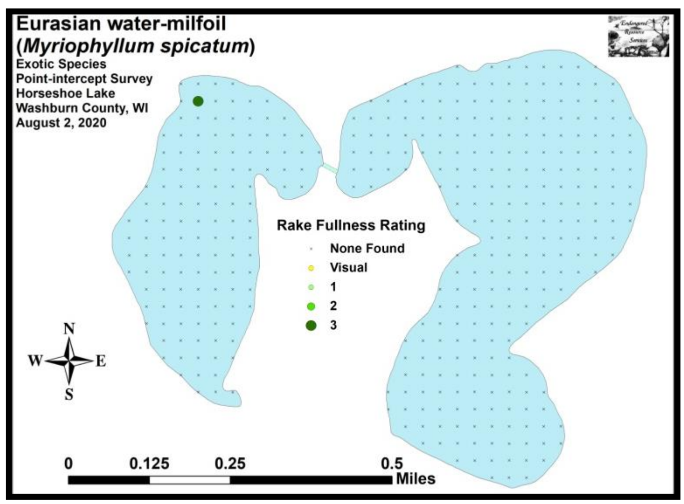
Warm-water Point-intercept Macrophyte Survey
Horseshoe Lake (WBIC: 2470000)
Washburn County, Wisconsin

White water lilies in bloom in the west basin 8/3/20

Vasey's pondweed – a WI special concern species

Project Initiated by:

The Horseshoe Lake Property Owners Association, Lake Education and Planning Services, LLC and the Wisconsin Department of Natural Resources (WDNR Grant # AEPP 61320)



Single survey point with EWM in the northwest bay of the west basin 8/2/20

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August 2, 2020

TABLE OF CONTENTS

ABSTRACT

Horseshoe Lake (WBIC 2470000) is a 177 acre seepage lake located in northwestern Washburn County, WI. Following the discovery of Eurasian water-milfoil (*Myriophyllum spicatum*) (EWM) in 2011, the Horseshoe Lake Property Owners Association (HLPOA), under the direction of Lake Education and Planning Services, LLC – Dave Blumer (LEAPS), developed an Aquatic Plant Management Plan using data from the lake's initial August 2-3, 2011 point-intercept survey. As a prerequisite to updating this plan in 2021 and to compare how the lake's vegetation may have changed since the last full survey, the HLPOA, LEAPS, and the Wisconsin Department of Natural Resources authorized a point-intercept survey for all aquatic macrophytes on August 2, 2020. During the survey, we found macrophytes growing at 253 sites which approximated to 65.3% of the entire lake bottom and 65.9% of the 22.0ft littoral zone. Despite a rise in lake levels of over 2.5ft since the last survey, this was almost identical to the 254 sites in 2011 (65.6% of the lake and 65.8% of the then 18.0ft littoral zone). Overall diversity was high with a Simpson Index value of 0.89 – down slightly from 0.91 in 2011. Species richness was relatively low with 23 species found in the rake (down from 27 in 2011). This total increased to 33 when including visuals and species seen during the boat survey (down from 41 total species found in 2011). There was an average of 1.89 native species/site with native vegetation – a nearly significant decline (p=0.08) from 2.03/site in 2011. Total rake fullness also experienced a nearly significant decline (p=0.06) from a low/moderate 1.70 in 2011 to 1.60 in 2020. Muskgrass (*Chara* sp.), Fern pondweed (*Potamogeton robbinsii*), Wild celery (*Vallisneria americana*), and Slender naiad (*Najas flexilis*) were the most common macrophyte species in 2020. They were found at 32.41%, 30.83%, 26.88%, and 18.18% of sites with vegetation and accounted for 57.32% of the total relative frequency. In August 2011, Slender naiad, Muskgrass, Fern pondweed, and Wild celery were the most common macrophyte species. Present at 28.35%, 27.95%, 25.20%, and 23.23% of survey points with vegetation, they accounted for 51.65% of the total relative frequency. Lakewide, from 2011-2020, eight species saw significant changes in distribution. Similar to the shoreline emergent community which almost completely disappeared following the rise in water levels, many isoetids saw significant declines. Brown fruited rush (*Juncus pelocarpus*) suffered a highly significant decline; filamentous algae experienced a moderately significant decline; and Slender naiad, Small purple bladderwort (*Utricularia resupinata*), Pipewort (*Eriocaulon aquaticum*), and Creeping spearwort (*Ranunculus flammula*) demonstrated significant declines. Conversely, White-stem pondweed (*Potamogeton praelongus*) enjoyed a moderately significant increase, and Northern naiad (*Najas gracillima*) saw a significant increase. The 22 native index species found in the rake during the August 2020 survey (down from 23 in 2011) produced an above average mean Coefficient of Conservatism of 7.3 (down from 7.4 in 2011). The Floristic Quality Index of 34.1 (down from 35.4 in 2011) was also above the median FQI for this part of the state. EWM was present in the rake at a single point with a rake fullness of 3 (In 2011, EWM was a visual at two points). This suggests the current integrated management approach that includes at least annual monitoring for new EWM plants/beds; manual removal of low density plants and beds; and small scale herbicide treatments to control larger or expanding beds is holding EWM in check. Other than EWM, we found no evidence of any other exotic plant species; however, exotic freshwater jellies (*Craspedacusta sowerbyi*) were abundant.

LIST OF FIGURES

LIST OF TABLES

Page

INTRODUCTION:

Horseshoe Lake (WBIC 2470000) is a 177 acre seepage lake in northwestern 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 2019). Secchi disc readings from 2014-2020 have averaged 12ft in the west basin and 14ft in the east basin. This suggests the lake is mesotrophic in nature with good to very good water clarity (WDNR 2020). The lake's 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 "nook" bay on the southeast end of the lake's west basin (Sather et al. 1971).

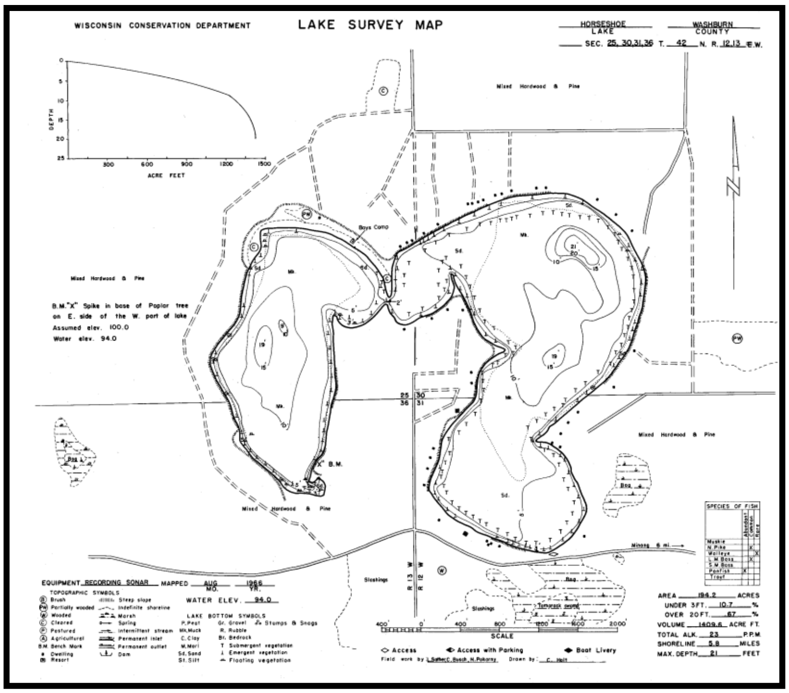


Figure 1: Horseshoe Lake Bathymetric Map

BACKGROUND AND STUDY RATIONALE:

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 2011, EWM was first found in Horseshoe Lake in May 2011. Following the lake's original point-intercept macrophyte survey on August 2-3, 2011, the Horseshoe Lake Property Owners Association (HLPOA), under the direction of Lake Education and Planning Services, LLC (LEAPS – Dave Blumer), developed the lake's original Wisconsin Department of Natural Resources (WDNR) approved Aquatic Plant Management Plant (APMP). In addition to manual removal, the plan outlined limited herbicide applications to manage EWM. These treatments, in 2011, 2012, 2016, and 2019, often reduced the EWM population to undetectable levels. Since 2013, the plan also authorized annual meandering shorelines surveys of the lake to look for surviving/new EWM plants/beds. These surveys have helped to rapidly identify and manage pioneer beds thus limiting the need for large-scale or annual treatments.

Per WDNR expectations, APMP are normally revisited every five – seven years to remain current. In anticipation of updating their plan in 2021, the HLPOA, LEAPS, and the WDNR authorized a warm-water point-intercept survey on Horseshoe Lake in 2020. The survey's objectives were to document the current levels EWM, and to compare data from the original 2011 survey with the 2020 data to identify any significant changes in the lake's vegetation over this time. This report is the summary analysis of that field survey conducted on August 2, 2020.

METHODS:

Warm-water Full Point-intercept Macrophyte Survey:

Prior to beginning the August point-intercept survey, we conducted a general boat survey to regain familiarity with the lake's macrophytes (Appendix I). All plants found were identified (Voss 1996, Boreman et al. 1997; Chadde 2002; Crow and Hellquist 2006; Skawinski 2019), and a datasheet was built from the species present.

Using a standard formula that takes into account the shoreline shape and distance, water clarity, depth, and total acreage, Michelle Nault (WDNR) generated the original 387 point sampling grid for Horseshoe Lake in 2011 (Appendix II). Using this same grid in 2020, we located each point with a GPS (Garmin 76CSx), recorded a depth reading with a metered pole or hand held sonar (Vexilar LPS-1), and took a rake sample. All plants on the rake, as well as any that were dislodged by the rake, were identified and assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of all plants within six feet of the sample point not found in the rake. In addition to a rake rating for each species, a total rake fullness rating was also noted. Substrate (bottom) type was assigned at each site where the bottom was visible or it could be reliably determined using the rake.

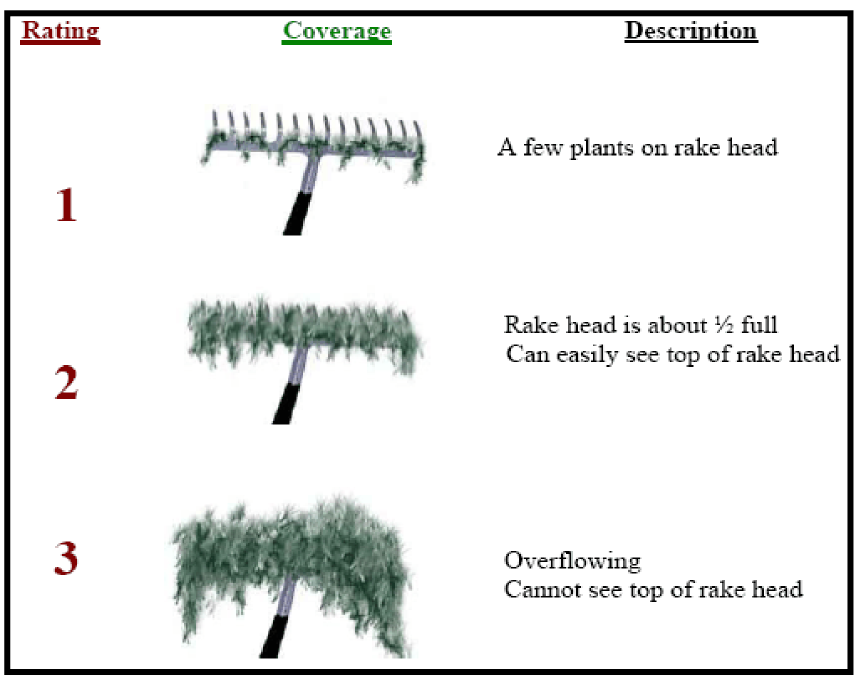


Figure 2: Rake Fullness Ratings (UWEX 2010)

DATA ANALYSIS:

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

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

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

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

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

Frequency of occurrence example:

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

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

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

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

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

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

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

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

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

Average rake fullness: This value is the average rake fullness of all species in the rake. It only takes into account those sites with vegetation (Table 1).

Relative frequency: This value shows a species' frequency relative to all other species. It is expressed as a percentage, and the total of all species' relative frequency will add up to 100%. Organizing species from highest to lowest relative frequency value gives us an idea of which species are most important within the macrophyte community (Tables 2 and 3).

Relative frequency example: Suppose that we sample 100 points and found 5 species of plants with the following results: Plant A was located at 70 sites. Its frequency of occurrence is thus 70/100 = 70% Plant B was located at 50 sites. Its frequency of occurrence is thus 50/100 = 50% Plant C was located at 20 sites. Its frequency of occurrence is thus 20/100 = 20% Plant D was located at 10 sites. Its frequency of occurrence is thus 10/100 = 10% To calculate an individual species' relative frequency, we divide the number of sites a plant is sampled at by the total number of times all plants were sampled. In our example that would be 150 samples (70+50+20+10). Plant A = 70/150 = .4667 or 46.67% Plant B = 50/150 = .3333 or 33.33% Plant C = 20/150 = .1333 or 13.33% Plant D = 10/150 = .0667 or 6.67% This value tells us that 46.67% of all plants sampled were Plant A.

Floristic Quality Index (FQI): This index measures the impact of human development on a lake's aquatic plants. The 124 species in the index are assigned a Coefficient of Conservatism (C) which ranges from 1-10. The higher the value assigned, the more likely the plant is to be negatively impacted by human activities relating to water quality or habitat modifications. Plants with low values are tolerant of human habitat modifications, and they often exploit these changes to the point where they may crowd out other species. The FQI is calculated by averaging the conservatism value for each native index species found in the lake during the point-intercept survey**, and multiplying it by the square root of the total number of plant species (N) in the lake ($FQI=(\Sigma(c1+c2+c3+\ldots cn)/N)*\sqrt{N}$). Statistically speaking, the higher the index value, the healthier the lake's macrophyte community is assumed to be. Nichols (1999) identified four eco-regions in Wisconsin: Northern Lakes and Forests, North Central Hardwood Forests, Driftless Area and Southeastern Wisconsin Till Plain. He recommended making comparisons of lakes within ecoregions to determine the target lake's relative diversity and health. Horseshoe Lake is in the Northern Lakes and Forests Ecoregion (Tables 4 and 5).

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

Comparison to Past Surveys: We compared data from our 2011 and 2020 warm-water point-intercept surveys to see if there were any significant changes in the lake's vegetation (Figure 8) (Tables 2 and 3). For individual plant species as well as count data, we used the Chi-square analysis on the WDNR Pre/Post survey worksheet. For comparing averages (mean species/point and mean rake fullness/point), we used t-tests. Differences were considered significant at $p<0.05$, moderately significant at $p<0.01$ and highly significant at $p<0.001$ (UWEX 2010). It should be noted that we used the number of littoral points (386 in 2011/384 in 2020) as the basis for "sample points".

RESULTS:

Warm-water Full Point-intercept Macrophyte Survey:

Depth readings taken at the lake's 387 survey points (Appendix II) revealed most of the western side of the lake drops off rapidly from shore into at least 8ft of water before leveling out in the 10-14ft range (Figure 3). The only interruption to this otherwise gently-sloped bowl is the 17-19ft hole on the west side midlake. Where the two basins meet, two 7-10ft deep 10-acre flats occur on either side of the channel. The eastern basin has a more varied underwater topography. An expansive 6-10ft flat covers the southeast bay near the boat landing, while most of the rest of the basin bottoms out in 10-15ft of water. Two notable exceptions are the lake's deep holes which reach 25.5ft in the northeast bay and 22ft midlake (Appendix III).

We characterized the lake's substrate as 78.3% organic and sandy muck (303 points) and 21.7% sand (84 points). Pure sugar sand lined the margins of the majority of the lake, but this transitioned to a thin sandy or marly muck at most depth over 8ft. The only nutrient-rich organic muck occurred in the nook bay in the southeast corner of the west basin (Figure 3) (Appendix III).

In August 2020, we found plants growing to 22.0ft (Table 1). Despite a rise in lake levels of more than 2.5ft over the past ten years, the total of 253 points with vegetation (approximately 65.3% of the entire lake and 65.9% of the littoral zone) was almost identical to 2011 when we found plants at 254 points (65.6% of the bottom/65.8% of the then 18.0ft littoral zone) (Figure 4) (Appendix IV). Growth in 2020 was slightly skewed to shallow water as the mean plant depth of 11.3ft was less than the median depth of 11.5ft. Both of these values were higher than in 2011 when the mean was 8.9ft and the median was 9.0ft (Figure 5).

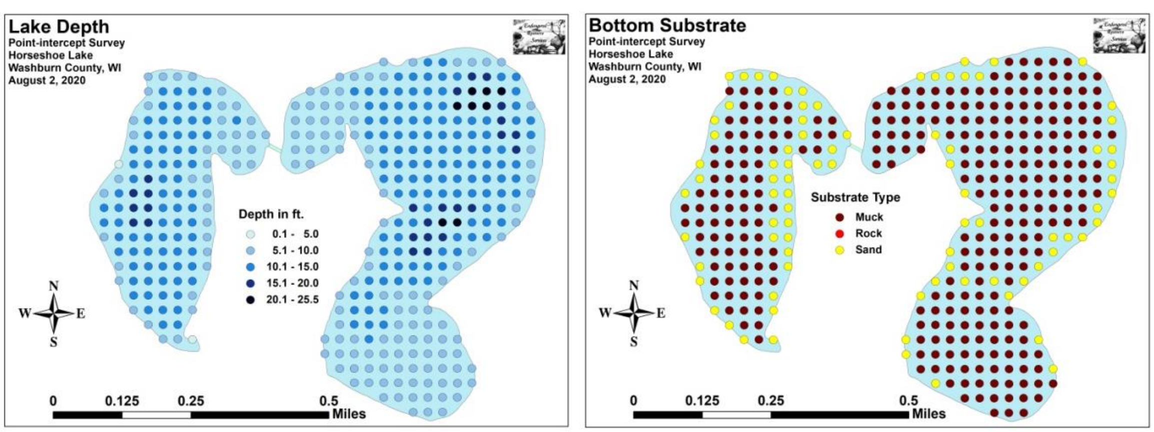


Figure 3: Lake Depth and Bottom Substrate

Table 1: Aquatic Macrophyte P/I Survey Summary Statistics
Horseshoe Lake, Washburn County
August 2-3, 2011 and August 2, 2020

Summary Statistics:	2011	2020
Total number of points sampled	387	387
Total number of sites with vegetation	254	253
Total number of sites shallower than the maximum depth of plants	386	384
Frequency of occurrence at sites shallower than maximum depth of plants	65.8	65.9
Simpson Diversity Index	0.91	0.89
Maximum depth of plants (ft)	18.0	22.0
Mean depth of plants (ft)	8.9	11.3
Median depth of plants (ft)	9.0	11.5
Average number of all species per site (shallower than max depth)	1.33	1.24
Average number of all species per site (veg. sites only)	2.03	1.89
Average number of native species per site (shallower than max depth)	1.33	1.24
Average number of native species per site (sites with native veg. only)	2.03	1.89
Species richness	27	23
Species richness (including visuals)	35	24
Species richness (including visuals and boat survey)	41	33
Mean rake fullness (veg. sites only)	1.70	1.60

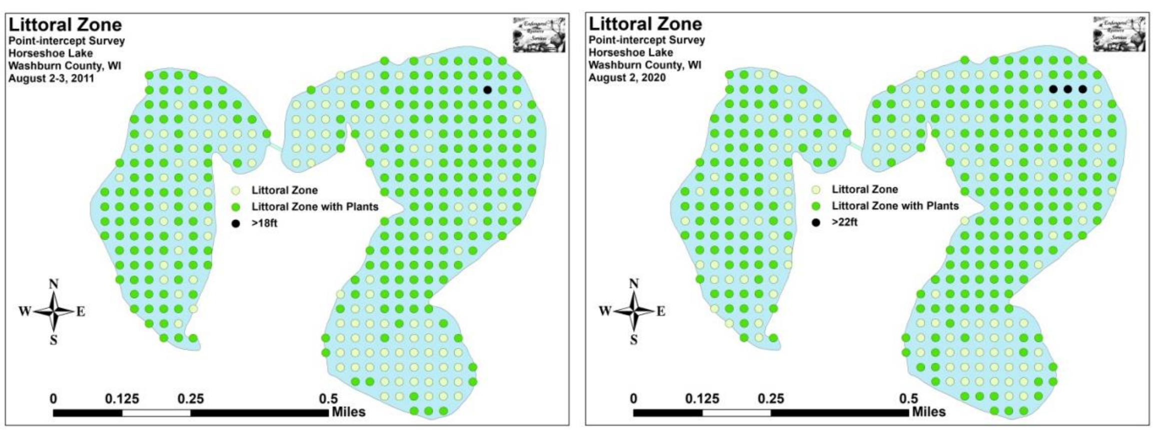


Figure 4: 2011 and 2020 Littoral Zone

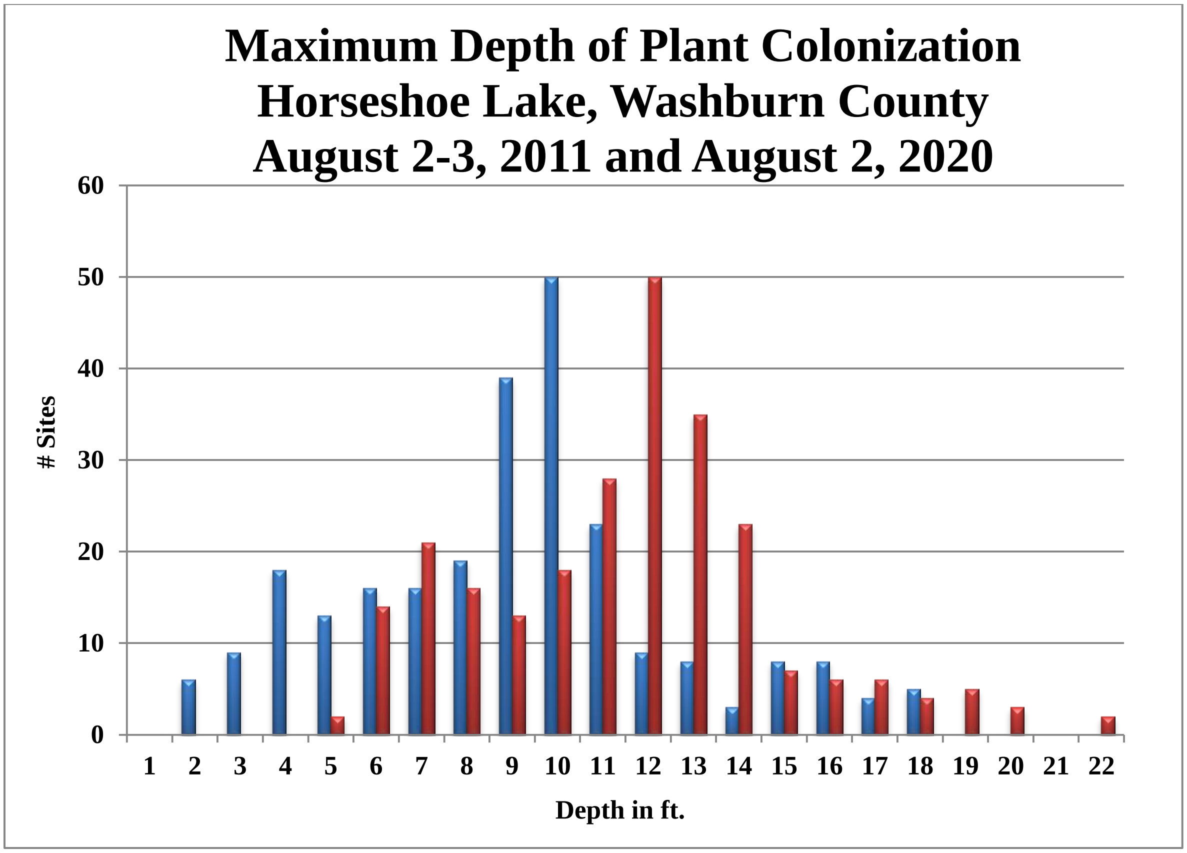


Figure 5: 2011 and 2020 Plant Colonization Depth Chart

Plant diversity was high in 2020 with a Simpson Index value of 0.89 – down slightly from 0.91 in 2011. Species richness was relatively low with 23 species found in the rake, although this total increased to 33 species when including visuals and plants seen during the boat survey (down from 27/41 in 2011). Along with the decline in overall richness, mean native species richness at sites with native vegetation experienced a nearly significant decline (p=0.08) from 2.03/site in 2011 to 1.89/site in 2020 (Figure 6) (Appendix IV).

