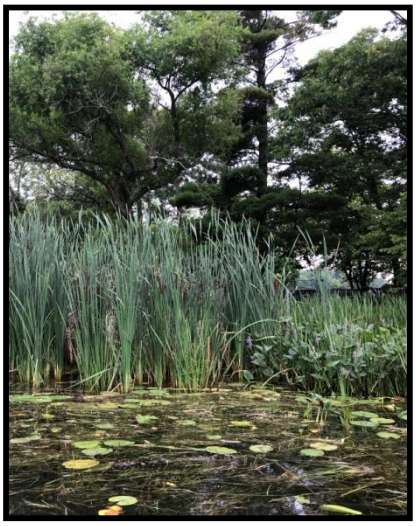
Warm-Water Macrophyte Point-Intercept Survey
Balsam Lake – WBIC: 2620600
Polk County, Wisconsin

Balsam Lake Aerial Photo (2015)



Hybrid cattails – A new exotic species (Berg 2020)

Project Initiated by:

Balsam Lake Protection and Rehabilitation District, Harmony Environmental, and the Wisconsin Department of Natural Resources – Grant ACEI212-18

Northern Wild Rice Bed at the Harder Creek Inlet in Stump Bay (Berg 2020)

Survey Conducted by and Report Prepared by:

Endangered Resource Services, LLC
Matthew S. Berg, Research Biologist
St. Croix Falls, Wisconsin
August 7-9, 2020

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ABSTRACT

Balsam Lake (WBIC 2620600) is a 2,054 acre stratified mesotrophic drainage lake located in central Polk County, WI. Following the lake's initial 2009 point-intercept surveys, in 2010, the Balsam Lake Protection and Rehabilitation District (BLPRD), under the direction of Cheryl Clemens – Harmony Environmental (HE), developed an Aquatic Plant Management Plan (APMP) that authorized chemical treatment of the lake's Curly-leaf pondweed (*Potamogeton crispus*) (CLP) infestation. After these surveys were repeated in 2014, this plan was revised in 2015 to also include mechanical harvesting of CLP. As a prerequisite to updating this plan in 2021, the BLPRD and the Wisconsin Department of Natural Resources (WDNR) authorized three surveys in 2020 – CLP point-intercept and bed mapping surveys and a full point-intercept survey for all aquatic macrophytes. Unfortunately, because the request came after the BLPRD had started active management, the WDNR informed the BLPRD and HE that the CLP PI should be postponed until the spring of 2021 although the warm-water survey could go on as planned. That survey, conducted on August 7-9, 2020, found macrophytes growing at 370 points (33.8% of the entire lake bottom and 72.8% of the 15.0ft littoral zone). This was nearly identical to the 377 sites with plants in 2014 (34.4% of the entire lake/70.1% of the then15.5ft littoral zone); however, it still represented a highly significant decline **(p=0.001)** from 2009 when we found plants growing at 600 points (54.8% of the lake bottom/88.8% of the then 19.0ft littoral zone which including almost all of East Balsam). Overall diversity was exceptionally high with a Simpson Diversity Index value of 0.92 – identical to 2014 and up slightly from 0.90 in 2009. Species richness was moderate with 48 species found growing in and immediately adjacent to the water – nearly unchanged from 46 in 2014 and 47 in 2009. There was an average of 3.55 native species/site with native vegetation – a non-significant increase (p=0.20) from 3.41 species/site in 2014, but a nearly significant increase (p=0.07) from the 3.35 species/site we found in 2009. In 2009, Coontail (*Ceratophyllum demersum*), Forked duckweed (*Lemna trisulca*), Small pondweed (*Potamogeton pusillus*), and Flat-stem pondweed (*Potamogeton zosteriformis*) were the most common species. Present at 57.33%, 55.17%, 48.00%, and 35.33% of survey points with vegetation respectively, they accounted for 55.48% of the total relative frequency. The 2014 survey found Coontail, Forked duckweed, Flat-stem pondweed, and Wild celery (*Vallisneria americana*) were the most common macrophyte species (64.99%, 40.85%, 40.58%, and 27.85% of sites with vegetation/49.95% of the total relative frequency). Lakewide from 2009-2014, Forked duckweed, Small pondweed, CLP, Fern pondweed (*Potamogeton robbinsii*), and White-stem pondweed (*Potamogeton praelongus*) suffered highly significant declines (Coontail also had a highly significant decline when considering only East Balsam); 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 expansions also appeared to be primarily due to changes in East Balsam. Between 2014 and 2020, Forked duckweed and Flat-stem pondweed both underwent highly significant declines; and filamentous algae saw a moderately significant decline. Despite these losses, Wild celery experienced a highly significant increase; Common waterweed (*Elodea canadensis*), Northern-water milfoil, Fern pondweed, and Common watermeal (*Wolffia columbiana*) demonstrated moderately significant increases; and Coontail had a significant increase. These significant differences again appeared to be mostly caused by changes in East Balsam. Northern wild rice (*Zizania palustris*) was present at three points with a mean rake fullness of 1.67 – similar to three points/mean rake of 1.33 in 2014, but up from one point with a rake of 2 in 2009. Dense rice beds occurred at the Rice Creek Inlet while rice at the Harder Creek Inlet was patchy and of poorer quality. Although valuable for wildlife, both areas had limited human harvest potential due to very shallow water which made them generally inaccessible. We did not see rice anywhere else in the system. Filamentous algae were present at 97 sites with a mean rake fullness of 1.47. This was a moderately significant decline **(p=0.003)** in distribution and a significant decline **(p=0.04)** in density from 2014 when they was present at 145 sites with a mean rake of 1.45. It was also a further decline from 2009 when these algae were present at 184 sites with a mean rake of 1.59. The 39 native index species found in the rake during the August 2020 survey (up from 37 in both 2014 and 2009) produced an above average mean Coefficient of Conservatism of 6.3 (identical to 2014 and up from 6.1 in 2009), and a Floristic Quality Index of 39.4 (up from 38.1 in 2014 and 37.2 in 2009) that was nearly double the median FQI for this part of the state. In addition to CLP, we found four other exotic species growing adjacent to Balsam Lake. Reed canary grass (*Phalaris arundinacea*) was present throughout; Purple loosestrife (*Lythrum salicaria*) was scattered in the bays south of First Island, in Idlewild Bay, near the village beach, and in Raskin Bay (fortunately, there were Galerucella beetles on most plants); Common forget-me-not (*Myosotis scorpioides*) was also found at a few scattered locations in the bays south of First Island and near the village beach; and a single but well-established stand of Hybrid cattail (*Typha* X *glauca*) was growing along the immediate shoreline southwest of Paradise and Big Islands. Future management considerations include working to preserve 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; managing CLP in a way that minimizes the impact on the native plant community; continuing to monitor for and eliminate Purple loosestrife wherever it is found; and continuing both the Clean Boats/Clean Waters watercraft inspections and the landing monitoring program to prevent or quickly identify Eurasian water-milfoil (*Myriophyllum spicatum*) should it be introduced to the lake.

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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). It 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) (Figure 1). The lake is mesotrophic bordering on eutrophic in nature, and water clarity is fair with historical summer Secchi readings averaging 5ft in East Balsam, 6ft in Little Balsam, and 8ft in the deep hole north of Cedar Island (WDNR 2020). Bottom substrate is variable with organic muck in most bays, and rock/sand in the Big and Little Narrows and around the lake's many islands.

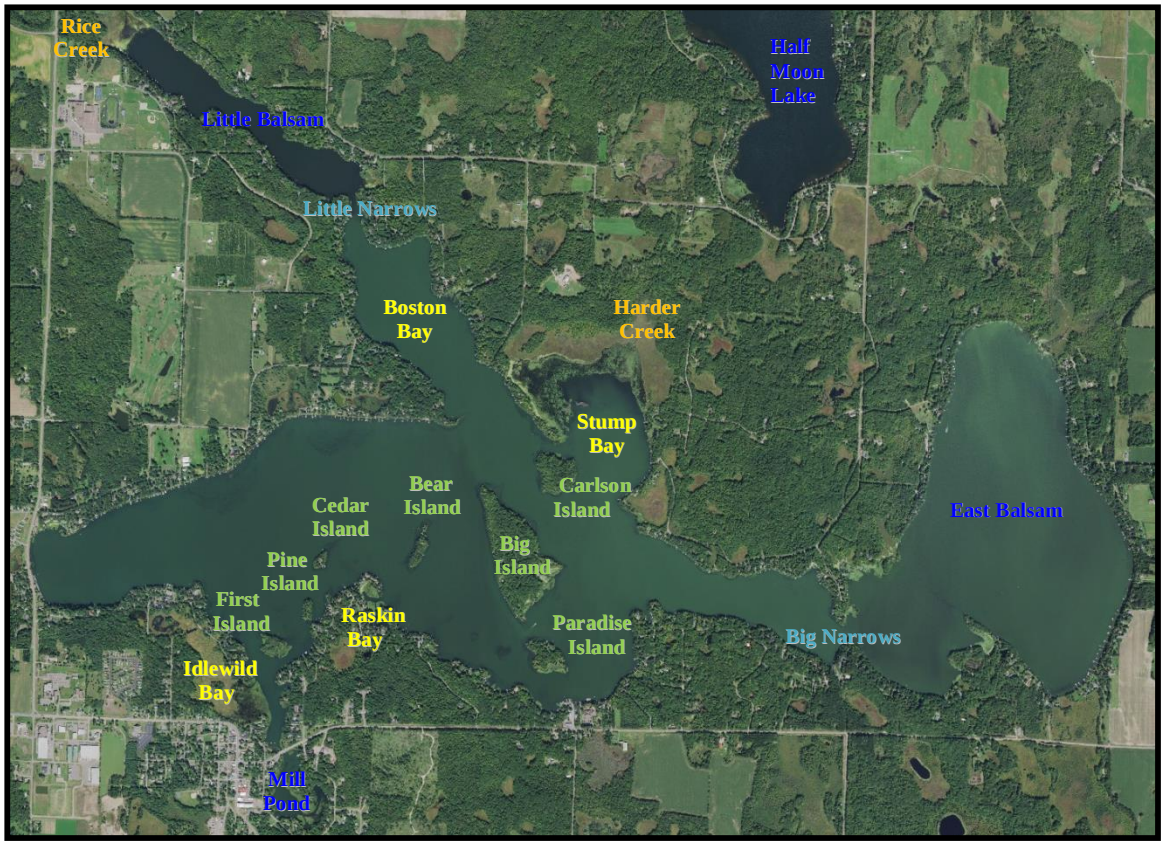


Figure 1: Aerial Photo of Balsam Lake

BACKGROUND AND STUDY RATIONALE:

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. Per WDNR expectations (Pamela Toshner/Alex Smith, WDNR – pers. comm.), whole lake plant surveys on actively managed lakes are normally repeated every five years as a prerequisite to updating a lake's Aquatic Plant Management Plan (APMP). Because the last surveys on Balsam Lake occurred in 2014 and the last management plan was updated in 2015, the BLPRD was informed they needed to have the lake resurveyed so they could update their APMP.

In anticipation of updating their plan in 2021, the BLPRD, under the direction of Cheryl Clemens – Harmony Environmental (HE), authorized three lakewide surveys on Balsam Lake in 2020. Unfortunately, the surveys weren't requested until after the lake had already treated CLP in East Balsam. Because of this, the WDNR informed the BLPRD/HE that the CLP point-intercept survey should be delayed until the spring of 2021 when it will occur prior to any active management. However, they asked that the warm-water point-intercept survey of all macrophytes continue as scheduled.

The late summer survey's objectives were to document the current levels of native plant growth in the lake; compare this data from the original survey in 2009 and the last survey in 2014 to identify any significant changes in the lake's vegetation over this time; and determine if Eurasian water-milfoil (*Myriophyllum spicatum*) or any other new exotic plants had invaded the lake. This report is the summary analysis of that field survey conducted from August 7-9, 2020.

METHODS:

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 I). All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2006; Skawinski 2019), and a data sheet was built from the species present.

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), and this same grid has been used for each whole lake survey since 2009 (Appendix II). These points were uploaded to a GPS (Garmin 76CSx) and located on the lake. At each site, we recorded a depth reading with a metered pole 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.

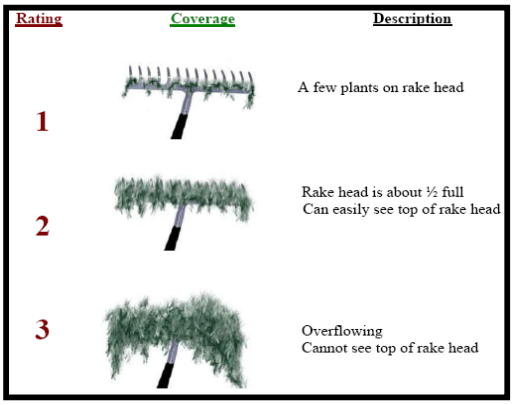


Figure 2: Rake Fullness Ratings (UWEX 2010)

DATA ANALYSIS:

In an effort to visualize the changes on the lake since the first point-intercept survey in 2009, we included summary statistics and maps in the 2020 report and attached CD from each prior survey. We also updated pre-2010 data to the current standard Aquatic Plant Management spreadsheet (Appendix I) (UWEX 2010). Using this same sheet for our 2020 survey, we entered all data collected in the field and calculated the following:

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

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

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

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

Frequency of occurrence example:

Plant A is sampled at 70 out of 700 total littoral points = 70/700 = .10 = 10%

This means that Plant A's frequency of occurrence = 10% when considering the entire littoral zone.

Plant A is sampled at 70 out of 350 total points with vegetation = 70/350 = .20 = 20%

This means that Plant A's frequency of occurrence = 20% when only considering the sites in the littoral zone that have vegetation.

From these frequencies, we can estimate how common each species was at depths where plants were able to grow, and at points where plants actually were growing.

Note the second value will be greater as not all the points (in this example, only ½) had plants growing at them.

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

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

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

Number of sites sampled using rope/pole rake: This indicates which rake type was used to take a sample. We use a 20ft pole rake and a 35ft rope rake for sampling.

Average number of species per site: This value is reported using four different considerations. 1) **shallower than maximum depth of plants** indicates the average number of plant species at all sites in the littoral zone. 2) **vegetative sites only** indicate the average number of plants at all sites where plants were found. 3) **native species shallower than maximum depth of plants** and 4) **native species at vegetative sites only** excludes exotic species from consideration.

Species richness: This value indicates the number of different plant species found in and directly adjacent to (on the waterline) the lake. Species richness alone only counts those plants found in the rake survey. The other two values include those seen at a sample point during the survey but not found in the rake, and those that were only seen during the initial boat survey or inter-point. **Note: Per WDNR protocol, filamentous algae, freshwater sponges, aquatic moss and the aquatic liverworts *Riccia fluitans* and *Ricciocarpus natans* are excluded from these totals.**

Average rake fullness: This value is the average rake fullness of all species in the rake. It only takes into account those sites with vegetation (Table 1).

Relative frequency: This value shows a species' frequency relative to all other species. It is expressed as a percentage, and the total of all species' relative frequencies will add up to 100%. Organizing species from highest to lowest relative frequency value gives us an idea of which species are most important within the macrophyte community (Tables 2-4).

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 5-7).

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

Comparison to Past Surveys: We compared data from the 2009 and 2014 warm-water point-intercept surveys to see if there were any significant changes in the whole lake's vegetation (Figure 8) (Tables 2 and 3) as well as just the East Balsam subset (Figure 24) (Tables 9 and 10). We also compared our 2014 and 2020 whole lake (Figure 9) (Table 4) and East Balsam data (Figure 25) (Table 11). For individual plant species as well as count data, we used the Chi-square analysis on the WDNR Pre/Post survey worksheet. For comparing averages (mean species/point and mean rake fullness/point), we used t-tests. Differences were considered significant at $p<0.05$, moderately significant at $p<0.01$ and highly significant at $p<0.001$ (UWEX 2010). It should be noted that we used the number of littoral points (676 in 2009/538 in 2014/508 in 2020 for the whole lake and 309 in 2009/214 in 2014/180 in 2020) as the basis for "sample points" in the comparison analysis.

RESULTS:

Warm-water Full Point-intercept Macrophyte Survey:

Depth readings taken at Balsam Lake's 1,095 point survey grid (Appendix II) 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 areas 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 an expansive 15-19ft flat (Figure 3) (Appendix III).

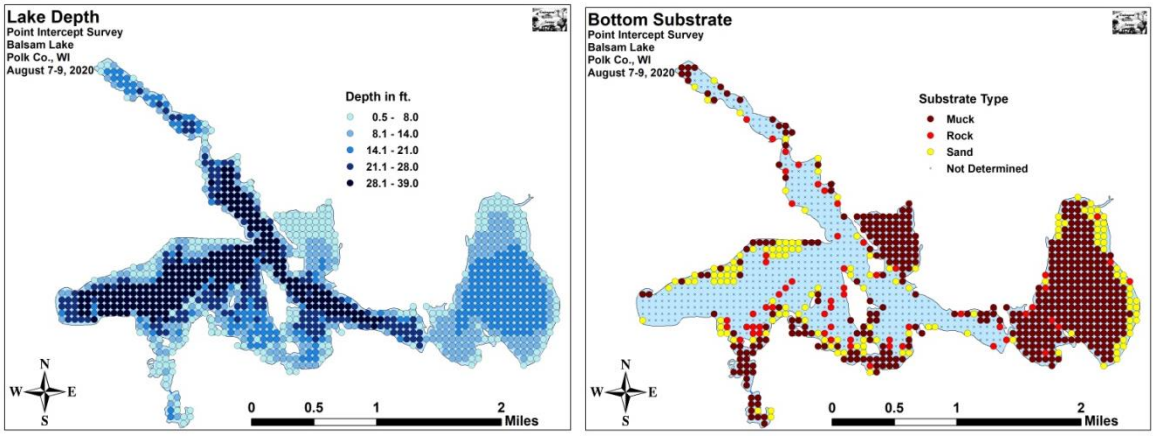


Figure 3: Lake Depth and Bottom Substrate

Of the 662 survey points where we could determine the substrate, 68.6% (454 points) were muck and sandy muck, 22.5% (149 points) were pure sand, and 8.9% (59 points) 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, as well as many shorelines in Boston Bay and Little Balsam, were dominated by gravel and cobble (Figure 3) (Appendix III).

In 2020, we found plants growing to 15.0ft (down from 15.5ft in 2014 and 19.0ft in 2009) (Table 1). The 370 points with vegetation (approximately 33.8% of the entire lake bottom and 72.8% of the littoral zone) was nearly identical to 2014 when we found 377 points with vegetation (34.4% of the entire lake bottom/70.1% of the littoral zone). However, it represented a highly significant decline **(p<0.001)** from 2009 when we found plants growing at 600 points (54.8% of the lake bottom/88.8% of the littoral zone) including almost all of East Balsam (Figure 4) (Appendix IV).

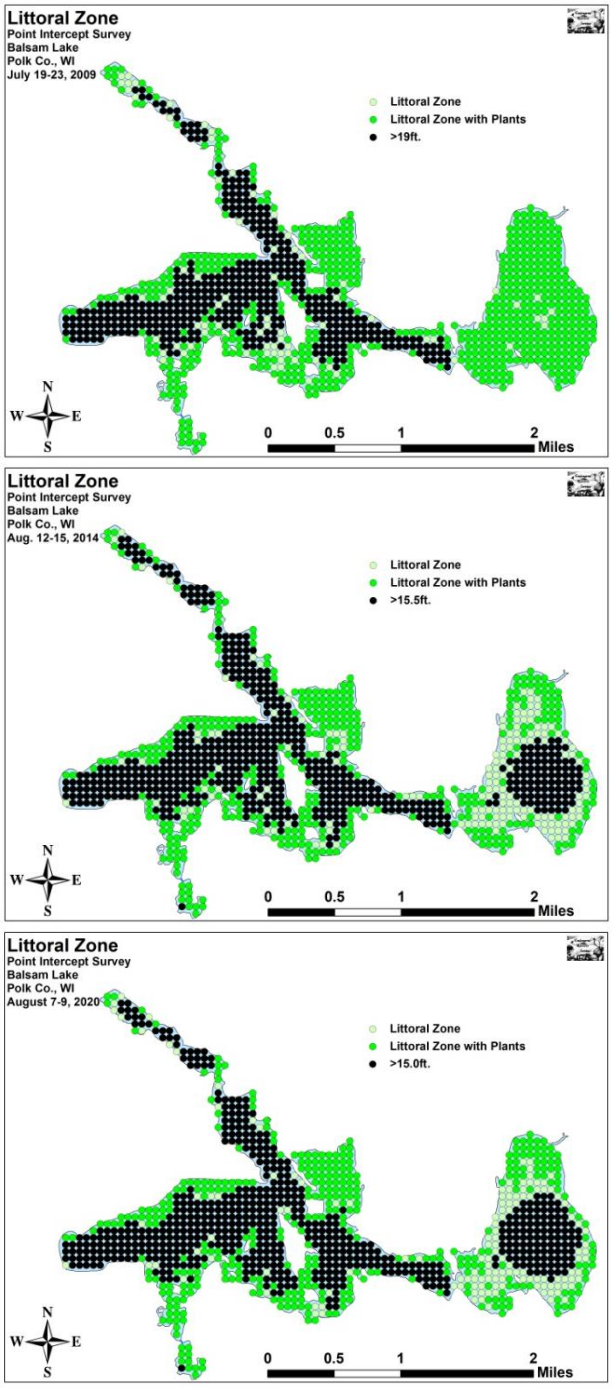


Figure 4: 2009, 2014, and 2020 Littoral Zone

Table 1: Aquatic Macrophyte P/I Surveys Summary Statistics
Balsam Lake, Polk County
July 17-22, 2009, August 12-15, 2014, and August 7-9, 2020

Summary Statistics:	**2009**	**2014**	**2020**
Total number of sites visited	1,095	1,095	1,095
Total number of sites with vegetation	600	377	370
Total number of sites shallower than the maximum depth of plants	676	538	508
Frequency of occurrence at sites shallower than maximum depth of plants	88.8	70.1	72.8
Simpson Diversity Index	0.90	0.92	0.92
Maximum depth of plants (ft)	19.0	15.5	15.0
Mean depth of plants (ft)	10.0	7.3	7.3
Median depth of plants (ft)	10.0	7.0	7.5
Number of sites sampled using rake on Rope (R)	116	148	0
Number of sites sampled using rake on Pole (P)	537	509	589
Average number of all species per site (shallower than max depth)	3.13	2.44	2.63
Average number of all species per site (veg. sites only)	3.53	3.49	3.61
Average number of native species per site (shallower than max depth)	2.97	2.38	2.59
Average number of native species per site (sites with native vegetation only)	3.35	3.41	3.55
Species richness	38	38	40
Species richness (including visuals)	39	38	42
Species richness (including visuals and boat survey)	47	46	48
Mean rake fullness (vegetative sites only)	2.32	2.03	2.24

Plant growth in 2020 was slightly skewed to shallow water as the mean depth of 7.3ft was less than than the median depth of 7.5ft (Table 1). This reversed the trend from 2014 where plant growth was slightly skewed to deep water (7.3ft mean/7.0ft median). All of these values represented a sharp decline from 2009 when the mean and median depths were both 10.0ft showing plants at that time were evenly distributed throughout the littoral zone.

Despite these sharp overall declines since 2009, we noted that these changes were not uniform throughout the lake. In the main lake, we observed the littoral zone was essentially unchanged at approximately 15ft during all three surveys. However, in East Balsam, we consistently found rooted plants to 18ft and occasionally to 19ft in 2009, but didn't locate any beyond 10-11ft in 2014 or 2020 (Figure 5).

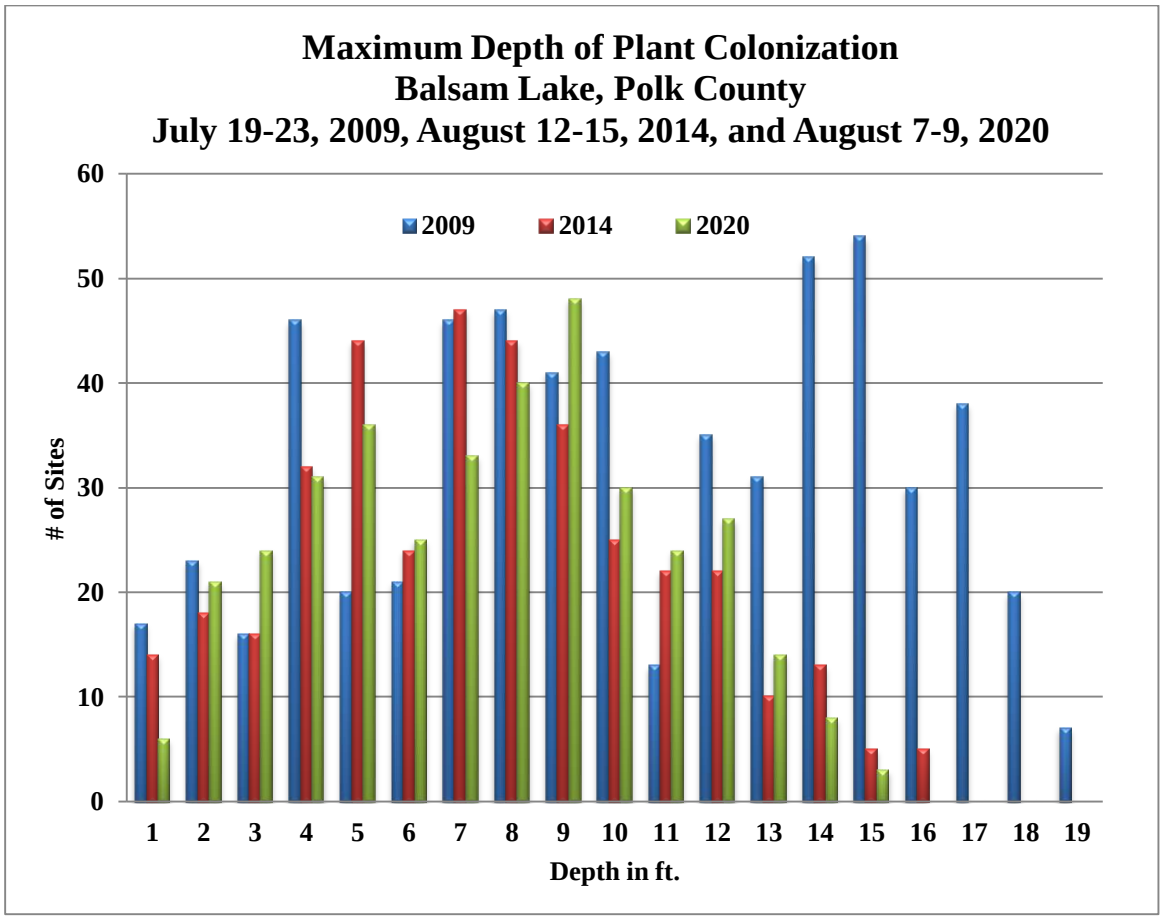


Figure 5: 2009, 2014, and 2020 Plant Colonization Depth Chart

Plant diversity was exceptionally high in 2020 with a Simpson Index value of 0.92 – identical to 2014 and up slightly from 0.90 in 2009. Total richness was moderate with 40 species found in the rake (up from 38 in both 2014 and 2009). This total increased to 48 species when including visuals and plants seen during the boat survey (up from 46 in 2014 and 47 in 2009).

Similar to total richness, mean localized richness was little changed over the three surveys. From 2009 to 2014, the average number of native species at sites with native vegetation experienced a non-significant increase (p=0.32) from 3.35/site to 3.41/site. This trend continued in 2020 with another non-significant increase (p=0.20) to a mean of 3.55 native species/site. The increase from 2009 to 2020 was also only nearly significant (p=0.07). Visual analysis of the maps shows the lake's muck bottom bays – especially Idlewild Bay, Raskin Bay, and Stump Bay – continue to support high richness (Figure 6) (Appendix IV).

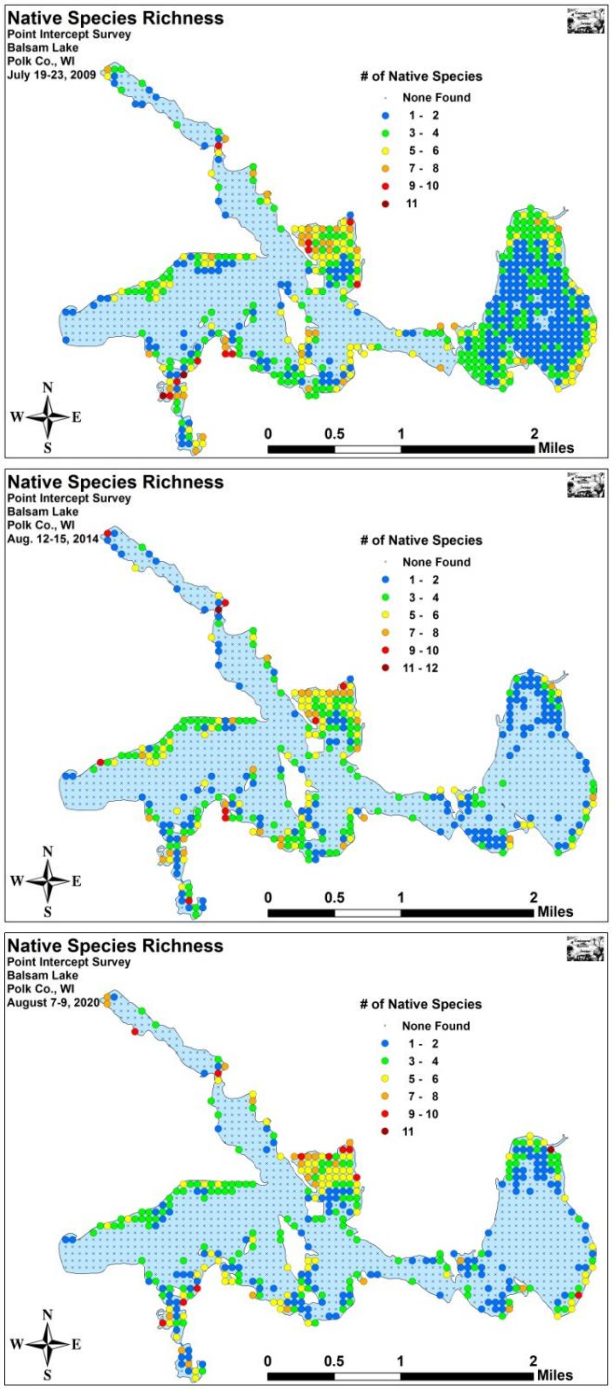


Figure 6: 2009, 2014, and 2020 Native Species Richness

Following several years of large-scale chemical management in East Balsam, northwest of the Big Narrows, near Big and Paradise Islands, and in the channel north of the village beach landing; total rake fullness experienced a highly significant decline **(p<0.001)** from a moderately high 2.32 in 2009 to a moderate 2.03 in 2014. After five years of limited chemical management, the 2020 survey documented a highly significant increase **(p<0.001)** in density back to a moderately high mean rake of 2.24. Analysis of the maps showed this rebound was most pronounced in East Balsam (Figure 7) (Appendix IV).

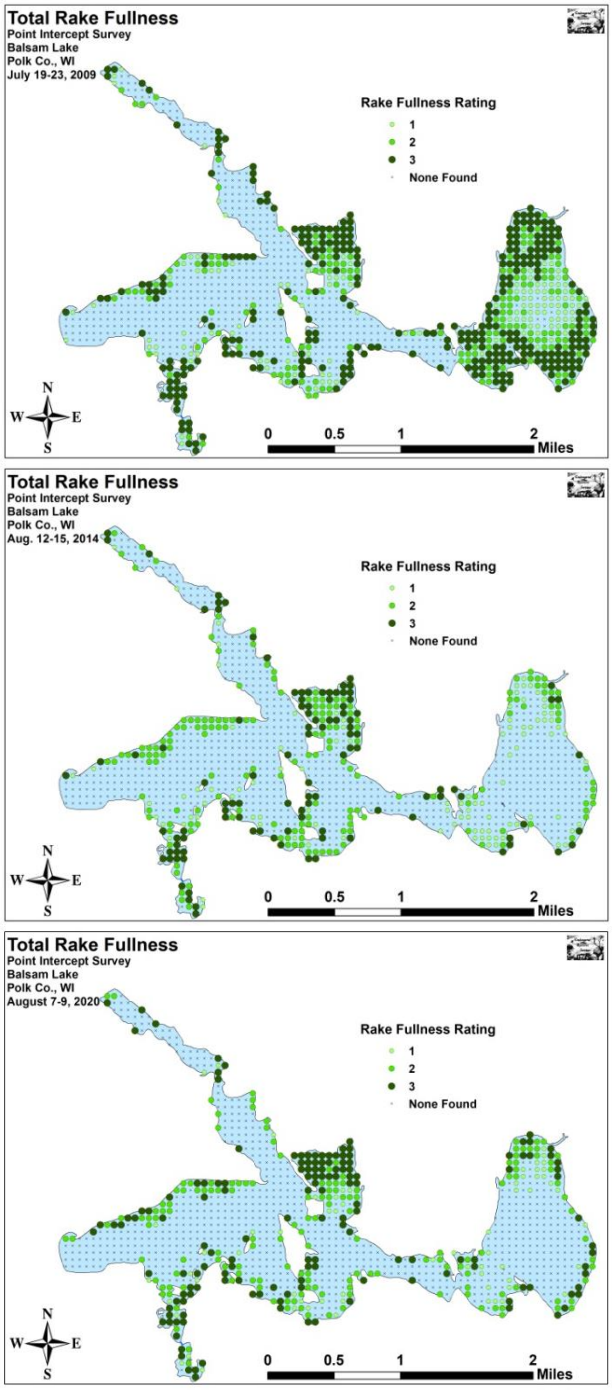


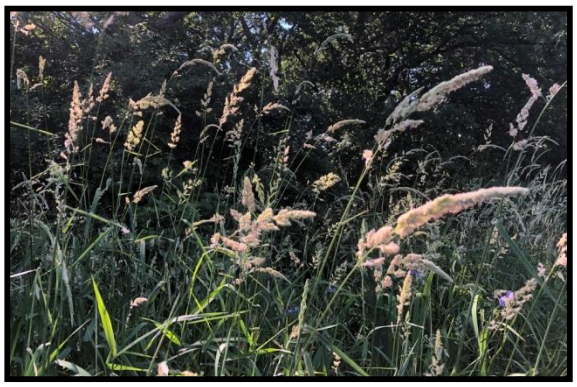
Figure 7: 2009, 2014, and 2020 Total Rake Fullness

Balsam Lake Plant Community:

The Balsam Lake ecosystem is home to a diverse plant community that is typical of moderately 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.

Highly developed and otherwise disturbed shoreline areas often had few emergent species. When present, this community tended to be dominated by exotic species; especially Reed canary grass (*Phalaris arundinacea*) which was common throughout the lake and in adjacent wetlands. Near the village beach and around the perimeter of Idlewild and Raskin Bays, we also found Purple loosestrife (*Lythrum salicaria*) and a few patches of Common forget-me-not (*Myosotis scorpioides*).



Reed canary grass (Berg 2020)

Purple loosestrife (Cameron 2018)

Purple loosestrife cluster east of Idlewild Bay (Berg 2017)

Common forget-me-not (Raymond 2011)

Along undeveloped sandy and rocky shorelines and over shallow sand and rock bars, the emergent community was dominated by Creeping spikerush (*Eleocharis palustris*), Hardstem bulrush (*Schoenoplectus acutus*), and Common bur-reed (*Sparganium eurycarpum*). We also found a single small stand of Hybrid cattail (*Typha* X *glauca*) in this environment.

Creeping spikerush (Legler 2016)

Hardstem bulrush (Dziuk 2015)

Common bur-reed (Raymond 2011)

Hybrid cattail along the Balsam Lake shoreline (Berg 2020)

In more sheltered shoreline areas where the bottom was dominated by sandy muck, we found beds of Pickerelweed (*Pontederia cordata*), Sessile-fruited arrowhead (*Sagittaria rigida*), Softstem bulrush (*Schoenoplectus tabernaemontani*) and Broad-leaved cattail (*Typha latifolia*).

Pickerelweed (Texas A&M 2012)

Sessile-fruited arrowhead (Chayka 2013)

Softstem bulrush (Schwarz 2011)

Broad-leaved cattail (Raymond 2011)

At the edge of wetlands adjacent to the Rice and Harder Creek Inlets where the soil was a more nutrient-rich organic muck, these species were joined by Wild calla (*Calla palustris*), Common arrowhead (*Sagittaria latifolia*), and open beds of Northern wild rice (*Zizania palustris*).

Wild calla (Pierce 2001)

Common arrowhead (Young 2009)

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

Northern wild rice inflorescence (Cameron 2017)

Scattered among the emergents in pure sand areas in water up to 5ft deep, we noted the plant community was dominated by generally fine-leaved submergent plants like Muskgrass (*Chara* sp.), Needle spikerush (*Eleocharis acicularis*), Slender naiad (*Najas flexilis*), Crested arrowhead (*Sagittaria cristata*), and Sago pondweed (*Stuckenia pectinata*). These species tend to form a carpet that stabilizes the bottom, and they work with the emergents to prevent erosion.

Typical shallow sand community on Balsam Lake (Collins 2009)

Muskgrass (Gibbons 2012)

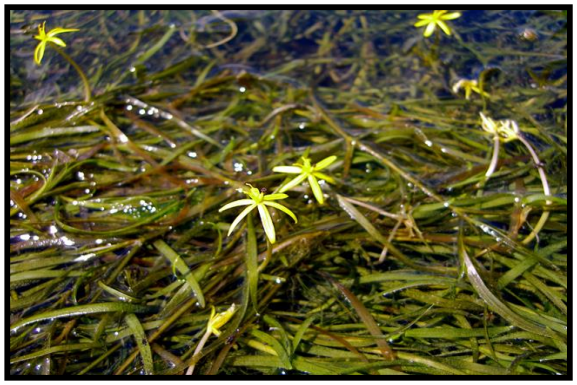
Needle spikerush (Fewless 2005)

Slender naiad (Apipp 2009)

Crested arrowhead (Fewless 2004)

Sago pondweed (Hilty 2012)

Shallow sandy-muck areas tended to support slightly broader-leaved species like Water star-grass (*Heteranthera dubia*), Northern water-milfoil (*Myriophyllum sibiricum*), Fries' pondweed (*Potamogeton friesii*), Clasping-leaf pondweed (*Potamogeton richardsonii*), White water crowfoot (*Ranunculus aquatilis*), 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)

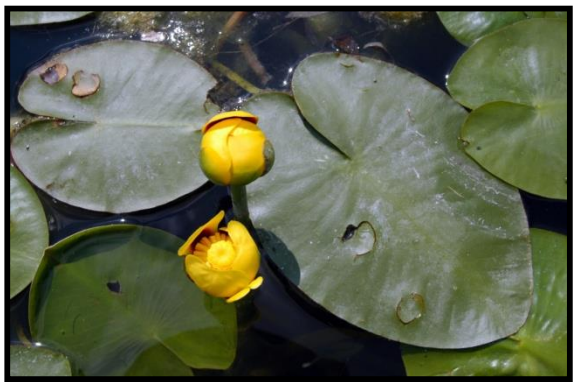
Fries pondweed with "fan-shape" turion (Berg 2002)

Clasping-leaf pondweed (Cameron 2014)

White water crowfoot (Wasser 2014)

Wild celery (Dalvi 2009)

The lake's sand and rock areas seldom had enough nutrients to support floating-leaf species. However, in muck-bottomed areas in up to 5ft of water, Spatterdock (*Nuphar variegata*) and White-water lily (*Nymphaea odorata*) often formed dense beds in the lake's sheltered bays. With this community, we also found Watershield (*Brasenia schreberi*), Ribbon-leaf pondweed (*Potamogeton epihydrus*), and Floating-leaf pondweed (*Potamogeton natans*) although these species tended to be rare and local. Large-leaf pondweed (*Potamogeton amplifolius*) and Illinois pondweed (*Potamogeton illinoensis*), also occasionally produced floating leaves when they were growing in shallow water. The canopy cover this community provides is often utilized by panfish and bass for protection.



Spatterdock (CBG 2014)

White water lily (Falkner 2009)

Watershield (Wed 2019)

Ribbon-leaf pondweed (Petroglyph 2007)

Floating-leaf pondweed (Sein 2014)

Large-leaf pondweed (Fewless 2010)

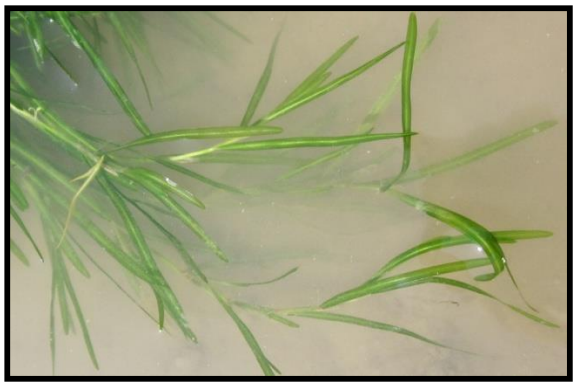
Growing amongst these floating-leaf species, we also encountered the submergent species Water marigold (*Bidens beckii*), Coontail (*Ceratophyllum demersum*), Common waterweed (*Elodea canadensis*), Whorled water-milfoil (*Myriophyllum verticillatum*), Small pondweed (*Potamogeton pusillus berchtoldii*), and Fern pondweed (*Potamogeton robbinsii*).

