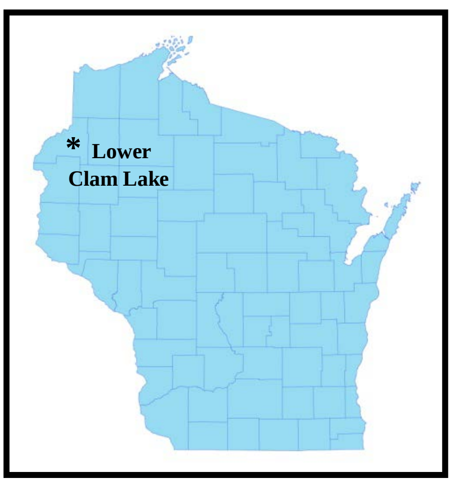
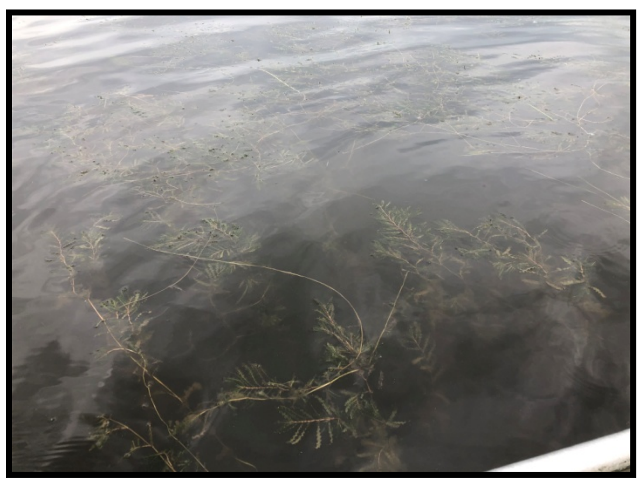
Curly-leaf pondweed (*Potamogeton crispus*) Point-intercept and Bed Mapping Surveys, and Warm-water Point-intercept Macrophyte Survey
Lower Clam Lake (WBIC: 2655300)
Burnett County, Wisconsin


Aerial Photo Lower Clam Lake (2015)


Dense Wild Rice - Lower Clam (Berg 2019)

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




Moderately Dense Curly-leaf Pondweed Bed – Lower Clam (Berg 2019)

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May 30, June 17, and August 25, 2019

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ABSTRACT

Lower Clam Lake (WBIC 2655300) is a 366 acre flowage 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 Curly-leaf pondweed (*Potamogeton crispus*) (CLP) – an exotic invasive species that dominated the lake's spring littoral zone. After the lake's Carp (*Cyprinus carpio*) 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 CLP 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 CLP density and bed mapping surveys on May 30th and June 17th, and a full point-intercept survey of all aquatic macrophytes on August 25, 2019. In 2019, we found CLP at 132 points (37.7% coverage with a mean rake fullness of 1.91) with 77 of these having a rake fullness of 2 or 3 (22.6% of the lake had a significant infestation). Compared to 2014 when we found CLP at 75 points (21.4% coverage with a mean rake fullness of 1.23) with 16 having a rake fullness of 2 or 3 (4.6% significant infestation), this represented a highly significant increase **(*p*<0.001)** in density, distribution and rake fullness 3; and a moderately significant increase **(*p*=0.005)** in rake fullness 2. Our 2014 bed mapping survey didn't find any canopied CLP in the lake; however, in 2019, we mapped five Curly-leaf pondweed beds totaling 57.75 acres (15.8% coverage). Although this was a large increase, it was still 73.8% less than the 220.18 acres (60.2% coverage) mapped in 2009. During the August 2019 full point-intercept survey, we found macrophytes growing at 141 sites which approximated to 40.3% of the entire lake bottom and 41.2% 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 49 points (14.0% of the bottom and 45.0% of the then 5.5ft littoral zone). Overall diversity was moderately high with a Simpson Index value of 0.88 – down slightly from 0.92 in 2016. Total richness was moderate with 30 species in the rake and 40 total found growing in and immediately adjacent to the water (both up sharply from 23/32 species in 2016 and the highest totals of any of our six surveys). There was an average of 2.96 native species/site with native vegetation – identical to 2016. Total rake fullness experienced a moderately significant decline **(*p*=0.003)** from a moderate 2.06 in 2016 to a moderately/low 1.67 in 2019. Common waterweed (*Elodea canadensis*), Coontail (*Ceratophyllum demersum*), Small pondweed (*Potamogeton pusillus*), and Wild celery (*Vallisneria americana*) were the most common species in 2019. Found at 60.28%, 58.87%, 51.06%, and 16.31% of sites with vegetation, they captured 62.77% of the total relative frequency. In 2016, Common waterweed, Coontail, White water lily (*Nymphaea odorata*), and Slender naiad (*Najas flexilis*) were the most common species (51.02%, 36.73%, 32.65%, and 22.45% of survey points with vegetation/48.61% of the total relative frequency). Lakewide, from 2016-2019, nine species showed significant changes in distribution – all of them increases. Common waterweed, Coontail, and Small pondweed all enjoyed highly significant increases; Large duckweed (*Spirodela polyrhiza*), Flat-stem pondweed (*Potamogeton zosteriformis*), filamentous algae, and Common bladderwort (*Utricularia vulgaris*) saw moderately significant increases; and Wild celery and Northern water-milfoil (*Myriophyllum sibiricum*) had significant increases. The 29 native index species found in the rake during the August 2019 survey (up from 22 in 2016) produced a below average mean Coefficient of Conservatism of 5.8 (up from 5.0 in 2016). The Floristic Quality Index of 31.2 (up from 23.7 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 15 points with a mean rake of 2.00 (up from eight points with a mean rake of 2.50 in 2016). The southeast corner of the northeast bay offered human harvest potential, but only over a relatively small area. Filamentous algae (13 points with a mean rake fullness of 1.00) underwent a moderately significant increase **(*p*=0.004)** in distribution compared to 2016 (two points/mean rake of 1.00). Curly-leaf pondweed was still present at a single points in August 2019 (down from two points in 2016). Other than CLP, we found three other exotic species growing in and immediately adjacent to Lower Clam Lake: Purple loosestrife (*Lythrum salicaria*) was increasingly common around the entire lakeshore; Reed canary grass (*Phalaris arundinacea*) was present along shorelines throughout; and Hybrid cattail (*Typha* X *glauca*) was found in a single bed on the northeast point. We encourage the CLPRD to initiate a volunteer water quality monitoring program; to harvest CLP in a way that minimizes damage to the native plant community whenever possible, and to manually remove Purple loosestrife in low density shoreline areas while considering the potential for raising and releasing a new population of loosestrife beetle (*Galerucella* spp.) to control the spreading infestation.

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INTRODUCTION:

Lower Clam Lake (WBIC 2655300) is a 366 acre flowage in central Burnett County, Wisconsin in the Town of Meenon (T39N R16W S26 SW SE). The lake reaches a maximum depth of 14ft on the west side just north of the HWY 70 Narrows and has an average depth of approximately 7ft (Figure 1). 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 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).

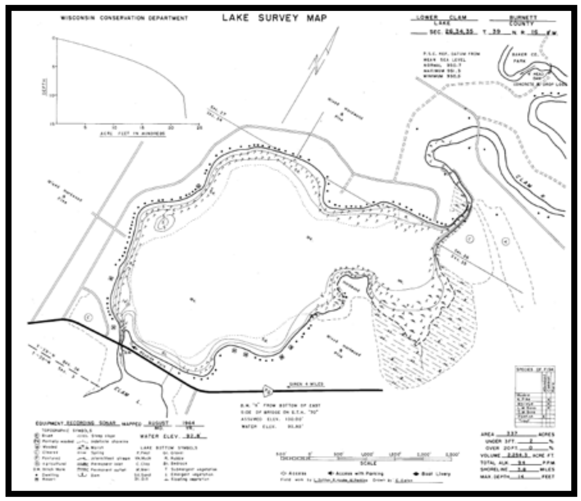


Figure 1: Lower Clam Lake Bathymetric Map

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 Lower Clam Lake, those surveys showed a very limited recovery of vegetation, but, by 2018, spring CLP 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 Lower Clam Lake in 2019. On May 30th, 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 on August 25th. 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, water clarity, depth, and total acreage, Jennifer Hauxwell (WDNR) generated the original 350 point sampling grid used for Lower 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.

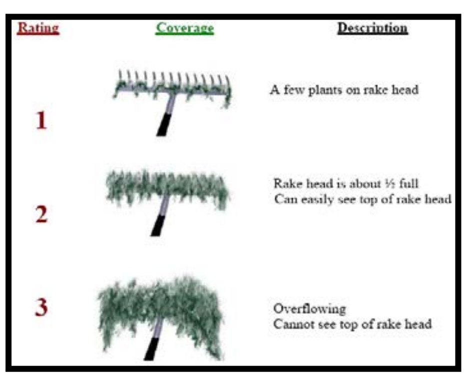


Figure 2: Rake Fullness Ratings (UWEX 2010)

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:

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

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

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

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

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

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

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

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

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

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

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

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

<u>Relative frequency:</u> 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. Lower 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 we were forced to estimate the spring 2009 littoral zone as depths weren't recorded during the original survey. By using the depths recorded during the 2009 warm-water survey, we estimated there were 343 points in May 2009. This was similar to the 338 littoral points in June 2014 and the 341 littoral points in May 2019. For the warm-water point-intercept surveys, we used the initial number of littoral points from 2009 (338) as the basis for "sample points" as the lake's clarity appeared to be nearly constant over this time, and we felt this gave us the best way to estimate changes that were, presumably, largely caused by Carp herbivory or the lack there of.

RESULTS:

Curly-leaf Pondweed Point-intercept Survey:

We rake sampled all 350 points in the lake during the 2019 early-season point-intercept survey and found Curly-leaf pondweed was present at 132 sites. This extrapolated to 37.7% of the entire lake and 38.7% of the 9.5ft spring littoral zone having at least some CLP present. Of these, 43 rated a rake fullness value of 3, 34 were a 2, and the remaining 55 were a 1 for a combined mean rake fullness of 1.91 (Figure 3) (Appendix III). The 77 points with a rake fullness of a 2 or a 3 suggested 22.0% of the entire lake and 22.6% of the spring littoral zone had a significant infestation.

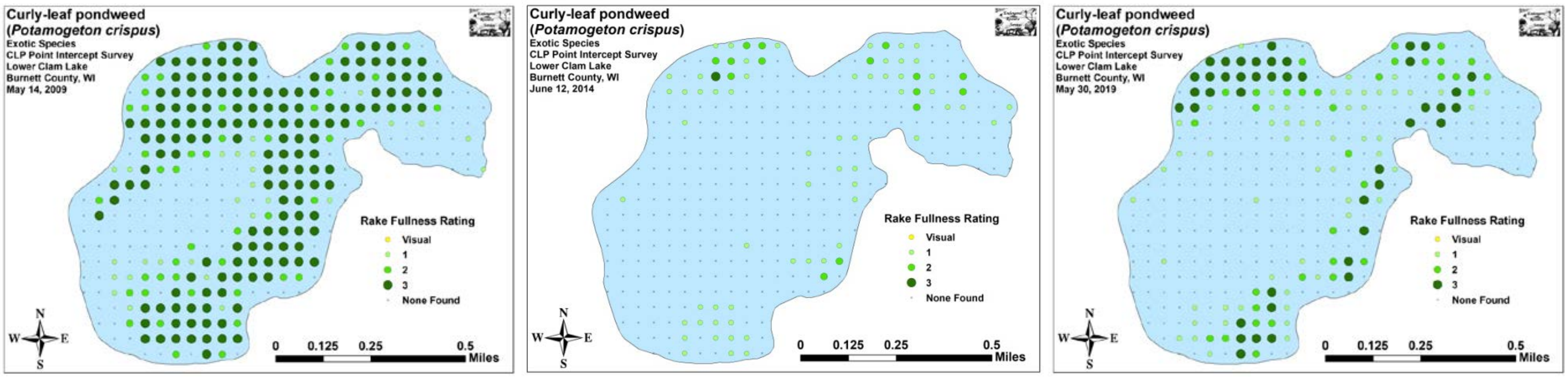


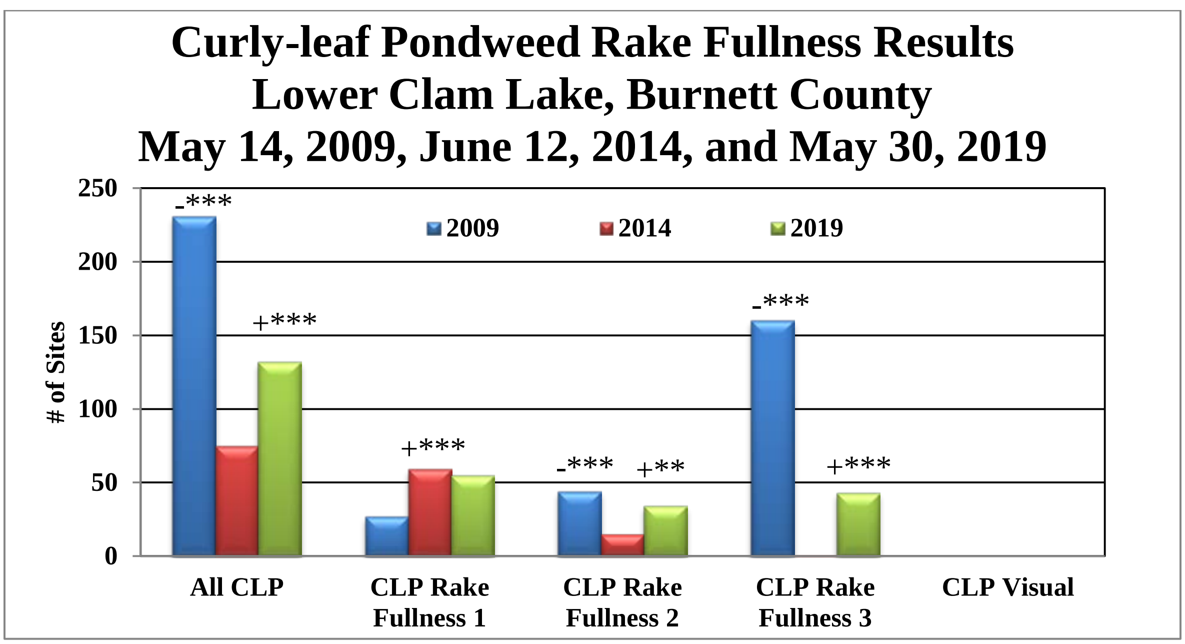
Figure 3: 2009, 2014, and 2019 Early-season Curly-leaf Pondweed Density and Distribution

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

The 2009 spring Curly-leaf pondweed point-intercept survey found CLP at 231 sites which approximated to 66.0% of the entire lake and 67.3% of the estimated 8.5ft spring littoral zone. Of these, we recorded a rake fullness value of 3 at 163 points, a 2 at 44 points, and a value of 1 at 27 points for a mean rake fullness of 2.58 (Figure 3) (Appendix III). The combined 204 points with a rake fullness of 2 or 3 extrapolated to 58.3% of the entire lake and 59.5% of the estimated littoral zone having a significant infestation.

In June of 2014, CLP was present in the rake at 75 points which extrapolated to 21.4% of the entire lake and 22.2% of the 8.0ft spring littoral zone. Of these, we recorded a rake fullness value of 3 at one point, a 2 at 15 points, and a value of 1 at 59 points for a mean rake fullness of 1.23. This suggested 4.6% of the lake had a significant infestation (rake fullness of 2 or 3) (Figure 3) (Appendix III). The declines in total density and distribution; rake fullness 3 and 2; and the increase in rake fullness 1 were all highly significant **(p<0.001)** (Figure 4). Collectively, they represented a greater than 67.5% reduction in total CLP coverage, also well as a 92.2% reduction in areas where the infestation was significant enough to be considered a nuisance.

Compared to 2014, our 2019 survey represented a highly significant increase **(p<0.001)** in density, distribution and rake fullness 3; and a moderately significant increase **(p=0.005)** in rake fullness 2 (Figure 4). However, when compared to 2009, our 2019 results suggest total CLP distribution, rake fullness 3, and mean rake fullness have all undergone **highly significant declines (p<0.001)**. The only increase (presumably due to low-level reestablishment) was rake fullness 1 which saw a **highly significant increase**. Collectively, the 2019 results suggest CLP is still both less widespread 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 a single canopied bed of Curly-leaf pondweed that dominated the majority of the lake's spring littoral zone (Figure 5). It covered 220.18 acres (60.2% of the lake's 366 acres), was almost monotypic, and, based on the numerous prop trails crisscrossing it, caused severe navigation impairment.

Following a dramatic reduction in CLP levels, our 2014 survey didn't find any canopied CLP anywhere in the system (Figure 5). Of the few CLP plants we were able to find by raking, most showed evidence of Carp herbivory.

The 2019 bed mapping survey located five beds totaling 57.75 acres (15.8% of the lake's surface area) (Table 1). Although it was a large increase when compared to 2014, it still represented a 162.44 acre decline (-73.8%) from our original 2009 bed mapping survey (Figure 5) (Appendix III).

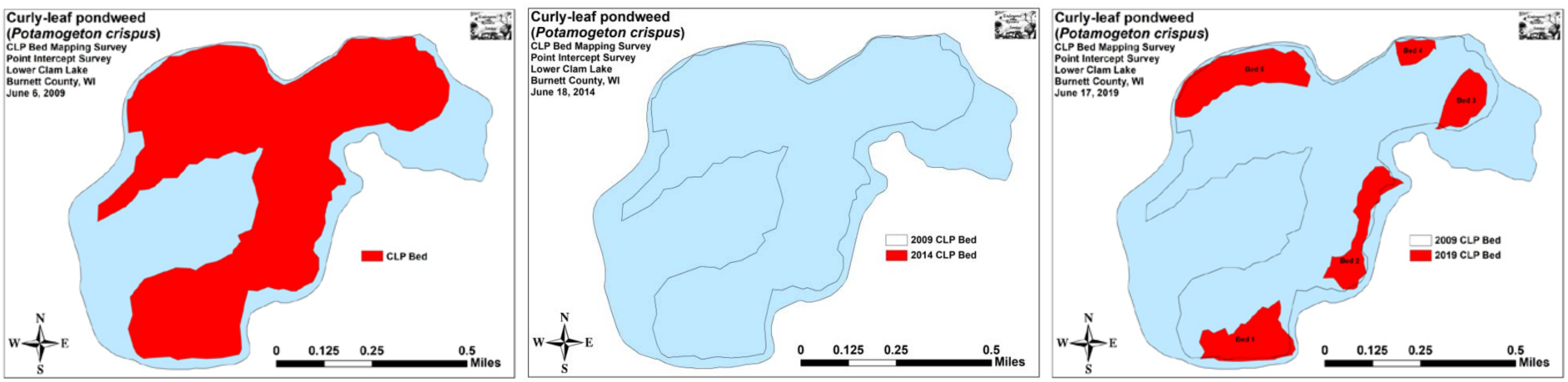


Figure 5: 2009, 2014, and 2019 Early-season Curly-leaf Pondweed Beds

Descriptions of Past and Present Curly-leaf Pondweed Beds:

Bed 1 – The bed in the lake's southwest bay was moderately dense (see photo on report cover). Despite being a monotypic canopied mat at its core, the outer edge became fragmented in most areas beyond 5ft. On the inner edge, we noted the CLP beds were interspersed with patches of Small pondweed (*Potamogeton pusillus*). We also documented prop trails through the bed; especially leading away from the HWY 70 public landing.

Bed 2 – This bed was identical in nature to Bed 1, and the two might have been connected if it wasn't for boats leaving the resort docks. Although motoring straight through the bed would have likely caused moderate impairment, this regular boat traffic appeared to be keeping a navigation channel open.

Bed 3 – Native plants - especially Northern wild rice (*Zizania palustris*), Coontail (*Ceratophyllum demersum*) and water lilies - again dominated the southeast corner of the lake's northeast bay. Directly outside of this swath of native vegetation, a moderately dense CLP bed stretched to 6ft of water. This area seemed to be important fish habitat as we noted Bluegills (*Lepomis macrochirus*) throughout the area and had to wait for people to finish angling before we could complete the survey.

Bed 4 – CLP was canopied and monotypic along the north shoreline of the northeast bay, but it was much more fragmented than in other parts of the lake. More a collection of solid patches than a true bed, it likely caused only minor impairment for the residents along this highly developed shoreline.

Bed 5 – The lake's north shoreline was easily the worst place on the lake. The broad shallow sand flat provided ideal habitat for CLP, and residents were forced to motor straight through the bed to reach open water.

Table 1: Curly-leaf Pondweed Bed Summary Lower 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	14.75	0.00	220.18	-205.43	<1-3; 2	3-6; 5	Moderate
2	11.66	0.00	Merged	11.66	<1-3; 2	3-6; 5	Moderate
3	8.05	0.00	Merged	8.05	<1-3; 2	3-6; 5	Moderate
4	3.37	0.00	Merged	3.37	<1-3;1	3-6; 4	Minor
5	19.91	0.00	Merged	19.91	1-3;3	3-6; 5	Severe
Total Acres	**57.74**	**0.00**	**220.18**	**-162.44**			

Warm-water Full Point-intercept Macrophyte Survey:

Depth soundings taken at Lower Clam Lake's 350 survey points (Appendix I) revealed the deepest areas in the lake occur on the west side where the channel from Upper Clam cuts a 9-13ft furrow along the shoreline before turning to the northeast approximately 400 yards north of the bridge. The central basin is a generally uniform 6-9ft bowl that gets gradually shallower moving west to east. The far south end of the eastern bay is a shallow 2-5ft flat that gradually slopes towards the 6ft river channel that exits the lake in the northeast corner (Figure 6) (Appendix IV).

Sand dominates the majority of the nearshore lake bottom on Lower Clam on the north, west, and south sides. This quickly transitions to nutrient-poor sandy muck at most depths beyond 4ft. Further to the east, this muck gradually thickens and becomes more nutrient-rich; especially in the south end of the east bay. Of the lake's 350 points, we categorized 298 (85.1%) as being muck or sandy muck and the remaining 52 (14.9%) as being pure sand (Figure 6) (Appendix IV).

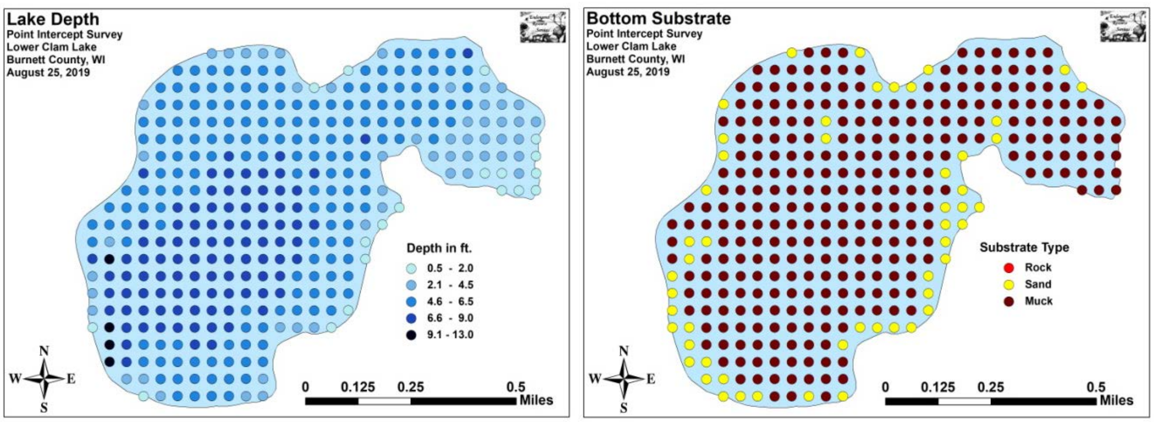


Figure 6: Lake Depth and Bottom Substrate

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 342 of the lake's 350 survey points (Table 2). Despite this highly significant increase **(*p*<0.001)** compared to the 109 littoral points in 2016's 5.5ft littoral zone, most growth ended in 6-7ft (Figure 7) (Appendix V).

We found plants at 141 points (40.3% of the bottom and 41.2% of the littoral zone). This was a highly significant increase **(*p*<0.001)** over the 2016 survey when plants were present at just 49 points (14.0% of the bottom and 45.0% of the littoral zone). It was also more than twice as many points as the next highest survey total of 69 points with vegetation in 2009.

Growth in 2019 was slightly skewed to shallow water as the mean plant depth of 4.4ft was less than the median depth of 5.0ft. Both of these values were higher than in 2016 when the mean was 3.2ft and the median was 3.5ft (Figure 8). They were also higher than any other survey dating back to 2009 suggesting that vegetation is spreading back into deeper water.

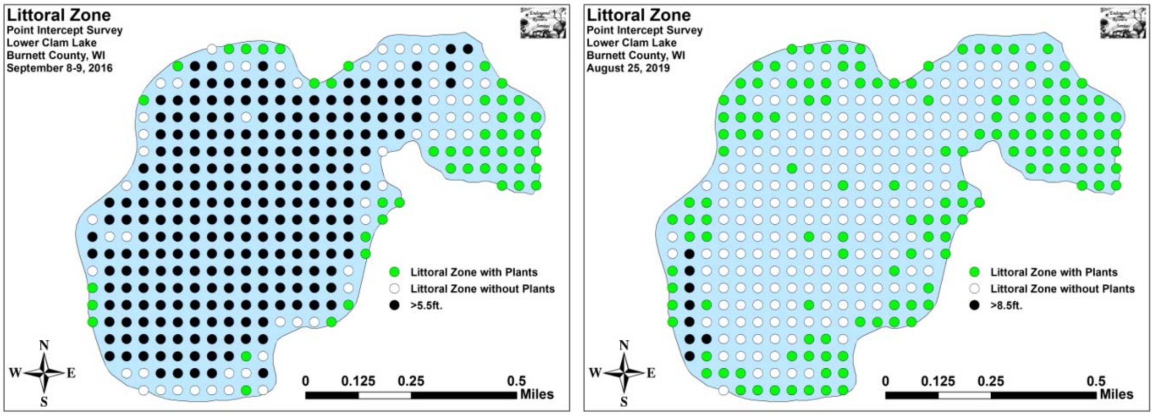


Figure 7: 2016 and 2019 Littoral Zone

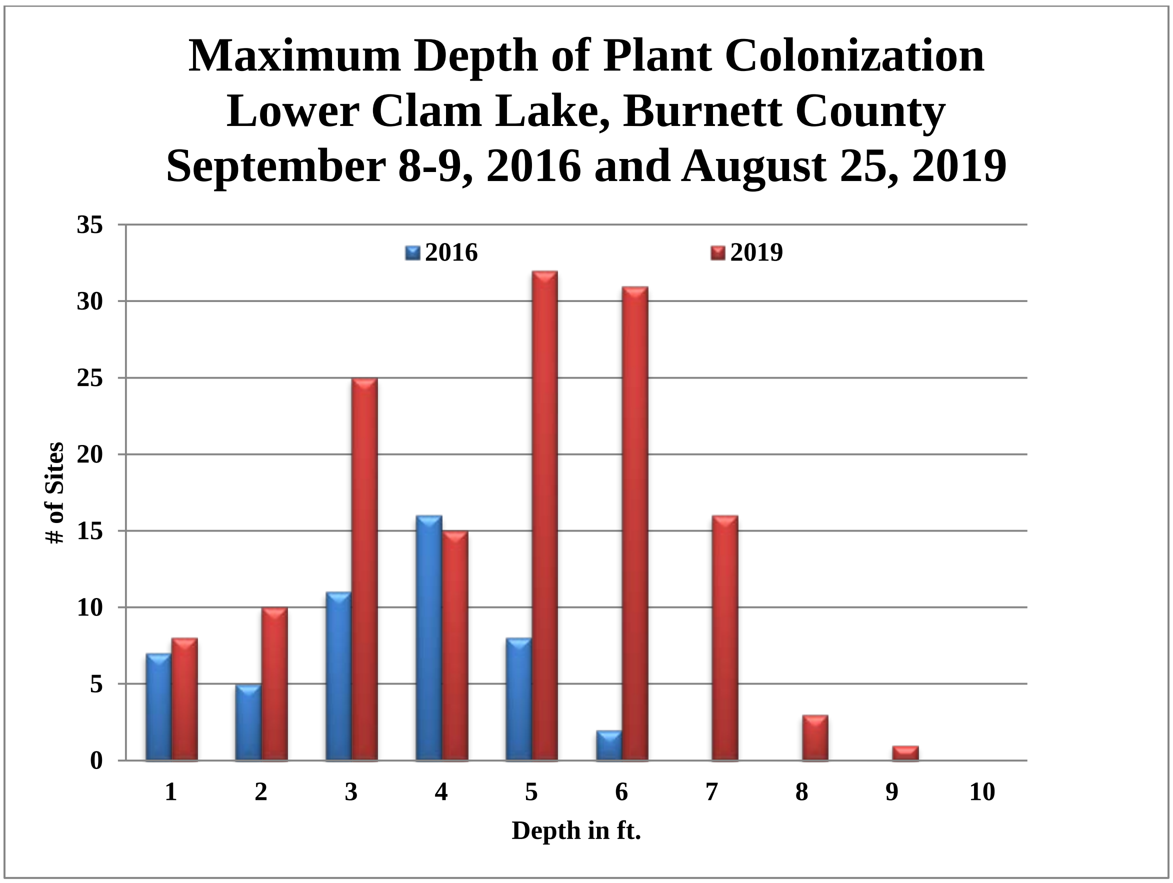


Figure 8: 2016 and 2019 Plant Colonization Depth Chart

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics
Lower Clam Lake, Burnett Co.
July 24-25, 2009, July 31-August 1, 2012, August 2, 2014, September 2-4, 2015, September 8-9, 2016, and August 25, 2019

Summary Statistics:	2009	2012	2014	2015	2016	2019
Total # of points sampled	350	350	350	350	350	350
Total # of sites with vegetation	69	42	30	57	49	141
Total # of sites shallower than the max. depth of plants	338	122	71	142	109	342
Freq. of occur. at sites shallower than max. depth of plants	20.41	34.43	42.25	40.14	44.95	41.23
Simpson Diversity Index	0.91	0.91	0.86	0.90	0.92	0.88
Maximum depth of plants (ft)	8.0	5.5	4.5	5.5	5.5	8.5
Mean depth of plants (ft)	3.9	2.9	2.6	3.1	3.2	4.4
Median depth of plants (ft)	3.5	3.0	3.0	3.5	3.5	5.0
Ave. # of all species per site (shallower than max depth)	0.45	0.88	0.89	0.94	1.31	1.23
Ave. # of all species per site (veg. sites only)	2.22	2.55	2.10	2.33	2.94	2.97
Ave. # of native species per site (shallower than max depth)	0.41	0.88	0.87	0.92	1.29	1.22
Ave. # of native species per site (sites with native veg. only)	2.34	2.55	2.14	2.38	2.96	2.96
Species richness	25	19	17	23	23	30
Species richness (including visuals)	27	22	21	27	27	33
Species richness (including visuals and boat survey)	29	33	28	32	32	40
Mean total rake fullness (veg. sites only)	1.71	1.86	2.00	2.00	2.06	1.67

Plant diversity was moderately high in 2019 with a Simpson Index value of 0.88 – down slightly from 0.92 in 2016. Total richness was moderate with 30 species found in the rake – up from 23 in 2016 and the highest total of any of the six surveys. This total increased to 40 species when including visuals and plants seen during the boat survey – also an increase from 32 in 2016 and the highest total ever recorded on the lake. Mean native species richness at sites with native vegetation was unchanged at 2.96 species/site in both 2016 and 2019 (Figure 9) (Appendix V). Although this value didn't increase, it was also the highest value for any of the six surveys.

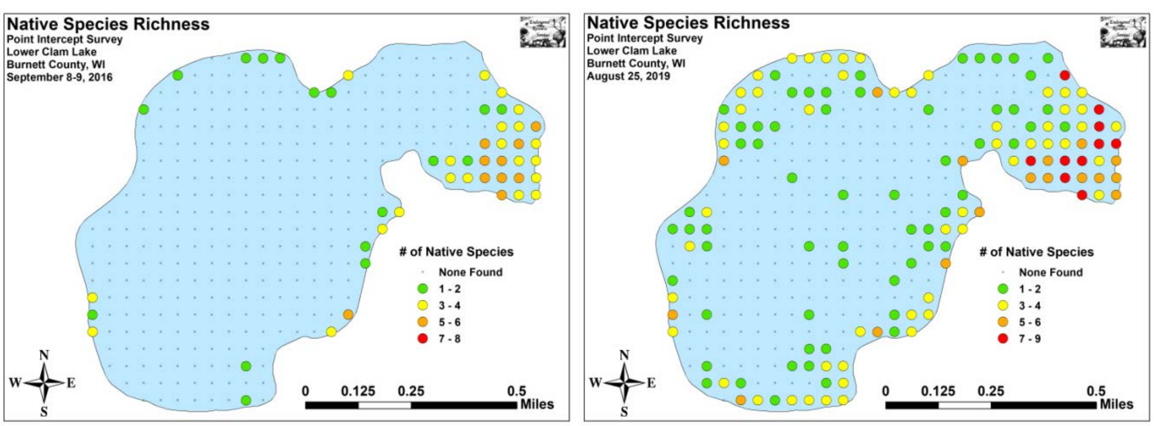


Figure 9: 2016 and 2019 Native Species Richness

Total rake fullness experienced a moderately significant decline **(*p*=0.003)** from a moderate 2.06 in 2016 to a moderately/low 1.67 in 2019. Visual analysis of the maps showed this average decline was due to low density expansion throughout the lake rather than the obvious loss of density in any area (Figure 10) (Appendix V).

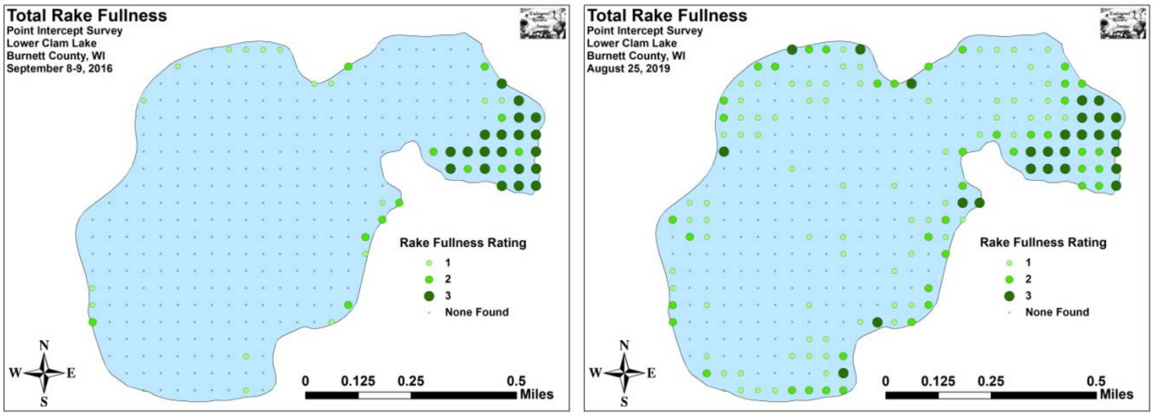


Figure 10: 2016 and 2019 Total Rake Fullness

Lower Clam Lake Plant Community:

The Lower Clam Lake ecosystem is currently home to a diverse but somewhat limited 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*), Reed canary grass (*Phalaris arundinacea*), Common reed (*Phragmites australis americanus*), Hardstem bulrush (*Schoenoplectus acutus*), Common bur-reed (*Sparganium eurycarpum*), Sessile-fruited arrowhead (*Sagittaria rigida*), and Hybrid cattail (*Typha* X *glauca*).

River bulrush (Ratzlaff 2008)

Hardstem bulrush (Dziuk 2015)

Common bur-reed (Raymond 2011)

Sessile-fruited arrowhead (Chayka 2013)

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*), Purple loosestrife (*Lythrum salicaria*), Common arrowhead (*Sagittaria latifolia*), Softstem bulrush (*Schoenoplectus tabernaemontani*), and Broad-leaved cattails (*Typha latifolia*). In slightly deeper water over soft muck on the south end of the east bay, we also recorded Northern wild rice plants. 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)

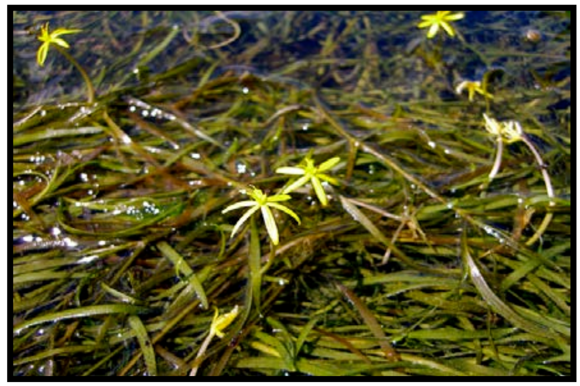
Three-way sedge (GMNRI 2016)

Common arrowhead (Young 2006)

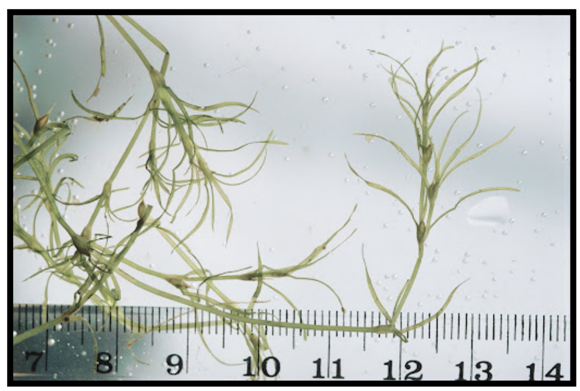
Softstem bulrush (Schwarz 2011)

Shallow sandy and sandy-muck areas around the western basin showed a significant expansion in both richness and density of submergent species. What had been only a few scattered patches of plants in 2016 was 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 on the eastern third of the lake were dominated by the floating-leaf species Spatterdock (*Nuphar variegata*) and White-water lily (*Nymphaea odorata*). We also found limited numbers of Ribbon-leaf pondweed (*Potamogeton epihydrus*), Floating-leaf pondweed (*Potamogeton natans*), and Vasey's pondweed (*Potamogeton vaseyi*). The protective canopy cover this group provides is often utilized by panfish and bass.

