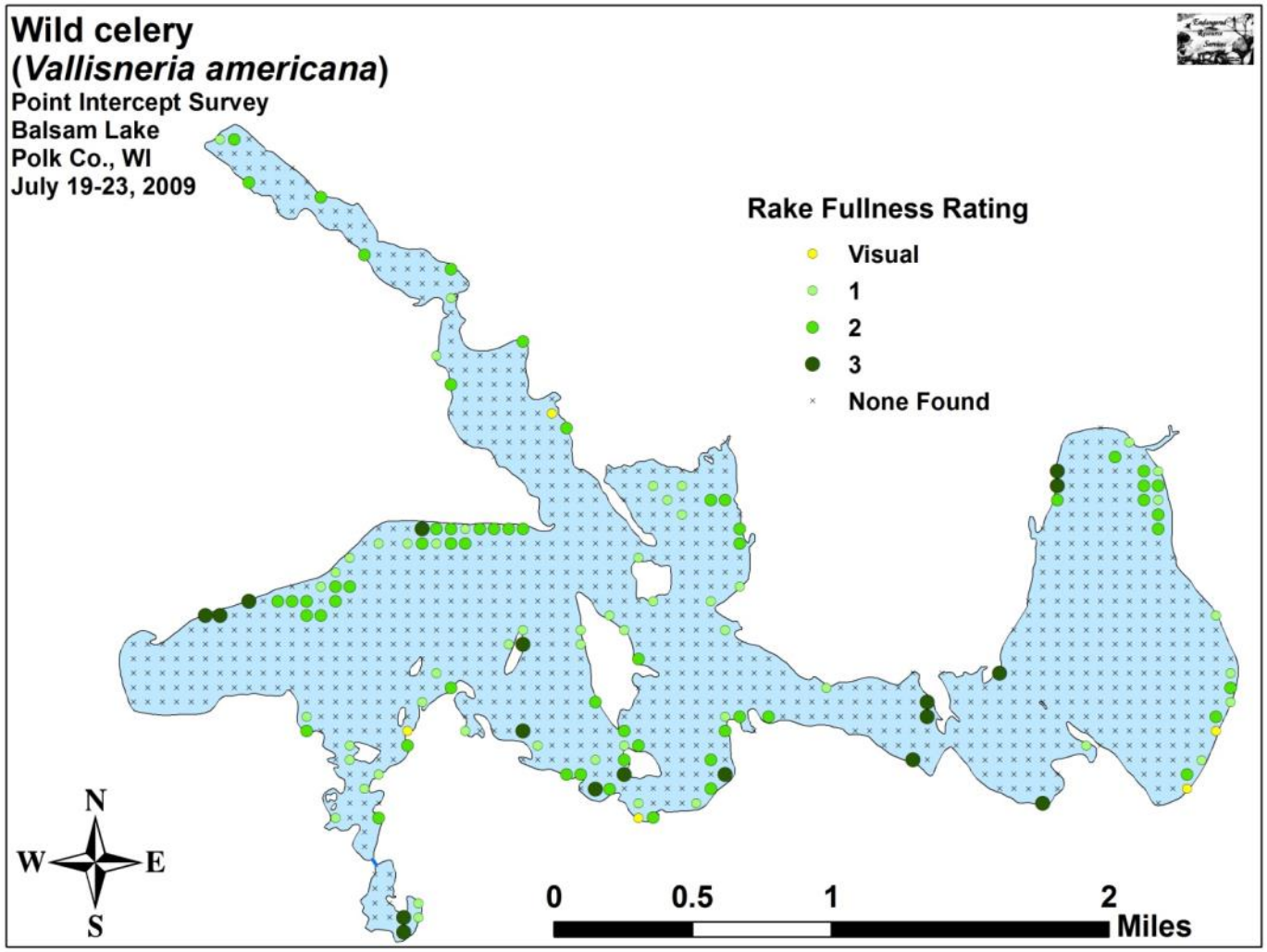
Miles


Wild celery
(Vallisneria americana)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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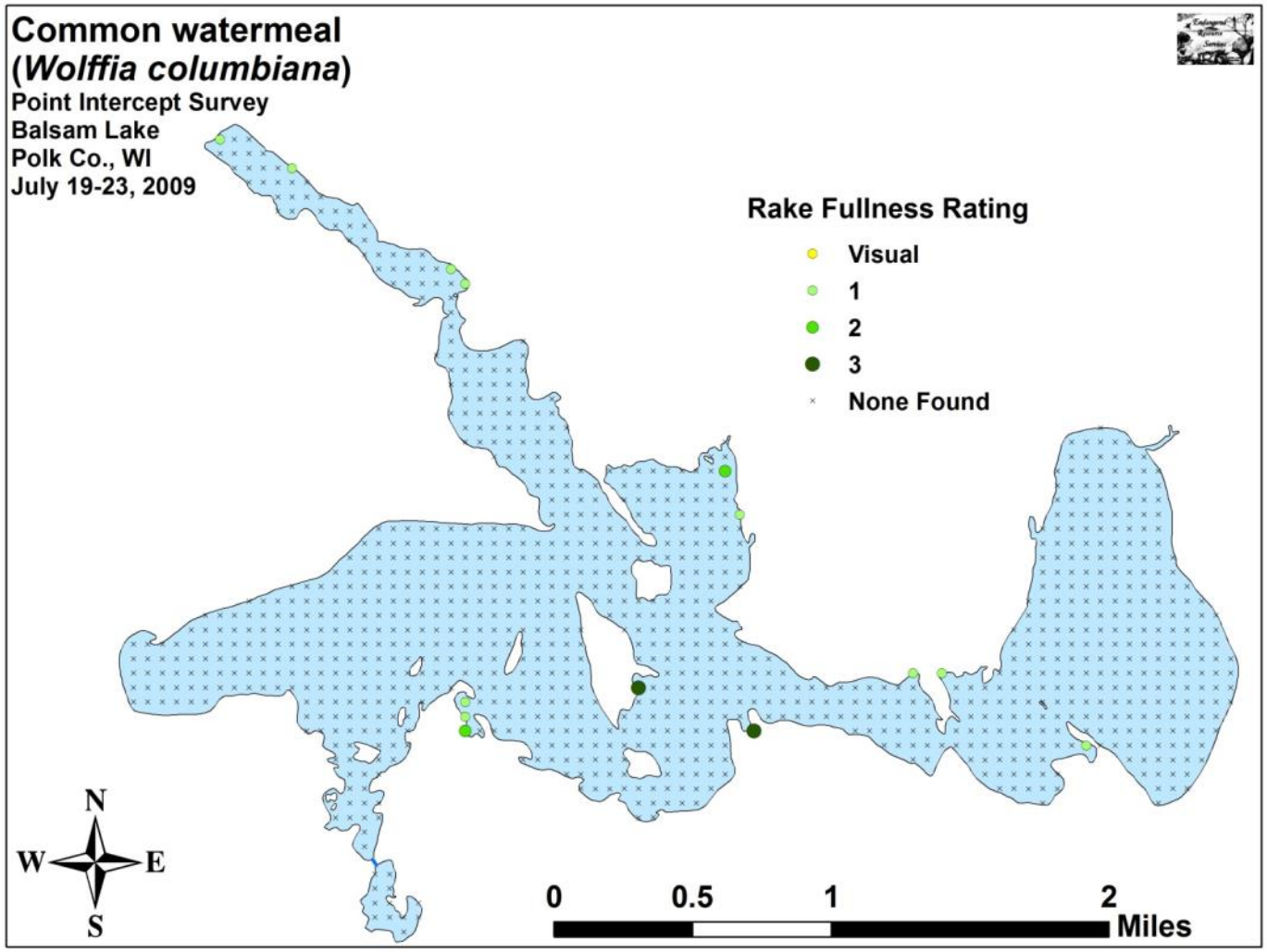
Miles


Common watermeal
(Wolffia columbiana)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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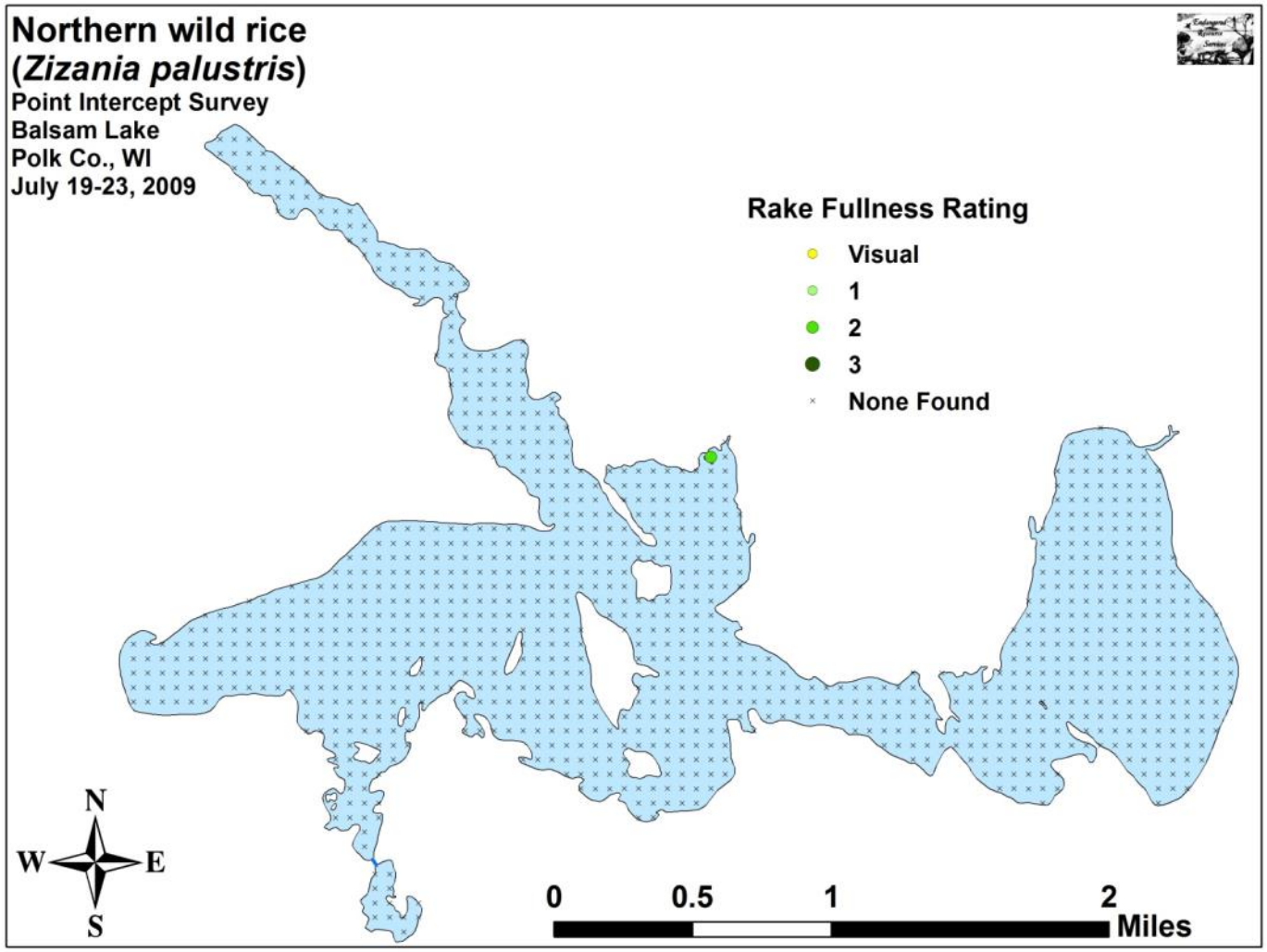
Miles


Northern wild rice
(Zizania palustris)
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
Visual
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None Found
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Miles

Appendix VII: 2009 Balsam Lake 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; 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*) Slender naiad, (*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*) Slender naiad

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*) Slender naiad, (*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*) 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: (*Bidens 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*) 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*) **Slender naiad**
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 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*) 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 2-3m.
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*) 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*) Slender naiad, (*Lemna trisulca*) Forked duckweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Ceratophyllum demersum*) Coontail

County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Potamogeton robbinsii*) **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*) 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*) Slender naiad, (*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*) Slender naiad, (*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*) Slender naiad, (*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

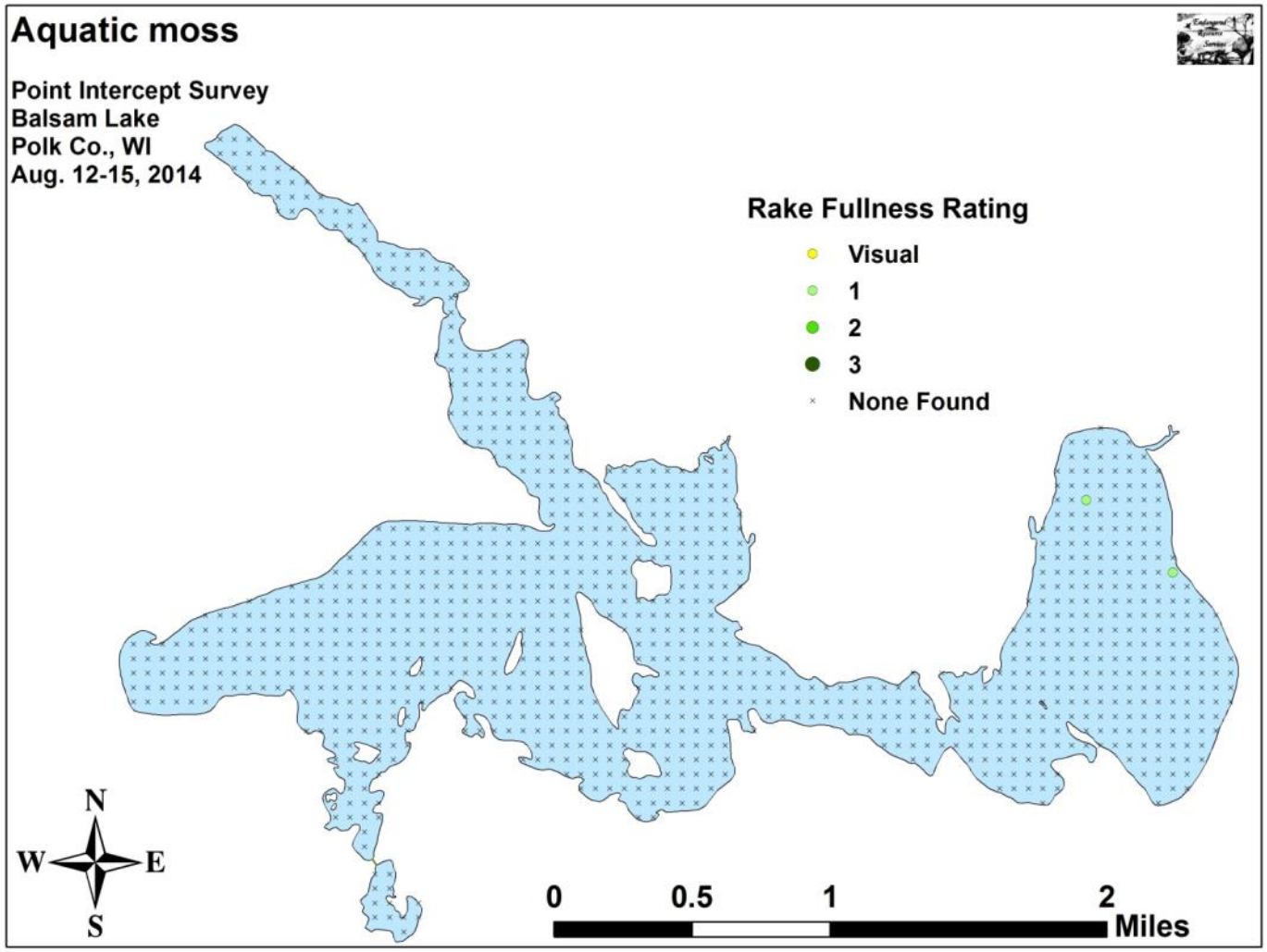
County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Vallisneria americana*) **Wild celery**
Specimen Location: Balsam Lake; N45.47047°, W92.42762°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-118
Habitat/Distribution: Found in almost any bottom conditions, but grows best in 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*) Slender naiad, (*Myriophyllum sibiricum*) Northern water milfoil

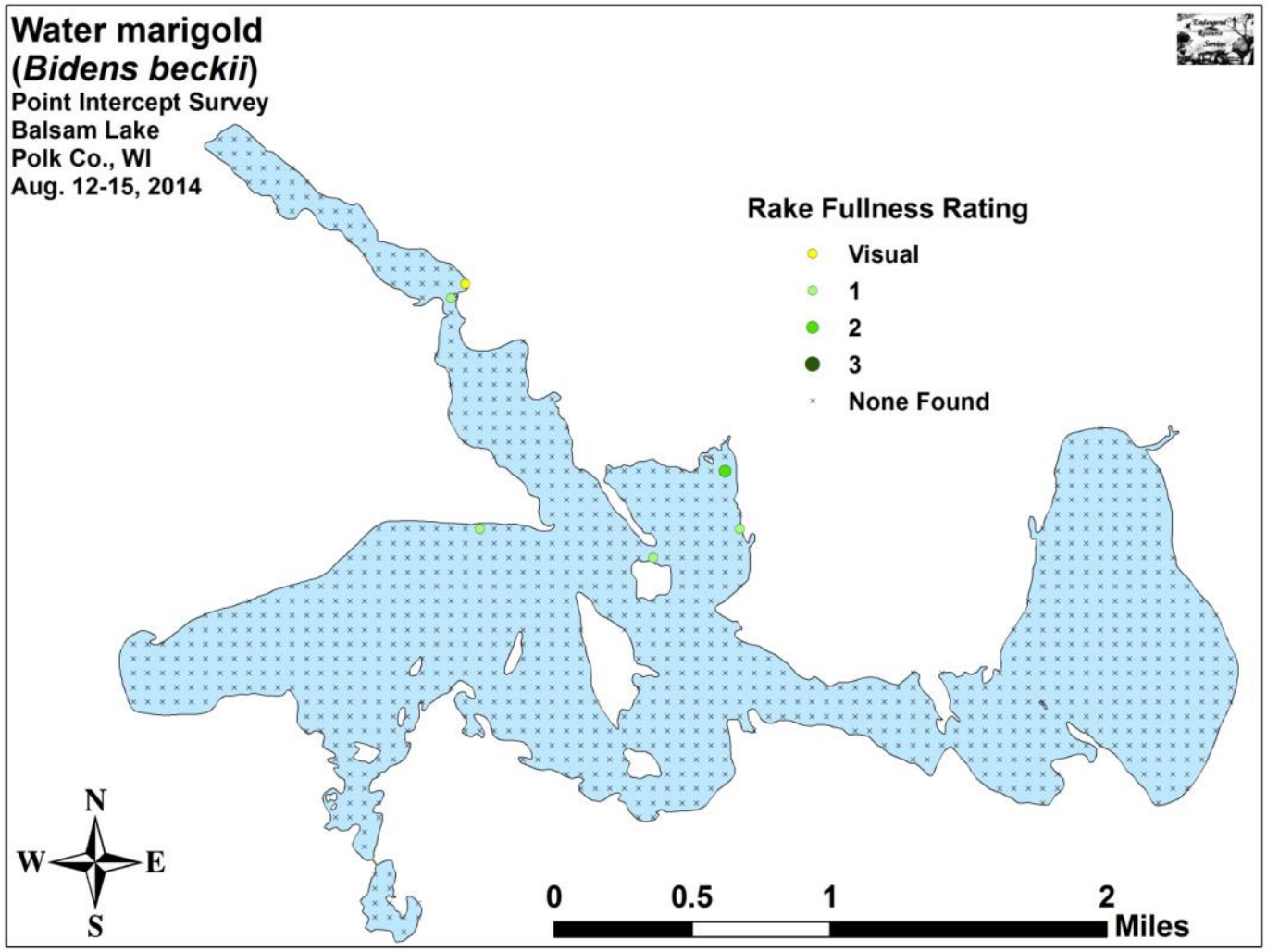
County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Wolffia columbiana*) **Common watermeal**
Specimen Location: Balsam Lake; N45.45408°, W92.45163°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-119
Habitat/Distribution: Located floating at or just under the surface in sheltered 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

