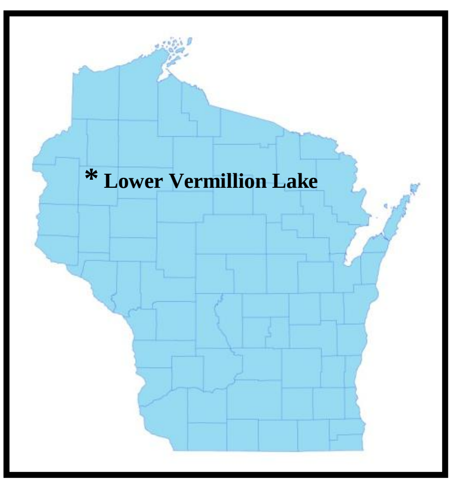
Eurasian water-milfoil (*Myriophyllum spicatum*) and Curly-leaf pondweed (*Potamogeton crispus*)
Pre/Posttreatment and Fall EWM Bed Mapping Surveys
Lower Vermillion Lake – WBIC: 2098200
Barron County, Wisconsin

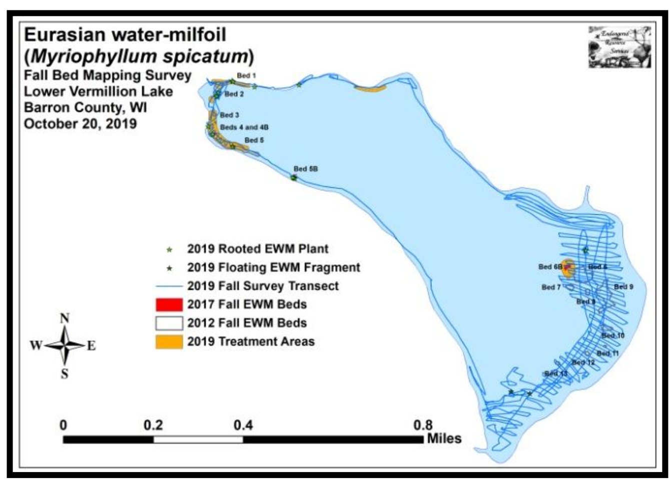

2019 EWM/CLP Treatment Areas


Eurasian water milfoil (Berg 2007)

Project Initiated by:

Vermillion Lakes Association, Wisconsin Department of Natural Resources and Lake Education and Planning Services, LLC (WDNR Grant ACEI20518)





2019 Fall EWM Bed Mapping Survey

Surveys Conducted by and Report Prepared by:

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St. Croix Falls, Wisconsin
May 14, June 30, and October 20, 2019

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INTRODUCTION:

Lower Vermillion Lake (WBIC 2098200) is a 215 acres stratified drainage lake in northwestern Barron County, Wisconsin in the Town of Cumberland (T35N R13W S22 SW NE). It reaches a maximum depth of 55 feet in the central basin and has an average depth of approximately 25ft (Busch et al 1967). The lake is mesotrophic in nature, and, from 2000-2019, water clarity has been fair to good with summer Secchi readings ranging from 6-12ft and averaging 8.9ft (WDNR 2019). This clarity produced a littoral zone that reached approximately 12.5ft in 2019. Bottom substrates along the north, south, and southeastern shorelines are primarily rock and sand, while most of the east bay and main basin are organic muck or sandy muck.

Figure 1: Aerial Photo of 2019 EWM/CLP Treatment Areas

BACKGROUND AND STUDY RATIONALE:

In 2008, the Wisconsin Department of Natural Resources (WDNR) confirmed the presence of Eurasian Water-milfoil (EWM) (*Myriophyllum spicatum*) in Lower Vermillion Lake, and the Vermillion Lakes Association (VLA) has been actively working to control this exotic invasive species ever since. Following the 2018 fall EWM bed mapping survey that found scattered patches of EWM throughout the northwest bays near the boat landing and in the east bay, the VLA, under the direction of D. Blumer - Lake Education and Planning Services, LLC (LEAPS) and in accordance with their WDNR approved Aquatic Plant Management Plan, decided to chemically treat five areas totaling approximately 2.78 acres (1.29% of the lake's total surface area) in 2019. The majority of these areas were simultaneously treated for Curly-leaf pondweed (CLP) (*Potamogeton crispus*) – another exotic invasive species that is locally abundant early in the growing season (Figure 1).

On May 14th, we conducted a pretreatment survey to gather baseline data from the scheduled treatment areas and to allow LEAPS and the VLA to finalize treatment plans. Following the herbicide application on May 30th, we completed a June 30th posttreatment survey to evaluate the effectiveness of the treatment. We also performed an October 20th EWM bed-mapping survey to determine where control might be considered in 2019. This report is the summary analysis of these three field surveys.

METHODS:
Pre/Post Herbicide Survey:
LEAPS provided treatment area shapefiles, and we generated pre/post survey points based on the size and shape of the proposed treatment areas. The 86 point sampling grid at 12m resolution approximated to 28 pts/acre. Although this was almost triple the 4-10 pts/acre required by WDNR protocol for pre/post treatment surveys, the high number of points was requested due to the narrowness of the treatment area and the difficulty in getting enough points in the target depths (Appendix I).

During the surveys, we located each point using a handheld mapping GPS unit (Garmin 76CSx) and used a rake to sample an approximately 2.5ft section of the bottom. All plants on the rake were assigned a rake fullness value of 1-3 as an estimation of abundance, and a total rake fullness for all species was also recorded (Figure 2). Visual sightings of EWM and CLP were noted if they occurred within 6ft of the point; however, visuals of other species were not recorded as they do not figure into the pre/posttreatment calculation. In addition to plant data, we recorded the lake depth using a metered pole and the substrate (bottom) type when we could see it or reliably determine it with the rake.

We entered all data collected into the standard APM spreadsheet (Appendix II) (UWEX 2010). Data was analyzed using the linked statistical summary sheet and the WDNR pre/post analysis worksheet (UWEX 2010). For pre/post differences of 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 determined to be significant at $p<0.05$, moderately significant at $p<0.01$ and highly significant at $p<0.001$.

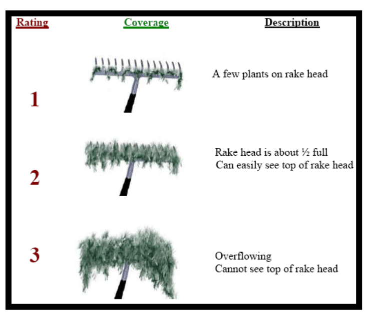


Figure 2: Rake Fullness Ratings

Fall Eurasian Water-milfoil Bed Mapping:
During the fall survey, we searched the visible littoral zone of the lake and mapped all known beds of EWM. A “bed” was determined to be any area where we visually estimated that EWM made up >50% of the area’s plants and was generally continuous with clearly defined borders. After we located a bed, we motored around the perimeter of the area, took GPS coordinates at regular intervals, and estimated both the range and mean rake fullness rating of EWM within the bed (Figure 2). Using the WDNR’s Forestry Tool’s Extension to ArcGIS 9.3.1, we plotted these coordinates to generate bed shapefiles and determine the acreage to the nearest hundredth of an acre. We also took waypoints of EWM plants outside these beds as they were generally few in number.

RESULTS AND DISCUSSION:

Finalization of Treatment Areas:

Initial expectations were to treat five areas totaling approximately 2.78 acres (Table 1). Although Eurasian water-milfoil was only found in the rake at a single point during the pretreatment survey, scattered plants were observed throughout the majority of the proposed treatment areas. Similarly, Curly-leaf pondweed was scattered throughout the proposed treatment areas. Because of this, it was decided to continue with the treatment as planned (Figure 3) (Appendix I). The chemical application was conducted by Northern Aquatic Services (Dresser, WI) on May 30th. The reported water temperature at the time of treatment was 59°F, while the air temp was 70°F. Winds were out of the north at 0-2mph.

Table 1: EWM/CLP Treatment Summary
Lower Vermillion Lake – May 30, 2019

Area	Total Area Acreage	Chemical (Brand), Rate, Total lbs/gal and Coverage
East Bay	0.67	2,4-D (Sculpin G) – 3ppm – 263.2 lbs – 0.67 acre Endothall (Aquathol K) – 4ppm – 12.7 gallons – 0.61 acre
North Shoreline	0.30	Endothall (Aquathol K) – 2.5ppm – 2.5 gallons – 0.30 acre
Northwest Bay - North Shoreline	0.56	2,4-D (Shredder Amine 4) – 4ppm – 2.6 gallons – 0.18 acre Endothall (Aquathol K) – 2.5ppm – 4.7 gallons – 0.56 acre
Northwest Bay - Center	0.10	2,4-D (Sculpin G) – 4ppm – 26.2lbs – 0.10 acre
Northwest Bay - South Shoreline	1.15	2,4-D (Shredder Amine 4) – 4ppm – 3.0 gallons – 0.26 acre Endothall (Aquathol K) – 2.5ppm – 7.7 gallons – 1.15 acres
Total Acres	**2.78**	

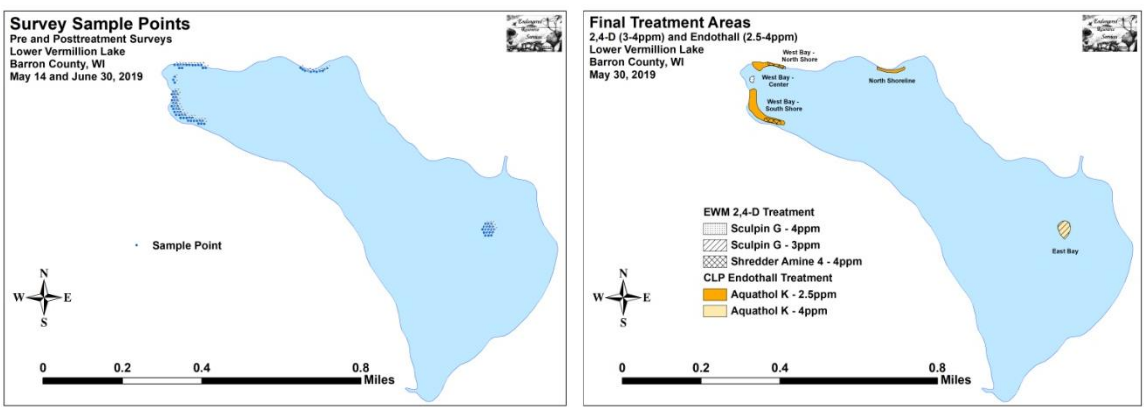


Figure 3: 2019 Survey Sample Points and Final Treatment Areas

Pre/Post Herbicide Survey:

All points occurred in areas between 1.0ft and 12.5ft of water. The mean depth for all plants was 5.4ft during both surveys; however, the median depth declined slightly from 5.5ft pretreatment to 5.3ft posttreatment (Table 2). Most Eurasian water-milfoil was established over sand and gravel, while Curly-leaf pondweed reached its highest densities over areas with at least some organic muck (Figure 4) (Appendix III).

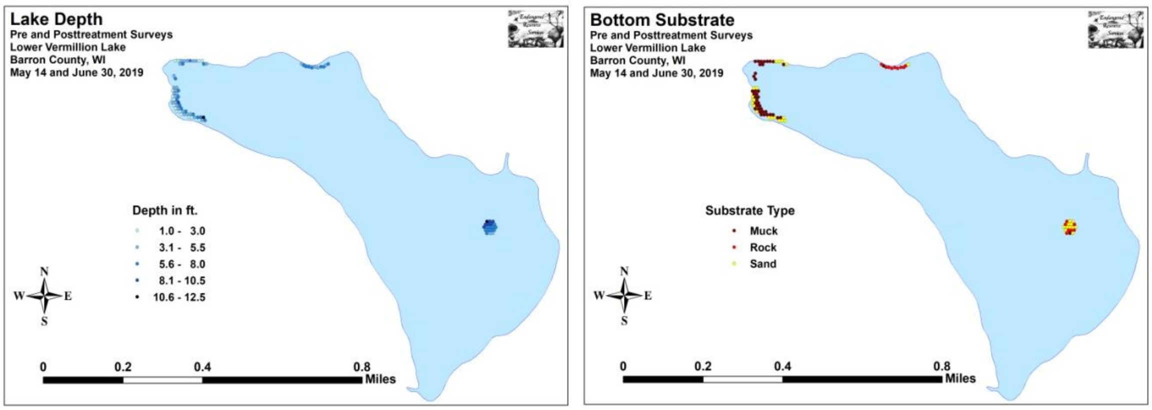


Figure 4: Treatment Area Depths and Bottom Substrate

The littoral zone was essentially unchanged at 12.0ft pretreatment and 12.5ft posttreatment. Within this zone, plants covered the majority of the bottom as the frequency of occurrence was 93.0% for each survey (Figure 5) (Appendix IV).

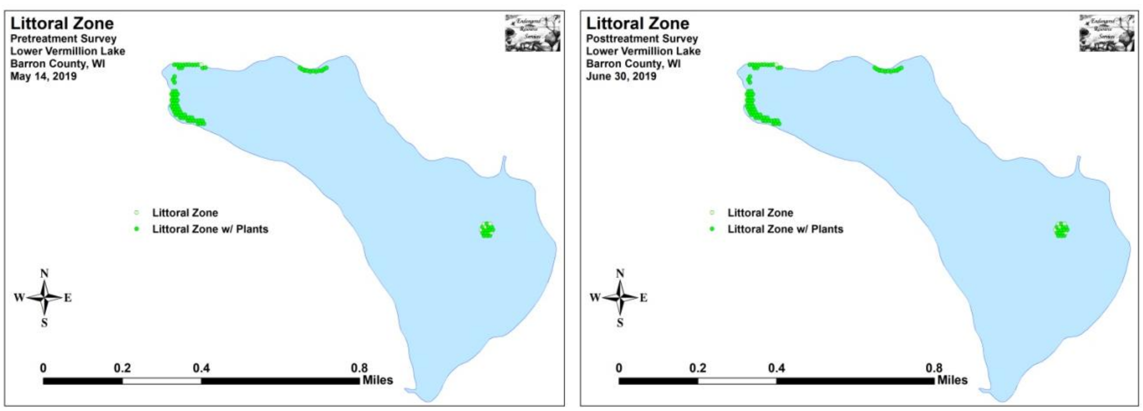


Figure 5: Pre/Posttreatment Littoral Zone

Diversity within the beds was moderate with a Simpson Index value of 0.75 pretreatment and 0.77 posttreatment. The Floristic Quality Index, another measure of only native species, decreased slightly from 22.5 pretreatment to 19.9 posttreatment. Total richness also declined slightly from 15 species pretreatment to 14 species posttreatment. However, the mean native species richness at sites with native vegetation experienced a non-significant increase (p=0.18) from 1.54 species/site pretreatment to 1.65 species/site posttreatment (Figure 6). Total rake fullness saw a moderate significant decline **(p=0.003)** from a low/moderate 1.84 pretreatment to a low 1.54 posttreatment (Figure 7) (Appendix IV).

Table 2: Pre/Posttreatment Surveys Summary Statistics
Lower Vermillion Lake, Barron County
May 14 and June 30, 2019

Summary Statistics:	Pre	Post
Total number of points sampled	86	86
Total number of sites with vegetation	80	80
Total number of sites shallower than the maximum depth of plants	86	86
Freq. of occur. at sites shallower than max. depth of plants (in percent)	93.0	93.0
Simpson Diversity Index	0.75	0.77
Mean Coefficient of Conservatism	6.2	5.8
Floristic Quality Index	22.5	19.9
Maximum depth of plants (ft)	12.0	12.5
Mean depth of plants (ft)	5.4	5.4
Median depth of plants (ft)	5.5	5.3
Average number of all species per site (shallower than max depth)	1.60	1.59
Average number of all species per site (veg. sites only)	1.73	1.71
Average number of native species per site (shallower than max depth)	1.40	1.51
Average number of native species per site (sites with native veg. only)	1.54	1.65
Species Richness	15	14
Mean Rake Fullness (veg. sites only)	1.84	1.54

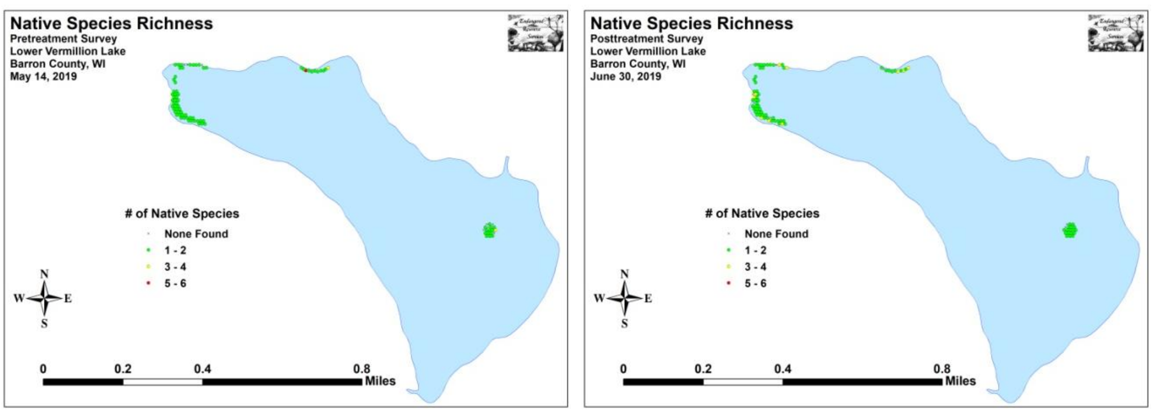


Figure 6: Pre/Posttreatment Native Species Richness

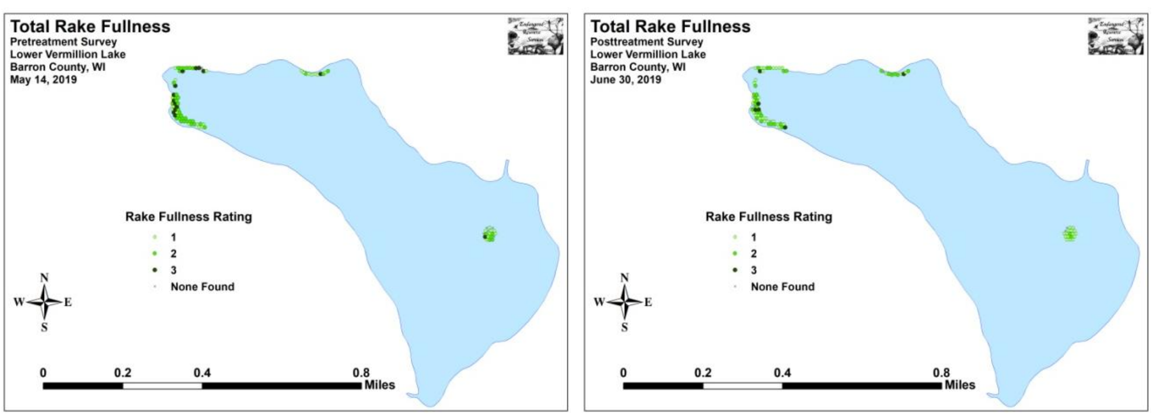
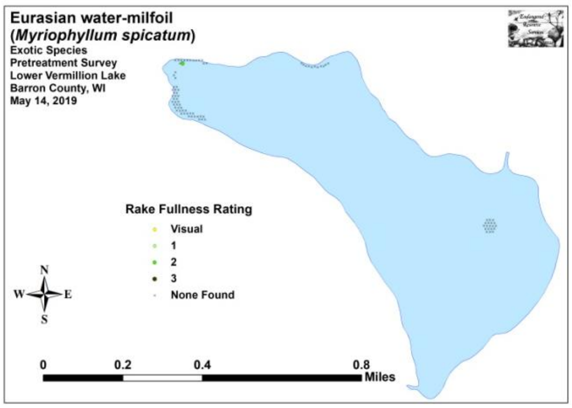


Figure 7: Pre/Posttreatment Total Rake Fullness

We found Eurasian water-milfoil at a single point with a rake fullness of 1 during the pretreatment survey. Despite this, we did note plants inter-point in the treatment areas. During the posttreatment survey, we located EWM at two points – one along the north shore and one in the west bay south of the boat landing (Figure 8) (Appendix V). We also saw several other large towers inter-point in the southwestern corner of the west bay. Although each of these plants was chemically burned, they all showed some evidence of regrowth. Because of this, we raked the majority of them out and notified both the VLA and LEAPS so they could check back on these locations during manual removal efforts throughout the rest of the summer. Due to the low number of EWM plants found during both surveys, none of our findings demonstrated a statistically significant change (Figure 9).



