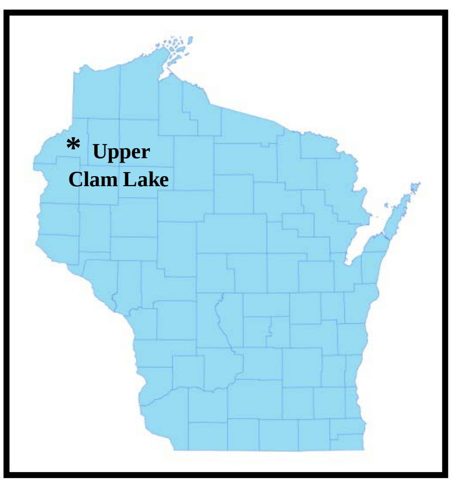
# **Curly-leaf pondweed (*Potamogeton crispus*) Point-intercept and Bed Mapping Surveys, and Warm-water Point-intercept Macrophyte Survey Upper Clam Lake (WBIC: 2656200) Burnett County, Wisconsin**

Dense Wild Rice on the Western Shoreline of the Southwest (Berg 2019)

Aerial photo Upper Clam Lake (2015)

**Project Initiated by:** The Wisconsin Department of Natural Resources, the Clam Lake Protection and Rehabilitation District, and Lake Education and Planning Services, LLC




Sea of Wild Rice in Upper Clam's Southeast Bay (Berg 2019)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June 1, 3, 17, and August 29-September 2, 2019

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# ABSTRACT

Upper Clam Lake (WBIC 2656200) is a 1,338 acre drainage lake in central Burnett County, Wisconsin. Following our original point-intercept surveys in 2009, the Clam Lakes Protection and Rehabilitation District (CLPRD), under the direction of Dave Blumer (Lake Education and Planning Services, LLC), developed an initial Aquatic Plant Management Plan that outlined a harvesting program to manage areas of high density native vegetation and Curly-leaf pondweed (*Potamogeton crispus*) (CLP) – an exotic invasive species that historically dominated the lake's spring littoral zone. After the lake's Carp (*Cyprinus carpio*) population exploded and the fish consumed almost all vegetation in the lake, a netting program (and potentially a natural die off) seems to have brought Carp numbers back down. Since then, increases in vegetation levels prompted the CLPRD to begin harvesting again in 2018. As a prerequisite to updating their plan in 2020 and to compare how the lake's vegetation had changed since the last CLP point-intercept survey in 2014 and the last warm-water survey in 2016, the CLPRD and the Wisconsin Department of Natural Resources authorized a CLP density survey on June 1st and 3rd, a CLP bed mapping survey on June 17th, and a full point-intercept survey of all aquatic macrophytes on August 29-September 2, 2019. In 2019, we found CLP at seven points (1.0% coverage with a mean rake fullness of 1.14) with just one of these having a rake fullness of 2 or 3 (0.2% of the lake had a significant infestation). Compared to 2014 when we didn't find CLP anywhere in the lake, this represented a highly significant increase **(*p*<0.001)** in density; a moderately significant increase **(*p*=0.008)** in total distribution; and a significant increase **(*p*=0.01)** in rake fullness 1. The 2019 bed mapping survey located ten Curly-leaf pondweed beds totaling 5.19 acres (0.4% coverage). This was a 98.1% increase over the 2.62 acres (0.2% coverage) mapped in 2009. During the August 2019 full point-intercept survey, we found macrophytes growing at 605 sites which approximated to 90.6% of the entire lake bottom and 90.7% of the 8.5ft littoral zone. This was a highly significant increase **(*p*<0.001)** over the 2016 survey when plants were present at just 213 points (31.9% of the bottom and 40.7% of the then 7.5ft littoral zone). Overall diversity was high with a Simpson Index value of 0.90 – down slightly from 0.92 in 2016. Total richness was moderate with 36 species in the rake (down slightly from 38 species in 2016) and 45 total found growing in and immediately adjacent to the water (up from 44 species in 2016 and the highest totals of any of our six surveys). There was an average of 3.70 native species/site with native vegetation – a moderately significant increase **(*p*=0.001)** from 3.24 species/site in 2016 and also the highest value for any of the six surveys. Total rake fullness experienced a moderately significant decline **(*p*=0.001)** from a moderately high 2.36 in 2016 to a moderate 2.17 in 2019. Coontail (*Ceratophyllum demersum*), Small pondweed (*Potamogeton pusillus*), Common waterweed (*Elodea canadensis*), and Water star-grass (*Heteranthera dubia*) were the most common species in 2019. Found at 72.56%, 59.50%, 44.96%, and 22.64% of sites with vegetation, they captured 53.95% of the total relative frequency. In 2016, Common waterweed, Coontail, Wild celery (*Vallisneria americana*), and Northern wild rice (*Zizania palustris*) were the most common species (46.01%, 39.91%, 38.50%, and 24.88% of survey points with vegetation/45.89% of the total relative frequency). Lakewide, from 2016-2019, 18 species showed significant changes in distribution with all but Water marigold (*Bidens beckii*) being increases. The 36 native index species found in the rake during the August 2019 survey (down from 38 in 2016) produced a below average mean Coefficient of Conservatism of 5.8 (up from 5.7 in 2016). The Floristic Quality Index of 35.9 (up from 34.9 in 2016) was, however, above the median FQI for this part of the state. Northern wild rice (*Zizania palustris*) was present in the rake at 137 points with a mean rake of 2.28 (22.64% of points with plants/relative frequency of 6.12%). This was a highly significant increase **(*p*<0.001)** in distribution from 53 points with a mean rake of 2.15 in 2016. The beds offered abundant human harvest potential throughout the southern bays, although the high density appeared to be limiting lake access for some residents. Filamentous algae (89 points with a mean rake fullness of 1.48) underwent a highly significant increase **(*p*<0.001)** in distribution compared to 2016 (33 points/mean rake of 1.55). Curly-leaf pondweed was still present at a single point in August 2019. Other than CLP, we found two other exotic species growing in and immediately adjacent to Upper Clam Lake: Reed canary grass (*Phalaris arundinacea*) was present along shorelines throughout; and Hybrid cattail (*Typha* X *glauca*) appeared to be expanding in the southeast bay and along the eastern shoreline. We encourage the CLPRD to initiate a volunteer water quality monitoring program; to harvest CLP and native plants in a way that maintains the majority of the native plant community; and to engage all shareholders to mitigate disagreements that may arise where rice levels may be impacting lake access.

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# 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. The lake is eutrophic with Secchi readings averaging 2-3ft at the time of the 2019 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 at least 8.5ft during the 2019 growing season. 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**

# BACKGROUND AND STUDY RATIONALE:
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 (APMP). At that time, the lakes were mechanically harvesting beds of Curly-leaf pondweed (*Potamogeton crispus*) (CLP) that dominated the spring littoral zone.

Immediately after developing their original APMP, the lakes experienced an explosion in their Carp (*Cyprinus carpio*) population. The fish devastated the lakes' plants including nearly eliminating CLP on Upper Clam and significantly reducing it on Lower Clam. They also nearly completely destroyed the expansive Northern wild rice (*Zizania palustris*) beds that formerly occupied large areas in the south bays of Upper Clam Lake and the southeast bay of Lower 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 the summers of 2012 and 2014. Unfortunately, neither of these surveys showed a significant rebound in vegetation (except inside the Carp exclosure on Upper Clam). However, because there was evidence the Carp population had experienced a die-off over the winter of 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. In Upper Clam Lake, those surveys showed some limited recovery of vegetation; especially near the river inlet. By 2018, vegetation levels had grown to the point that the CLPRD decided to resume actively harvesting plants to keep navigation channels open.

Per WDNR expectations, plant surveys are normally repeated every five to seven years to remain current (Pamela Toshner/Alex Smith, WDNR – pers. comm.). Because the last Curly-leaf pondweed surveys occurred in 2014, and the last management plan was updated that same year; the CLPRD was informed they needed to have the lakes resurveyed so they could update their APMP.

In anticipation of updating their plan in 2020, the CLPRD, under the direction of D. Blumer -Lake Education and Planning Services, LLC (LEAPS), authorized three lakewide surveys on Upper Clam Lake in 2019. On June 1st and 3rd, we conducted an early-season CLP point-intercept survey. This was followed by a CLP bed mapping survey on June 17th, and a warm-water point-intercept survey of all macrophytes from August 29th-September 2nd. The surveys' objectives were to document the current levels of CLP; determine if Eurasian water-milfoil (*Myriophyllum spicatum*) or any other new exotic plants had invaded the lake; and to compare CLP data from the 2009 and 2014 surveys and native vegetation from the 2016 survey with the 2019 data to identify any significant changes in the lake's vegetation over this time. This report is the summary analysis of these three 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, Jennifer Hauxwell (WDNR) generated the original 668 point sampling grid used for Upper Clam Lake in 2009, 2012, 2014, 2015, and 2016 (Appendix I). Using this same grid in 2019, we completed a density survey where we sampled for Curly-leaf pondweed at each point in the lake. We located each survey point using a handheld mapping GPS unit (Garmin 76CSx) and used a rake to sample an approximately 2.5ft section of the bottom. When found, CLP was assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also noted visual sightings of CLP within six feet of the sample point.

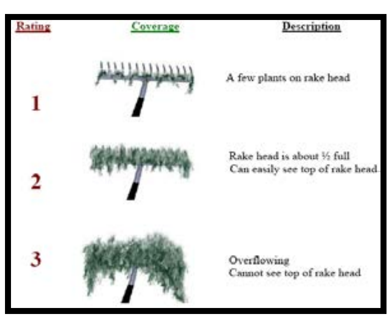



**Figure 2: Rake Fullness Ratings (UWEX 2010)**

## Curly-leaf Pondweed Bed Mapping Survey:

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 2), 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 August point-intercept survey, we conducted a general boat survey to regain familiarity with the lake's macrophytes (Appendix II). All plants found were identified (Voss 1996; Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2009; and Skawinski 2018), and a datasheet was built from the species present. We again located each survey point with a GPS, recorded a depth reading with a metered pole rake, and took a rake sample. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of all plants within six feet of the sample point not found in the rake. In addition to a rake rating for each species, a total rake fullness value 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:

**<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 or kayak.

**<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.

**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. Upper Clam Lake is in the Northern Lakes and Forests Ecoregion (Tables 5 and 6).

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

**Comparison to Past Surveys:** We compared data from our 2009, 2014, and 2019 CLP point-intercept surveys (Figure 4) and 2016 and 2019 warm-water point-intercept surveys (Figure 11) (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 $p<0.05$, moderately significant at $p<0.01$ and highly significant at $p<0.001$ (UWEX 2010). It should be noted that we used the initial number of littoral points from the 2009 warm-water survey (661) as the basis for "sample points" in all comparisons 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:

## Curly-leaf Pondweed Point-intercept Survey:

We rake sampled all 668 points in the lake during the 2019 early-season point-intercept survey and found Curly-leaf pondweed was present in the rake at seven sites with one additional visual sighting. This extrapolated to 1.0% of the entire lake and 1.1% of the 9.5ft spring littoral zone having at least some CLP present. Of these, none rated a rake fullness value of 3, one was a 2, and the remaining six were a 1 for a combined mean rake fullness of 1.14 (Figure 3) (Appendix III). The single point with a rake fullness of a 2 or a 3 suggested just 0.1% of the entire lake and 0.2% of the spring littoral zone had a significant infestation.

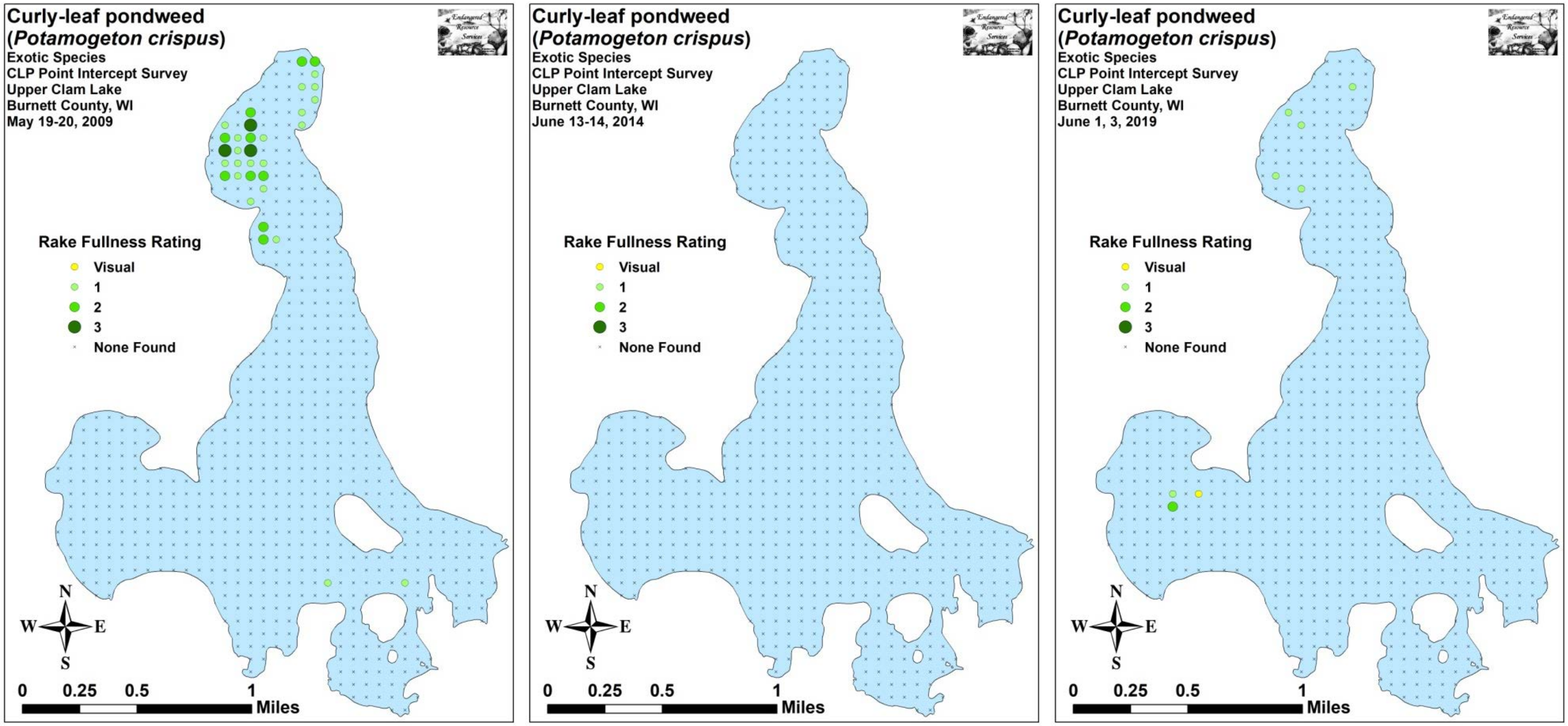


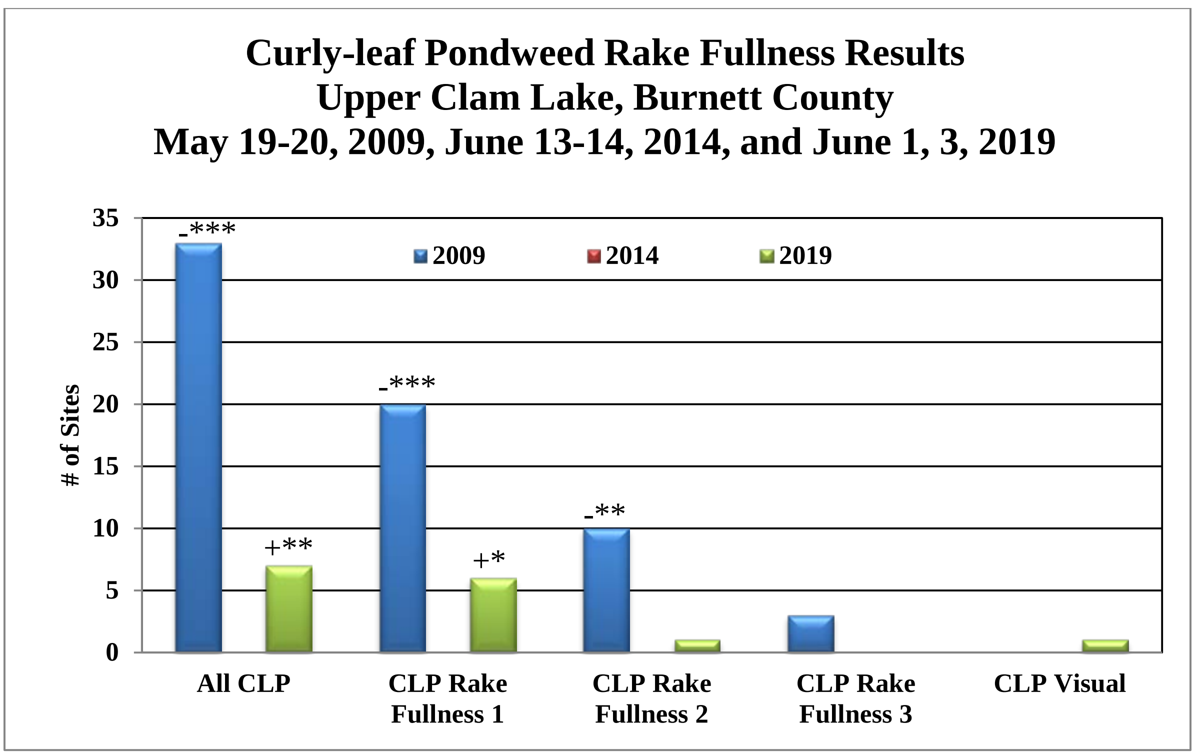

**Figure 3: 2009, 2014, and 2019 Early-season Curly-leaf Pondweed Density and Distribution**

## Comparison of Curly-leaf Pondweed in 2009, 2014, and 2019:

The 2009 spring Curly-leaf pondweed point-intercept survey found CLP at 33 sites which approximated to 4.9% of the entire lake and 5.0% of the estimated spring littoral zone. Of these, we recorded a rake fullness value of 3 at three points, a 2 at ten points, and a value of 1 at 20 points for a mean rake fullness of 1.48 (Figure 3) (Appendix III). The combined 13 points with a rake fullness of 2 or 3 extrapolated to 1.9% of the entire lake and 2.0% of the estimated littoral zone having a significant infestation.

In June of 2014, CLP wasn't present in the rake at any point (Figure 3) (Appendix III). The declines in total density and distribution, and rake fullness 1 were all highly significant **(*p*<0.001)**; and the decline in rake fullness 2 was moderately significant **(*p*=0.002)** (Figure 4).

Compared to 2014, our 2019 survey represented a highly significant increase **(*p*<0.001)** in mean density; a moderately significant increase **(*p*=0.008)** in total distribution; and a significant increase **(*p*=0.01)** in rake fullness 1 (Figure 4). However, when compared to 2009, our 2019 results show total CLP sustained a highly significant decline **(*p*<0.001)** in distribution; a moderately significant decline **(*p*=0.006)** in rake fullness 2 and 1; and a significant decline **(*p*=0.04)** in mean density. Collectively, the 2019 data suggests CLP is still both less widely distributed and less abundant than it was in 2009.




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

**Figure 4: 2009, 2014, and 2019 Changes in Early-season CLP Rake Fullness**

## Curly-leaf Pondweed Bed Mapping Survey:

In 2009, we mapped two beds of Curly-leaf pondweed in the lake's northeast bay (Figure 5). Although they covered 2.62 acres (0.2% of the lake's 1,338 acres), we noted that few of the plants in them were truly canopied, and neither bed seemed likely to cause significantly navigation impairment.

Following a dramatic reduction in CLP levels, neither our 2014 point-intercept nor our shoreline bed mapping surveys found any evidence of CLP in the lake (Figure 5). However, by 2015, scattered plants started reappearing near the river inlet, and the 2019 bed mapping survey located ten beds totaling 5.19 acres (0.4% of the lake's surface area) – a 98.1% increase over 2009 (Table 1). Despite this, most of these "beds" were better described as patches because all but one was <0.50 acre, they had large numbers of natives mixed in, and they likely caused no or only minor impairment over the majority of the area (Figure 5) (Appendix III).

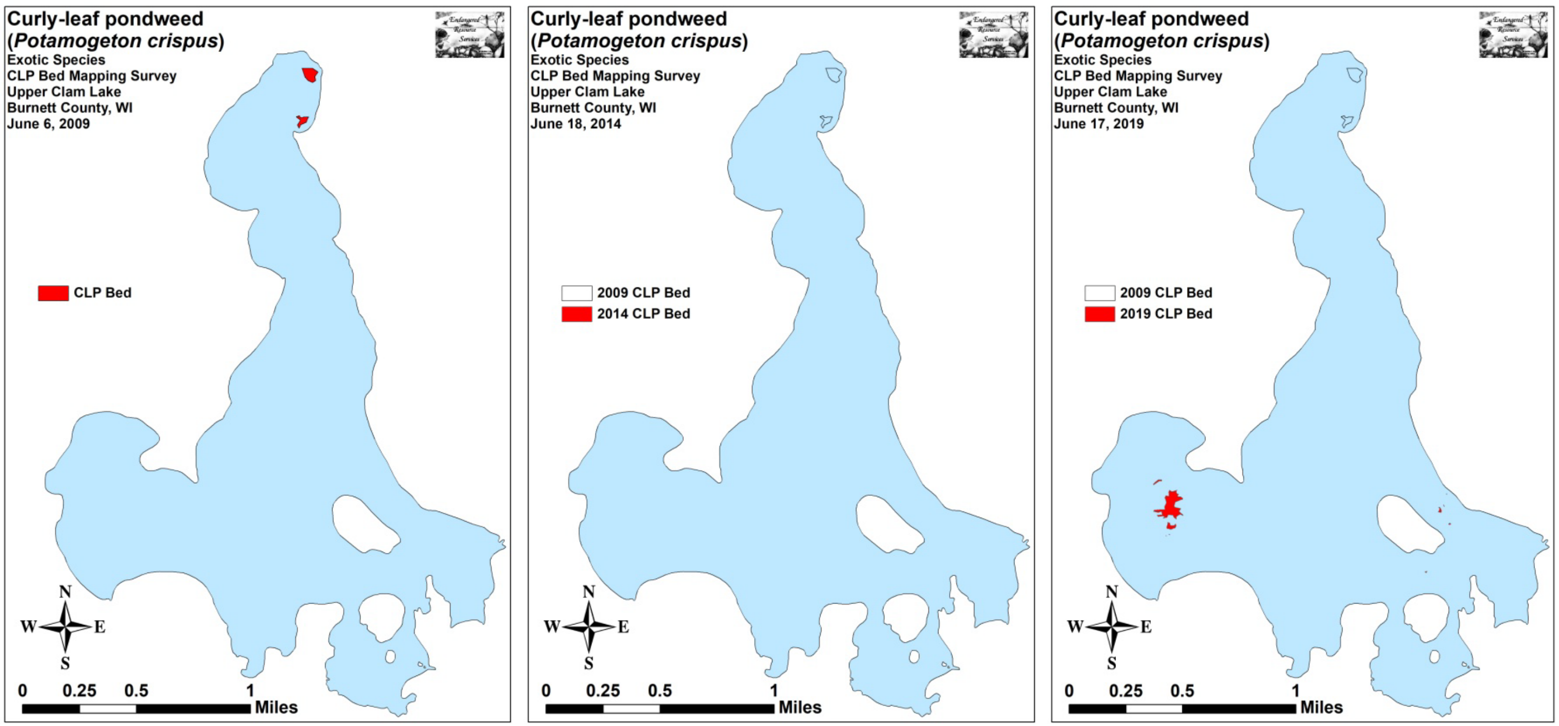



**Figure 5: 2009, 2014, and 2019 Early-season Curly-leaf Pondweed Beds**

## Descriptions of Past and Present Curly-leaf Pondweed Beds:

**Former Beds in the Northeast Bay –** We saw almost no Curly-leaf pondweed in either of these areas during the 2019 survey.

**Beds 1-5 –** Native plants dominated the southeast bays. Although most CLP plants in this area were canopied, these "micro-patches" were no worse than the surrounding vegetation in regards to navigation.

**Bed 6-7 –** These two satellite clusters were similar in composition to Beds 1-5. They were separated from Beds 8-10 by patches of open water, but, for management purposes, it would be reasonable to pool them into a single "High Density Area".

**Bed 8-10 –** Scattered among beds of native plants, these areas formed a patchwork of moderate to dense clusters in the center of the entrance to the southwest bay. Although motoring through them could have caused minor to moderate impairment, there were lanes of open water on either side of the beds, and, because they were generally small in size, we found they were fairly easy to avoid.

**Table 1: Curly-leaf Pondweed Bed Summary Upper Clam Lake, Burnett County – June 17, 2019**

| Bed Number | 2019 Acreage | 2014 Acreage | 2009 Acreage | 2009-2019 Diff. | 2019 Rake Range; Mean Rake | 2019 Depth Range; Mean Depth | 2019 Potential Navigation Impairment Level |
|---|---|---|---|---|---|---|---|
| 1-2009 | 0.00 | 0.00 | 1.82 | -1.82 | <<<1 | 3-6; 5 | None |
| 2-2009 | 0.00 | 0.00 | 0.79 | -0.79 | <<<1 | 3-6; 5 | None |
| 1 | <0.01 | 0.00 | 0.00 | <0.01 | 3; 3 | 4-5; 4 | None |
| 2 | 0.01 | 0.00 | 0.00 | 0.01 | 3; 3 | 4-5; 4 | None |
| 3 | 0.10 | 0.00 | 0.00 | 0.10 | <1-3; 1 | 3-4; 3 | Minor |
| 4 | 0.03 | 0.00 | 0.00 | 0.03 | 3; 3 | 4-5; 4 | None |
| 5 | 0.02 | 0.00 | 0.00 | 0.02 | 3; 3 | 4-5; 4 | None |
| 6 | <0.01 | 0.00 | 0.00 | <0.01 | <1-3; 3 | 4-5; 4 | None |
| 7 | <0.01 | 0.00 | 0.00 | <0.01 | <1-3; 3 | 4-5; 4 | None |
| 8 | 0.45 | 0.00 | 0.00 | 0.45 | <1-3; 1 | 4-5; 5 | Minor |
| 9 | 4.42 | 0.00 | 0.00 | 4.42 | <1-3; 1 | 4-5; 5 | Minor |
| 10 | 0.16 | 0.00 | 0.00 | 0.16 | <1-3; 2 | 4-5; 5 | Moderate |
| **Total Acres** | **5.19** | **0.00** | **2.62** | **+2.57** | | | |

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

Depth soundings taken at Upper Clam's 668 survey points (Appendix I) 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 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 6) (Appendix IV).

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 578 (86.5%) as being muck or sandy muck and 90 (13.5%) as being pure sand (Figure 6) (Appendix IV).

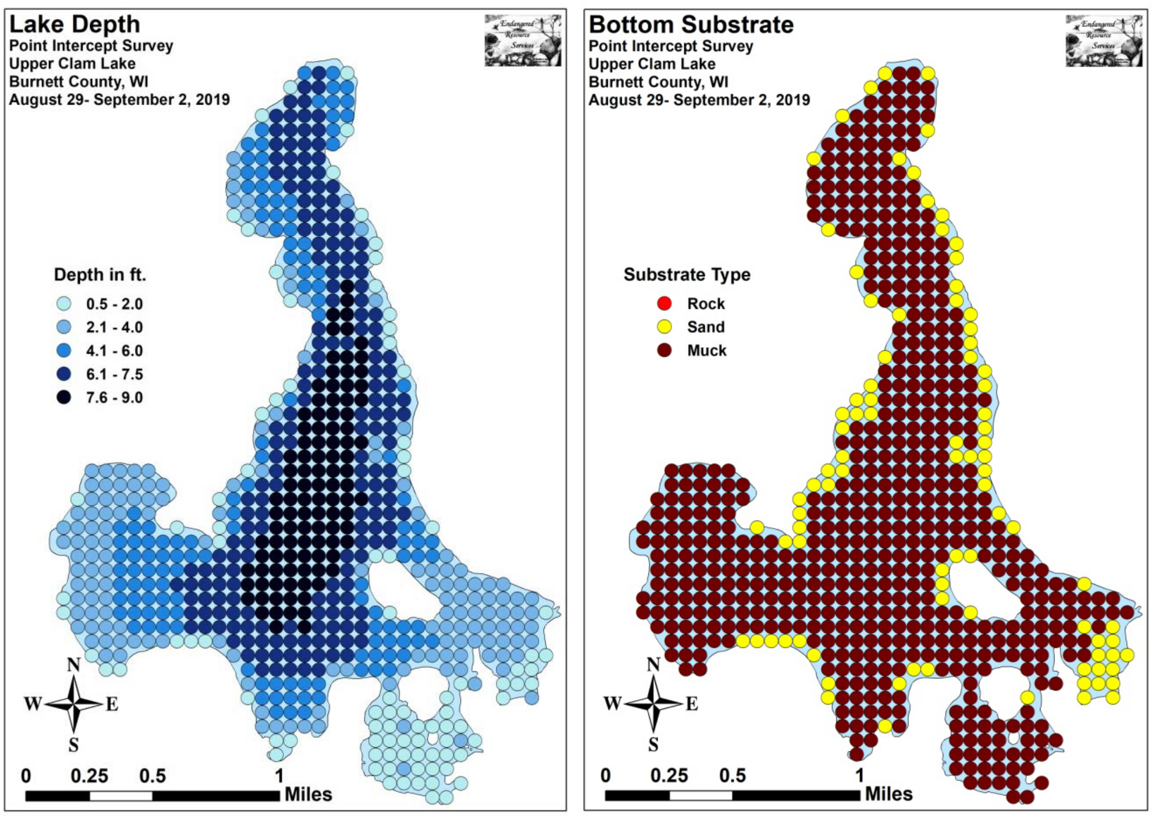



**Figure 6: Lake Depth and Bottom Substrate**

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 8.5ft and included 667 of the lake's 668 survey points (Table 2). This total was a highly significant increase **($p$<0.001)** compared to the 523 littoral points in 2016's 7.5ft littoral zone (Figure 7) (Appendix V).

We found plants at 605 points (90.6% of the bottom and 90.7% of the littoral zone). This was a highly significant increase **($p$<0.001)** over the 2016 survey when plants were present at just 213 points (31.9% of the bottom and 40.7% of the littoral zone). It was also a 178% increase over the next highest survey total of 218 points with vegetation in 2009.

Growth in 2019 was slightly skewed to shallow water as the mean plant depth of 5.2ft was less than the median depth of 5.5ft. Both of these values were more than 2ft higher than in 2016 when the mean and median depths were both 3.0ft (Figure 8). They were also higher than any other survey dating back to 2009 suggesting that vegetation is spreading back into deeper water.

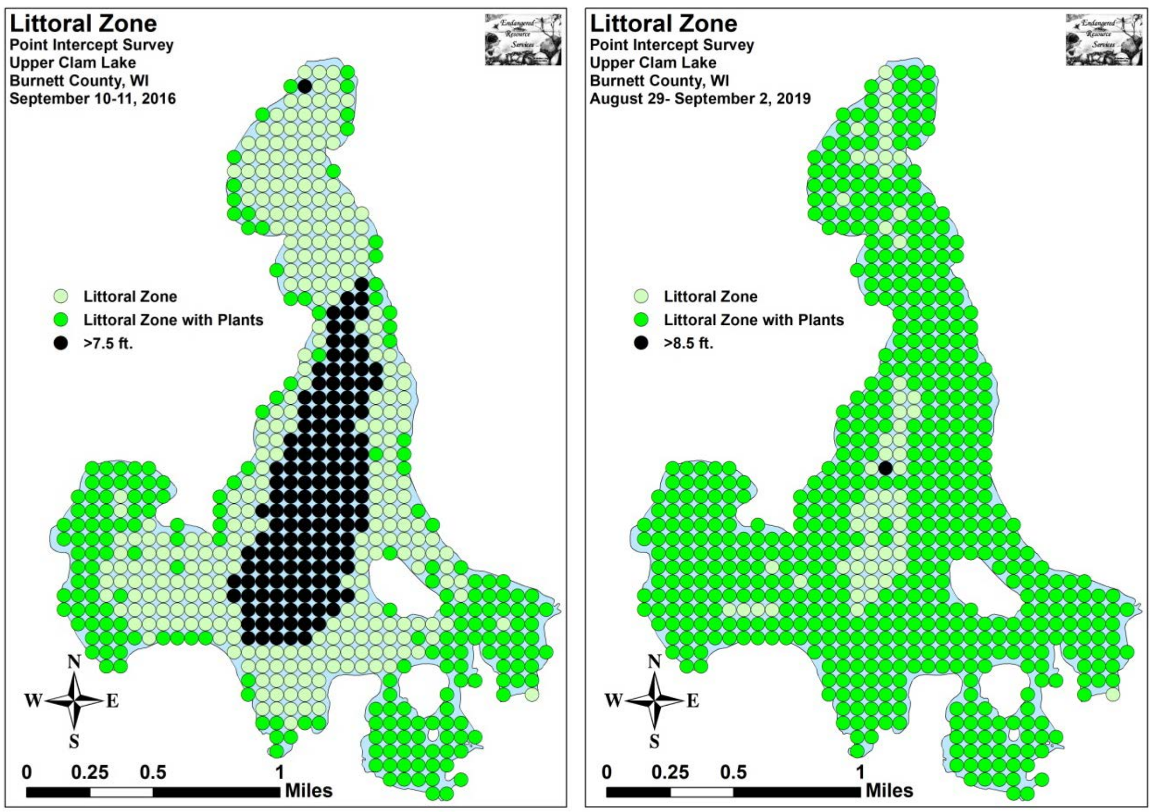



**Figure 7: 2016 and 2019 Littoral Zone**

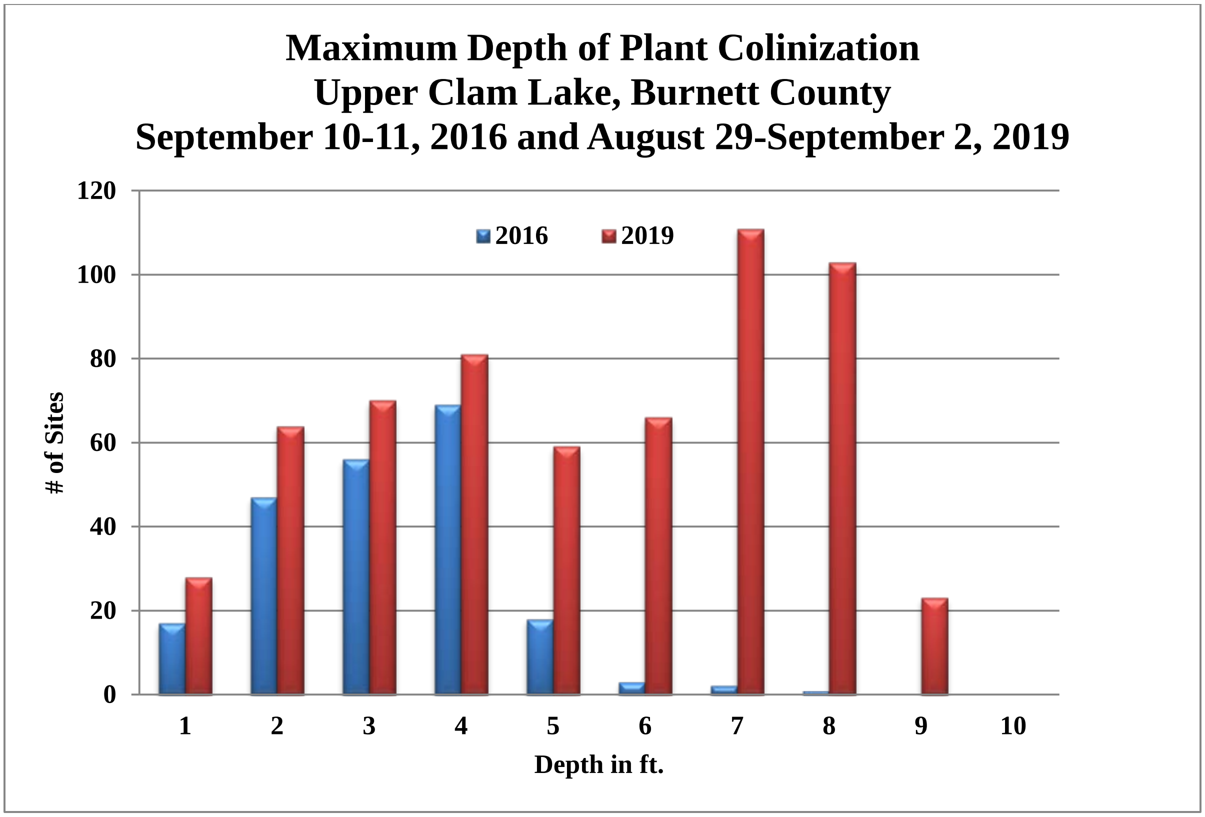



**Figure 8: 2016 and 2019 Plant Colonization Depth Chart**

## Table 2: 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, September 10-11, 2016 and August 29-September 2, 2019

| Summary Statistics: | 2009 | 2012 | 2014 | 2015 | 2016 | 2019 |
|---|---|---|---|---|---|---|
| Total # of points sampled | 668 | 668 | 668 | 668 | 668 | 668 |
| Total # of sites with vegetation | 218 | 197 | 153 | 187 | 213 | 605 |
| Total # of sites shallower than the max. depth of plants | 661 | 650 | 305 | 439 | 523 | 667 |
| Freq. of occur. at sites shallower than max. depth of plants | 32.98 | 30.31 | 50.16 | 42.60 | 40.73 | 90.70 |
| Simpson Diversity Index | 0.90 | 0.91 | 0.92 | 0.93 | 0.92 | 0.90 |
| Maximum depth of plants (ft) | 9.00 | 8.00 | 5.00 | 6.50 | 7.50 | 8.50 |
| Mean depth of plants (ft) | 3.30 | 2.67 | 2.53 | 2.73 | 3.00 | 5.02 |
| Median depth of plants (ft) | 3.50 | 3.00 | 2.50 | 3.00 | 3.00 | 5.50 |
| Ave. # of all species per site (shallower than max depth) | 0.88 | 0.93 | 1.28 | 1.49 | 1.33 | 3.36 |
| Ave. # of all species per site (veg. sites only) | 2.68 | 3.07 | 2.54 | 3.50 | 3.25 | 3.70 |
| Ave. # of native species per site (shallower than max depth) | 0.88 | 0.93 | 1.28 | 1.49 | 1.32 | 3.36 |
| Ave. # of native species per site (sites with native veg. only) | 2.69 | 3.06 | 2.54 | 3.50 | 3.24 | 3.70 |
| Species richness | 37 | 33 | 29 | 30 | 38 | 36 |
| Species richness (including visuals) | 39 | 34 | 32 | 35 | 39 | 39 |
| Species richness (including visuals and boat survey) | 43 | 38 | 38 | 40 | 44 | 45 |
| Mean total rake fullness (veg. sites only) | 1.76 | 2.09 | 1.89 | 2.34 | 2.36 | 2.17 |

Plant diversity was high in 2019 with a Simpson Index value of 0.90 – down slightly from 0.92 in 2016. Total richness was moderate with 36 species found in the rake – also down slightly from 38 in 2016. This total increased to 45 species when including visuals and plants seen during the boat survey – an incremental increase from 44 species in 2016 and the highest total ever recorded on the lake. Mean native species richness at sites with native vegetation underwent a moderately significant increase **(*p*=0.001)** from 3.24 species/site in 2016 to 3.70 species/site in 2019 (Figure 9) (Appendix V). This was also the highest value for any of the six surveys.

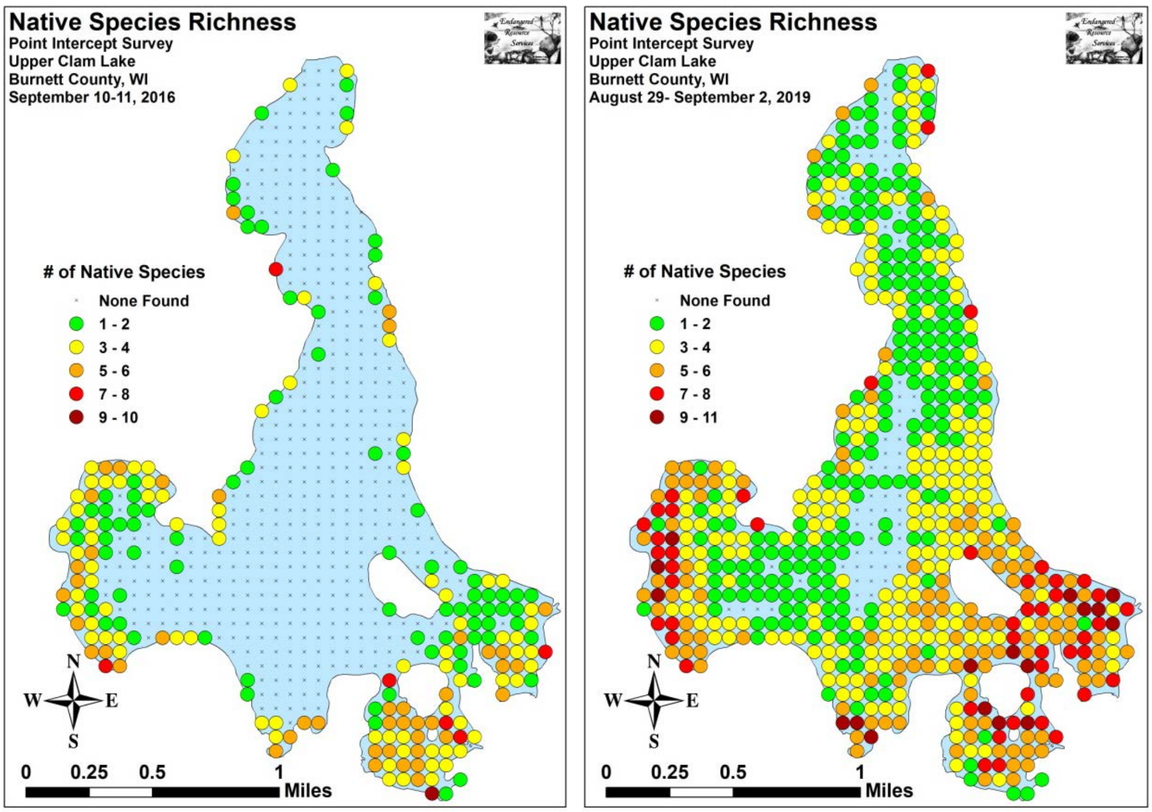



**Figure 9: 2016 and 2019 Native Species Richness**

Total rake fullness experienced a moderately significant decline **(*p*=0.001)** from a moderately high 2.36 in 2016 to a moderate 2.17 in 2019. Visual analysis of the maps showed this average decline was due to low density expansion in deeper areas throughout the lake rather than the obvious loss of density in any area. In the southern bays, vegetative density actually increased sharply (Figure 10) (Appendix V).