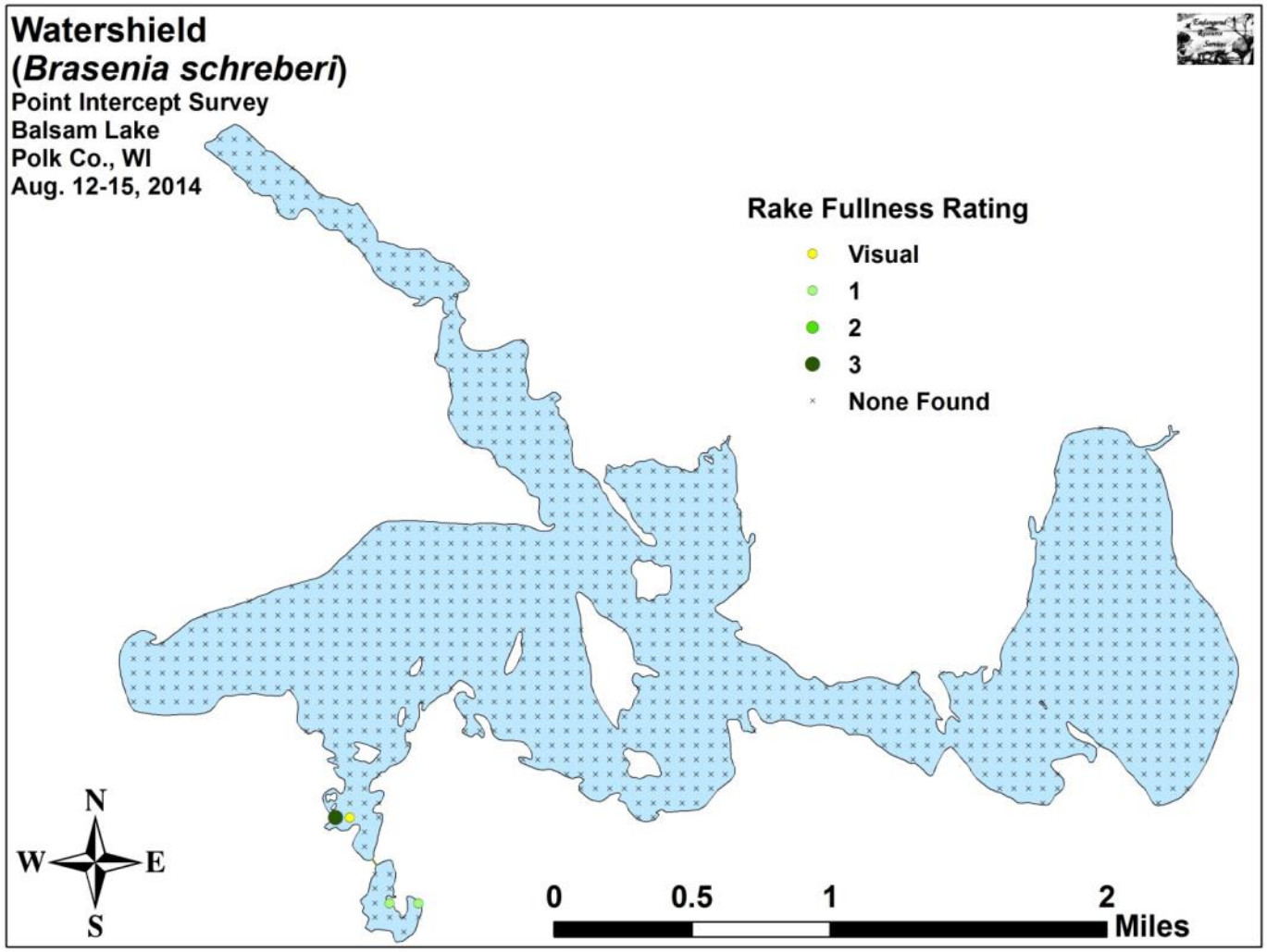
County/State: Polk County, Wisconsin **Date:** 7/21/09
Species: (*Zizania palustris*) **Northern wild rice**
Specimen Location: Balsam Lake; N45.48938°, W92.46284°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-120
Habitat/Distribution: Found in muck bottom areas that have water flow. The 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

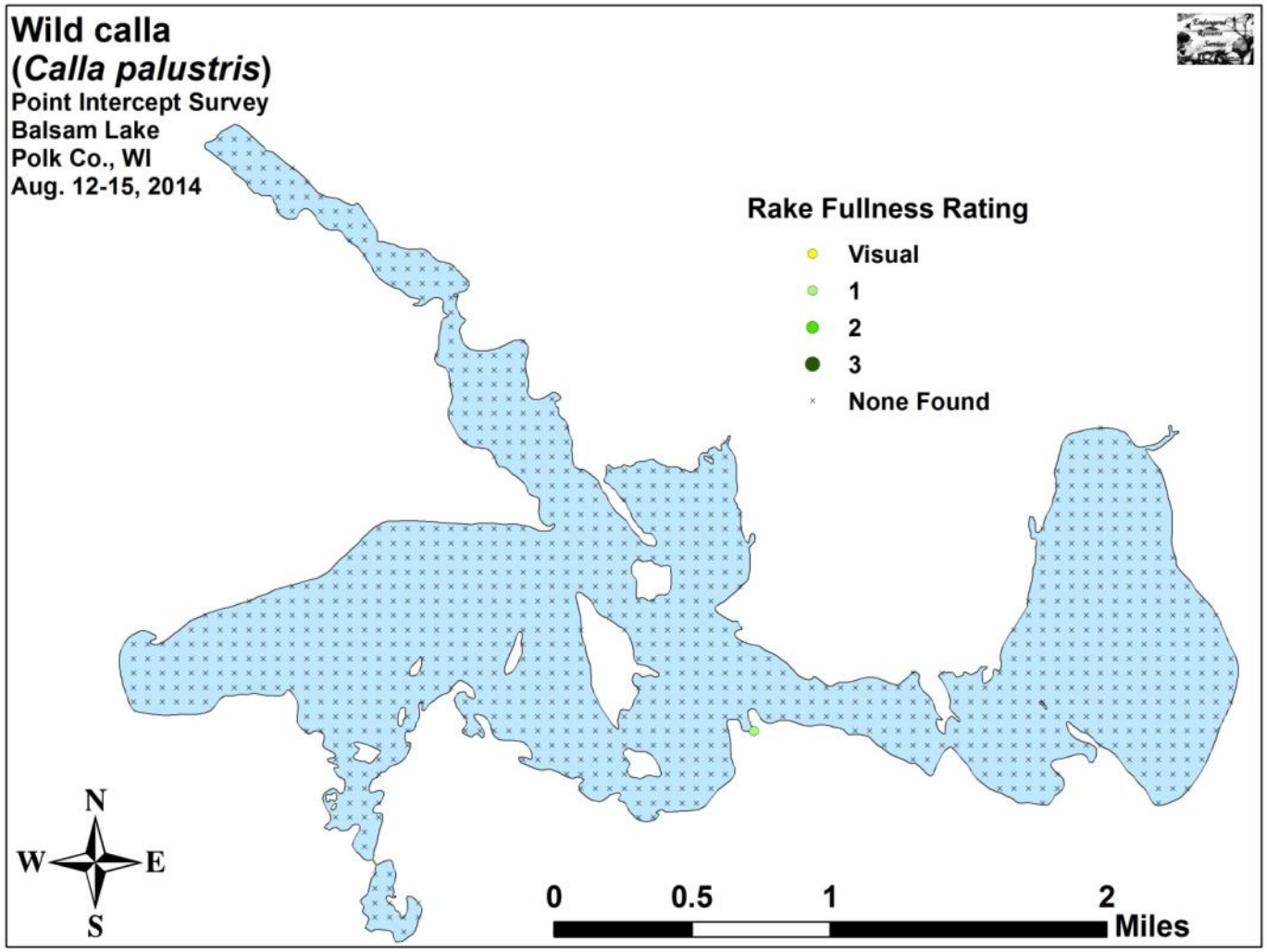
County/State: Polk County, Wisconsin **Date:** 7/20/09
Species: (*Potamogeton amplifolius* X *illinoensis*)
Large-leaf X Illinois pondweed Hybrid?
Specimen Location: Balsam Lake; N45.46173°, W92.44766°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-121
Habitat/Distribution: Located on the 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*.

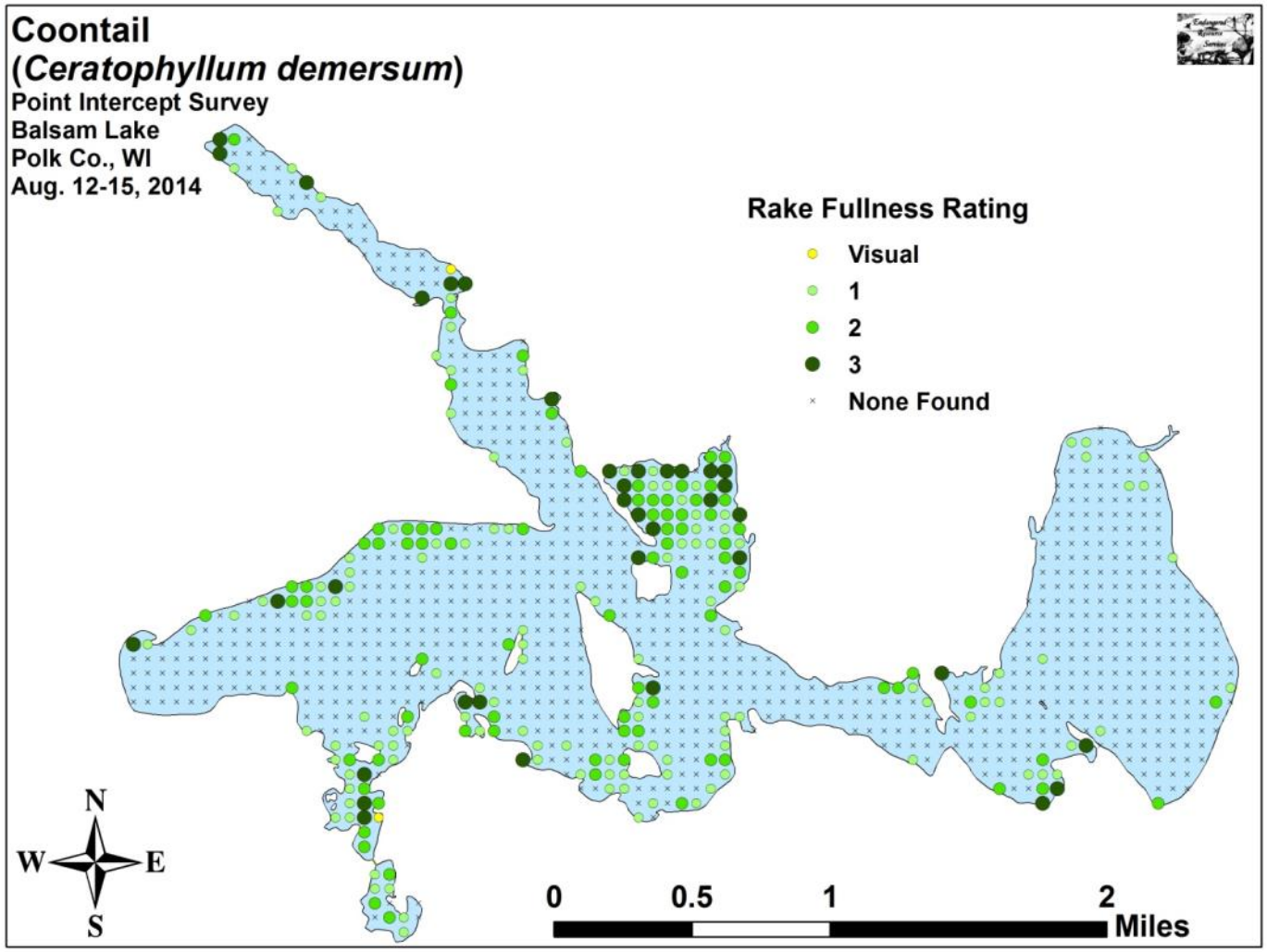
Appendix VIII: August 2014 Species Density and Distribution Maps

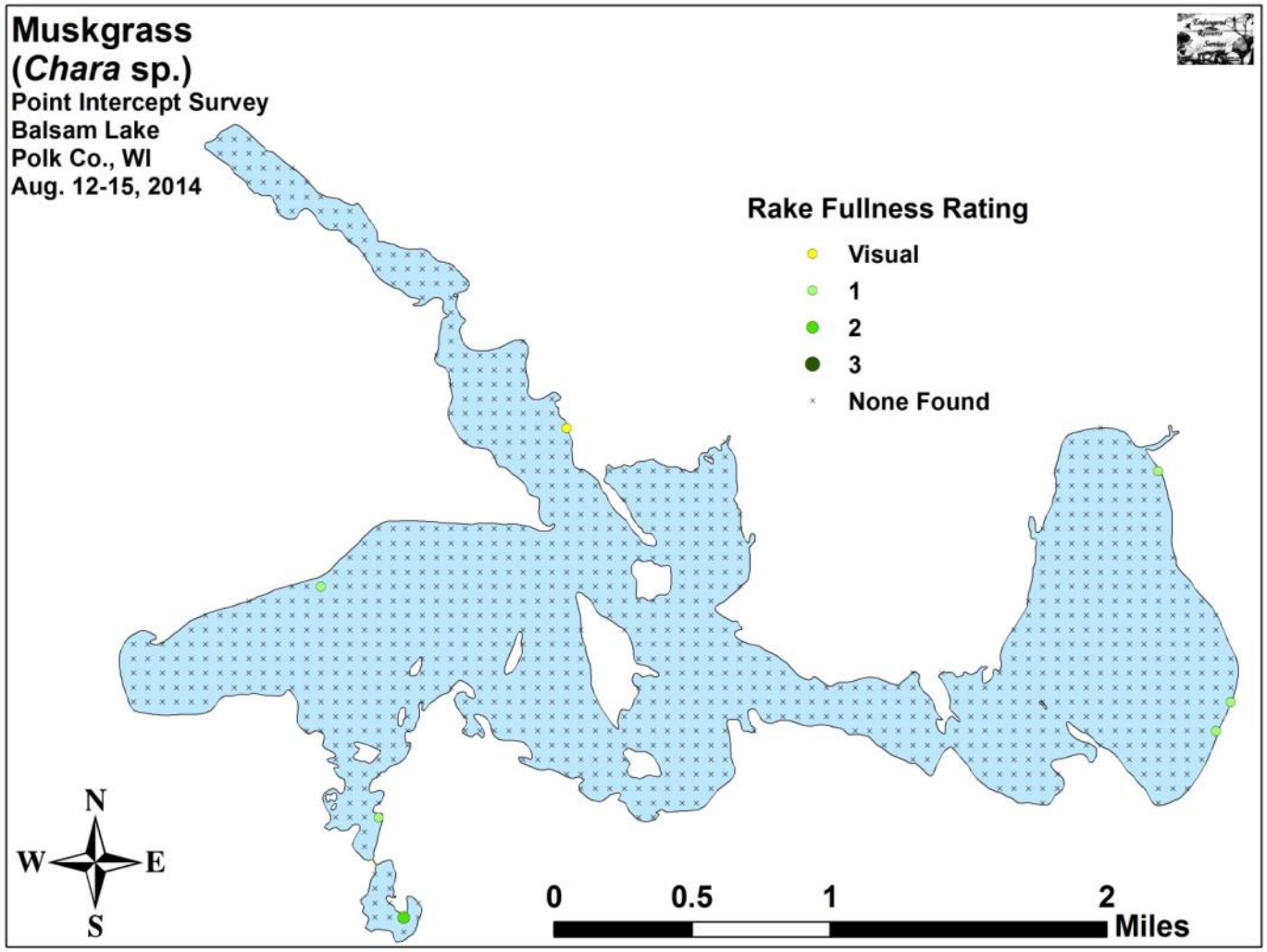

Aquatic moss
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

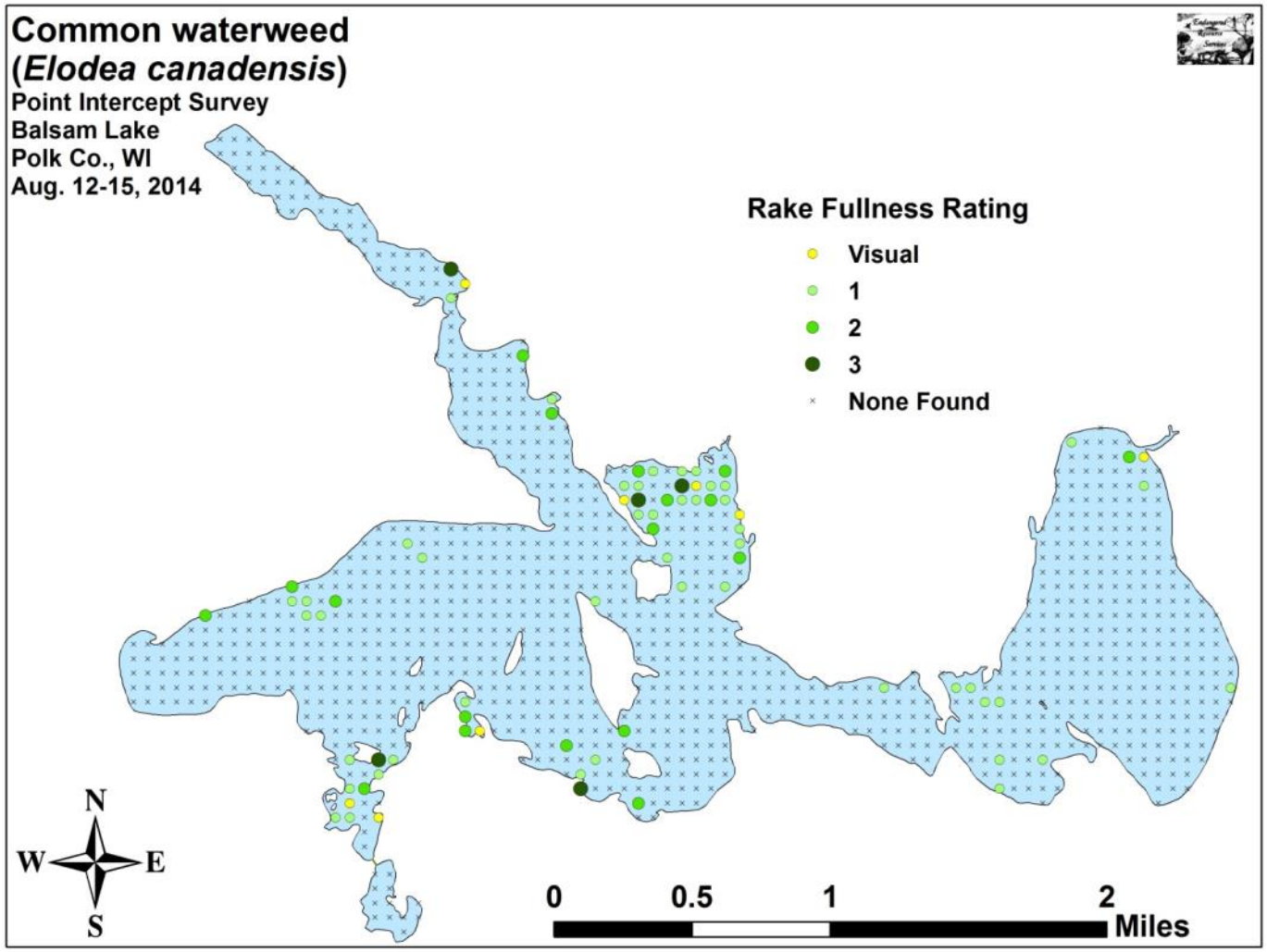

Water marigold
(Bidens beckii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles

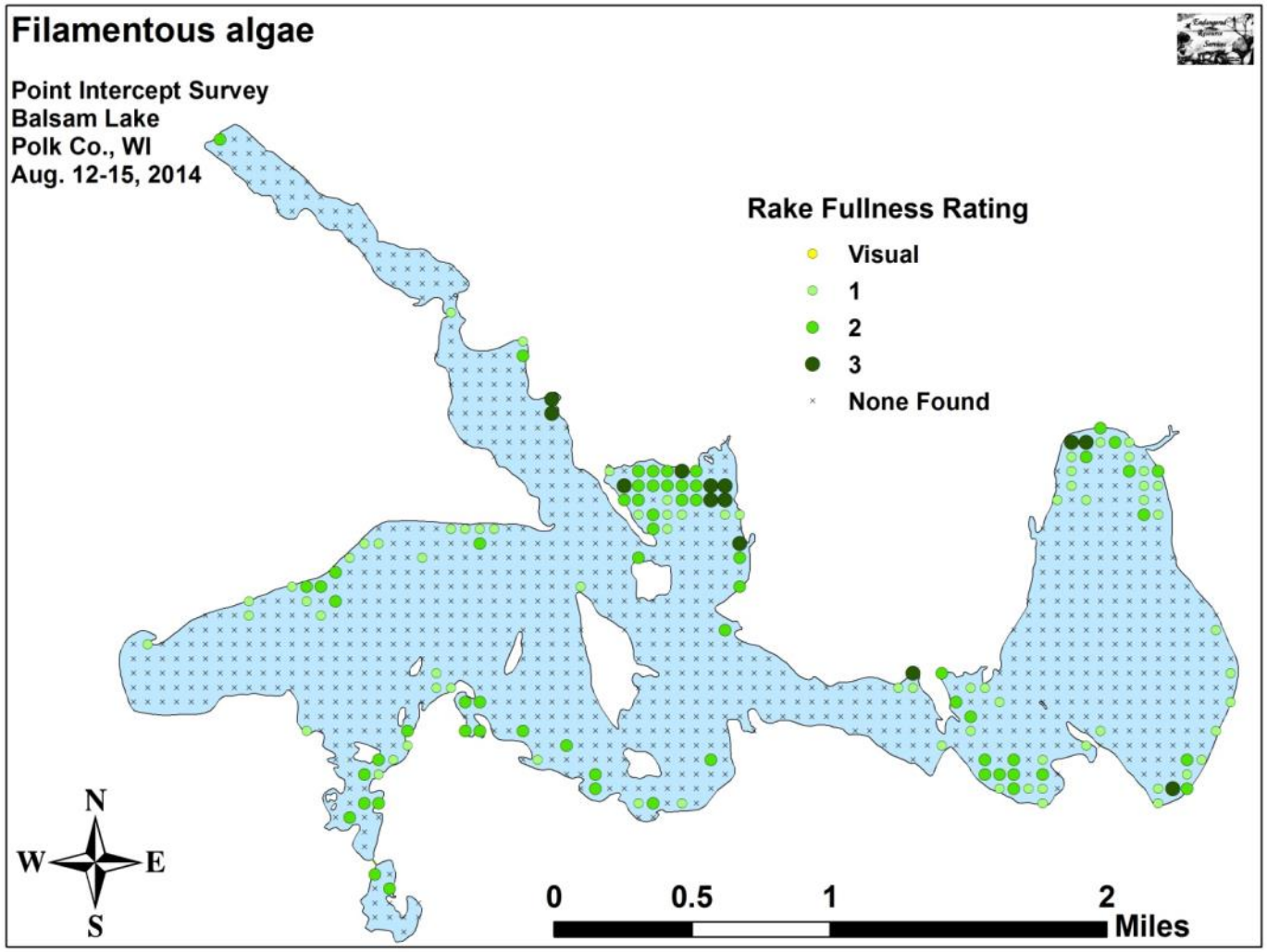

Watershield
(Brasenia schreberi)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Wild calla
(Calla palustris)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Coontail
(Ceratophyllum demersum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Muskgrass
(Chara sp.)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Common waterweed
(Elodea canadensis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.5
1
2
Miles