Spatterdock and White water lily (Falkner, 2009)

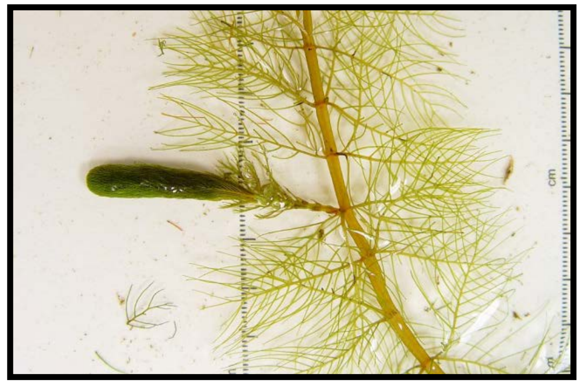
Ribbon-leaf pondweed (Petroglyph 2007)

Floating-leaf pondweed (Petroglyph 2007)

Vasey's pondweed (Skawinski 2010)

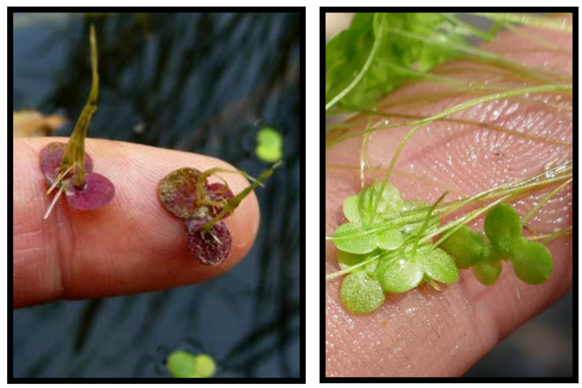
Growing amongst these floating-leaf species in boggy areas of the northeast bay, we found limited numbers of Water marigold (*Bidens beckii*) and Whorled water-milfoil (*Myriophyllum verticillatum*). Floating between the lilypads and rice in this area, we also occasionally saw Forked duckweed (*Lemna trisulca*), Small duckweed (*Lemna minor*), and Large duckweed (*Spirodela polyrhiza*) 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.

Water marigold (Dziuk 2012)

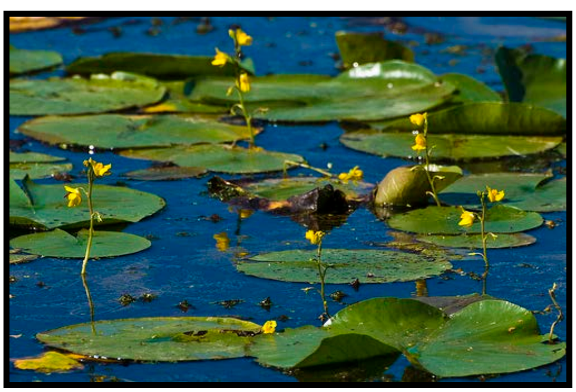


Whorled water-milfoil (Cameron 2018)

Forked duckweed (Curtis 2010)



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



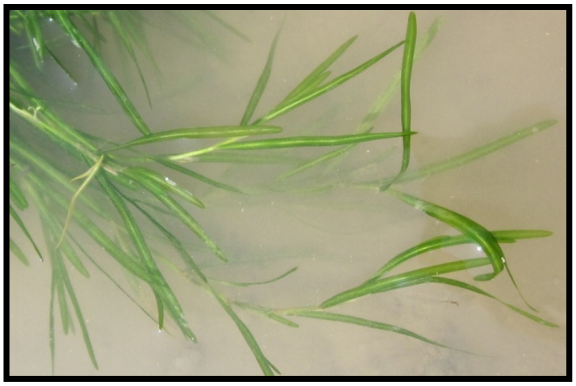
Common bladderwort flowers among lilypads (Hunt, 2010)

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, Common waterweed (*Elodea canadensis*), Northern water milfoil, Small pondweed, Flat-stem pondweed (*Potamogeton zosteriformis*), and, especially in the spring, Curly-leaf pondweed. 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)



Small pondweed (Villa 2011)

Flat-stem pondweed (Fewless 2004)

Curly-leaf pondweed (USGS 2019)

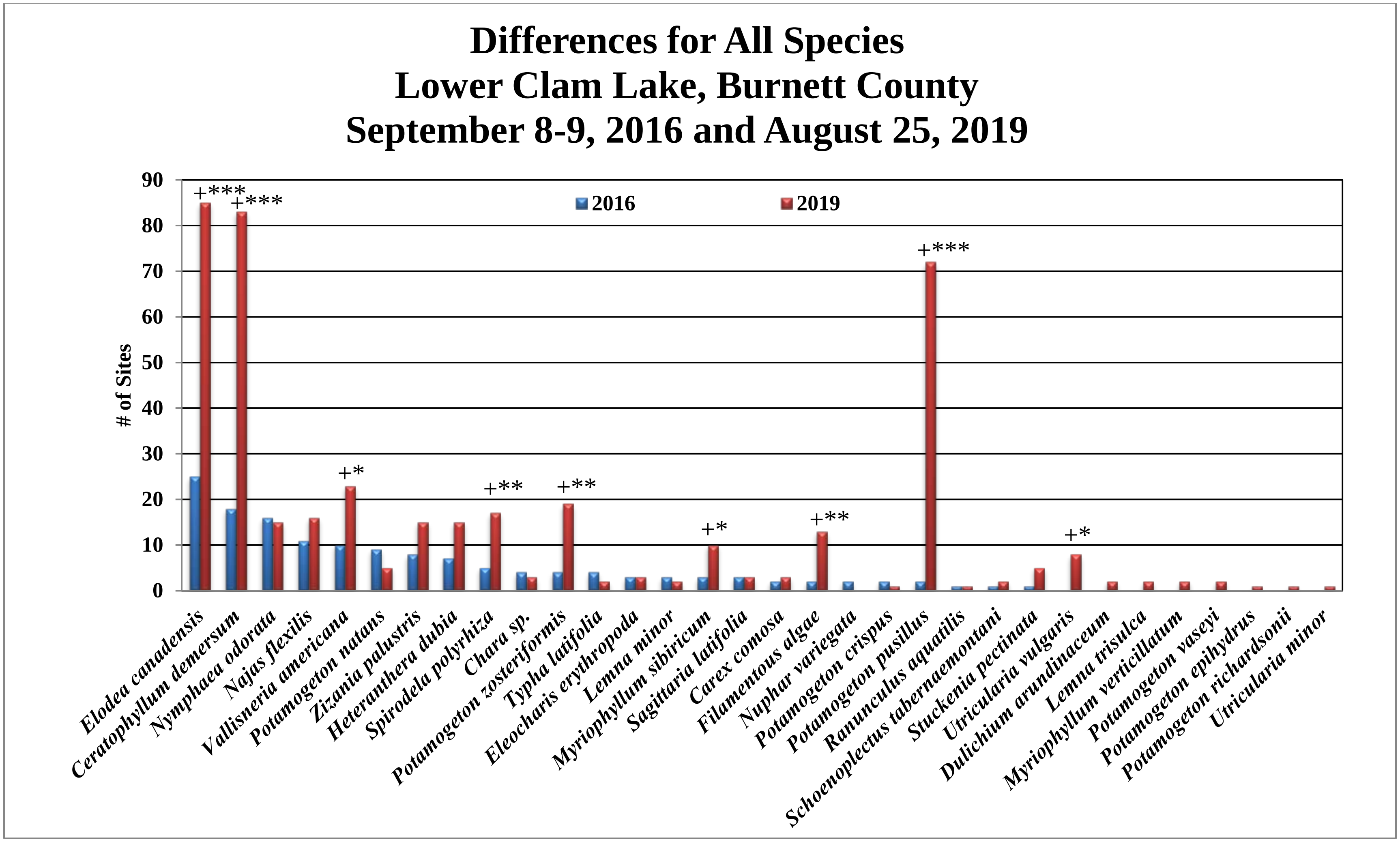
Canopied CLP on Lower Clam in June (Berg 2019)

Comparison of Native Macrophyte Species in 2016 and 2019:

In 2016, we documented Common waterweed, Coontail, White water lily, and Slender naiad as the most common species (Table 3). Present at 51.02%, 36.73%, 32.65%, and 22.45% of survey points with vegetation, they accounted for 48.61% of the total relative frequency. Wild celery (6.94%), Floating-leaf pondweed (6.25%), Northern wild rice (5.56%), and Water star-grass (4.86%) 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, Common waterweed, Coontail, Small pondweed, and Wild celery were the most common species. They were found at 60.28%, 58.87%, 51.06%, and 16.31% of sites with vegetation (Table 4). Collectively, they captured 62.77% of the total relative frequency. Flat-stem pondweed (4.53%) and Large duckweed (4.06%) 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, nine species showed significant changes in distribution from 2016 to 2019 with all of them being increases (Figure 11). Common waterweed, Coontail, and Small pondweed enjoyed highly significant increases; Large duckweed, Flat-stem pondweed, filamentous algae, and Common bladderwort saw moderately significant increases; and Wild celery and Northern water-milfoil experienced significant increases.



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
Lower Clam Lake, Burnett County
September 8-9, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sightings
Elodea canadensis	Common waterweed	25	17.36	51.02	22.73	1.44	0
Ceratophyllum demersum	Coontail	18	12.50	36.73	16.36	1.89	2
Nymphaea odorata	White water lily	16	11.11	32.65	14.55	1.50	6
Najas flexilis	Slender naiad	11	7.64	22.45	10.00	1.09	0
Vallisneria americana	Wild celery	10	6.94	20.41	9.09	1.50	2
Potamogeton natans	Floating-leaf pondweed	9	6.25	18.37	8.18	1.56	4
Zizania palustris	Northern wild rice	8	5.56	16.33	7.27	2.50	1
Heteranthera dubia	Water star-grass	7	4.86	14.29	6.36	1.00	0
Spirodela polyrhiza	Large duckweed	5	3.47	10.20	4.55	1.00	0
Chara sp.	Muskgrass	4	2.78	8.16	3.64	1.00	0
Potamogeton zosteriformis	Flat-stem pondweed	4	2.78	8.16	3.64	1.50	2
Typha latifolia	Broad-leaved cattail	4	2.78	8.16	3.64	1.75	0
Eleocharis erythropoda	Bald spikerush	3	2.08	6.12	2.73	1.67	1
Lemna minor	Small duckweed	3	2.08	6.12	2.73	1.00	1
Myriophyllum sibiricum	Northern water-milfoil	3	2.08	6.12	2.73	1.33	1
Sagittaria latifolia	Common arrowhead	3	2.08	6.12	2.73	1.33	2
Carex comosa	Bottle brush sedge	2	1.39	4.08	1.82	2.00	0
Nuphar variegata	Spatterdock	2	1.39	4.08	1.82	1.50	2
Potamogeton crispus	Curly-leaf pondweed	2	1.39	4.08	1.82	1.00	0

Table 3 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Lower Clam Lake, Burnett County
September 8-9, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sightings
Potamogeton pusillus	Small pondweed	2	1.39	4.08	1.82	1.00	1
	Filamentous algae	2	*	4.08	1.82	1.00	0
Ranunculus aquatilis	White water crowfoot	1	0.69	2.04	0.91	1.00	0
Schoenoplectus tabernaemontani	Softstem bulrush	1	0.69	2.04	0.91	1.00	0
Stuckenia pectinata	Sago pondweed	1	0.69	2.04	0.91	1.00	0
Bolboschoenus fluviatilis	River bulrush	**	**	**	**	**	2
Lythrum salicaria	Purple loosestrife	**	**	**	**	**	3
Phalaris arundinacea	Reed canary grass	**	**	**	**	**	1
Riccia fluitans	Slender riccia	**	**	**	**	**	1
Utricularia vulgaris	Common bladderwort	**	**	**	**	**	1
Myriophyllum verticillatum	Whorled water-milfoil	***	***	***	***	***	***
Phragmites australis americanus	Common reed (native)	***	***	***	***	***	***
Potamogeton epihydrus	Ribbon-leaf pondweed	***	***	***	***	***	***
Schoenoplectus acutus	Hardstem bulrush	***	***	***	***	***	***
Sparganium eurycarpum	Common bur-reed	***	***	***	***	***	***

* Excluded from Relative Frequency Calculation ** Visual Only *** Boat Survey Only

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Lower Clam Lake, Burnett County
August 25, 2019

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Elodea canadensis	Common waterweed	85	20.29	60.28	24.85	1.28	0
Ceratophyllum demersum	Coontail	83	19.81	58.87	24.27	1.29	2
Potamogeton pusillus	Small pondweed	72	17.18	51.06	21.05	1.15	1
Vallisneria americana	Wild celery	23	5.49	16.31	6.73	1.61	4
Potamogeton zosteriformis	Flat-stem pondweed	19	4.53	13.48	5.56	1.16	3
Spirodela polyrhiza	Large duckweed	17	4.06	12.06	4.97	1.12	0
Najas flexilis	Slender naiad	16	3.82	11.35	4.68	1.31	0
Heteranthera dubia	Water star-grass	15	3.58	10.64	4.39	1.27	0
Nymphaea odorata	White water lily	15	3.58	10.64	4.39	1.80	4
Zizania palustris	Northern wild rice	15	3.58	10.64	4.39	2.00	5
	Filamentous algae	13	*	9.22	3.80	1.00	0
Myriophyllum sibiricum	Northern water-milfoil	10	2.39	7.09	2.92	1.20	5
Utricularia vulgaris	Common bladderwort	8	1.91	5.67	2.34	1.13	2
Potamogeton natans	Floating-leaf pondweed	5	1.19	3.55	1.46	1.80	1
Stuckenia pectinata	Sago pondweed	5	1.19	3.55	1.46	1.20	6
Carex comosa	Bottle brush sedge	3	0.72	2.13	0.88	1.00	0
Chara sp.	Muskgrass	3	0.72	2.13	0.88	1.00	0
Eleocharis erythropoda	Bald spikerush	3	0.72	2.13	0.88	1.67	0
Sagittaria latifolia	Common arrowhead	3	0.72	2.13	0.88	2.00	1
Dulichium arundinaceum	Three-way sedge	2	0.48	1.42	0.58	1.50	0
Lemna minor	Small duckweed	2	0.48	1.42	0.58	1.00	0
Lemna trisulca	Forked duckweed	2	0.48	1.42	0.58	1.00	0
Myriophyllum verticillatum	Whorled water-milfoil	2	0.48	1.42	0.58	1.00	0

*Excluded from relative frequency analysis

Table 4 (cont): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Lower Clam Lake, Burnett County
August 25, 2019

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton vaseyi	Vasey's pondweed	2	0.48	1.42	0.58	1.00	0
Schoenoplectus tabernaemontani	Softstem bulrush	2	0.48	1.42	0.58	1.50	0
Typha latifolia	Broad-leaved cattail	2	0.48	1.42	0.58	1.50	2
Potamogeton crispus	Curly-leaf pondweed	1	0.24	0.71	0.29	1.00	0
Potamogeton epihydrus	Ribbon-leaf pondweed	1	0.24	0.71	0.29	1.00	0
Potamogeton richardsonii	Clasping-leaf pondweed	1	0.24	0.71	0.29	1.00	2
Ranunculus aquatilis	White water crowfoot	1	0.24	0.71	0.29	1.00	0
Utricularia minor	Small bladderwort	1	0.24	0.71	0.29	1.00	0
Nuphar variegata	Spatterdock	**	**	**	**	**	2
Bidens beckii	Water marigold	**	**	**	**	**	1
Lythrum salicaria	Purple loosestrife	**	**	**	**	**	1
Bolboschoenus fluviatilis	River bulrush	***	***	***	***	***	***
Phalaris arundinacea	Reed canary grass	***	***	***	***	***	***
Phragmites australis	Common reed	***	***	***	***	***	***
Sagittaria graminea	Grass-leaved arrowhead	***	***	***	***	***	***
Schoenoplectus acutus	Hardstem bulrush	***	***	***	***	***	***
Sparganium eurycarpum	Common bur-reed	***	***	***	***	***	***
Typha X *glauca*	Hybrid cattail	***	***	***	***	***	***

** Visual only   *** Boat survey only

Common waterweed, the most common species in both 2016 (25 sites) and 2019 (85 sites), underwent a highly significant increase **(*p*<0.001)** in distribution. After being largely restricted to the southeast end of the northeast bay in 2016, it showed a dramatic expansion and was found in almost all nearshore areas in 2019. However, many of these newly colonized areas had low density resulting in a non-significant decline (*p*=0.17) in mean rake fullness from 1.44 in 2016 to 1.28 in 2019 (Figure 12).

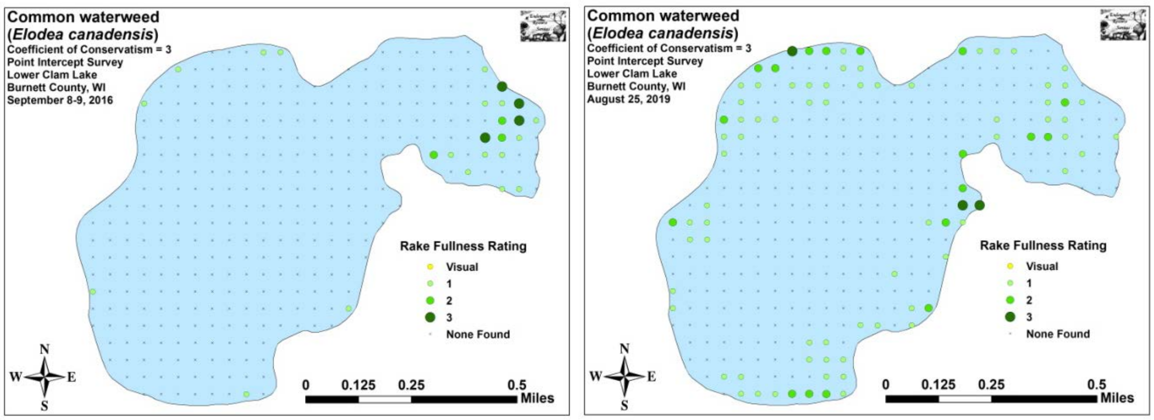


Figure 12: 2016 and 2019 Common Waterweed Density and Distribution

Coontail was the second most common species in both 2016 and 2019. Despite its highly significant increase **(*p*<0.001)** in distribution (18 points in 2016/83 in 2019), we documented a significant decrease **(*p*=0.01)** in density (mean rake fullness of 1.89 in 2016/1.29 in 2019). Visual analysis of the maps showed its expansion closely mirrored Common waterweed (Figure 13).

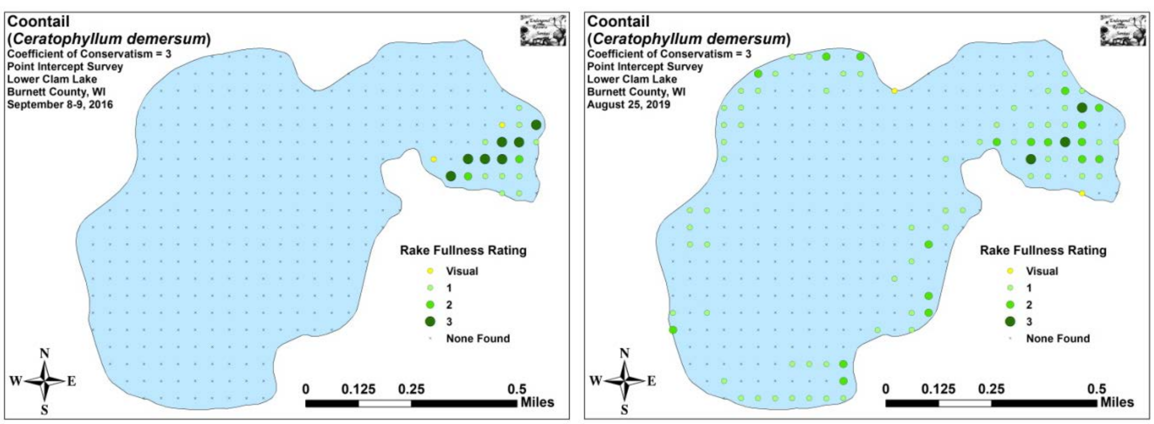


Figure 13: 2016 and 2019 Coontail Density and Distribution

White water lily was the third most common species in 2016 (16 sites) and the eighth most common in 2019 (15 sites). Although its distribution was almost unchanged, we documented a nearly significant increase (*p*=0.11) in density (mean rake fullness of 1.50 in 2016/1.80 in 2019). This was almost identical to Slender naiad which, despite increasing in distribution from 11 sites in 2016 to 16 sites in 2019, fell in rank from the fourth most common species to just the seventh. It also saw a nearly significant increase (*p*=0.08) in mean rake fullness from 1.09 in 2016 to 1.31 in 2019.

Wild celery more than doubled its distribution from 10 sites in 2016 (fifth most common species) to 23 sites in 2019 (fourth most common species). Although this was a significant increase **(*p*=0.02)** in distribution, the accompanying increase in density from a mean rake of 1.50 in 2016 to a mean rake of 1.61 in 2019 was not significant (*p*=0.31) (Figure 14).

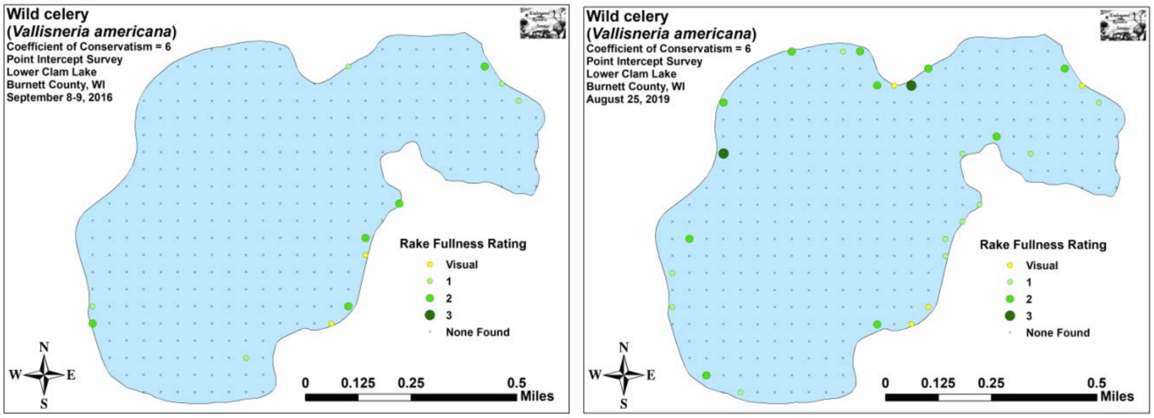


Figure 14: 2016 and 2019 Wild Celery Density and Distribution

In 2016, Small pondweed was present at just two points with each sample represented by a single plant (Figure 15). Following highly significant increases **(*p*<0.001)** in both distribution (72 points) and density (mean rake fullness of 1.15), it became the third most common species (up from 17th in 2016) and was present along the shoreline throughout the entire lake.

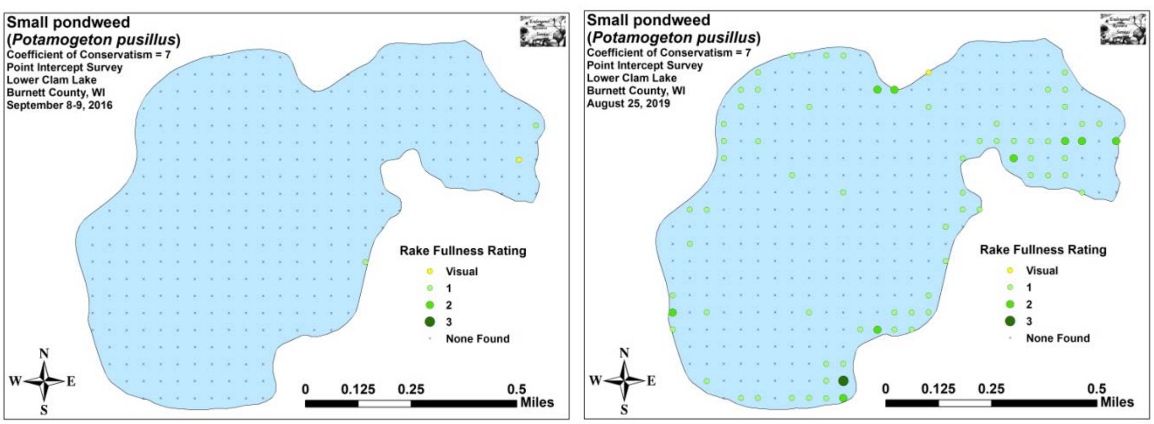


Figure 15: 2016 and 2019 Small Pondweed Density and Distribution

Comparison of Floristic Quality Indexes in 2016 and 2019:

In 2016, we found 22 **native index species** in the rake during the point-intercept survey (Table 5). They produced a mean Coefficient of Conservatism of 5.0 and a Floristic Quality Index of 23.7.

Table 5: Floristic Quality Index of Aquatic Macrophytes Lower Clam Lake, Burnett County September 8-9, 2016

Species	Common Name	C
Carex comosa	Bottle brush sedge	5
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Eleocharis erythropoda	Bald spikerush	3
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Myriophyllum sibiricum	Northern water-milfoil	6
Najas flexilis	Slender naiad	6
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Potamogeton natans	Floating-leaf pondweed	5
Potamogeton pusillus	Small pondweed	7
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8
Sagittaria latifolia	Common arrowhead	3
Schoenoplectus tabernaemontani	Softstem bulrush	4
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Typha latifolia	Broad-leaved cattail	1
Vallisneria americana	Wild celery	6
Zizania palustris	Northern wild rice	8
N		**22**
Mean C		**5.0**
FQI		**23.7**

In 2019, we found a total of 29 **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 31.2 (Table 6). All of these values represented a sharp increase from 2016 totals. They were also the highest values found during any of the previous surveys (22 species/Mean C 5.2/FQI 24.5 in 2015; 16 species/Mean C 4.8/FQI 19.3 in 2014; 19 species/Mean C 4.9/FQI 21.3 in 2012; 24 species/Mean C 5.3/FQI 26.1 in 2009). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Ecoregion of 6.7 meaning Lower 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 Lower Clam Lake, Burnett County August 25, 2019

Species	Common Name	C
Carex comosa	Bottle brush sedge	5
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Dulichium arundinaceum	Three-way sedge	9
Eleocharis erythropoda	Bald spikerush	3
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
Nymphaea odorata	White water lily	6
Potamogeton epihydrus	Ribbon-leaf pondweed	8
Potamogeton natans	Floating-leaf pondweed	5
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton vaseyi	Vasey's pondweed	10
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	White water crowfoot	8
Sagittaria latifolia	Common arrowhead	3
Schoenoplectus tabernaemontani	Softstem bulrush	4
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Typha latifolia	Broad-leaved cattail	1
Utricularia minor	Small bladderwort	10
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
Zizania palustris	Northern wild rice	8
N		**29**
Mean C		**5.8**
FQI		**31.2**

Comparison of Northern Wild Rice from 2009 – 2019:

The 2009 and 2012 surveys found a very limited number of wild rice plants growing along the margins of the east bay (Figure 16). By 2014, the number and density of plants appeared to be much increased albeit not covering a wide enough area to be quantified by the survey as it was only found in the rake at two points (mean rake fullness of 2.00) with two additional visual sightings. In 2015, we found rice in the rake at five points (mean rake fullness of 2.00) with five additional visuals sightings.

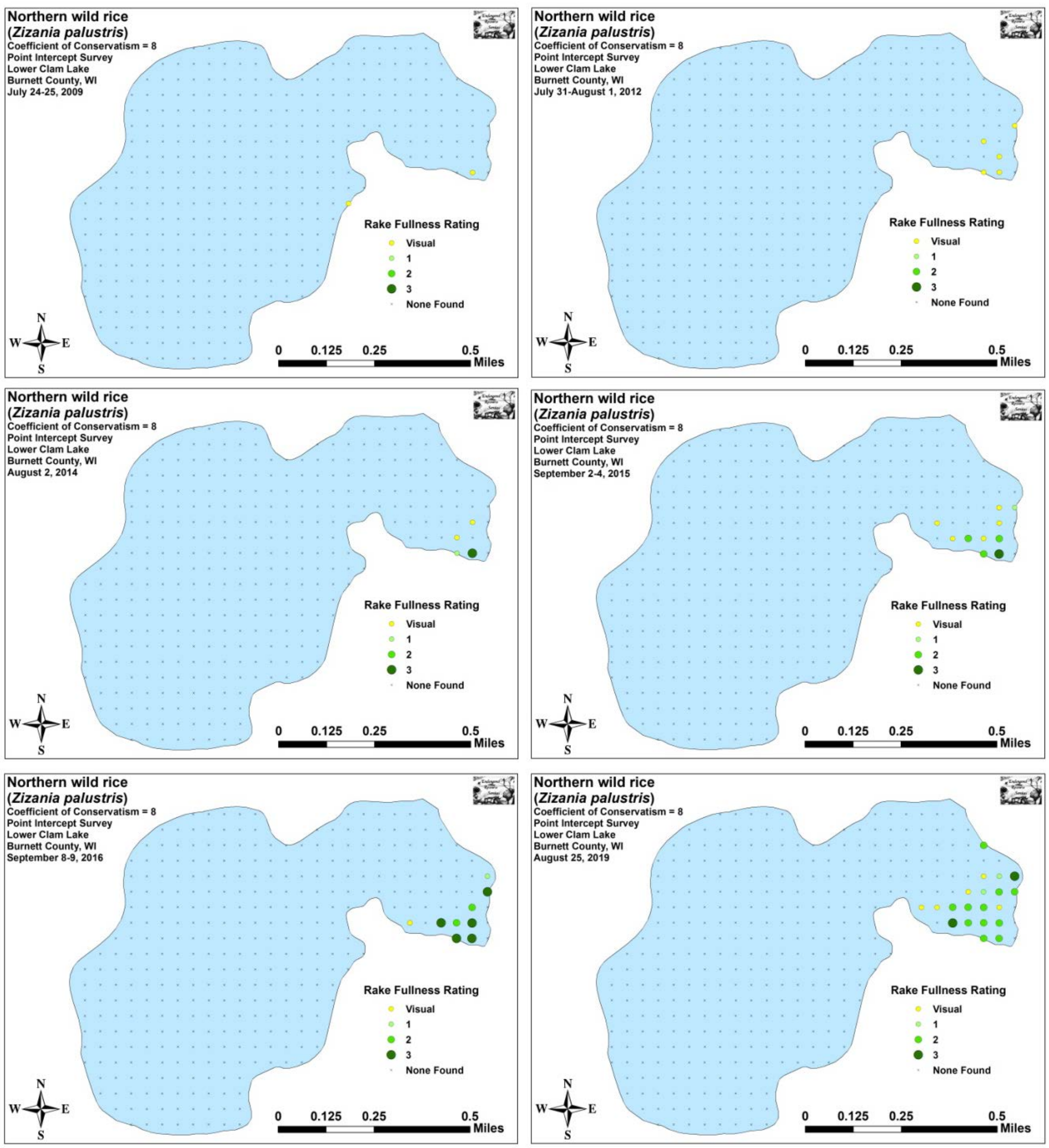


Figure 16: 2009, 2012, 2014, 2015, 2016, and 2019 Northern Wild Rice Density and Distribution

The 2016 survey documented a continued spread and thickening as rice was in the rake at eight points (mean rake fullness of 2.50) with an additional visual sighting. In 2019, rice underwent a further non-significant expansion (p=0.14) to 15 points with five additional visual sightings. Conversely, its density saw a nearly significant decline (p=0.06) to a mean rake fullness of 2.00 (Figure 16) (Appendix VII). The west side of the bay (Figure 17) continued to be somewhat patchy, but the eastern side was so dense that the beds offered significant human harvest potential, albeit over a relatively small area (Figure 18).

Figure 17: Panorama of Northern Wild Rice in Southeast Corner of East Bay Facing Southeast - 8/25/19

Figure 18: Panorama of Northern Wild Rice from Southeast Corner of East Bay Facing Northwest - 8/25/19

Comparison of Filamentous Algae in 2016 and 2019:

Filamentous algae, normally associated with excessive nutrients in the water column, underwent a moderately significant increase **(*p*=0.004)** in distribution from two points in 2016 to 13 points in 2019 (Figure 19). Despite this expansion, the mean rake fullness was 1.00 for each year suggesting the amount of free nutrients was not severe.

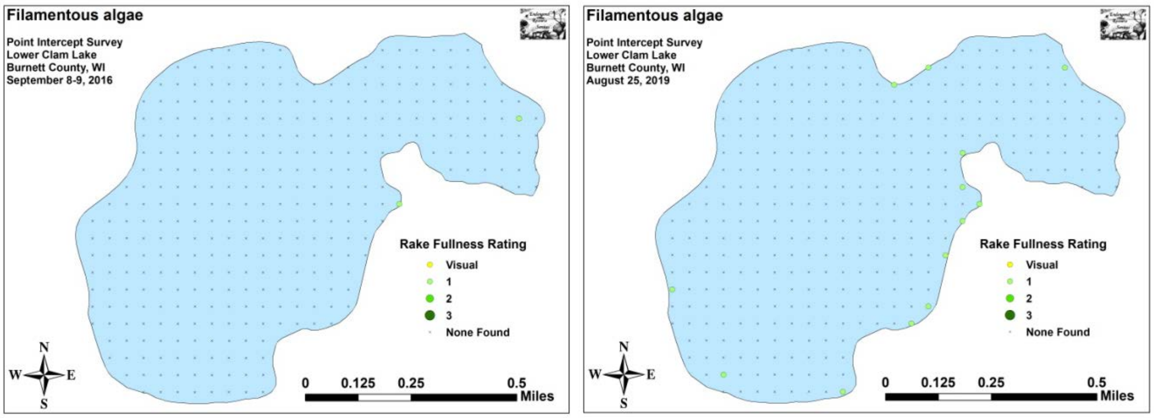


Figure 19: 2016 and 2019 Filamentous Algae Density and Distribution

Comparison of Late Summer 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, CLP was still present at two points (mean rake fullness 1.00). In 2019, we documented it at a single point with a rake fullness of 1 (Figure 20) (Appendix VIII).

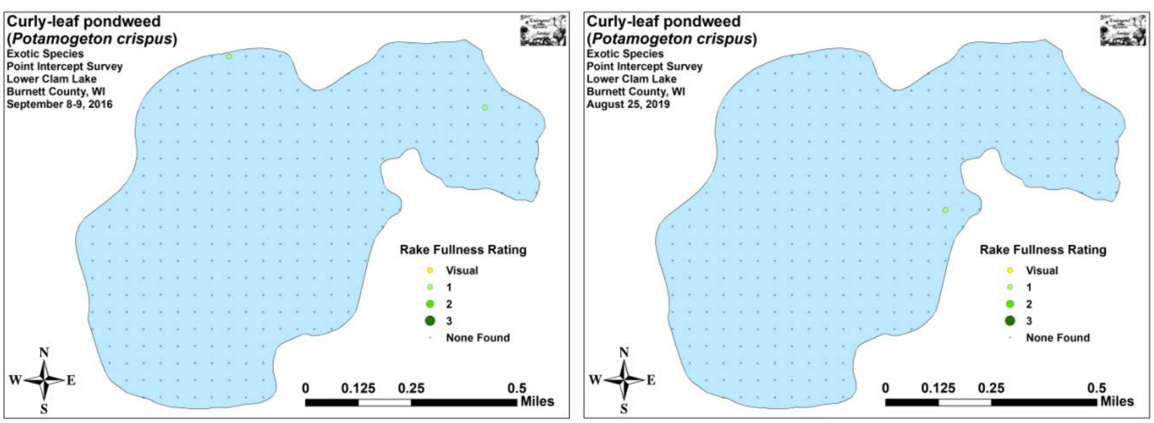


Figure 20: 2016 and 2019 Late Summer CLP Density and Distribution

Other Exotic Plant Species:

We did NOT find any evidence or Eurasian water-milfoil in Lower Clam Lake during any of our surveys. However, in addition to Curly-leaf pondweed, we documented three other exotic species growing around the lake: Purple loosestrife (PL), Reed canary grass (RCG), and Hybrid cattail (HC). PL showed a noticeable uptick around the lake. Previously largely restricted to the southeast shoreline of the east bay, in 2019, we found satellite clusters around much of the lake (Figure 21).

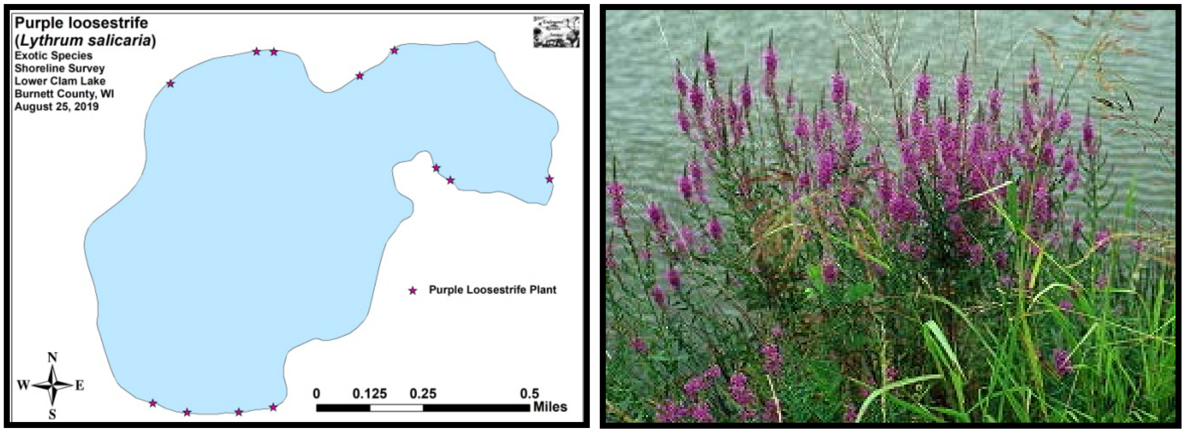


Figure 21: 2019 Purple Loosestrife Distribution and Inflorescence

Despite only being recorded as a visual at one point in 2016 (Figure 22) and only seen during the boat survey in 2019, 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).