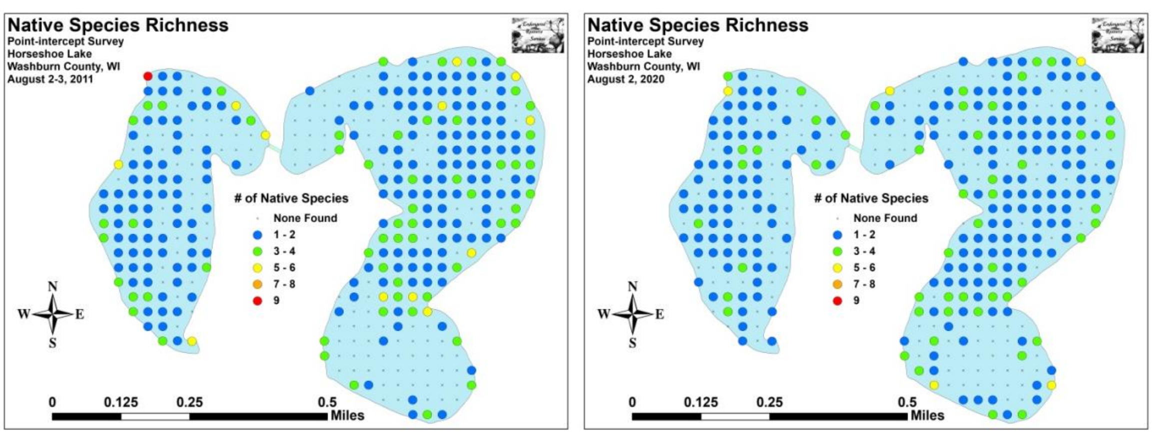


Figure 6: 2011 and 2020 Native Species Richness

Total rake fullness also experienced a nearly significant decline (p=0.06) from a low/ moderate 1.70 in 2011 to 1.60 in 2020. We noted both the declines in richness and density appeared to be tied to the loss of emergent and shallow submergent species following the rise in lake levels (Figure 7) (Appendix IV).

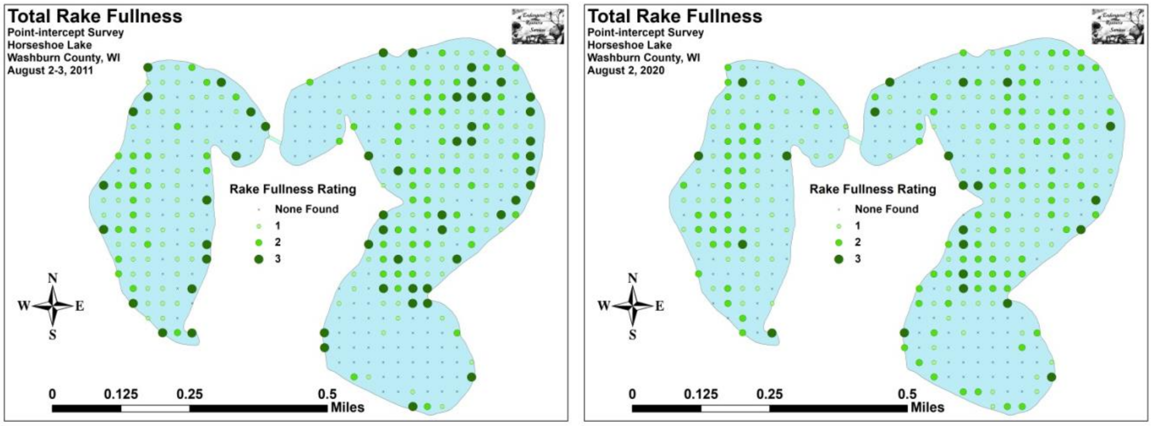


Figure 7: 2011 and 2020 Total Rake Fullness

Horseshoe Lake Plant Community:

The Horseshoe Lake ecosystem is home to a moderately rich and highly diverse plant community that is fairly typical of mesotrophic lakes with good water clarity. This community can be subdivided into four distinct zones (emergent, shallow submergent, floating-leaf, and deep submergent) with each zone having its own characteristic functions in the aquatic ecosystem. Depending on the local bottom type (sand, rock, sandy muck or nutrient-rich organic muck), these zones often had somewhat different species present.

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

Elevated lake levels in 2020 eliminated the majority of the emergent community we originally documented in 2011. Beds showed dramatic reductions in size, and, although they will likely return when the water recedes, many species disappeared altogether. On exposed sandy shorelines, we found a few small stands of Common rush (*Juncus effusus*) and Prairie chordgrass (*Spartina pectinata*). Away from the immediate shoreline, they were replaced by narrow beds of Creeping spikerush (*Eleocharis palustris*) and Hardstem bulrush (*Schoenoplectus acutus*).

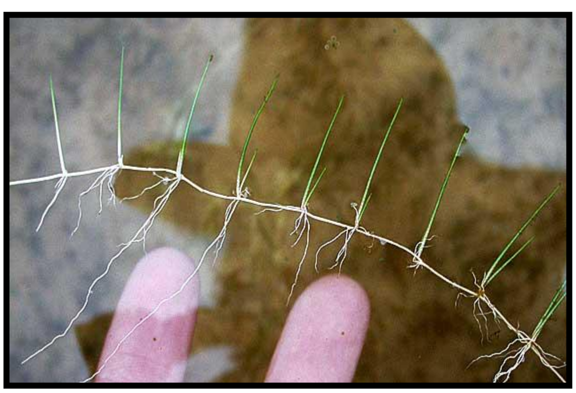

Common rush (Eggers 2008)


Prairie chordgrass (Lewallen 2001)


Creeping spikerush (Legler 2016)


Hardstem bulrush (Dziuk 2015)

Pure sugar sand dominated the majority of the lake's nearshore (<6ft deep) substrate. These areas naturally tend to have low total biomass as the nutrient-poor substrate provides habitat most suited to fine-leaved "isoetid" species like Needle spikerush (*Eleocharis acicularis*), Brown-fruited rush (*Juncus pelocarpus*), Dwarf water-milfoil (*Myriophyllum tenellum*), Slender naiad (*Najas flexilis*), Northern naiad (*Najas gracillima*), and Variable pondweed (*Potamogeton gramineus*).


Needle spikerush (Fewless 2005)


Brown-fruited rush (Koshere 2002)

Dwarf water-milfoil (Koshere 2002)

Slender naiad (Cameron 2013)

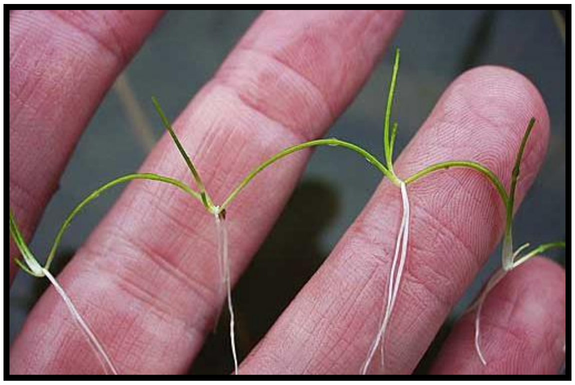
Northern naiad (Kallor 2016)

Variable pondweed – form with small submergent leaves (Cameron 2019)

In the most pristine shoreline areas on the lake, these shallow sandy habitats also supported an often limited number of uncommon to rare species. These plants, which are extremely sensitive to human disturbance, included Waterwort (*Elatine minima*), Pipewort (*Eriocaulon aquaticum*), Creeping spearwort (*Ranunculus flammula*), and Small purple bladderwort (*Utricularia resupinata*). All of these "turf" species, along with the emergents, stabilize the bottom and prevent wave action erosion.

Waterwort (Fewless 2005)

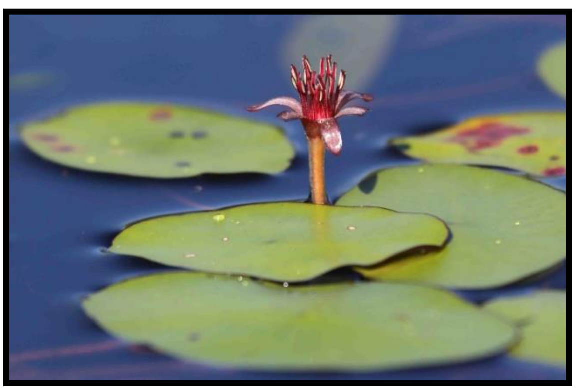
Pipewort (Fewless 2005)



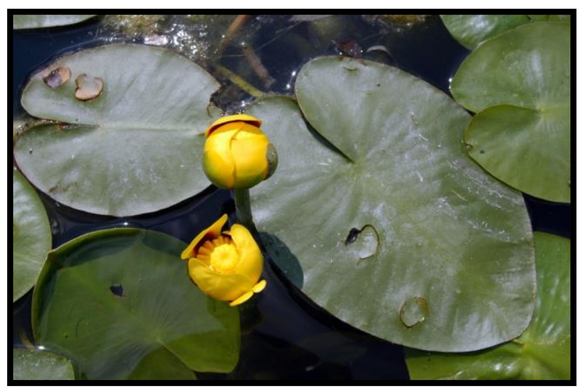
Creeping spearwort “stolons” (Fewless 2005)

Small purple bladderwort (Cameron 2019)

Few substrates in the lake had enough nutrients to provide habitat for floating-leaf species, and, even when present, individuals tended to be few in number and spindly in growth form. The most nutrient-rich substrates on the entire lake occurred in the nook bay, in the bay immediately southwest of the channel, and near the public boat landing. In these areas, we found a handful of Watershield (*Brasenia schreberi*), Spatterdock (*Nuphar variegata*), White water lily (*Nymphaea odorata*), Water smartweed (*Polygonum amphibium*), Floating-leaf pondweed (*Potamogeton natans*), and, with its flowing ribbon-like leaves, Narrow-leaved bur-reed (*Sparganium angustifolium*).



Watershield (WED 2019)



Spatterdock (CBG 2014)

White water lily (Falkner 2009)

Water smartweed (Someya 2009)

Floating-leaf pondweed (Petroglyph 2007)

Narrow-leaved bur-reed (Schouh 2006)

Other species that only occasionally produce floating-leaves like Large-leaf pondweed (*Potamogeton amplifolius*), Variable pondweed, Spiral-fruited pondweed (*Potamogeton spirillus*), and Vasey's pondweed (*Potamogeton vaseyi*) seldom had them unless they were growing near shore over substrate with at least a thin layer of muck. The protective canopy cover this entire group provides is often utilized by panfish and bass.

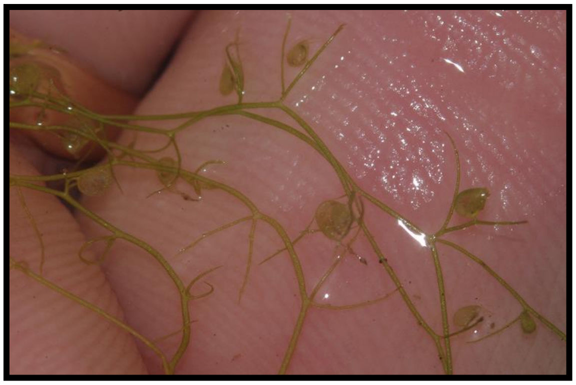
Large-leaf pondweed (Fewless 2010)

Variable pondweed with floating leaf (Koshere 2002)

Spiral-fruited pondweed (Cameron 2019)

Vasey's pondweed (Skawinski 2010)

Entangled amongst these floating-leaf species, we also occasionally found the carnivorous Creeping bladderwort (*Utricularia gibba*). Rather than drawing nutrients up through roots like other plants, bladderworts trap zooplankton and minute insects in their bladders, digest their prey, and use the nutrients to further their growth.



Creeping bladderwort (Eyewed 2010)

Bladders for catching plankton and insect larvae (Wontolla 2007)

Sand and marly-muck areas in water over 6ft deep were often completely devoid of plants, and, even when present, rake samples frequently included just a single individual. In this environment, we documented Large-leaf pondweed, White-stem pondweed (*Potamogeton praelongus*), Crested arrowhead (*Sagittaria cristata*), and Wild celery (*Vallisneria americana*). The roots, shoots, and seeds of all these submergent species are heavily utilized by both resident and migratory waterfowl for food. They also provide important habitat for the lake's fish throughout their lifecycles; as well as support a myriad of invertebrates like scuds, dragonfly and mayfly nymphs, and snails.

Large-leaf pondweed (Martin 2002)

White-stem pondweed (Fewless 2005)

Crested arrowhead (Fewless 2004)

Wild celery (Dalvi 2009)

In areas from 6-10ft with more sandy muck, these species tended to become more common and stands thickened into small beds. This habitat also supported Muskgrass (*Chara* sp.), Common waterweed (*Elodea canadensis*), Small pondweed (*Potamogeton pusillus*), and, rarely, Eurasian water-milfoil.


Muskgrass (Fischer 2014)

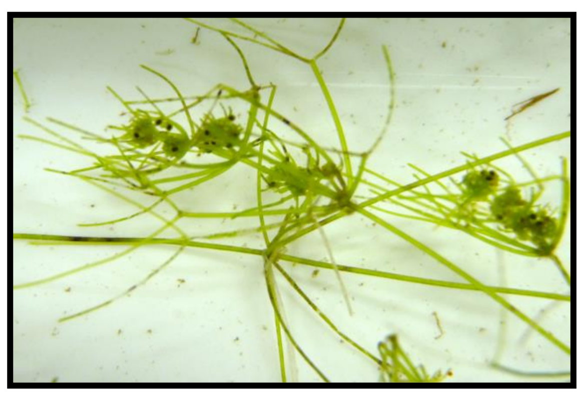

Common waterweed (Pinkka 2013)


Small pondweed (Villa 2011)


Eurasian water-milfoil (Berg 2007)

At depths over 10ft, this environment was dominated by Muskgrass and Fern pondweed (*Potamogeton robbinsii*). We also found a few patches of the colonial algae Nitella (*Nitella* sp. likely flexilis). Predatory fish like the lake's Northern pike are often found along the edges of these deepwater beds waiting in ambush.


Fern pondweed (Apipp 2011)


Nitella (USGS 2008)

Comparison of Native Macrophyte Species in 2011 and 2020:

In August 2011, Slender naiad, Muskgrass, Fern pondweed, and Wild celery were the most common macrophyte species (Table 2). We found them at 28.35%, 27.95%, 25.20%, and 23.23% of survey points with vegetation respectively; and, collectively, they accounted for 51.65% of the total relative frequency. Variable pondweed (7.18%), Crested arrowhead (6.41%), Brown-fruited rush (5.63%), Small purple bladderwort (5.24%), and Dwarf water-milfoil (5.05%) were the only other species with relative frequencies over 4.0 (Maps for all species found in August 2011 are located in the CD attached to this report).

The August 2020 survey identified Muskgrass, Fern pondweed, Wild celery, and Slender naiad as the most common macrophyte species. Present at 32.41%, 30.83%, 26.88%, and 18.18% of sites with vegetation (Table 3), they encompassed 57.32% of the total relative frequency. Crested arrowhead (9.41%), Variable pondweed (6.28%), and White-stem pondweed (5.65%) also had relative frequencies over 4.0 (Species accounts for all plants found in 2011 and 2020, and maps for all species found in August 2020 are located in Appendixes V and VI).

Lakewide, eight species showed significant changes in distribution from 2011 to 2020 (Figure 8). Similar to the emergents, isoetid species lost much of their shallow-water habitat following the rise in lake levels. Because of this, it wasn’t surprising that Brown fruited rush suffered a highly significant decline; and Slender naiad, Small purple bladderwort, Pipewort, and Creeping spearwort demonstrated significant declines. Filamentous algae also experienced a moderately significant decline, but for no obvious reason. Conversely, White-stem pondweed enjoyed a moderately significant increase, and Northern naiad saw a significant increase as the percentage of the lake in their preferred habitat expanded.

Table 2: 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	8
Potamogeton robbinsii	Fern pondweed	64	12.43	25.20	16.58	1.69	3
Vallisneria americana	Wild celery	59	11.46	23.23	15.28	1.34	2
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	11
Juncus pelocarpus f. submersus	Brown-fruited rush	29	5.63	11.42	7.51	1.86	13
Utricularia resupinata	Small purple bladderwort	27	5.24	10.63	6.99	2.04	1
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	1
Eriocaulon aquaticum	Pipewort	16	3.11	6.30	4.15	1.81	9
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	1
Potamogeton pusillus	Small pondweed	10	1.94	3.94	2.59	1.40	6
	Filamentous algae	9	*	3.54	2.33	1.00	0
Elodea canadensis	Common waterweed	6	1.17	2.36	1.55	1.67	1
Ranunculus flammula	Creeping spearwort	4	0.78	1.57	1.04	1.75	2
Eleocharis palustris	Creeping spikerush	2	0.39	0.79	0.52	1.00	3
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	2

* Excluded from relative frequency analysis

Table 2 (continued): 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.
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
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	American water-horehound	***	***	***	***	***	***
Nuphar variegata	Spatterdock	***	***	***	***	***	***
Potamogeton natans	Floating-leaf pondweed	***	***	***	***	***	***
Schoenoplectus pungens	Threesquare	***	***	***	***	***	***
Spartina pectinata	Prairie cordgrass	***	***	***	***	***	***

** Visual Only *** Boat Survey Only

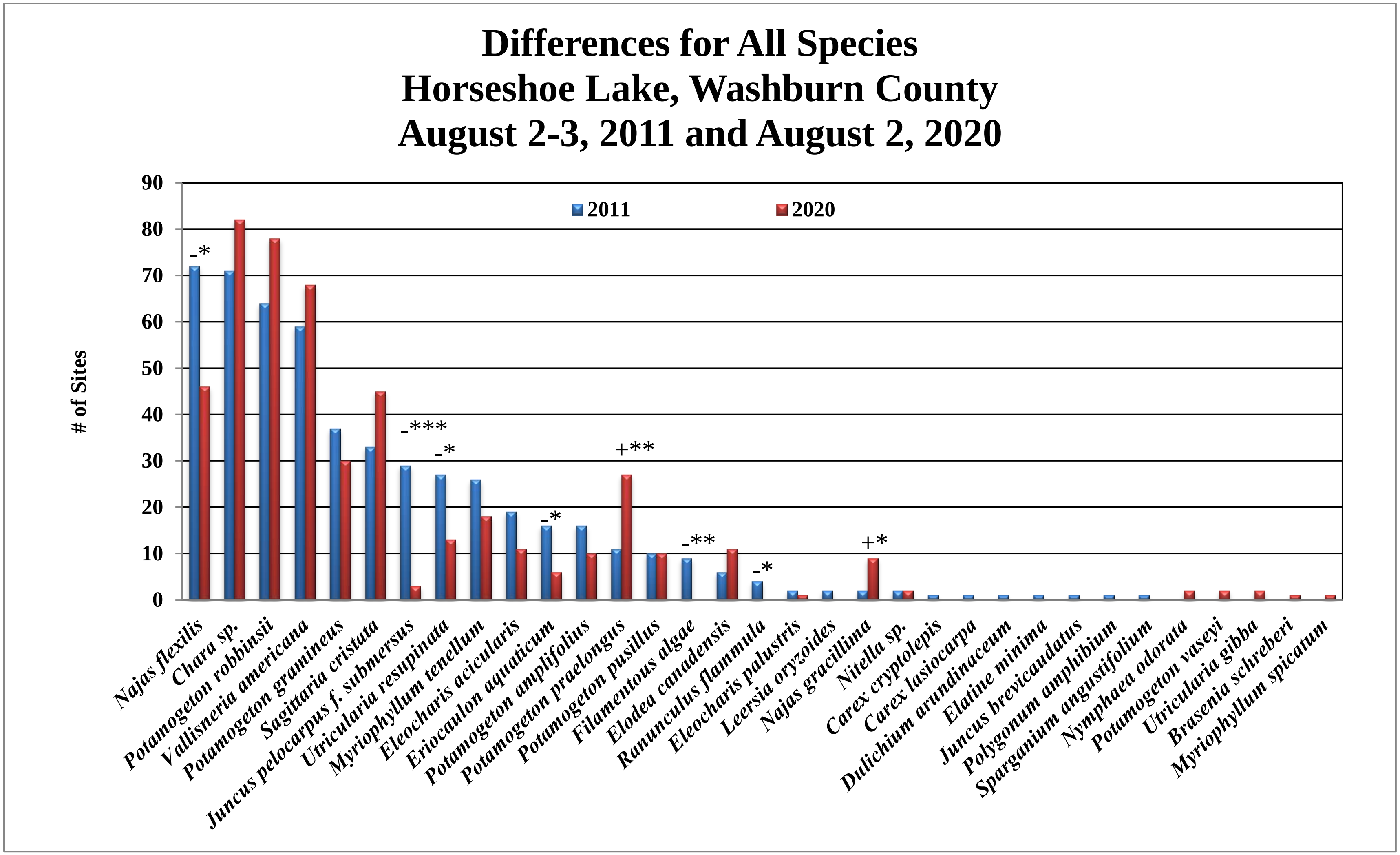
Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2, 2020

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Chara sp.	Muskgrass	82	17.15	32.41	21.35	1.50	0
Potamogeton robbinsii	Fern pondweed	78	16.32	30.83	20.31	1.59	0
Vallisneria americana	Wild celery	68	14.23	26.88	17.71	1.25	0
Najas flexilis	Slender naiad	46	9.62	18.18	11.98	1.11	0
Sagittaria cristata	Crested arrowhead	45	9.41	17.79	11.72	1.16	0
Potamogeton gramineus	Variable pondweed	30	6.28	11.86	7.81	1.27	0
Potamogeton praelongus	White-stem pondweed	27	5.65	10.67	7.03	1.30	1
Myriophyllum tenellum	Dwarf water-milfoil	18	3.77	7.11	4.69	1.50	0
Utricularia resupinata	Small purple bladderwort	13	2.72	5.14	3.39	1.77	0
Eleocharis acicularis	Needle spikerush	11	2.30	4.35	2.86	1.45	0
Elodea canadensis	Common waterweed	11	2.30	4.35	2.86	1.27	0
Potamogeton amplifolius	Large-leaf pondweed	10	2.09	3.95	2.60	1.00	2
Potamogeton pusillus	Small pondweed	10	2.09	3.95	2.60	1.50	0
Najas gracillima	Northern naiad	9	1.88	3.56	2.34	1.33	0
Eriocaulon aquaticum	Pipewort	6	1.26	2.37	1.56	2.50	0
Juncus pelocarpus f. submersus	Brown-fruited rush	3	0.63	1.19	0.78	2.00	0
Nitella sp.	Nitella	2	0.42	0.79	0.52	1.00	0
Nymphaea odorata	White water lily	2	0.42	0.79	0.52	1.00	2
Potamogeton vaseyi	Vasey's pondweed	2	0.42	0.79	0.52	1.50	0
Utricularia gibba	Creeping bladderwort	2	0.42	0.79	0.52	1.50	0
Brasenia schreberi	Watershield	1	0.21	0.40	0.26	2.00	2
Eleocharis palustris	Creeping spikerush	1	0.21	0.40	0.26	1.00	0
Myriophyllum spicatum	Eurasian water-milfoil	1	0.21	0.40	0.26	3.00	0

Table 3 (continued): Frequencies and Mean Rake Sample of Aquatic Macrophytes
Horseshoe Lake, Washburn County
August 2, 2020

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sight.
Schoenoplectus acutus	Hardstem bulrush	**	**	**	**	**	2
Elatine minima	Waterwort	***	***	***	***	***	***
Juncus effusus	Common rush	***	***	***	***	***	***
Nuphar variegata	Spatterdock	***	***	***	***	***	***
Polygonum amphibium	Water smartweed	***	***	***	***	***	***
Potamogeton natans	Floating-leaf pondweed	***	***	***	***	***	***
Potamogeton spirillus	Spiral-fruited pondweed	***	***	***	***	***	***
Ranunculus flammula	Creeping spearwort	***	***	***	***	***	***
Sparganium angustifolium	Narrow-leaved bur-reed	***	***	***	***	***	***
Spartina pectinata	Prairie cordgrass	***	***	***	***	***	***

** Visual Only   *** Boat Survey Only



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

Figure 8: Macrophyte Changes from 2011-2020

Slender naiad, the most common species in 2011 and the fourth most common in 2020, was present throughout the lake at most points with sandy muck in 7-11ft of water (Figure 9). Although it suffered a significant decline **(*p*=0.01)** in distribution from 72 sites in 2011 to 46 sites in 2020, its mean rake fullness underwent a non-significant increase (*p*=0.25) from 1.07 in 2011 to 1.11 in 2020. Visual analysis of the maps showed this decline in distribution was essentially a lakewide phenomenon with the loss of habitat in deep water. Offsetting this was some expansion nearer the shore; especially in the west basin.

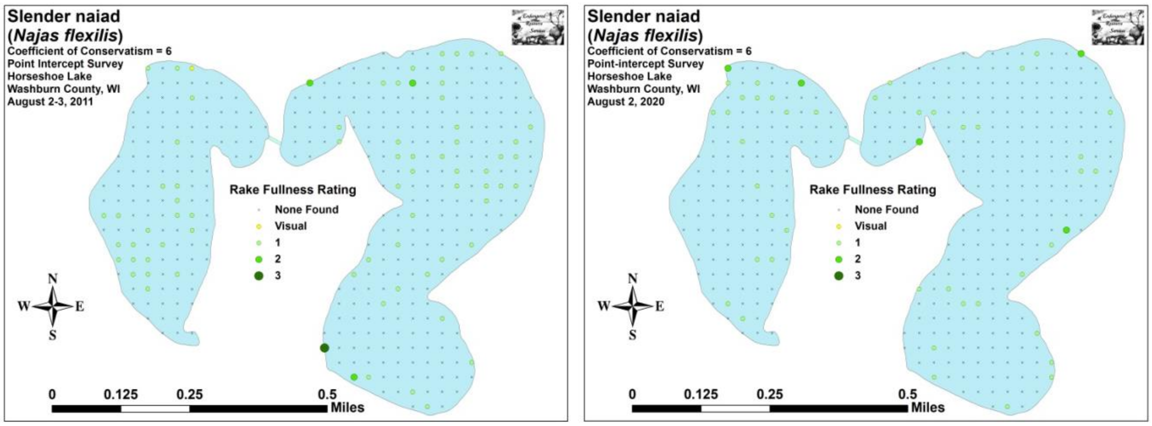


Figure 9: 2011 and 2020 Slender Naiad Density and Distribution

Muskgrasses were the second most common macrophyte in 2011 and the most common in 2020. Although the shallow-water species (likely *Chara aspera*) nearly disappeared from the lake along with much of the rest of the isoetid community, the deep-water species (likely *Chara globularis* or *contraria*), colonized most of the deeper areas in the western basin (Figure 10). Collectively, they experienced a non-significant increase (*p*=0.30) in distribution from 71 sites in 2011 to 82 sites in 2020. The accompanying increase in density from a mean rake fullness of 1.46 in 2011 to 1.50 in 2020 was also not significant (*p*=0.35).