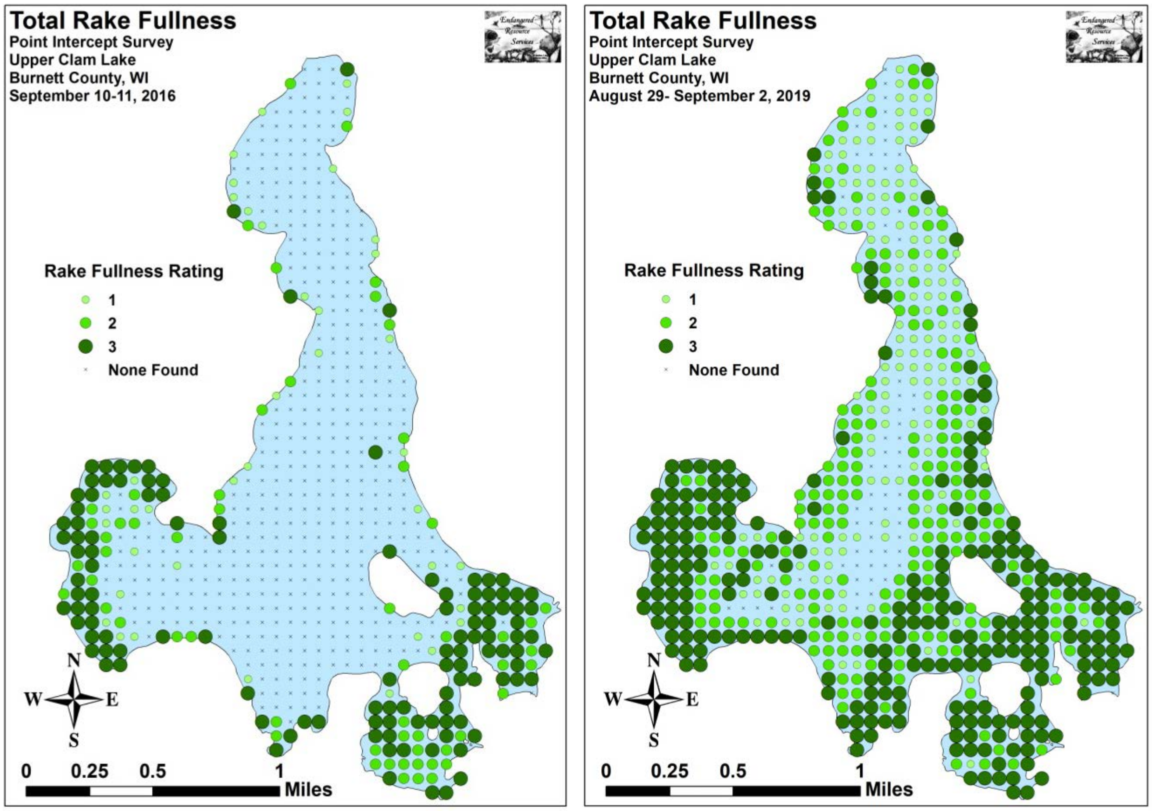



**Figure 10: 2016 and 2019 Total Rake Fullness**

## Upper Clam Lake Plant Community:

The Upper Clam Lake ecosystem is home to a diverse and expansive plant community that is typical of high-nutrient lakes with fair to poor water clarity. 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, sandy muck, or nutrient-rich organic muck), these zones often had somewhat different species present.

Over firm sand, the emergent community was dominated by River bulrush (*Bolboschoenus fluviatile*), Water horsetail (*Equisetum fluviatile*), Common reed (*Phragmites australis*), Pickerelweed (*Pontederia cordata*), Sessile-fruited arrowhead (*Sagittaria rigida*), Hardstem bulrush (*Schoenoplectus acutus*), Three-square bulrush (*Schoenoplectus pungens*), Common bur-reed (*Sparganium eurycarpum*), and Hybrid cattail (*Typha* X *glauca*).


River bulrush (Ratzlaff 2008)

Water horsetail (Dziak 2005)

Pickerelweed (Texas A&M 2012)

Sessile-fruited arrowhead (Chayka 2013)

Hardstem bulrush (Dziuk 2015)

Three-square bulrush (Mittlhauser 2016)

In shoreline areas with firm, more nutrient-rich muck, these species were replaced by Bottle brush sedge (*Carex comosa*), Three-way sedge (*Dulichium arundinaceum*), Bald spikerush (*Eleocharis erythropoda*), Common arrowhead (*Sagittaria latifolia*), Softstem bulrush (*Schoenoplectus tabernaemontani*), and Broad-leaved cattails (*Typha latifolia*). In slightly deeper water over soft muck, we also recorded abundant levels of Northern wild rice (*Zizania palustris*). All of these 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.

Bottle-brush sedge (Penta 2009)

Three-way sedge (GMNRI 2016)

Common arrowhead (Young 2006)

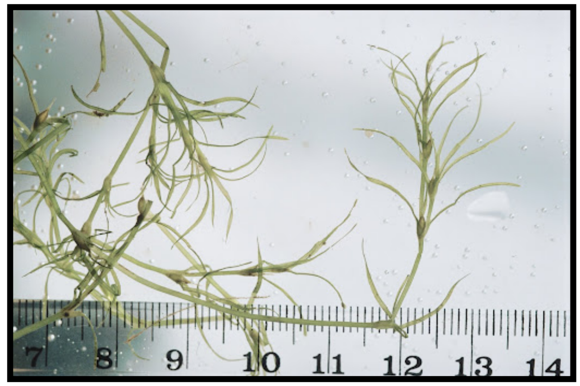
Softstem bulrush (Schwarz 2011)

Shallow sandy and sandy-muck areas showed a significant expansion in both localized richness and density of submergent species. Especially in the northern half of that lake, many of these areas that had only a few scattered patches of plants in 2016 supported a ring of nearly continuous vegetation in 2019. In this environment, we documented Muskgrass (*Chara* sp.), Water stargrass (*Heteranthera dubia*), Northern water-milfoil (*Myriophyllum sibiricum*), Slender naiad (*Najas flexilis*), Clasping-leaf pondweed (*Potamogeton richardsonii*), White water crowfoot (*Ranunculus aquatilis*), Sago pondweed (*Stuckenia pectinata*), and Wild celery (*Vallisneria americana*). The roots, shoots, and seeds of these plants are heavily utilized by 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.

Muskgrass (Gibbons 2012)

Water star-grass (Mueller 2009)


Northern water-milfoil (Berg 2007)



Slender naiad (Koshere 2002)


Clasping-leaf pondweed (Cameron 2013)


White water crowfoot (Wasser 2013)


Sago pondweed (Hilty 2012)


Wild celery (Dalvi 2009)

Just beyond the emergents, in up to 4ft of water, organic muck-bottomed areas supported beds of the floating-leaf species Spatterdock (*Nuphar variegata*) and White-water lily (*Nymphaea odorata*). We also found limited numbers of Large-leaf pondweed (*Potamogeton amplifolius*), Floating-leaf pondweed (*Potamogeton natans*), and Long-leaf pondweed (*Potamogeton nodosus*). The protective canopy cover this group provides is often utilized by panfish and bass.

Spatterdock and White water lily (Falkner, 2009)

Large-leaf pondweed (Fewless 2010)

Floating-leaf pondweed (Sein 2013)

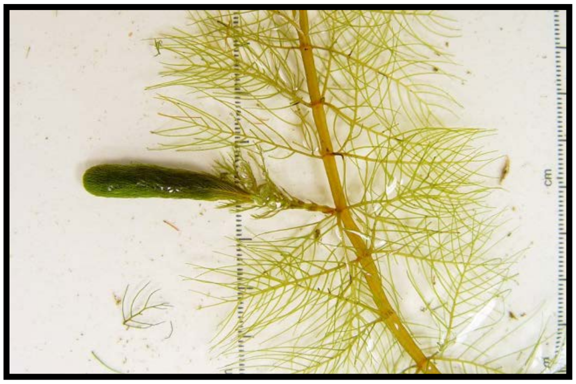
Long-leaf pondweed (Hilty 2012)

Growing amongst these floating-leaf species in boggy areas of the southern bays, we found limited numbers of Water marigold (*Bidens beckii*), Fries' pondweed (*Potamogeton friesii*), and Whorled water-milfoil (*Myriophyllum verticillatum*).

Water marigold (Dziuk 2012)

Fries' pondweed (End 2012)

Floating between the lilypads and rice in these areas, we also often found Small duckweed (*Lemna minor*), Forked duckweed (*Lemna trisulca*), Slender riccia (*Riccia fluitans*), Large duckweed (*Spirodela polyrhiza*), and Common watermeal (*Wolffia columbiana*) along with the carnivorous Common bladderwort (*Utricularia vulgaris*) and Small bladderwort (*Utricularia minor*). Rather than drawing nutrients up through roots like other plants, bladderworts trap zooplankton and minute insects in their bladders, digest their prey, and use the nutrients to further their growth.

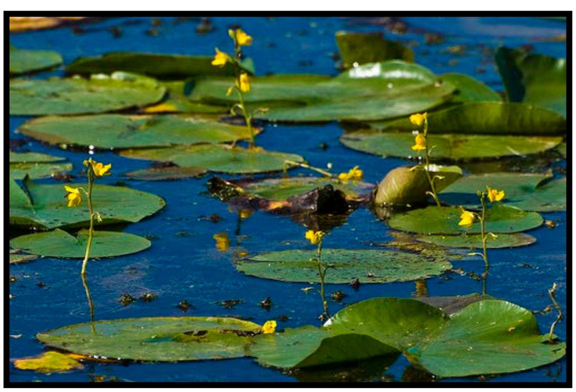


Whorled water-milfoil (Cameron 2018)

Small duckweed and Common watermeal (Kieron 2009)

Slender riccia (Barth 2018) and Forked duckweed (Curtis 2010)

Large duckweed (Thomas 2014) and Small duckweed (Kramer 2013)



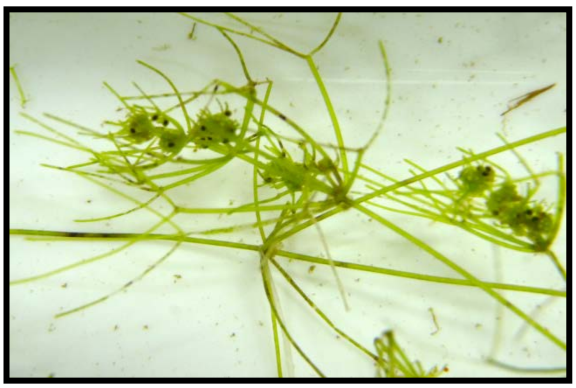
Common bladderwort flowers among lilypads (Hunt, 2010)

Bladders for catching plankton and insect larvae (Wontolla, 2007)

Organic and sandy-muck areas in water greater than 4ft were dominated by the submergent species Coontail (*Ceratophyllum demersum*), Common waterweed (*Elodea canadensis*), Northern water milfoil, Nitella (*Nitella* sp.), Curly-leaf pondweed, Small pondweed (*Potamogeton pusillus*), and Flat-stem pondweed (*Potamogeton zosteriformis*). Predatory fish like the lake's pike are often found along the edges of these deep beds waiting in ambush.

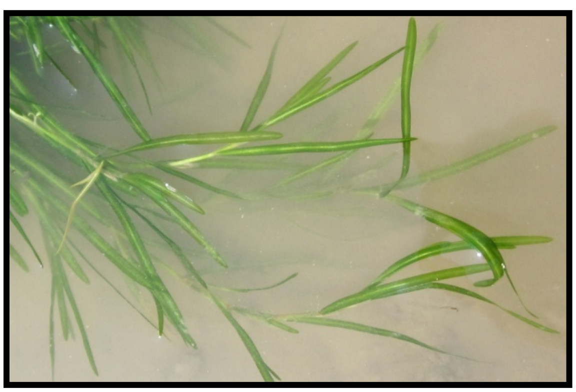
Coontail (Hassler 2011)

Common waterweed (Fischer 2009)



Nitella (USGS 2008)

Curly-leaf pondweed (USGS 2019)



Small pondweed (Villa 2011)

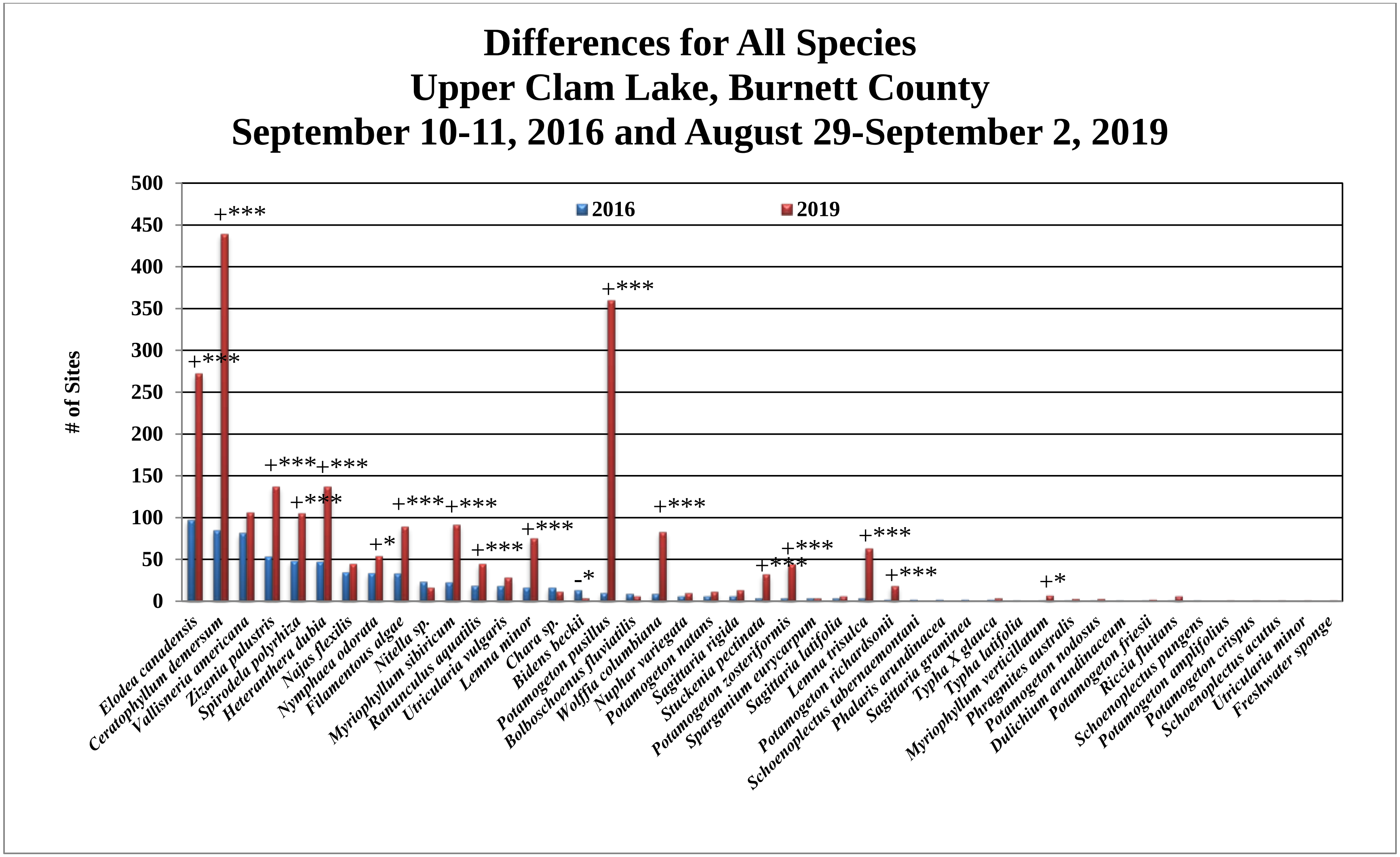
Flat-stem pondweed (Fewless 2004)

## Comparison of Native Macrophyte Species in 2016 and 2019:

In 2016, we documented Common waterweed, Coontail, Wild celery, and Northern wild rice as the most common species (Table 3). Present at 46.01%, 39.91%, 38.50%, and 24.88% of survey points with vegetation, they 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%) were the only other species that had relative frequencies over 4.0% (Density and distribution maps for all native plant species found in 2016 and survey data from all previous surveys can be found in the CD attached to this report).

During our 2019 survey, Coontail, Small pondweed, Common waterweed, and Water star-grass were the most common species. They were found at 72.56%, 59.50%, 44.96%, and 22.64% of sites with vegetation (Table 4). Collectively, they captured 53.95% of the total relative frequency. Northern wild rice (6.12% - identical to Water star-grass), Wild celery (4.73%), Large duckweed (4.69%), and Northern water-milfoil (4.11%) also had relative frequencies over 4.0% (Density and distribution maps for all native plant species found in 2019 are located in Appendix VI).

Lakewide, 18 species showed significant changes in distribution from 2016 to 2019 (Figure 11). Common waterweed, Coontail, Northern wild rice, Large duckweed, Water star-grass, filamentous algae, Northern water milfoil, White water lily, Small duckweed, Small pondweed, Common watermeal, Sago pondweed, Flat-stem pondweed, Forked duckweed, and Clasping-leaf pondweed all enjoyed highly significant increases; and White water lily and Whorled water-milfoil experienced significant increases. Conversely, Water marigold suffered a significant decrease.




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

**Figure 11: Macrophytes Showing Significant Changes from 2016-2019**

## 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 Sight. |
|---|---|---|---|---|---|---|---|
| *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 analysis

**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 Sight. |
|---|---|---|---|---|---|---|---|
| *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 analysis ** Visual only *** Boat survey only

**Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes**
**Upper Clam Lake, Burnett County**
**August 29-September 2, 2019**

| Species | Common Name | Total Sites | Relative Freq. | Freq. in Veg. | Freq. in Lit. | Mean Rake | Visual Sight. |
|---|---|---|---|---|---|---|---|
| *Ceratophyllum demersum* | Coontail | 439 | 19.61 | 72.56 | 65.82 | 1.60 | 11 |
| *Potamogeton pusillus* | Small pondweed | 360 | 16.08 | 59.50 | 53.97 | 1.15 | 10 |
| *Elodea canadensis* | Common waterweed | 272 | 12.15 | 44.96 | 40.78 | 1.31 | 1 |
| *Heteranthera dubia* | Water star-grass | 137 | 6.12 | 22.64 | 20.54 | 1.61 | 9 |
| *Zizania palustris* | Northern wild rice | 137 | 6.12 | 22.64 | 20.54 | 2.28 | 24 |
| *Vallisneria americana* | Wild celery | 106 | 4.73 | 17.52 | 15.89 | 1.72 | 18 |
| *Spirodela polyrhiza* | Large duckweed | 105 | 4.69 | 17.36 | 15.74 | 1.61 | 2 |
| *Myriophyllum sibiricum* | Northern water-milfoil | 92 | 4.11 | 15.21 | 13.79 | 1.20 | 35 |
| | Filamentous algae | 89 | * | 14.71 | 13.34 | 1.48 | 0 |
| *Wolffia columbiana* | Common watermeal | 83 | 3.71 | 13.72 | 12.44 | 1.07 | 0 |
| *Lemna minor* | Small duckweed | 75 | 3.35 | 12.40 | 11.24 | 1.12 | 0 |
| *Lemna trisulca* | Forked duckweed | 63 | 2.81 | 10.41 | 9.45 | 1.21 | 1 |
| *Nymphaea odorata* | White water lily | 54 | 2.41 | 8.93 | 8.10 | 1.37 | 36 |
| *Najas flexilis* | Slender naiad | 45 | 2.01 | 7.44 | 6.75 | 1.36 | 7 |
| *Ranunculus aquatilis* | White water crowfoot | 45 | 2.01 | 7.44 | 6.75 | 1.38 | 1 |
| *Potamogeton zosteriformis* | Flat-stem pondweed | 44 | 1.97 | 7.27 | 6.60 | 1.32 | 18 |
| *Stuckenia pectinata* | Sago pondweed | 32 | 1.43 | 5.29 | 4.80 | 1.31 | 24 |
| *Utricularia vulgaris* | Common bladderwort | 28 | 1.25 | 4.63 | 4.20 | 1.04 | 2 |
| *Potamogeton richardsonii* | Clasping-leaf pondweed | 18 | 0.80 | 2.98 | 2.70 | 1.44 | 16 |
| *Nitella* sp. | Nitella | 16 | 0.71 | 2.64 | 2.40 | 1.13 | 0 |
| *Sagittaria rigida* | Sessile-fruited arrowhead | 13 | 0.58 | 2.15 | 1.95 | 1.23 | 11 |
| *Chara* sp. | Muskgrass | 11 | 0.49 | 1.82 | 1.65 | 1.55 | 2 |
| *Potamogeton natans* | Floating-leaf pondweed | 11 | 0.49 | 1.82 | 1.65 | 1.36 | 5 |

*Excluded from relative frequency analysis

## Table 4 (cont): Frequencies and Mean Rake Sample of Aquatic Macrophytes
## Upper Clam Lake, Burnett County
## August 29-September 2, 2019

| Species | Common Name | Total Sites | Relative Freq. | Freq. in Veg. | Freq. in Lit. | Mean Rake | Visual Sight. |
|---|---|---|---|---|---|---|---|
| *Nuphar variegata* | Spatterdock | 10 | 0.45 | 1.65 | 1.50 | 1.40 | 15 |
| *Myriophyllum verticillatum* | Whorled water-milfoil | 7 | 0.31 | 1.16 | 1.05 | 1.00 | 3 |
| *Bolboschoenus fluviatilis* | River bulrush | 6 | 0.27 | 0.99 | 0.90 | 3.00 | 2 |
| *Riccia fluitans* | Slender riccia | 6 | * | 0.99 | 0.90 | 1.00 | 0 |
| *Sagittaria latifolia* | Common arrowhead | 6 | 0.27 | 0.99 | 0.90 | 1.33 | 0 |
| *Bidens beckii* | Water marigold | 4 | 0.18 | 0.66 | 0.60 | 1.00 | 1 |
| *Sparganium eurycarpum* | Common bur-reed | 4 | 0.18 | 0.66 | 0.60 | 2.50 | 1 |
| *Typha* X *glauca* | Hybrid cattail | 4 | 0.18 | 0.66 | 0.60 | 2.50 | 2 |
| *Phragmites australis* | Common reed | 3 | 0.13 | 0.50 | 0.45 | 2.33 | 0 |
| *Potamogeton nodosus* | Long-leaf pondweed | 3 | 0.13 | 0.50 | 0.45 | 2.00 | 4 |
| *Potamogeton friesii* | Fries' pondweed | 2 | 0.09 | 0.33 | 0.30 | 1.00 | 0 |
| *Potamogeton amplifolius* | Large-leaf pondweed | 1 | 0.04 | 0.17 | 0.15 | 1.00 | 1 |
| *Potamogeton crispus* | Curly-leaf pondweed | 1 | 0.04 | 0.17 | 0.15 | 1.00 | 0 |
| *Schoenoplectus acutus* | Hardstem bulrush | 1 | 0.04 | 0.17 | 0.15 | 2.00 | 0 |
| *Utricularia minor* | Small bladderwort | 1 | 0.04 | 0.17 | 0.15 | 1.00 | 0 |
| | Freshwater sponge | 1 | * | 0.17 | 0.15 | 1.00 | 0 |
| *Carex comosa* | Bottle brush sedge | ** | ** | ** | ** | ** | 1 |
| *Phalaris arundinacea* | Reed canary grass | ** | ** | ** | ** | ** | 1 |
| *Schoenoplectus tabernaemontani* | Softstem bulrush | ** | ** | ** | ** | ** | 2 |
| *Dulichium arundinaceum* | Three-way sedge | *** | *** | *** | *** | *** | *** |
| *Eleocharis erythropoda* | Bald spikerush | *** | *** | *** | *** | *** | *** |
| *Equisetum fluviatile* | Water horsetail | *** | *** | *** | *** | *** | *** |
| *Pontederia cordata* | Pickerelweed | *** | *** | *** | *** | *** | *** |
| *Schoenoplectus pungens* | Three-square bulrush | *** | *** | *** | *** | *** | *** |
| *Typha latifolia* | Broad-leaved cattail | *** | *** | *** | *** | *** | *** |

* Aquatic liverworts and Freshwater sponges are excluded from the relative frequency analysis ** Visual only *** Boat survey only

Coontail, the second most common species in 2016 (85 sites) and the most common in 2019 (439 sites), underwent a highly significant increase **(*p*<0.001)** in distribution. After being restricted to the southern bays in 2016, it showed a dramatic expansion and was found in almost all but the deepest areas in 2019. In addition to this growth in distribution, its mean density saw a moderately significant increase **(*p*=0.006)** from a mean rake fullness of 1.40 in 2016 to a mean rake of 1.60 in 2019 (Figure 12).

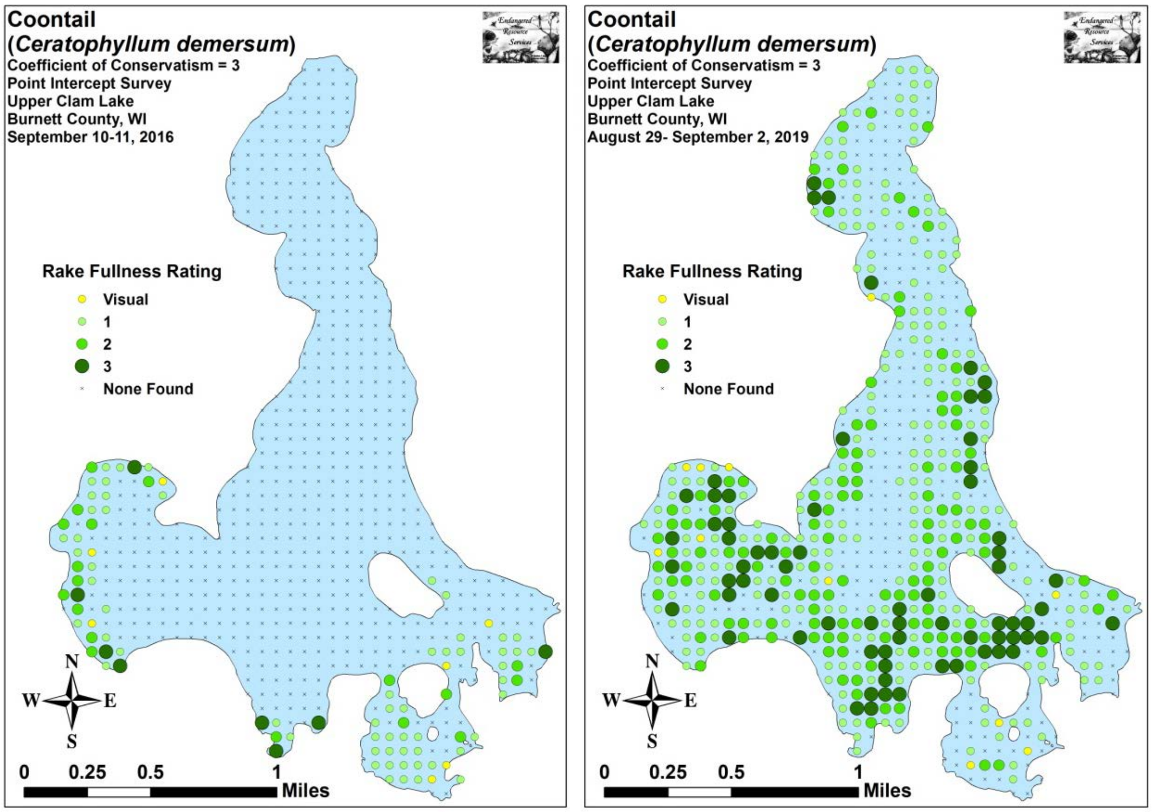



**Figure 12: 2016 and 2019 Coontail Density and Distribution**

In 2016, Small pondweed was present at just ten points with a mean rake fullness of 1.00 (Figure 13). Following highly significant increases **(*p*<0.001)** in both distribution (360 points) and density (mean rake fullness of 1.15), it became the second most common species in 2019 (up from 16$^{th}$ in 2016) and was present throughout the majority of the lake; especially as a deepwater colonizer.

Common waterweed was the most common species in 2016 and the third most common in 2019. Despite its highly significant increase **(*p*<0.001)** in distribution (98 points in 2016/272 in 2019), we documented a highly significant decrease **(*p*<0.001)** in density (mean rake fullness of 1.83 in 2016/1.31 in 2019). Visual analysis of the maps showed this rapidly growing species is colonizing barren substrate in deeper water. However, as more and more species establish in an area, it seems to decline in density or gets pushed out altogether. It also doesn't seem to survive well in areas where wild rice shades the submergent plant community (Figure 14).

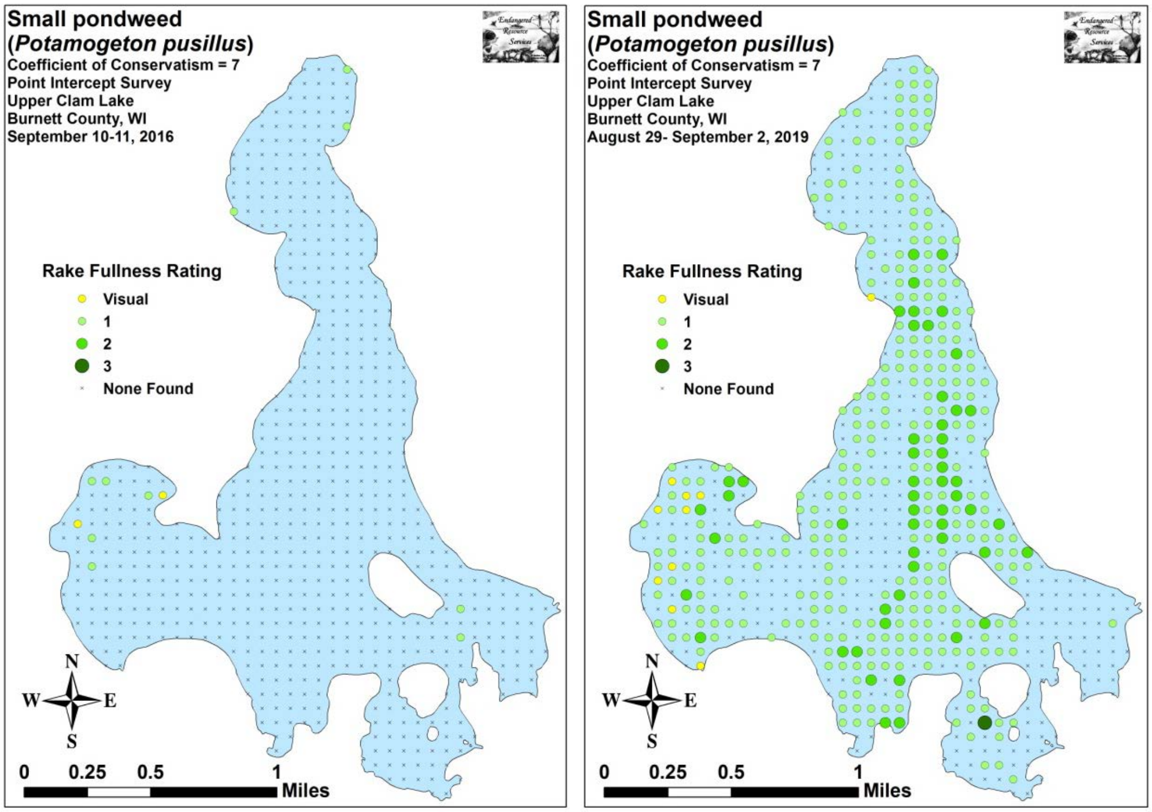



**Figure 13: 2016 and 2019 Small Pondweed Density and Distribution**

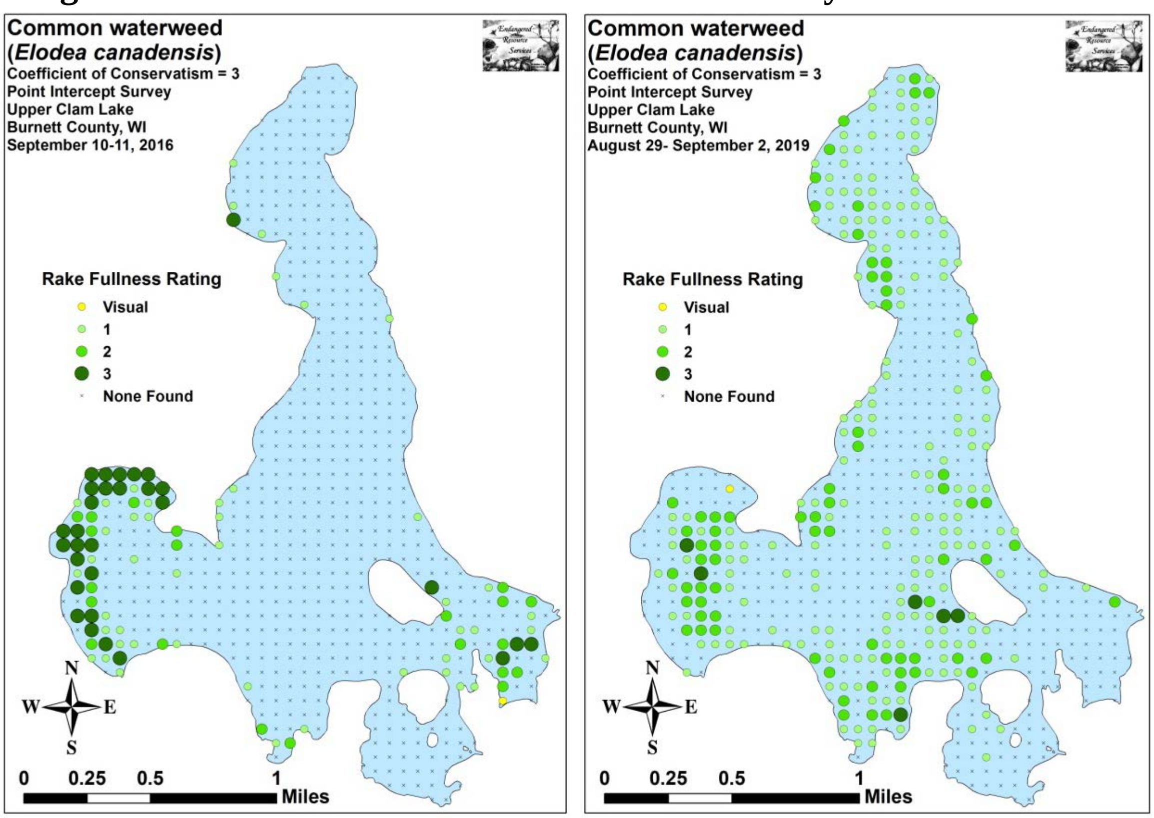



**Figure 14: 2016 and 2019 Common Waterweed Density and Distribution**

Wild celery was the third most common species in 2016 (82 sites) and the sixth most common in 2019 (106 sites) (Figure 15). Its increase in distribution was nearly significant ($p$=0.06), but this was accompanied by a significant decline ($p$=0.03) in density (mean rake fullness of 1.96 in 2016/1.72 in 2019). Many of the places it dominated in the river inlet during the 2016 survey were covered in wild rice or mixed with other natives in 2019.

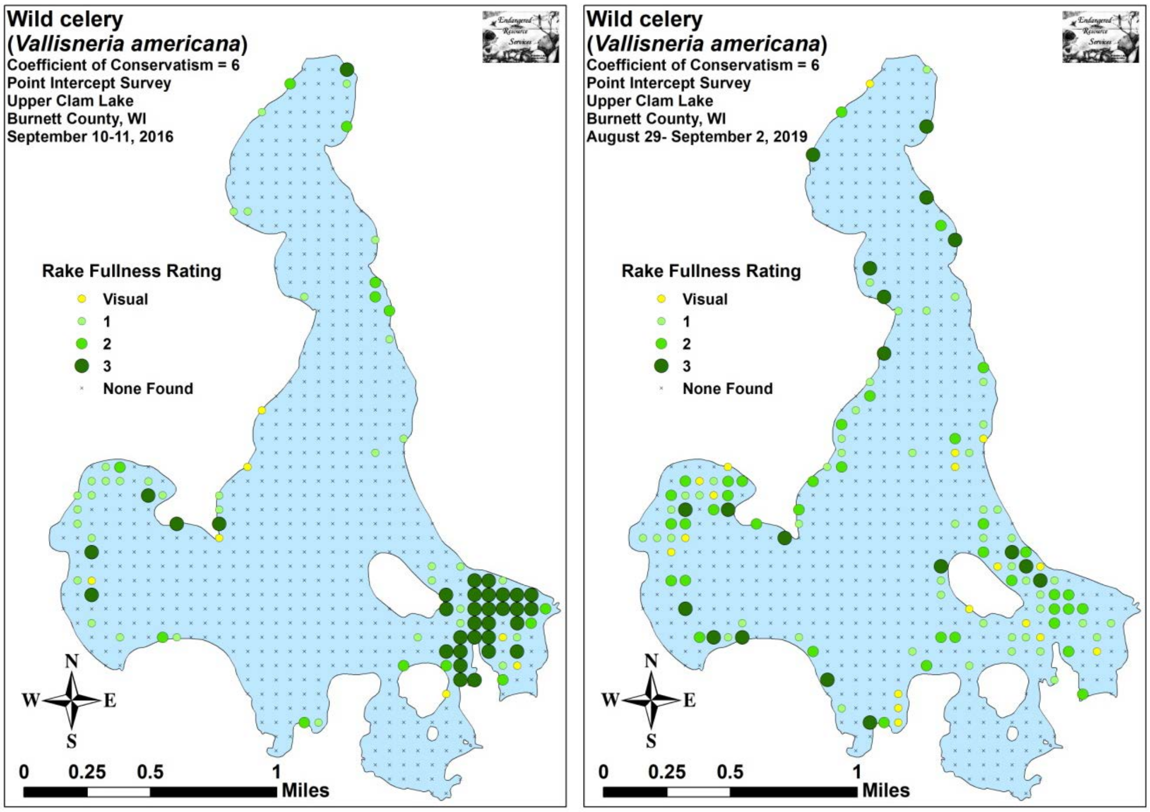



**Figure 15: 2016 and 2019 Wild Celery Density and Distribution**

Water star-grass nearly tripled its distribution from 47 sites in 2016 (sixth most common species) to 137 sites in 2019 (fourth most common species). This highly significant increase **($p$<0.001)** in distribution was accompanied by a significant increase **($p$=0.03)** in density (mean rake of 1.38 in 2016/mean rake of 1.61 in 2019). A riverine species, it was especially common just beyond the edge of the rice beds in the southern bays (Figure 16).

Northern water-milfoil saw a more than fourfold increase in distributions from 22 points in 2016 to 92 points in 2019 with much of this increase occurring in deeper areas around the central basin (Figure 17). Similar to Water star-grass, this highly significant increase **($p$<0.001)** in distribution was accompanied by a significant increase **($p$=0.01)** in density (mean rake of 1.05 in 2016/mean rake of 1.20 in 2019). Although most positive samples in shallow areas were represented by single individuals, many points in deeper water supported beds of moderate density with numerous plants in the rake.

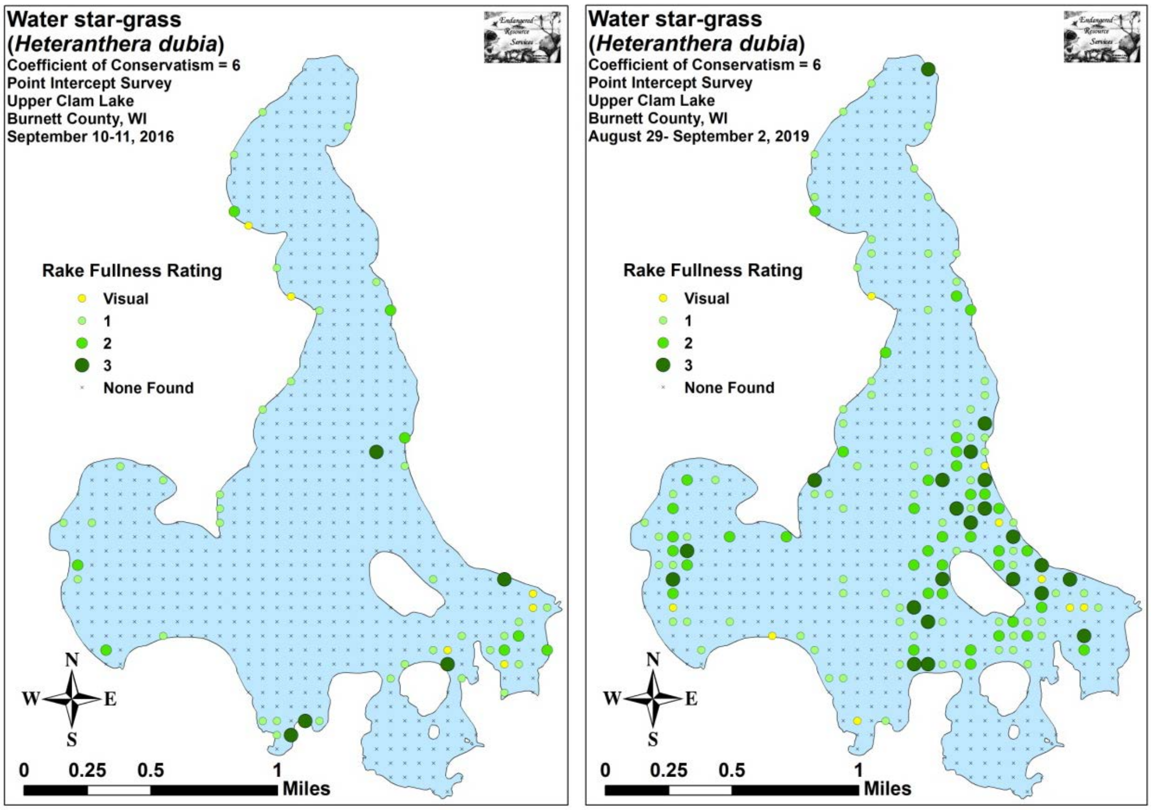



**Figure 16: 2016 and 2019 Water Star-grass Density and Distribution**

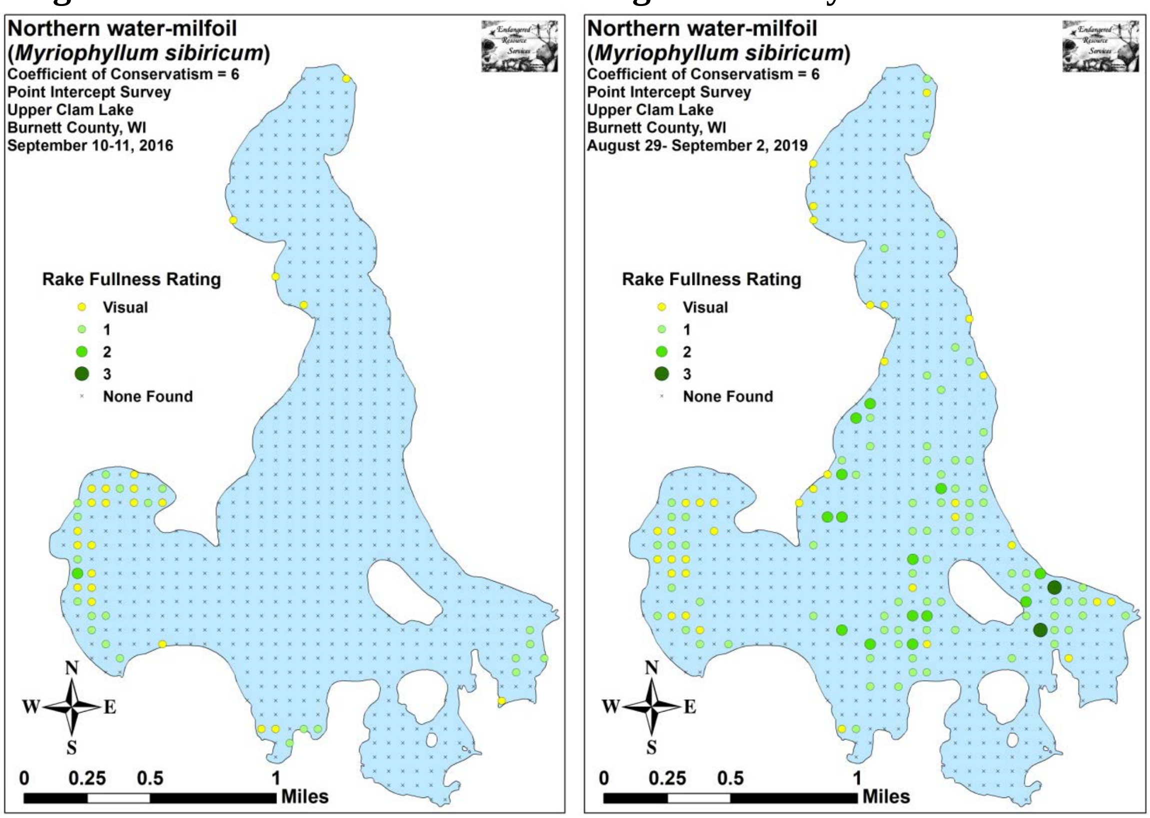



**Figure 17: 2016 and 2019 Northern Water-milfoil Density and Distribution**

## Comparison of Floristic Quality Indexes in 2016 and 2019:

In 2016, we found 38 **native index species** in the rake during the point-intercept survey (Table 5). They produced a mean Coefficient of Conservatism of 5.7 and a Floristic Quality Index of 34.9.