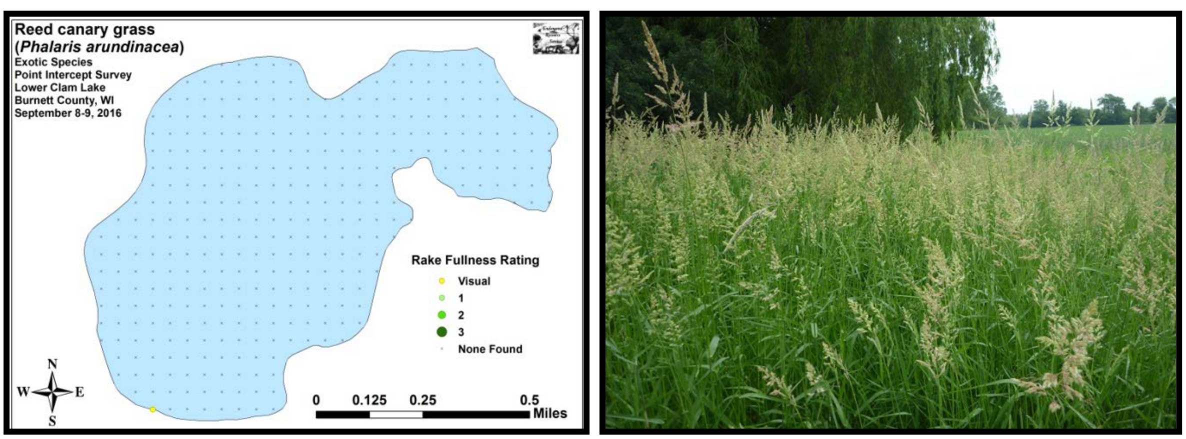


Figure 22: 2016 Reed Canary Grass Density and Distribution and Inflorescence

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. We found a single stand of Narrow-leaved cattail/Hybrid cattail on the western edge of the northeast point where they appeared to be expanding in shallow water and crowding out other emergent species (Figure 23).

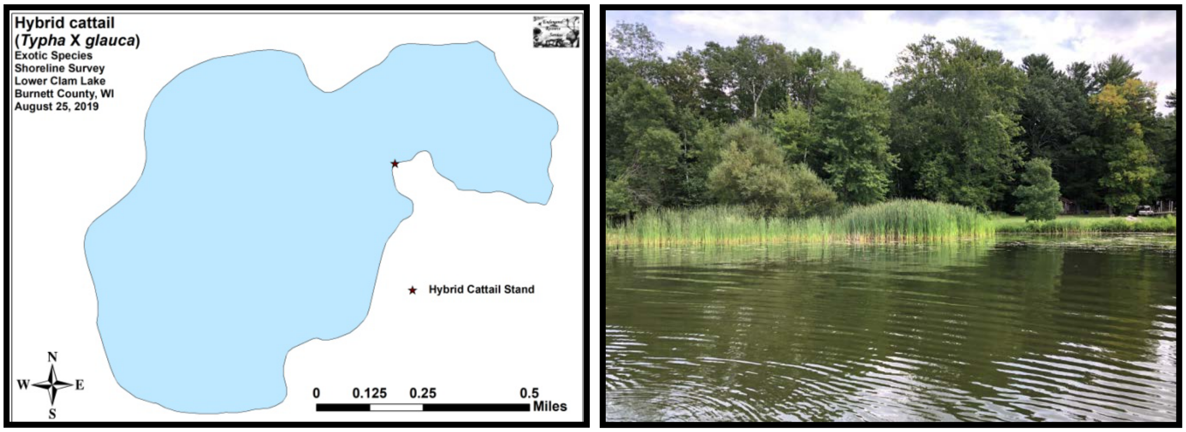


Figure 23: 2019 Hybrid Cattail Distribution and Stand on East Shoreline

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 24) (Appendix VIII).

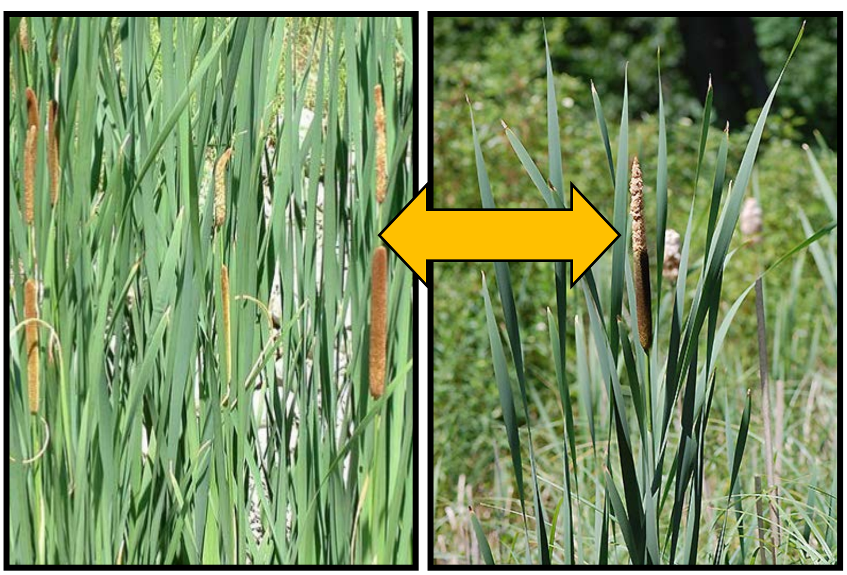


Figure 24: Exotic Hybrid and Native Broad-leaved Cattail Identification

Common reed (*Phragmites australis*), a potentially highly invasive species in its exotic form, is also found on Lower Clam Lake. Fortunately, careful analysis of the plants present showed their leaf sheaths are detached, and the culms (stems) are red in color (Figure 25). These characteristics suggest it is the native subspecies *americanus* which is NOT generally invasive. The bed also has native plants mixed in with it, has occurred at the same location on the lake since our first survey in 2009, and, anecdotally at least, doesn't seem to be expanding. Although the bed deserves to be looked at again in the future, based on all these considerations, we aren't overly concerned about its presence at this time.

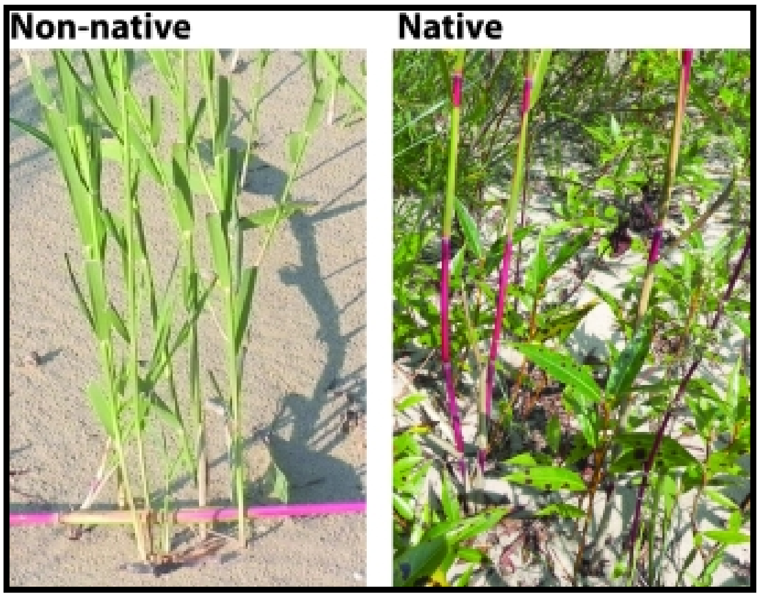


Figure 25: Stem Pattern on Exotic vs. Native Common Reed

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. Because of their role in providing both habitat and water purification, we strongly encourage managers to work to avoid harvesting these native nearshore beds unless absolutely necessary to relieve navigation impairment.

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 the east bay, we found very few uprooted rice plants or lilypad roots/stems in this area. Also on the positive side, the wild rice bed in the uninhabited areas of the eastern bay seems to have thickened and stabilized with rice now appearing to occupy most if not all available habitat in this area.

Curly-leaf Pondweed Management:

The sharp uptick in Curly-leaf pondweed is another indicator of the Carp population's decline. Although the increase in native vegetation associated with Carp decline is a positive from a habitat standpoint, the tendency for CLP to grow to canopy and impair navigation is frustrating. Because CLP can spread rapidly by turions, it is likely that the springtime beds will continue to expand to previous levels when it dominated the majority of the lake's littoral zone. Consequently, harvesting in many areas of the lake is once again likely to be an annual chore to maintain navigation lanes.

Purple Loosestrife Management:

The 2019 survey found Purple Loosestrife was noticeably more common than in 2016, and inspection of plants showed no evidence of the Loosestrife beetles (*Galerucella* spp.) released on Lower Clam Lake in June/July 2015 by Grantsburg High School students and the Burnett County Land and Water Conservation office. If beetles don't recover in the near future, it may be time to raise another batch for release on the lake. In the mean time, we again encourage all residents to watch for and remove any PL plants in August and September when the bright fuchsia candle-shaped flower spikes are easily seen. Plants should be bagged and disposed of well away from any wetland. Also, because the plants have an extensive root system, care should be taken to remove the entire plant as even small root fragments can survive and produce new plants the following year.

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

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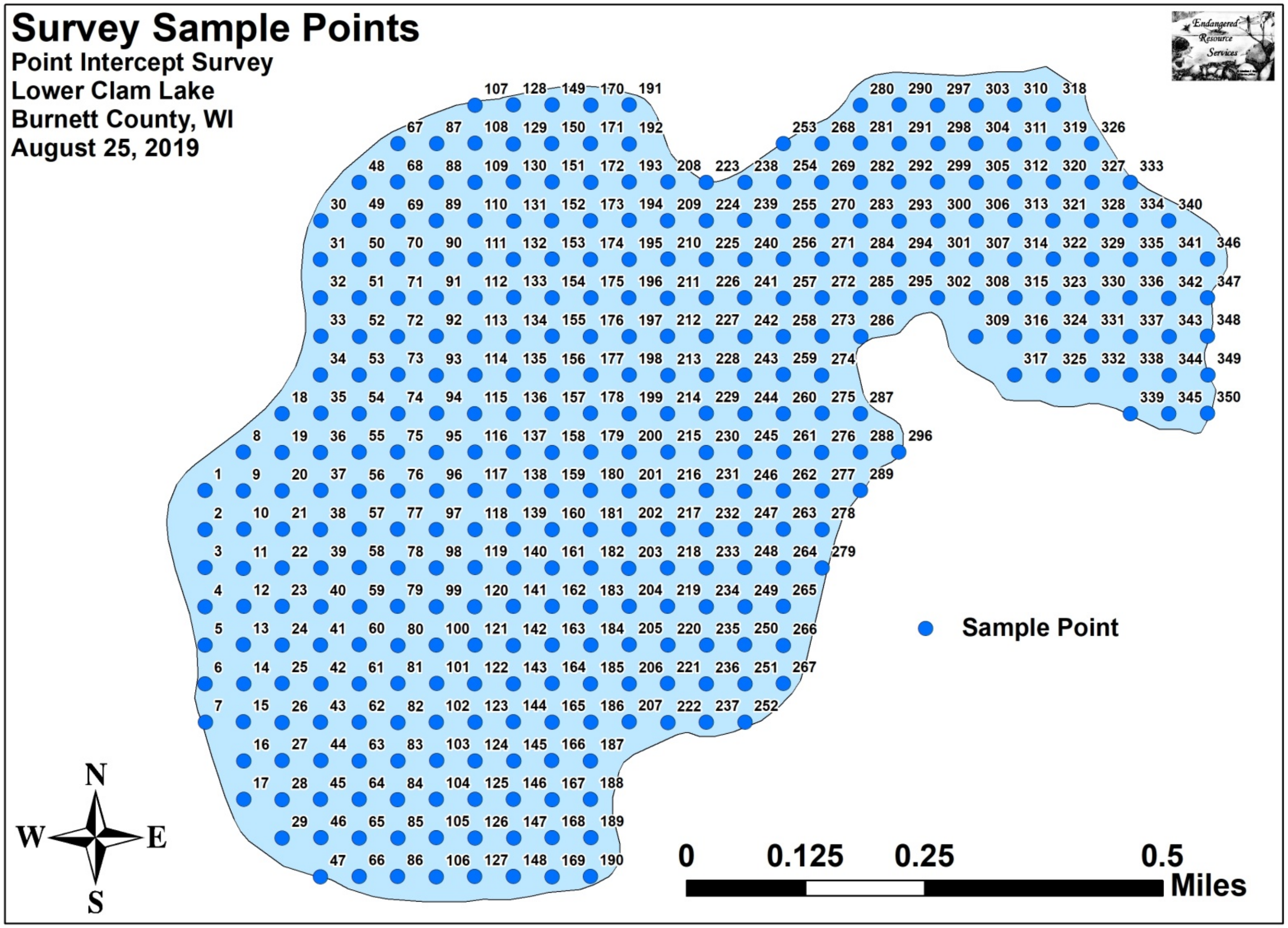
Appendix I: Survey Sample Points Map

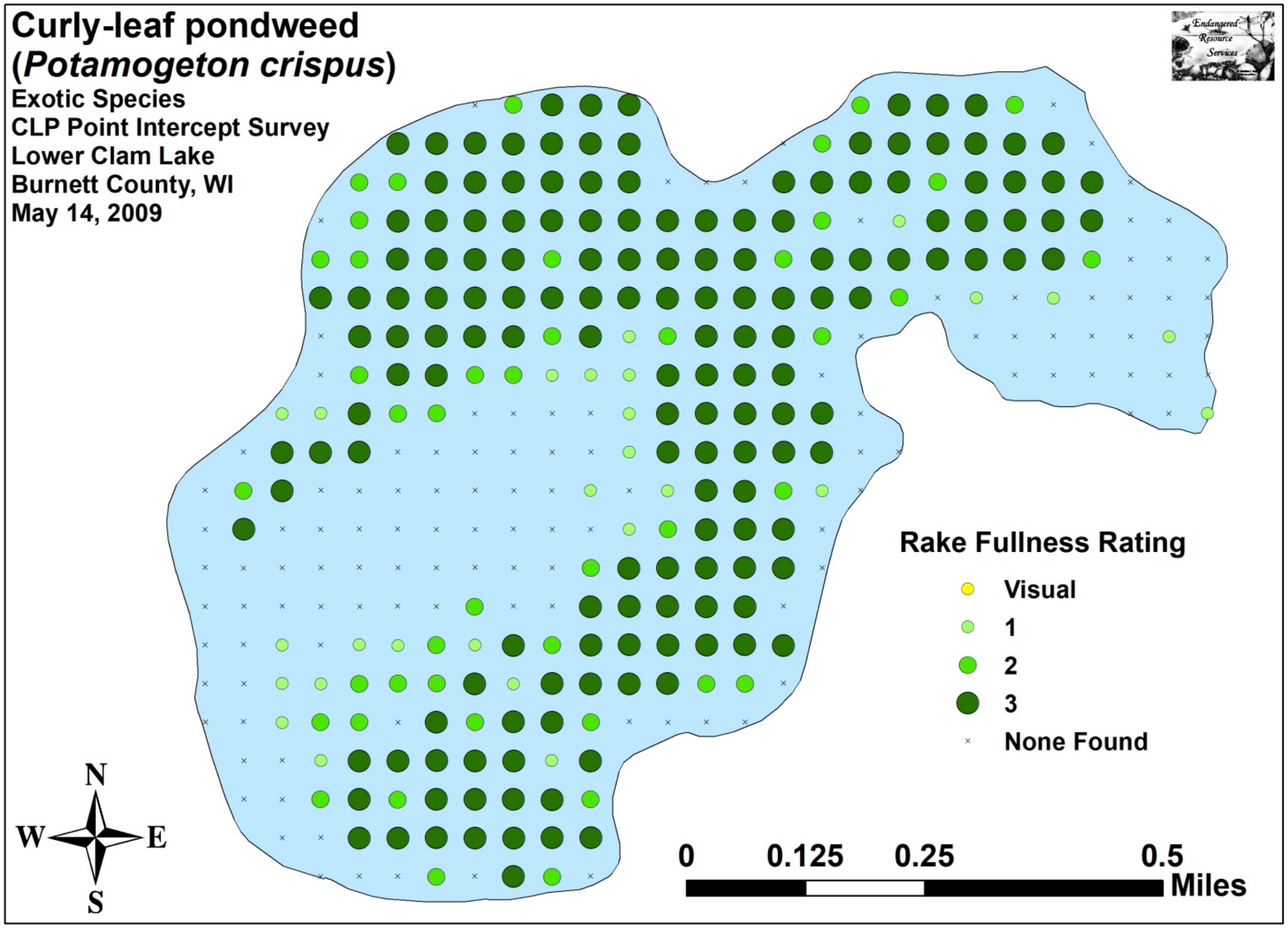

Survey Sample Points
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Sample Point
0
0.125
0.25
0.5
Miles
N
S
W
E

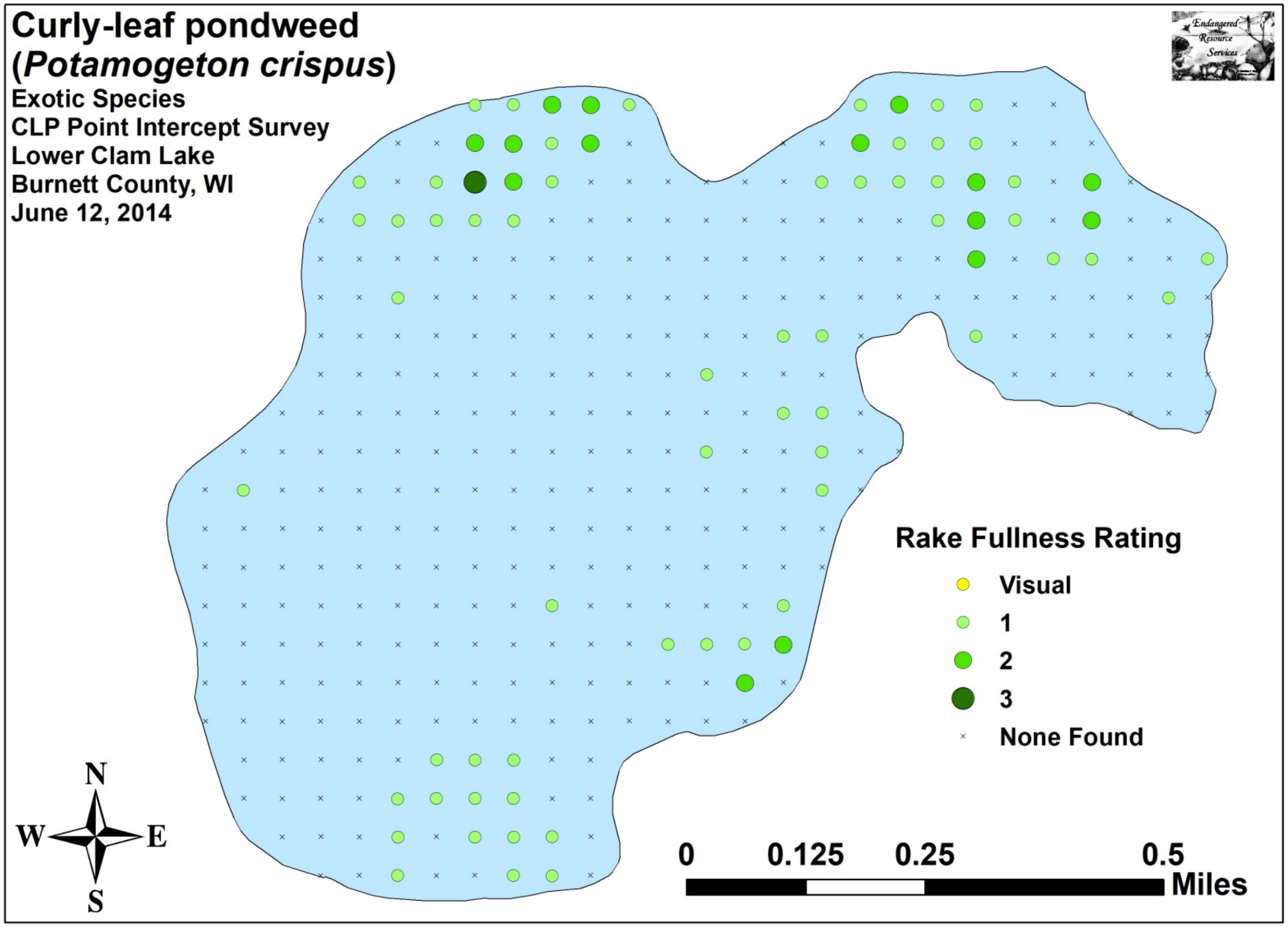
Appendix II: Boat and Vegetative Survey Datasheets

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

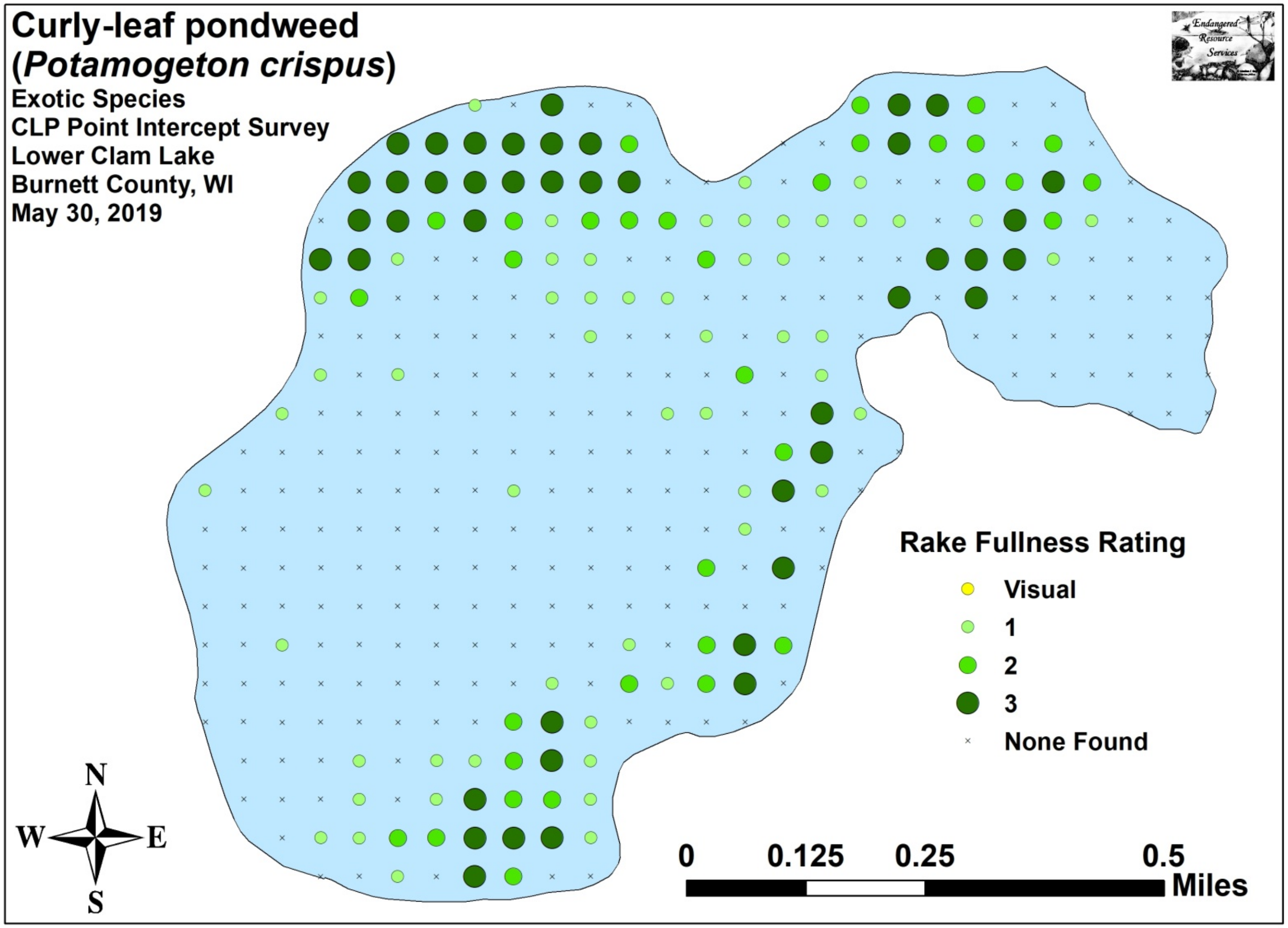
Observers for this lake: names and hours worked by each:																									
Lake:									**WBIC**									**County**						**Date:**	
Site #	**Depth (ft)**	**Muck (M), Sand (S), Rock (R)**	**Rake pole (P) or rake rope (R)**	**Total Rake Fullness**	**EWM**	**CLP**	**1**	**2**	**3**	**4**	**5**	**6**	**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																									

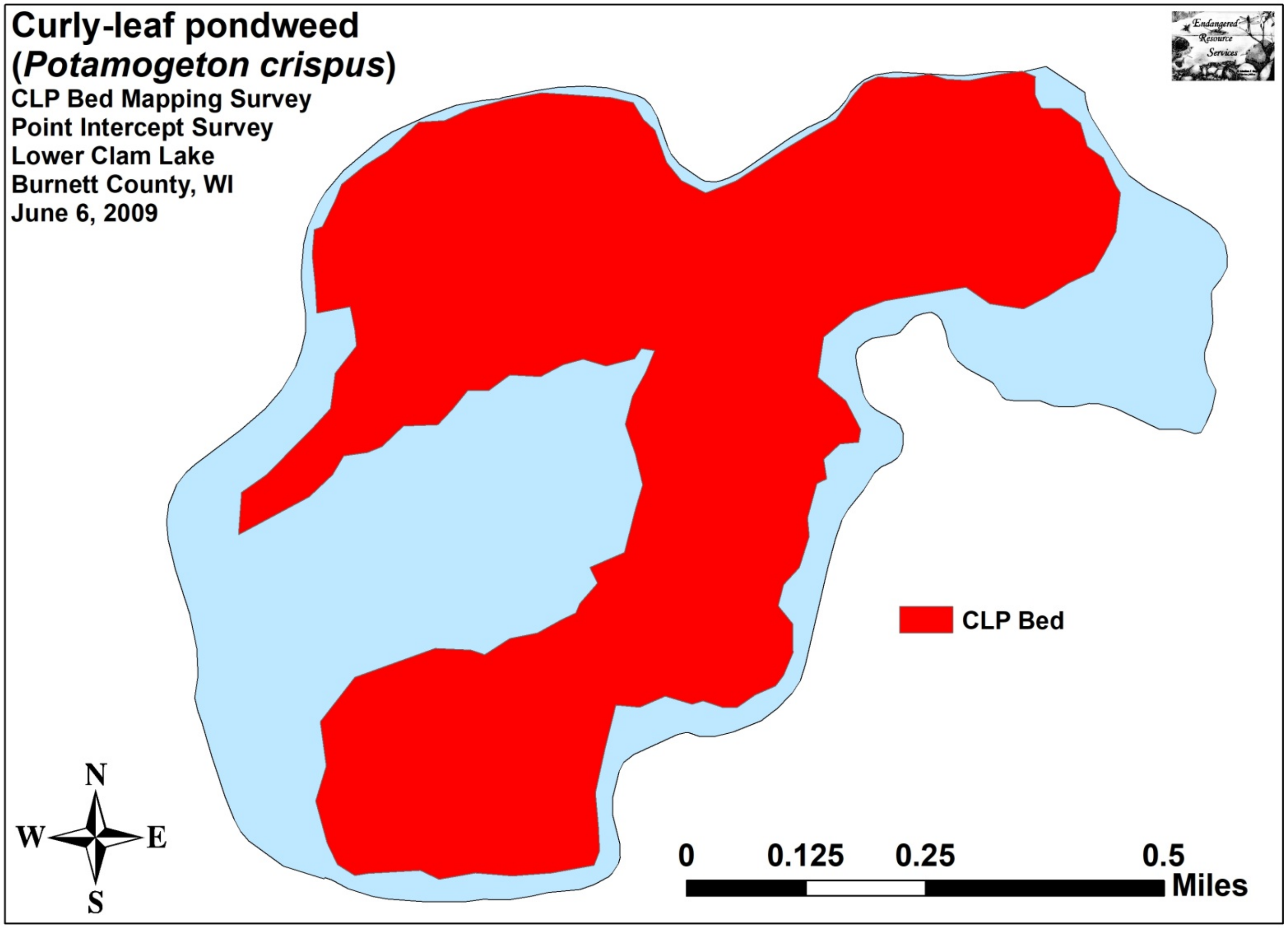
Appendix III: 2009, 2014, and 2019 Early-season CLP Density and Distribution and CLP Bed Maps

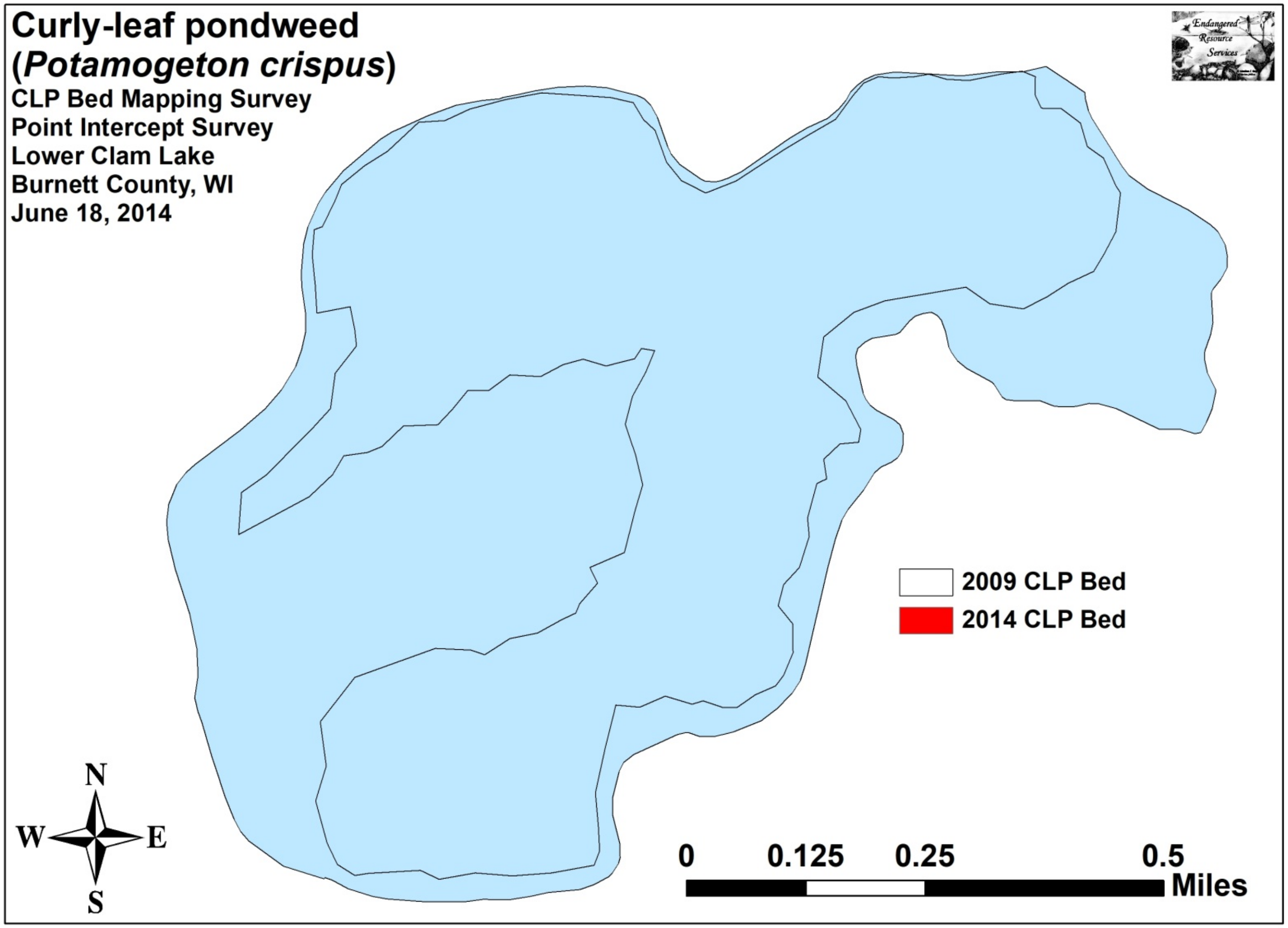

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Point Intercept Survey
Lower Clam Lake
Burnett County, WI
May 14, 2009
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

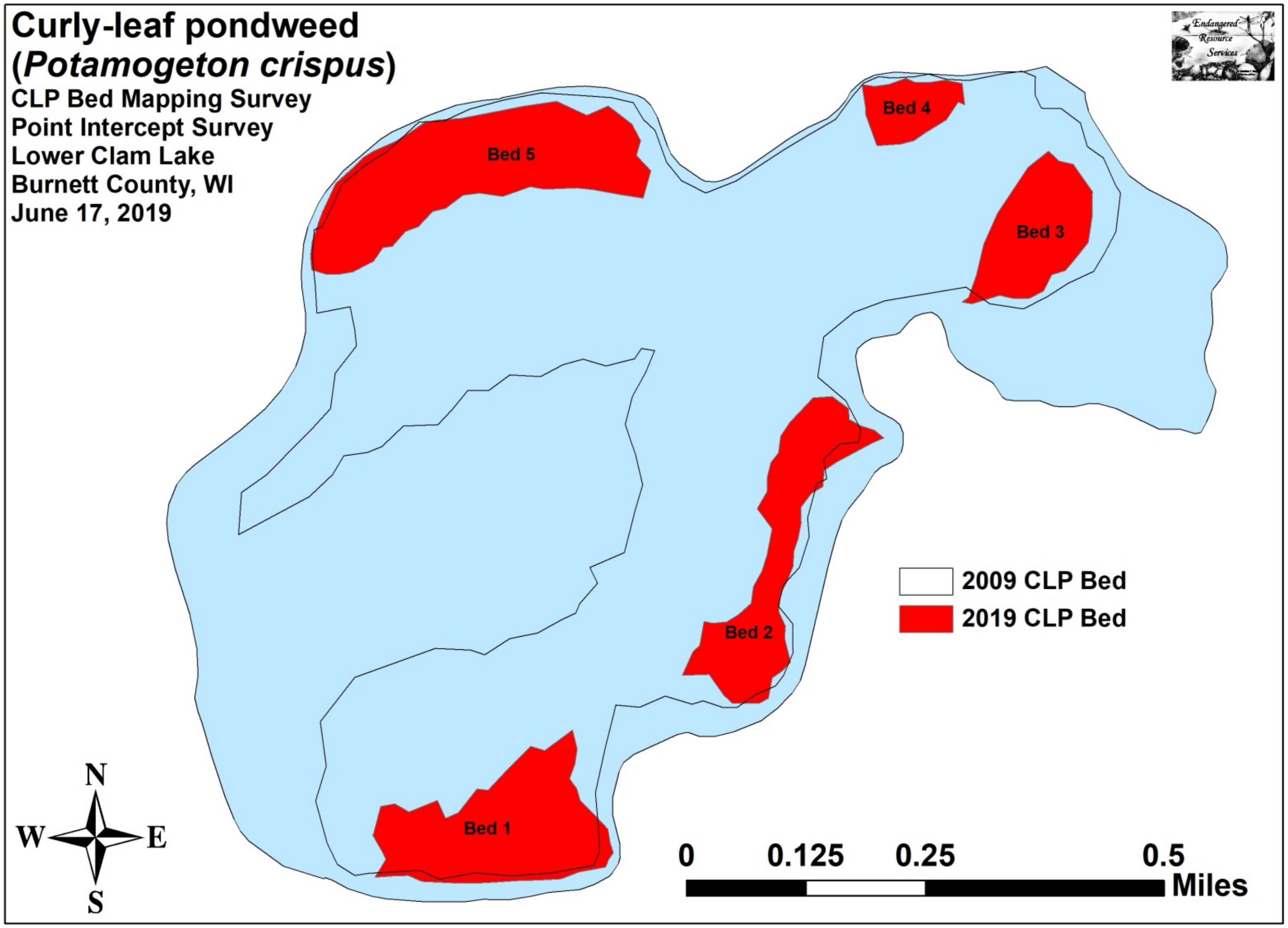


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Point Intercept Survey
Lower Clam Lake
Burnett County, WI
June 12, 2014
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