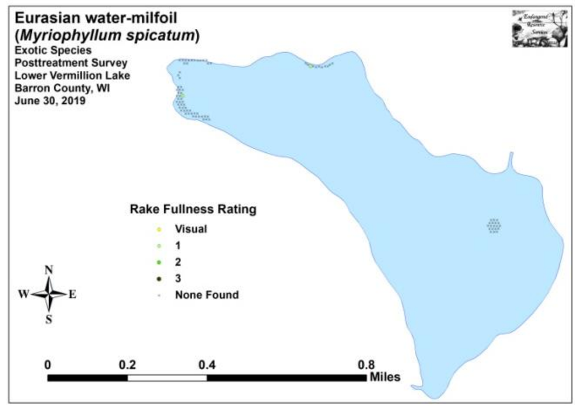
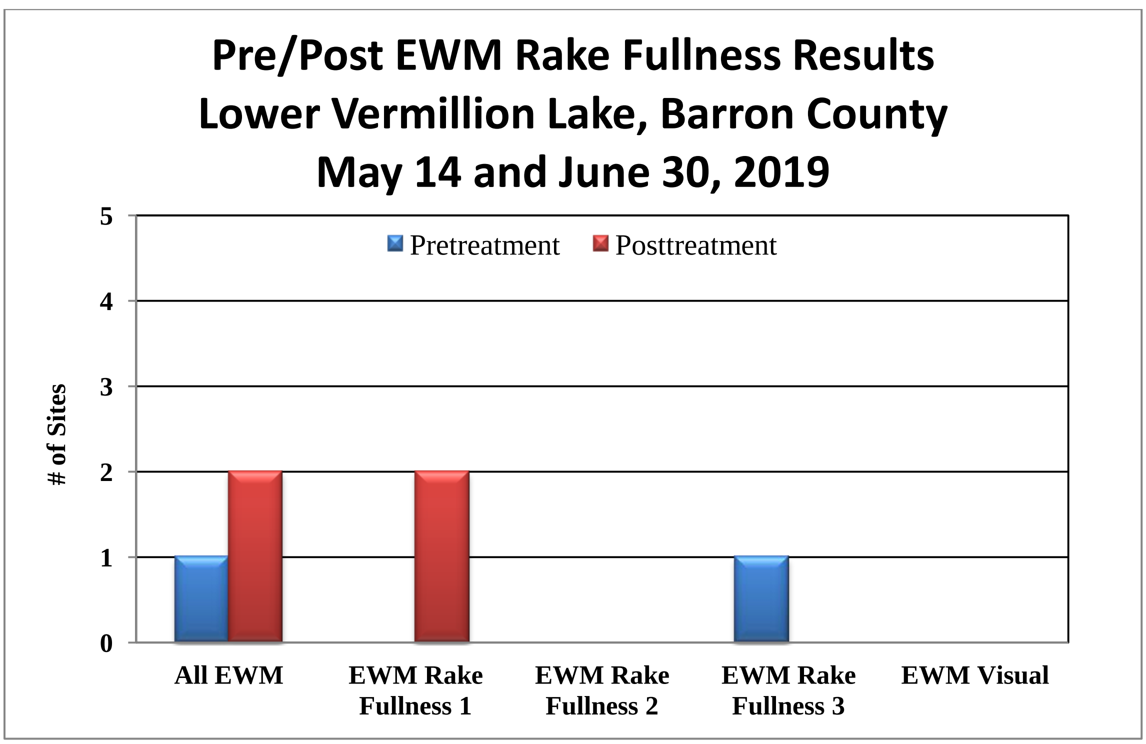


Figure 8: Pre/Posttreatment EWM Density and Distribution



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

Figure 9: Pre/Posttreatment Changes in EWM Rake Fullness

Curly-leaf pondweed was present at 17 of 86 sites during the pretreatment survey (19.8% coverage) with four additional visual sightings (Figure 10). Of these, one had a rake fullness rating of 3, nine rated a 2, and the remaining seven were a 1. This produced a mean rake fullness of 1.65 and suggested that 11.6% of the treatment areas had a significant infestation (rake fullness 2 or 3). During the posttreatment survey, we found CLP at just five points (5.8% coverage) all of which rated a 1 (Appendix V). **Our results demonstrated a moderately significant decline in total CLP distribution and rake fullness 2; and a significant decline in visual sightings** (Figure 11). They also demonstrated a highly significant decline **(*p*<0.001)** in mean rake fullness.

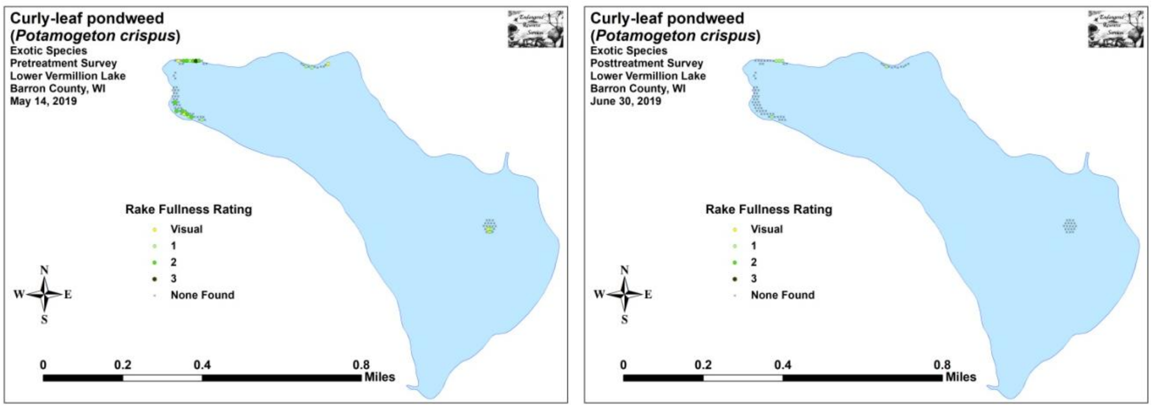
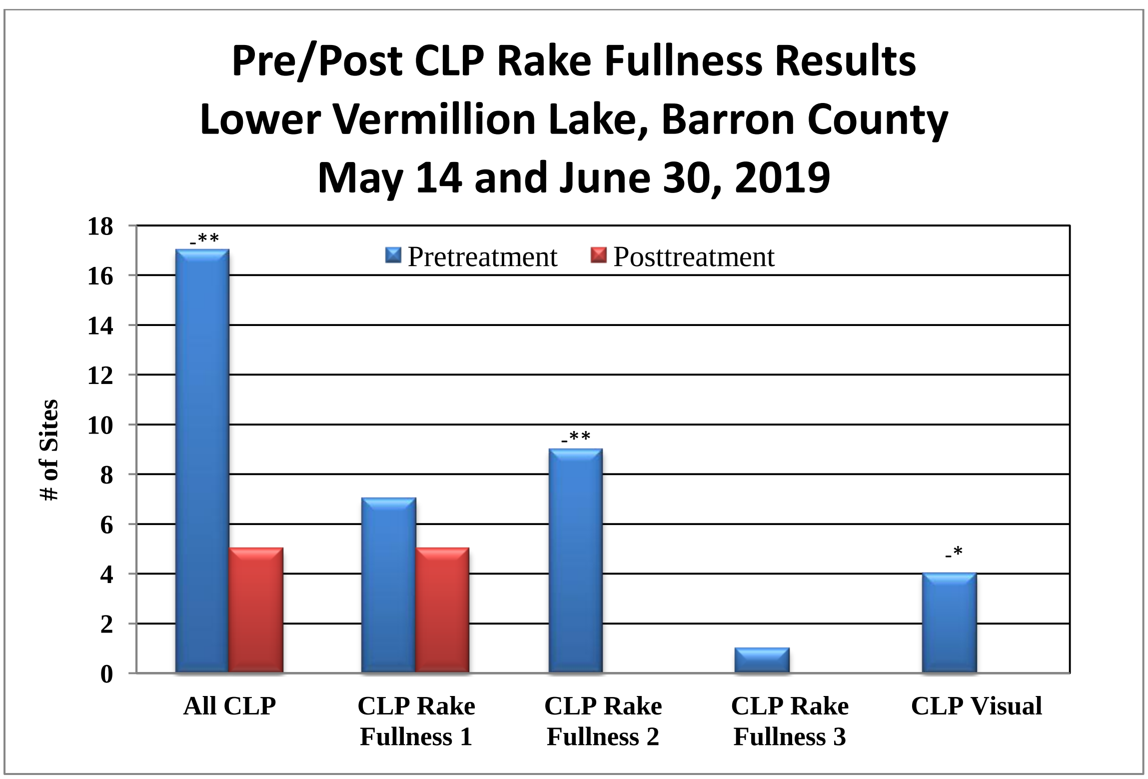


Figure 10: Pre/Posttreatment CLP Density and Distribution



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

Figure 11: Pre/Posttreatment Changes in CLP Rake Fullness

We found Coontail (*Ceratophyllum demersum*) and Common waterweed (*Elodea canadensis*) were the two most common native species in both the pre and posttreatment surveys (Tables 3 and 4). Present at 59 sites during the pretreatment survey, Coontail experience a non-significant decline (p=0.34) in distribution to 53 sites posttreatment. It also suffered a moderately significant decline **(p=0.005)** in mean rake fullness from 1.68 pre to 1.36 post (Figure 12).

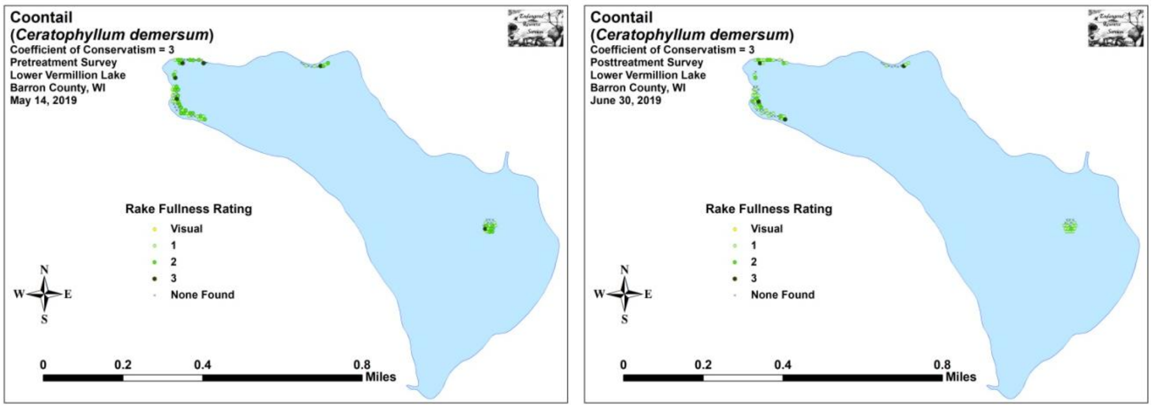


Figure 12: Pre/Post Coontail Density and Distribution

Common waterweed was present at 27 sites with a mean rake fullness of 1.74 during the pretreatment survey (Figure 13). Posttreatment, we found there was a non-significant expansion (p=0.26) to 34 sites. However, this was accompanied by a significant decline in density **(p=0.01)** to a mean rake fullness of 1.32.

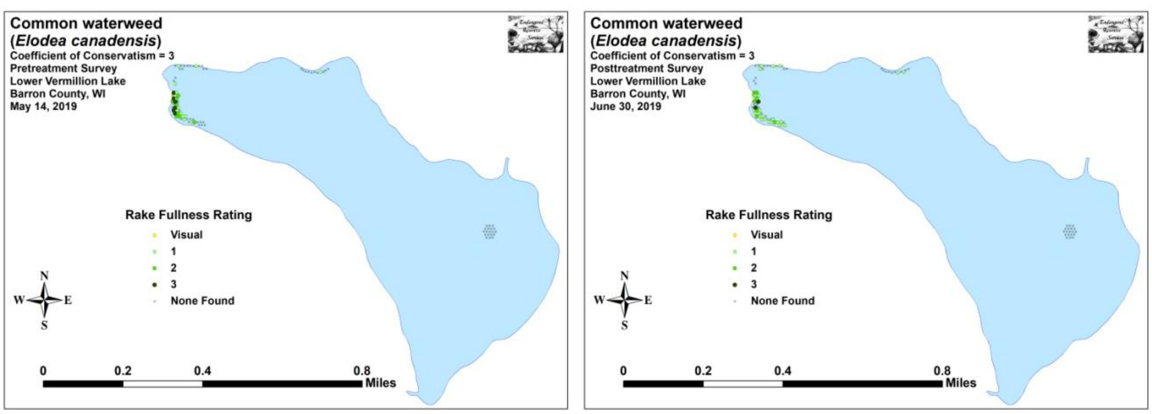


Figure 13: Pre/Post Common Waterweed Density and Distribution

Flat-stem pondweed (*Potamogeton zosteriformis*) – a species known to be sensitive to Endothall – was the only native species that suffered a significant decline **(p=0.02)** in distribution posttreatment. Conversely, several late-growing species experienced significant expansions – Spatterdock (*Nuphar variegata*) saw a moderately significant increase in distribution **(p=0.007)**, and Wild celery (*Vallisneria americana*) and Slender naiad (*Najas flexilis*) demonstrated significant increases **(p=0.01)/(p=0.04)** (Figure 14) (Maps for all native species from the pre and posttreatment surveys can be found in Appendixes VI and VII).

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Pretreatment Survey Lower Vermillion Lake, Barron County
May 14, 2019

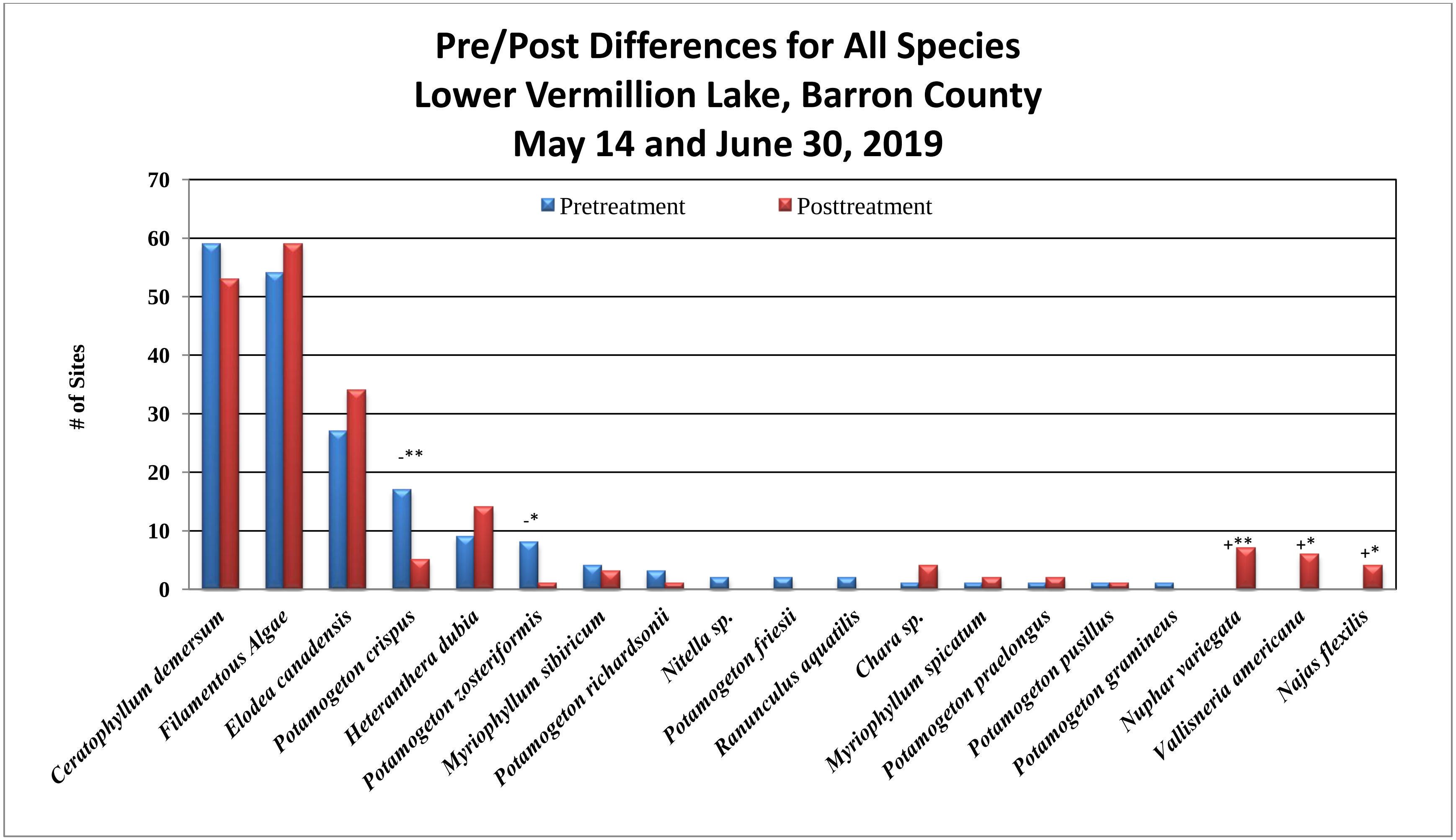
Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sites
Ceratophyllum demersum	Coontail	59	42.75	73.75	68.60	1.68	0
	Filamentous algae	54	*	67.50	62.79	1.17	0
Elodea canadensis	Common waterweed	27	19.57	33.75	31.40	1.74	0
Potamogeton crispus	Curly-leaf pondweed	17	12.32	21.25	19.77	1.65	4
Heteranthera dubia	Water star-grass	9	6.52	11.25	10.47	1.00	0
Potamogeton zosteriformis	Flat-stem pondweed	8	5.80	10.00	9.30	1.00	0
Myriophyllum sibiricum	Northern water-milfoil	4	2.90	5.00	4.65	1.25	0
Potamogeton richardsonii	Clasping-leaf pondweed	3	2.17	3.75	3.49	1.00	0
Nitella sp.	Nitella	2	1.45	2.50	2.33	1.00	0
Potamogeton friesii	Fries' pondweed	2	1.45	2.50	2.33	1.00	0
Ranunculus aquatilis	White water crowfoot	2	1.45	2.50	2.33	1.50	0
Myriophyllum spicatum	Eurasian water-milfoil	1	0.72	1.25	1.16	2.00	0
Chara sp.	Muskgrass	1	0.72	1.25	1.16	1.00	0
Potamogeton gramineus	Variable pondweed	1	0.72	1.25	1.16	1.00	0
Potamogeton praelongus	White-stem pondweed	1	0.72	1.25	1.16	1.00	0
Potamogeton pusillus	Small pondweed	1	0.72	1.25	1.16	1.00	0
Vallisneria americana	Wild celery	1	0.60	1.45	1.33	1.00	0

* Excluded from Relative Frequency Analysis

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Posttreatment Survey Lower Vermillion Lake, Barron County
June 30, 2019

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake	Visual Sites
	Filamentous algae	59	*	73.75	68.60	1.24	0
Ceratophyllum demersum	Coontail	53	38.69	66.25	61.63	1.36	0
Elodea canadensis	Common waterweed	34	24.82	42.50	39.53	1.32	0
Heteranthera dubia	Water star-grass	14	10.22	17.50	16.28	1.50	0
Nuphar variegata	Spatterdock	7	5.11	8.75	8.14	1.57	0
Vallisneria americana	Wild celery	6	4.38	7.50	6.98	1.17	0
Potamogeton crispus	Curly-leaf pondweed	5	3.65	6.25	5.81	1.00	0
Chara sp.	Muskgrass	4	2.92	5.00	4.65	1.25	0
Najas flexilis	Slender naiad	4	2.92	5.00	4.65	1.00	0
Myriophyllum sibiricum	Northern water-milfoil	3	2.19	3.75	3.49	1.00	0
Myriophyllum spicatum	Eurasian water-milfoil	2	1.46	2.50	2.33	1.00	0
Potamogeton praelongus	White-stem pondweed	2	1.46	2.50	2.33	1.00	0
Potamogeton pusillus	Small pondweed	1	0.73	1.25	1.16	1.00	0
Potamogeton richardsonii	Clasping-leaf pondweed	1	0.73	1.25	1.16	1.00	0
Potamogeton zosteriformis	Flat-stem pondweed	1	0.73	1.25	1.16	1.00	0

* Excluded from Relative Frequency Analysis



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

Figure 14: Pre/Posttreatment Macrophyte Changes

Fall Eurasian Water-milfoil Bed Mapping Survey:

On October 20th, 2019, we searched 21.9 kilometers (13.6 miles) of transects within the lake's littoral zone (Figure 15). Although we didn't find any true beds, we did locate 21 individual plants and two floating fragments near the lake outlet. This was a significant decline from the 0.31acre we mapped during our last fall survey in 2017 (Table 5) (Appendix VIII).