### 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** |

In 2019, we found a total of 36 **native index species** in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 5.8 and a Floristic Quality Index of 35.0 (Table 6). All of these values were nearly identical to 2016 totals, but they continue to be sharply higher than during any of the previous surveys (30 species/Mean C 5.6/FQI 30.5 in 2015; 29 species/Mean C 5.5/FQI 29.5 in 2014; 31 species/Mean C 5.3/FQI 29.5 in 2012; 35 species/Mean C 5.7/FQI 33.8 in 2009). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Ecoregion of 6.7 meaning Upper Clam Lake continues to be well below average. The FQI was, however, well above the median FQI of 24.3 for this part of the state.

## Table 6: Floristic Quality Index of Aquatic Macrophytes Upper Clam Lake, Burnett County August 29-September 2, 2019

| 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 amplifolius* | Large-leaf pondweed | 7 |
| *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 latifolia* | Common arrowhead | 3 |
| *Sagittaria rigida* | Sessile-fruited arrowhead | 8 |
| *Schoenoplectus acutus* | Hardstem bulrush | 6 |
| *Sparganium eurycarpum* | Common bur-reed | 5 |
| *Spirodela polyrhiza* | Large duckweed | 5 |
| *Stuckenia pectinata* | Sago pondweed | 3 |
| *Typha* X *glauca* | Hybrid cattail | 1 |

## Table 6 (cont'): Floristic Quality Index of Aquatic Macrophytes
## Upper Clam Lake, Burnett County
## August 29-September 2, 2019

| Species | Common Name | C |
|---|---|---|
| *Utricularia minor* | Small bladderwort | 10 |
| *Utricularia vulgaris* | Common bladderwort | 7 |
| *Vallisneria americana* | Wild celery | 6 |
| *Wolffia columbiana* | Common watermeal | 5 |
| *Zizania palustris* | Northern wild rice | 8 |
| | | |
| **N** | | **36** |
| **Mean C** | | **5.8** |
| **FQI** | | **35.0** |

## Comparison of Northern Wild Rice from 2009 – 2019:

The 2009 survey found Northern wild rice in the rake at just five points all of which had a rake fullness value of 1. Following the placement of the Carp exclosure nets, in 2012 we documented a highly significant increase (***p*<0.001**) in rice distribution (34 sites) and density (mean rake fullness of 2.21) (Figure 18).

In 2014, the number of points with rice increased again to 46 sites. Although this was not significant (*p* = 0.17), the decline in density to a mean rake fullness of 1.80 was (***p*=0.02)**. Most of the 2014 increases in distribution occurred near the river inlet on either side of the channel. Interestingly, the rice inside the exclosures was much reduced in density; especially on the west side where broad areas had open water with almost 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 (***p*< 0.001**) from 2014.

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 (***p*=0.003**). Rice was again present throughout the entire southeast bay behind the Carp exclosure. Although patchier and somewhat less dense than in 2015 (Figure 18), 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. Elsewhere, the majority of the bay was moderately dense, but with occasional gaps of open water.

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. The other southern bays again had just a scattering of plants in shallow water near the shoreline.

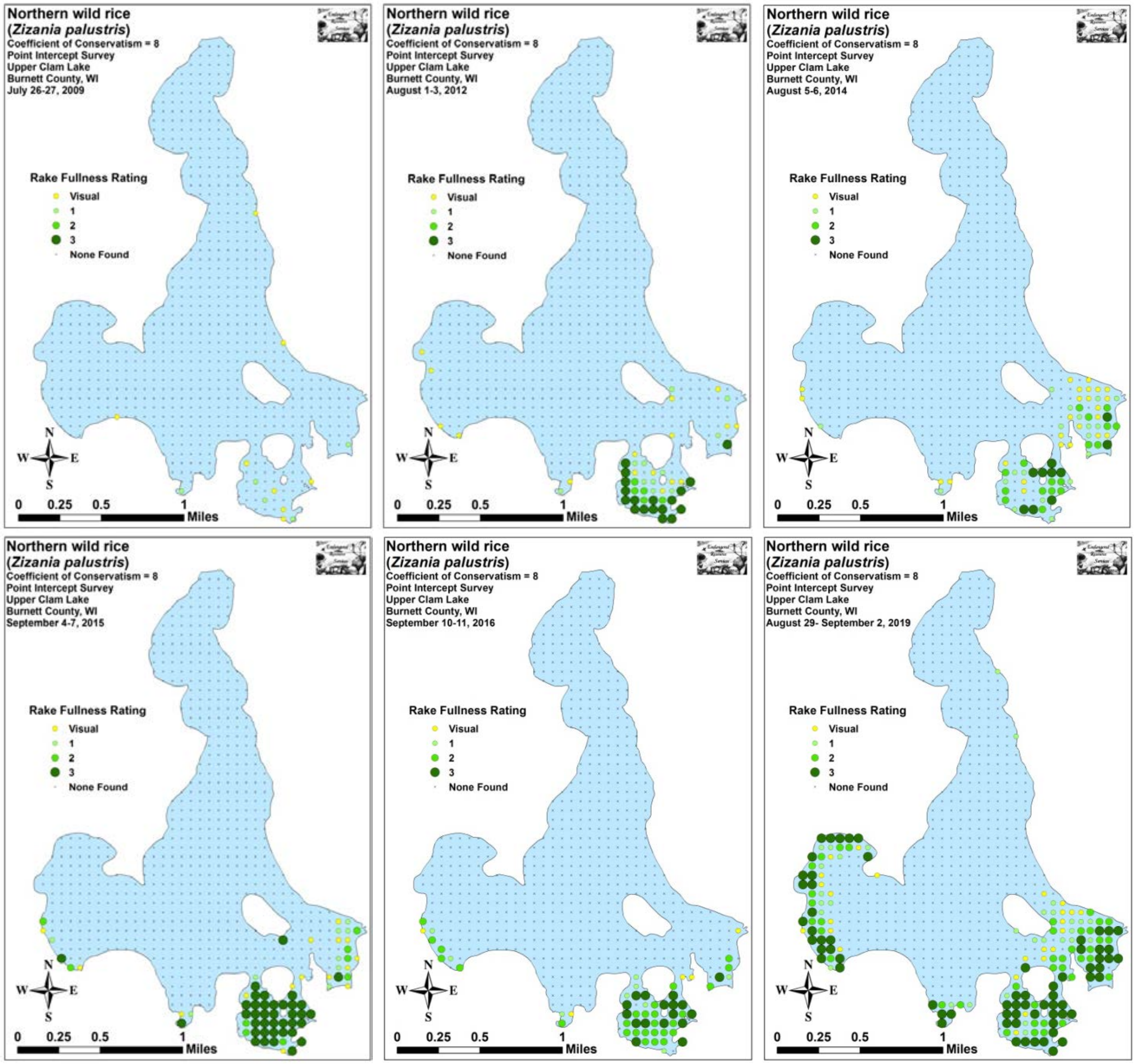



**Figure 18: 2009, 2012, 2014, 2015, 2016, and 2019 Northern Wild Rice Density and Distribution**

In 2019, rice underwent a highly significant expansion (***p*****<0.001**) in distribution. Present at 137 points with 24 additional visual sightings, it was tied for Water star-grass as the fourth most widely distributed species (22.64% of points with plants present/20.54% of the littoral zone). Of these, we rated 68 a rake fullness of 3, 39 a 2, and the remaining 30 a 1 for a mean rake fullness of 2.28 (Figure 18) (Appendix VII). Although this was also an increase in density from 2016, it was not significant ($p$=0.14). Most of the beds offered significant human harvest potential, and we found many places were so dense that using a canoe and pole was impossible. This forced us to survey by kayak, and it took us three days to push and pull our way through the "forest" of rice. Although wonderful for wildlife and those harvesting, these dense areas of rice clearly made things difficult for those accessing the lake from their shorelines in these southern bays; especially if they were doing so infrequently (Figure 19).

Broken out by region, the southwest bay had more rice than at any point since our first survey in 2009. Viewed from Lone Star Road on the bay's southwest side, a wall of rice extended out from shore (Figure 19). On the open water margin, the rice was more fragmented, but the majority of areas were still extremely dense (Figure 20), and harvest trails crisscrossed the bed.

**Figure 19: Shoreline Impairment and Typical Density in the Southwest Bay –
Panorama of Northern Wild Rice on the Southwest Shoreline of the Southwest Bay 8/31/19**

**Figure 20: Panorama of Northern Wild Rice in the Southwest Bay Facing Southwest 8/31/19**

The south-central bay also had harvestable density. A nearly continuous wall of plants reached the landing on the southwest side of the bay and stretched almost uninterrupted back up the creek inlet (Figure 21).

**Figure 21: Panorama of Northern Wild Rice in the South-central Bay 8/30/19**

In the southeast bay, much of the river inlet was impassable by canoe and nearly so by kayak as it took us an entire day to survey 50 points in this area. Along the north shoreline, residents seemed to be having significant difficulty keeping a path open as both the patchy rice and submergent vegetation made motor travel difficult (Figure 22).

**Figure 22: Panorama of North Shoreline in the Southeast Bay Facing East Towards the River Inlet 8/31/19**

In the entrance to the southeast bay south of the river inlet (the former Carp exclosure), rice also created an almost impenetrable wall that was only accessible by kayak (Figure 23). Density was high throughout most of the bay, but we did find a sizable area of open water in the southwest corner of the bay (Figure 24).

**Figure 23: Panorama of Northern Wild Rice from SE Side of Former Exclosure Facing South 9/2/19**

**Figure 24: Panorama of Northern Wild Rice from the Southwest End of the Exclosure Facing North 9/2/19**

## Comparison of Filamentous Algae in 2016 and 2019:

Filamentous algae, normally associated with excessive nutrients in the water column, underwent a highly significant increase **($p$<0.001)** in distribution from 33 points in 2016 to 89 points in 2019 (Figure 25). Despite this expansion in coverage, the mean rake fullness saw a non-significant ($p$=0.31) decline from 1.55 in 2016 to 1.48 in 2019. The majority of these algae were again found in the river inlet, but we also documented their presence at many more sites along shorelines in the northern bays.

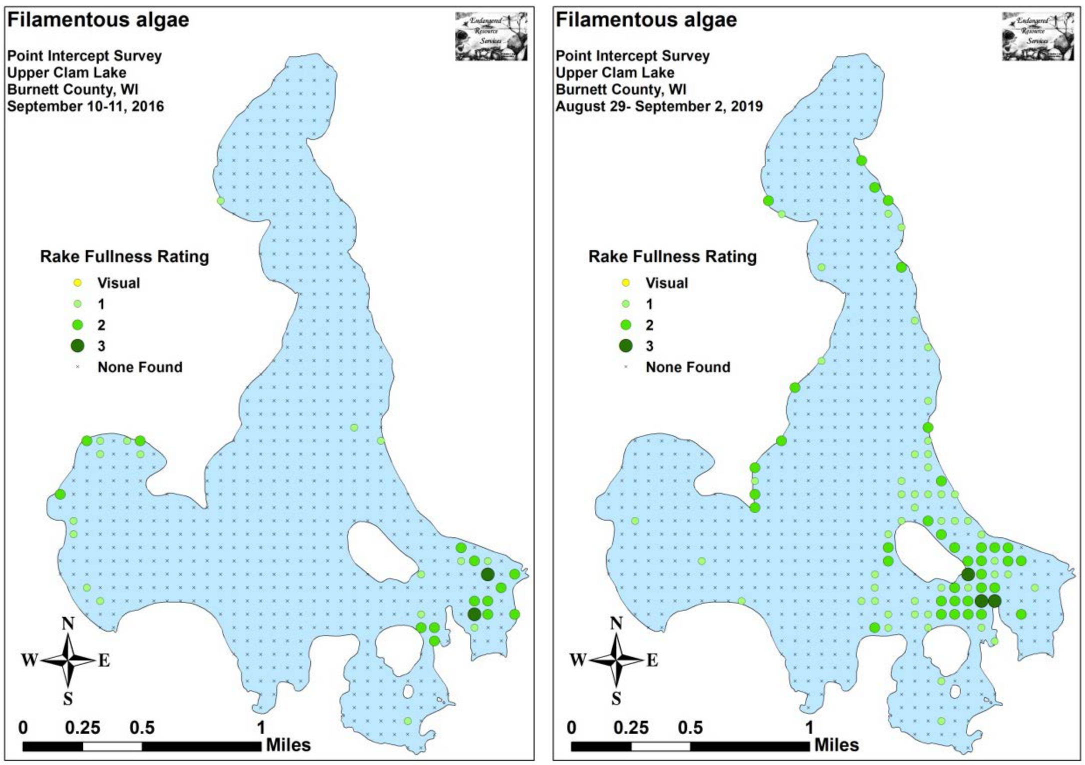



**Figure 25: 2016 and 2019 Filamentous Algae Density and Distribution**

## Comparison of Midsummer Curly-leaf Pondweed in 2016 and 2019:

Curly-leaf pondweed normally completes its annual life cycle by late June, and most plants have set turions and senesced by early July. During our 2016 survey, we didn't find CLP anywhere during the late summer. In 2019, after finding it at seven points in June, we documented it at a single point with a rake fullness of 1 in August (Figure 26) (Appendix VIII).

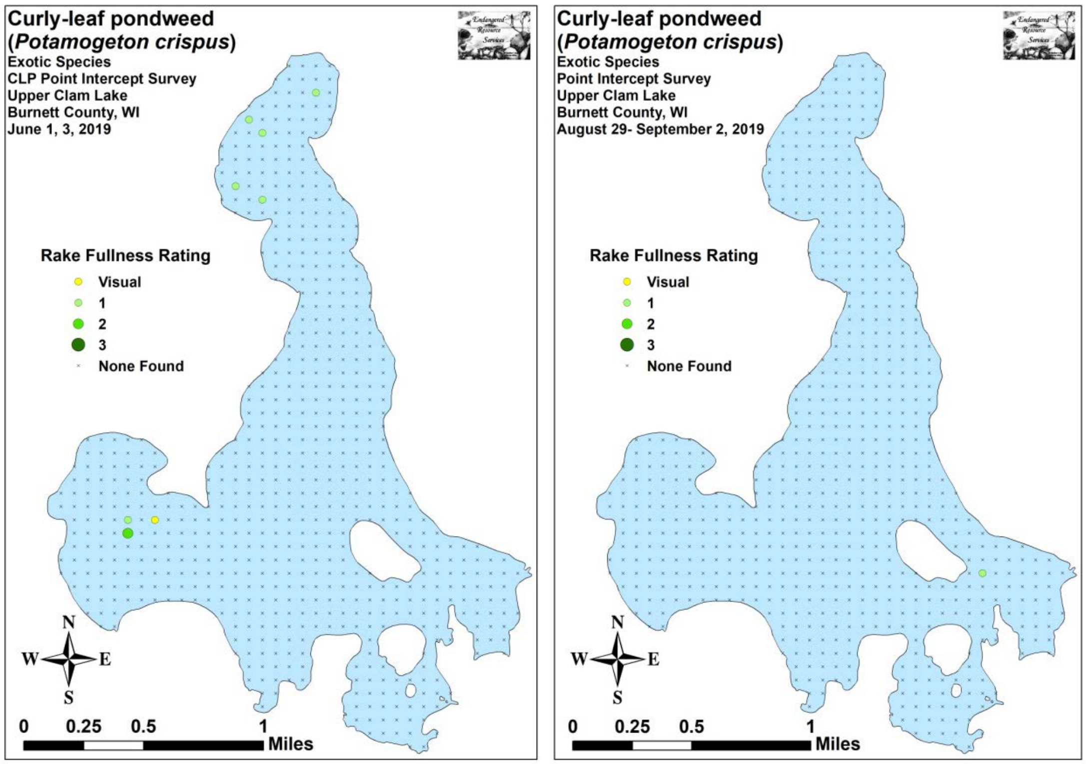



**Figure 26: 2019 June and Late Summer CLP Density and Distribution**

## Other Exotic Plant Species:

We did NOT find any evidence or Eurasian water-milfoil in Upper Clam Lake during any of our surveys. However, in addition to Curly-leaf pondweed, we documented two other exotic species growing around the margins of the lake: Reed canary grass (RCG) and Hybrid cattail (HC). Despite only being recorded as a visual at one point in 2019 (Figure 27), RCG occurred throughout in adjacent wetlands and next to mowed or otherwise disturbed shoreline areas. A ubiquitous plant in the state, there's likely little that can be done about it (For more information on a sampling of aquatic exotic invasive plant species, see Appendix IX).

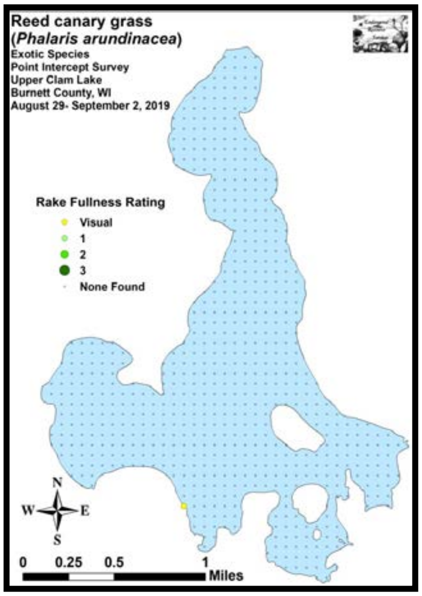



**Figure 27: 2019 Reed Canary Grass Density and Distribution and Inflorescence**

Native to southern but not northern Wisconsin, Narrow-leaved cattail and its hybrids with Broad-leaved cattail are becoming increasingly common in northern Wisconsin where they also tend to be invasive. This species appears to be expanding in shallow water and crowding out other emergent species. It is now firmly established in the southeast bay (former Carp exclosure) and in scattered locations on the eastern shoreline (Figure 28).

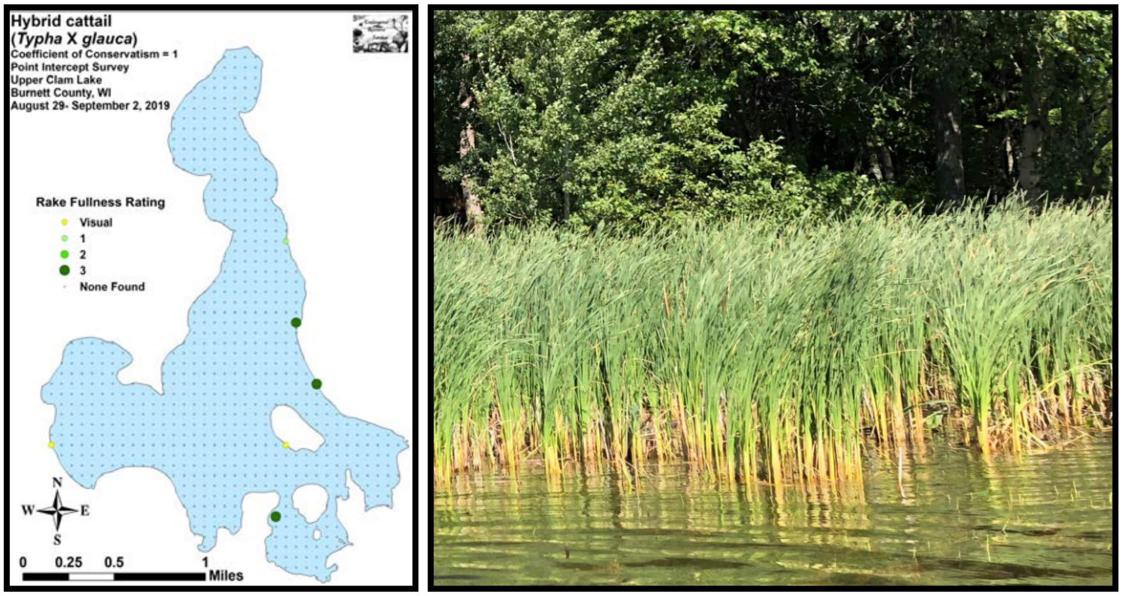



**Figure 28: 2019 Hybrid Cattail Density and Distribution – Stand on East Shoreline**

Besides having narrower leaves, the exotics 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 29) (Appendix VIII).

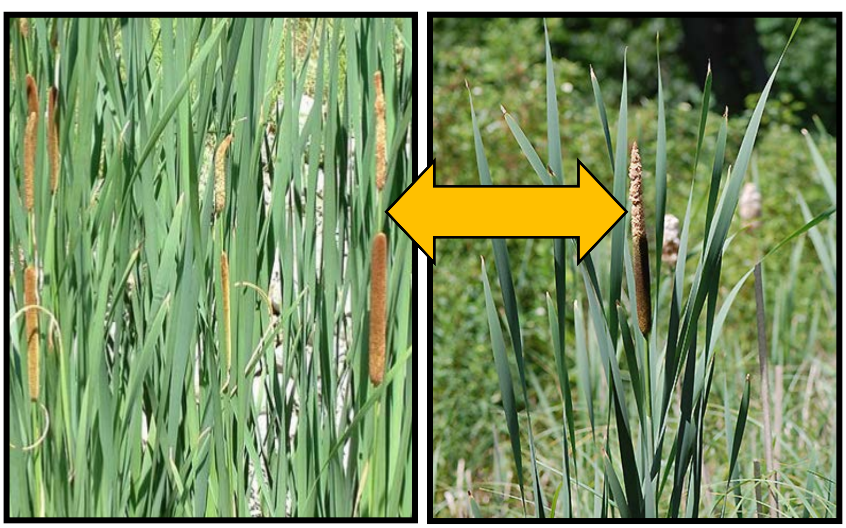


**Figure 29: Exotic Hybrid and Native Broad-leaved Cattail Identification**

Common reed (*Phragmites australis*), a potentially highly invasive species in its exotic form, is also found on Upper Clam Lake in a few small patches scattered around the southern bays.  Fortunately, careful analysis of the plants present showed their leaf sheaths are detached, and the culms (stems) are red in color (Figure 30).  These characteristics suggest it is the native subspecies *americanus* which is NOT generally invasive.  Although the beds deserve to be looked at again in the future, based on all these considerations, we aren't overly concerned about its presence at this time.

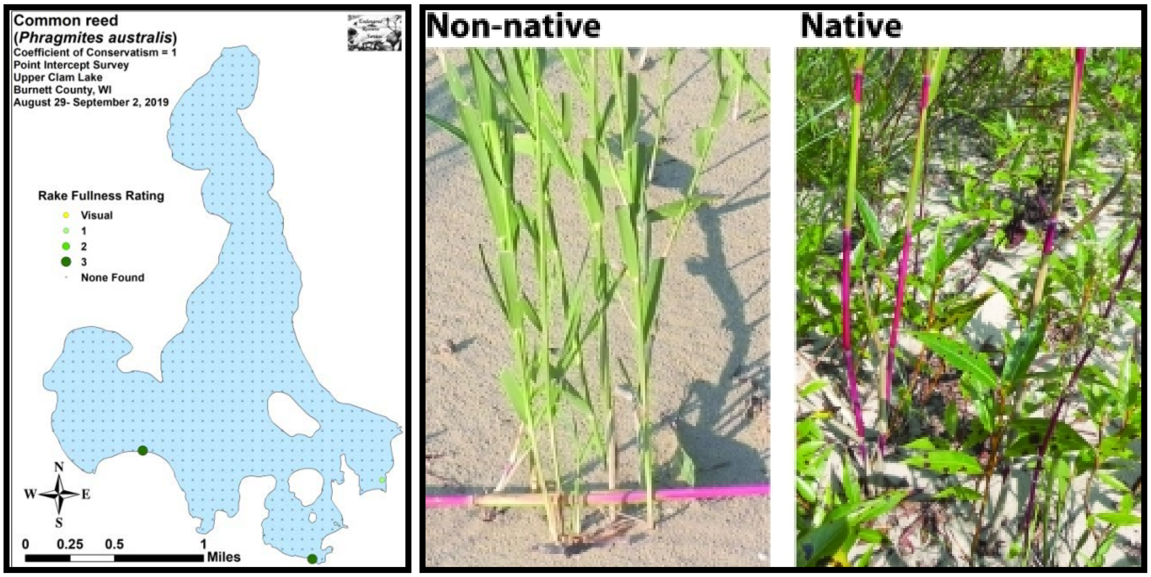



**Figure 30:  Common Reed Density and Distribution and Stem Pattern on Exotic vs. Native Common Reed**

## DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

### Native Plant Community:

The richness of the lake's native plant community was higher than in any previous survey. By extension, this suggests the overall productivity or "health" of the lake's ecosystem has also increased. 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.

With a return of abundant native vegetation in the lake's shallow bays, harvesting these native nearshore beds will likely again be necessary to relieve navigation impairment. Because of their role in providing both habitat and water purification, we strongly encourage managers to work to avoid doing more harvesting than necessary.

### Carp and Wild Rice Management:

We anecdotally noted there seemed to be fewer Carp than in years past. Although we still saw scattered Carp jump/bubble trails from small schools in shallow bays, we found very few uprooted rice plants or lilypad roots/stems in these areas. This suggests the Carp population is low enough that native plants can tolerate current levels of herbivory. Specifically, with the exception of the southwest corner of the southeast bay, the wild rice beds in the lake's southern bays have rebounded to become incredibly productive again. Rice is now so abundant that some shoreline owners appear to be struggling to access open water. Mitigating disagreements about this resource will likely need to be addressed by shareholders in the updated management plan.

### Curly-leaf Pondweed Management:

The uptick in Curly-leaf pondweed is another indicator of the Carp population's decline. Unlike in Lower Clam where few native species are found beyond the immediate shoreline in most areas, Upper Clam's recolonization seems to be led primarily by the native community with only scattered patches of CLP. As the majority of areas with CLP are likely also going to suffer moderate to severe navigation impairment from native plants later in the growing season, what species is causing the impairment is probably a moot point.

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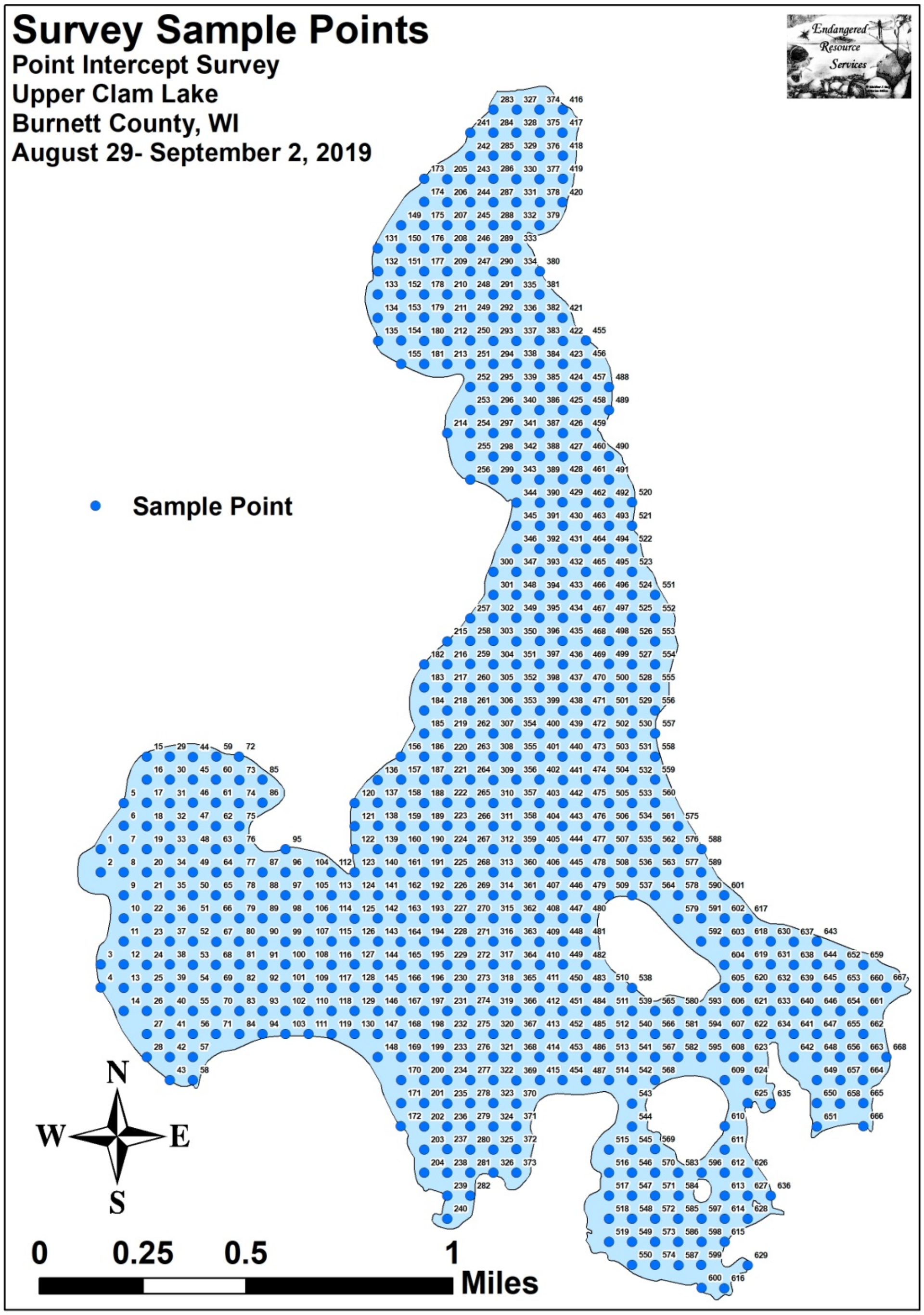
WDNR. [online]. 2010. Reed canary grass fact sheet. http://dnr.wi.gov/invasives/fact/reed_canary.htm (2010, August).

WDNR. [online]. 2019. Wisconsin Lake Citizen Monitoring Data: Upper Clam Lake, Burnett County. https://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2429600&page=waterquality (2019, December)

## Appendix I:  Survey Sample Points Map


Survey Sample Points
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Sample Point
N
W
E
S
0
0.25
0.5
1
Miles

# Appendix II:  Boat and Vegetative Survey Datasheets

| | |
|---|---|
| **Boat Survey** | |
| **Lake Name** | |
| **County** | |
| **WBIC** | |
| **Date of Survey** | |
| **(mm/dd/yy)** | |
| **workers** | |
| | |
| **Nearest Point** | **Species seen, habitat information** |
| | |
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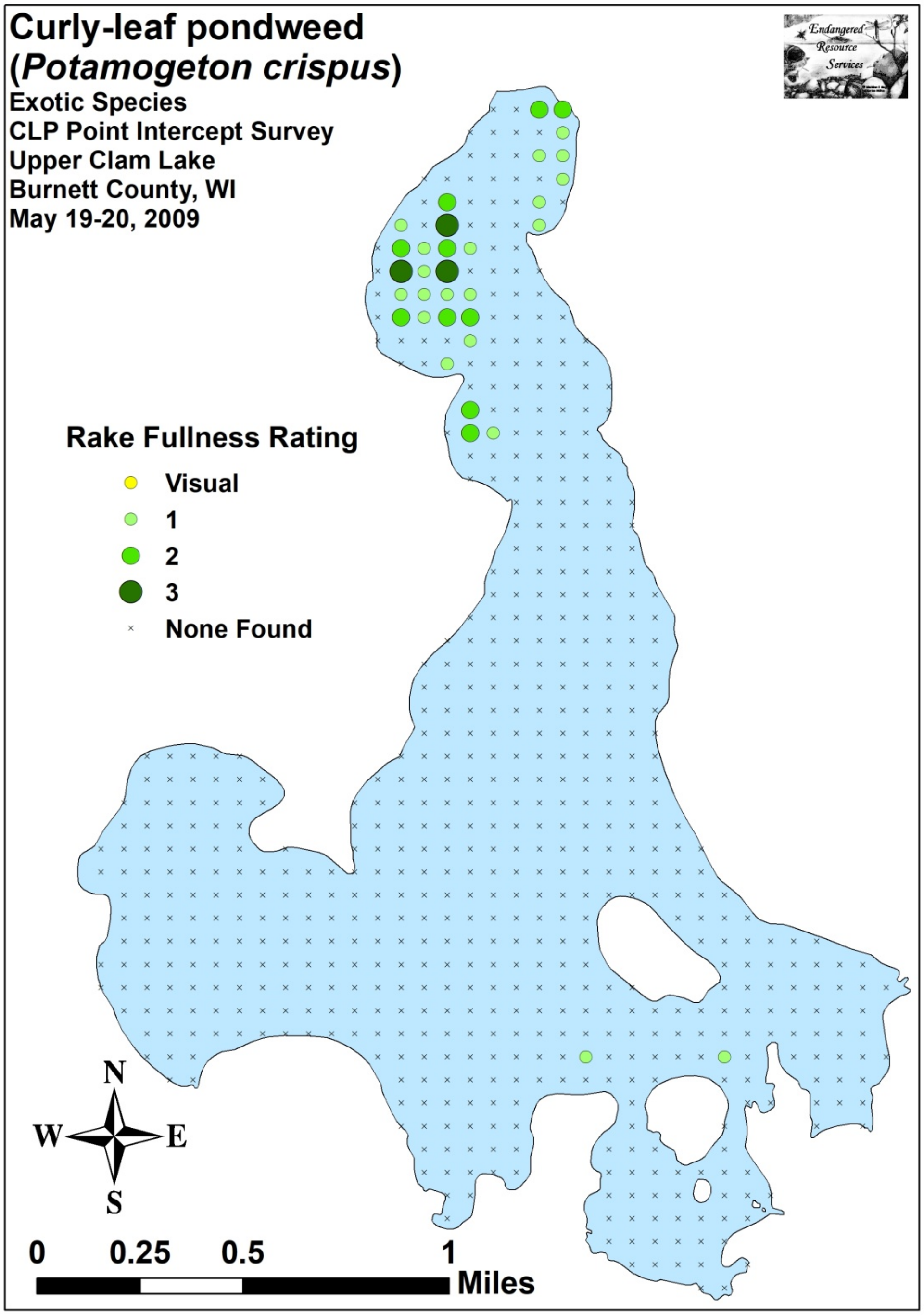
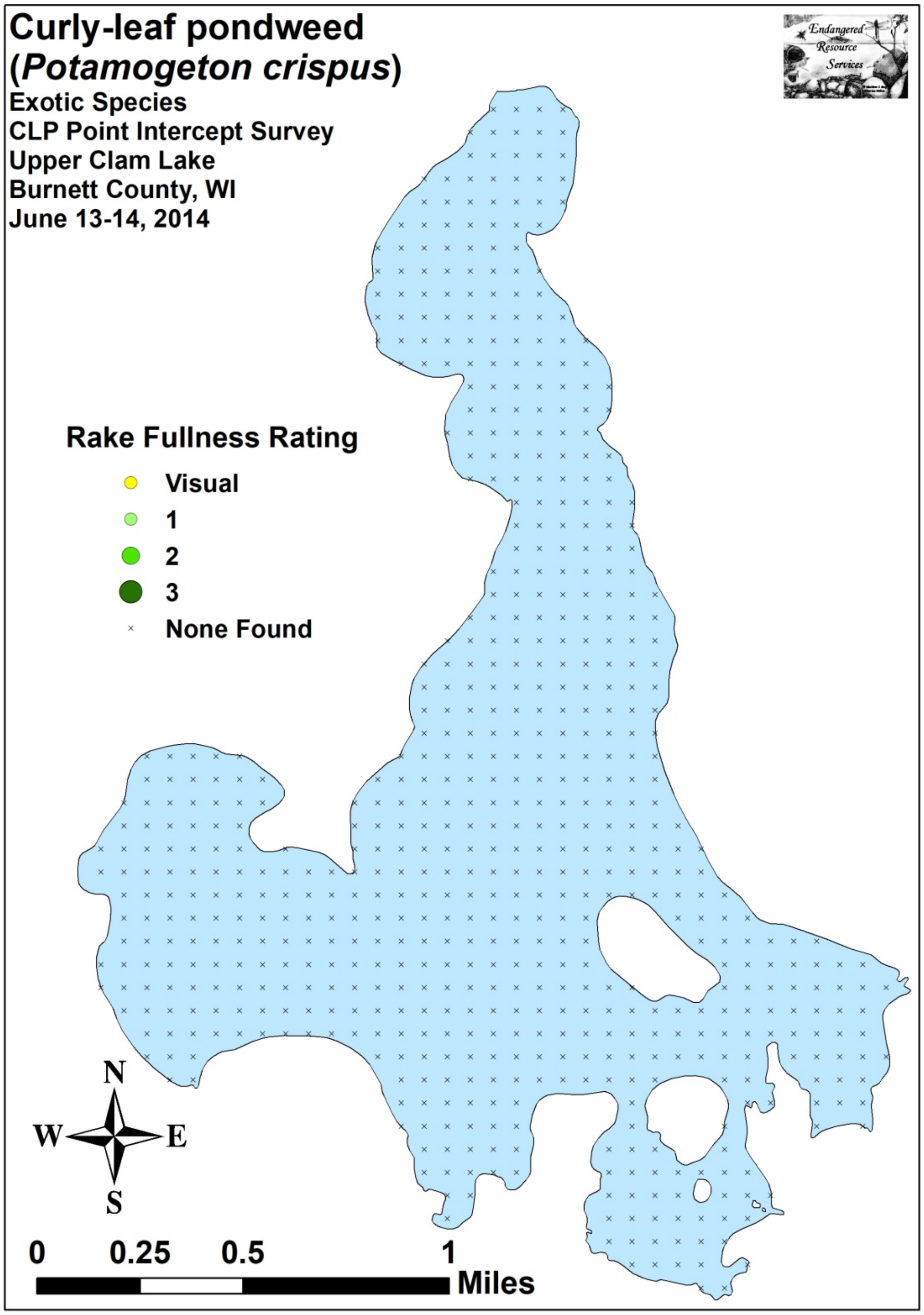
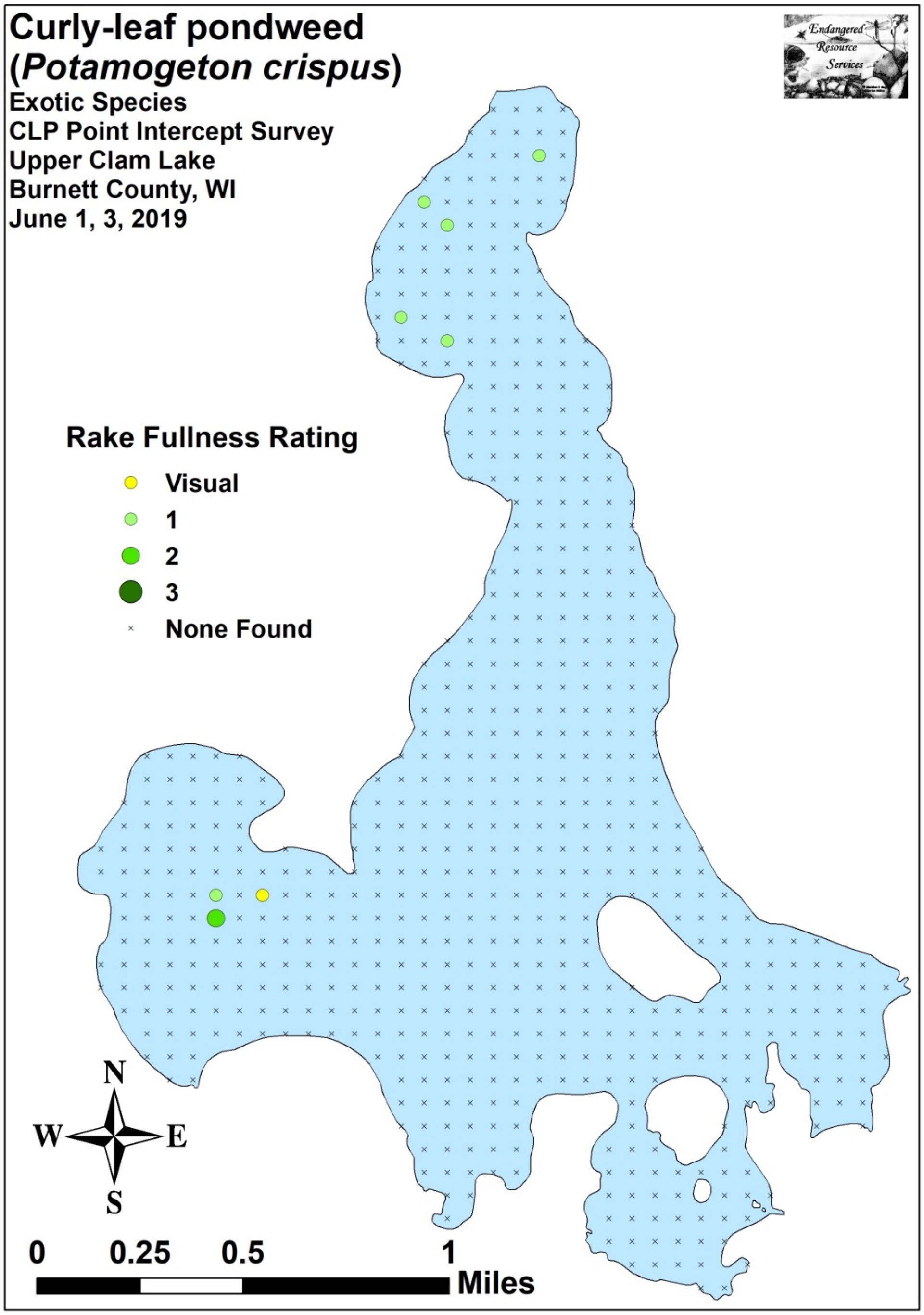
| Observers for this lake: names and hours worked by each: | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lake: | | | | | | | | | WBIC | | | | | | | | | County | | | | | | Date: | |
| **Site #** | **Depth (ft)** | **Muck (M), Sand (S), Rock (R)** | **Rake pole (P) or rake rope (R)** | **Total Rake Fullness** | **EWM** | **CLP** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **16** | **17** | **18** | **19** |
| 1 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | | | | | | | | | | | |

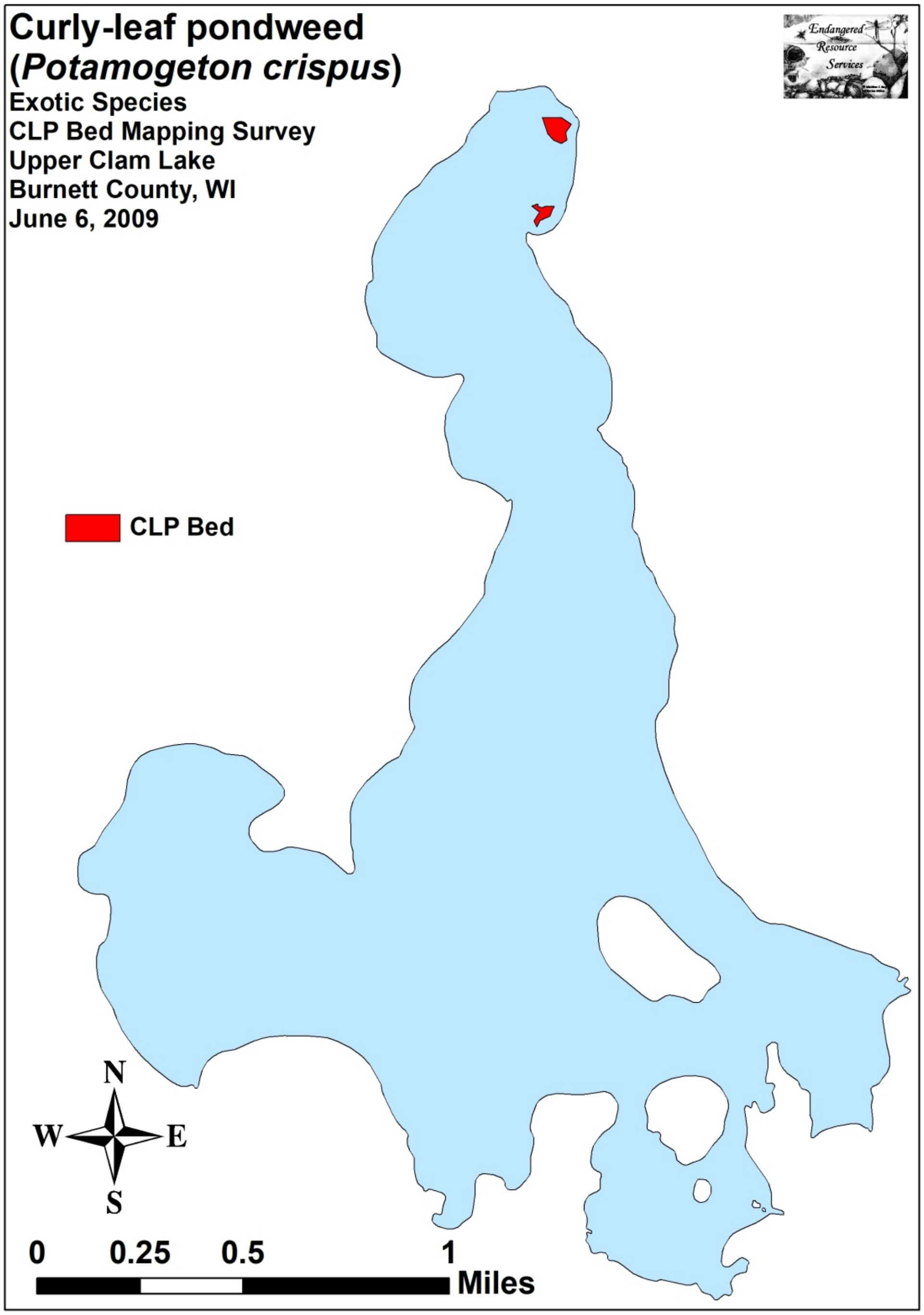
# Appendix III:  2009, 2014, and 2019 Early-season CLP Density and Distribution and CLP Bed Maps