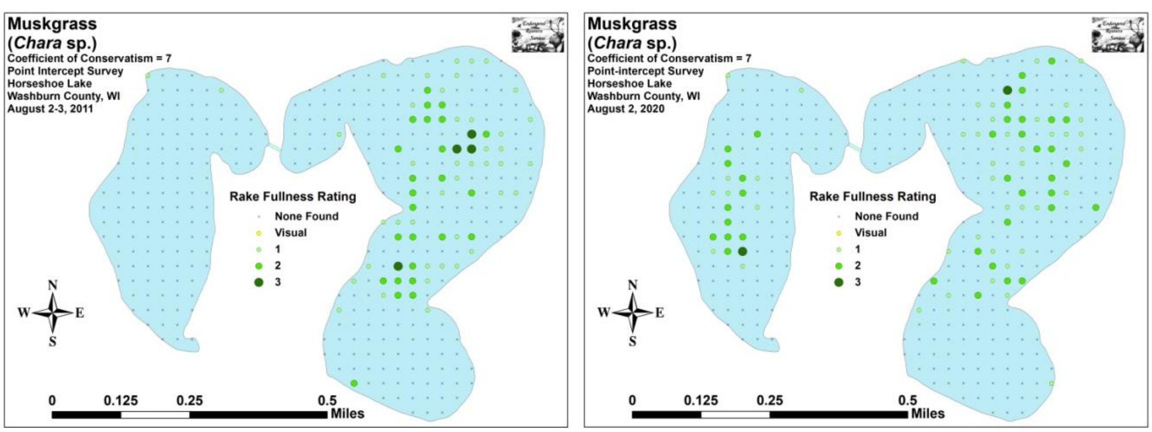


Figure 10: 2011 and 2020 Muskgrass Density and Distribution

Fern pondweed also expanded into the deeper areas of the west basin as its community rank increased from the third most common species in 2011 to the second most common in 2020 (Figure 11). However, neither this total increase in distribution (64 sites in 2011/78 sites in 2020), nor the decline in mean rake fullness (1.69 in 2011/1.59 in 2020) were significant (*p*=0.18/p=0.22).

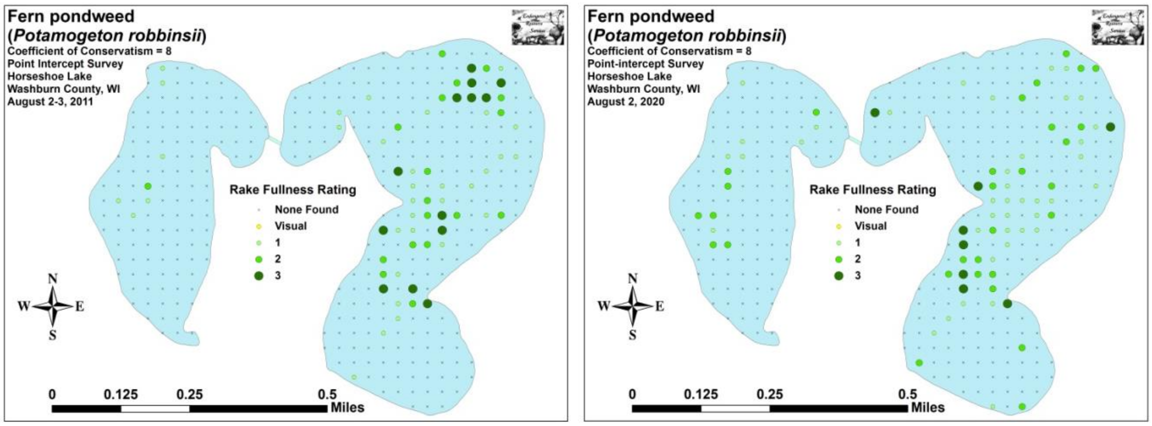


Figure 11: 2011 and 2020 Fern Pondweed Density and Distribution

Wild celery adapted fairly well to changing water levels (Figure 12). Its increase from the fourth most widely-distributed species (59 sites in 2011) to the third most (68 sites in 2020) was not significant (*p*=0.36). Similarly, the decline in density (mean rake fullness of 1.34 in 2011/1.25 in 2020) was not significant (*p*=0.16).

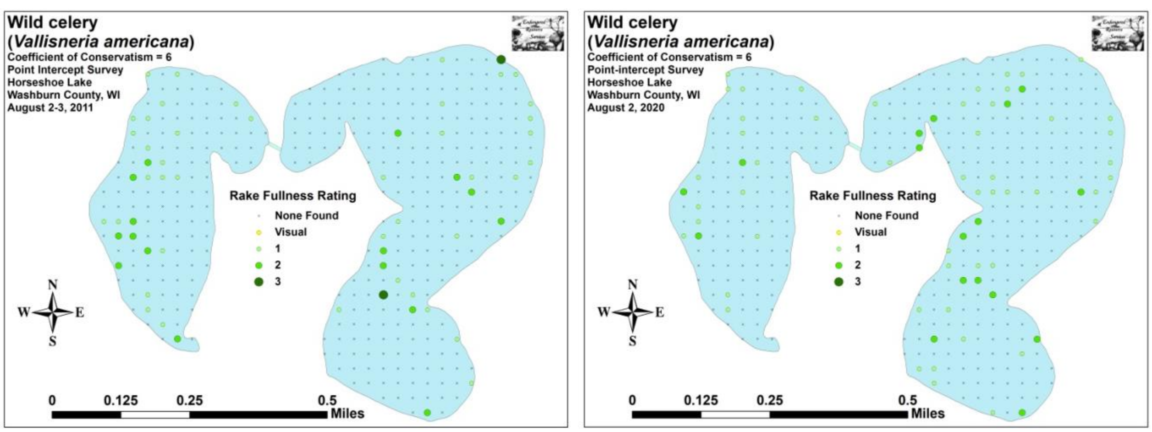


Figure 12: 2011 and 2020 Wild Celery Density and Distribution

Comparison of Floristic Quality Indexes in 2011 and 2020:

In 2011, we identified a total of 23 **native index species** in the rake during the point-intercept survey (Table 4). They produced a mean Coefficient of Conservatism of 7.4 and a Floristic Quality Index of 35.4.

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 f. submersus	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**

During the 2020 point-intercept survey, we found 22 **native index plants** in the rake. They produced a mean Coefficient of Conservatism of 7.3 and a Floristic Quality Index of 34.1 (Table 5). Nichols (1999) reported an average mean C for the Northern Lakes and Forest Region of 6.7 putting Horseshoe Lake well above average for this part of the state. The FQI was also much above the median FQI of 24.3 for the Northern Lakes and Forest Region (Nichols 1999). Six exceptionally high value species of note included Pipewort (C = 9), Dwarf water-milfoil (C = 10), Crested arrowhead (C = 9), Creeping bladderwort (C = 9), and the State Species of Special Concern** Vasey's pondweed (C = 10) and Small purple bladderwort (C = 9).

Table 5: Floristic Quality Index of Aquatic Macrophytes Horseshoe Lake, Washburn County August 2, 2020

Species	Common Name	C
Brasenia schreberi	Watershield	6
Chara sp.	Muskgrass	7
Eleocharis acicularis	Needle spikerush	5
Eleocharis palustris	Creeping spikerush	6
Elodea canadensis	Common waterweed	3
Eriocaulon aquaticum	Pipewort	9
Juncus pelocarpus f. submersus	Brown-fruited rush	8
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Slender naiad	6
Najas gracillima	Northern naiad	7
Nitella sp.	Nitella	7
Nymphaea odorata	White water lily	6
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
Potamogeton vaseyi	Vasey's pondweed	10
Sagittaria cristata	Crested arrowhead	9
Utricularia gibba	Creeping bladderwort	9
Utricularia resupinata	Small purple bladderwort	9
Vallisneria americana	Wild celery	6
N		**22**
Mean C		**7.3**
FQI		**34.1**

Comparison of Filamentous Algae in 2011 an 2020:

Filamentous algae are normally associated with excessive nutrients in the water column from such things as runoff or internal nutrient recycling. In 2011, we documented them at nine points with a mean rake fullness of 1.00 (Figure 13). During the 2020 survey, we didn't find these algae in the rake at any point. Although this was a moderately significant decline **(*p*=0.003)** in distribution, the reasons for it are unclear. Because all the points in 2011 were located in the western basin around the deep hole, it suggests that shoreline runoff was not the cause. It may simply be that changes in lake levels led to a local plant die-off and this produced a short-term increase in algal levels in this area. It may also be that the increased numbers of macrophytes seen in this area during the 2020 survey were able to utilize the majority of available nutrients.

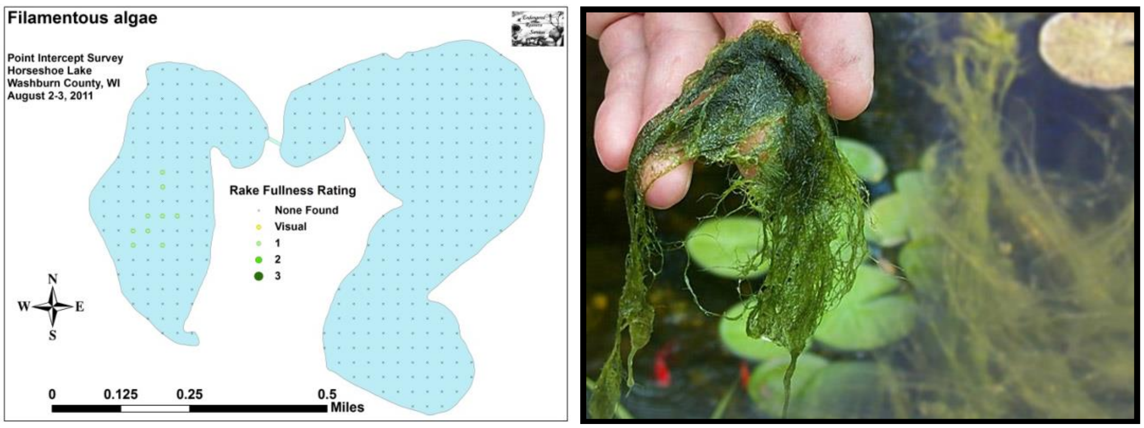


Figure 13: 2011 Filamentous Algae Density and Distribution

Comparison of Midsummer Eurasian Water-milfoil in 2011 an 2020:

In August 2011, we didn't find Eurasian water-milfoil in the rake at any point, but did record it as a visual at two sites (Figure 14) (Appendix VII). During the 2020 August survey, EWM was present at a single point in the middle of the newly discovered bed in the northwest bay. Away from this immediate area, we saw no evidence of EWM anywhere else in the system. Because of the low number of detections during each survey, none of these changes were significant (Figure 15).

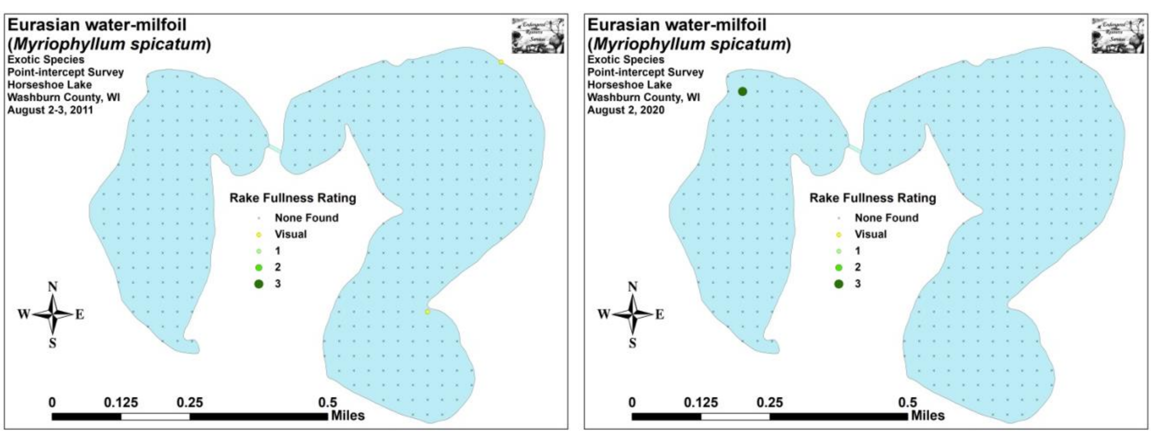


Figure 14: 2011 and 2020 Eurasian Water-milfoil Density and Distribution

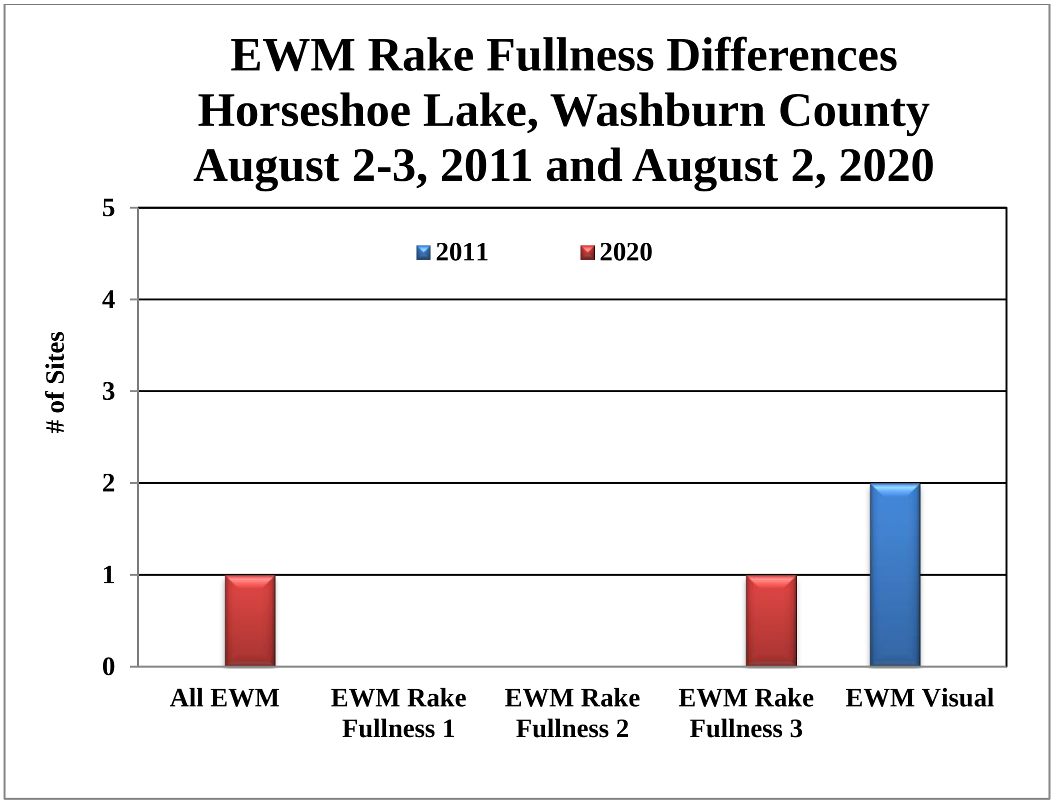


Figure 15: Changes in EWM Rake Fullness from 2011-2020

Other Exotic Plant Species:

Other than Eurasian water-milfoil, we saw no evidence of any other exotic plant species; however, freshwater jellies (*Craspedacusta sowerbyi*) an exotic animal, were abundant. For more information on a sampling of aquatic exotic invasive plant species, see Appendix VIII.

DISCUSSION AND CONSIDERATIONS FOR MANAGEMENT:

Native Aquatic Macrophytes and Eurasian Water-milfoil Management:

Horseshoe Lake continues to have a diverse native plant community with many sensitive and relatively rare species. Unfortunately, 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. This threat to the lake's native plant communities is a significant one because they are the base of the aquatic food pyramid, provide habitat for fish and 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.

The current management program has been successful at minimizing EWM's impact on the aquatic ecosystem. Hopefully, with continued early detection, manual removal when possible, and small scale treatments when necessary, the HLPOA can maintain or even further reduce EWM from its current low levels while simultaneously minimizing the impact on the lake's native plants.

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Appendix I: Boat and Vegetative Survey Datasheets

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

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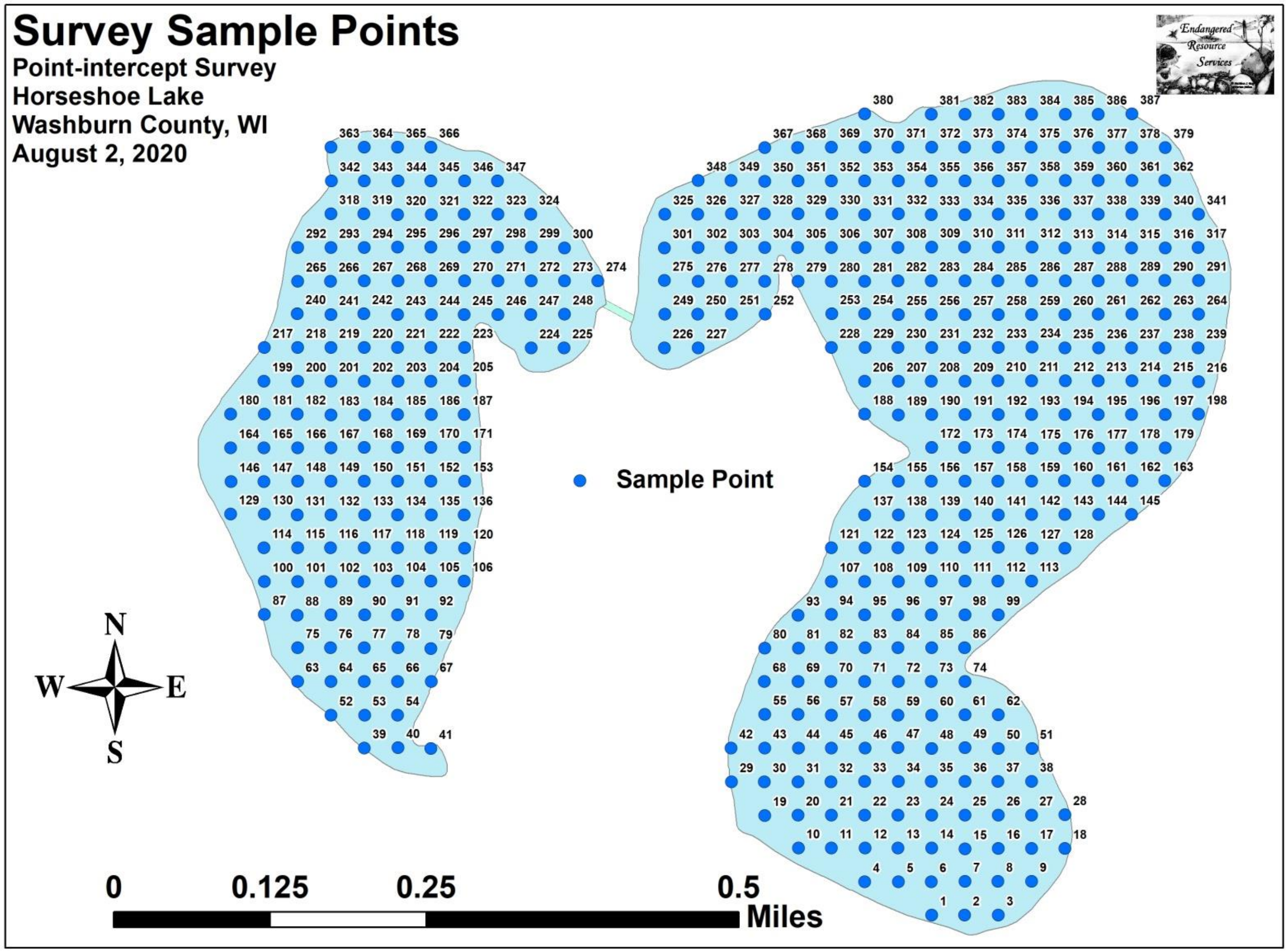
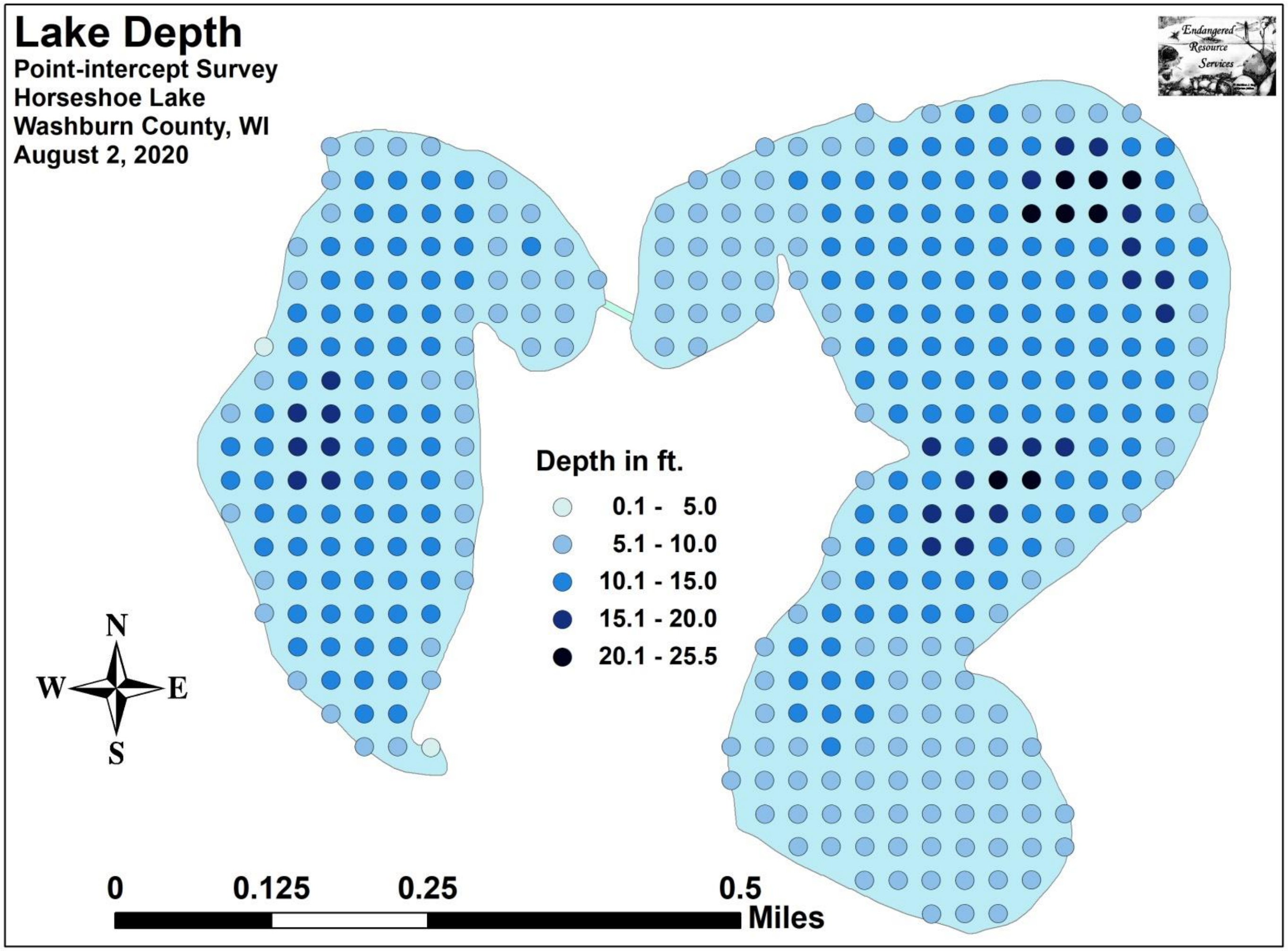
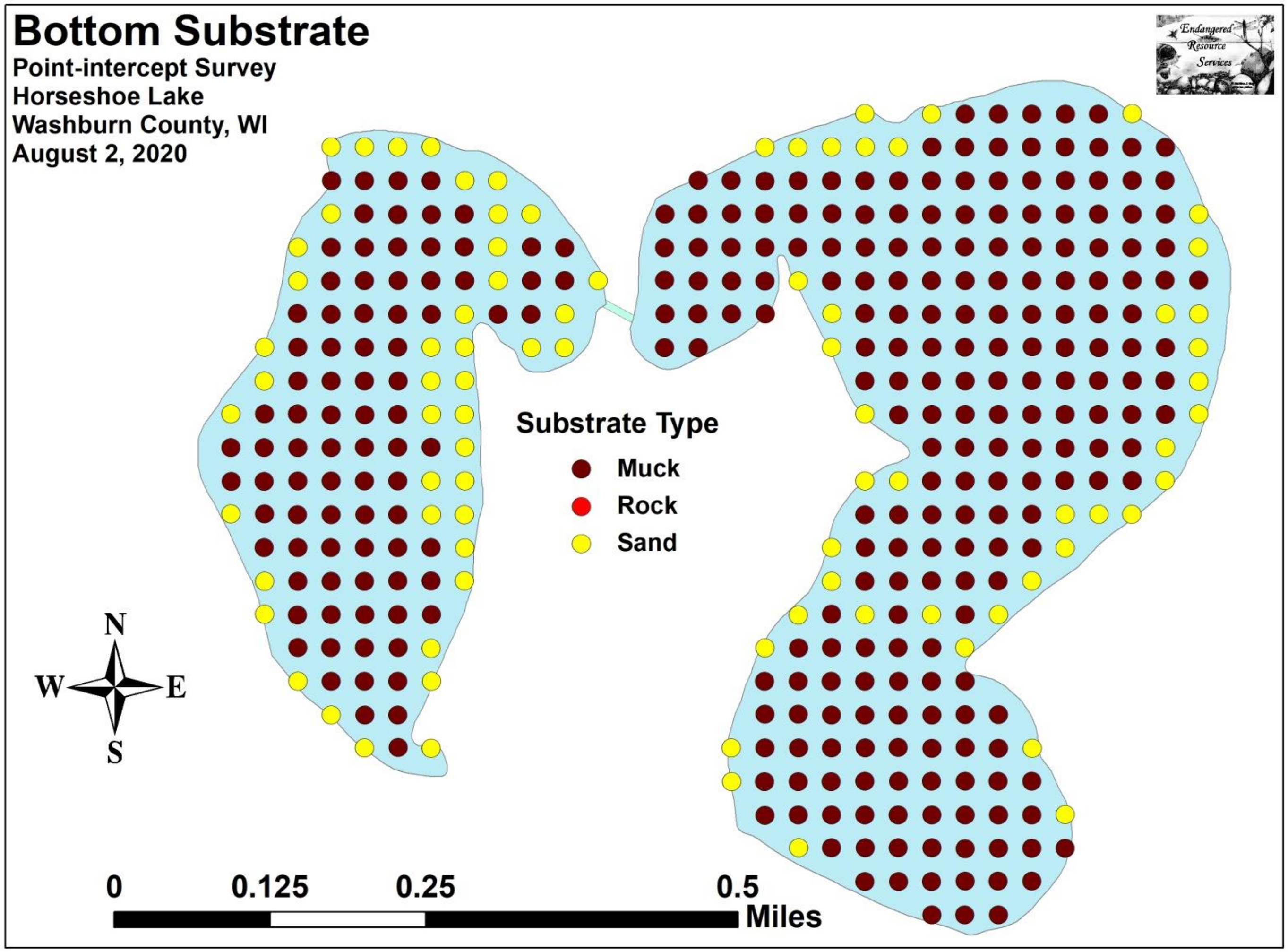
Appendix II: Survey Sample Points Map


