Curly-leaf pondweed (*Potamogeton crispus*) Point-intercept and Bed Mapping Surveys, and Warm-water Macrophyte Point-intercept Survey Echo Lake - WBIC: 2630200 Barron County, Wisconsin

Echo Lake Aerial Photo (2015)

Common reed bed on the south shoreline 7 27/17

Project Initiated by:

The Echo Lake Association, Lake Education and Planning Services, LLC, and the Wisconsin Department of Natural Resources

Eurasian water-milfoil rake removed 7/ 27/17

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June 23, and July 24, 27, 2017

TABLE OF CONTENTS

ABSTRACT

Echo Lake (WBIC 2630200) is a 172 acre stratified seepage lake located in west-central Barron County, WI. Following the discovery of Eurasian water-milfoil (*Myriophyllum spicatum*) (EWM) in the lake in 2004 and the Wisconsin Department of Natural Resources' (WDNR) original point-intercept survey in 2007, the Echo Lake Association (ELA) began aggressively managing this highly invasive exotic species with a combination of herbicide treatments and manual removal. Following our point-intercept surveys in 2012, the ELA, under the direction of Dave Blumer (Lake Education and Planning Services, LLC), completed an Aquatic Plant Management Plan in 2013. As a prerequisite to updating this plan in 2018 and to compare how the lake's vegetation may have changed since the last point-intercept surveys, the ELA and the WDNR authorized Curly-leaf pondweed (*Potamogeton crispus*) (CLP) density and bed mapping surveys on June 23rd, and a full point-intercept survey for all aquatic macrophytes on July 24, 27, 2017. During the 2012 early-season survey, we found a single CLP plant at a single point (0.2% coverage). In 2017, we didn't' find CLP in the rake at any point. EWM was present at a single point in both 2012 (rake fullness of 2) and 2017 (rake fullness 1). On June 9th, 2012, we mapped a single 1.49 acres "high CLP density area" that contained 50 of the 88 total CLP plants found during the survey – most of which were rake removed. As with every other survey since 2012, we didn't see any evidence of CLP during our 2017 CLP bed mapping survey. During the July 2017 full point-intercept survey, we found macrophytes growing at 273 sites which approximated to 45.6% of the entire lake bottom and 84.8% of the 19.5ft littoral zone. This was a highly significant decline **(p<0.001)** from the 2012 survey when we found plants growing at 371 points (63.9% of the bottom and 87.7% of the then 22.5ft littoral zone). Overall diversity was very high with a Simpson Index value of 0.90 – identical to 2012. Species richness was moderately high with 45 species found growing in and immediately adjacent to the water; down from 53 species in 2012. There was an average of 2.34 native species/site with native vegetation – a non- significant decline (p=0.35) from 2.41/site in 2012. Total rake fullness experienced a highly significant decline **(p<0.001)** from a moderate 2.10 in 2012 to a low/moderate 1.52 in 2017; potentially in response to rising water levels and an accompanying loss in clarity. In 2017, we found Fern pondweed (*Potamogeton robbinsii*), Common waterweed (*Elodea canadensis*), Wild celery (*Vallisneria americana*), Northern naiad (*Najas gracillima*), and Spiral-fruited pondweed (*Potamogeton spirillus*) were the most common macrophyte species. Found at 61.17%, 23.44%, 18.68%, 14.65%, and 14.65% of sites with vegetation, they accounted for 56.30% of the total relative frequency. In 2012, Fern pondweed, Common waterweed, Nitella (*Nitella* sp.), Spiral-fruited pondweed, and Needle spikerush (*Eleocharis acicularis*) were the most common species being found at 44.20%, 41.24%, 39.35%, 17.25%, and 12.40% of points with vegetation and accounting for 64.02% of the total relative frequency. Lakewide, from 2012-2017, 17 species saw significant changes in distribution: Common waterweed, Nitella, Needle spikerush, and Waterwort (*Elatine minima*) all suffered highly significant declines; Pickerelweed (*Pontederia cordata*) and Woolgrass (*Scirpus cyperinus*) experienced moderately significant declines; and Branched bur-reed (*Sparganium androcladum*), Greater waterwort (*Elatine triandra*), and Softstem bulrush (*Schoenoplectus tabernaemontani*) showed significant declines. Conversely, Fern pondweed, Wild celery, Northern naiad, Vasey's pondweed (*Potamogeton vaseyi*), Creeping bladderwort (*Utricularia gibba*), Blunt-leaf pondweed (*Potamogeton obtusifolius*), and Water smartweed (*Polygonum amphibium*) demonstrated highly significant increases; and Common bladderwort (*Utricularia vulgaris*) saw a significant increase. The 37 native index species found in the rake during the July 2017 survey (down from 39 in 2012) produced a much above average mean Coefficient of Conservatism of 7.4 (up from 7.3 in 2012), and a Floristic Quality Index of 45.2 (down from 45.6 in 2012) that was more than double the median FQI for this part of the state. Other than EWM, Reed canary grass (*Phalaris arundinacea*) was the only other exotic species found although a small bed of the native subspecies of Common Reed (*Phragmites australis americanus*) was present on the south shoreline. Following 13 years of active management that included herbicide treatments covering a total of 62.43 acres, EWM was reduced from 106 points with a mean rake fullness of 1.28 in August 2007, to one point in July 2012, to no points in July 2017. Continuing to aggressively manage EWM to limit its spread while simultaneously working to minimize its impact on Echo Lake's native plants and keeping economic costs low; and proactively working to limit nutrient inputs around the lake which can fuel both algal as well as milfoil growth are management priorities for the ELA to consider as they update their management plan.

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION:

Echo Lake (WBIC 2630200) is a 172 acre stratified seepage lake in west-central Barron County, Wisconsin in the Town of Almena (T34N R14W S07 NE NE). The lake reaches a maximum depth of 41ft in the southeast corner of the central basin and has an average depth of 20ft (Busch et al. 1967) (Figure 1). Echo Lake is mesotrophic bordering on oligotrophic in nature, and water clarity is good to very good with summer Secchi readings from 2004-17 averaging 11.7ft (WDR 2017). The lake's bottom substrate is variable with sandy muck bottoms in most bays, and rock/sand bars along most points and around the exposed and sunken islands.

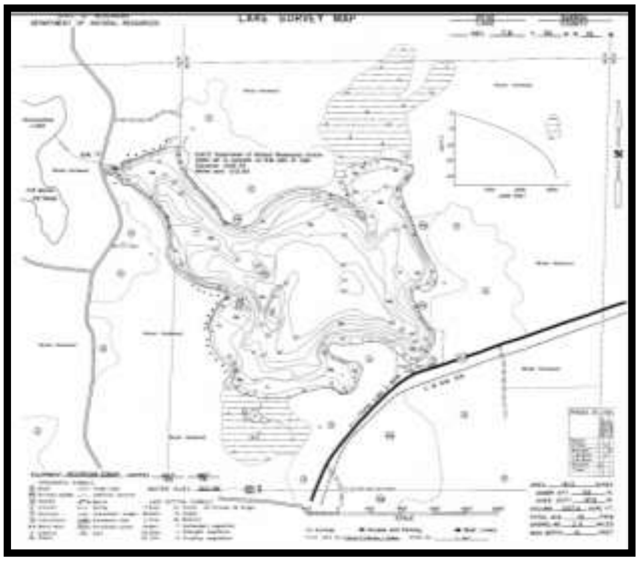


Figure 1: Echo Lake Bathymetric Map

BACKGROUND AND STUDY RATIONALE:

Eurasian water-milfoil (*Myriophyllum spicatum*) (EWM) was discovered in Echo Lake in 2004, and the Echo Lake Association (ELA) has been actively managing this aggressive exotic invasive species since 2008. Following the completion of their last Aquatic Plant Management Plan (APMP) in 2013, the ELA outlined a course of action for controlling EWM using a combination strategy of targeted herbicide applications and manual rake and SCUBA removal. In addition to EWM, the plan also suggested manual removal for the lake's limited Curly-leaf pondweed (*Potamogeton crispus*) (CLP) infestation - another exotic invasive species that is present, but has been historically rare in the lake.

Per Wisconsin Department of Natural Resource (WDNR) expectations, APMP are normally updated every five years to remain current. In anticipation of updating their plan in 2018, the ELA, under the direction of Dave Blumer (Lake Education and Planning Services, LLC), and the WDNR authorized three lakewide surveys on Echo in 2017. On June 23rd, we conducted an early-season exotic species point-intercept survey. This was immediately followed by a CLP bed mapping survey. On July 24th and 27th, we returned to the lake to complete a warm-water point-intercept survey of all macrophytes. The goals of these surveys were to document the current levels of CLP and EWM in the lake, and to compare our 2012 survey to the 2017 data to determine how the lake's vegetation may have changed. This report is the summary analysis of these three field surveys.

METHODS:

Curly-leaf Pondweed Point Intercept Survey:

Using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth and total acreage, Jennifer Hauxwell (WDNR) generated a 599 point sampling grid for Echo Lake prior to the original 2007 WDNR survey (Appendix I). Using this same grid in both 2012 and 2017, we completed a density survey where we sampled for Curly-leaf pondweed at each point in and adjacent to the lake's littoral zone. We located each survey point using a handheld mapping GPS unit (Garmin 76CSx) and used a rake to sample an approximately 2.5ft section of the bottom. When found, CLP was assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also noted visual sightings of CLP within six feet of the sample point. Although not the specific target of this survey, we recorded any Eurasian water-milfoil encountered to further assist with early-season control methods.

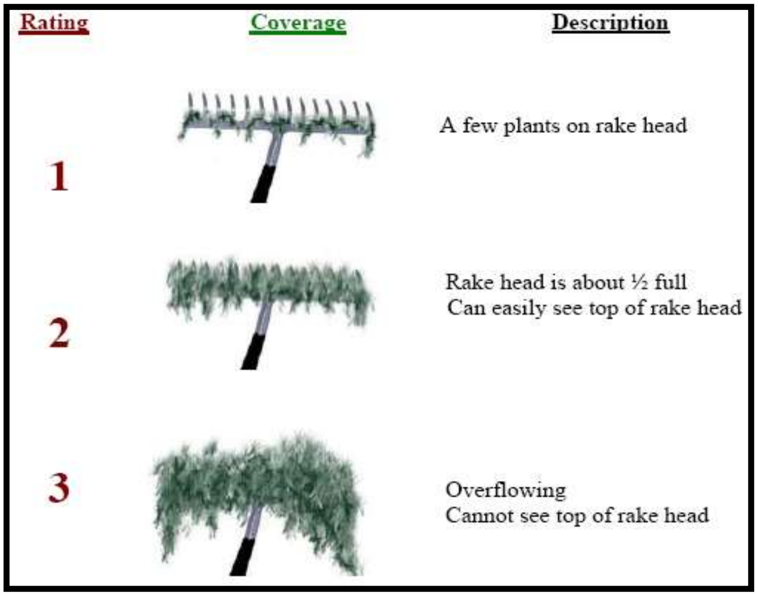


Figure 2: Rake Fullness Ratings (UWEX 2010)

Curly-leaf Pondweed Bed Mapping Survey:

During the bed mapping survey, we searched the lake's entire visible littoral zone. By definition, a "bed" was determined to be any area where we visually estimated that CLP made up >50% of the area's plants, was generally continuous with clearly defined borders, and was canopied, or close enough to being canopied that it would likely interfere with boat traffic. After we located a bed, we motored around the perimeter of the area taking GPS coordinates at regular intervals. We also estimated the rake density range and mean rake fullness of the bed (Figure 2), the maximum depth of the bed, whether it was canopied, and the impact it was likely to have on navigation (**none** – easily avoidable with a natural channel around or narrow enough to motor through/**minor** – one prop clear to get through or access open water/**moderate** – several prop clears needed to navigate through/**severe** – multiple prop clears and difficult to impossible to row through). These data were then mapped using ArcMap 9.3.1, and we used the WDNR's Forestry Tools Extension to determine the acreage of each bed to the nearest hundredth of an acre (Table 1).

Warm-water Full Point-intercept Macrophyte Survey:

Prior to beginning the July point-intercept survey, we conducted a general boat survey of the lake to regain familiarity with the species present (Appendix II). All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2012; Skawinski 2014), and a data sheet was built from the species present. We again located each survey point with a GPS, recorded a depth reading with a metered pole rake or hand held sonar (Vexilar LPS-1), and took a rake sample. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of all plants within six feet of the sample point not found in the rake. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

DATA ANALYSIS:

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

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

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

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

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

Frequency of occurrence example:

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

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

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

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

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

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

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

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

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

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

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

Relative frequency example:

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

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

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

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

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

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

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

Comparison to Past Surveys: We compared data from our 2012 and 2017 CLP point-intercept surveys (Figure 4) and warm-water point-intercept surveys (Figure 12) (Tables 3 and 4) to see if there were any significant changes in the lake's vegetation. For individual plant species as well as count data, we used the Chi-square analysis on the WDNR Pre/Post survey worksheet. For comparing averages (mean species/point and mean rake fullness/point), we used t-tests. Differences were considered significant at $p < .05$, moderately significant at $p < .01$ and highly significant at $p < .001$ (UWEX 2010). It should be noted that when comparing the warm-water point-intercept surveys, we used the number of littoral points with plants (371 in 2012/273 in 2017) as the basis for "sample points".

RESULTS:

Curly-leaf Pondweed Point-intercept Survey:

During our initial 2012 survey, we found the spring littoral zone extended to 22ft. A single CLP plant was found in the rake at a single sample point. This extrapolated to only 0.2% of the lake having any CLP at all and no area having a significant infestation. CLP was also recorded as a visual at two additional points (Figure 3).

In 2017, following a fall/winter/spring that saw a dramatic rise in water levels on the lake of several feet; we recorded Secchi disc readings of only 6.5ft (this improved later in the summer). In these turbid conditions, we found plants were growing to 15ft, but showed evidence of dying (blackened leaves) in water as shallow as 9ft – apparently in response to low light conditions. Although we rake sampled 323 points, we saw no evidence of Curly-leaf pondweed at or inter-point (Figure 3) (Appendix III). Although encouraging from a management perspective, this decline in CLP plants was not significant (Figure 4).

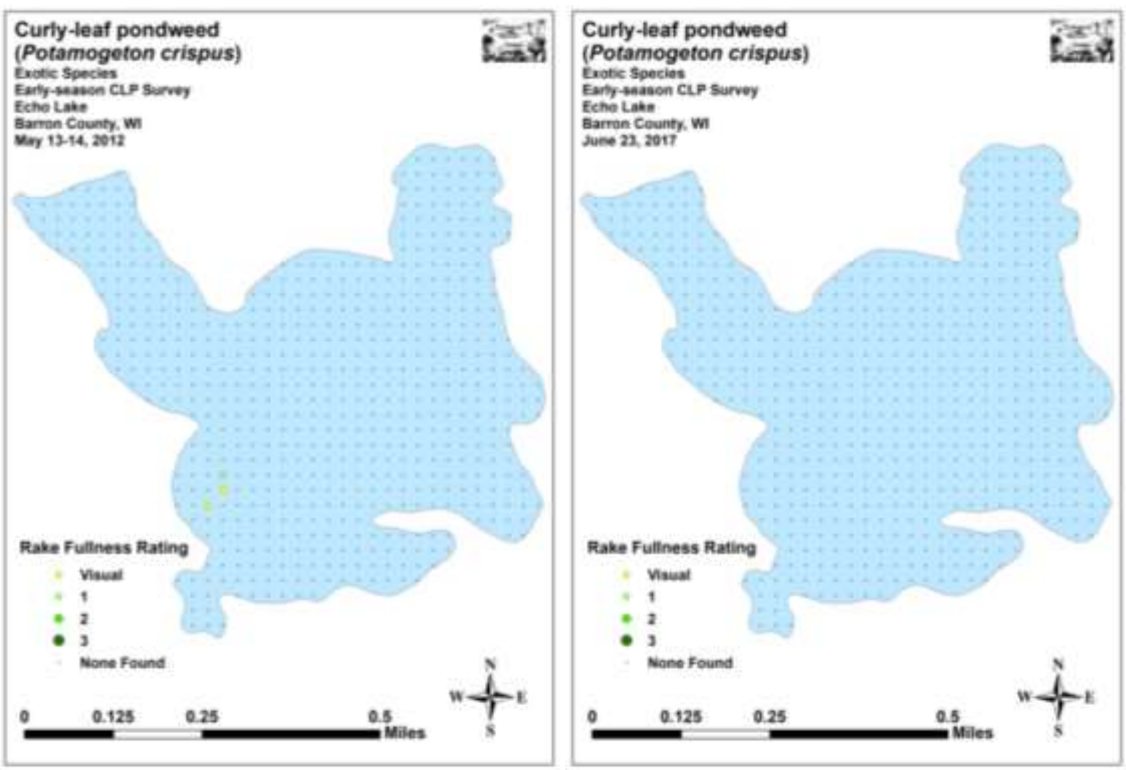
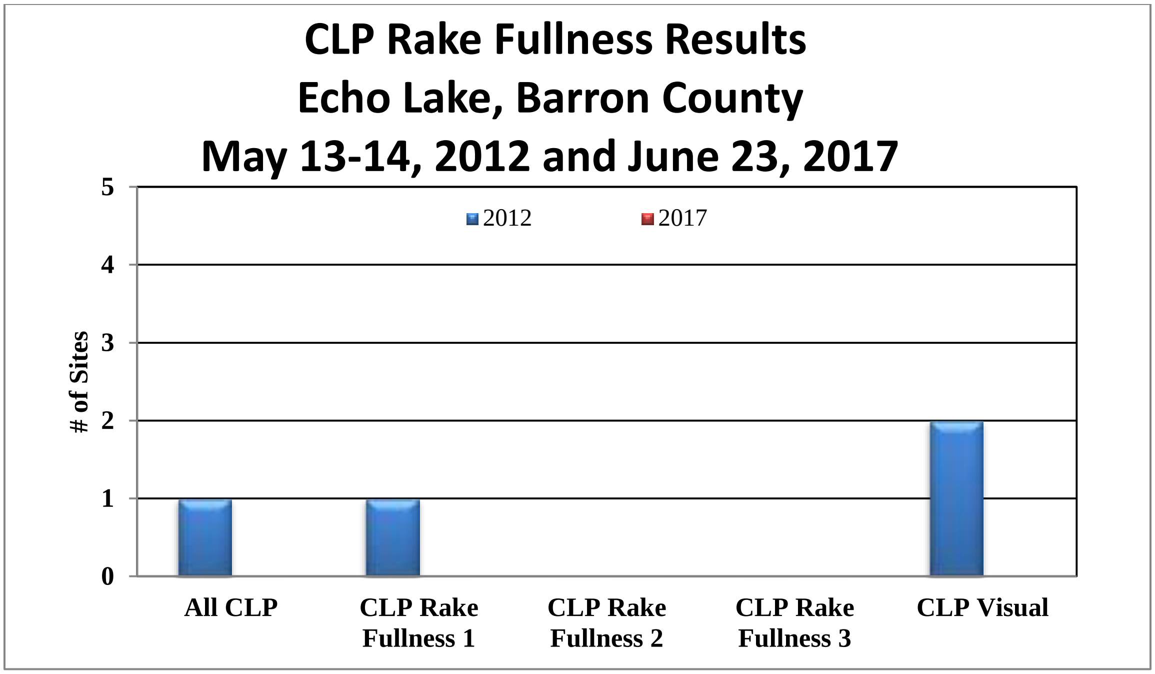


Figure 3: 2012 and 2017 Early-season CLP Density and Distribution



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

Figure 4: 2012 and 2017 Changes in Early-season CLP Rake Fullness

During the 2012 early-season survey, we found Eurasian water-milfoil at a single point (rake fullness of 2) with three additional visual records. In 2017, it was again present at a single point (rake fullness of 1) with two visual sightings (Figure 5) (Appendix III).

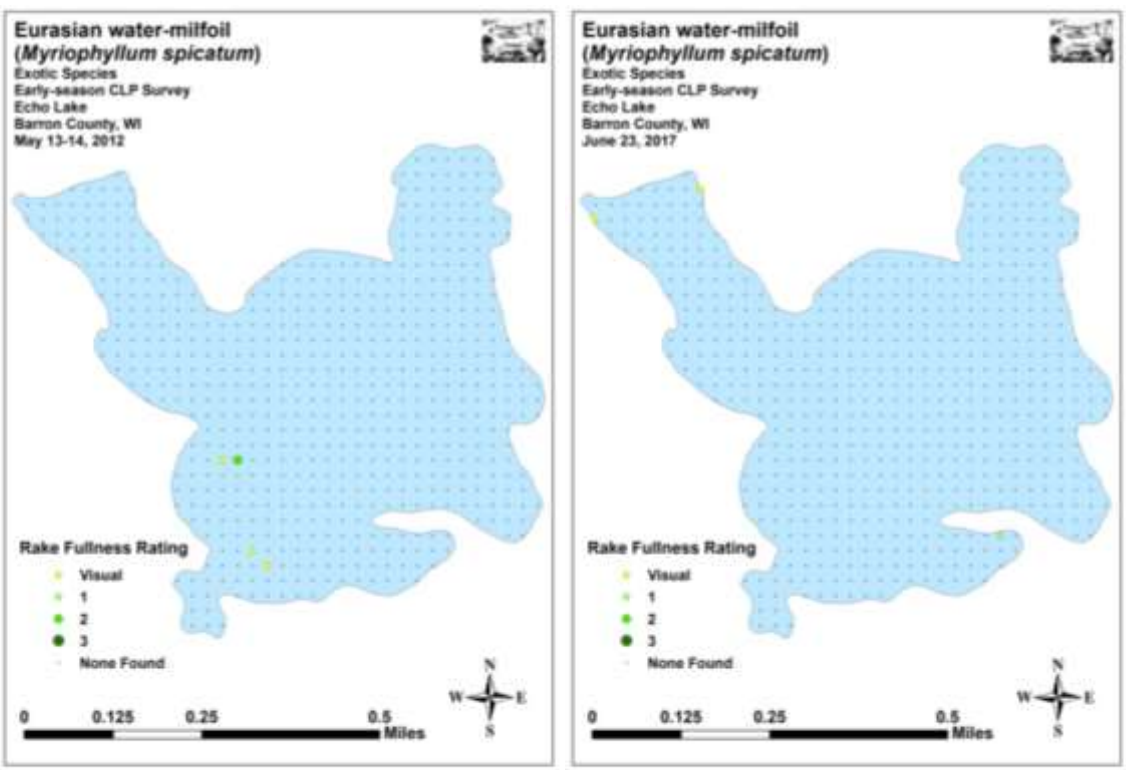


Figure 5: 2012 and 2017 Early-season EWM Density and Distribution

Curly-leaf Pondweed Bed Mapping Survey:

In June 2012, individual Curly-leaf pondweed plants were uncommon to rare throughout the lake's visible littoral zone. Although we saw plants in water from 4-9ft deep over a variety of bottom types, almost all plants occurred in the 6-7ft range over at least moderately nutrient-rich muck. As CLP was so rare on the lake, we logged a GPS waypoint for each plant we found. We also used a rake to remove the majority of these plants. Collectively, we located and mapped 88 individual CLP plants (Figure 6) (Appendix III). Although there were no true beds on the lake, 59 of these plants occurred inside a 1.49 acres polygon in the lake's west-central bay (Table 1). Even calling this area "high density" was a stretch, but, as the majority of plants on the lake occurred in this location, we felt it was worth describing.

In 2017, we spent extensive time searching the west-central bay in the "high density area" identified in 2012, as well as the area inshore from this location. As with our point-intercept survey and every other survey on the lake since 2012, the littoral zone survey failed to locate any Curly-leaf pondweed plants on Echo Lake (Figure 6) (Appendix III).

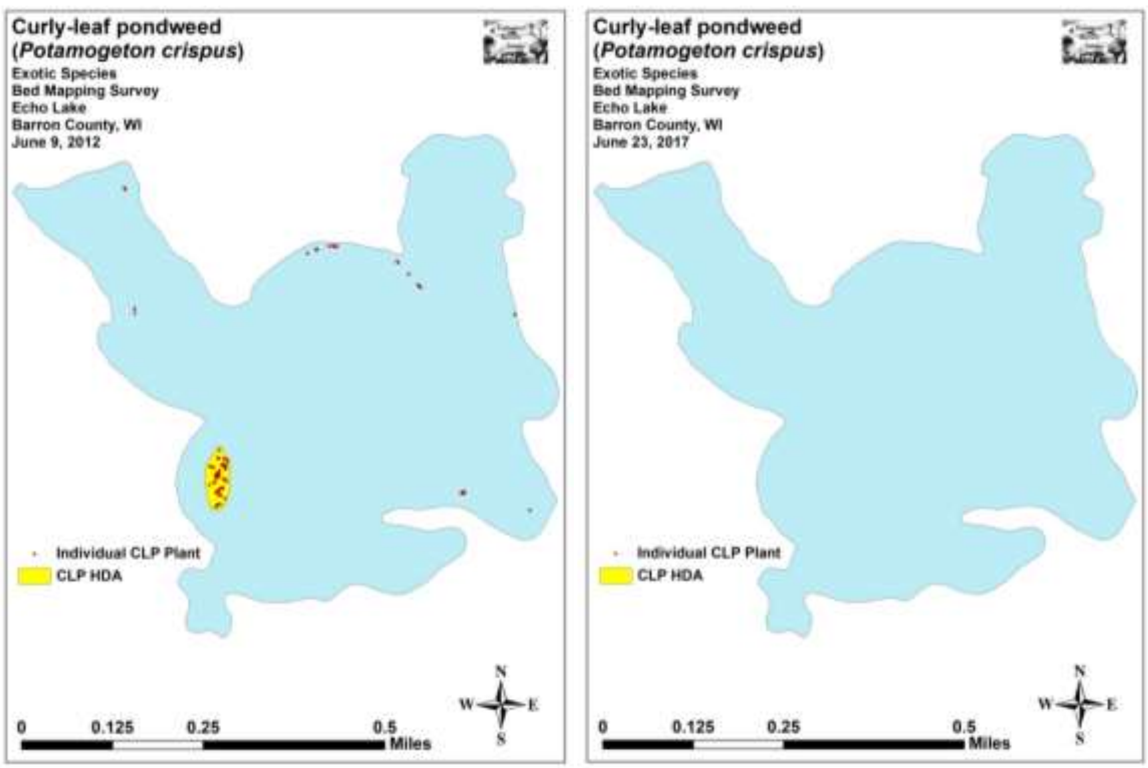


Figure 6: 2012 and 2017 Early-season Curly-leaf Pondweed Beds

Table 1: CLP High Density Area Summary
Echo Lake, Barron Co. June 9, 2012 and June 23, 2017

HDA Number	2017 Acreage	2012 Acreage	Change in Acreage	2012 Mean Rake Fullness
1	0	1.49	-1.49	<1-1
Total Acres	**0.00**	**1.49**	**-1.49**	

Warm-water Full Point-intercept Macrophyte Survey:

Depth readings taken at Echo Lake's 599 survey points (Appendix I) revealed the lake's northeast, south, and southwest bays have broad flats that slope gradually into the 30ft+ central basin, while the southeast and northwest bays tend to have much sharper drop-offs into 20ft+ of water. In addition to the lake's two exposed rock islands, two sunken islands occur on the north-central end of the central basin and at the entrance to the northwest bay (Figure 7) (Appendix IV). It should also be noted that the 18 points that were on land in 2012 due to the prolonged drought were all accessible by water in 2017.

Of the 337 points where we could determine the substrate, 63.2% (213 points) were organic and sandy muck, 21.4% (72 points) were pure sand, and the remaining 15.4% (52 points) were rock. Most sandy areas occurred immediately along the shoreline of the central basin and in the lake's northwest, south, and southeast bays. These areas quickly transitioned to nutrient-poor sandy muck at most depths over 10ft. Slightly more nutrient-rich muck occurred in the west-central, southwest, and northeast bays. Most of the rocky areas occurred around the emergent and sunken islands, near the lake's many exposed points, and north of the southeast finger peninsula (Figure 7) (Appendix IV).

In 2017, we found plants growing to 19.5ft (down from 22.5ft in 2012 and 21.5 in 2007) (Table 2) (Figure 8). The 273 points with vegetation (approximately 45.6% of the entire lake bottom and 84.8% of the littoral zone) represented a highly significant decline **($p<0.001$)** from the 2012 survey when we found plants growing at 371 points (63.9% of the bottom and 87.7% of the littoral zone) (Appendix V).

Growth in 2017 was slightly skewed to deep water as the mean depth of 9.2ft was higher than the median of 9.0ft. The mean were similar to the 2012 survey (9.1ft), but the median was much higher (7.0ft in 2012) suggesting a shift in growth patterns. Looking at the depths of plant coverage for the three surveys (Figure 9) showed that the 2007 and 2012 surveys exhibited a bimodal (twin peak) distribution. This unusual growth depth chart (most lakes show decreasing coverage with depth in a more or less normal distribution with skew to deep water) captured both the tendency to drop off rapidly from the shallower shoreline areas and flats as well as the nearly universal coverage of Charophytes (valuable habitat producing colonial algae that look like higher plants) from 11ft to the edge of the littoral zone. In 2017, the entire graph demonstrated a shift of approximately 2-3ft to the right that mirrored the lake's rise in water. The formerly diverse and nearly universal shoreline community in water <2ft was absent in 2017; apparently not having the ability to keep up with rapidly rising water levels. In the 9-12ft range where most vascular macrophytes disappeared in the past, we found many pondweeds "hanging on" although they were visibly stressed with dead or dying leaves. Areas deeper than 12ft were often devoid of any vegetation other than a few Charophyte strands. This was a dramatic difference from 2012 when we often found beds of Nitella (*Nitella* sp.) that were several feet thick in a mat covering the bottom.

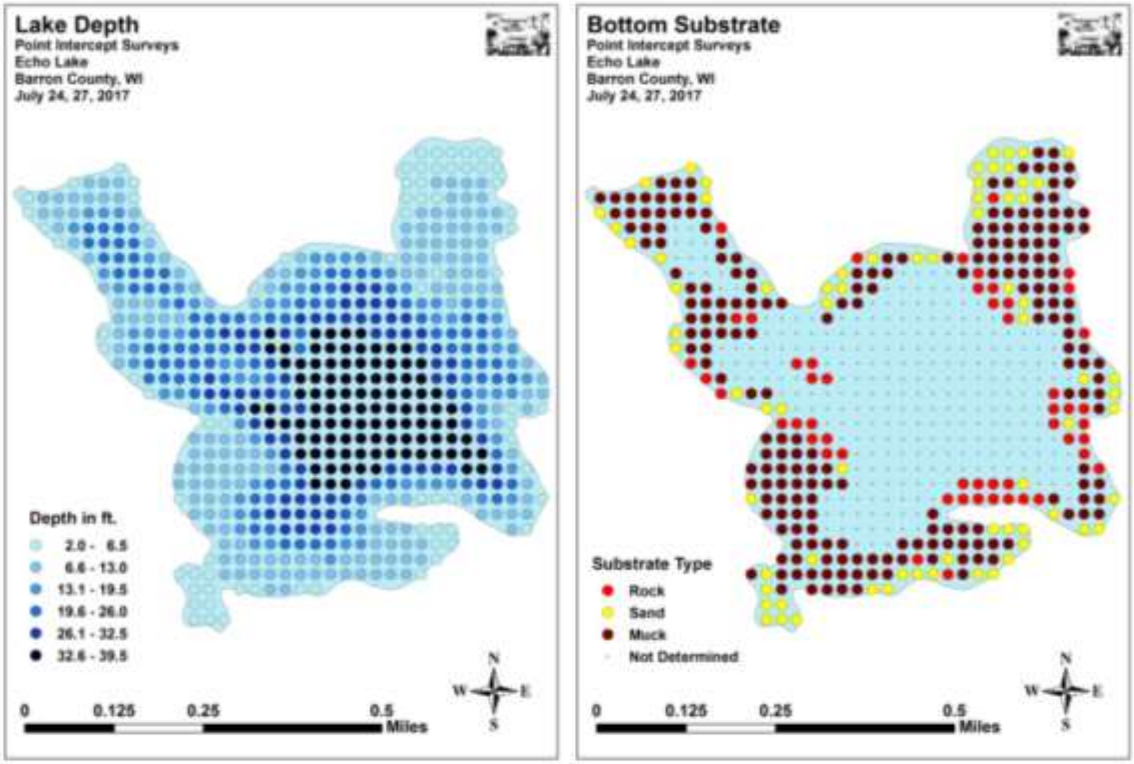


Figure 7: Lake Depth and Bottom Substrate

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics
Echo Lake, Barron County
August 7, 2007, July 16, 19-20, 2012, and July 24, 27, 2017

Summary Statistics:	2012	2012	2017
Total number of points sampled	428	581	599
Total number of sites with vegetation	347	371	273
Total number of sites shallower than the max. depth of plants	374	423	322
Freq. of occurrence at sites shallower than max. depth of plants	92.78	87.71	84.78
Simpson Diversity Index	0.81	0.90	0.90
Maximum depth of plants (ft)	21.5	22.5	19.5
Mean depth of plants (ft)	8.9	9.1	9.2
Median depth of plants (ft)	7.5	7.0	9.0
Ave. number of all species per site (shallower than max depth)	1.88	2.11	2.00
Ave. number of all species per site (veg. sites only)	2.03	2.41	2.36
Ave. number of native species per site (shallower than max depth)	1.60	2.11	1.99
Ave. number of native species per site (sites with native veg. only)	1.73	2.41	2.34
Species richness	23	45	38
Species richness (including visuals)	28	47	39
Species richness (including visuals and boat survey)	33	53	45
Mean rake fullness (veg. sites only)	2.30	2.10	1.53

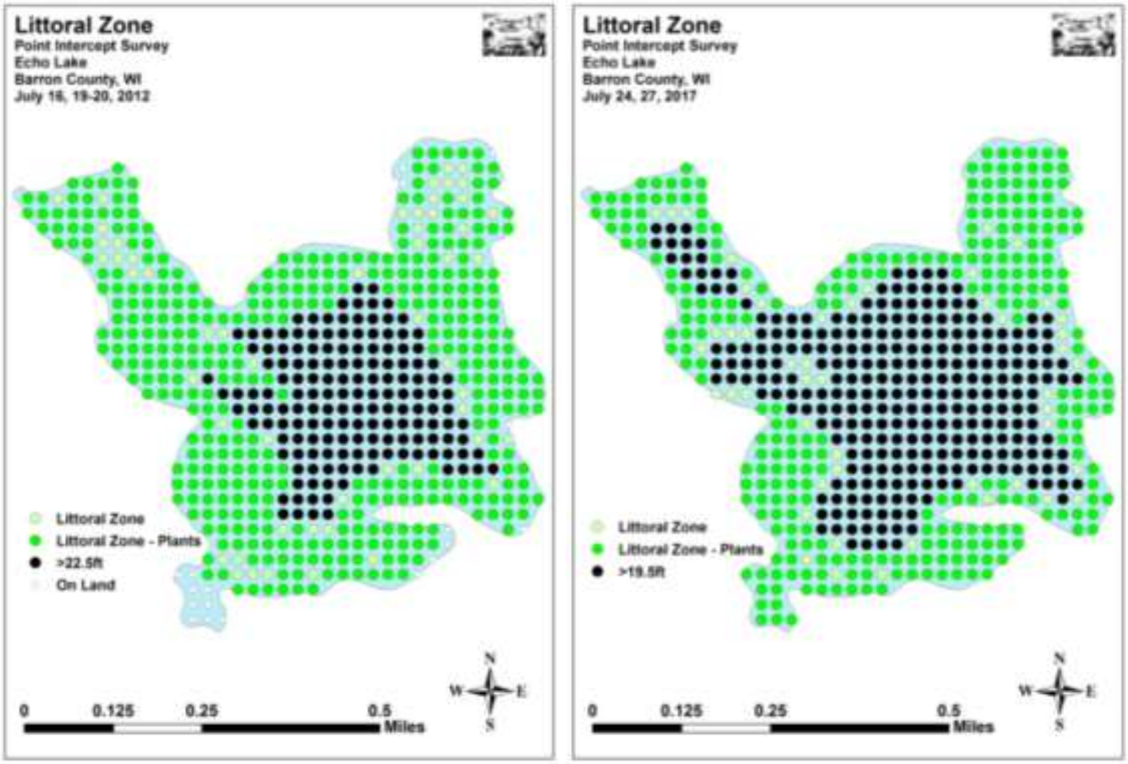


Figure 8: 2012 and 2017 Littoral Zone

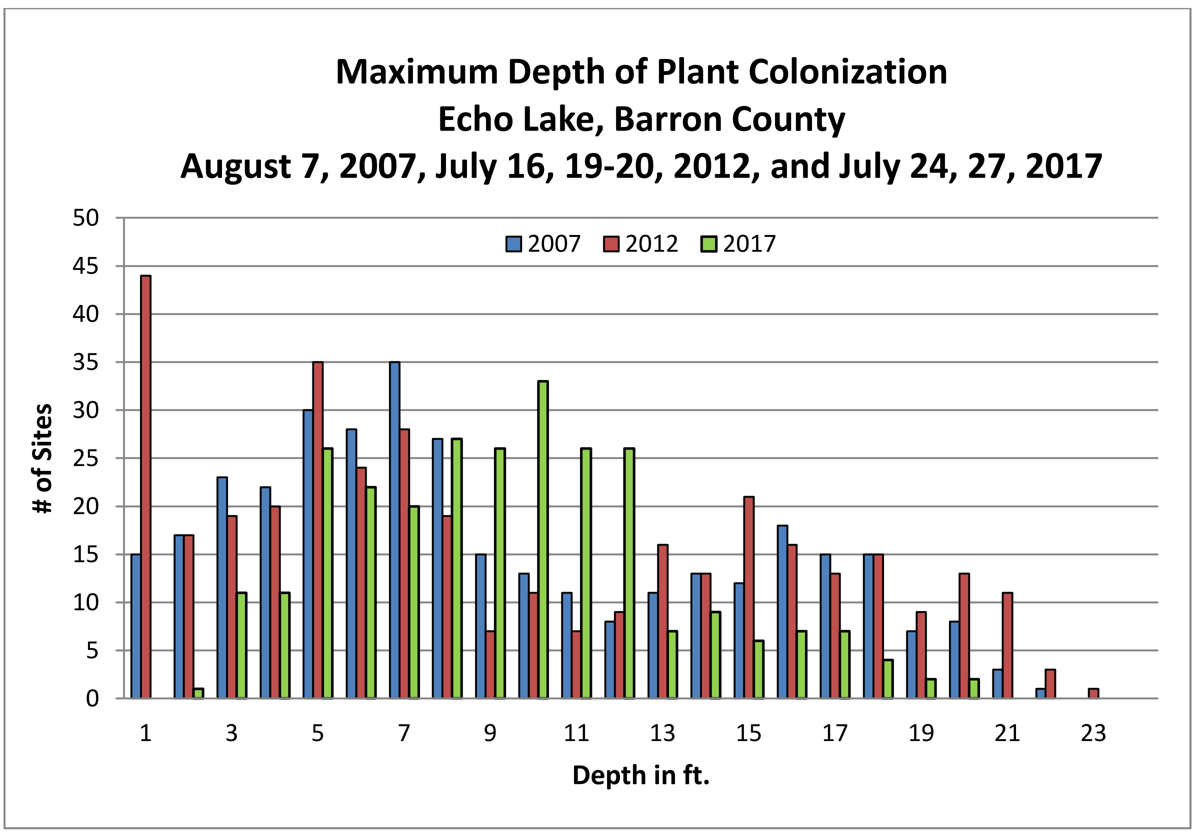


Figure 9: 2007, 2012, and 2017 Plant Colonization Depth Chart

Plant diversity was very high in 2017 with a Simpson Index value of 0.90 (identical to 2012). Richness was moderately high with 38 species found in the rake (down from 45 in 2012). This total jumped to 45 when including visuals and plants seen during the boat survey (down from 53 total species in 2012). Along with the drop in overall richness, mean native species at sites with native vegetation fell from 2.41/site in 2012 to 2.34/site in 2017; although this was not a significant decline (p=0.35). Visual analysis of the maps suggested most localized declines occurred in shallow shoreline areas. Several other parts of the lake appeared to have generally increased in localized richness; especially in the northeast and southwest bays (Figure 10) (Appendix V).

Total rake fullness experienced a highly significant decline **(p<0.001)** from a moderate 2.10 in 2012 to a low/moderate 1.52 in 2017. We noted this decrease was lakewide with all ecological communities showing a reduction in total individuals (Figure 11) (Appendix V). As with the declines in richness, this loss of biomass may simply be due to plants struggling to adjust to the rapid changes in water depth and the accompanying loss of clarity.

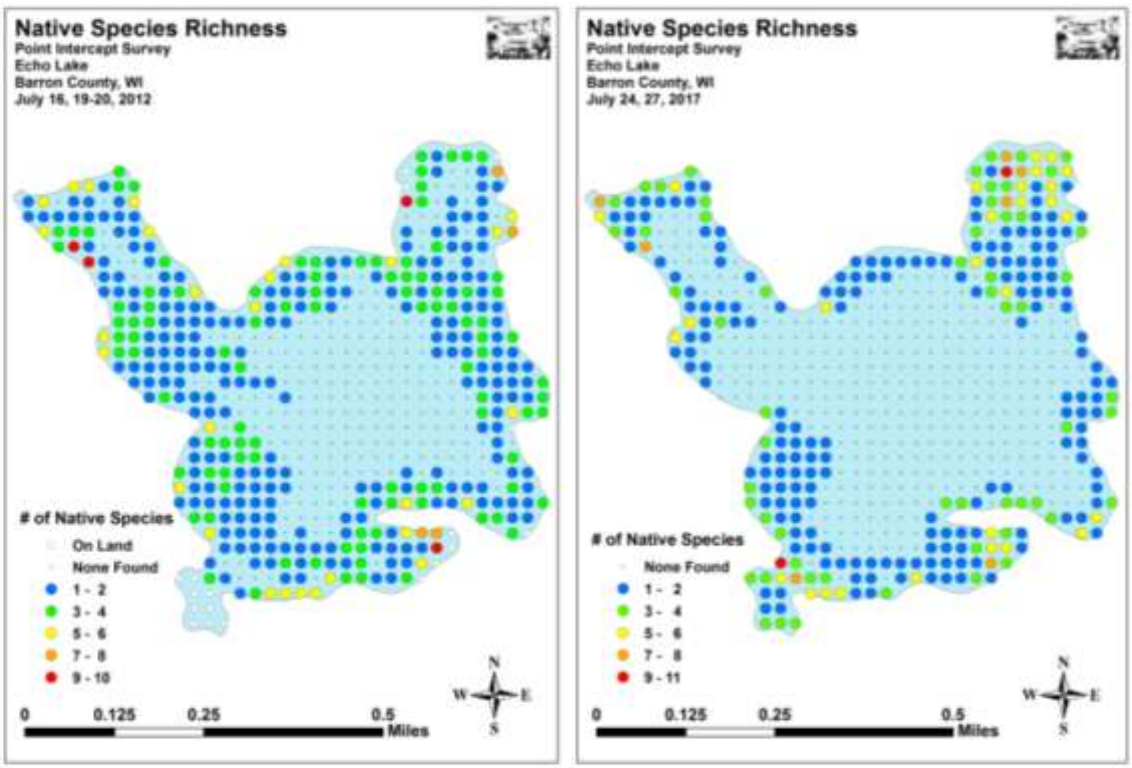


Figure 10: 2012 and 2017 Native Species Richness

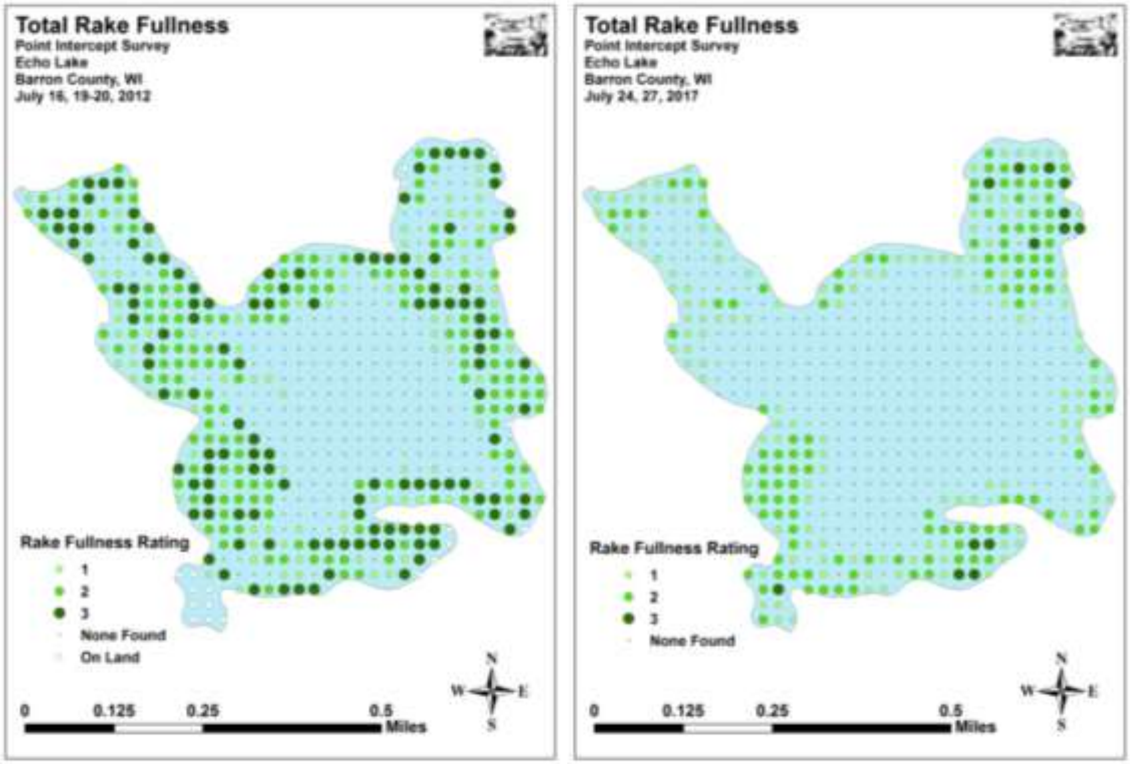


Figure 11: 2012 and 2017 Total Rake Fullness

Echo Lake Plant Community:

The Echo Lake ecosystem is home to a sensitive and rare plant community that is characteristic of pristine, low-nutrient, soft-water, seepage lakes. This community can be subdivided into four distinct zones (emergent, shallow submergent, floating-leaf, and deep submergent) with each zone having its own characteristic functions in the lake ecosystem. Depending on the local bottom type (sand, rock, sandy muck or nutrient-rich organic muck), these zones often had somewhat different species present.

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

At the time of the 2012 survey, many emergent plants were actually out of the water due to the prolonged drought, and there was a rich community of rushes (*Juncus* spp.), sedges (*Carex* and *Scirpus* spp.), and grasses like Rice cut-grass (*Leersia oryzoides*) and Northern manna-grass (*Glyceria borealis*). In 2017, many members of this community was absent or greatly diminished in both numbers and distribution. Over rock and pure sand substrates, we found Creeping spikerush (*Eleocharis palustris*), Common reed (*Phragmites australis americanus*), and Hardstem bulrush (*Schoenoplectus acutus*). In sandy muck areas in water up to 2ft deep, we found beds of Pickerelweed (*Pontederia cordata*) and Branched bur-reed (*Sparganium androcladum*) in undeveloped areas. In the lake's northeast and southwest bays where the soil was a more nutrient-rich organic muck, we documented Three-way sedge (*Dulichium arundinaceum*) and Reed canary grass (*Phalaris arundinacea*).

Typical Echo shoreline emergent community at low water in 2012

Typical Echo shoreline emergent community at high water in 2017

Branched bur-reed (Sulman 2008)

Patch of Common reed along Echo's southern shoreline (Berg 2017)

Hardstem bulrush (Per 2002)

Creeping spikerush (Lovit 2017)

Just beyond the emergents, the lake's shallow sugar sand areas tended to have low total biomass as the nutrient-poor substrates provided habitat most suited to fine-leaved "isoetid" turf-forming species that, along with the emergents, work to stabilize the bottom and prevent wave action erosion. Species present in this habitat in 2017 included Crested arrowhead (*Sagittaria cristata*), Waterwort (*Elatine minima*), Needle spikerush (*Eleocharis acicularis*), Brown-fruited rush (*Juncus pelocarpus*), Pipewort (*Eriocaulon aquaticum*), Quillworts (*Isoetes* spp.), Slender naiad (*Najas flexilis*), Spiral-fruited pondweed (*Potamogeton spirillus*), and Dwarf water-milfoil (*Myriophyllum tenellum*). In 2012, this community was extremely diverse and dominated the majority of the lake's shoreline; however, in 2017, it was completely absent from much of the shoreline. Even when present, the community tended to be dominated by just a few species suggesting many members needed more time to recolonize in response to the changing water levels.

Crested arrowhead (Fewless 2004)

Waterwort (Fewless 2005)

Needle spikerush (Fewless 2005)

Brown-fruited rush (Koshere 2002)

Spiny-spored quillwort (Haines 2012)

Dwarf water-milfoil (Koshere 2002)

Shallow sandy muck areas supported the lake's most unique and diverse submergent plant communities. Greater waterwort (*Elatine triandra*), Vasey's pondweed (*Potamogeton vaseyi*), Wild celery (*Vallisneria americana*), Water-thread pondweed (*Potamogeton diversifolius*), Small pondweed (*Potamogeton pusillus pusillus*), Blunt-leaf pondweed* (*Potamogeton obtusifolius*), and Northern naiad (*Najas gracillima*) dominated these areas. The roots, shoots, and seeds of these species are heavily utilized by waterfowl for food. They also provide important habitat for the lake's fish throughout their lifecycles, as well as a myriad of invertebrates like scuds, dragonfly and mayfly nymphs, and snails.

*This plant is actually likely *Potamogeton berchtoldii* – We had a long discussion with Skawinski/Freckmann about it in 2012. It is rusty red, and has waxy floating leaves like *obtusifolius,* BUT the nutlet lacks the keel that *obtusifolius* should have. It may be a hybrid or at least have some genes from another pondweed.

Vasey's pondweed (Skawinski 2010)

Wild celery (Dalvi 2009)

Water-thread pondweed d (Graves 2012)

Small, Vasey's, Water-thread and "Blunt-leaf" in Echo (Berg 2012)

In addition to the small floating leaves of Vasey's and Water-thread pondweed, these nutrient-poor areas also supported limited numbers of Northern manna-grass and Narrow-leaved bur-reed (*Sparganium angustifolia*) – two species with long ribbon-like floating leaves. In areas with more nutrient-rich organic muck bottoms, we found species with larger floating leaves like White-water lily (*Nymphaea odorata*), Spatterdock (*Nuphar variegata*), Watershield (*Brasenia schreberi*), Water smartweed (*Polygonum amphibium*), Ribbon-leaf pondweed (*Potamogeton epihydrus*), and Large-leaf pondweed (*Potamogeton amplifolius*). The protective canopy cover they provide is often utilized by panfish and bass, and mature gamefish are often found prowling around the edges of these beds.

Spatterdock and White water lily (Falkner, 2009)

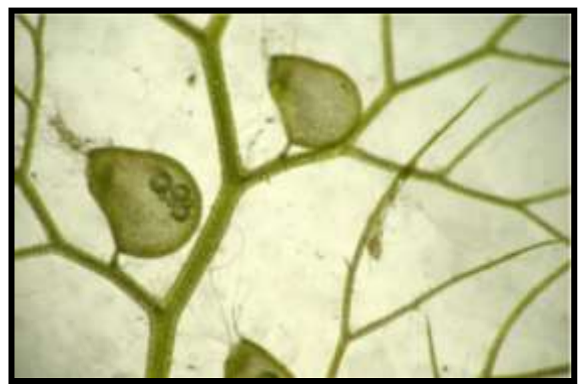
Ribbon-leaf pondweed (Petroglyph 2007)

Watershield (Gmelin, 2009)

Water smartweed (Someya 2009)

Growing among the floating-leaf canopy in the northeast and southwest bays, we also encountered Creeping bladderwort (*Utricularia gibba*), Common bladderwort (*Utricularia vulgaris*), Flat-leaf bladderwort (*Utricularia intermedia*), and Small bladderwort (*Utricularia minor*). Rather than drawing nutrients up through roots like other plants, these carnivores trap zooplankton and minute insects in their bladders, digest their prey, and use the nutrients to further their growth.

Common bladderwort flowers among lilypads (Hunt 2010)



Bladders for catching plankton and insect larvae (Wontolla 2007)

Floating-leaf and shallow submergent species generally disappeared on Echo Lake in water over 6ft deep. These deeper areas from 6.5-15ft were dominated by Common waterweed (*Elodea canadensis*), Fern pondweed (*Potamogeton robbinsii*), Coontail (*Ceratophyllum demersum*), Spiny hornwort (*Ceratophyllum echinatum*), and Muskgrass (*Chara* sp.) with a very few Eurasian water-milfoil plants mixed in. In water over 15ft to the outer littoral limit of 19.5ft, Nitella was often the only species present. Predatory fish like the lake's pike are often found along the edges of these beds waiting in ambush.

Common waterweed (Fischer 2007)

Fern pondweed (Apipp 2011)

Coontail (Hassler 2011)

Spiny hornwort (Skawinski 2010)

Eurasian water-milfoil (Berg 2007)

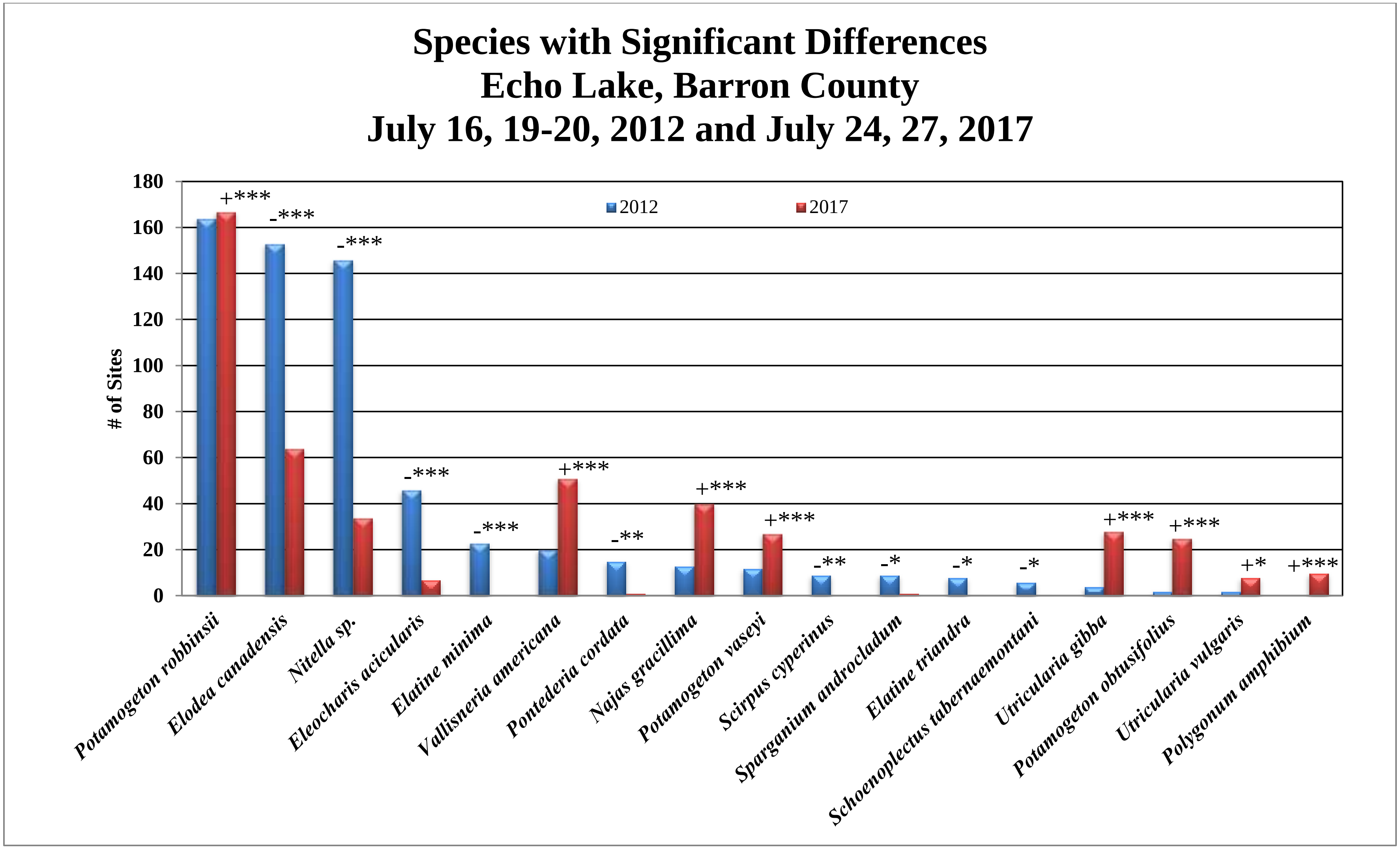
Rake full of Nitella (Berg 2012)

Comparison of Native Macrophyte Species in 2012 and 2017:

During the July 2012 survey, Fern pondweed, Common waterweed, Nitella, Spiral-fruited pondweed, and Needle spikerush were the most common macrophyte species (Table 3). They were present at 44.20%, 41.24%, 39.35%, 17.25%, and 12.40% of survey points with vegetation respectively and accounted for 64.02% of the total relative frequency. Spiny hornwort (3.46), and White water lily (3.13) also had relative frequencies over 3.0 (Maps for all species found in July 2012 are located in Appendix VI).

In 2017, Fern pondweed, Common waterweed, Wild celery, Northern naiad, and Spiral-fruited pondweed were the most common species. We found them at 61.17%, 23.44%, 18.68%, 14.65%, and 14.65% of sites with vegetation (Table 4), and they accounted for 56.30% of the total relative frequency. Nitella (5.29), Creeping bladderwort (4.35), Vasey's pondweed (4.20), Blunt-leaf pondweed (3.89), Spiny hornwort (3.27), and Small pondweed (3.27) also had relative frequencies over 3.0 (Species accounts for all species found in 2012 and 2017, and maps for all plants found in July 2017 can be found in Appendixes VII and VIII).

Lakewide, 17 species showed significant changes in distribution from 2012 to 2017 (Figure 12). Common waterweed, Nitella, Needle spikerush, and Waterwort all suffered highly significant declines; Pickerelweed and Woolgrass experienced moderately significant declines; and Branched bur-reed, Greater waterwort, and Softstem bulrush showed significant declines. Conversely, Fern pondweed, Wild celery, Northern naiad, Vasey's pondweed, Creeping bladderwort, Blunt-leaf pondweed, and Water smartweed demonstrated highly significant increases; and Common bladderwort saw a significant increase.



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

Figure 12: Macrophytes Showing Significant Changes from 2012-2017

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Echo Lake, Barron County
July 16, 19-20, 2012

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton robbinsii	Fern pondweed	164	18.32	44.20	38.77	1.51	0
Elodea canadensis	Common waterweed	153	17.09	41.24	36.17	1.74	2
Nitella sp.	Nitella	146	16.31	39.35	34.52	1.84	0
Potamogeton spirillus	Spiral-fruited pondweed	64	7.15	17.25	15.13	1.52	15
Eleocharis acicularis	Needle spikerush	46	5.14	12.40	10.87	1.54	0
Ceratophyllum echinatum	Spiny hornwort	31	3.46	8.36	7.33	1.10	0
Nymphaea odorata	White water lily	28	3.13	7.55	6.62	1.64	11
Elatine minima	Waterwort	23	2.57	6.20	5.44	1.22	3
Vallisneria americana	Wild celery	20	2.23	5.39	4.73	1.35	8
	Filamentous algae	20	*	5.39	4.73	1.00	1
Potamogeton pusillus	Small pondweed	17	1.90	4.58	4.02	1.06	1
Pontederia cordata	Pickerelweed	15	1.68	4.04	3.55	1.67	7
Najas gracillima	Northern naiad	13	1.45	3.50	3.07	1.00	1
Potamogeton vaseyi	Vasey's pondweed	12	1.34	3.23	2.84	1.33	6
Chara sp.	Muskgrass	11	1.23	2.96	2.60	1.09	1
Brasenia schreberi	Watershield	10	1.12	2.70	2.36	2.30	3
Isoetes lacustris	Lake quillwort	10	1.12	2.70	2.36	1.00	2
Juncus pelocarpus f. submersus	Brown-fruited rush	9	1.01	2.43	2.13	1.22	2
Scirpus cyperinus	Woolgrass	9	1.01	2.43	2.13	1.56	5
Sparganium androcladum	Branched bur-reed	9	1.01	2.43	2.13	1.56	7
Elatine triandra	Greater waterwort	8	0.89	2.16	1.89	1.25	0
Isoetes echinospora	Spiny spored-quillwort	8	0.89	2.16	1.89	1.13	0
Sagittaria cristata	Crested arrowhead	8	0.89	2.16	1.89	1.25	3
Potamogeton epihydrus	Ribbon-leaf pondweed	7	0.78	1.89	1.65	1.43	2
Potamogeton amplifolius	Large-leaf pondweed	6	0.67	1.62	1.42	1.67	6

* Excluded from relative frequency analysis

Table 3 (cont): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Echo Lake, Barron County
July 16, 19-20, 2012

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Schoenoplectus tabernaemontani	Softstem bulrush	6	0.67	1.62	1.42	2.00	2
	Aquatic moss	6	*	1.62	1.42	1.00	0
Ceratophyllum demersum	Coontail	5	0.56	1.35	1.18	1.00	0
Dulichium arundinaceum	Three-way sedge	5	0.56	1.35	1.18	2.40	2
Eleocharis palustris	Creeping spikerush	5	0.56	1.35	1.18	1.60	3
Sagittaria latifolia	Common arrowhead	5	0.56	1.35	1.18	1.60	2
Sagittaria rigida	Sessile-fruited arrowhead	5	0.56	1.35	1.18	1.00	2
Juncus effusus	Common rush	4	0.45	1.08	0.95	1.75	5
Leersia oryzoides	Rice cut-grass	4	0.45	1.08	0.95	1.25	2
Lemna minor	Small duckweed	4	0.45	1.08	0.95	1.00	0
Utricularia gibba	Creeping bladderwort	4	0.45	1.08	0.95	1.00	0
Phalaris arundinacea	Reed canary grass	3	0.34	0.81	0.71	1.67	2
Potamogeton diversifolius	Water-thread pondweed	3	0.34	0.81	0.71	1.00	0
Myriophyllum tenellum	Dwarf water-milfoil	2	0.22	0.54	0.47	1.50	0
Nuphar variegata	Spatterdock	2	0.22	0.54	0.47	2.50	1
Potamogeton obtusifolius	Blunt-leaf pondweed	2	0.22	0.54	0.47	1.00	0
Utricularia intermedia	Flat-leaf bladderwort	2	0.22	0.54	0.47	1.00	0
Utricularia minor	Small bladderwort	2	0.22	0.54	0.47	1.50	1
Utricularia vulgaris	Common bladderwort	2	0.22	0.54	0.47	1.00	1
Glyceria borealis	Northern manna grass	1	0.11	0.27	0.24	2.00	1
Juncus brevicaudatus	Narrow-panicle rush	1	0.11	0.27	0.24	1.00	0
Myriophyllum spicatum	Eurasian water-milfoil	1	0.11	0.27	0.24	1.00	8
Eriocaulon aquaticum	Pipewort	**	**	**	**	**	1
Typha latifolia	Broad-leaved cattail	**	**	**	**	**	5

* Excluded from relative frequency analysis   ** Visual Only

Table 3 (cont): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Echo Lake, Barron County
July 16, 19-20, 2012

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Carex scoparia	Broom sedge	***	***	***	***	***	***
Lindernia dubia	False pimpernel	***	***	***	***	***	***
Ranunculus flammula	Creeping spearwort	***	***	***	***	***	***
Sparganium angustifolium	Narrow-leaved bur-reed	***	***	***	***	***	***
Veronica americana	American speedwell	***	***	***	***	***	***
Potamogeton crispus	Curly-leaf pondweed	****	****	****	****	****	****

*** Boat Survey Only   **** Seen During the June Survey Only

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Echo Lake, Barron County
July 24, 27, 2017

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Potamogeton robbinsii	Fern pondweed	167	25.97	61.17	51.86	1.40	0
Elodea canadensis	Common waterweed	64	9.95	23.44	19.88	1.34	0
Vallisneria americana	Wild celery	51	7.93	18.68	15.84	1.22	0
Najas gracillima	Northern naiad	40	6.22	14.65	12.42	1.28	0
Potamogeton spirillus	Spiral-fruited pondweed	40	6.22	14.65	12.42	1.20	0
Nitella sp.	Nitella	34	5.29	12.45	10.56	1.18	0
Utricularia gibba	Creeping bladderwort	28	4.35	10.26	8.70	1.07	0
Potamogeton vaseyi	Vasey's pondweed	27	4.20	9.89	8.39	1.44	3
Potamogeton obtusifolius	Blunt-leaf pondweed	25	3.89	9.16	7.76	1.28	1
Ceratophyllum echinatum	Spiny hornwort	21	3.27	7.69	6.52	1.05	0
Potamogeton pusillus	Small pondweed	21	3.27	7.69	6.52	1.00	0
Brasenia schreberi	Watershield	14	2.18	5.13	4.35	1.36	8
Nymphaea odorata	White water lily	14	2.18	5.13	4.35	1.50	12
Polygonum amphibium	Water smartweed	10	1.56	3.66	3.11	1.20	7
Potamogeton amplifolius	Large-leaf pondweed	10	1.56	3.66	3.11	1.70	8
	Filamentous algae	8	*	2.93	2.48	1.00	0
Utricularia vulgaris	Common bladderwort	8	1.24	2.93	2.48	1.00	0
Eleocharis acicularis	Needle spikerush	7	1.09	2.56	2.17	1.00	0
	Aquatic moss	6	*	2.20	1.86	1.17	0
Eleocharis palustris	Creeping spikerush	6	0.93	2.20	1.86	1.17	3
Myriophyllum tenellum	Dwarf water-milfoil	6	0.93	2.20	1.86	1.33	0
Dulichium arundinaceum	Three-way sedge	5	0.78	1.83	1.55	1.20	0
Nuphar variegata	Spatterdock	5	0.78	1.83	1.55	1.20	0
Sagittaria cristata	Crested arrowhead	5	0.78	1.83	1.55	1.20	0

*Excluded from relative frequency analysis

Table 4 (cont): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Echo Lake, Barron County
July 24, 27, 2017

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Chara sp.	Muskgrass	4	0.62	1.47	1.24	1.00	0
Isoetes lacustris	Lake quillwort	4	0.62	1.47	1.24	1.00	0
Juncus pelocarpus f. submersus	Brown-fruited rush	4	0.62	1.47	1.24	1.00	0
Utricularia minor	Small bladderwort	4	0.62	1.47	1.24	1.00	0
Phalaris arundinacea	Reed canary grass	3	0.47	1.10	0.93	1.33	3
Utricularia intermedia	Flat-leaf bladderwort	3	0.47	1.10	0.93	1.00	0
Ceratophyllum demersum	Coontail	2	0.31	0.73	0.62	1.00	0
Glyceria borealis	Northern manna grass	2	0.31	0.73	0.62	1.00	3
Potamogeton diversifolius	Water-thread pondweed	2	0.31	0.73	0.62	1.00	0
Isoetes echinospora	Spiny spored-quillwort	1	0.16	0.37	0.31	1.00	0
Najas flexilis	Slender naiad	1	0.16	0.37	0.31	1.00	0
Pontederia cordata	Pickerelweed	1	0.16	0.37	0.31	1.00	1
Potamogeton epihydrus	Ribbon-leaf pondweed	1	0.16	0.37	0.31	1.00	1
Potamogeton nodosus	Long-leaf pondweed	1	0.16	0.37	0.31	1.00	0
Sparganium androcladum	Branched bur-reed	1	0.16	0.37	0.31	1.00	1
Sparganium angustifolium	Narrow-leaved bur-reed	1	0.16	0.37	0.31	1.00	0
Myriophyllum spicatum	Eurasian water-milfoil	**	**	**	**	**	2
Elatine minima	Waterwort	***	***	***	***	***	***
Elatine triandra	Greater waterwort	***	***	***	***	***	***
Lemna minor	Small duckweed	***	***	***	***	***	***
Phragmites australis americanum	Common reed	***	***	***	***	***	***
Riccia fluitans	Slender riccia	***	***	***	***	***	***
Schoenoplectus acutus	Hardstem bulrush	***	***	***	***	***	***

** Visual Only   *** Boat Survey Only

Fern pondweed, the most common species in both 2012 and 2017, was found throughout the lake in areas from 3-19ft deep over sandy and organic muck (Figure 13). Present at 164 sites in 2012, it increased in distribution to 167 sites in 2017. Despite being a highly significant statistical increase **(p<0.001)** because of the overall shrinking of the littoral zone, analysis of the maps showed its distribution was actually little changed. However, its mean rake fullness value experience a significant decline **(p=0.04)** from 1.51 in 2012 to 1.40 in 2017. This loss was most evident around the central basin with the only obvious expansions occurring in the northeast bay and the west-central flat in areas previously dominated by Common waterweed.