Closer analysis of the 2019 spring treatment areas and fall EWM distribution showed that, for the most part, the treated areas remained relatively free of EWM throughout the growing season (Figure 5). It also showed that, immediately outside of the treated areas, EWM was still present, but generally occurred as scattered individuals. In the east bay, we noted that EWM continues to stubbornly reappear in the same general area on the northwest corner of the flat we have been finding it at since 2012. Whether this is a reintroduction from anglers motoring over from the landing, or if these are simply surviving plants that take several years to expand and canopy following treatment is unknown. Regardless, the area around Bed 6 will continue to be a high priority search area during bed mapping surveys in the future.

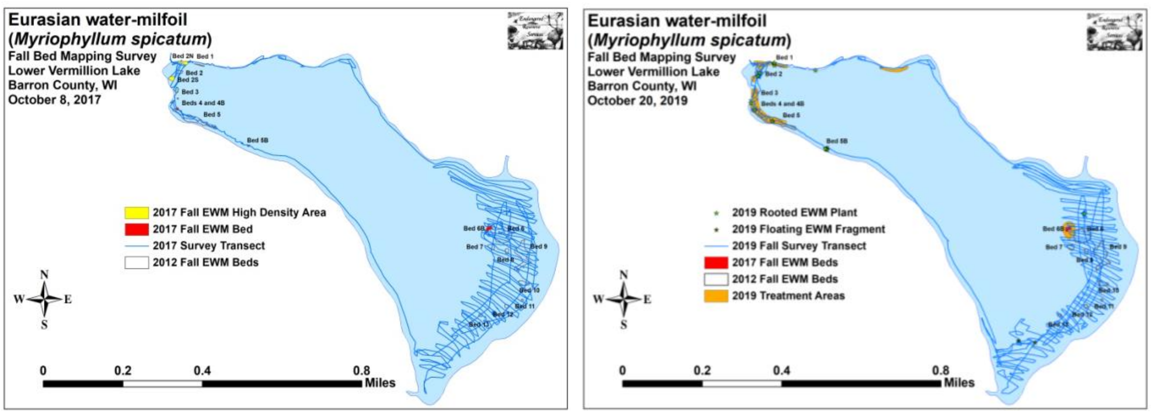


Figure 15: 2017 and 2019 Fall Eurasian Water-milfoil Bed Maps

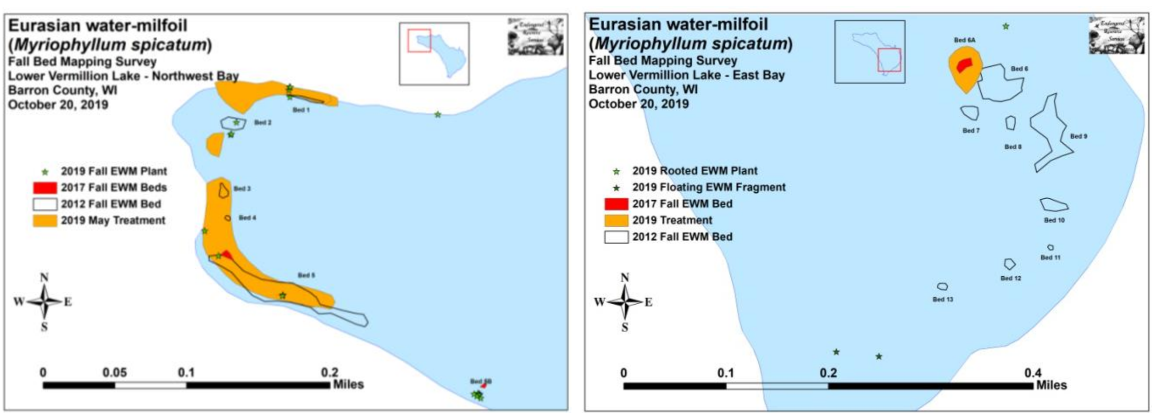


Figure 16: Fall 2019 Close-up of Northwest and East Bays

Descriptions of Past and Present EWM Beds/HDAs:

Bed 1and the Northwest Shoreline – Treatment coupled with manual removal efforts eliminated the majority of EWM plants in this area. Five of the six plants we found in this area were located near the boat landing among docks.

Bed 2 – We cleanly raked out the only three plants we found directly out from the public boat landing.

Bed 3 – No EWM was found in the treatment area south of the creek inlet.

Beds 4 and 4B – We found and removed a single EWM plant from the area with shingle debris.

Bed 5 – Despite rake removal efforts in this area over the summer (T. Margotto – pers. comm.), we found three plants scattered in 2-3ft of water near the shoreline.

Bed 5B – Manual removal in this area over the summer also got most, but not all plants as we found seven plants scattered in 3-4ft of water near the shoreline.

Beds 6 and 6A – We found and carefully removed a single EWM plant just north of the Bed 6A treatment area. No other sign of EWM was seen anywhere in the east bay treatment area.

Beds 7-13 – We saw no evidence of EWM anywhere else in the eastern bay with the exception of two floating fragments found near the lake outlet. Extensive searching in the immediate vicinity turned up no further evidence of EWM so it's possible they were drawn here by currents and actually originated further up the shoreline.

Table 5: Fall Eurasian Water-milfoil Bed Mapping Summary
Lower Vermillion Lake, Barron County
October 20, 2019

Bed Number	2019 Fall Bed Acreage	2017 Fall Bed/HDA Acreage	2016 Fall HDA Acreage	2015 Fall Bed Acreage	2014 Fall Bed Acreage	2013 Fall Bed Acreage	2012 Fall Bed Acreage	2011 Fall Bed Acreage	2017-19 Change in Acreage	Range and Est. 2019 Mean Rake	2019 Bed Characteristics And Field Notes
1	0	0	<0.01	0	0.01	0.02	0.02	0	0	<<<1-1; <1	6 EWM plants
2	0	0.17	0.21	0.47	0.39	0.43	0.07	0.49	-0.17	<<<1-<1	3 EWM plants – **RR***
3	0	0.02	0	0	0.01	<0.01	0.03	0	-0.02	0	No EWM found
4 and 4B	0	0.01	0	0.05	0.04	0	0.01	0	0	<<<1	1 EWM plant – **RR***
5	0	0.02	0.01	0.89	0.54	0.22	0.70	0.35	-0.02	<<<1-<1	3 EWM plants
5B	0	0.01	0.03	0.26	0.13	0	0	0	-0.01	<<1-<1	7 EWM plants
6	0	0	0	0	0.06	0.04	0.68	0	0	0	No EWM found
6A	0	0.09	0	0	0	0	0	0	-0.09	<<<1	1 EWM plant – **RR***
7	0	0	0	0.11	0.01	0	0.10	0	0	0	No EWM found
8	0	0	0	0	0	0	0.06	0	0	0	No EWM found
9	0	0	0	0	<0.01	0	0.80	0	0	0	No EWM found
10	0	0	0	0	0	0	0.14	0	0	0	No EWM found
11	0	0	0	0	0	0	0.01	0	0	0	No EWM found
12	0	0	0	0	0	0	0.05	0	0	0	No EWM found
13	0	0	0	0	0	0	0.03	0	0	0	No EWM found
Total	**0.00**	**0.31**	**0.25**	**1.77**	**1.18**	**0.71**	**2.70**	**0.84**	**-0.31**		

***RR = Rake Removed**

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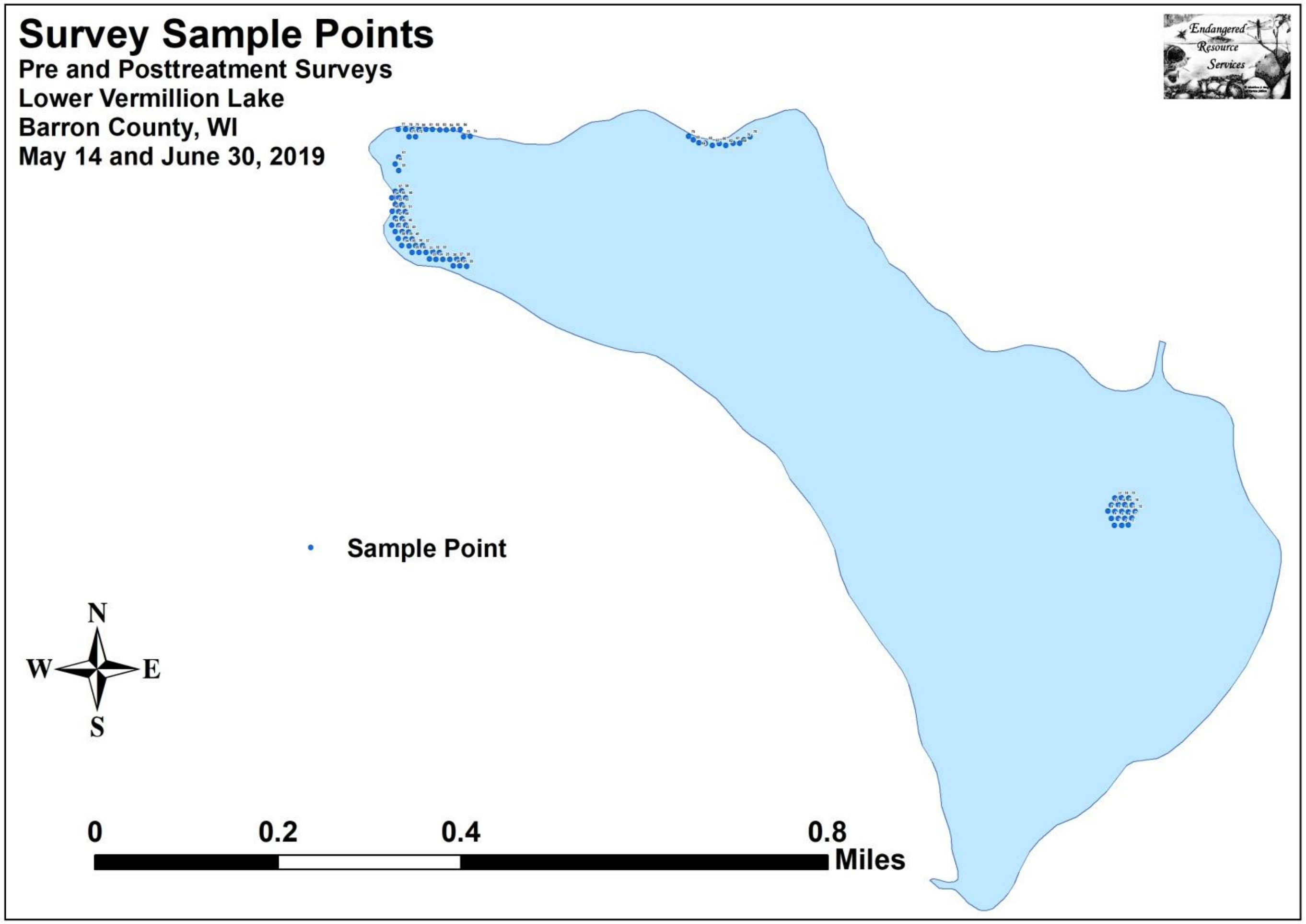
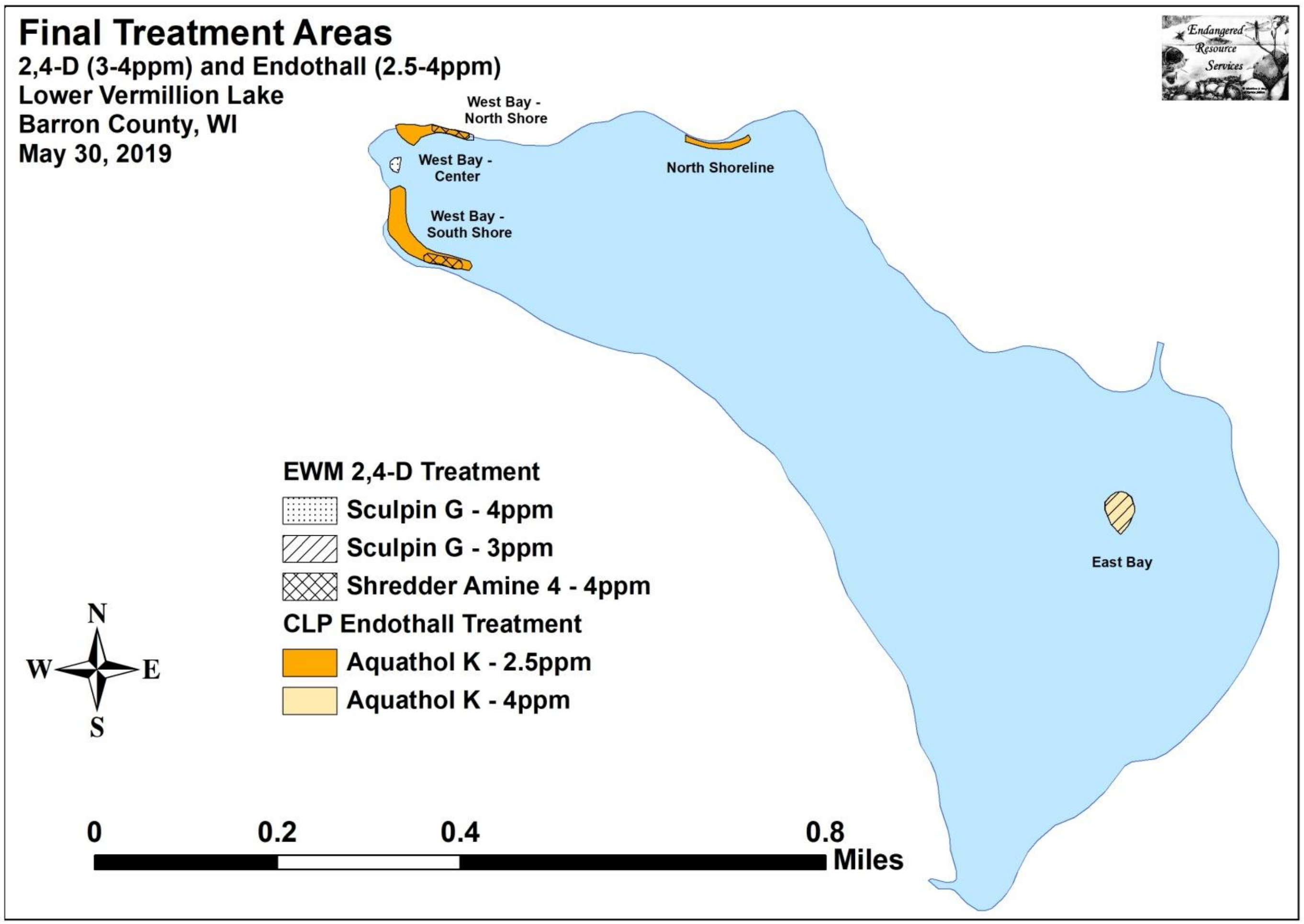
UWEX Lakes Program. [online]. 2010. Aquatic Plant Management in Wisconsin. Available from http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/aquaticplants/default.aspx (2019, October).

UWEX Lakes Program. [online]. 2010. Pre/Post Herbicide Comparison. Available from http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic%20Plants/Appendix-D.pdf (2019, October).

WDNR. [online]. 2019. Lower Vermillion Citizen Lake Monitoring Water Quality Database. Available from http://dnr.wi.gov/lakes/waterquality/Station.aspx?id=033185 (2019, October).

Appendix I: Survey Sample Points and EWM/CLP Treatment Areas

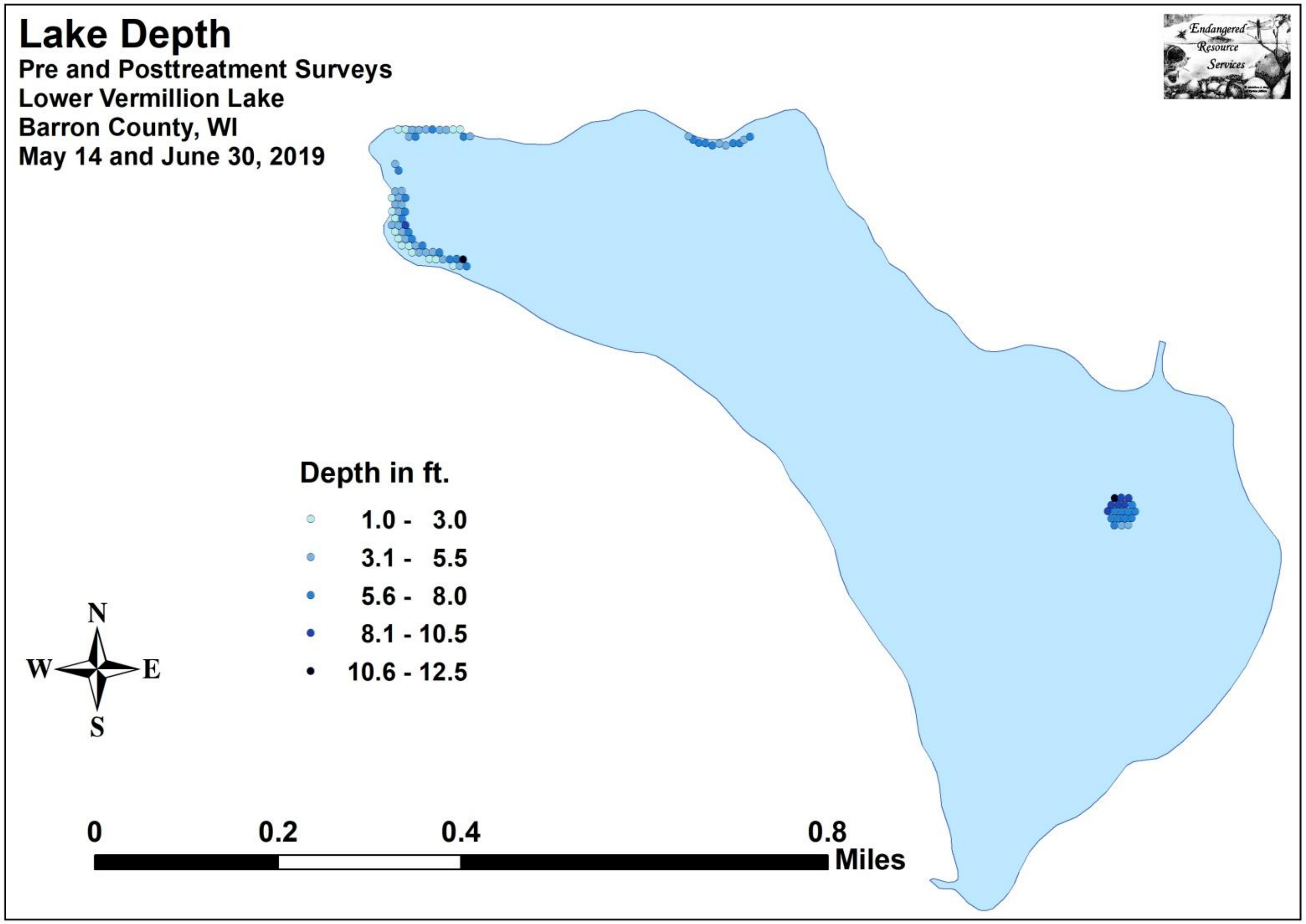

Survey Sample Points
Pre and Posttreatment Surveys
Lower Vermillion Lake
Barron County, WI
May 14 and June 30, 2019
Endangered Resource Services
Sample Point
N
W
E
S
0
0.2
0.4
0.8
Miles