Water marigold (Dziuk 2012)

Coontail (Hassler 2011)

Common waterweed (Pinkka 2013)

Whorled water-milfoil (Cameron 2018)



Small pondweed (Villa 2011)

Fern pondweed (Apipp 2011)

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 species in 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. 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)

Floating-leaf and many shallow submergent species disappeared in water over 5ft. These deeper areas were dominated by Coontail, Common waterweed, Curly-leaf pondweed, Large-leaf pondweed, Illinois pondweed, Small pondweed, White-stem pondweed (*Potamogeton praelongus*), and Flat-stem pondweed (*Potamogeton zosteriformis*). We also found limited numbers of aquatic moss and the colonial macroalgae Nitella (Nitella flexilis) in this environment. Predatory fish like the lake's pike are often found along the edges of these beds waiting in ambush.

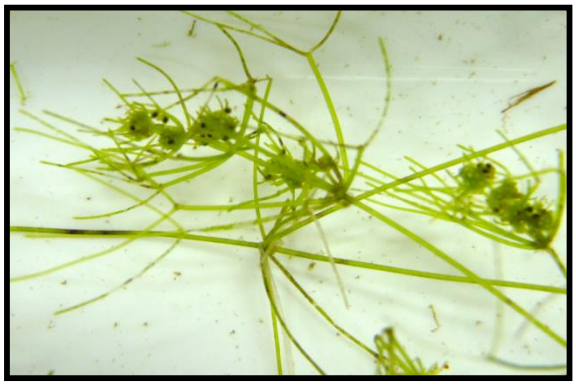
Curly-leaf pondweed (USGS 2019)

Large-leaf and Illinois pondweeds (Dziuk 2018)

White-stem pondweed (Fewless 2005)

Flat-stem pondweed (Dziuk 2019)

Aquatic moss (Skawinski 2010)



Nitella (USFS 2013)

Comparison of Macrophyte Species in 2009, 2014, and 2020:

During the original July 2009 survey, we found Coontail, Forked duckweed, Small pondweed, and Flat-stem pondweed were the most common species (Table 2). Present at 57.33%, 55.17%, 48.00%, and 35.33% of survey points with vegetation respectively, they collectively accounted for 55.48% of the total relative frequency. Wild celery (6.00%), Northern water-milfoil (5.81%), Curly-leaf pondweed (5.34%), and Fern pondweed (4.39%) also had relative frequencies greater than 4.0%.

In 2014, Coontail, Forked duckweed, Flat-stem pondweed, and Wild celery were the most common species (Table 3). Present at 64.99%, 40.85%, 40.58%, and 27.85% of sites with vegetation, they accounted for 49.95% of the total relative frequency. Common waterweed (5.25%), Northern water-milfoil (5.02%), Clasping-leaf pondweed (4.56%), and Small pondweed (4.33%) were the only other species with relative frequencies above 4.0%. These results suggest a slightly more diverse and even plant community existed in 2014 than in 2009 (Maps for all species found in 2009 and 2014 are located on the CD attached to this report).

Lakewide, 12 species showed significant changes in distribution from 2009 to 2014 (Figure 8). Forked duckweed, Small pondweed, Curly-leaf pondweed, Fern pondweed, and White-stem pondweed all suffered highly significant declines; while Northern water-milfoil and White water crowfoot saw moderately significant declines. Conversely, Water star grass showed a highly significant increase; Fries' pondweed had a moderately significant increase; and Slender naiad, Spatterdock, and Nitella all saw significant increases.

Our 2020 survey identified Coontail, Wild celery, Common waterweed, and Northern water-milfoil as the most widely distributed macrophyte species (Table 4). They were present at 71.62%, 45.14%, 26.76%, and 25.41% of points with vegetation and accounted for 46.85% of the total relative frequency. Forked duckweed (6.45%), Flat-stem pondweed (5.85%), Clasping-leaf pondweed (5.10%), and Fern pondweed (4.20%) also had relative frequencies over 4.0% (Species accounts for all plants found during the surveys and maps for all species found in 2020 can be found in Appendixes V and VI).

Comparing the 2014 and 2020 surveys identified nine species with significant changes is distribution (Figure 9). Forked duckweed and Flat-stem pondweed both underwent highly significant declines; and filamentous algae saw a moderately significant decline. Despite these losses, Wild celery experienced a highly significant increase in distribution; Common waterweed, Northern-water milfoil, Fern pondweed, and Common watermeal demonstrated moderately significant increases; and Coontail had a significant increase. These significant differences again appeared to be mostly caused by changes in East Balsam.

Table 2: 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 relative frequency analysis

Table 2 (continued): 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	***	***	***	***	***	***

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

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
August 12-15, 2014

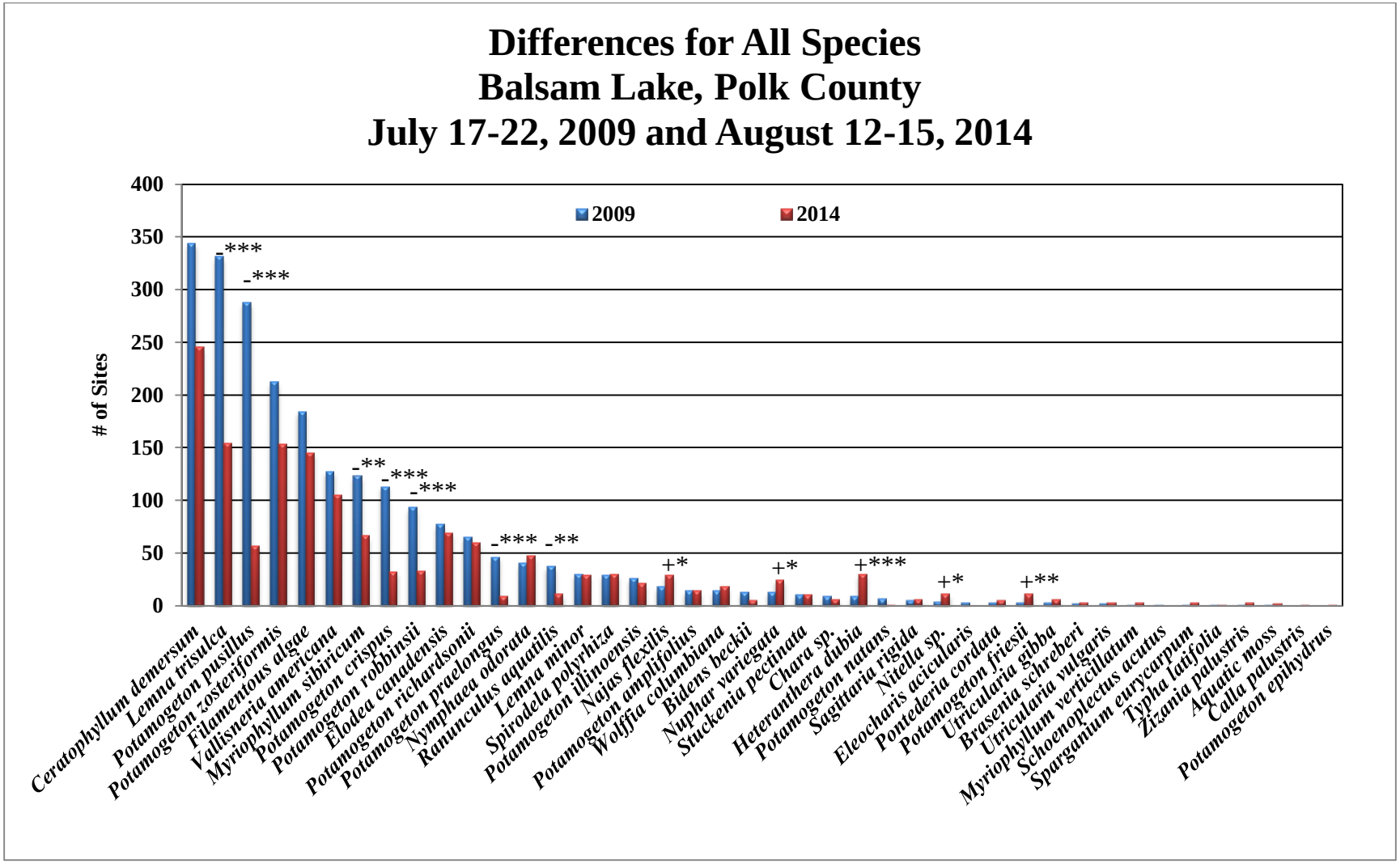
Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Ceratophyllum demersum	Coontail	245	18.63	64.99	45.54	1.64	1
Lemna trisulca	Forked duckweed	154	11.71	40.85	28.62	1.21	1
Potamogeton zosteriformis	Flat-stem pondweed	153	11.63	40.58	28.44	1.61	18
	Filamentous 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 relative frequency analysis

Table 3 (continued): 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	***	***	***	***	***	***

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



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

Figure 8: Macrophyte Changes from 2009-2014

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
August 7-9, 2020

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Ceratophyllum demersum	Coontail	265	19.87	71.62	52.17	1.63	1
Vallisneria americana	Wild celery	167	12.52	45.14	32.87	1.66	1
Elodea canadensis	Common waterweed	99	7.42	26.76	19.49	1.38	2
	Filamentous algae	97	*	26.22	19.09	1.47	0
Myriophyllum sibiricum	Northern water-milfoil	94	7.05	25.41	18.50	1.56	15
Lemna trisulca	Forked duckweed	86	6.45	23.24	16.93	1.31	0
Potamogeton zosteriformis	Flat-stem pondweed	78	5.85	21.08	15.35	1.46	10
Potamogeton richardsonii	Clasping-leaf pondweed	68	5.10	18.38	13.39	1.44	20
Potamogeton robbinsii	Fern pondweed	56	4.20	15.14	11.02	1.48	5
Nymphaea odorata	White water lily	45	3.37	12.16	8.86	2.04	4
Heteranthera dubia	Water star-grass	40	3.00	10.81	7.87	1.28	2
Potamogeton pusillus	Small pondweed	38	2.85	10.27	7.48	1.18	0
Lemna minor	Small duckweed	35	2.62	9.46	6.89	1.03	0
Spirodela polyrhiza	Large duckweed	35	2.62	9.46	6.89	1.34	0
Wolffia columbiana	Common watermeal	35	2.62	9.46	6.89	1.54	1
Potamogeton illinoensis	Illinois pondweed	32	2.40	8.65	6.30	1.88	4
Nuphar variegata	Spatterdock	23	1.72	6.22	4.53	2.13	3
Potamogeton crispus	Curly-leaf pondweed	19	1.42	5.14	3.74	1.05	1
Najas flexilis	Slender naiad	17	1.27	4.59	3.35	1.18	0
Potamogeton amplifolius	Large-leaf pondweed	15	1.12	4.05	2.95	1.47	6
Ranunculus aquatilis	White water crowfoot	15	1.12	4.05	2.95	1.27	0
Potamogeton praelongus	White-stem pondweed	13	0.97	3.51	2.56	1.00	1
Nitella sp.	Nitella	8	0.60	2.16	1.57	1.63	0

* Excluded from relative frequency analysis

Table 4 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
August 7-9, 2020

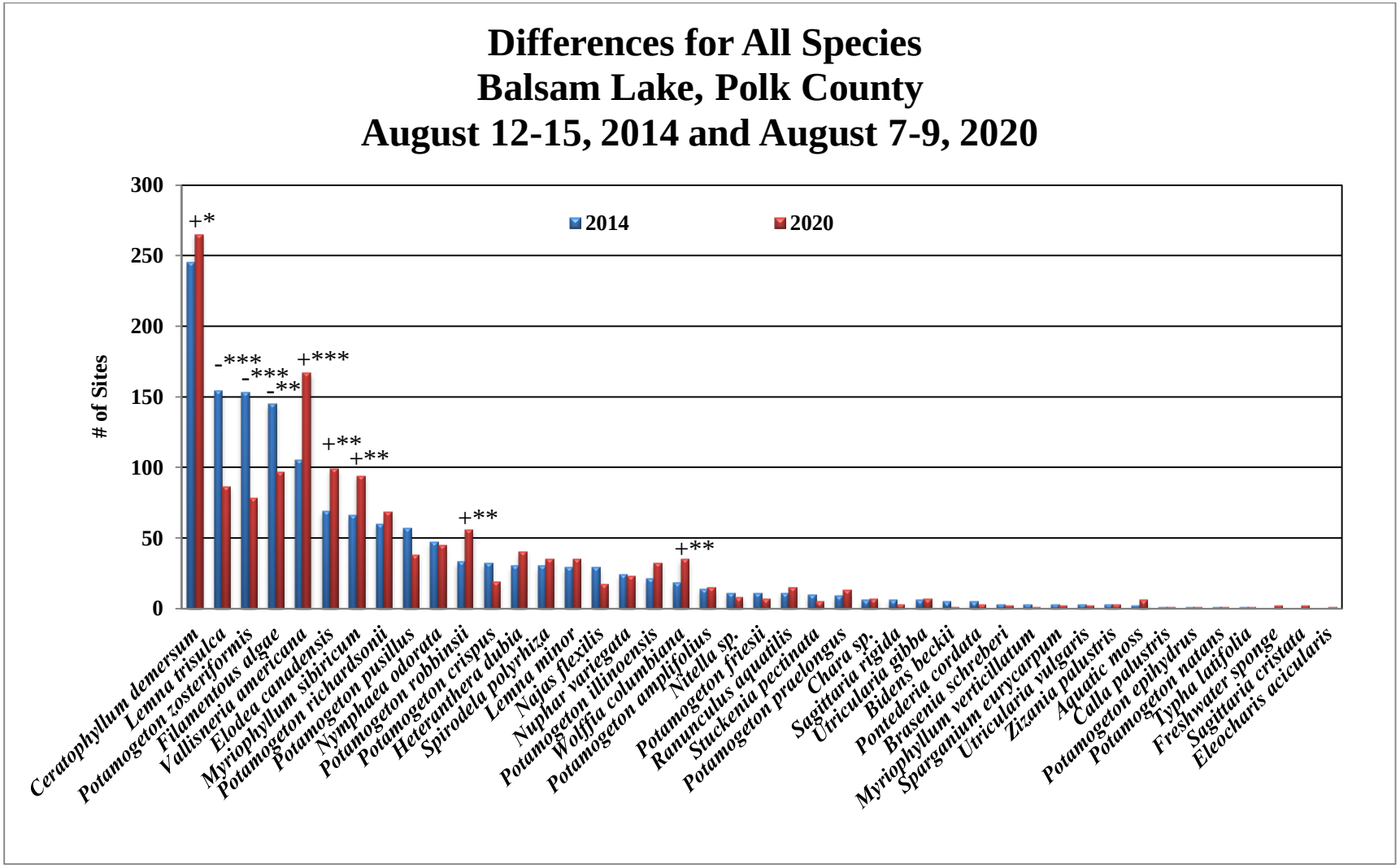
Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Chara sp.	Muskgrass	7	0.52	1.89	1.38	1.43	0
Potamogeton friesii	Fries' pondweed	7	0.52	1.89	1.38	1.00	0
Utricularia gibba	Creeping bladderwort	7	0.52	1.89	1.38	1.43	0
	Aquatic moss	6	*	1.62	1.18	1.33	0
Stuckenia pectinata	Sago pondweed	5	0.37	1.35	0.98	1.80	1
Brasenia schreberi	Watershield	3	0.22	0.81	0.59	2.00	4
Pontederia cordata	Pickerelweed	3	0.22	0.81	0.59	2.00	3
Sagittaria rigida	Sessile-fruited arrowhead	3	0.22	0.81	0.59	1.33	1
Zizania palustris	Northern wild rice	3	0.22	0.81	0.59	1.67	0
Sagittaria cristata	Crested arrowhead	2	0.15	0.54	0.39	1.50	0
Sparganium eurycarpum	Common bur-reed	2	0.15	0.54	0.39	2.00	0
Utricularia vulgaris	Common bladderwort	2	0.15	0.54	0.39	1.00	2
	Freshwater sponge	2	*	0.54	0.39	1.00	0
Bidens beckii	Water marigold	1	0.07	0.27	0.20	2.00	1
Calla palustris	Wild calla	1	0.07	0.27	0.20	1.00	1
Eleocharis acicularis	Needle spikerush	1	0.07	0.27	0.20	1.00	1
Myriophyllum verticillatum	Whorled water-milfoil	1	0.07	0.27	0.20	2.00	1
Potamogeton epihydrus	Ribbon-leaf pondweed	1	0.07	0.27	0.20	2.00	2
Potamogeton natans	Floating-leaf pondweed	1	0.07	0.27	0.20	2.00	2
Typha latifolia	Broad-leaved cattail	1	0.07	0.27	0.20	3.00	1
Sagittaria latifolia	Common arrowhead	**	**	**	**	**	1
Schoenoplectus tabernaemontani	Softstem bulrush	**	**	**	**	**	1

* Excluded from relative frequency analysis ** Visual only

Table 4 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Balsam Lake, Polk County
August 7-9, 2020

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Eleocharis palustris	Creeping spikerush	***	***	***	***	***	***
Lythrum salicaria	Purple loosestrife	***	***	***	***	***	***
Myosotis scorpioides	Common forget-me-not	***	***	***	***	***	***
Phalaris arundinacea	Reed canary grass	***	***	***	***	***	***
Schoenoplectus acutus	Hardstem bulrush	***	***	***	***	***	***
Typha X glauca	Hybrid cattail	***	***	***	***	***	***

*** Boat survey only



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

Figure 9: Macrophyte Changes from 2014-2020

Coontail was the most common species during each of the three surveys (Figure 10). Found at 344 sites in 2009, it saw a nearly significant decline (p=0.06) in distribution to 245 sites in 2014. However, its mean rake fullness value was almost unchanged (p=0.25) from 1.68 in 2009 to 1.64 in 2014. The 2020 survey documented a significant rebound **(p=0.03)** in distribution to 265 sites with a mean rake fullness of 1.63 that was nearly identical (p=0.47) to the 2014 survey. Most of the changes with this species since 2009 occurred in East Balsam where it disappeared from many areas following wide-scale treatment in 2014, but has since showed significant recovery.

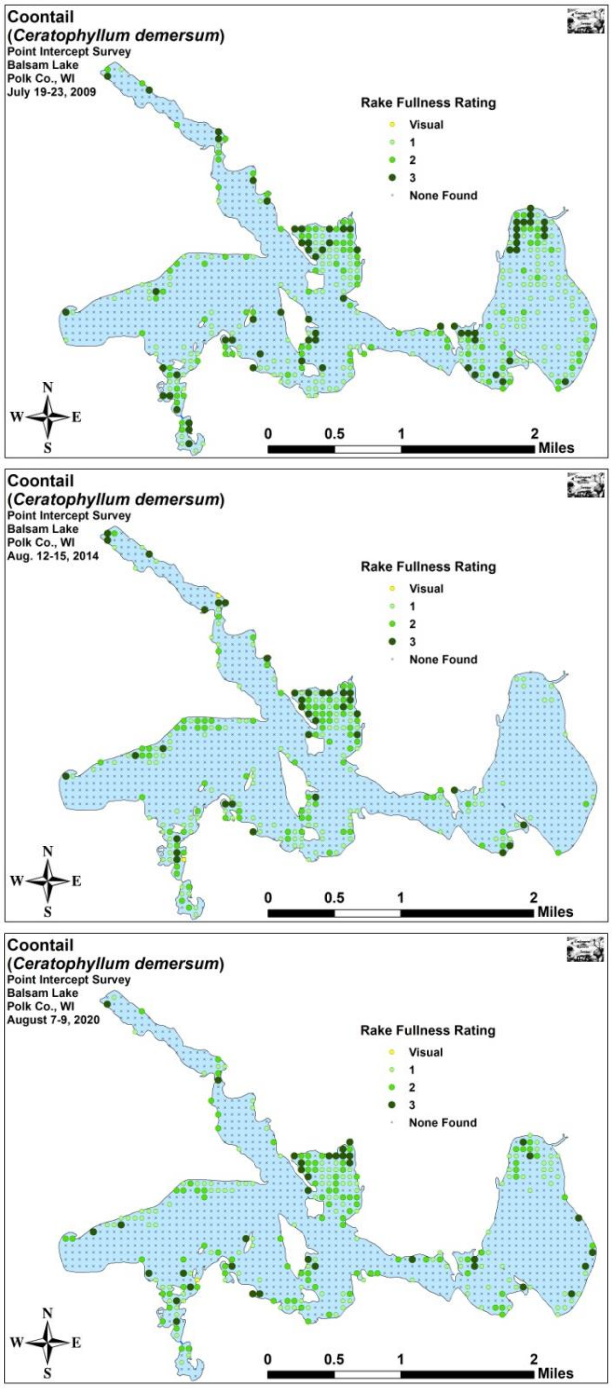


Figure 10: 2009, 2014, and 2020 Coontail Density and Distribution

From 2009 to 2014, Forked duckweed – the second most common species each year – experienced a highly significant decline **(p<0.001)** in both distribution (331 sites in 2009/154 sites in 2014) and density (mean rake fullness of 1.49 in 2009/1.21 in 2014) (Figure 11). In 2020, it experienced a further highly significant decline **(p<0.001)** in distribution to 86 sites (fifth most common species), but a nearly significant increase (p=0.05) in density to 1.31. We have historically found this species in areas that had significant Curly-leaf pondweed stands in June as the nutrient release from CLP's early summer senescence seemed to fuel its growth and expansion. It may be that the harvesting program explains its continued decline.

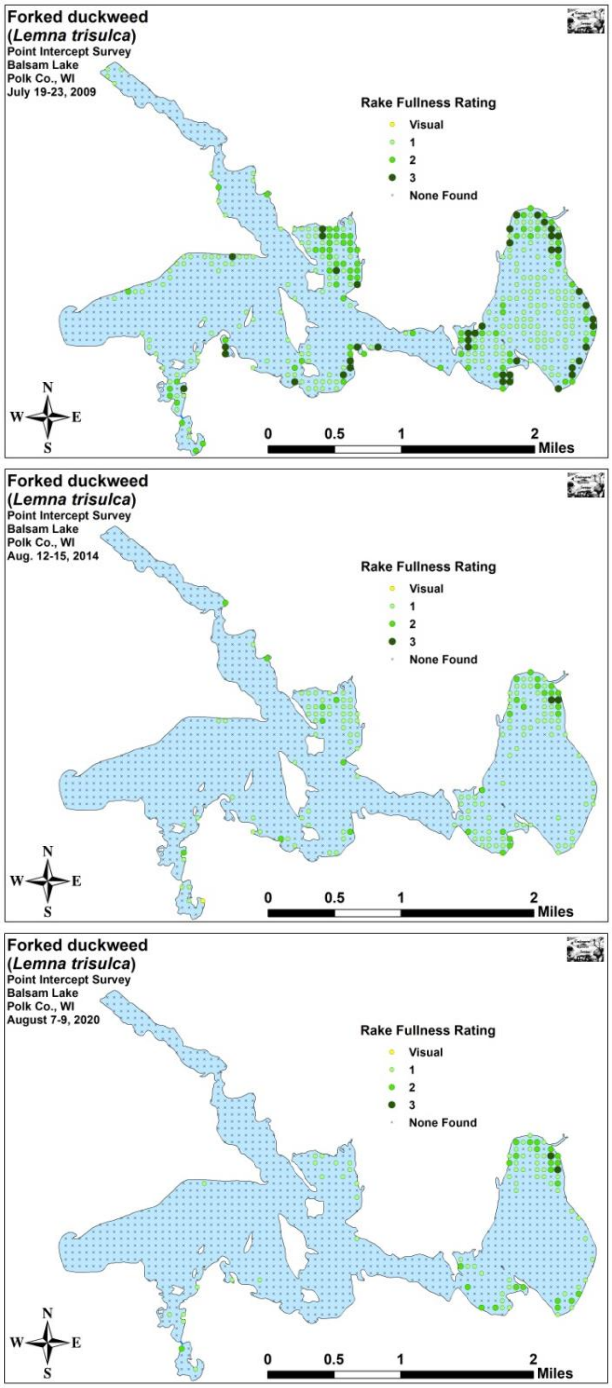


Figure 11: 2009, 2014, and 2020 Forked Duckweed Density and Distribution

Small pondweed suffered a highly significant decline **($p<0.001$)** in distribution and density when it fell from the third most common species in 2009 (288 sites/mean rake 1.90) to the eighth most common in 2014 (57 sites/mean rake 1.33) (Figure 12). By 2020, it was just the eleventh most common species as it experienced further nearly significant declines ($p=0.08$/$p=0.07$) in distribution (38 sites) and density (mean rake 1.23). Prior to being nearly eliminated by herbicide treatments, this species covered the majority of the deep flat in East Balsam where it completely dominated the 10-18ft bathymetric ring and produced a dense 8-10ft tall "forest" of habitat. In 2014 and 2020, this area was nearly devoid of vegetation.

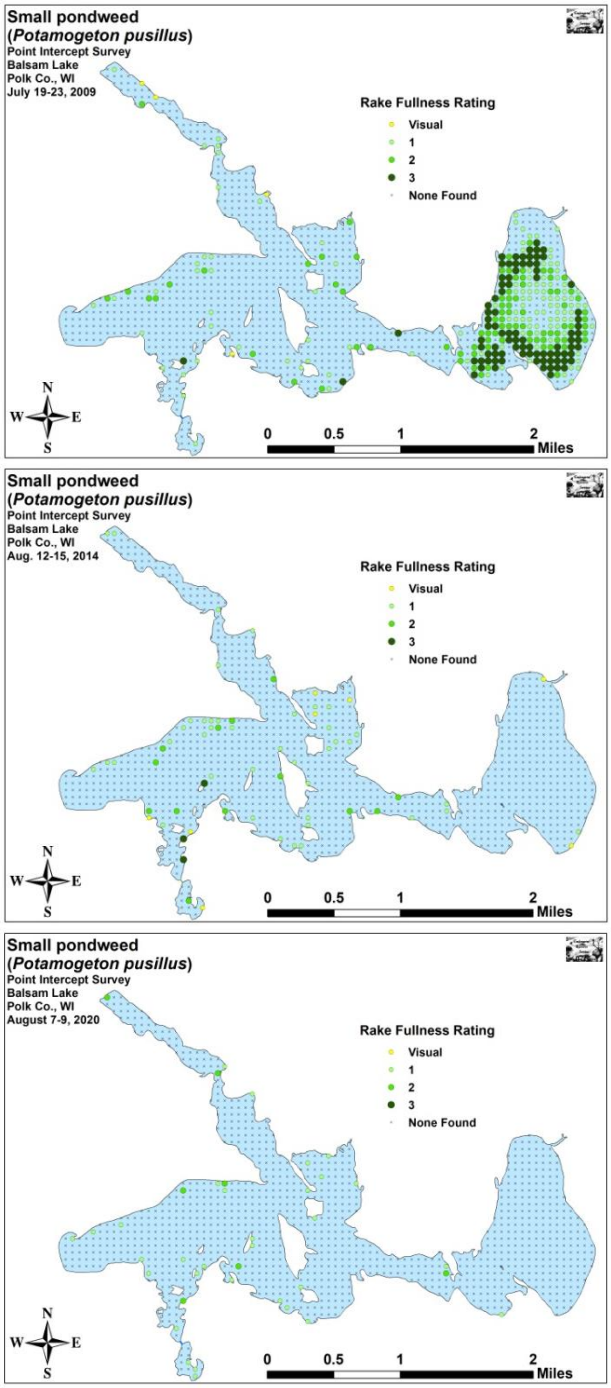


Figure 12: 2009, 2014, and 2020 Small Pondweed Density and Distribution

Flat-stem pondweed was the fourth most common species in 2009 (212 sites) and the third most common in 2014 (153). Neither its increase in density (2009 – mean rake 1.55/2014 – mean rake 1.61) nor its lakewide decline in distribution were significant (p=0.17/p=0.27); however, it was essentially eliminated from East Balsam (Figure 13). In 2020, we documented a further and highly significant decline **(p<0.001)** in distribution (78 sites - sixth most common species). Its decline in density (mean rake 1.46) was also significant **(p=0.04)**.

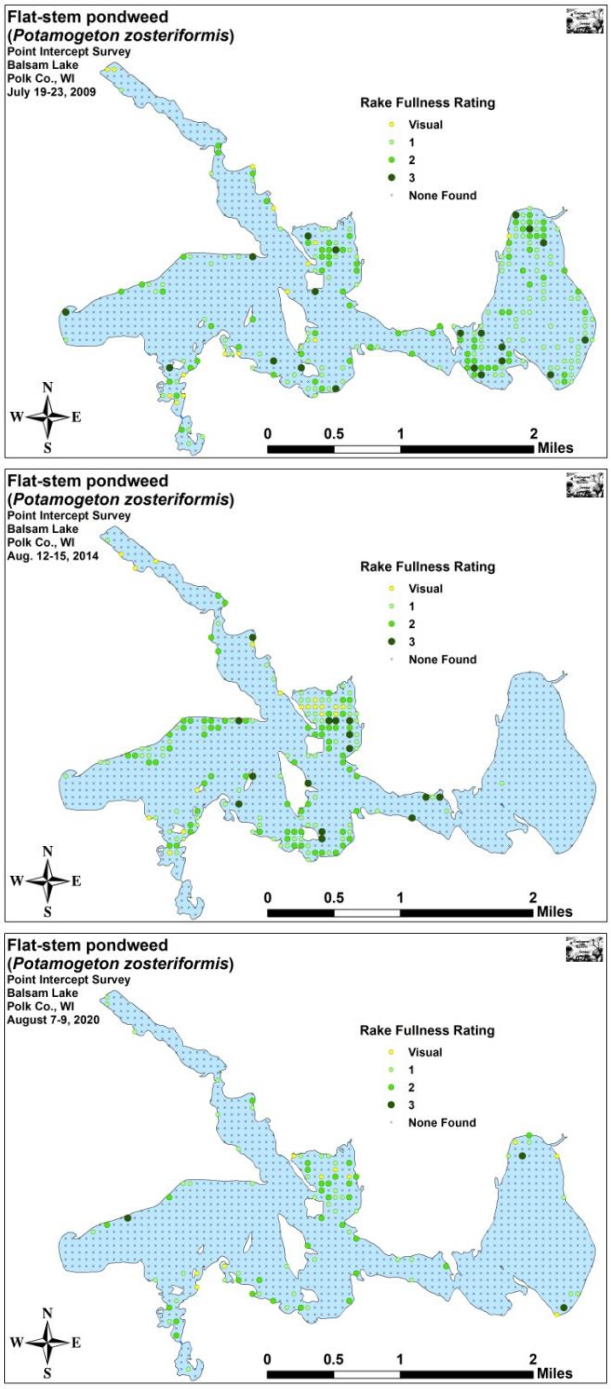


Figure 13: 2009, 2014, and 2020 Flat-stem Pondweed Density and Distribution

Wild celery was the fifth most common species in 2009 (127 sites/mean rake 1.74) (Figure 14). Despite a non-significant decline (p=0.74) in distribution and a significant decline in density **(p=0.02)**, in 2014 we found it had increased its rank to become the fourth most common species (105 sites/mean rake 1.58). This trend continued in 2020 when it underwent a highly significant expansion **(p<0.001)** in distribution and became the second most common species (167 sites). However, its increase in density to a mean rake of 1.66 was not significant (p=0.13).

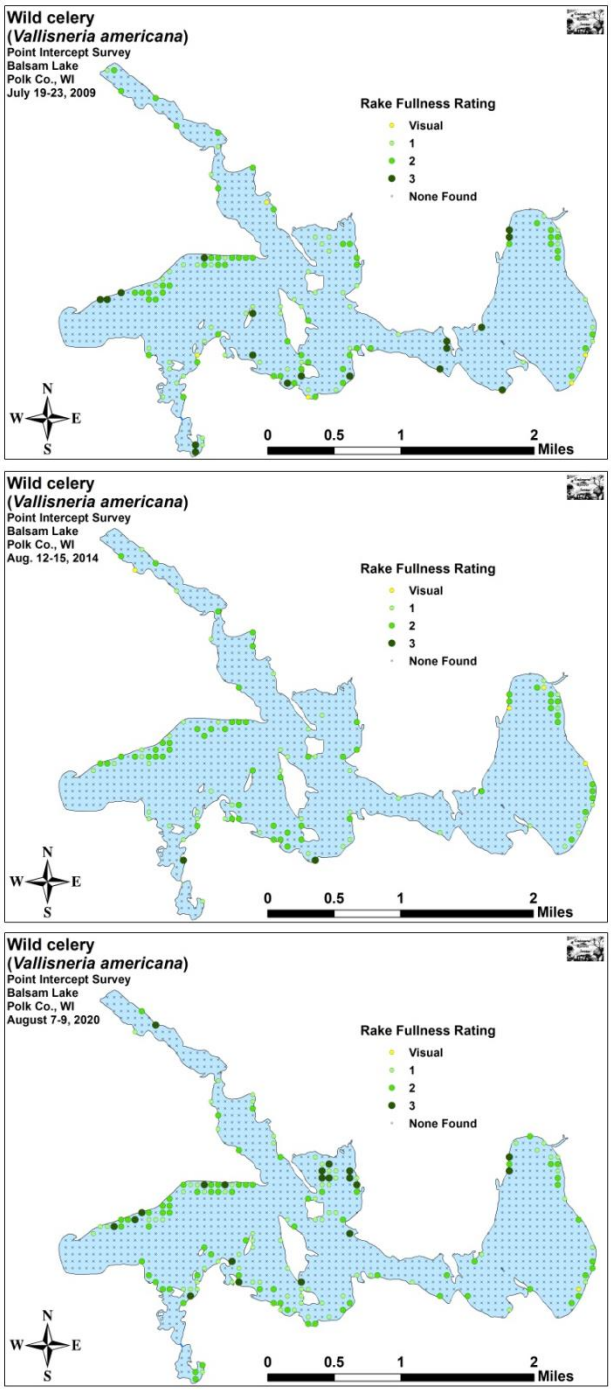


Figure 14: 2009, 2014, and 2020 Wild Celery Density and Distribution

In 2009, Northern water-milfoil was found throughout the lake and often formed dense beds (123 sites/mean rake 1.79) (Figure 15). Despite a moderately significant decline **(p=0.005)** in distribution (66 sites) and a highly significant decline **(p<0.001)** in density, it remained the sixth most common species in 2014. Following a moderately significant increase **(p=0.002)** in distribution and a significant increase **(p=0.03)** in density, in 2020 it become the fourth most common species (94 sites/mean rake 1.56) as it reestablished in East Balsam.

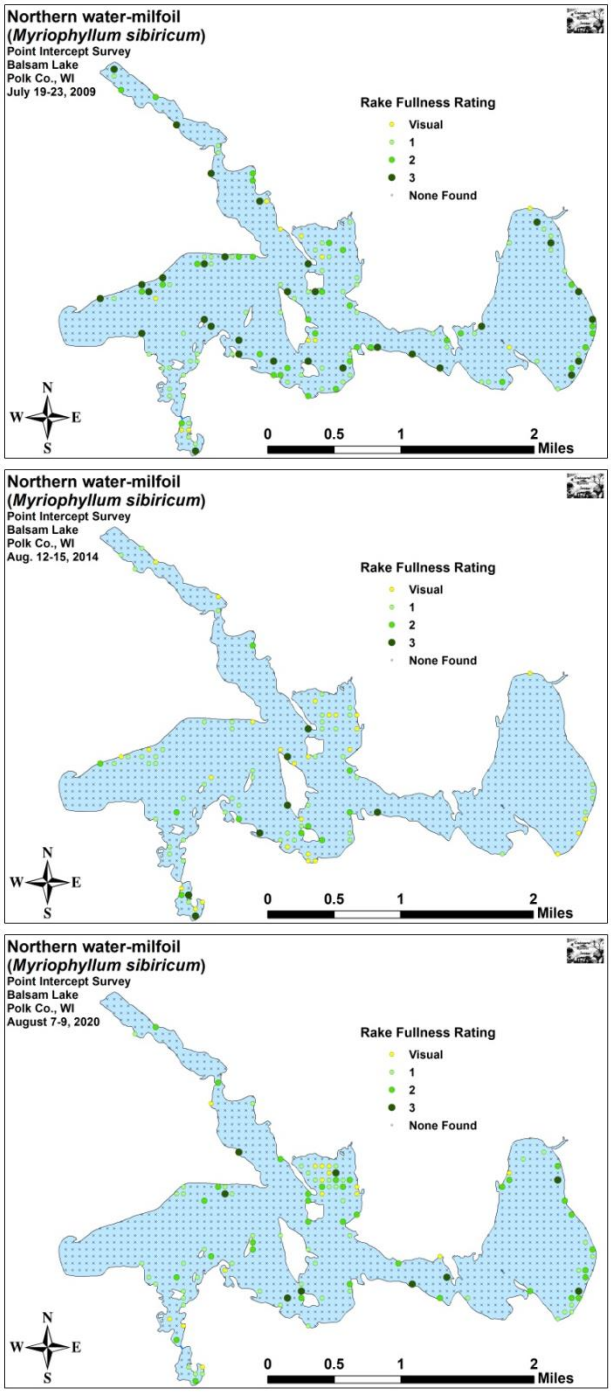


Figure 15: 2009, 2014, and 2020 Northern Water-milfoil Density and Distribution

Comparison of Northern Wild Rice in 2009, 2014, and 2020:

Northern wild rice, a plant of significant wildlife and cultural value, was present in Little Balsam at the Rice Creek Inlet and Stump Bay at the Harder Creek Inlet. Outside of these areas, we didn't find rice anywhere else in the system (Figure 16). In 2009, rice was present at a single point with a rake of 2; in 2014, we found it at three points with a mean rake fullness of 1.33; and, in 2020, it was also located at three points but with a mean of 1.67.

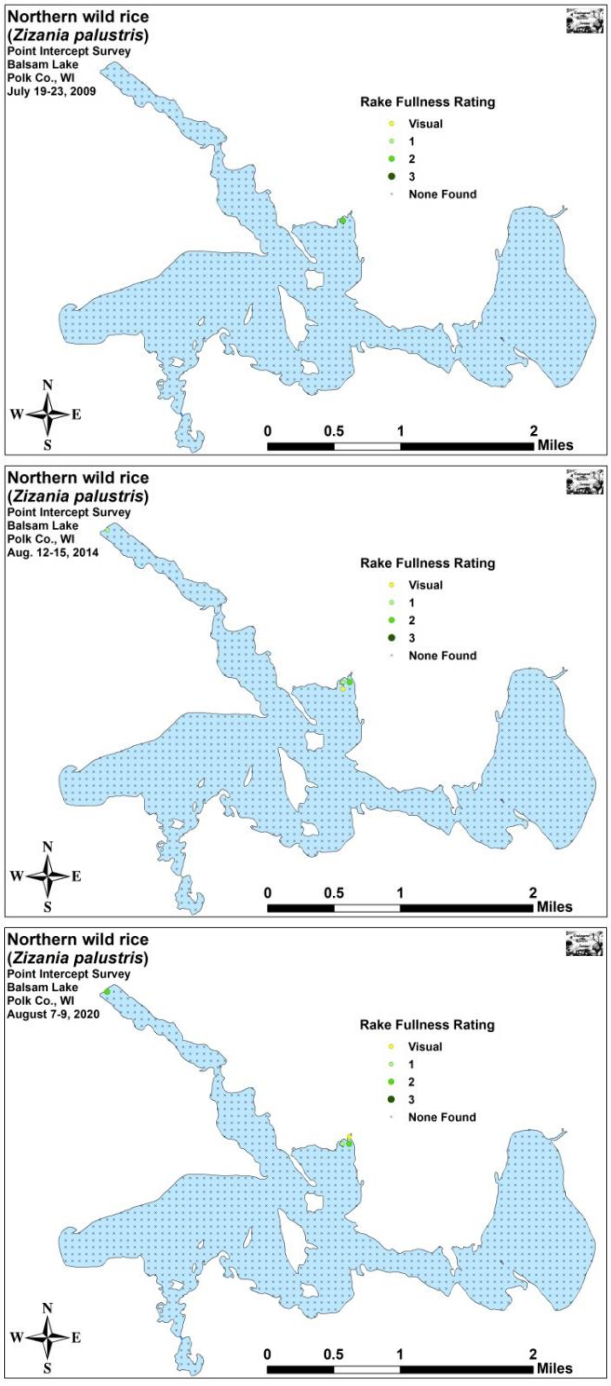


Figure 16: 2009, 2014, and 2020 Northern Wild Rice Density and Distribution

The bed at the Rice Creek Inlet in Little Balsam extended as far upstream as we could see and likely covered several acres. Although the bed had at least a mean rake fullness of 2 and was a solid 3 in many areas, plants were established in shallow water over thick muck which would likely have made navigation difficult to impossible for anyone trying to harvest rice. At the Harder Creek Inlet, the water was also very shallow, and the many stumps and floating muck bogs coupled with a low overall rice density that varied from 1-2 likely meant that human harvest in this area would also be difficult to impossible. Despite these human challenges, we noted large numbers of waterfowl and other wildlife utilizing these important habitat areas during our time on the lake.

