Curly-leaf pondweed (*Potamogeton crispus*) Point-Intercept and Bed Mapping Surveys, and July Full Point-Intercept Macrophyte Survey
Big Moon Lake (WBIC: 2079000) - Barron County, WI


Canopied CLP Near the Lake Outlet (Berg 2013)


Aerial Photo of Big Moon Lake (2008)

Project Initiated by:
The Big Moon Lake Association, Short Elliott Hendrickson Inc., and the Wisconsin Department of Natural Resources – Grant LPL-1517-13


Fries pondweed (End 2012)

Survey Conducted by and Report Prepared by:
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June 12, 16, and July 13, 2013

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ABSTRACT

Big Moon Lake (WBIC 2079000) is a 187 acre stratified seepage lake located in southwestern Barron County, Wisconsin. The lake is eutrophic with a littoral zone that reached 9ft. in 2013. As a prerequisite to developing an Aquatic Plant Management Plan, the Big Moon Lake Association, Short Elliott Hendrickson Inc., and the Wisconsin Department of Natural Resources authorized Curly-leaf pondweed (*Potamogeton crispus*) density and bed mapping surveys on June 12th and 16th, and a full point-intercept macrophyte survey on July 13, 2013. In June, we found CLP at 95 sample points which extrapolated to approximately 14.6% of the lake. Of these, 59 (9.1%) had a rake fullness of 2 or 3 indicating a significant infestation. We also mapped 9 beds totaling 17.53 acres and covering 9.4% of the lake. During the July survey, we recorded macrophytes growing at 141 sites or 21.6% of the entire lake bottom and in 92.8% of the littoral zone. Overall diversity and localized richness were high with a Simpson Diversity Index value of 0.92 and sites with vegetation averaging 3.65 native species; however, total species richness was low with only 24 species found in the rake. The boat survey, which included many shoreline emergents, increased this total to 38 species. Flat-stem pondweed (*Potamogeton zosteriformis*), Coontail (*Ceratophyllum demersum*), Forked duckweed (*Lemna trisulca*), and Large duckweed (*Spirodela polyrhiza*) were the most common macrophyte species being found 55.32%, 51.77%, 34.75%, and 26.95% of survey points with vegetation and combining for 43% of the total relative frequency. The 20 native index species found in the rake during the July survey produced a below average mean Coefficient of Conservatism of 5.2 and a Floristic Quality Index of 23.3 that was slightly above the median FQI for this part of the state. In addition to CLP, other exotic species found included Reed canary grass (*Phalaris arundinacea*), Sweet-flag (*Acorus calamus*), and Narrow-leaved cattail (*Typha angustifolia*). Future management considerations include working to preserve the lake's limited native plants and the critical habitat they provide for the whole lake ecosystem; improving water clarity and decreasing algal growth; encouraging all lakeshore property owners to proactively reduce nutrient runoff and erosion by not mowing down to the water, bagging grass clippings, eliminating fertilizer applications near the water, restoring shorelines, and establishing buffer strips of native vegetation; continuing to monitor the CLP beds for expansion; and working to prevent the spread of CLP by refraining from removing native plants which can expose the lake substrate and make it easier for CLP to establish. At the public boat landings, establishing a Clean Boats/Clean Waters Program – at least on weekends; improving the current signage to remind boaters of the dangers/impacts of AIS; and conducting monthly landing and annual whole lake visible littoral zone surveys for AIS are all management strategies for the BMLA to consider as they develop their APMP.

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INTRODUCTION:

Big Moon Lake (WBIC 2079000) is a 187 acre stratified seepage lake located in the Town of Turtle Lake in southwestern Barron County (T33N R14W S16 SW NW). The lake reaches a maximum depth of 48ft in the eastern basin and has an average depth of 24ft (Figure 1). The lake is eutrophic in nature with fair water clarity that produced Secchi readings ranging from 4-10ft and averaging 6.7ft from 2000-2012 (WDNR 2013). These conditions produced a littoral zone that extended to approximately 9ft in 2013. Bottom substrate is predominantly organic muck in the sheltered bays on the lake's south and west ends, and a mixture of sand, rock, and sandy muck along the north and east shorelines, projecting from exposed points, and around the western sunken island (Miller et al. 1965).

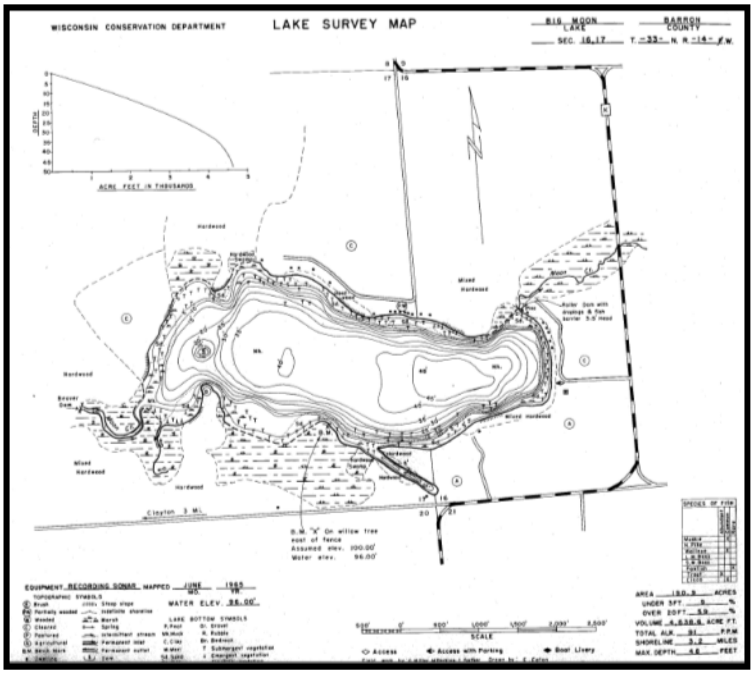


Figure 1: Big Moon Lake Bathymetric Map

The Big Moon Lake Association (BMLA), Short Elliott Hendrickson Inc. (SEH), and the Wisconsin Department of Natural Resources (WDNR) authorized a series of full lake plant surveys on Big Moon Lake in 2013 prior to developing an Aquatic Plant Management Plan. On June 12th, we completed a cold-water Curly-leaf pondweed (*Potamogeton crispus*) (CLP) point-intercept survey. This was followed by a CLP bed mapping survey on June 16th, and a warm-water point-intercept survey of all aquatic macrophytes on July 13th. Both point-intercept surveys used the WDNR's statewide guidelines for conducting systematic macrophyte sampling. These methods ensure that all surveys in the state will be conducted in the same manner, thus allowing data to be compared across time and space. The immediate goals of the surveys were to document the extent of the lake's known CLP infestation, determine if Eurasian water milfoil (*Myriophyllum spicatum*) had invaded the lake, and establish data on the richness, diversity, abundance and distribution of other native aquatic plant populations. These data provide a baseline for long-term monitoring of the lake's macrophyte community as well as a way to measure any impacts on the lake's plants if active management occurs in the future.

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, Michelle Nault (WDNR) generated a 652 point sampling grid for Big Moon Lake (Appendix I). Using this grid, we completed a density survey where we sampled for CLP at each point on the grid. 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. CLP was assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of CLP within six feet of the sample point.

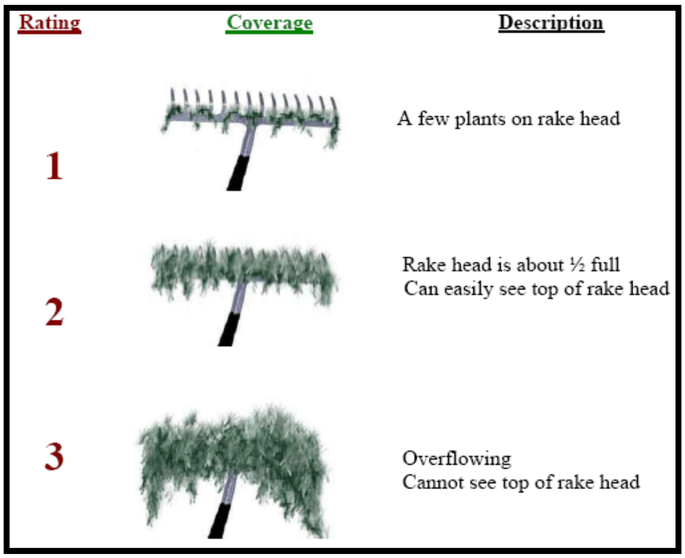


Figure 2: Rake Fullness Ratings (UWEX 2010)

CLP Bed Mapping Survey:

Following the CLP density survey, we used the resulting map coupled with a meandering littoral zone search to locate and delineate all significant beds of CLP on the lake. We defined a bed based on the following two criteria: CLP plants made up greater than 50% of all aquatic plants in the area, and the CLP had canopied at the surface or was close enough to the surface that it would likely interfere with normal boat traffic.

Upon finding a bed, we circled around the perimeter and used a GPS unit to record waypoints at regular intervals. We then uploaded these points into ArcMap 9.3.1, created bed shapefiles using the WDNR Forestry Tools Extension, and determined the total acreage of the beds to the nearest hundredth of an acre (Table 1).

July Point Intercept Macrophyte Survey:

Prior to beginning the July point-intercept survey, we conducted a general boat survey of the lake to gain familiarity with the species present (Appendix II). All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2006; Skawinski 2011), and two vouchers were pressed and mounted for herbarium specimens – one to be retained by the BMLA, and one to be sent to the state herbarium in Stevens

Point for identification confirmation. We again located each survey point with a GPS, recorded a depth reading with a hand held sonar unit (Vexilar LPS-1), and took a rake sample. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of all plants within six feet of the sample point not found in the rake. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (lake bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

DATA ANALYSIS:

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

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

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

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

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

Frequency of occurrence example:

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

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

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

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

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

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

<u>Number of sites sampled using rope/pole rake:</u> This indicates which rake type was used to take a sample. As is standard protocol, we used a 15ft pole rake and a 25ft 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).

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

Relative frequency example:

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

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

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

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

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

Floristic Quality Index (FQI): This index measures the impact of human development on a lake's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each native index species found in the lake during the point intercept survey**, and multiplying it by the square root of the total number of plant species (N) in the lake ($FQI=(\Sigma(c1+c2+c3+\ldots cn)/N)*\sqrt{N}$). Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Big Moon Lake is in the Northern Central Hardwood Forests Ecoregion (Table 4).

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

RESULTS:

Curly-leaf Pondweed Point Intercept Survey:

Following the establishment of the June littoral zone at approximately 9ft of water, we sampled for Curly-leaf pondweed at all points in and adjacent to this zone. CLP was common to abundant and widely distributed over areas with thick organic and sandy muck in 2-9ft of water. We found CLP in the rake at 95 sample points or approximately 14.6% of the lake. Collectively, they averaged a rake fullness of 1.89 with 26 points rating a 3, 33 points a two, and the remaining 36 a 1. This extrapolated to 9.1% of the lake having a significant infestation (rake fullness 2 and 3). We also recorded CLP as a visual at eight additional points (Figure 3) (Appendix III).

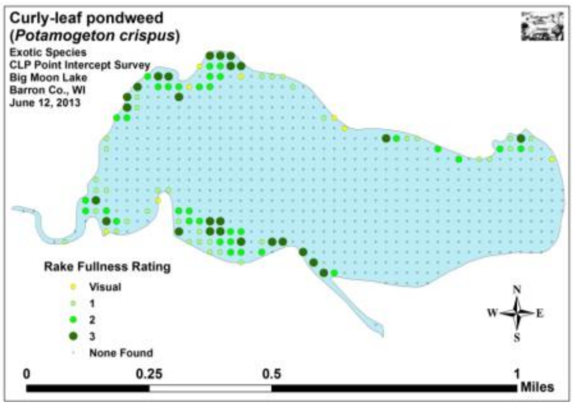


Figure 3: Big Moon Lake's June CLP Density and Distribution

CLP Bed Mapping Survey:

We located and mapped nine CLP beds totaling 17.53 acres (9.4% of the lake's 187 acres) with the biggest being 4.96 acres (Bed 2) and the smallest being 0.04 acre (Bed 9) (Figure 4) (Table 1). Each of these beds was canopied or near canopy, and, although scattered plants extended to 9.0ft, the densest monotypic growth generally started at 4ft before ended abruptly at 7ft forming a hard outer edge to the beds. The inner edges were more fragmented as they were normally mixed with at least some natives (Appendix III).

Table 1: CLP Bed Summary
Big Moon Lake, Barron Co. June 16, 2013

Bed Number	Acreage	Estimated Range and Mean Rake Fullness
1	0.38	<1-2; Mostly 1
2	4.96	1-3; Mostly 2
3	2.52	<1-3; Mostly 2
4	3.99	<1-3; Mostly 2
5	2.73	1-3; Mostly 2
6	0.13	<1-1; Mostly 1
7	2.17	<1-1; Mostly 1
8	0.61	1-3; Mostly 2
9	0.04	<1-3; Mostly 2
Total Acres	**17.53**	

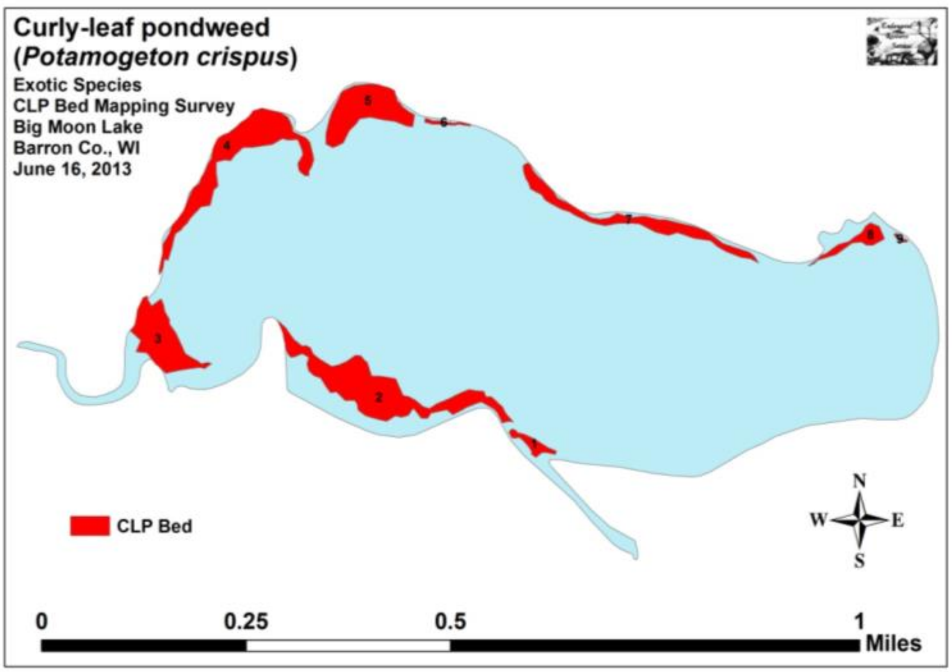


Figure 4: Big Moon Lake June CLP Bed Map

Description of Beds:

Bed 1: Located at the entrance to the "Lagoon" and stretching across the entire bay, Bed 1 was moderately dense and canopied, but not monotypic (Figure 5). In addition to "lilypads", we noted that valuable habitat providing native species like Large-leaf pondweed (*Potamogeton amplifolius*) and Northern water milfoil (*Myriophyllum sibiricum*) were found here and almost nowhere else in the lake. Because of this, we believe this is an area where any future CLP management, if not avoided, should be done very cautiously.

Beds 2 and 3: CLP in Beds 2 and 3 extended to 9ft, was canopied throughout, and was often dense to the point of being a potential navigation impairment (Figure 5). Fortunately, there were few residences in these areas as the majority of the beds were bordered by undeveloped wetlands. Although nearly monotypic CLP in June, Coontail (*Ceratophyllum demersum*) and Flat-stem-pondweed (*Potamogeton zosteriformis*) filled in many of these areas by the time of the July survey.

Figure 5: Representative CLP in Beds 1 and 3

Beds 4 and 5: We found that Beds 4 and 5 were also moderate to dense and canopied along the western shoreline and the northwest bays. However, as the worst of these areas were again adjacent to undeveloped wetlands and too shallow (<2ft in the bays) to be boated through, it seems unlikely that they would cause navigation issues. The only area in the beds that could have the potential to interfere with recreation was the eastern finger of Bed 4 which covered the gravel/sand bar projecting to the southeast (Figure 6).

Beds 6 and 7: These beds occurred adjacent to the highly developed northern shoreline of the lake, but their narrow width likely meant that residents didn't need to clear their motors more than one time to access navigable water. We noted that CLP was canopied in most areas, but the sand and gravel substrates along this shoreline tended to produce low density stands. Later in the growing season, CLP in this area was replaced by beds of native plants dominated by Fries' pondweed (*Potamogeton friesii*) and Wild celery (*Vallisneria americana*).

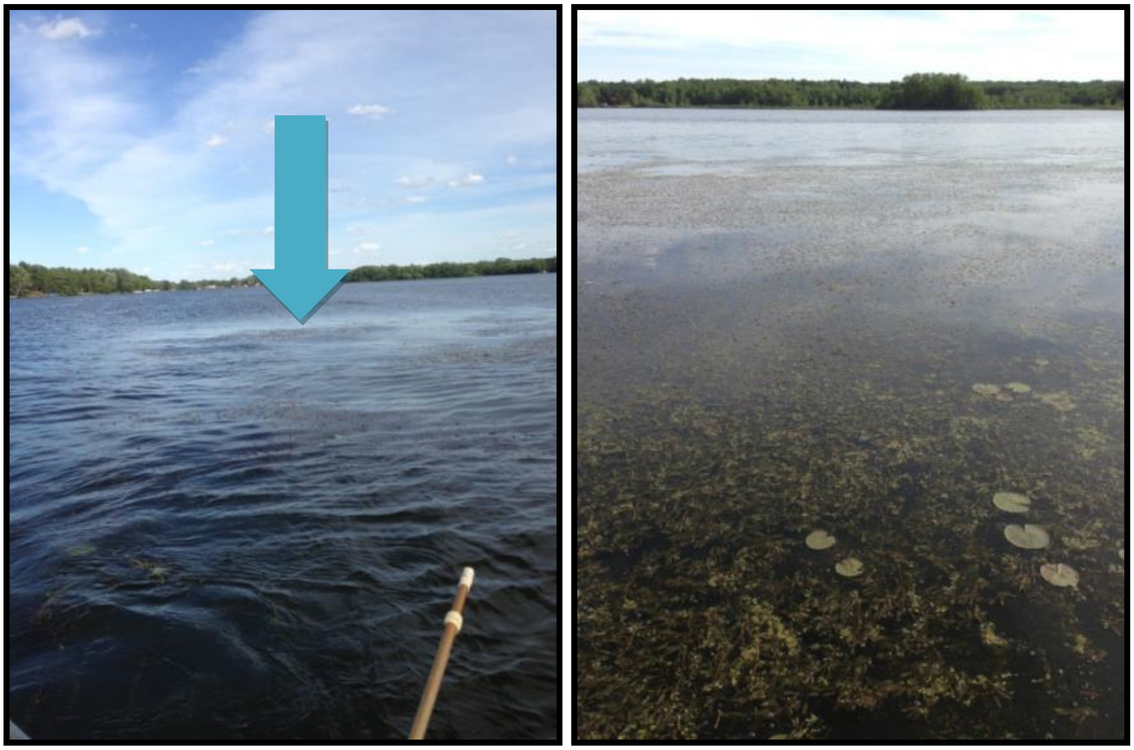


Figure 6: Canopied CLP in Bed 4 (on the bar) and Bed 5

Beds 8 and 9: These dense beds were established near the lake outlet. Although there were a few residences in the area, regular boat traffic, water flow, or a combination of the two appeared to be keeping a navigable channel open between the two beds (Figure 7).

Figure 7: CLP in Bed 8 at the Dam Outlet

July Point Intercept Macrophyte Survey:

Depth soundings taken at Big Moon Lake's 652 survey points revealed the bays on the lake's west side generally sloped gradually to 10ft+ of water, while the north, south, and east shorelines of the central basin tended to drop of sharply into 30ft+ of water. Within this basin, we mapped two 40ft+ holes – one on either side of the lake's midpoint. The only other topography of note was a sunken island that topped out at approximately 6ft due north of the point on the lake's southwest side (Figure 8) (Appendix IV).

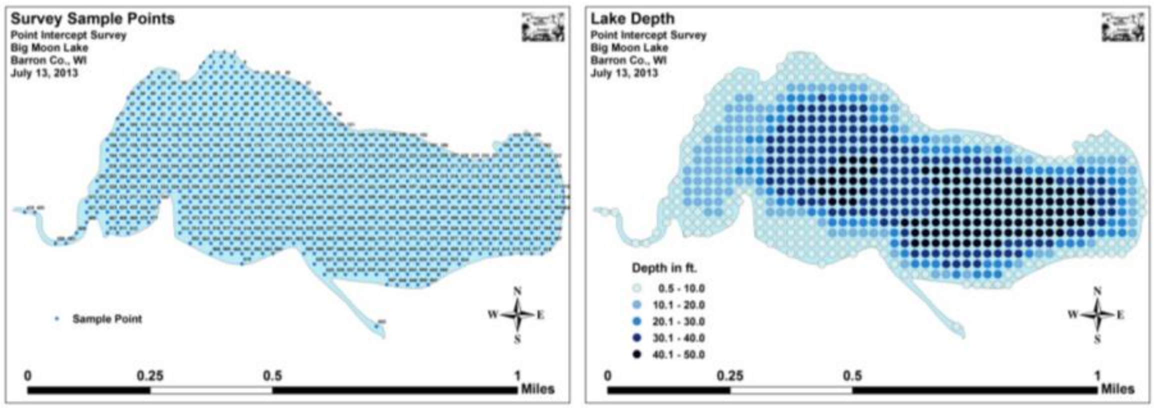


Figure 8: Survey Sample Points and Lake Depth

Of the 183 survey points where we could determine the substrate, 53.55% were muck, 13.66% were rock, and 32.79% were pure sand. Nutrient rich organic muck dominated the lake bottom in the western and southern bays while sandy muck was common in deeper areas beyond the sandy/rocky north and eastern shorelines. Throughout the lake, most of the exposed points, bars, and islands were also sandy/rocky in nature (Figure 9). We found plants growing at 141 sites or approximately 21.63% of the entire lake bottom and in 92.76% of the littoral zone. Plant growth was slightly skewed to deeper water as the mean depth was 4.2ft while the median depth was 4.0ft. Despite a lakewide July littoral upper limit of 8.5ft, most plant growth ended in 7.0ft of water, and these plants were starting to die back due to lack of light/poor water clarity (Figure 9) (Table 2) (Appendix IV).

Species richness was fairly low as we found only 24 species in the rake during the survey. Visuals and boat survey species brought this total up to 38 species, but most of these were emergents rather than true aquatics. Despite this low number of species, overall diversity was very high with a Simpson Diversity Index value of 0.92. Localized richness was also high with an average of 3.65 native species per/site with native vegetation. Total rake fullness was moderate averaging 2.13 at sites with vegetation. In general, species richness, diversity and total rake biomass declined rapidly at depths beyond 5ft (Figure 10) (Appendix V).

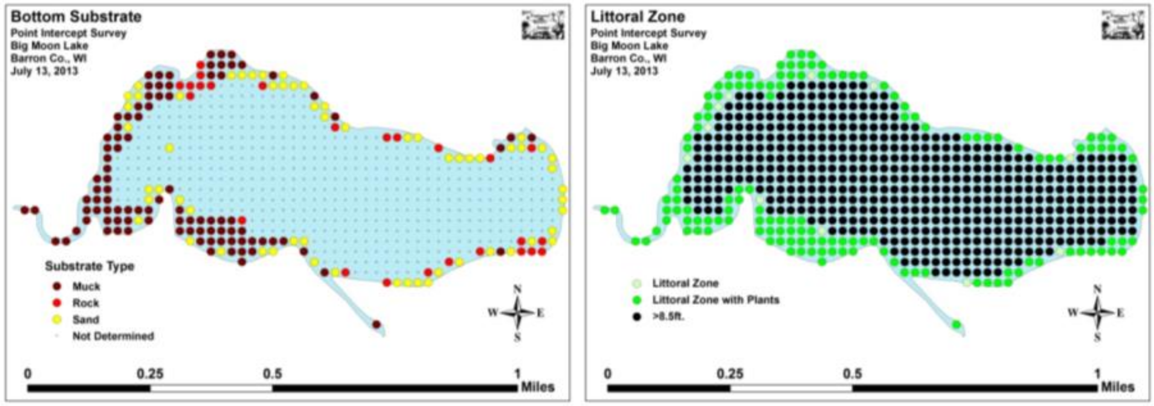


Figure 9: Bottom Substrate and Littoral Zone

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics
Big Moon Lake, Barron County
July 13, 2013

Summary Statistics:

Total number of points sampled	652
Total number of sites with vegetation	141
Total number of sites shallower than the maximum depth of plants	152
Frequency of occurrence at sites shallower than maximum depth of plants	92.76
Simpson Diversity Index	0.92
Maximum depth of plants (ft)	8.5
Mean depth of plants (ft)	4.2
Median depth of plants (ft)	4.0
Number of sites sampled using rope rake (R)	0
Number of sites sampled using pole rake (P)	183
Average number of all species per site (shallower than max depth)	3.61
Average number of all species per site (veg. sites only)	3.89
Average number of native species per site (shallower than max depth)	3.29
Average number of native species per site (veg. sites only)	3.65
Species richness	24
Species richness (including visuals)	31
Species richness (including visuals and boat survey)	38
Average rake fullness (veg. sites only)	2.13

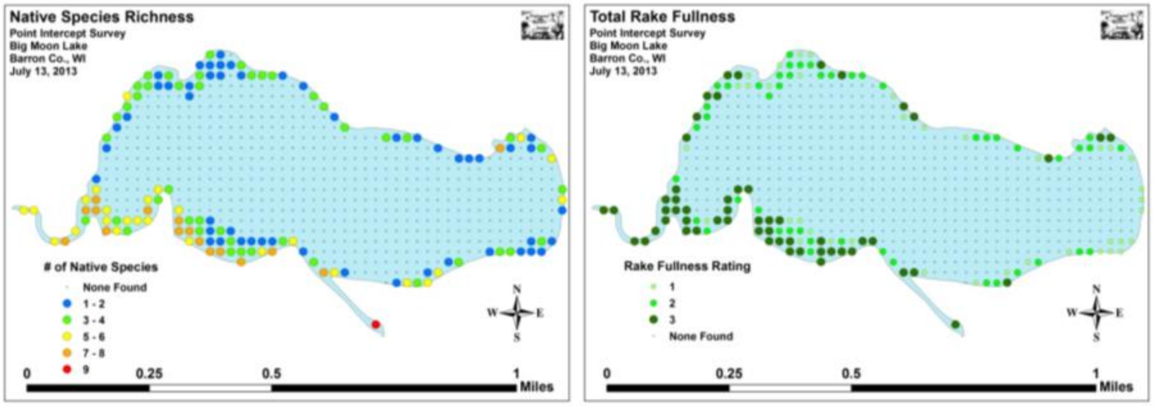


Figure 10: Native Species Richness and Total Rake Fullness

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

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

Scattered along undeveloped shoreline areas over firm sand and gravel, this emergent community was dominated by Softstem bulrush (*Schoenoplectus tabernaemontani*), Common bur-reed (*Sparganium eurycarpum*), Sweet-flag (*Acorus calamus*), and Creeping spikerush (*Eleocharis palustris*) with small numbers of Pickerelweed (*Pontederia cordata*), Water horsetail (*Equisetum fluviatile*), and Hardstem bulrush (*Schoenoplectus acutus*) mixed in. In areas over firm muck, they were replaced by Common arrowhead (*Sagittaria latifolia*), Cattails (*Typha* spp.), and Reed canary grass (*Phalaris arundinacea*). In shallow boggy bay areas near the Moon Creek Inlet, we found Bald spikerush (*Eleocharis erythropoda*), Northern blue flag (*Iris versicolor*), and tussocks of sedge (*Carex* spp.) to be the most common emergent species.