Filamentous algae
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
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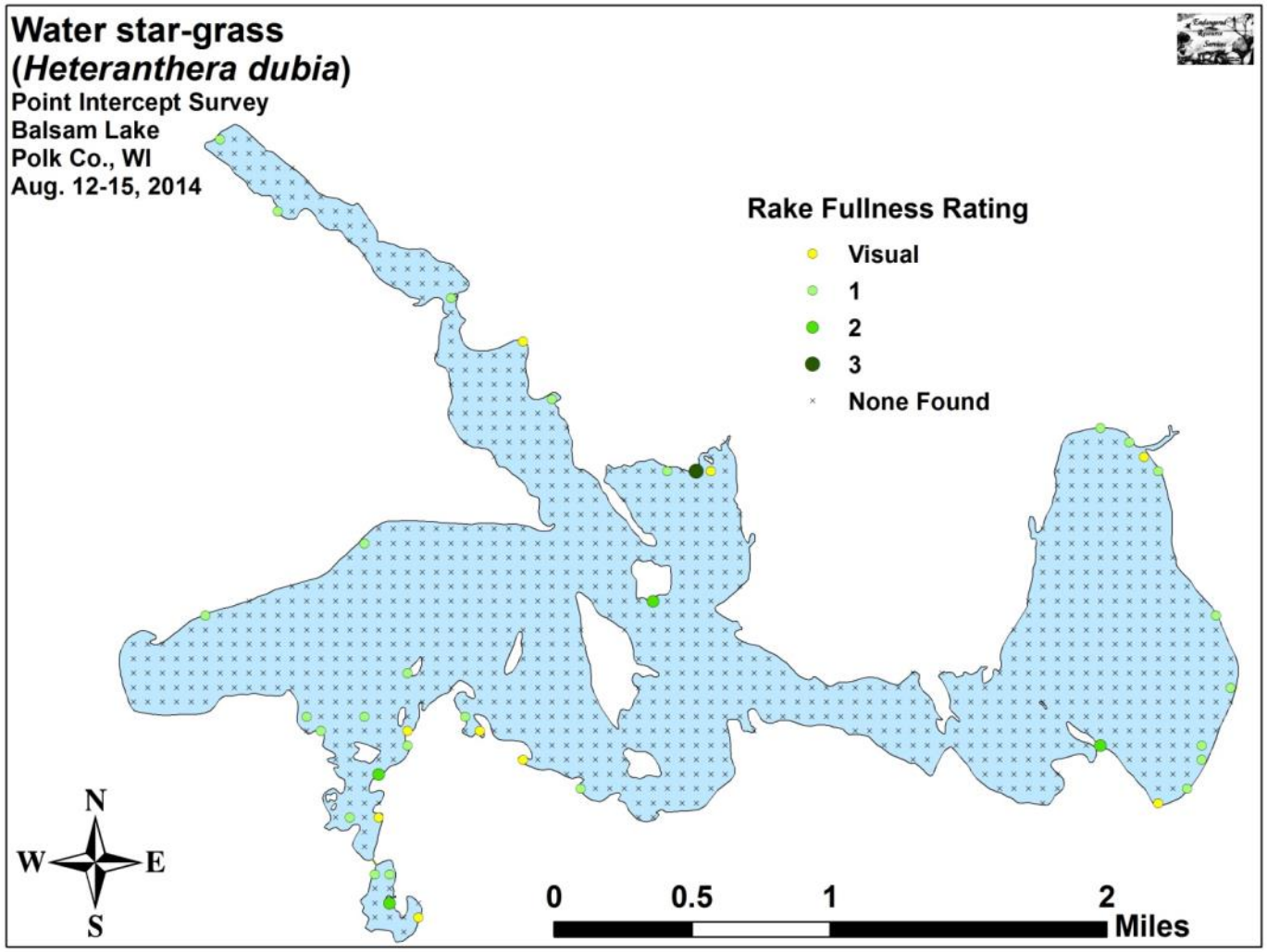
Miles


Water star-grass
(Heteranthera dubia)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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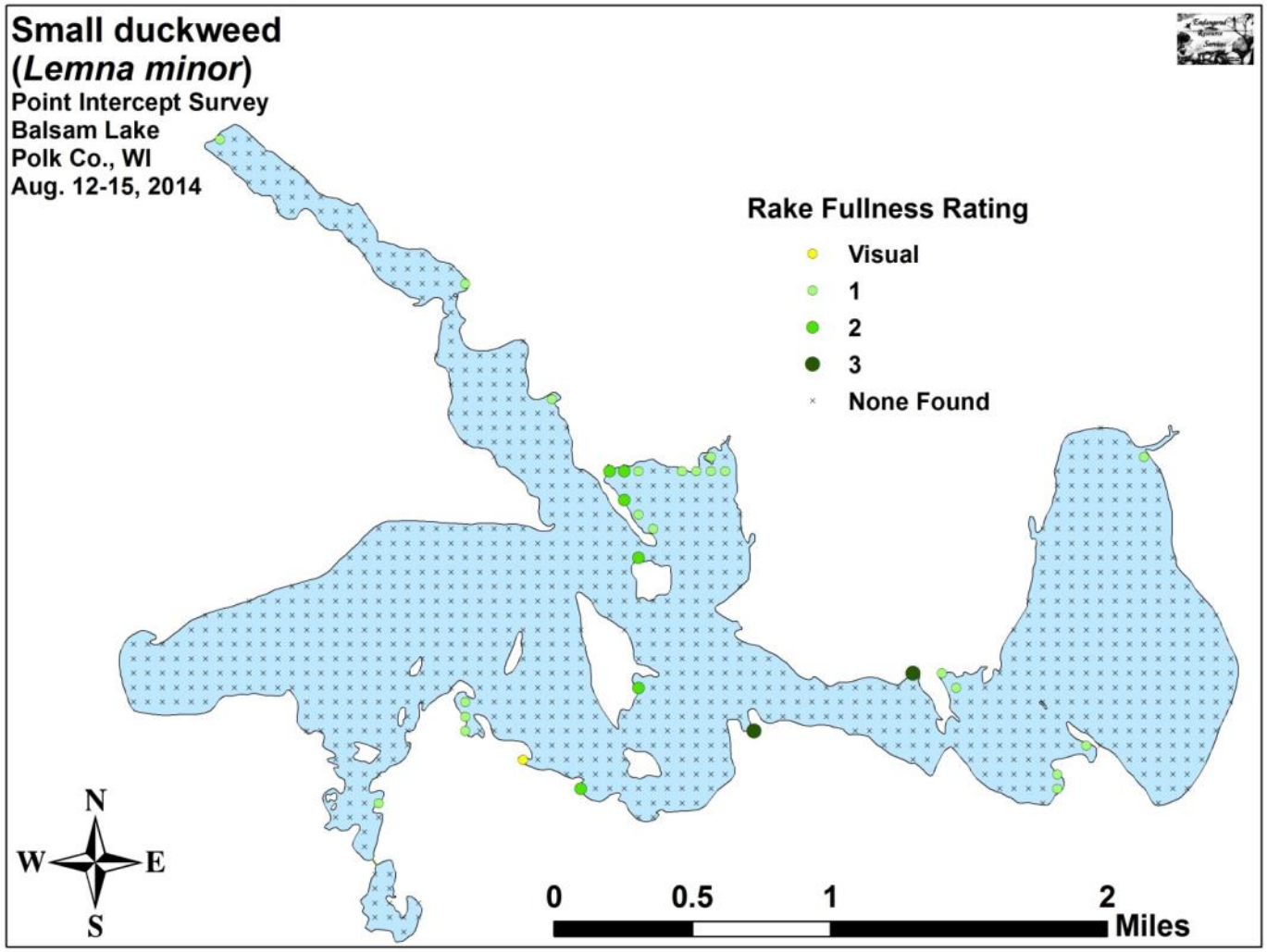
Miles


Small duckweed
(Lemna minor)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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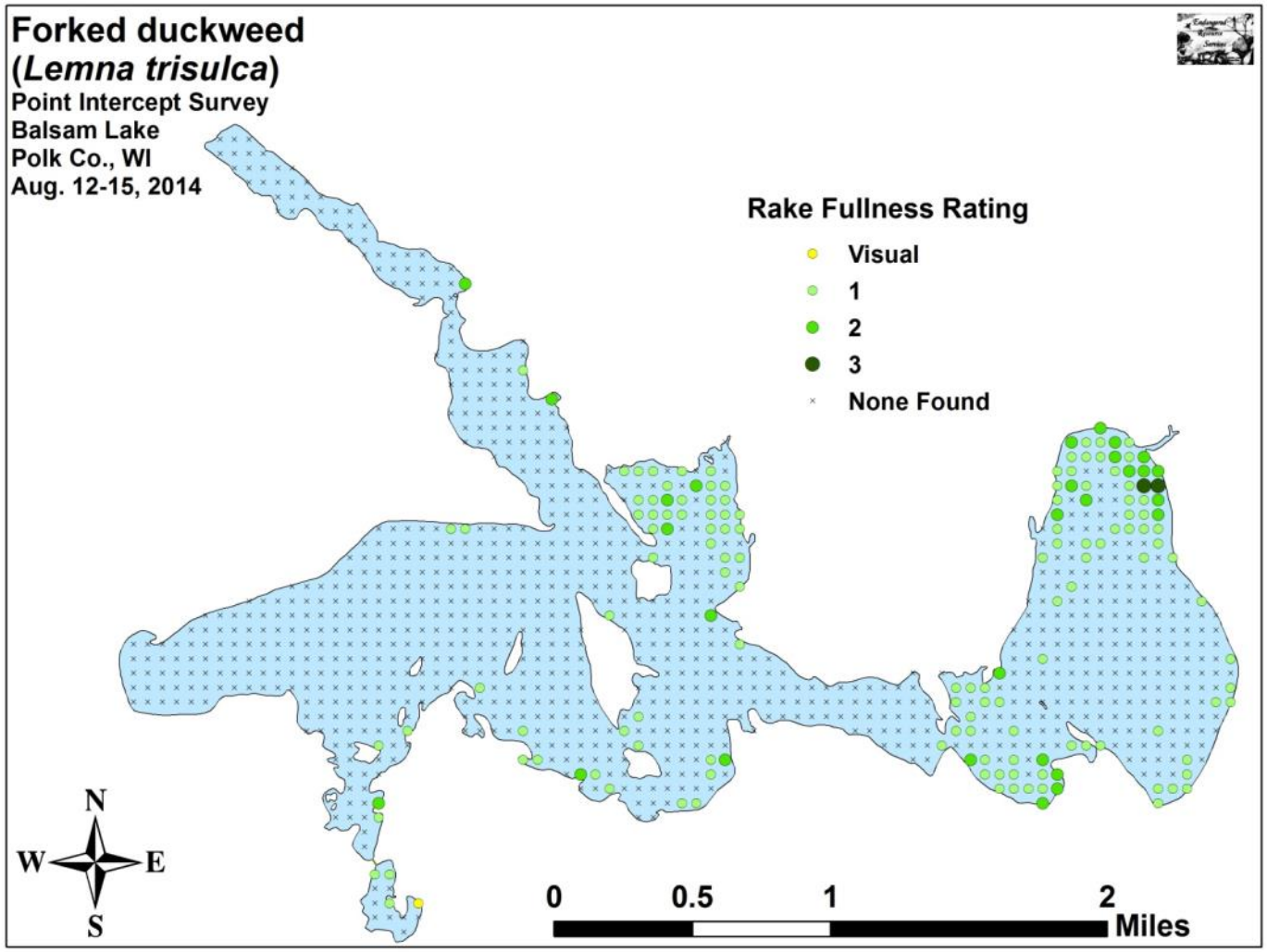
Miles


Forked duckweed
(Lemna trisulca)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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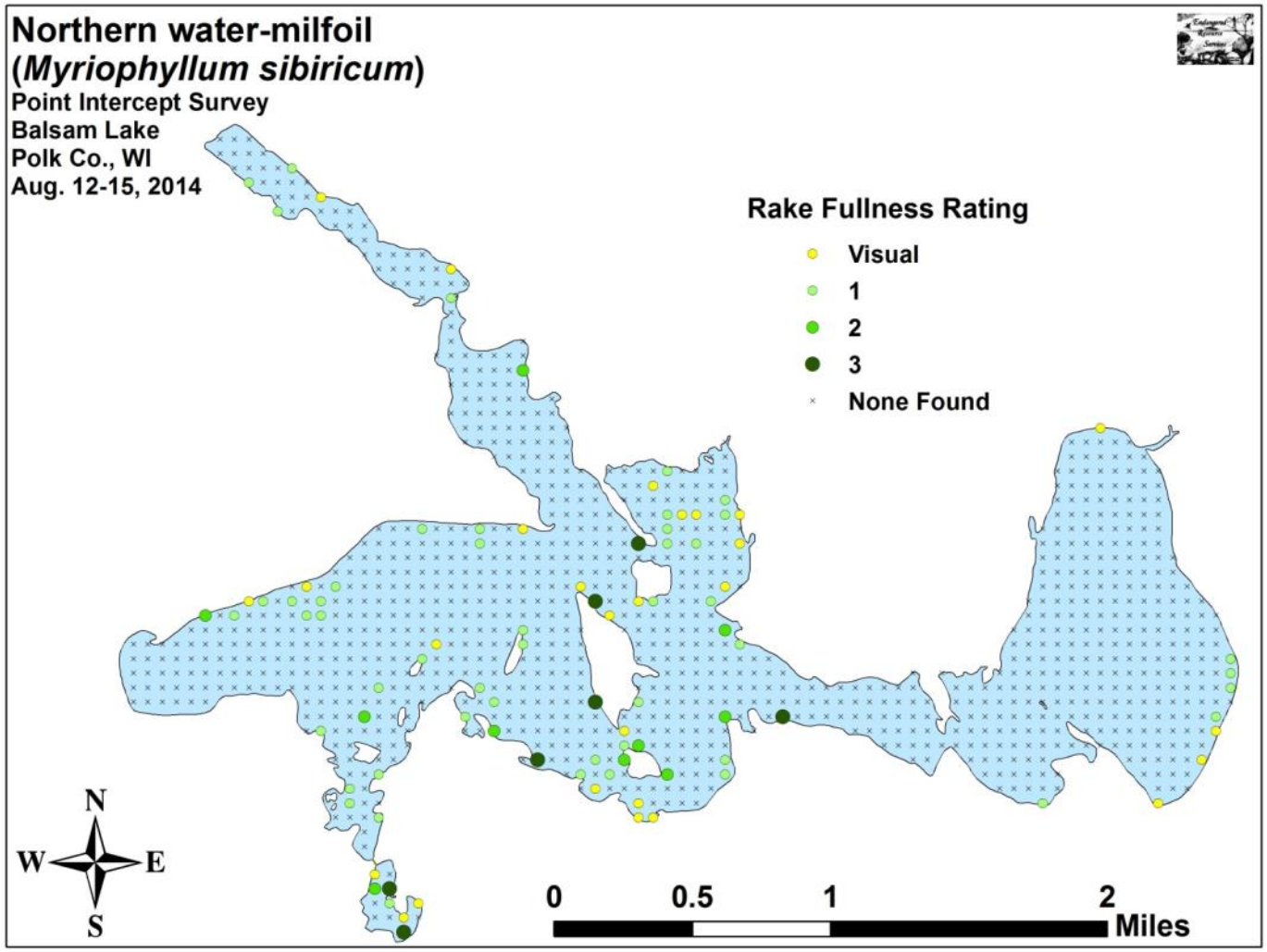
Miles


Northern water-milfoil
(Myriophyllum sibiricum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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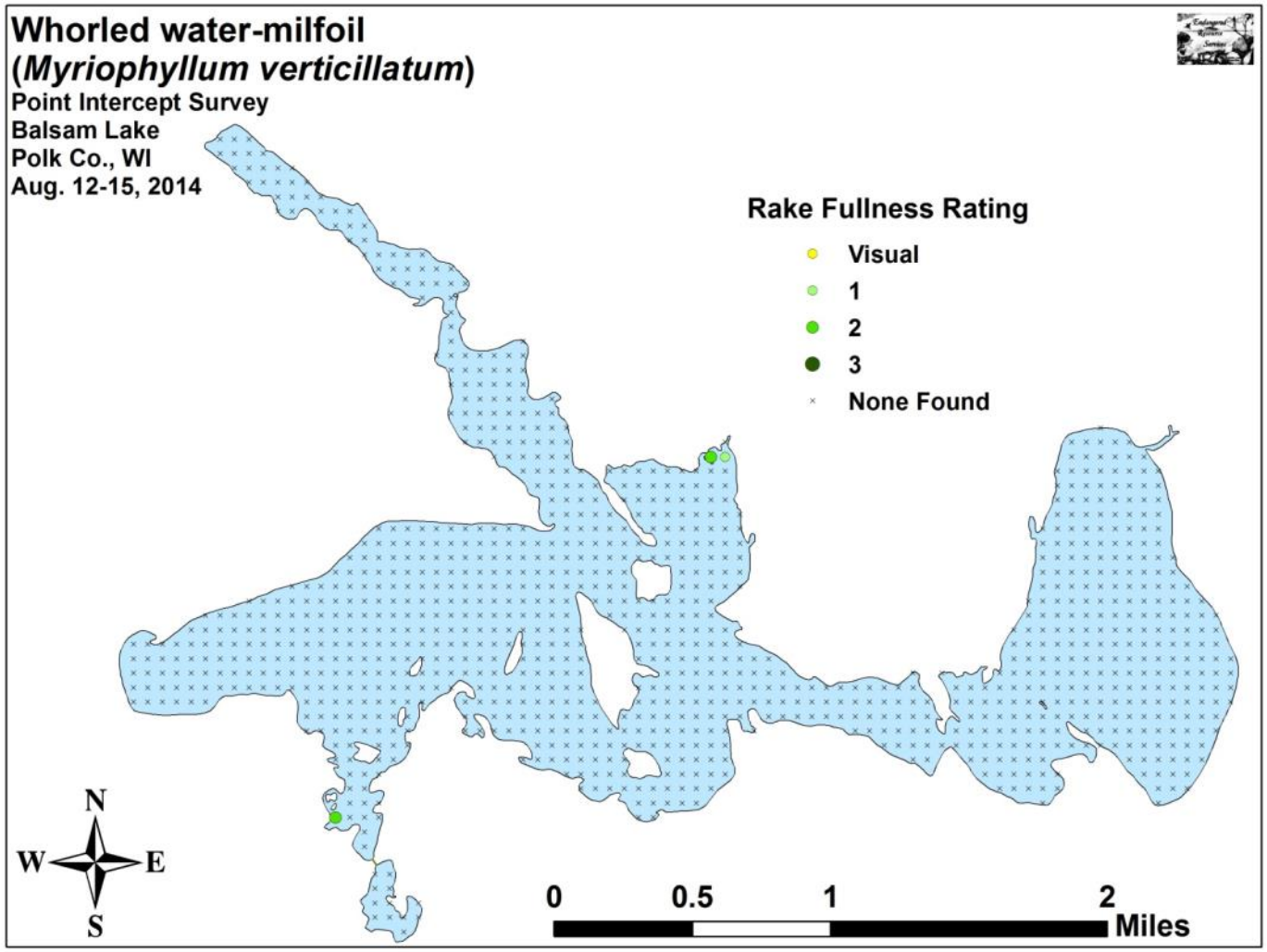
Miles


