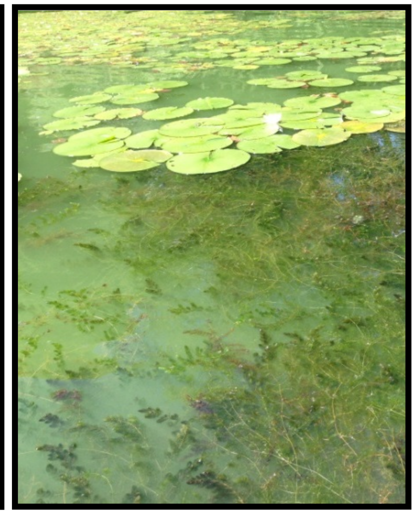
Curly-leaf pondweed (*Potamogeton crispus*) Point-Intercept and Bed Mapping Surveys, and Warm-water Macrophyte Point-intercept Survey Long Lake - WBIC: 2478200 Polk County, Wisconsin

Long Lake Aerial Photo (2015)



Blue-green algae among Coontail 7/24/16

Project Initiated by:

Long Lake Protection and Rehabilitation District, Harmony Environmental, and the Wisconsin Department of Natural Resources

Open water in the lake's northwest bay 7/24/16

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June 11 and July 23-24, 2016

TABLE OF CONTENTS

ABSTRACT

Long Lake (WBIC 2478200) is a 272 acre eutrophic seepage lake located in central Polk County, WI. In 2010, the Long Lake Protection and Rehabilitation District, under the direction of Harmony Environmental, developed an Aquatic Plant Management Plan that authorized chemical treatment of the lake's Curly-leaf pondweed (*Potamogeton crispus*) infestation. As a prerequisite to updating this plan in 2017 and to compare how the lake's vegetation had changed since the last point-intercept surveys in 2012, the LLPRD and the Wisconsin Department of Natural Resources authorized CLP density and bed mapping surveys on June 11th, and a full point-intercept survey for all aquatic macrophytes from July 23-24, 2016. The cold-water survey did not find CLP at any survey point suggesting the May 5th Aquathol treatment of nearly 35 acres (12.9% of the lake's surface area) achieved CLP control over the entire lake. This was similar to May 22, 2012 when we found CLP at a single point following a 58 acre treatment (21.3% surface area). No posttreatment CLP beds were found on the lake during any year from 2010-2014. However, in 2015 when treatment was suspended, we mapped 13 CLP beds totaling 43.21 acres and covering 15.9% of the lake. Following the resumption of treatment in 2016, we were again unable to locate any CLP beds. During the July 2016 full point-intercept survey, we found macrophytes growing at 152 sites or 33.6% of the entire lake bottom and in 60.8% of the 15.0 littoral zone. This was up slightly from 142 sites in 2012 (31.3% of the lake and 78.5% of the then 10.5ft littoral zone). Overall diversity was moderately high with a Simpson Index value of 0.87 – down slightly from 0.88 in 2012. Species richness was low with 27 species found growing in and immediately adjacent to the water; however, this was up from 18 in 2012. There was an average of 2.59 native species/site with native vegetation – a highly significant decline (p=0.003) from 3.25/site in 2012. Coontail (*Ceratophyllum demersum*), White water lily (*Nymphaea odorata*), Small duckweed (*Leman minor*), and Large duckweed (*Spirodela polyrhiza*) were the most common macrophyte species being found at 74.34%, 30.92%, 25.66%, and 25.66% of sites with vegetation and accounting for 59.50% of the total relative frequency. In 2012, Common waterweed (*Elodea canadensis*), Coontail, Small duckweed, and White water lily were the most common native species being found at 74.65%, 41.55%, 37.32%, and 30.99% of survey points with vegetation and accounting for 56.7 1% of the total relative frequency. Lakewide, from 2012-2016, six species saw significant changes in distributions: Common waterweed and Forked duckweed (*Lemna trisulca*) both suffered highly significant declines; Muskgrass (*Chara* sp.) a moderately significant decline, and Small duckweed a significant decline. Conversely, Coontail experienced a highly significant increase, and filamentous algae had a significant increase. Despite these changes in distribution, none of these species had significant changes in their mean rake fullness with the exception of filamentous algae which demonstrated a highly significant decline (p<0.001). The 21 native index species found in the rake during the July 2016 survey (up from 16 in 2012) produced a well below average mean Coefficient of Conservatism of 5.1 (up from 4.8 in 2012). However, the Floristic Quality Index of 23.3 (up from 19.0 in 2012) was slightly above the median FQI for this part of the state. Other than CLP, we found two other exotic species growing adjacent to Long Lake: Reed canary grass (*Phalaris arundinacea*) was present along shorelines throughout, and Hybrid cattail (*Typha* X *glauca*) was rapidly displacing the native Broad-leaved cattail (*Typha latifolia*) in adjacent wetlands. Future management considerations include working to limit nutrient inputs wherever possible; maintain CLP at its current low levels; and continuing the Clean Boats/Clean Waters watercraft inspection program to help prevent the introduction of Eurasian Water-milfoil (*Myriophyllum spicatum*) or any other new Aquatic Invasive Species to the lake.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION:

Long Lake (WBIC 2478200) is a 272 acre seepage lake in central Polk County, Wisconsin in the Town of Balsam Lake (T34N R17W S07 NE NE). It reaches a maximum depth of just over 17ft in the central basin and has an average depth of approximately 11ft (Busch et al. 1969) (Figure 1). Long Lake is eutrophic trending toward hypereutrophic, and visibility is generally poor with summer Secchi readings averaging 4.6ft since 1992 (WDNR 2016). The bottom substrate in the lake's bays and central basin is predominately thick organic muck, while exposed points and most north/south shorelines are dominated by gravel and sand substrates.

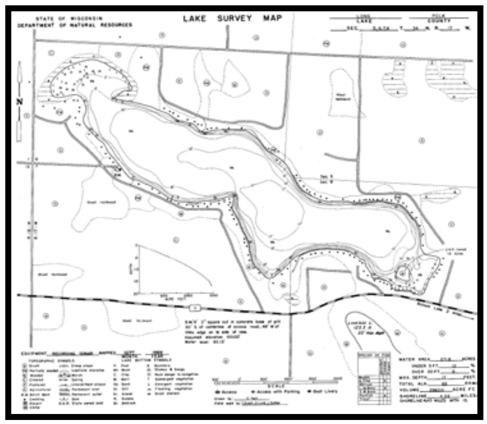


Figure 1: Long Lake Bathymetric Map

BACKGROUND AND STUDY RATIONALE:

Long Lake and the Long Lake Protection and Rehabilitation District (LLPRD) have an extended history of battling Curly-leaf pondweed (*Potamogeton crispus*) (CLP) - an exotic invasive species that thrives in the nutrient rich sediments found in many parts of the lake. In the past, CLP often grew so densely in the spring and early summer that it made lake access and boating difficult for Long Lake residents. CLP's late June-early July senescence was also cited in past studies by Barr Engineering and the Polk County Land and Water Conservation Department (PCLWCD) as a significant contributor to the lake's overall phosphorus load and was at least partially responsible for the lake's frequent late summer toxic blue-green algae blooms. In 2010, after years of study, the LLPRD, the PCLWCD, and the Wisconsin Department of Natural Resources (WDNR) authorized lakewide herbicide treatments in accordance with the District's WDNR approved Aquatic Plant Management Plan (APMP). Following an initial treatment of over 65 acres of CLP in 2010, the lake treated nearly 57 acres in 2011, 58 acres in 2012, 27 acres in 2013, and 20 acres in 2014. Although **the 2010-2013 treatments resulted in highly significant reductions** in both CLP coverage and density on the lake, **the 2014 treatment showed no significant change from pretreatment levels**. A follow-up survey of CLP turions in the lake's sediment suggested 2015 CLP levels would likely be very low in most parts of the lake. Based on these data and following a discussion with the lake's executive board and APMP director Cheryl Clemens (Harmony Environmental) in the fall of 2014, it was decided **not to treat CLP in 2015**. However, because point-intercept and turion surveys suggested CLP had made a significant rebound throughout much of the lake in 2015, **it was decided that herbicide treatments would resume in 2016**, and, on May 5th, Aquathol K ® was applied to 34.97 acres of CLP (12.9% of the lake's surface area) (Figure 2).

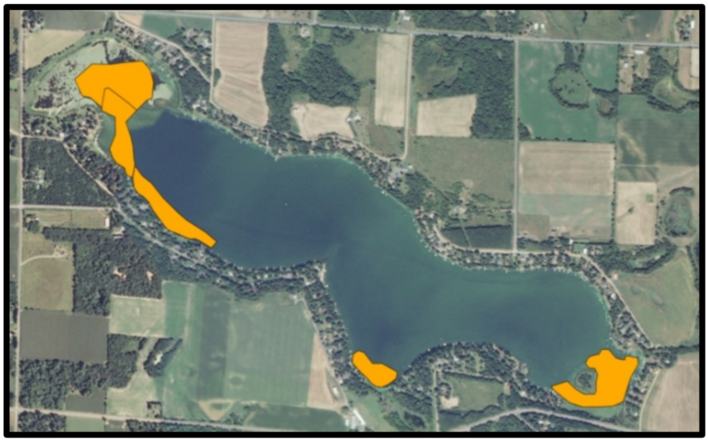


Figure 2: Long Lake with 2016 CLP Treatment Areas

Per WDNR expectations, Aquatic Plant Management Plans (APMP) are normally updated every five years to remain current. In anticipation of updating their plan in 2017, the LLPRD, under the direction of Harmony Environmental, authorized three lakewide surveys in 2016. On June 11th, we conducted early-season CLP point-intercept and bed mapping surveys. These were followed by a warm-water point-intercept survey of all macrophytes from July 23-24th. The surveys' objectives were to document the current levels of CLP in the lake, determine if Eurasian water-milfoil (*Myriophyllum spicatum*), or any other new exotic plants had invaded the lake, and to compare data from 2012 and 2016 to identify any significant changes in the lake's vegetation over this time. This report is the summary analysis of these field surveys.

METHODS:

Curly-leaf Pondweed Point-intercept Survey:

Using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth, and total acreage, Michelle Nault (WDNR) generated the original 453 point sampling grid for Long Lake (Appendix I). Using this grid, we completed a density survey where we sampled for Curly-leaf pondweed at each point in and adjacent to the lake's littoral zone. We located each survey point using a handheld mapping GPS unit (Garmin 76CSx) and used a rake to sample an approximately 2.5ft section of the bottom. When found, CLP was assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 3). We also noted visual sightings of CLP within six feet of the sample point.

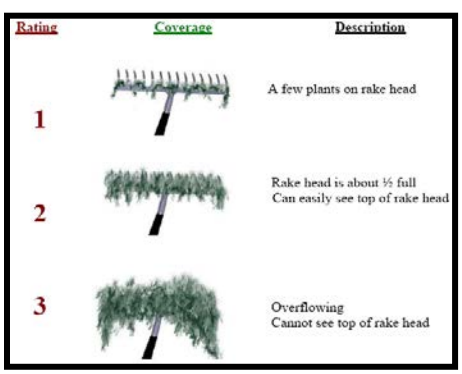


Figure 3: Rake Fullness Ratings (UWEX 2010)

Curly-leaf Pondweed Bed Mapping Survey:

During the bed mapping survey, we searched the lake's entire visible littoral zone. By definition, a "bed" was determined to be any area where we visually estimated that CLP made up >50% of the area's plants, was generally continuous with clearly defined borders, and was canopied, or close enough to being canopied that it would likely interfere with boat traffic. After we located a bed, we motored around the perimeter of the area taking GPS coordinates at regular intervals. We also estimated the rake density range and mean rake fullness of the bed (Figure 3), the maximum depth of the bed, whether it was canopied, and the impact it was likely to have on navigation (**none –** easily avoidable with a natural channel around or narrow enough to motor through/**minor –** one prop clear to get through or access open water/**moderate –** several prop clears needed to navigate through/**severe –** multiple prop clears and difficult to impossible to row through). These data were then mapped using ArcMap 9.3.1, and we used the WDNR's Forestry Tools Extension to determine the acreage of each bed to the nearest hundredth of an acre (Table 1).

Warm-water Full Point-intercept Macrophyte Survey:

Prior to beginning the July point-intercept survey, we conducted a general boat survey of the lake to regain familiarity with the species present (Appendix II). All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2012; Skawinski 2014), and a data sheet was built from the species present. We again located each survey point with a GPS, recorded a depth reading with a metered pole rake or hand held sonar (Vexilar LPS-1), and took a rake sample. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 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.

DATA ANALYSIS:

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

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

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

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

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

> Frequency of occurrence example:
>
> Plant A is sampled at 70 out of 700 total littoral points = 70/700 = .10 = 10%
> This means that Plant A's frequency of occurrence = 10% when considering the entire littoral zone.
>
> Plant A is sampled at 70 out of 350 total points with vegetation = 70/350 = .20 = 20%
> This means that Plant A's frequency of occurrence = 20% when only considering the sites in the littoral zone that have vegetation.
>
> From these frequencies, we can estimate how common each species was at depths where plants were able to grow, and at points where plants actually were growing. Note the second value will be greater as not all the points (in this example, only ½) had plants growing at them.

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

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

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

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

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

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

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

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

Relative frequency example:

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

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

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

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

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

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

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

Comparison to Past Surveys: We compared data from our 2012 and 2016 CLP point-intercept surveys and our 2012 and 2016 warm-water point-intercept surveys (Figure 10) (Tables 3 and 4) to see if there were any significant changes in the lake's vegetation. For individual plant species as well as count data, we used the Chi-square analysis on the WDNR Pre/Post survey worksheet. For comparing averages (mean species/point and mean rake fullness/point), we used t-tests. Differences were considered significant at $p < .05$, moderately significant at $p < .01$ and highly significant at $p < .005$ (UWEX 2010). It should be noted that when comparing the warm-water point-intercept surveys, we used the number of littoral points with plants (142 in 2012/153 in 2016) as the basis for "sample points". We felt this gave us the best chance to capture real differences as a few widely scattered Coontail (*Ceratophyllum demersum*) detections in deep water greatly increased the number of littoral points in 2016 (250 points) when compared to 2012 (181 points).

RESULTS:

Curly-leaf Pondweed Point-intercept Survey:

Following the establishment of the June littoral zone at approximately 14.0ft of water, we sampled for Curly-leaf pondweed at all points in and adjacent to this zone. Despite treating just 12.9% of the lake's surface area, it appeared that a whole lake treatment was achieved as our June 11, 2016 survey did not find CLP present in the rake at any point (Figure 4). This was similar to the May 22, 2012 survey when we found CLP at a single point following a 58 acre herbicide treatment (21.3% of the lake's surface area) (Appendix III).

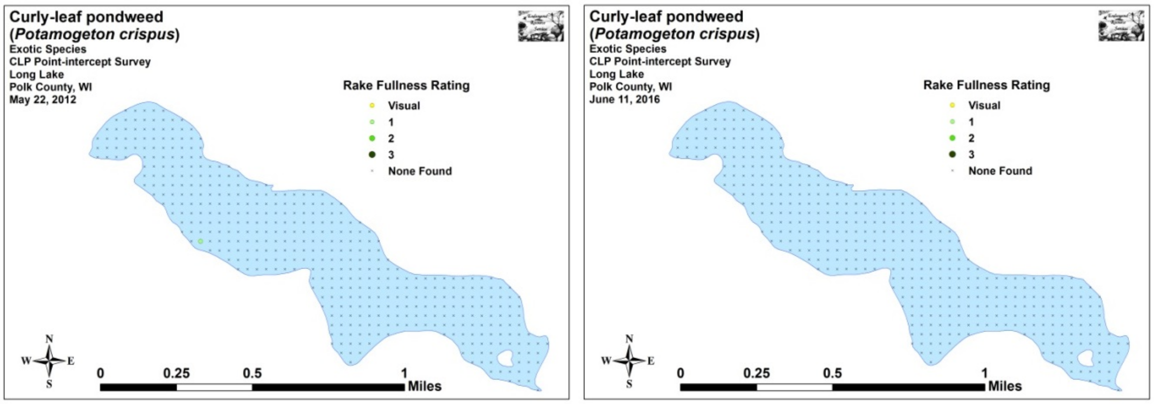


Figure 4: 2012 and 2016 June CLP Density and Distribution

Curly-leaf Pondweed Bed Mapping Survey:

No bed mapping surveys were conducted from 2010-2014 as there was little canopied CLP anywhere in the lake following the herbicide treatments. However, following a spring without treatment, in 2015 we located and mapped 13 CLP beds totaling 43.21 acres **(15.9% of the lake's 272 acres)** (Figure 5) (Appendix III). The biggest was 15.79 acres (Bed 1 in the western bay), and the smallest was just 0.09 acre (Bed 8 on the north shoreline midlake) (Table 1). Despite this significant increase, it was still well below the original 85.51 acres **(-49.5% reduction)** mapped by Barr Engineering in 2009 prior to the beginning of the expanded treatment program.

Following a return to chemical treatment in 2016, our June survey found there was no canopied CLP left anywhere in the lake (Figure 5). We also found CLP continued to be rare throughout the summer as we saw just a handful of plants during the July survey.

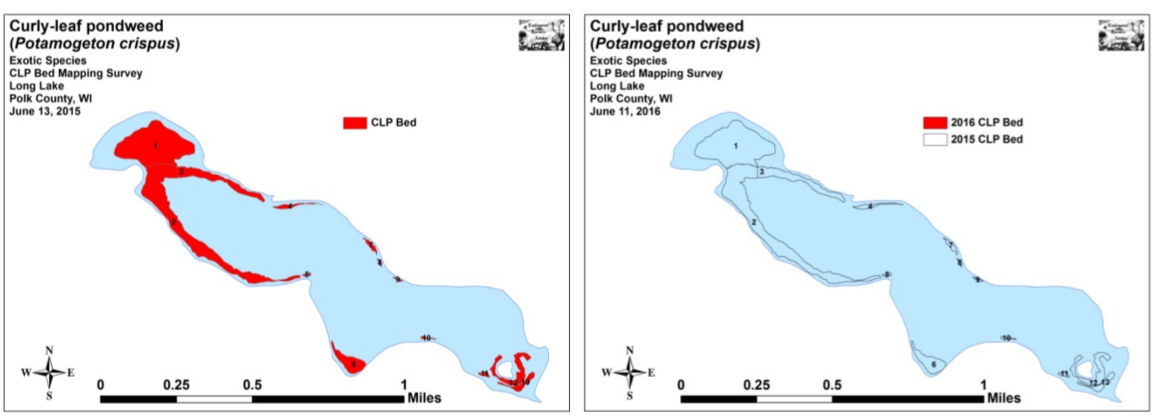


Figure 5: 2015 and 2016 June Curly-leaf Pondweed Beds

Table 1: CLP Bed Summary
Long Lake, Polk County - June 13, 2015 and June 11, 2016

Bed Number	2016 Acreage	2015 Acreage	2016 Acreage Change	2015 Rake Range	2015 Mean Rake Fullness	2015 Max Depth of CLP	2015 Canopied	2015 Potential Navigation Impairment Level
1	0.00	15.79	-15.79	<1-3	2	5	Yes	Severe
2	0.00	15.13	-15.13	<1-3	2	11	Near	Minor
3	0.00	4.15	-4.15	<1-2	<1	11	Near	None
4	0.00	0.63	-0.63	<<<1-1	<<1	10	Near	None
5	0.00	0.10	-0.10	<<<1-1	<<1	7	Near	None
6	0.00	2.63	-2.63	<1-3	2	11	Near	Moderate
7	0.00	0.41	-0.41	<<1-2	<1	8	Near	None
8	0.00	0.09	-0.09	<<1-2	<1	8	Near	None
9	0.00	0.10	-0.10	<<1-2	<1	8	Near	None
10	0.00	0.14	-0.14	<<<1-2	<<1	8	Near	None
11	0.00	0.24	-0.24	<1-3	2	8	Yes	Minor
12	0.00	2.79	-2.79	<1-3	2	7	Yes	Minor
13	0.00	1.01	-1.01	<1-3	2	4	Yes	Minor
Total Acres	**0.00**	**43.21**	**-43.21**					

Warm-water Full Point-intercept Macrophyte Survey:

Depth readings taken at Long Lake's 453 survey points (Appendix I) revealed both the northwest and southwest bays were shallow flats that dropped off gradually until they reach the central basin (Figure 6). Around this basin, the north and south shorelines fell rapidly into 12-16ft on the western half of the lake and 16-20ft on the eastern half (Appendix IV).

We characterized the lake's substrate as 52.8% muck and sandy muck, 34.4% pure sand, and 12.8% rock. Nutrient-rich organic muck dominated the northwest, southeast and southern bay midlake while the central basin was a combination of sandy muck on the lake's western half that trended toward pure sand on the eastern half. Sand also dominated the shoreline around the central basin with areas of cobble and gravel primarily located around points, and north and west of the lake's eastern island (Figure 6) (Appendix IV).

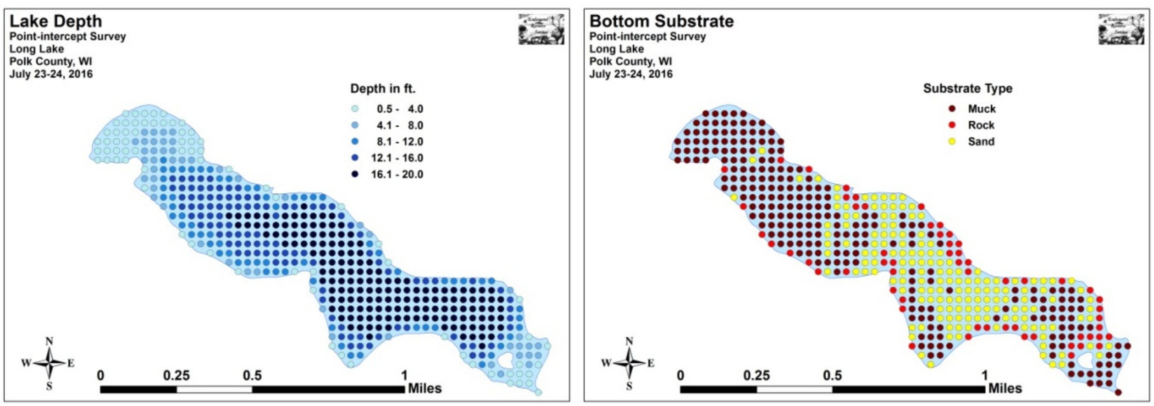


Figure 6: Lake Depth and Bottom Substrate

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics
Long Lake, Polk County
July 27-28, 2012and July 23-24, 2016

Summary Statistics:	2012	2016
Total number of points sampled	453	453
Total number of sites with vegetation	142	152
Total number of sites shallower than the maximum depth of plants	181	250
Frequency of occurrence at sites shallower than maximum depth of plants	78.5	60.8
Simpson Diversity Index	0.88	0.87
Maximum depth of plants (ft)	10.5	15.0
Mean depth of plants (ft)	4.3	5.6
Median depth of plants (ft)	4.0	4.5
Average number of all species per site (shallower than max depth)	2.55	1.60
Average number of all species per site (veg. sites only)	3.25	2.63
Average number of native species per site (shallower than max depth)	2.55	1.58
Average number of native species per site (sites with native veg. only)	3.25	2.59
Species richness	17	23
Species richness (including visuals)	17	24
Species richness (including visuals and boat survey)	18	27
Mean rake fullness (veg. sites only)	2.15	1.93

In 2016, we found plants growing to 15.0ft (up from 10.5ft in 2012) (Table 2) (Figure 7). This represented a highly significant increase (p<0.001) in littoral points from 181 in 2012 to 250 in 2016. Despite this increase, most plant growth ended in 9.0ft of water (similar to 2012) and the 152 points with vegetation (approximately 33.6% of the entire lake bottom and 60.8% of the littoral zone) represented a non-significant increase from 2012 when we found plants growing at 142 points (31.3% of the bottom and 78.5% of the littoral zone). These few deep points in 2016 resulted in growth that was strongly skewed to deep water as the mean plant depth of 5.6ft was much greater than the median depth of 4.5ft (compared to a mean of 4.3ft and a median of 4.0ft in 2012 (Appendix V).

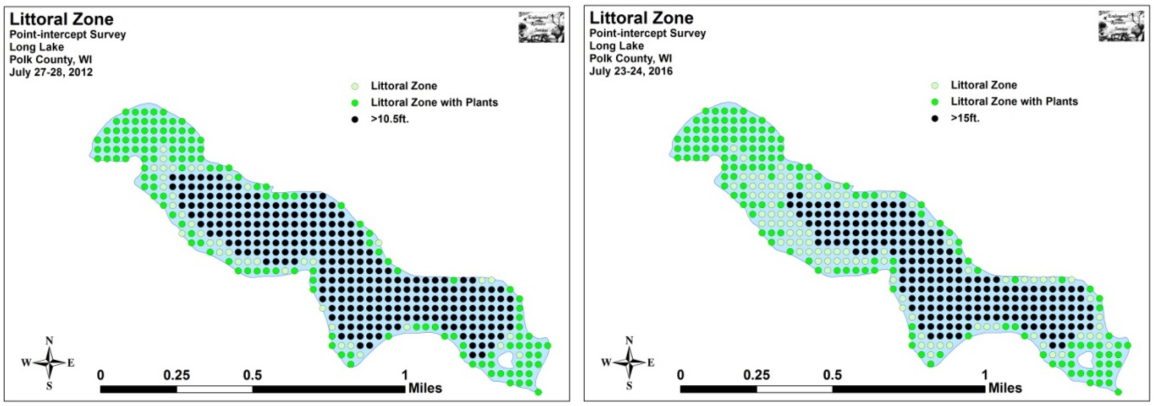


Figure 7: 2012 and 2016 Littoral Zone

Plant diversity was moderately high in 2016 with a Simpson Index value of 0.87 – down slightly from 0.88 in 2012. Species richness was, however, quite low with only 23 species found in the rake (up from 17 in 2012) although this total increased to 27 species when including visuals and plants seen during the boat survey. This number was up from the 18 total species we documented in 2012. Although overall richness increased, mean native species richness at sites with vegetation experienced a highly significant decline (p=0.003) from 3.25/site in 2012 to 2.59/site in 2016. Visual analysis of the maps suggested most of this loss could be attributed to changes in the northwest bay where the decline was consistent across areas that both have and have not been chemically treated (Figure 8). Total rake fullness experienced a nearly-significant declined (p=0.10) from a moderate 2.15 in 2012 to 1.93 in 2016, and this decline was also most evident in the northwest bay (Figure 9) (Appendix V).

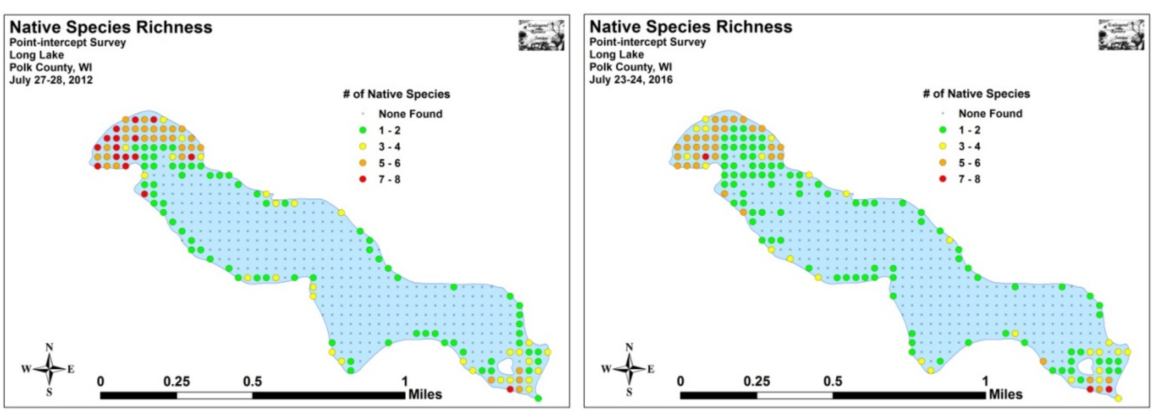


Figure 8: 2012 and 2016 Native Species Richness

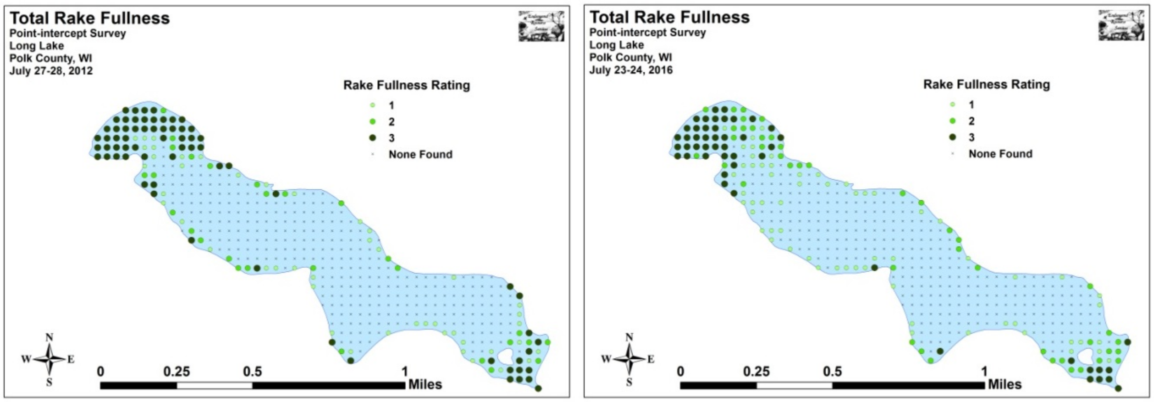


Figure 9: 2012 and 2016 Total Rake Fullness

Long Lake Plant Community:

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

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

Exposed sandy and rocky shorelines around the lake's central basin had few emergents, but sandy muck areas around the entrances to the lake's northwest and southeast bays supported scattered patches of Softstem bulrush (*Schoenoplectus tabernaemontani*), small beds of Common bur-reed (*Sparganium eurycarpum*), and dense stands of Hybrid cattail (*Typha* X *glauca*). Around the organic muck margins of these bays, these species were joined by Bottle brush sedge (*Carex comosa*), Common rush (*Juncus effusus*), Reed canary grass (*Phalaris arundinacea*), Common arrowhead (*Sagittaria latifolia*), and Broad-leaved cattails (*Typha latifolia*).

Softstem bulrush (Schwarz 2011)

Common bur-reed (Raymond 2011)

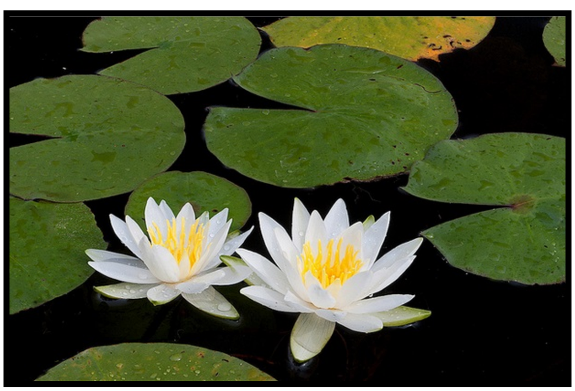
Bottle brush sedge (Spence 2011)

Common rush (Betham 2012)

Common arrowhead (Young 2012)

Broad-leaved cattail (Raymond 2011)

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



White water lily (Falkner 2012)

White water lily and Coontail 7/24/16

Growing amongst the lilypads, we also frequently encountered the submergent species Coontail, Common waterweed (*Elodea canadensis*), and Curly-leaf pondweed. We also found a handful of Small pondweed (*Potamogeton pusillus berchtoldii*) in the southeast bay – a species we had never seen on the lake prior to 2016. In addition to these plants, a large number of "duckweeds" were found floating among the lilypads and emergents. Forked duckweed (*Lemna trisulca*) was the most widely distributed species in this group, and we documented it throughout the lake's littoral zone. Large duckweed (*Spirodela polyrhiza*), Small duckweed (*Lemna minor*), and Common watermeal (*Wolffia columbiana*) were also common, but they tended to be more restricted to shallow sheltered areas.

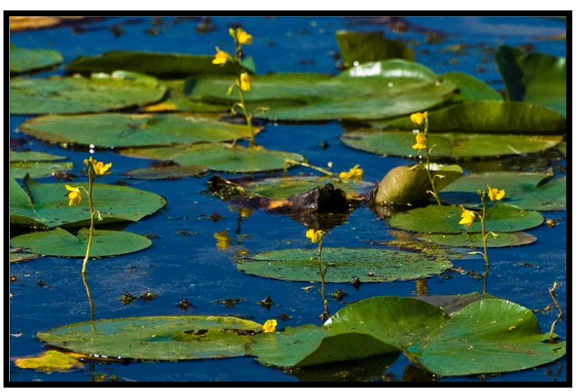
Along with the duckweeds in the northwest bay, we also documented a limited number of the aquatic liverwort Slender riccia (*Riccia fluitans*) and the carnivorous Common bladderwort (*Utricularia vulgaris*) floating among the lilypads. Rather than drawing nutrients up through roots like other macrophytes, bladderworts trap zooplankton and minute insects in their bladders, digest their prey, and use the nutrients to further their growth.

Forked duckweed (Curtis 2010)

Large duckweed (Thomas 2016)

Small duckweed and Common watermeal (Kieron 2010)

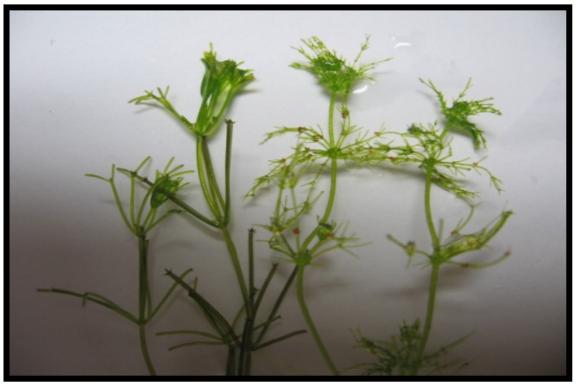
Slender riccia (Barth 2016)



Common bladderwort flowers among lilypads (Hunt 2010)

Bladders for catching plankton and insect larvae (Wontolla 2012)

Shallow rocky areas were almost entirely devoid of plants. However, in areas with at least some sand, in water up to 5ft deep, we noted the plant community was dominated by submergent plants like Muskgrass (*Chara* sp.), Needle spikerush (*Eleocharis acicularis*), Slender naiad (*Najas flexilis*), and Grass-leaved arrowhead (*Sagittaria graminea*). These fine-leaved species tend to form a carpet that stabilizes the bottom.


Muskgrass (Penuh 2012)


Needle spikerush (Fewless 2005)


Slender naiad (Apipp 2012)

Grass-leaved arrowhead (USDA 2012)

Shallow sandy muck areas tended to support slightly broader-leaved species like Water star-grass (*Heteranthera dubia*) and Northern Water-milfoil (*Myriophyllum sibiricum*). For the first time ever, we also found a few locations with Leafy pondweed (*Potamogeton foliosus*) and a single Wild celery (*Vallisneria americana*) plant. 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)

Keeled nutlets of Leafy pondweed (Kleinman 2009)

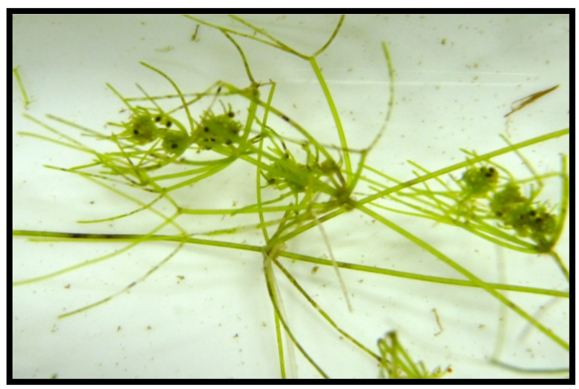
Wild celery (Dalvi 2012)

Organic muck areas in water greater than 5ft were dominated by Coontail, Common waterweed, and, in the early spring prior to treatment, Curly-leaf pondweed. Nitella (*Nitella* sp.), a colonial alga that acts looks like a higher plant, was uncommon at low densities in sandy muck areas. Predatory fish like the lake's pike are often found along the edges of these deep water beds waiting in ambush.