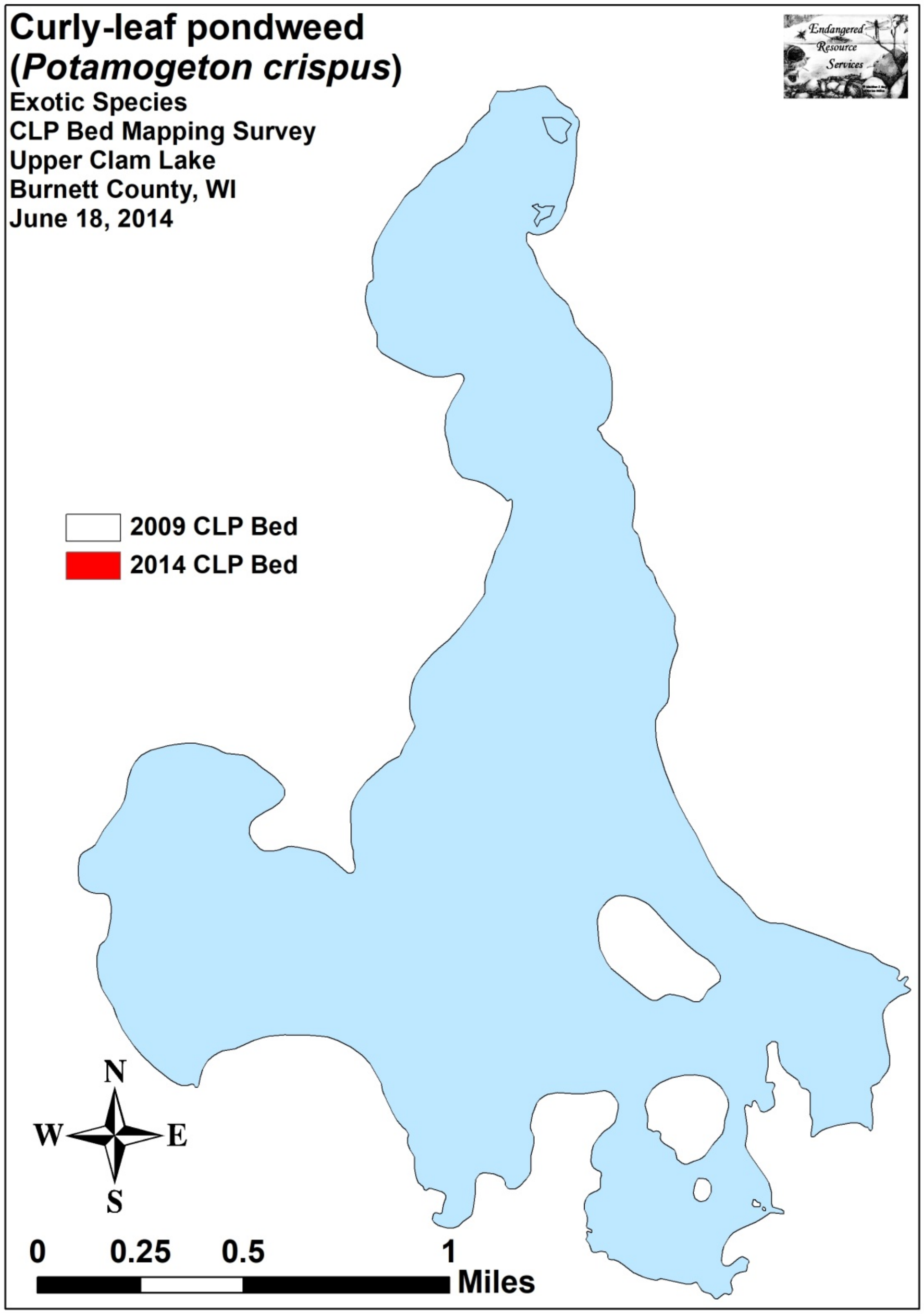

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Point Intercept Survey
Upper Clam Lake
Burnett County, WI
May 19-20, 2009
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

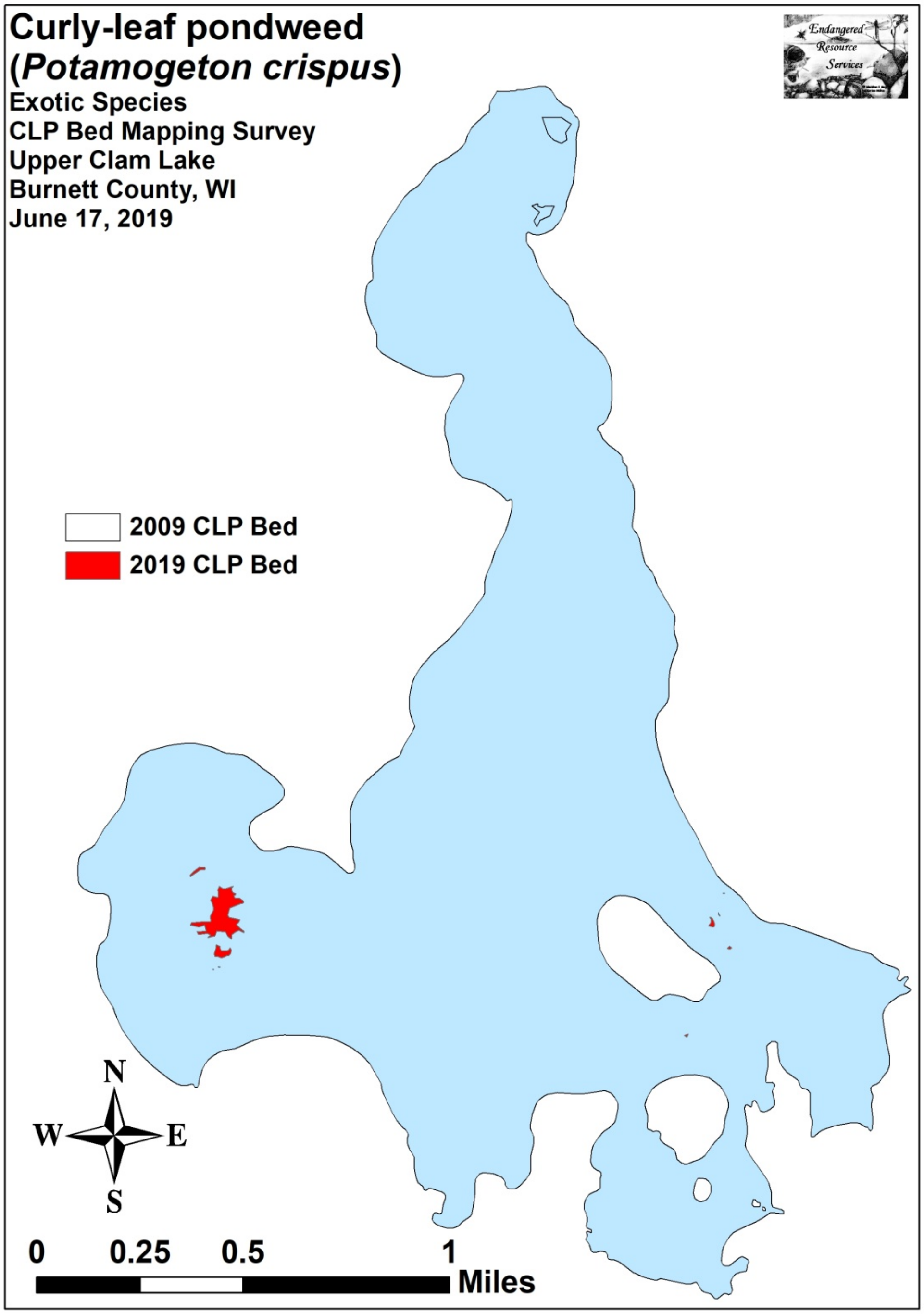


Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Point Intercept Survey
Upper Clam Lake
Burnett County, WI
June 13-14, 2014
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

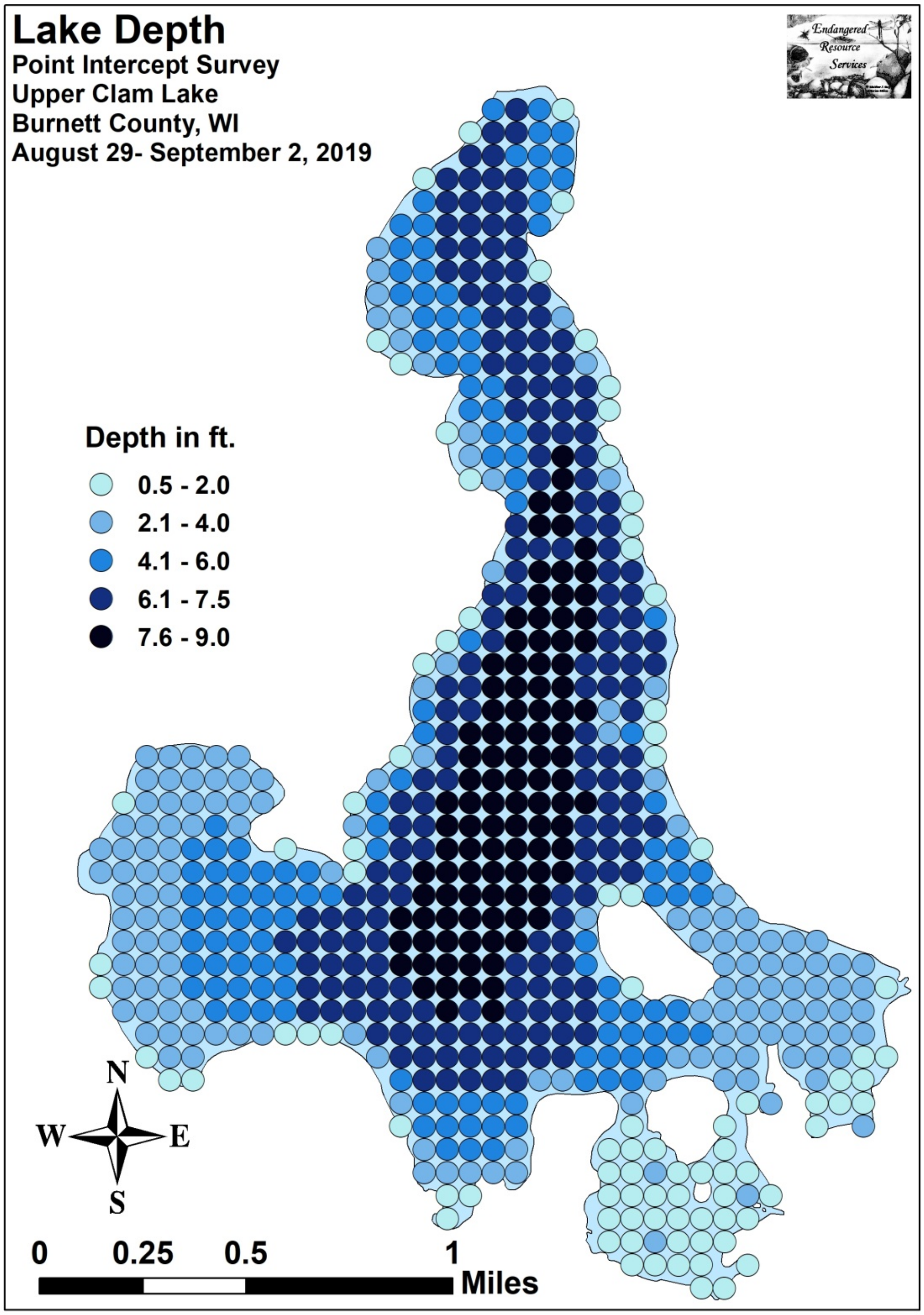

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Point Intercept Survey
Upper Clam Lake
Burnett County, WI
June 1, 3, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

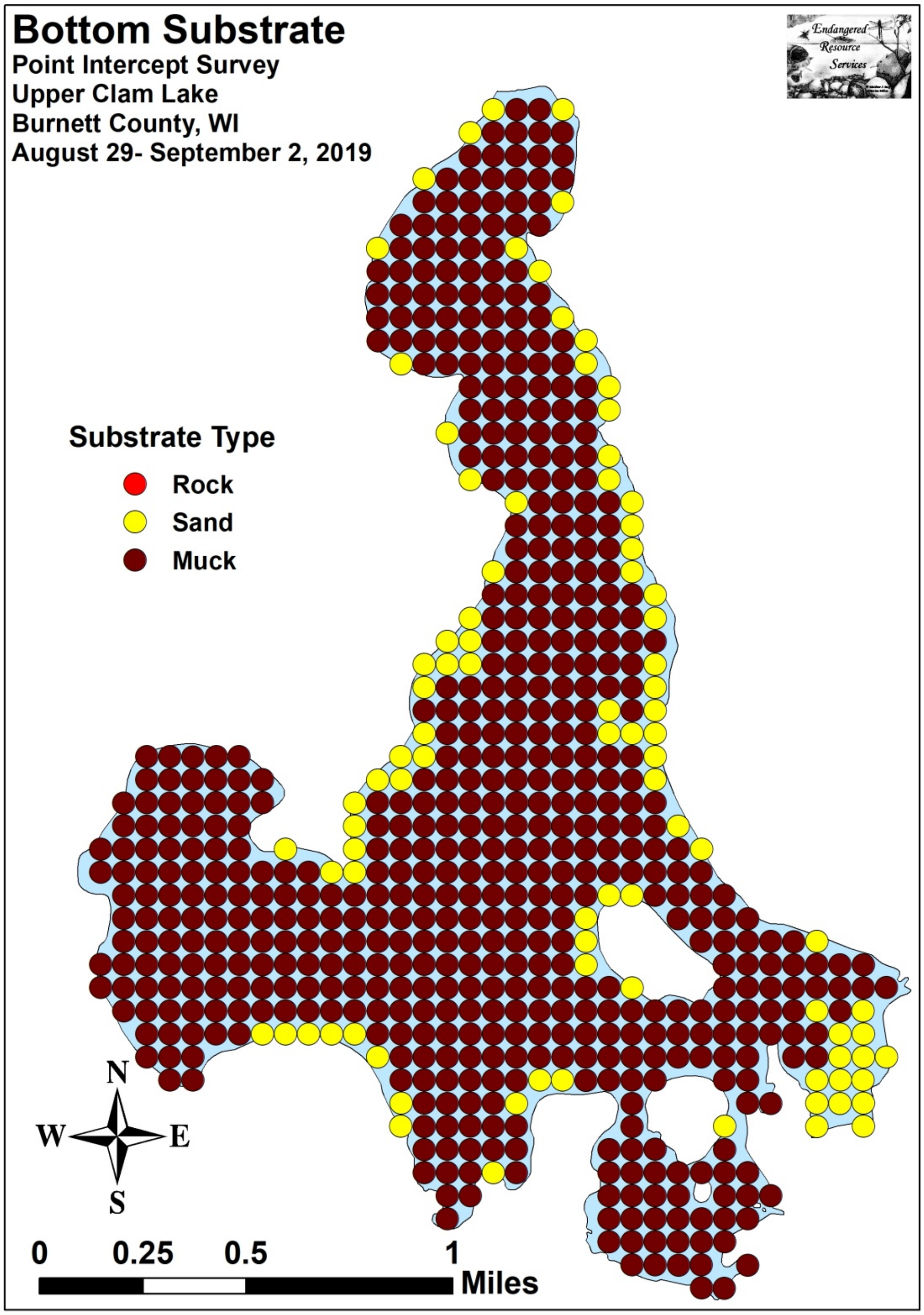

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Bed Mapping Survey
Upper Clam Lake
Burnett County, WI
June 6, 2009
Endangered Resource Services
CLP Bed
N
W
E
S
0
0.25
0.5
1
Miles


Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Bed Mapping Survey
Upper Clam Lake
Burnett County, WI
June 18, 2014
Endangered Resource Services
2009 CLP Bed
2014 CLP Bed
N
W
E
S
0
0.25
0.5
1
Miles

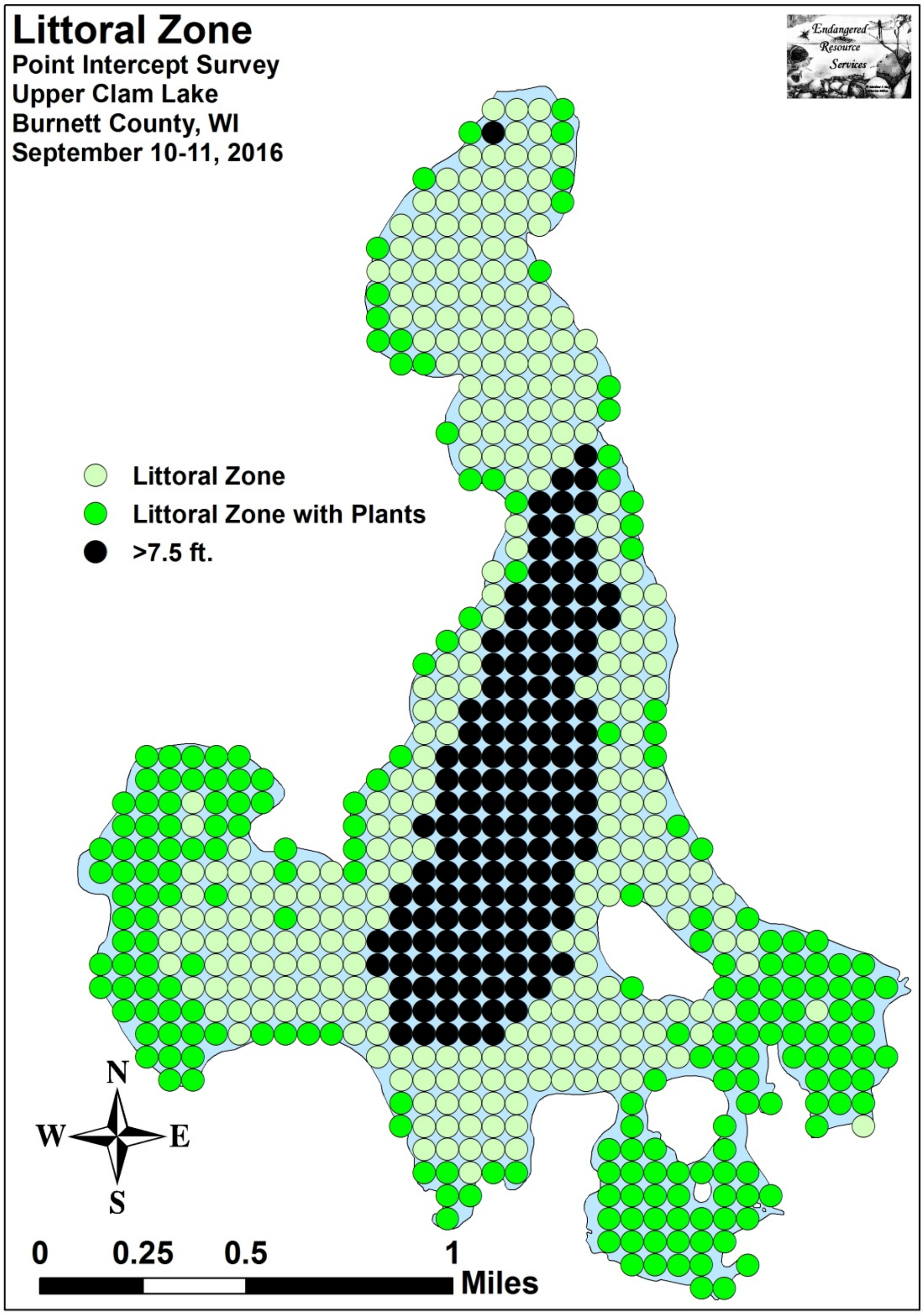

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Bed Mapping Survey
Upper Clam Lake
Burnett County, WI
June 17, 2019
Endangered Resource Services
2009 CLP Bed
2019 CLP Bed
N
W
E
S
0
0.25
0.5
1
Miles

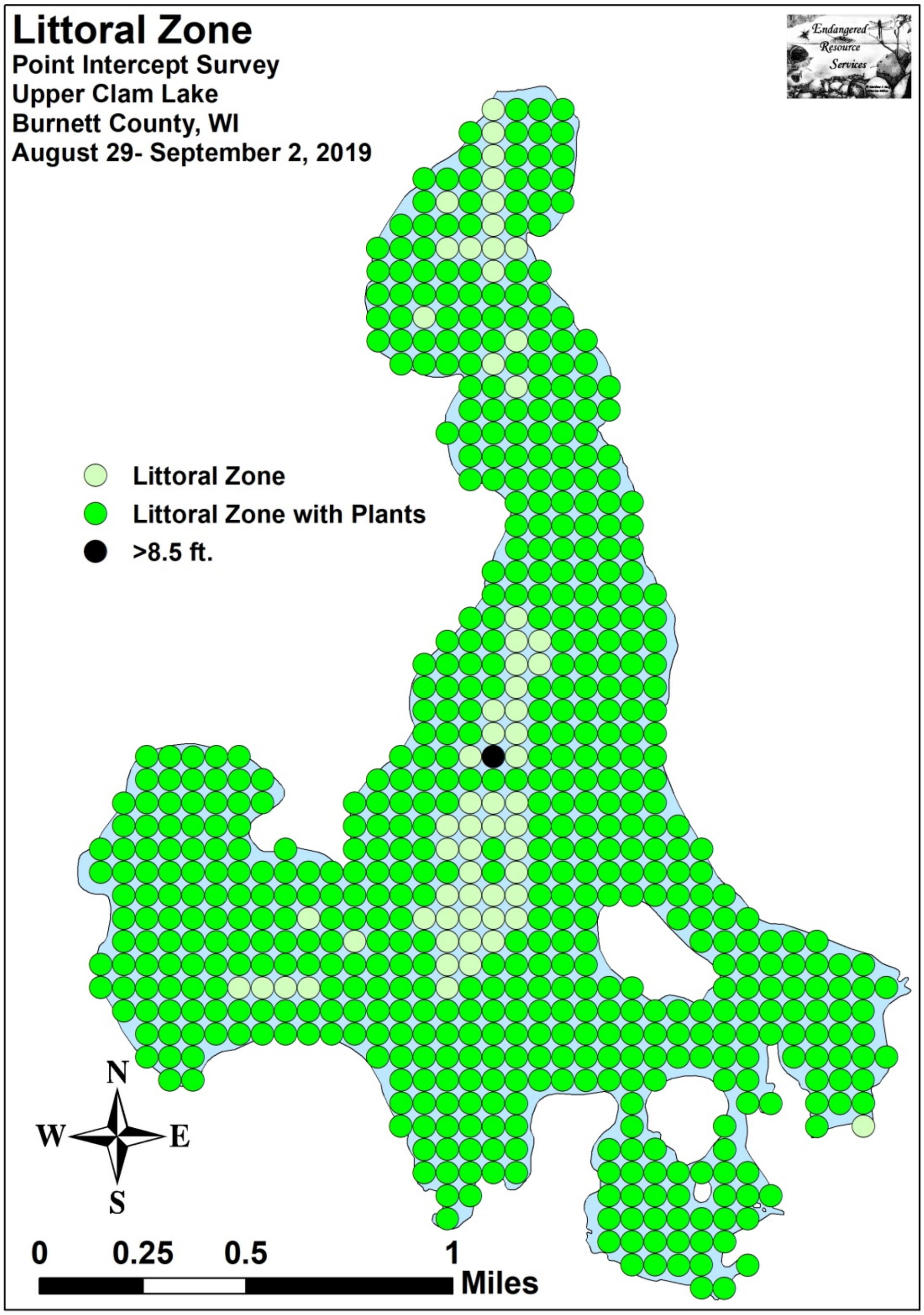
## Appendix IV:  Habitat Variable Maps

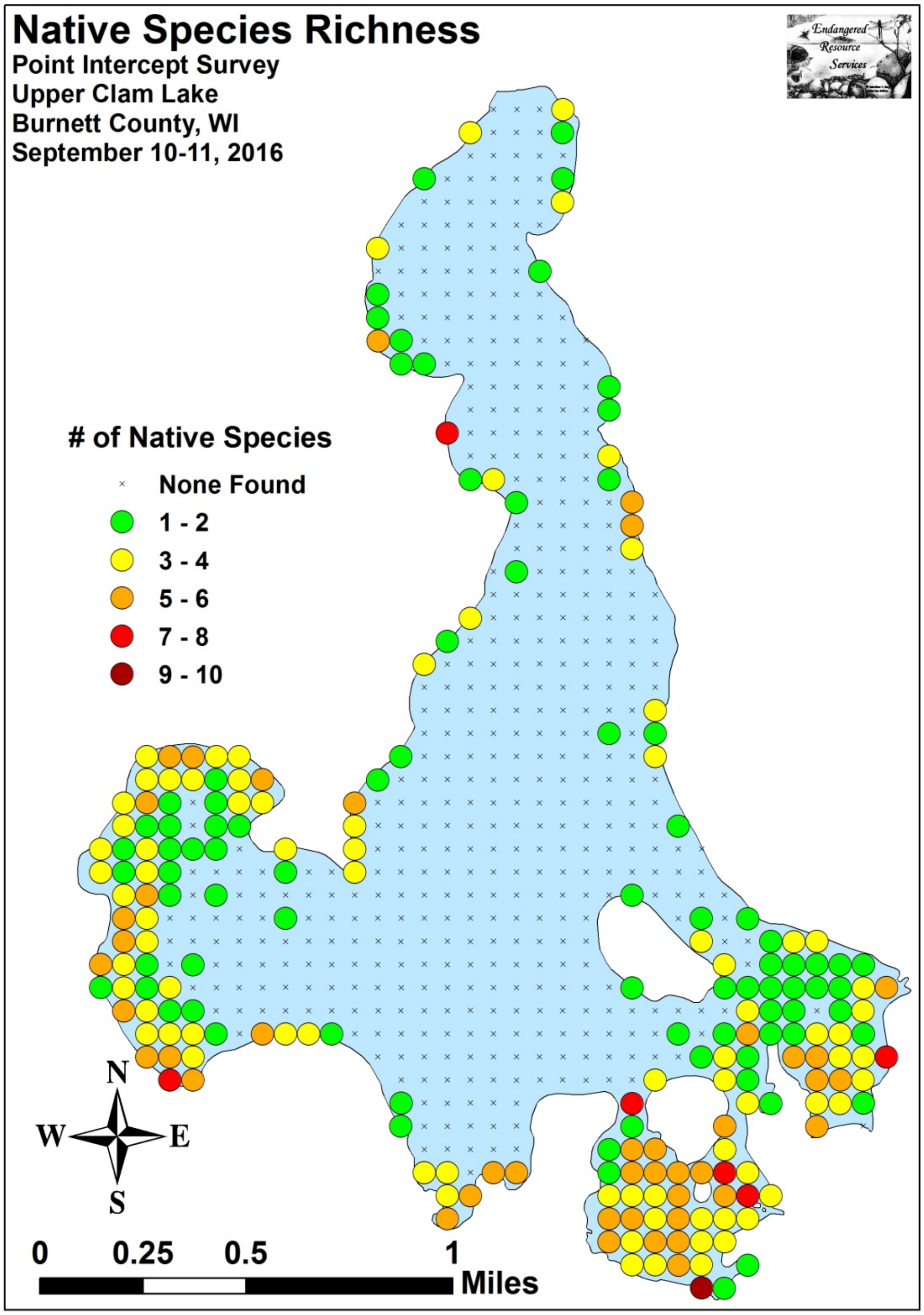

Lake Depth
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Depth in ft.
0.5 - 2.0
2.1 - 4.0
4.1 - 6.0
6.1 - 7.5
7.6 - 9.0
N
W
E
S
0
0.25
0.5
1
Miles

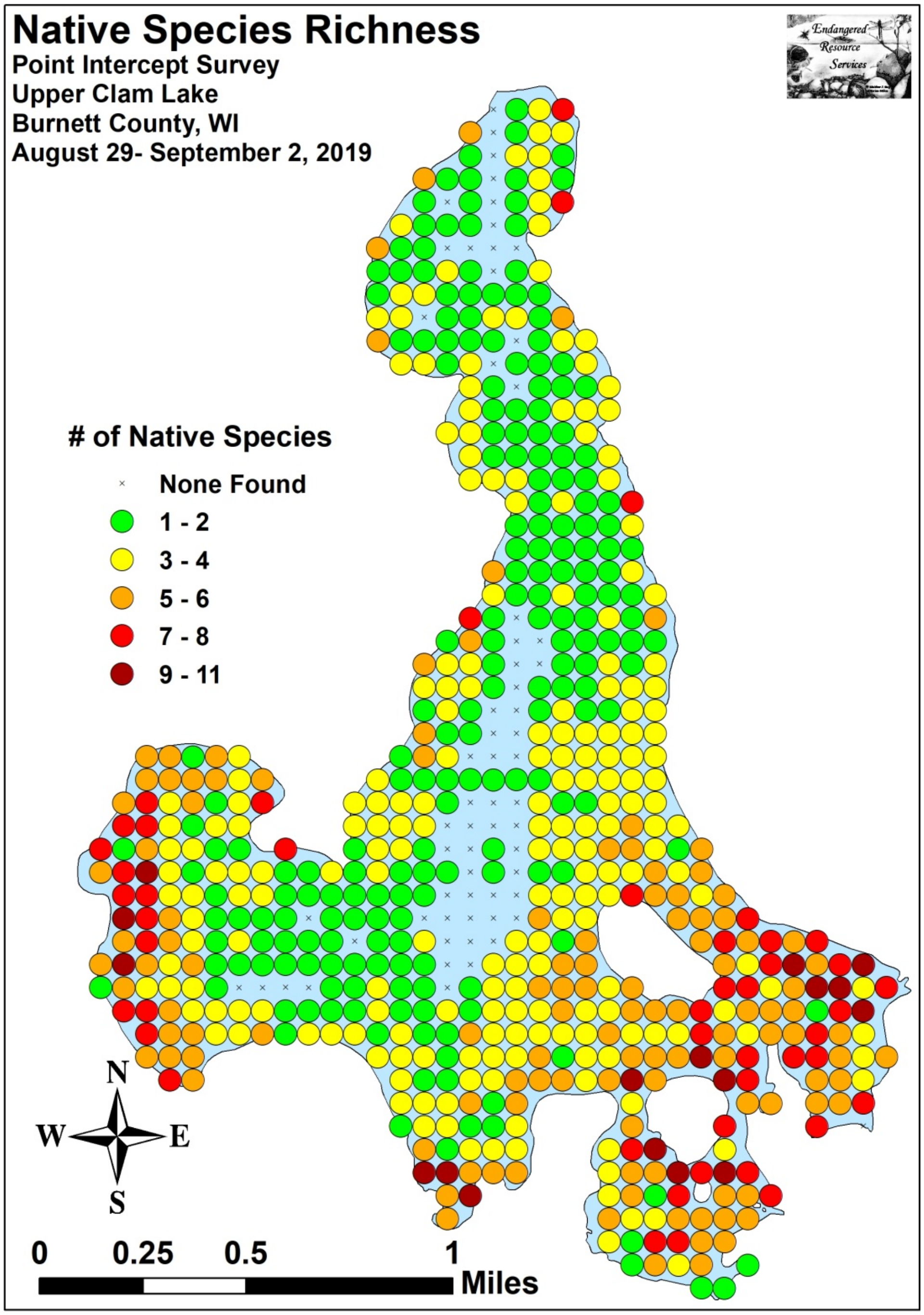

Bottom Substrate
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Substrate Type
Rock
Sand
Muck
N
W
E
S
0
0.25
0.5
1
Miles

## Appendix V: 2016 and 2019 Littoral Zone, Native Species Richness, and Total Rake Fullness Maps

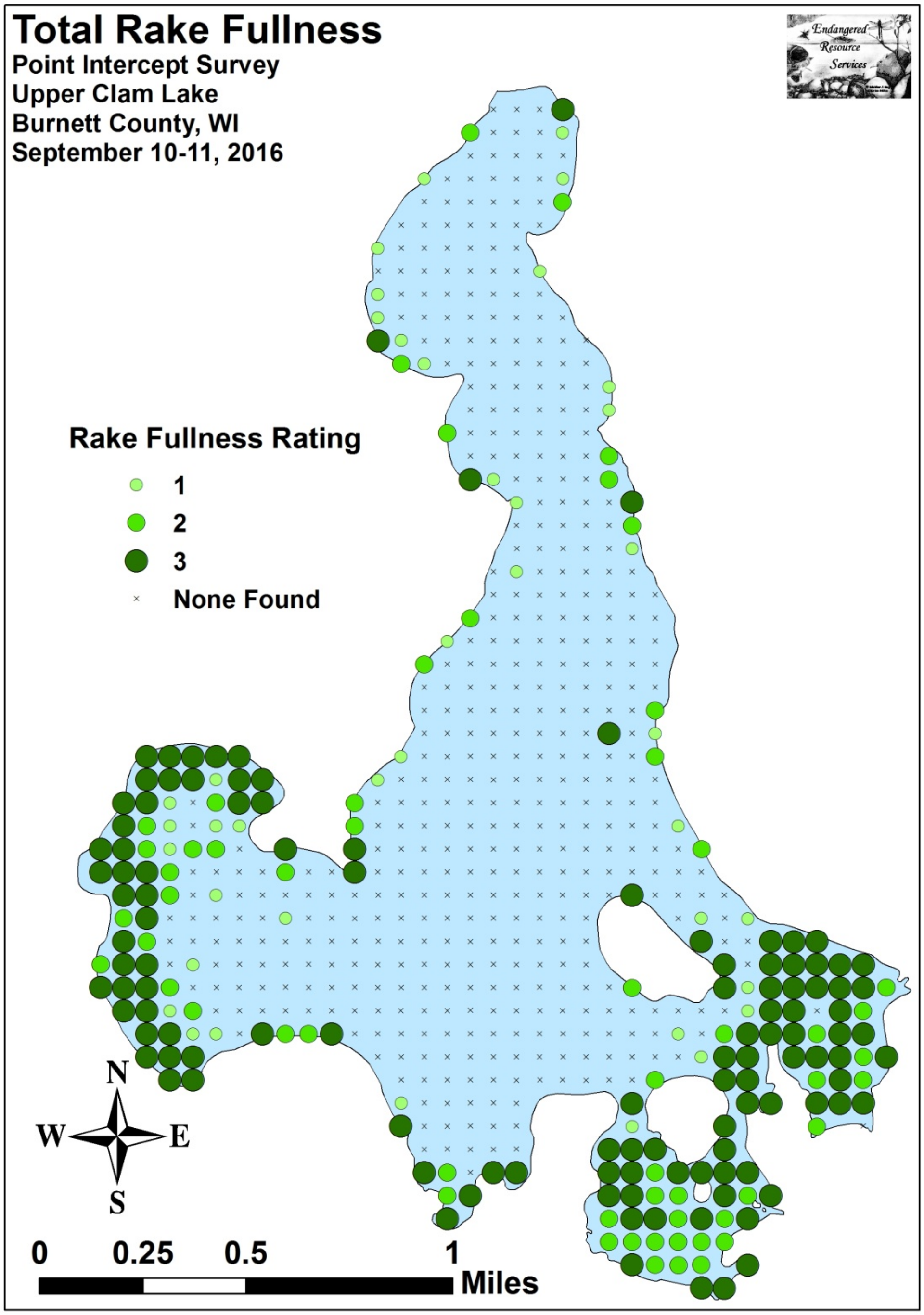

Littoral Zone
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
Littoral Zone
Littoral Zone with Plants
>7.5 ft.
N
W
E
S
0
0.25
0.5
1
Miles


Littoral Zone
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Littoral Zone
Littoral Zone with Plants
>8.5 ft.
N
W
E
S
0
0.25
0.5
1
Miles

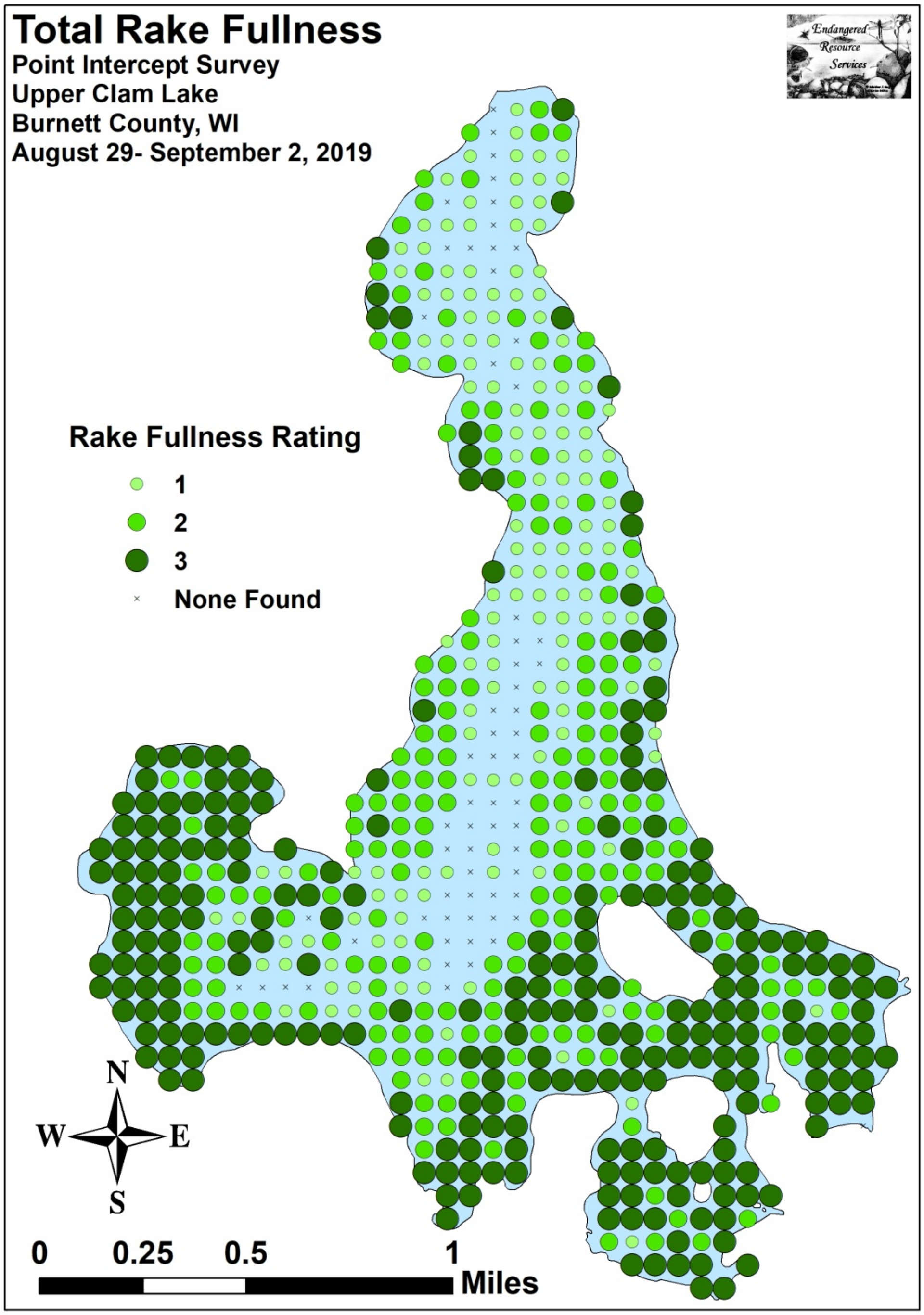

Native Species Richness
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
N
W
E
S
0
0.25
0.5
1
Miles



Native Species Richness
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9 - 11
N
W
E
S
0
0.25
0.5
1
Miles

