Point-intercept Macrophyte Survey and Hybrid Eurasian water-milfoil (*Myriophyllum spicatum X sibiricum*) Shoreline Survey/Manual Removal

Namekagon Lake – WBIC: 2732600 - Bayfield County, Wisconsin

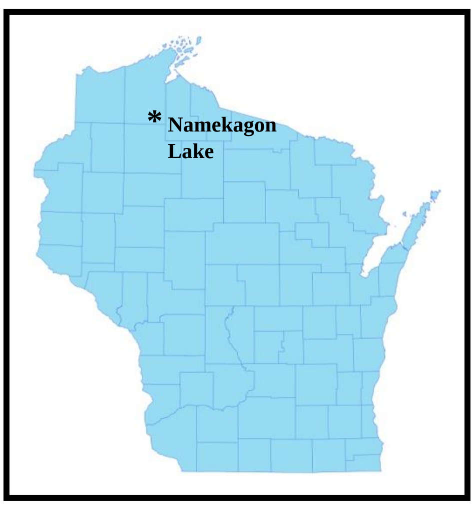
Namekagon Lake Aerial Photo (2015)

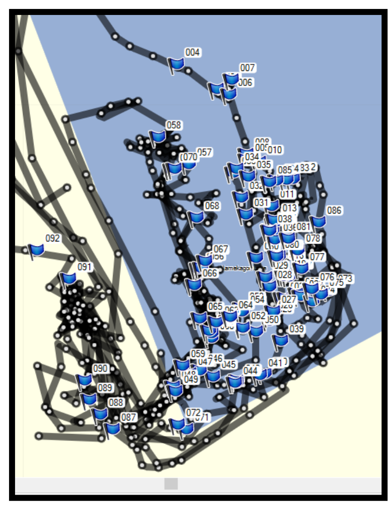
Typical Rake of Wild Celery (Berg 2016)

HWM with 24-30 Leaflets (Berg 2016)

Project Initiated by:

The Wisconsin Department of Natural Resources, the Namekagon Lake Association, and the Bayfield County Land & Water Conservation Department





HWM Plant - Locations of HWM Removed from Northwoods Marina (8/25/16)

Survey Conducted by and Report Prepared by:

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Saint Croix Falls, Wisconsin
August 23-25, 2016

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ABSTRACT

Namekagon Lake (WBIC 2732600) is a 2,897 acre eutrophic drainage lake located in south-central Bayfield County, WI. In June 2016, Hybrid Eurasian X Northern water-milfoil (*Myriophyllum spicatum* X *sibiricum*) (HWM) was discovered at the Northwoods Marina Landing. Following DNA confirmation in July, Wisconsin Department of Natural Resources (WDNR) and the Sawyer County Land and Water Conservation Department (SCLWCD) completed a shoreline survey of the lake on August 15th during which they found a few scattered plants in the bay southwest of Paine's Island and two additional plants in the bay near the river outlet. This was followed by hand removal efforts coordinated and overseen by the WDNR (Pamela Toshner – Regional Lake Biologist), SCLWCD (Andrew Teal – Bayfield County Aquatic Invasive Species Coordinator), and the University of Wisconsin Extension (Paul Skawinski - Citizen Lake Monitoring Network) on both August 15th and 23rd. On these dates, volunteers from the Namekagon Lake Association (NLA) and employees from the Northwoods Resort removed dozens of plants. In anticipation of developing an Aquatic Plant Management Plan in 2017 to guide a response to the new infestation, we were asked to complete a full warm-water point-intercept macrophyte survey. The goals of the survey were to establish data on the richness, diversity, abundance and distribution of native aquatic plant populations; document the current density of HWM within its known distribution; remove as many HWM plants as possible; search for additional HWM populations; and report any other exotic species found. During the August 23-25, 2016 survey, we found macrophytes growing to 11ft. Within this littoral zone, plants were present at 387 of the 515 littoral points (75%). Overall diversity was high with a Simpson Index value of 0.90. Total richness was moderate with 60 species found growing in and immediately adjacent to the water (48 species in the rake). Localized richness was also moderate with a mean native species/site with vegetation of 2.68. Plant density was moderately low as we found a mean rake fullness of 1.73 at sites with vegetation. Wild celery (*Vallisneria americana*), Variable pondweed (*Potamogeton gramineus*), Clasping-leaf pondweed (*Potamogeton richardsonii*), and Northern water-milfoil (*Myriophyllum sibiricum*) were the most common species being found 73.64%, 19.38%, 18.35%, and 15.50% of survey points with vegetation and accounting for 47.35% of the total relative frequency. The 43 native index species found in the rake produced a mean Coefficient of Conservatism of 6.5 and a Floristic Quality Index of 42.5. For this part of the state, this was slightly below the mean C of 6.7, but much above the median FQI of 24.3. HWM was not found in the rake at any point, and no new populations were found anywhere in the lake. However; we rake removed 89 additional plants at the Northwoods Marina, and three plants in the bay southeast of Paine's island. No other exotics were found in the rake, but we saw four additional species during the boat survey. We removed a single Purple loosestrife (*Lythrum salicaria*) plant near the river outlet; we located Common forget-me-not (*Myosotis scorpioides*) around cold-water seeps east of the Northwoods Marina; we found several small beds of Common reed (*Phragmites australis subsp. americanus* likely) although they appeared to be the native less invasive form; and we mapped a patch of approximately 50 Hybrid cattail (*Typha* X *glauca*) plants on the north shore of Mumm's Bay. Filamentous algae were present at 13 sites (mean rake 1.46). Future management considerations include working to slow the spread of HWM by continuing manual removal at known locations; educating as many residents as possible to look for new beds; potentially organizing systematic survey efforts to search for additional HWM; and continuing to monitor, and, if possible, remove Purple loosestrife, Hybrid Cattail, and any other new exotics like Yellow iris (*Iris pseudacorus*) should they be found on the lake.

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INTRODUCTION:

Namekagon Lake (WBIC 2732600) is a 2,897 acre drainage lake in south-central Bayfield County, Wisconsin in the Towns of Namekagon and Grand View (T43/44N R5/6W). The lake has a maximum depth of 51ft and an average depth of approximately 16ft. It is eutrophic bordering on mesotrophic in nature, and water clarity is generally fair with Summer Secchi readings ranging from 6-14ft and averaging 8.0ft in the deep hole northeast of Paine's Island over the past 21 years (Figure 1) (WDNR 2016). This clarity produced a littoral zone that extended to approximately 11.0ft in August 2016. The lake's bottom substrate is variable with sand and rock occurring along the majority of shorelines and around the lake's numerous islands, while sandy and organic muck dominate the deep flats and sheltered bays (Holt et al. 1971).

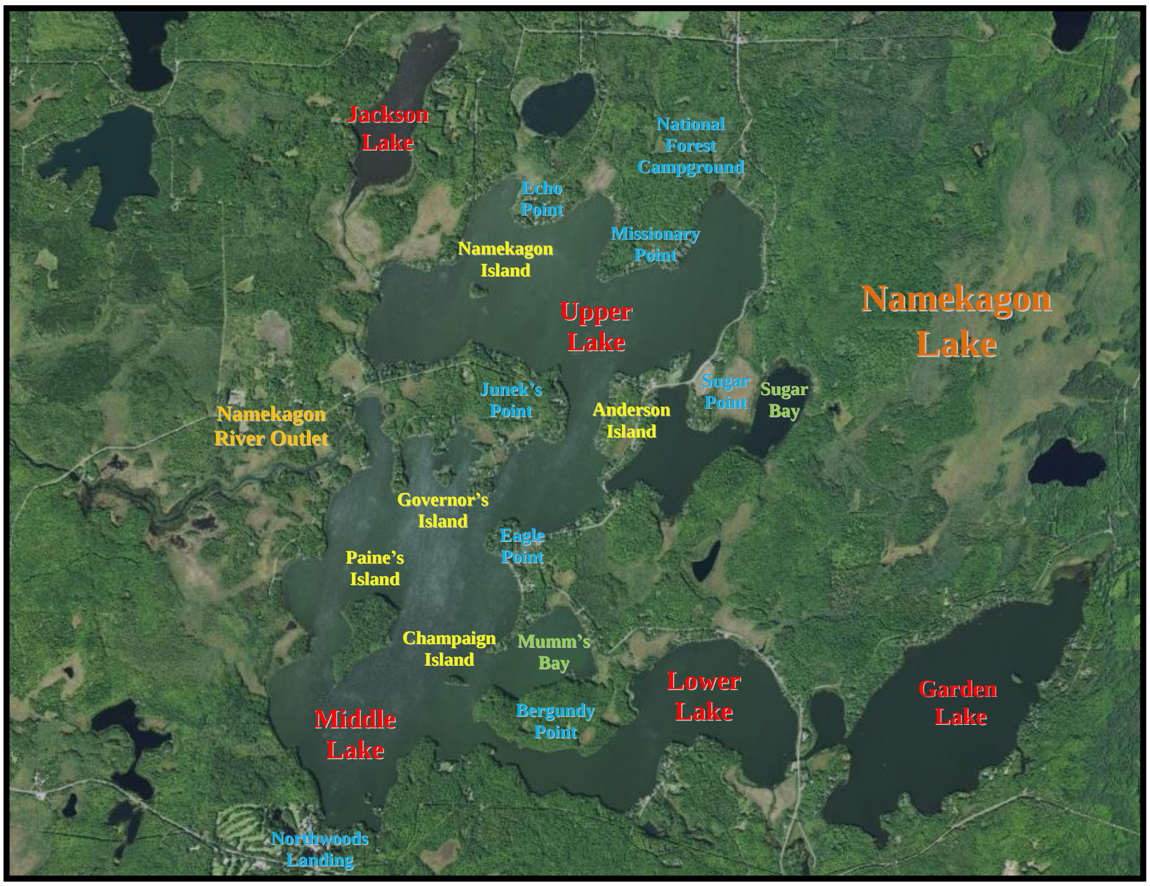


Figure 1: Namekagon Lake Aerial Photo

STUDY BACKGROUND AND RATIONALE:

On June 17, 2016, while doing bird surveys on the lake, we discovered plants at the Northwoods Marina Landing that looked to be intermittent between the exotic invasive Eurasian water-milfoil (*Myriophyllum spicatum*) and native Northern water-milfoil (*Myriophyllum sibiricum*). Wisconsin Department of Natural Resources (WDNR) and Sawyer County Land and Water Conservation Department (SCLWCD) immediately followed-up with a collection of plants on June 20th that were sent to the state lab where DNA analysis confirmed them as Hybrid water-milfoil (HWM) on July 15th.

On August 15th, a team of professionals from the WDNR and SCLWCD conducted a shoreline survey of the lake. They found and rake removed a few scattered plants in the bay immediately northwest of the Northwoods Marina Landing/southwest of Paine's Island as well as two additional plants in the bay near the river outlet (Figure 2). This survey was followed by hand removal efforts coordinated and overseen by the WDNR (Pamela Toshner – Regional Lake Biologist), SCLWCD (Andrew Teal – Bayfield County Aquatic Invasive Species Coordinator), and the University of Wisconsin Extension (Paul Skawinski - Citizen Lake Monitoring Network) on both August 15th and 23rd. On these dates, volunteers from the Namekagon Lake Association (NLA) and employees from the Northwoods Resort joined the professionals in rake removing dozens of HWM plants from the marina area.

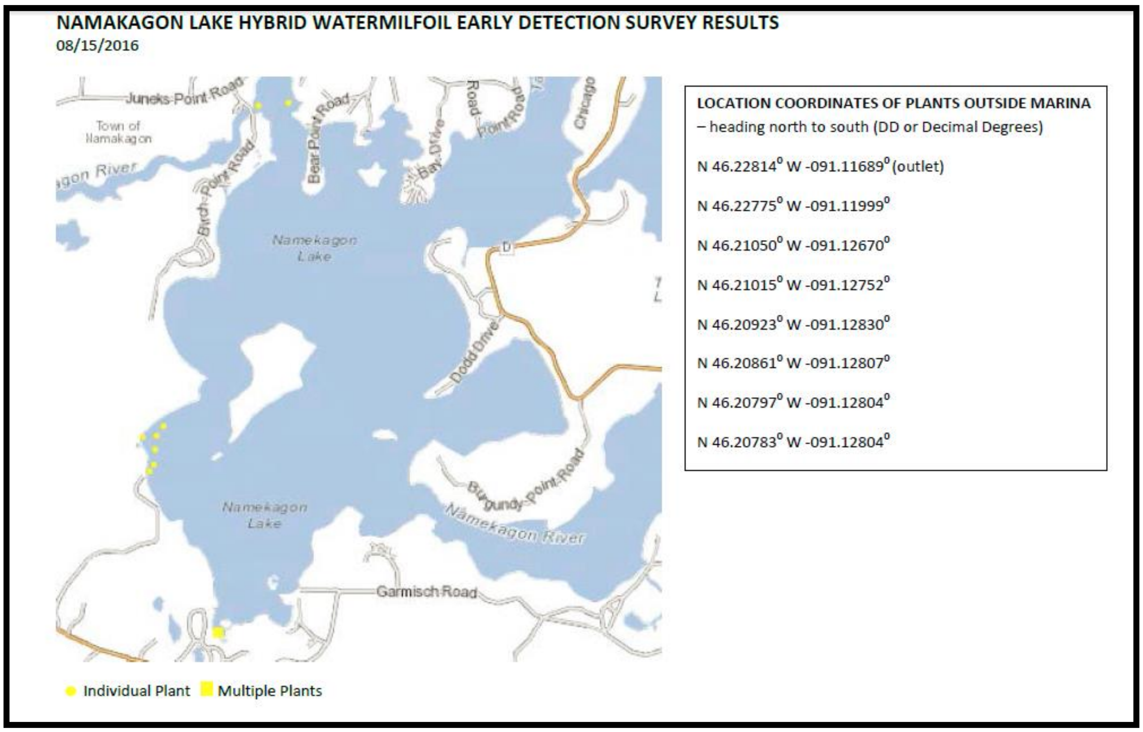


Figure 2: HWM Locations – Early Detection Survey - 8/15/16

In anticipation of developing an Aquatic Plant Management Plan (APMP) in 2017 to guide a response to the new infestation, we were asked to complete a full warm-water point-intercept macrophyte survey on Namekagon Lake. The immediate goal of the survey was to establish data on the richness, diversity, abundance and distribution of native aquatic plant populations. These data provide a baseline for long-term monitoring of the lake's macrophyte community as well as a way to measure any impacts on the lake's plants if active management occurs in the future. Other goals included documenting the current density of HWM within its known distribution, removing as many of these plants as possible, searching for additional HWM populations, and reporting any other exotic species found. This report is the summary analysis of this field survey conducted from August 23-25, 2016.

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 gain 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 2014), and a field datasheet was developed.

The 1,291 point survey sampling grid for Namekagon Lake was developed by the WDNR using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth, and total acreage (Appendix II). Using this grid, we located each point using a handheld mapping GPS unit (Garmin 76CSx), recorded a depth reading with a metered pole rake or hand held sonar (Vexilar LPS-1), and used a rake to sample an approximately 2.5ft section of the bottom. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 3). 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.

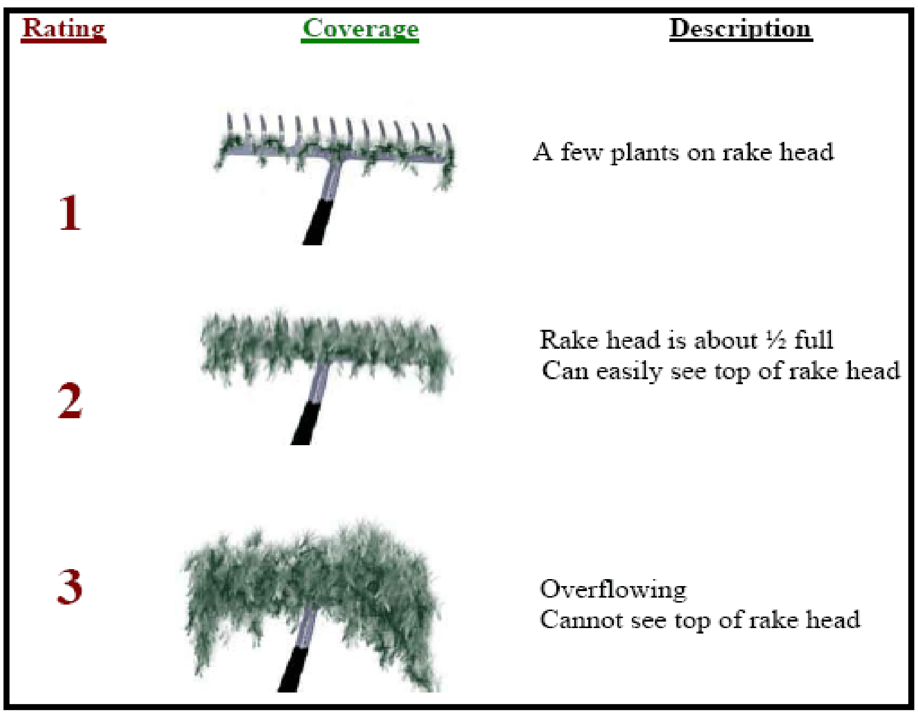


Figure 3: Rake Fullness Ratings (UWEX 2010)

Hybrid Water-milfoil Removal:

Using a telescopic rake, we removed Hybrid water-milfoil plants and disposed of them well away from the lakeshore. Care was taken to make sure we got the roots as well as any fragments that broke off the stem as even a node with a single leaflet is capable as settling to the bottom and growing an entirely new plant. In the marina, we rake removed four times over three days as stirred up sediment made it easy to miss plants.

DATA ANALYSIS:

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

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

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

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

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

Frequency of occurrence example:

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

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

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

<u>Simpson's Diversity Index:</u> 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.

<u>Maximum depth of plants:</u> 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.

<u>Mean and median depth of plants:</u> 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.

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

<u>Average number of species per site:</u> 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.

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

<u>Average rake fullness:</u> This value is the average rake fullness of all species in the rake at all sites. 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 frequency will add up to 100%. Organizing species from highest to lowest relative frequency value gives us an idea of which species are most important within the macrophyte community (Table 2).

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, Northern Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Namekagon Lake is in the Northern Lakes and Forests Ecoregion (Table 3).

**** 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.**

RESULTS:
Warm-water Full Point-intercept Macrophyte Survey:

Depth soundings taken at Namekagon Lake's 1,291 survey points revealed an extremely varied underwater topography with numerous flats, saddles, and sunken islands. With the exception of Sugar and Mumm's Bay, the north bays of the upper lake, and the finger bay near the Namekagon River outlet, most shorelines dropped off rapidly from shore into over 15ft of water (Figure 4) (Appendix III).

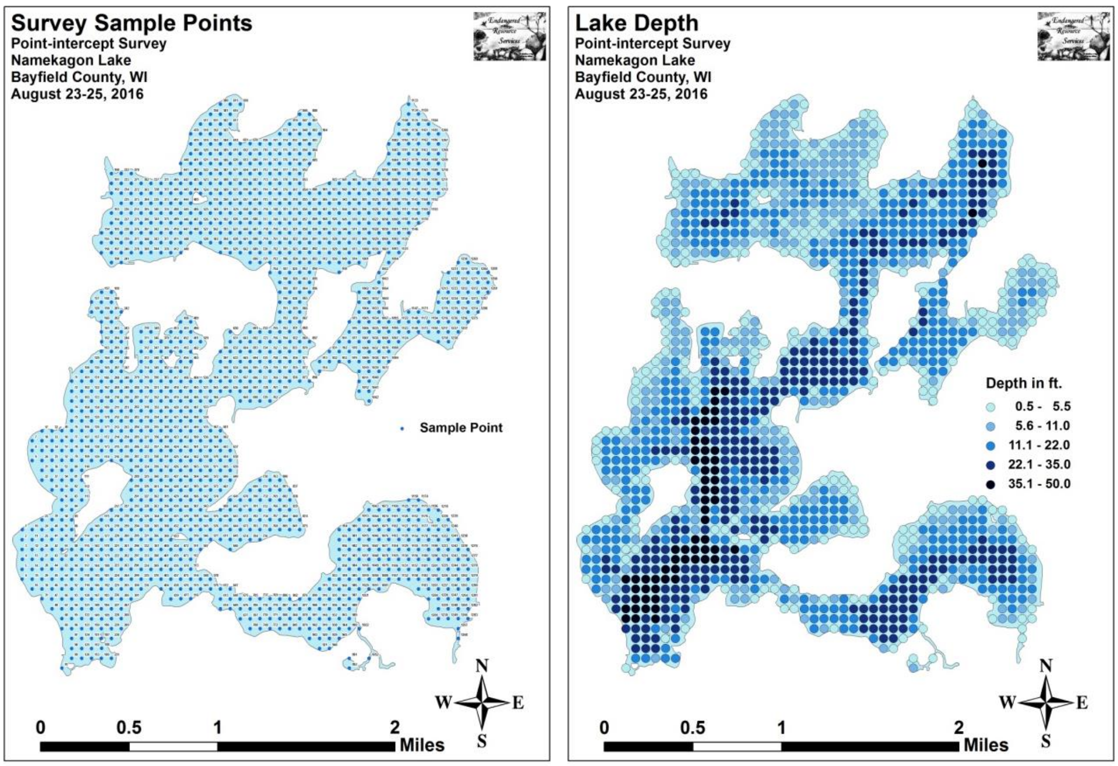
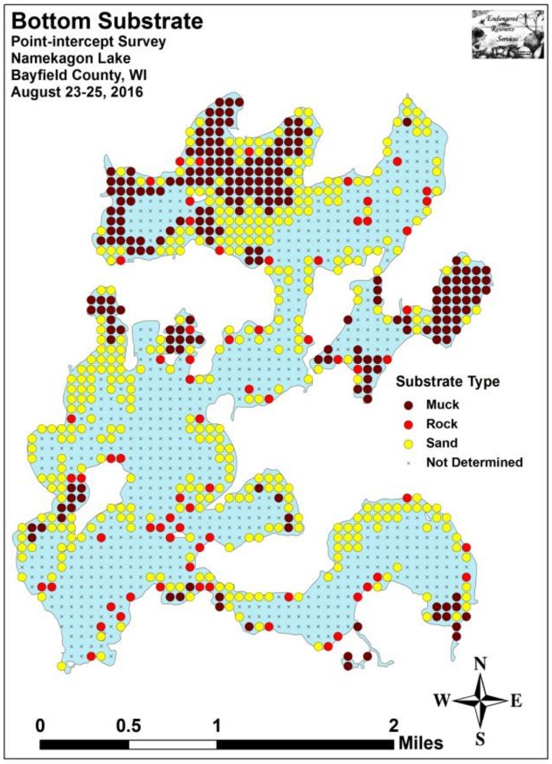


Figure 4: Survey Sample Points and Lake Depth

Nutrient poor sand and sandy muck dominated the majority of the littoral lake bottom. Most rock areas occurred around islands, on sunken islands, or along the immediate shoreline. Nutrient rick organic muck dominated Sugar Bay, the northwest bays of the upper lake near the Jackson Lake Channel, the bay in lower lake near the Garden Lake Channel, and near the river outlet (Figure 5). Collectively, we categorized the littoral bottom as 55.7% pure sand, 34.0% sandy and organic muck, and 10.3% rock (Appendix III).

At the time of the survey, Secchi disc readings were around 7ft. This fair water clarity produced a littoral zone that extended to 11.0ft with the mean and median depths of plants being 5.4ft and 5.5ft respectively (Table 1). Plant coverage was spotty with 387 out of 515 points (75.2%) having at least some macrophytes present (Figure 5) (Appendix III).



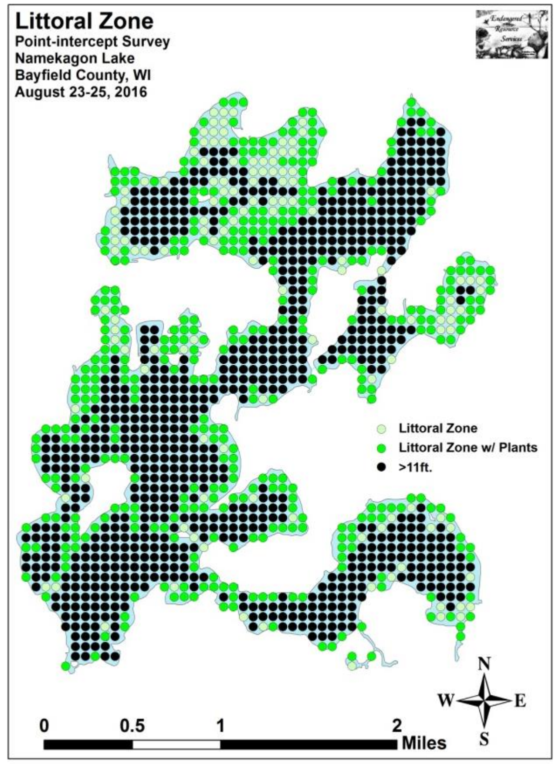


Figure 5: Bottom Substrate and Littoral Zone

Table 1: Aquatic Macrophyte P/I Survey Summary Statistics
Namekagon Lake, Bayfield County
August 23-25, 2016

Summary Statistics:	2016
Total number of points sampled	1,291
Total number of sites with vegetation	387
Total number of sites shallower than the maximum depth of plants	515
Frequency of occurrence at sites shallower than maximum depth of plants	75.15
Simpson Diversity Index	0.90
Maximum depth of plants (ft)	11.0
Mean depth of plants (ft)	5.4
Median depth of plants (ft)	5.5
Average number of all species per site (shallower than max depth)	2.01
Average number of all species per site (vegetative sites only)	2.68
Average number of native species per site (shallower than max depth)	2.01
Average number of native species per site (sites with native species only)	2.68
Species richness	48
Species richness (including visuals)	51
Species richness (including visuals and boat survey)	60
Mean total rake fullness (vegetative sites only)	1.73

Overall diversity in the lake was high as our data produced a Simpson Index value of 0.90. Richness, however, was only moderate for such a large lake with 48 species found in the rake. When including plants recorded as visuals or during the boat survey, this total jumped to 60 species growing in and immediately adjacent to the lake.

Localized richness was also moderate as the mean species richness/site was 2.68 species at sites with vegetation. As no exotic species were found in the rake at any point, the mean native species/site was identical. Overall, plant density was moderately low with a mean rake fullness of 1.73 at sites with vegetation (Figure 6) (Appendix IV).

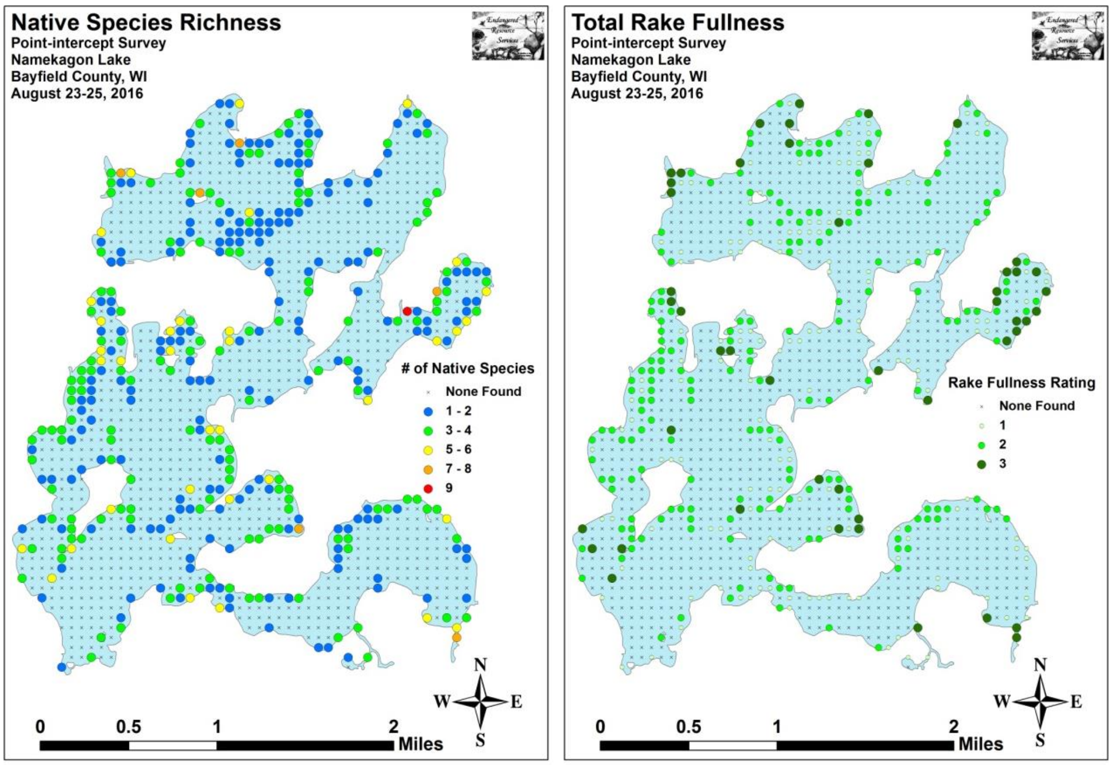


Figure 6: Native Species Richness and Total Rake Fullness

Namekagon Lake's Plant Community:

The Namekagon Lake ecosystem is home to a rich and diverse plant community that is primarily a function of the local water depth and substrate. This community can be subdivided into four distinct zones (emergent, floating-leaf, shallow submergent, and deep submergent) with each zone having its own characteristic functions in the lake ecosystem. Depending on the local bottom type (sand, rock, firm nutrient poor sandy muck, or soft nutrient rich organic muck (boggy)), 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.

On sand and gravel bars and around the lake's numerous islands, the emergent community was dominated by Creeping spikerush (*Eleocharis palustris*), Hardstem bulrush (*Schoenoplectus acutus*), and Common bur-reed (*Sparganium eurycarpum*) with a few very widely scattered patches of River bulrush (*Bolboschoenus fluviatile*), Common reed (*Phragmites australis*) and Hybrid cattail (*Typha* X *glauca*) mixed in. In sandy muck areas, these species were often replaced by Three-way sedge (*Dulichium arundinaceum*), Water horsetail (*Equisetum fluviatile*), Pickerelweed (*Pontederia cordata*), and Softstem bulrush (*Schoenoplectus tabernaemontani*).


Hardstem bulrush (Per 2002)


Common bur-reed (Raymond 2011)


Creeping spikerush (Cremlin 2009)


Softstem bulrush (Schwarz 2011)


Pickerelweed (Texas A&M 2012)


Water horsetail (Elliot 2007)

In shoreline areas where the soil was a more nutrient rich organic muck, we documented Bottle brush sedge (*Carex comosa*), Swamp loosestrife (*Decodon verticillatus*), Short-stemmed bur-reed (*Sparganium emersum*), Common arrowhead (*Sagittaria latifolia*), and Broad-leaved cattail (*Typha latifolia*). Away from the immediate lake shore, many shallow wetlands surrounding the lake supported nearly monotypic stands of either Narrow-leaved woolly sedge (*Carex lasiocarpa*) or Common yellow lake sedge (*Carex utriculata*).


Bottle brush sedge (Penta 2010)


Short-stemmed bur-reed (Gmelin 2009)

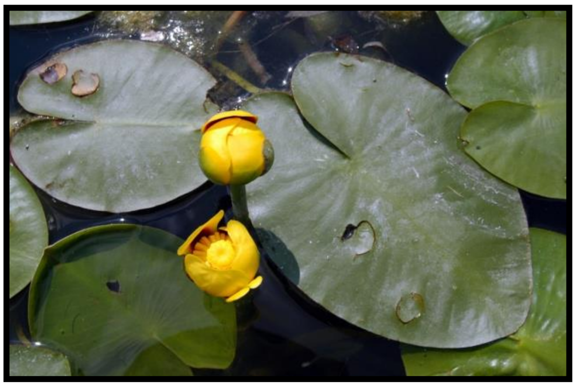

Common arrowhead (Young 2008)


Broad-leaved cattail (Raymond 2011)

Narrow-leaved wooly sedge (Navratil 2016)


Common yellow lake sedge (Lavin 2011

Just beyond the emergents, in up to 4ft of water, sheltered areas like Sugar Bay that had nutrient-rich organic muck bottoms were dominated by the floating-leaf species Spatterdock, (*Nuphar variegata*), White-water lily (*Nymphaea odorata*), Ribbon-leaf pondweed (*Potamogeton epihydrus*), Watershield (*Brasenia schreberi*), Large-leaf pondweed (*Potamogeton amplifolius*), and Floating-leaf pondweed (*Potamogeton natans*). The protective canopy cover they provide is often utilized by panfish and bass.


Spatterdock (CBG 2014)


White water lily (Falkner 2009)


Watershield (Gmelin, 2009)


Ribbon-leaf pondweed (Petroglyph 2007)


Floating-leaf pondweed (Sein 2014)


Large-leaf pondweed (Fewless 2010)

Growing amongst and just beyond these floating-leaf species, we also often found the submergent species Water marigold (*Bidens beckii*), Coontail (*Ceratophyllum demersum*), Common waterweed (*Elodea canadensis*), Whorled water-milfoil (*Myriophyllum verticillatum*), White-stem pondweed (*Potamogeton praelongus*), Small pondweed (*Potamogeton pusillus*), Fern pondweed (*Potamogeton robbinsii*), and Flat-stem pondweed (*Potamogeton zosteriformis*). Predatory fish like the lake's Musky and Northern pike are often found along the edges of these rich underwater forests waiting in ambush.

Coontail (Hassler 2011)

Common waterweed (Fischer 2005)

White-stem pondweed (Fewless 2005)

Small pondweed (Villa 2011)

Fern pondweed (Apipp 2011)

Flat-stem pondweed (Fewless 2004)

In addition to these rooted plants, in boggy areas, we also frequently encountered carnivorous Common bladderworts (*Utricularia vulgaris*) floating among the lilypads. Rather than drawing nutrients up through roots like other plants, bladderworts trap zooplankton and minute insects in their bladders, digest their prey, and use the nutrients to further their growth.

Common bladderwort flowers among lilypads (Hunt 2010)

Bladders for catching plankton and insect larvae (Wontolla 2007)

The lake's shallow pure sand and gravel areas tended to have low total biomass as these nutrient-poor substrates provide habitat most suited to fine-leaved "isoetid" turf forming species like Muskgrass (*Chara* sp.), Needle spikerush (*Eleocharis acicularis*), Spiny-spored quillwort (*Isoetes echinospora*), Slender naiad (*Najas flexilis*), Spiral-fruited pondweed (*Potamogeton spirillus*), White water crowfoot (*Ranunculus aquatilis*), Crested arrowhead (*Sagittaria cristata*), Grass-leaved arrowhead (*Sagittaria graminea*), and Sago pondweed (*Stuckenia pectinata*). These species, along with the emergents, stabilize the bottom and prevent wave action erosion.

Muskgrass (Penuh 2007)

Needle spikerush (Fewless 2005)

Spiny-spored quillwort (Fewless 2005)

Slender naiad (Apipp 2009)

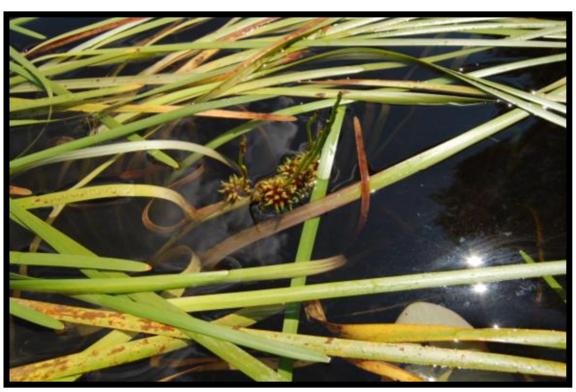
Spiral-fruited pondweed (Koshere 2002)

Crested arrowhead (Fewless 2004)

White water crowfoot (Wasser 2014)

Sago pondweed (Hilty 2012)

Sand and sandy muck areas in water <4ft deep supported fewer and narrower leaved floating-leaf species than organic muck areas, but they still provided important canopy habitat. This was especially true in the lower lake where we found expansive beds of Floating-leaf bur-reed (*Sparganium fluctuans*) and Short-stemmed bur-reed along with an occasional patch of Northern manna-grass (*Glyceria borealis*) mixed in.



Floating-leaved bur-reed (Sullman 2009)

Northern manna-grass (Fewless 2010)

Sandy muck areas in water >4ft tended to support low to moderate density stands of species like Water star-grass (*Heteranthera dubia*), Northern water-milfoil, Fries' pondweed (*Potamogeton friesii*), Variable pondweed (*Potamogeton gramineus*), Clasping-leaf pondweed (*Potamogeton richardsonii*), and, the dominant plant on the lake, Wild celery (*Vallisneria americana*). The roots, shoots, and seeds of these species are heavily utilized by both resident and migratory waterfowl for food. They also provide important habitat for the lake's fish throughout their lifecycles, as well as a myriad of invertebrates like scuds, dragonfly and mayfly nymphs, and snails.

Water star-grass (Mueller 2010)

Northern water-milfoil (Berg 2007)

Fries' pondweed (End 2012)

Variable pondweed (Koshere 2002)

Clasping-leaf pondweed (Cameron 2014)

Wild celery (Dalvi 2009)

When considering the lake as a whole, we found that Wild celery, Variable pondweed, Clasping-leaf pondweed, and Northern water-milfoil were the most common species (Table 2). They were present at 73.64%, 19.38%, 18.35%, and 15.50% of survey points with vegetation, and, collectively, they accounted for 47.35% of the total relative frequency (Figure 7). Fern pondweed (5.01), Water marigold (4.24), and Common waterweed (4.05), were the only other species that had relative frequencies over 4% (Density and distribution maps for all species found in the rake or reported as visuals can be found in Appendix V).

