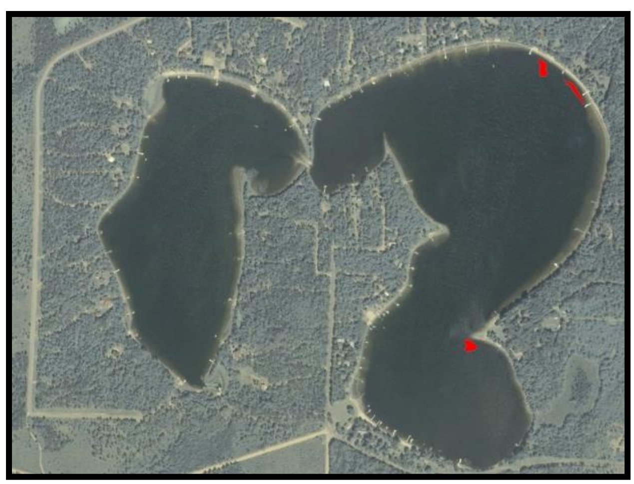
Eurasian water milfoil (*Myriophyllum spicatum*) June Littoral Zone and Bed Mapping Surveys, August Warm Water Point Intercept Survey, and October Herbicide Assessment Swimover Survey Horseshoe Lake (WBIC: 2470000) Washburn County, Wisconsin

Eurasian water milfoil (Berg 2007)

Small purple bladderwort (Horky, 2011)

Project Initiated by: Horseshoe Lake Property Owners Association and the Wisconsin Department of Natural Resources



2011 EWM Treatment Areas

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June 12, August 2-3, and October 8, 2011

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ABSTRACT

Horseshoe Lake (WBIC 2470000) is a 194-acre, oligotrophic seepage lake located in north-central Washburn County, Wisconsin. The lake's average depth is 7ft, and the bottom substrate is predominantly sand and sandy/muck. Water clarity is good to very good with Secchi values averaging 10ft at the time of the survey. In May 2011, Eurasian water milfoil (*Myriophyllum spicatum*) was discovered in the lake. Because of this, the Horseshoe Lake Property Owners Association and the WDNR commissioned a June EWM bed mapping survey, an August full point intercept macrophyte survey, and an October post herbicide swimover assessment survey in preparation for developing an Aquatic Plant Management Plan for the lake. The June survey identified three EWM beds on the east side of the lake totaling 0.53 acre. The August survey found macrophytes at 254 of the 387 total survey points. Forty-one species found growing in and adjacent to the lake produced a Simpson Index Value of 0.91. Plant growth was moderate with a mean total rake fullness value at vegetative sites of 1.70. Slender naiad (*Najas flexilis*), Muskgrass (*Chara* sp.), Fern pondweed (*Potamogeton robbinsii*), and Wild celery (*Vallisneria americana*) were the most common species being found at 28.35%, 27.95%, 25.20% and 23.23% of survey points with vegetation respectively. A total of 23 native index species produced a mean Coefficient of Conservatism of 7.4 and an above average Floristic Quality Index of 35.4. EWM was recorded as a visual at only two sites and was not found anywhere in the lake other than the three previously identified beds. Other than EWM, no other exotic species were located. The September 15th herbicide treatment appeared to provide complete control of EWM plants. Future management considerations include preserving the lake's rich, diverse, and rare native plant community, training volunteers to recognize EWM, and conducting at least monthly shoreline surveys to quickly identify and economically control new EWM beds. Lakeshore owners can help prevent the spread of EWM and improve water clarity and quality by refraining from removing native plants from the lake, working to reduce nutrient input into the lake, restoring shorelines with buffer strips of native vegetation to prevent erosion and runoff, and avoiding beaching watercraft and motor start-up in shallow water which can dislodge the lake's "turf" of native plants. Finally, completing an Aquatic Plant Management Plan will help guide the management of EWM and the lake's native plants moving forward.

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INTRODUCTION:

Horseshoe Lake (WBIC 2470000) is a 194 acre seepage lake in north-central Washburn County, Wisconsin in the Town of Minong (T42N R12W S30 SW SW). It reaches a maximum depth of 21ft in the northeast corner of the eastern basin and has an average depth of approximately 7ft (WDNR 2010). The lake appears to be oligotrophic in nature with good to very good water clarity. Although no historical water quality data exists (WDNR 2011), we could see the bottom clearly in 6-7ft of water during the June survey, and Secchi readings were in the 10ft range with the littoral zone extending to at least 18ft in August. The bottom substrate is predominately sand along the shoreline, but this gradually transitions to sandy muck at most depths over 6ft (Figure 1). The only organic muck occurs in the tiny hook bay on the southeast end of the lake's west basin (Sather et al. 1971).

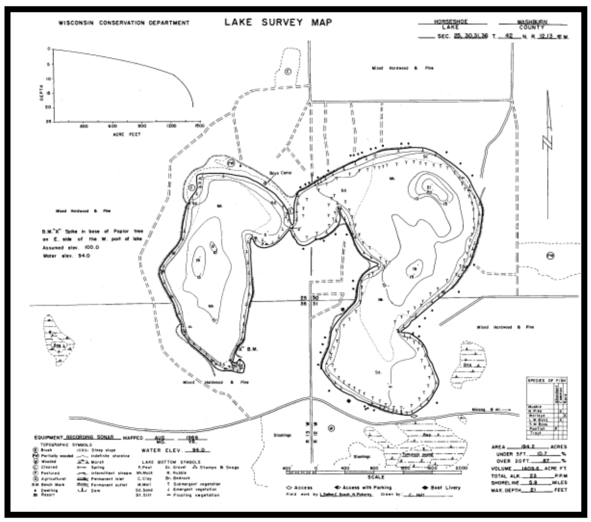

Figure 1: Horseshoe Lake Bathymetric Map

Eurasian water milfoil (*Myriophyllum spicatum*) (EWM) is an exotic invasive plant species that is a growing problem in the lakes and rivers of northwestern Wisconsin. Present in nearby Nancy Lake since 1991, the Minong Flowage since 2002, and Gilmore Lake since 2009, EWM was first found in Horseshoe Lake in May 2011. Thinking it was a small localized infestation, the Horseshoe Lake Property Owners Association (HLPOA) authorized a June 12th SCUBA removal of the known bed and a meandering littoral zone survey to look for evidence of further spread. After the initial bed was found to be bigger than anticipated making dive removal unfeasible and rooted plants were found at two additional locations in the east basin, the Wisconsin Department of Natural Resources (WDNR) authorized a lakewide systematic point intercept macrophyte survey. Conducted on August 2-3rd, the standardized methods of this survey ensure that all sampling in the state will be conducted in the same manner, thus allowing data to be compared across time and space. Following the September 15th herbicide application, an October 8th swimover survey was conducted to evaluate the effectiveness of the treatment. This report is the summary analysis of these surveys. The primary goals of the project were to determine the level of the EWM infestation, establish baseline data on native plant density and distribution, and suggest ideas for the HLPOA to consider as they work to control EWM and manage their resource moving forward.

PLANT SURVEY METHODS:

Dive Removal:

We used SCUBA to assess the size and density of the EWM bed discovered in May on the northeast corner of the eastern basin. While the diver was underwater, volunteers in kayaks and boats took GPS coordinates at the edges of the bed based on the divers position underwater and gathered any EWM fragments that floated up. All EWM plants that were removed were dug up by the roots, placed in mess bags while underwater, and immediately removed and disposed of away from the water.

Meandering Littoral Zone and Bed Mapping Surveys:

Following the initial dive assessment, we conducted a meandering survey of the lake's visible littoral zone spacing transects close enough that our field of view overlapped from one transect to another. We paid special attention to the areas around docks as this is where EWM brought in on props is most likely to establish. All individual EWM plants and floating fragments were marked with GPS and rake removed. When we located an EWM bed, we motored around the perimeter of the area and took GPS coordinates at regular intervals. These data were then mapped using ArcMap 9.3.1. We used the WDNR's Forestry Tools Extension to determine the acreage of each bed to the nearest hundredth of an acre and the perimeter to the nearest meter.

August Warm Water Full Point/Intercept Survey:

Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth, and total lake acres, Michelle Nault (WDNR) generated a 387 point sampling grid for Horseshoe Lake (Appendix I). Prior to beginning the point intercept survey on August 2nd, we conducted a general boat survey of the lake to gain familiarity with the species present (Appendix II). All plants found were identified, and a set of vouchers was pressed and mounted to be sent to the state herbarium in Stevens Point for identification confirmation. During the point intercept survey, we located each survey point using a handheld mapping GPS unit (Garmin 76CSX) and recorded a depth reading with a metered pole rake or hand held sonar (Vexlar LPS-1). At each of these points, we used the rake to sample an approximately 2.5ft. section of the bottom. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of plants within six feet of the sample point. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (lake bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

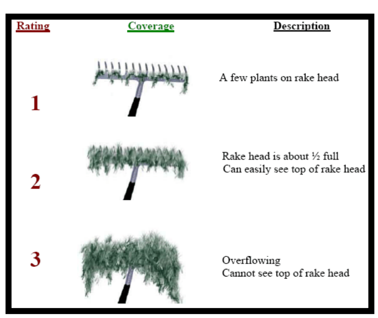

Figure 2: Rake Fullness Ratings (UWEX, 2011)

October Post Herbicide Treatment Dive Assessment Survey:

We completed a dive swim over of the three herbicided areas to assess the apparent effectiveness of the treatment. In addition to looking for live plants, we pulled up treated plants by the roots to make sure they were completely dead and checked for surviving fragments on and around treated plants. We also noted visible impacts on the native plant community.

DATA ANALYSIS:

We entered all data collected into the standard APM spreadsheet (Appendix II) (UWEX, 2011). From this, we calculated the following:

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

Total number of sites with vegetation: These included all sites where vegetation was found 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, this value is used to estimate how prevalent vegetation is throughout the littoral zone. For example, if 60% of the sites shallower than the maximum depth of plants have vegetation, then we estimate that 60% of the lake's littoral zone has plants.

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

Frequency of occurrence example:

Plant A is sampled at 70 out of 700 total littoral points = 70/700 = .10 = 10%

This means that Plant A's frequency of occurrence = 10% when considering the entire littoral zone.

Plant A is sampled at 70 out of 350 total points with vegetation = 70/350 = .20 = 20%

This means that Plant A's frequency of occurrence = 20% when only considering the sites in the littoral zone that have vegetation.

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

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 individuals (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.

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

Average number of species per site: This value is reported using four different considerations. 1) **shallower than the 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 the 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 additional visual species seen at a point but not found in the rake, and additional species found during the initial boat survey or between points.

Note: Per WDNR protocol, filamentous algae, freshwater sponges, aquatic moss and the aquatic liverworts *Riccia fluitans* and *Ricciocarpus natans* are excluded from these totals.

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 (Table 2).

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

Relative frequency example:

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

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

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

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

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

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

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

RESULTS:

Dive Removal:

On the June 12th, we, along with a host of volunteer helpers, gathered on the sandy shoreline due north of the known bed. Upon entering the water, we began to run into EWM plants only 15-20 meters from shore even though the buoyed bed of plants was still well over 40 meters away. Although we initially started pulling plants, we quickly realized that, even with multiple divers over multiple days, this was not going to be a feasible method of control. When we reached the assumed "parent bed" (Bed 1), we found it was canopied in 10.5ft of water, composed of 1000's of individual stems in a dense mass with a completely intertwined root-ball, and was actively fragmenting with perhaps 100's of additional individual plants/small clusters radiating away from it in all directions. Because of this, we quickly abandoned our SCUBA gear and focused on searching the rest of the lake from the boat to better quantify the extent of the infestation.

Meandering Littoral Zone and Bed Mapping Surveys:

We searched approximately 9.4 miles of the lake's visible littoral zone. Two additional beds were found and delineated bringing the total to three beds that covered just over half an acre (Table 1) (Figure 3). Bed 2 was located southeast of Bed 1 in 4-7ft of water. Although there were two significant clusters within the bed where plants were canopied, monotypic and extremely dense, most of the area had only scattered EWM and both the numbers and sizes of satellite clusters were generally smaller than in Bed 1. Located due south of the rock point and due north of the boat landing, Bed 3 appeared to be the most recently establish. Although EWM was nearly monotypic at the core, the bed became increasing fragmented on the periphery. Most plants were canopied or near canopy as the area was very shallow with the majority of plants in <4.5ft of water. Away from the three beds, we also found and removed a single rooted plant and three floating stem fragments that were sprouting roots (Figure 3) (Appendix III).

**Table 1: EWM Bed Mapping Survey Summary
Horseshoe Lake, Washburn Co.
June 12, 2011**

Bed Number	June 2011 Area in Acres	June 2011 Perimeter in Meters	June 2011 Est. Mean Rakefull
1	0.19	129	<1-3
2	0.16	173	<1-3
3	0.18	118	<1-2
Total	**0.53**		

Despite the local expansion that was occurring around the three beds, the infestation appeared contained to these areas. However, although we were able to confidently see down at least 6ft during the meandering survey, we found a few EWM plants growing in up to 13ft of water while diving. Because of this, it is possible, and perhaps likely, that there are other EWM plants/beds that will not be found until they grow closer to the surface at some point in the future.

In the eastern side of the lake, the vast majority of EWM plants were established over soft sandy muck areas that generally occurred away from the immediate shoreline which was predominantly sand. Additionally, we found White-stem pondweed (*Potamogeton praelongus*) and Large-leaf pondweed (*Potamogeton amplifolius*) interspersed in almost all the areas where EWM was growing. Because of this, we believe these two species will continue to be reliable indicators of preferred EWM habitat, and focusing future searching on areas where these plants occur will likely continue to turn up new EWM plants.

We found no evidence of EWM on the western side of the lake. Random rake samples revealed that most of the substrate was firm sand or sandy muck with little organic matter and extremely limited plant growth. This doesn't mean EWM won't be found here in the future, but it doesn't appear to offer the plant its preferred habitat of nutrient rich organic muck.

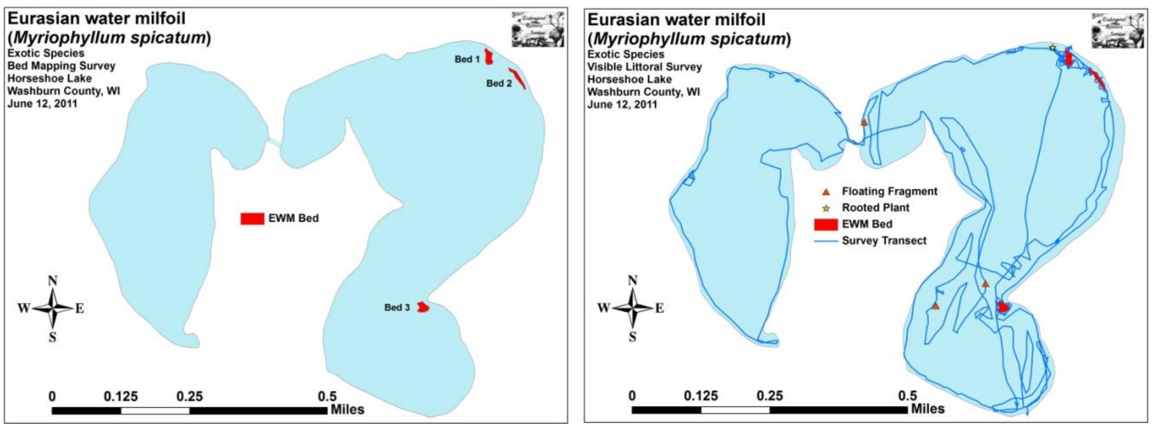

Figure 3: Horseshoe Lake EWM Beds and Littoral Transect Survey

August Warm Water Full Point/Intercept Survey:

The Horseshoe Lake survey grid contained 387 points (Figure 4). Because the entire lake fell within a few feet of the known littoral zone, we rake surveyed the entire lake. Most of the western side of the lake rapidly drops off from shore into at least 7ft of water before leveling out in the 10-12ft range with the exception of the >17.5ft hole on the west side mid-lake. Two 5-8ft deep, approximately 10-acre flats occur on either side of the channel where the two basins meet. On the eastern side, there is greater underwater topography. An expansive 5-7ft flat covers the southeast end near the boat landing, and the lake's two deepest holes reach 22ft in the northeast bay and more than 17.5ft mid-lake (Figure 4) (Appendix IV).

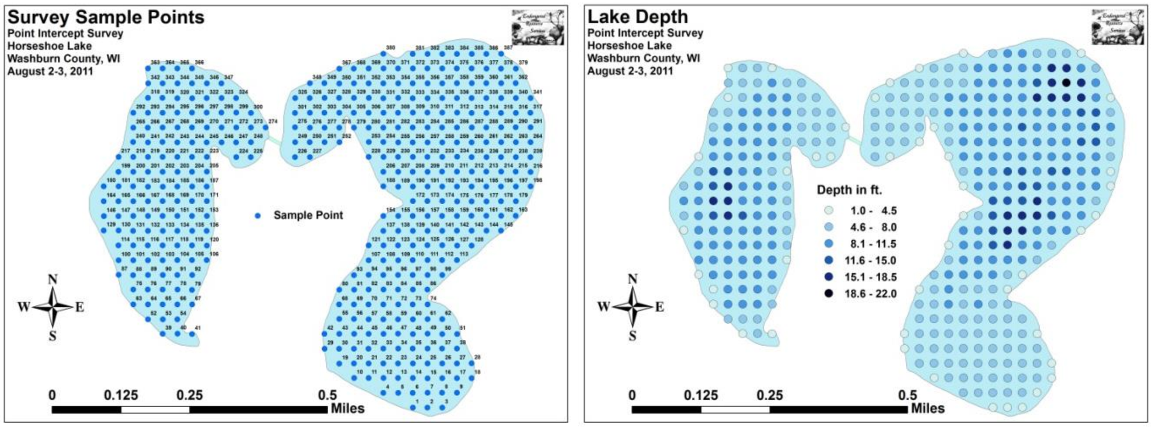

Figure 4: Survey Points and Lake Depth

Sugar sand lined the margins of the majority of the lake. This quickly transitioned to sandy muck at most depths beyond 6ft. The only dark organic muck occurred in the southeast bay in the western basin. Collectively, these conditions extrapolated to 80.9% of the bottom being covered in muck and sandy muck, 18.9% with pure sand, and 0.2% with rock (Figure 5). The littoral zone extended to 18ft, but plants were only widely scattered throughout with just over 65.8% of the lake's available substrate being colonized (Table 2). As essentially the entire lake fell in the littoral zone, plant density was as much a product of bottom type as depth (Appendix IV). Overall diversity was high with a Simpson Diversity Index value of 0.91. Species richness was also relatively high for such a small lake with 41 total species found growing in and immediately adjacent to the lake; however, the average number of native species per site was low with only 2.03 species/vegetative site.

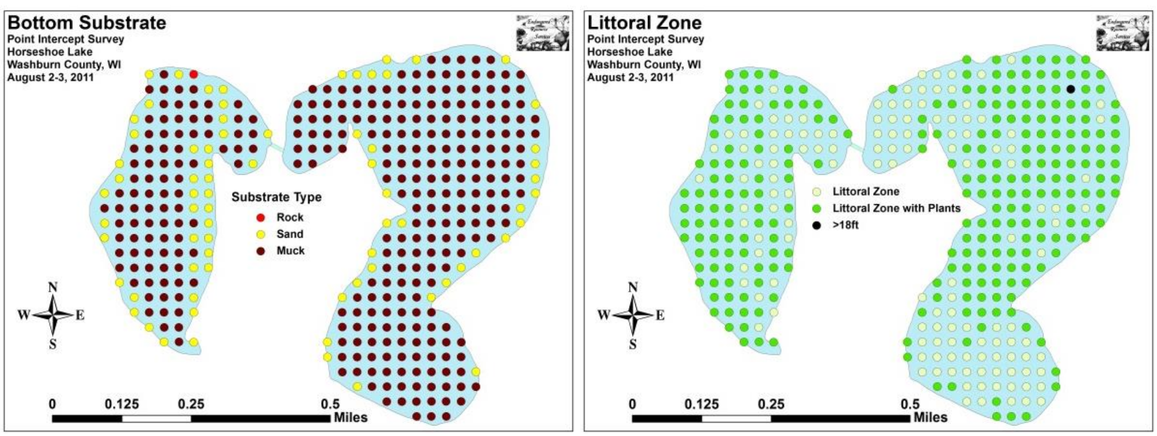

Figure 5: Bottom Substrate and Littoral Zone

Table 2: Aquatic Macrophyte P/I Survey Summary Statistics Horseshoe Lake, Washburn County August 2-3, 2011

Summary Statistics:

Total number of points sampled	387
Total number of sites with vegetation	254
Total number of sites shallower than the maximum depth of plants	386
Frequency of occurrence at sites shallower than maximum depth of plants	65.80
Simpson Diversity Index	0.91
Maximum depth of plants (ft)	18.0
Mean depth of plants (ft)	8.8
Median depth of plants (ft)	9.0
Number of sites sampled using rope rake (R)	20
Number of sites sampled using pole rake (P)	367
Average number of all species per site (shallower than max depth)	1.33
Average number of all species per site (veg. sites only)	2.03
Average number of native species per site (shallower than max depth)	1.33
Average number of native species per site (veg. sites only)	2.03
Species richness	27
Species richness (including visuals)	35
Species richness (including visuals and boat survey)	41
Mean total rake fullness (veg. sites only)	1.70

Lakewide, only 13 of the 254 sites with vegetation had more than 4 species present in the rake. Overall plant density was moderate with a mean rake fullness of 1.70 at sites with vegetation (Figure 6) (Appendix V).

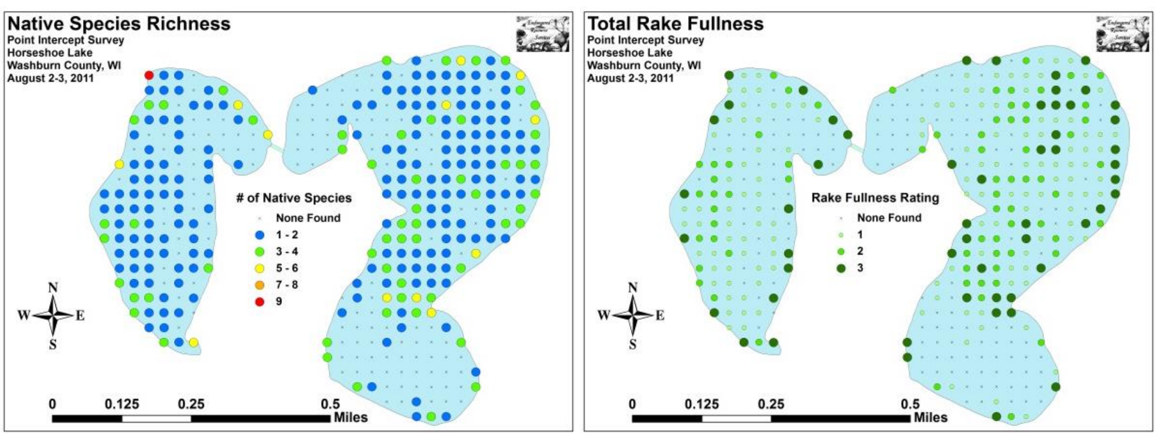

Figure 6: Native Species Richness and Total Rake Fullness Rating

The Horseshoe Lake plant community can be broken into five distinct zones each of which has its own characteristic species and functions in the lake ecosystem. Around the shoreline, emergent species such as Hardstem bulrush (*Schoenoplectus acutus*), Threesquare (*Schoenoplectus pungens*), Creeping spikerush (*Eleocharis palustris*), Smooth saw-grass (*Cladium mariscoides*), and Prairie cordgrass (*Spartina pectinata*) stabilize the lakeshore, 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.

Hardstem bulrush (Per, 2002)

Smooth saw-grass (Perlman, 2011)

Just beyond the emergents, shallow sugar sand areas tended to have the greatest species richness. They also tended to have low total biomass as the nutrient poor substrates provided habitat most suited to fine leaved "isoetids" turf forming species like Creeping spearwort (*Ranunculus flammula*), Needle spikerush (*Eleocharis acicularis*), Brown-fruited rush (*Juncus pelocarpus*), Small purple bladderwort (*Utricularia resupinata*), Pipewort (*Eriocaulon aquaticum*) and Dwarf water milfoil (*Myriophyllum tenellum*). These species are typical of low nutrient, sand bottom lakes like Horseshoe and, along with the emergents, work to stabilize the bottom and prevent wave action erosion.

Dwarf water milfoil (Koshere, 2002)

Small purple bladderwort (Zerr, 2008)

Shallow organic muck bottomed areas were the rarest habitat in the lake. Because of this, floating leaf species like White-water lily (*Nymphaea odorata*), Spatterdock (*Nuphar variegata*), Watershield (*Brasenia schreberi*), and Floating-leaf pondweed (*Potamogeton natans*) that require this type of substrate were also uncommon. The protective canopy cover they provide is often utilized by panfish and bass.

Spatterdock (Lind, 2011)

Watershield (Gmelin, 2009)

In slightly deeper water that had low nutrient sandy-muck, Wild celery (*Vallisneria americana*), Slender naiad (*Najas flexilis*), Northern naiad (*Najas gracillima*), Muskgrass (*Chara* sp.), and Variable pondweed (*Potamogeton gramineus*) were common. These species are heavily utilized by waterfowl for food and larval insects for habitat.

Wild celery (Dalvi, 2009)

Variable pondweed (Koshere, 2002)

Deeper areas over thicker muck were dominated by broader-leaved species such as Fern pondweed (*Potamogeton robbinsii*), Large-leaf pondweed, Common waterweed (*Elodea canadensis*), Crested arrowhead (*Sagittaria cristata*), and White-stem pondweed. All of these species offer prime habitat for mature gamefish.

Fern pondweed (Apipp, 2011)

White-stem pondweed (Fewless, 2005)

When considering the lake as a whole, Slender naiad, Muskgrass, Fern pondweed, and Wild celery were the most common species (Table 3). They were found at 28.35%, 27.95%, 25.20% and 23.23% of survey points with vegetation respectively. Collectively, they accounted for 51.65% of the total relative frequency (Figure 7). Although many other species were relatively common and widely distributed, only Variable pondweed (7.18), Crested arrowhead (6.41), Brown-fruited rush (5.63), Small purple bladderwort (5.24), and Dwarf water milfoil (5.05) had relative frequencies over 5% (Distribution maps and species accounts for all plants found are located in Appendices VI and VII).