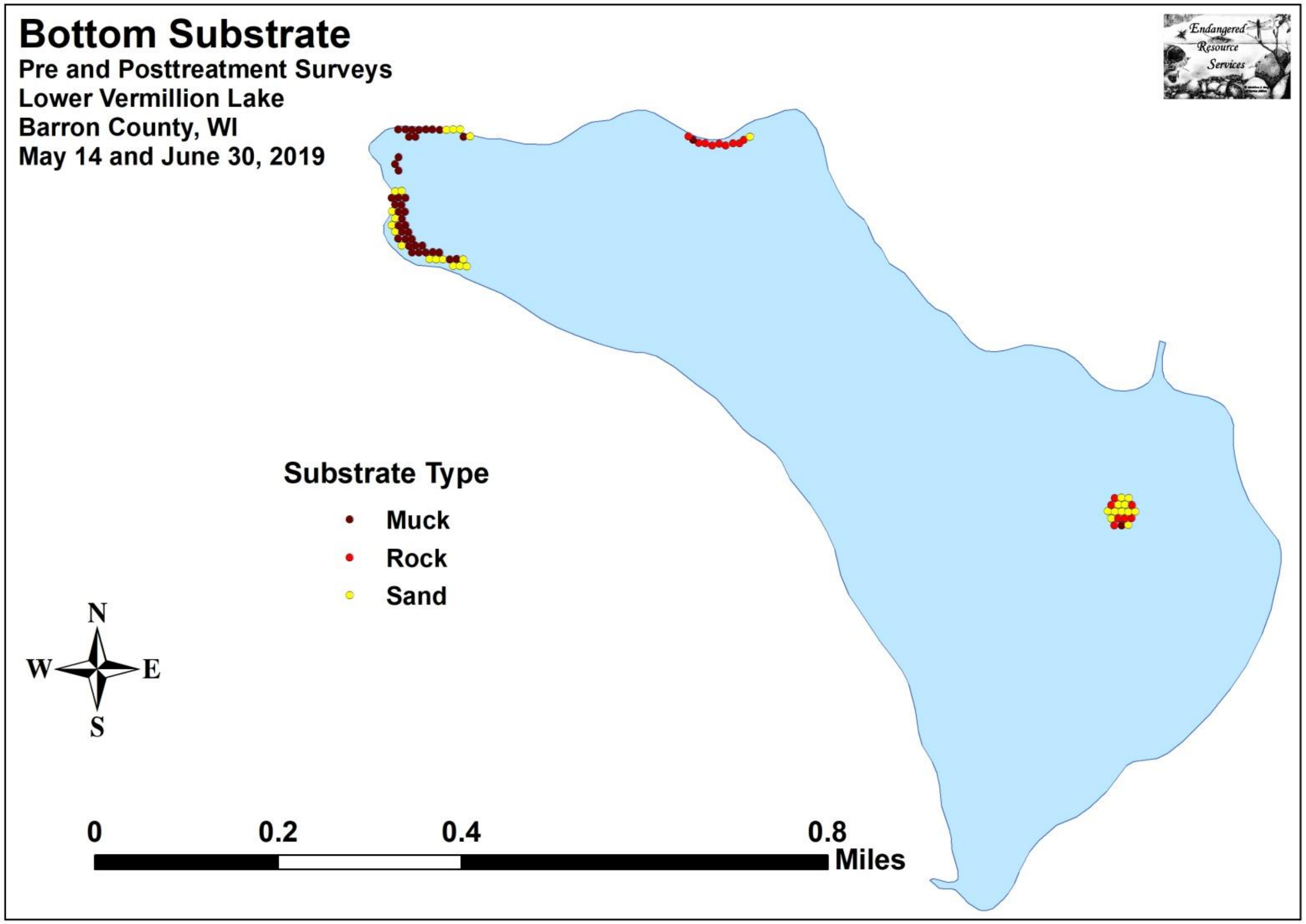

Final Treatment Areas
2,4-D (3-4ppm) and Endothall (2.5-4ppm)
Lower Vermillion Lake
Barron County, WI
May 30, 2019
Endangered Resource Services
West Bay - North Shore
West Bay - Center
West Bay - South Shore
North Shoreline
East Bay
EWM 2,4-D Treatment
Sculpin G - 4ppm
Sculpin G - 3ppm
Shredder Amine 4 - 4ppm
CLP Endothall Treatment
Aquathol K - 2.5ppm
Aquathol K - 4ppm
N
W
E
S
0
0.2
0.4
0.8
Miles

Appendix II: Vegetative Survey Datasheet

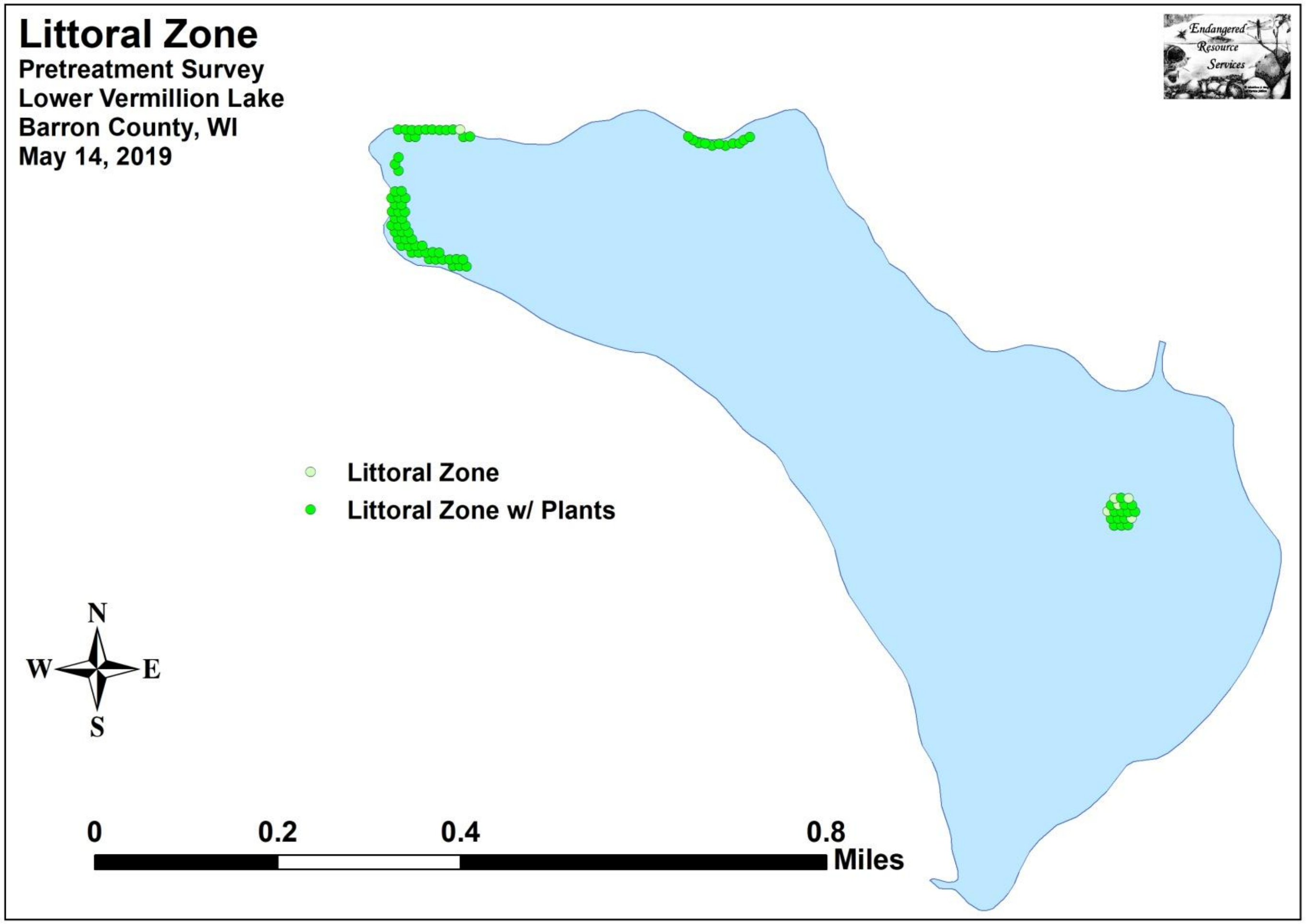
Observers for this lake: names and hours worked by each:																									
Lake:									WBIC									County						Date:	
Site #	Depth (ft)	Muck (M), Sand (S), Rock (R)	Rake pole (P) or rake rope (R)	Total Rake Fullness	EWM	CLP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1																	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

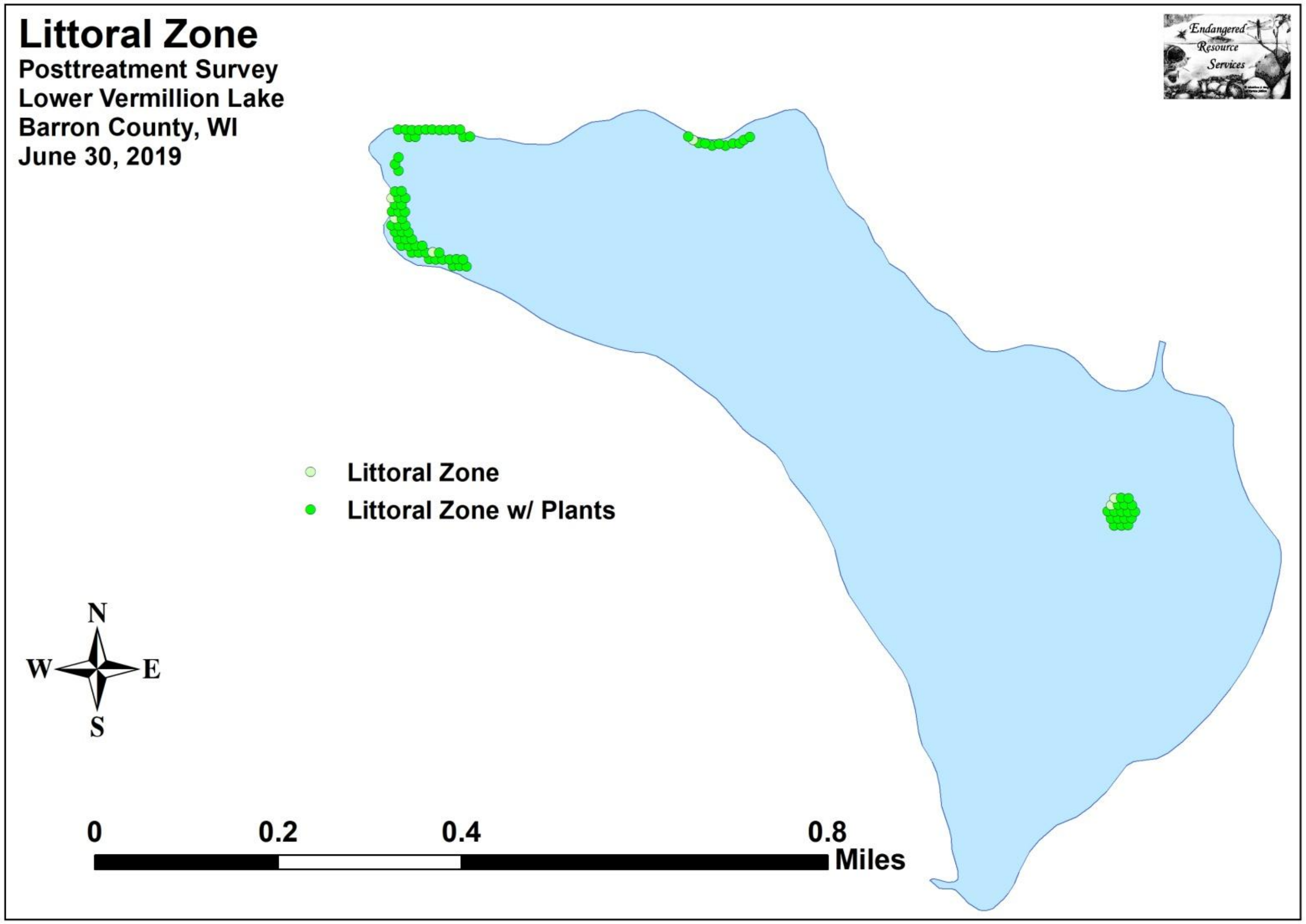
Appendix III: Pre/Post Habitat Variables

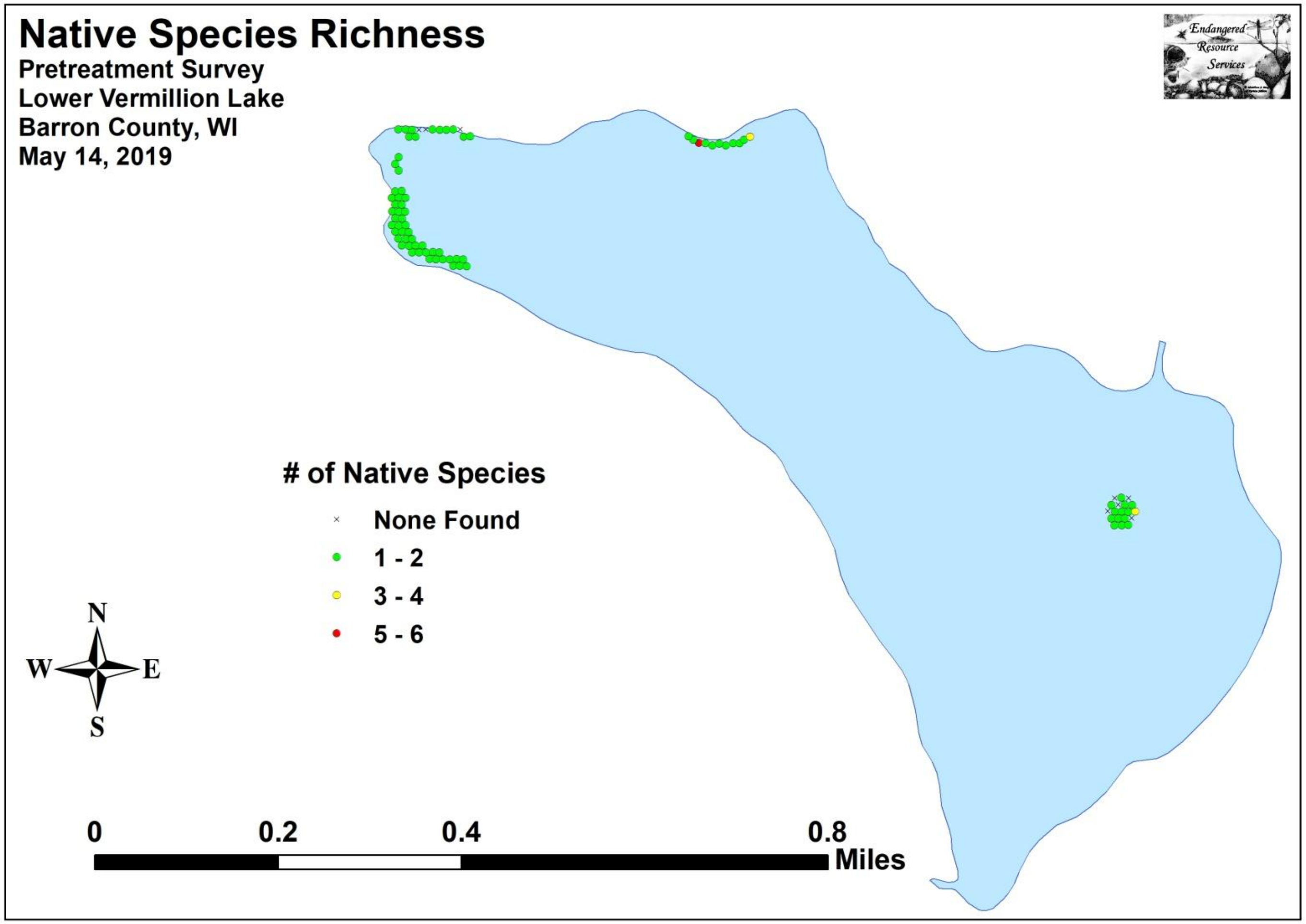

Lake Depth
Pre and Posttreatment Surveys
Lower Vermillion Lake
Barron County, WI
May 14 and June 30, 2019
Endangered Resource Services
Depth in ft.
1.0 - 3.0
3.1 - 5.5
5.6 - 8.0
8.1 - 10.5
10.6 - 12.5
N
W
E
S
0
0.2
0.4
0.8
Miles

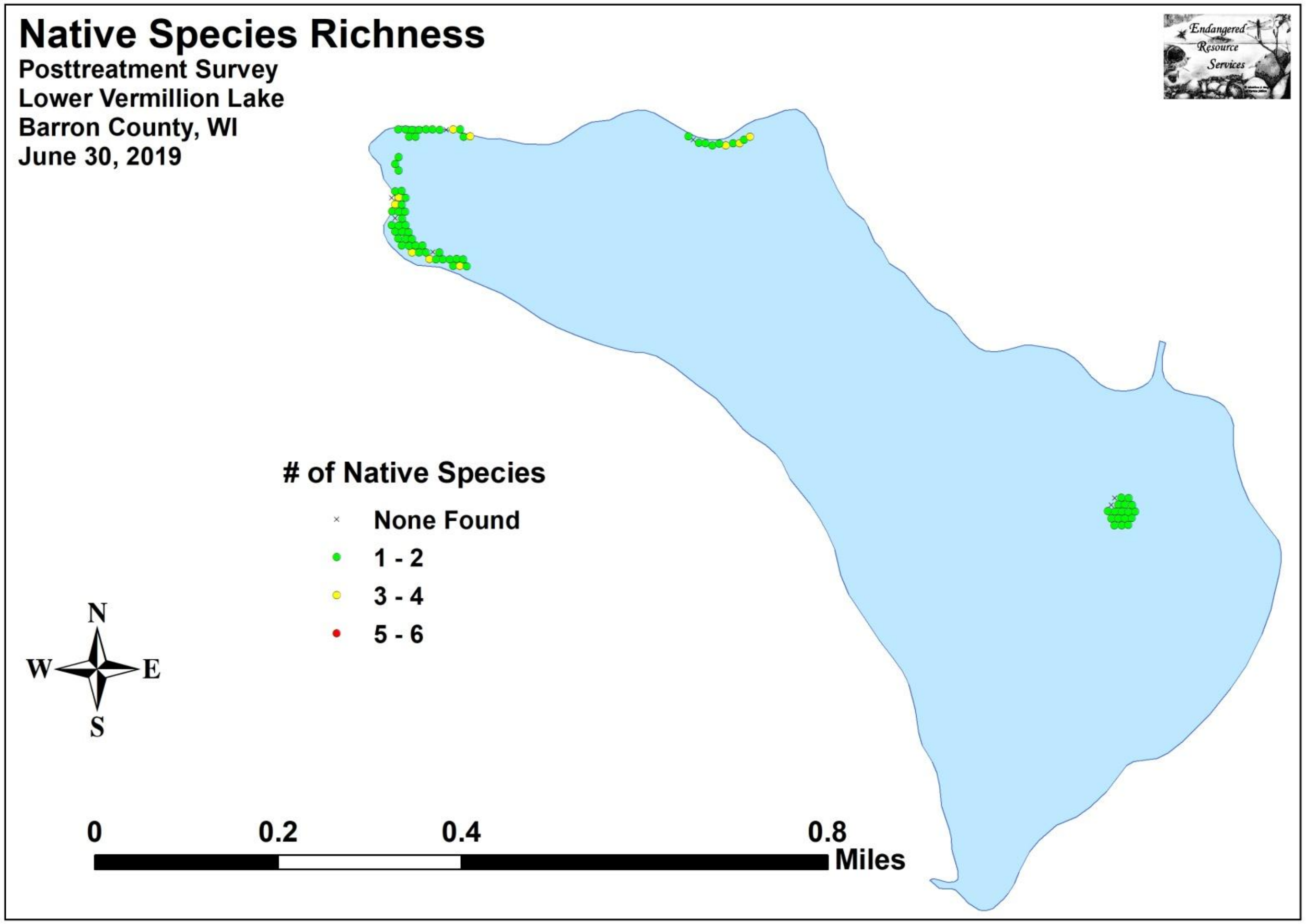

Bottom Substrate
Pre and Posttreatment Surveys
Lower Vermillion Lake
Barron County, WI
May 14 and June 30, 2019
Endangered
Resource
Services
Substrate Type
Muck
Rock
Sand
N
W
E
S
0
0.2
0.4
0.8
Miles