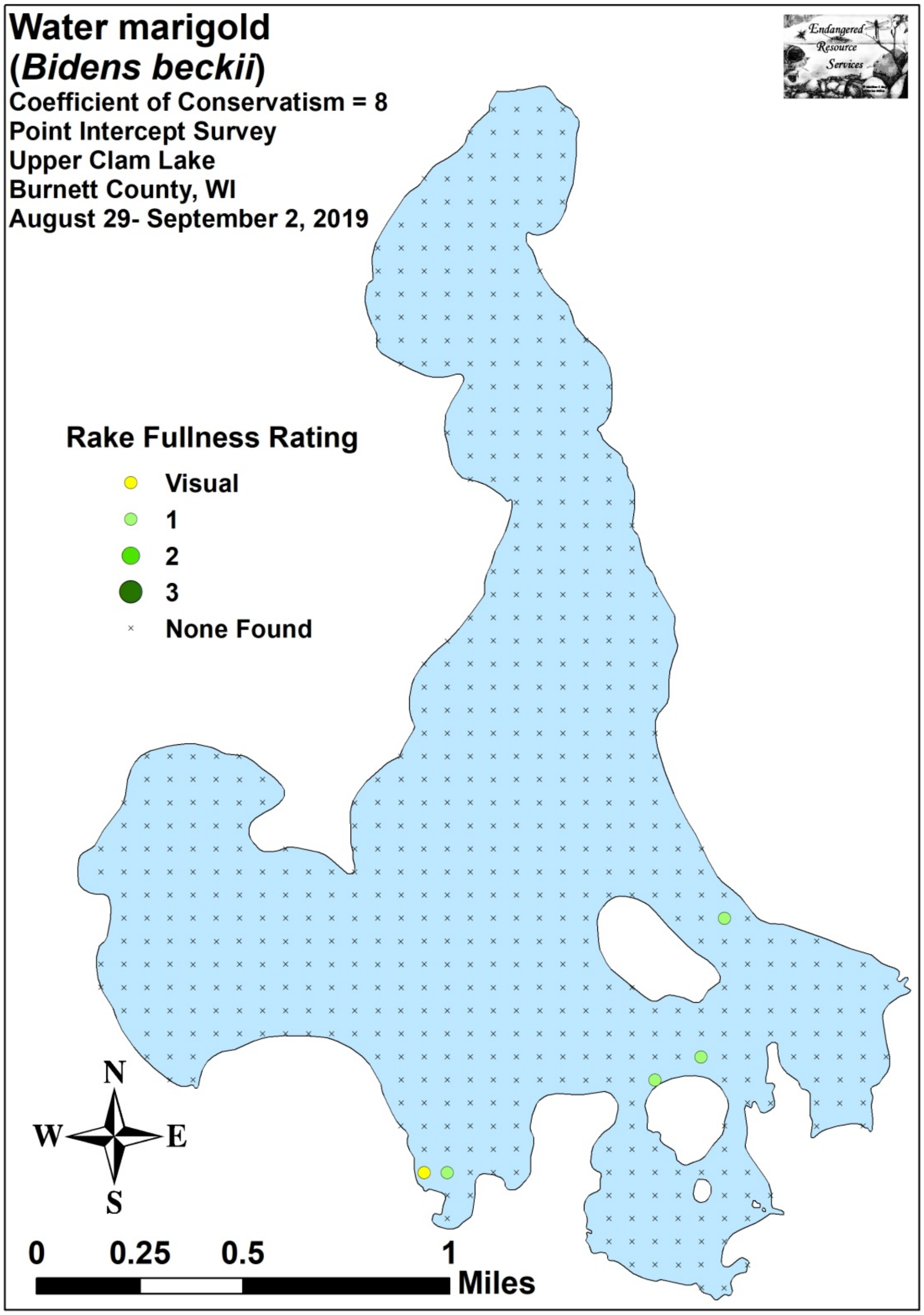


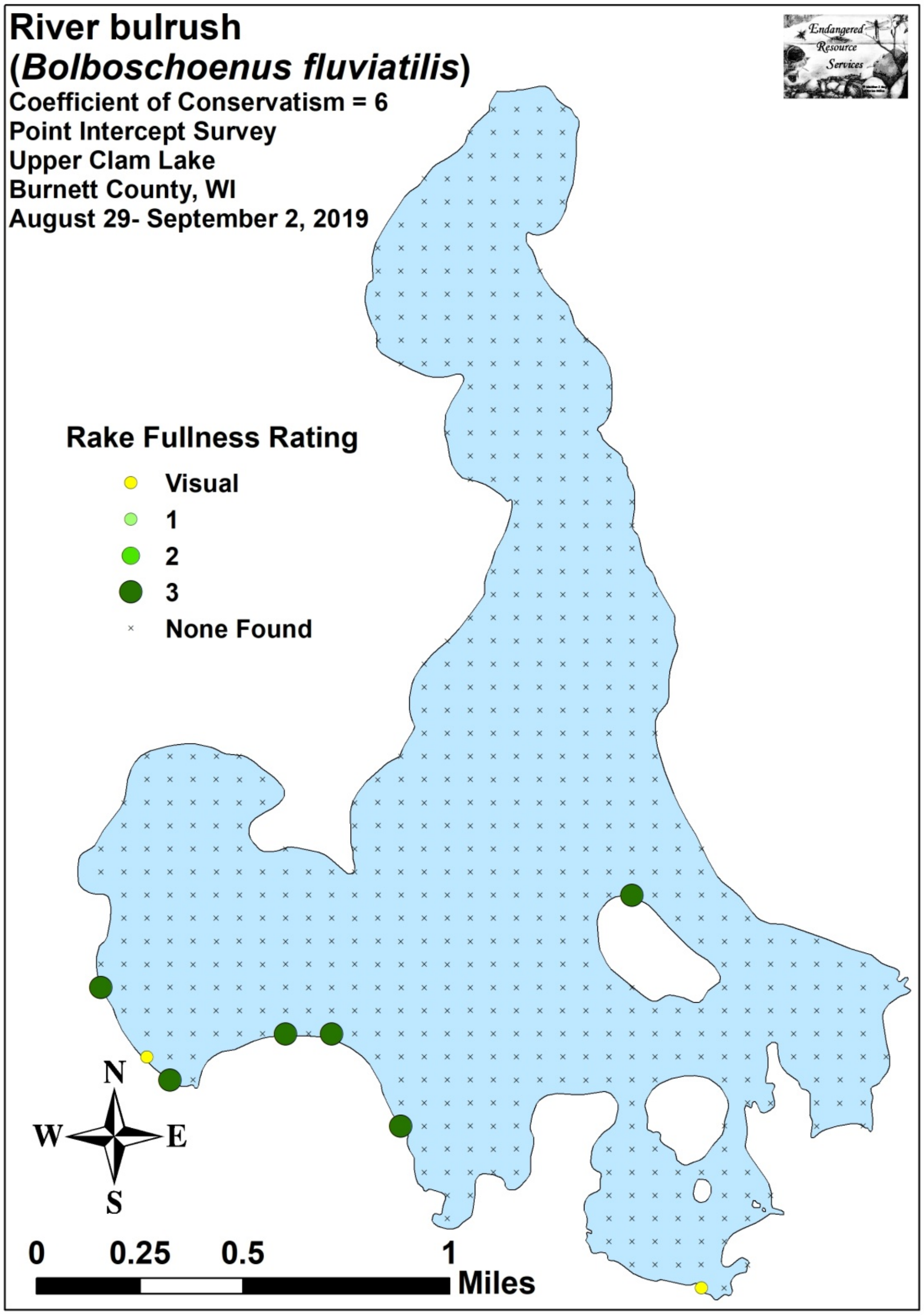
Total Rake Fullness
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
September 10-11, 2016
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

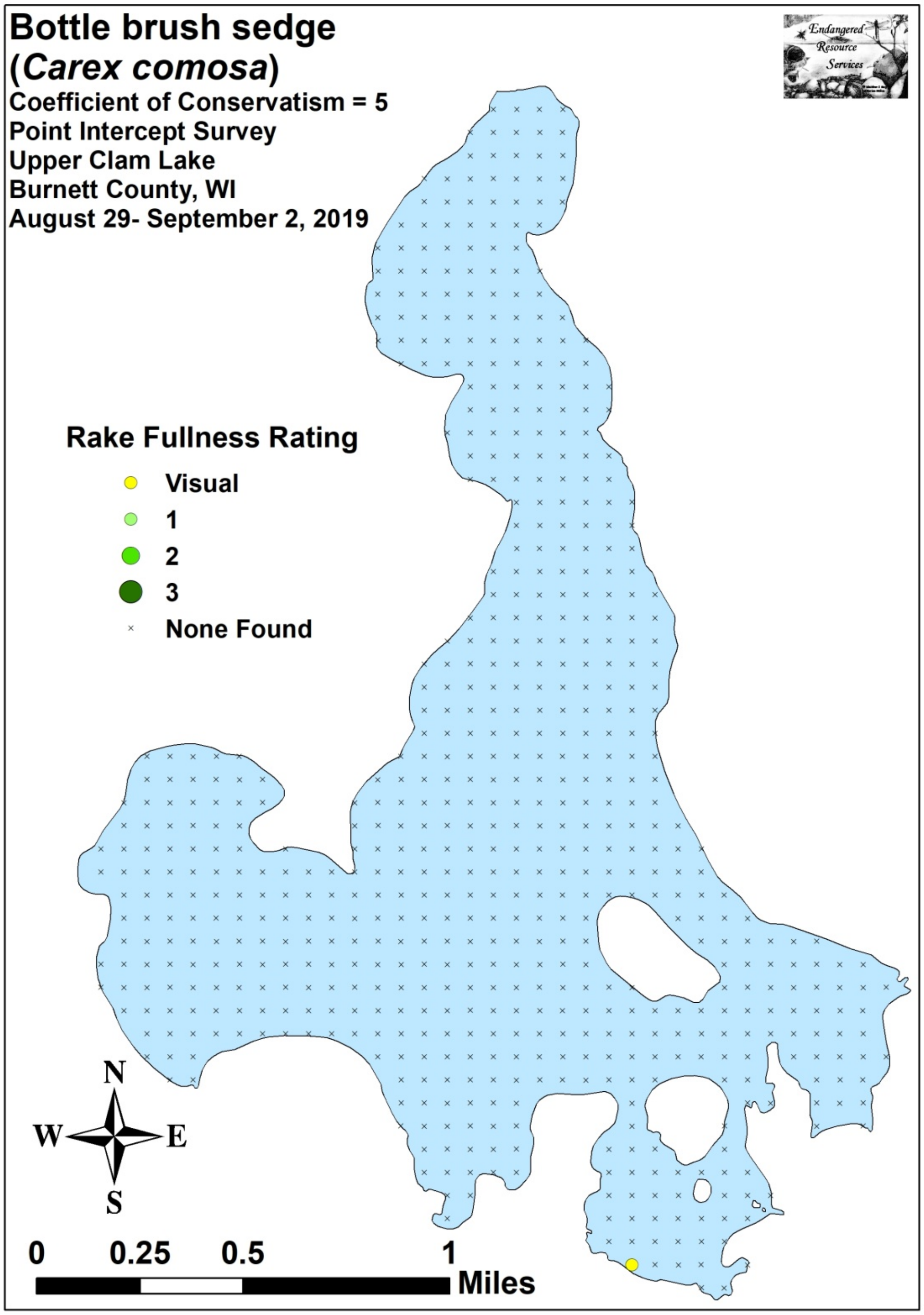


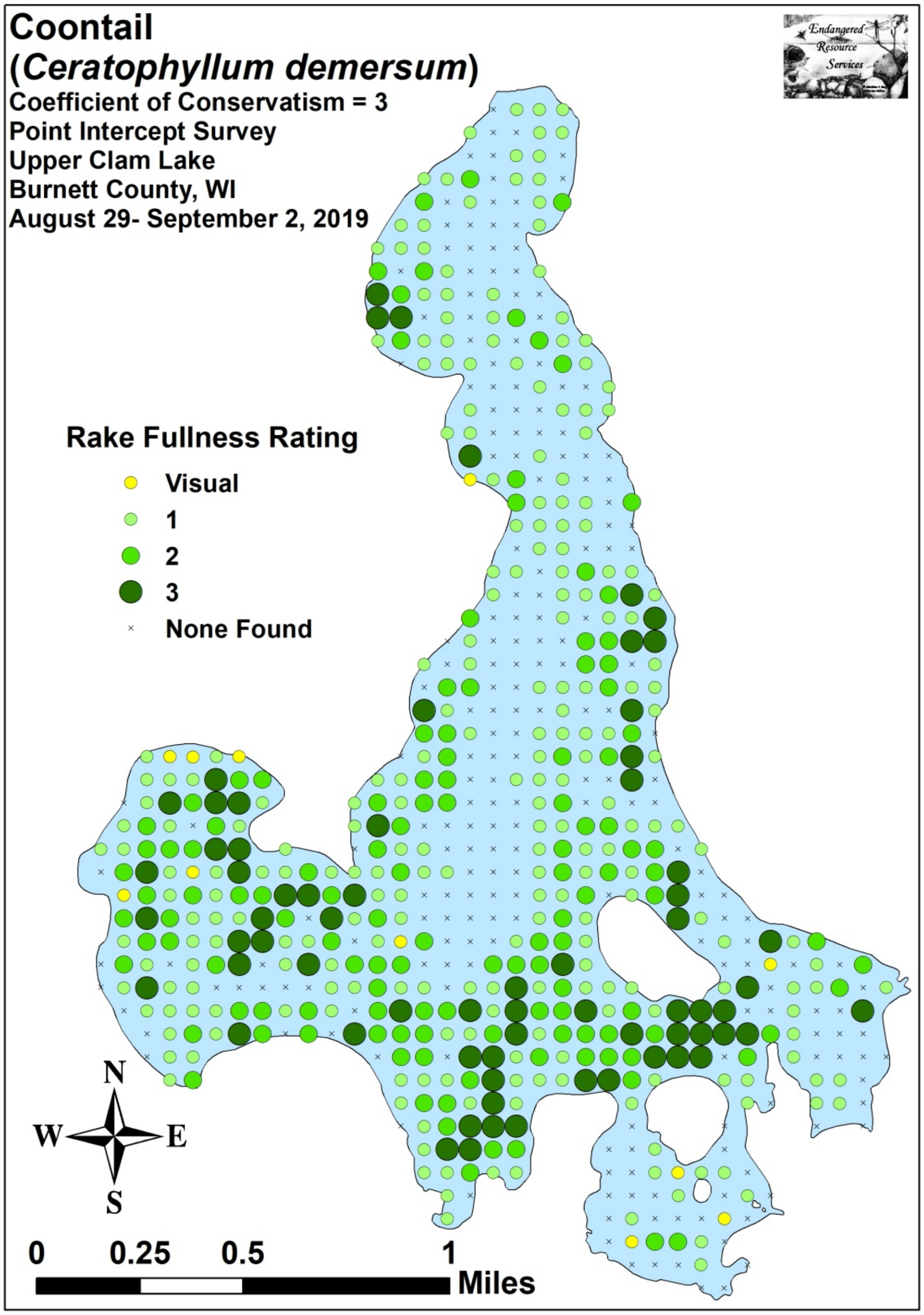
Total Rake Fullness
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

## Appendix VI: 2019 August/September Native Plant Species Density and Distribution Maps

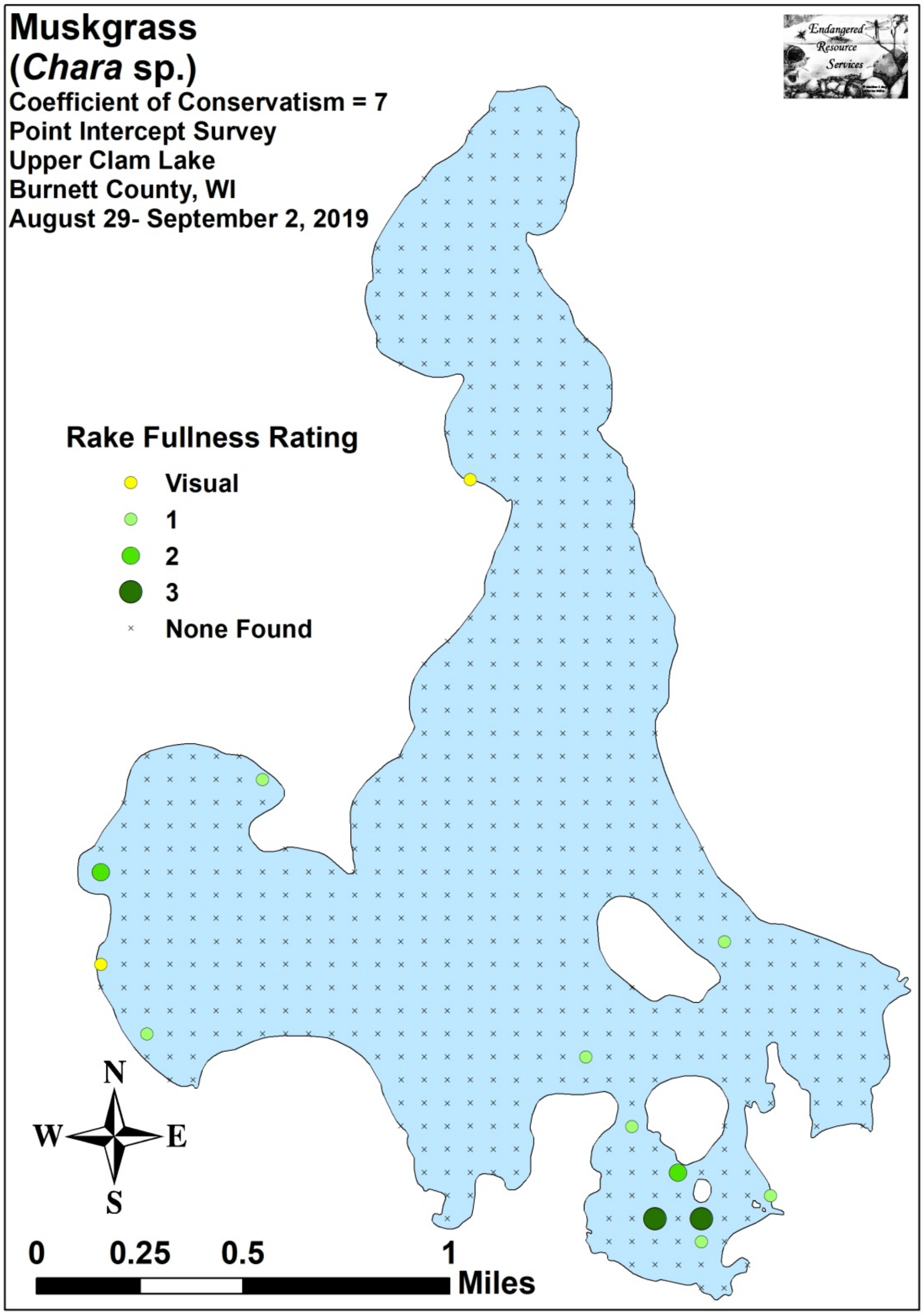

Water marigold
(Bidens beckii)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

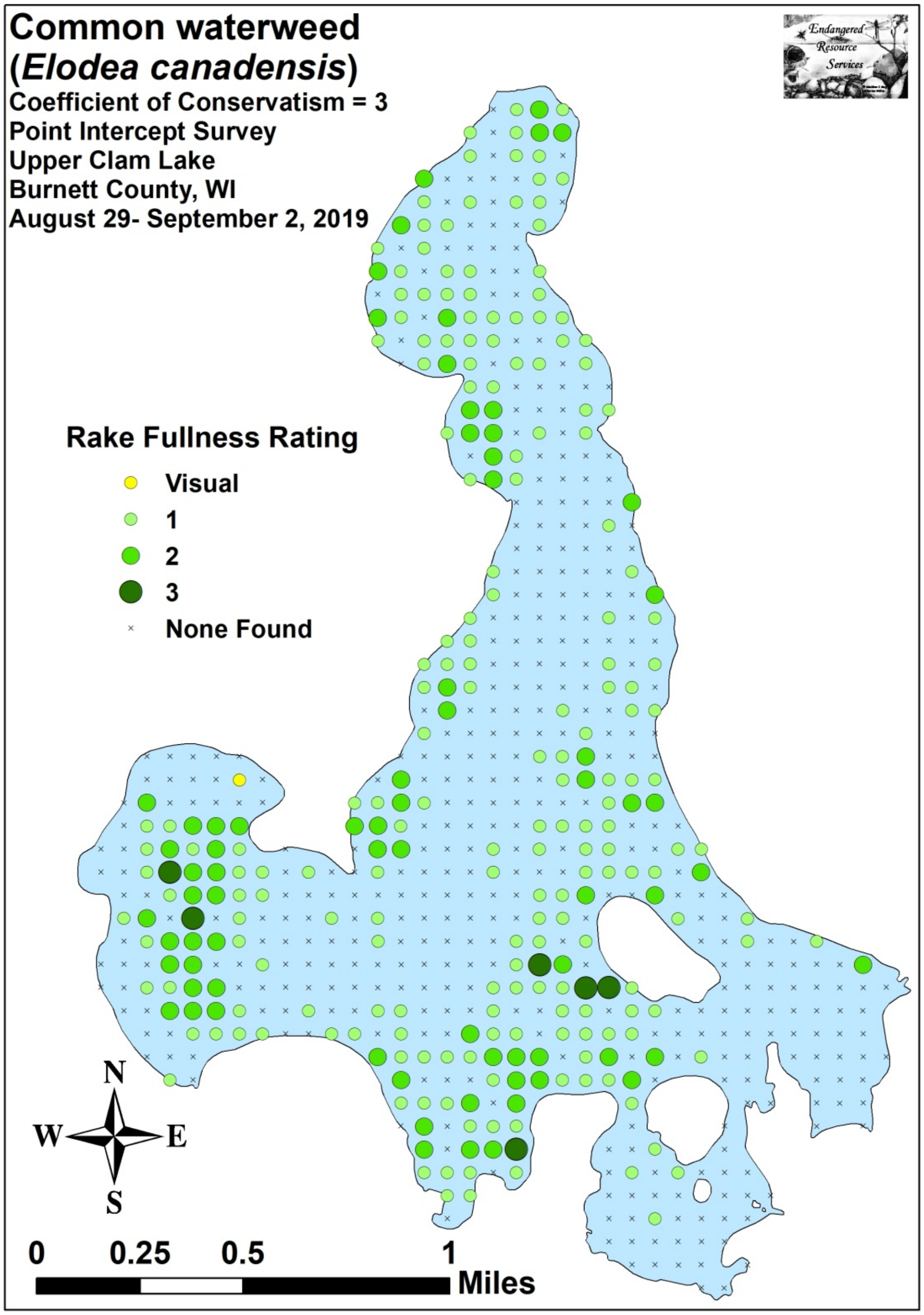

River bulrush
(*Bolboschoenus fluviatilis*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Bottle brush sedge
(Carex comosa)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

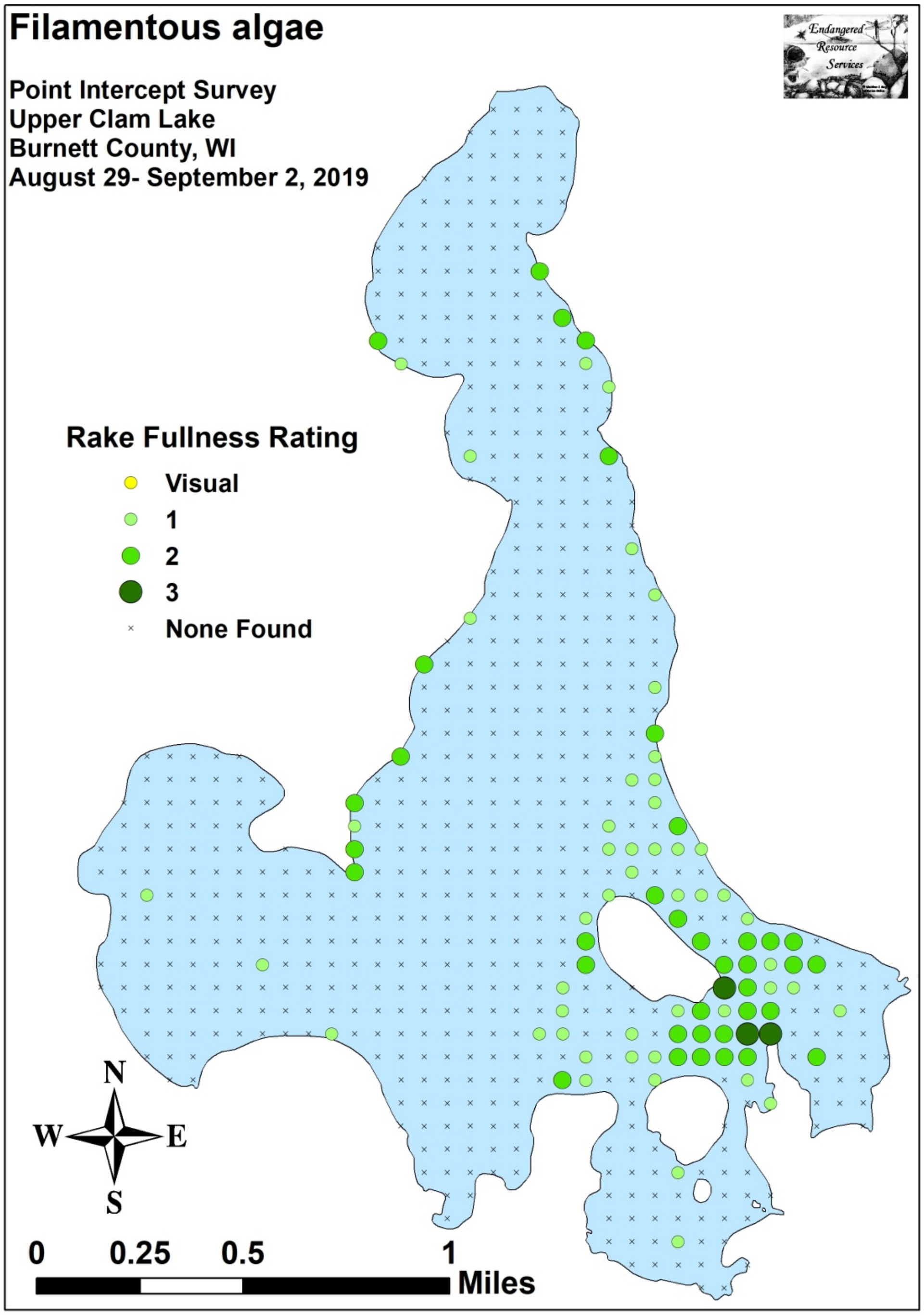


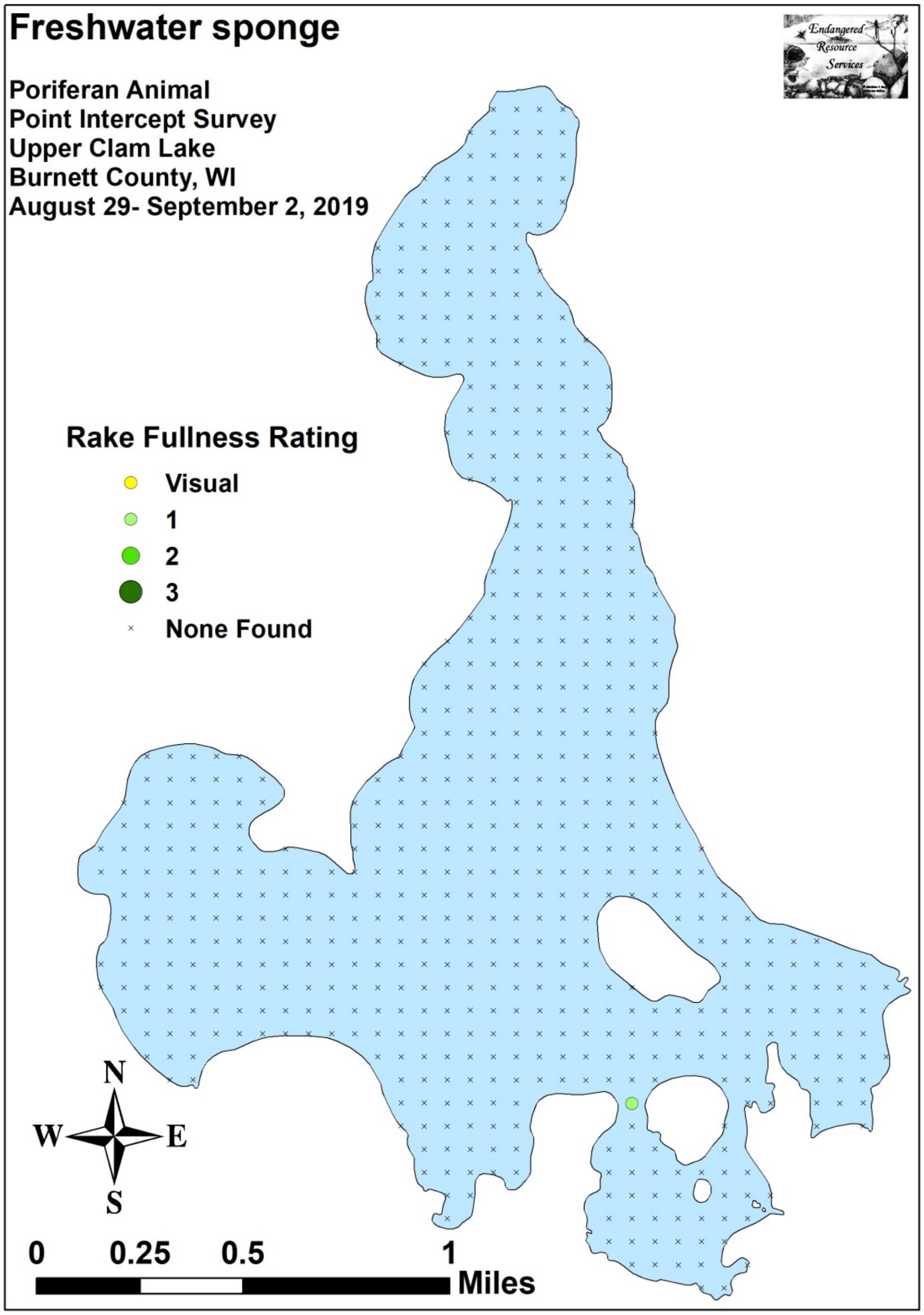
Coontail
(*Ceratophyllum demersum*)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

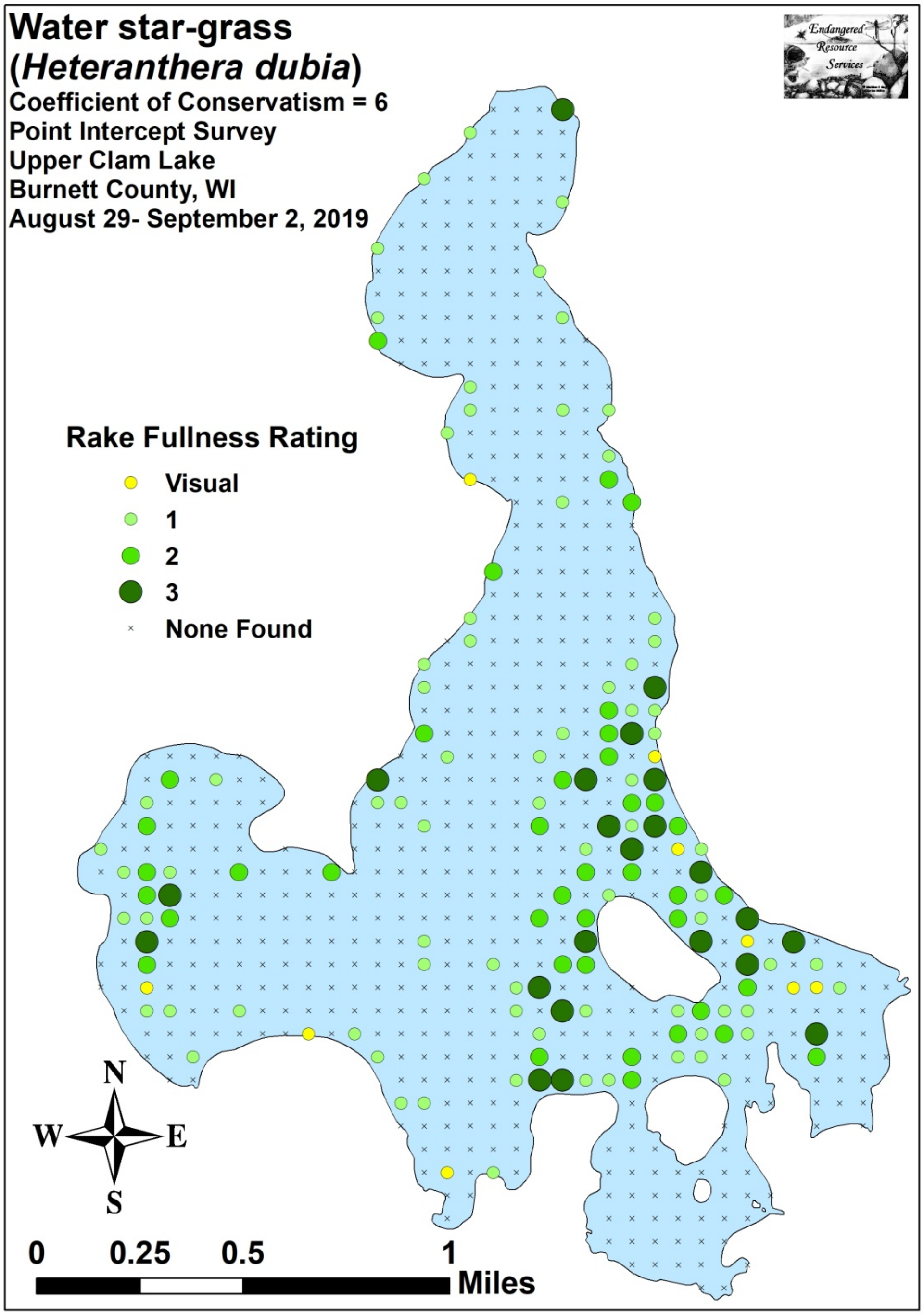

Muskgrass
(Chara sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

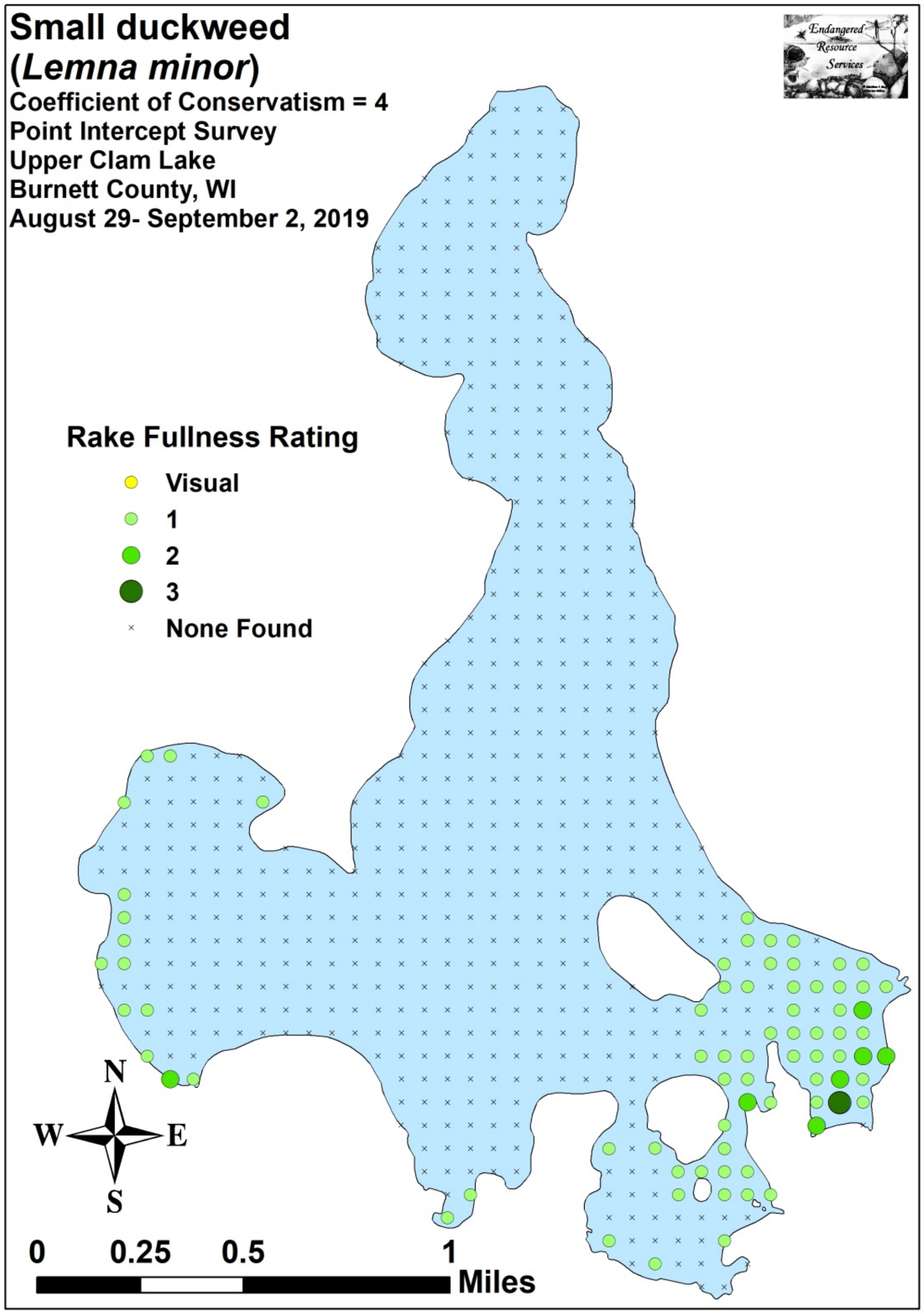


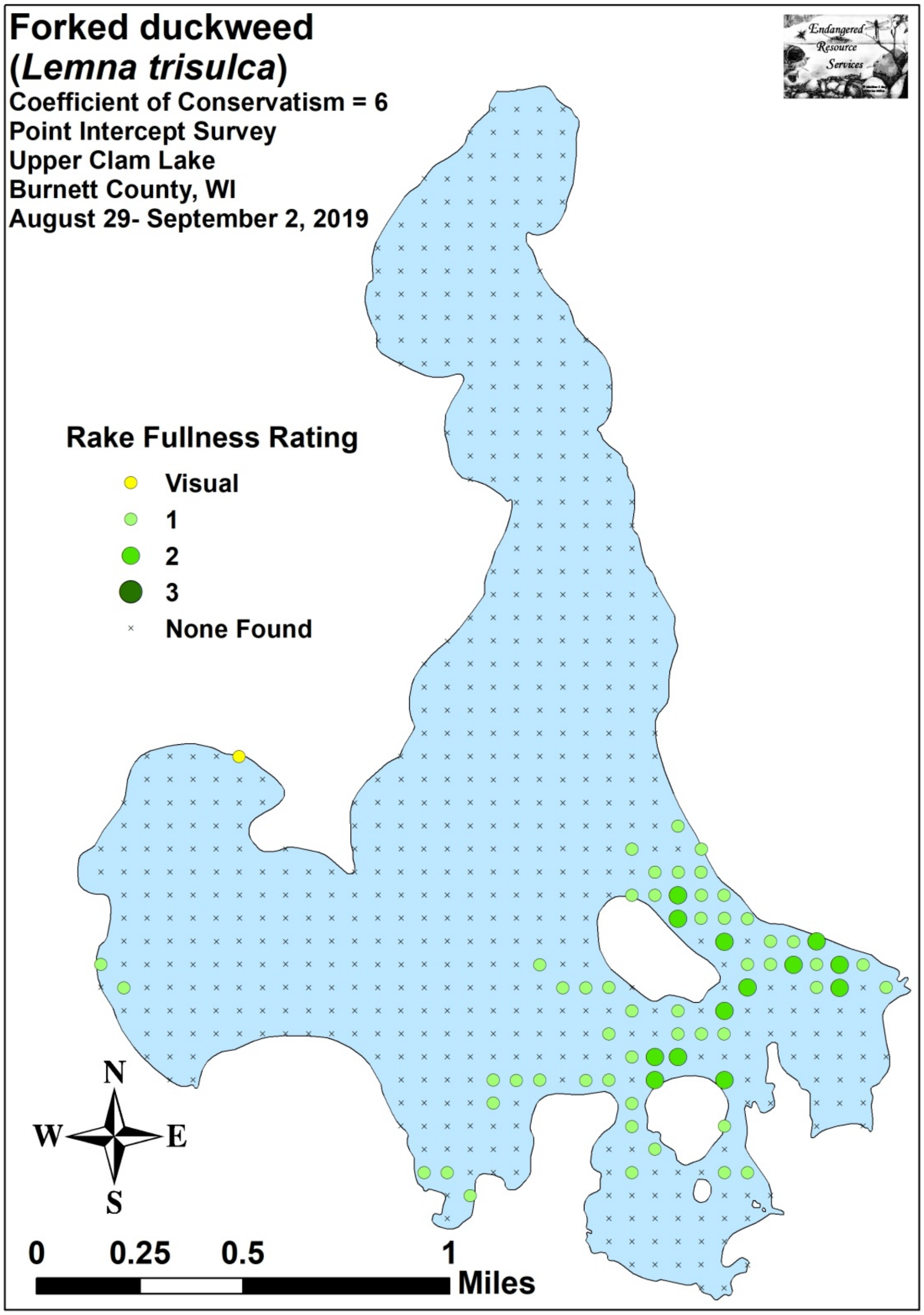
Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

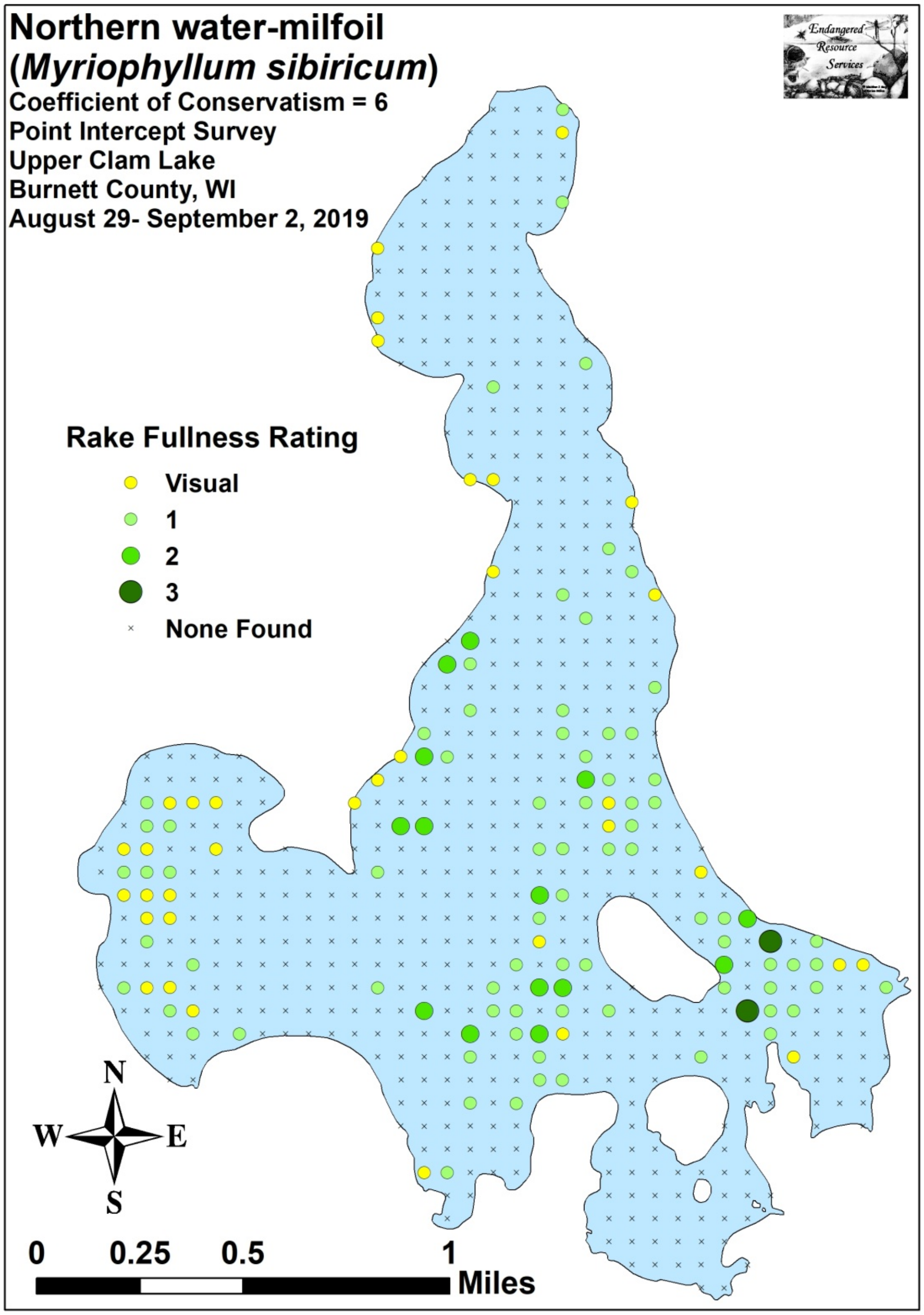

Filamentous algae
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

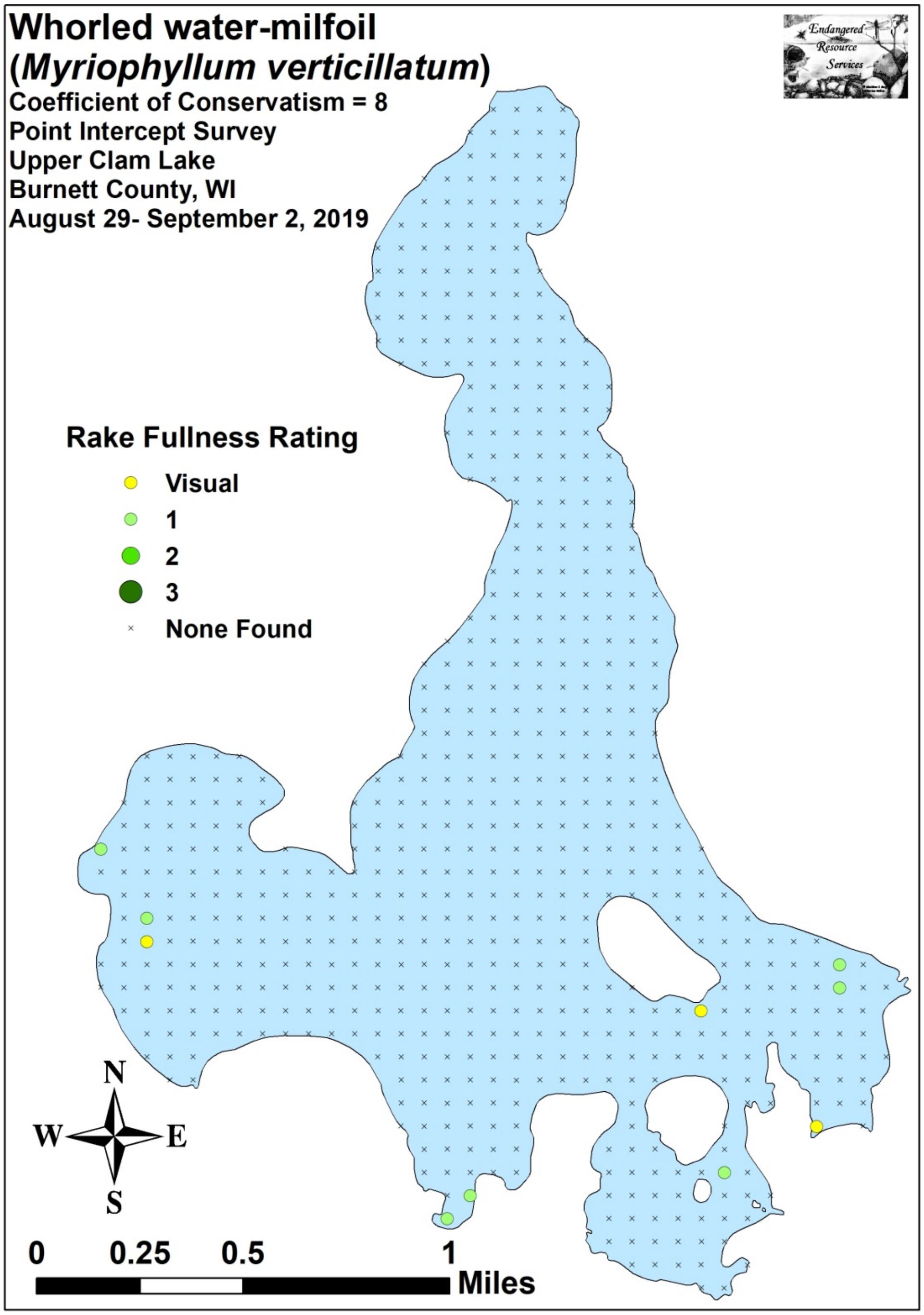

Freshwater sponge
Poriferan Animal
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