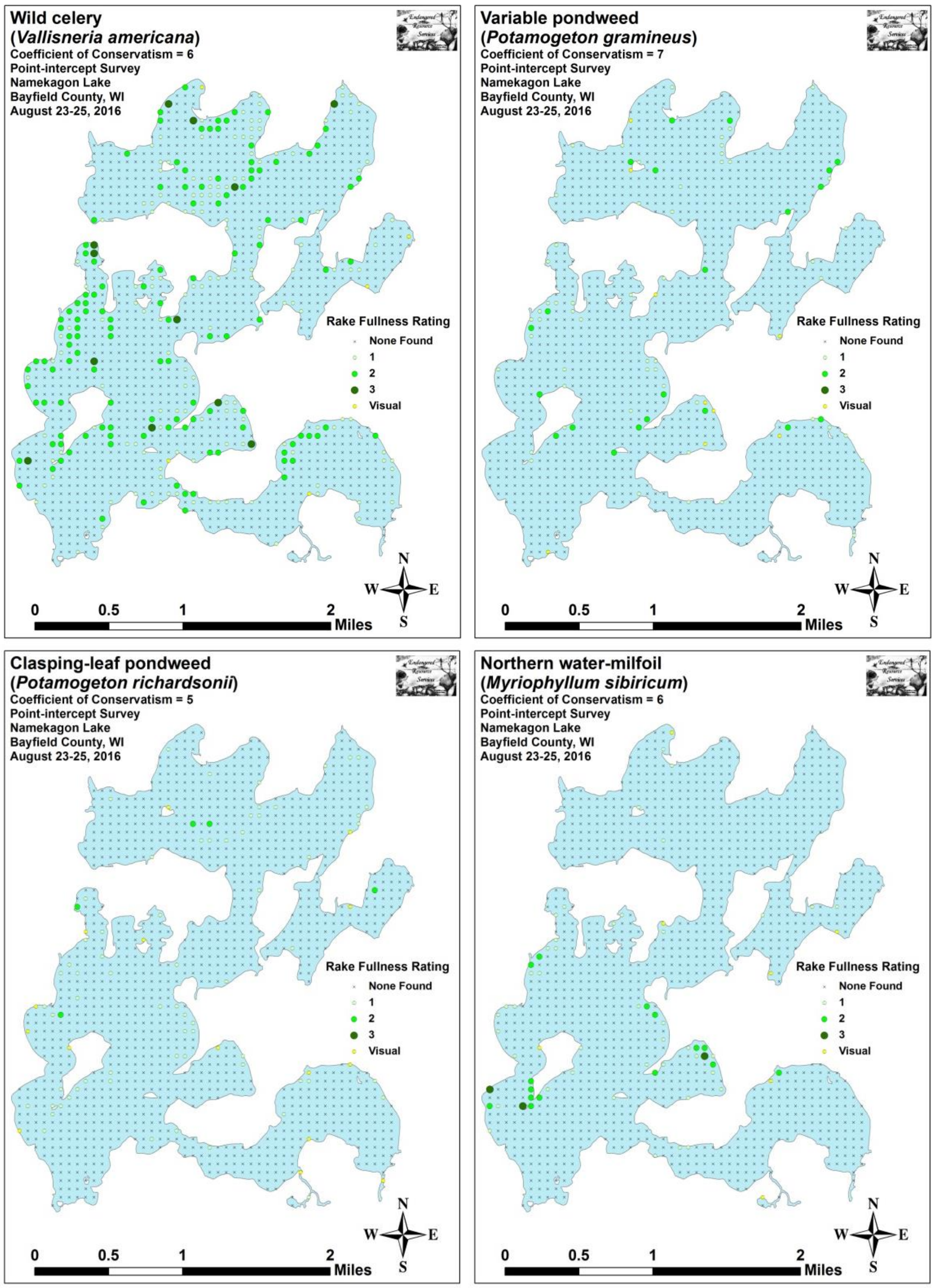


Figure 7: Namekagon Lake's Most Common Species

Table 2: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Namekagon Lake, Bayfield County
August 23-25, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Vallisneria americana	Wild celery	285	27.48	73.64	55.34	1.52	5
Potamogeton gramineus	Variable pondweed	75	7.23	19.38	14.56	1.28	9
Potamogeton richardsonii	Clasping-leaf pondweed	71	6.85	18.35	13.79	1.07	15
Myriophyllum sibiricum	Northern water-milfoil	60	5.79	15.50	11.65	1.35	7
Potamogeton robbinsii	Fern pondweed	52	5.01	13.44	10.10	1.33	1
Bidens beckii	Water marigold	44	4.24	11.37	8.54	1.20	4
Elodea canadensis	Common waterweed	42	4.05	10.85	8.16	1.10	0
Potamogeton pusillus	Small pondweed	39	3.76	10.08	7.57	1.03	2
	Freshwater sponge	38	*	9.82	7.38	1.00	0
Ceratophyllum demersum	Coontail	37	3.57	9.56	7.18	1.11	1
Potamogeton amplifolius	Large-leaf pondweed	37	3.57	9.56	7.18	1.32	5
Najas flexilis	Slender naiad	32	3.09	8.27	6.21	1.03	0
Nymphaea odorata	White water lily	26	2.51	6.72	5.05	1.69	12
Chara sp.	Muskgrass	23	2.22	5.94	4.47	1.00	0
Potamogeton zosteriformis	Flat-stem pondweed	23	2.22	5.94	4.47	1.00	12
Pontederia cordata	Pickerelweed	17	1.64	4.39	3.30	2.29	4
Potamogeton praelongus	White-stem pondweed	16	1.54	4.13	3.11	1.31	0
Eleocharis palustris	Creeping spikerush	13	1.25	3.36	2.52	1.38	4
	Filamentous algae	13	*	3.36	2.52	1.46	0
Nuphar variegata	Spatterdock	10	0.96	2.58	1.94	1.30	7
Sparganium fluctuans	Floating-leaf bur-reed	10	0.96	2.58	1.94	1.80	2
Eleocharis acicularis	Needle spikerush	9	0.87	2.33	1.75	1.00	0
Isoetes echinospora	Spiny spored-quillwort	9	0.87	2.33	1.75	1.00	0

* Excluded from the Relative Frequency Calculation

Table 2 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Namekagon Lake, Bayfield County
August 23-25, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Schoenoplectus acutus	Hardstem bulrush	9	0.87	2.33	1.75	1.89	2
Utricularia vulgaris	Common bladderwort	9	0.87	2.33	1.75	1.11	3
Sparganium emersum	Short-stemmed bur-reed	8	0.77	2.07	1.55	1.38	4
Brasenia schreberi	Watershield	8	0.77	2.07	1.55	1.75	5
Equisetum fluviatile	Water horsetail	7	0.68	1.81	1.36	1.29	1
Potamogeton friesii	Fries' pondweed	7	0.68	1.81	1.36	1.00	0
Potamogeton spirillus	Spiral-fruited pondweed	7	0.68	1.81	1.36	1.00	3
Dulichium arundinaceum	Three-way sedge	6	0.58	1.55	1.17	1.67	0
Nitella sp.	Nitella	6	0.58	1.55	1.17	1.00	0
Sagittaria graminea	Grass-leaved arrowhead	6	0.58	1.55	1.17	1.00	0
Sagittaria latifolia	Common arrowhead	4	0.39	1.03	0.78	1.00	2
Heteranthera dubia	Water star-grass	3	0.29	0.78	0.58	1.00	1
Ranunculus aquatilis	White water crowfoot	3	0.29	0.78	0.58	1.00	0
Sparganium eurycarpum	Common bur-reed	3	0.29	0.78	0.58	1.67	2
Typha latifolia	Broad-leaved cattail	3	0.29	0.78	0.58	1.00	2
Carex lasiocarpa	Narrow-leaved woolly sedge	3	0.29	0.78	0.58	3.00	0
Lemna trisulca	Forked duckweed	2	0.19	0.52	0.39	1.00	0
Sagittaria cristata	Crested arrowhead	2	0.19	0.52	0.39	1.00	0
	Aquatic moss	2	*	0.52	0.39	1.00	0
Carex utriculata	Common yellow lake sedge	2	0.19	0.52	0.39	1.00	0
Potamogeton X *scoliophyllus*	Large-leaf X Illinois pondweed Hybrid (likely)	2	0.19	0.52	0.39	1.50	0
Carex comosa	Bottle brush sedge	1	0.10	0.26	0.19	1.00	0
Decodon verticillatus	Swamp loosestrife	1	0.10	0.26	0.19	1.00	0

* Excluded from the Relative Frequency Calculation

Table 2 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Namekagon Lake, Bayfield County
August 23-25, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton epihydrus	Ribbon-leaf pondweed	1	0.10	0.26	0.19	2.00	1
Potamogeton vaseyi	Vasey's pondweed	1	0.10	0.26	0.19	1.00	1
Schoenoplectus tabernaemontani	Softstem bulrush	1	0.10	0.26	0.19	2.00	2
Stuckenia pectinata	Sago pondweed	1	0.10	0.26	0.19	1.00	0
Carex sp. likely *pellita* – not in fruit	Sedge	1	0.10	0.26	0.19	1.00	0
Utricularia intermedia	Flat-leaf bladderwort	**	**	**	**	**	1
Bolboschoenus fluviatilis	River bulrush	**	**	**	**	**	1
Myriophyllum verticillatum	Whorled water-milfoil	**	**	**	**	**	1
Acorus americanus	Sweet-flag	***	***	***	***	***	***
Glyceria borealis	Northern manna-grass	***	***	***	***	***	***
Lythrum salicaria	Purple loosestrife	***	***	***	***	***	***
Myosotis scorpioides	Common forget-me-not	***	***	***	***	***	***
Myriophyllum spicatum X *sibiricum*	Hybrid water-milfoil	***	***	***	***	***	***
Phragmites australis	Common reed	***	***	***	***	***	***
Potamogeton alpinus	Alpine pondweed	***	***	***	***	***	***
Potamogeton natans	Floating-leaf pondweed	***	***	***	***	***	***
Typha X *glauca*	Hybrid cattail	***	***	***	***	***	***

** Visual Only   *** Boat Survey Only

We identified a total of 43 **native index species** in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 6.5 and a Floristic Quality Index of 42.5 (Table 3). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Namekagon Lake slightly below average. The FQI was, however, much above the median FQI of 24.3 for this part of the state (Nichols 1999).

Five exceptionally high value index plants of note included Three-way sedge (C = 9), the State Species of Special Concern** Vasey's pondweed (*Potamogeton vaseyi*) (C = 10), Crested arrowhead (C = 9), Grass-leaved arrowhead (C = 9), and Floating-leaf bur-reed (C = 10). Three additional high value species found were either not part of the index (Narrow-leaved woolly sedge (C = 9)), were only recorded as a visual (Flat-leaf bladderwort (*Utricularia intermedia*) (C = 9)), or were only seen during the boat survey (Alpine pondweed (*Potamogeton alpinus*) C = 9)).

** "Special Concern" species are those species about which some problem of abundance or distribution is suspected but not yet proved. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.

Table 3: Floristic Quality Index of Aquatic Macrophytes Namekagon Lake, Bayfield County August 23-25, 2016

Species	Common Name	C
Bidens beckii	Water marigold	8
Brasenia schreberi	Watershield	6
Carex comosa	Bottle brush sedge	5
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Dulichium arundinaceum	Three-way sedge	9
Eleocharis acicularis	Needle spikerush	5
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Equisetum fluviatile	Water horsetail	7
Heteranthera dubia	Water star-grass	6
Isoetes echinospora	Spiny-spored quillwort	8
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
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 gramineus	Variable pondweed	7
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7

Table 3 (cont'): Floristic Quality Index of Aquatic Macrophytes
Namekagon Lake, Bayfield County
August 23-25, 2016

Species	Common Name	C
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Fern pondweed	8
Potamogeton spirillus	Spiral-fruited pondweed	8
Potamogeton vaseyi	Vasey's pondweed	10
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8
Sagittaria cristata	Crested arrowhead	9
Sagittaria graminea	Grass-leaved arrowhead	9
Sagittaria latifolia	Common arrowhead	3
Schoenoplectus acutus	Hardstem bulrush	6
Schoenoplectus tabernaemontani	Softstem bulrush	4
Sparganium emersum	Short-stemmed bur-reed	8
Sparganium eurycarpum	Common bur-reed	5
Sparganium fluctuans	Floating-leaf bur-reed	10
Stuckenia pectinata	Sago pondweed	3
Typha latifolia	Broad-leaved cattail	1
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		43
Mean C		6.5
FQI		42.5

Hybrid Water-milfoil:

We found and rake removed approximately 89 individual Hybrid water-milfoil plants from the Northwoods Marina during our August survey (Figure 8) (Appendix VI). Almost all of these were growing over organic muck in 2-5ft of water although a couple plants at the north end of the area were growing in 7-8ft at the edge of the local littoral zone. Most of the plants we found were new sprouts that were 1-2ft long and submerged making it difficult to see them as they were mixed in with the bay's moderately dense native vegetation. It should be noted that volunteers did a commendable job of removing almost all mature canopied plants from the area on the morning of August 23rd as we found only a handful of stems that had been broken off when we did our initial search of the area that evening. In addition to rooted plants, we removed many floating fragments that were mixed in with other uprooted plants floating near shore and among the moored boats. As these were not associated with any particular location, we opted not to take GPS coordinates for them. No floating fragments were seen anywhere else in the lake.

Outside of the marina, the only HWM we found were three large canopied plants with multiple stems that we removed in the previously identified area southwest of Paine's Island (Figure 8). They were growing in 5-7ft of water over sandy muck, and, unfortunately, were imbedded within a dense Northern water-milfoil bed which made it difficult to get the roots (For more information on this and a selection of other aquatic exotic plant species, please see Appendix VII).

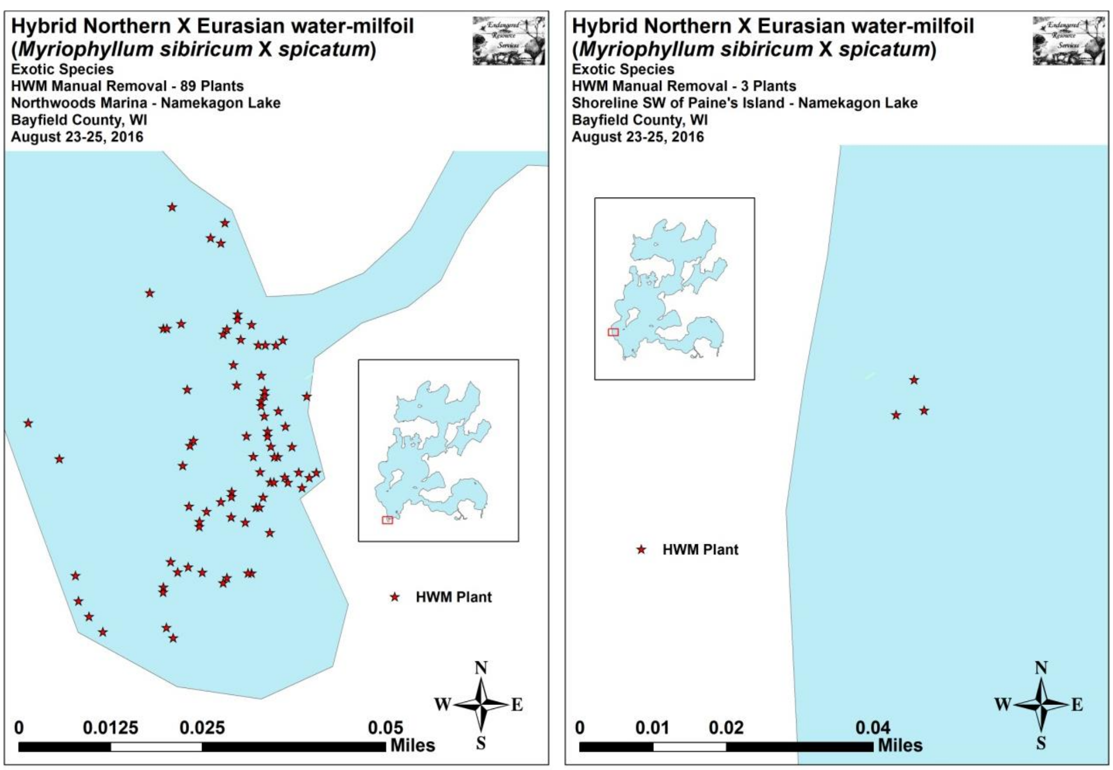


Figure 8: Hybrid Water-milfoil Distribution and Manual Removal Areas Northwoods Marina and the Bay Southwest of Paine's Island

Other Exotic Species:

We saw and removed a single Purple loosestrife (*Lythrum salicaria*) plant in a wetland immediately adjacent to the lake near the river outlet (Figure 9). A few more plants were seen in ditches within a mile of the lake, but these tended to occur as individuals or in small clusters mixed in with sedges and cattails rather than in monotypic beds.

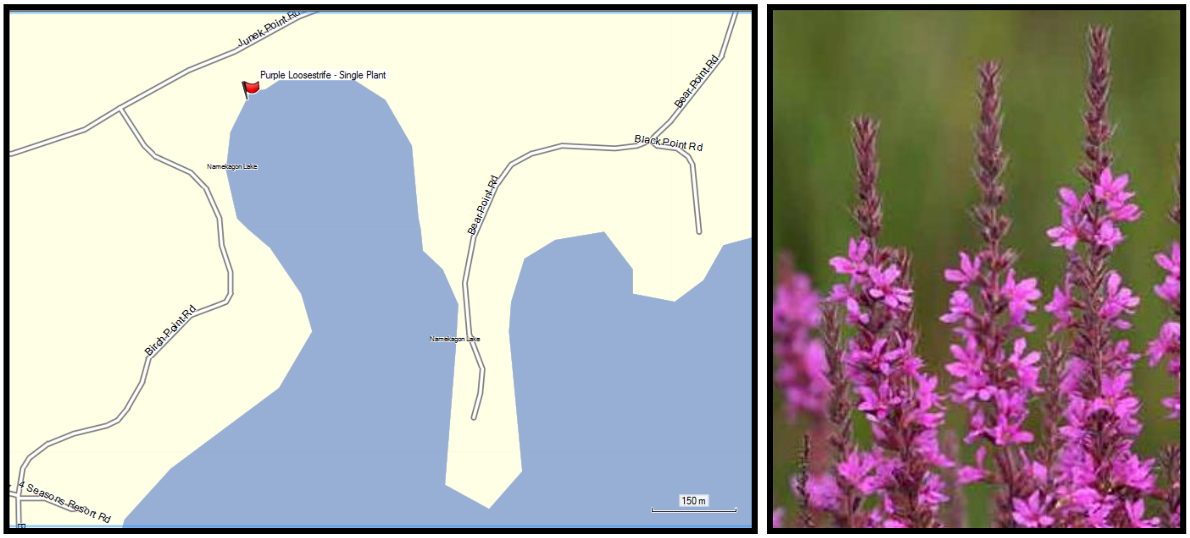


Figure 9: Purple Loosestrife Distribution

We found Common forget-me-nots (*Myosotis scorpioides*) at the Northwoods Marina along the cold-water seeps that are bubbling up due east of the landing (Figure 10). A common exotic in this habitat throughout northern Wisconsin, it is likely that an exhaustive search for this species would find it in many other places along the lakeshore.

Figure 10: Common Forget-me-not Distribution

Common reed (*Phragmites australis*) is a potentially highly invasive plant found in wetland habitats throughout Wisconsin (Figure 11). It has two subspecies – the native (*P. australis americanus*) and the exotic (*P. australis americanus*). Both of these forms can produce dense stands, but the exotic form tends to grow much taller and be more invasive. We weren't required to take vouchers for this project, so we didn't collect individuals to confirm subspecies. However, based on the overall growth pattern, we believe that the stand on the west side of Paine's Island and the other small scattered patches seen on the lake were the native subspecies as they were <2m tall and did not appear to be invasive.

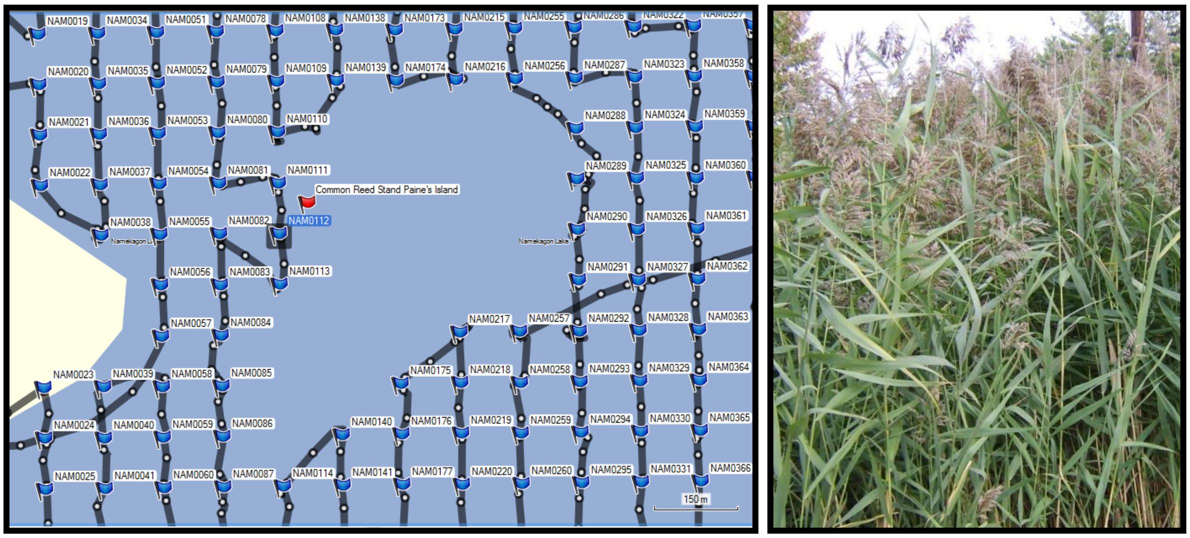


Figure 11: Common Reed Distribution

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 stand of approximately 50 individual Hybrid cattails (*Typha* X *glauca*) in shallow water along the north entrance to Mumm's Bay (Figure 12).

Figure 12: Hybrid Cattail Distribution

Yellow iris is present throughout the Namekagon River corridor, and it appears to be increasing in both density and distribution (M. Berg, unpublished data). Once established, the plants tend to quickly spread, and they can eventually take over entire wetlands (Figure 13). Although there are unconfirmed reports of this species on the lake, we did not see any during our survey. However, as the plants finish blooming in June, if they occur at low levels, they could have been easily overlooked (Figure 13).

Figure 13: Yellow Iris Bloom and Cluster of Plants on Nearby Waterbody

Filamentous Algae:

Filamentous and floating algae are symptomatic of excess nutrients in the water column, and lakes with healthy populations of rooted plant usually have low algae levels. In total, we recorded filamentous algae at just 13 sites (Figure 14). They were present at approximately 3% of littoral points with plants and had a low/moderate average rake fullness value of 1.46.

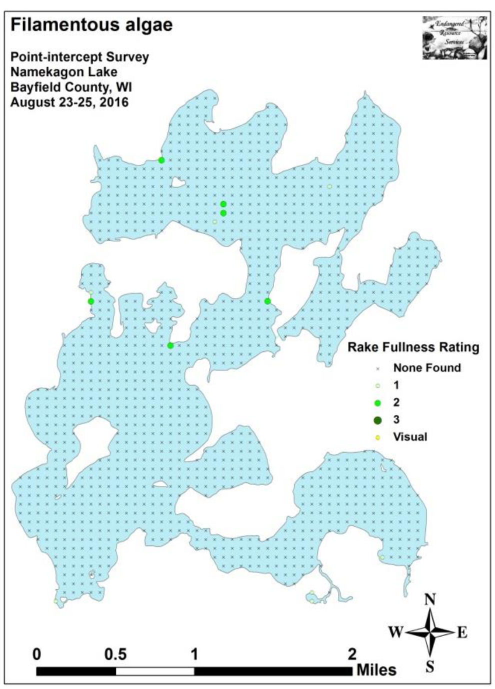


Figure 14: Filamentous Algae Density and Distribution

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:
Hybrid water-milfoil:

Although it is impossible to know how or exactly when Hybrid water-milfoil was introduced to Namekagon Lake, the fact that we did not find plants to be widespread suggests it was a recent introduction. This is definitely a positive as it gives the NLA time to coordinate a response to both slow the spread of HWM and to minimize the impact of the infestation on the lake's ecosystem. The current low levels should not, however, be viewed as a reason for complacency as the lake also has moderate amounts of native Northern water-milfoil. Because both the hybrid and its parent species share the same habitat preferences, we believe it is HIGHLY likely that HWM will continue to spread throughout the lake without the continuation of some form of active management. Based on this expectation, we encourage the NLA to continue regular manual removal at known HWM locations. We also believe that continuing to monitor for newly established beds outside the current known area of distribution will allow for more rapid identification and potentially economic control when new beds are found. To assist with these efforts, educating as many residents as possible to be on the lookout for new plants/beds is also strongly encouraged. If volunteers find anything they think even looks suspicious, they are invited to promptly contact us (saintcroixdfly@gmail.com and/or 715-338-7502) with a picture, specimen, description of, and/or preferably GPS coordinates, and we will add these locations to the existing map for management consideration.

Because the native Northern water-milfoil is widely distributed throughout the lake and closely resembles HWM, finding and identifying HWM will likely be challenging for volunteers. To assist in identification, surveyors should remember that Northern water-milfoil has leaflets numbering <24 whereas EWM normally has >26 with HWM tending to have leaflet numbers that range from 20-30 – intermittent between both parent species (Figure 15). EWM and HWM also tend to have a bright red growth tip on the top of the plant whereas NWM has a bright lime green growth tip. In the fall, NWM also forms winter buds on the tips of shoots whereas EWM/HWM have none (Figure 16).

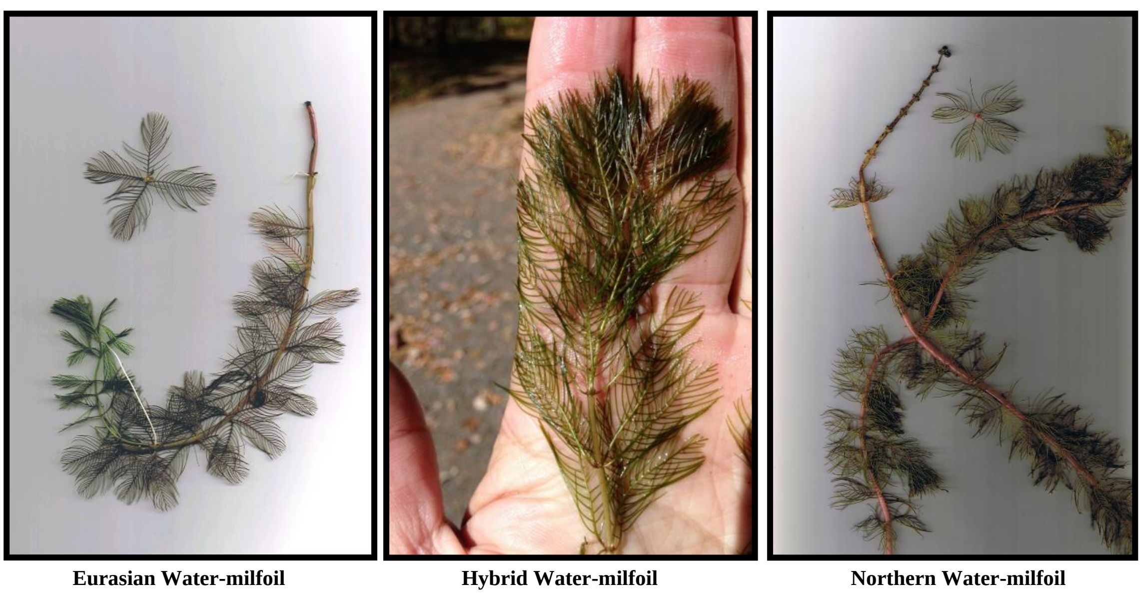


Figure 15: Eurasian, Hybrid, and Northern Water-milfoil Identification

**Figure 16: Limp Nature of EWM/HWM Leaflets along Stem –
Stiff Nature of NWM Leaflets along Stem and Overwintering Turions
October 2016**

Other Exotic Species:

Purple loosestrife currently occurs at very low levels in the greater Namekagon Lake area. Because of this, we do not believe there are enough plants to support a loosestrife beetle (*Galerucella* spp.) population at this time. However, if monitoring shows an increase in plants, a beetle release could be considered in the future. In the meantime, residents should be on the lookout 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.

Hybrid cattail and Common reed also occur at low levels on the lake. The small bed of Hybrid cattails in Mumm's Bay could likely be easily removed, but this is probably not an option with Common reed as most stands occurred in relatively inaccessible places meaning this species likely on the lake to stay. The same could be said about Common forget-me-not, although neither species seems to be particularly invasive at this time. Yellow iris is of greater concern to us as it can also expand aggressively once established. Although we did not find any during our survey, because there are unconfirmed reports from the lake, residents should be on the lookout for the plant's bright yellow fleur-de-lis flower in June. As it also has an extensive root systems, care should be taken to remove the entire plant to prevent regrowth.

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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																									
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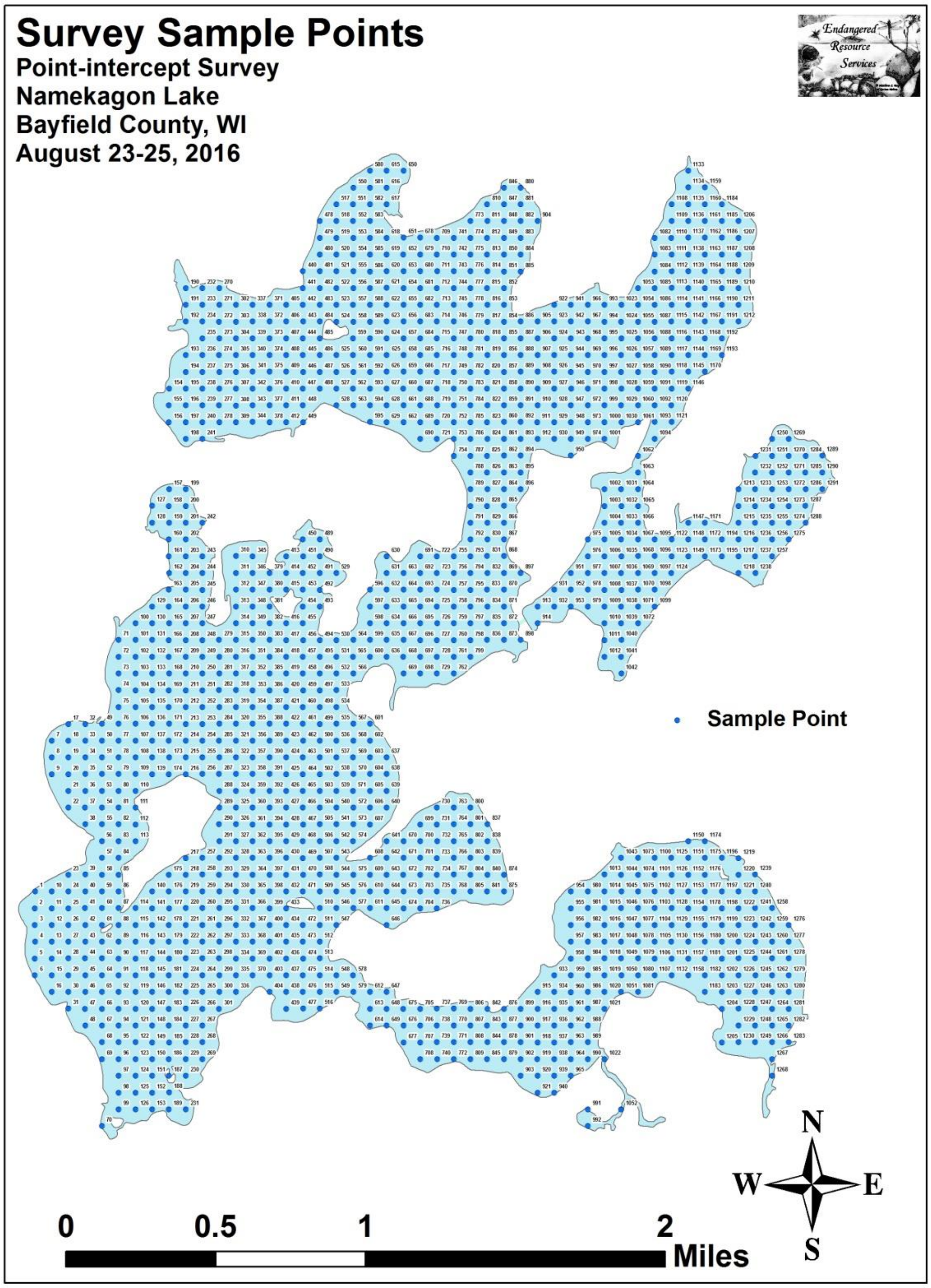
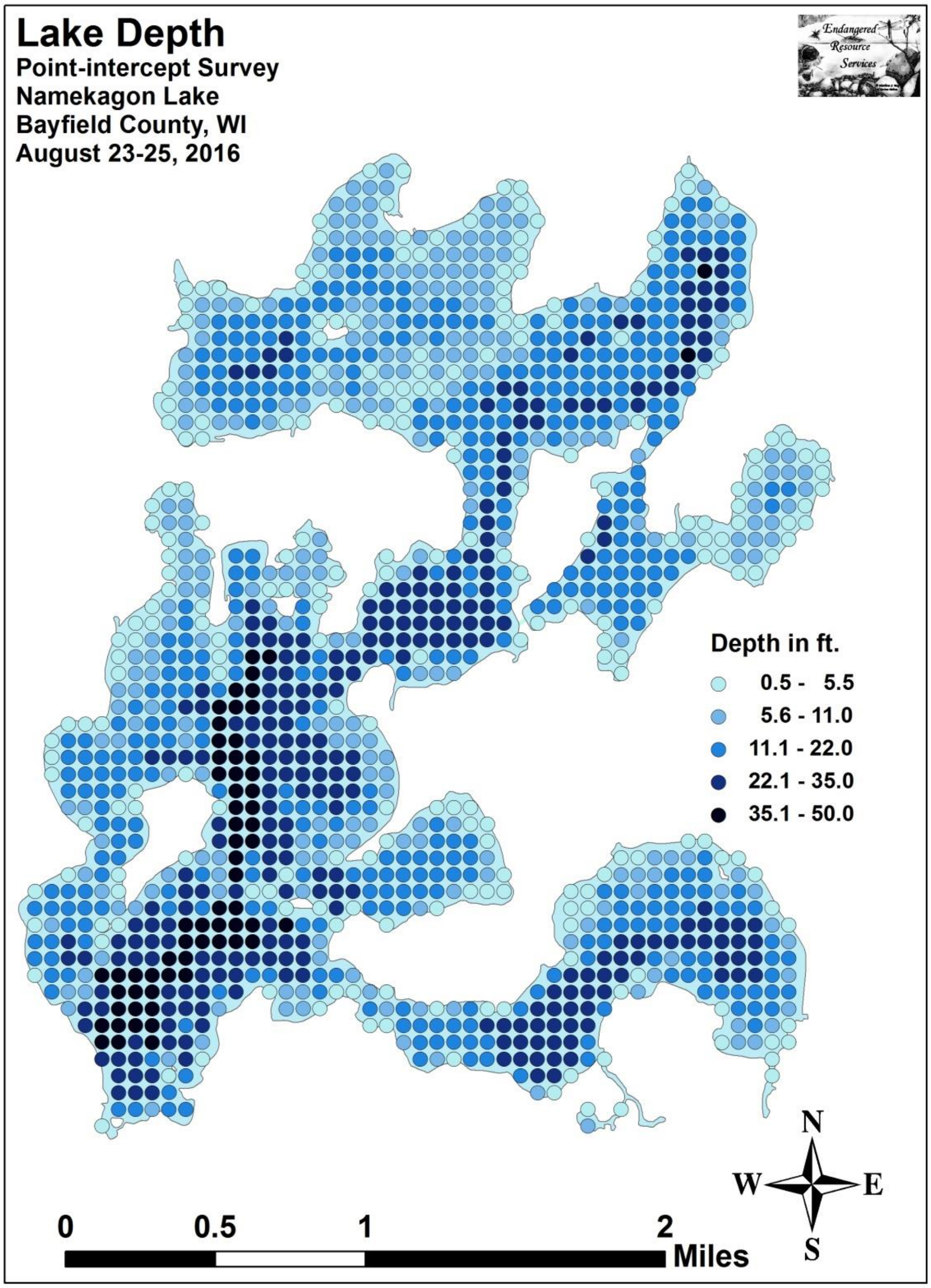
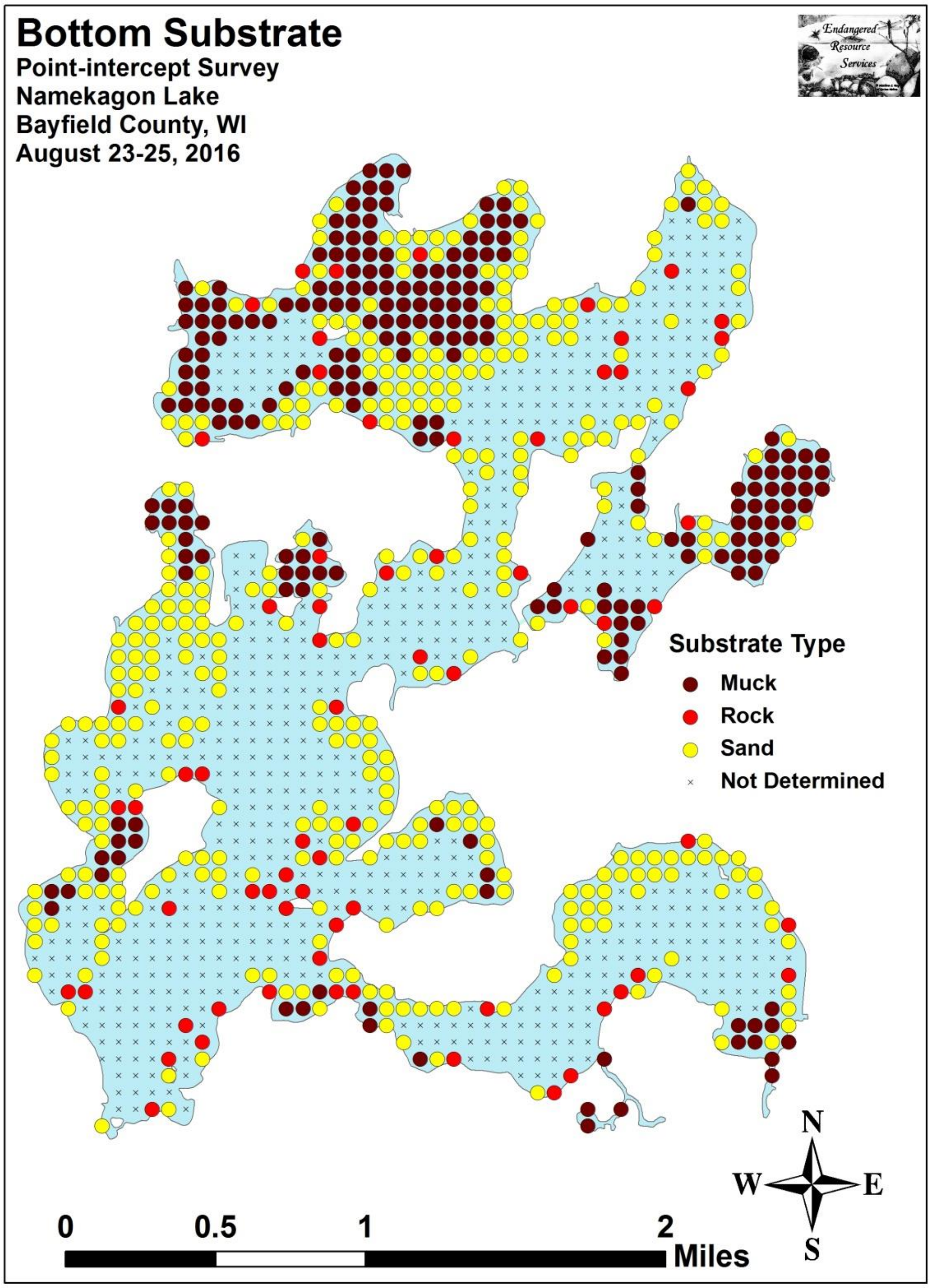
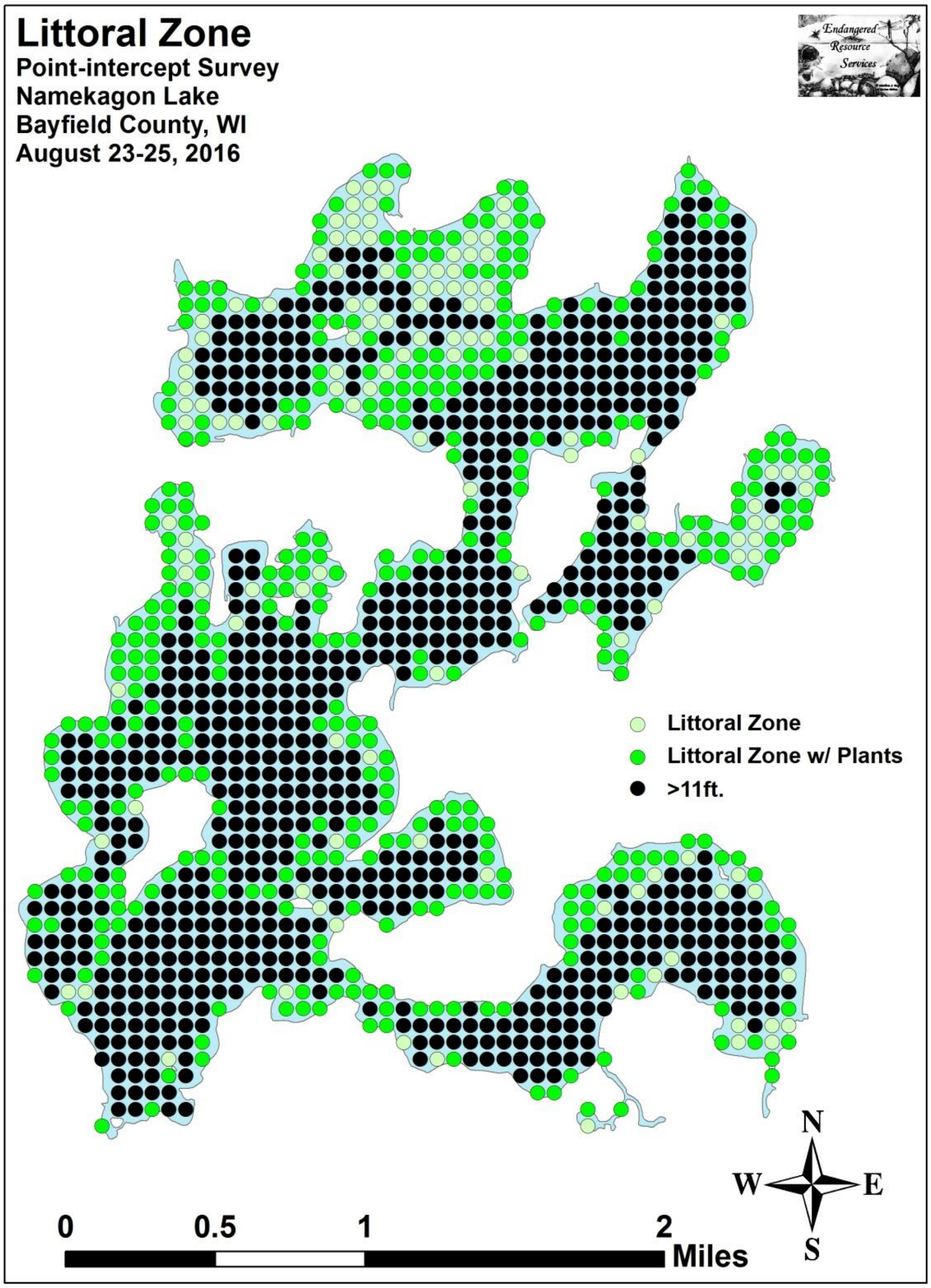
Appendix II: Survey Sample Points Map