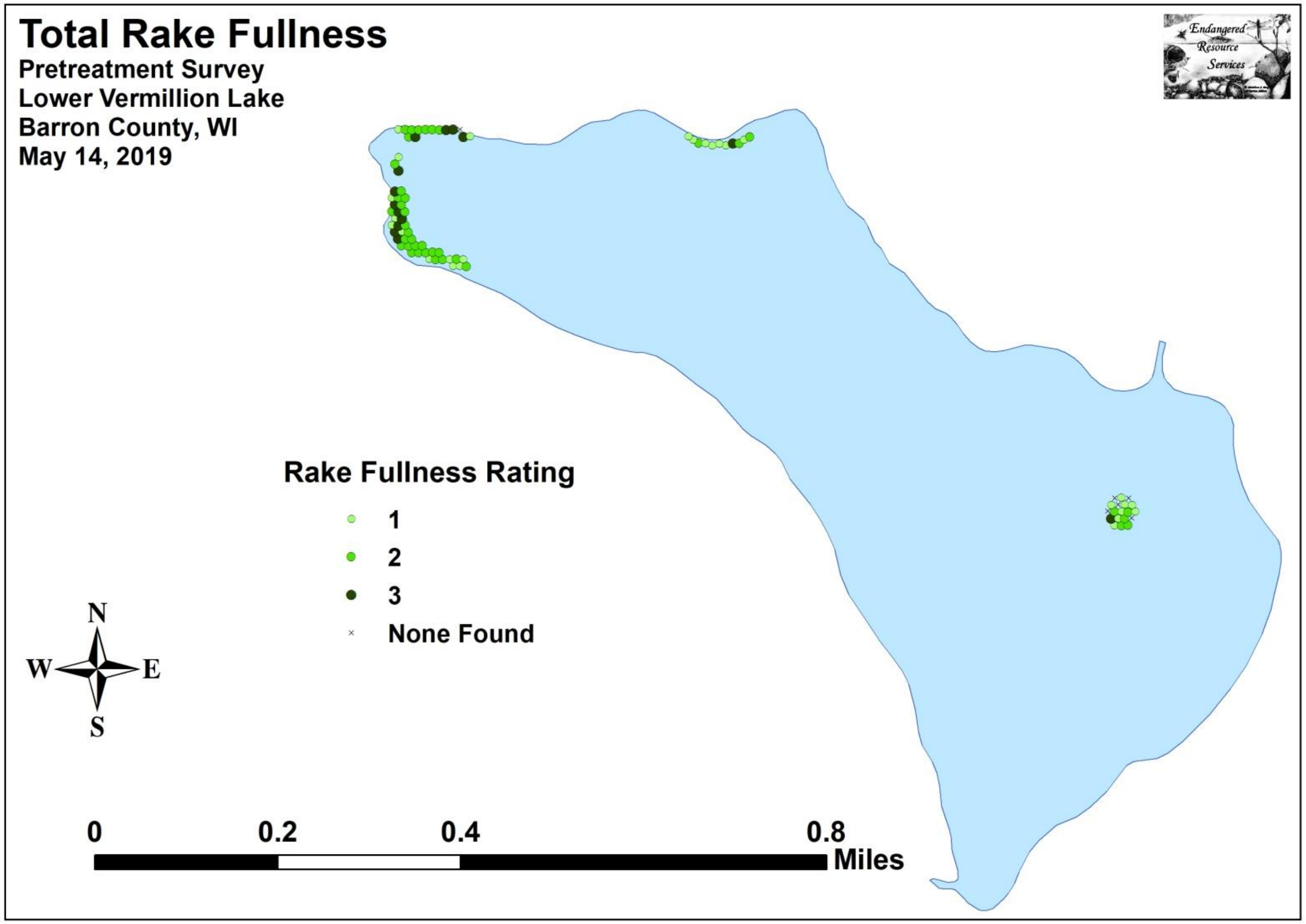
Appendix IV: Pre/Post Littoral Zone, Native Species Richness and Total Rake Fullness

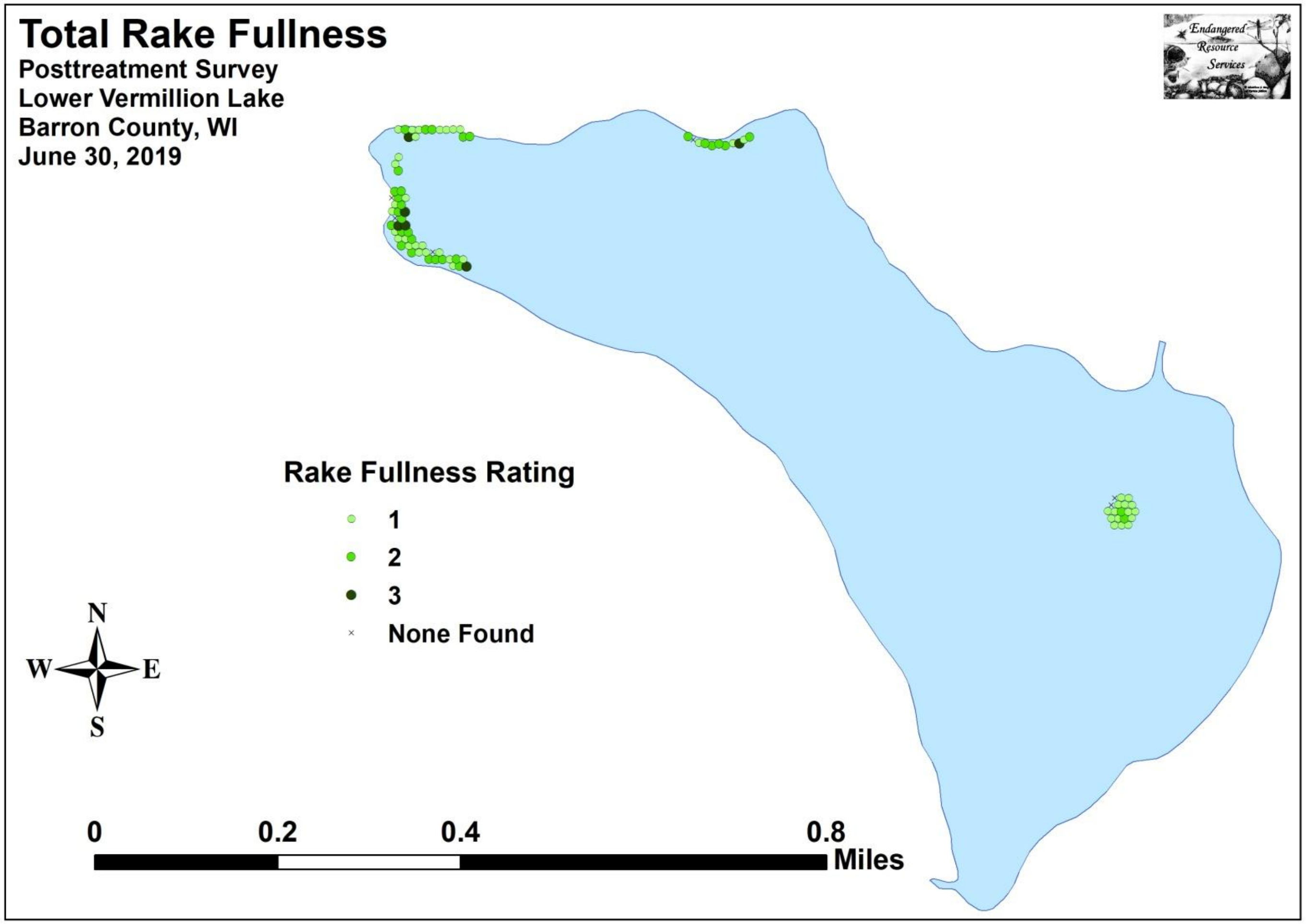

Littoral Zone
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Littoral Zone
Littoral Zone w/ Plants
N
W
E
S
0
0.2
0.4
0.8
Miles


Littoral Zone
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Littoral Zone
Littoral Zone w/ Plants
N
W
E
S
0
0.2
0.4
0.8
Miles

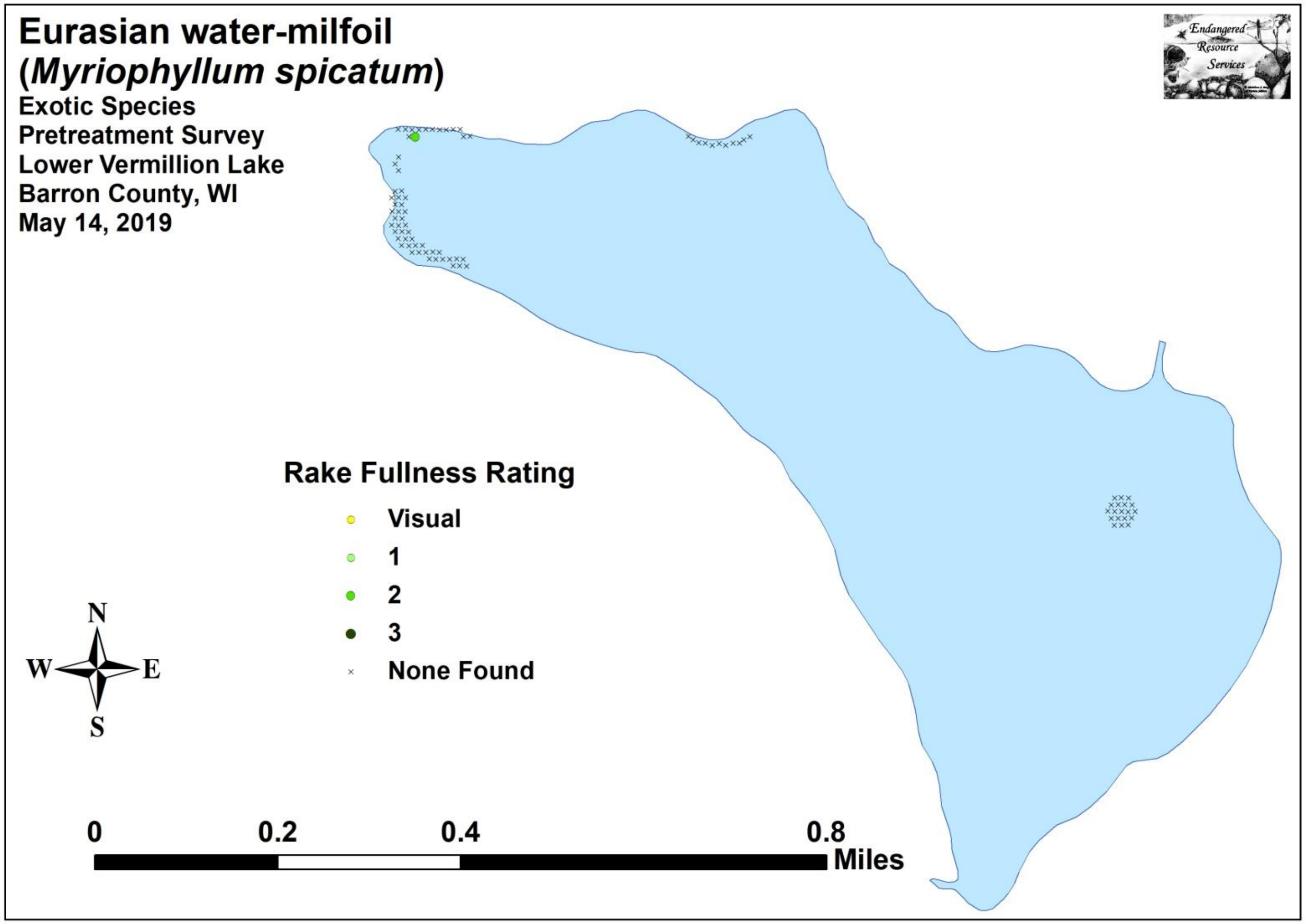

Native Species Richness
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
N
W
E
S
0
0.2
0.4
0.8
Miles

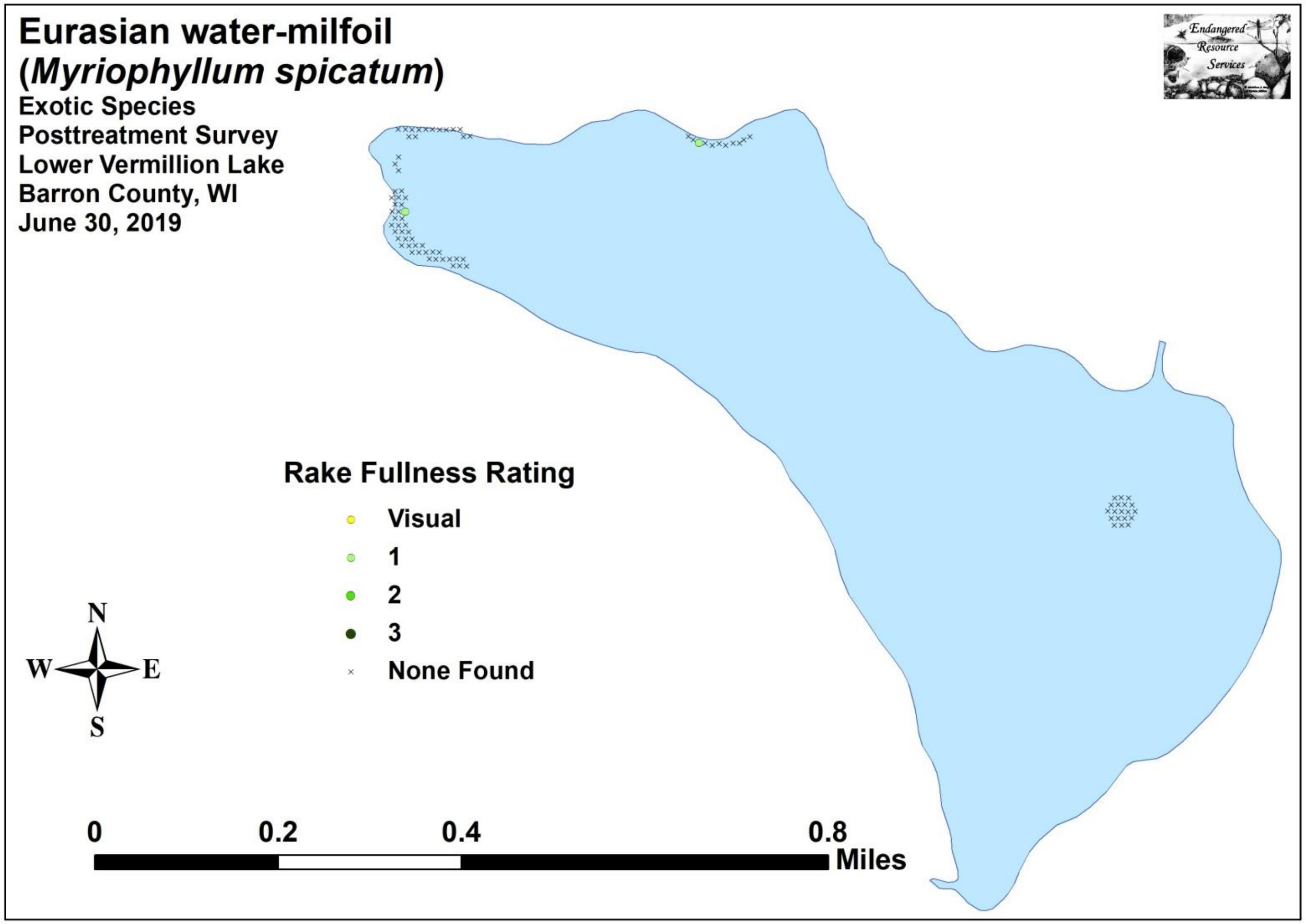

Native Species Richness
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
# of Native Species
None Found
1 - 2
3 - 4
5 - 6
N
W
E
S
0
0.2
0.4
0.8
Miles