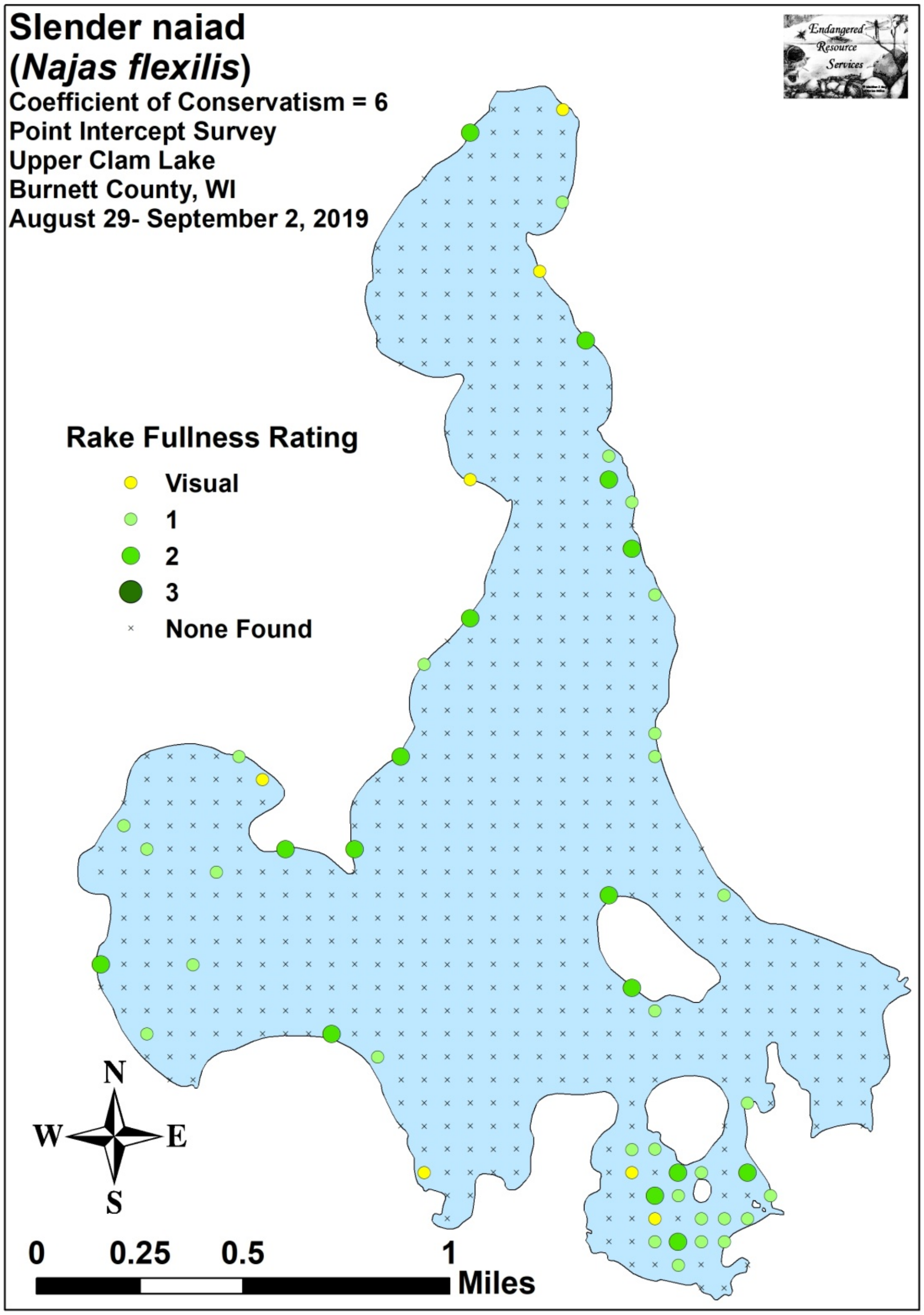

Small duckweed
(Lemna minor)
Coefficient of Conservatism = 4
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Forked duckweed
(*Lemna trisulca*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
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
August 29- September 2, 2019
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
August 29- September 2, 2019
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
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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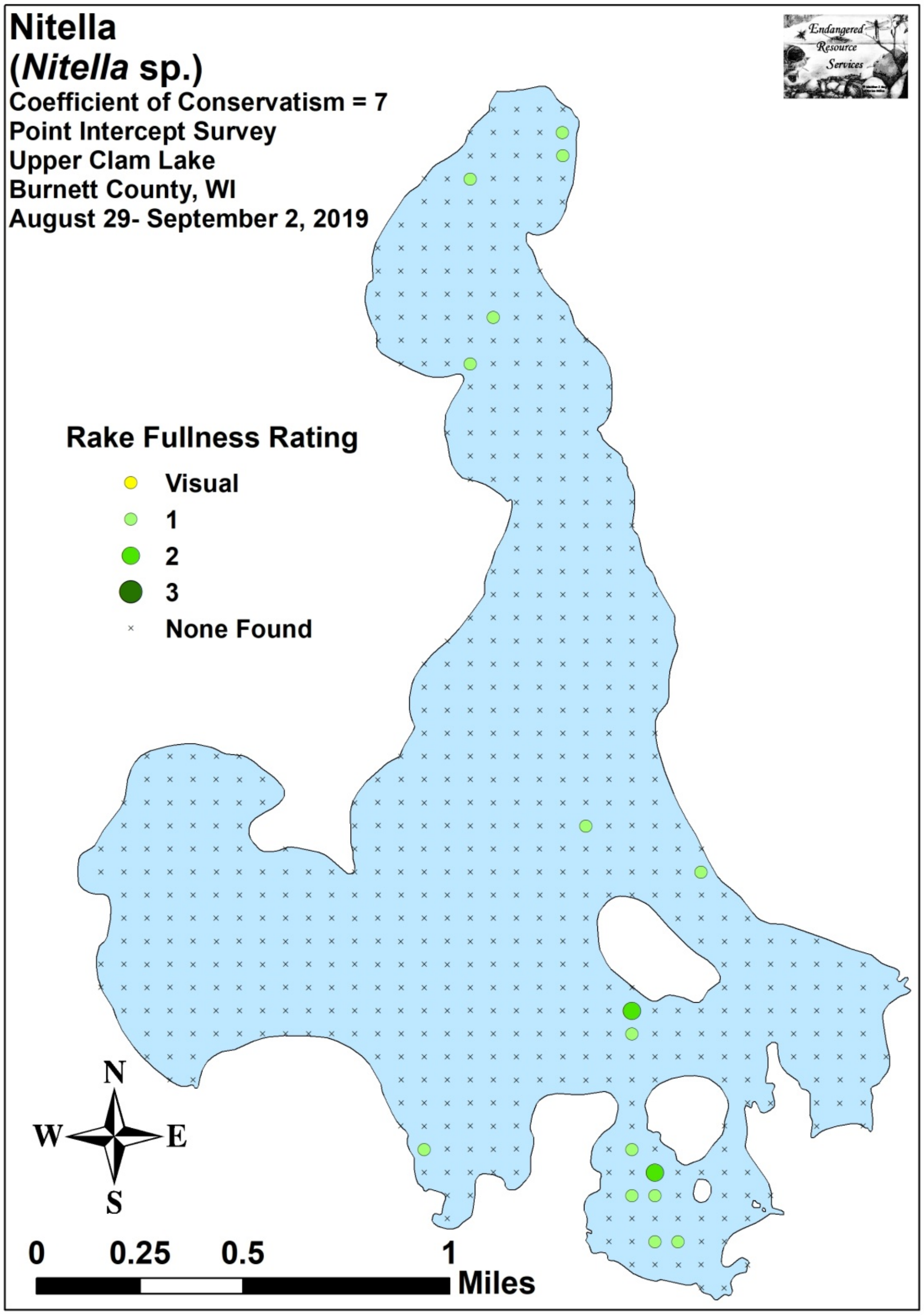
Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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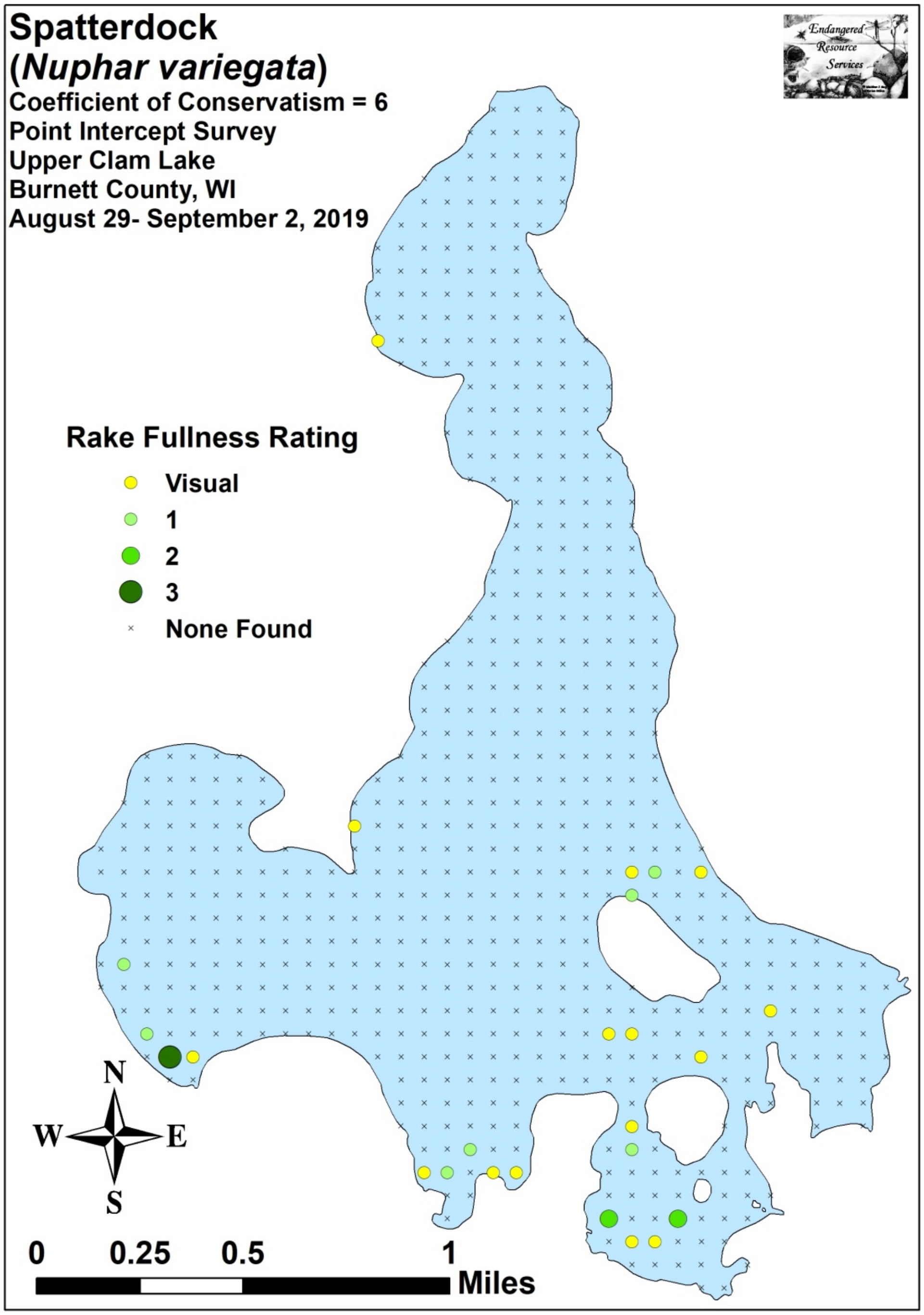
Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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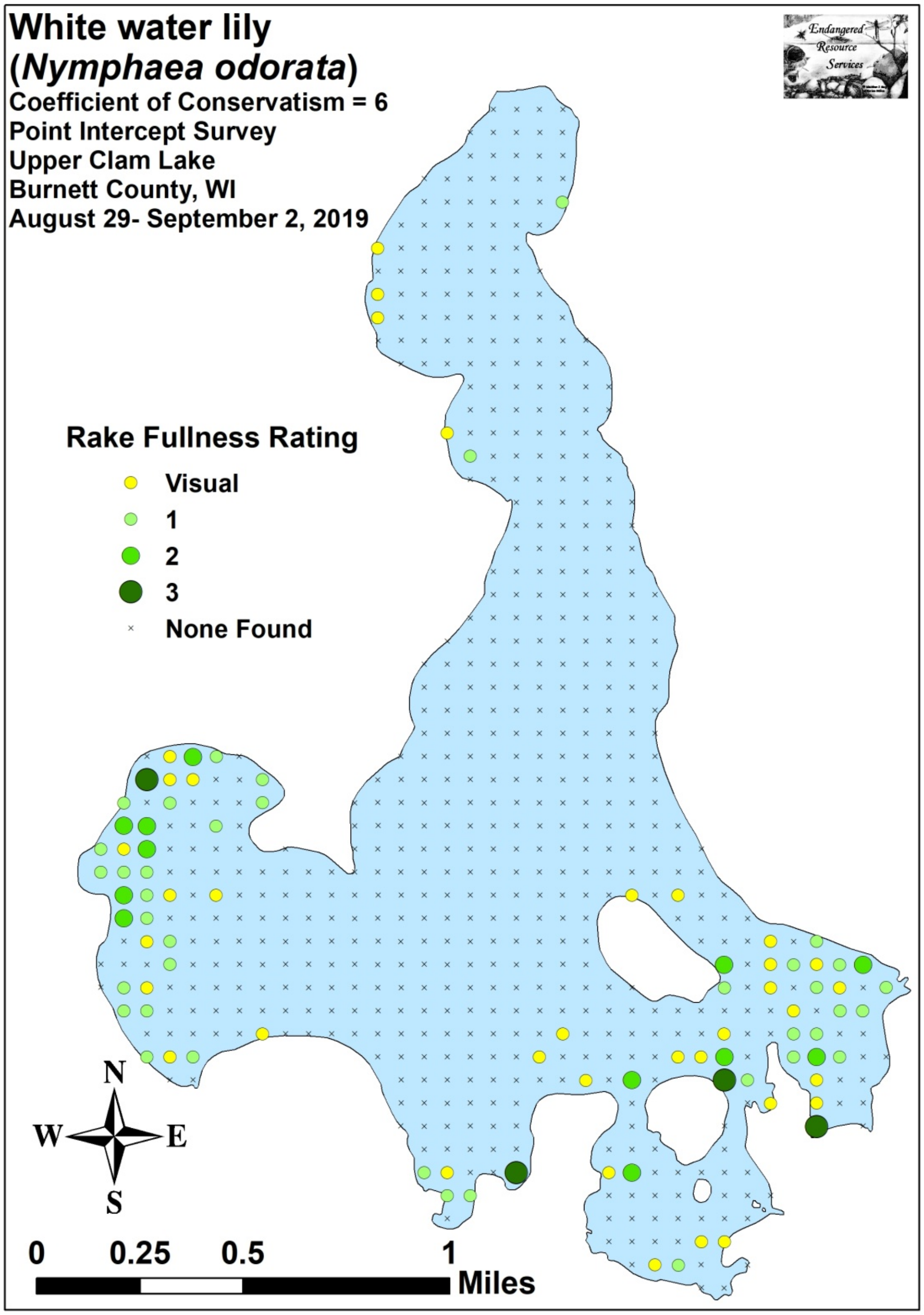
White water lily
(*Nymphaea odorata*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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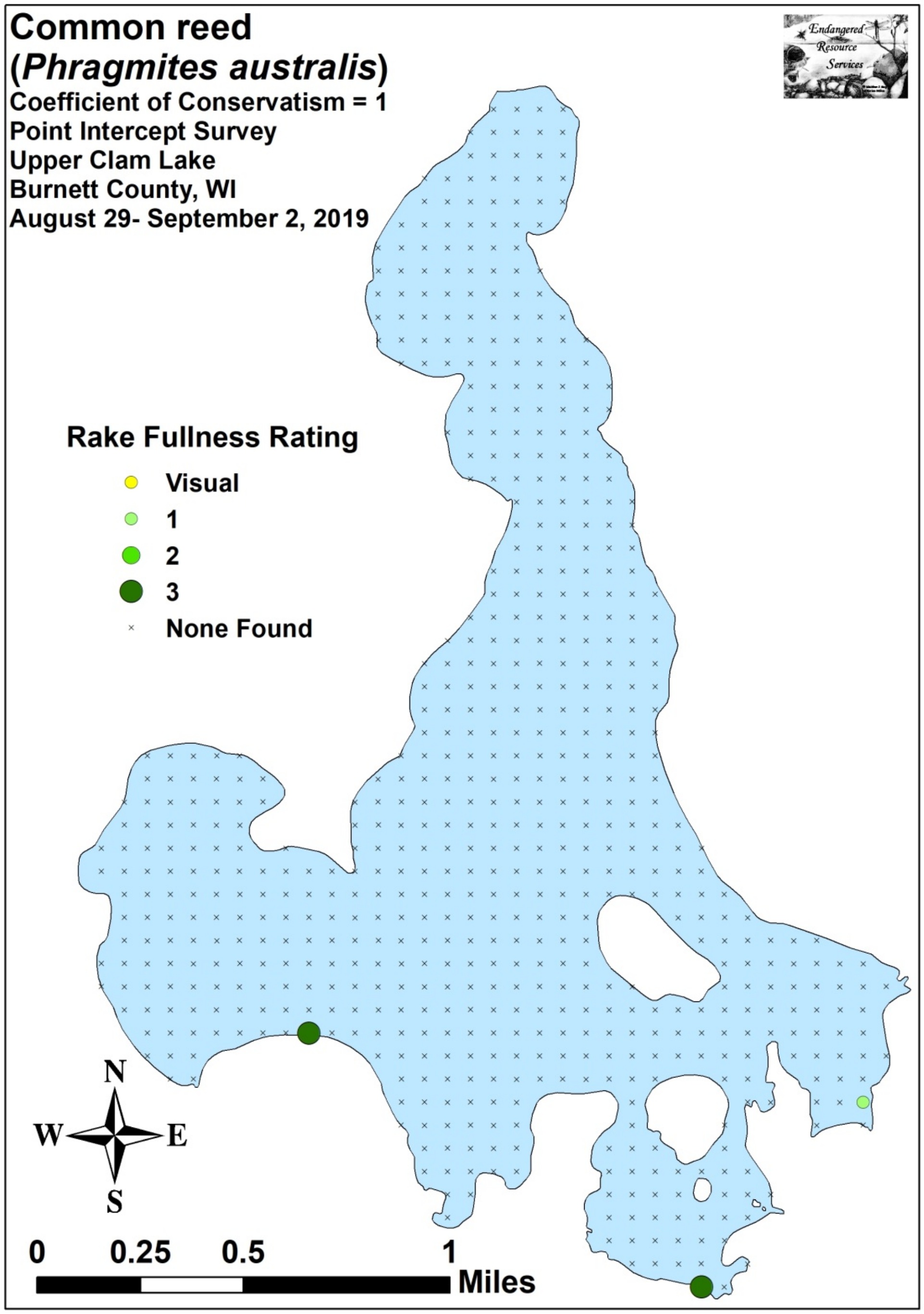
Miles


Common reed
(Phragmites australis)
Coefficient of Conservatism = 1
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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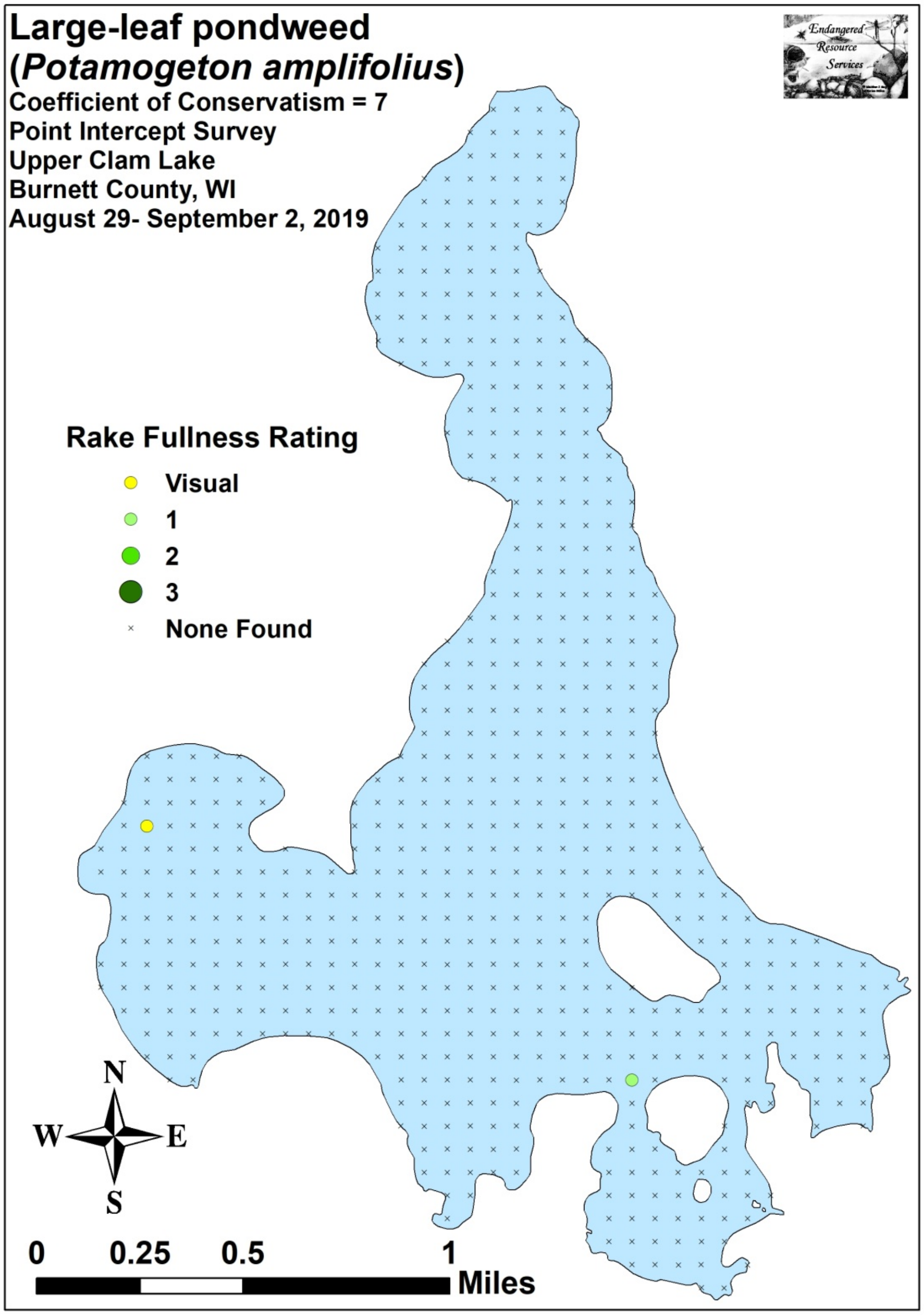
Miles


Large-leaf pondweed
(*Potamogeton amplifolius*)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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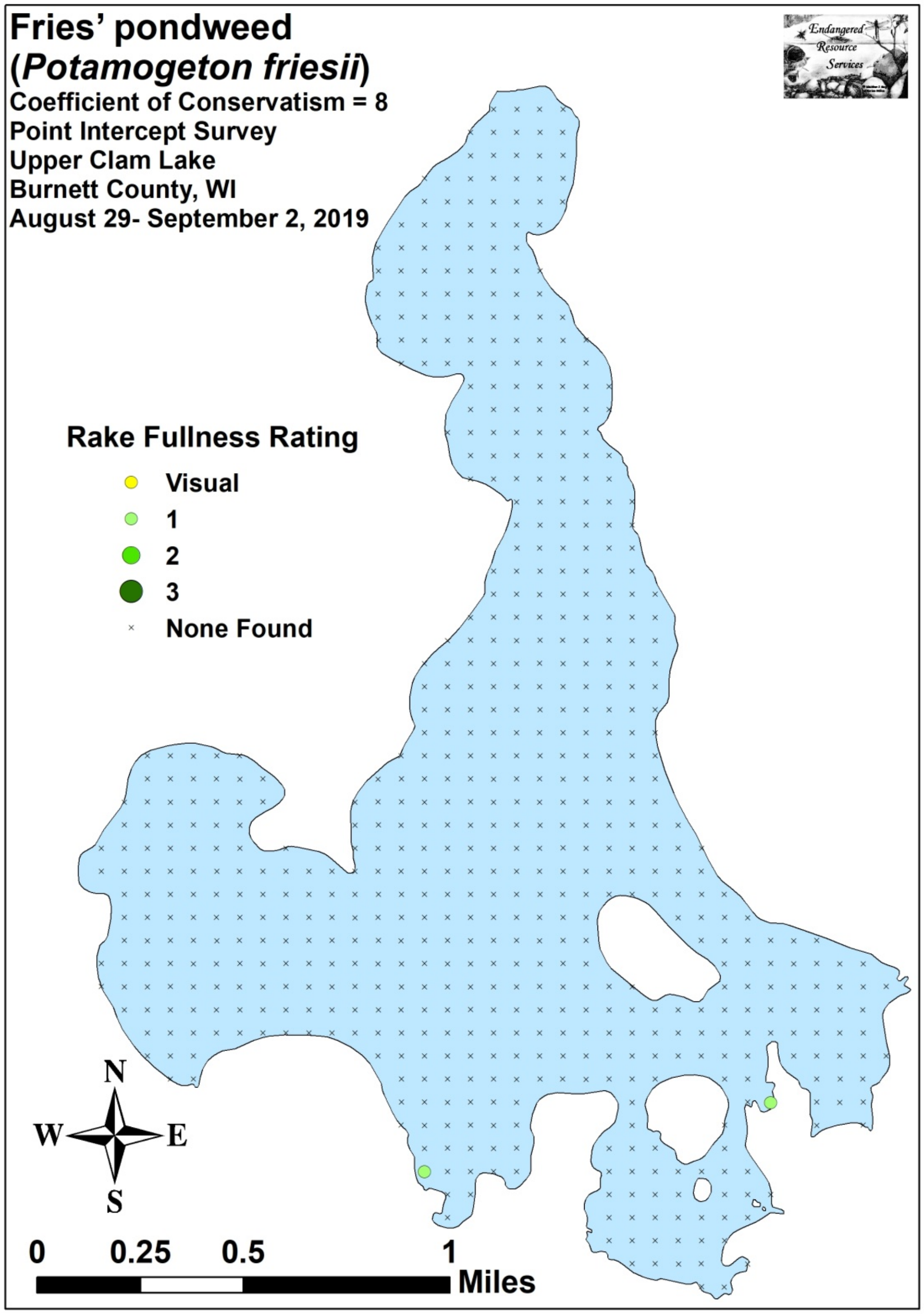
Fries' pondweed
(*Potamogeton friesii*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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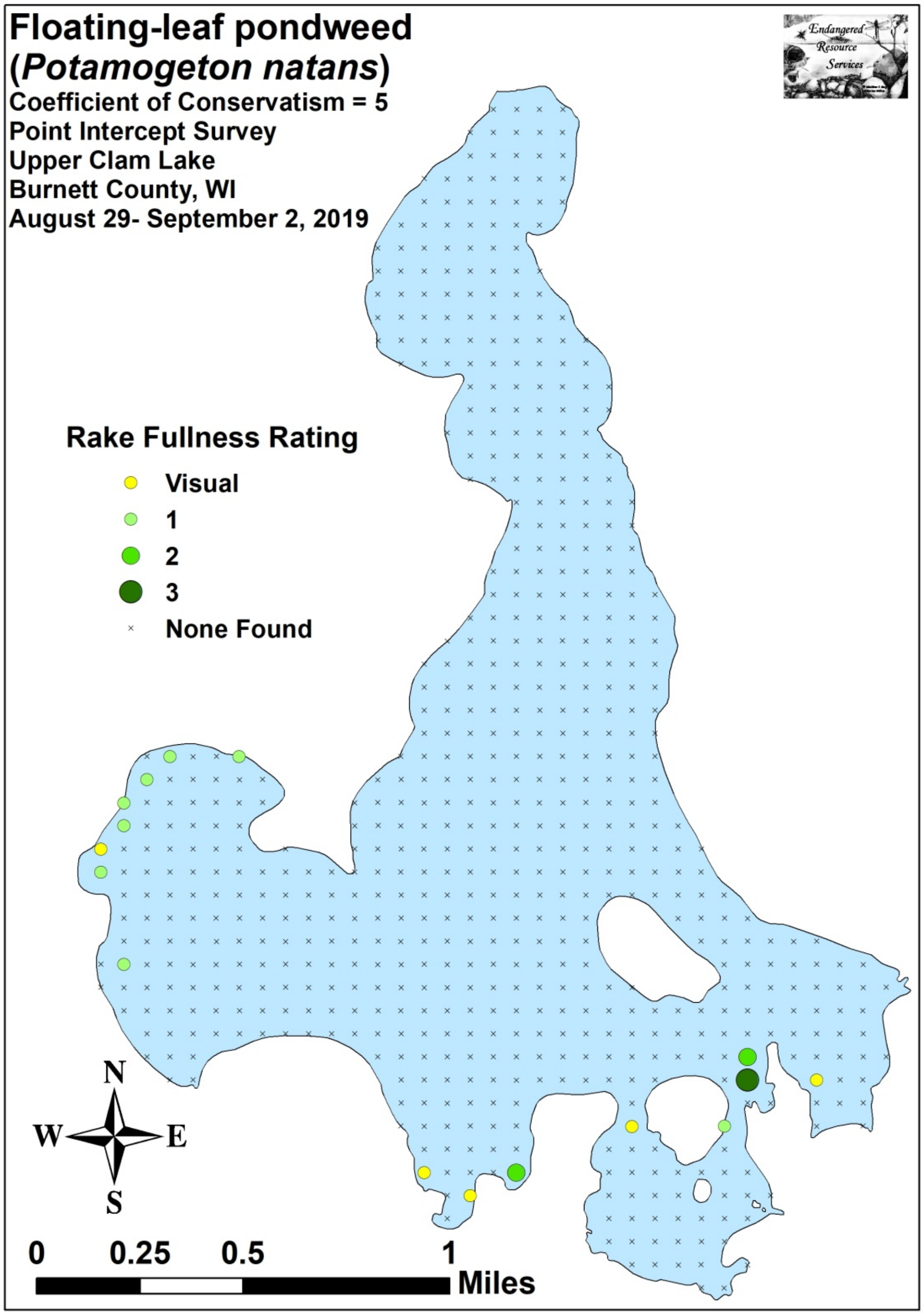
Miles


Floating-leaf pondweed
(*Potamogeton natans*)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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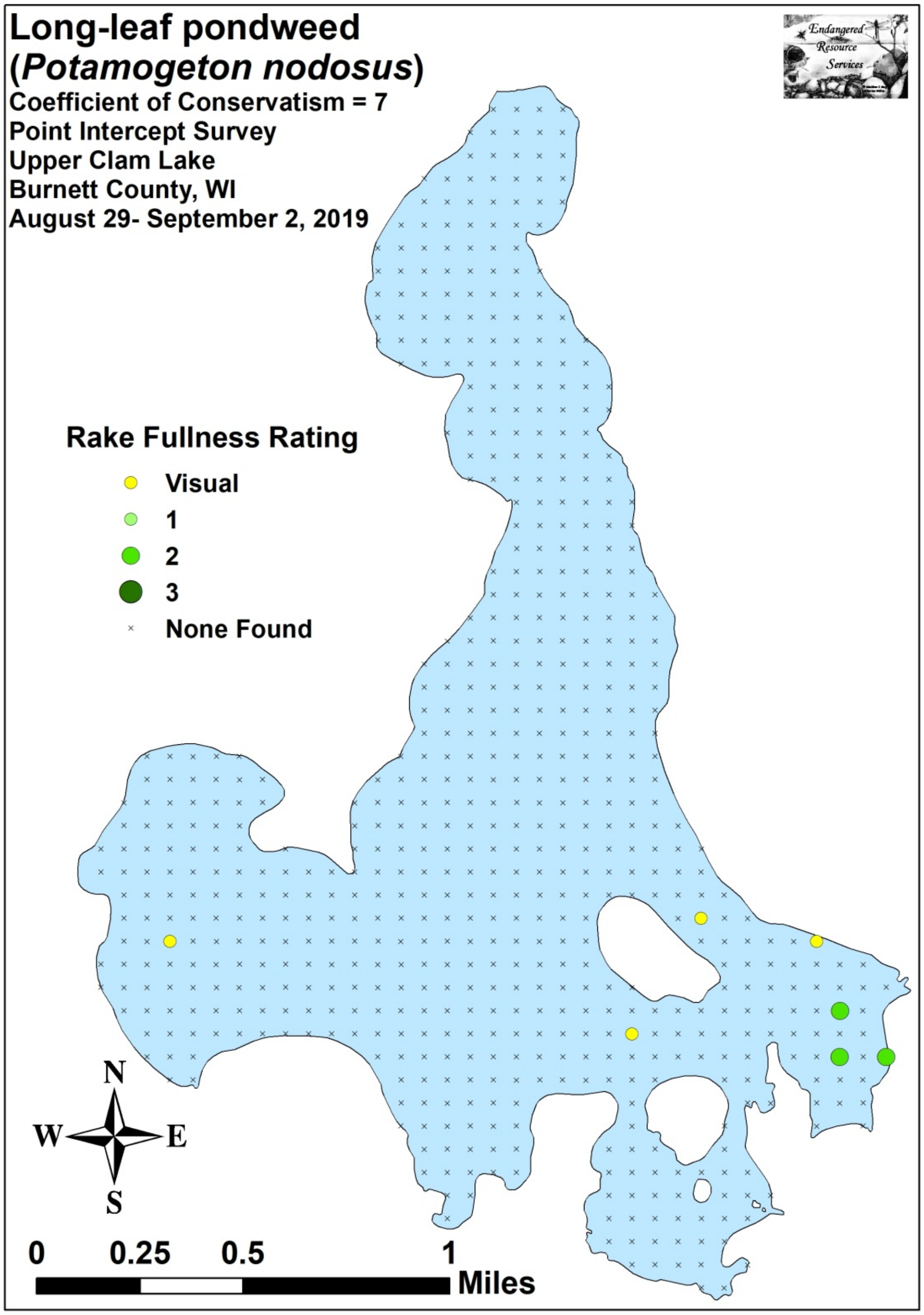
Long-leaf pondweed
(*Potamogeton nodosus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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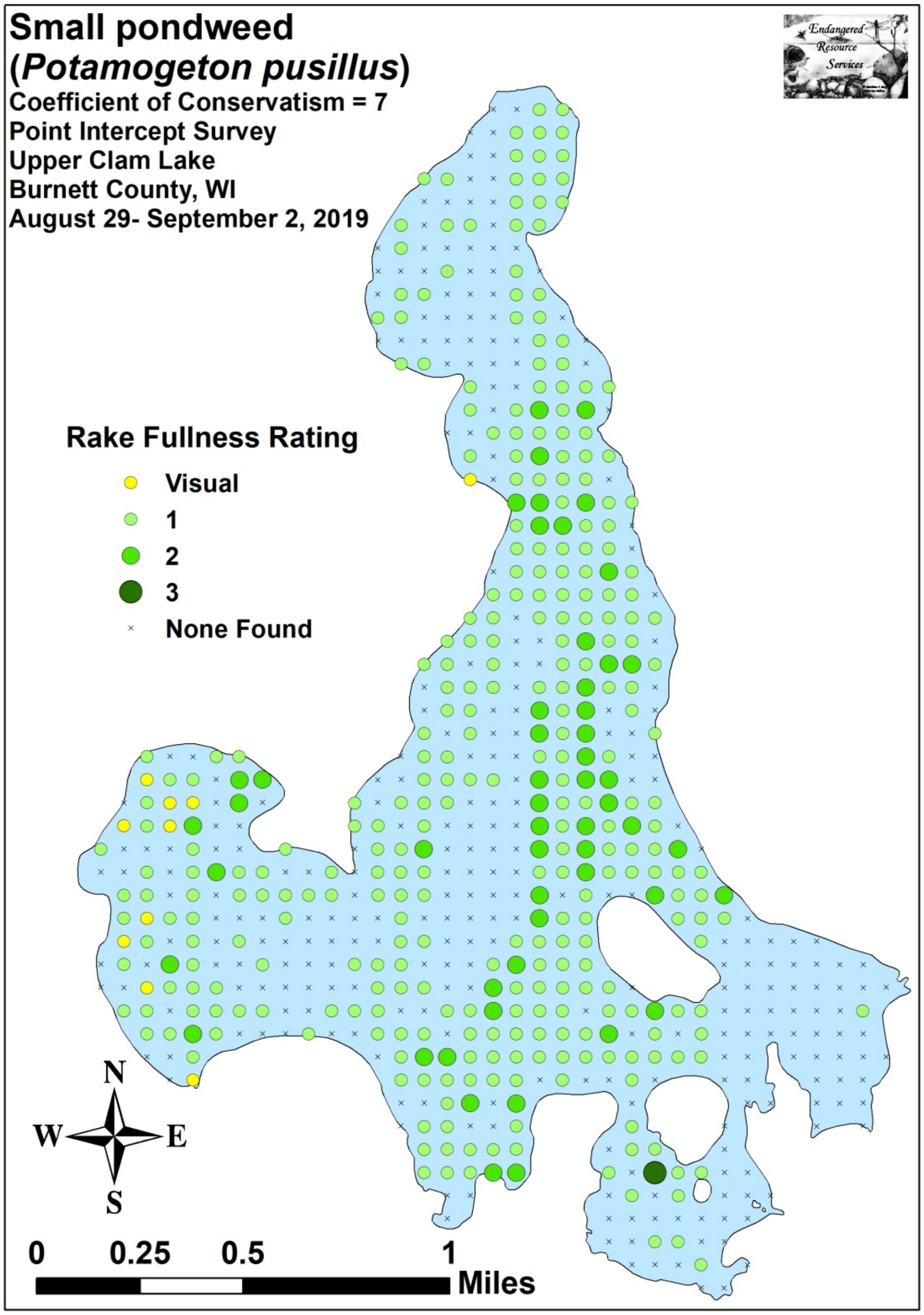
Miles


Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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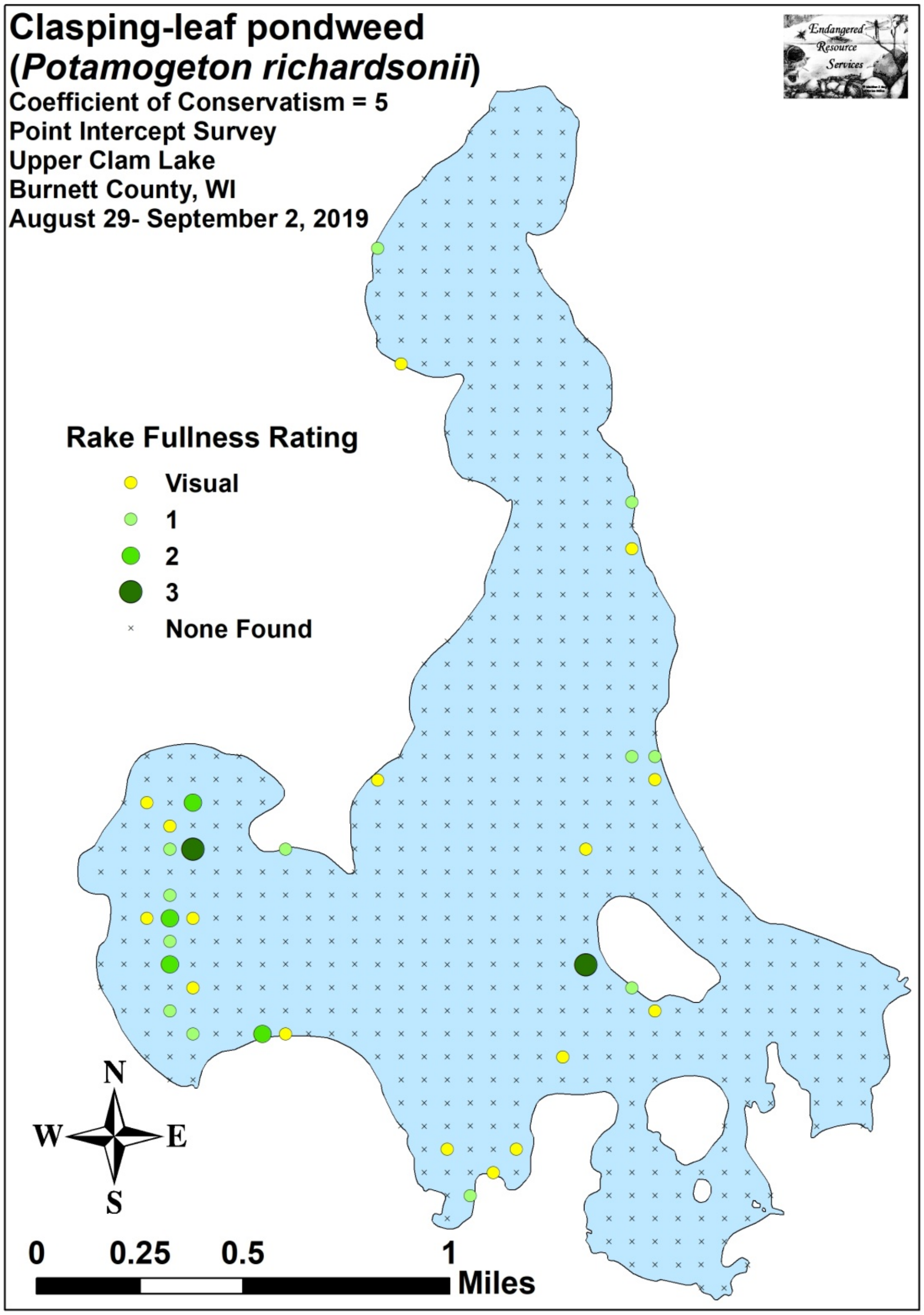
Miles