Survey Sample Points
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Sample Point
N
W
E
S
0
0.125
0.25
0.5
Miles

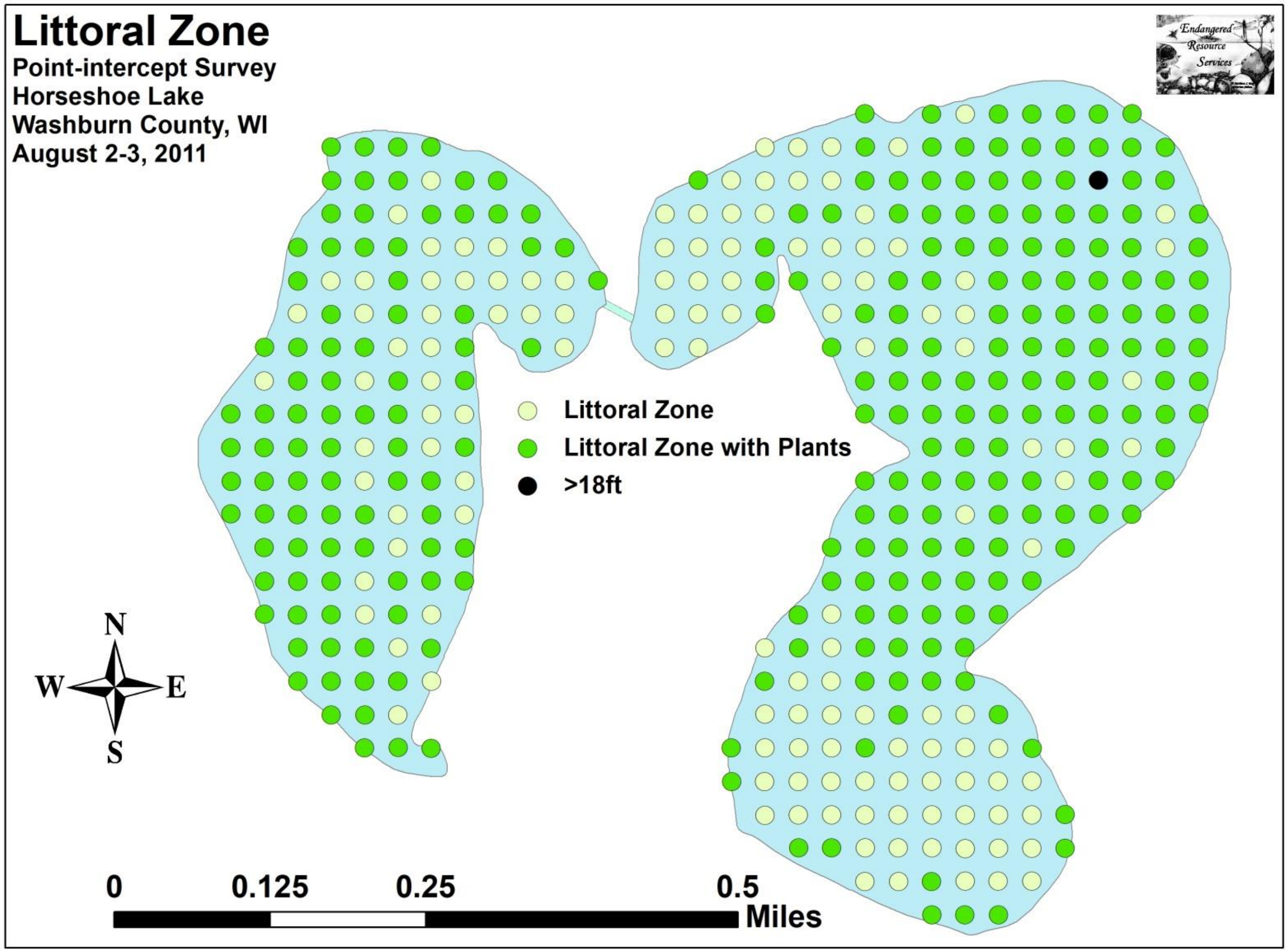
Appendix III: Habitat Variable Maps

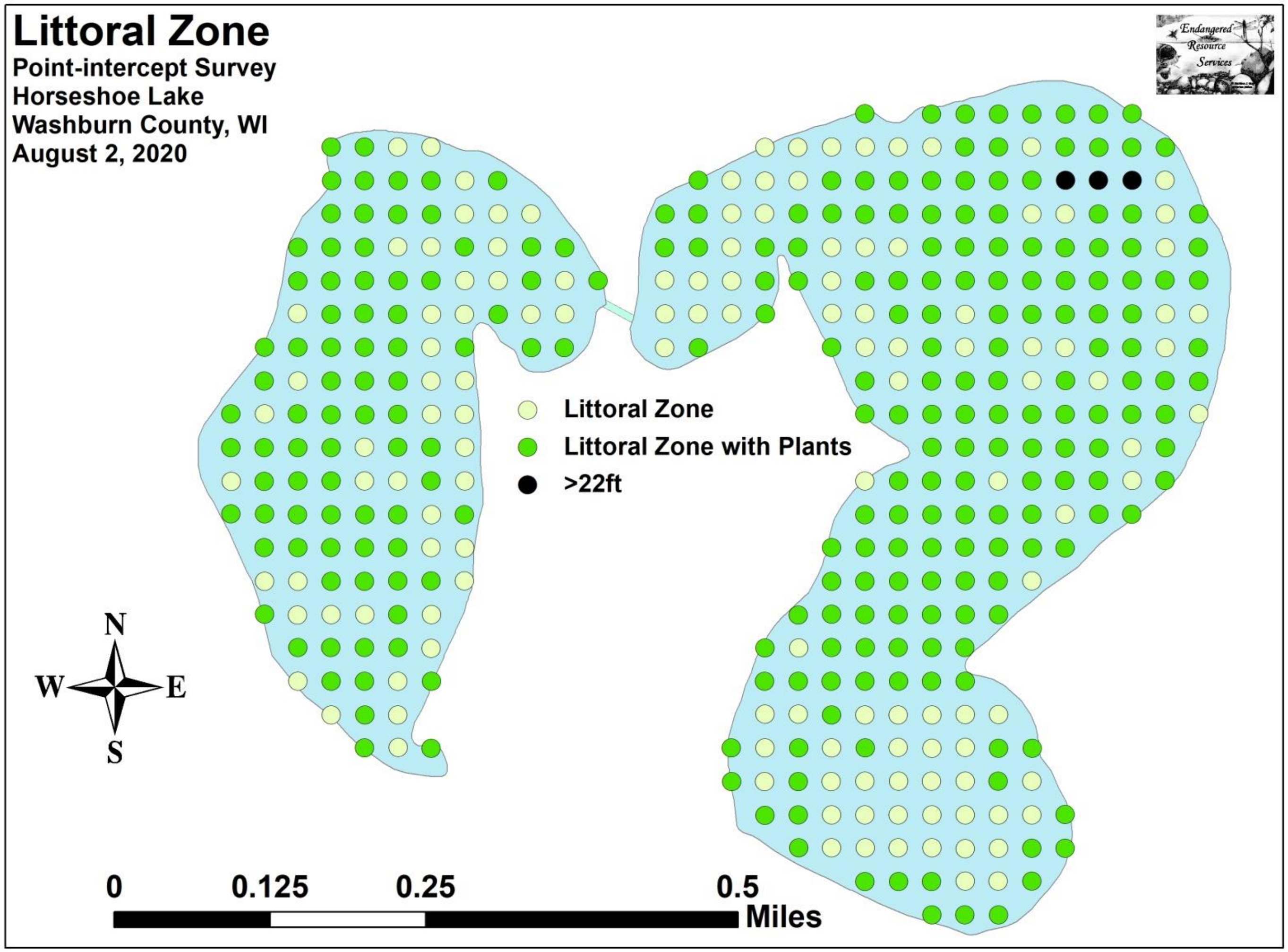

Lake Depth
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Depth in ft.
0.1 - 5.0
5.1 - 10.0
10.1 - 15.0
15.1 - 20.0
20.1 - 25.5
N
W
E
S
0
0.125
0.25
0.5
Miles

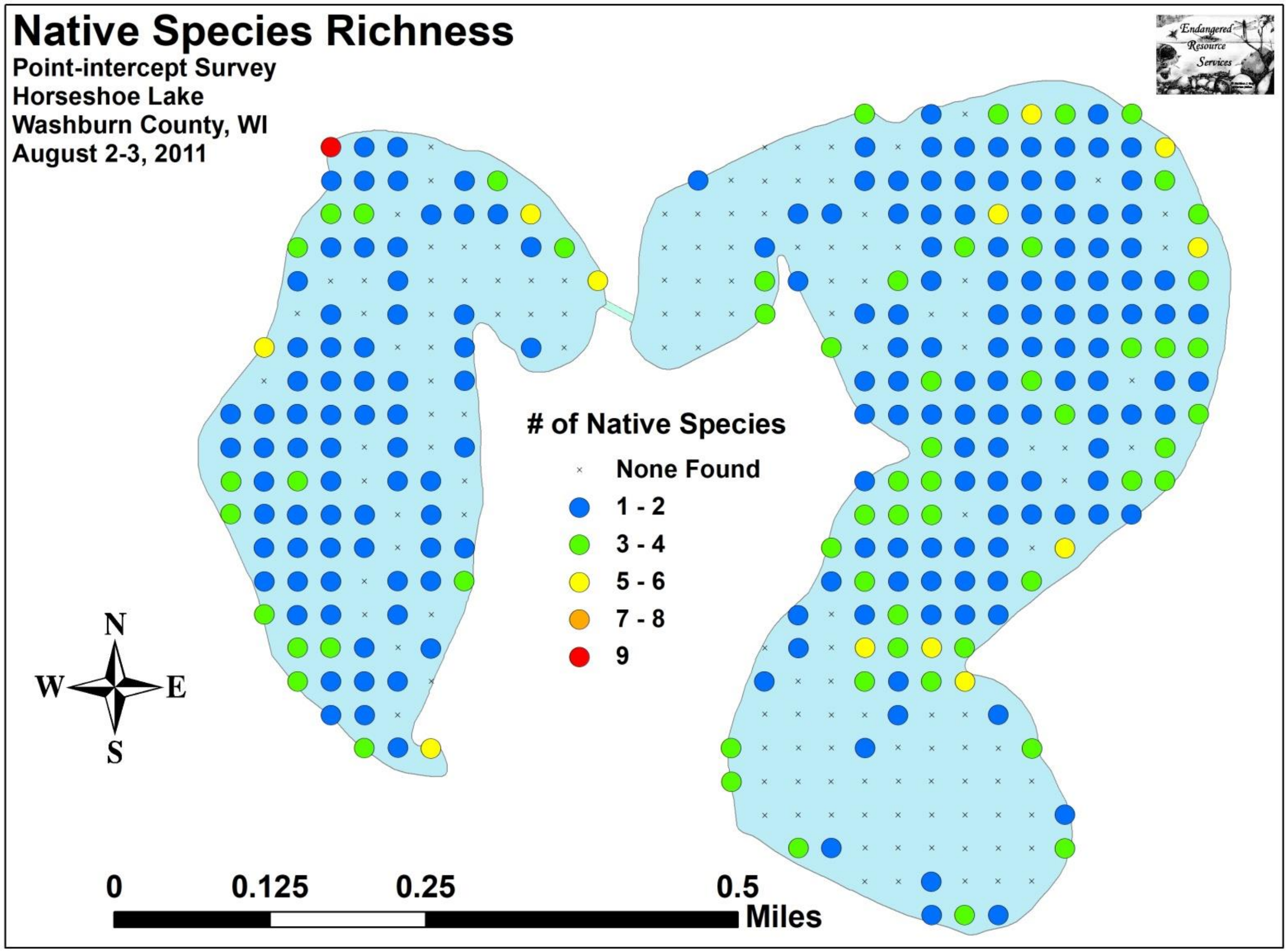


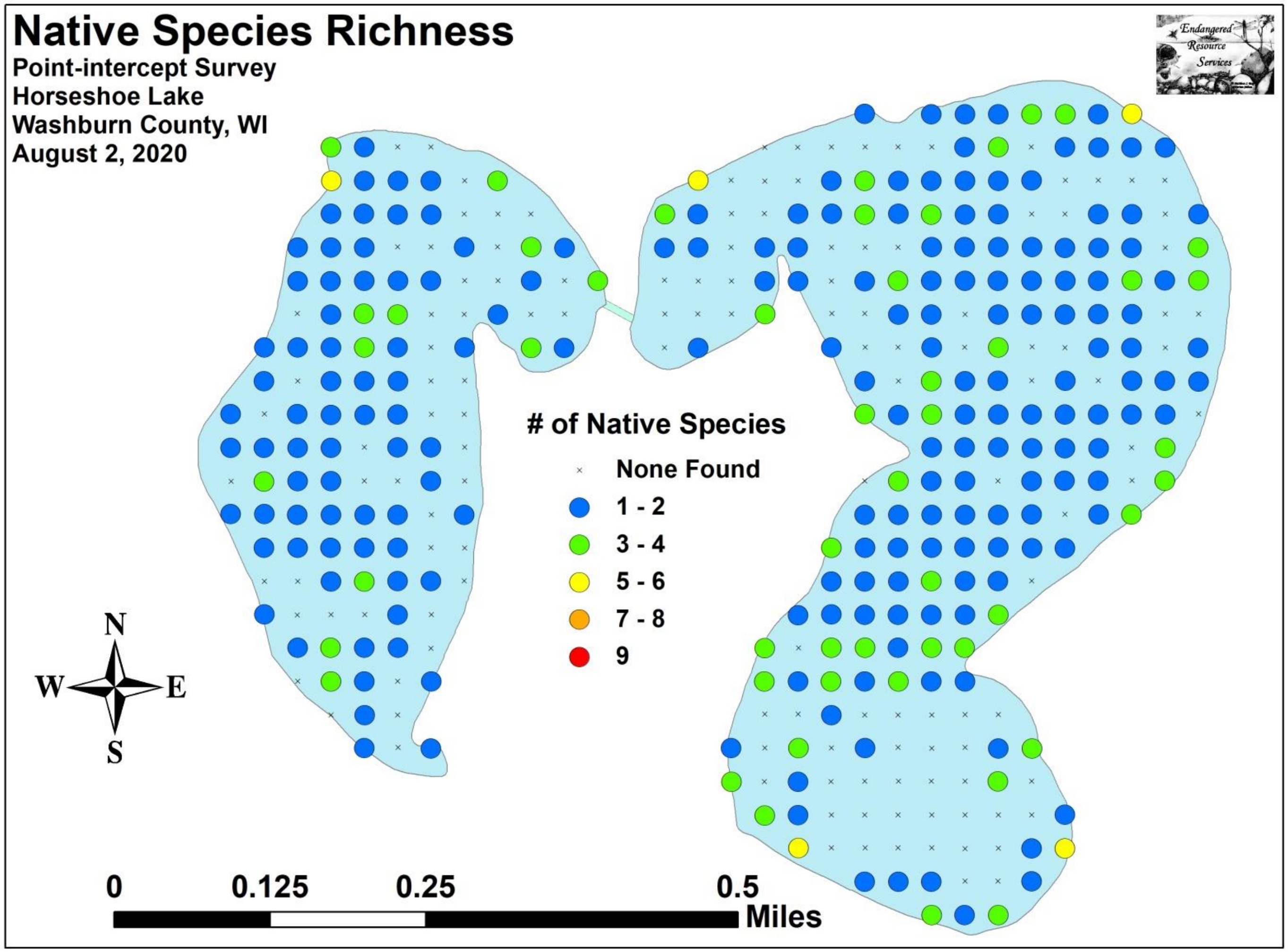
Bottom Substrate
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Substrate Type
Muck
Rock
Sand
N
W
E
S
0
0.125
0.25
0.5
Miles

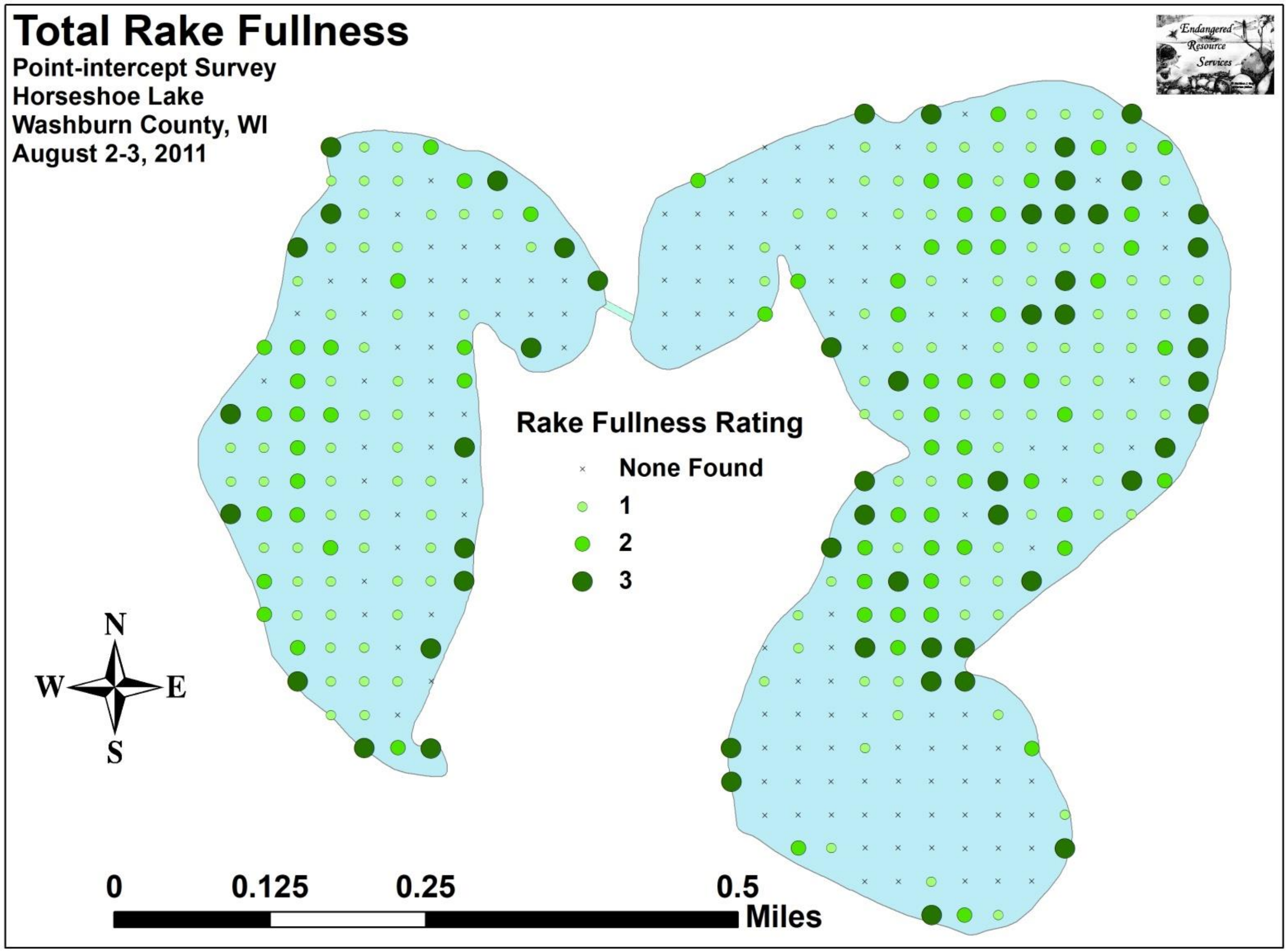
Appendix IV: 2011 and 2020 Littoral Zone, Native Species Richness, and Total Rake Fullness Maps

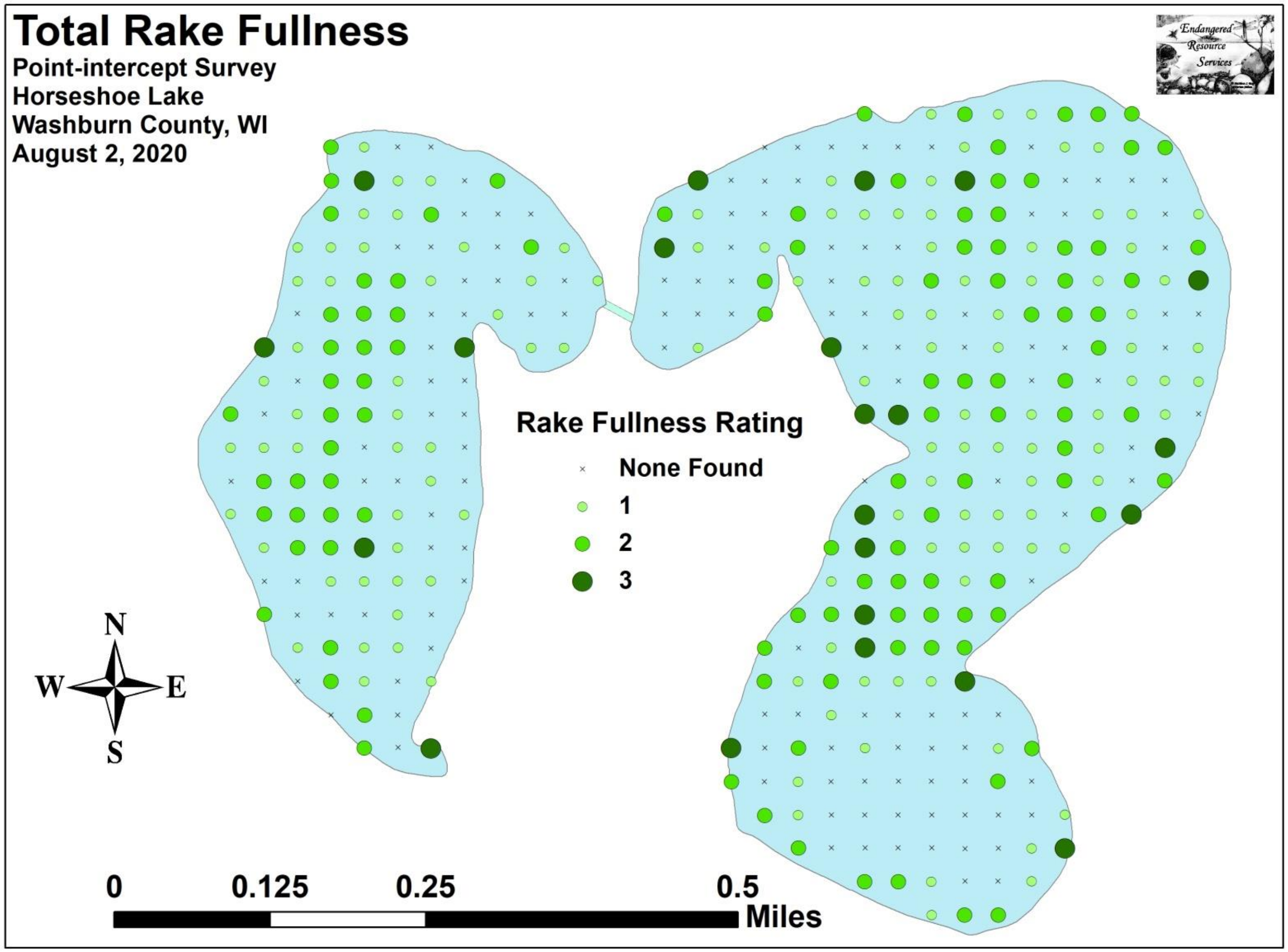

Littoral Zone
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
Endangered Resource Services
Littoral Zone
Littoral Zone with Plants
>18ft
N
W
E
S
0
0.125
0.25
0.5
Miles