Whorled water-milfoil
(Myriophyllum verticillatum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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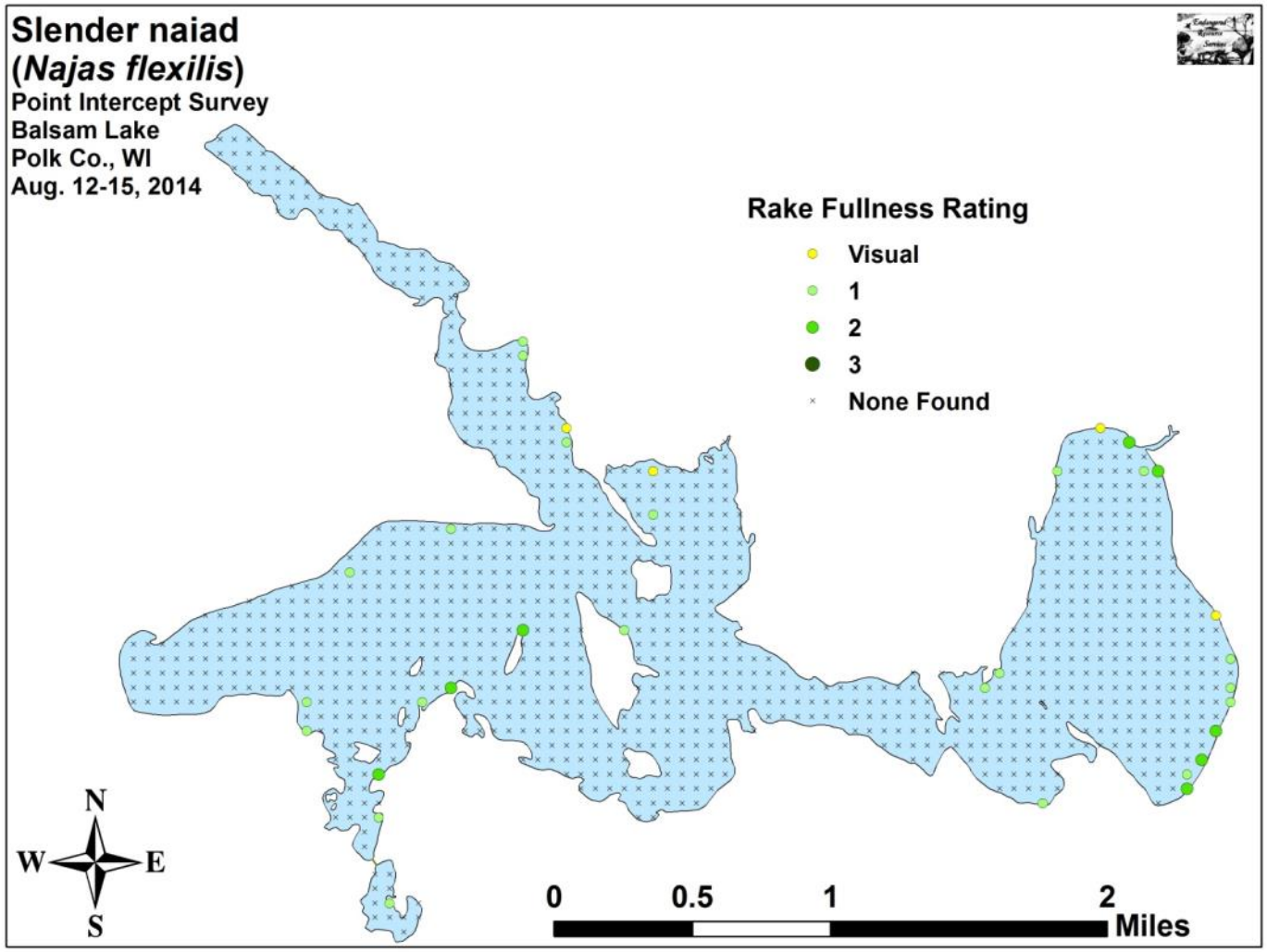
Miles


Slender naiad
(Najas flexilis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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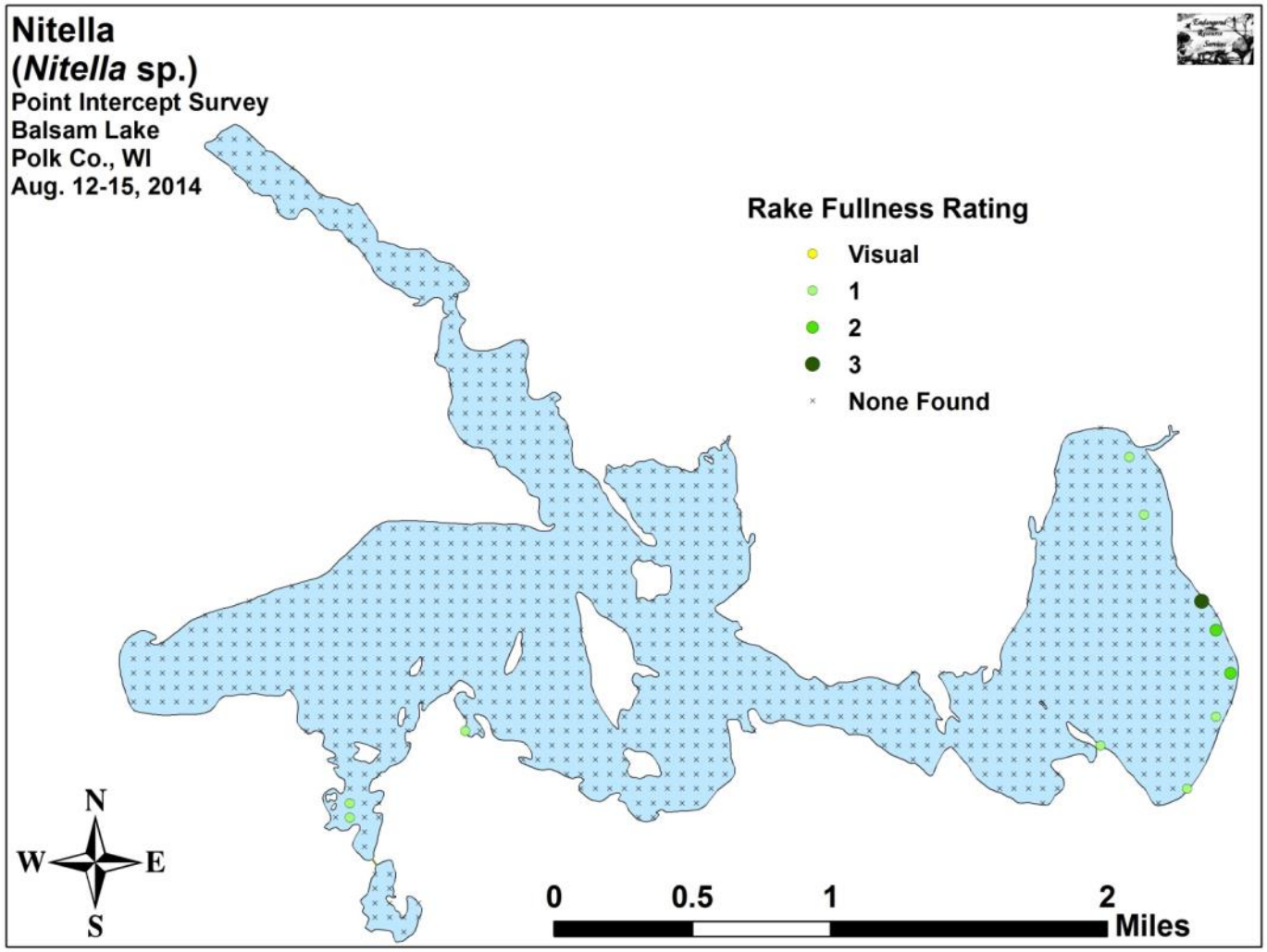
Miles


Nitella
(*Nitella* sp.)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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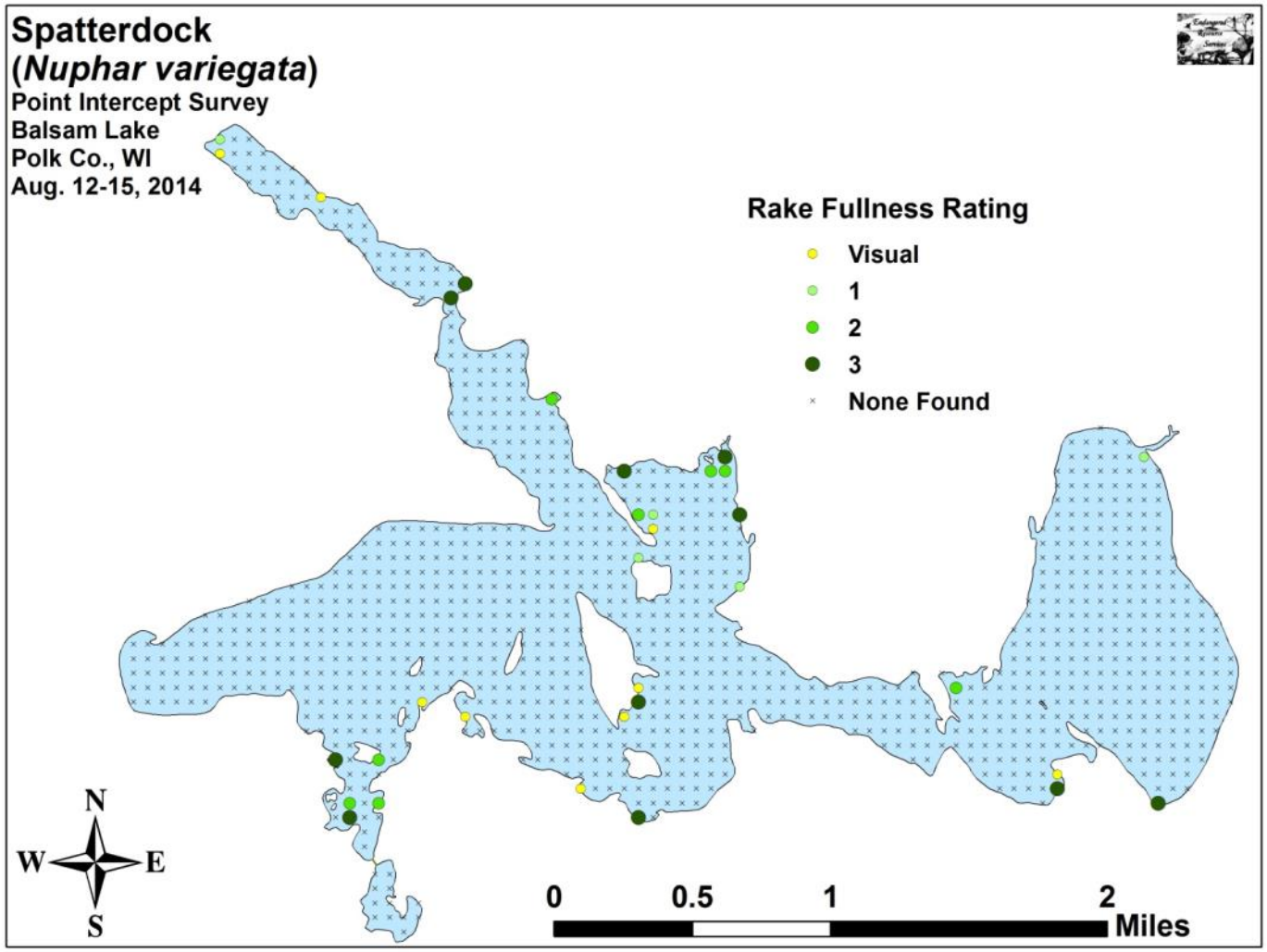
Miles


Spatterdock
(Nuphar variegata)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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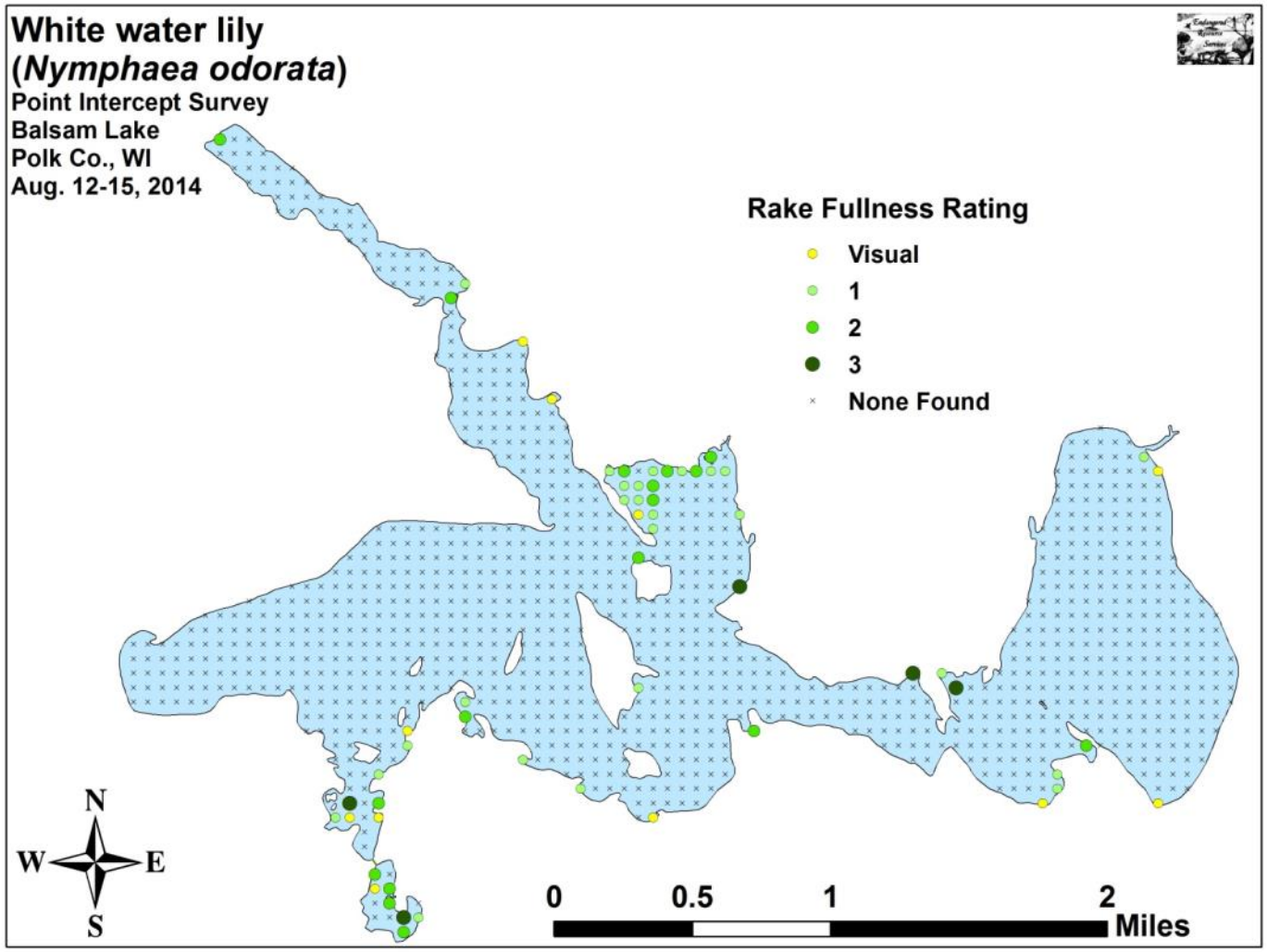
Miles


White water lily
(*Nymphaea odorata*)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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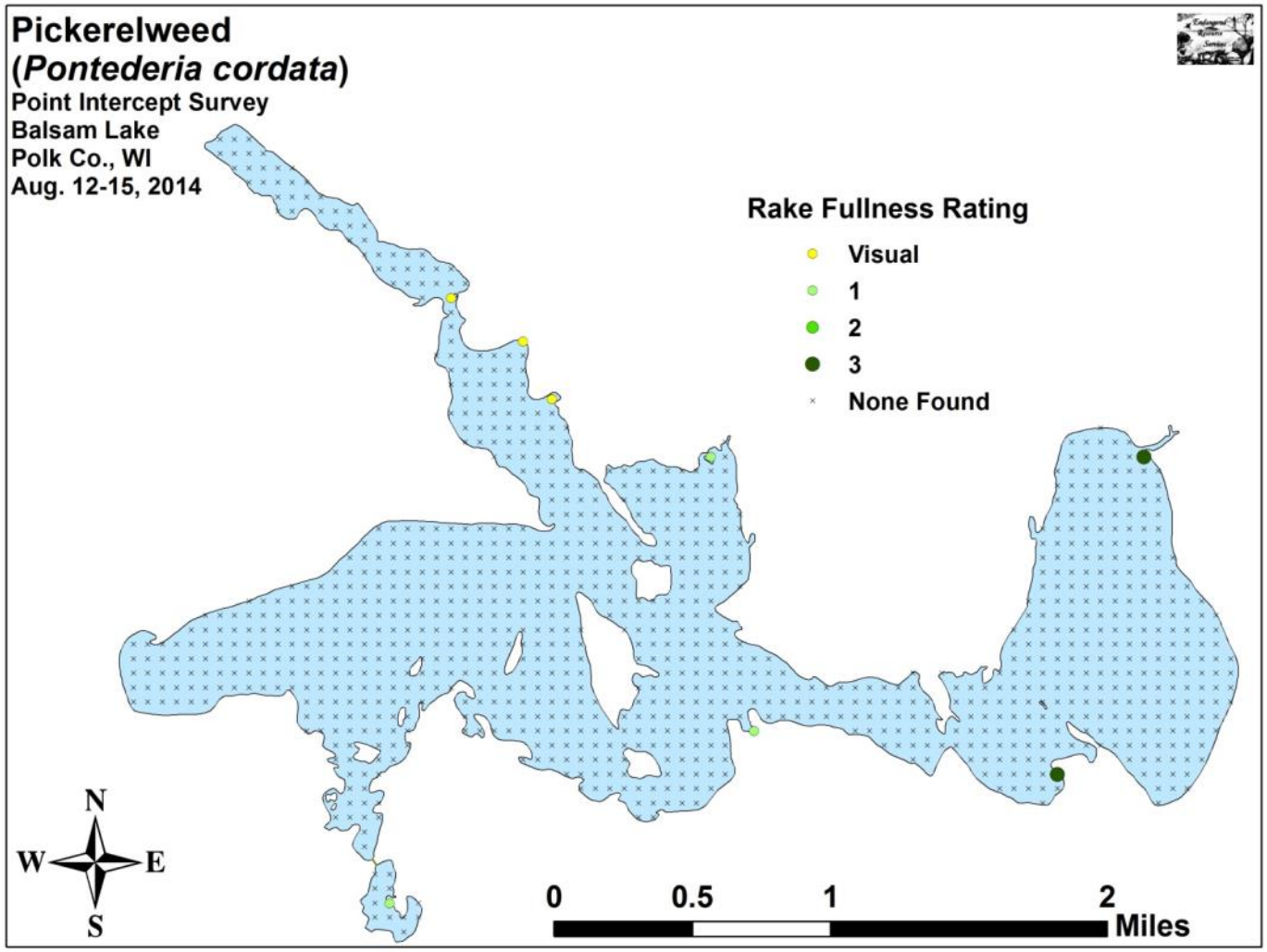
Miles


Pickerelweed
(*Pontederia cordata*)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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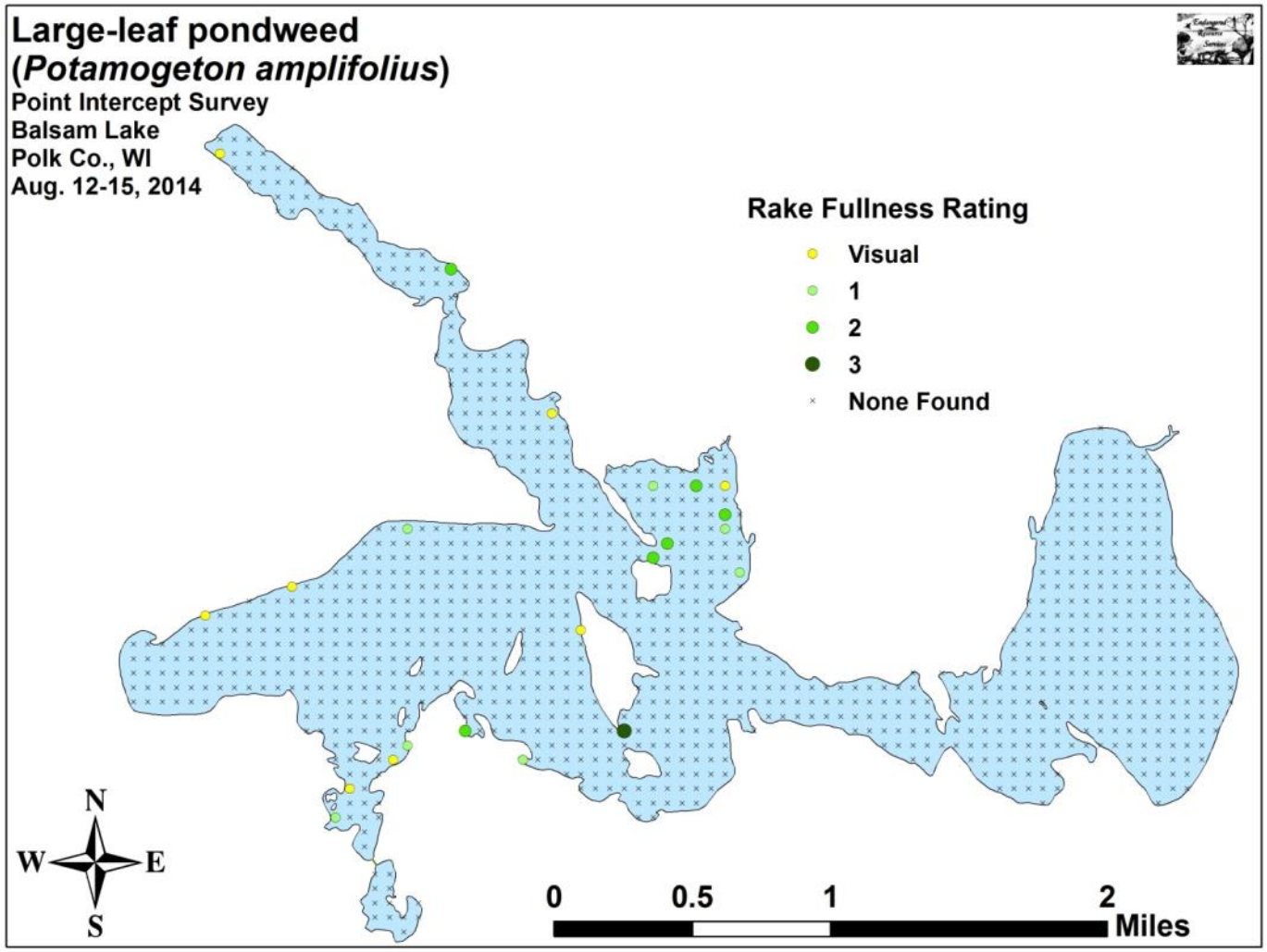
Miles