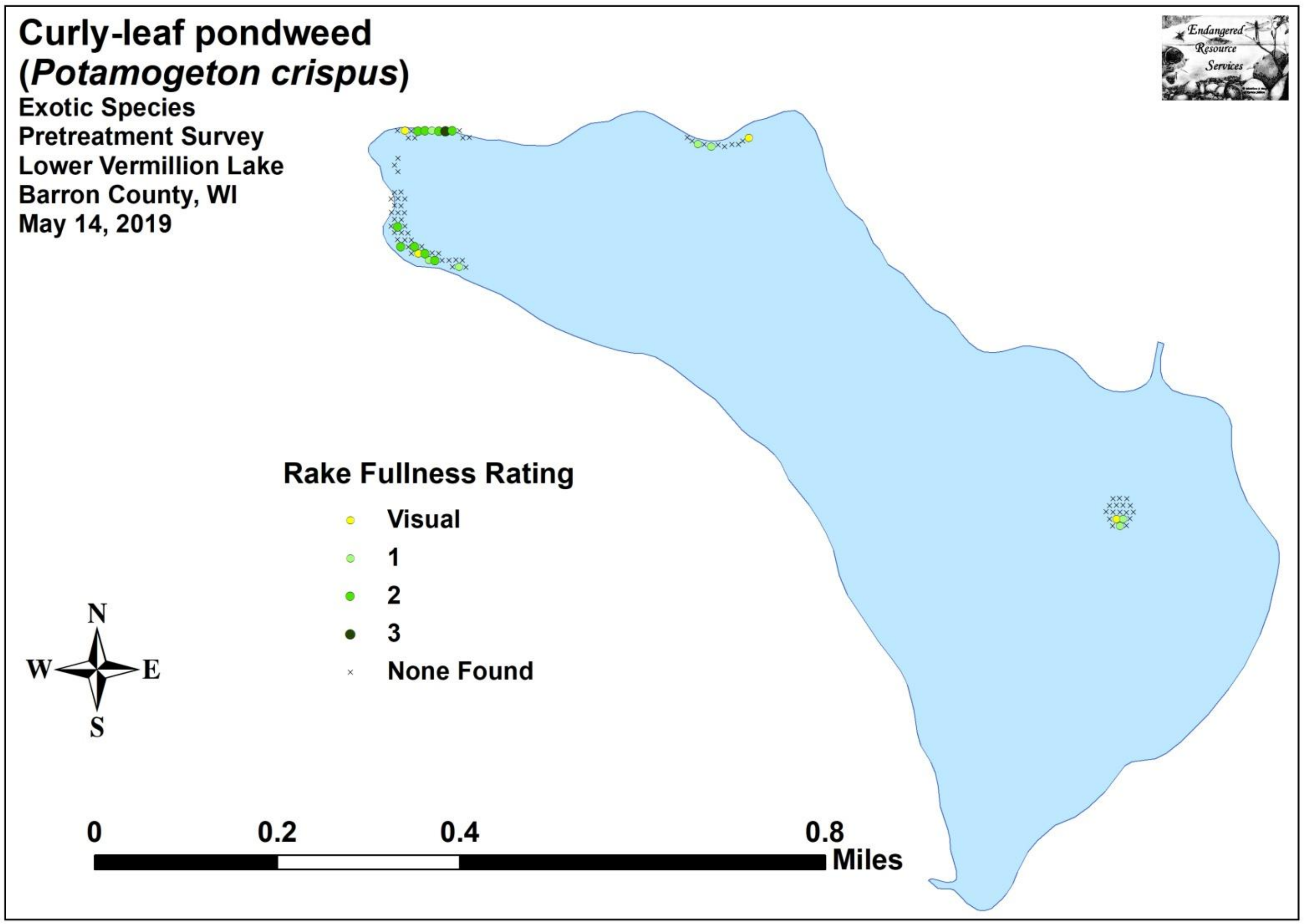

Total Rake Fullness
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

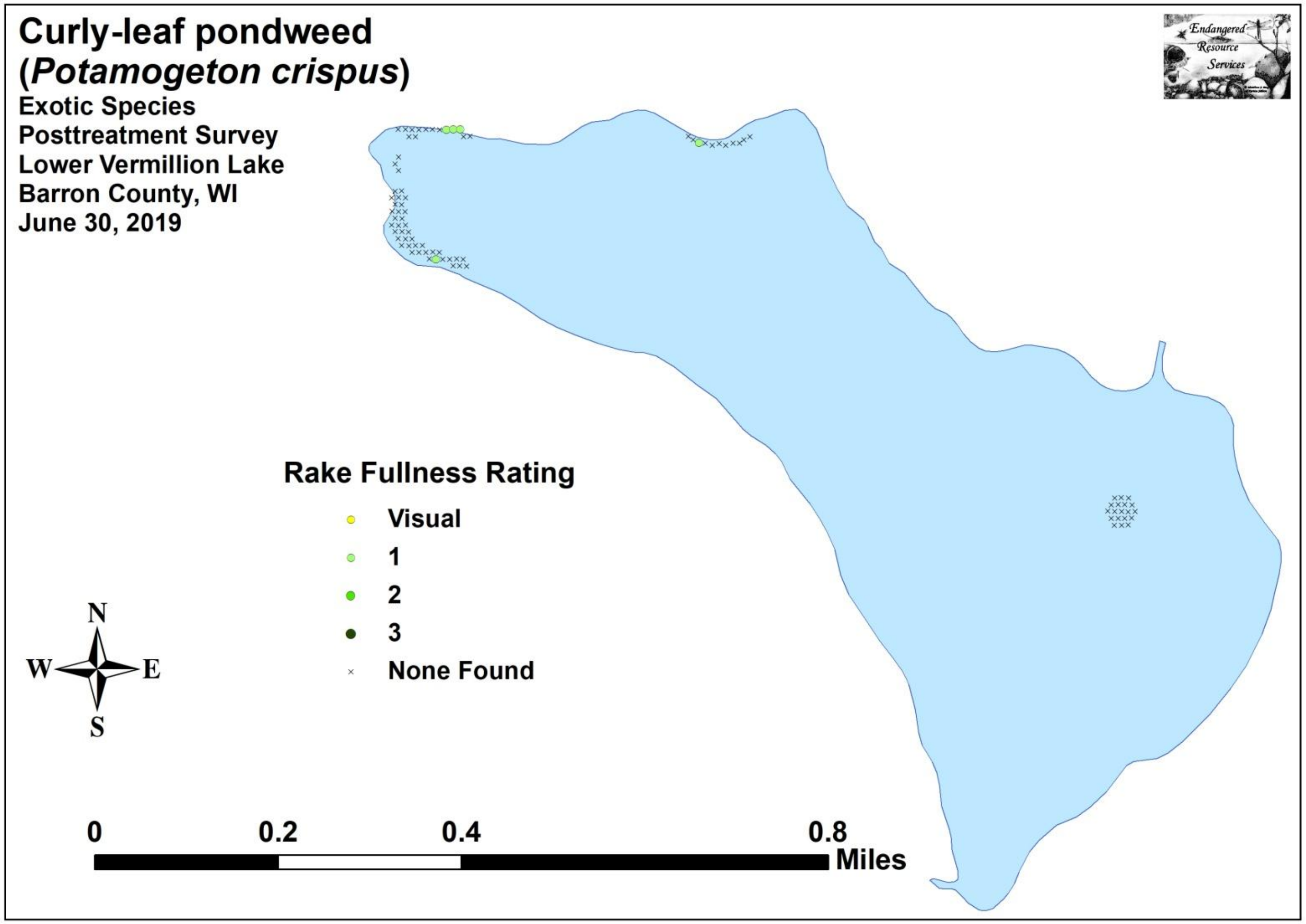

Total Rake Fullness
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

Appendix V: EWM and CLP Pre/Post Density and Distribution

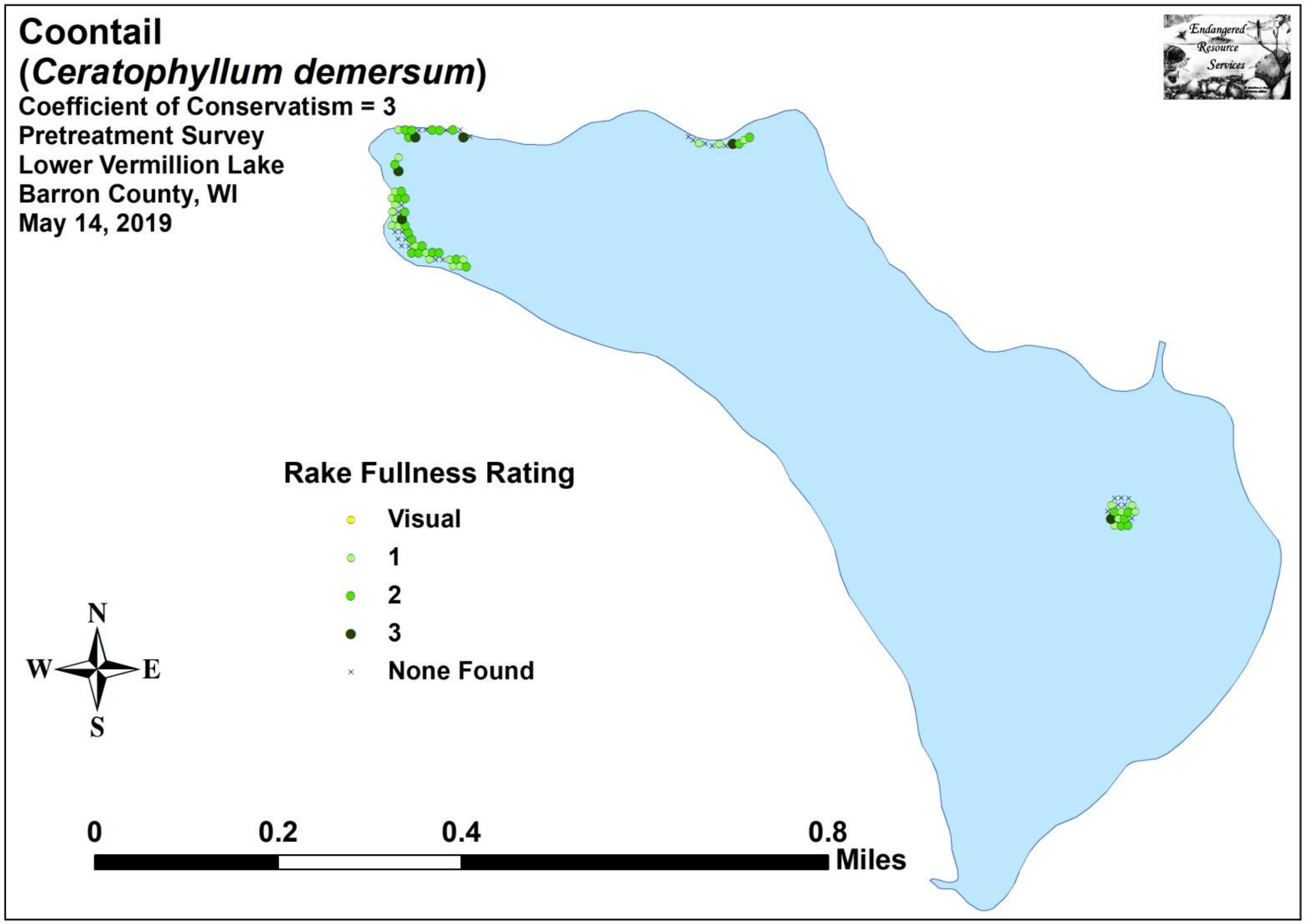

Eurasian water-milfoil
(*Myriophyllum spicatum*)
Exotic Species
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

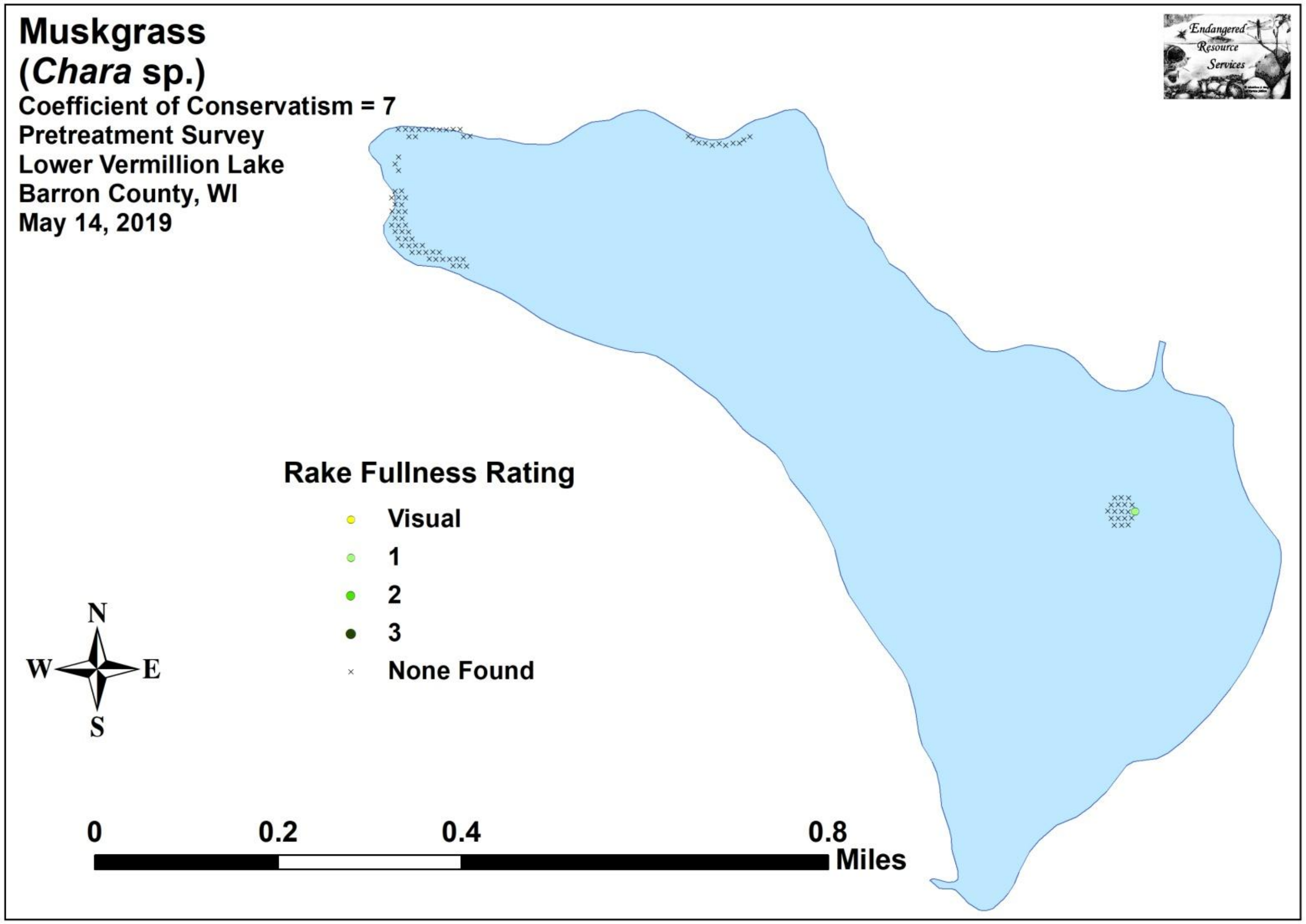

Eurasian water-milfoil
(*Myriophyllum spicatum*)
Exotic Species
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

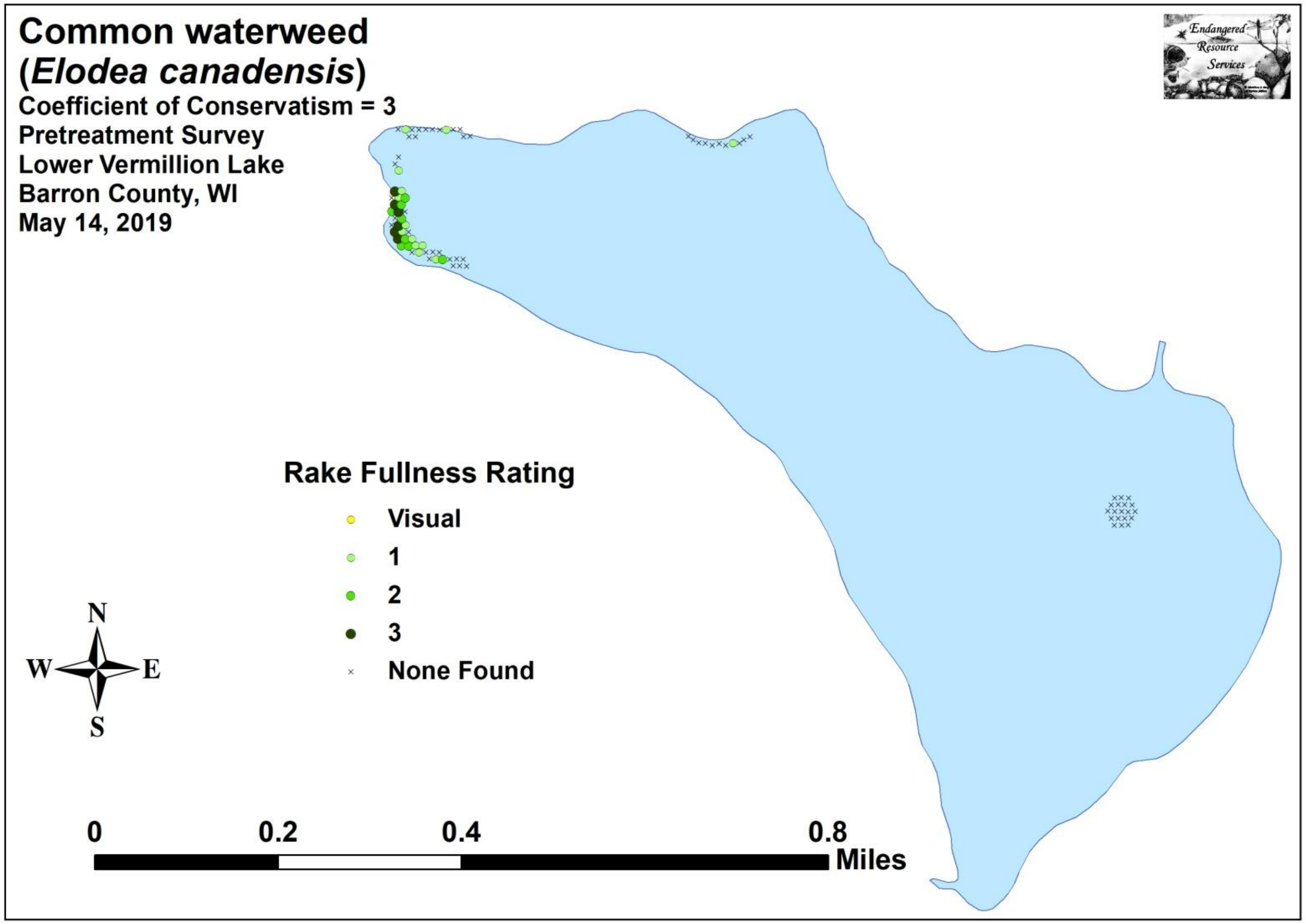

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

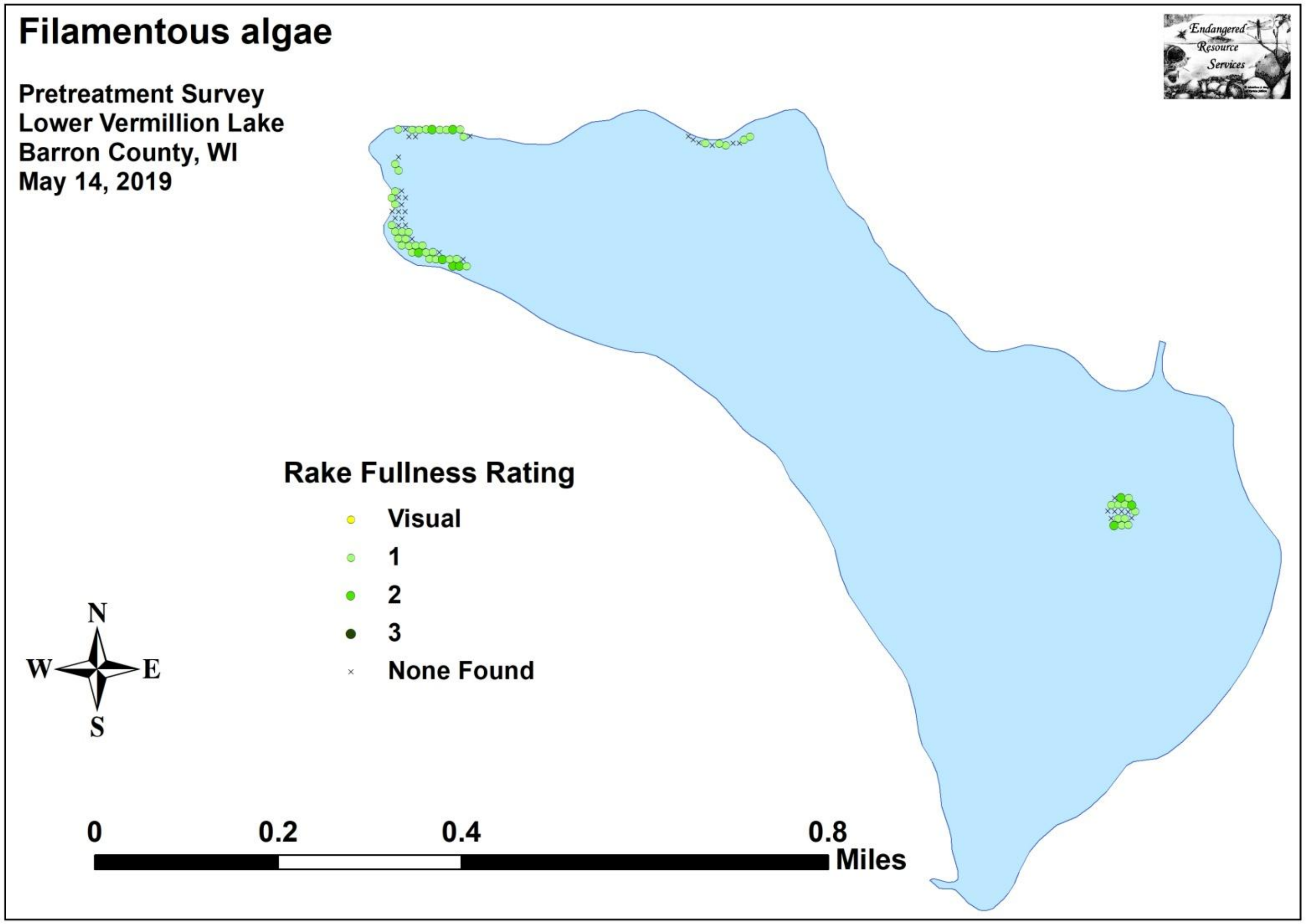

Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

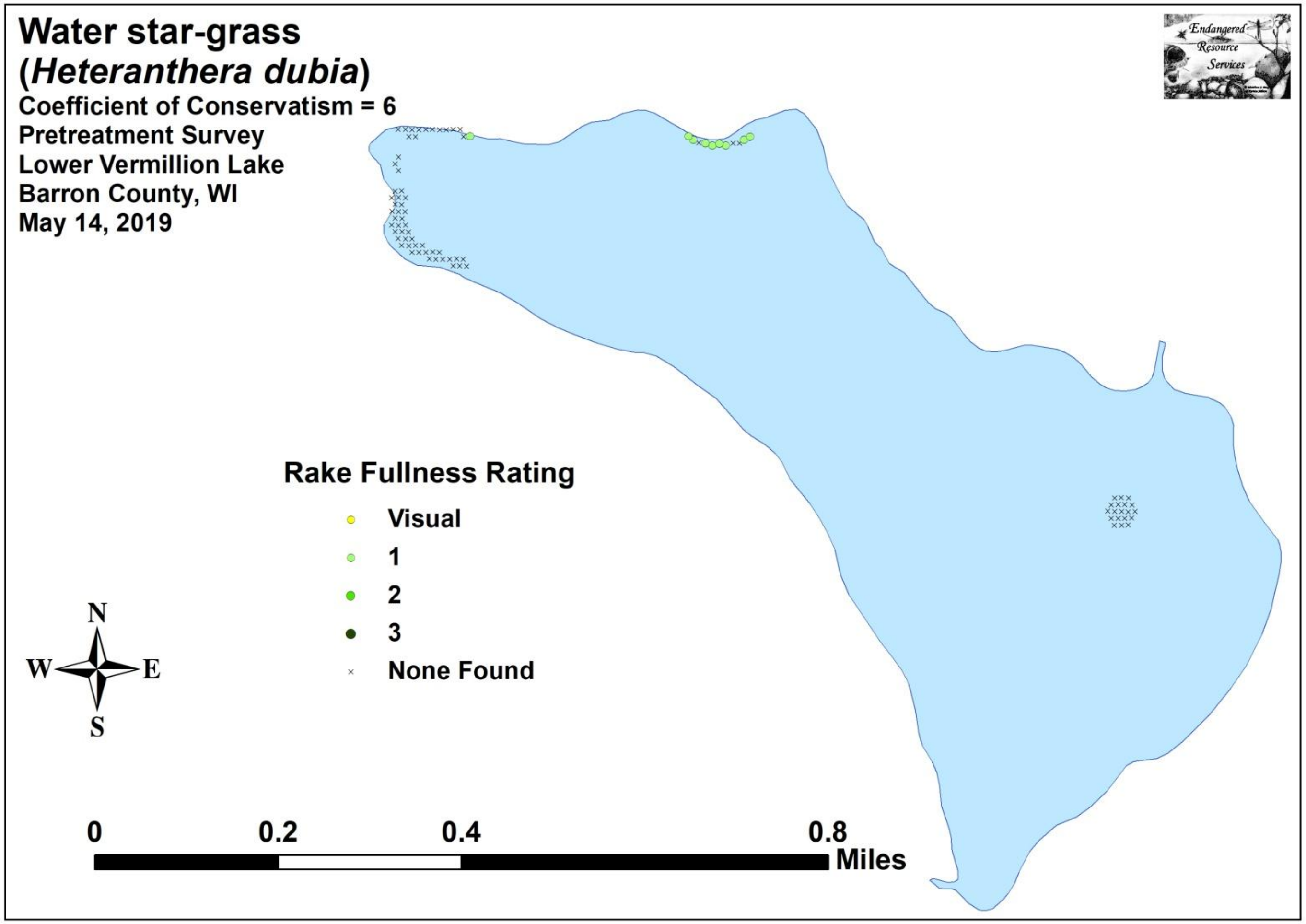
Appendix VI: Pretreatment Native Species Density and Distribution