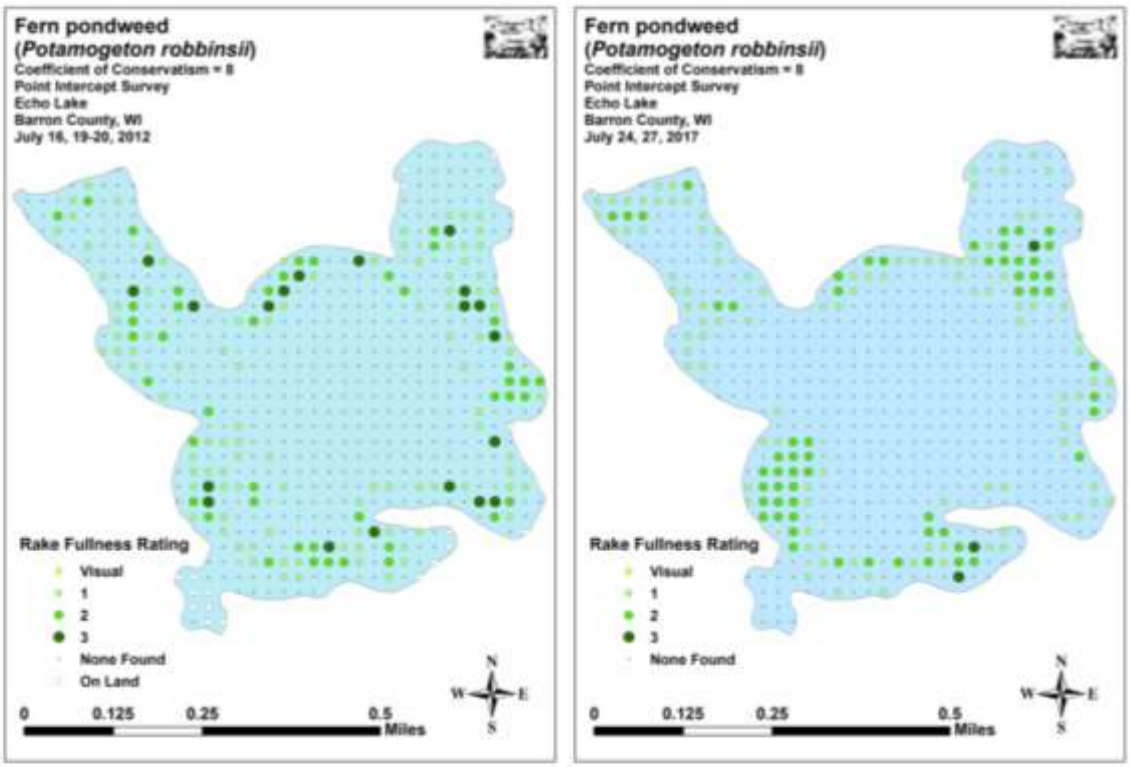


Figure 13: 2012 and 2017 Fern Pondweed Density and Distribution

Common waterweed was the second most common species in both 2012 and 2017, but it showed a dramatic and highly significant decline **(p<0.001)** in distribution (153 sites in 2012/64 sites in 2017) and density (mean rake fullness of 1.74 in 2012/1.34 in 2017) (Figure 14). A native species that can quickly exploit barren substrates after herbicide treatments, the jump seen in 2012 may have been a short-lived response to the decline in EWM; while the lower levels in 2017 may reflect increased competition as other native species recolonized the areas formerly occupied by EWM.

Nitella was the third most widely distributed species in 2012 (146 sites), and it dominated the majority of the deep water littoral zone (Figure 15). Following a lakewide population crash in 2017 (34 sites), it dropped to the sixth ranked species in the community. This highly significant decline in distribution **(p<0.001)** was accompanied by an equally significant decline in density (mean rake fullness of 1.84 in 2012/1.18 in 2017) as most samples in 2017 were represented by a single individual.

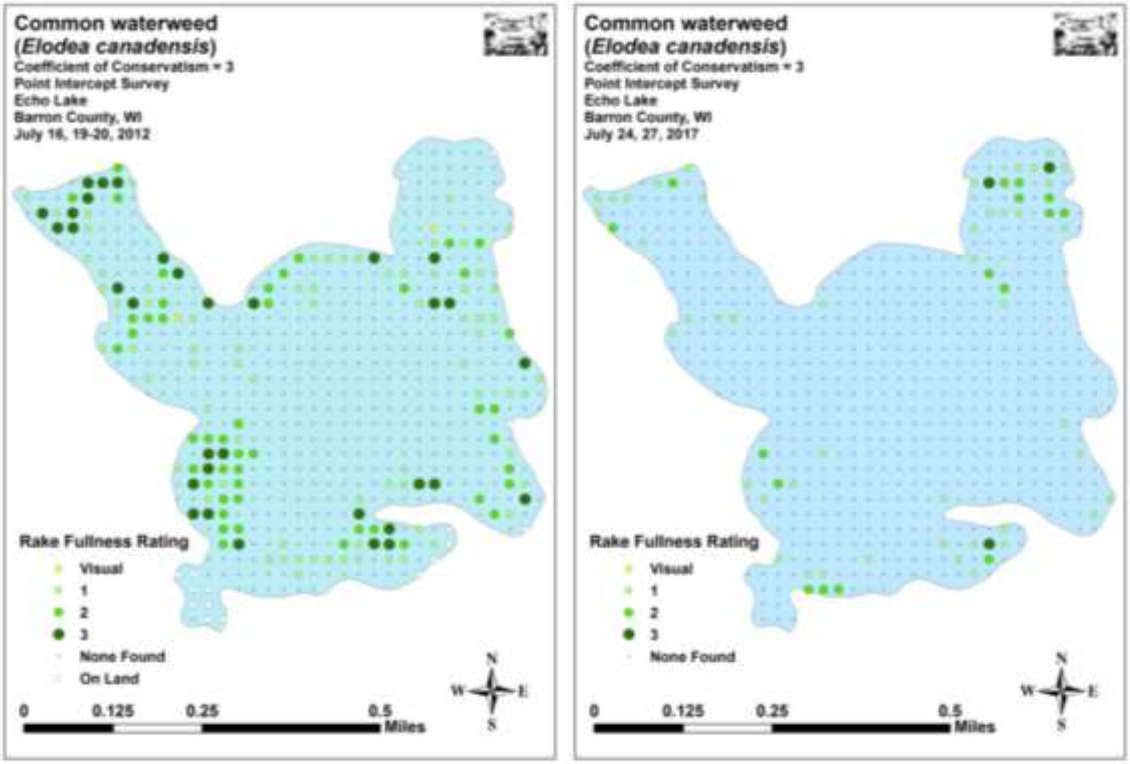


Figure 14: 2012 and 2017 Common Waterweed Density and Distribution

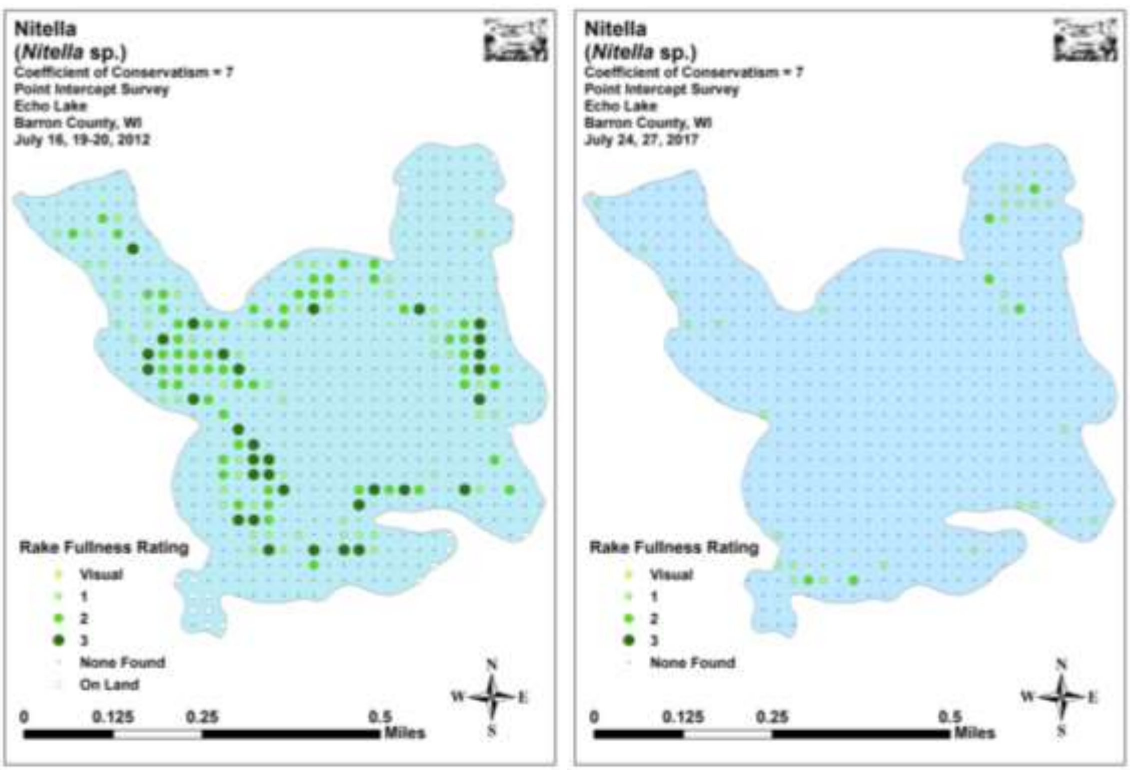


Figure 15: 2012 and 2017 Nitella Density and Distribution

Spiral-fruited pondweed, the fourth most common species in both 2012 (64 sites) and 2017 (40 sites) experienced a non-significant decline (p=0.38) in distribution, but a moderately significant decline in density **(p=0.001)**. It proved more resilient than many other shallow-water species like Needle spikerush (Figure 16) which, after being the fifth most common species in 2012 (46 sites/mean rake fullness 1.54) suffered a highly significant decline **(p<0.001)** in both density and distribution to become just the 17th most common species in 2017 (7 sites/mean rake 1.00). As these and other shallow sand obligates like Waterwort declined, they were replaced by species that reproduce by seed (Northern naiad), grow laterally using rhizomes (Wild celery), or produce large numbers of floating turions (Vasey's pondweed) and thus can quickly respond to changing water depth. We expect most of these extreme jumps and declines in individual populations will be short-lived as the less nimble species catch up to changing environmental conditions and reestablish themselves along the new shoreline.

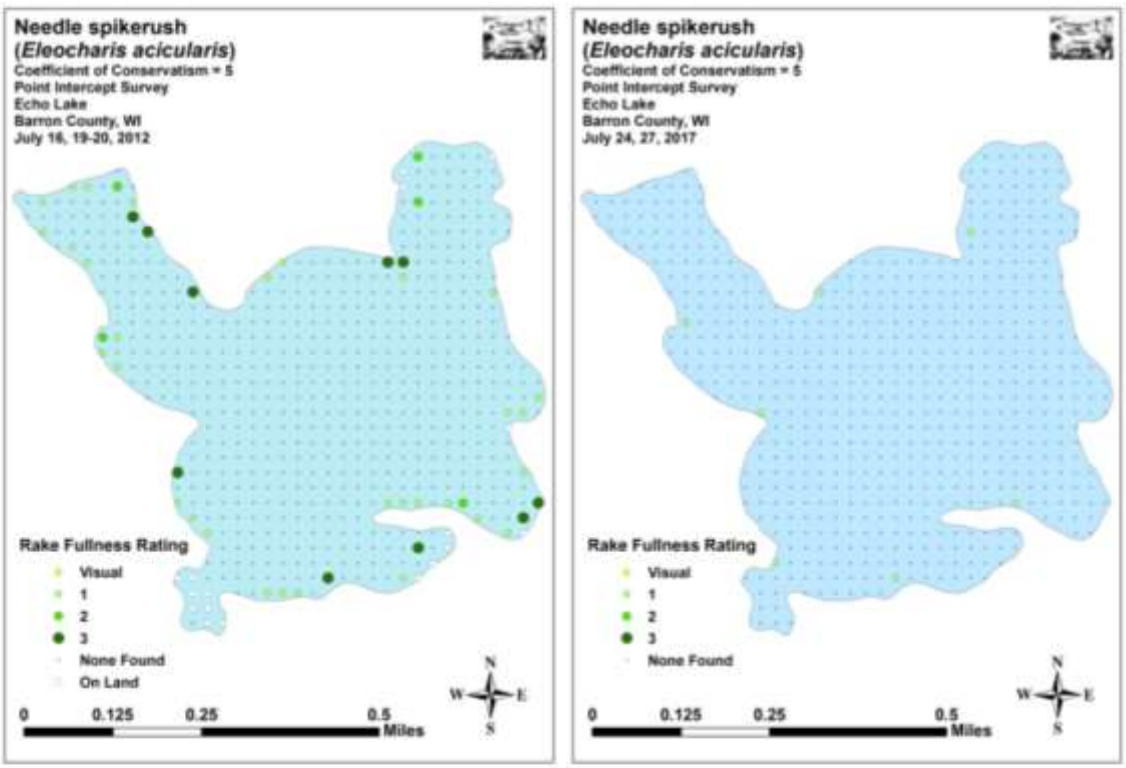


Figure 16: 2012 and 2017 Needle Spikerush Density and Distribution

Comparison of Floristic Quality Indexes in 2012 and 2017:

In 2012, we identified a total of 39 **native index species** in the rake during the point-intercept survey (Table 5). They produced a mean Coefficient of Conservatism of 7.3 and a Floristic Quality Index of 45.6.

Table 5: Floristic Quality Index of Aquatic Macrophytes
Echo Lake, Barron County
July 16, 19-20, 2012

Species	Common Name	C
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Ceratophyllum echinatum	Spiny hornwort	10
Chara sp.	Muskgrass	7
Dulichium arundinaceum	Three-way sedge	9
Elatine minima	Waterwort	9
Elatine triandra	Greater waterwort	9
Eleocharis acicularis	Needle spikerush	5
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Glyceria borealis	Northern manna grass	8
Isoetes echinospora	Spiny-spored quillwort	8
Isoetes lacustris	Lake quillwort	8
Juncus pelocarpus f. submersus	Brown-fruited rush	8
Lemna minor	Small duckweed	4
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas gracillima	Northern naiad	7
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	8
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton diversifolius	Water-thread pondweed	8
Potamogeton epihydrus	Ribbon-leaf pondweed	8
Potamogeton obtusifolius	Blunt-leaf pondweed	9
Potamogeton pusillus	Small pondweed	7
Potamogeton robbinsii	Fern pondweed	8
Potamogeton spirillus	Spiral-fruited pondweed	8
Potamogeton vaseyi	Vasey's pondweed	10
Sagittaria cristata	Crested arrowhead	9
Sagittaria latifolia	Common arrowhead	3
Sagittaria rigida	Sessile-fruited arrowhead	8
Schoenoplectus tabernaemontani	Softstem bulrush	4
Sparganium androcladum	Branched bur-reed	8
Utricularia gibba	Creeping bladderwort	9
Utricularia intermedia	Flat-leaf bladderwort	9

Table 5 (cont'): Floristic Quality Index of Aquatic Macrophytes
Echo Lake, Barron County
July 16, 19-20, 2012

Species	Common Name	C
Utricularia minor	Small bladderwort	10
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		**39**
Mean C		**7.3**
FQI		**45.6**

In 2017, we identified a total of 37 **native index plants** in the rake during the point-intercept survey. They produced a mean Coefficient of Conservatism of 7.4 and a Floristic Quality Index of 45.2 (Table 6). Nichols (1999) reported an average mean C for the North Central Hardwood Forests Region of 5.6 putting Echo Lake well above average for this part of the state. The FQI was also more than double the median FQI of 20.9 for the North Central Hardwood Forests (Nichols 1999). Ten high-value species of note included Spiny hornwort (C = 10), Three-way sedge (C = 9), Dwarf water-milfoil (C =10), Blunt-leaf pondweed (C = 9), Crested arrowhead (C = 9), Narrow-leaved bur-reed (C = 9), Creeping bladderwort (C = 9), Flat-leaf bladderwort (C = 9), Small bladderwort (C = 10), and the State Species of Special Concern ** Vasey's pondweed (C = 10).

** "Special Concern" species are those species about which some problem of abundance or distribution is suspected but not yet proved. The main purpose of this category is to focus attention on certain species before they become threatened or endangered.

Table 6: Floristic Quality Index of Aquatic Macrophytes
Echo Lake, Barron County
July 24, 27, 2017

Species	Common Name	C
Brasenia schreberi	Watershield	6
Ceratophyllum demersum	Coontail	3
Ceratophyllum echinatum	Spiny hornwort	10
Chara sp.	Muskgrass	7
Dulichium arundinaceum	Three-way sedge	9
Eleocharis acicularis	Needle spikerush	5
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Glyceria borealis	Northern manna grass	8
Isoetes echinospora	Spiny-spored quillwort	8
Isoetes lacustris	Lake quillwort	8
Juncus pelocarpus f. submersus	Brown-fruited rush	8
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Najas gracillima	Northern naiad	7

Table (cont') 6: Floristic Quality Index of Aquatic Macrophytes
Echo Lake, Barron County
July 24, 27, 2017

Species	Common Name	C
Nitella sp.	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Polygonum amphibium	Water smartweed	5
Pontederia cordata	Pickerelweed	8
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton diversifolius	Water-thread pondweed	8
Potamogeton epihydrus	Ribbon-leaf pondweed	8
Potamogeton nodosus	Long-leaf pondweed	7
Potamogeton obtusifolius	Blunt-leaf pondweed	9
Potamogeton pusillus	Small pondweed	7
Potamogeton robbinsii	Fern pondweed	8
Potamogeton spirillus	Spiral-fruited pondweed	8
Potamogeton vaseyi	Vasey's pondweed	10
Sagittaria cristata	Crested arrowhead	9
Sparganium androcladum	Branched bur-reed	8
Sparganium angustifolium	Narrow-leaved bur-reed	9
Utricularia gibba	Creeping bladderwort	9
Utricularia intermedia	Flat-leaf bladderwort	9
Utricularia minor	Small bladderwort	10
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6
N		**37**
Mean C		**7.4**
FQI		**45.2**

Comparison of Filamentous Algae in 2012 an 2017:

Filamentous algae, normally associated with excessive nutrients in the water column, were located at eight points in 2017. This was a non-significant decline (p=0.13) from the 20 points we found them at in 2012. The mean rake fullness was 1.00 in both years (Figure 17).

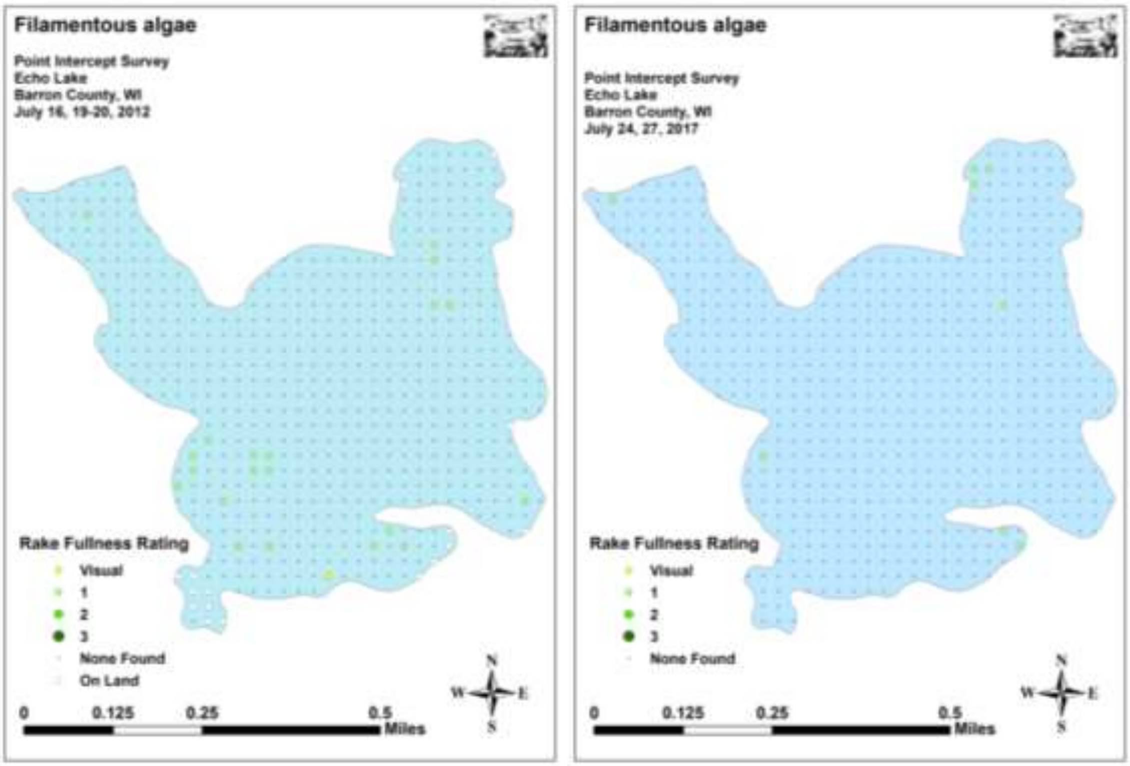


Figure 17: 2012 and 2017 Filamentous Algae Density and Distribution

Comparison of Eurasian Water-milfoil in 2007, 2012, and 2017:

Following the confirmation of Eurasian water-milfoil in Echo Lake in August 2004 (WDNR 2017), the Echo Lake Association began an herbicide treatment program to manage the infestation of this exotic invasive species (Table 7). Initial treatments in 2005 and 2006 were small (<2 acres) and focused on areas near the public boat landing. Unfortunately, these early treatments proved to be unsuccessful as the initial point-intercept survey conducted by WDNR biologists in 2007 found EWM was essentially distributed throughout the lake's entire littoral zone in water <18ft. At this time, it was the third most common species in the lake and had a relative frequency of 15.08. Present in the rake at 106 of 347 points with vegetation (30.55% littoral coverage), WDNR biologists rated five points a rake fullness of 3, 20 a 2, and the remaining 81 a 1 for a mean rake fullness of 1.28. They also reported EWM as a visual at 19 points (Figure 18) (Appendix IX).

Following expanded treatments in 2007-2011, EWM levels declined over 99%. In 2012, we found EWM in the rake at a single point with a rake fullness of 1, and noted it as a visual at eight additional points. This suggested a highly significant decline **($p<0.001$)** in overall EWM as well as rake fullness 1 and 2; a significant decline **($p=0.02$)** in rake fullness 3; and a moderately significant decline **($p=0.008$)** in visual sightings (Figure 19). Further targeted treatments in 2012, 2013, and 2014 pushed EWM levels in the lake down to such a low level that it was almost undetectable. Rake and SCUBA removal of the few handfuls of plants found during the summer and fall of 2014 and 2015 proved so successful that almost no plants were found the following spring, and spring herbicide treatments that were scheduled in 2015 and 2016 were ultimately cancelled. Following an uptick in plants in the boat landing bay in the fall of 2016, a small treatment occurred there in the spring of 2017. This brought the total area treated from 2005-2017 to 62.43 acres (Table 7).

During the July 2017 survey, we found and removed a total of 45 EWM plants in the northeast and southern finger bays. Despite this uptick in plants, EWM was not present in the rake at any point, and we only recorded it as a visual at two points (Figure 18). None of these declines were significant when compared to our results from the 2012 survey (Figure 19).

Table 7: Eurasian Water-milfoil Treatment History
Echo Lake, Barron County - 2005-2017

Year	Acreage	Area Treated
2005	0.95	Near Boat Landing
2006	1.88	Near Boat Landing
2007	5.90	SE, EC, WC and NW Bays
2008	9.90	Scattered Throughout
2009	28.10	NW Bay and Border of Majority of Central Basin
2010	5.20	Primarily NW, SC, SW, and WC Bays
2011	1.66	South-central and West-central Bays
2012	3.37	Northwest and South-central Bays
2013	1.43	Western Midlake Flat and East-central Bay
2014	3.67	NW Bay and Many Small Beds around Central Basin
2015	0	Manual Removal Only
2016	0	Manual Removal Only
2017	0.37	Northwest Corner of Northwest Boat Landing Bay
Total Acres	**62.43**	

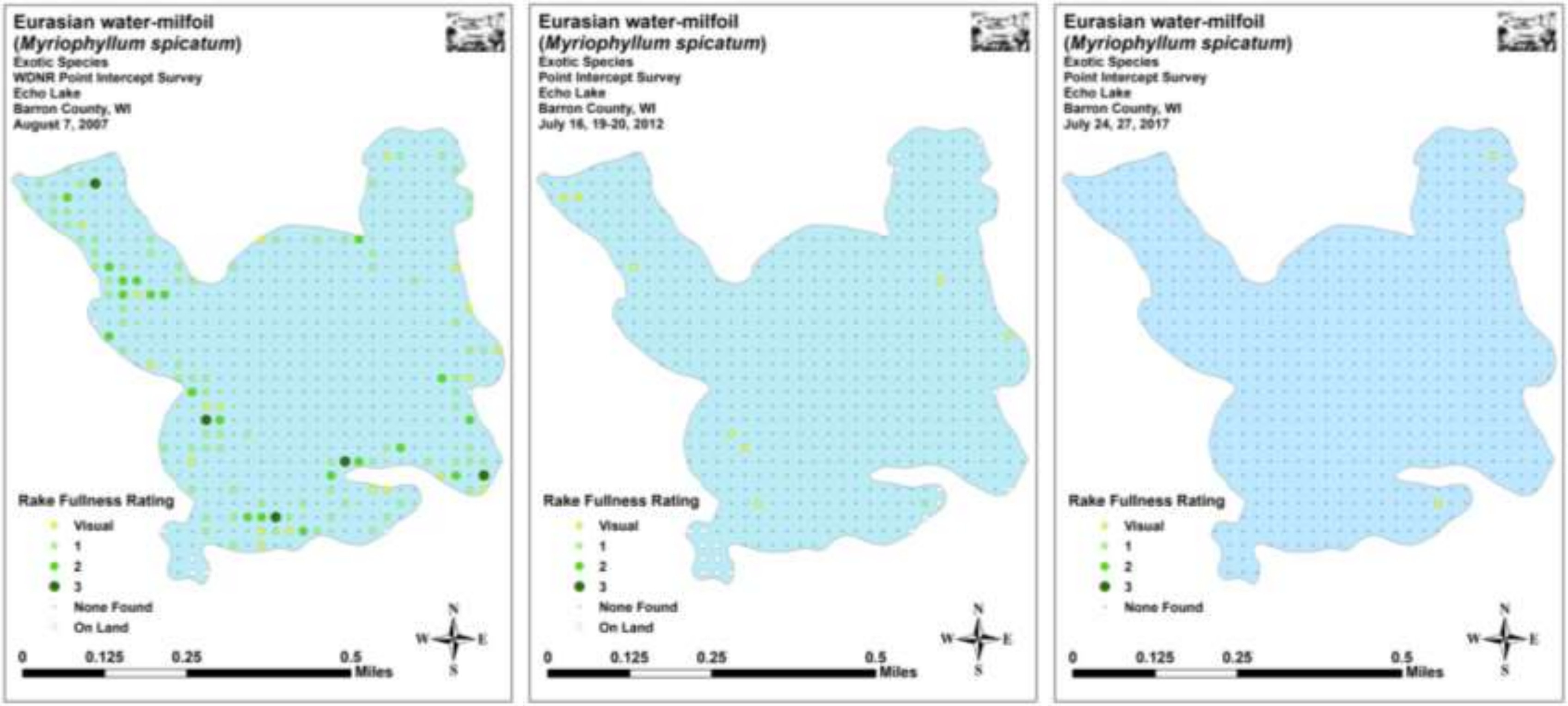
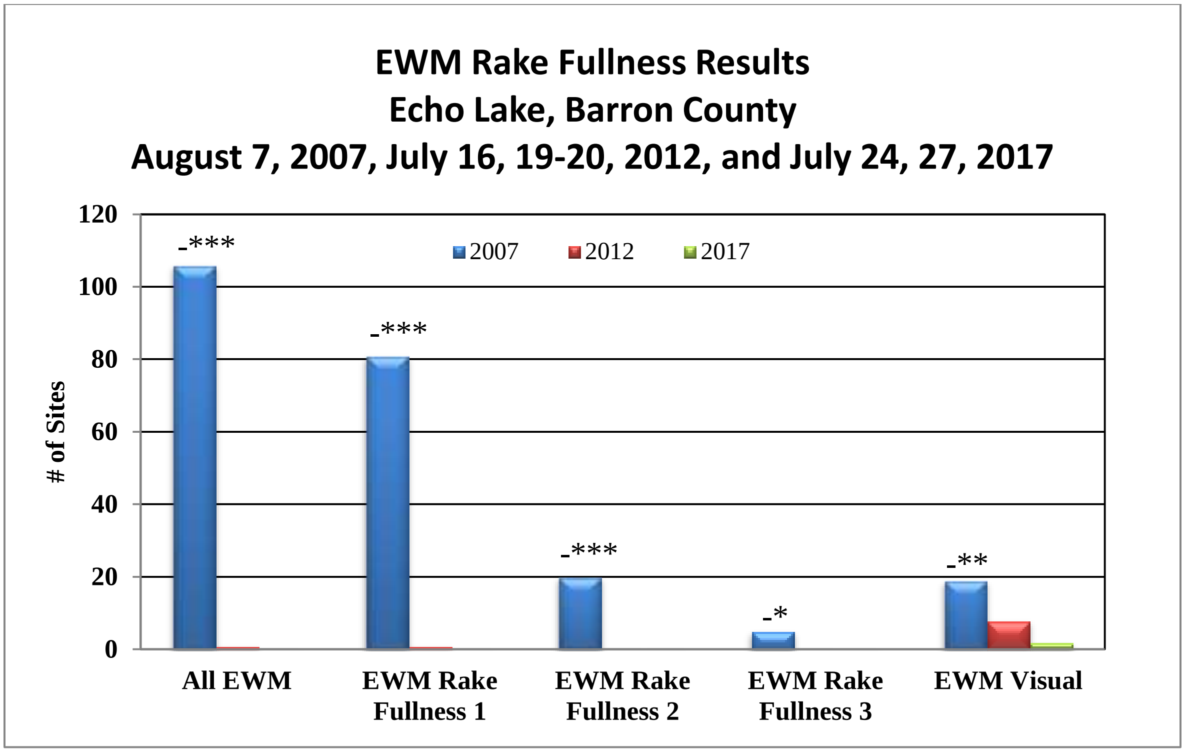


Figure 18: 2007, 2012, and 2017 Eurasian Water-milfoil Density and Distribution



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

Figure 19: 2007, 2012, and 2017 Changes in EWM Rake Fullness

Other Exotic Plant Species:

In addition to Eurasian water-milfoil, we found one other exotic species on the lake: Reed canary grass was present in the rake at three survey points, and we recorded it as a visual at three additional sites (Figure 20). A dominant plant just beyond the lakeshore, we noticed patches in wetlands adjacent to the lake and next to mowed and otherwise disturbed shorelines. A ubiquitous plant in the state, there's likely little that can be done about it.

Although we have found and removed Purple loosestrife (*Lythrum salicaria*) near the boat landing in the past, we didn't observe this species during any of our surveys in 2017. Likewise, we saw no evidence of Curly-leaf pondweed during the summer survey. The only other plant of concern we found was Common reed (*Phragmites australis*). This species, which is potentially highly invasive in its exotic form, was found at a single location along the south shoreline (Figure 21). Fortunately, careful analysis of the plants present showed their leaf sheaths were detached, and the culms (stems) were red in color (Figure 22). These characteristics suggest it is the native subspecies *americanus* which is NOT generally invasive. We hadn't noticed the bed previously, but that may simply be because it was out of the water and away from the immediate shoreline during the drought. Although the bed deserves to be looked at again in the future, at this time, we aren't overly concerned about its presence (For more information on a sampling of aquatic exotic invasive plant species, see Appendix X).

Figure 20: 2017 Reed Canary Grass Density and Distribution

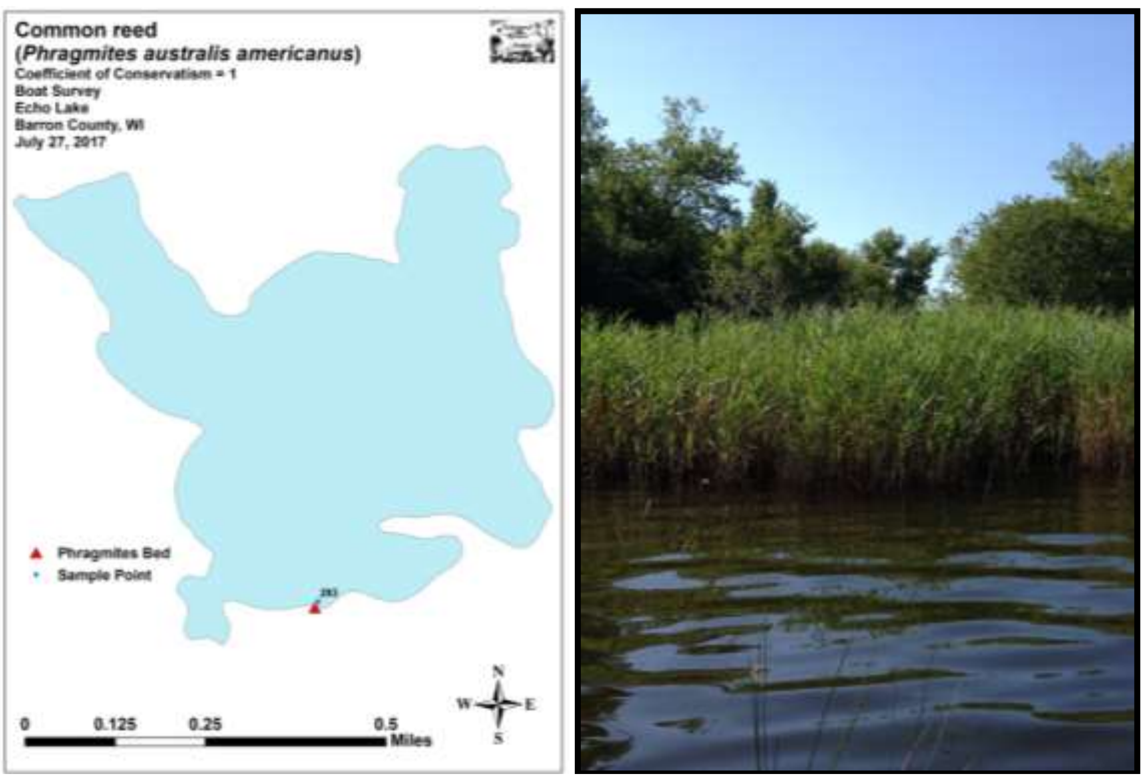


Figure 21: Common Reed Distribution and Bed along South Shoreline

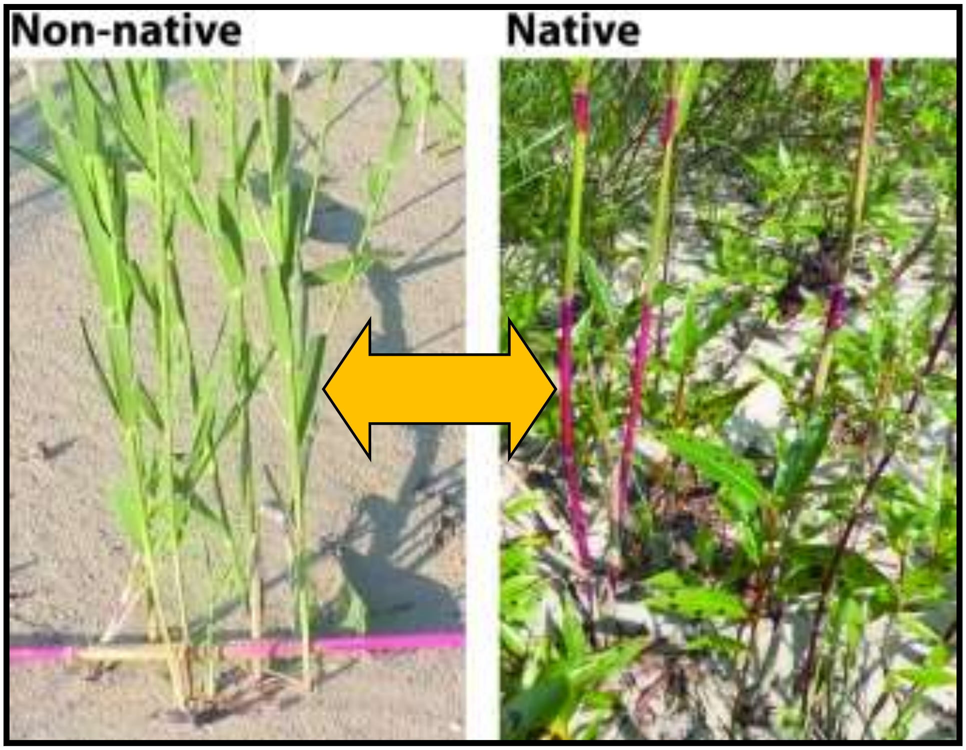


Figure 22: Stem Pattern on Exotic vs. Native Common Reed

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Water Clarity, Nutrient Inputs, and the Role of Native Macrophytes:

Echo Lake continues to have a healthy native plant community that is dominated by high-value species that tend to be both sensitive and rare. Like trees in a forest, these plants are the basis of the aquatic ecosystem. They capture the sun's energy and turn it into usable food, "clean" the water of excess nutrients, and provide habitat for other organisms like aquatic invertebrates and the lake's fish populations. Because of this, preserving them is critical to maintaining the lake's overall health.

Although many property owners on the lake are practicing sound shoreline conservation, there is always room for improvement. By consciously working to limit runoff, residents can proactively cut the amount of phosphorus and nitrogen entering the system. This is an important initial management goal because, when levels of these nutrients increase in the water column, they tend to promote excessive plant growth (like milfoil) and algae blooms that negatively impact sensitive plant species as well as general lake esthetics.

Simple things like establishing or maintaining a buffer strip of native vegetation along the lakeshore to prevent erosion, building rain gardens, bagging grass clippings, switching to a phosphorus-free fertilizer or preferably eliminating fertilizer near the lake altogether, collecting pet waste, and disposing of the ash from fire pits away from the lakeshore can all significantly reduce the amount of nutrients entering the lake. Hopefully, a greater understanding of how all property owners can have lake-wide impacts will result in more people taking appropriate conservation actions to not only help improve water clarity and quality, but also to benefit the lake's native plant species.

Eurasian Water-milfoil Management:

Eurasian water-milfoil is widely-established in Echo Lake making eradication an unrealistic expectation. However, past control measures have been extremely successfully at holding the plant in check thus reducing the annual cost to the ELA while simultaneously minimizing its impact on the lake's aquatic ecosystem. Continuing to aggressively manage EWM by regularly surveying for and manually removing plants during the summer growing season and augmenting these efforts with targeted herbicide application will hopefully continue what has been a model of successful containment.

Curly-leaf Pondweed Management:

Although it was apparently never a common species in the lake, the absence of Curly-leaf pondweed since the 2012 survey is somewhat surprising. It may be that our efforts to remove all CLP plants in 2012 and the subsequent manual removal efforts by volunteers from the ELA have extirpated the species from the lake. It may also be that poor clarity in the spring of 2017 resulted in poor turion germination. Regardless of the cause, it seems that future CLP surveys and control efforts are unnecessary with the possible exception of looking for and removing the species in early June during a regularly scheduled EWM littoral zone and manual removal survey.

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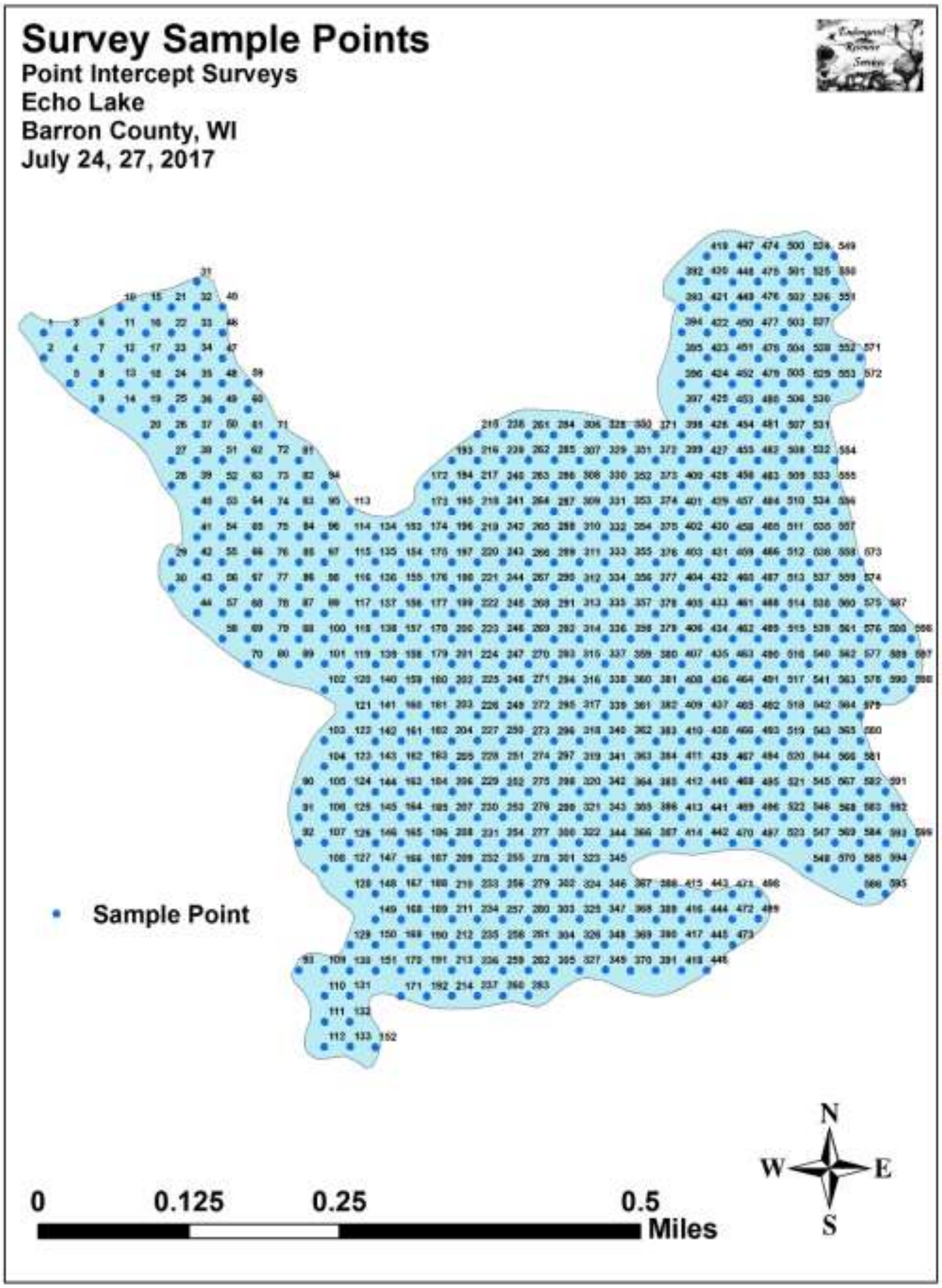
WDNR. [online]. 2010. Reed canary grass fact sheet. http://dnr.wi.gov/invasives/fact/reed_canary.htm (2010, August).

Appendix I: Survey Sample Points Map

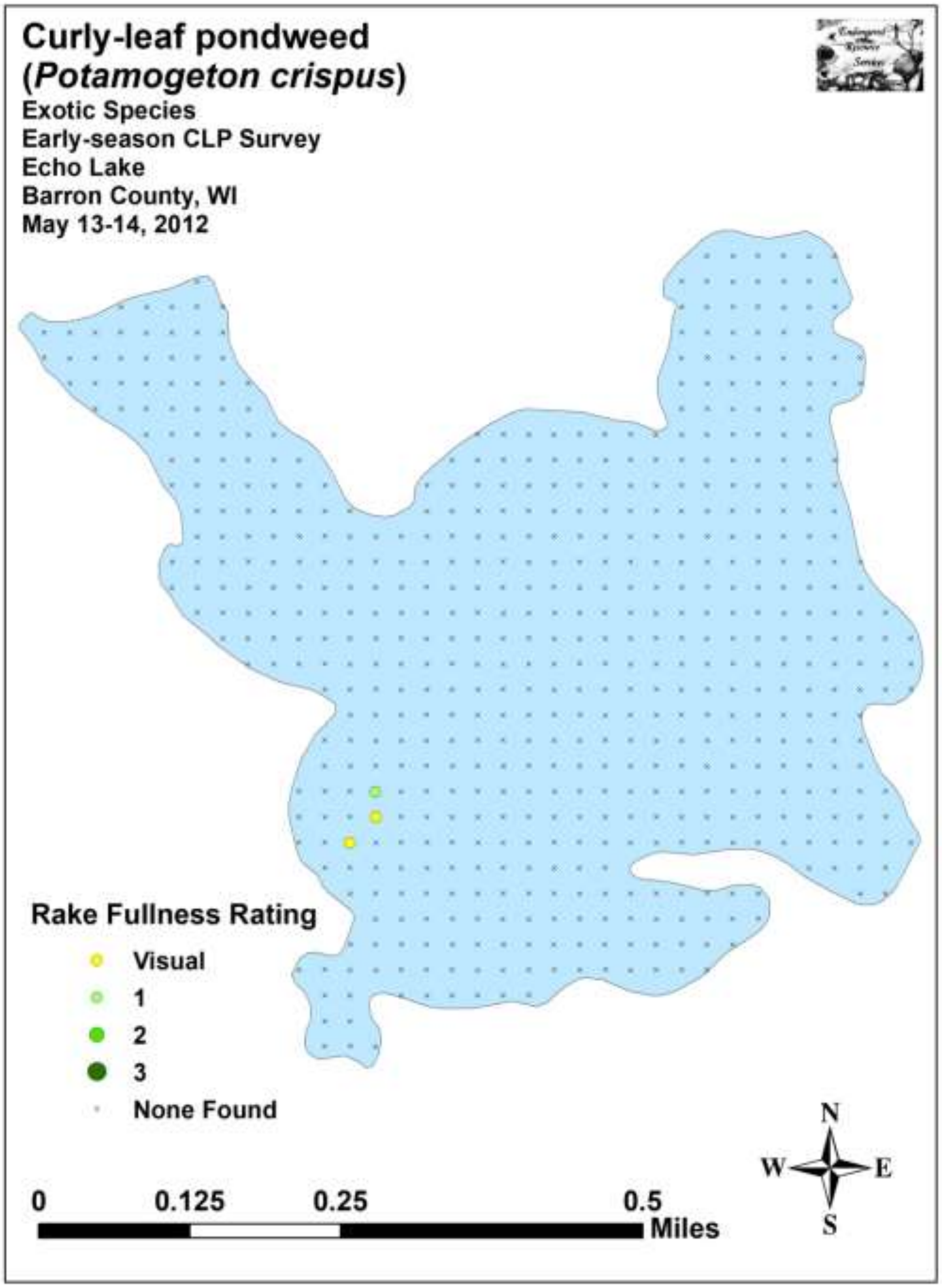

Survey Sample Points
Point Intercept Surveys
Echo Lake
Barron County, WI
July 24, 27, 2017
Sample Point
0
0.125
0.25
0.5
Miles
N
W
E
S

Appendix II: Boat and Vegetative Survey Data Sheets

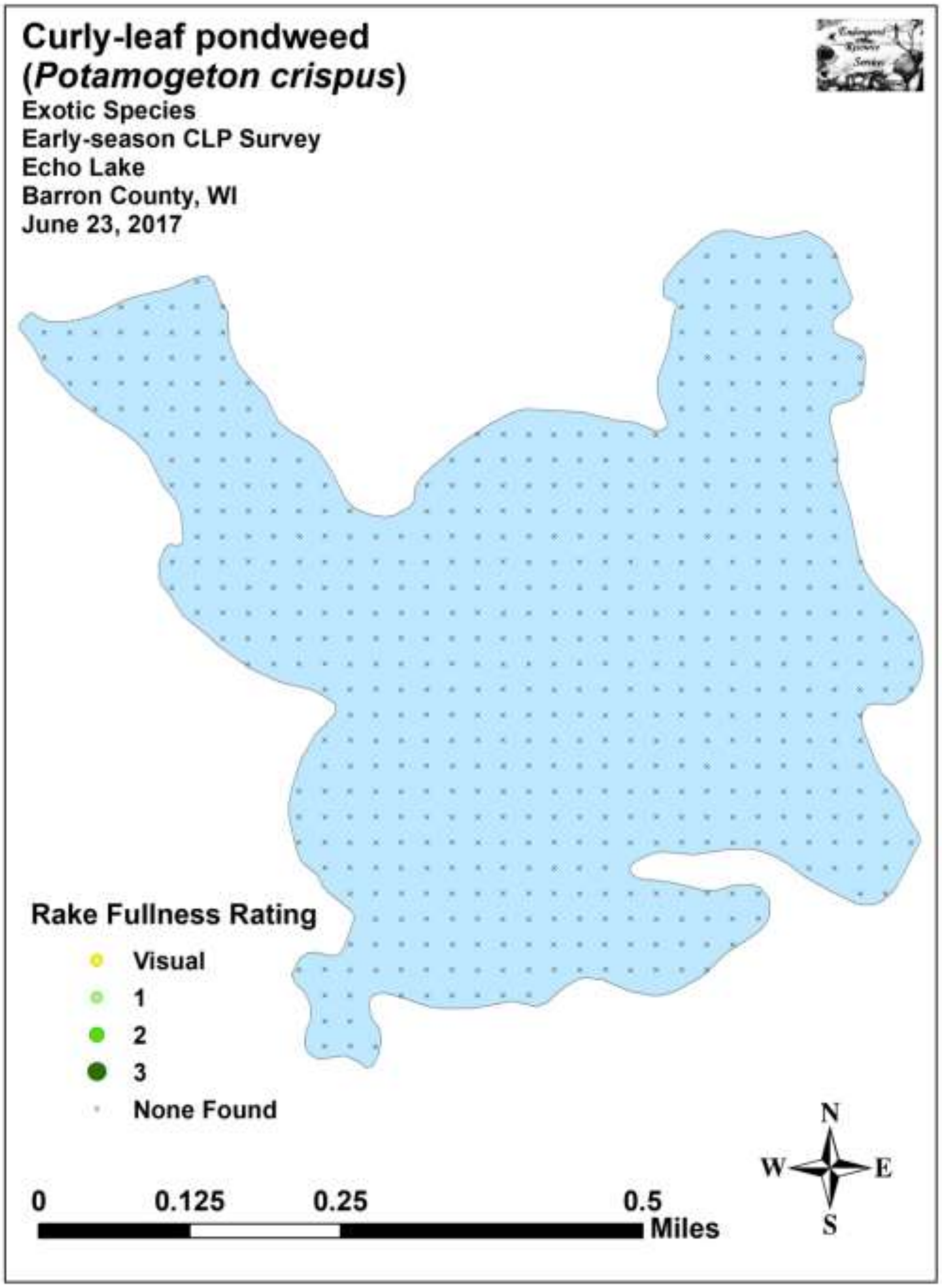
Boat Survey	
Lake Name	
County	
WBIC	
Date of Survey	
(mm/dd/yy)	
workers	
Nearest Point	**Species seen, habitat information**

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																									

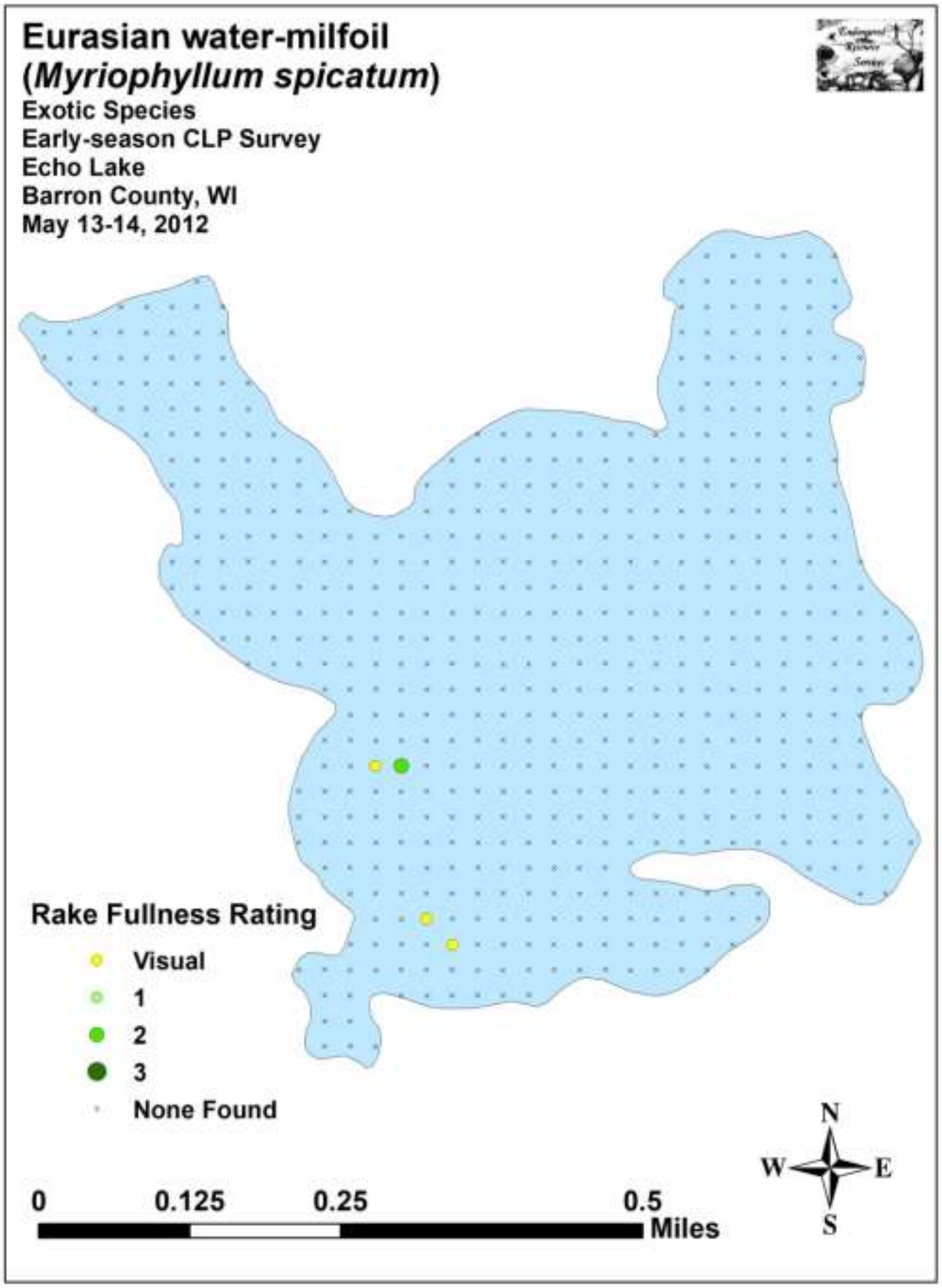
Appendix III: 2012 and 2017 Early-season CLP and EWM Density and Distribution and CLP Bed Maps

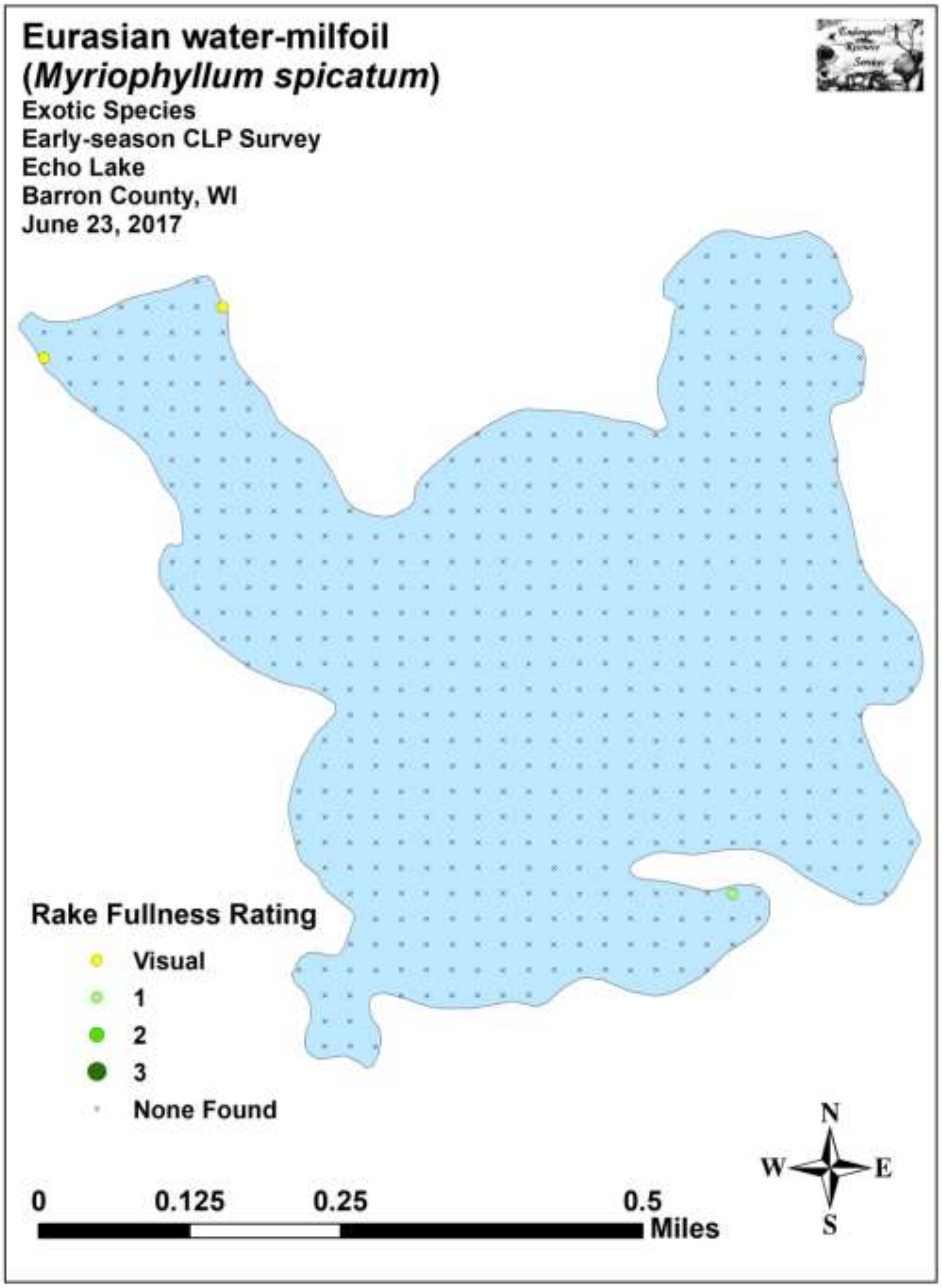


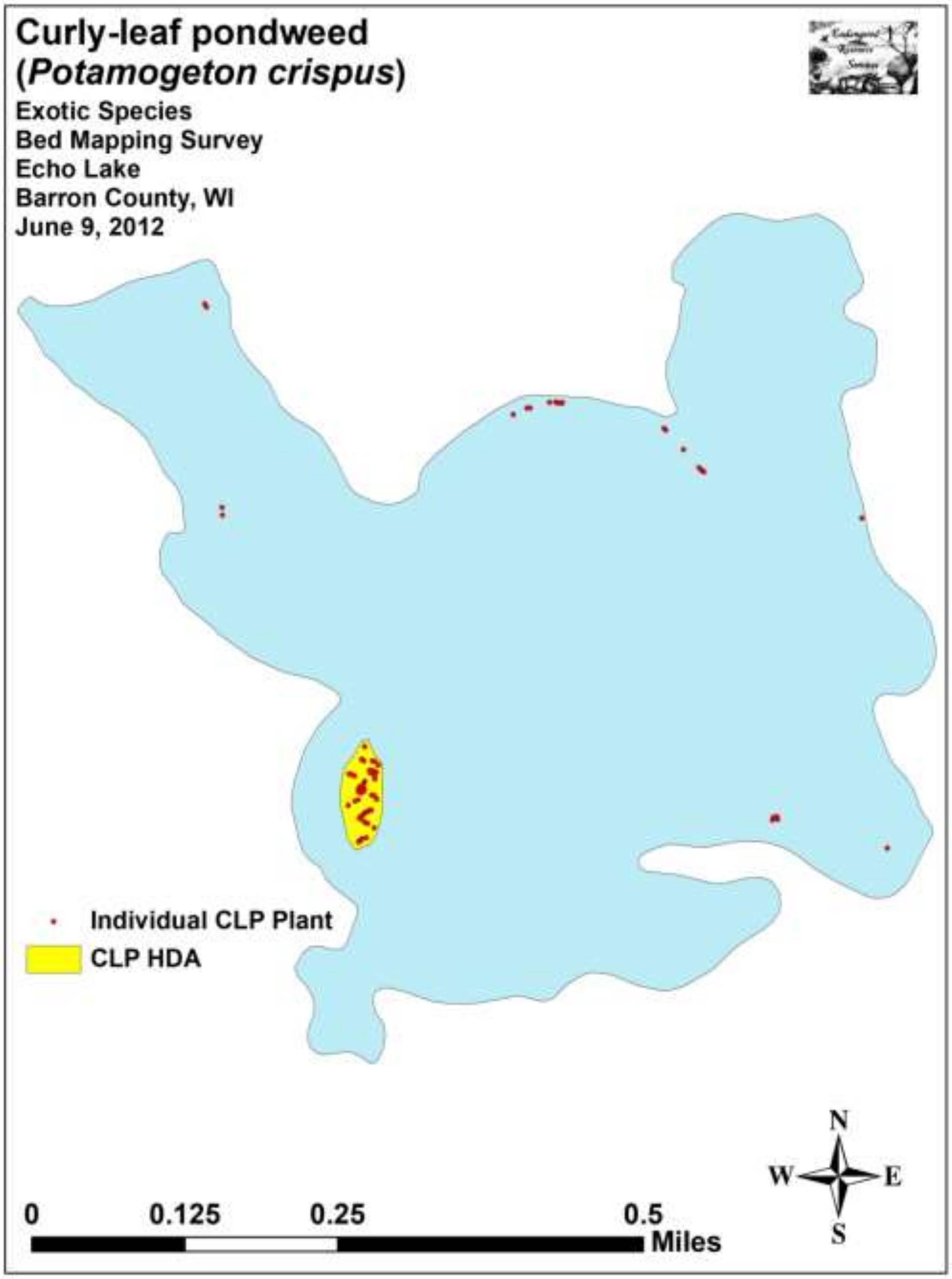
Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Early-season CLP Survey
Echo Lake
Barron County, WI
May 13-14, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

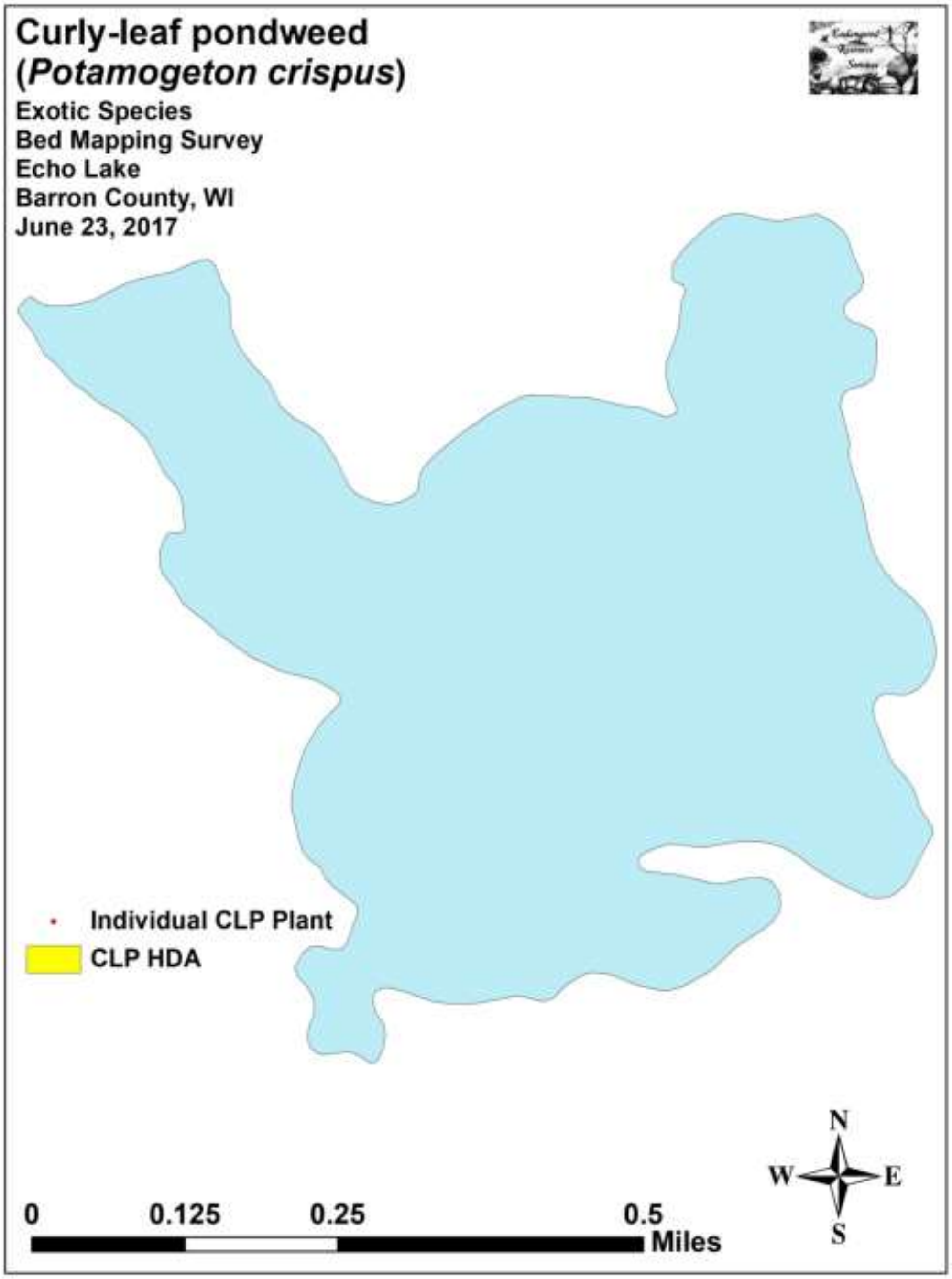


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
Early-season CLP Survey
Echo Lake
Barron County, WI
June 23, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