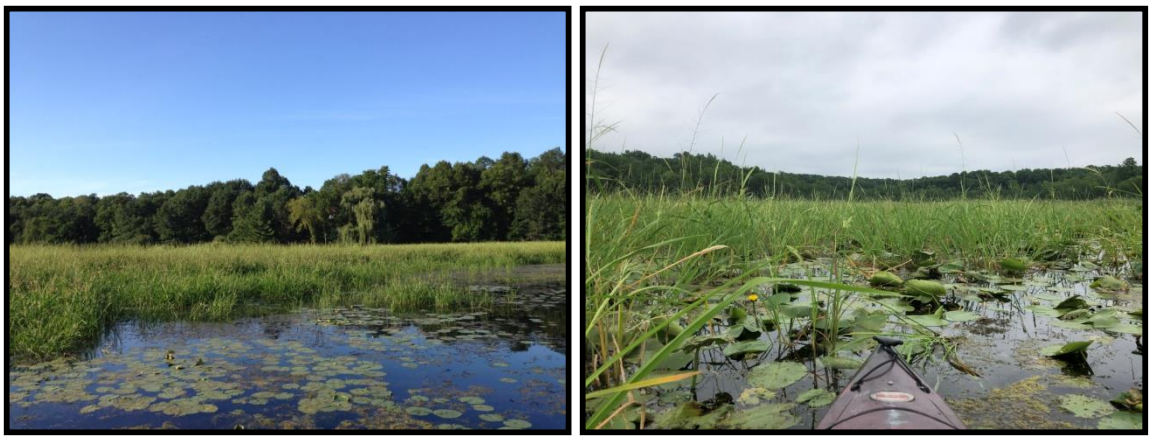


Figure 17: Dense Wild Rice Beds at the Rice Creek Inlet and Patchy Rice at the Harder Creek Inlet

Comparison of Filamentous Algae in 2009, 2014, and 2020:

Filamentous algae are normally associated with excessive nutrients in the water column. In 2009, we found these algae at 184 points with a mean rake of 1.59 (Figure 18). The 2014 survey documented a non-significant decline (p=0.86) in distribution (145 sites), and a non-significant increase (p=0.40) in mean rake fullness (1.45). The 2020 survey documented a further and moderately significant decline **(p=0.003)** in distribution (97 sites) and a significant decline **(p=0.04)** in density (mean rake 1.47). Interestingly, many of the highest density shoreline areas documented in 2009 had little to no algae in 2020.

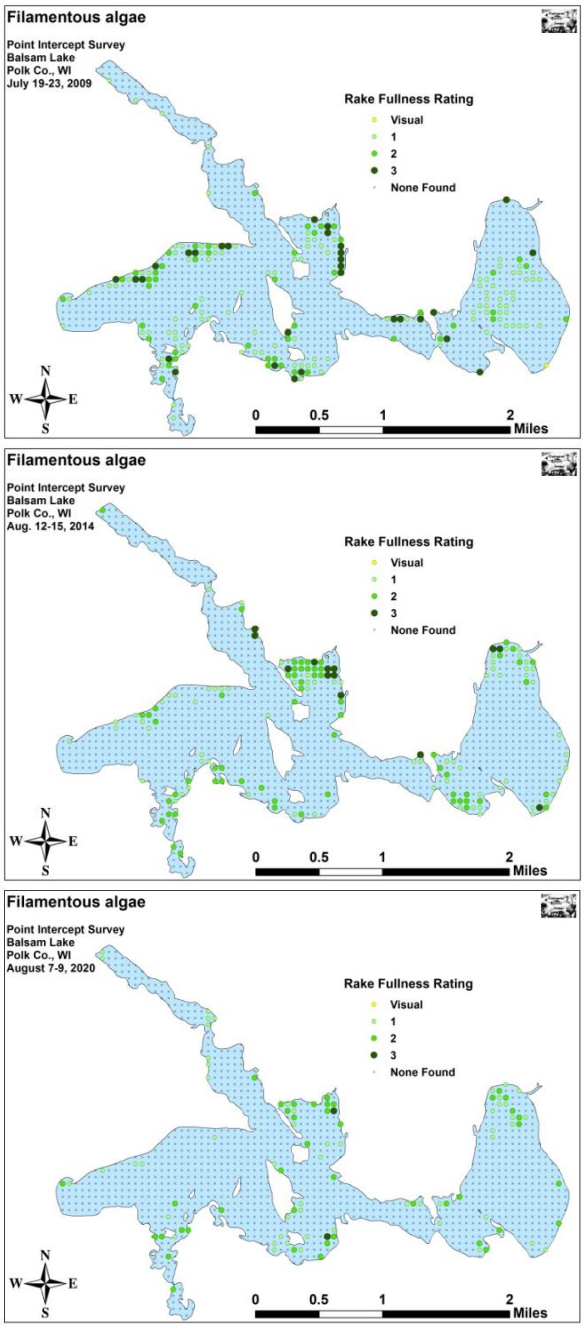


Figure 18: 2009, 2014, and 2020 Filamentous Algae Density and Distribution

Comparison of Floristic Quality Indexes in 2009, 2014, and 2020:

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** in the rake during the point- intercept survey (Table 6). They produced a mean Coefficient of Conservatism of 6.3 and a Floristic Quality Index of 38.1. Both of these were fractionally higher than in 2009.

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
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**

During the 2020 survey, we identified a total of 39 **native index plants** in the rake during the point- intercept survey. Compared to 2014, they again produced a mean Coefficient of Conservatism of 6.3 and a slightly higher Floristic Quality Index of 39.4 (Table 7). 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). Thirteen 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), Crested arrowhead (C = 9), Sessile-fruited arrowhead (C = 8), Creeping bladderwort (C = 9), and Northern wild rice (C = 8).

Table 7: Floristic Quality Index of Aquatic Macrophytes
Balsam Lake, Polk County
August 7-9, 2020

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
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 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
Sagittaria cristata	Crested arrowhead	9
Sagittaria rigida	Sessile-fruited arrowhead	8

Table 7 (continued): Floristic Quality Index of Aquatic Macrophytes
Balsam Lake, Polk County
August 7-9, 2020

Species	Common Name	C
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		**39**
Mean C		**6.3**
FQI		**39.4**

Exotic Plant Species:

In addition to Curly-leaf pondweed, during the boat survey we found four other exotic species growing in and immediate adjacent to the lake: Reed canary grass, Purple loosestrife, Common forget-me-not, and Hybrid cattail. Two of these – Common forget-me-not and Hybrid cattail – had not been documented previously.

Reed canary grass was often a dominant plant at and just beyond the lakeshore (Figure 19). 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 19: Reed Canary Grass Near the Village Beach

Purple loosestrife continues to be scattered and local along muck-bottomed shorelines in the bays south of First Island, in Idlewild Bay, near the village beach (Figure 20), and in Raskin Bay. 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 along the shoreline directly down the hill from (north of) the Minit Mart station. At this time, we contacted the Polk County Land and Water Resources Deptartment (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 21). 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). Since that time, beetles have continued to spread and are now found to a greater or lesser extent on most plants in the area.

Figure 20: Purple Loosestrife at the Village Beach Docks

Figure 21: Loosestrife Near the Village Beach with Heavy Beetle Damage

Common forget-me-not was also found at a few scattered locations in the bays south of First Island and near the village beach. A habitat specialist that prefers disturbed areas in and around cool and cold-water springs, this species likely has limited habitat to spread into; especially if residents maintain native shoreline vegetation.

Native to southern but not northern Wisconsin, Narrow-leaved cattail (*Typha angustifolia*) and its hybrids with Broad-leaved cattail are becoming increasingly common in northern Wisconsin where they also tend to be invasive. We found a single but well-established stand along the immediate shoreline southwest of Paradise and Big Islands near survey point 503 (Figure 22 and documenting photo on page 13).

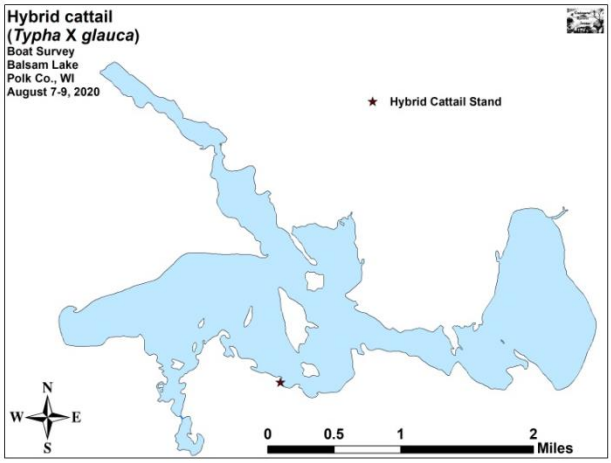


Figure 22: 2020 Hybrid Cattail Distribution

Besides having narrower leaves, the exotics can be told from our native cattails by having a relatively narrower and longer "hotdog-shaped" tan colored female cattail flower whereas our native species tends to produce a fatter and shorter "bratwurst-shaped" dark chocolate colored female flower. Narrow-leaved cattail and its hybrids also have a male flower that is separated from the female flower by a thin green stem, while the native Broad-leaved cattail has its male and female flowers connected (Figure 23) (For more information on a sampling of aquatic exotic invasive plant species, see Appendix VII).

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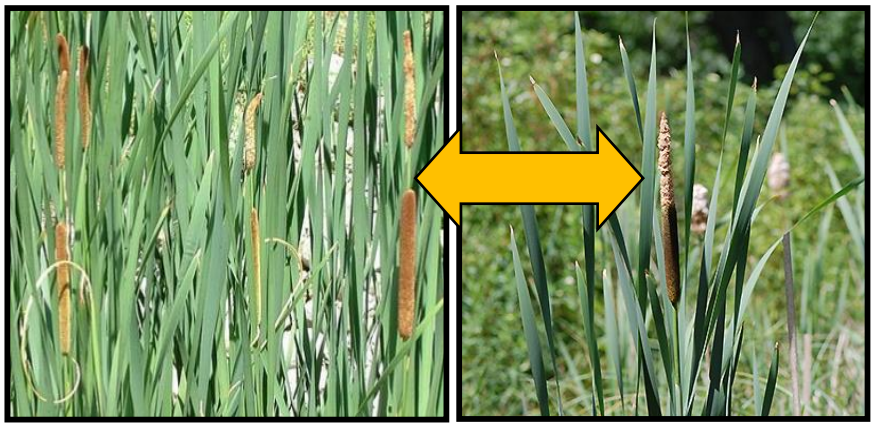


Figure 23: Exotic Narrow-leaved Cattail vs. Native Broad-leaved Cattail

Comparison of East Balsam in 2009, 2014, and 2020:

Visual analysis of both individual species maps and community data suggested the majority of changes observed from 2009 to 2020 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 8).

After finding plants growing at 301 of 309 survey points (97.4% coverage) in 2009 (all of East Balsam fell within the 19ft littoral zone), in 2014 we documented plants at just 102 points. This extrapolated to 33.3% coverage and 47.7% of the then 15.5ft littoral zone. This zone contracted further to 14.5ft in 2020, but the number of points with vegetation was almost unchanged at 100 (32.4% total coverage/55.6% littoral coverage). Similarly, the mean and median depths of plant growth both showed significant declines from 2009 to 2014 with the mean dropping 3.5ft from 12.5ft to 8.0ft and the median dropping 6.5ft from 14.0ft to 7.5ft. The 2020 values were relatively similar to 2014 with a mean of 7.8ft and a median of 8.0ft.

From 2009 to 2014, the average number of native species at sites with native species experienced a significant decline **(p=0.03)** from 2.64 species/site to 2.28 species/site. In 2020, we documented a significant rebound **(p=0.01)** to 2.87 native species/site. Similarly, mean rake fullness showed a highly significant decline **(p<0.001)** from a moderately high 2.31 in 2009 to a low moderate 1.59 in 2014. 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. Although these deep water areas were little changed in 2020, the recovery of vegetation in nearshore areas produced a highly significant increase **(p<0.001)** in mean rake fullness to a moderate 1.99.

In 2009, Small pondweed, Forked duckweed, Coontail, and Flat-stem pondweed were the most common species (Table 9). Present at 76.74%, 56.48%, 43.52%, and 35.88% of survey points with vegetation respectively, they accounted for a very high 73.48% of the total relative frequency. In 2014, we found Forked duckweed, Coontail, Wild celery, and Curly-leaf pondweed were most common species (Table 10). They were present at 88.24%, 27.45%, 23.53%, and 21.57% of sites with vegetation 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 declined.

From 2009 to 2014, 11 macrophytes and filamentous algae showed significant distribution changes in East Balsam (Figure 24). Small pondweed, Coontail, Flat-stem pondweed, Curly-leaf pondweed, Fern pondweed, and White-stem pondweed all suffered highly significant declines with all but Coontail and CLP being effectively eliminated from the area. Forked duckweed and Northern water-milfoil also experienced moderately significant declines. Conversely, Nitella showed a moderately significant increase; and filamentous algae, Slender naiad, and Water star grass demonstrated significant increases. These results suggested that species that over winter vegetatively (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, CLP, 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.

Our 2020 survey identified Coontail and Forked duckweed as the most common species with Wild celery and Northern water-milfoil as the third and fourth most common. Present at 66.00%, 66.00%, 28.00%, and 23.00% of sites with vegetation, they encompassed 60.60% of the total relative frequency. Our results also demonstrated increases in the Simpson's Diversity Index, Total N, Mean C, FQI, and Species Richness values suggesting a general, albeit incomplete, recovery of the plant community.

Nine species saw significant changes in distribution from 2014 to 2020 (Figure 25). Coontail and Northern-water milfoil underwent highly significant recoveries; Clasping-leaf pondweed and Flat-stem pondweed saw moderately significant increases; and Illinois pondweed, White-stem pondweed, and Common watermeal had significant increases. Only Nitella and Slender naiad, two species that increases sharply in 2014, had moderately significant and significant declines respectively.

Taken as a whole, these significant changes suggested a recovery by many species that are sensitive to Endothall treatments, but reproduce by seeds (broad-leaved pondweeds) or vegetatively (Coontail). However, most Endothall-sensitive species that primarily reproduce by turions (Small pondweed/Fern pondweed/Flat-stem pondweed), continued to be rare or absent.

Table 8: Aquatic Macrophyte P/I Survey Summary Statistics
East Balsam Lake, Polk County
July 21-22, 2009, August 15, 2014, and August 7, 2020

Summary Statistics:	2009	2014	2020
Total number of sites visited	309	309	309
Total number of sites with vegetation	301	102	100
Total number of sites shallower than the maximum depth of plants	309	214	180
Frequency of occurrence at sites shallower than maximum depth of plants	97.4	47.7	55.6
Simpson Diversity Index	0.84	0.83	0.88
Number of Floristic Quality Index Species (N)	28	22	26
Mean Coefficient of Conservatism (C)	6.0	5.8	6.0
Floristic Quality Index (FQI)	31.7	27.1	30.8
Maximum depth of plants (ft)	19.0	15.5	14.5
Mean depth of plants (ft)	12.5	8.0	7.8
Median depth of plants (ft)	14.0	7.5	8.0
Number of sites sampled using rake on Rope (R)	94	122	0
Number of sites sampled using rake on Pole (P)	215	187	258
Average number of all species per site (shallower than max depth)	2.82	1.18	1.68
Average number of all species per site (veg. sites only)	2.89	2.47	3.02
Average number of native species per site (shallower than max depth)	2.57	1.07	1.59
Average number of native species per site (sites with native vegetation only)	2.64	2.28	2.87
Species richness	29	23	27
Species richness (including visuals)	29	23	27
Mean rake fullness (vegetative sites only)	2.31	1.59	1.99

Table 9: 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 relative frequency analysis

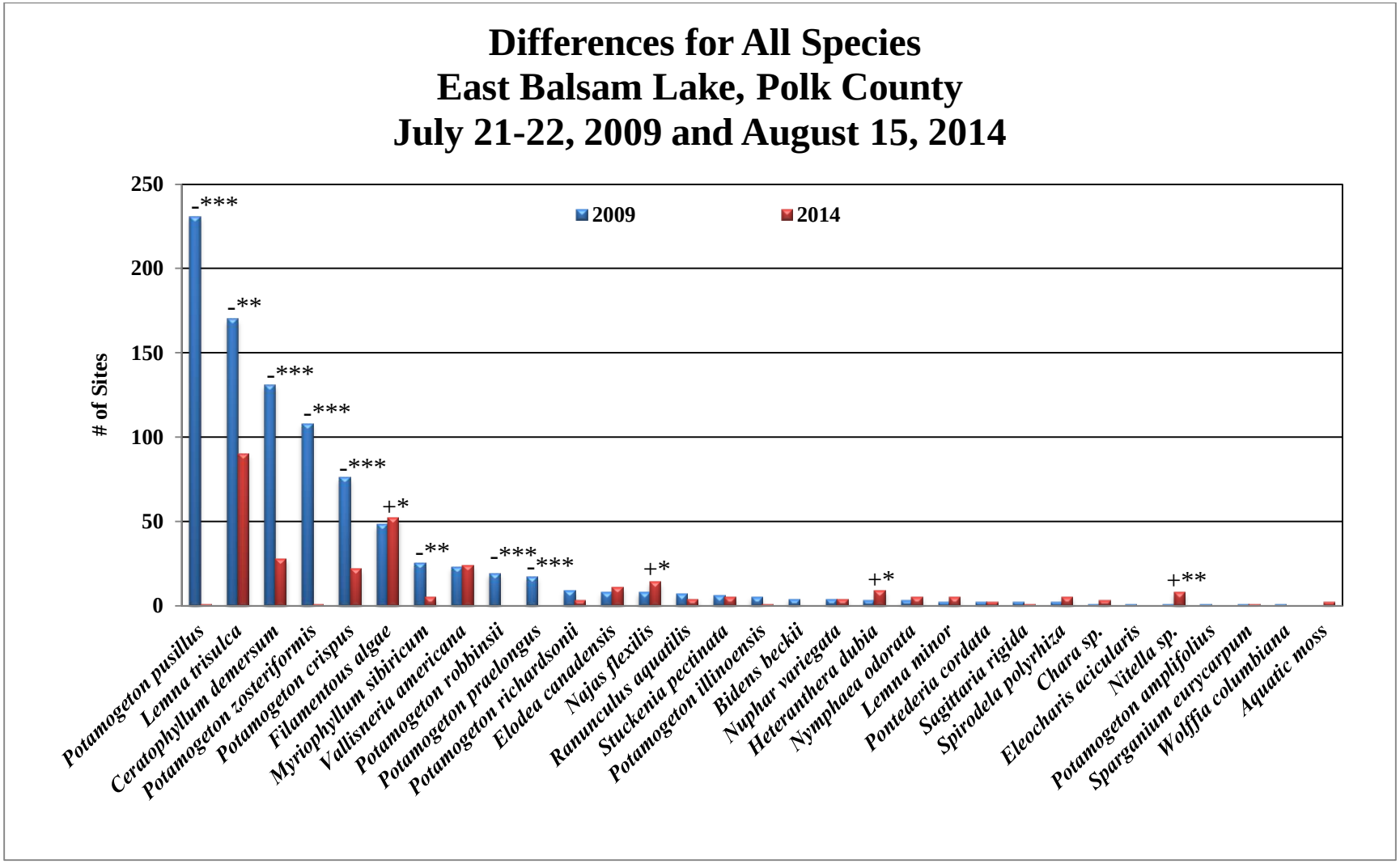
Table 9 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
East Balsam Lake, Polk County
July 21-22, 2009

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
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 10: 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 relative frequency analysis



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

Figure 24: Macrophyte Changes from 2009-2014 – East Balsam

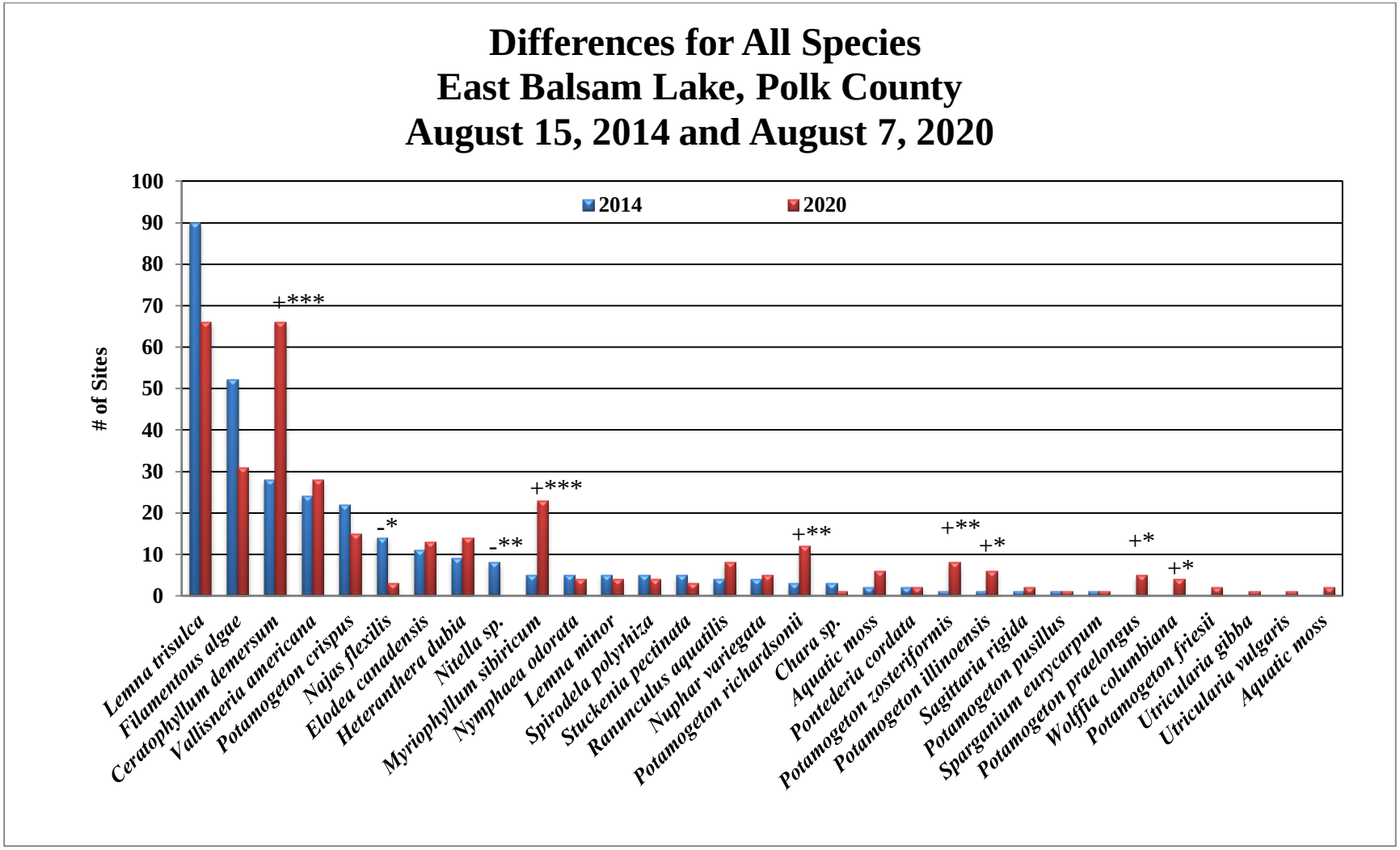
Table 11: Frequencies and Mean Rake Sample of Aquatic Macrophytes
East Balsam Lake, Polk County
August 7, 2020

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Ceratophyllum demersum	Coontail	66	21.85	66.00	36.67	1.53	0
Lemna trisulca	Forked duckweed	66	21.85	66.00	36.67	1.39	0
	Filamentous algae	31	*	31.00	17.22	1.42	0
Vallisneria americana	Wild celery	28	9.27	28.00	15.56	1.68	1
Myriophyllum sibiricum	Northern water-milfoil	23	7.62	23.00	12.78	1.65	1
Potamogeton crispus	Curly-leaf pondweed	15	4.97	15.00	8.33	1.07	0
Heteranthera dubia	Water star-grass	14	4.64	14.00	7.78	1.36	1
Elodea canadensis	Common waterweed	13	4.30	13.00	7.22	1.38	0
Potamogeton richardsonii	Clasping-leaf pondweed	12	3.97	12.00	6.67	1.42	0
Potamogeton zosteriformis	Flat-stem pondweed	8	2.65	8.00	4.44	1.63	3
Ranunculus aquatilis	White water crowfoot	8	2.65	8.00	4.44	1.25	1
Potamogeton illinoensis	Illinois pondweed	6	1.99	6.00	3.33	1.50	0
	Aquatic moss	6	*	6.00	3.33	1.33	0
Nuphar variegata	Spatterdock	5	1.66	5.00	2.78	1.80	0
Potamogeton praelongus	White-stem pondweed	5	1.66	5.00	2.78	1.00	0
Lemna minor	Small duckweed	4	1.32	4.00	2.22	1.00	0
Nymphaea odorata	White water lily	4	1.32	4.00	2.22	2.50	0
Spirodela polyrhiza	Large duckweed	4	1.32	4.00	2.22	1.25	0
Wolffia columbiana	Common watermeal	4	1.32	4.00	2.22	1.25	0
Najas flexilis	Slender naiad	3	0.99	3.00	1.67	1.33	0
Stuckenia pectinata	Sago pondweed	3	0.99	3.00	1.67	1.67	0
Pontederia cordata	Pickerelweed	2	0.66	2.00	1.11	2.00	0
Potamogeton friesii	Fries' pondweed	2	0.66	2.00	1.11	1.00	0
Sagittaria rigida	Sessile-fruited arrowhead	2	0.66	2.00	1.11	1.00	0

* Excluded from relative frequency analysis

Table 11 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
East Balsam Lake, Polk County
August 7, 2020

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Chara sp.	Muskgrass	1	0.33	1.00	0.56	1.00	0
Potamogeton pusillus	Small pondweed	1	0.33	1.00	0.56	1.00	0
Sparganium eurycarpum	Common bur-reed	1	0.33	1.00	0.56	2.00	0
Utricularia gibba	Creeping bladderwort	1	0.33	1.00	0.56	1.00	0
Utricularia vulgaris	Common bladderwort	1	0.33	1.00	0.56	1.00	0



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

Figure 25: Macrophyte Changes from 2014-2020 – East Balsam

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Native Aquatic Macrophytes:

Aquatic plants are the basis of a lake's ecosystem and are as important to the lake 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 deep-water habitat-producing plants has 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 since 2009 has produced mixed outcomes. Large-scale herbicide treatments initially resulted in declines in both CLP acreage and density. Unfortunately, they also significantly reduced many native species populations; especially in East Balsam. Since that time, the recovery of both CLP and natives has been patchy, and the initiation of a harvesting program coupled with extreme weather events (several years of record or near record early and late ice-out) since the last APMP in 2015 will likely make it difficult to assess which of these control methods is providing the most favorable results. Whether to continue herbicide applications, harvesting, or some combination of both will be clarified during the 2021 update of the APMP. Regardless of what course of action is decided upon, all lake residents are reminded that CLP thrives on disturbance, and, because of this, 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 establish and spread.

Purple Loosestrife:

Purple loosestrife has remained largely confined to near the village beach and in Idlewild Bay with only a few plants appearing on the shoreline east of First and Pine Islands and in Raskin Bay. Although the population of Galerucella beetles has fluctuated over the years, most plants continue to show at least some beetle herbivory. Because of this and because we continue to remove plants when possible during our landing checks, we don't believe an additional beetle release is warranted at this time. However, 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 annual notes in the summer 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 is 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.

Exotic Cattails:

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

Aquatic Invasive Species Prevention:

The lake's active Clean Boats/Clean Water Program appears to be a model as there were diligent workers on duty every time we launched on the lake. In addition to the education and reeducation they offer to residents and visitors alike, the physical checking of incoming/outgoing watercraft for Aquatic Invasive Species provides an important safeguard for the lake. Because of this, we strongly encourage the BLPRD to continue their established Clean Boats/Clean Waters program.

Eurasian Water Milfoil:

Eurasian water-milfoil has now expanded into seven lakes in Polk County all of which have public landings and in/out boat traffic. Because of this, in addition to the CB/CW program, continuing regular transect surveys near the lake's boat landings throughout the growing season is also encouraged. CB/CW monitors decrease the likelihood EWM will be introduced into the lake, and regular landing monitoring could allow for early detection if EWM or another AIS is introduced. The sooner an AIS is detected, the greater the chances it can be successfully and economically controlled.

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Appendix I: 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																									
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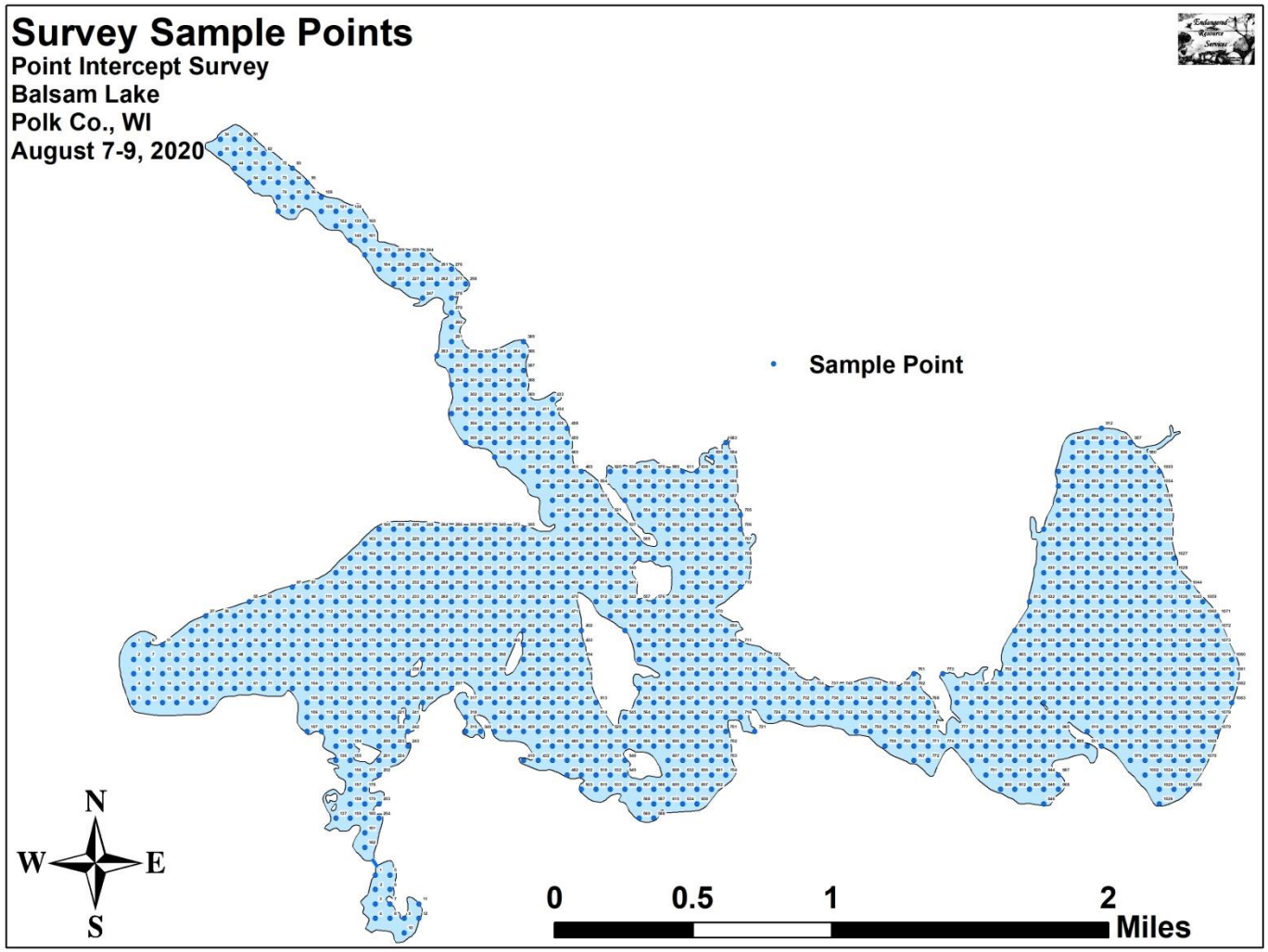
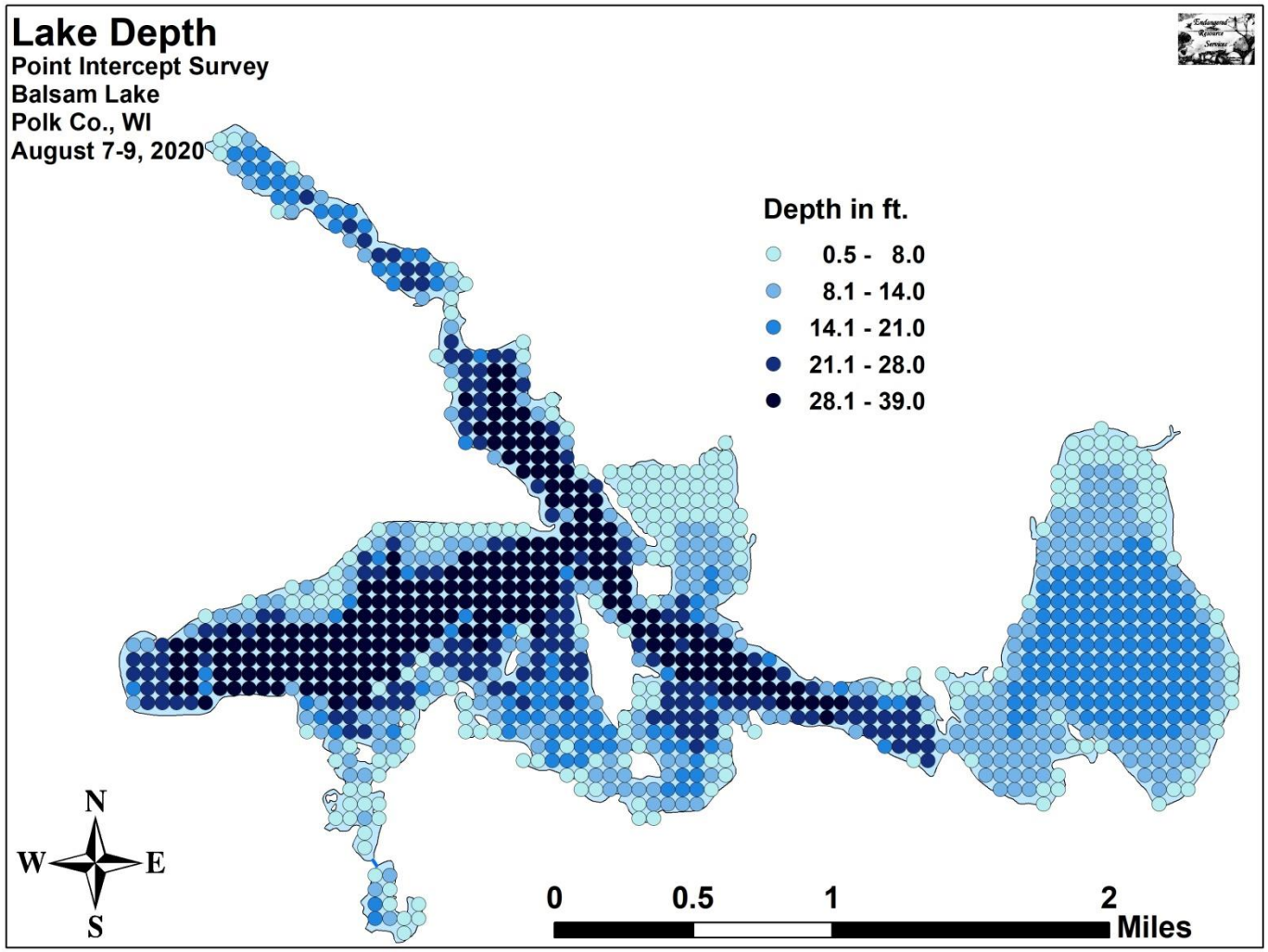
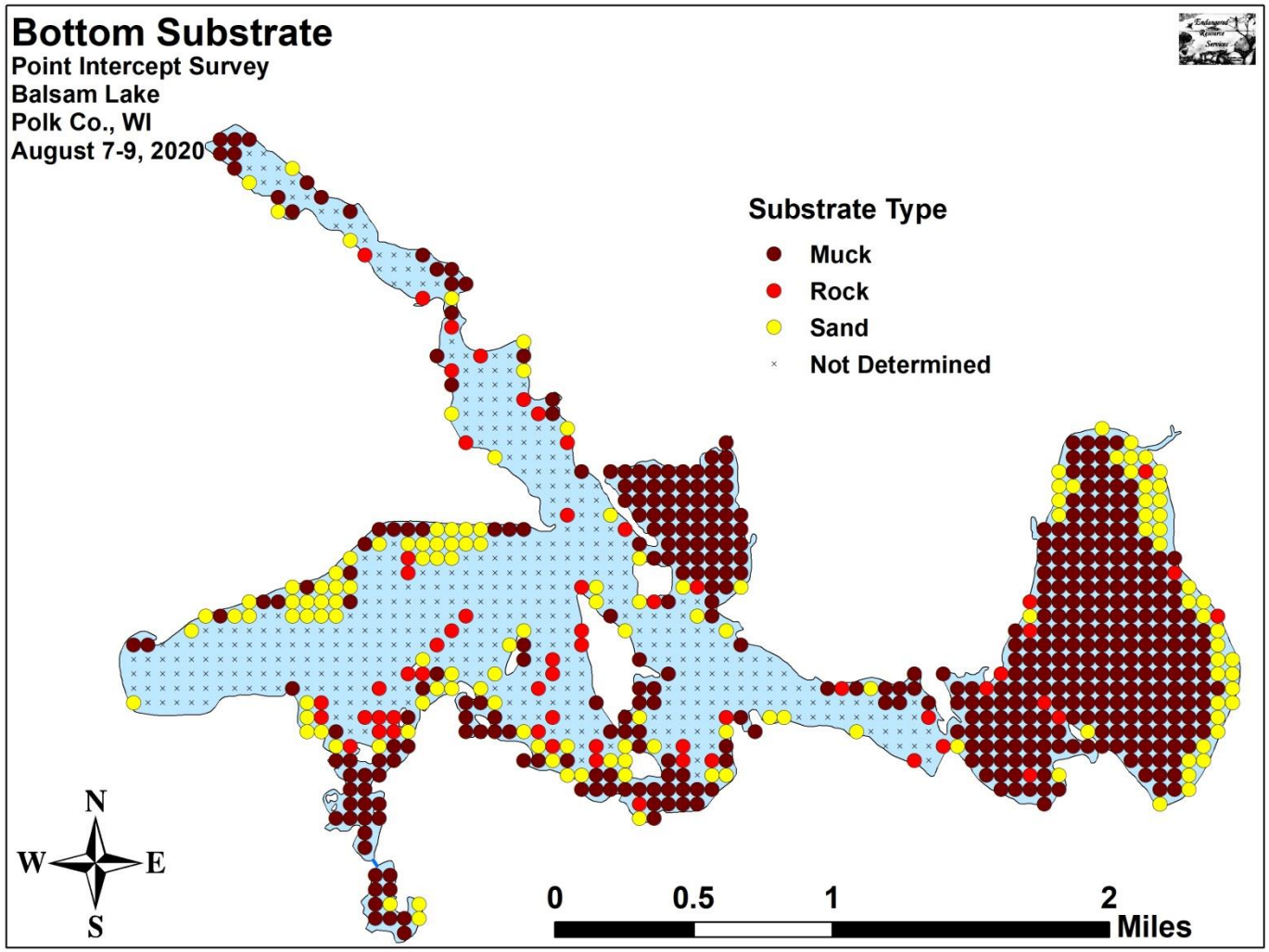
17																									
18																									
19																									
20																									

Appendix II: Survey Sample Points Map

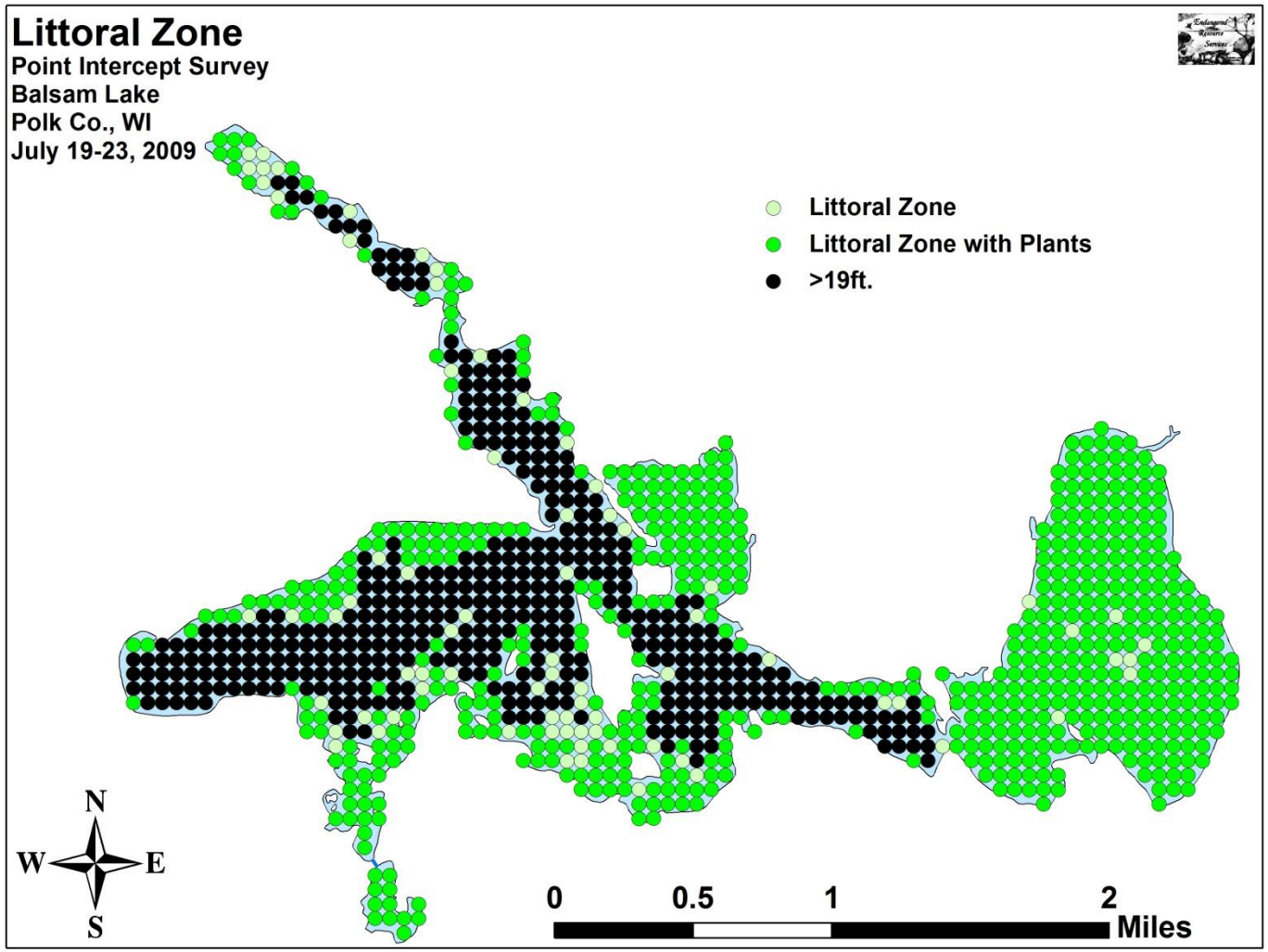

Survey Sample Points
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Sample Point
N
W
E
S
0
0.5
1
2
Miles