Softstem bulrush (Schwarz 2011)


Common bur-reed (Hilty 2012)


Pickerelweed (Texas A&M 2012)


Water horsetail (Elliot 2007)


Broad-leaved cattail (Raymond 2011)


Common arrowhead (Young 2006)


Northern blue flag (Tracey 2007)

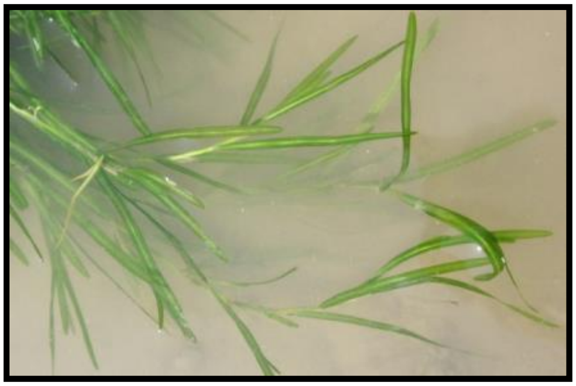

Lake sedge (CBG 2006)

Just beyond the emergents, in up to 5ft of water, organic muck bottomed areas were dominated by the floating-leaf species Spatterdock, (*Nuphar variegata*), White-water lily (*Nymphaea odorata*), and, rarely, Large-leaf pondweed. The protective canopy cover they provide is often utilized by panfish and bass.

Growing amongst these floating-leaf species, we also found the submergent species Coontail, Small pondweed (*Potamogeton pusillus*), Common waterweed (*Elodea canadensis*), and Northern water milfoil. In sheltered areas, in addition to these rooted plants, we also encountered "duckweeds" and, in the "Lagoon", the carnivorous Common bladderwort (*Utricularia vulgaris*) floating among the lilypads. Bladderworts trap microscopic plankton and insect larvae in their bladders, digest the bodies of their prey, and use the minerals to further their growth.


Spatterdock and "Duckweeds" near the Moon Creek Inlet (Berg 2013)


Large-leaf pondweed (Fewless 2010)


Small pondweed (Villa 2011)


Northern water milfoil (Berg 2007)

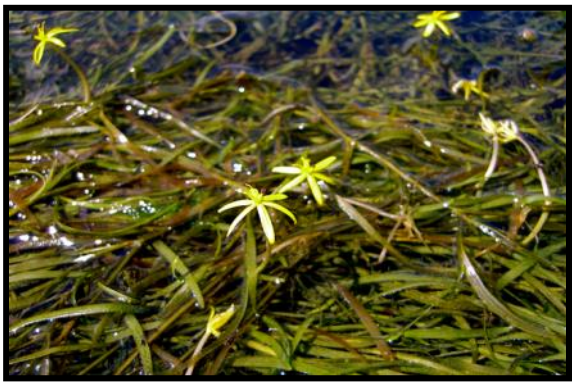

Common bladderwort flowers among White water lilypads (Hunt 2010)


Bladders for catching plankton and insect larvae (Wontolla 2007)

Sand and sandy muck bottomed areas supported few floating-leaf species other than an occasional patch of Spatterdock. In these areas, in water up to 4ft deep, we noted the plant community was dominated by generally finer leaved submergent plants like Fries pondweed, Sago pondweed (*Stuckenia pectinata*), Water star-grass (*Heteranthera dubia*), Wild celery, Muskgrass (*Chara* sp.), and Slender naiad (*Najas flexilis*). These species are heavily utilized by waterfowl for food and larval insects and other invertebrates for habitat as well as providing a variety of fish habitat throughout their life cycles. They also tend to form a carpet that stabilizes bottom substrates.


Fries pondweed (End 2012)


Sago pondweed (Hilty 2012)


Water star-grass (Muller 2010)


Wild celery (Dalvi 2009)

Deeper areas in 5-9ft of water over sand and rock were often devoid of plants, but muck bottom areas were dominated by Curly-leaf pondweed in June, and Coontail and Flat-stem pondweed in July. Predatory fish like the lake's muskies are often found along the edges of these beds waiting in ambush.


Coontail (Hassler 2011)


Flat-stem pondweed (Fewless 2004)

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Big Moon Lake, Barron County
July 13, 2013

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sightings
Potamogeton zosteriformis	Flat-stem pondweed	78	14.23	55.32	51.32	1.63	8
Ceratophyllum demersum	Coontail	73	13.32	51.77	48.03	1.66	4
	Filamentous algae	61	*	43.26	40.13	1.87	0
Lemna trisulca	Forked duckweed	49	8.94	34.75	32.24	1.06	1
Potamogeton crispus	Curly-leaf pondweed	48	8.76	34.04	31.58	1.02	7
Spirodela polyrhiza	Large duckweed	38	6.93	26.95	25.00	1.68	0
Wolffia columbiana	Common watermeal	38	6.93	26.95	25.00	1.97	0
Heteranthera dubia	Water star-grass	37	6.75	26.24	24.34	1.27	0
Lemna minor	Small duckweed	37	6.75	26.24	24.34	1.19	0
Potamogeton friesii	Fries' pondweed	32	5.84	22.70	21.05	1.44	0
Nymphaea odorata	White water lily	29	5.29	20.57	19.08	1.21	10
Nuphar variegata	Spatterdock	25	4.56	17.73	16.45	2.52	9
Stuckenia pectinata	Sago pondweed	22	4.01	15.60	14.47	1.05	10
Potamogeton pusillus	Small pondweed	21	3.83	14.89	13.82	1.24	0
Elodea canadensis	Common waterweed	4	0.73	2.84	2.63	1.25	0
Myriophyllum sibiricum	Northern water-milfoil	4	0.73	2.84	2.63	1.00	2
Vallisneria americana	Wild celery	4	0.73	2.84	2.63	1.25	0
Potamogeton amplifolius	Large-leaf pondweed	2	0.36	1.42	1.32	1.50	0
Acorus calamus	Sweet-flag	1	0.18	0.71	0.66	2.00	0
Calamagrostis canadensis	Blue-joint	1	0.18	0.71	0.66	1.00	1
Carex emoryi	Emory's sedge	1	0.18	0.71	0.66	3.00	0
Chara sp.	Muskgrass	1	0.18	0.71	0.66	1.00	0

* Excluded from Rel. Freq. Calc.

Table 3 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Big Moon Lake, Barron County
July 13, 2013

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sightings
Schoenoplectus tabernaemontani	Softstem bulrush	1	0.18	0.71	0.66	3.00	3
Sparganium eurycarpum	Common bur-reed	1	0.18	0.71	0.66	1.00	0
Typha latifolia	Broad-leaved cattail	1	0.18	0.71	0.66	1.00	2
Carex comosa	Bottle brush sedge	**	**	**	**	**	3
Eleocharis erythropoda	Bald spikerush	**	**	**	**	**	1
Eleocharis palustris	Creeping spikerush	**	**	**	**	**	1
Iris versicolor	Northern blue flag	**	**	**	**	**	2
Phalaris arundinacea	Reed canary grass	**	**	**	**	**	2
Sagittaria latifolia	Common arrowhead	**	**	**	**	**	1
Utricularia vulgaris	Common bladderwort	**	**	**	**	**	1
Carex diandra	Bog panicled sedge	***	***	***	***	***	***
Carex lacustris	Lake sedge	***	***	***	***	***	***
Equisetum fluviatile	Water horsetail	***	***	***	***	***	***
Najas flexilis	Slender naiad	***	***	***	***	***	***
Pontederia cordata	Pickerelweed	***	***	***	***	***	***
Schoenoplectus acutus	Hardstem bulrush	***	***	***	***	***	***
Typha angustifolia	Narrow-leaved cattail	***	***	***	***	***	***

** Visual Only   *** Boat Survey Only

When considering the lake's entire July plant community, Flat-stem pondweed, Coontail, Forked duckweed (*Lemna trisulca*), and Large duckweed (*Spirodela polyrhiza*) were the most common native species being found at 55.32%, 51.77%, 34.75%, and 26.95% of survey points with vegetation respectively (Table 3) (Figure 11). Together, they combined for a low 43.43% of the total relative frequency which indicated a high level of evenness in the plant community (Often, the top four species in a lake are >50%). Curly-leaf pondweed (8.76), Common watermeal (*Wolffia columbiana*) (6.93), Water star-grass (6.75), Small duckweed (*Lemna minor*) (6.75), Fries' pondweed (5.84), and White water lily (5.29) were the only other species with relative frequencies over 5.0 (Species accounts and distribution maps for all plants found are located in Appendixes VI and VII).

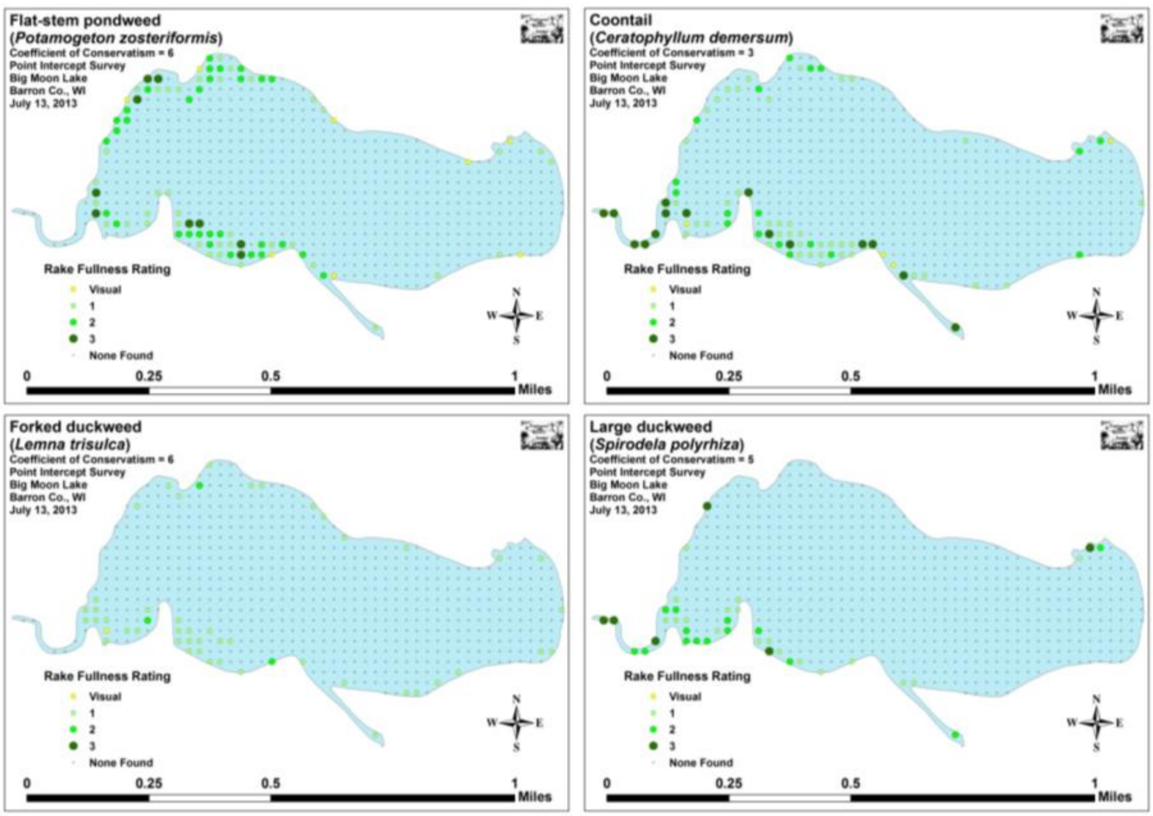


Figure 11: Big Moon Lake's Most Common Native Macrophyte Species

Table 4: Floristic Quality Index of Aquatic Macrophytes
Big Moon Lake, Barron County
July 13, 2013

Species	Common Name	C
Ceratophyllum demersum	Coontail	3
Chara sp.	Muskgrass	7
Elodea canadensis	Common waterweed	3
Heteranthera dubia	Water star-grass	6
Lemna minor	Small duckweed	4
Lemna trisulca	Forked duckweed	6
Myriophyllum sibiricum	Northern water-milfoil	6
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton friesii	Fries' pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton zosteriformis	Flat-stem pondweed	6
Schoenoplectus tabernaemontani	Softstem bulrush	4
Sparganium eurycarpum	Common bur-reed	5
Spirodela polyrhiza	Large duckweed	5
Stuckenia pectinata	Sago pondweed	3
Typha latifolia	Broad-leaved cattail	1
Vallisneria americana	Wild celery	6
Wolffia columbiana	Common watermeal	5
N		**20**
Mean C		**5.2**
FQI		**23.3**

We identified a total of 20 **native index plants** to species on the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 5.2 and a Floristic Quality Index of 23.3 (Table 4). Nichols (1999) reported an average Mean C for the Northern Central Hardwood Forests Region of 5.6 putting Big Moon Lake slightly below average for this part of the state. The FQI was, however, slightly above the median FQI of 20.9 for the Northern Central Hardwood Forests Region (Nichols 1999).

Exotic Species:

We did NOT find any evidence of Eurasian water milfoil in Big Moon Lake during the June Curly-leaf pondweed surveys or the July full point-intercept survey. By July, the majority of CLP we documented in June had senesced, but we still found it in the rake at 48 points. Of these, one had a rake fullness of 2 while the other 47 were a 1. This produced a mean rake fullness value of 1.02 (Figure 12). We also recorded CLP as a visual at an additional seven points (Appendix III).

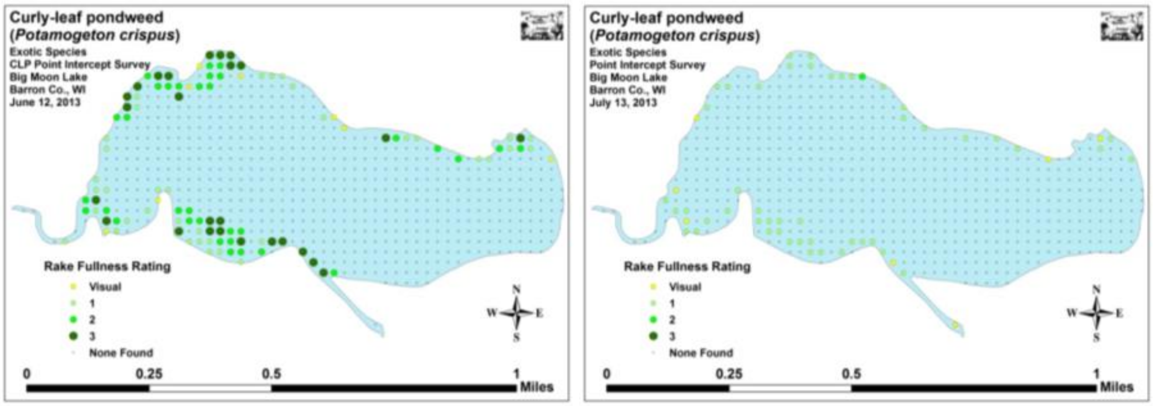


Figure 12: Big Moon Lake's June/July CLP Density and Distribution

We noted three other exotic plant species on the margins of the lake: 1) Reed canary grass (Figure 13) was a dominant species in most low-lying undeveloped shoreline areas; especially on the western half of the lake. 2) Narrow-leaved cattail (*Typha angustifolia*) is native to southern but not northern Wisconsin. It is potentially invasive and often excludes the native Broad-leaved cattail (*Typha latifolia*) from places where the two are found together. Because of this, there is the potential that it will continue to spread beyond the single stand we documented during the boat survey near the lake outlet. 3) The Sweet-flag species on the lake is the exotic *calamus* (not the native *americanus*). It is widespread throughout the state, but is not considered invasive (For more information on the exotic species Reed canary grass, EWM, CLP, and Purple loosestrife (*Lythrum salicaria*), see Appendix VIII).

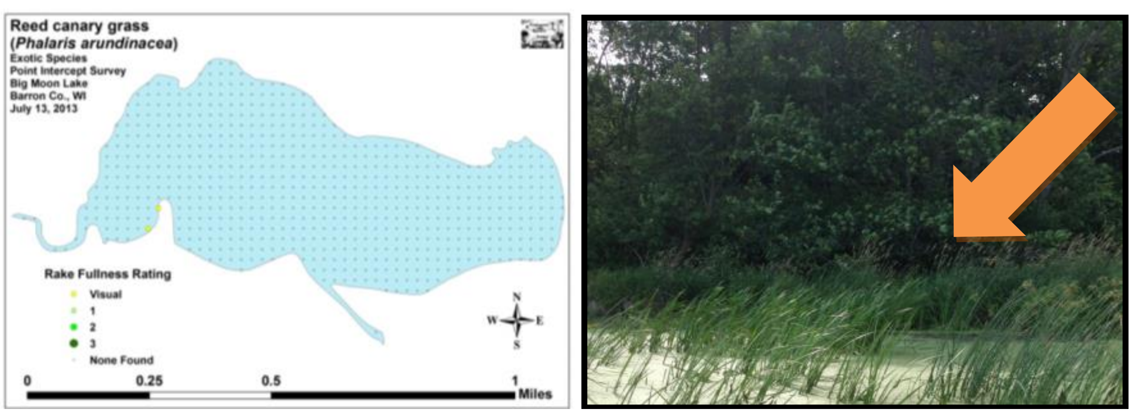


Figure 13: Big Moon Lake's Reed Canary Grass Density and Distribution

Filamentous Algae:

We located filamentous algae at 61 sites throughout Big Moon Lake. It was present at approximately 40% of the littoral points and had an average rake fullness value of 1.87. Normally, these algae proliferate in environments where there are excessive nutrients in the water. We noticed that these locations had little to no correlation with residences, but did seem to align with the lake's more organic rich muck sediments suggesting these growths may be caused by nutrient recycling from these sediments (Figure 14).

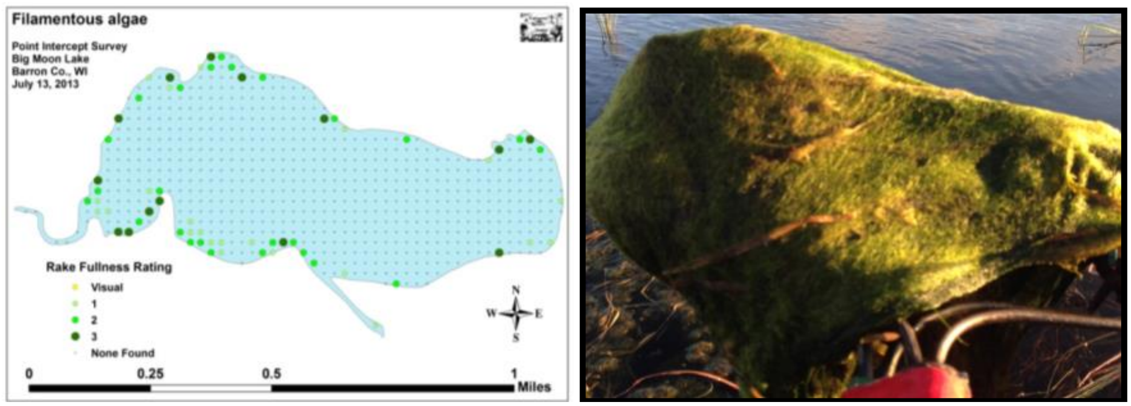


Figure 14: Big Moon Lake's Filamentous Algae Density and Distribution

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Water Clarity and the Role of Native Macrophytes:

Big Moon Lake has a somewhat limited native plant community in both species present and overall lake coverage, and, because of this, preserving them should be a top management priority. Macrophytes are the base of the aquatic food pyramid, provide habitat for other aquatic organisms, are important food sources for waterfowl and other wildlife, stabilize the shoreline, and work to improve water clarity by absorbing excess nutrients from the water.

When nutrients in the water column increase to levels beyond what macrophytes can absorb, filamentous and floating algae tend to proliferate leading to declines in both water clarity and quality. During the 2013 growing season, the lake experienced declining clarity, and by July, most species of plants were not able to grow much past 7ft. This lack of rooted plants appeared to be creating a negative feedback loop: Lack of light kills macrophytes → decomposing macrophytes release nutrients into the water column → excessive nutrients results in more algae which further decrease clarity. The addition of these nutrients to the water column later in the growing season may be partially to blame for the loss of clarity we observed from June to July in 2013, but the presence of scattered patches of thick filamentous algae in areas of the lake with organic rich muck anecdotally suggests that nutrient recycling from sediments is also likely a significant factor contributing to the lake's overall nutrient load.

Regardless of where a lake's nutrient load comes from, educating residents about reducing nutrient input directly along the lake is one of the easiest ways to help decrease algal growth and improve water clarity. Not mowing or weed whipping down to the shoreline, bagging grass clippings, removing pet waste, disposing of fire pit ash far away from the lake, and switching to a phosphorus-free fertilizer or eliminating fertilizer altogether would all be positive steps towards this end. Wherever possible, restoring shorelines, constructing rain gardens and creating buffer strips of native vegetation would also enhance water quality by preventing erosion and runoff (Figure 15). Hopefully, a greater understanding of how individual property owners can have lakewide impacts will result in more people taking appropriate conservation actions to ensure improved water quality and clarity for all of Big Moon Lake's residents.

Figure 15: Model Natural Shoreline vs. Mowed Down to the Shore/Erosion

Curly-leaf pondweed:

Curly-leaf pondweed was widespread and often abundant in Big Moon Lake during the early June survey. Fortunately, most of the worst areas were adjacent to undeveloped lowlands and likely weren't significantly impacting resident access or general recreational use. The CLP beds also had numbers of natives species mixed in with them. These plants grew to replace the CLP when it senesced in June, and they continued to provide habitat throughout the growing season. Because of this, active management may not the best current option as it could negatively impact the lake's native vegetation. Rather, working to limit CLP's opportunities to spread and periodically monitoring the size of the present beds to check for expansion are other strategies to consider at the present time.

Curly-leaf pondweed is an opportunistic species that can rapidly exploit disturbed areas. Because of this, residents can minimize CLP's opportunities to spread by maintaining the lake's native plants. Lakeshore owners should consider avoiding the removal of rooted native plants from the lake unless absolutely necessary as these barren patches of substrate give CLP a new place to establish where it has a competitive advantage. Avoiding motor start ups in water <5ft deep would also help limit CLP's spread by not clipping or uprooting vegetation.

Aquatic Invasive Species Prevention:

Aquatic Invasive Species (AIS) such as Eurasian water milfoil are an increasing problem in the lakes of northern Wisconsin in general, and several nearby lakes in the Turtle Lake area in particular. Preventing their introduction into Big Moon Lake with proactive measures is strongly encouraged. Currently, the lake has no program to monitor its landing or inspect incoming water craft. Establishing a Clean Boats/Clean Waters program, at least during weekends or other peak use times, could reduce the chances an AIS will be introduced into the lake by providing education, reeducation, and continual reminders of the dangers/impacts of aquatic invasive species to lake owners and visitors alike.

Without inspectors, a sign must serve as the "guardian" of the lake, and the current white sign is faded and easily ignored. Making the current sign more noticeable, or adding a secondary sign that is bright, large, and simple will increase the chances that people will both read it and consider their actions before launching (Figure 16).

Figure 16: Bright Signage at a nearby Barron Co. Public Boat Landing

Conducting monthly visual inspections in the area around the public boat landing throughout the growing season and at least one annual meandering survey of the lake's entire littoral zone are further suggestions to consider as these surveys can result in early detection if an AIS is introduced into the lake. The sooner an infestation is detected, the greater the chances it can be successfully and economically controlled. Finally, developing an Aquatic Plant Management Plan prior to an infestation would help streamline an appropriate response if/when an infestation of EWM or some other AIS occurs.

Management Considerations Summary:

- Preserve native plants and the critical habitat they provide for the whole lake ecosystem.
- Promote improved water clarity and reduce excess algal growth by working to limit nutrient inputs.
- Specifically, avoid mowing down to the lakeshore and reduce or, if possible, eliminate grass clippings runoff, fertilizer applications, and other sources of nutrients near the lakeshore such as pet waste and ash from fire pits.
- Encourage shoreline restoration and the establishment of native vegetation buffer strips along the lakeshore to further prevent runoff and erosion.
- Carefully consider the potential cost/benefit of active management on the lake's Curly-leaf pondweed beds as they are generally mixed with beneficial native vegetation.
- Periodically monitor the size of the lake's CLP beds to determine if they are expanding.
- Refrain from removing native plants from the lake unless absolutely necessary as these patches of barren substrate make it easier for CLP and new Aquatic Invasive Species to establish.
- Consider establishing a Clean Boats/Clean Waters program to inspect incoming watercraft and educate lake residents and visitors about the dangers of AIS.
- Improve the signage at the lake's boat landing that warns people about the AIS in the absence of monitors.
- Consider carrying out monthly landing inspections and at least annual meandering shoreline surveys of the lake's littoral zone to look for new AIS.
- Complete an Aquatic Plant Management Plan that clarifies a potential response to a new AIS, such as Eurasian water milfoil, if one becomes established in the lake.