Coontail (Hassler 2011)

Common waterweed (Fischer 2012)

Curly-leaf pondweed (USGS 2016)

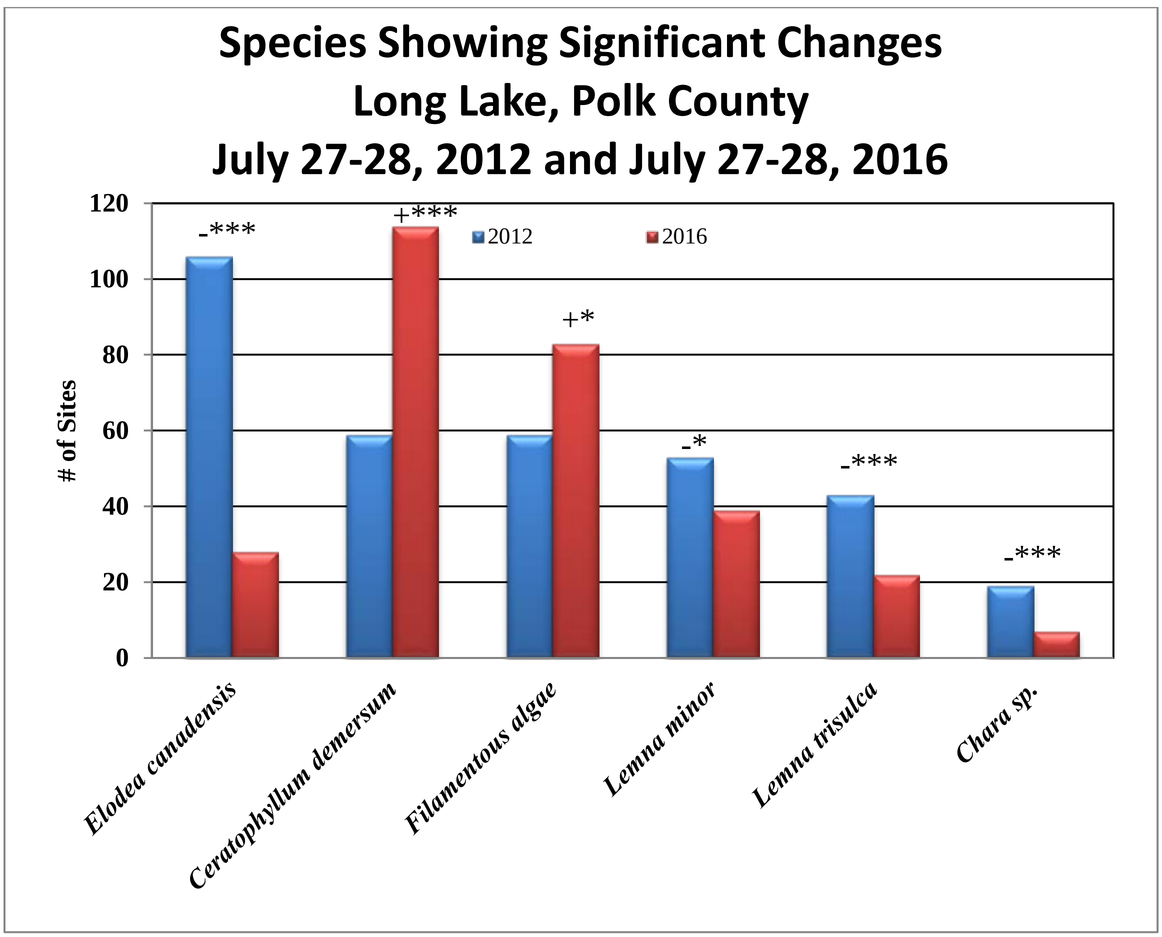


Nitella (USGS 2012)

Comparison of Native Macrophyte Species in 2012 and 2016:

In July 2012, Common waterweed, Coontail, Small duckweed, and White water lily were the most common macrophyte species (Table 3). They were present at 74.65%, 41.55%, 37.32%, and 30.99% of survey points with vegetation respectively and accounted for 56.71% of the total relative frequency (Maps for all species found in July 2012 are located in Appendix VI). In 2016, Coontail, White water lily, Small duckweed, and Large duckweed were the most common macrophyte species during the July survey. We found them at 74.34%, 30.92%, 25.66%, and 25.66% of sites with vegetation (Table 4), and they accounted for 59.50% of the total relative frequency (Species accounts for all species found in 2012 and 2016, and maps for all plants found in July 2016 can be found in Appendixes VII and VIII). These results suggest a slightly less diverse and even plant community existed in 2016 than in 2012.

Lakewide, six species showed significant changes in distribution from 2012 to 2016 (Figure 10). Common waterweed and Forked duckweed both suffered highly significant declines; Muskgrass a moderately significant decline; and Small duckweed a significant decline. Conversely, Coontail experienced a highly significant increase, and filamentous algae a significant increase.



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

Figure 10: Macrophytes Showing Significant Changes from 2012-2016

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Long Lake, Polk County
July 27-28, 2012

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Elodea canadensis	Common waterweed	106	22.94	74.65	58.56	1.77	0
Ceratophyllum demersum	Coontail	59	12.77	41.55	32.60	1.64	0
	Filamentous algae	59	*	41.55	32.60	1.85	0
Lemna minor	Small duckweed	53	11.47	37.32	29.28	1.68	0
Nymphaea odorata	White water lily	44	9.52	30.99	24.31	2.45	0
Lemna trisulca	Forked duckweed	43	9.31	30.28	23.76	1.09	0
Spirodela polyrhiza	Large duckweed	43	9.31	30.28	23.76	1.42	0
Wolffia columbiana	Common watermeal	39	8.44	27.46	21.55	1.13	0
Chara sp.	Muskgrass	19	4.11	13.38	10.50	1.74	0
Heteranthera dubia	Water star-grass	13	2.81	9.15	7.18	1.15	0
Nitella sp.	Nitella	10	2.16	7.04	5.52	1.00	0
Typha sp.	Cattails (Broad-leaved/Hybrid)	10	2.16	7.04	5.52	2.60	0
Najas flexilis	Slender naiad	9	1.95	6.34	4.97	1.22	0
Eleocharis acicularis	Needle spikerush	5	1.08	3.52	2.76	1.20	0
Schoenoplectus tabernaemontani	Softstem bulrush	3	0.65	2.11	1.66	1.00	0
Sparganium eurycarpum	Common bur-reed	3	0.65	2.11	1.66	2.33	0
Sagittaria latifolia	Common arrowhead	2	0.43	1.41	1.10	1.00	0
Potamogeton crispus	Curly-leaf pondweed	1	0.22	0.70	0.55	1.00	0
Phalaris arundinacea	Reed canary grass	***	***	***	***	***	***

* Excluded from relative frequency analysis ** Visual Only *** Boat Survey Only

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Long Lake, Polk County
July 23-24, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Ceratophyllum demersum	Coontail	113	28.25	74.34	45.20	1.59	3
	Filamentous algae	83	*	54.61	33.20	1.28	1
Nymphaea odorata	White water lily	47	11.75	30.92	18.80	2.45	6
Lemna minor	Small duckweed	39	9.75	25.66	15.60	1.67	0
Spirodela polyrhiza	Large duckweed	39	9.75	25.66	15.60	1.62	0
Wolffia columbiana	Common watermeal	35	8.75	23.03	14.00	1.43	0
Elodea canadensis	Common waterweed	28	7.00	18.42	11.20	1.68	0
Lemna trisulca	Forked duckweed	22	5.50	14.47	8.80	1.14	0
Najas flexilis	Slender naiad	19	4.75	12.50	7.60	1.32	1
Heteranthera dubia	Water star-grass	10	2.50	6.58	4.00	1.10	0
Chara sp.	Muskgrass	7	1.75	4.61	2.80	1.43	0
Nitella sp.	Nitella	7	1.75	4.61	2.80	1.43	1
Typha X *glauca*	Hybrid cattail	7	1.75	4.61	2.80	2.57	6
Eleocharis acicularis	Needle spikerush	5	1.25	3.29	2.00	1.00	0
Potamogeton crispus	Curly-leaf pondweed	5	1.25	3.29	2.00	1.00	4
Sparganium eurycarpum	Common bur-reed	5	1.25	3.29	2.00	2.20	3
Myriophyllum sibiricum	Northern water-milfoil	3	0.75	1.97	1.20	1.00	2
Potamogeton foliosus	Leafy pondweed	2	0.50	1.32	0.80	1.00	0
Riccia fluitans	Slender riccia	2	*	1.32	0.80	1.00	2
Schoenoplectus tabernaemontani	Softstem bulrush	2	0.50	1.32	0.80	2.00	3
Carex comosa	Bottle brush sedge	1	0.25	0.66	0.40	1.00	0
Juncus effusus	Common rush	1	0.25	0.66	0.40	1.00	0
Phalaris arundinacea	Reed canary grass	1	0.25	0.66	0.40	1.00	4
Sagittaria graminea	Grass-leaved arrowhead	1	0.25	0.66	0.40	1.00	1

*Excluded from relative frequency analysis

Table 4 (cont): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Long Lake, Polk County
July 23-24, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Typha latifolia	Broad-leaved cattail	1	0.25	0.66	0.40	2.00	2
Potamogeton pusillus	Small pondweed	**	**	**	**	**	1
Sagittaria latifolia	Common arrowhead	***	***	***	***	***	***
Utricularia vulgaris	Common bladderwort	***	***	***	***	***	***
Vallisneria americana	Wild celery	***	***	***	***	***	***

** Visual Only *** Boat Survey Only

Coontail, the most common species in 2016 after being the second most common in 2012, was abundant in the lake's organic muck bottom bays; especially in the northwest bay (Figure 11). Found at 59 sites in 2012, it demonstrated a highly significant increase in distribution to 113 sites in 2016. Its mean rake fullness value, however, was almost unchanged from 1.64 in 2012 to 1.59 in 2016.

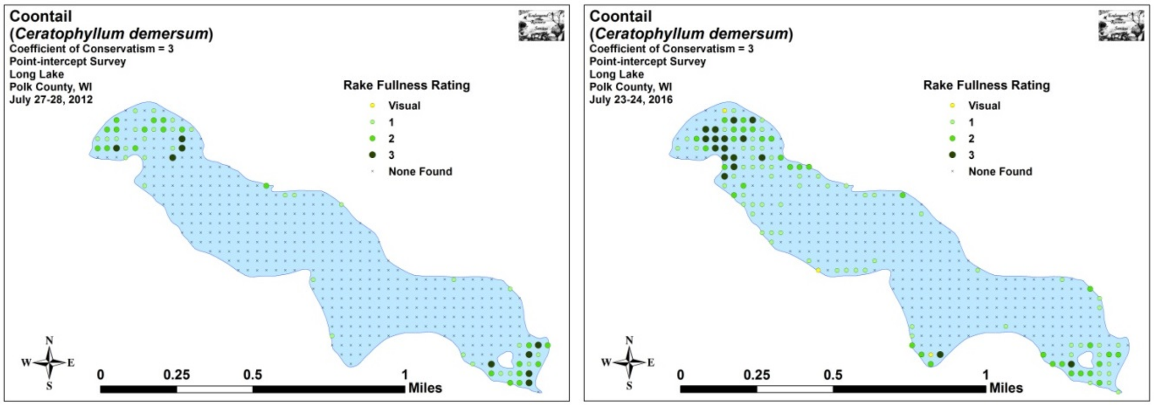


Figure 11: 2012 and 2016 Coontail Density and Distribution

White water lily was the second most common macrophyte in 2016 after being the fourth most common in 2012. Despite this jump in relative frequency, the species actually showed little change in distribution (44 sites in 2012 to 47 sites in 2016) and no change in density (mean rake fullness of 2.45 both years) (Figure 12). Avoiding direct application of herbicide to the "lilypad" beds seems to be allowing these important habitat areas to survive little changed.

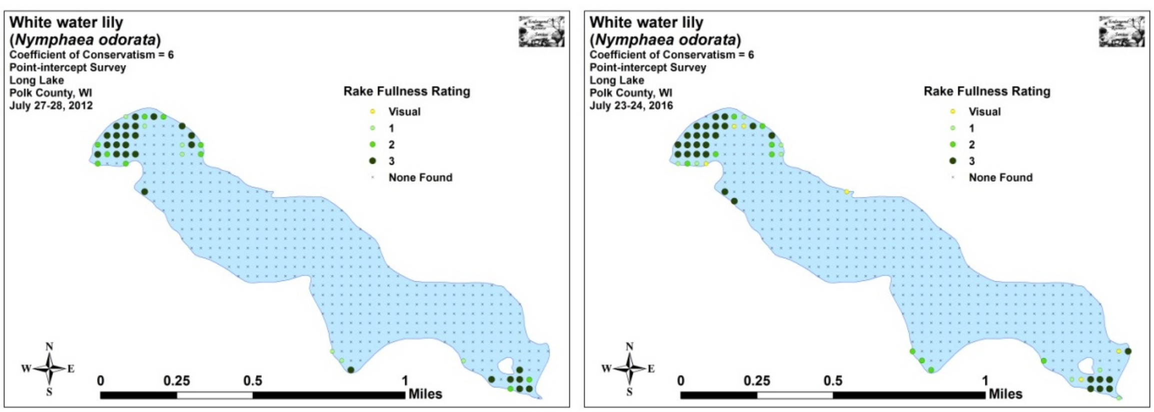


Figure 12: 2012 and 2016 White Water Lily Density and Distribution

Present at 106 sites in 2012, Common waterweed was the most common macrophyte species in the lake; however, we documented a highly significant decline in distribution to just 28 sites in 2016 dropping it to the six most common species. This was accompanied by a non-significant decline in density (mean rake fullness of 1.77 in 2012 to 1.68 in 2016) (Figure 13). Although this overall decline might seem concerning, analysis of the maps for Coontail show that these two species were essentially exchanged for one another. After looking back at all the years of July surveys (2010-2012, 2016), we noted that, at least on Long Lake, these two species seem to compete with each other to fill much of the void left by the elimination of Curly-leaf pondweed in shallow water following the spring treatment.

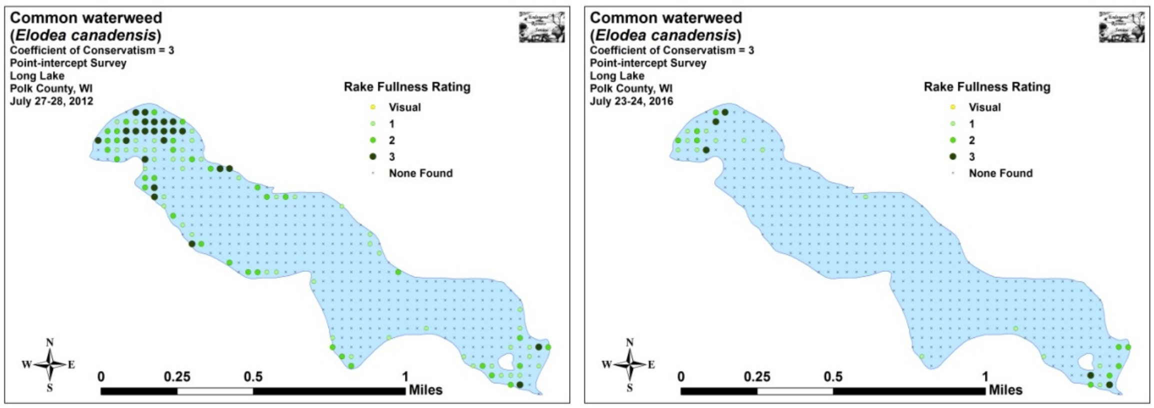


Figure 13: 2012 and 2016 Common Waterweed Density and Distribution

Comparison of Filamentous Algae in 2012 an 2016:

Filamentous algae, normally associated with excessive nutrients in the water column, were located at 83 survey points. Although this was a significant increase in distribution from the 59 points they were found at in 2012, the mean rake fullness experienced a highly significant decline (p<0.001) from 1.85 in 2012 to 1.28 in 2016 (Figure 14). Most of the highest density algae areas occurred along the north shore of the northwest bay. We also regularly found thin mats growing over pure sand on the edges of exposed points.

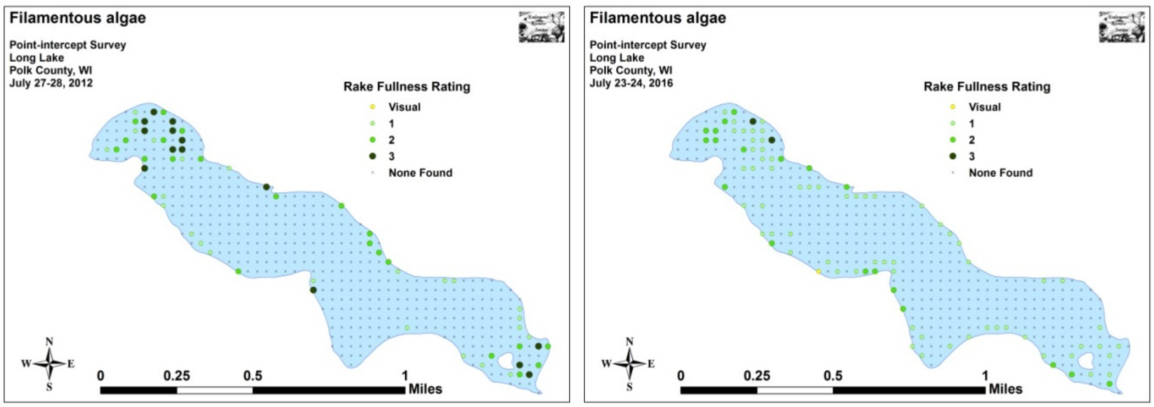


Figure 14: 2012 and 2016 Filamentous Algae Density and Distribution

Comparison of Floristic Quality Indexes in 2012 and 2016:

In 2012, we identified a total of 16 **native index species** in the rake during the point-intercept survey (Table 5). They produced a mean Coefficient of Conservatism of 4.8 and a Floristic Quality Index of 19.0.

Table 5: Floristic Quality Index of Aquatic Macrophytes
Long Lake, Polk County
July 27-28, 2012

Species	Common Name	C
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nymphaea odorata	White water lily	6
Sagittaria latifolia	Common arrowhead	3
Schoenoplectus tabernaemontani	Softstem bulrush	4
Sparganium eurycarpum	Common bur-reed	5
Spirodela polyrhiza	Large duckweed	5
Typha sp.	Cattails	1
Wolffia columbiana	Common watermeal	5
N		**16**
Mean C		**4.8**
FQI		**19.0**

In 2016, we identified a total of 21 **native index plants** in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 5.1 and a Floristic Quality Index of 23.3 (Table 6). Nichols (1999) reported an average mean C for the North Central Hardwood Forests Region of 5.6 putting Long Lake well below average for this part of the state. The FQI was, however, just above the median FQI of 20.9 for the North Central Hardwood Forests (Nichols 1999). Both the mean C and the total FQI were noticeably higher than in 2012. Although this could simply be capturing changes in annual growing conditions, we believe it actually reflects a trend of generally improving conditions on the lake that have allowed the colonization of new species. Specifically, the 2016 index included four species (Leafy pondweed, Small pondweed, Slender riccia, and Grass-leaved arrowhead) that have not been seen on the lake during any of our seven years of surveying on the lake; a fifth species, Wild celery, was also seen for the first time in 2016, but it was excluded from the index as it was found during the boat survey.

Table 6: Floristic Quality Index of Aquatic Macrophytes
Long Lake, Polk County
July 23-24, 2016

Species	Common Name	C
Carex comosa	Bottle brush sedge	5
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nymphaea odorata	White water lily	6
Potamogeton foliosus	Leafy pondweed	6
Riccia fluitans	Slender riccia	7
Sagittaria graminea	Grass-leaved arrowhead	9
Schoenoplectus tabernaemontani	Softstem bulrush	4
Sparganium eurycarpum	Common bur-reed	5
Spirodela polyrhiza	Large duckweed	5
Typha latifolia	Broad-leaved cattail	1
Typha X *glauca*	Hybrid cattail	1
Wolffia columbiana	Common watermeal	5
N		**21**
Mean C		**5.1**
FQI		**23.3**

Other Exotic Plant Species:

In addition to Curly-leaf pondweed, we found two other exotic species growing adjacent to Long Lake: Reed canary grass and Hybrid cattail.

Despite only being reported from the boat survey, Reed canary grass was often a dominant plant just beyond the lakeshore (Figure 15). We noticed patches in wetlands adjacent to the lake and next to mowed and otherwise disturbed shorelines. A ubiquitous plant in the state, there's likely little that can be done about it.

Figure 15: Reed Canary Grass

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. First noticed in 2011, Hybrid cattails have now crowded out most native cattails around the lake and in adjacent wetlands, and they are firmly and likely irrevocably established (Figure 16) (For more information on select aquatic exotic species, see Appendix IX).

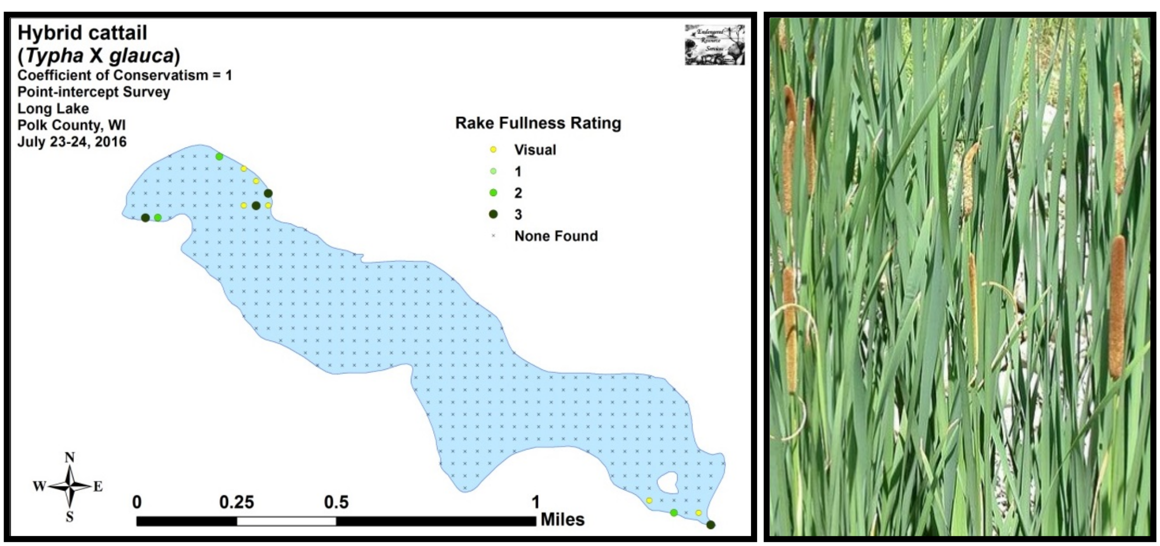


Figure 16: Hybrid Cattail Density and Distribution

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Water Clarity and the Role of Native Macrophytes:

Like trees in a forest, a lake's native plants are the basis of the aquatic ecosystem. They capture the sun's energy and turn it into usable food, "clean" the water of excess nutrients, and provide habitat for other organisms like aquatic invertebrates and the lake's fish populations. Because of this, preserving them is critical to maintaining the lake's overall health.

Over the past seven years, we've observed that fluctuations in water clarity and quality appear to be a significant driving factor in native plant growth as well as annual diversity. Specifically, in years where there are significant algal blooms, we have found that more sensitive species like Muskgrass, Water star-grass, and Slender naiad tend to have population crashes; conversely, in years with better water clarity, they often carpet the bottom. These particular native species are especially beneficial as they have a low growth profile that doesn't interfere with watercraft navigation; start growing later in the season making them unlikely to be impacted by early-season herbicide treatments; and are photosynthetic late into the summer meaning they continue to pull nutrients out of the water column after many other species begin their annual senescence. Unfortunately, when phosphorus and nitrogen levels exceed what the lake's macrophytes can utilize, it tends to promote these algae blooms which impact these sensitive species as well as general lake esthetics. Although past studies have shown that internal loading and agricultural runoff are significant contributors to the lake's overall nutrient load, all lake residents have the opportunity to help reduce runoff by evaluating how their shoreline practices may be impacting the lake. Simple things like establishing or maintaining a buffer strip of native vegetation along the lake shore to prevent erosion, building rain gardens, bagging grass clippings, switching to a phosphorus-free fertilizer or preferably eliminating fertilizer near the lake altogether, collecting pet waste, and disposing of the ash from fire pits away from the lakeshore can all significantly reduce the amount of nutrients entering the lake. Hopefully, a greater understanding of how individual property owners can have lake-wide impacts will result in more people taking appropriate conservation actions to not only help improved water clarity and quality, but also to benefit the lake's sensitive plant species.

Curly-leaf pondweed:

The aggressive management of Curly-leaf pondweed in six of the past seven years has significantly reduced the overall area and density of this exotic invasive species in the lake. Although there was significant concern raised that annual treatments would potentially eliminate native vegetation, the data suggests new species may actually be colonizing the lake as richness has steadily grown over this time period. That said, large-scale Aquathol applications have temporarily impacted some non-target species like Northern water-milfoil – one of the lake's most important habitat plants. With that in mind, we continue to encourage the LLPRD to strive for minimal applications that still meet their CLP management goals.

Eurasian Water-milfoil:

Eurasian water-milfoil has now expanded into four lakes in Polk County all of which have public landings and in/out boat traffic. Because of this, we encourage the lake to continue its Clean Boats/Clean Waters program to inspect watercraft. Although there are no guarantees, CBCW monitoring decreases the likelihood that EWM or any other Aquatic Invasive Species will be introduced into the lake.

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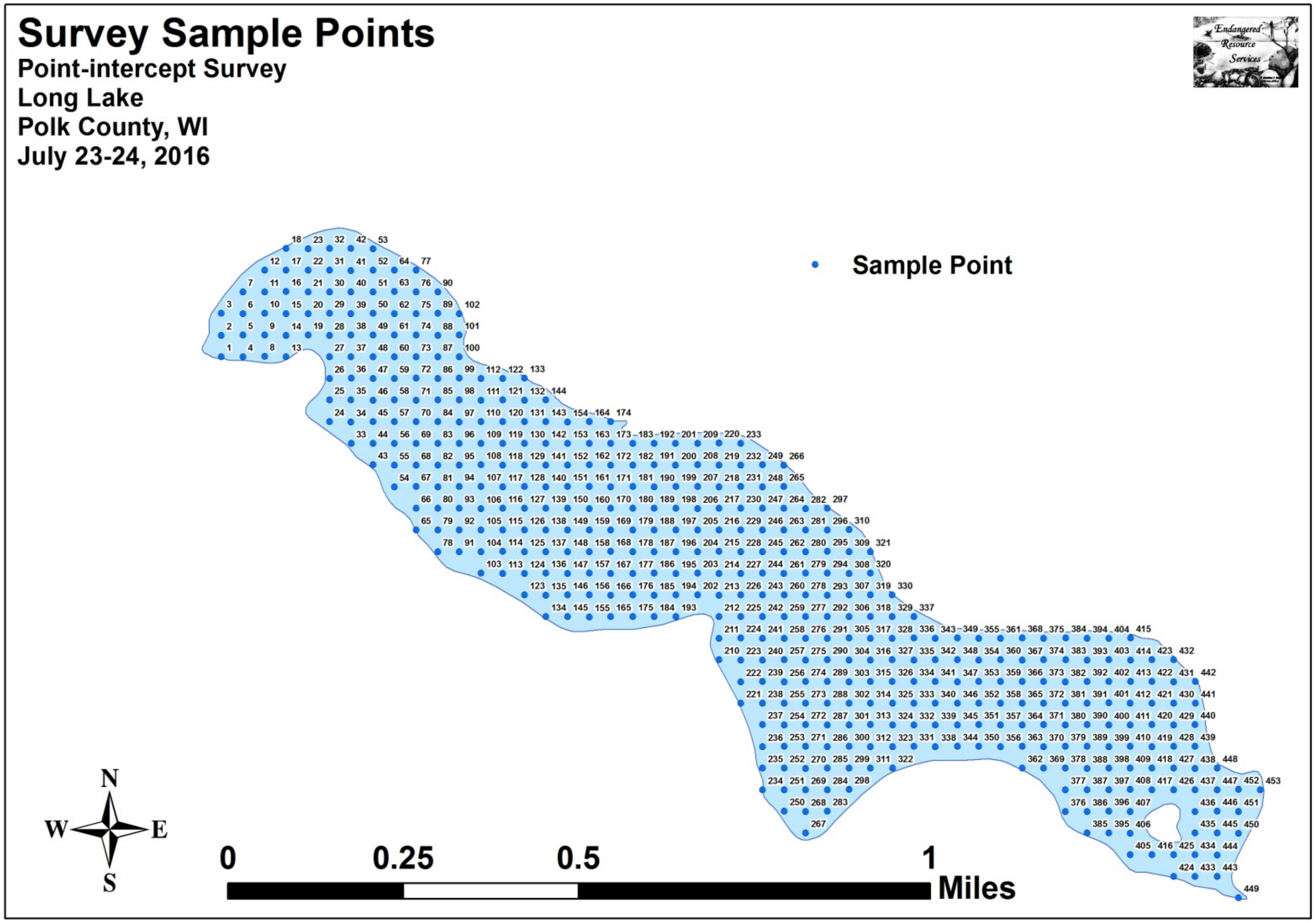
Appendix I: Survey Sample Points Map


Survey Sample Points
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Endangered Resource Services
Sample Point
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Appendix II: Boat and Vegetative Survey Data Sheets

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

Observers for this lake: names and hours worked by each:																									
Lake:									**WBIC**									**County**						**Date:**	
Site #	**Depth (ft)**	**Muck (M), Sand (S), Rock (R)**	**Rake pole (P) or rake rope (R)**	**Total Rake Fullness**	**EWM**	**CLP**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
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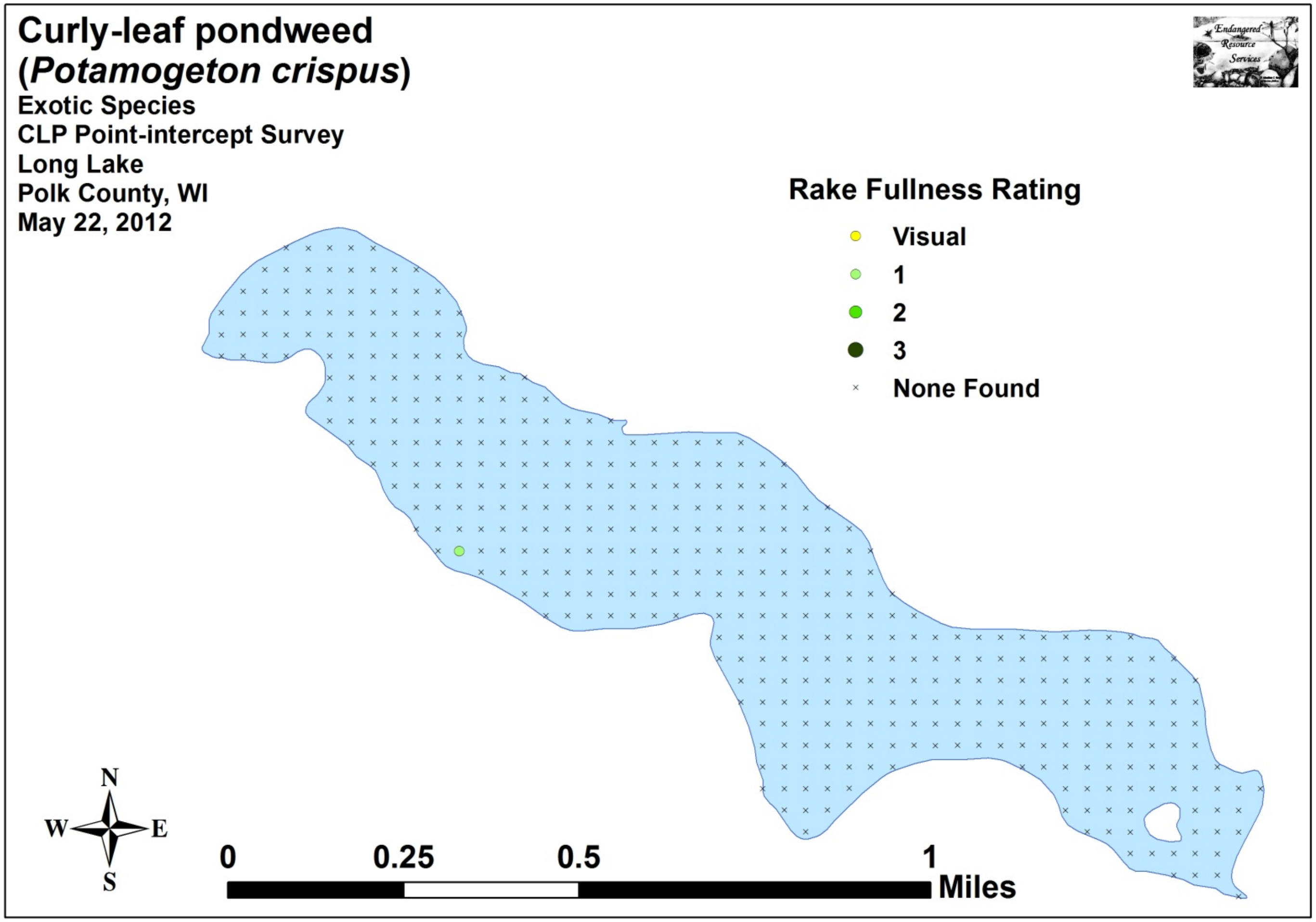
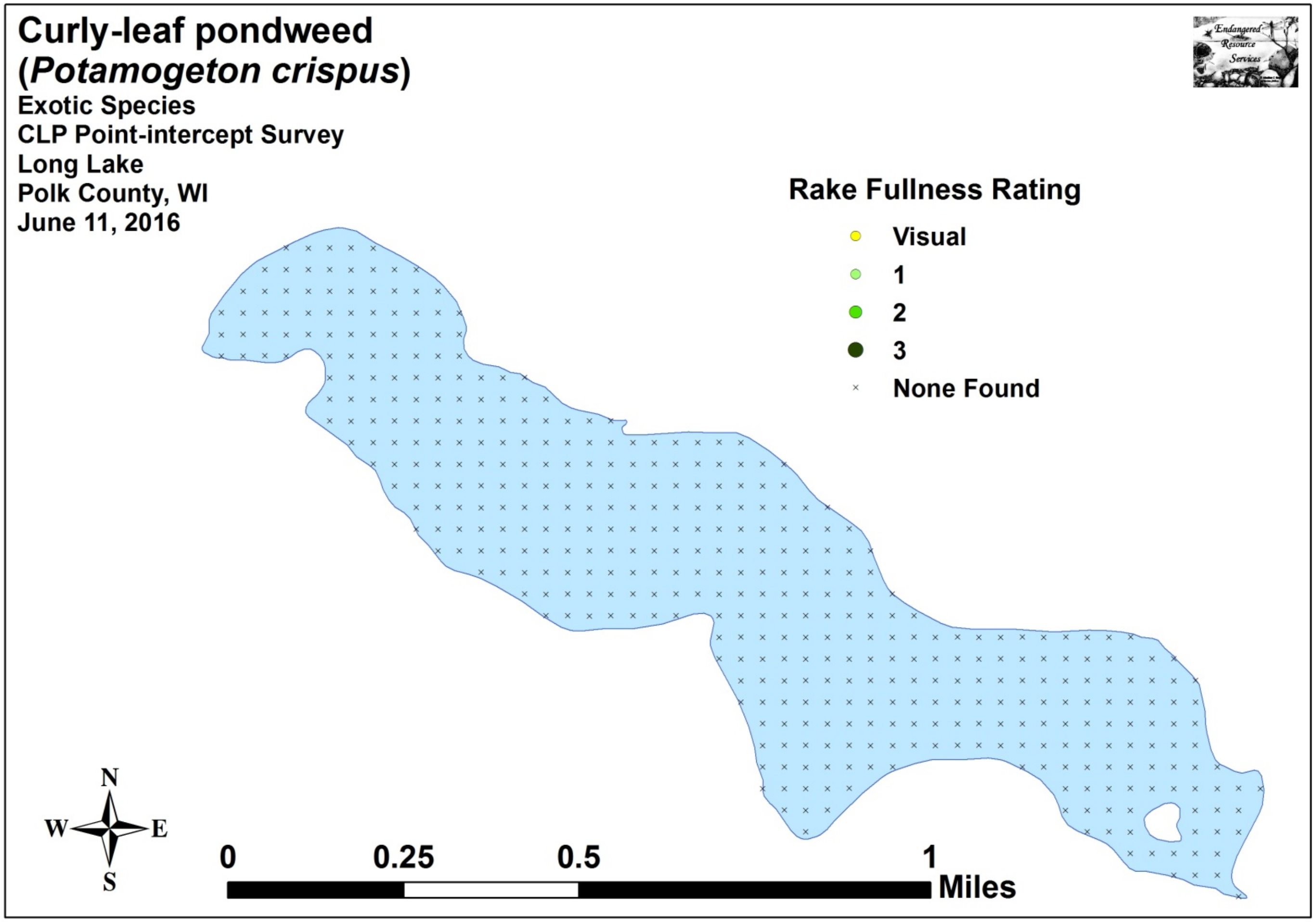
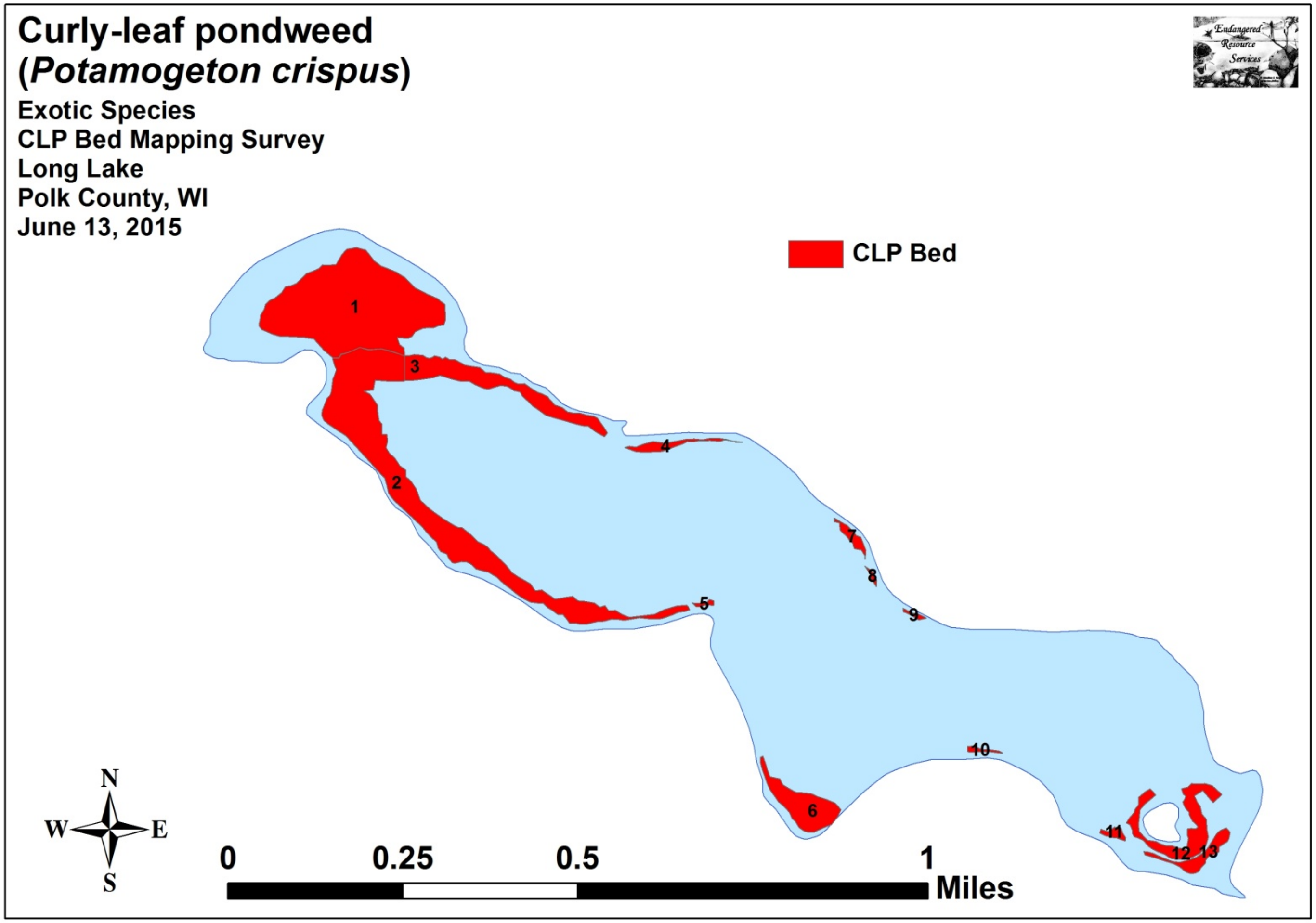
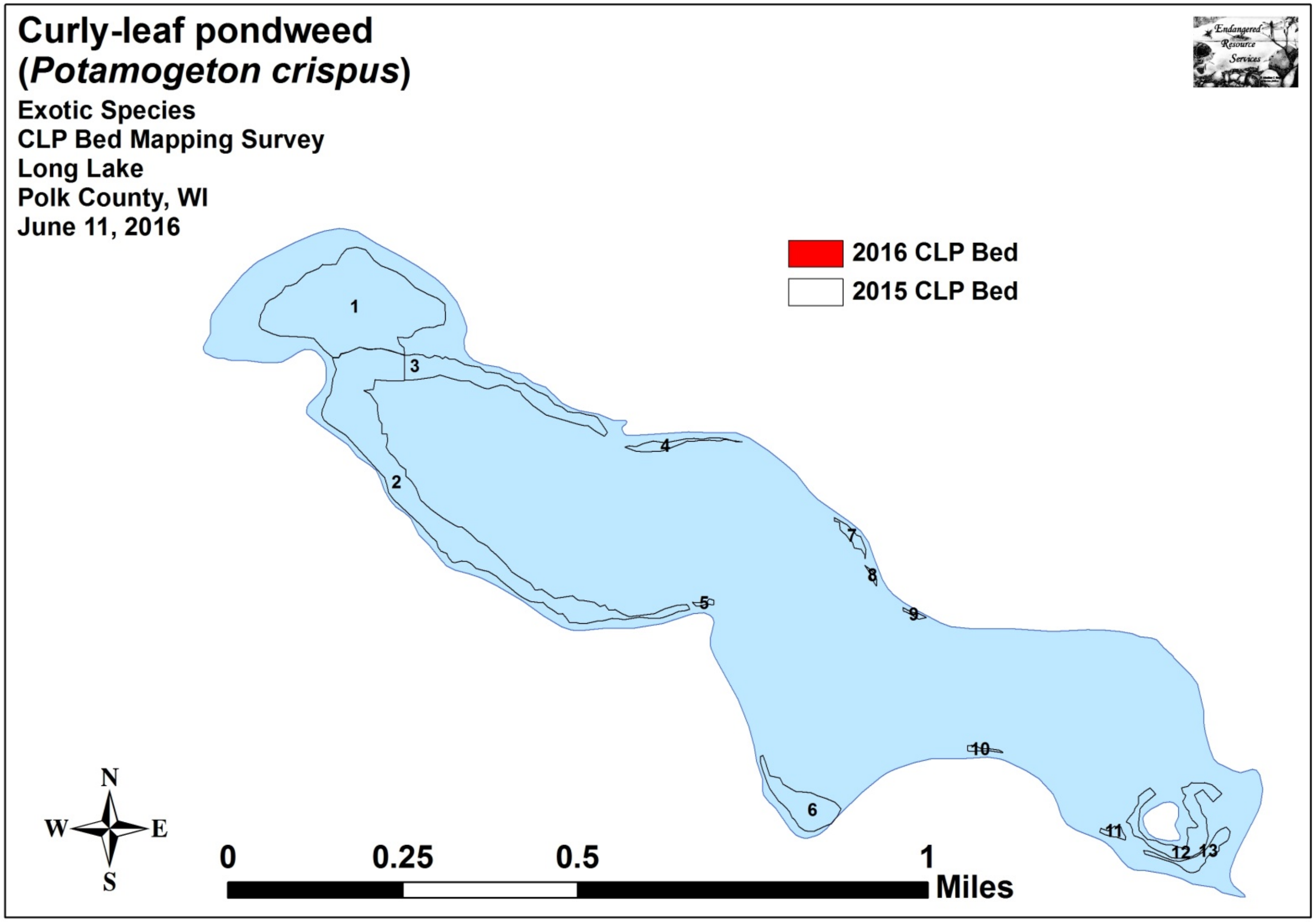
Appendix III: 2012 and 2016 Early-season CLP Density and Distribution and 2015 and 2016 CLP Bed Maps



Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Point-intercept Survey
Long Lake
Polk County, WI
May 22, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

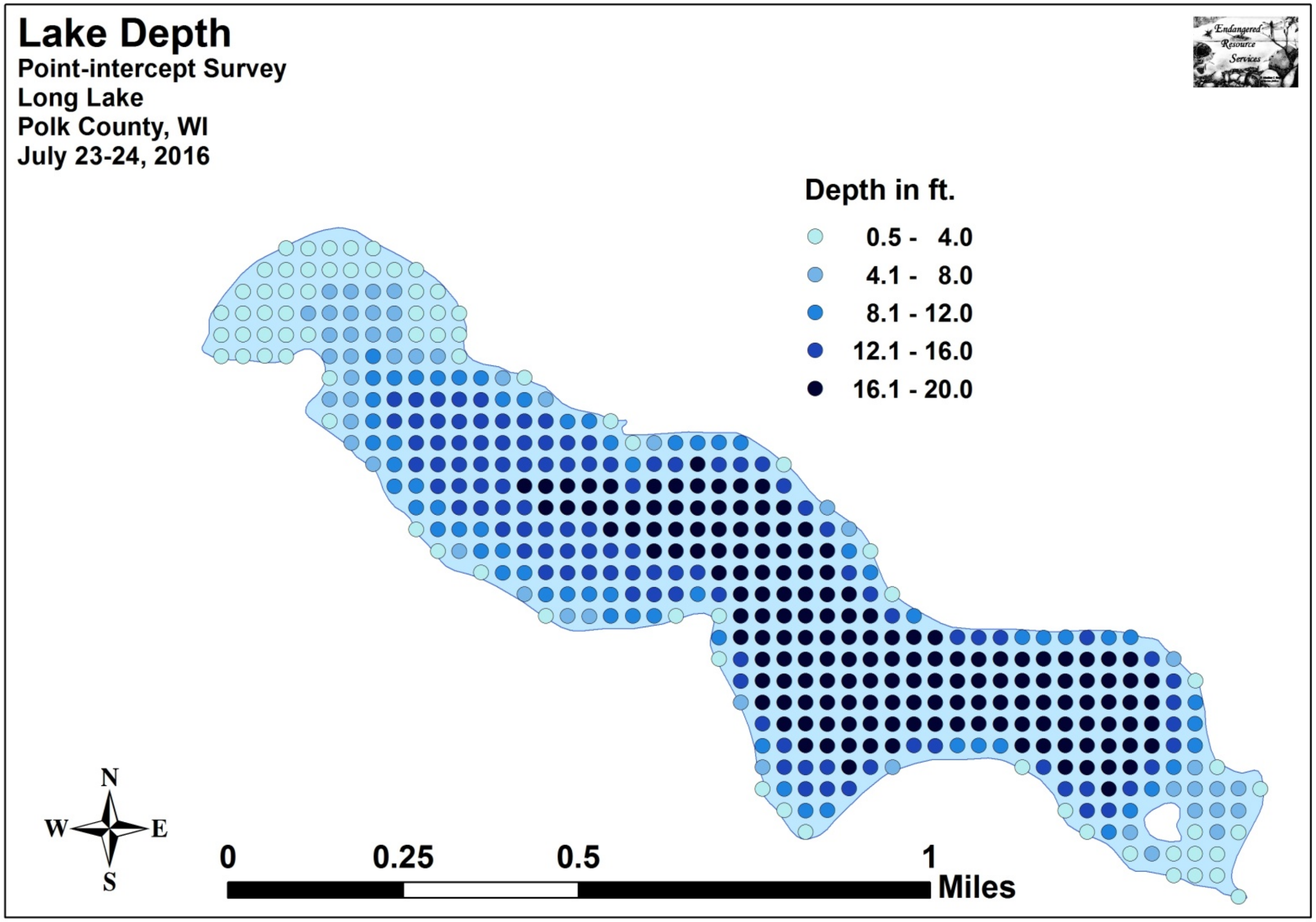

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Point-intercept Survey
Long Lake
Polk County, WI
June 11, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

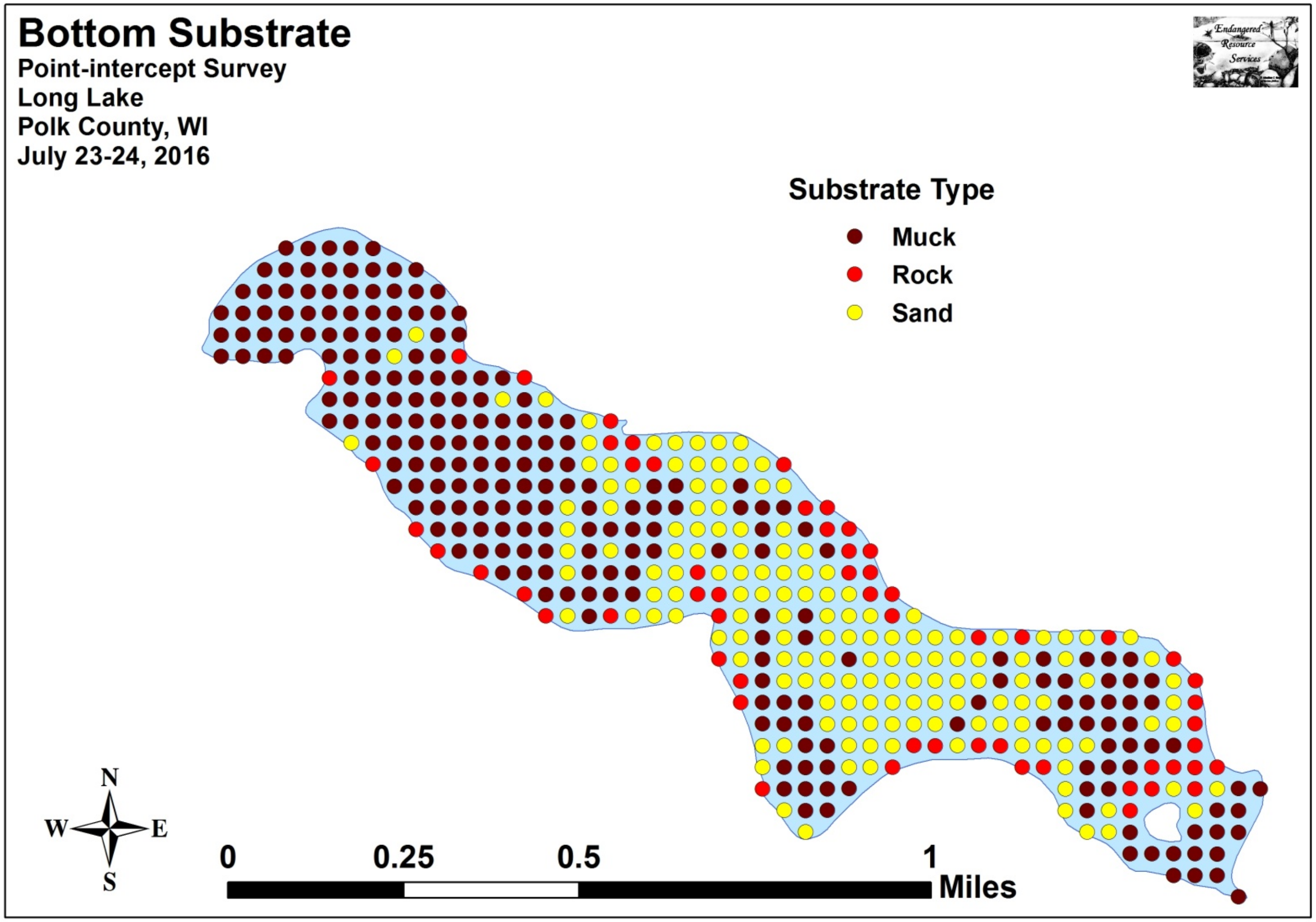

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Bed Mapping Survey
Long Lake
Polk County, WI
June 13, 2015
CLP Bed
1
2
3
4
5
6
7
8
9
10
11
12
13
N
W
E
S
0
0.25
0.5
1
Miles



Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Bed Mapping Survey
Long Lake
Polk County, WI
June 11, 2016
2016 CLP Bed
2015 CLP Bed
1
2
3
4
5
6
7
8
9
10
11
12
13
N
W
E
S
0
0.25
0.5
1
Miles

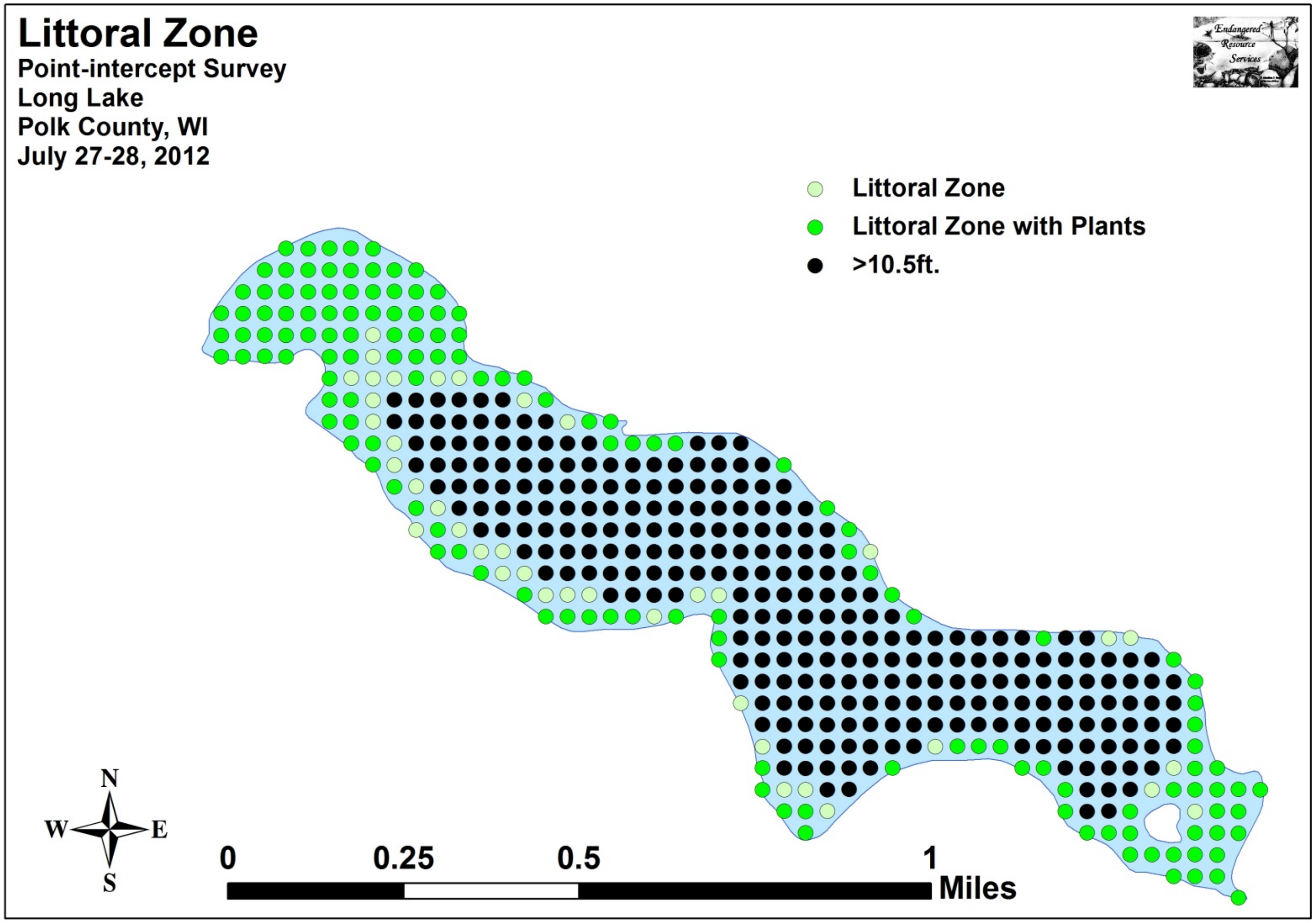
Appendix IV: Habitat Variable Maps


Lake Depth
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Depth in ft.
0.5 - 4.0
4.1 - 8.0
8.1 - 12.0
12.1 - 16.0
16.1 - 20.0
N
W
E
S
0
0.25
0.5
1
Miles

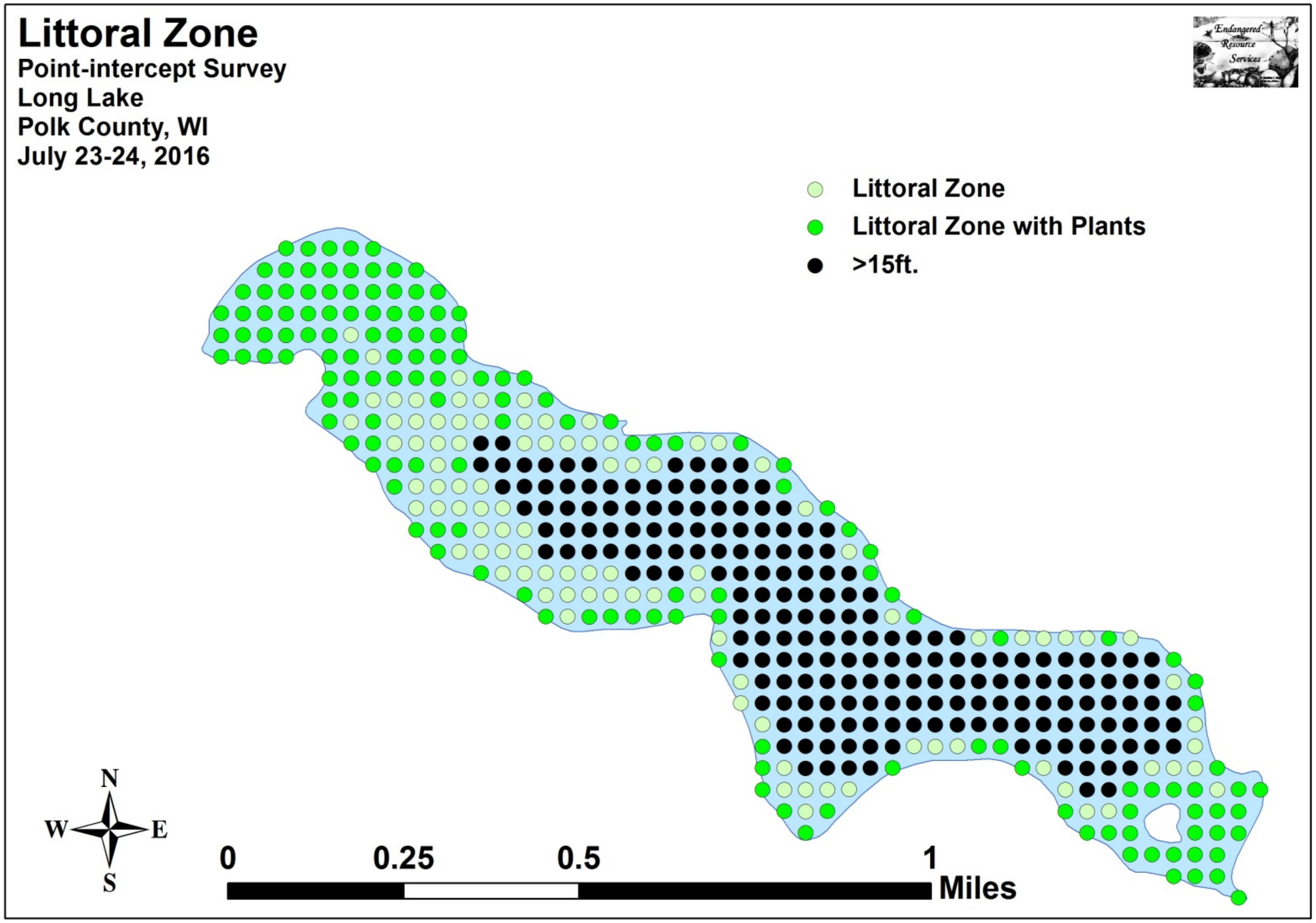


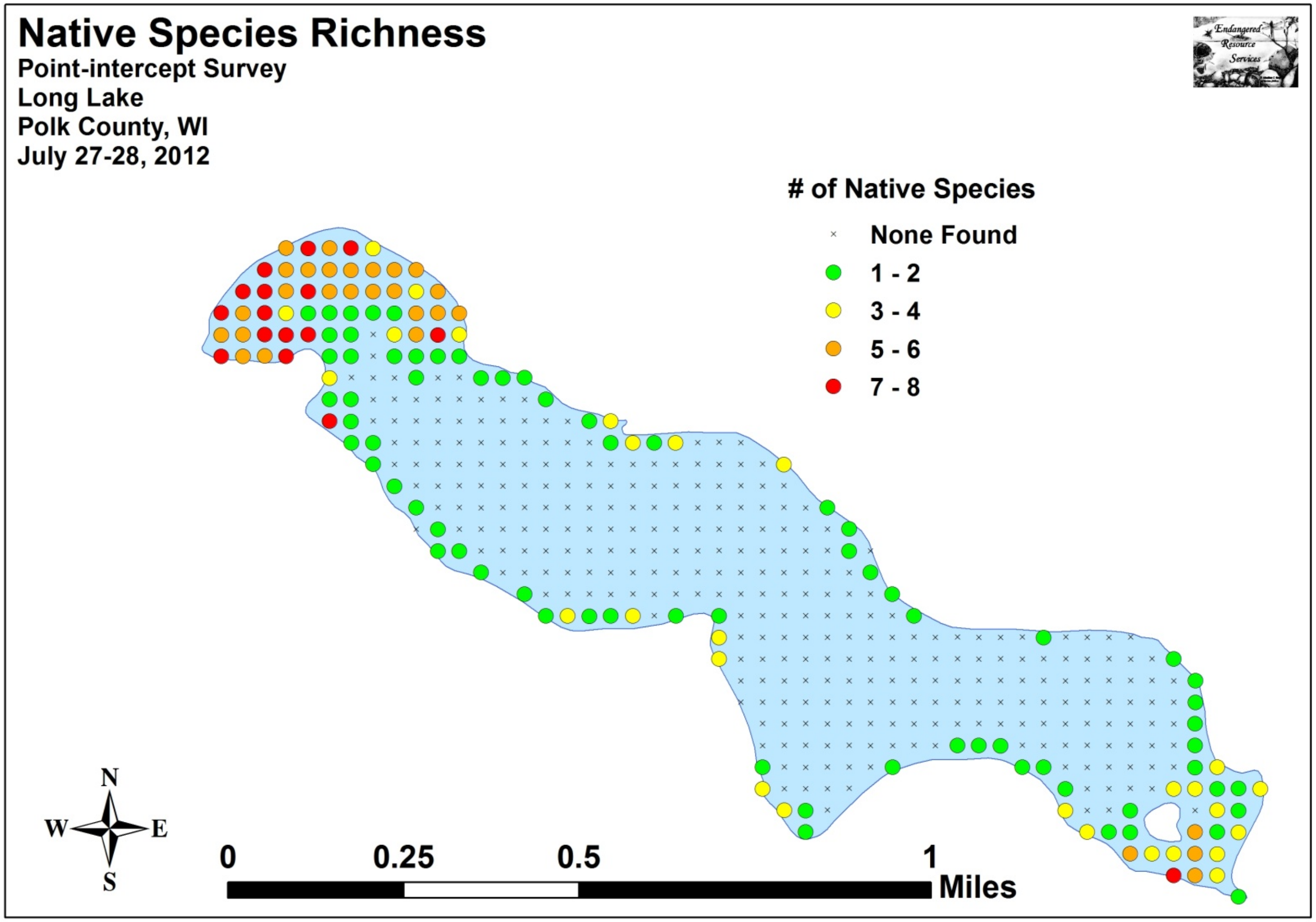
Bottom Substrate
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Endangered Resource Services
Substrate Type
Muck
Rock
Sand
N
W
E
S
0
0.25
0.5
1
Miles

Appendix V: 2012 and 2016 Littoral Zone, Native Species Richness and Total Rake Fullness Maps

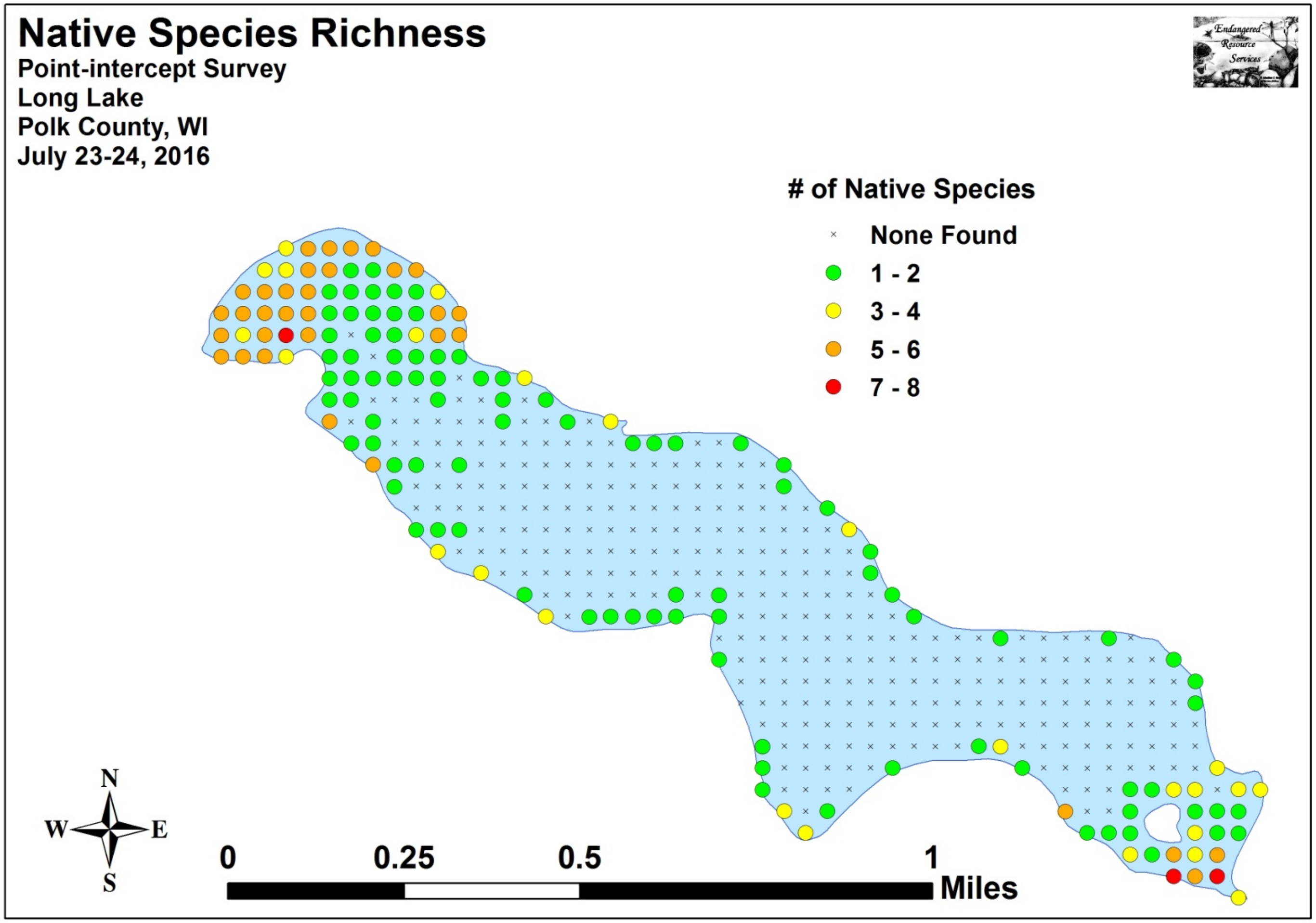


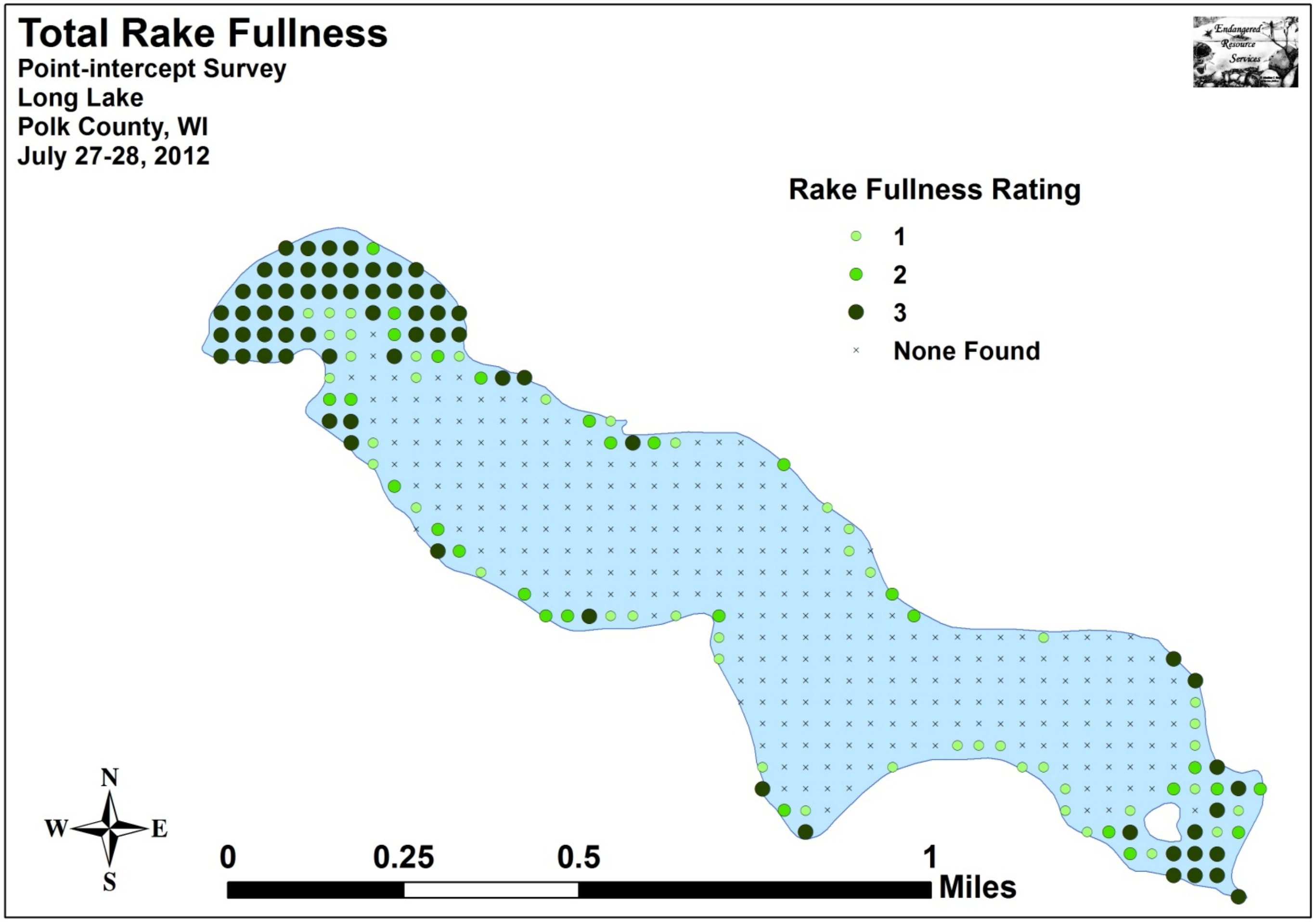
Littoral Zone
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Littoral Zone
Littoral Zone with Plants
>10.5ft.
N
W
E
S
0
0.25
0.5
1
Miles