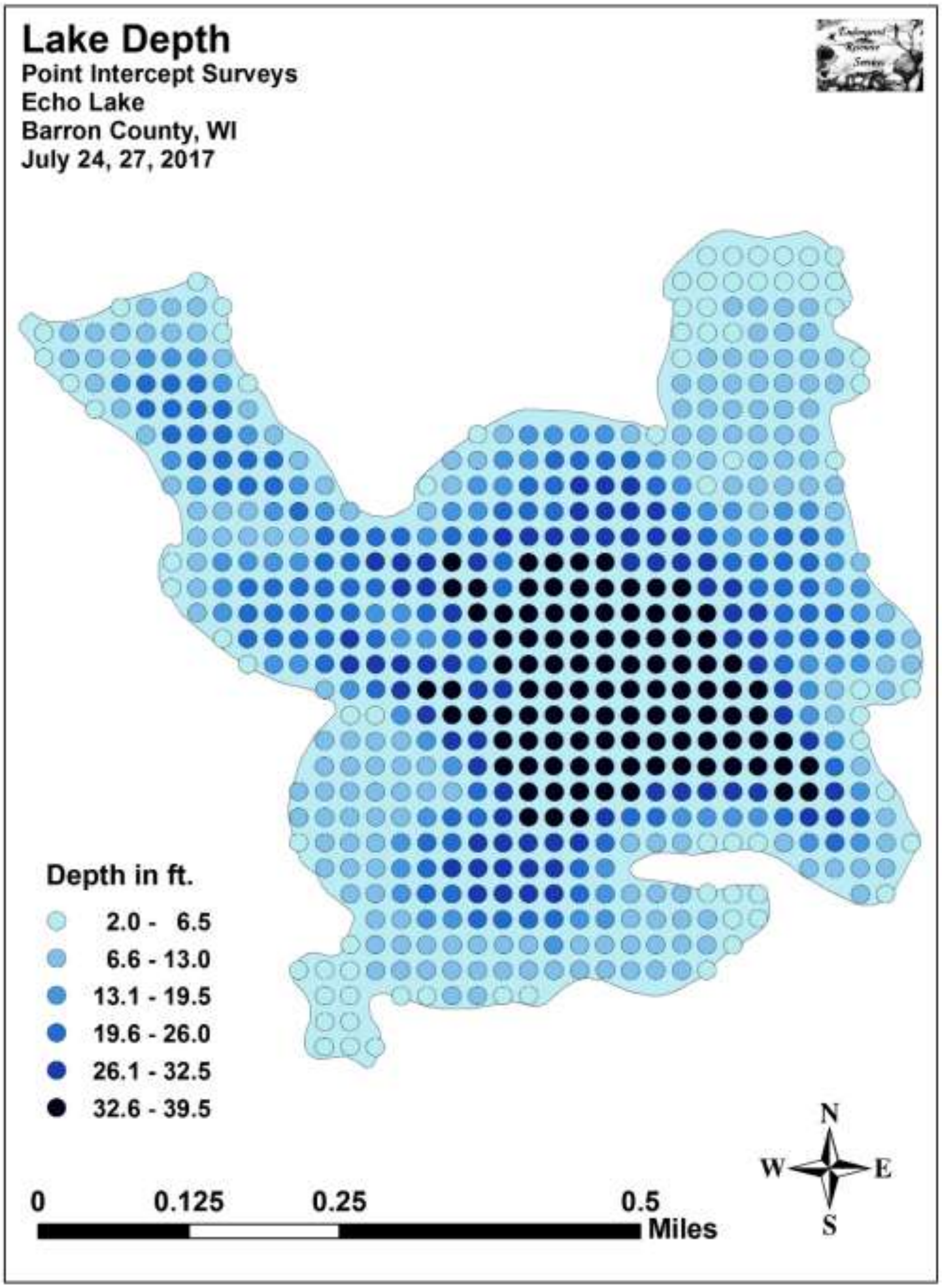

Eurasian water-milfoil
(*Myriophyllum spicatum*)
Exotic Species
Early-season CLP Survey
Echo Lake
Barron County, WI
May 13-14, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles


Eurasian water-milfoil
(Myriophyllum spicatum)
Exotic Species
Early-season CLP Survey
Echo Lake
Barron County, WI
June 23, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

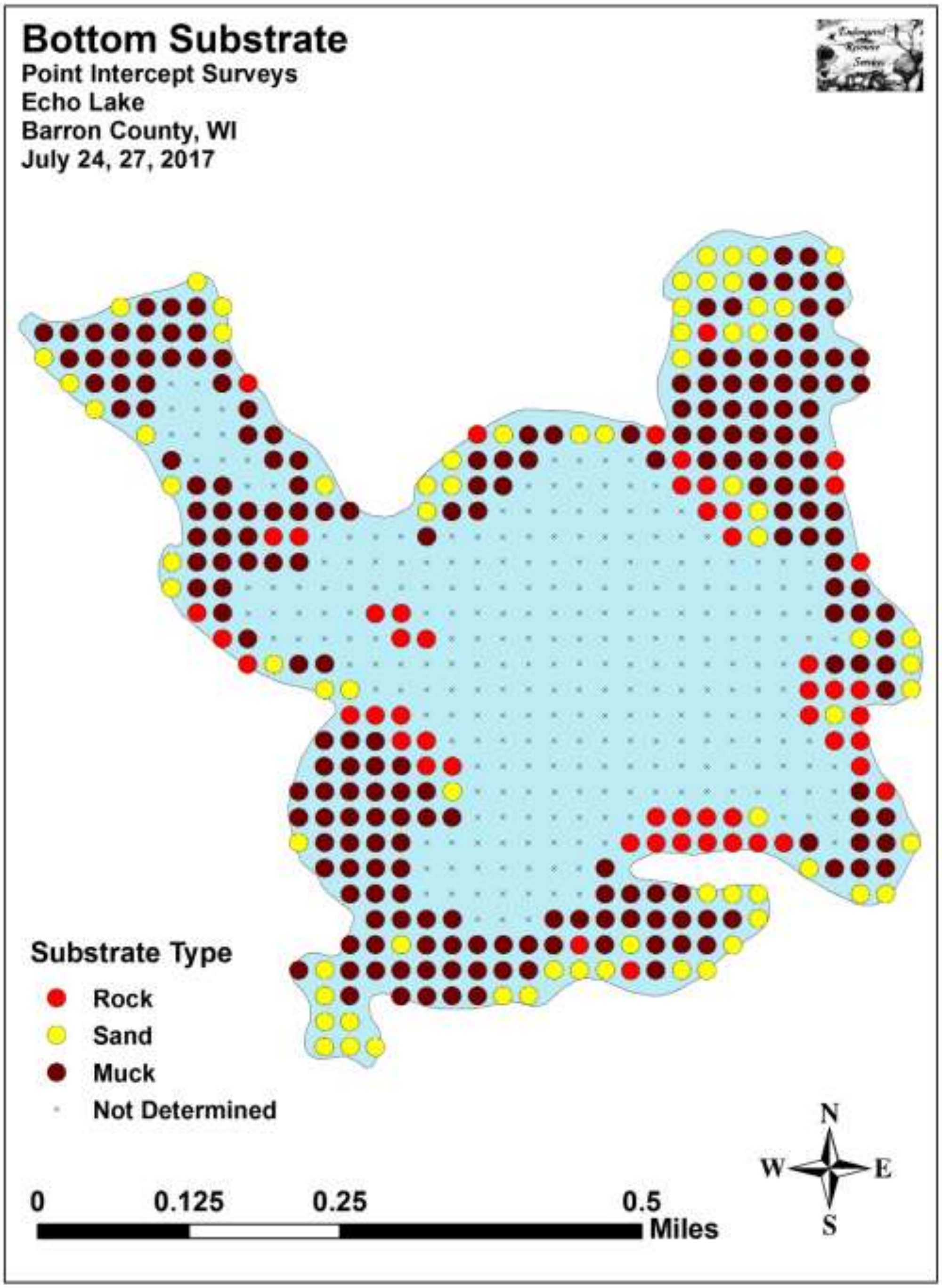

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Bed Mapping Survey
Echo Lake
Barron County, WI
June 9, 2012
Individual CLP Plant
CLP HDA
0
0.125
0.25
0.5
Miles
N
W
E
S


Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Bed Mapping Survey
Echo Lake
Barron County, WI
June 23, 2017
Individual CLP Plant
CLP HDA
0
0.125
0.25
0.5
Miles
N
W
E
S

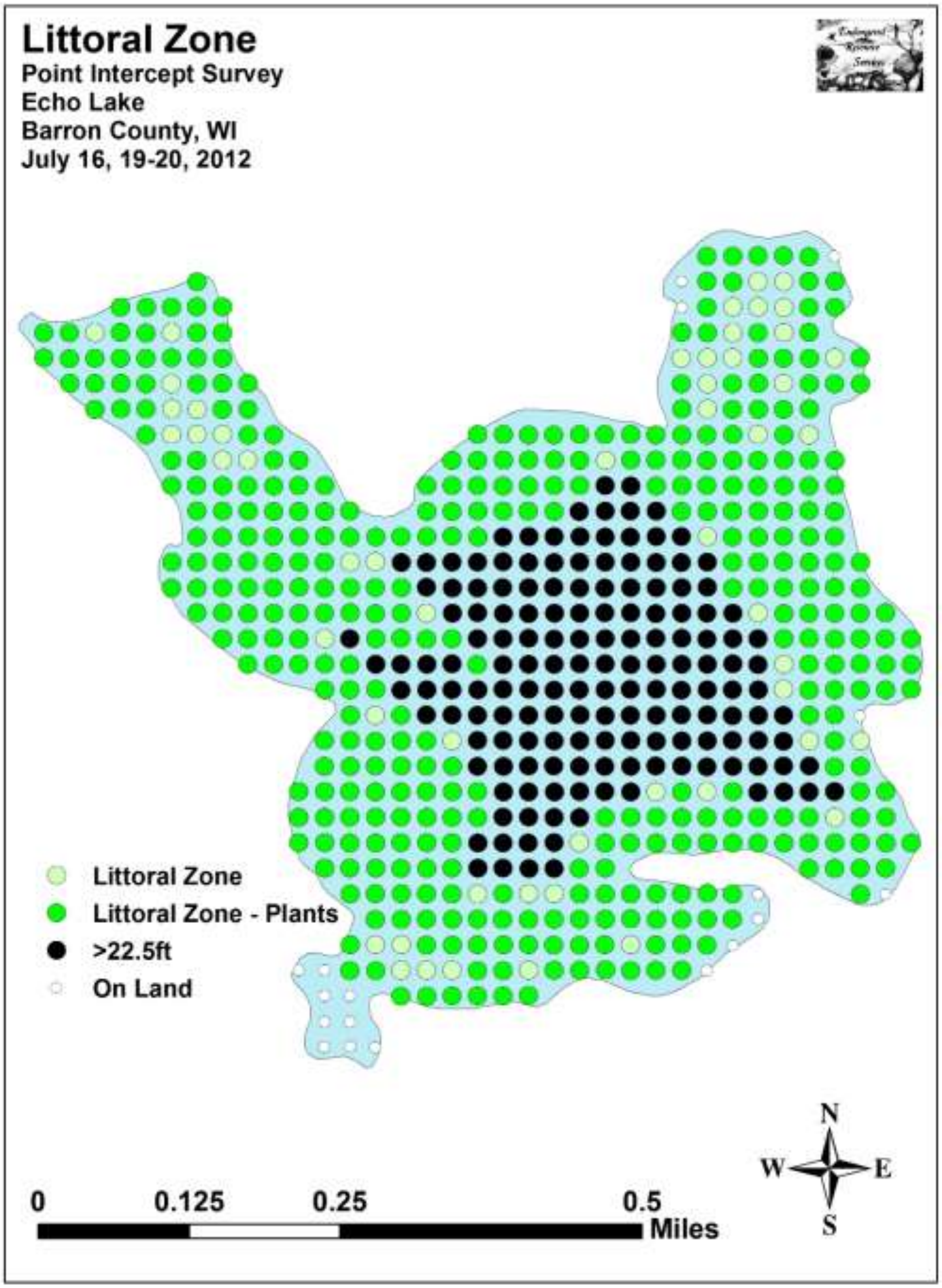
Appendix IV: Habitat Variable Maps

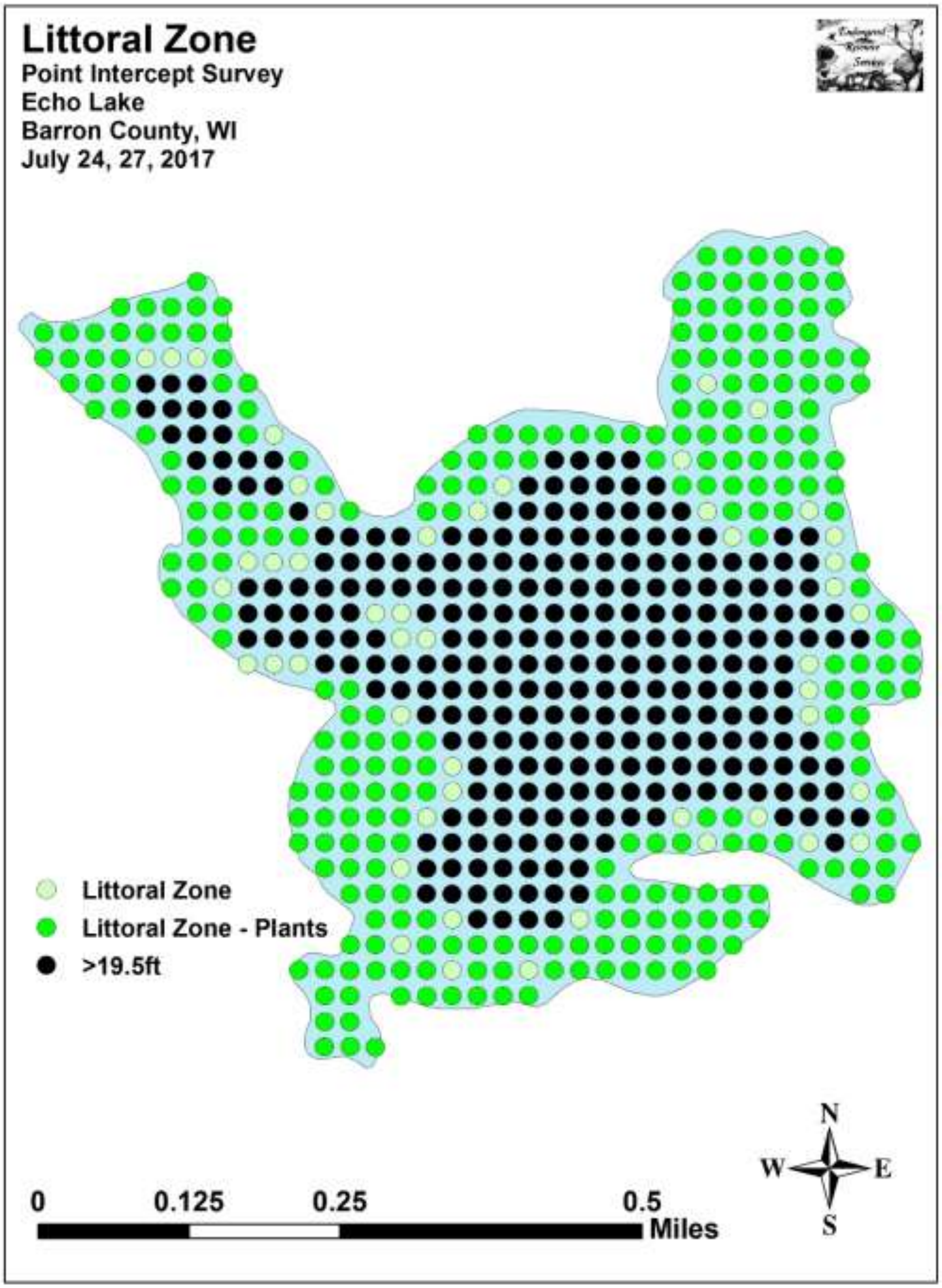


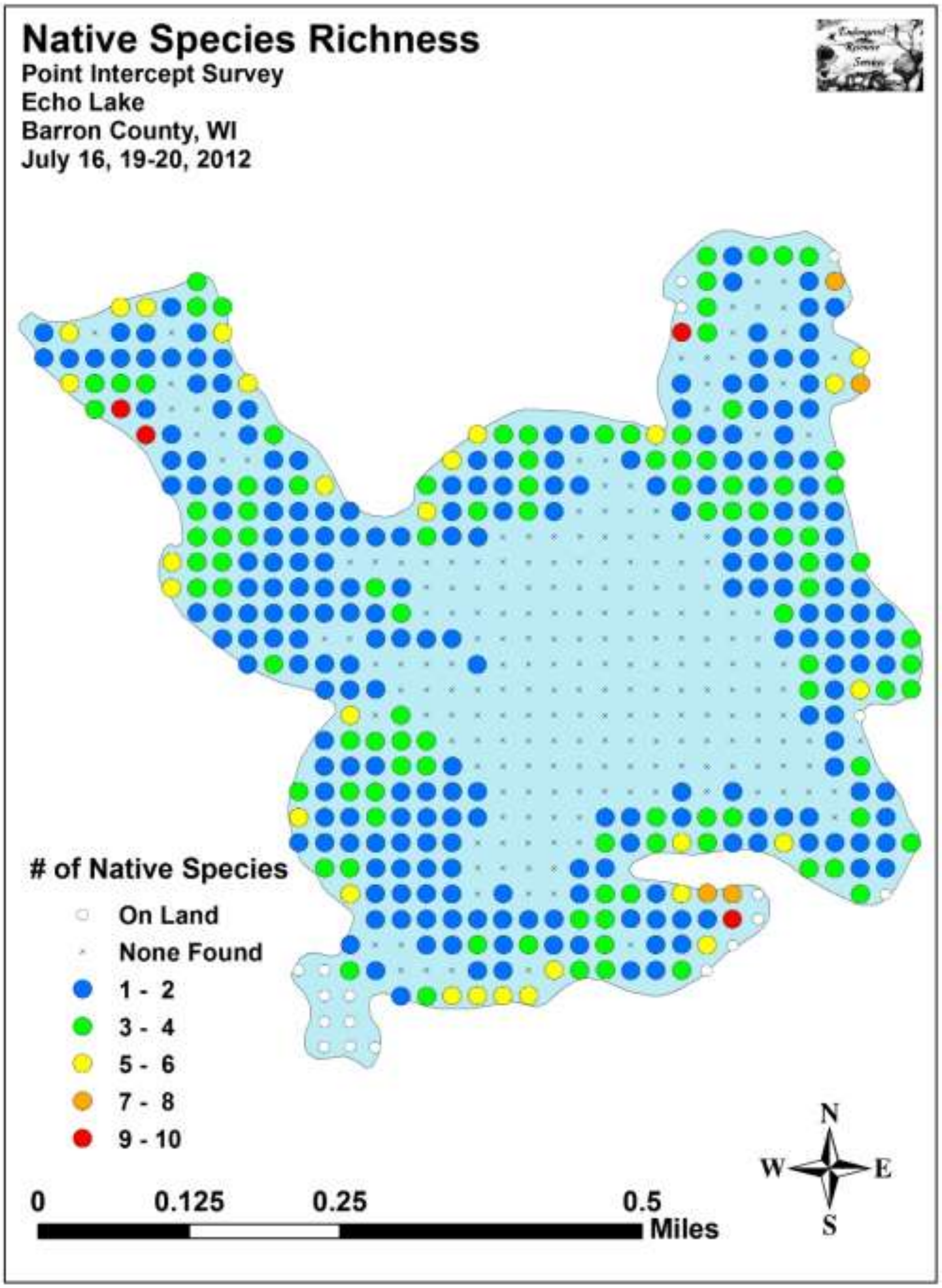
Lake Depth
Point Intercept Surveys
Echo Lake
Barron County, WI
July 24, 27, 2017
Depth in ft.
2.0 - 6.5
6.6 - 13.0
13.1 - 19.5
19.6 - 26.0
26.1 - 32.5
32.6 - 39.5
N
W
E
S
0
0.125
0.25
0.5
Miles

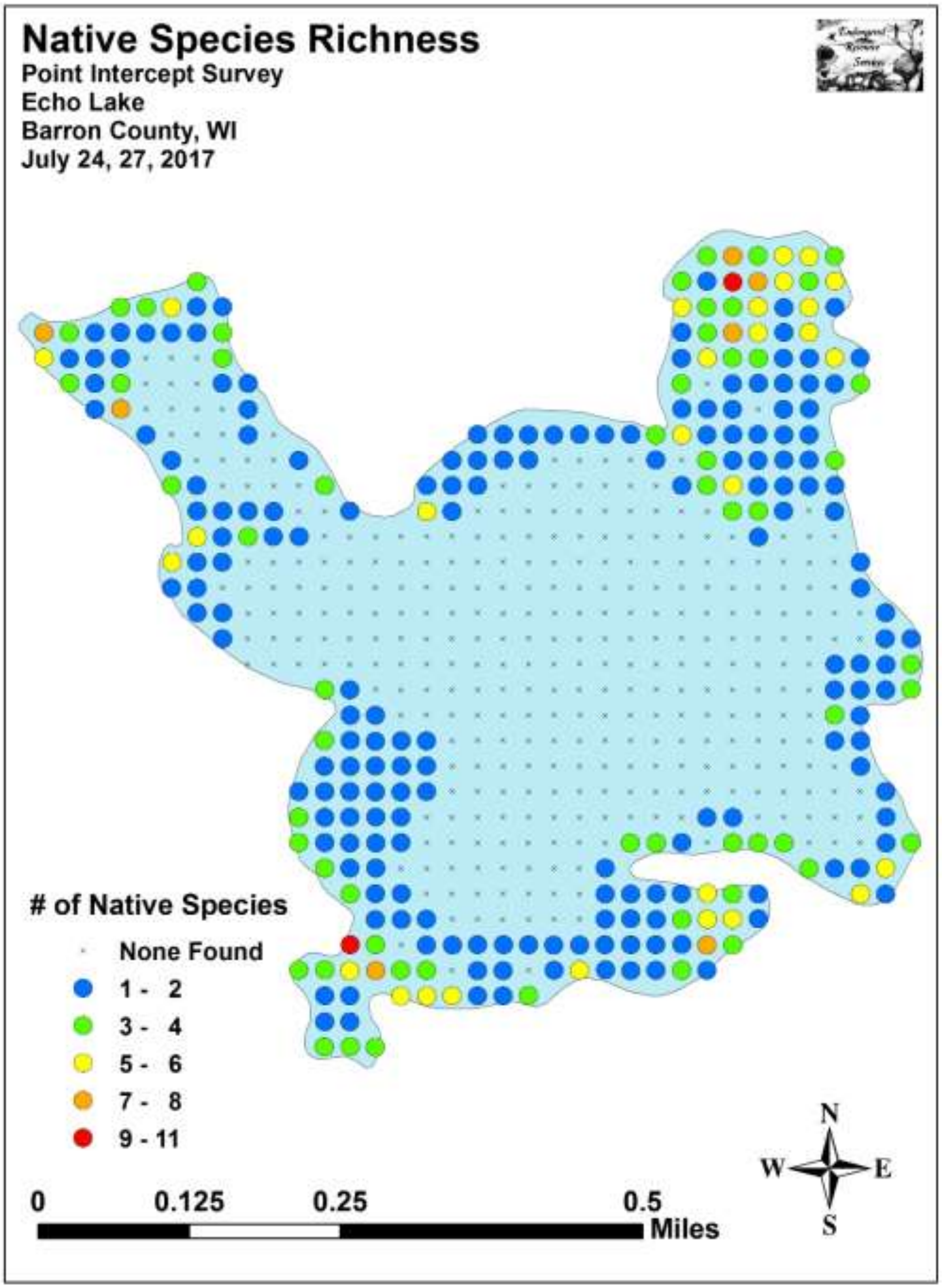

Bottom Substrate
Point Intercept Surveys
Echo Lake
Barron County, WI
July 24, 27, 2017
Substrate Type
Rock
Sand
Muck
Not Determined
0
0.125
0.25
0.5
Miles
N
W
E
S

Appendix V: 2012 and 2017 Littoral Zone, Native Species Richness, and Total Rake Fullness Maps

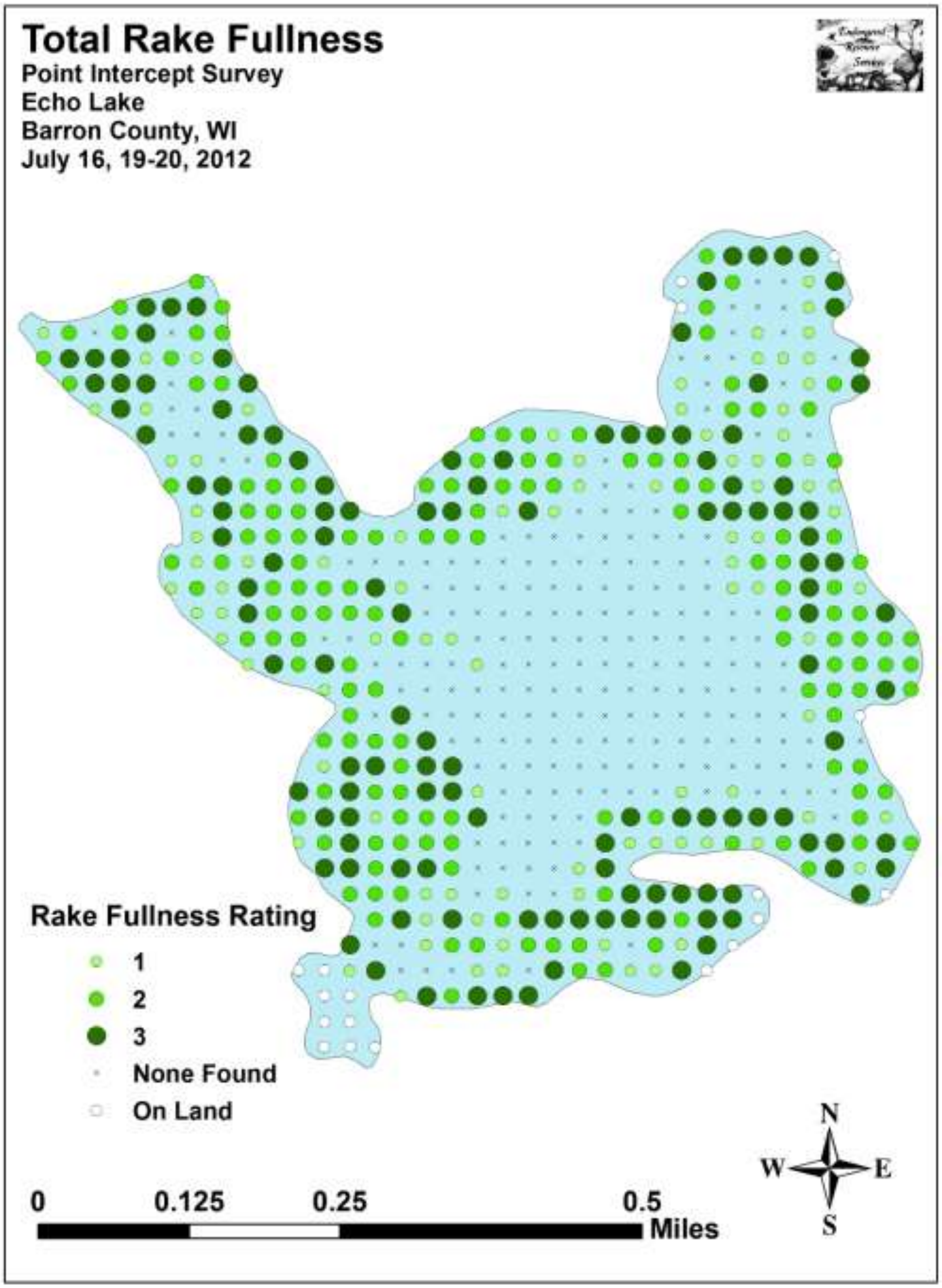

Littoral Zone
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Littoral Zone
Littoral Zone - Plants
>22.5ft
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S

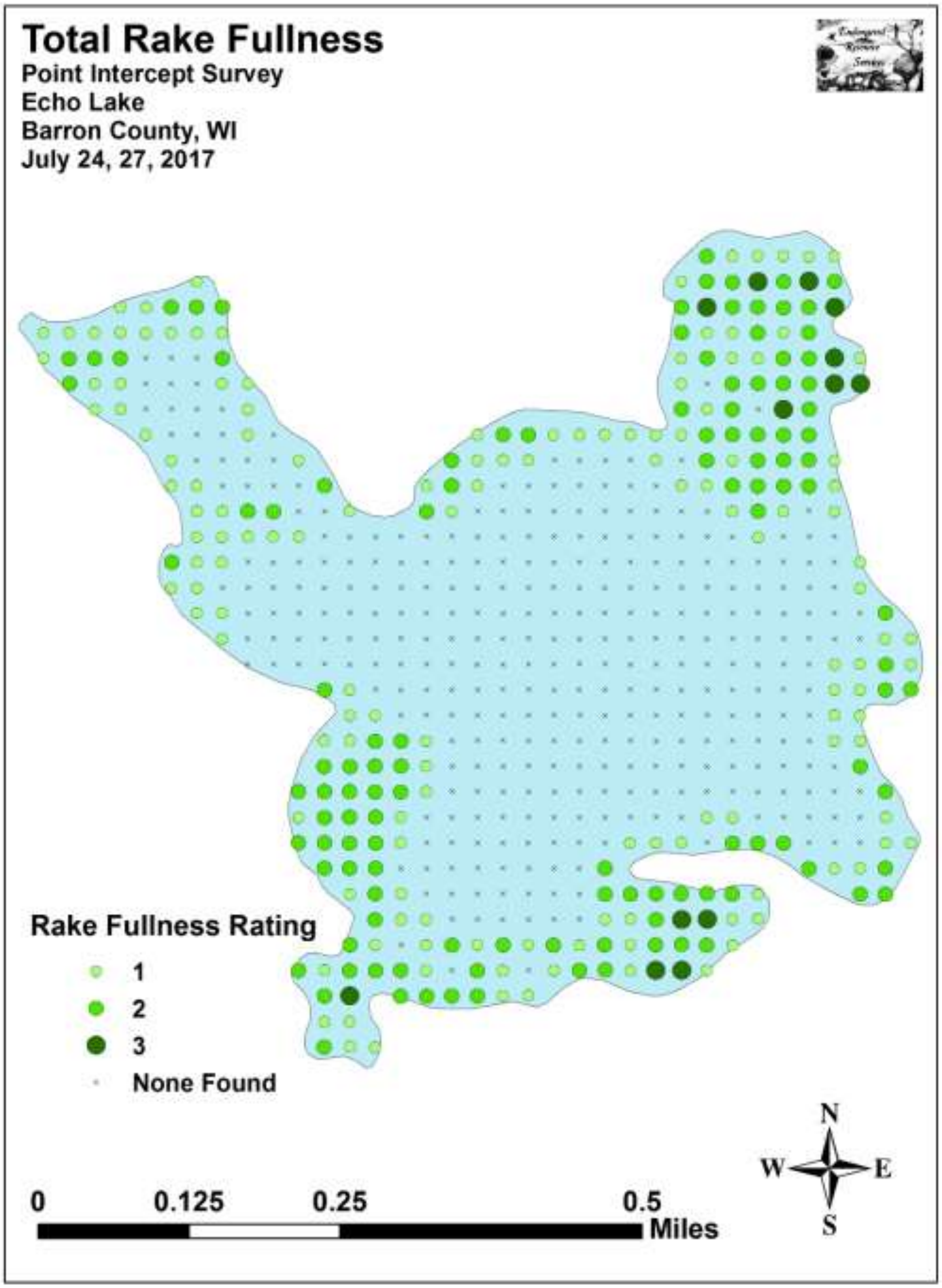

Littoral Zone
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Littoral Zone
Littoral Zone - Plants
>19.5ft
N
W
E
S
0
0.125
0.25
0.5
Miles


Native Species Richness
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
# of Native Species
On Land
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9 - 10
0
0.125
0.25
0.5
Miles
N
W
E
S

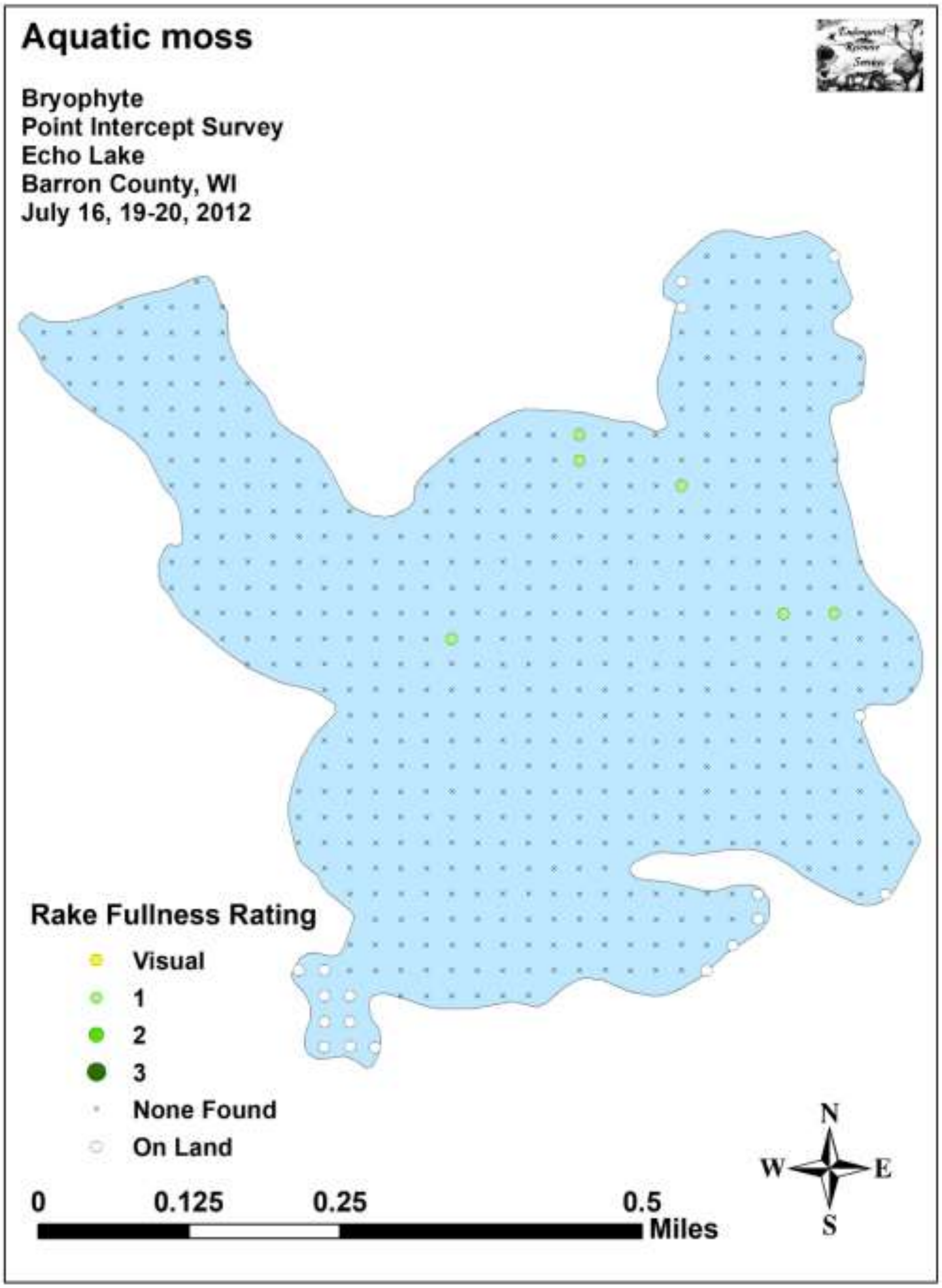


Native Species Richness
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9 - 11
0
0.125
0.25
0.5
Miles
N
W
E
S

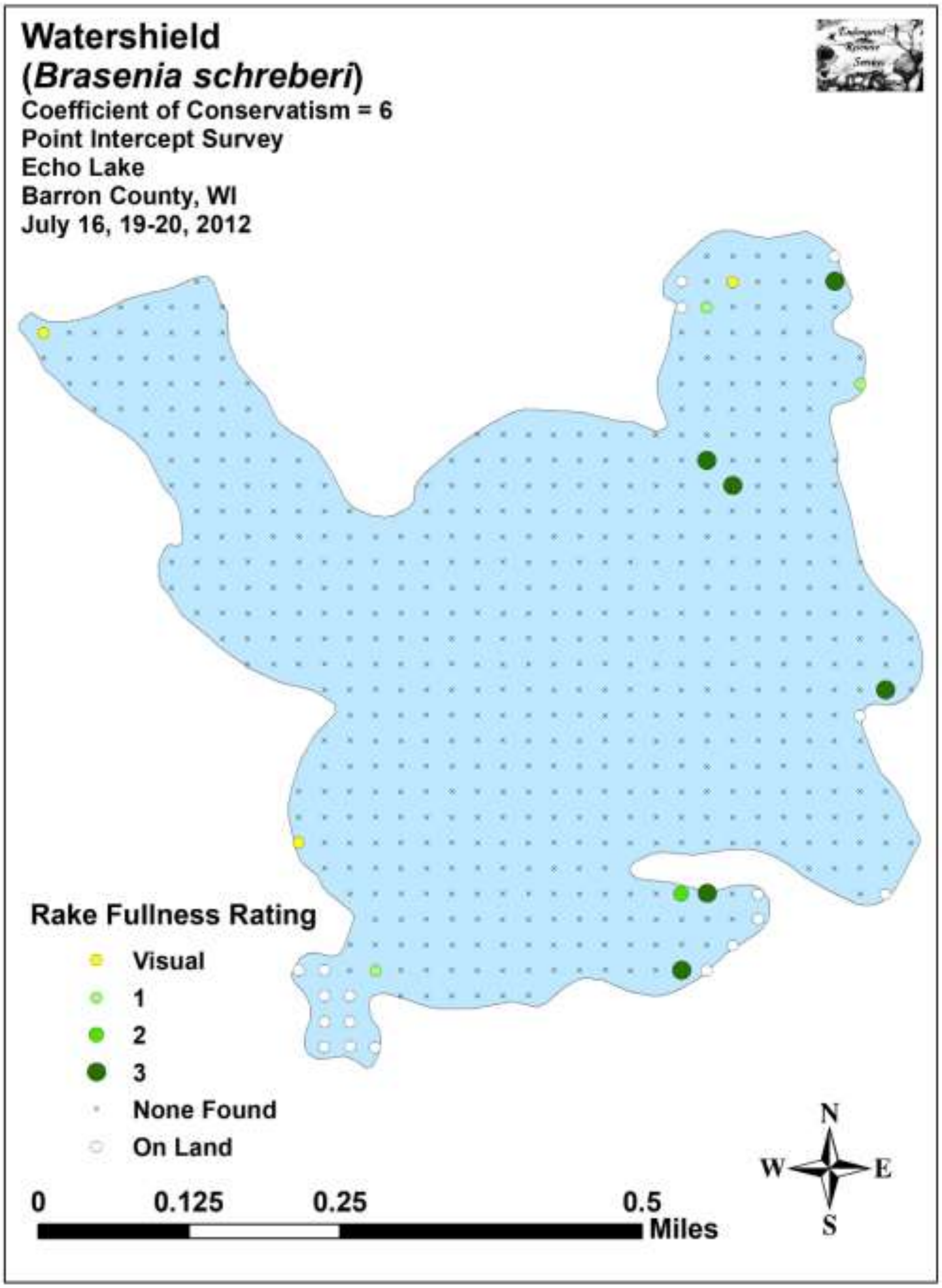

Total Rake Fullness
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
1
2
3
None Found
On Land
N
W
E
S
0
0.125
0.25
0.5
Miles


Total Rake Fullness
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S

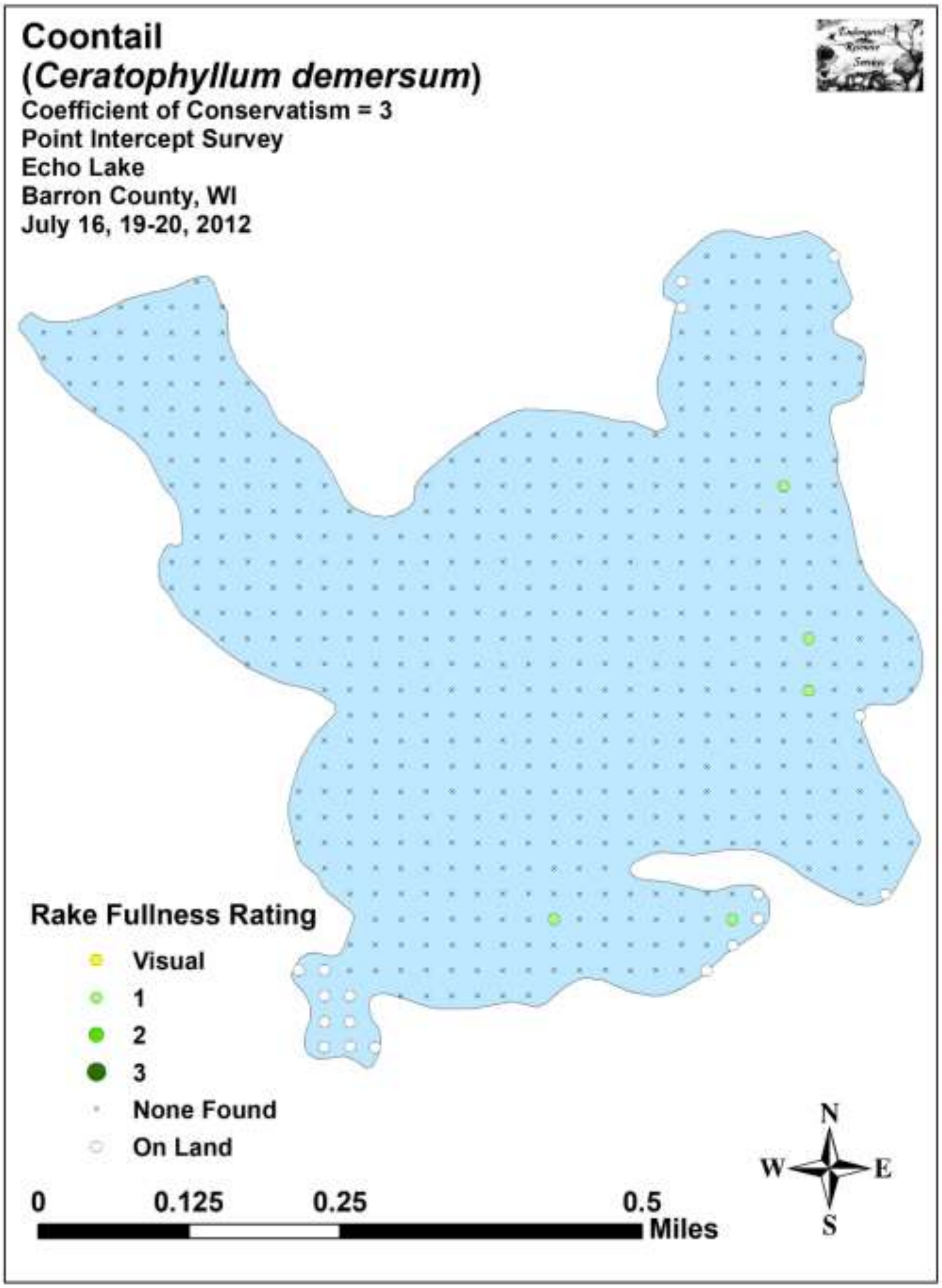
Appendix VI: July 2012 Species Density and Distribution Maps



Aquatic moss
Bryophyte
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S



Watershield
(*Brasenia schreberi*)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S


Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
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None Found
On Land
N
W
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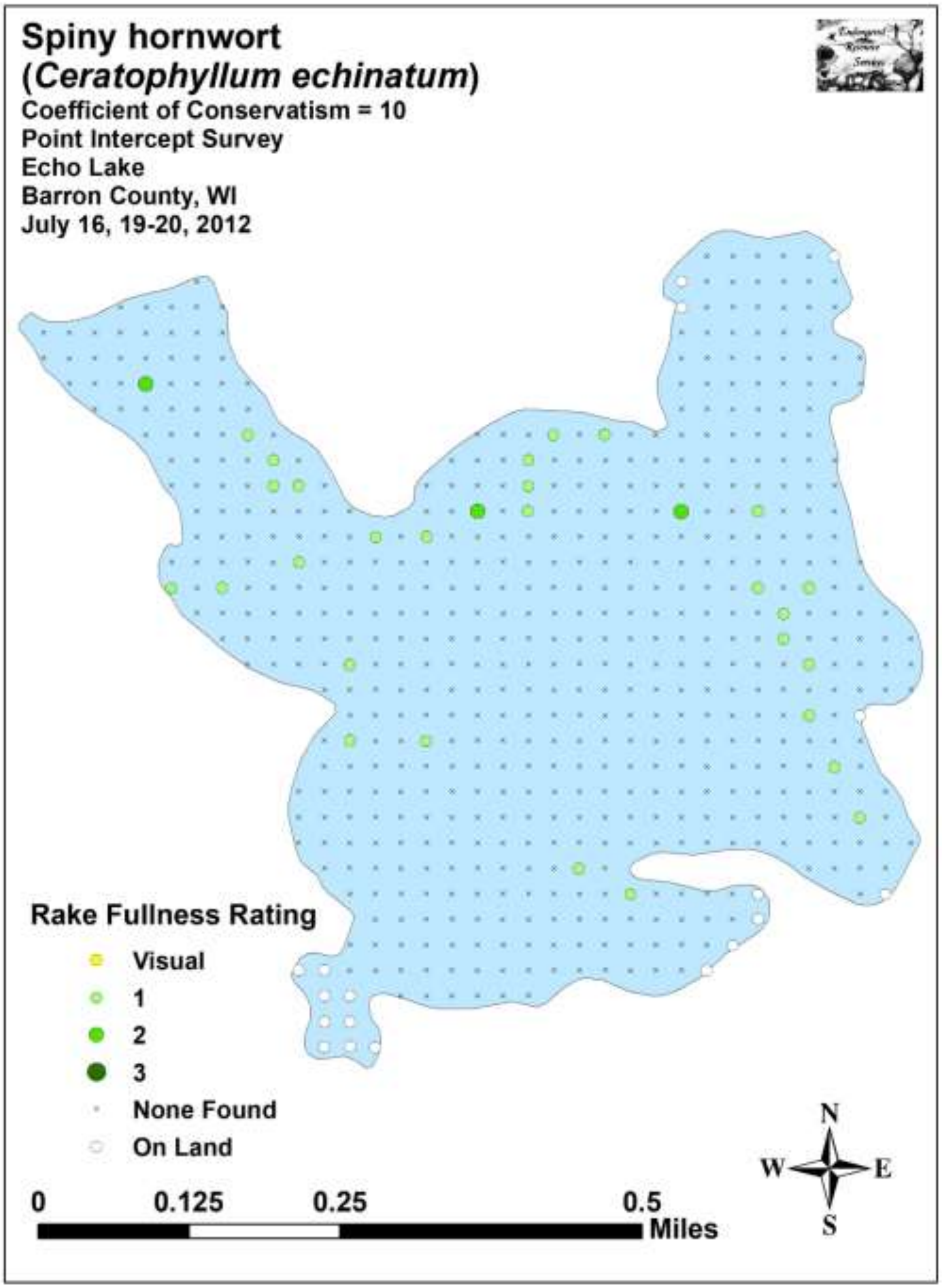
S
0
0.125
0.25
0.5
Miles



Spiny hornwort
(Ceratophyllum echinatum)
Coefficient of Conservatism = 10
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
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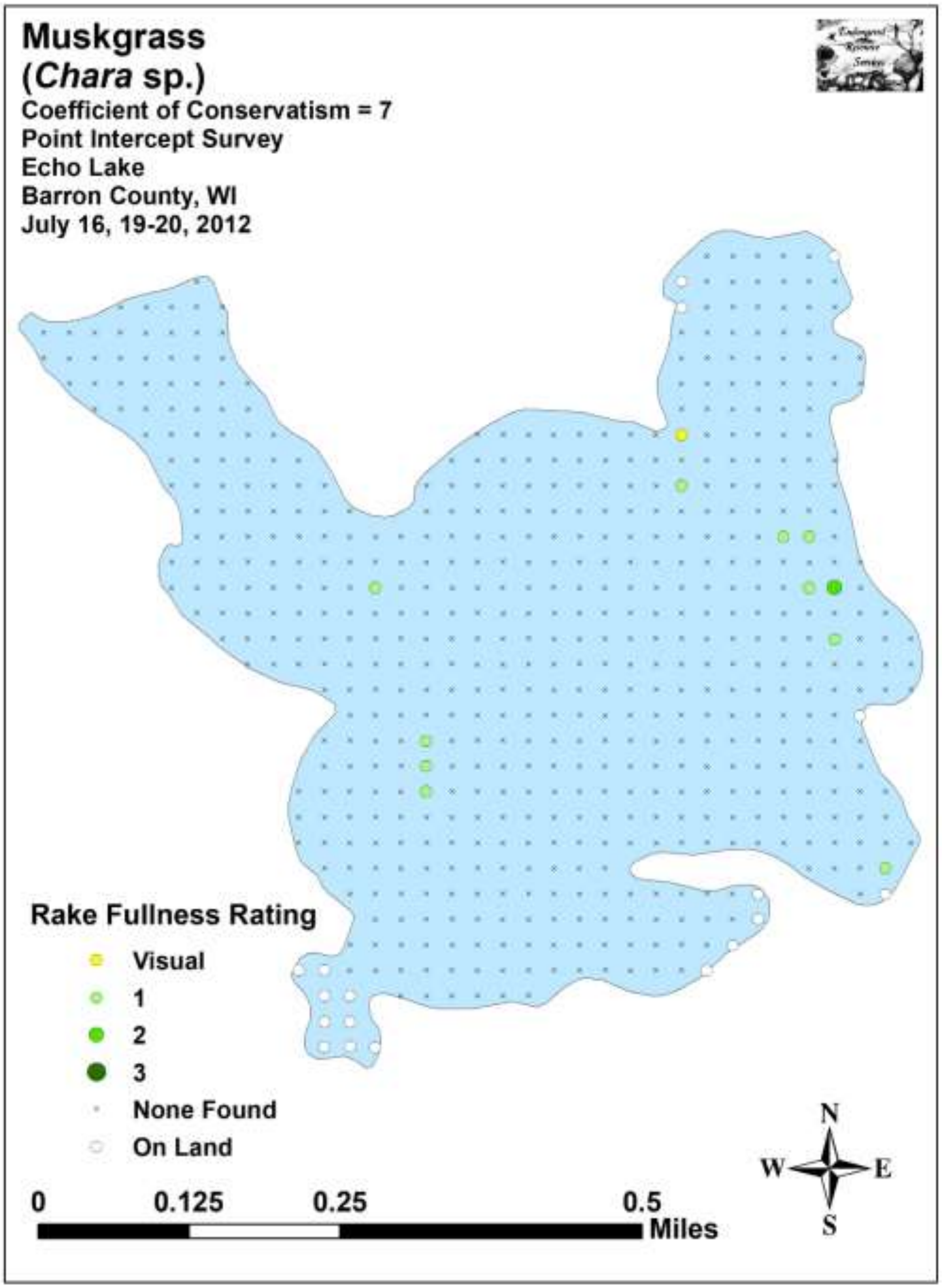
Muskgrass
(Chara sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
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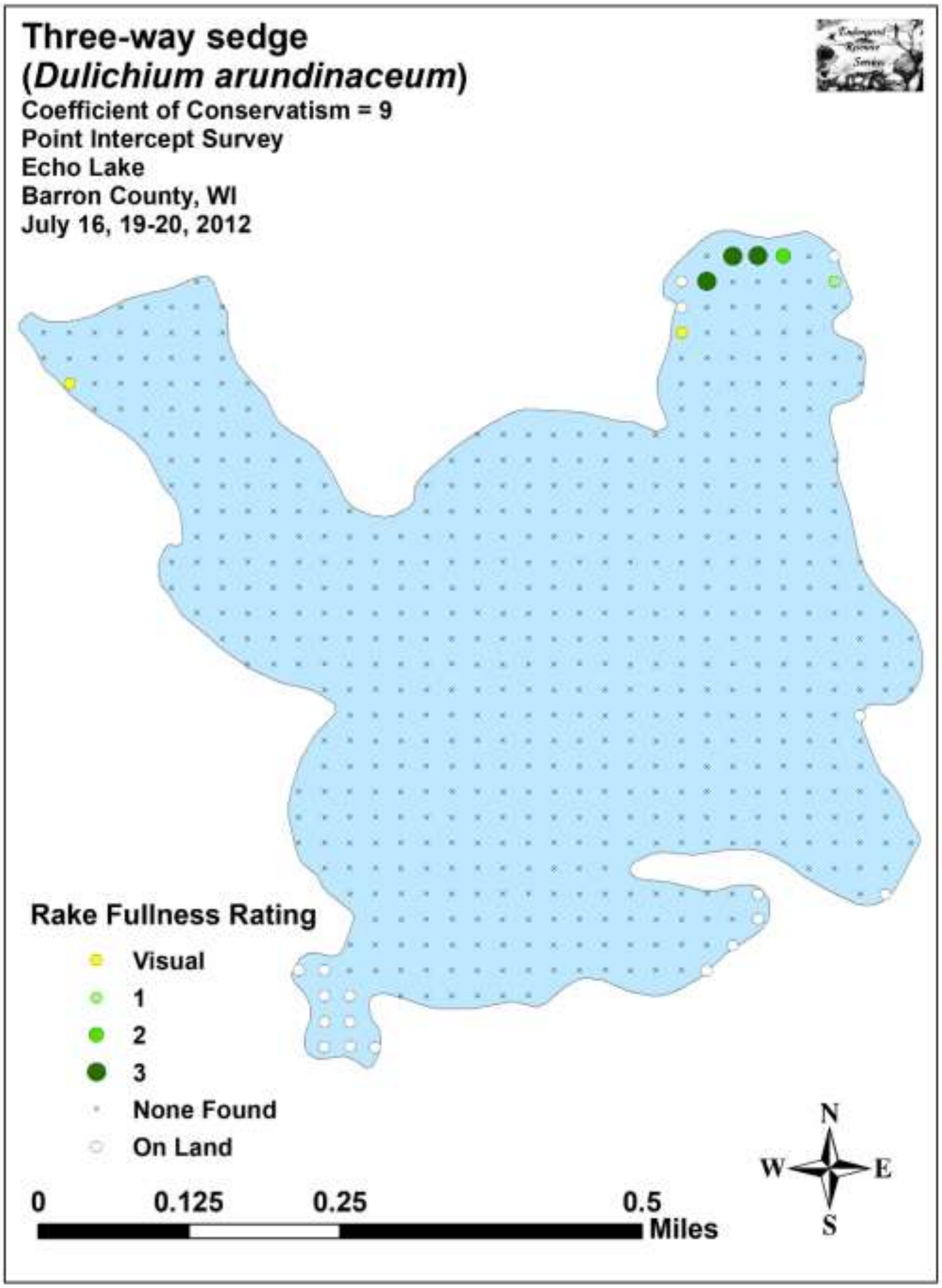

Three-way sedge
(*Dulichium arundinaceum*)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
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None Found
On Land
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0.125
0.25
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Miles
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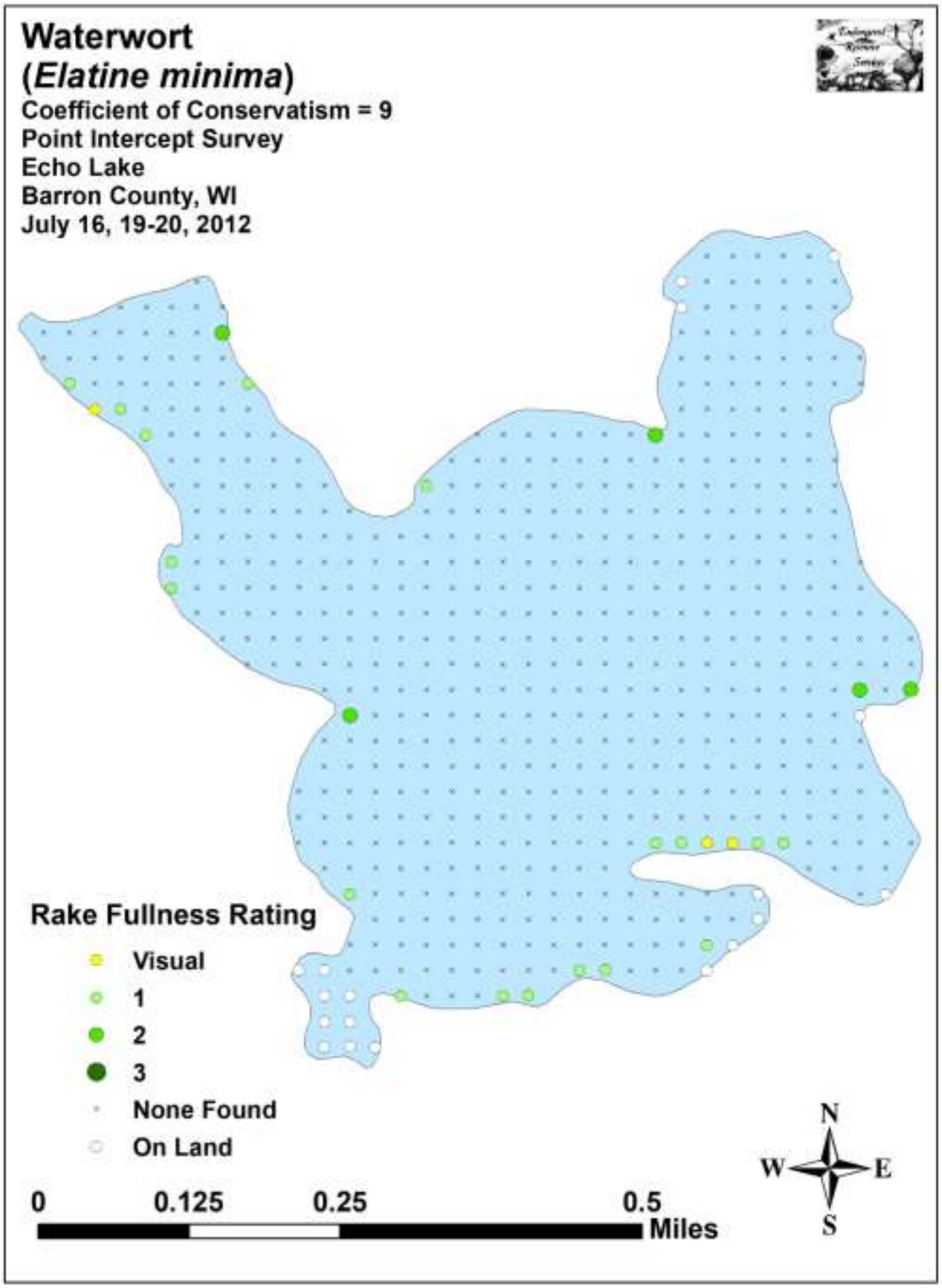