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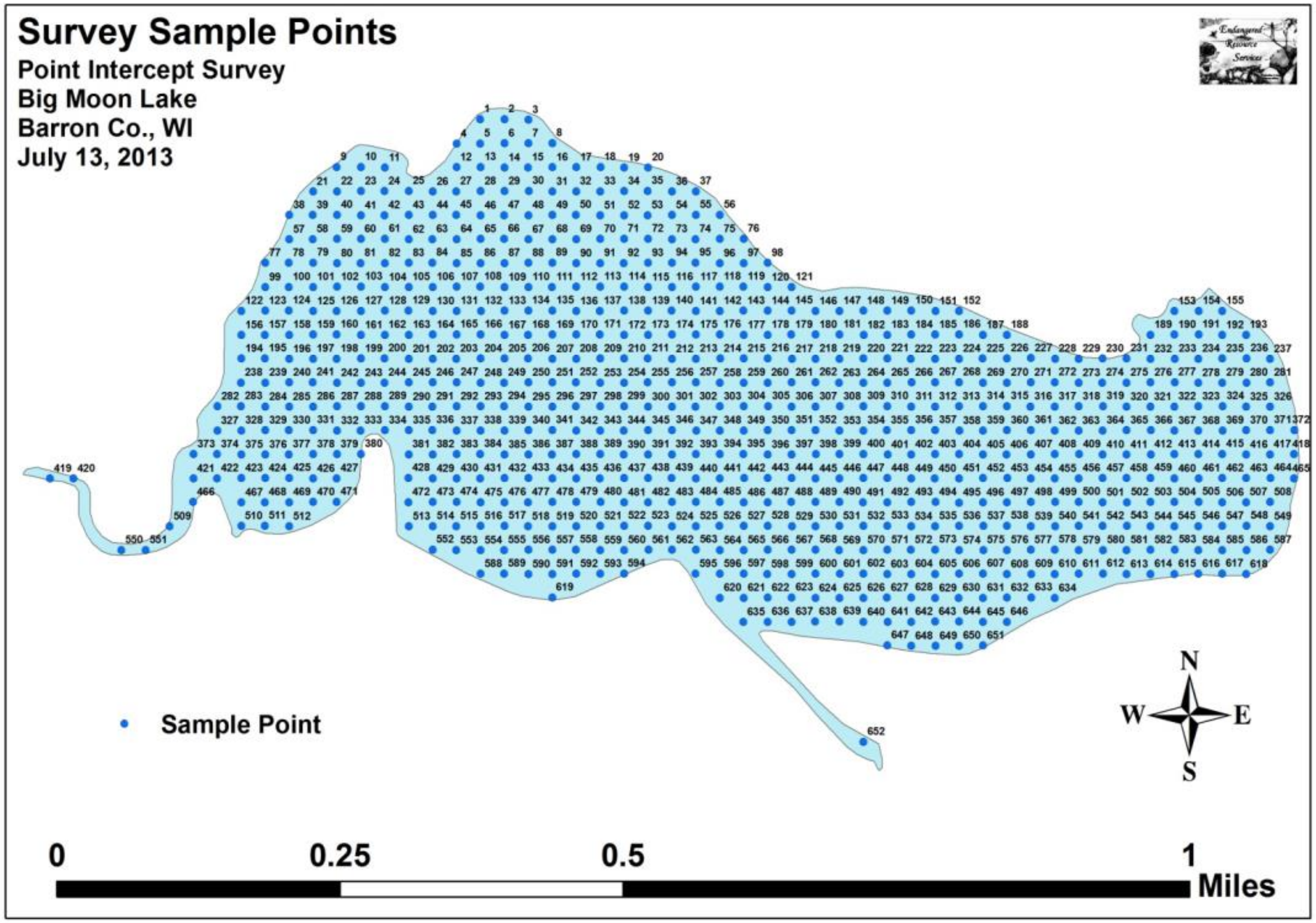
Appendix I: Big Moon Lake Map with Sample Points

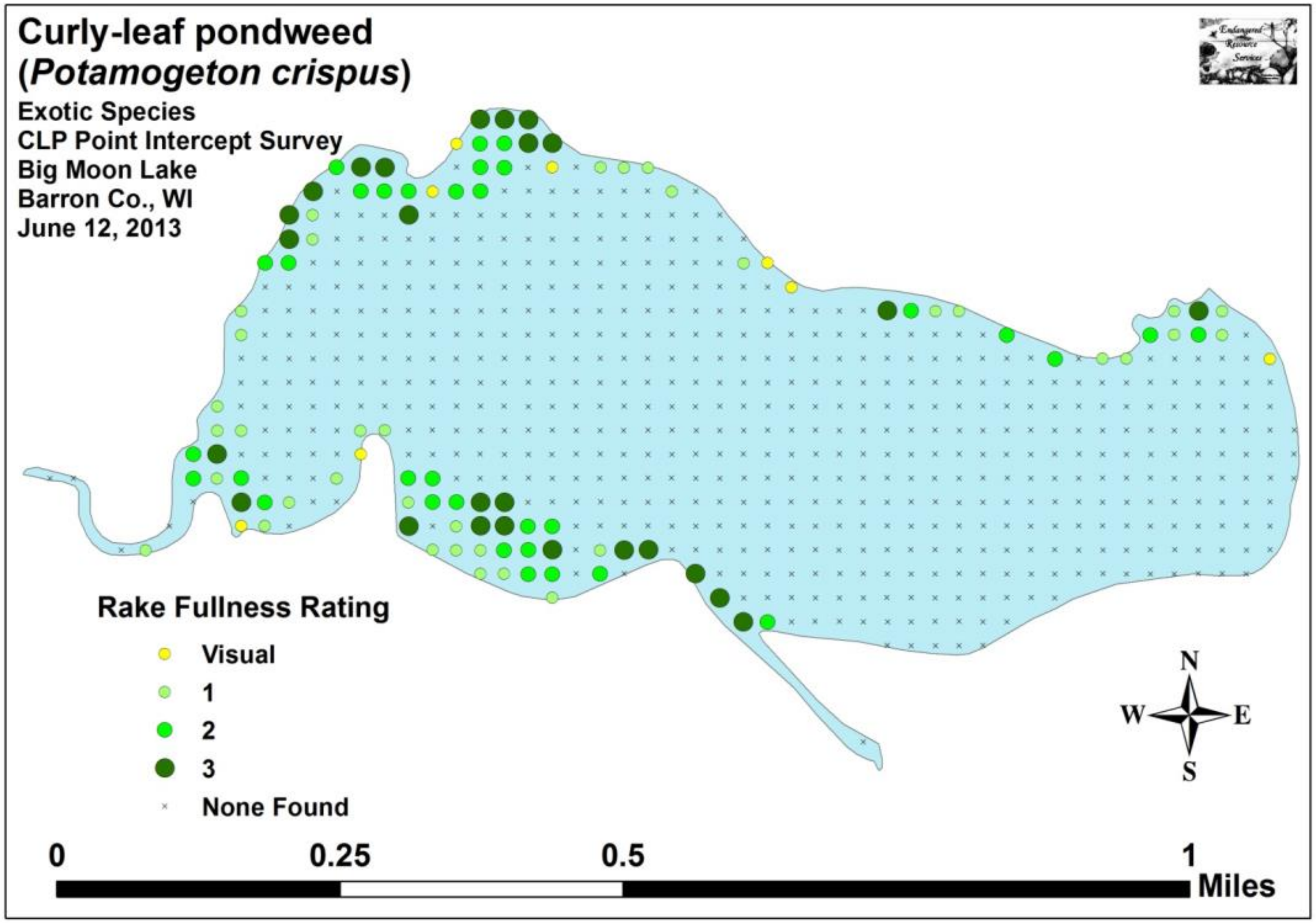

Survey Sample Points
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Endangered Resource Services
Sample Point
N
W
E
S
0
0.25
0.5
1
Miles

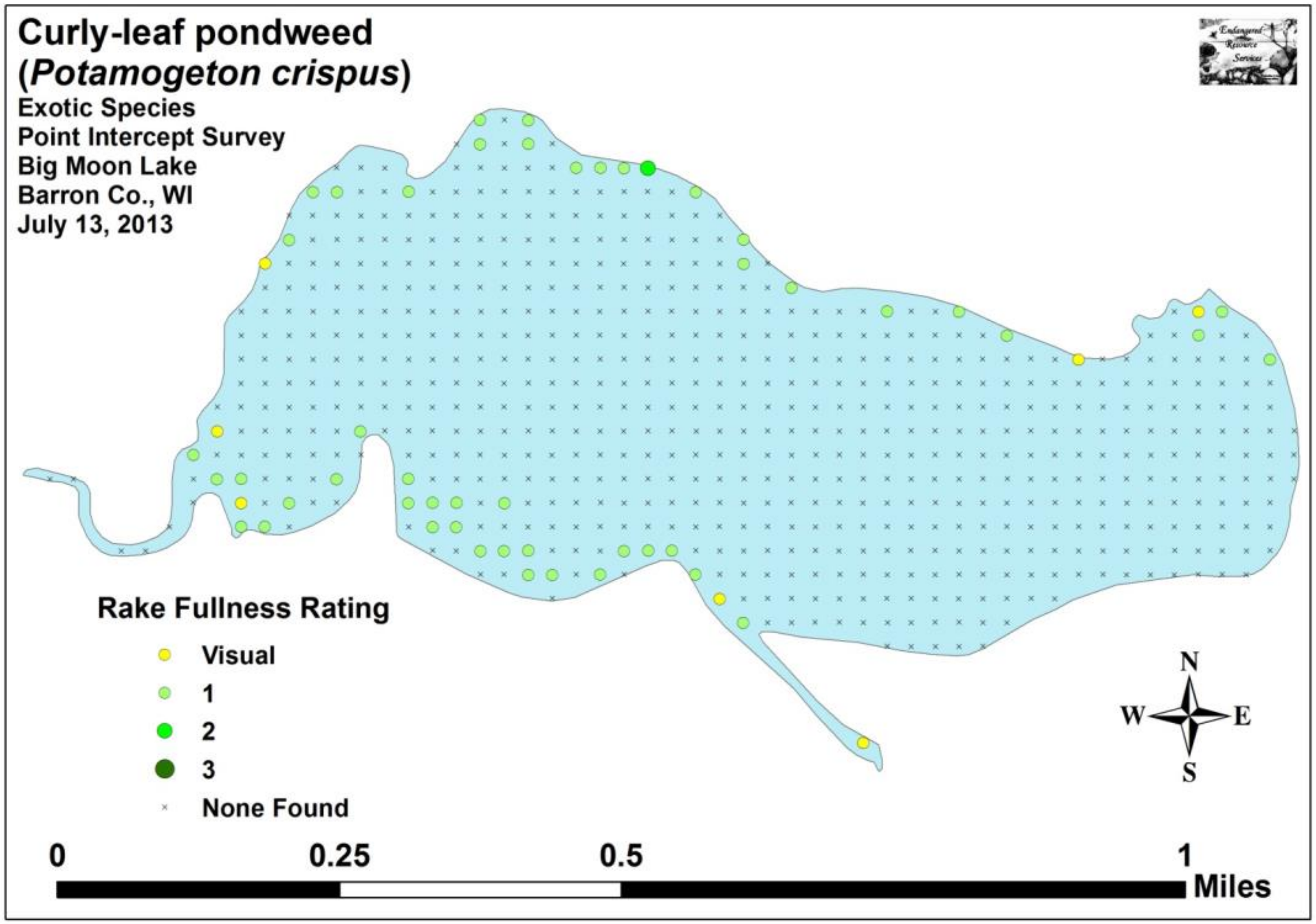
Appendix II: Boat and Vegetative Survey Data Sheets

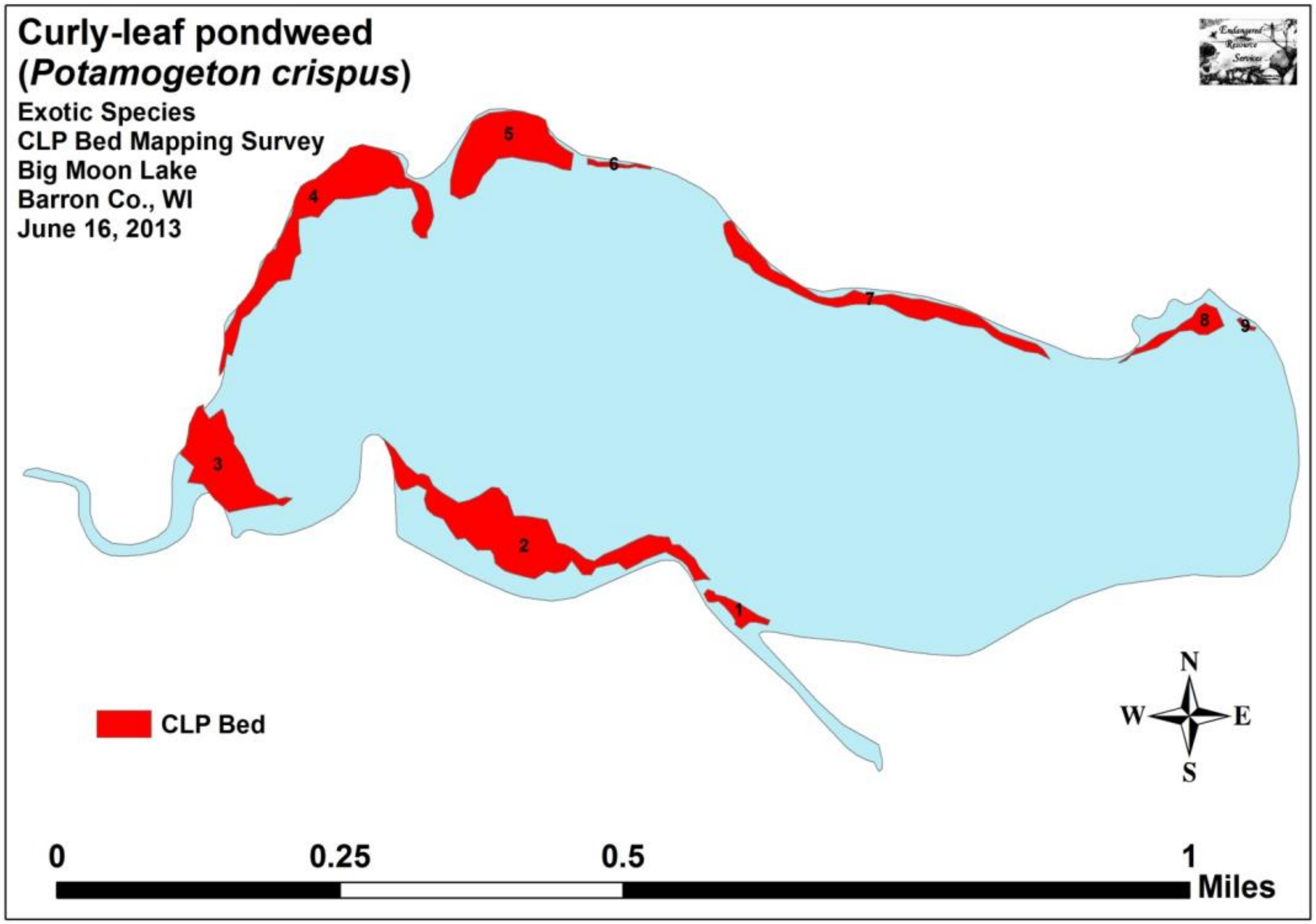
Boat Survey	
Lake Name	
County	
WBIC	
Date of Survey	
(mm/dd/yy)	
workers	
Nearest Point	**Species seen, habitat information**

Observers for this lake: names and hours worked by each:																									
Lake:									**WBIC**									**County**						**Date:**	
Site #	**Depth (ft)**	**Muck (M), Sand (S), Rock (R)**	**Rake pole (P) or rake rope (R)**	**Total Rake Fullness**	**EWM**	**CLP**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
1																									
2																									
3																									
4																									
5																									
6																									
7																									
8																									
9																									
10																									
11																									
12																									
13																									
14																									
15																									
16																									
17																									
18																									
19																									
20																									

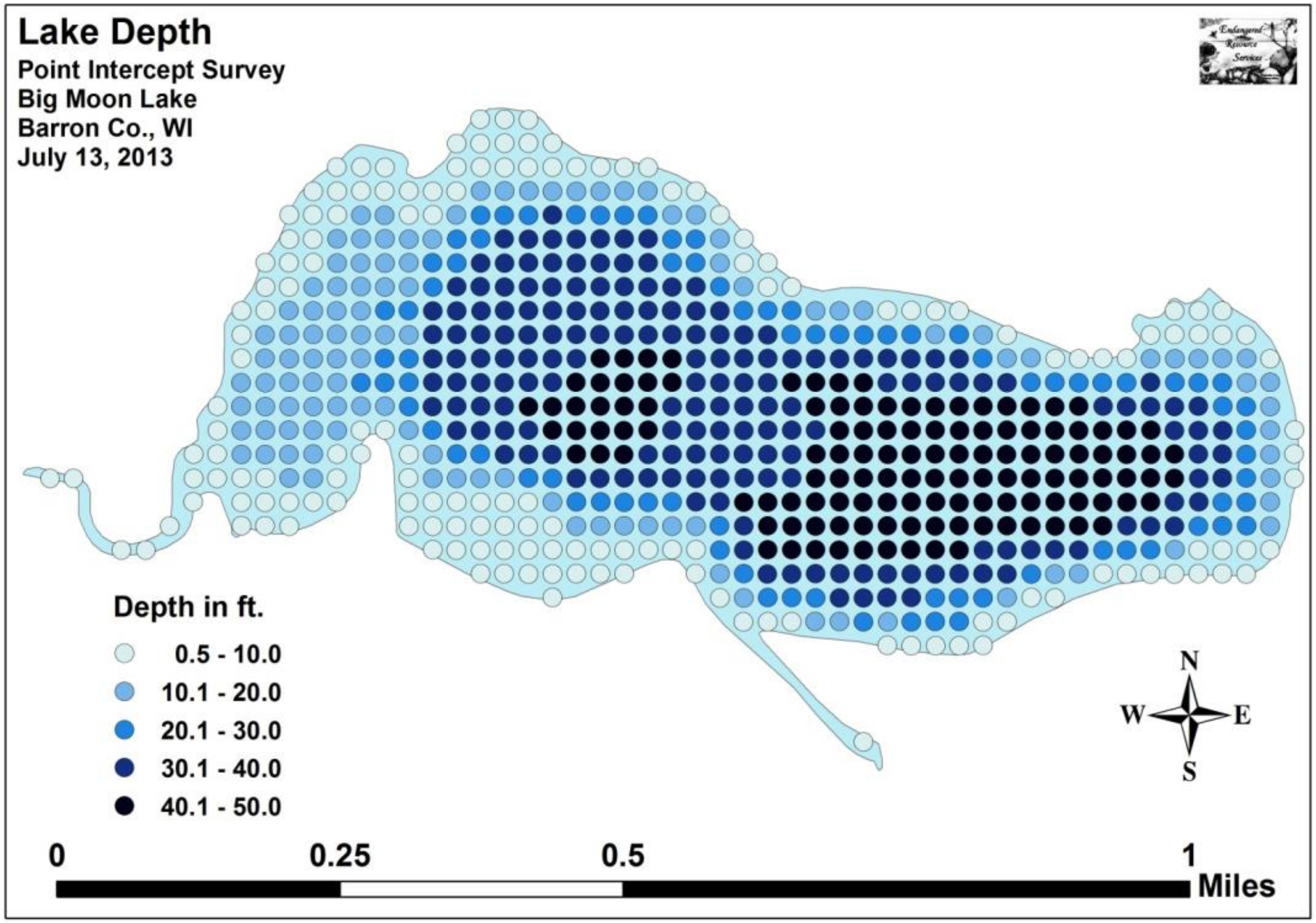
Appendix III: June/July CLP Density and Distribution and June CLP Bed Maps

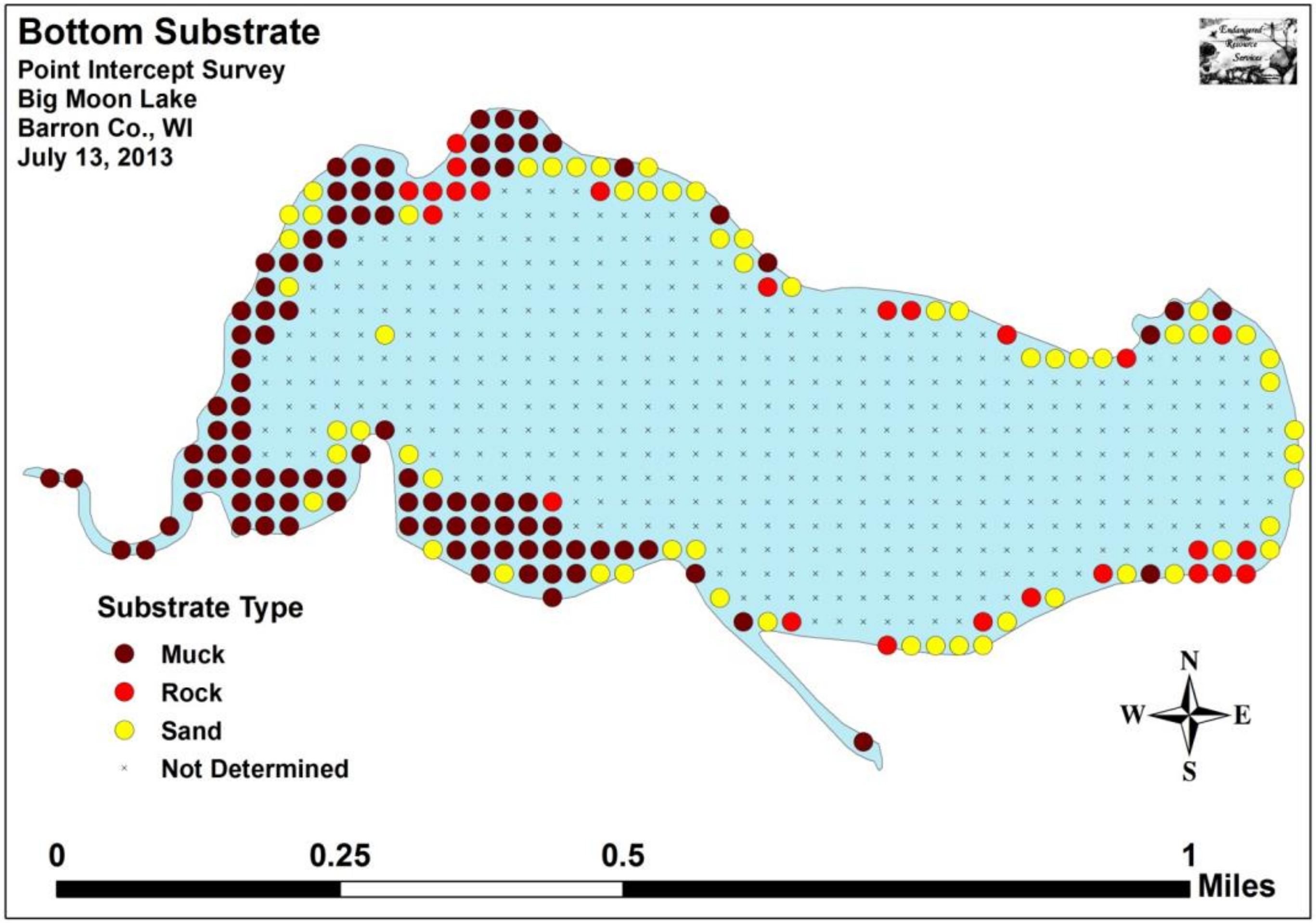

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Point Intercept Survey
Big Moon Lake
Barron Co., WI
June 12, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

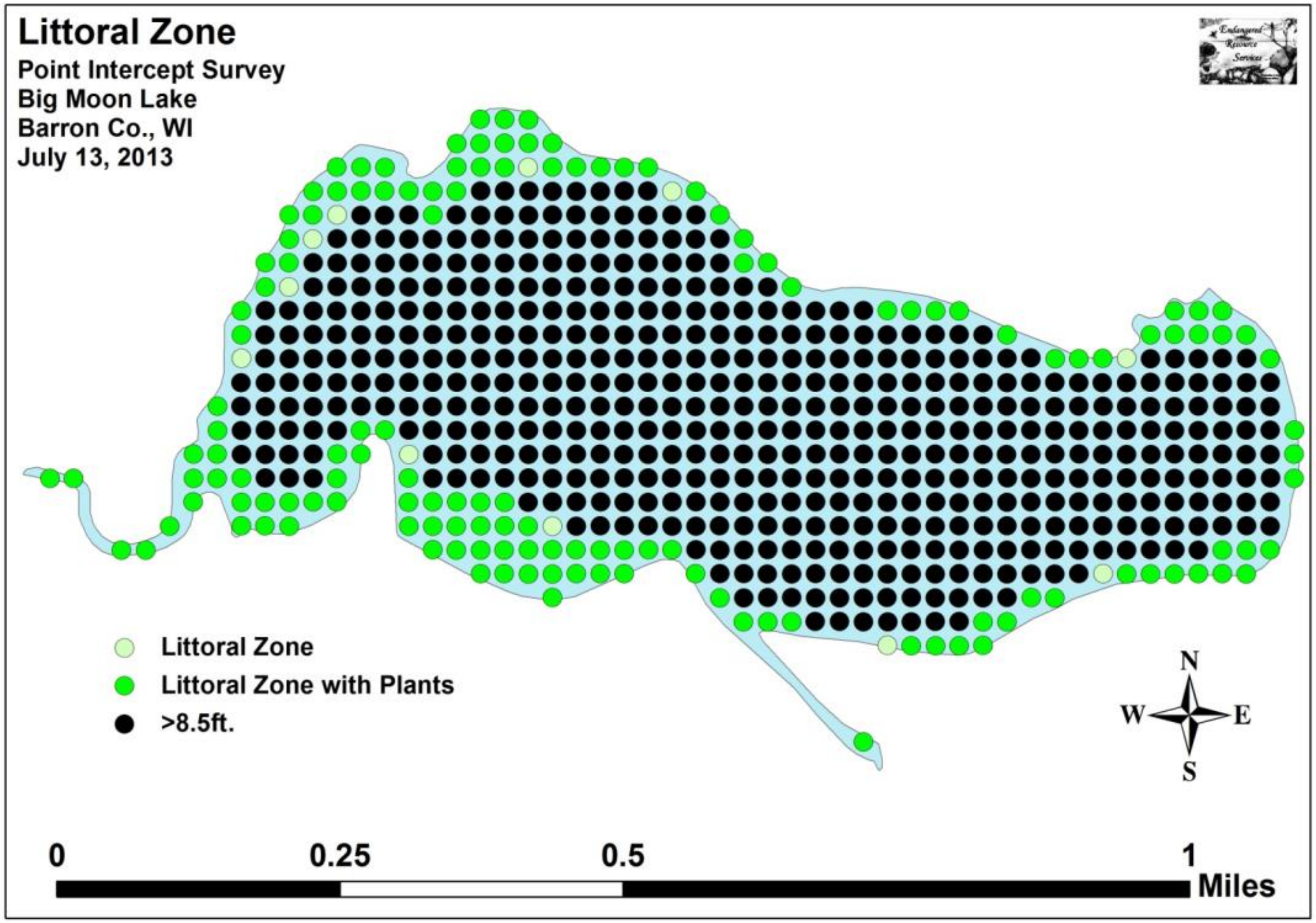

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
CLP Bed Mapping Survey
Big Moon Lake
Barron Co., WI
June 16, 2013
1
2
3
4
5
6
7
8
9
CLP Bed
N
W
E
S
0
0.25
0.5
1
Miles

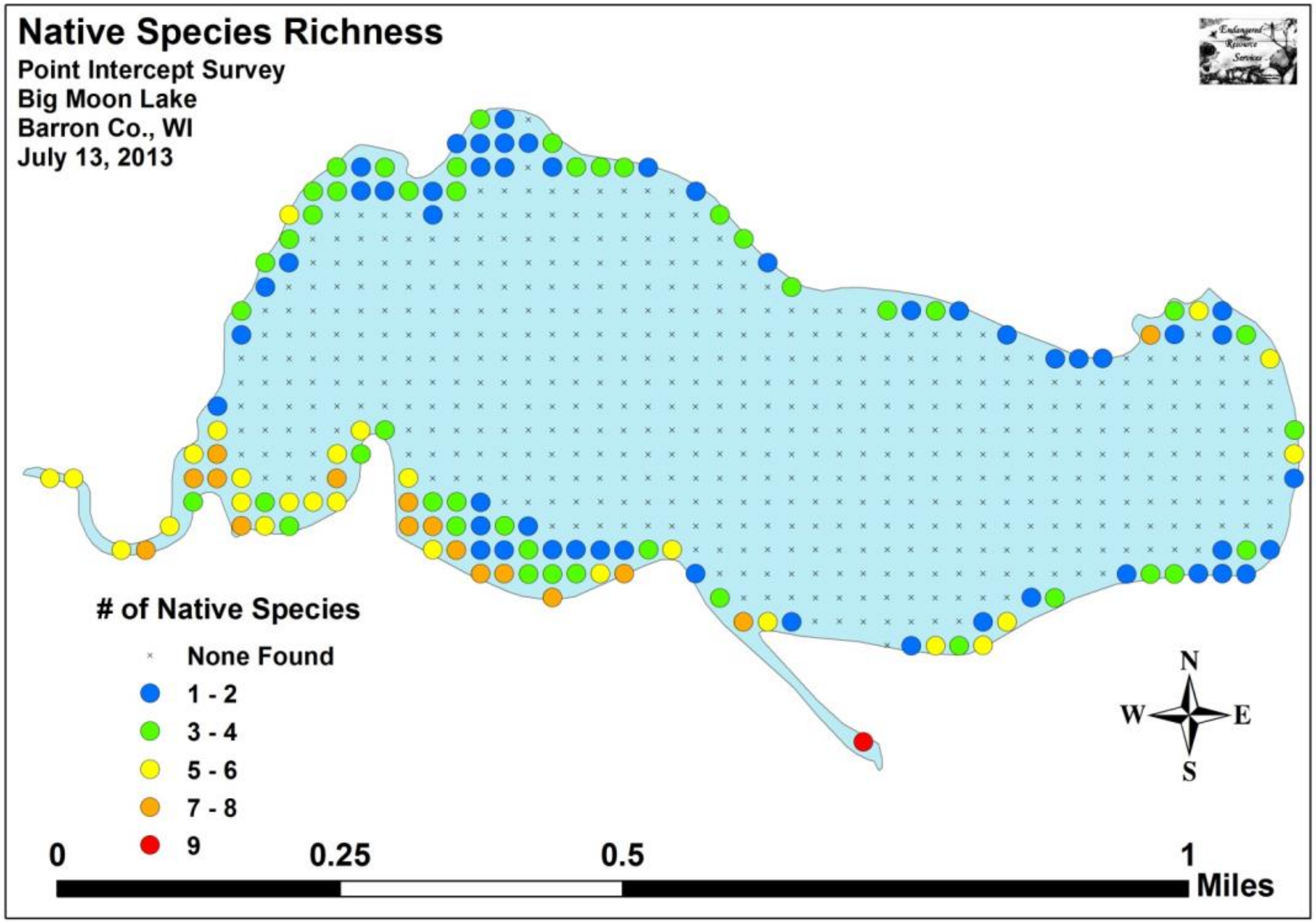
Appendix IV: Habitat Variable Maps

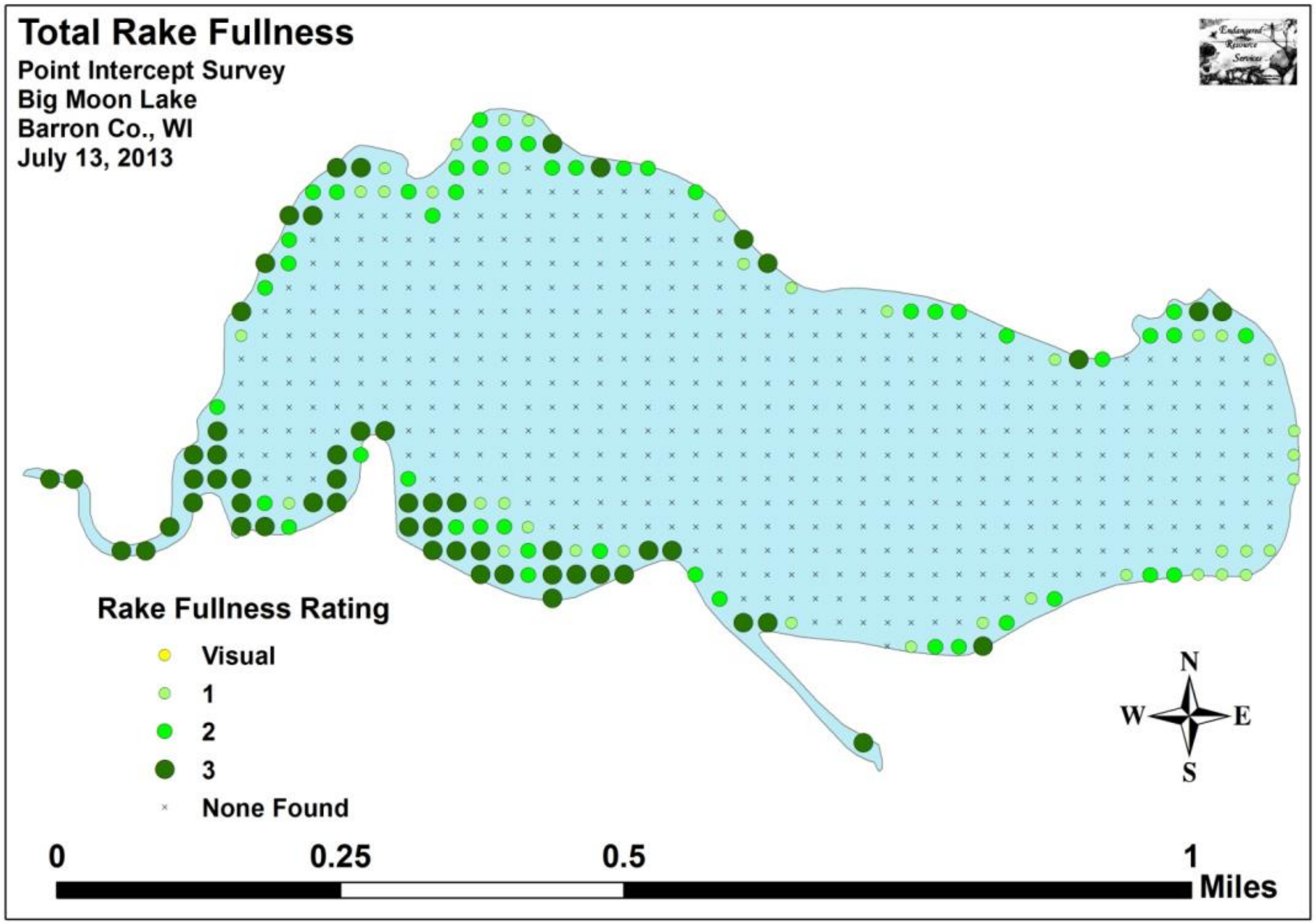

Lake Depth
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Depth in ft.
0.5 - 10.0
10.1 - 20.0
20.1 - 30.0
30.1 - 40.0
40.1 - 50.0
N
W
E
S
0
0.25
0.5
1
Miles