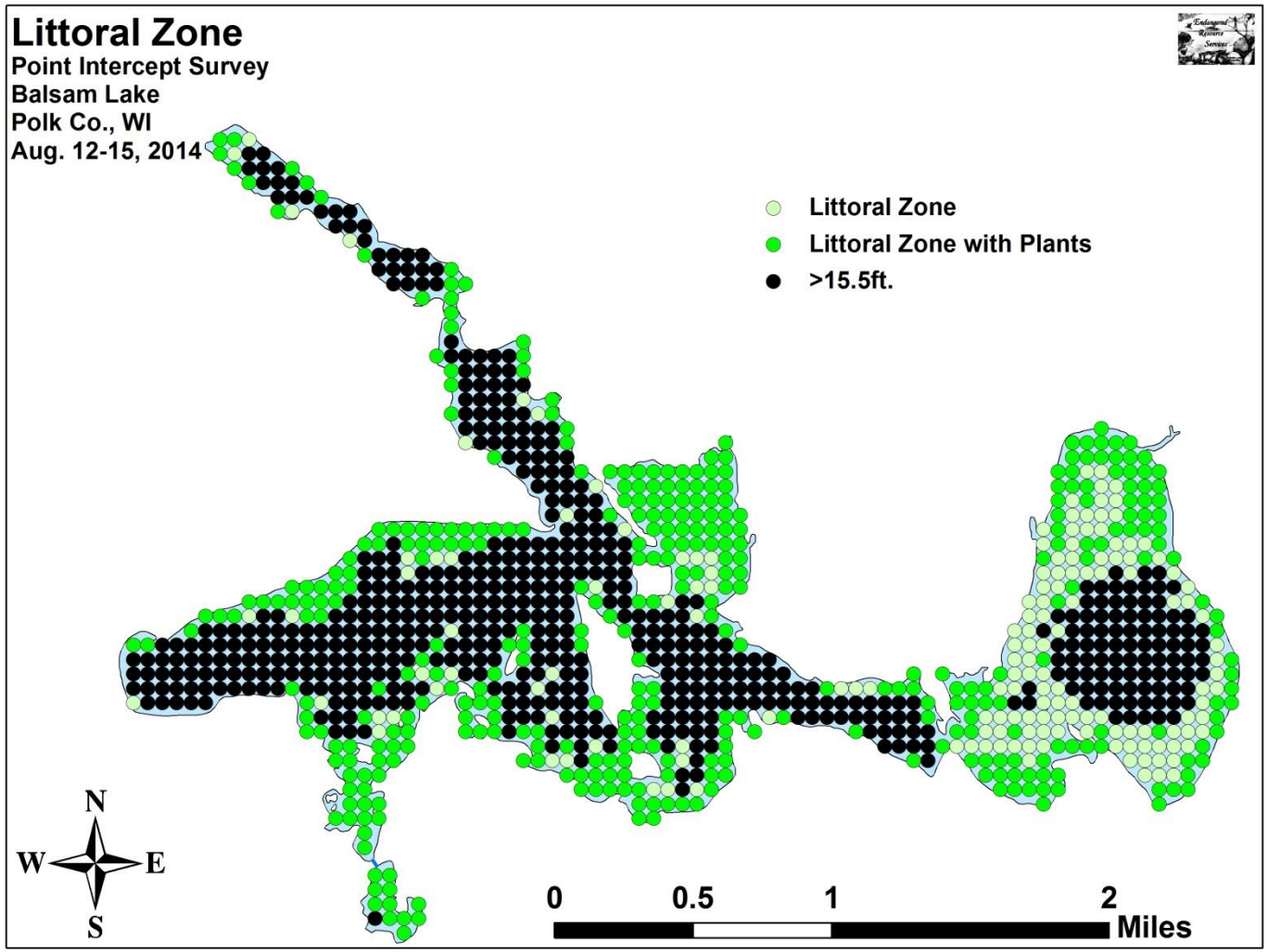
Appendix III: Habitat Variable Maps

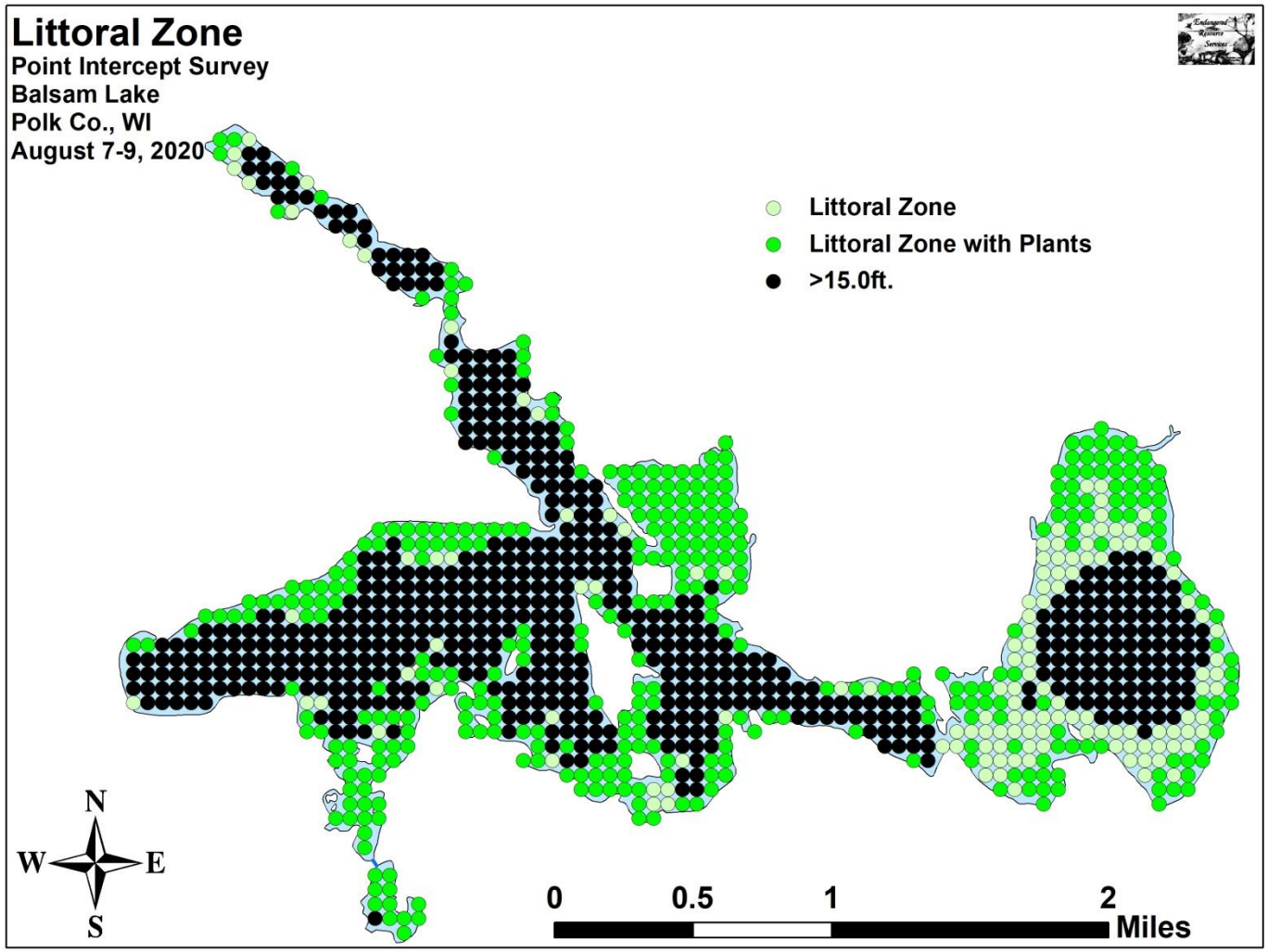

Lake Depth
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Depth in ft.
0.5 - 8.0
8.1 - 14.0
14.1 - 21.0
21.1 - 28.0
28.1 - 39.0
N
W
E
S
0
0.5
1
2
Miles

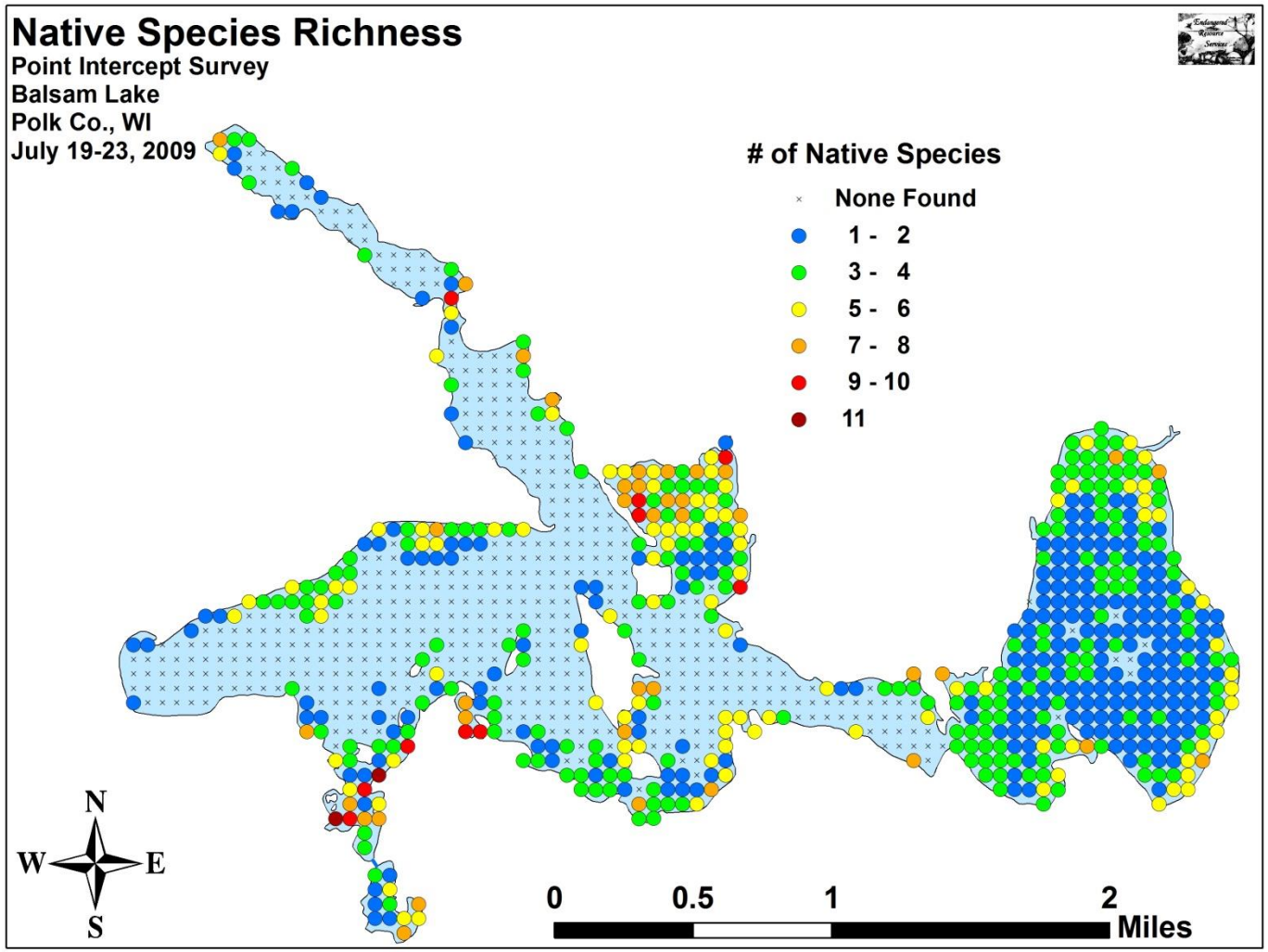

Bottom Substrate
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Substrate Type
Muck
Rock
Sand
Not Determined
N
W
E
S
0
0.5
1
2
Miles

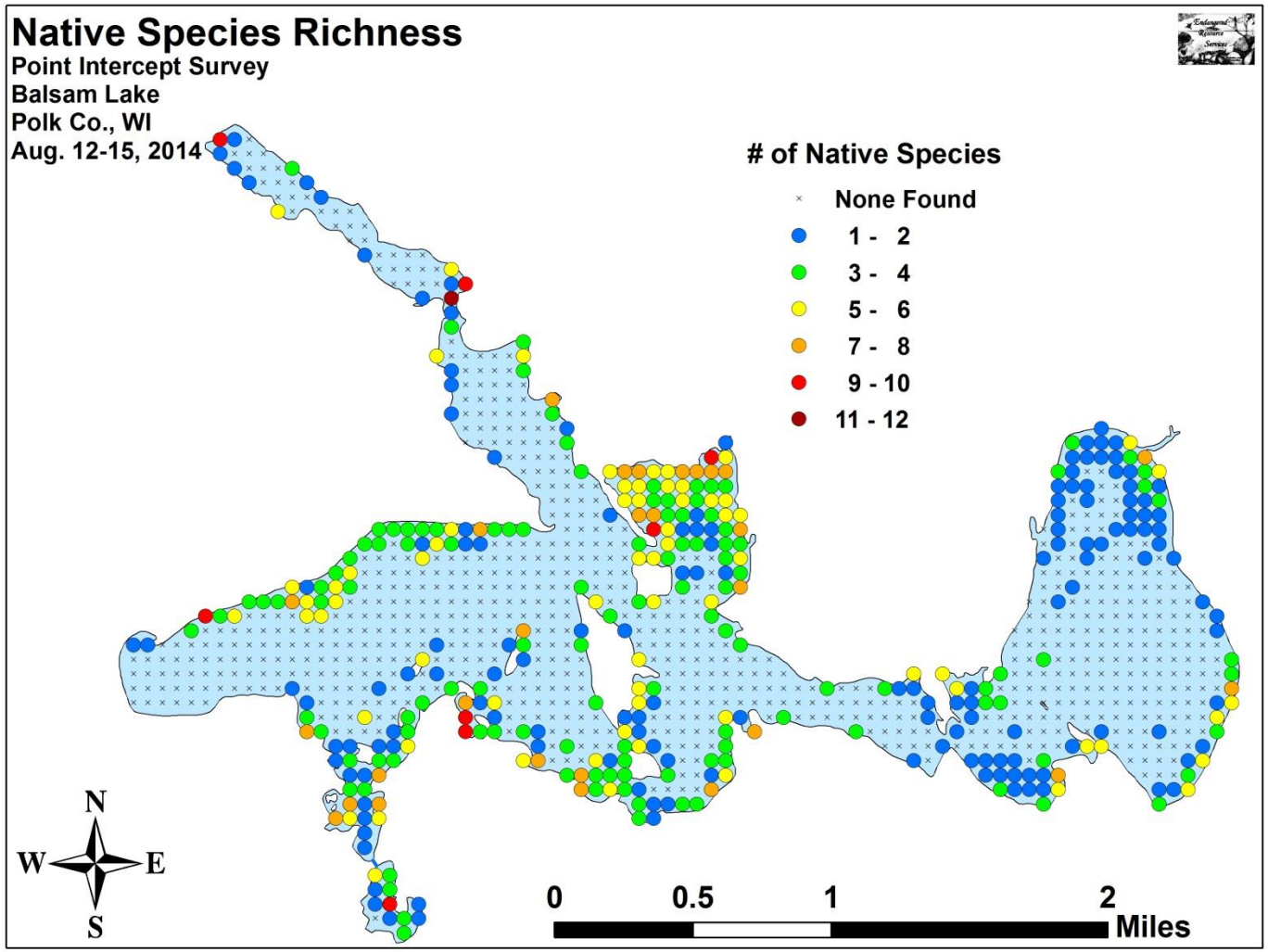
Appendix IV: 2009, 2014, and 2020 Littoral Zone, Native Species Richness and Total Rake Fullness Maps

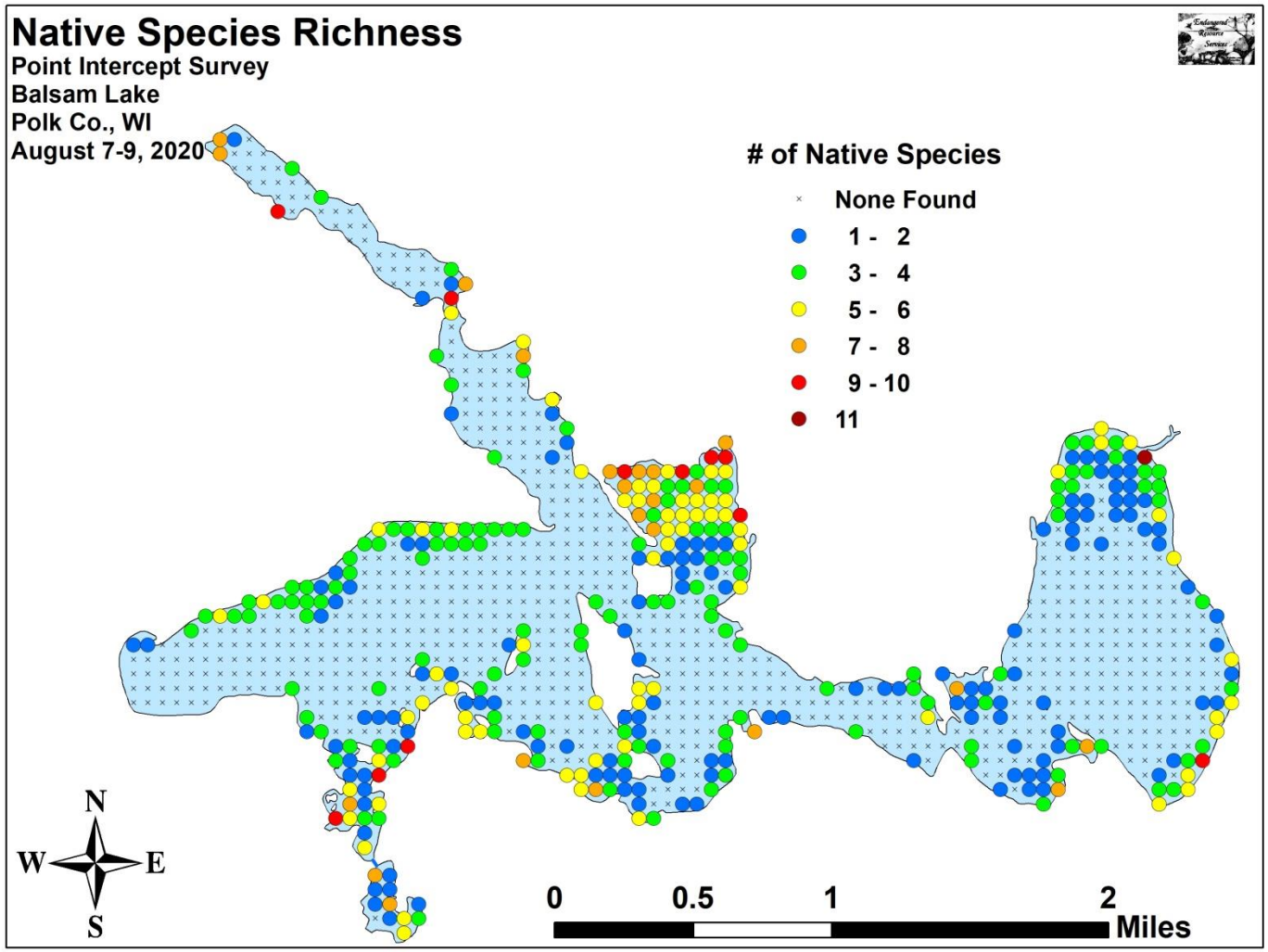

Littoral Zone
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Littoral Zone
Littoral Zone with Plants
>19ft.
N
W
E
S
0
0.5
1
2
Miles

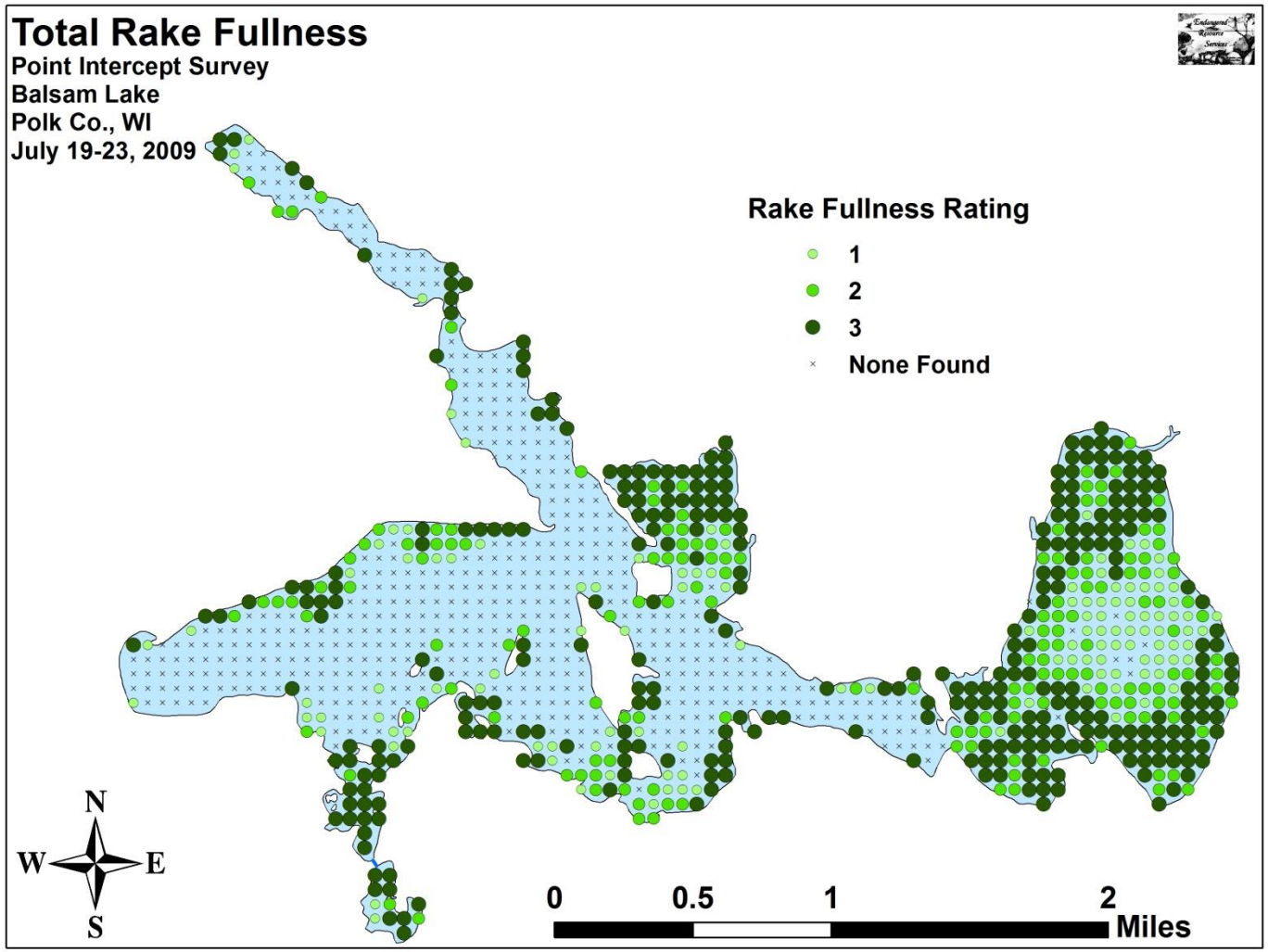

Littoral Zone
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Littoral Zone
Littoral Zone with Plants
>15.5ft.
N
W
E
S
0
0.5
1
2
Miles


Littoral Zone
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Littoral Zone
Littoral Zone with Plants
>15.0ft.
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


Native Species Richness
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
# 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


Total Rake Fullness
Point Intercept Survey
Balsam Lake
Polk Co., WI
July 19-23, 2009
Rake Fullness Rating
1
2
3
None Found
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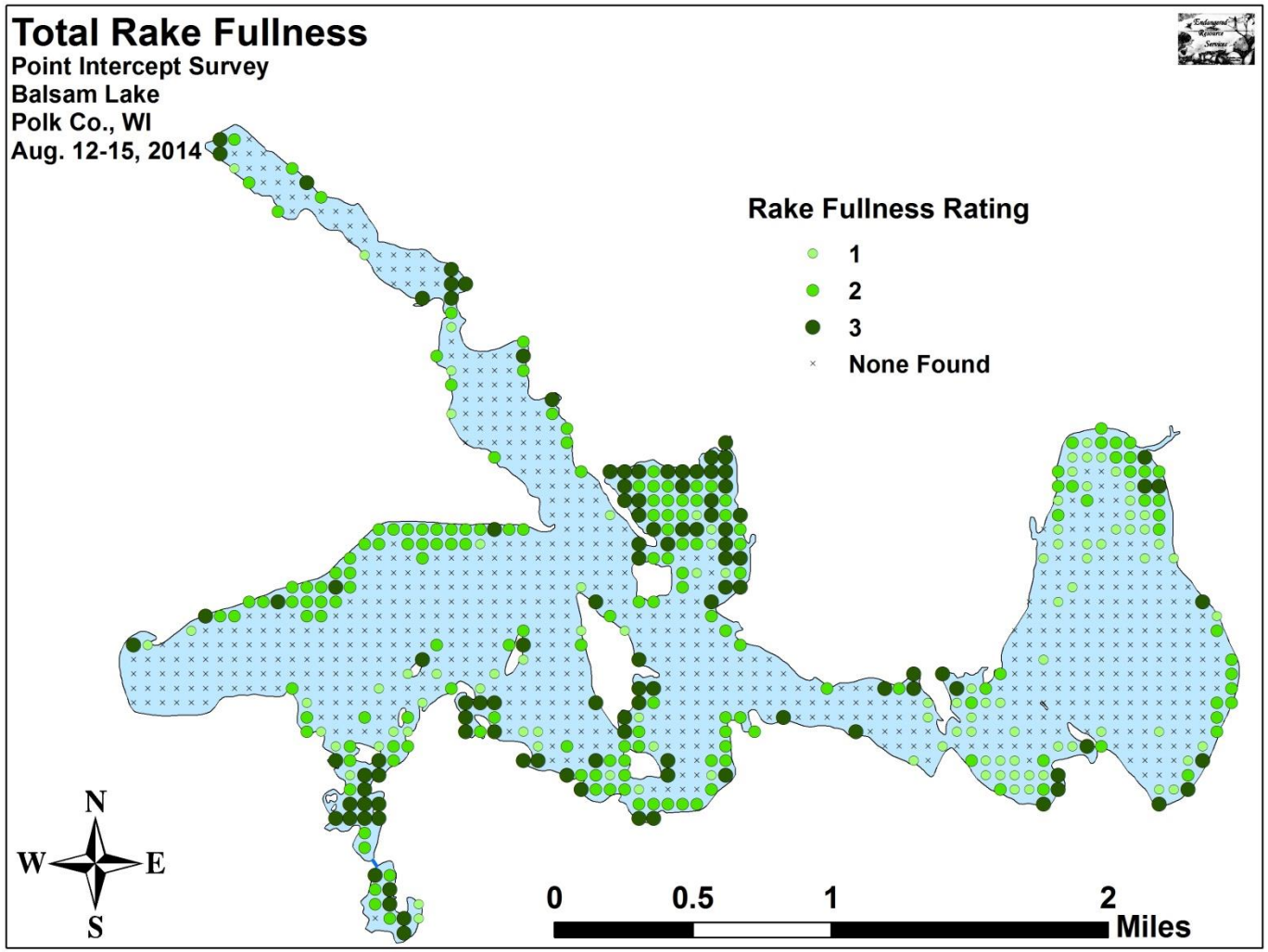
Total Rake Fullness
Point Intercept Survey
Balsam Lake
Polk Co., WI
Aug. 12-15, 2014
Rake Fullness Rating
1
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None Found
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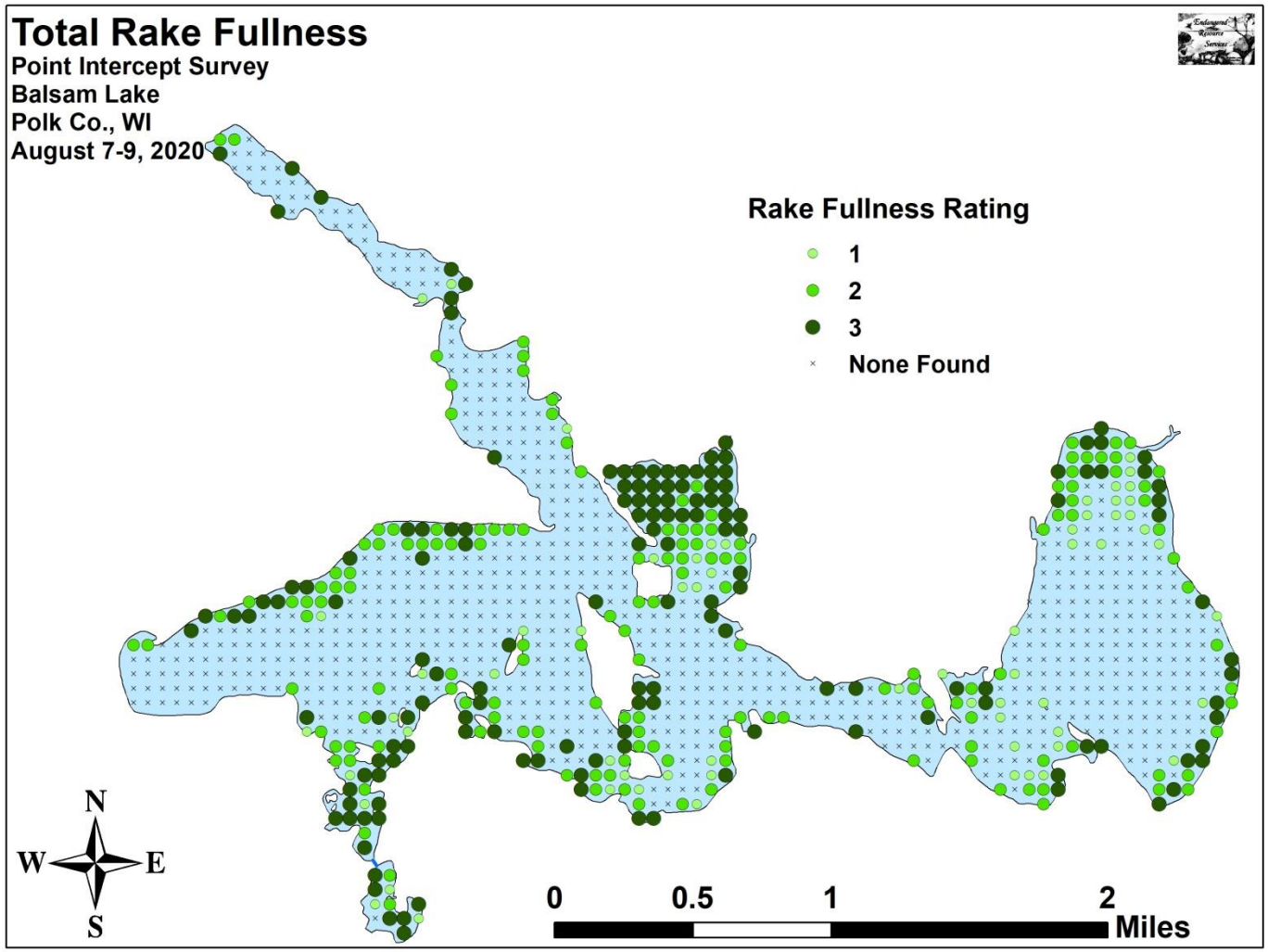
Total Rake Fullness
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
1
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3
None Found
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Miles

Appendix V: 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:** 8/9/20
Species: (*Myosotis scorpioides*) **Common forget-me-not**
Specimen Location: Balsam Lake; N45.45406°, W92.45270°
Collected/Identified by: Matthew S. Berg
Habitat/Distribution: Uncommon, a few patches of plants were located near the village beach landing and scattered along the shore near seeps southeast of First Island. 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: (*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:** 8/9/20
Species: (*Typha* X *glauca*) **Hybrid cattail**
Specimen Location: Balsam Lake; N45.45596°, W92.43452°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-115
Habitat/Distribution: Firm sand/muck in water <0.25 meters. A small bed occurred at the point. Not seen anywhere else.
Common Associates: (*Pontederia cordata*) Pickerelweed

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-

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

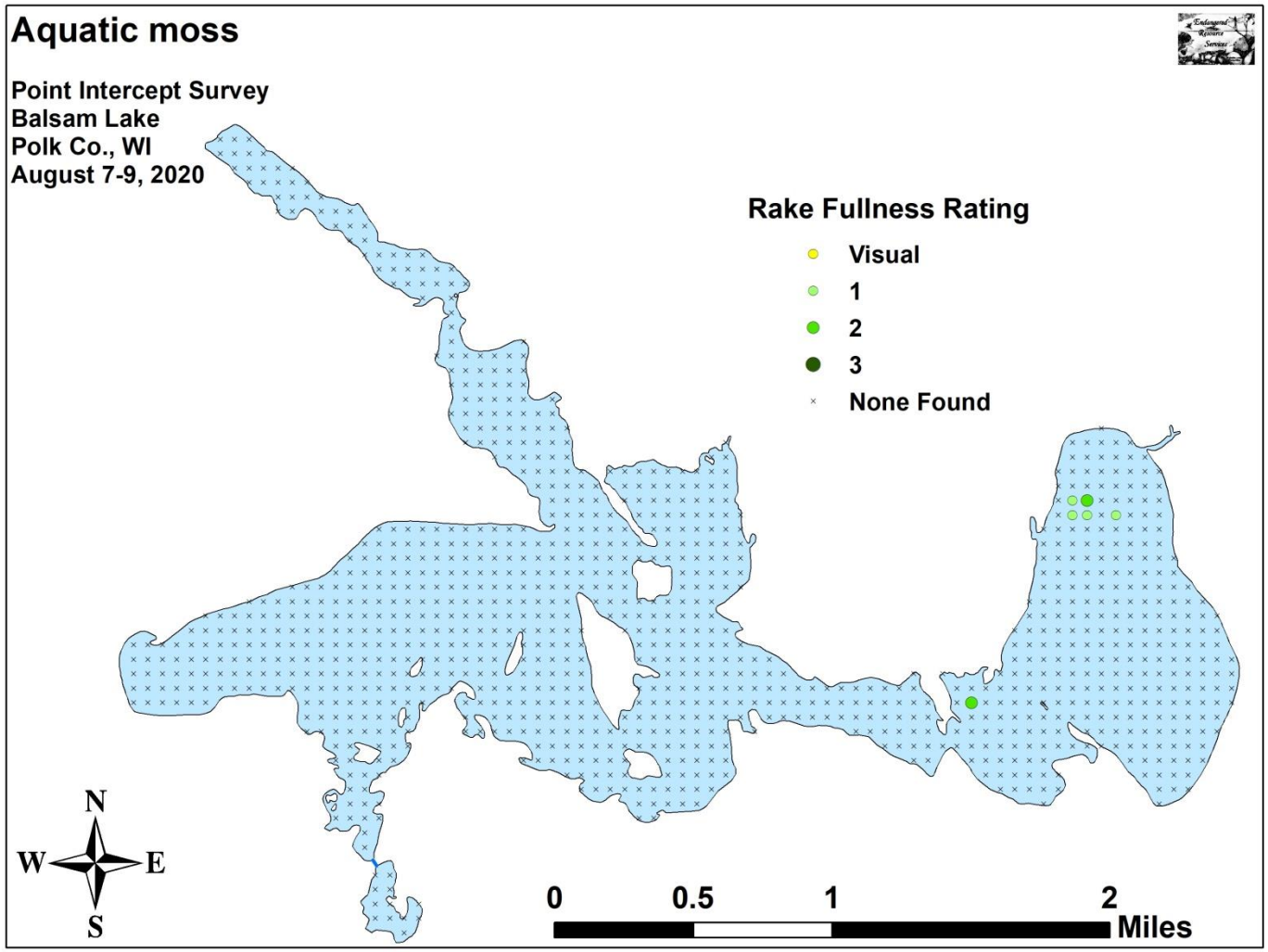
County/State: Polk County, Wisconsin **Date:** 7/19/09
Species: (*Vallisneria americana*) **Wild celery**
Specimen Location: Balsam Lake; N45.47047°, W92.42762°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2009-118
Habitat/Distribution: Found in almost any bottom conditions, but grows best in 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 VI: August 2020 Species Density and Distribution Maps


Aquatic moss
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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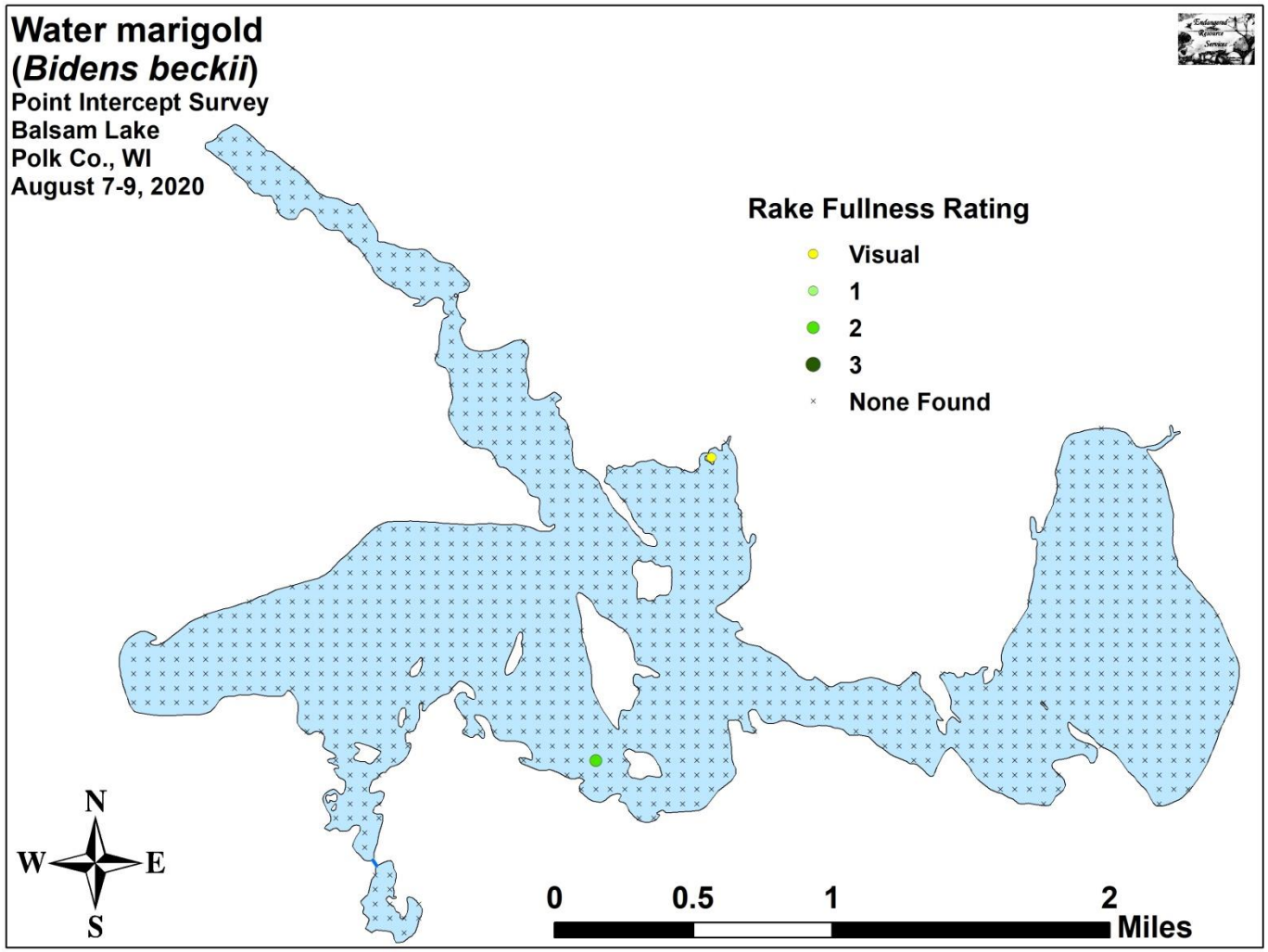
Miles