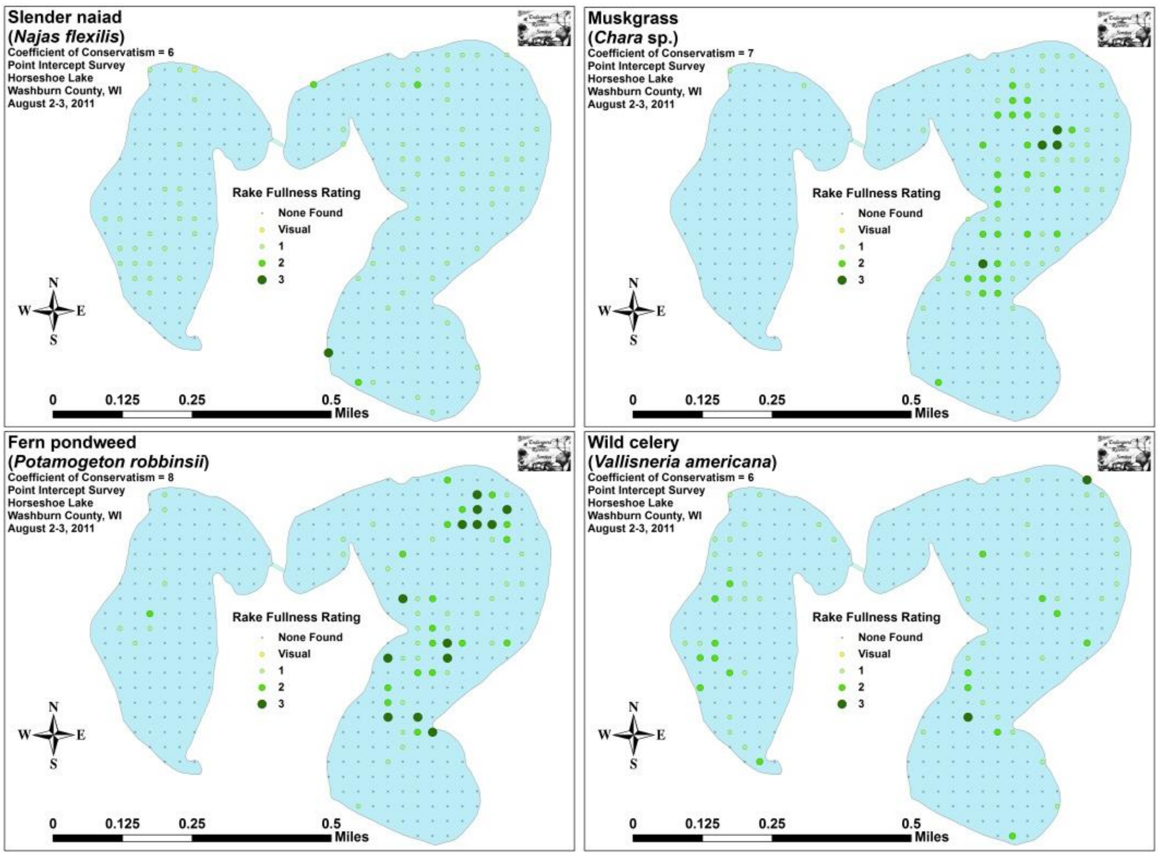

Figure 7: Horseshoe Lake's Most Common Species

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2-3, 2011

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Najas flexilis	Slender naiad	72	13.98	28.35	18.65	1.07	1
Chara sp.	Muskgrass	71	13.79	27.95	18.39	1.46	0
Potamogeton robbinsii	Fern pondweed	64	12.43	25.20	16.58	1.69	0
Vallisneria americana	Wild celery	59	11.46	23.23	15.28	1.34	0
Potamogeton gramineus	Variable pondweed	37	7.18	14.57	9.59	1.14	1
Sagittaria cristata	Crested arrowhead	33	6.41	12.99	8.55	1.12	0
Juncus pelocarpus	Brown-fruited rush	29	5.63	11.42	7.51	1.86	0
Utricularia resupinata	Small purple bladderwort	27	5.24	10.63	6.99	2.04	0
Myriophyllum tenellum	Dwarf water-milfoil	26	5.05	10.24	6.74	2.15	0
Eleocharis acicularis	Needle spikerush	19	3.69	7.48	4.92	1.68	0
Eriocaulon aquaticum	Pipewort	16	3.11	6.30	4.15	1.81	1
Potamogeton amplifolius	Large-leaf pondweed	16	3.11	6.30	4.15	1.06	1
Potamogeton praelongus	White-stem pondweed	11	2.14	4.33	2.85	1.27	0
Potamogeton pusillus	Small pondweed	10	1.94	3.94	2.59	1.40	0
	Filamentous algae	9	*	3.54	2.33	1.00	0
Elodea canadensis	Common waterweed	6	1.17	2.36	1.55	1.67	0
Ranunculus flammula	Creeping spearwort	4	0.78	1.57	1.04	1.75	0
Eleocharis palustris	Creeping spikerush	2	0.39	0.79	0.52	1.00	1
Leersia oryzoides	Rice cut-grass	2	0.39	0.79	0.52	1.00	0
Najas gracillima	Northern naiad	2	0.39	0.79	0.52	1.50	0
Nitella sp.	Nitella	2	0.39	0.79	0.52	1.00	0
Carex cryptolepis	Small yellow sedge	1	0.19	0.39	0.26	1.00	0
Carex lasiocarpa	Narrow-leaved woolly sedge	1	0.19	0.39	0.26	2.00	0
Dulichium arundinaceum	Three-way sedge	1	0.19	0.39	0.26	1.00	0

* Filamentous algae are not included in the Relative Frequency Calculation

Table 3 (cont'): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2-3, 2011

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Elatine minima	Waterwort	1	0.19	0.39	0.26	2.00	0
Juncus brevicaudatus	Narrow-panicle rush	1	0.19	0.39	0.26	2.00	0
Polygonum amphibium	Water smartweed	1	0.19	0.39	0.26	2.00	0
Sparganium angustifolium	Narrow-leaved bur-reed	1	0.19	0.39	0.26	3.00	0
Cladium mariscoides	Smooth sawgrass	**	**	**	**	**	1
Glyceria canadensis	Rattlesnake manna grass	**	**	**	**	**	1
Juncus effusus	Common rush	**	**	**	**	**	1
Myriophyllum spicatum	Eurasian water milfoil	**	**	**	**	**	2
Nymphaea odorata	White water lily	**	**	**	**	**	1
Potamogeton spirillus	Spiral-fruited pondweed	**	**	**	**	**	3
Schoenoplectus acutus	Hardstem bulrush	**	**	**	**	**	1
Utricularia gibba	Creeping bladderwort	**	**	**	**	**	1
Brasenia schreberi	Watershield	***	***	***	***	***	***
Lycopus uniflorus	Northern water-horehound	***	***	***	***	***	***
Nuphar variegata	Spatterdock	***	***	***	***	***	***
Potamogeton natans	Floating-leaf pondweed	***	***	***	***	***	***
Schoenoplectus pungens	Threesquare	***	***	***	***	***	***
Spartina pectinata	Prairie cordgrass	***	***	***	***	***	***

** Visual Only

*** Boat Survey Only

Table 4: Floristic Quality Index of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2-3, 2011

Species	Common Name	C
Chara sp.	Muskgrass	7
Dulichium arundinaceum	Three-way sedge	9
Elatine minima	Waterwort	9
Eleocharis acicularis	Needle spikerush	5
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Eriocaulon aquaticum	Pipewort	9
Juncus pelocarpus	Brown-fruited rush	8
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Najas gracillima	Northern naiad	7
Nitella sp.	Nitella	7
Polygonum amphibium	Water smartweed	5
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton gramineus	Variable pondweed	7
Potamogeton praelongus	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton robbinsii	Fern pondweed	8
Ranunculus flammula	Creeping spearwort	9
Sagittaria cristata	Crested arrowhead	9
Sparganium angustifolium	Narrow-leaved bur-reed	9
Utricularia resupinata	Small purple bladderwort	9
Vallisneria americana	Wild celery	6
N		23
Mean C		7.4
FQI		35.4

We identified a total of 23 **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 35.4 (Table 4). Nichols (1999) reported an Average mean C for the Northern Lakes and Forest Region of 6.7 putting Horseshoe Lake above average for this part of the state. The FQI was also well above the median FQI of 24.3 for the Northern Lakes and Forest Region (Nichols 1999). These high values are likely the result of the many pristine shoreline areas and variety of habitats that Horseshoe Lake offers. Specifically, index plants like Three-way sedge (*Dulichium arundinaceum*) (C = 9), Dwarf water milfoil (C = 10), Waterwort (*Elatine minima*) (C = 9), Pipewort (C = 9), Creeping spearwort (C = 9), Crested arrowhead (C = 9), Narrow-leaved bur-reed (*Sparganium angustifolium*) (C = 9), and the State Species of Special Concern ** Small purple bladderwort (C = 9) would not be present if Horseshoe Lake had not enjoyed a history of apparent good water clarity and quality. Two other high value species, Narrow-leaved woolly sedge (*Carex lasiocarpa*) (C = 9) and Smooth Sawgrass (C = 10) were found growing on the lake's shoreline.

** "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.

Eurasian water milfoil was recorded as a visual at only two points during the August full point intercept survey, and, despite covering 29.3 miles of transects on the lake, we did not find it growing anywhere outside of the three known beds mapped in June (Figure 8) (Appendix VIII). We also did not locate any other exotic invasive plants on the lake (For more information on aquatic exotic invasive plant species, see Appendix IX).

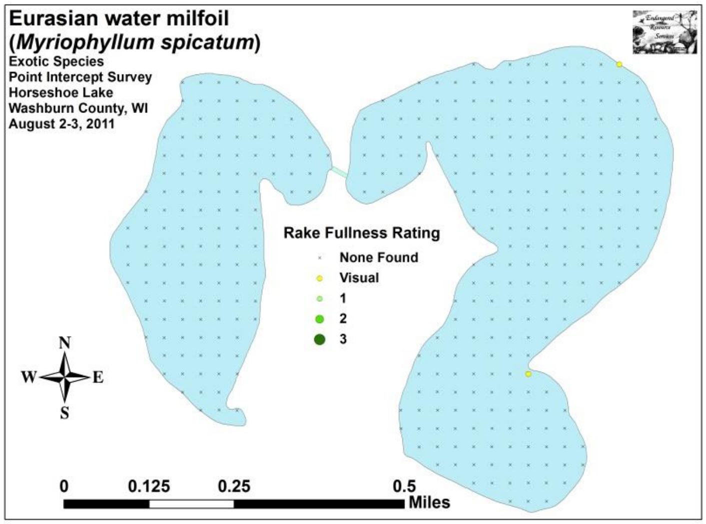

Figure 8: EWM Density and Distribution 8 2-3, 2011

October Post Herbicide Treatment Dive Assessment Survey:

On October 8th, following the September 15th treatment of the three known beds by Northern Aquatic Services (Dale Dressel) with Diquat dibromide herbicide (Reward ®), we conducted a dive swimover to assess the effectiveness of the treatment. The surface water temp was an unusually warm 64 degrees, and visibility at the surface was in the 7-8ft range. The beds were easily relocated, and we were able to hover at the surface and see the bottom in all but the deepest areas. Somewhat surprisingly considering the initial density and number of plants in the giant tower at the buoy in Bed 1, we documented what appeared to be complete control of all visible plants. Unlike 2-4 D treated plants on other lakes we have observed in the past that look burned (brown to black and withered), the Diquat treated plants just turned pale and fell over rather than disintegrating. The only hint of green was in a few stems we raked up off the edge of the tower. However, they didn't seem viable as there was NO evidence of any regrowth, and the roots looked black/dead as well. Impressively, many if not most of the native pondweeds in the treatment area (primarily Fern, Large-leaf, and White-stem pondweeds) seemed to survive the treatment.

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Eurasian water milfoil Management:

Horseshoe Lake has a rich, diverse and rare plant community that is unique to sand bottomed, seepage lakes with good water quality. Unfortunately, the introduction of Eurasian water-milfoil will pose a continued threat to that diversity and the resource as a whole moving forward as it is unlikely that EWM will ever be totally eliminated from the lake. With this reality in mind, working to minimize the spread of EWM within the lake, and quickly identifying and eliminating new beds that appear will likely be high priority management goals moving forward.

To assist in meeting these goals, lakeshore owners should minimize the removal of native plants from the lake unless absolutely necessary as these patches of barren substrate can provide an easy place for EWM fragments to take root and become established. Training volunteers to recognize EWM is another low cost management strategy that we strongly encourage. At least monthly volunteer meandering shoreline surveys of the whole lake would likely result in early detection of new beds. The sooner these beds can be found, the greater the chances the infestation can continue to be economically maintained at its current low level (Figure 9).

As there are no similar looking native milfoils in the lake, any suspicious looking plants that are found in the future should be immediately investigated to determine species. If any lake resident or boater discovers a plant they even suspect may be EWM, they are invited to contact Matthew Berg, ERS, LLC Research Biologist at 715-338-7502 mberg@grantsburg.k12.wi.us and/or Pamela Toshner/Alex Smith, Regional Lakes Management Coordinators in the Spooner DNR office at 715-635-4073 for identification confirmation. If possible, a specimen, a jpg, and the accompanying GPS coordinates of the location it was found at should be included.

Figure 9: Tower of EWM in Bed 1 – June 2011

Native Aquatic Macrophytes, Algae and Water Clarity:

Horseshoe Lake's somewhat limited plant community is characterized by sensitive, fine-leaved species typical of low nutrient systems and dependent on water clarity, quality, chemistry, and generally positive shoreline practices. The lake currently supports ten extremely high quality species (C value of 9 or 10), but several of them are very limited in both numbers and distribution making them vulnerable to lake-wide extinction. These plants are the basis of the ecosystem, and they are as important to the aquatic environment as trees are to a forest. Because of this, preserving them is critical to maintaining a healthy lake. As the basis of the food pyramid, they provide habitat for other aquatic organisms, are important food sources for waterfowl and other wildlife, stabilize the shoreline, and work to improve water clarity by absorbing excess nutrients from the water.

During our time on the lake, we immediately noticed that most residents were currently practicing good shoreline conservation (Figure 10). We also noticed that there were few filamentous or floating algae in the lake. This is likely not a coincidence. These algae proliferate in the presence of excessive nutrients in the water. Because the lake's plant community is so limited, even a small percentage decline in macrophyte plants or a small increase in nutrient input could tip the lake's current balance allowing algae to proliferate and leading to a decline in both water clarity and quality. Conversely, working to limit nutrient input could result in fewer algal blooms and better clarity throughout the summer. It could also inhibit EWM growth as it favors higher nutrient waters.

Such things as internal loading from sediments, failed septic systems, and lawn and field fertilizer runoff are common causes of excess nutrients in surface water. Educating lake residents about reducing nutrient input directly along the lake is one of the easiest ways to limit algal growth and maintain or even improve water clarity and quality. Not mowing down to the lakeshore, bagging grass clippings, and switching to a phosphorus-free fertilizer or eliminating fertilizer altogether would all be positive steps to this end. Wherever possible, restoring shorelines, building rain gardens, and establishing buffer strips of native vegetation would also enhance water clarity/quality by preventing erosion and runoff.

Figure 10: Model Natural Shorelines on Horseshoe and Another Nearby Washburn Co. Lake

On Horseshoe, we also noticed evidence of motor start-ups in shallow water and the grounding of personal watercraft. These actions can lead to the tearing of the underwater "turf" of native vegetation which can then float away and create obstacles for watercraft (Figure 11). It also results in the release of nutrients from the lake bottom into the water column which promotes algal growth. As previously mentioned, these exposed bare patches of substrate also present EWM with an ideal place to establish. To prevent this, residents are encouraged to use lifts for their watercraft whenever possible, and try to avoid starting their motors in water less than 5ft in depth.

Figure 11: Dislodged Floating Mat of Native Vegetation

Finally, completing an Aquatic Plant Management Plan (APMP) will help the lake clarify a management strategy for dealing with EWM moving forward. A team approach that uses all available data from this report and the lake usership survey that would accompany the development of the plan coupled with open and frank communication between the HLPOA, WDNR, interested citizens and the plan manager will be critical in formulating the best APMP possible for the lake.

MANAGEMENT CONSIDERATIONS SUMMARY:

- Preserve the lake's rich, diverse, and rare plant community by continuing to maintain/reduce Eurasian water milfoil at/from its current low rates.

- Train volunteers to recognize EWM, and conduct at least monthly shoreline surveys so new beds can be quickly and economically controlled before they spread.

- Whenever possible, refrain from unnecessary removal of native plants from the lake as this provides a place for exotic species like EWM to more easily establish and colonize.

- Reduce and, wherever possible, eliminate fertilizer applications, soil erosion, and grass clipping and leaf runoff as these nutrient inputs encourage algal growth.

- Encourage shoreline restoration that establishes native vegetation buffer strips along the lakeshore to help prevent runoff and erosion.

- Avoid beaching watercraft and shallow water motor start-ups as they can dislodge the "turf" of native plants, release nutrients into the water column, promote algal blooms, and provide EWM and easy place to establish.

- Complete an Aquatic Plant Management Plan (APMP) to guide the management of EWM and the lake's native plants moving forward.

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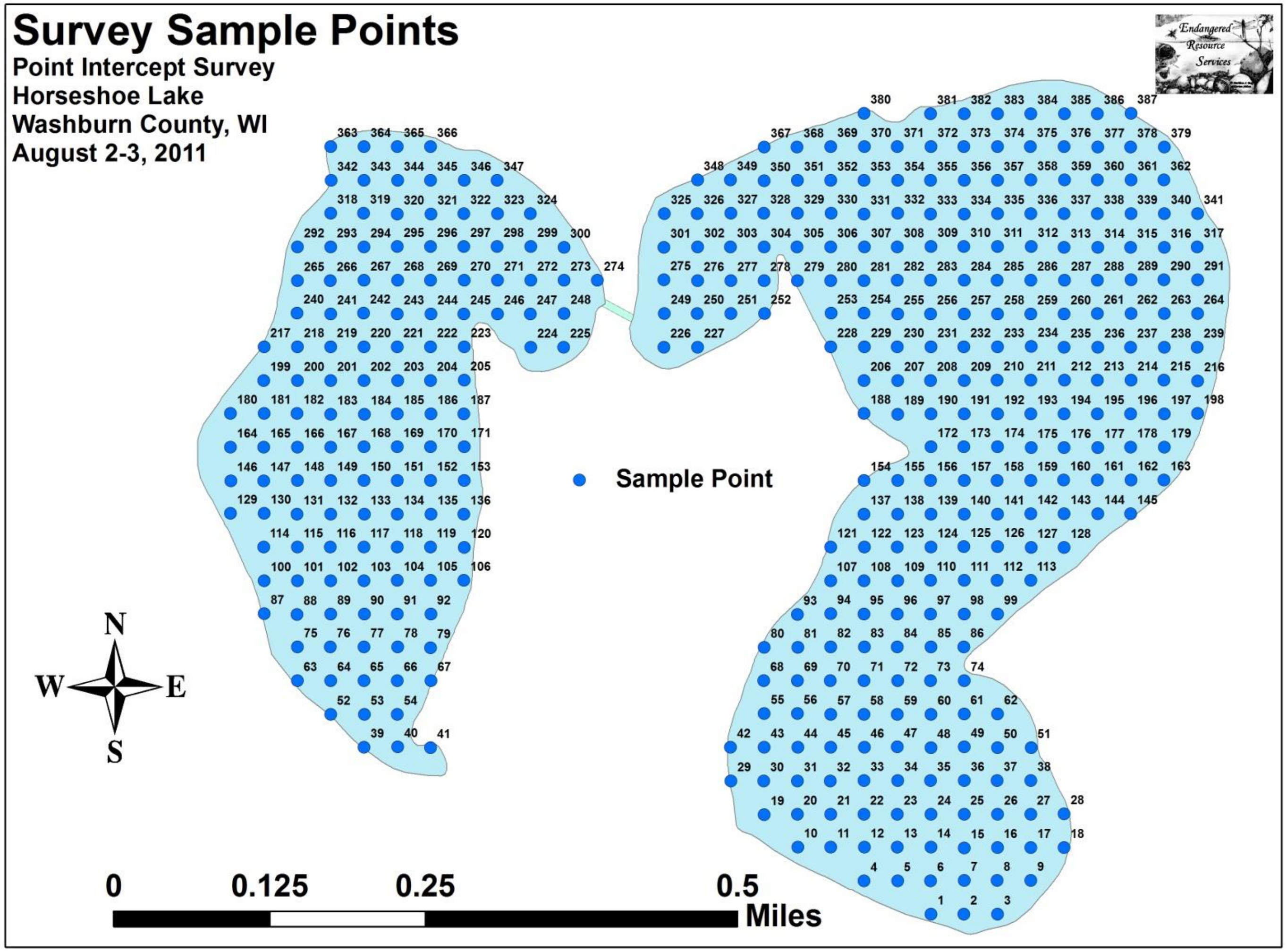
Appendix I: Horseshoe Lake Survey Sample Points

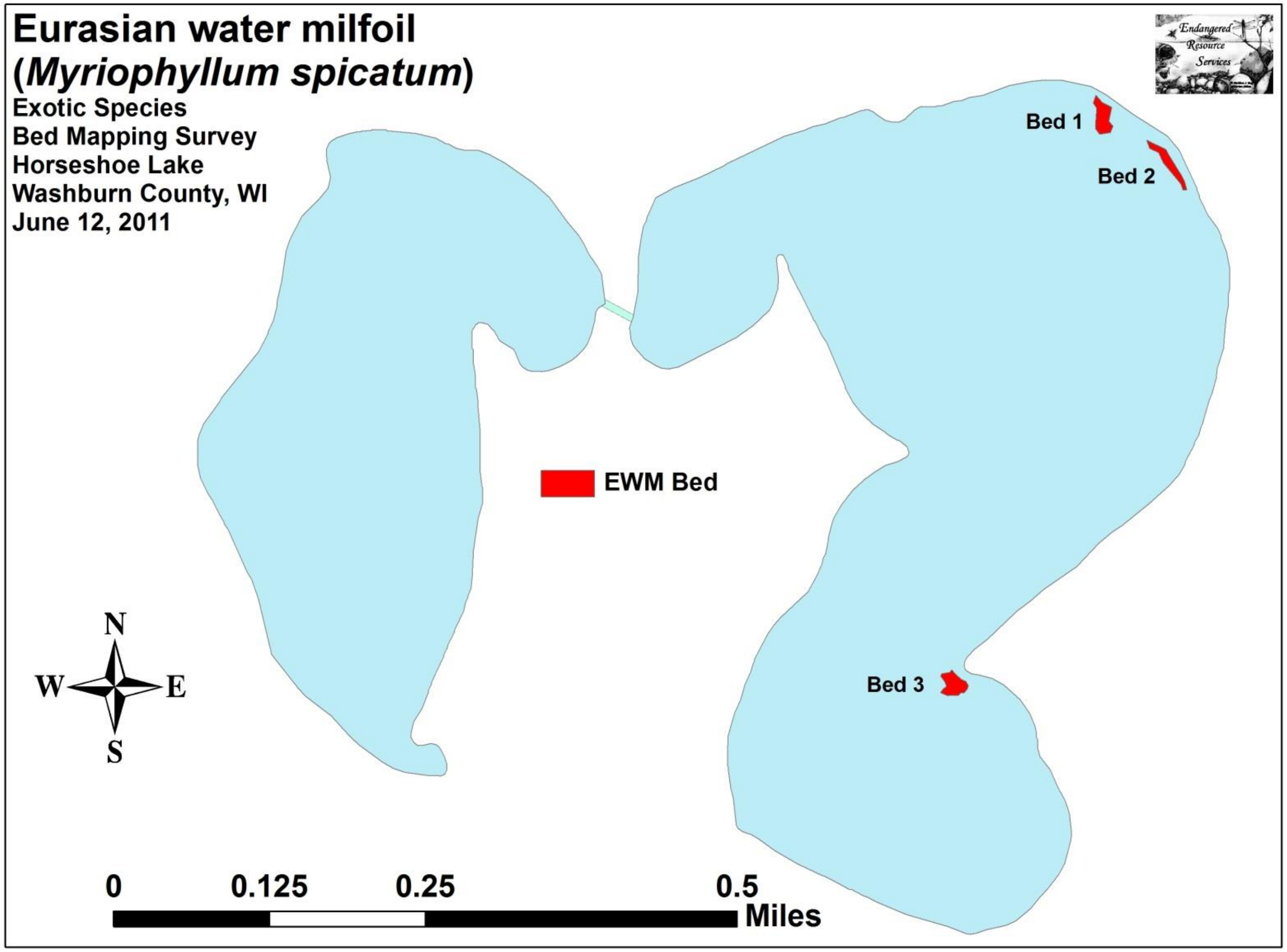

Survey Sample Points
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Sample Point
0
0.125
0.25
0.5
Miles
N
S
W
E
Endangered Resource Services

Appendix II: Boat and Vegetative Survey Data Sheets

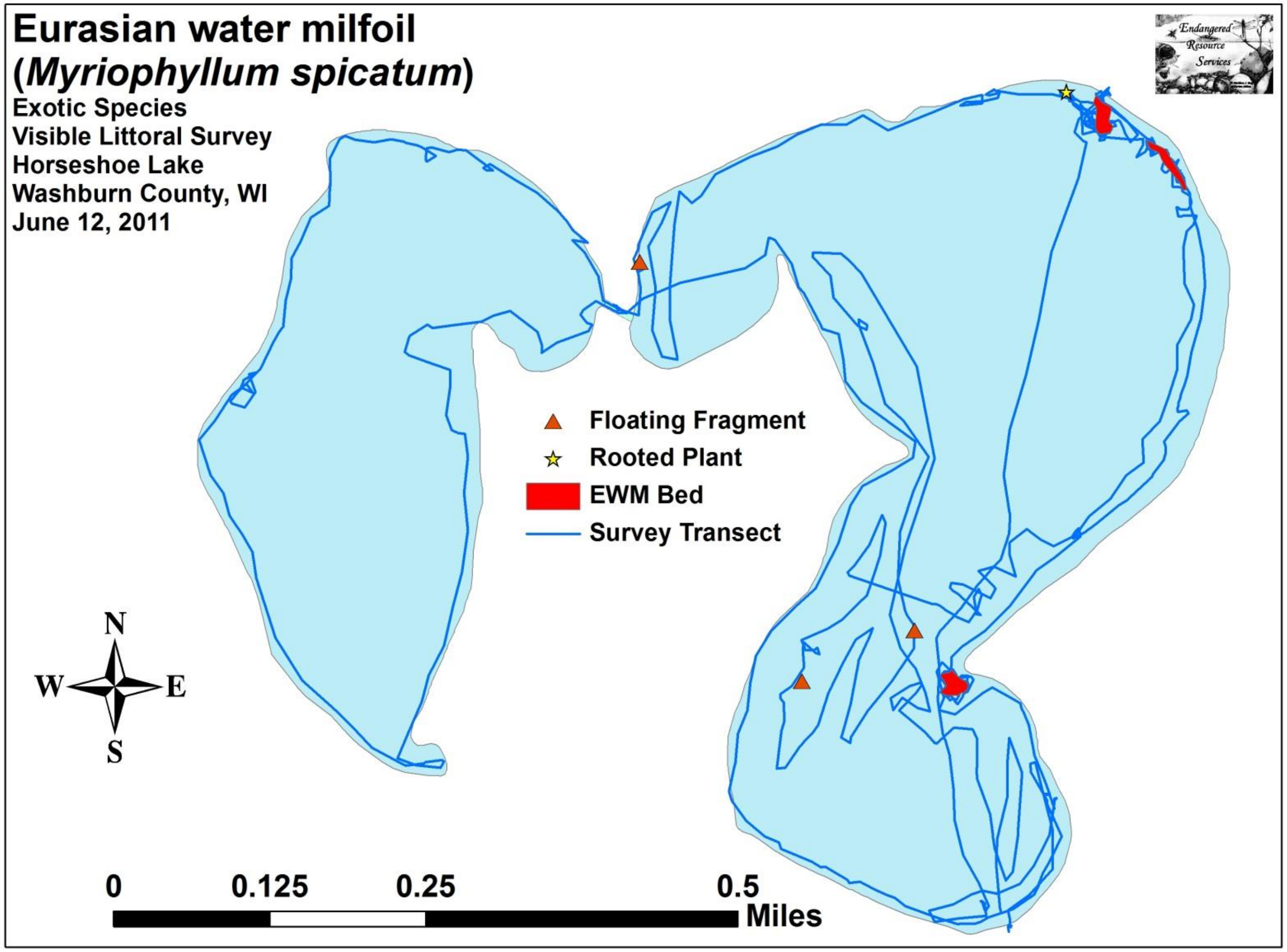
# Boat Survey	
Lake Name	
County	
WBIC	
Date of Survey	
(mm/dd/yy)	
workers	
Nearest Point	**Species seen, habitat information**

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																									

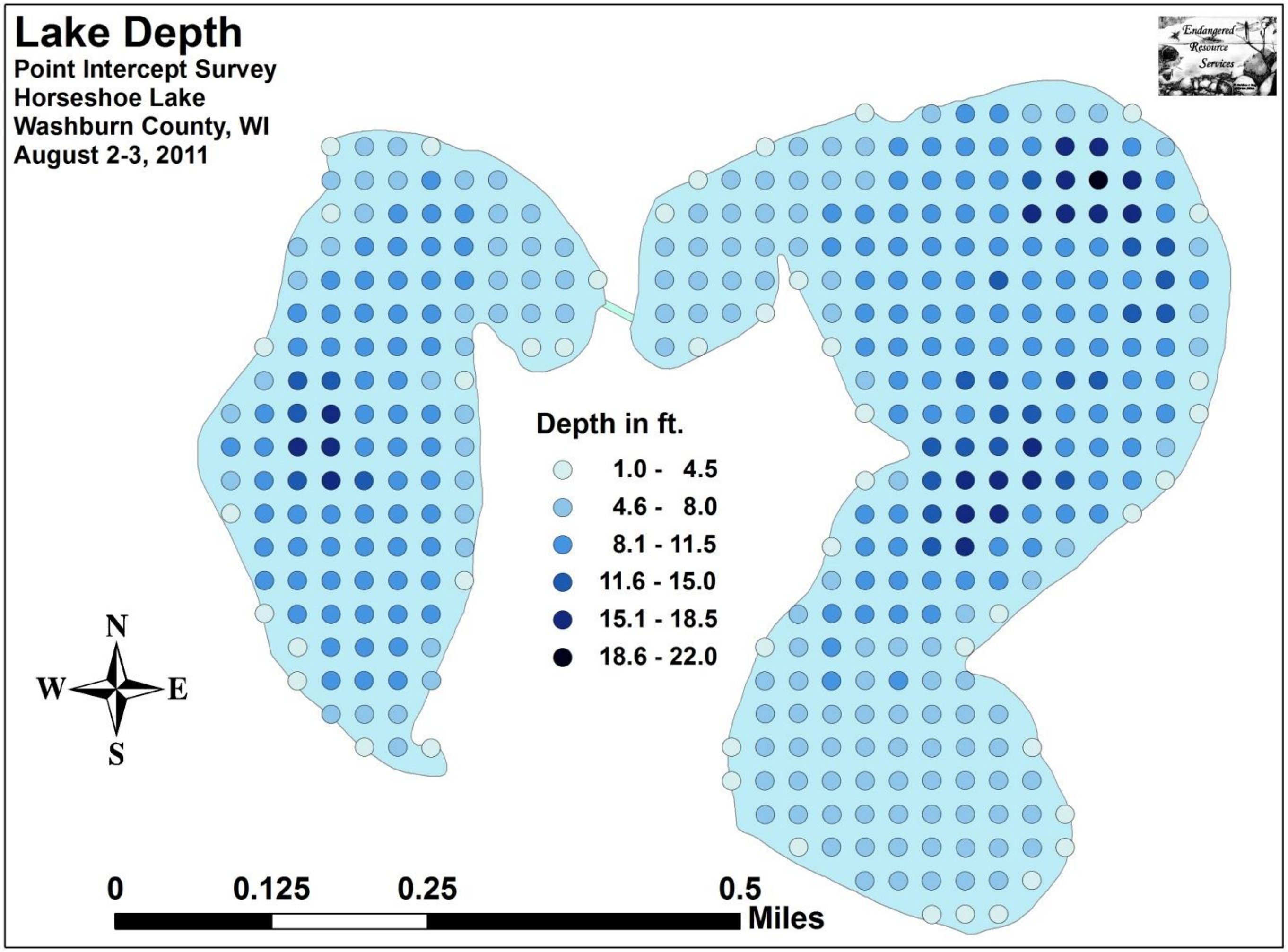
Appendix III: EWM Bed Map and Visible Littoral Zone Survey