Bottom Substrate
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Substrate Type
Muck
Rock
Sand
Not Determined
N
W
E
S
0
0.25
0.5
1
Miles


Littoral Zone
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Littoral Zone
Littoral Zone with Plants
>8.5ft.
N
W
E
S
0
0.25
0.5
1
Miles

Appendix V: Native Species Richness and Total Rake Fullness Maps


Native Species Richness
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9
0
0.25
0.5
1
Miles
N
W
E
S


Total Rake Fullness
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

Appendix VI: Big Moon Lake Plant Species Accounts

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Acorus calamus*) **Sweet-flag**
Specimen Location: Big Moon Lake; N45.34131°, W92.12037°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-001
Habitat/Distribution: Scattered in shoreline emergent beds on the western ½ of the lake.
Common Associates: (*Sparganium eurycarpum*) Common bur-reed, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Equisetum fluviatile*) Water horsetail

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Calamagrostis canadensis*) **Blue-joint**
Specimen Location: Big Moon Lake; N45.34108°, W92.12950°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-002
Habitat/Distribution: Muck bottom at the shoreline. Plants were found growing interspersed with sedges at the water's edge in the Moon Creek Inlet.
Common Associates: (*Carex emoryi*) Emory's sedge, (*Carex lacustris*) Lake sedge, (*Sagittaria latifolia*) Common arrowhead

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Carex comosa*) **Bottle brush sedge**
Specimen Location: Big Moon Lake; N45.34108°, W92.12950°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-003
Habitat/Distribution: Muck bottom at the shoreline. Plants were found growing interspersed with other sedges on tussocks at the water's edge in the Moon Creek Inlet.
Common Associates: (*Carex emoryi*) Emory's sedge, (*Carex lacustris*) Lake sedge

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Carex diandra*) **Bog panicled sedge**
Specimen Location: Big Moon Lake; N45.34108°, W92.12950°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-004
Habitat/Distribution: Muck bottom at the shoreline. Plants were found growing interspersed with other sedges on tussocks at the water's edge in the Moon Creek Inlet.
Common Associates: (*Carex emoryi*) Emory's sedge, (*Carex lacustris*) Lake sedge

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Carex emoryi*) **Emory's sedge**
Specimen Location: Big Moon Lake; N45.34108°, W92.12950°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-005
Habitat/Distribution: Muck bottom at the shoreline. Plants were found growing interspersed with other sedges on tussocks at the water's edge in the Moon Creek Inlet.
Common Associates: (*Carex diandra*) Bog panicled sedge, (*Carex lacustris*) Lake sedge

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Carex lacustris*) **Lake sedge**
Specimen Location: Big Moon Lake; N45.34108°, W92.12950°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-006
Habitat/Distribution: Muck bottom at the shoreline. Plants were found growing interspersed with other sedges on tussocks at the water's edge in the Moon Creek Inlet.
Common Associates: (*Carex emoryi*) Emory's sedge, (*Carex diandra*) Panicled bog sedge

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Ceratophyllum demersum*) **Coontail**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-007
Habitat/Distribution: Muck bottoms in 0-2.5+ meters. Common to abundant in the "Lagoon" channel off the southern shoreline and western sheltered bays.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Nuphar variegata*) Spatterdock, (*Nymphaea odorata*) White water lily, (*Elodea canadensis*) Common waterweed, (*Myriophyllum sibiricum*) Northern water milfoil

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Chara* sp.) **Muskgrass**
Specimen Location: Big Moon Lake; N45.34396°, W92.10919°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-008
Habitat/Distribution: Only plants found were at the point in 1.25m of water over sand where they formed a moderately dense carpet.
Common Associates: (*Stuckenia pectinata*) Sago pondweed, (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Myriophyllum sibiricum*) Northern water milfoil, (*Heteranthera dubia*) Water star-grass

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Eleocharis erythropoda*) **Bald spikerush**
Specimen Location: Big Moon Lake; N45.34108°, W92.12950°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-009
Habitat/Distribution: Mucky to firm bottoms in 0-0.25 meters of water. Scattered individuals found growing among cattails and other emergents at the Moon Creek Inlet.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Calamagrostis canadensis*) Blue-joint, (*Carex comosa*) Bottle brush sedge, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Sagittaria latifolia*) Common arrowhead

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Eleocharis palustris*) **Creeping spikerush**
Specimen Location: Big Moon Lake; N45.34274°, W92.12564°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-010
Habitat/Distribution: Firm sandy or rocky bottoms in 0-0.5 meters of water. Scattered individuals were found growing in Softstem bulrush or Common bur-reed beds or in monotypic stands.
Common Associates: (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Sparganium eurycarpum*) Common bur-reed

County/State**:** Barron County, Wisconsin **Date:** 7/13/13
Species: (*Elodea canadensis*) **Common waterweed**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-011
Habitat/Distribution: Muck bottom in <1m of water. Restricted to the "Lagoon" channel off the southern shoreline and the Moon Creek Inlet where plants were often abundant and canopied.
Common Associates: (*Potamogeton crispus*) Curly-leaf pondweed**,** (*Ceratophyllum demersum*) Coontail, (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Spirodela polyrhiza*) Large duckweed, (*Wolffia columbiana*) Common watermeal, (*Lemna trisulca*) Forked duckweed

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Equisetum fluviatile*) **Water horsetail**
Specimen Location: Big Moon Lake; N45.34131°, W92.12037°
Collected/Identified by: **Matthew S. Berg Col. #:** MSB-2013-012
Habitat/Distribution: Sandy bottoms in 0-.25m of water. Uncommon in scattered emergent beds on the west side of the lake.
Common Associates: (*Sparganium eurycarpum*) Common bur-reed, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Acorus calamus*) Sweet-flag

County/State: Barron County, Wisconsin **Date:** 9/21/13
Species: (*Heteranthera dubia*) **Water star-grass**
Specimen Location: Big Moon Lake; N45.34306°, W92.10872°
Collected/Identified by: **Matthew S. Berg Col. #:** MSB-2013-013
Habitat/Distribution: Firm sand and muck bottoms in water up to 2 meters deep. Common and widespread; especially on the eastern half of the lake.
Common Associates: (*Stuckenia pectinata*) Sago pondweed, (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Iris versicolor*) **Northern blue flag**
Specimen Location: Big Moon Lake; N45.34108°, W92.12950°
Collected/Identified by: **Matthew S. Berg Col. #:** MSB-2013-014
Habitat/Distribution: Firm muck bottoms at the shoreline. A few plants were scattered near the point and at the Moon Creek Inlet.
Common Associates: (*Calamagrostis canadensis*) Blue-joint, (*Carex comosa*) Bottle brush sedge, (*Typha latifolia*) Broad-leaved cattail

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Lemna minor*) **Small duckweed**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg Col. #:** MSB-2013-015
Habitat/Distribution: Located floating at or just under the surface in sheltered areas interspersed between the lilypads. Common to abundant; especially in the bays on the west side of the lake.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Spirodela polyrhiza*) Large duckweed, (*Wolffia columbiana*) Common watermeal, (*Lemna trisulca*) Forked duckweed, (*Ceratophyllum demersum*) Coontail

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Lemna trisulca*) **Forked duckweed**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg Col. #:** MSB-2013-016
Habitat/Distribution: Common and widely distributed. Found entangled in other rooted macrophytes throughout the majority of the littoral zone.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Wolffia columbiana*) Common watermeal, (*Spirodela polyrhiza*) Large duckweed, (*Ceratophyllum demersum*) Coontail, (*Lemna minor*) Small duckweed

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Myriophyllum sibiricum*) **Northern water milfoil**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-017
Habitat/Distribution: Muck to sand bottom in water up to 1.5m deep. Uncommon and largely restricted to areas on and around exposed shoreline points.
Common Associates: (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Heteranthera dubia*) Water star-grass, (*Stuckenia pectinata*) Sago pondweed

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Najas flexilis*) **Slender naiad**
Specimen Location: Big Moon Lake; N45.34648°, W92.12230°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-018
Habitat/Distribution: A single partial specimen found floating near the point was the only plant seen on the lake.
Common Associates: (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Heteranthera dubia*) Water star-grass

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Nuphar variegata*) **Spatterdock**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-019
Habitat/Distribution: Muck and sandy bottoms in 0.25-1.25m of water. The dominant floating-leaf species on the lake, it was present in most muck bays and sheltered shorelines where it often formed dense canopies.
Common Associates: (*Nymphaea odorata*) White water lily, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Ceratophyllum demersum*) Coontail, (*Spirodela polyrhiza*) Large duckweed, (*Wolffia columbiana*) Common watermeal, (*Lemna minor*) Small duckweed

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Nymphaea odorata*) **White water lily**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-020
Habitat/Distribution: Muck bottom in 0-2 meters. Common and widespread, but seldom abundant. Most plants were found in the sheltered bays on the south and west sides of the lake.
Common Associates: (*Nuphar variegata*) Spatterdock,
(*Elodea canadensis*) Common waterweed, (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Utricularia vulgaris*) Common bladderwort

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Phalaris arundinacea*) **Reed canary grass**
Specimen Location: Big Moon Lake; N45.34131°, W92.12037°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2013-021
Habitat/Distribution: Common and often abundant in muck soil at the shoreline. The dominant grass in undeveloped and disturbed low areas. Present throughout.
Common Associates: (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Typha latifolia*) Broad-leaved cattail

County/State: Barron County, Wisconsin **Date:** 9/21/13
Species: (*Pontederia cordata*) **Pickerelweed**
Specimen Location: Big Moon Lake; N45.34013°, W92.11574°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-022
Habitat/Distribution: A single bed composed of not more than 20 stems was located at the point over sand/gravel in water <0.5m deep.
Common Associates: (*Heteranthera dubia*) Water star-grass, (*Nuphar variegata*) Spatterdock

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Potamogeton amplifolius*) **Large-leaf pondweed**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-023
Habitat/Distribution: Uncommon and local over sandy to organic muck bottom in <2m of water. Almost all individuals were found in the south bays; especially near the entrance to the "Lagoon" channel off the southern shoreline.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Ceratophyllum demersum*) Coontail, (*Myriophyllum sibiricum*) Northern water milfoil

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Potamogeton crispus*) **Curly-leaf pondweed**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-024
Habitat/Distribution: Widely distributed and abundant throughout the lake's early-season littoral zone. Plants ranged from 0.5-2.5m deep over organic and sandy muck bottoms. Frequently monotypic beyond 1.5m deep.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Myriophyllum sibiricum*) Northern water milfoil, (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Potamogeton friesii*) **Fries' pondweed**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-025
Habitat/Distribution: Muck and sand bottom in <2 m of water. Abundant in its preferred habitat – especially on the north side of the lake.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Vallisneria americana*) Wild celery, (*Heteranthera dubia*) Water star-grass

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Potamogeton pusillus tenuissimus*) **Small pondweed**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg/Donald Les**
Col. #: MSB-2013-026
Habitat/Distribution: Muck and sandy muck in water <2m deep. Common near the Moon Creek Inlet and in the "Lagoon" channel off the southern shoreline; rare elsewhere. Most plants formed atypical flat turions with no side leaves, but DNA analysis confirmed identification.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Potamogeton zosteriformis*) Flat-stem pondweed, (*Elodea canadensis*) Common waterweed, (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Potamogeton zosteriformis*) **Flat-stem pondweed**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-027
Habitat/Distribution: Widely distributed and common over organic rich muck in 0.5-2.5m of water.
Common Associates: (*Ceratophyllum demersum*) Coontail, (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Potamogeton friesii*) Fries' pondweed, (*Heteranthera dubia*) Water star-grass

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Sagittaria latifolia*) **Common arrowhead**
Specimen Location: Big Moon Lake; N45.34108°, W92.12950°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-028
Habitat/Distribution: Relatively common in undeveloped shoreline areas with firm muck bottom in 0-0.25m of water; especially near the Moon Creek Inlet.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass, (*Calamagrostis canadensis*) Blue-joint, (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Barron County, Wisconsin **Date:** 9/21/13
Species: (*Schoenoplectus acutus*) **Hardstem bulrush**
Specimen Location: Big Moon Lake; N45.34430°, W92.11376°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-029
Habitat/Distribution: A single cluster of plants occurred over rocky and sandy bottoms in 0-0.5 meter of water.
Common Associates: (*Potamogeton friesii*) Fries pondweed, (*Vallisneria americana*) Wild celery, (*Stuckenia pectinata*) Sago pondweed

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Schoenoplectus tabernaemontani*) **Softstem bulrush**
Specimen Location: Big Moon Lake; N45.34274°, W92.12564°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-030
Habitat/Distribution: Firm muck and sand bottoms in 0-0.5 meter of water. The dominant emergent in reed beds throughout the lake.
Common Associates: (*Eleocharis palustris*) Creeping spikerush, (*Sparganium eurycarpum*) Common bur-reed, (*Typha latifolia*) Broad-leaved cattail, (*Sagittaria latifolia*) Common arrowhead, (*Equisetum fluviatile*) Water horsetail, (*Acorus calamus*) Sweet-flag

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Sparganium eurycarpum*) **Common bur-reed**
Specimen Location: Big Moon Lake; N45.34131°, W92.12037°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-031
Habitat/Distribution: Firm sand in water <0.5m deep. Plants were relatively common adjacent to undeveloped areas on the south and west shorelines.
Common Associates: (*Eleocharis palustris*) Creeping spikerush, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Typha latifolia*) Broad-leaved cattail, (*Sagittaria latifolia*) Common arrowhead, (*Equisetum fluviatile*) Water horsetail, (*Acorus calamus*) Sweet-flag

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Spirodela polyrhiza*) **Large duckweed**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-032
Habitat/Distribution: Located floating at or just under the surface in sheltered areas interspersed between the lilypads. Common to abundant; especially on the bays on the west side of the lake.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Lemna minor*) Small duckweed, (*Wolffia columbiana*) Common watermeal, (*Lemna trisulca*) Forked duckweed, (*Ceratophyllum demersum*) Coontail

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Stuckenia pectinata*) **Sago pondweed**
Specimen Location: Big Moon Lake; N45.34306°, W92.10872°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-033
Habitat/Distribution: **Habitat/Distribution:** Firm sand and muck bottoms in water up to 2 meters deep. Common and widespread throughout the lake although seldom abundant.
Common Associates: (*Heteranthera dubia*) Water star-grass, (*Potamogeton friesii*) Fries' pondweed, (*Potamogeton zosteriformis*) Flat-stem pondweed

County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Typha angustifolia*) **Narrow-leaved cattail**
Specimen Location: Big Moon Lake; N45.34455°, W92.11051°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-034
Habitat/Distribution: Thick muck soil in and out of water <0.25 meters. Only plants found were in a thick bed near the dam at the lake outlet.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Eleocharis erythropoda*) Bald spikerush

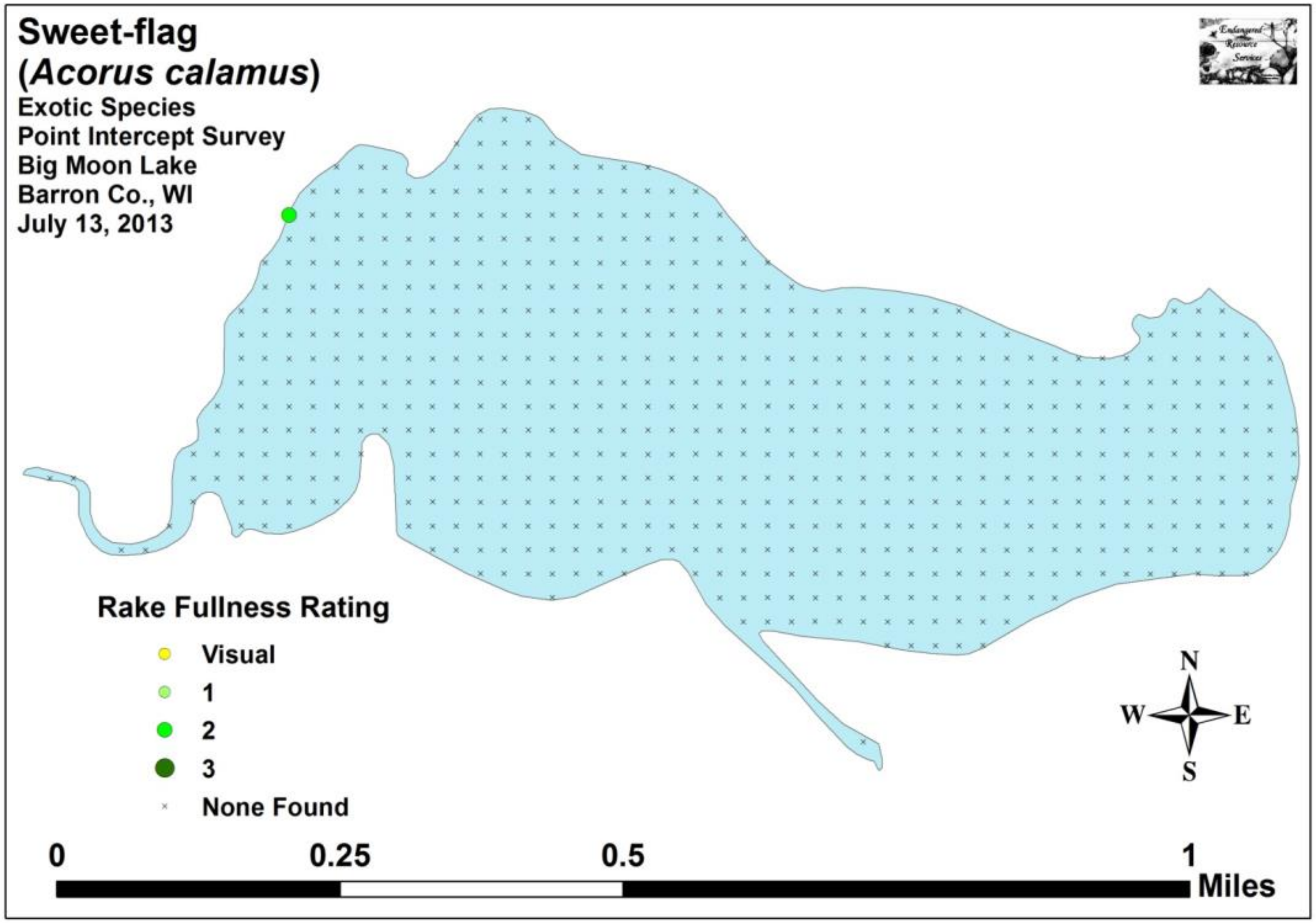
County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Typha latifolia*) **Broad-leaved cattail**
Specimen Location: Big Moon Lake; N45.34108°, W92.12950°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-035
Habitat/Distribution: Thick muck soil in and out of water <0.25 meters. Found in undeveloped shoreline areas throughout; especially common on the western end of the lake near the Moon Creek Inlet.
Common Associates: (*Sagittaria latifolia*) Common arrowhead, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Eleocharis erythropoda*) Bald spikerush

County/State**:** Barron County, Wisconsin **Date:** 7/13/13
Species: (*Utricularia vulgaris*) **Common bladderwort**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-036
Habitat/Distribution: Thick muck bottom in shallow water 0-0.5 meters deep. Rare; a very few individuals were found growing in the "Lagoon" channel off the southern shoreline.
Common Associates: (*Nymphaea odorata*) White water lily, (*Ceratophyllum demersum*) Coontail, (*Nuphar variegata*) Spatterdock

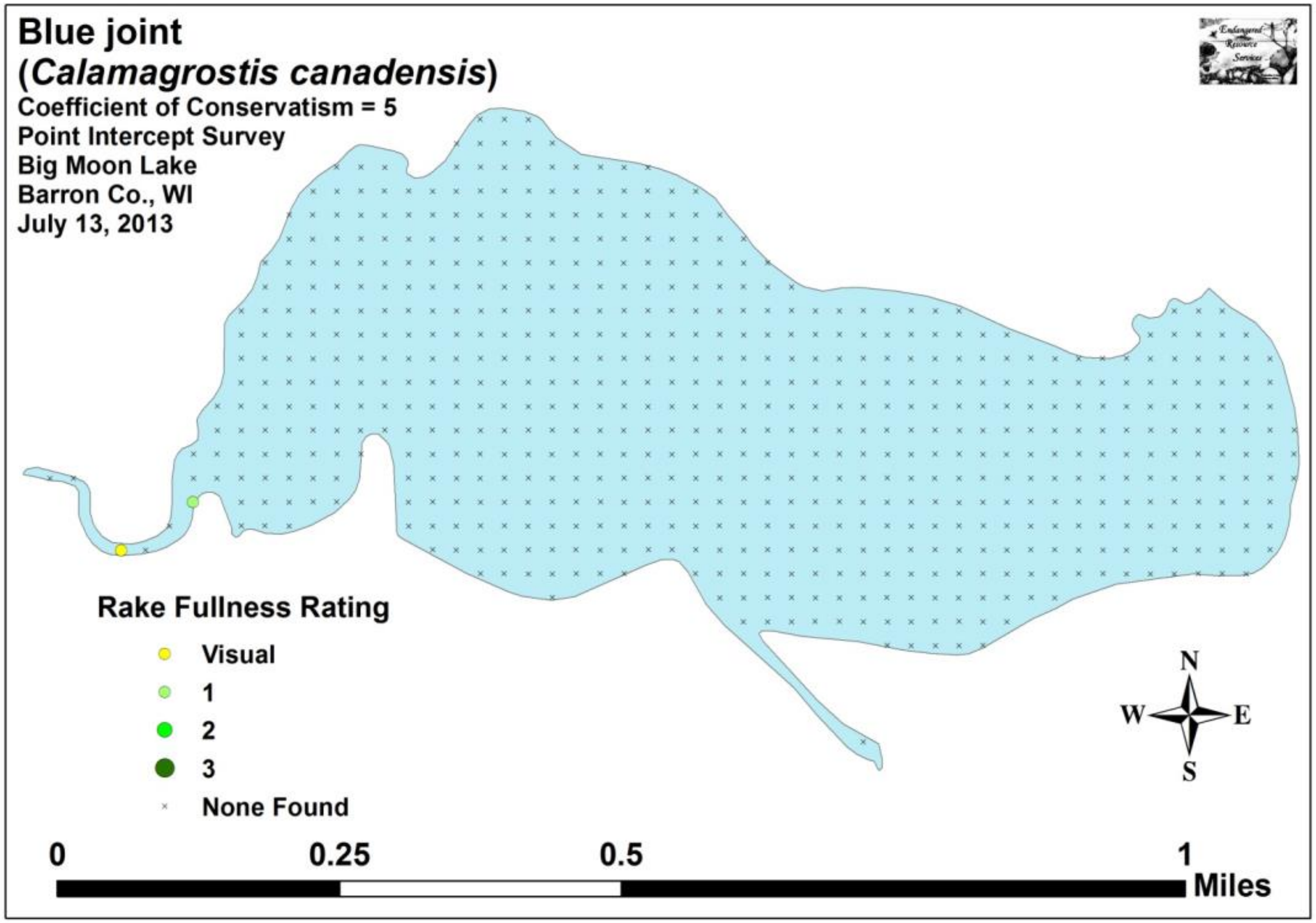
County/State: Barron County, Wisconsin **Date:** 7/13/13
Species: (*Vallisneria americana*) **Wild celery**
Specimen Location: Big Moon Lake; N45.34306°, W92.10872°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-037
Habitat/Distribution: Sandy to sandy muck bottoms in 1-1.5m of water. Uncommon; most plants were located along the eastern and northern shorelines.
Common Associates: (*Potamogeton pusillus*) Small pondweed, (*Potamogeton friesii*) Fries' pondweed, (*Heteranthera dubia*) Water star-grass, (*Chara* sp.) Muskgrass, (*Stuckenia pectinata*) Sago pondweed