Water marigold
(Bidens beckii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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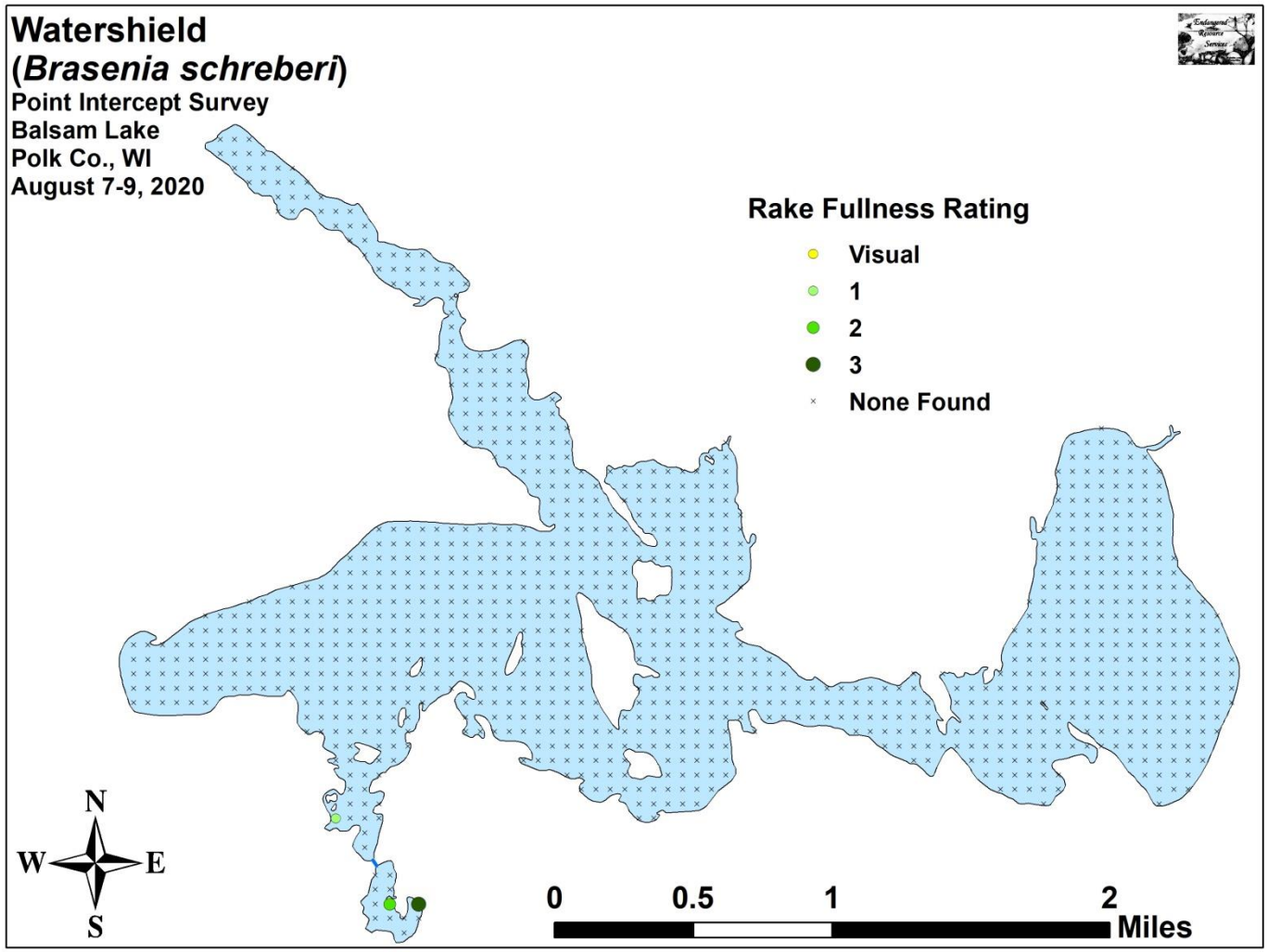
Miles


Watershield
(Brasenia schreberi)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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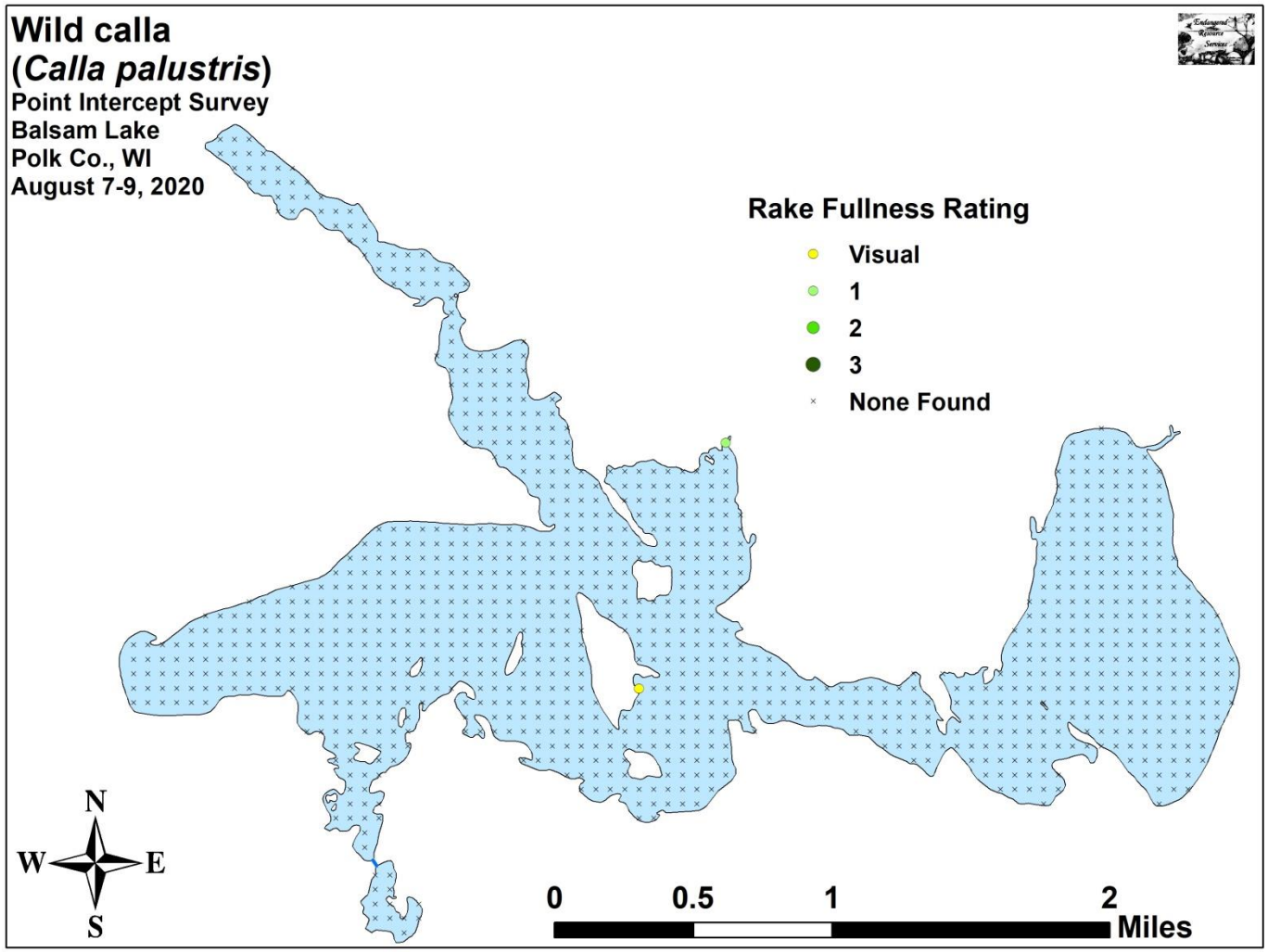
Miles


Wild calla
(Calla palustris)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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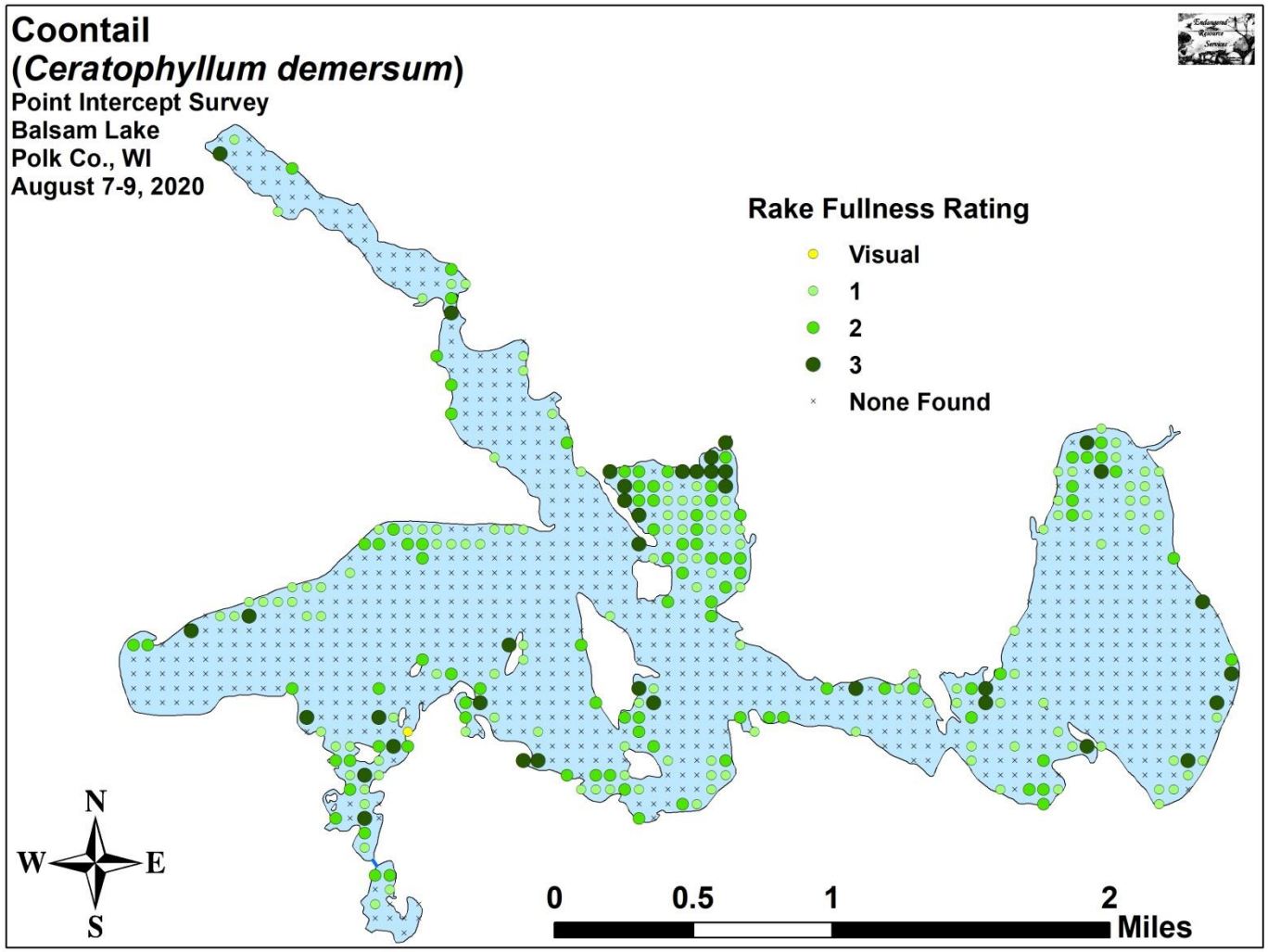
Miles


Coontail
(Ceratophyllum demersum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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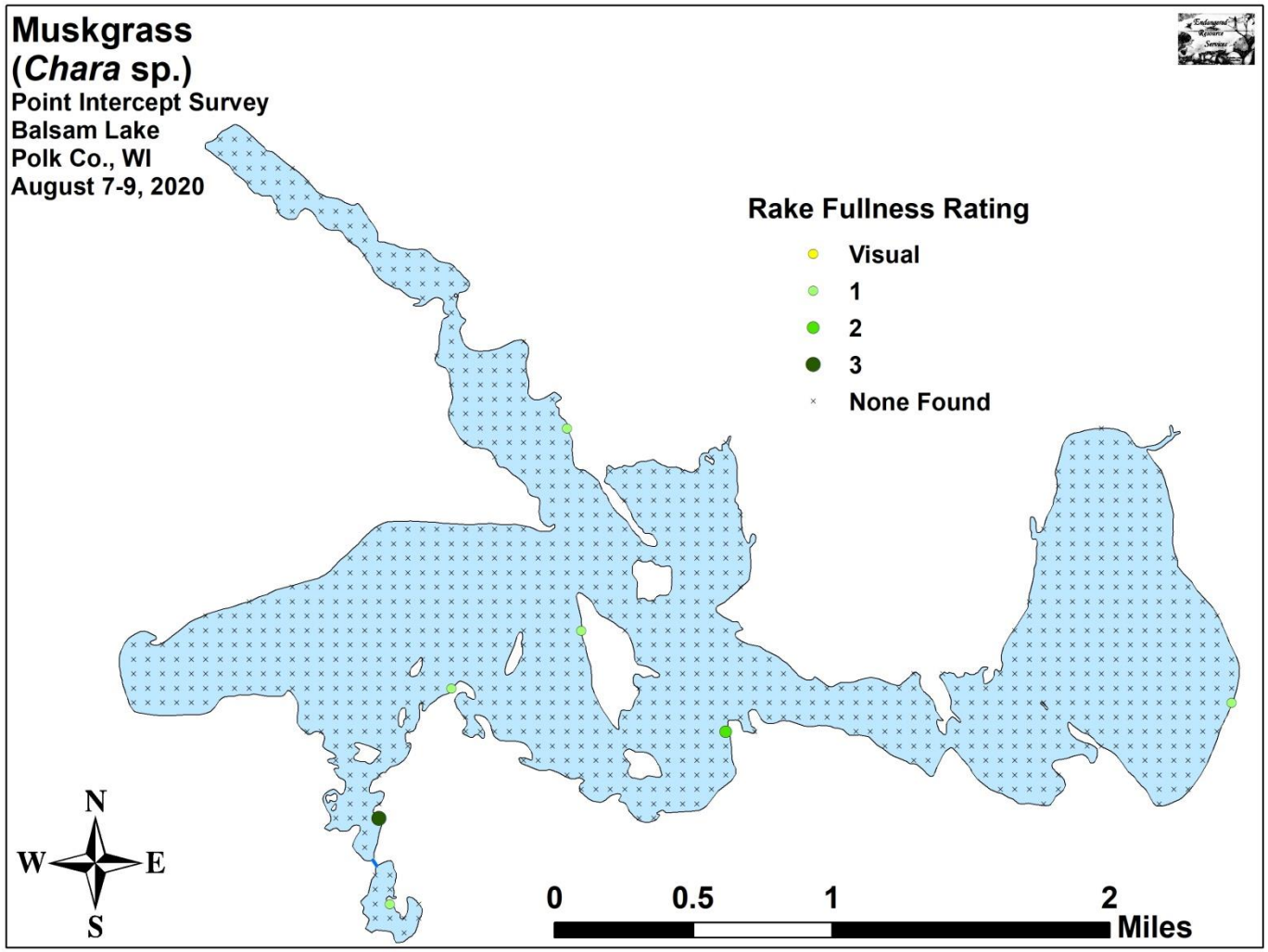
Miles


Muskgrass
(Chara sp.)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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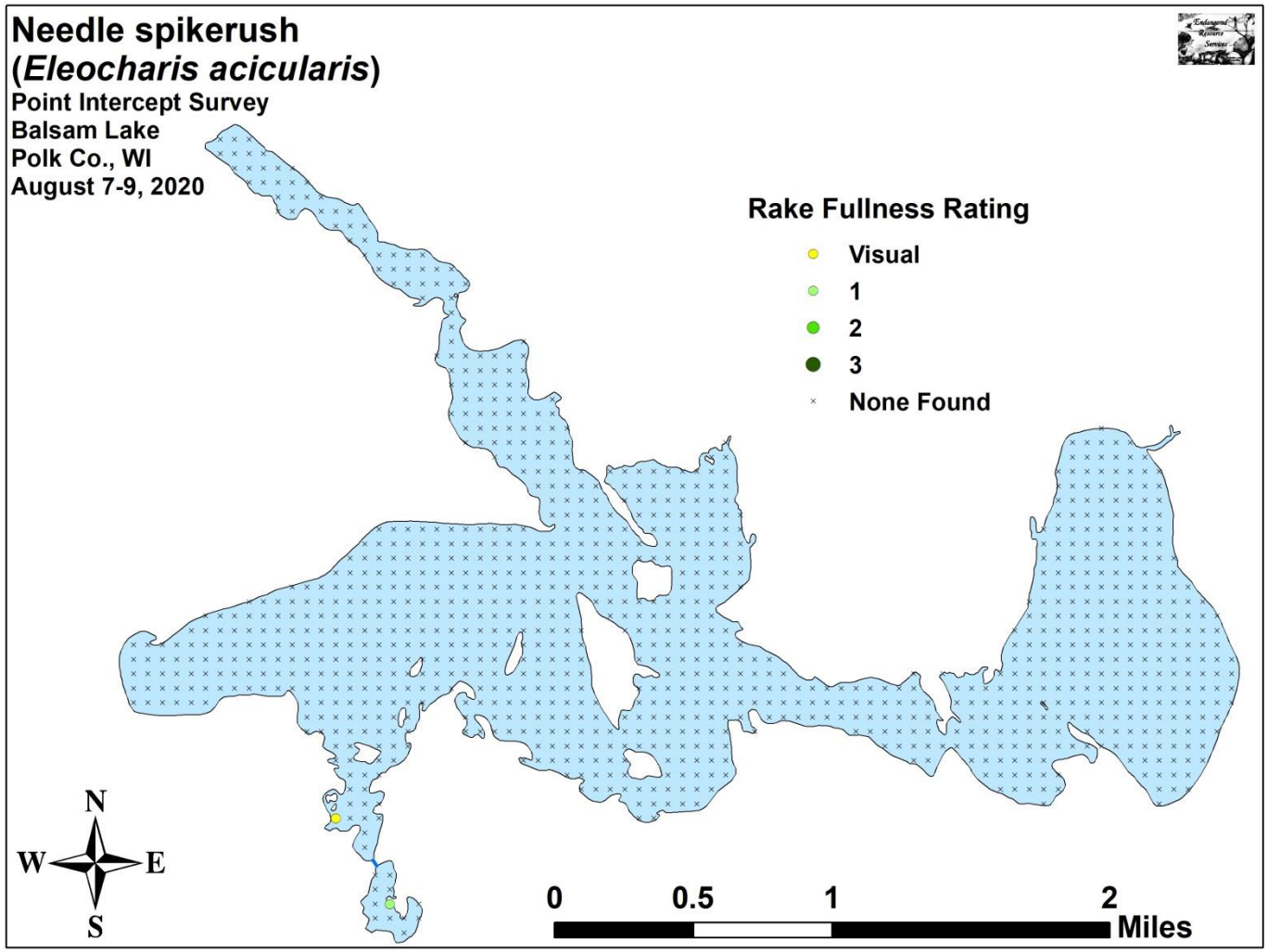
Miles


Needle spikerush
(Eleocharis acicularis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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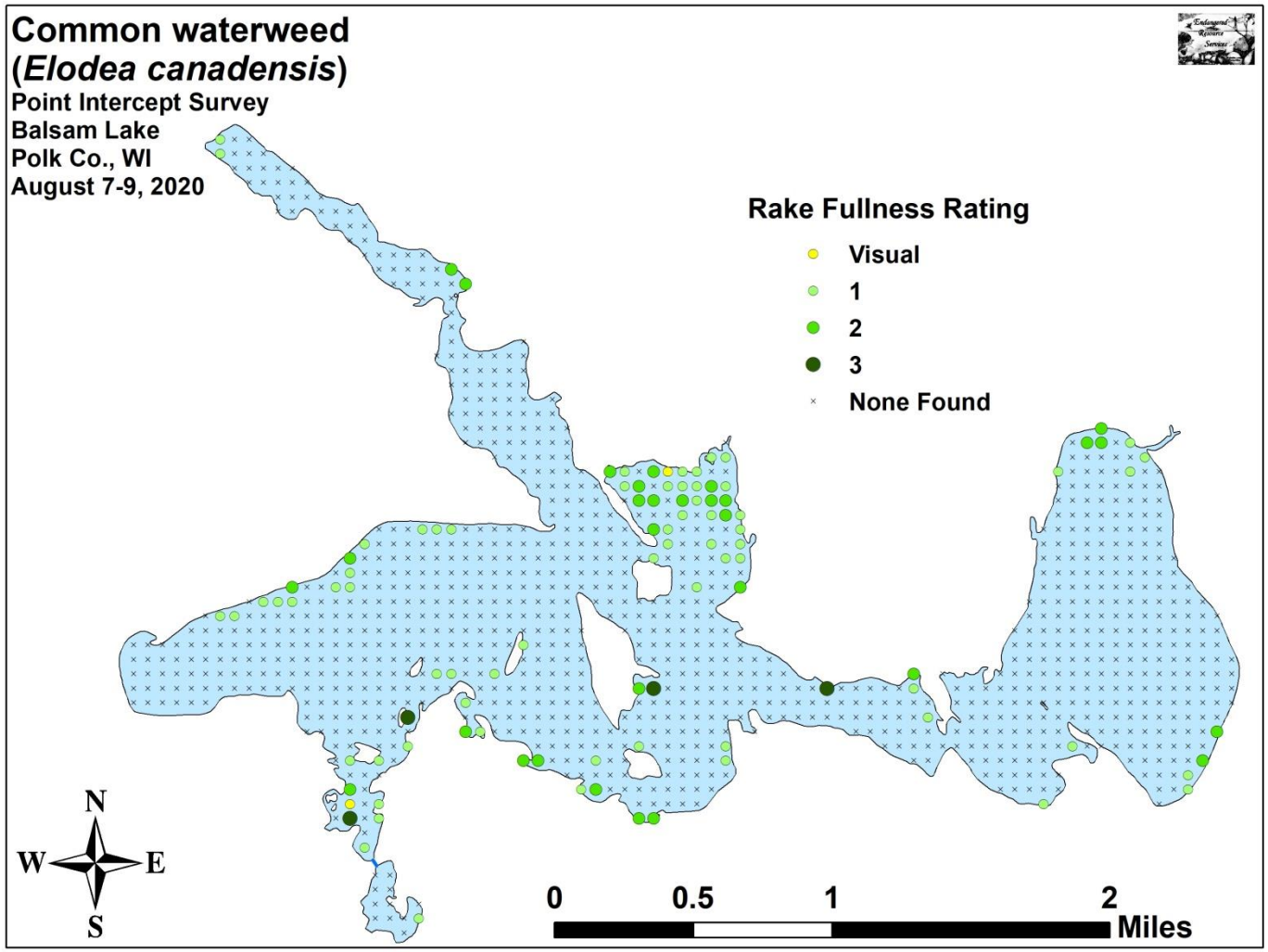
Miles


Common waterweed
(Elodea canadensis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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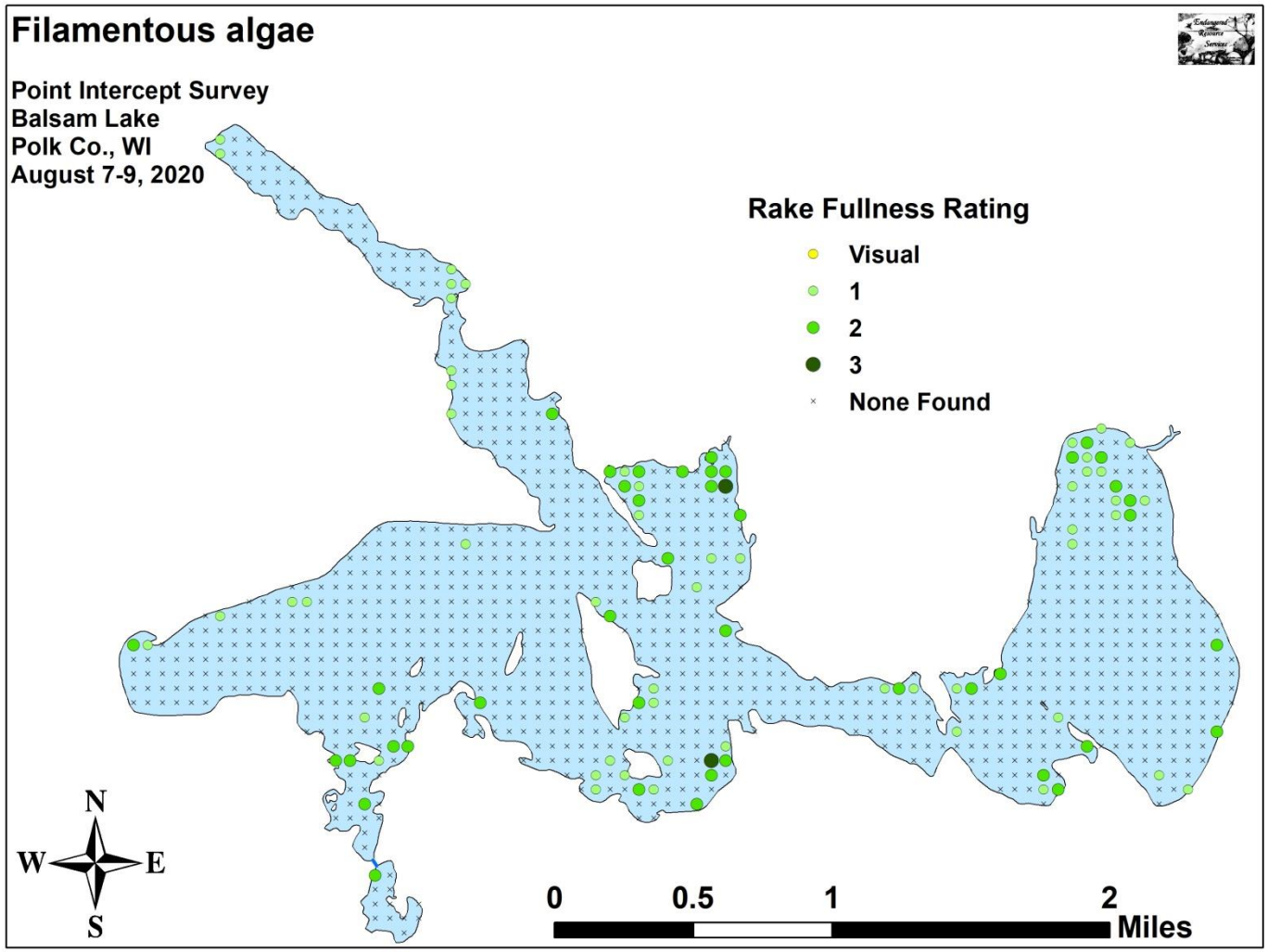
Miles


Filamentous algae
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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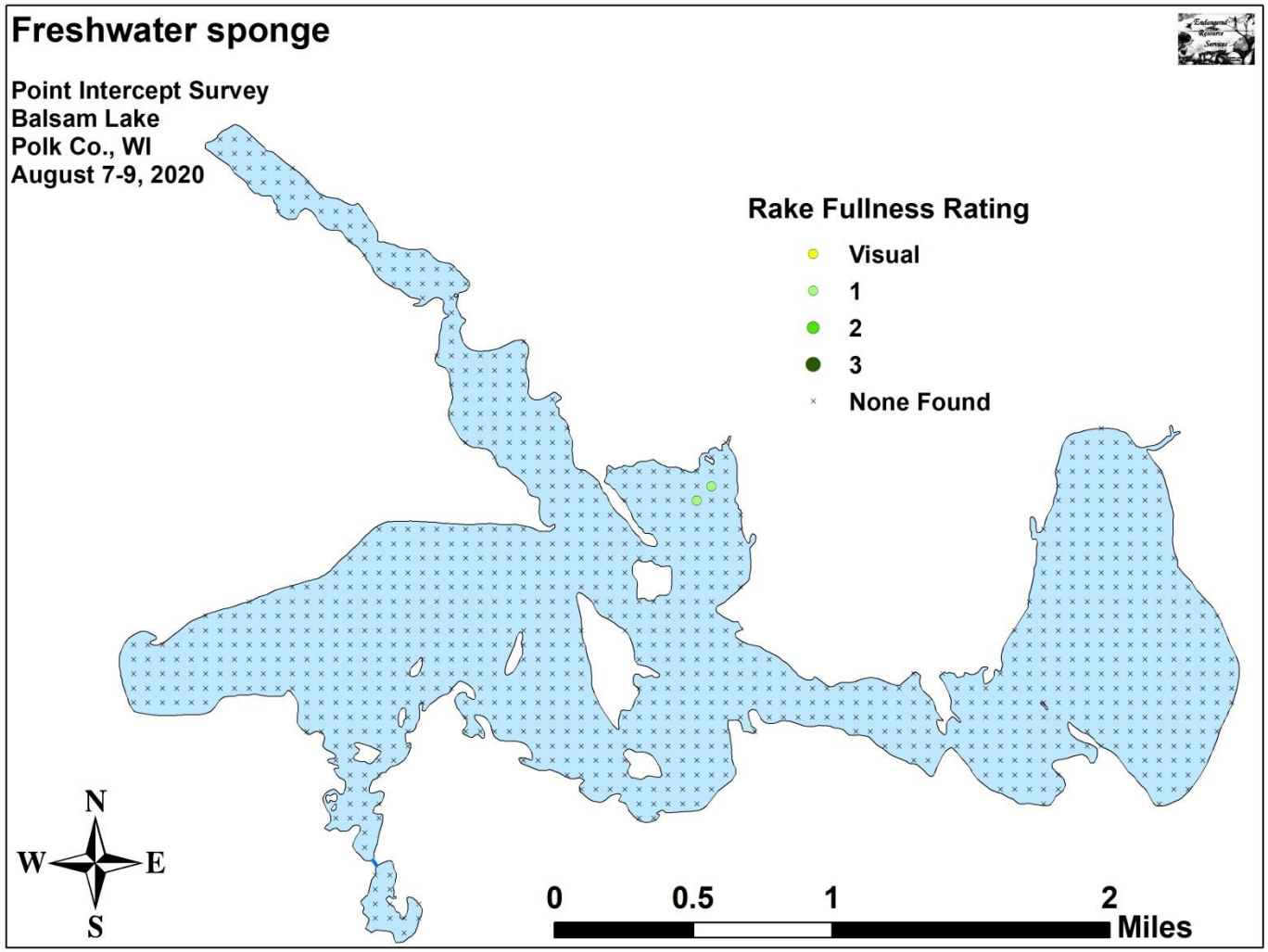
Miles


Freshwater sponge
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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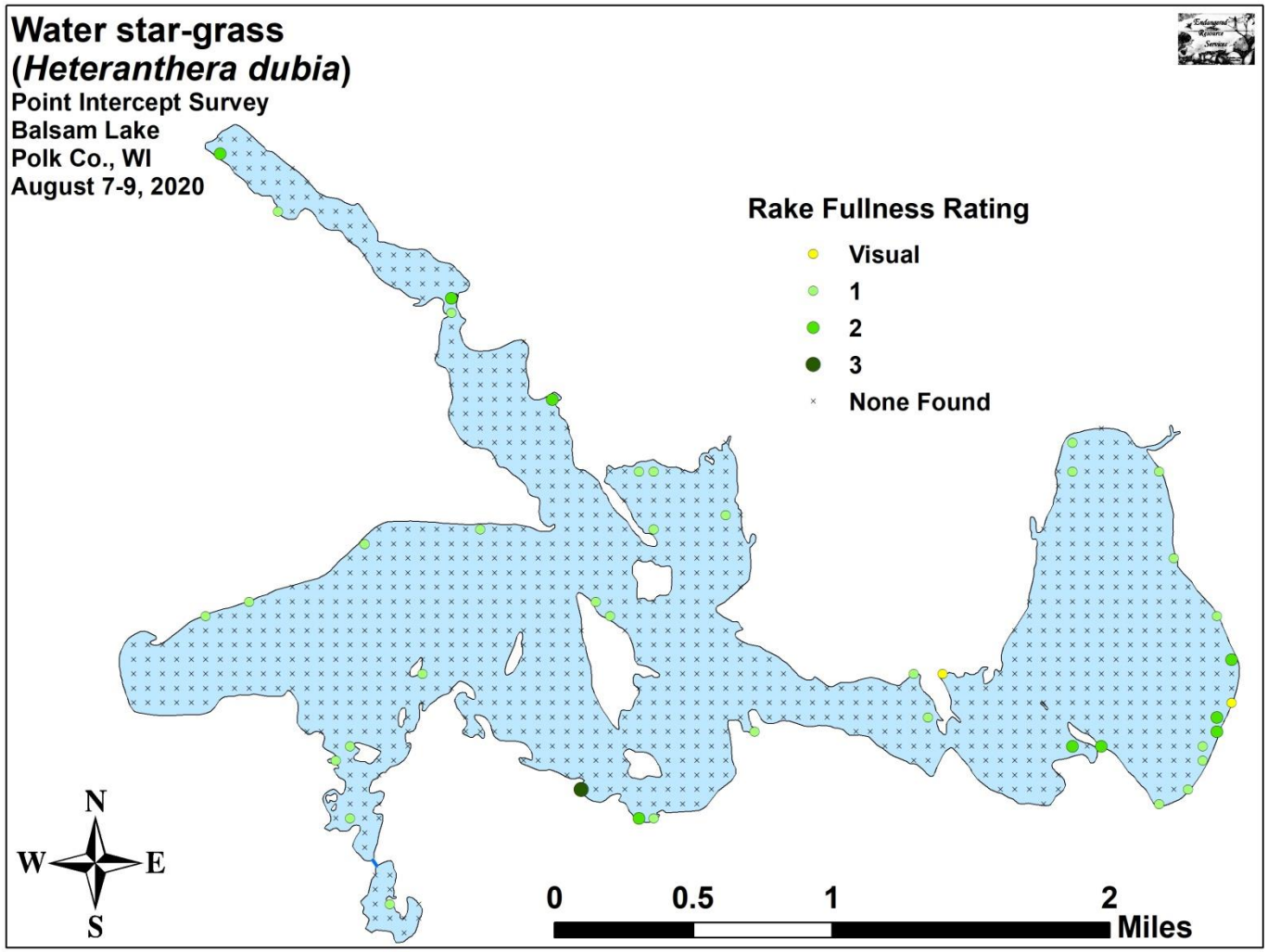
Miles


Water star-grass
(Heteranthera dubia)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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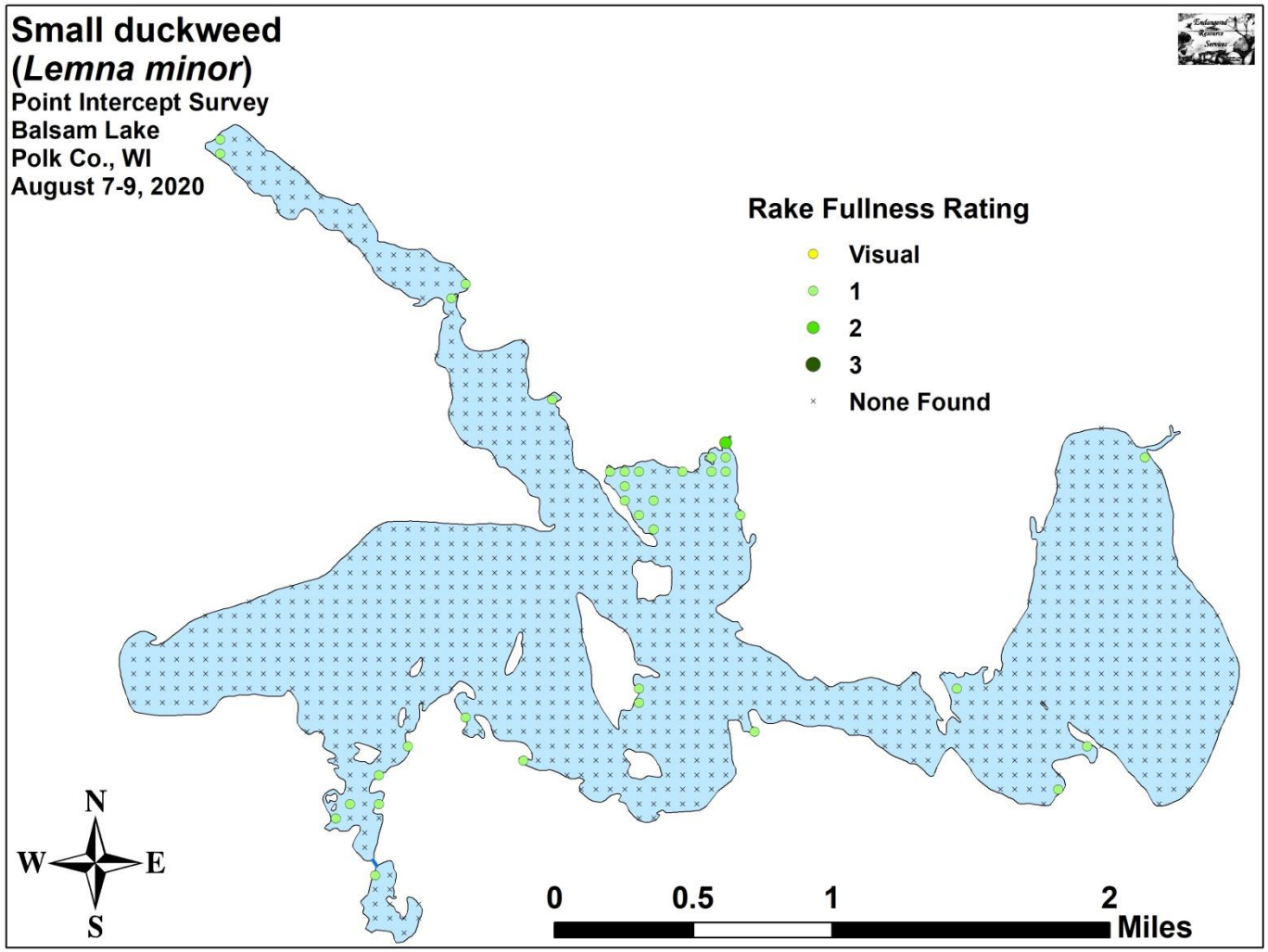
Miles


Small duckweed
(Lemna minor)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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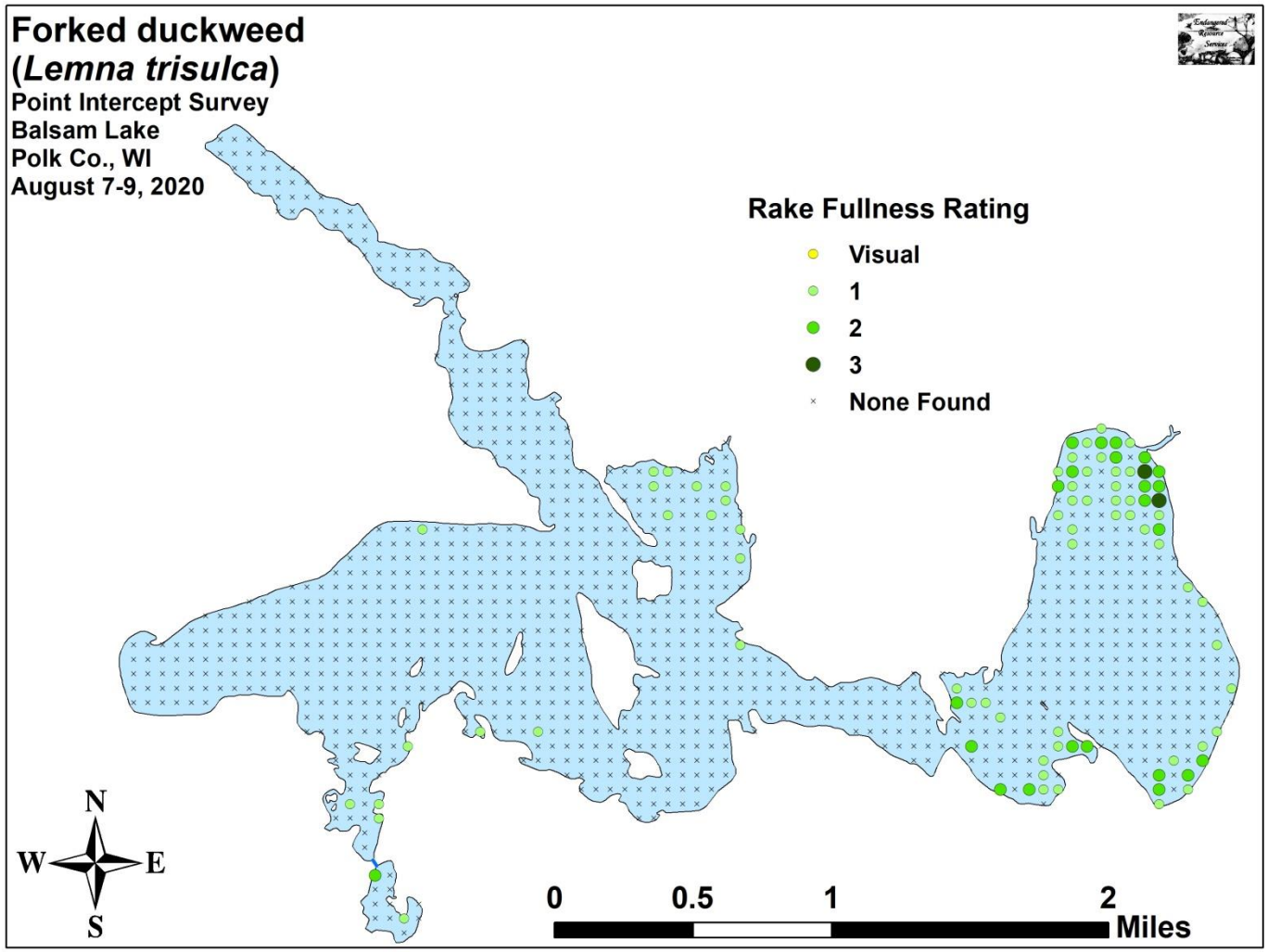
Miles