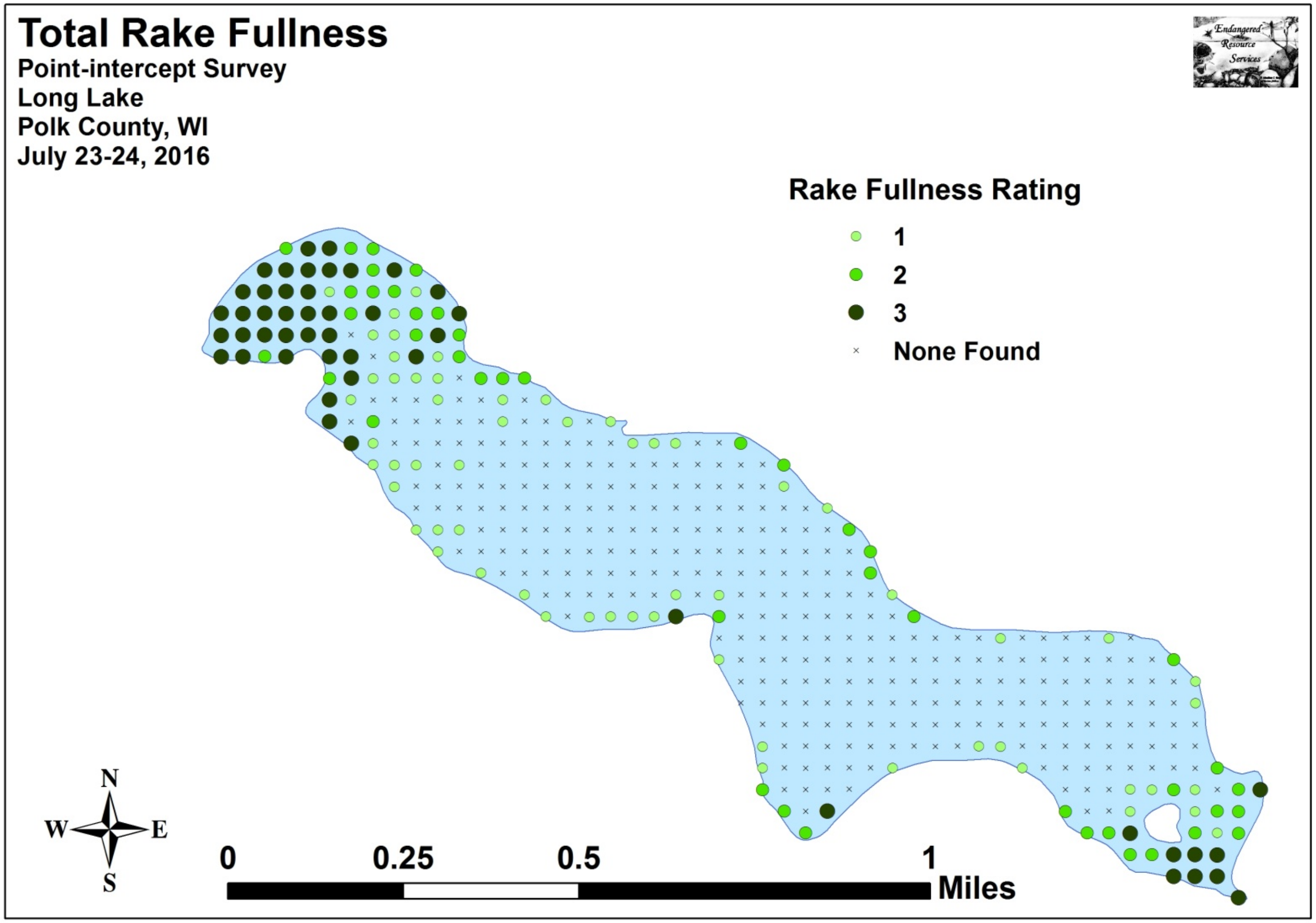

Littoral Zone
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Littoral Zone
Littoral Zone with Plants
>15ft.
N
W
E
S
0
0.25
0.5
1
Miles



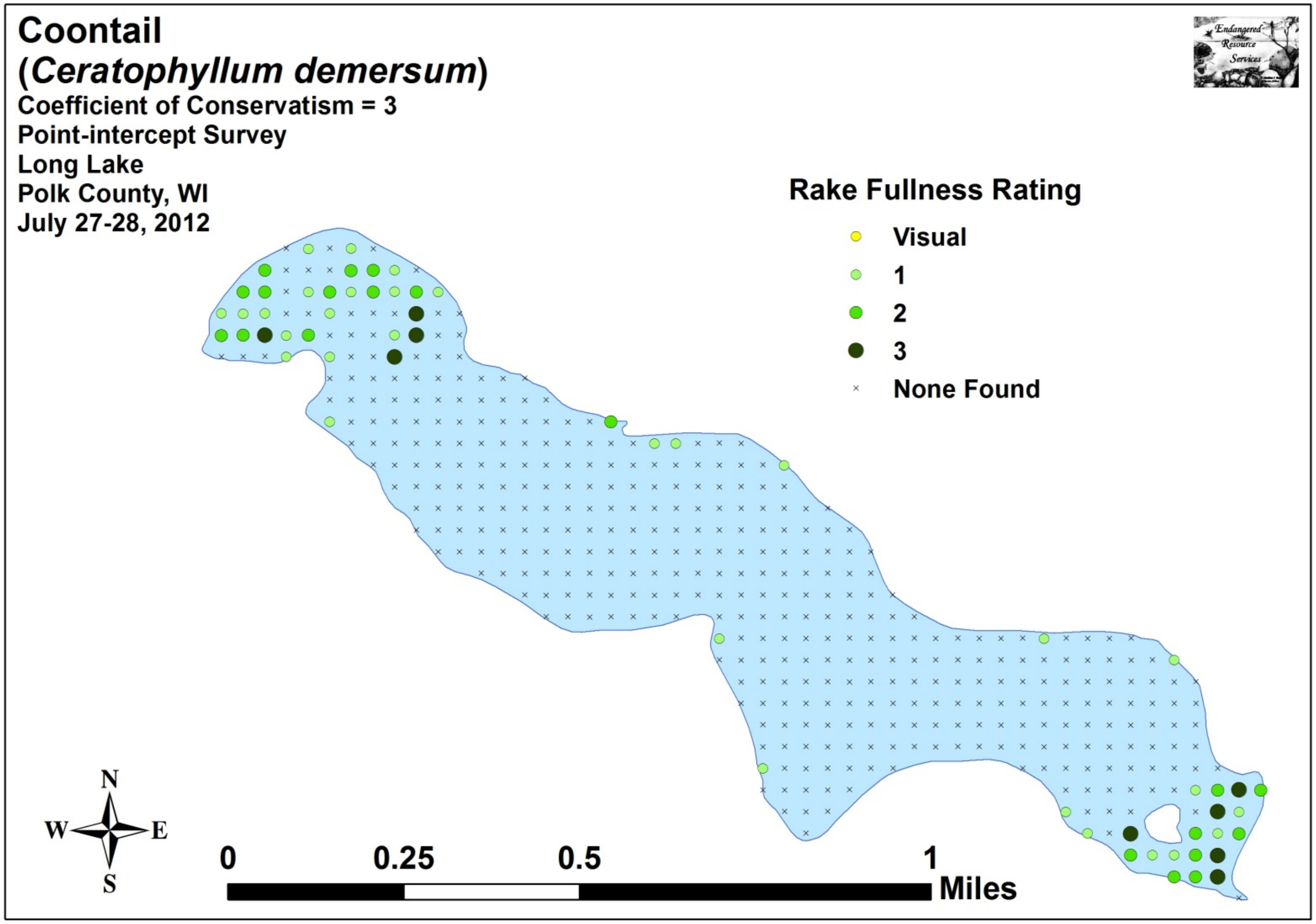
Native Species Richness
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
N
W
E
S
0
0.25
0.5
1
Miles


Native Species Richness
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
N
W
E
S
0
0.25
0.5
1
Miles

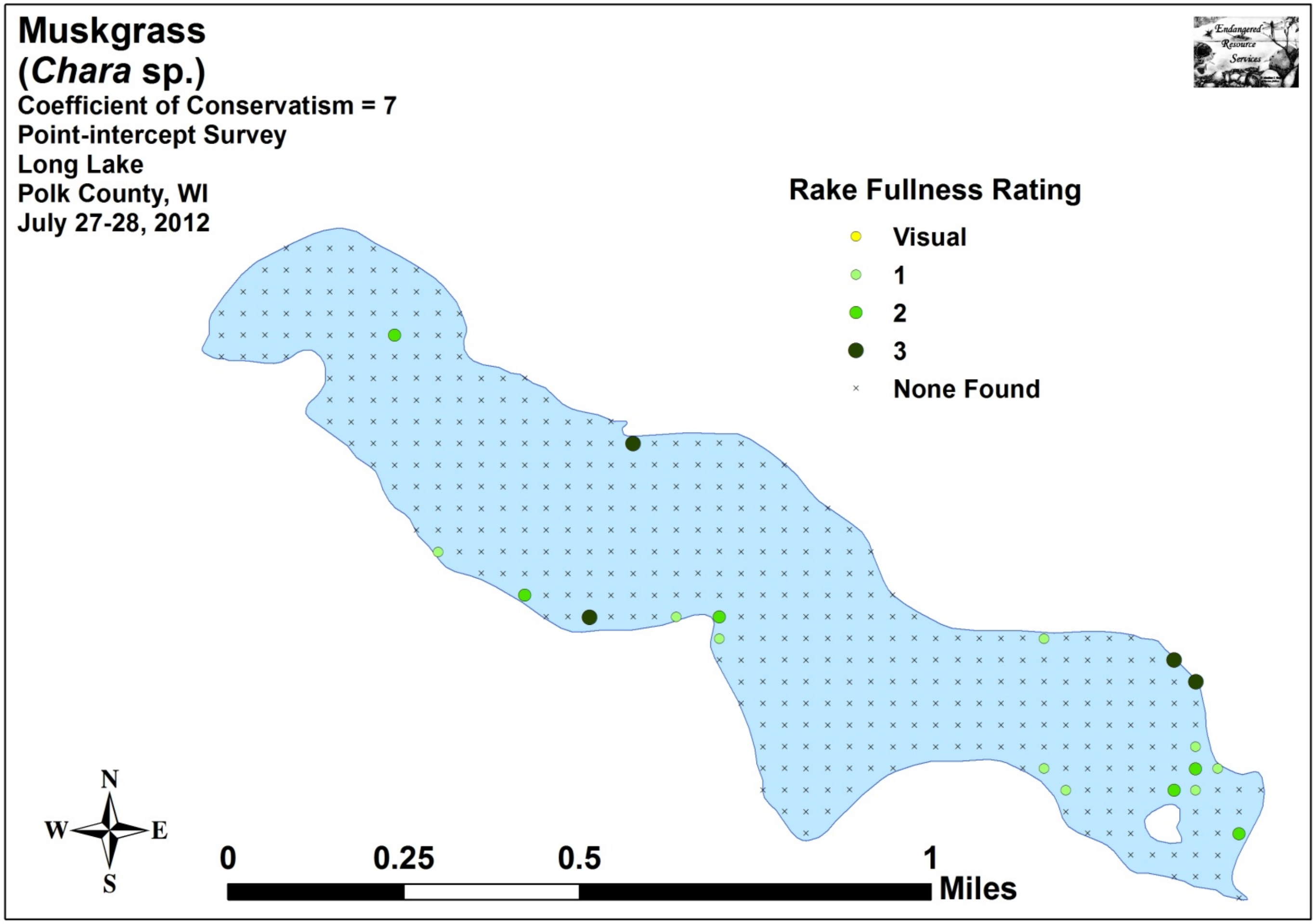

Total Rake Fullness
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

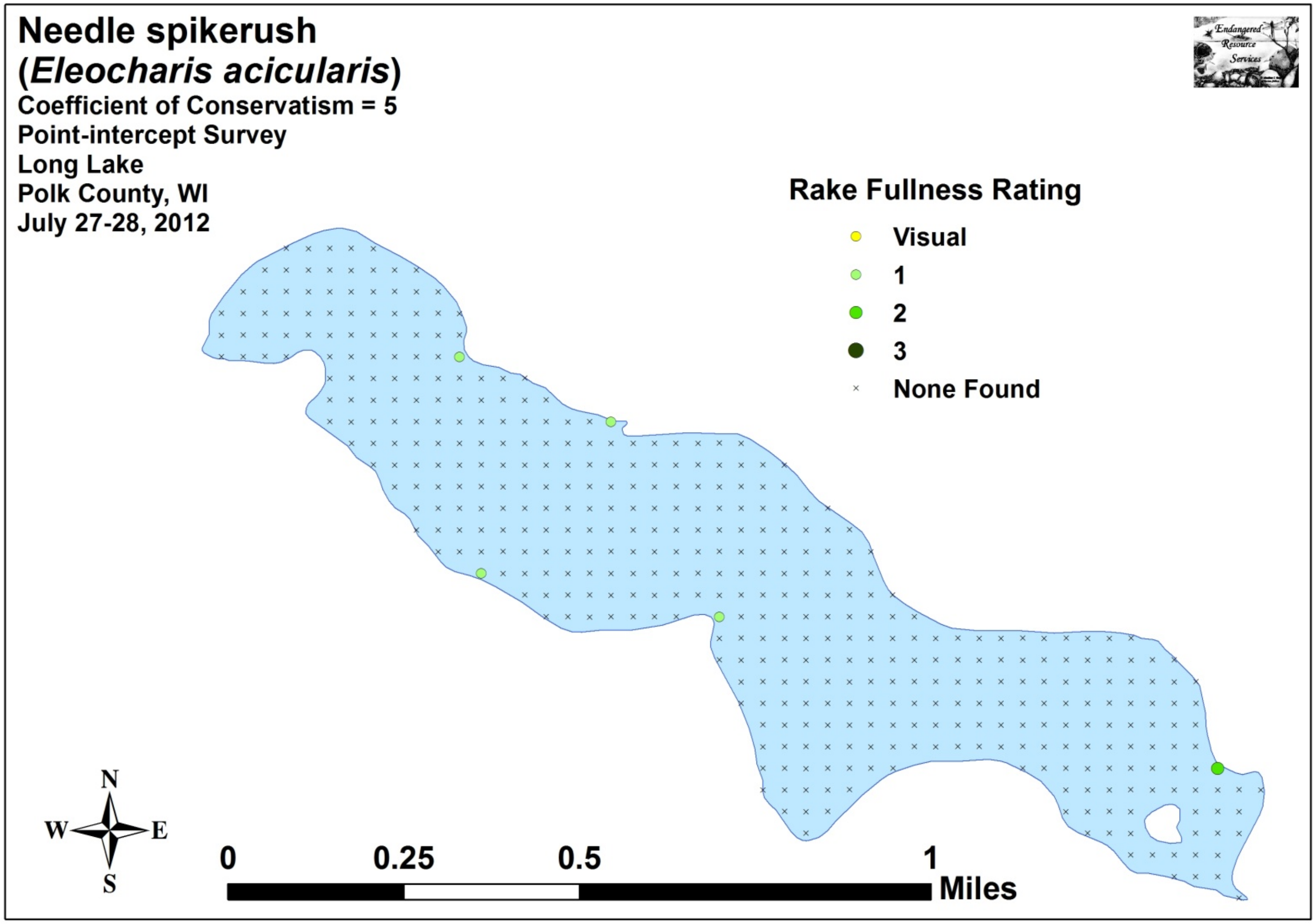

Total Rake Fullness
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

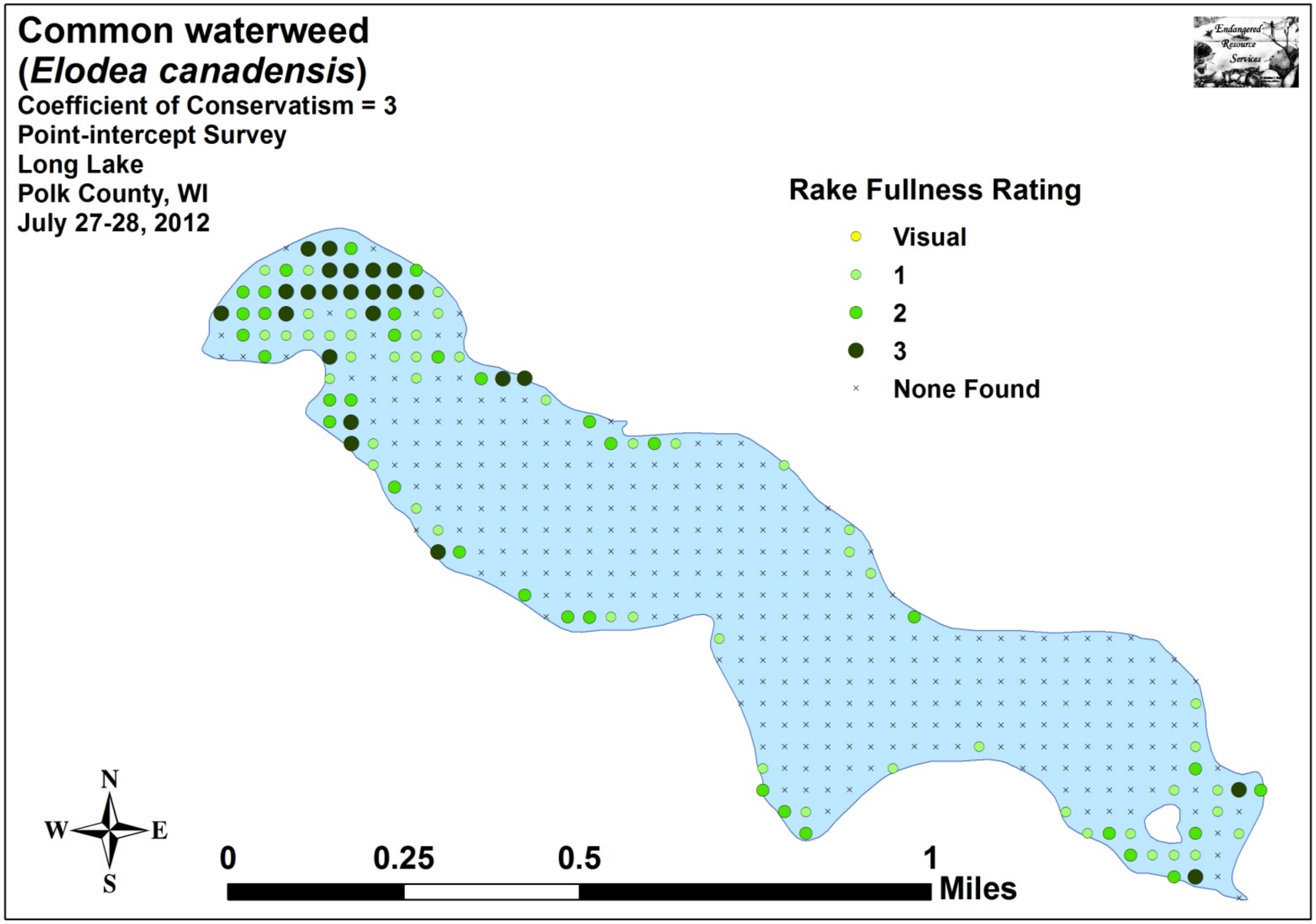
Appendix VI: July 2012 Species Density and Distribution Maps



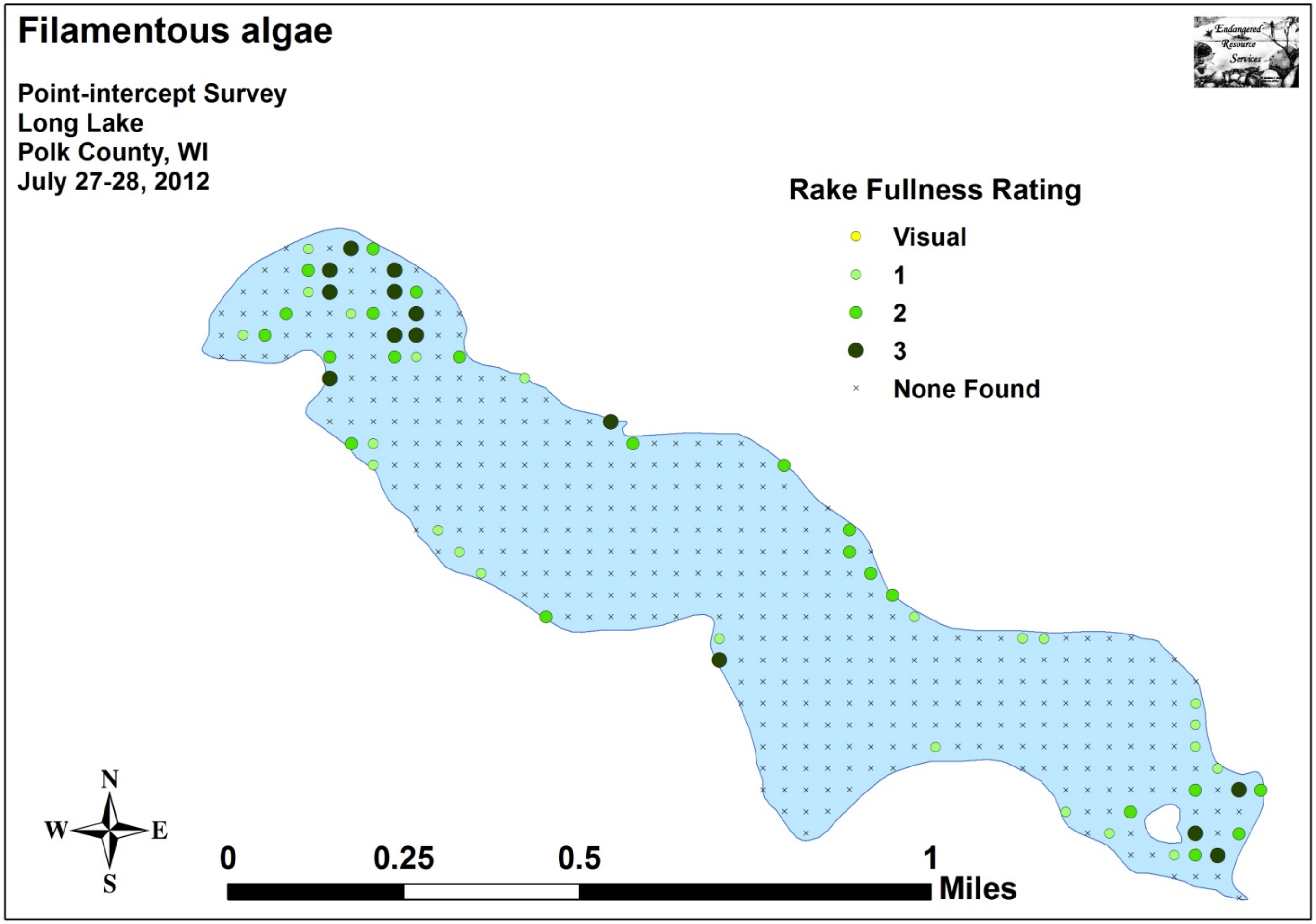
Coontail
(*Ceratophyllum demersum*)
Coefficient of Conservatism = 3
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

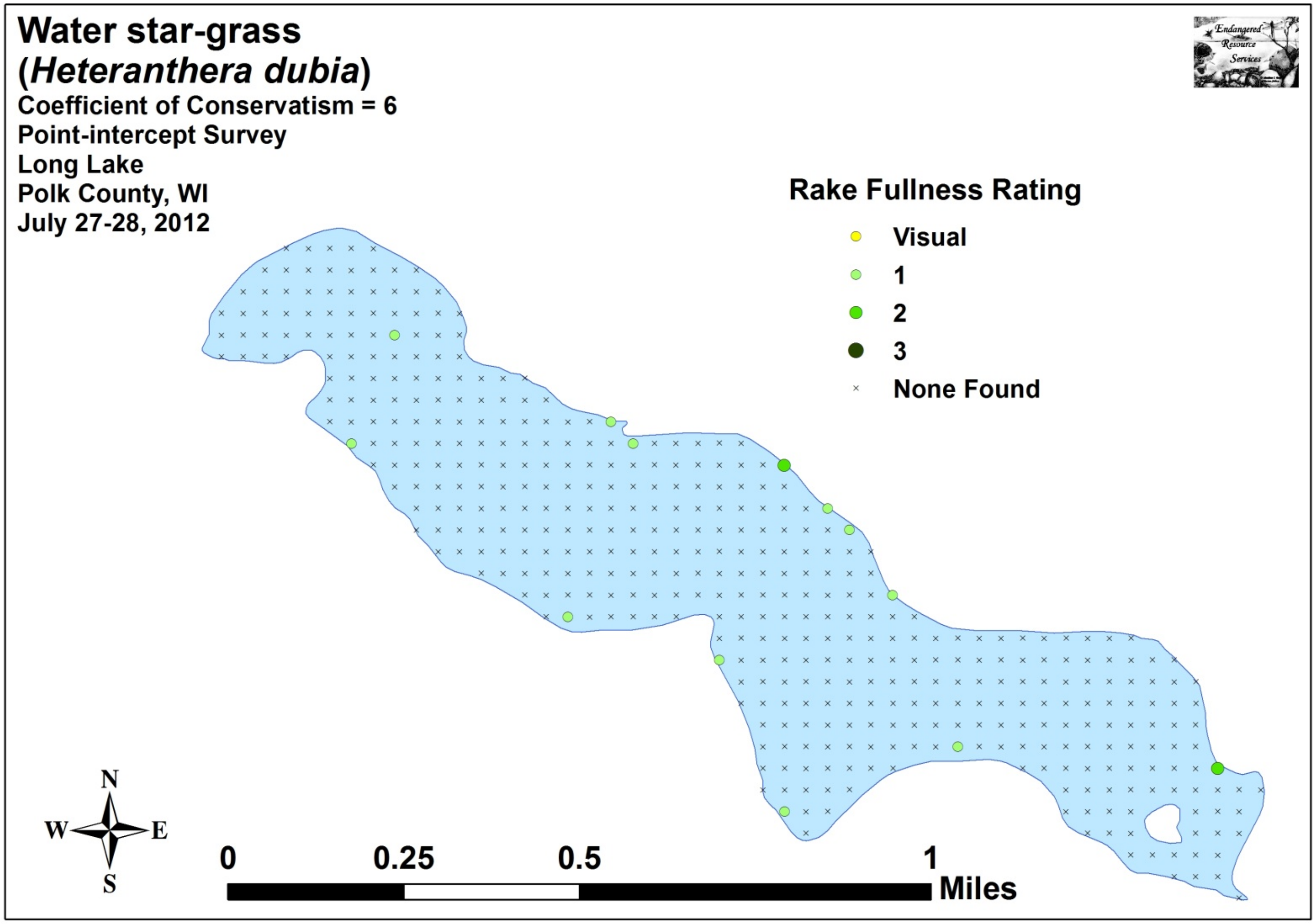

Needle spikerush
(*Eleocharis acicularis*)
Coefficient of Conservatism = 5
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

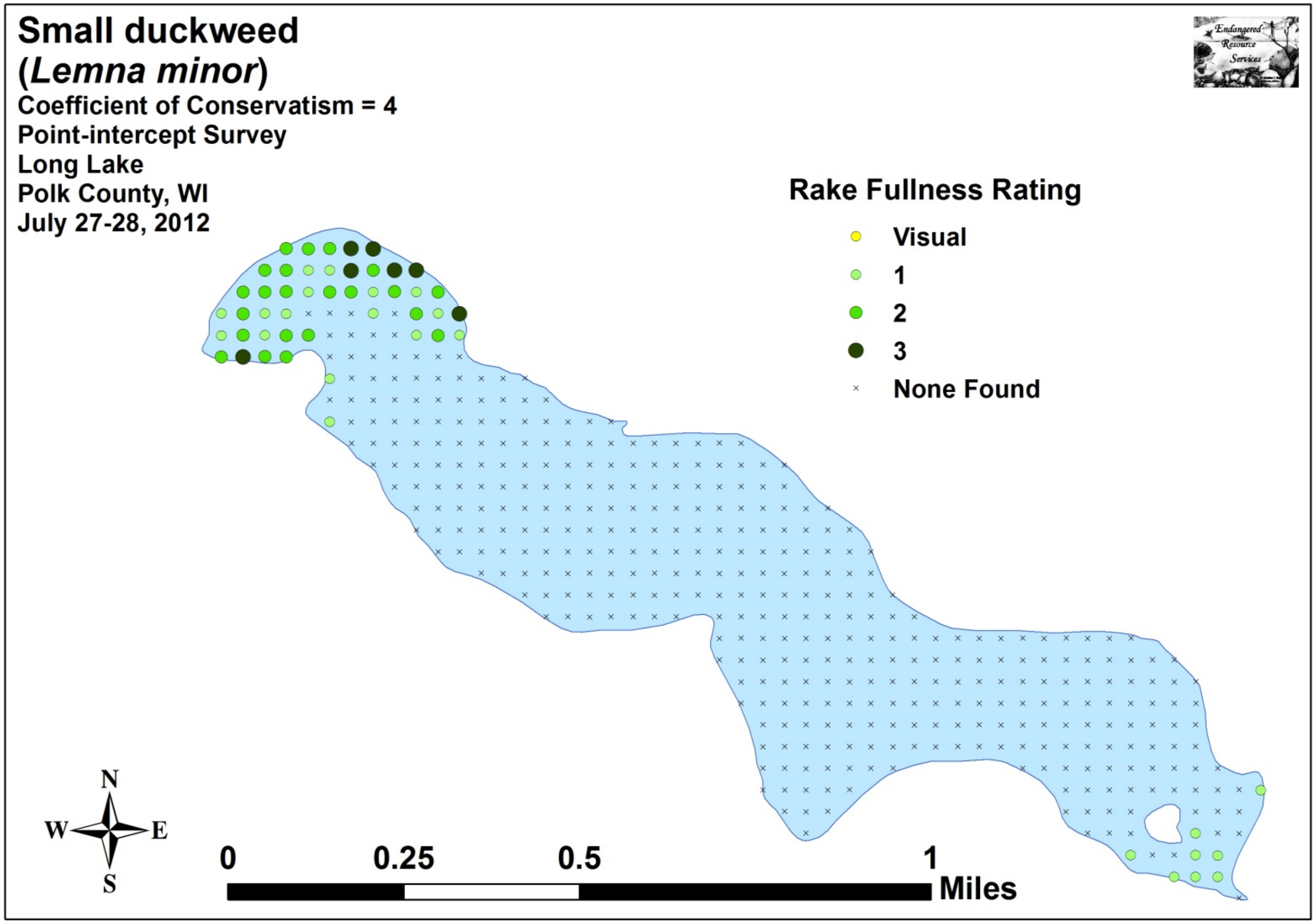


Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

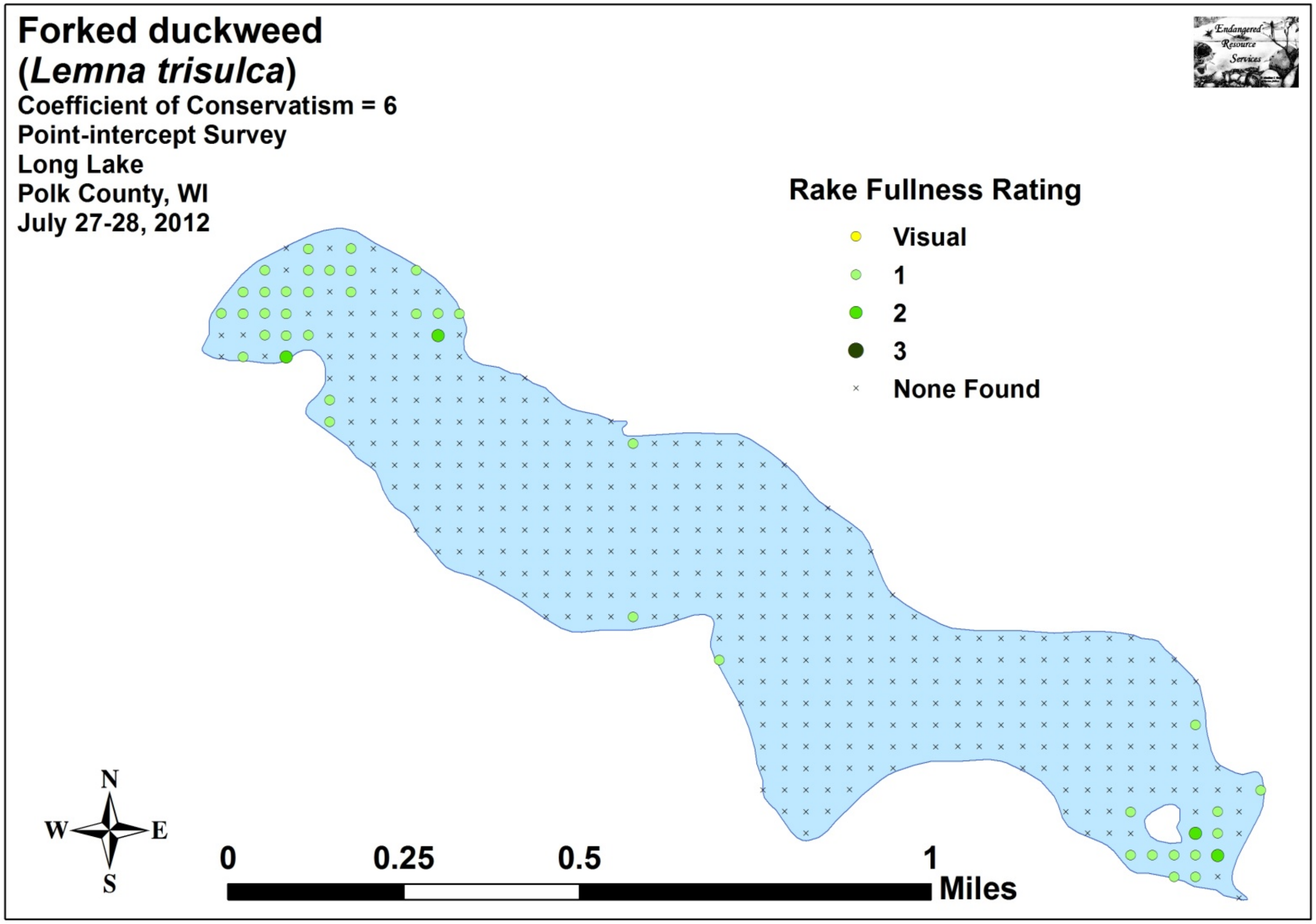


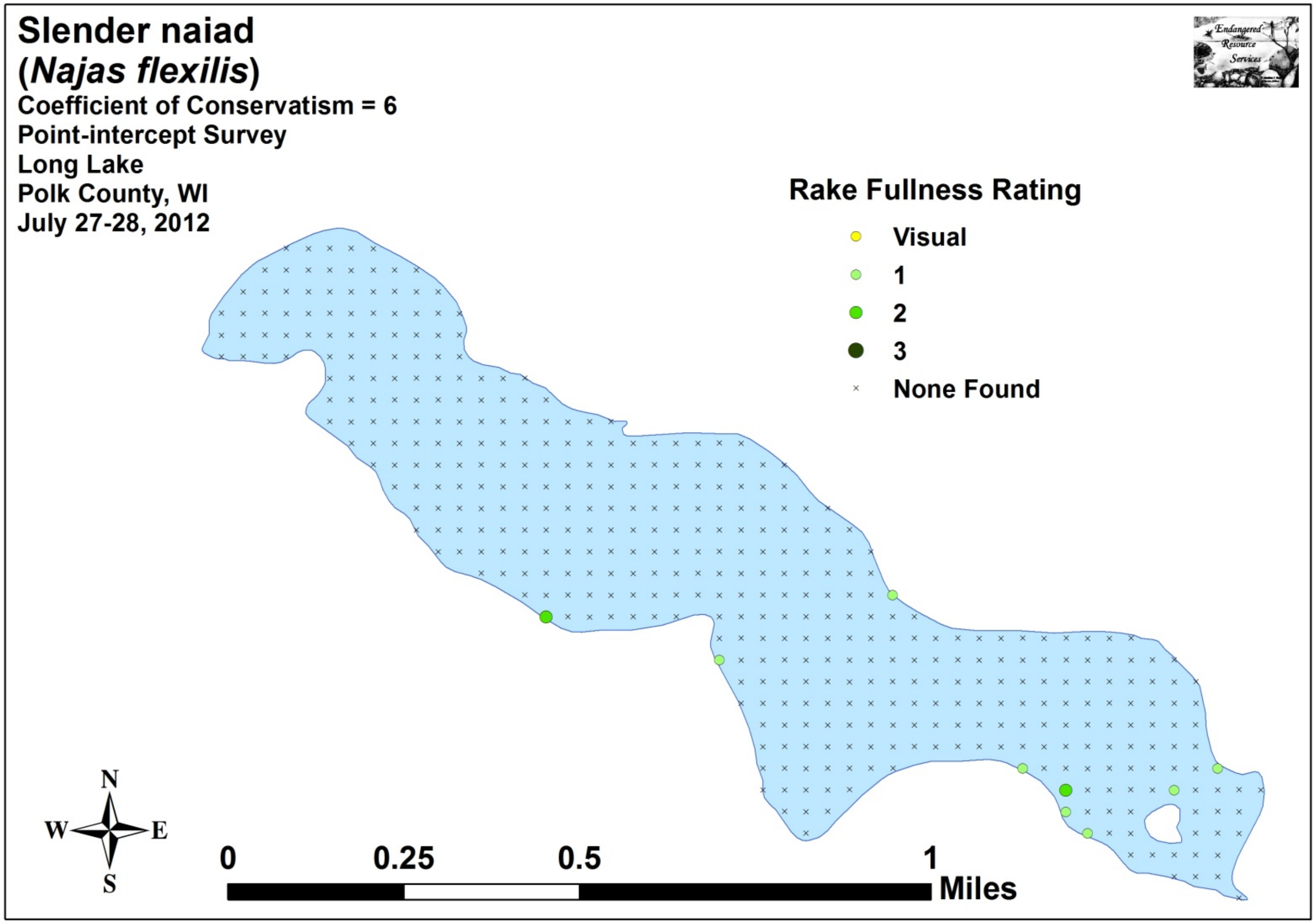
Filamentous algae
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