Survey Sample Points
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Sample Point
N
W
E
S
0
0.5
1
2
Miles

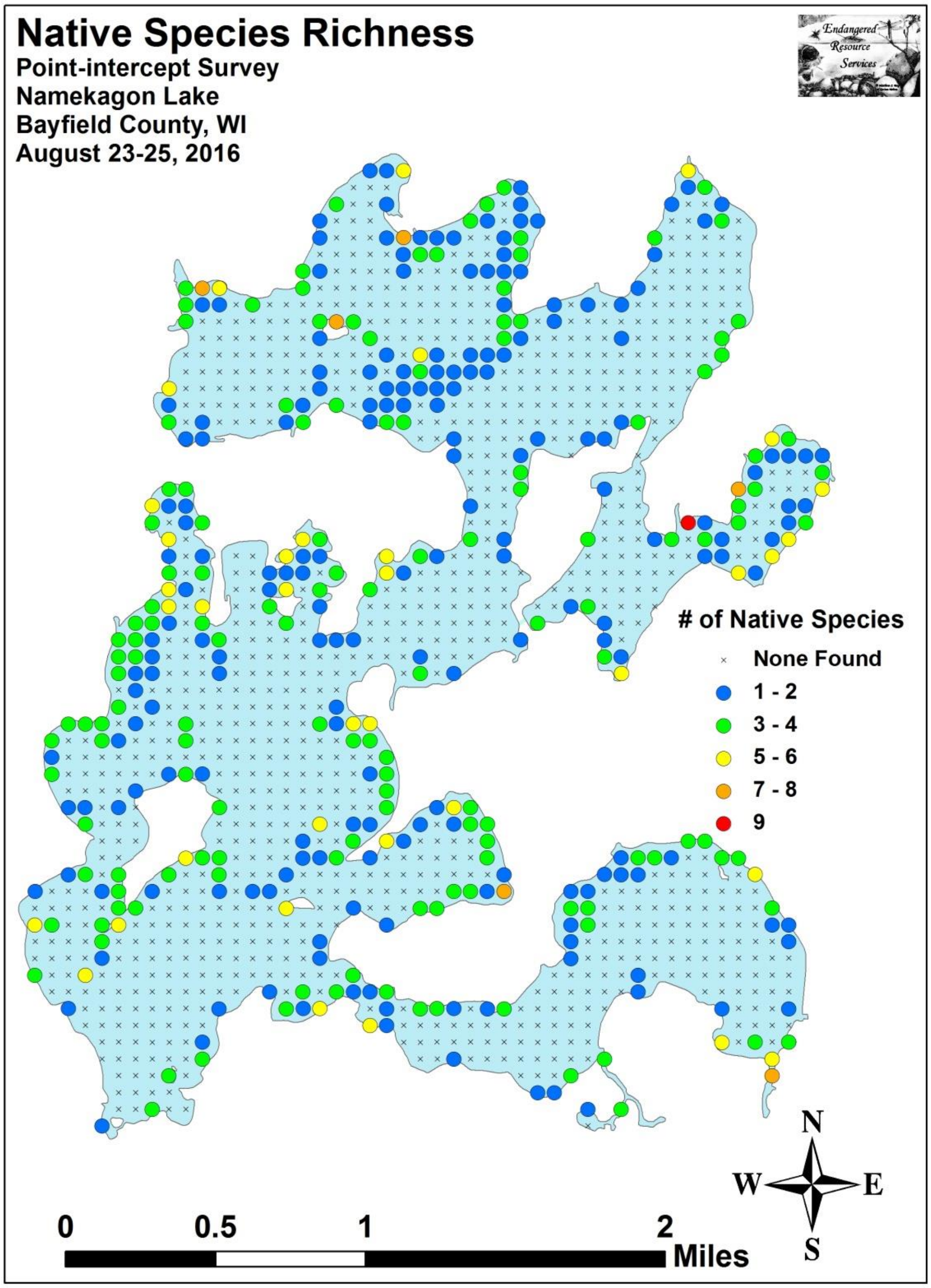
Appendix III: Habitat Variable Maps

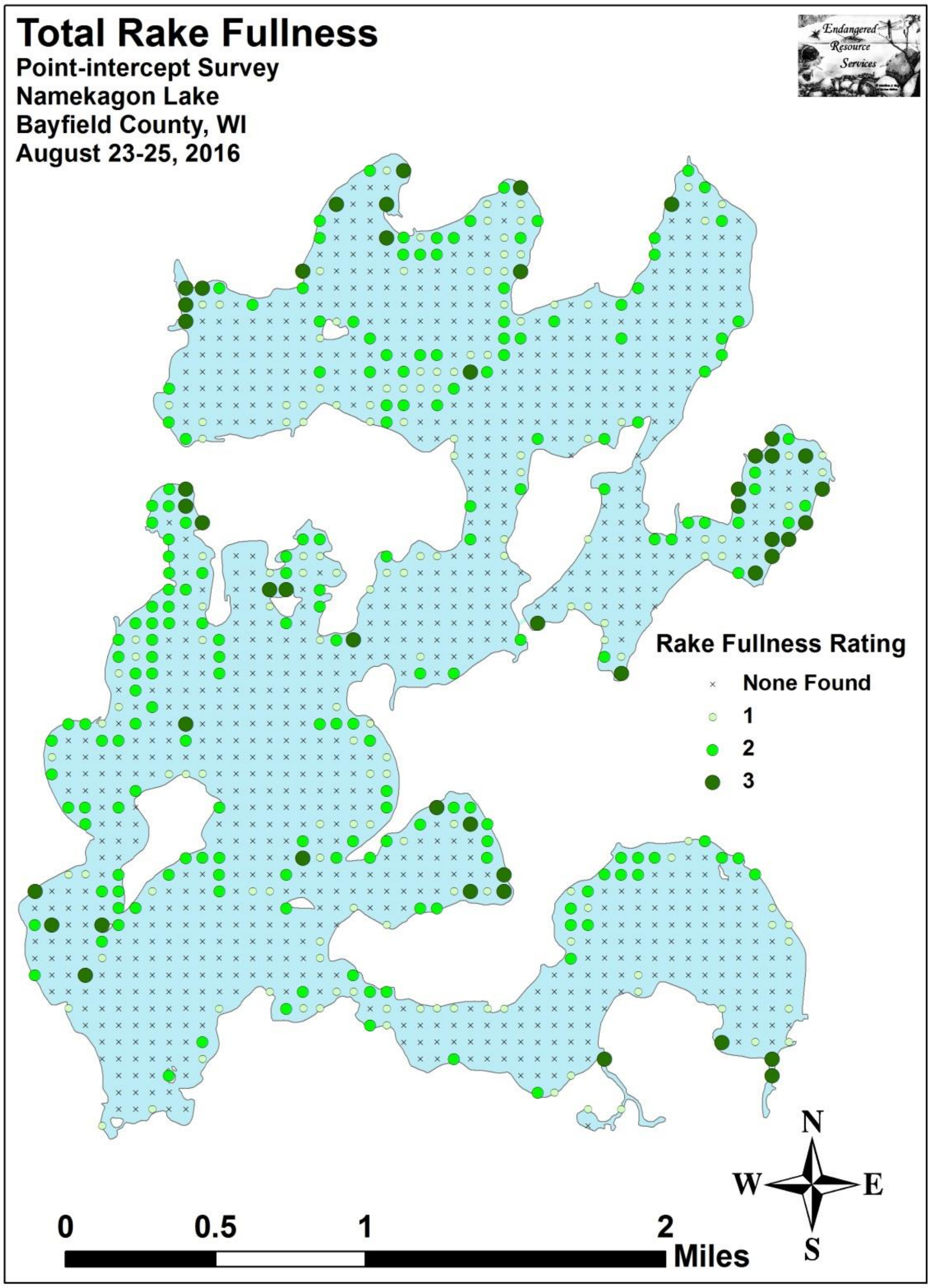

Lake Depth
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Depth in ft.
0.5 - 5.5
5.6 - 11.0
11.1 - 22.0
22.1 - 35.0
35.1 - 50.0
N
W
E
S
0
0.5
1
2
Miles


Bottom Substrate
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Substrate Type
Muck
Rock
Sand
Not Determined
N
W
E
S
0
0.5
1
2
Miles


Littoral Zone
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Littoral Zone
Littoral Zone w/ Plants
>11ft.
N
W
E
S
0
0.5
1
2
Miles

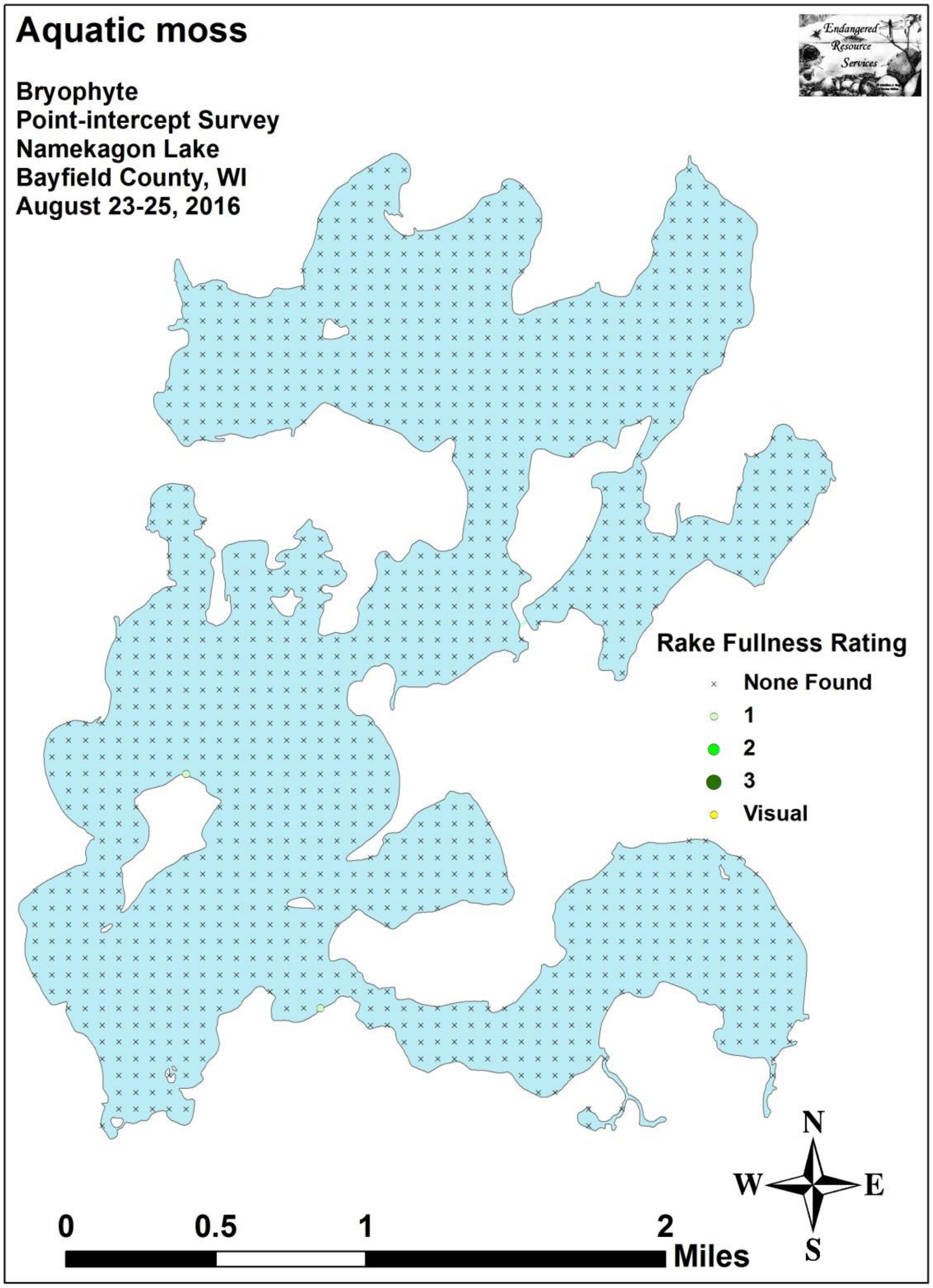
Appendix IV: Native Species Richness and Total Rake Fullness Maps

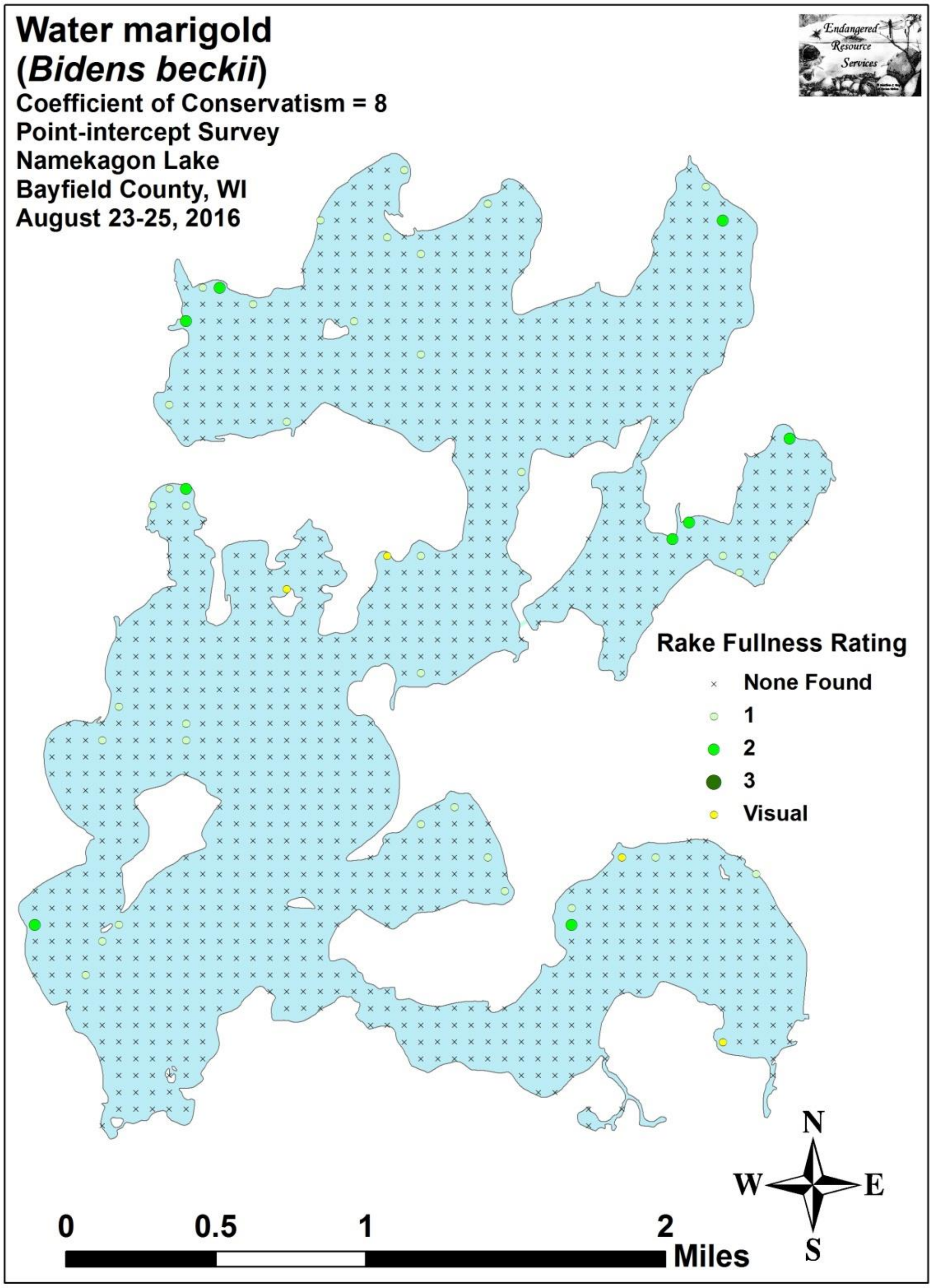

Native Species Richness
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9
N
W
E
S
0
0.5
1
2
Miles

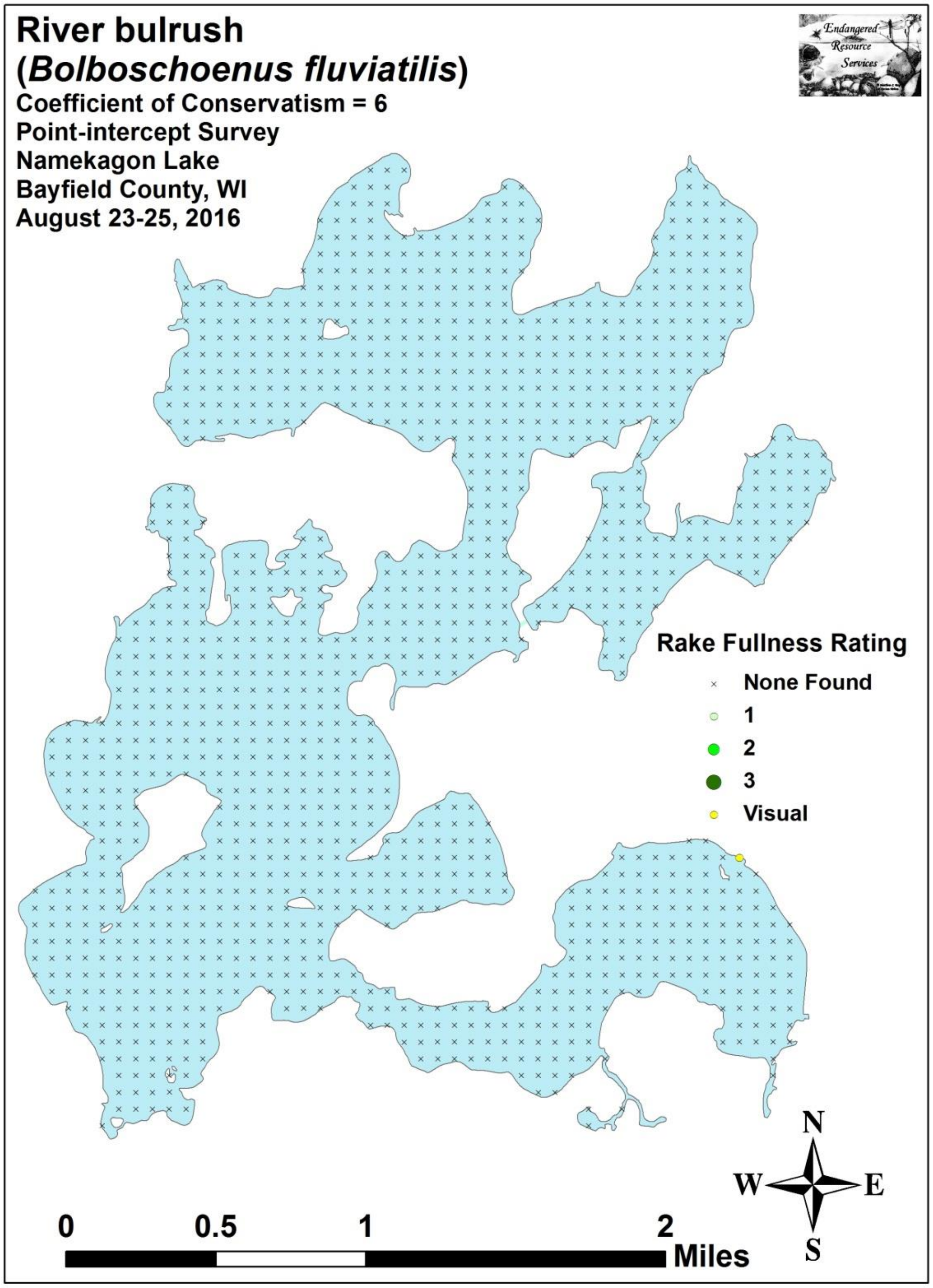


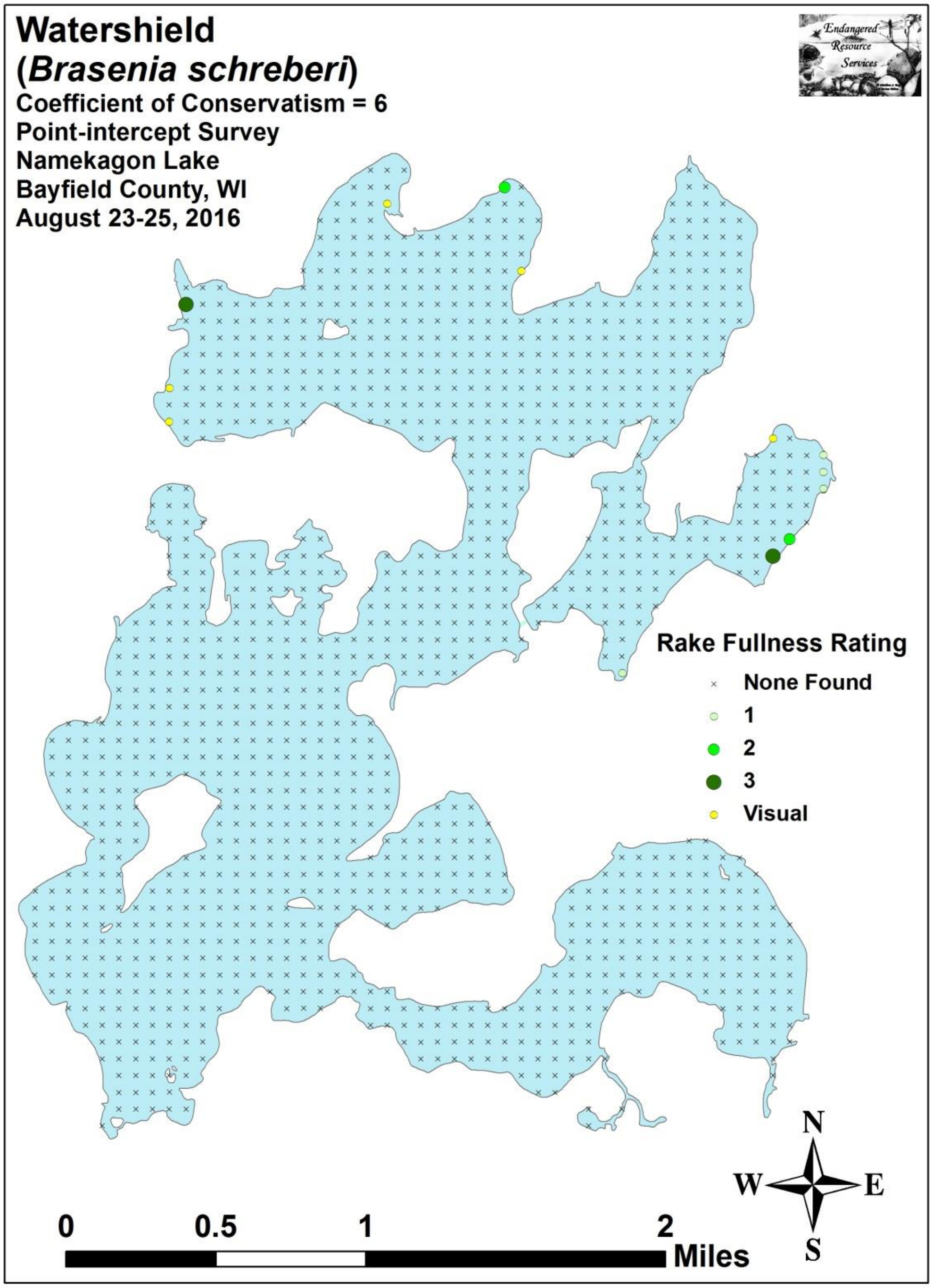
Total Rake Fullness
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
N
W
E
S
0
0.5
1
2
Miles

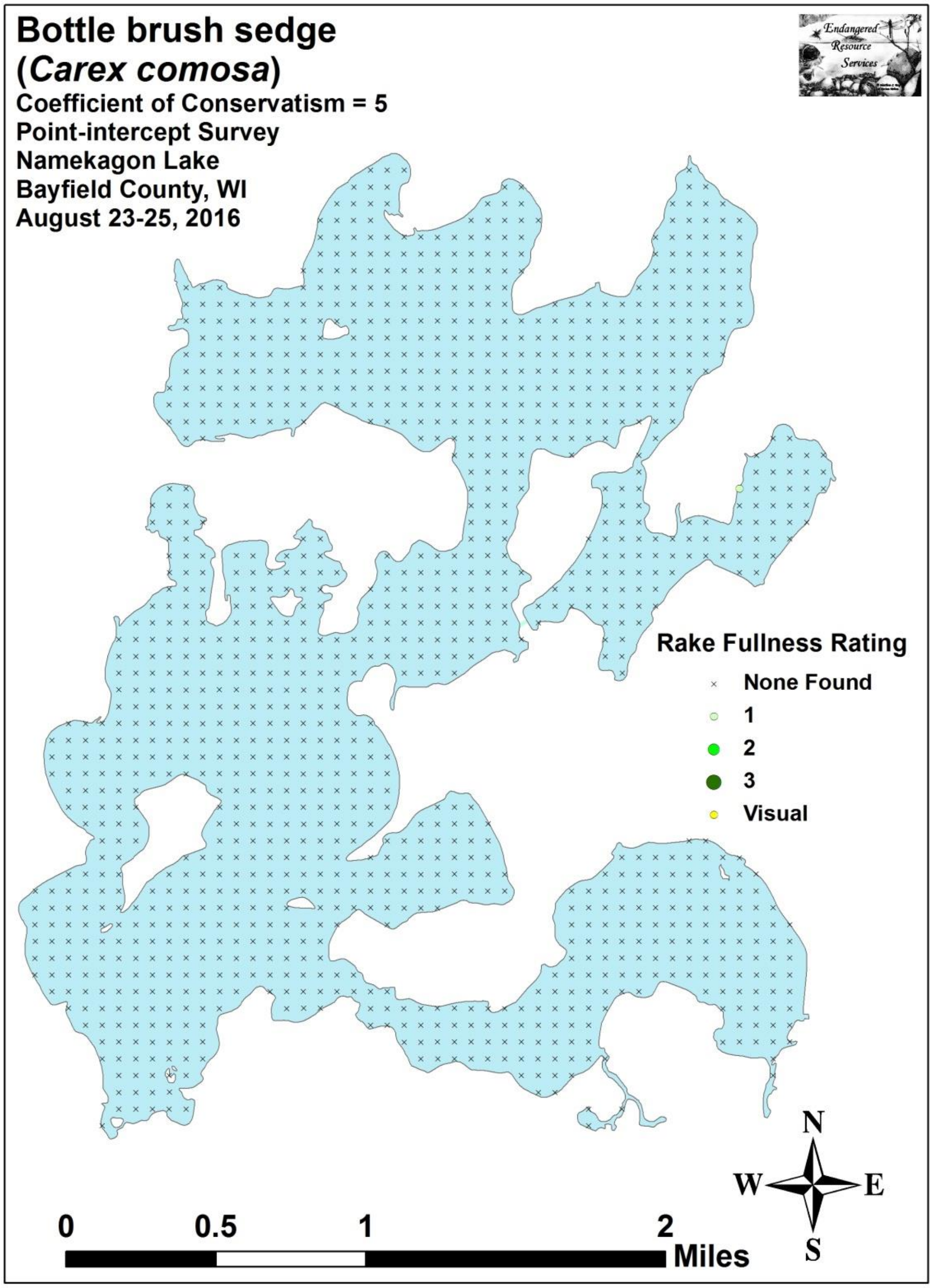
Appendix V: Native Species Density and Distribution Maps


Aquatic moss
Bryophyte
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
N
W
E
S
0
0.5
1
2
Miles

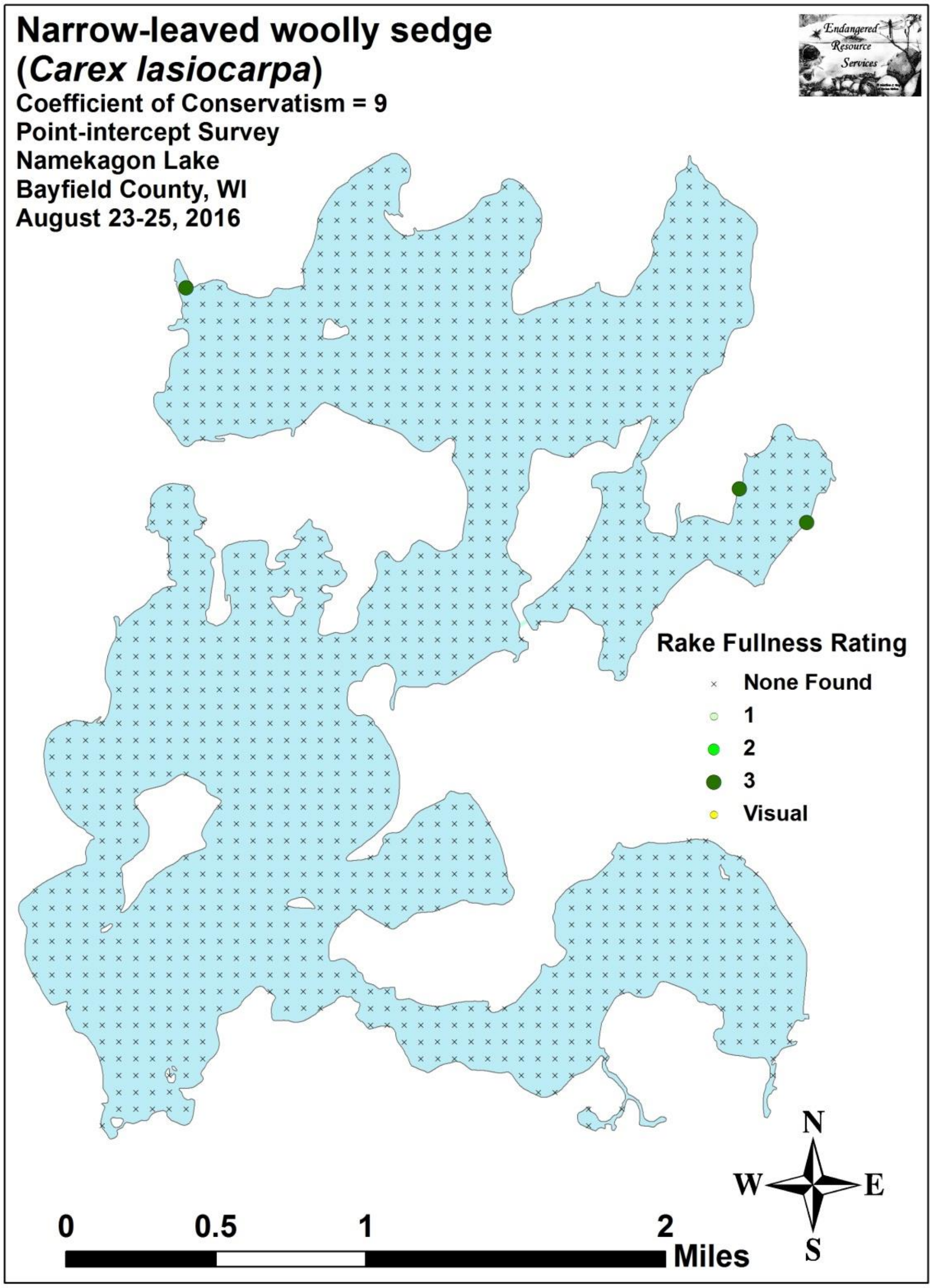

Water marigold
(*Bidens beckii*)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
N
W
E
S
0
0.5
1
2
Miles


River bulrush
(*Bolboschoenus fluviatilis*)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
N
W
E
S
0
0.5
1
2
Miles


Watershield
(*Brasenia schreberi*)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
N
W
E
S
0
0.5
1
2
Miles



Bottle brush sedge
(*Carex comosa*)
Coefficient of Conservatism = 5
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
N
W
E
S
0
0.5
1
2
Miles