Littoral Zone
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Littoral Zone
Littoral Zone with Plants
>22ft
N
W
E
S
0
0.125
0.25
0.5
Miles


Native Species Richness
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2-3, 2011
# 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
Endangered Resource Services


Native Species Richness
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
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


Total Rake Fullness
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
1
2
3
N
W
E
S
0
0.125
0.25
0.5
Miles

Appendix V: 2011 and 2020 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:** 8/2/20
Species: (*Potamogeton vaseyi*) **Vasey's pondweed**
Specimen Location: Horseshoe Lake; N46.08199°, W91.91756°
Collected/Identified by: **Matthew S. Berg** **Col. #:** MSB-2020-001
Habitat/Distribution: Sandy muck in 1.5-2.5m of water. All plants were located in a narrow habitat zone near the point. Many 1,000's of individuals, but only a few had floating leaves.
Common Associates: (*Chara* sp.) Muskgrass, (*Najas flexilis*) Slender naiad, (*Potamogeton pusillus*) Small pondweed, (*Utricularia gibba*) Creeping bladderwort

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

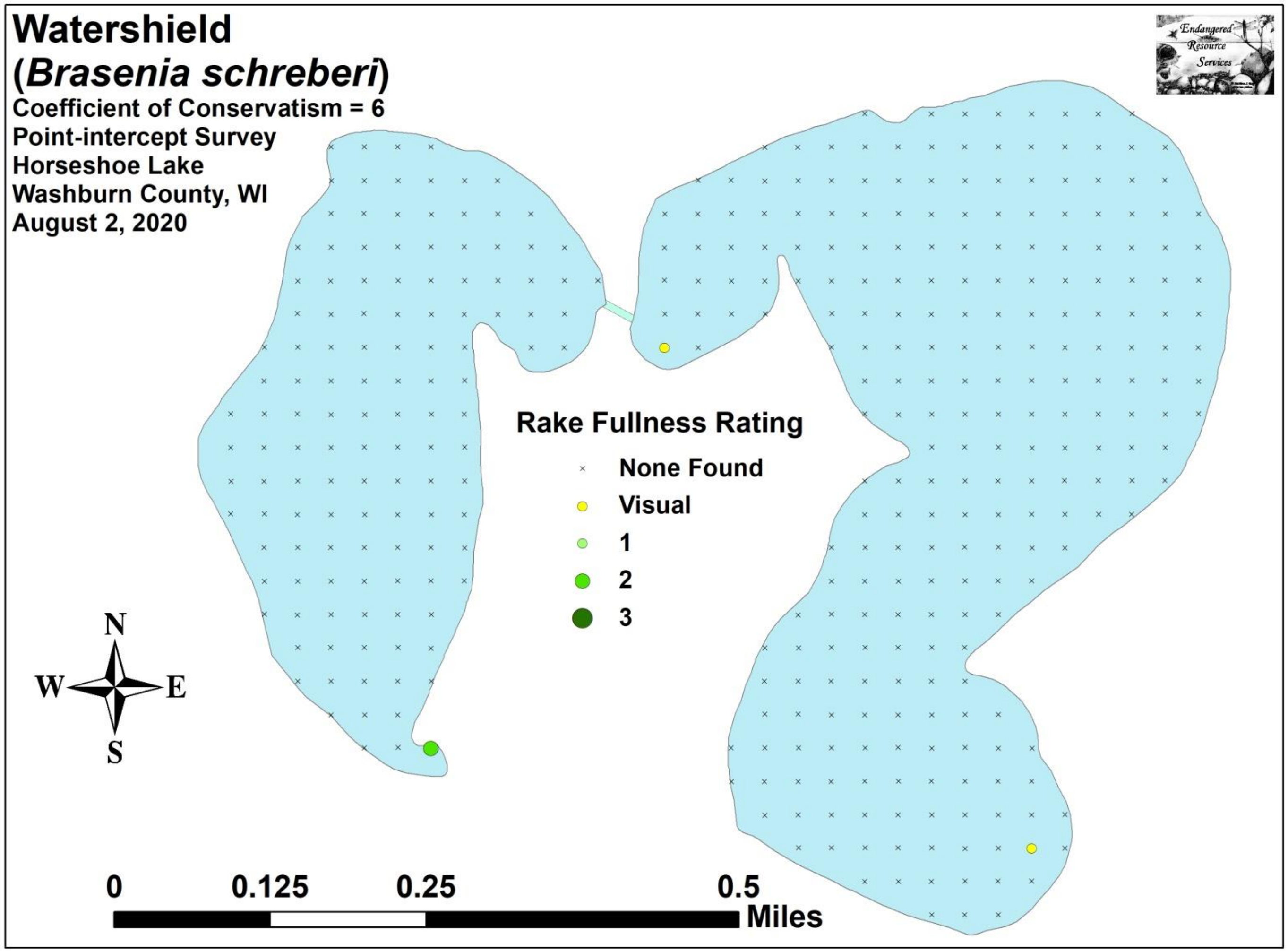
County/State: Washburn County, Wisconsin **Date:** 8/2/11
Species: (*Spartina pectinata*) **Prairie cordgrass**
Specimen Location: Horseshoe Lake; N46.08120°, W91.91864°
Collected/Identified by: Matthew S. Berg Col. #: MSB-2011-123
Habitat/Distribution: Found in scattered sugar sand areas directly adjacent 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 VI: August 2020 Native Species Density and Distribution Maps


Watershield
(Brasenia schreberi)
Coefficient of Conservatism = 6
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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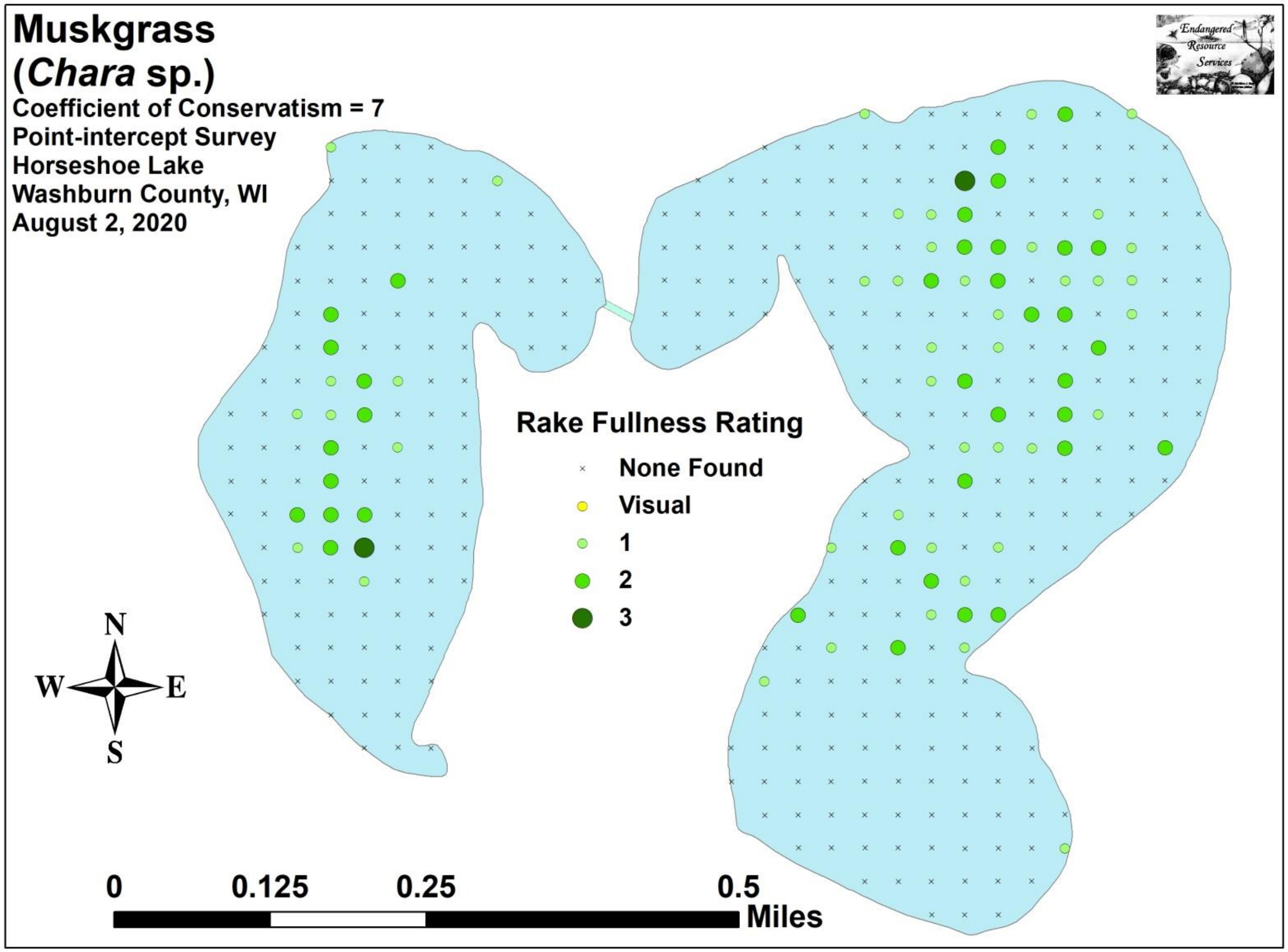
Miles


Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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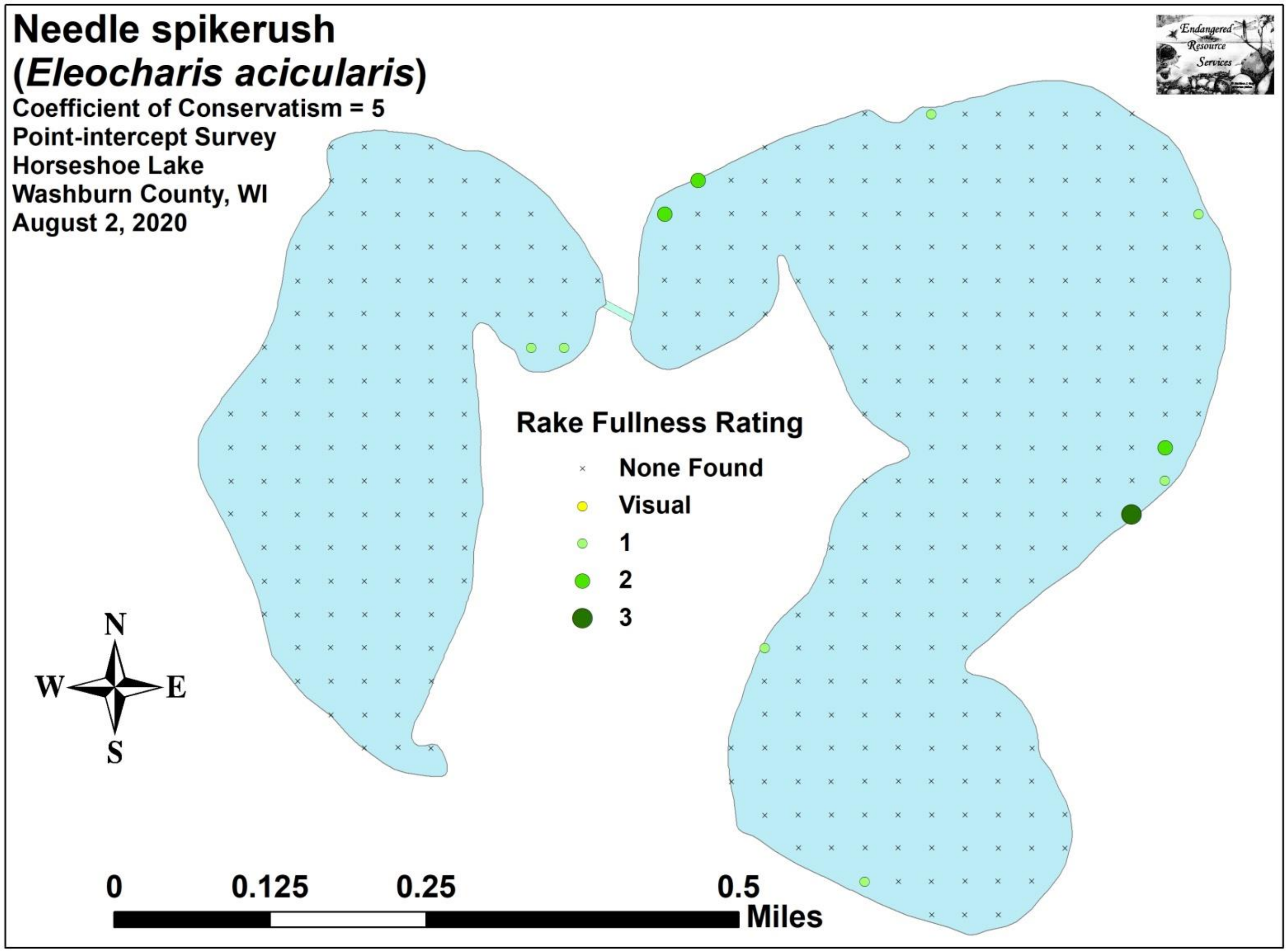
Miles


Needle spikerush
(*Eleocharis acicularis*)
Coefficient of Conservatism = 5
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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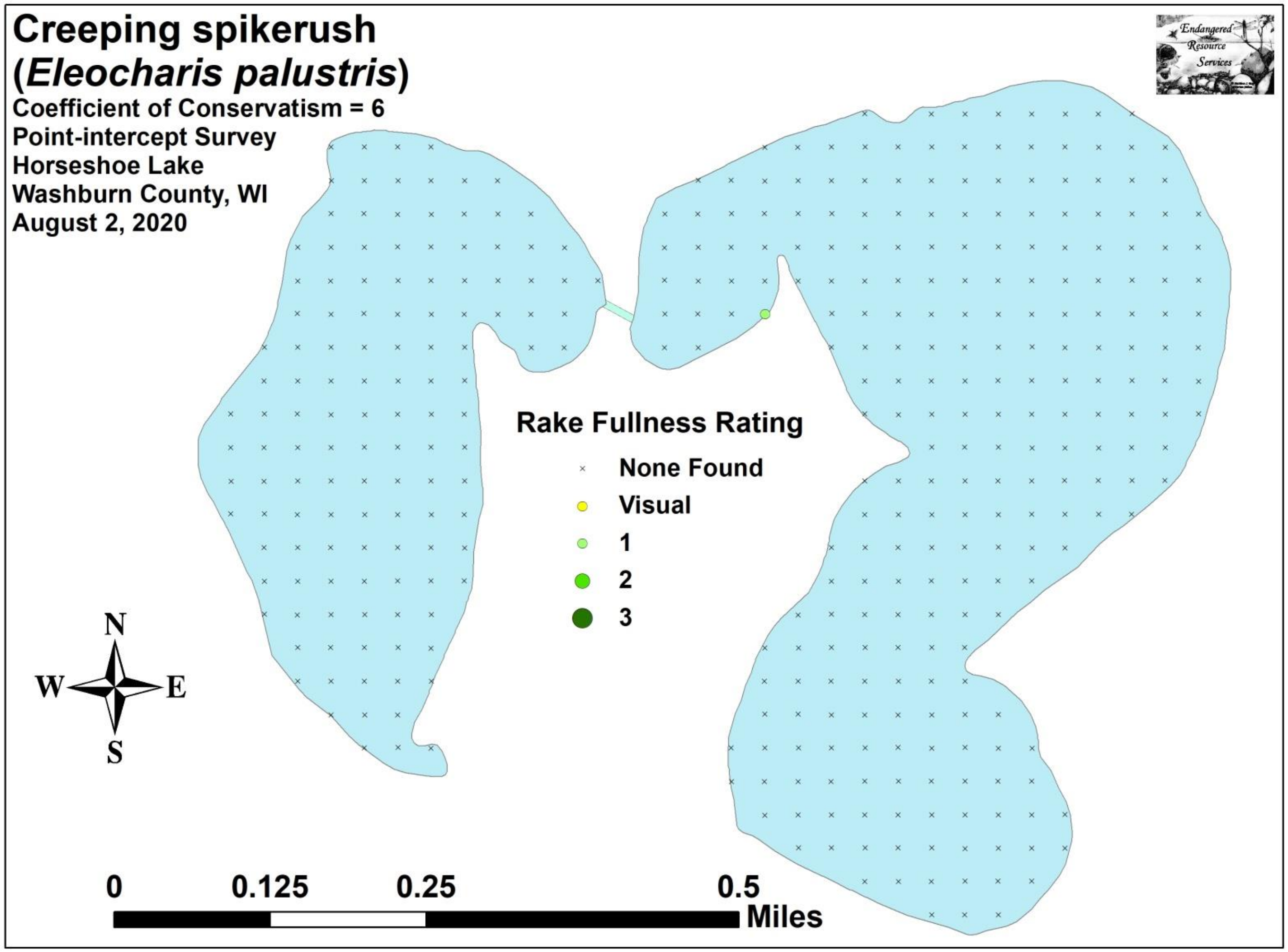
Miles



Creeping spikerush
(*Eleocharis palustris*)
Coefficient of Conservatism = 6
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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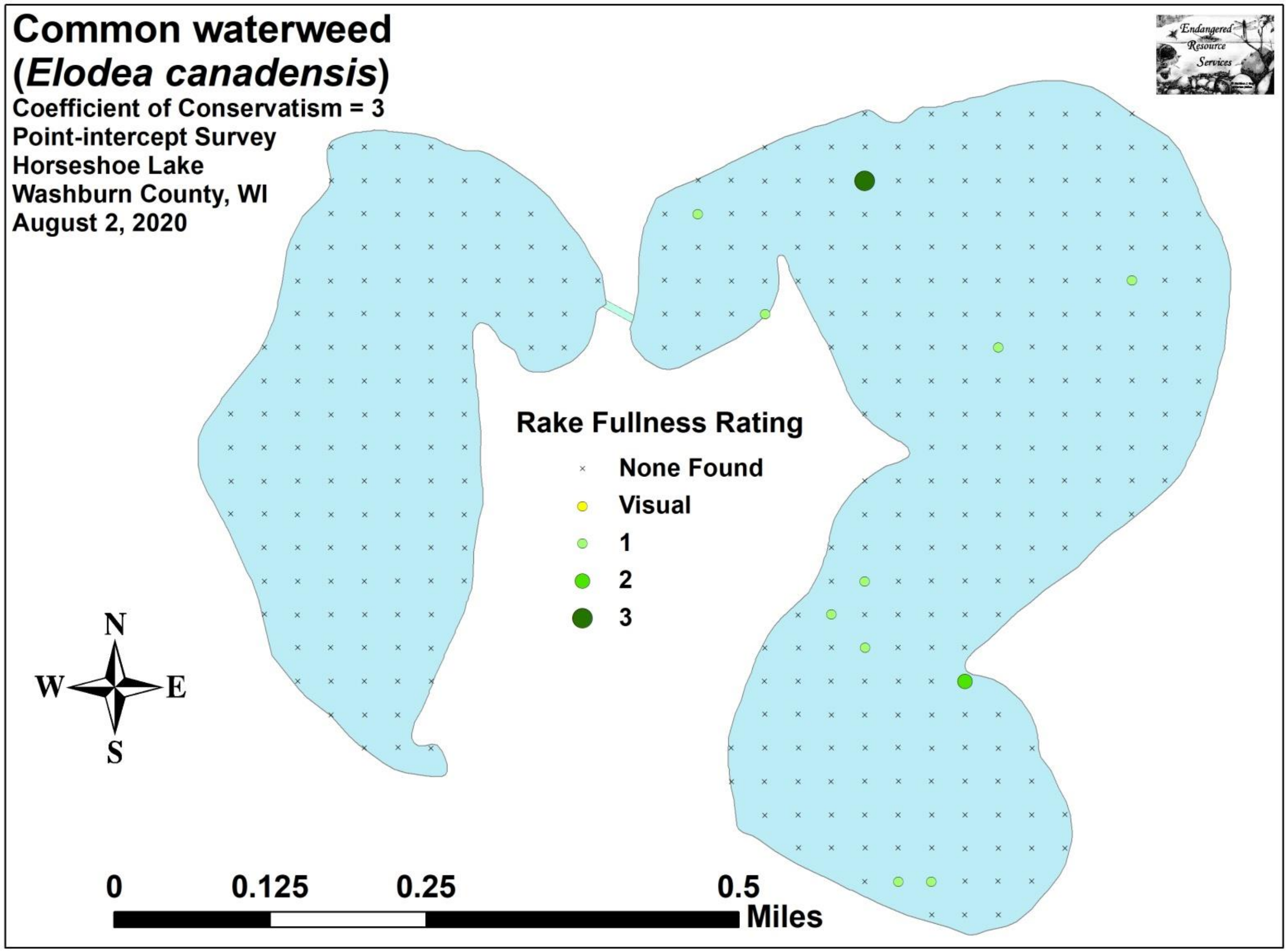
Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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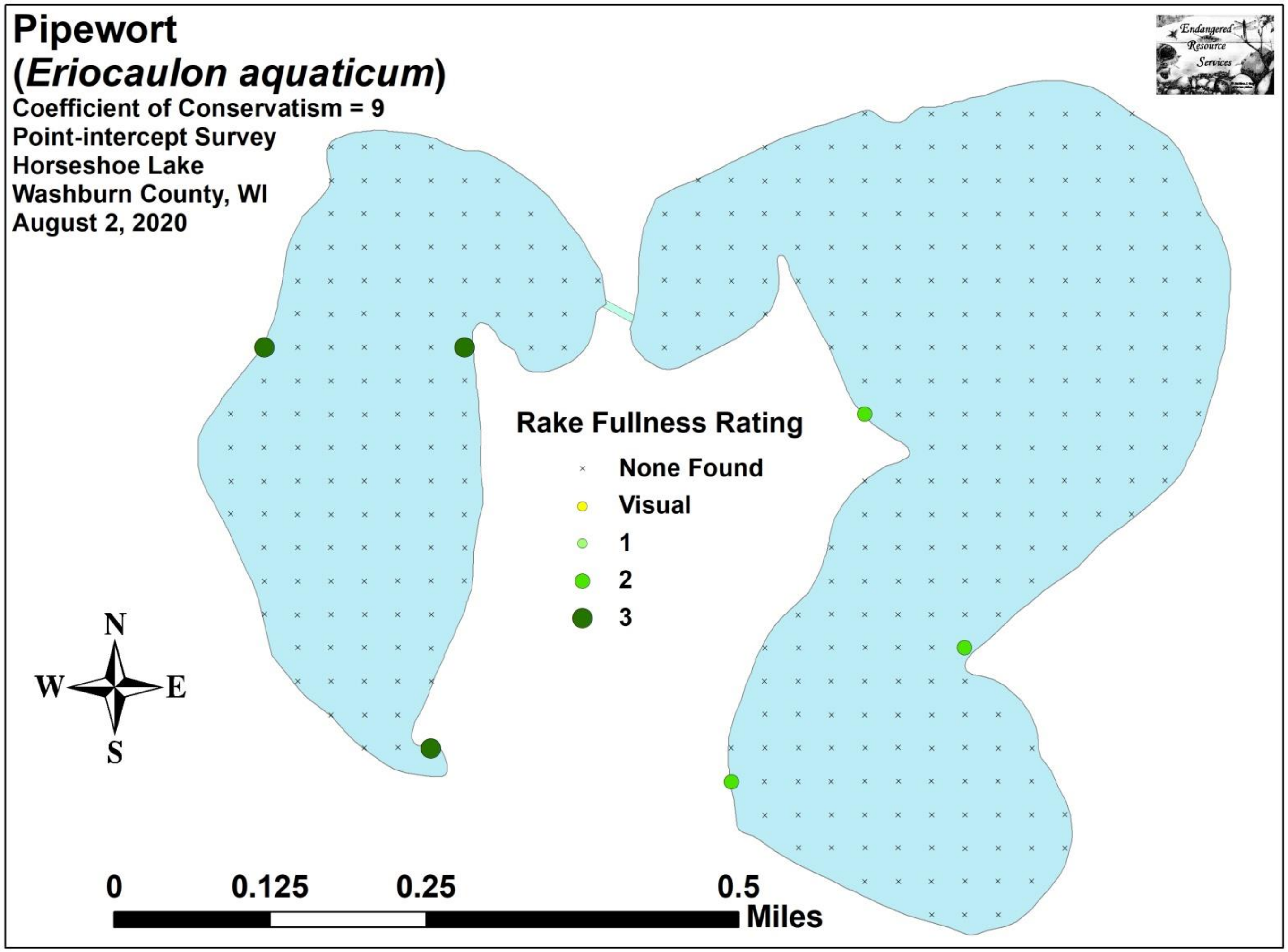
Miles