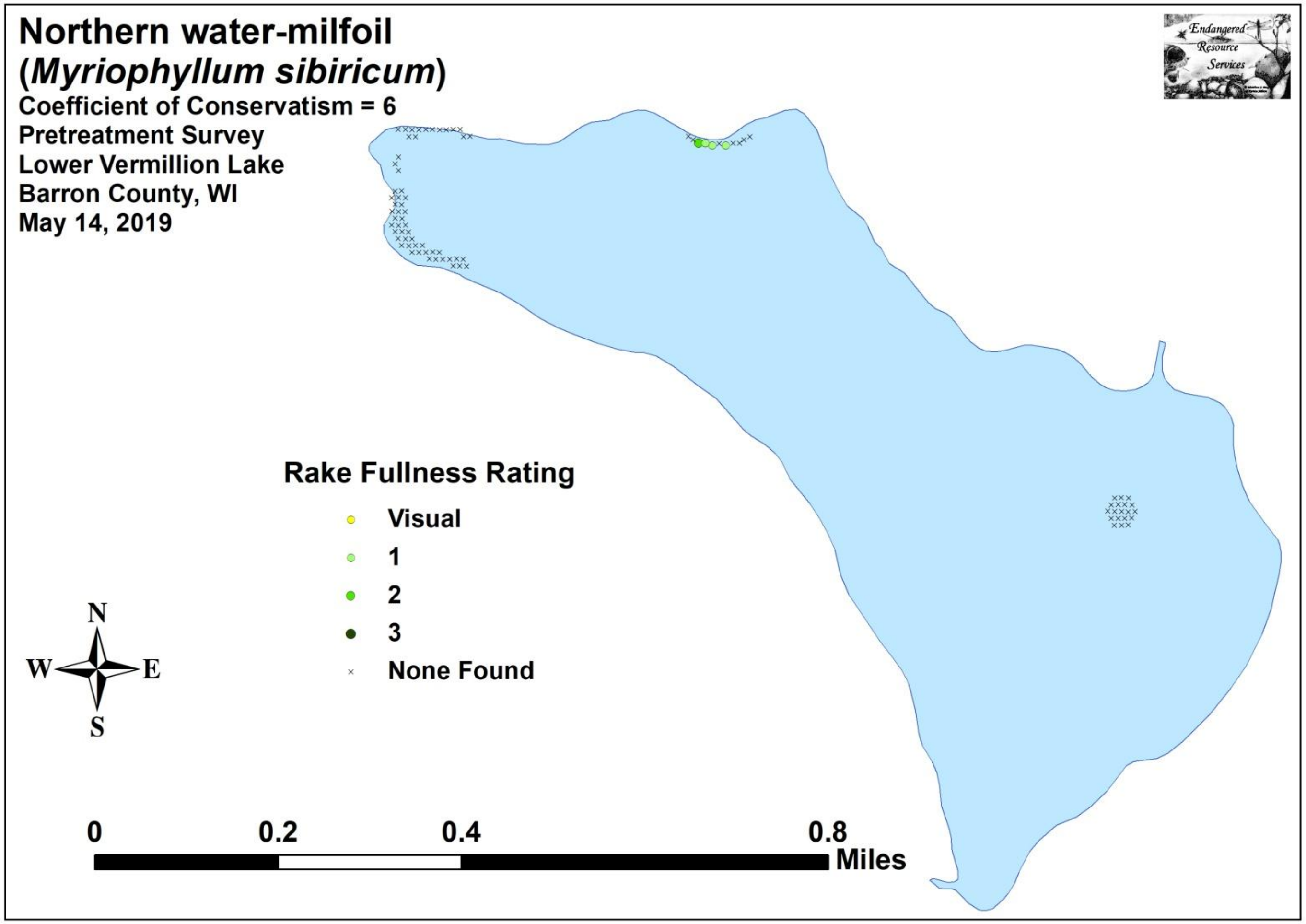

Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Muskgrass
(Chara sp.)
Coefficient of Conservatism = 7
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

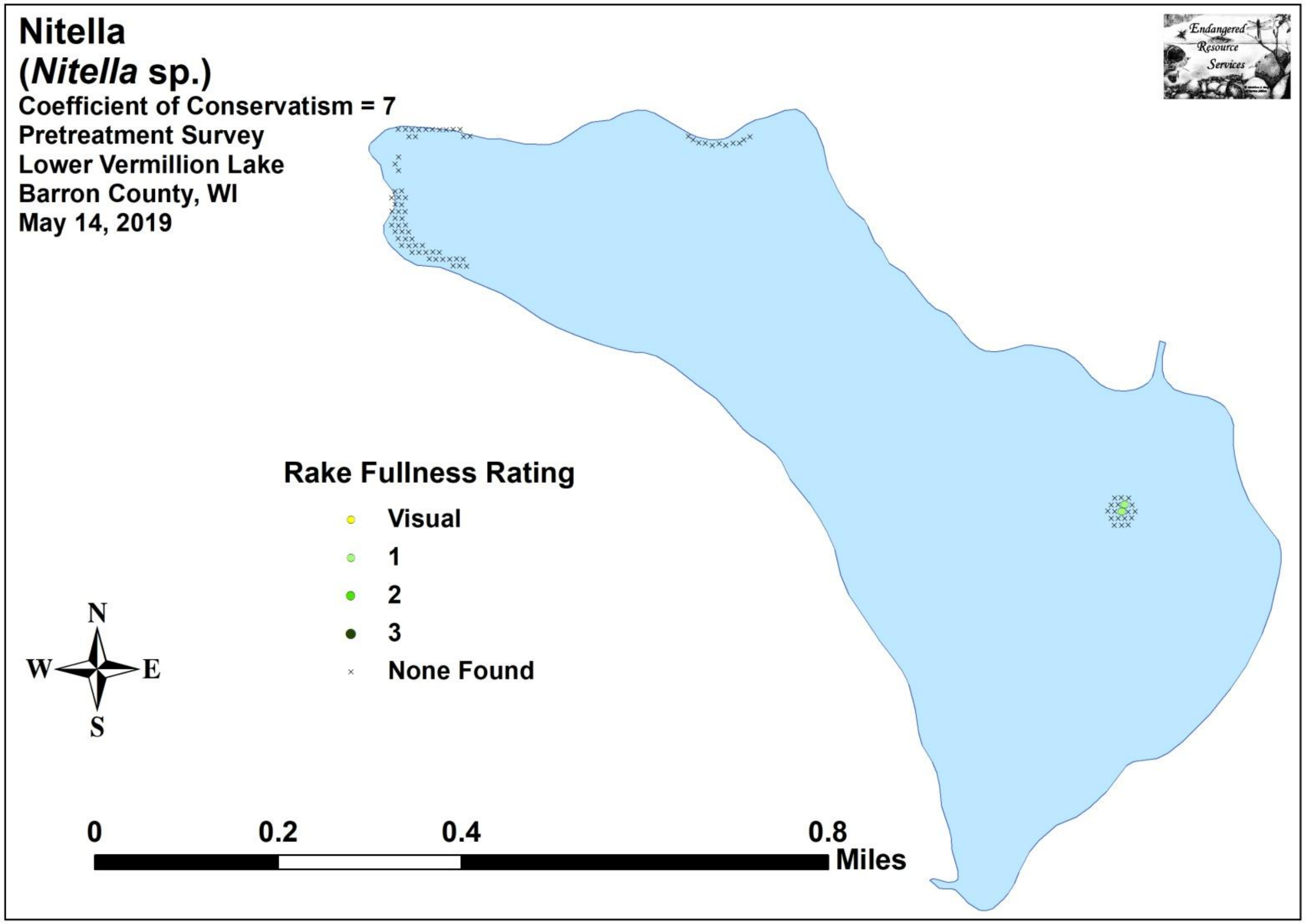

Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

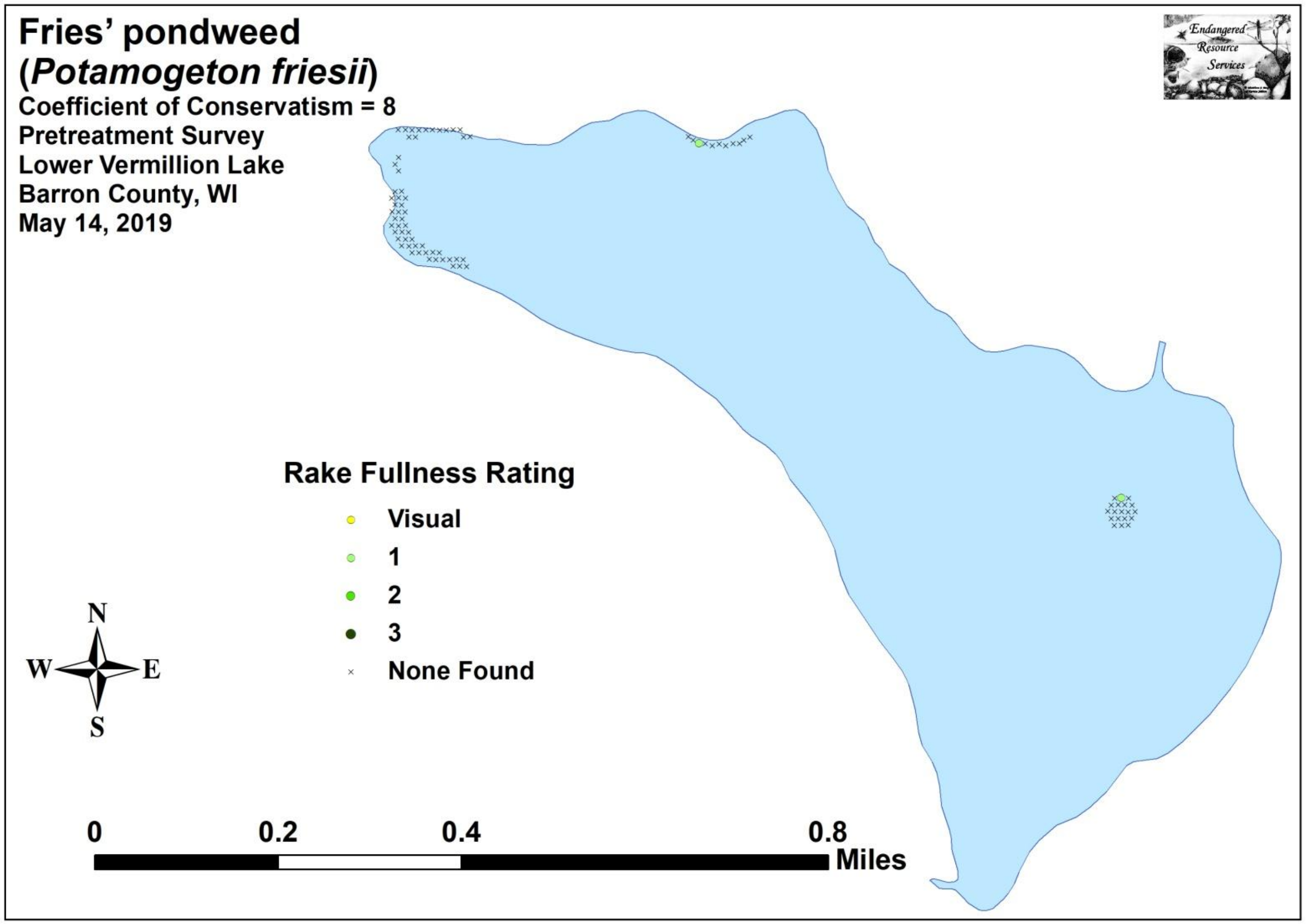

Filamentous algae
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

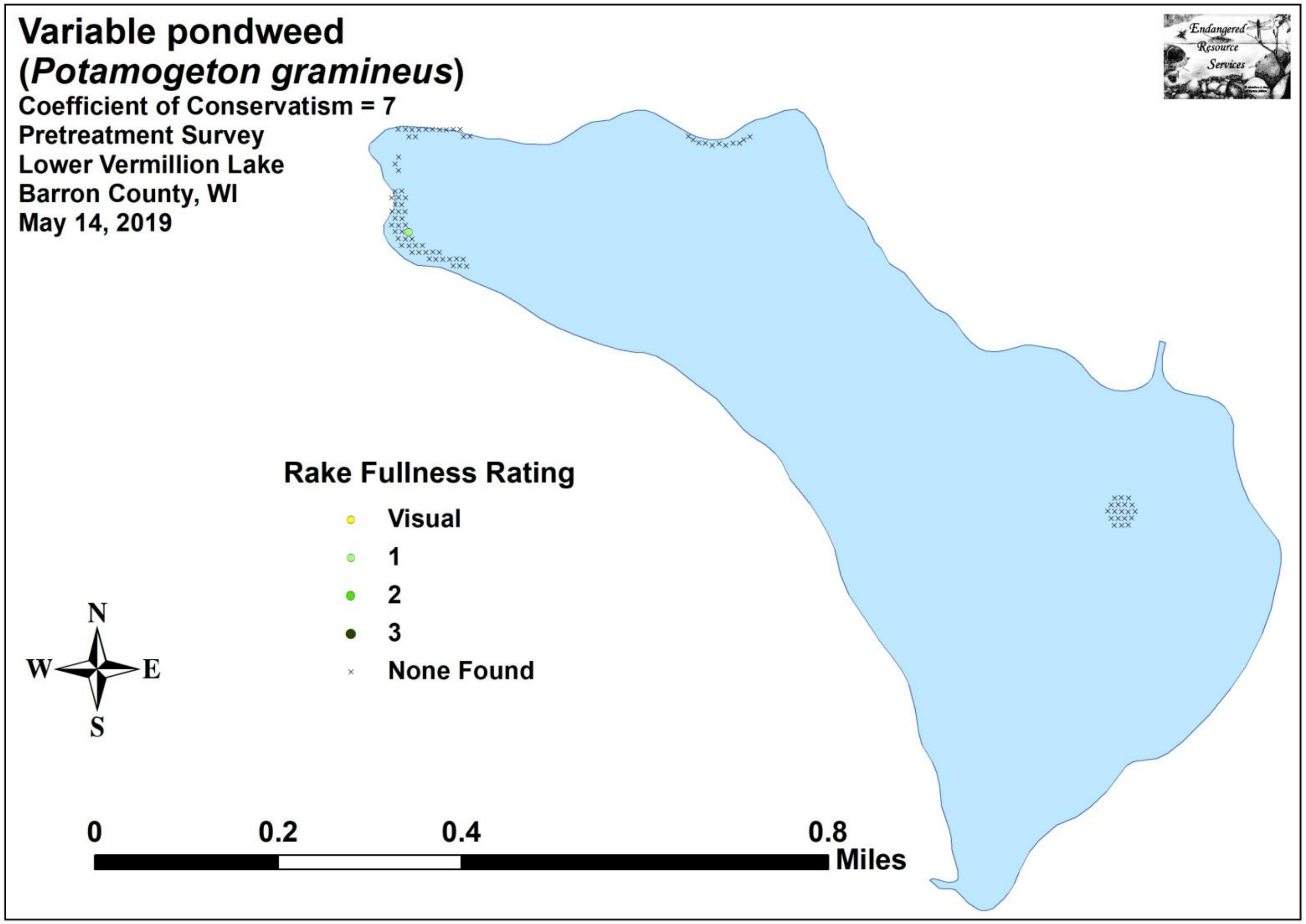

Water star-grass
(*Heteranthera dubia*)
Coefficient of Conservatism = 6
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