Waterwort
(Elatine minima)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
0.25
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Miles
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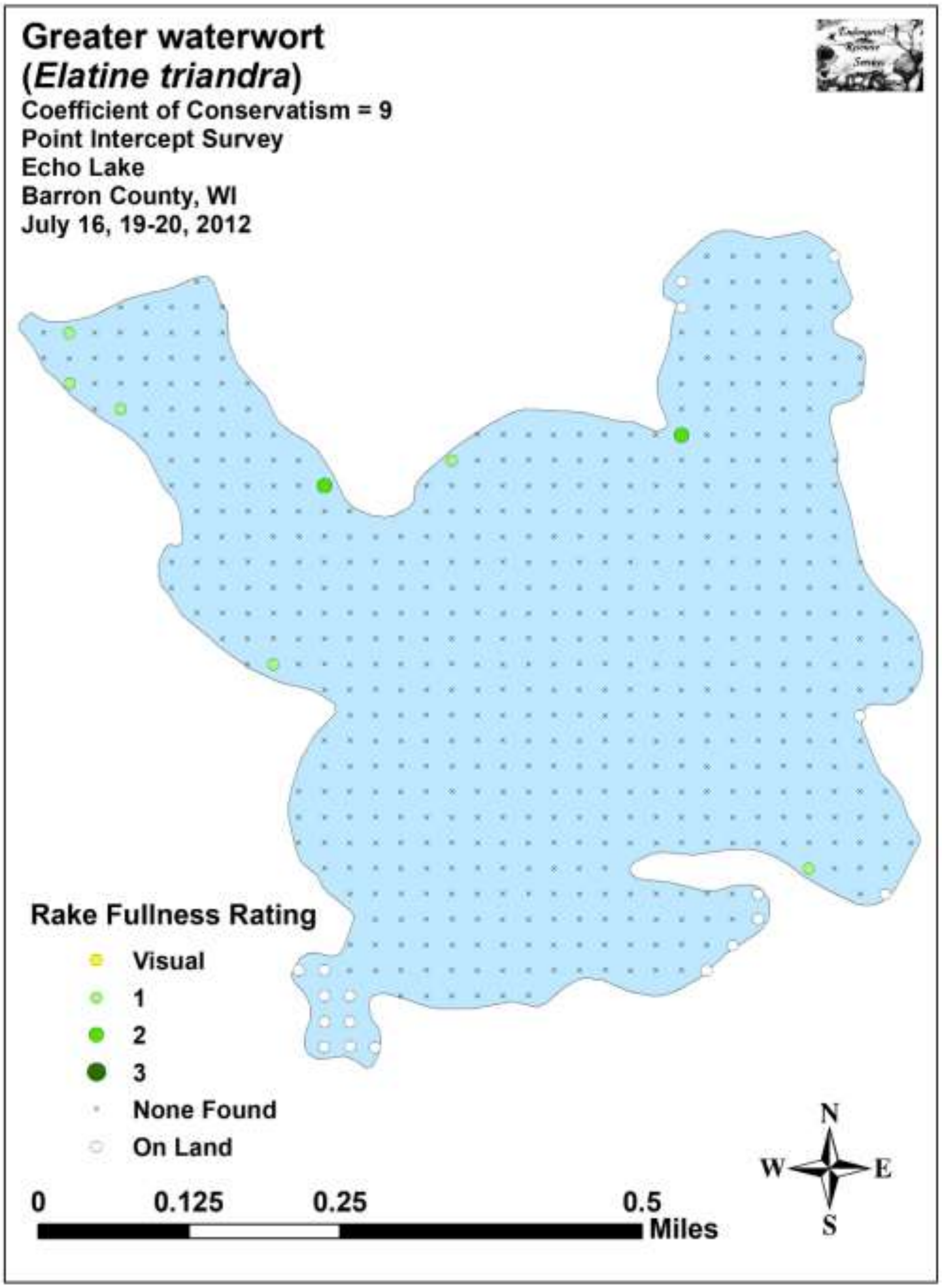
Greater waterwort
(*Elatine triandra*)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
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None Found
On Land
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0.125
0.25
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Miles
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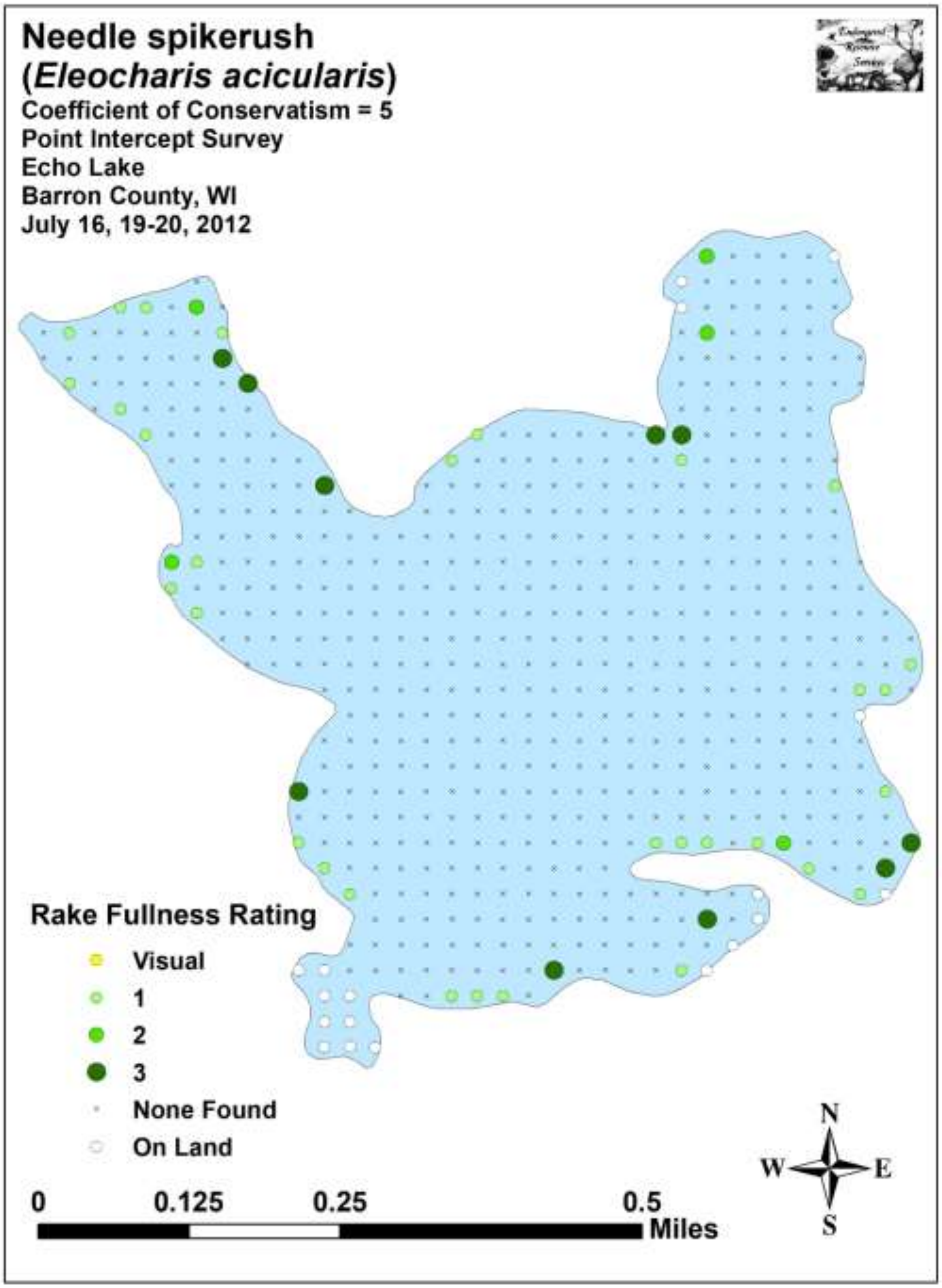
Needle spikerush
(*Eleocharis acicularis*)
Coefficient of Conservatism = 5
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
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None Found
On Land
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0.125
0.25
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Miles
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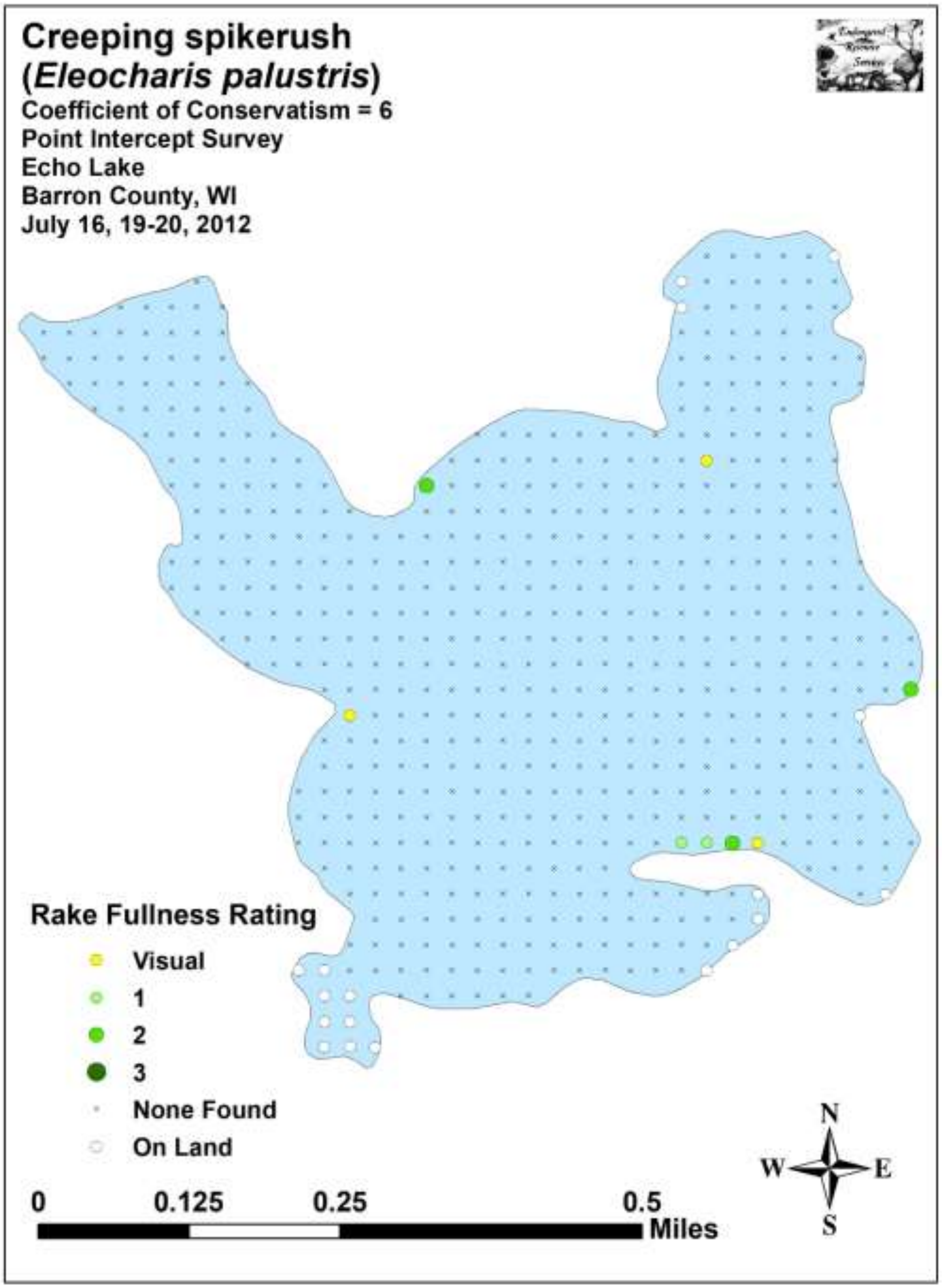
Creeping spikerush
(*Eleocharis palustris*)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
0.25
0.5
Miles
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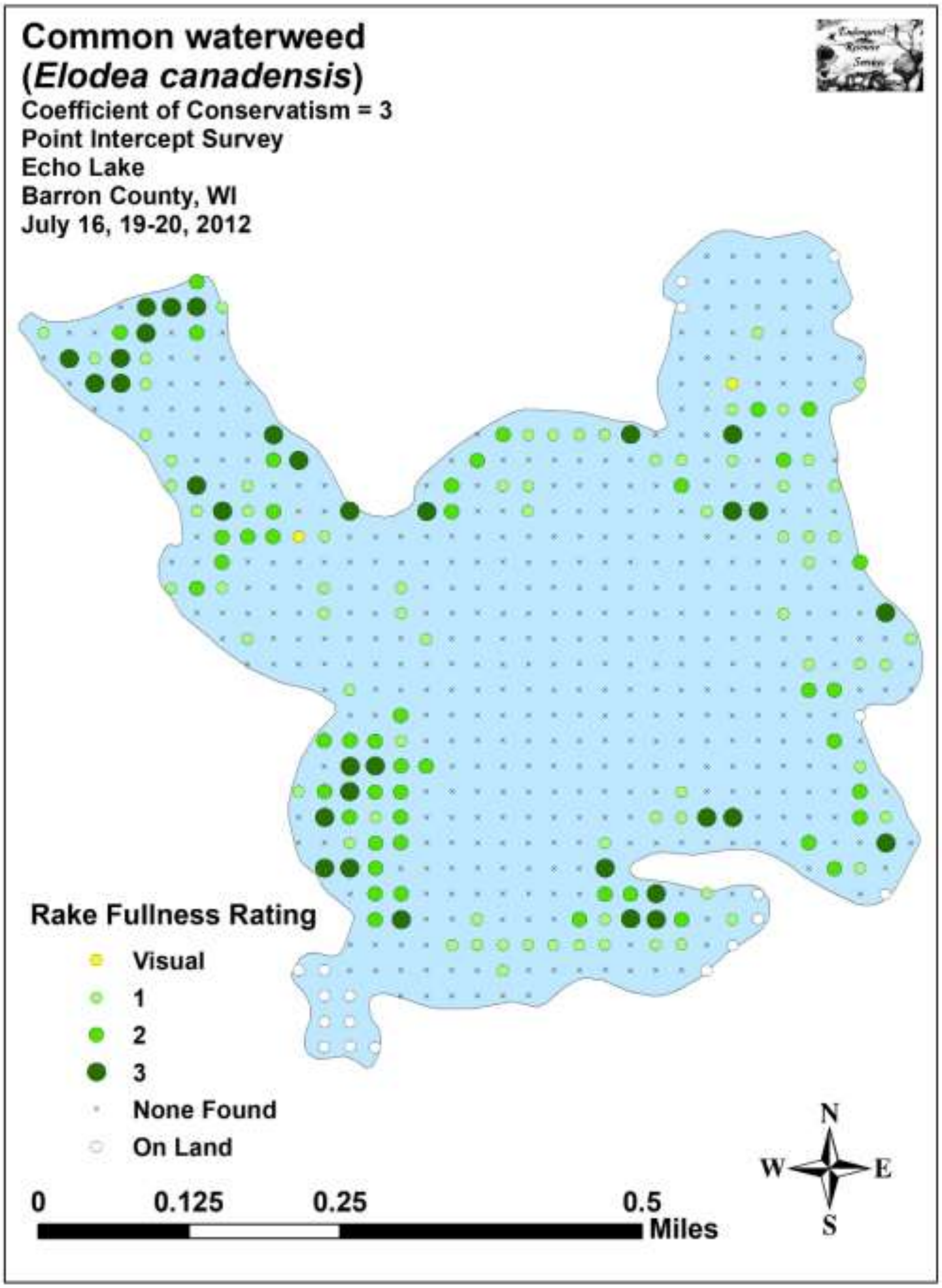
Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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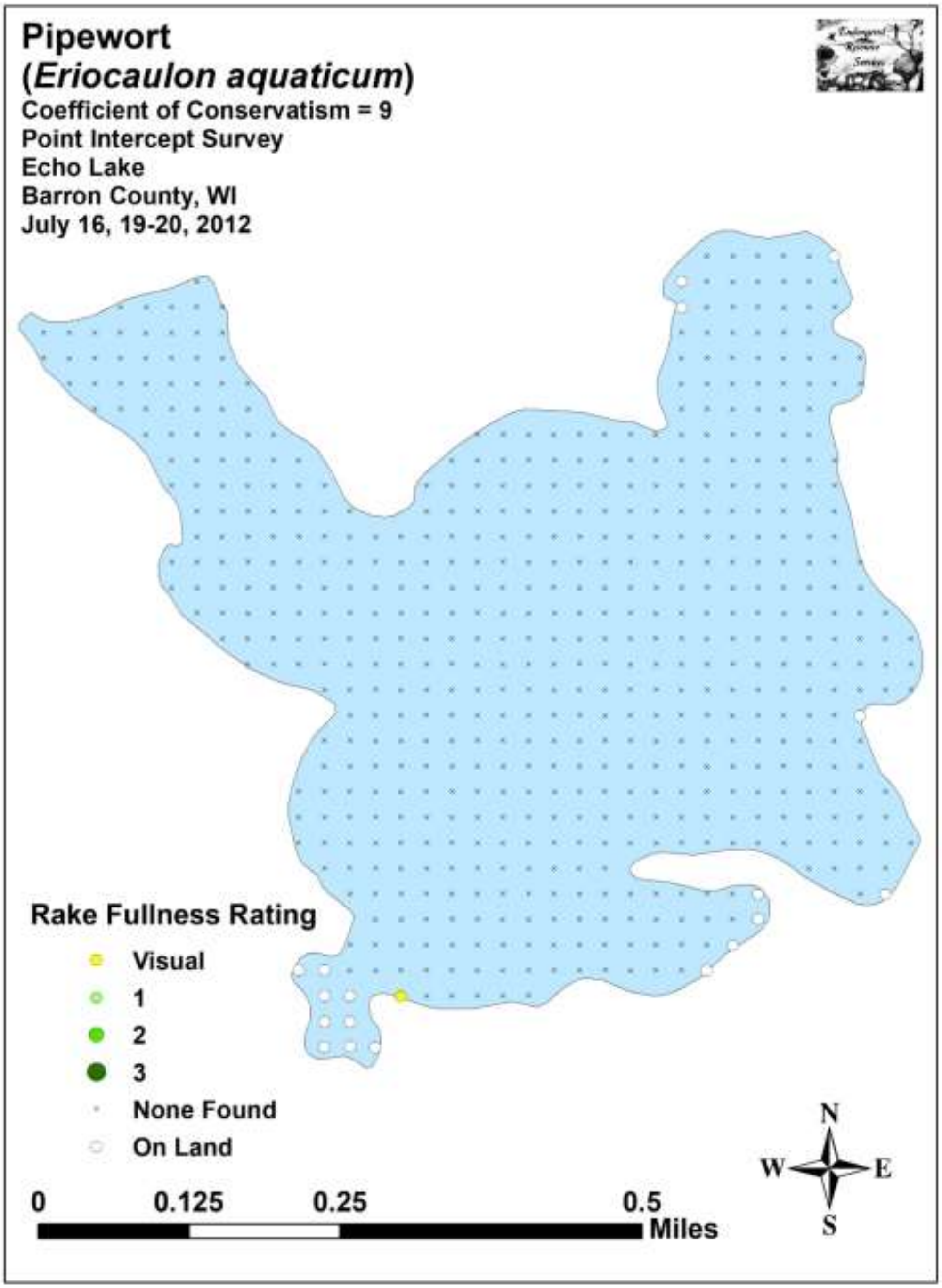
Pipewort
(*Eriocaulon aquaticum*)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.5
Miles
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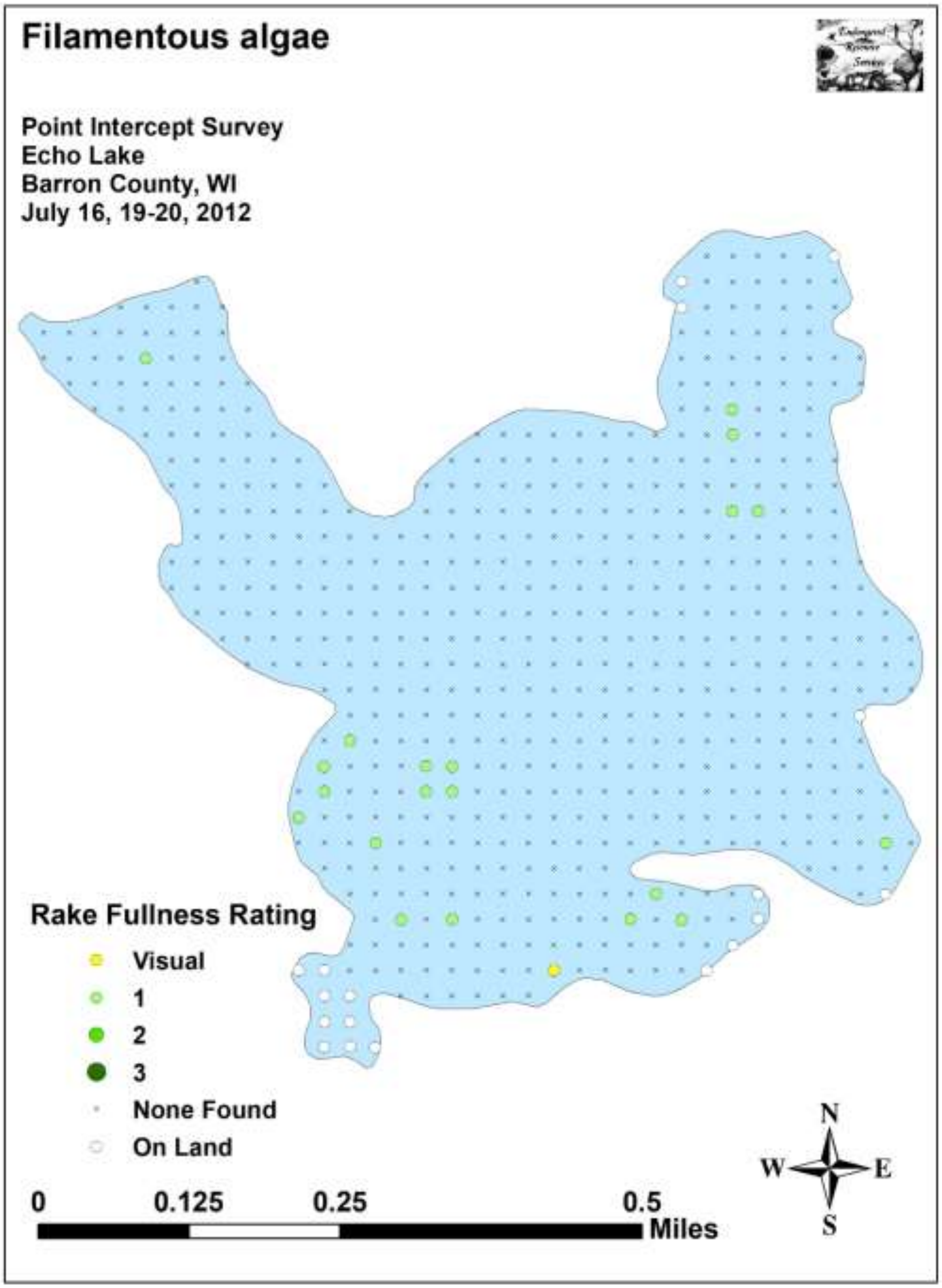
Filamentous algae
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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0.5
Miles
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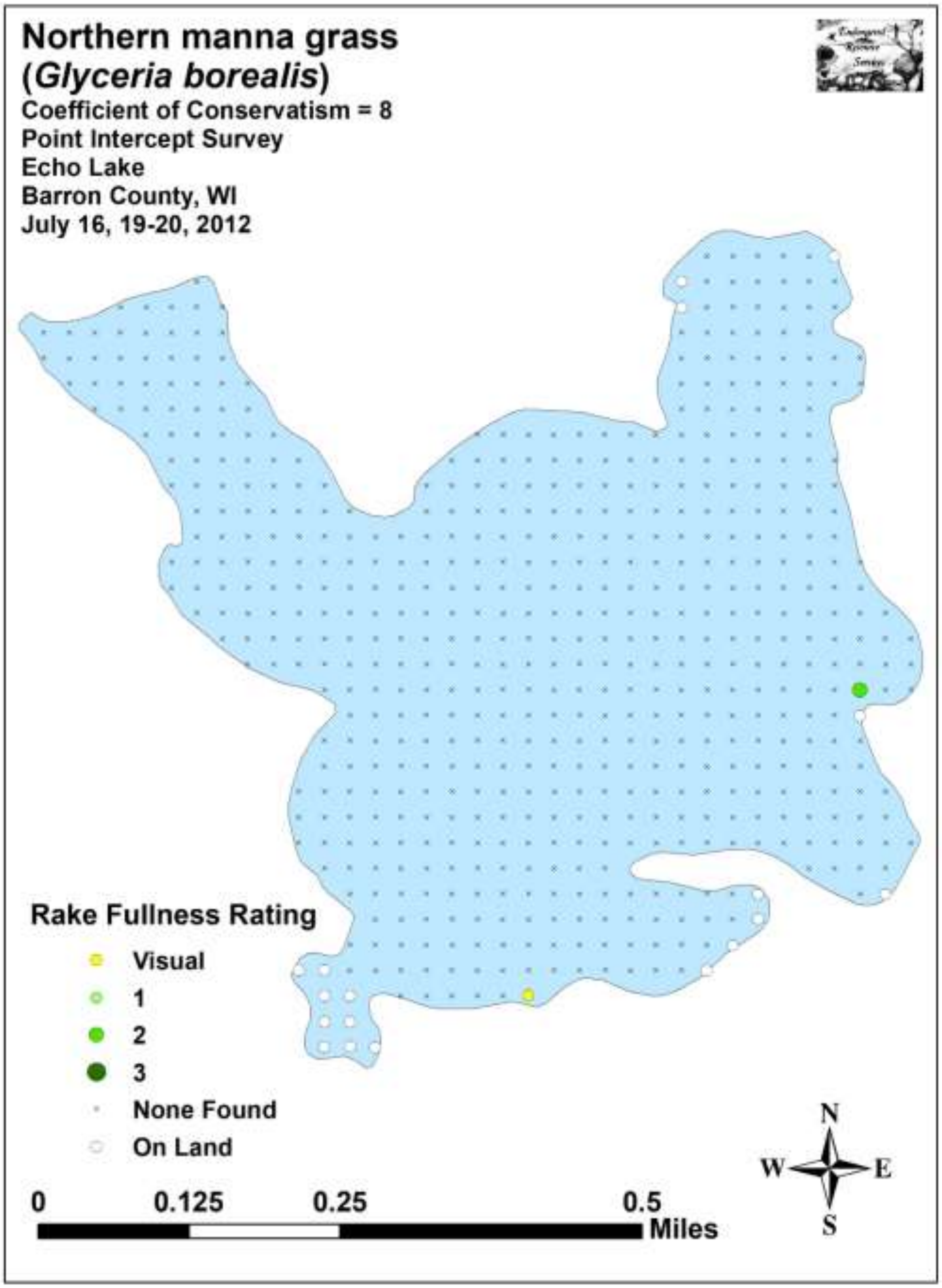
Northern manna grass
(Glyceria borealis)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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Miles
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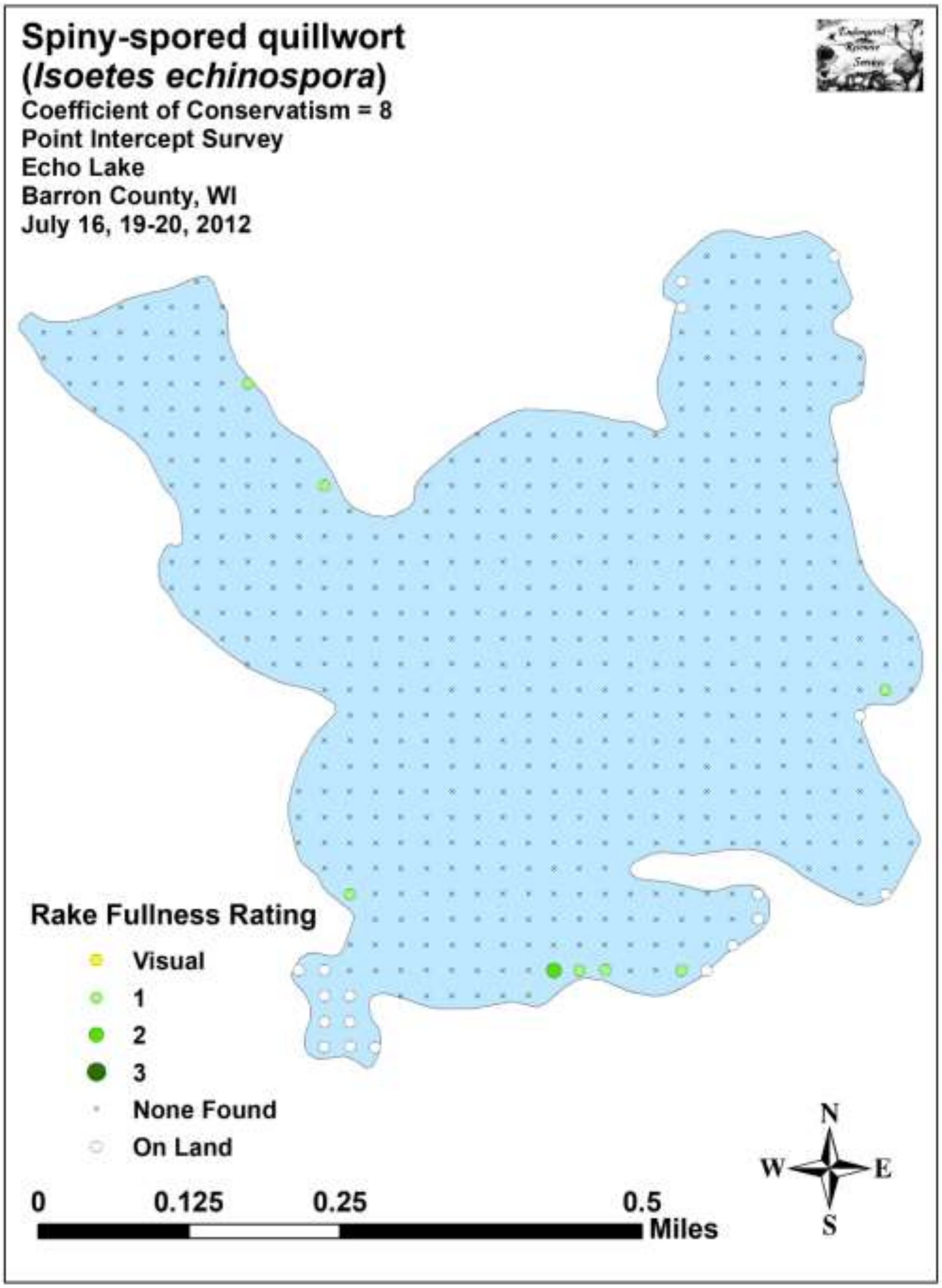

Spiny-spored quillwort
(*Isoetes echinospora*)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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Miles
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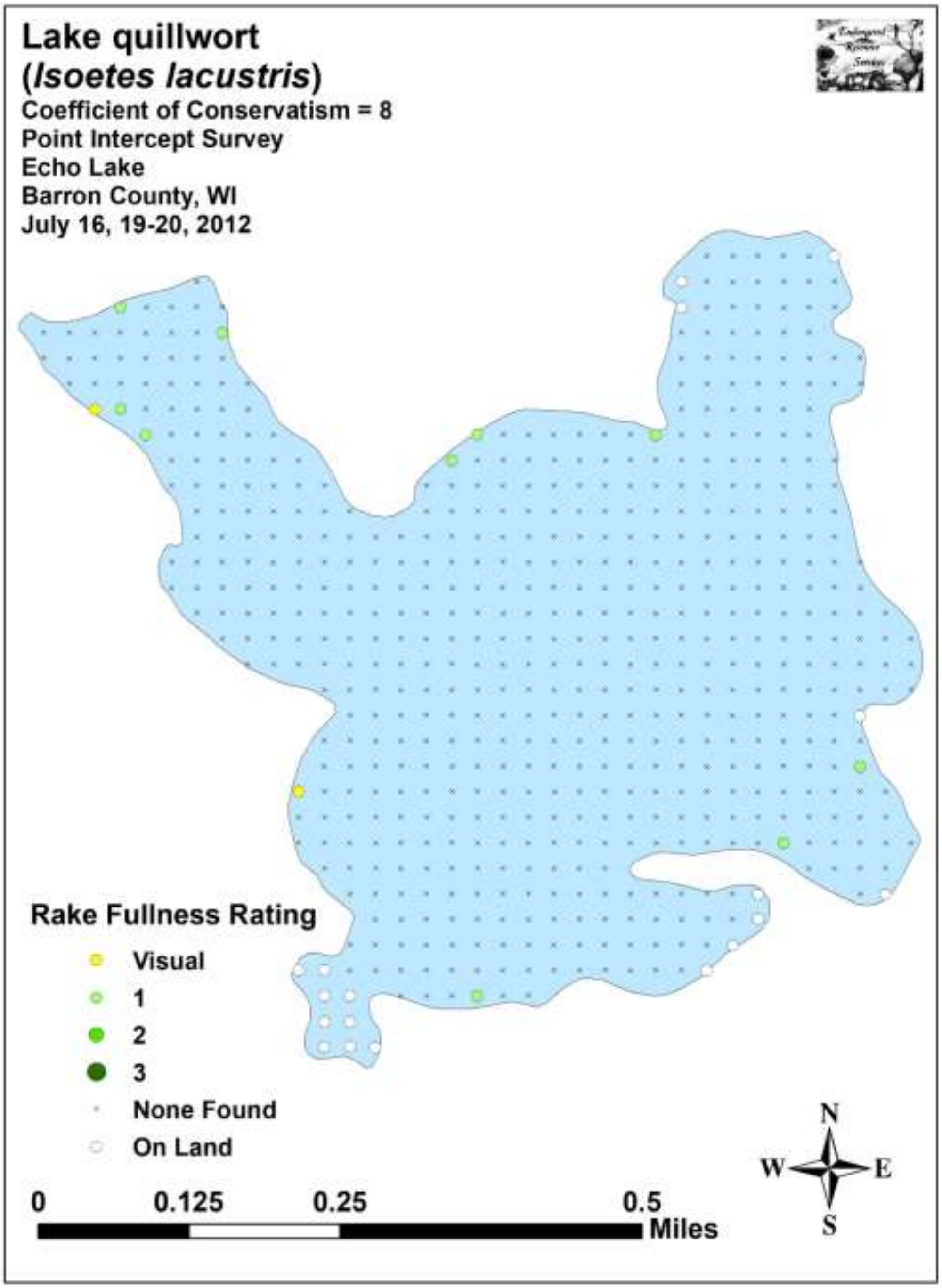
Lake quillwort
(Isoetes lacustris)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.5
Miles
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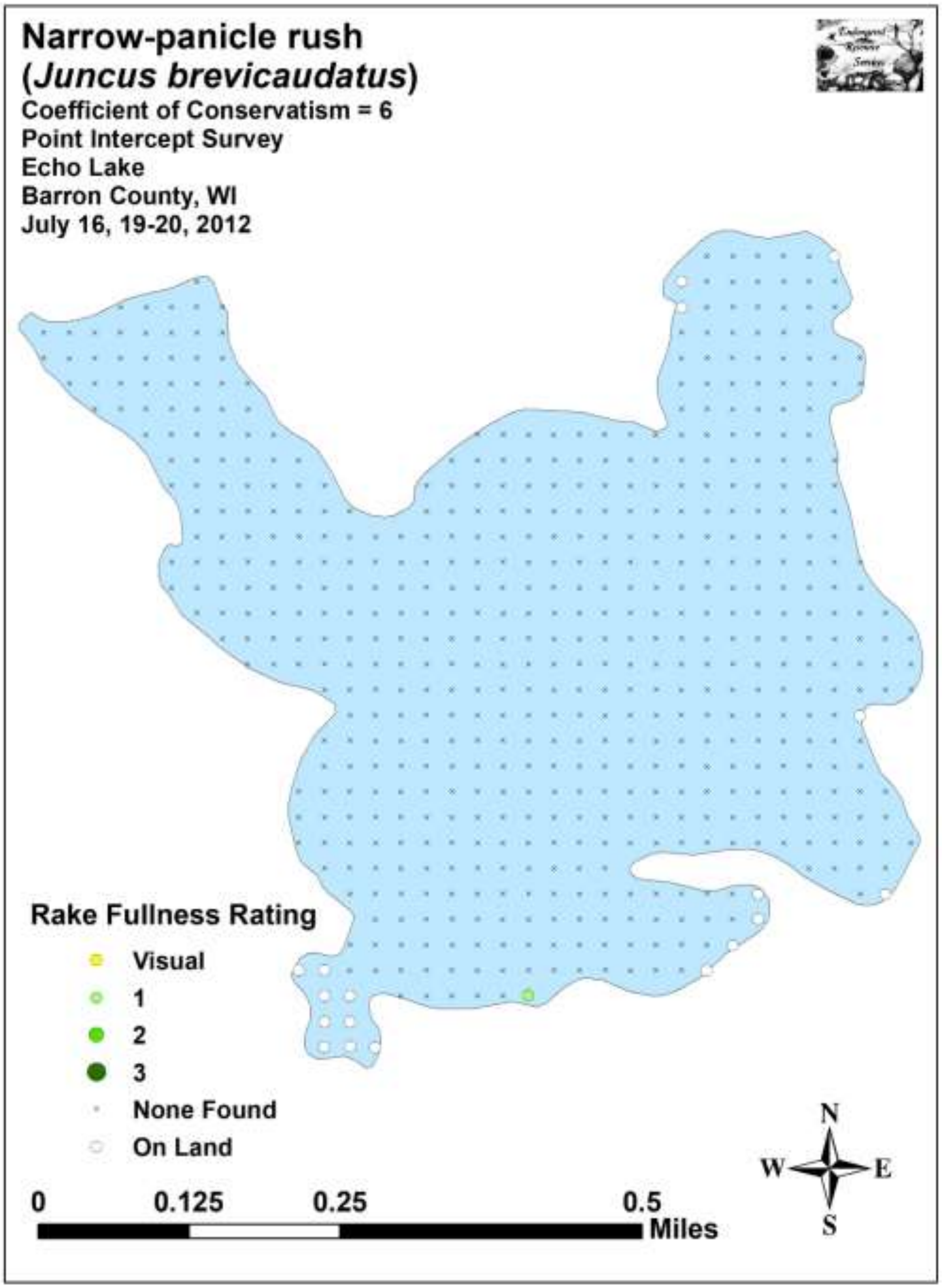

Narrow-panicle rush
(Juncus brevicaudatus)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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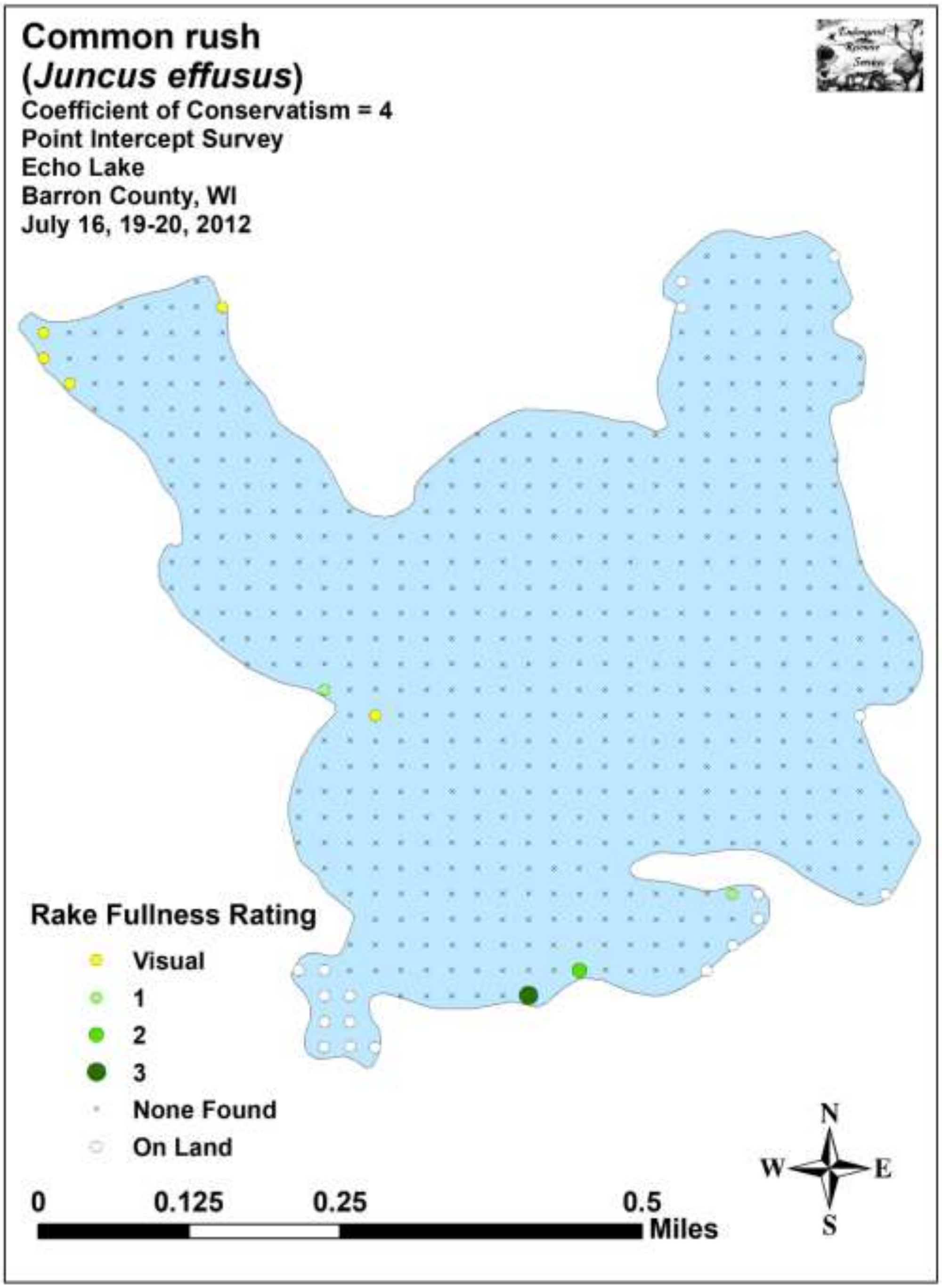
Common rush
(Juncus effusus)
Coefficient of Conservatism = 4
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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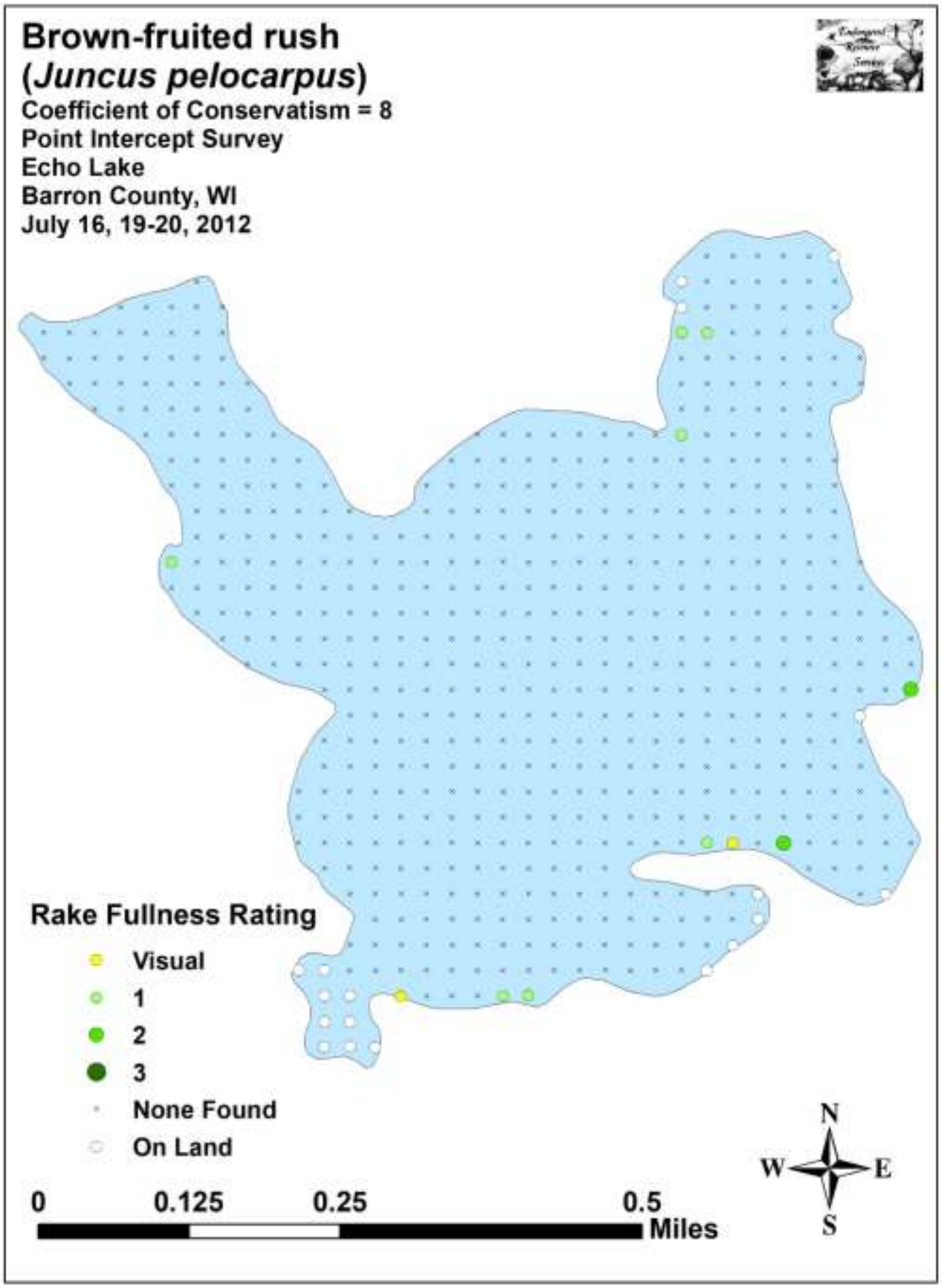
Brown-fruited rush
(Juncus pelocarpus)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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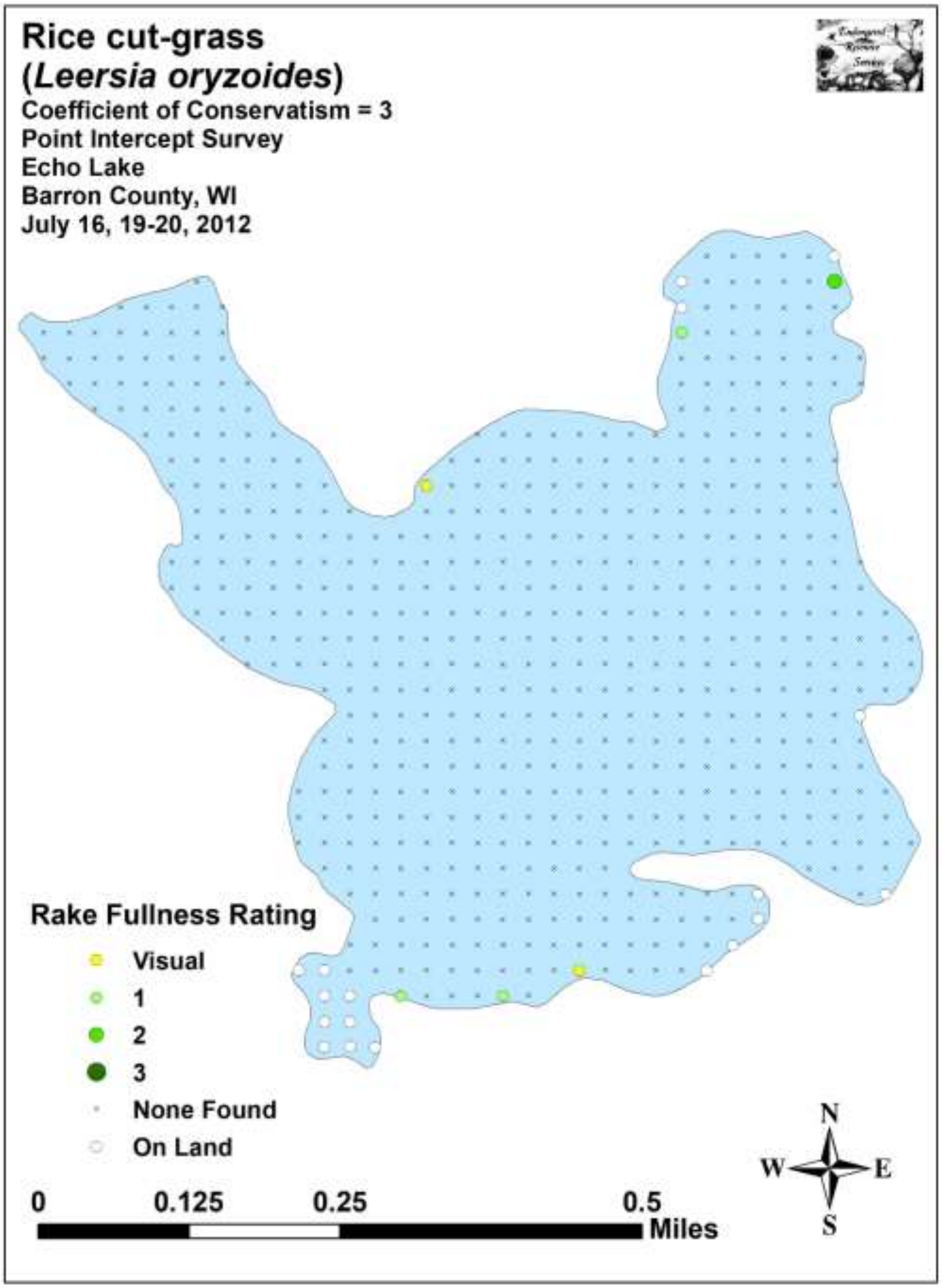
Miles


Rice cut-grass
(*Leersia oryzoides*)
Coefficient of Conservatism = 3
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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Miles
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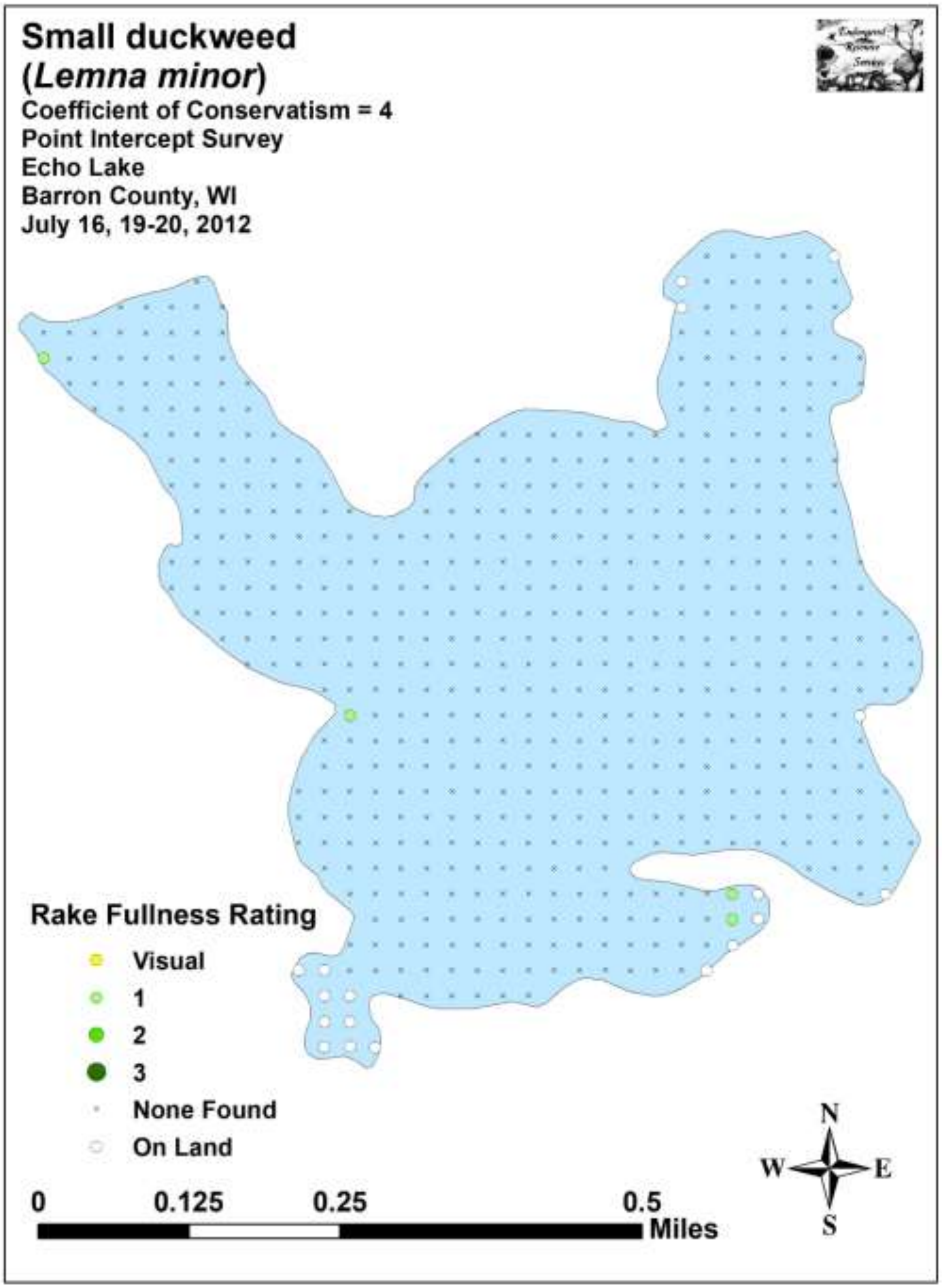
Small duckweed
(Lemna minor)
Coefficient of Conservatism = 4
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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Miles
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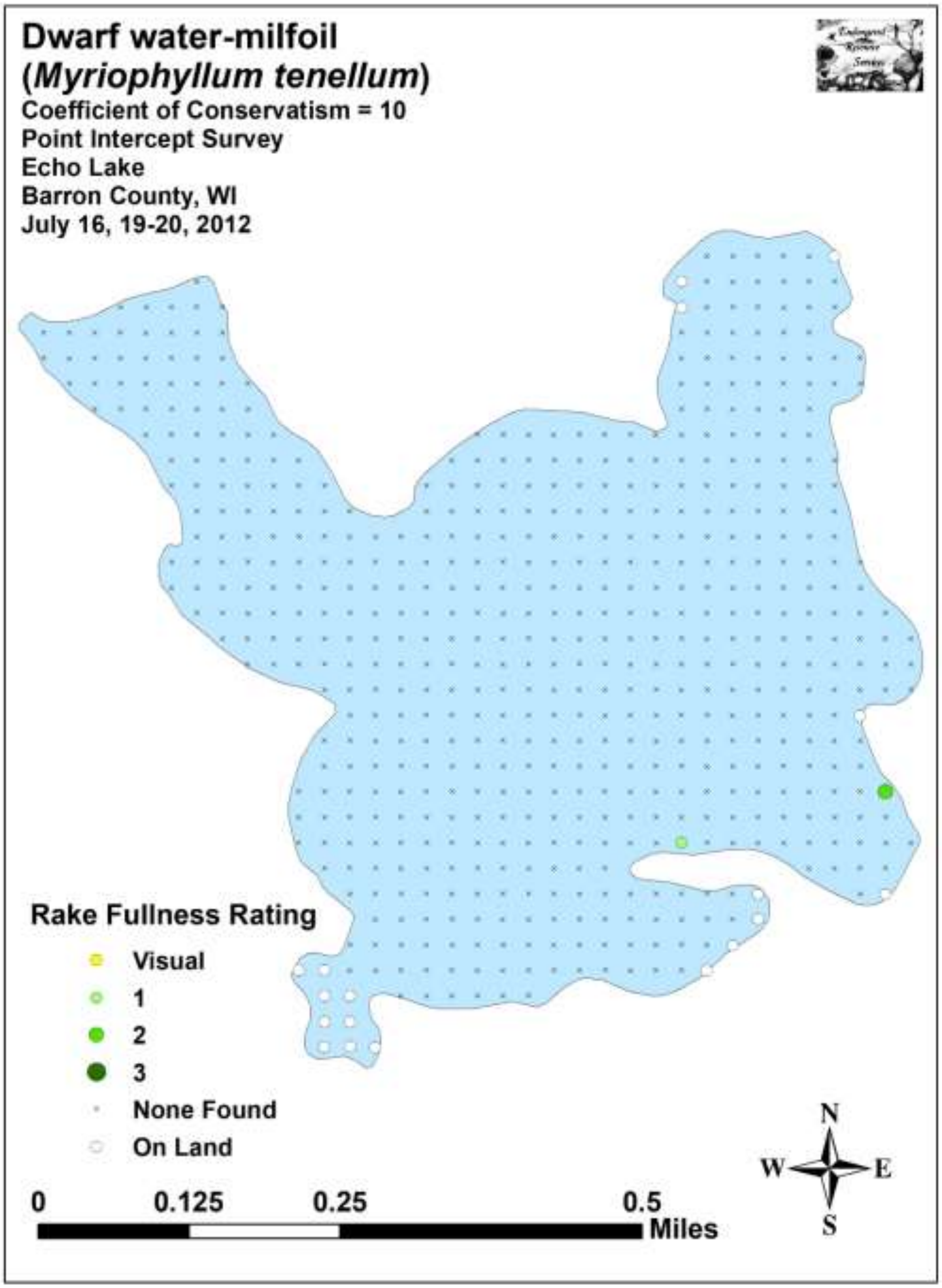
Dwarf water-milfoil
(Myriophyllum tenellum)
Coefficient of Conservatism = 10
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.5
Miles
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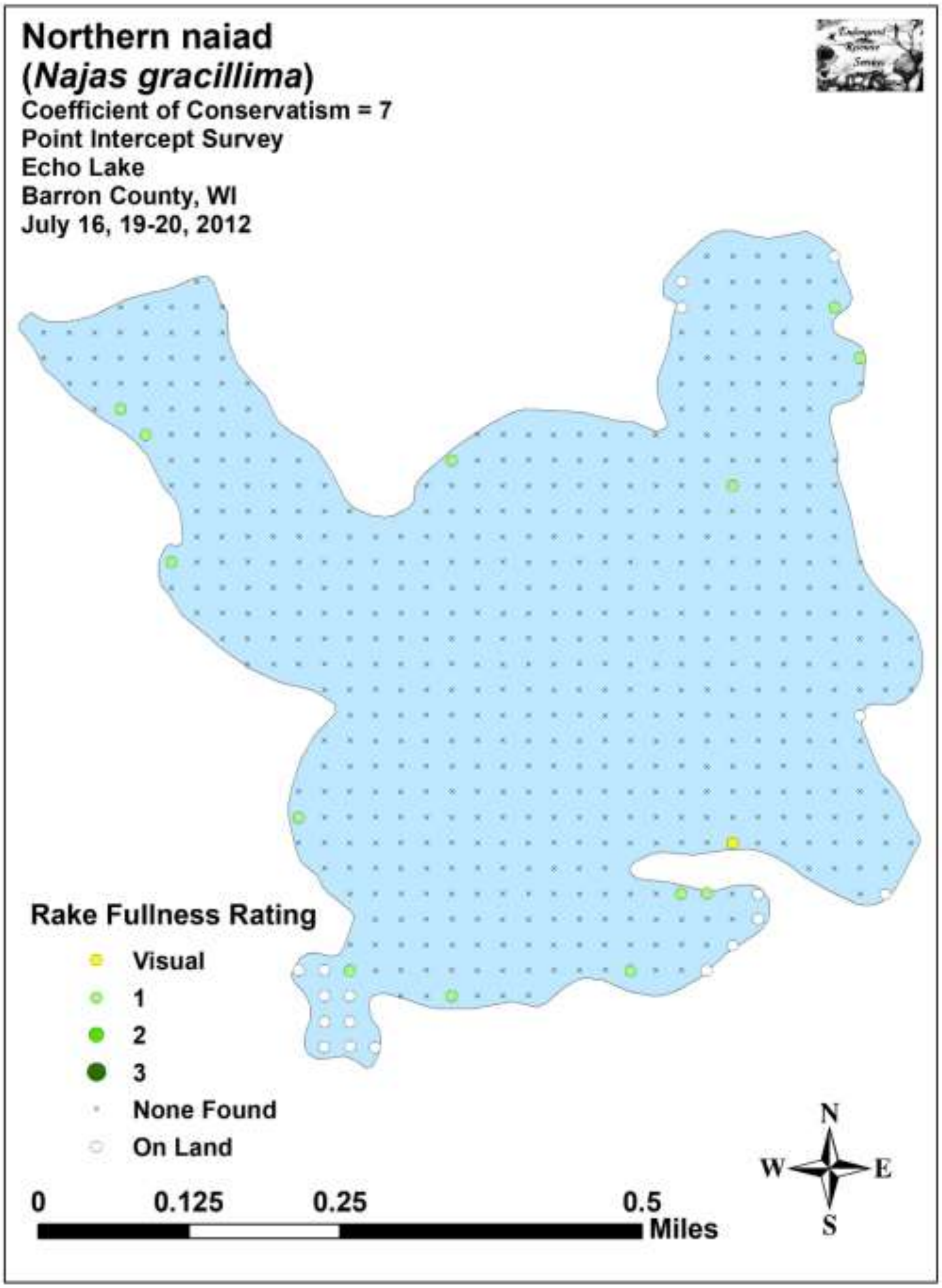

Northern naiad
(*Najas gracillima*)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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0.5
Miles
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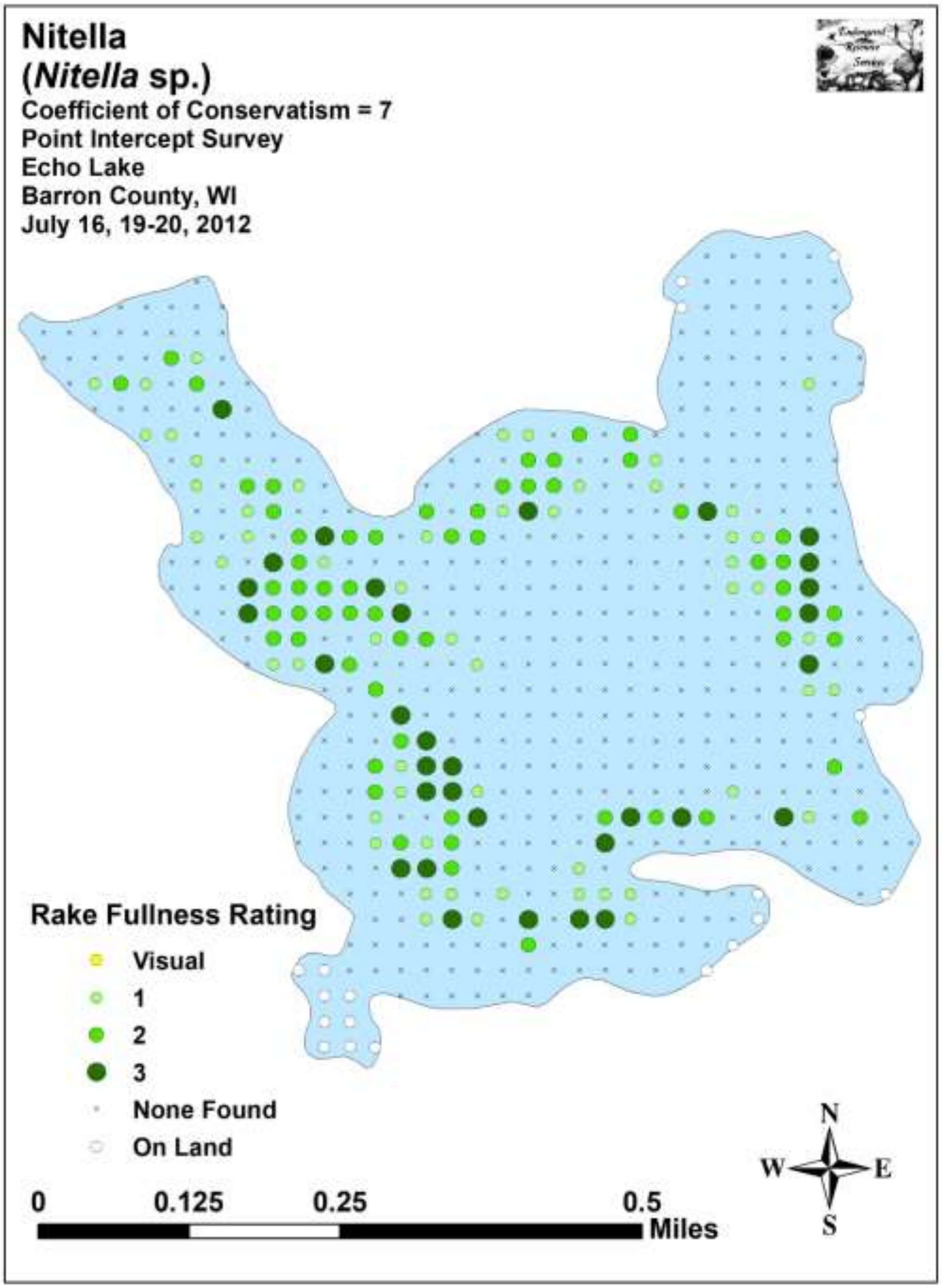
Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
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None Found
On Land
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0.125
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0.5
Miles
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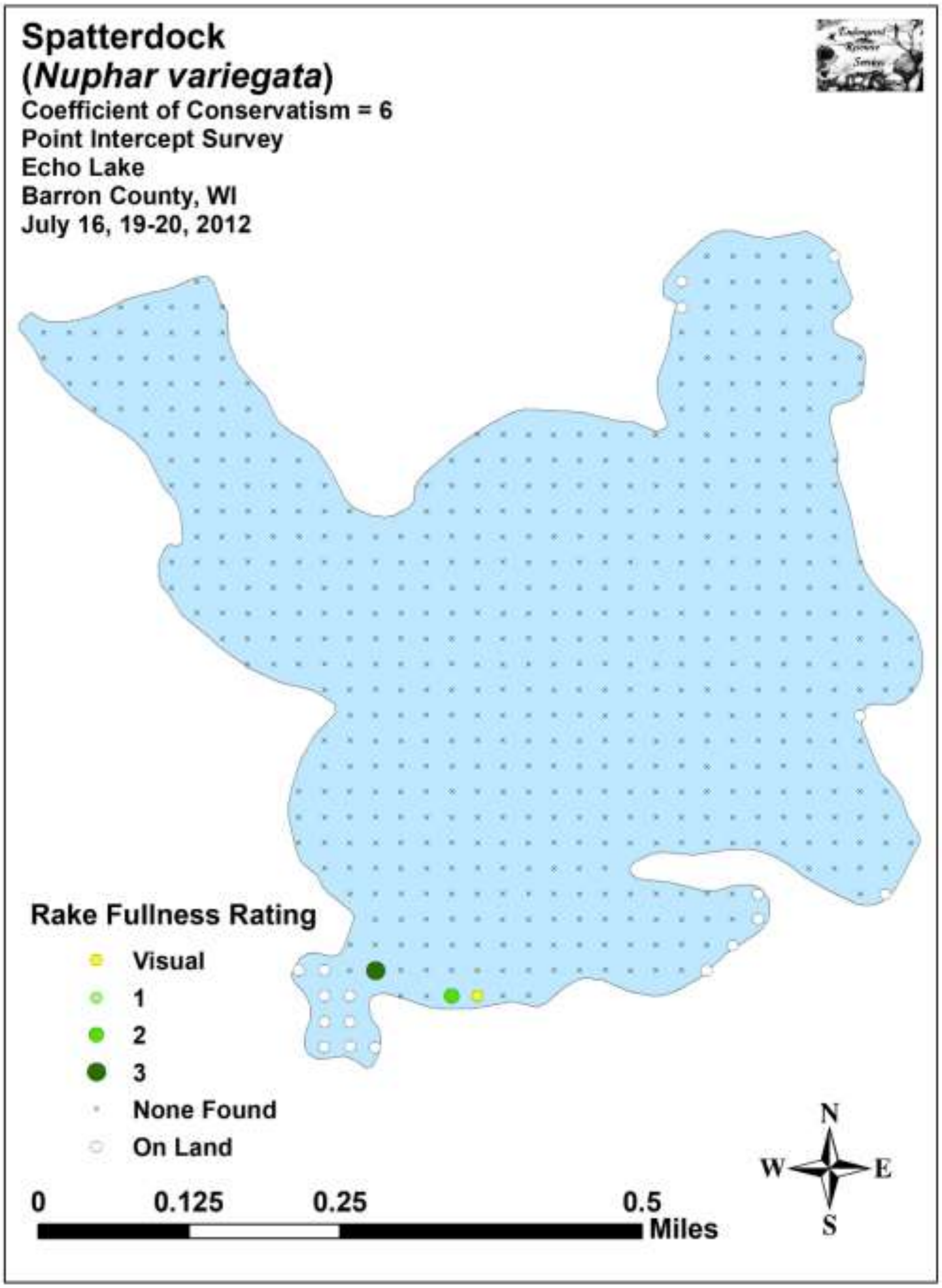
Spatterdock
(*Nuphar variegata*)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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Miles
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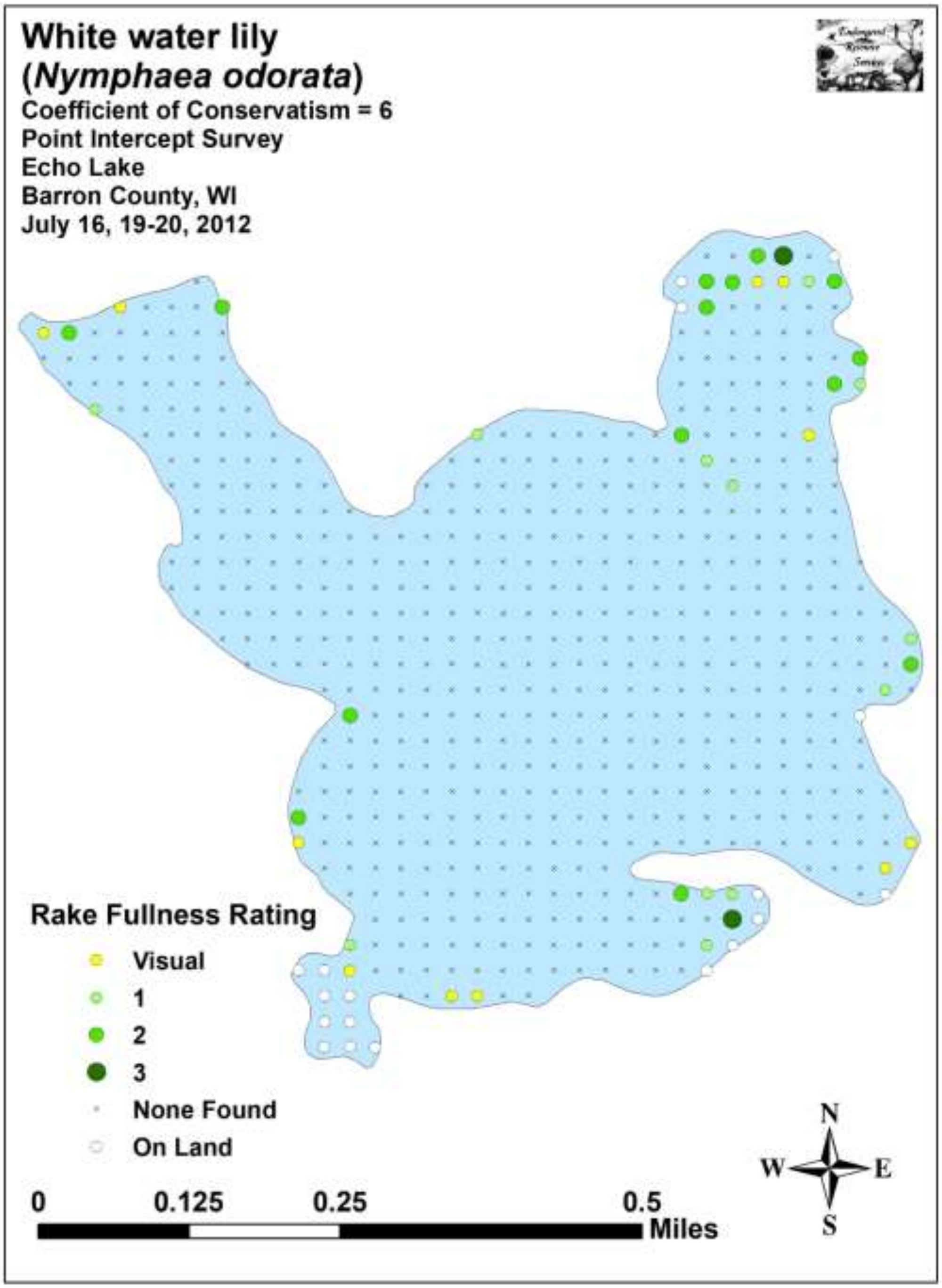

White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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0.5
Miles
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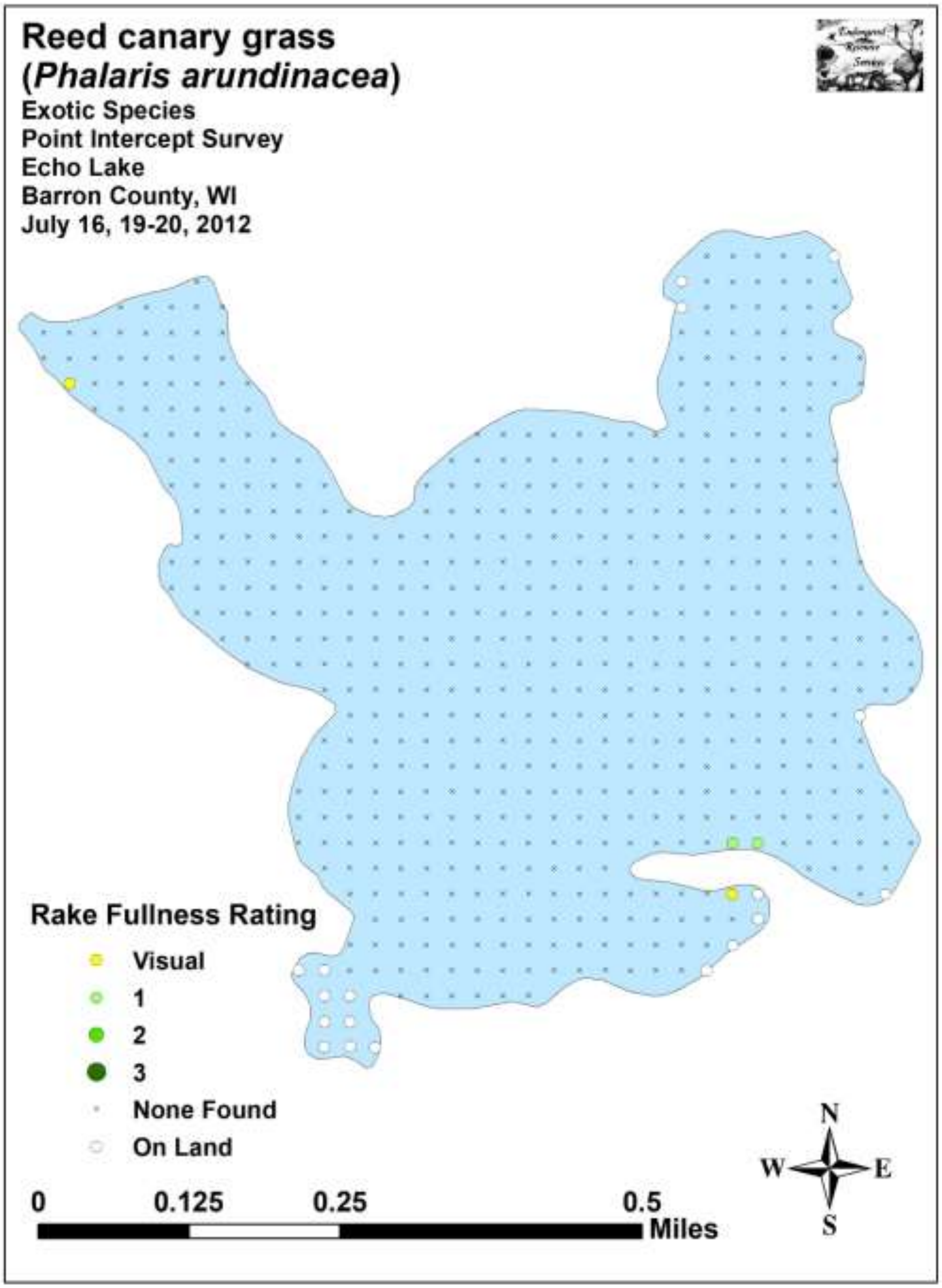