Large-leaf pondweed
(Potamogeton amplifolius)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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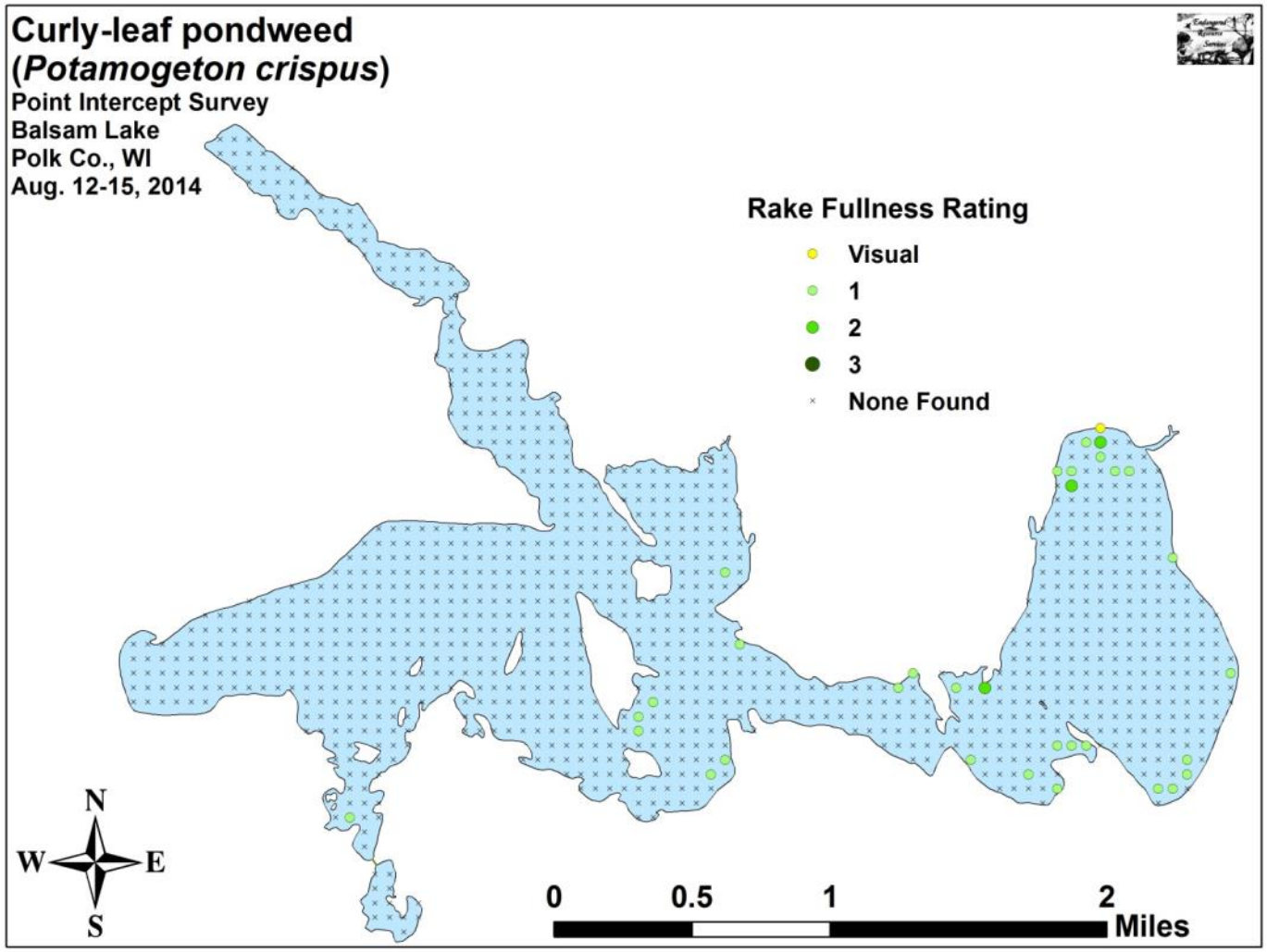
Miles


Curly-leaf pondweed
(Potamogeton crispus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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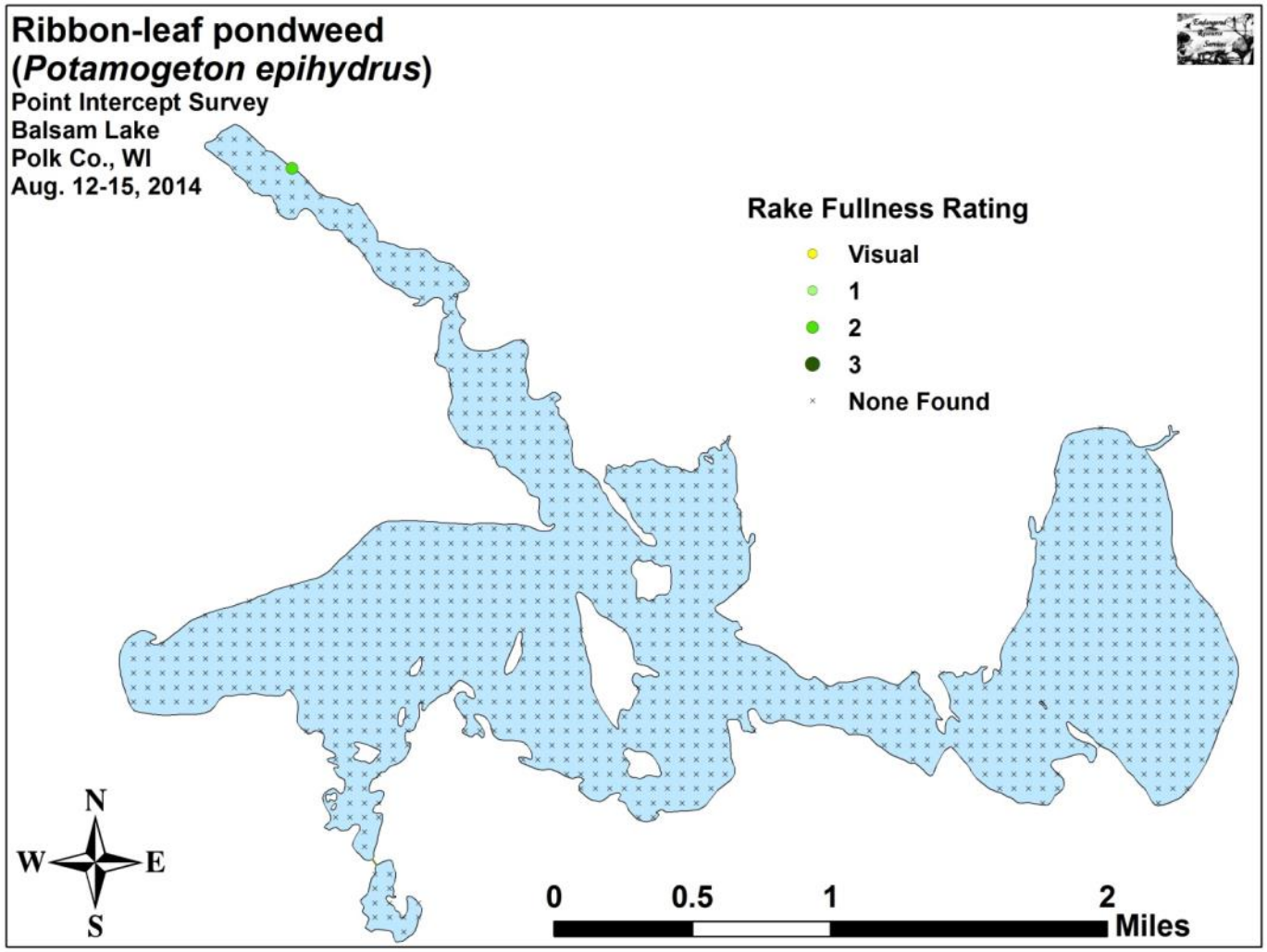
Miles


Ribbon-leaf pondweed
(Potamogeton epihydrus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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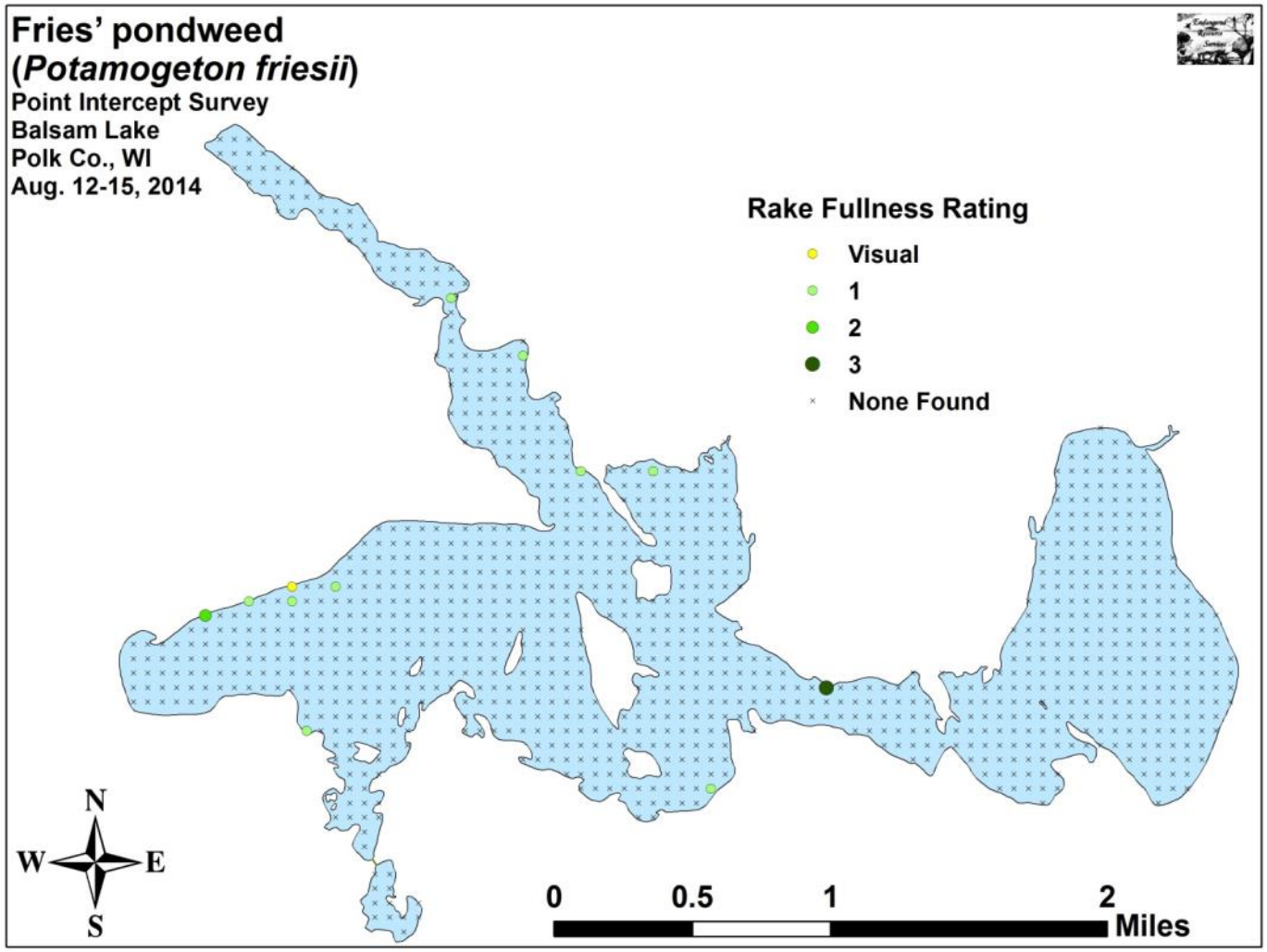
Miles