Narrow-leaved woolly sedge
(*Carex lasiocarpa*)
Coefficient of Conservatism = 9
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
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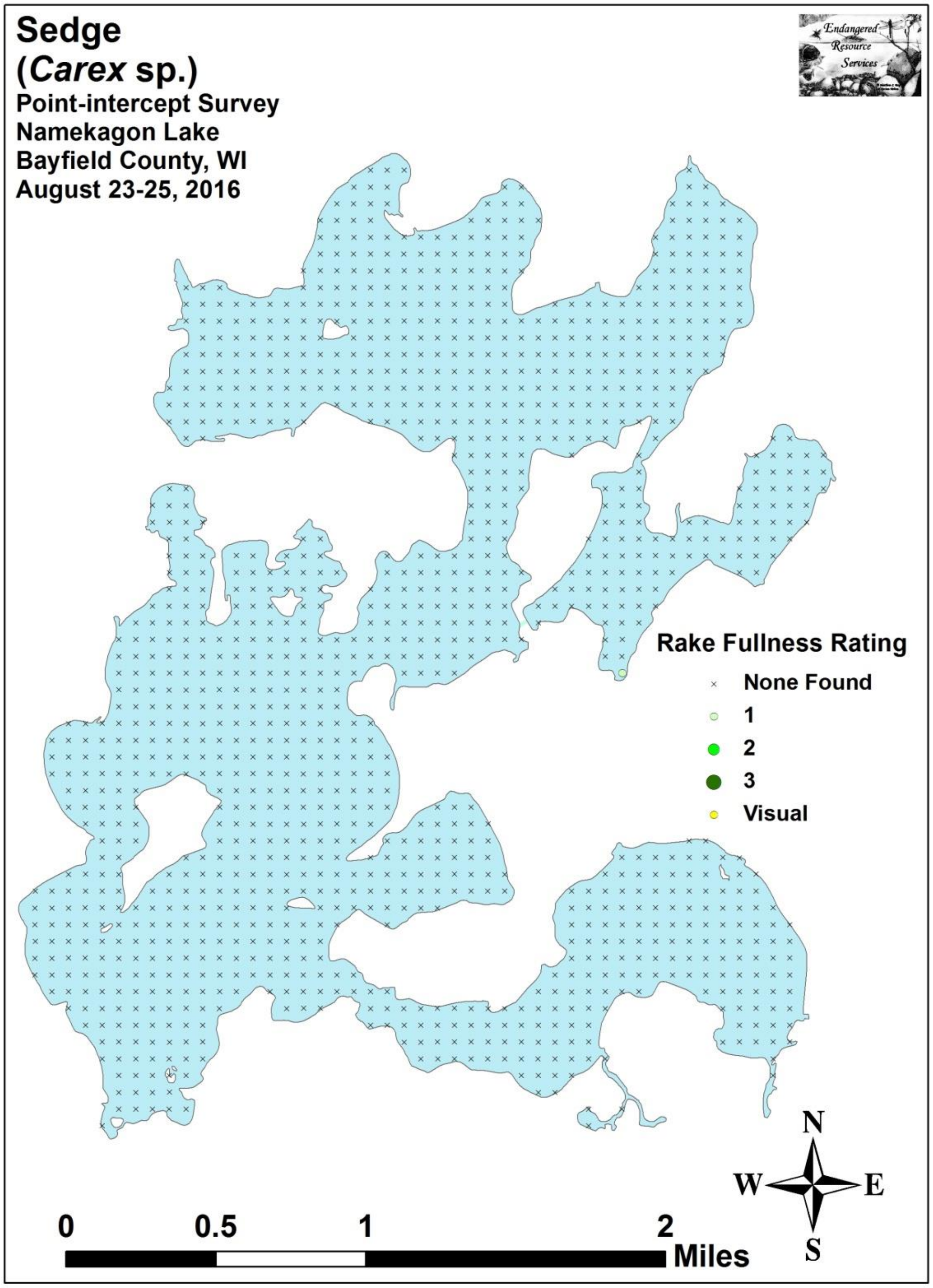
0
0.5
1
2
Miles


Sedge
(Carex sp.)
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
N
W
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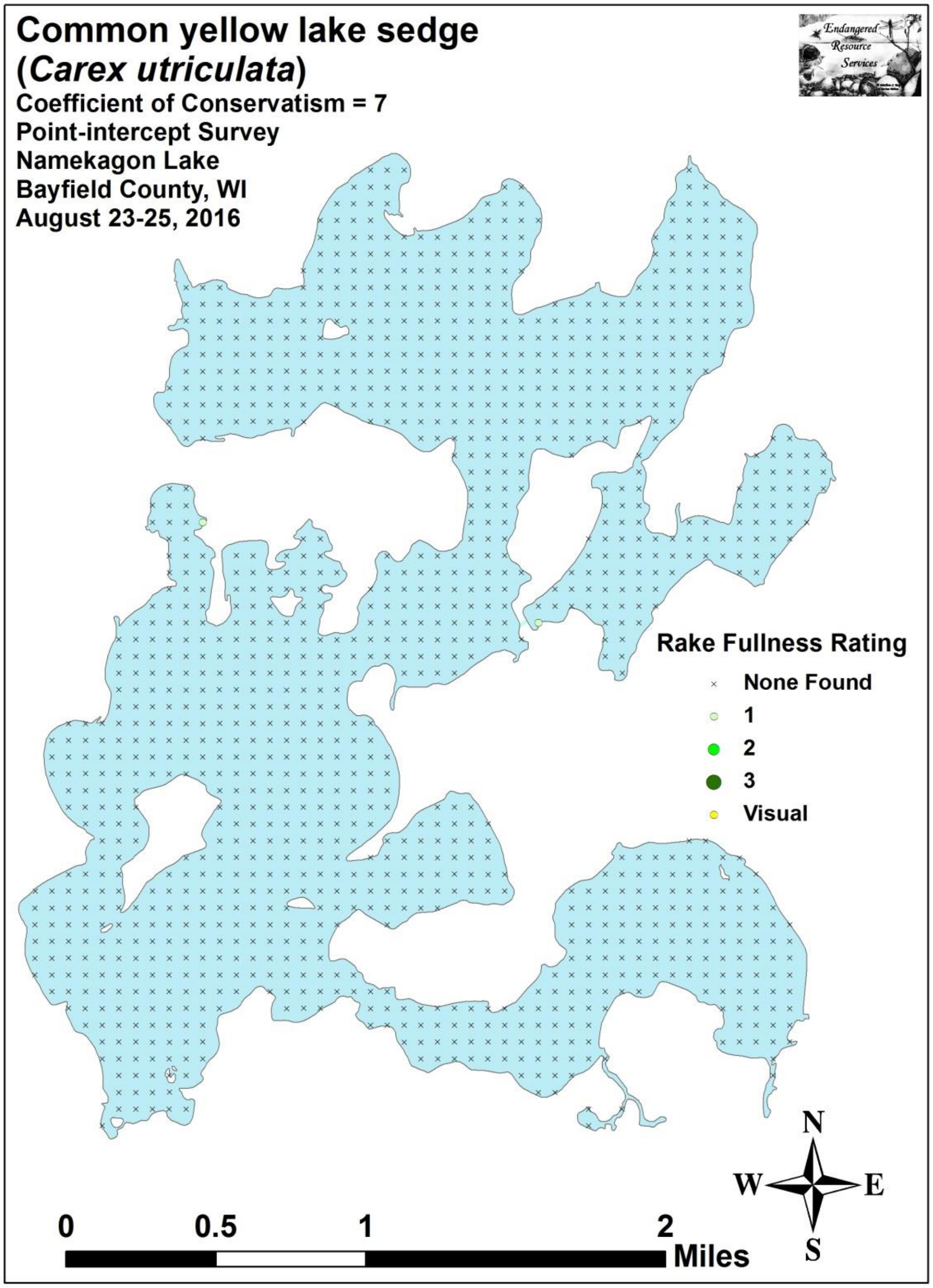
0
0.5
1
2
Miles


Common yellow lake sedge
(*Carex utriculata*)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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3
Visual
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S
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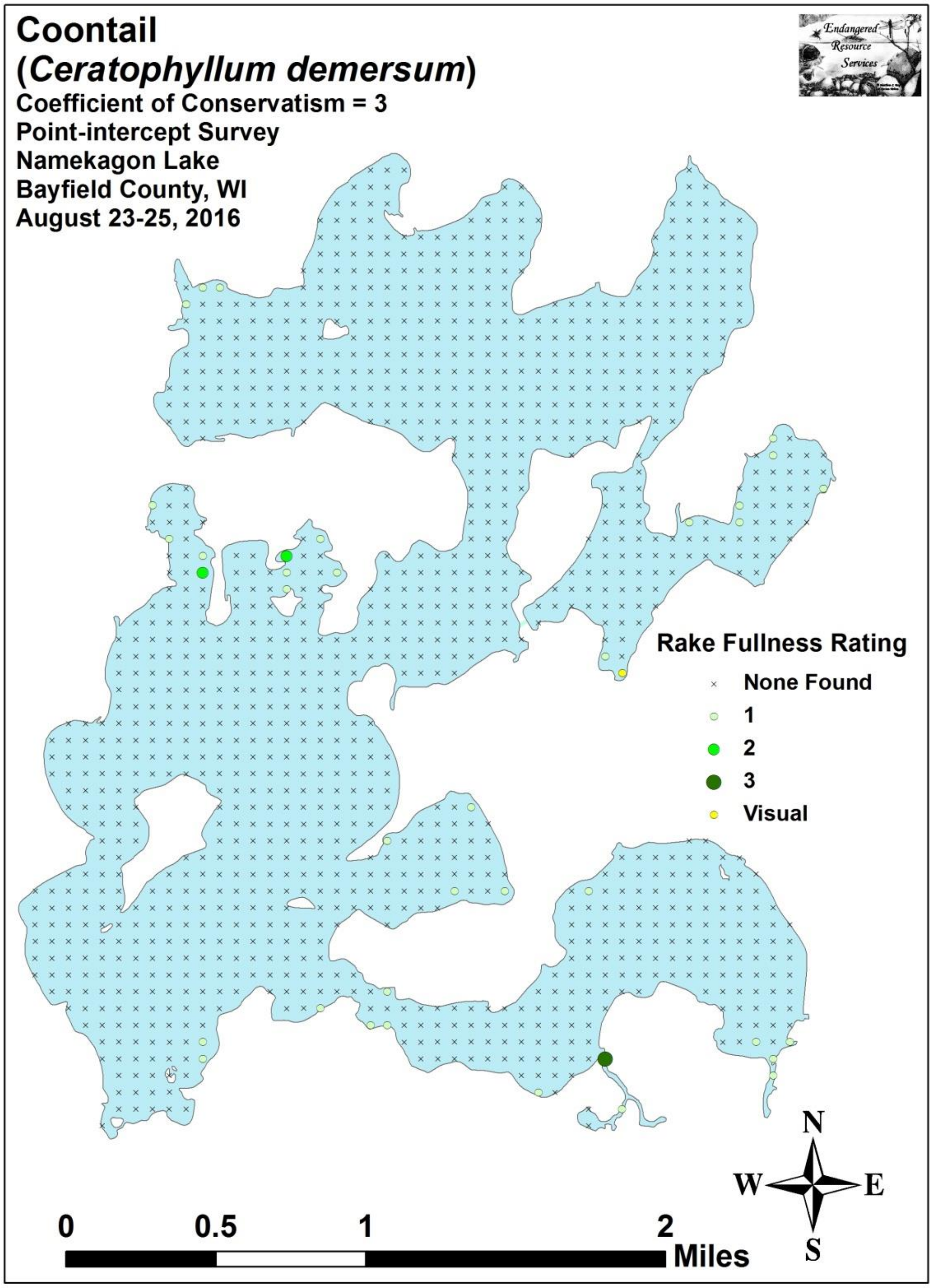
0.5
1
2
Miles


Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
N
W
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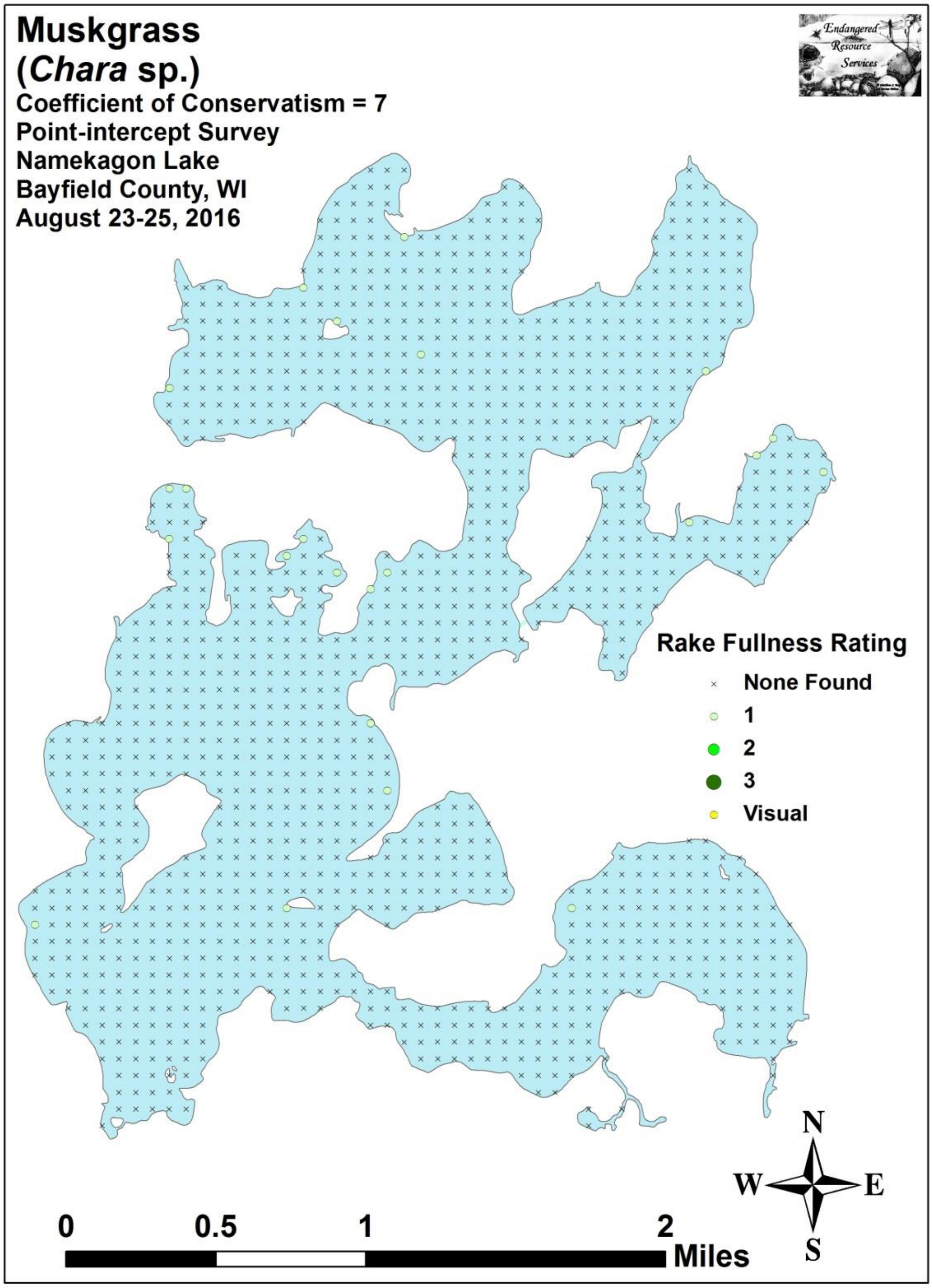
0.5
1
2
Miles


Muskgrass
(Chara sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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3
Visual
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0.5
1
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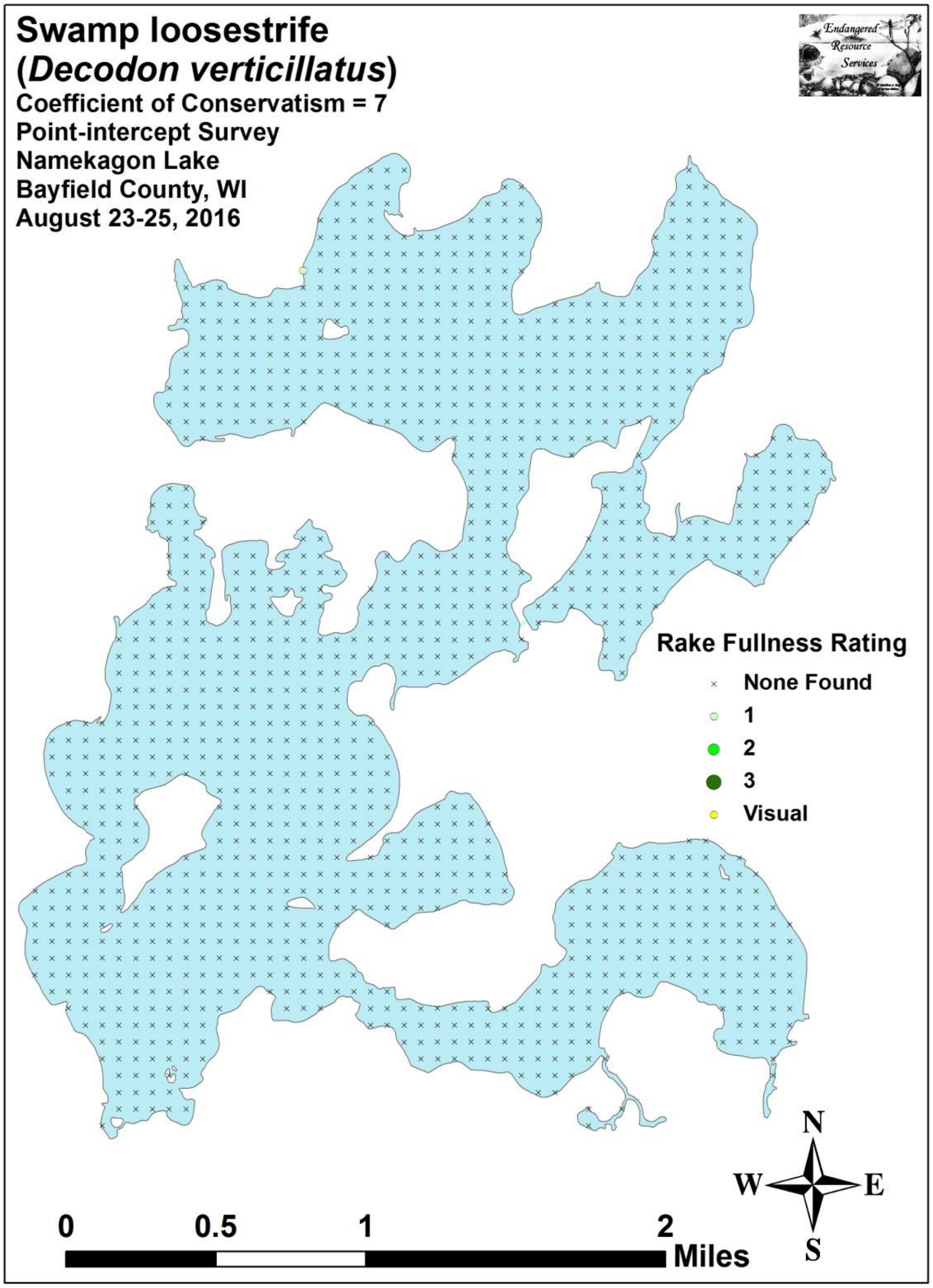
Miles


Swamp loosestrife
(Decodon verticillatus)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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Visual
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0.5
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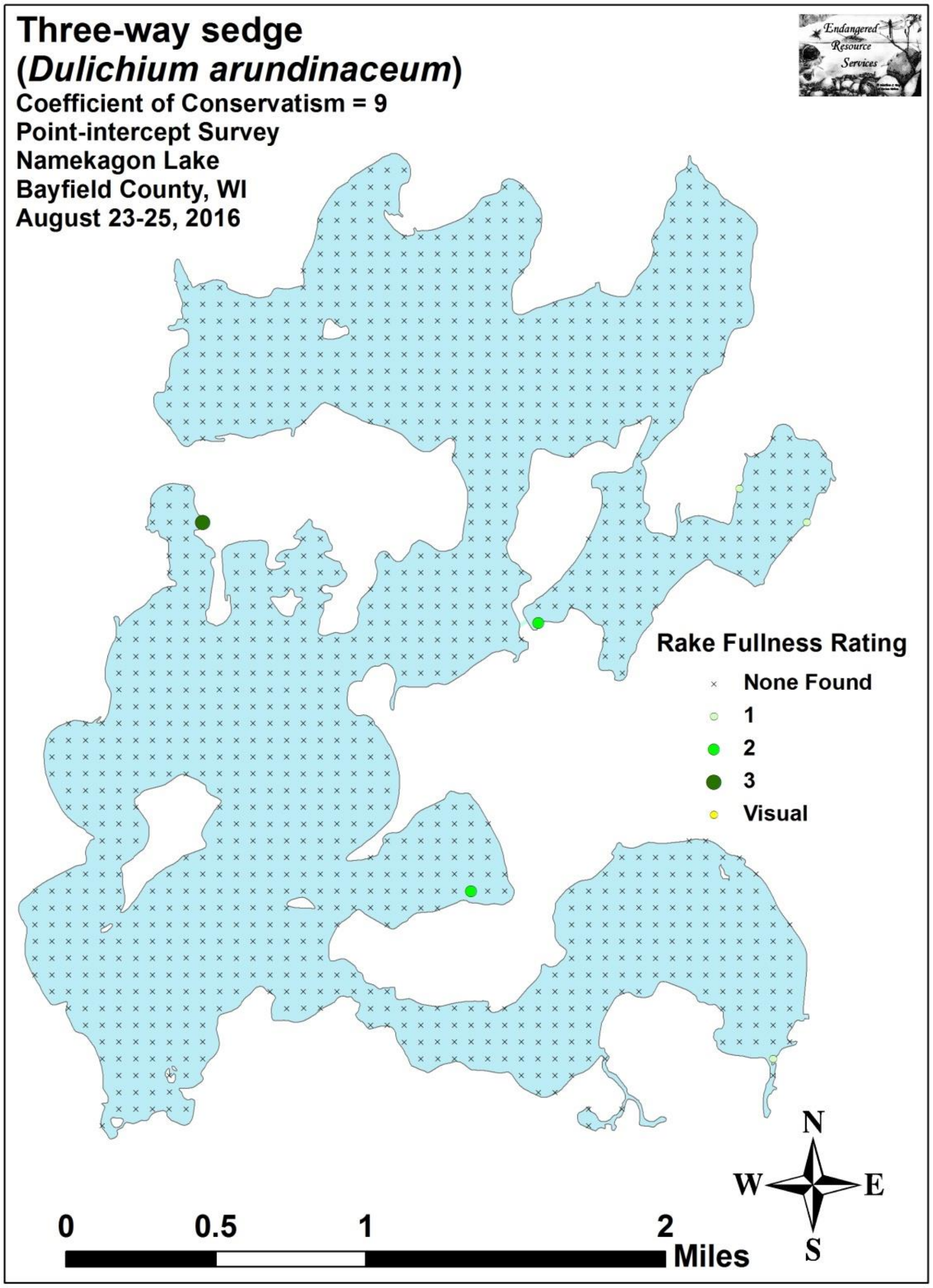
Miles


Three-way sedge
(*Dulichium arundinaceum*)
Coefficient of Conservatism = 9
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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Visual
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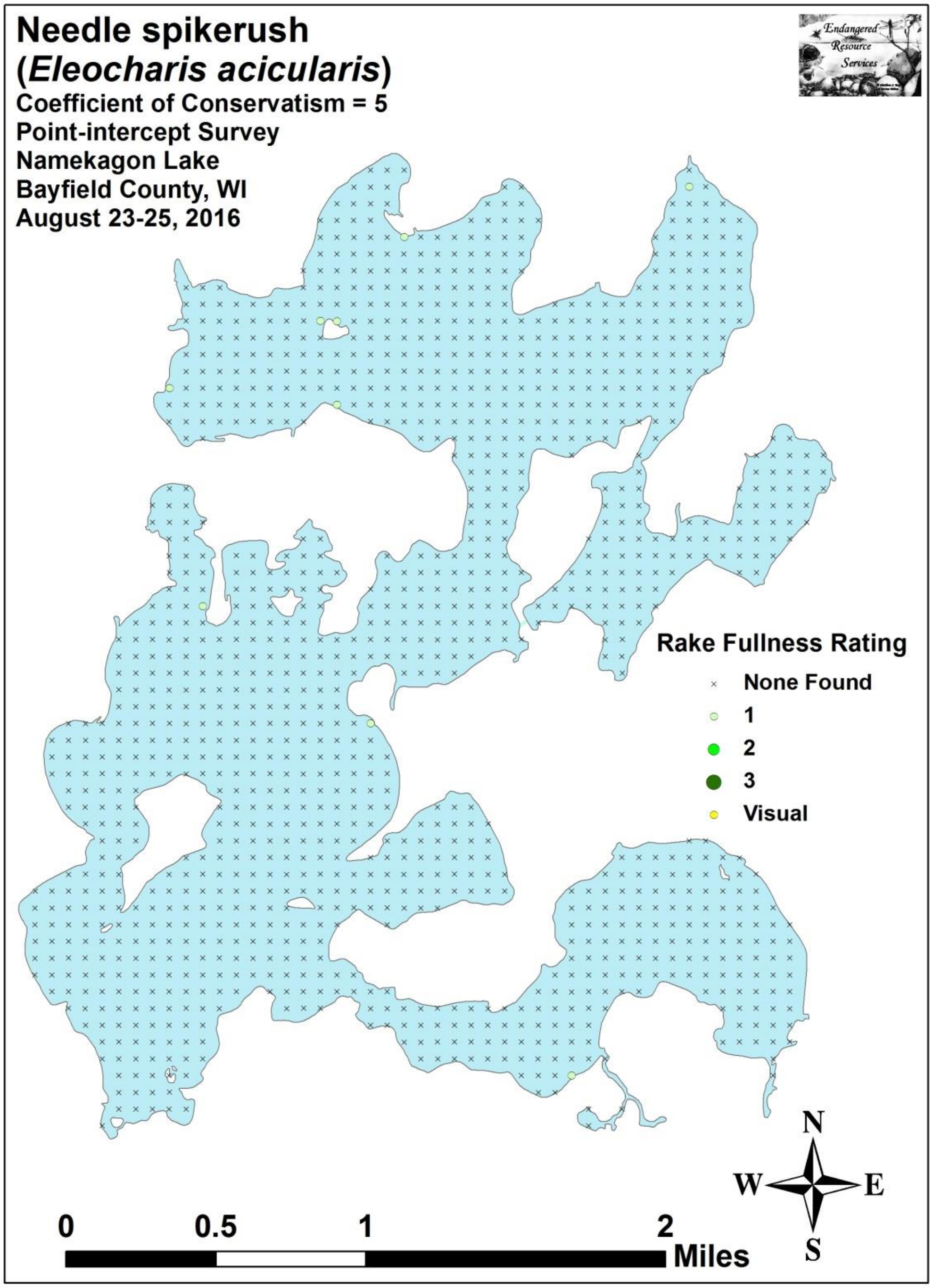
Miles



Needle spikerush
(Eleocharis acicularis)
Coefficient of Conservatism = 5
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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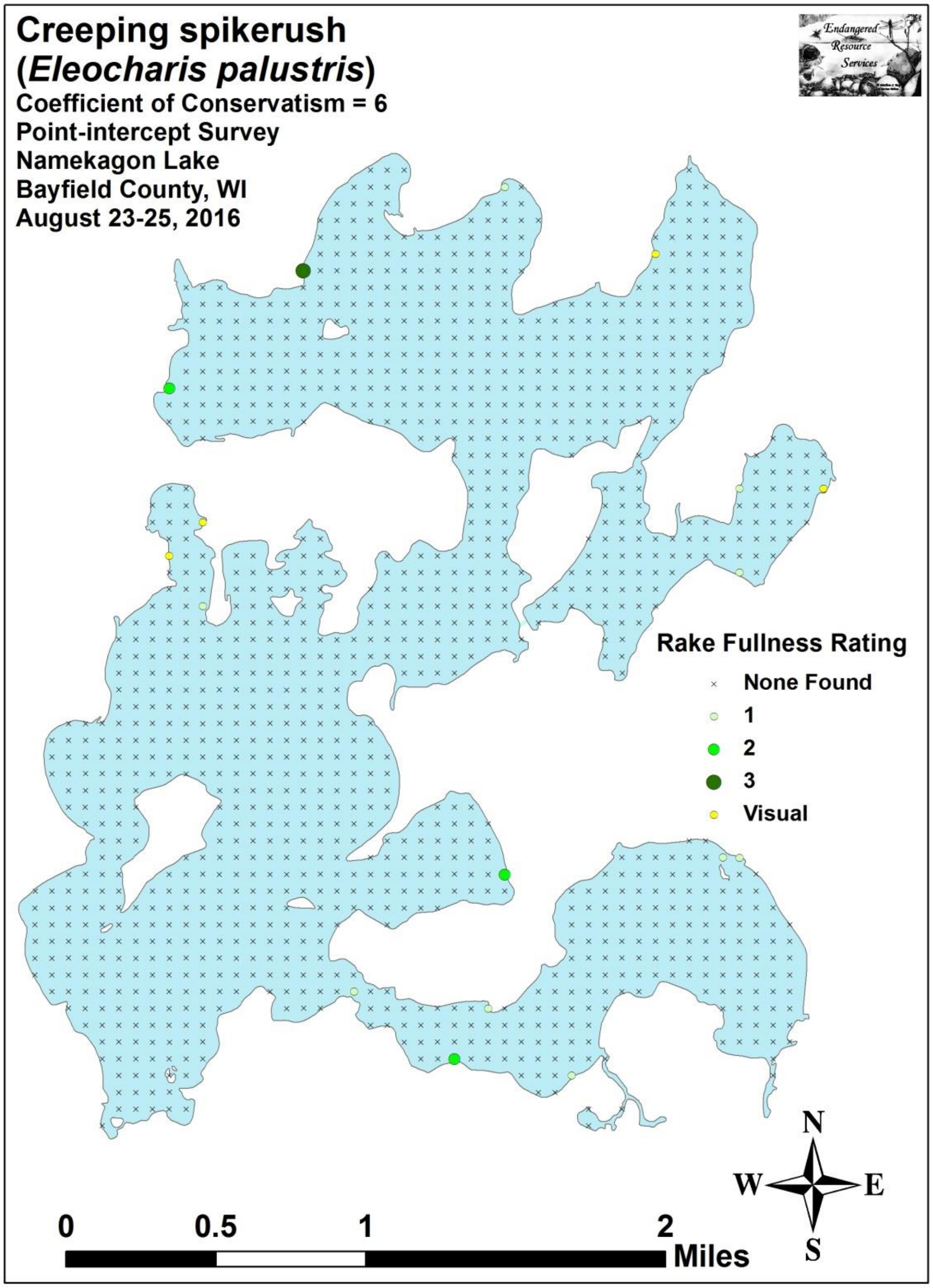
Miles


Creeping spikerush
(Eleocharis palustris)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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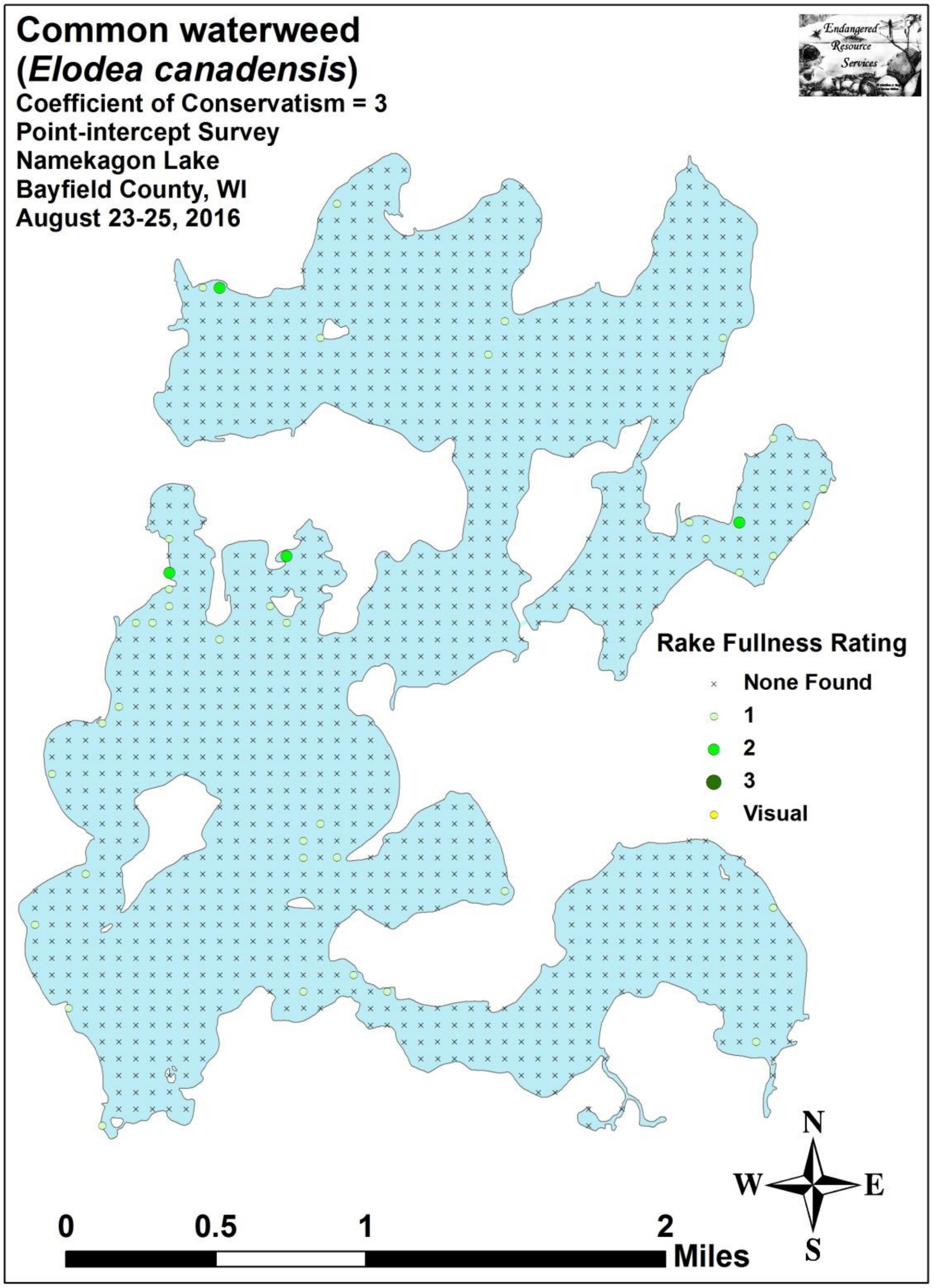
Miles


Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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Visual
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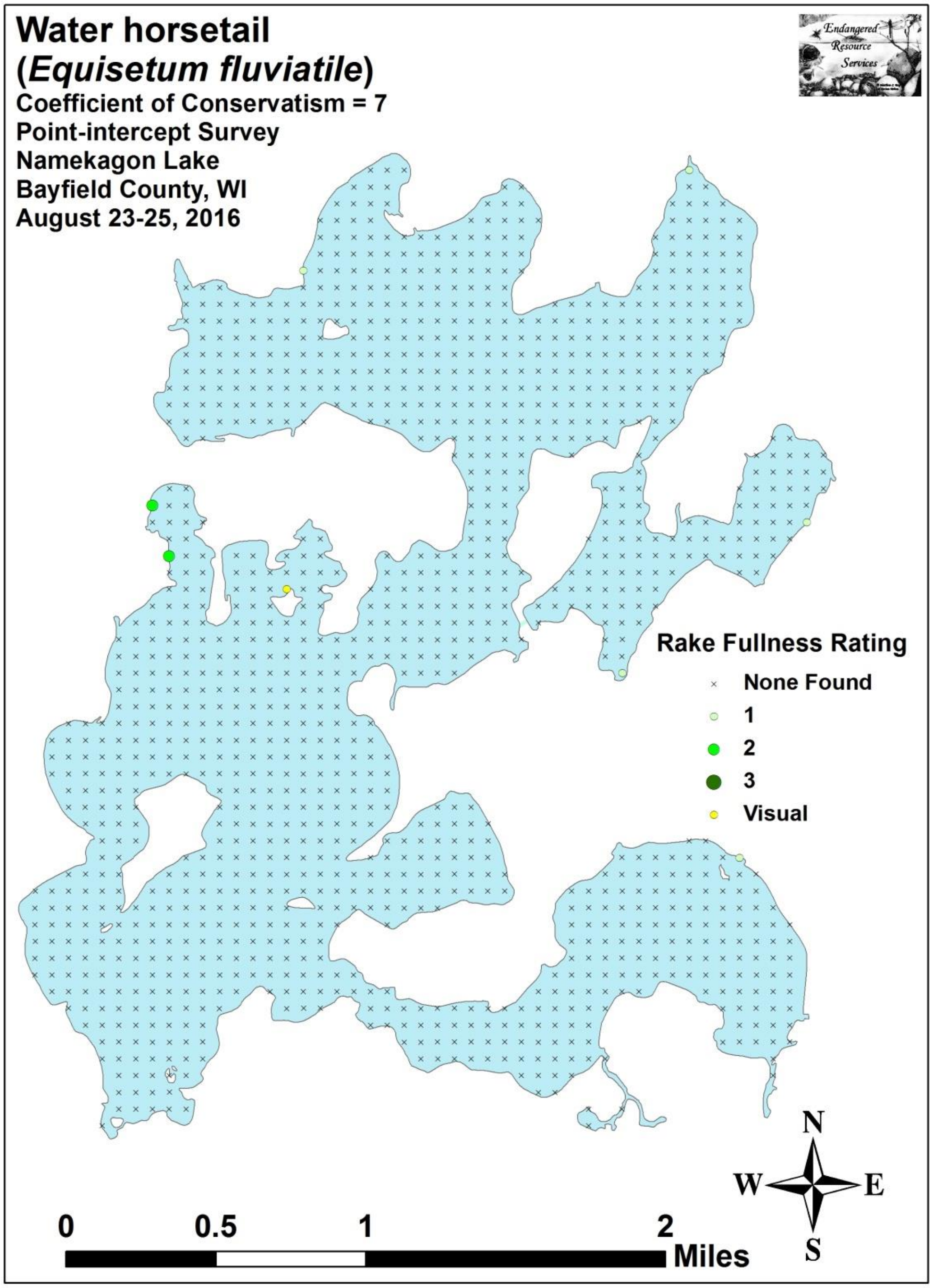
Miles