Clasping-leaf pondweed
(*Potamogeton richardsonii*)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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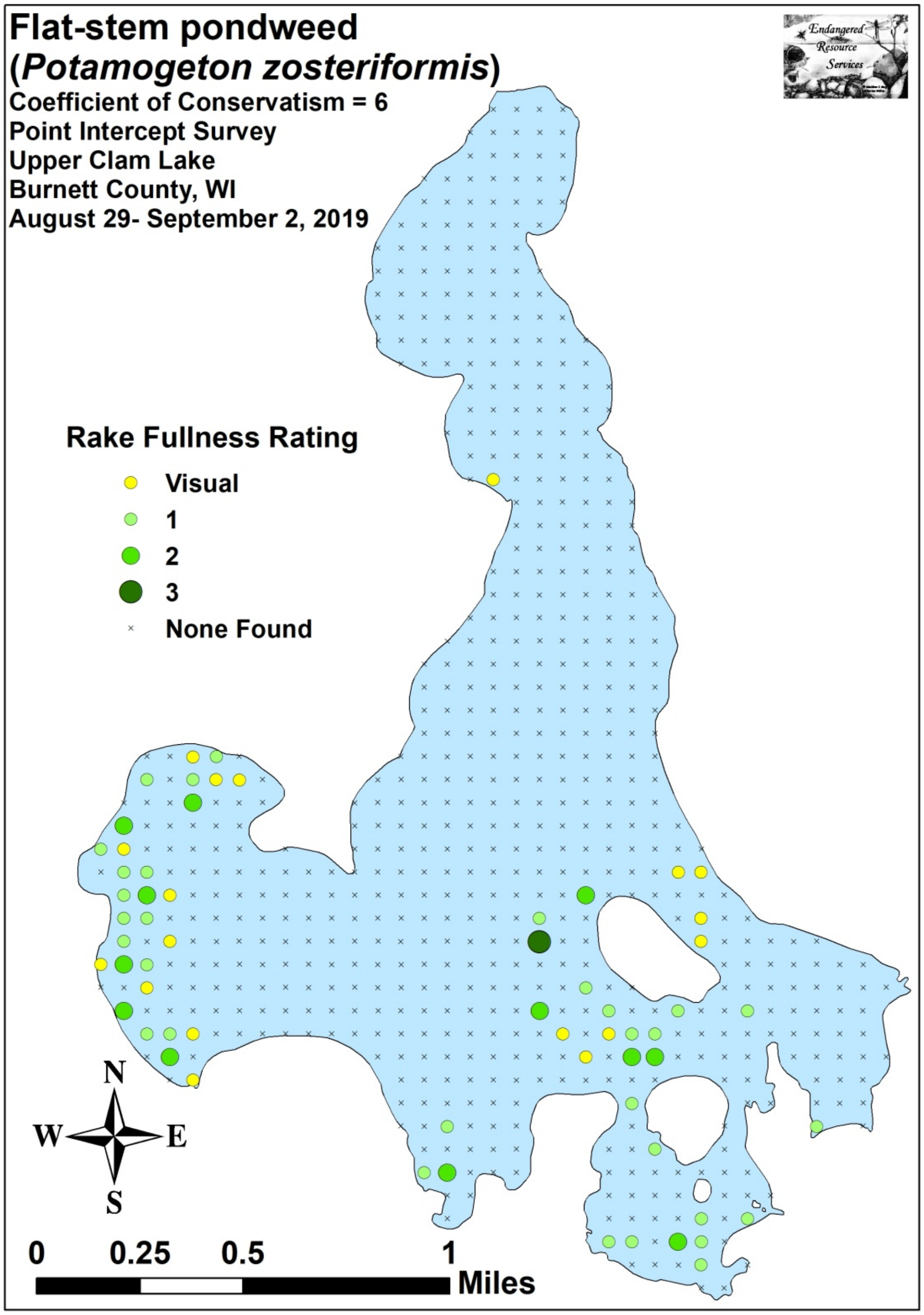
Miles


Flat-stem pondweed
(Potamogeton zosteriformis)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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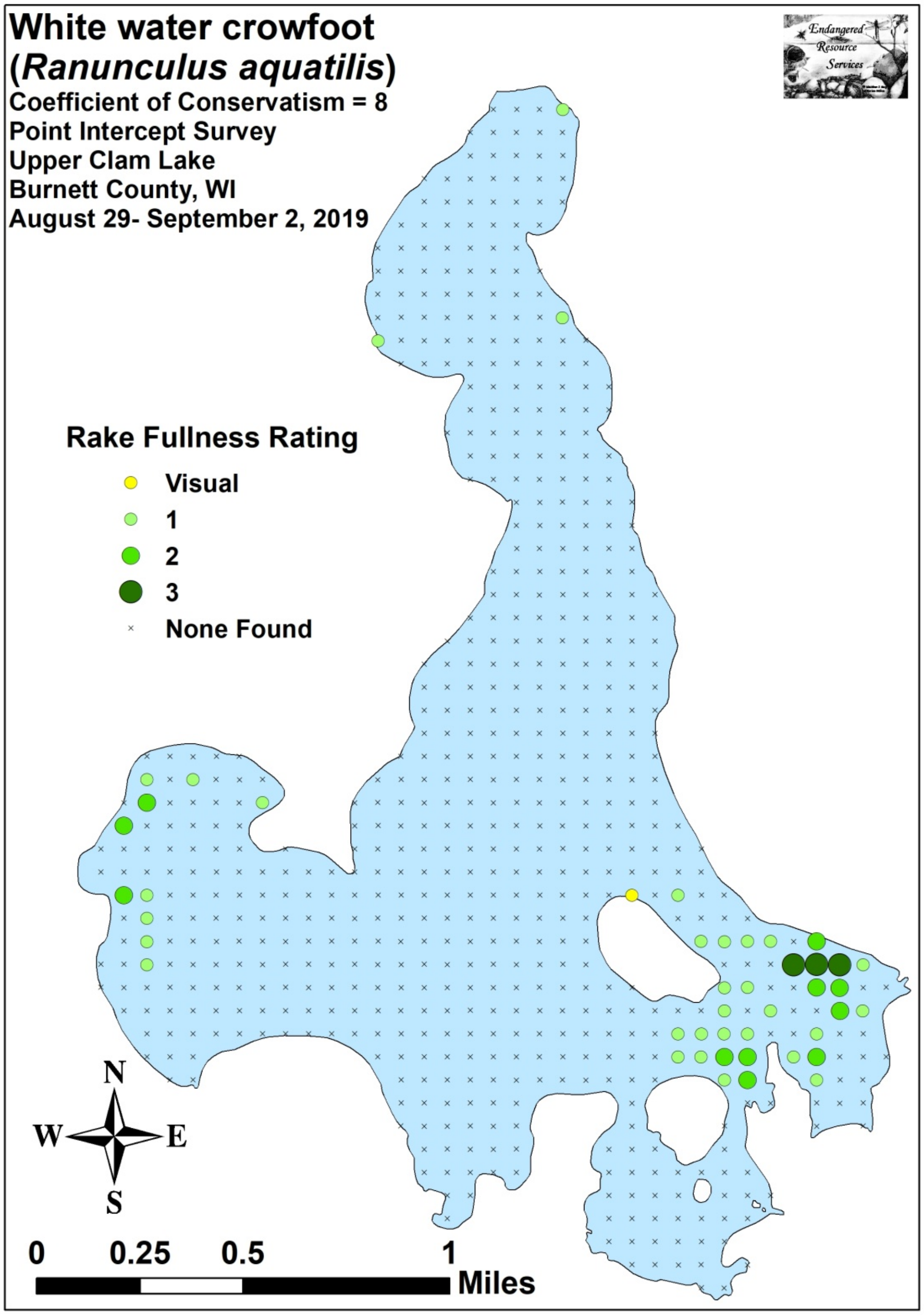
White water crowfoot
(*Ranunculus aquatilis*)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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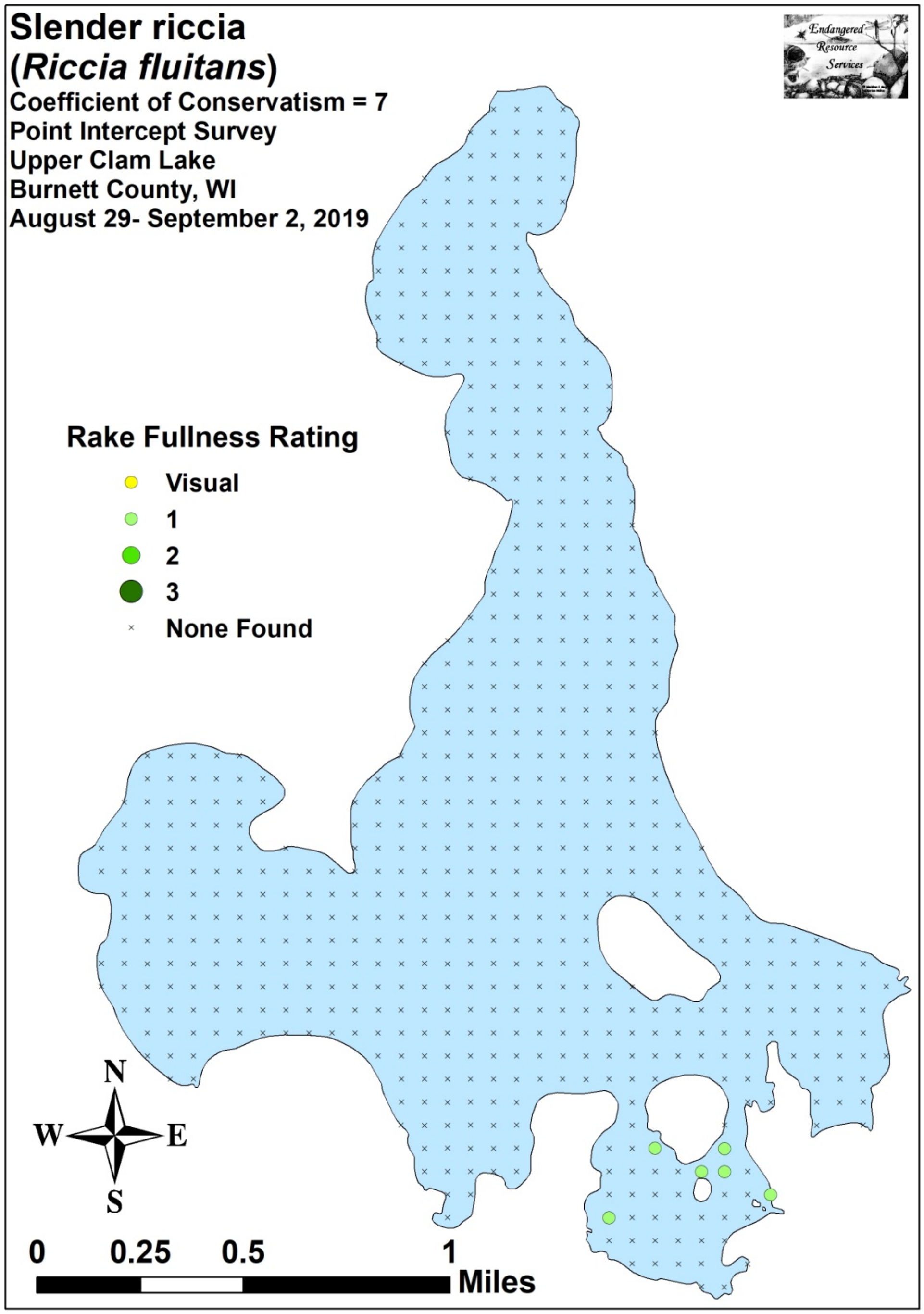
Miles


Slender riccia
(*Riccia fluitans*)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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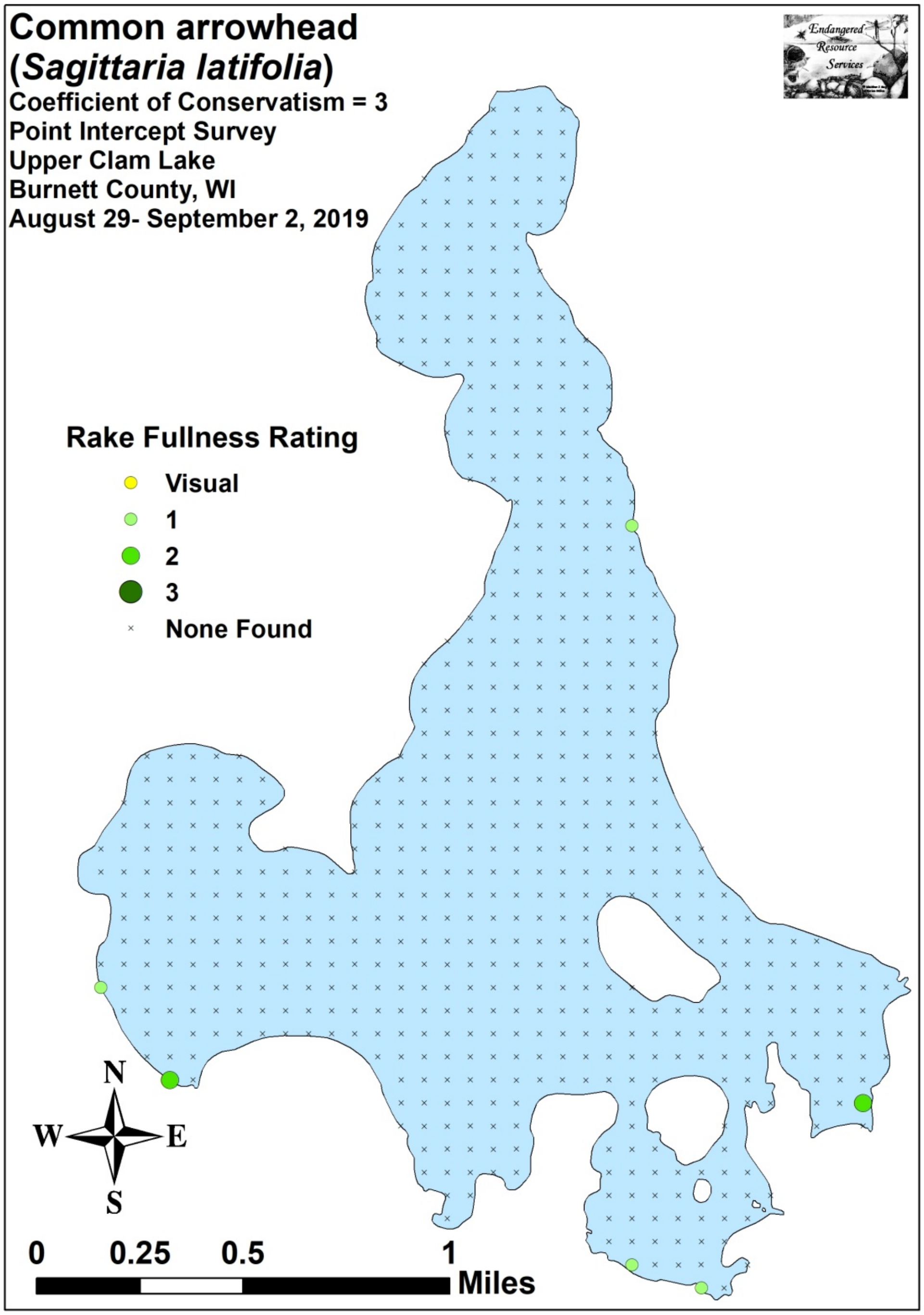
Miles


Common arrowhead
(Sagittaria latifolia)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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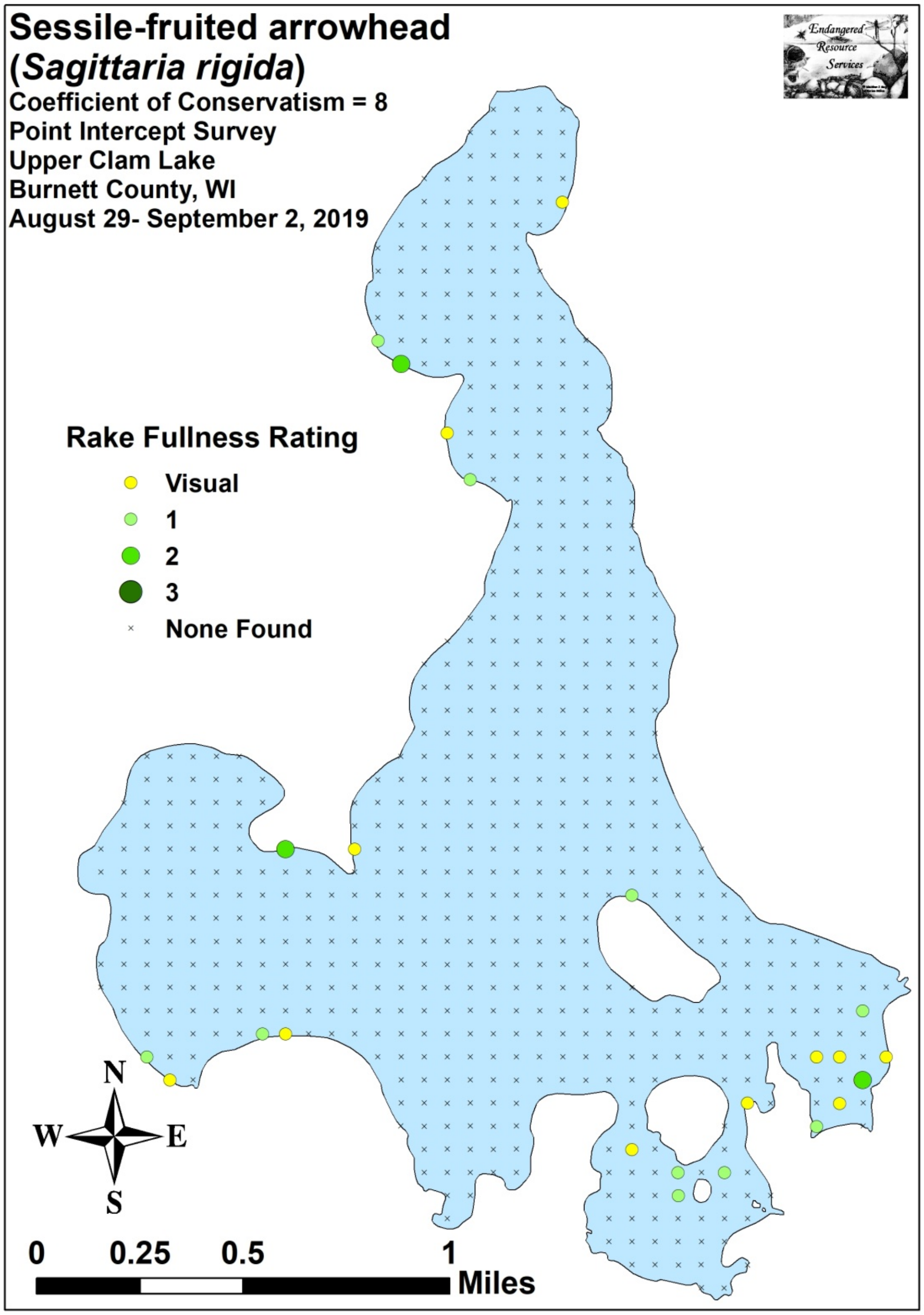
Miles


Sessile-fruited arrowhead
(Sagittaria rigida)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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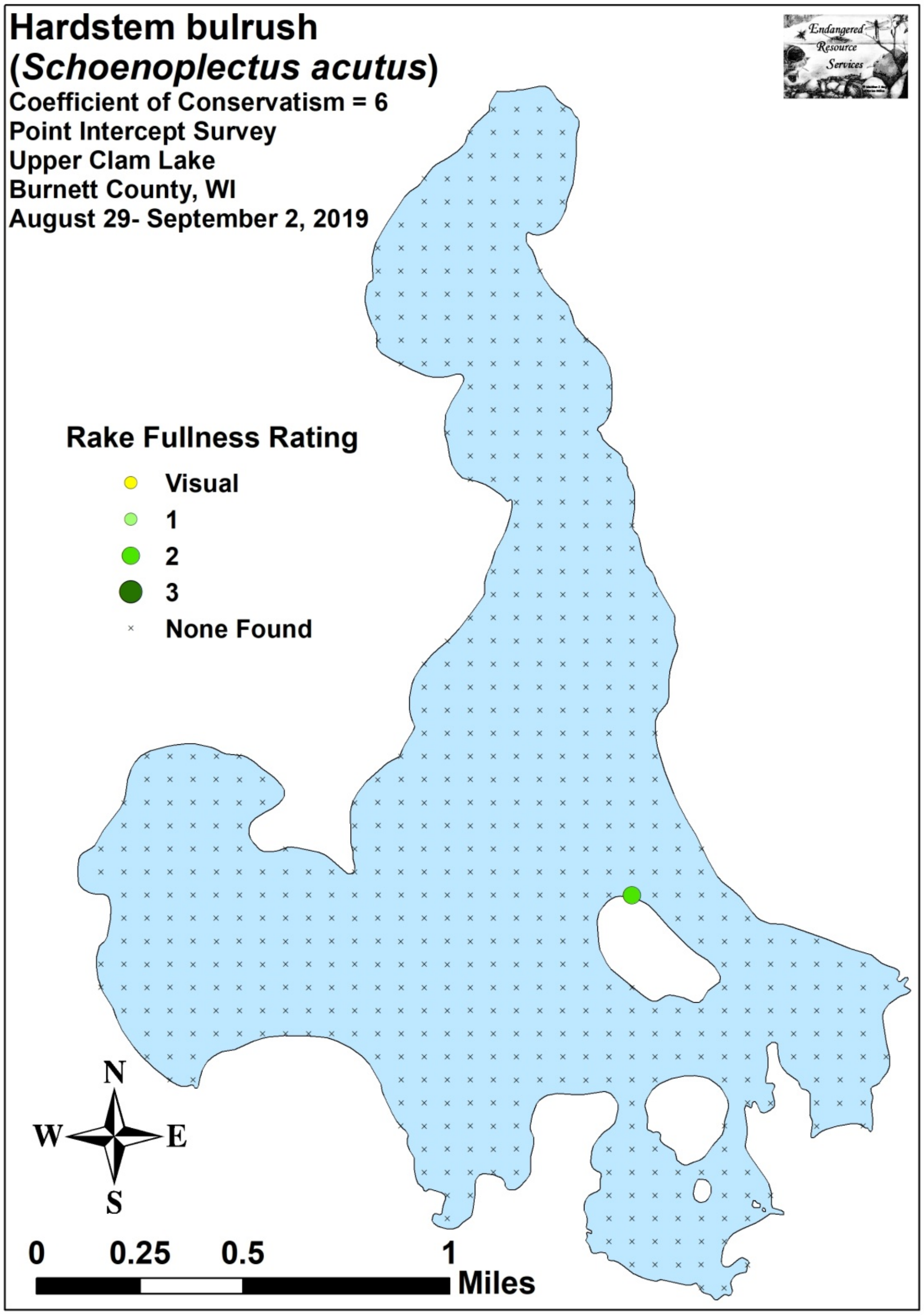
Miles


Hardstem bulrush
(*Schoenoplectus acutus*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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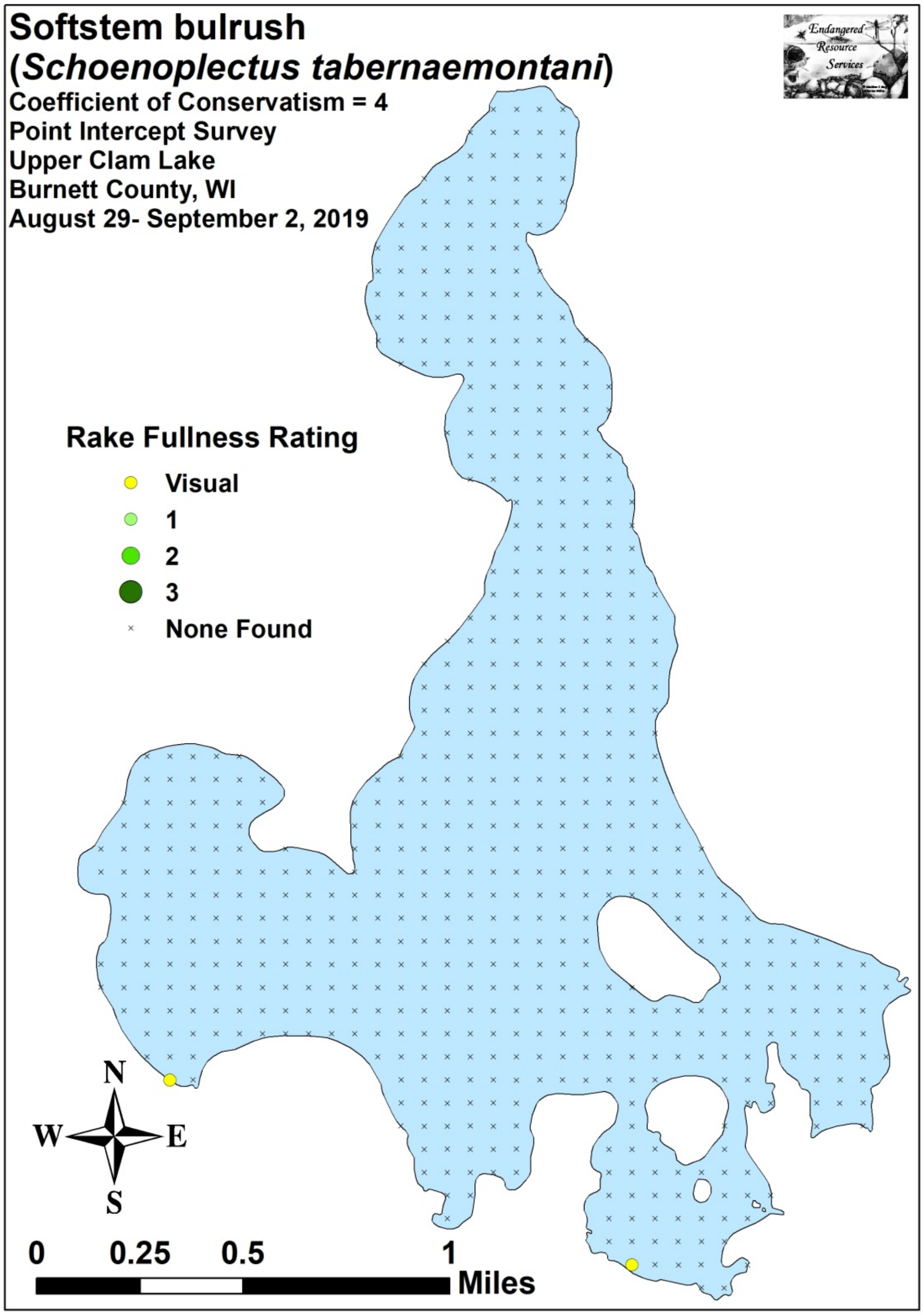
Miles


Softstem bulrush
(Schoenoplectus tabernaemontani)
Coefficient of Conservatism = 4
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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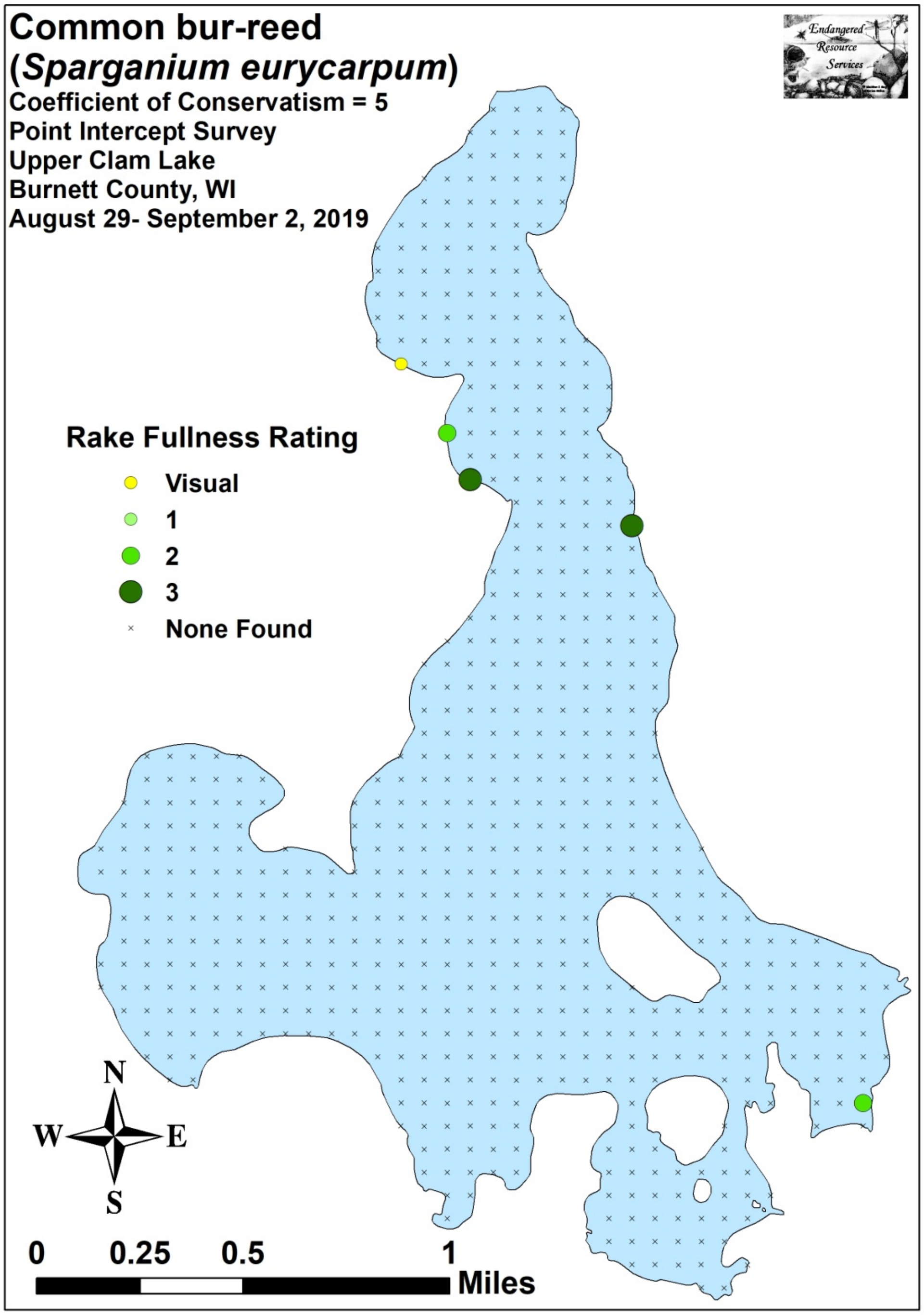
Miles


Common bur-reed
(*Sparganium eurycarpum*)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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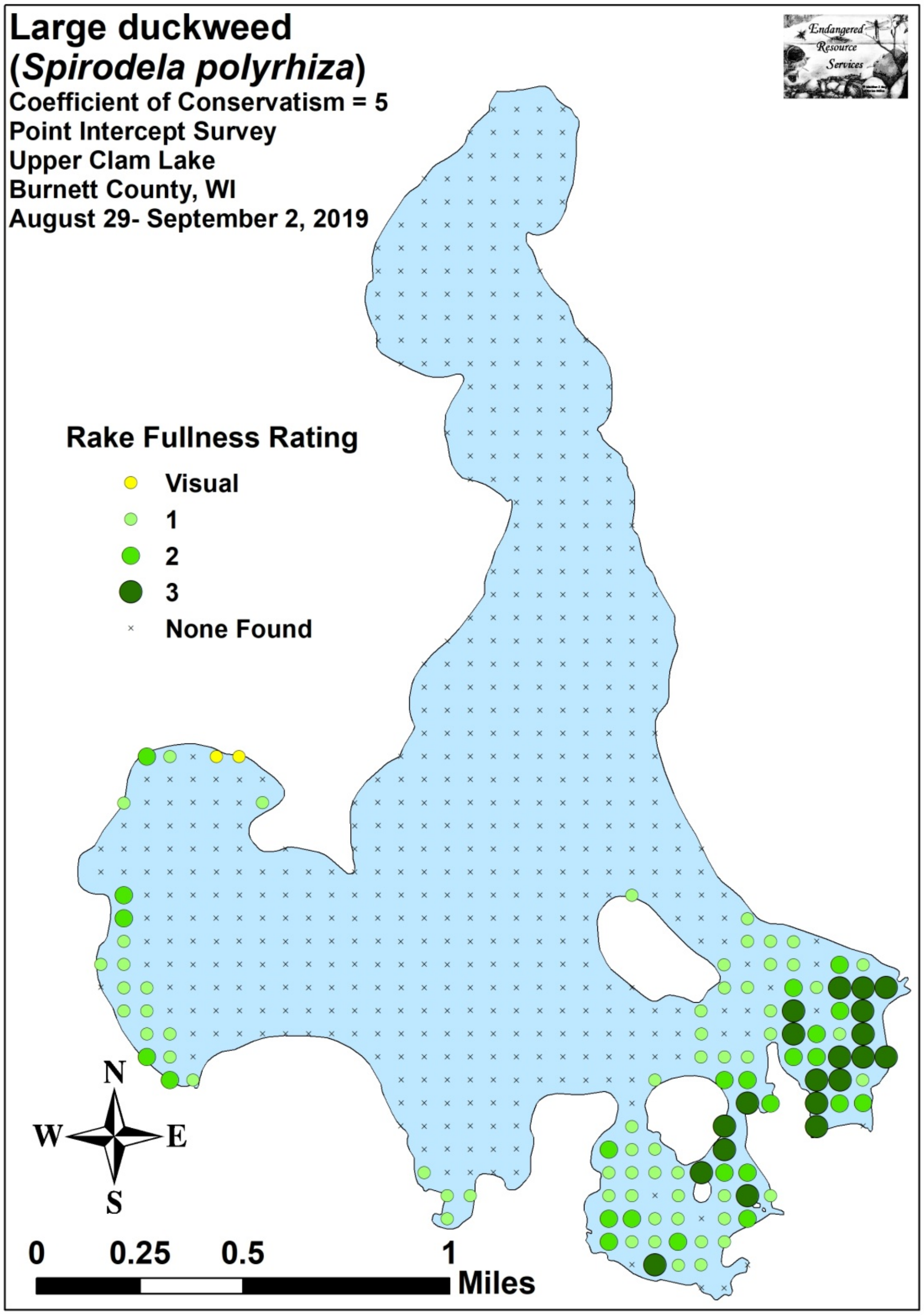
Miles


Large duckweed
(Spirodela polyrhiza)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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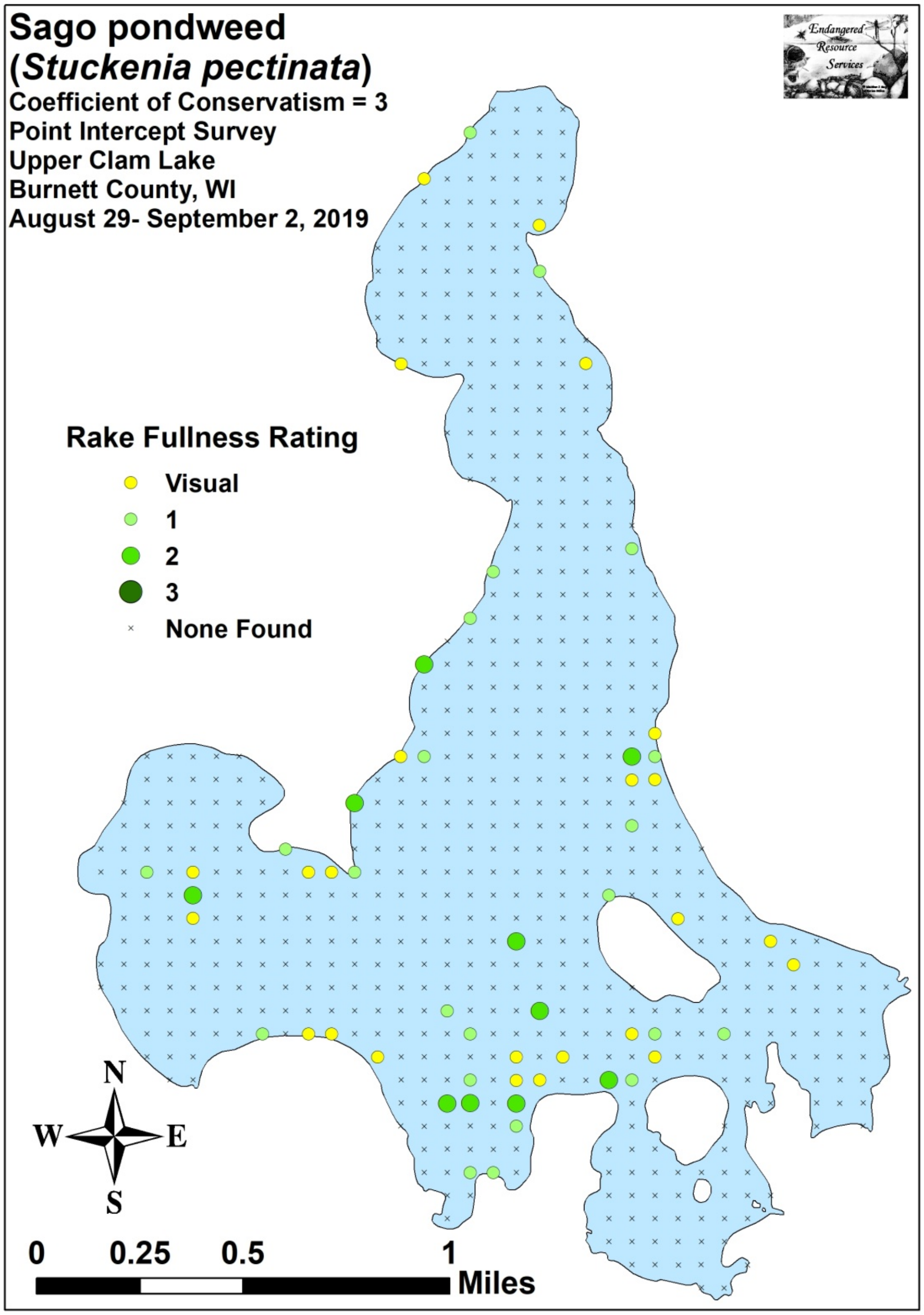

Sago pondweed
(*Stuckenia pectinata*)
Coefficient of Conservatism = 3
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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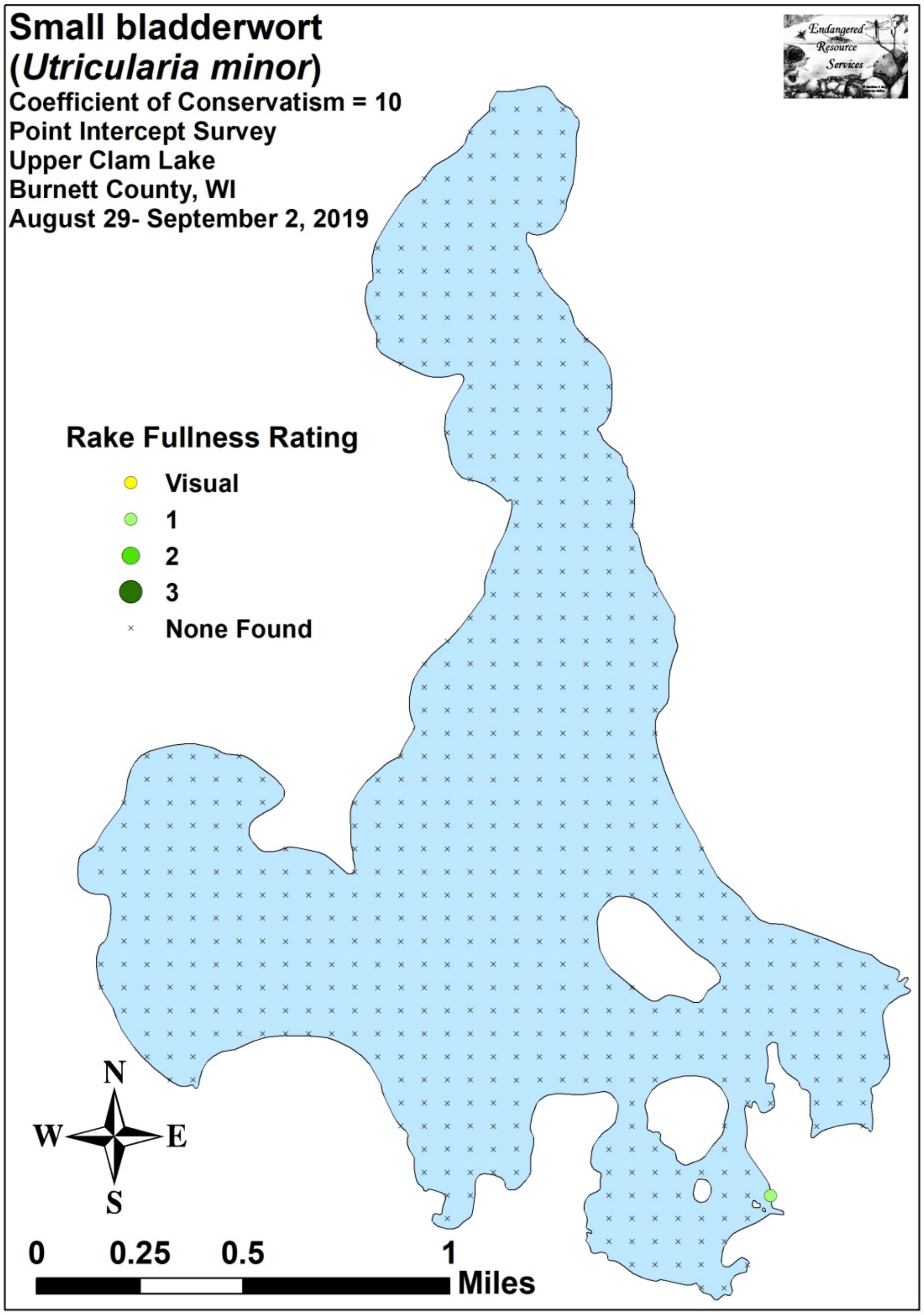
Miles


Small bladderwort
(*Utricularia minor*)
Coefficient of Conservatism = 10
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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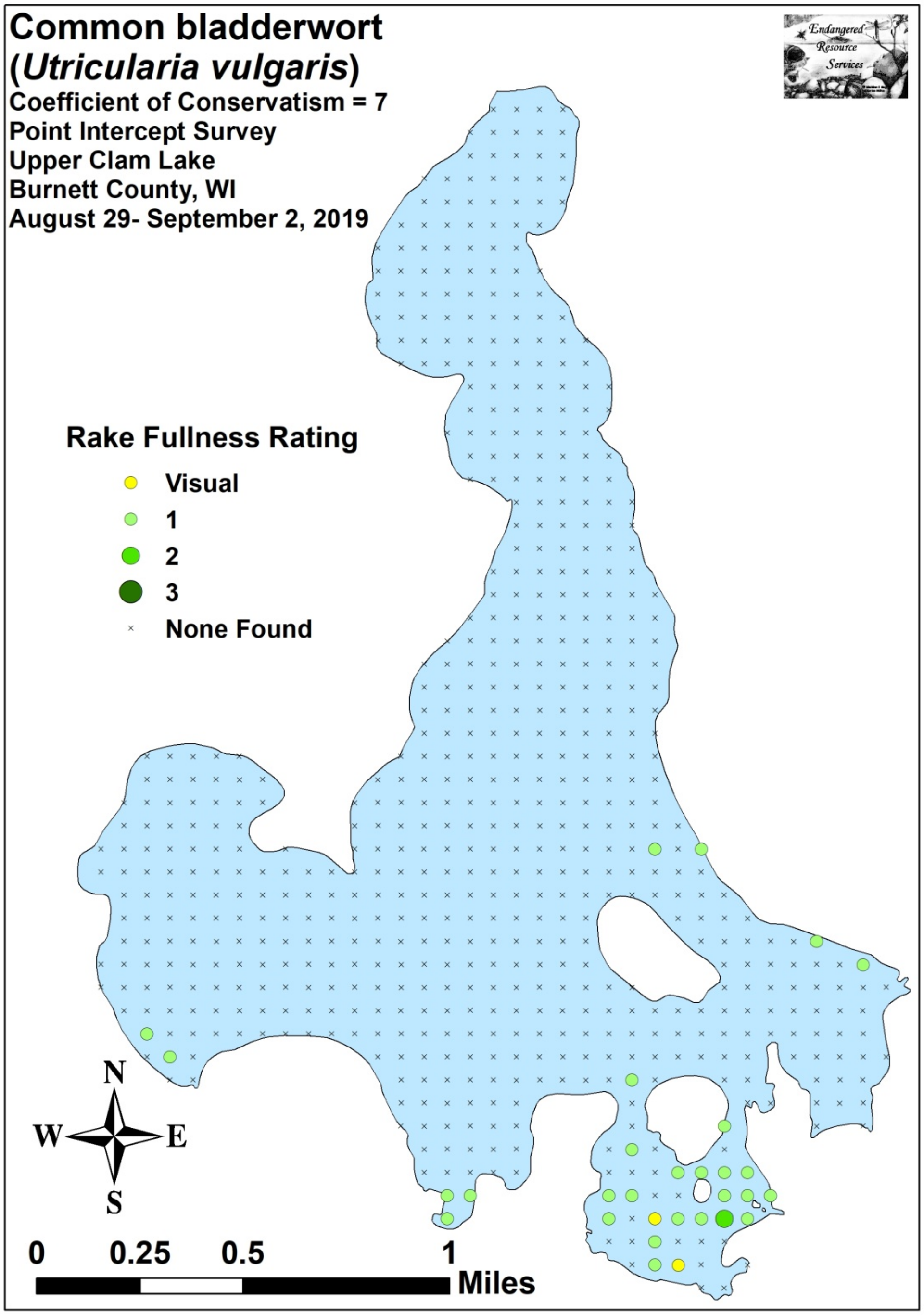
Miles