Forked duckweed
(Lemna trisulca)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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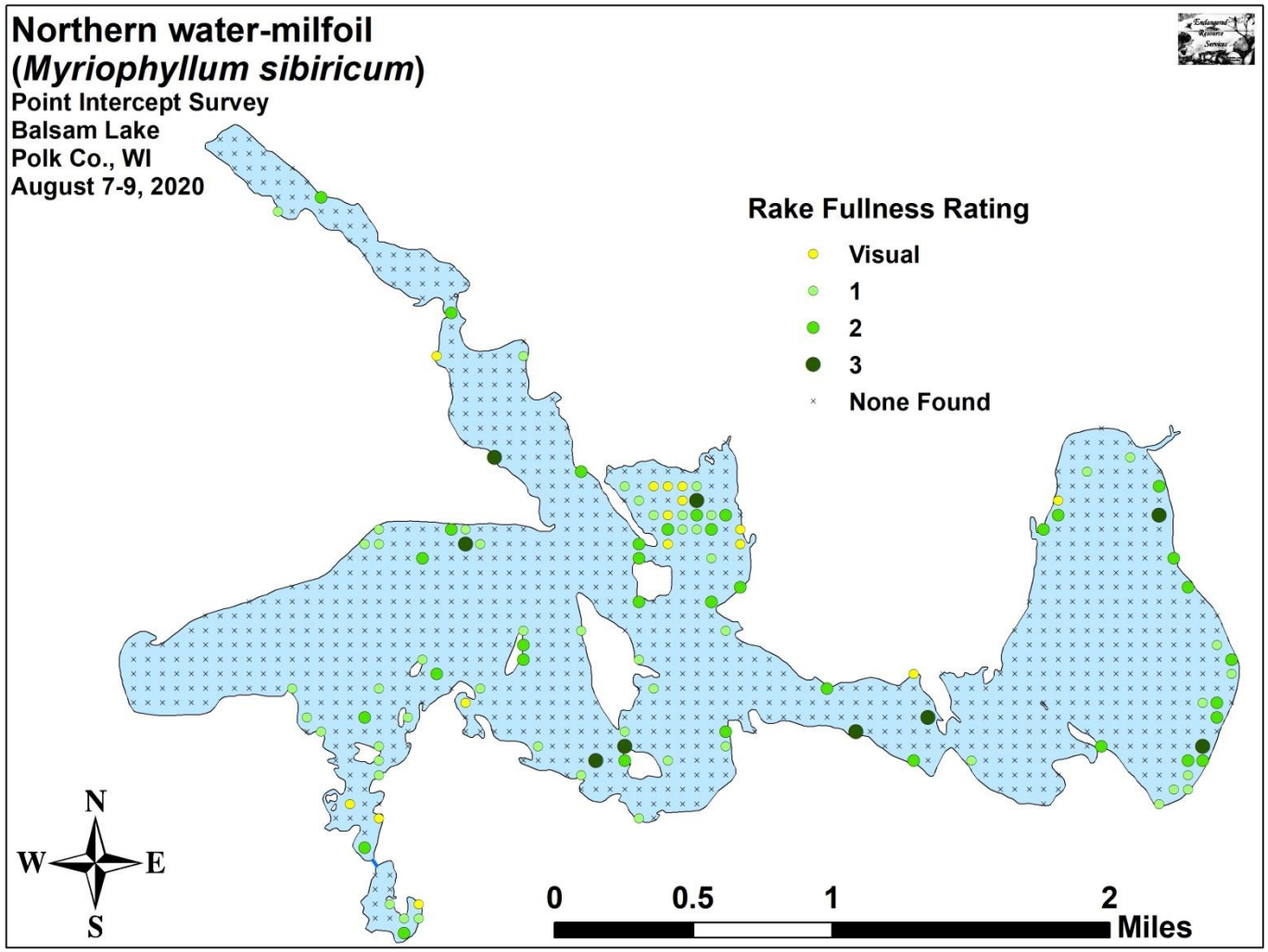
Miles


Northern water-milfoil
(Myriophyllum sibiricum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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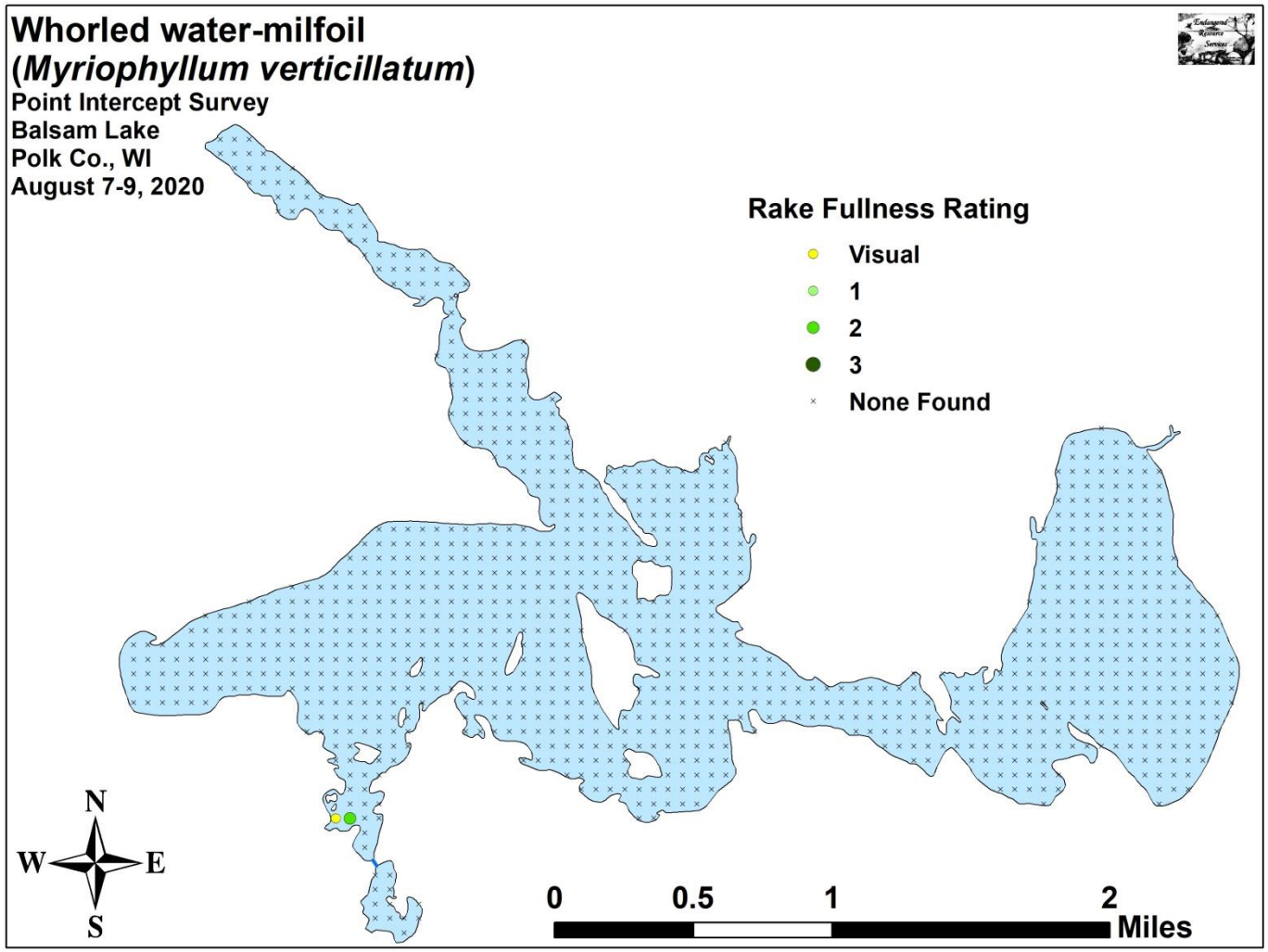
Miles


Whorled water-milfoil
(Myriophyllum verticillatum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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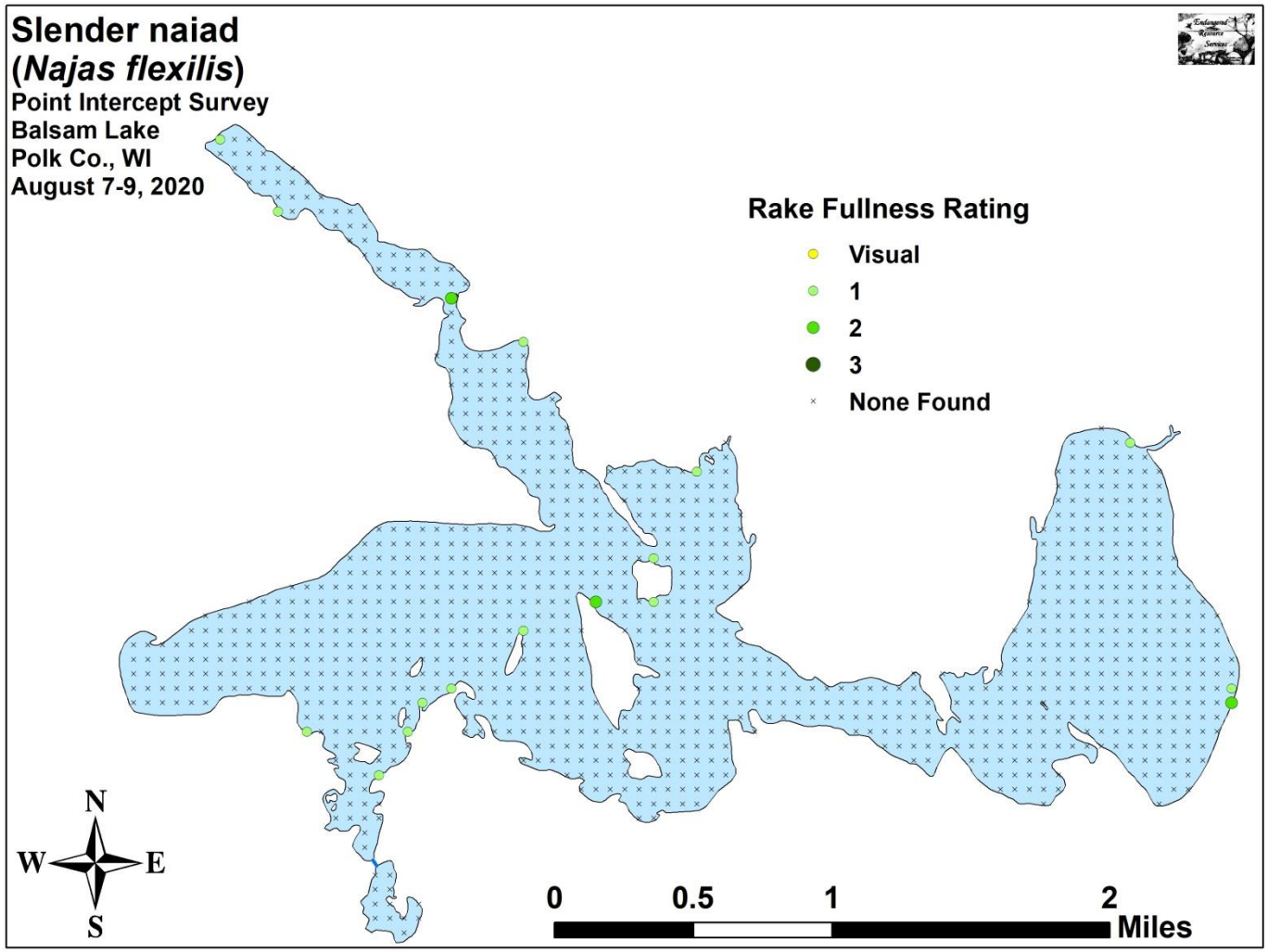
Miles


Slender naiad
(Najas flexilis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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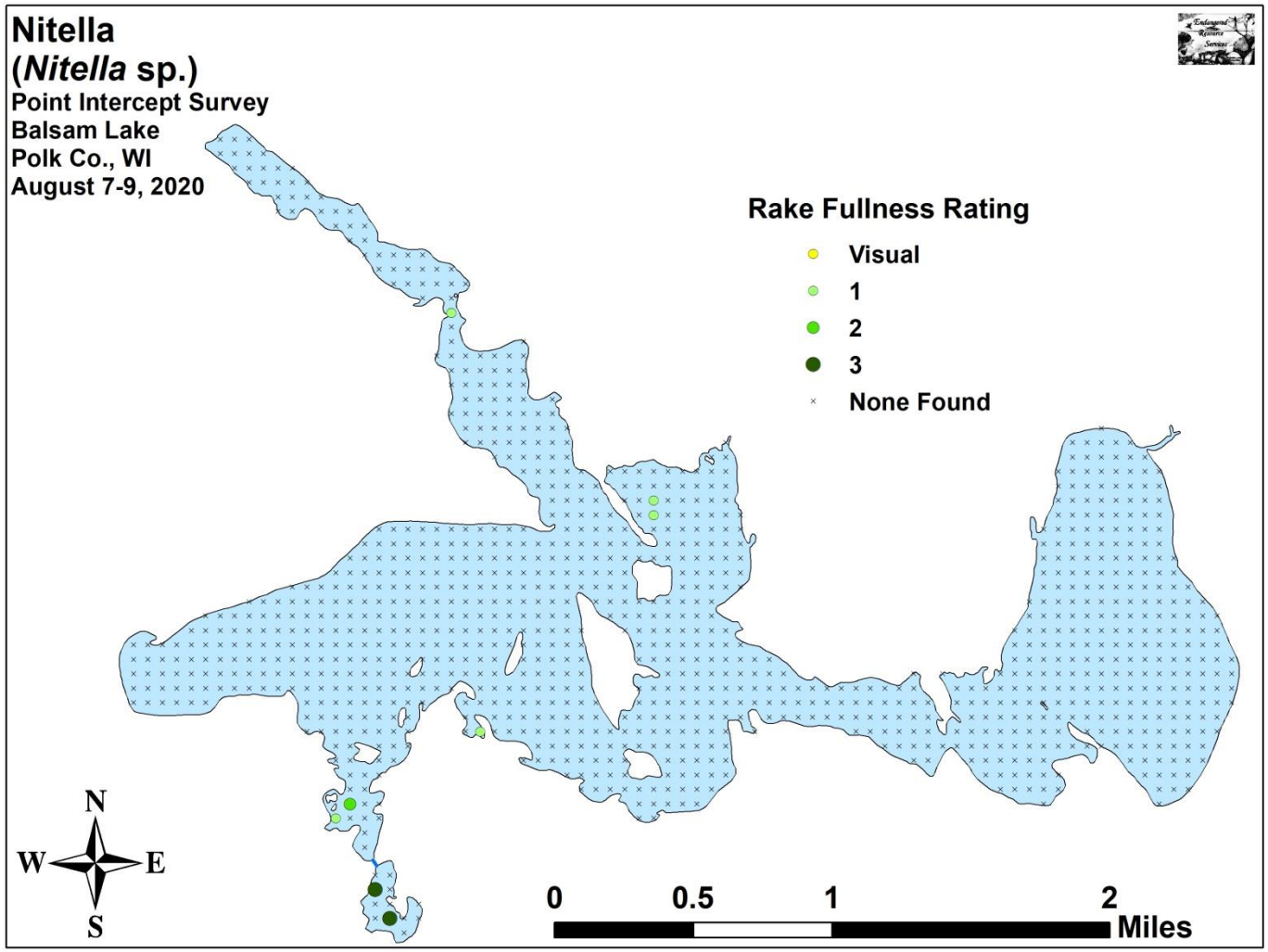
Miles


Nitella
(*Nitella* sp.)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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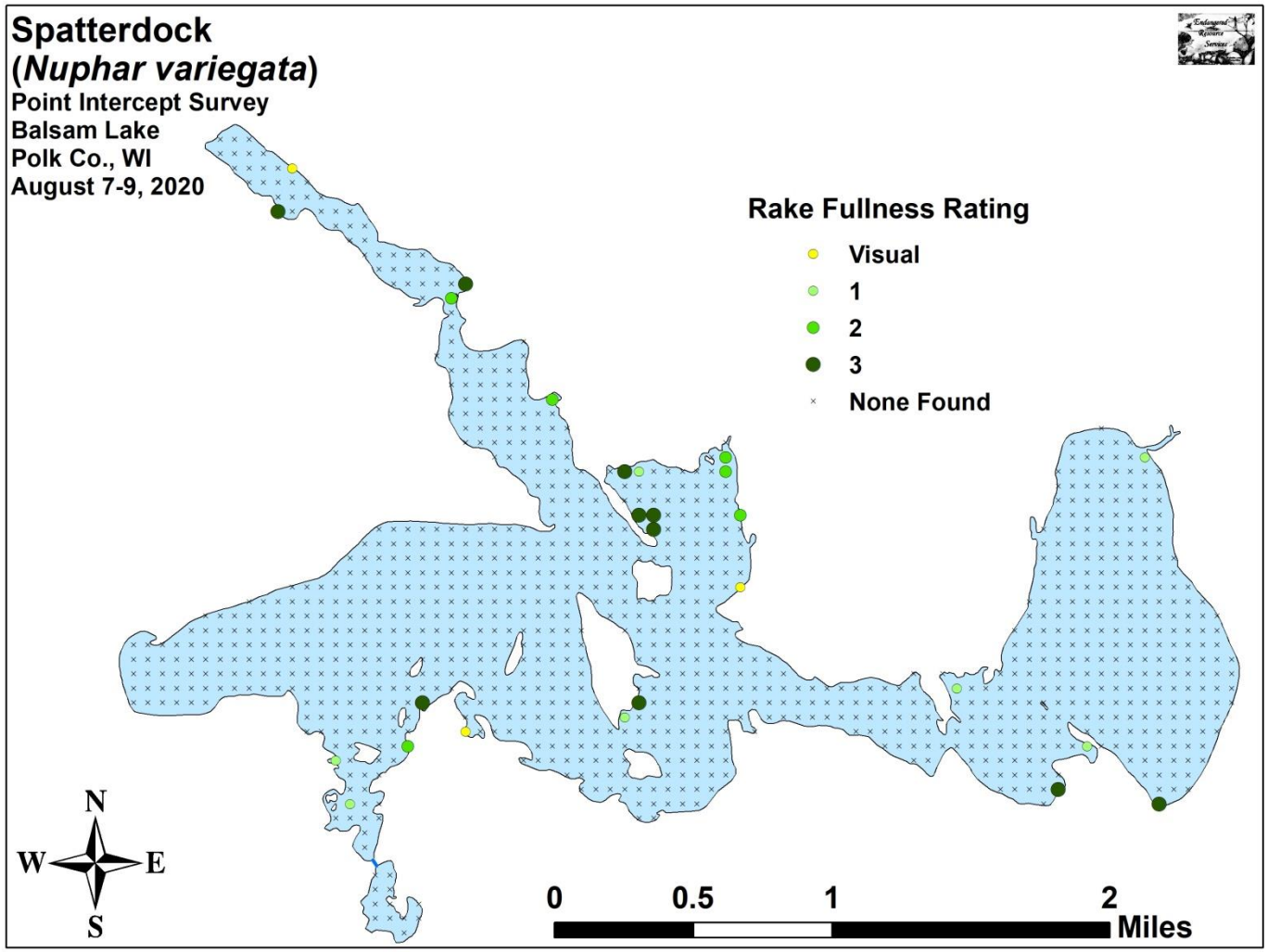
Miles


Spatterdock
(Nuphar variegata)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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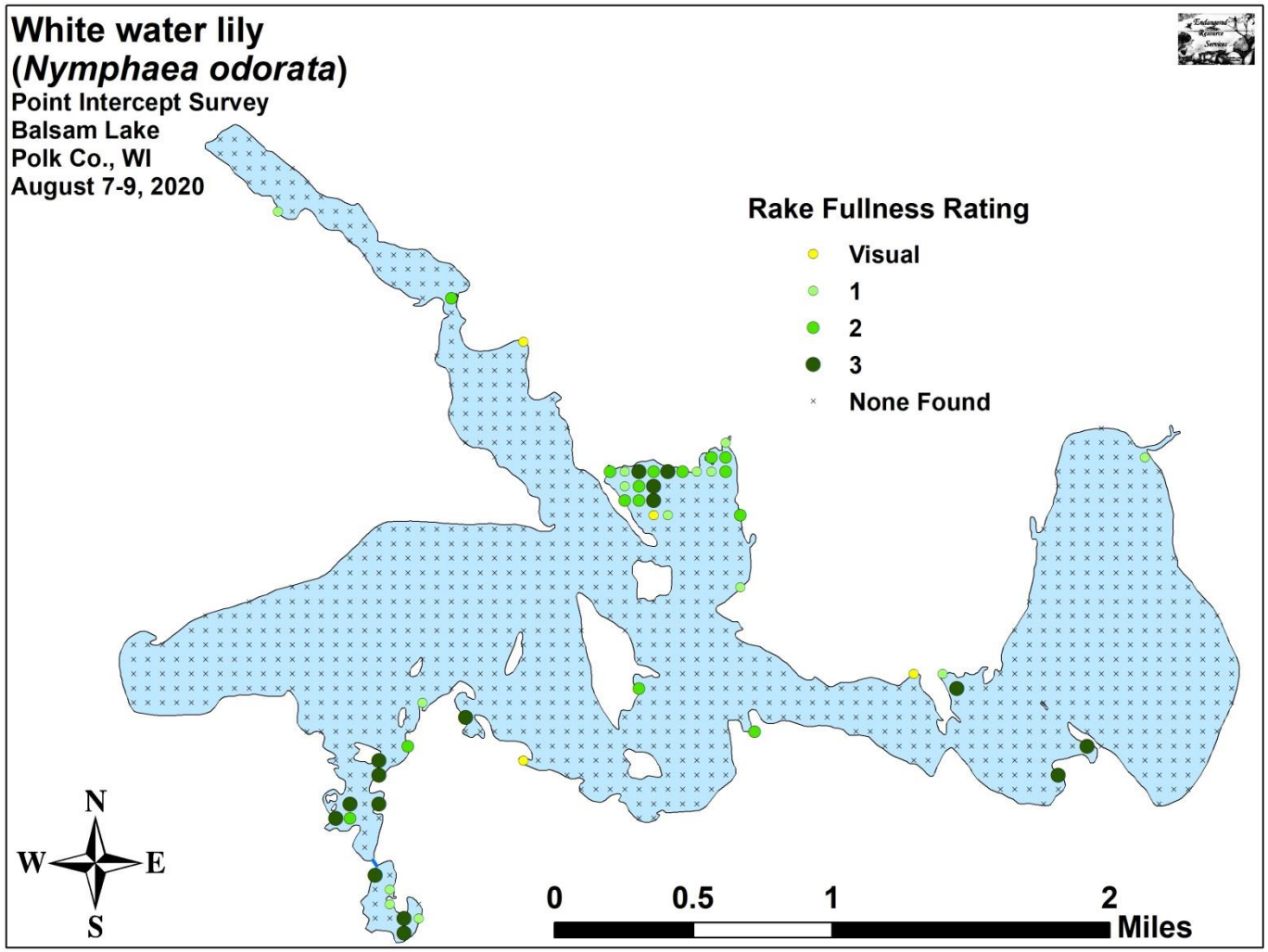
Miles


White water lily
(*Nymphaea odorata*)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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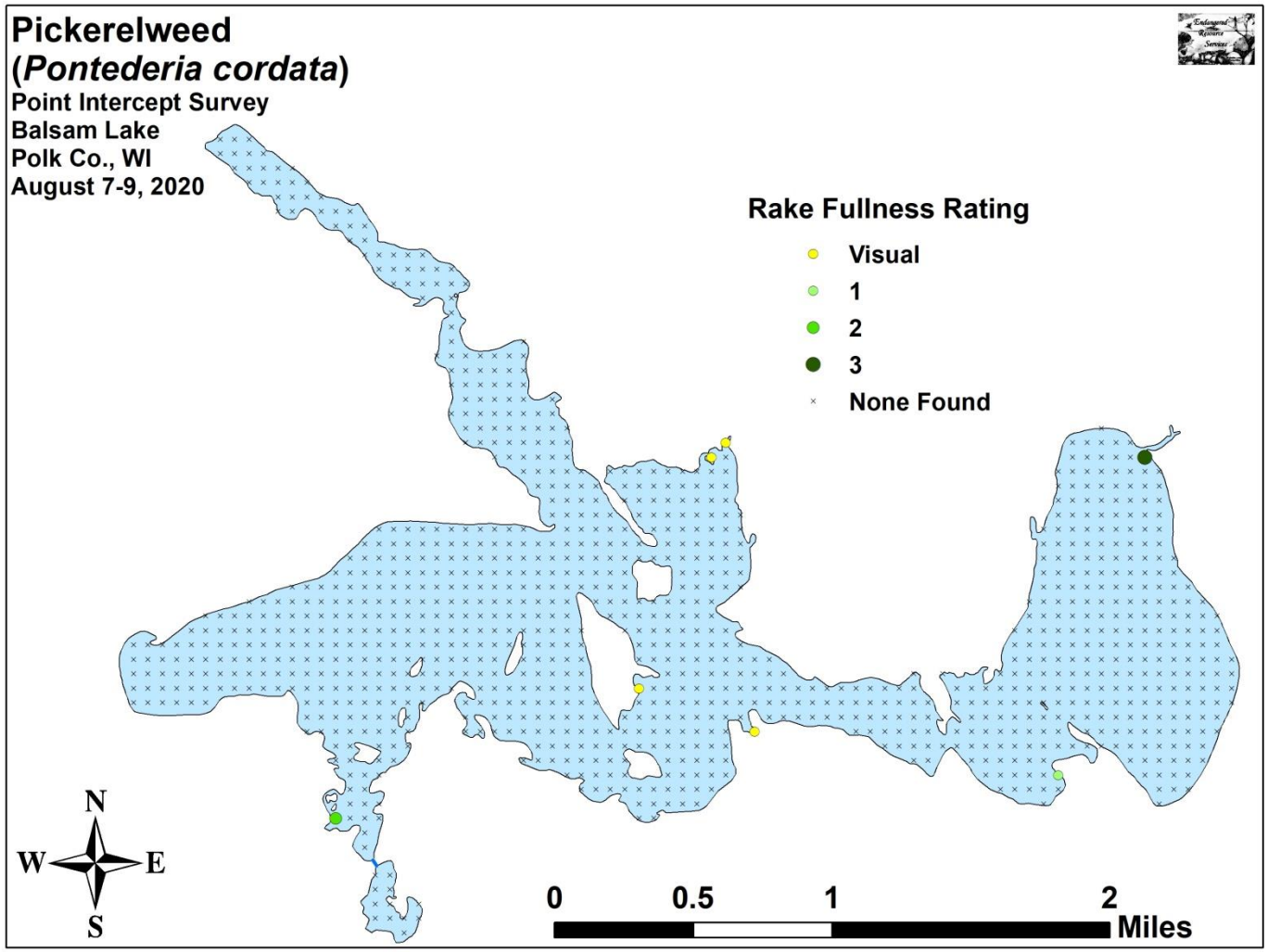
Miles


Pickerelweed
(*Pontederia cordata*)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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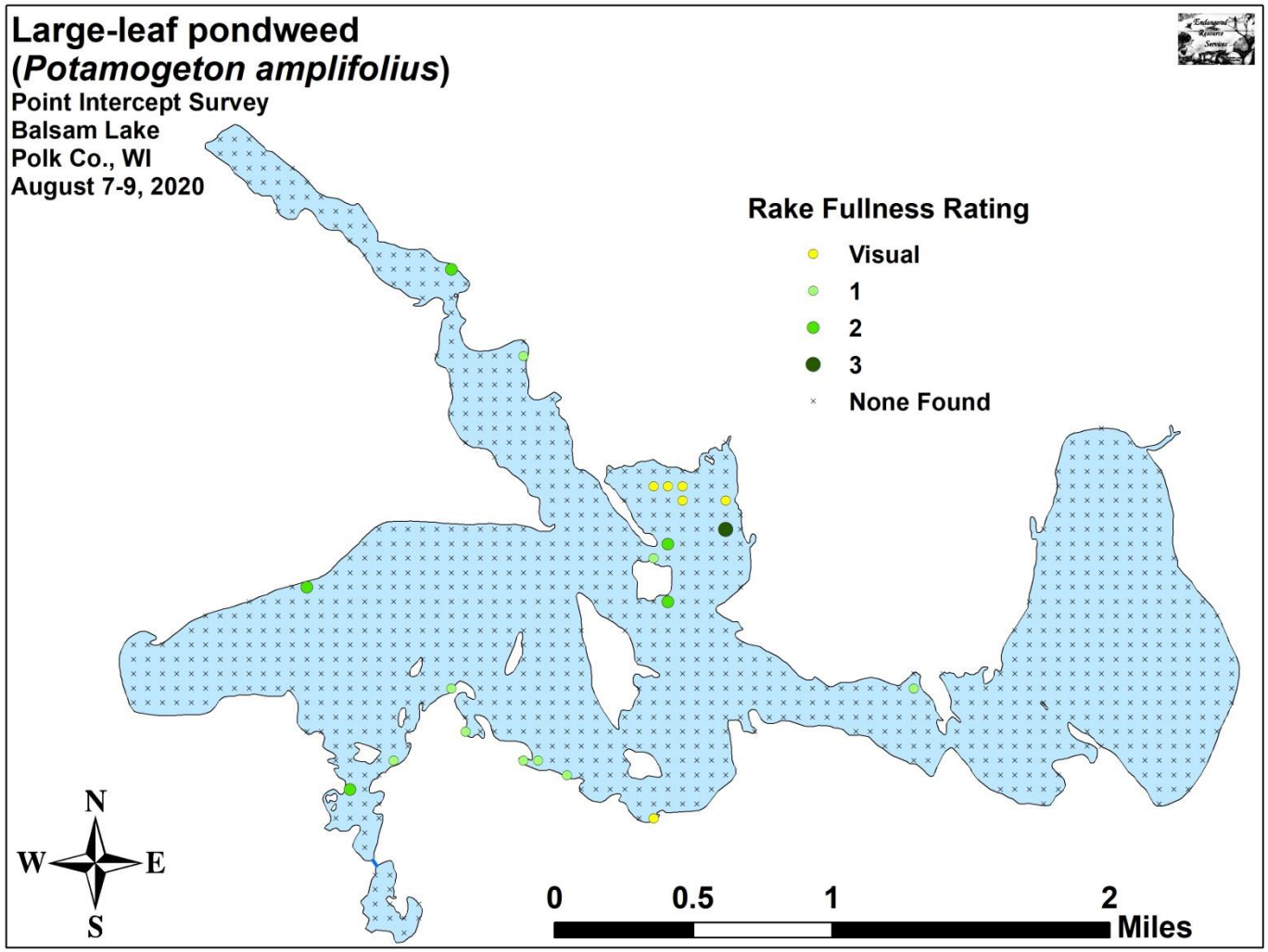
Miles


Large-leaf pondweed
(Potamogeton amplifolius)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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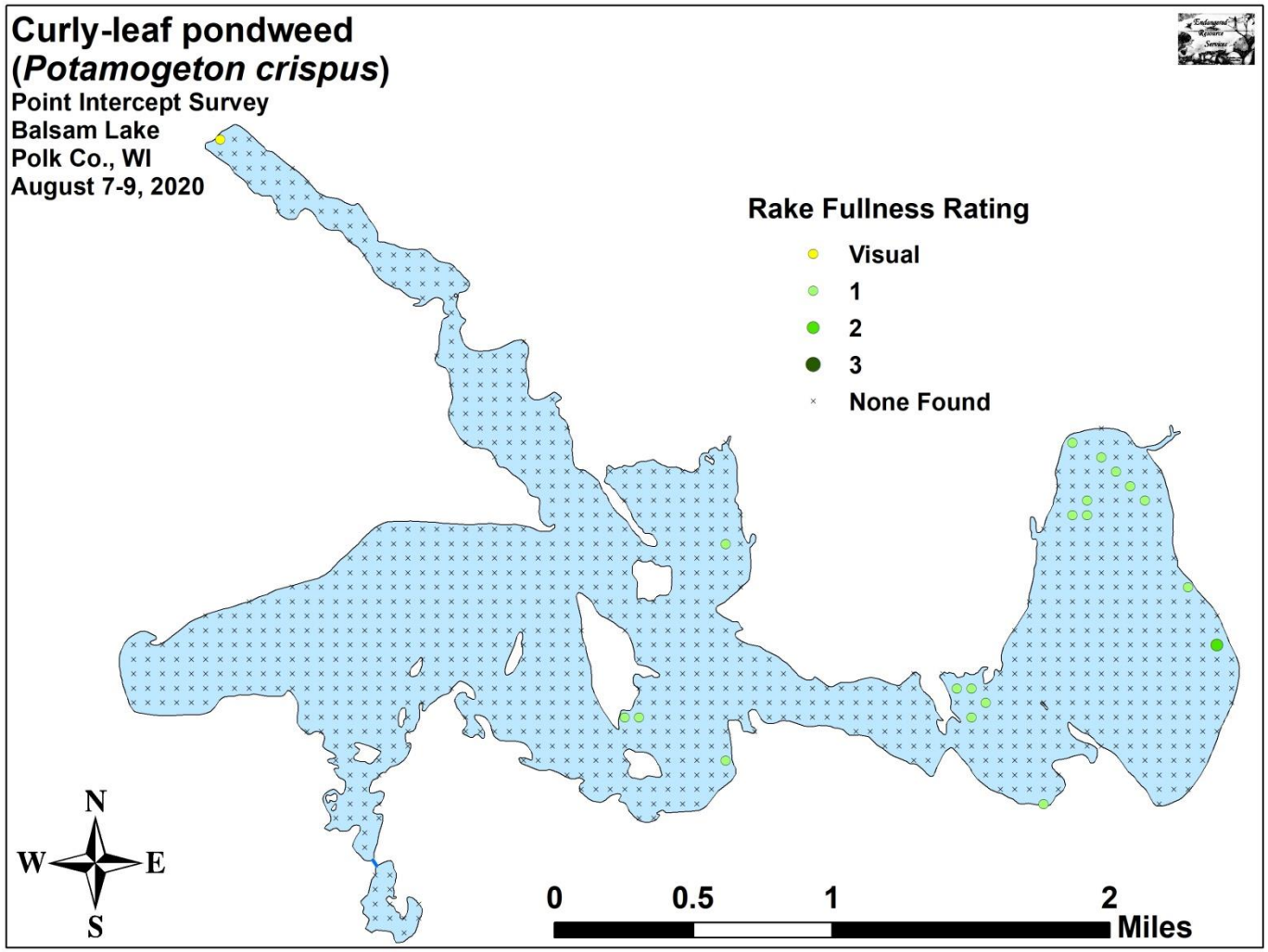
Miles


Curly-leaf pondweed
(Potamogeton crispus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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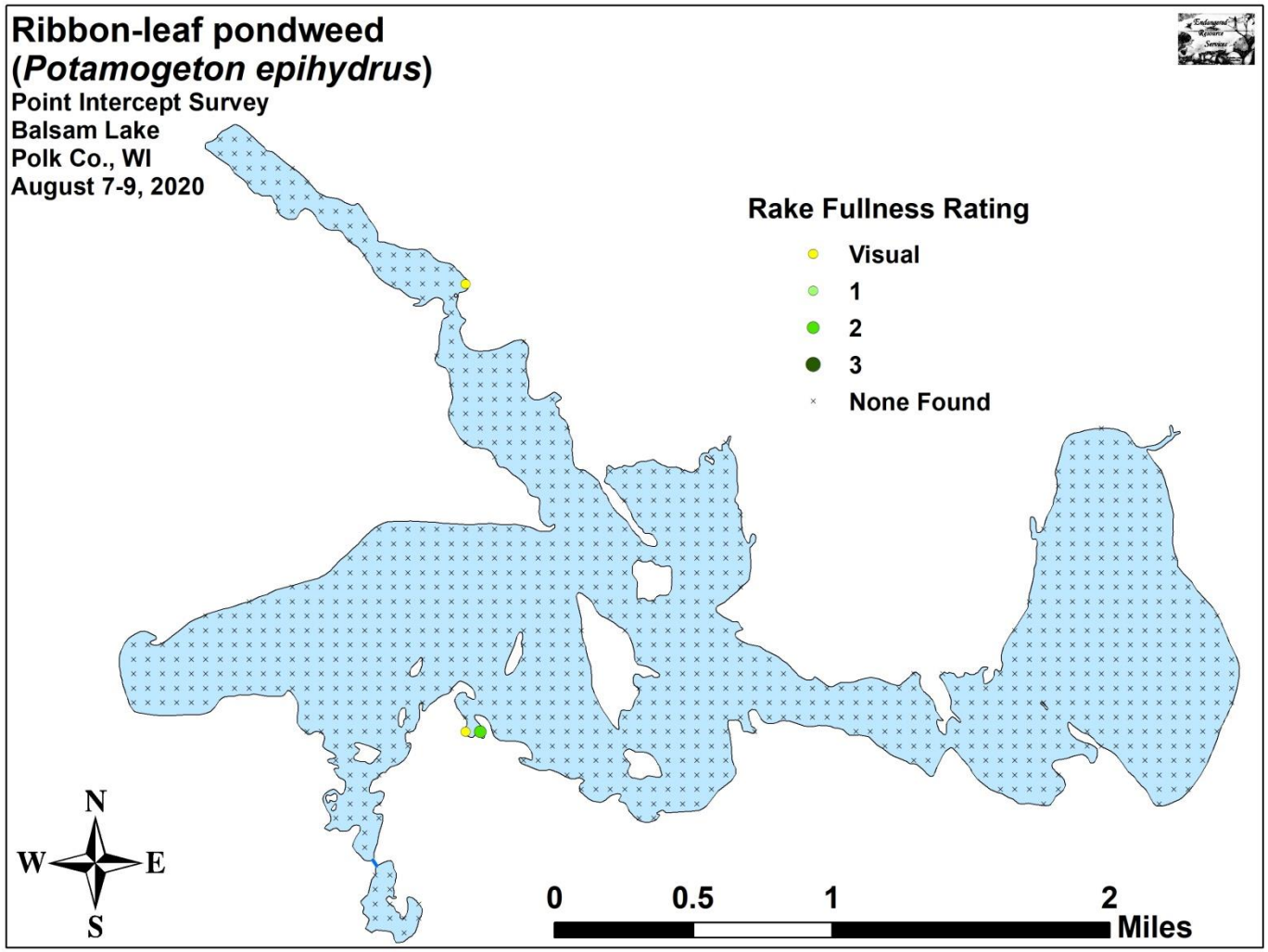
Miles


Ribbon-leaf pondweed
(Potamogeton epihydrus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
1
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None Found
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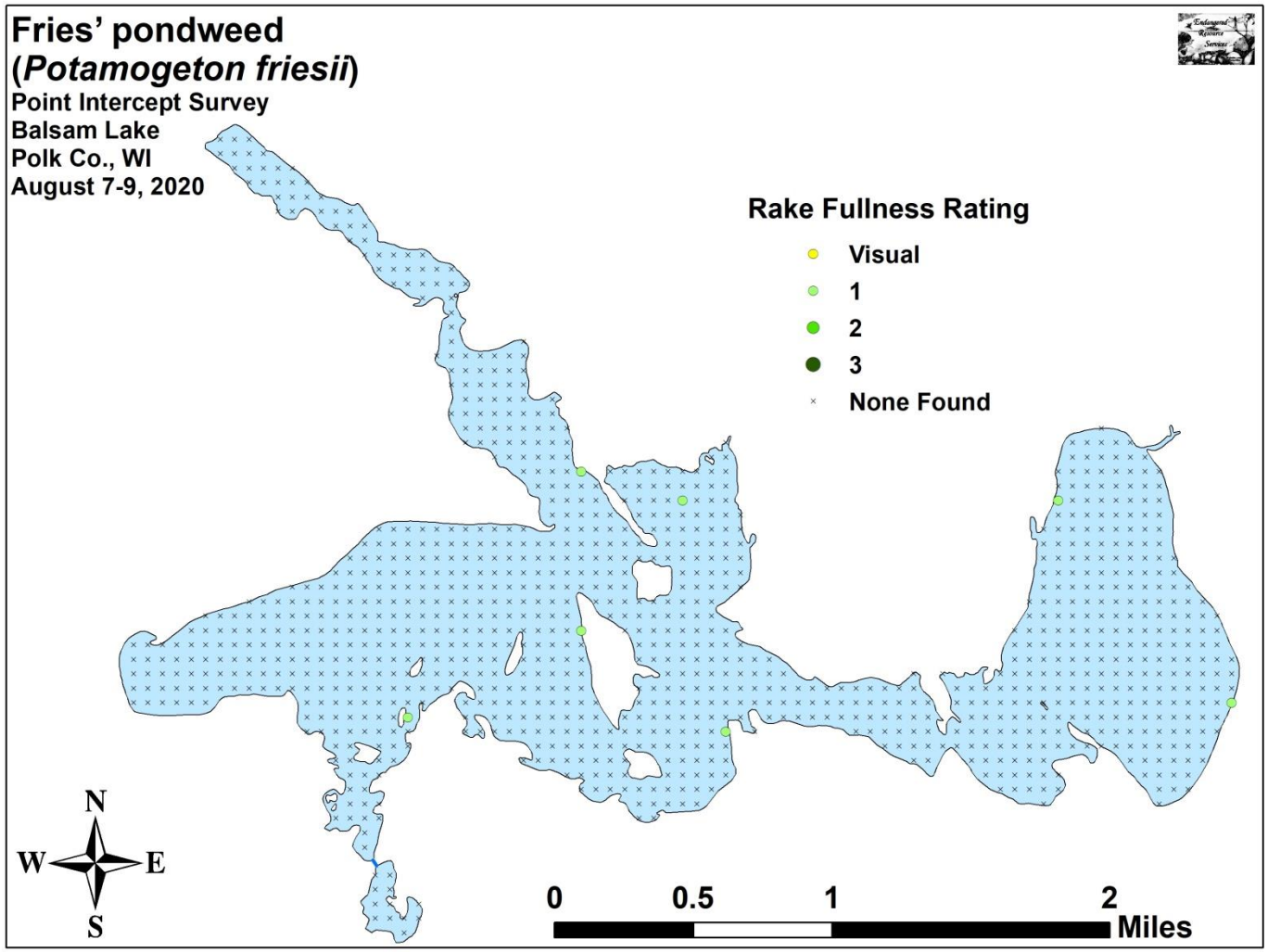
Miles