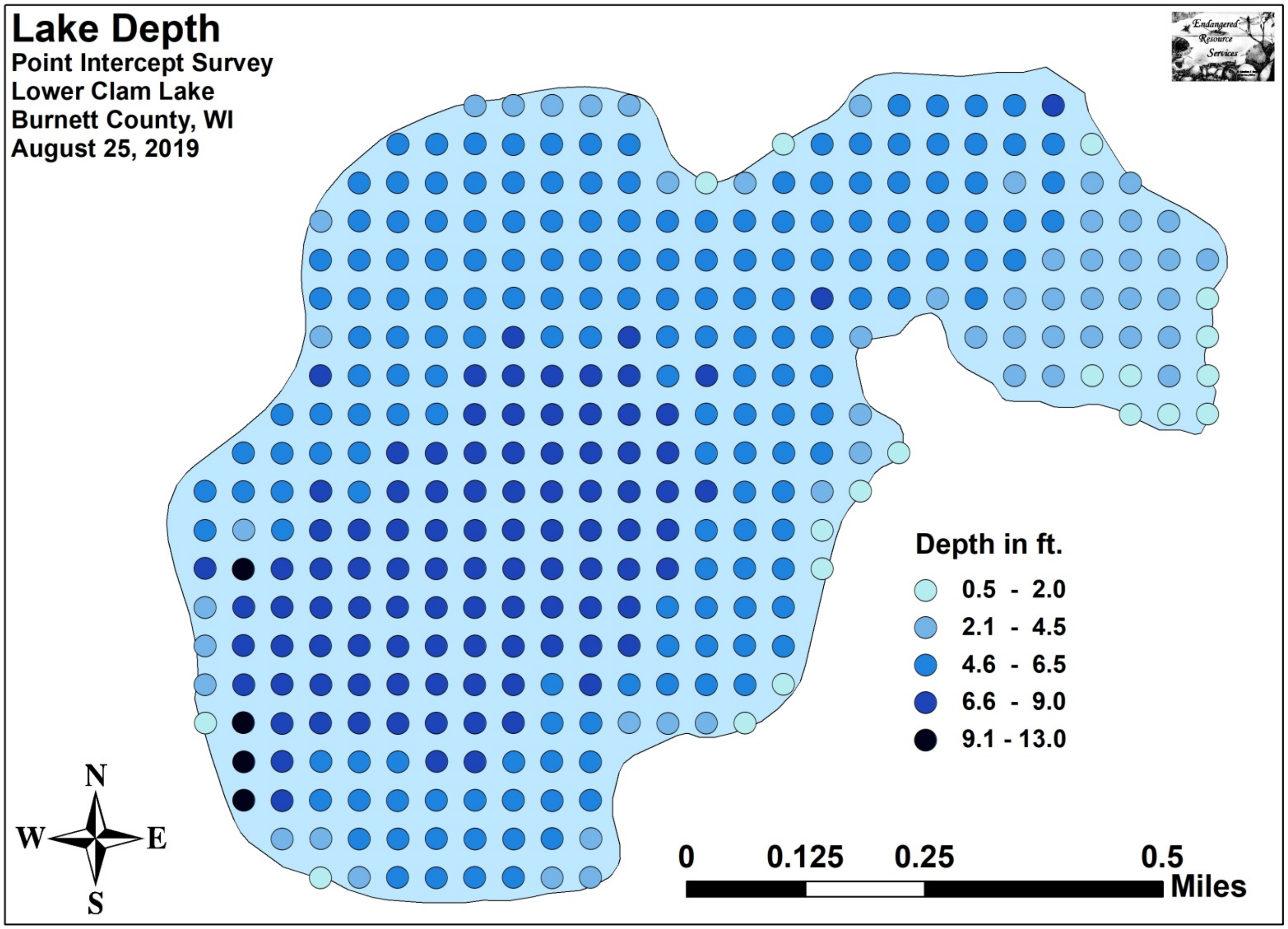

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Point Intercept Survey
Lower Clam Lake
Burnett County, WI
May 30, 2019
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles


Curly-leaf pondweed
(*Potamogeton crispus*)
CLP Bed Mapping Survey
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
June 6, 2009
Endangered Resource Services
CLP Bed
N
W
E
S
0
0.125
0.25
0.5
Miles

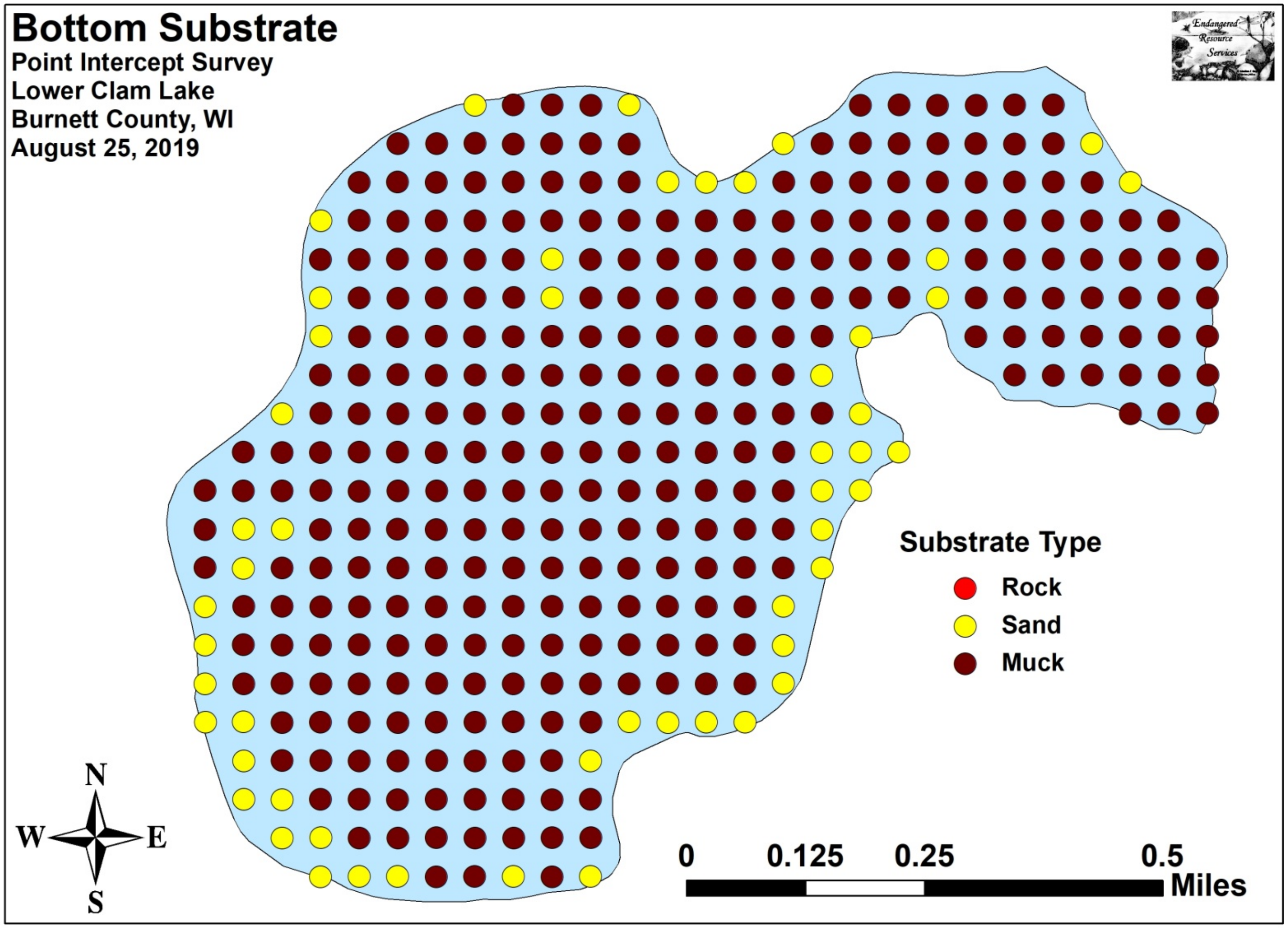

Curly-leaf pondweed
(*Potamogeton crispus*)
CLP Bed Mapping Survey
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
June 18, 2014
2009 CLP Bed
2014 CLP Bed
N
W
E
S
0
0.125
0.25
0.5
Miles


Curly-leaf pondweed
(*Potamogeton crispus*)
CLP Bed Mapping Survey
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
June 17, 2019
Endangered Resource Services
Bed 1
Bed 2
Bed 3
Bed 4
Bed 5
2009 CLP Bed
2019 CLP Bed
N
S
E
W
0
0.125
0.25
0.5
Miles

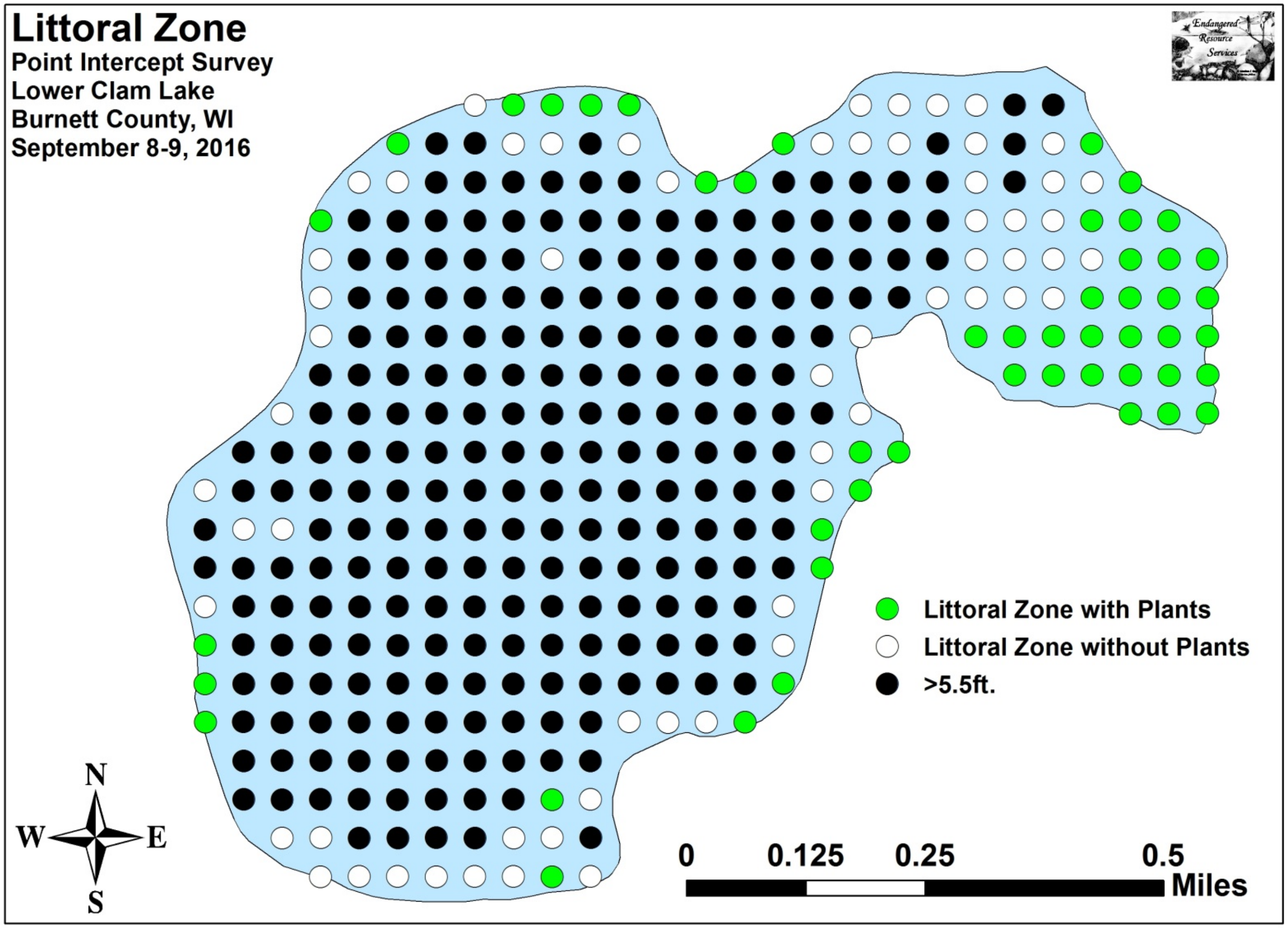
Appendix IV: Habitat Variable Maps

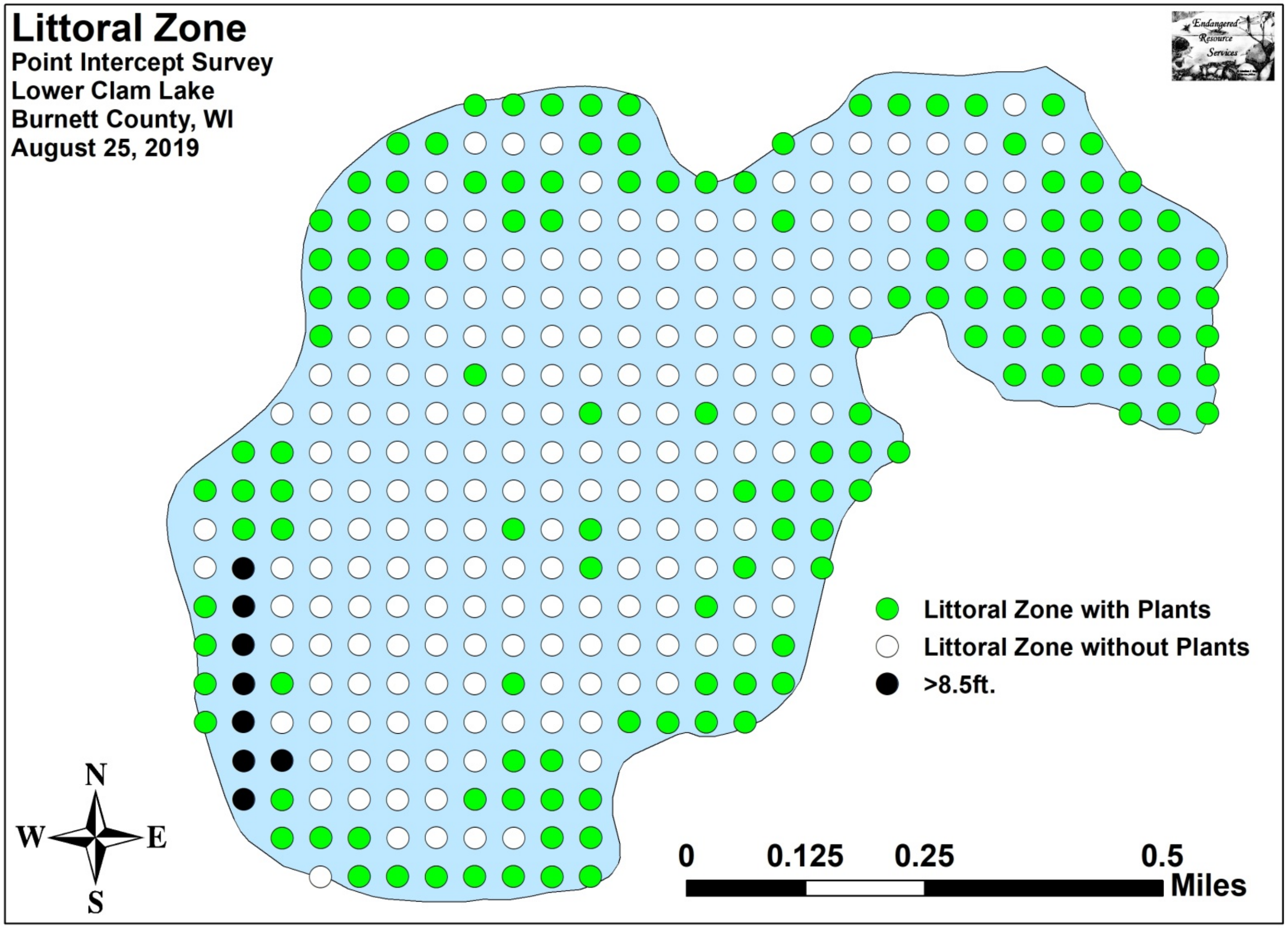


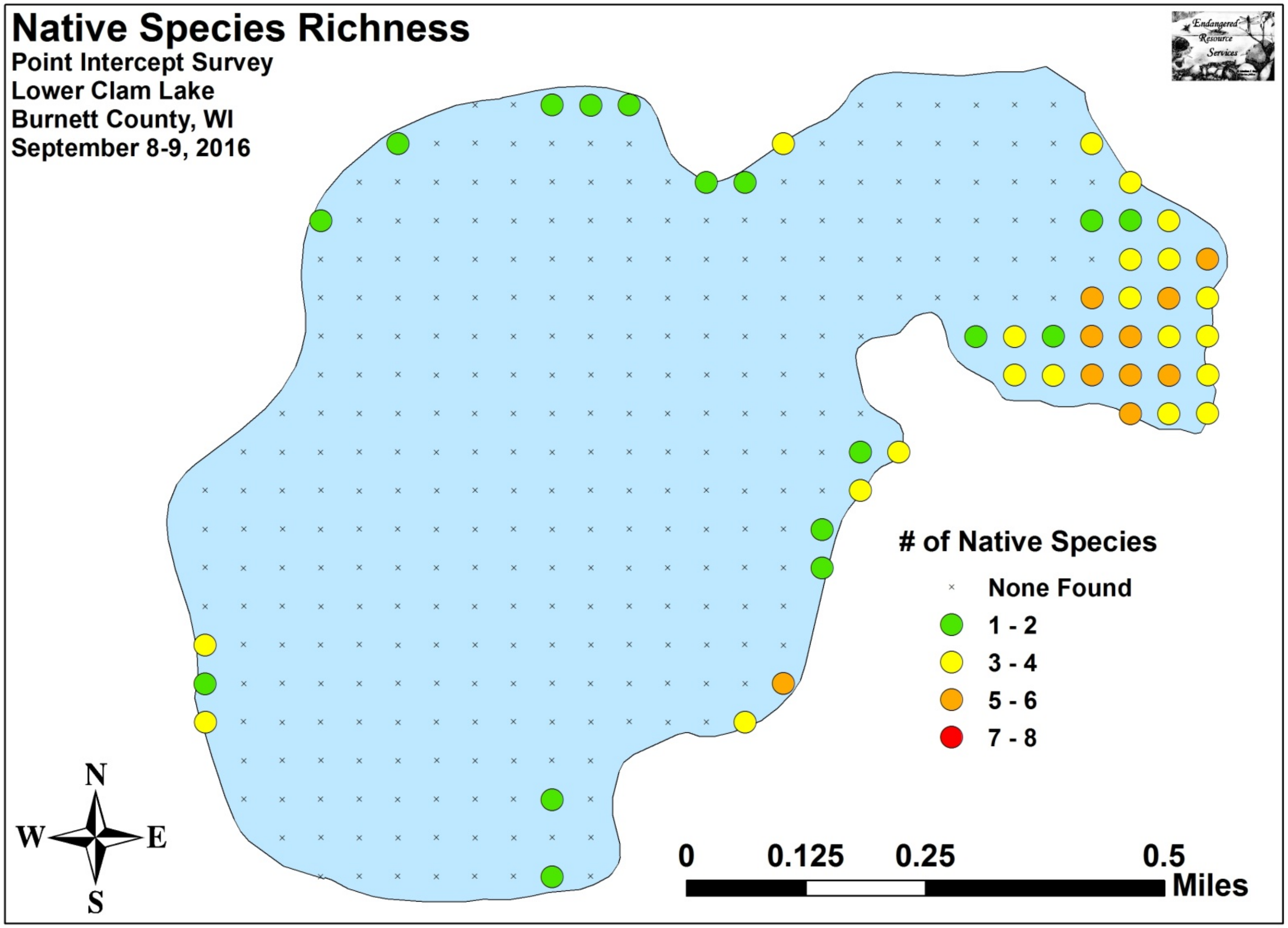
Lake Depth
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Depth in ft.
0.5 - 2.0
2.1 - 4.5
4.6 - 6.5
6.6 - 9.0
9.1 - 13.0
N
W
E
S
0
0.125
0.25
0.5
Miles


Bottom Substrate
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Substrate Type
Rock
Sand
Muck
N
W
E
S
0
0.125
0.25
0.5
Miles

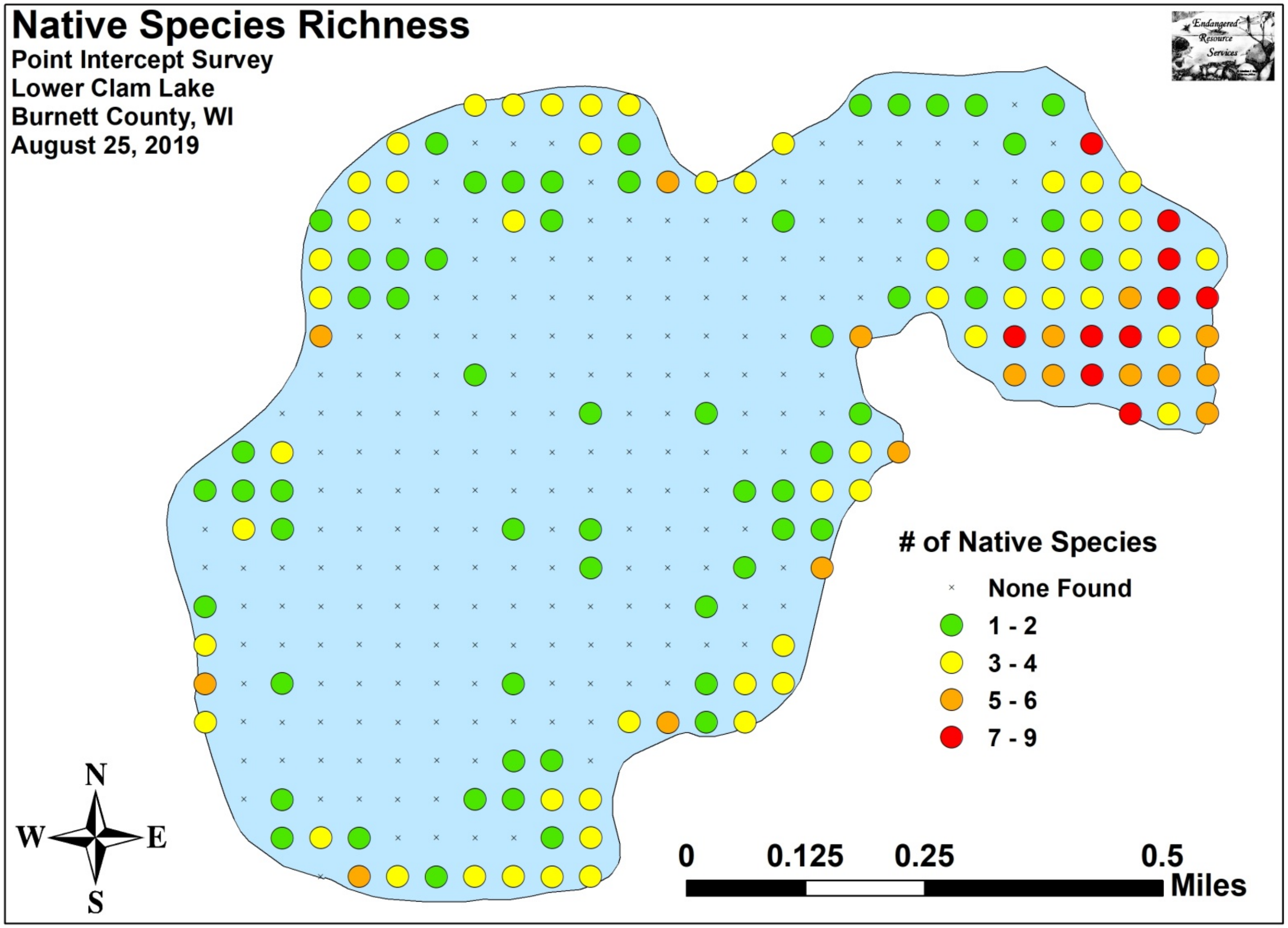
Appendix V: 2016 and 2019 Littoral Zone, Native Species Richness, and Total Rake Fullness Maps

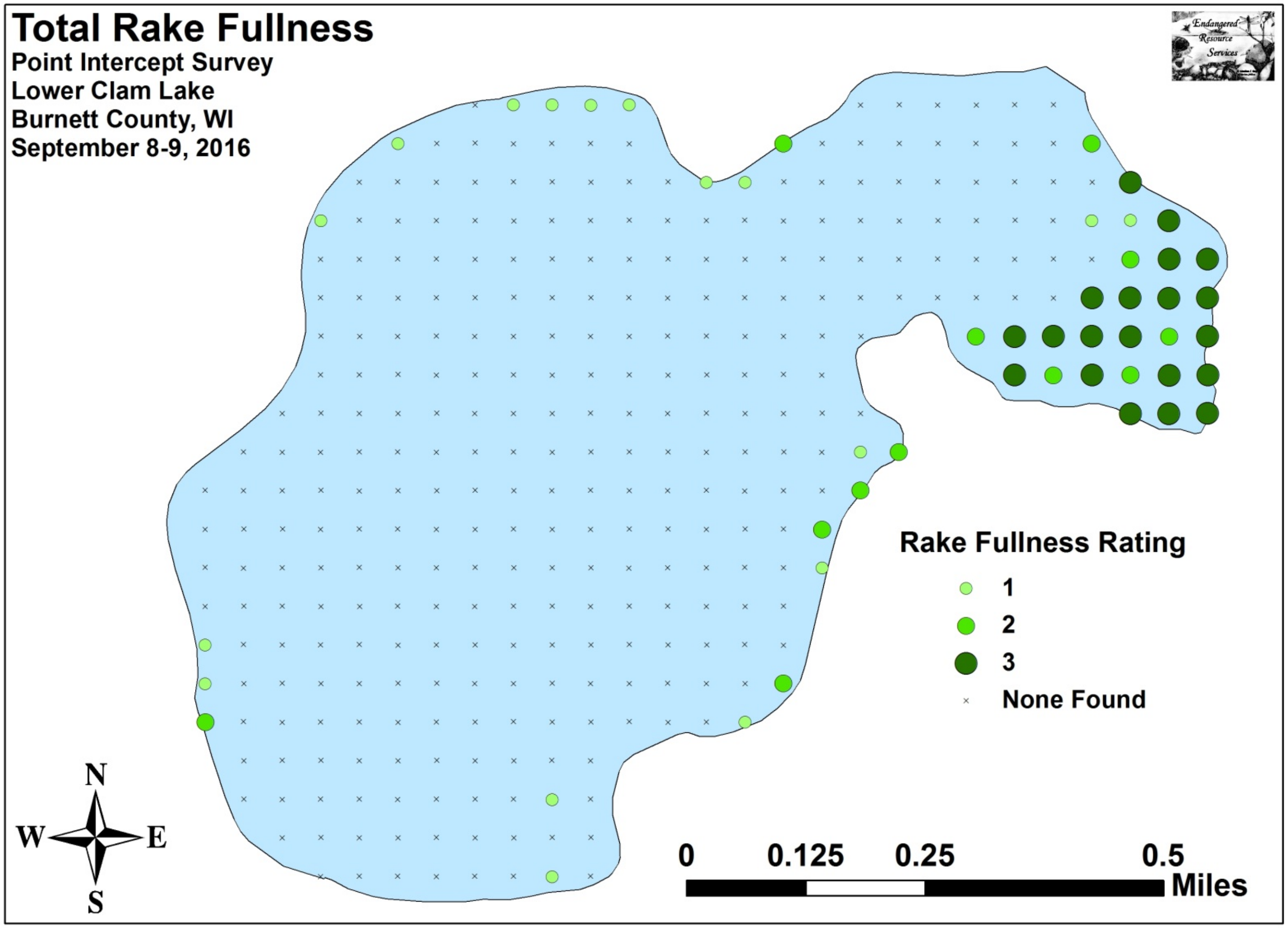

Littoral Zone
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
September 8-9, 2016
Littoral Zone with Plants
Littoral Zone without Plants
>5.5ft.
N
W
E
S
0
0.125
0.25
0.5
Miles


Littoral Zone
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Littoral Zone with Plants
Littoral Zone without Plants
>8.5ft.
N
W
E
S
0
0.125
0.25
0.5
Miles

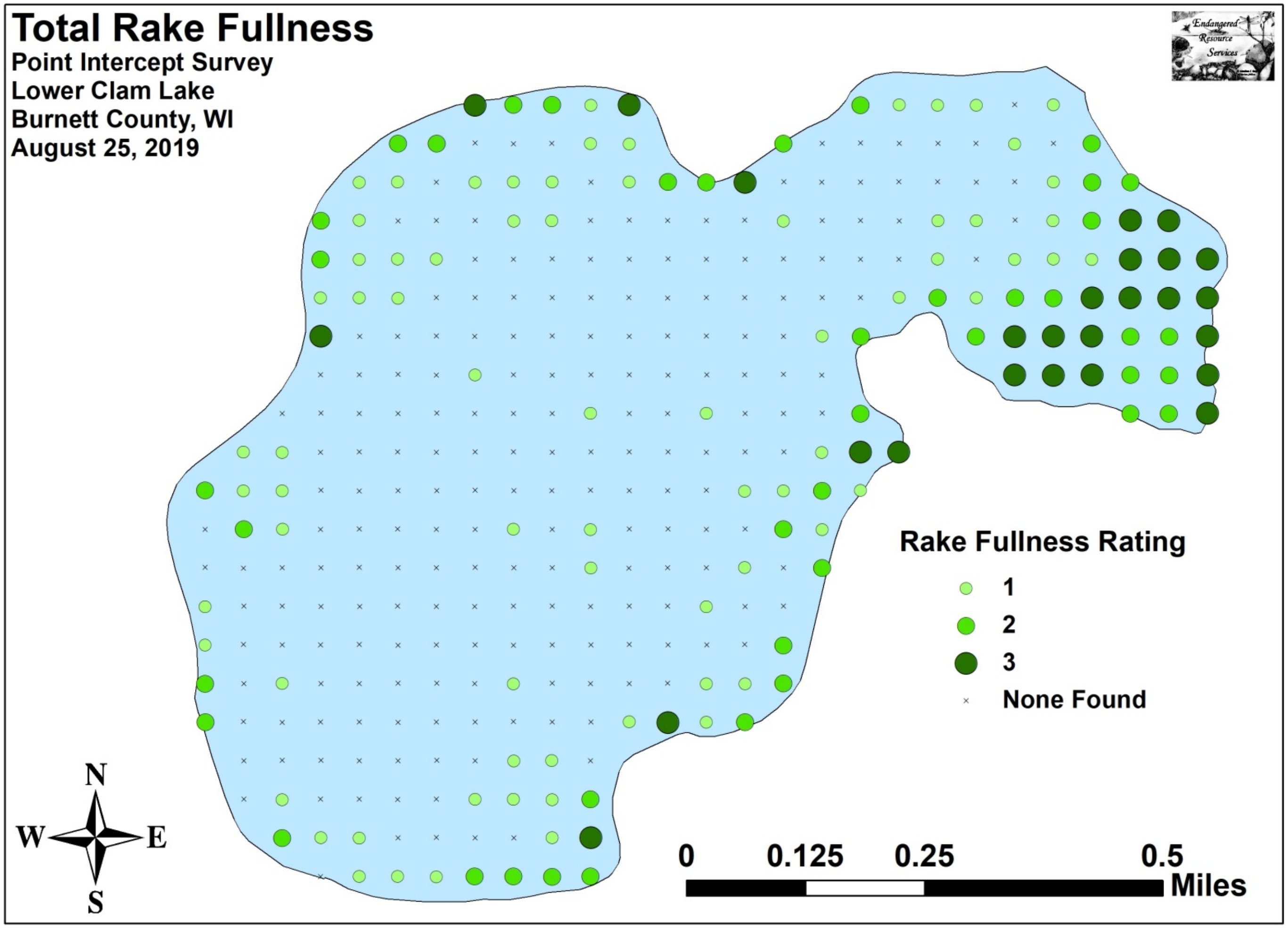


Native Species Richness
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
September 8-9, 2016
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
N
W
E
S
0
0.125
0.25
0.5
Miles

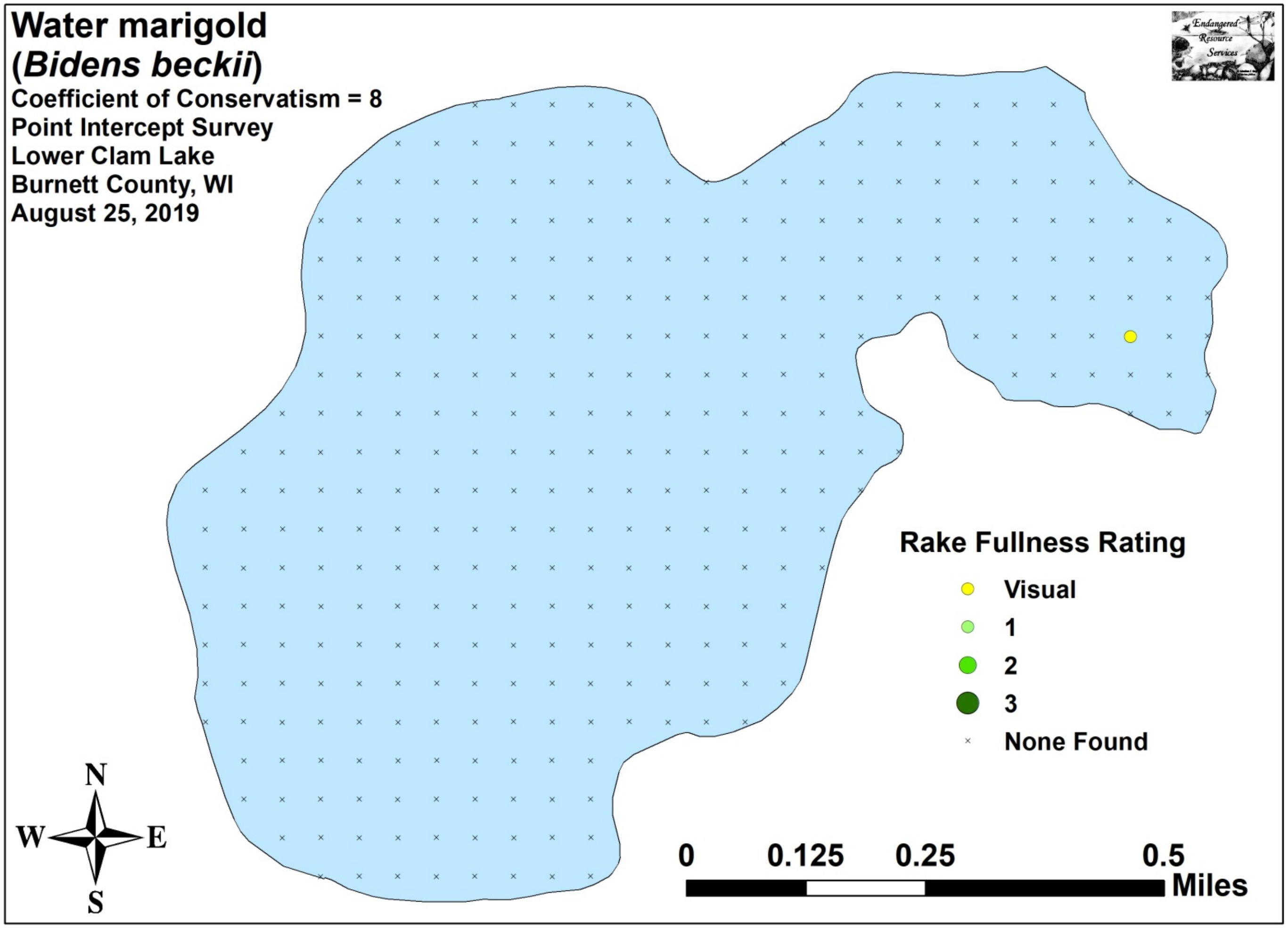

Native Species Richness
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 9
N
S
E
W
0
0.125
0.25
0.5
Miles



Total Rake Fullness
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
September 8-9, 2016
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles


Total Rake Fullness
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

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


Water marigold
(Bidens beckii)
Coefficient of Conservatism = 8
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
1
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None Found
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0.125
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Miles
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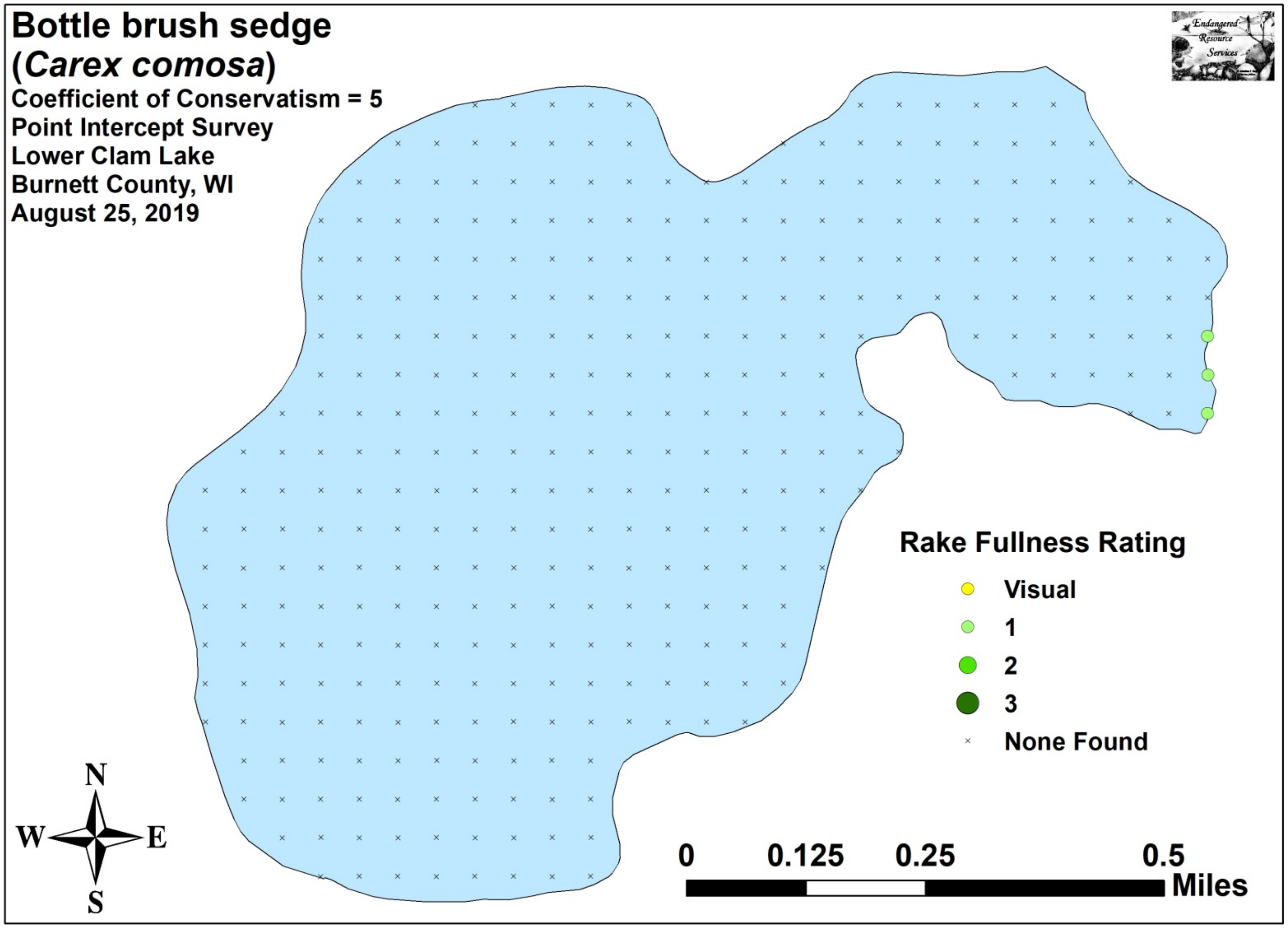
Bottle brush sedge
(*Carex comosa*)
Coefficient of Conservatism = 5
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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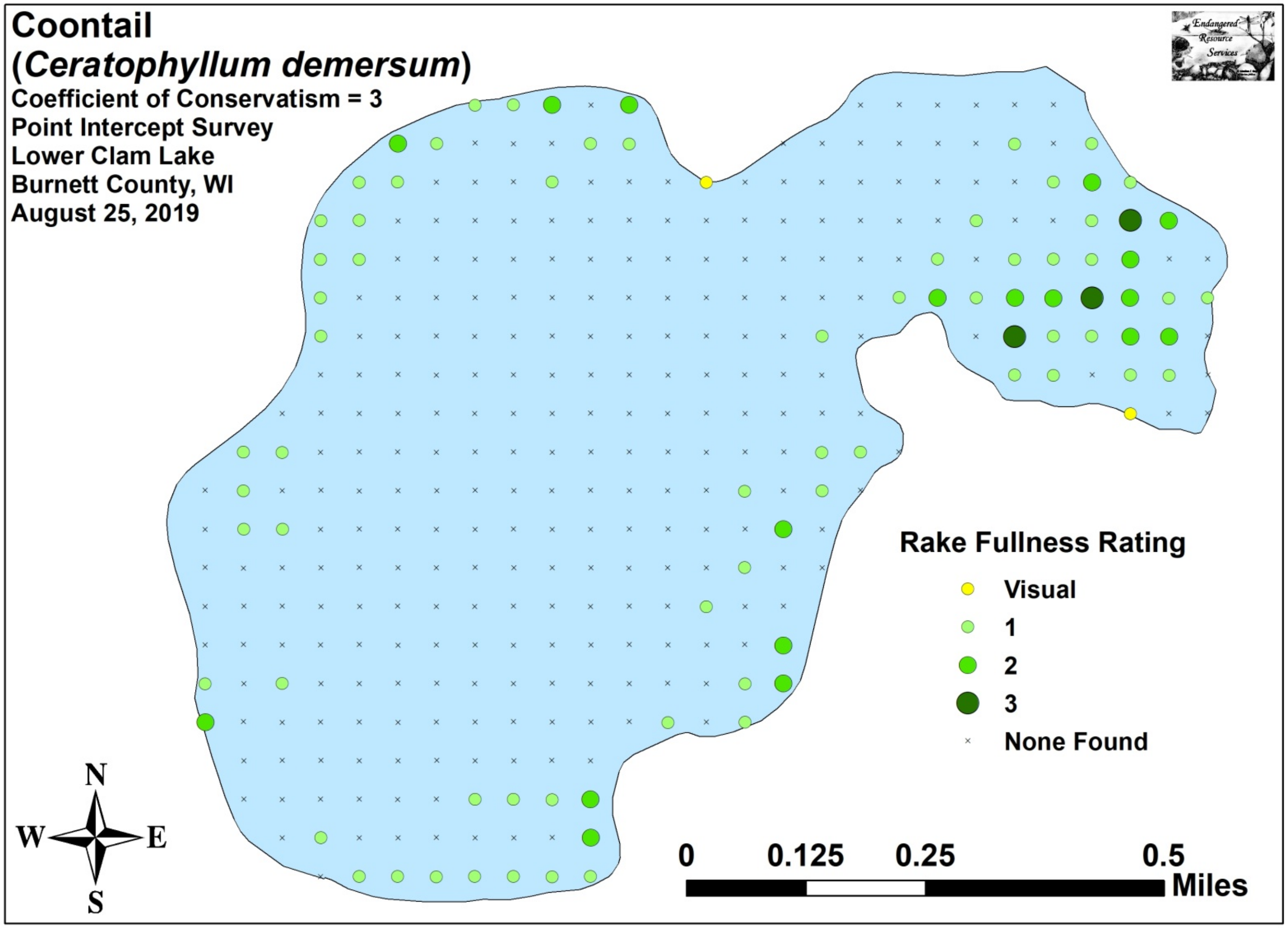
Miles


Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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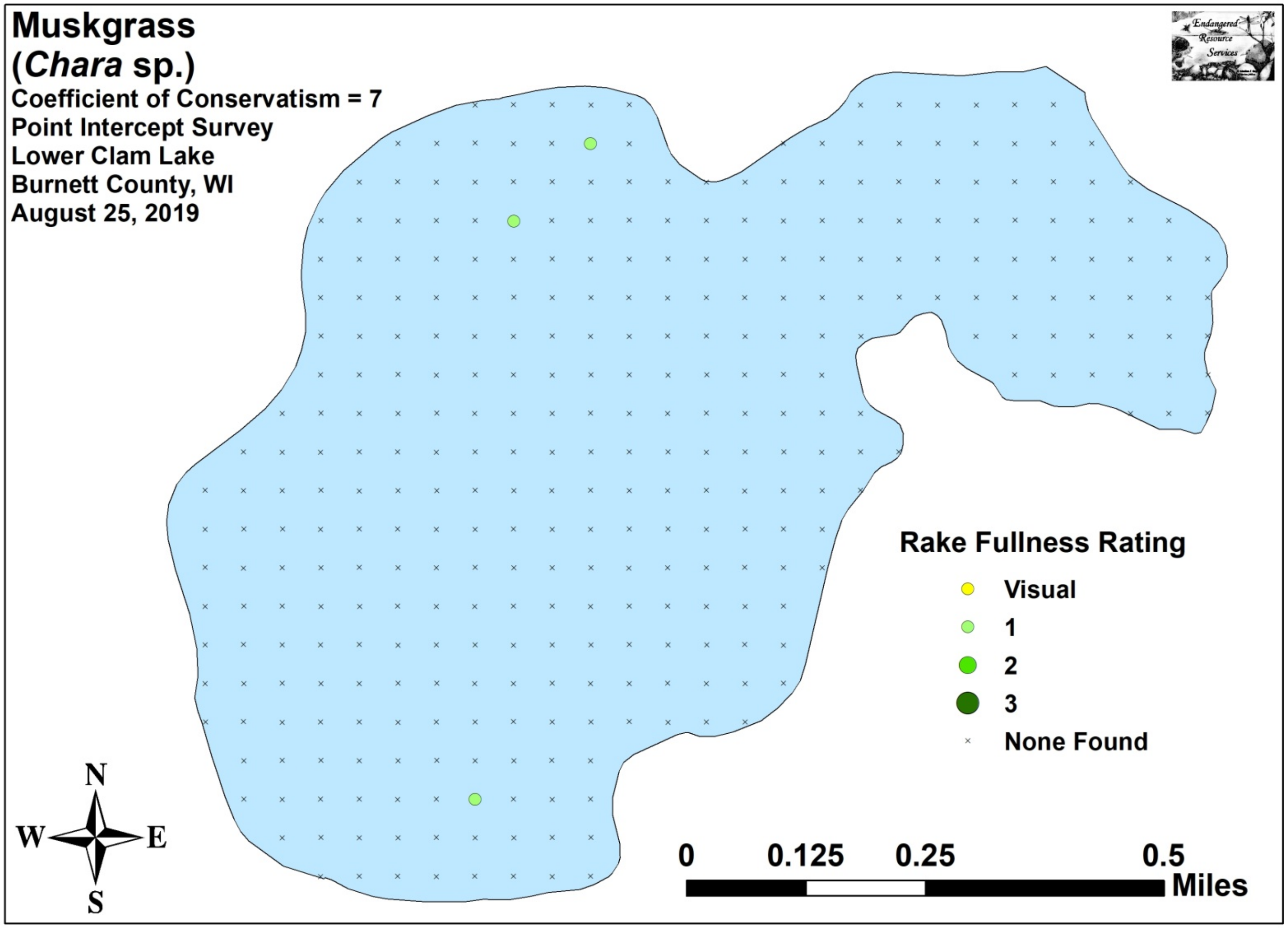
Miles



Muskgrass
(Chara sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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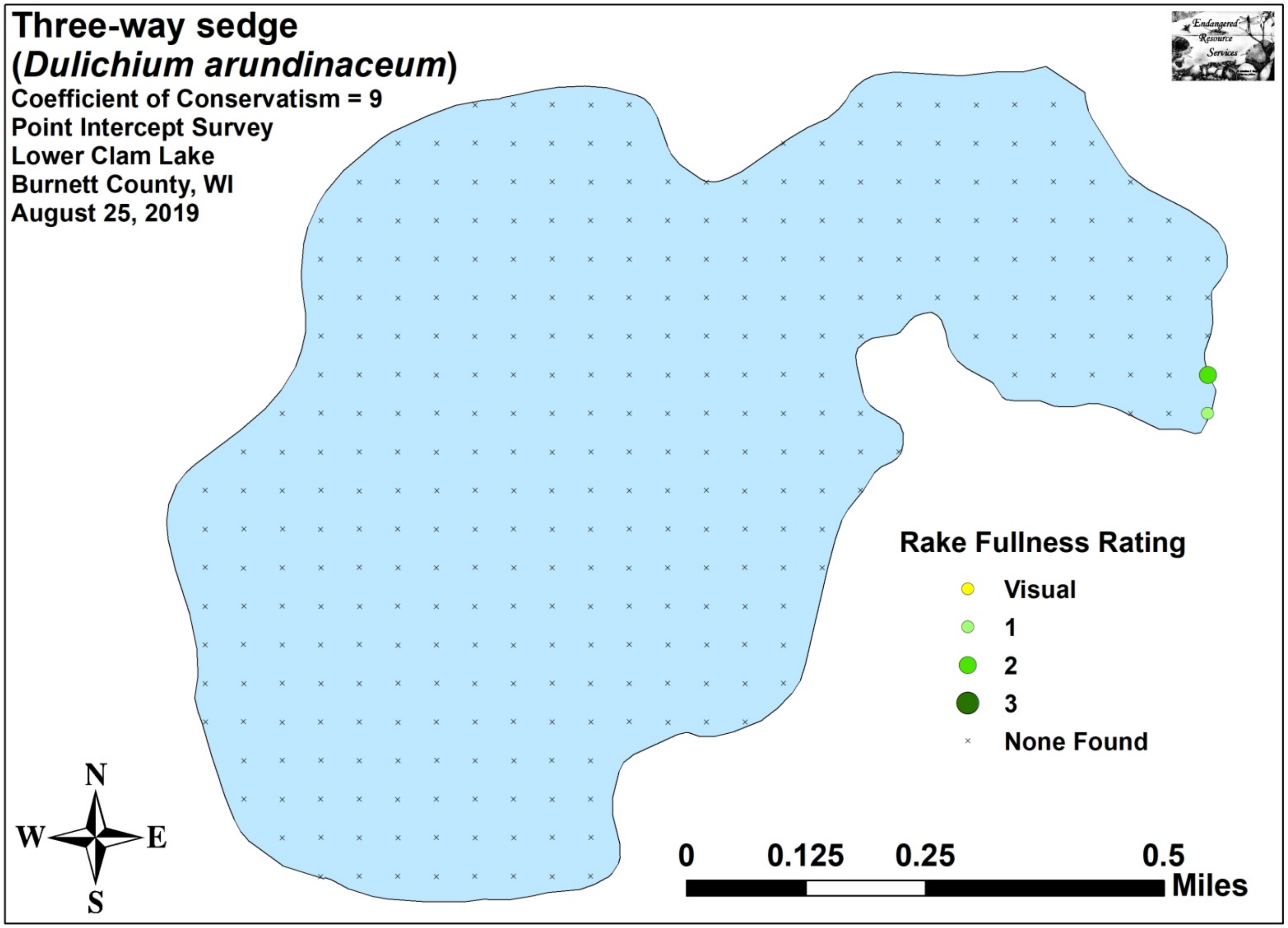
Miles


Three-way sedge
(*Dulichium arundinaceum*)
Coefficient of Conservatism = 9
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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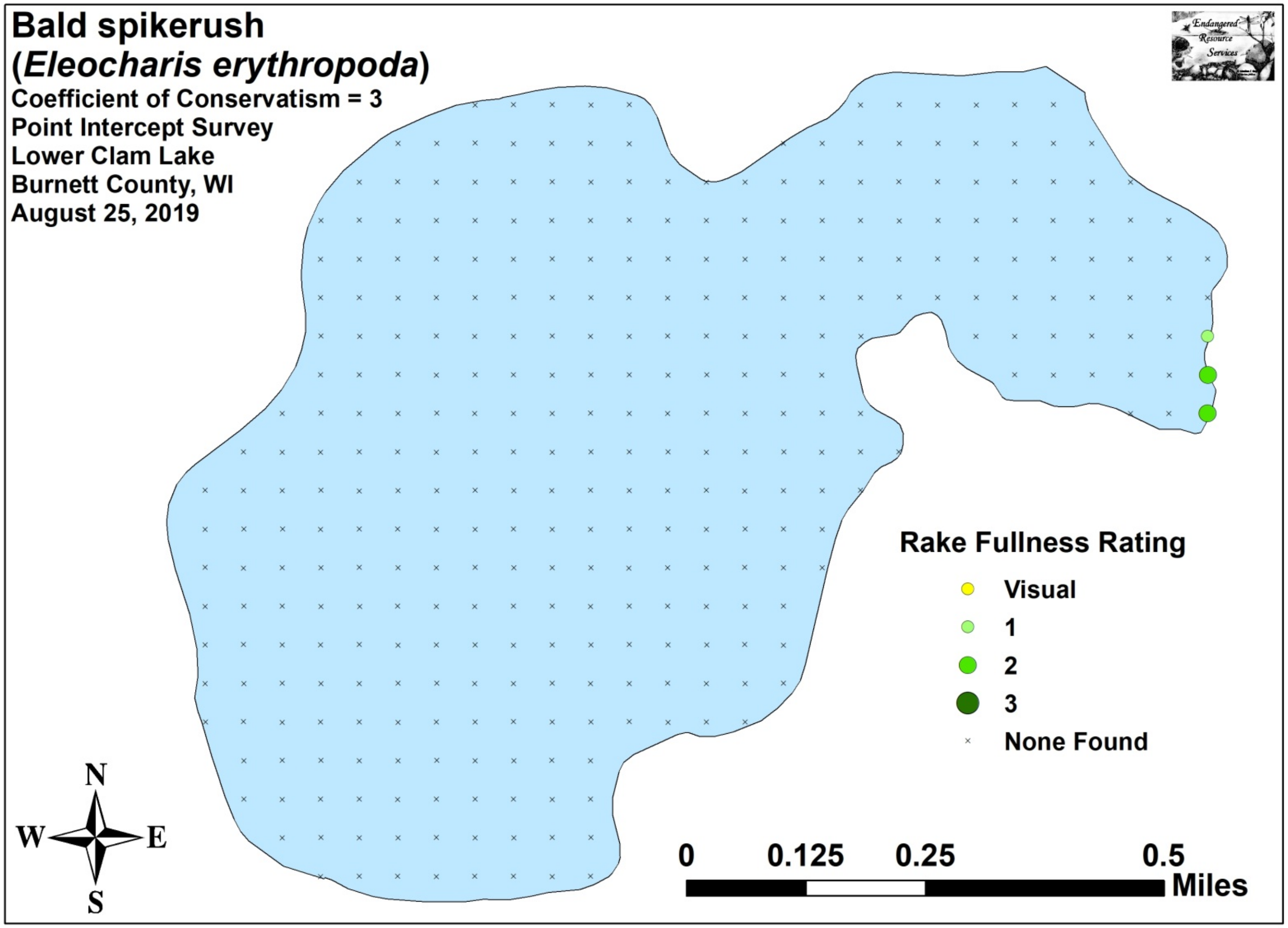
Miles



Bald spikerush
(*Eleocharis erythropoda*)
Coefficient of Conservatism = 3
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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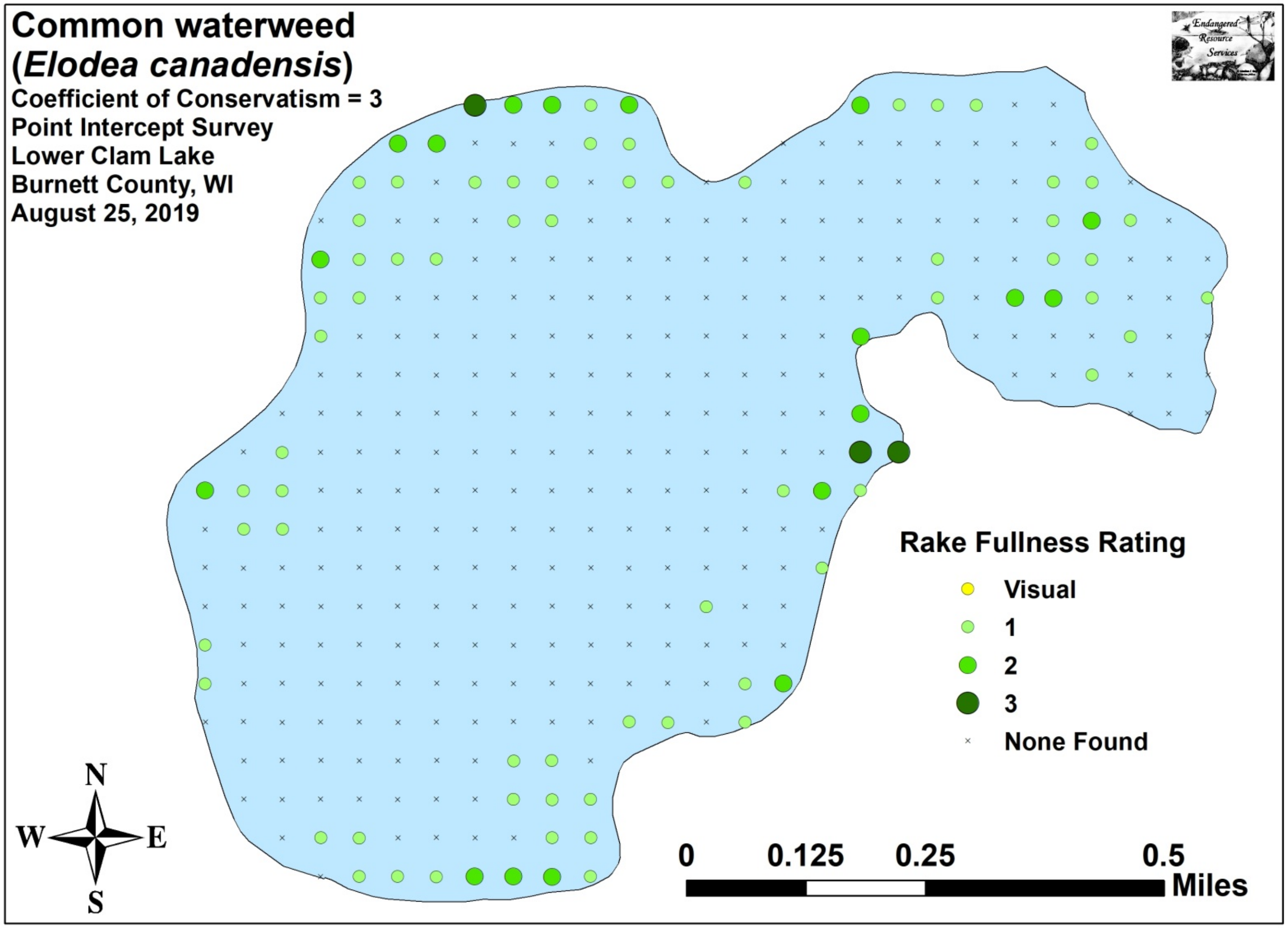
Miles


Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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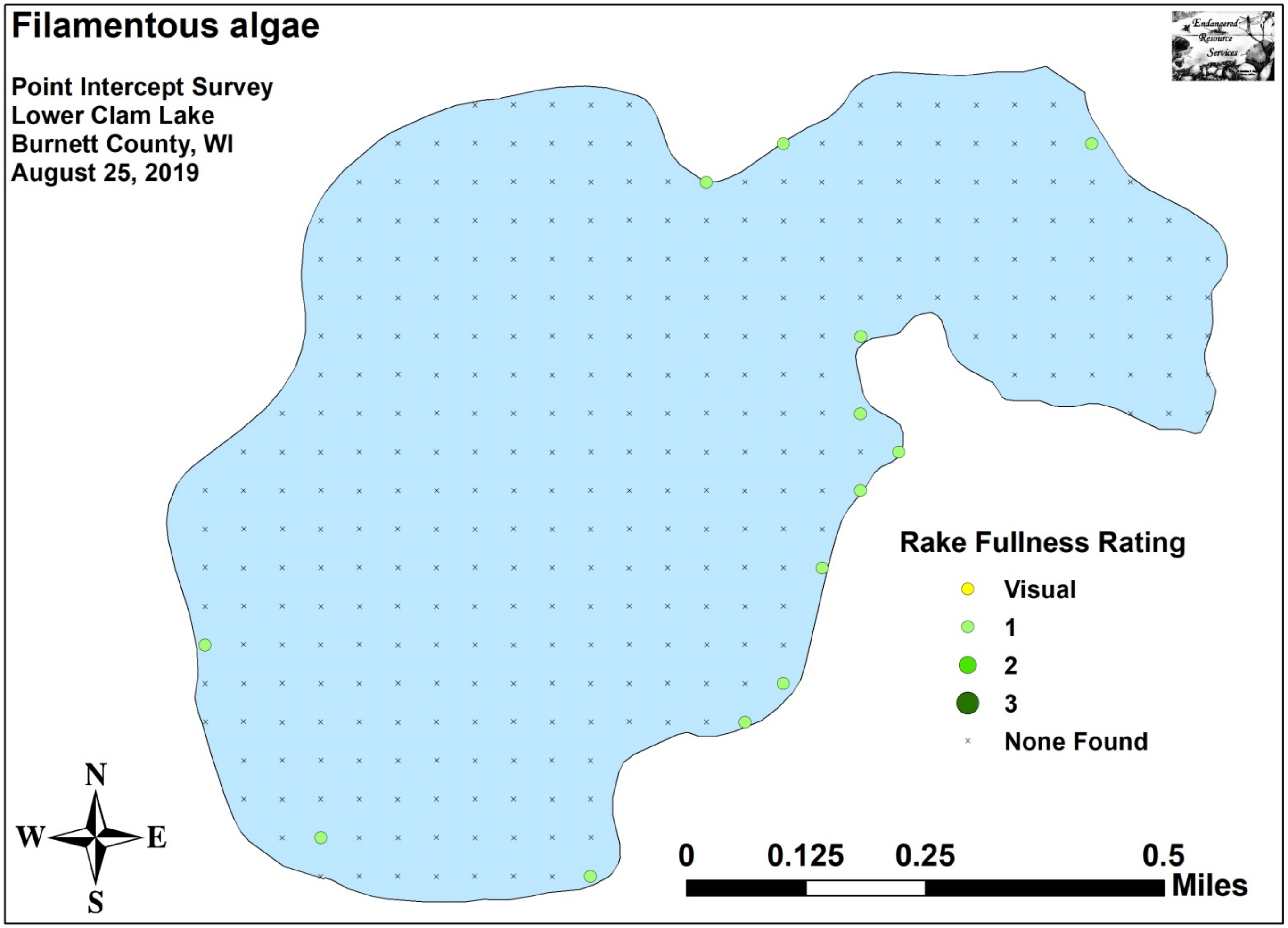
Miles


Filamentous algae
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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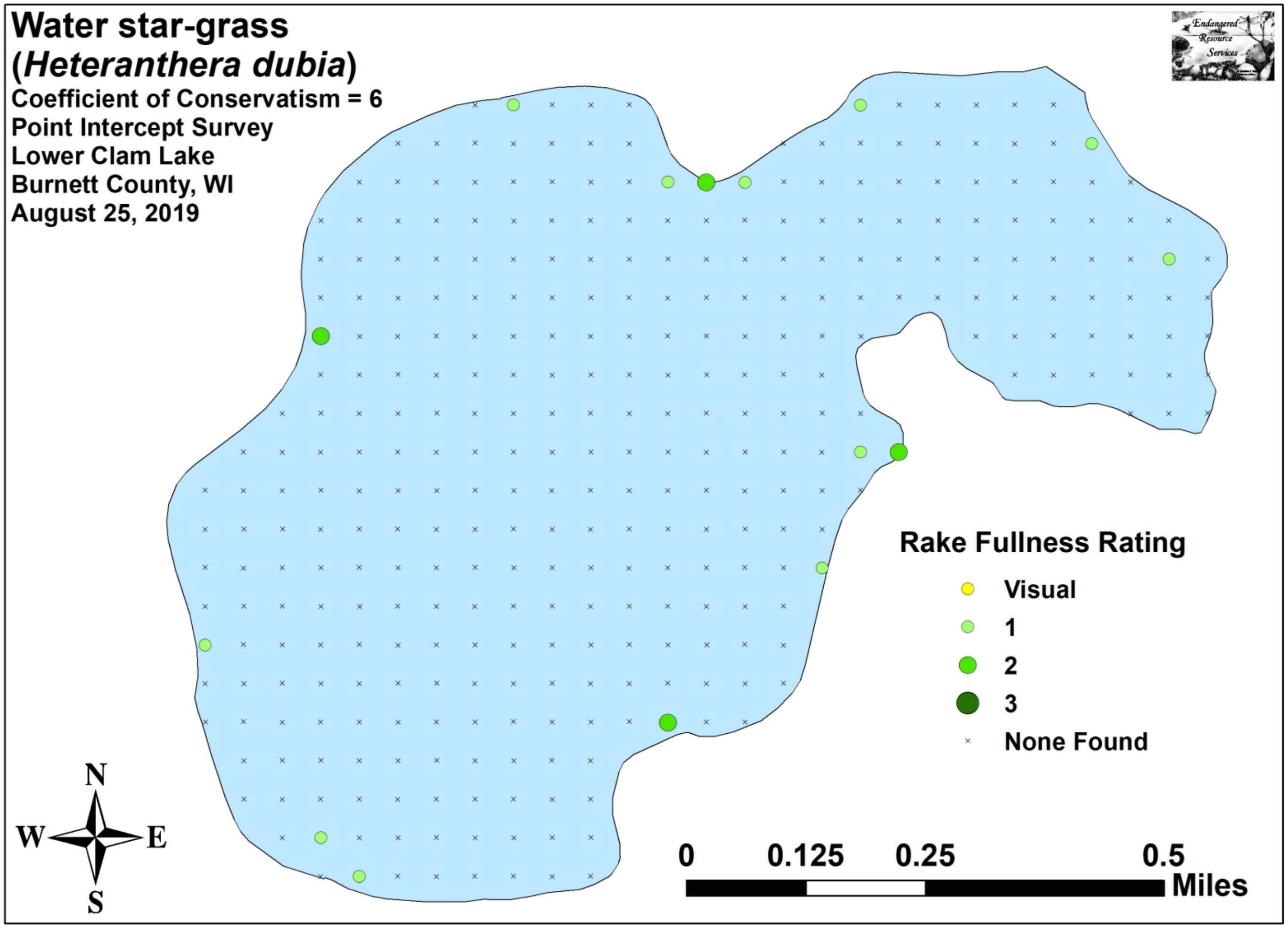
Miles



Water star-grass
(*Heteranthera dubia*)
Coefficient of Conservatism = 6
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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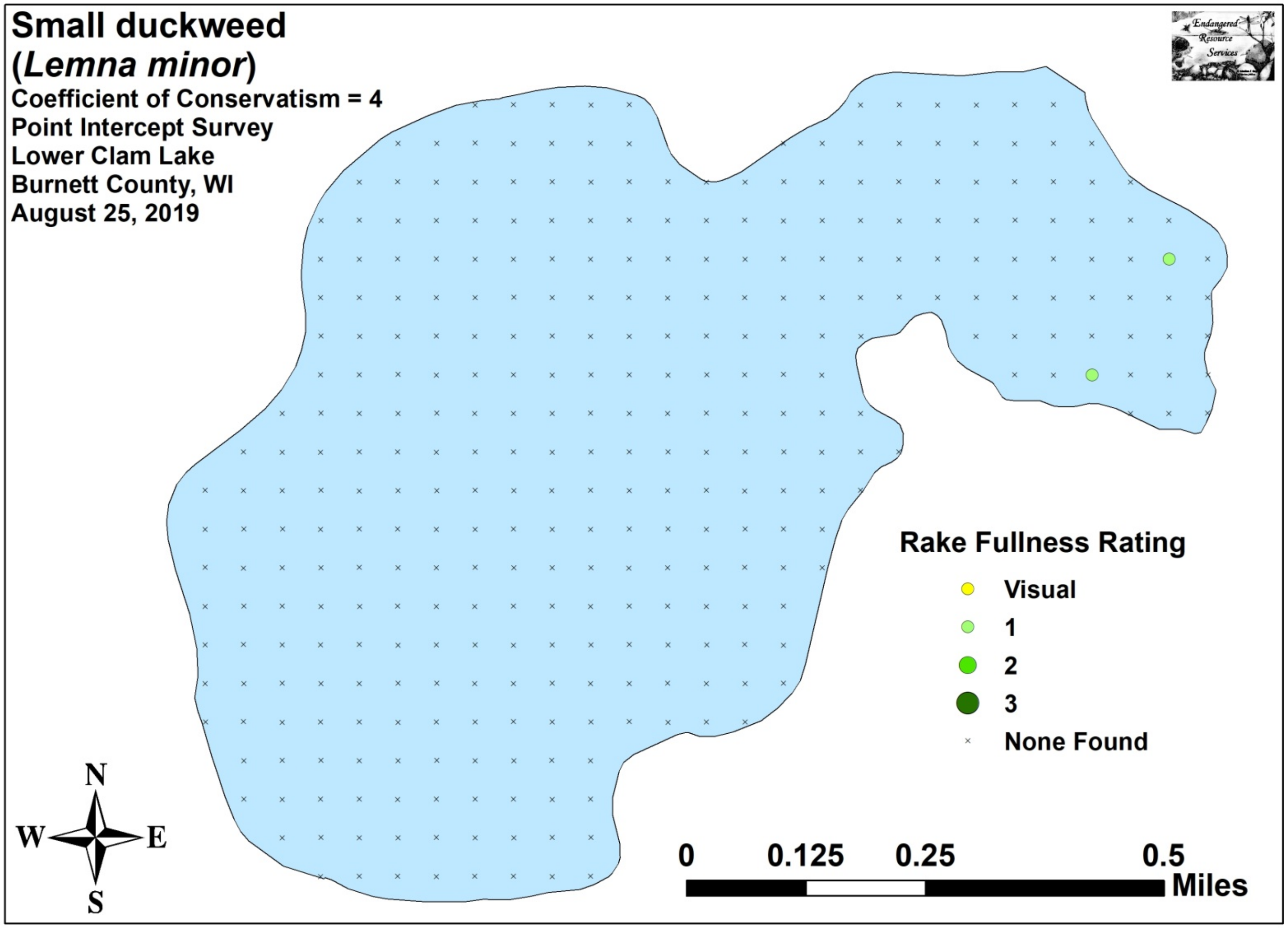
Miles


Small duckweed
(*Lemna minor*)
Coefficient of Conservatism = 4
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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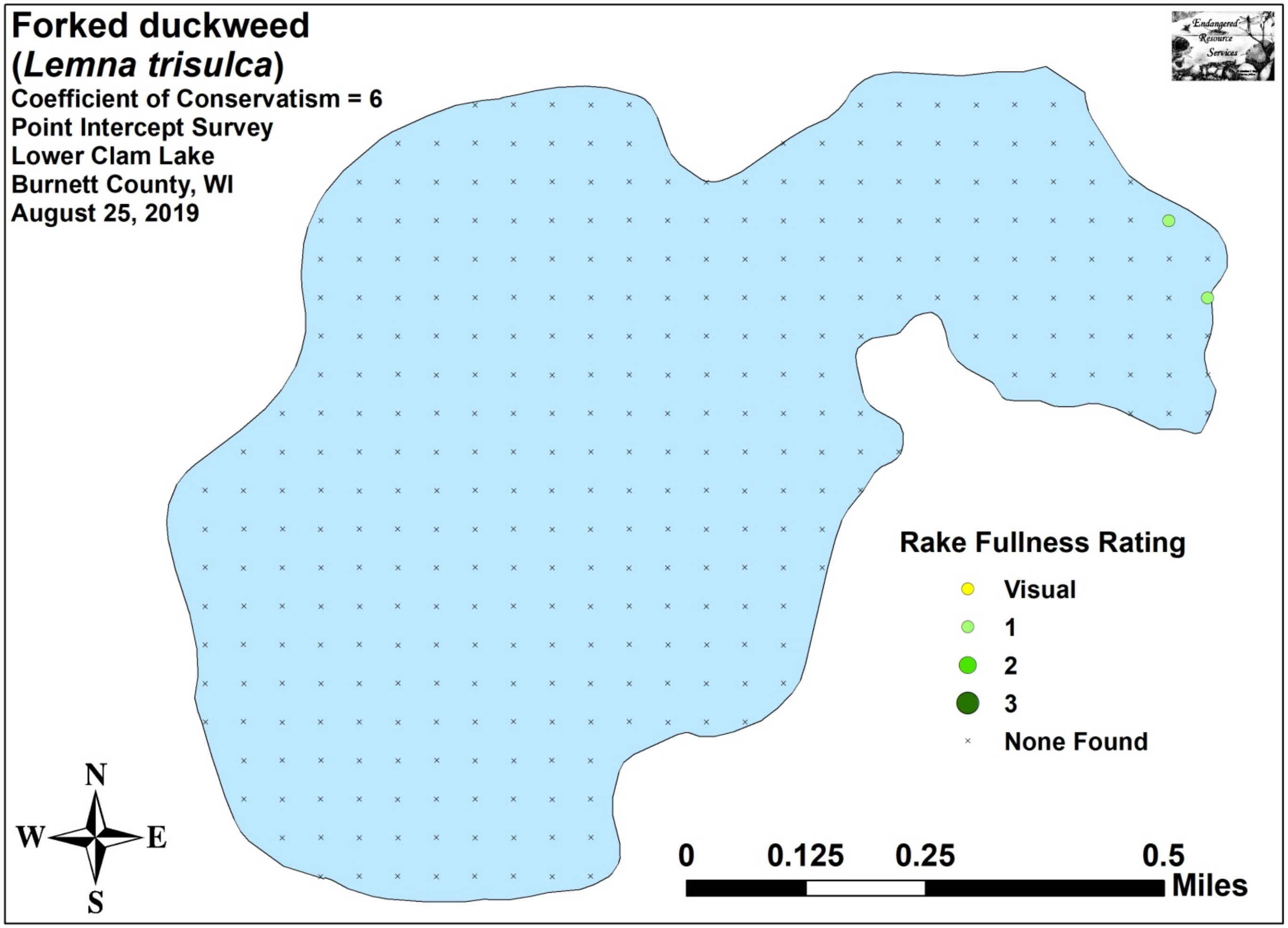
Miles


Forked duckweed
(Lemna trisulca)
Coefficient of Conservatism = 6
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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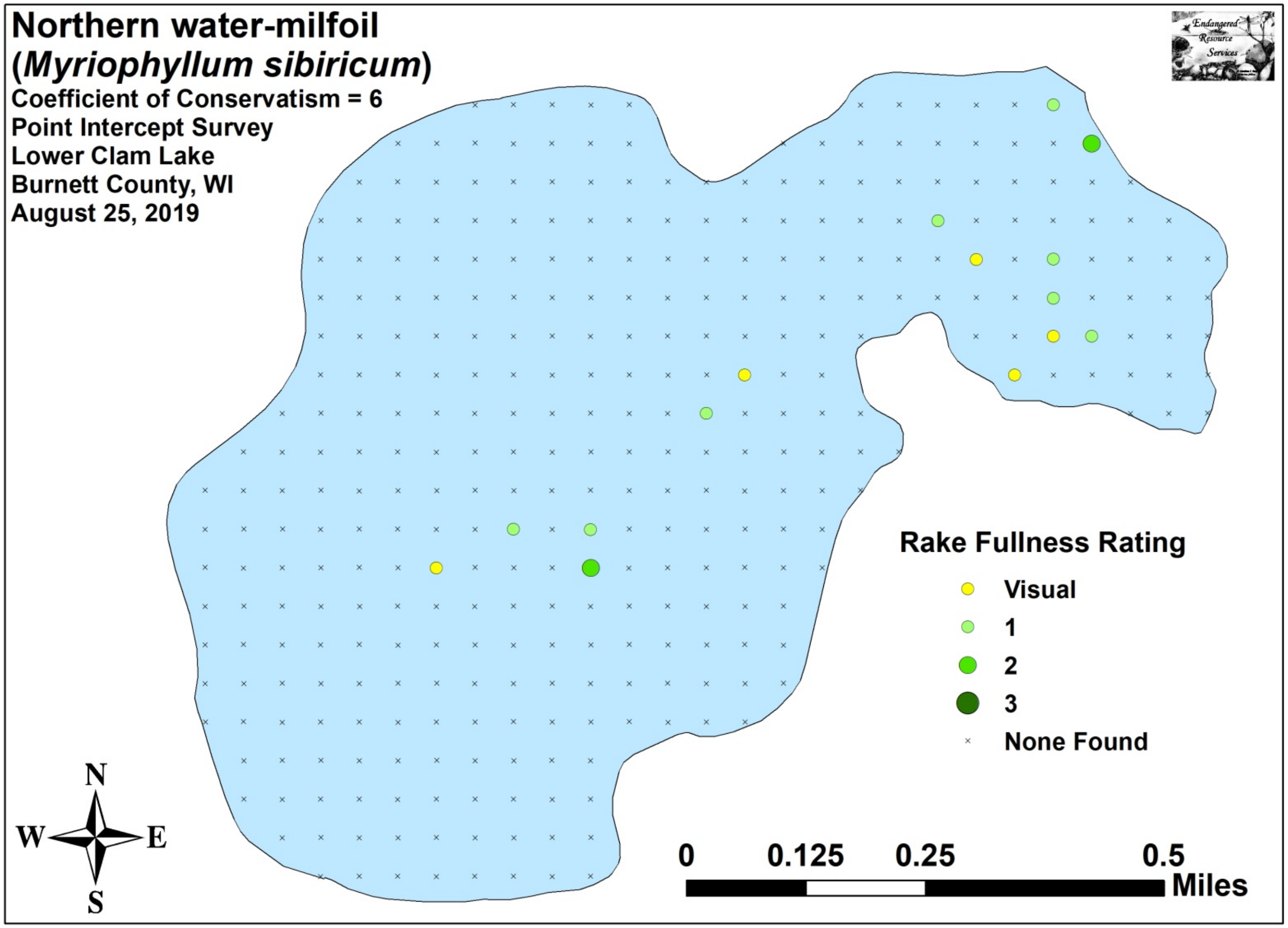
Miles


