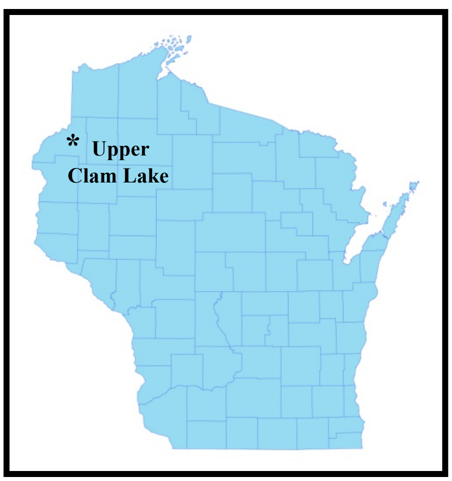
Warm-Water Point-intercept Macrophyte Survey
Upper Clam Lake (WBIC: 2656200)
Burnett County, Wisconsin

Dense rice inside the Carp exclosure in the SE bay (Berg 2016)

Aerial photo Upper Clam Lake

Project Initiated by: The St. Croix Tribal Environmental Department and the Clam Lake Protection and Rehabilitation District



Recovering rice along the south shore of the SW bay (Berg 2016)

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September 10-11, 2016

TABLE OF CONTENTS

ABSTRACT

Upper Clam Lake (WBIC 2656200) is a 1,338 acre drainage lake in central Burnett County, Wisconsin. The lake's average depth is 5ft, and the bottom substrate is predominantly muck and sandy/muck with a pure sand shoreline. The lake is eutrophic and water clarity is very poor with Secchi values ranging from 2-4ft from 2009-2016. Following the netting and removal of 1,000's of Carp (*Cyprinus carpio*) from the Clam Lakes in the winters of 2011-2012 and 2013-14, the St. Croix Tribal Environmental Department and the Clam Lakes Protection and Rehabilitation District requested follow-up warm-water full point-intercept surveys in 2012 and 2014. Neither of these surveys found a significant increase in vegetation, but, because there was evidence of a Carp die-off over the winter of 2014-15, and because plants appeared to be recovering, additional full-lake warm-water point-intercept surveys were requested in September 2015 and 2016. During the 2016 survey, we found macrophytes at 213 points. This extrapolated to 31.9% of the lake bottom and 40.7% of the 7.5ft littoral zone. This was a further increase from the 2015 survey when plants were found at 187 points (28.0% of the bottom/42.6% of the then 6.5ft littoral zone). Overall diversity was very high with a Simpson Diversity Index of 0.92 (down from 0.93 in 2015). Mean native species/site with vegetation was 3.24 – a non-significant decline from 3.50 in 2015, but still well above the 2.54 found in 2014. Of the 38 species found in the rake (up from 30 in 2015), Common waterweed (*Elodea canadensis*), Coontail (*Ceratophyllum demersum*), Wild celery (*Vallisneria americana*), and Northern wild rice (*Zizania palustris*) were the most common species. They were present at 46.01%, 39.91%, 38.50%, and 24.88% of survey points with vegetation and accounted for 45.89% of the total relative frequency. From 2015 to 2016, eight species experienced significant changes: Common waterweed experienced a highly significant increase; Wild celery and Common watermeal (*Wolffia columbiana*) moderately significant increases; and Water marigold (*Bidens beckii*) a significant increase. Conversely, Small duckweed (*Lemna minor*) experienced a highly significant decline; Small pondweed (*Potamogeton pusillus*) a moderately significant decline; and Slender naiad (*Najas flexilis*) and Sago pondweed (*Stuckenia pectinata*) significant declines. The 38 native index species in the rake during the 2016 survey produced a much below average mean Coefficient of Conservatism of 5.7, but a Floristic Quality Index of 34.9 that was above the median for lakes in this part of the state. Each of these values increased slightly from 2015 when 30 index plants had a mean C of 5.6 and produced an FQI of 30.5. Northern wild rice was present at 53 sites – a non-significant decline from 56 sites in 2015, but still above the 46 sites with rice in 2014. Although the decline in distribution wasn't significant, the decline in density from a mean rake fullness of 2.52 in 2015 to a mean rake of 2.15 was moderately significant **($p = 0.003$)**; however, this was also still well above the 2014 mean rake of 1.80. Despite these average declines, the southeast bay continued to offer significant human harvest potential, and the southwest bay (when considered on its own) experienced increases in both density and distribution. Scattered Reed canary grass (*Phalaris arundinacea*) and Hybrid cattail (*Typha* X *glauca*) were the only exotic species found. Future management considerations include resuming Secchi disc monitoring of water clarity to document improvements that should accompany an increase in rooted plants; and potentially seeding additional rice grain to hasten recovery; especially in areas outside the exclosure.

LIST OF FIGURES

LIST OF TABLES

Page #

INTRODUCTION:

Upper Clam Lake (WBIC 2656200) is a 1,338 acre drainage lake in central Burnett County, Wisconsin in the Towns of Siren and Meenon (T39N R16W S34 SE SE) (Figure 1). The lake reaches a maximum depth of 11ft in the central basin with an average depth of approximately 5ft (Sather et al, 1964). The lake is eutrophic with Secchi readings averaging 2-3ft at the time of the 2016 survey and never higher than the 4ft we recorded in 2009. Tribal data also suggests there has been little change over this time (Havranek, pers. comm.). This very poor water clarity produced a littoral zone that extended to 7.5ft in September of 2016. The lake's bottom substrate is predominately muck and sandy muck with a ring of pure sand around the majority of the shoreline (Sather et al, 1964).

Figure 1: Upper Clam Lake Aerial Photo

The Clam Lakes Protection and Rehabilitation District (CLPRD) originally authorized lakewide systematic point-intercept macrophyte surveys in May and July/August 2009 as part of developing a Wisconsin Department of Natural Resources approved Aquatic Plant Management Plan. At that time, the lakes were mechanically harvesting beds of Curly-leaf pondweed (*Potamogeton crispus*) that dominated the spring littoral zone. However, since then, the lakes have experienced an explosion in their Carp (*Cyprinus carpio*) population, and the fish have devastated the lakes' plants including nearly eliminating CLP on Upper Clam and significantly reducing it on Lower Clam. The Carp had also largely destroyed the expansive Northern wild rice (*Zizania palustris*) beds that formerly occupied large areas in the south bays of Upper Clam Lake. Following the netting and removal of 1,000's of Carp from the lakes in the winters of 2011-2012 and 2013-2014, the St. Croix Tribal Environmental Department (SCTED) and the CLPRD requested follow up warm-water point-intercept surveys in summer 2012 and 2014. Neither of these surveys showed a significant rebound in vegetation (except inside the carp exclosure), but, because there was evidence the carp population had experienced a die-off over the winter in 2014-15 and plants anecdotally appeared to be recovering on the lakes in 2015 and 2016, additional full point-intercept surveys were requested late in the summers of 2015 and 2016. This report is the summary analysis of the September 10-11, 2016 survey.

METHODS:
Warm-water Full Point-intercept Macrophyte Survey:
Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth, islands, and total acreage, Jennifer Hauxwell (WDNR) generated the 668 point sampling grid used for Upper Clam Lake in 2009, 2012, 2014, 2015, and again in 2016 (Appendix I). Prior to beginning the point-intercept survey, we conducted a general boat survey of the lake to regain familiarity with the species present. All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2009; Skawinski 2011), and a data sheet was built from the species present (Appendix II).

During the point-intercept survey, we located each point using a handheld mapping GPS unit (Garmin 76CSx), recorded a depth reading with a metered pole rake or hand held sonar (Vexilar LPS-1), and used a rake to sample an approximately 2.5ft section of the bottom. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of all plants within six feet of the sample point not found in the rake. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

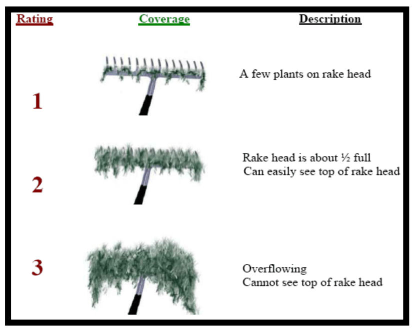


Figure 2: Rake Fullness Ratings (UWEX 2010)

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

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

<u>Total number of sites with vegetation:</u> 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.

<u>Total number of sites shallower than the maximum depth of plants:</u> 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.

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 1).

Relative frequency: This value shows a species' frequency relative to all other species. It is expressed as a percentage, and the total of all species' relative frequency will add up to 100%. Organizing species from highest to lowest relative frequency value gives us an idea of which species are most important within the macrophyte community (Tables 2-3).

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. Upper Clam Lake is in the Northern Lakes and Forests Ecoregion (Tables 4-5).

**** 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 2015 and 2016 warm-water point-intercept surveys (Figures 7) 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, mean rake fullness/point, and individual species densities), we used t-tests. Differences were considered significant at $p < .05$, moderately significant at $p < .01$ and highly significant at $p < .001$ (UWEX 2010). It should be noted that we used the initial number of littoral points from 2009 (661) as the basis for "sample points" as the lake's clarity appeared to be nearly constant over this time, and we felt this gave us the best way to estimate changes that were, presumably, largely caused by carp herbivory or the lack there of.

RESULTS:
Warm-water Full Point-intercept Macrophyte Survey:
Depth soundings taken at Upper Clam's 668 survey points revealed the deepest areas in the lake occur in the middle of the central basin. This 7-9ft groove follows the river channel to the lake outlet on the north side. The southwest bay is a gently sloping flat that angles uniformly from 2 to 7ft towards the south end of the central basin. The southeast bays (behind the Carp exclosure and where the Clam River enters the lake) are also flats that slowly slope from 2 to 5ft before dropping off more rapidly into the central basin west of the islands. The 7-9ft main basin has steeper sides midlake and is generally bowl-shaped with the exception of a sand bar on the eastern shore just north of where the lake narrows. The many north side bays are mostly in the 2-6ft range and tend to slope gradually into the channel (Figure 3) (Appendix III).

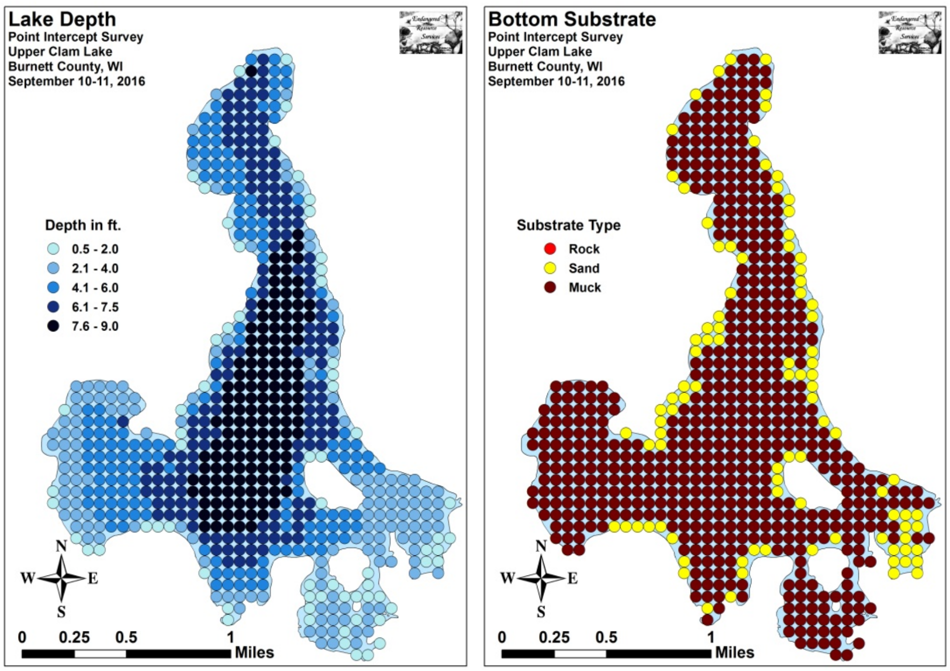


Figure 3: Lake Depth and Bottom Substrate

Bottom sediments in the southwest, south and both southeast bays were dominated by thick organic muck while the main basin was primarily sandy muck. We found pure sugar sand along the big island's shoreline, at the Clam River Inlet, on the midlake bar, and on the margins of the main basin. Of the lake's 668 points, we categorized 573 (85.8%) as being muck or sandy muck and 95 (14.2%) as being pure sand (Figure 3) (Appendix III).

At the time of the survey, Secchi disc readings were in the 2-3ft range. This very poor water clarity produced a littoral zone that extended to 7.5ft and included 523 survey points (Figure 4) (Appendix IV). This was a highly significant increase from 2015 when plants were found to 6.5ft and there were 439 littoral points. Along with the increase in littoral points, we noted the mean depth of plant growth continued a slight upward trend from 2.7ft in 2015 to 3.0ft in 2016; however, the median depth was 3.0ft for both years (Table 1). Lakewide in 2016, 213 points (31.9% of the bottom/40.7% of the littoral zone) were colonized by plants. This was a nearly significant increase (p=0.11) from the 187 points (28.0% of the bottom/42.6% of the littoral zone) with plants in 2015, and a further increase from 153 points with plants in 2014.

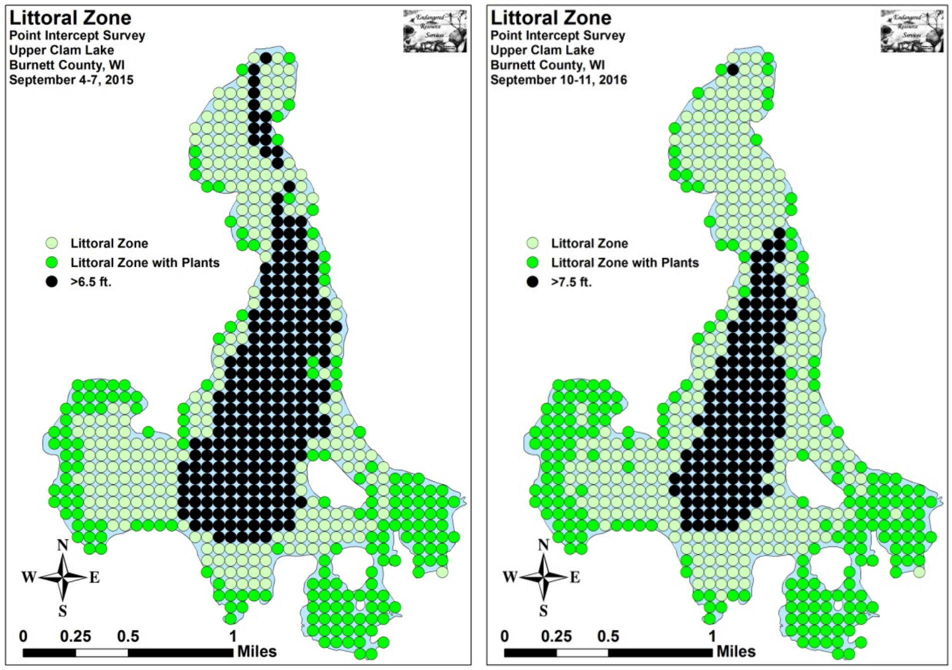


Figure 4: 2015 and 2016 Littoral Zone

**Table 1: Aquatic Macrophyte P/I Survey Summary Statistics
Upper Clam Lake, Burnett Co.
July 26-27, 2009, August 1-3, 2012, August 5-6, 2014, September 4-7, 2015, and September 10-11, 2016**

Summary Statistics:	2009	2012	2014	2015	2016	*p*
Total number of points sampled	668	668	668	668	668	n.s.
Total number of sites with vegetation	218	197	153	187	213	n.s.
Total number of sites shallower than the max. depth of plants	661	650	305	439	523	+***
Freq. of occurrence at sites shallower than max. depth of plants	32.98	30.31	50.16	42.60	40.73	n.s.
Simpson Diversity Index	0.90	0.91	0.92	0.93	0.92	n.s.
Maximum depth of plants (ft)	9.0	8.0	5.0	6.5	7.5	n.s.
Mean depth of plants (ft)	3.3	2.7	2.5	2.7	3.0	n.s.
Median depth of plants (ft)	3.5	3.0	2.5	3.0	3.0	n.s.
Average # of all species per site (shallower than max depth)	0.88	0.93	1.28	1.49	1.33	n.s.
Average # of all species per site (veg. sites only)	2.68	3.07	2.54	3.50	3.25	n.s.
Average # of native species per site (shallower than max depth)	0.88	0.93	1.28	1.49	1.32	n.s.
Average # of native species per site (sites with native veg. only)	2.69	3.06	2.54	3.50	3.24	n.s.
Species richness	37	33	29	30	38	n.s.
Species richness (including visuals)	39	34	32	35	39	n.s.
Species richness (including visuals and boat survey)	43	38	38	40	44	n.s.
Mean total rake fullness (veg. sites only)	1.76	2.09	1.89	2.34	2.36	n.s.

n.s. = Not Significant - Significant differences = * $p < .05$, ** $p < .01$, *** $p < .001$

Diversity was very high at 0.92; down from 0.93 in 2015. Richness jumped from 30 species in the rake in 2015 to 38 in 2016 – the highest ever recorded; however, localized native species richness experienced a nearly significant (p=0.08) decline from 3.50 native species/vegetated site in 2015 to 3.24/site in 2016 (Figure 5) (Appendix IV).

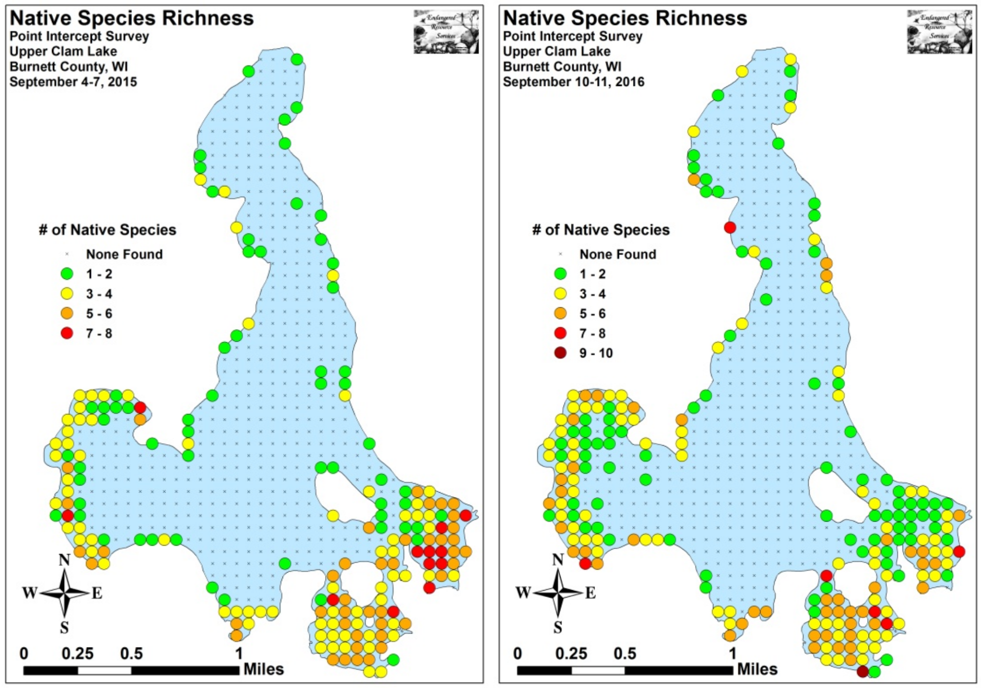


Figure 5: 2015 and 2016 Native Species Richness

Mean rake fullness at sites with vegetation was almost unchanged from a moderately high 2.34 in 2015 to 2.36 in 2016. This similarity was actually a bit deceptive as density behind the Carp exclosure nets declined, but the southwest bay experienced a significant thickening and expansion (Figure 6) (Appendix IV).

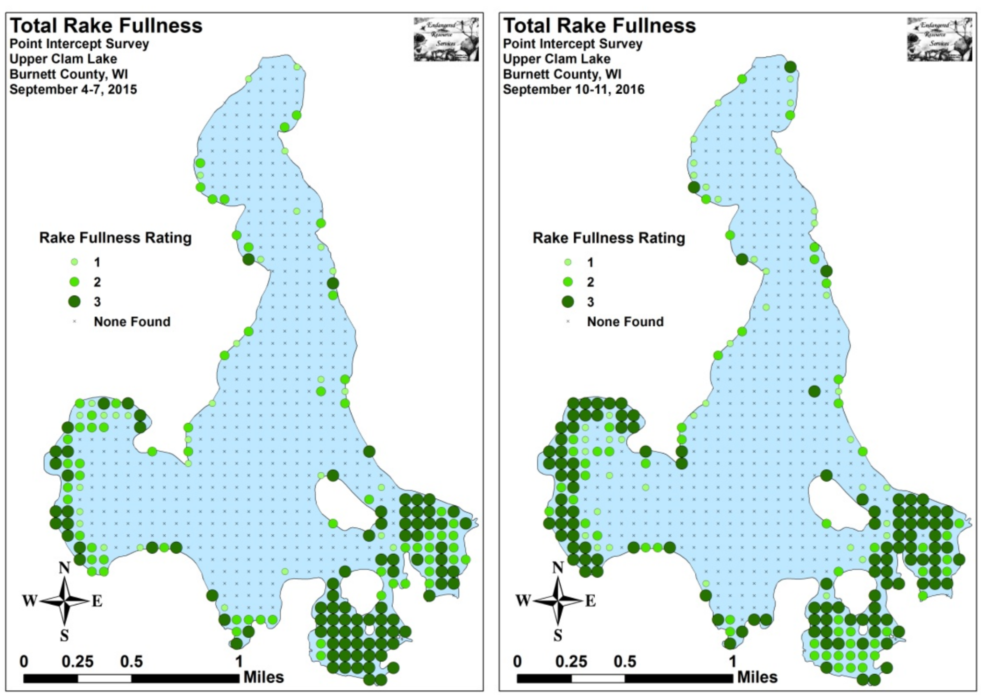


Figure 6: 2015 and 2016 Total Rake Fullness Rating

Comparison of the 2015 and 2016 Plant Communities:

In September 2015, we found Coontail (*Ceratophyllum demersum*), Common waterweed (*Elodea canadensis*), Northern wild rice, and Slender naiad (*Najas flexilis*) to be the most common species (Table 2). They were present at 47.06%, 31.55%, 29.95%, and 29.41% of survey points with vegetation and accounted for 39.45% of the total relative frequency. Wild celery (*Vallisneria americana*) (7.80), Large duckweed (*Spirodela polyrhiza*) (7.65), White water lily (*Nymphaea odorata*) (7.34), Small duckweed (*Lemna minor*) (6.88), Water star-grass (*Heteranthera dubia*) (6.42), and Small pondweed (*Potamogeton pusillus*) (4.28) also had relative frequencies greater than 4.0% (Species accounts and distribution maps for all plants found in 2009, 2012, 2014, and 2015 can be found in the attached CD).

During our 2016 survey, Common waterweed, Coontail, Wild celery, and Northern wild rice were the most common macrophyte species (Table 3). They were present at 46.01%, 39.91%, 38.50%, and 24.88% of survey points with vegetation and accounted for 45.89% of the total relative frequency. Large duckweed (6.93), Water star-grass (6.78), Slender naiad (5.05), and White water lily (4.91) also had relative frequencies greater than 4.0% (Density and distribution maps for all plants found in 2016 can be found in Appendix V).

From 2015 to 2016, eight species experienced significant changes: Common waterweed experienced a highly significant increase; Wild celery and Common watermeal (*Wolffia columbiana*) moderately significant increases; and Water marigold (*Bidens beckii*) a significant increase. Conversely, Small duckweed experienced a highly significant decline; Small pondweed a moderately significant decline; and Slender naiad and Sago pondweed (*Stuckenia pectinata*) significant declines (Figure 7).

Table 2: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Clam Lake, Burnett County
September 4-7, 2015

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sightings
Ceratophyllum demersum	Coontail	88	13.46	47.06	20.05	1.47	5
Elodea canadensis	Common waterweed	59	9.02	31.55	13.44	1.59	1
Zizania palustris	Northern wild rice	56	8.56	29.95	12.76	2.52	15
Najas flexilis	Slender naiad	55	8.41	29.41	12.53	1.53	3
Vallisneria americana	Wild celery	51	7.80	27.27	11.62	2.06	7
Spirodela polyrhiza	Large duckweed	50	7.65	26.74	11.39	1.36	0
Nymphaea odorata	White water lily	48	7.34	25.67	10.93	1.33	24
Lemna minor	Small duckweed	45	6.88	24.06	10.25	1.18	1
Heteranthera dubia	Water star-grass	42	6.42	22.46	9.57	1.48	8
Potamogeton pusillus	Small pondweed	28	4.28	14.97	6.38	1.32	4
	Filamentous algae	24	*	12.83	5.47	1.17	0
Ranunculus aquatilis	White water crowfoot	23	3.52	12.30	5.24	1.13	8
Chara sp.	Muskgrass	14	2.14	7.49	3.19	1.14	0
Nitella sp.	Nitella	13	1.99	6.95	2.96	1.46	0
Stuckenia pectinata	Sago pondweed	13	1.99	6.95	2.96	1.46	3
Myriophyllum sibiricum	Northern water-milfoil	12	1.83	6.42	2.73	1.17	16
Utricularia vulgaris	Common bladderwort	12	1.83	6.42	2.73	1.17	4
Nuphar variegata	Spatterdock	7	1.07	3.74	1.59	1.71	5
Bolboschoenus fluviatilis	River bulrush	6	0.92	3.21	1.37	3.00	4
Potamogeton natans	Floating-leaf pondweed	5	0.76	2.67	1.14	1.60	4
Potamogeton zosteriformis	Flat-stem pondweed	5	0.76	2.67	1.14	1.00	3
Bidens beckii	Water marigold	4	0.61	2.14	0.91	1.50	4
Typha latifolia	Broad-leaved cattail	4	0.61	2.14	0.91	2.00	2

* Algae are excluded from the Relative Frequency Calculation

Table 2 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Clam Lake, Burnett County
September 4-7, 2015

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sightings
Sagittaria rigida	Sessile-fruited arrowhead	3	0.46	1.60	0.68	1.67	4
Sparganium eurycarpum	Common bur-reed	3	0.46	1.60	0.68	2.67	1
Myriophyllum verticillatum	Whorled water-milfoil	2	0.31	1.07	0.46	1.00	1
Ricciocarpus natans	Purple-fringed riccia	2	*	1.07	0.46	1.00	0
Sagittaria latifolia	Common arrowhead	2	0.31	1.07	0.46	2.00	1
Lemna trisulca	Forked duckweed	1	0.15	0.53	0.23	1.00	1
Phragmites australis americanus	Common reed (native)	1	0.15	0.53	0.23	3.00	0
Potamogeton nodosus	Long-leaf pondweed	1	0.15	0.53	0.23	2.00	3
Potamogeton richardsonii	Clasping-leaf pondweed	1	0.15	0.53	0.23	2.00	5
Phalaris arundinacea	Reed canary grass	**	**	**	**	**	1
Potamogeton epihydrus	Ribbon-leaf pondweed	**	**	**	**	**	1
Riccia fluitans	Slender riccia	**	**	**	**	**	1
Schoenoplectus acutus	Hardstem bulrush	**	**	**	**	**	1
Schoenoplectus pungens	Three-square bulrush	**	**	**	**	**	1
Schoenoplectus tabernaemontani	Softstem bulrush	**	**	**	**	**	1
Carex comosa	Bottle brush sedge	***	***	***	***	***	***
Dulichium arundinaceum	Three-way sedge	***	***	***	***	***	***
Eleocharis erythropoda	Bald spikerush	***	***	***	***	***	***
Pontederia cordata	Pickerelweed	***	***	***	***	***	***
Potamogeton crispus	Curly-leaf pondweed	***	***	***	***	***	***

* Aquatic Liverworts are excluded from the Relative Frequency Calculation   ** Visual Only   *** Boat Survey Only

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Clam Lake, Burnett County
September 10-11, 2016

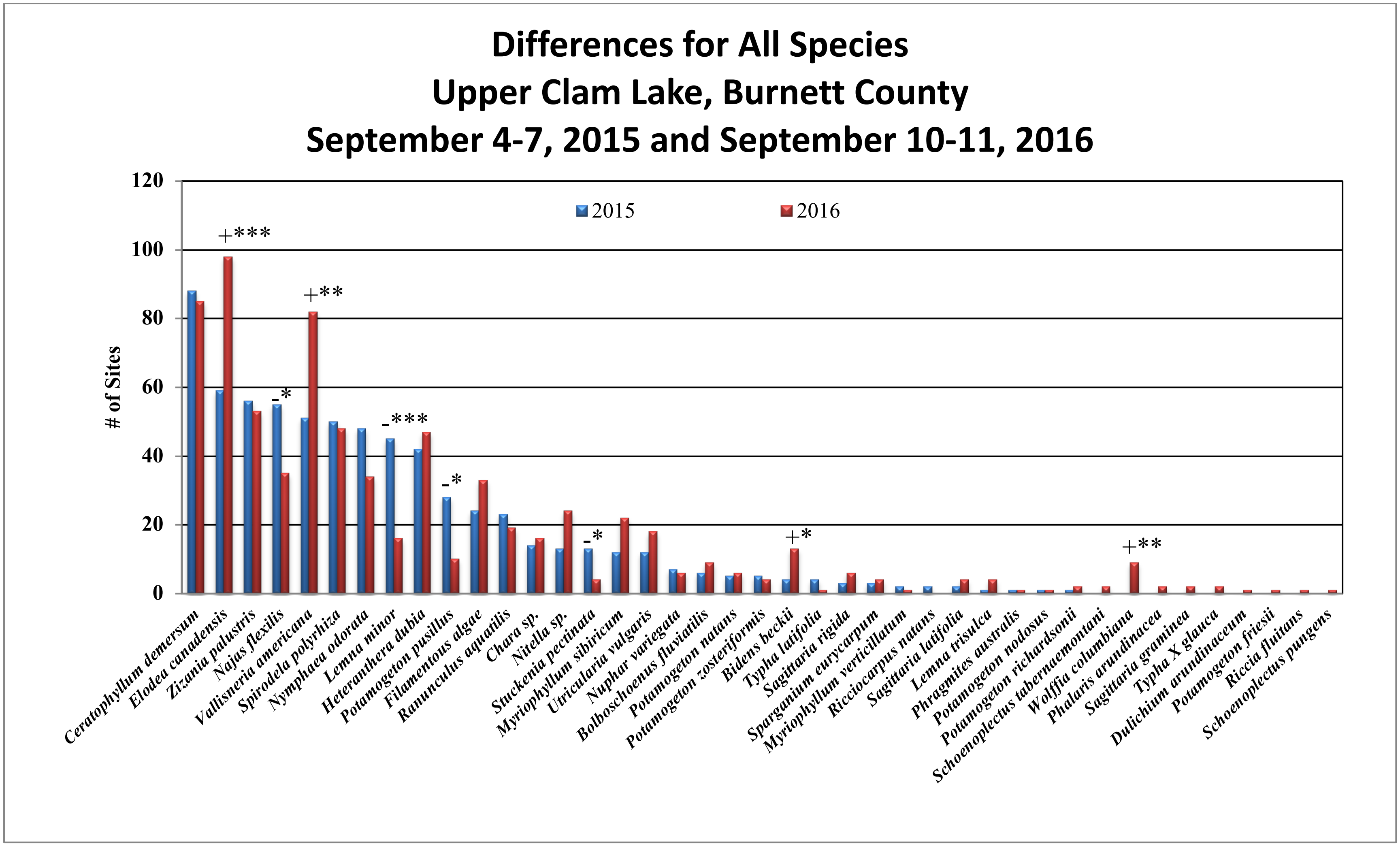
Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sightings
Elodea canadensis	Common waterweed	98	14.14	46.01	18.74	1.83	1
Ceratophyllum demersum	Coontail	85	12.27	39.91	16.25	1.40	7
Vallisneria americana	Wild celery	82	11.83	38.50	15.68	1.96	7
Zizania palustris	Northern wild rice	53	7.65	24.88	10.13	2.15	5
Spirodela polyrhiza	Large duckweed	48	6.93	22.54	9.18	1.21	4
Heteranthera dubia	Water star-grass	47	6.78	22.07	8.99	1.38	6
Najas flexilis	Slender naiad	35	5.05	16.43	6.69	1.46	2
Nymphaea odorata	White water lily	34	4.91	15.96	6.50	1.41	26
	Filamentous algae	33	*	15.49	6.31	1.55	0
Nitella sp.	Nitella	24	3.46	11.27	4.59	1.29	0
Myriophyllum sibiricum	Northern water-milfoil	22	3.17	10.33	4.21	1.05	23
Ranunculus aquatilis	White water crowfoot	19	2.74	8.92	3.63	1.26	1
Utricularia vulgaris	Common bladderwort	18	2.60	8.45	3.44	1.06	0
Chara sp.	Muskgrass	16	2.31	7.51	3.06	1.19	0
Lemna minor	Small duckweed	16	2.31	7.51	3.06	1.06	0
Bidens beckii	Water marigold	13	1.88	6.10	2.49	1.15	3
Potamogeton pusillus	Small pondweed	10	1.44	4.69	1.91	1.00	2
Bolboschoenus fluviatilis	River bulrush	9	1.30	4.23	1.72	2.44	1
Wolffia columbiana	Common watermeal	9	1.30	4.23	1.72	1.00	0
Nuphar variegata	Spatterdock	6	0.87	2.82	1.15	1.50	8
Potamogeton natans	Floating-leaf pondweed	6	0.87	2.82	1.15	1.83	6
Sagittaria rigida	Sessile-fruited arrowhead	6	0.87	2.82	1.15	1.33	4
Lemna trisulca	Forked duckweed	4	0.58	1.88	0.76	1.25	0

* Algae are excluded from the Relative Frequency Calculation

Table 3 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Upper Clam Lake, Burnett County
September 10-11, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sightings
Potamogeton zosteriformis	Flat-stem pondweed	4	0.58	1.88	0.76	1.00	2
Sagittaria latifolia	Common arrowhead	4	0.58	1.88	0.76	1.25	0
Sparganium eurycarpum	Common bur-reed	4	0.58	1.88	0.76	2.00	0
Stuckenia pectinata	Sago pondweed	4	0.58	1.88	0.76	1.50	0
Phalaris arundinacea	Reed canary grass	2	0.29	0.94	0.38	1.00	1
Potamogeton richardsonii	Clasping-leaf pondweed	2	0.29	0.94	0.38	1.00	1
Sagittaria graminea	Grass-leaved arrowhead	2	0.29	0.94	0.38	1.50	1
Schoenoplectus tabernaemontani	Softstem bulrush	2	0.29	0.94	0.38	1.50	0
Typha X *glauca*	Hybrid cattail	2	0.29	0.94	0.38	3.00	0
Dulichium arundinaceum	Three-way sedge	1	0.14	0.47	0.19	1.00	0
Myriophyllum verticillatum	Whorled water-milfoil	1	0.14	0.47	0.19	1.00	1
Phragmites australis	Common reed	1	0.14	0.47	0.19	1.00	0
Potamogeton friesii	Fries' pondweed	1	0.14	0.47	0.19	1.00	0
Potamogeton nodosus	Long-leaf pondweed	1	0.14	0.47	0.19	2.00	2
Riccia fluitans	Slender riccia	1	*	0.47	0.19	2.00	0
Schoenoplectus pungens	Three-square bulrush	1	0.14	0.47	0.19	2.00	0
Typha latifolia	Broad-leaved cattail	1	0.14	0.47	0.19	2.00	0
Equisetum fluviatile	Water horsetail	**	**	**	**	**	1
Carex comosa	Bottle-brush sedge	***	***	***	***	***	***
Eleocharis erythropoda	Bald spikerush	***	***	***	***	***	***
Pontederia cordata	Pickerelweed	***	***	***	***	***	***
Potamogeton epihydrus	Ribbon-leaf pondweed	***	***	***	***	***	***
Schoenoplectus acutus	Hardstem bulrush	***	***	***	***	***	***

* Aquatic Liverworts are excluded from the Relative Frequency Calculation ** Visual Only *** Boat Survey Only



Significant differences = * *p* < .05, ** *p* < .01, * *p* < .001**

Figure 7: 2015 – 2016 Macrophyte Changes

Coontail was the second most common species in 2016 (85 sites) after being the most common species in 2014 (58 sites) and 2015 (88 sites) (Figure 8). Along with this non-significant decline in distribution, it also experienced a non-significant decline in density from a mean rake of 1.47 in 2015 to a mean rake of 1.40 in 2016. However, it was still above the mean of 1.31 in 2014. Visual analysis of the maps suggested there was little change with this species anywhere on the lake.