Pipewort
(*Eriocaulon aquaticum*)
Coefficient of Conservatism = 9
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered
Resource
Services
Rake Fullness Rating
None Found
Visual
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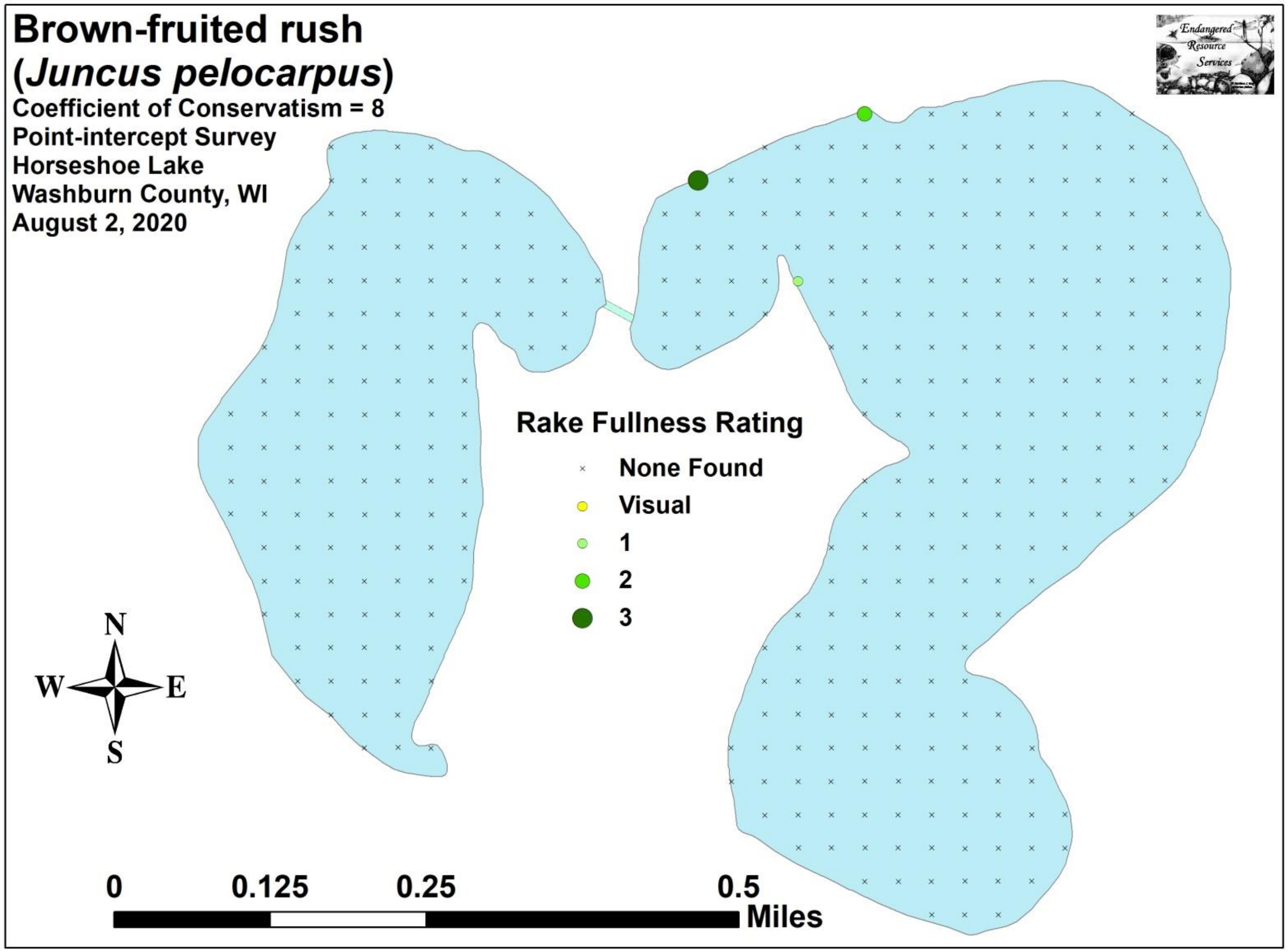
Miles


Brown-fruited rush
(*Juncus pelocarpus*)
Coefficient of Conservatism = 8
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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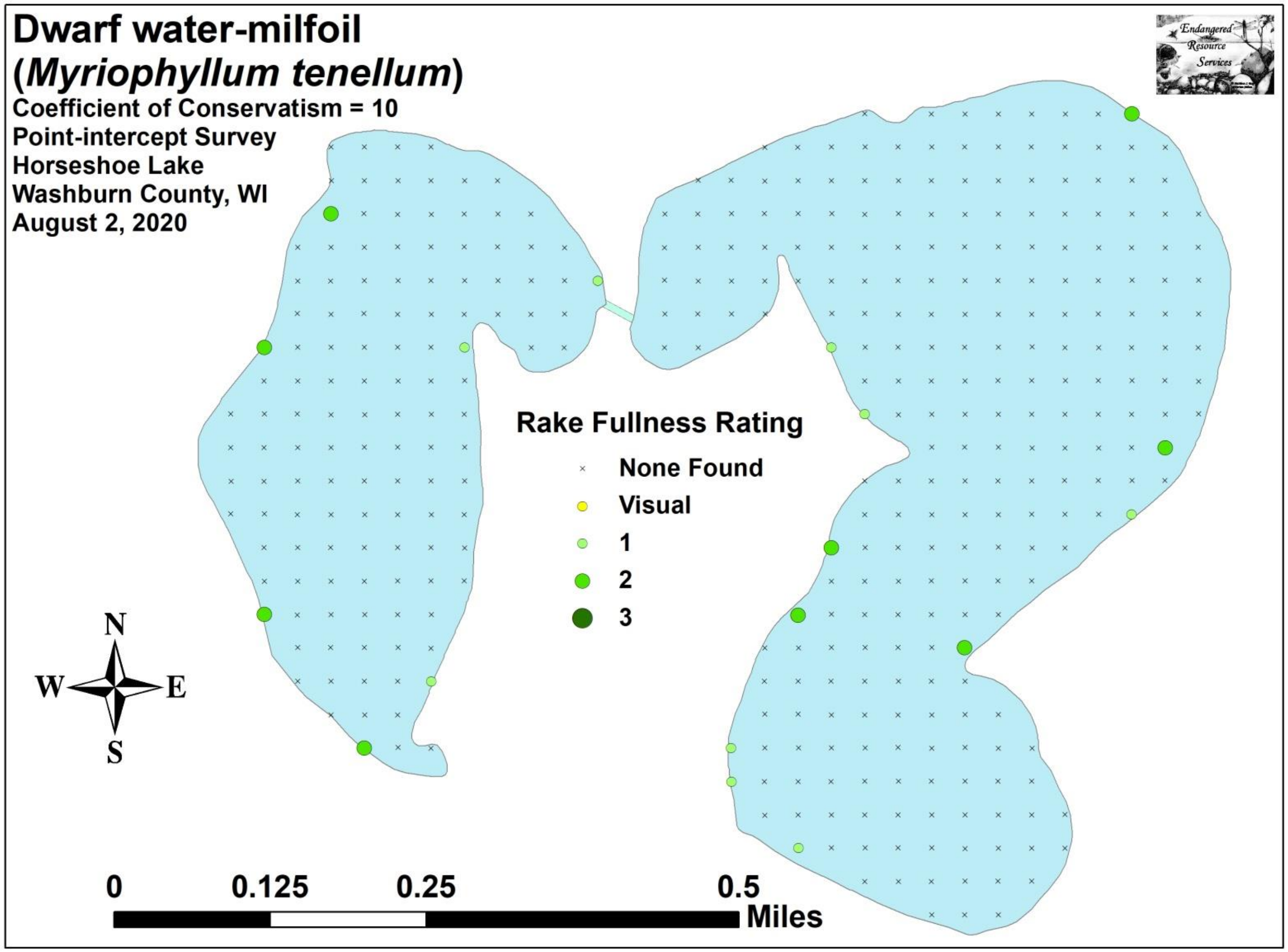
Miles


Dwarf water-milfoil
(*Myriophyllum tenellum*)
Coefficient of Conservatism = 10
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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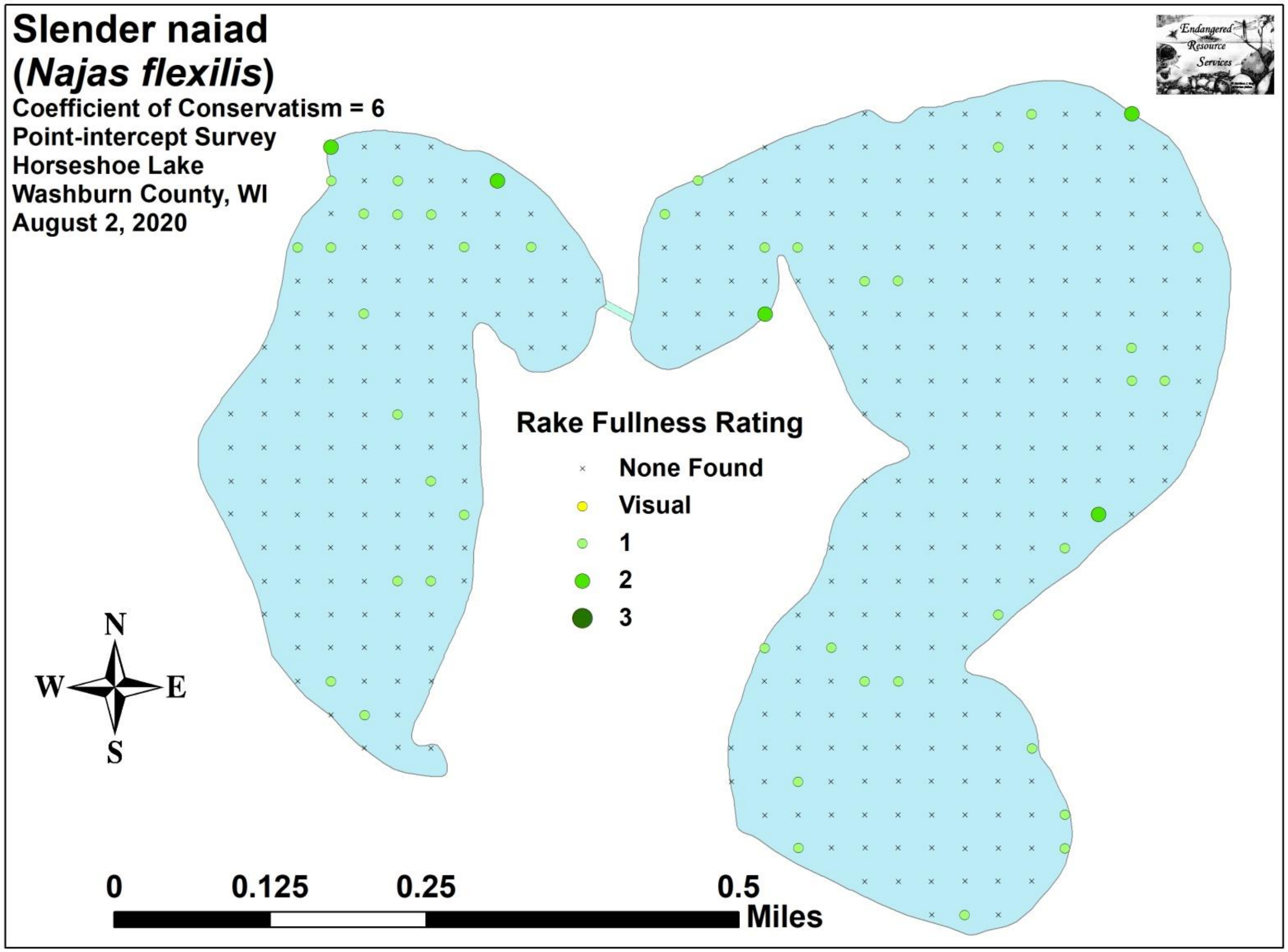
Miles


Slender naiad
(*Najas flexilis*)
Coefficient of Conservatism = 6
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Rake Fullness Rating
None Found
Visual
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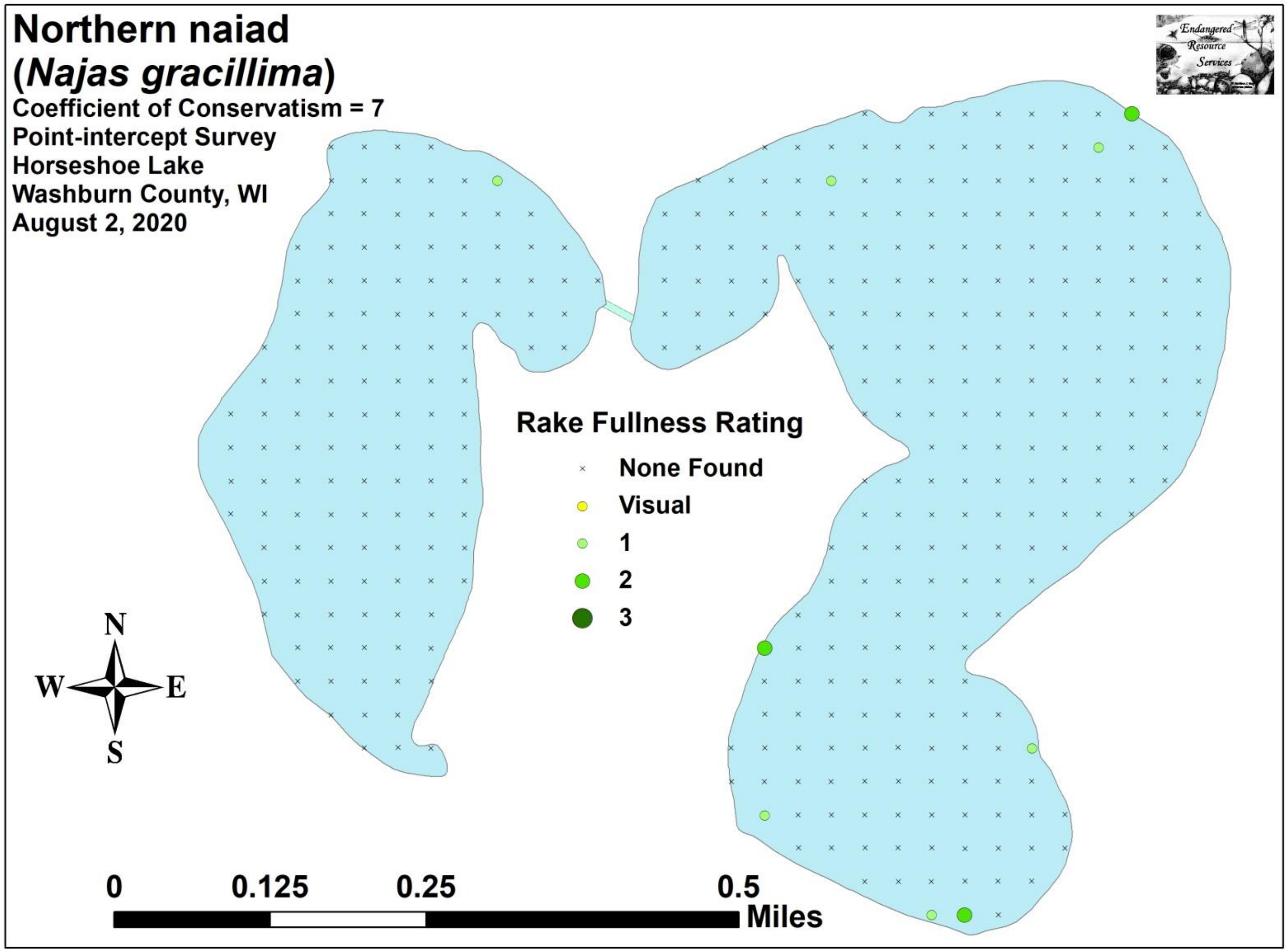
Miles
Endangered Resource Services



Northern naiad
(*Najas gracillima*)
Coefficient of Conservatism = 7
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered
Resource
Services
Rake Fullness Rating
None Found
Visual
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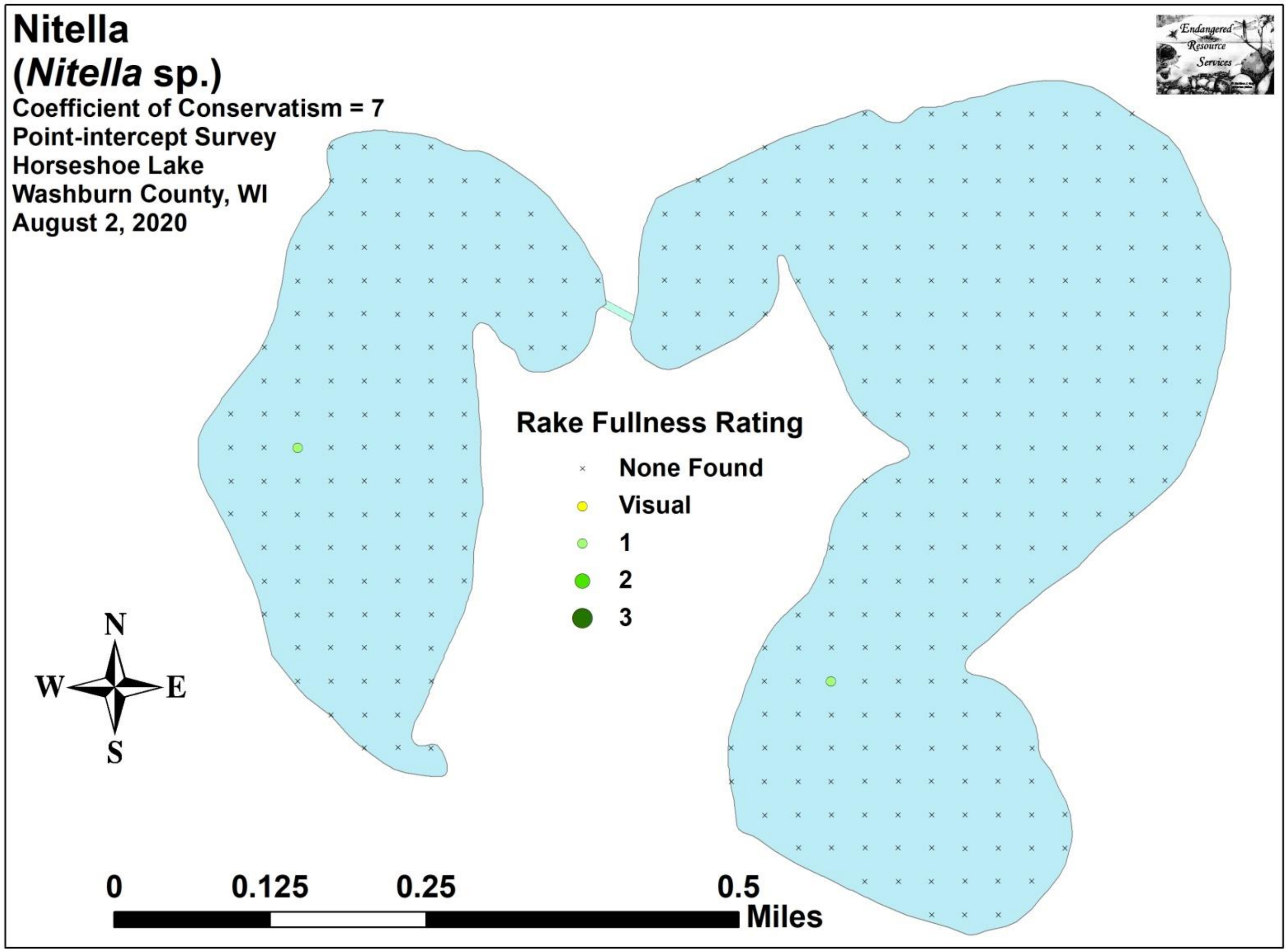
Miles


Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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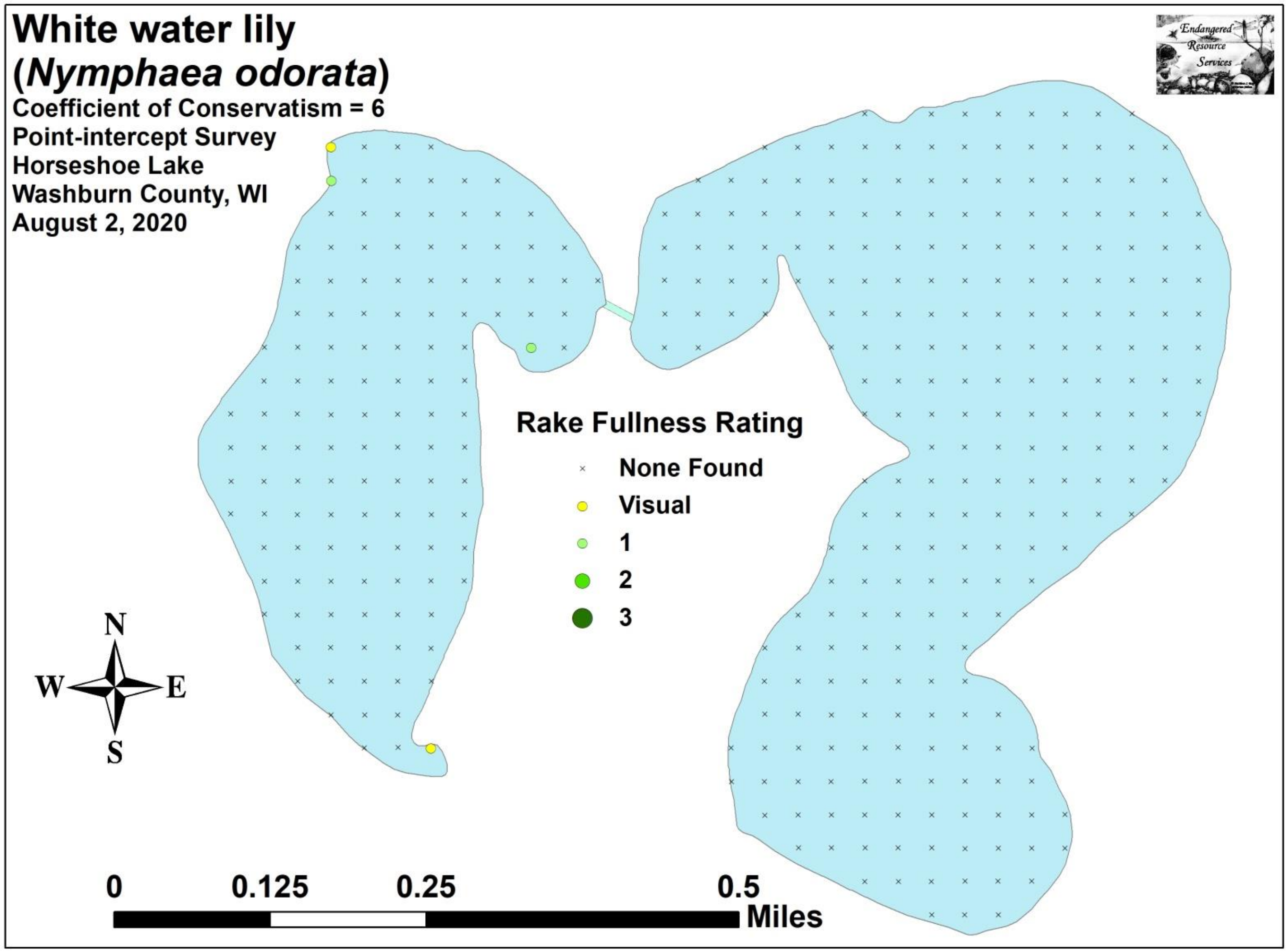
Miles