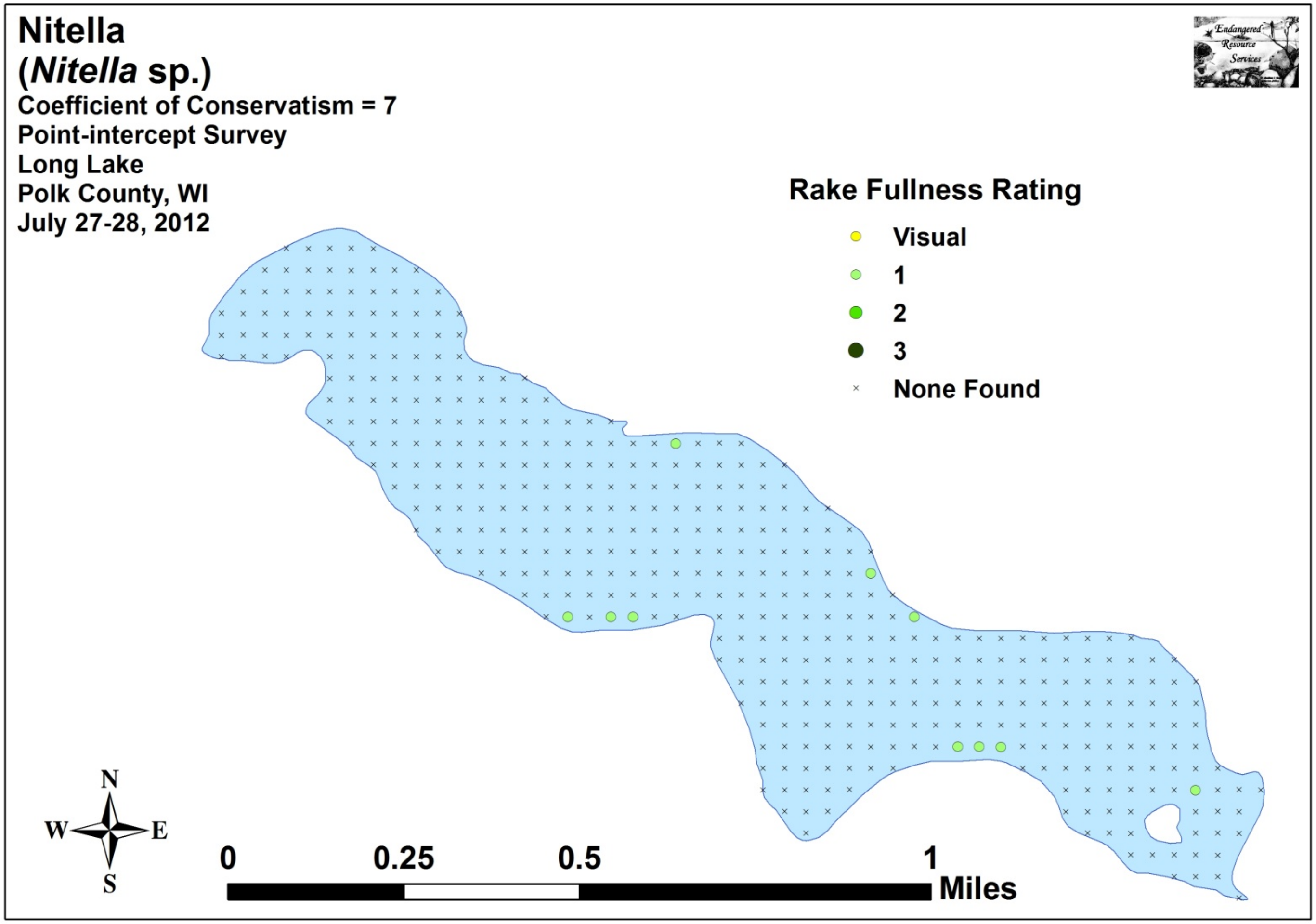


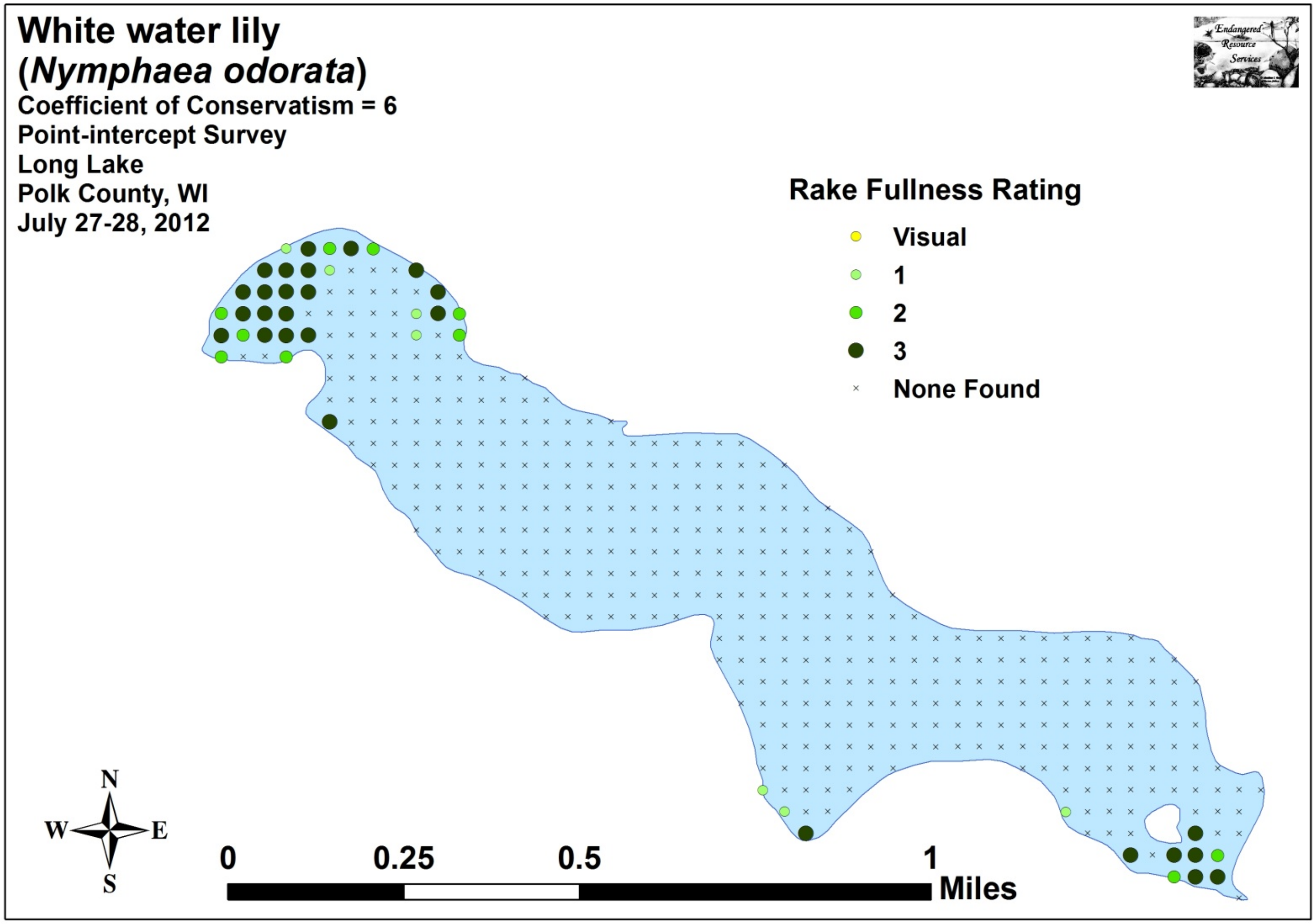
Small duckweed
(*Lemna minor*)
Coefficient of Conservatism = 4
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles
Endangered Resource Services

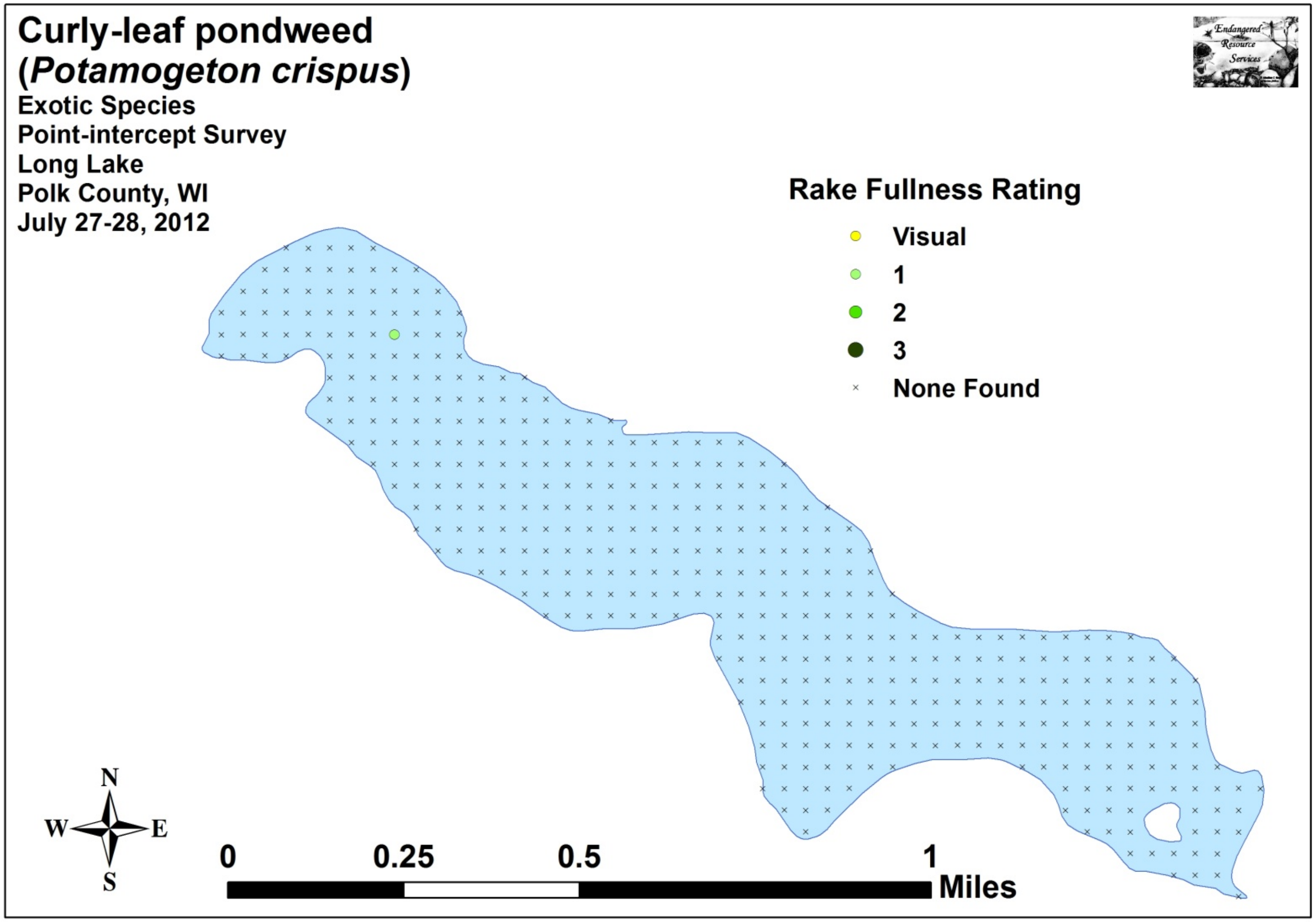

Forked duckweed
(*Lemna trisulca*)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

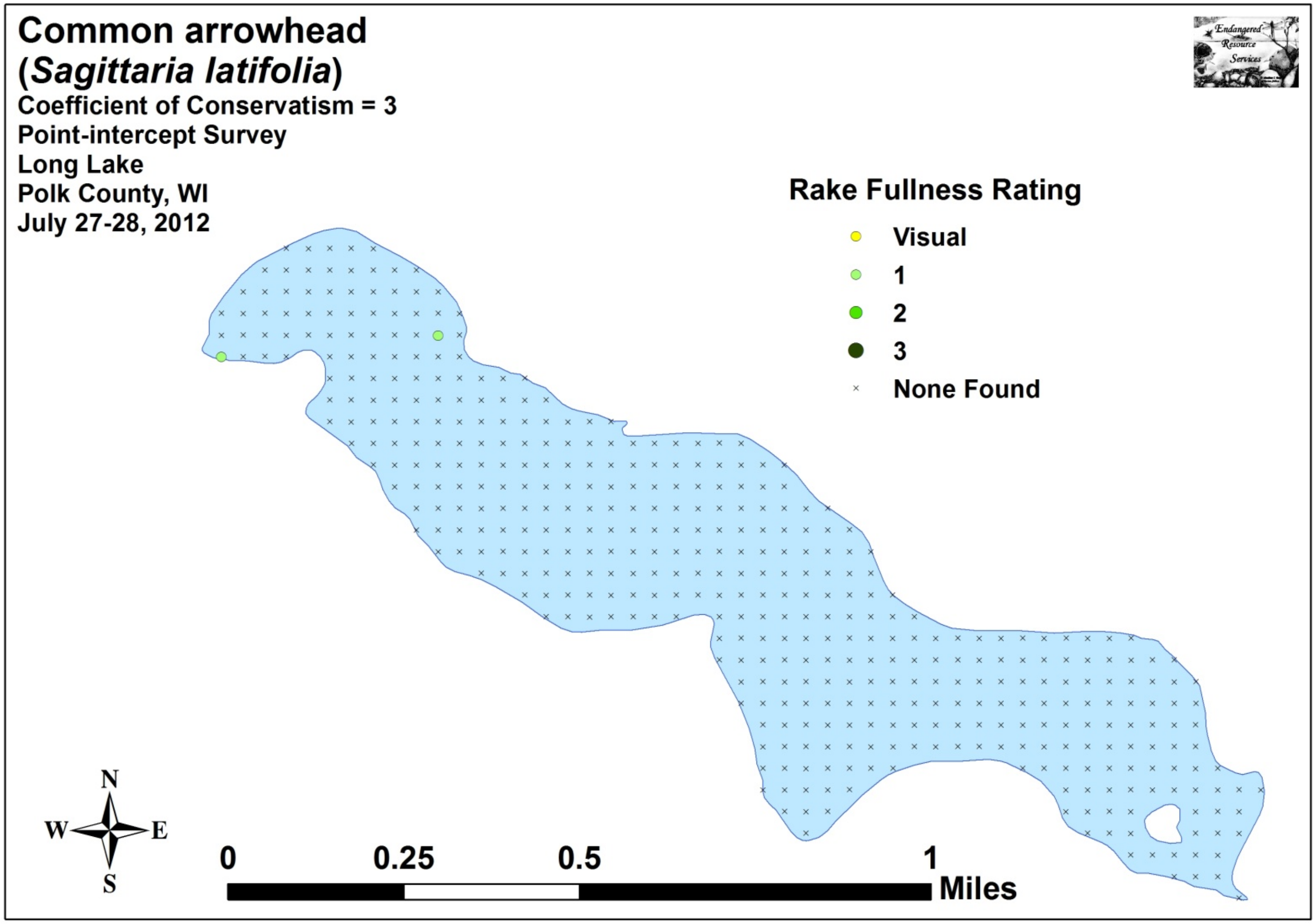


Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

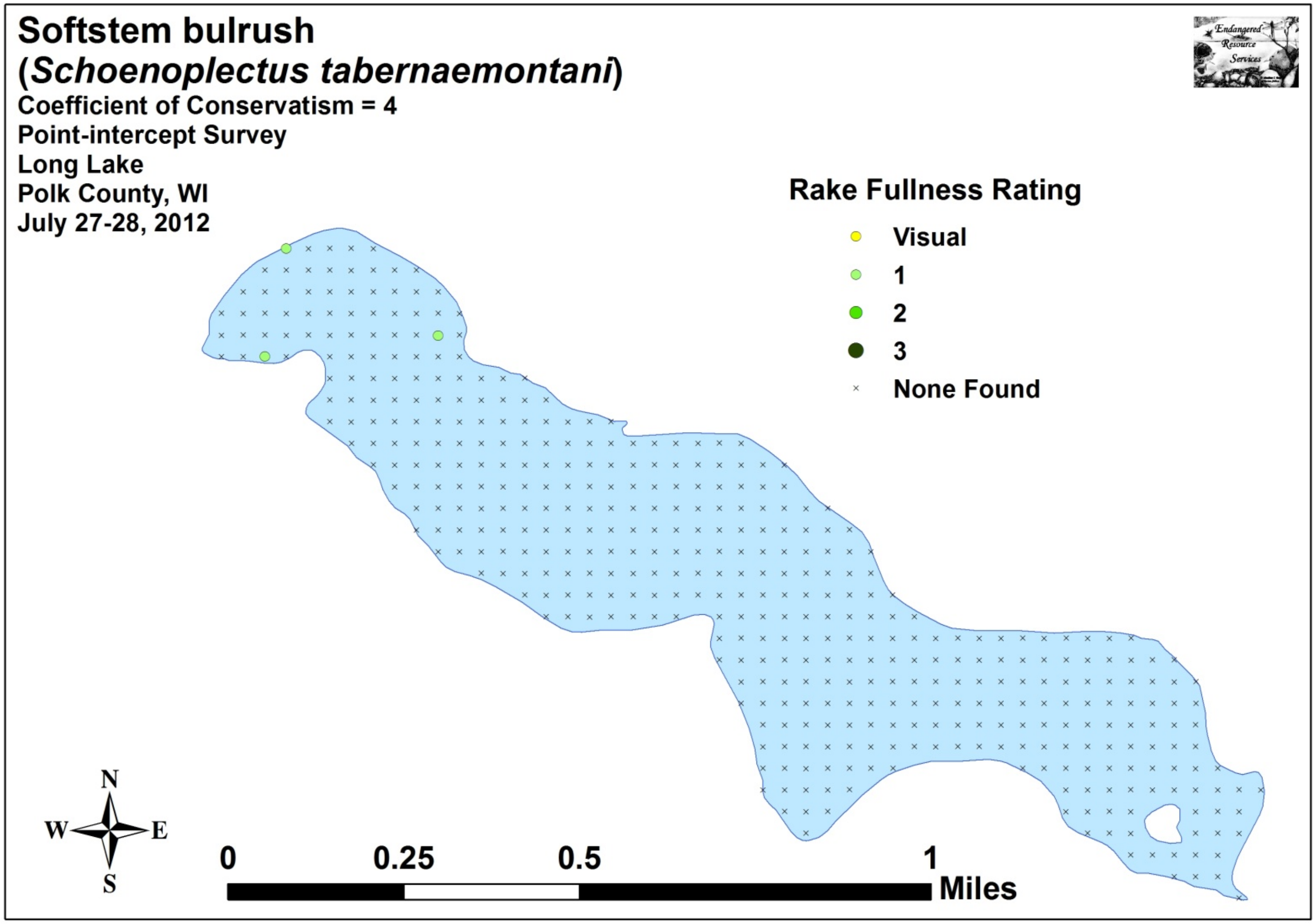

Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
Endangered Resource Services
N
W
E
S
0
0.25
0.5
1
Miles


White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

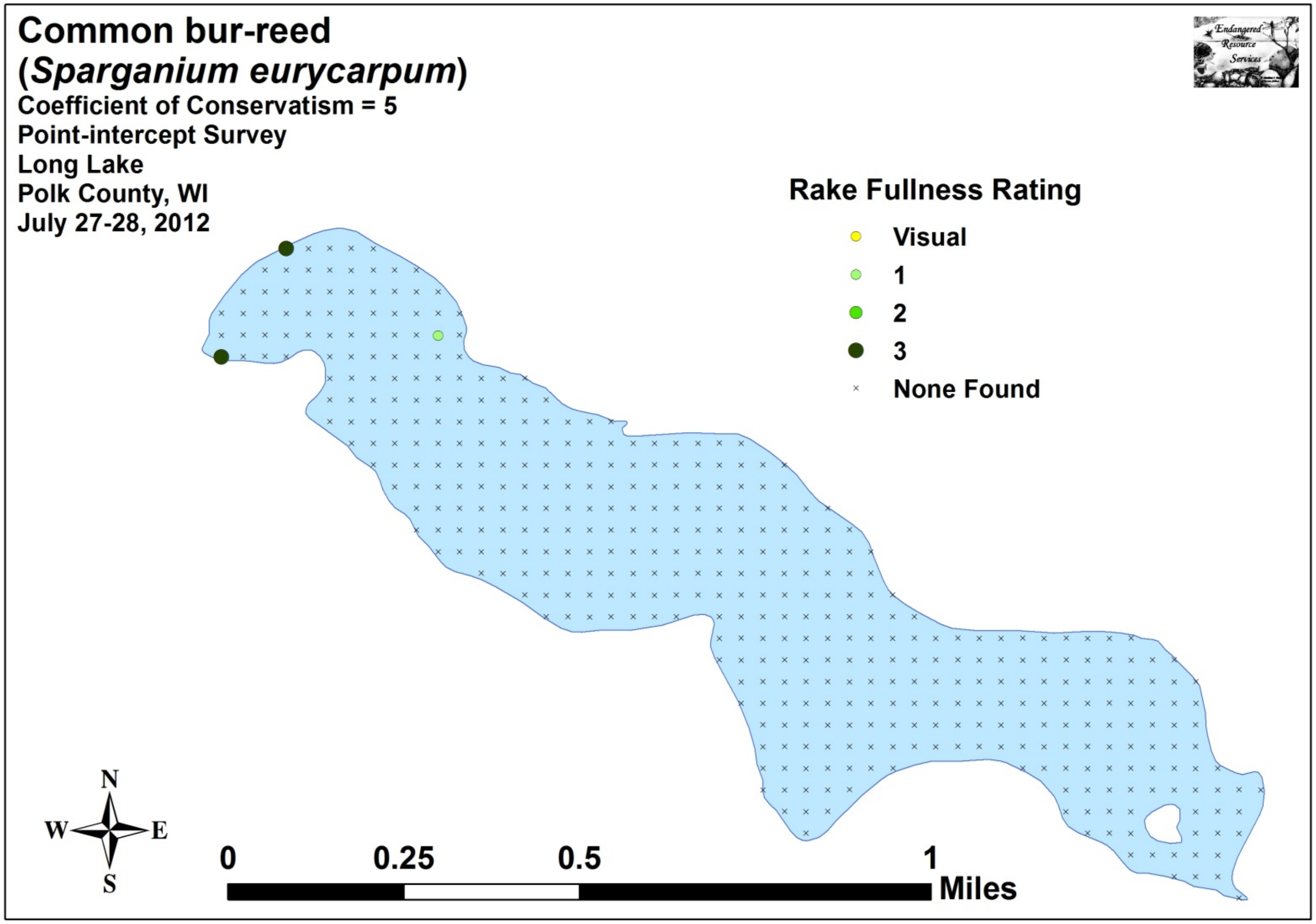

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

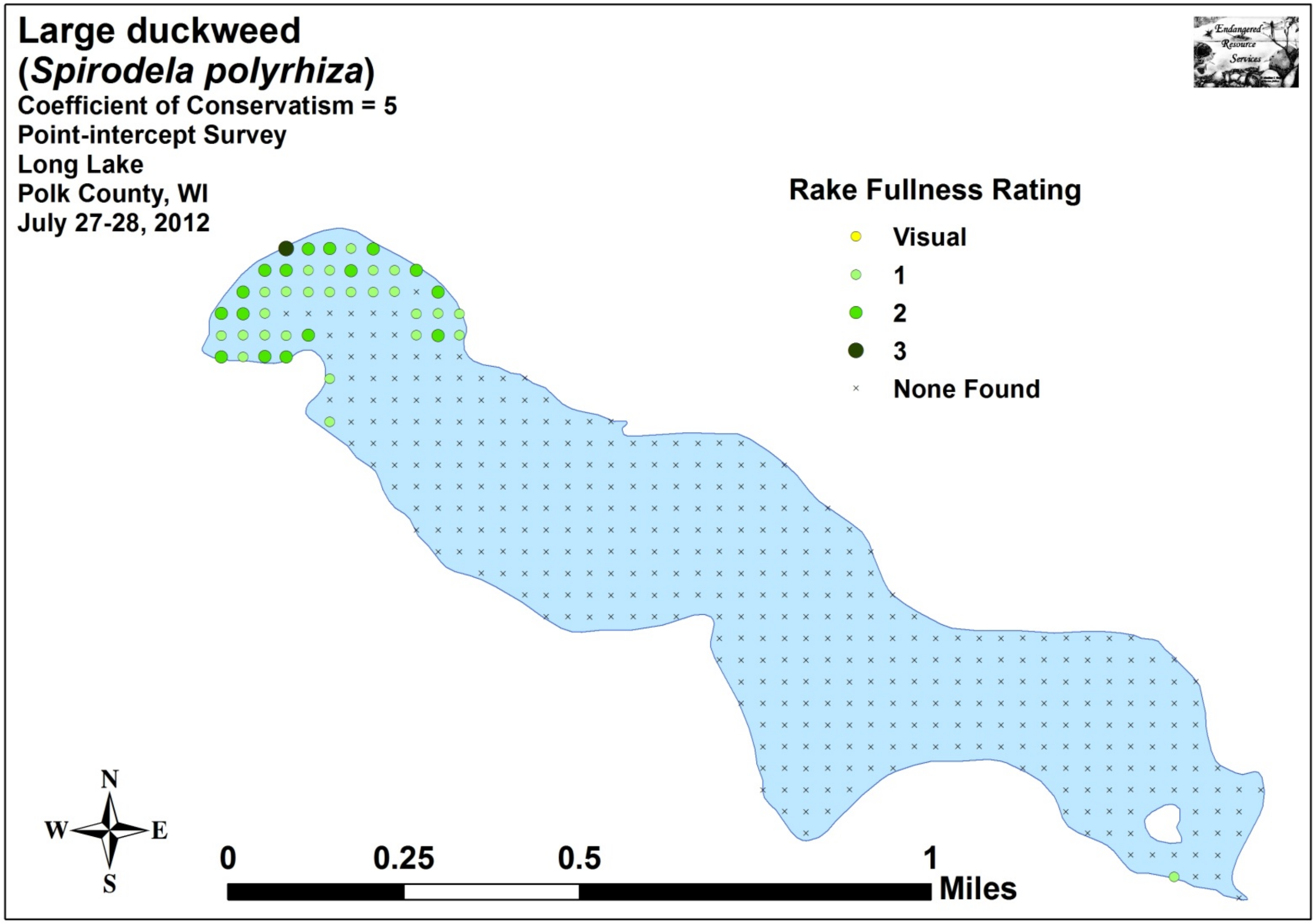


Common arrowhead
(*Sagittaria latifolia*)
Coefficient of Conservatism = 3
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

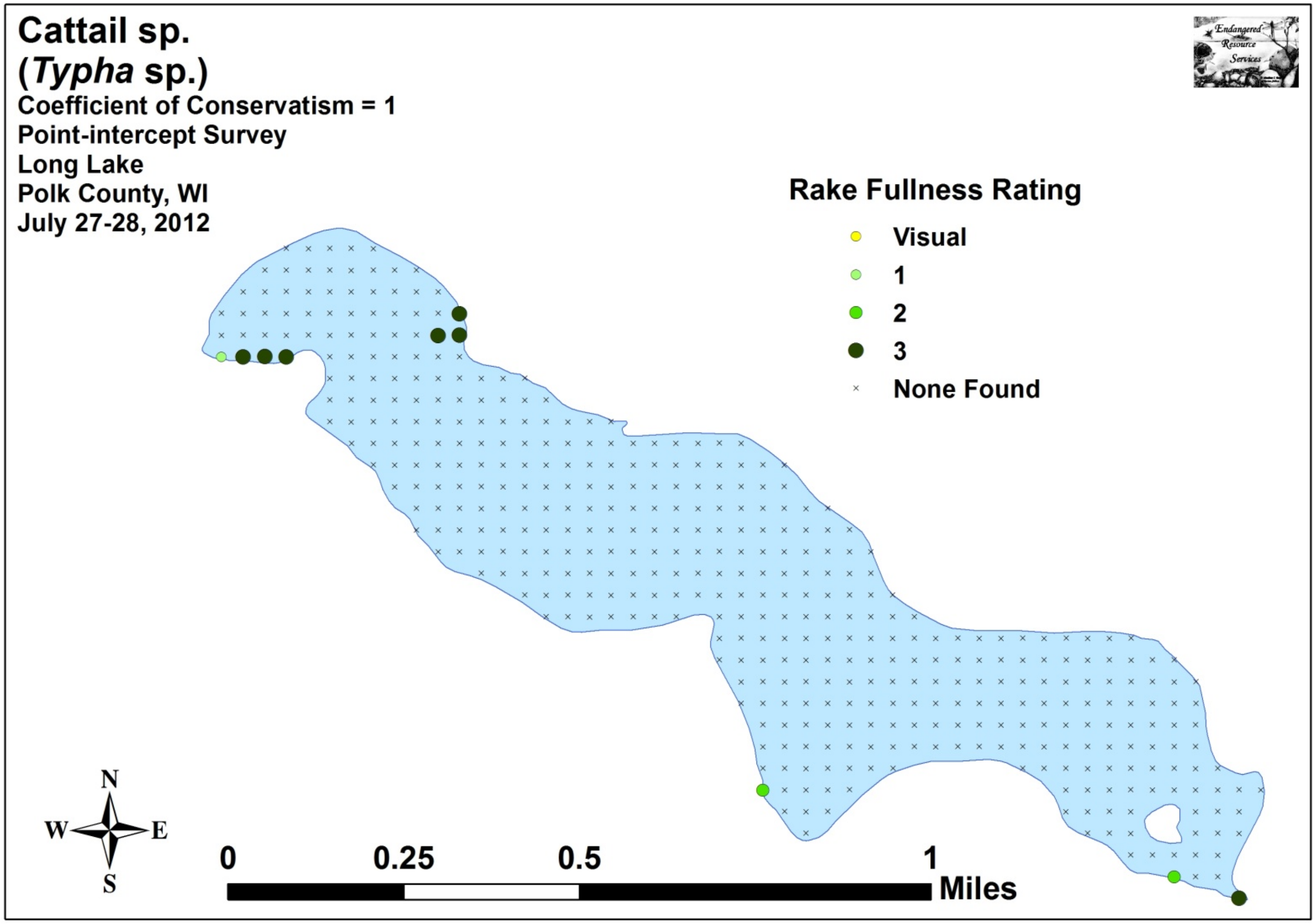


Softstem bulrush
(Schoenoplectus tabernaemontani)
Coefficient of Conservatism = 4
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

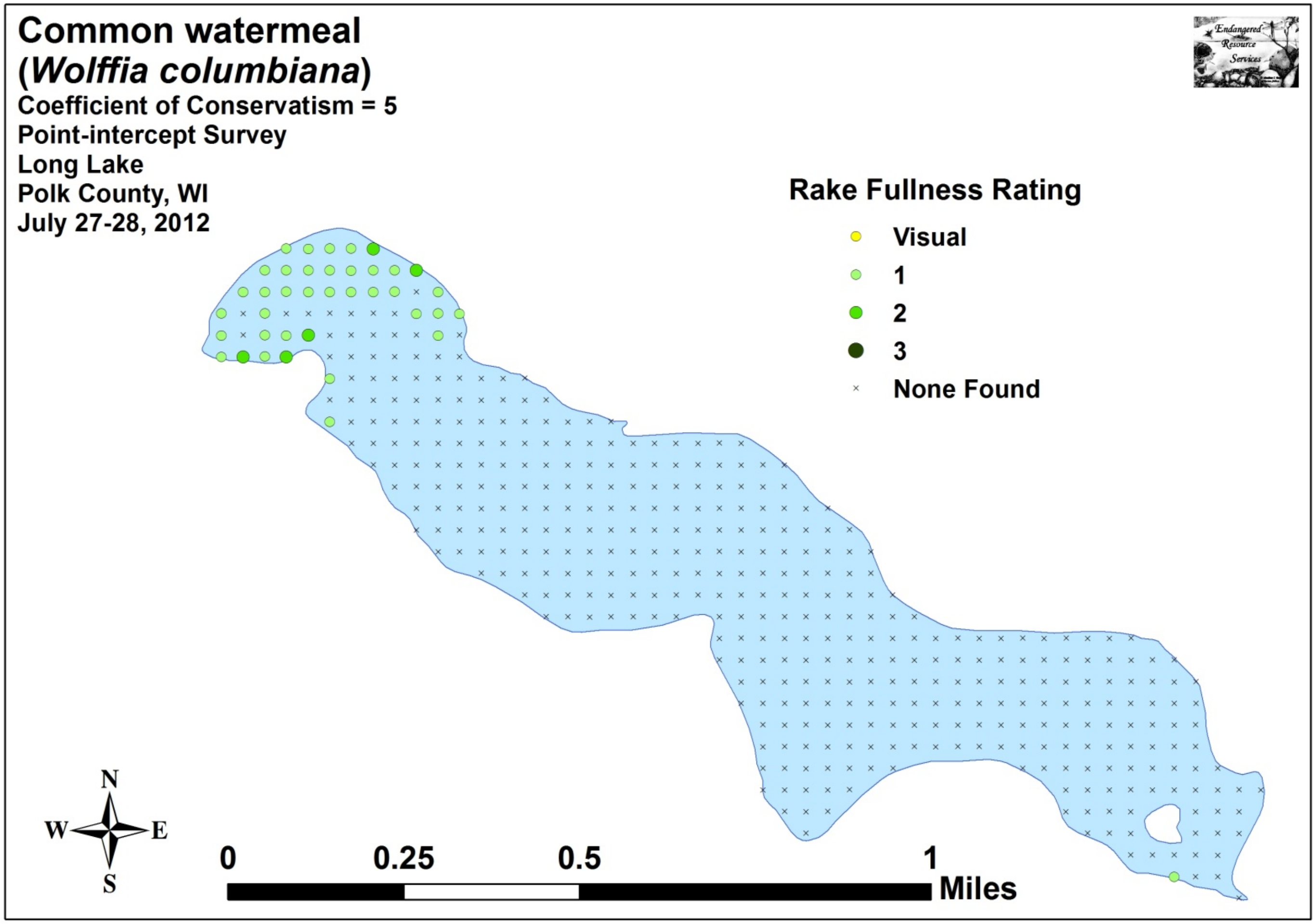

Common bur-reed
(Sparganium eurycarpum)
Coefficient of Conservatism = 5
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



Large duckweed
(Spirodela polyrhiza)
Coefficient of Conservatism = 5
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



Cattail sp.
(Typha sp.)
Coefficient of Conservatism = 1
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Common watermeal
(*Wolffia columbiana*)
Coefficient of Conservatism = 5
Point-intercept Survey
Long Lake
Polk County, WI
July 27-28, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

Appendix VII: Long Lake Plant Species Accounts

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: **Aquatic moss**
Specimen Location: Long Lake; N45.45332°, W92.51423°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-330
Habitat/Distribution: Rare; a few single plants were found scattered in water up to 4m deep around the lake's central basin.
Common Associates: (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/24/16
Species: (*Carex comosa*) **Bottle brush sedge**
Specimen Location: Long Lake; N45.46019°, W92.52659°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2016-003
Habitat/Distribution: Uncommon in scattered mucky shoreline locations in the west bay.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Ceratophyllum demersum*) **Coontail**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-331
Habitat/Distribution: Muck bottom in 0-4.5 meters. Abundant; especially in the east/west bays.
Common Associates: (*Potamogeton crispus*) Curly-leaf pondweed, (*Nymphaea odorata*) White water lily, (*Elodea canadensis*) Common waterweed

County/State: Polk County, Wisconsin **Date:** 7/24/10
Species: (*Chara* sp.) **Muskgrass**
Specimen Location: Long Lake; N45.45388°, W92.52142°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-332
Habitat/Distribution: A single dense patch was found over rock and sand in water <1 meter deep.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Heteranthera dubia*) Water star-grass

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Eleocharis acicularis*) **Needle spikerush**
Specimen Location: Long Lake; N45.45388°, W92.52142°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-333
Habitat/Distribution: More common than the survey indicates in sand/silt/rock bottom areas in water from 0 – 1 meter deep. **Common Associates:** (*Chara* sp.) Muskgrass, (*Heteranthera dubia*) Water star-grass, (*Najas flexilis*) Slender naiad

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Elodea canadensis*) **Common waterweed**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-334
Habitat/Distribution: Muck bottom in 0-4 meters of water.
Abundant throughout; especially in the east and west bays were it grew in to replace the CLP that was eliminated by the herbicide.
Common Associates: (*Potamogeton crispus*) Curly-leaf pondweed**,** (*Ceratophyllum demersum*) Coontail, (*Nymphaea odorata*) White water lily