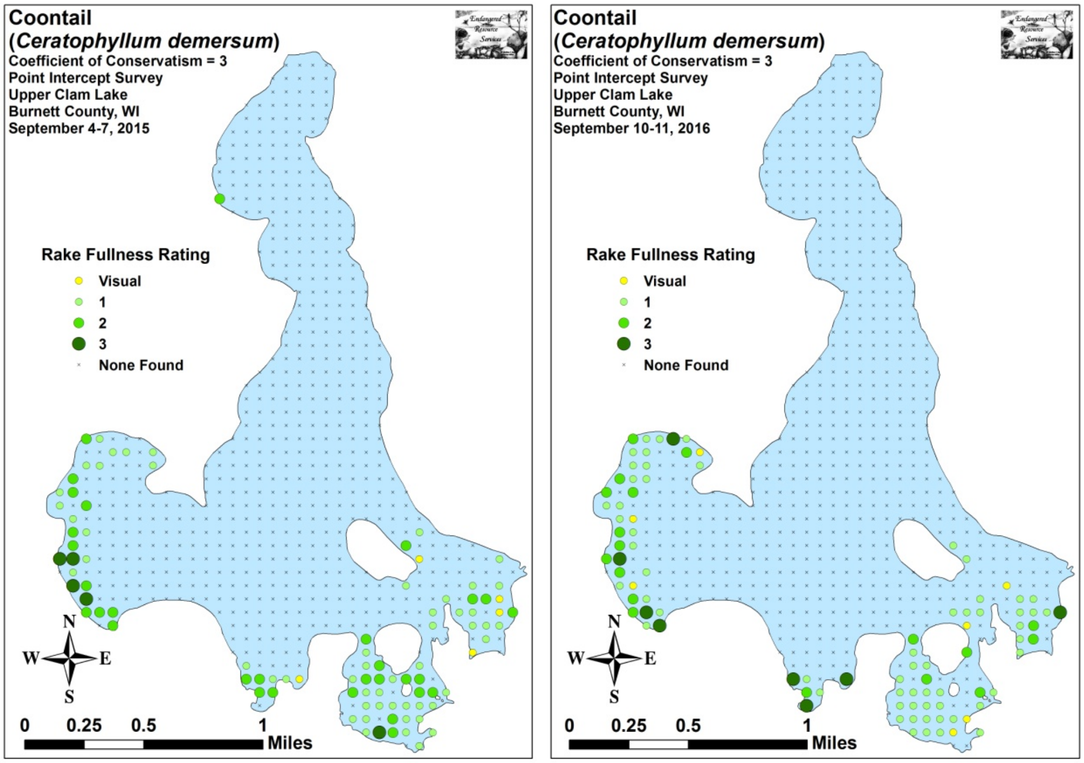


Figure 8: 2015 and 2016 Coontail Density and Distribution

Common waterweed has experienced significant fluctuations in both density and distribution on Upper Clam Lake. In 2009, it was found at just two points with each having a rake fullness of 1; but, by 2012, it had experienced a highly significant increase in both distribution and density to become the fourth most common species (66 sites with a mean rake of 1.79). The 2014 survey found it had crashed again with highly significant declines in both distribution (present at 13 sites) and density (mean rake of 1.23). Fortunately, the 2015 survey found it had experienced another highly significant increase in distribution (***p* < 0.001**) to become the second most common species (59 sites) (Figure 9). This was also accompanied by a significant increase in density (***p* = 0.03**) to a mean rake of 1.59. In 2016, it experienced another highly significant increase in its distribution (***p* < 0.001**) to become the most common species on the lake (98 sites). It also significantly increased in density (***p* = 0.03**) to a mean rake fullness of 1.83. Almost all of this expansion occurred in the southwest bay where it nearly completely domination of the nearshore littoral zone.

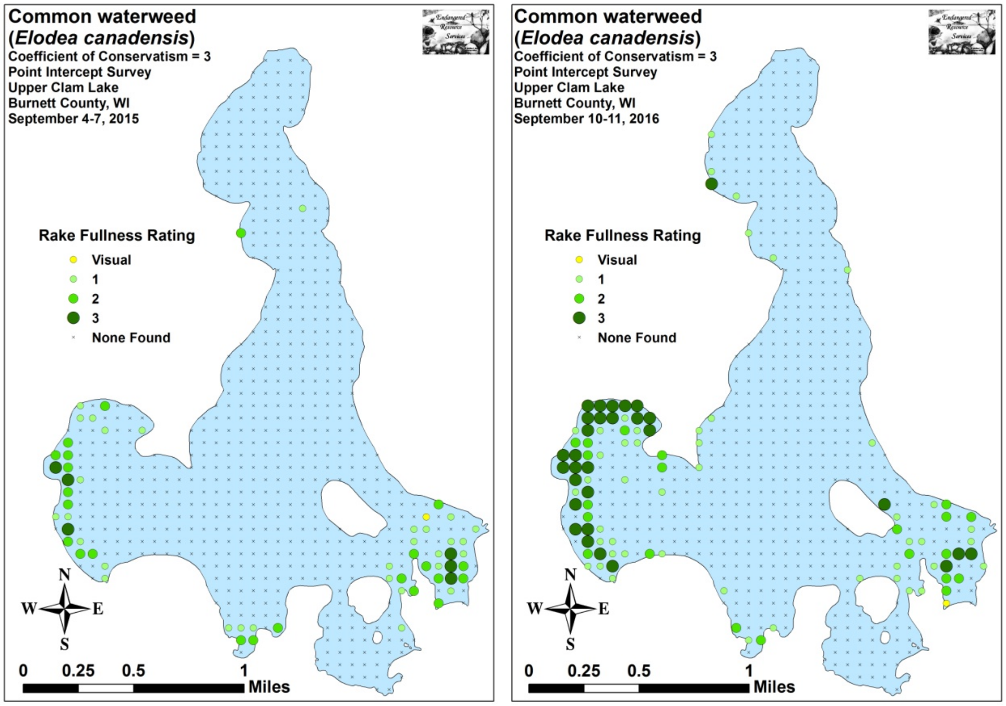


Figure 9: 2015 and 2016 Common Waterweed Density and Distribution

In 2009, Wild celery was present at 10 points with a mean rake fullness of 1.14 - tied for just the 14th most widely distributed species on the lake. Since then, it has undergone a continuous expansion while generally increasing in density (2012 – 14 points/mean rake 1.00; 2014 – 32 points/mean rake 2.13; 2015 – 51 points/mean rake 2.06). In 2016, we found it at 82 sites (3rd most common species) with a mean rake of 1.96 (Figure 10).

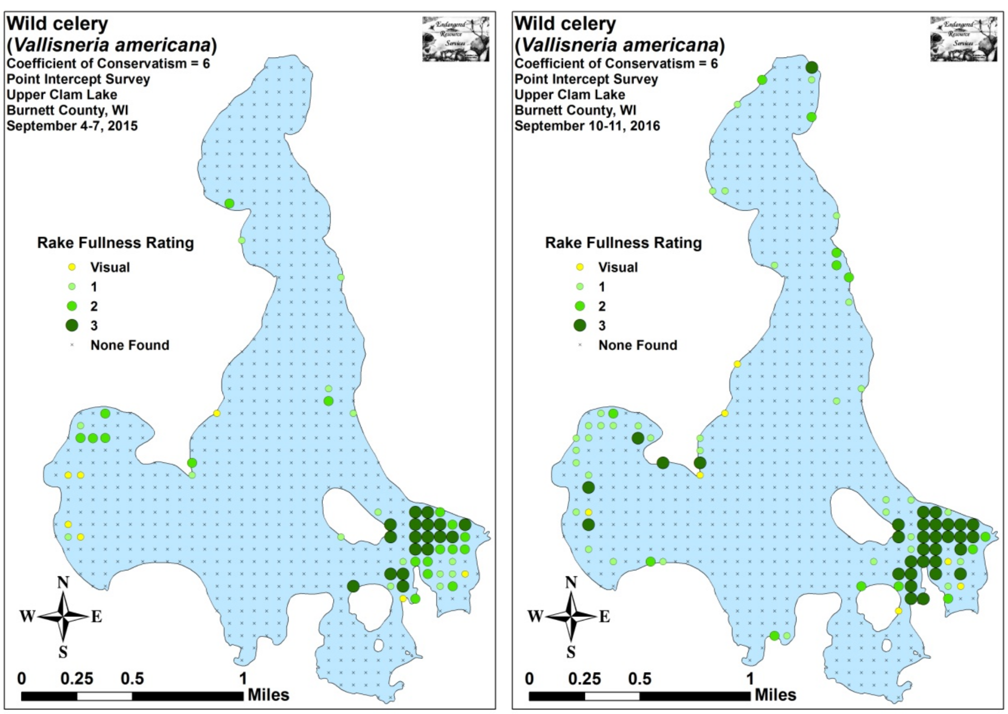


Figure 10: 2015 and 2016 Wild Celery Density and Distribution

In 2015, we identified a total of 30 **native index species** in the rake during the point-intercept survey (Table 4). They produced a mean Coefficient of Conservatism of 5.6 and a Floristic Quality Index of 30.5. Nichols (1999) reported an average mean C for the Northern Lakes and Forest Ecoregion of 6.7 and a median FQI of 24.3. This put Upper Clam Lake well below the average mean C, but slightly above the median FQI for lakes in this part of the state.

Table 4: Floristic Quality Index of Aquatic Macrophytes
Upper Clam Lake, Burnett County
September 4-7, 2015

Species	Common Name	C
Bidens beckii	Water marigold	8
Bolboschoenus fluviatilis	River bulrush	6
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum verticillatum	Whorled water-milfoil	8
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Phragmites australis	Common reed	1
Potamogeton natans	Floating-leaf pondweed	5
Potamogeton nodosus	Long-leaf pondweed	7
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8
Sagittaria latifolia	Common arrowhead	3
Sagittaria rigida	Sessile-fruited arrowhead	8
Sparganium eurycarpum	Common bur-reed	5
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Typha latifolia	Broad-leaved cattail	1
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
Zizania palustris	Northern wild rice	8
N		**30**
Mean C		**5.6**
FQI		**30.5**

During the 2016 point-intercept survey, each of these values increased. We identified 38 **native index species** in the rake that produced a mean Coefficient of Conservatism of 5.7 and a Floristic Quality Index of 34.9 (Table 5).

Table 5: Floristic Quality Index of Aquatic Macrophytes Upper Clam Lake, Burnett County September 10-11, 2016

Species	Common Name	C
Bidens beckii	Water marigold	8
Bolboschoenus fluviatilis	River bulrush	6
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Dulichium arundinaceum	Three-way sedge	9
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Myriophyllum verticillatum	Whorled water-milfoil	8
Najas flexilis	Slender naiad	6
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Phragmites australis	Common reed	1
Potamogeton friesii	Fries' pondweed	8
Potamogeton natans	Floating-leaf pondweed	5
Potamogeton nodosus	Long-leaf pondweed	7
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8
Riccia fluitans	Slender riccia	7
Sagittaria graminea	Grass-leaved arrowhead	9
Sagittaria latifolia	Common arrowhead	3
Sagittaria rigida	Sessile-fruited arrowhead	8
Schoenoplectus pungens	Three-square bulrush	5
Schoenoplectus tabernaemontani	Softstem bulrush	4
Sparganium eurycarpum	Common bur-reed	5
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Typha latifolia	Broad-leaved cattail	1
Typha X glauca	Hybrid cattail	1
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
Wolffia columbiana	Common watermeal	5
Zizania palustris	Northern wild rice	8
N		**38**
Mean C		**5.7**
FQI		**34.9**

Northern Wild Rice:

The 2009 survey found Northern wild rice in the rake at just five points all of which had a rake fullness value of 1 (Figure 11). Following the placement of the Carp exclosure nets in 2012, rice experienced a highly significant increase in both distribution (34 sites) and density (mean rake fullness of 2.21). In 2014, the number of points with rice experienced a non-significant increase again to 46 points, but a significant decline in density to a mean rake of 1.80 ($\boldsymbol{p} = \mathbf{0.02}$). Most of the 2014 increase occurred near the river inlet while the rice inside the exclosures was much reduced in density; especially on the west side where broad areas had open water with no rice at all. The 2015 survey found rice in the rake at 56 points, another non-significant increase ($p = 0.30$) in distribution. We also recorded it as a visual at 15 points. Density jumped to a mean rake fullness of 2.52 – a highly significant increase from 2014 ($\boldsymbol{p} < \mathbf{0.001}$). In 2016, we found rice at 53 points with five additional visual sightings. Although this decline in distribution wasn't significant, the decline in density to a mean rake fullness of 2.15 was moderately significant ($\boldsymbol{p} = \mathbf{0.003}$).

We found the changes in rice density and distribution were not uniform. In the southwest end of the lake's southwest bay, we noted a further expansion in both density and distribution of the low to moderately dense rice that ringed much of the bay's immediate shoreline (Figure 12). In 2015, we saw many uprooted rice plants on the outer edges of the bed in this area, but that was not the case in 2016. Anecdotally, this suggests there were fewer Carp, and it could also explain why the rice increased here while declining elsewhere.

During the 2015 survey, we found a dense rice bed extending from the lake back up the creek in the southern midlake bay. Although limited in size, at that time, it would have made for profitable human harvest as it was so thick that we were unable to pole the boat through the area. In 2016, we found the rice density had fallen to the point that we were able to pole through the area, and there were really no places that had human harvest potential. Despite this, significant numbers of rice plants were still found along both the eastern, southern (Figure 13) and southwest (Figure 14) shorelines of the bay.

Wild rice was again present throughout the entire southeast bay behind the Carp exclosure. Although patchier and somewhat less dense than in 2015 (Figure 15), there was still so much rice that the only way we could access the points was by canoe/push pole. Even this was especially difficult near the southeast entrance to the bay where the rice was denser than anywhere else and nearly as dense as the levels seen in 2015 (Figures 16 and 17). Elsewhere, the majority of the bay was moderately dense, but with occasional gaps of open water – similar to pictures taken from the south shoreline of the bay (Figure 18).

As in 2015, all of the grain had fallen by the time of the survey. If this hadn't been the case, we would have needed to stop and empty the canoe regularly. Surprisingly, we only saw one canoe harvest trail through the bed.

Outside the exclosure and extending back towards the Clam River inlet, rice was still present, but was both less common and less dense than in 2015. This was especially true along the shoreline north and east of the inlet.

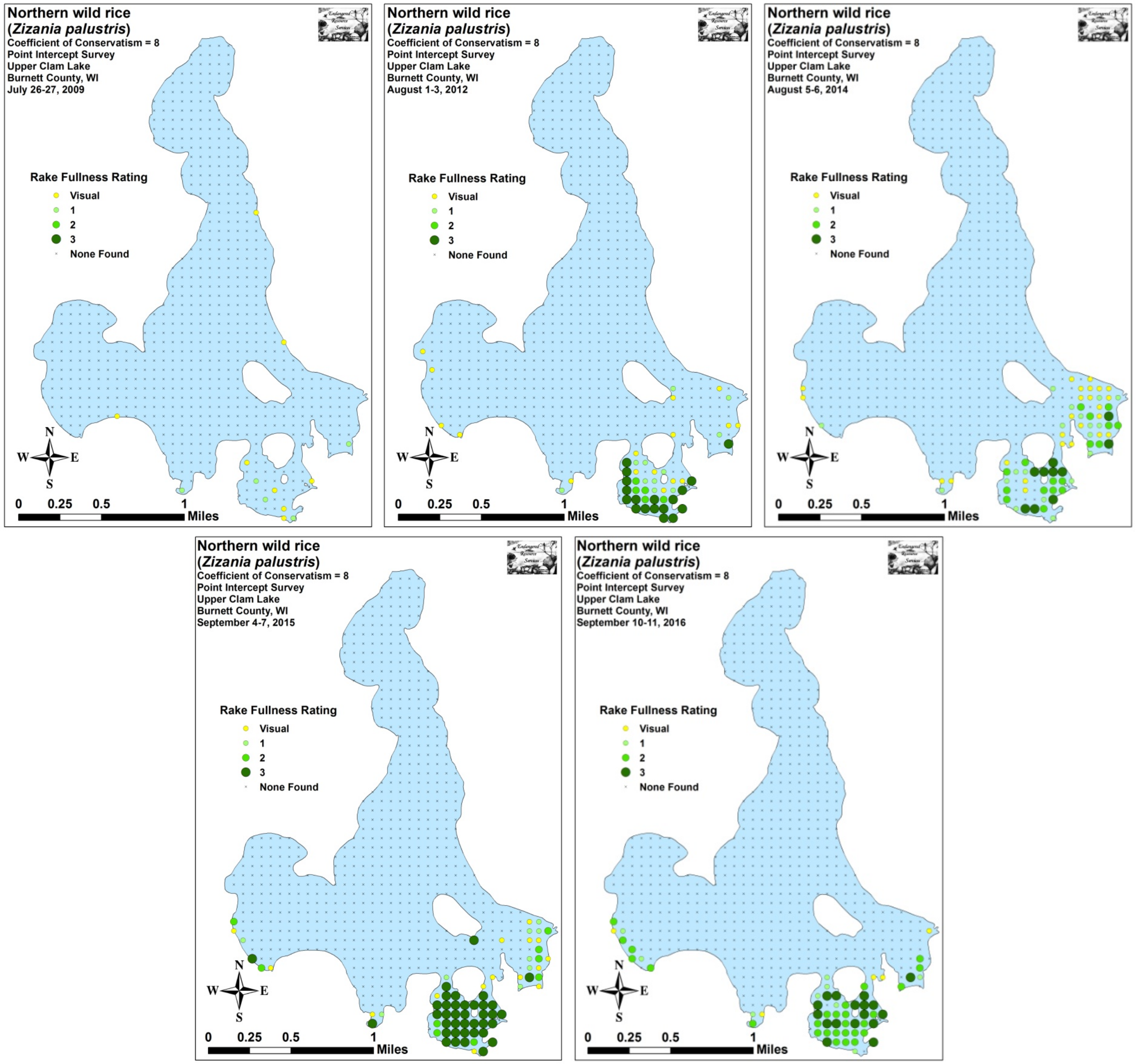


Figure 11: 2009, 2012, 2014, 2015, and 2016 Northern Wild Rice Density and Distribution

Figure 12: Panorama of Northern Wild Rice in the Southwest End of the Southwest Bay 9/10/16

Figure 13: Panorama of Northern Wild Rice on the East Shoreline of the South Bay Midlake 9/10/16 – Highest Rice Density in the South End of the South Bay

Figure 14: Panorama of Northern Wild Rice on the Southwest Shoreline of the South Bay Midlake 9/10/16

Figure 15: Visual Comparison of Rice Density Behind Exclosure - 9/7/15 and 9/11/16

Figure 16: Panorama of Northern Wild Rice from SE Side of Exclosure Facing West 9/11/16

Figure 17: Panorama of Northern Wild Rice from SE Side of Exclosure Facing North 9/11/16

Figure 18: Panorama of Northern Wild Rice from the South End of the Exclosure Facing North 9/11/16

Exotic Species:

We did not see Curly-leaf pondweed anywhere on Upper Clam Lake in 2016. Likewise, Purple loosestrife, a species which is present around Lower Clam Lake, along the Clam River, and in undeveloped areas of the Clam Flowage, was still absent from the Upper Clam Lake shoreline.

As in the past, we found Reed canary grass growing in scattered nearshore locations; especially along the edge of mowed and otherwise disturbed shorelines. A common species that was more often seen growing out of the water than in it, the survey map tells little about its actual distribution around the lake (Figure 19) (Appendix VII).

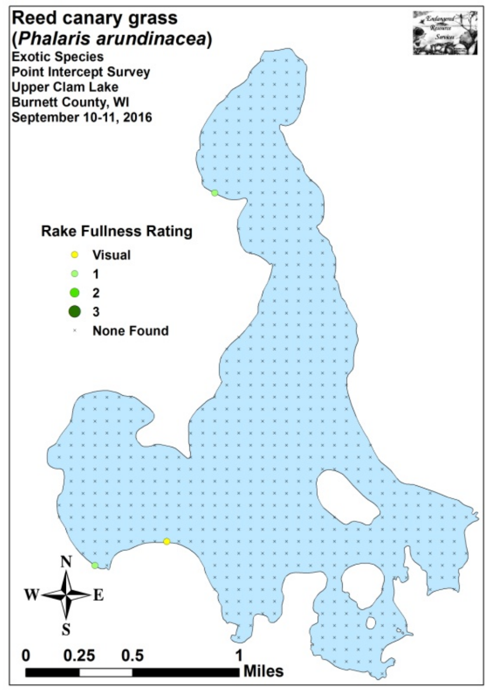


Figure 19: Reed Canary Grass and 2016 Density and Distribution

Narrow-leaved cattail (*Typha angustifolia*) is a species that is native to southern but not northern Wisconsin. It, along with its hybrids with Broad-leaved cattail (*Typha latifolia*), tend to be invasive, and, unfortunately, we found Hybrid cattail (*Typha* X *glauca*) at two sites in the southeast bay. This is the first time we have noticed the species on the lake, and we noted it appeared to be rapidly expanding and replacing native Broad-leaved cattails around the shoreline inside the Carp exclosure (Figure 20).

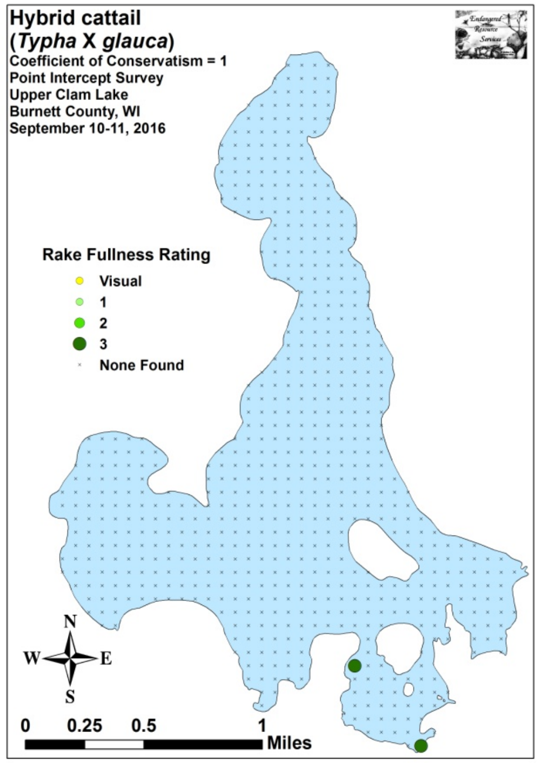


Figure 20: 2016 Hybrid Cattail Density and Distribution

Besides having narrower leaves, the exotic cattails can be told from our native cattails by having a relatively narrower and longer “hotdog-shaped” tan female cattail flower; whereas our native species tends to produce a fatter and shorter “bratwurst-shaped” dark chocolate colored female flower. Narrow-leaved cattail and its hybrids also have a male flower that is separated from the female flower by a thin green stem, while the native Broad-leaved cattail has its male and female flowers connected (Figure 21).

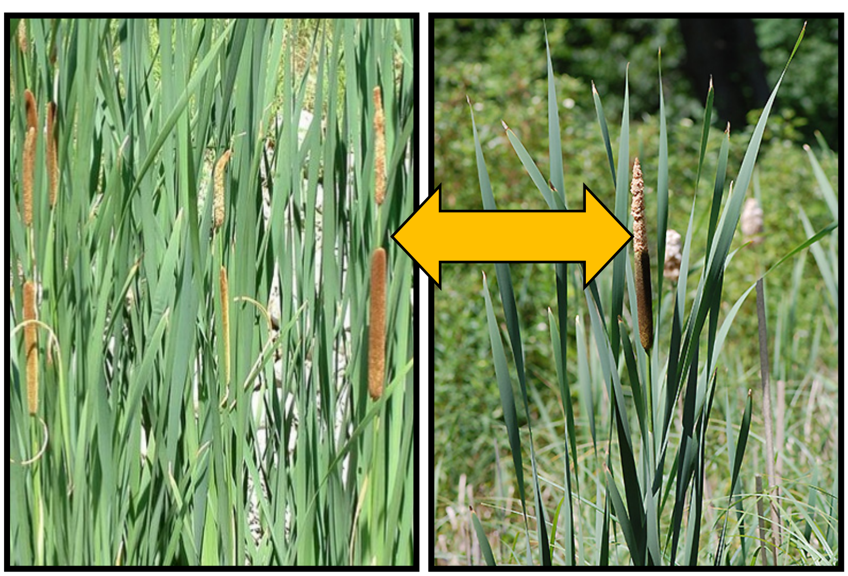


Figure 21: Exotic Hybrid and Native Broad-leaved Cattail Identification

Common reed (*Phragmites australis*), a potentially highly invasive species in its exotic form, is also found on Upper Clam Lake. Fortunately, careful analysis of the plants present showed their leaf sheaths are detached, and the culms (stems) are red in color. These characteristics suggest it is the native subspecies *americanus* which is NOT generally invasive. The bed also has native plants mixed in with it, has occurred at the same location on the lake since our first survey in 2009, and, anecdotally at least, doesn't seem to be expanding. Although the bed deserves to be looked at again in the future, based on all these considerations, we aren't overly concerned about its presence at this time.

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Native Plant Community:

Upper Clam Lake plant community continued its recovery in 2016 with a further increase in vegetated area and total species richness; all while maintaining a moderately high mean rake fullness. Because these rooted plants absorb nutrients out of the water column, an increase in their numbers should also result in an increase in water clarity. Unfortunately, we again noticed that no Secchi Disc data has been taken on the lake since 2011. It would be helpful to monitor this as it is a quick and inexpensive way to track changes in water clarity, and would be useful to compare with plant data assuming the lake's macrophytes continue to rebound.

Carp and Wild Rice Management:

After an exceptional rice crop in 2015, the decline in rice density behind the exclosure we documented in 2016 seemed a bit disappointing. We still saw no evidence of Carp behind the nets so the drop-off in production may simply be tied to rice's natural population cycle. It might also have been impacted by the high water event from the extended period of heavy rain in July 2016. Regardless if it was either of these, a combination, or some other unknown factor altogether, there was still plenty of grain producing plants in the bay. Because so little of the 2016 crop was harvested by people (we again saw just a single human harvest trail through the bed), and because there didn't seem to be any Carp left behind the exclosure, there should be plenty of seed in the substrate for 2017. Outside the exclosure, assuming the Carp population really has crashed, we expect the expansion of the rice beds to continue in 2017. Despite this expected natural expansion, especially in the southwest bay, additional human seedings could potentially accelerate the rice population's recovery.