White water lily
(*Nymphaea odorata*)
Coefficient of Conservatism = 6
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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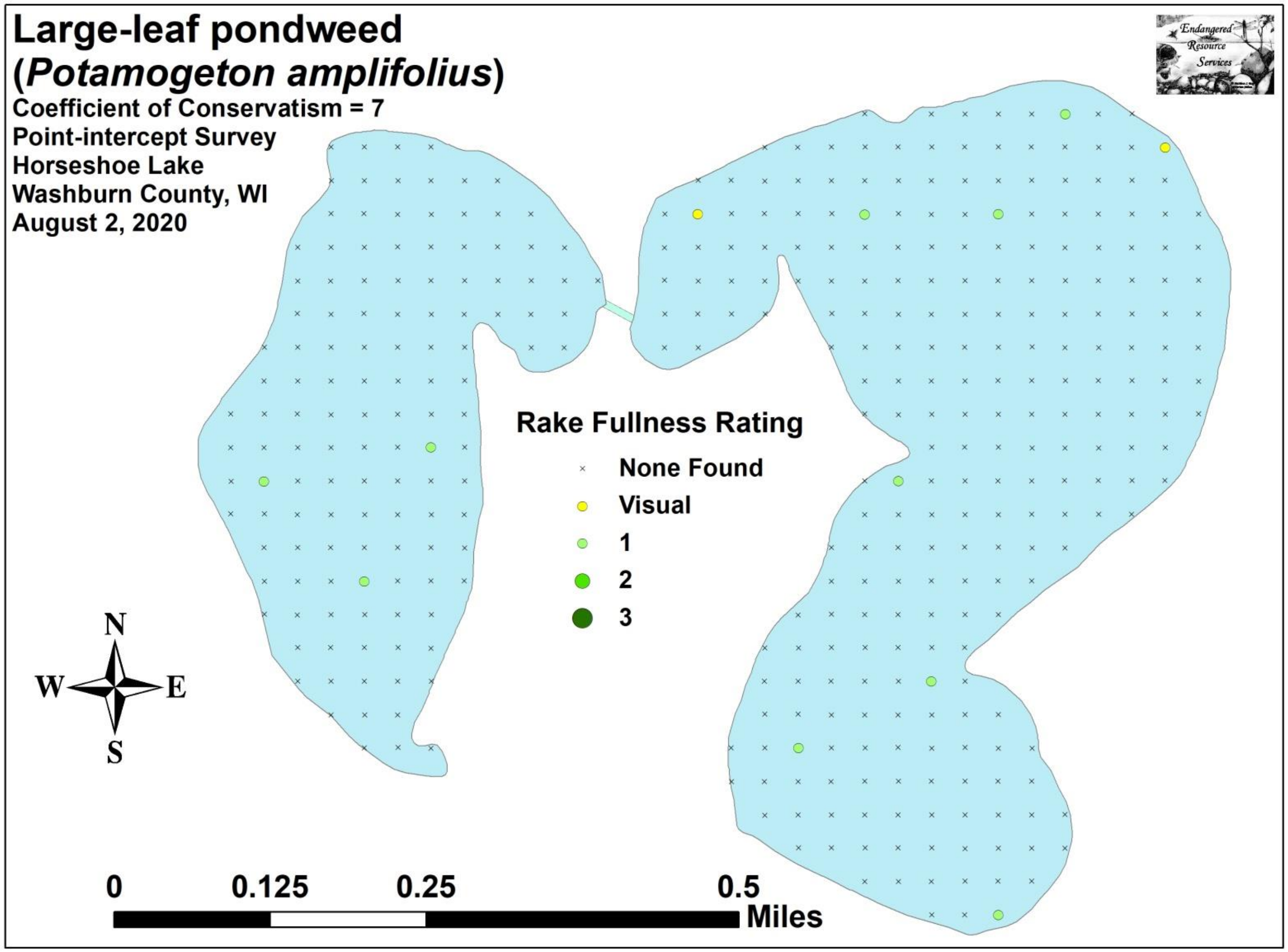
Miles


Large-leaf pondweed
(Potamogeton amplifolius)
Coefficient of Conservatism = 7
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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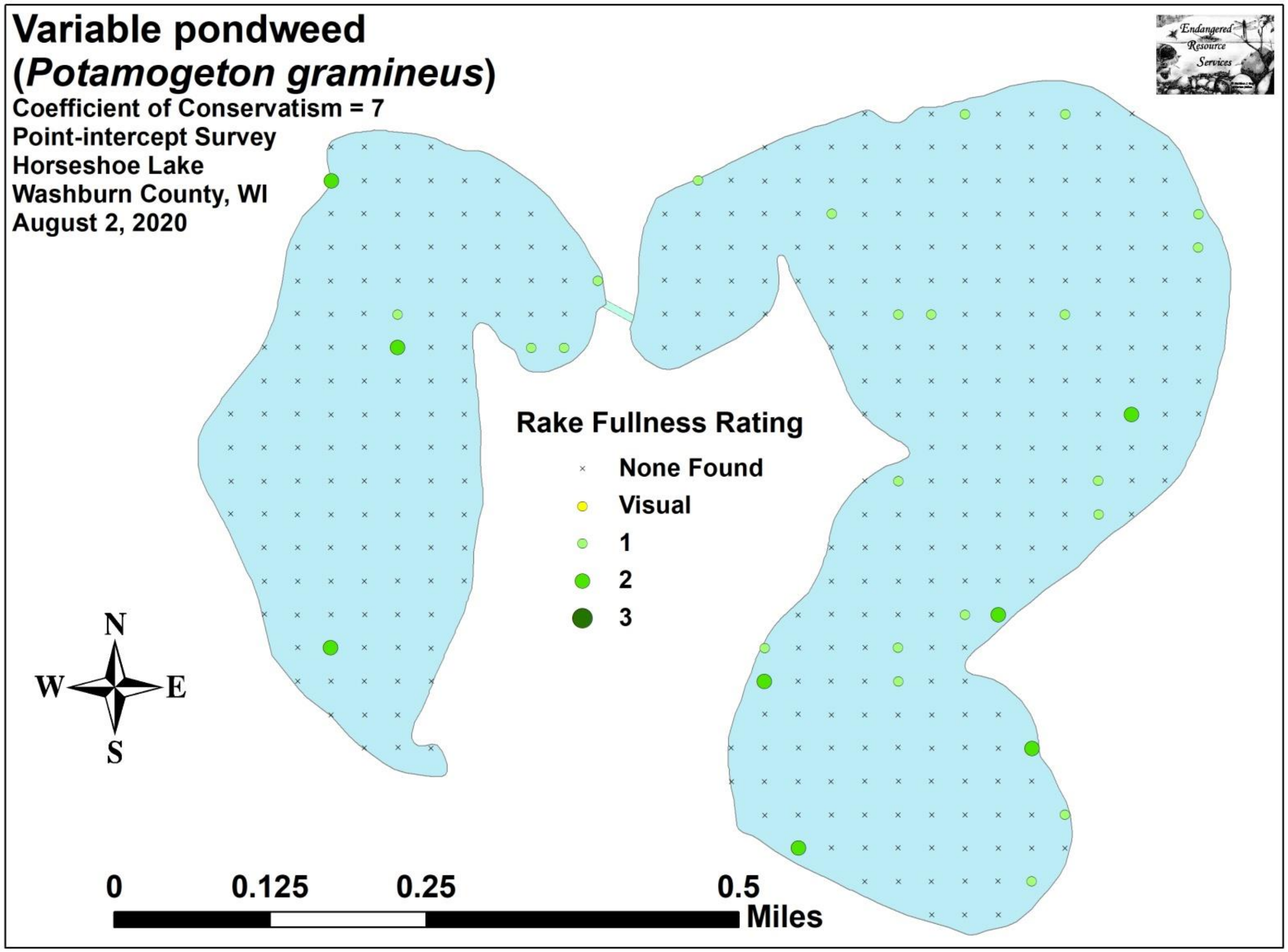
Miles



Variable pondweed
(*Potamogeton gramineus*)
Coefficient of Conservatism = 7
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered
Resource
Services
Rake Fullness Rating
None Found
Visual
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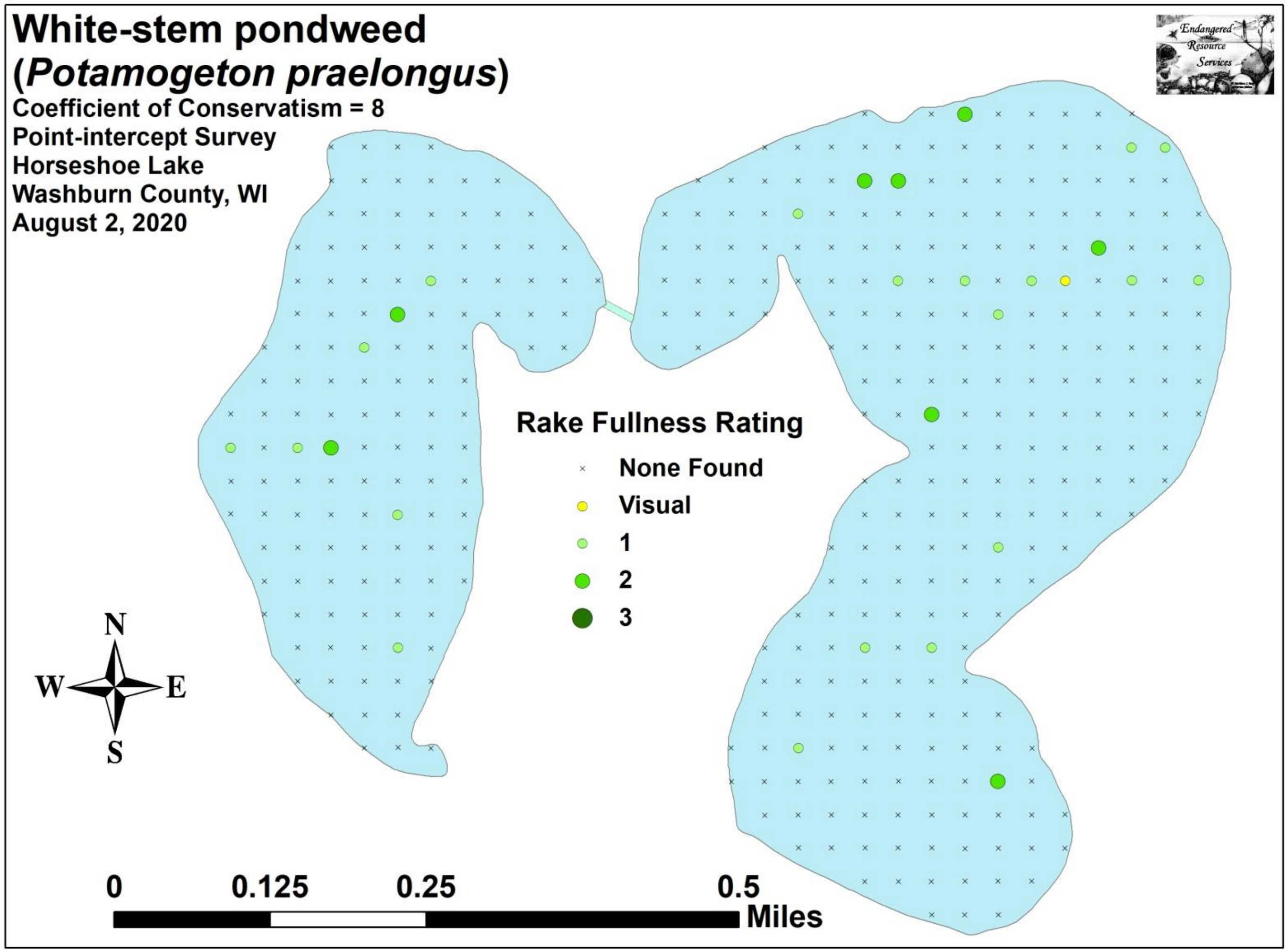
Miles


White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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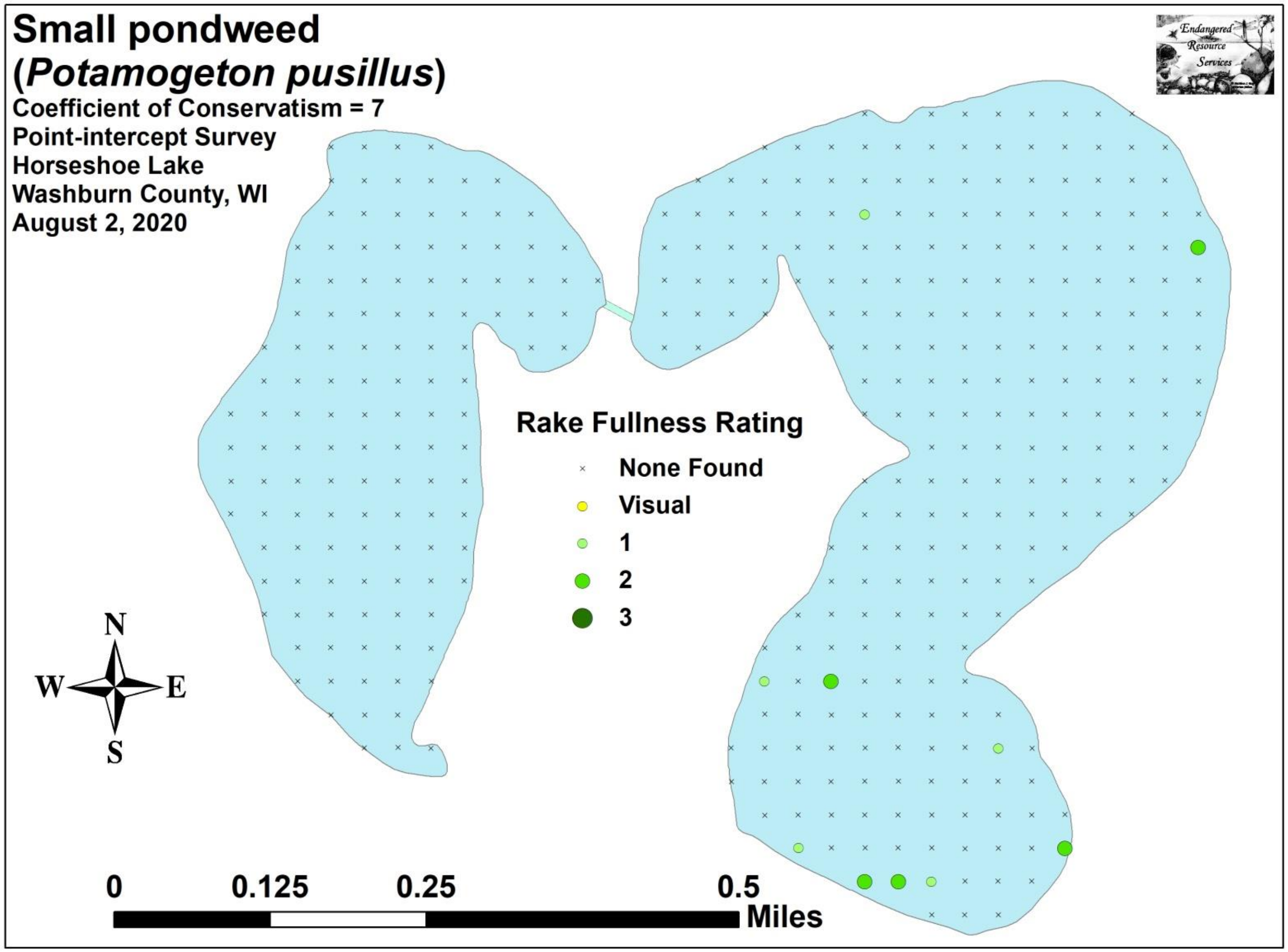
Miles


Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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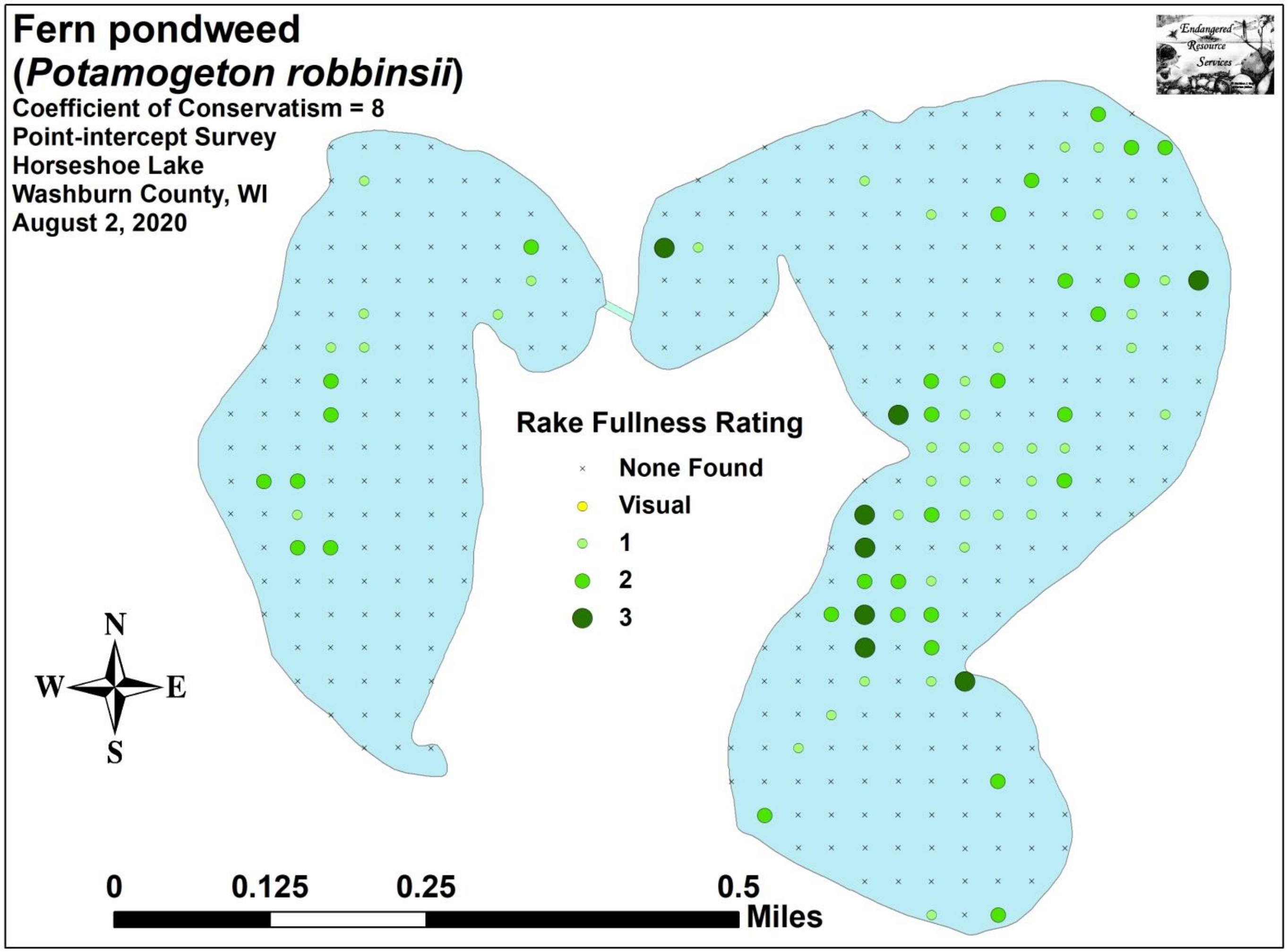
Miles


Fern pondweed
(*Potamogeton robbinsii*)
Coefficient of Conservatism = 8
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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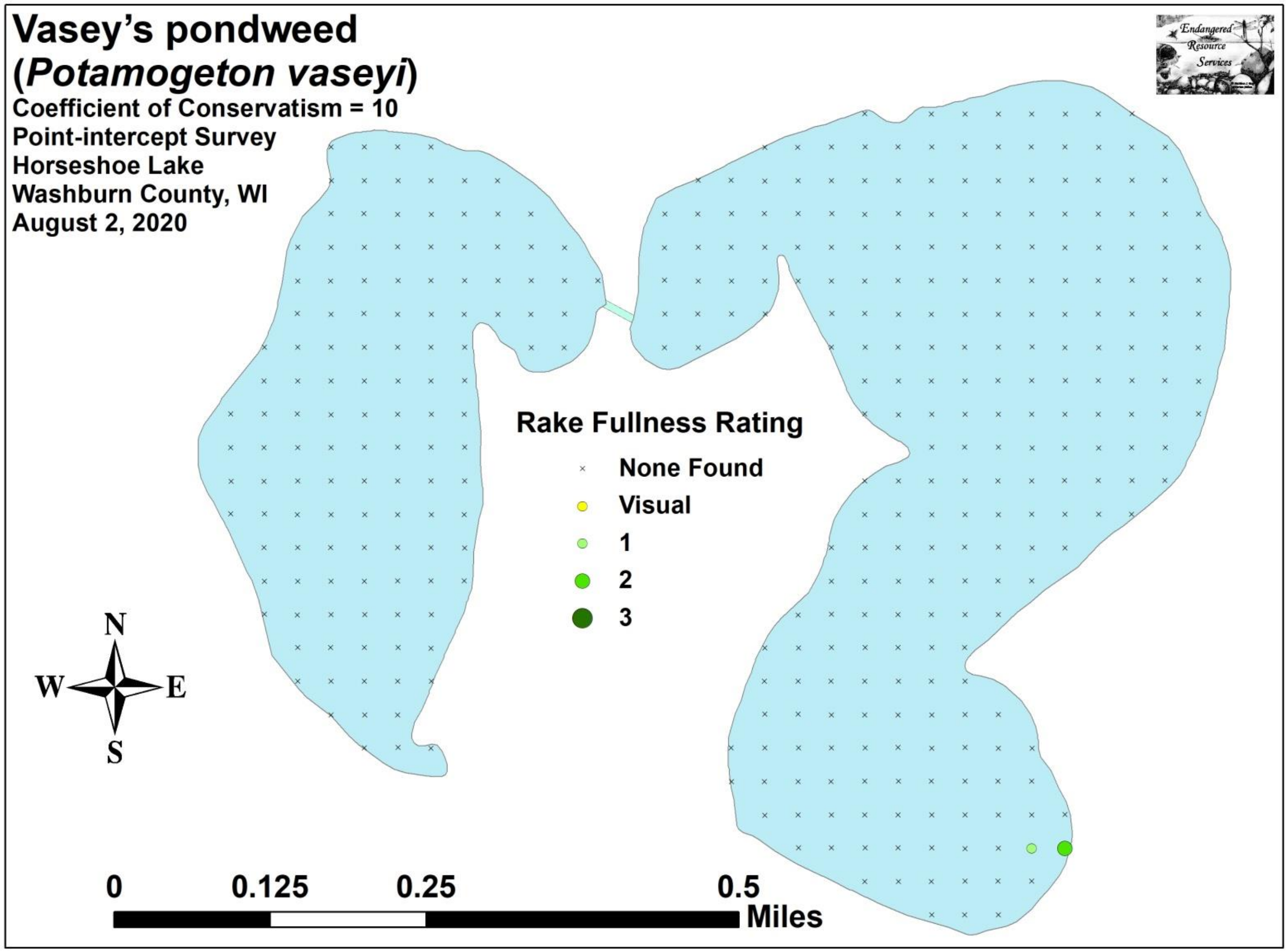
Miles


Vasey's pondweed
(Potamogeton vaseyi)
Coefficient of Conservatism = 10
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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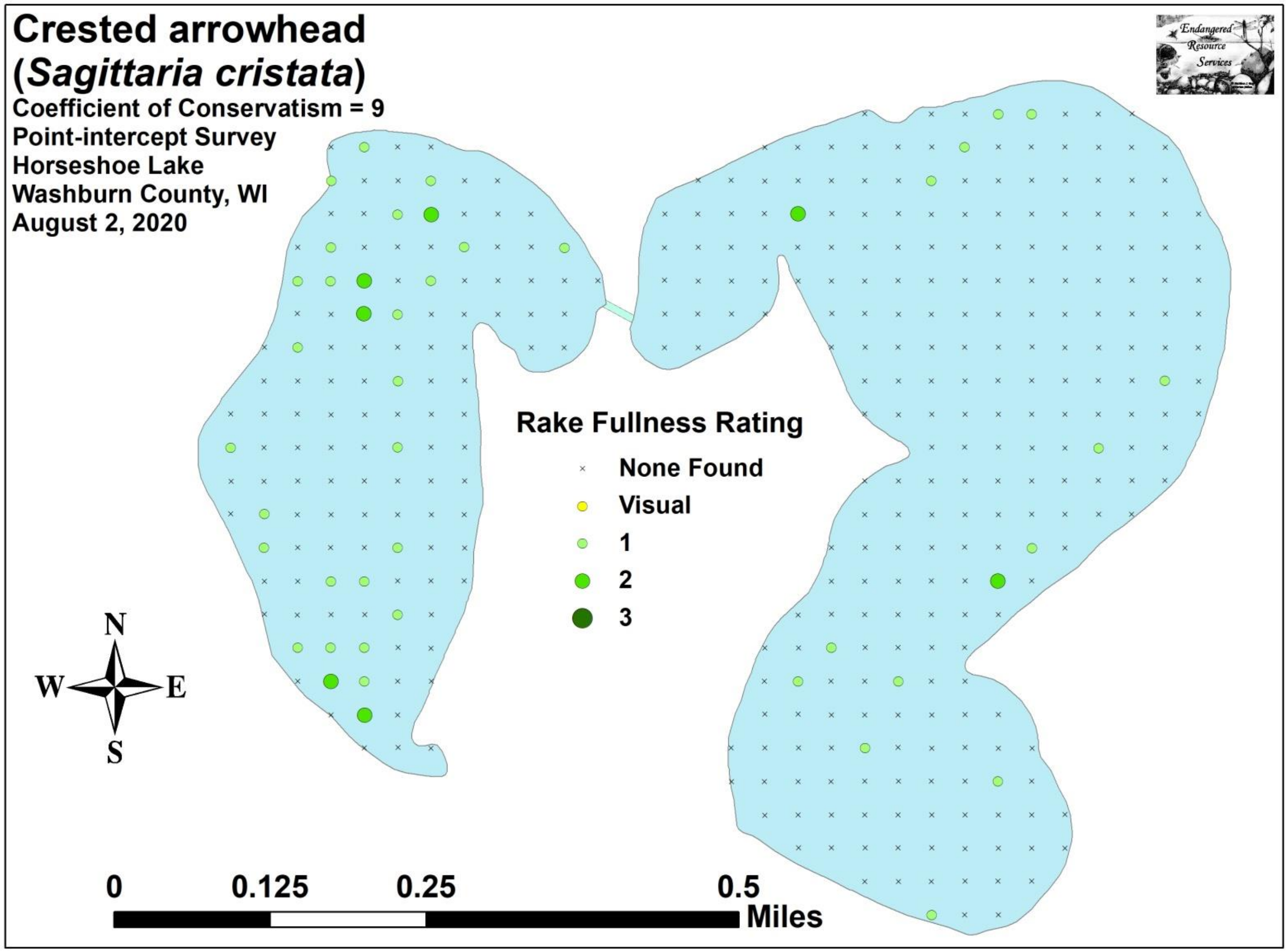
Miles