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Heteranthera dubia*) **Water star-grass**
Specimen Location: Long Lake; N45.88480°, W89.69220°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-335
Habitat/Distribution: Firm muck, sand and rock bottoms in water <2 meter deep. Widespread and relatively common.
Common Associates: (*Elodea canadensis*) Common waterweed, (*Ceratophyllum demersum*) Coontail, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/24/16
Species: (*Juncus effusus*) **Common rush**
Specimen Location: Long Lake; N45.46019°, W92.52659°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2016-004
Habitat/Distribution: Uncommon in scattered mucky shoreline locations in the west bay.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Lemna minor*) **Small duckweed**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-336
Habitat/Distribution: Located floating at or just under the surface over muck bottom areas. Abundant throughout; especially interspersed between the lilypads.
Common Associates: (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Elodea canadensis*) Common waterweed, (*Spirodela polyrhiza*) Large duckweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Lemna trisulca*) **Forked duckweed**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-337
Habitat/Distribution: Located entangled in other plants and along the bottom. Common throughout the lake's littoral zone.
Common Associates: (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Elodea canadensis*) Common waterweed, (*Spirodela polyrhiza*) Large duckweed, (*Lemna minor*) Small duckweed

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Myriophyllum sibiricum*) **Northern Water-milfoil**
Specimen Location: Long Lake; N45.44961°, W92.50012°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-338
Habitat/Distribution: Muck to sand bottom in water up to 2 meters. Widespread but not common.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Elodea canadensis*) Common waterweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Najas flexilis*) **Slender naiad**
Specimen Location: Long Lake; N45.45884°, W92.52716°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-339
Habitat/Distribution: Found in almost any bottom conditions, but grows best in rock/ sand bottoms in <1 meter of water. Widely distributed, but uncommon.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Heteranthera dubia*) Water star-grass

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Nitella* sp.) **Nitella**
Specimen Location: Long Lake; N45.45730°, W92.51933°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-340
Habitat/Distribution: Rare, found in a few scattered locations around the north side of the central basin.
Common Associates: (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Nymphaea odorata*) **White water lily**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-341
Habitat/Distribution: Muck bottom in 0-2 meters where it forms dense canopies. Abundant in the east and west bays.
Common Associates: (*Elodea canadensis*) Common waterweed, (*Ceratophyllum demersum*) Coontail

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Phalaris arundinacea*) **Reed canary grass**
Specimen Location: Long Lake; N45.45448°, W92.52253°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-342
Habitat/Distribution: Relatively common along shore in undeveloped low areas throughout.
Common Associates: (*Schoenoplectus tabernaemontani*) Softstem bulrush**,** (*Typha latifolia*) Broad-leaved cattail

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Potamogeton crispus*) **Curly-leaf pondweed**
Specimen Location: Long Lake; N45.45884°, W92.52716°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-343
Habitat/Distribution: Found in most mucky bottom areas in water from 1-4m deep. Abundant in the spring survey, but almost completely eliminated by the herbicide application.
Common Associates: (*Elodea canadensis*) Common waterweed, (*Ceratophyllum demersum*) Coontail

County/State: Polk County, Wisconsin **Date:** 7/24/16
Species: (*Potamogeton foliosus*) **Leafy pondweed**
Specimen Location: Long Lake; N45.45448°, W92.52253°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2016-005
Habitat/Distribution: Sandy muck bottom in shallow water <1m deep. Rare; a few scattered plants were found growing at the shoreline near the landing and on the north shore midlake.
Common Associates: (*Heteranthera dubia*) Water star-grass, (*Najas flexilis*) Slender naiad, (*Vallisneria americana*) Wild celery

County/State: Polk County, Wisconsin **Date:** 7/23/16
Species: (*Potamogeton pusillus berchtoldii*) **Small pondweed**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2016-006
Habitat/Distribution: A few individuals were found in the east bay over muck in <1m.
Common Associates: (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Elodea canadensis*) Common waterweed, (*Spirodela polyrhiza*) Large duckweed, (*Lemna minor*) Small duckweed

County/State: Polk County, Wisconsin **Date:** 7/24/16
Species: (*Riccia fluitans*) **Slender riccia**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2016-007
Habitat/Distribution: Located floating at or just under the surface over muck bottom areas. Scattered clusters occurred interspersed between the lilypads in the western bay.
Common Associates: (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Elodea canadensis*) Common waterweed, (*Spirodela polyrhiza*) Large duckweed, (*Lemna minor*) Small duckweed

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Sagittaria latifolia*) **Common arrowhead**
Specimen Location: Long Lake; N45.46024°, W92.52405°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-344
Habitat/Distribution: Uncommon in scattered mucky shoreline locations in the west bay.
Common Associates: (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Phalaris arundinacea*) Reed canary grass

County/State: Polk County, Wisconsin **Date:** 7/23/16
Species: (*Sagittaria graminea*) **Grass-leaved arrowhead**
Specimen Location: Long Lake; N45.45009°, W92.49887°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2016-008
Habitat/Distribution: A few scattered plants along the north shore over sand/gravel in <0.5m.
Common Associates: (*Eleocharis acicularis*) Needle spikerush

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Sagittaria rigida*) **Sessile-fruited arrowhead**
Specimen Location: Long Lake; N45.45983°, W92.52277°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-345
Habitat/Distribution: Emergent plants were found in only two places along the shore in water <0.5m.
Common Associates: (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Schoenoplectus tabernaemontani*) **Softstem bulrush**
Specimen Location: Long Lake; N45.45796°, W92.52649°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-346
Habitat/Distribution: Firm muck bottoms in 0-0.5 meter of water. Scattered individuals found in undeveloped low areas – especially common in the west bay.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Sparganium eurycarpum*) **Common bur-reed**
Specimen Location: Long Lake; N45.44783°, W92.50004°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-347
Habitat/Distribution: Uncommon in scattered mucky shoreline locations.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass

County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Spirodela polyrhiza*) **Large duckweed**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-348
Habitat/Distribution: Located floating at or just under the surface over muck bottom areas. Abundant throughout; especially interspersed between the lilypads.
Common Associates: (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Elodea canadensis*) Common waterweed, (*Lemna minor*) Small duckweed, (*Lemna trisulca*) Forked duckweed

County/State: Polk County, Wisconsin **Date:** 7/24/16
Species: (*Typha* X *glauca*) **Hybrid cattail**
Specimen Location: Long Lake; N45.45796°, W92.52649°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2016-09
Habitat/Distribution: Firm muck bottoms in 0-0.5 meter of water. Spreading rapidly, these hybrids now dominate the majority of cattail beds on the lake; especially on the rocky point at the north entrance to the northwest bay.
Common Associates: (*Phalaris arundinacea*) Reed canary grass (*Schoenoplectus tabernaemontani*) Softstem bulrush

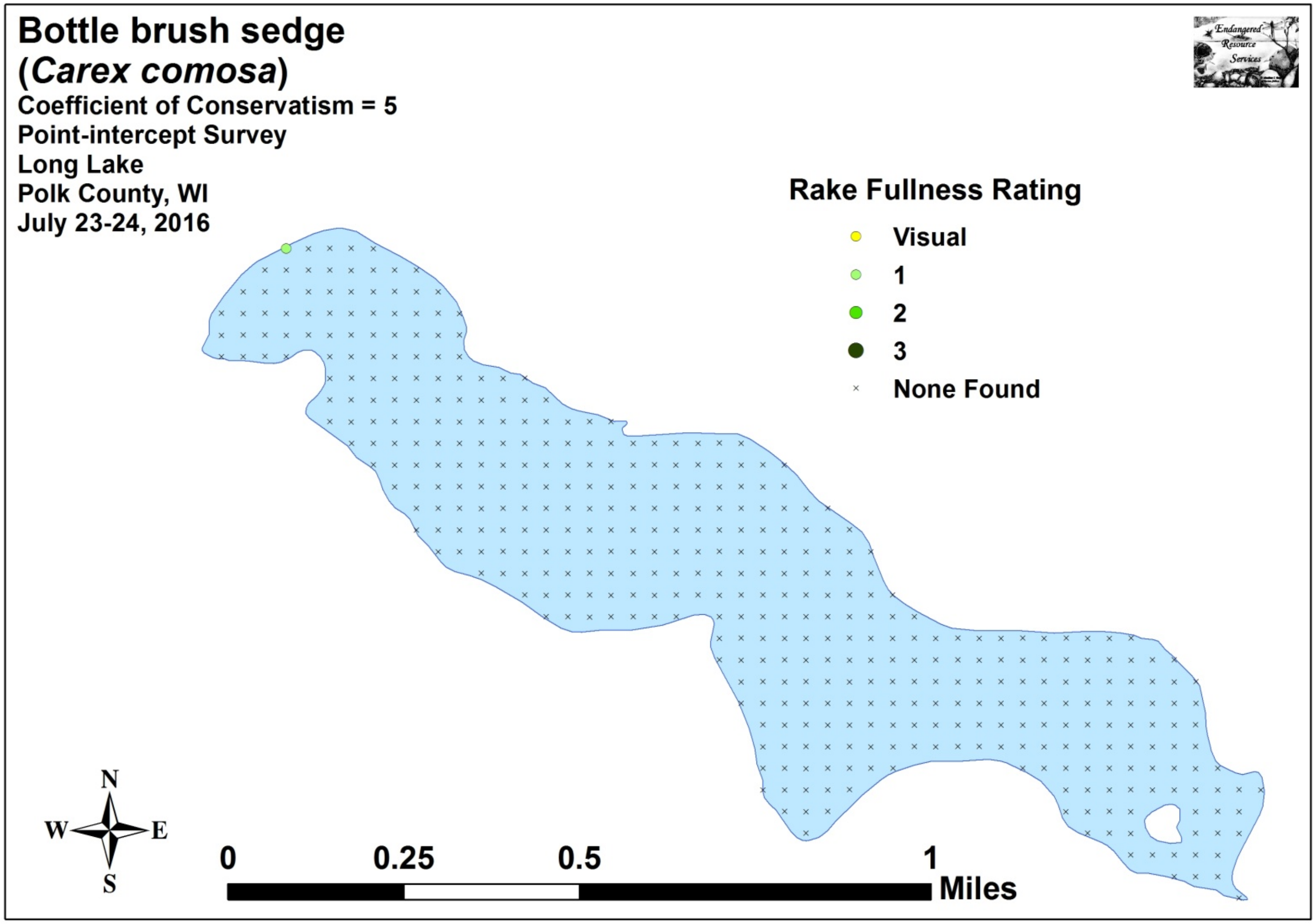
County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Typha latifolia*) **Broad-leaved cattail**
Specimen Location: Long Lake; N45.45796°, W92.52649°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-349
Habitat/Distribution: Firm muck bottoms in 0-0.5 meter of water. Scattered individuals found in undeveloped low areas – especially common in the east bay around the island.
Common Associates: (*Phalaris arundinacea*) Reed canary grass (*Schoenoplectus tabernaemontani*) Softstem bulrush

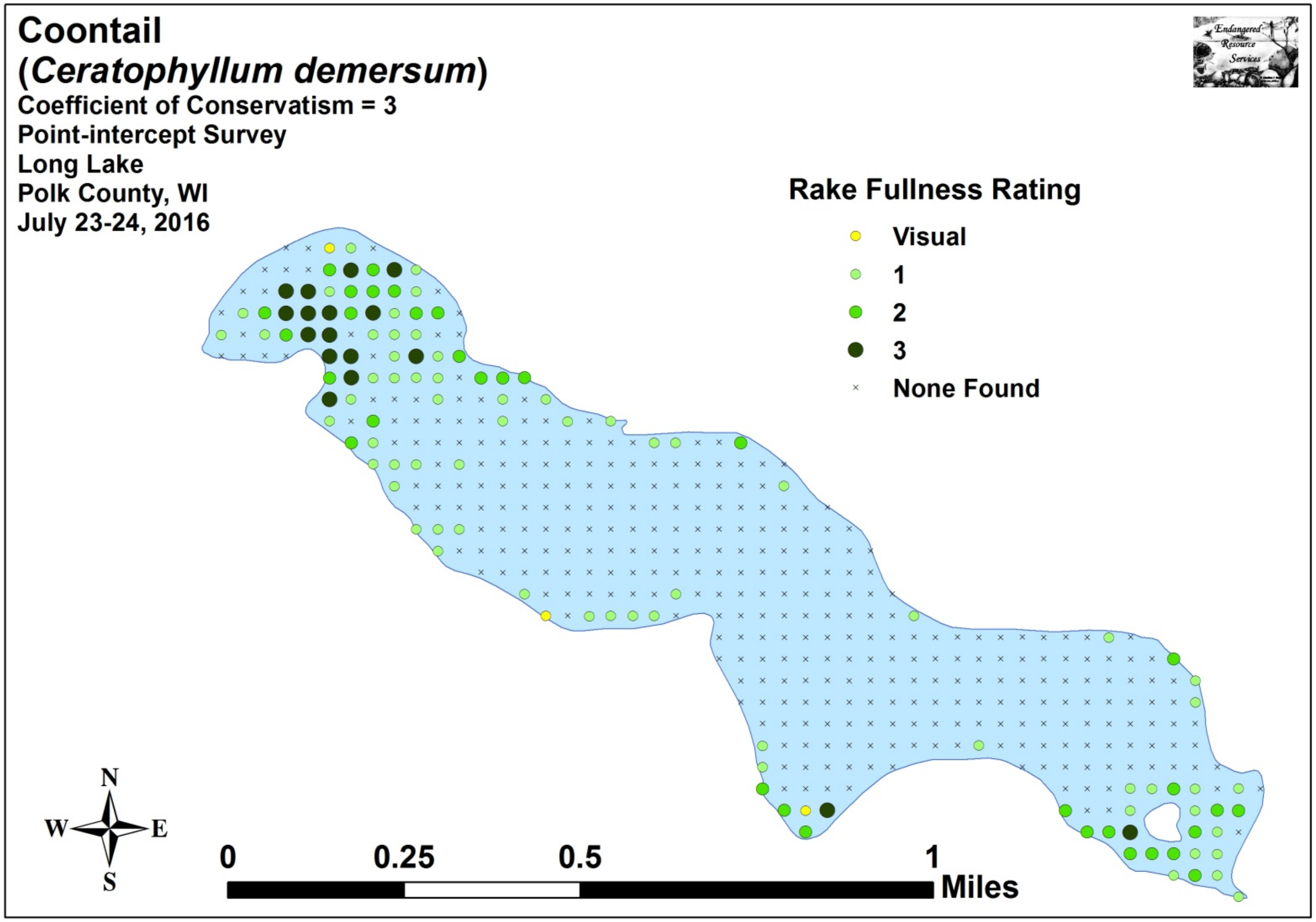
County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Utricularia minor*) **Small bladderwort**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2010-350
Habitat/Distribution: Muck bottom in shallow water 0-0.5 meters deep. Rare; restricted to south corner of the west bay where a handful of individuals were found floating among lilypads/Coontail.
Common Associates: (*Utricularia vulgaris*) Common bladderwort, (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail

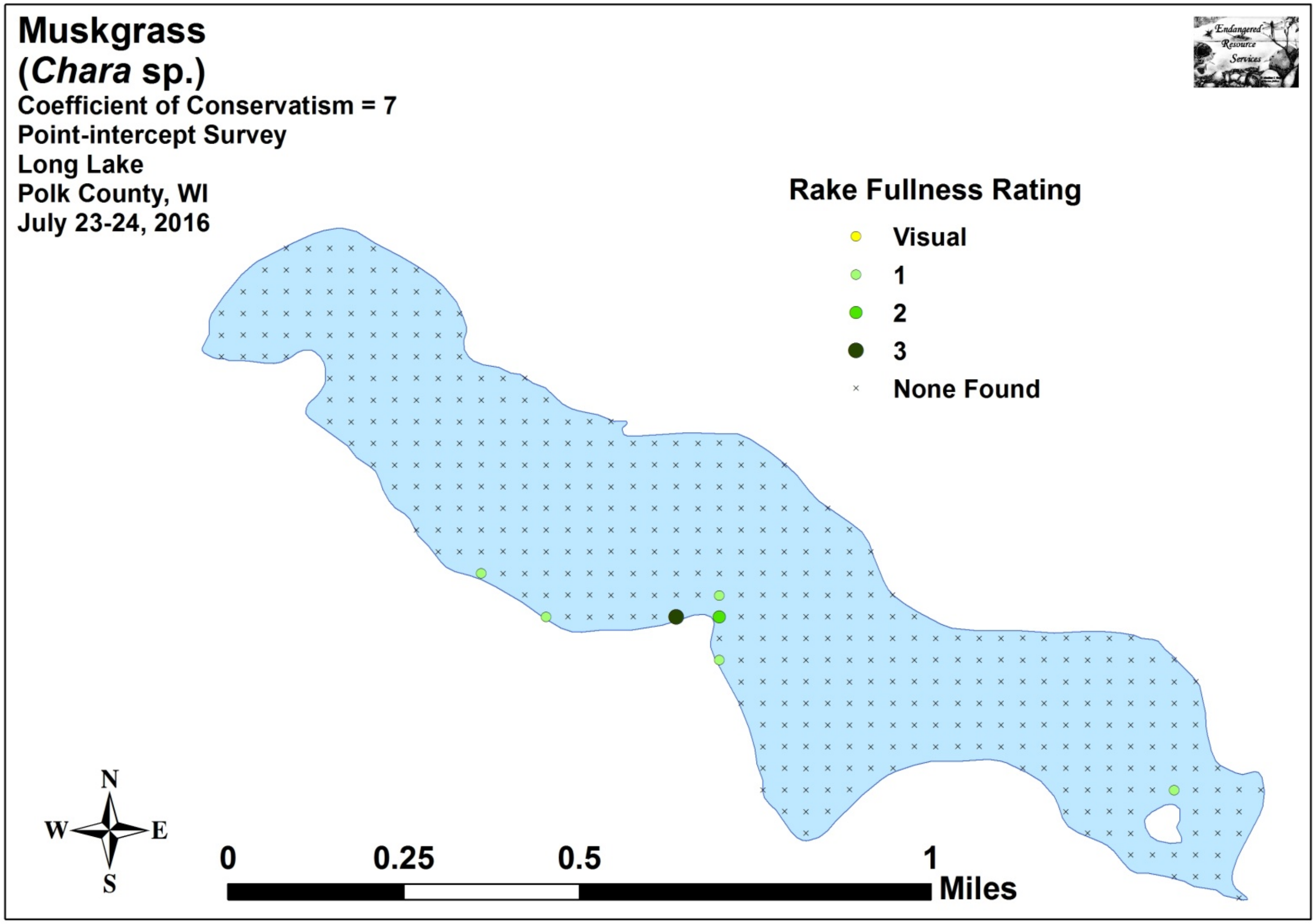
County/State: Polk County, Wisconsin **Date:** 7/25/10
Species: (*Utricularia vulgaris*) **Common bladderwort**
Specimen Location: Long Lake; N45.45839°, W92.52714°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2010-351
Habitat/Distribution: Muck bottom in shallow water 0-0.5 meters deep. Rare; restricted to south corner of the west bay where a handful of individuals were found floating among lilypads/Coontail.
Common Associates: (*Utricularia minor*) Small bladderwort, (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail

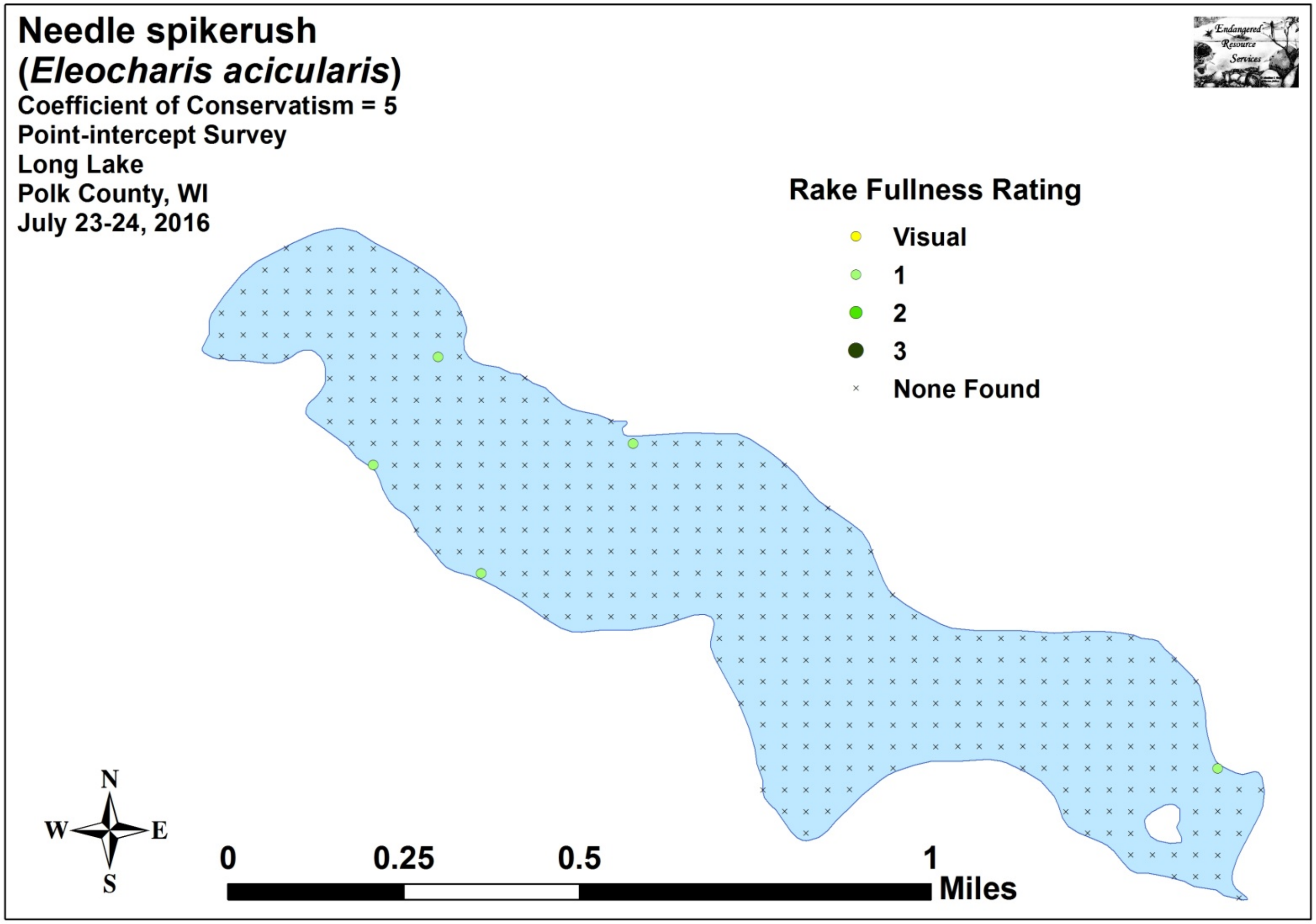
County/State: Polk County, Wisconsin **Date:** 7/24/16
Species: (*Vallisneria americana*) **Wild celery**
Specimen Location: Long Lake; N45.45448°, W92.52253°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2016-010
Habitat/Distribution: Sandy muck bottom in shallow water 0-0.5 meters deep. Rare; a single plant was found growing near the landing.
Common Associates: (*Heteranthera dubia*) Water star-grass, (*Najas flexilis*) Slender naiad, (*Potamogeton foliosus*) Leafy pondweed

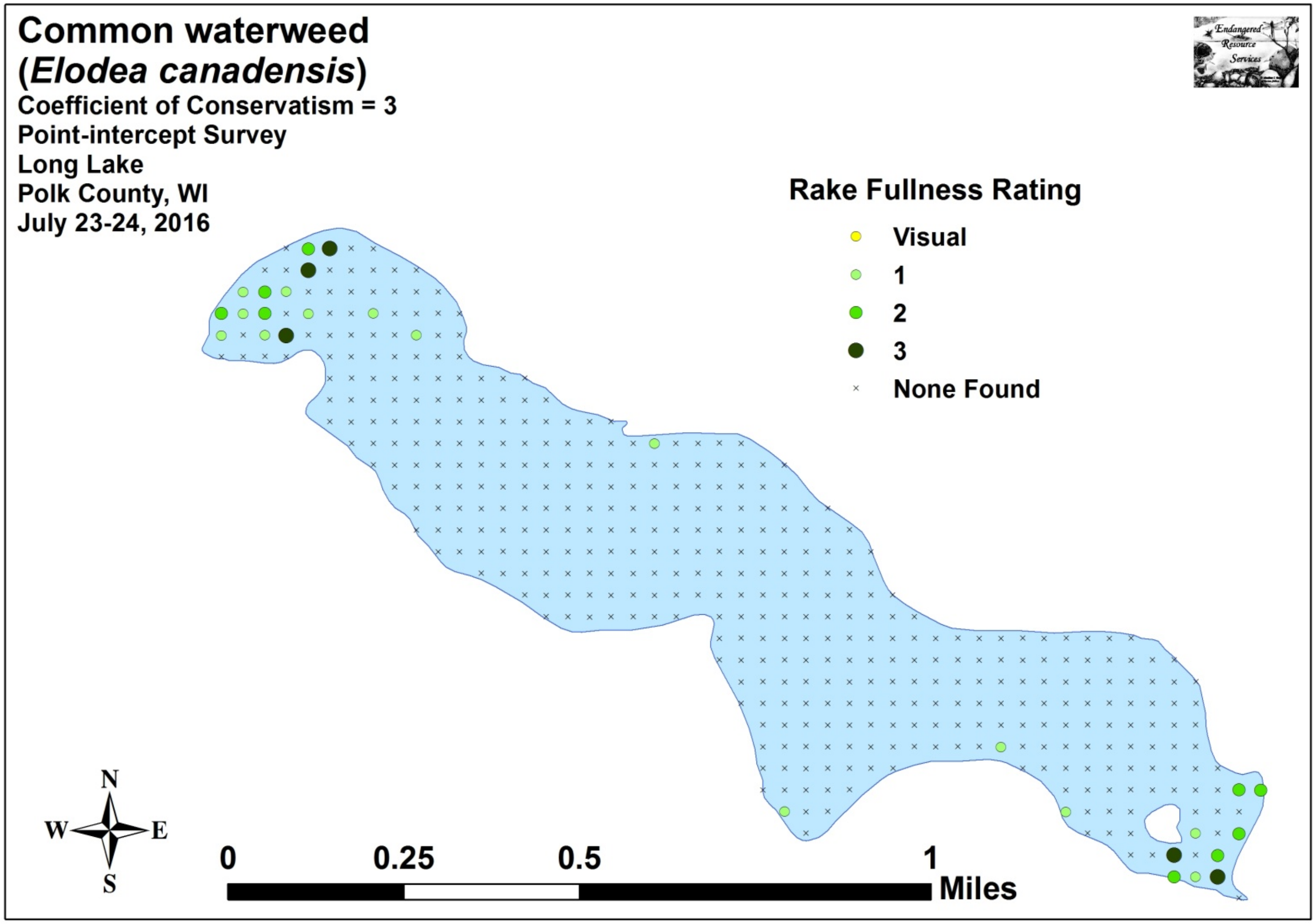
Appendix VIII: July 2016 Species Density and Distribution Maps

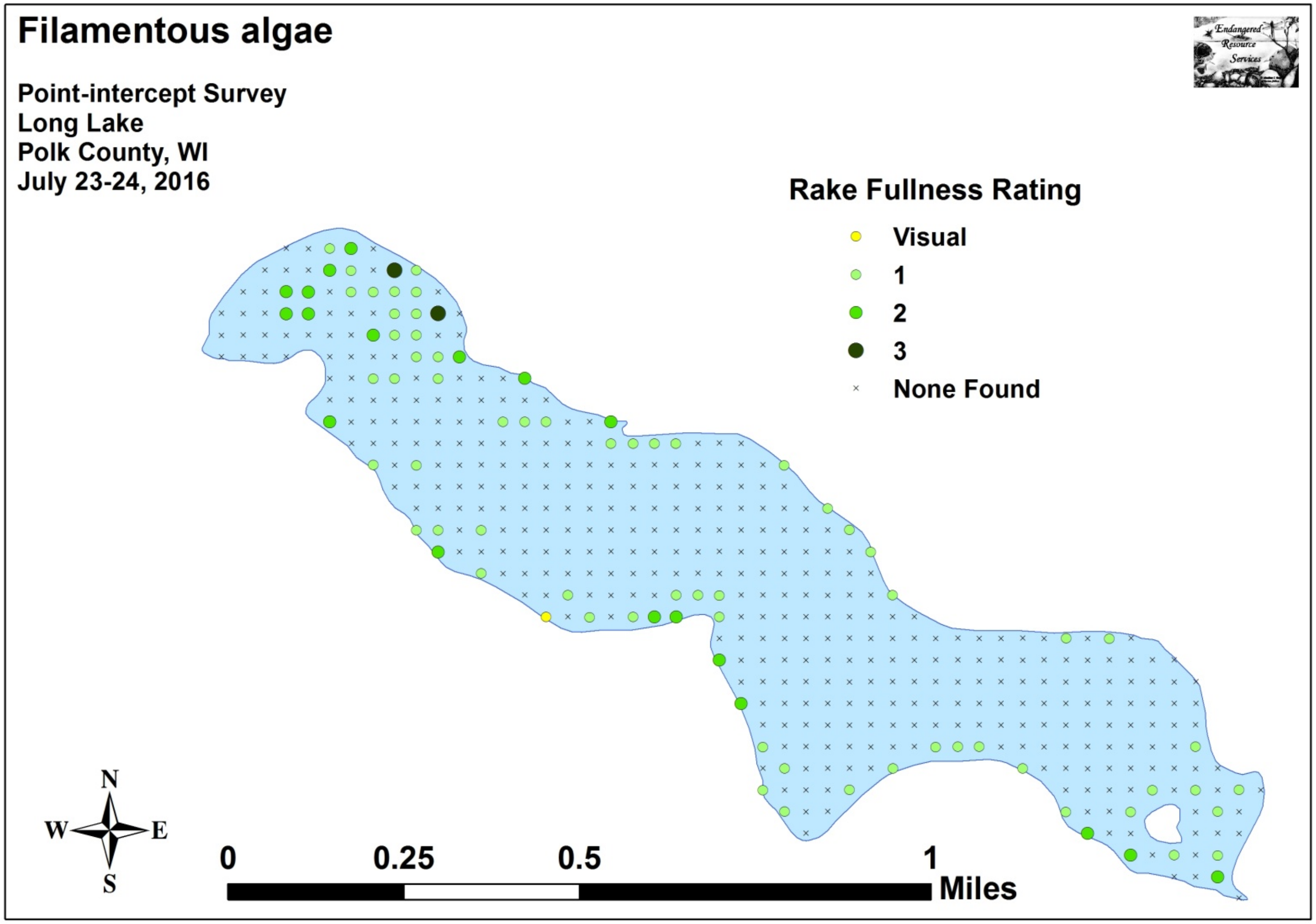

Bottle brush sedge
(*Carex comosa*)
Coefficient of Conservatism = 5
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Coontail
(*Ceratophyllum demersum*)
Coefficient of Conservatism = 3
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

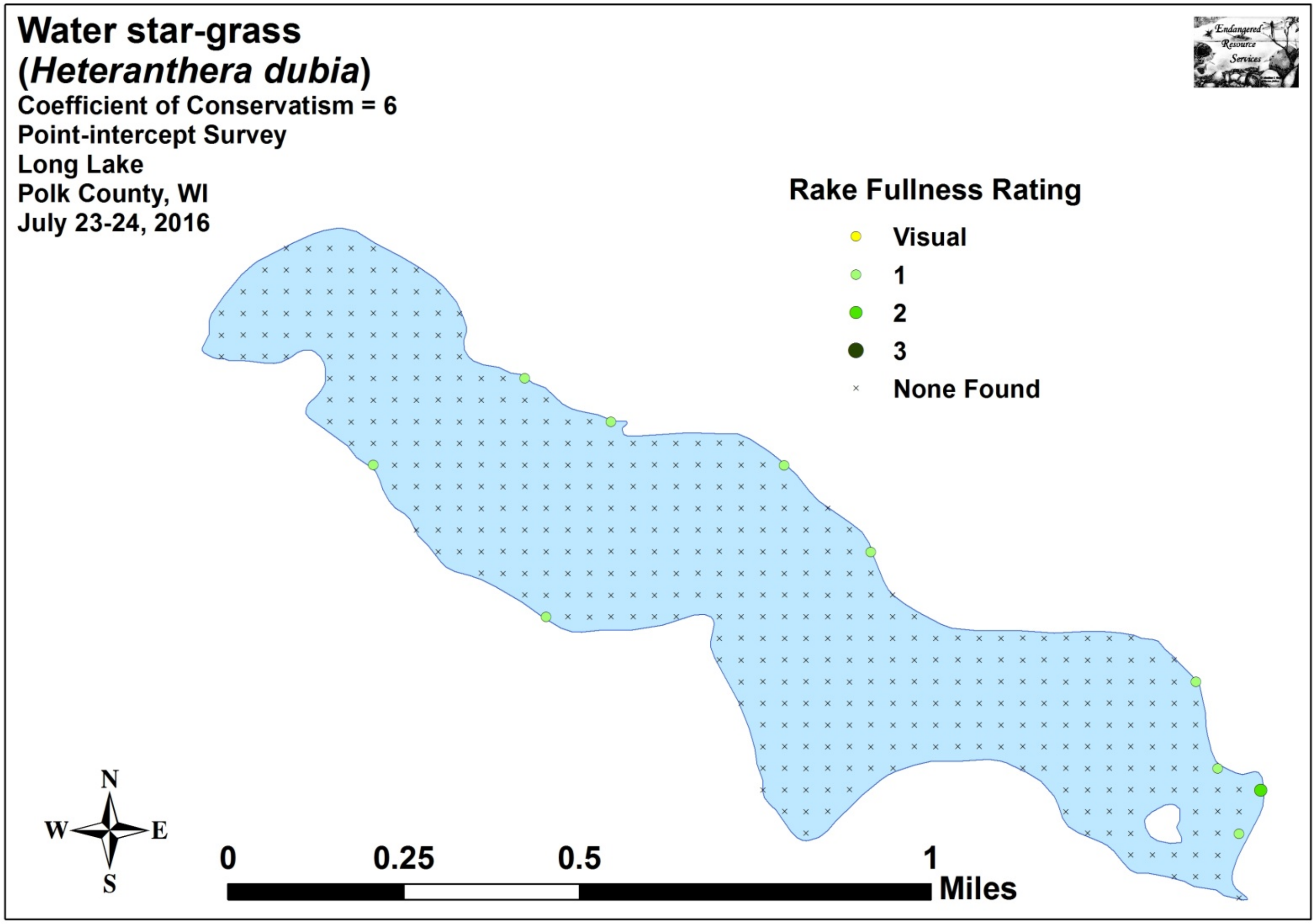

Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

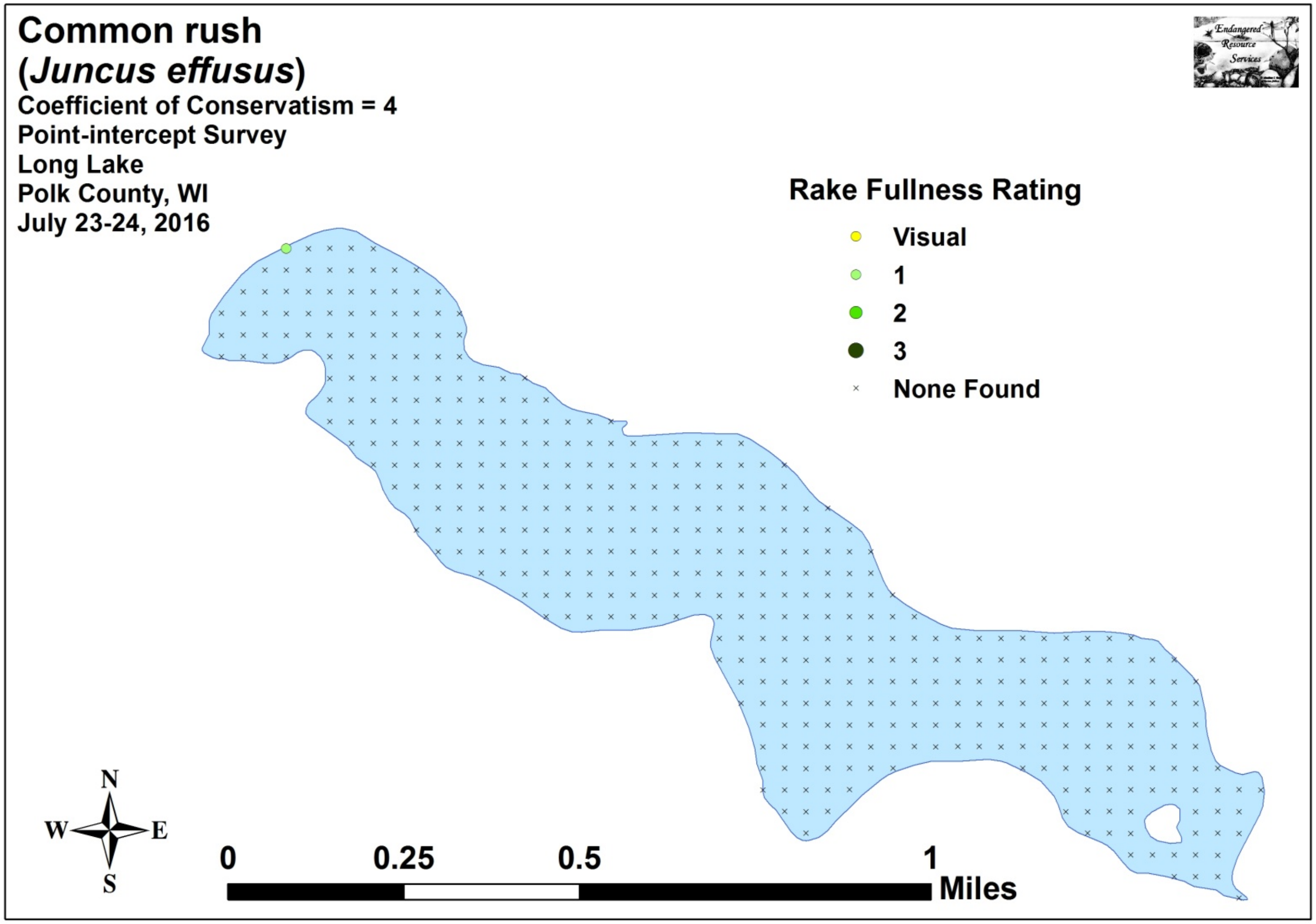

Needle spikerush
(*Eleocharis acicularis*)
Coefficient of Conservatism = 5
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