Fries' pondweed
(Potamogeton friesii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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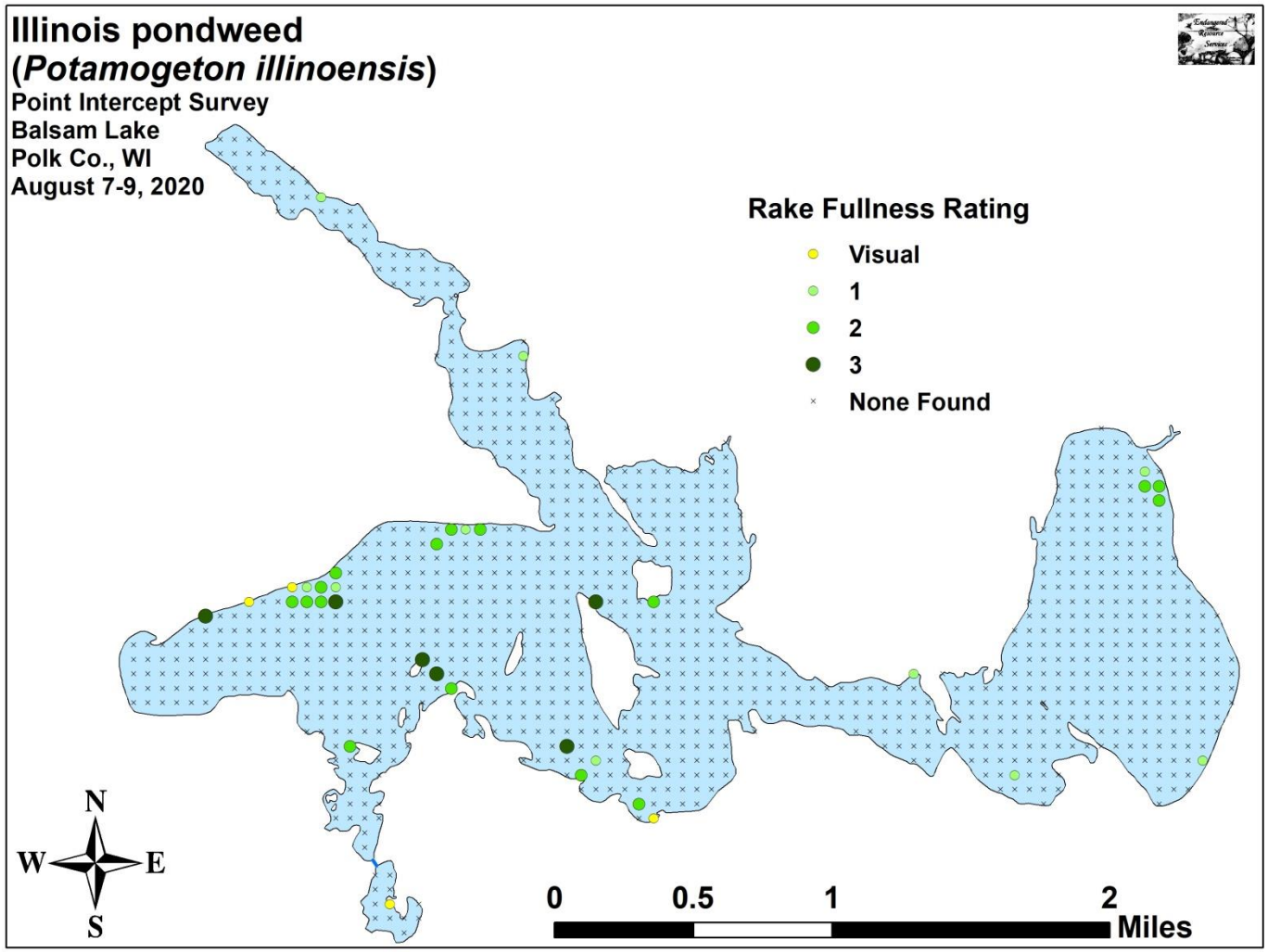
Miles


Illinois pondweed
(Potamogeton illinoensis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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None Found
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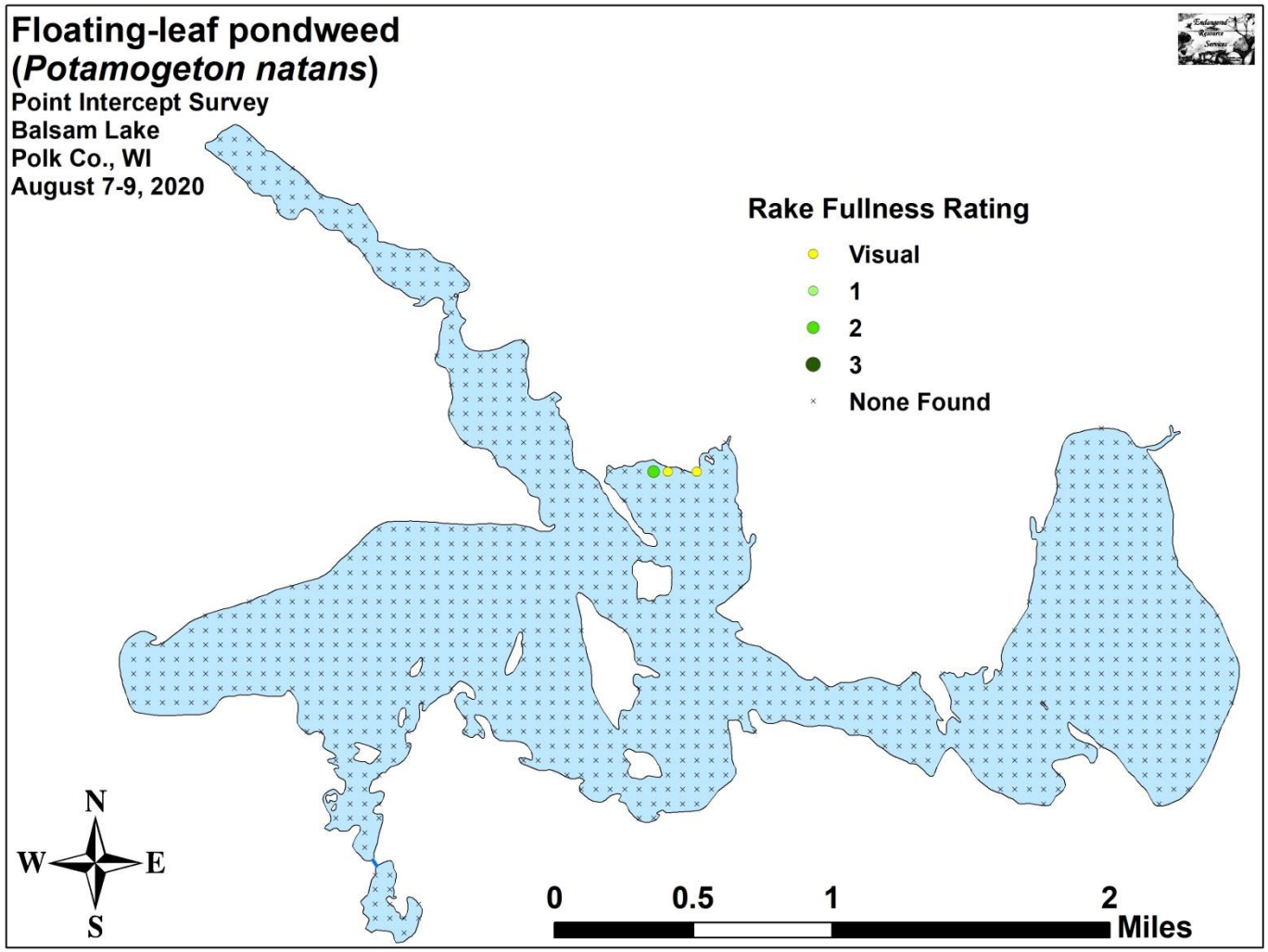
Miles


Floating-leaf pondweed
(Potamogeton natans)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
1
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None Found
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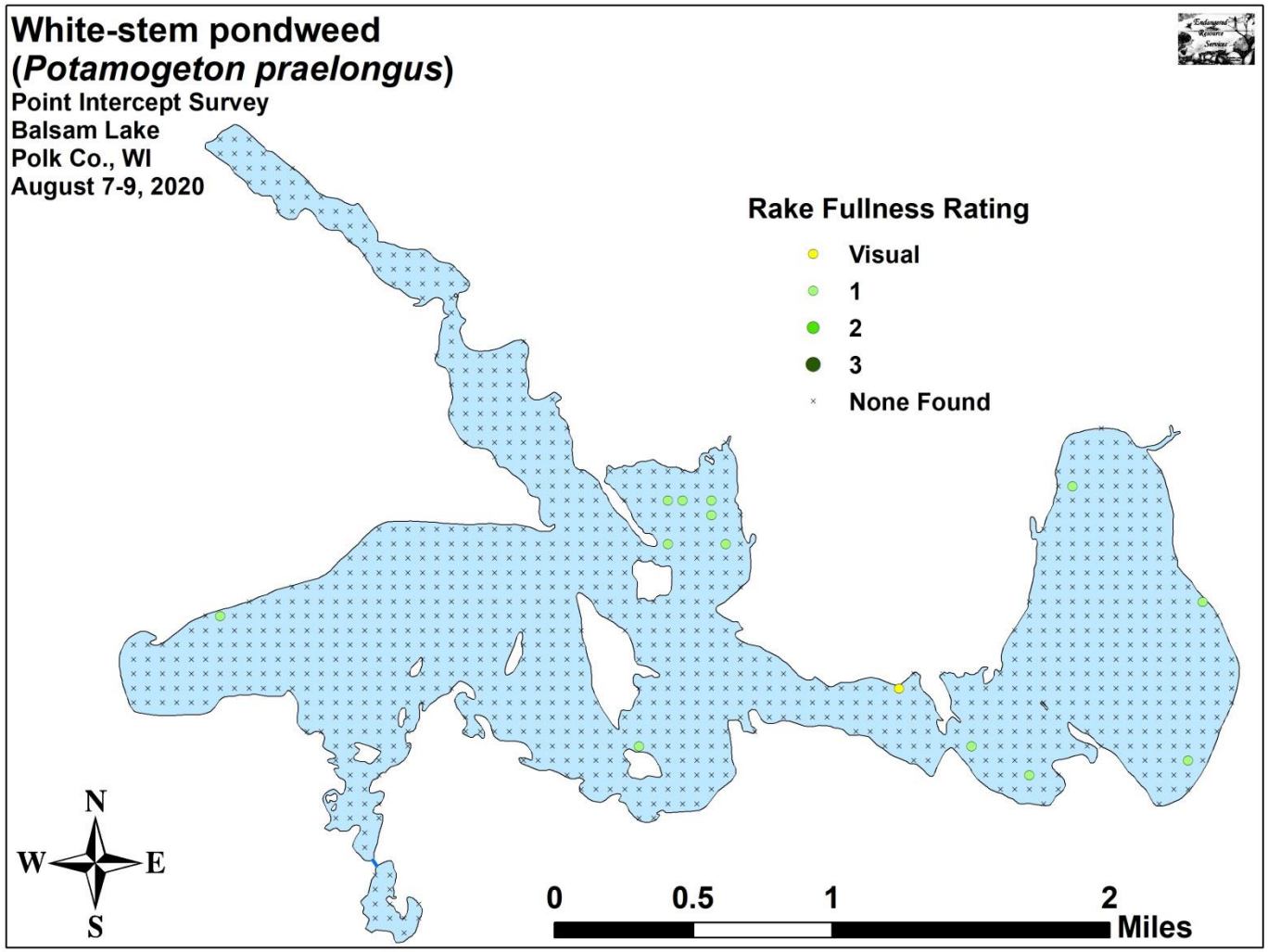
Miles