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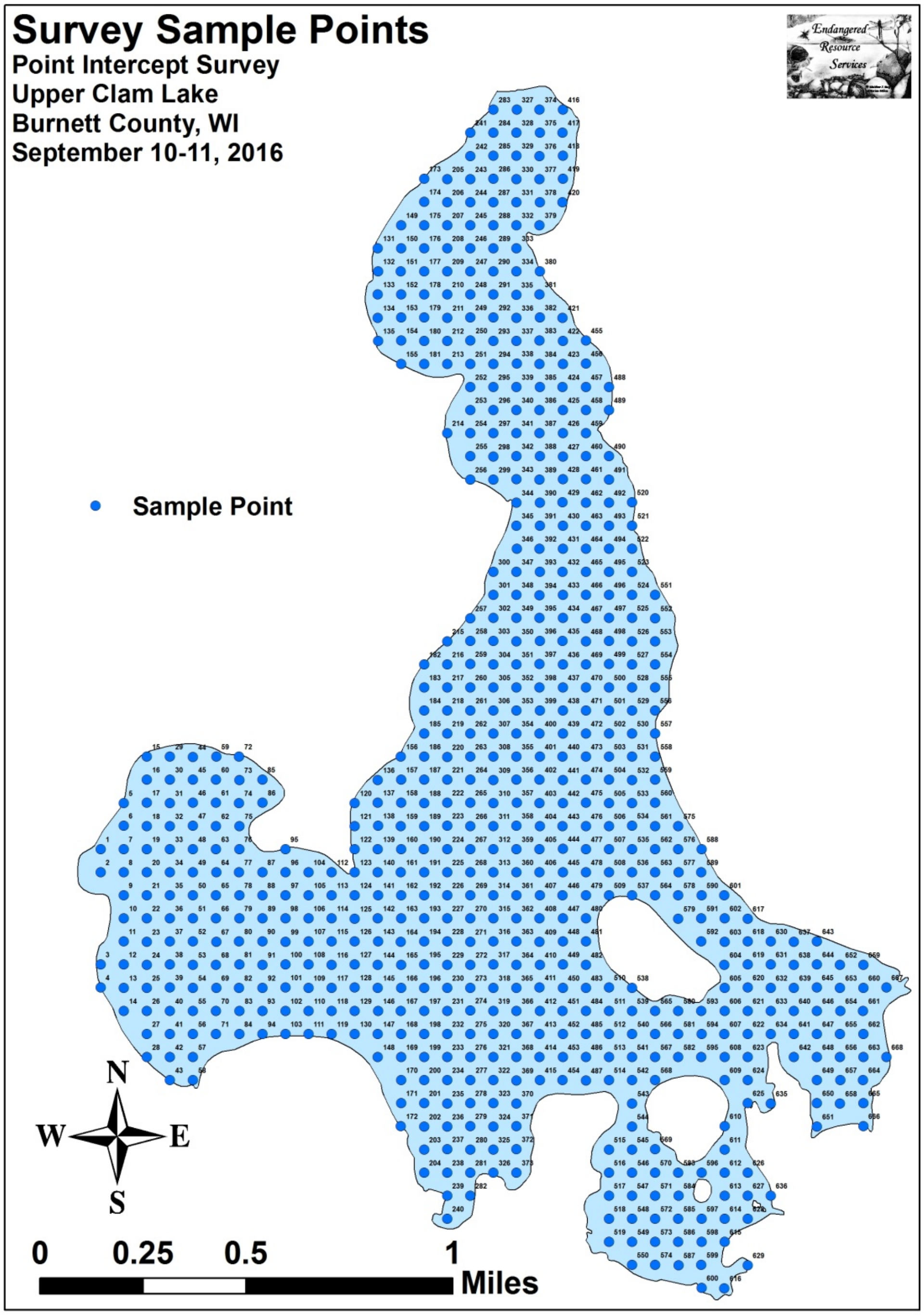
Appendix I: Upper Clam Lake Survey Sample Points


Survey Sample Points
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Sample Point
N
W
E
S
0
0.25
0.5
1
Miles

Appendix II: Boat and Vegetative Survey Data Sheets

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

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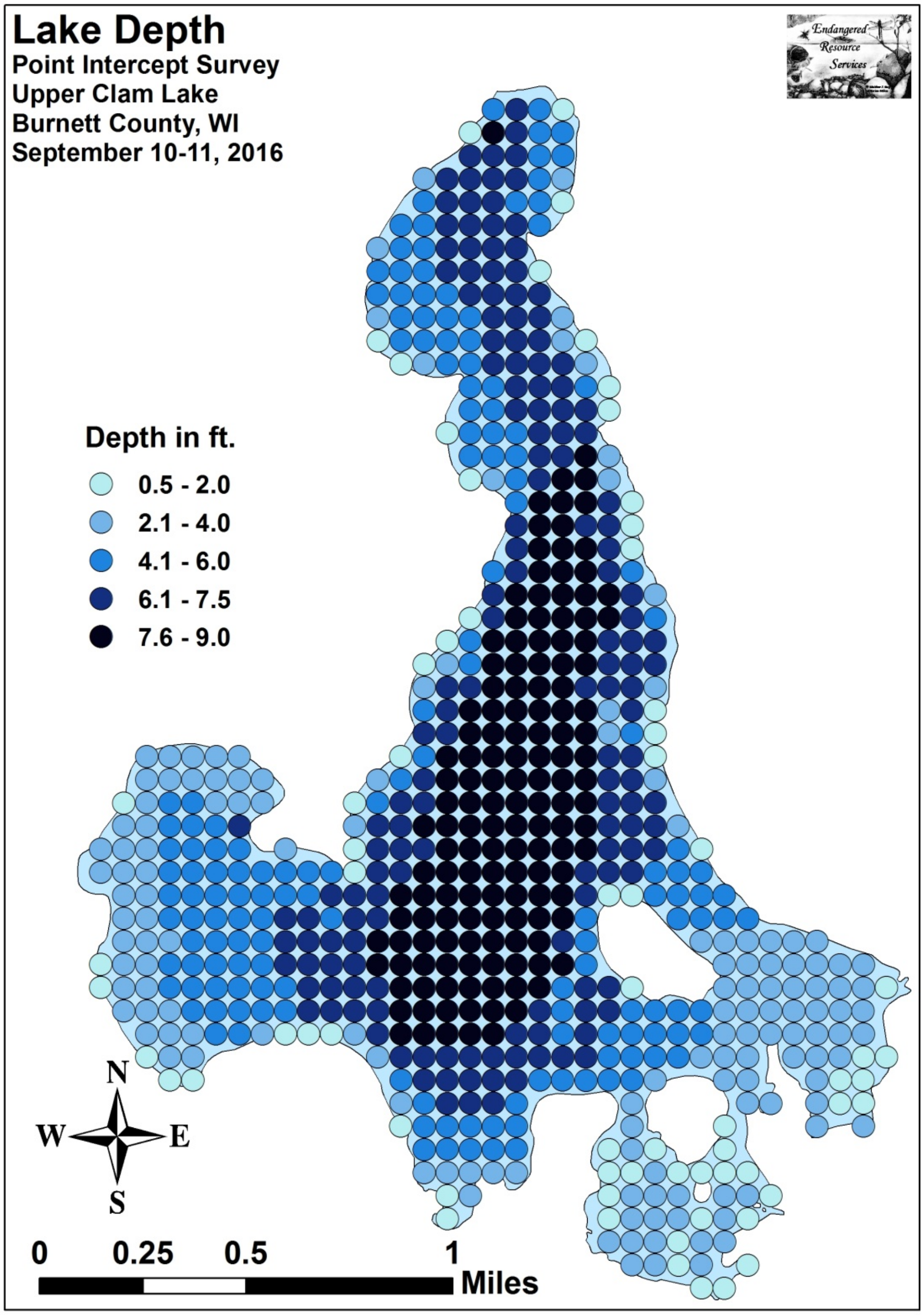
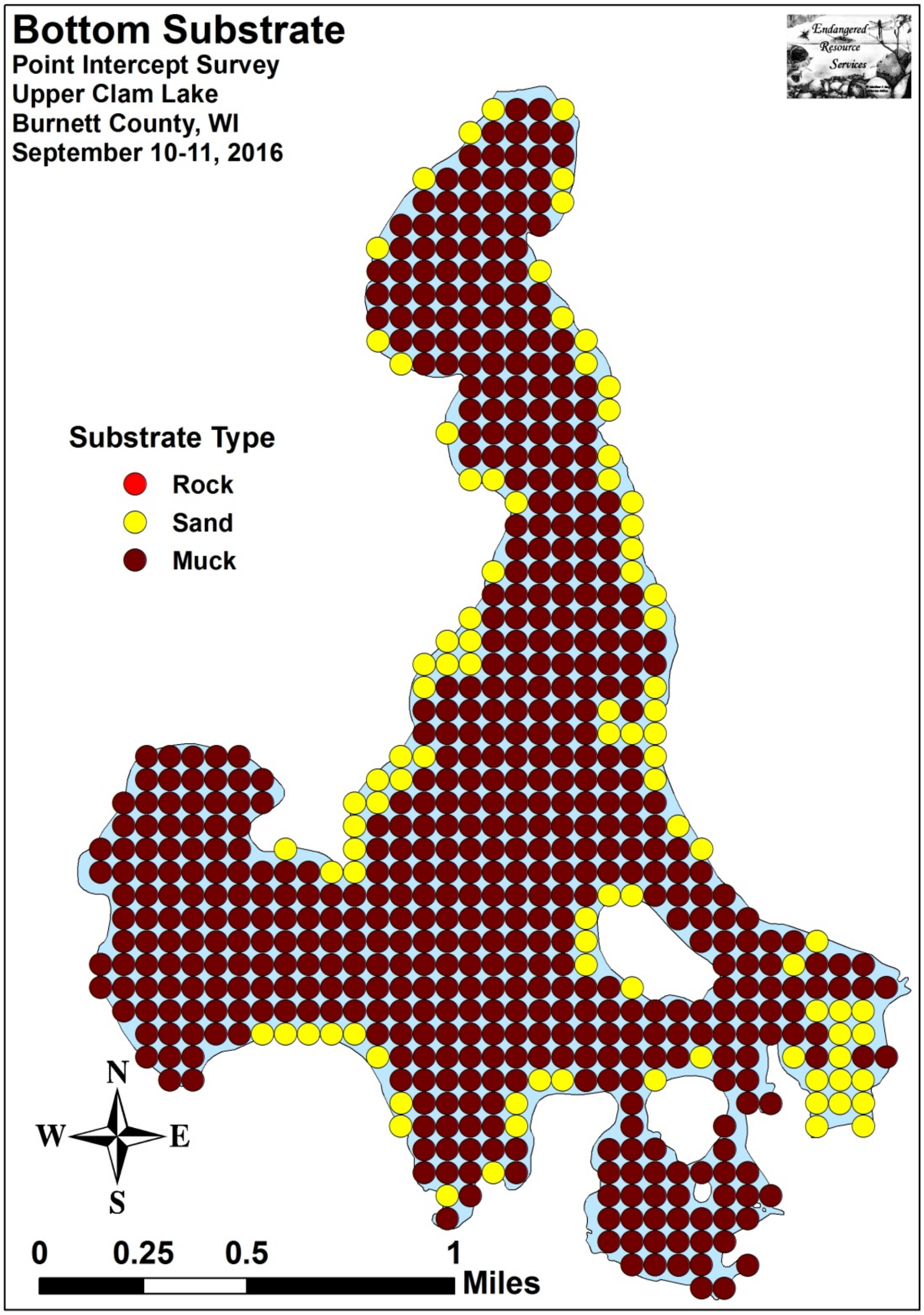
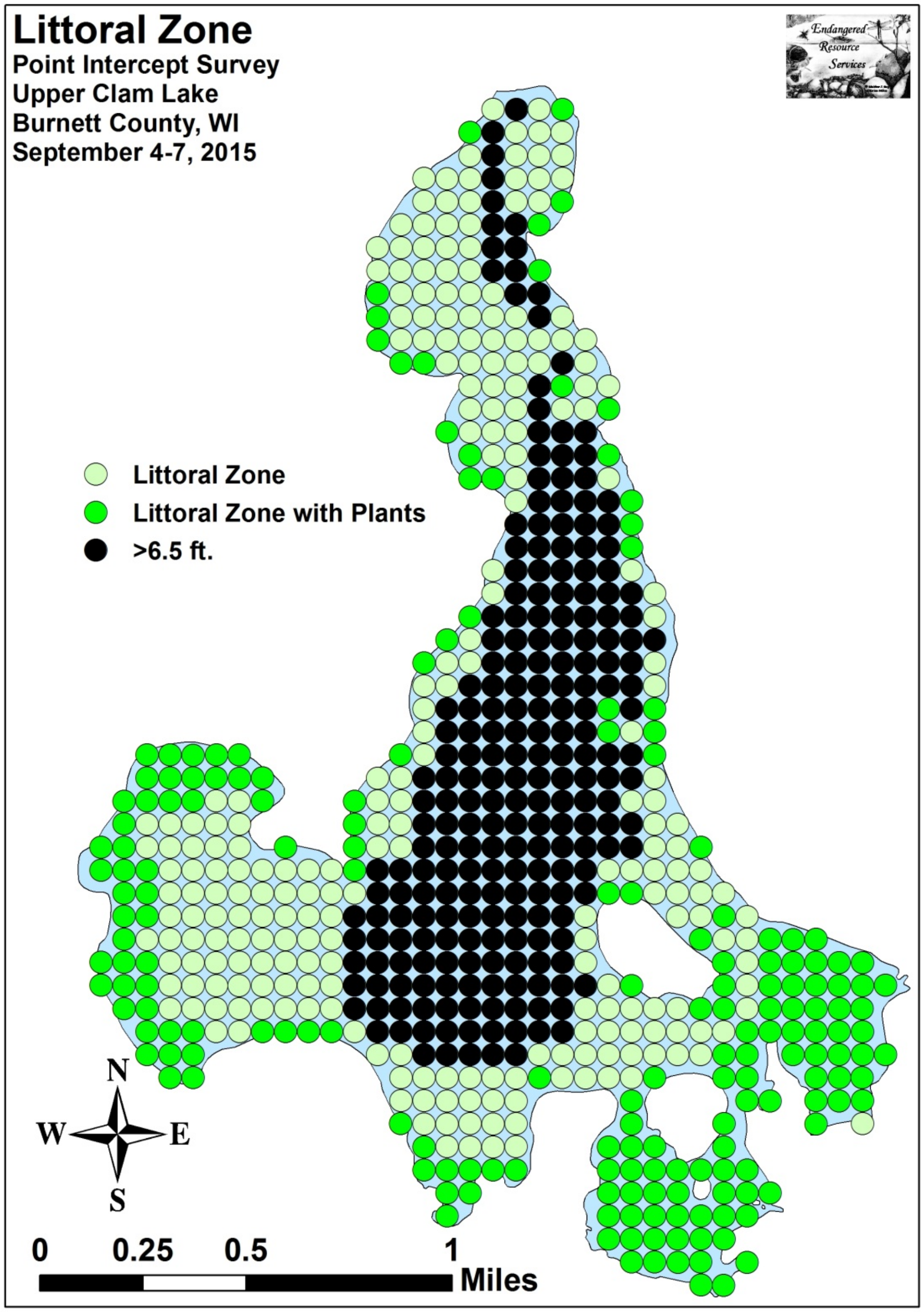
Appendix III: Habitat Variable Maps

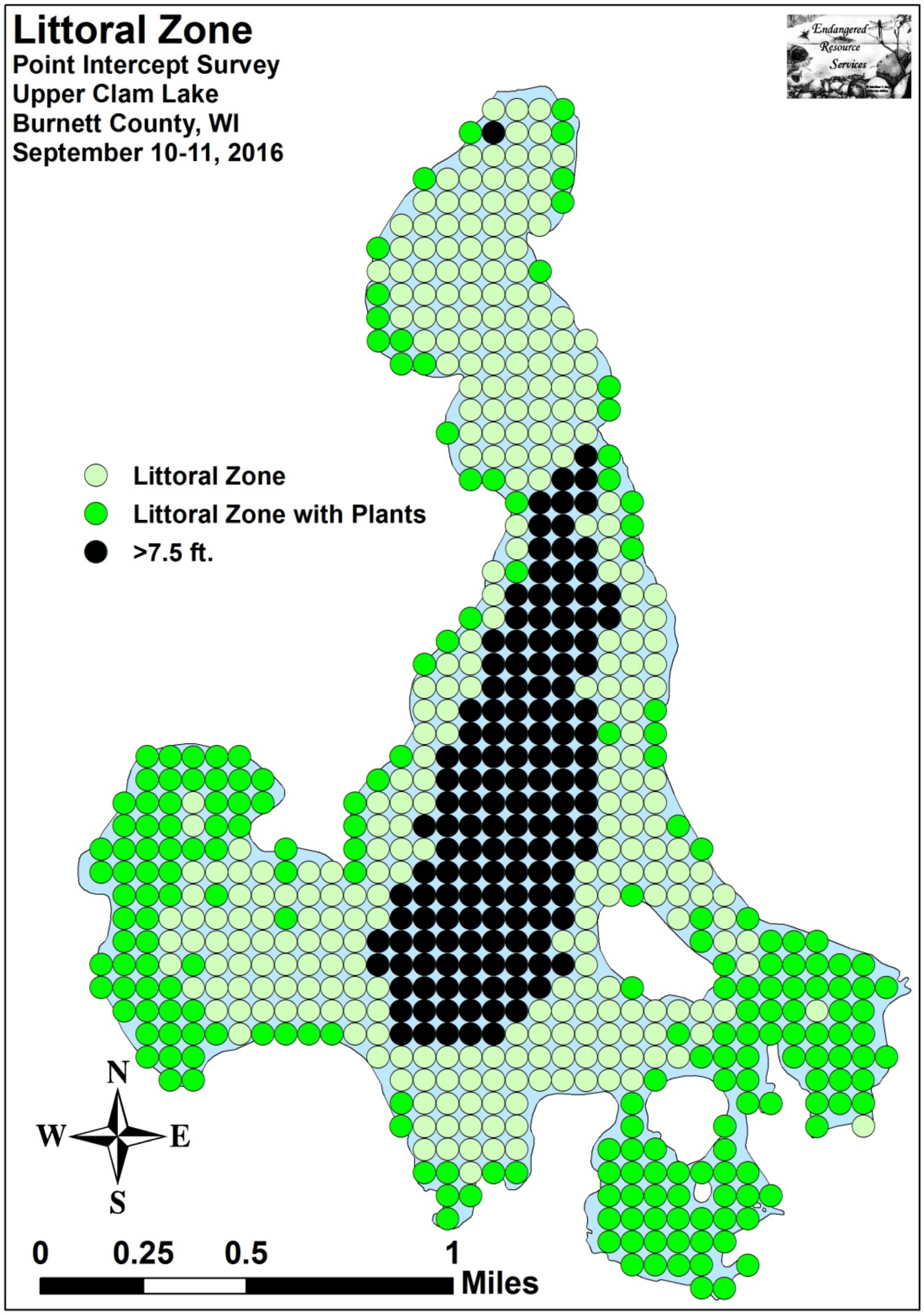

Lake Depth
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Depth in ft.
0.5 - 2.0
2.1 - 4.0
4.1 - 6.0
6.1 - 7.5
7.6 - 9.0
N
W
E
S
0
0.25
0.5
1
Miles

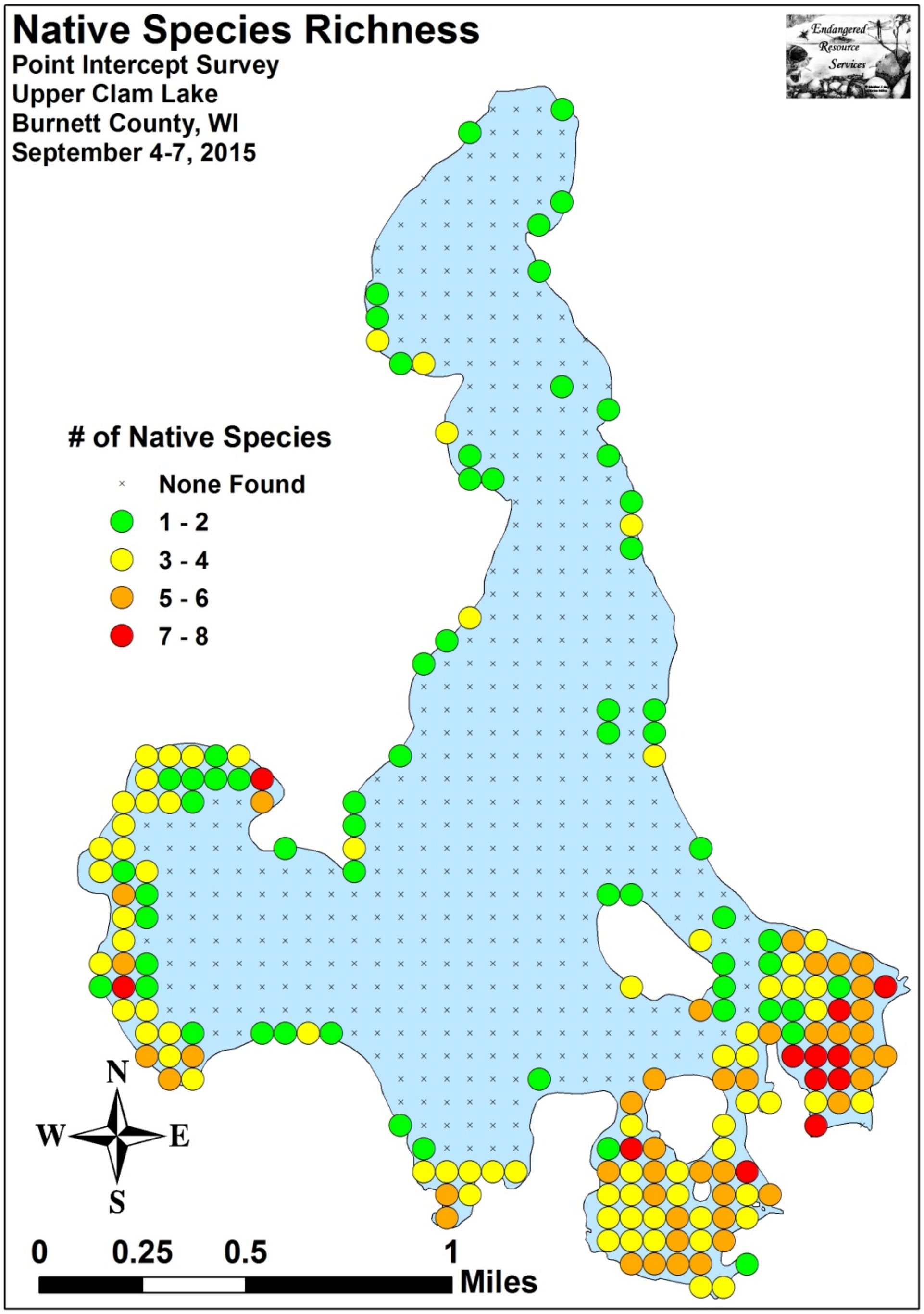

Bottom Substrate
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Substrate Type
Rock
Sand
Muck
N
W
E
S
0
0.25
0.5
1
Miles

Appendix IV: 2015 and 2016 Littoral Zone, Native Species Richness, and Total Rake Fullness Maps

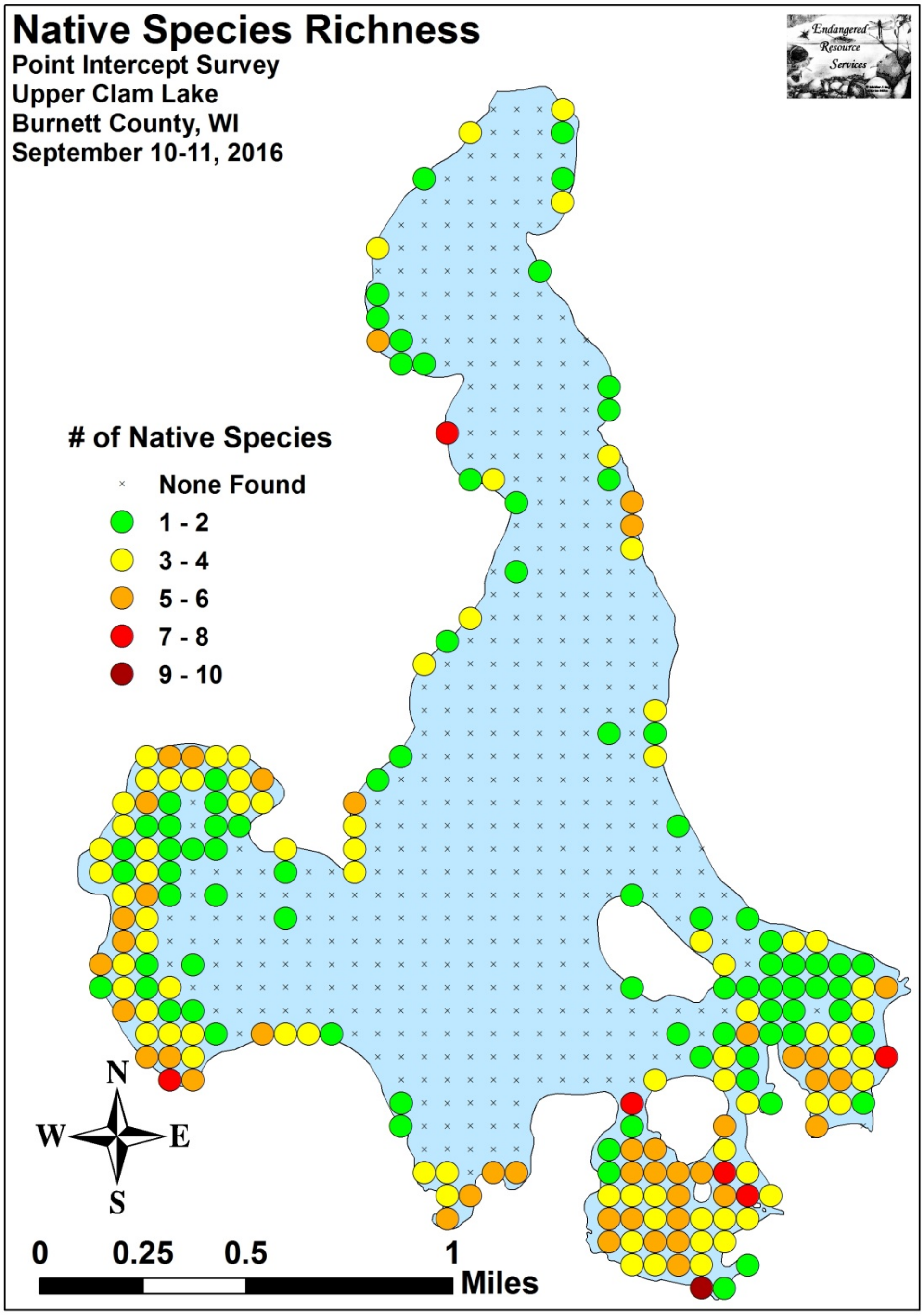


Littoral Zone
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 4-7, 2015
Endangered Resource Services
Littoral Zone
Littoral Zone with Plants
>6.5 ft.
N
W
E
S
0
0.25
0.5
1
Miles

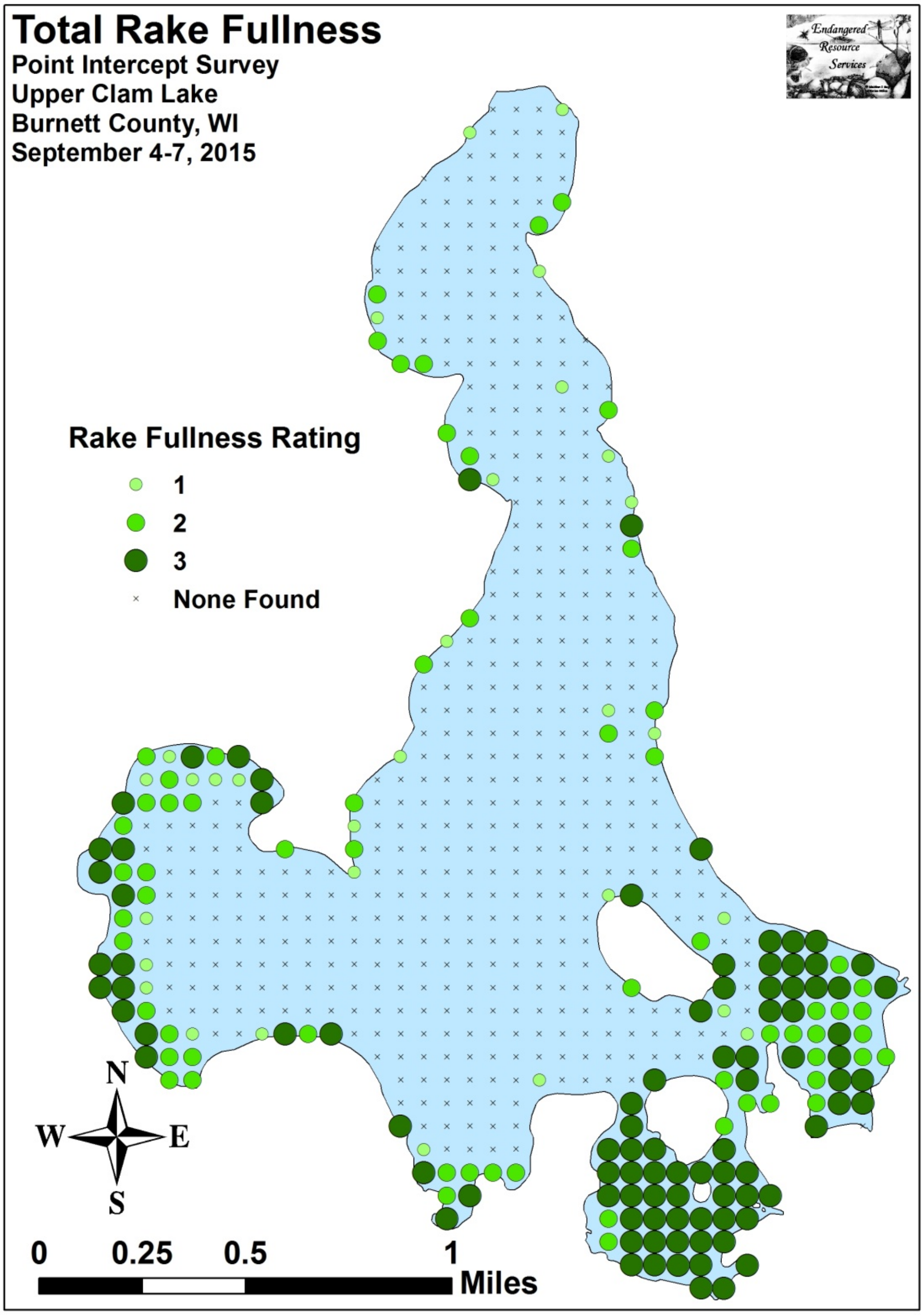

Littoral Zone
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Littoral Zone
Littoral Zone with Plants
>7.5 ft.
N
W
E
S
0
0.25
0.5
1
Miles



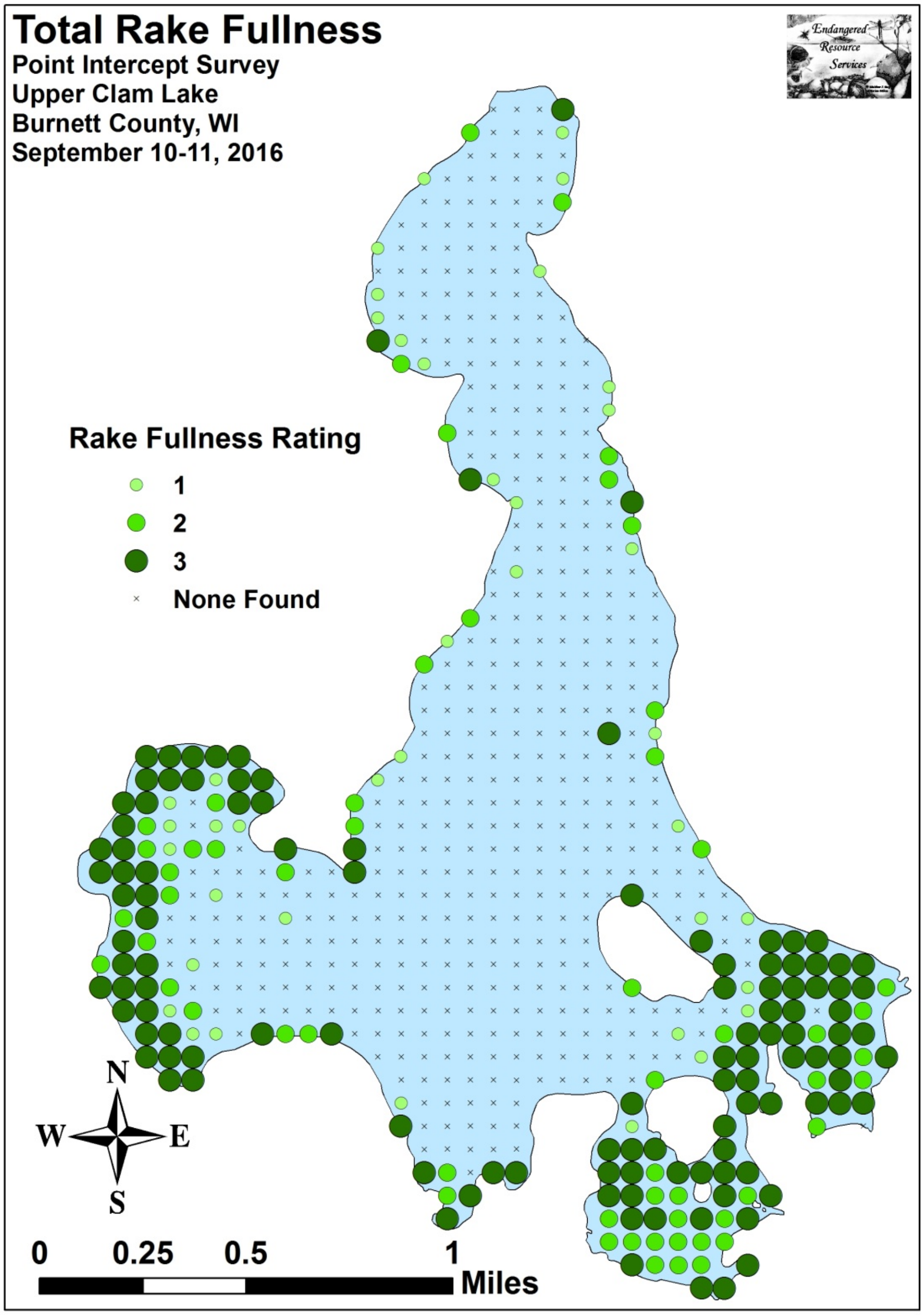
Native Species Richness
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 4-7, 2015
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
N
W
E
S
0
0.25
0.5
1
Miles



Native Species Richness
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
N
W
E
S
0
0.25
0.5
1
Miles