Reed canary grass
(*Phalaris arundinacea*)
Exotic Species
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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Miles
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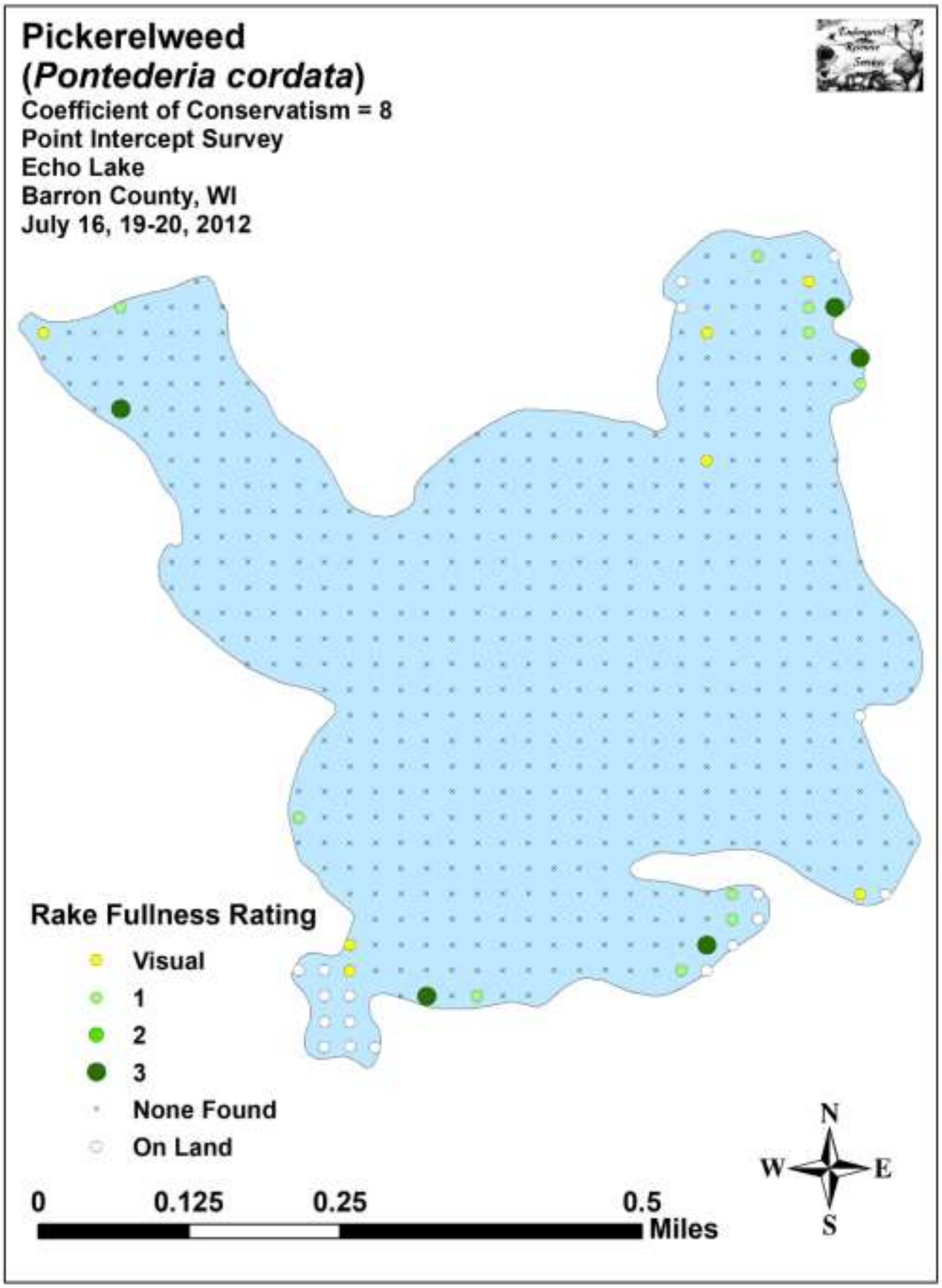
Pickerelweed
(Pontederia cordata)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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Miles
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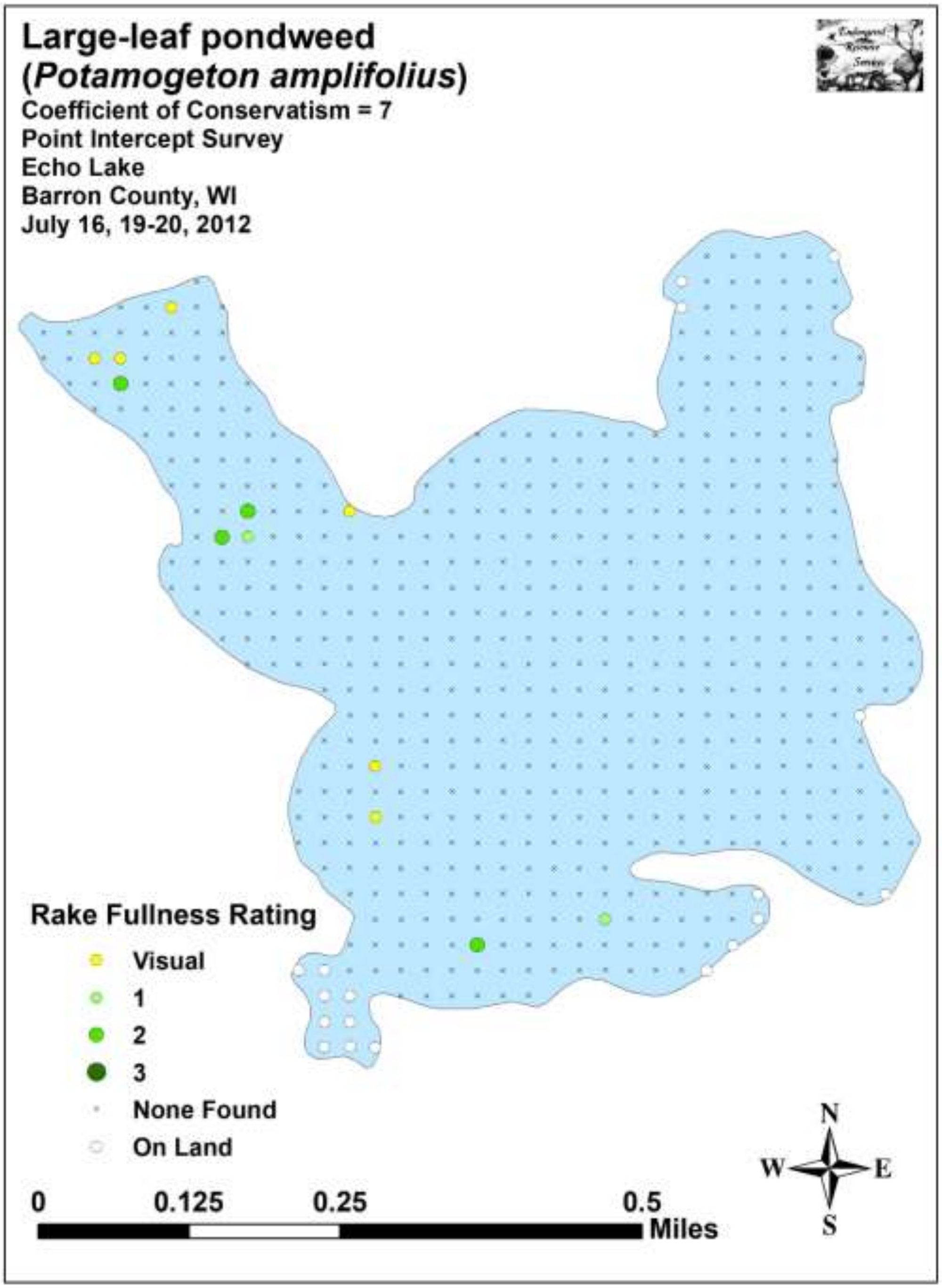

Large-leaf pondweed
(*Potamogeton amplifolius*)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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Miles
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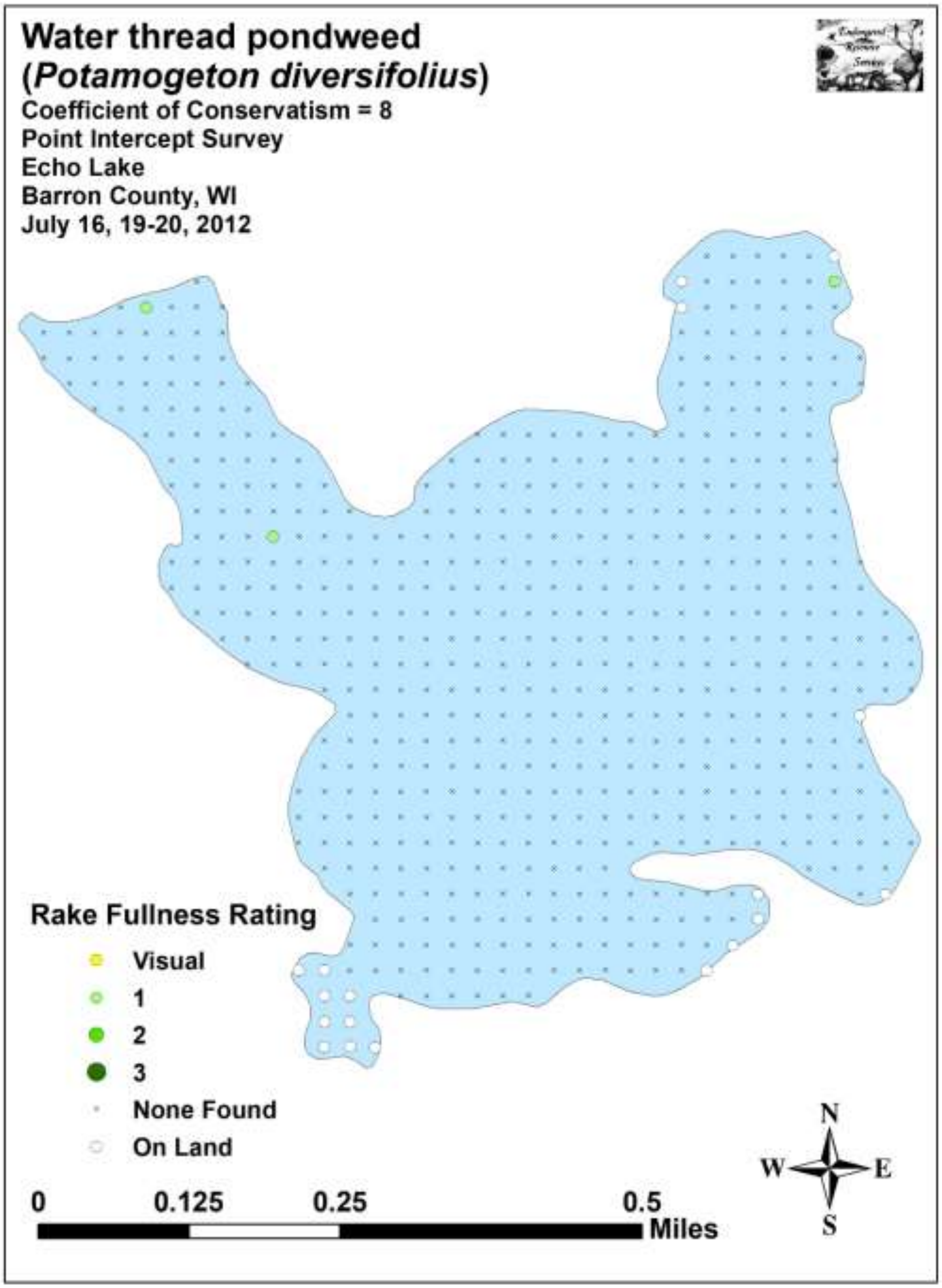
Water thread pondweed
(Potamogeton diversifolius)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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0.125
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Miles
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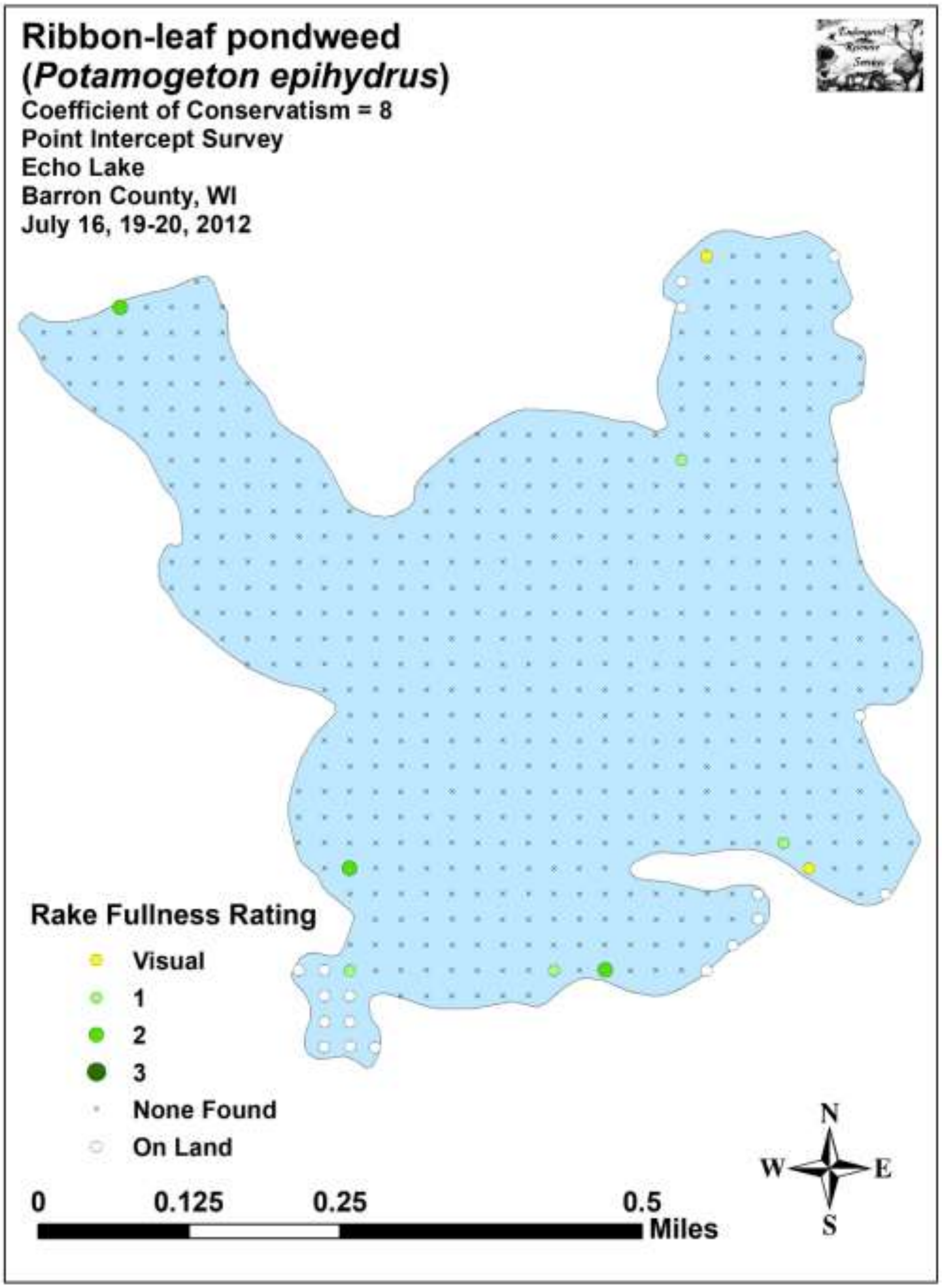

Ribbon-leaf pondweed
(Potamogeton epihydrus)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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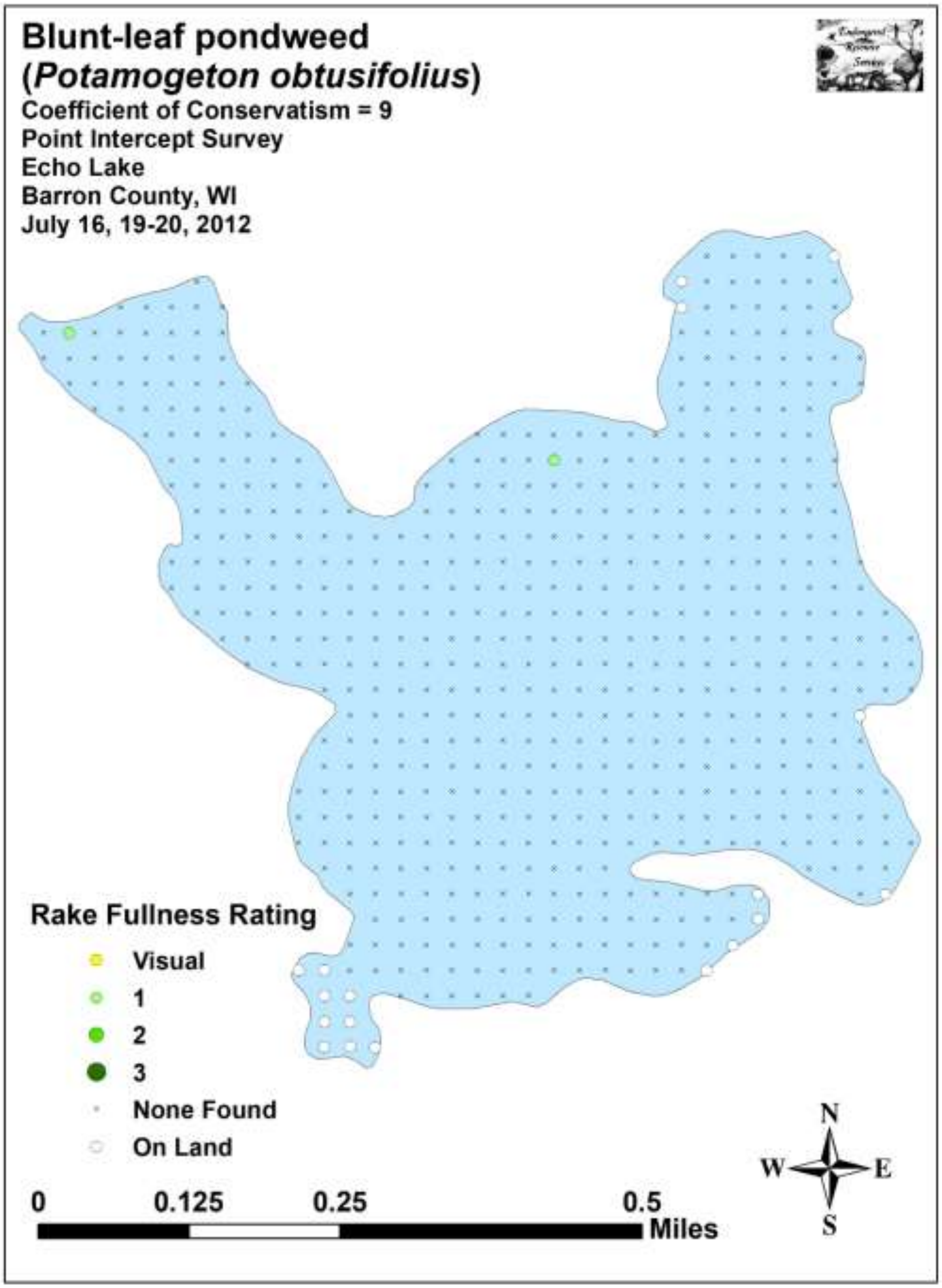
Blunt-leaf pondweed
(Potamogeton obtusifolius)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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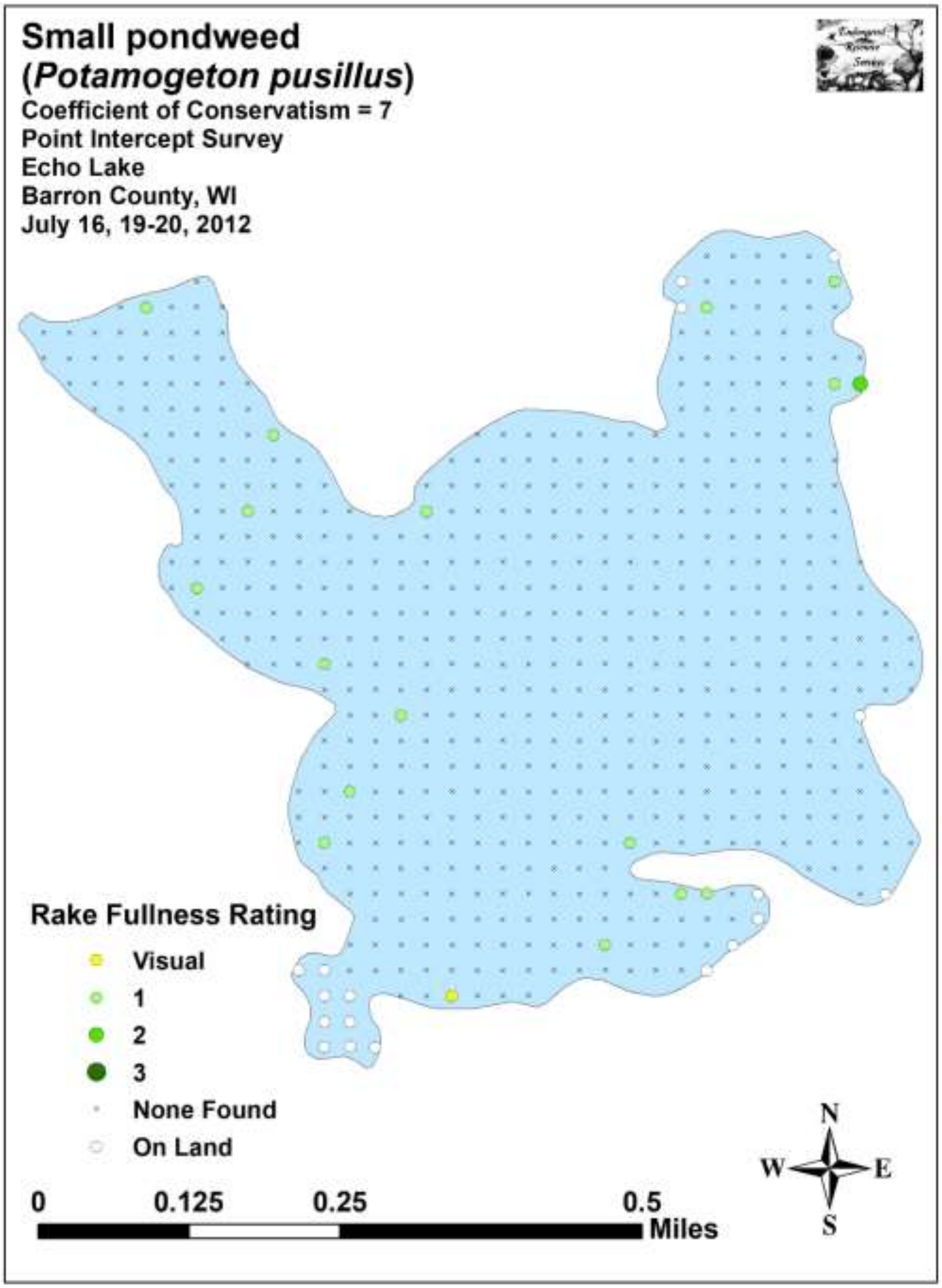
Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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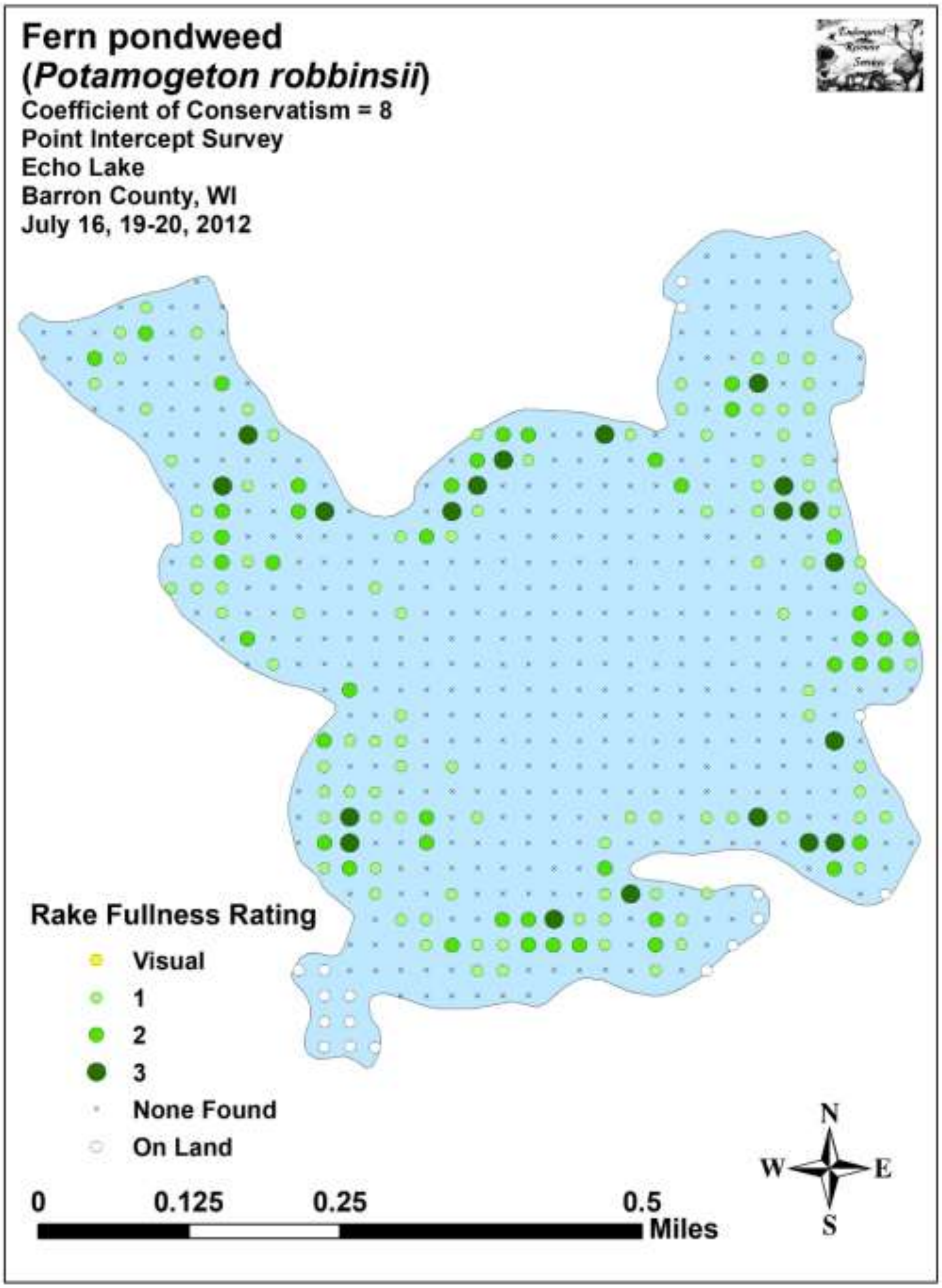
Fern pondweed
(Potamogeton robbinsii)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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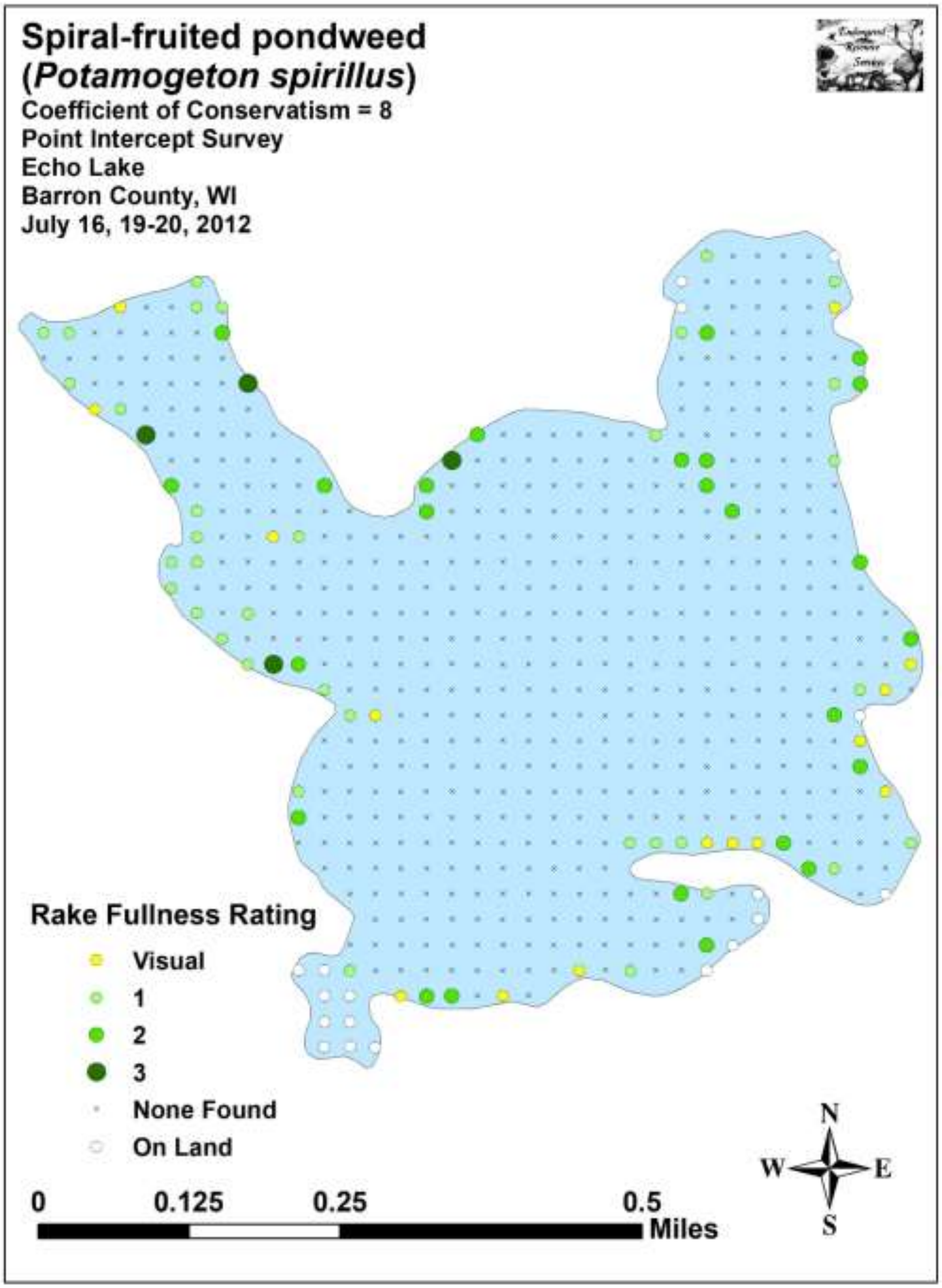
Spiral-fruited pondweed
(*Potamogeton spirillus*)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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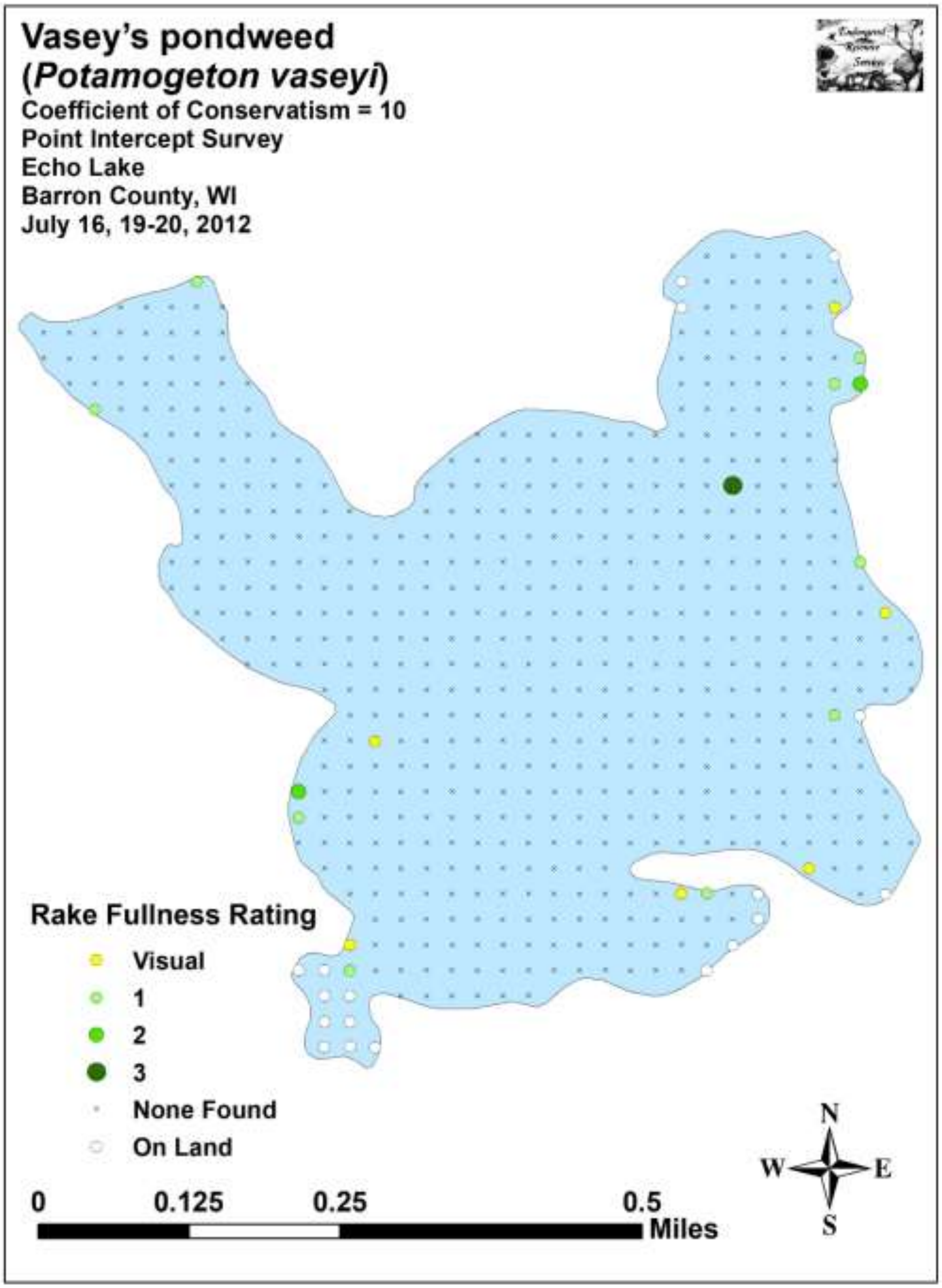
Vasey's pondweed
(*Potamogeton vaseyi*)
Coefficient of Conservatism = 10
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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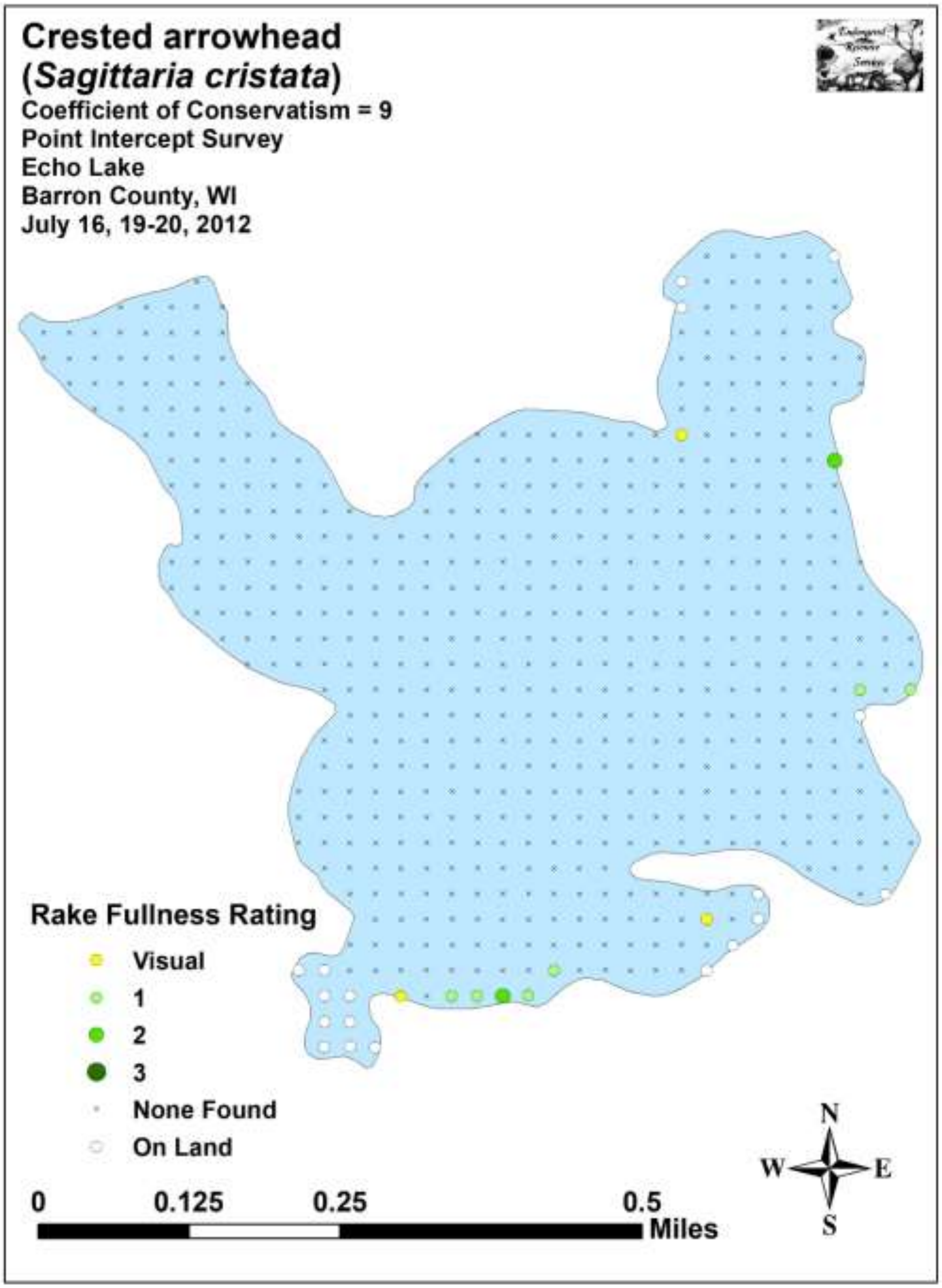
Miles



Crested arrowhead
(Sagittaria cristata)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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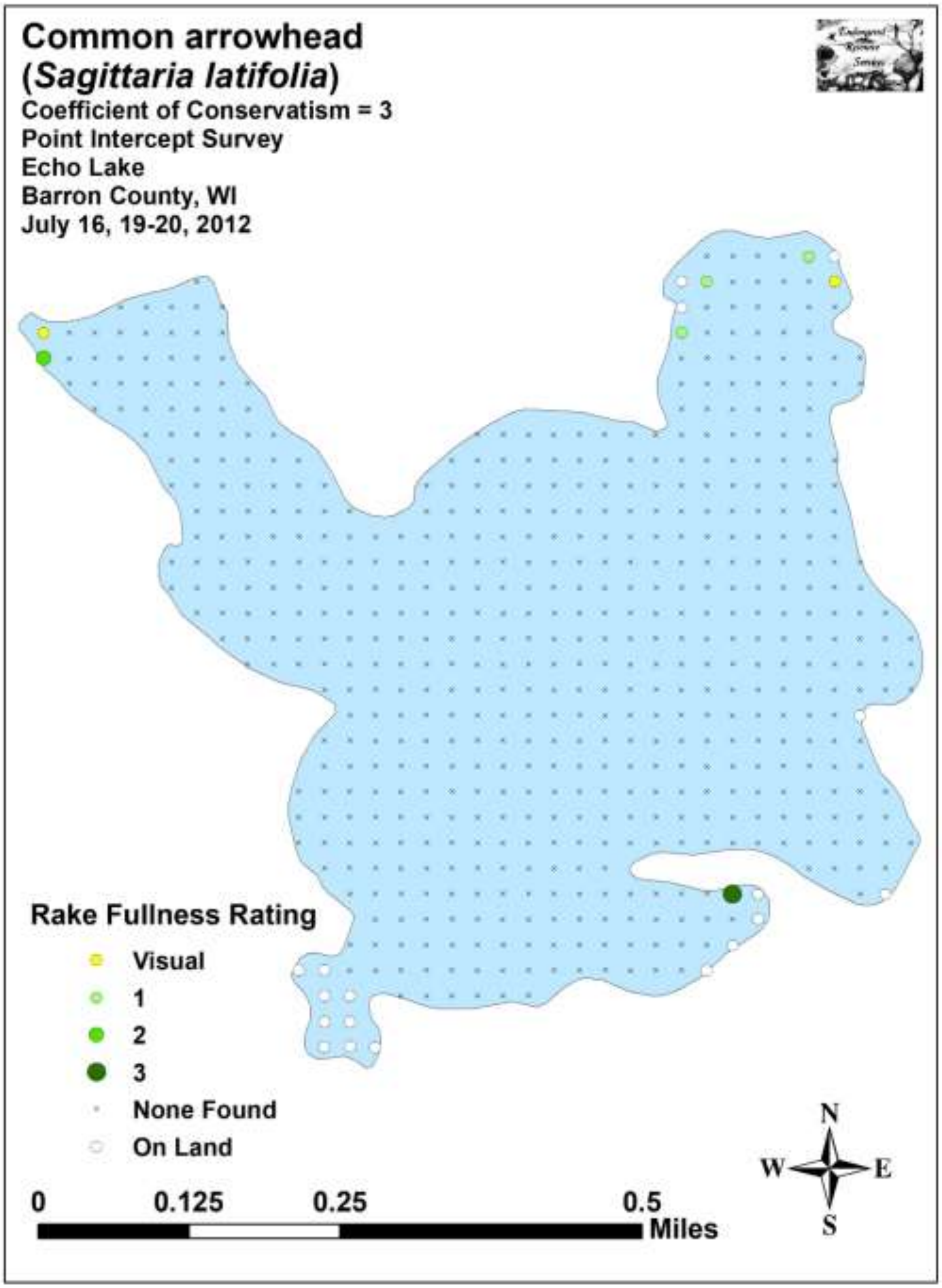
Common arrowhead
(*Sagittaria latifolia*)
Coefficient of Conservatism = 3
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
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None Found
On Land
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Miles
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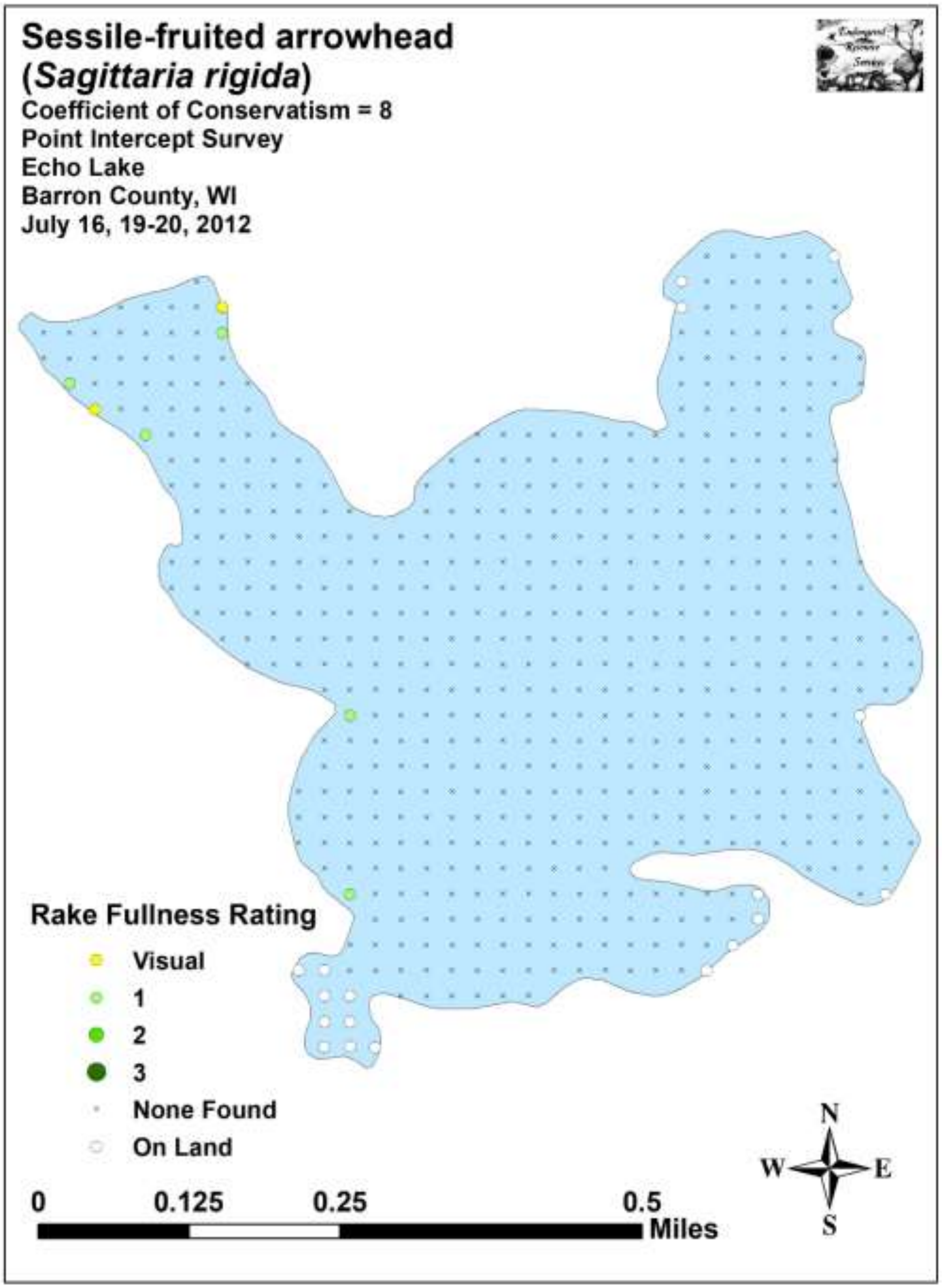
Sessile-fruited arrowhead
(*Sagittaria rigida*)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
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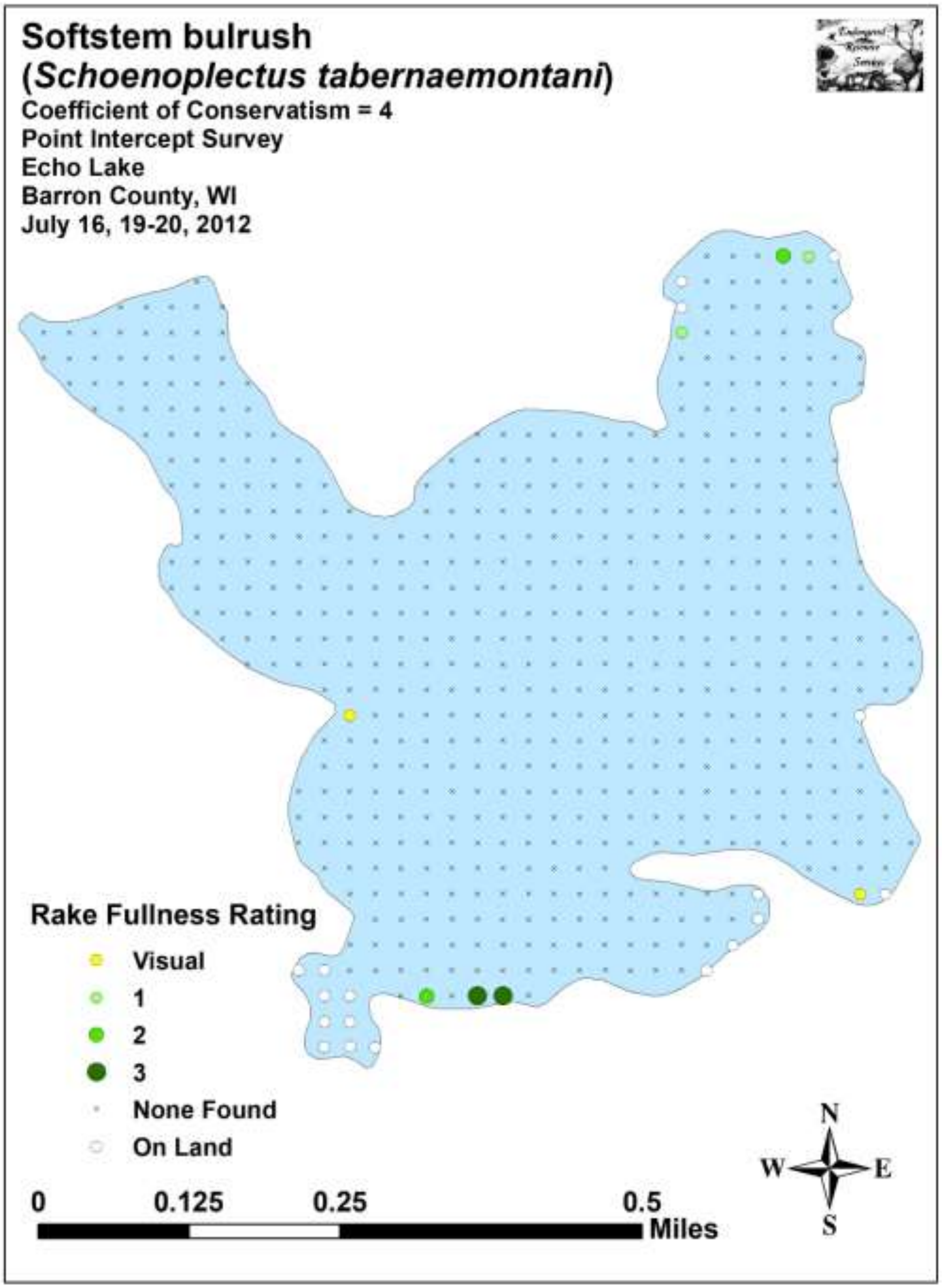
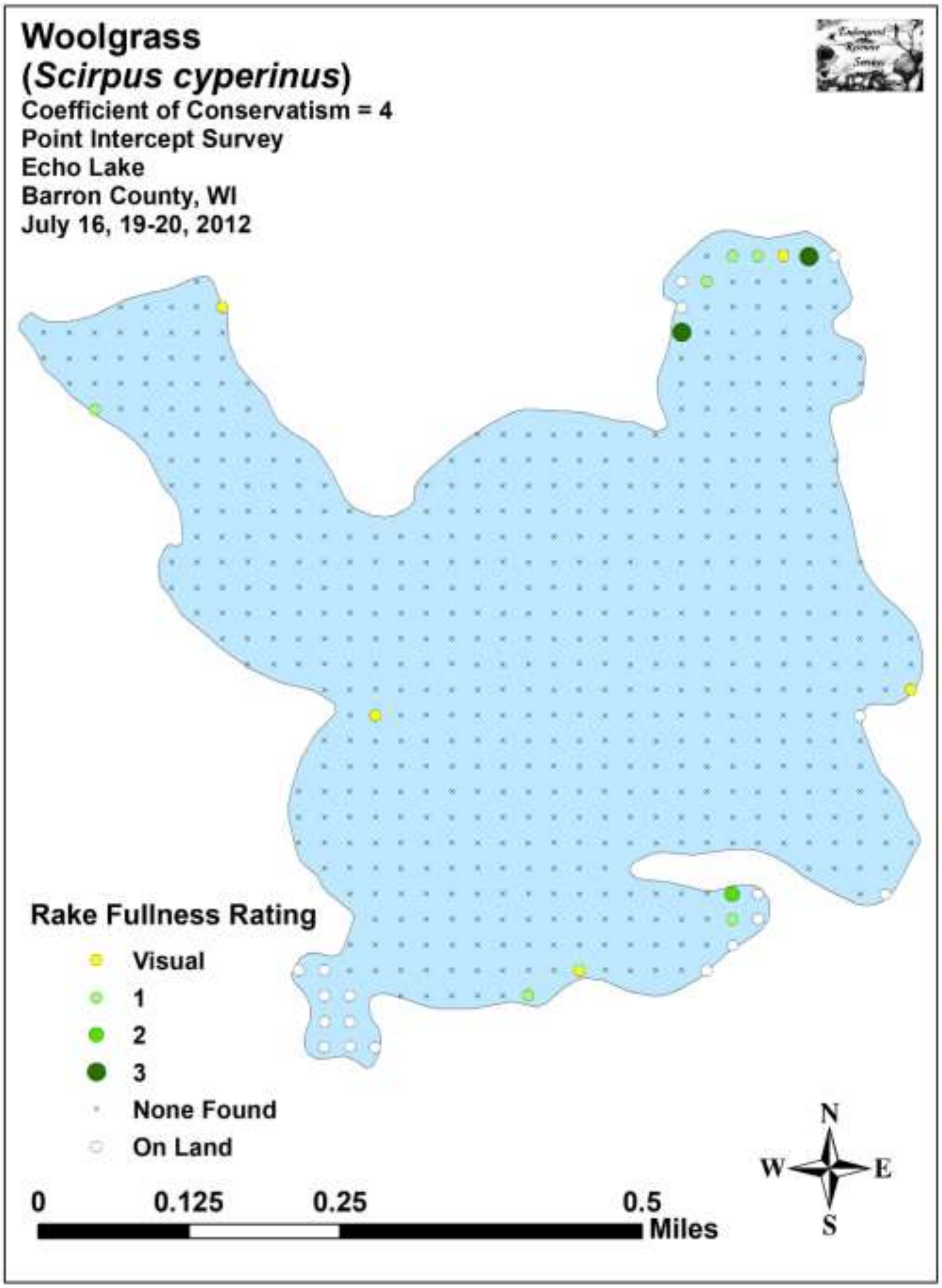
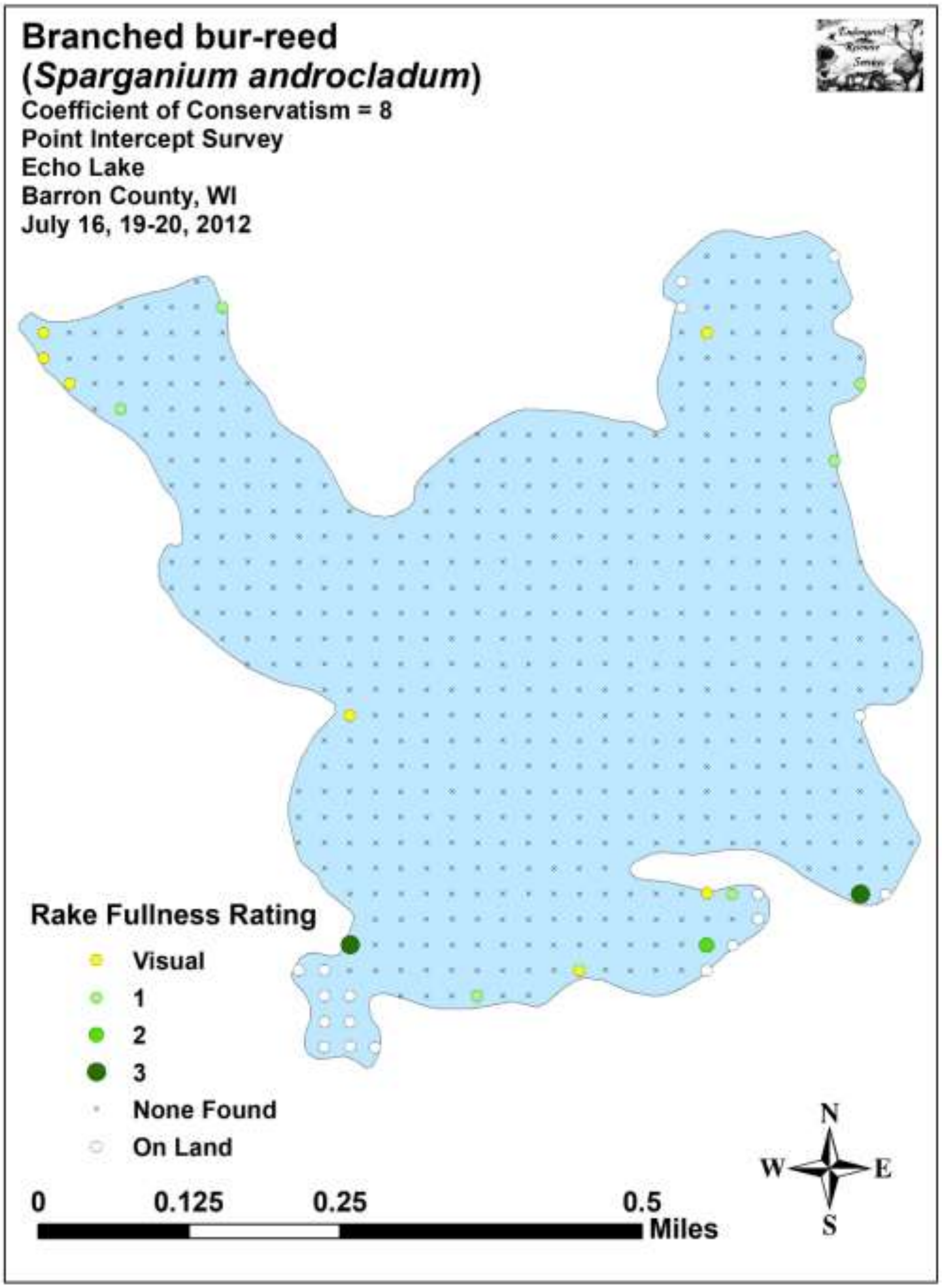
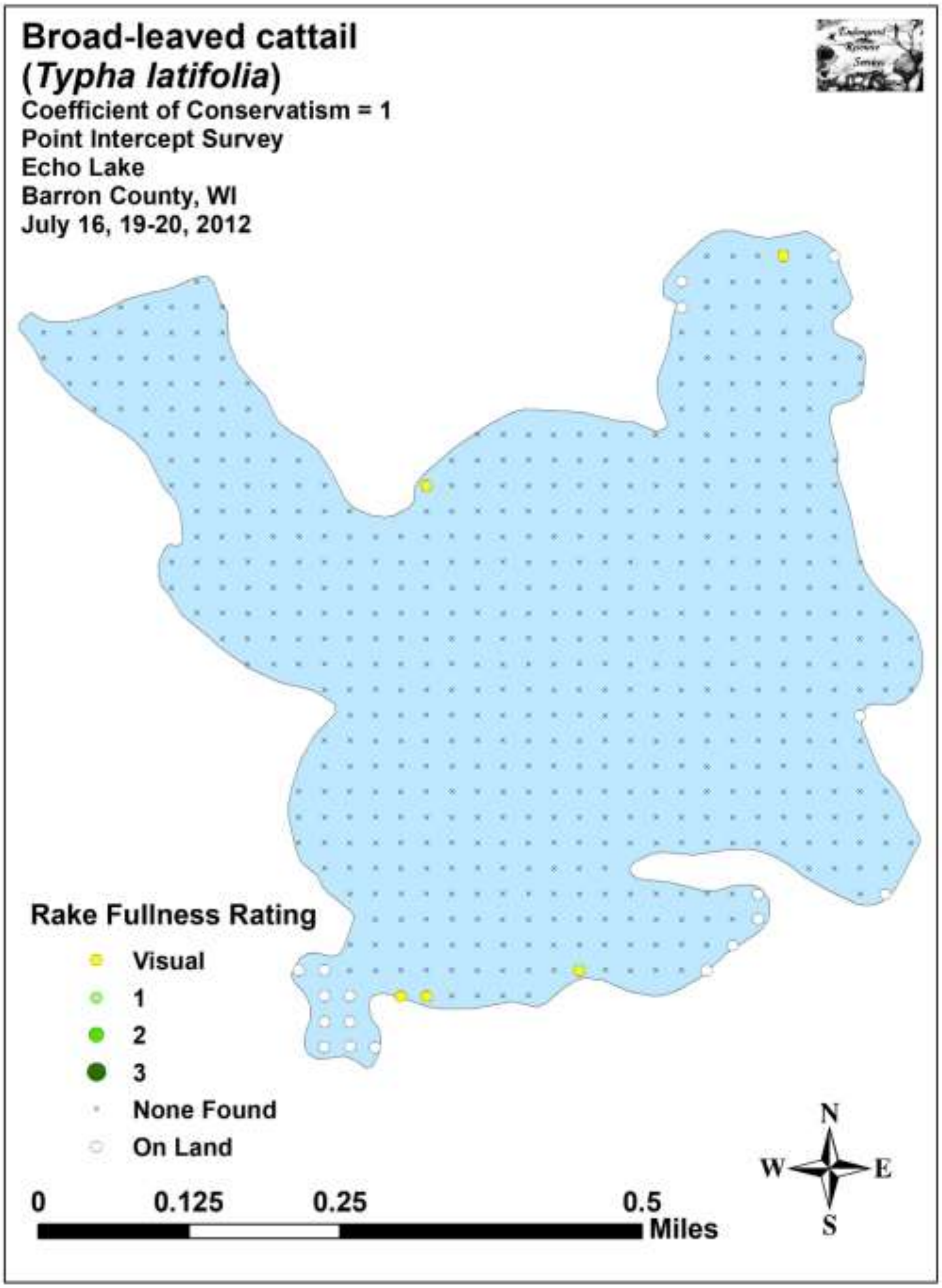
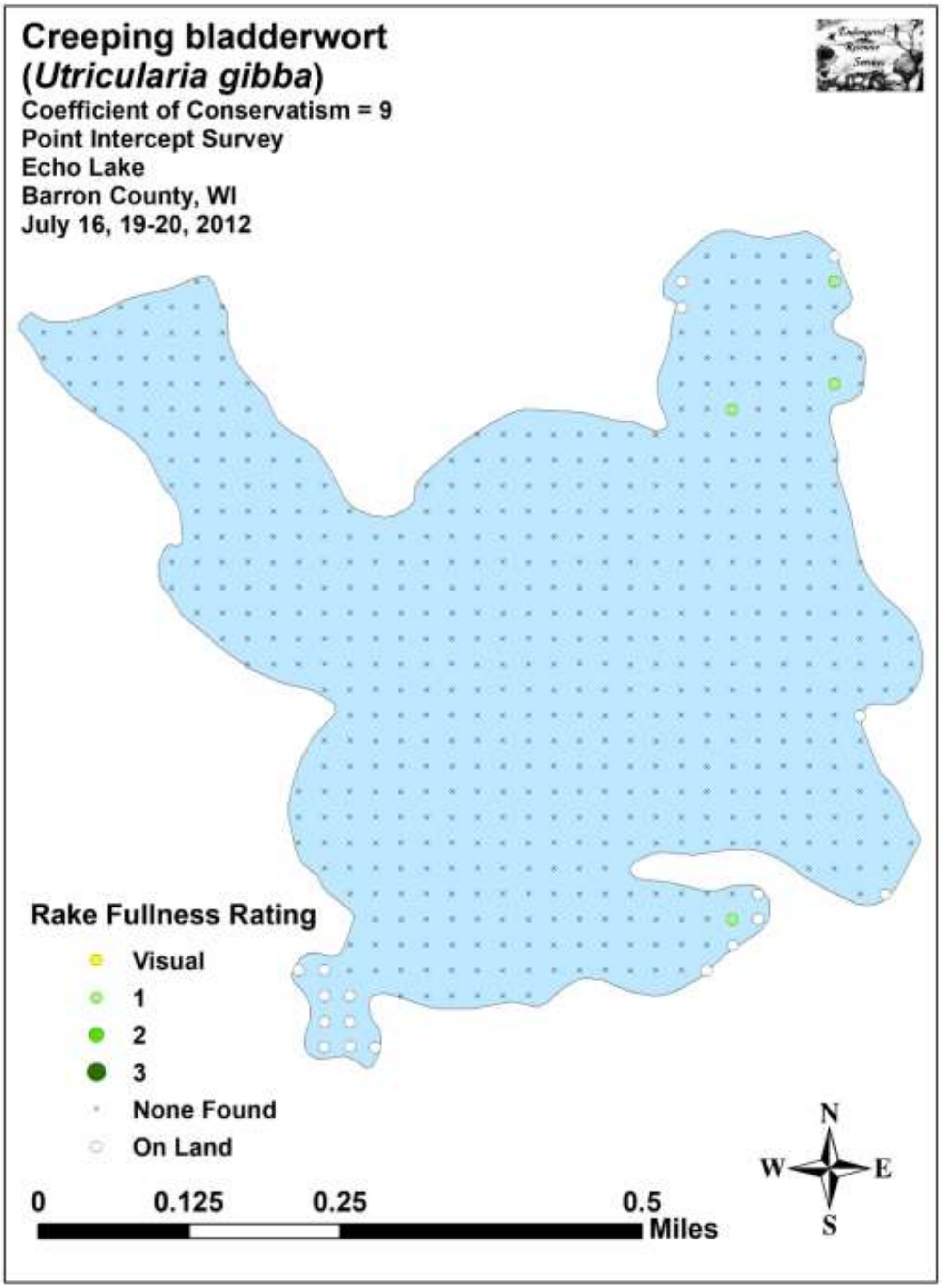
0.125
0.25
0.5
Miles
N
W
E
S


Softstem bulrush
(Schoenoplectus tabernaemontani)
Coefficient of Conservatism = 4
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
N
W
E
S
0
0.125
0.25
0.5
Miles

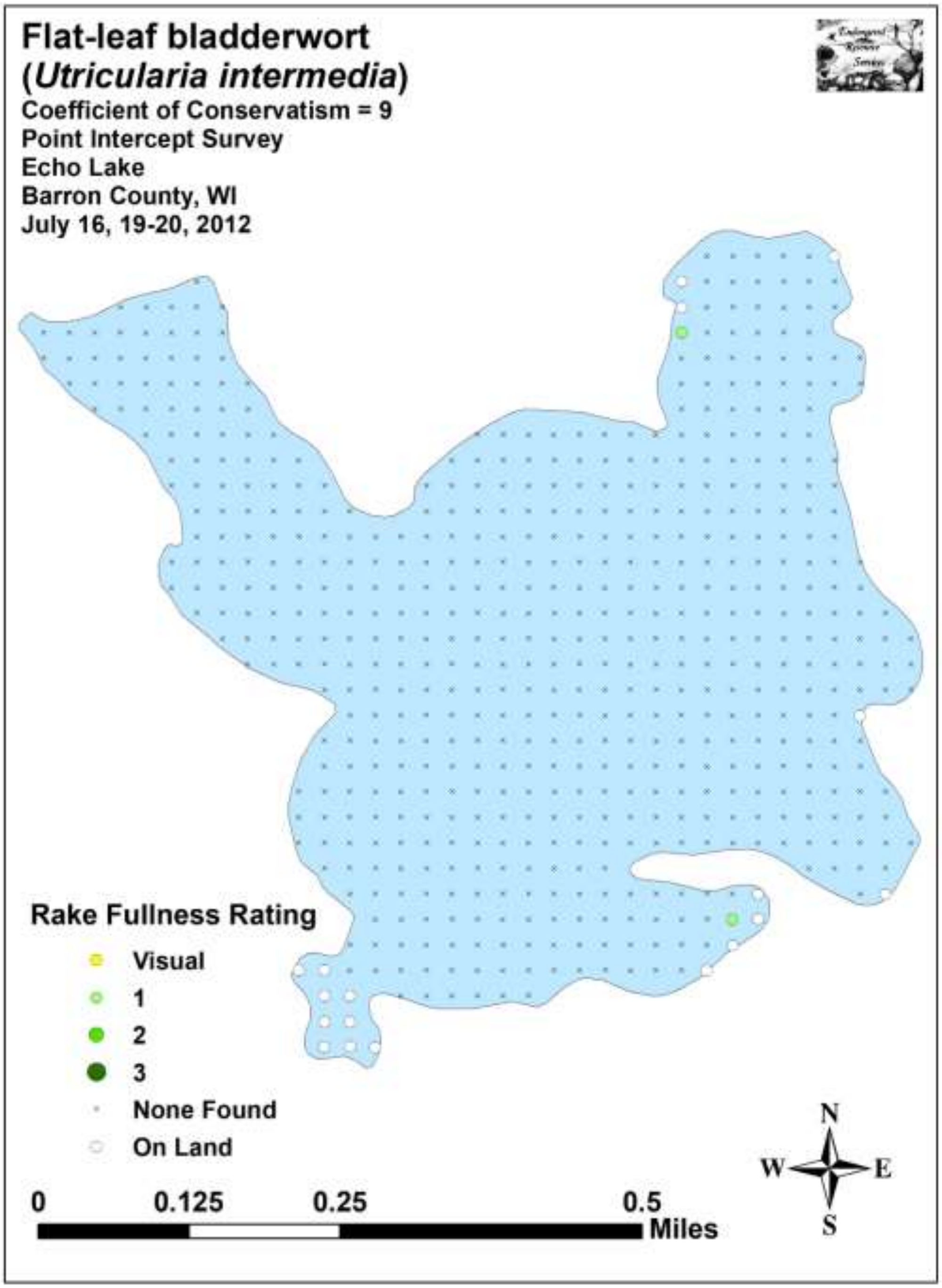

Woolgrass
(Scirpus cyperinus)
Coefficient of Conservatism = 4
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S


Branched bur-reed
(Sparganium androcladum)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S