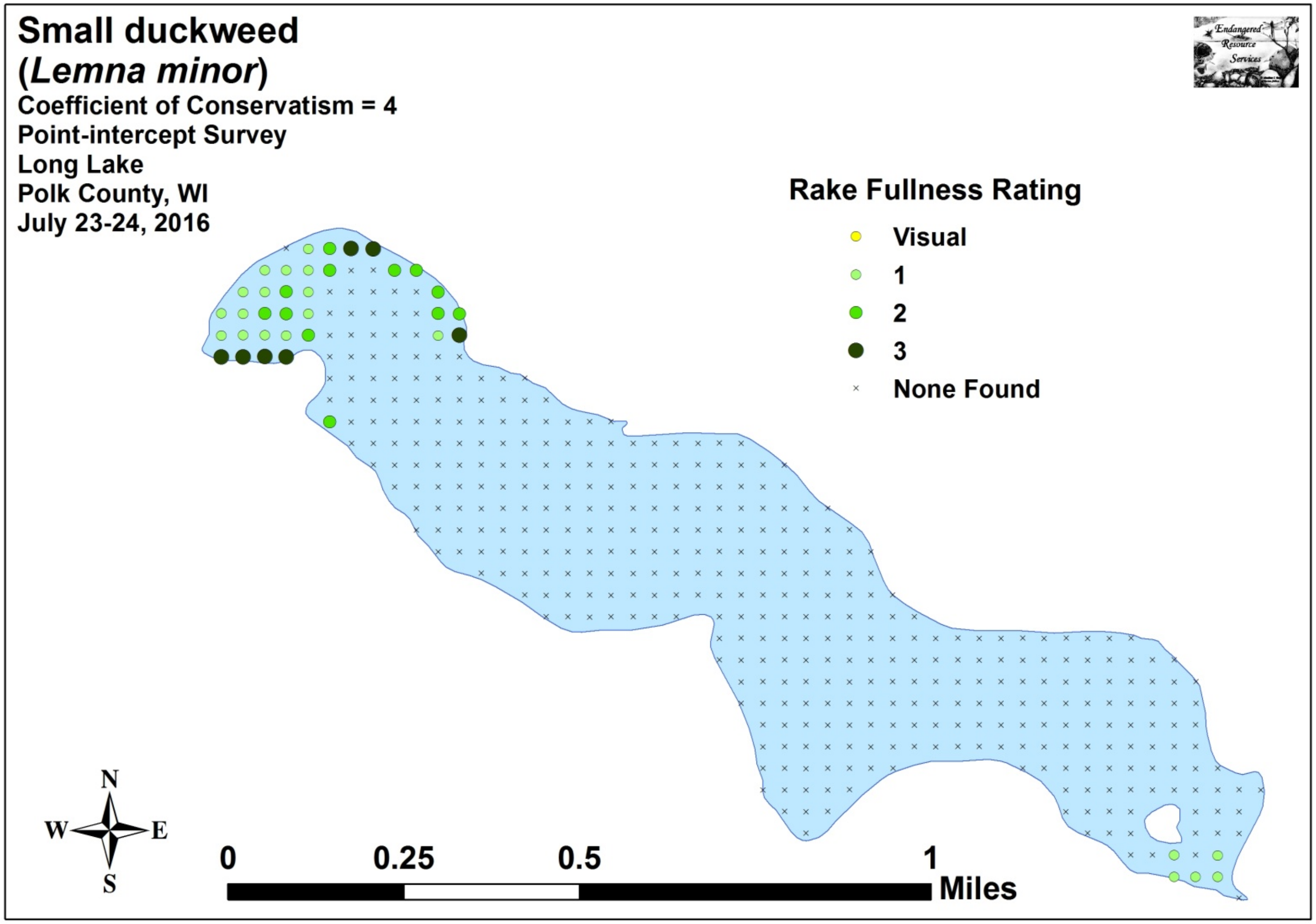

Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

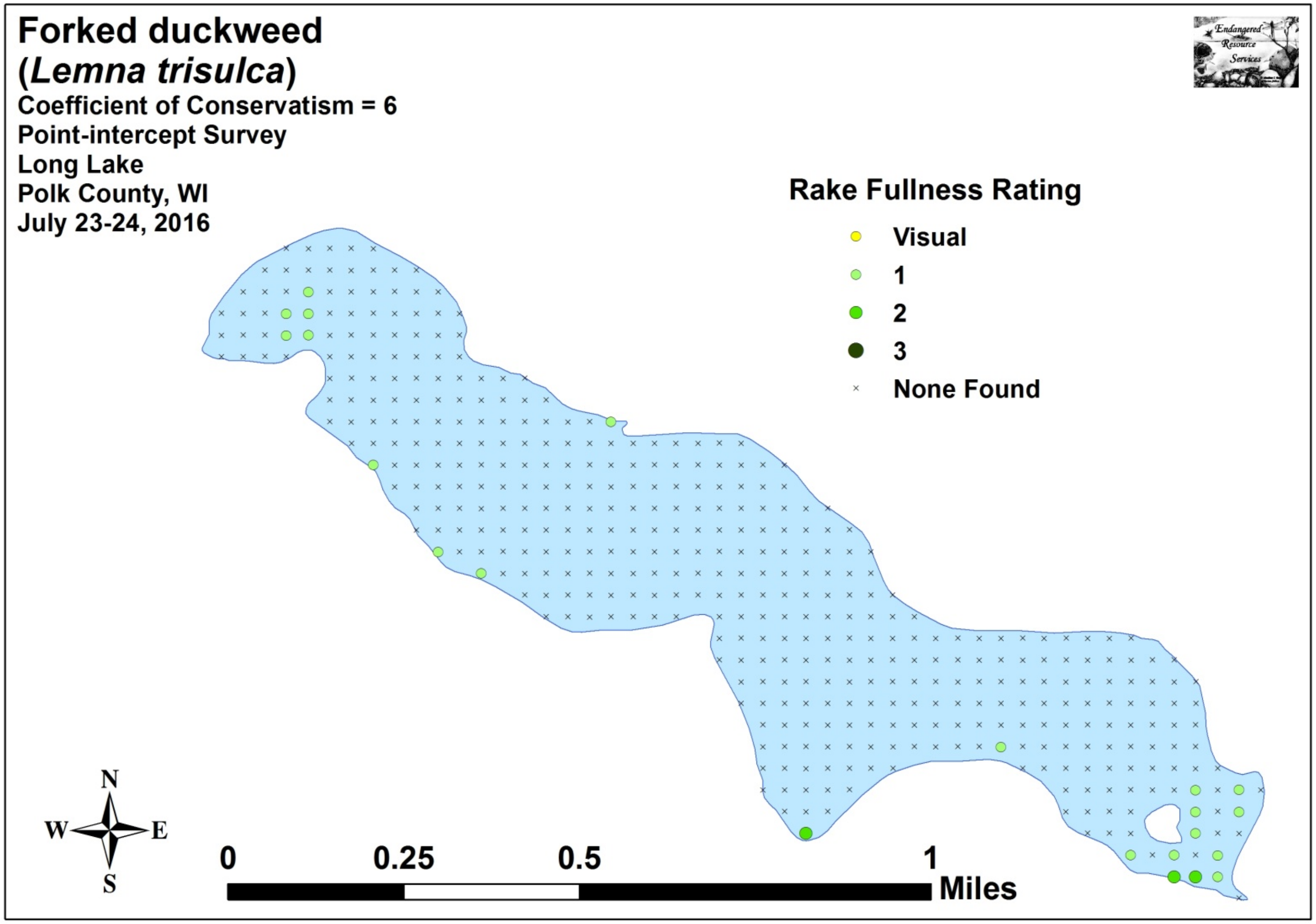


Filamentous algae
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

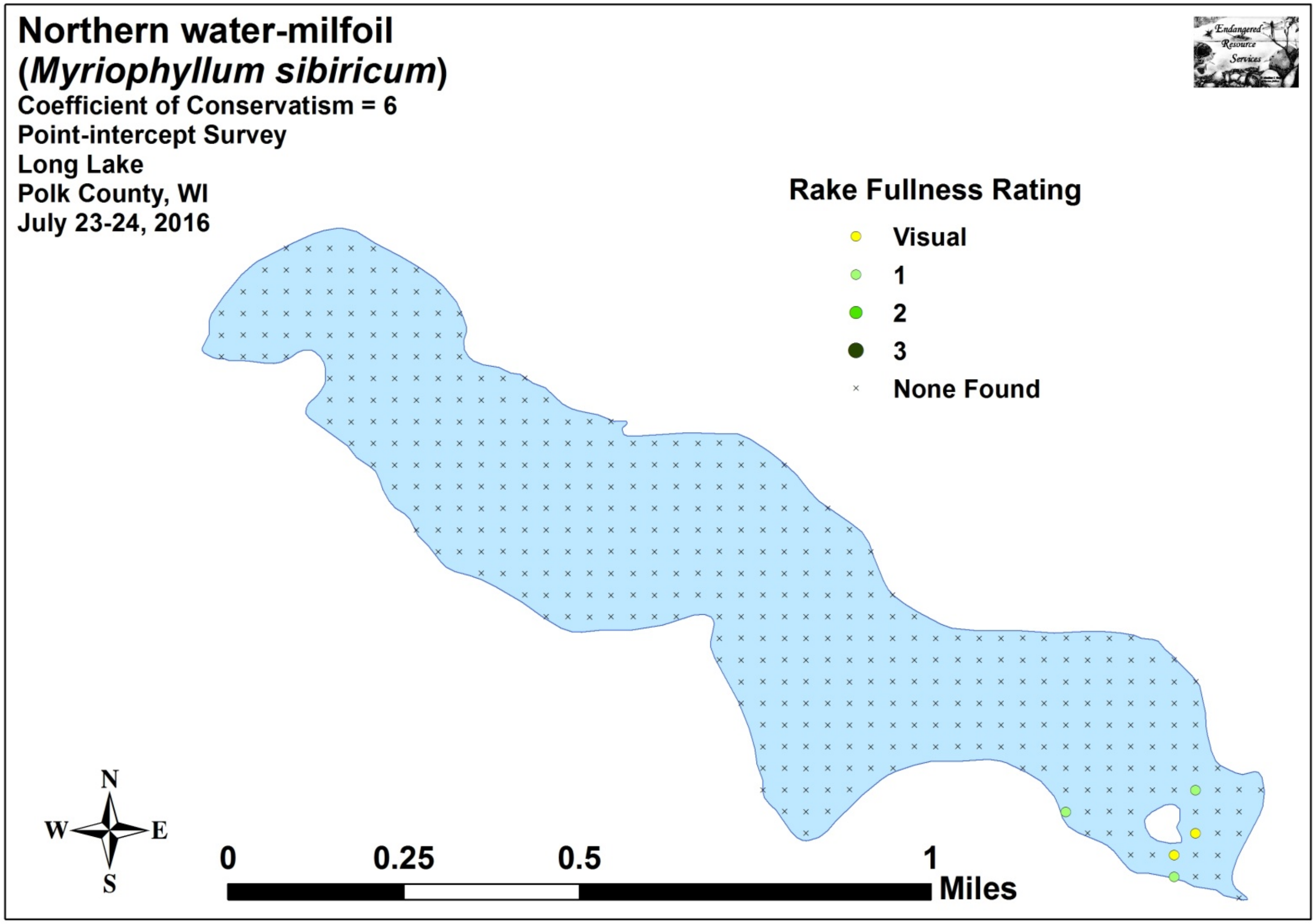

Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

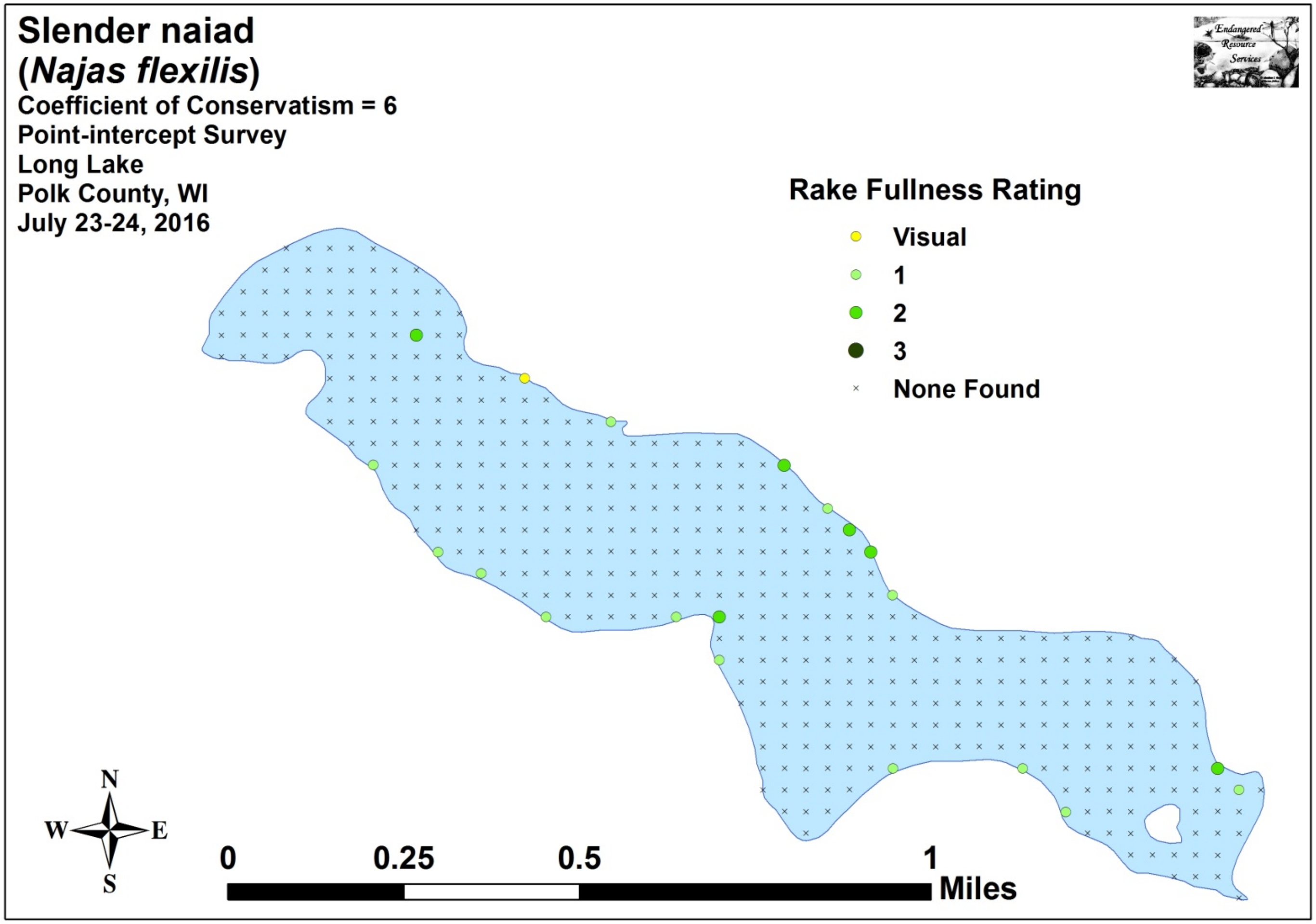

Common rush
(Juncus effusus)
Coefficient of Conservatism = 4
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Small duckweed
(*Lemna minor*)
Coefficient of Conservatism = 4
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

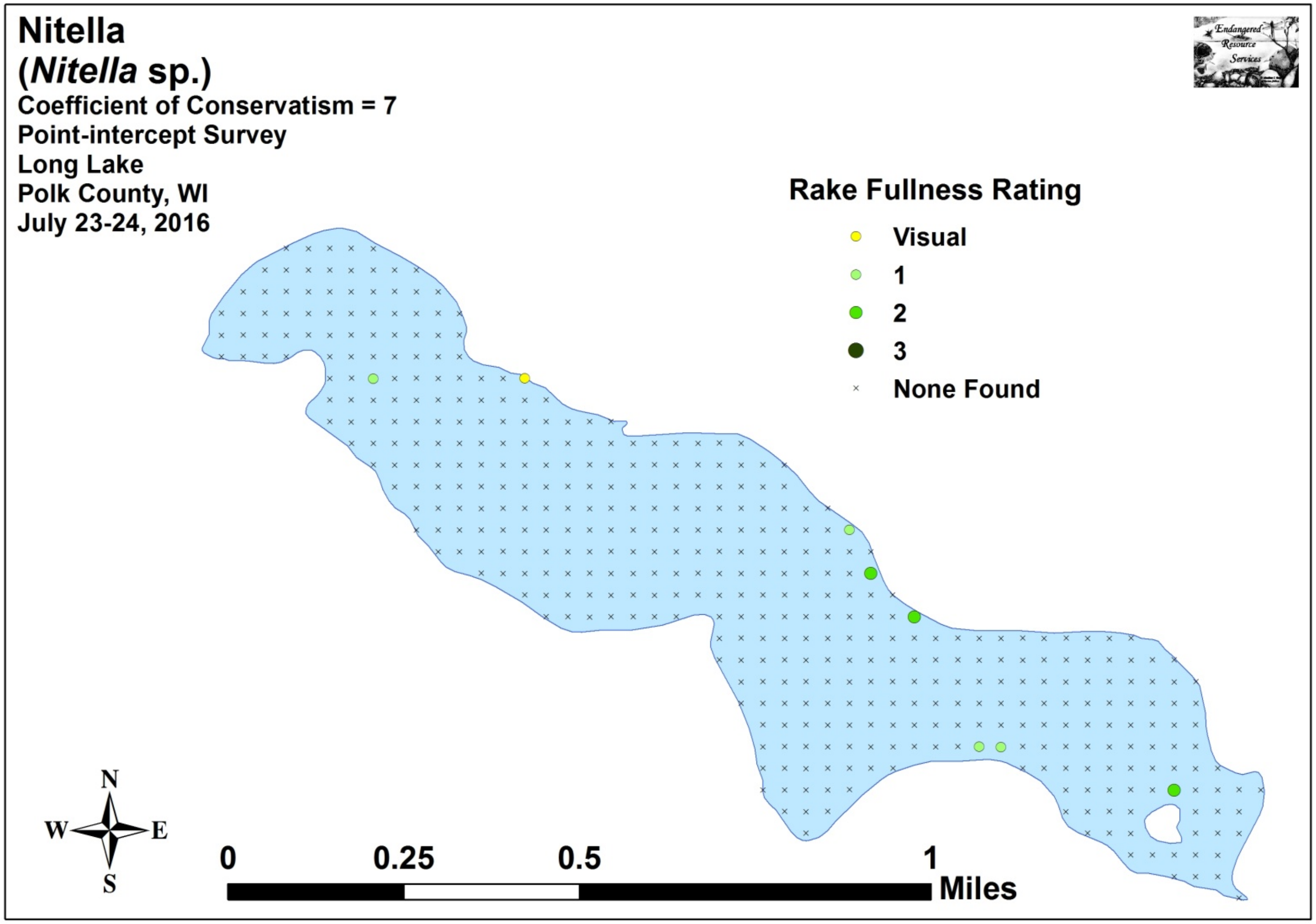


Forked duckweed
(*Lemna trisulca*)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

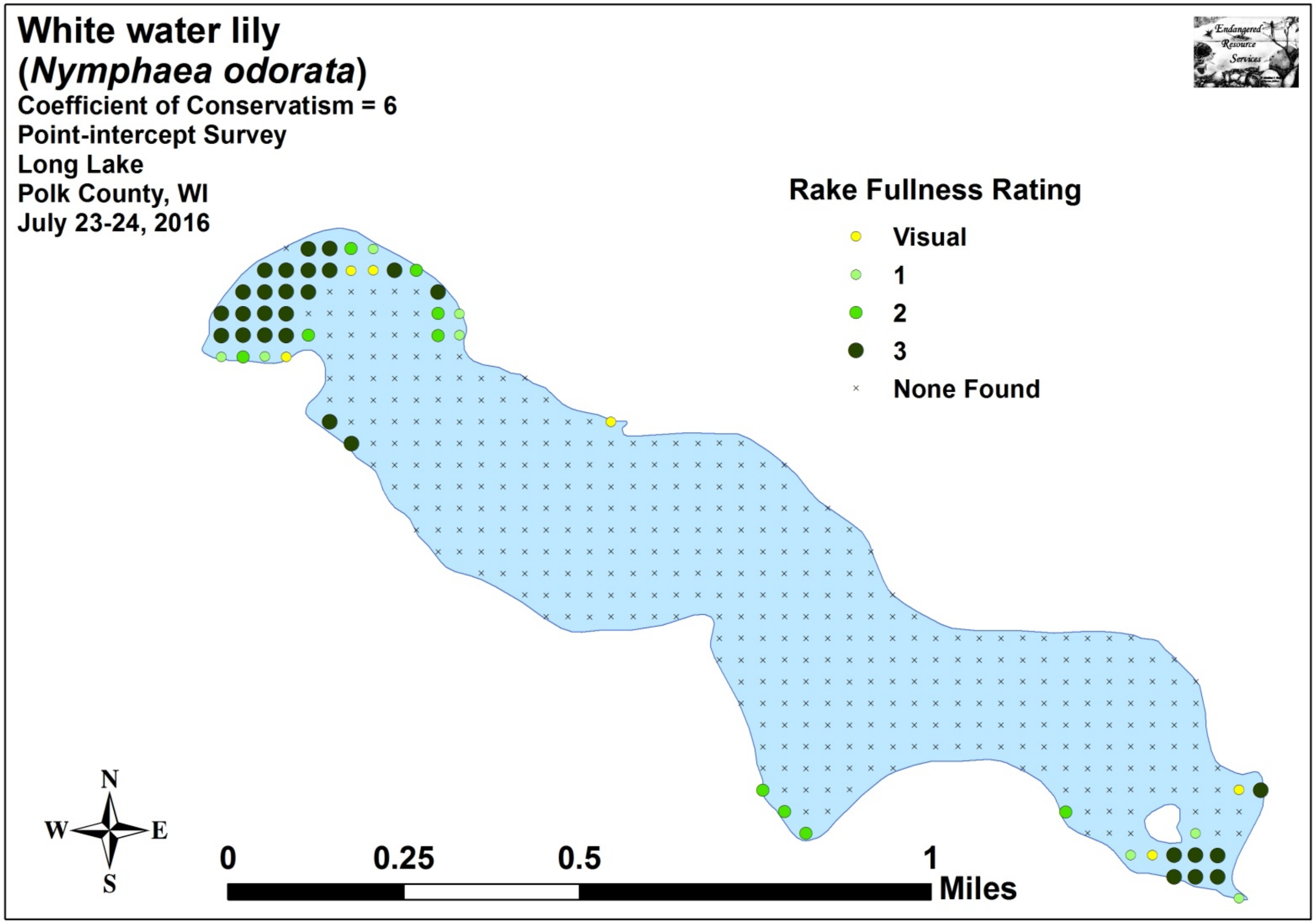

Northern water-milfoil
(*Myriophyllum sibiricum*)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



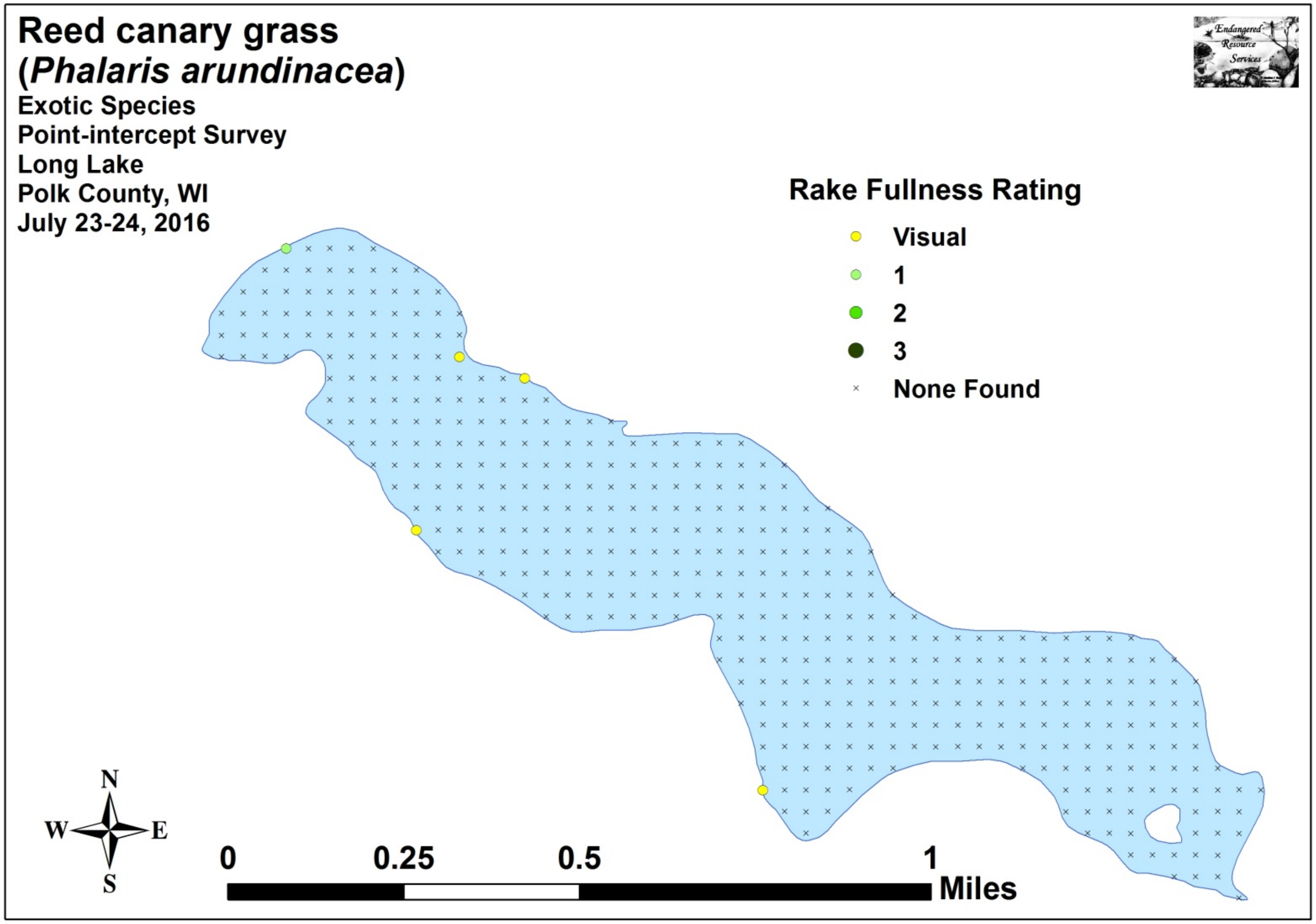
Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



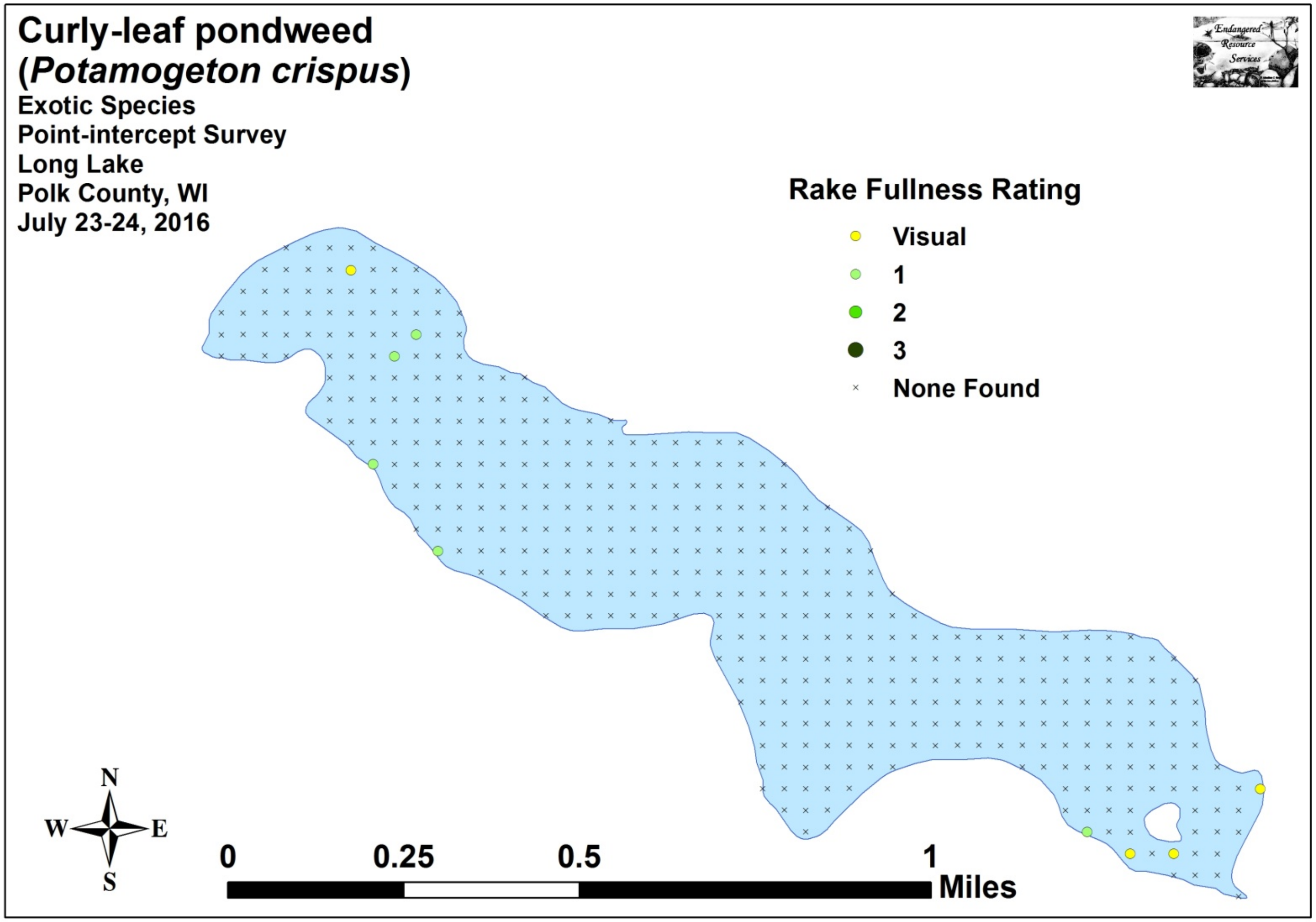
Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

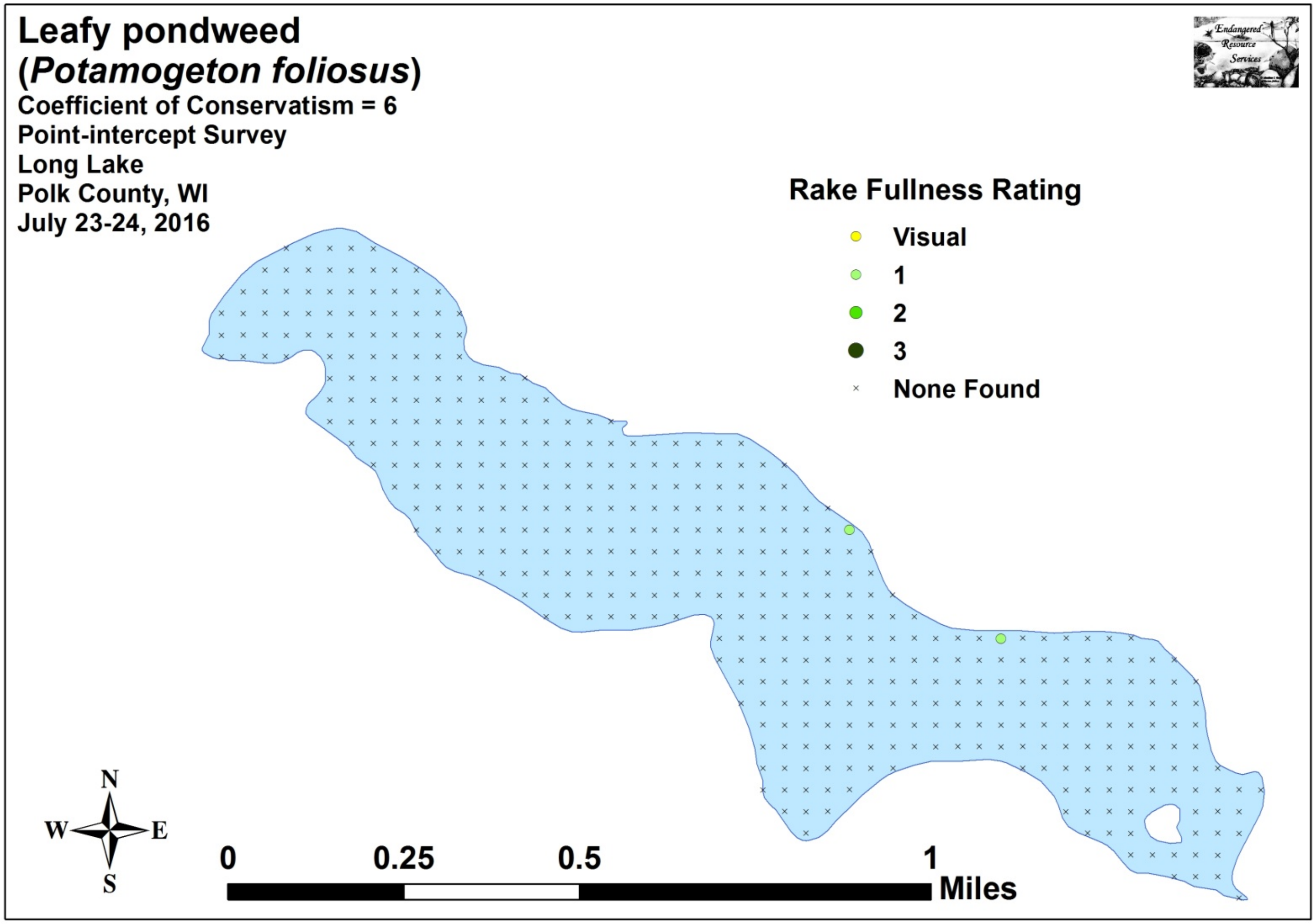


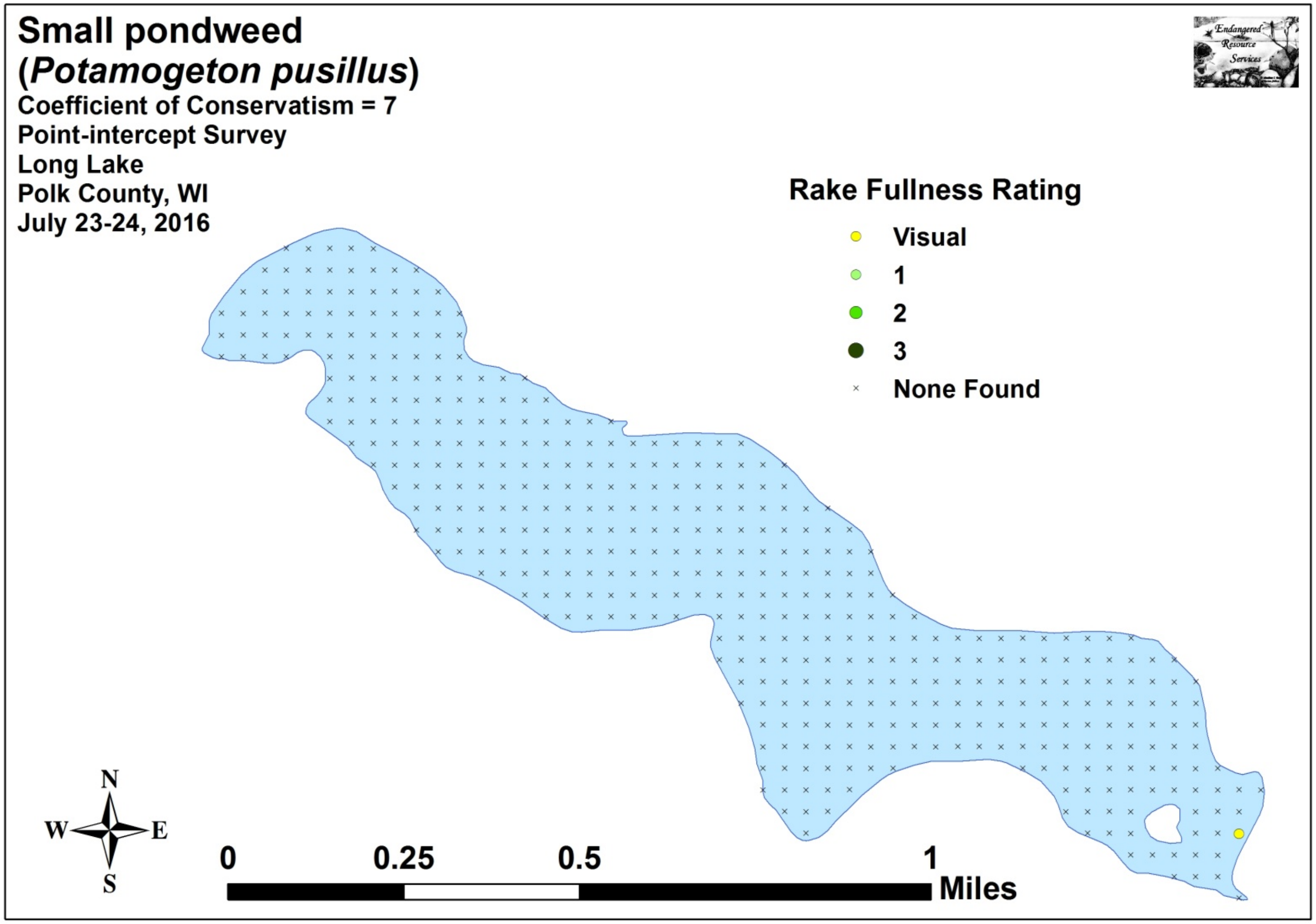
White water lily
(*Nymphaea odorata*)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