Northern water-milfoil
(*Myriophyllum sibiricum*)
Coefficient of Conservatism = 6
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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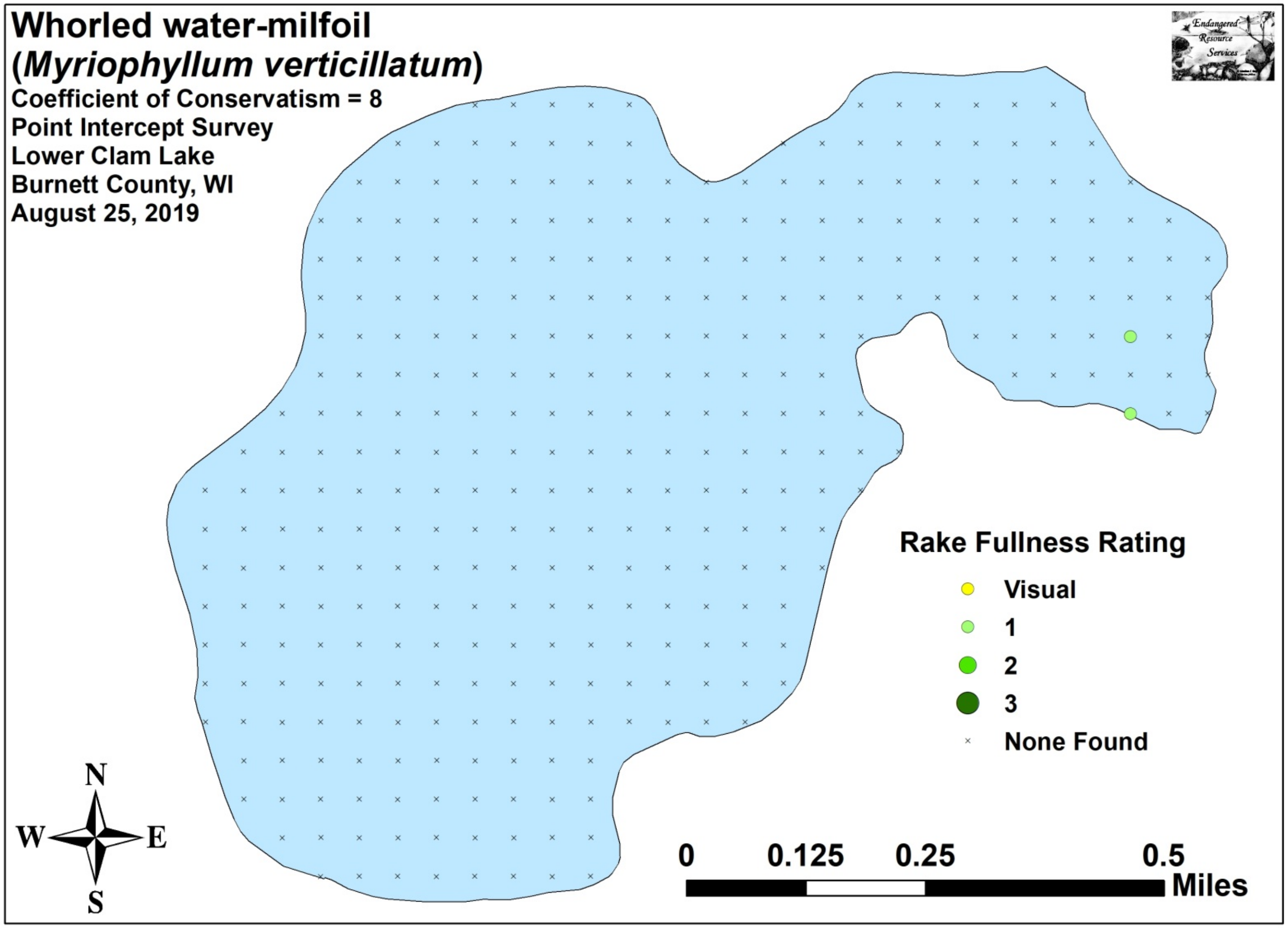
Miles


Whorled water-milfoil
(*Myriophyllum verticillatum*)
Coefficient of Conservatism = 8
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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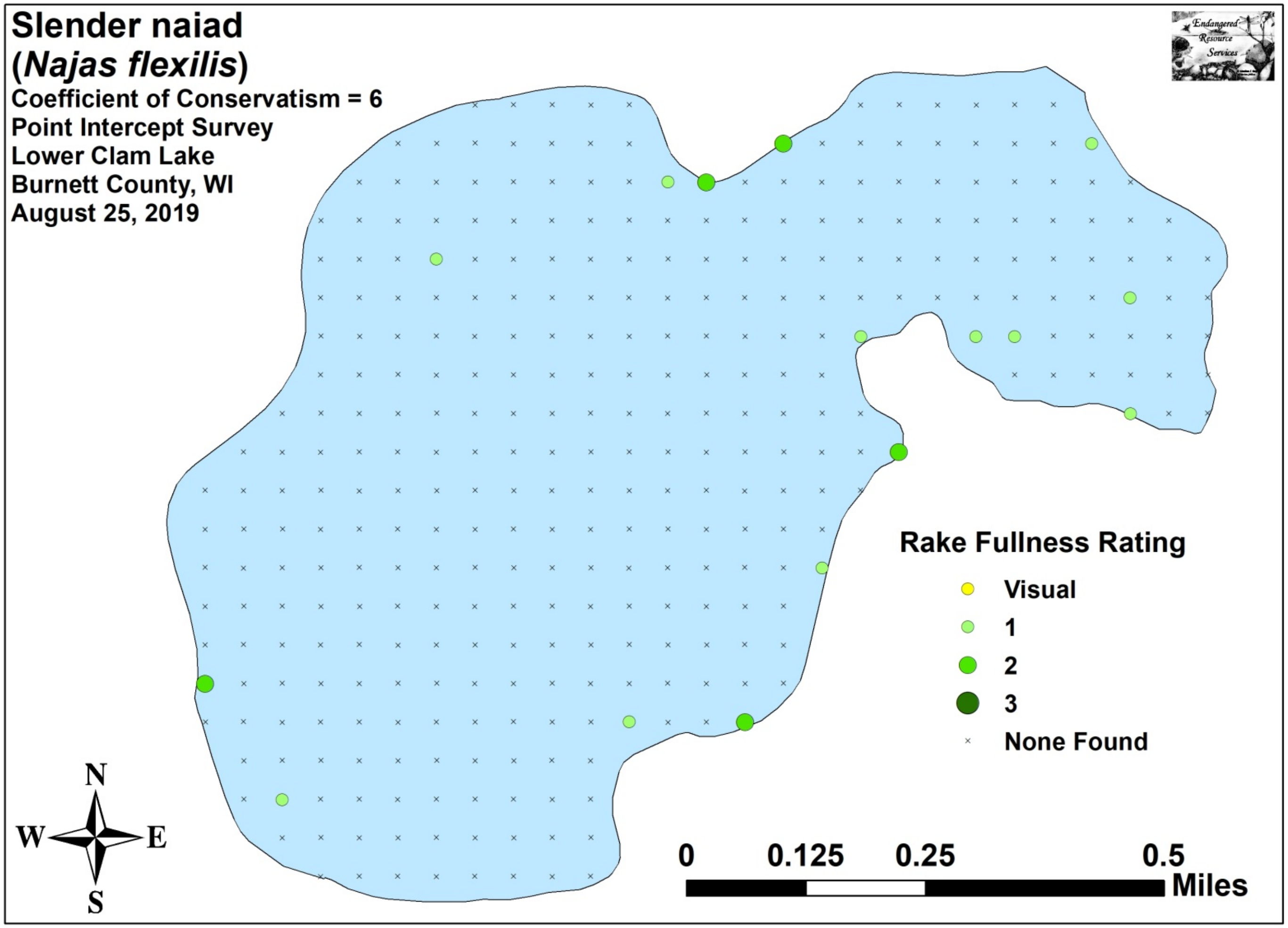
Miles



Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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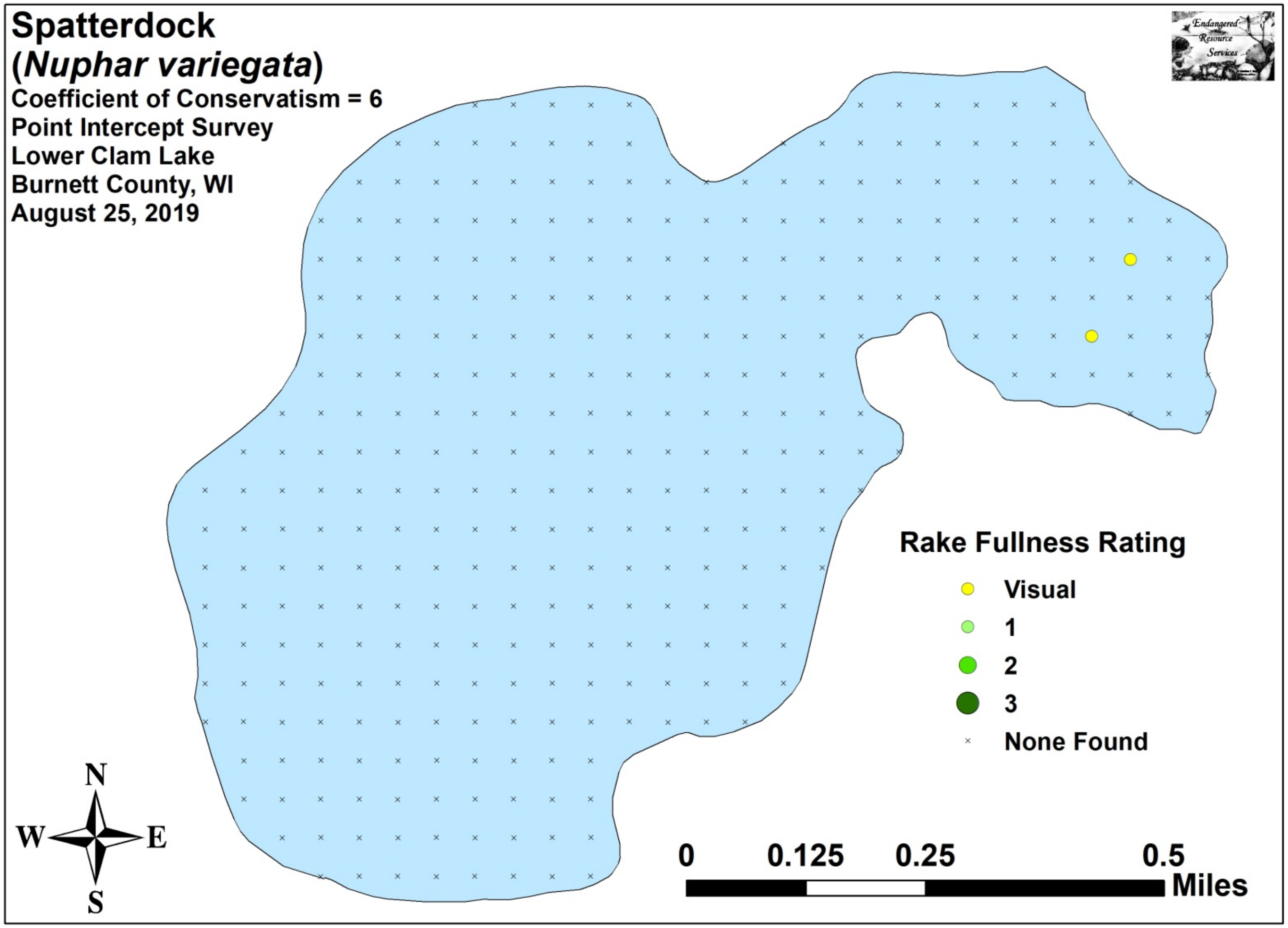
Miles



Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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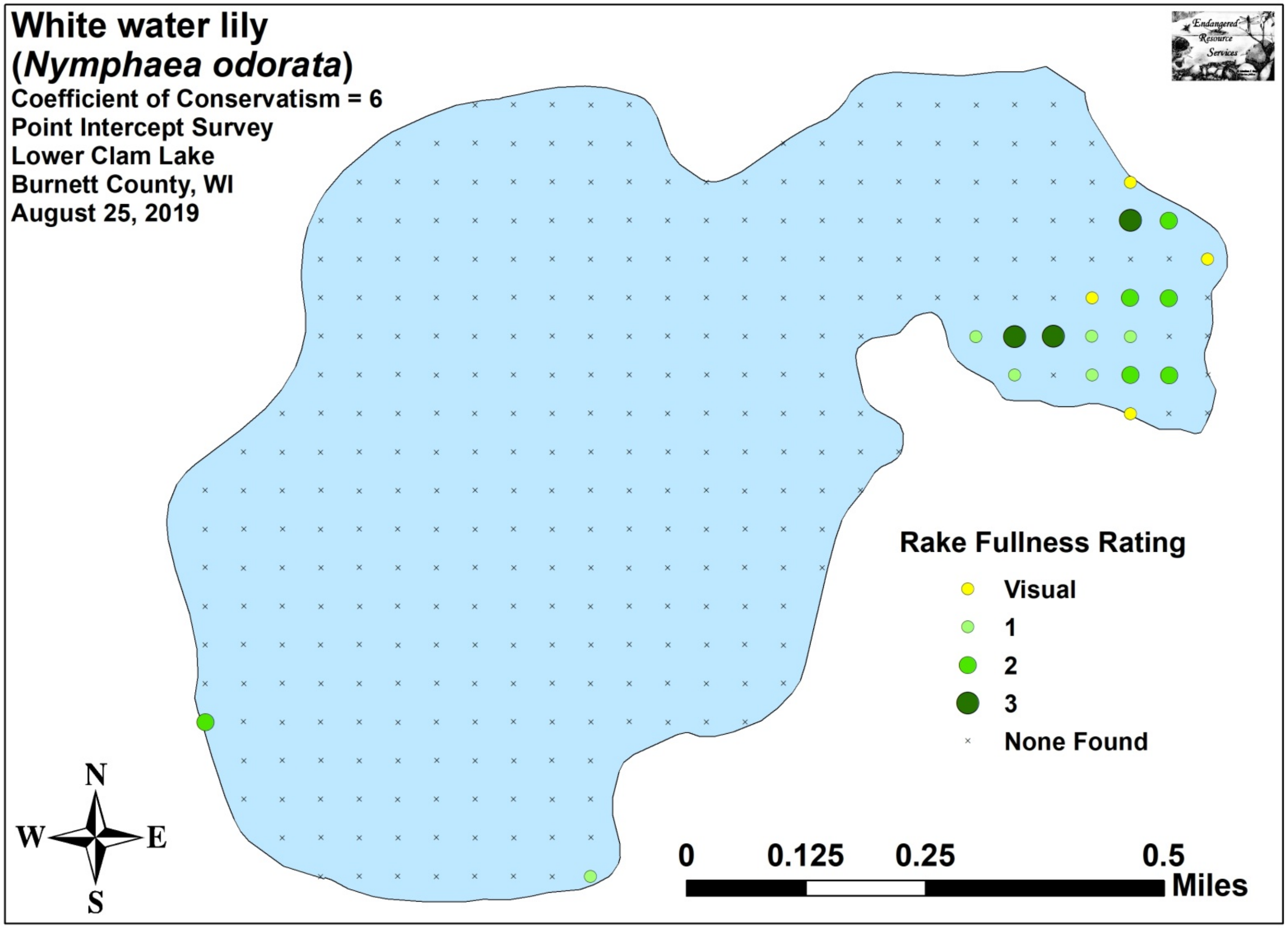
Miles


White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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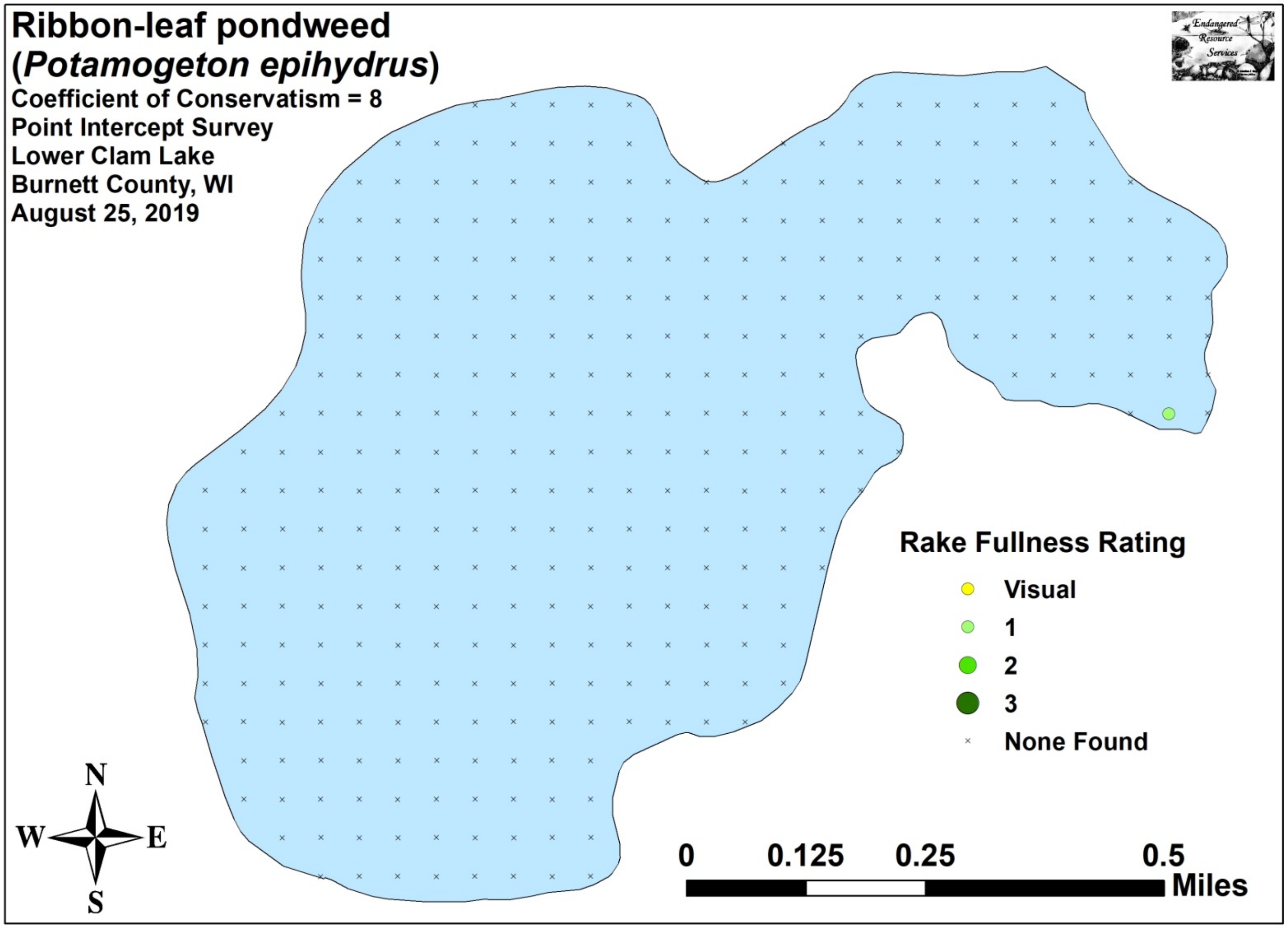
Miles


Ribbon-leaf pondweed
(Potamogeton epihydrus)
Coefficient of Conservatism = 8
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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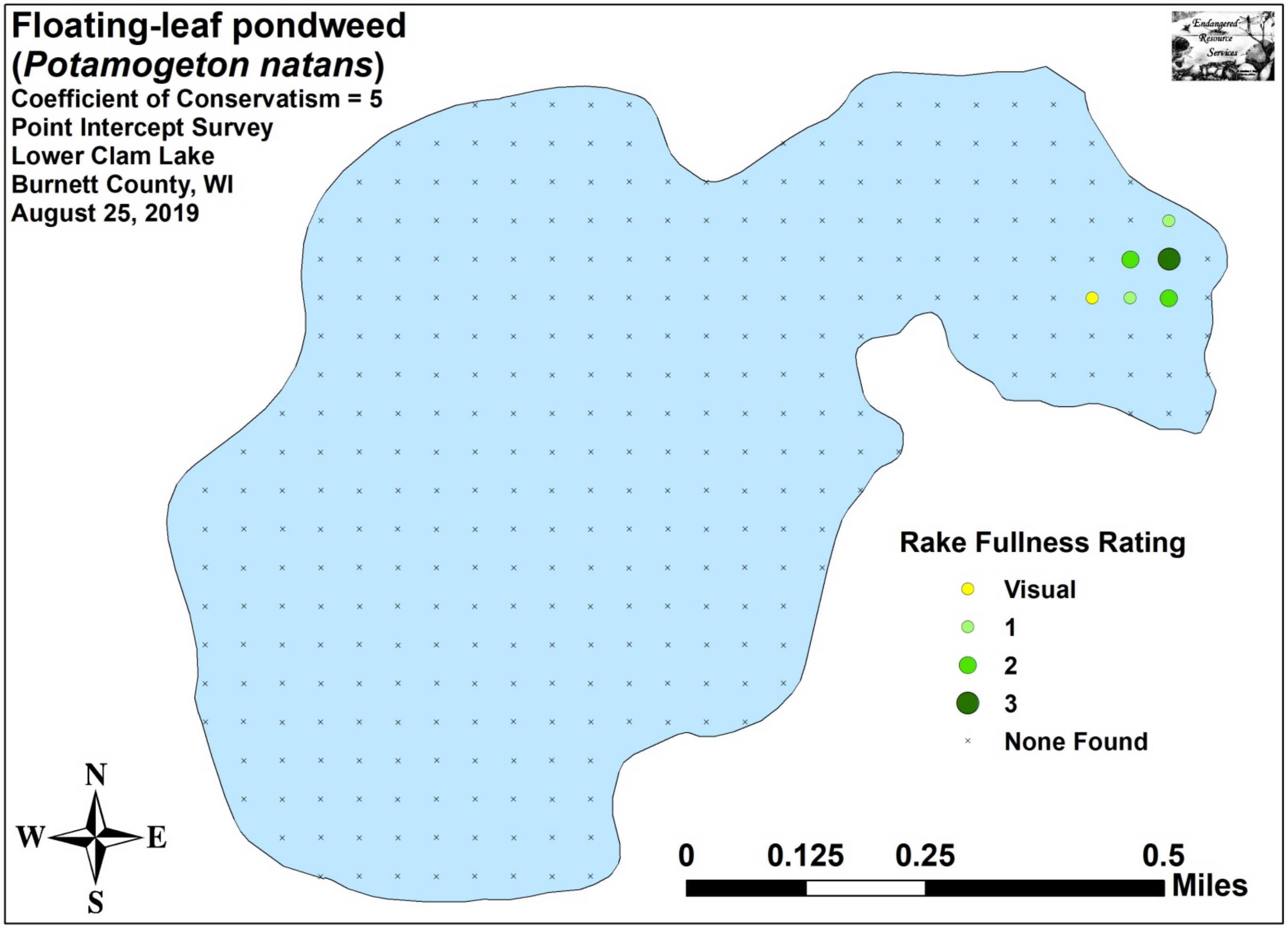
Miles



Floating-leaf pondweed
(*Potamogeton natans*)
Coefficient of Conservatism = 5
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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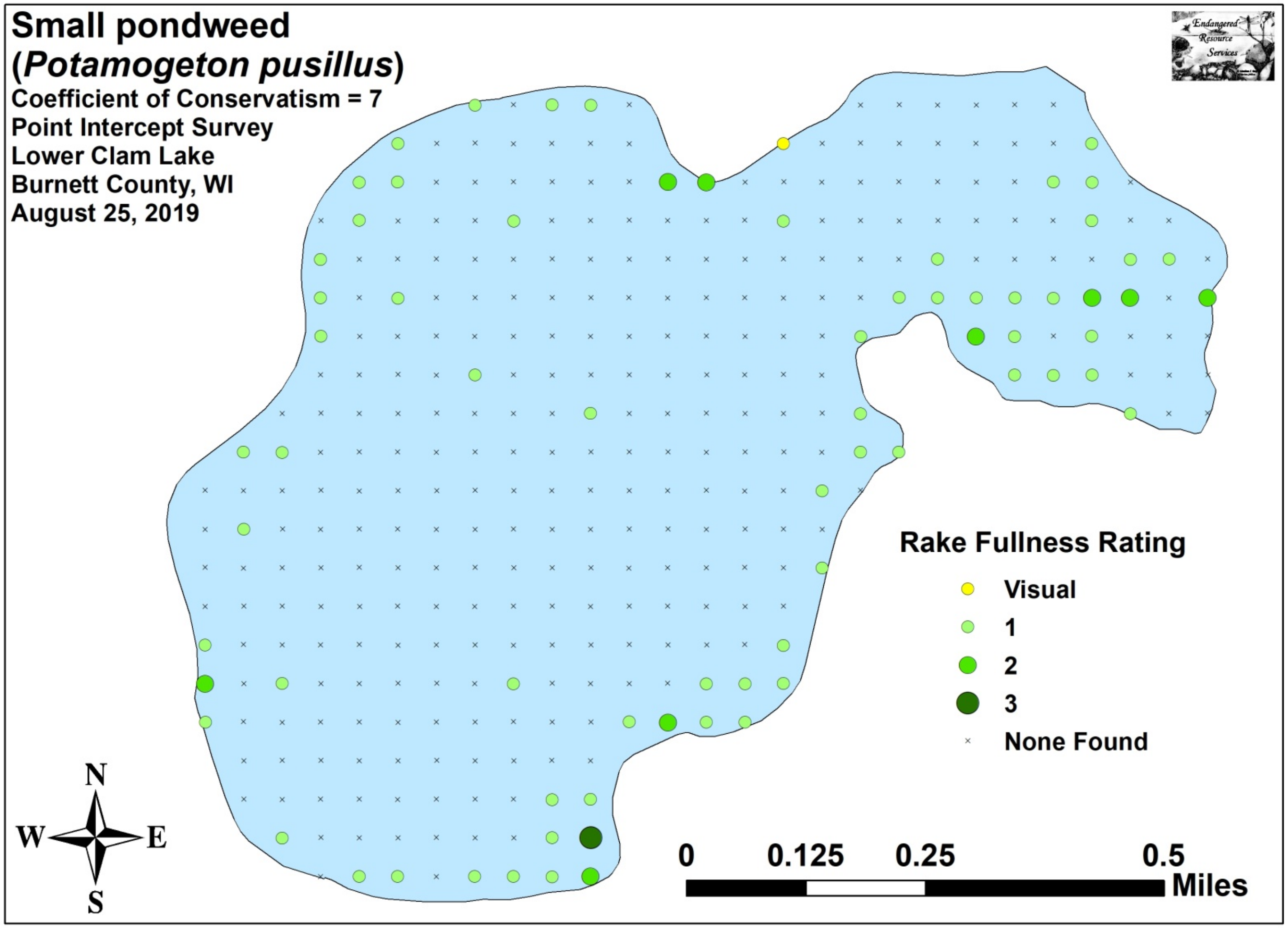
Miles



Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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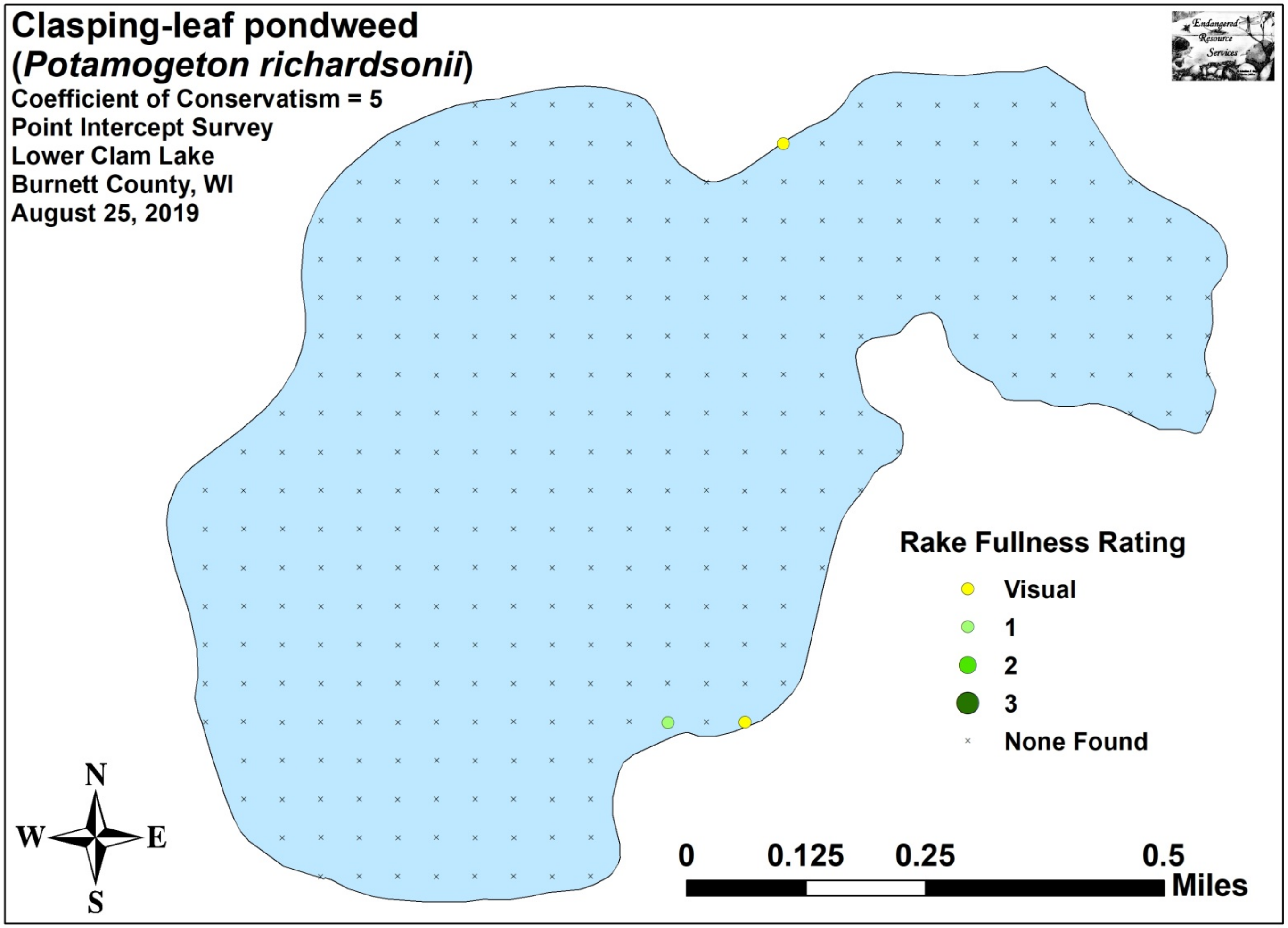
Miles


Clasping-leaf pondweed
(Potamogeton richardsonii)
Coefficient of Conservatism = 5
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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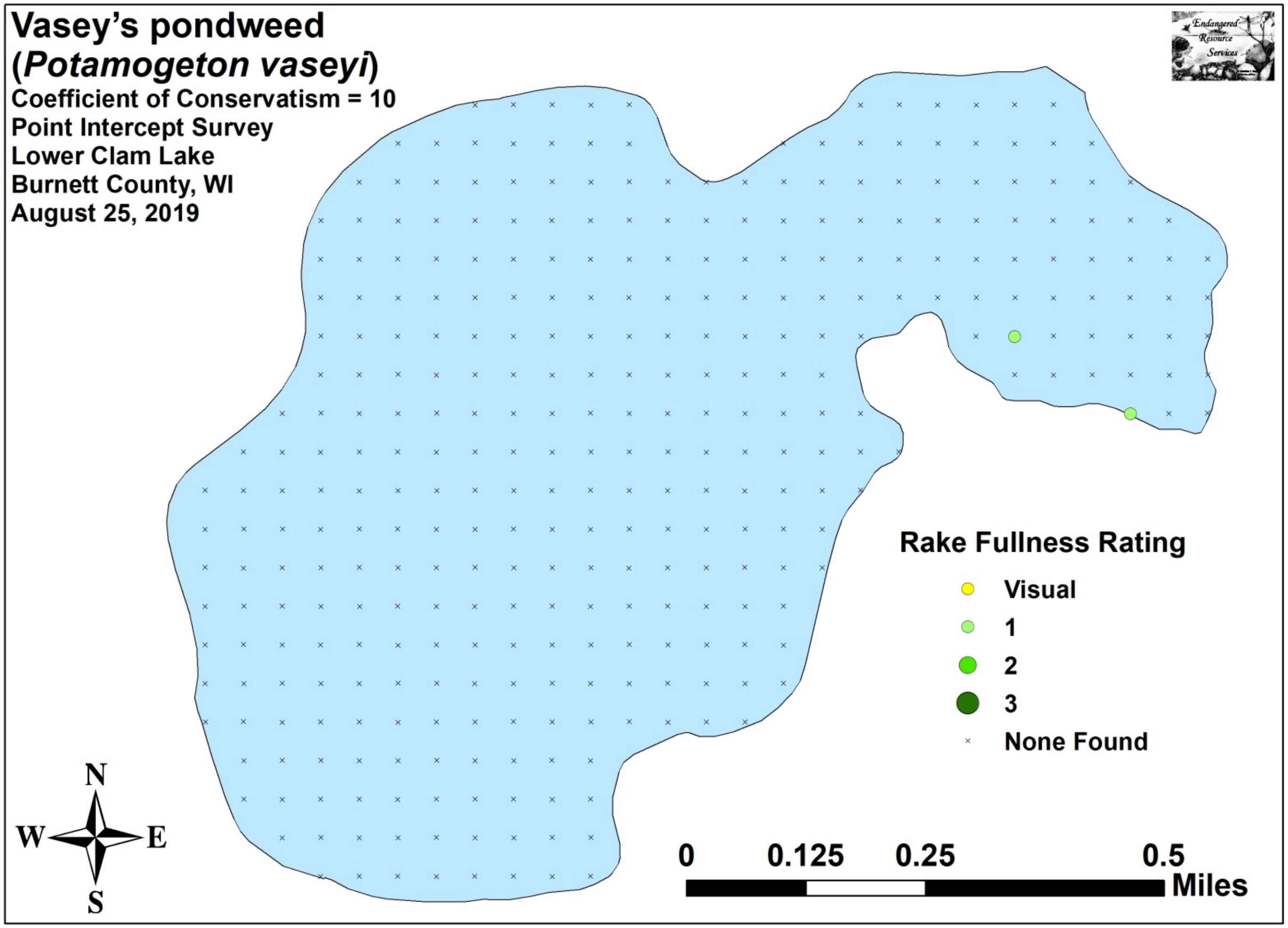
Miles



Vasey's pondweed
(Potamogeton vaseyi)
Coefficient of Conservatism = 10
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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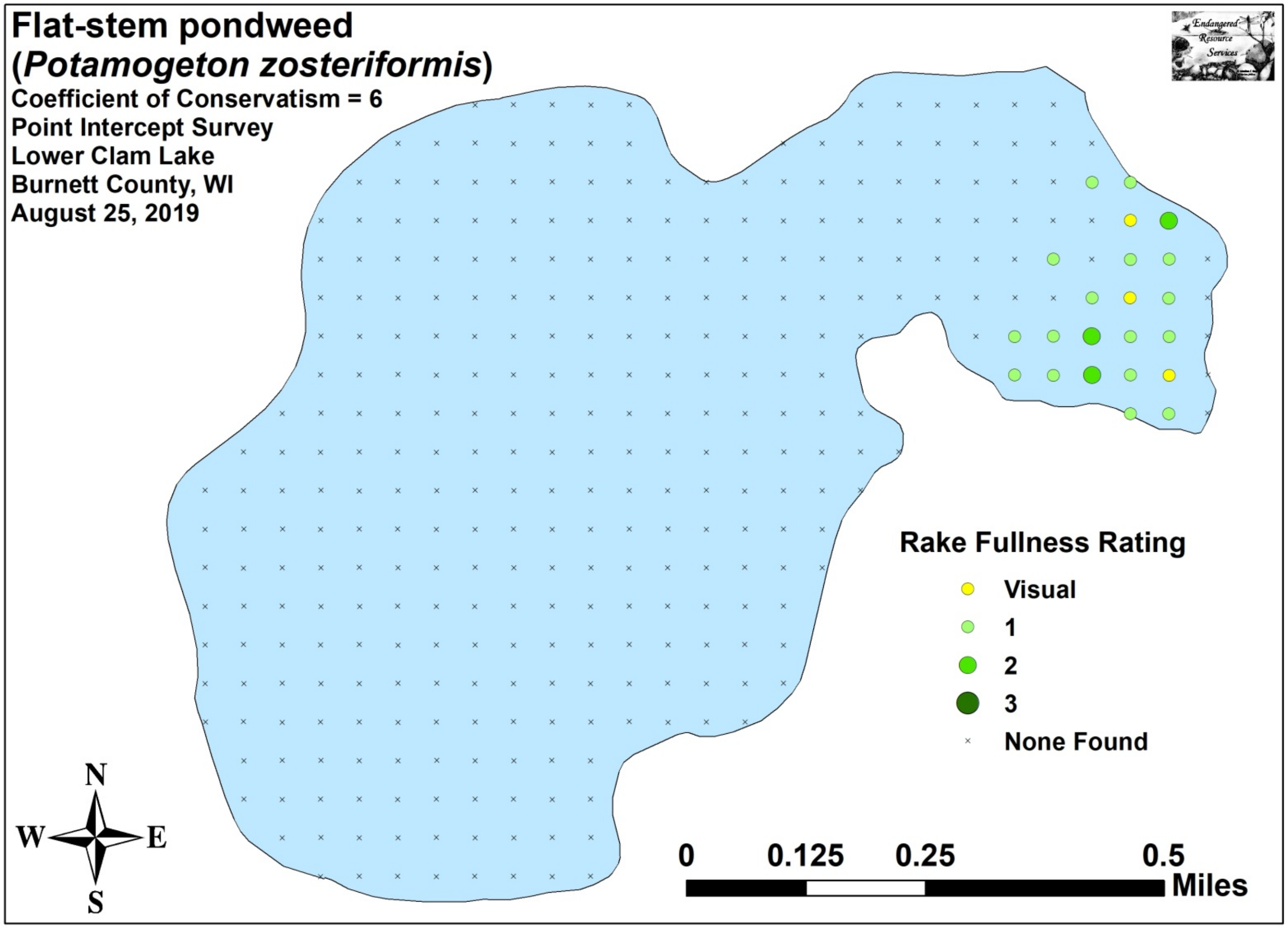
Miles