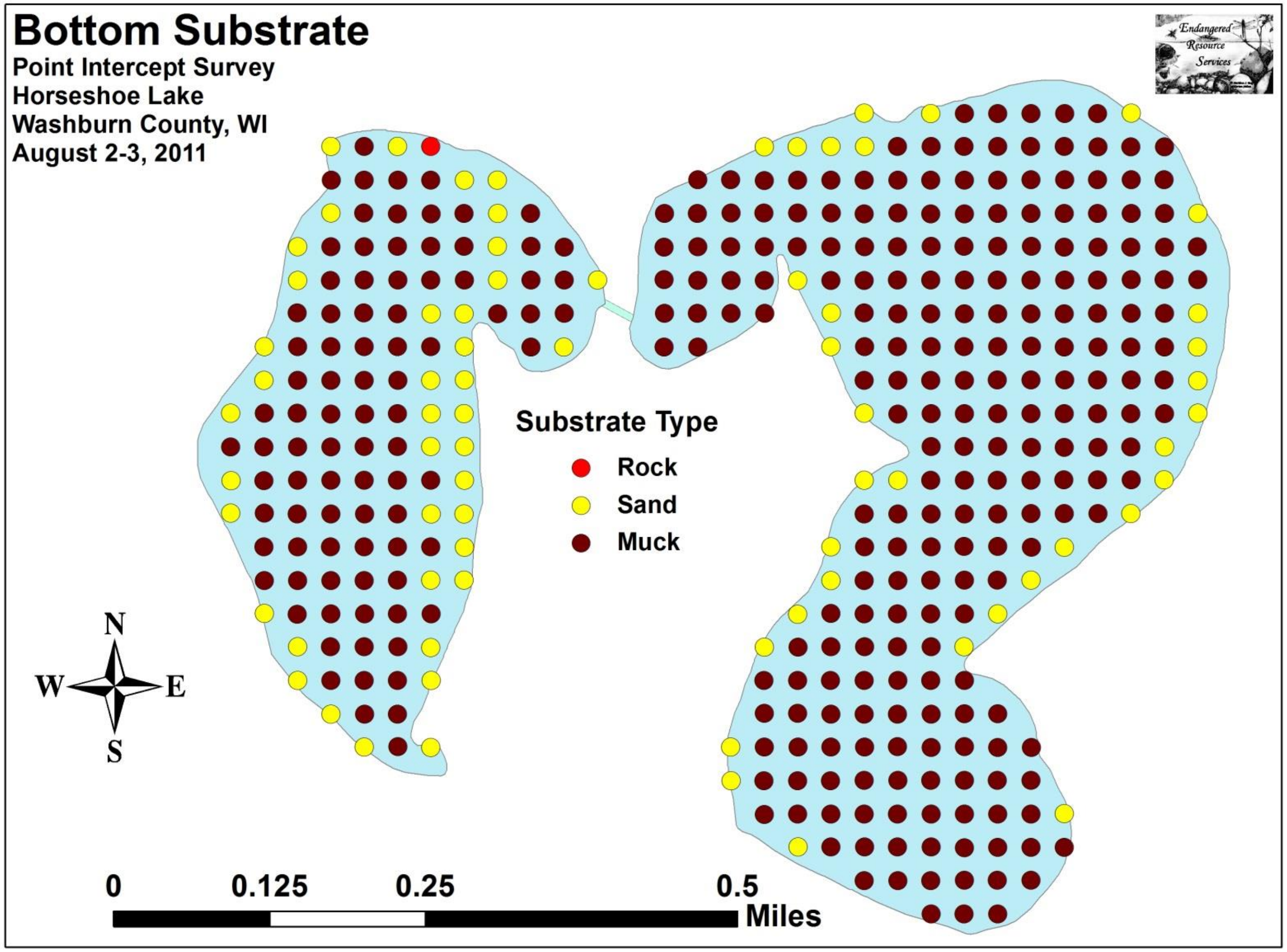


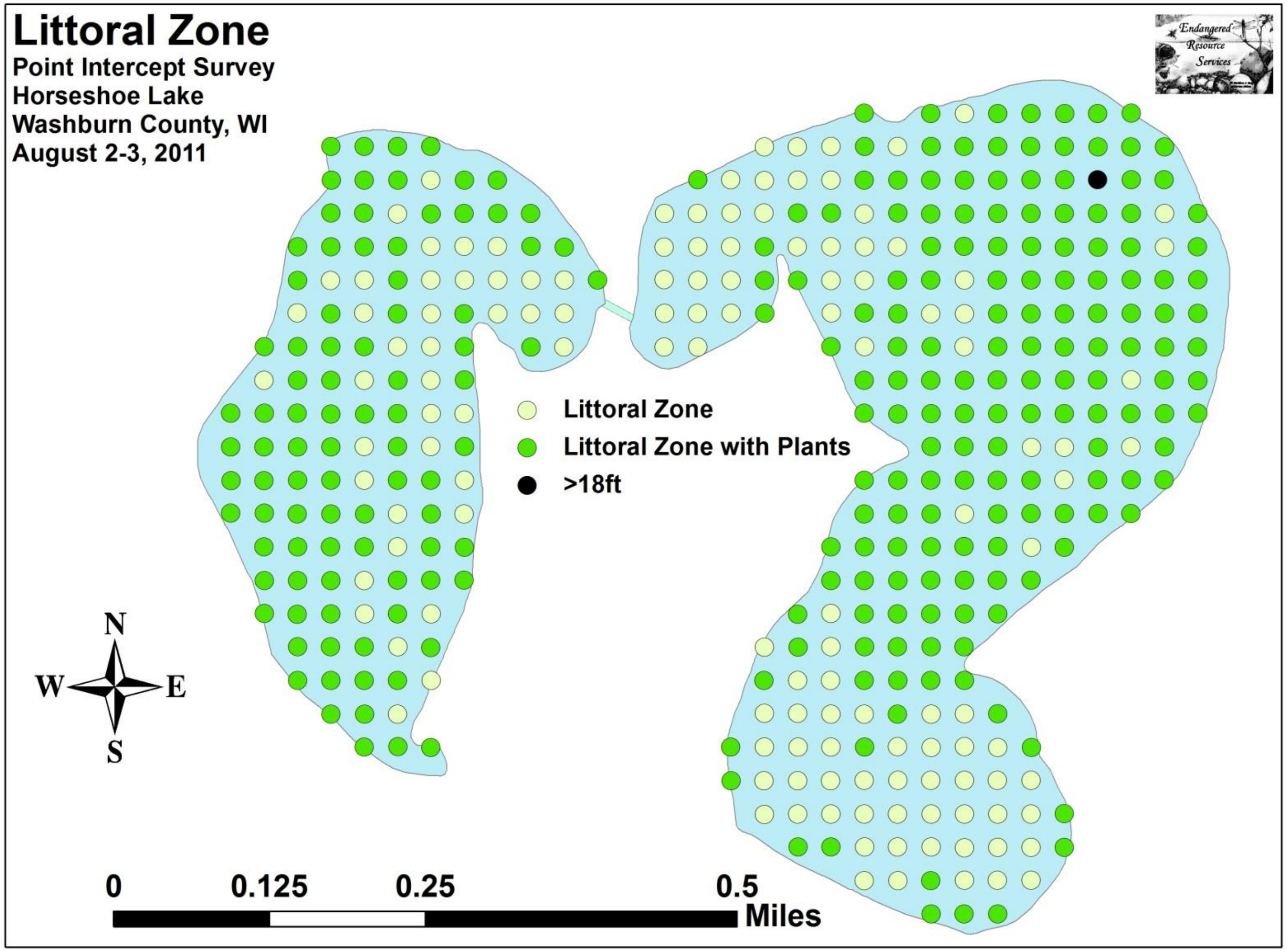
Eurasian water milfoil
(*Myriophyllum spicatum*)
Exotic Species
Bed Mapping Survey
Horseshoe Lake
Washburn County, WI
June 12, 2011
Bed 1
Bed 2
Bed 3
EWM Bed
N
W
E
S
0
0.125
0.25
0.5
Miles


Eurasian water milfoil
(*Myriophyllum spicatum*)
Exotic Species
Visible Littoral Survey
Horseshoe Lake
Washburn County, WI
June 12, 2011
Endangered Resource Services
Floating Fragment
Rooted Plant
EWM Bed
Survey Transect
N
W
E
S
0
0.125
0.25
0.5
Miles

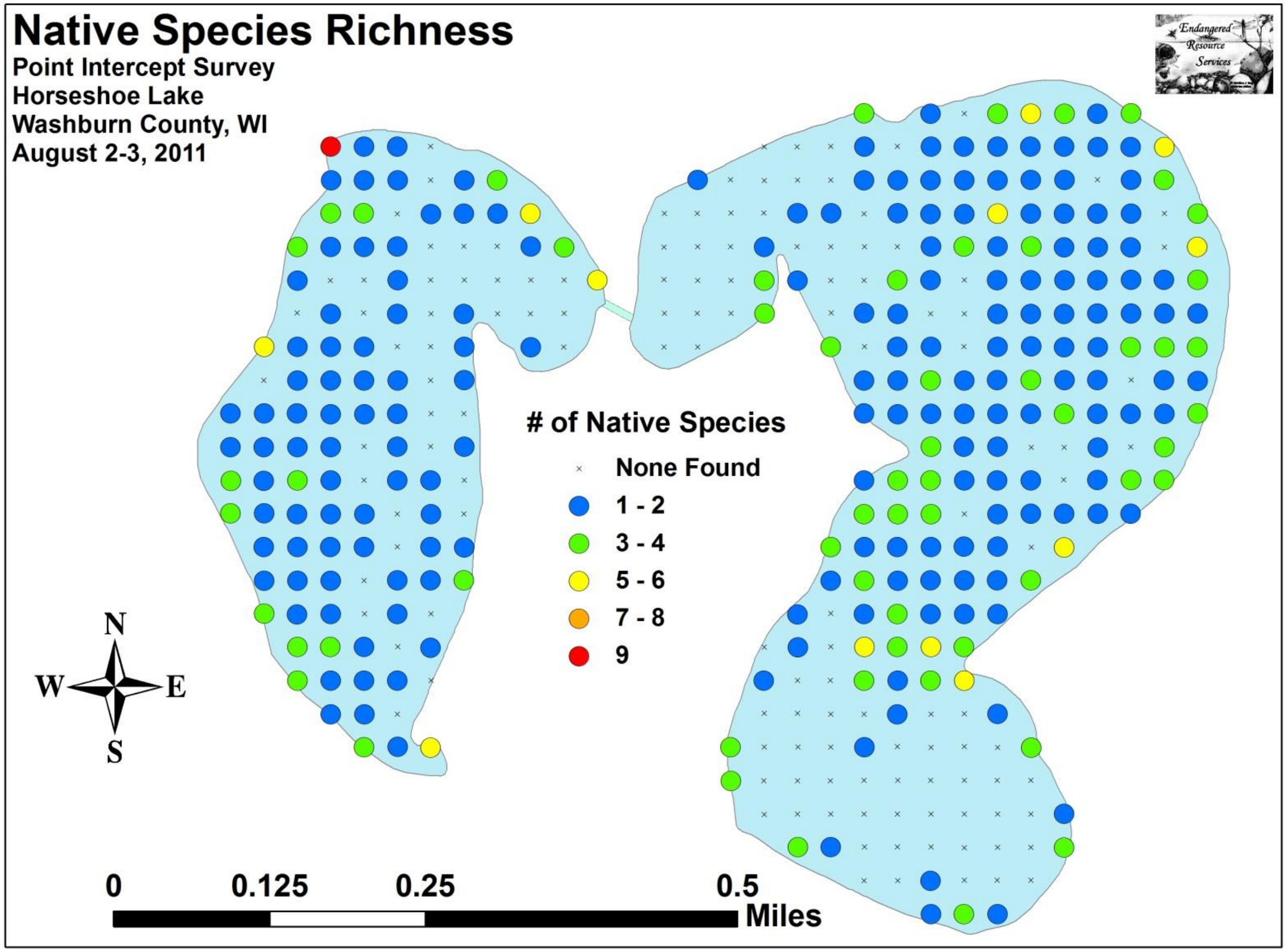
Appendix IV: Habitat Variable Maps

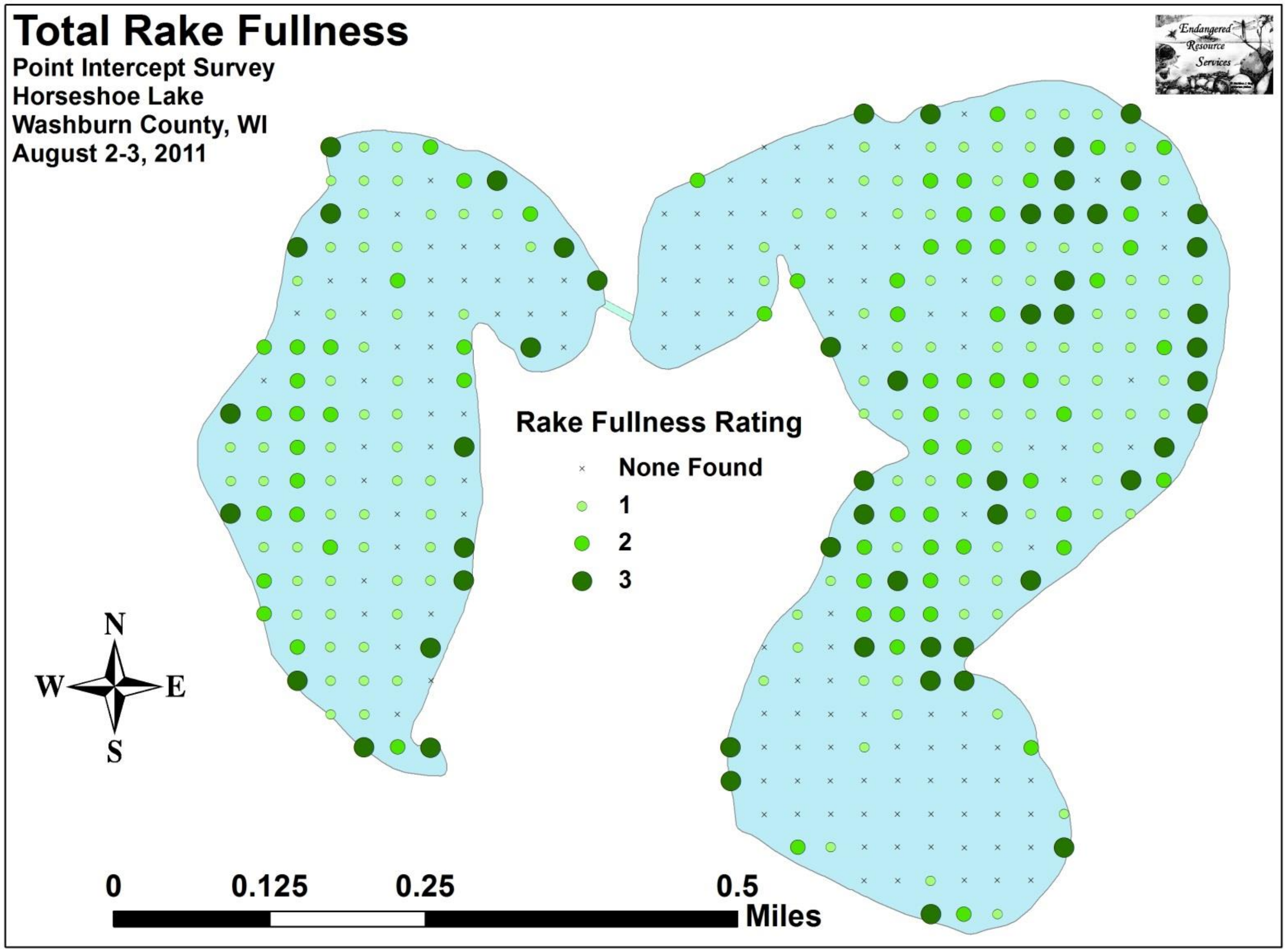

Lake Depth
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Depth in ft.
1.0 - 4.5
4.6 - 8.0
8.1 - 11.5
11.6 - 15.0
15.1 - 18.5
18.6 - 22.0
N
W
E
S
0
0.125
0.25
0.5
Miles


Bottom Substrate
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Substrate Type
Rock
Sand
Muck
N
W
E
S
0
0.125
0.25
0.5
Miles


Littoral Zone
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Littoral Zone
Littoral Zone with Plants
>18ft
N
W
E
S
0
0.125
0.25
0.5
Miles

Appendix V: Native Species Richness and Total Rake Fullness Maps


Native Species Richness
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
7 - 8
9
N
W
E
S
0
0.125
0.25
0.5
Miles


Total Rake Fullness
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
N
W
E
S
0
0.125
0.25
0.5
Miles

Appendix VI: Plant Species Accounts

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Brasenia schreberi*) **Watershield**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-086
Habitat/Distribution: Muck bottom in 0.5-1.5 meters of water. Rare; only plants found were located near the point in the southeast bay in the western side of the lake.
Common Associates: (*Nuphar variegata*) Spatterdock, (*Potamogeton natans*) Floating-leaf pondweed

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Carex cryptolepis*) **Small yellow sedge**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-087
Habitat/Distribution: Firm sand and sandy muck on the shoreline. Plants found were few in number and were only found at the point. Perigynia 3.8-4.2mm with a beak that was 1.2mm or greater. Female scales were pale on the sides with a bright lime green midvein. Achene is tan and 3-angled; only filled the bottom ½ of the perigynia.
Common Associates: (*Dulichium arundinaceum*) Three-way sedge, (*Juncus brevicaudatus*) Narrow-panicle rush, (*Eleocharis palustris*) Creeping spikerush, (*Carex lasiocarpa*) Narrow-leaved woolly sedge

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Carex lasiocarpa*) **Narrow-leaved woolly sedge**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-088
Habitat/Distribution: Firm sand and sandy muck on the shoreline. Plants found were few in number and were only found at the point. **Common Associates:** (*Carex cryptolepis*) Small yellow sedge, (*Juncus brevicaudatus*) Narrow-panicle rush, (*Eleocharis palustris*) Creeping spikerush, (*Dulichium arundinaceum*) Three-way sedge, (*Glyceria canadensis*) Rattlesnake manna grass

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Chara* sp.) **Muskgrass**
Specimen Location: Horseshoe Lake; N46.08957°, W91.92728°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-089
Habitat/Distribution: Common to abundant on the east side; uncommon to rare on the west. Most plants were growing in sandy muck in water from 1-5m deep.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Potamogeton pusillus*) Small pondweed, (*Potamogeton gramineus*) Variable pondweed, (*Vallisneria americana*) Wild celery, (*Najas flexilis*) Slender naiad

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Cladium mariscoides*) **Smooth sawgrass**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-090
Habitat/Distribution: Firm sand bottoms along the shoreline. Scattered clusters of plants occurred throughout; most common in undeveloped areas on the western side of the lake.
Common Associates: (*Eleocharis palustris*) Creeping spikerush, (*Spartina pectinata*) Prairie cordgrass, (*Schoenoplectus pungens*) Threesquare, (*Schoenoplectus acutus*) Hardstem bulrush

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Dulichium arundinaceum*) **Three-way sedge**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-091
Habitat/Distribution: Firm sand and sandy muck on the shoreline. Plants found were few in number and were only found at the point.
Common Associates: (*Carex cryptolepis*) Small yellow sedge, (*Juncus brevicaudatus*) Narrow-panicle rush, (*Eleocharis palustris*) Creeping spikerush, (*Carex lasiocarpa*) Narrow-leaved woolly sedge, (*Glyceria canadensis*) Rattlesnake manna grass

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Elatine minima*) **Waterwort**
Specimen Location: Horseshoe Lake; N46.08628°, W91.91604°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-092
Habitat/Distribution: Firm sand bottoms in 0-1.0 meter of water. Uncommon; scattered patches occurred directly along the shoreline.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water milfoil, (*Juncus pelocarpus*) Brown-fruited rush, (*Utricularia resupinata*) Small purple bladderwort, (*Eriocaulon aquaticum*) Pipewort, (*Ranunculus flammula*) Creeping spearwort

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Eleocharis acicularis*) **Needle spikerush**
Specimen Location: Horseshoe Lake; N46.08957°, W91.92728°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-093
Habitat/Distribution: Common along the shoreline throughout. Rarer in deeper water where plants tended to be longer (up to 10cm).
Common Associates: (*Chara* sp.) Muskgrass, (*Potamogeton gramineus*) Variable pondweed, (*Myriophyllum tenellum*) Dwarf water milfoil, (*Juncus pelocarpus*) Brown-fruited rush, (*Utricularia resupinata*) Small purple bladderwort, (*Eriocaulon aquaticum*) Pipewort, (*Ranunculus flammula*) Creeping spearwort

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Eleocharis palustris*) **Creeping spikerush**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-094
Habitat/Distribution: Firm bottoms in 0-0.5 meter of water.
Scattered shoreline locations. This species was the dominant reed on the lake.
Common Associates: (*Cladium mariscoides*) Smooth sawgrass, (*Spartina pectinata*) Prairie cordgrass, (*Schoenoplectus pungens*) Threesquare, (*Schoenoplectus acutus*) Hardstem bulrush

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Elodea canadensis*) **Common waterweed**
Specimen Location: Horseshoe Lake; N46.11166°, W91.89508°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-095
Habitat/Distribution: Muck bottom in 1.5-3 meters of water.
Uncommon; only found during the survey on the east side of the lake.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Potamogeton pusillus*) Small pondweed, (*Chara* sp.) Muskgrass, (*Potamogeton gramineus*) Variable pondweed, (*Vallisneria americana*) Wild celery

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Eriocaulon aquaticum*) **Pipewort**
Specimen Location: Horseshoe Lake; N46.08844°, W91.92557°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-096
Habitat/Distribution: Most common in sand bottom areas in water from 0 – 1 meter deep. Widely distributed along the shoreline on both sides of the lake.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Chara* sp.) Muskgrass, (*Myriophyllum tenellum*) Dwarf water milfoil, (*Juncus pelocarpus*) Brown-fruited rush, (*Utricularia resupinata*) Small purple bladderwort, (*Ranunculus flammula*) Creeping spearwort

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Glyceria canadensis*) **Rattlesnake manna grass**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-097
Habitat/Distribution: Firm sand and sandy muck on the shoreline. Plants found were few in number and were only found at the point.
Common Associates: (*Carex cryptolepis*) Small yellow sedge, (*Juncus brevicaudatus*) Narrow-panicle rush, (*Eleocharis palustris*) Creeping spikerush, (*Dulichium arundinaceum*) Three-way sedge, (*Juncus effusus*) Common rush

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Juncus brevicaudatus*) **Narrow-panicle rush**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-098
Habitat/Distribution: Firm sand and sandy muck on the shoreline. Plants found were few in number and were only found at the point. Some individuals had insect galls and were much distorted from their normal growth habit.
Common Associates: (*Glyceria canadensis*) Rattlesnake manna grass, (*Carex cryptolepis*) Small yellow sedge, (*Juncus effusus*) Common rush, (*Eleocharis palustris*) Creeping spikerush, (*Dulichium arundinaceum*) Three-way sedge

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Juncus effusus*) **Common rush**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-099
Habitat/Distribution: Firm sand and sandy muck on the shoreline. Plants found were few in number and were only found at the point.
Common Associates: (*Carex cryptolepis*) Small yellow sedge, (*Juncus brevicaudatus*) Narrow-panicle rush, (*Eleocharis palustris*) Creeping spikerush, (*Dulichium arundinaceum*) Three-way sedge, (*Glyceria canadensis*) Rattlesnake manna grass

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Juncus pelocarpus*) **Brown-fruited rush**
Specimen Location: Horseshoe Lake; N46.08844°, W91.92557°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-100
Habitat/Distribution: Most common in sand bottom areas in water from 0 – 1 meter deep. Widely distributed along the shoreline on both sides of the lake.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water milfoil, (*Utricularia resupinata*) Small purple bladderwort, (*Elatine minima*) Waterwort, (*Eleocharis palustris*) Creeping spikerush, (*Ranunculus flammula*) Creeping spearwort

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Leersia oryzoides*) **Rice cutgrass**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-101
Habitat/Distribution: Wet muck and sand at the shoreline. Scattered undeveloped shoreline areas throughout.
Common Associates: (*Dulichium arundinaceum*) Three-way sedge, (*Juncus brevicaudatus*) Narrow-panicle rush, (*Eleocharis palustris*) Creeping spikerush, (*Carex lasiocarpa*) Narrow-leaved woolly sedge, (*Glyceria canadensis*) Rattlesnake manna grass, (*Carex cryptolepis*) Small yellow sedge, (*Juncus effusus*) Common rush

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Lycopus uniflorus*) **Northern water-horehound**
Specimen Location: Horseshoe Lake; N46.08991°, W91.93007°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-102
Habitat/Distribution: Plants were submerged by rising water levels on this seepage lake and seemed to be clinging to life. We used mature individual's leaves and the curving tuberous root to make a tentative determination.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water milfoil, (*Ranunculus flammula*) Creeping spearwort

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Myriophyllum spicatum*) **Eurasian water milfoil**
Specimen Location: Horseshoe Lake; N46.09031 °, W91.91720 °
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-103
Habitat/Distribution: Muck to sandy bottom in water up to 4 meters. Rare; at the time of the survey, we found plants at only three general locations; the giant tower at the point, the shorelines just to the north and east, and on the point due north of the public boat landing.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Potamogeton amplifolius*) Large-leaf pondweed, (*Vallisneria americana*) Wild celery, (*Potamogeton praelongus*) White-stem pondweed

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Myriophyllum tenellum*) **Dwarf water milfoil**
Specimen Location: Horseshoe Lake; N46.08874°, W91.93058°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-104
Habitat/Distribution: Most common in sand bottom areas in water from 0 – 1 meter deep. Widely distributed along the shoreline on both sides of the lake.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Utricularia resupinata*) Small purple bladderwort, (*Elatine minima*) Waterwort, (*Eleocharis palustris*) Creeping spikerush, (*Ranunculus flammula*) Creeping spearwort, (*Juncus pelocarpus*) Brown-fruited rush

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Najas flexilis*) **Slender naiad**
Specimen Location: Horseshoe Lake; N46.08991°, W91.93007°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-105
Habitat/Distribution: Found in almost any bottom conditions, but grows best in sand bottoms in 0.5-4 meters of water. Common but not abundant; widely distributed throughout both sides of the lake.
Common Associates: (*Chara* sp.) Muskgrass, (*Eleocharis acicularis*) Needle spikerush, (*Potamogeton gramineus*) Variable pondweed, (*Vallisneria americana*) Wild celery, (*Utricularia resupinata*) Small purple bladderwort

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Najas gracillima*) **Northern naiad**
Specimen Location: Horseshoe Lake; N46.08991°, W91.93007°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-106
Habitat/Distribution: Rare; sand bottom areas in water from 0 – 1.5 meters deep. Found at only two locations – one on each side of the lake. Plants were abundant at the point on the east side of the lake.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Utricularia resupinata*) Small purple bladderwort, (*Elatine minima*) Waterwort, (*Eleocharis palustris*) Creeping spikerush, (*Ranunculus flammula*) Creeping spearwort, (*Juncus pelocarpus*) Brown-fruited rush, (*Myriophyllum tenellum*) Dwarf water milfoil

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Nitella* sp.) **Nitella**
Specimen Location: Horseshoe Lake; N46.08642°, W91.93050°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-107
Habitat/Distribution: Muck bottom in the deep hole (5+meters) on the west side of the lake. Only a few individual plants were found.
Common Associates: (*Potamogeton praelongus*) White-stem pondweed

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Nuphar variegata*) **Spatterdock**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-108
Habitat/Distribution: Muck 0.5-1.5 meters. Rare; only plants found in the lake were located near the point in the southeast bay on the western side of the lake.
Common Associates: (*Potamogeton natans*) Floating-leaf pondweed, (*Brasenia schreberi*) Watershield

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Nymphaea odorata*) **White water lily**
Specimen Location: Horseshoe Lake; N46.08764°, W91.92665°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-109
Habitat/Distribution: Sandy muck bottom in 0-1.5 meters. Rare; a few small beds were located along the shoreline near the point in the western side of the lake in the bay just southwest of the channel. Plants were very small, but fragrant.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water milfoil

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Polygonum amphibium*) **Water smartweed**
Specimen Location: Horseshoe Lake; N46.08628°, W91.91604°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-110
Habitat/Distribution: Sandy muck in water <1 meter. A small cluster of plants occurred at the point, and another large bed ringed the southeast bay of the east side of the lake near the public boat landing.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Utricularia resupinata*) Small purple bladderwort, (*Elatine minima*) Waterwort

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Potamogeton amplifolius*) **Large-leaf pondweed**
Specimen Location: Horseshoe Lake; N46.08426°, W91.92097°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-111
Habitat/Distribution: Found in a narrow range from 1.75-3.25 meters over sandy muck. Relatively common, but not abundant. Plants were widely distributed throughout the east side, but only found at one point on the west. It was a strong EWM associate.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Chara* sp.) Muskgrass, (*Potamogeton gramineus*) Variable pondweed, (*Najas flexilis*) Slender naiad, (*Vallisneria americana*) Wild celery, (*Myriophyllum spicatum*) Eurasian water milfoil

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Potamogeton gramineus*) **Variable pondweed**
Specimen Location: Horseshoe Lake; N46.08426°, W91.92097°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-112
Habitat/Distribution: Widespread and common but not abundant. Found throughout the lake in almost any bottom condition in all but the deepest parts of the littoral zone from 0.5-5 meters deep.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Chara* sp.) Muskgrass, (*Utricularia resupinata*) Small purple bladderwort, (*Najas flexilis*) Slender naiad, (*Vallisneria americana*) Wild celery

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Potamogeton natans*) **Floating-leaf pondweed**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92871°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-113
Habitat/Distribution: Muck and sandy muck bottom in 1-1.5 meters of water. Only plants found were at the point. Leaves somewhat resembled *P. oakesianus*, but the phyllode leaves were 1-2mm wide, stipules 5cm+, floating leaf length to 7.5cm and width to 3cm+ (ratio Oakes-like, but both lengths too long), and the base/petiole jct. was distinctly lighter than the rest of the petiole. There were also no red spots on the stems. Unfortunately, no plants were in flower or fruit.
Common Associates: (*Brasenia schreberi*) Watershield, (*Nuphar variegata*) Spatterdock, (*Sparganium angustifolium*) Narrow-leaved bur-reed