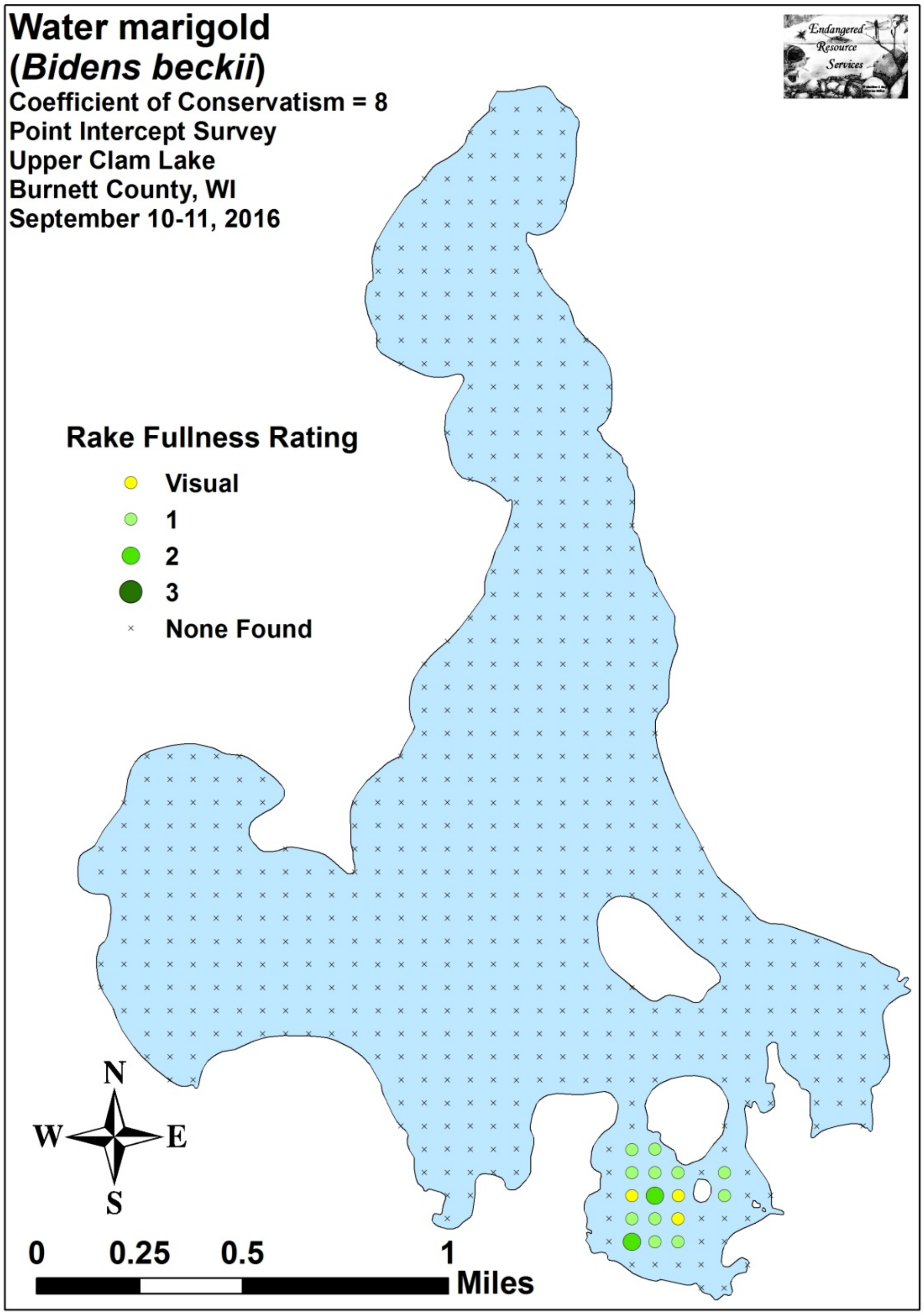


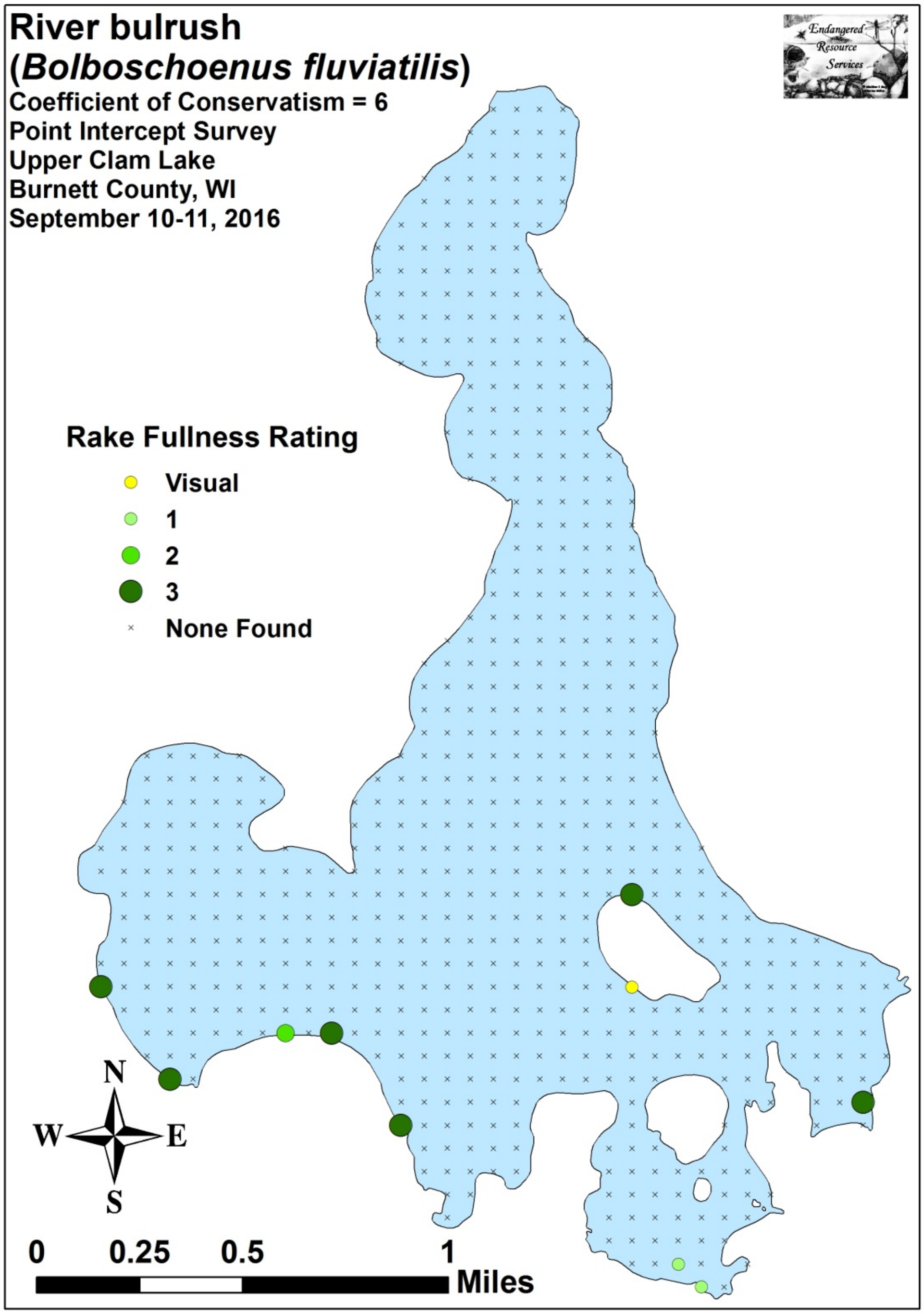
Total Rake Fullness
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 4-7, 2015
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

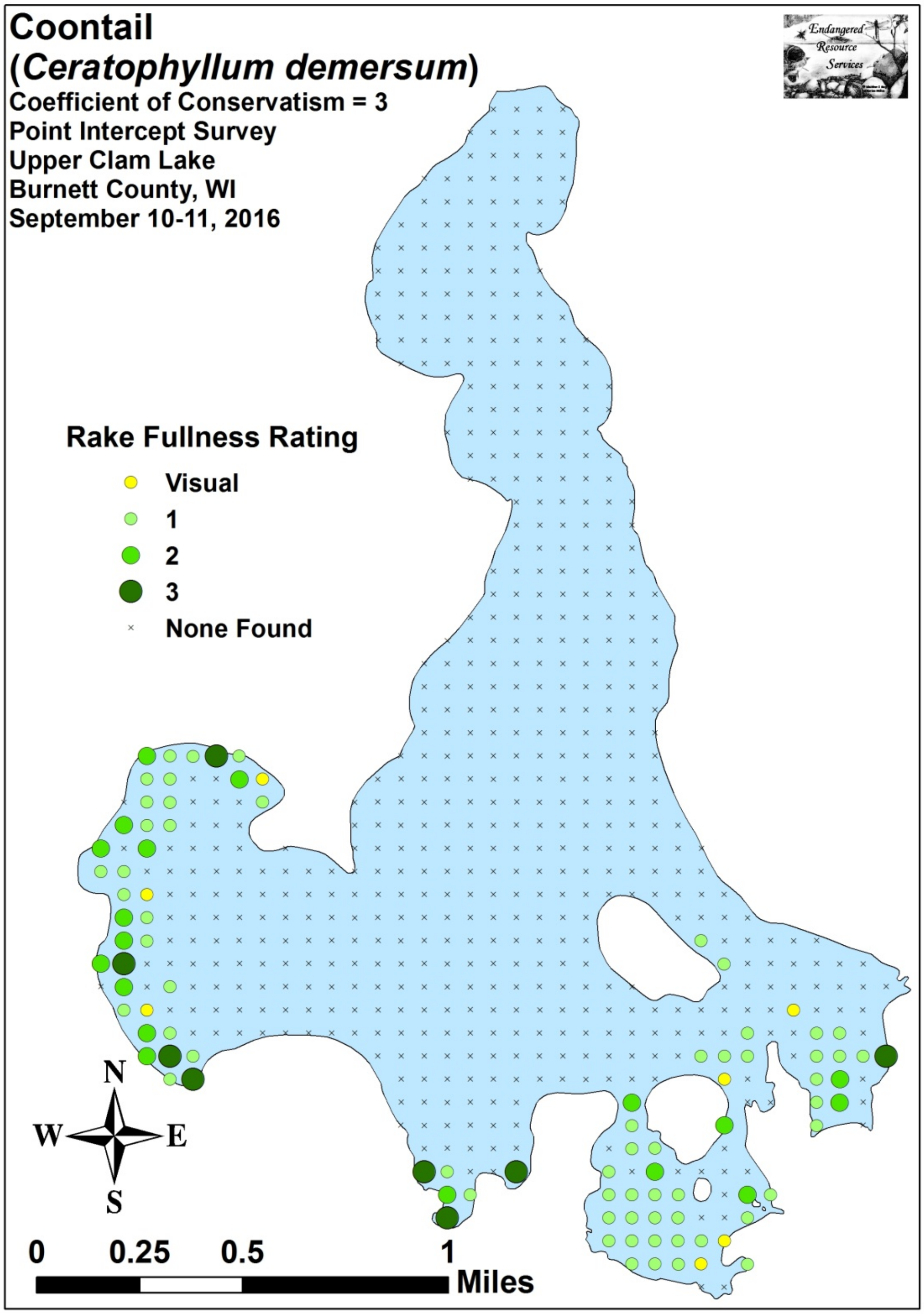


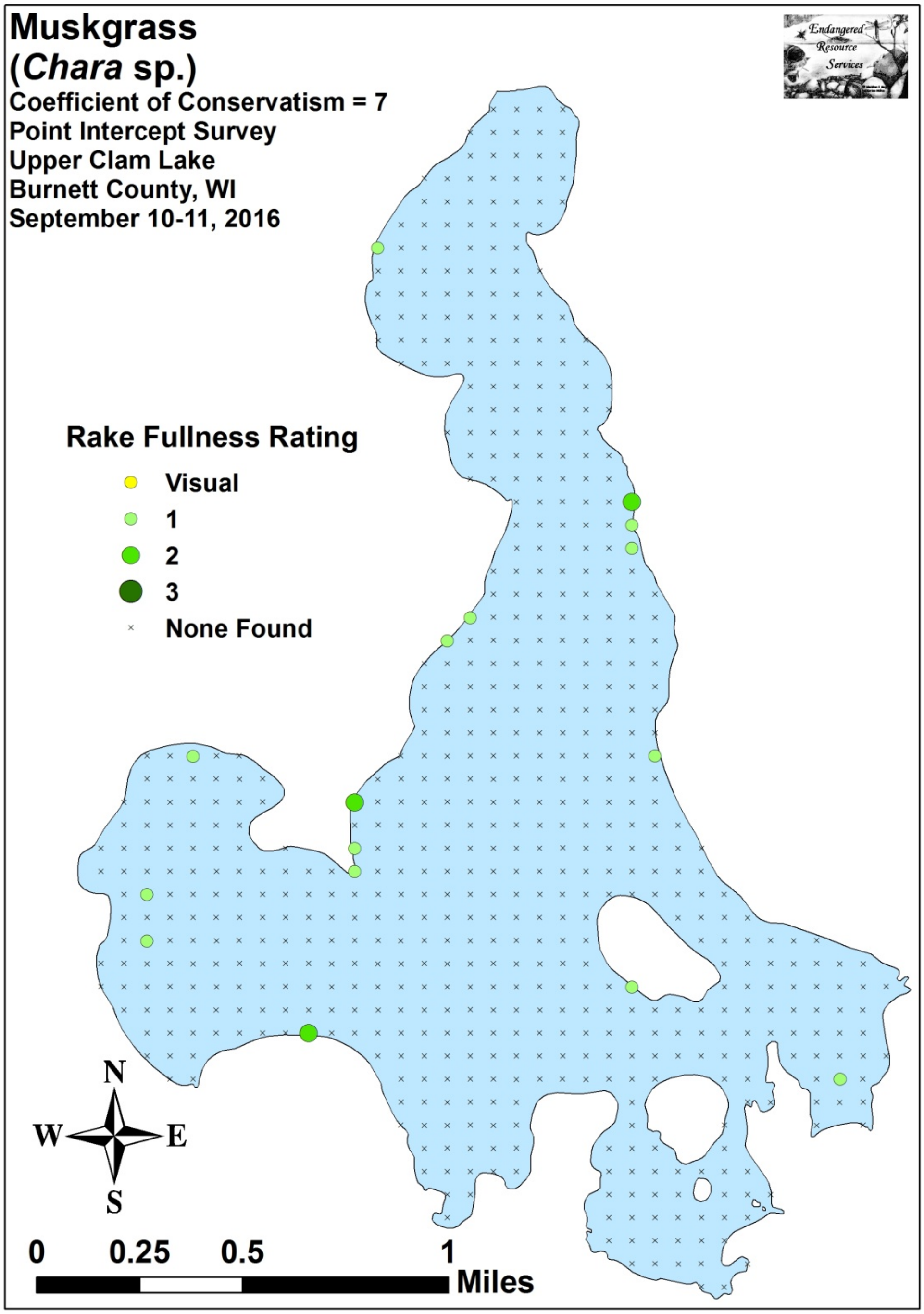
Total Rake Fullness
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

Appendix V: 2016 Plant Species Density and Distribution Maps

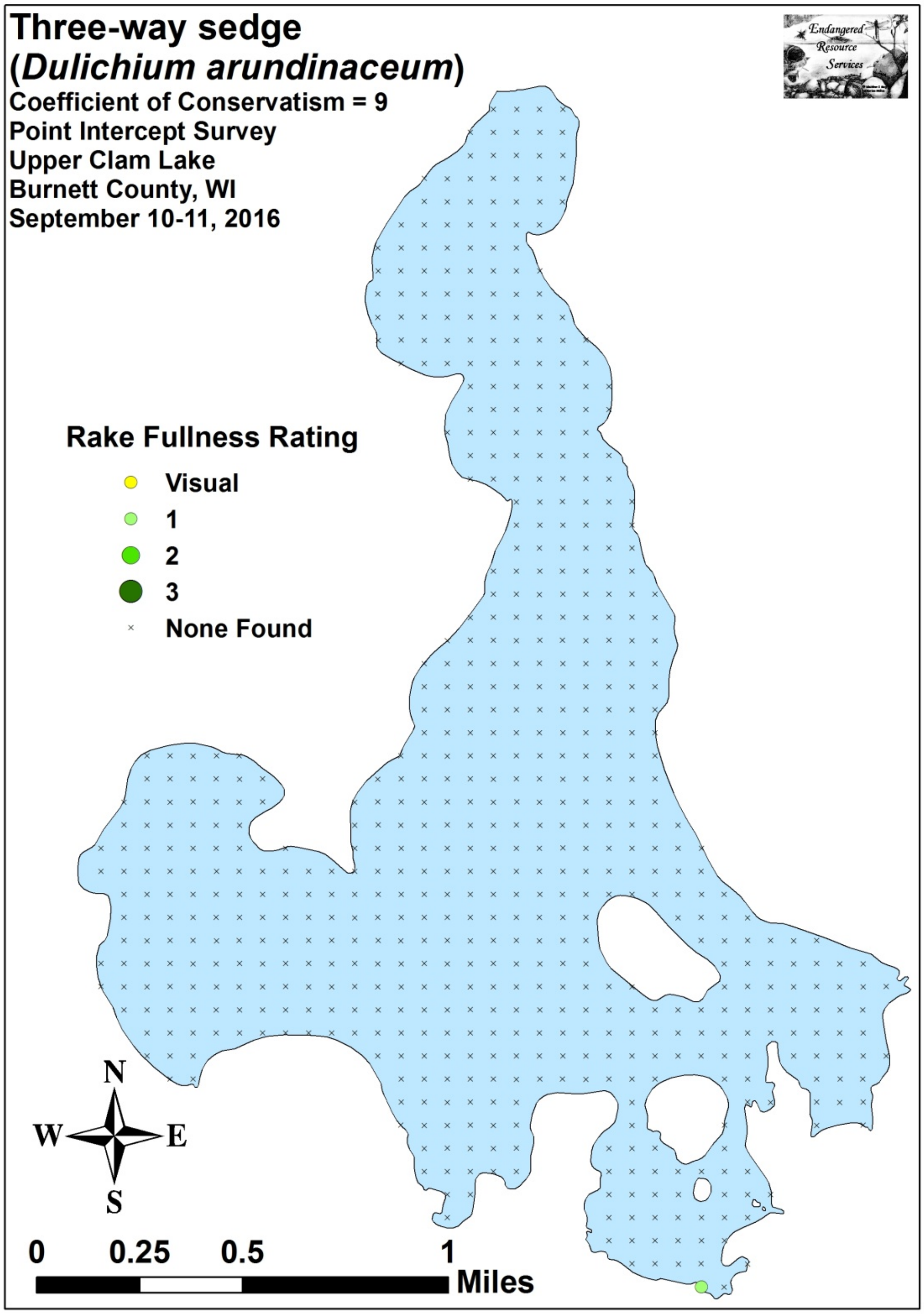

Water marigold
(*Bidens beckii*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

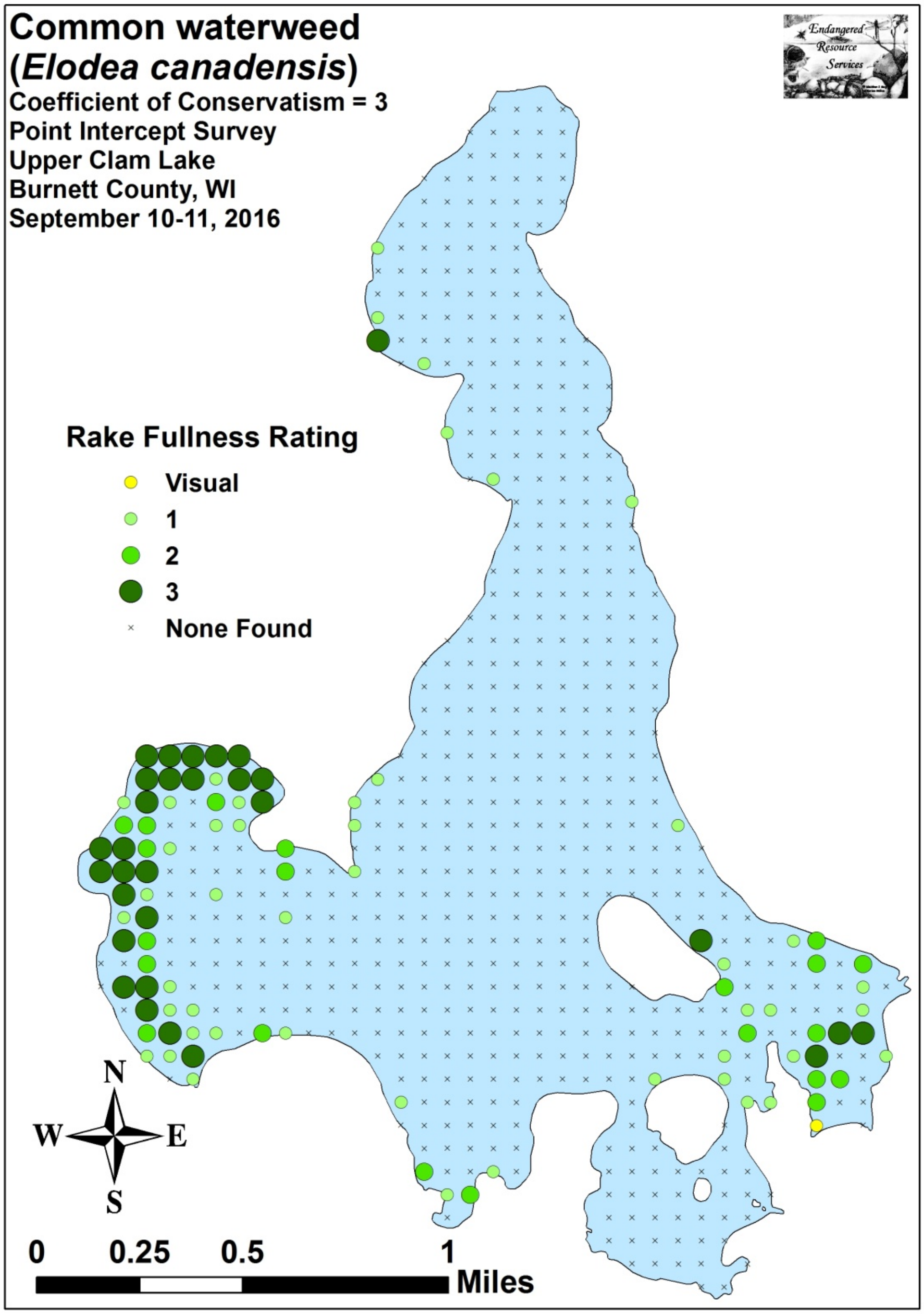

River bulrush
(Bolboschoenus fluviatilis)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

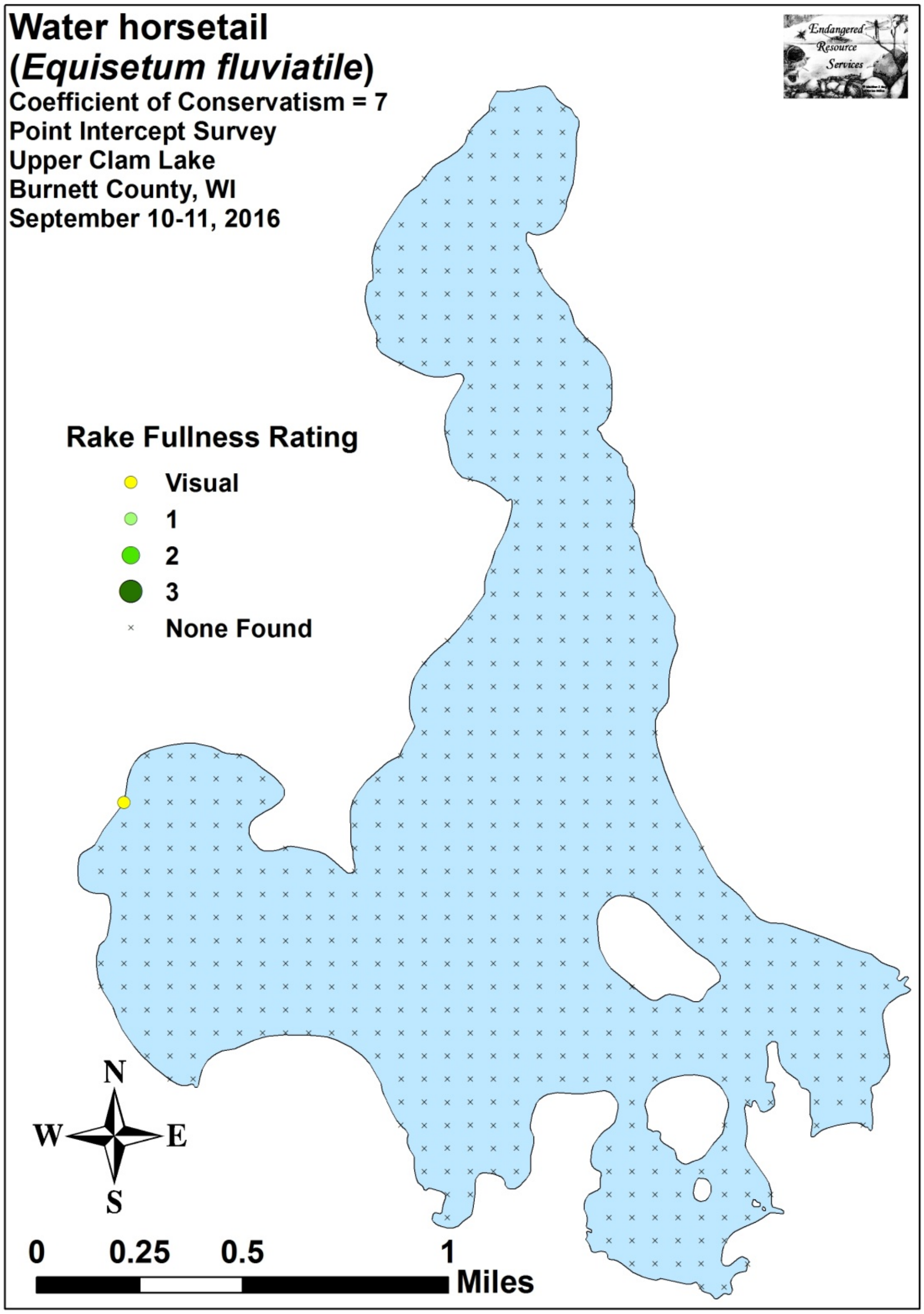

Coontail
(*Ceratophyllum demersum*)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

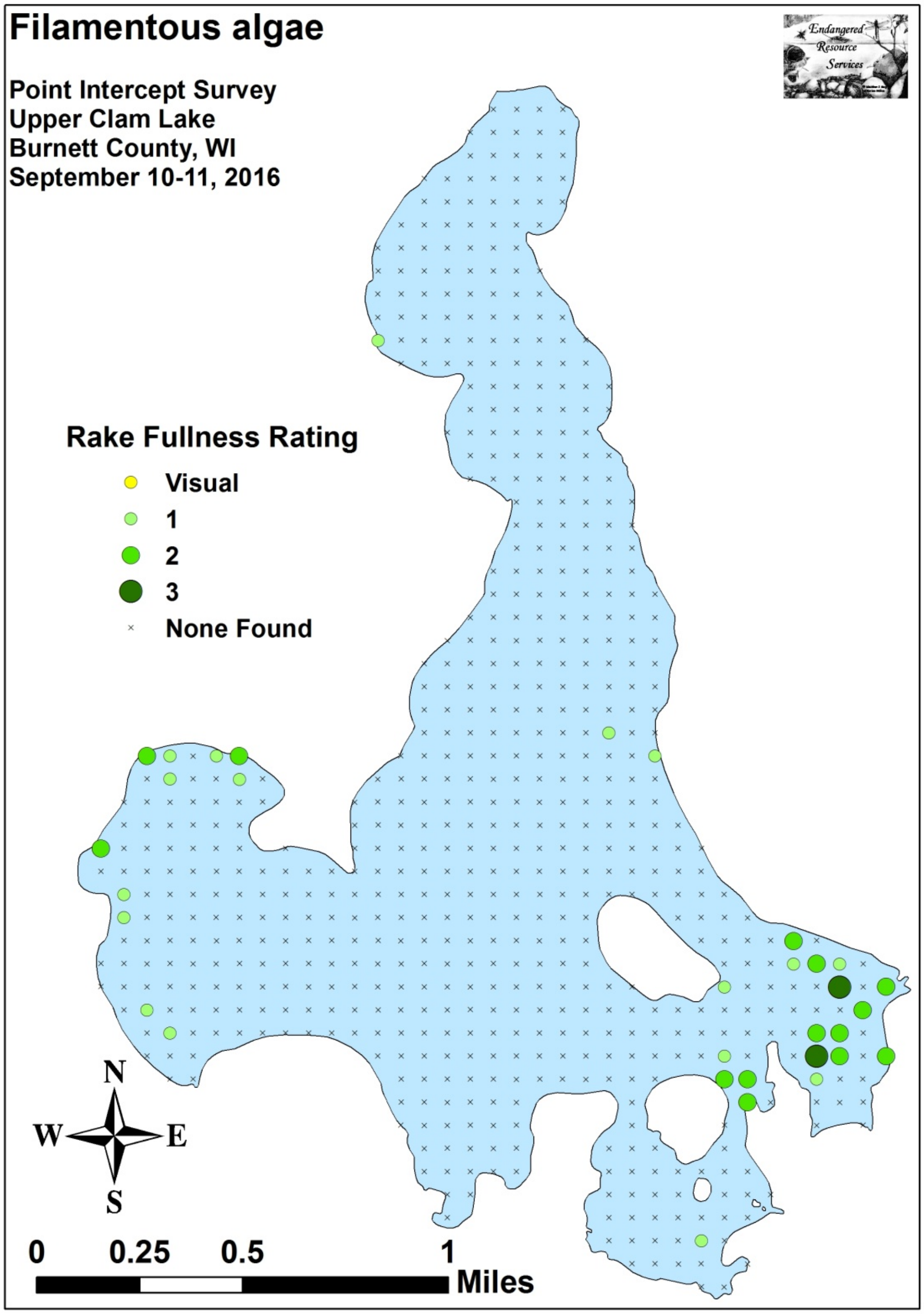


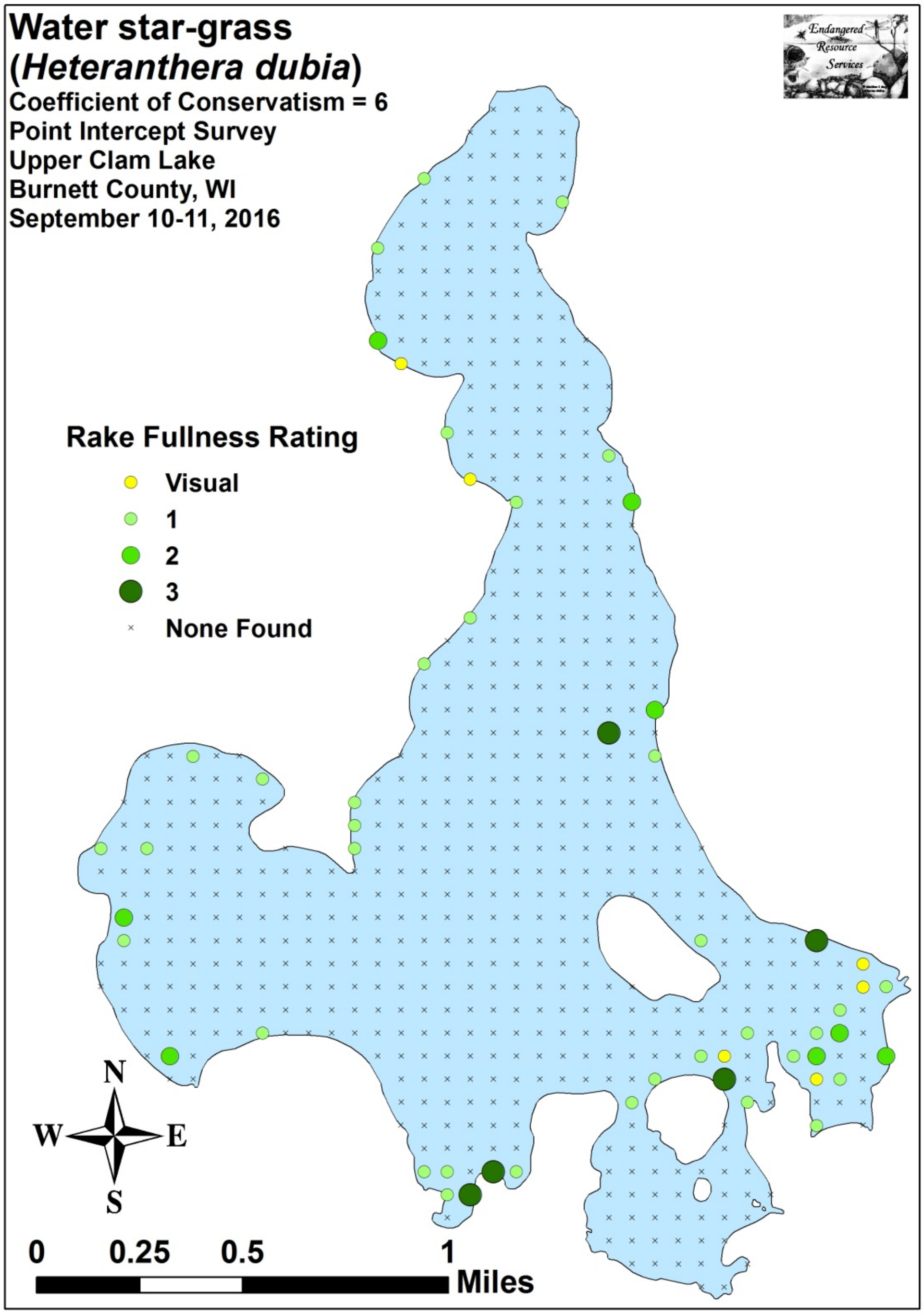
Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Three-way sedge
(*Dulichium arundinaceum*)
Coefficient of Conservatism = 9
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