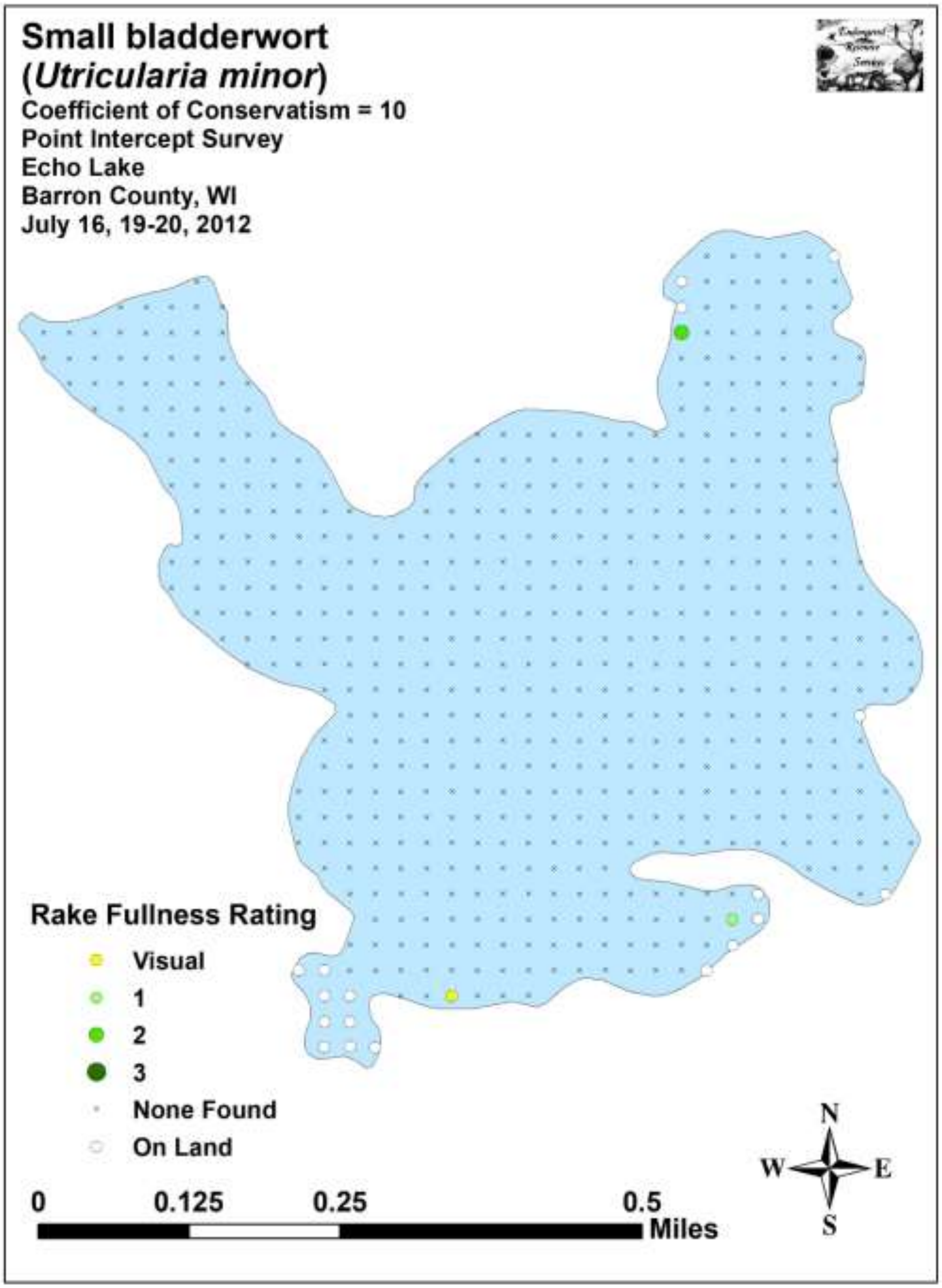

Broad-leaved cattail
(Typha latifolia)
Coefficient of Conservatism = 1
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
N
W
E
S
0
0.125
0.25
0.5
Miles

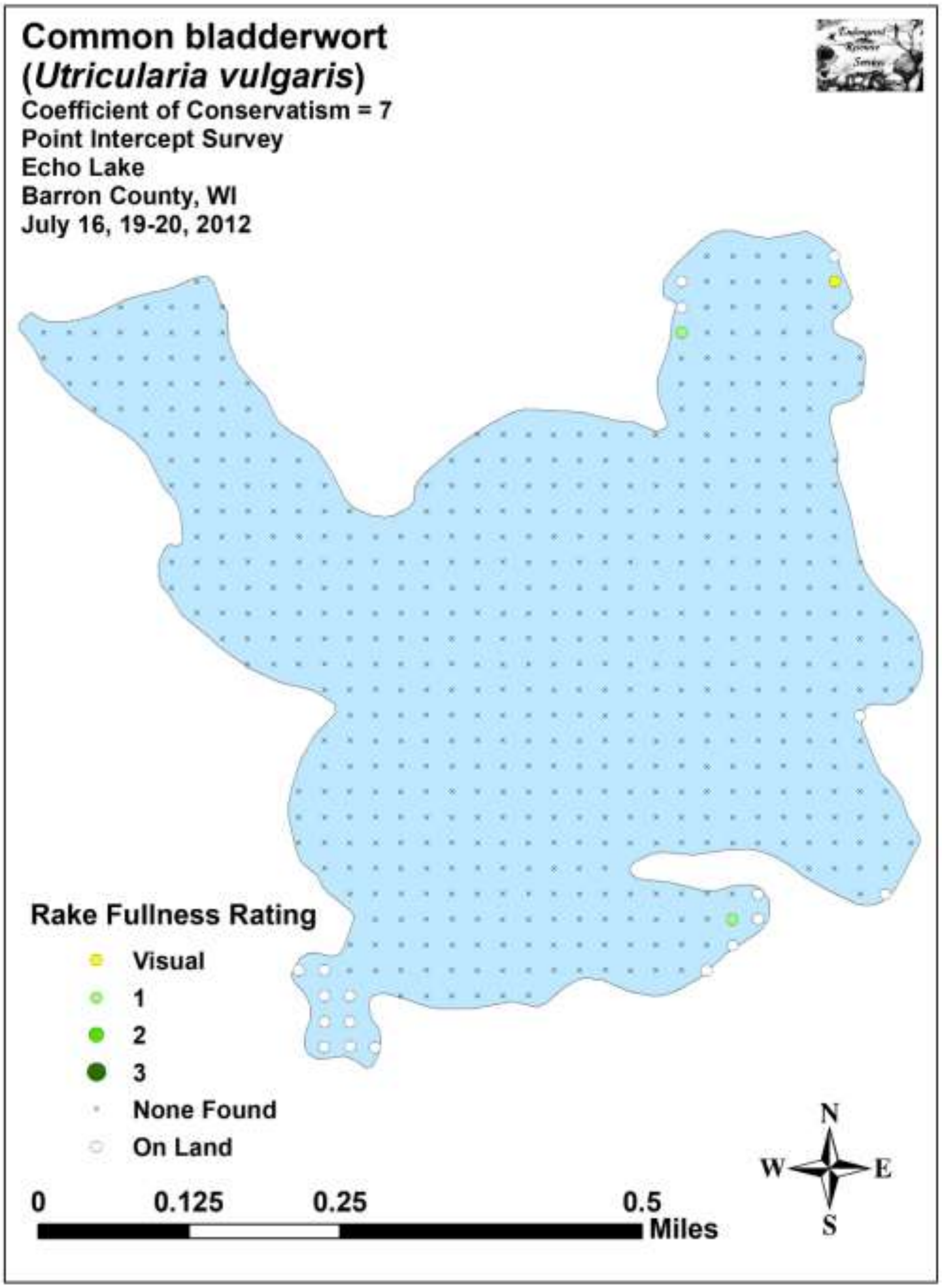


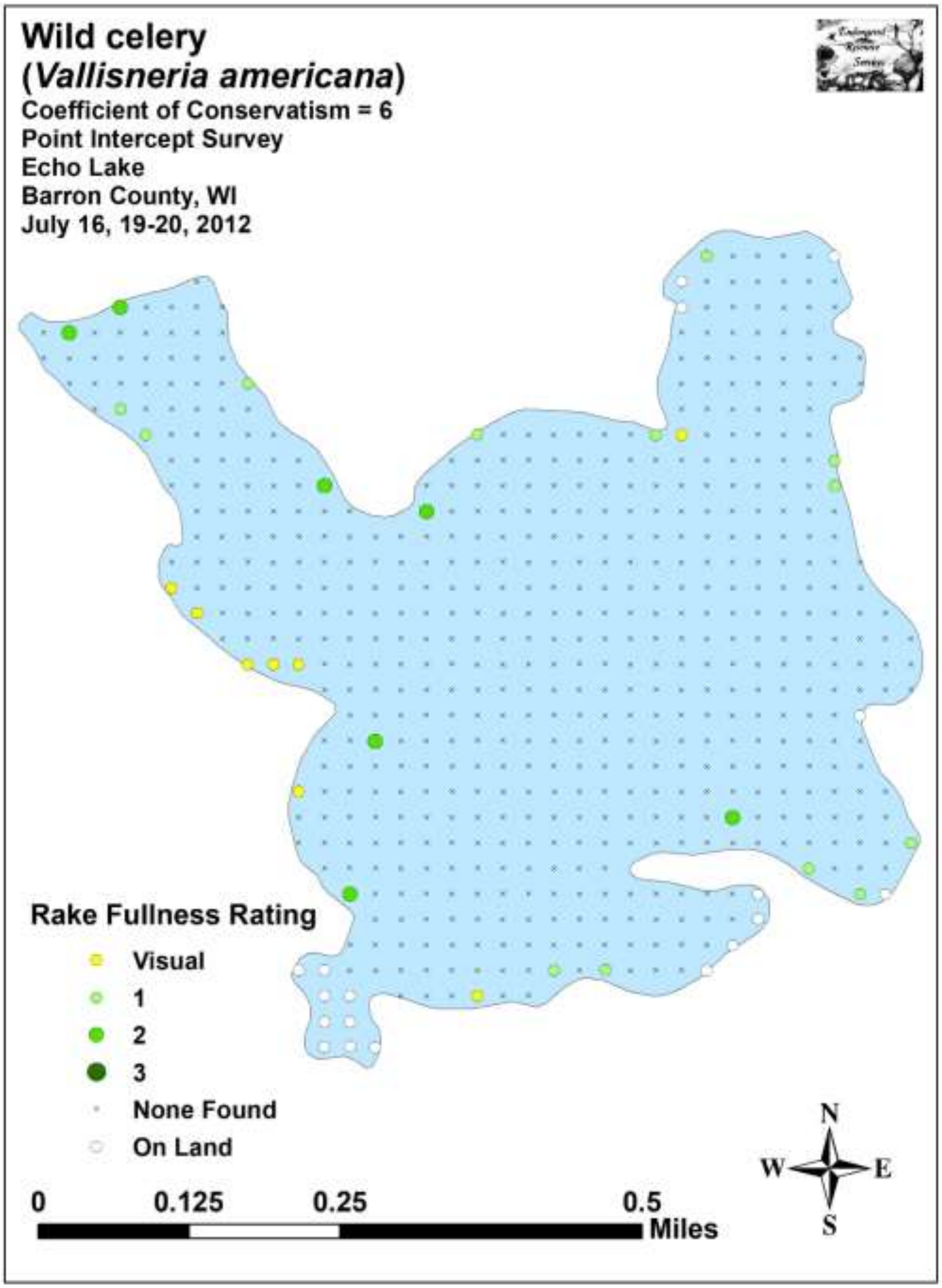
Creeping bladderwort
(Utricularia gibba)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S



Flat-leaf bladderwort
(Utricularia intermedia)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S


Small bladderwort
(Utricularia minor)
Coefficient of Conservatism = 10
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S


Common bladderwort
(Utricularia vulgaris)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S


Wild celery
(*Vallisneria americana*)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S

Appendix VII: 2012 and 2017 Plant Species Accounts

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: **Aquatic moss**
Specimen Location: Echo Lake; N45.44595°, W92.13128°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-172
Habitat/Distribution: Rock and muck bottoms in 5-7 meters of water. Uncommon; scattered individuals were found at the edge of the littoral zone.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Nitella* sp.) Nitella, (*Elodea canadensis*) Common waterweed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Brasenia schreberi*) **Watershield**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-173
Habitat/Distribution: Muck and mucky sand bottom in 0.5-1.5 meters. Common and widely distributed; especially in the northeast bay and along the northeast side of the rock island/bar in the northeast end of the lake.
Common Associates: (*Nuphar variegata*) Spatterdock, (*Sparganium androcladum*) Branched bur-reed, (*Pontederia cordata*) Pickerelweed, (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Carex scoparia*) **Broom sedge**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-174
Habitat/Distribution: Sandy muck at the shoreline. Scattered individuals occurred around much of the lake in areas that were formerly underwater, but now exposed by the drought.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Sagittaria latifolia*) Common arrowhead, (*Dulichium arundinaceum*) Three-way sedge, (*Phalaris arundinacea*) Reed canary grass, (*Juncus effusus*) Common rush

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Ceratophyllum demersum*) **Coontail**
Specimen Location: Echo Lake; N45.44607°, W92.12520°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-175
Habitat/Distribution: Muck bottom in 2-6+ meters. Rare; a few plants were located along the eastern and southern shorelines.
Common Associates: (*Nitella* sp.) Nitella, (*Potamogeton robbinsii*) Fern pondweed, (*Elodea canadensis*) Common waterweed, (*Nymphaea odorata*) White water lily, (*Ceratophyllum echinatum*) Spiny hornwort

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Ceratophyllum echinatum*) **Spiny hornwort**
Specimen Location: Echo Lake; N45.44891°, W92.13661°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-176
Habitat/Distribution: Muck bottom in 0-5+ meters. Common and widely distributed throughout although seldom abundant.
Common Associates: (*Potamogeton amplifolius*) Large-leaf pondweed, (*Potamogeton robbinsii*) Fern pondweed, (*Chara* sp.) Muskgrass, (*Elodea canadensis*) Common waterweed, (*Nitella* sp.) Nitella

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Chara* sp.) **Muskgrass**
Specimen Location: Echo Lake; N45.44472°, W92.13167°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-177
Habitat/Distribution: Very local in 2-5m over muck. Most plants were located south of the western island and on the eastern shoreline.
Common Associates: (*Potamogeton amplifolius*) Large-leaf pondweed, (*Potamogeton robbinsii*) Fern pondweed, (*Nitella* sp.) Nitella, (*Elodea canadensis*) Common waterweed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Dulichium arundinaceum*) **Three-way sedge**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-178
Habitat/Distribution: Located at the edge of the water in mucky soil. Common in scattered locations throughout.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Sagittaria latifolia*) Common arrowhead, (*Phalaris arundinacea*) Reed canary grass, (*Sparganium androcladum*) Branched bur-reed

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Elatine minima*) **Waterwort**
Specimen Location: Echo Lake; N45.44500°, W92.13298°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-179
Habitat/Distribution: Most common in sand/rock bottom areas in water from 0 – 1 meter deep. Widespread and common; especially around the lake's rock islands and along the sandy southern shoreline.
Common Associates: (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Isoetes echinospora*) Spiny-spored quillwort, (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water-milfoil, (*Juncus pelocarpus*) Brown-fruited rush

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Elatine triandra*) **Greater waterwort**
Specimen Location: Echo Lake; N45.44919°, W92.13836°
Collected/Identified by: **Matthew S. Berg/Paul Skawinski**
Col. #: MSB-2012-180
Habitat/Distribution: Common in thick sandy muck bottom areas in water <1m deep. Plants were often abundant in the northwest bay near the boat landing where they carpeted the bottom in several areas. We returned in Sept. to find individuals in fruit to confirm identification.
Common Associates: (*Potamogeton diversifolius*) Water-thread pondweed, (*Potamogeton pusillus*) Small pondweed, (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Elodea canadensis*) Common waterweed, (*Potamogeton vaseyi*) Vasey's pondweed, (*Najas gracillima*) Northern naiad

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Eleocharis acicularis*) **Needle spikerush**
Specimen Location: Echo Lake; N45.44500°, W92.13298°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-181
Habitat/Distribution: Most common in sand/rock bottom areas in water from 0 – 1 meter deep. Widespread and common; especially around the lake's rock islands and along the sandy southern shoreline.
Common Associates: (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Isoetes echinospora*) Spiny-spored quillwort, (*Myriophyllum tenellum*) Dwarf water-milfoil, (*Juncus pelocarpus*) Brown-fruited rush

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Eleocharis palustris*) **Creeping spikerush**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-182
Habitat/Distribution: Firm muck and rocky bottoms in 0-0.25 meters of water. Scattered individuals and small beds were found growing along the shoreline; especially along the undeveloped southern shoreline.
Common Associates: (*Leersia oryzoides*) Rice cut-grass, (*Juncus pelocarpus*) Brown-fruited rush, (*Elatine minima*) Waterwort

County/State**:** Barron County, Wisconsin **Date:** 7/19/12
Species: (*Elodea canadensis*) **Common waterweed**
Specimen Location: Echo Lake; N45.44891°, W92.13661°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-183
Habitat/Distribution: Muck bottom in 0-6+ meters. Common and widely distributed throughout. Plants were especially abundant in areas that had been herbicide treated where they often formed thick mats that occasionally canopied at the surface.
Common Associates: (*Potamogeton amplifolius*) Large-leaf pondweed, (*Potamogeton robbinsii*) Fern pondweed, (*Chara* sp.) Muskgrass, (*Ceratophyllum echinatum*) Spiny hornwort, (*Nitella* sp.) Nitella

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Eriocaulon aquaticum*) **Pipewort**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-184
Habitat/Distribution: Sandy to sandy muck bottoms in 0-.25m of water. A few individuals were growing in and out of the water near the point and in the southwest bay. Not found anywhere else.
Common Associates: (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Isoetes echinospora*) Spiny-spored quillwort, (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water-milfoil, (*Juncus pelocarpus*) Brown-fruited rush

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Glyceria borealis*) **Northern manna-grass**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-185
Habitat/Distribution: Sandy to sandy muck bottoms in 0-.25m of water. A few individuals were growing in and out of the water near the point along the south shoreline. Not found anywhere else.
Common Associates: (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Isoetes echinospora*) Spiny-spored quillwort, (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water-milfoil, (*Juncus pelocarpus*) Brown-fruited rush

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Isoetes echinospora*) **Spiny-spored quillwort**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-186
Habitat/Distribution: Sandy to sandy muck bottoms in 0-.25m of water. Relatively common throughout.
Common Associates: (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Elatine minima*) Waterwort, (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water-milfoil, (*Juncus pelocarpus*) Brown-fruited rush

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Isoetes lacustris*) **Lake quillwort**
Specimen Location: Echo Lake; N45.44860°, W92.13703°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-187
Habitat/Distribution: Widespread, but not common in water <2m deep. Most plants were located over muck or rock.
Common Associates: (*Najas gracillima*) Northern naiad, (*Elatine triandra*) Greater waterwort, (*Elodea canadensis*) Common waterweed, (*Potamogeton diversifolius*) Water-thread pondweed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Juncus brevicaudatus*) **Narrow-panicle rush**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-188
Habitat/Distribution: Sandy muck at the shoreline. Plants were especially common on the southern shoreline and in the southwestern bay.
Common Associates: (*Sagittaria cristata*) Crested arrowhead, (*Sparganium androcladum*) Branched bur-reed, (*Leersia oryzoides*) Rice cut-grass

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Juncus effusus*) **Common rush**
Specimen Location: Echo Lake; N45.44947°, W92.13864°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-189
Habitat/Distribution: Mucky soil at the shoreline. Scattered locations throughout in areas exposed by the drought.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Sagittaria latifolia*) Common arrowhead, (*Dulichium arundinaceum*) Three-way sedge, (*Phalaris arundinacea*) Reed canary grass, (*Sparganium androcladum*) Branched bur-reed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Juncus pelocarpus*) **Brown-fruited rush**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-190
Habitat/Distribution: Rocky to sandy bottoms in < 1m of water. Scattered throughout, it was especially common on the south shore.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water-milfoil, (*Elatine minima*) Waterwort, (*Sagittaria cristata*) Crested arrowhead

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Leersia oryzoides*) **Rice-cut grass**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-191
Habitat/Distribution: Firm muck bottoms in 0-0.25 meters of water. Scattered individuals were found growing along the southern shoreline.
Common Associates: (*Eleocharis palustris*) Creeping spikerush, (*Juncus pelocarpus*) Brown-fruited rush, (*Elatine minima*) Waterwort, (*Sparganium androcladum*) Branched bur-reed

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Lemna minor*) **Small duckweed**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-192
Habitat/Distribution: Located floating at or just under the surface in sheltered areas. Uncommon in sheltered shoreline areas and interspersed between the lilypads.
Common Associates: (*Nymphaea odorata*) White water lily, (*Nuphar variegata*) Spatterdock, (*Brasenia schreberi*) Watershield, (*Sagittaria latifolia*) Common arrowhead

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Lindernia dubia*) **False pimpernel**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-193
Firm muck bottoms in 0-0.25 meters of water. Scattered individuals were found growing along the southern shoreline.
Common Associates: (*Eleocharis palustris*) Creeping spikerush, (*Juncus pelocarpus*) Brown-fruited rush, (*Elatine minima*) Waterwort (*Leersia oryzoides*) Rice cut-grass

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Myriophyllum spicatum*) **Eurasian water-milfoil**
Specimen Location: Echo Lake; N45.44711°, W92.13480°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-194
Habitat/Distribution: Muck bottom areas in water up to 3.5m. Widely scattered throughout, but becoming difficult to find. Herbicide treatment has all but eliminated the plant from the lake.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Nitella* sp.) Nitella, (*Elodea canadensis*) Common waterweed, (*Ceratophyllum echinatum*) Spiny hornwort, (*Potamogeton amplifolius*) Large-leaf pondweed

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Myriophyllum tenellum*) **Dwarf water-milfoil**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-195
Habitat/Distribution: Rocky to sandy bottoms in 0-1 meter of water. Rare; a few scattered populations were located on the south side of the lake.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Juncus pelocarpus*) Brown-fruited rush, (*Eriocaulon aquaticum*) Pipewort, (*Elatine minima*) Waterwort, (*Sagittaria cristata*) Crested arrowhead, (*Isoetes echinospora*) Spiny-spored quillwort

County/State: Barron County, Wisconsin **Date: 7**/27/17
Species: (*Najas flexilis*) **Slender naiad**
Specimen Location: Echo Lake; N45.44821°, W92.12484°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2017-008
Habitat/Distribution: Rare; only seen at the point over rock in water <2m deep.
Common Associates: (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Najas gracillima*) Northern naiad

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Najas gracillima*) **Northern naiad**
Specimen Location: Echo Lake; N45.44919°, W92.13836°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-196
Habitat/Distribution: Common and widespread in thick sandy muck bottom areas in water < 1m.
Common Associates: (*Potamogeton diversifolius*) Water-thread pondweed, (*Potamogeton pusillus*) Small pondweed, (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Elodea canadensis*) Common waterweed, (*Potamogeton vaseyi*) Vasey's pondweed

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Nitella* sp.) **Nitella**
Specimen Location: Echo Lake; N45.44711°, W92.13480°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-197
Habitat/Distribution: Muck bottom area in water up to 7 meters. Abundant throughout where it was the deepest growing macrophyte in the lake.
Common Associates: (*Elodea canadensis*) Common waterweed, (*Ceratophyllum echinatum*) Spiny hornwort, (*Chara* sp.) Muskgrass, (*Potamogeton robbinsii*) Fern pondweed, (*Potamogeton amplifolius*) Large-leaf pondweed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Nuphar variegata*) **Spatterdock**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-198
Habitat/Distribution: Muck bottom in 0-1.5 meters of water. Much less common than Nymphaea in the lake. Plants were restricted to areas adjacent to the boggy southwest and northeast bays.
Common Associates: (*Nymphaea odorata*) White water lily, (*Sparganium androcladum*) Branched bur-reed, (*Pontederia cordata*) Pickerelweed, (*Brasenia schreberi*) Watershield, (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Nymphaea odorata*) **White water lily**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-199
Habitat/Distribution: Muck bottom in 0-1.5 meters. Plants were common and widely distributed. In the far ends of bays, plants formed dense canopies with other floating leaf species. Elsewhere, they tended to be much less dense.
Common Associates: (*Nuphar variegata*) Spatterdock, (*Sparganium androcladum*) Branched bur-reed, (*Pontederia cordata*) Pickerelweed, (*Brasenia schreberi*) Watershield, (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Phalaris arundinacea*) **Reed canary grass**
Specimen Location: Echo Lake; N45.44947°, W92.13864°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-200
Habitat/Distribution: Common, but not abundant. Prefers thick muck soil in and out of water <0.25m. Primarily found on shore in disturbed low areas. Present throughout; especially near the boat landing.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Sagittaria latifolia*) Common arrowhead, (*Dulichium arundinaceum*) Three-way sedge, (*Juncus effusus*) Common rush, (*Sparganium androcladum*) Branched bur-reed

County/State: Barron County, Wisconsin **Date:** 7/27/17
Species: (*Phragmites australis americanus*) **Common reed**
Specimen Location: Echo Lake; N45.44157°, W92.1299°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2017-009
Firm sand bottoms in 0-0.25 meters of water. A single bed was growing along the southern shoreline.
Common Associates: (*Eleocharis palustris*) Creeping spikerush, (*Schoenoplectus acutus*) Hardstem bulrush

County/State: Barron County, Wisconsin **Date:** 7/27/17
Species: (*Polygonum amphibium*) **Water smartweed**
Specimen Location: Echo Lake; N45.44919°, W92.13836°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2017-010
Firm bottoms in <1.5m. Plants were common in many shoreline areas.
Common Associates: (*Eleocharis palustris*) Creeping spikerush, (*Nymphaea odorata*) White water lily

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Pontederia cordata*) **Pickerelweed**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-201
Habitat/Distribution: Silt to muck bottom over firm substrate in 0-1 meter of water. Common in emergent beds along undisturbed shorelines throughout the lake.
Common Associates: (*Nymphaea odorata*) White water lily, (*Sparganium androcladum*) Branched bur-reed, (*Brasenia schreberi*) Watershield, (*Schoenoplectus tabernaemontani*) Softstem bulrush (*Nuphar variegata*) Spatterdock

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Potamogeton amplifolius*) **Large-leaf pondweed**
Specimen Location: Echo Lake; N45.44711°, W92.13480°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-202
Habitat/Distribution: Reestablishing and becoming increasingly common in areas where EWM was chemically treated/eliminated. Most plants were in mucky bottom areas in water from 1-3m deep. Restricted to the western half of the lake.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Nitella* sp.) Nitella, (*Elodea canadensis*) Common waterweed, (*Ceratophyllum echinatum*) Spiny hornwort, (*Myriophyllum spicatum*) Eurasian water-milfoil

County/State: Barron County, Wisconsin **Date:** 5/13/12
Species: (*Potamogeton crispus*) **Curly-leaf pondweed**
Specimen Location: Echo Lake; N45.44409°, W92.13252°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-203
Habitat/Distribution: Widely distributed, but rare. During the mapping survey, we found 88 individual plants in the entire lake. Over 50% of them were located near the point over the richest nutrient muck in the lake in 1-2m of water in the west central bay.
Common Associates: (*Elodea canadensis*) Common waterweed, (*Ceratophyllum demersum*) Coontail, (*Nitella* sp.) Nitella, (*Potamogeton robbinsii*) Fern pondweed, (*Myriophyllum spicatum*) Eurasian water-milfoil

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Potamogeton diversifolius*) **Water-thread pondweed**
Specimen Location: Echo Lake; N45.44712°, W92.13437°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-204
Habitat/Distribution: Widely distributed, but not common at the time of the July survey; however, by September, it had become a dominant plant replacing *P. vaseyi* and *P. spirillus* which had largely senesced by this time. Most common in 0.5-2m over sand and rock.
Common Associates: (*Potamogeton vaseyi*) Vasey's pondweed, (*Potamogeton pusillus*) Small pondweed, (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Elodea canadensis*) Common waterweed

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Potamogeton epihydrus*) **Ribbon-leaf pondweed**
Specimen Location: Echo Lake; N45.44950°, W92.13794°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-205
Habitat/Distribution: Found in mucky bottom conditions in shallow water 0.5-1.5 meters deep. Uncommon, but found in scattered locations throughout.
Common Associates: (*Elodea canadensis*) Common waterweed, (*Potamogeton obtusifolius*) Blunt-leaf pondweed, (*Potamogeton robbinsii*) Fern pondweed

County/State: Barron County, Wisconsin **Date: 7**/27/17
Species: (*Potamogeton nodosus*) **Long-leaf pondweed**
Specimen Location: Echo Lake; N45.44889°, W92.13791°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2017-011
Habitat/Distribution: A single individual was found in 2m over sand. All leaves were submergent and tapered to a thin, but awn-less tip. Told from *P. illinoensis* by the petioles which were as long as the blades, and the bright white veins in the leaf.
Common Associates: (*Elodea canadensis*) Common waterweed, (*Potamogeton robbinsii*) Fern pondweed

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Potamogeton obtusifolius*) **Blunt-leaf pondweed?**
Specimen Location: Echo Lake; N45.44950°, W92.13794°
Collected/Identified by: Matthew S. Berg/Paul Skawinski/Robert Freckmann
Col. #: MSB-2012-206
Habitat/Distribution: Very narrow leaves for this taxon; more suggestive of a wide-leaved *P. berchtoldii*. However, Skawinski felt that the bright rusty red and much branched stems with abundant fruit suggested this taxon. The nutlets lack keels which *obtusifolius* should have leading Freckmann to lean towards *berchtoldii*. The turion shape was ambiguous, and it also had waxy leaves (as in *P. epihydrus*). Perhaps this is a small morph of *P. obtusifolius* in a low nutrient muck of this seepage lake. It may also be a hybrid.
Common Associates: (*Potamogeton vaseyi*) Vasey's pondweed, (*Potamogeton pusillus*) Small pondweed, (*Potamogeton diversifolius*) Water-thread pondweed, (*Elatine triandra*) Greater waterwort

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Potamogeton pusillus*) **Small pondweed**
Specimen Location: Echo Lake; N45.44950°, W92.13794°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2012-207
Habitat/Distribution: Most plants were growing over sandy muck in 1-3.5 meters of water. Widely distributed, but neither common nor abundant. Clearly different from the plant we've called *P. obtusifolius*.
Common Associates: (*Ceratophyllum echinatum*) Spiny hornwort, (*Najas gracillima*) Northern naiad, (*Elodea canadensis*) Common waterweed, (*Potamogeton diversifolius*) Water-thread pondweed, (*Potamogeton vaseyi*) Vasey's pondweed

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Potamogeton robbinsii*) **Fern pondweed**
Specimen Location: Echo Lake; N45.44711°, W92.13480°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-208
Habitat/Distribution: Common to abundant in water from 2-4 meters deep over organic muck. Plants dominated the lake in this zone.
Common Associates: (*Potamogeton amplifolius*) Large-leaf pondweed, (*Nitella* sp.) Nitella, (*Ceratophyllum echinatum*) Spiny hornwort, (*Elodea canadensis*) Common waterweed, (*Myriophyllum spicatum*) Eurasian water-milfoil

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Potamogeton spirillus*) **Spiral-fruited pondweed**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-209
Habitat/Distribution: Widely distributed and common over sand and sandy muck in 0.25-1.5m of water. Abundant in July before nearly disappearing by September.
Common Associates: (*Myriophyllum tenellum*) Dwarf water-milfoil, (*Juncus pelocarpus*) Brown-fruited rush, (*Eleocharis acicularis*) Needle spikerush, (*Elatine minima*) Waterwort

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Potamogeton vaseyi*) **Vasey's pondweed**
Specimen Location: Echo Lake; N45.44919°, W92.13836°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-210
Habitat/Distribution: Widely distributed and common over sandy muck in 0.5-1.5m of water. Plants were abundant in July, but almost absent by September. Often found with other fine-leaved species.
Common Associates: (*Potamogeton diversifolius*) Water-thread pondweed, (*Potamogeton pusillus*) Small pondweed, (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Elodea canadensis*) Common waterweed, (*Elatine triandra*) Greater waterwort

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Ranunculus flammula*) **Creeping spearwort**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-211
Habitat/Distribution: Rare on the southern shoreline over sand. A few emergent individuals were the only plants found. Plants were growing in areas exposed by the prolonged drought.
Common Associates: (*Myriophyllum tenellum*) Dwarf water-milfoil, (*Juncus pelocarpus*) Brown-fruited rush, (*Eleocharis acicularis*) Needle spikerush, (*Sagittaria cristata*) Crested arrowhead

County/State: Barron County, Wisconsin **Date:** 7/27/17
Species: (*Riccia fluitans*) **Slender riccia**
Specimen Location: Echo Lake; N45.44949°, W92.13837°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2017-012
Habitat/Distribution: Located floating at or just under the surface in sheltered areas. Rare; only see at the landing.
Common Associates: (*Nymphaea odorata*) White water lily, (*Brasenia schreberi*) Watershield, (*Lemna minor*) Small duckweed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Sagittaria cristata*) **Crested arrowhead**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-212
Habitat/Distribution: Common at the shoreline over sand; especially in the south-central and east-central bays.
Common Associates: (*Myriophyllum tenellum*) Dwarf water-milfoil, (*Juncus pelocarpus*) Brown-fruited rush, (*Eleocharis acicularis*) Needle spikerush, (*Elatine minima*) Waterwort

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Sagittaria latifolia*) **Common arrowhead**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-213
Habitat/Distribution: Relatively common in undeveloped shoreline areas with firm muck bottom in 0-0.25m of water.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass, (*Dulichium arundinaceum*) Three-way sedge, (*Juncus effusus*) Common rush, (*Sparganium androcladum*) Branched bur-reed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Sagittaria rigida*) **Sessile-fruited arrowhead**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-214
Habitat/Distribution: Uncommon in shallow water at the shoreline in scattered undeveloped shoreline areas. This species replaced *S. cristata* in more nutrient rich organic and sandy muck areas.
Common Associates: (*Sparganium androcladum*) Branched bur-reed, (*Pontederia cordata*) Pickerelweed, (*Schoenoplectus tabernaemontani*) Softstem bulrush

County/State: Barron County, Wisconsin **Date:** 7/27/17
Species: (*Schoenoplectus acutus*) **Hardstem bulrush**
Specimen Location: Echo Lake; N45.44157°, W92.1299°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2017-013
Firm sand bottoms in 0-0.25 meters of water. A single bed was growing along the southern shoreline.
Common Associates: (*Eleocharis palustris*) Creeping spikerush, (*Phragmites australis*) Common reed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Schoenoplectus tabernaemontani*) **Softstem bulrush**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-215
Habitat/Distribution: Firm muck bottoms in 0-0.25 meter of water. Scattered beds occurred in the south and northeast bays.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass, (*Sagittaria latifolia*) Common arrowhead, (*Dulichium arundinaceum*) Three-way sedge, (*Sparganium androcladum*) Branched bur-reed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Scirpus cyperinus*) **Woolgrass**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-216
Habitat/Distribution: Firm muck bottoms in 0-0.25 meter of water. Scattered individuals were located throughout Echo Lake in shoreline areas that were exposed by the receding water levels.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass, (*Sagittaria latifolia*) Common arrowhead, (*Dulichium arundinaceum*) Three-way sedge, (*Sparganium androcladum*) Branched bur-reed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Sparganium androcladum*) **Branched bur-reed**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-217
Habitat/Distribution: Firm muck bottoms at the shoreline to 0.25m of water. Dense emergent beds were common in undeveloped areas around the lake; it was especially common in the southwest and northwest bays, and in the southeast corner of the south bay. Mature beaks on the achenes were >5mm with most reaching 7mm in length.
Common Associates: (*Typha latifolia*) Broad-leaved cattail, (*Phalaris arundinacea*) Reed canary grass, (*Sagittaria latifolia*) Common arrowhead, (*Dulichium arundinaceum*) Three-way sedge, (*Scirpus cyperinus*) Woolgrass

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Sparganium angustifolium*) **Narrow-leaf bur-reed**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-218
Habitat/Distribution: Soft muck bottoms at the shoreline to 0.5 meter of. A single, small, poorly developed plant was raked up at the point in the east end of the south bay. Not seen anywhere else.
Common Associates: (*Elodea canadensis*) Common waterweed, (*Ceratophyllum echinatum*) Spiny hornwort, (*Potamogeton pusillus*) Small pondweed, (*Potamogeton robbinsii*) Fern pondweed

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Typha latifolia*) **Broad-leaved cattail**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-219
Habitat/Distribution: Thick muck soil in and out of water <0.25 meters. Found in undeveloped shoreline areas throughout; especially common in the south and northeast bays.
Common Associates: (*Schoenoplectus tabernaemontani*) Softstem bulrush, (*Phalaris arundinacea*) Reed canary grass, (*Sagittaria latifolia*) Common arrowhead, (*Dulichium arundinaceum*) Three-way sedge, (*Sparganium androcladum*) Branched bur-reed

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Utricularia gibba*) **Creeping bladderwort**
Specimen Location: Echo Lake; N45.45036°, W92.12492°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-220
Habitat/Distribution: Thick organic muck bottom in shallow water <1m deep. Plants were restricted to the northeast and southwest bays, and the eastern end of the south bay were they were found floating among other plants.
Common Associates: (*Brasenia schreberi*) Watershield, (*Nymphaea odorata*) White water lily, (*Utricularia vulgaris*) Common bladderwort, (*Utricularia minor*) Small bladderwort

County/State: Barron County, Wisconsin **Date:** 7/19/12
Species: (*Utricularia intermedia*) **Flat-leaf bladderwort**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-221
Habitat/Distribution: Thick organic muck bottom in shallow water <1m deep. Plants were restricted to the northeast and southwest bays, and the eastern end of the south bay.
Common Associates: (*Brasenia schreberi*) Watershield, (*Nymphaea odorata*) White water lily, (*Utricularia gibba*) Creeping bladderwort, (*Utricularia minor*) Small bladderwort, (*Utricularia vulgaris*) Common bladderwort

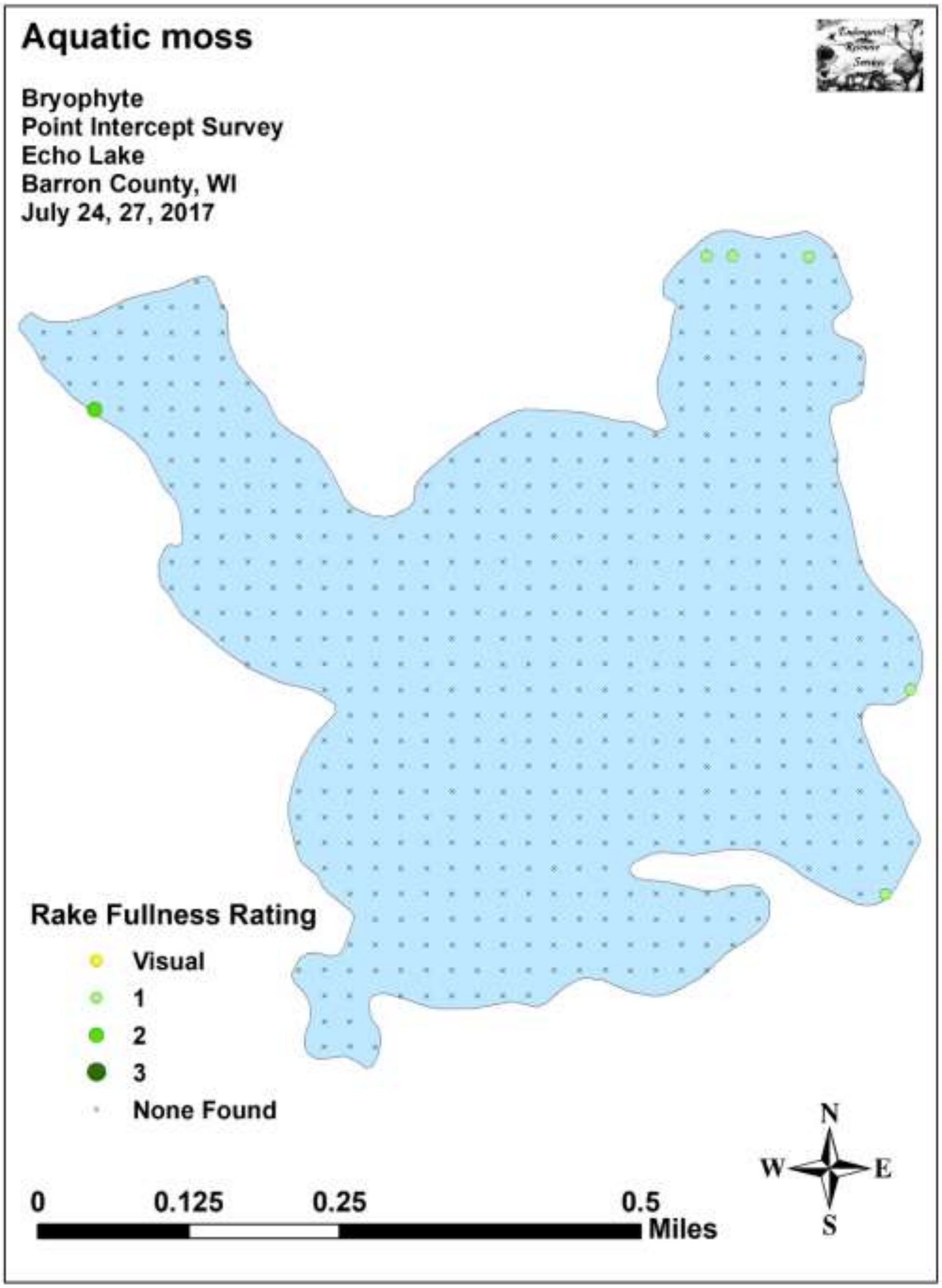
County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Utricularia minor*) **Small bladderwort**
Specimen Location: Echo Lake; N45.44194°, W92.13287°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-222
Habitat/Distribution: Thick organic muck bottom in shallow water <1m deep. Plants were restricted to the northeast and southwest bays, and the eastern end of the south bay were they were found floating among other plants.
Common Associates: (*Brasenia schreberi*) Watershield, (*Nymphaea odorata*) White water lily, (*Utricularia gibba*) Creeping bladderwort, (*Utricularia minor*) Small bladderwort

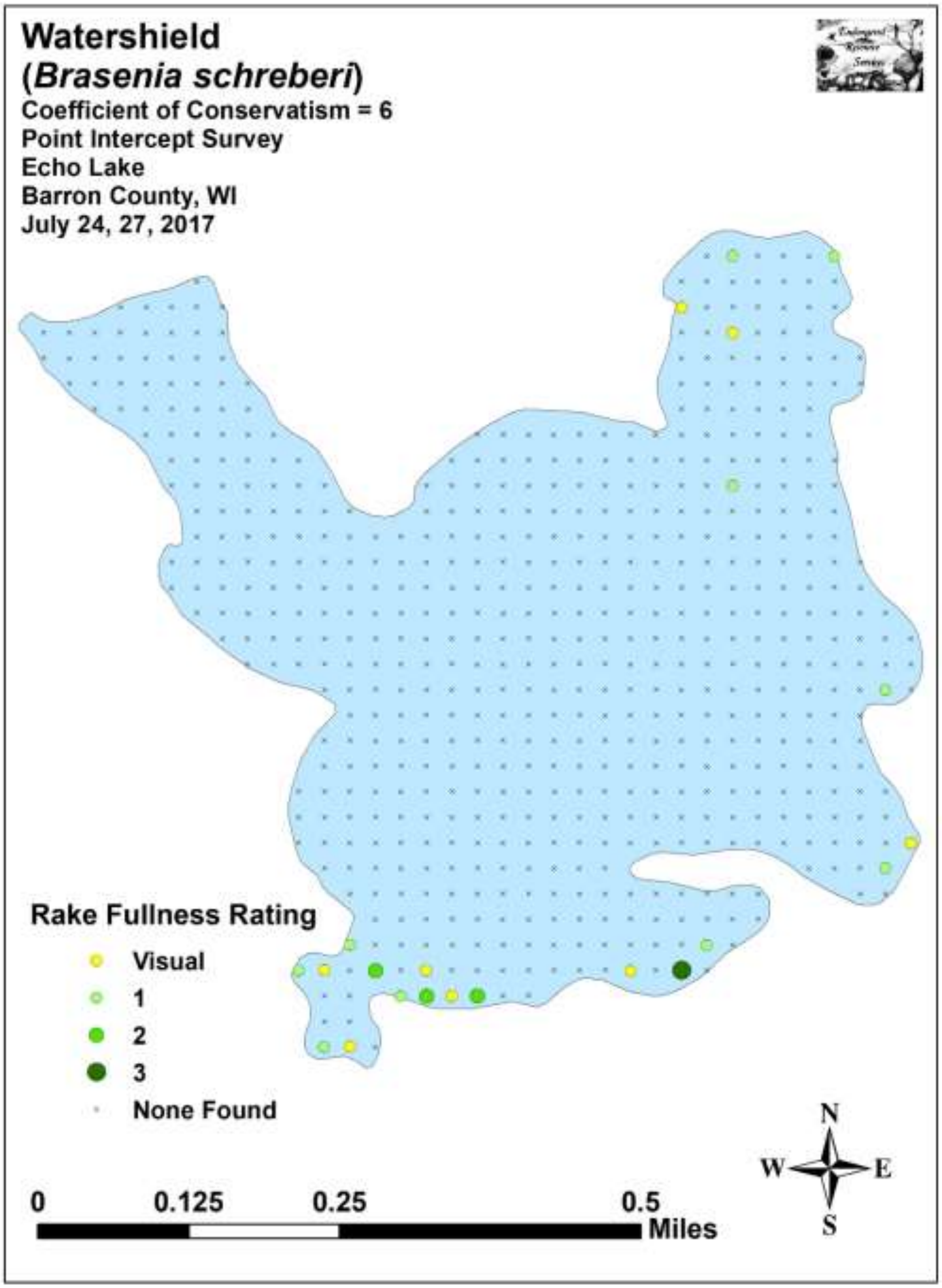
County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Utricularia vulgaris*) **Common bladderwort**
Specimen Location: Echo Lake; N45.45036°, W92.12492°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-223
Habitat/Distribution: Thick organic muck bottom in shallow water <1m deep. Plants were restricted to the northeast and southwest bays, and the eastern end of the south bay were they were found floating among other plants.
Common Associates: (*Brasenia schreberi*) Watershield, (*Nymphaea odorata*) White water lily, (*Utricularia gibba*) Creeping bladderwort, (*Utricularia minor*) Small bladderwort

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Vallisneria americana*) **Wild celery**
Specimen Location: Echo Lake; N45.44169°, W92.13025°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-224
Habitat/Distribution: Found in almost any bottom conditions, but grows best in sandy to sand/muck bottoms in 0.5-2 meters of water. Relatively common and widely distributed throughout.
Common Associates: (*Potamogeton diversifolius*) Water-thread pondweed, (*Eleocharis acicularis*) Needle spikerush, (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Elodea canadensis*) Common waterweed, (*Elatine triandra*) Greater waterwort

County/State: Barron County, Wisconsin **Date:** 9/16/12
Species: (*Veronica americana*) **American speedwell**
Specimen Location: Echo Lake; N45.44947°, W92.13864°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2012-225
Habitat/Distribution: A few plants were found at the boat landing. Because they were few in number, we only picked a specimen for the herbarium.
Common Associates: (*Phalaris arundinacea*) Reed canary grass, (*Sagittaria latifolia*) Common arrowhead, (*Juncus effusus*) Common rush

Appendix VIII: July 2017 Species Density and Distribution Maps


Aquatic moss
Bryophyte
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles


Watershield
(*Brasenia schreberi*)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
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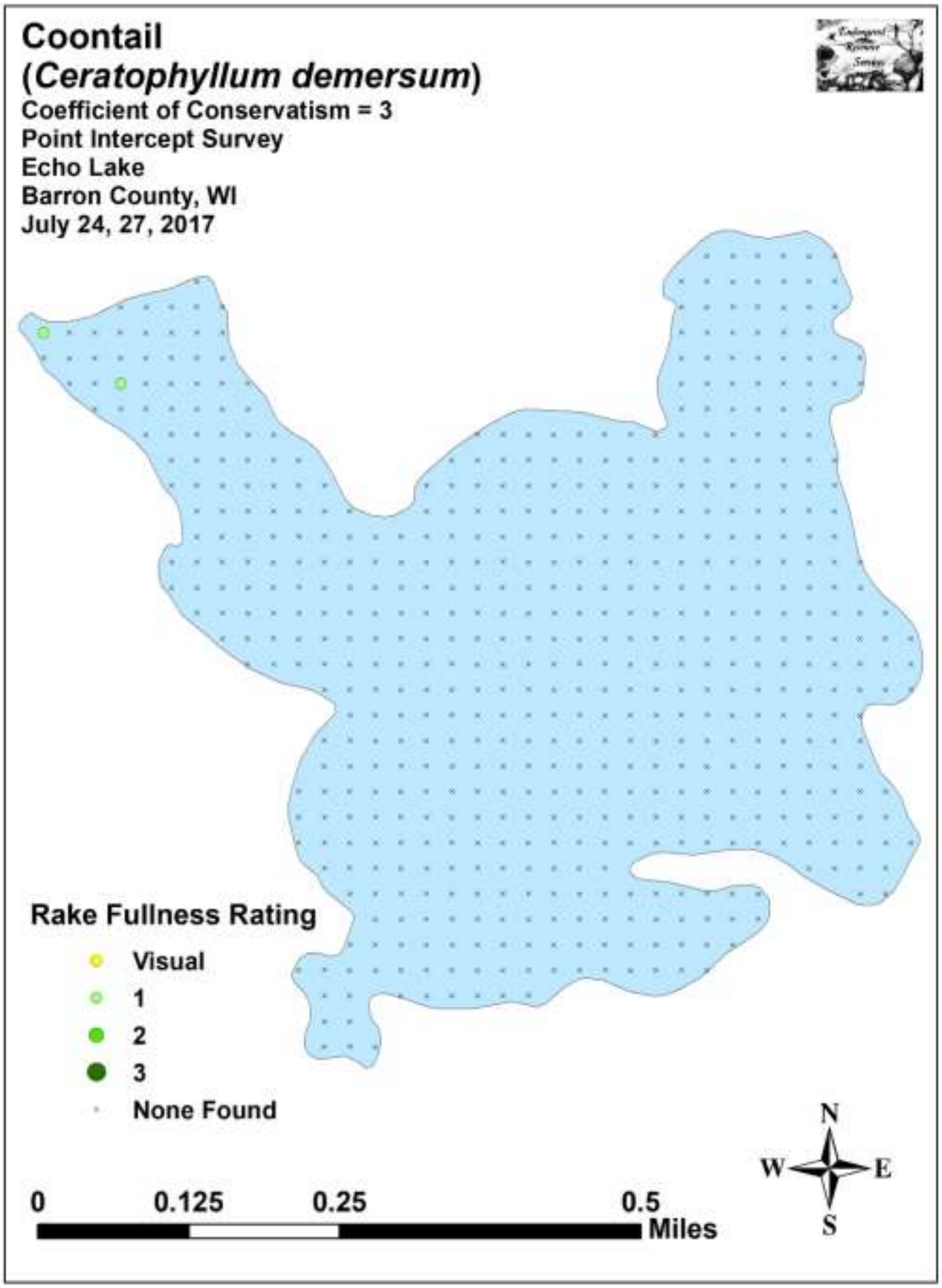
Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
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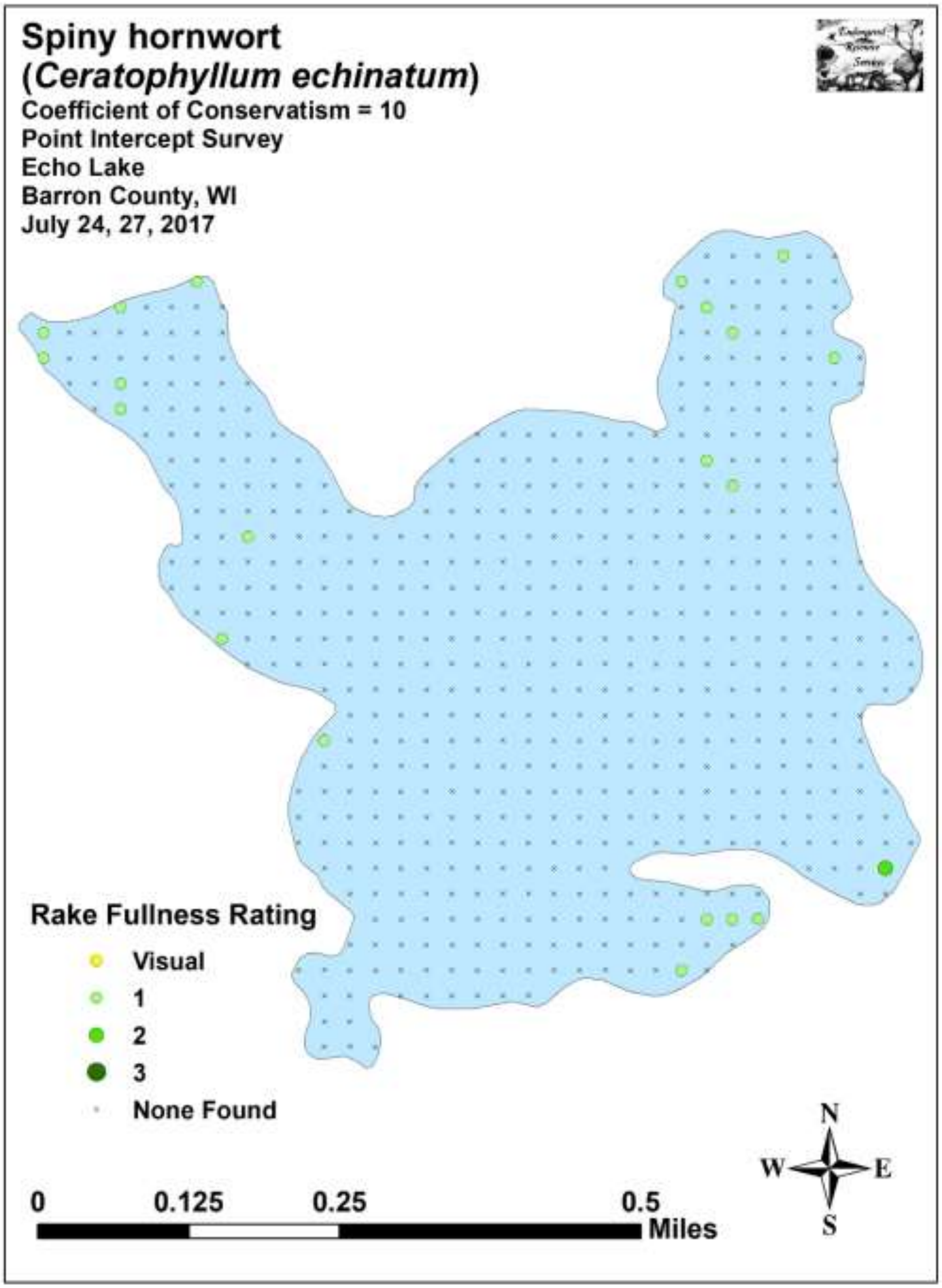
W
E
S


Spiny hornwort
(*Ceratophyllum echinatum*)
Coefficient of Conservatism = 10
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
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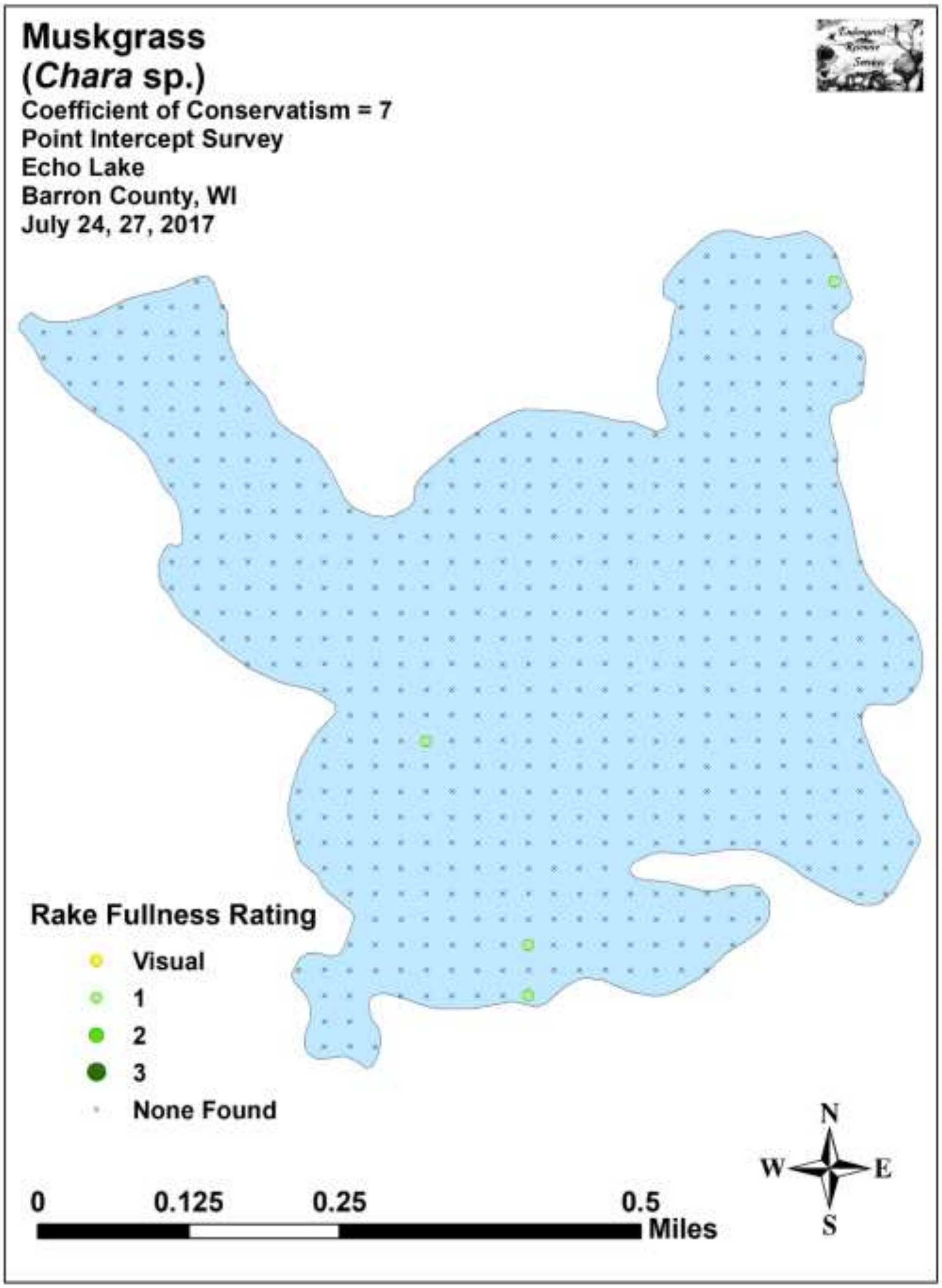
Muskgrass
(Chara sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
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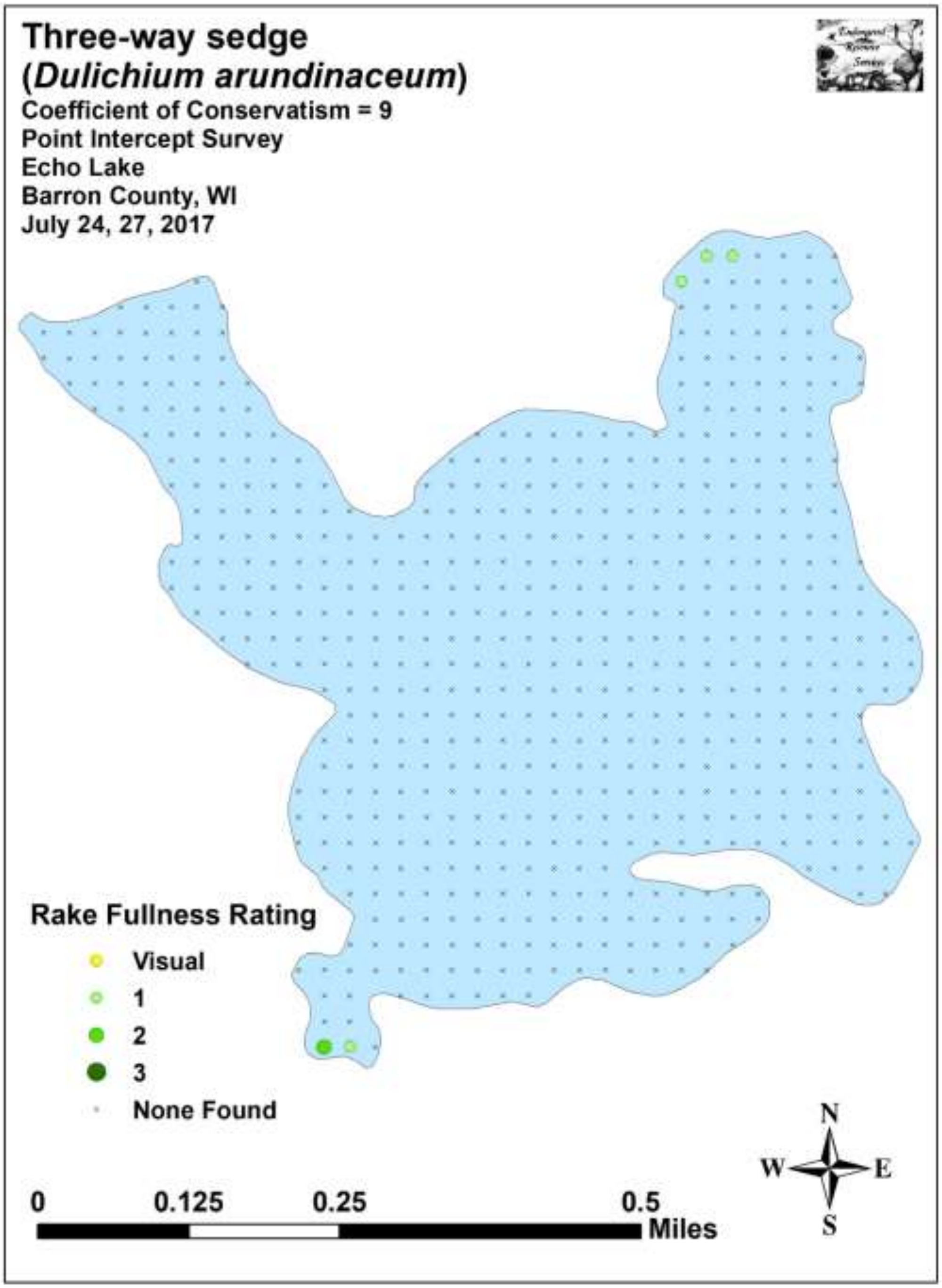
0
0.125
0.25
0.5
Miles