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Potamogeton praelongus*) **White-stem pondweed**
Specimen Location: Horseshoe Lake; N46.08642°, W91.93050°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-114
Habitat/Distribution: Sandy muck substrate in 2-5.5 meters of water. Uncommon but widely distributed. It was one of the deepest growing plants in the lake with most individuals being found in water over 3.5 meters. It was also a strong EWM associate.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Potamogeton amplifolius*) Large-leaf pondweed, (*Vallisneria americana*) Wild celery, (*Chara* sp.) Muskgrass, (*Myriophyllum spicatum*) Eurasian water milfoil

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Potamogeton pusillus*) **Small pondweed**
Specimen Location: Horseshoe Lake; N46.08991°, W91.93007°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-115
Habitat/Distribution: Uncommon, but widely distributed throughout in sand and sandy muck. Plants were found in 1-4m; deeper plants had wider leaves, but they all had identical fruit confirming identification.
Common Associates: (*Potamogeton robbinsii*) Fern pondweed, (*Vallisneria americana*) Wild celery, (*Chara* sp.) Muskgrass, (*Najas flexilis*) Slender naiad, (*Potamogeton gramineus*) Variable pondweed

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Potamogeton robbinsii*) **Fern pondweed**
Specimen Location: Horseshoe Lake; N46.08681°, W91.92996°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-116
Habitat/Distribution: Common to abundant in sandy muck in 1-5.5 meters of water. Most plants were on the east side of the lake. On the west side, we found large numbers of rotten leaves of this species in areas that no longer had any living plants.
Common Associates: (*Potamogeton amplifolius*) Large-leaf pondweed, (*Potamogeton gramineus*) Variable pondweed, (*Vallisneria americana*) Wild celery, (*Potamogeton praelongus*) White-stem pondweed

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Potamogeton spirillus*) **Spiral-fruited pondweed**
Specimen Location: Horseshoe Lake; N46.08991°, W91.93007°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2011-117
Habitat/Distribution: Found in shallow (<1m) sand bottom areas that were not dominated by carpet forming isoetids. Most plants were on the west and north shorelines on the west side of the lake.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Utricularia resupinata*) Small purple bladderwort, (*Ranunculus flammula*) Creeping spearwort, (*Juncus pelocarpus*) Brown-fruited rush, (*Myriophyllum tenellum*) Dwarf water milfoil (*Najas flexilis*) Slender naiad, (*Vallisneria americana*) Wild celery

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Ranunculus flammula*) **Creeping spearwort**
Specimen Location: Horseshoe Lake; N46.08844°, W91.92557°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-118
Habitat/Distribution: Uncommon in sand <1.5 meters deep. Widely scattered populations were found on the north shorelines on both sides of the lake.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water milfoil, (*Juncus pelocarpus*) Brown-fruited rush, (*Elatine minima*) Waterwort, (*Eriocaulon aquaticum*) Pipewort, (*Utricularia resupinata*) Small purple bladderwort

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Sagittaria cristata*) **Crested arrowhead**
Specimen Location: Horseshoe Lake; N46.08374°, W91.92874°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-119
Habitat/Distribution: Relatively common in sand muck from 1.5-3.5 meters deep. Widely distributed on the west side, but only scattered on the east end of the lake. No emergent plants were found anywhere along the shoreline.
Common Associates: (*Potamogeton gramineus*) Variable pondweed, (*Vallisneria americana*) Wild celery, (*Najas flexilis*) Slender naiad, (*Eleocharis acicularis*) Needle spikerush

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Schoenoplectus acutus*) **Hardstem bulrush**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-120
Habitat/Distribution: Sandy bottoms in 0-0.5 meters of water. Rare; a small bed was located at the point and around the entrance of the southeast bay in the west end of the lake.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Eleocharis palustris*) Creeping spikerush, (*Brasenia schreberi*) Watershield, (*Sparganium angustifolium*) Narrow-leaved bur-reed

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Schoenoplectus pungens*) **Three-square bulrush**
Specimen Location: Horseshoe Lake; N46.08994°, W91.92840°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-121
Habitat/Distribution: Clusters of plants occurred on the north shoreline of the western side of the lake.
Common Associates: (*Cladium mariscoides*) Smooth sawgrass, (*Potamogeton spirillus*) Spiral-fruited pondweed, (*Vallisneria americana*) Wild celery, (*Najas flexilis*) Slender naiad, (*Eleocharis acicularis*) Needle spikerush

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Sparganium angustifolium*) **Narrow-leaved bur-reed**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92871°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-122
Habitat/Distribution: Rare being found at only two locations – at the point near the entrance to the southeast bay of the western side of the lake, and along the shoreline due west of the public boat landing in the eastern side of the lake. Plants were growing in water <1.5m over sandy muck.
Common Associates: (*Nuphar variegata*) Spatterdock, (*Brasenia schreberi*) Watershield

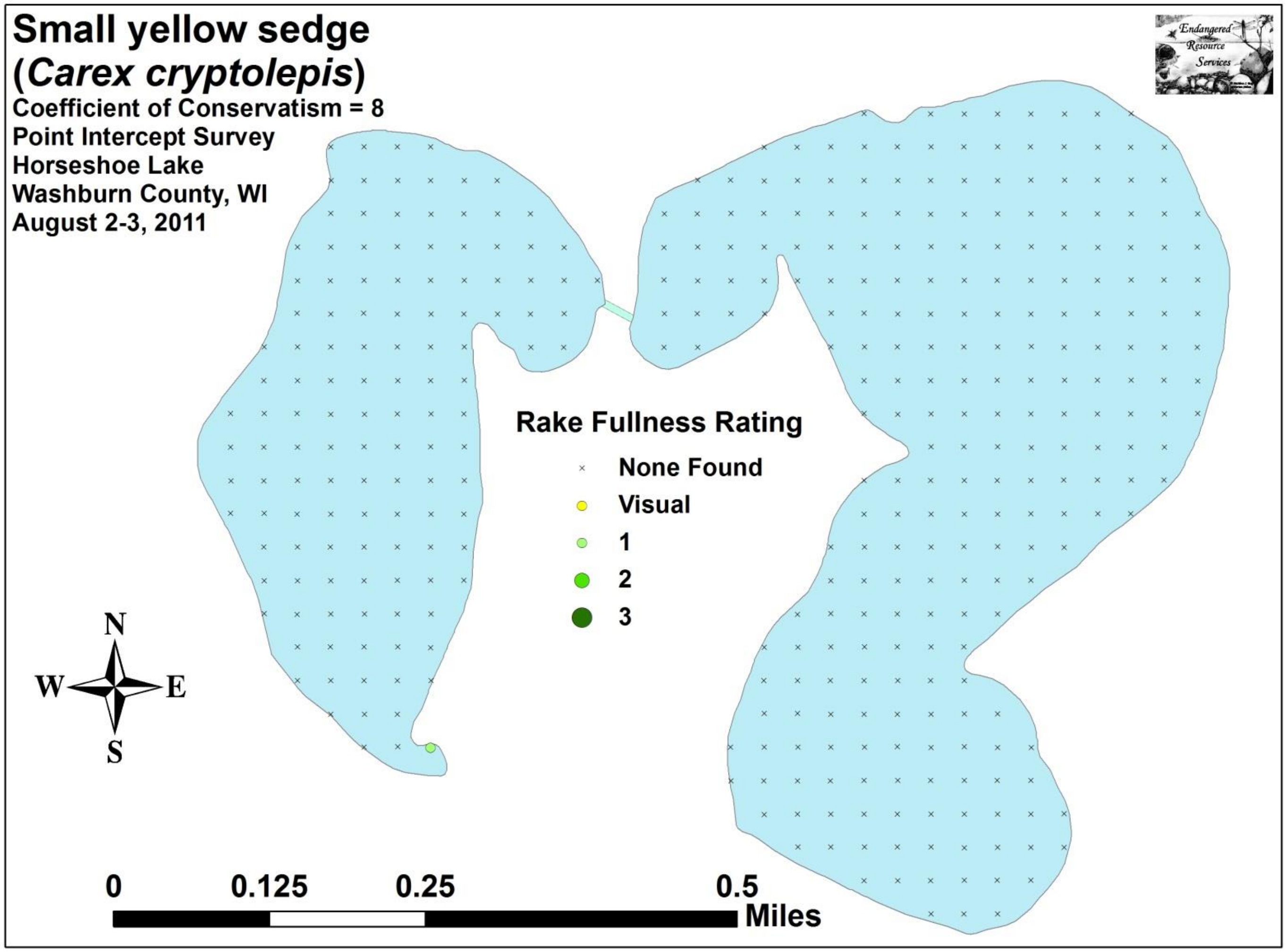
County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Spartina pectinata*) **Prairie cordgrass**
Specimen Location: Horseshoe Lake; N46.08120°, W91.91864°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-123
Habitat/Distribution: Found in scattered sugar sand areas directly adjacent to the shoreline; especially common near the public boat landing.
Common Associates: (*Eleocharis palustris*) Creeping spikerush, (*Cladium mariscoides*) Smooth sawgrass, (*Schoenoplectus pungens*) Threesquare

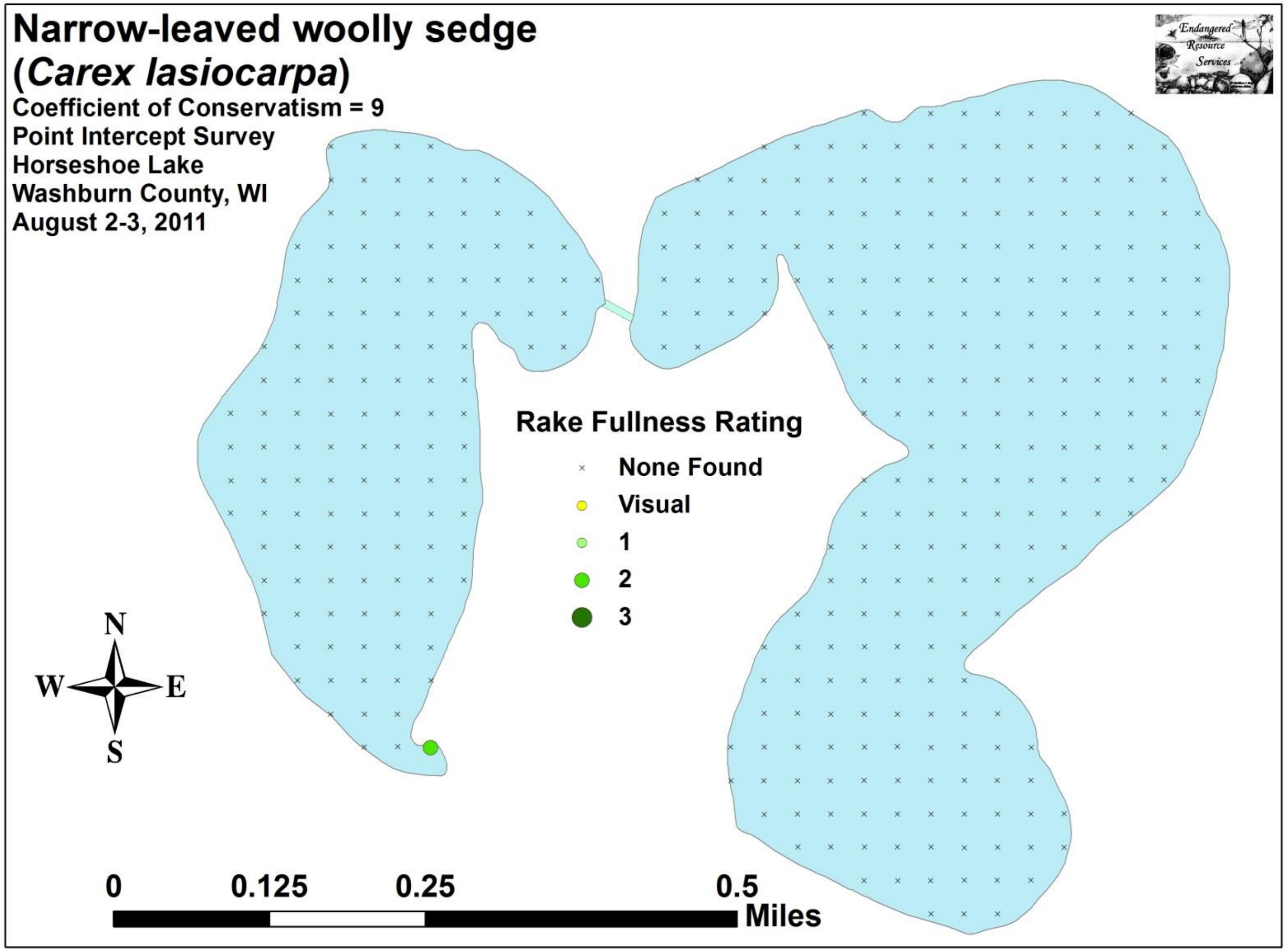
County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Utricularia gibba*) **Creeping bladderwort**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-124
Habitat/Distribution: Muck bottom in shallow water 0-1 meter deep. Rare; only plants found were near the point in the southeast corner of the western side of the lake where it was entangled among floating leaf species.
Common Associates: (*Brasenia schreberi*) Watershield, (*Potamogeton natans*) Floating-leaf pondweed, (*Nuphar variegata*) Spatterdock

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Utricularia resupinata*) **Small purple bladderwort**
Specimen Location: Horseshoe Lake; N46.08297°, W91.92816°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-125
Habitat/Distribution: Most common in sand bottom areas in water from 0 – 1 meter deep. Widely distributed and frequently abundant along the shoreline on both sides of the lake.
Common Associates: (*Eleocharis acicularis*) Needle spikerush, (*Myriophyllum tenellum*) Dwarf water milfoil, (*Juncus pelocarpus*) Brown-fruited rush, (*Elatine minima*) Waterwort, (*Eleocharis palustris*) Creeping spikerush, (*Ranunculus flammula*) Creeping spearwort

County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Vallisneria americana*) **Wild celery**
Specimen Location: Horseshoe Lake; N46.08486°, W91.93100°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-126
Habitat/Distribution: Found over sand and sandy muck in 1.0-4.5 meters of water. Common and widely distributed throughout both sides of the lake.
Common Associates: (*Potamogeton gramineus*) Variable pondweed, (*Chara* sp.) Muskgrass, (*Potamogeton robbinsii*) Fern pondweed, (*Eleocharis acicularis*) Needle spikerush, (*Najas flexilis*) Slender naiad, (*Potamogeton pusillus*) Small pondweed

Appendix VII: Native Plant Species Density and Distribution Maps


Small yellow sedge
(*Carex cryptolepis*)
Coefficient of Conservatism = 8
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Rake Fullness Rating
None Found
Visual
1
2
3
N
W
E
S
0
0.125
0.25
0.5
Miles
Endangered
Resource
Services


Narrow-leaved woolly sedge
(*Carex lasiocarpa*)
Coefficient of Conservatism = 9
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
1
2
3
N
W
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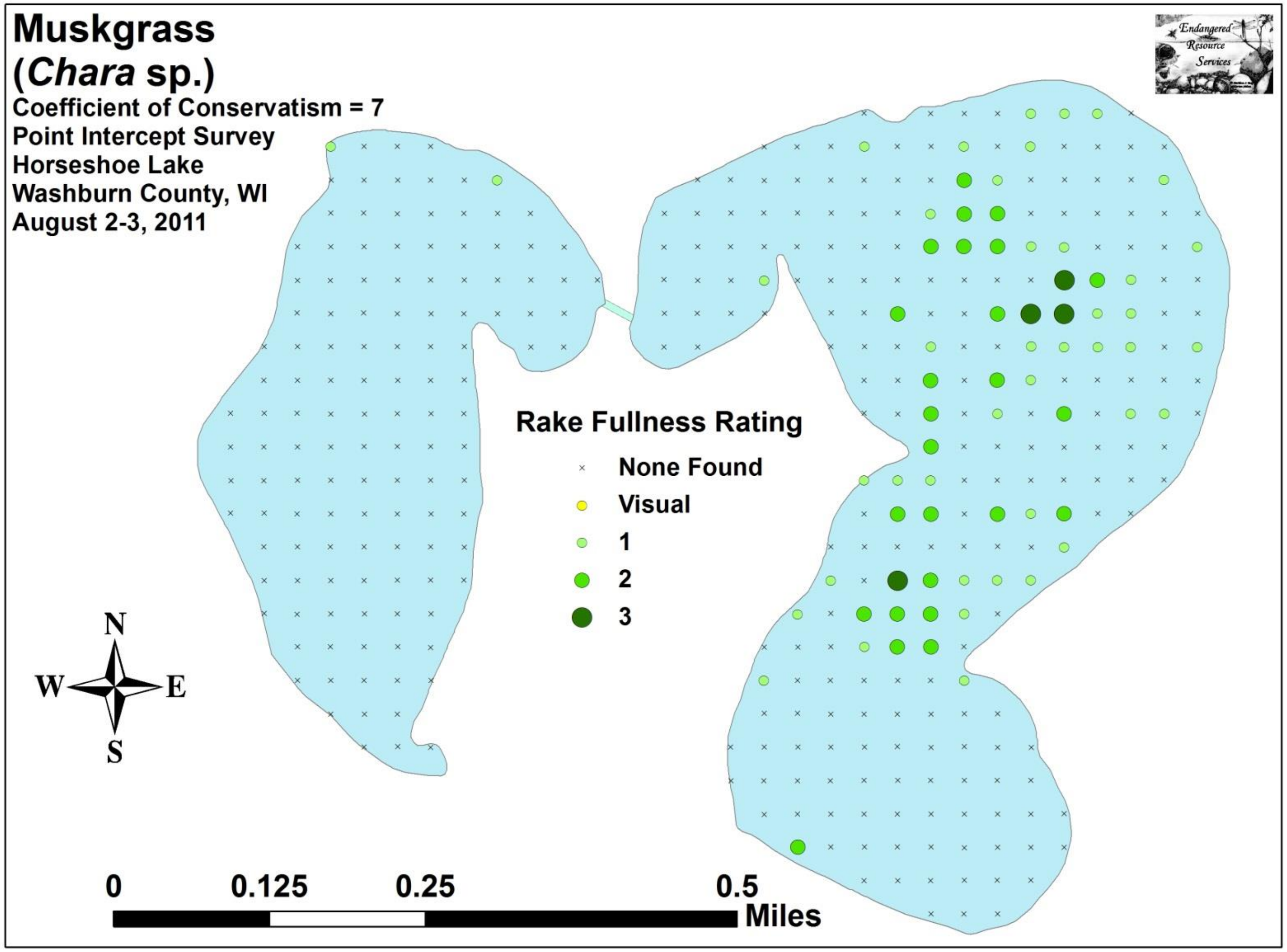
S
0
0.125
0.25
0.5
Miles


Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
1
2
3
N
W
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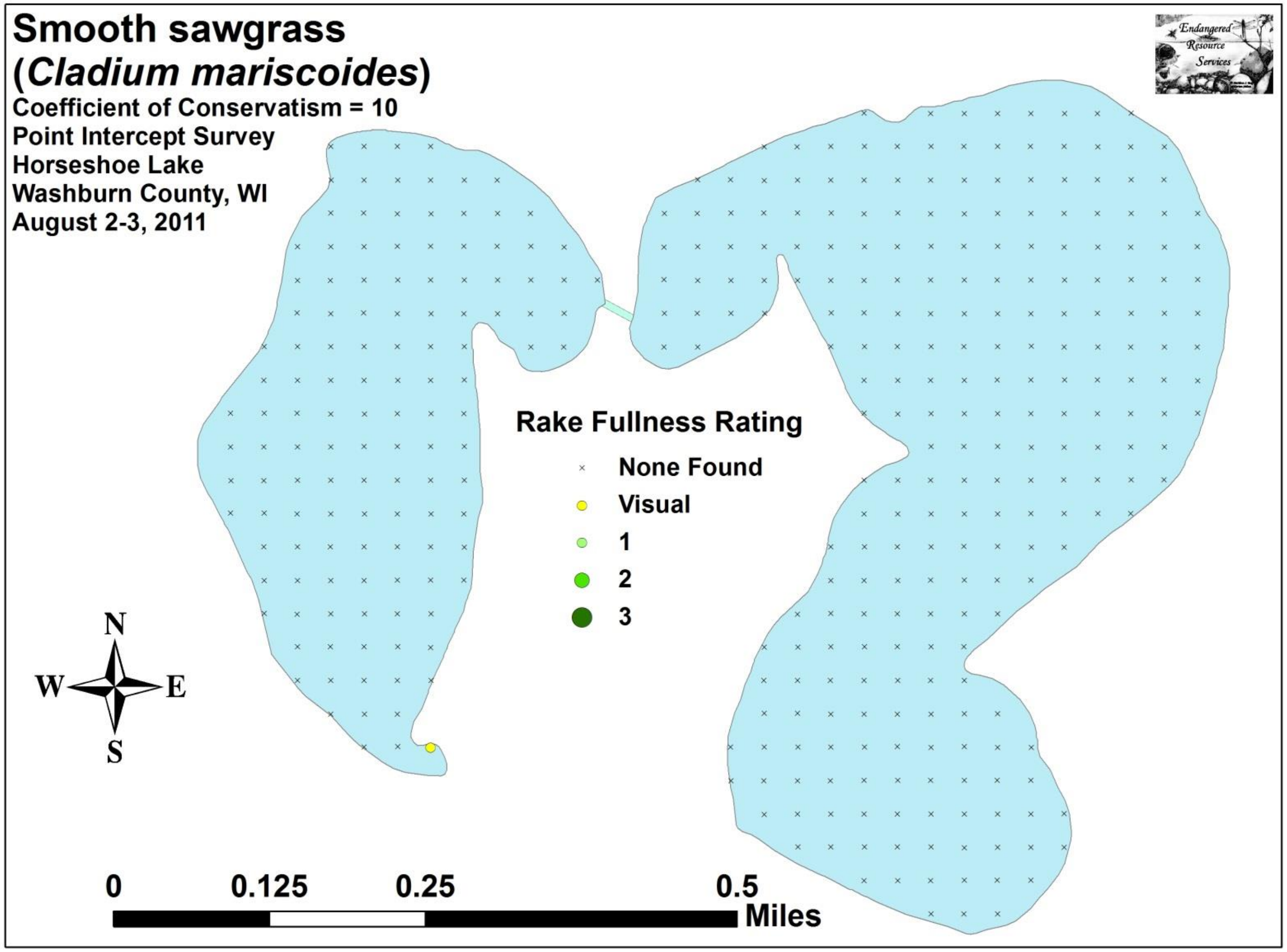
S
0
0.125
0.25
0.5
Miles


Smooth sawgrass
(*Cladium mariscoides*)
Coefficient of Conservatism = 10
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
1
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3
N
W
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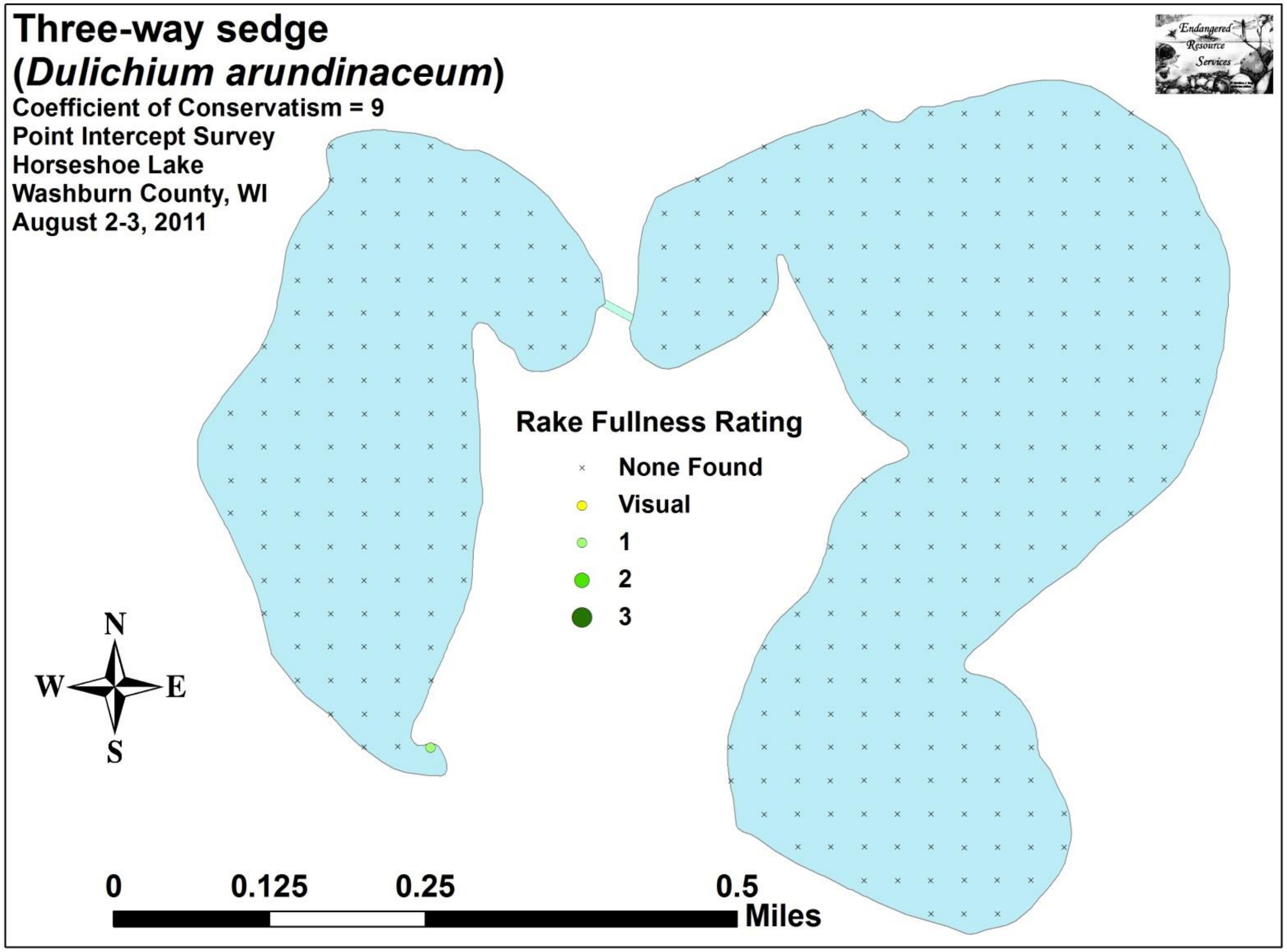
0
0.125
0.25
0.5
Miles