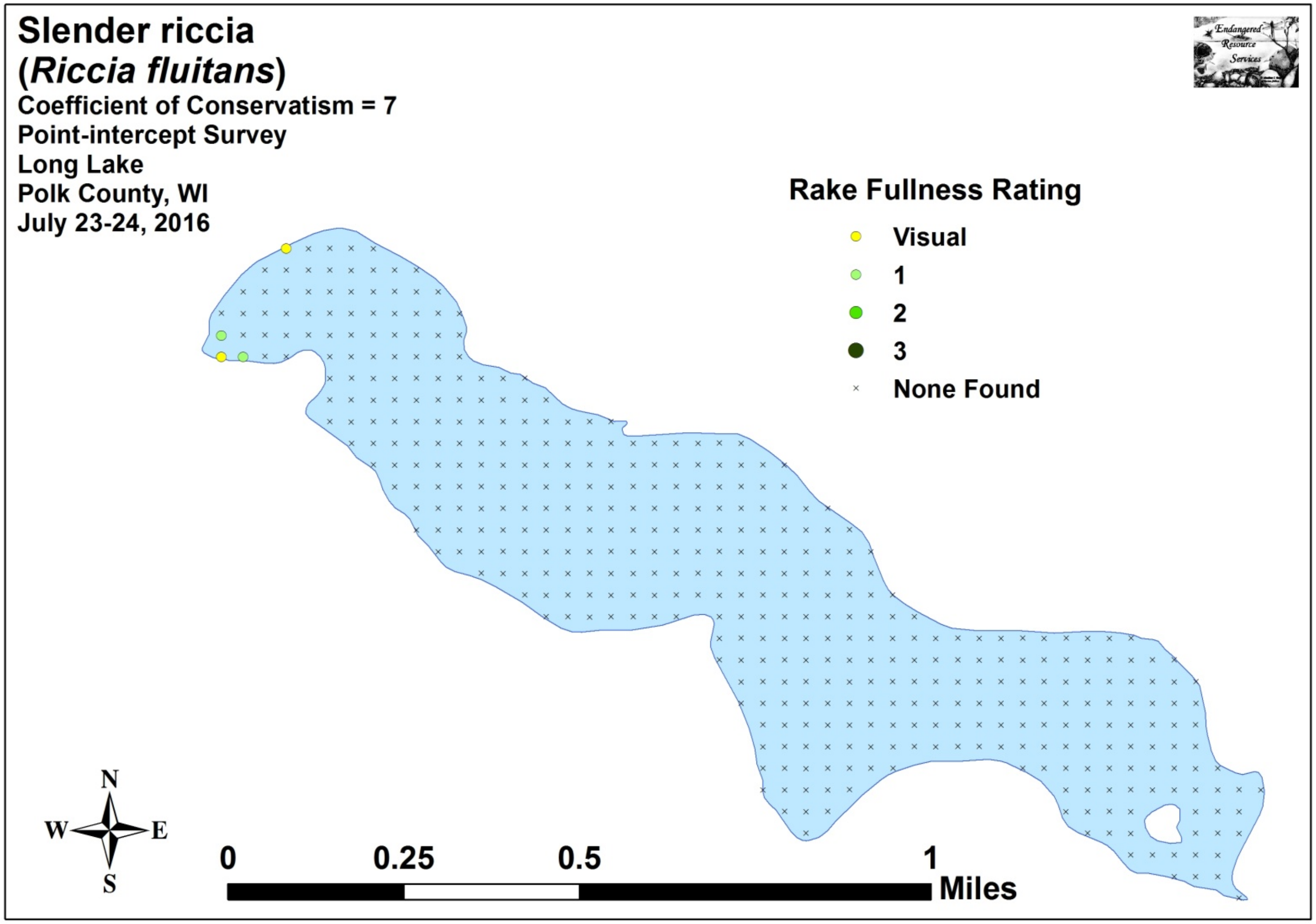


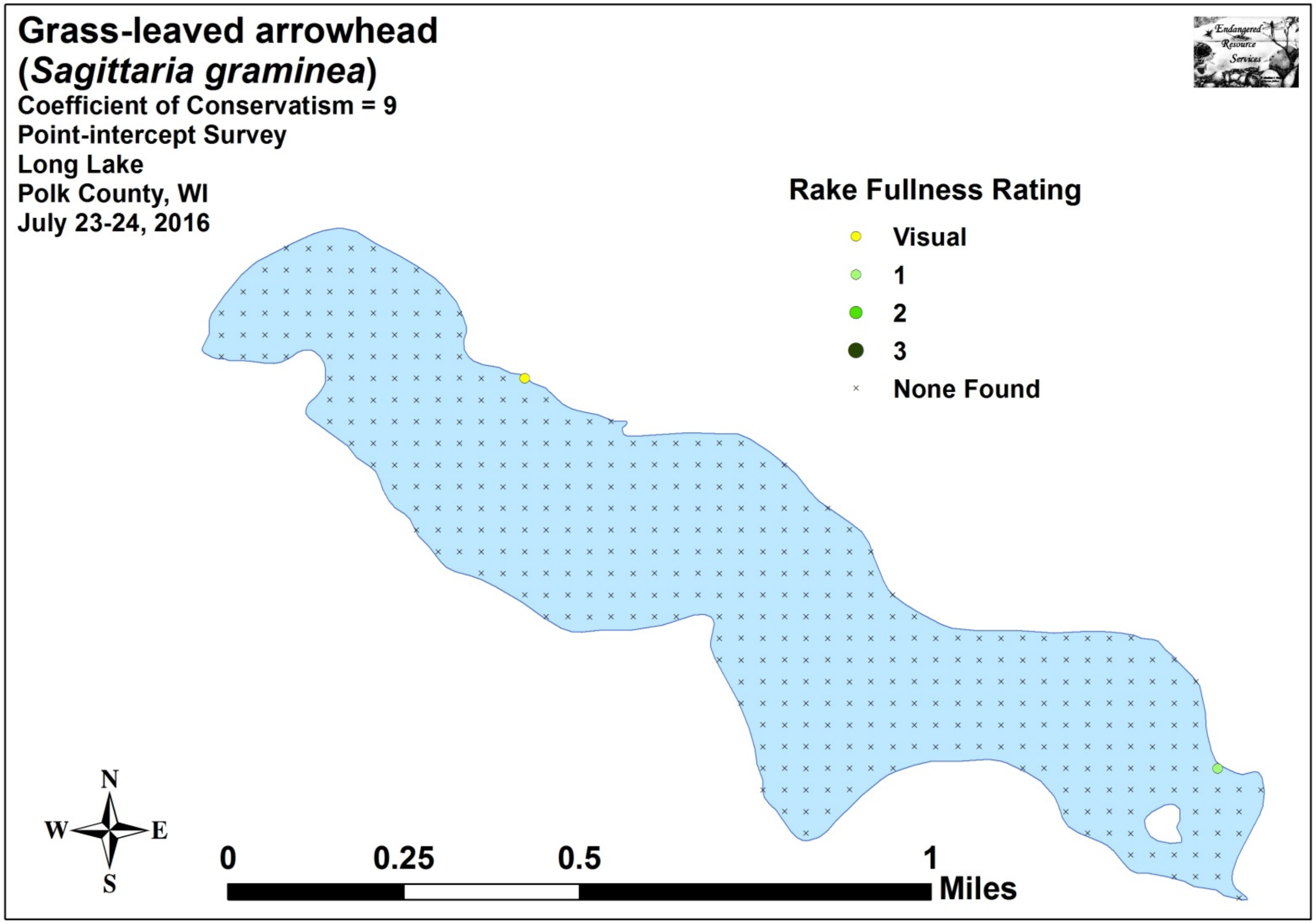
Reed canary grass
(*Phalaris arundinacea*)
Exotic Species
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

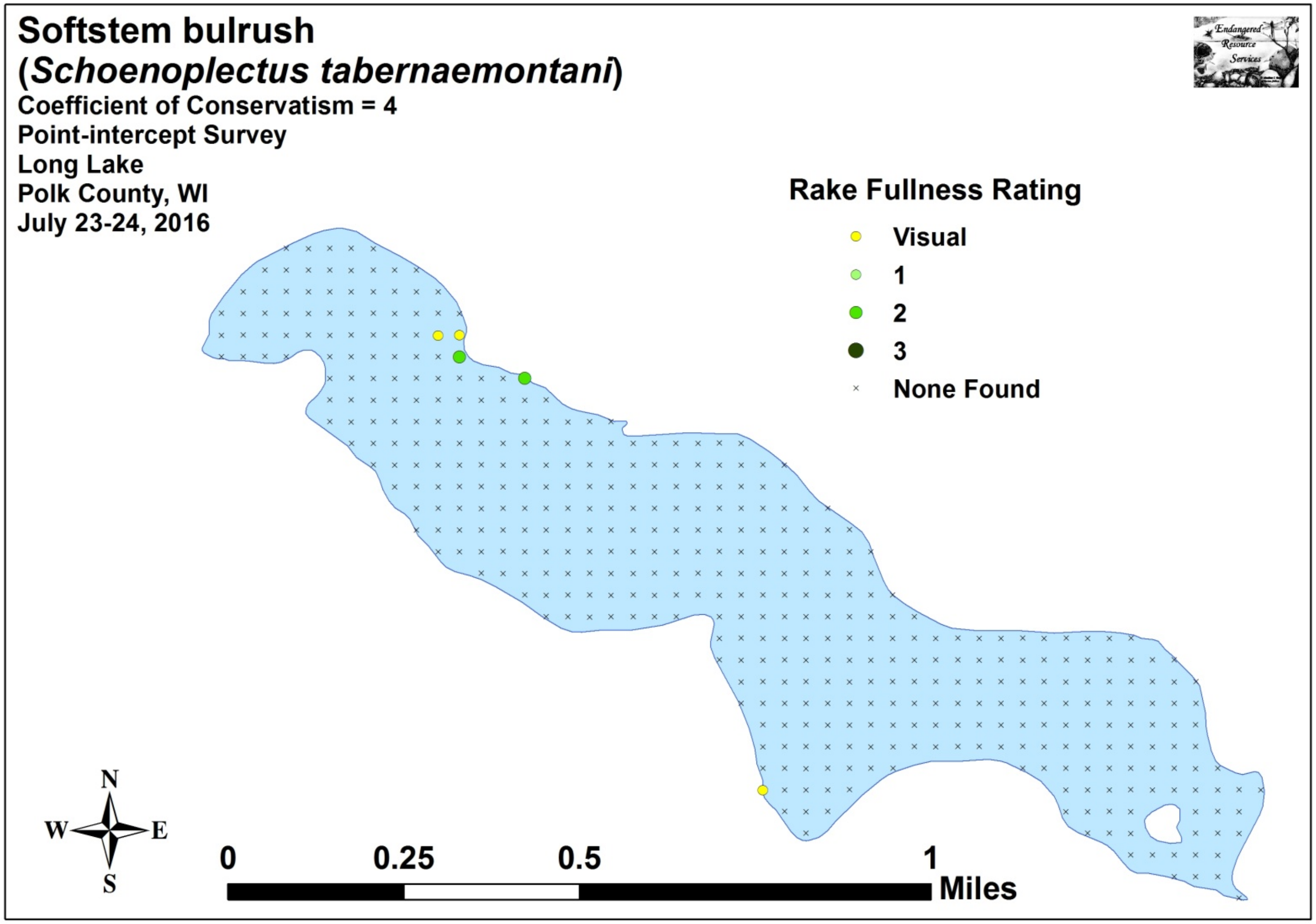

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Leafy pondweed
(*Potamogeton foliosus*)
Coefficient of Conservatism = 6
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

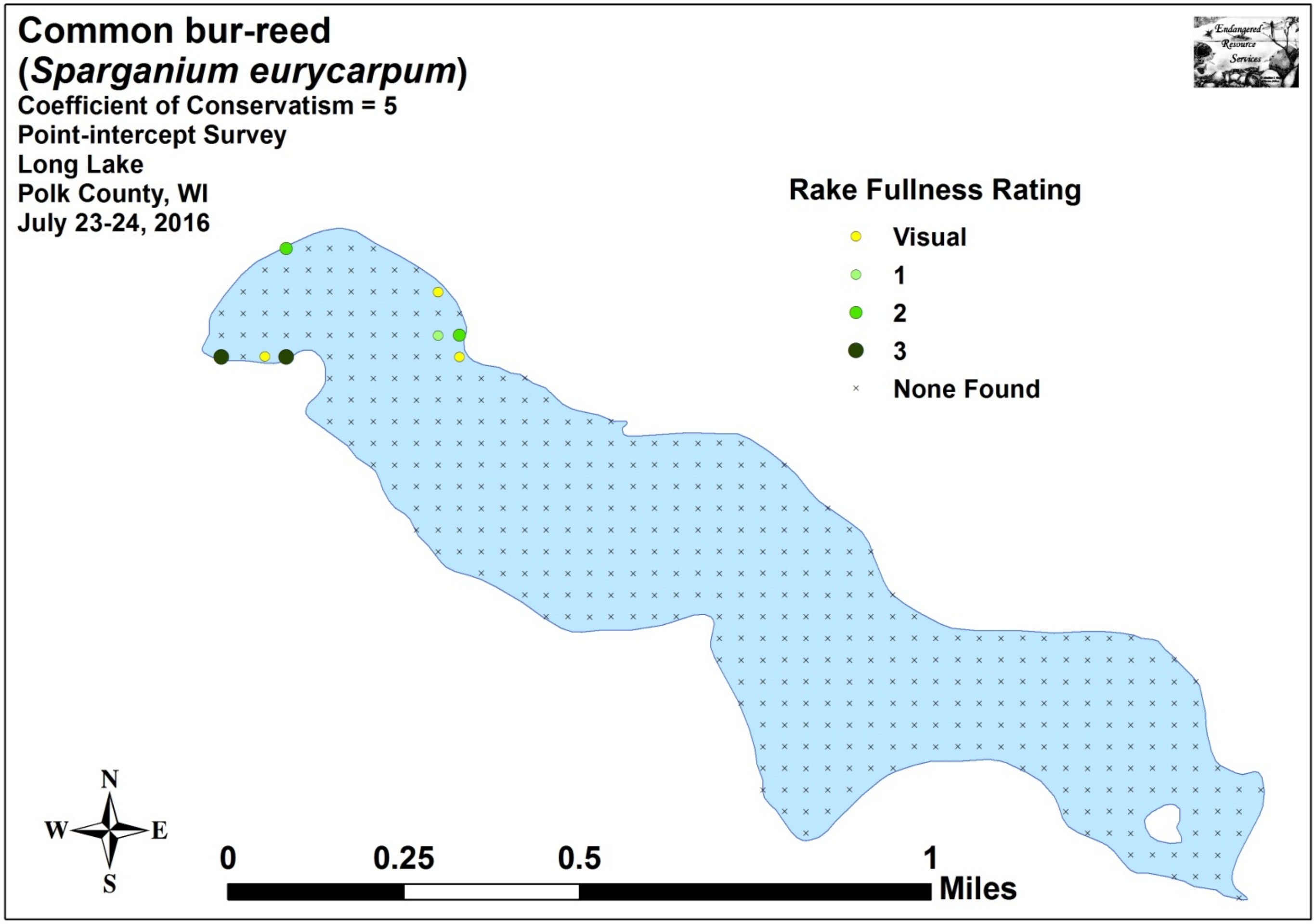

Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

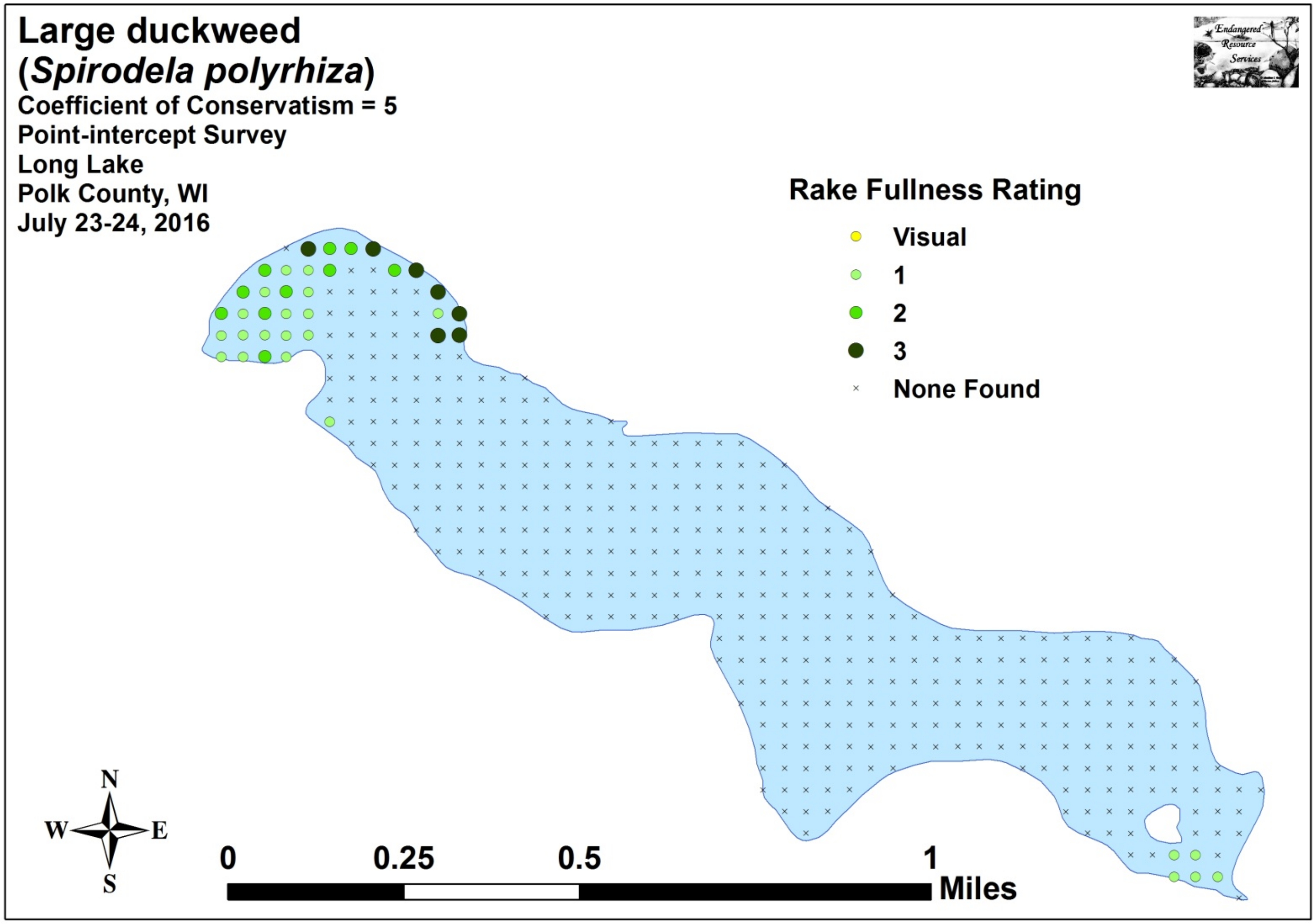

Slender riccia
(Riccia fluitans)
Coefficient of Conservatism = 7
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

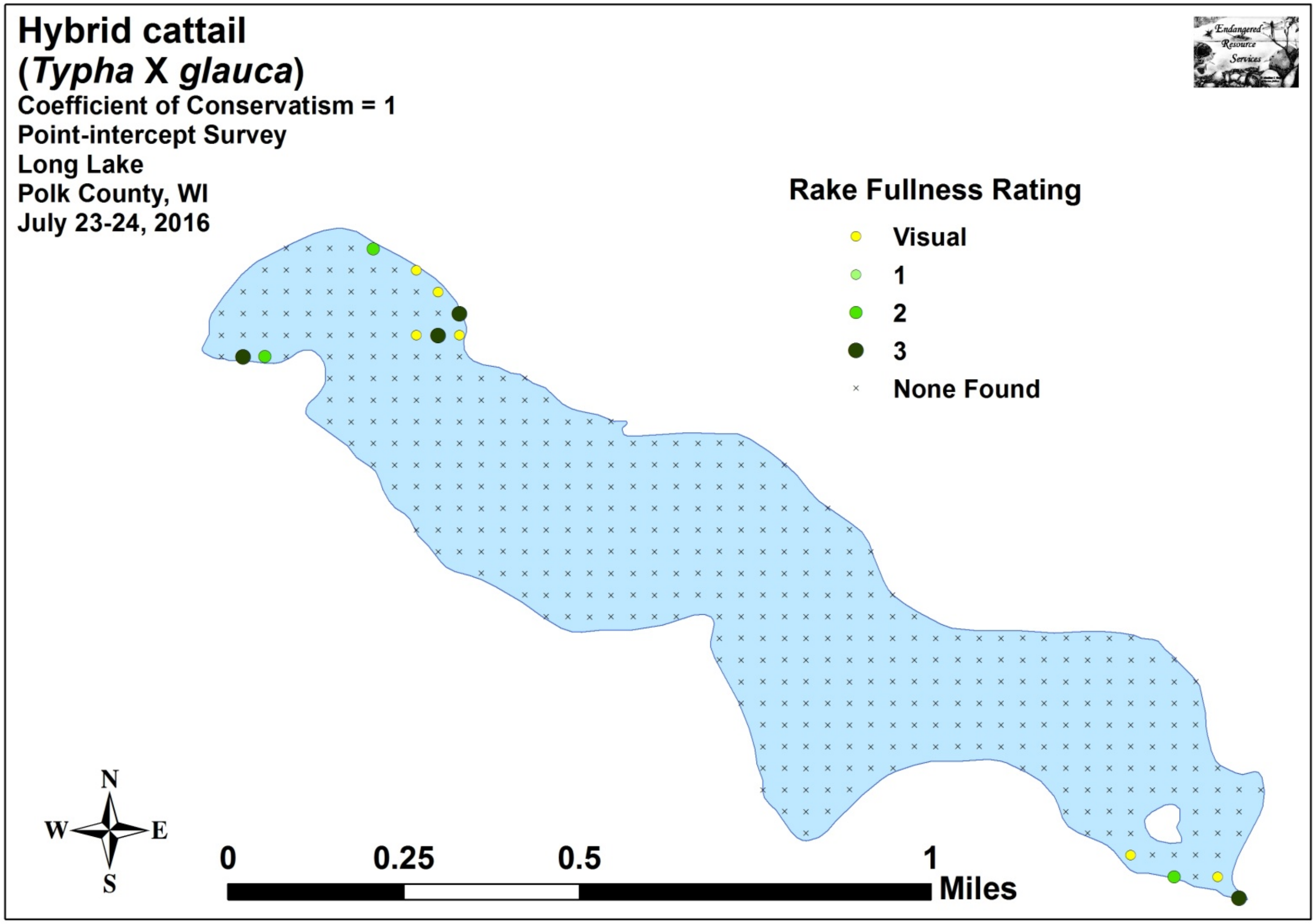

Grass-leaved arrowhead
(*Sagittaria graminea*)
Coefficient of Conservatism = 9
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

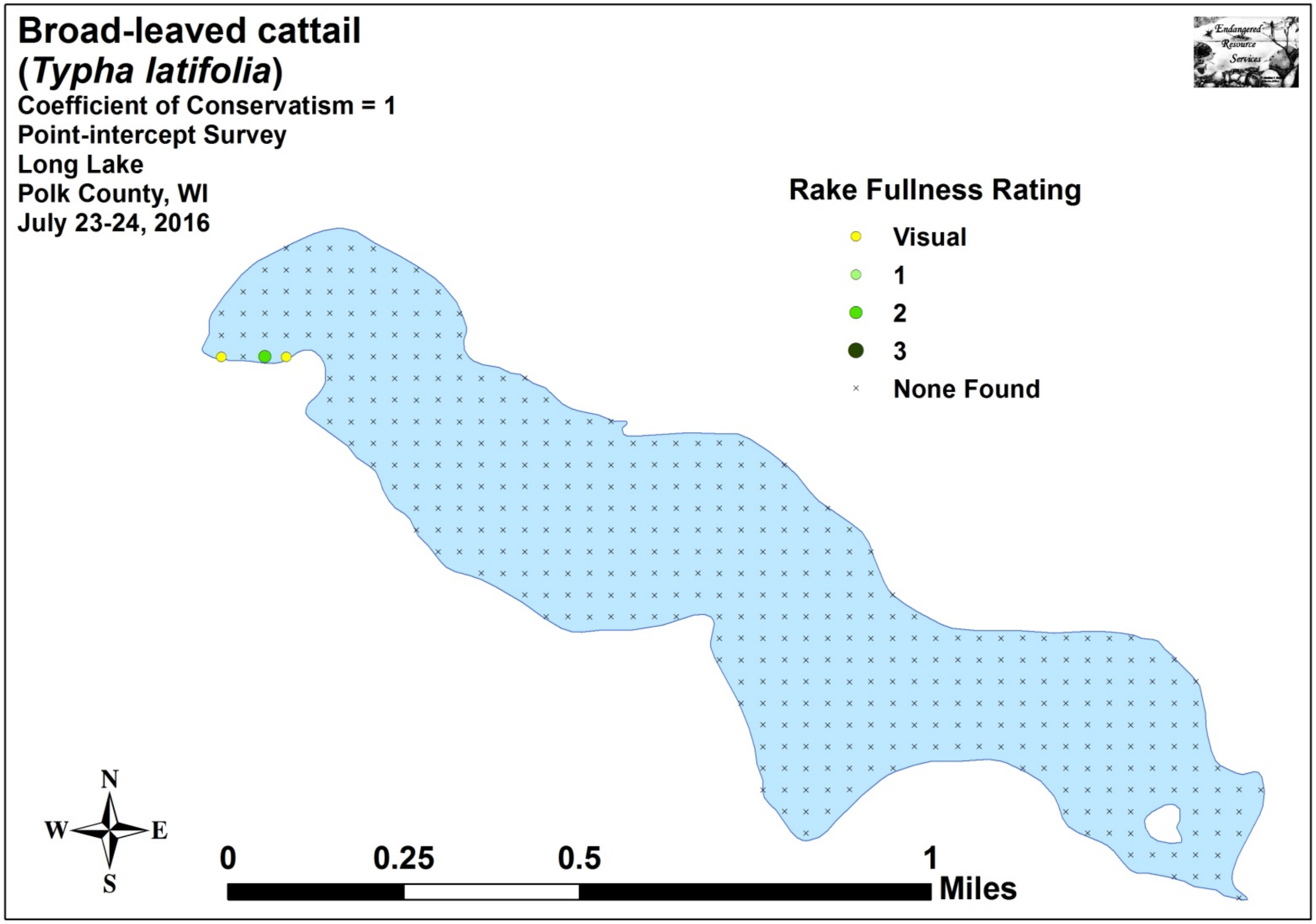


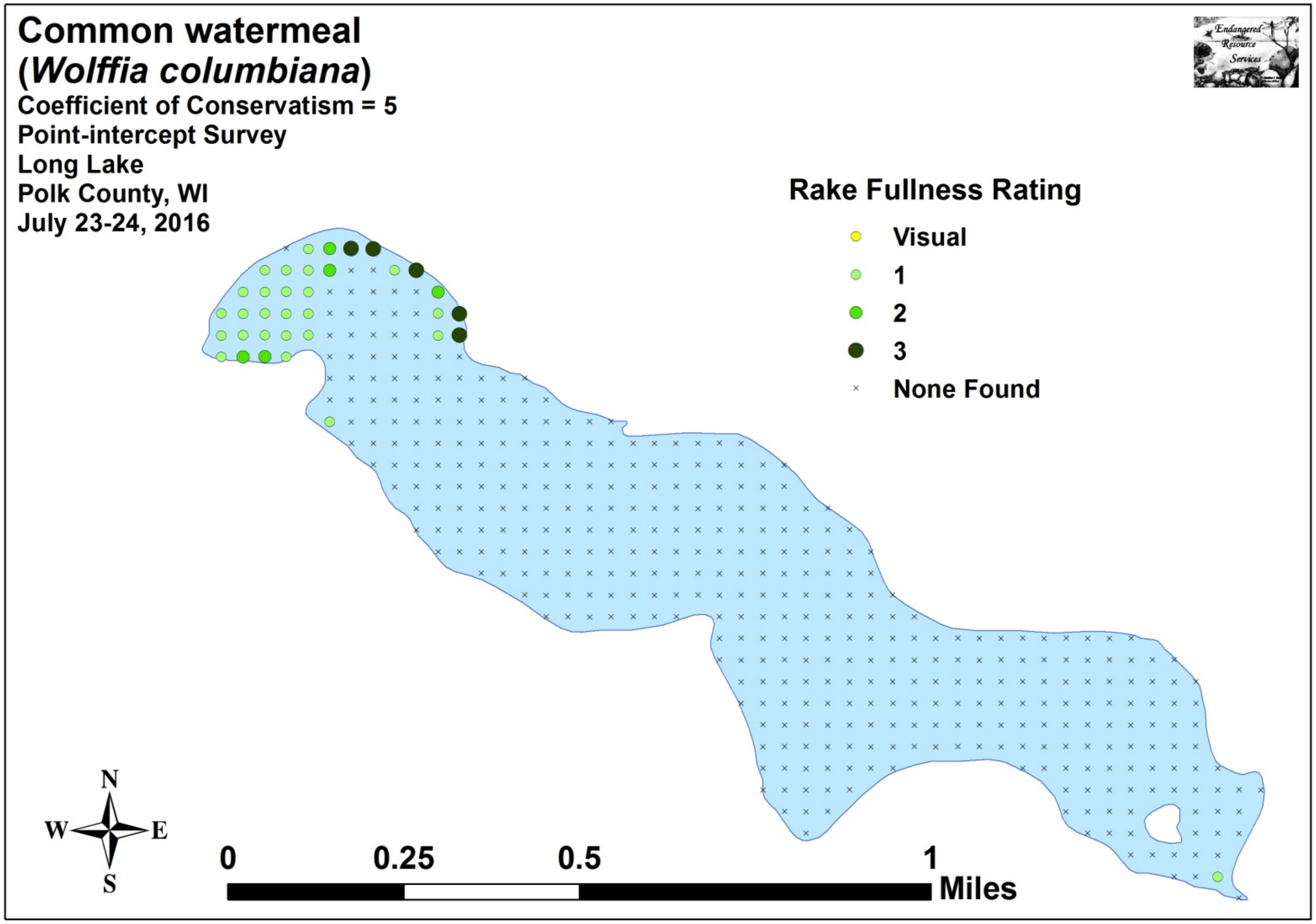
Softstem bulrush
(*Schoenoplectus tabernaemontani*)
Coefficient of Conservatism = 4
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Common bur-reed
(Sparganium eurycarpum)
Coefficient of Conservatism = 5
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Large duckweed
(Spirodela polyrhiza)
Coefficient of Conservatism = 5
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Hybrid cattail
(Typha X glauca)
Coefficient of Conservatism = 1
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Broad-leaved cattail
(Typha latifolia)
Coefficient of Conservatism = 1
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Common watermeal
(*Wolffia columbiana*)
Coefficient of Conservatism = 5
Point-intercept Survey
Long Lake
Polk County, WI
July 23-24, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

Appendix IX: Aquatic Exotic Invasive Plant Species Information

Eurasian Water-milfoil

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

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

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

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

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

Dense stands of Eurasian Water-milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by Eurasian Water-milfoil may lead to deteriorating water quality and algae blooms of infested lakes. (Taken in its entirety from WDNR, 2010 http://www.dnr.state.wi.us/invasives/fact/milfoil.htm)

Curly-leaf pondweed

DESCRIPTION: Curly-leaf pondweed is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. The plant usually drops to the lake bottom by early 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, 2010 http://www.dnr.state.wi.us/invasives/fact/curlyleaf_pondweed.htm)

Reed canary grass

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

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

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

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

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

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

This species prefers disturbed areas, but can easily move into native wetlands. Reed canary grass can invade a disturbed wetland in less than twelve years. Invasion is associated with disturbances including ditching of wetlands, stream channelization, deforestation of swamp forests, sedimentation, and intentional planting. The difficulty of selective control makes reed canary grass invasion of particular concern. Over time, it forms large, monotypic stands that harbor few other plant species and are subsequently of little use to wildlife. Once established, reed canary grass dominates an area by building up a tremendous seed bank that can eventually erupt, germinate, and recolonize treated sites. (Taken in its entirety from WDNR, 2010 http://www.dnr.state.wi.us/invasives/fact/reed_canary.htm)

Purple loosestrife
(Photo Courtesy Brian M. Collins)

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

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

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

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

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

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

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

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

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

Purple loosestrife displaces native wetland vegetation and degrades wildlife habitat. As native vegetation is displaced, rare plants are often the first species to disappear. Eventually, purple loosestrife can overrun wetlands thousands of acres in size, and almost entirely eliminate the open water habitat. The plant can also be detrimental to recreation by choking waterways. (Taken in its entirety from WDNR, 2010 http://www.dnr.state.wi.us/invasives/fact/loosestrife.htm)

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

Aquatic:

organisms that live in or frequent water.

Cultural Eutrophication:

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

Dissolved Oxygen (DO):

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

Diversity:

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

Drainage lakes:

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

Ecosystem:

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

Eutrophication:

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

Exotic:

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

Habitat:

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

Limnology:

the study of inland lakes and waters.

Littoral:

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

Macrophytes:

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

Nutrients:

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

Organic Matter:

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

Photosynthesis:

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

Phytoplankton:

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

Plankton:

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

ppm:

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

Richness:

number of species in a particular community or habitat.

Rooted Aquatic Plants:

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

Runoff:

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

Secchi Disc:

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

Seepage lakes:

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

Turbidity:

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

Watershed:

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

Zooplankton:

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

Appendix XI: 2016 Raw Data Spreadsheets