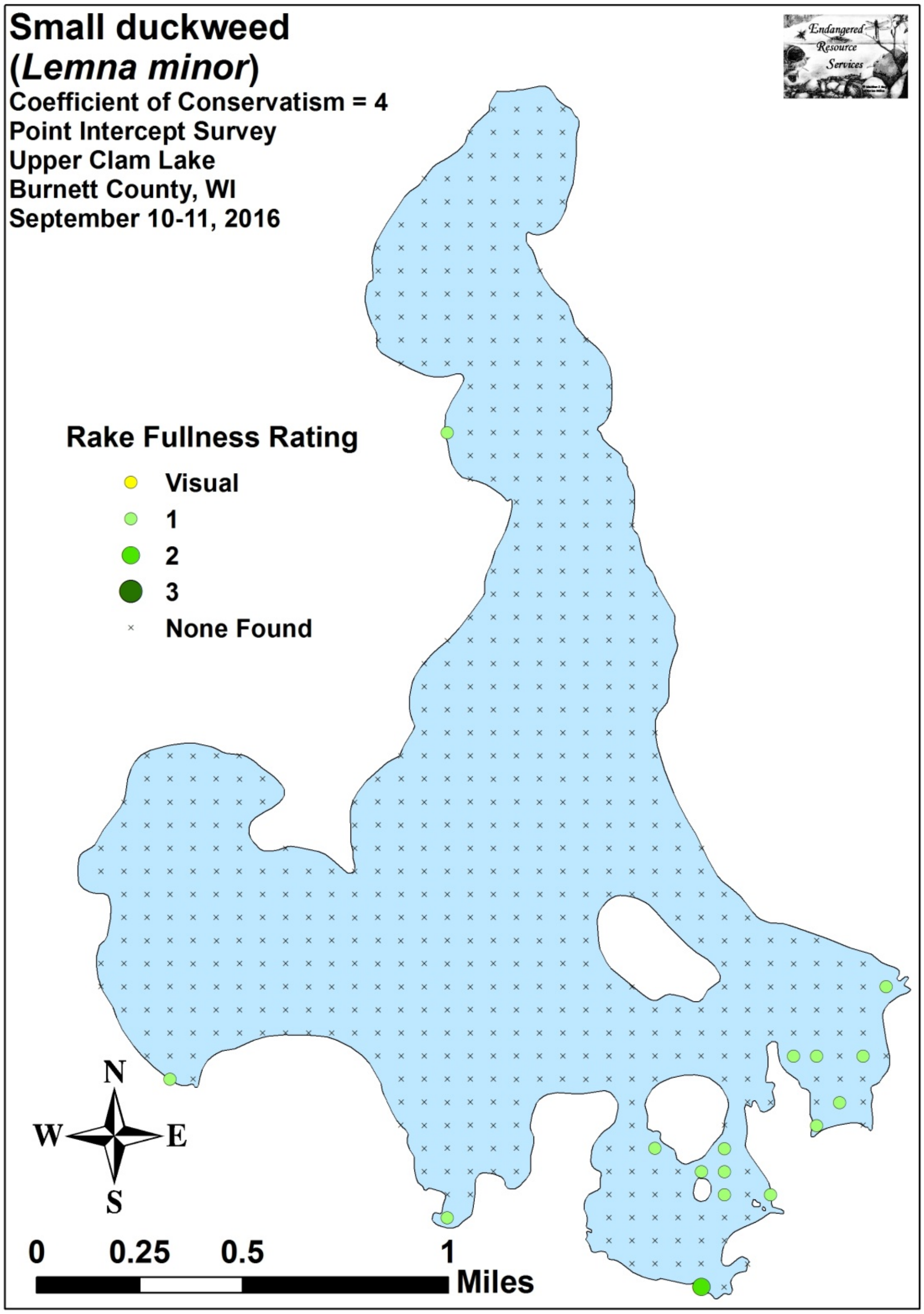

Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

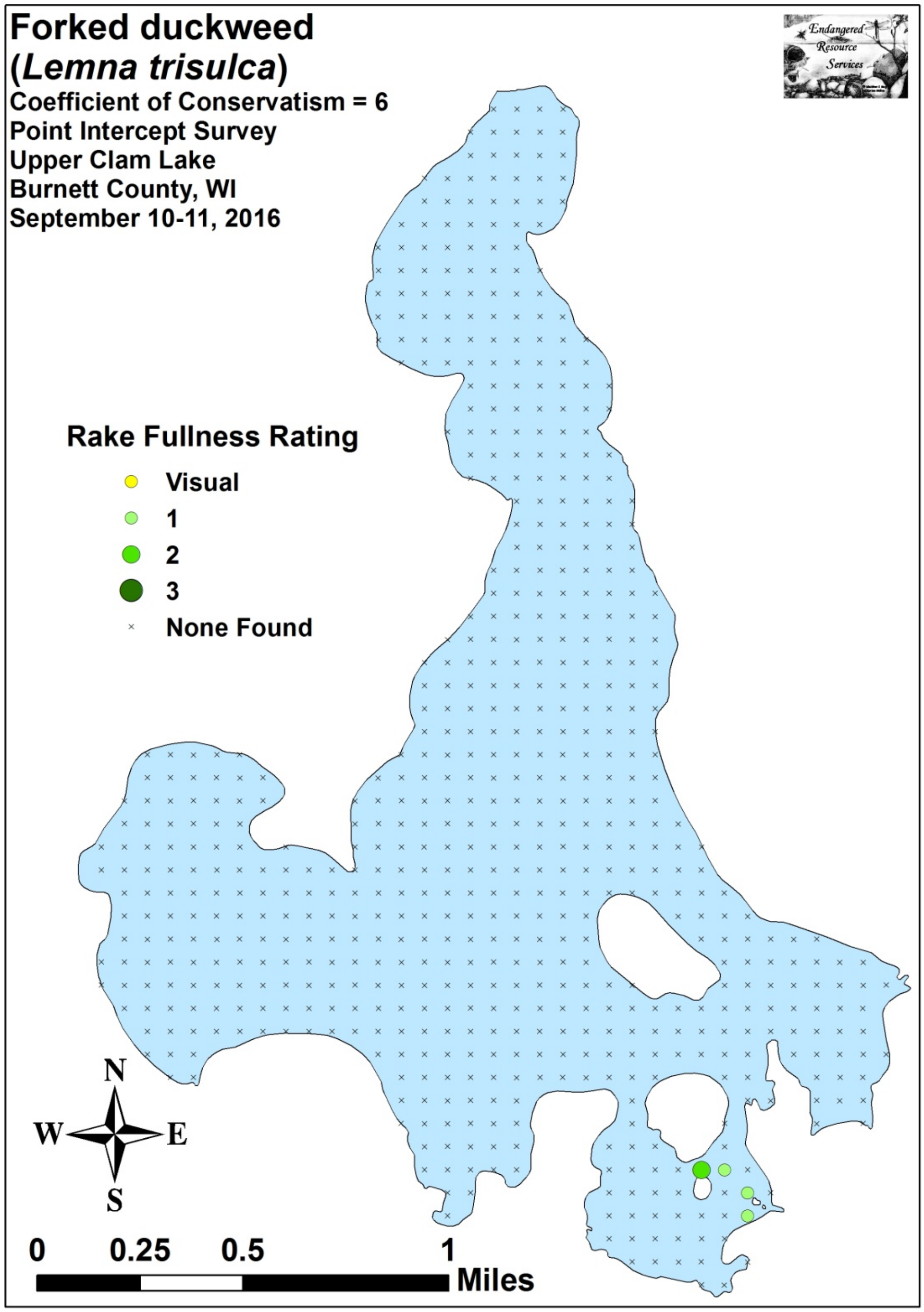

Water horsetail
(Equisetum fluviatile)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

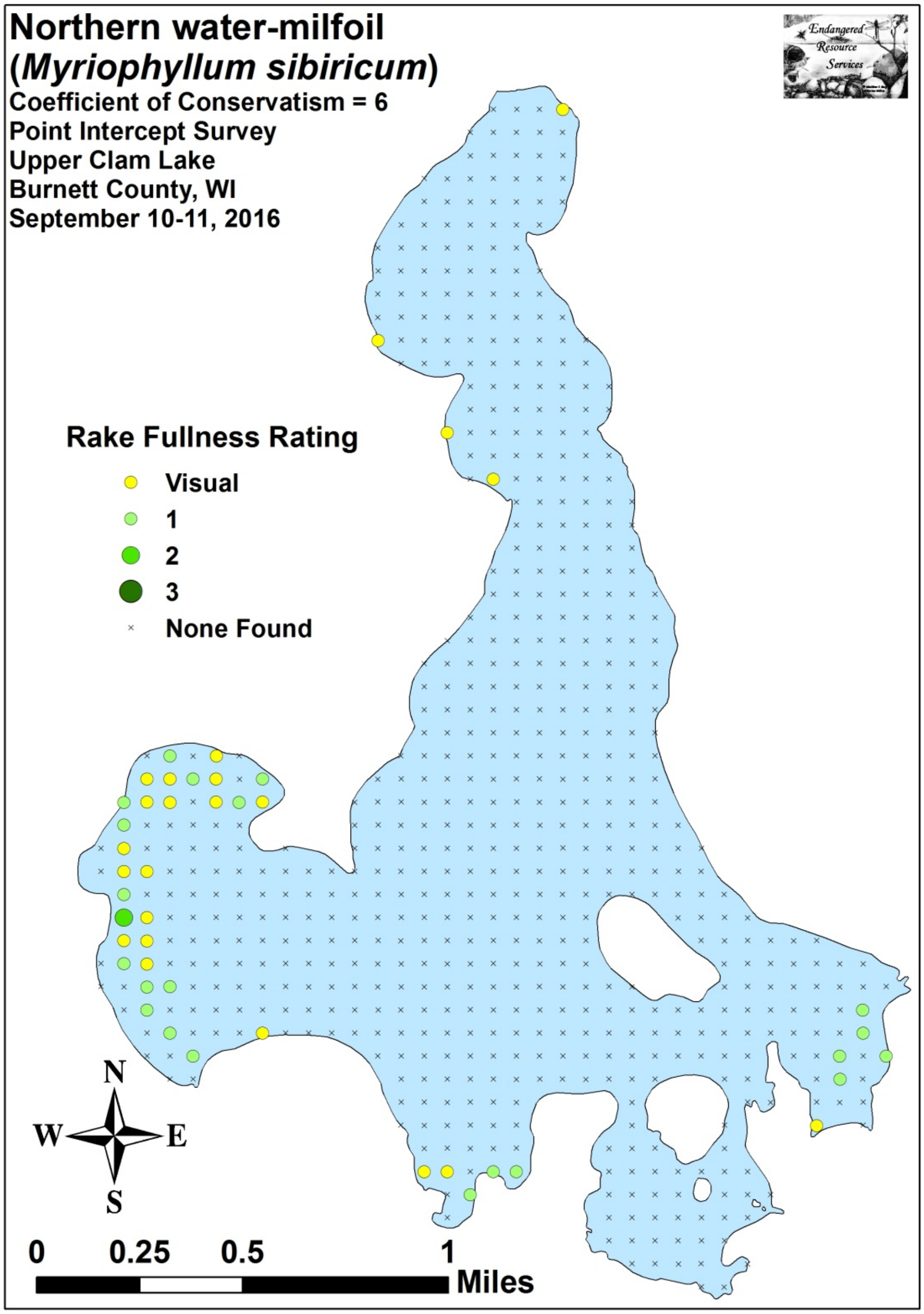

Filamentous algae
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

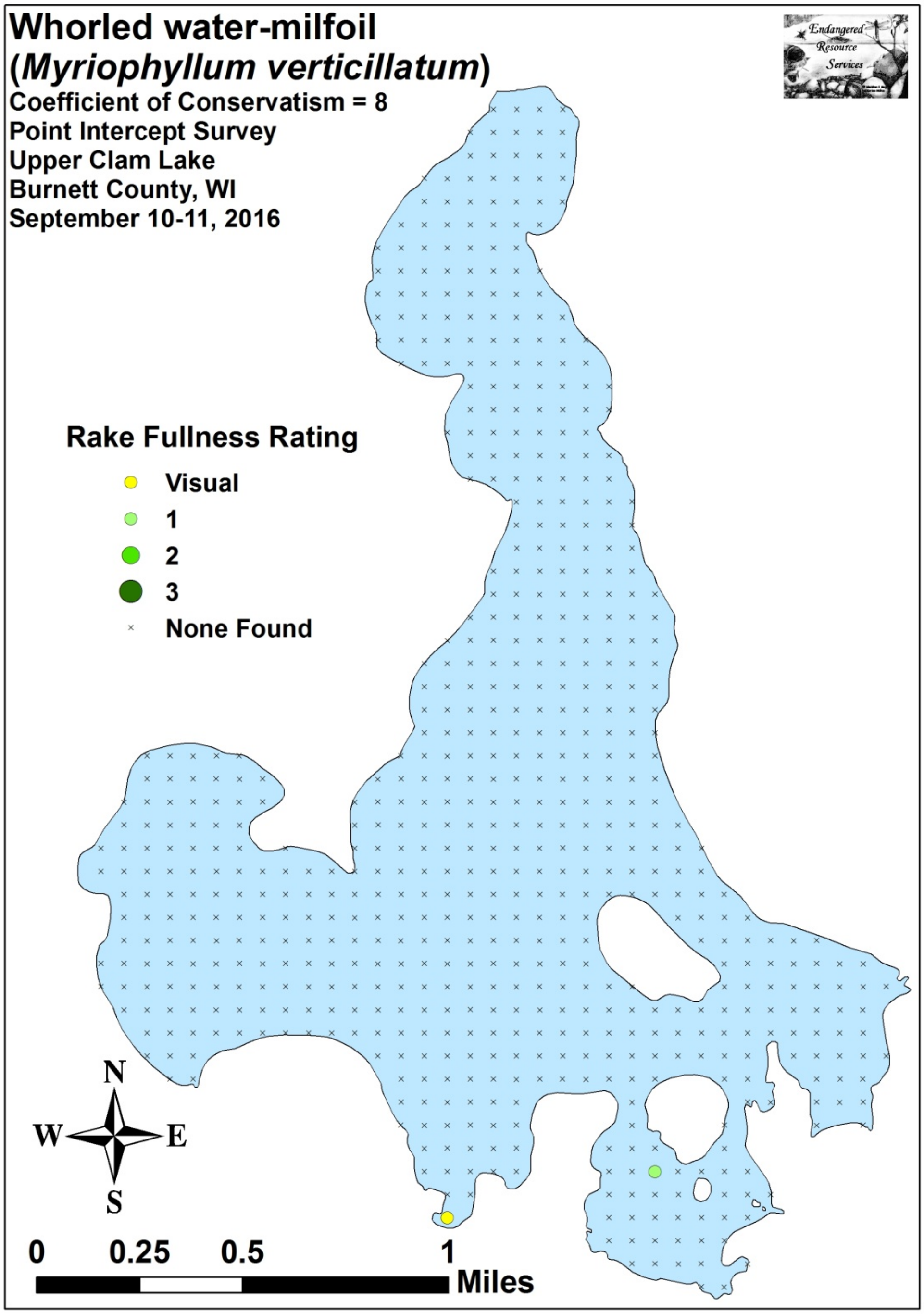


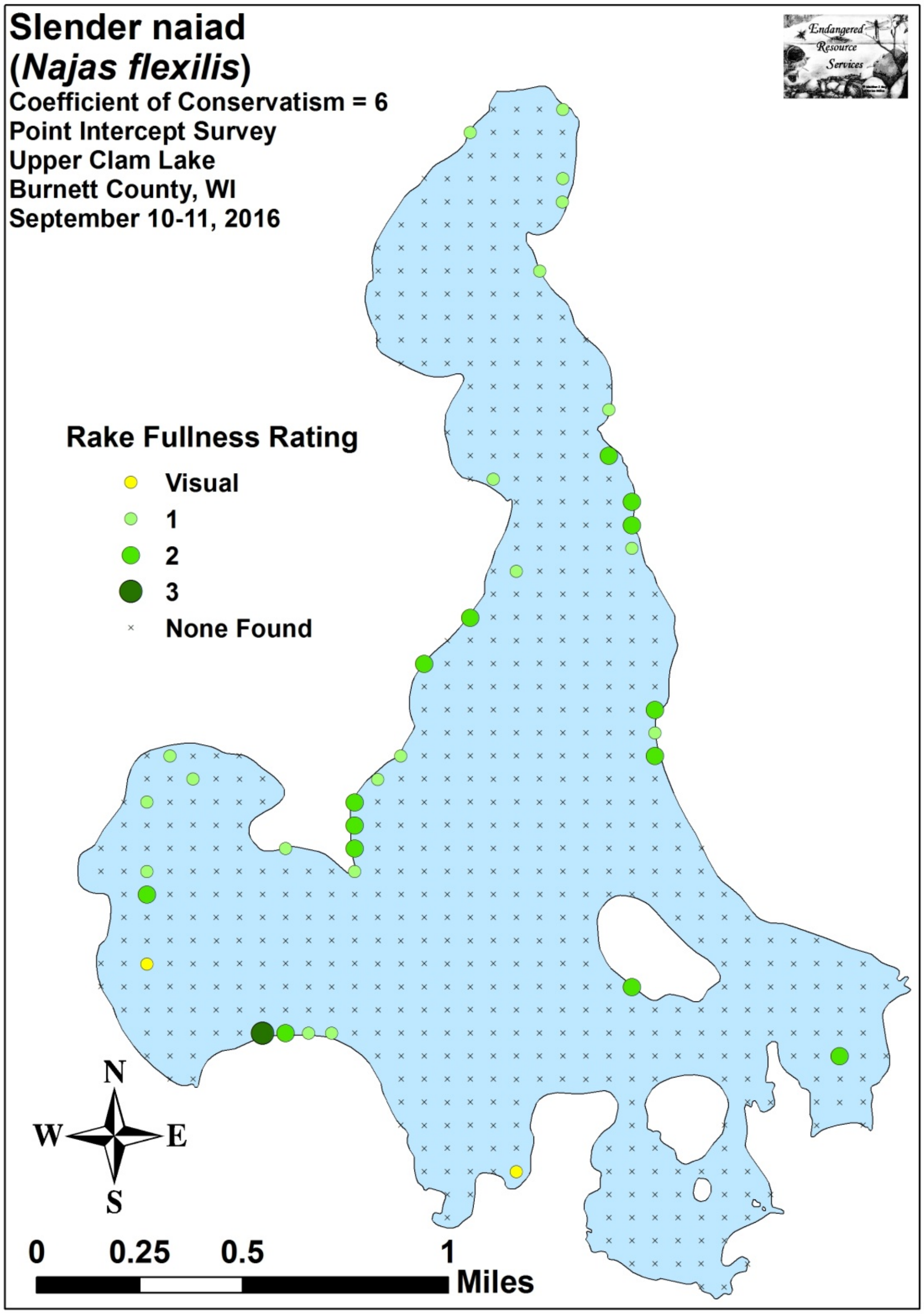
Water star-grass
(*Heteranthera dubia*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

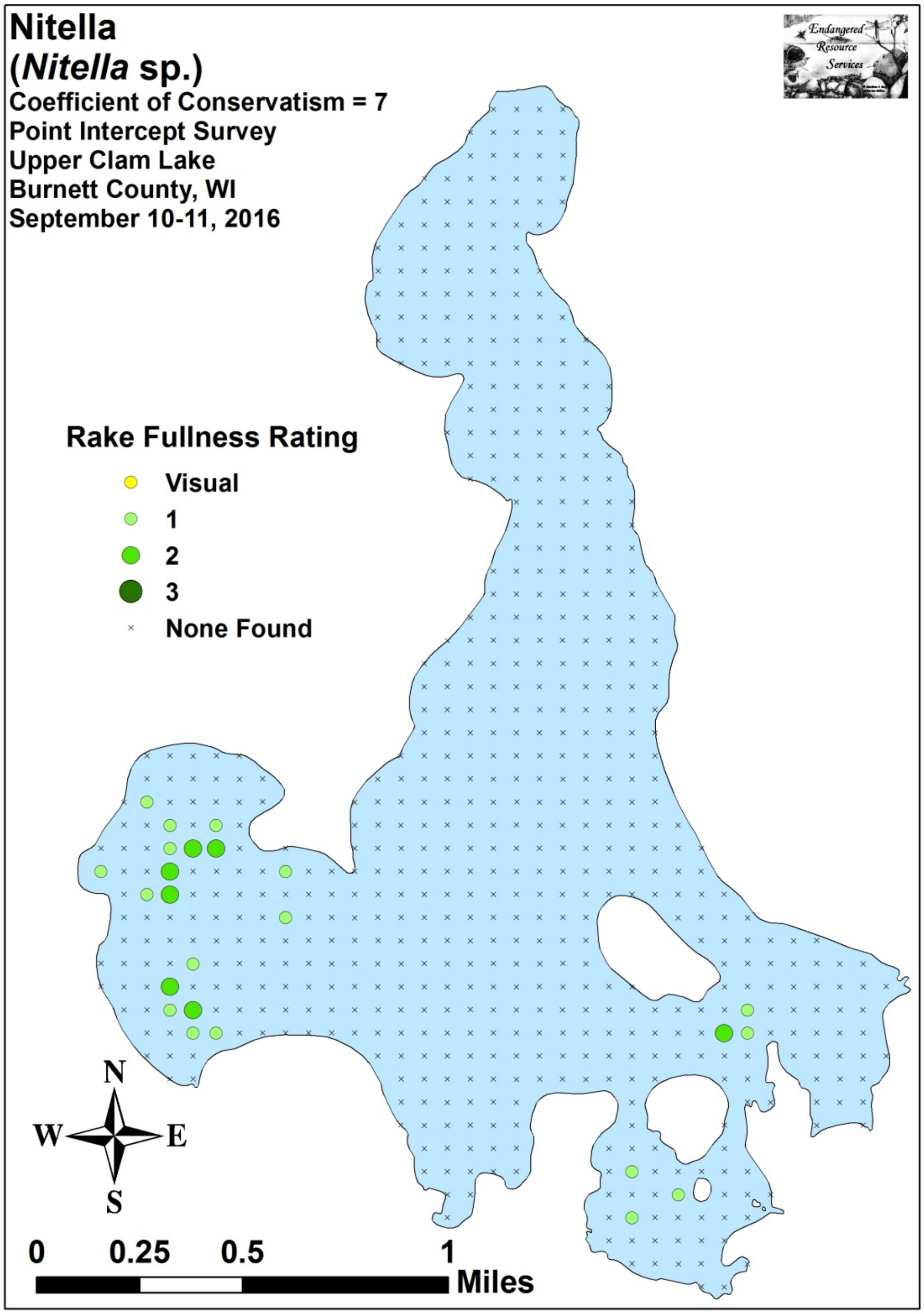

Small duckweed
(Lemna minor)
Coefficient of Conservatism = 4
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Forked duckweed
(Lemna trisulca)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

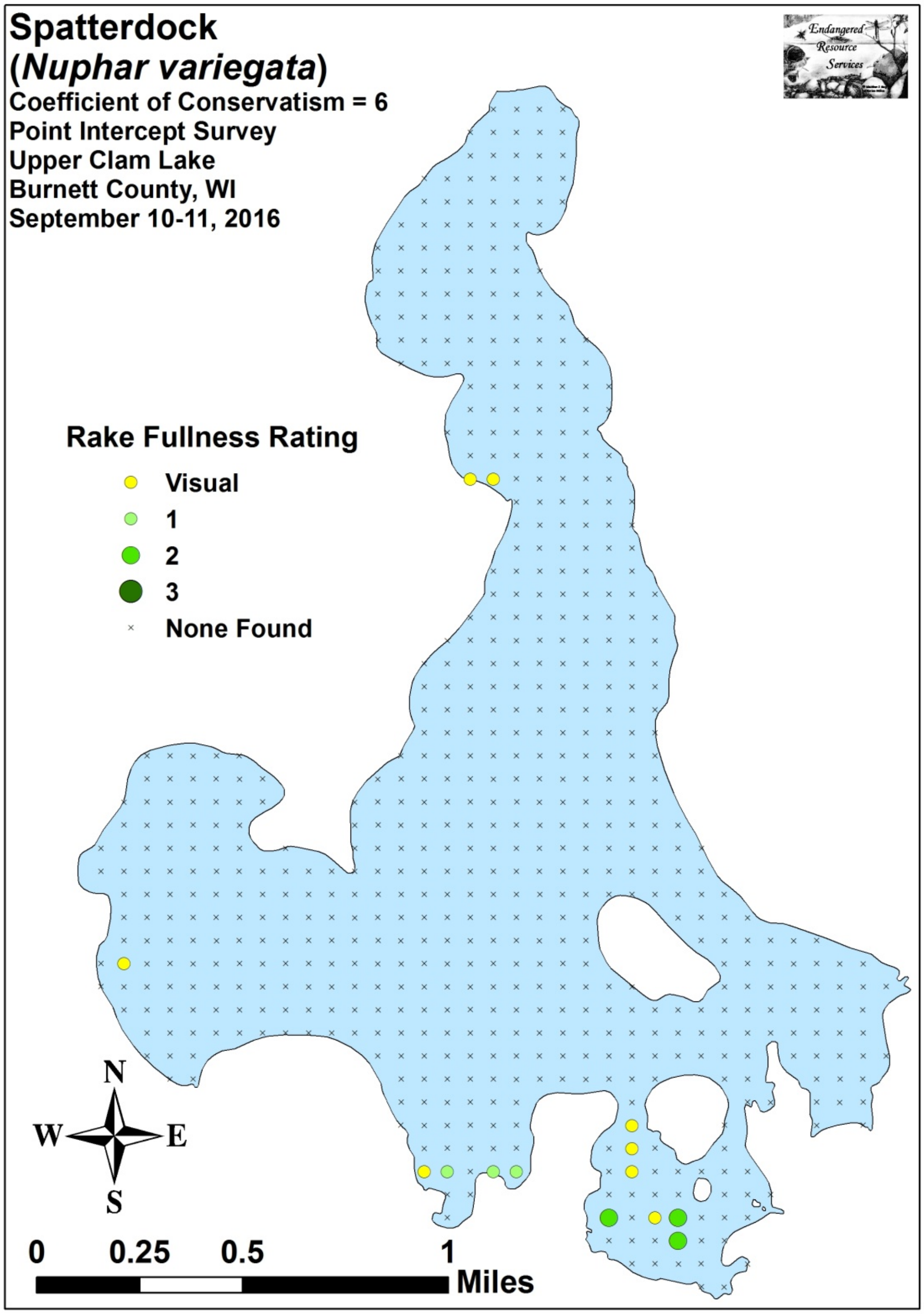

Northern water-milfoil
(Myriophyllum sibiricum)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

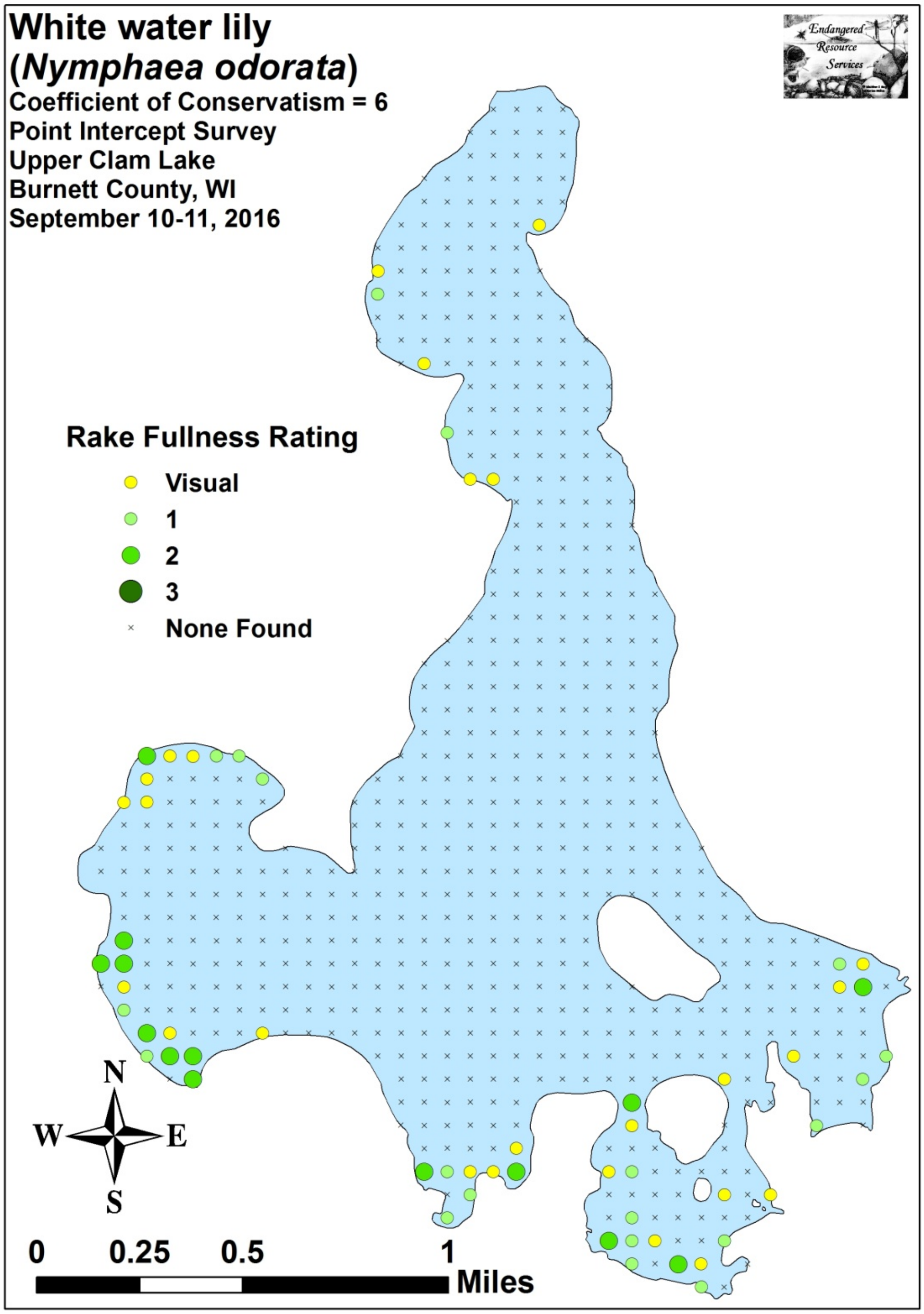

Whorled water-milfoil
(*Myriophyllum verticillatum*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Slender naiad
(*Najas flexilis*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

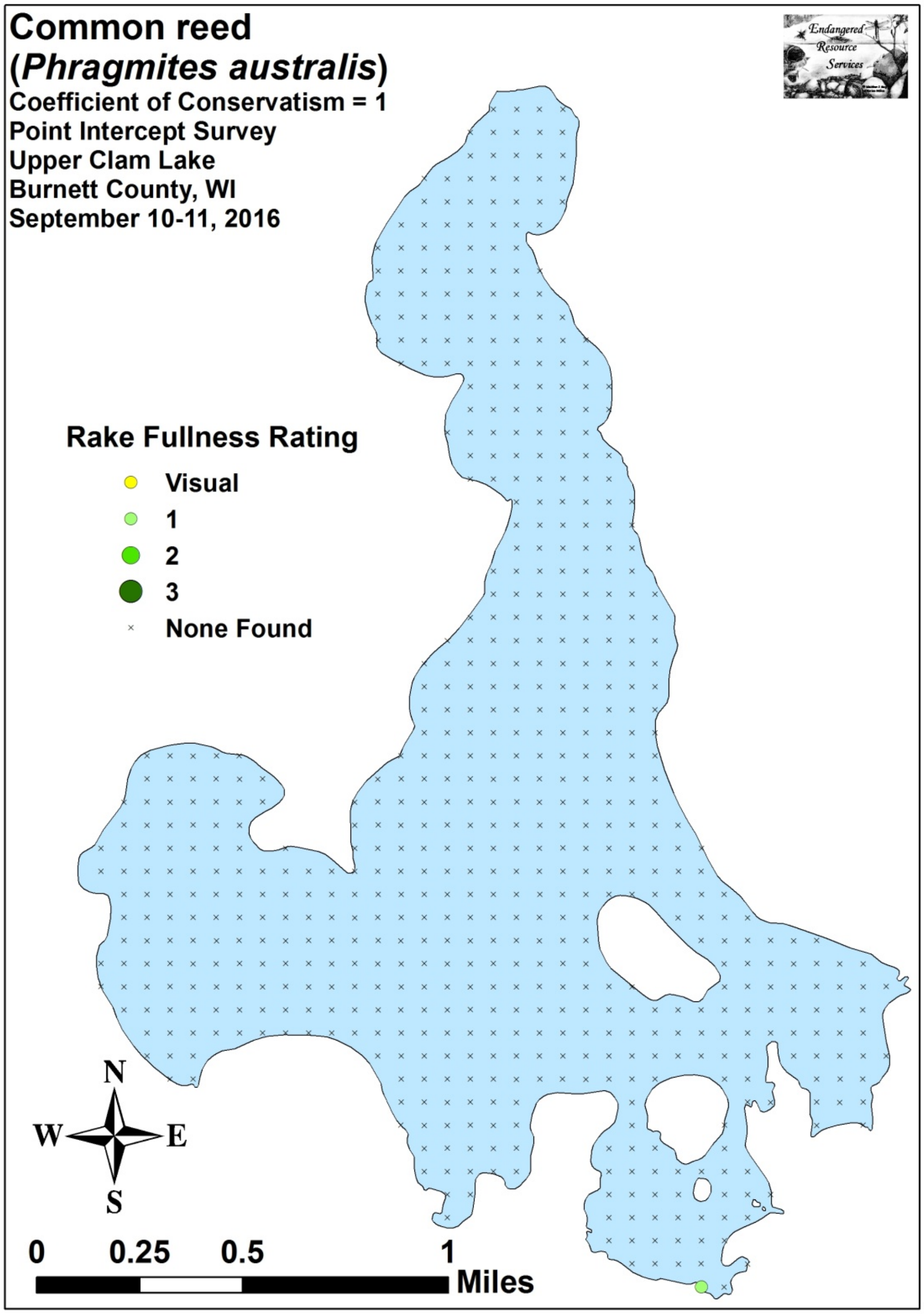


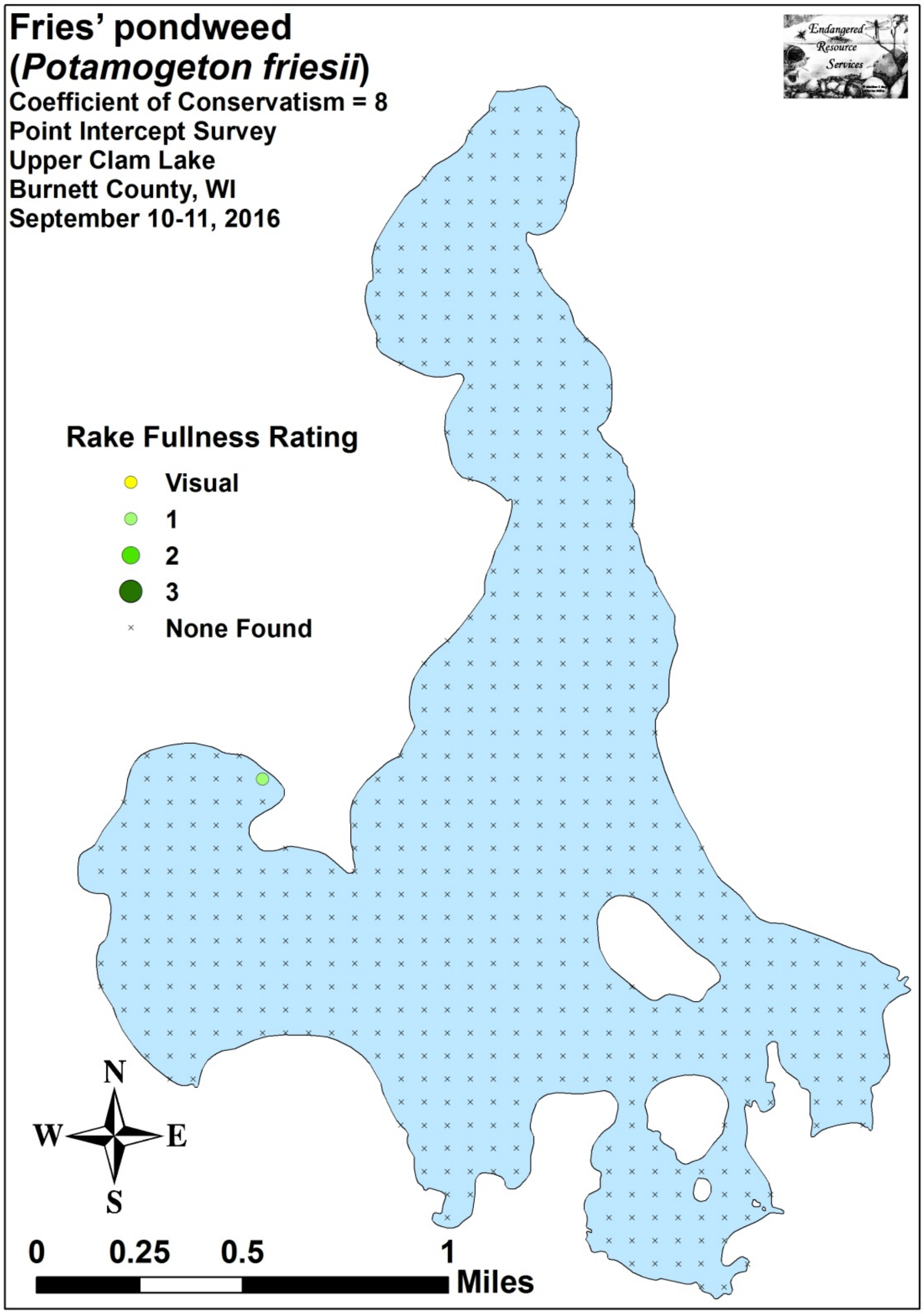
Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