Three-way sedge
(*Dulichium arundinaceum*)
Coefficient of Conservatism = 9
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
1
2
3
N
W
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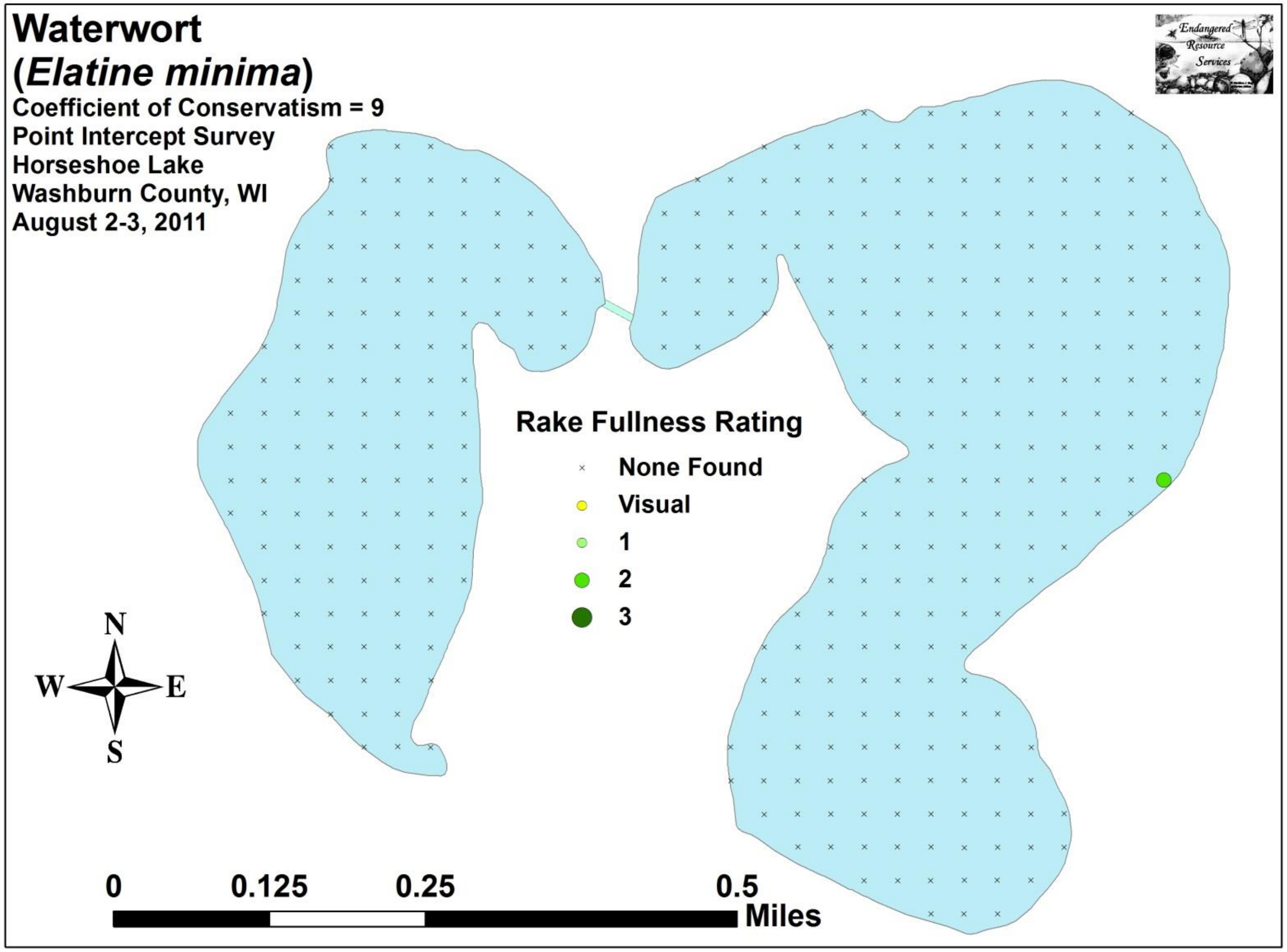
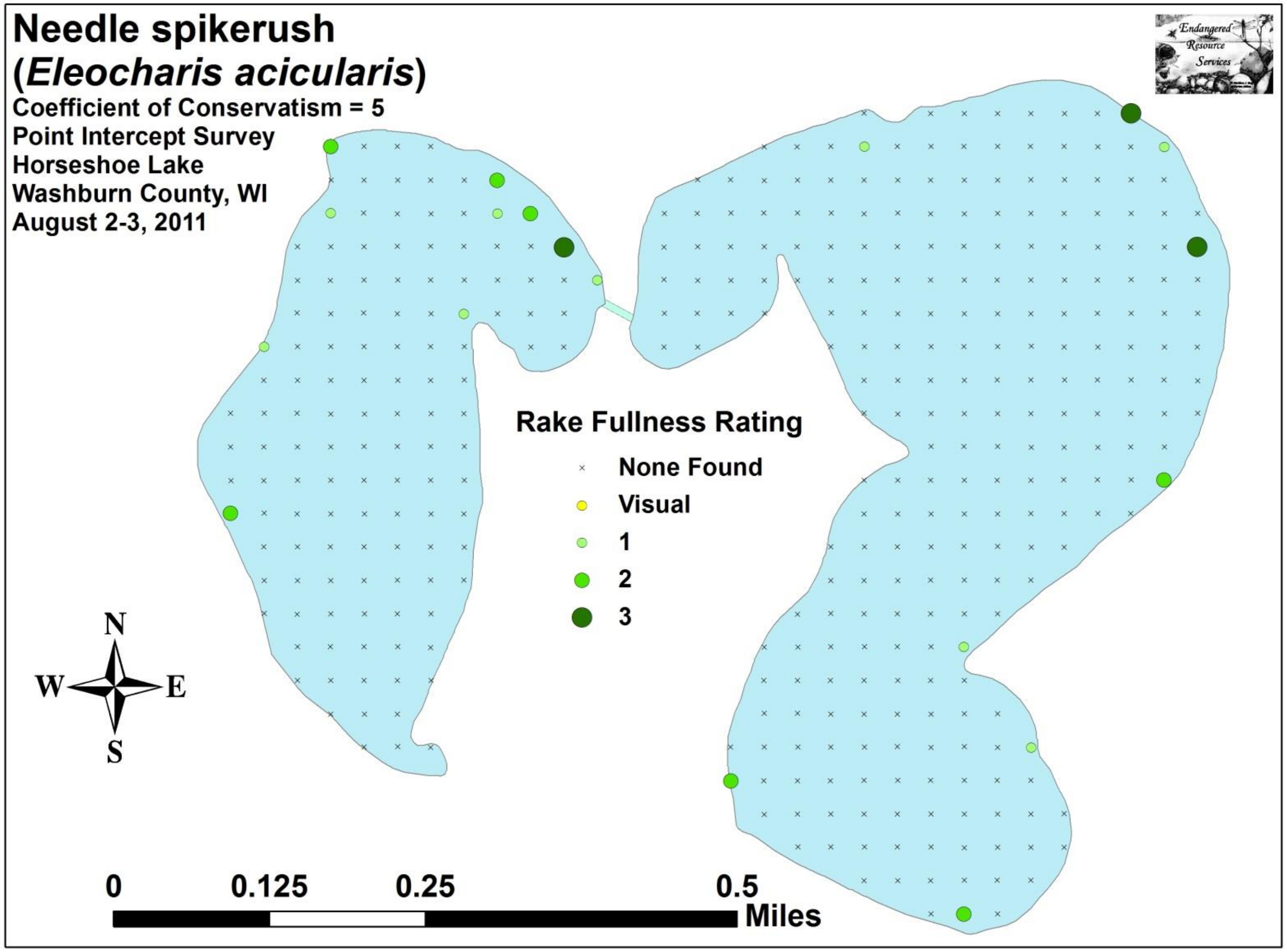
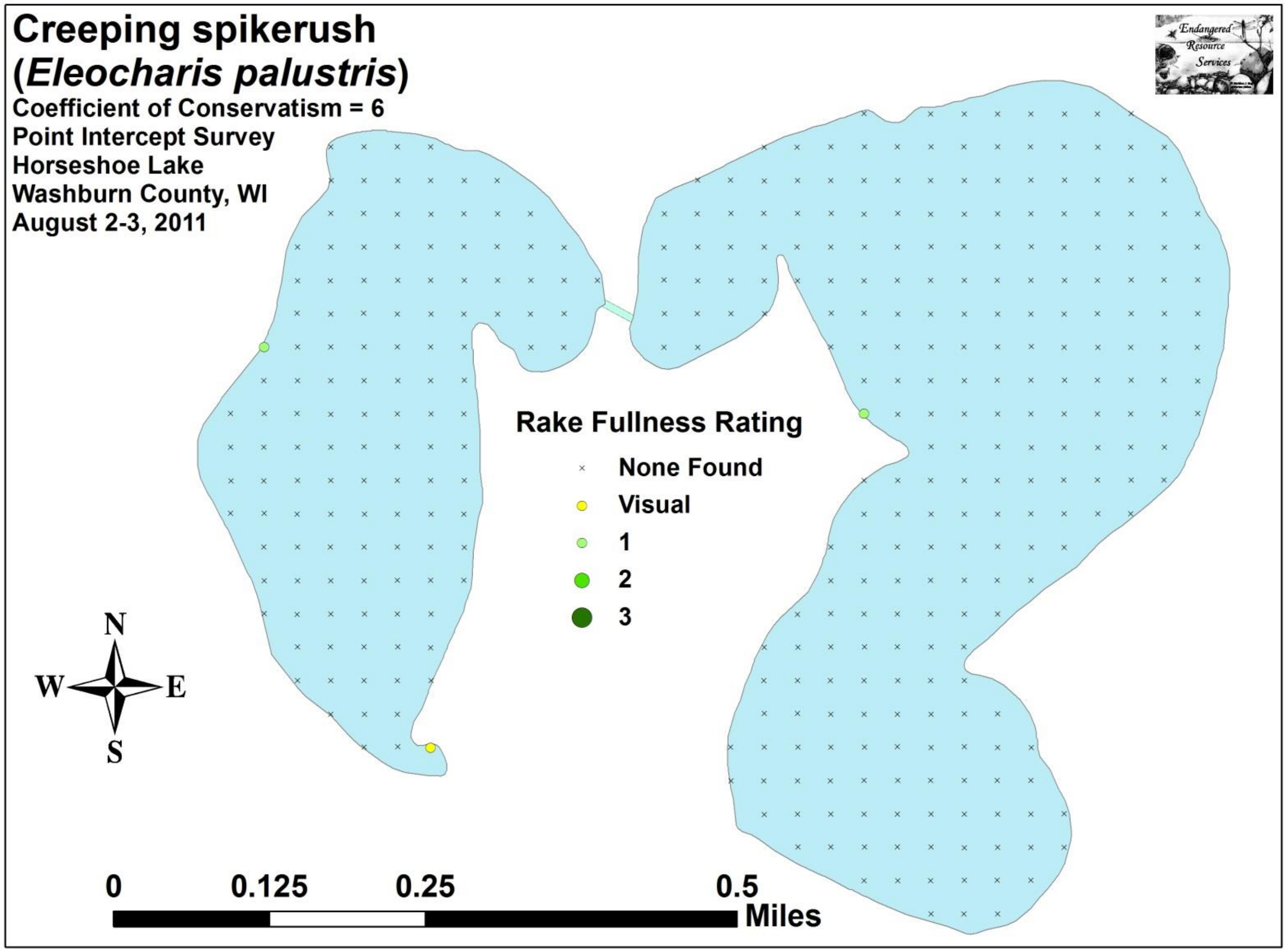
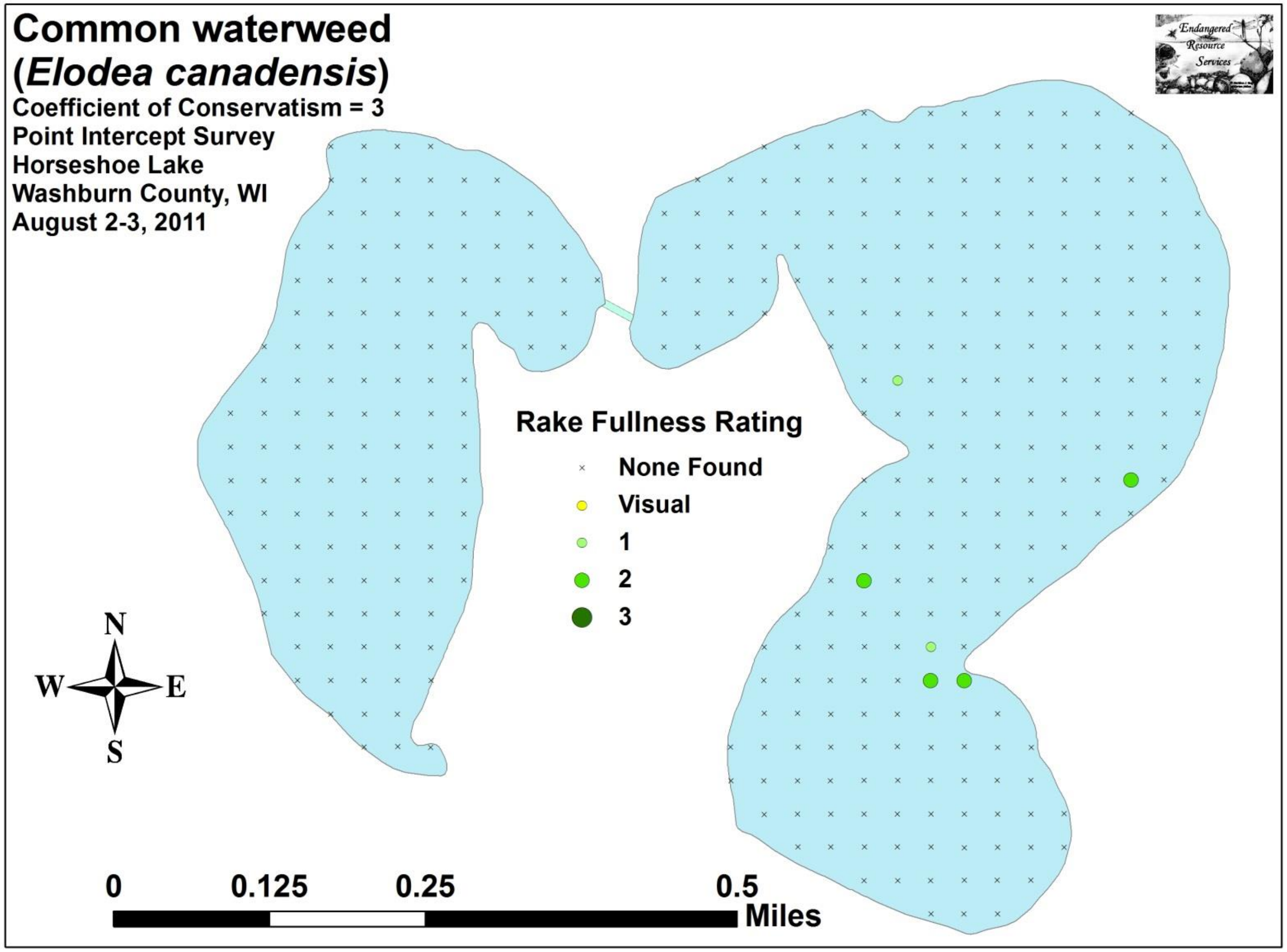
0
0.125
0.25
0.5
Miles


Waterwort
(Elatine minima)
Coefficient of Conservatism = 9
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
1
2
3
N
W
E
S
0
0.125
0.25
0.5
Miles


Needle spikerush
(Eleocharis acicularis)
Coefficient of Conservatism = 5
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
1
2
3
N
W
E
S
0
0.125
0.25
0.5
Miles


Creeping spikerush
(Eleocharis palustris)
Coefficient of Conservatism = 6
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
1
2
3
N
W
E
S
0
0.125
0.25
0.5
Miles


Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
1
2
3
N
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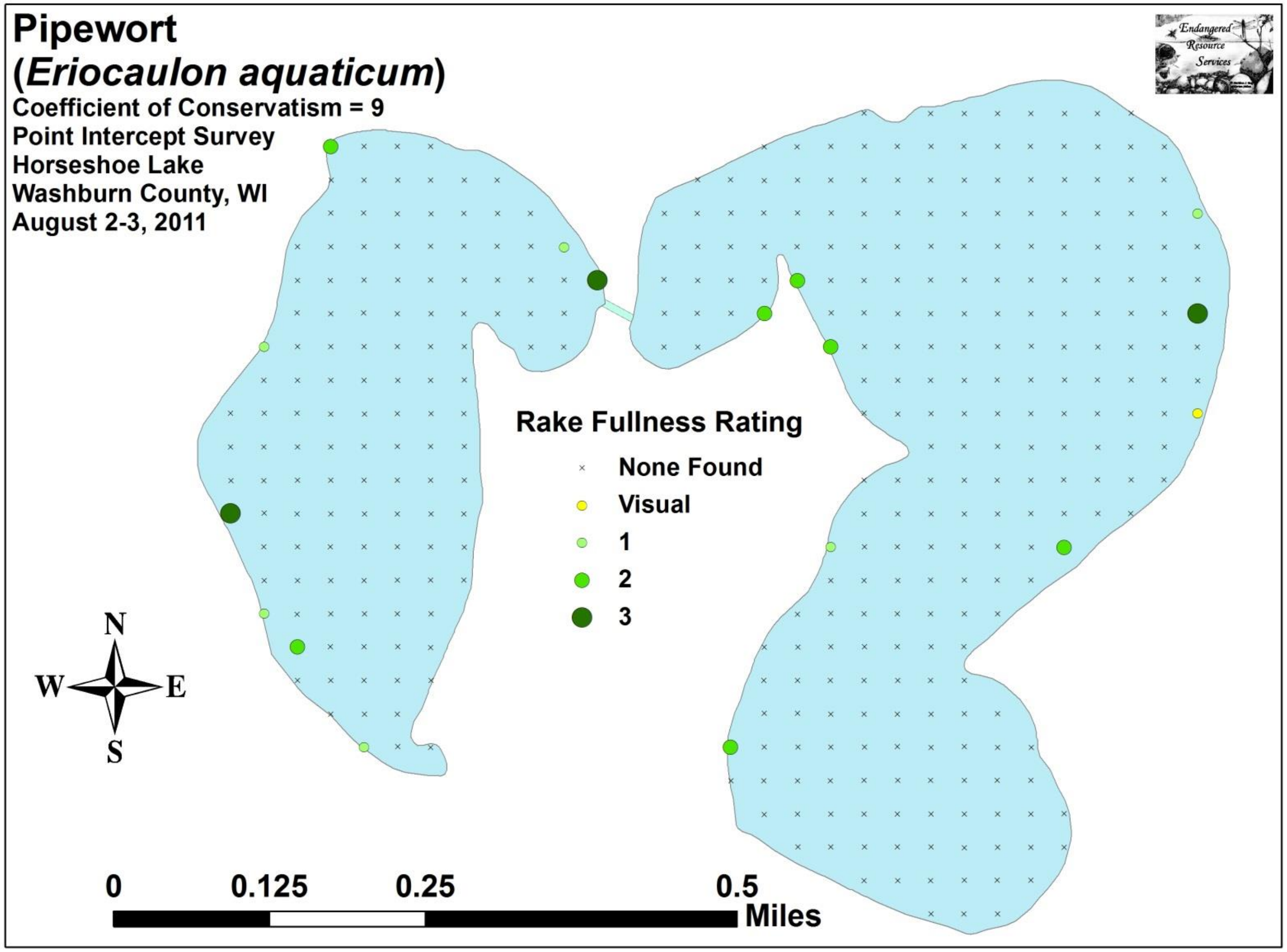
Miles


Pipewort
(Eriocaulon aquaticum)
Coefficient of Conservatism = 9
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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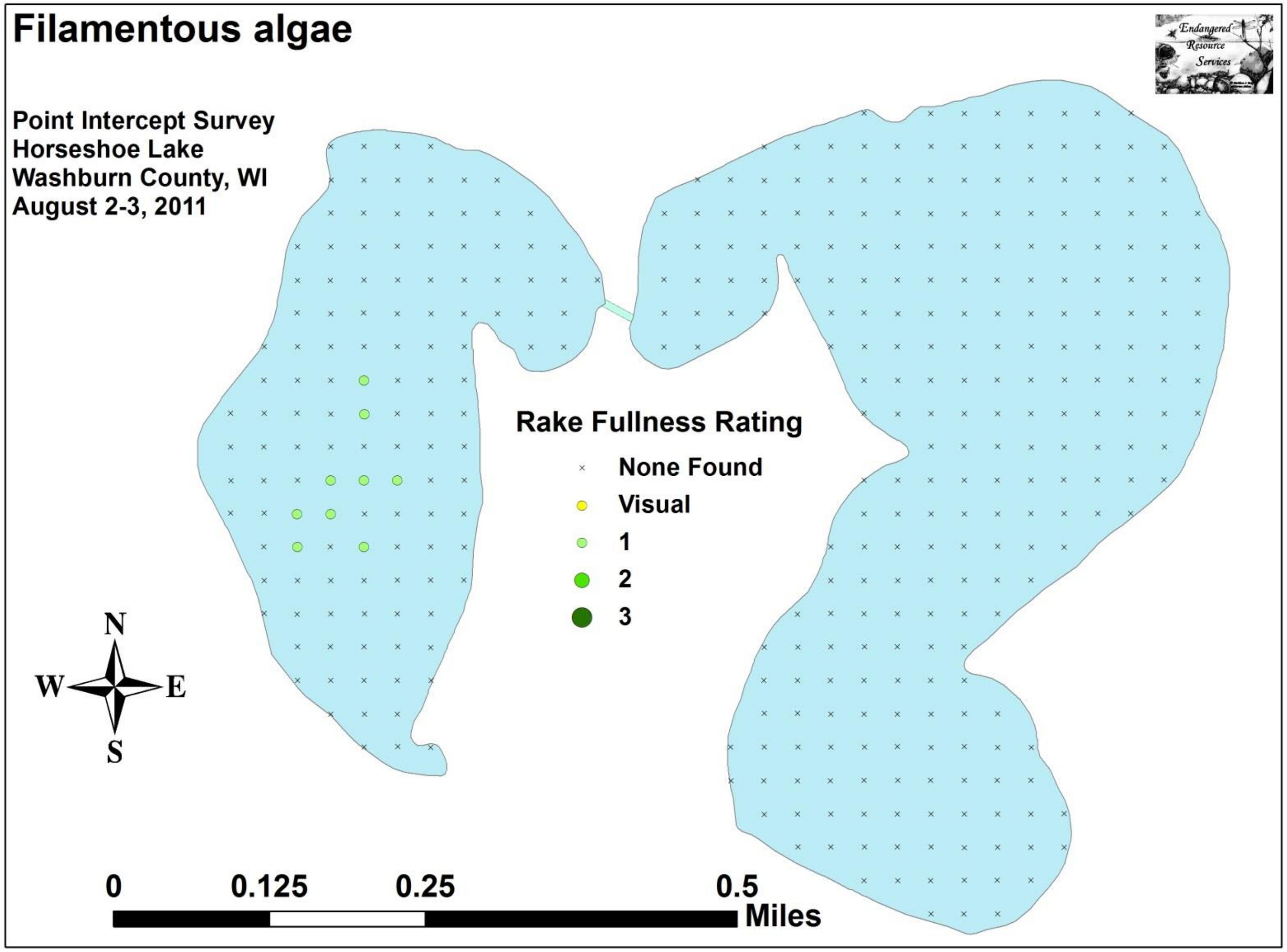
Miles



Filamentous algae
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
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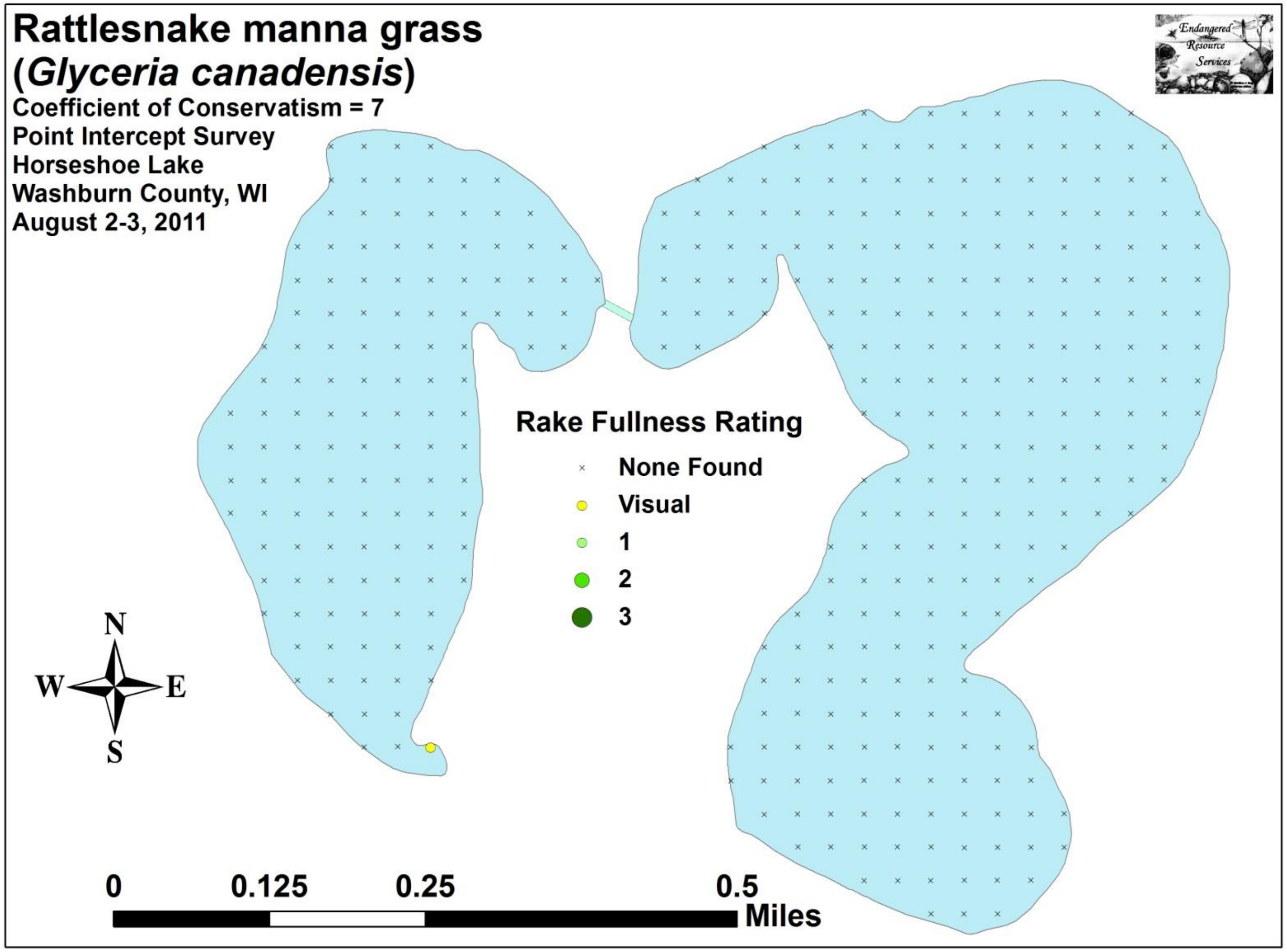

Rattlesnake manna grass
(Glyceria canadensis)
Coefficient of Conservatism = 7
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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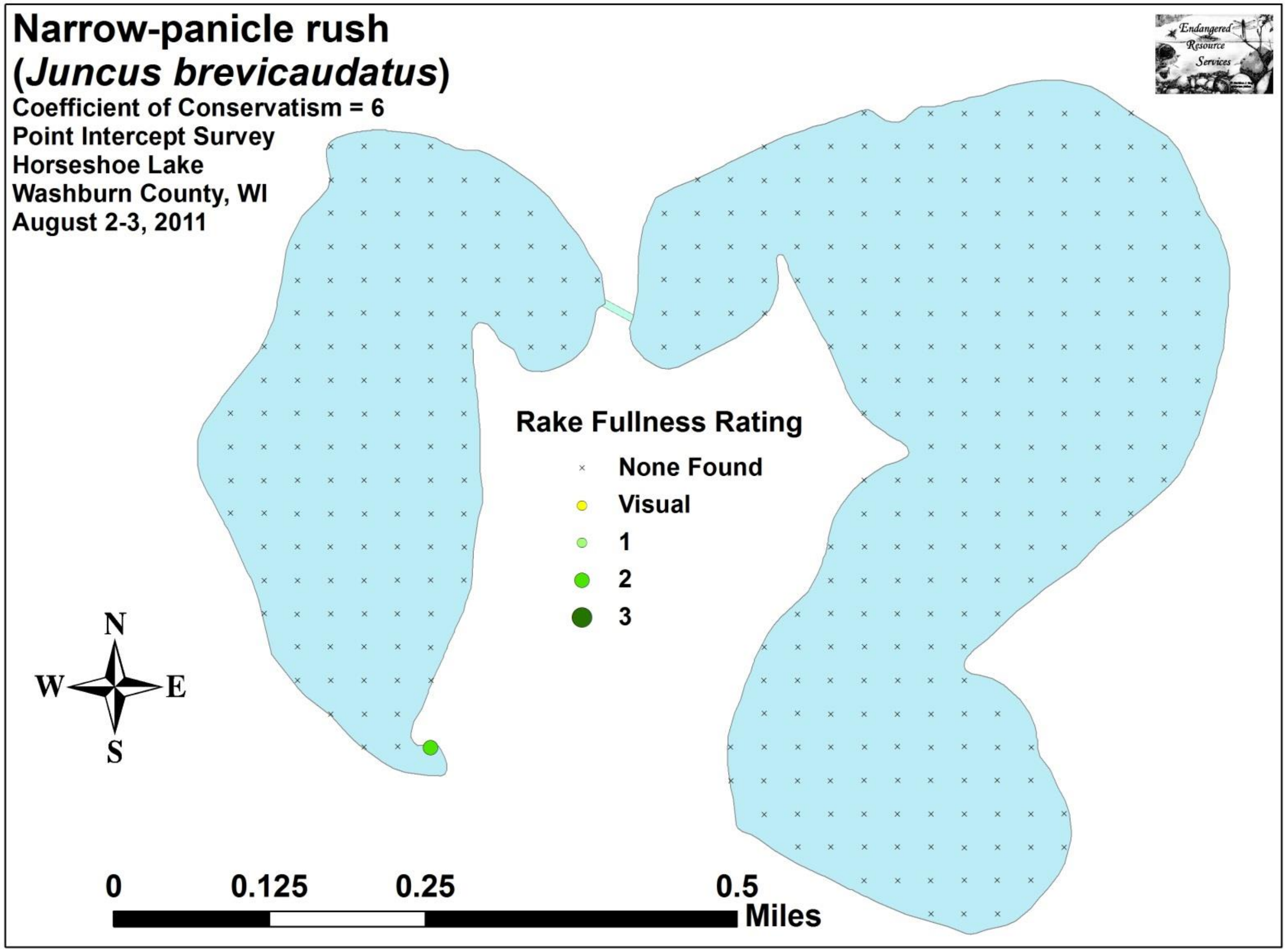
Miles