Flat-stem pondweed
(Potamogeton zosteriformis)
Coefficient of Conservatism = 6
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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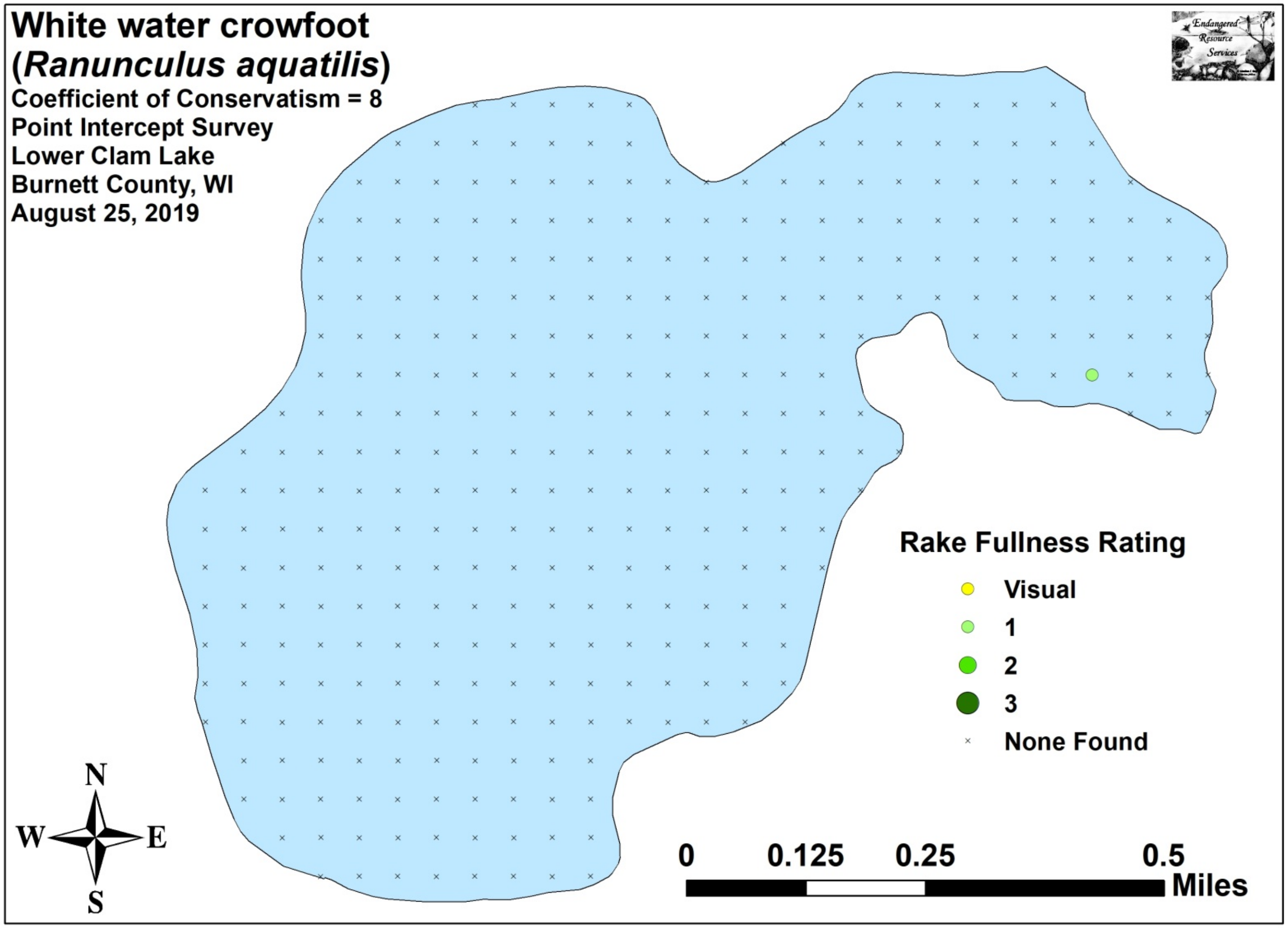
Miles


White water crowfoot
(Ranunculus aquatilis)
Coefficient of Conservatism = 8
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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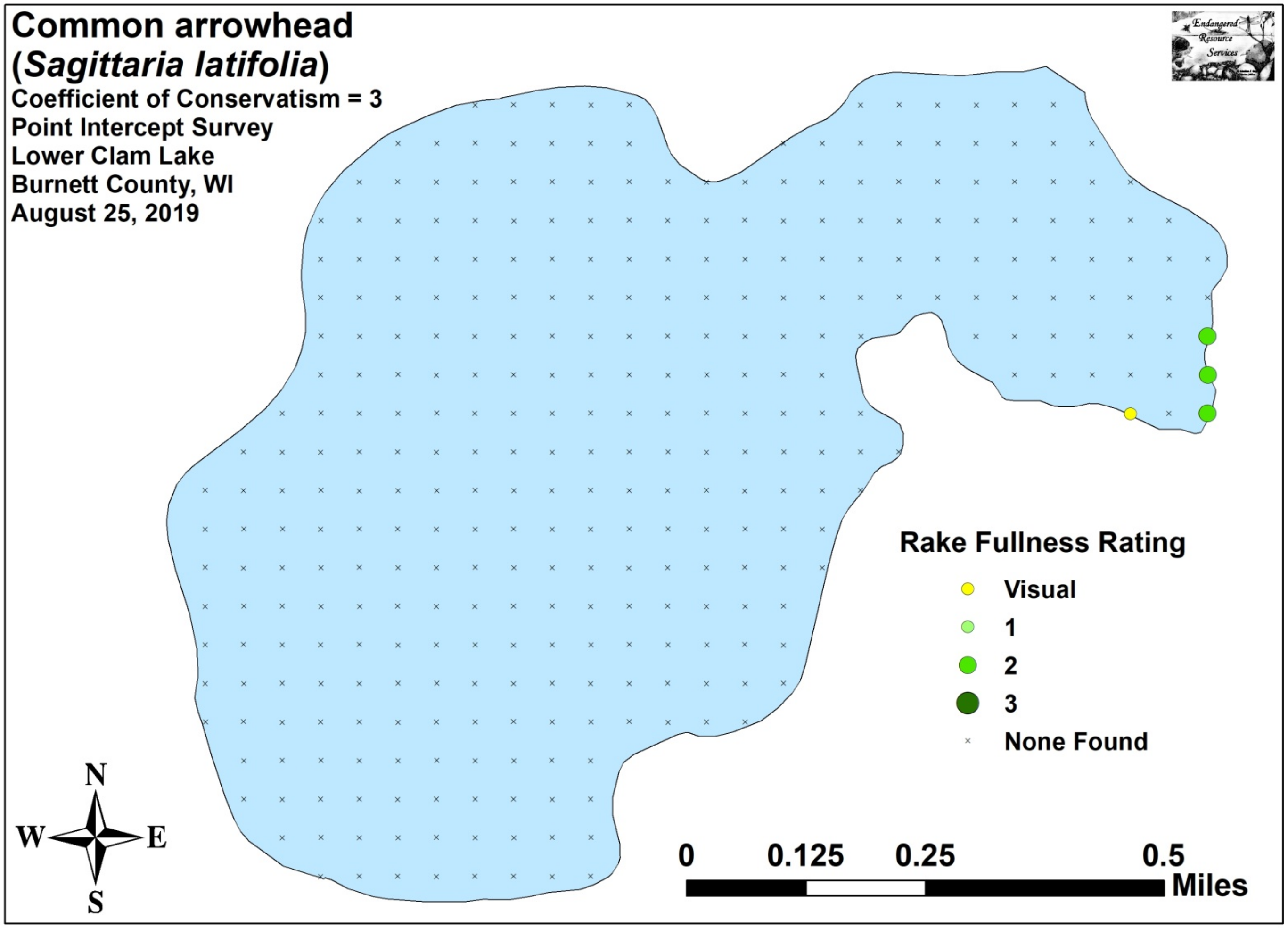
Miles


Common arrowhead
(Sagittaria latifolia)
Coefficient of Conservatism = 3
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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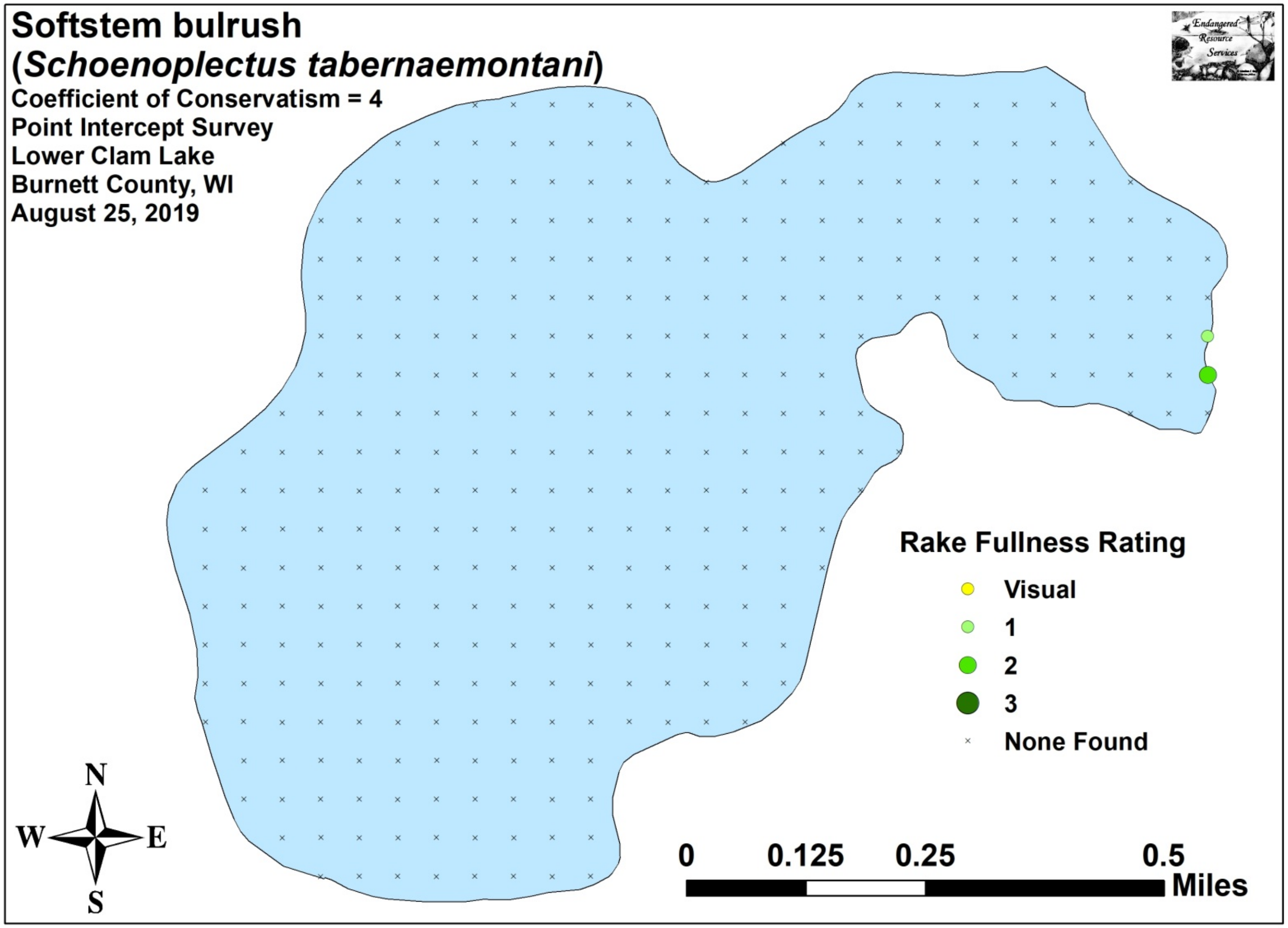
Miles


Softstem bulrush
(Schoenoplectus tabernaemontani)
Coefficient of Conservatism = 4
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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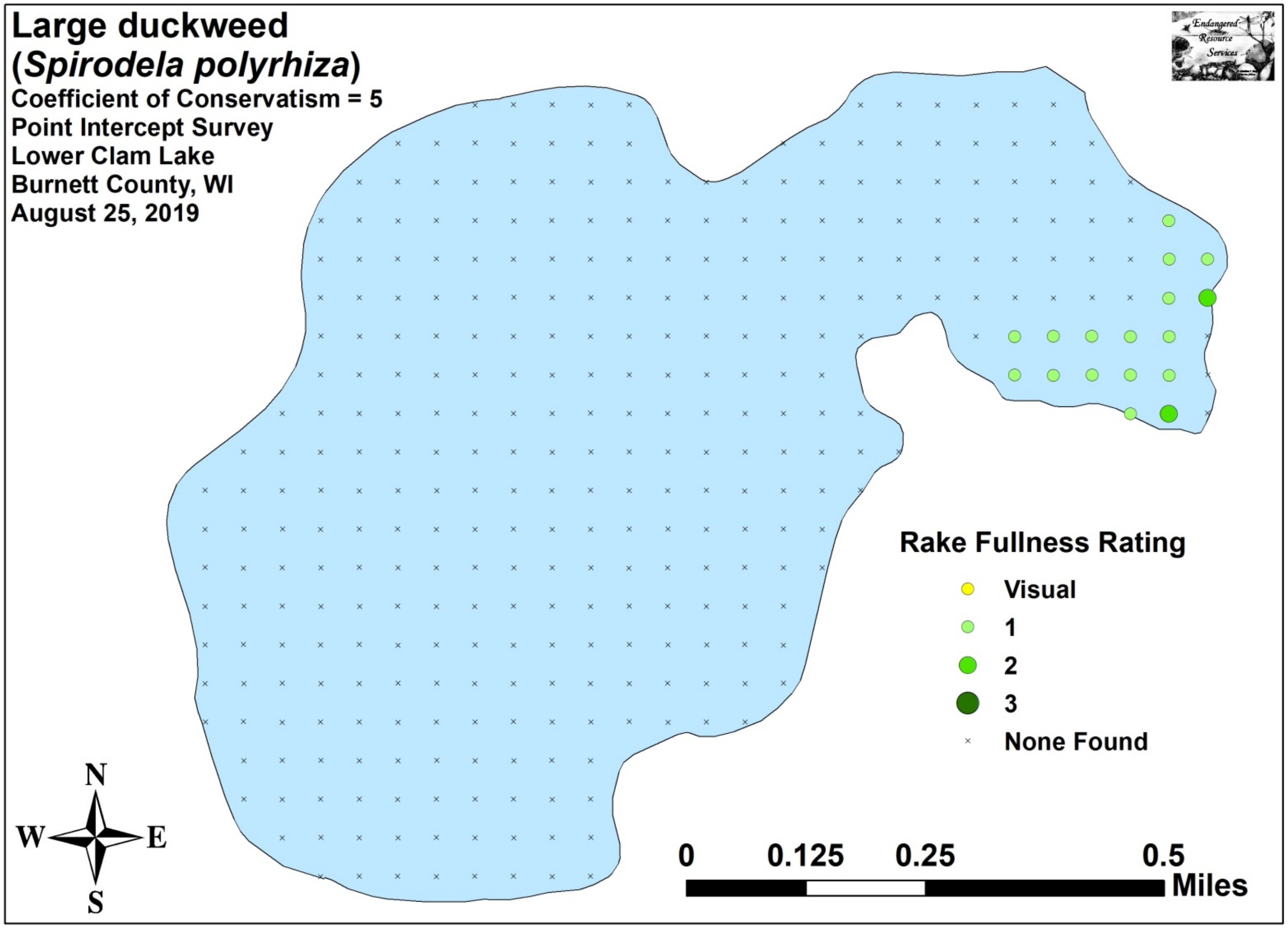
Miles


Large duckweed
(*Spirodela polyrhiza*)
Coefficient of Conservatism = 5
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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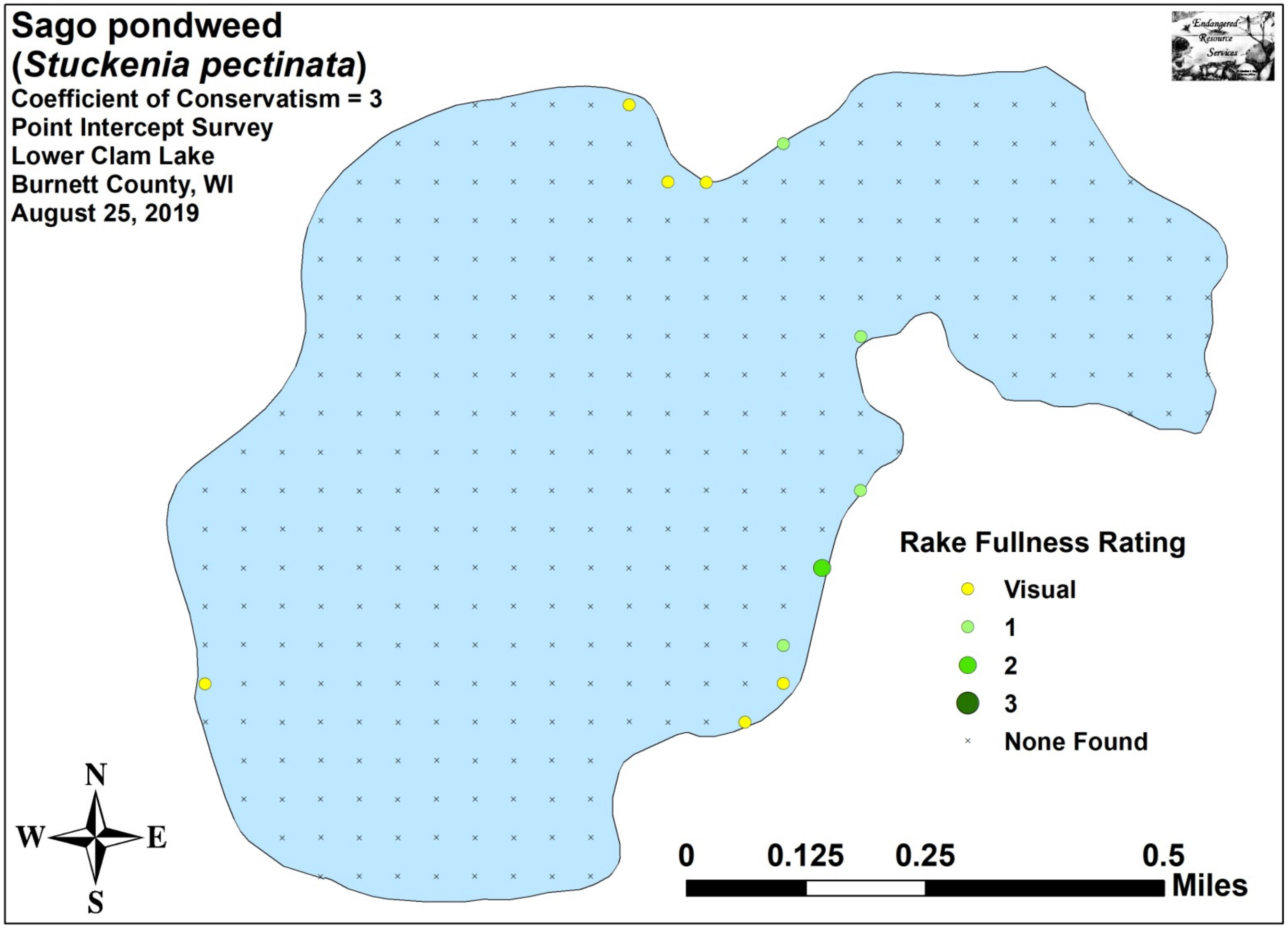
Miles


Sago pondweed
(Stuckenia pectinata)
Coefficient of Conservatism = 3
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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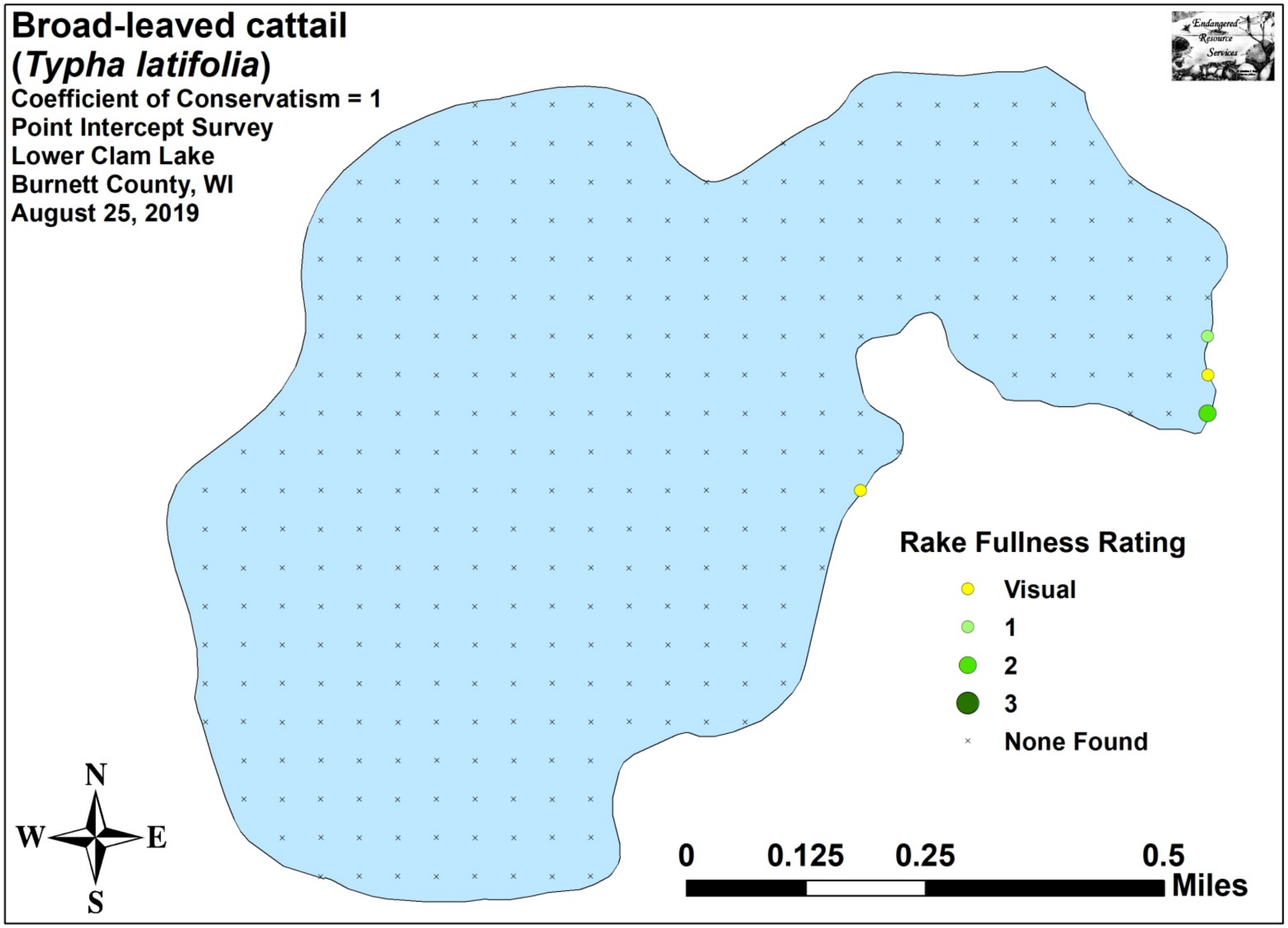
Miles


Broad-leaved cattail
(*Typha latifolia*)
Coefficient of Conservatism = 1
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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0.125
0.25
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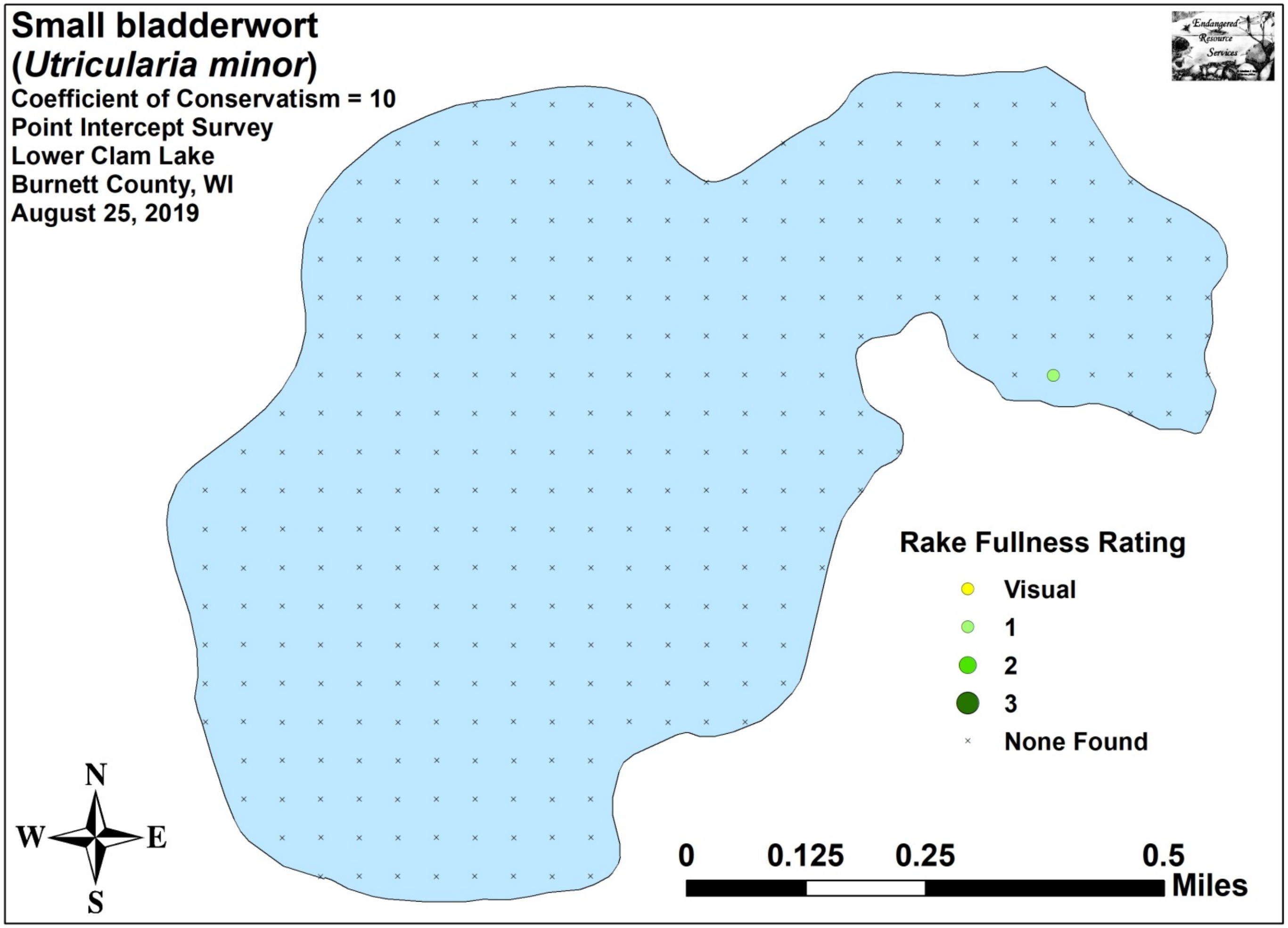
Miles


Small bladderwort
(Utricularia minor)
Coefficient of Conservatism = 10
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
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None Found
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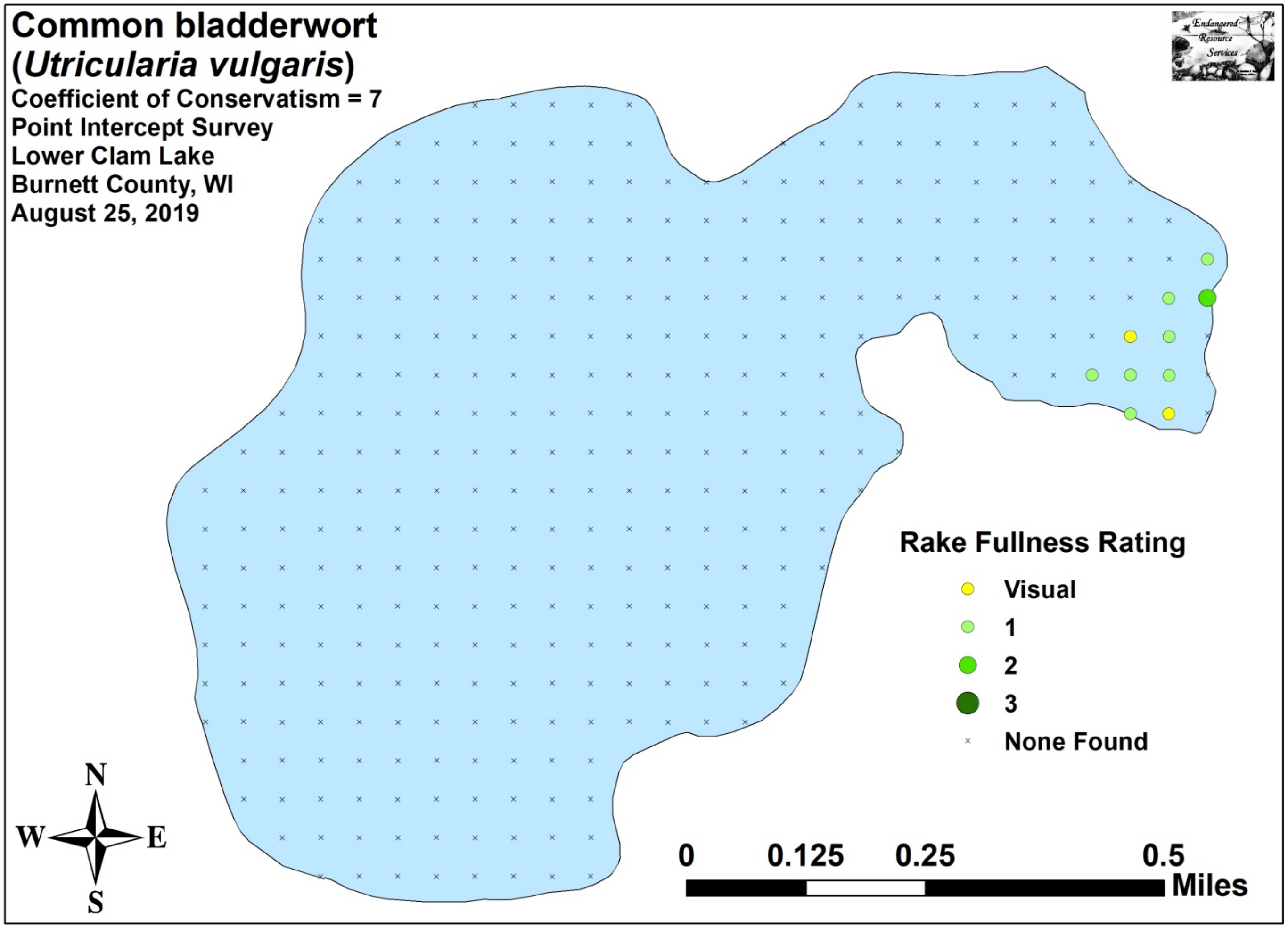
Miles



Common bladderwort
(*Utricularia vulgaris*)
Coefficient of Conservatism = 7
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
1
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None Found
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0.125
0.25
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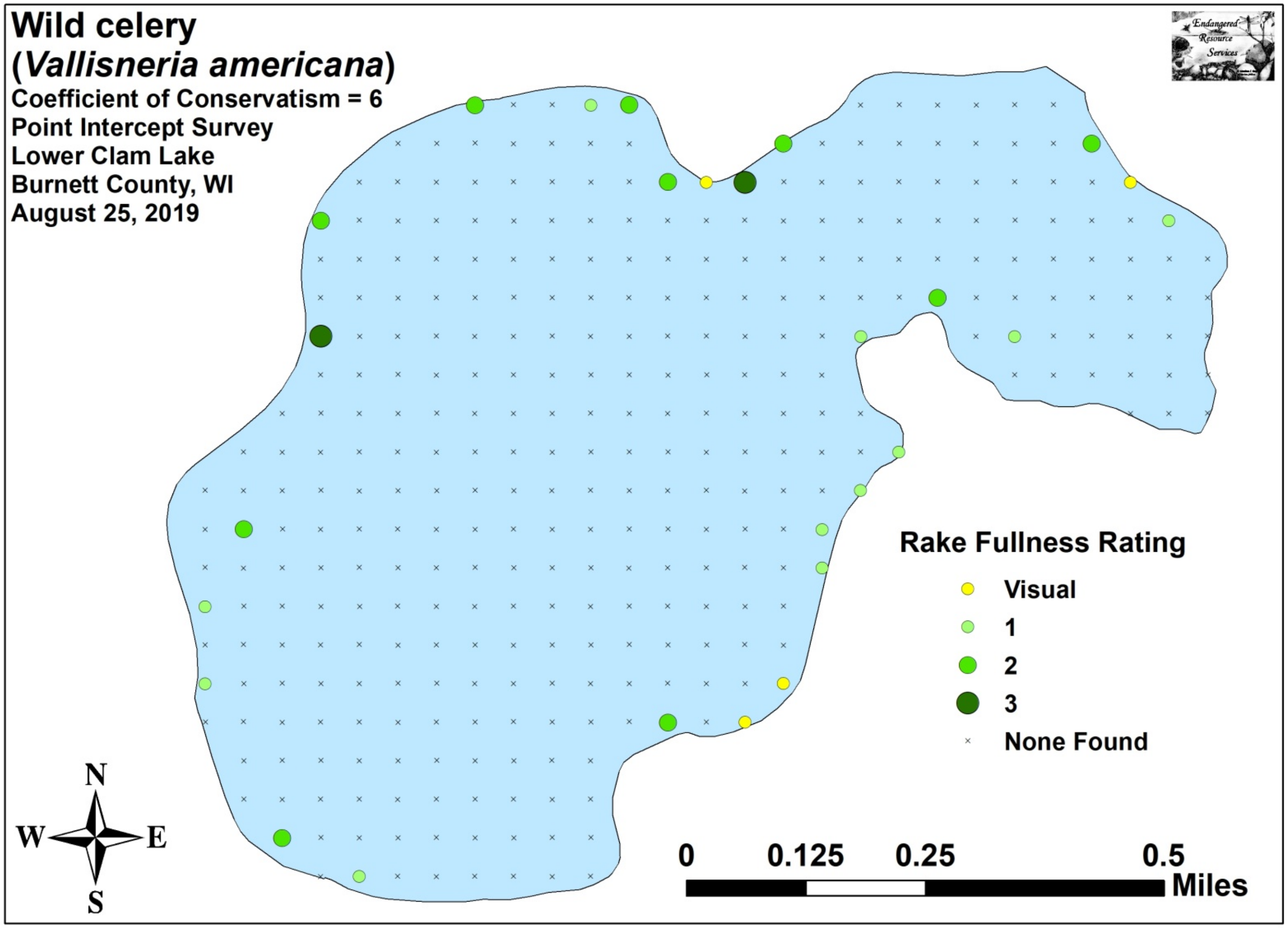
Miles