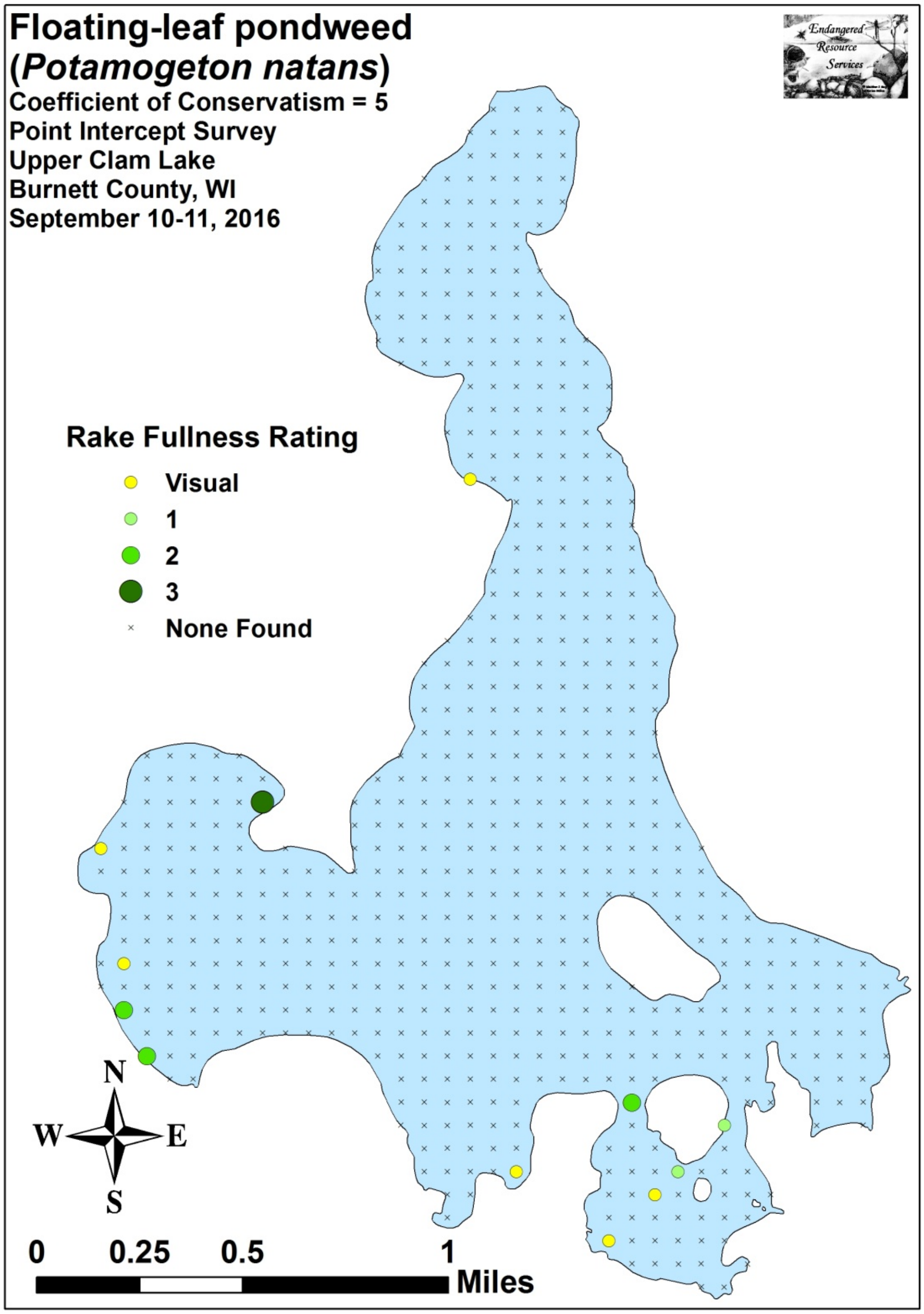

Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

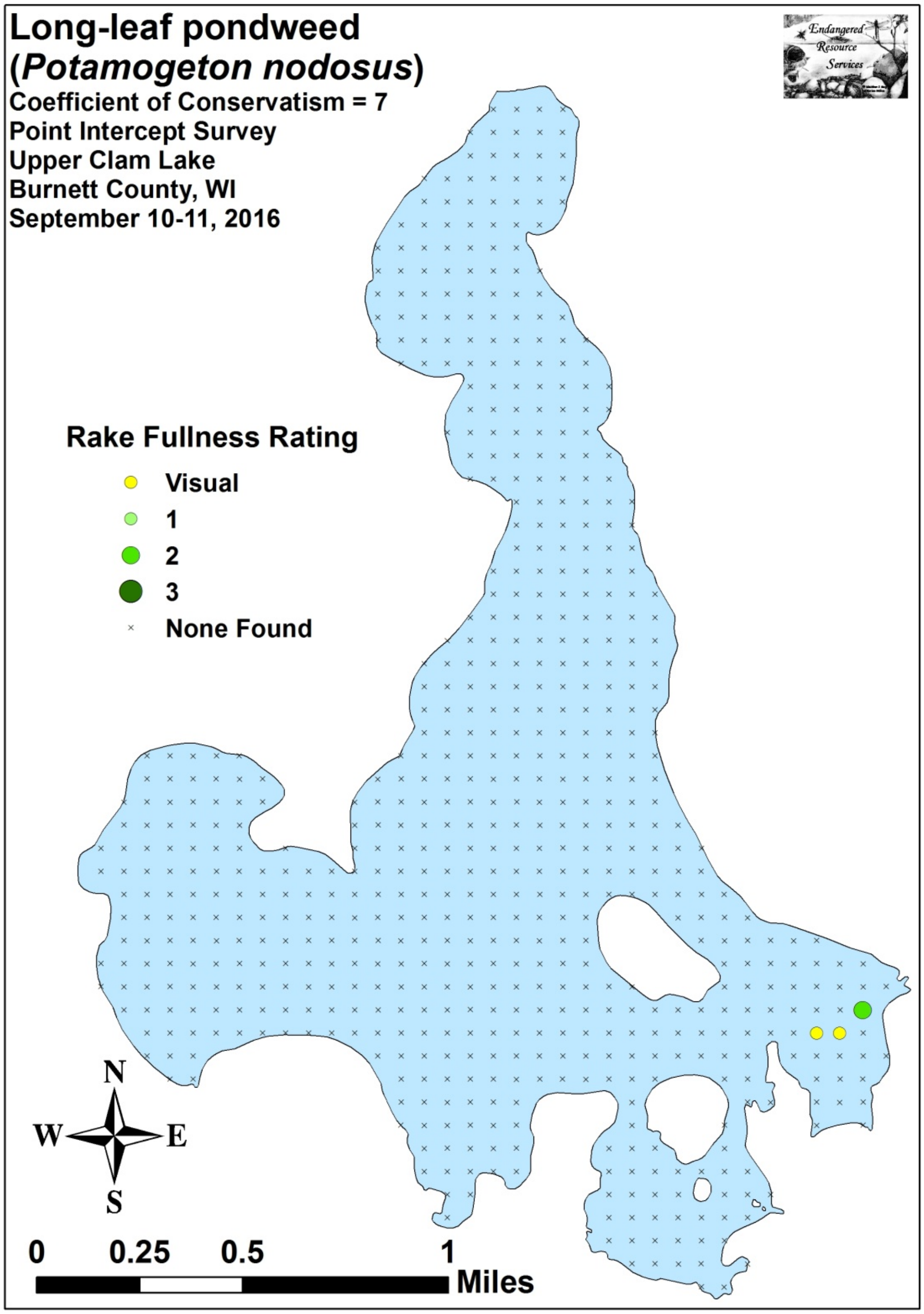


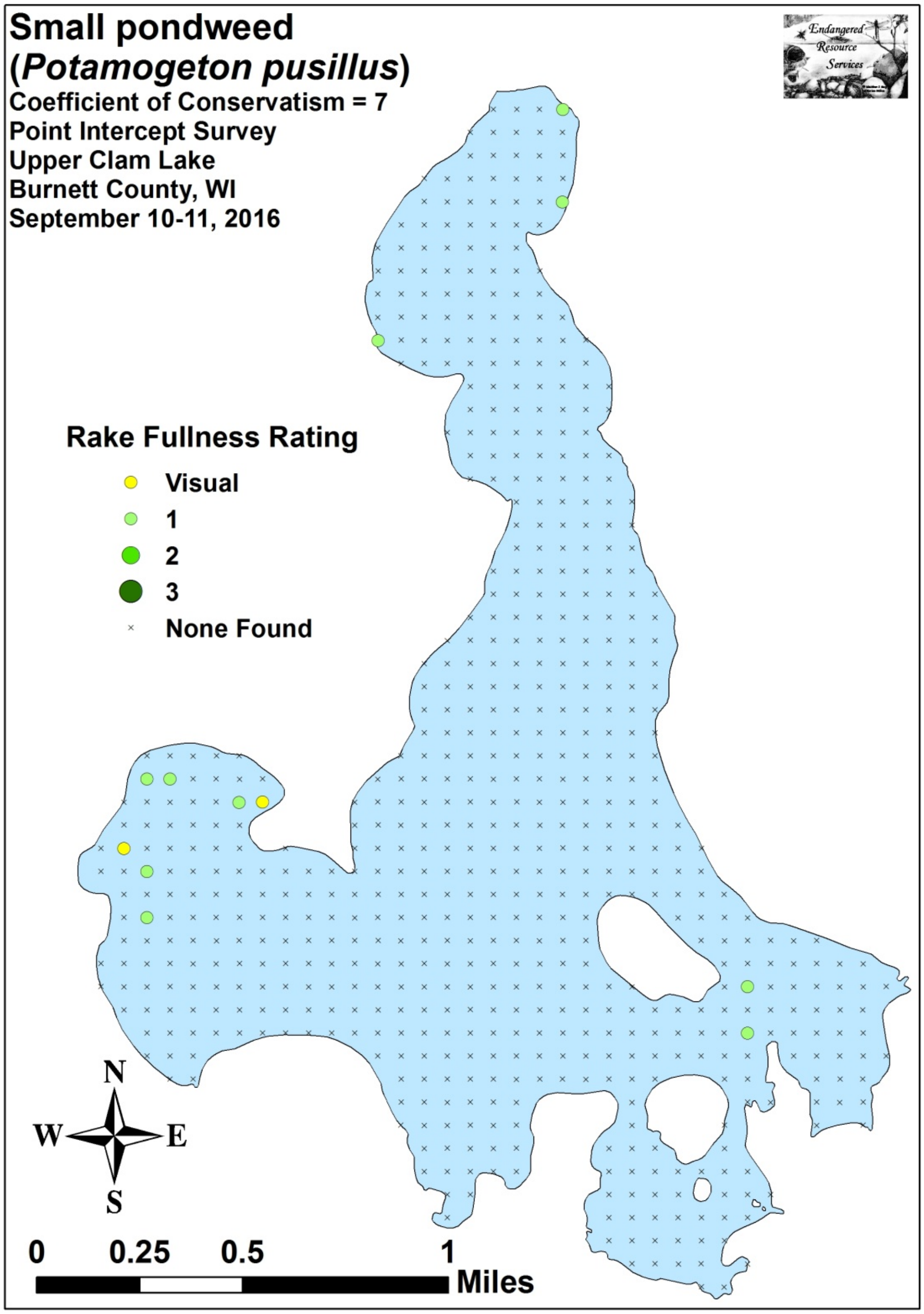
White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

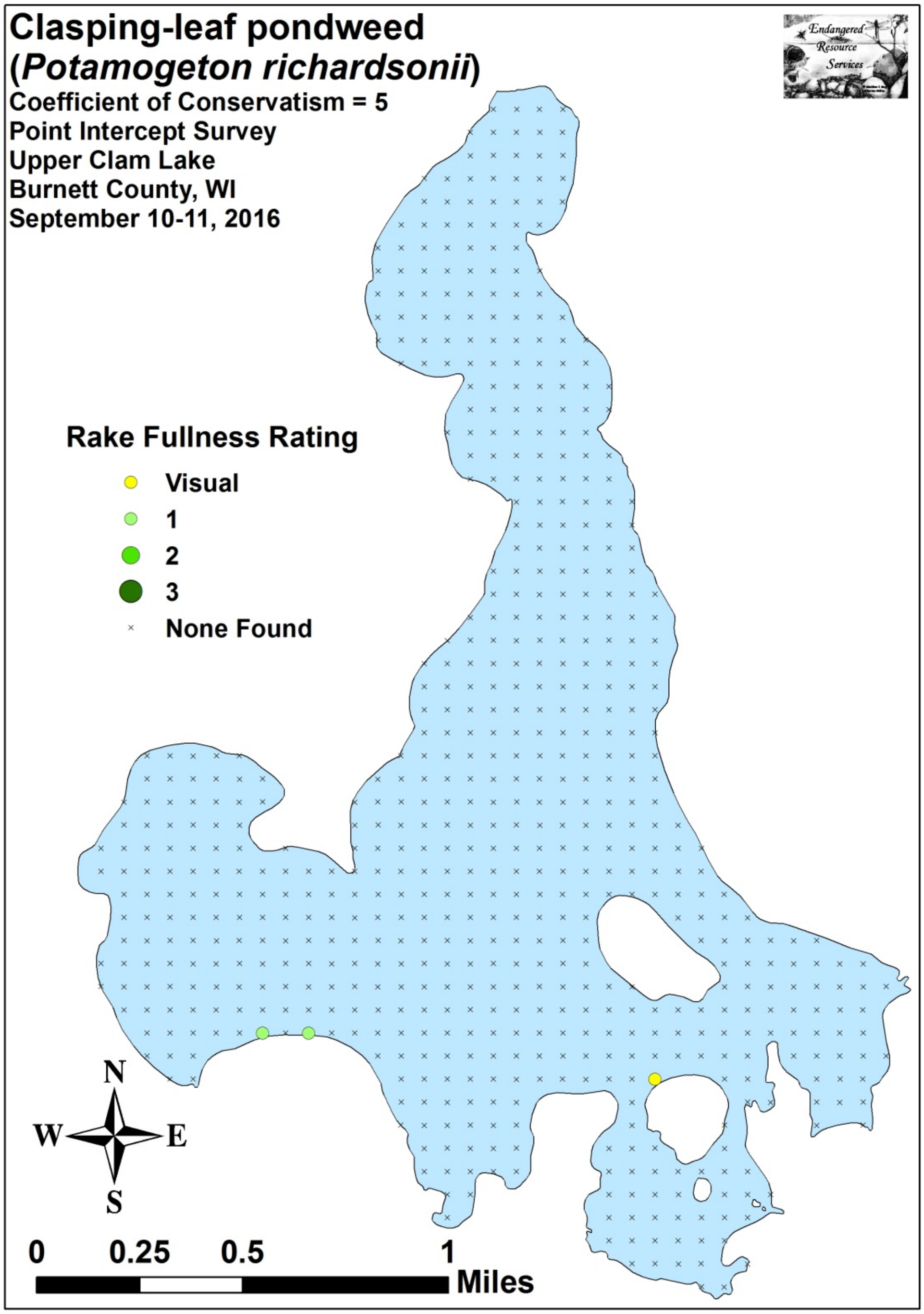

Common reed
(*Phragmites australis*)
Coefficient of Conservatism = 1
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

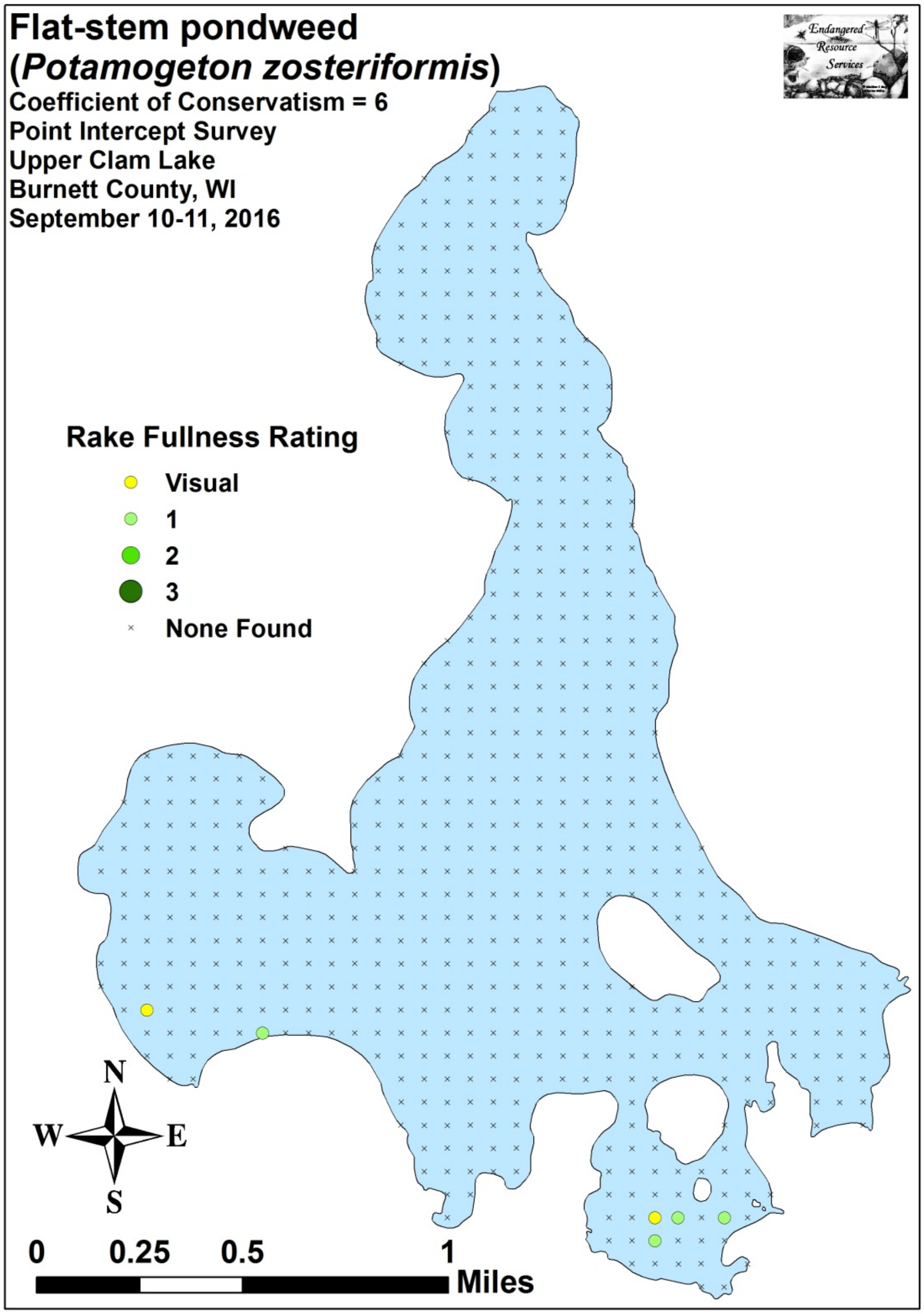

Fries' pondweed
(*Potamogeton friesii*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

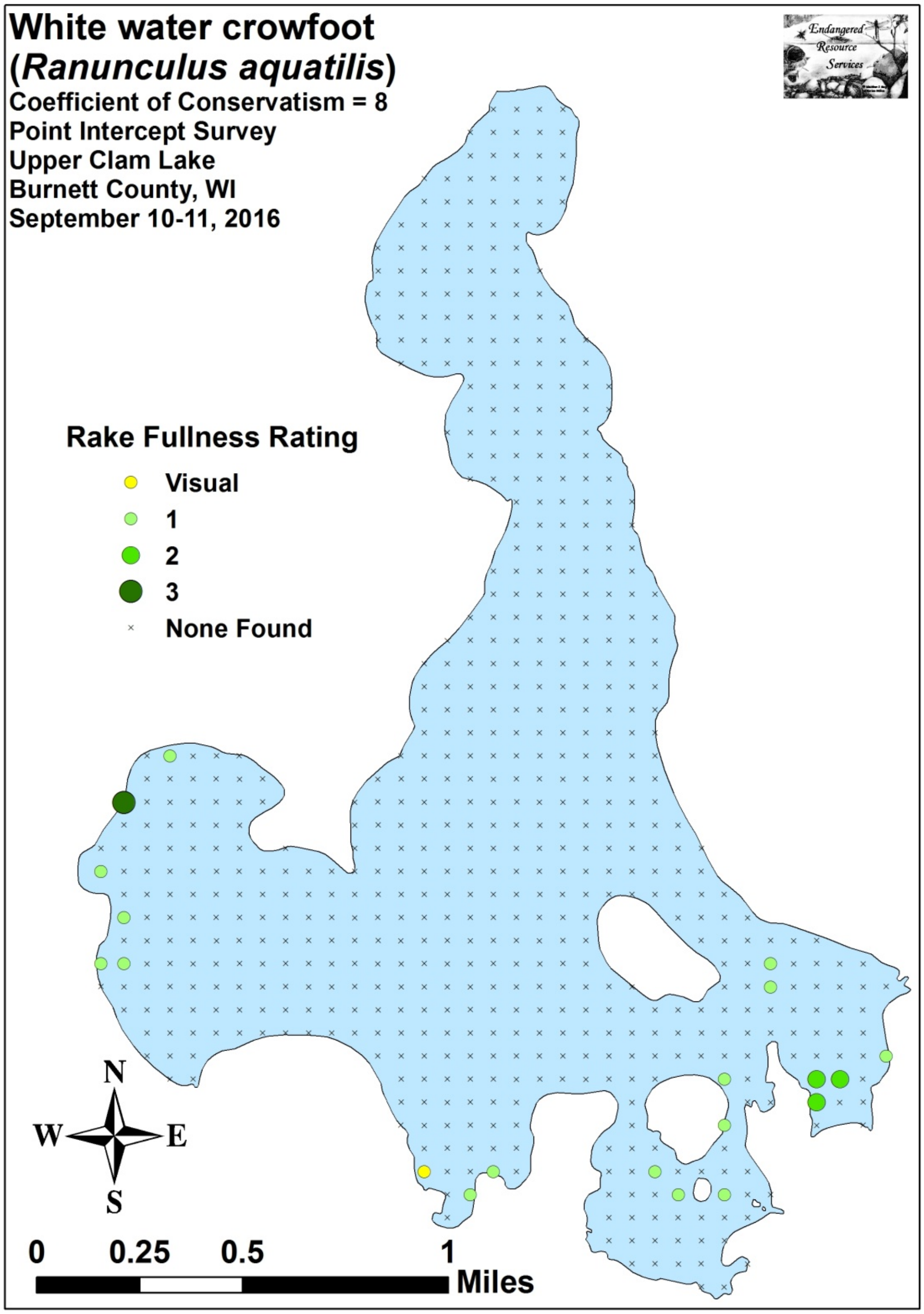

Floating-leaf pondweed
(Potamogeton natans)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

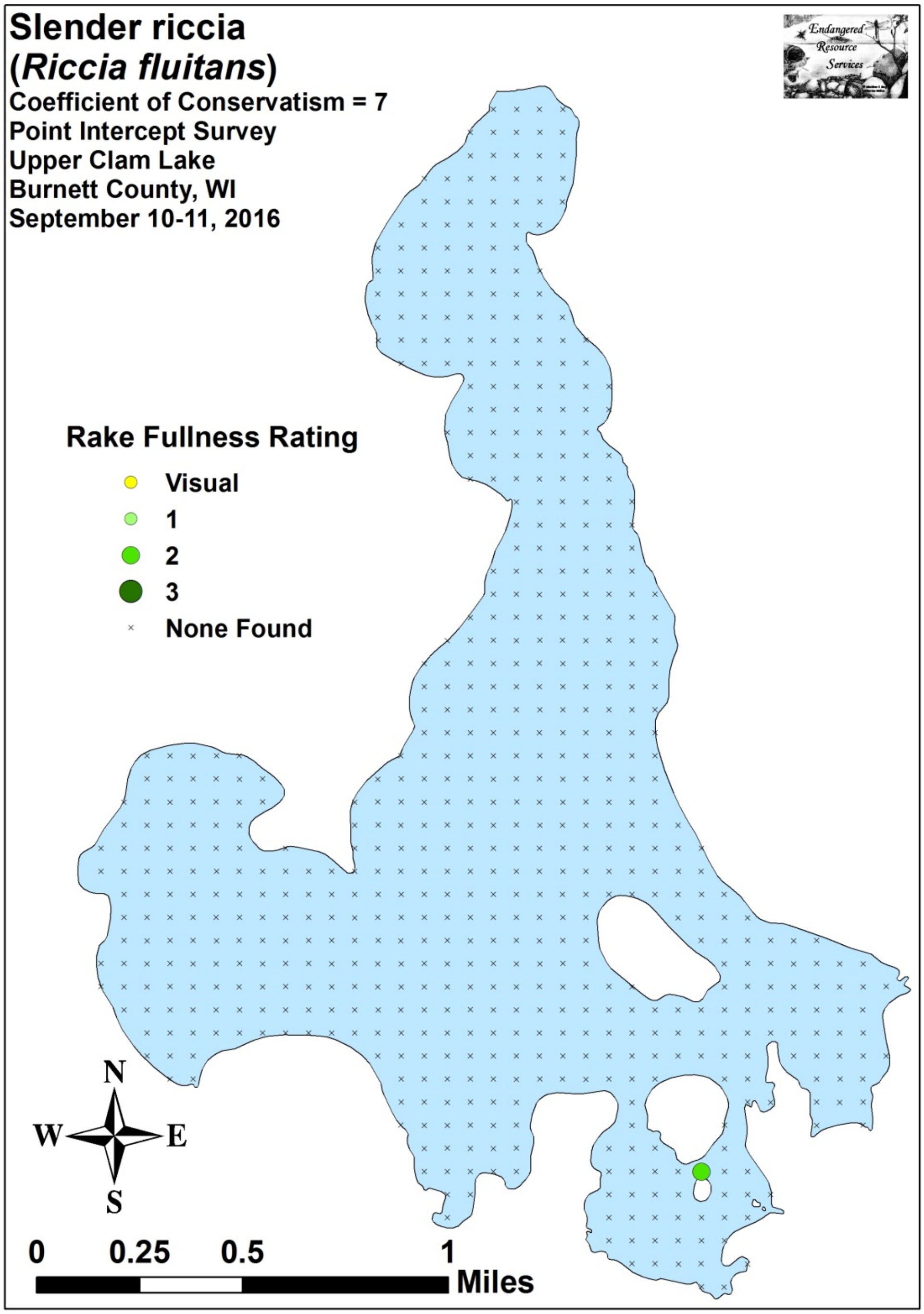

Long-leaf pondweed
(*Potamogeton nodosus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

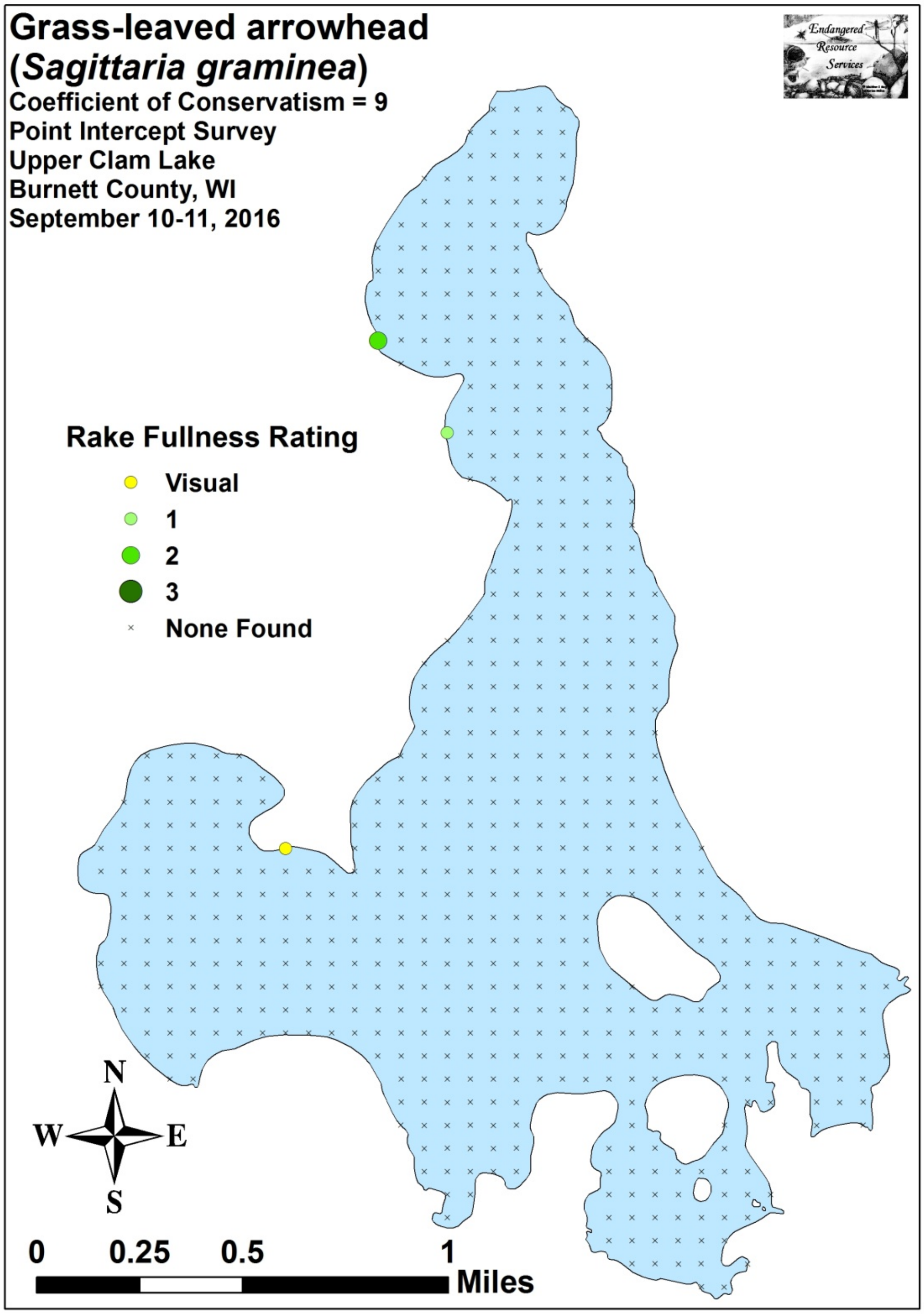

Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Clasping-leaf pondweed
(*Potamogeton richardsonii*)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

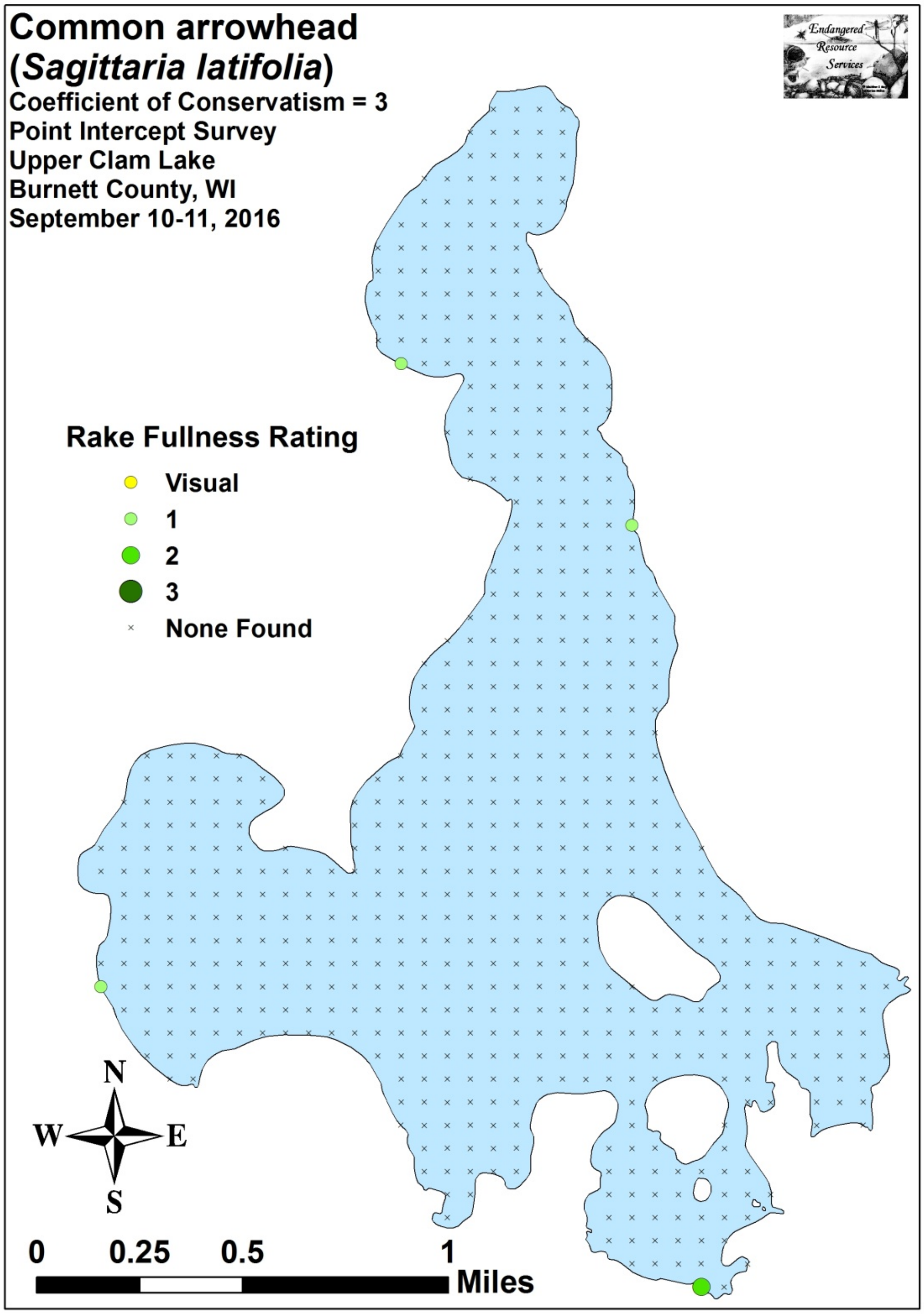

Flat-stem pondweed
(*Potamogeton zosteriformis*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