Water horsetail
(*Equisetum fluviatile*)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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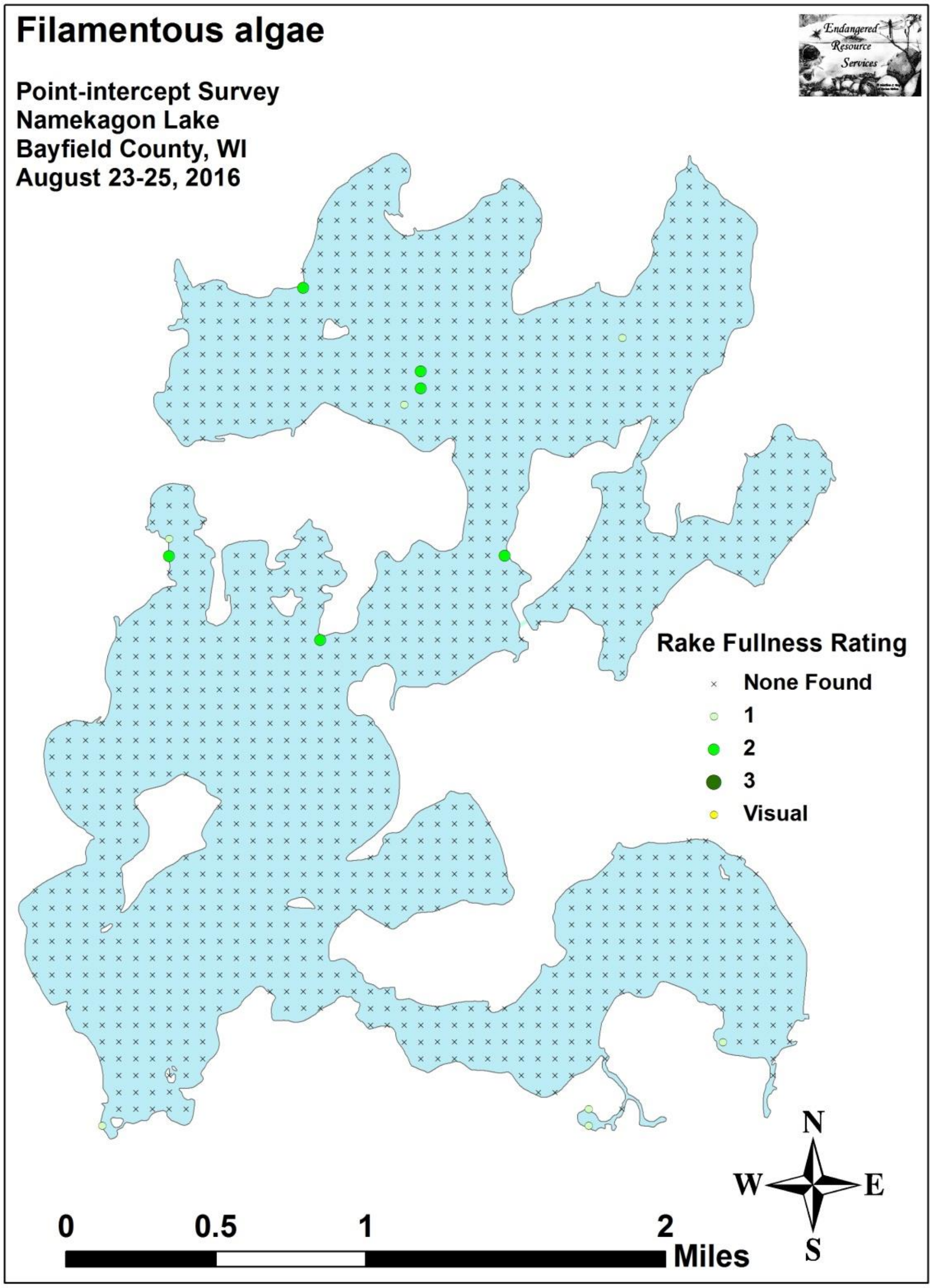
Miles


Filamentous algae
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Rake Fullness Rating
None Found
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Visual
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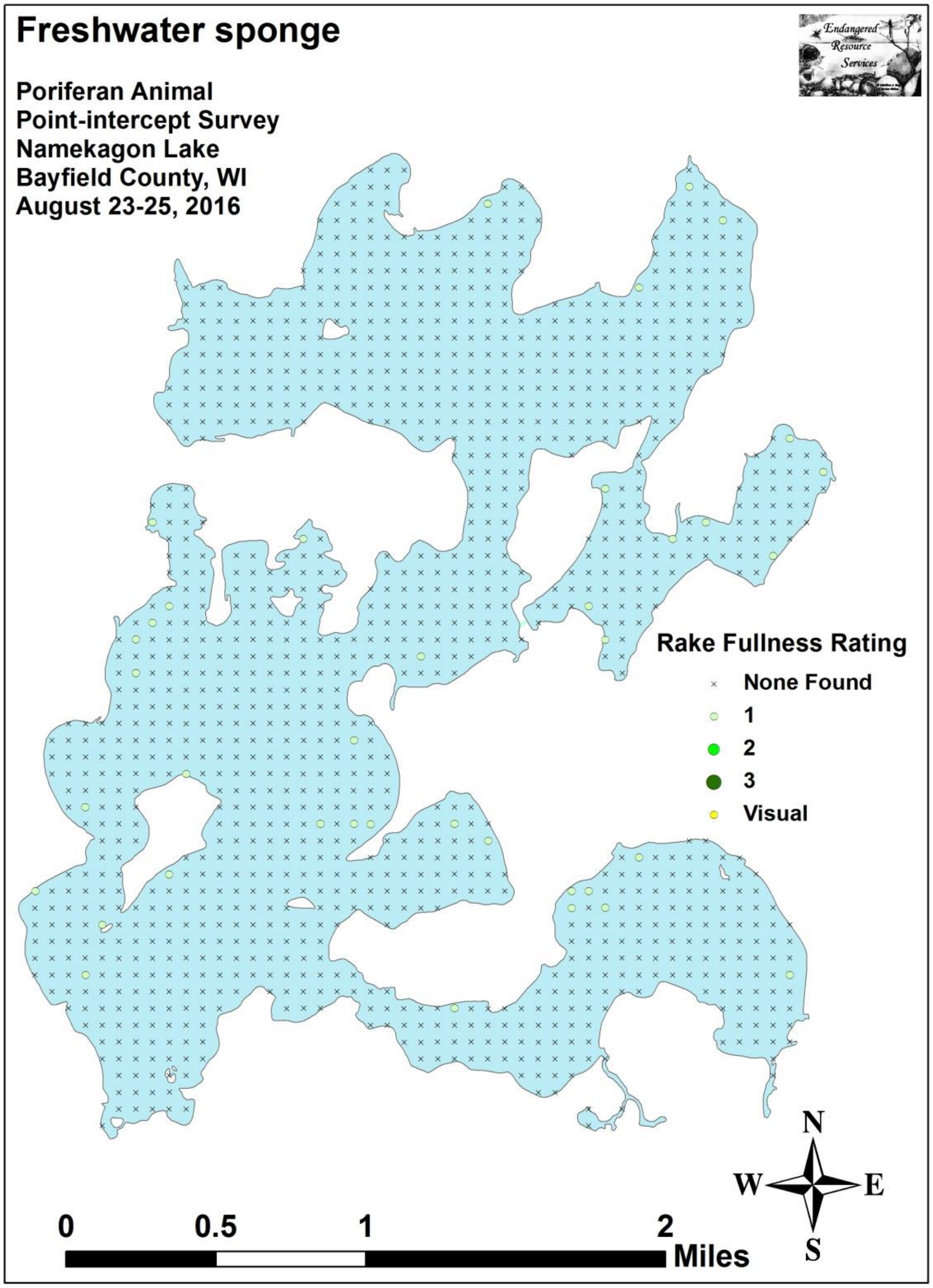
Miles


Freshwater sponge
Poriferan Animal
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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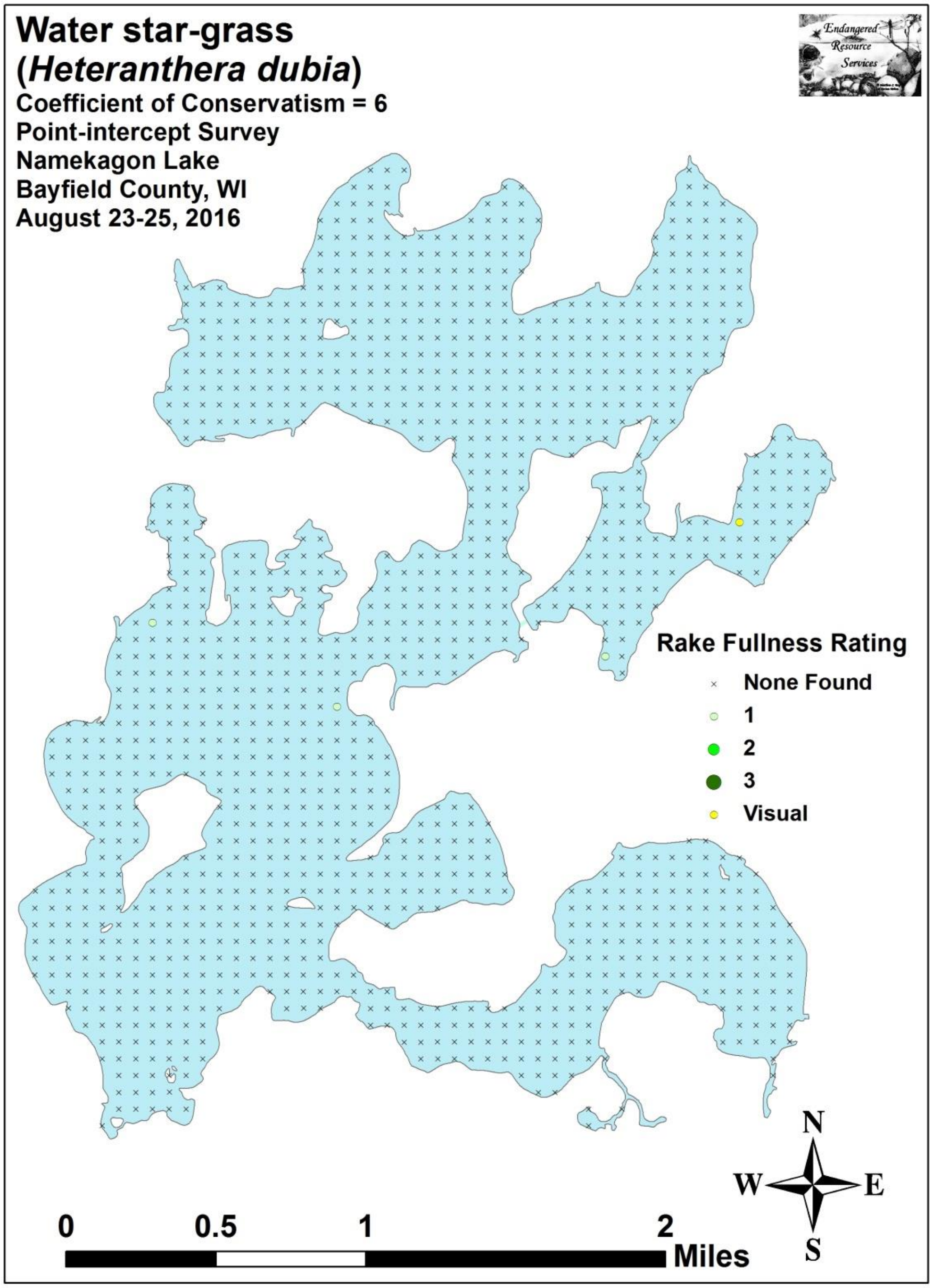
Miles



Water star-grass
(*Heteranthera dubia*)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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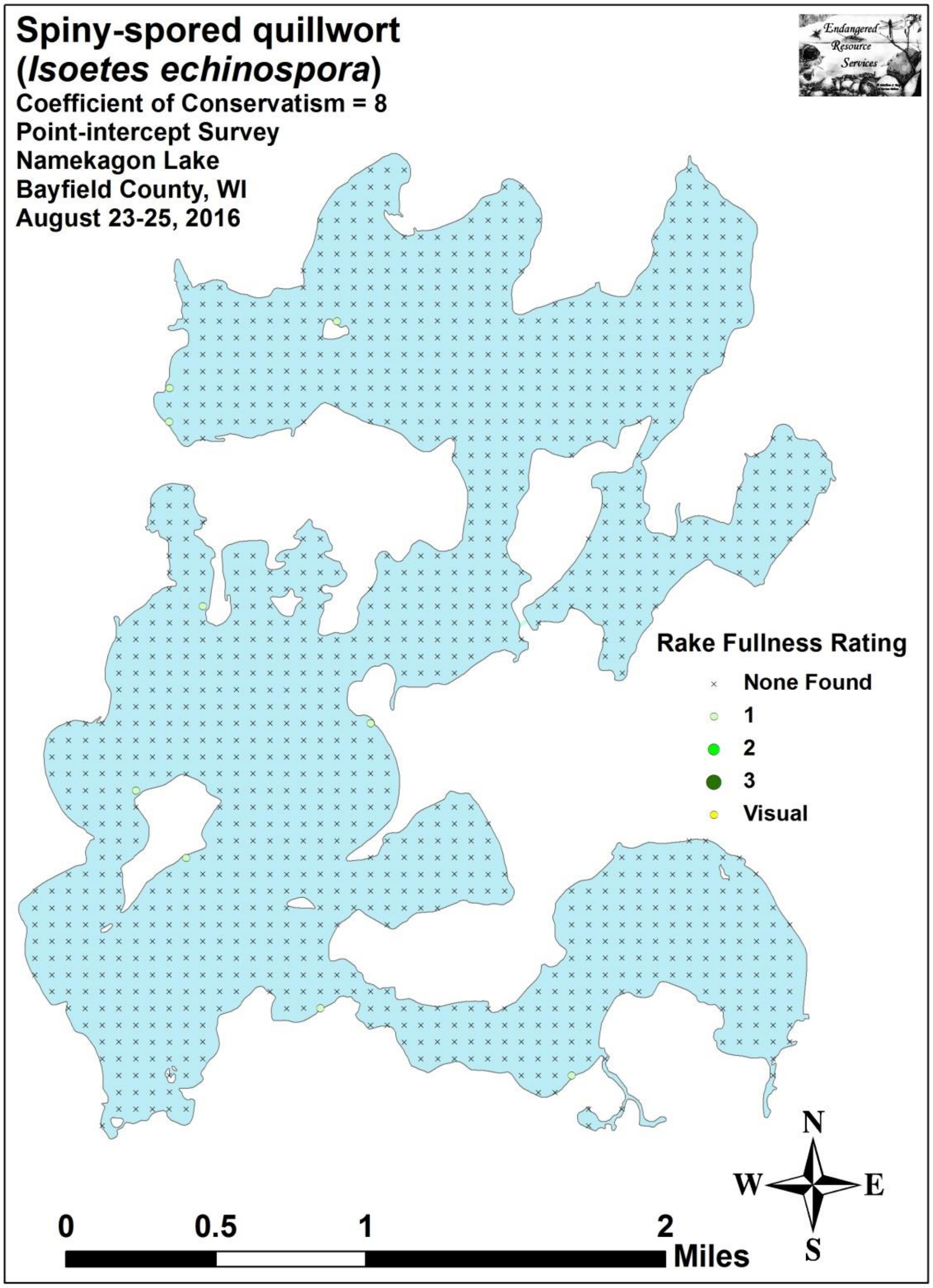
Miles


Spiny-spored quillwort
(Isoetes echinospora)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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Visual
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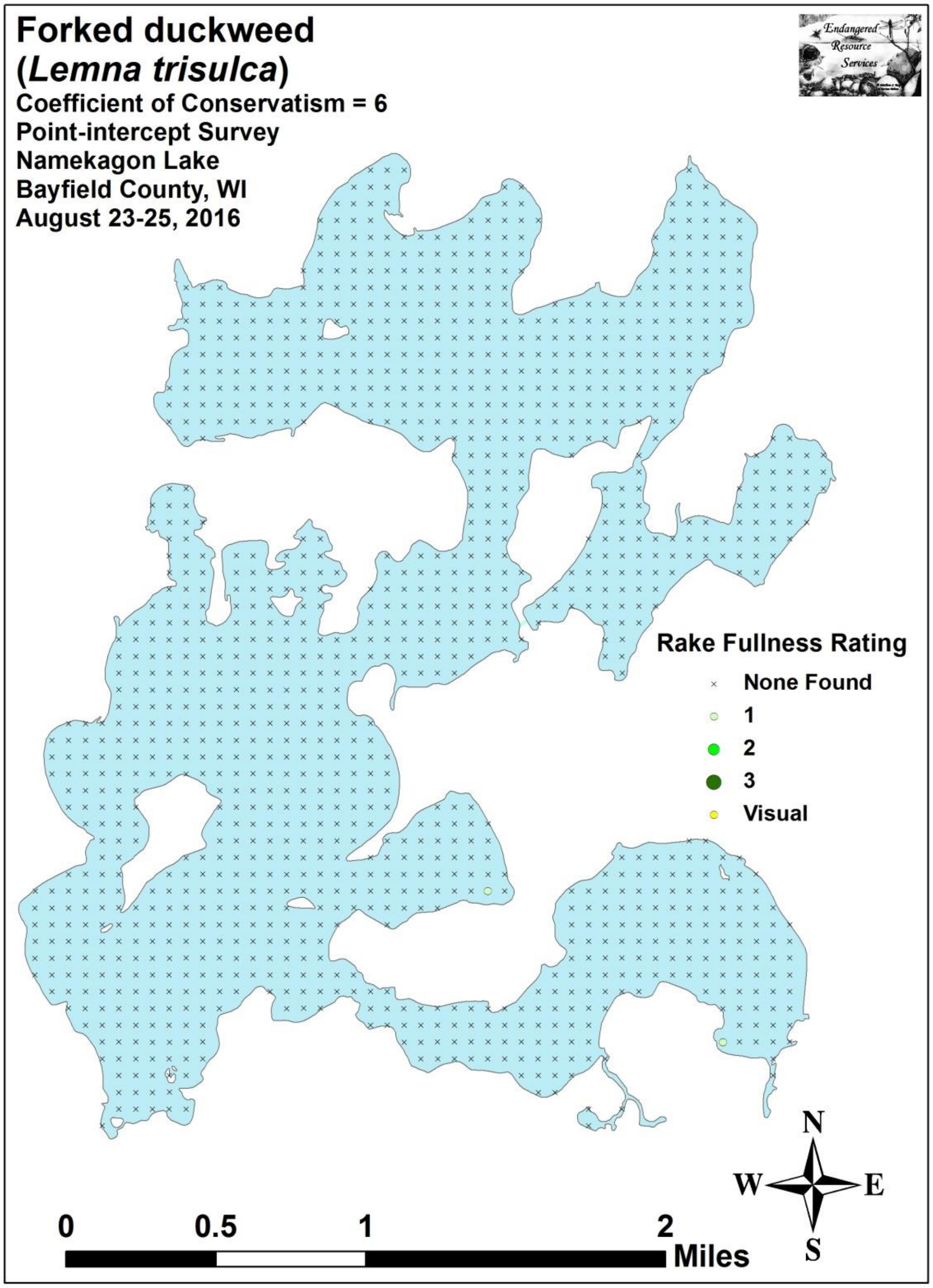
Miles



Forked duckweed
(Lemna trisulca)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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Visual
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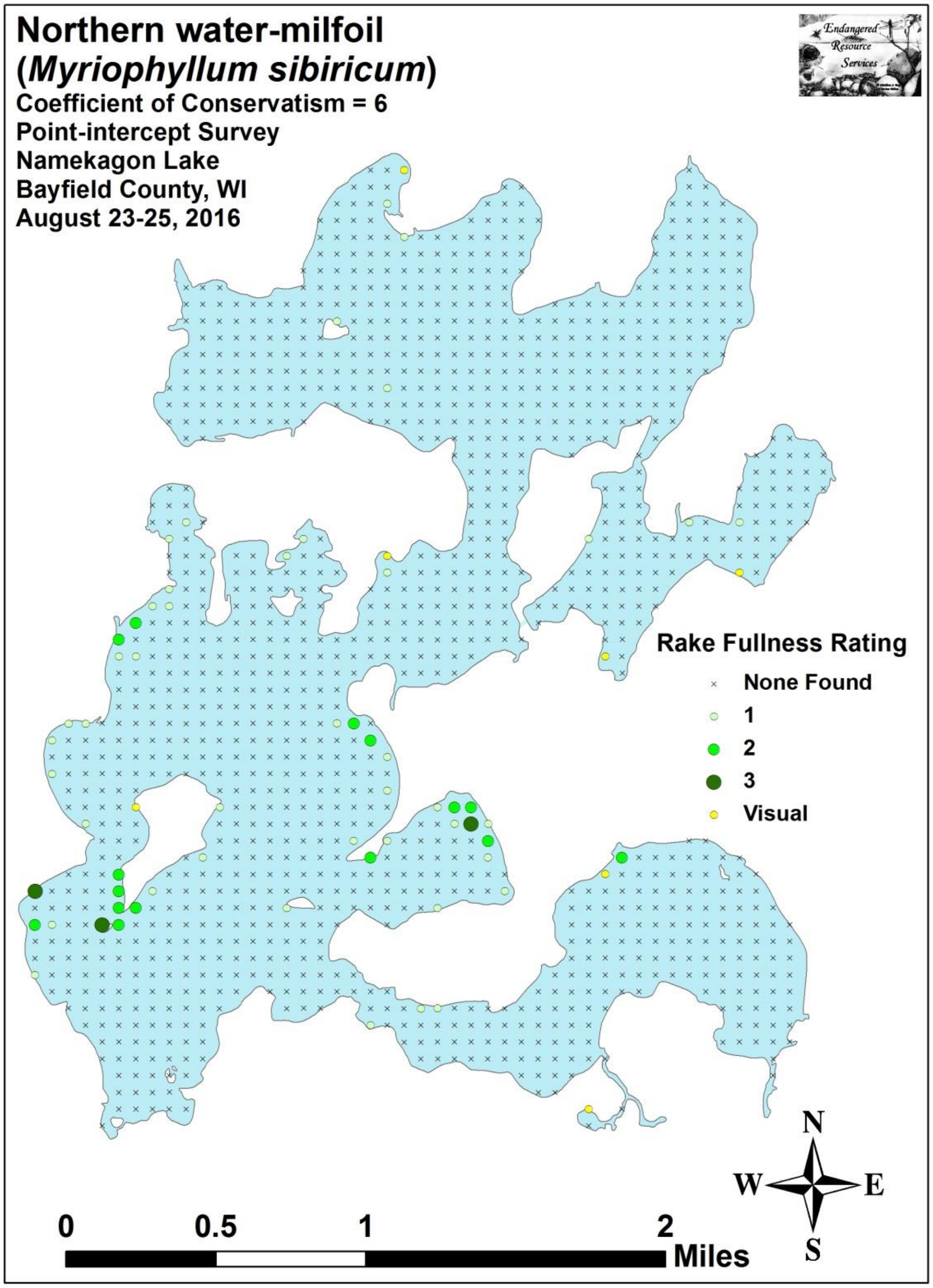
Miles



Northern water-milfoil
(Myriophyllum sibiricum)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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Visual
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0.5
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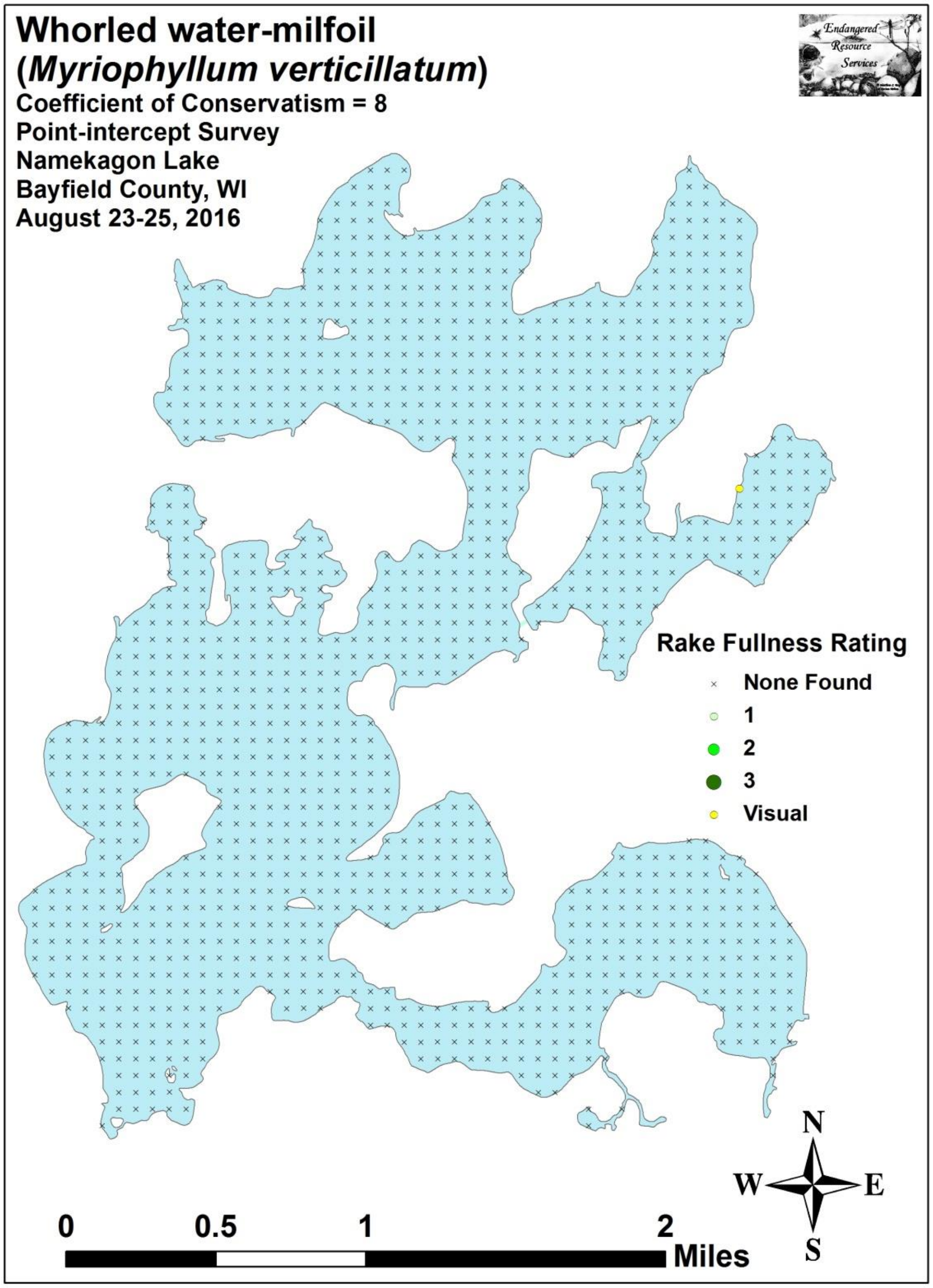
Miles


Whorled water-milfoil
(Myriophyllum verticillatum)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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Visual
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0.5
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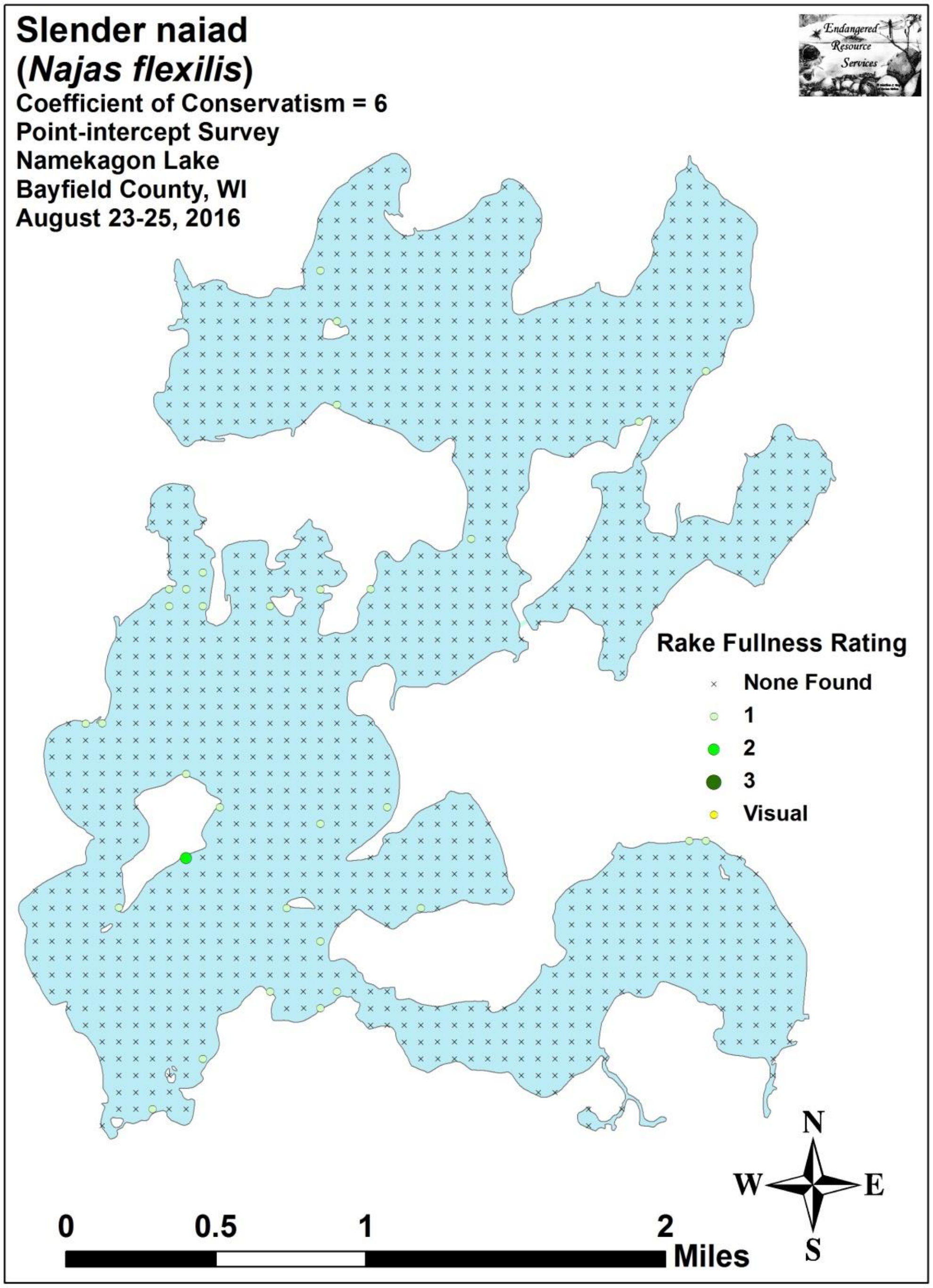
Miles


Slender naiad
(*Najas flexilis*)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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3
Visual
N
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0.5
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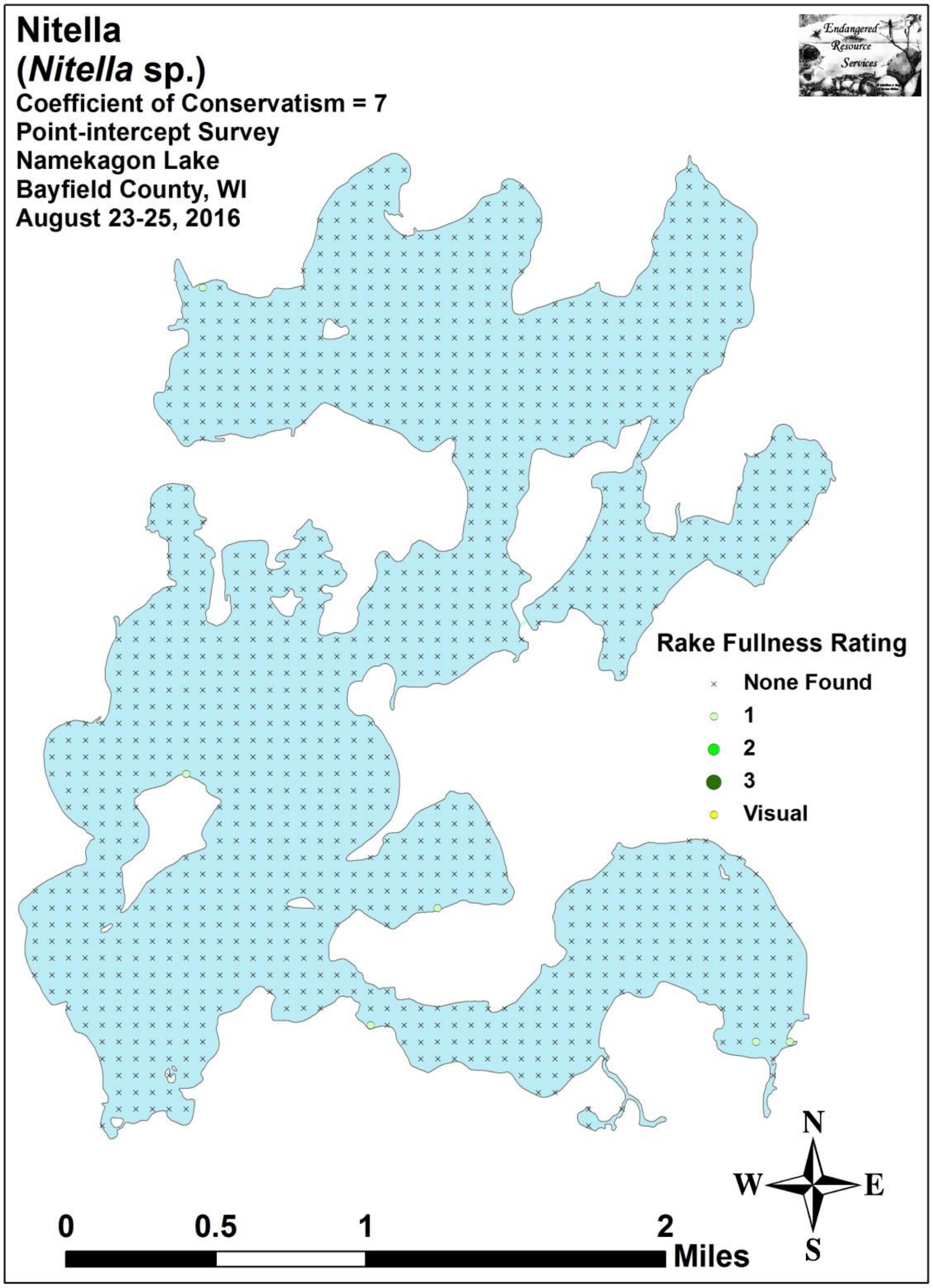
Miles



Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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3
Visual
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0.5
1
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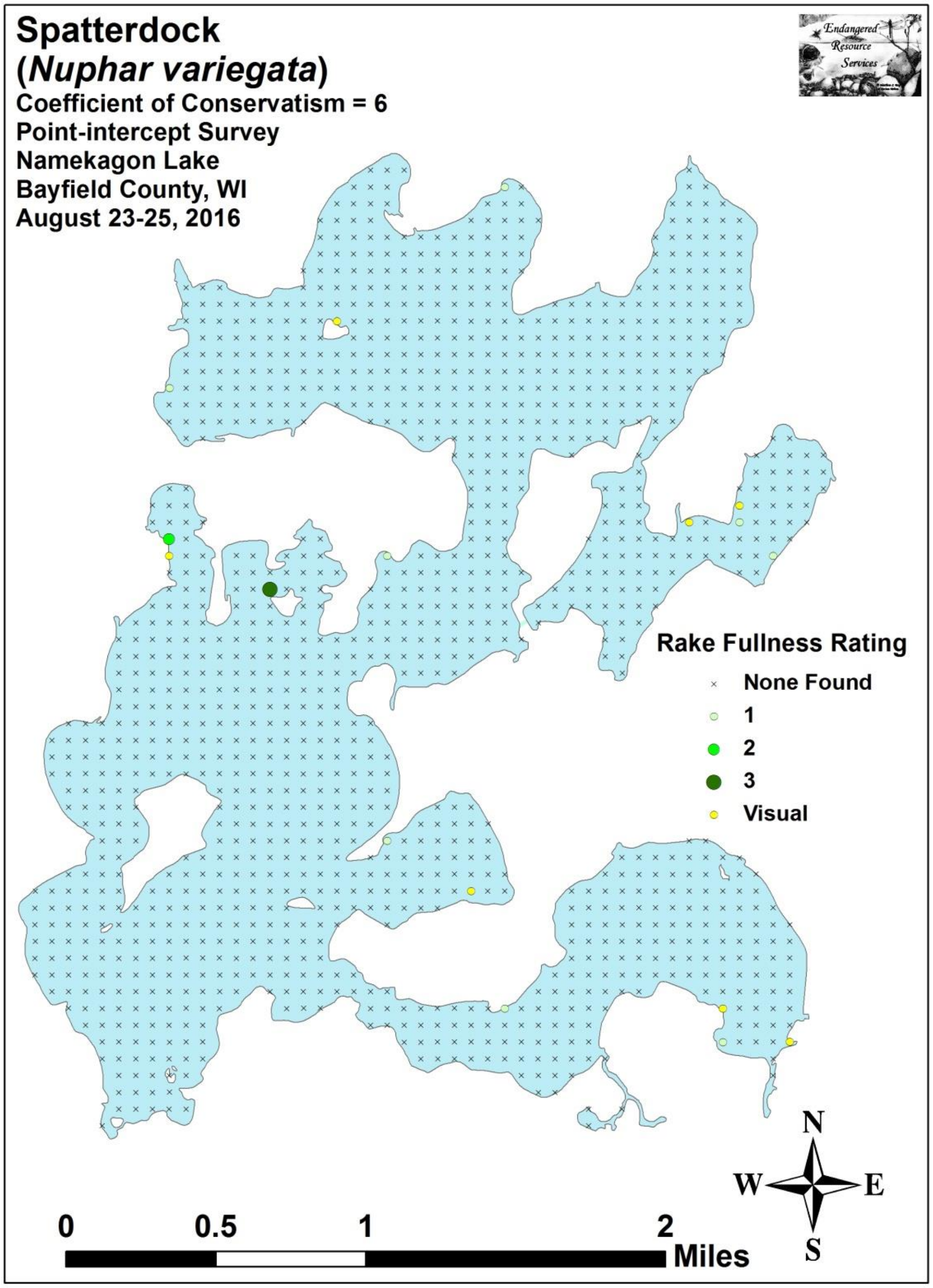
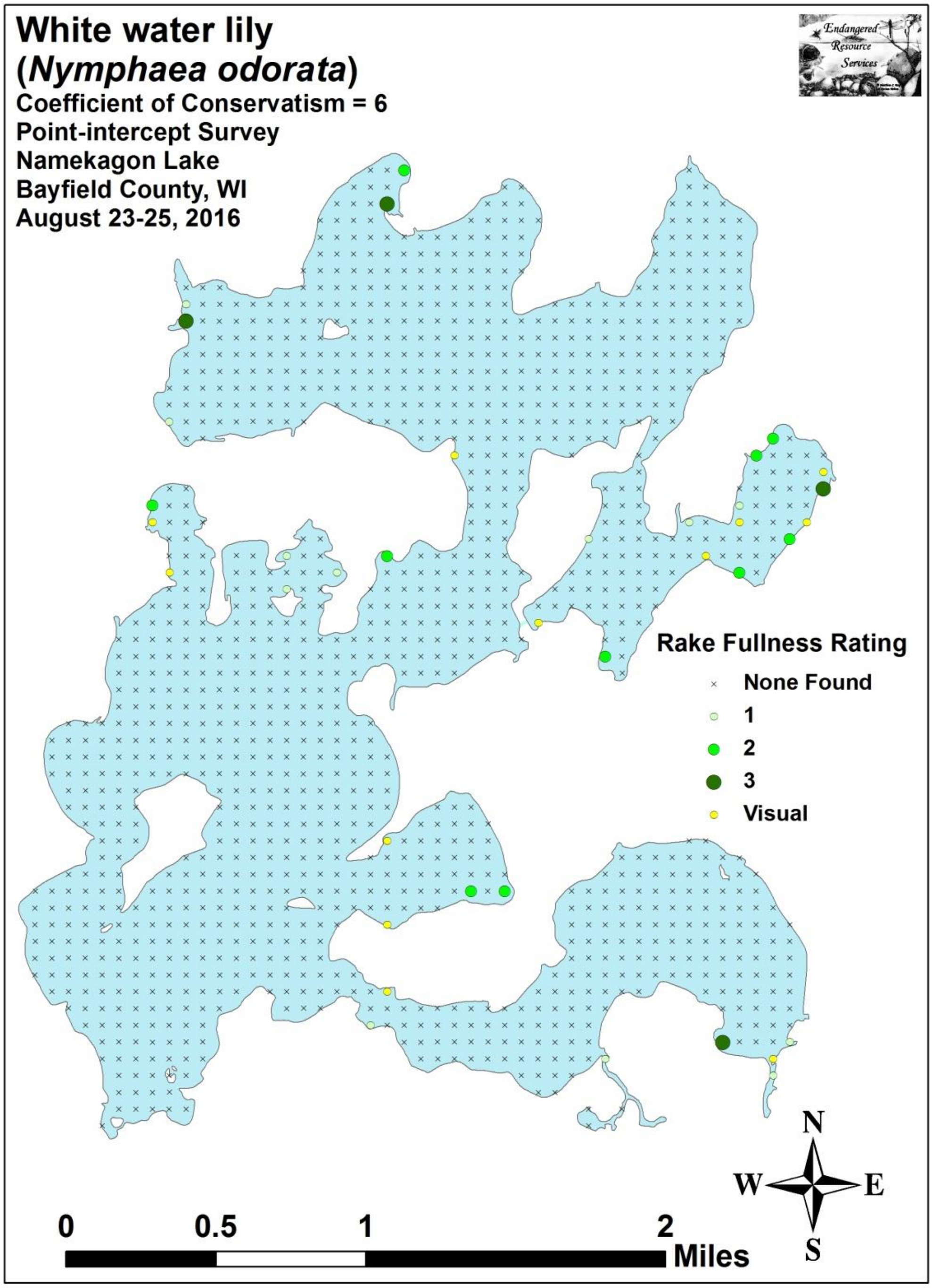
Miles


Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
N
W
E
S
0
0.5
1
2
Miles


White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
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3
Visual
N
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0.5
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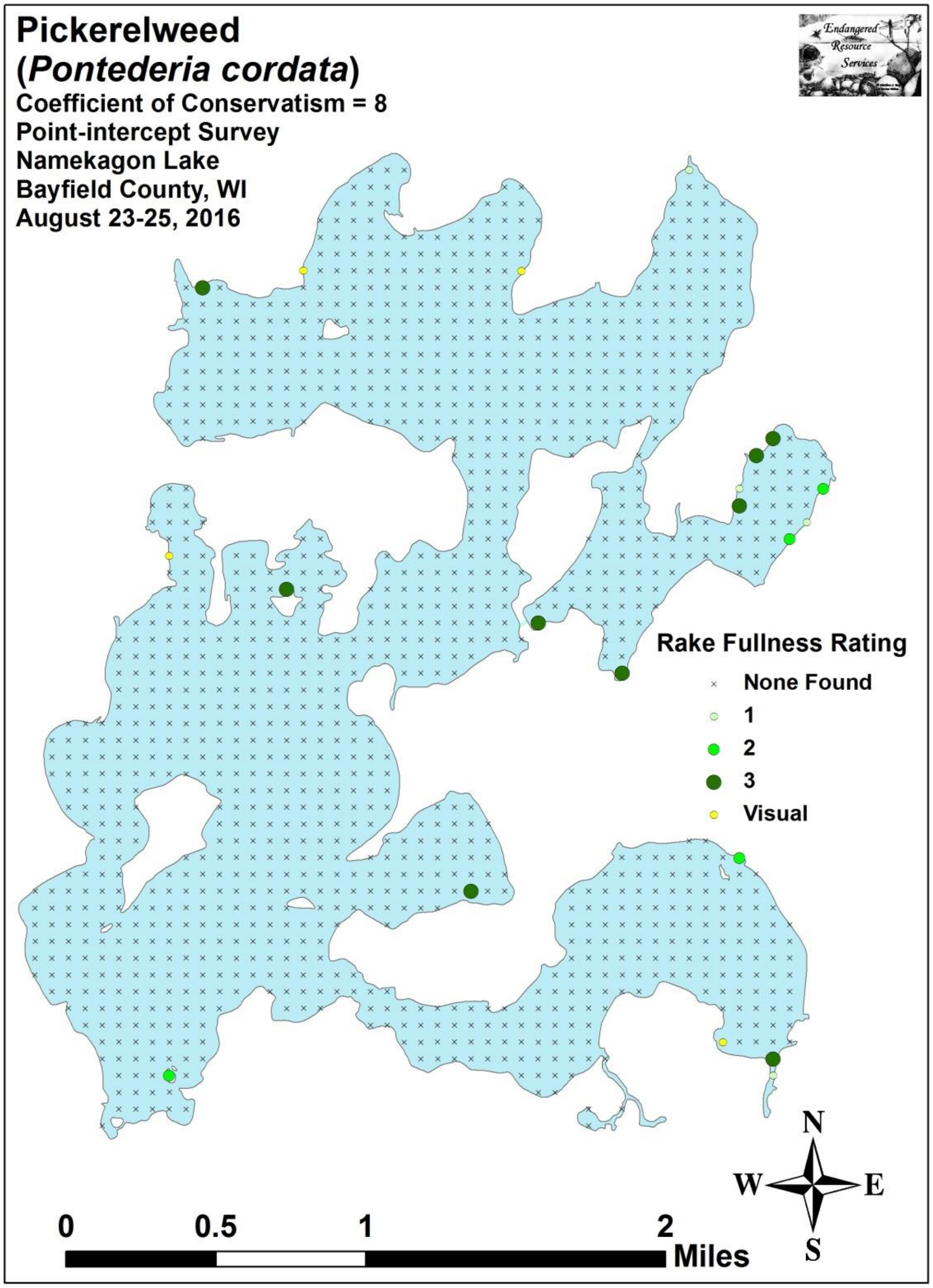
Miles


Pickerelweed
(Pontederia cordata)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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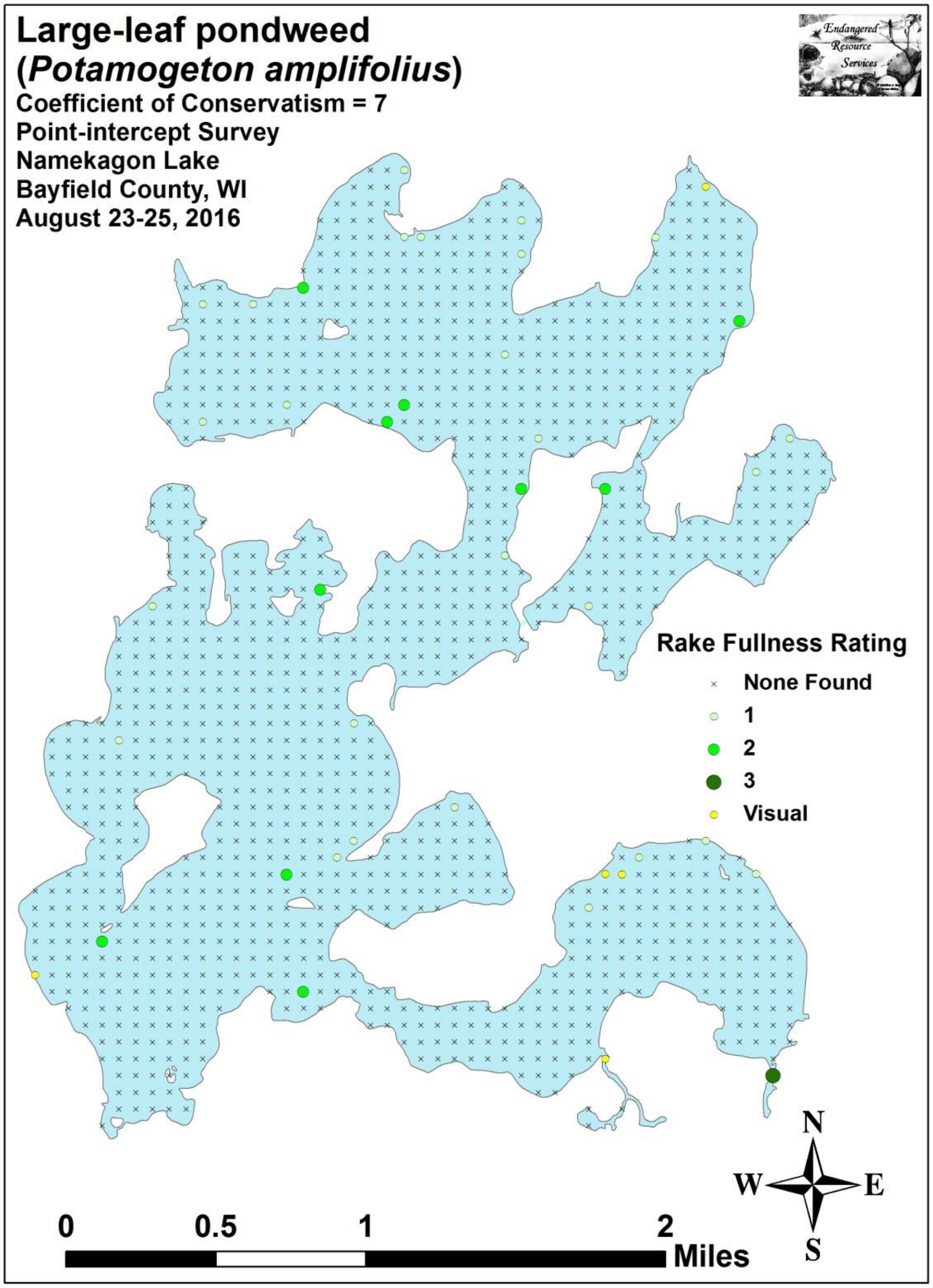
Miles


Large-leaf pondweed
(Potamogeton amplifolius)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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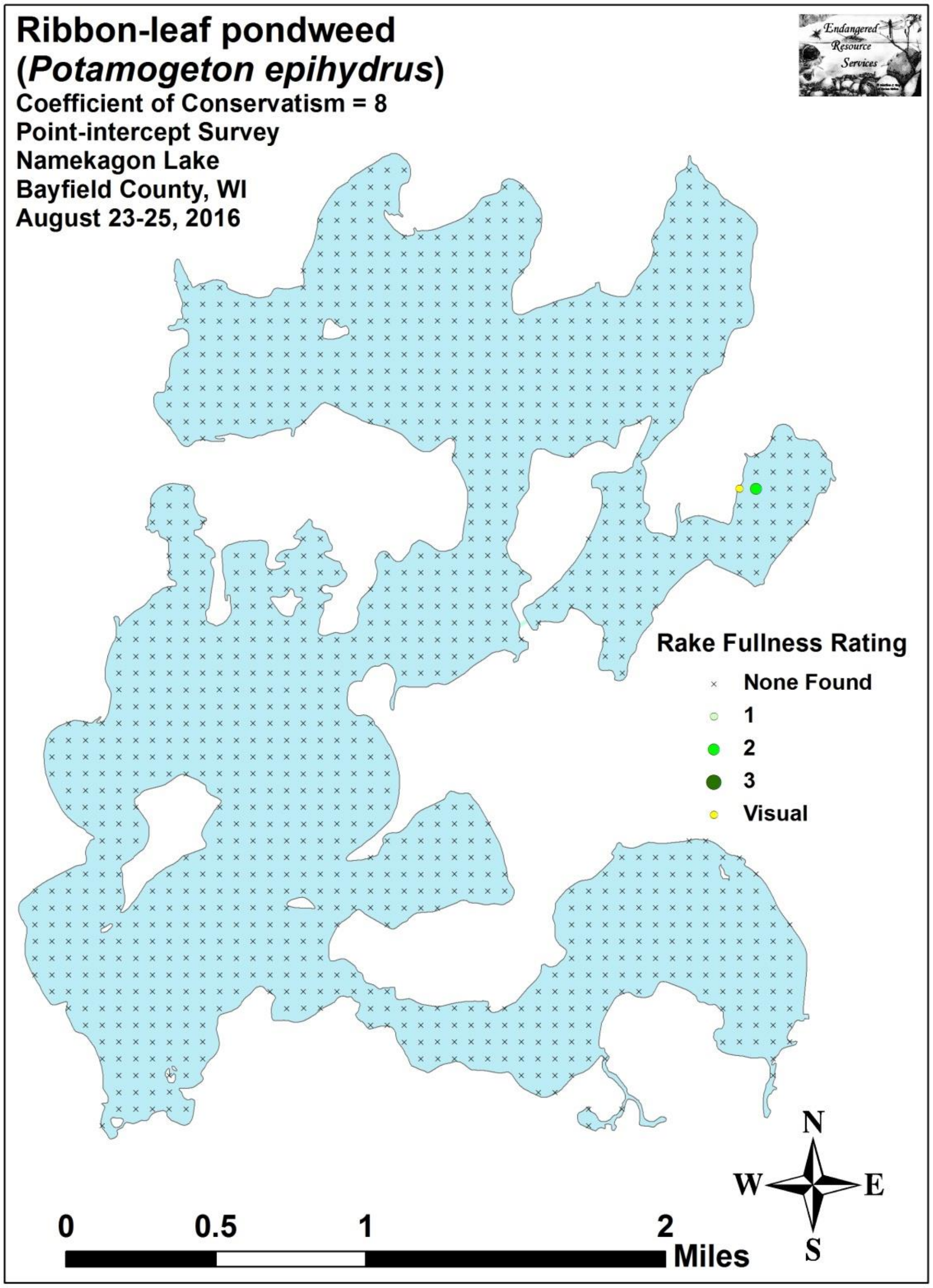
Miles


Ribbon-leaf pondweed
(*Potamogeton epihydrus*)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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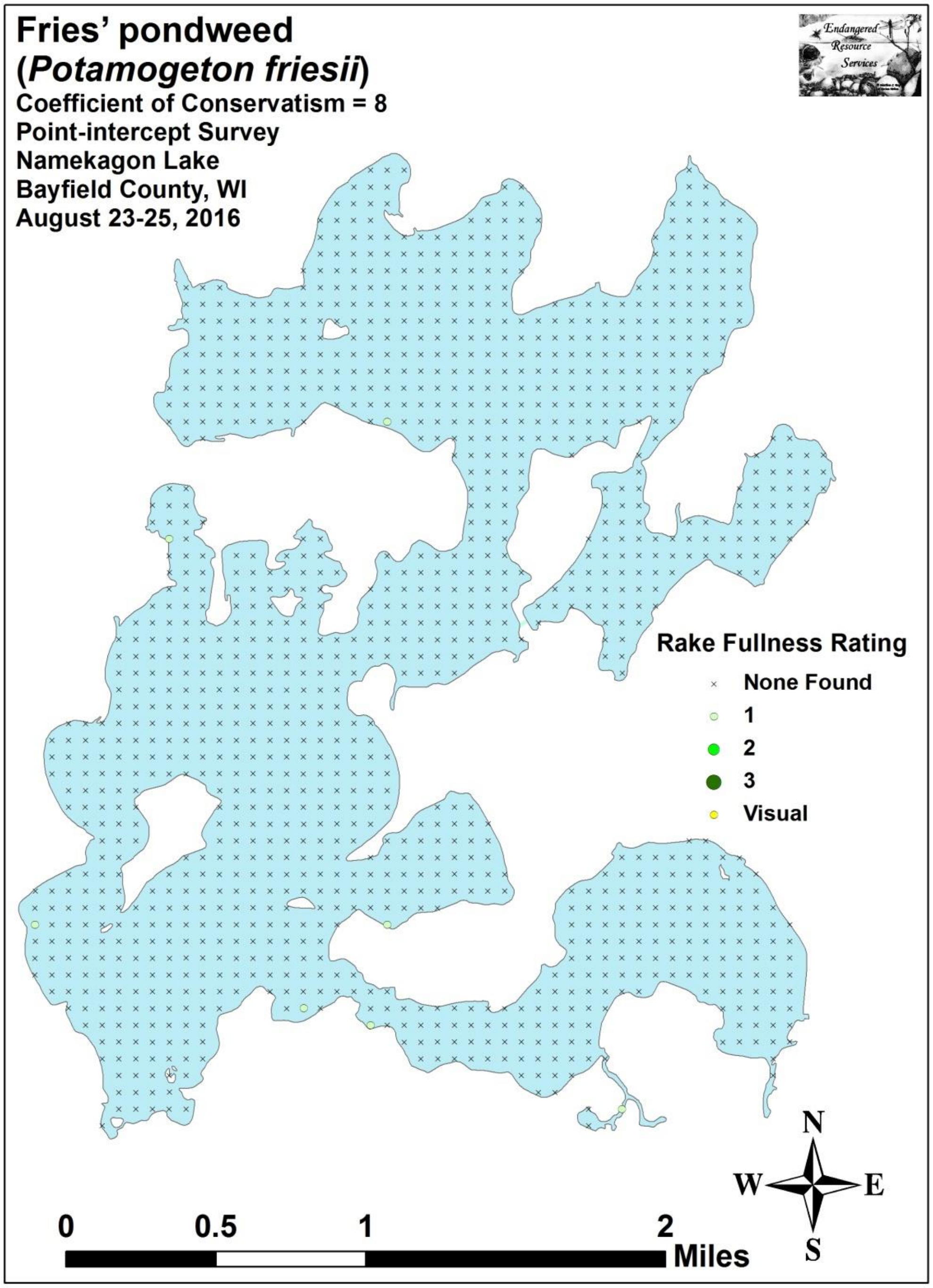
Miles


Fries' pondweed
(Potamogeton friesii)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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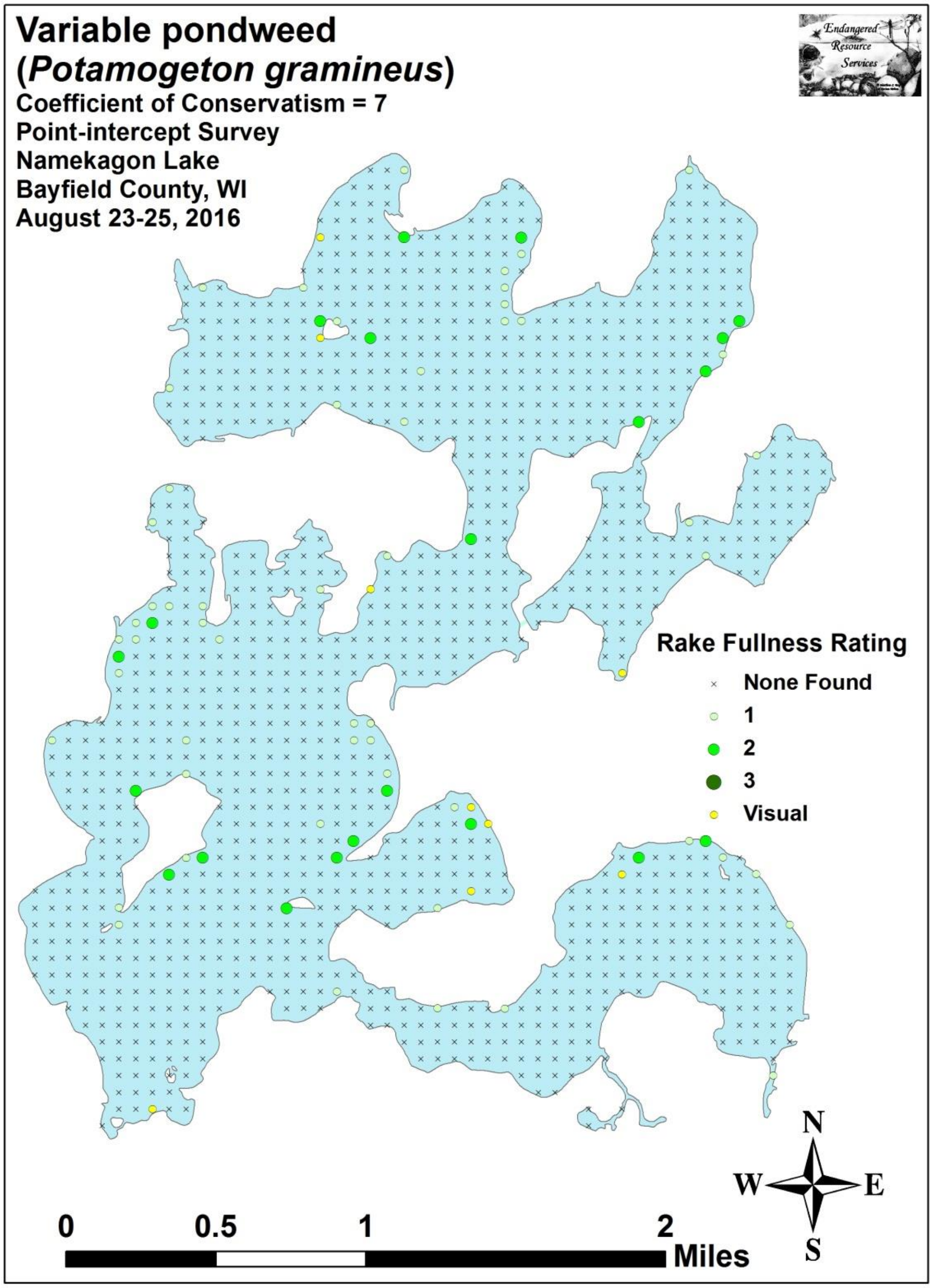
Miles


Variable pondweed
(*Potamogeton gramineus*)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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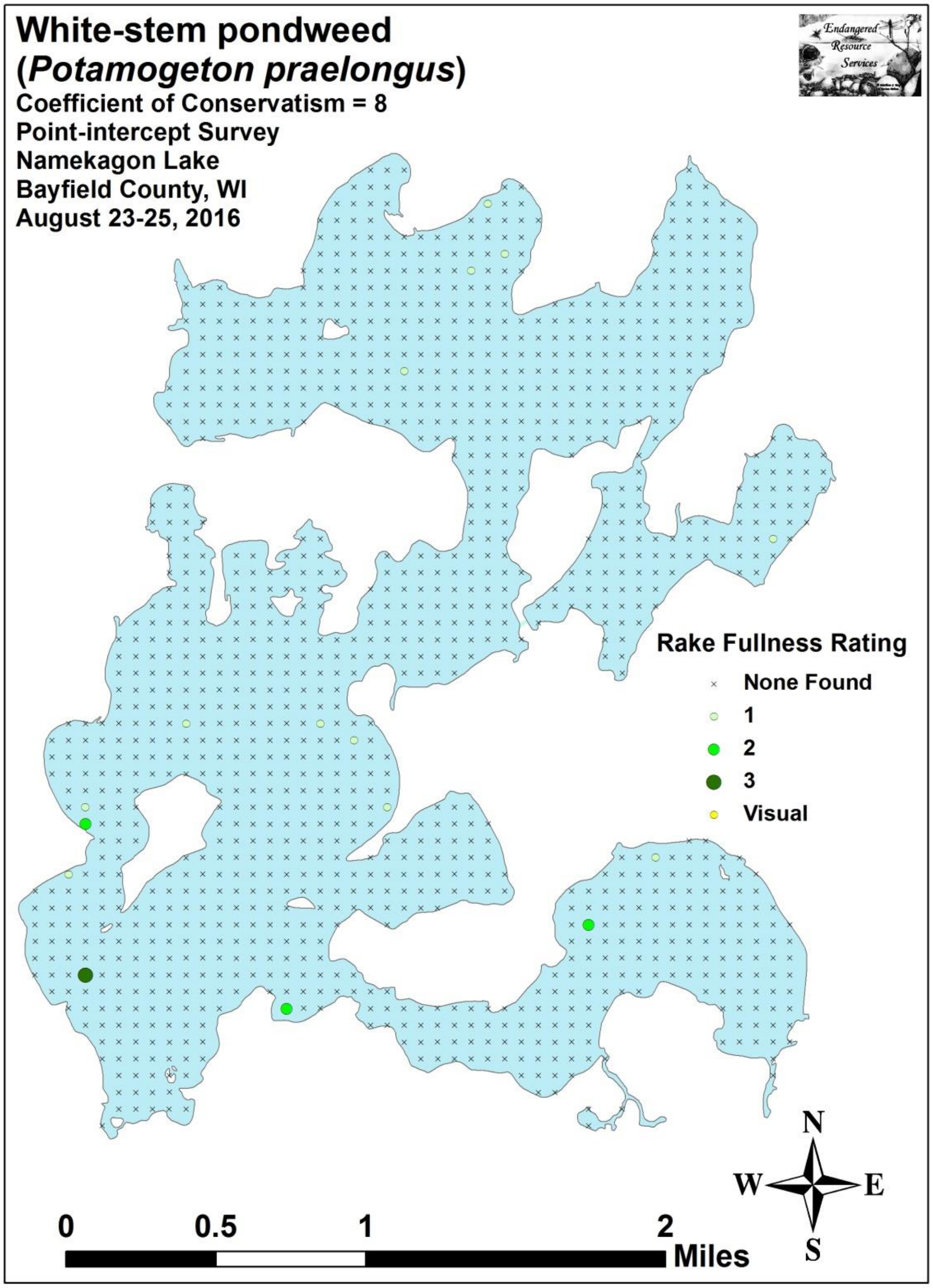
Miles


White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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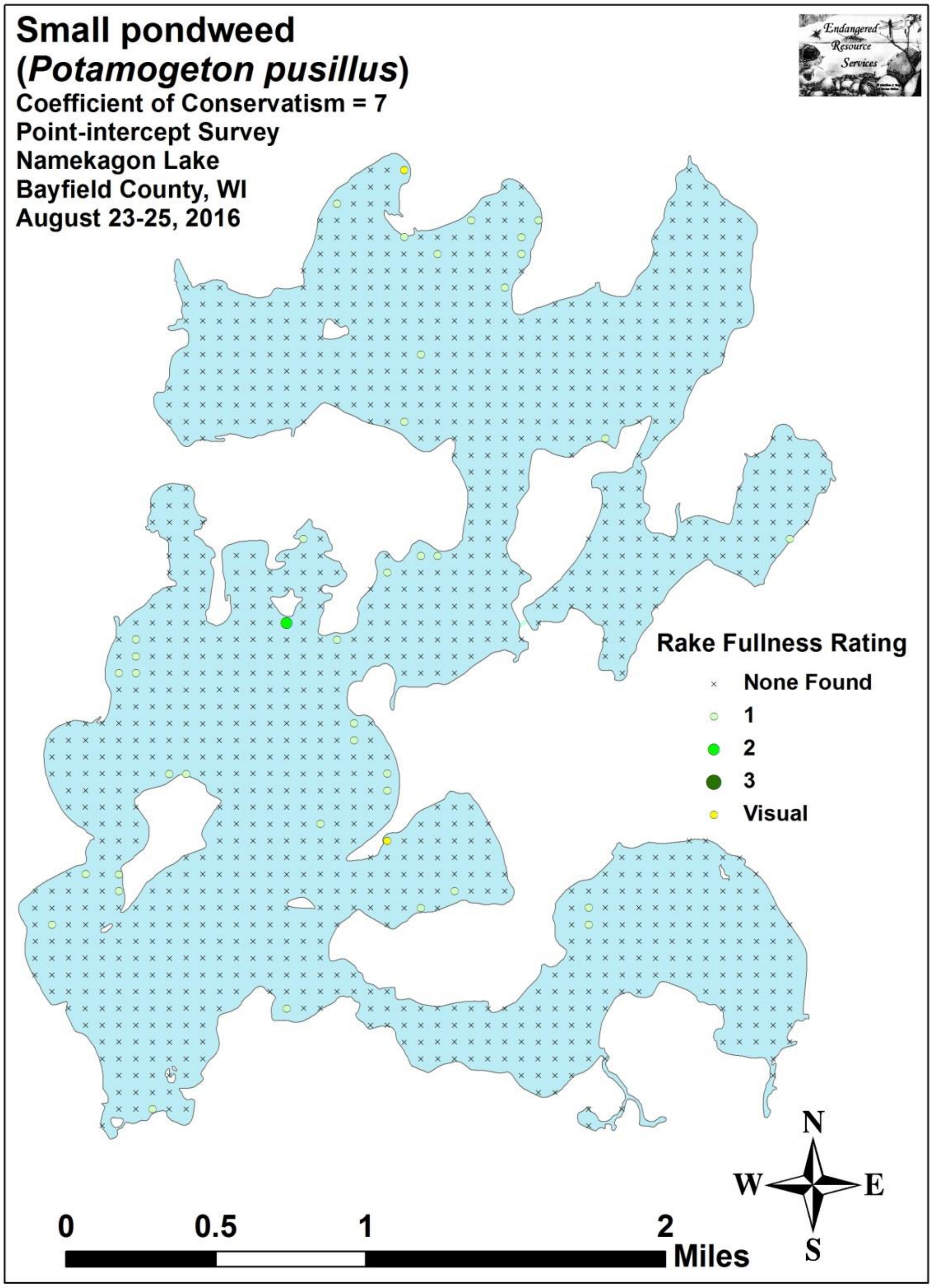
Miles


Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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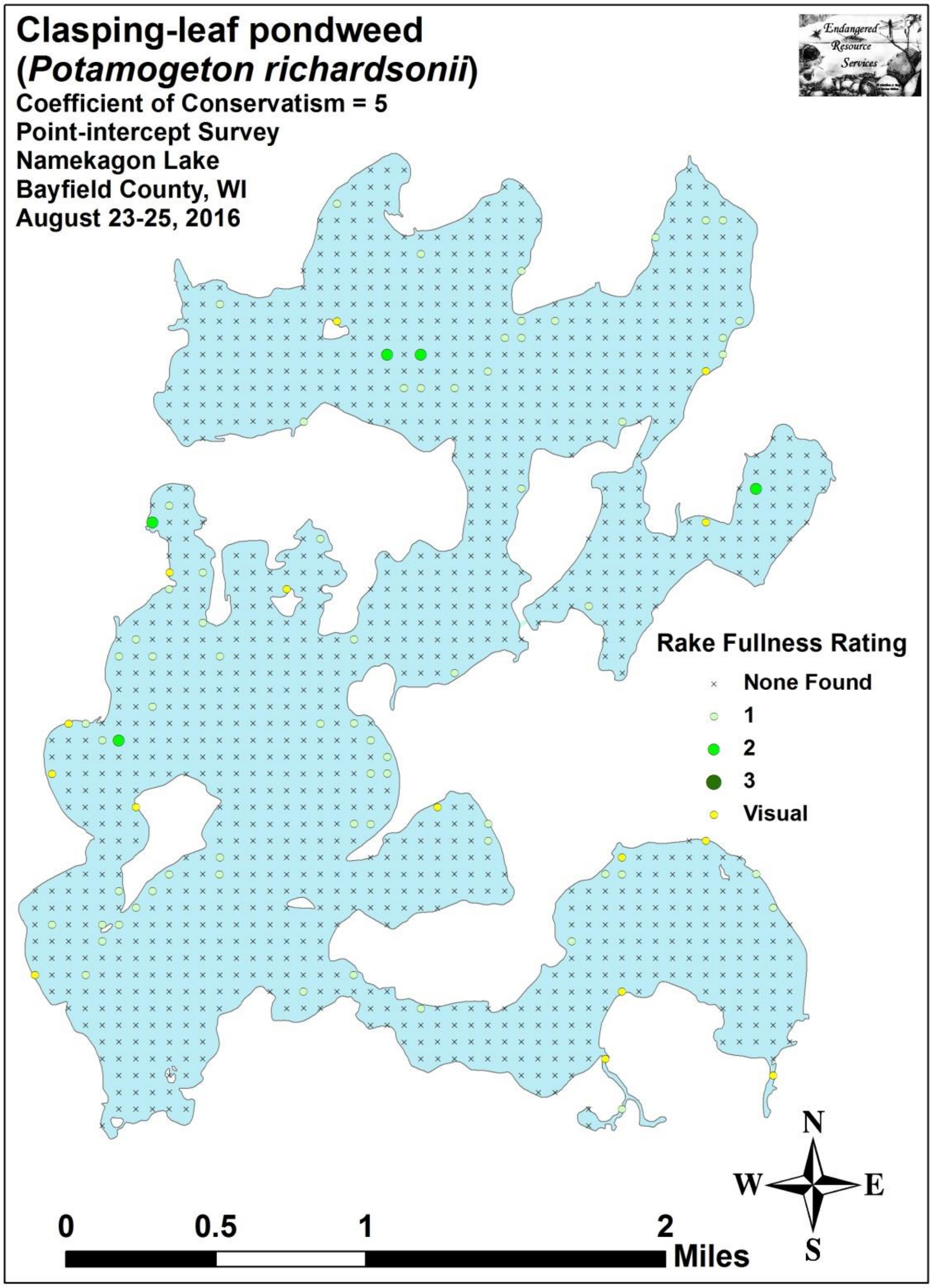
Miles



Clasping-leaf pondweed
(*Potamogeton richardsonii*)
Coefficient of Conservatism = 5
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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Visual
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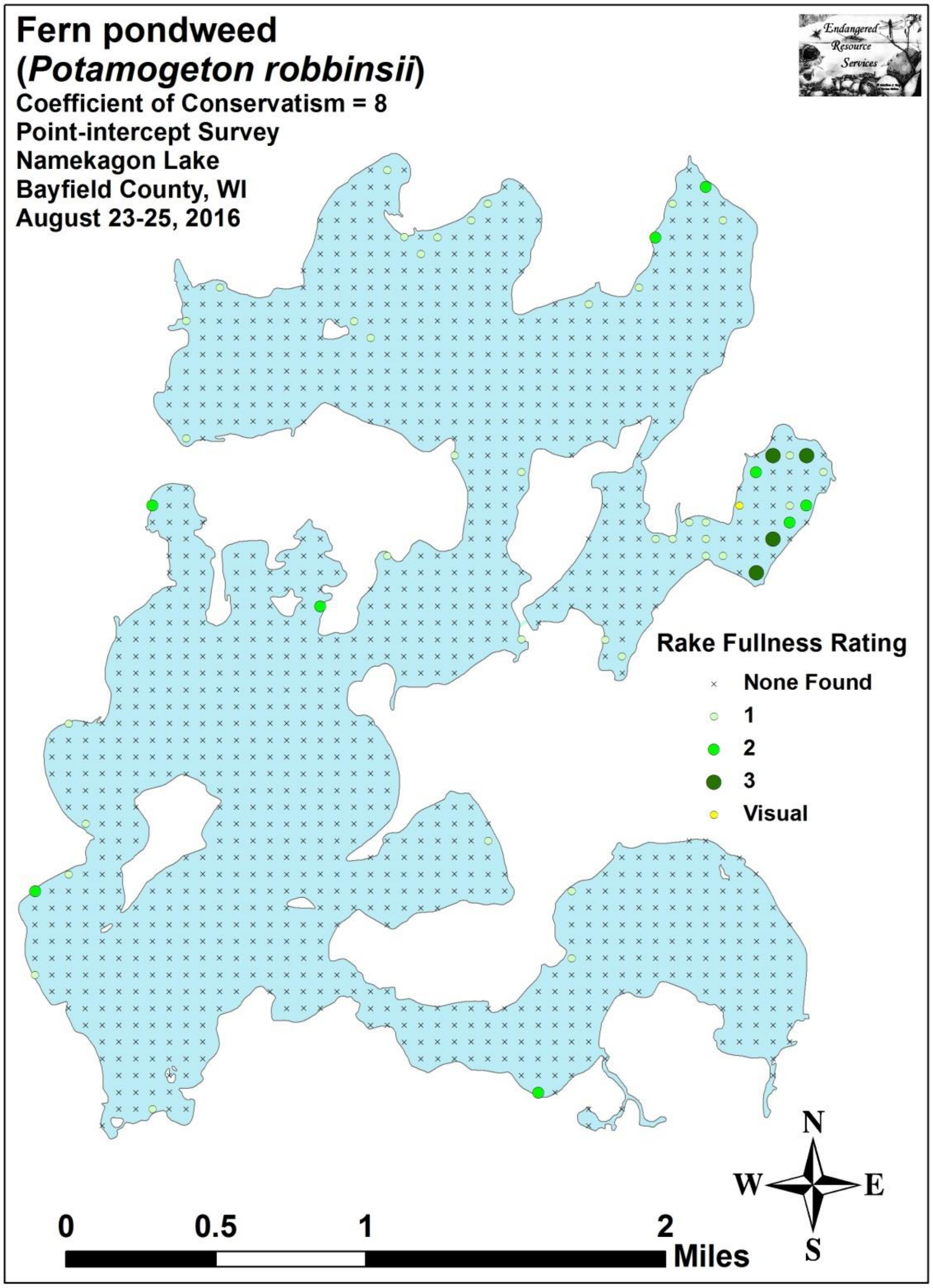
Miles