White-stem pondweed
(Potamogeton praelongus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
Visual
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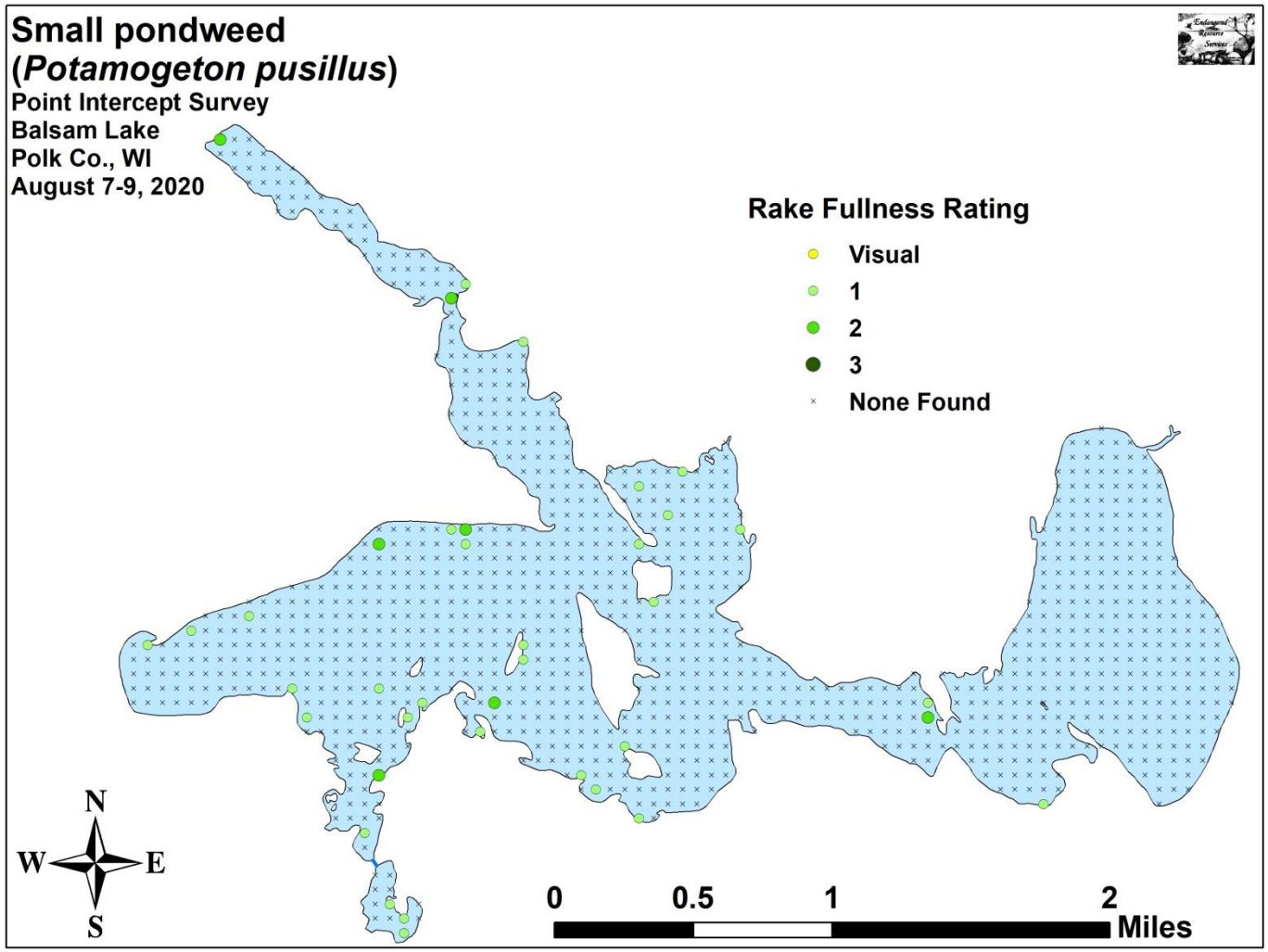
Small pondweed
(Potamogeton pusillus)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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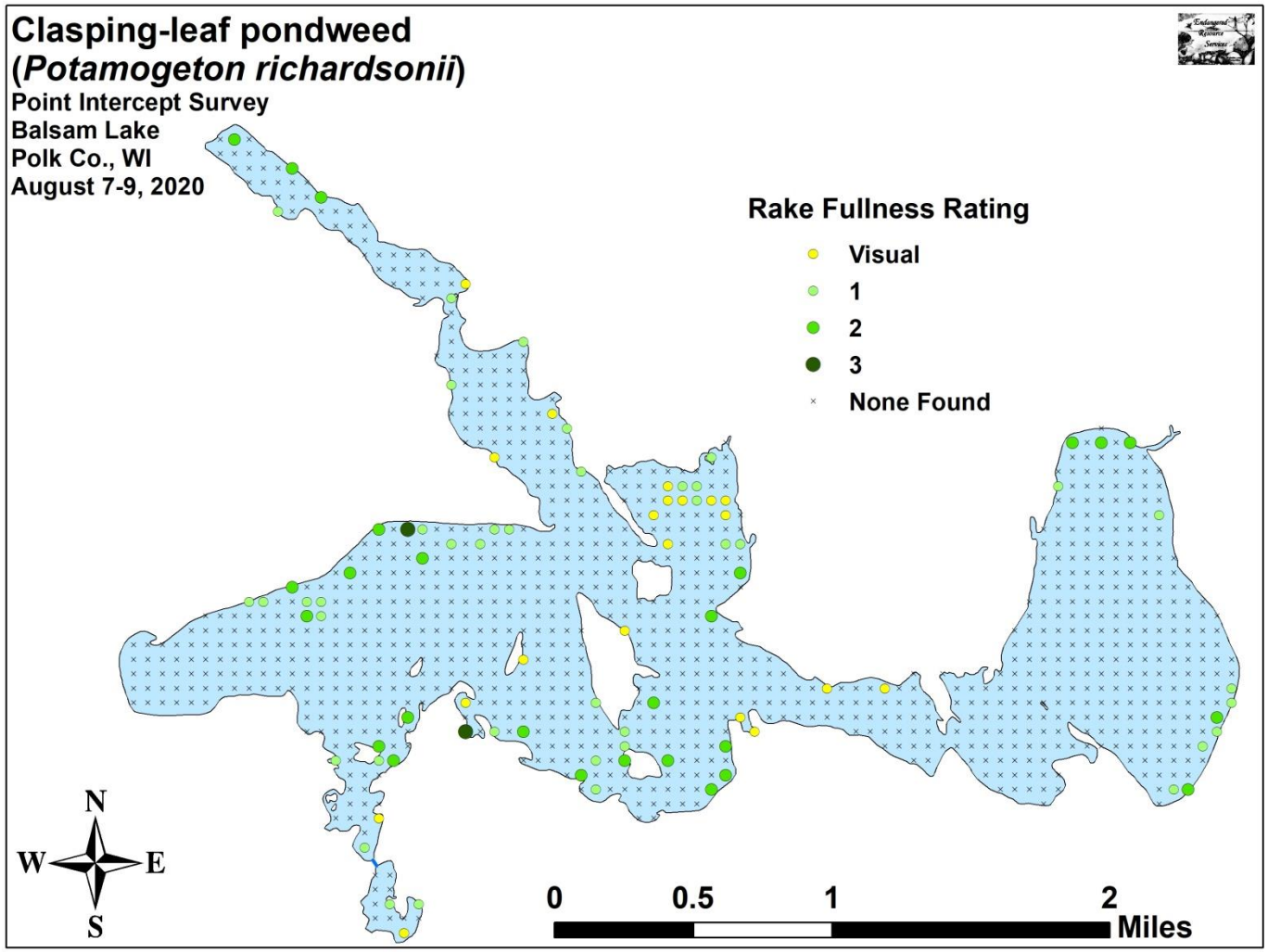
Clasping-leaf pondweed
(Potamogeton richardsonii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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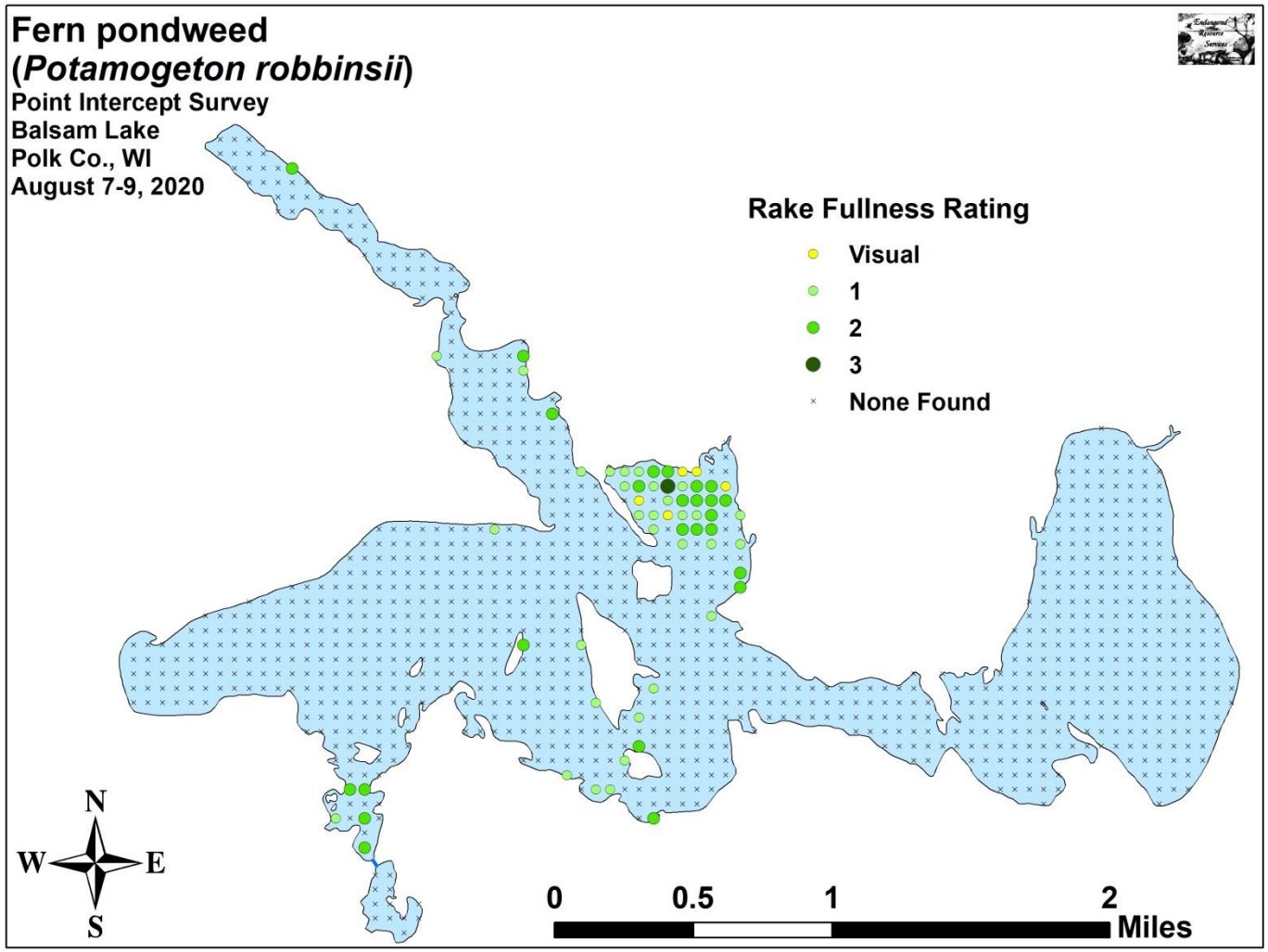
Fern pondweed
(Potamogeton robbinsii)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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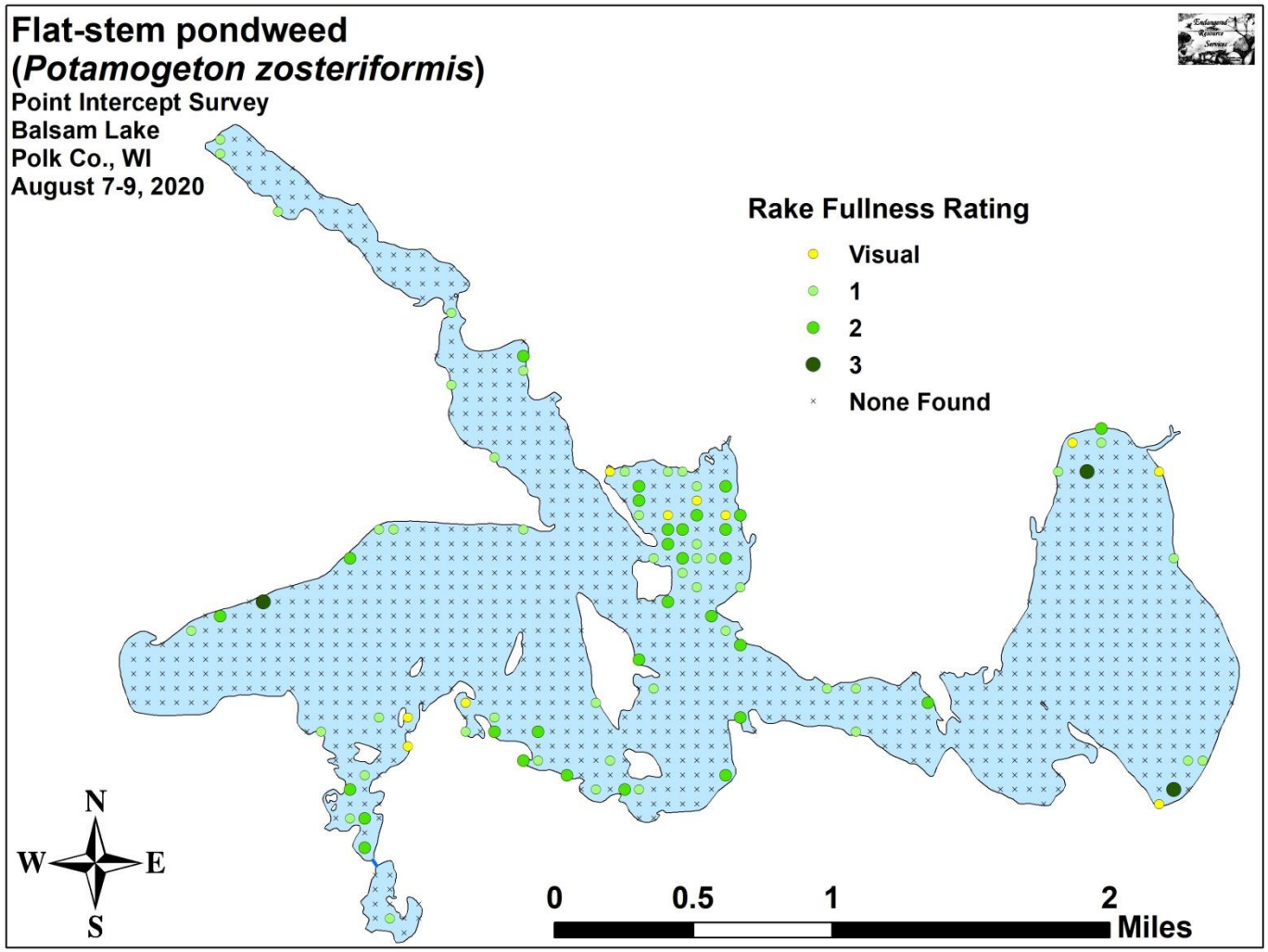
Flat-stem pondweed
(Potamogeton zosteriformis)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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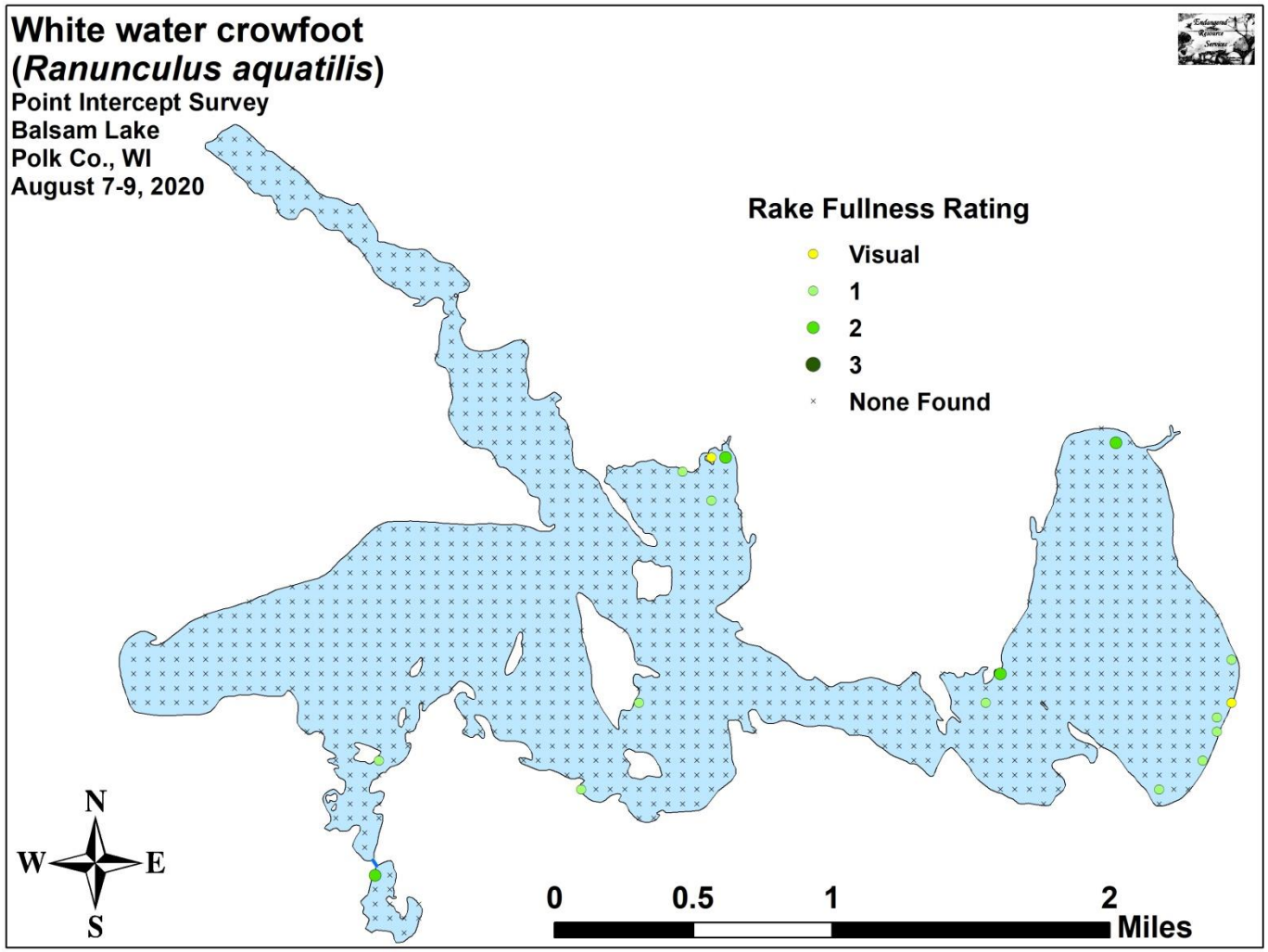
White water crowfoot
(*Ranunculus aquatilis*)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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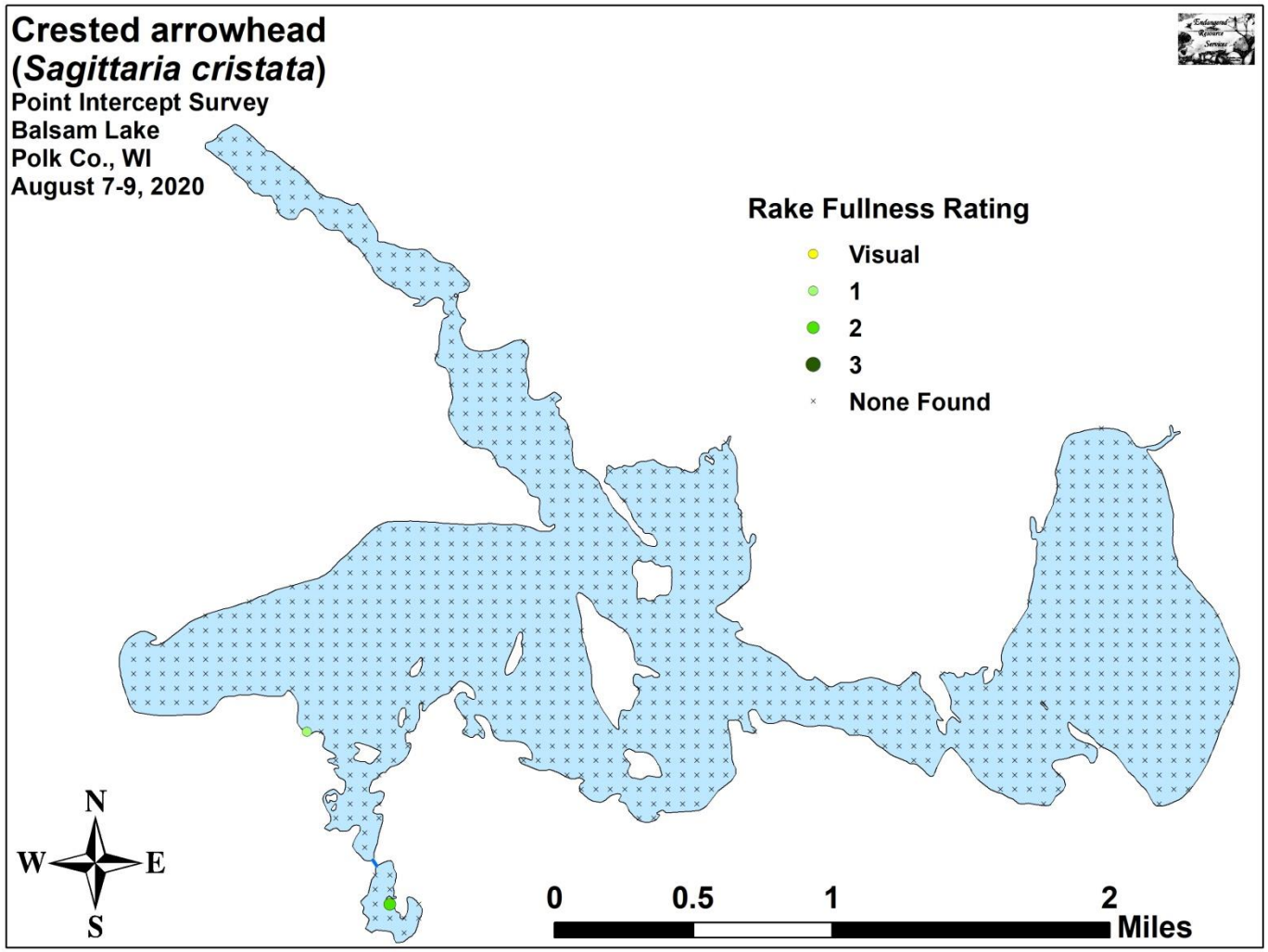
Crested arrowhead
(Sagittaria cristata)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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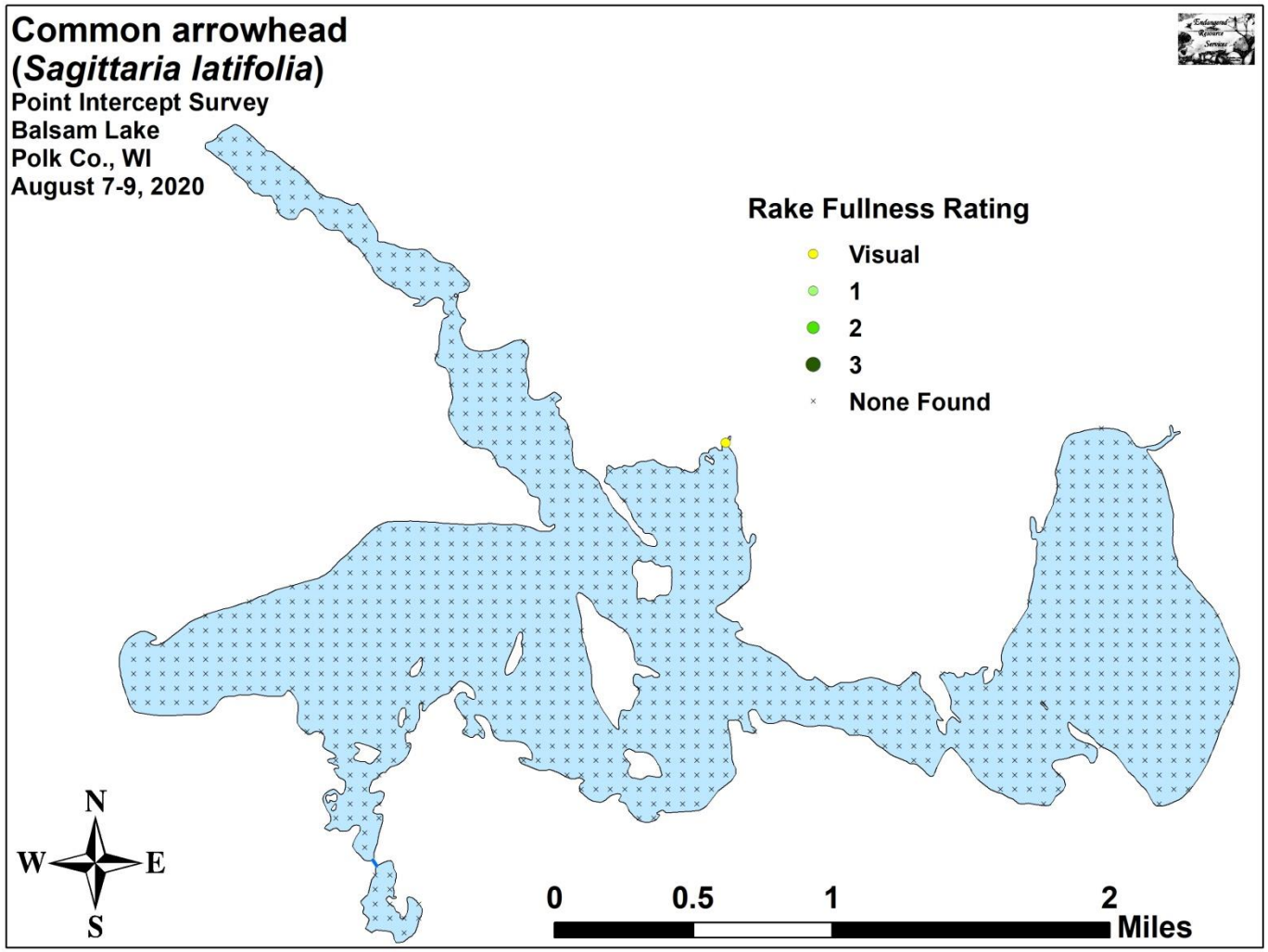
Common arrowhead
(Sagittaria latifolia)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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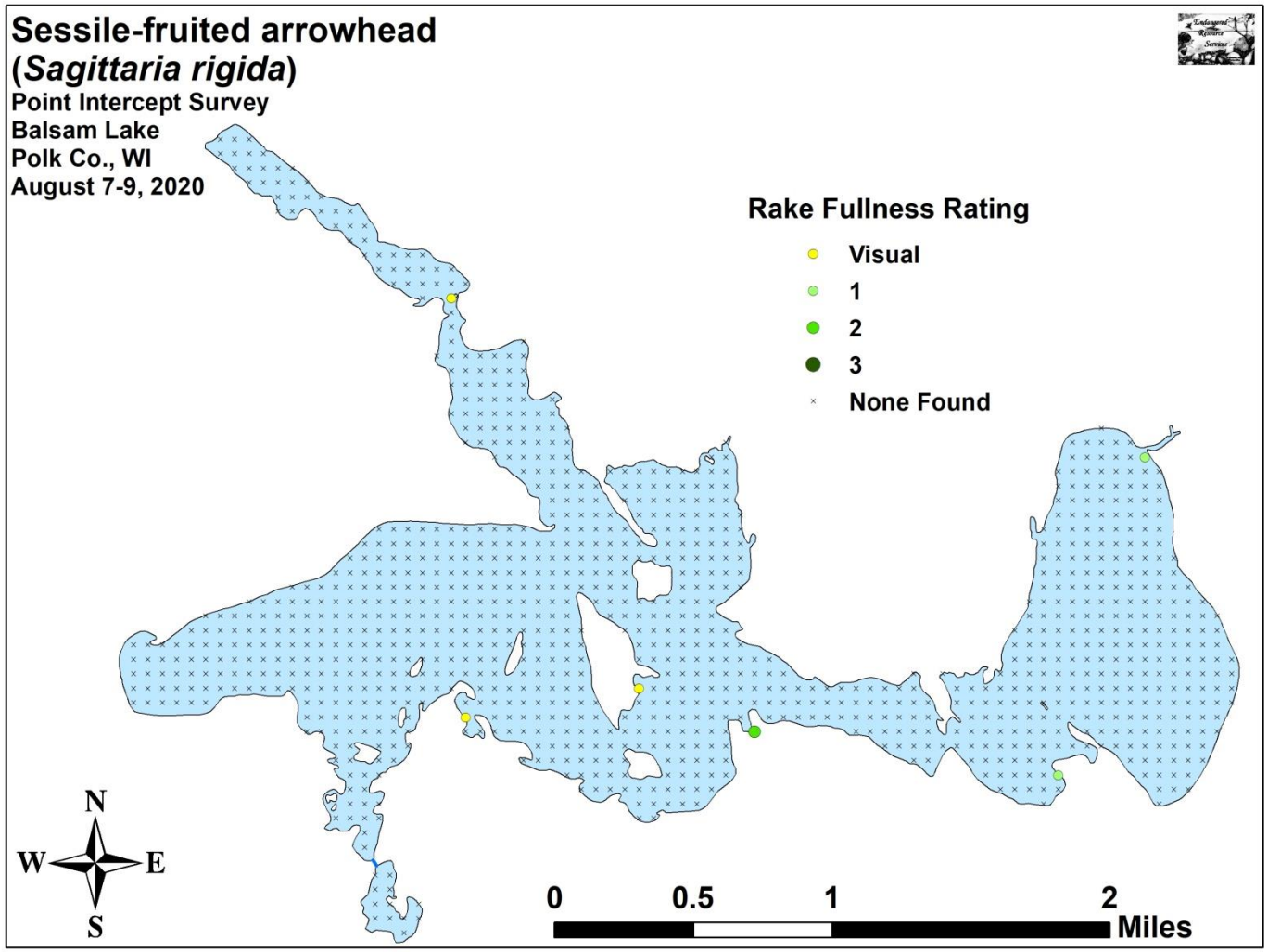
Sessile-fruited arrowhead
(Sagittaria rigida)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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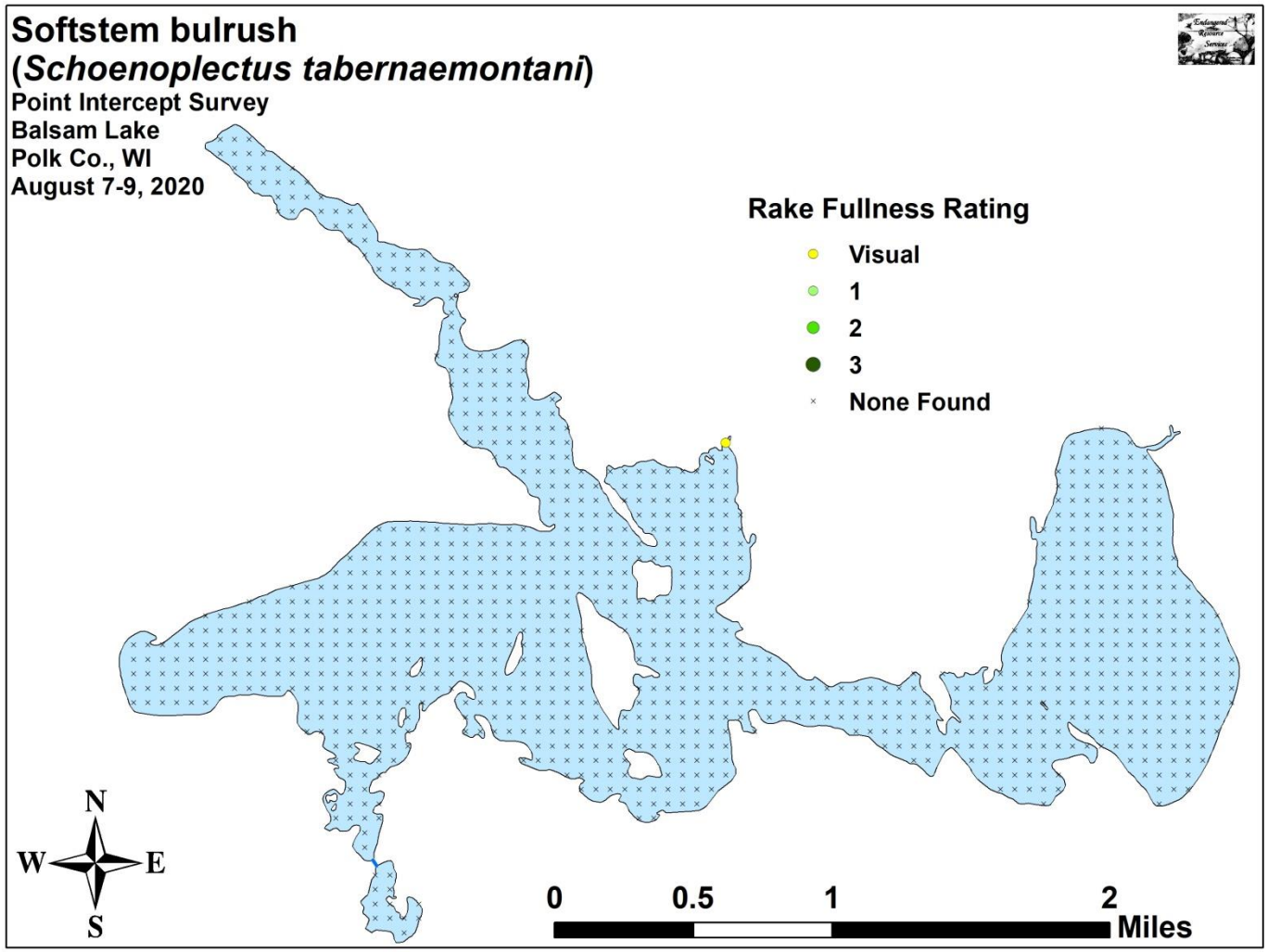
Softstem bulrush
(Schoenoplectus tabernaemontani)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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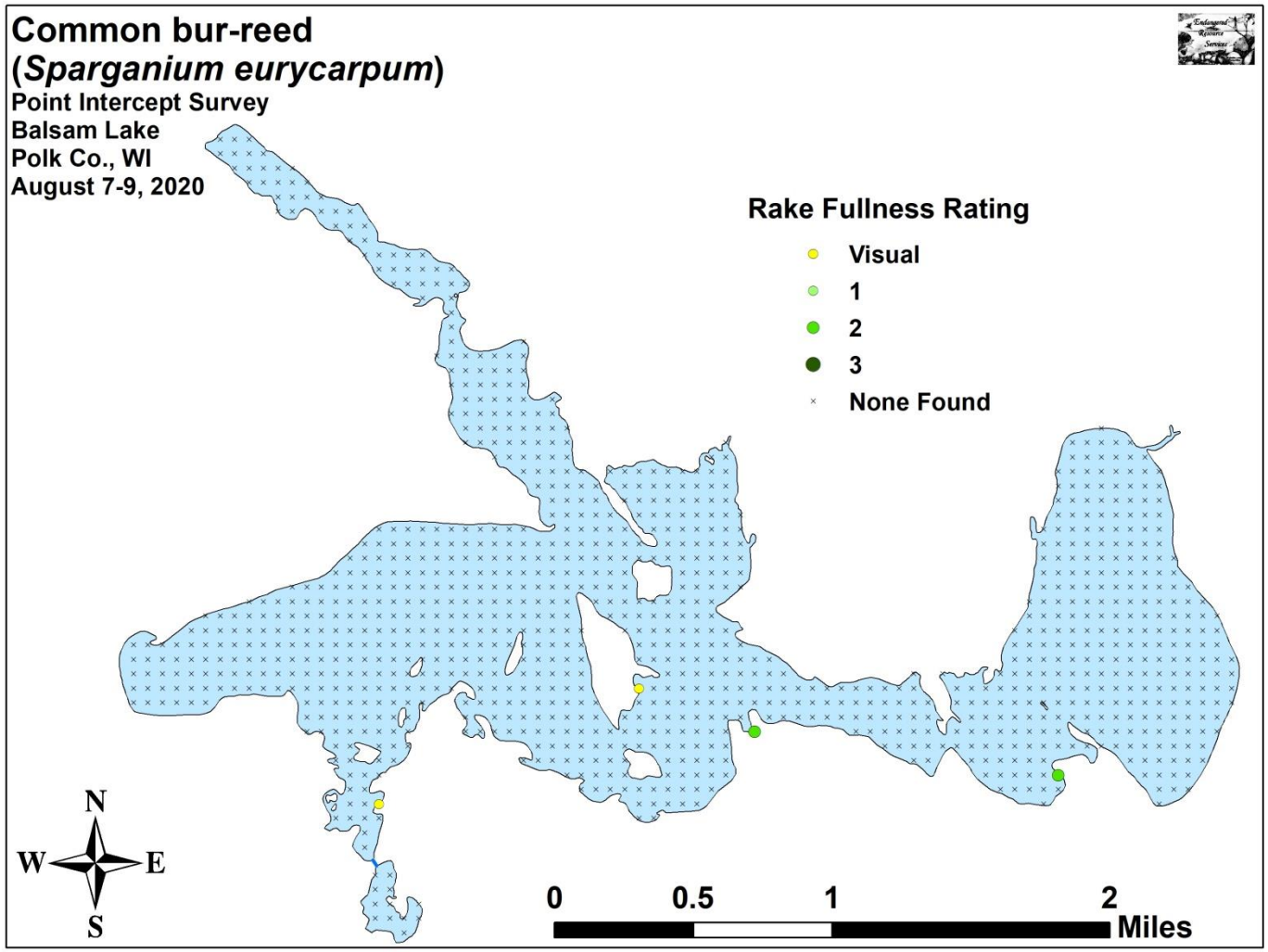
Common bur-reed
(Sparganium eurycarpum)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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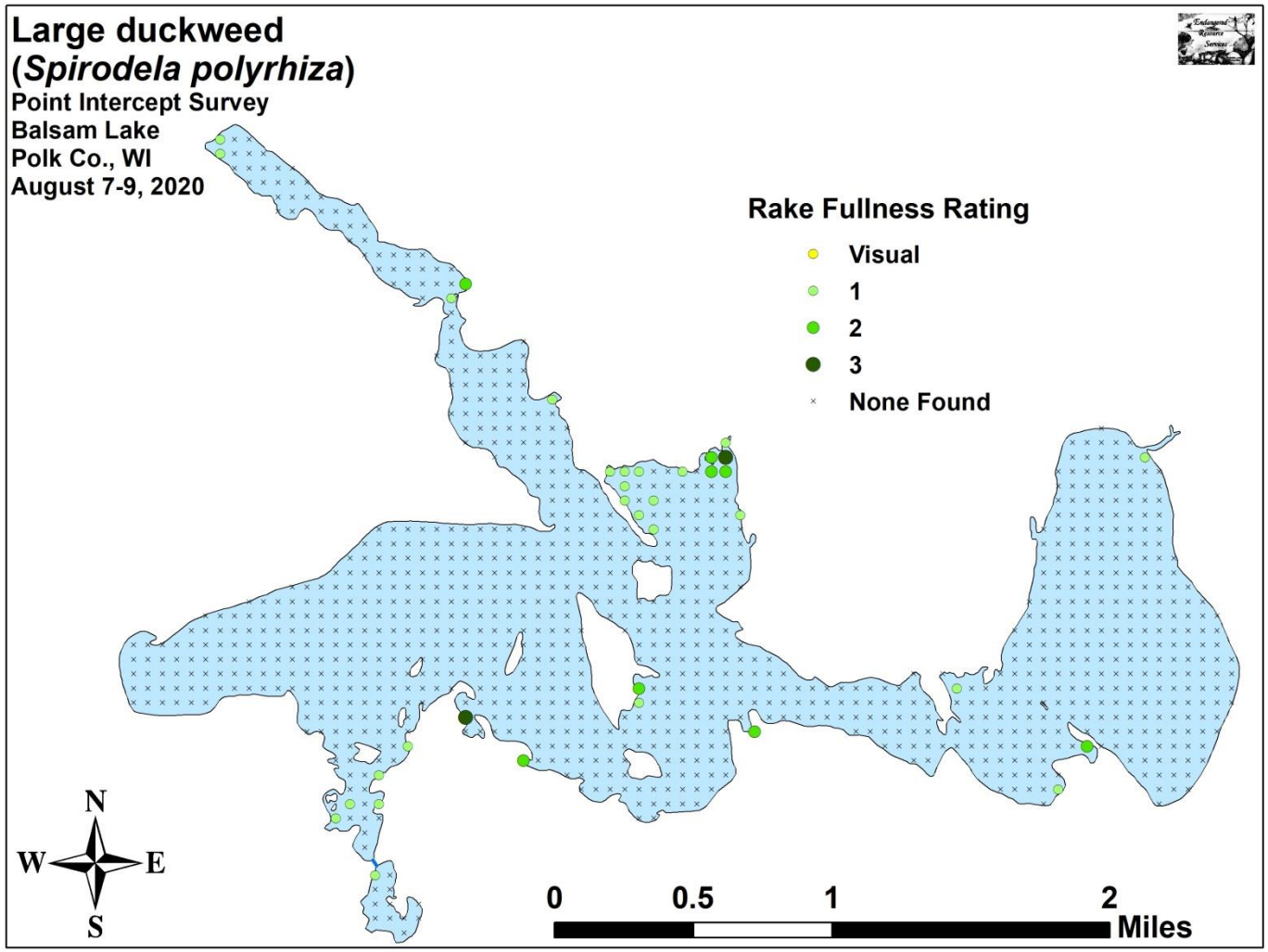
Large duckweed
(Spirodela polyrhiza)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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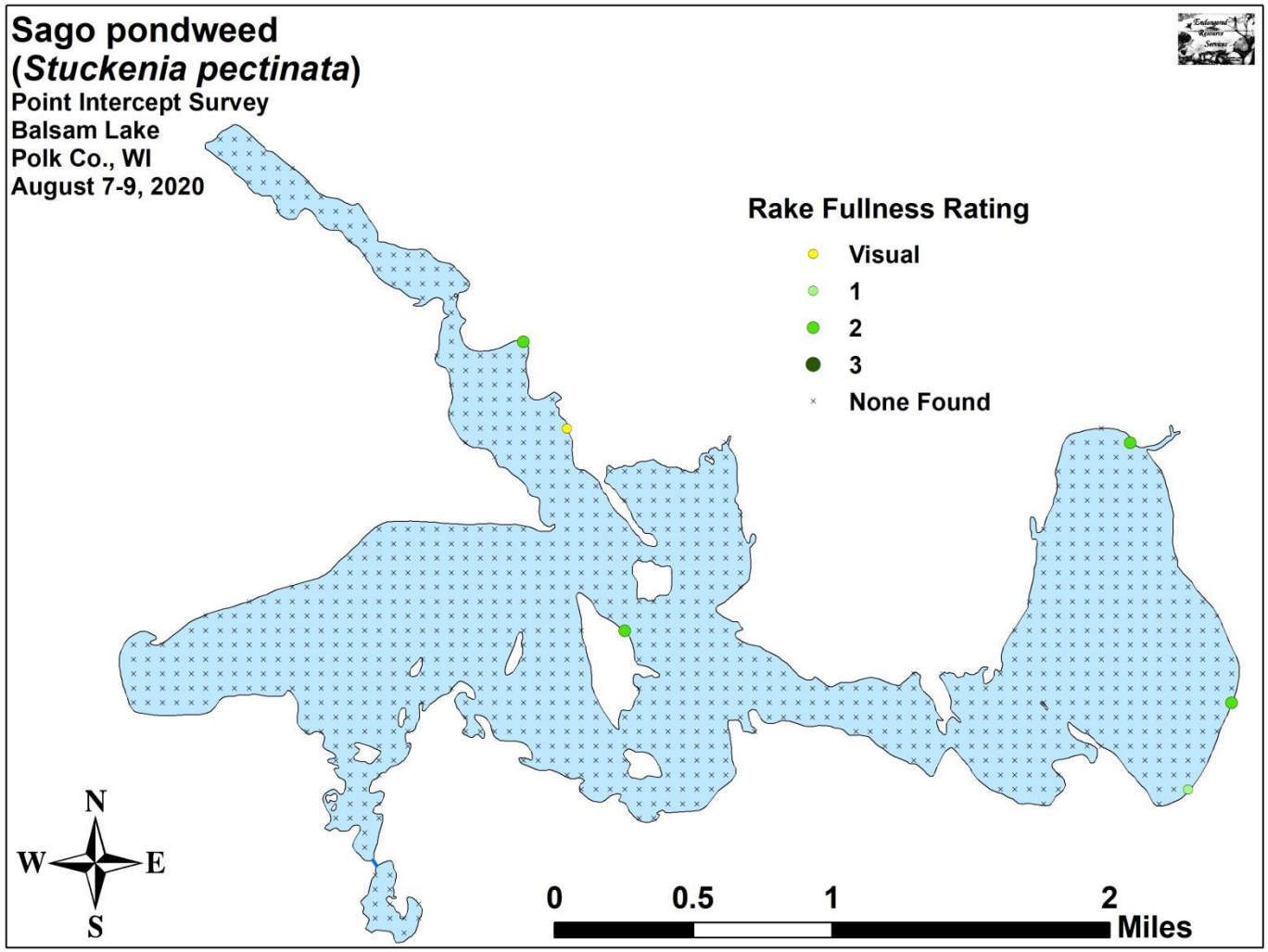
Sago pondweed
(Stuckenia pectinata)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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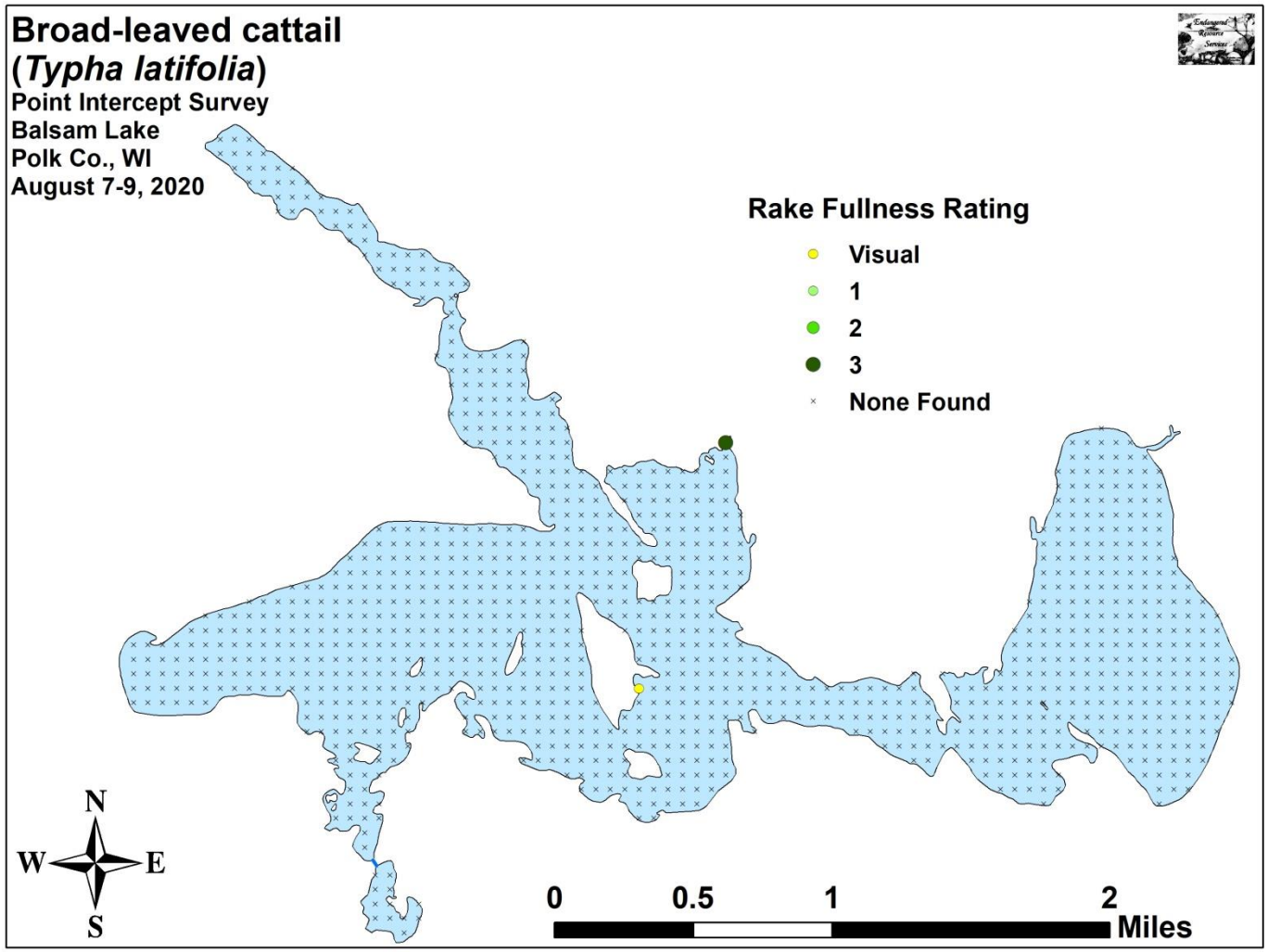
Broad-leaved cattail
(Typha latifolia)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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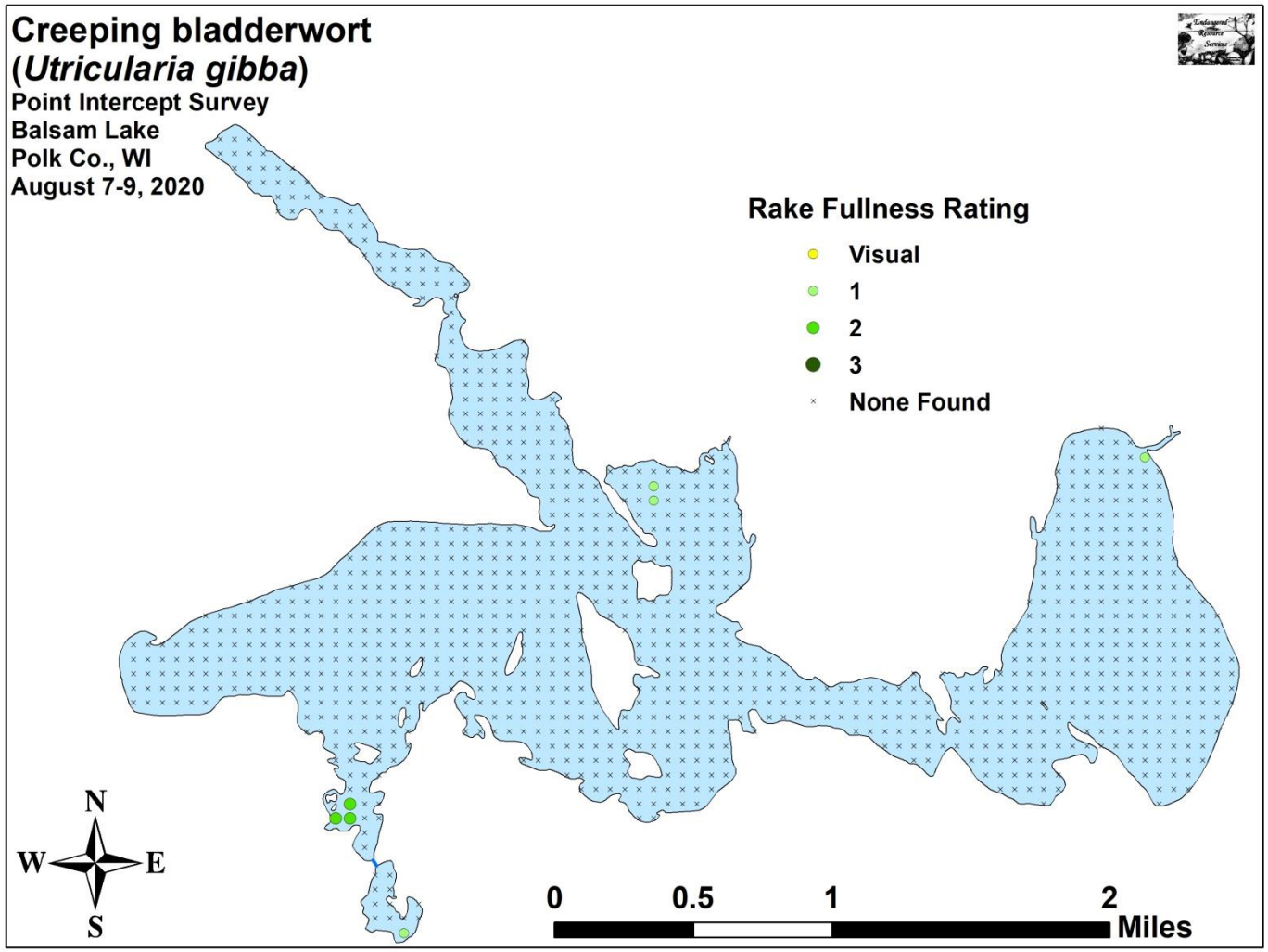
Creeping bladderwort
(Utricularia gibba)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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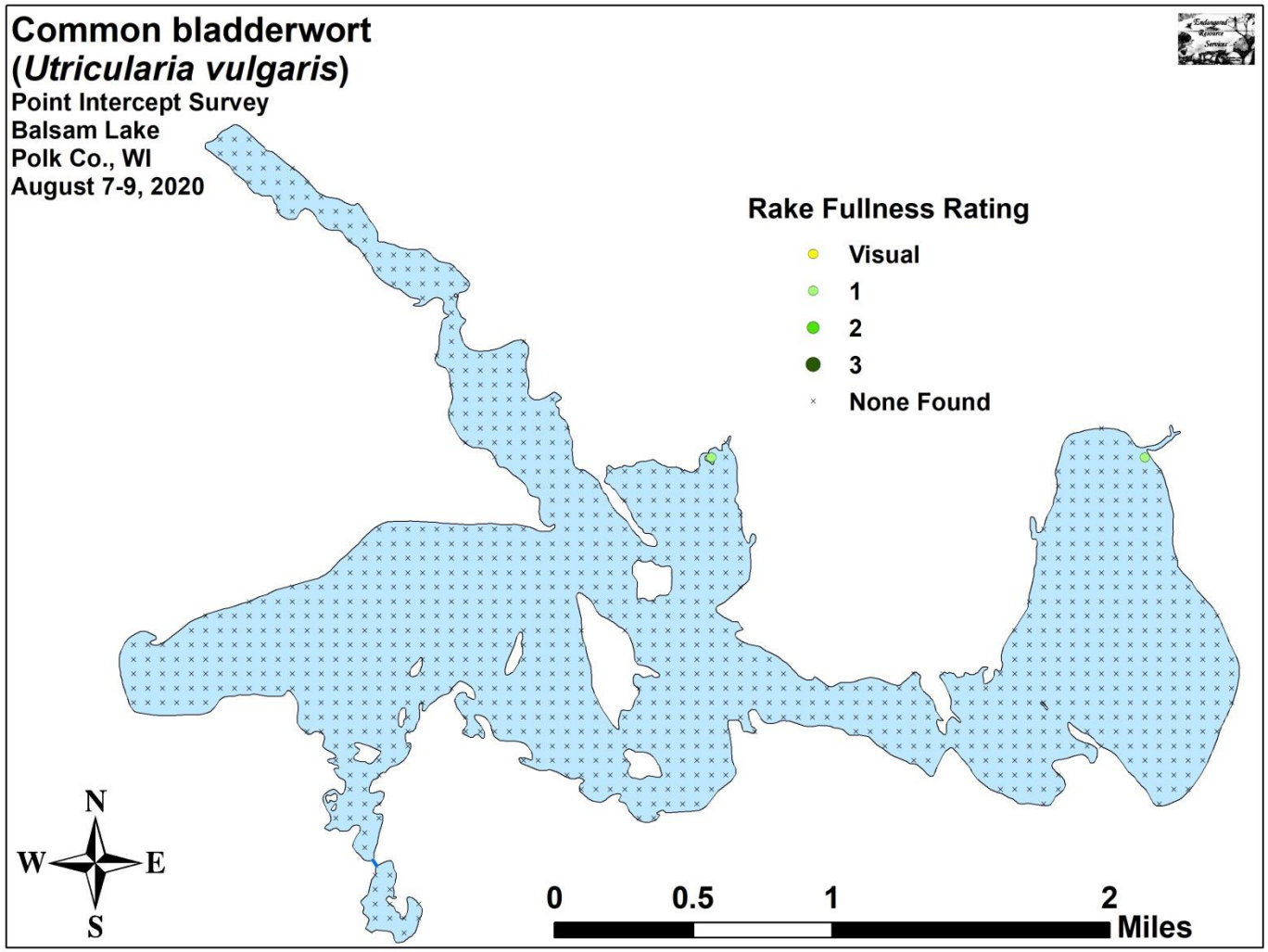
Common bladderwort
(Utricularia vulgaris)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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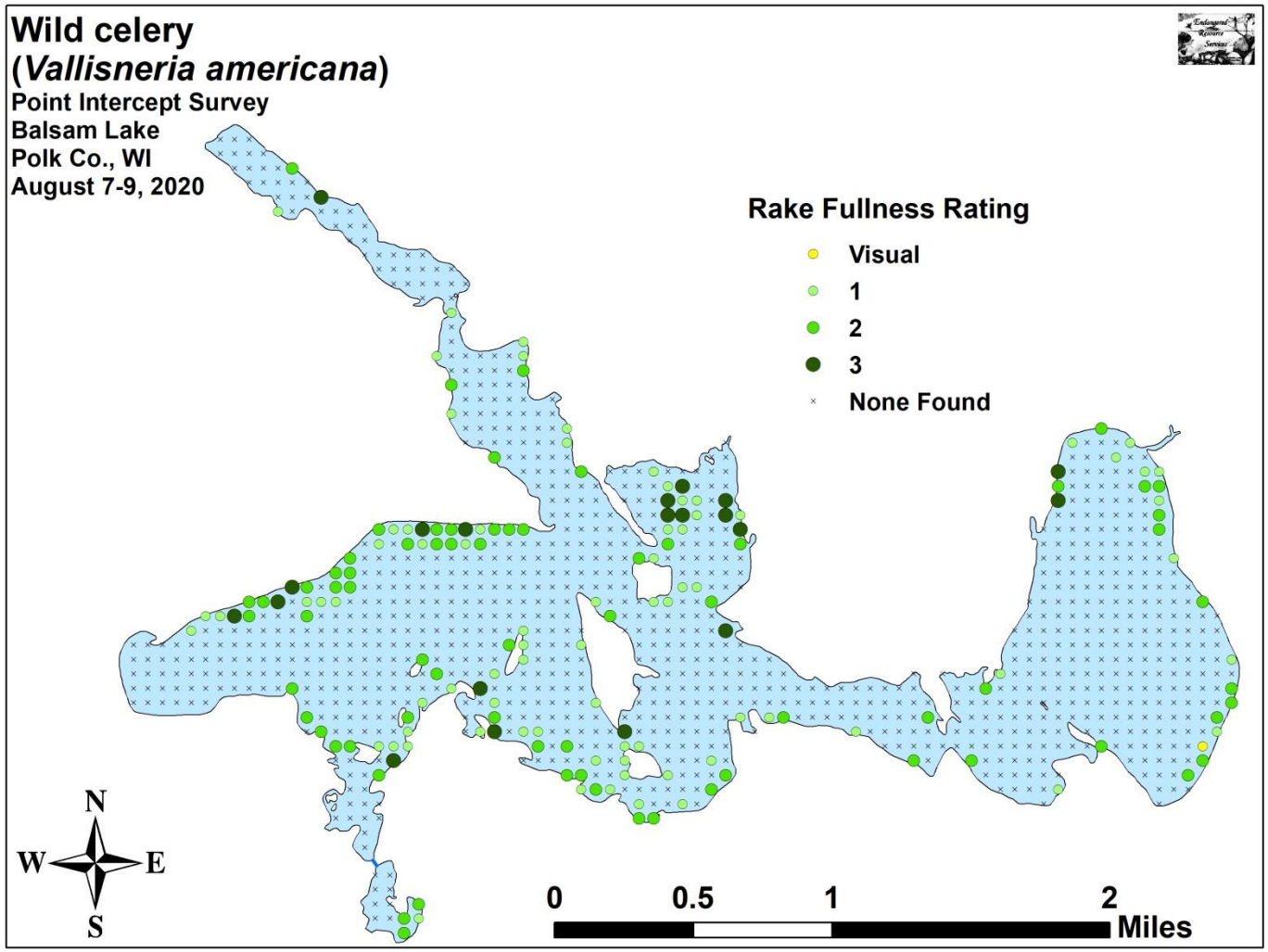
Wild celery
(Vallisneria americana)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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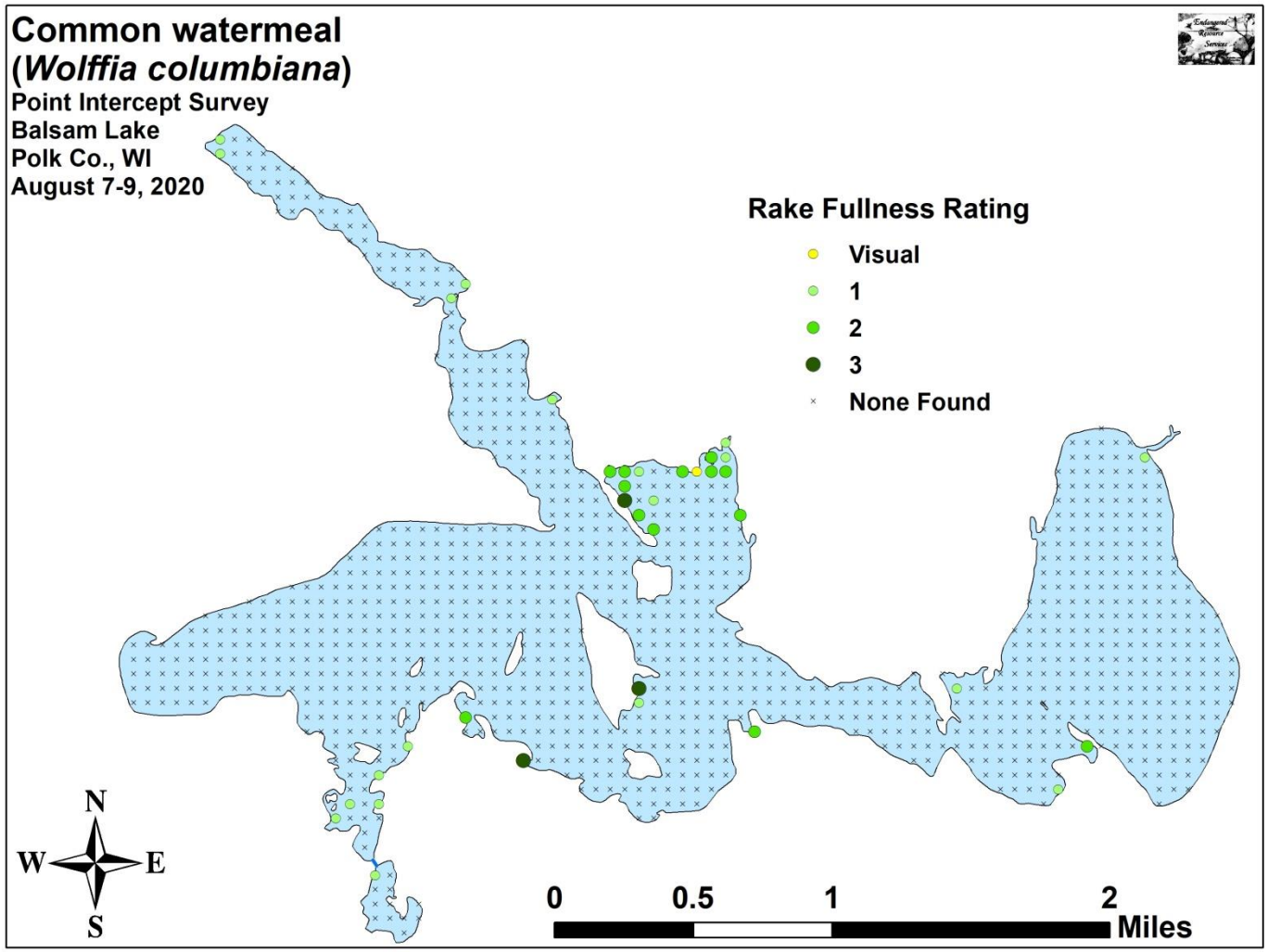
Common watermeal
(Wolffia columbiana)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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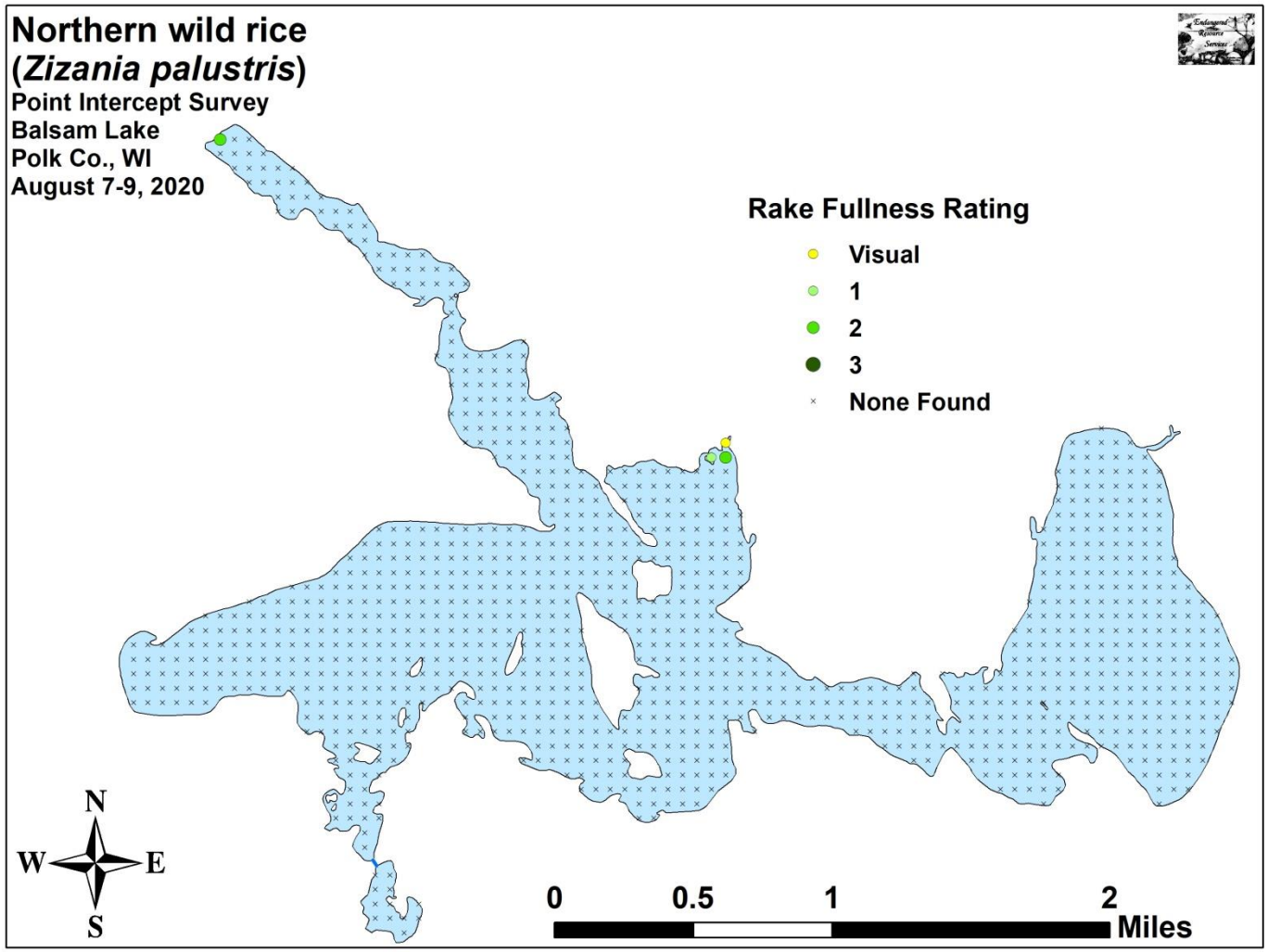
Northern wild rice
(Zizania palustris)
Point Intercept Survey
Balsam Lake
Polk Co., WI
August 7-9, 2020
Rake Fullness Rating
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Appendix VII: Aquatic Exotic Invasive Plant Species Information

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 water-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 July.

DISTRIBUTION AND HABITAT: Curly-leaf pondweed is commonly found in alkaline and high nutrient waters, preferring soft substrate and shallow water depths. It tolerates low light and low water temperatures. It has been reported in all states but Maine

LIFE HISTORY AND EFFECTS OF INVASION: Curly-leaf pondweed spreads through burr-like winter buds (turions), which are moved among waterways. These plants can also reproduce by seed, but this plays a relatively small role compared to the vegetative reproduction through turions. New plants form under the ice in winter, making curly-leaf pondweed one of the first nuisance aquatic plants to emerge in the spring.

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out compete native plants in the spring. In mid-summer, when most aquatic plants are growing, curly-leaf pondweed plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. Curly-leaf pondweed forms surface mats that interfere with aquatic recreation. (Taken in its entirety from WDNR, 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 VIII: 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 IX: 2020 Raw Data Spreadsheets