Fries' pondweed
(Potamogeton friesii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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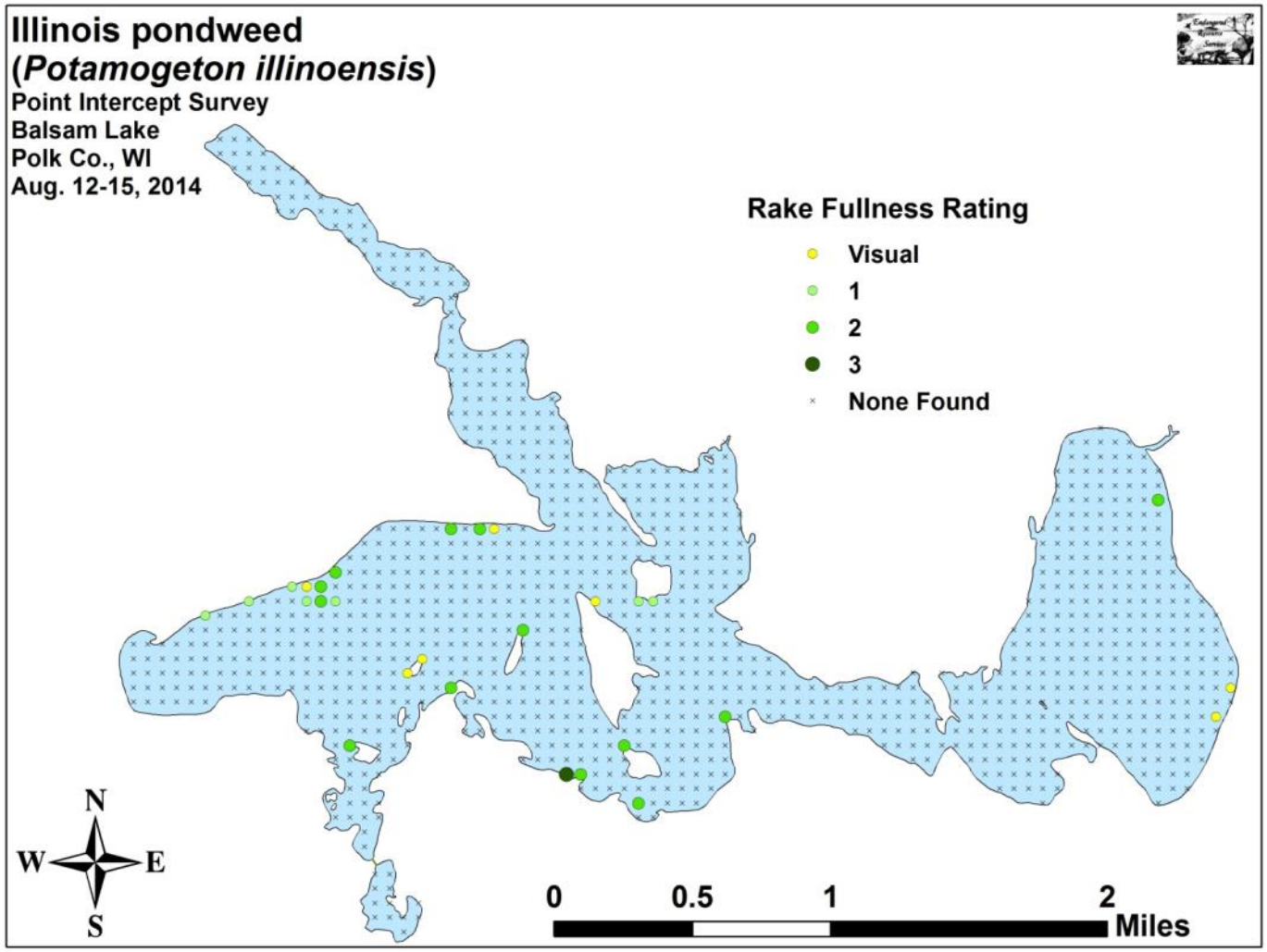
Illinois pondweed
(Potamogeton illinoensis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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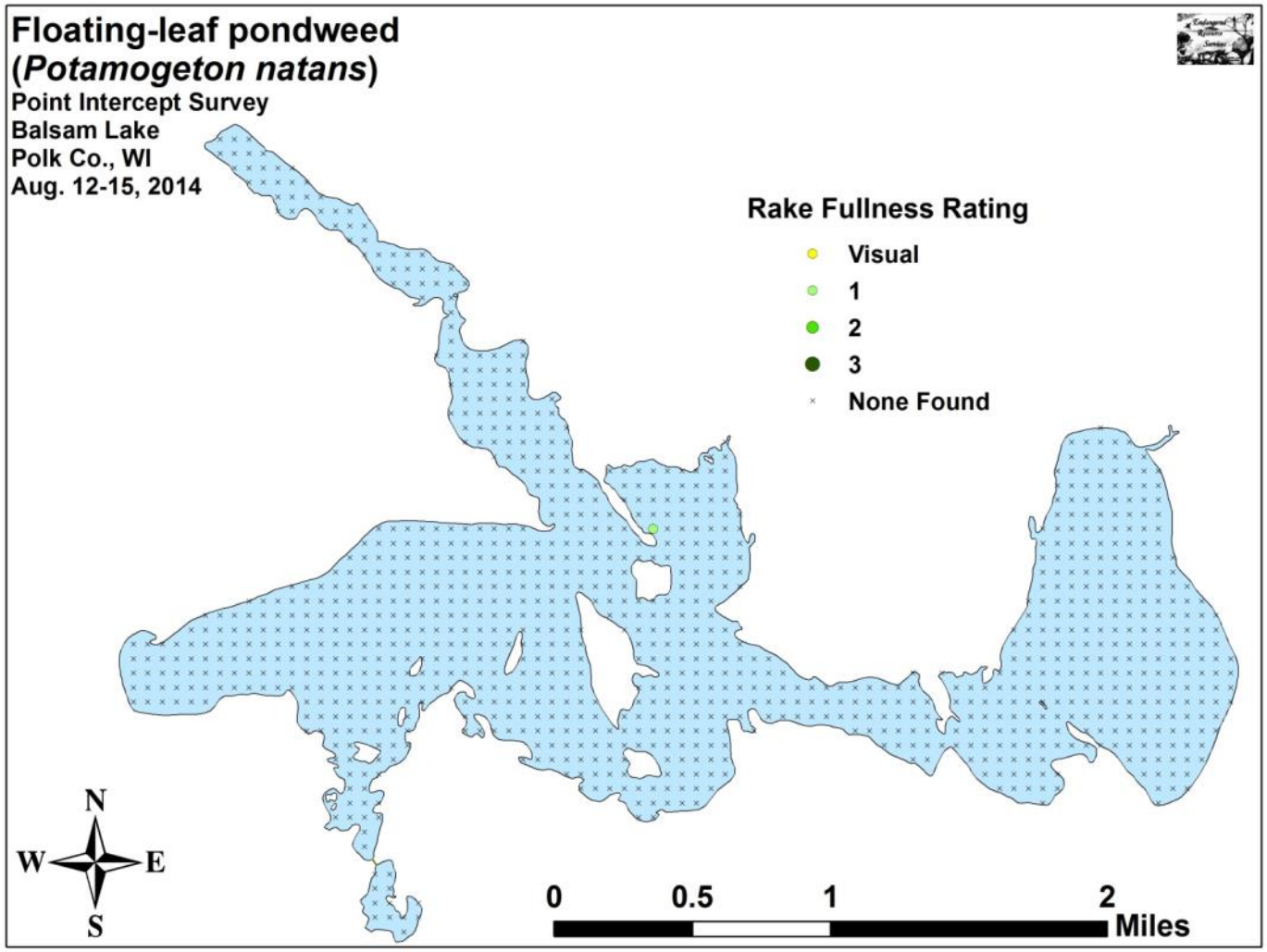
Floating-leaf pondweed
(Potamogeton natans)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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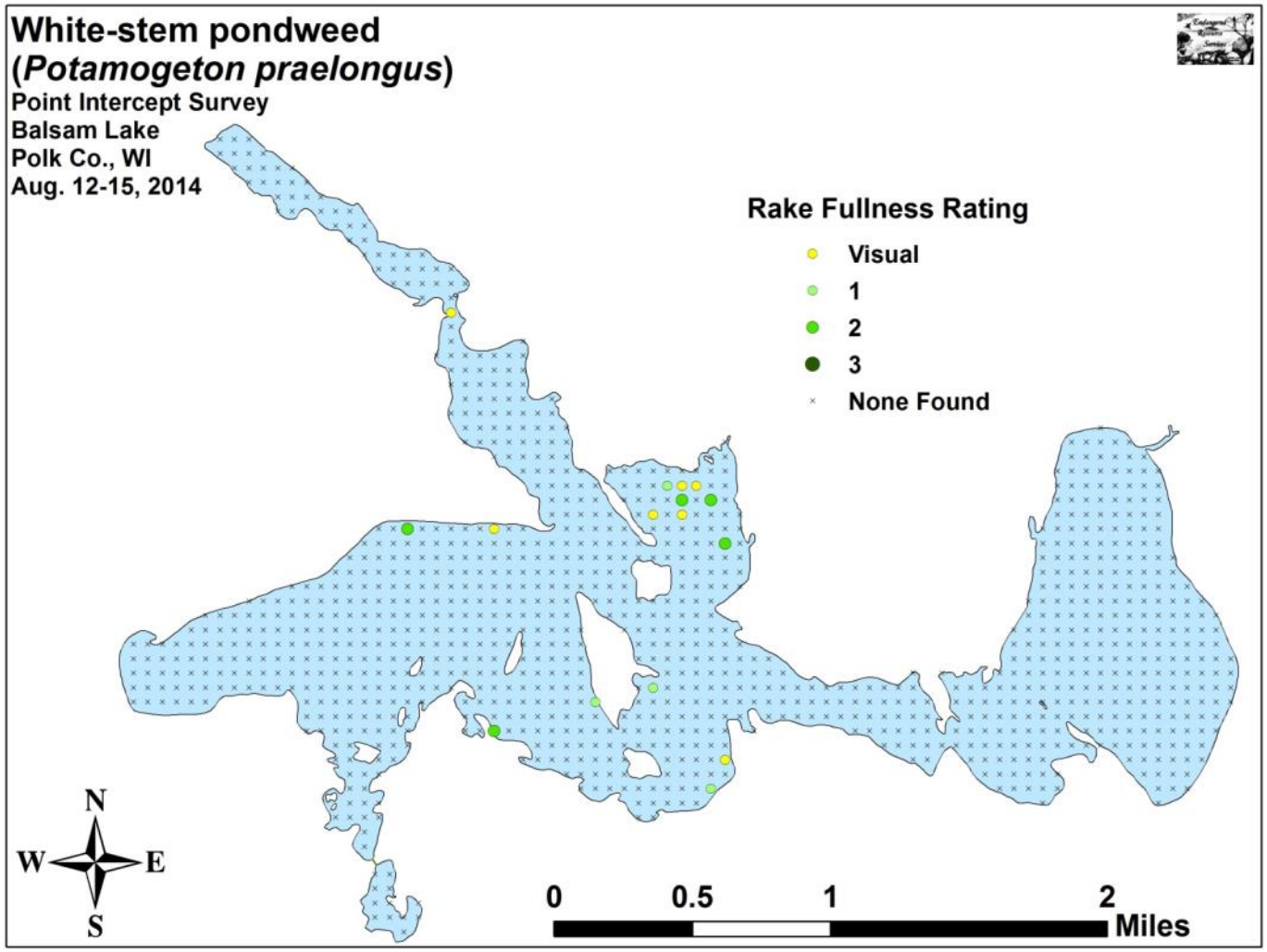
White-stem pondweed
(Potamogeton praelongus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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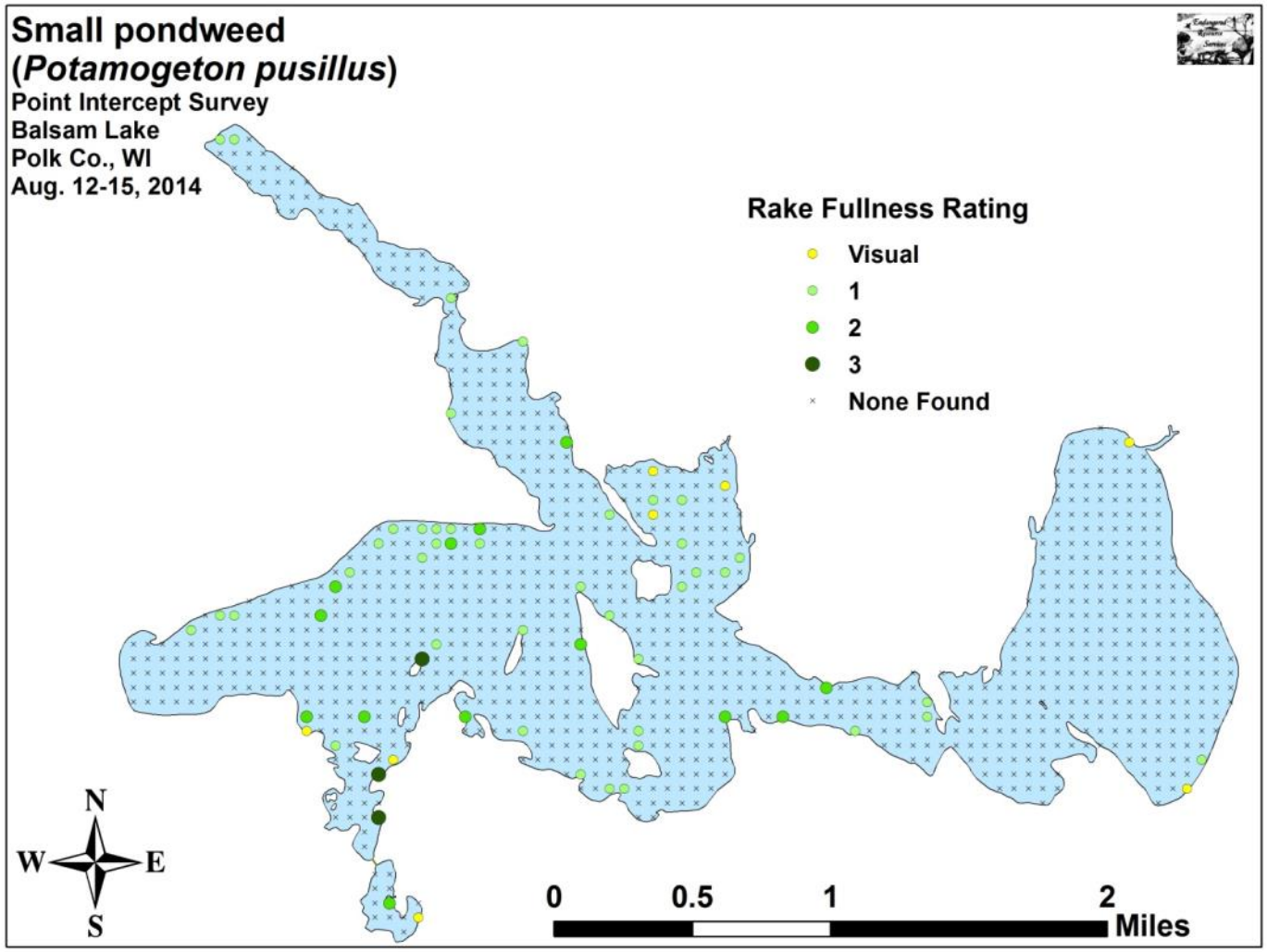
Small pondweed
(Potamogeton pusillus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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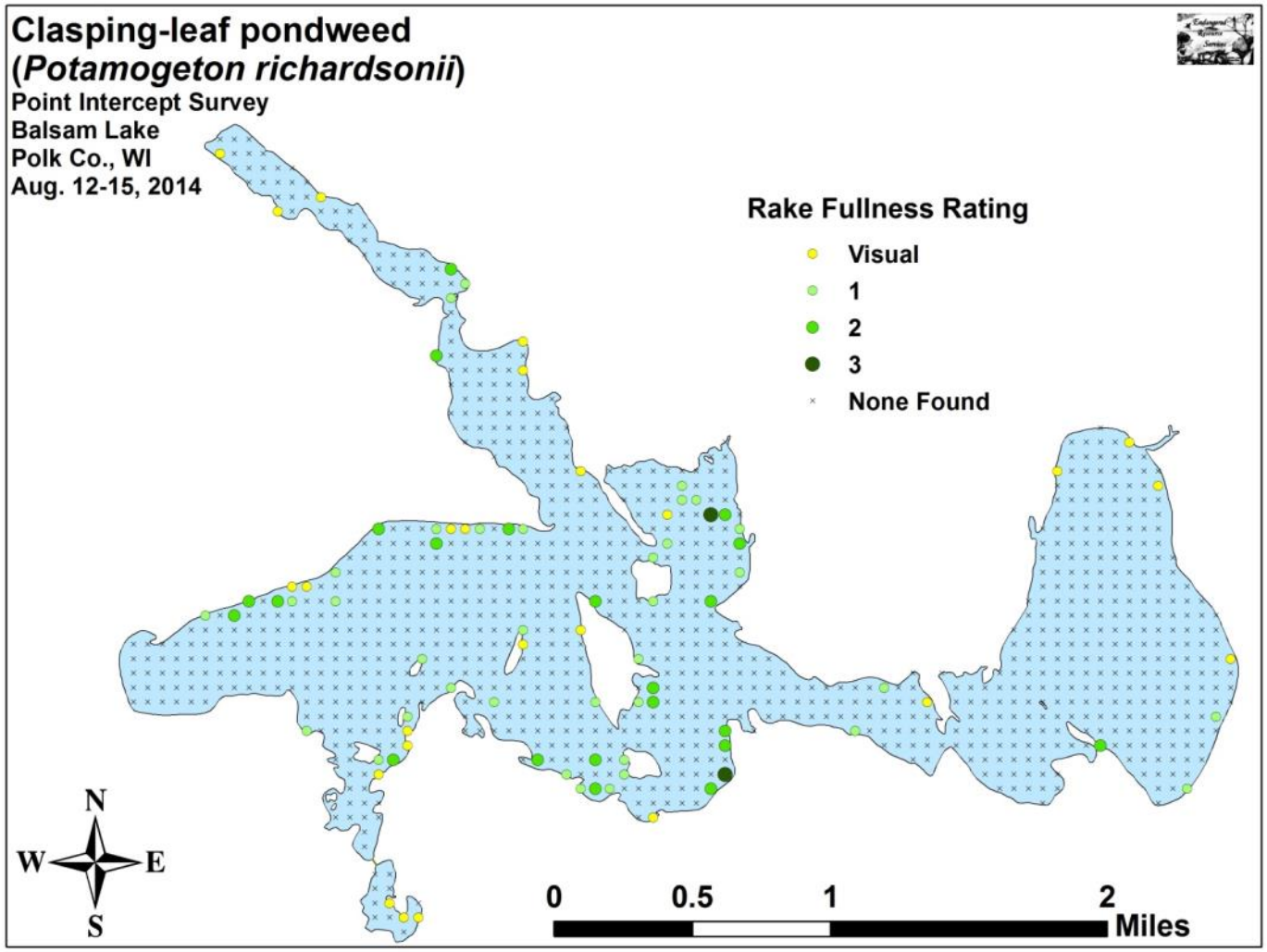
Clasping-leaf pondweed
(Potamogeton richardsonii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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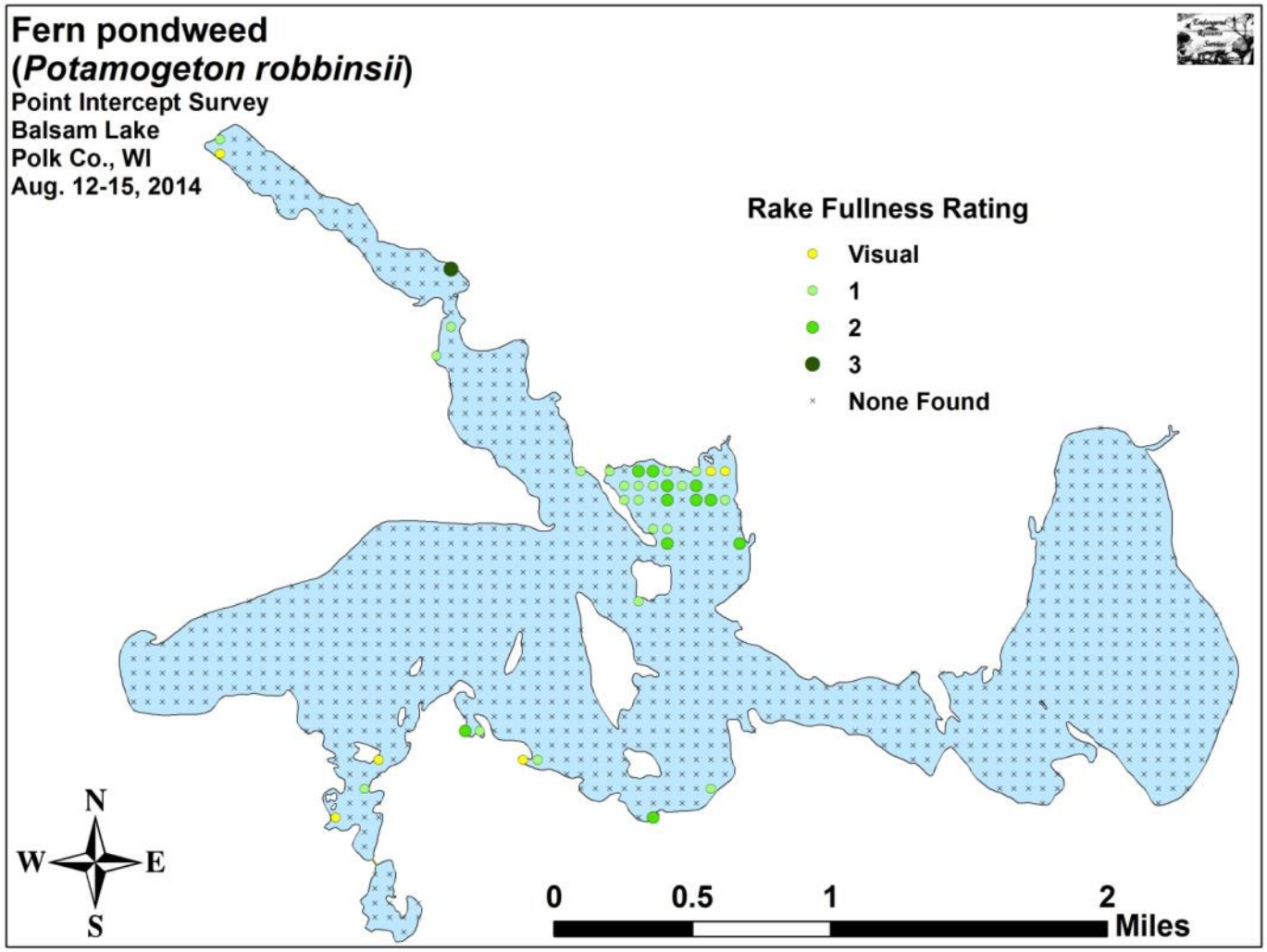
Miles


Fern pondweed
(Potamogeton robbinsii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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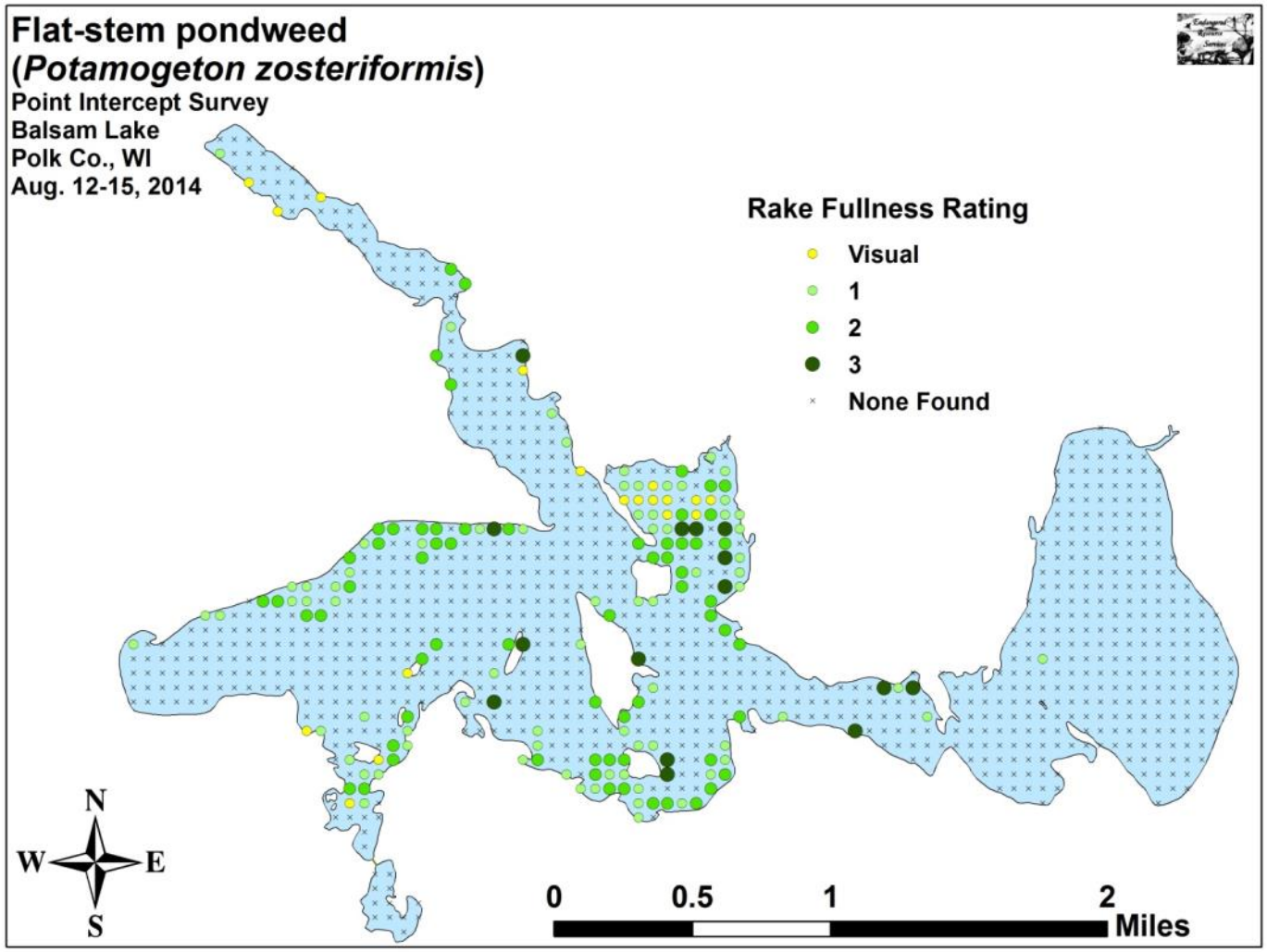
Miles