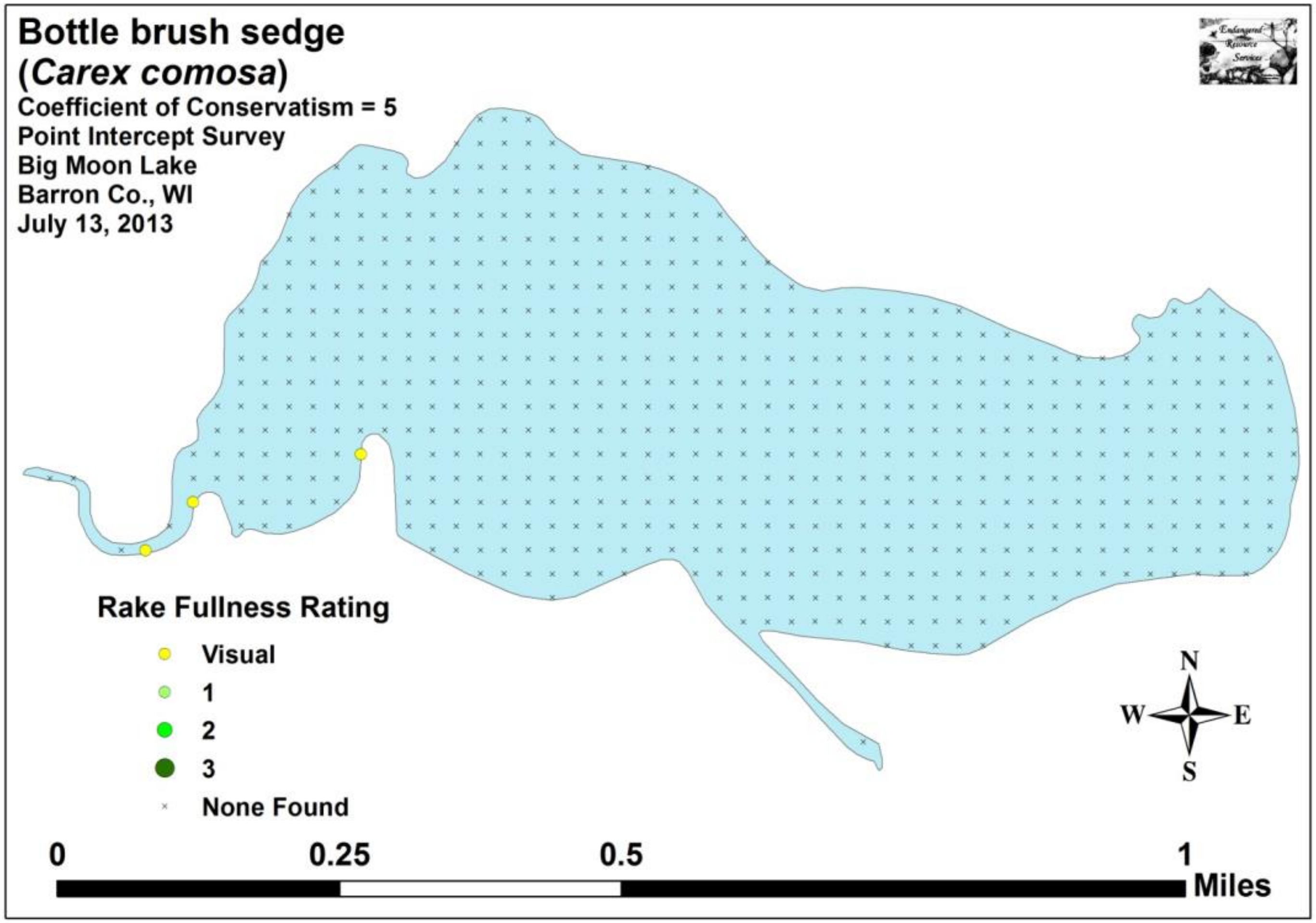
County/State: Barron County, Wisconsin **Date:** 9/21/13
Species: (*Wolffia columbiana*) **Common watermeal**
Specimen Location: Big Moon Lake; N45.33893°, W92.11638°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2013-038
Habitat/Distribution: Located floating at or just under the surface in stagnant bays. Common to abundant; scattered individuals occur interspersed between the lilypads primarily in the "Lagoon" channel off the southern shoreline and bays of the western half of Big Moon.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Lemna minor*) Small duckweed, (*Spirodela polyrhiza*) Large duckweed, (*Ceratophyllum demersum*) Coontail

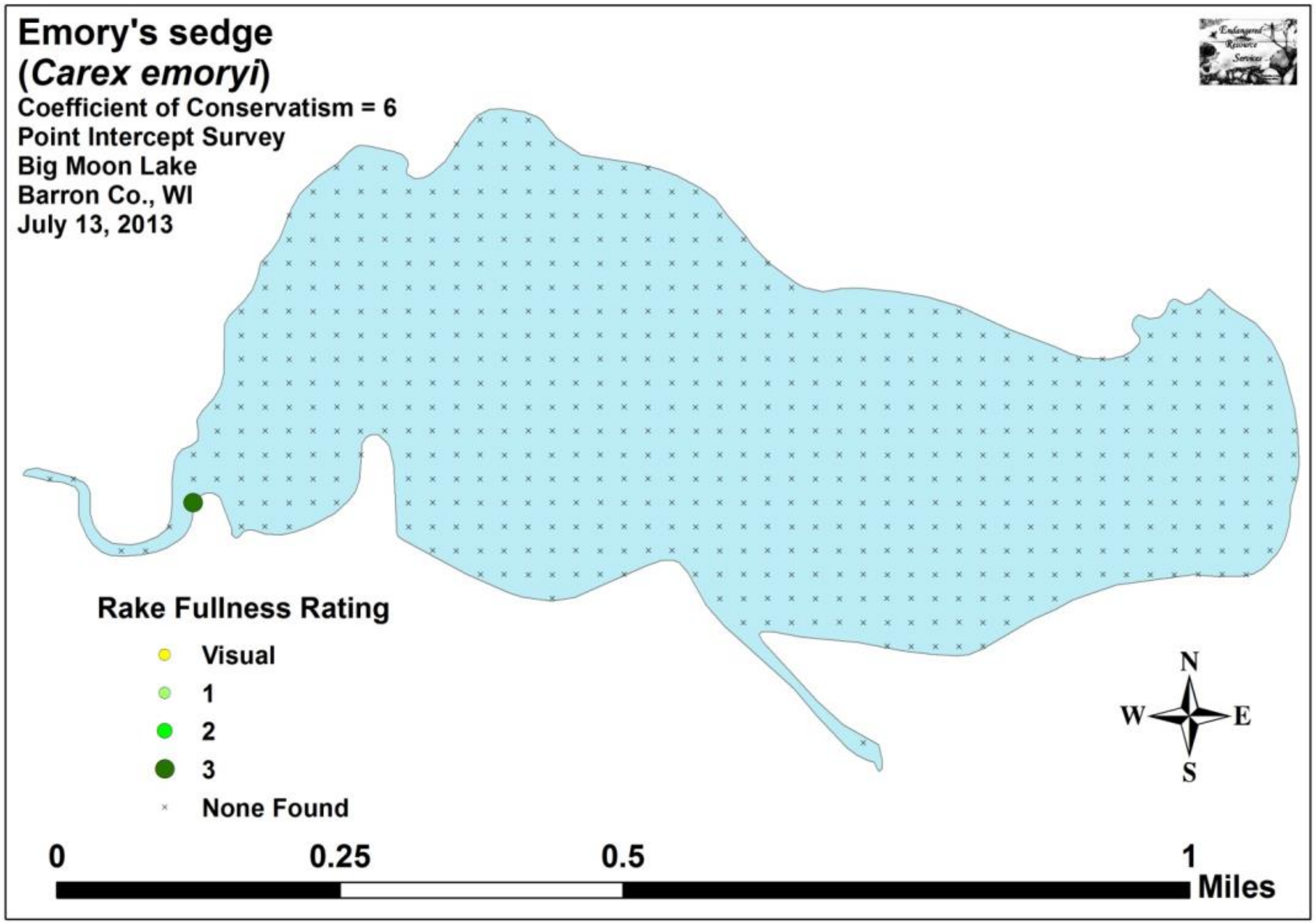
Appendix VII: Big Moon Lake July PI Density and Distribution Maps

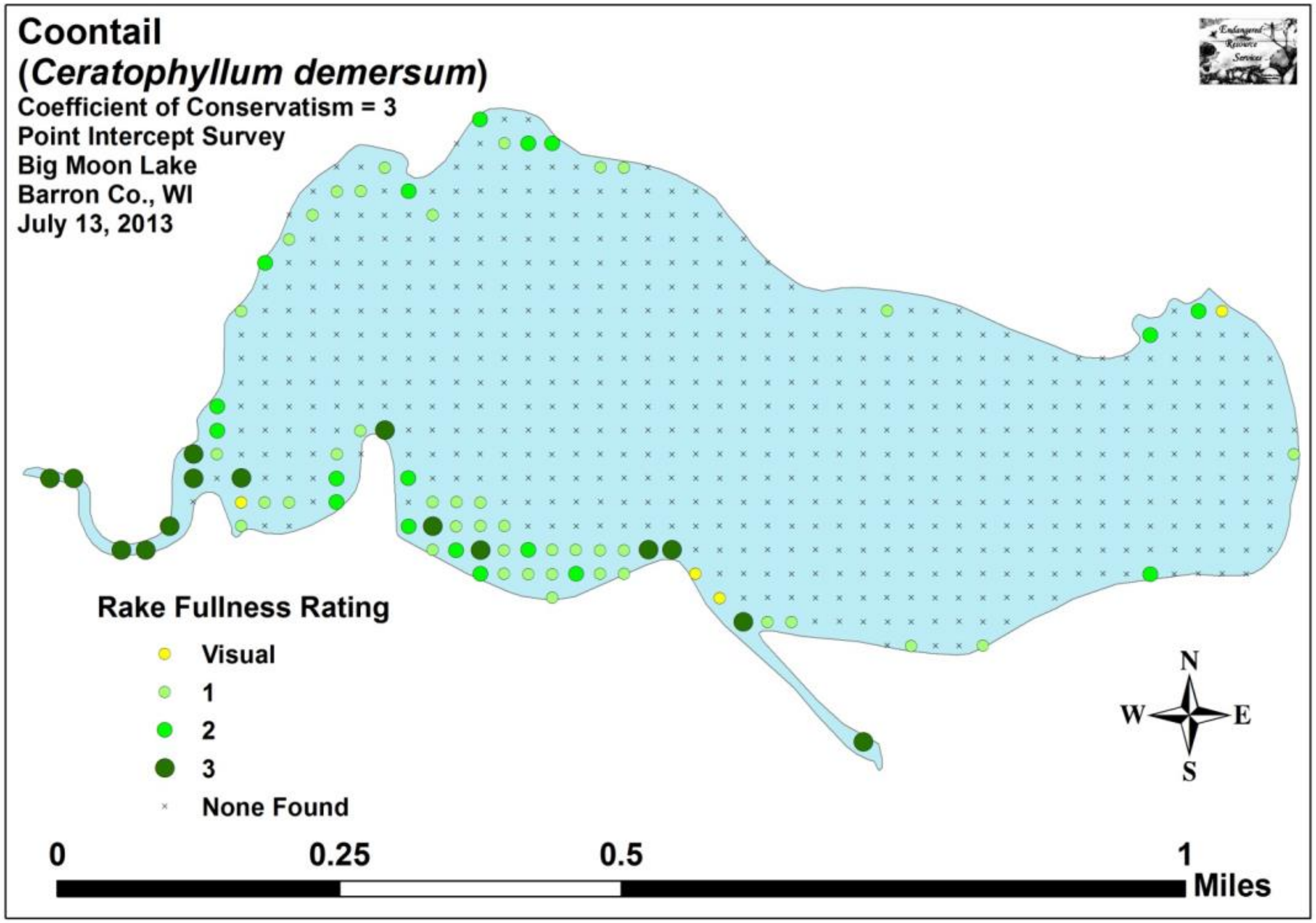


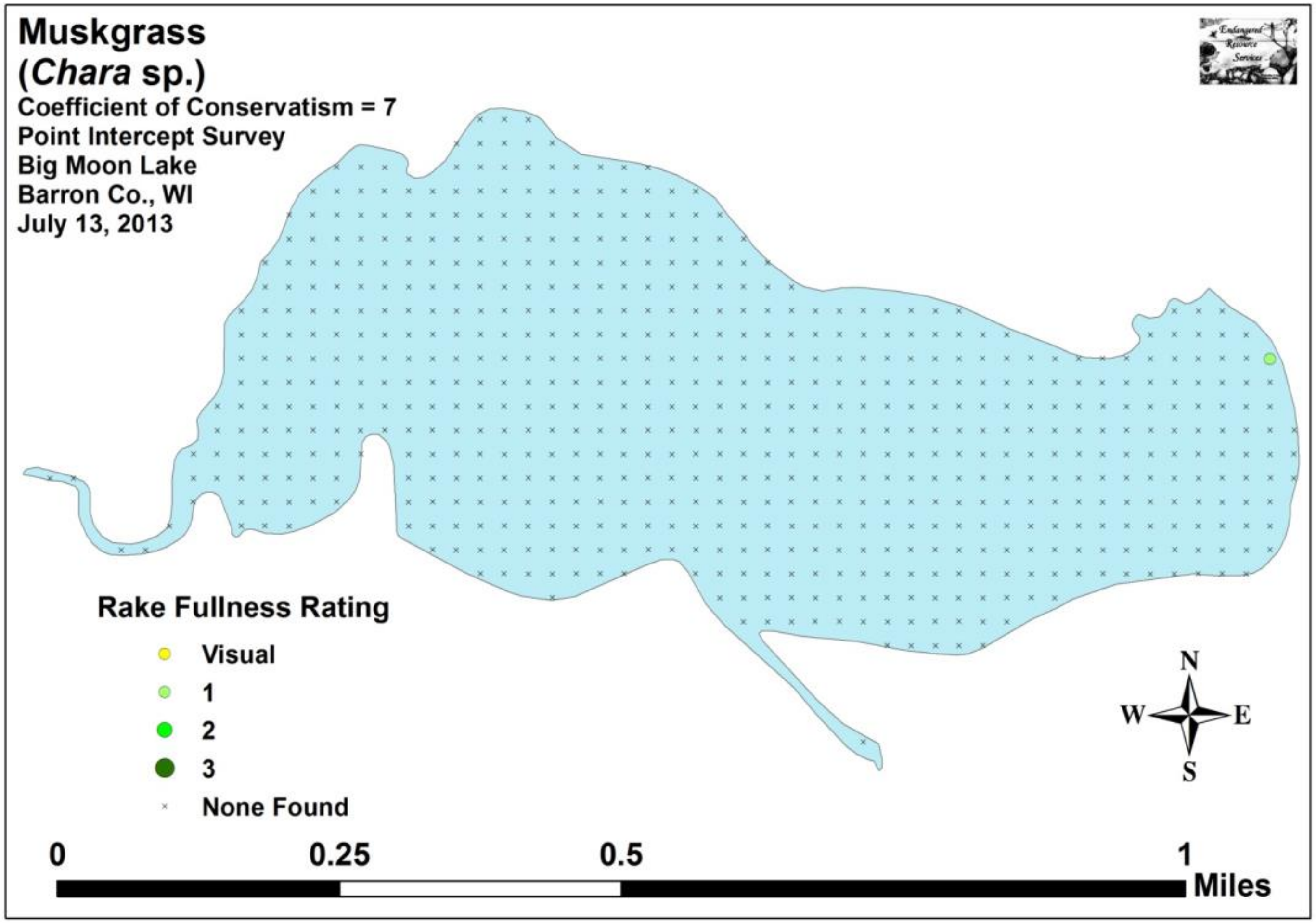
Sweet-flag
(*Acorus calamus*)
Exotic Species
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

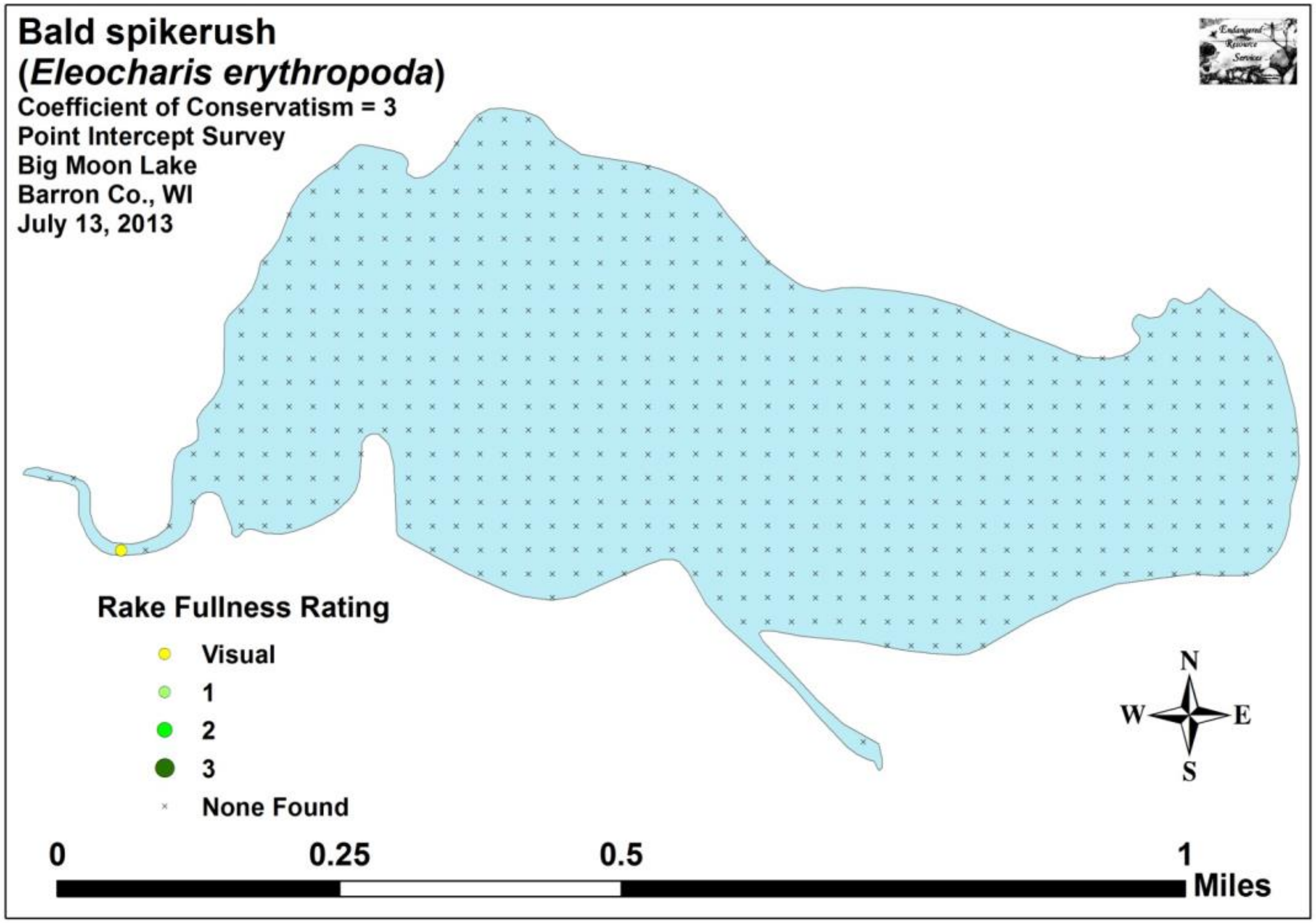

Blue joint
(Calamagrostis canadensis)
Coefficient of Conservatism = 5
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

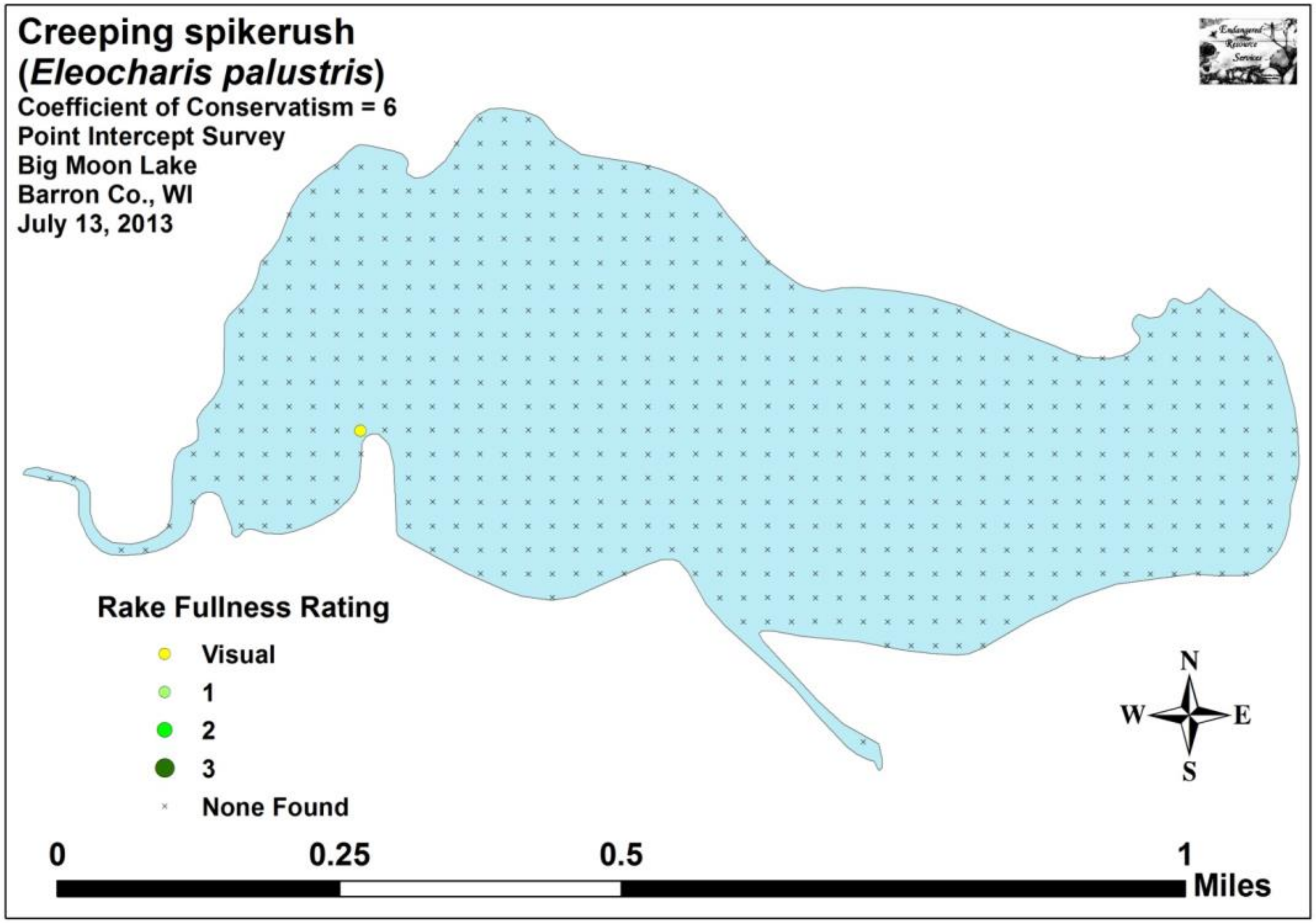

Bottle brush sedge
(*Carex comosa*)
Coefficient of Conservatism = 5
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.25
0.5
1
Miles
N
W
E
S

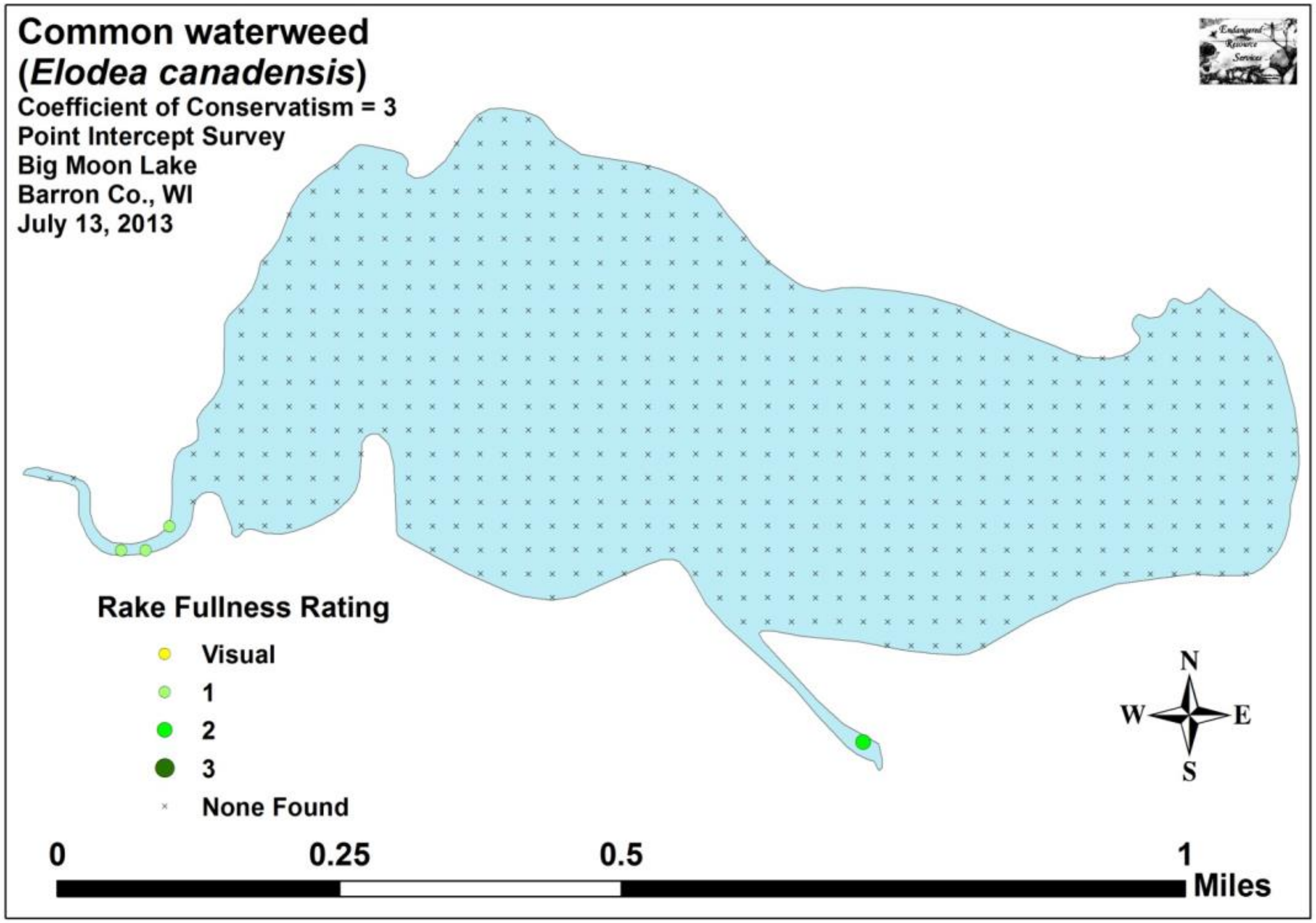

Emory's sedge
(Carex emoryi)
Coefficient of Conservatism = 6
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles

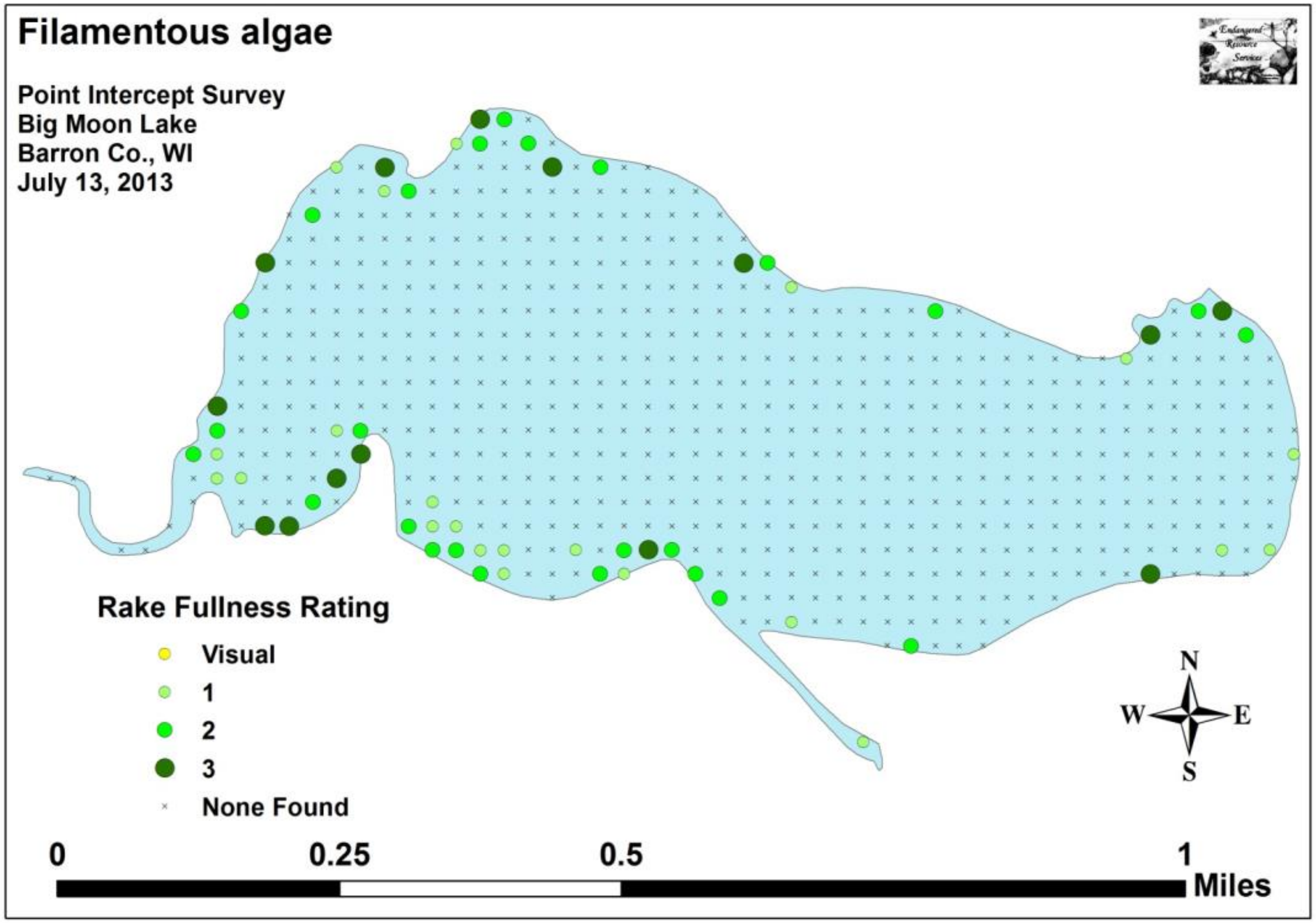

Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Muskgrass
(Chara sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Bald spikerush
(*Eleocharis erythropoda*)
Coefficient of Conservatism = 3
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Creeping spikerush
(*Eleocharis palustris*)
Coefficient of Conservatism = 6
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles


Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.25
0.5
1
Miles



Filamentous algae
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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None Found
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0.5
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Miles
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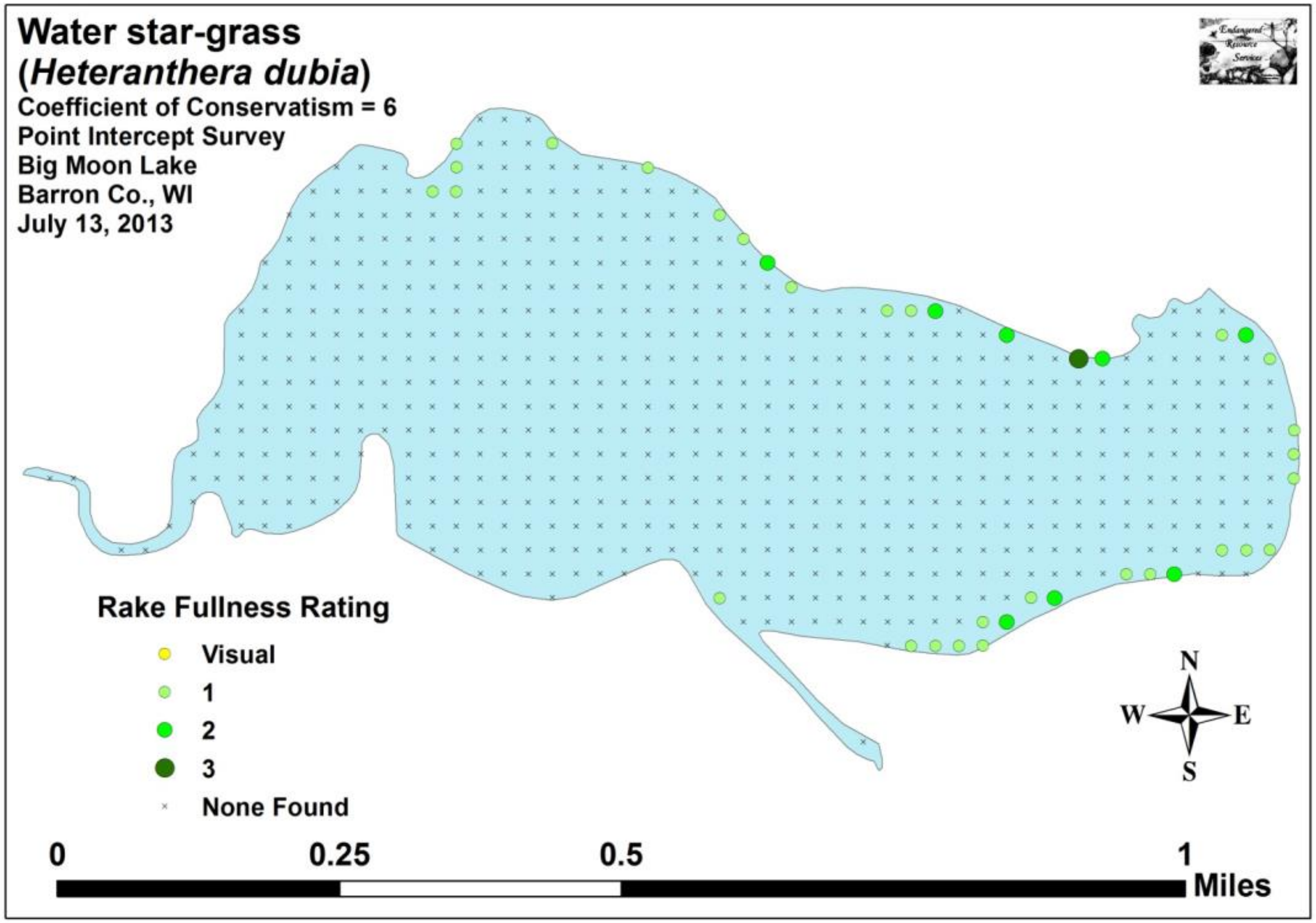
Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
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None Found
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0
0.25
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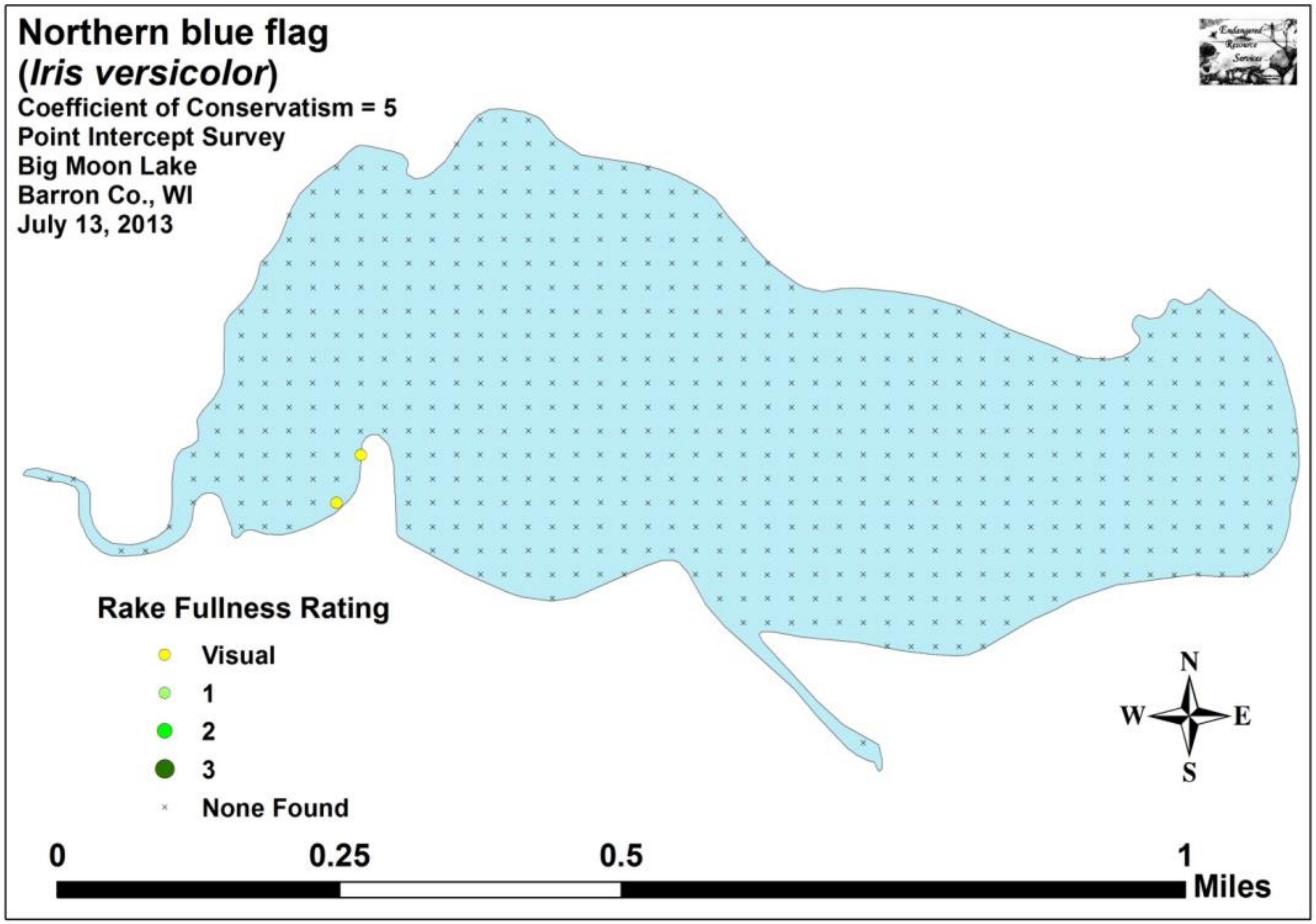
Miles


Northern blue flag
(*Iris versicolor*)
Coefficient of Conservatism = 5
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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None Found
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0.25
0.5
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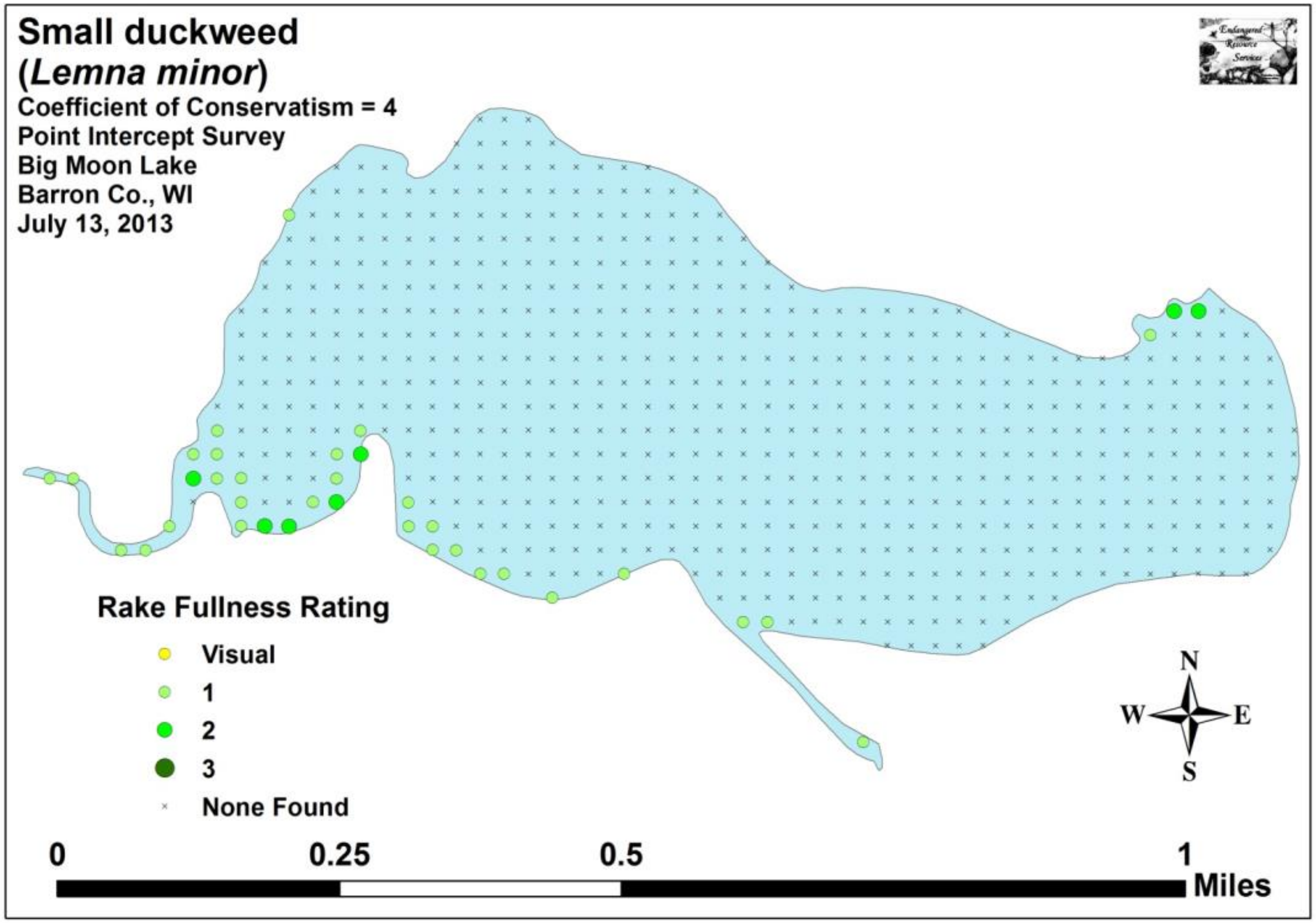
Miles


Small duckweed
(Lemna minor)
Coefficient of Conservatism = 4
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
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None Found
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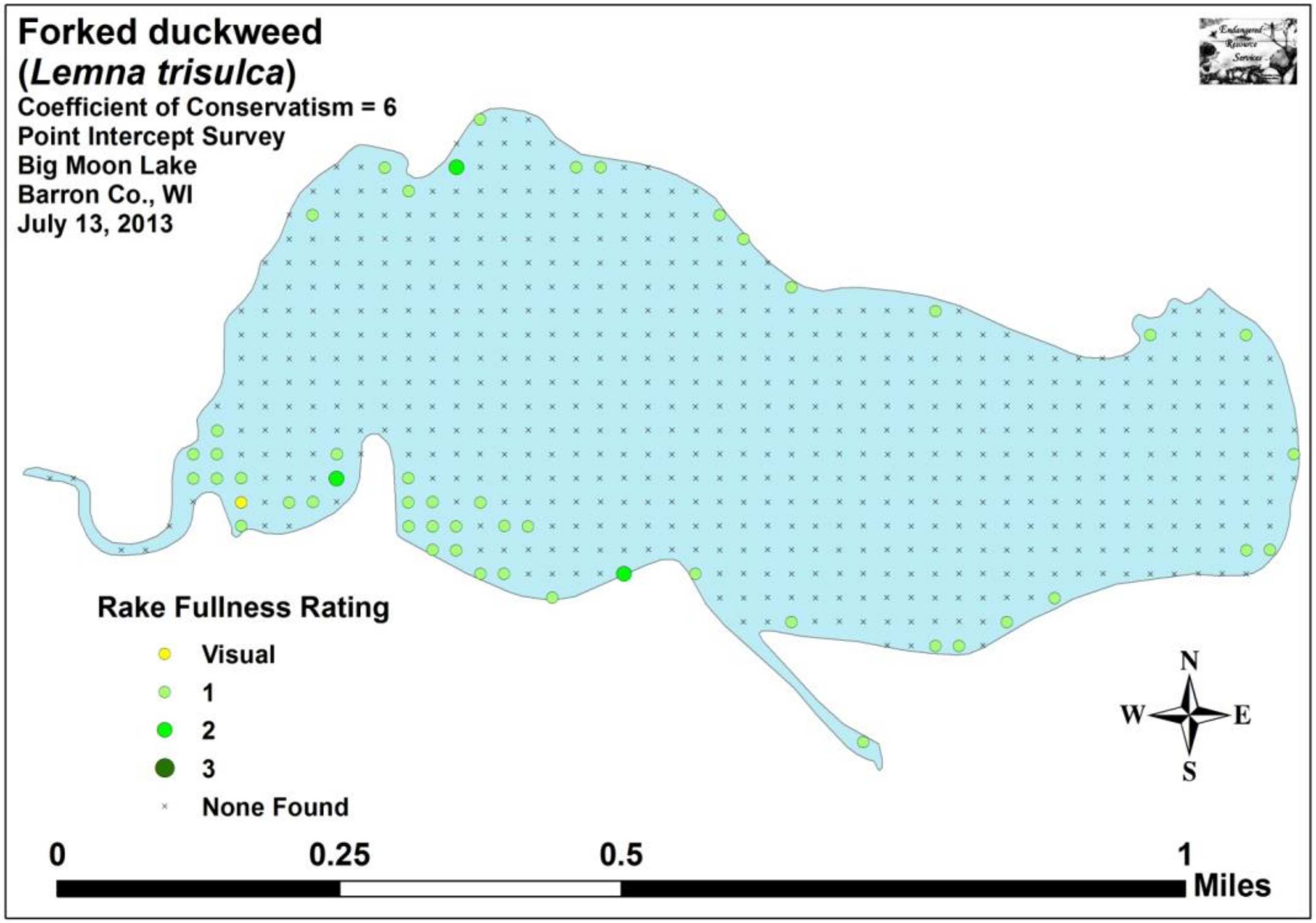
Miles


Forked duckweed
(Lemna trisulca)
Coefficient of Conservatism = 6
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
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None Found
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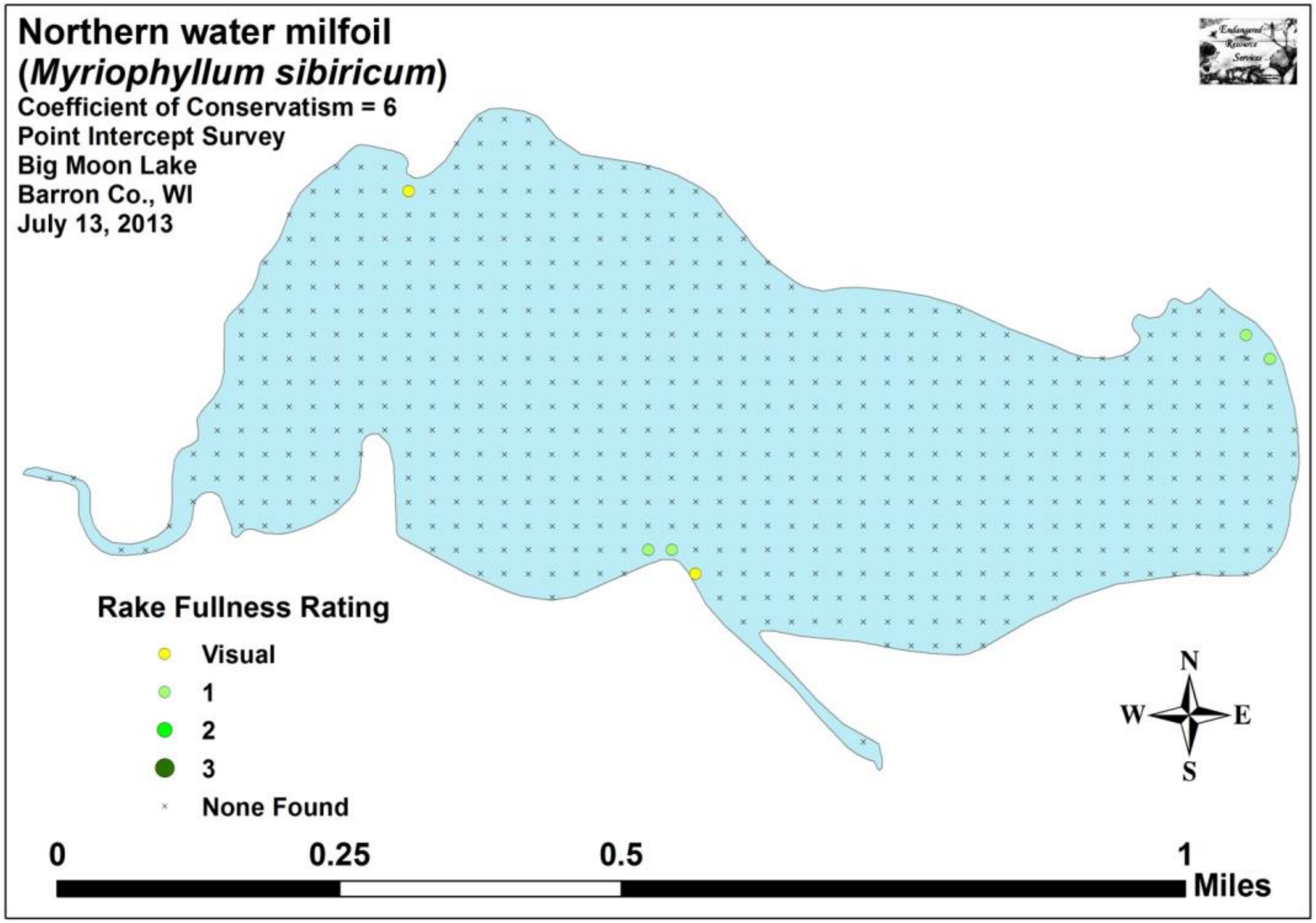
Miles



Northern water milfoil
(*Myriophyllum sibiricum*)
Coefficient of Conservatism = 6
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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None Found
N
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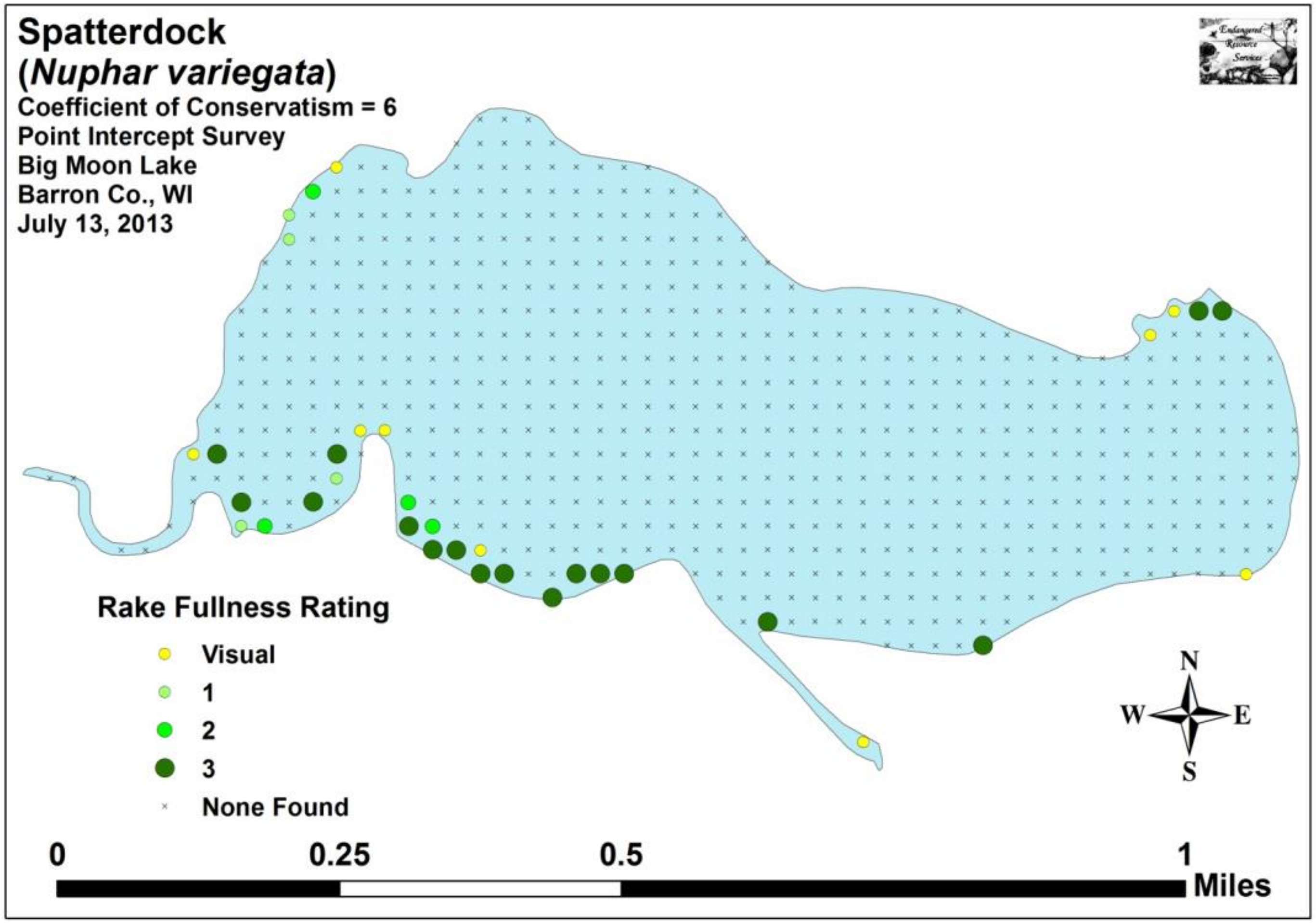
Miles


Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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None Found
N
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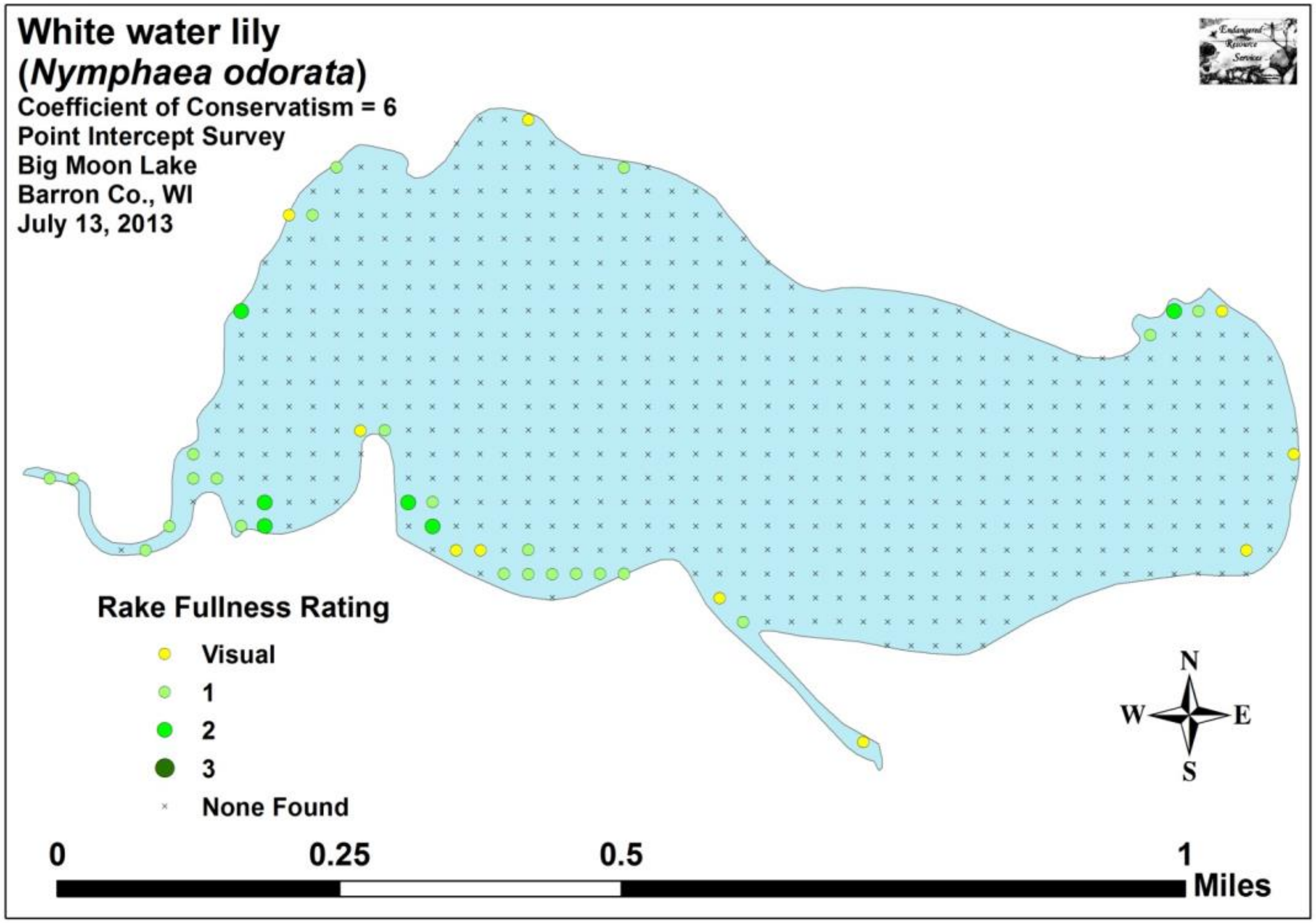
White water lily
(*Nymphaea odorata*)
Coefficient of Conservatism = 6
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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None Found
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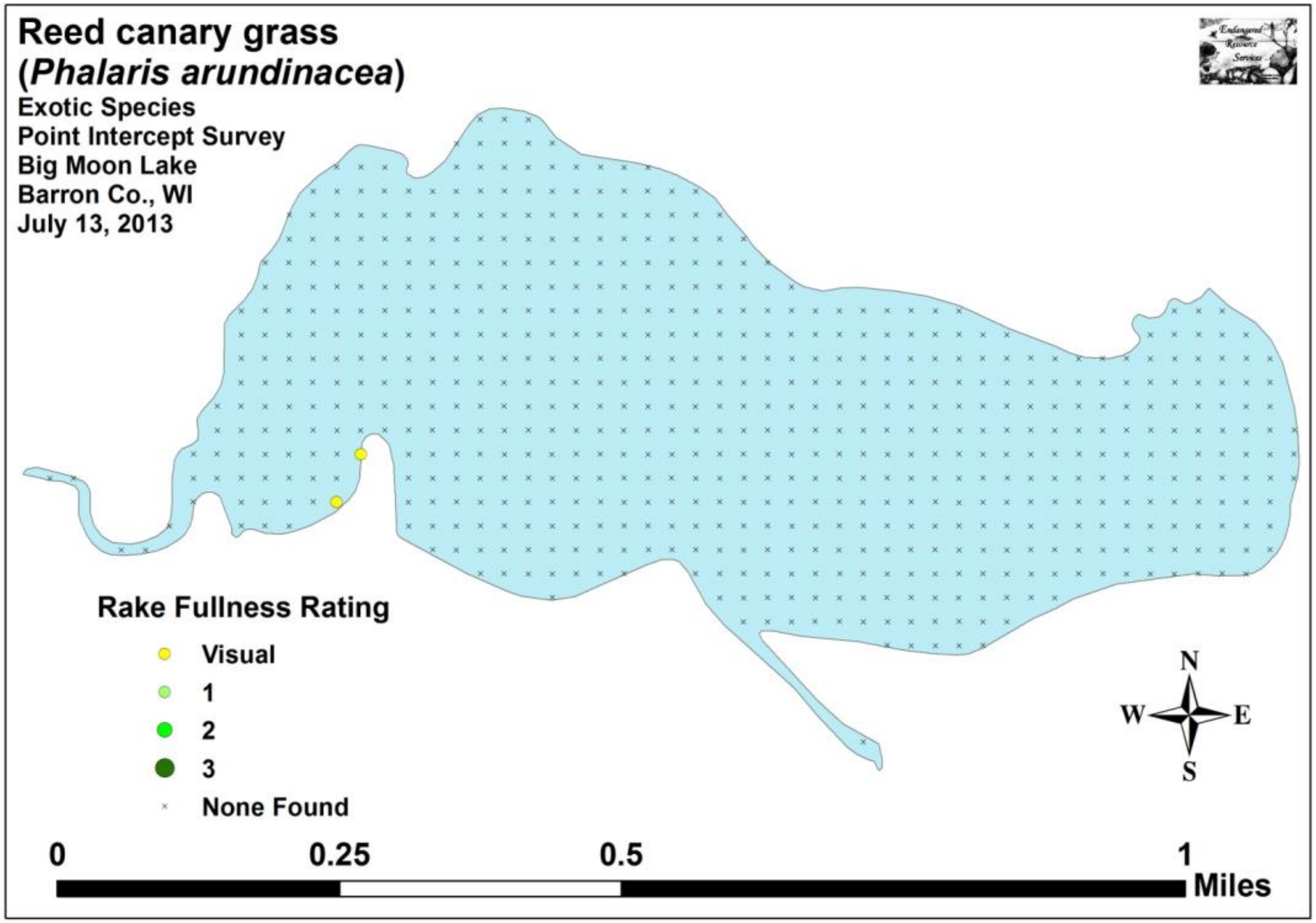
Miles



Reed canary grass
(*Phalaris arundinacea*)
Exotic Species
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
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None Found
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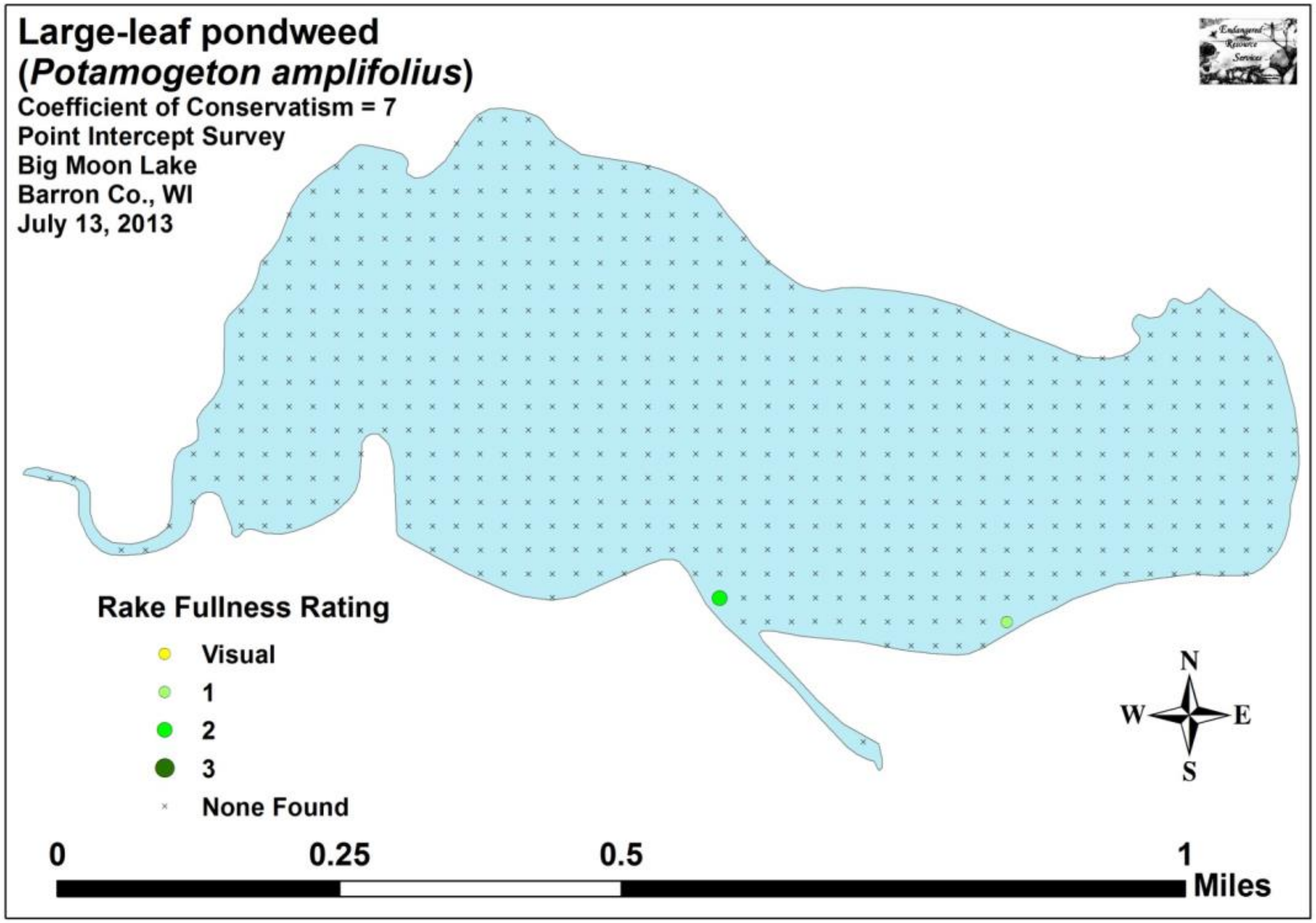
Miles


Large-leaf pondweed
(Potamogeton amplifolius)
Coefficient of Conservatism = 7
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
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None Found
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0.5
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Miles
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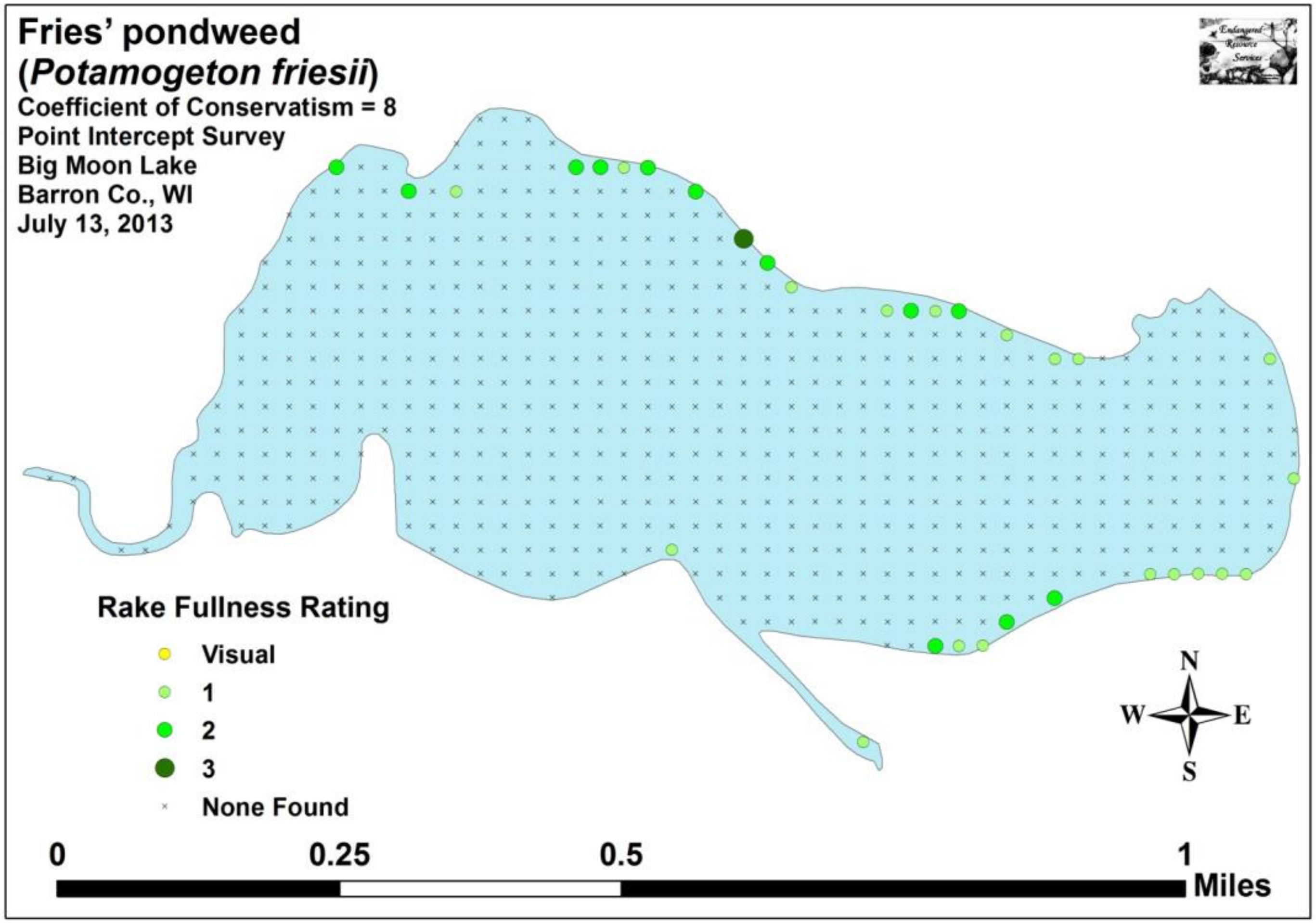

Fries' pondweed
(*Potamogeton friesii*)
Coefficient of Conservatism = 8
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
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None Found
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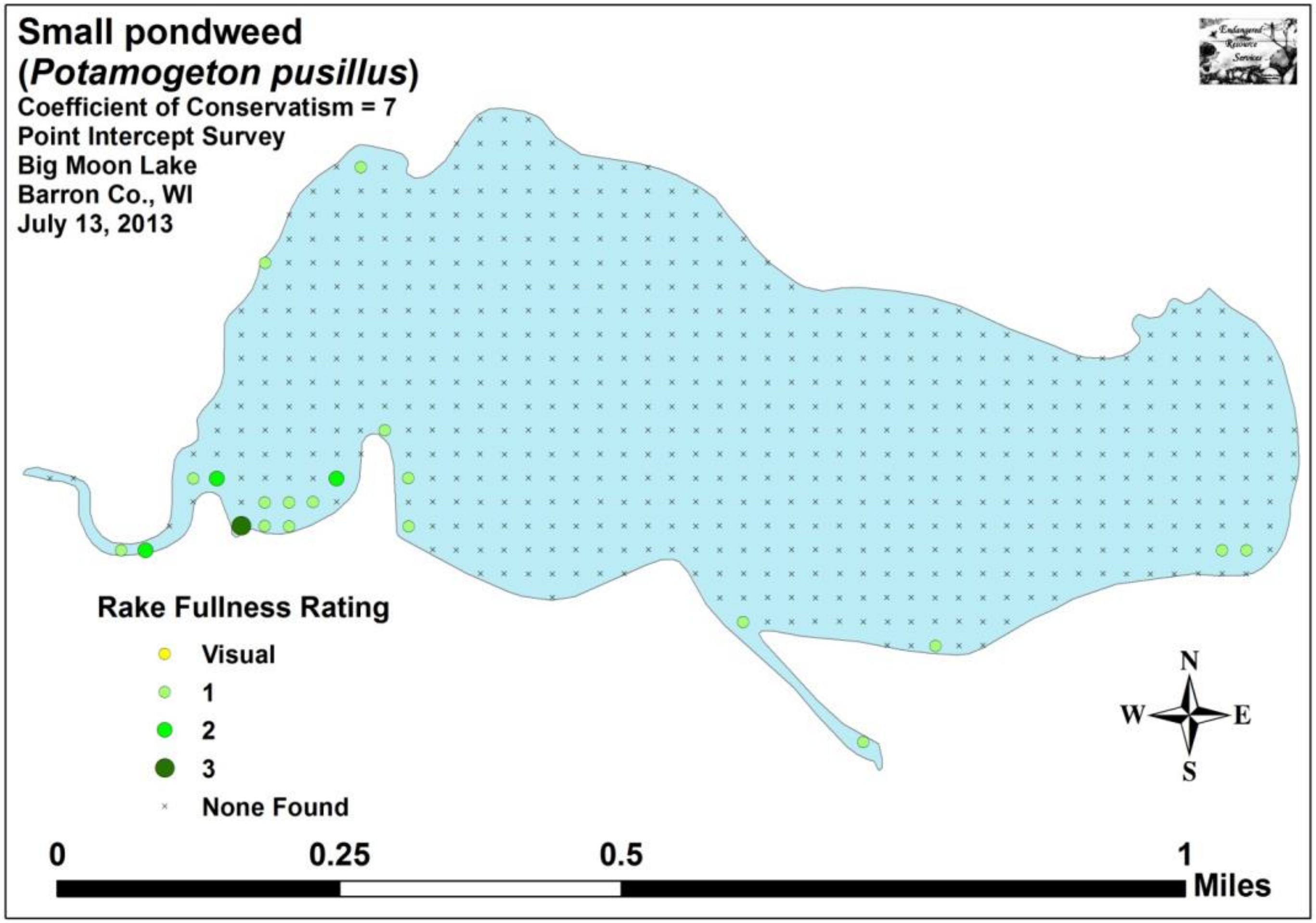
Miles


Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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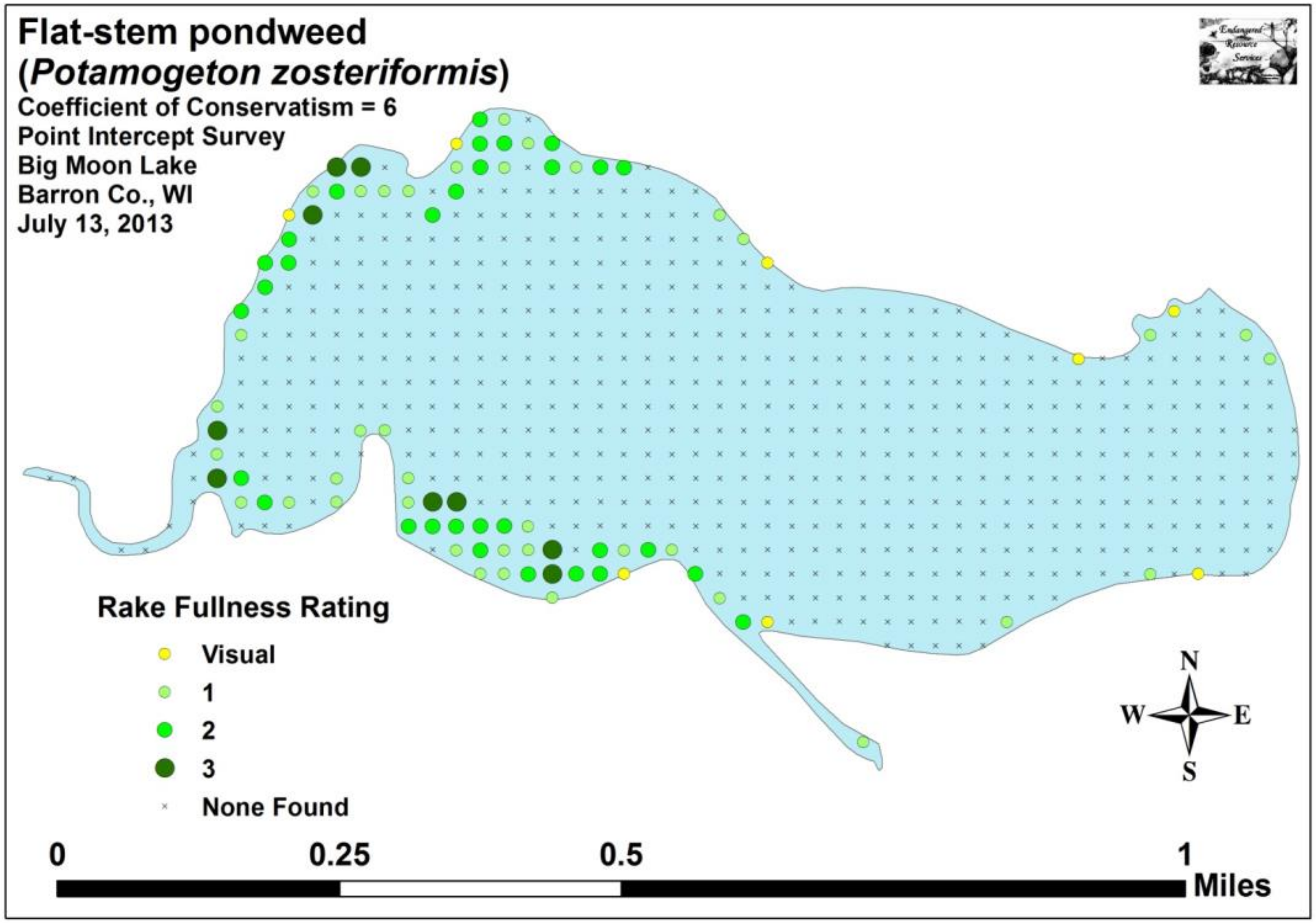
Flat-stem pondweed
(Potamogeton zosteriformis)
Coefficient of Conservatism = 6
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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3
None Found
N
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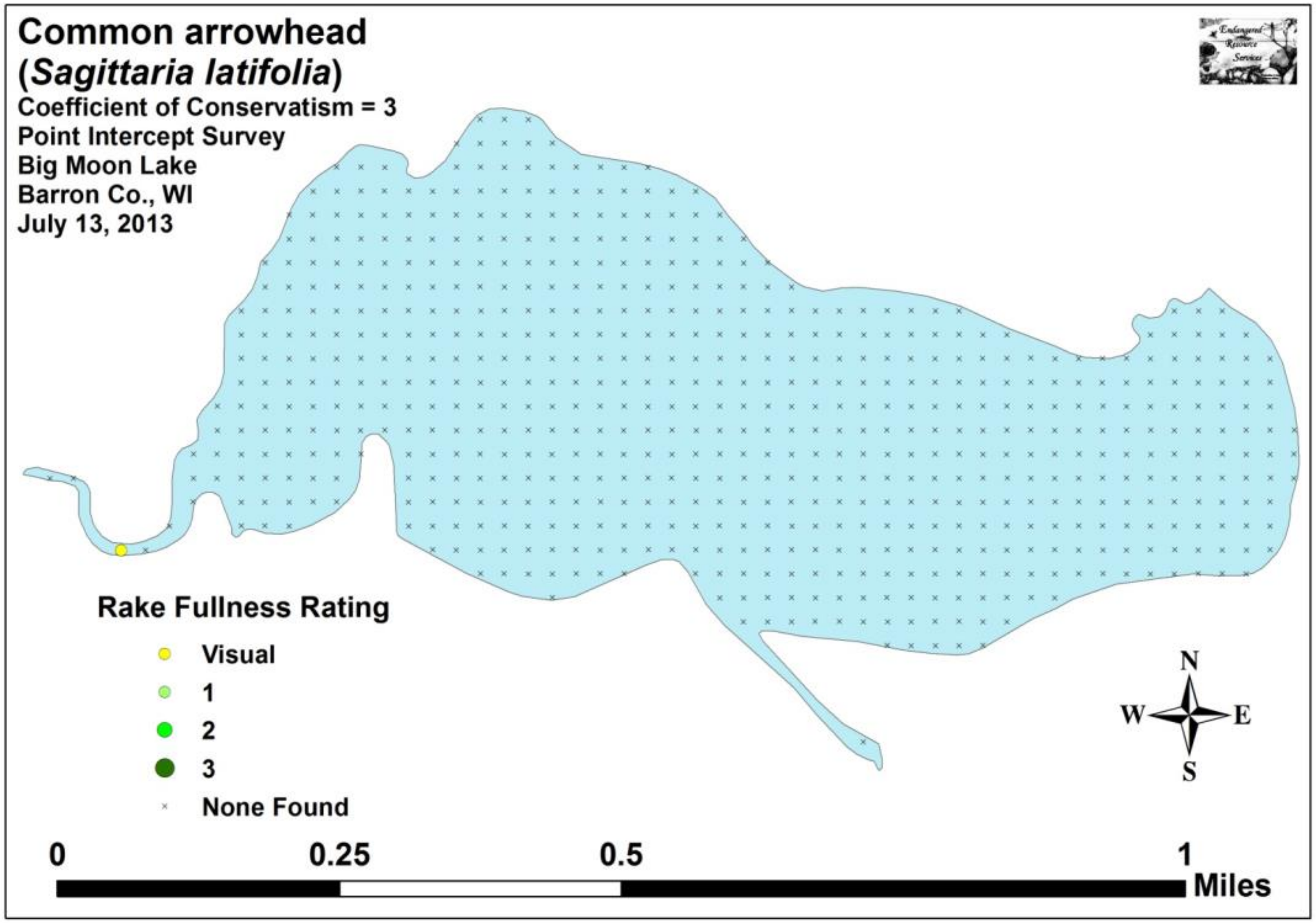
0.5
1
Miles


Common arrowhead
(Sagittaria latifolia)
Coefficient of Conservatism = 3
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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Miles
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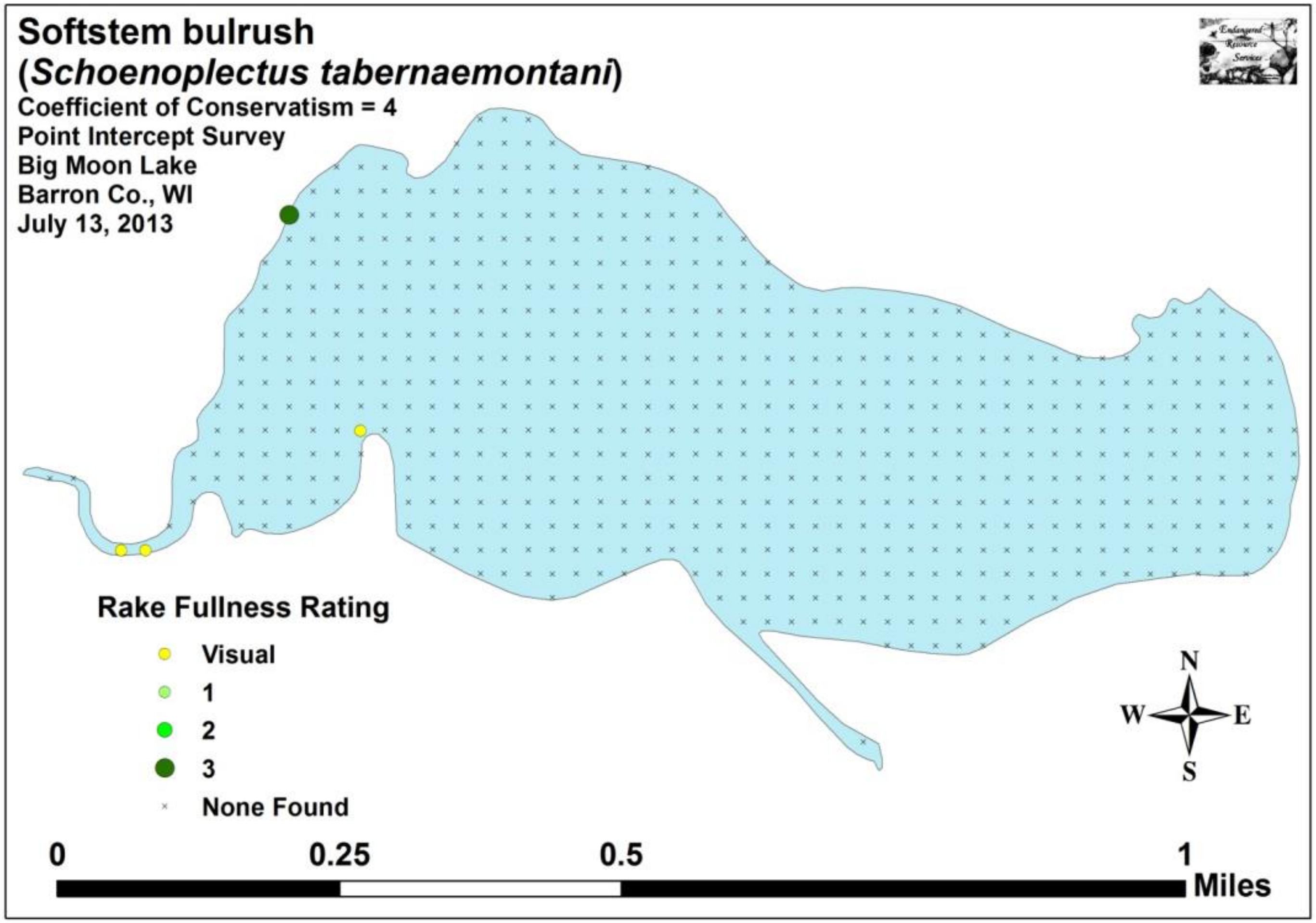
Softstem bulrush
(Schoenoplectus tabernaemontani)
Coefficient of Conservatism = 4
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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None Found
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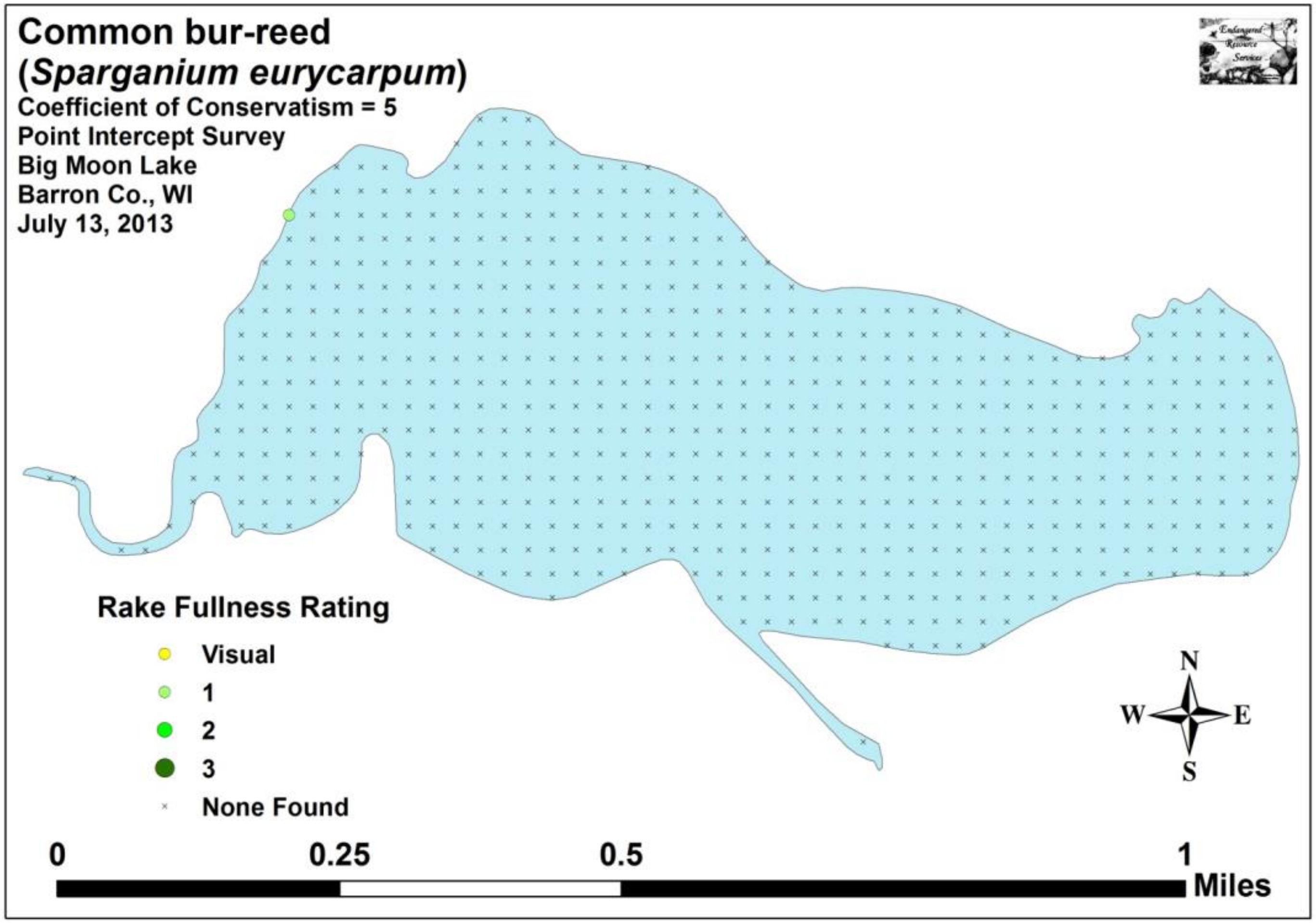
Miles