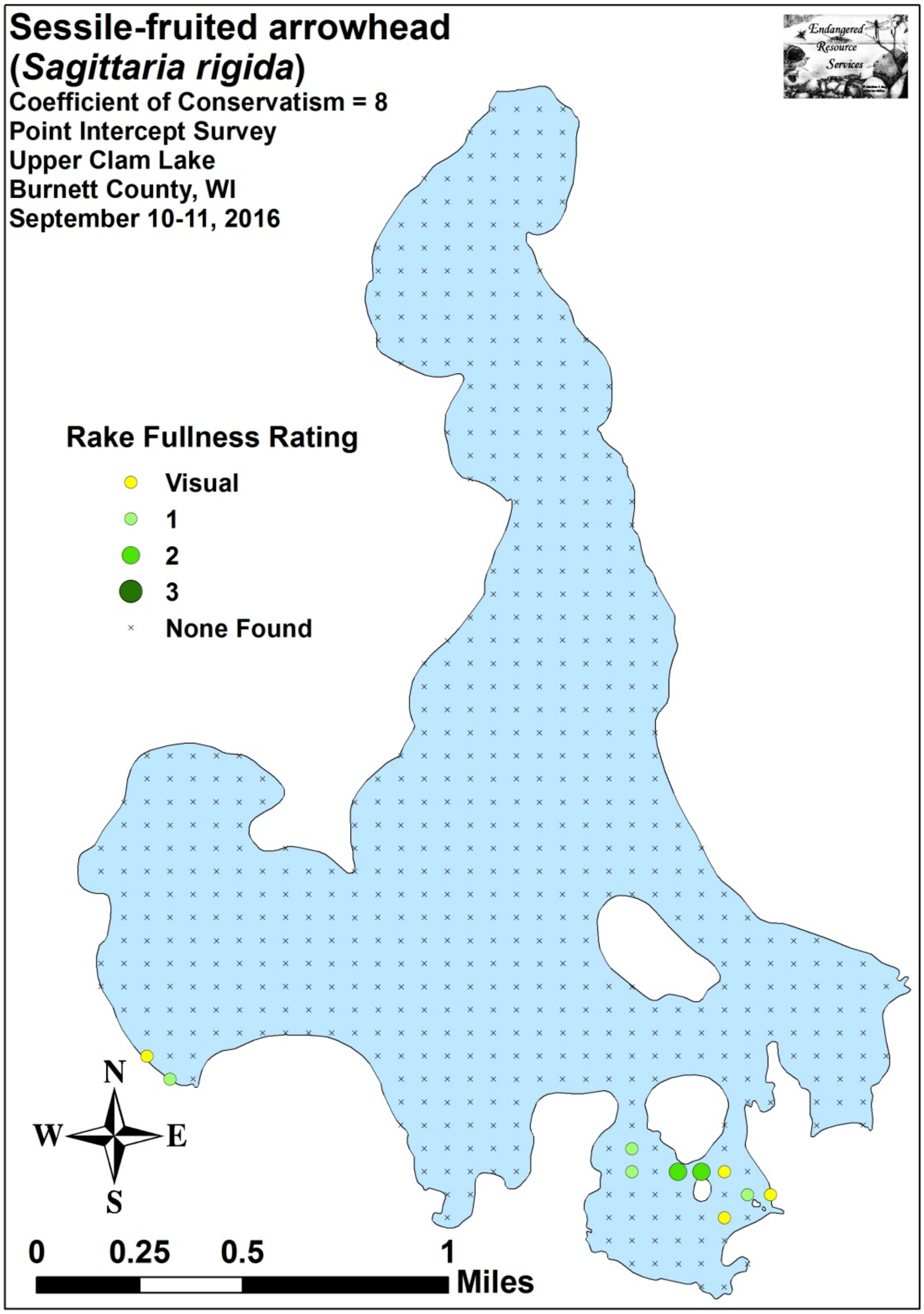

White water crowfoot
(*Ranunculus aquatilis*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

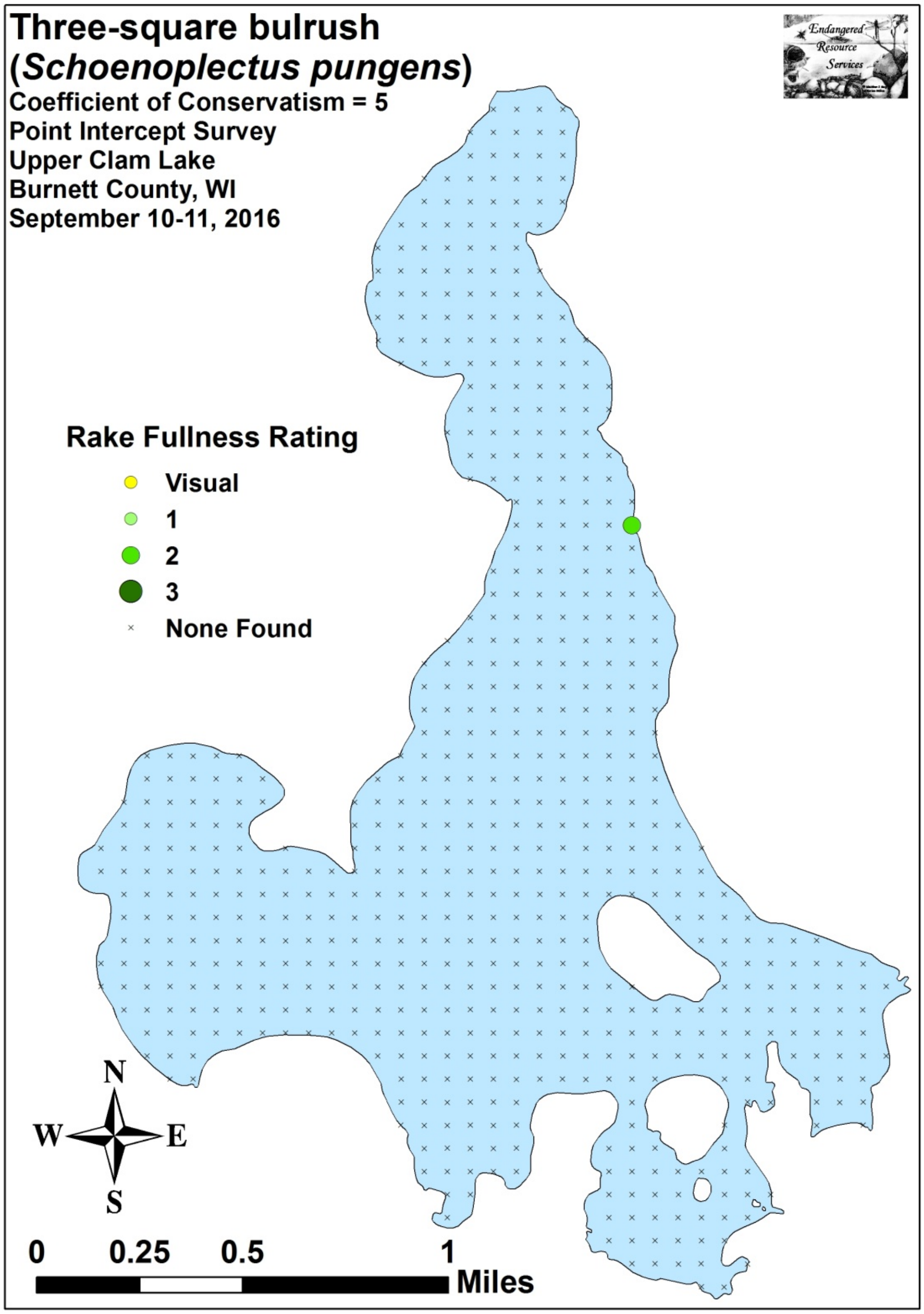

Slender riccia
(Riccia fluitans)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



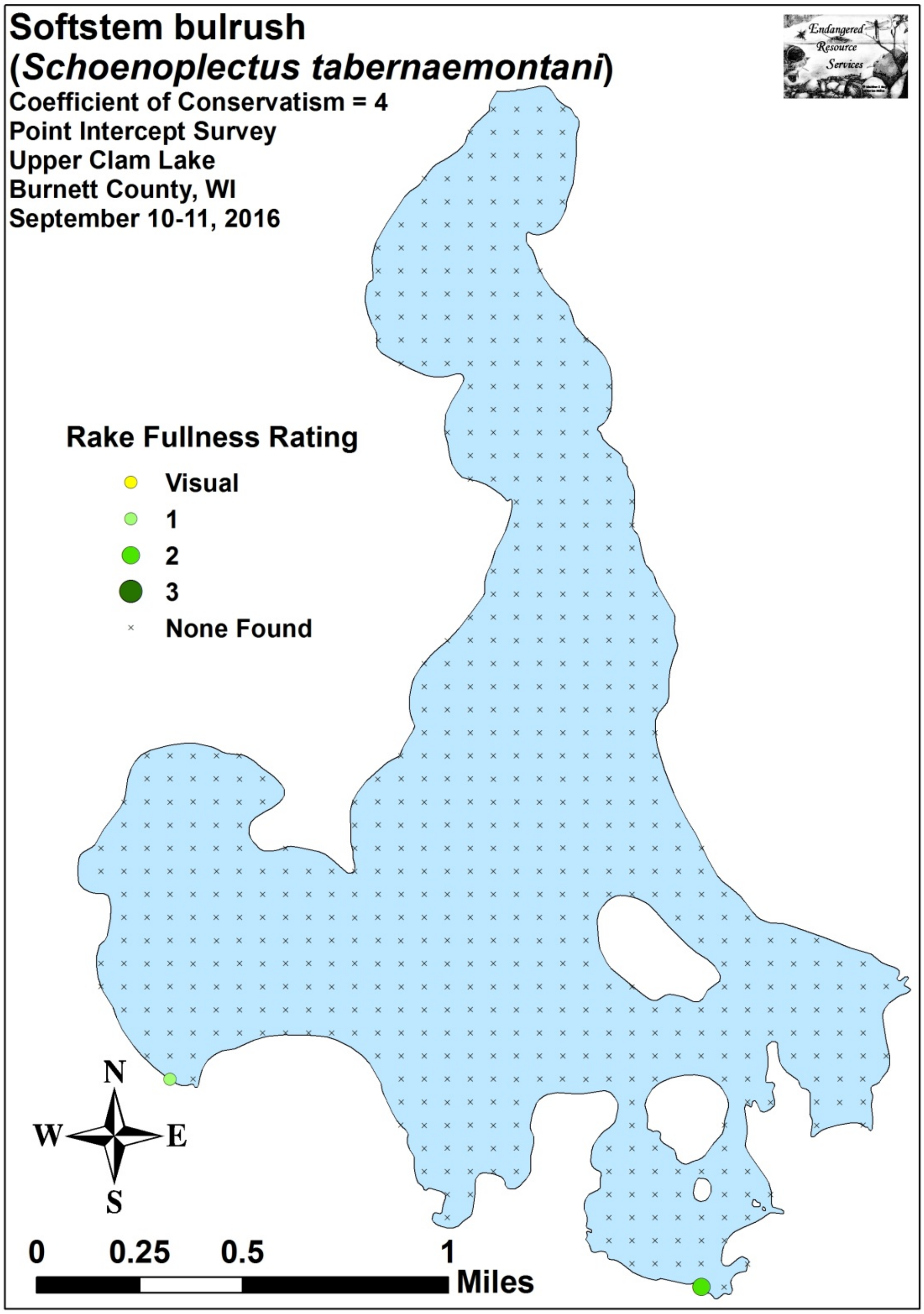
Grass-leaved arrowhead
(Sagittaria graminea)
Coefficient of Conservatism = 9
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

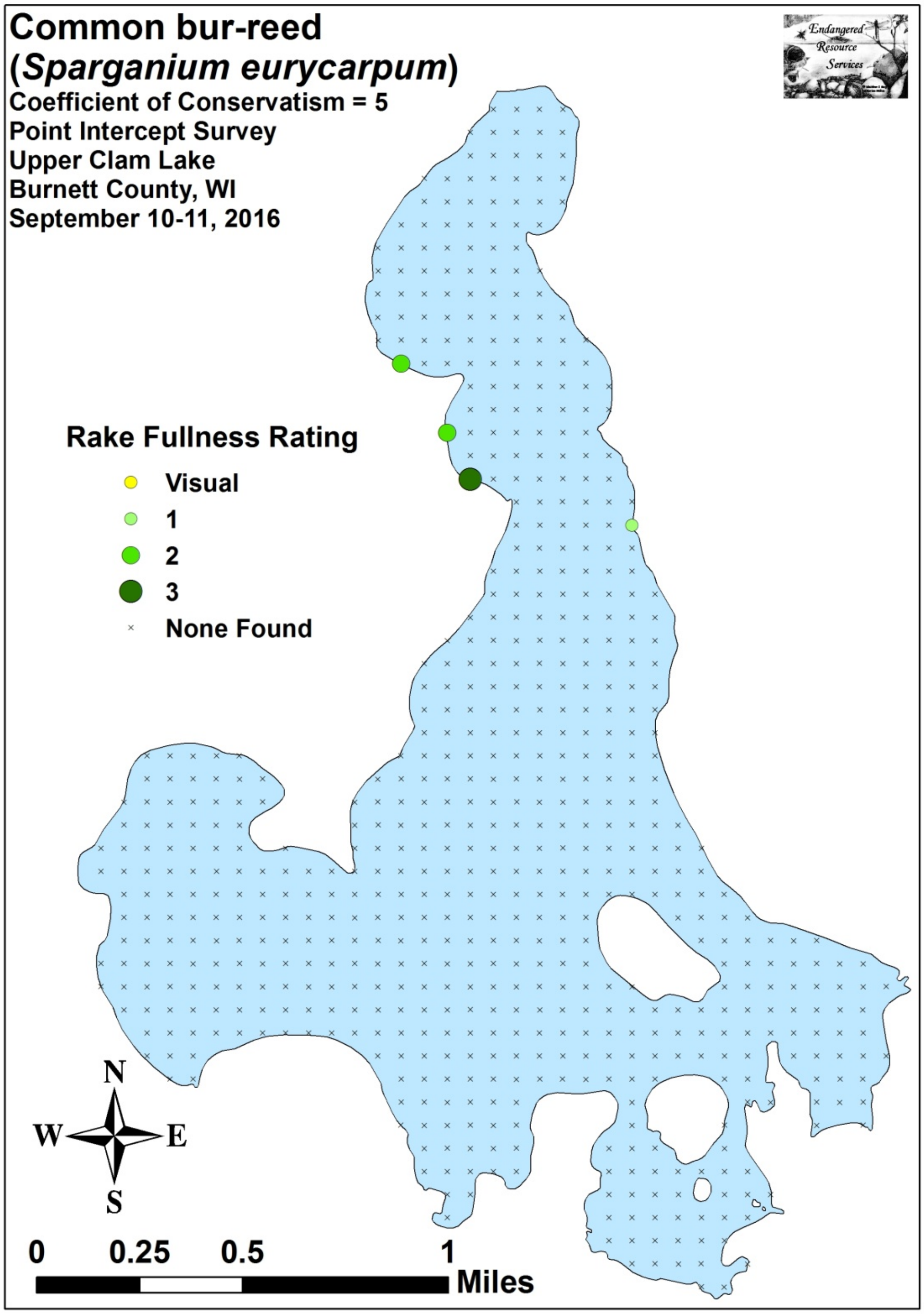

Common arrowhead
(Sagittaria latifolia)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

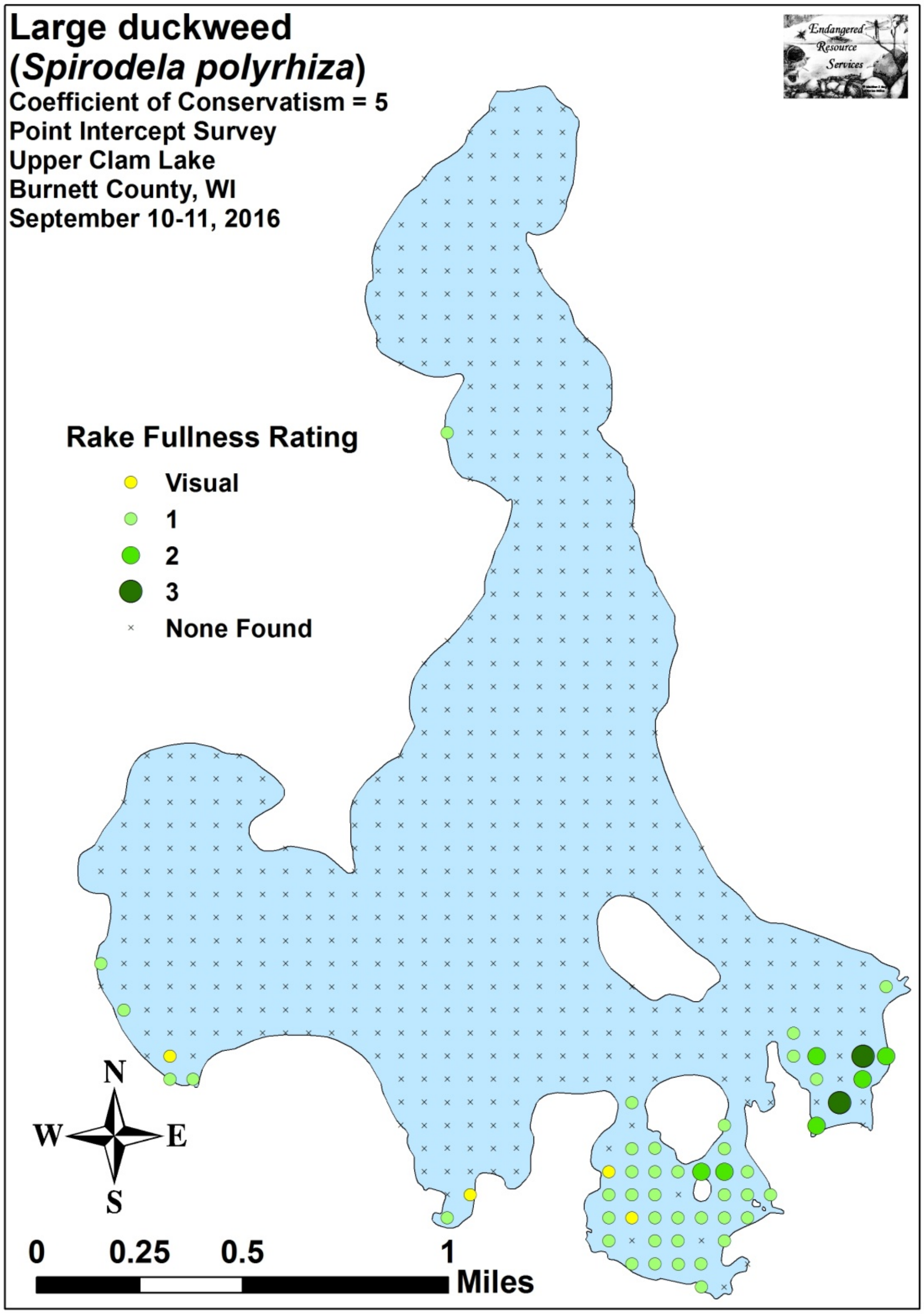

Sessile-fruited arrowhead
(Sagittaria rigida)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

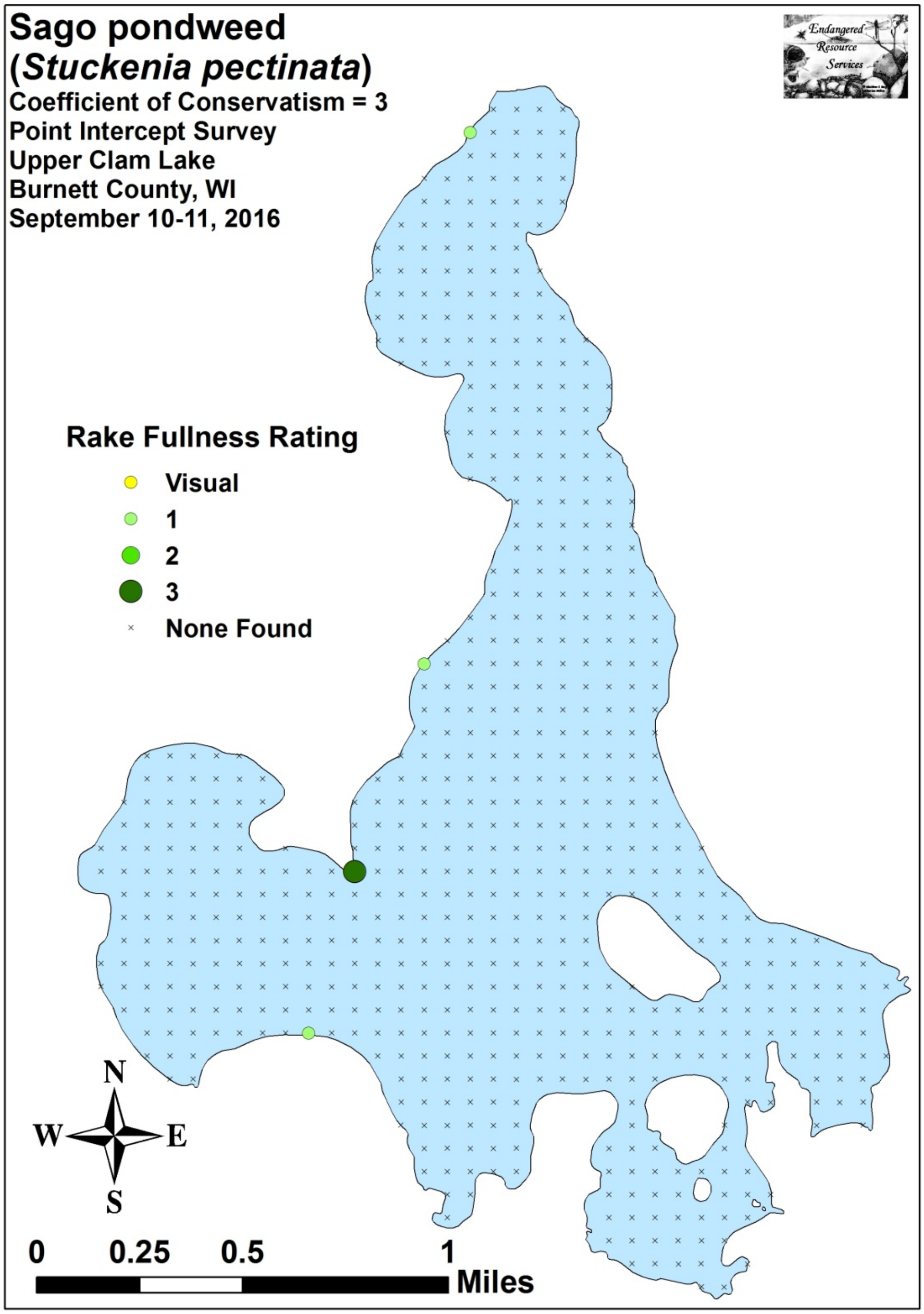


Three-square bulrush
(*Schoenoplectus pungens*)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Softstem bulrush
(*Schoenoplectus tabernaemontani*)
Coefficient of Conservatism = 4
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
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
Upper Clam Lake
Burnett County, WI
September 10-11, 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
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Sago pondweed
(Stuckenia pectinata)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
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2
3
None Found
N
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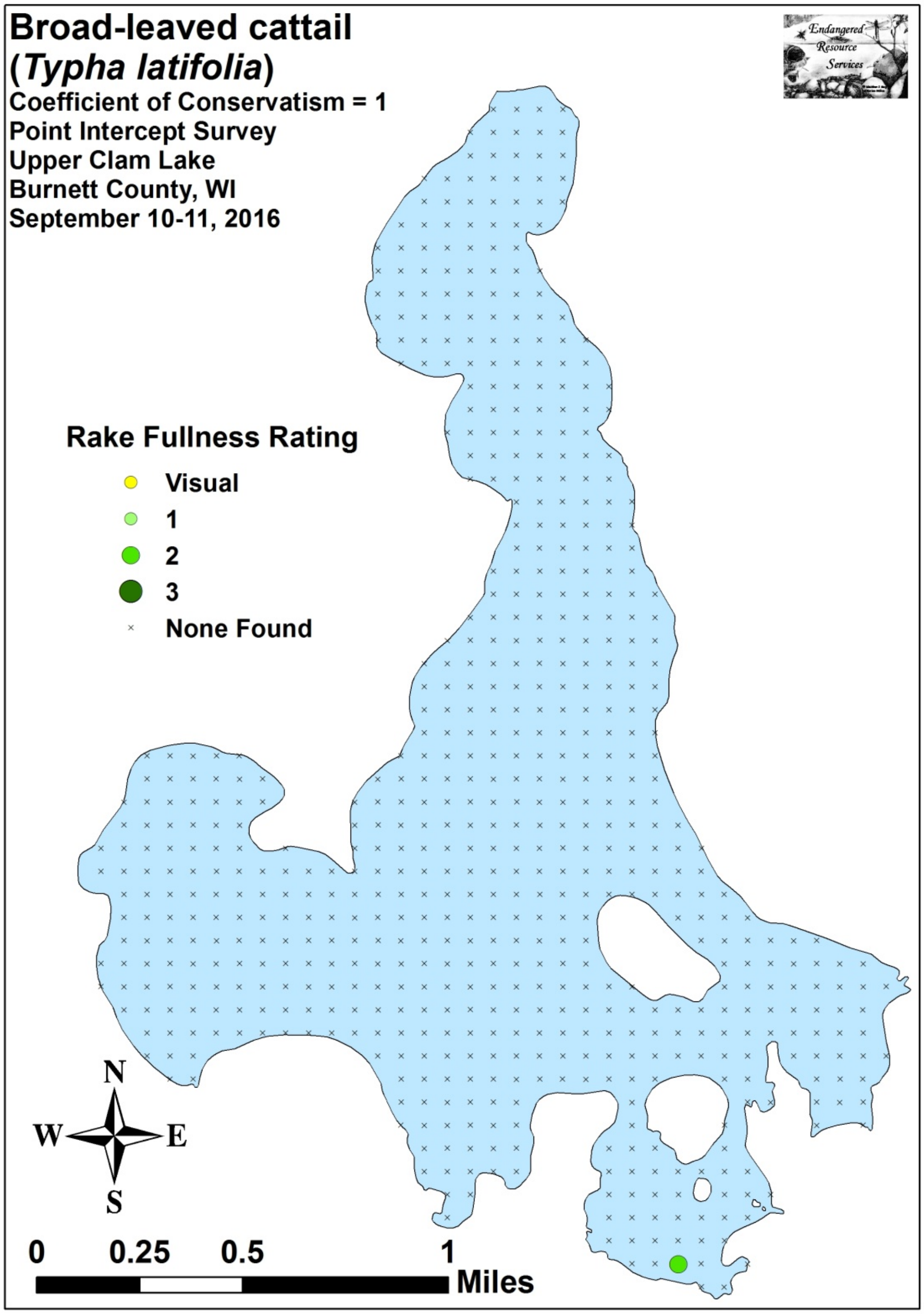
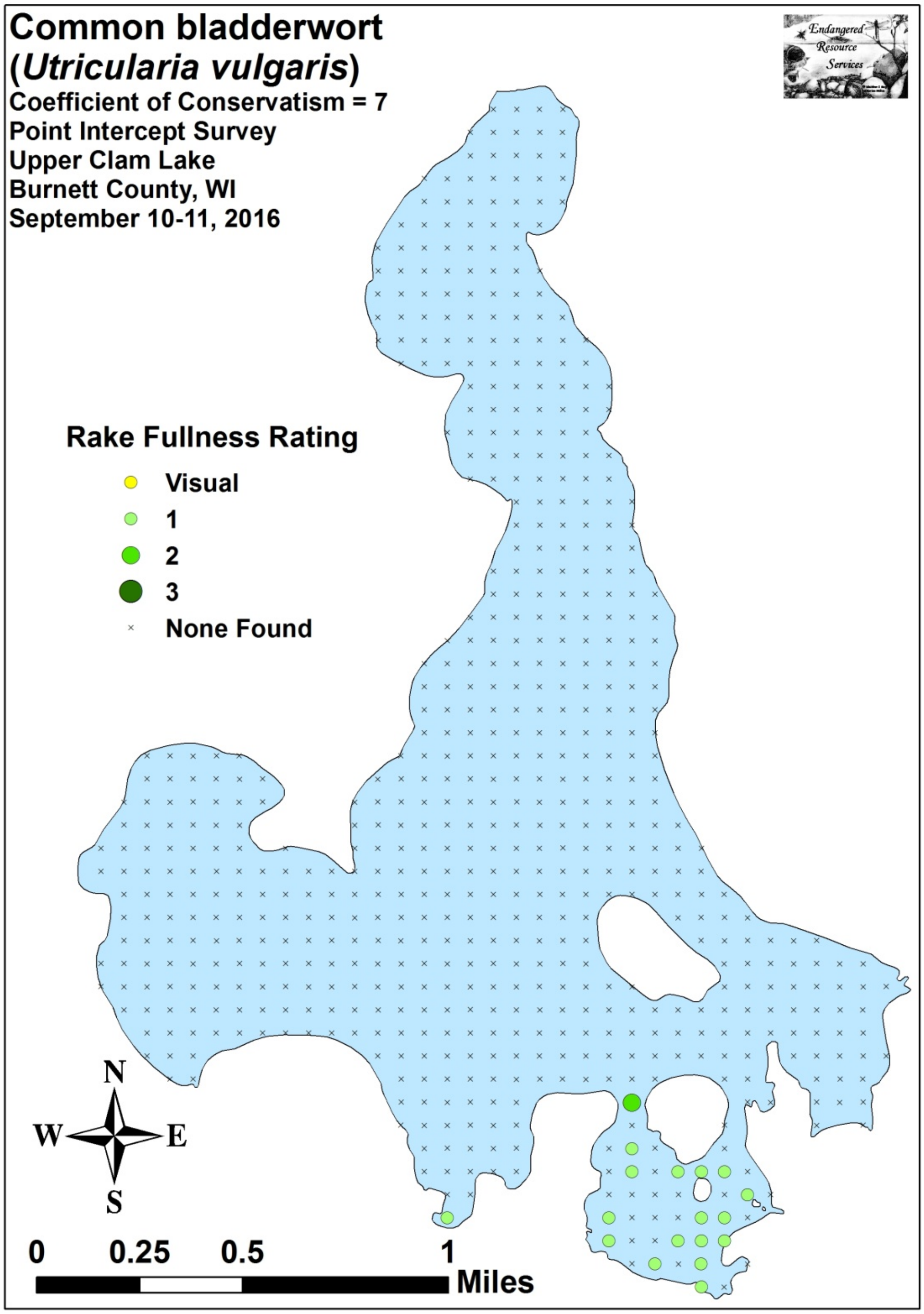
0.25
0.5
1
Miles


Broad-leaved cattail
(*Typha latifolia*)
Coefficient of Conservatism = 1
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Common bladderwort
(Utricularia vulgaris)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
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S
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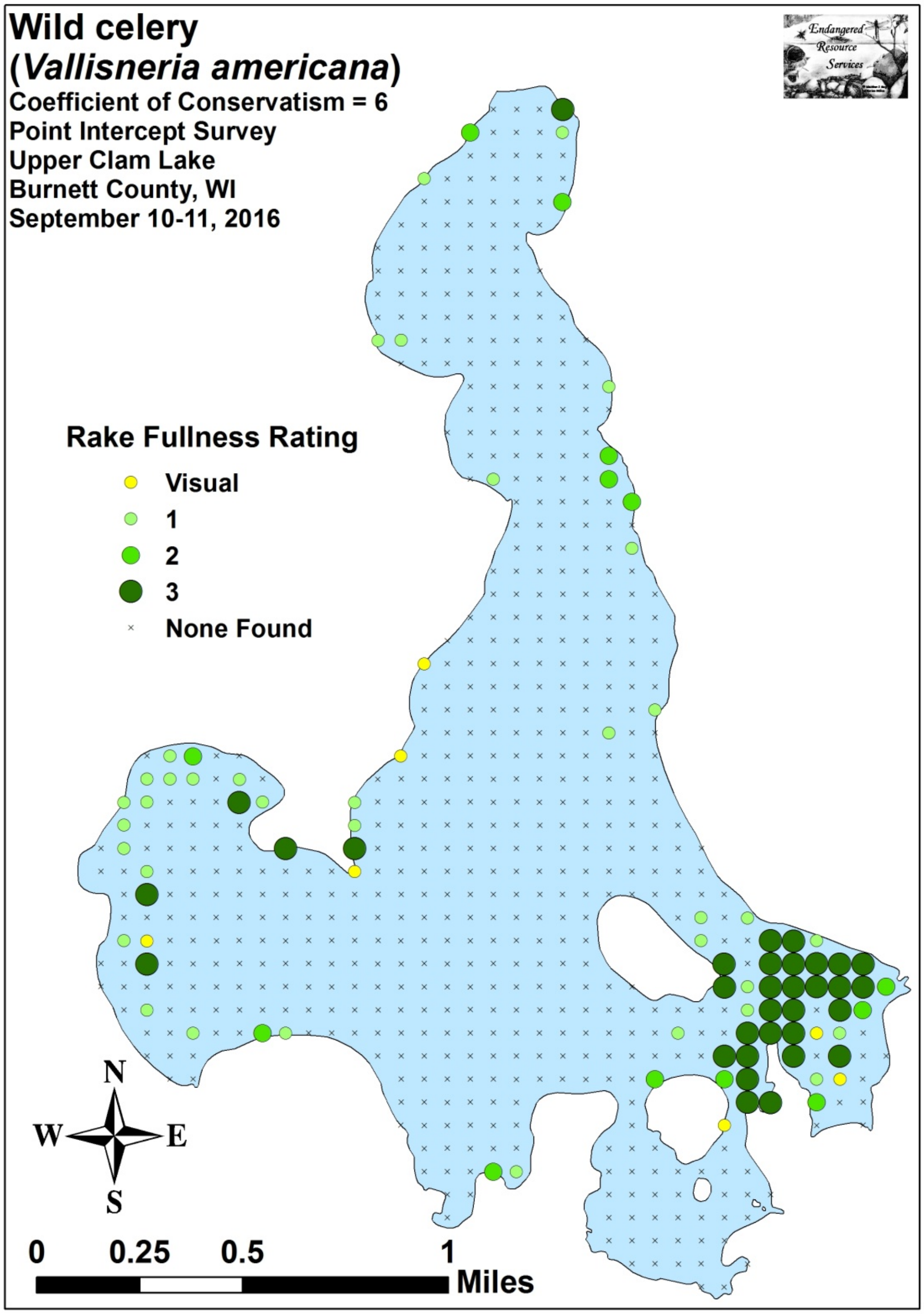
0.5
1
Miles