Narrow-panicle rush
(Juncus brevicaudatus)
Coefficient of Conservatism = 6
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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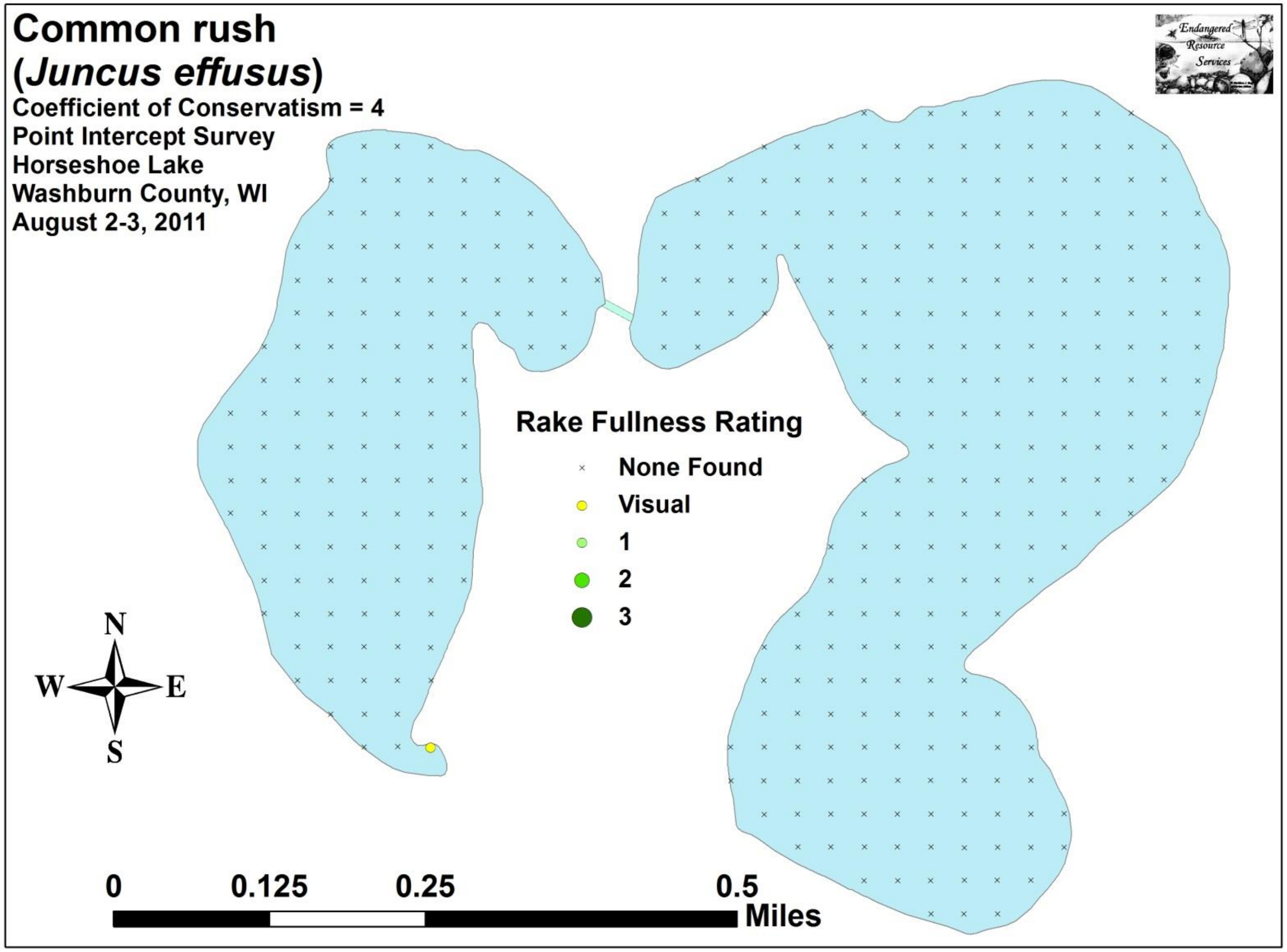
Miles


Common rush
(Juncus effusus)
Coefficient of Conservatism = 4
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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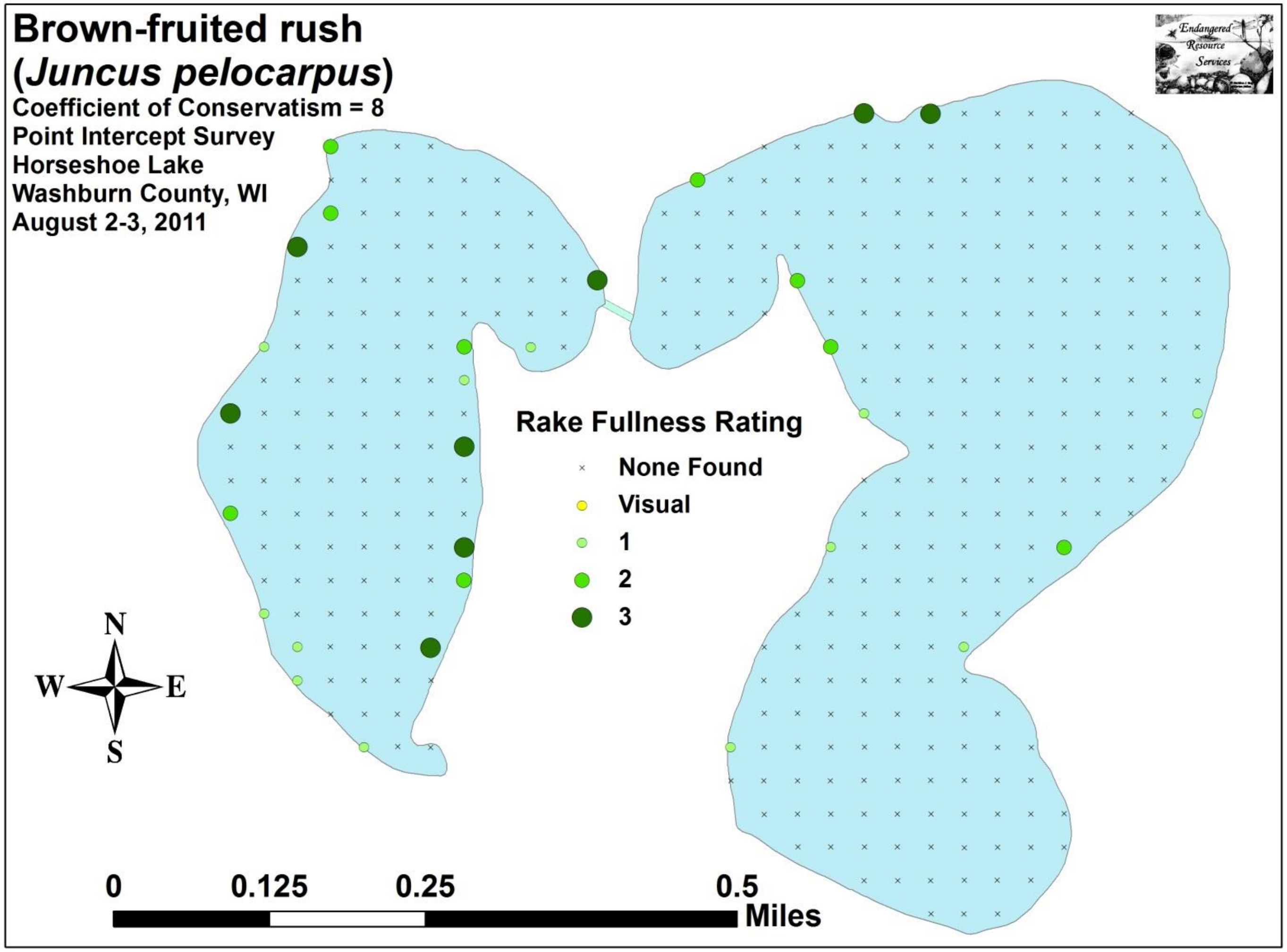
Miles


Brown-fruited rush
(Juncus pelocarpus)
Coefficient of Conservatism = 8
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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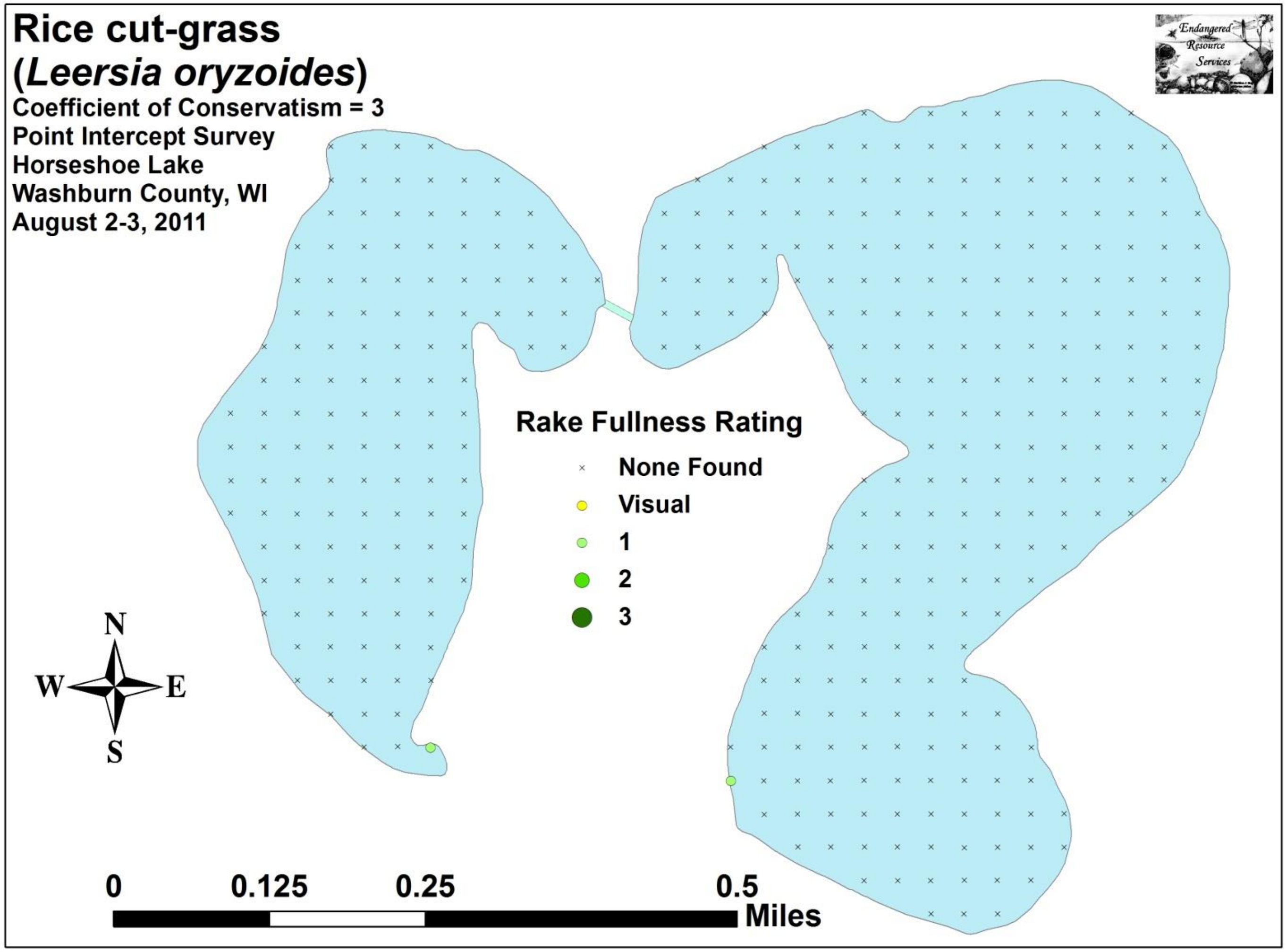
Rice cut-grass
(*Leersia oryzoides*)
Coefficient of Conservatism = 3
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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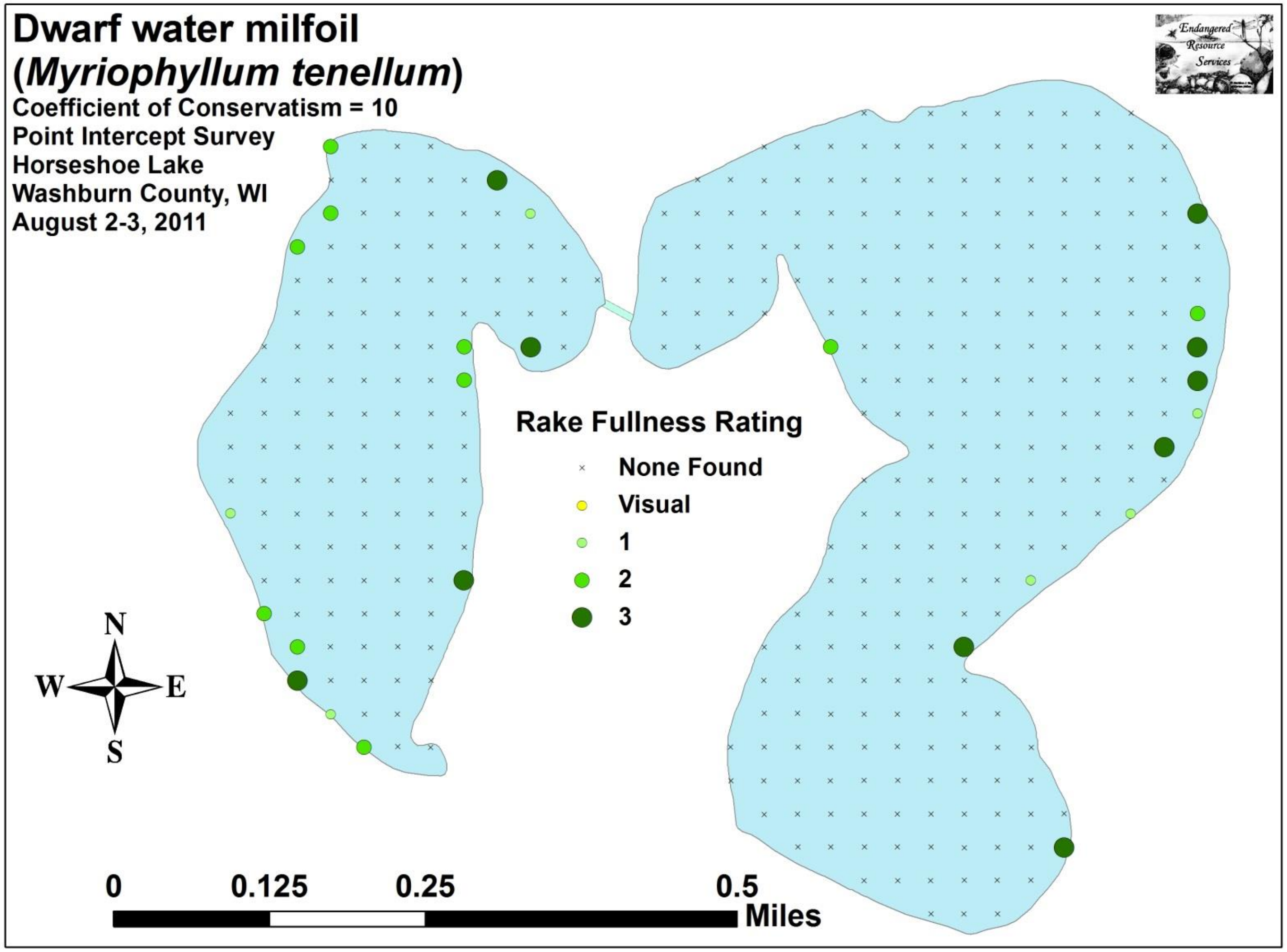
Miles


Dwarf water milfoil
(*Myriophyllum tenellum*)
Coefficient of Conservatism = 10
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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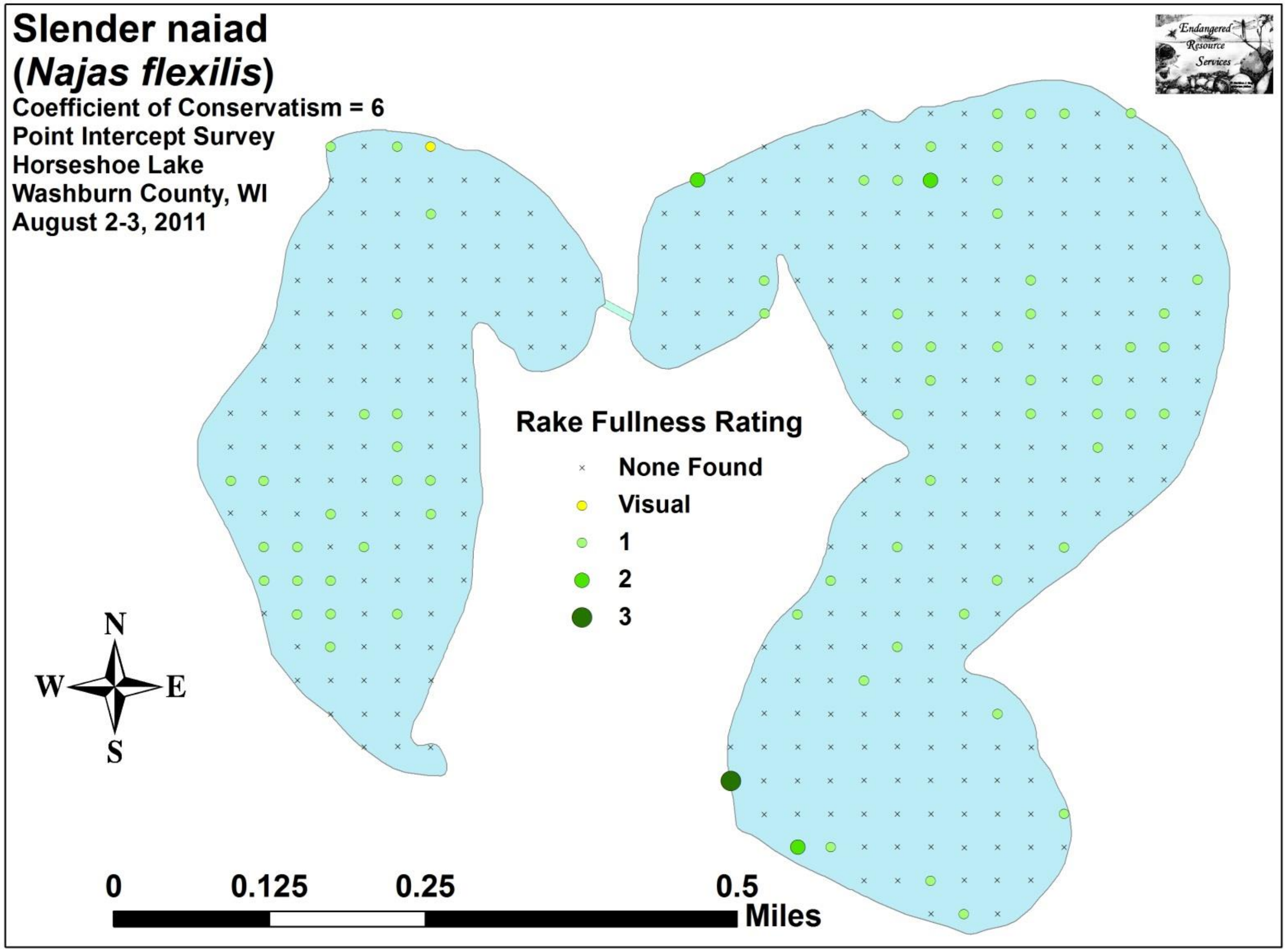
Miles



Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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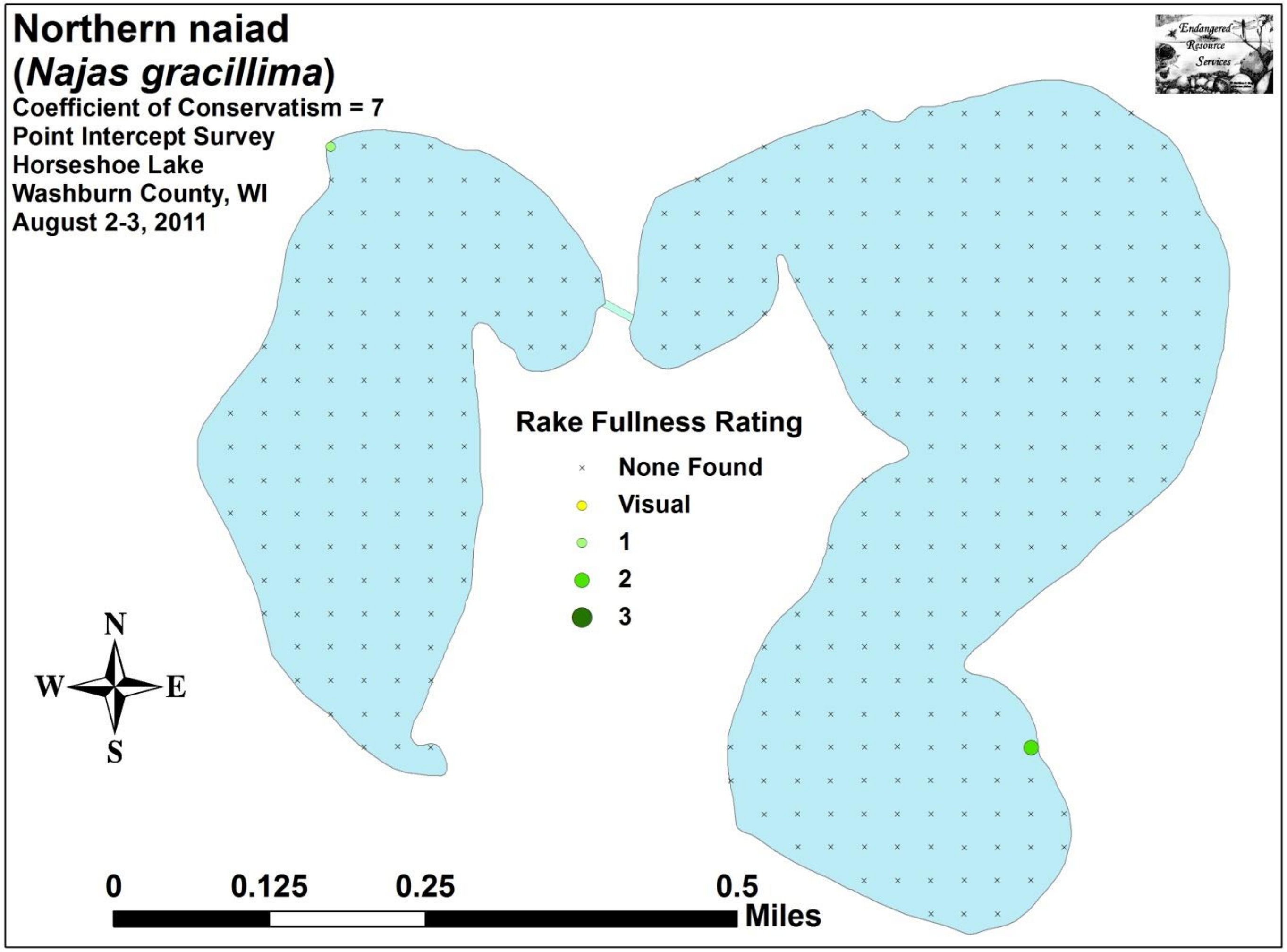
Miles


Northern naiad
(Najas gracillima)
Coefficient of Conservatism = 7
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Rake Fullness Rating
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Visual
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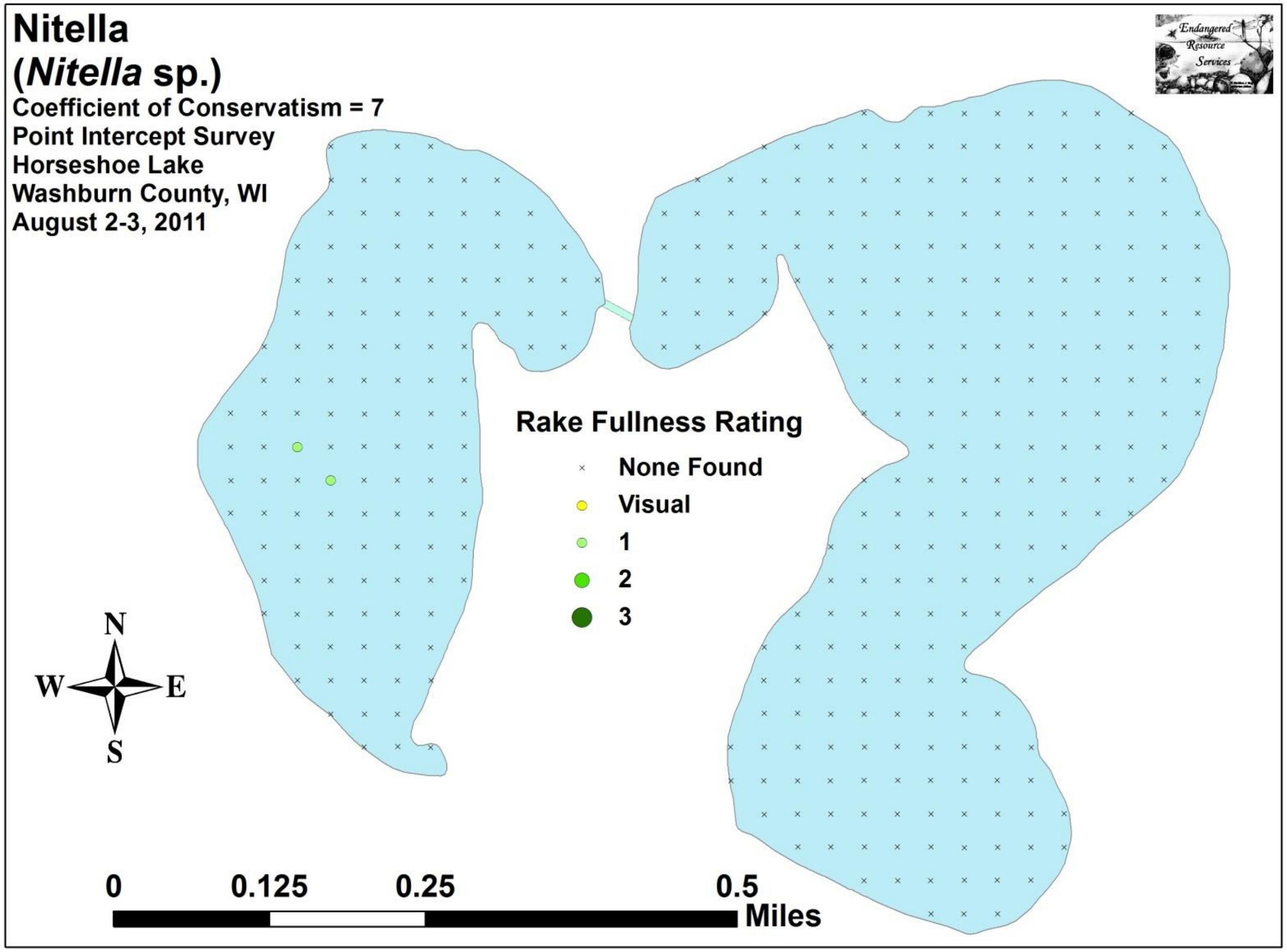
Miles



Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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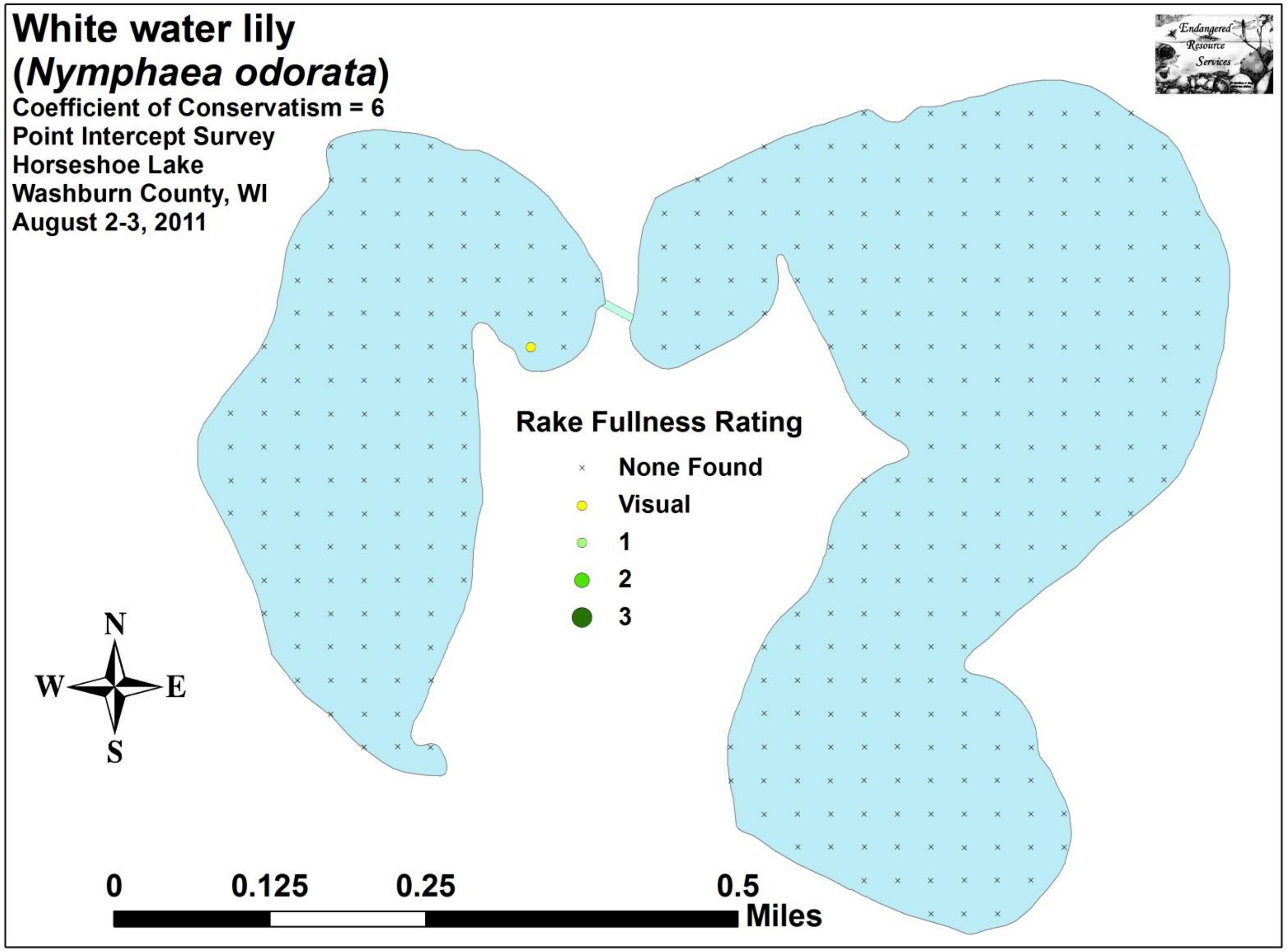
White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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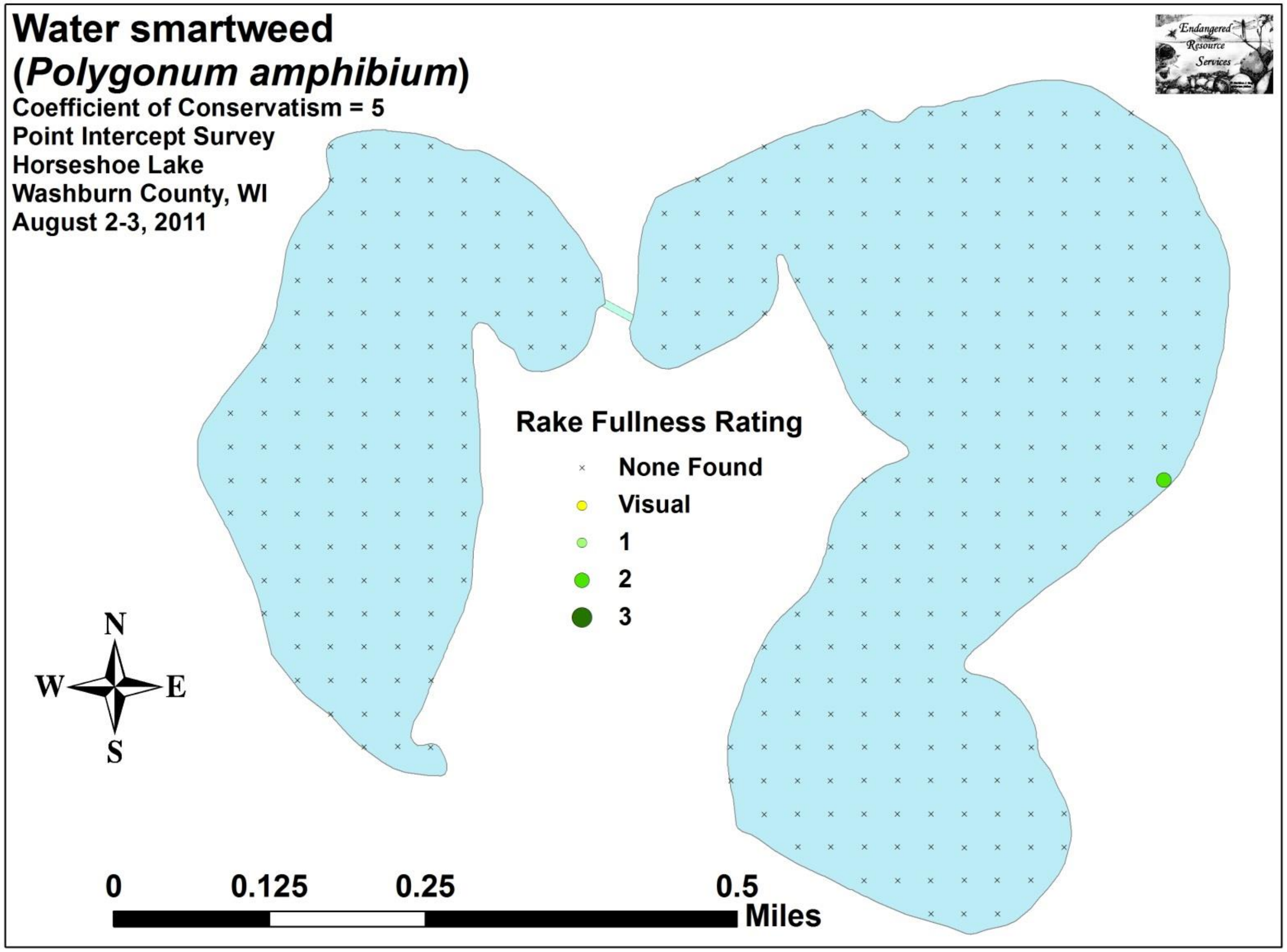
Miles