Common bladderwort
(*Utricularia vulgaris*)
Coefficient of Conservatism = 7
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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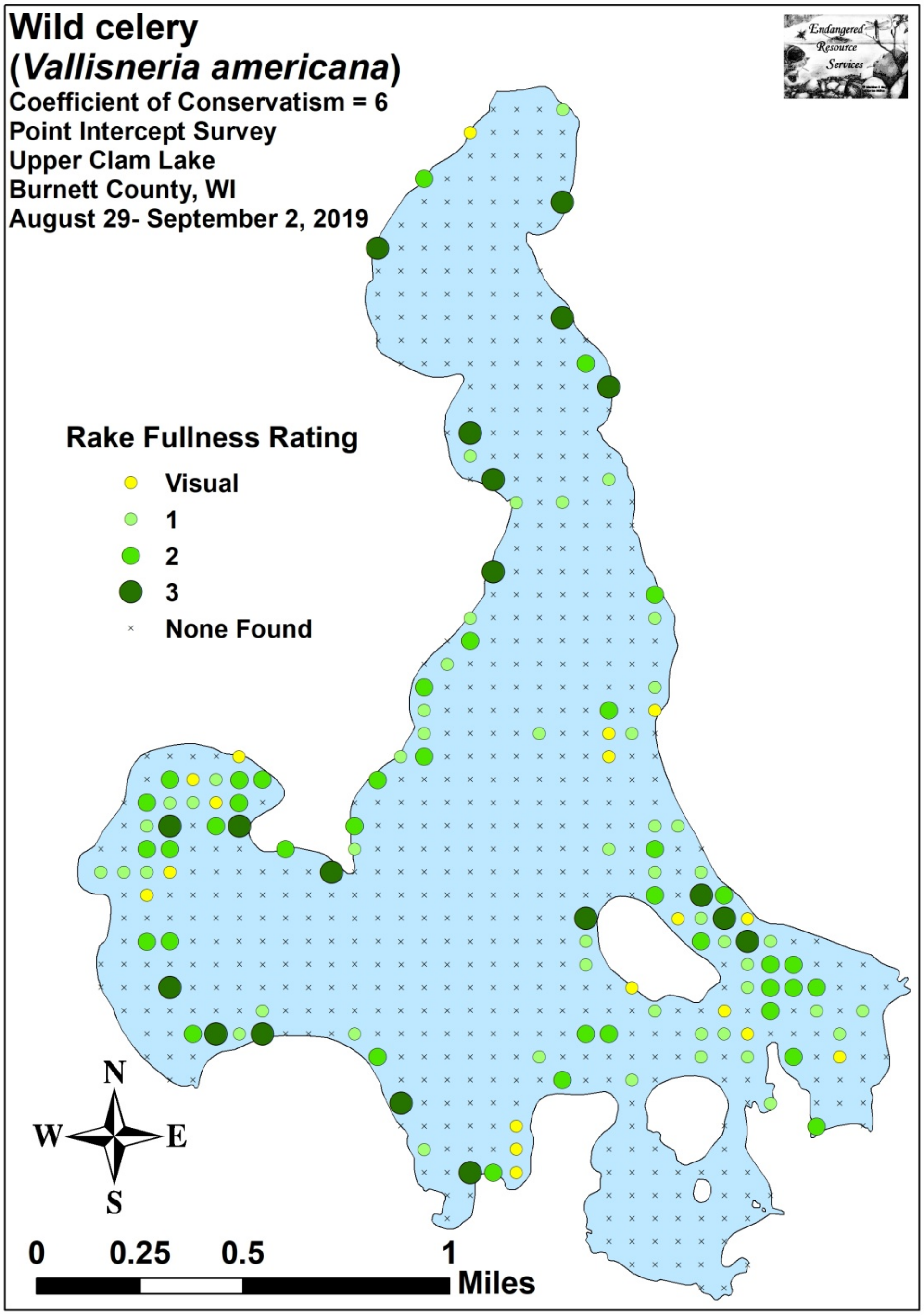
Miles



Wild celery
(*Vallisneria americana*)
Coefficient of Conservatism = 6
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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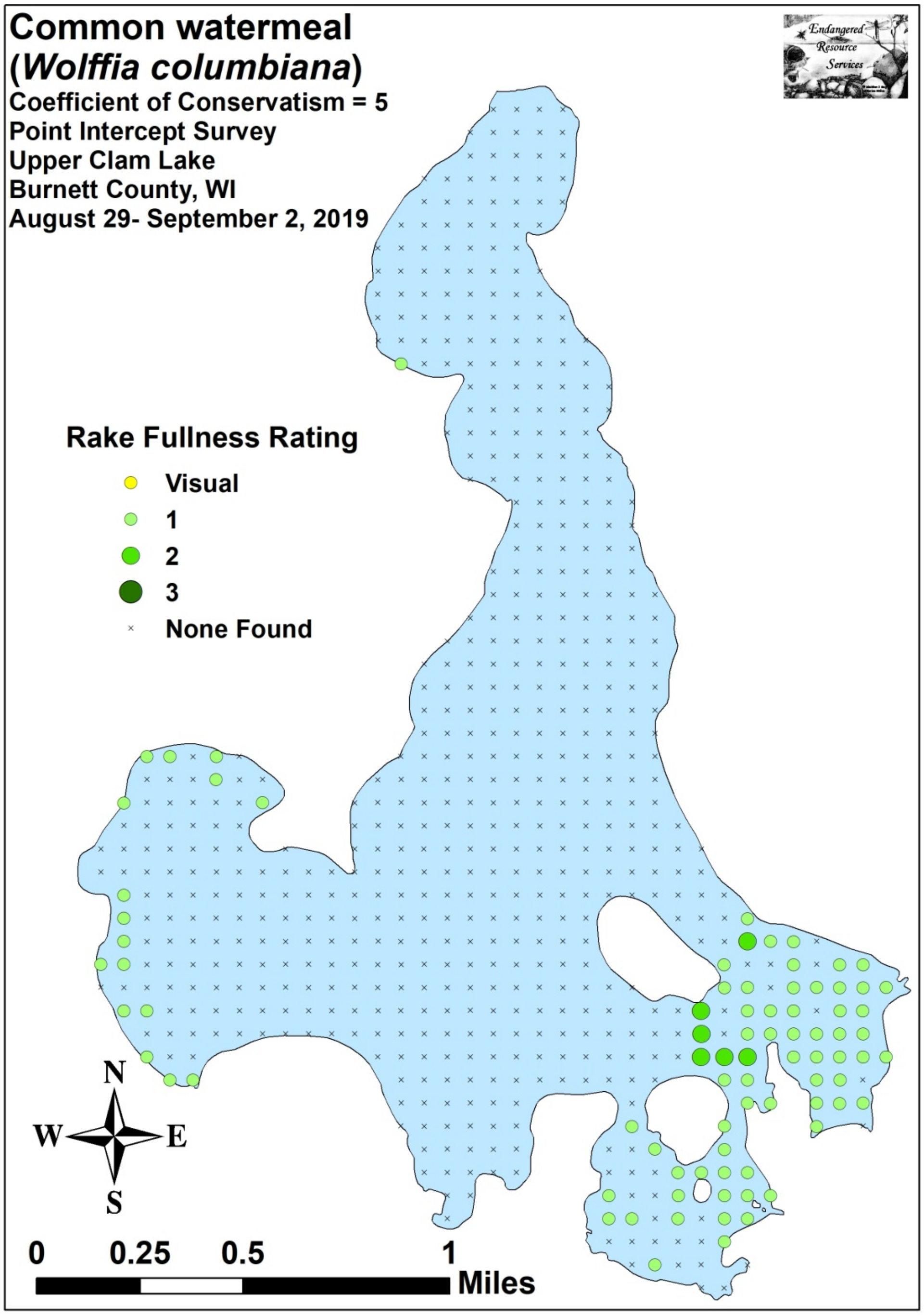
Common watermeal
(Wolffia columbiana)
Coefficient of Conservatism = 5
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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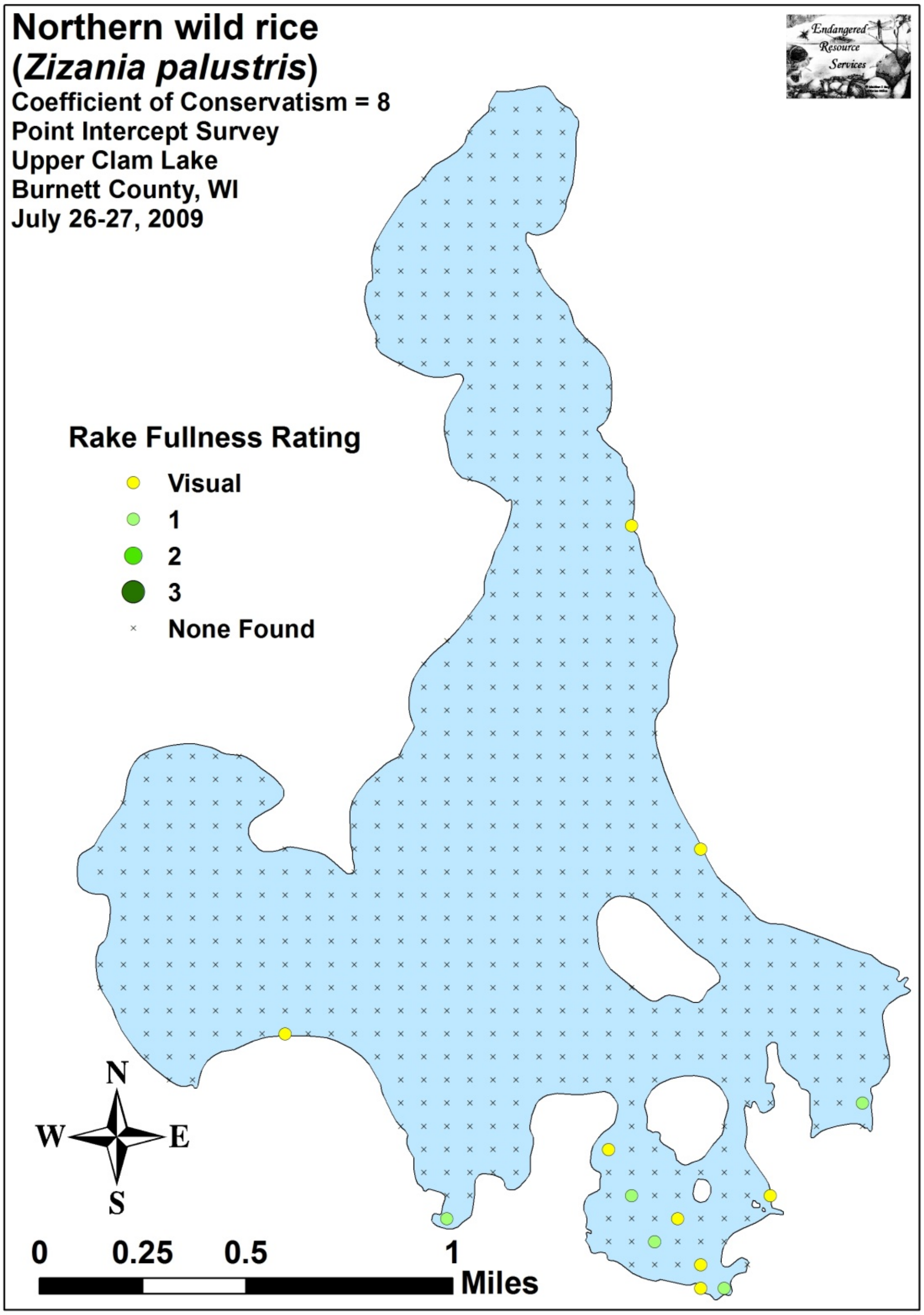
1
Miles

# Appendix VII: 2009, 2012, 2014, 2015, 2016, and 2019 Northern Wild Rice Density and Distribution Maps



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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None Found
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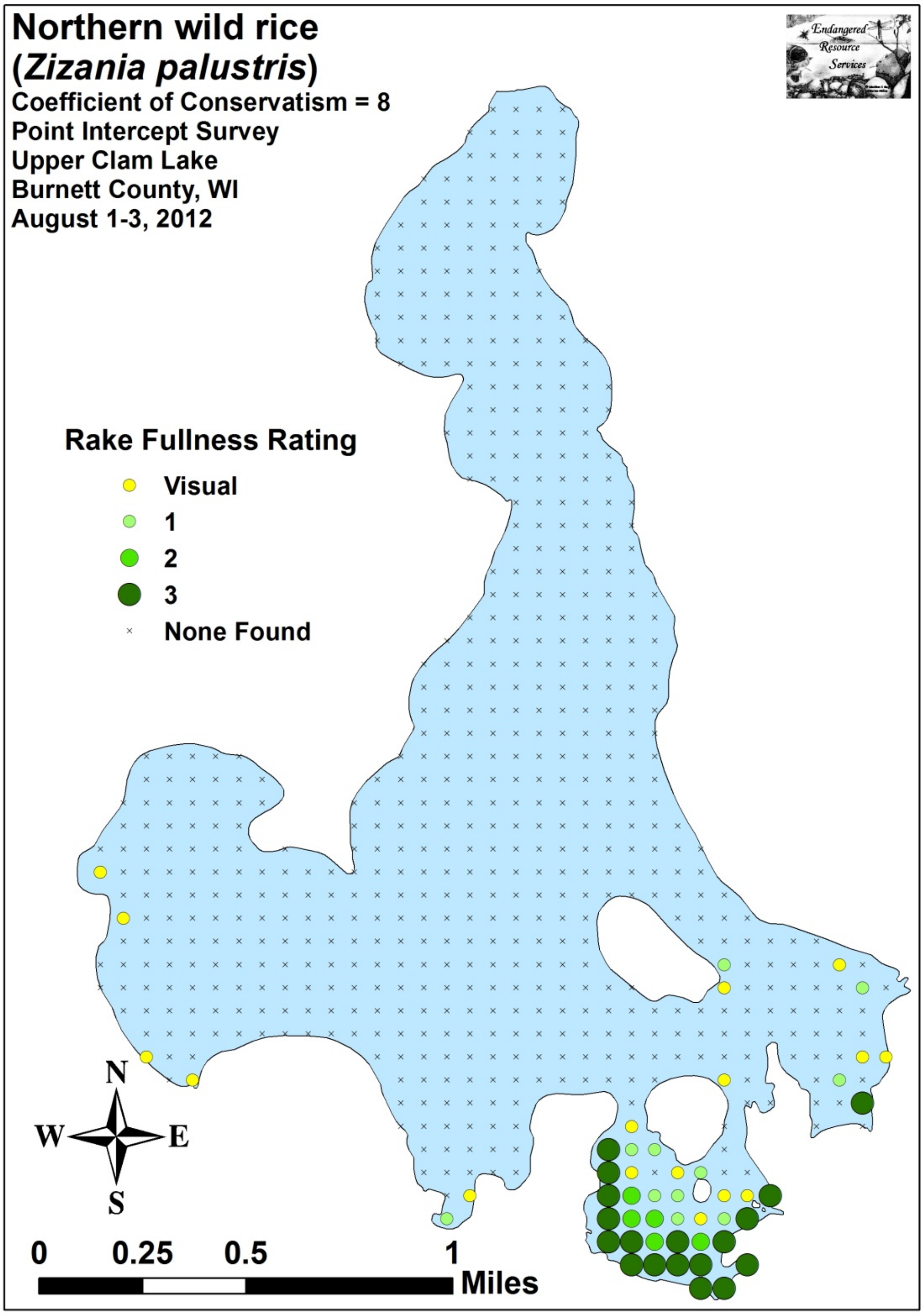
Miles


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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None Found
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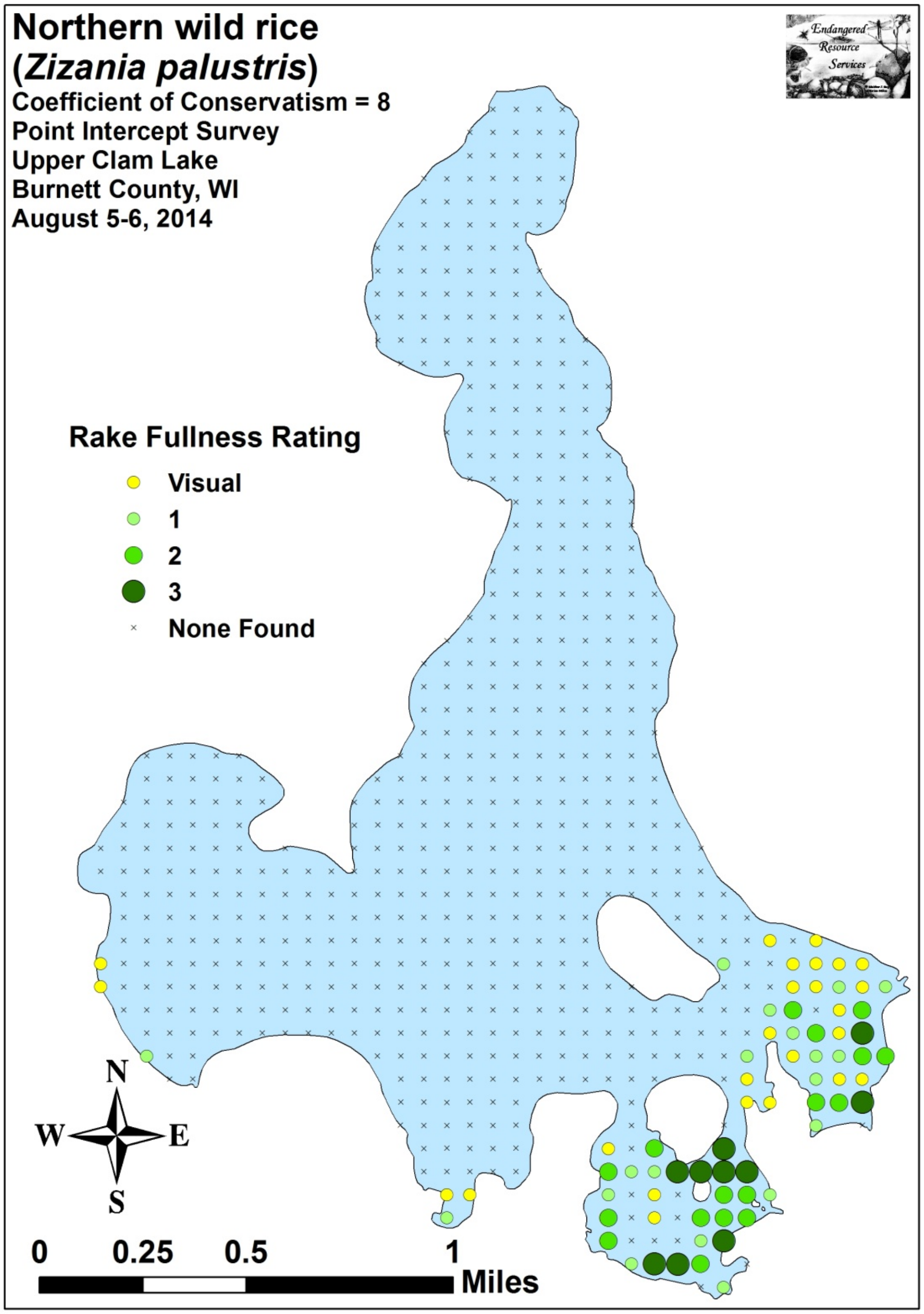
Miles


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
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None Found
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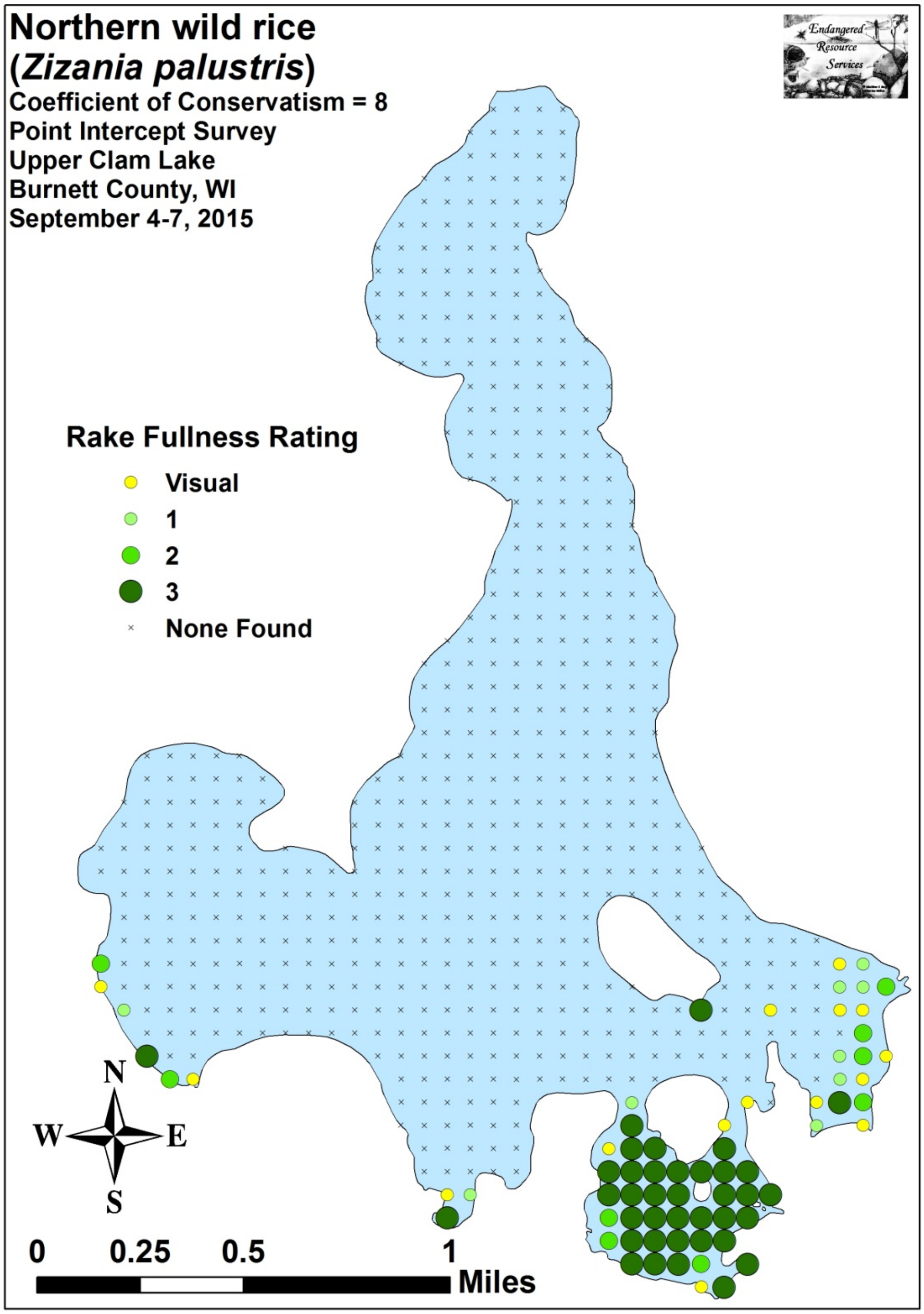
Miles


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
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None Found
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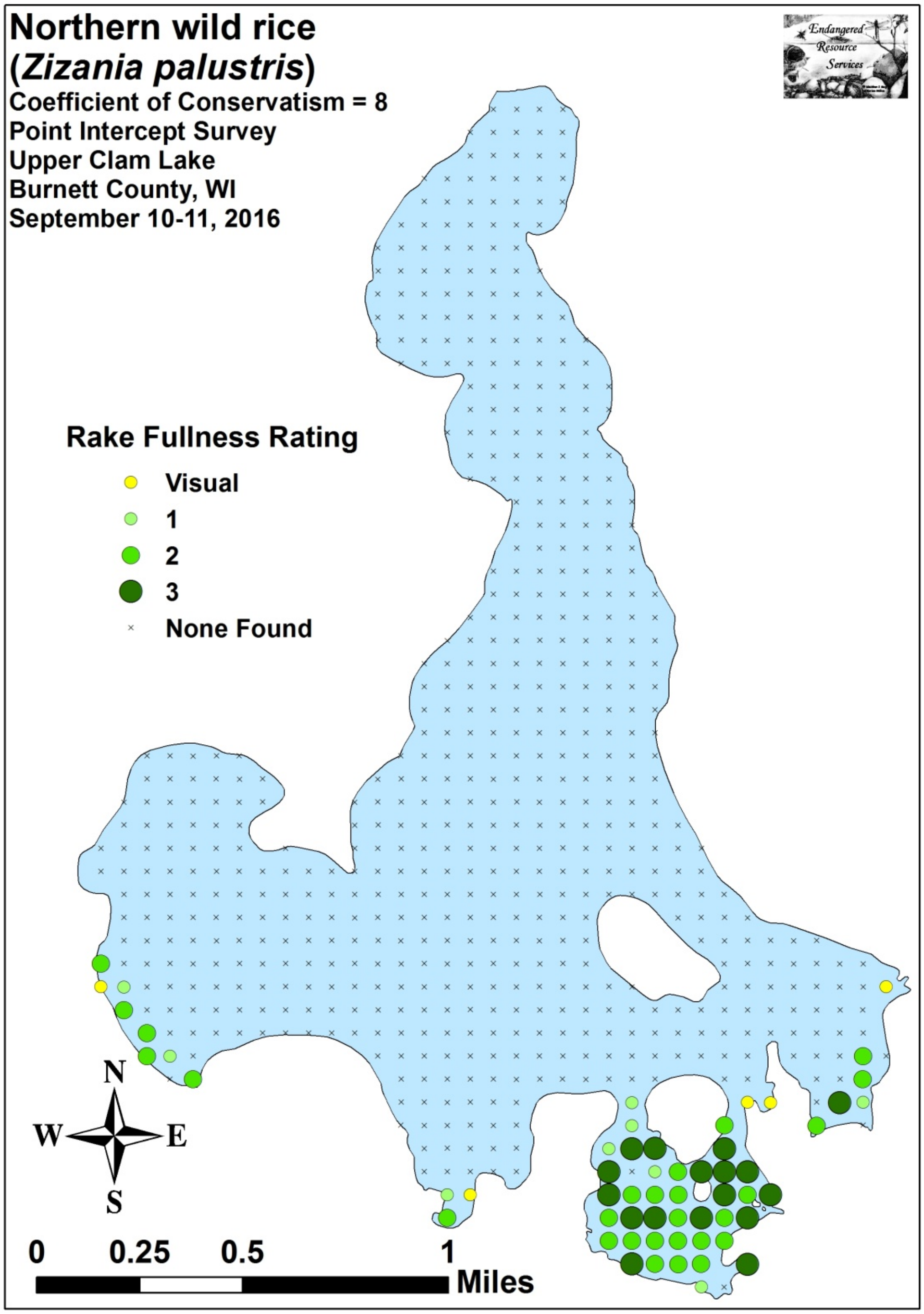
Miles


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
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None Found
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0.5
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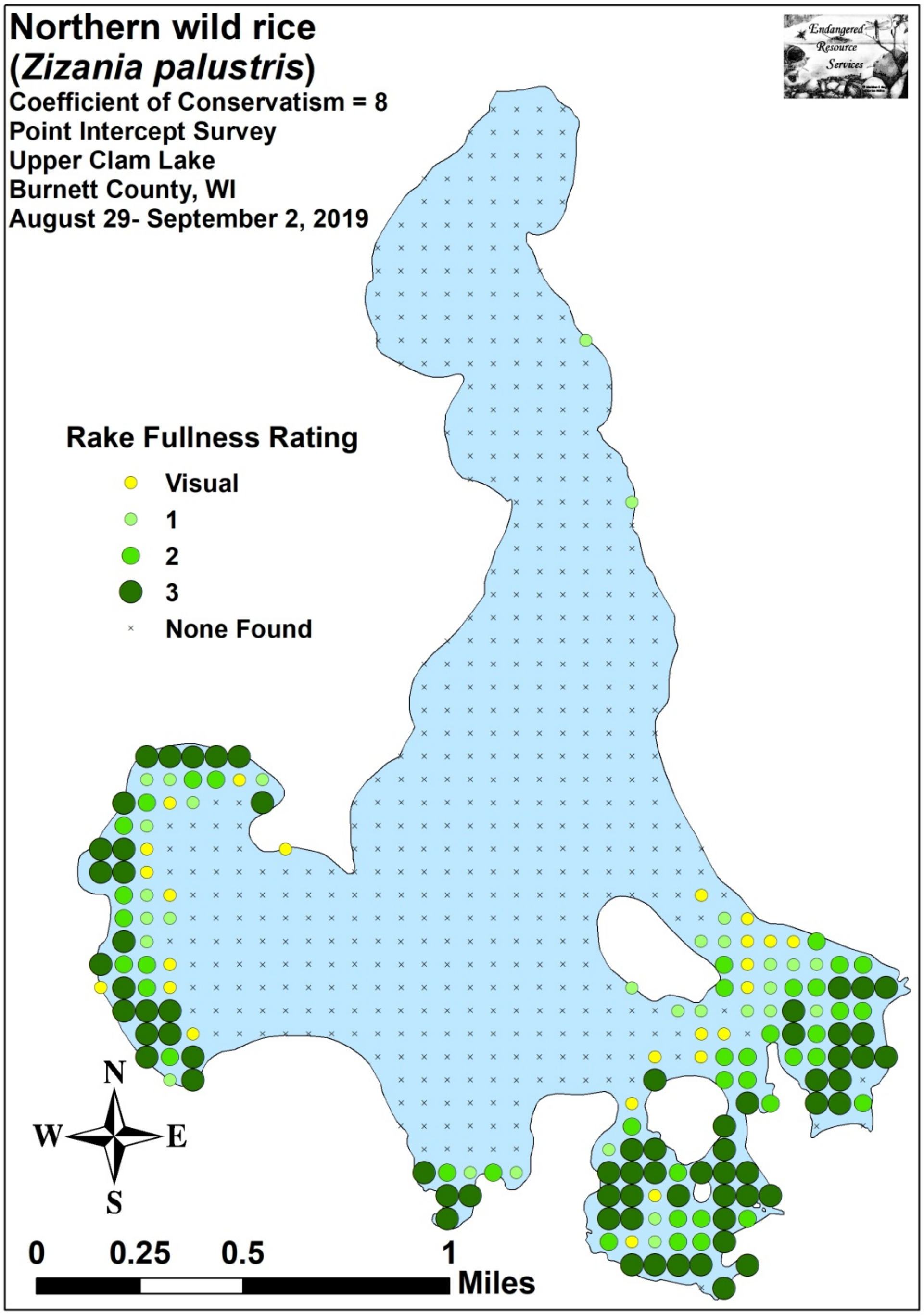
Miles



Northern wild rice
(Zizania palustris)
Coefficient of Conservatism = 8
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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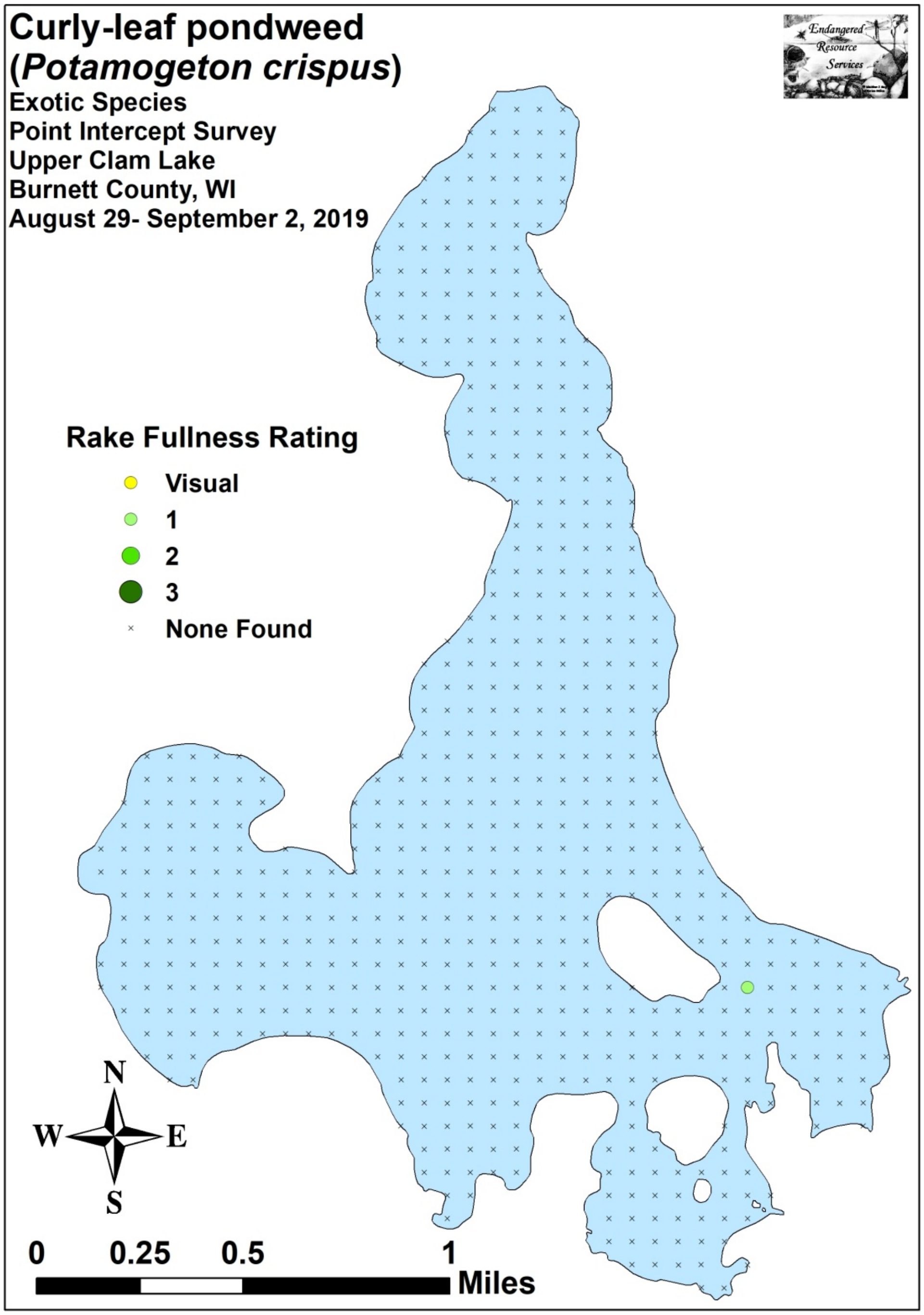
Miles

## Appendix VIII: 2019 August CLP and Other Exotic Species Density and Distribution Maps


Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
N
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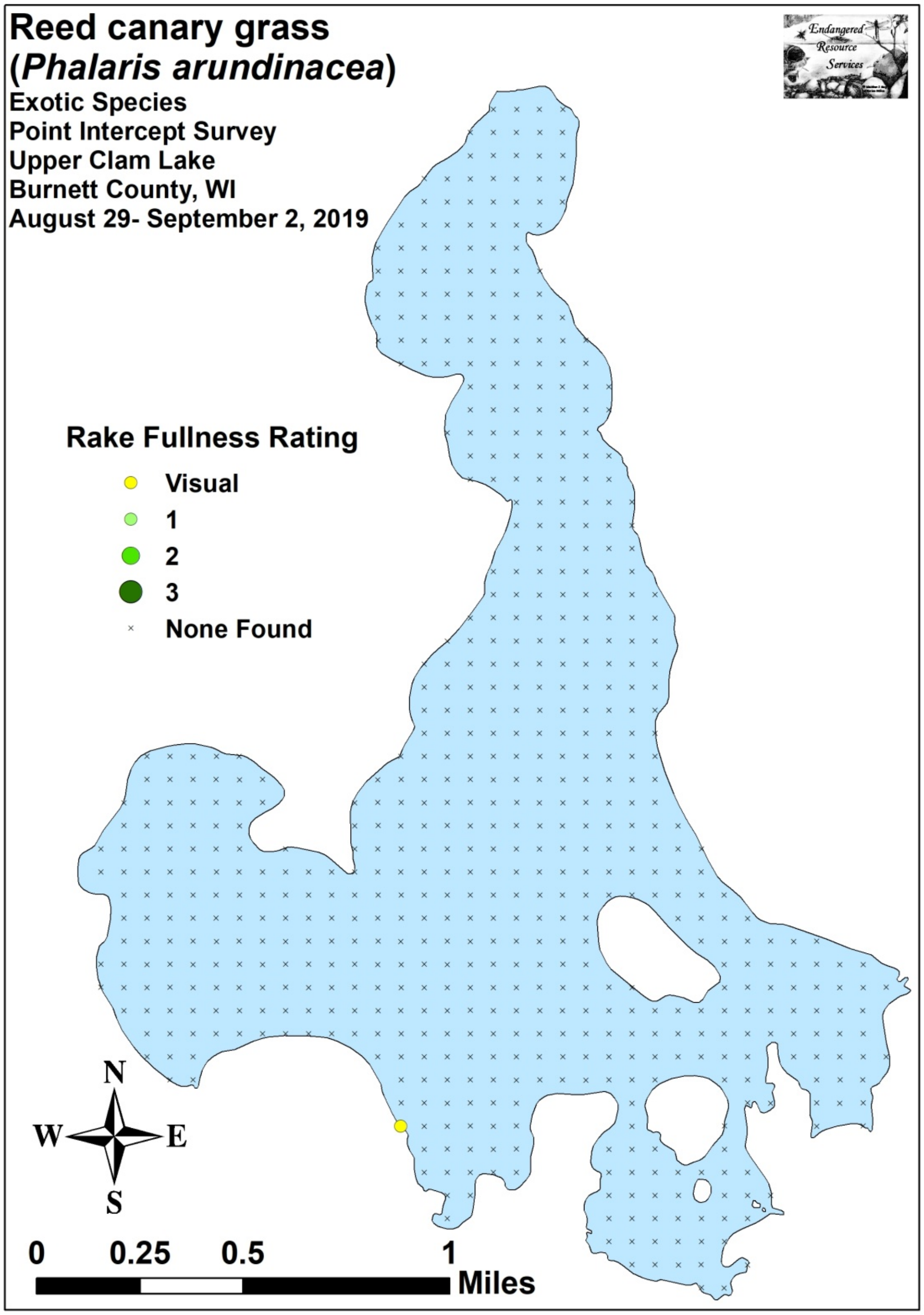
Miles


Reed canary grass
(Phalaris arundinacea)
Exotic Species
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
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None Found
N
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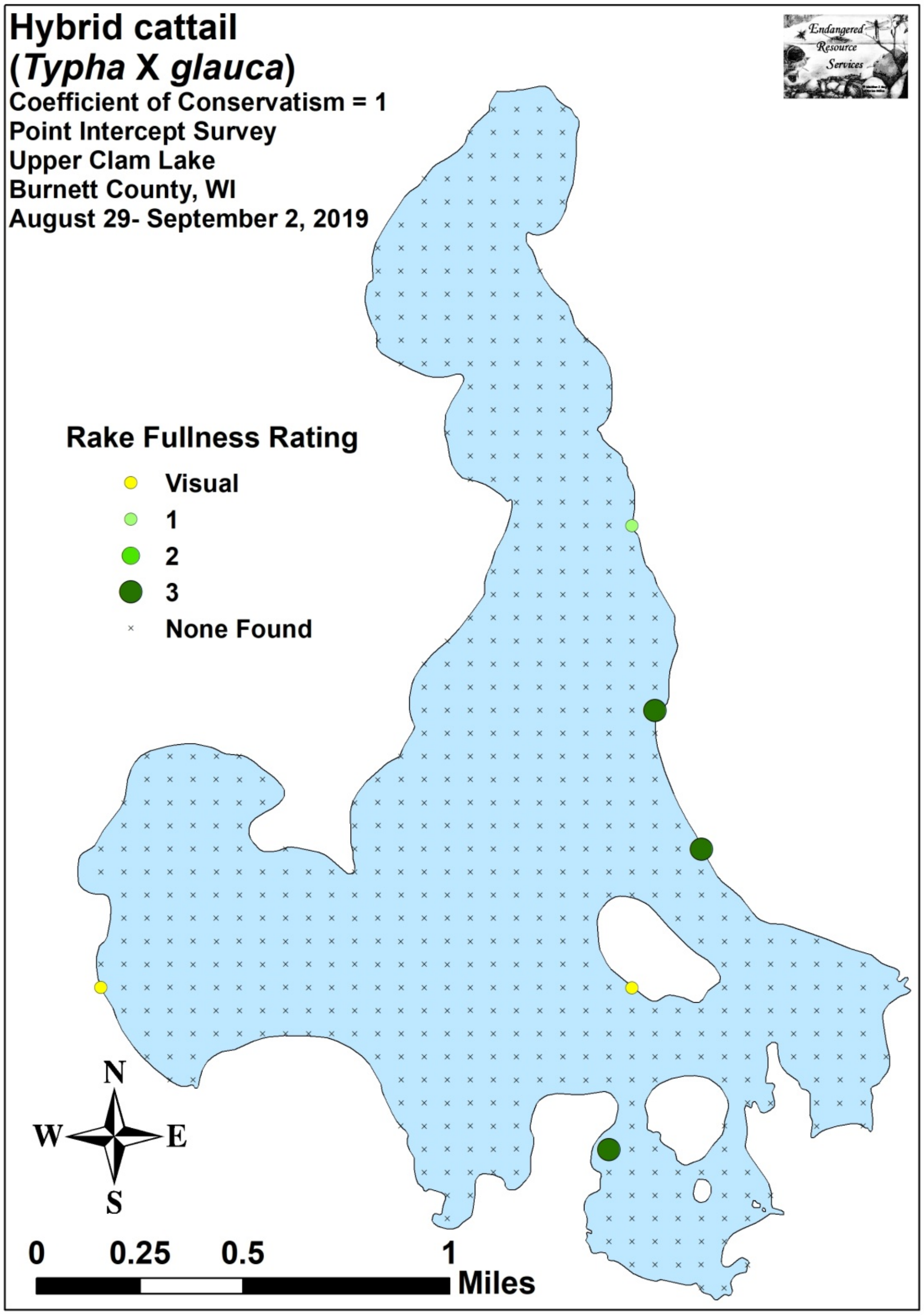
0.5
1
Miles


Hybrid cattail
(*Typha X glauca*)
Coefficient of Conservatism = 1
Point Intercept Survey
Upper Clam Lake
Burnett County, WI
August 29- September 2, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
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None Found
N
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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, 2009 http://www.dnr.state.wi.us/invasives/fact/milfoil.htm)

**Curly-leaf pondweed**

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

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

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

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out compete native plants in the spring. In mid-summer, when most aquatic plants are growing, curly-leaf pondweed plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. Curly-leaf pondweed forms surface mats that interfere with aquatic recreation. (Taken in its entirety from WDNR, 2009 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, 2009 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, 2009 http://www.dnr.state.wi.us/invasives/fact/loosestrife.htm)

# Appendix X: Glossary of Biological Terms
# (Adapted from UWEX 2009)

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: 2019 Raw Data Spreadsheets