Fern pondweed
(Potamogeton robbinsii)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
Visual
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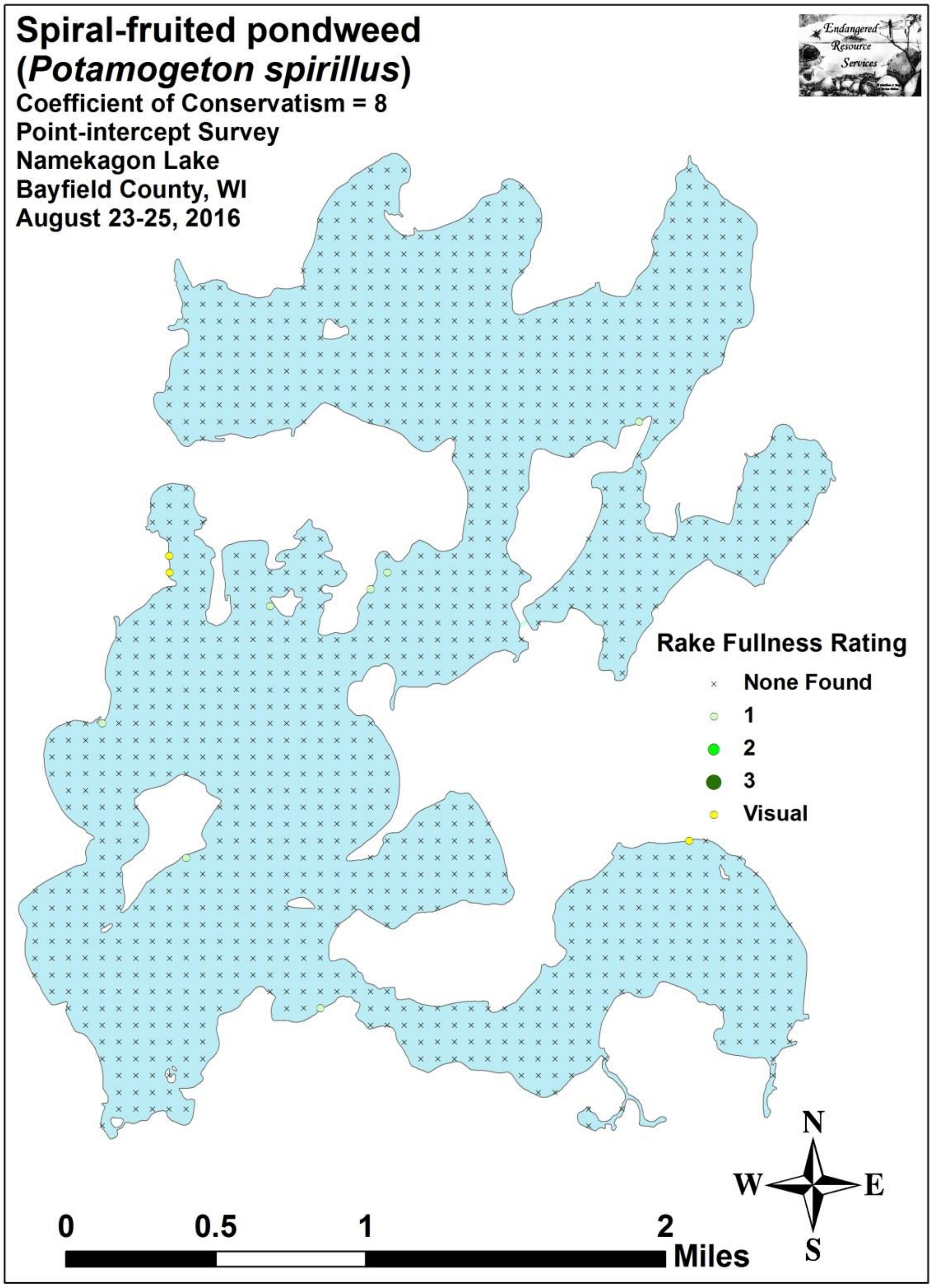

Spiral-fruited pondweed
(*Potamogeton spirillus*)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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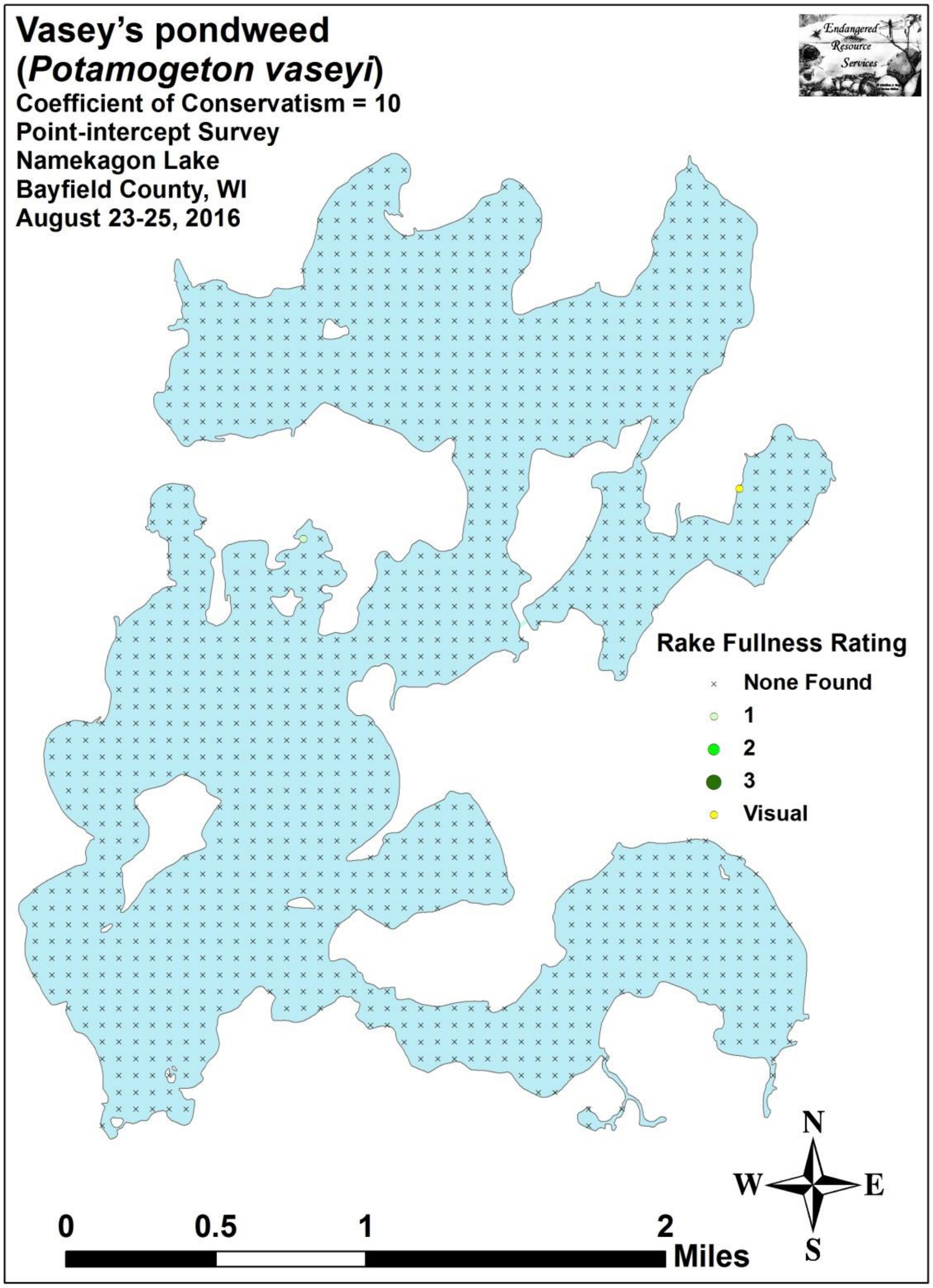
Vasey's pondweed
(*Potamogeton vaseyi*)
Coefficient of Conservatism = 10
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered
Resource
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Rake Fullness Rating
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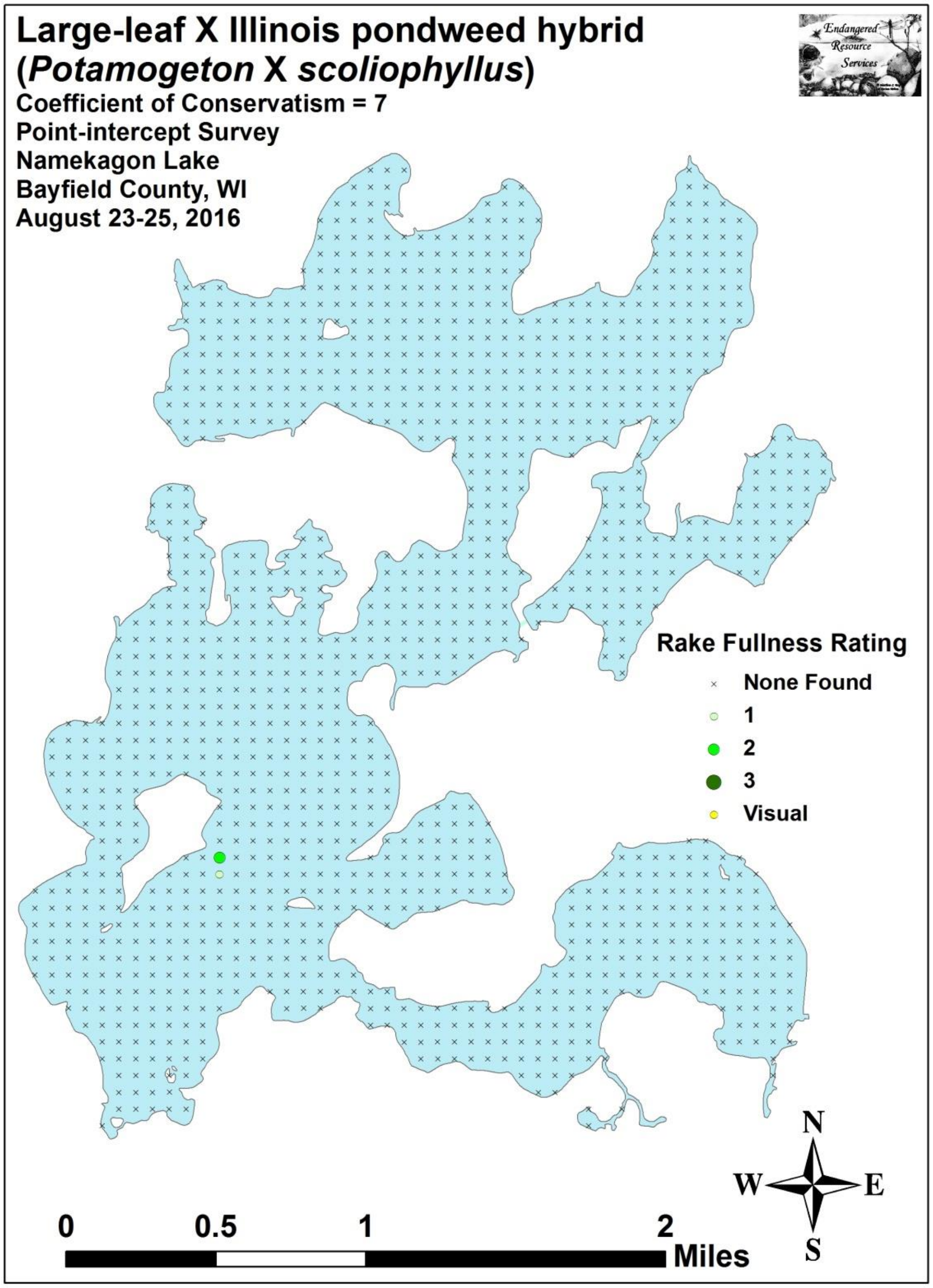

Large-leaf X Illinois pondweed hybrid
(Potamogeton X scoliophyllus)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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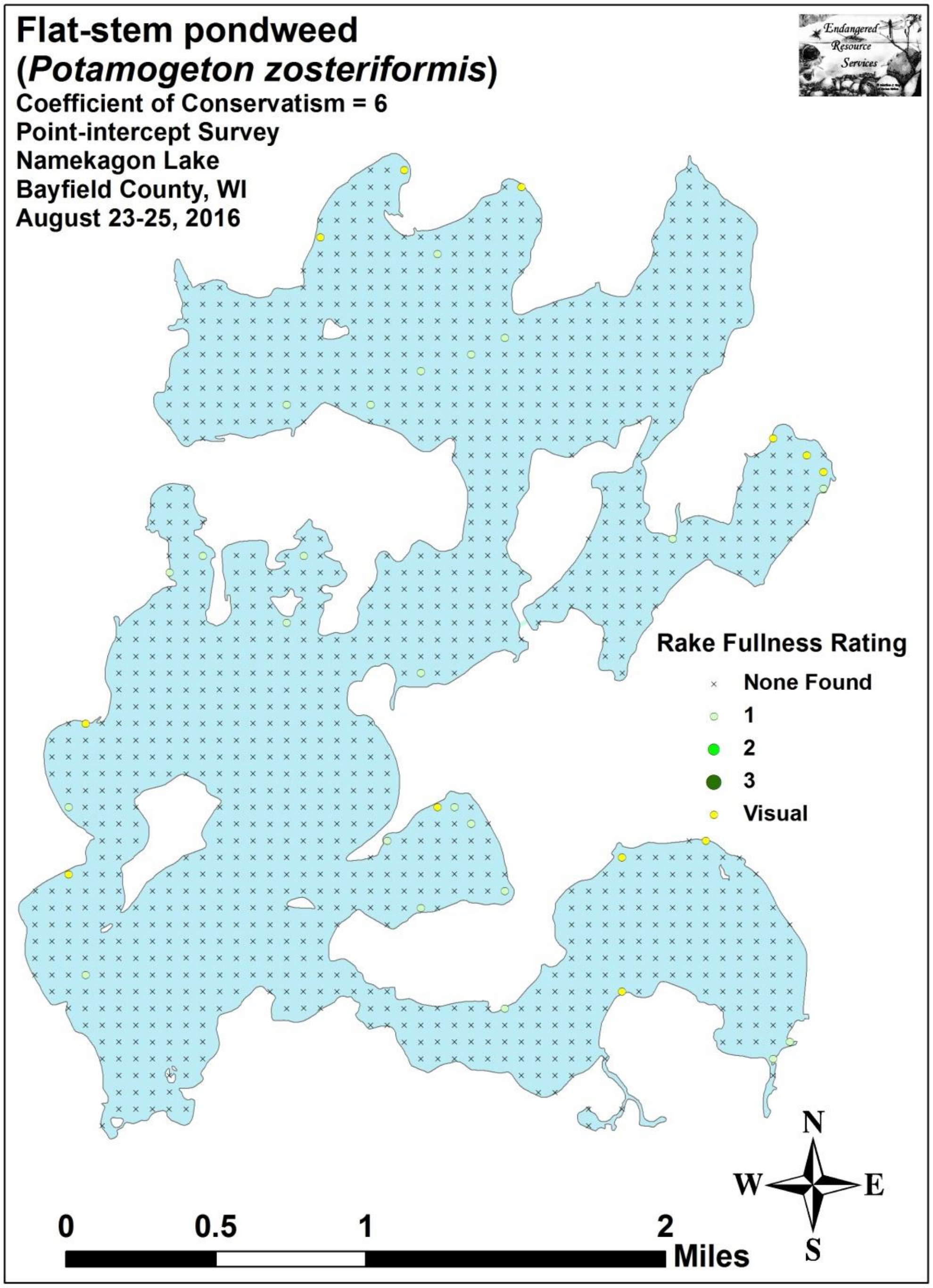
Flat-stem pondweed
(*Potamogeton zosteriformis*)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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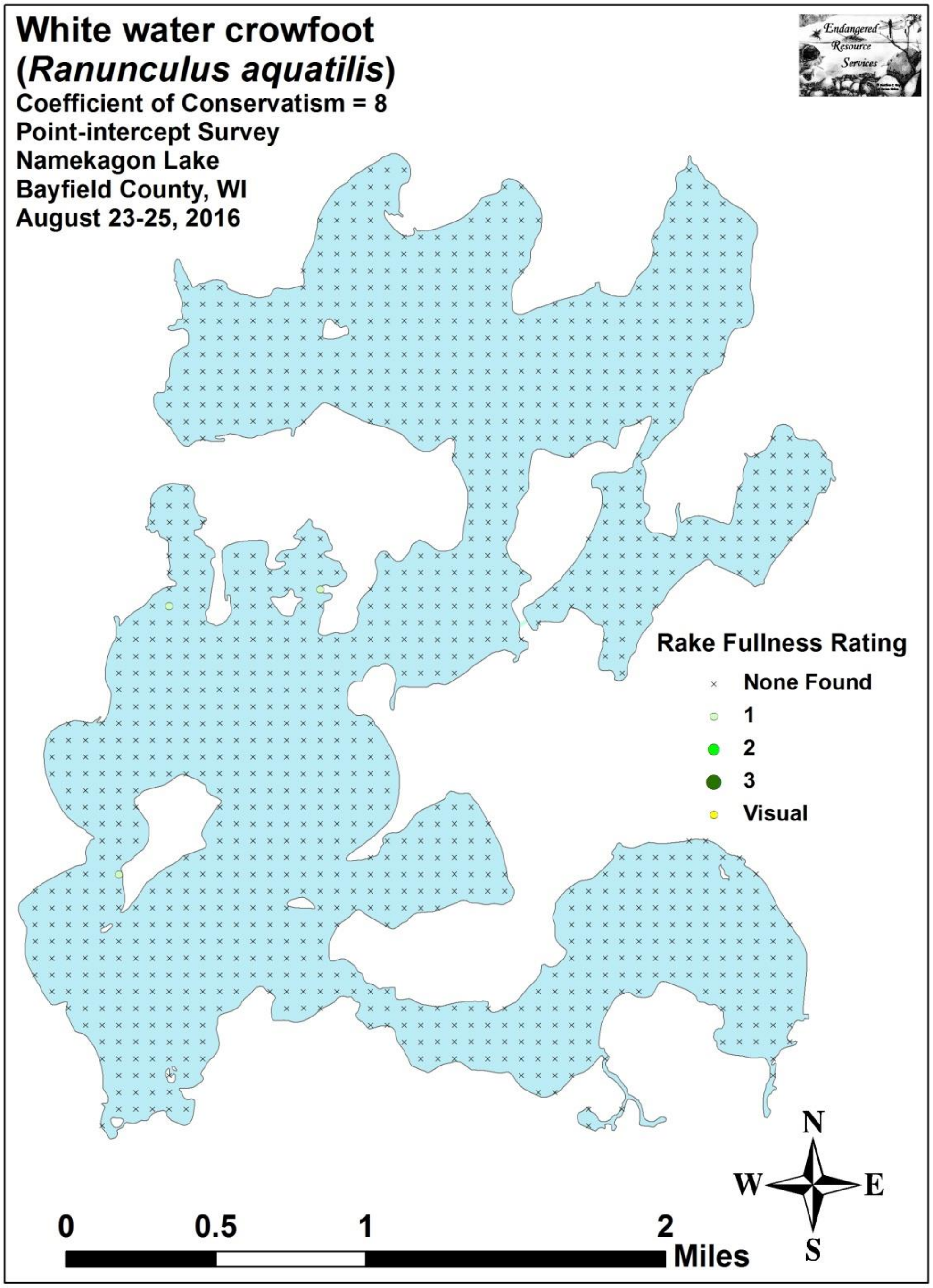

White water crowfoot
(Ranunculus aquatilis)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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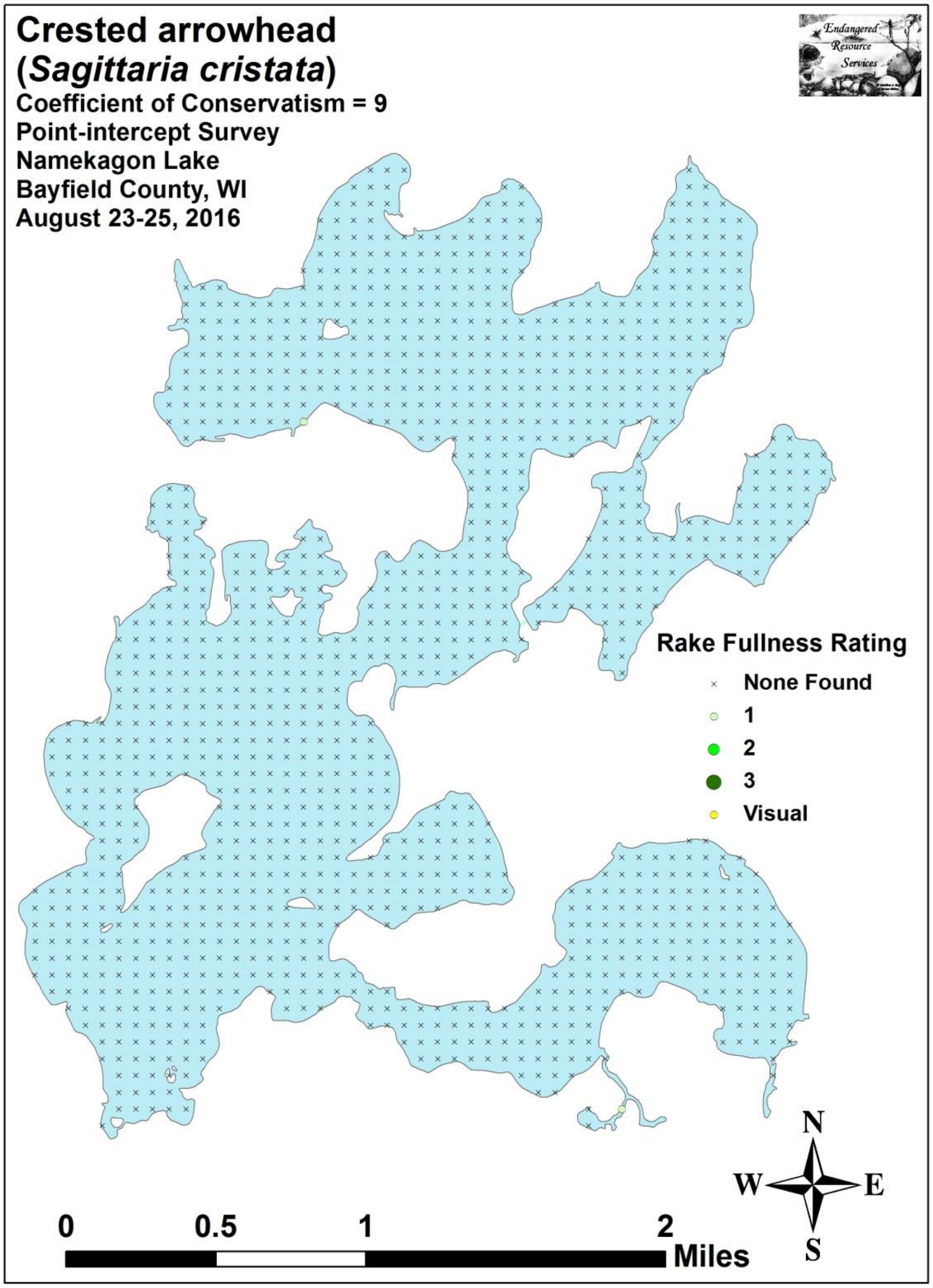
Crested arrowhead
(Sagittaria cristata)
Coefficient of Conservatism = 9
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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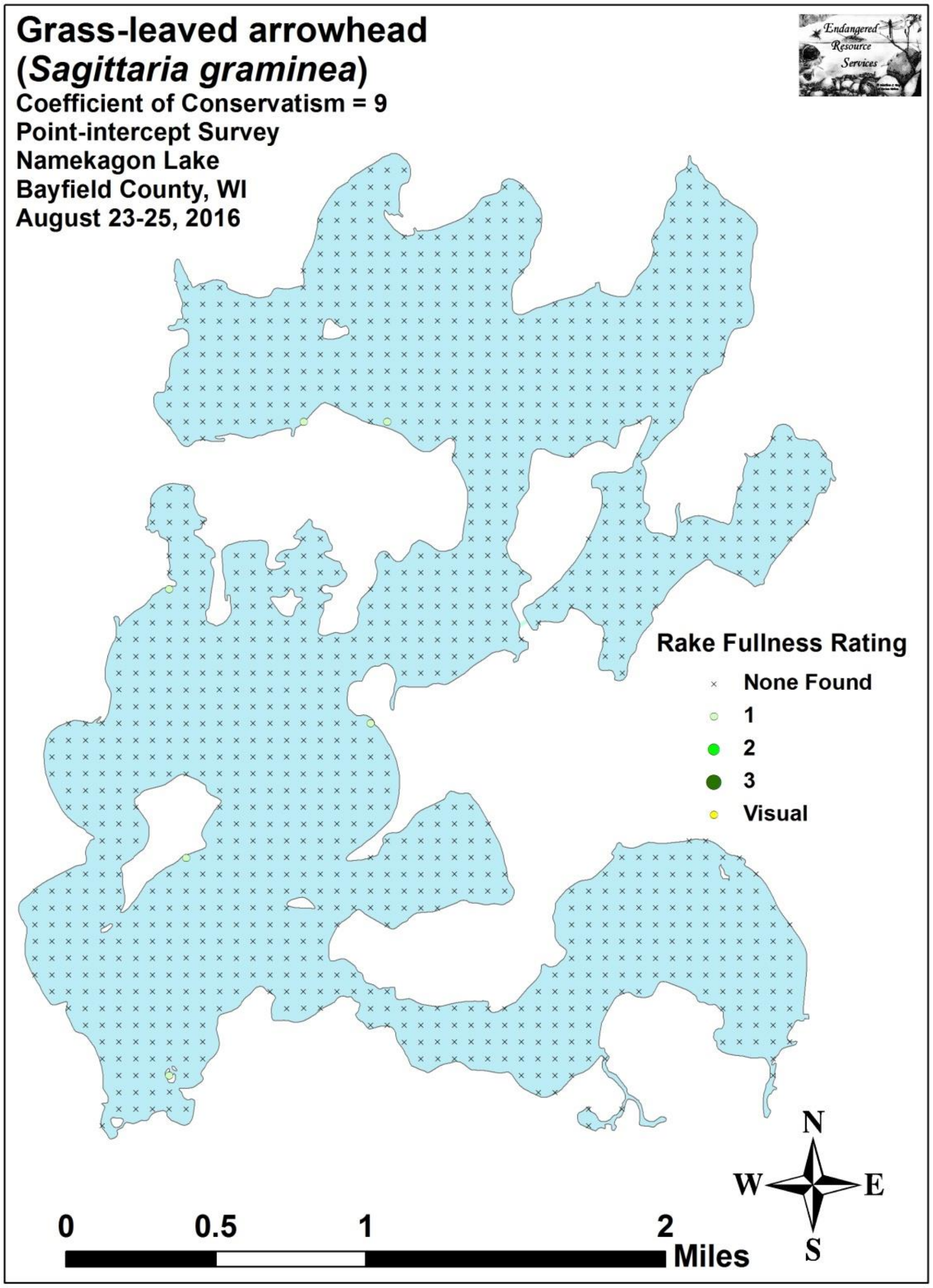
Grass-leaved arrowhead
(*Sagittaria graminea*)
Coefficient of Conservatism = 9
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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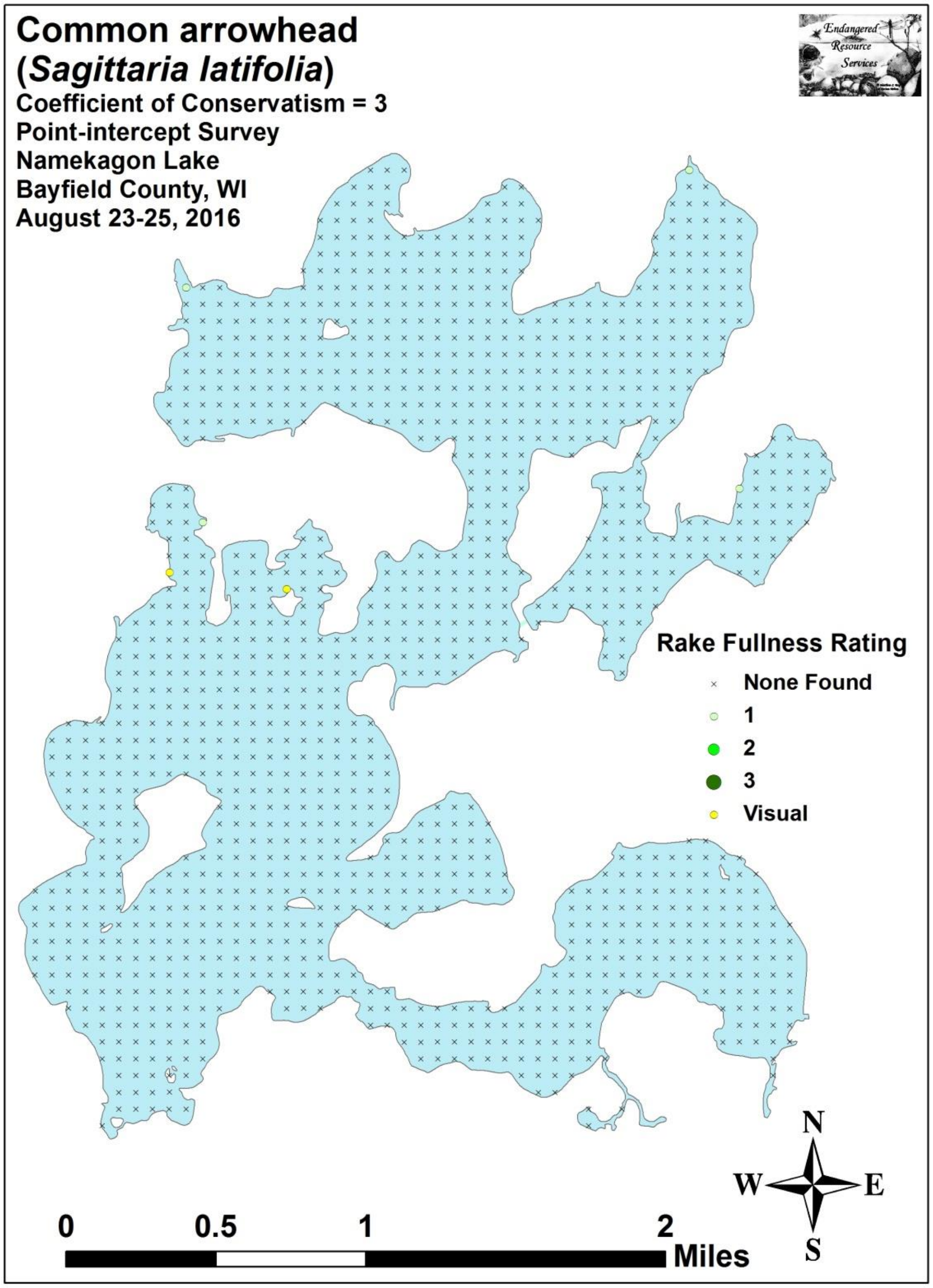
Common arrowhead
(Sagittaria latifolia)
Coefficient of Conservatism = 3
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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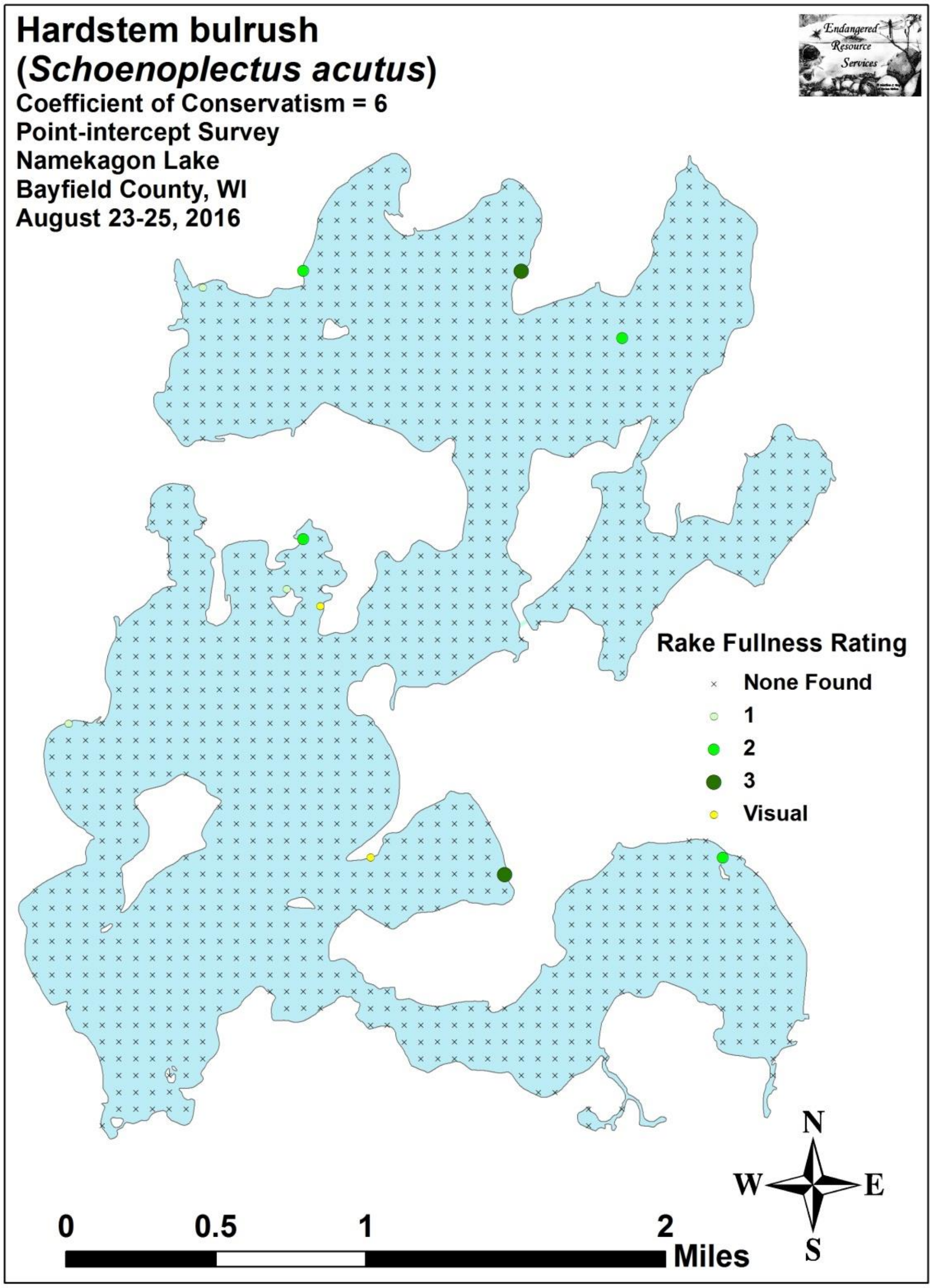
Hardstem bulrush
(*Schoenoplectus acutus*)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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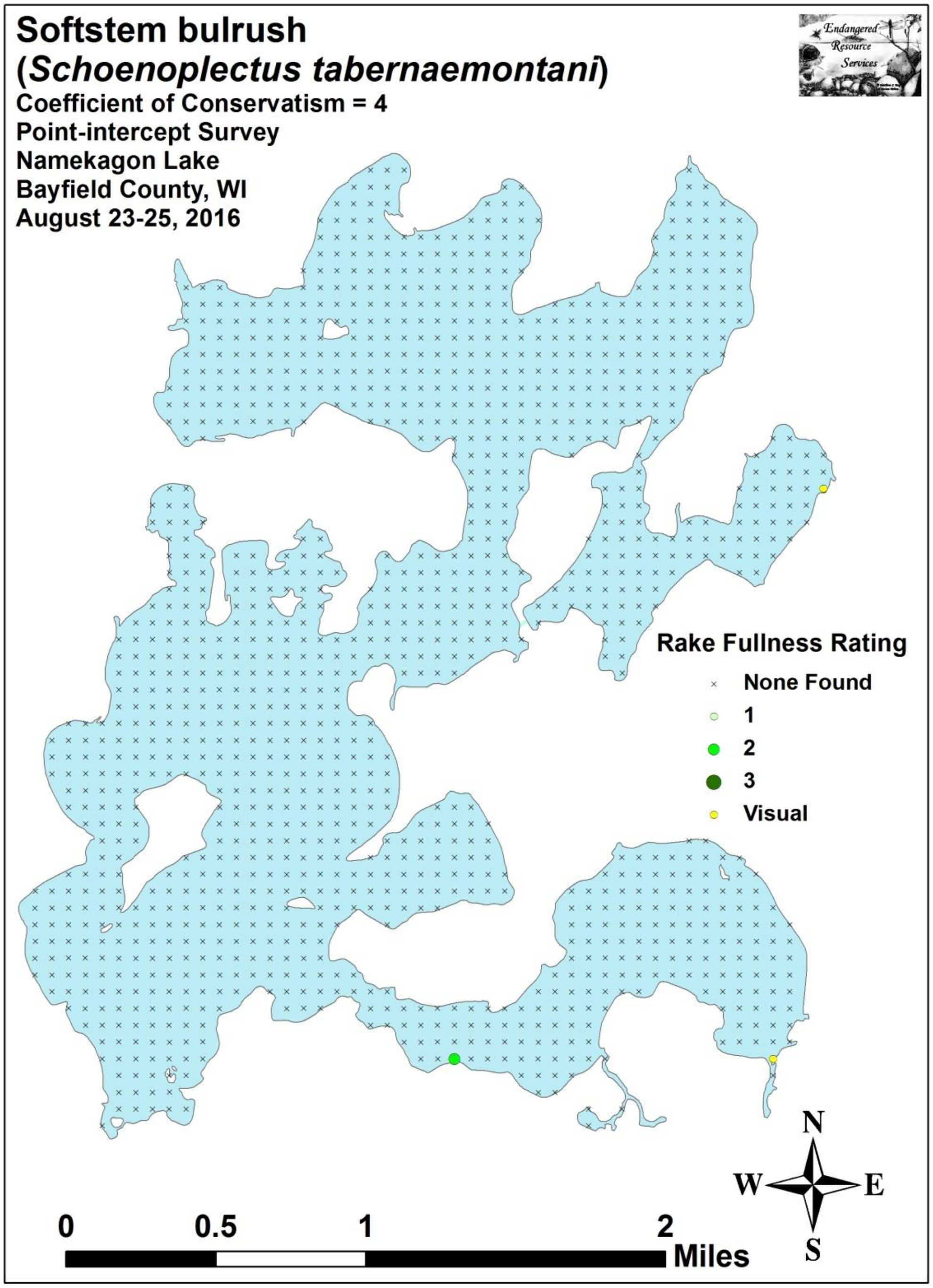
Softstem bulrush
(Schoenoplectus tabernaemontani)
Coefficient of Conservatism = 4
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
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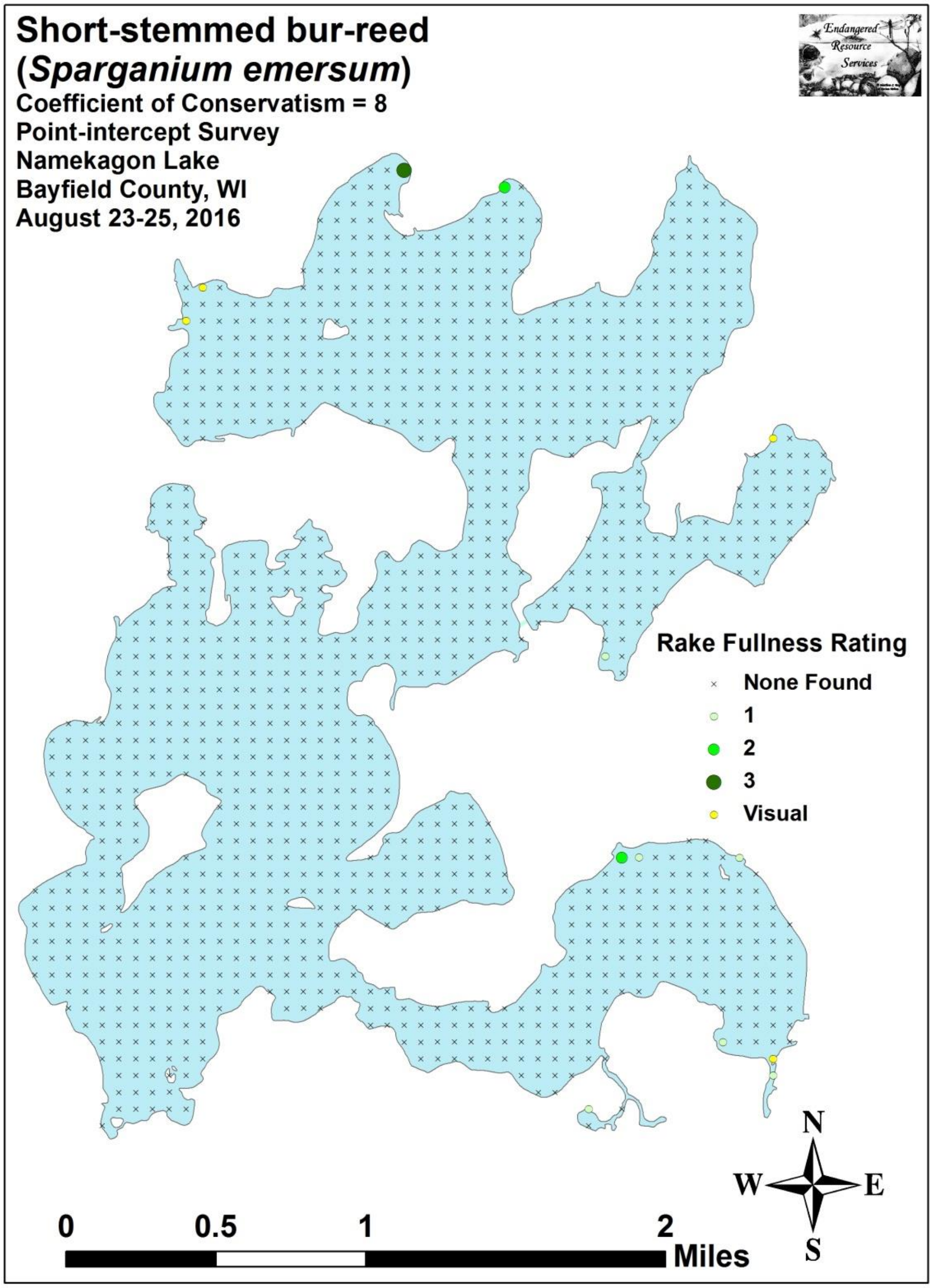