Common bur-reed
(Sparganium eurycarpum)
Coefficient of Conservatism = 5
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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None Found
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Miles
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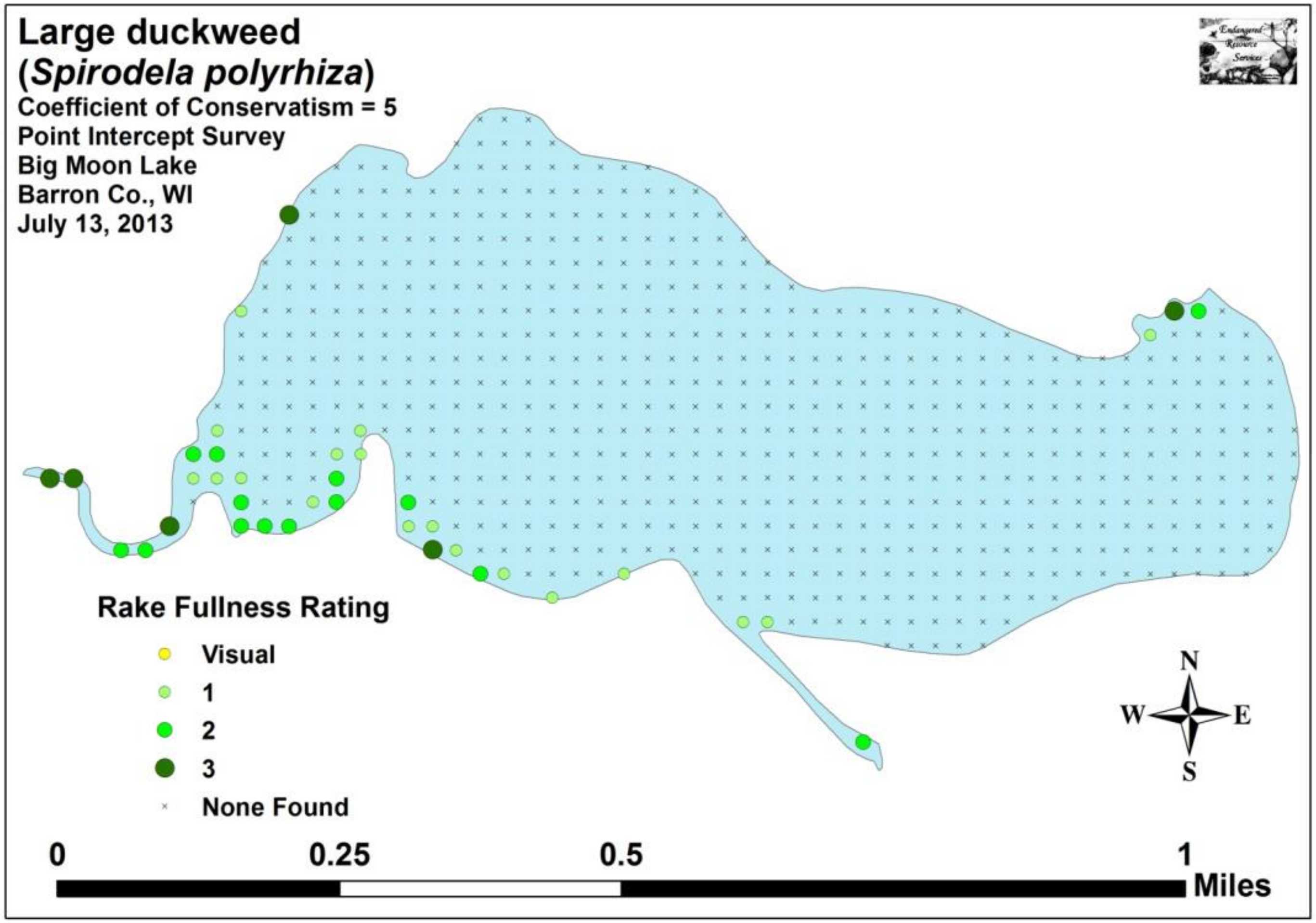
Large duckweed
(Spirodela polyrhiza)
Coefficient of Conservatism = 5
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
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None Found
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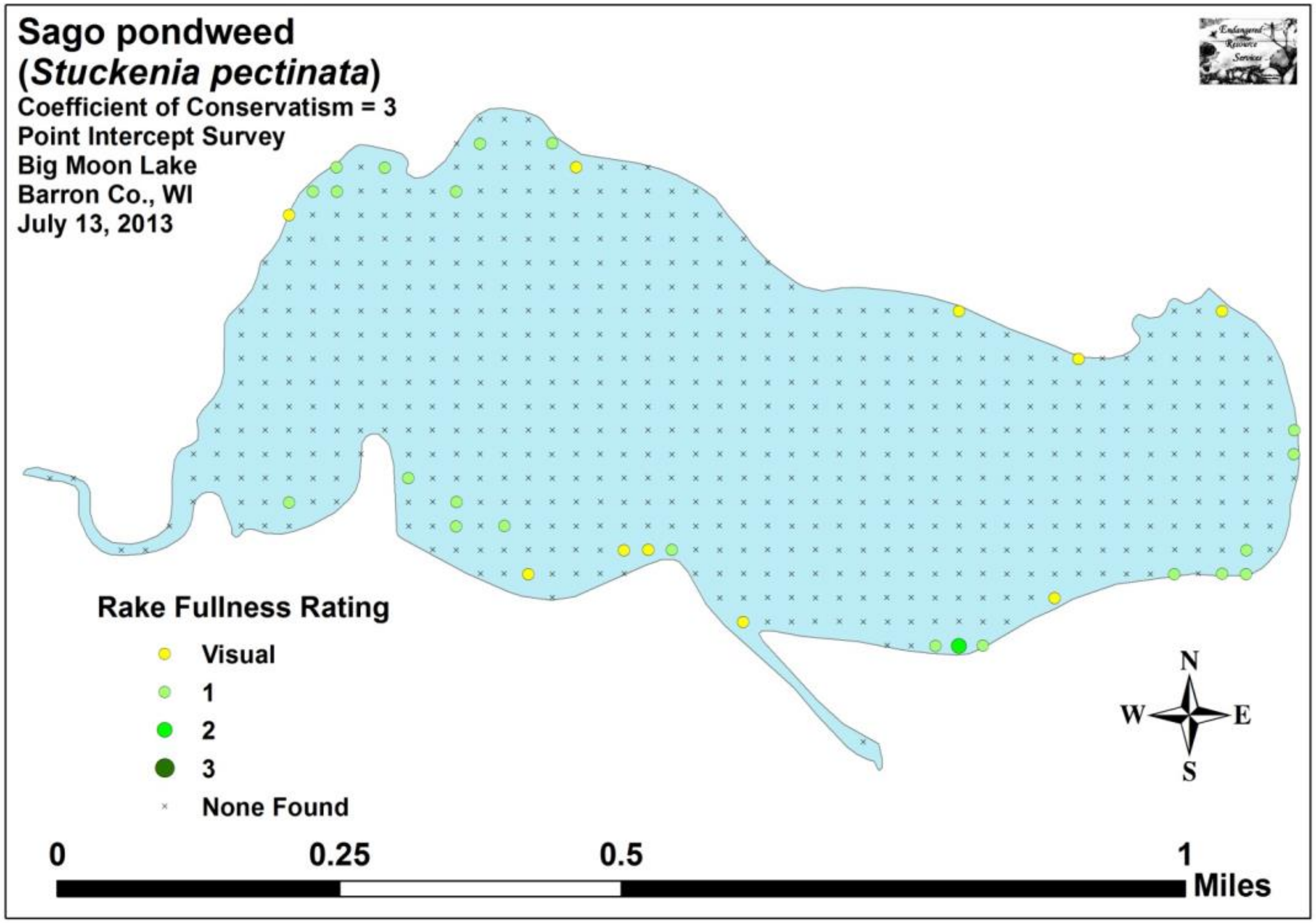
Miles



Sago pondweed
(*Stuckenia pectinata*)
Coefficient of Conservatism = 3
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Endangered Resource Services
Rake Fullness Rating
Visual
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None Found
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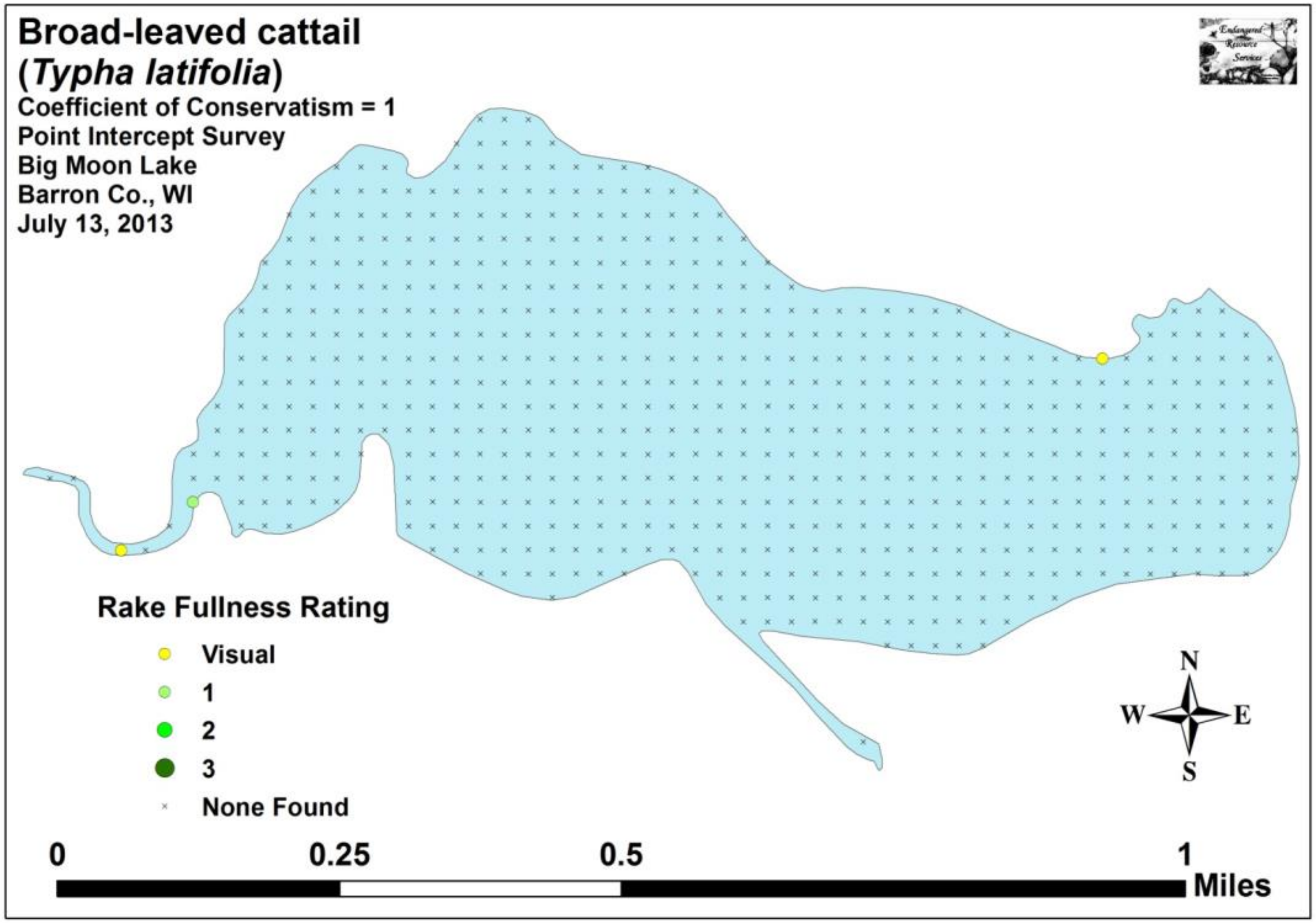
Miles


Broad-leaved cattail
(*Typha latifolia*)
Coefficient of Conservatism = 1
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
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None Found
N
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0.25
0.5
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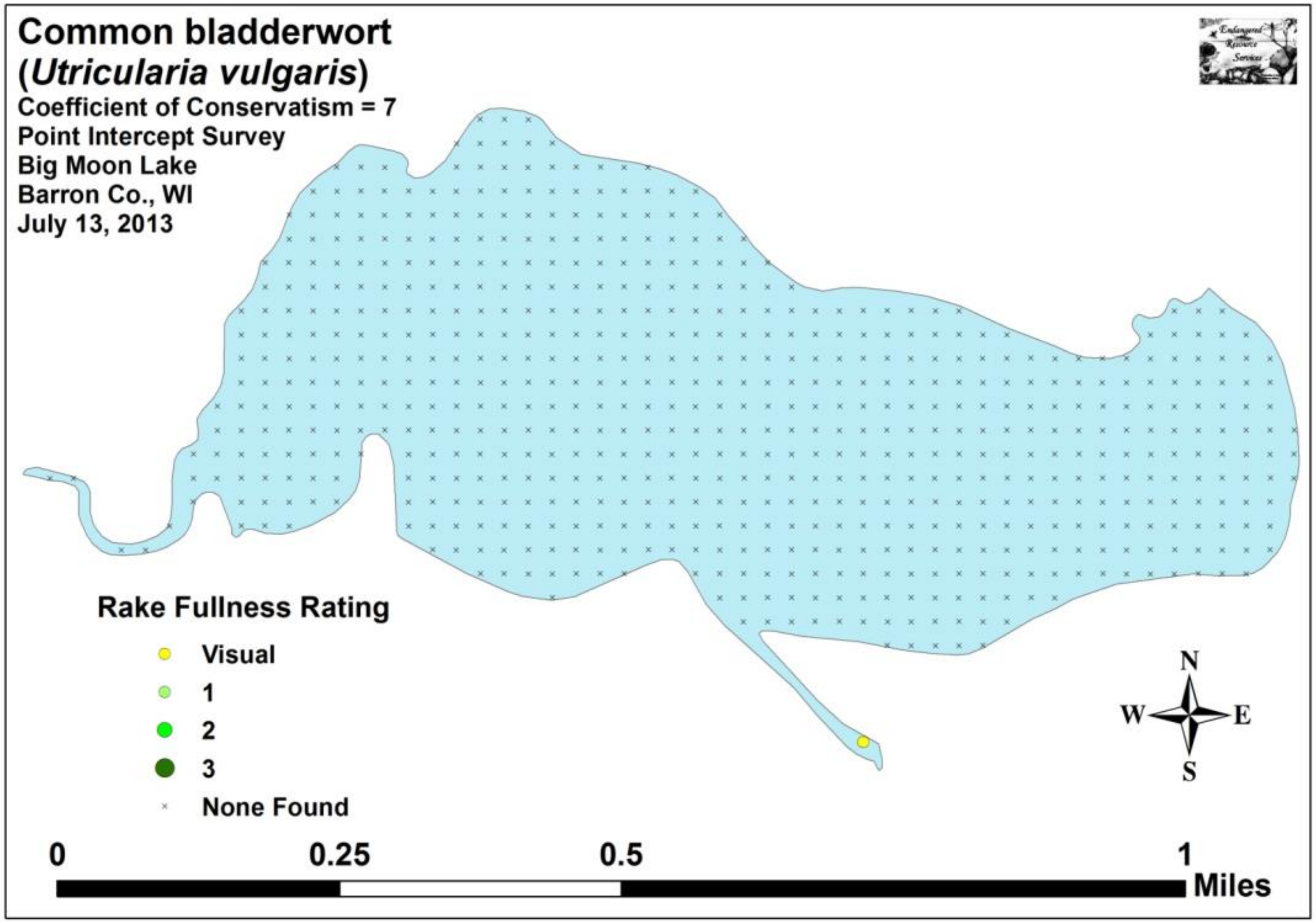
Miles


Common bladderwort
(Utricularia vulgaris)
Coefficient of Conservatism = 7
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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None Found
0
0.25
0.5
1
Miles
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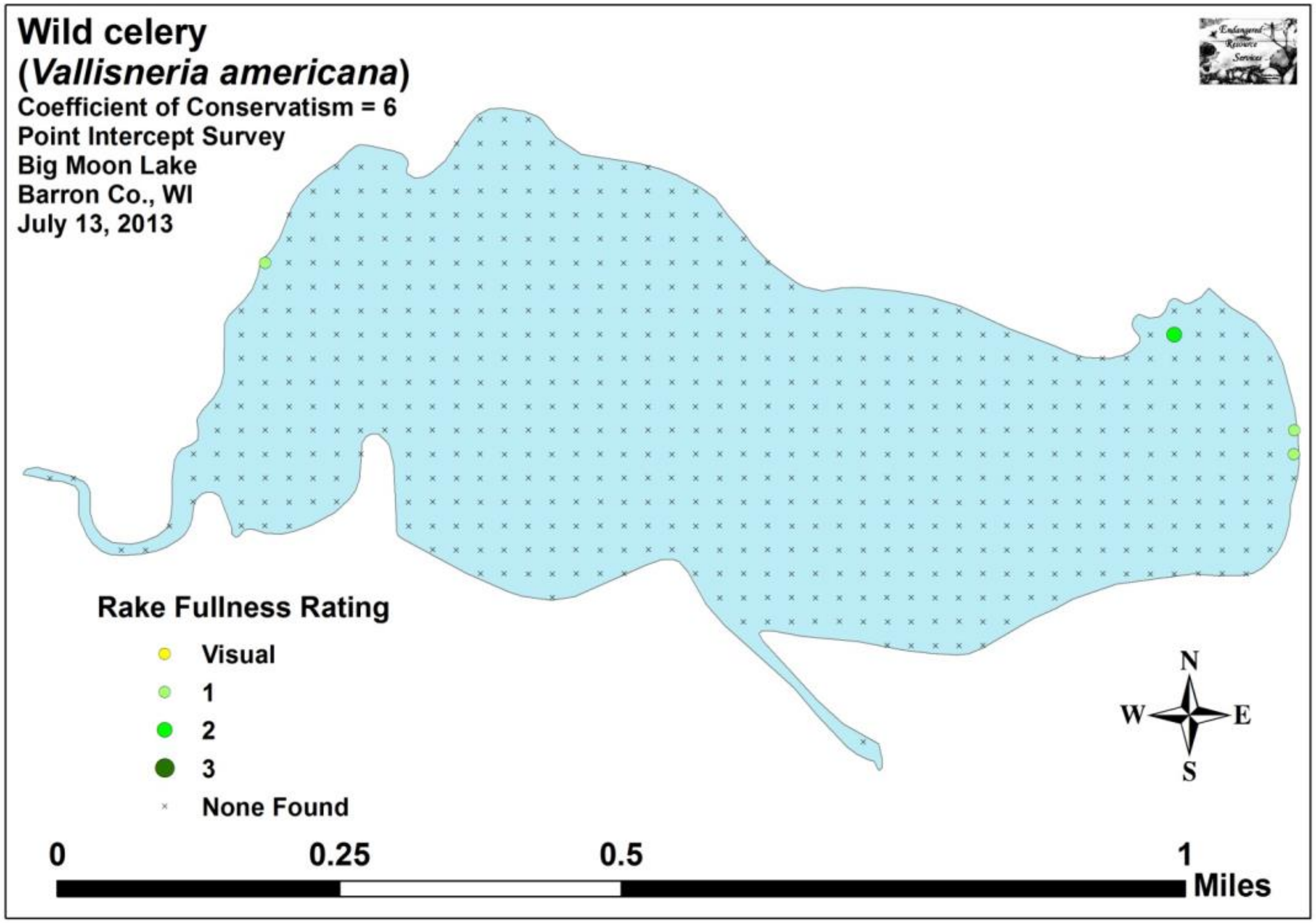
Wild celery
(Vallisneria americana)
Coefficient of Conservatism = 6
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
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None Found
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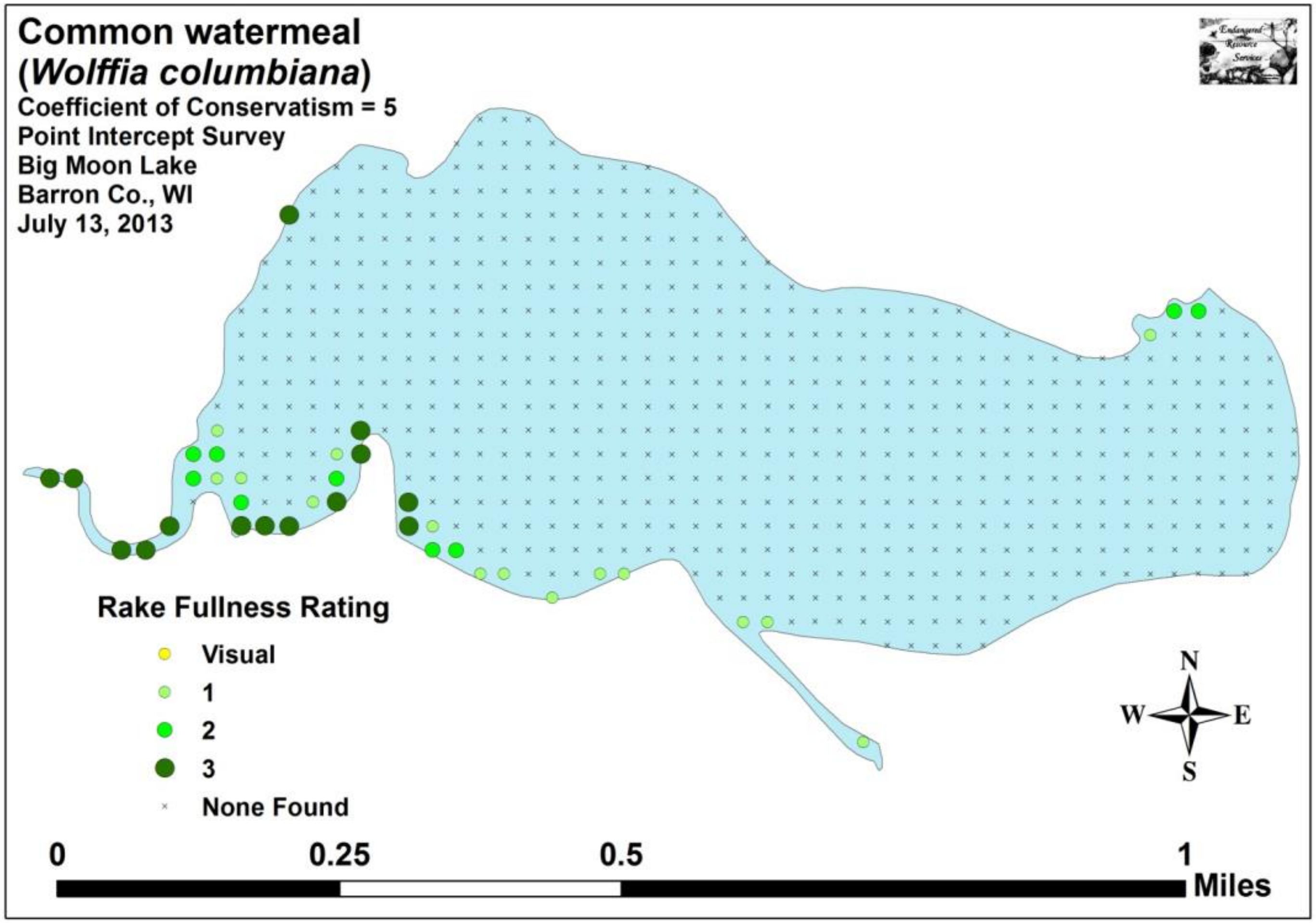
Miles


Common watermeal
(*Wolffia columbiana*)
Coefficient of Conservatism = 5
Point Intercept Survey
Big Moon Lake
Barron Co., WI
July 13, 2013
Rake Fullness Rating
Visual
1
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None Found
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Miles

Appendix VIII: Aquatic Exotic Invasive Plant Species Information

Curly-leaf pondweed

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

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

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

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out compete native plants in the spring. In mid-summer, when most aquatic plants are growing, curly-leaf pondweed plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. Curly-leaf pondweed forms surface mats that interfere with aquatic recreation. (Taken in its entirety from WDNR, 2013 http://dnr.wi.gov/invasives/fact/curlyleaf_pondweed.htm)

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, 2013 http://dnr.wi.gov/invasives/fact/milfoil.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, 2013 http://dnr.wi.gov/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, 2013 http://dnr.wi.gov/invasives/fact/loosestrife.htm)

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

Aquatic:
: organisms that live in or frequent water.

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

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

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

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

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

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

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

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

Limnology:
: the study of inland lakes and waters.

Littoral:

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

Macrophytes:

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

Nutrients:

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

Organic Matter:

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

Photosynthesis:

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

Phytoplankton:

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

Plankton:

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

ppm:

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

Richness:
number of species in a particular community or habitat.

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

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

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

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

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

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

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

Appendix X: Raw Data Spreadsheets