Three-way sedge
(Dulichium arundinaceum)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
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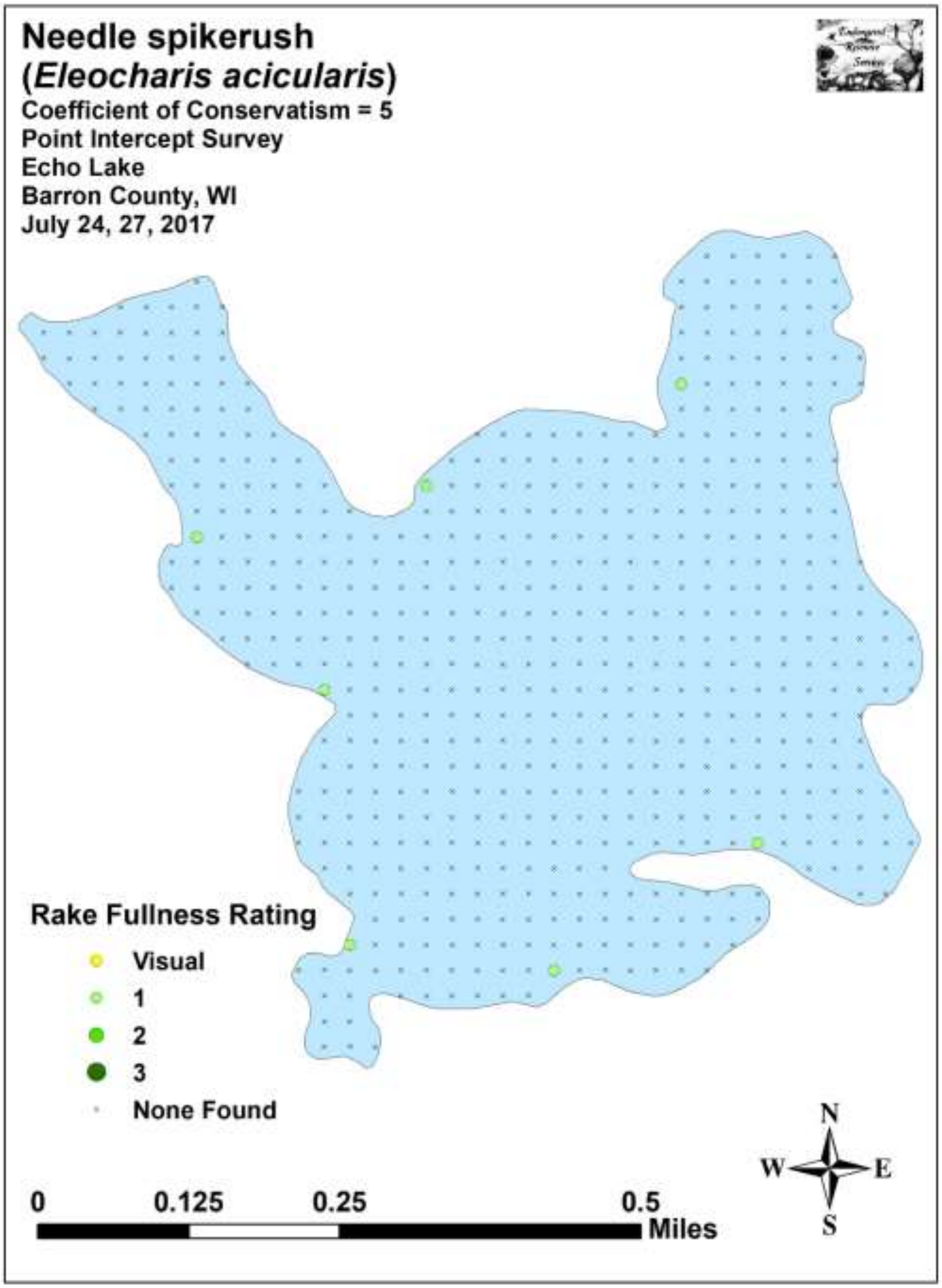
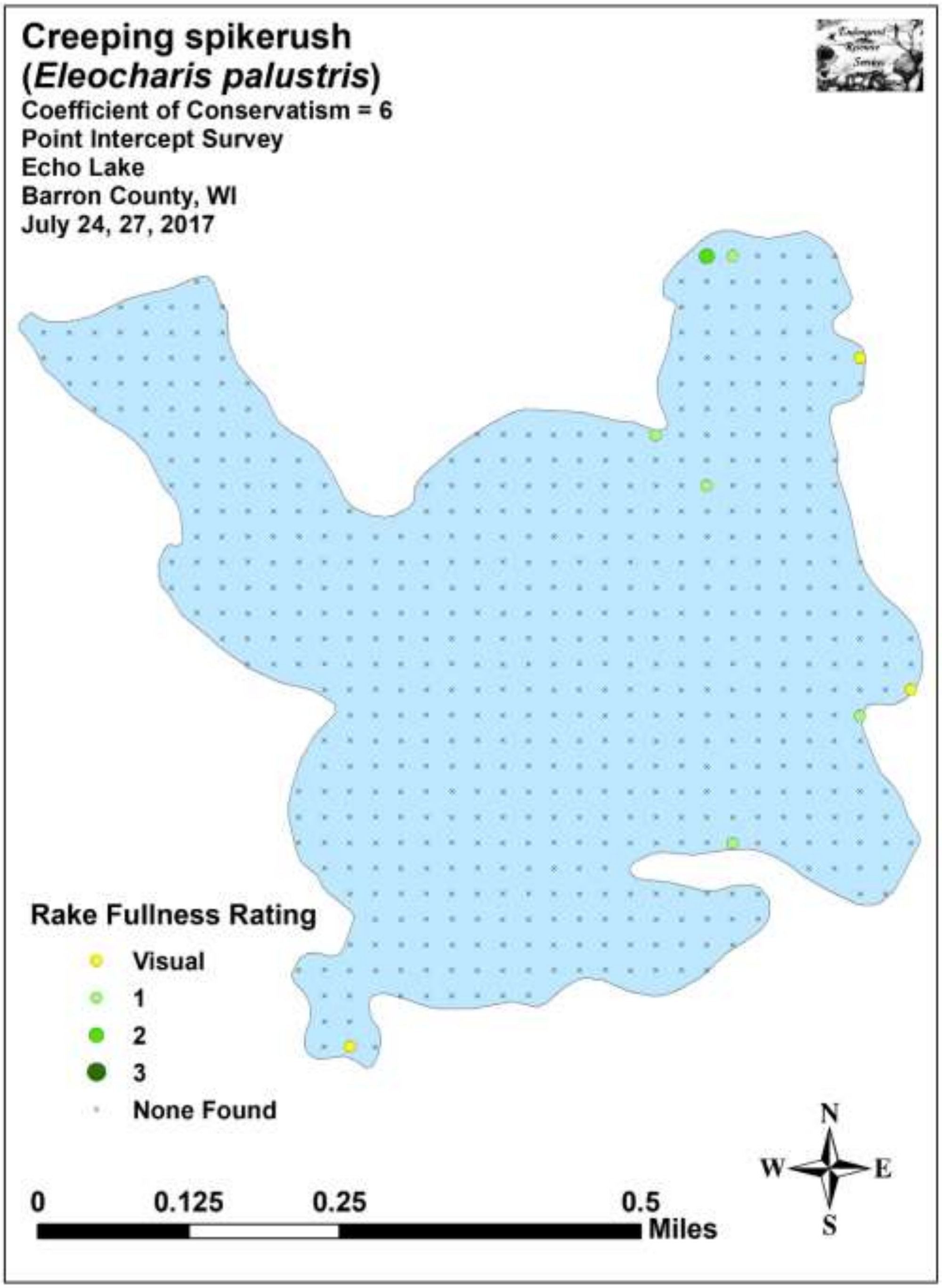
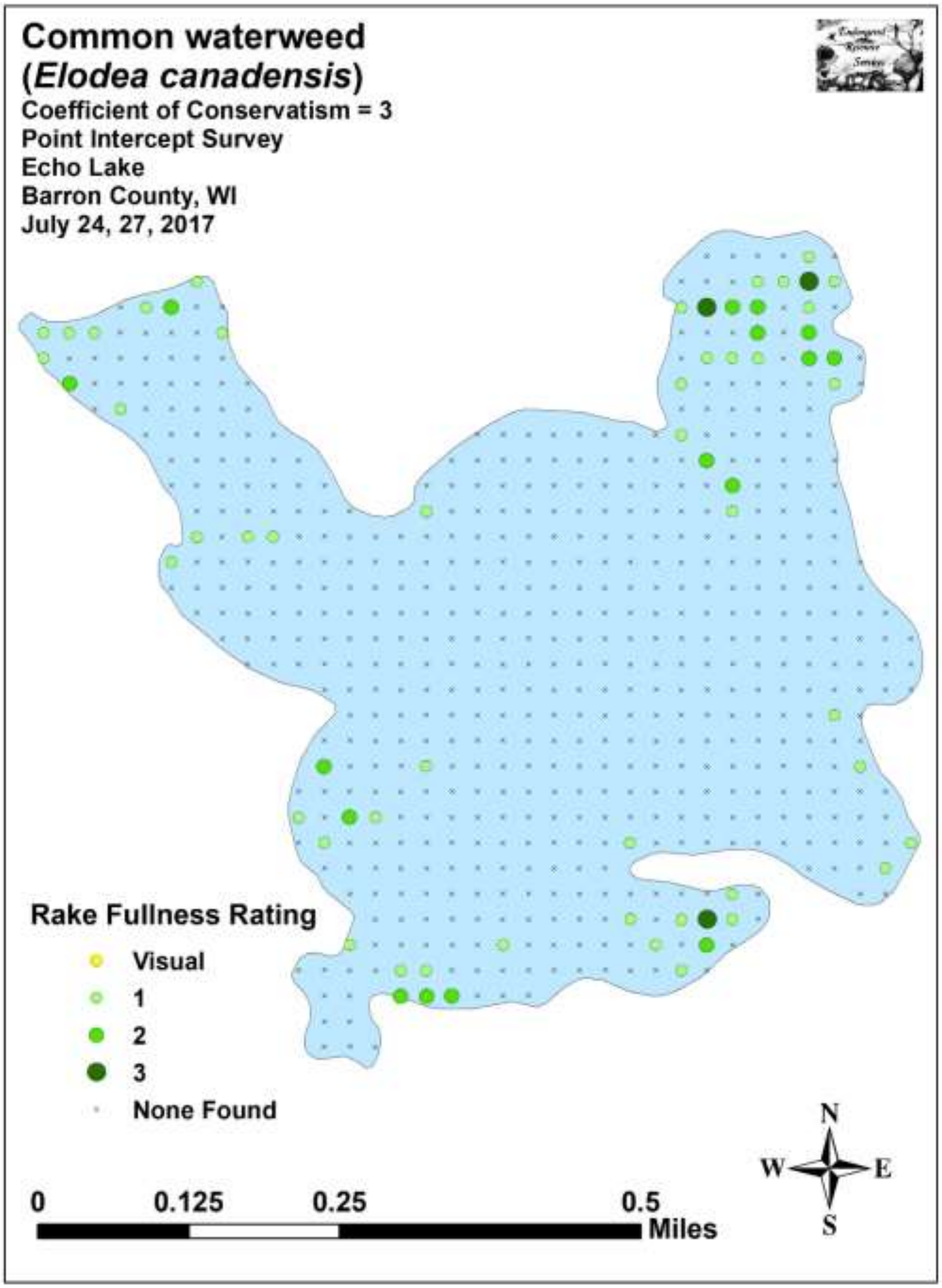
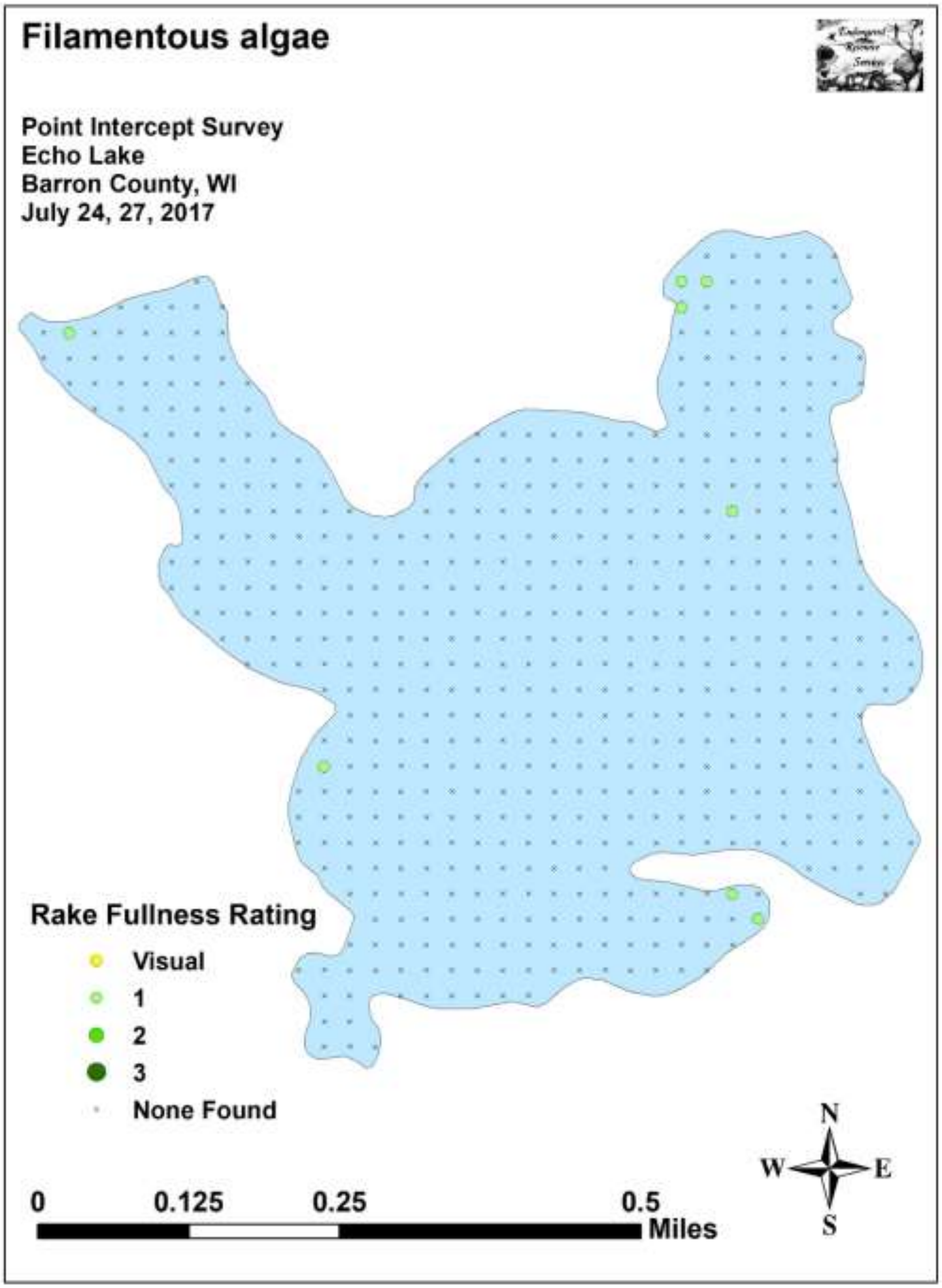
S
0
0.125
0.25
0.5
Miles


Needle spikerush
(Eleocharis acicularis)
Coefficient of Conservatism = 5
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

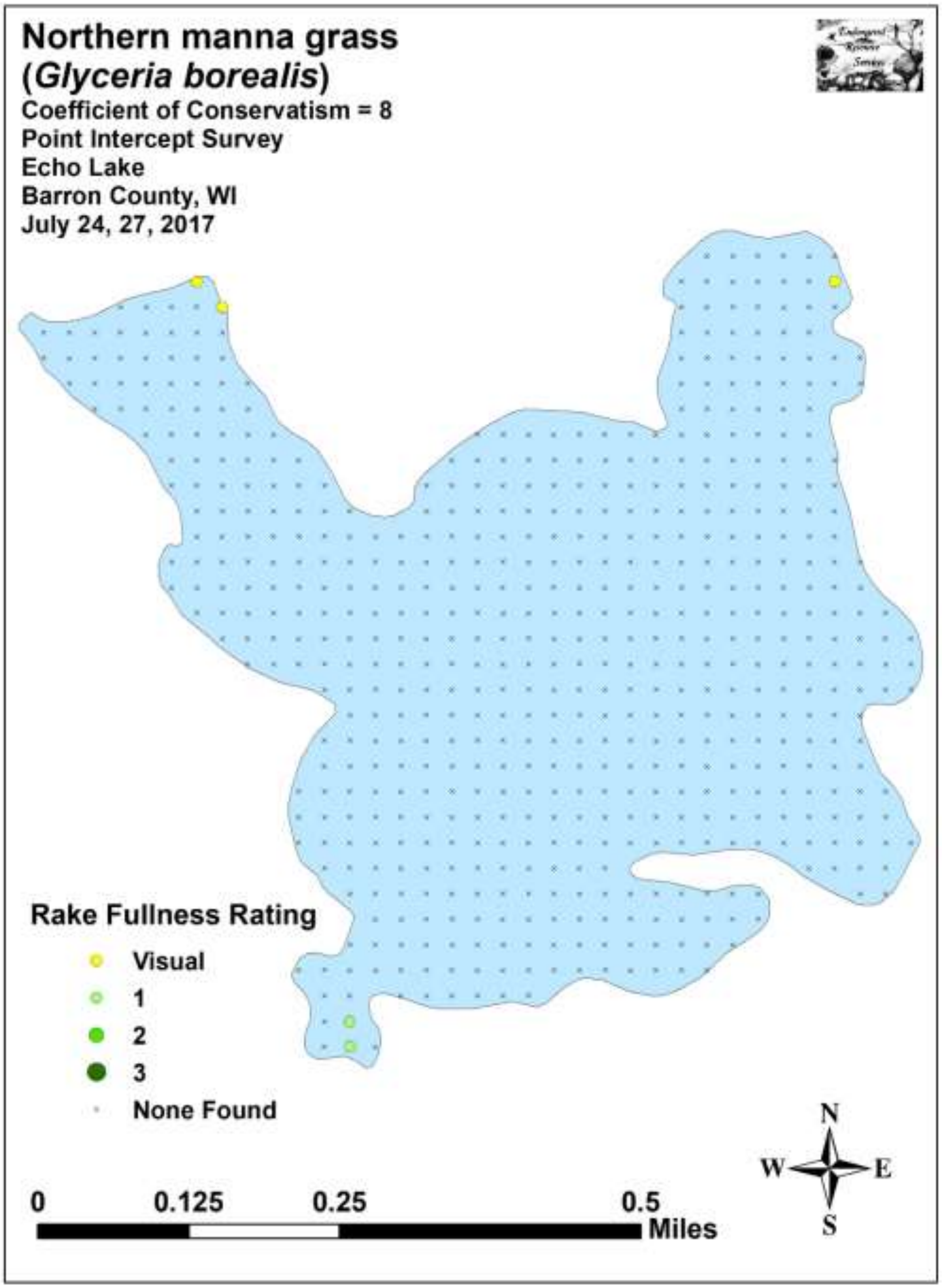

Creeping spikerush
(*Eleocharis palustris*)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

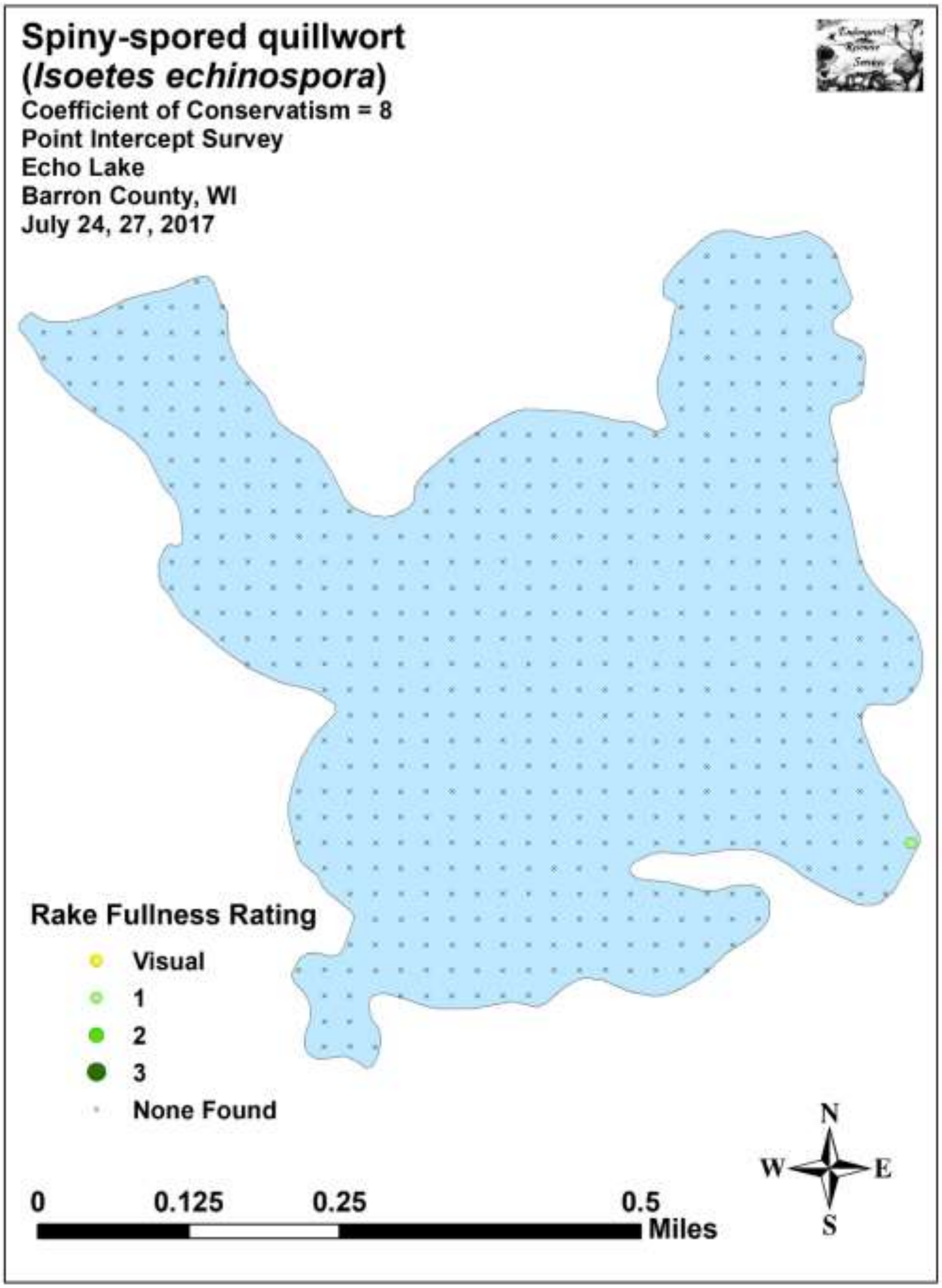


Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

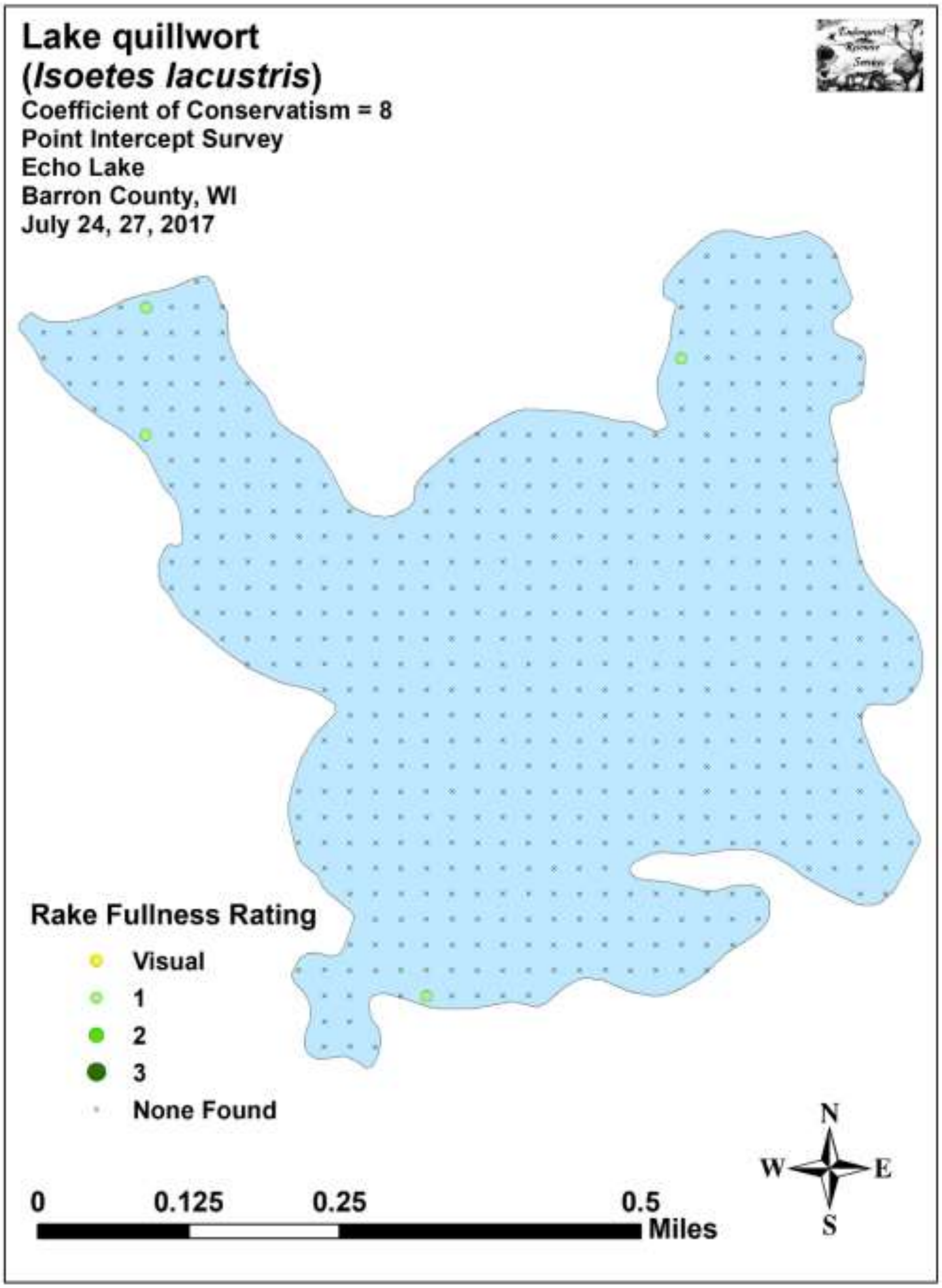


Filamentous algae
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S

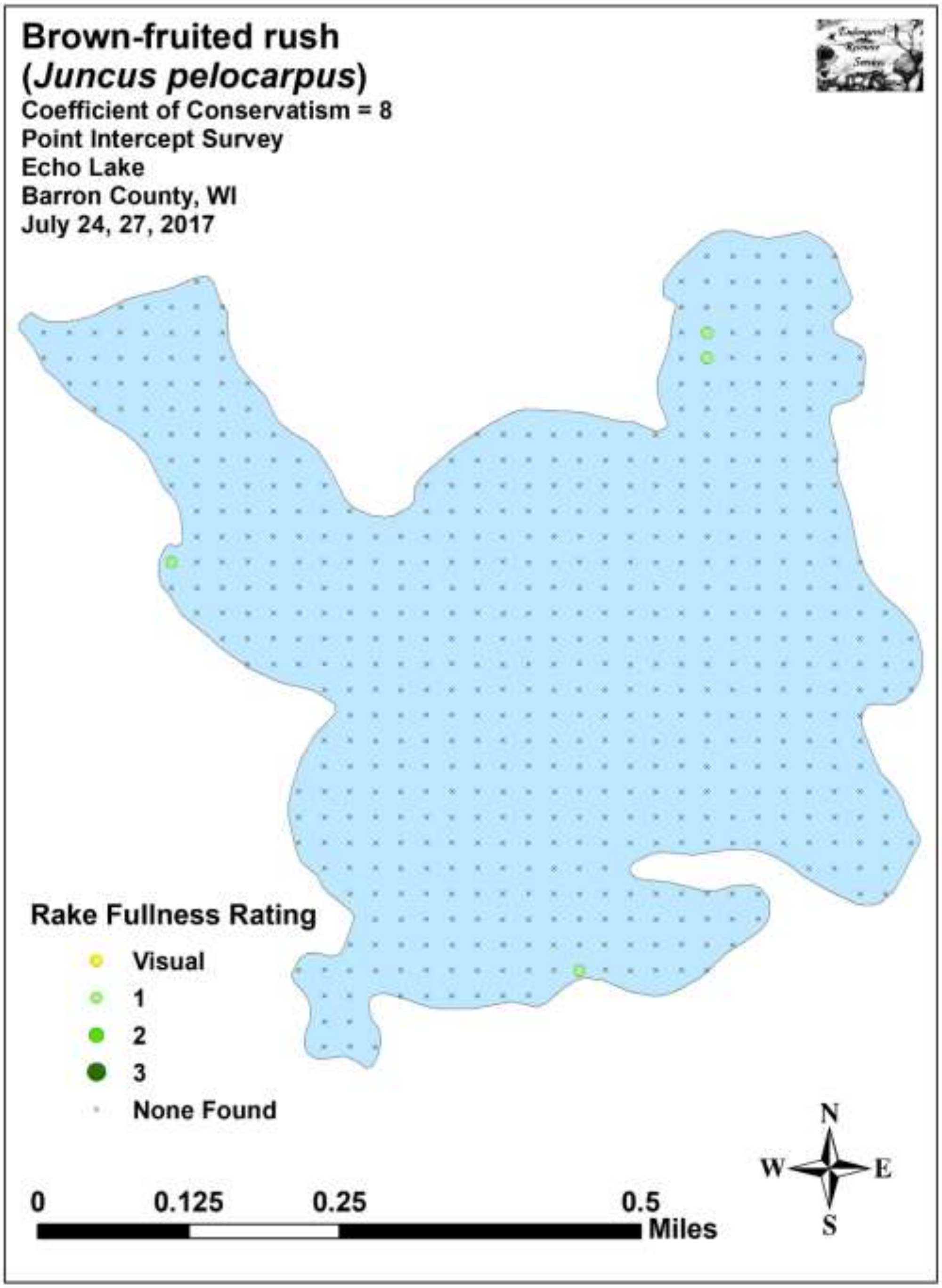

Northern manna grass
(Glyceria borealis)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

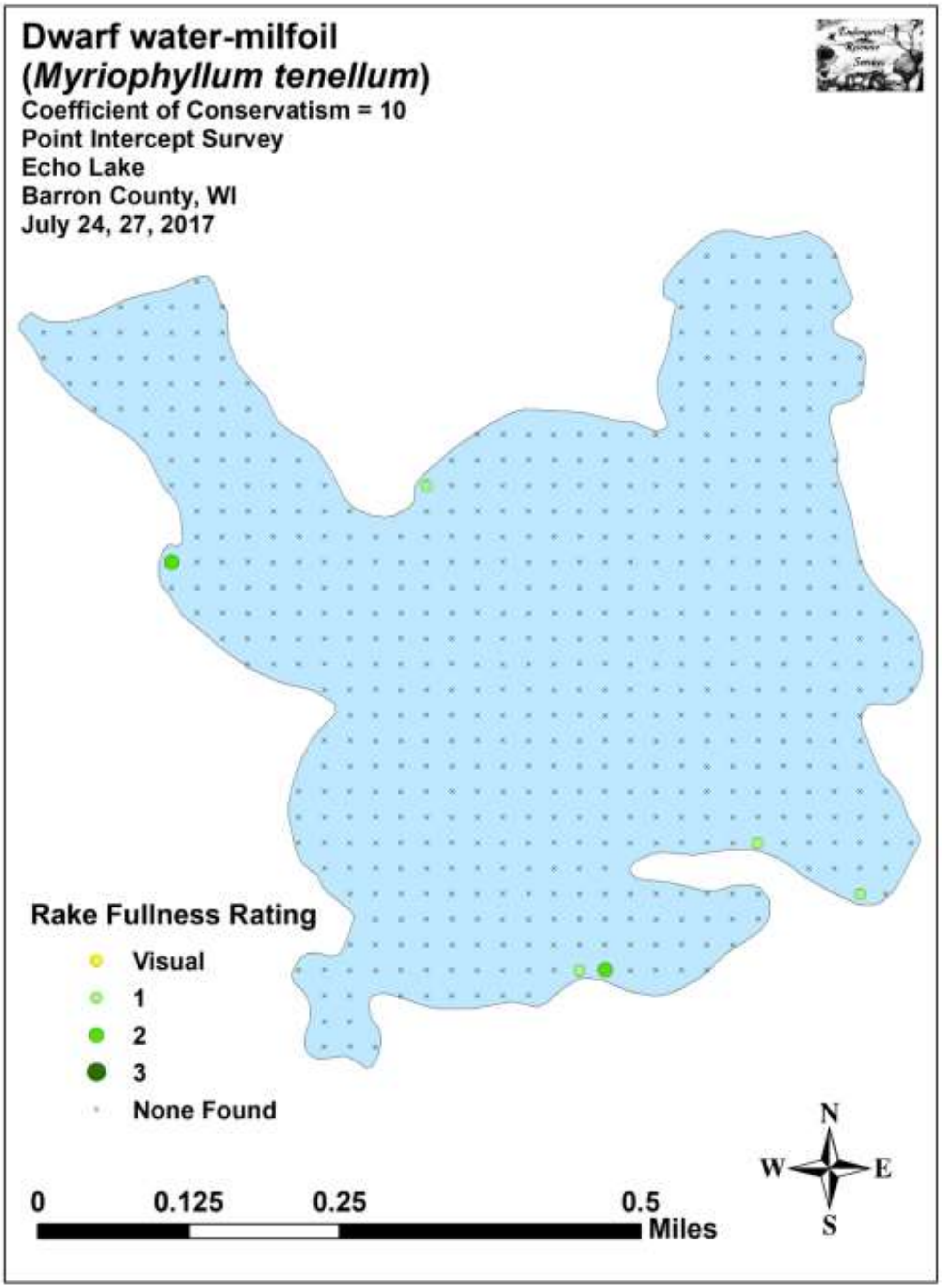


Spiny-spored quillwort
(*Isoetes echinospora*)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S

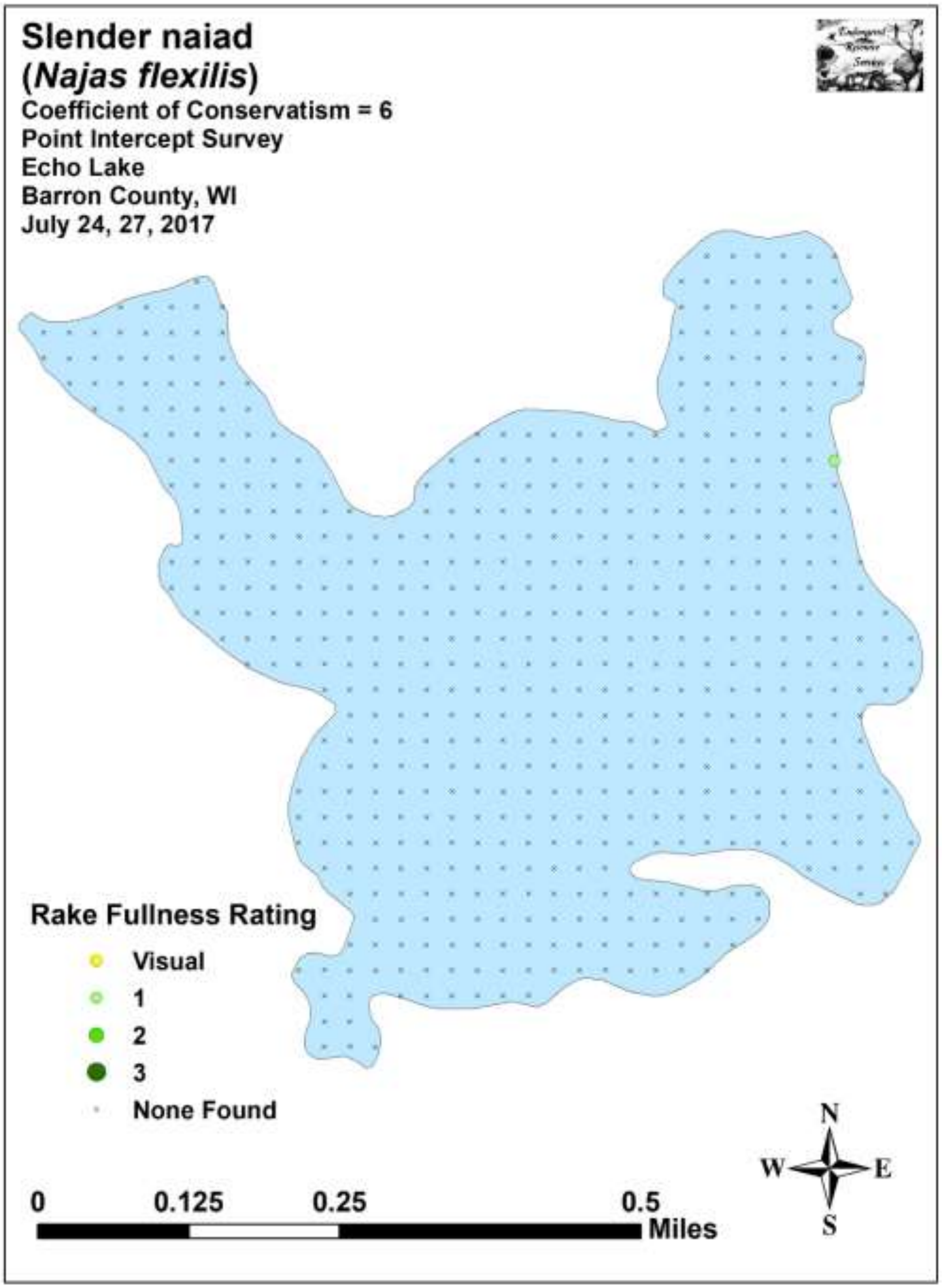


Lake quillwort
(*Isoetes lacustris*)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S

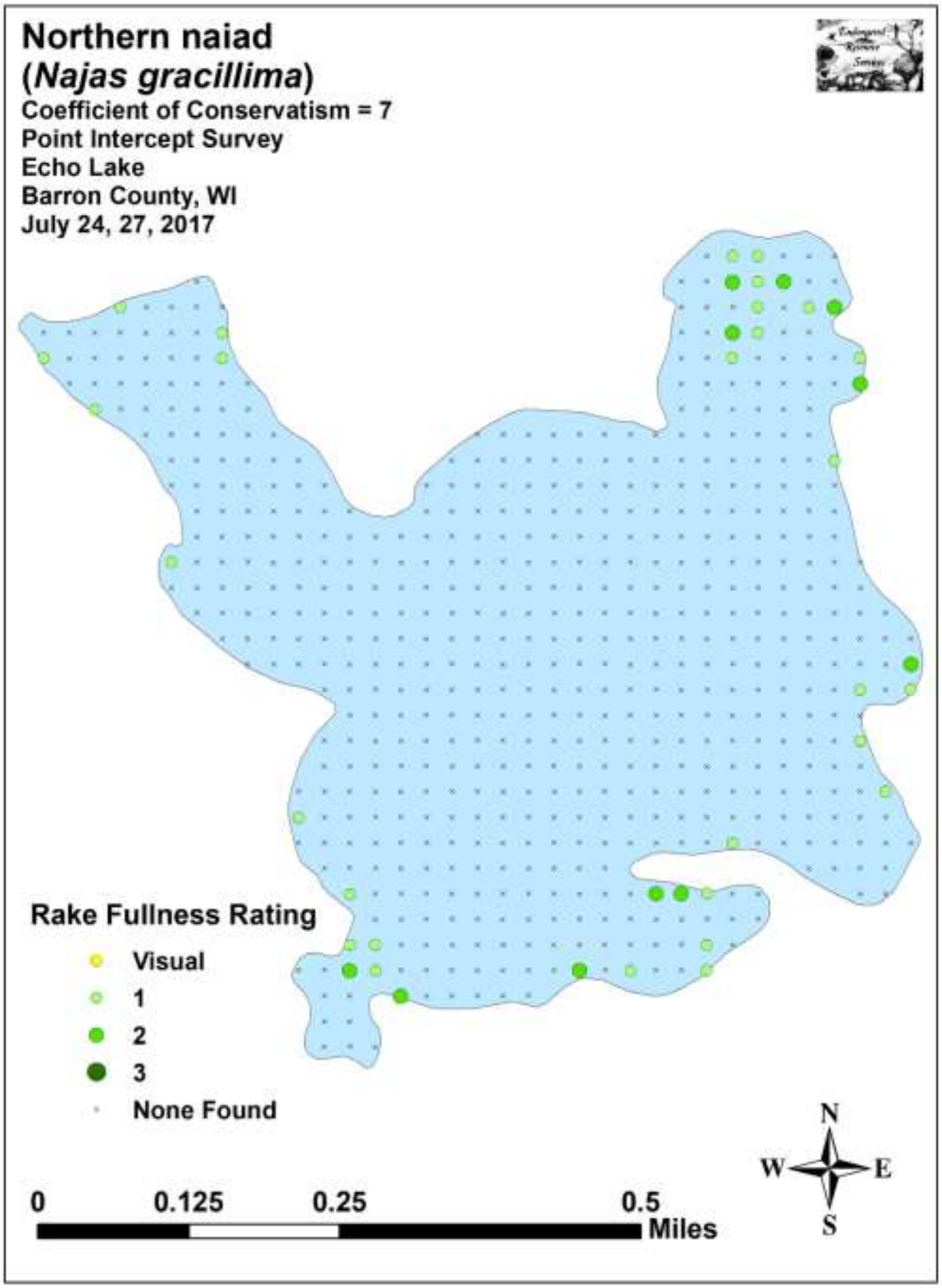

Brown-fruited rush
(Juncus pelocarpus)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles



Dwarf water-milfoil
(*Myriophyllum tenellum*)
Coefficient of Conservatism = 10
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S



Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles



Northern naiad
(Najas gracillima)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
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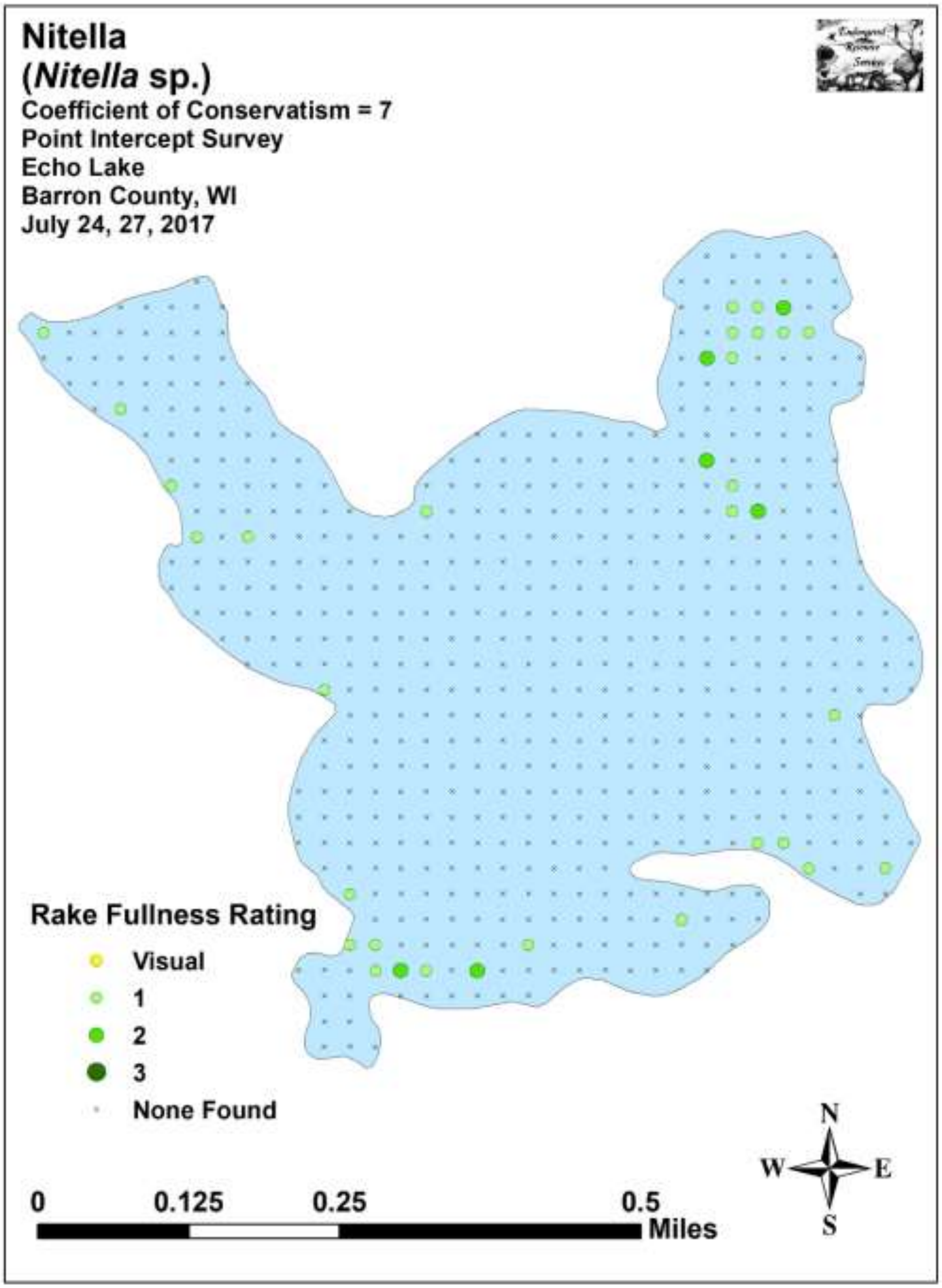
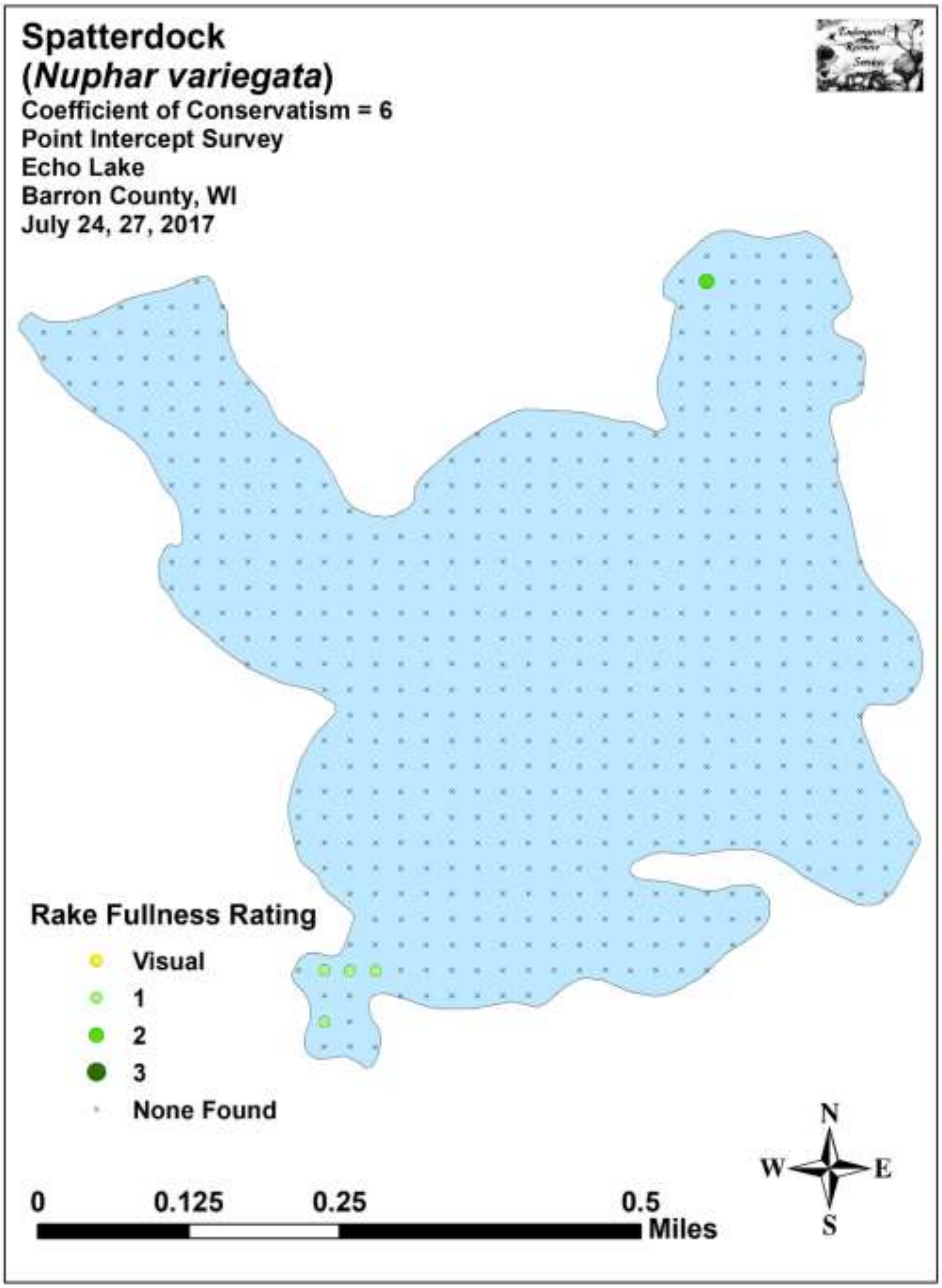
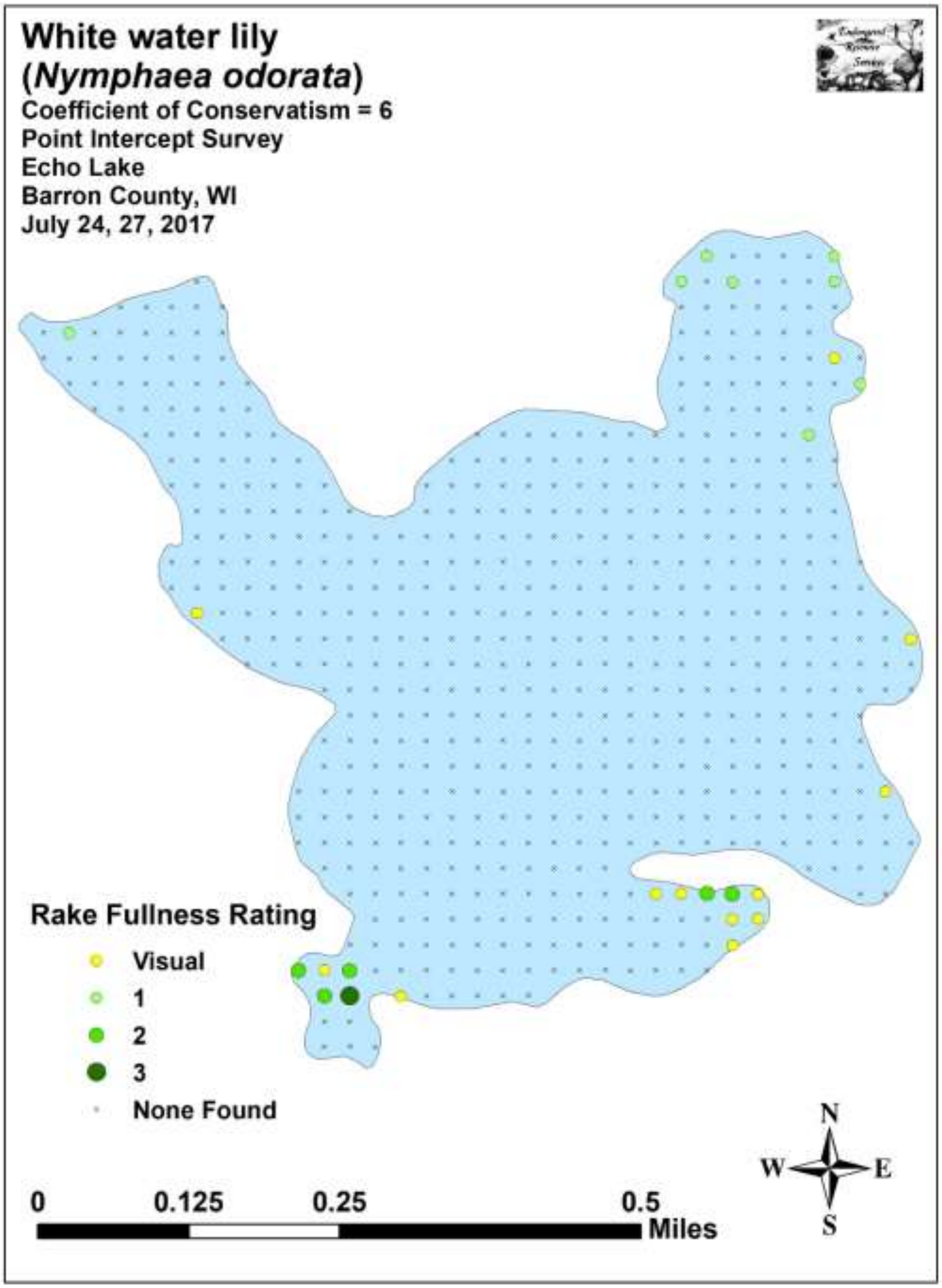
S


Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles


Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles



White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
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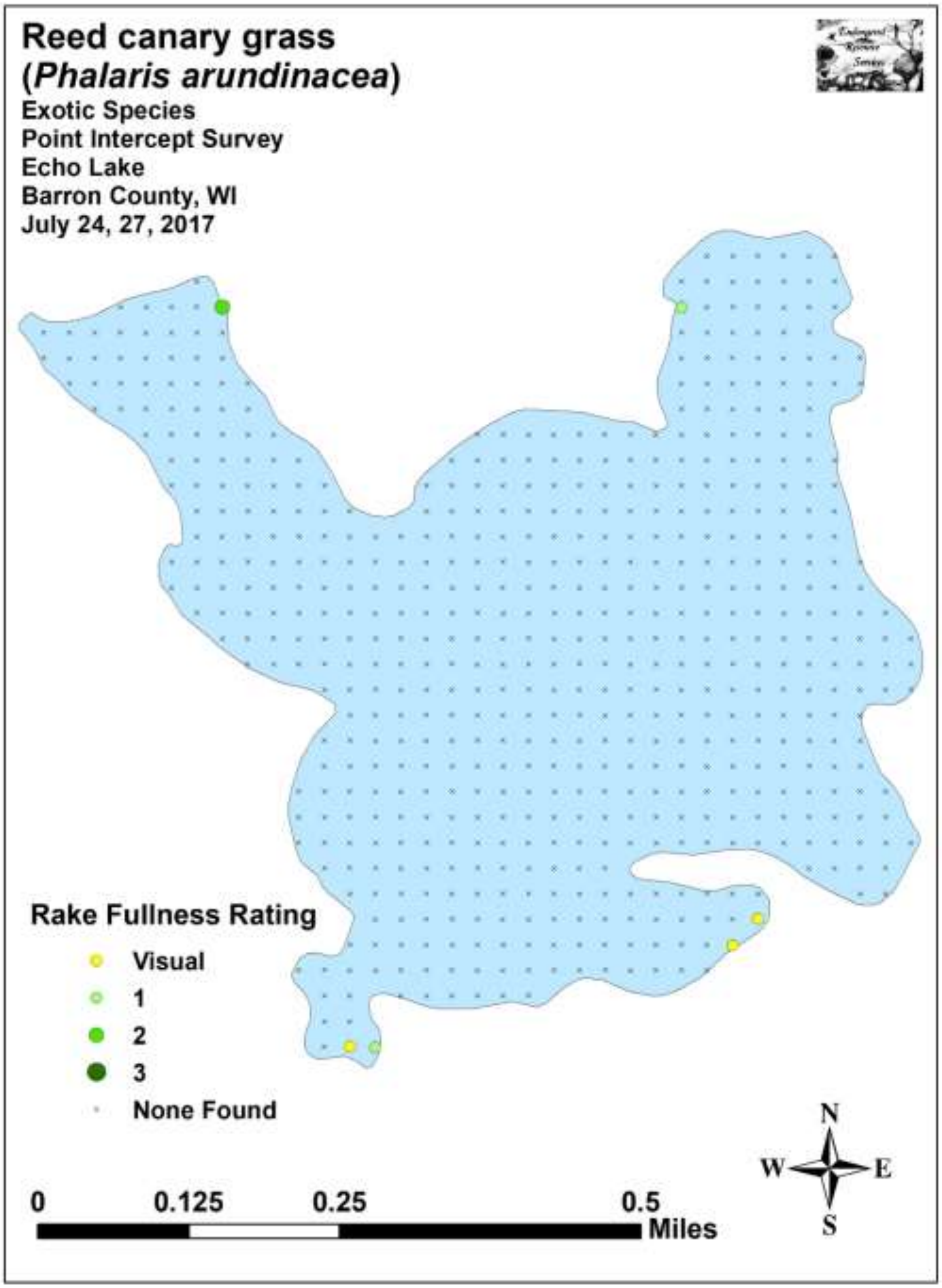
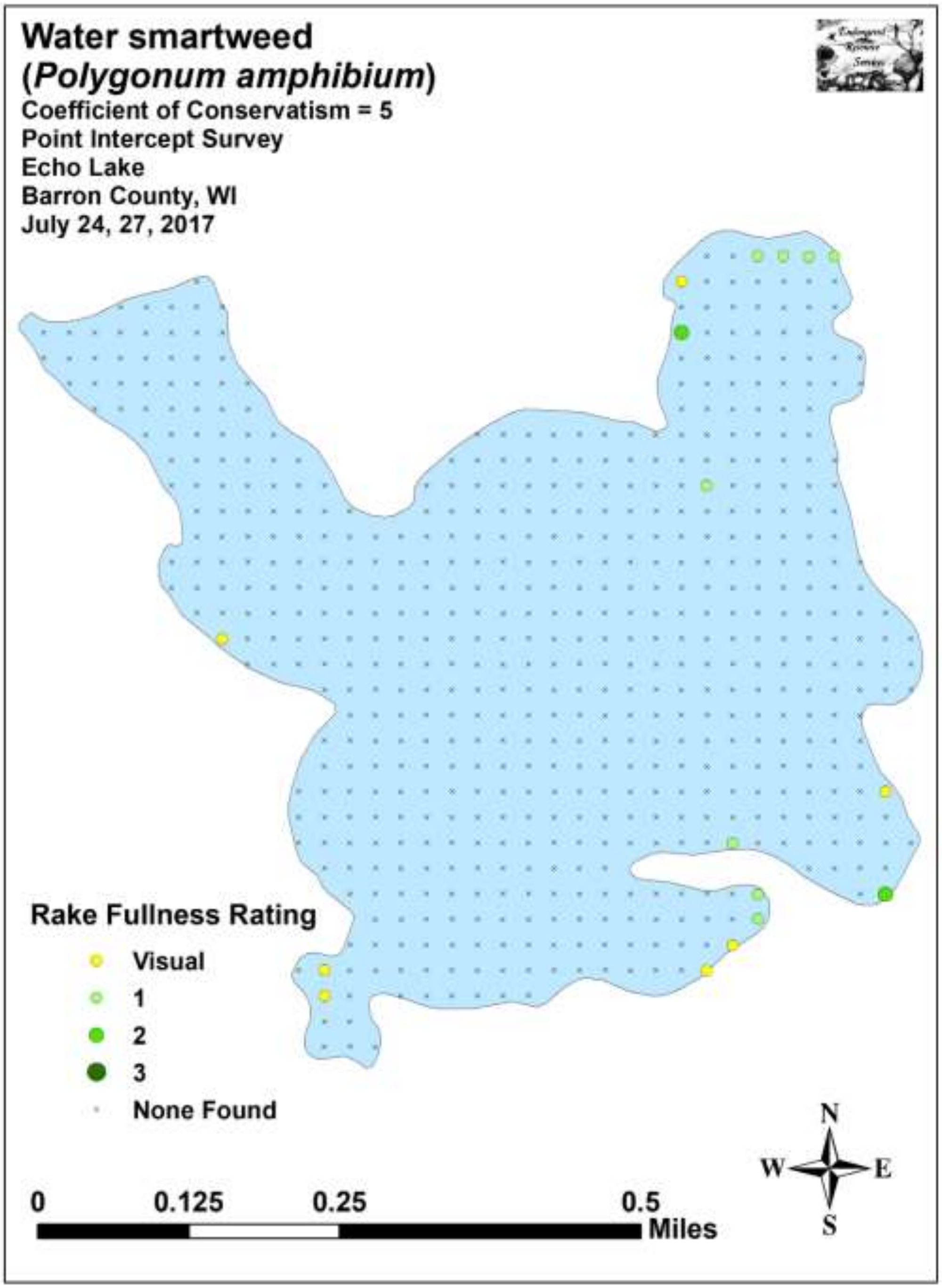
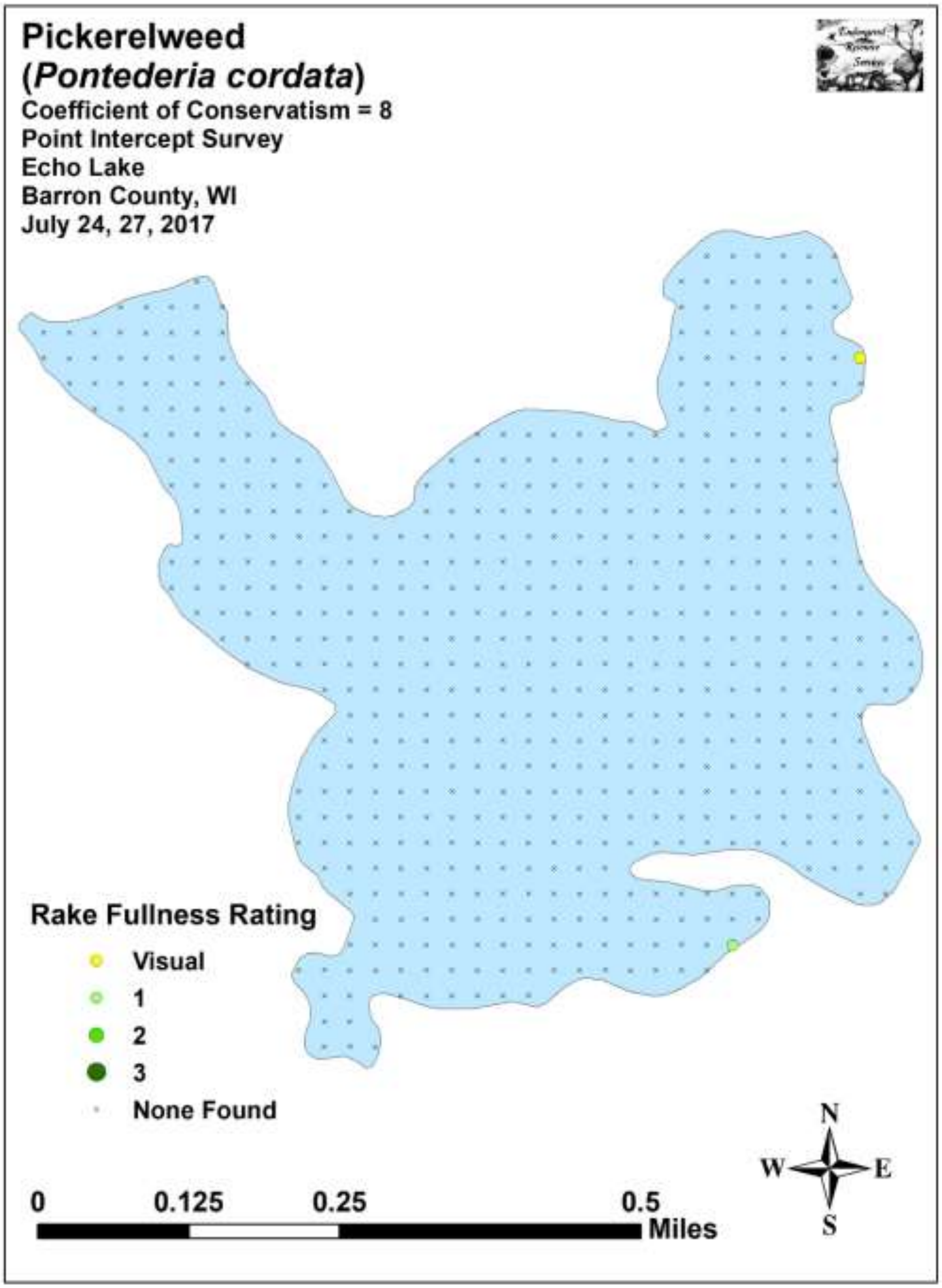
S
0
0.125
0.25
0.5
Miles

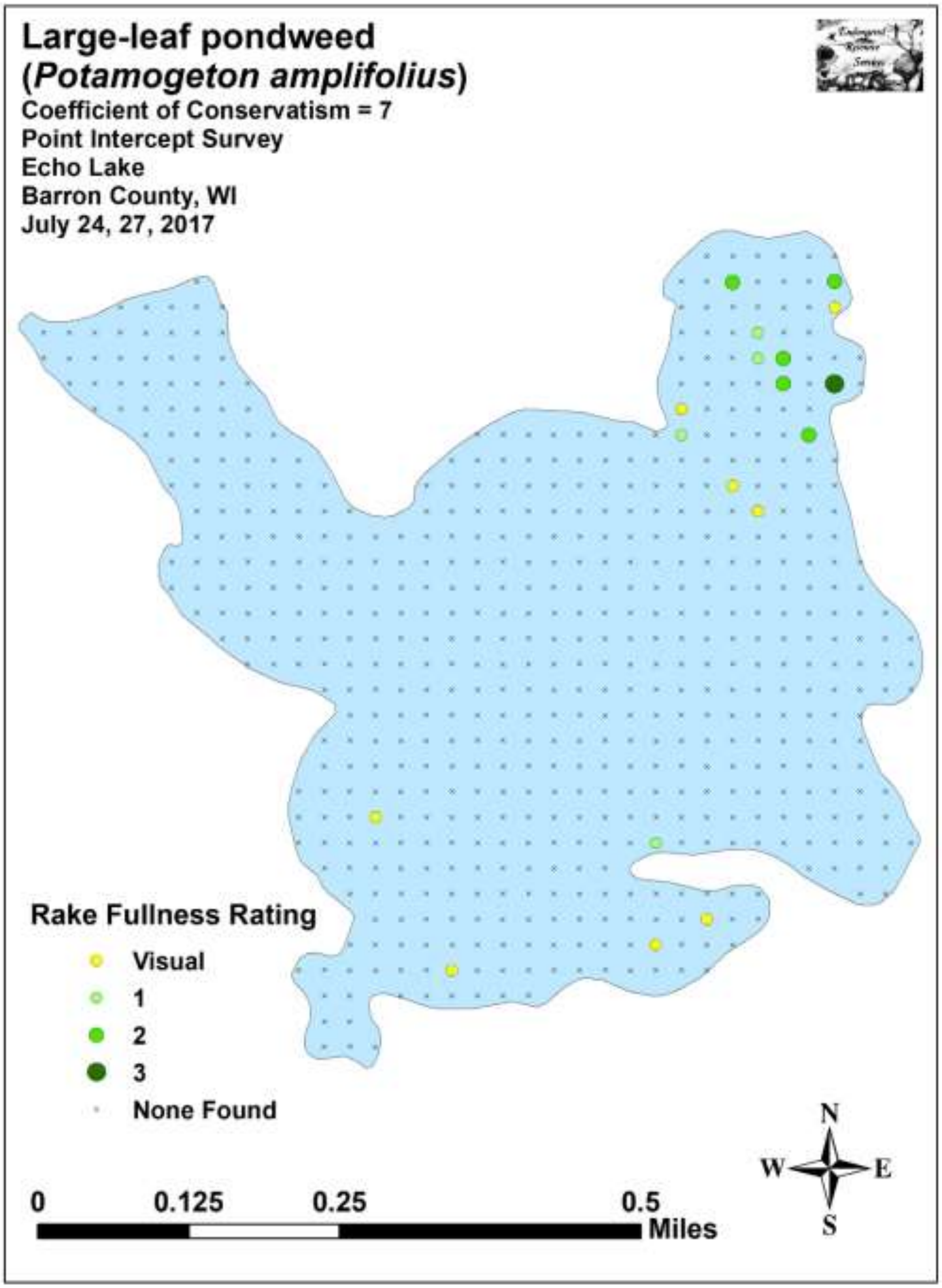


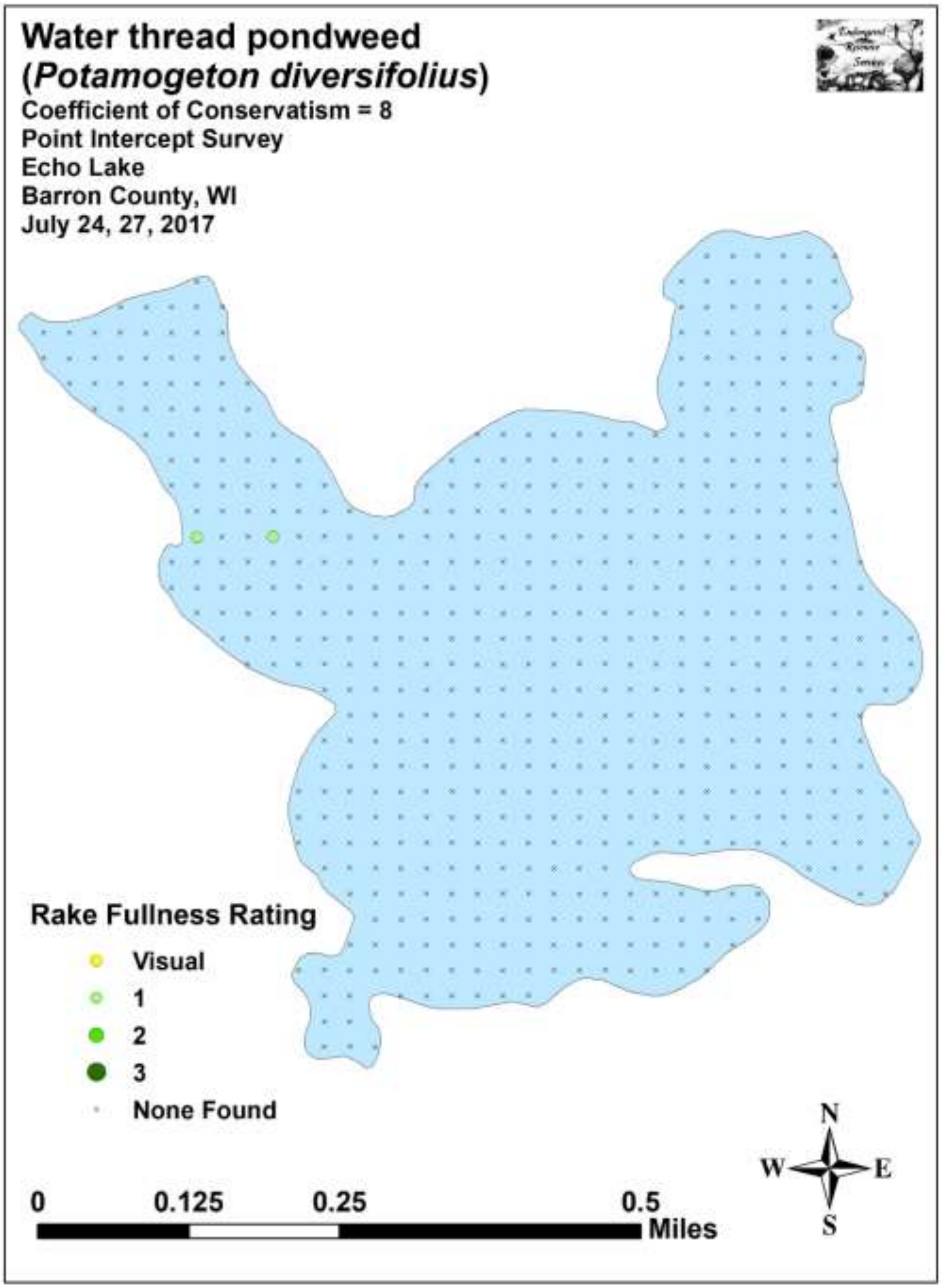
Reed canary grass
(Phalaris arundinacea)
Exotic Species
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S


Water smartweed
(*Polygonum amphibium*)
Coefficient of Conservatism = 5
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S



Pickerelweed
(Pontederia cordata)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S


Large-leaf pondweed
(Potamogeton amplifolius)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles


Water thread pondweed
(Potamogeton diversifolius)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
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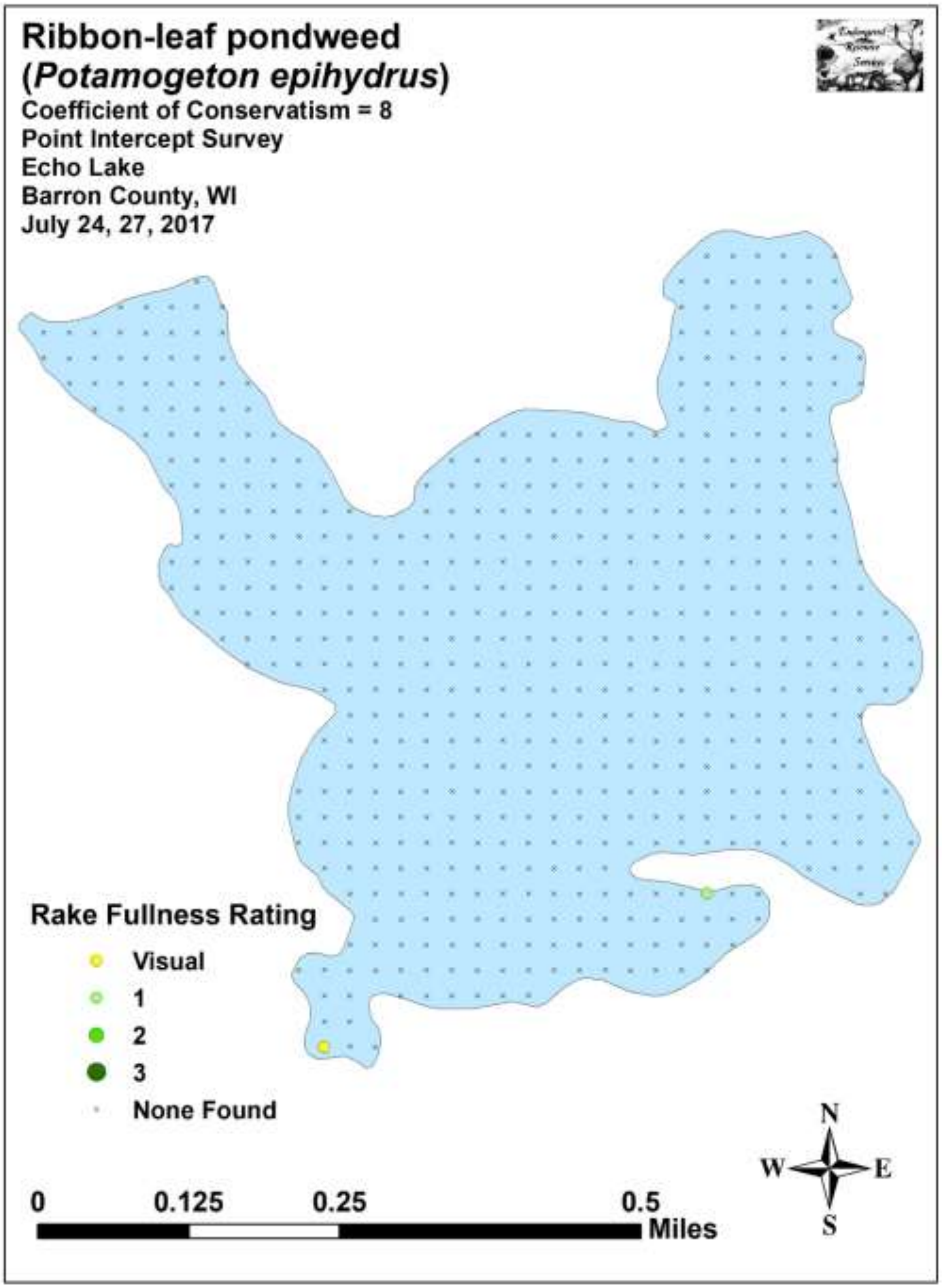
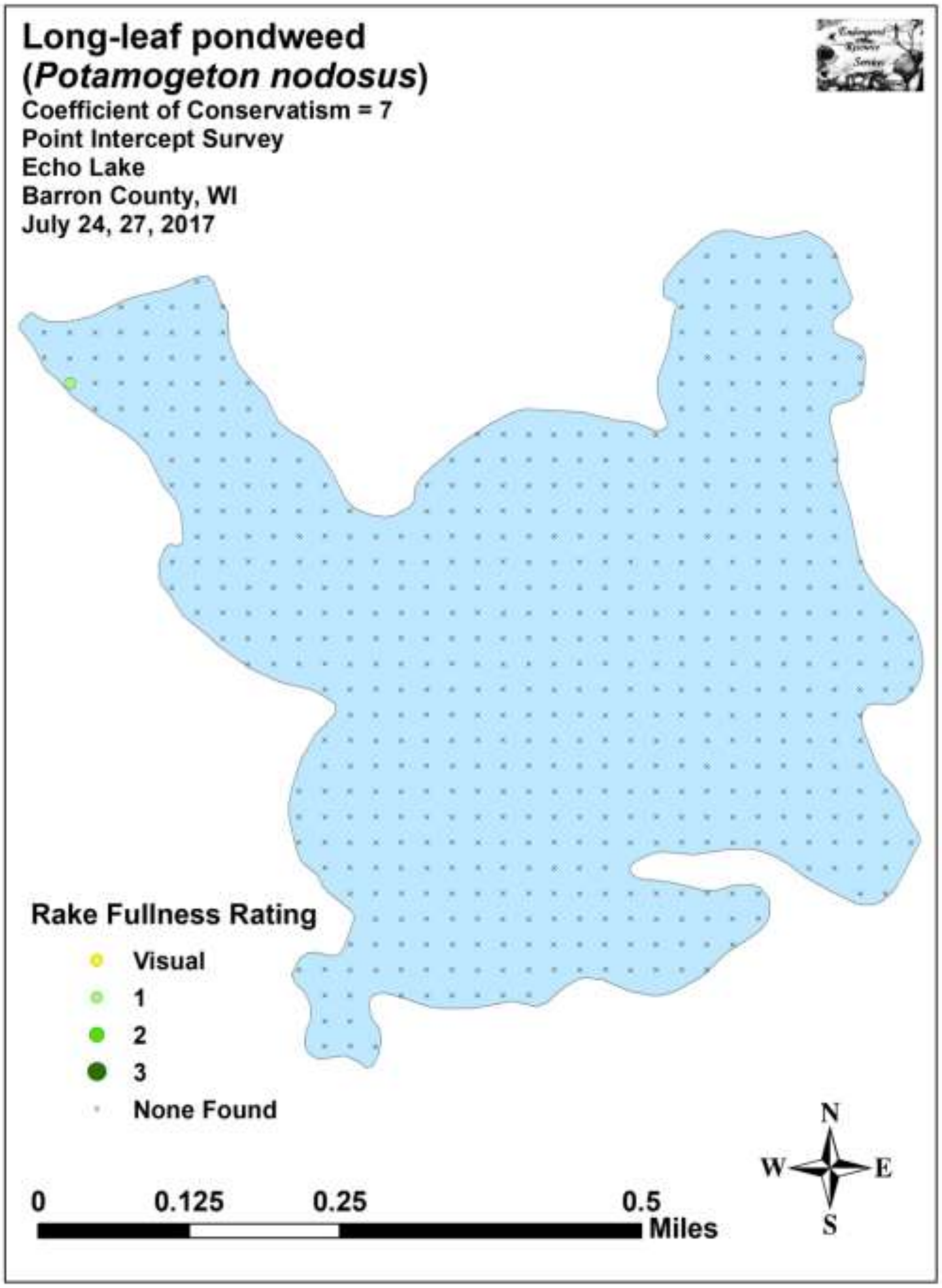
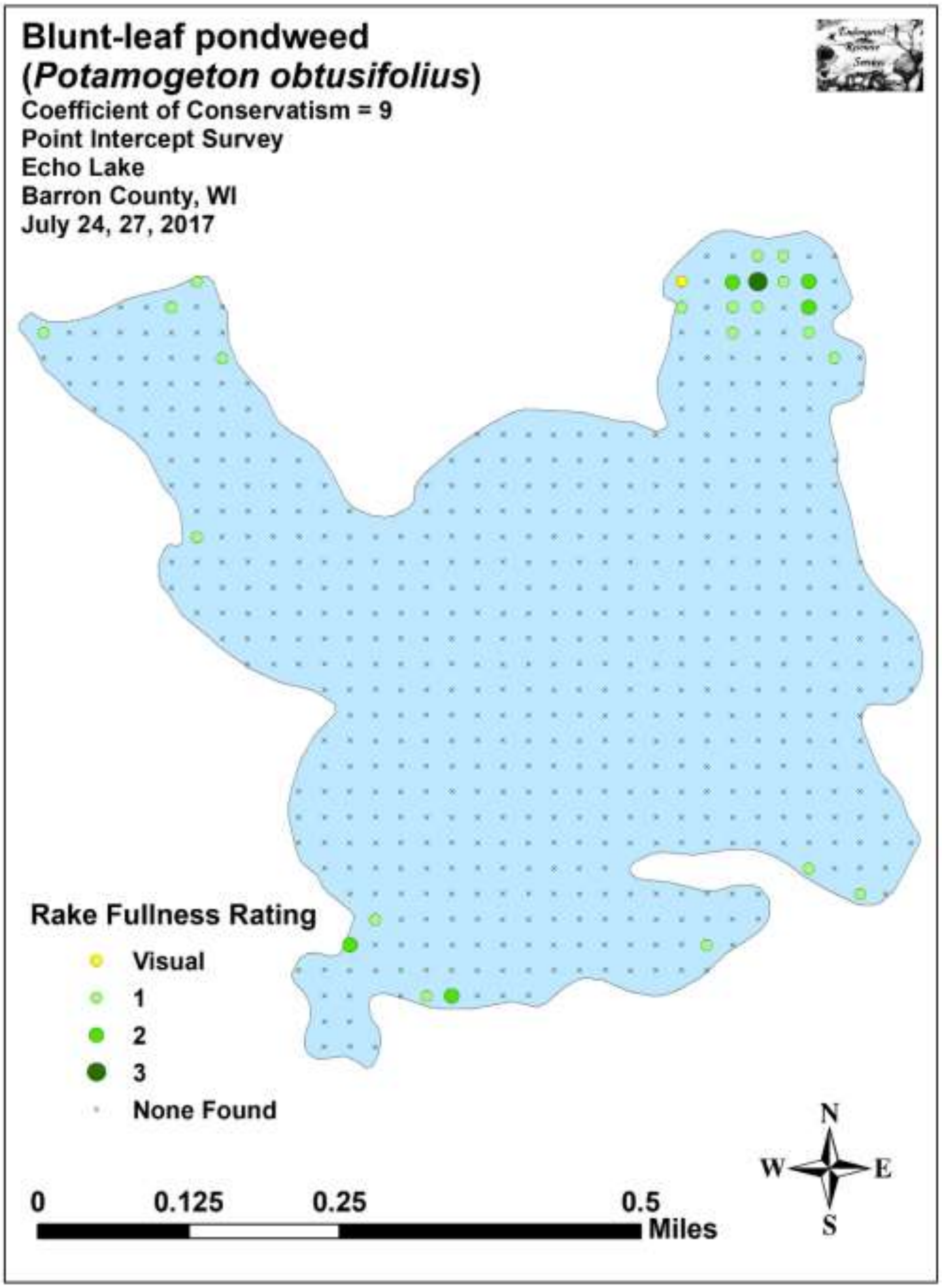
S

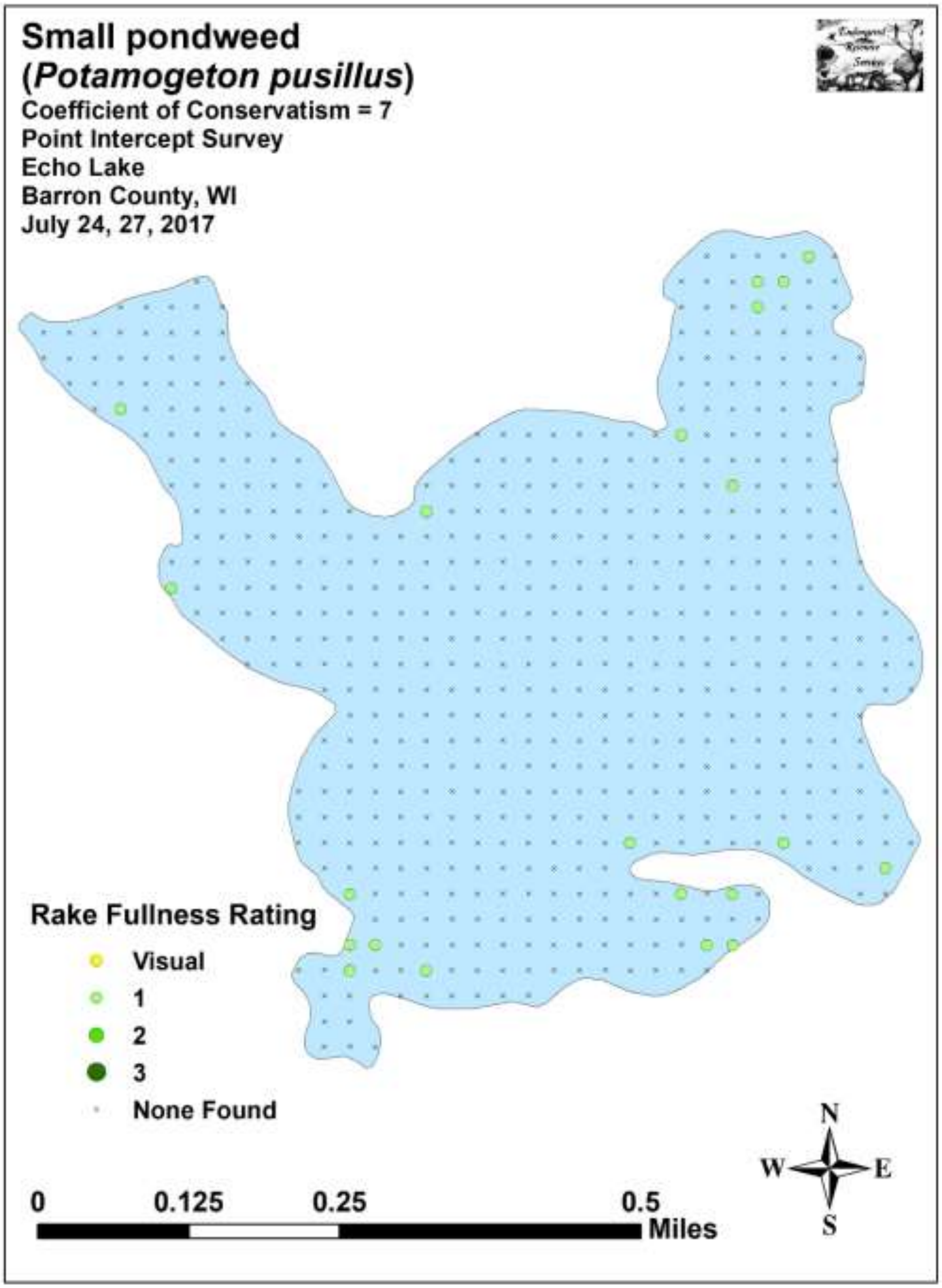

Ribbon-leaf pondweed
(*Potamogeton epihydrus*)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

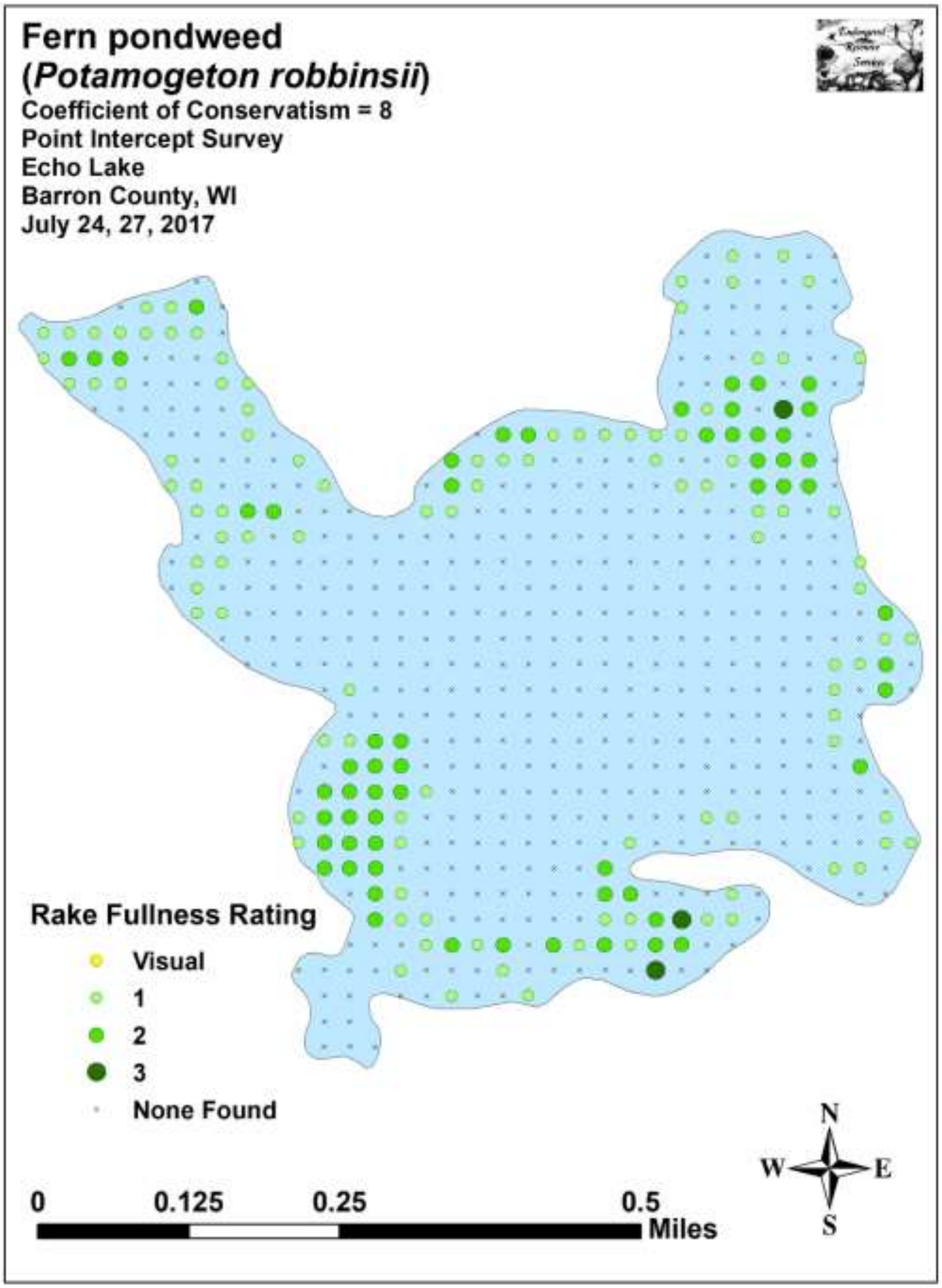


Long-leaf pondweed
(*Potamogeton nodosus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles



Blunt-leaf pondweed
(Potamogeton obtusifolius)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S


Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S


Fern pondweed
(Potamogeton robbinsii)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
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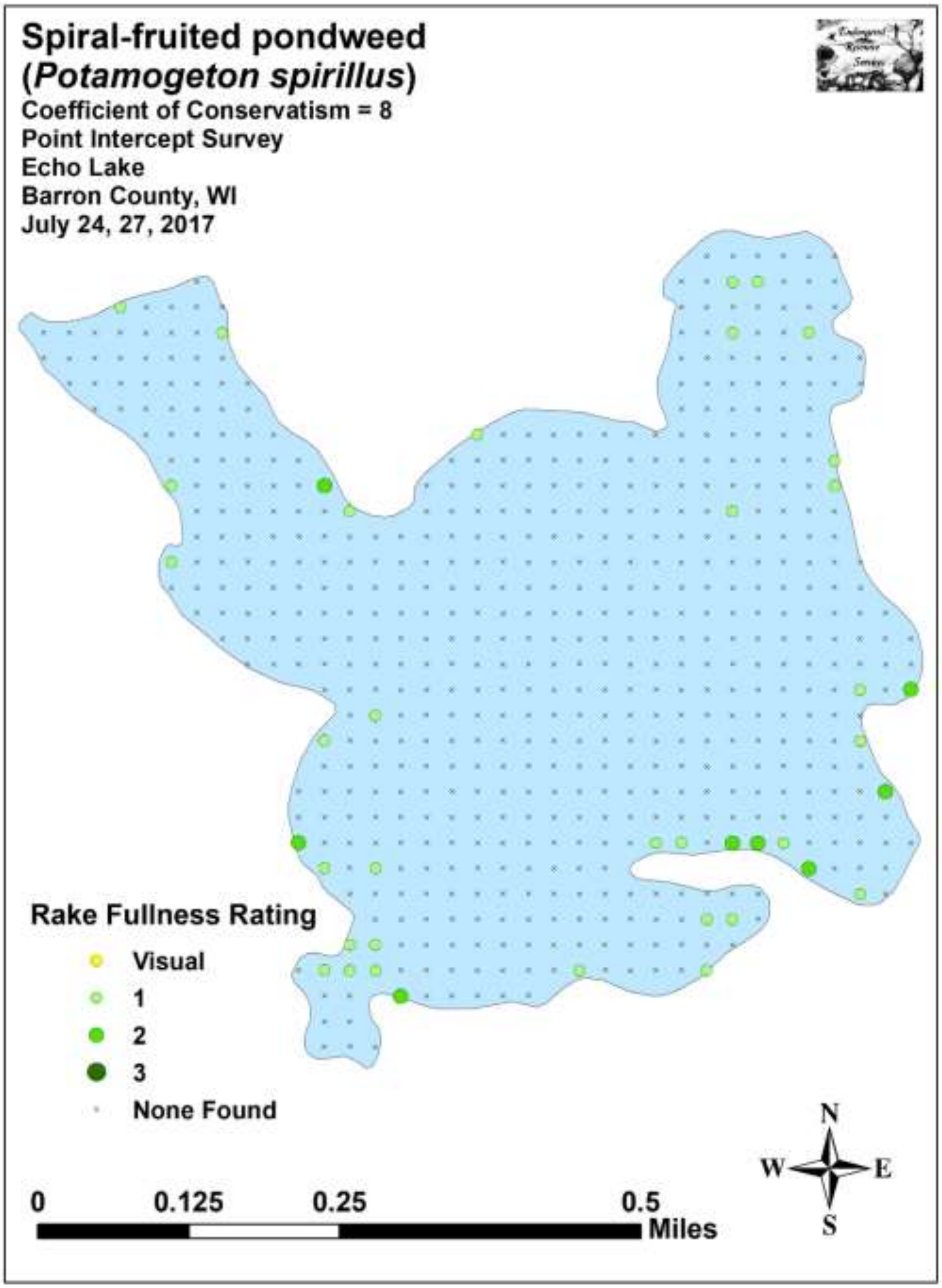
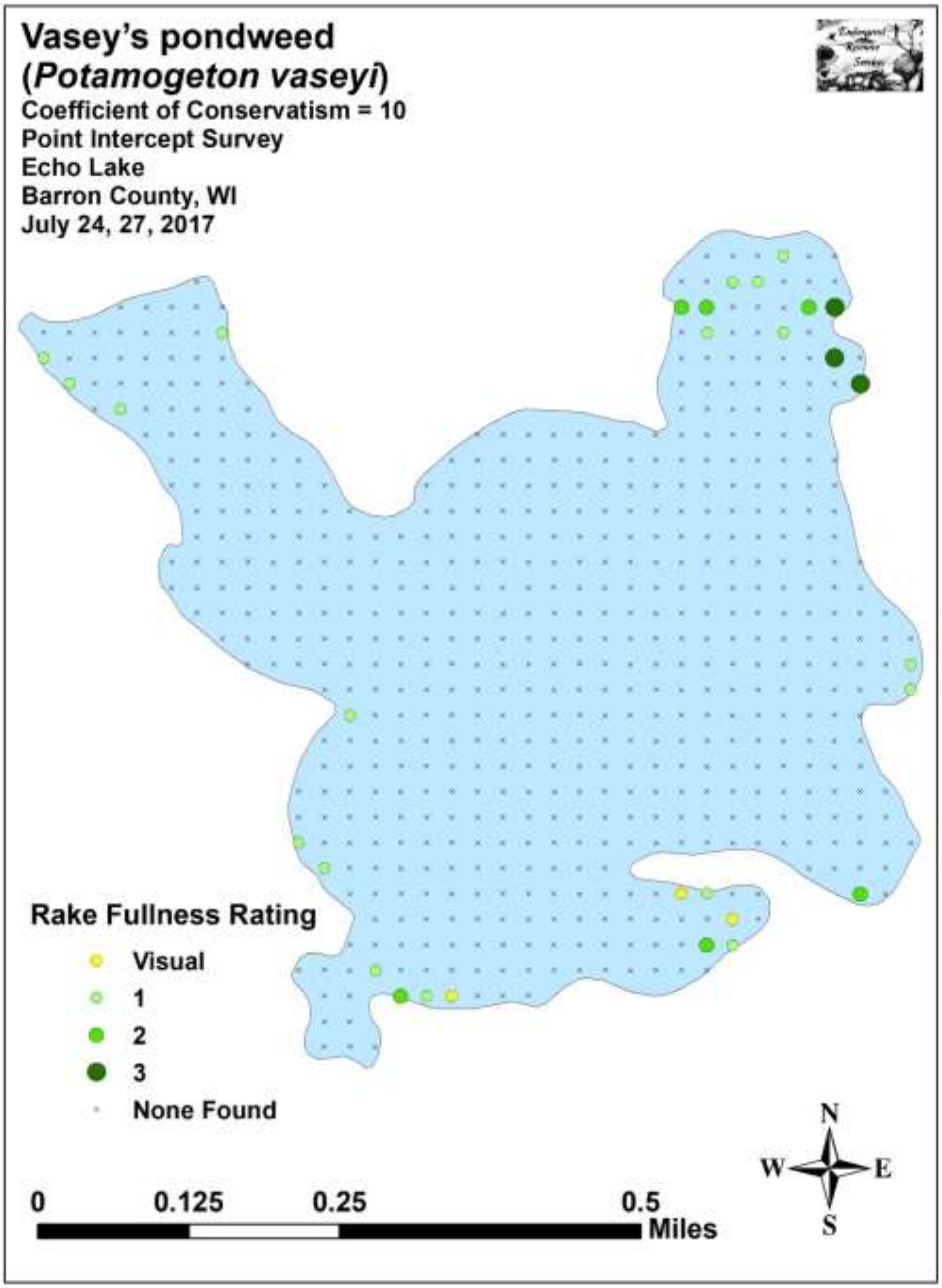
0.5
Miles



Spiral-fruited pondweed
(*Potamogeton spirillus*)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S


Vasey's pondweed
(*Potamogeton vaseyi*)
Coefficient of Conservatism = 10
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
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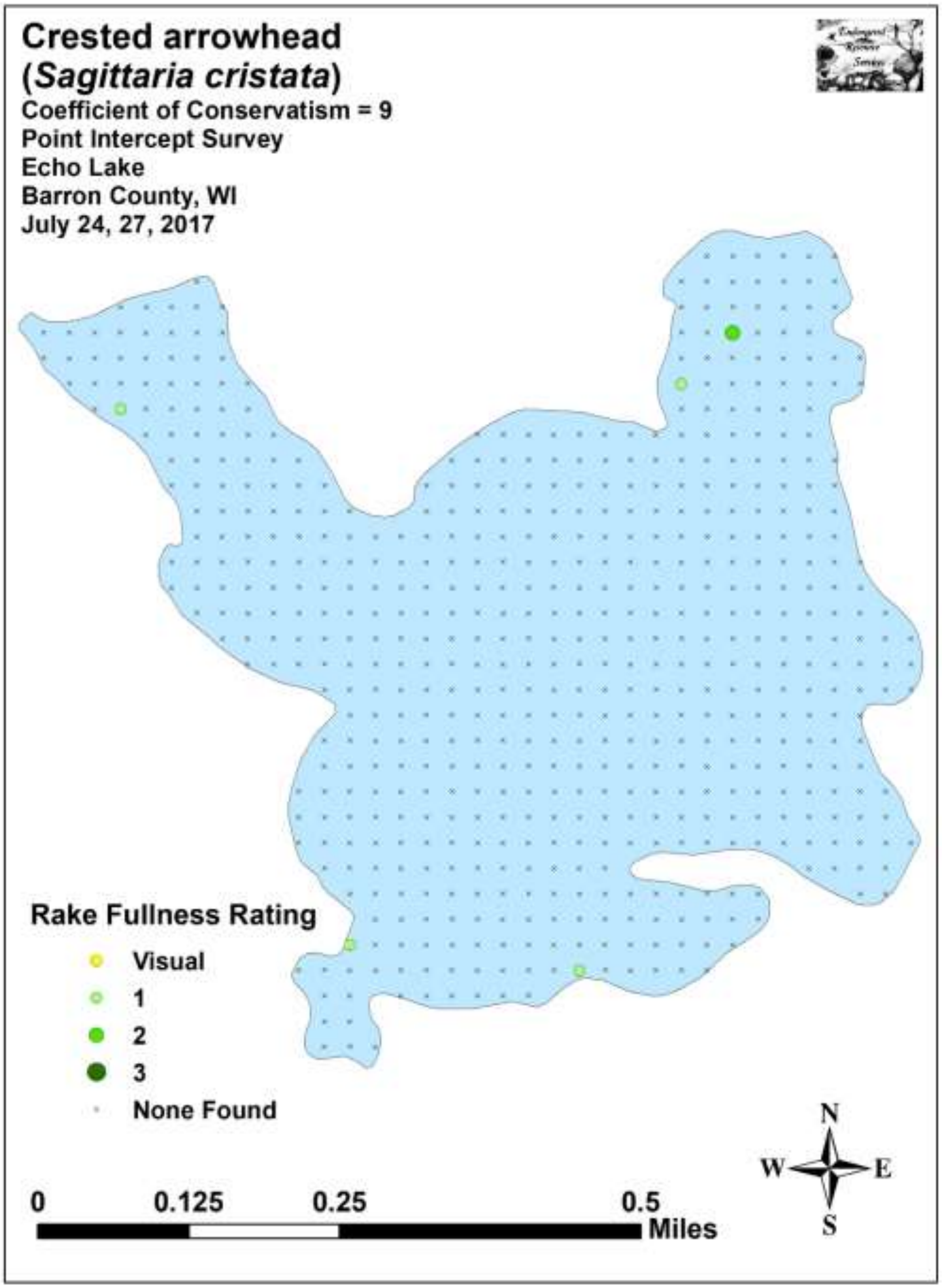
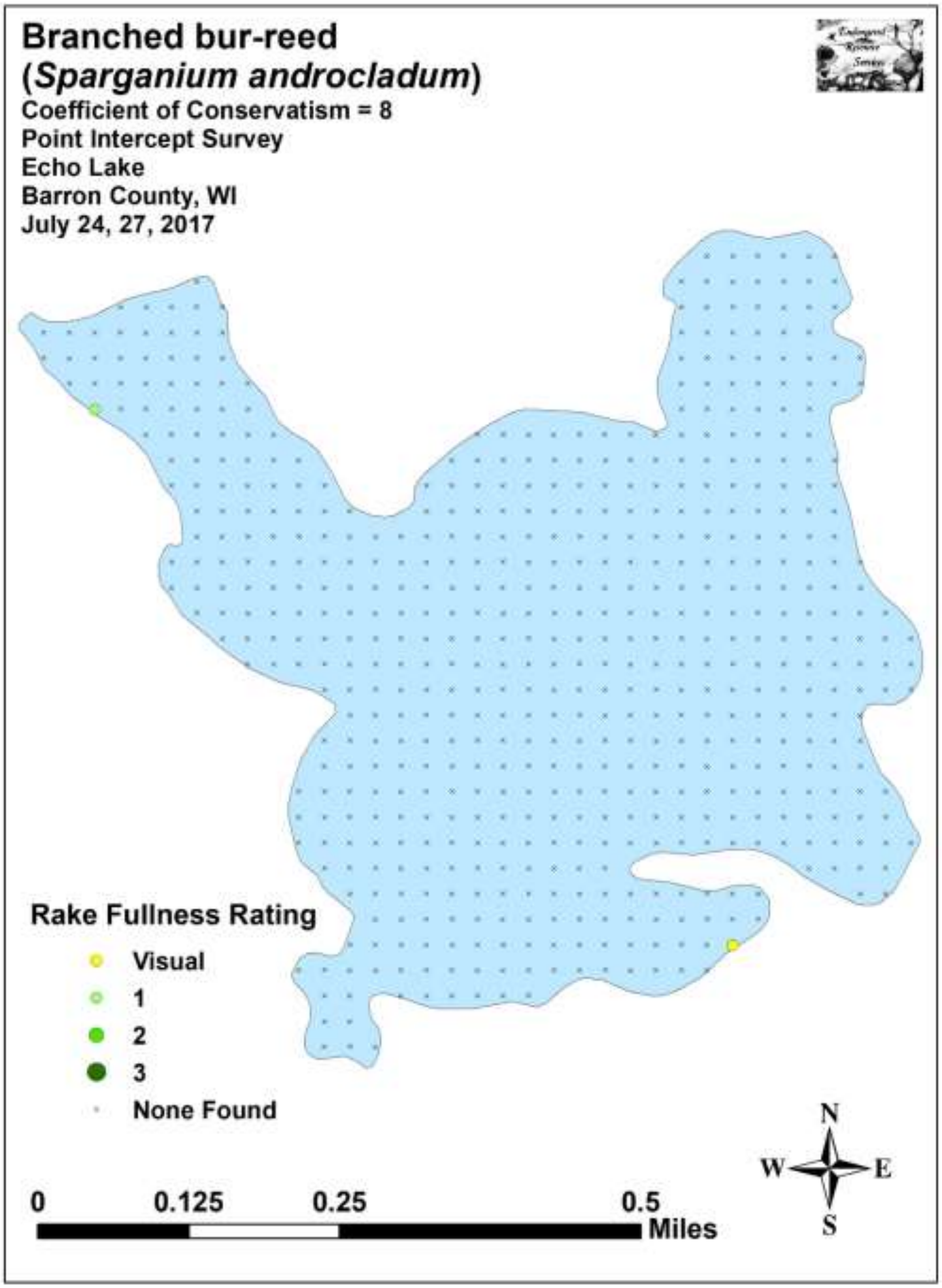
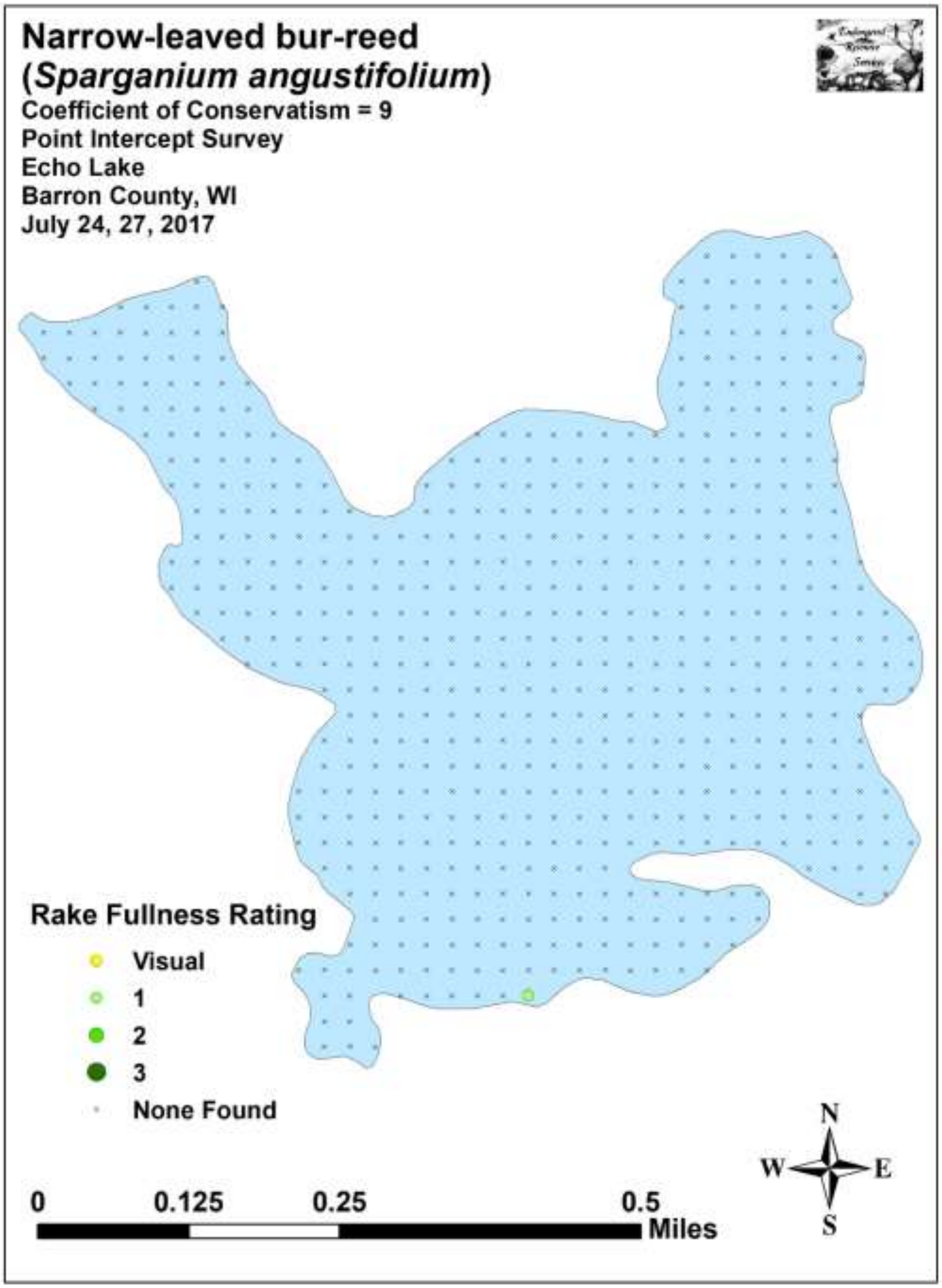
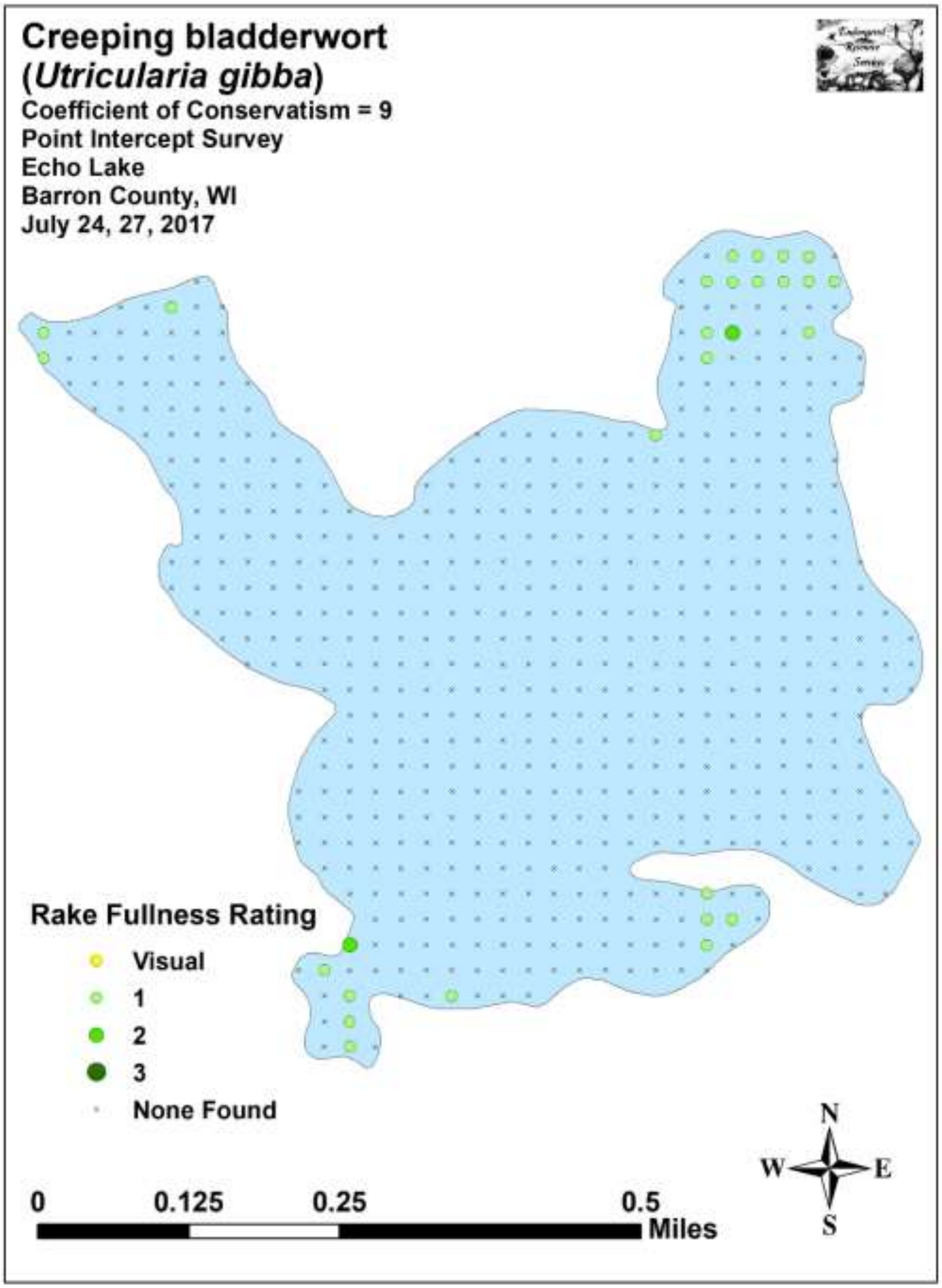
S



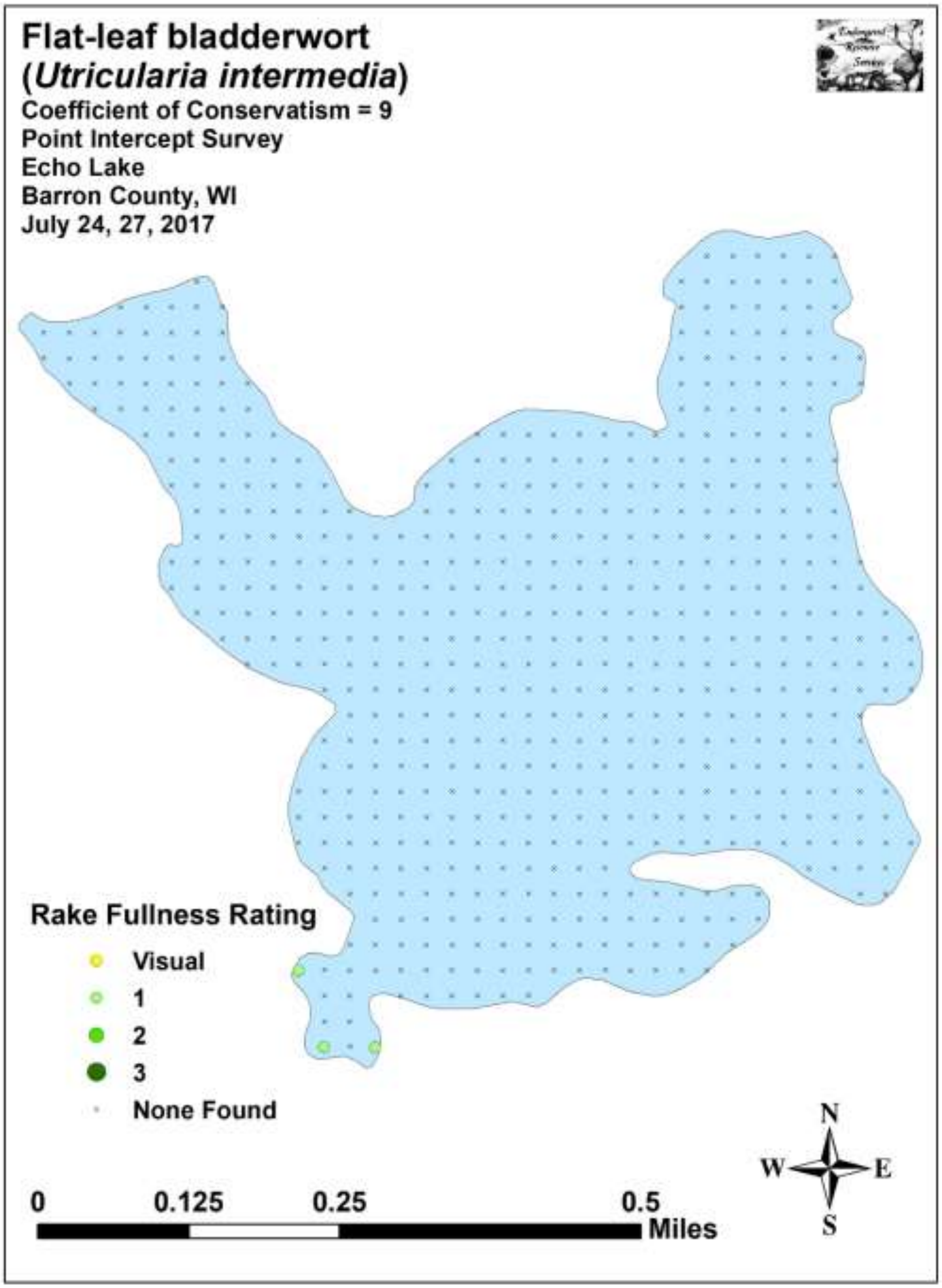
Crested arrowhead
(Sagittaria cristata)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

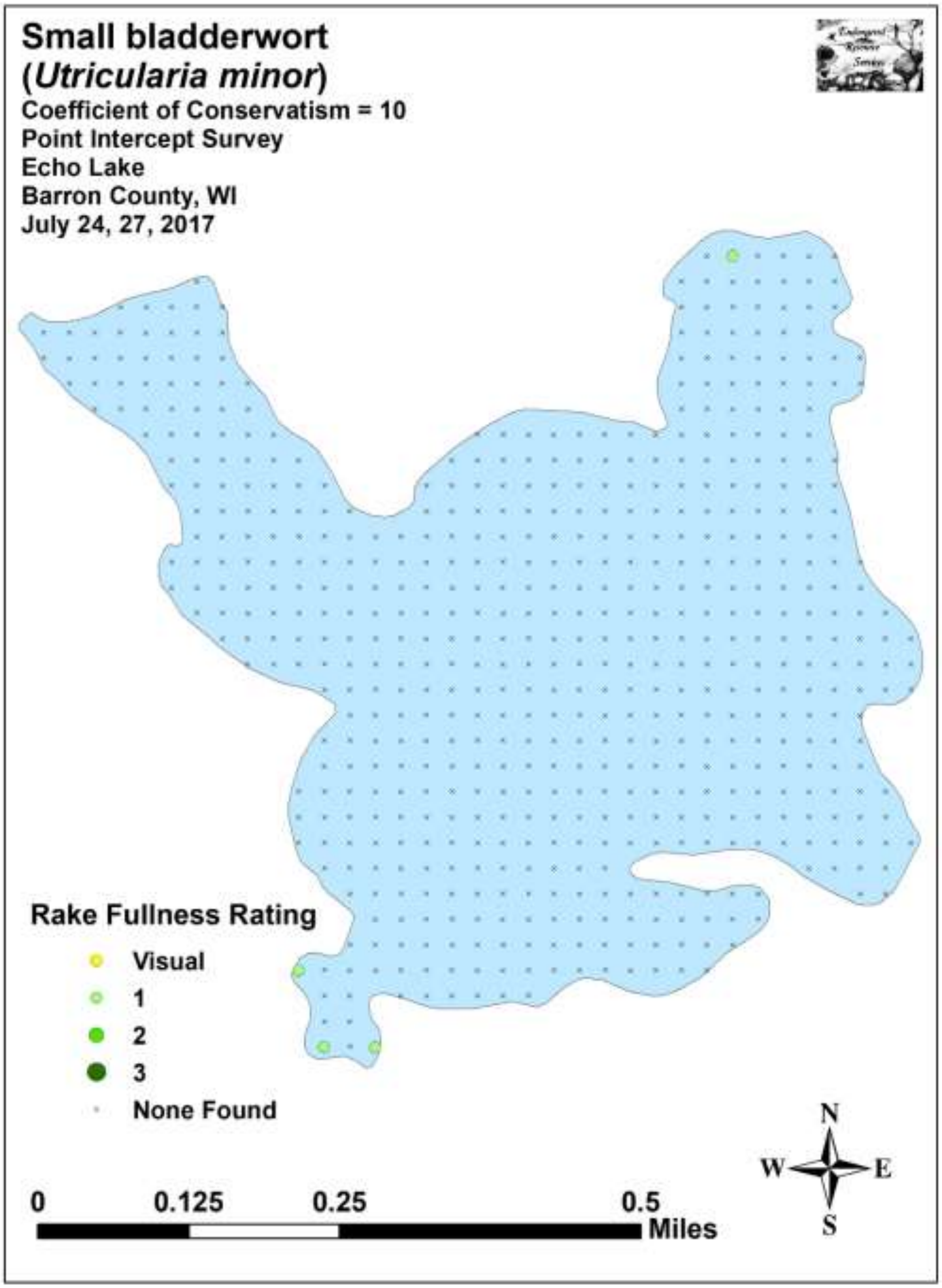

Branched bur-reed
(Sparganium androcladum)
Coefficient of Conservatism = 8
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S

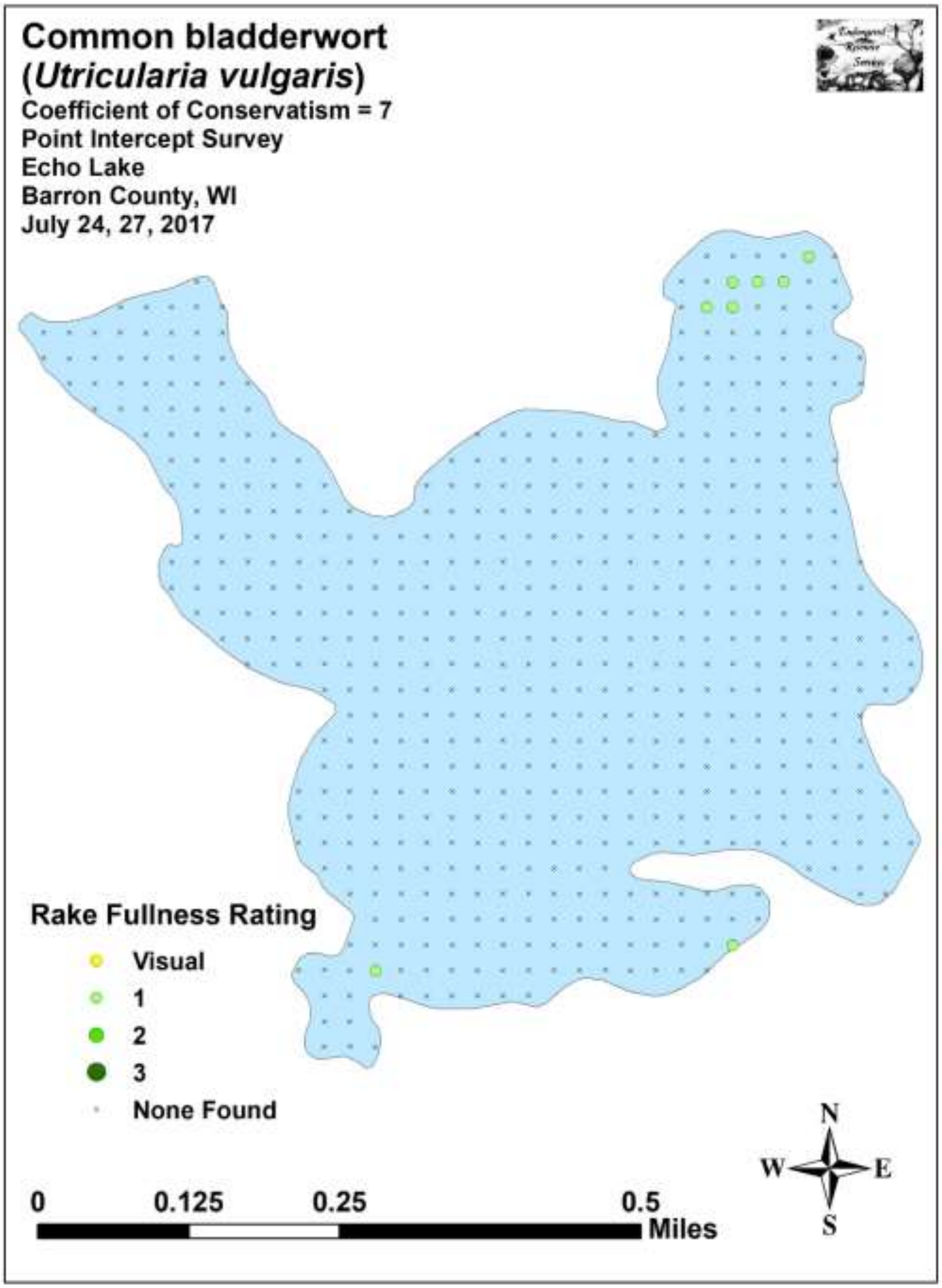

Narrow-leaved bur-reed
(*Sparganium angustifolium*)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S



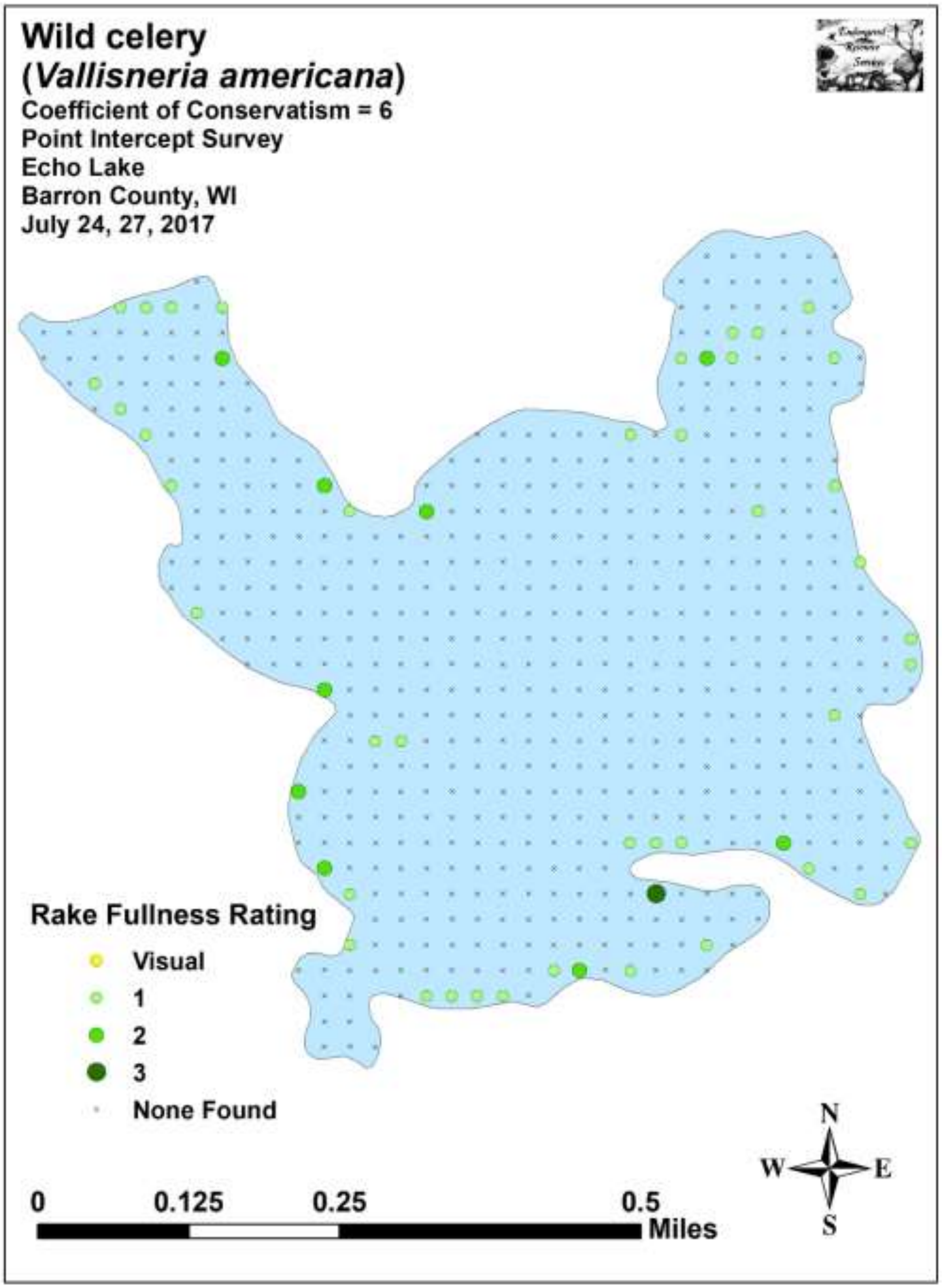
Creeping bladderwort
(Utricularia gibba)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles


Flat-leaf bladderwort
(Utricularia intermedia)
Coefficient of Conservatism = 9
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S

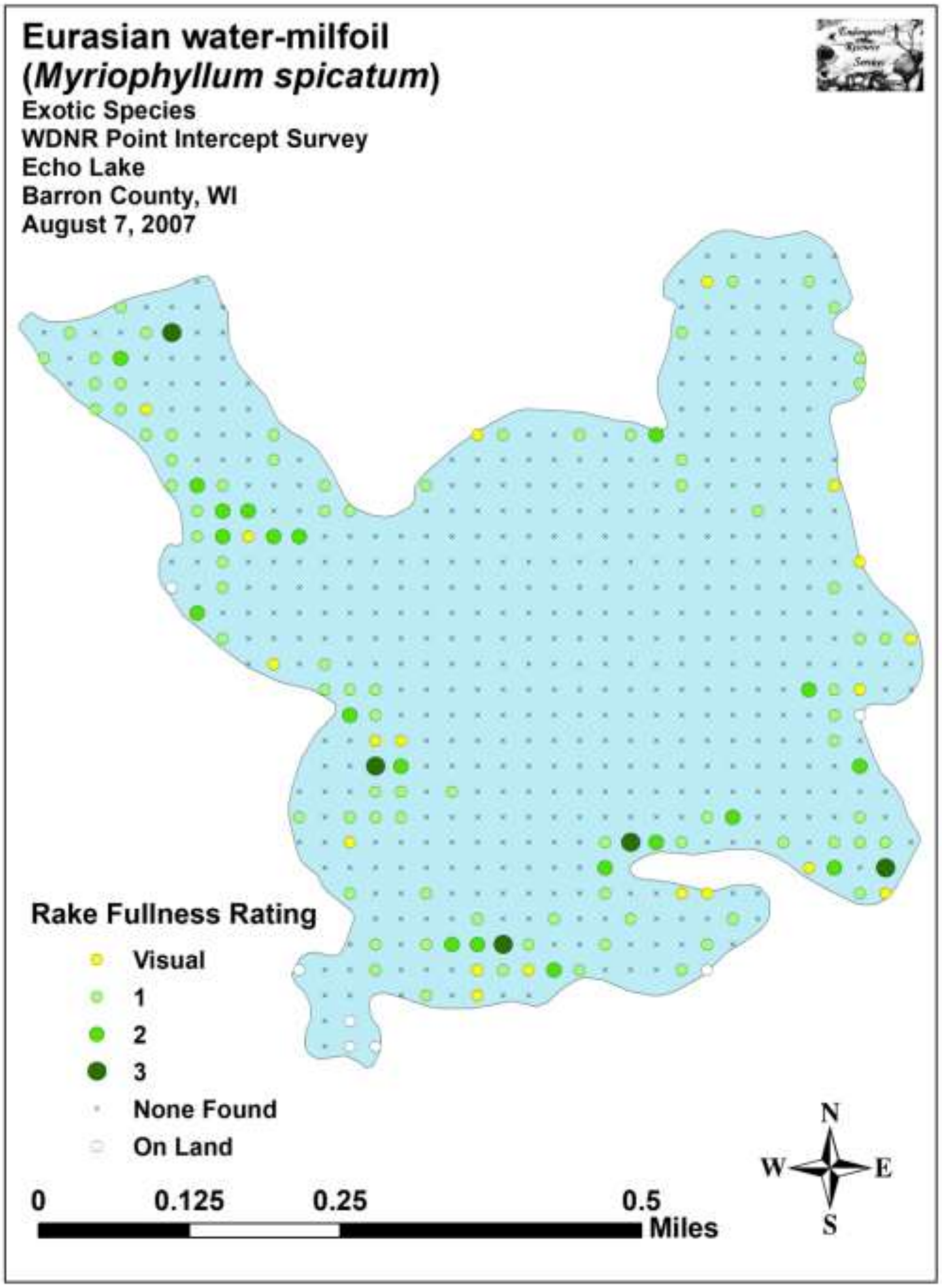

Small bladderwort
(Utricularia minor)
Coefficient of Conservatism = 10
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

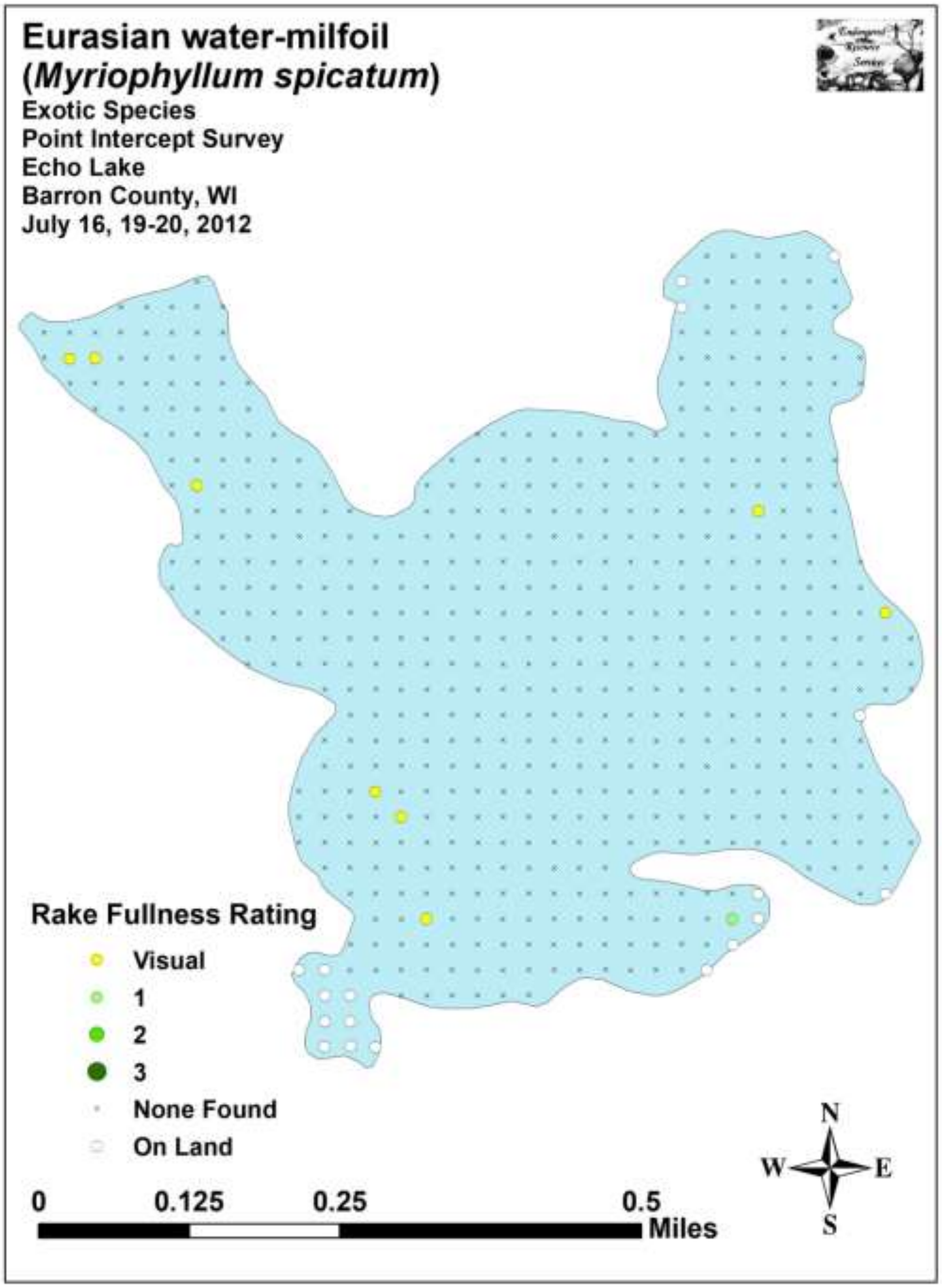


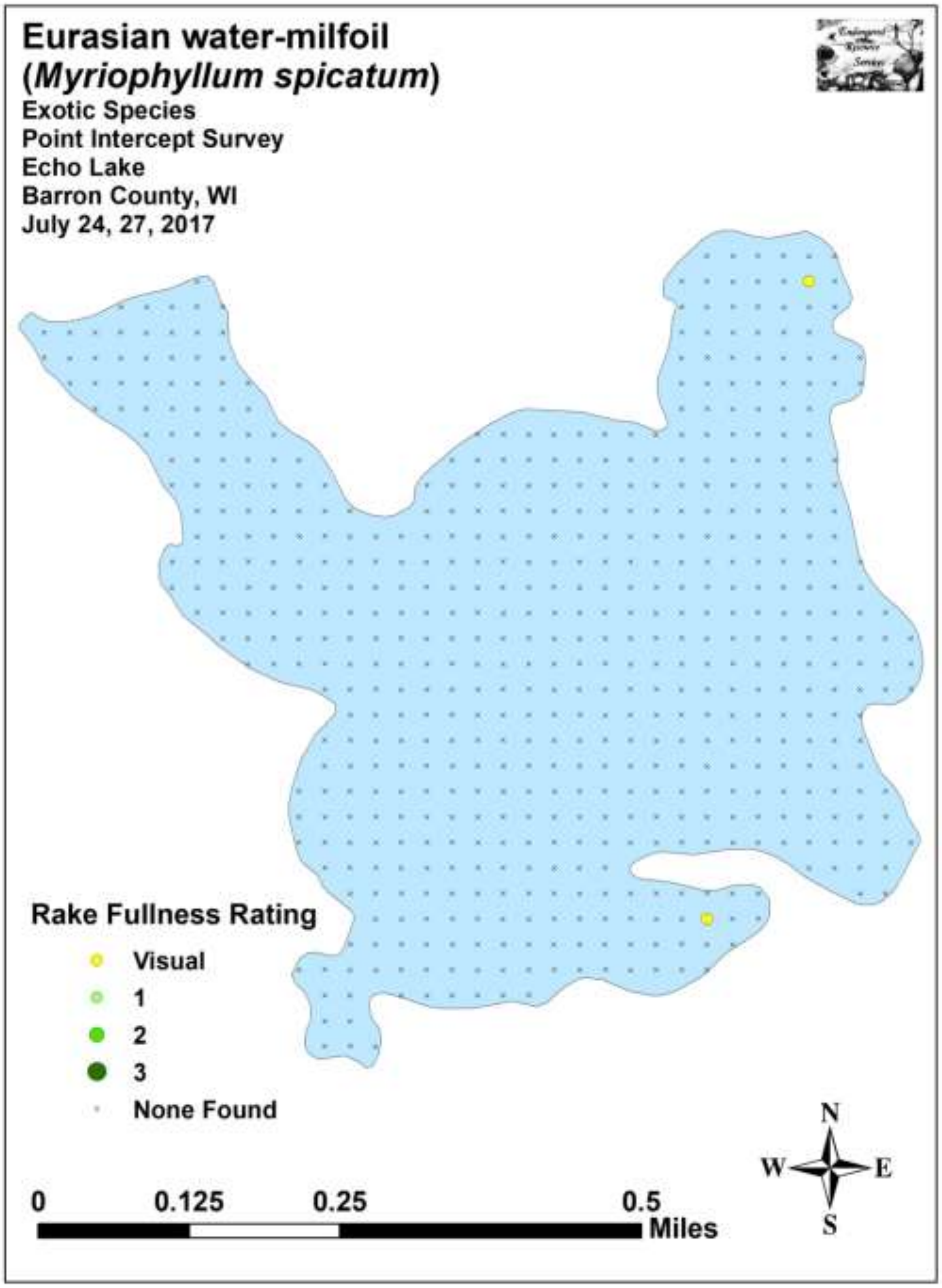
Common bladderwort
(Utricularia vulgaris)
Coefficient of Conservatism = 7
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
E
S


Wild celery
(*Vallisneria americana*)
Coefficient of Conservatism = 6
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.125
0.25
0.5
Miles

Appendix IX: 2007, 2012, and 2017 Eurasian Water-milfoil Density and Distribution Maps


Eurasian water-milfoil
(*Myriophyllum spicatum*)
Exotic Species
WDNR Point Intercept Survey
Echo Lake
Barron County, WI
August 7, 2007
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
0
0.125
0.25
0.5
Miles
N
W
E
S


Eurasian water-milfoil
(Myriophyllum spicatum)
Exotic Species
Point Intercept Survey
Echo Lake
Barron County, WI
July 16, 19-20, 2012
Rake Fullness Rating
Visual
1
2
3
None Found
On Land
N
W
E
S
0
0.125
0.25
0.5
Miles


Eurasian water-milfoil
(Myriophyllum spicatum)
Exotic Species
Point Intercept Survey
Echo Lake
Barron County, WI
July 24, 27, 2017
Rake Fullness Rating
Visual
1
2
3
None Found
0
0.125
0.25
0.5
Miles
N
W
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Appendix X: Aquatic Exotic Invasive Plant Species Information

Eurasian Water-milfoil

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

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

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

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

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

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

Curly-leaf pondweed

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

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

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

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out compete native plants in the spring. In mid-summer, when most aquatic plants are growing, curly-leaf pondweed plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. Curly-leaf pondweed forms surface mats that interfere with aquatic recreation. (Taken in its entirety from WDNR, 2010 http://www.dnr.state.wi.us/invasives/fact/curlyleaf_pondweed.htm)

Reed canary grass

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

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

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

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

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

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

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

Purple loosestrife
(Photo Courtesy Brian M. Collins)

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

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

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

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

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

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

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

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

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

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

Appendix XI: 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 XII: 2017 Raw Data Spreadsheets