Crested arrowhead
(Sagittaria cristata)
Coefficient of Conservatism = 9
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Rake Fullness Rating
None Found
Visual
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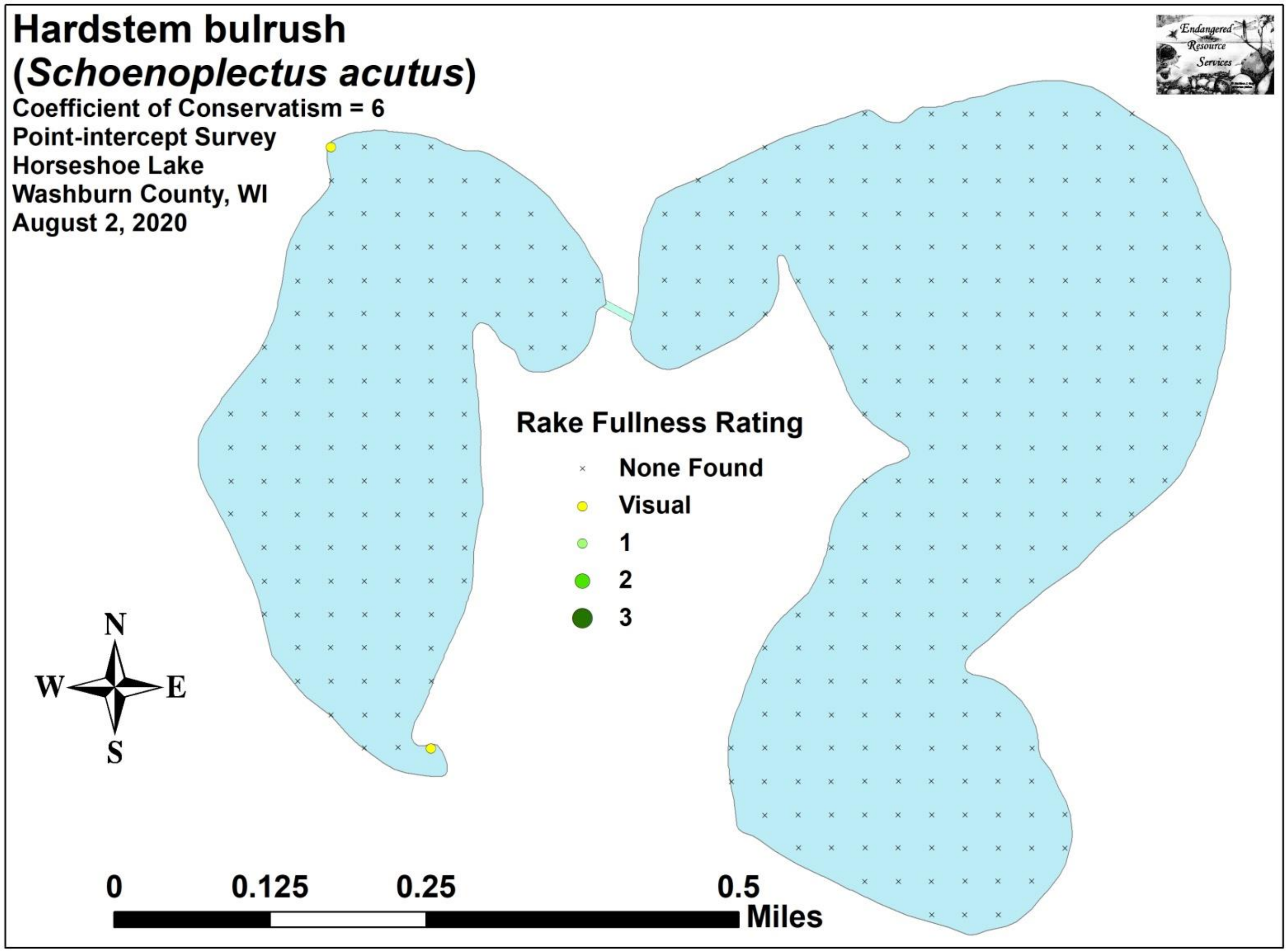
Miles



Hardstem bulrush
(Schoenoplectus acutus)
Coefficient of Conservatism = 6
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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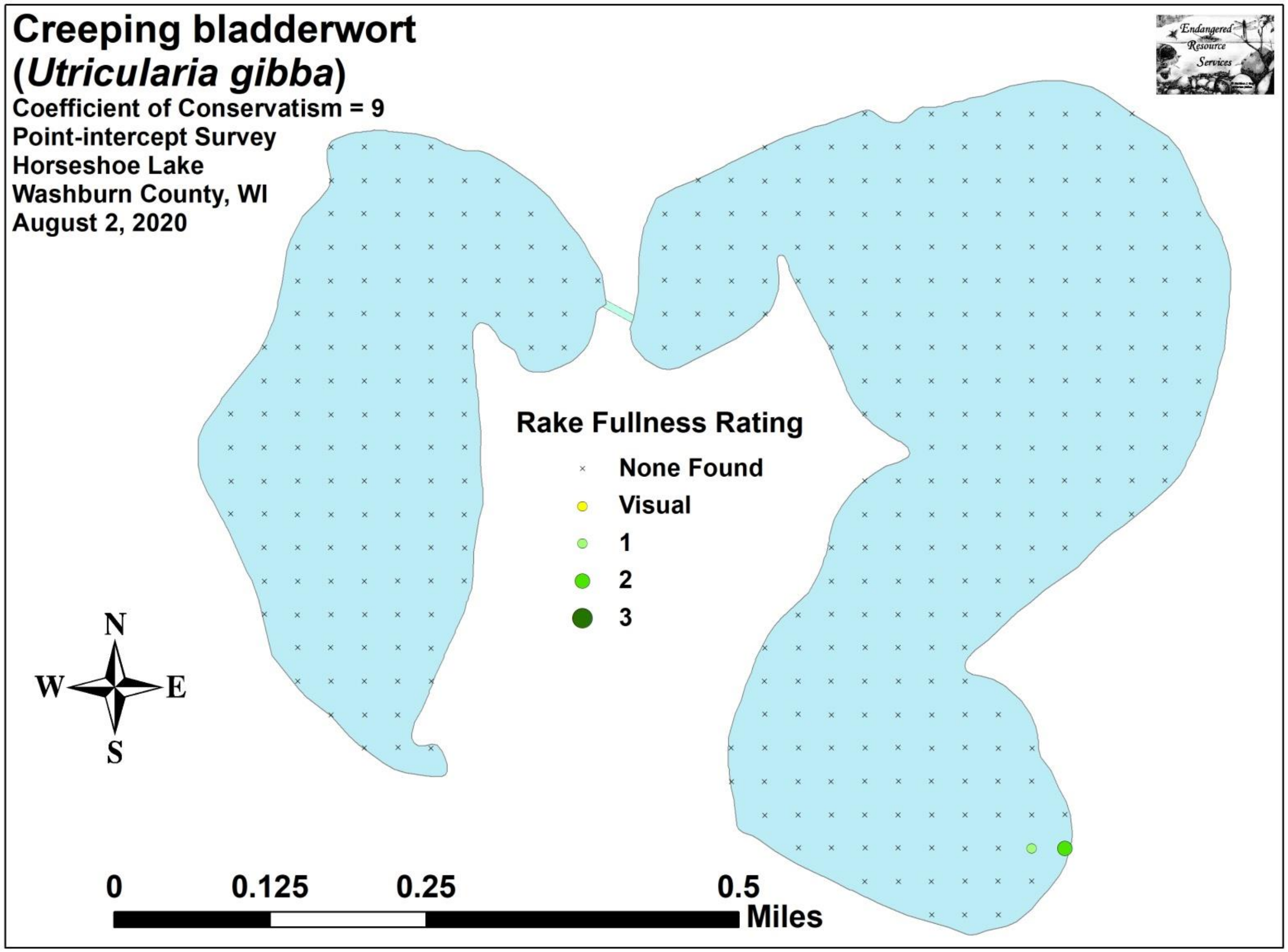
Miles


Creeping bladderwort
(*Utricularia gibba*)
Coefficient of Conservatism = 9
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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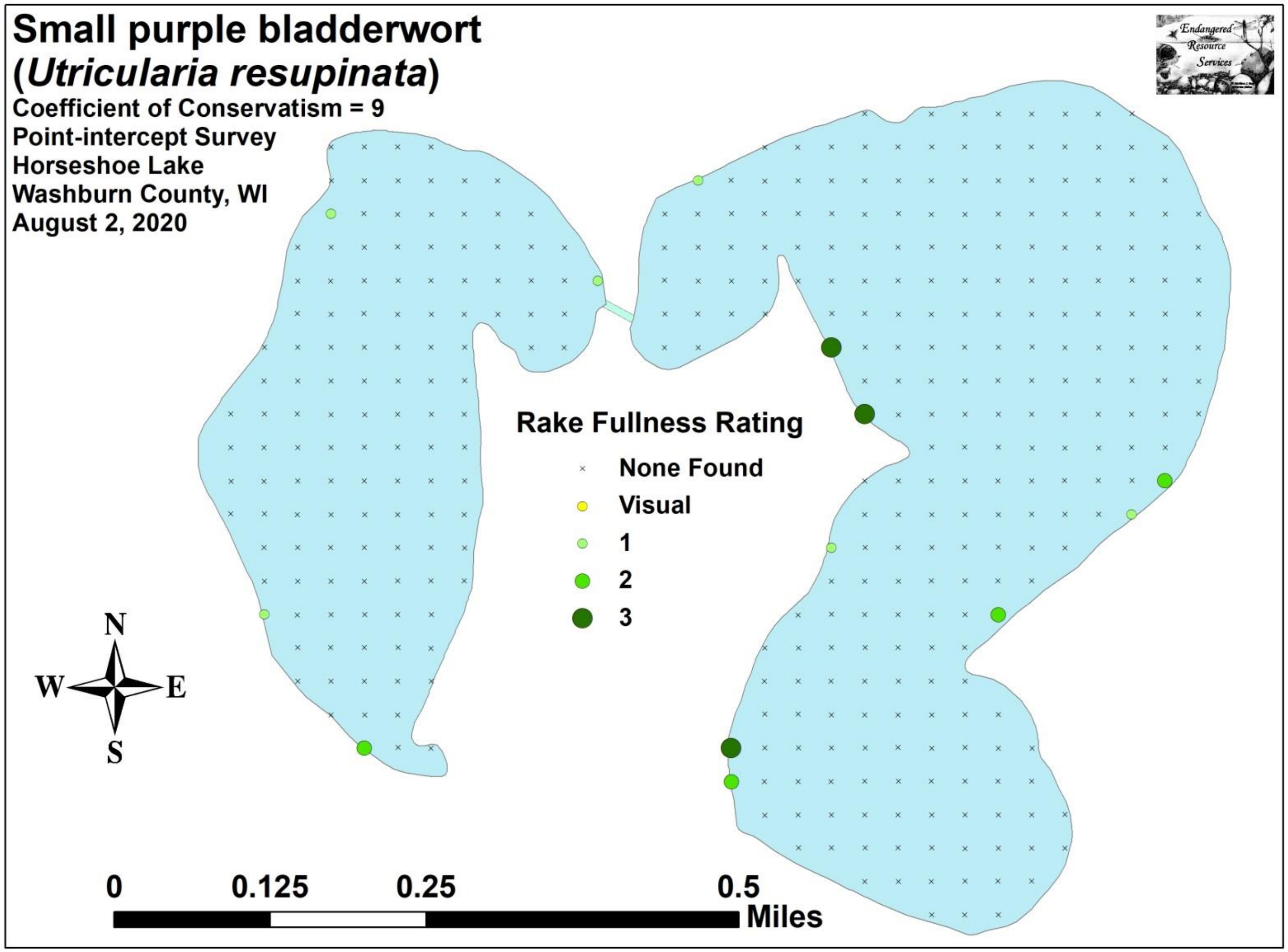
Miles


Small purple bladderwort
(*Utricularia resupinata*)
Coefficient of Conservatism = 9
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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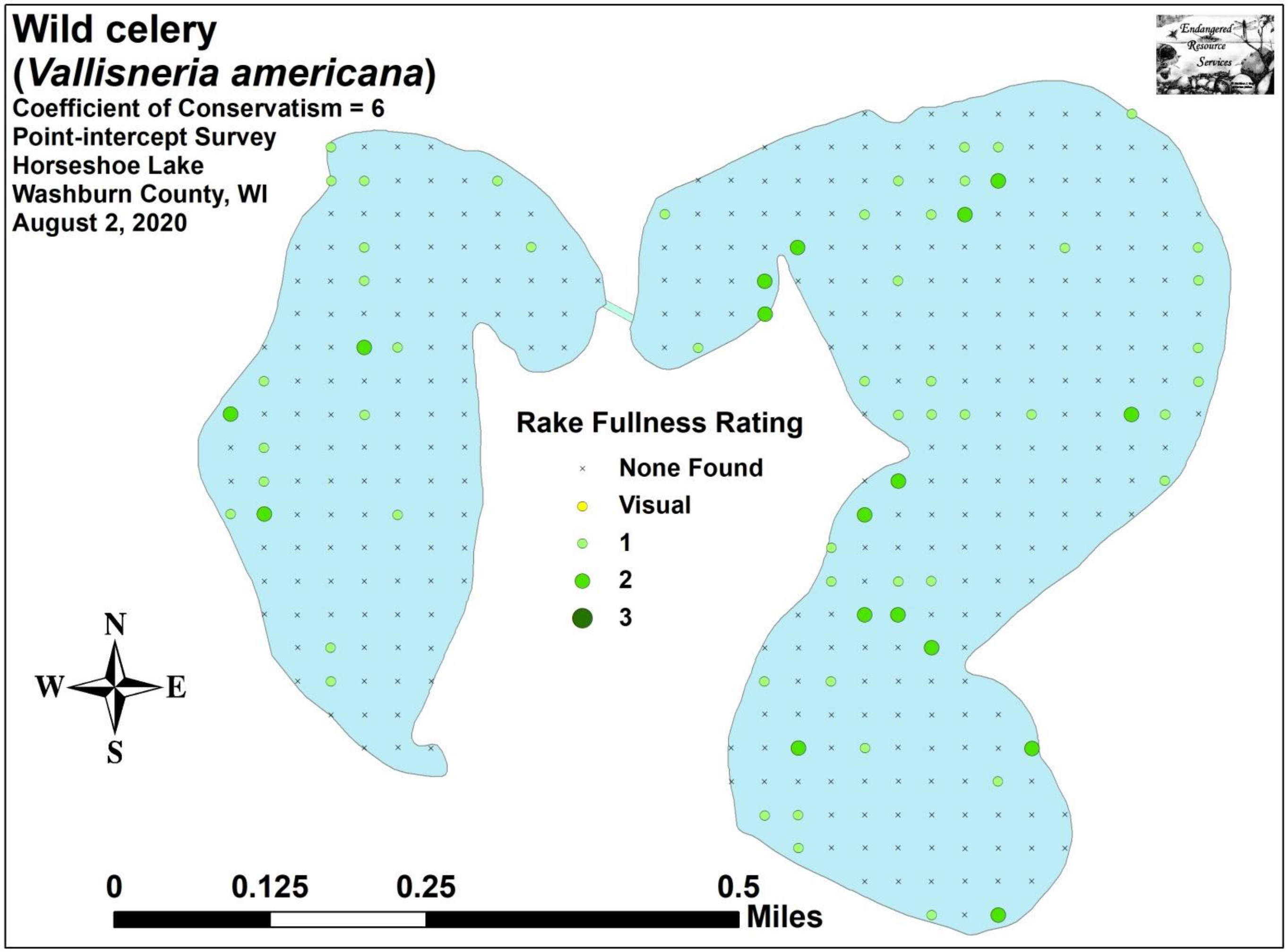
Miles


Wild celery
(*Vallisneria americana*)
Coefficient of Conservatism = 6
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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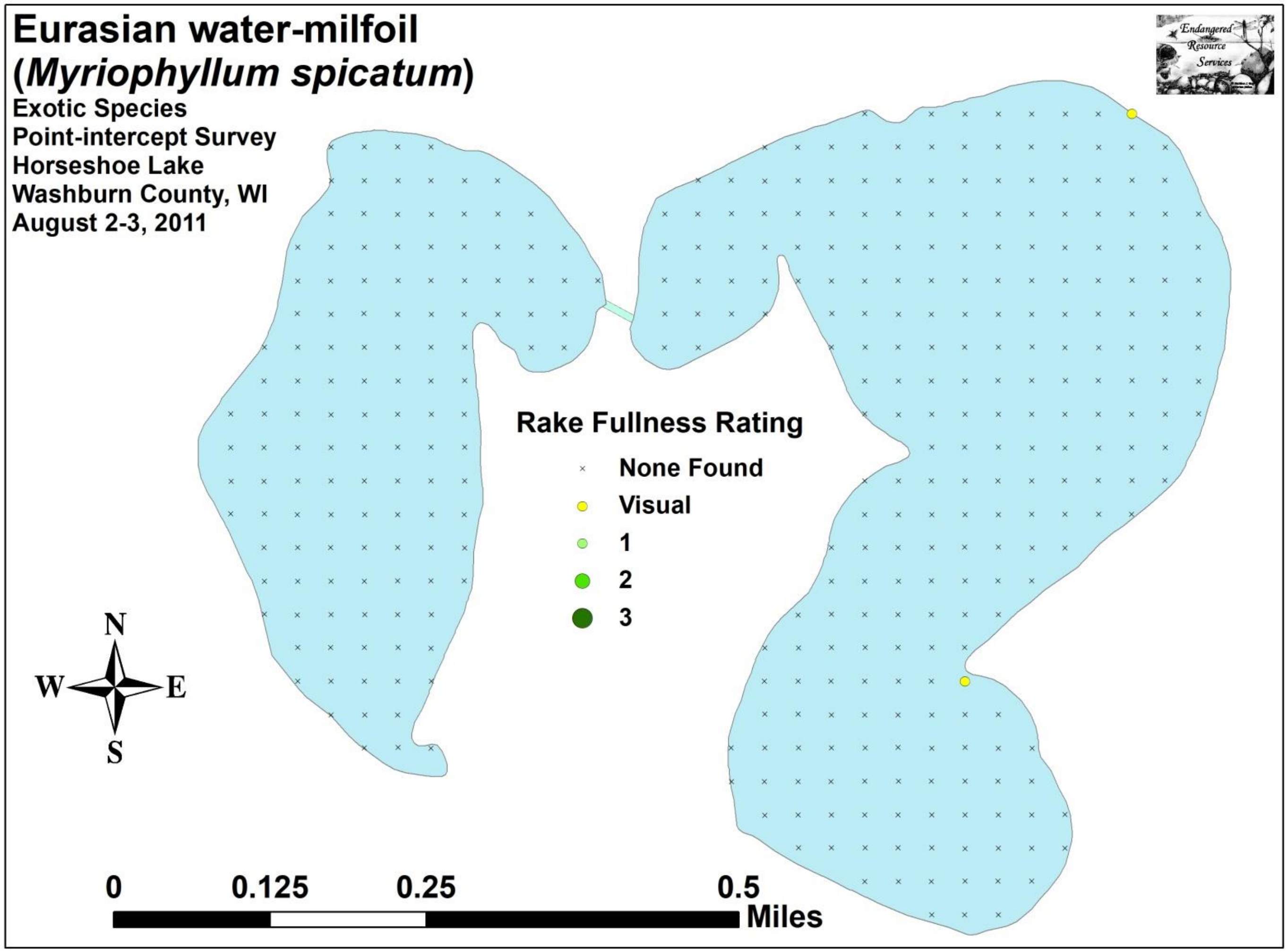
Miles

Appendix VII: 2011 and 2020 Eurasian Water-milfoil Density and Distribution Maps


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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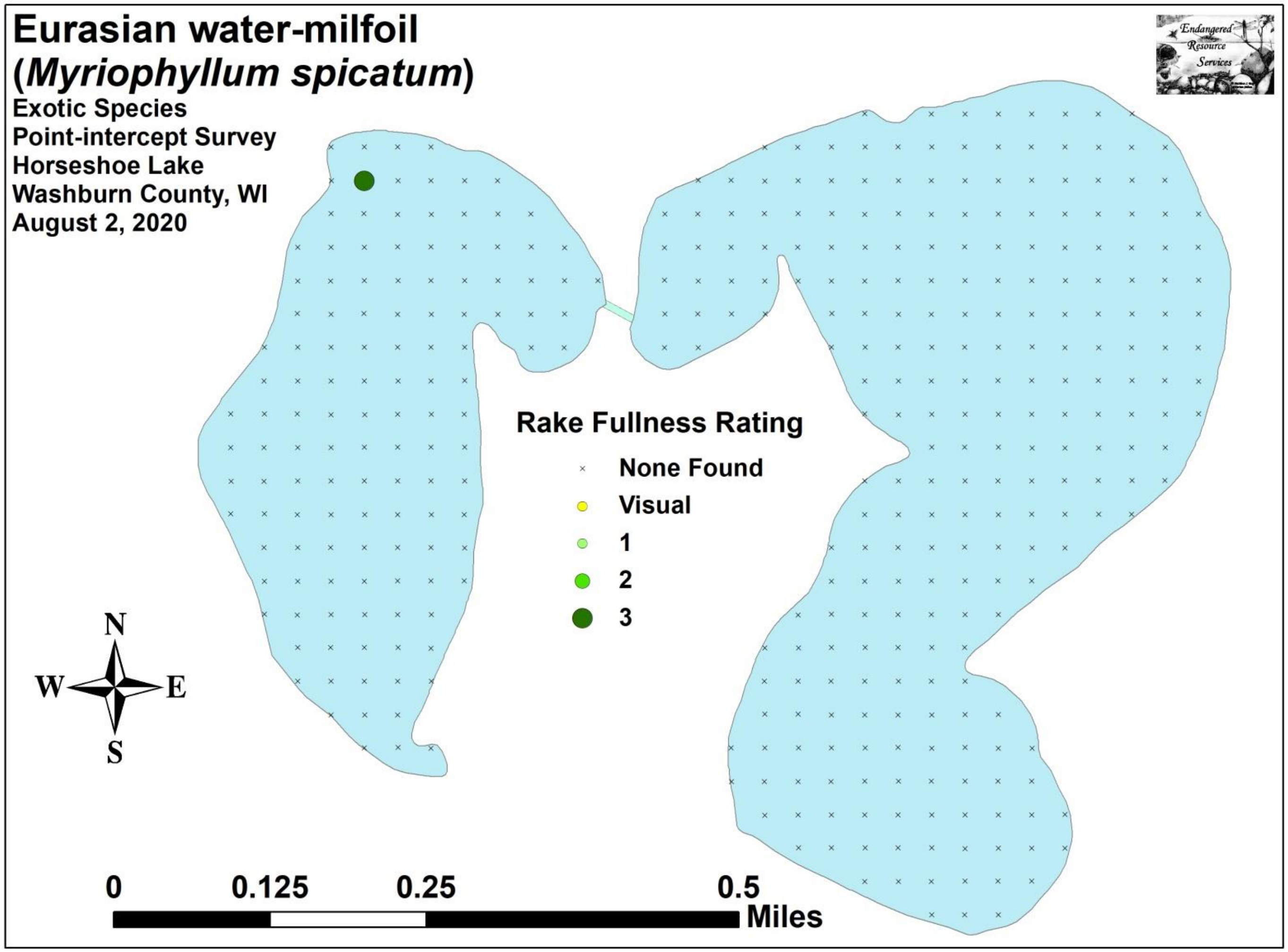
Miles


Eurasian water-milfoil
(*Myriophyllum spicatum*)
Exotic Species
Point-intercept Survey
Horseshoe Lake
Washburn County, WI
August 2, 2020
Endangered Resource Services
Rake Fullness Rating
None Found
Visual
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Miles

Appendix VIII: Aquatic Exotic Invasive Plant Species Information

Eurasian Water-milfoil

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

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

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

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

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

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

Curly-leaf pondweed

DESCRIPTION: Curly-leaf pondweed is an invasive aquatic perennial that is native to Eurasia, Africa, and Australia. It was accidentally introduced to United States waters in the mid-1880s by hobbyists who used it as an aquarium plant. The leaves are reddish-green, oblong, and about 3 inches long, with distinct wavy edges that are finely toothed. The stem of the plant is flat, reddish-brown and grows from 1 to 3 feet long. The plant usually drops to the lake bottom by early 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, 2010 http://www.dnr.state.wi.us/invasives/fact/curlyleaf_pondweed.htm)

Reed canary grass

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

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

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

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

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

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

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

Purple loosestrife
(Photo Courtesy Brian M. Collins)

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

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

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

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

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

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

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

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

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

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

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

Aquatic:
organisms that live in or frequent water.

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

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

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

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

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

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

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

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

Limnology:
the study of inland lakes and waters.

Littoral:

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

Macrophytes:

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

Nutrients:

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

Organic Matter:

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

Photosynthesis:

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

Phytoplankton:

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

Plankton:

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

ppm:

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

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

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

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

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

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

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

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

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

Appendix X: 2020 Raw Data Spreadsheets