Water smartweed
(Polygonum amphibium)
Coefficient of Conservatism = 5
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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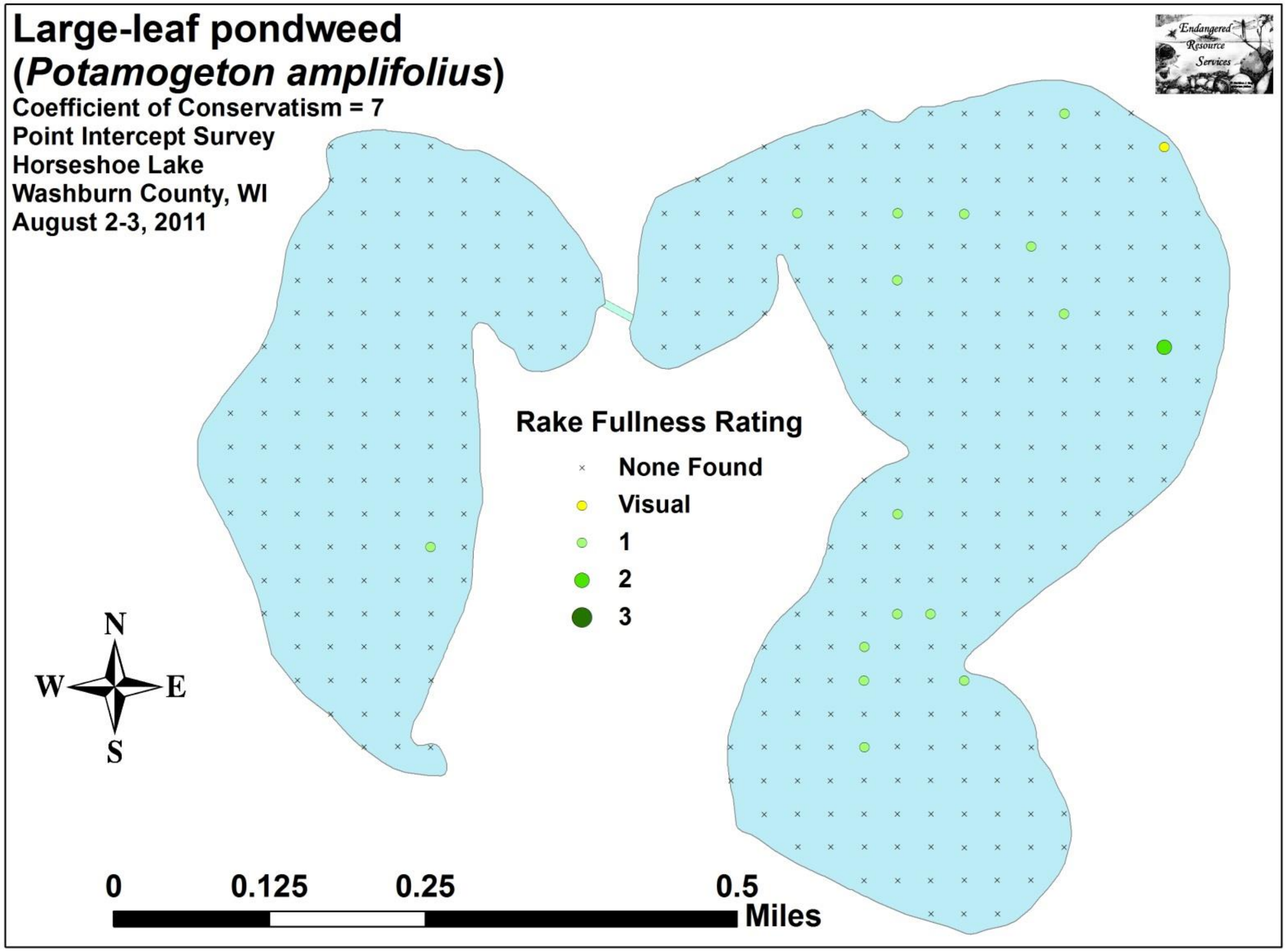
Miles



Large-leaf pondweed
(*Potamogeton amplifolius*)
Coefficient of Conservatism = 7
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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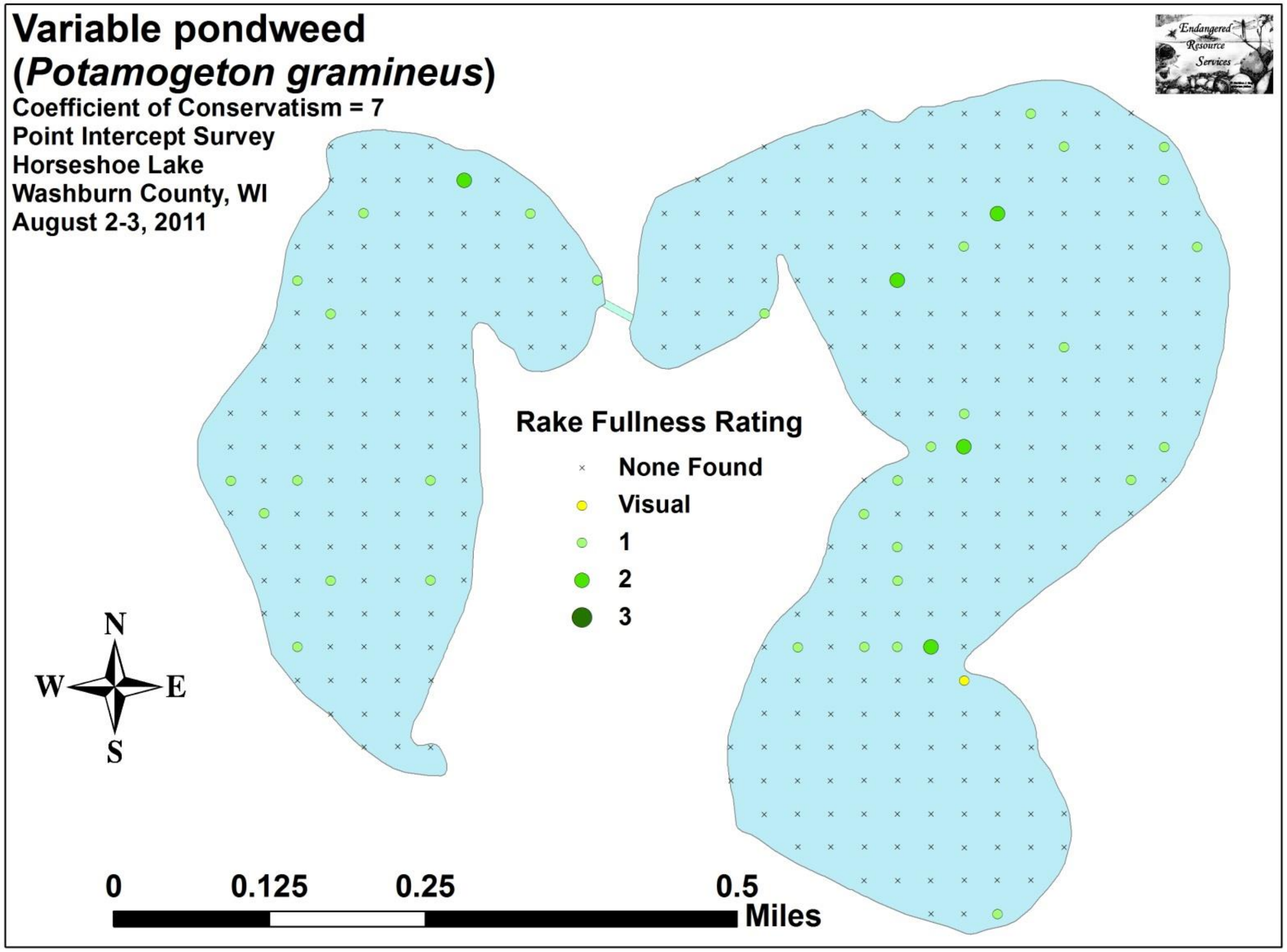
Miles



Variable pondweed
(*Potamogeton gramineus*)
Coefficient of Conservatism = 7
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
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Visual
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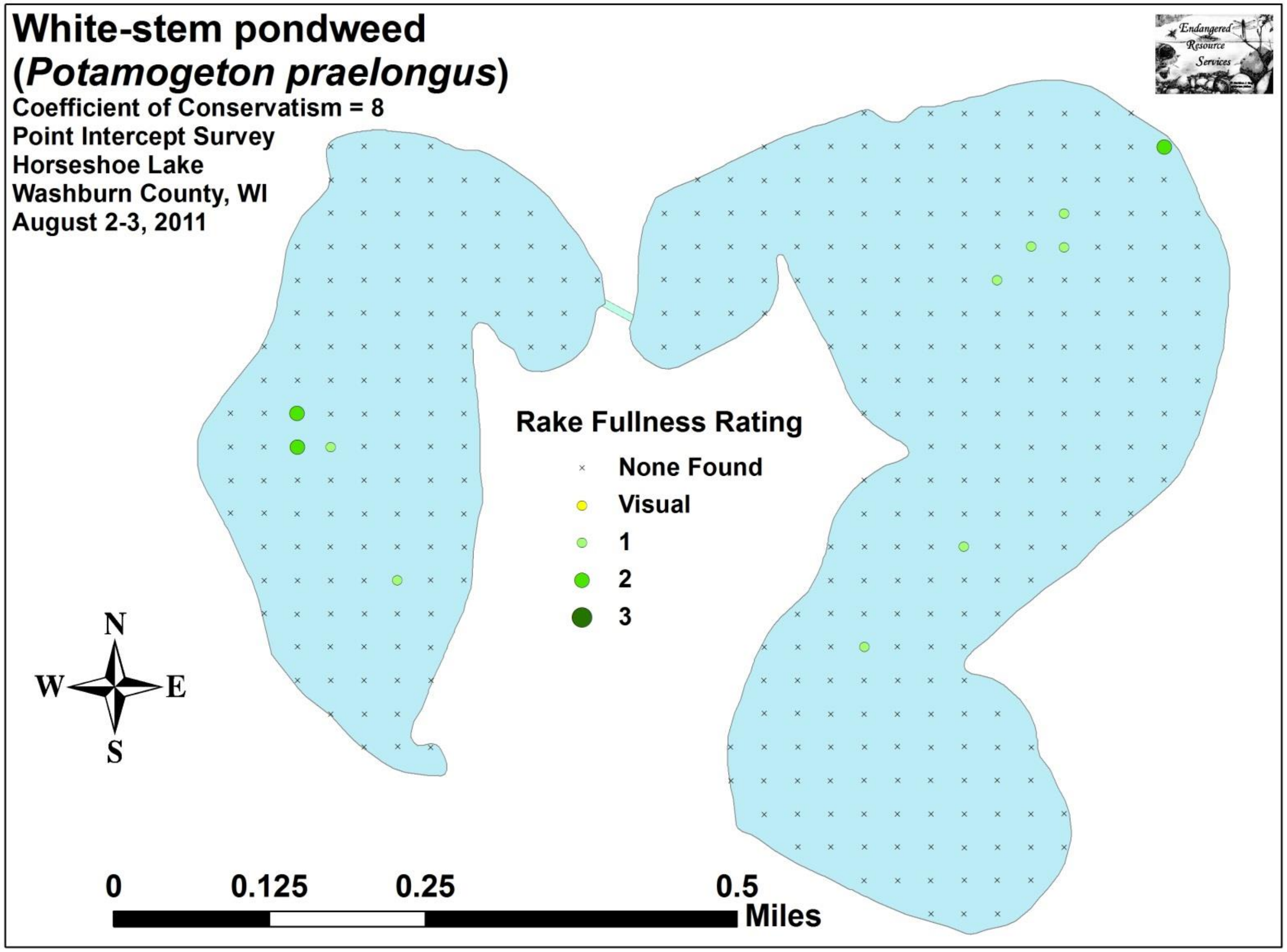
White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
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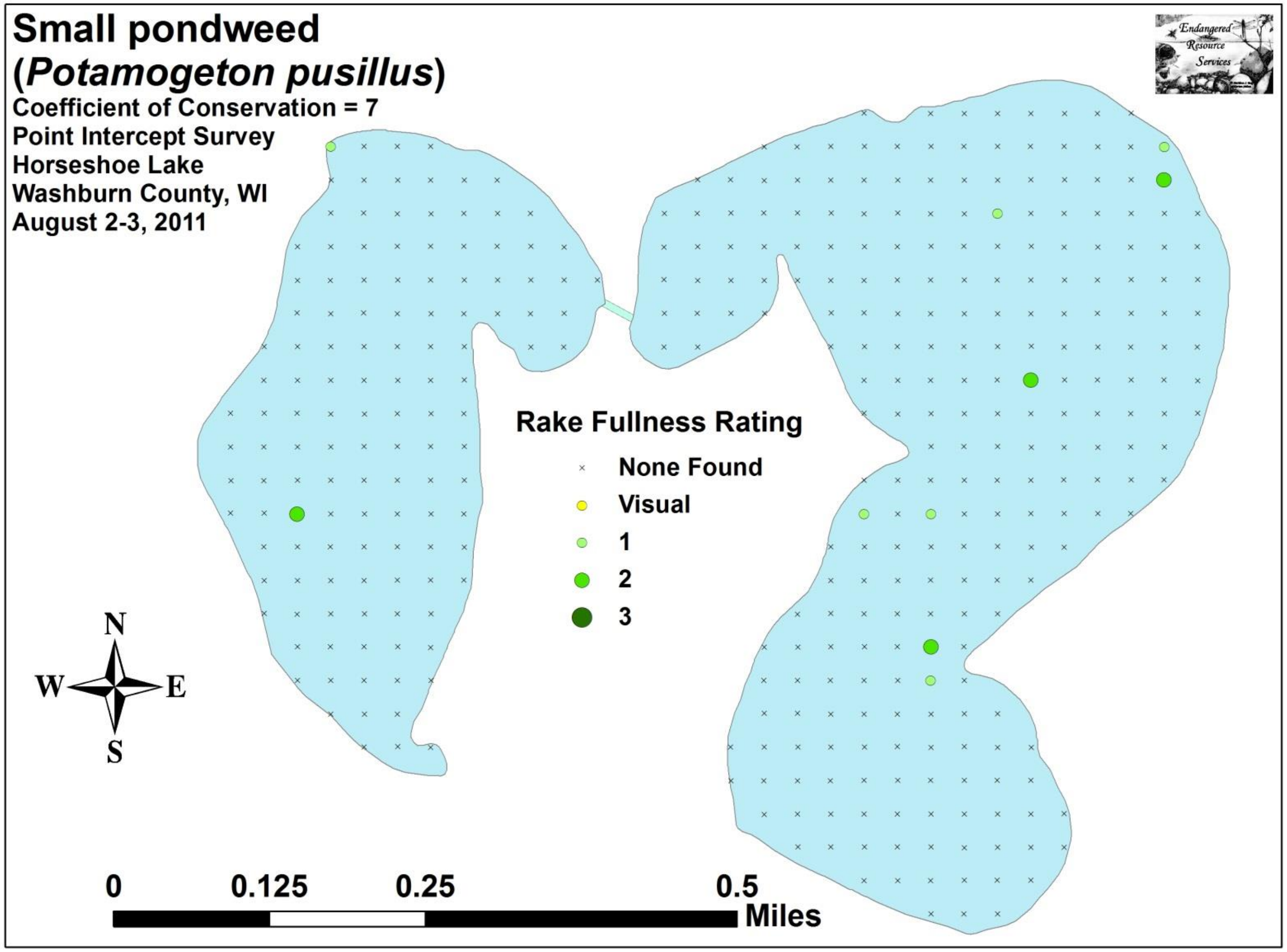
Small pondweed
(Potamogeton pusillus)
Coefficient of Conservation = 7
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Rake Fullness Rating
None Found
Visual
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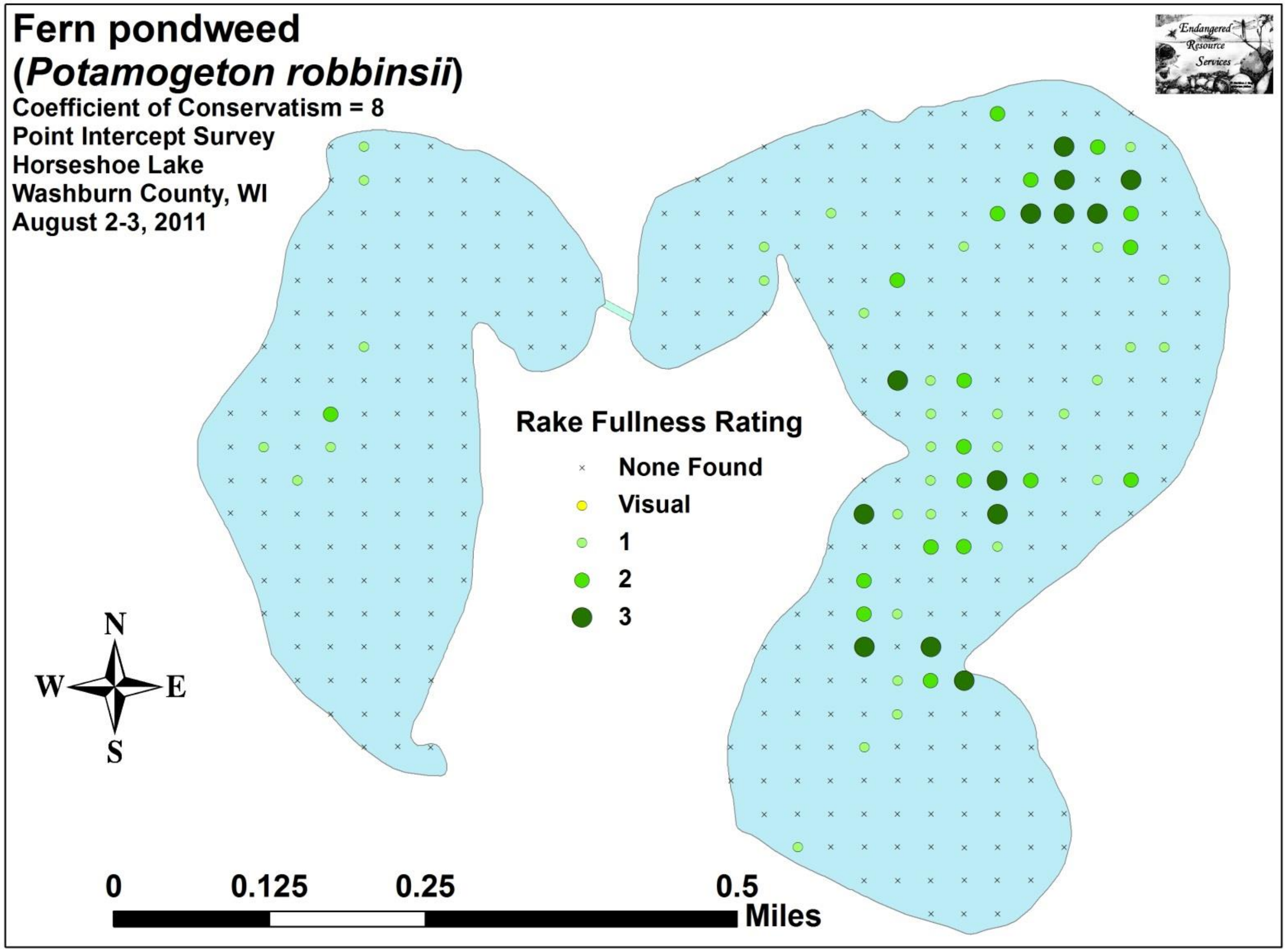
Fern pondweed
(Potamogeton robbinsii)
Coefficient of Conservatism = 8
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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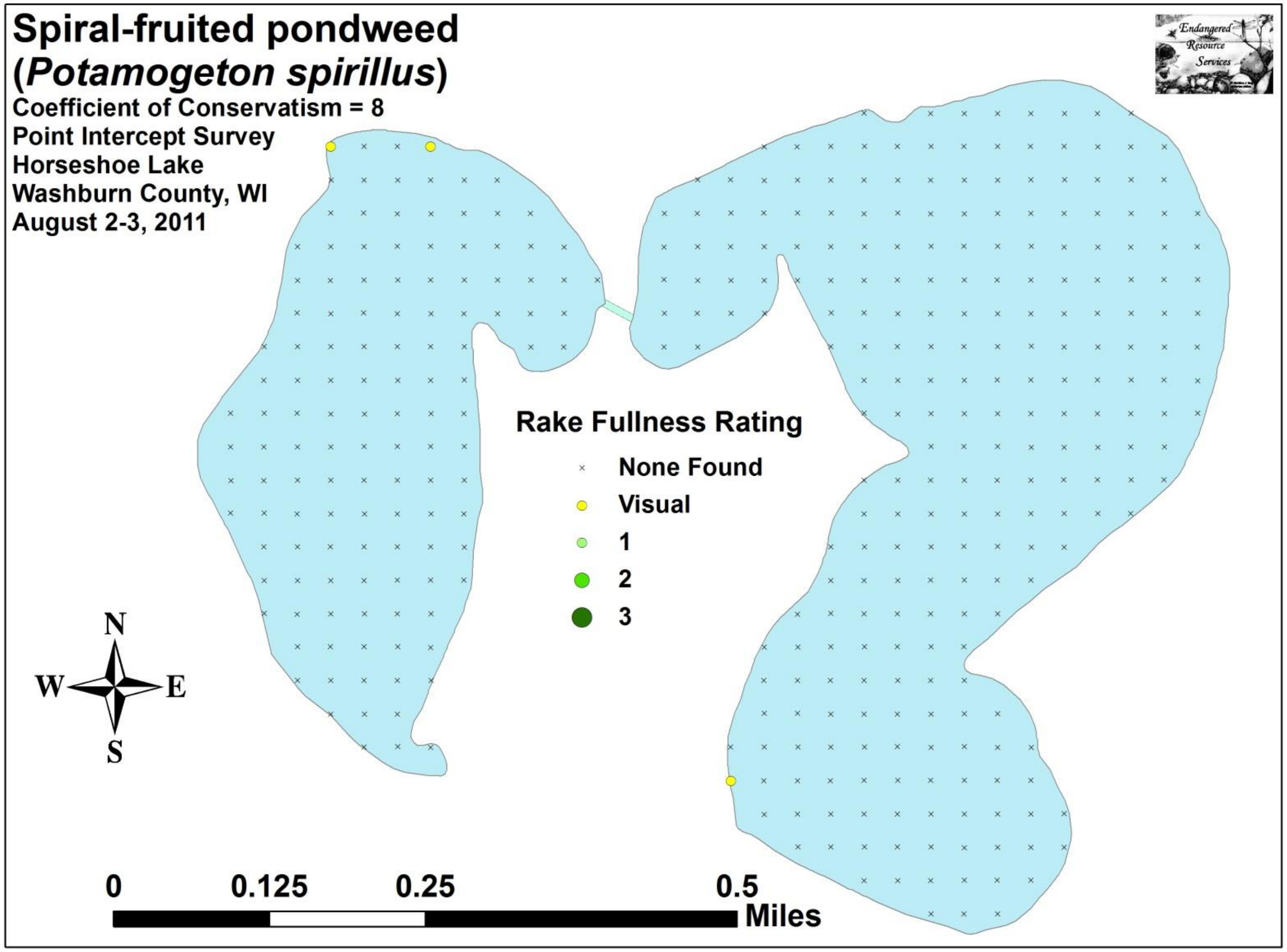
Spiral-fruited pondweed
(*Potamogeton spirillus*)
Coefficient of Conservatism = 8
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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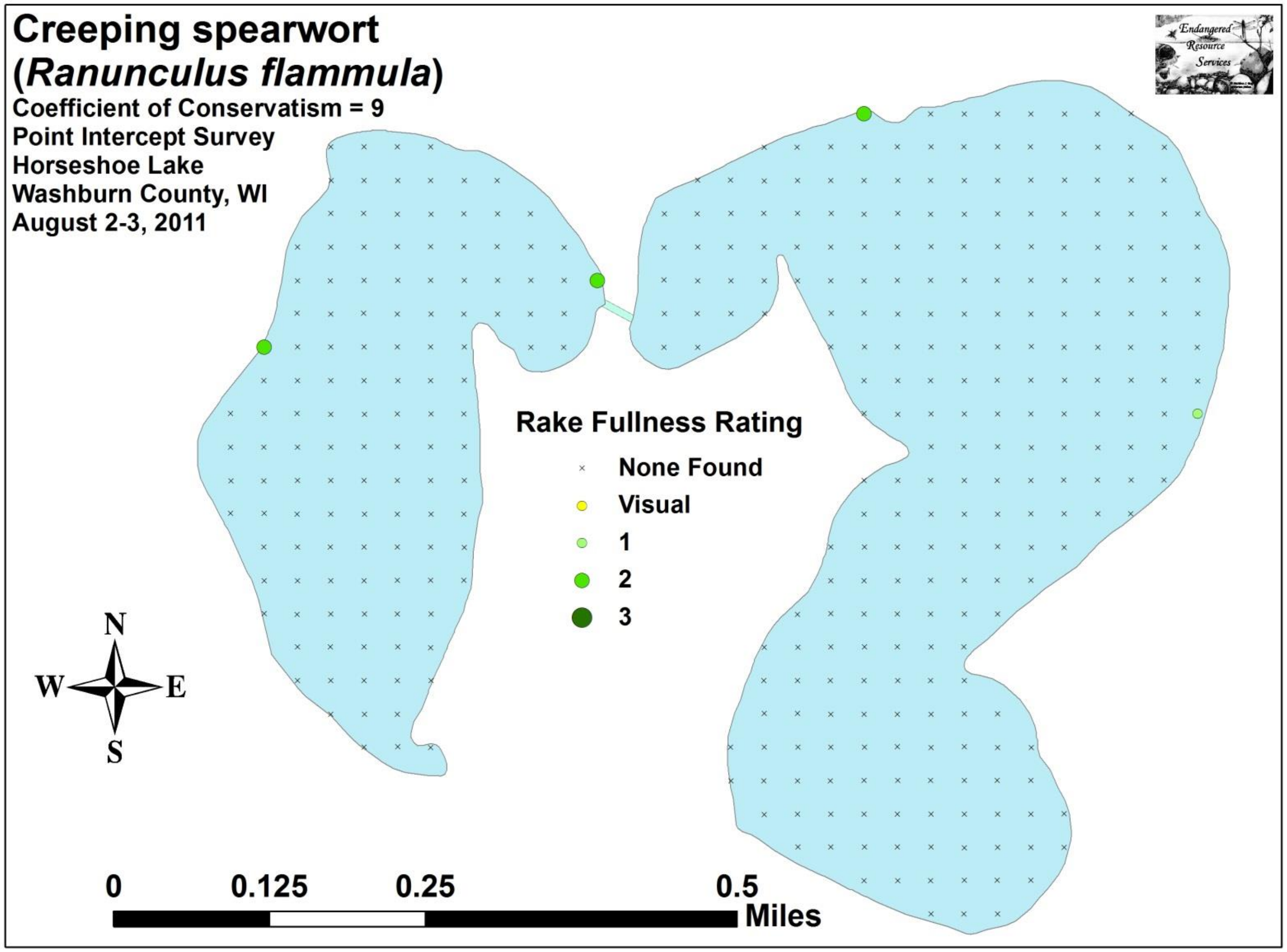
Creeping spearwort
(Ranunculus flammula)
Coefficient of Conservatism = 9
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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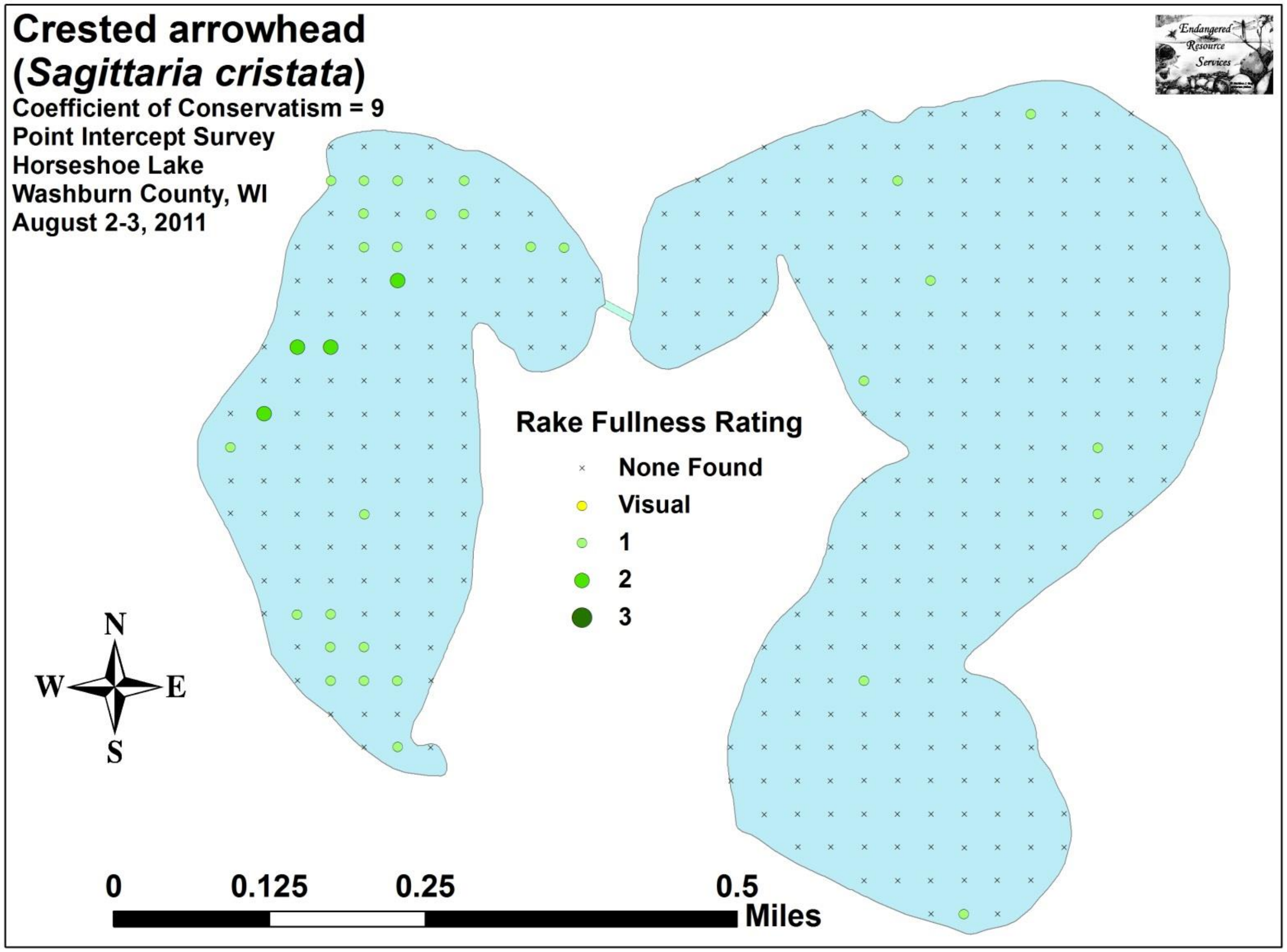
Miles