Flat-stem pondweed
(Potamogeton zosteriformis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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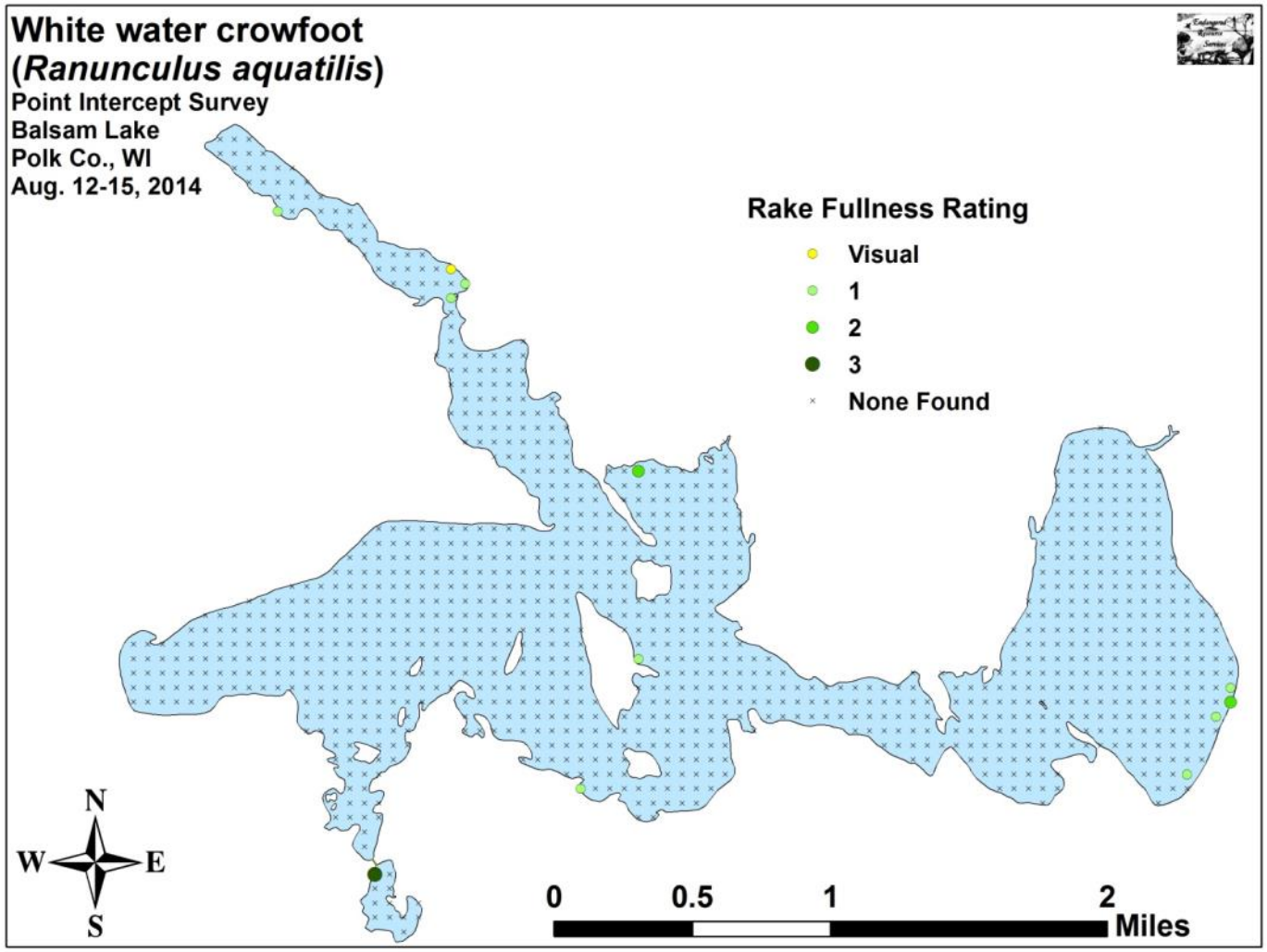
White water crowfoot
(Ranunculus aquatilis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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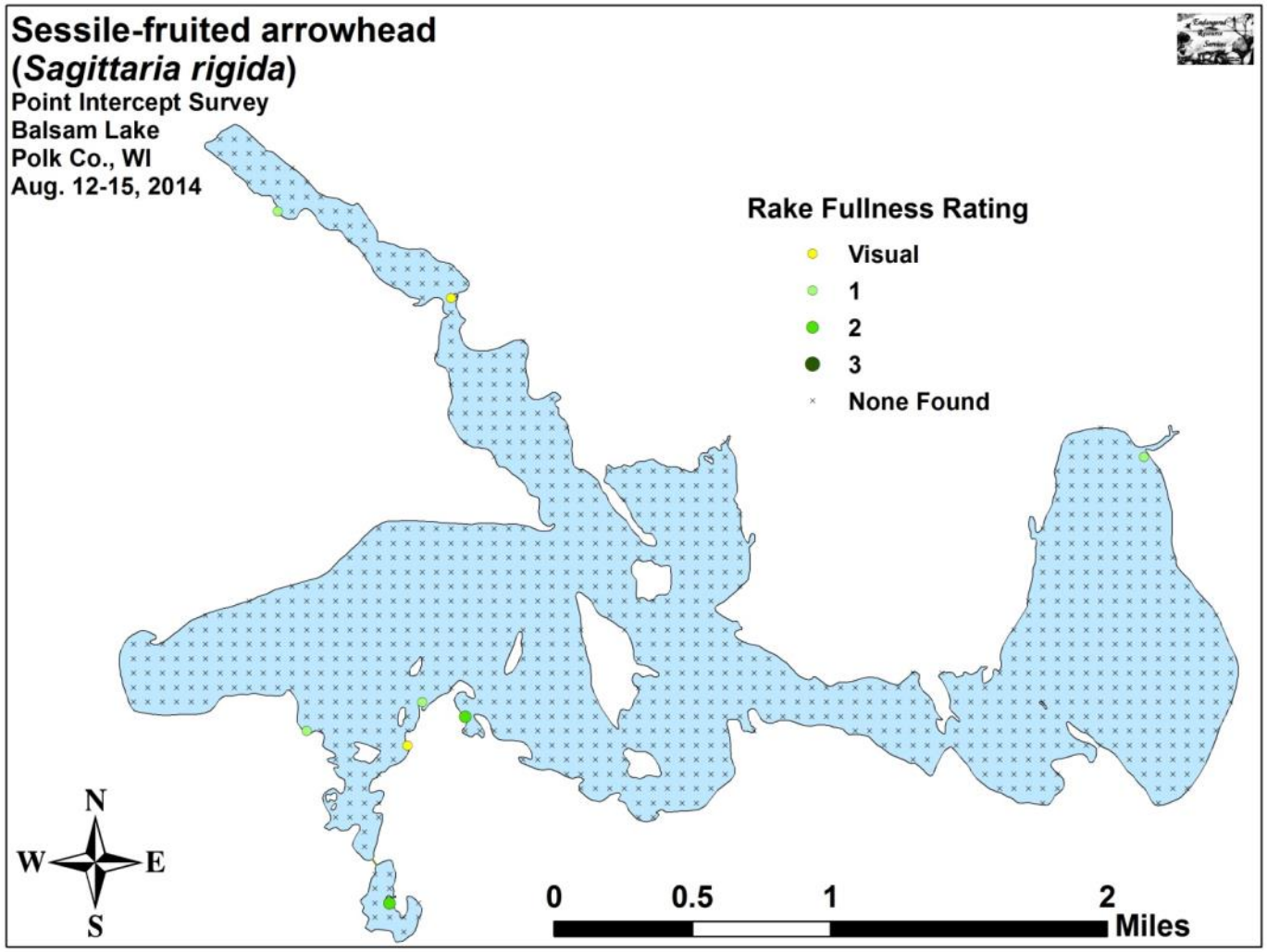
Sessile-fruited arrowhead
(Sagittaria rigida)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
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None Found
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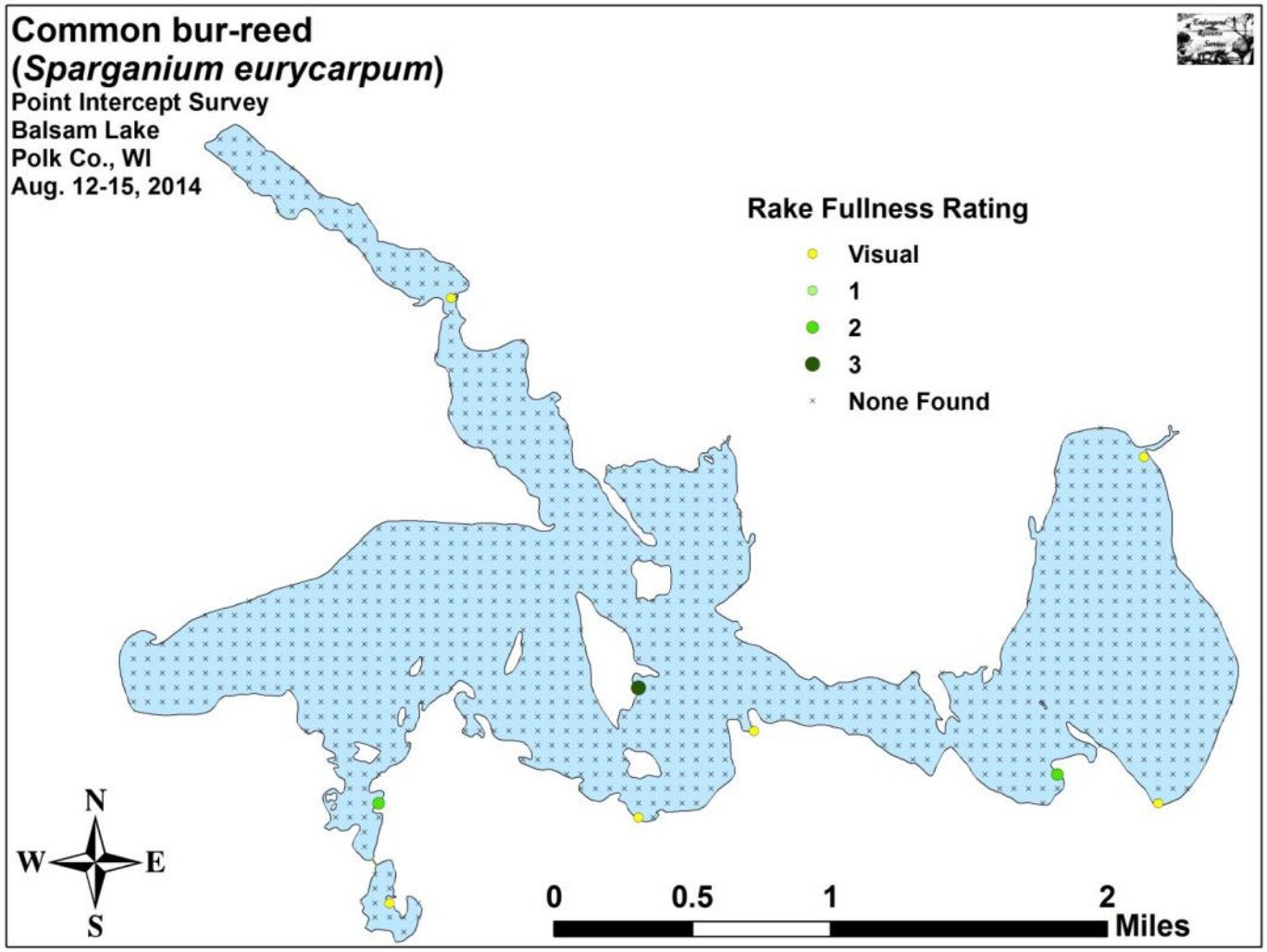
Common bur-reed
(Sparganium eurycarpum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
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None Found
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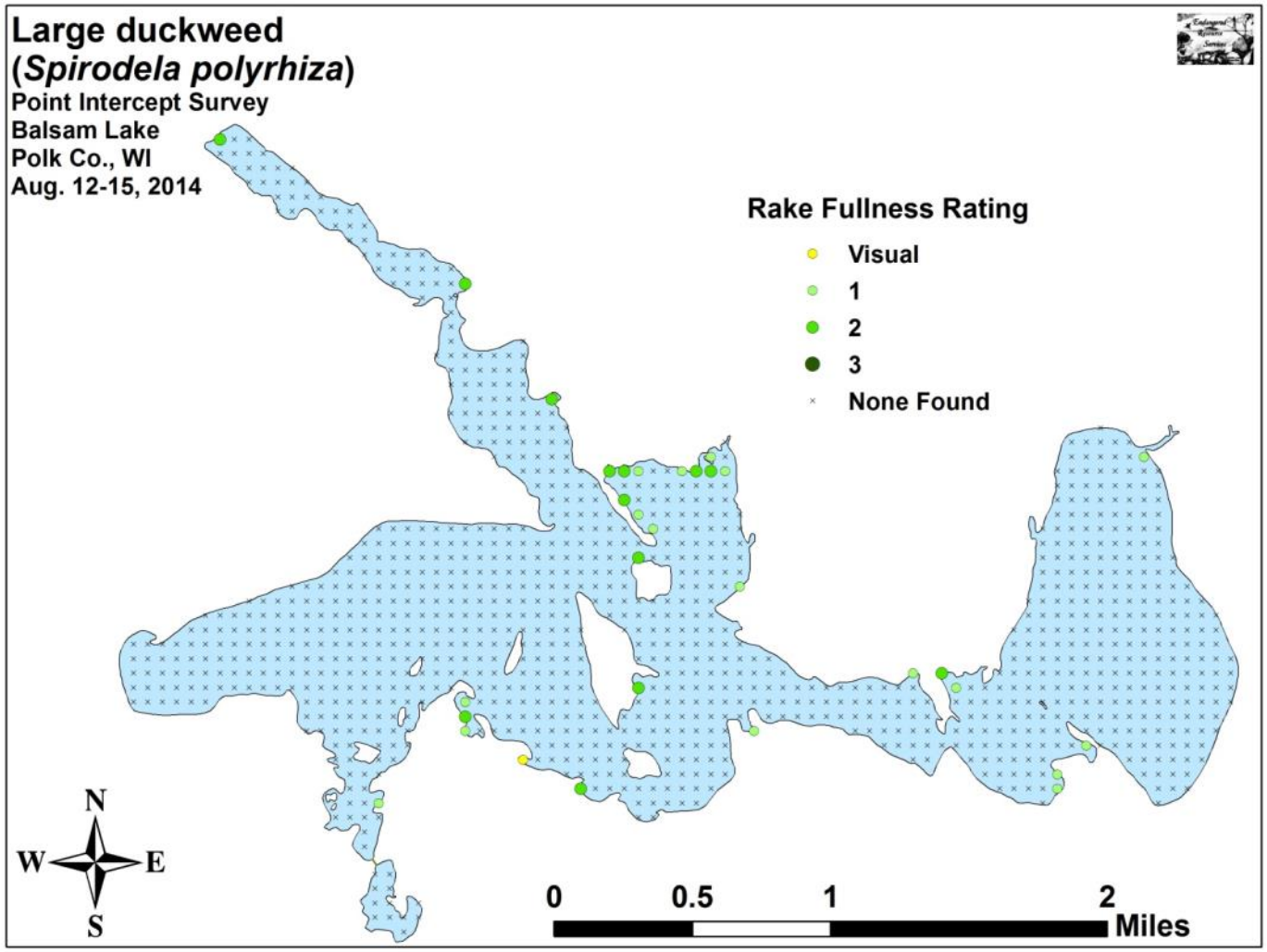
Large duckweed
(Spirodela polyrhiza)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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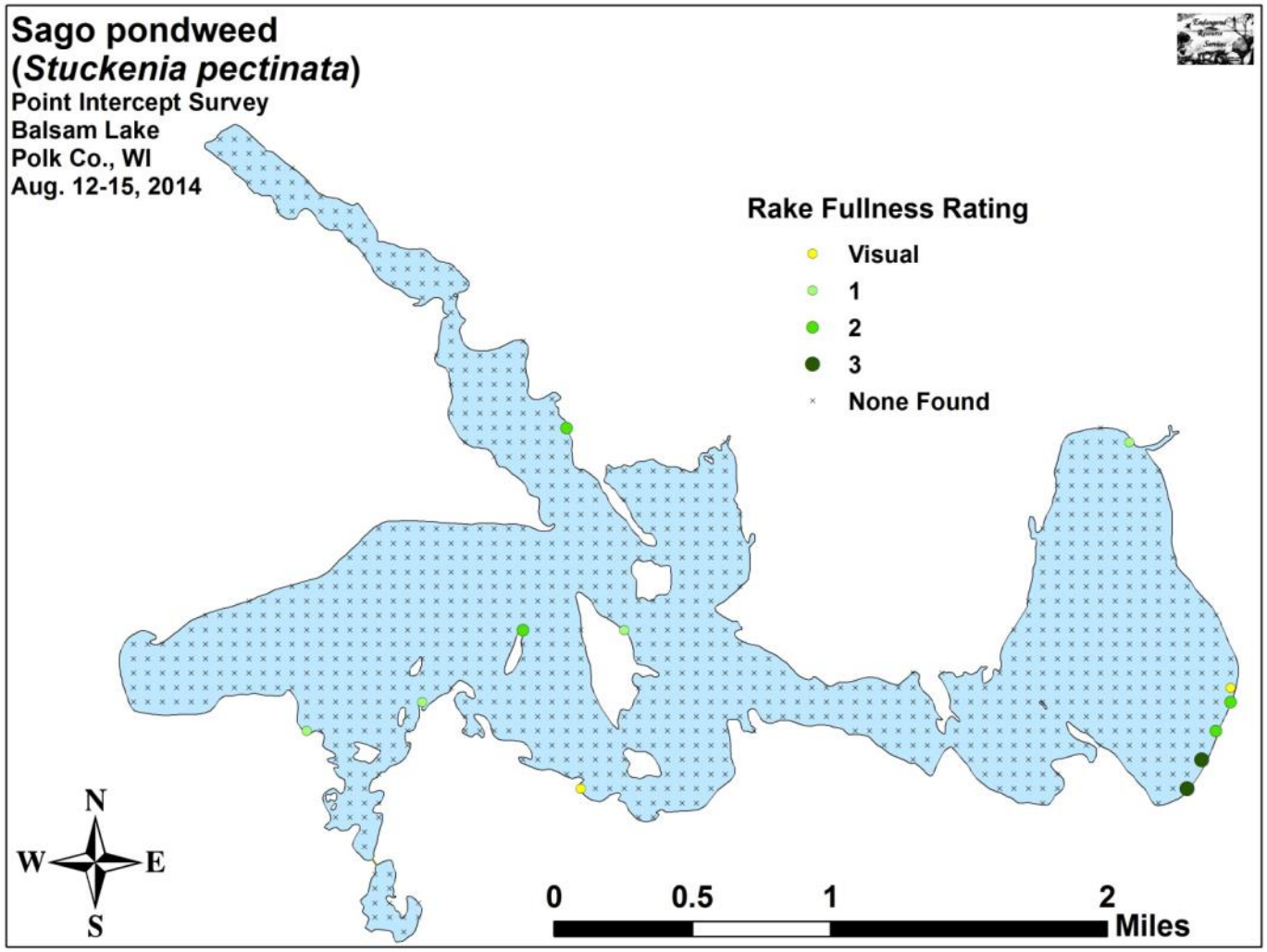
Miles


Sago pondweed
(Stuckenia pectinata)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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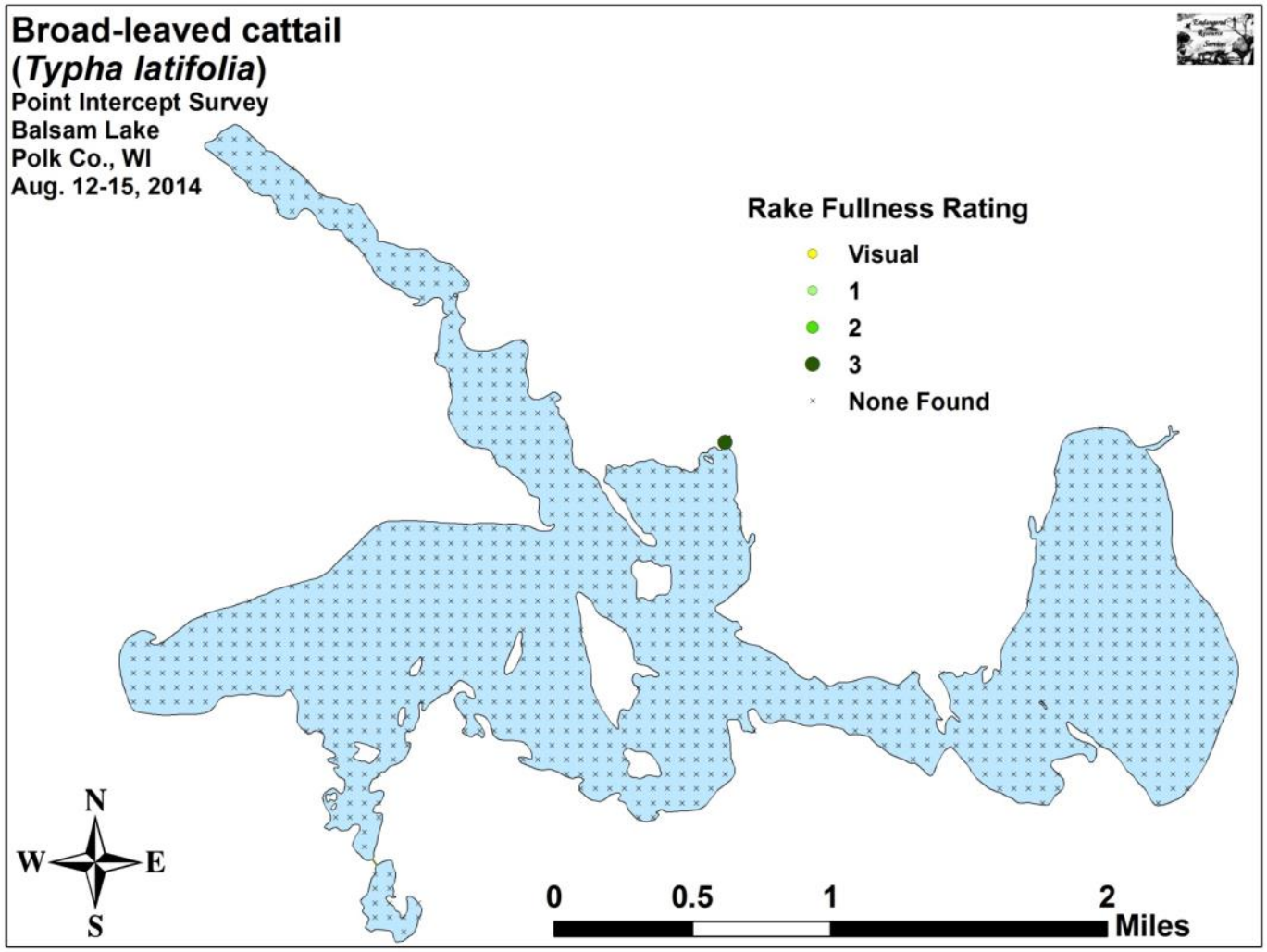
Miles