Wild celery
(Vallisneria americana)
Coefficient of Conservatism = 6
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
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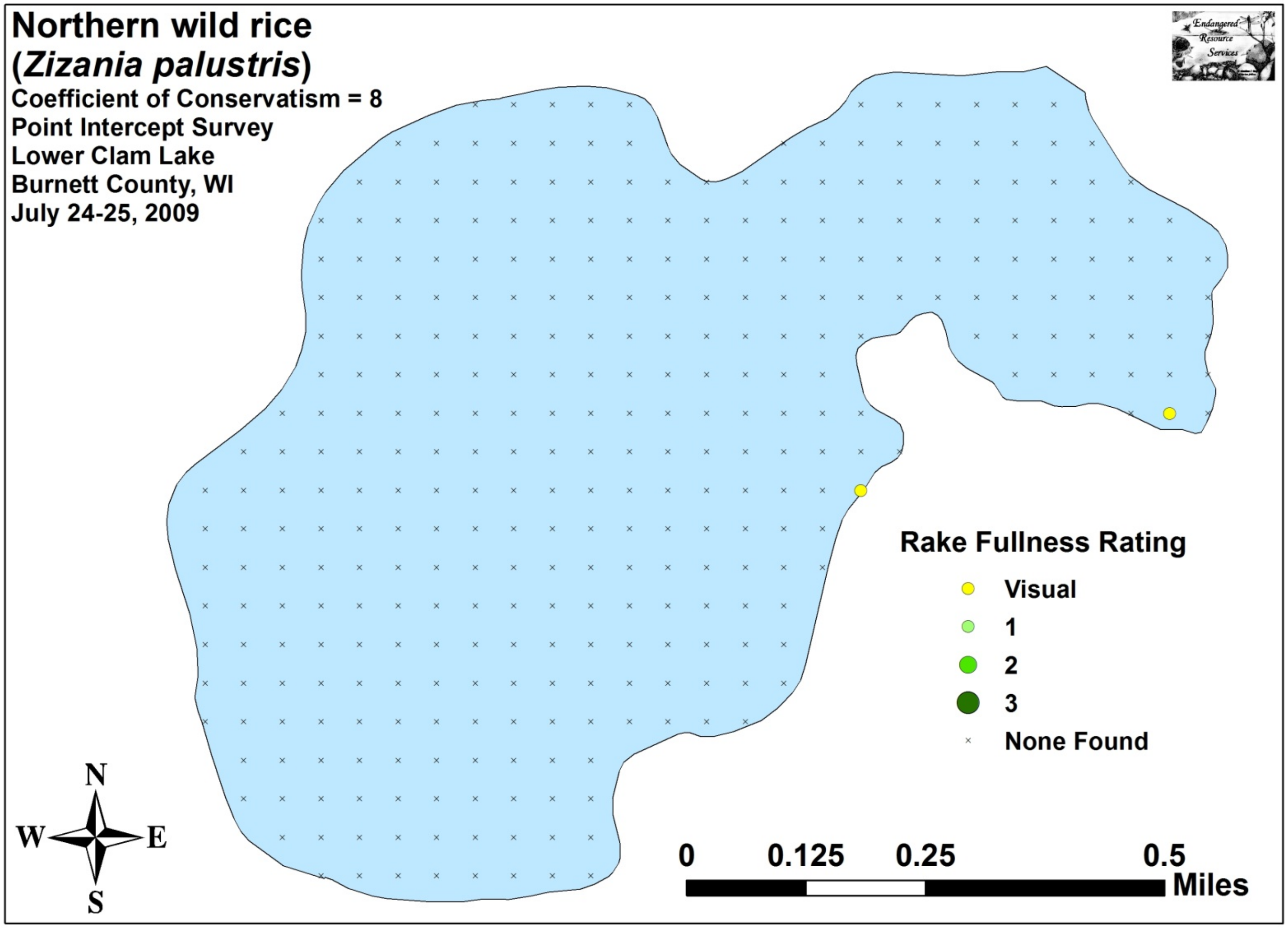
0.125
0.25
0.5
Miles

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
Lower Clam Lake
Burnett County, WI
July 24-25, 2009
Rake Fullness Rating
Visual
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None Found
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0.125
0.25
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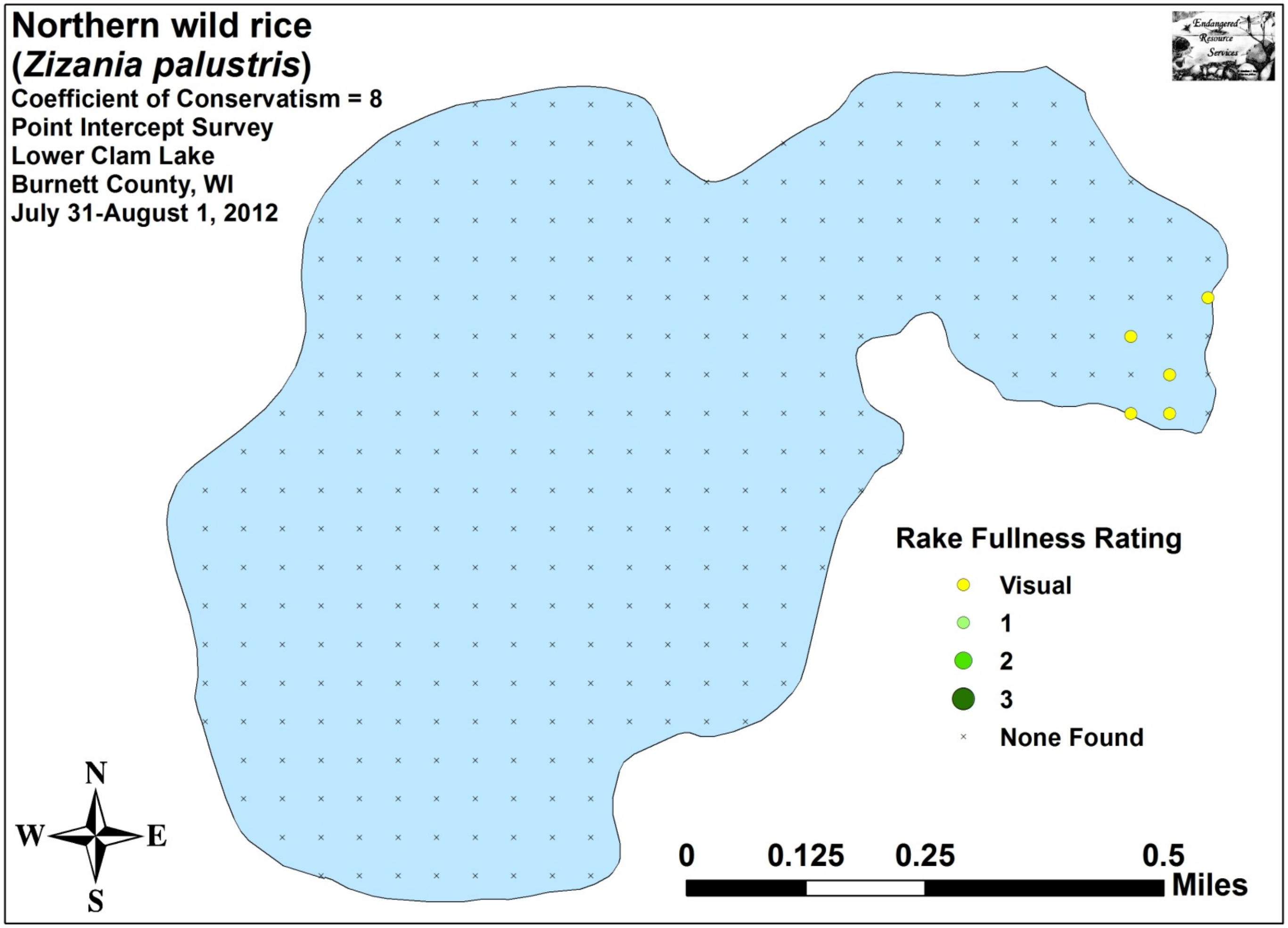
Miles


Northern wild rice
(*Zizania palustris*)
Coefficient of Conservatism = 8
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
July 31-August 1, 2012
Rake Fullness Rating
Visual
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None Found
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0.125
0.25
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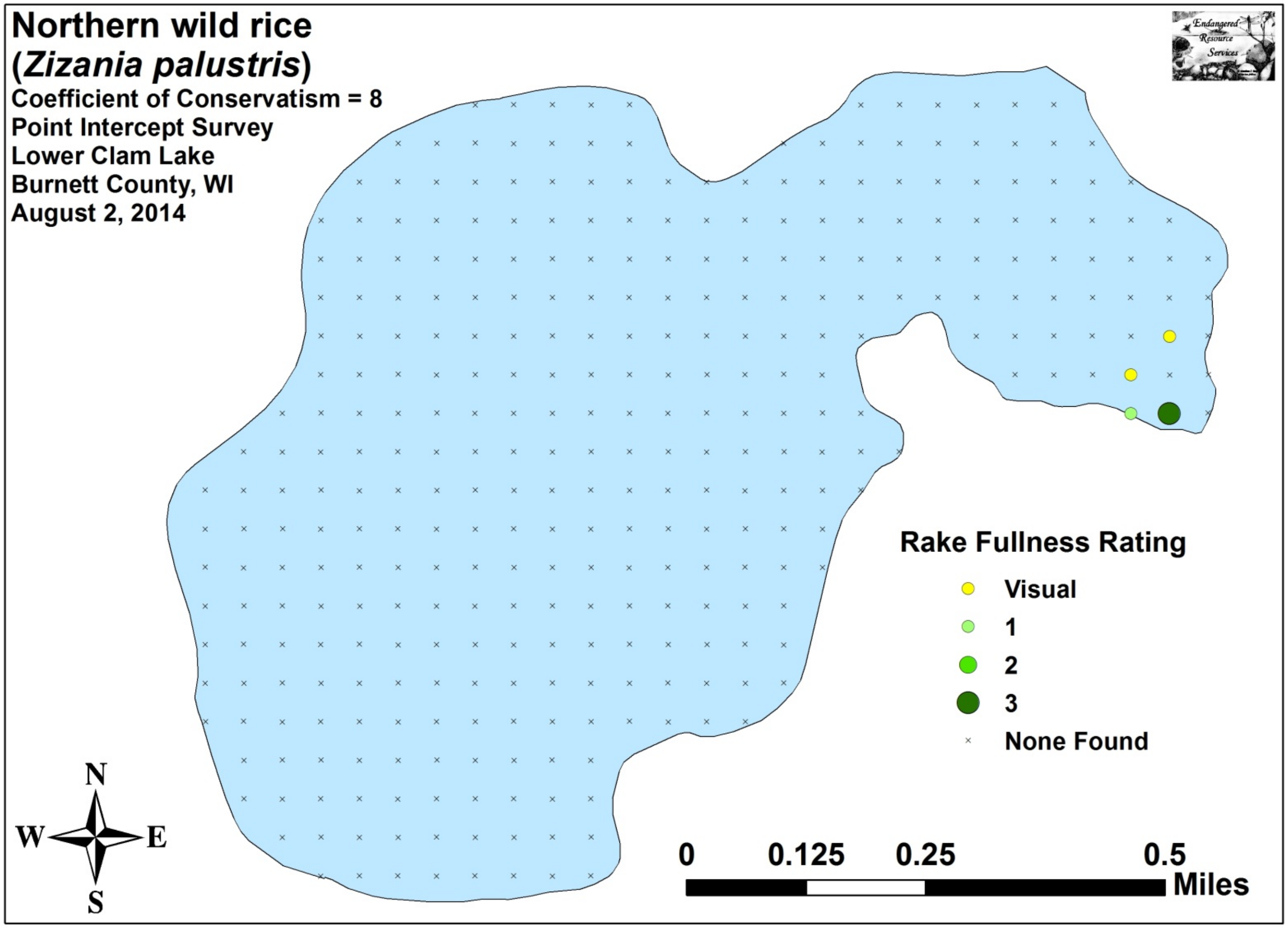
Miles



Northern wild rice
(*Zizania palustris*)
Coefficient of Conservatism = 8
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 2, 2014
Endangered Resource Services
Rake Fullness Rating
Visual
1
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None Found
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0.125
0.25
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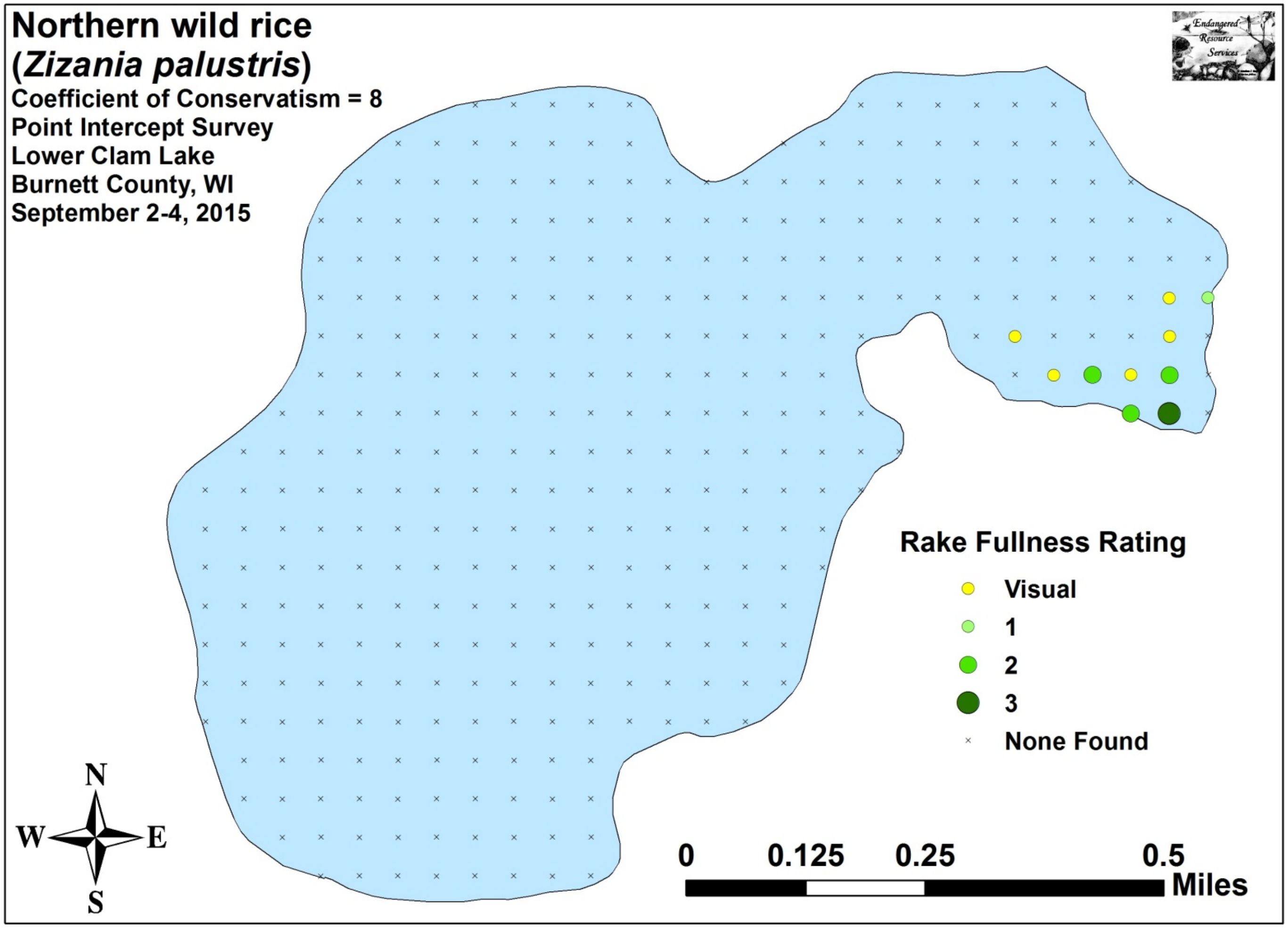
Miles


Northern wild rice
(Zizania palustris)
Coefficient of Conservatism = 8
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
September 2-4, 2015
Endangered Resource Services
Rake Fullness Rating
Visual
1
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None Found
N
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0.125
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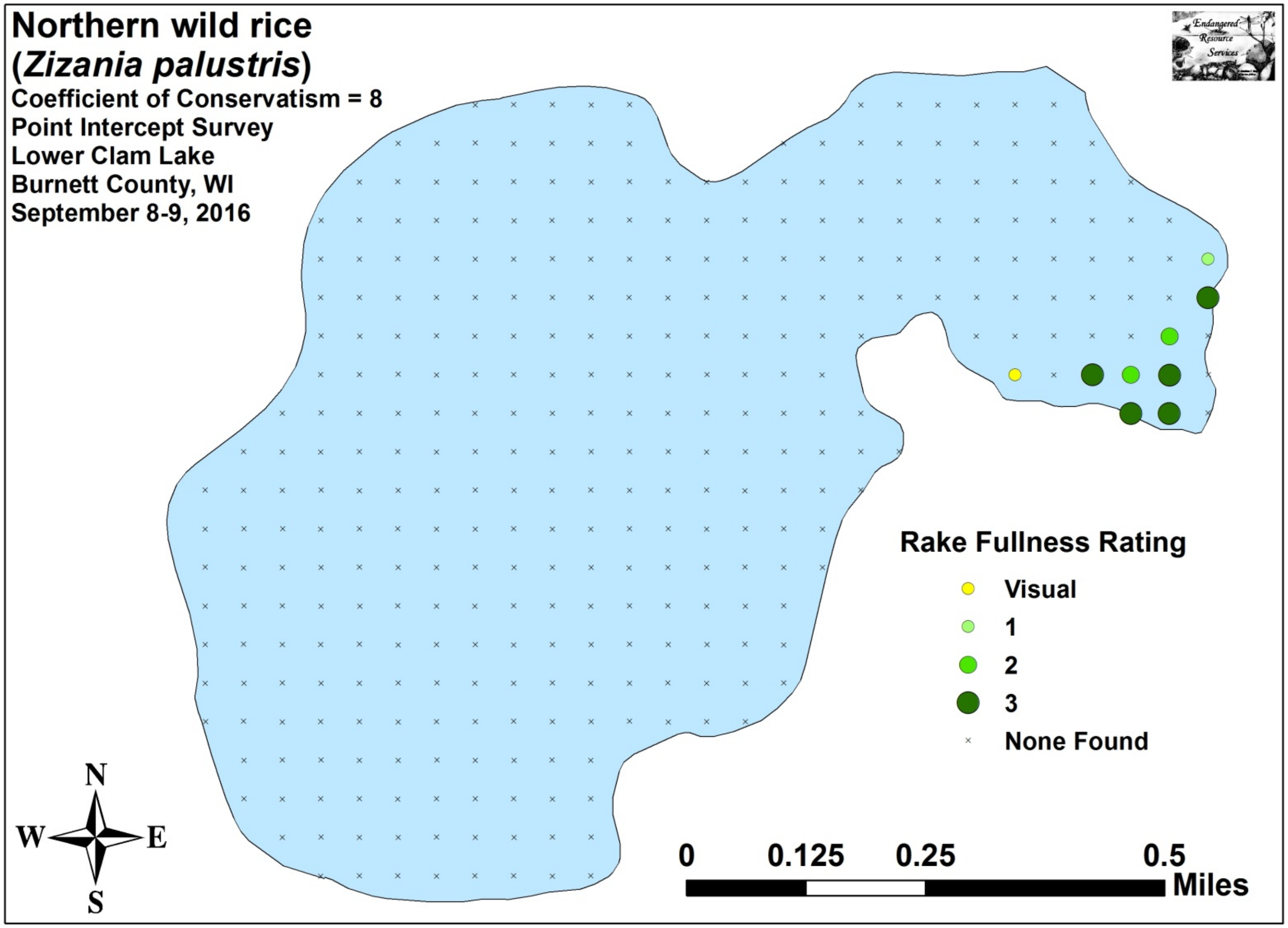
0.5
Miles


Northern wild rice
(*Zizania palustris*)
Coefficient of Conservatism = 8
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
September 8-9, 2016
Rake Fullness Rating
Visual
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None Found
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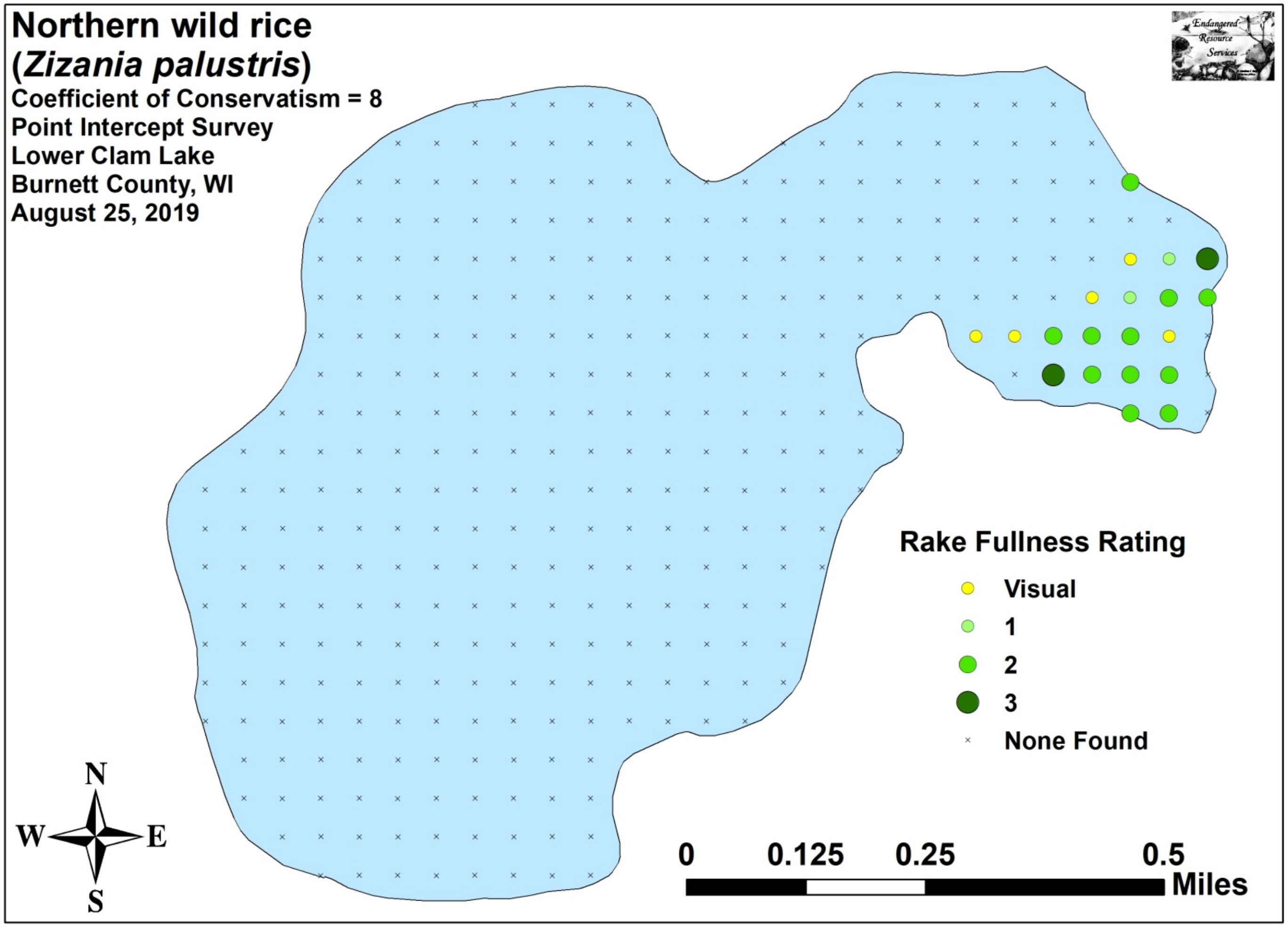
Miles


Northern wild rice
(*Zizania palustris*)
Coefficient of Conservatism = 8
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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W
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S
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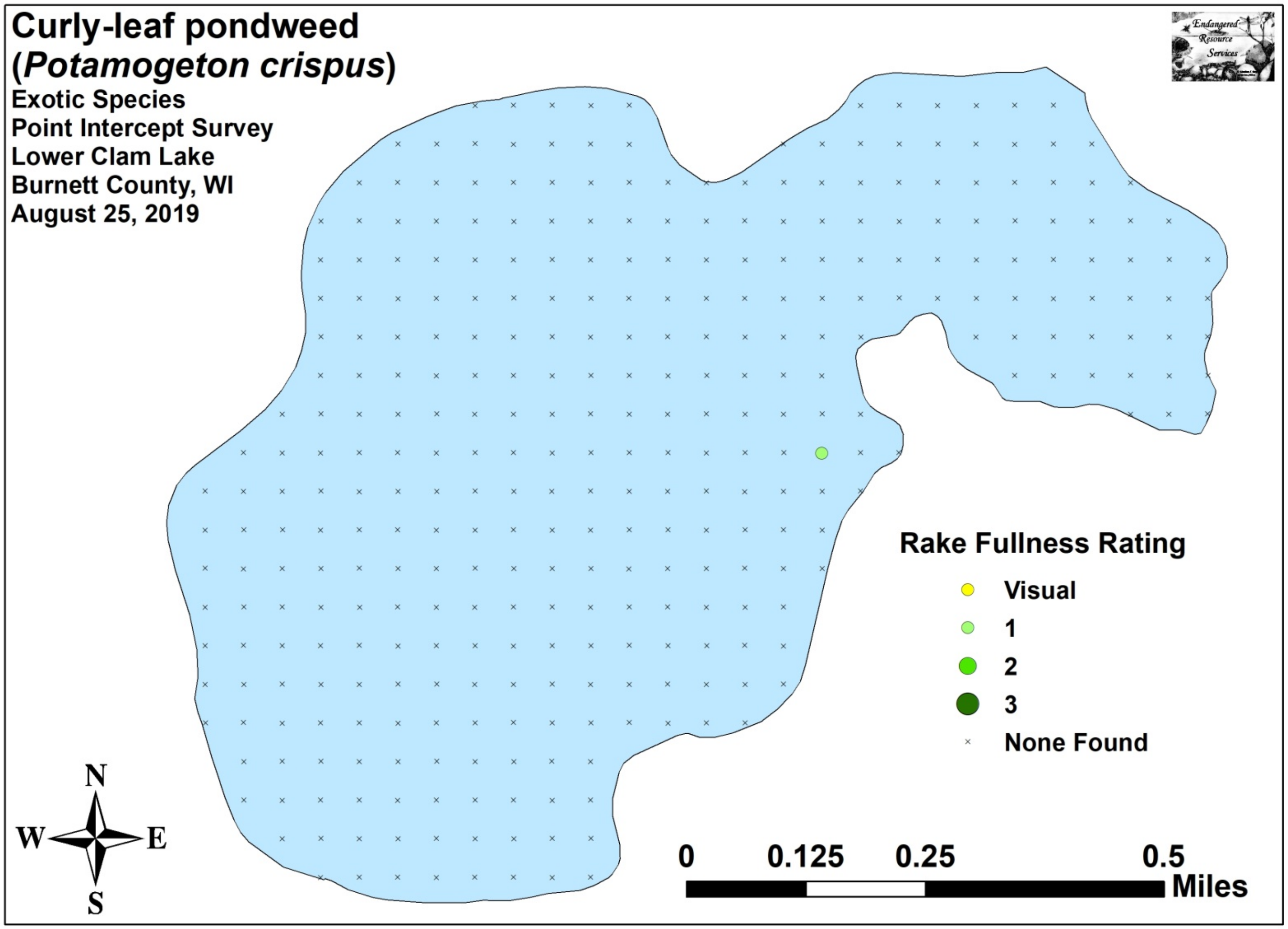
0.125
0.25
0.5
Miles

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


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
1
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None Found
0
0.125
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Miles
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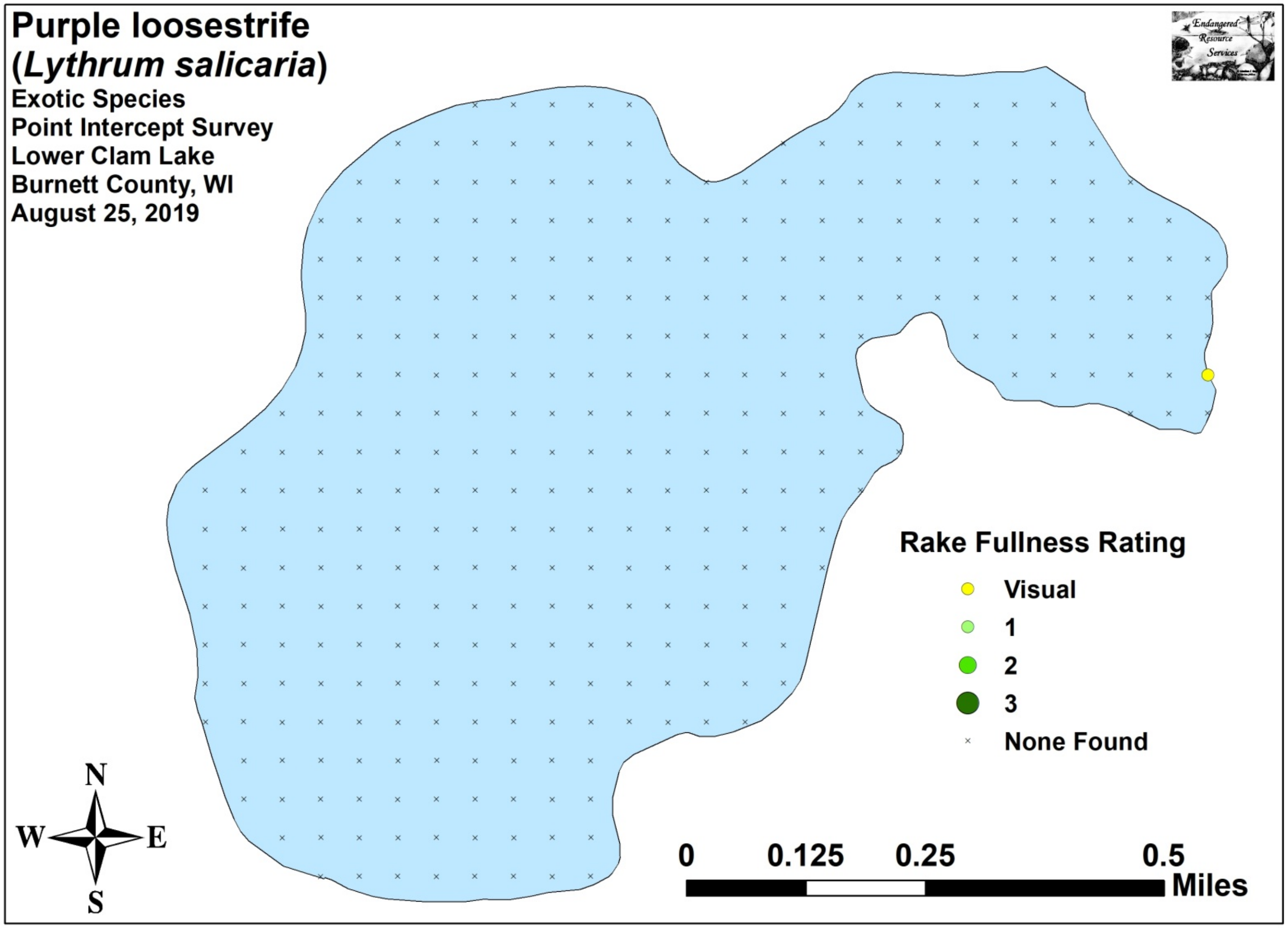
Purple loosestrife
(Lythrum salicaria)
Exotic Species
Point Intercept Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Rake Fullness Rating
Visual
1
2
3
None Found
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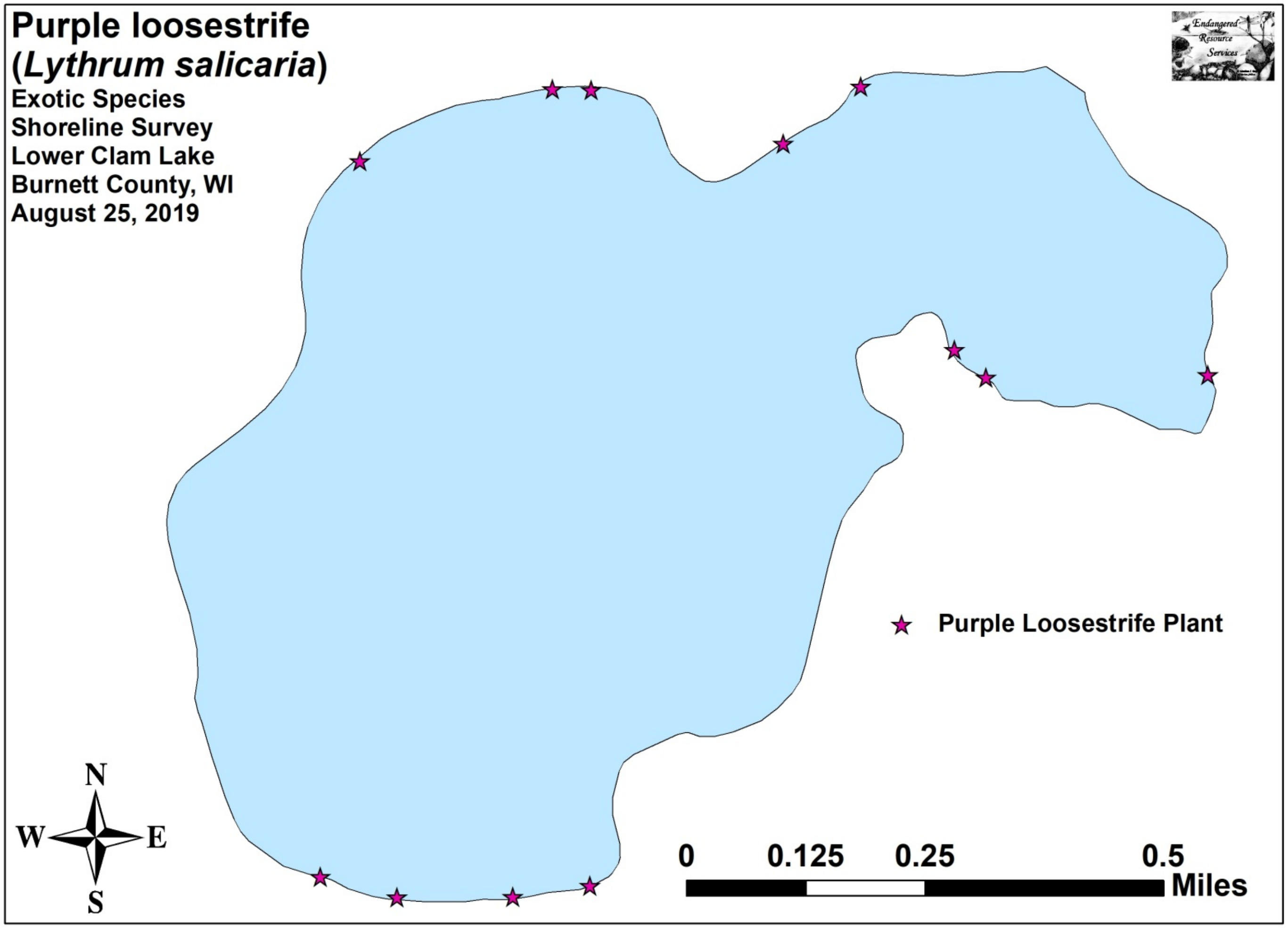
Purple loosestrife
(*Lythrum salicaria*)
Exotic Species
Shoreline Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Purple Loosestrife Plant
N
W
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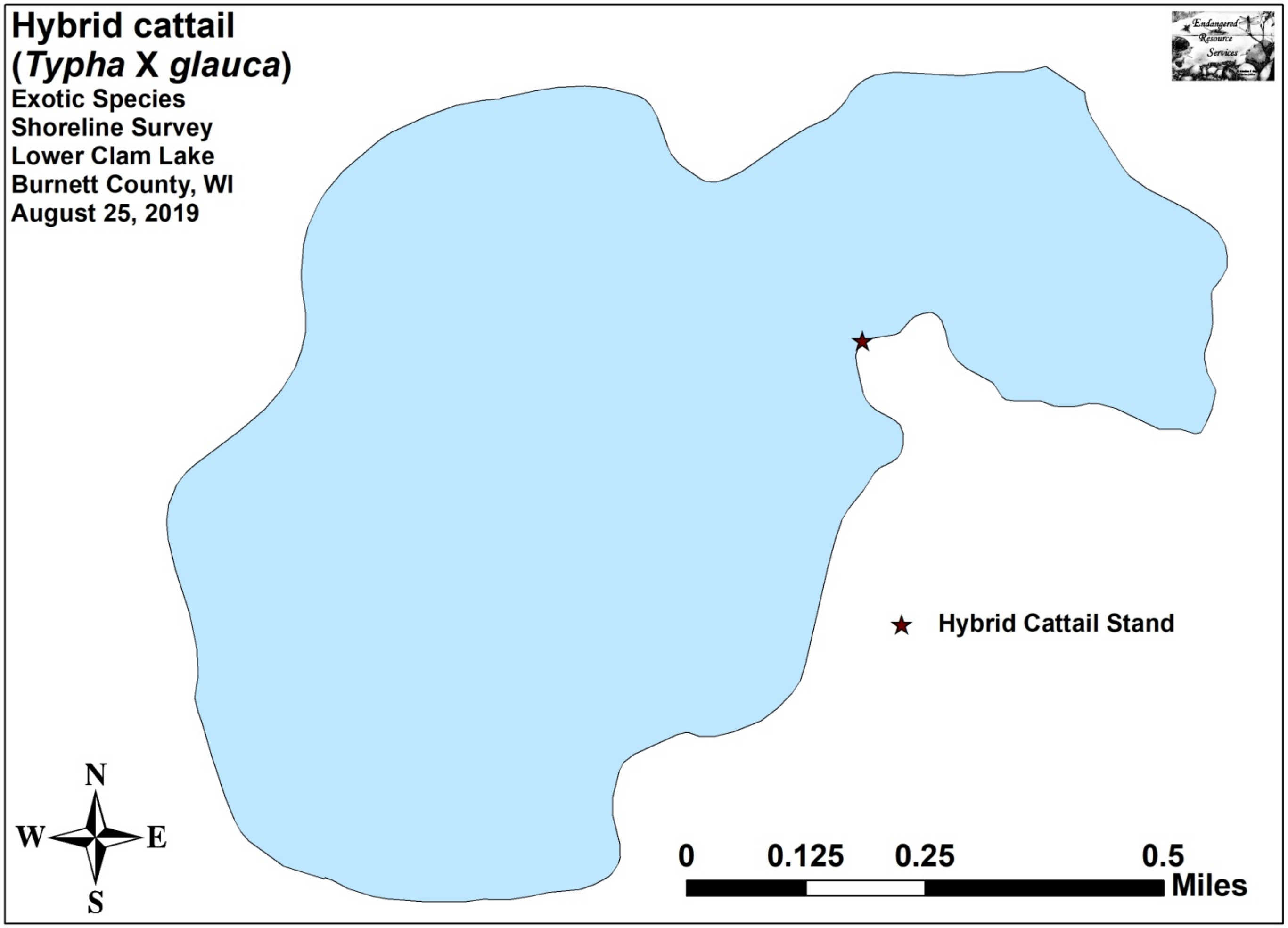
Hybrid cattail
(*Typha X glauca*)
Exotic Species
Shoreline Survey
Lower Clam Lake
Burnett County, WI
August 25, 2019
Hybrid Cattail Stand
N
W
E
S
0
0.125
0.25
0.5
Miles

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