Crested arrowhead
(Sagittaria cristata)
Coefficient of Conservatism = 9
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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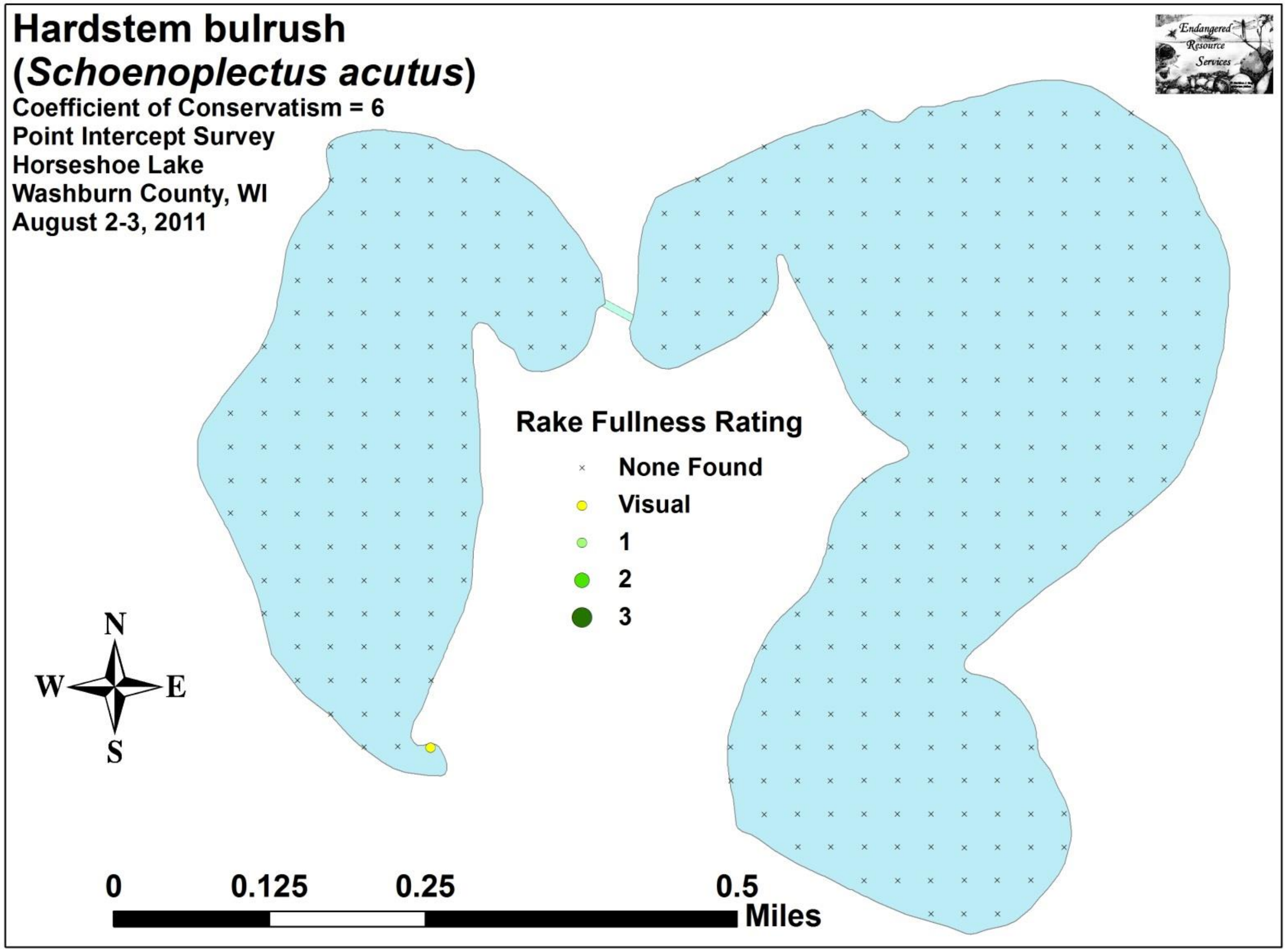
Hardstem bulrush
(*Schoenoplectus acutus*)
Coefficient of Conservatism = 6
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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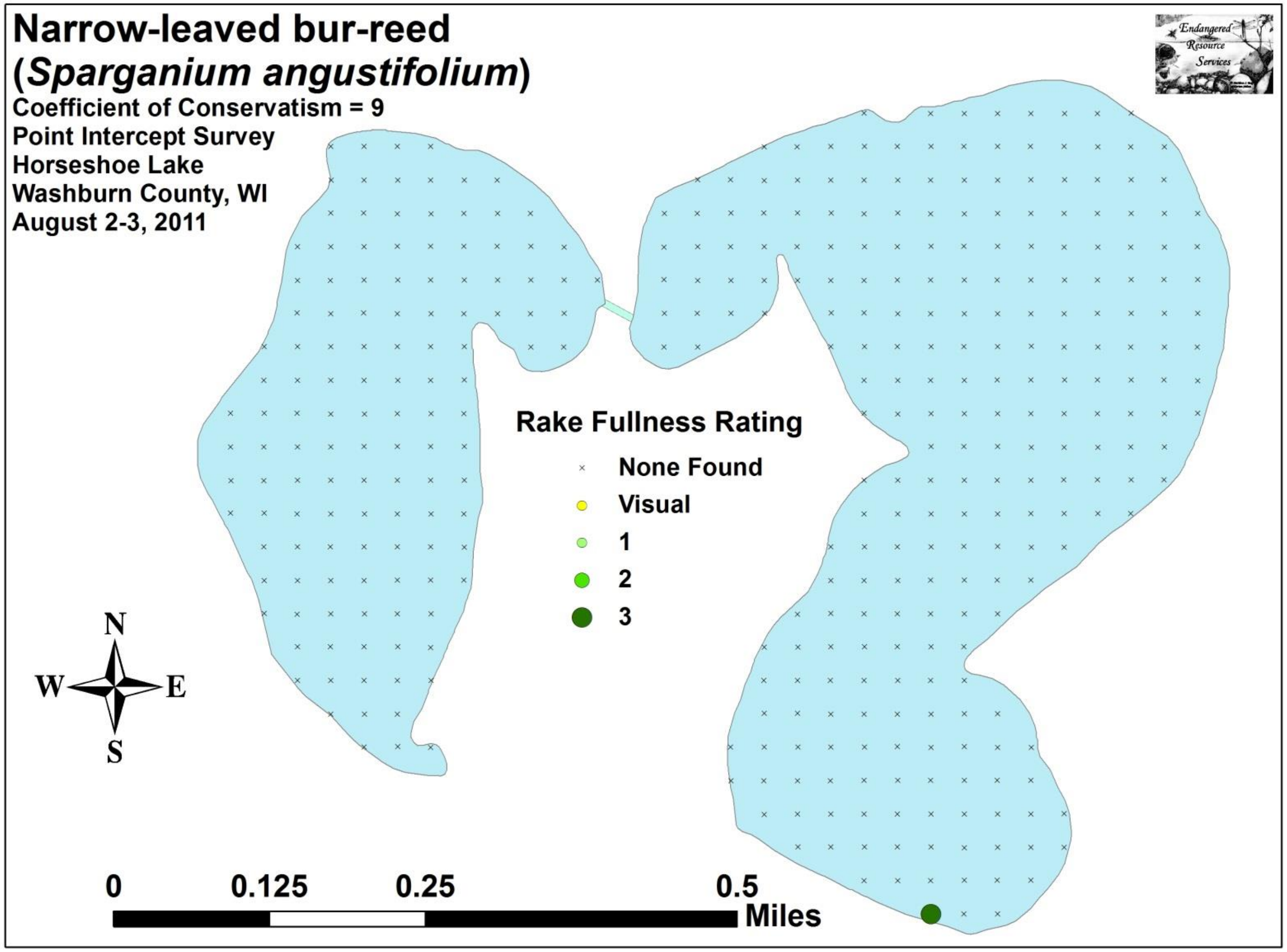
Narrow-leaved bur-reed
(*Sparganium angustifolium*)
Coefficient of Conservatism = 9
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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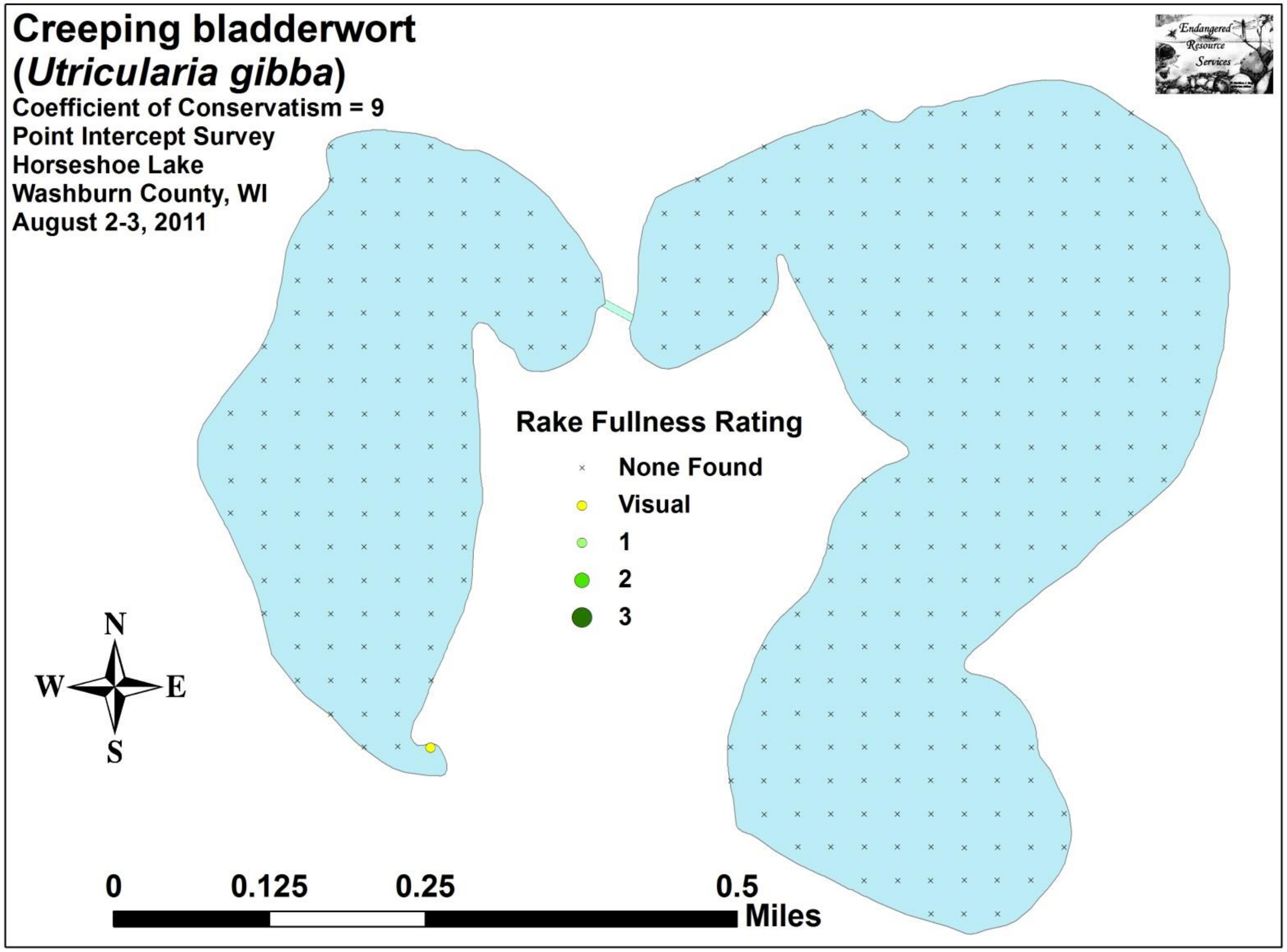

Creeping bladderwort
(Utricularia gibba)
Coefficient of Conservatism = 9
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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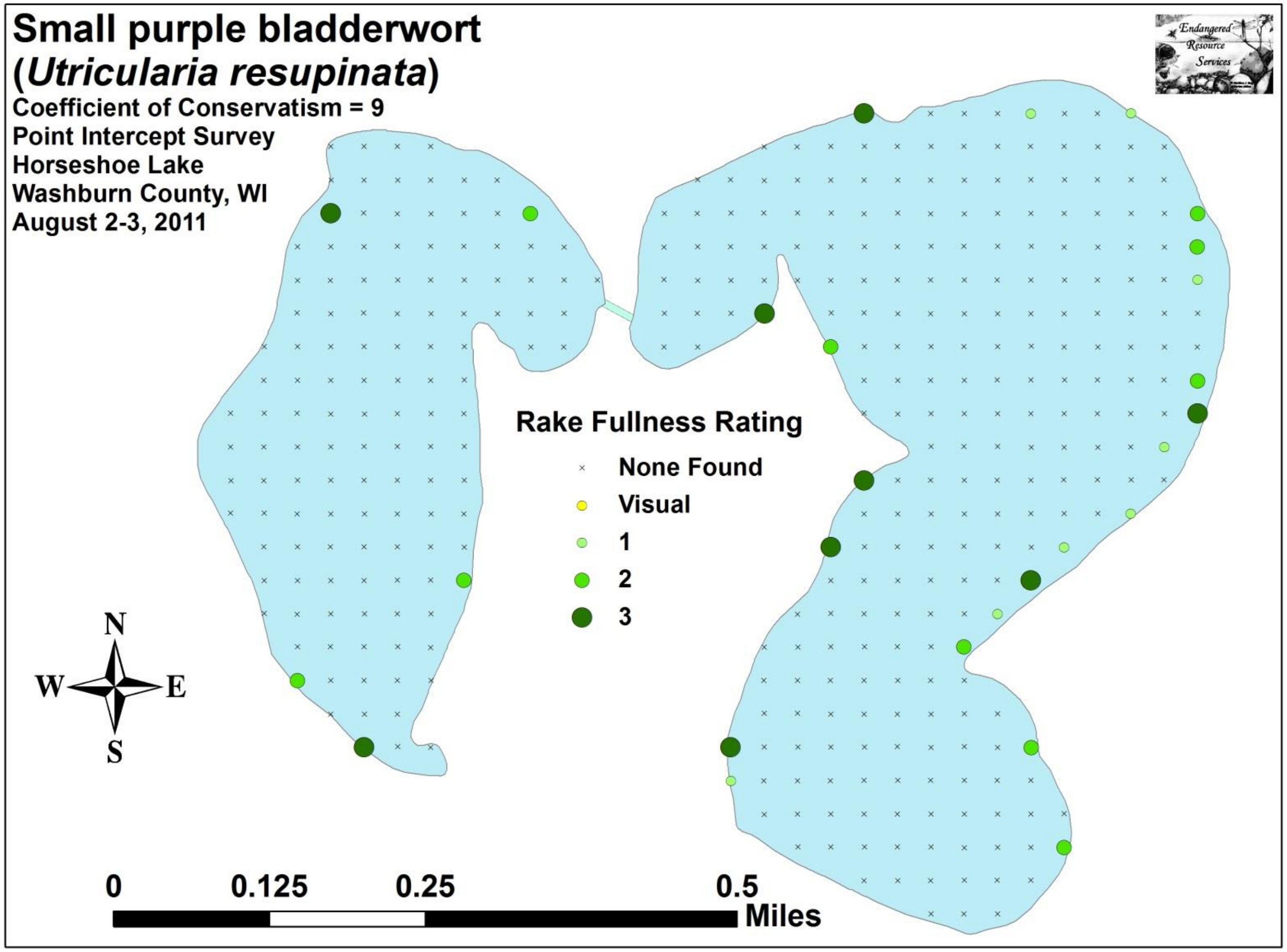
Miles



Small purple bladderwort
(Utricularia resupinata)
Coefficient of Conservatism = 9
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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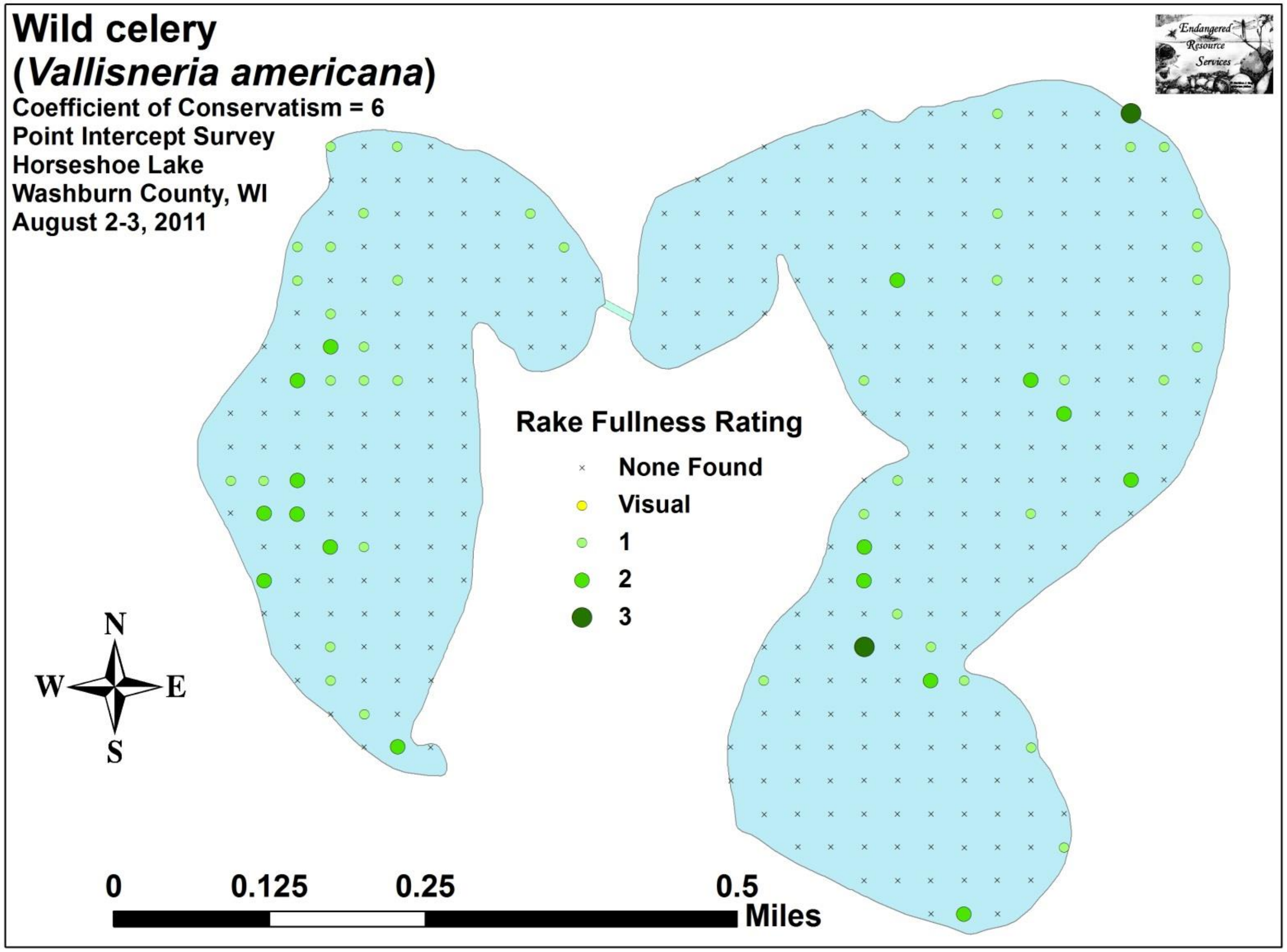
Miles


Wild celery
(Vallisneria americana)
Coefficient of Conservatism = 6
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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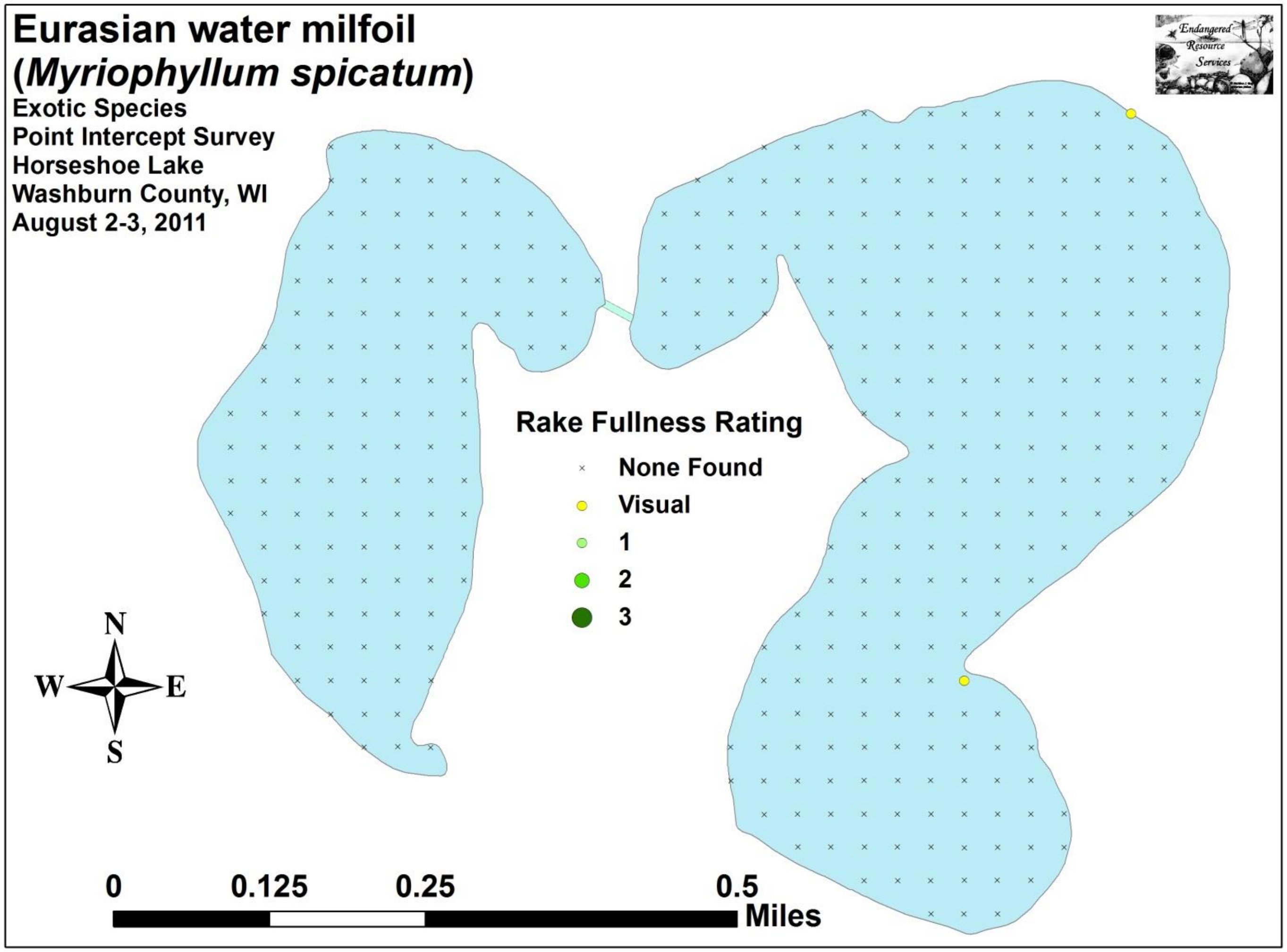
Appendix VIII: EWM Density and Distribution Map


Eurasian water milfoil
(*Myriophyllum spicatum*)
Exotic Species
Point Intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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Appendix IX: Aquatic Exotic Invasive Plant Species Information

Eurasian water milfoil

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

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

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

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

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

Dense stands of Eurasian water milfoil also inhibit recreational uses like swimming, boating, and fishing. Some stands have been dense enough to obstruct industrial and power generation water intakes. The visual impact that greets the lake user on milfoil-dominated lakes is the flat yellow-green of matted vegetation, often prompting the perception that the lake is "infested" or "dead". Cycling of nutrients from sediments to the water column by Eurasian water milfoil may lead to deteriorating water quality and algae blooms of infested lakes. (Taken in its entirety from WDNR, 2011 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 August

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

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

It becomes invasive in some areas because of its tolerance for low light and low water temperatures. These tolerances allow it to get a head start on and out compete native plants in the spring. In mid-summer, when most aquatic plants are growing, curly-leaf pondweed plants are dying off. Plant die-offs may result in a critical loss of dissolved oxygen. Furthermore, the decaying plants can increase nutrients which contribute to algal blooms, as well as create unpleasant stinking messes on beaches. Curly-leaf pondweed forms surface mats that interfere with aquatic recreation. (Taken in its entirety from WDNR, 2011 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, 2011 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, 2011 http://www.dnr.state.wi.us/invasives/fact/loosestrife.htm)

Appendix X: Glossary of Biological Terms
(Adapted from UWEX 2011)

Aquatic:
organisms that live in or frequent water.

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

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

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

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

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

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

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

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

Limnology:
the study of inland lakes and waters.

Littoral:

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

Macrophytes:

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

Nutrients:

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

Organic Matter:

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

Photosynthesis:

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

Phytoplankton:

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

Plankton:

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

ppm:

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

Richness:

number of species in a particular community or habitat.

Rooted Aquatic Plants:

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

Runoff:

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

Secchi Disc:

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

Seepage lakes:

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

Turbidity:

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

Watershed:

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

Zooplankton:

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

Appendix XI: Raw Data Spreadsheets