Broad-leaved cattail
(Typha latifolia)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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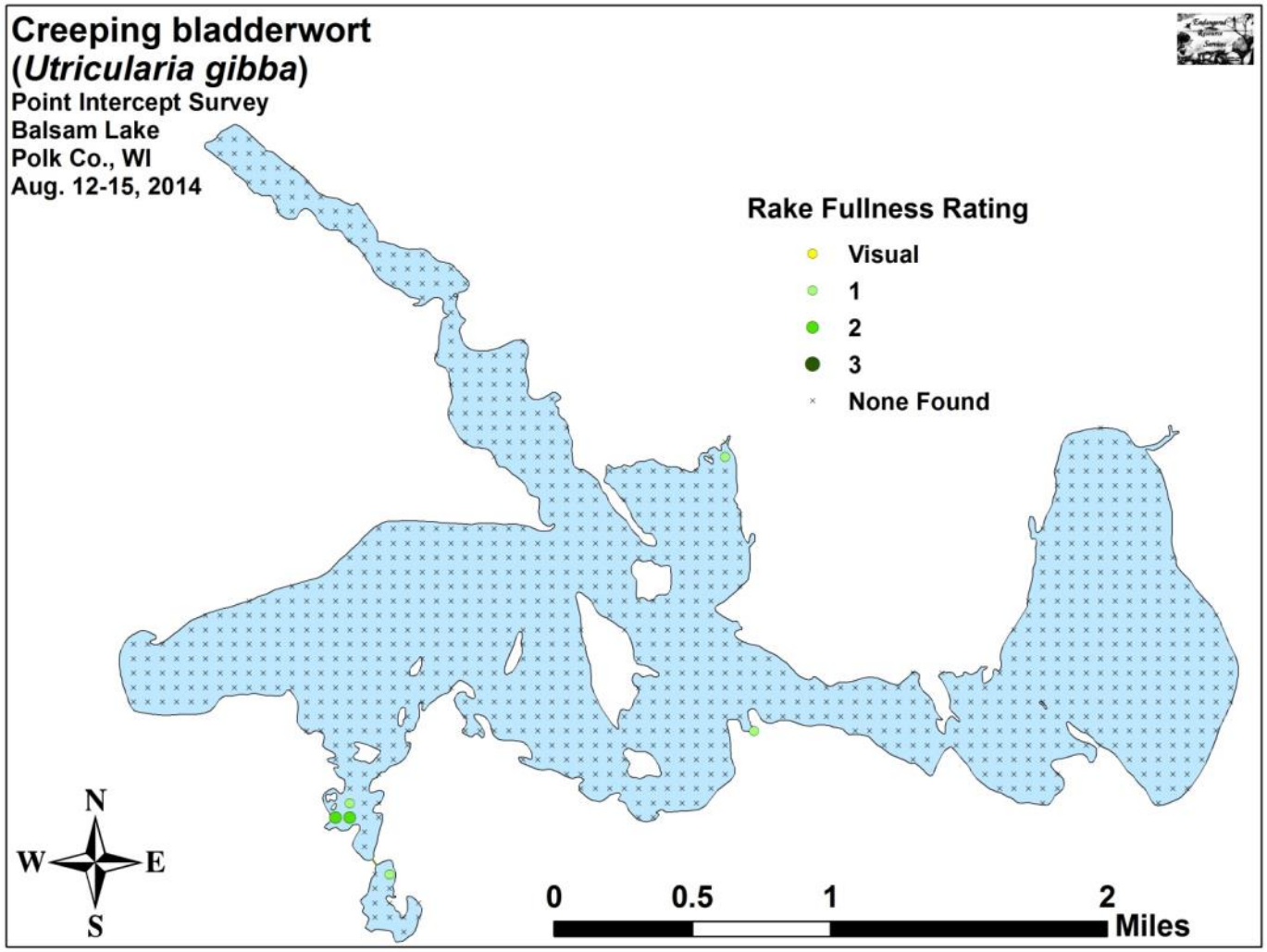
Miles


Creeping bladderwort
(Utricularia gibba)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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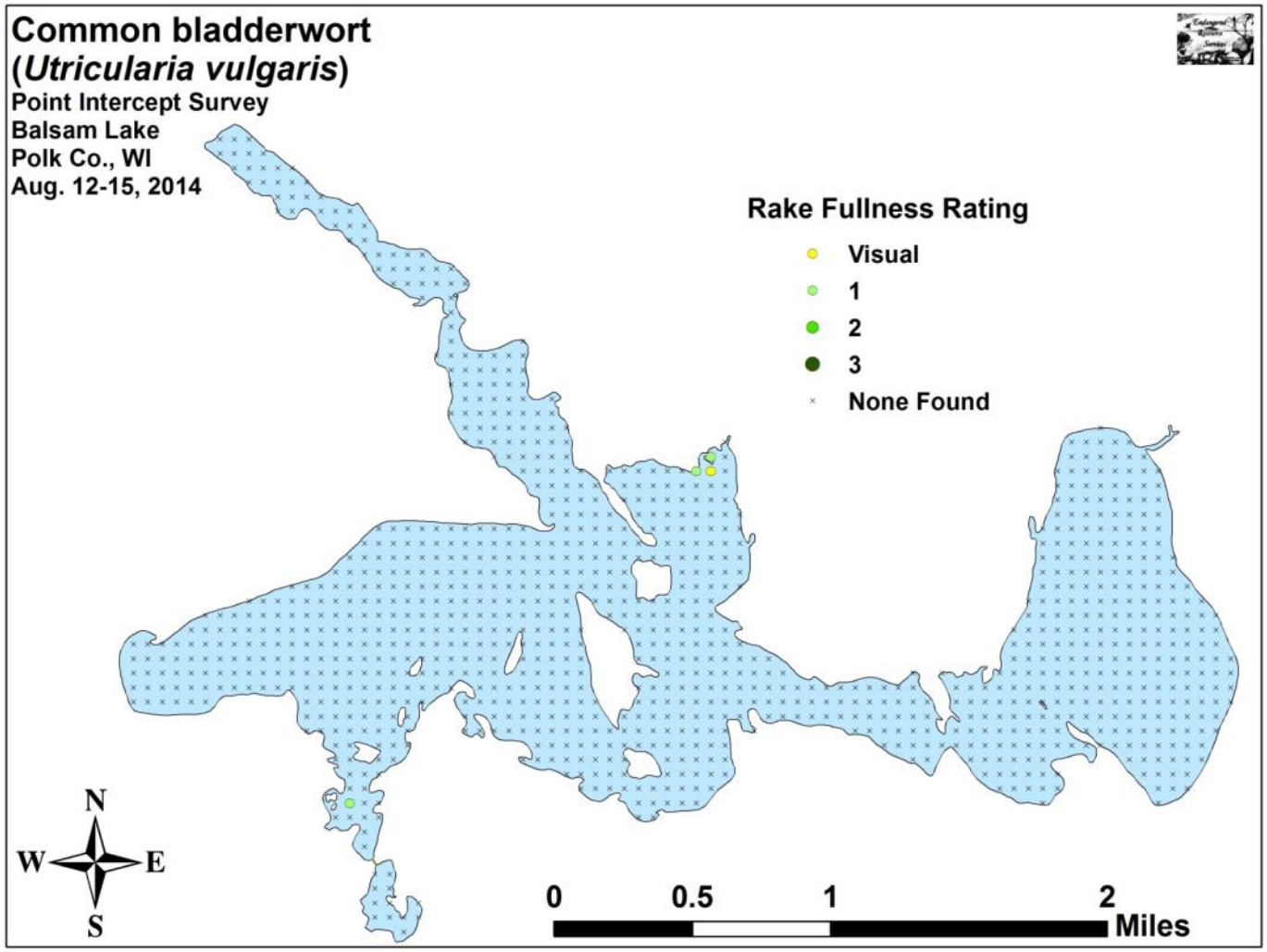
Common bladderwort
(Utricularia vulgaris)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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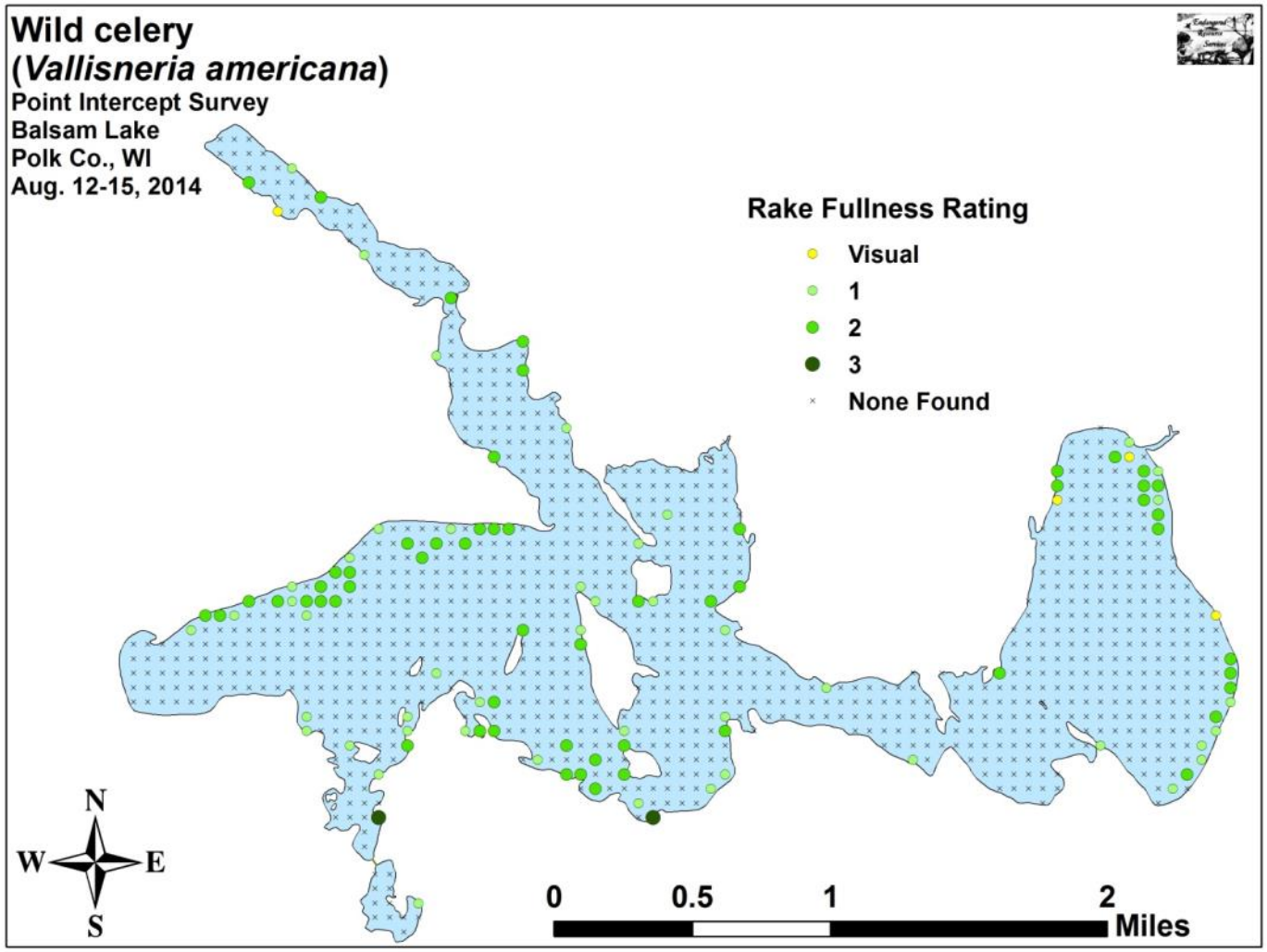
Wild celery
(Vallisneria americana)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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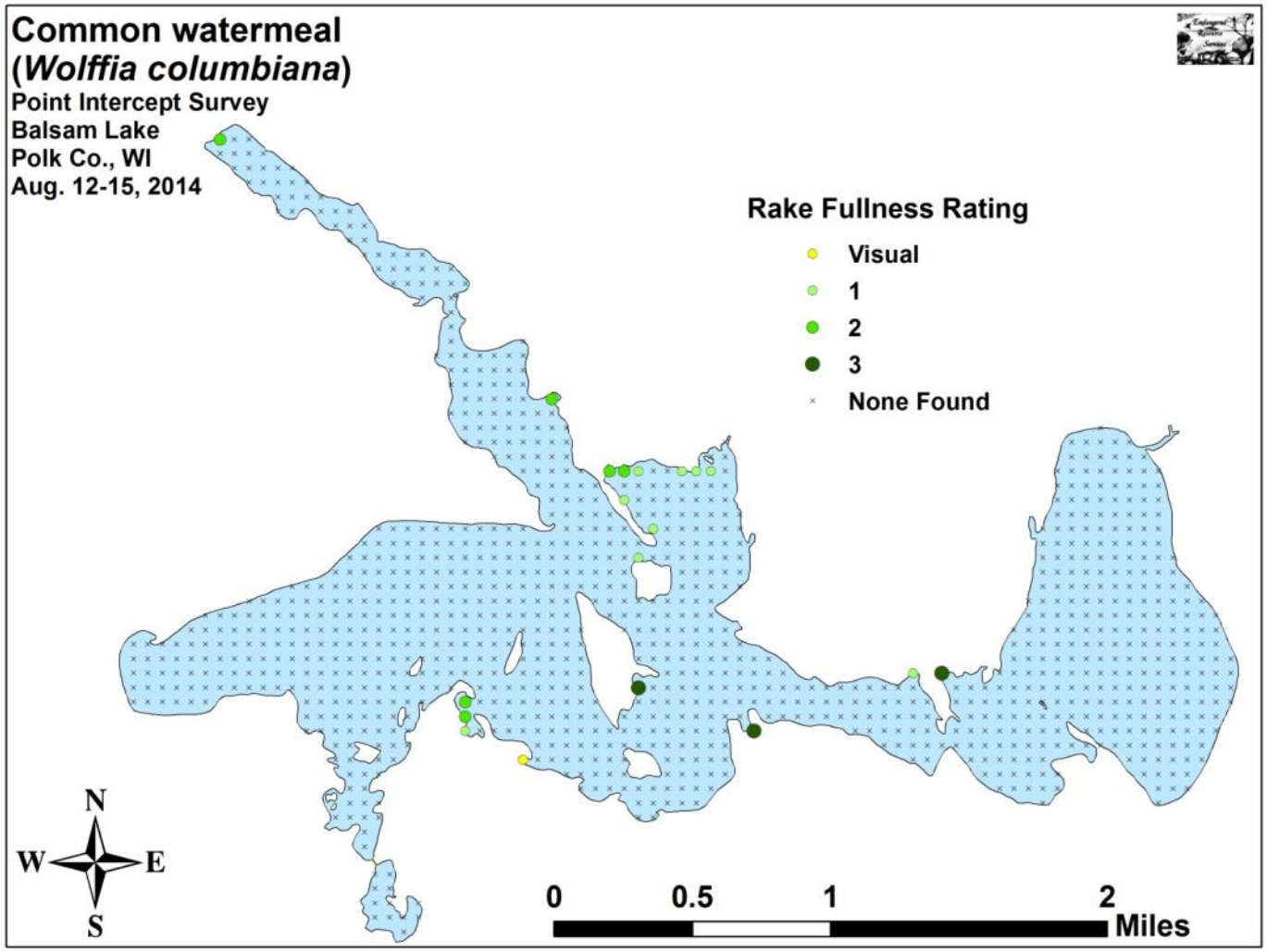
Common watermeal
(Wolffia columbiana)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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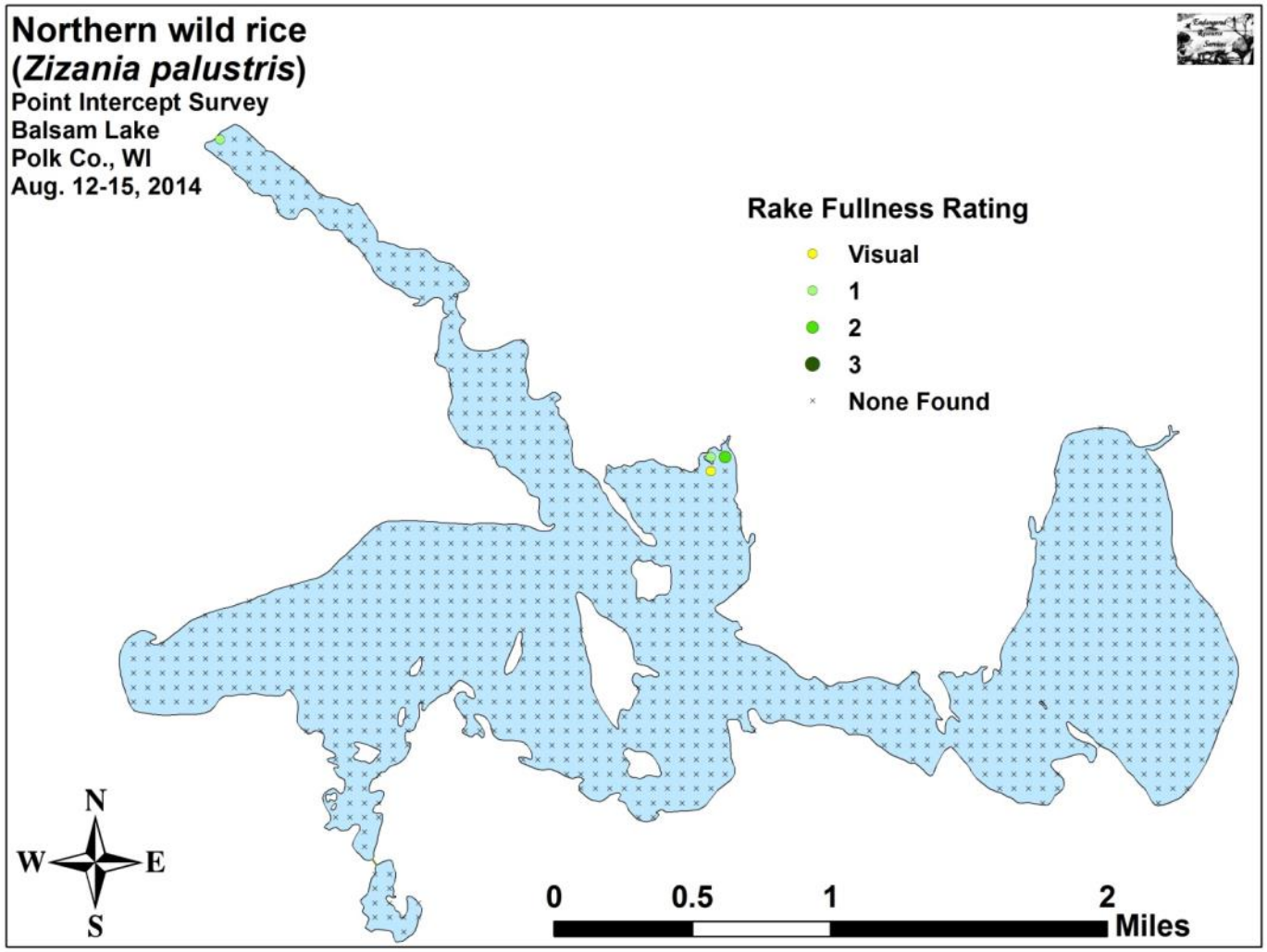
Northern wild rice
(Zizania palustris)
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
Visual
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None Found
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Appendix IX: Aquatic Exotic Invasive Plant Species Information

Eurasian water milfoil

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

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

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

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

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

Dense stands of Eurasian water milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by Eurasian water milfoil may lead to deteriorating water quality and algae blooms of infested lakes. (Taken in its entirety from WDNR, 2014 http://www.dnr.state.wi.us/invasives/fact/milfoil.htm)

Curly-leaf pondweed

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

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, 2014 http://www.dnr.state.wi.us/invasives/fact/curlyleaf_pondweed.htm)

Reed canary grass

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

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

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

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

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

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

This species prefers disturbed areas, but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in less than twelve years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, deforestation of swamp forests, sedimentation, and intentional planting. The difficulty of selective control makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites. (Taken in its entirety from WDNR, 2014 http://www.dnr.state.wi.us/invasives/fact/reed_canary.htm)

Purple loosestrife
(Photo Courtesy Brian M. Collins)

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

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

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

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

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

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

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

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

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

Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways. (Taken in its entirety from WDNR, 2014 http://www.dnr.state.wi.us/invasives/fact/loosestrife.htm)

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

Aquatic:

organisms that live in or frequent water.

Cultural Eutrophication:

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

Dissolved Oxygen (DO):

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

Diversity:

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

Drainage lakes:

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

Ecosystem:

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

Eutrophication:

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

Exotic:

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

Habitat:

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

Limnology:

the study of inland lakes and waters.

Littoral:

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

Macrophytes:

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

Nutrients:

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

Organic Matter:

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

Photosynthesis:

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

Phytoplankton:

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

Plankton:

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

ppm:

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

Richness:

number of species in a particular community or habitat.

Rooted Aquatic Plants:

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

Runoff:

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

Secchi Disc:

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

Seepage lakes:

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

Turbidity:

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

Watershed:

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

Zooplankton:

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

Appendix XI: 2014 Raw Data Spreadsheets