Wild celery
(*Vallisneria americana*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
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S
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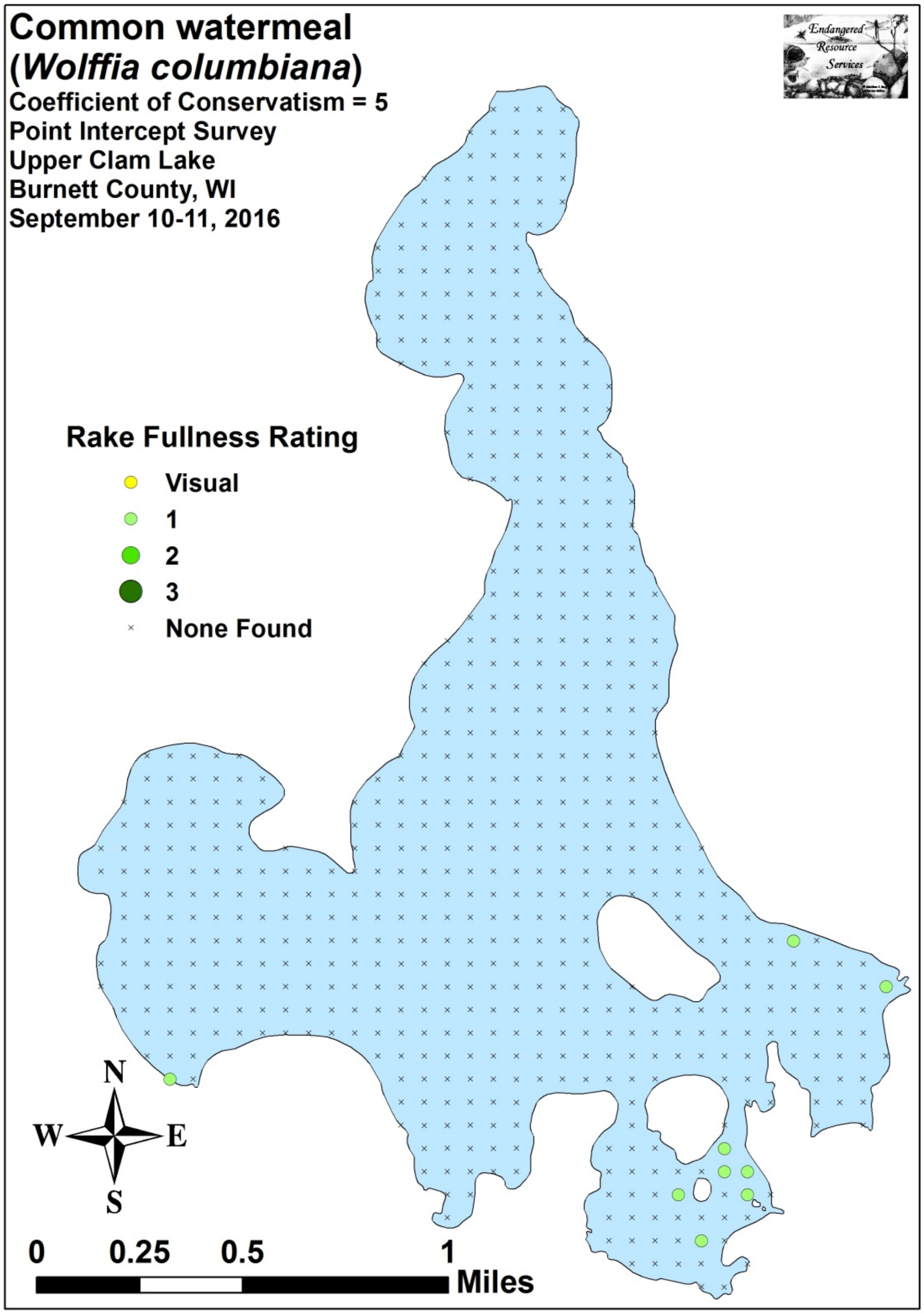
0.5
1
Miles


Common watermeal
(*Wolffia columbiana*)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
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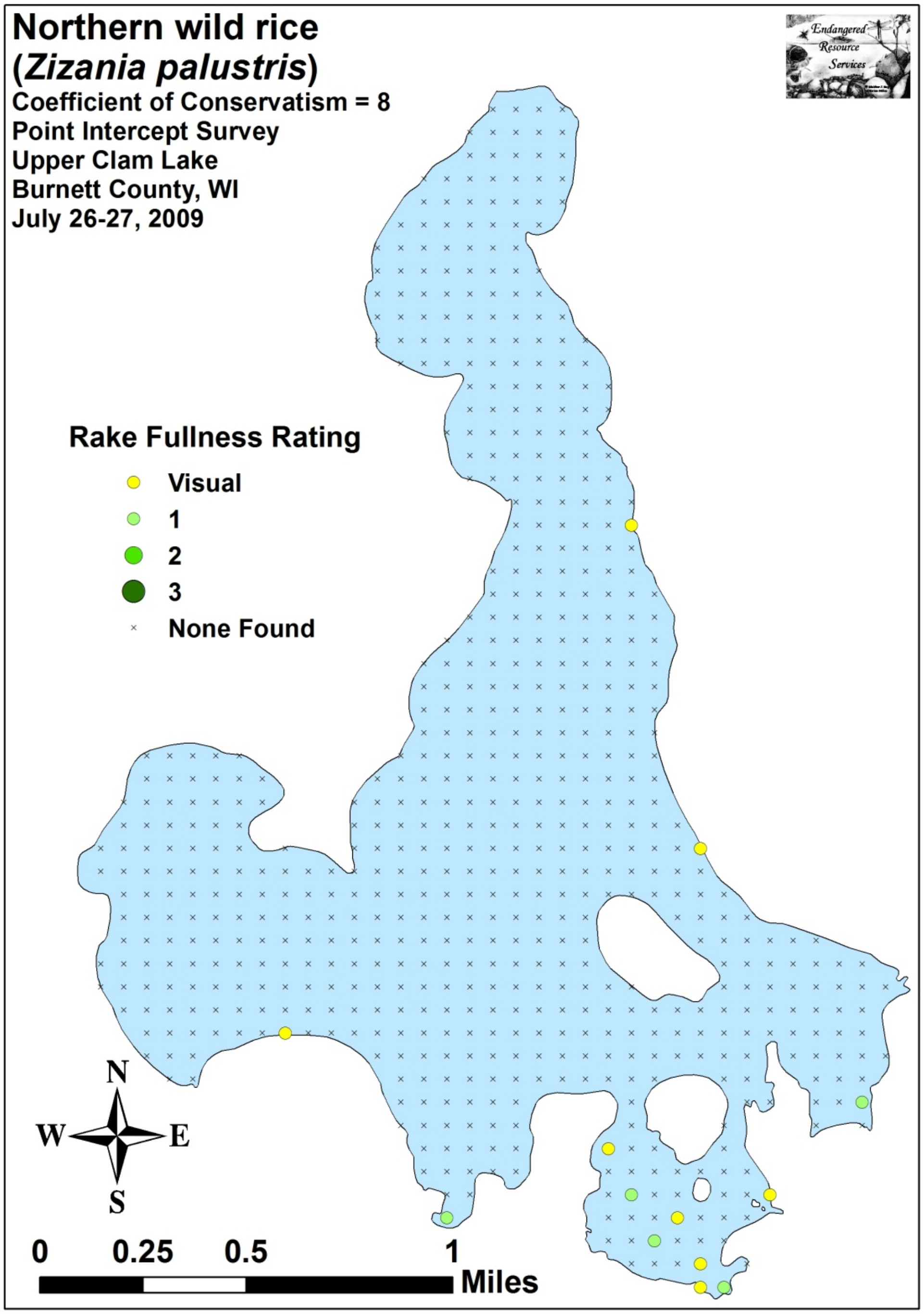
0
0.25
0.5
1
Miles

Appendix VI: Northern Wild Rice Density and Distribution 2009, 2012, 2014, 2015, and 2016


Northern wild rice
(Zizania palustris)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
July 26-27, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
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2
3
None Found
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S
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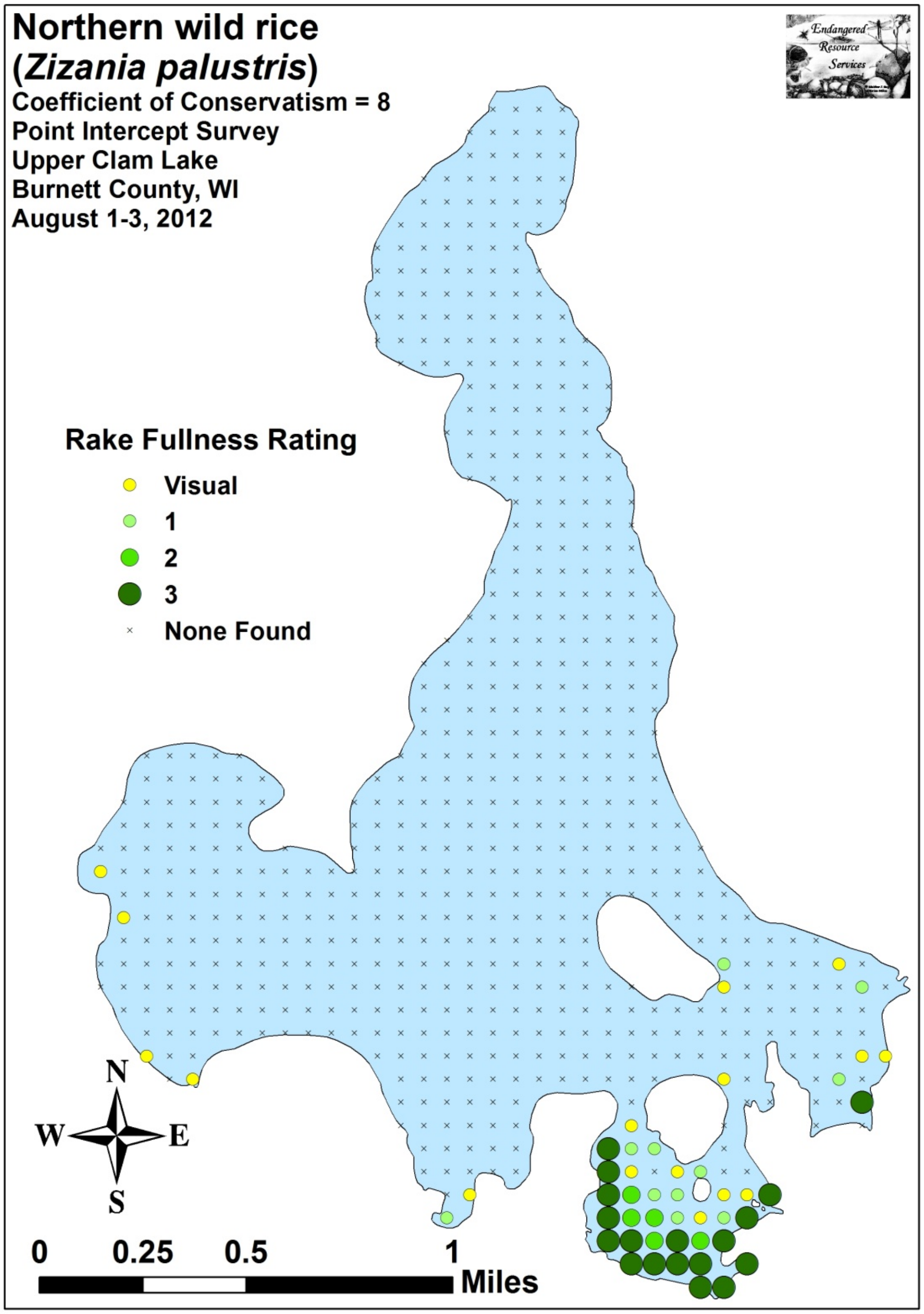
Miles



Northern wild rice
(*Zizania palustris*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 1-3, 2012
Endangered Resource Services
Rake Fullness Rating
Visual
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2
3
None Found
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E
S
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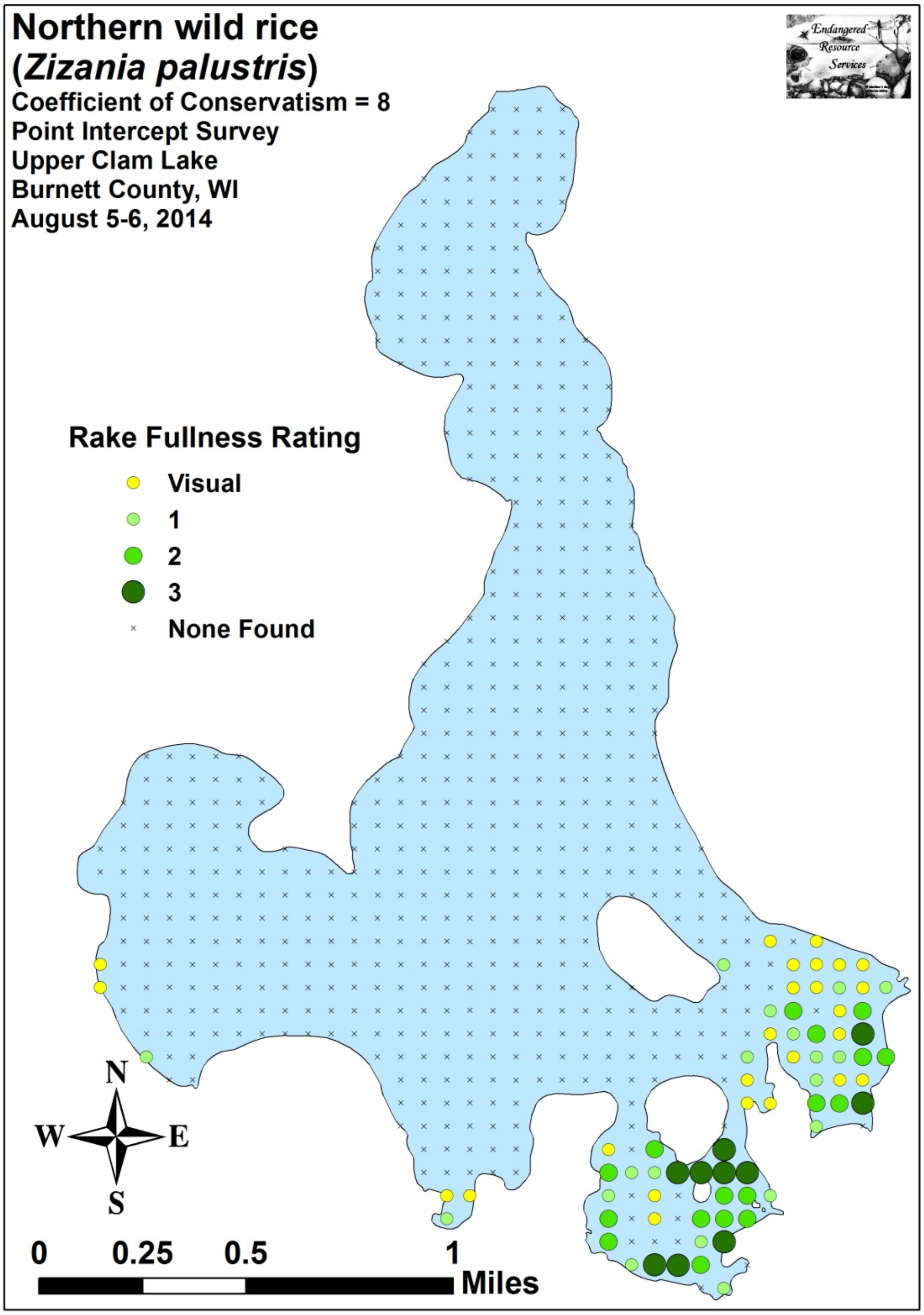
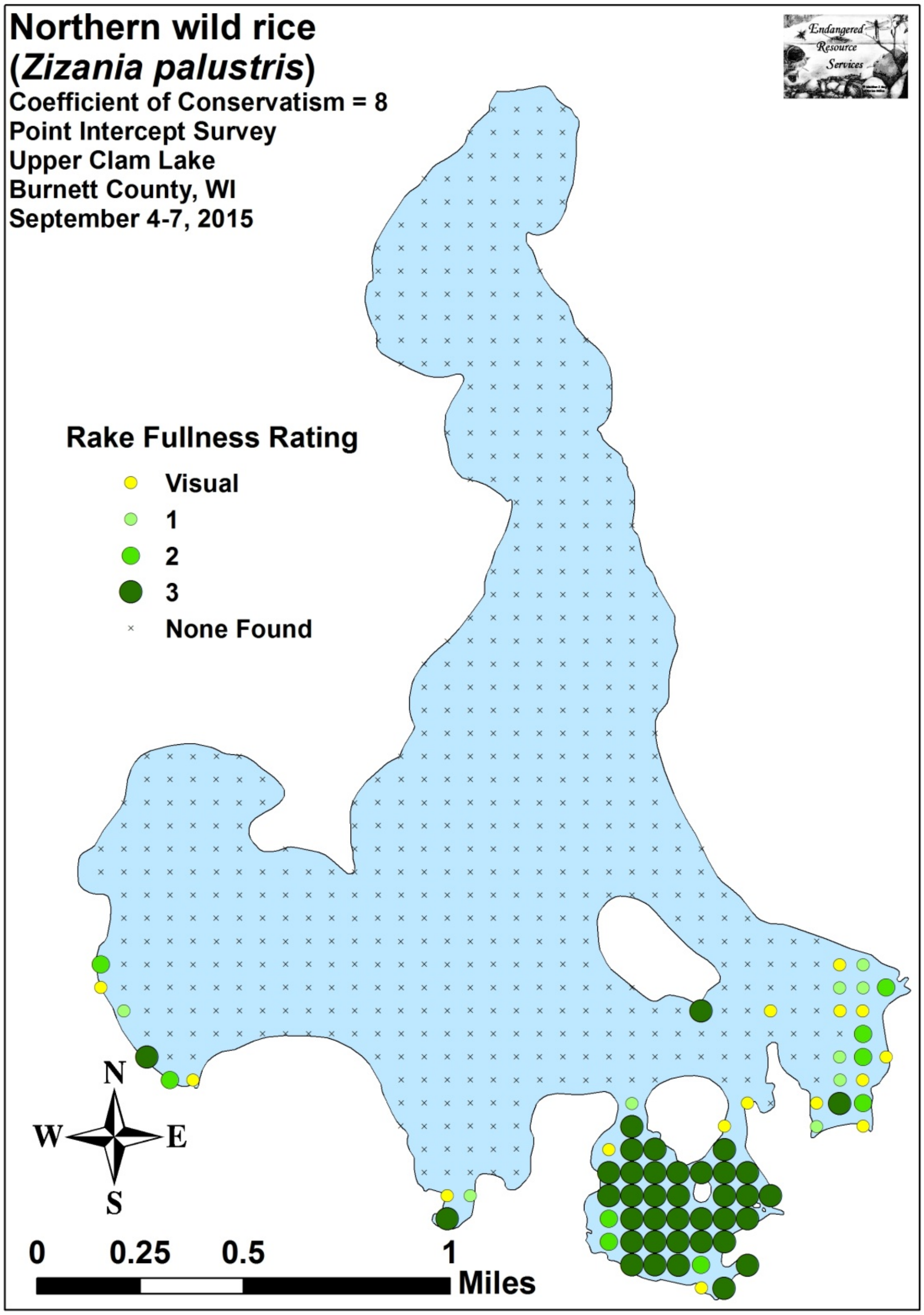
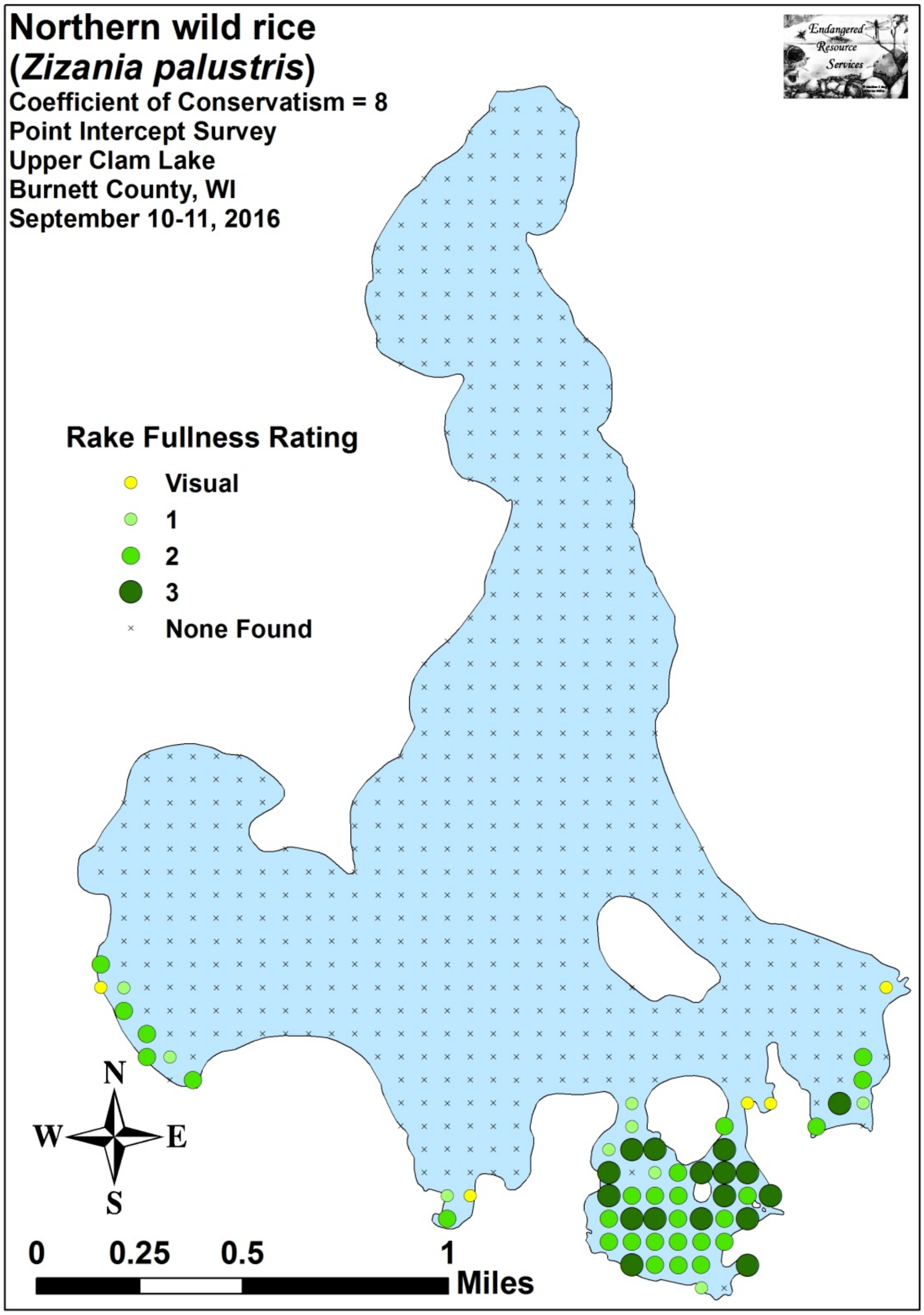
0.5
1
Miles


Northern wild rice
(Zizania palustris)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 5-6, 2014
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Northern wild rice
(*Zizania palustris*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 4-7, 2015
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Northern wild rice
(*Zizania palustris*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
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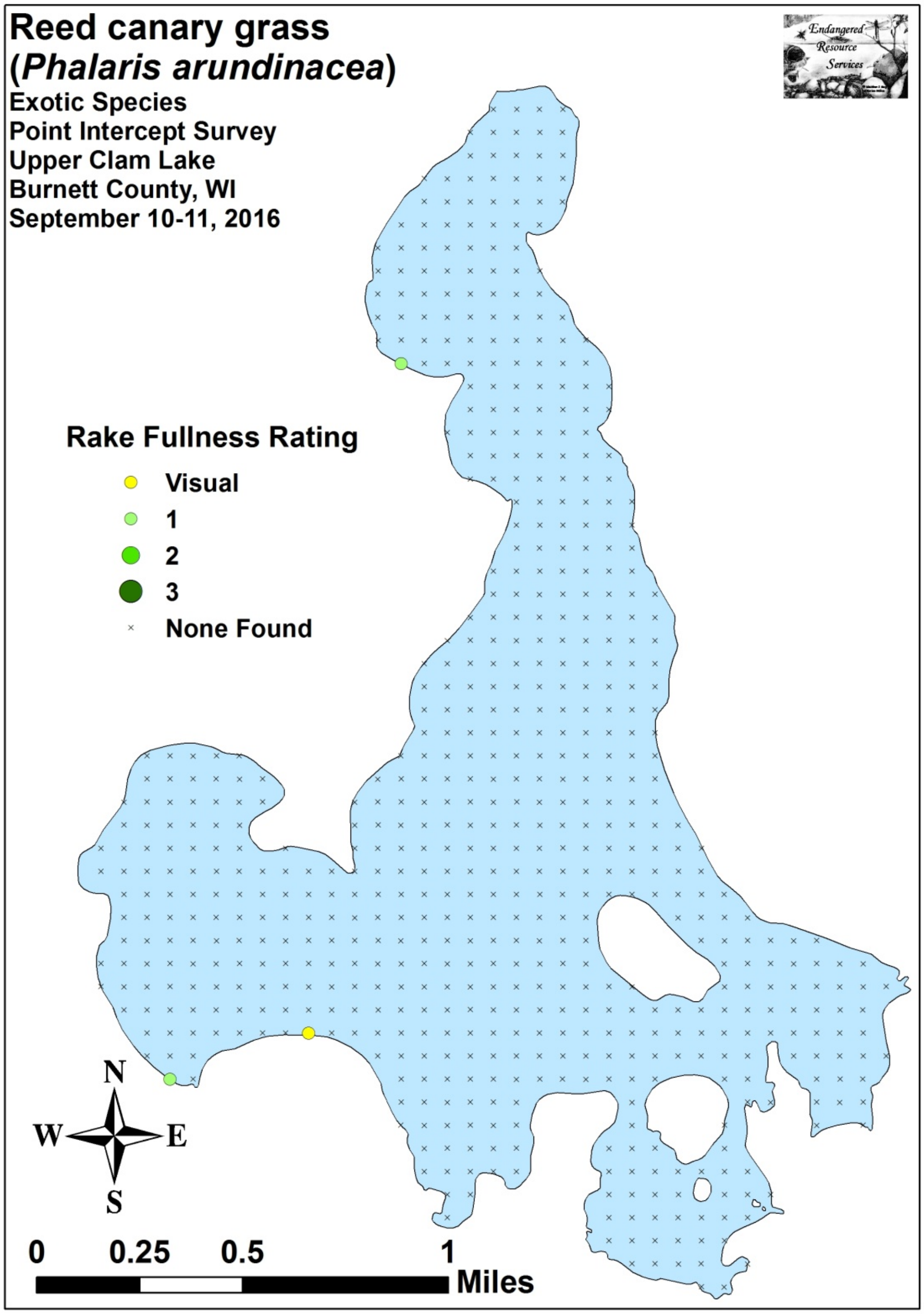
0.25
0.5
1
Miles

Appendix VII: 2016 Exotic Species Density and Distribution Maps


Reed canary grass
(*Phalaris arundinacea*)
Exotic Species
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
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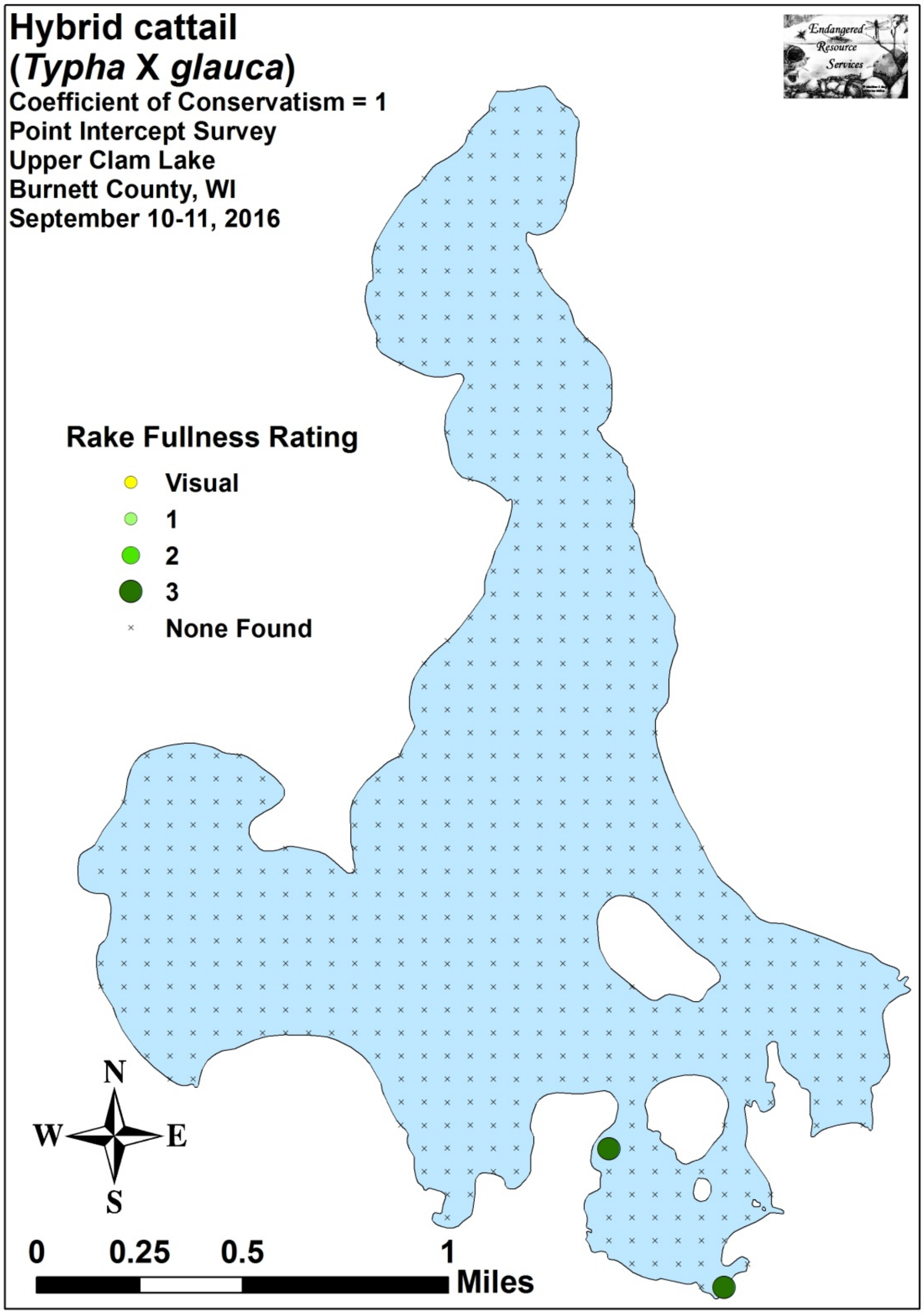
S
0
0.25
0.5
1
Miles


Hybrid cattail
(*Typha X glauca*)
Coefficient of Conservatism = 1
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
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S
0
0.25
0.5
1
Miles

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

Aquatic:

organisms that live in or frequent water.

Cultural Eutrophication:

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

Dissolved Oxygen (DO):

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

Diversity:

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

Drainage lakes:

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

Ecosystem:

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

Eutrophication:

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

Exotic:

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

Habitat:

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

Limnology:

the study of inland lakes and waters.

Littoral:

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

Macrophytes:

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

Nutrients:

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

Organic Matter:

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

Photosynthesis:

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

Phytoplankton:

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

Plankton:

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

ppm:

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

Richness:

number of species in a particular community or habitat.

Rooted Aquatic Plants:

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

Runoff:

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

Secchi Disc:

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

Seepage lakes:

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

Turbidity:

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

Watershed:

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

Zooplankton:

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

Appendix IX: 2016 Raw Data Spreadsheets