Short-stemmed bur-reed
(Sparganium emersum)
Coefficient of Conservatism = 8
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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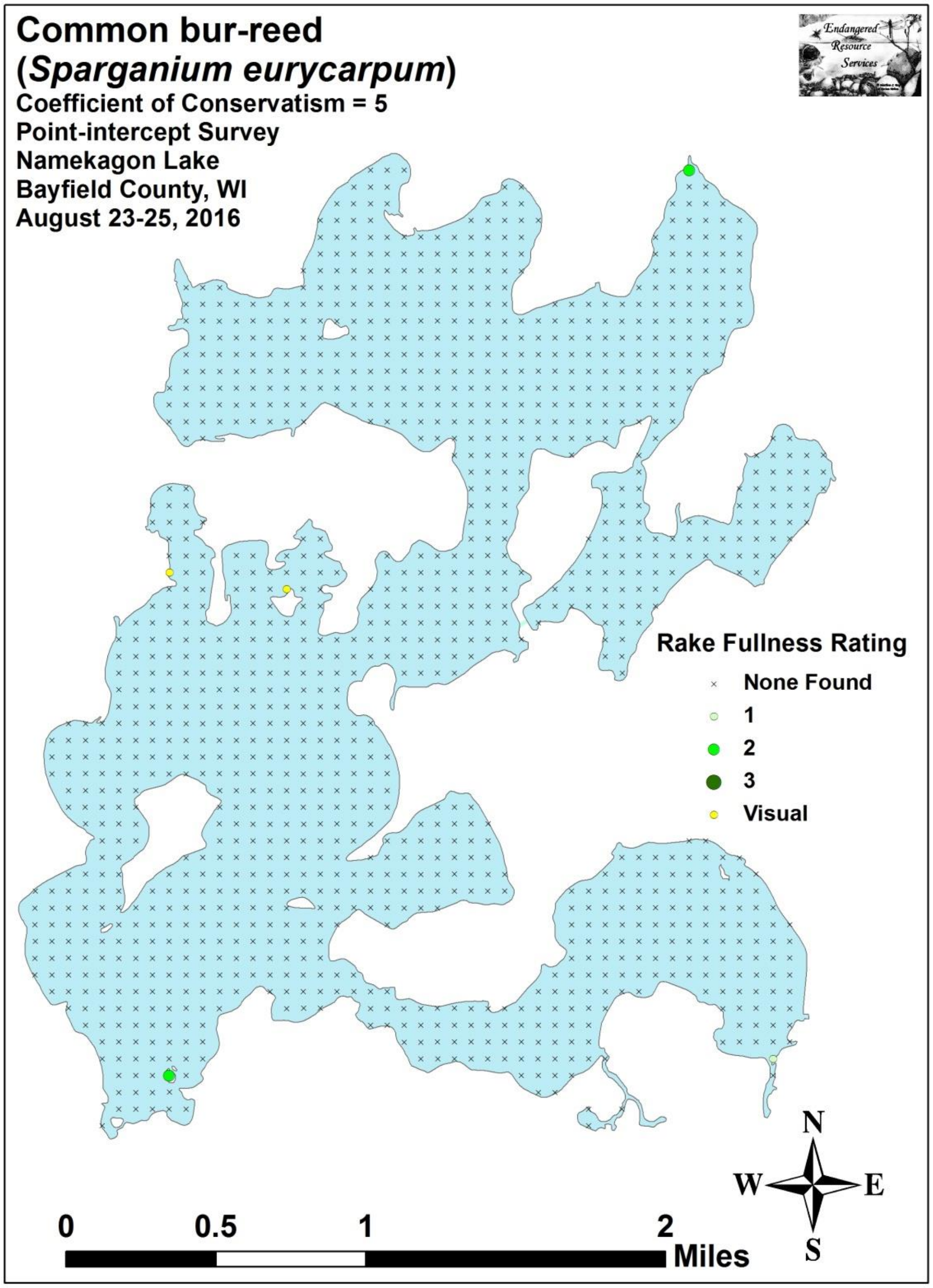

Common bur-reed
(*Sparganium eurycarpum*)
Coefficient of Conservatism = 5
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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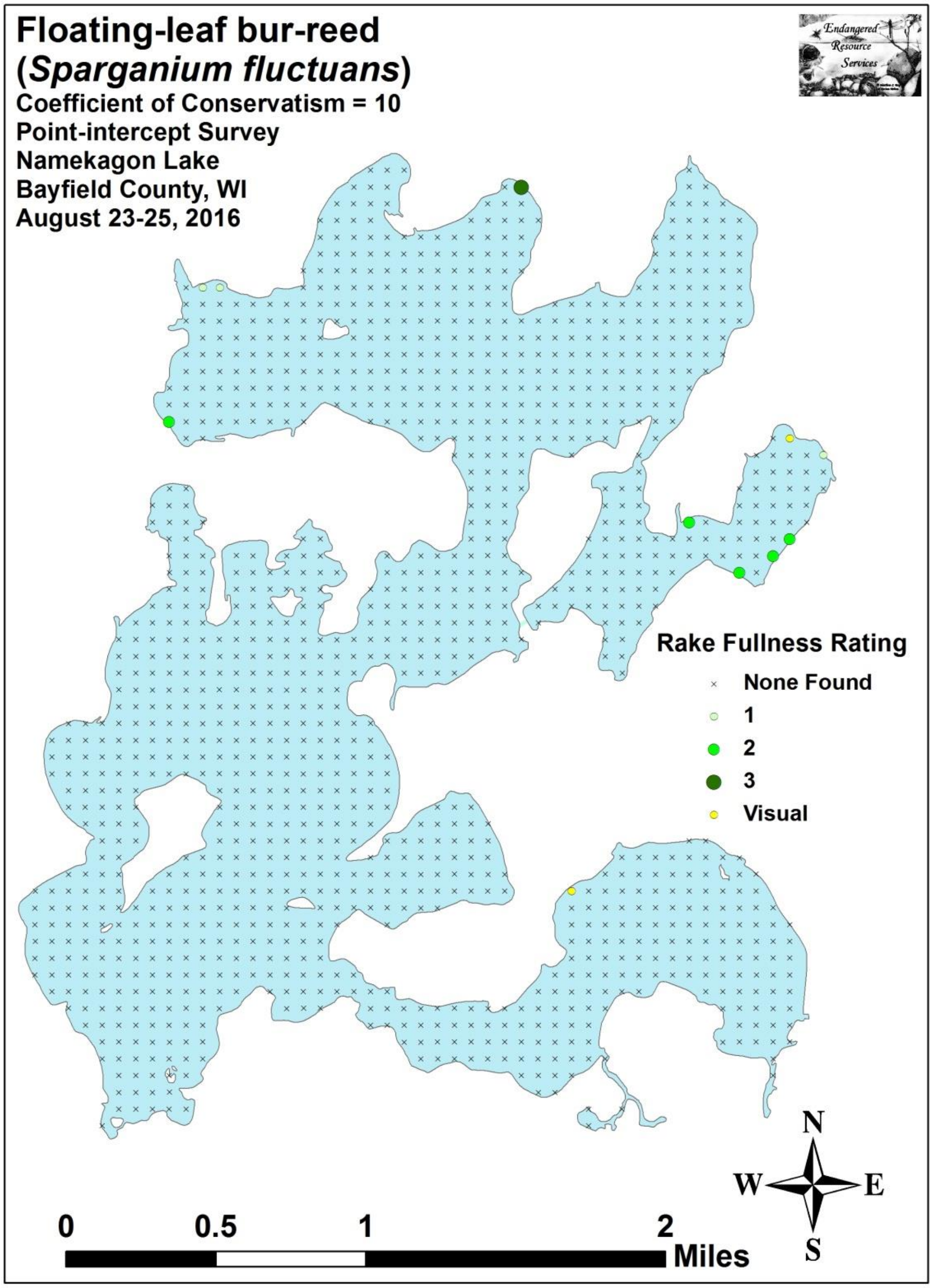
Miles


Floating-leaf bur-reed
(Sparganium fluctuans)
Coefficient of Conservatism = 10
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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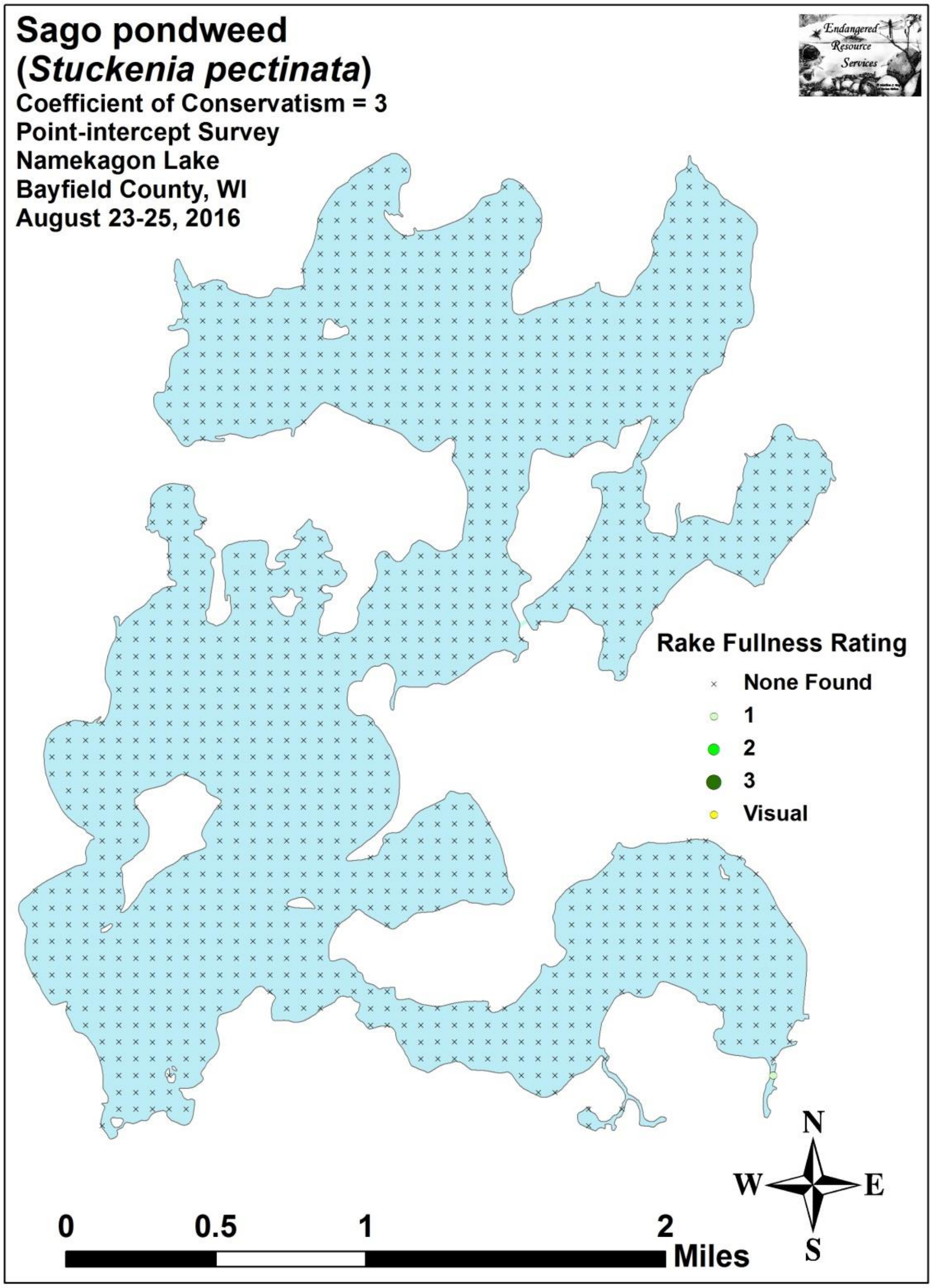
Sago pondweed
(*Stuckenia pectinata*)
Coefficient of Conservatism = 3
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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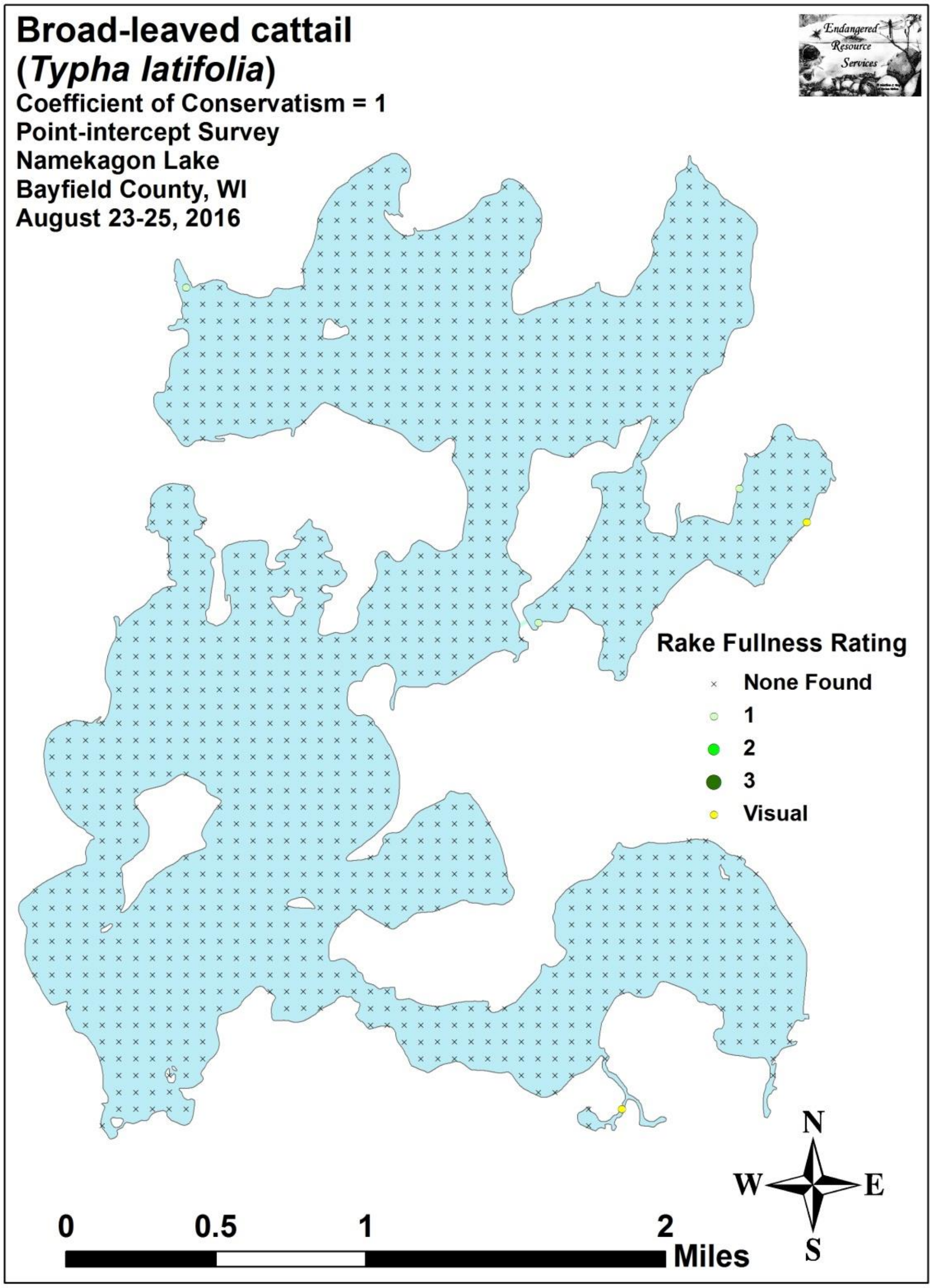

Broad-leaved cattail
(Typha latifolia)
Coefficient of Conservatism = 1
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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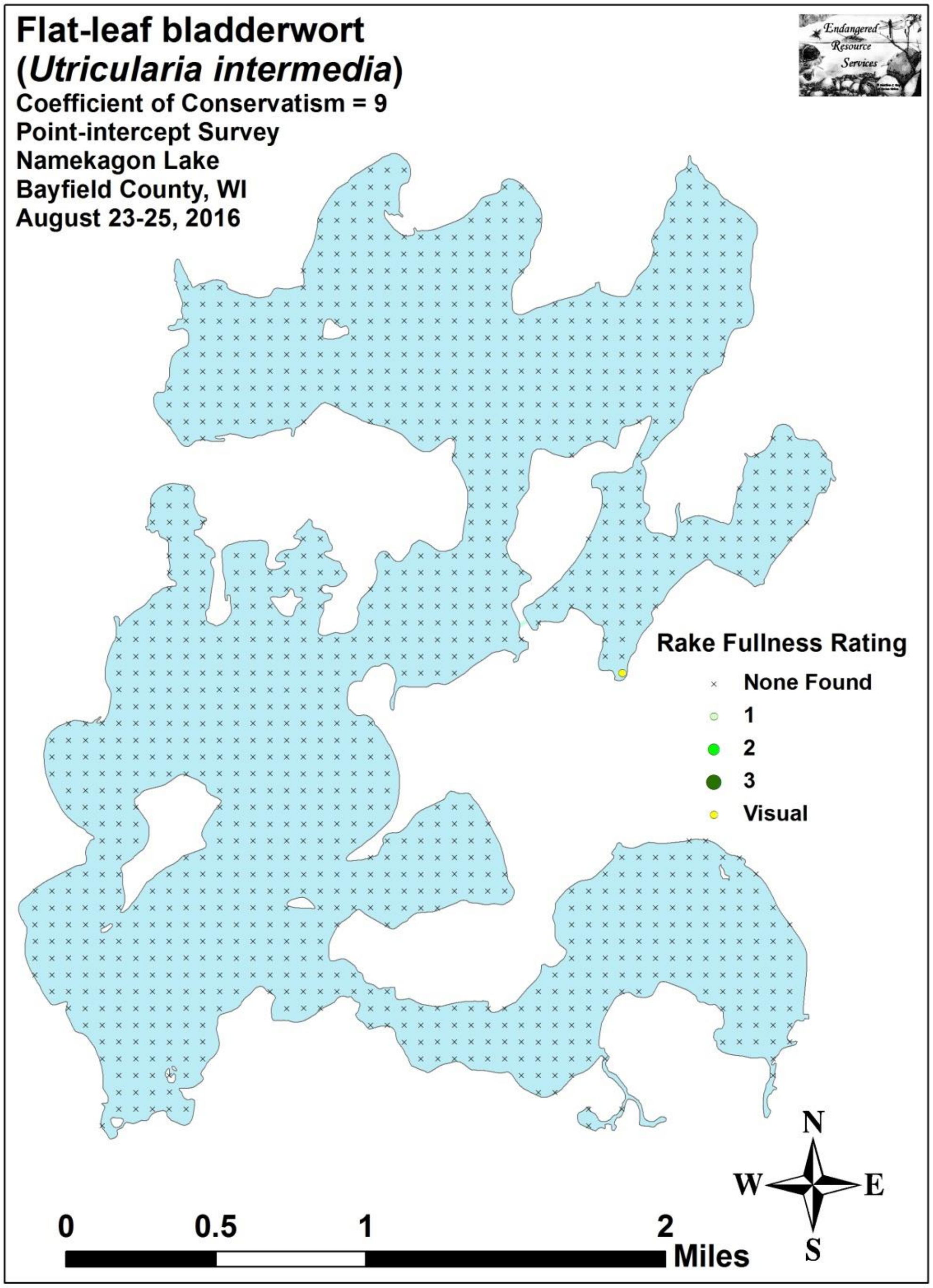
Flat-leaf bladderwort
(*Utricularia intermedia*)
Coefficient of Conservatism = 9
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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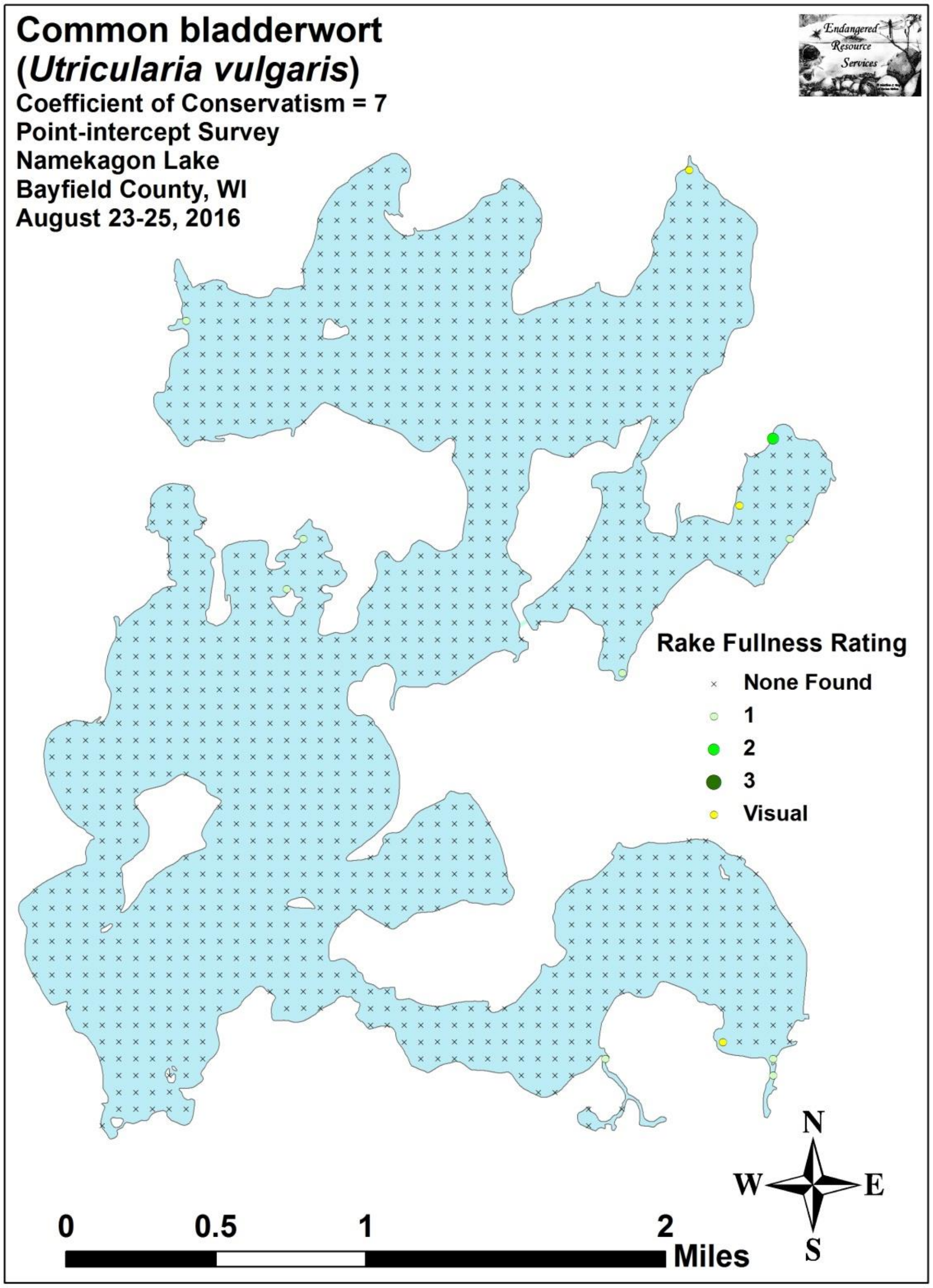
Miles



Common bladderwort
(*Utricularia vulgaris*)
Coefficient of Conservatism = 7
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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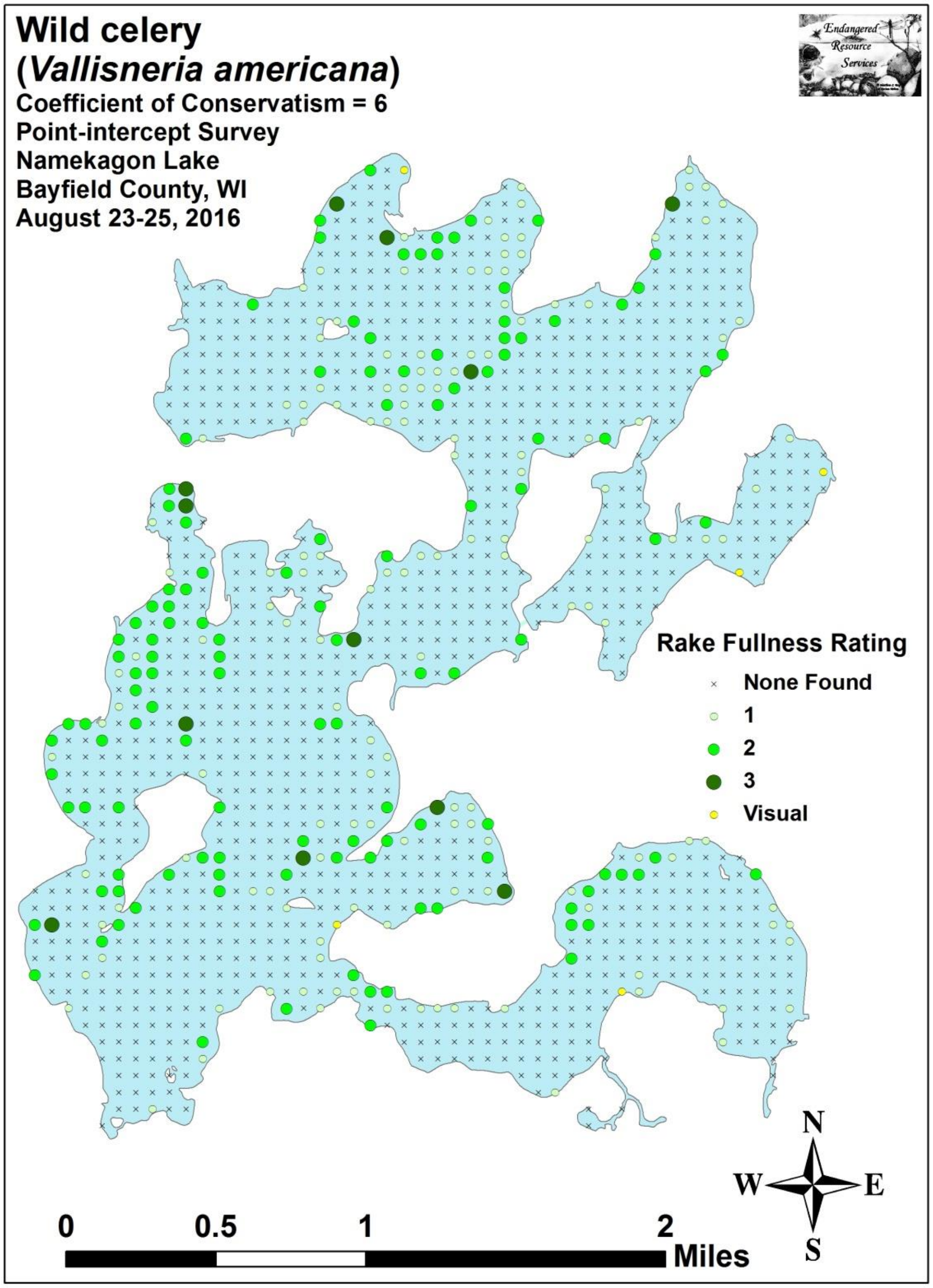
Miles


Wild celery
(*Vallisneria americana*)
Coefficient of Conservatism = 6
Point-intercept Survey
Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
Rake Fullness Rating
None Found
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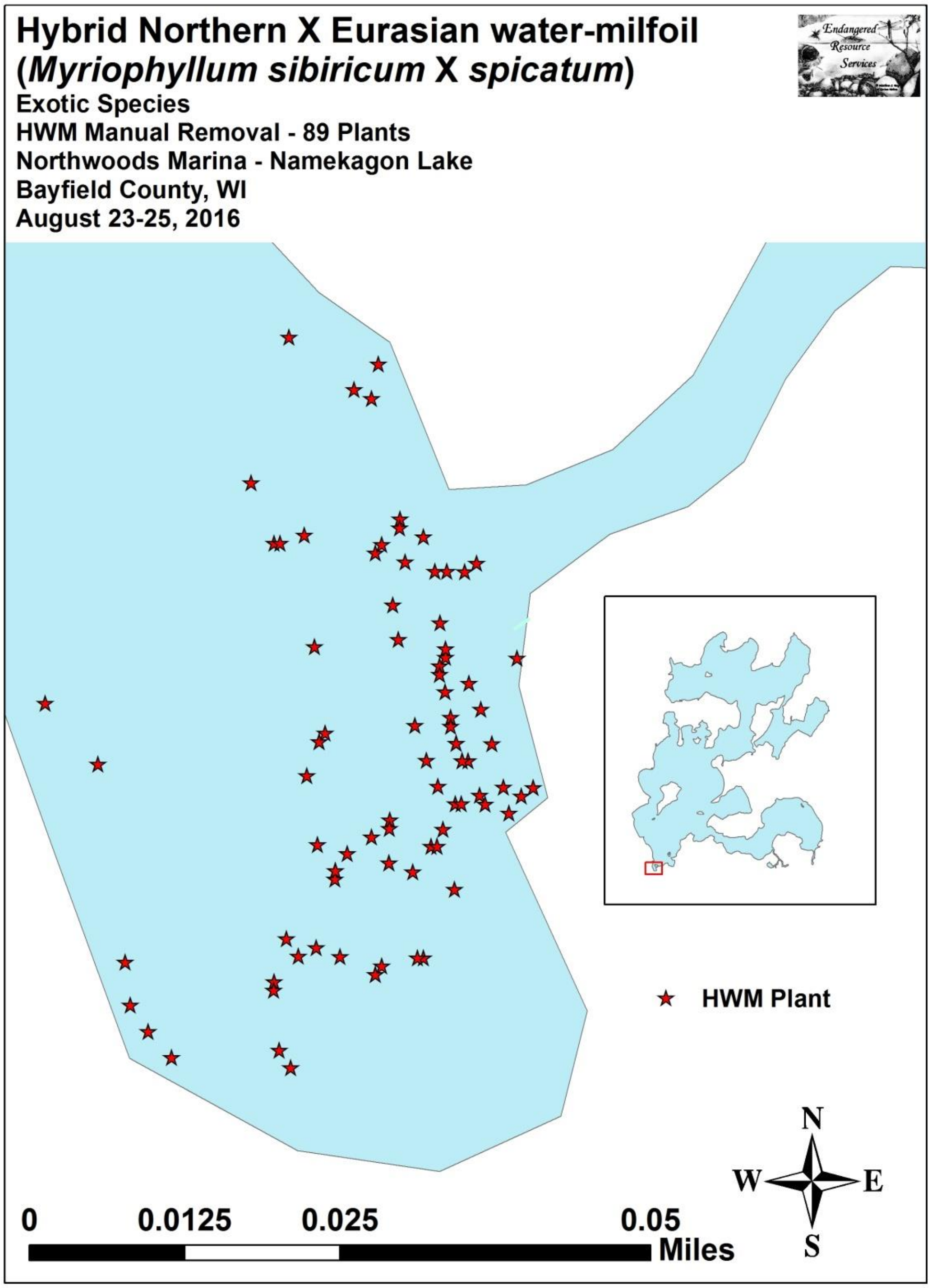
Miles

Appendix VI: HWM Distribution and Manual Removal Maps


Hybrid Northern X Eurasian water-milfoil
(Myriophyllum sibiricum X spicatum)
Exotic Species
HWM Manual Removal - 89 Plants
Northwoods Marina - Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
HWM Plant
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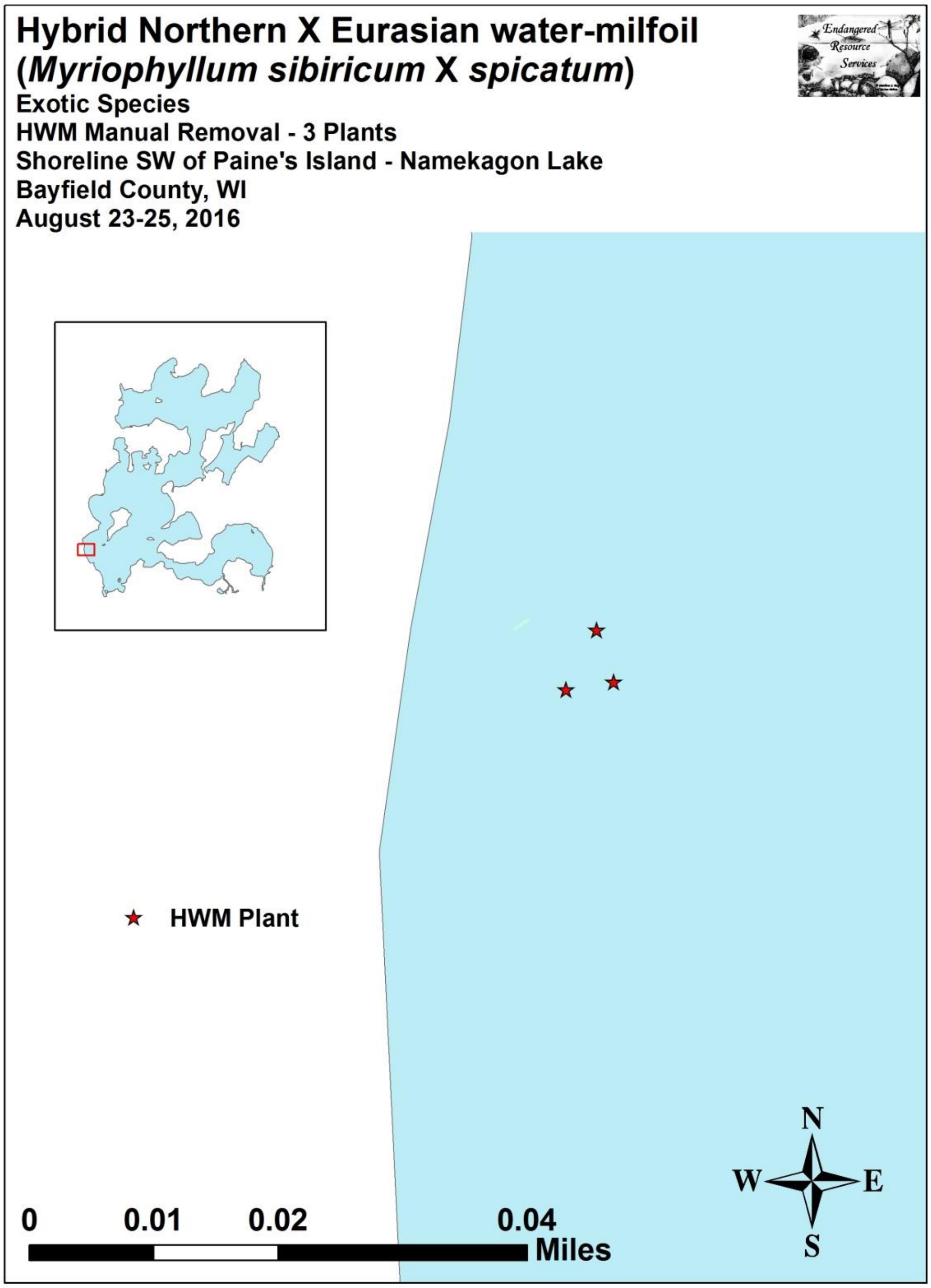
0.0125
0.025
0.05
Miles


Hybrid Northern X Eurasian water-milfoil
(Myriophyllum sibiricum X spicatum)
Exotic Species
HWM Manual Removal - 3 Plants
Shoreline SW of Paine's Island - Namekagon Lake
Bayfield County, WI
August 23-25, 2016
Endangered Resource Services
HWM Plant
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0.01
0.02
0.04
Miles

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 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, 2012 http://www.dnr.state.wi.us/invasives/fact/milfoil.htm)

Curly-leaf pondweed

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

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

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

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out compete native plants in the spring. In mid-summer, when most aquatic plants are growing, curly-leaf pondweed plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. Curly-leaf pondweed forms surface mats that interfere with aquatic recreation. (Taken in its entirety from WDNR, 2012 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, 2012 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, 2012 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: 2016 Raw Data Spreadsheets