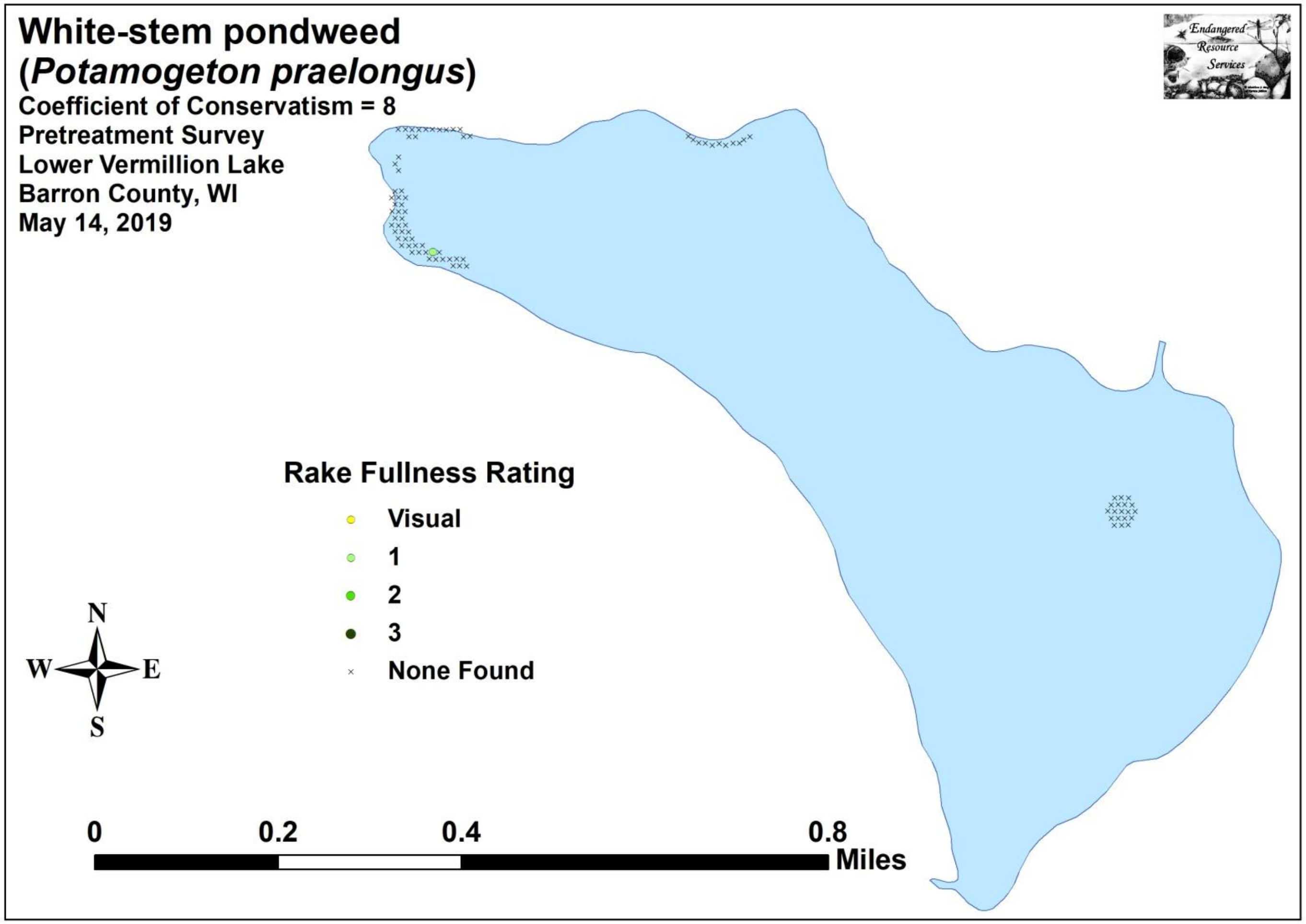


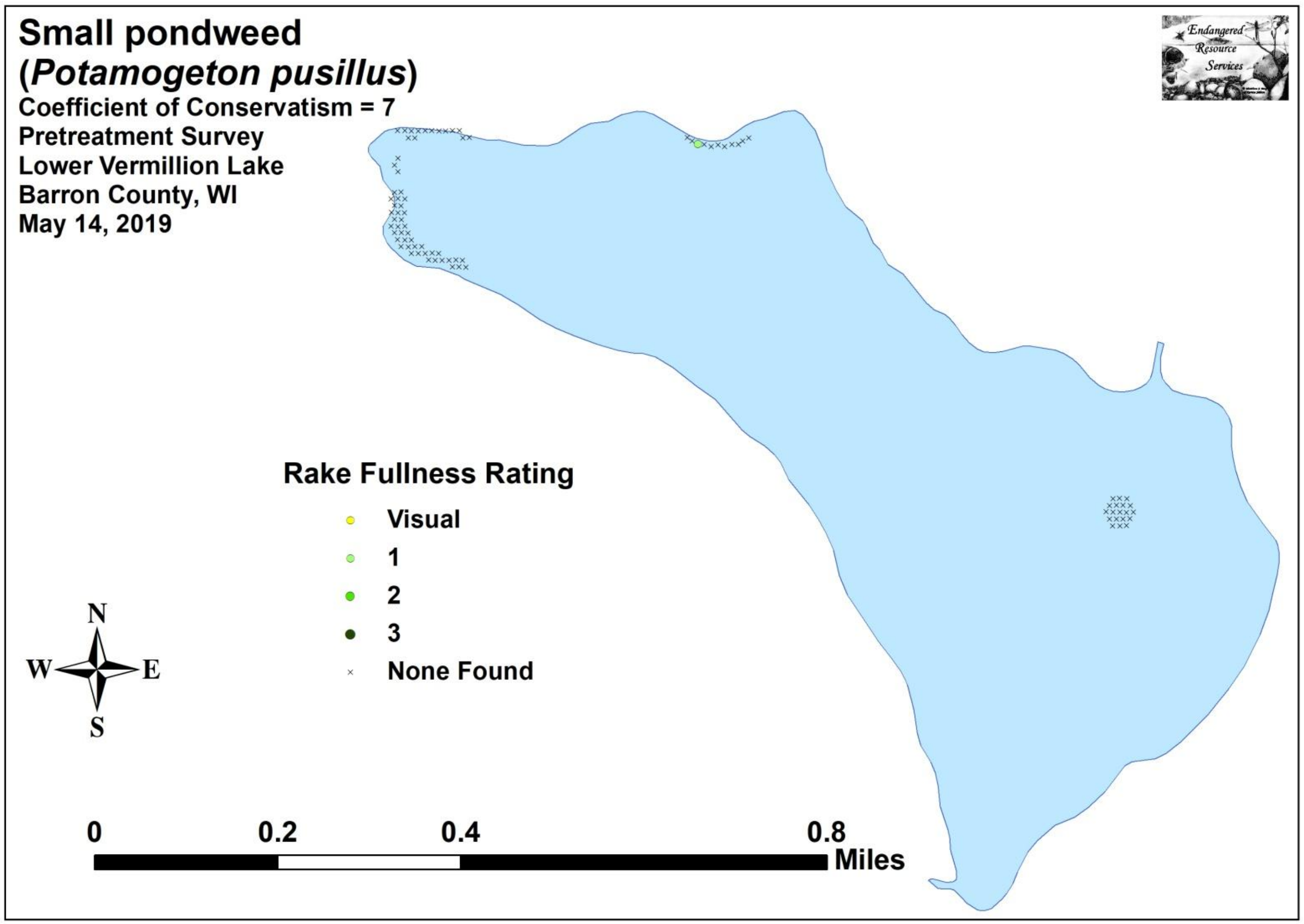
Northern water-milfoil
(Myriophyllum sibiricum)
Coefficient of Conservatism = 6
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

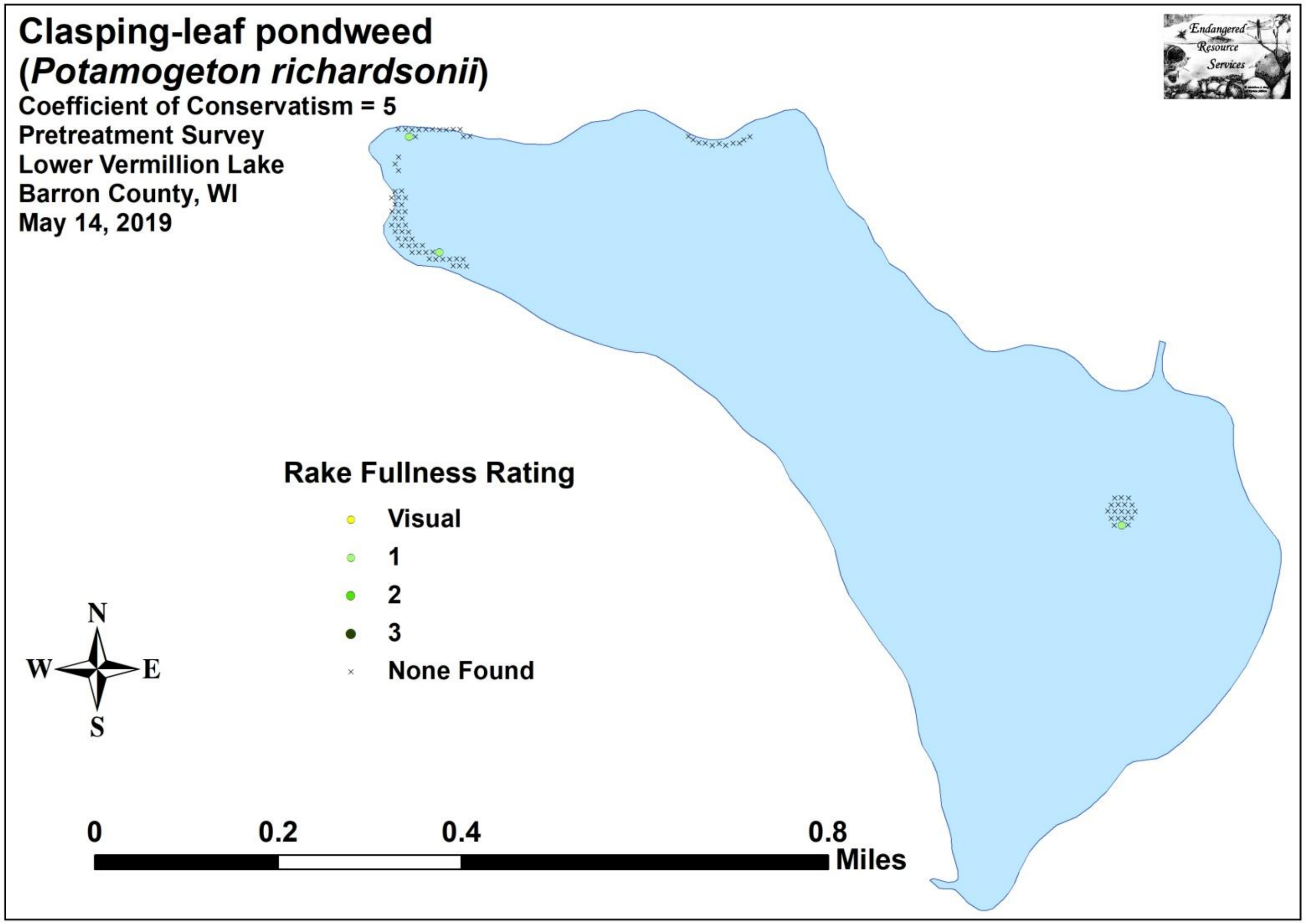

Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

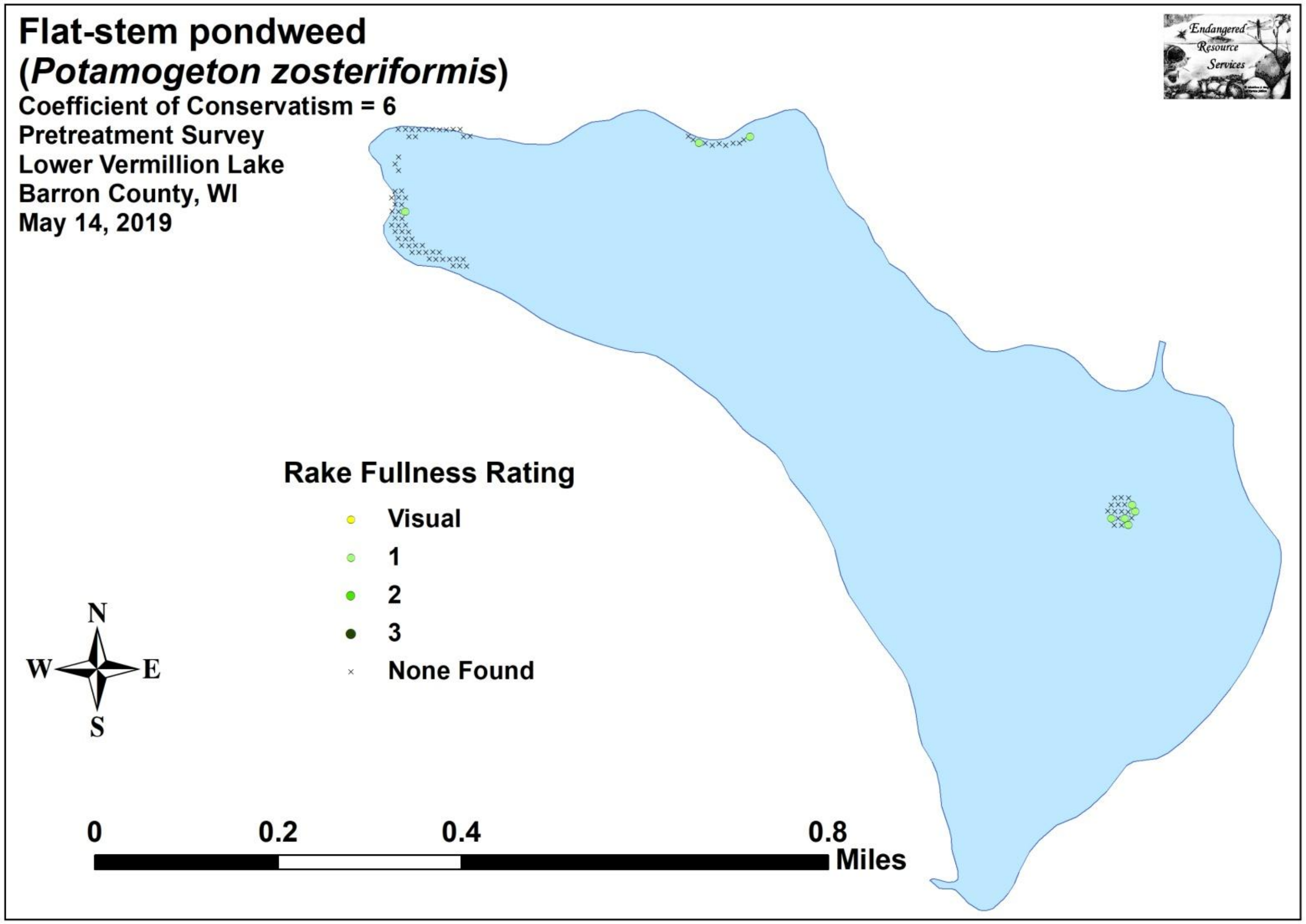

Fries' pondweed
(*Potamogeton friesii*)
Coefficient of Conservatism = 8
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

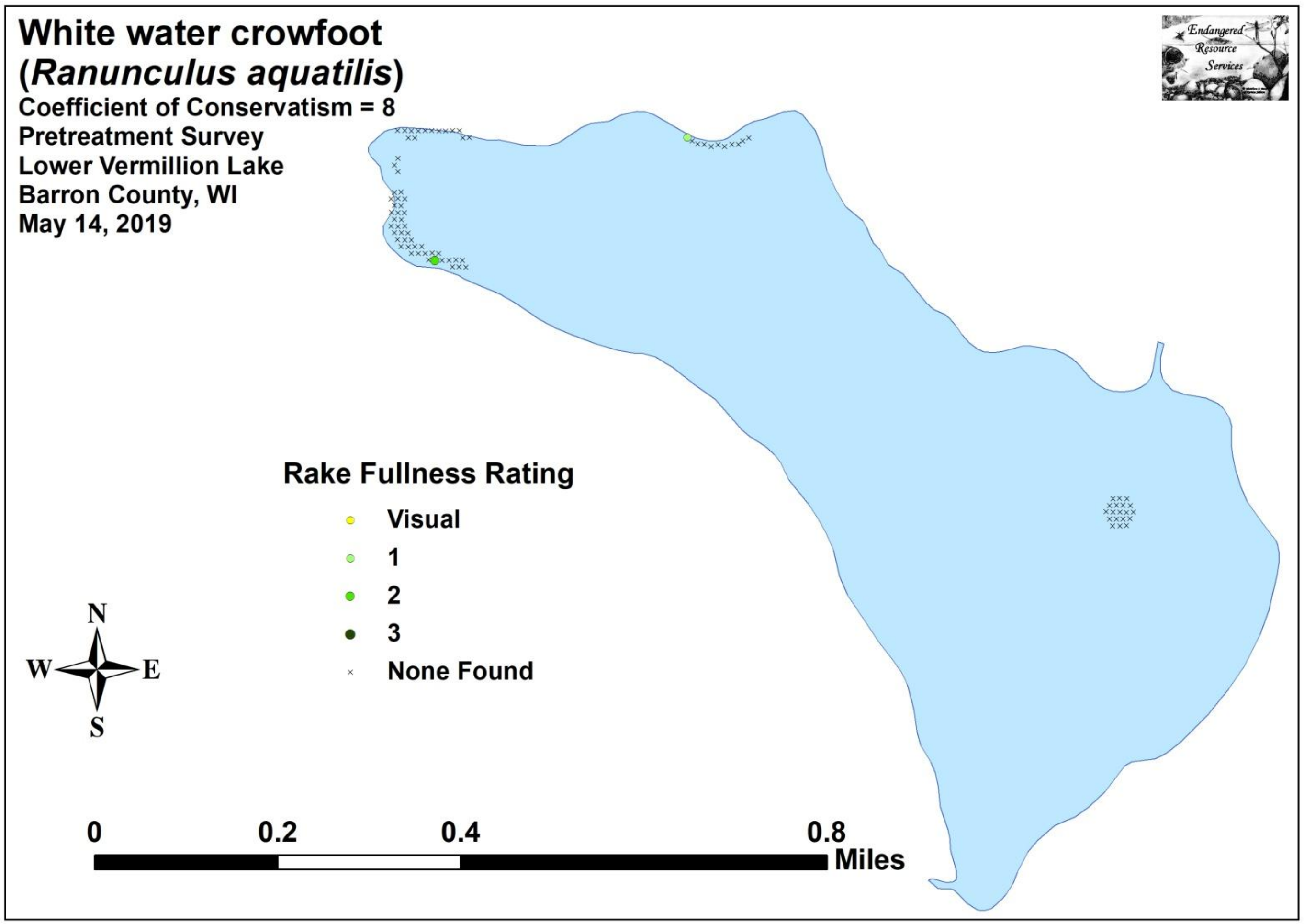

Variable pondweed
(*Potamogeton gramineus*)
Coefficient of Conservatism = 7
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

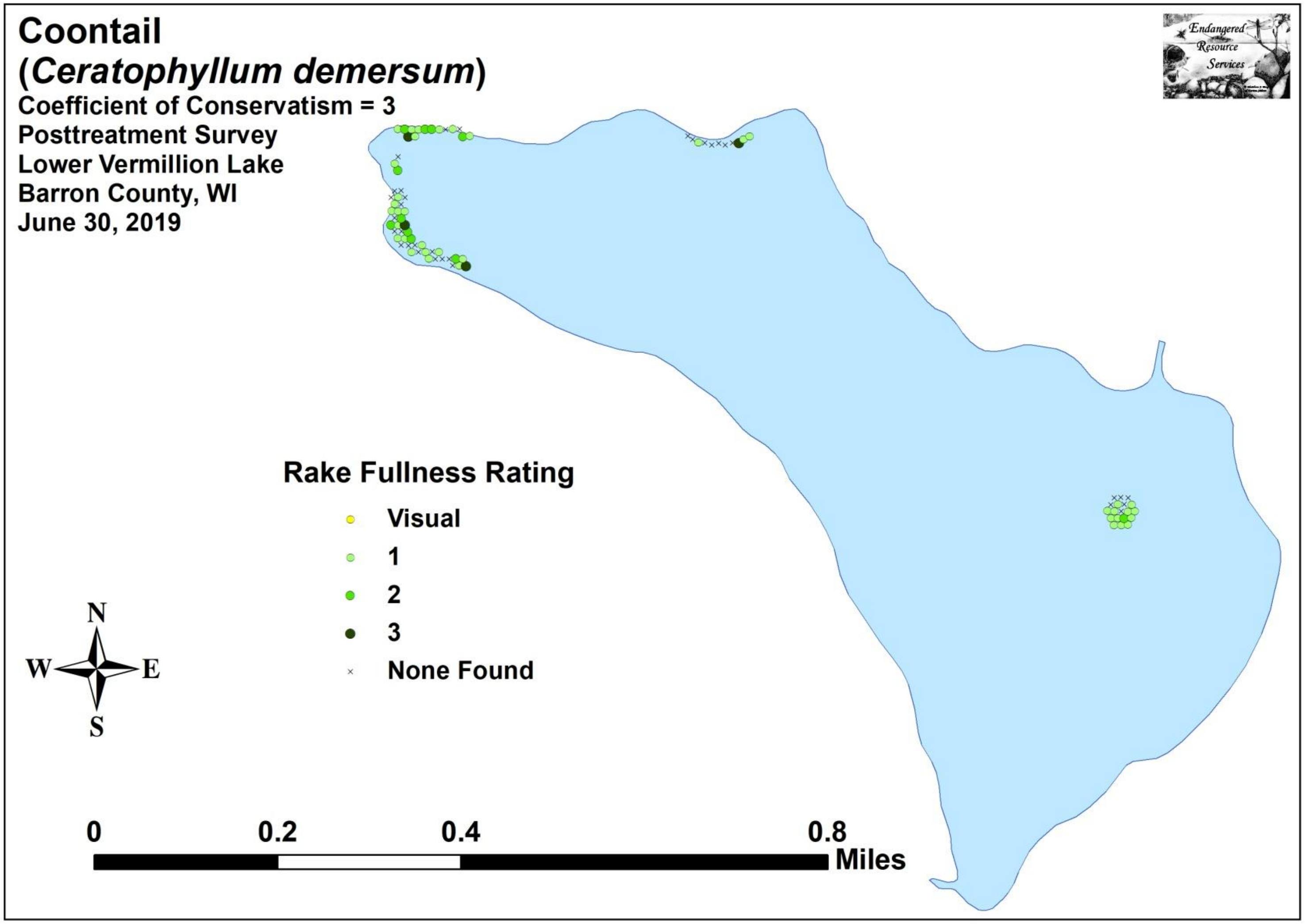

Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


Clasping-leaf pondweed
(Potamogeton richardsonii)
Coefficient of Conservatism = 5
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

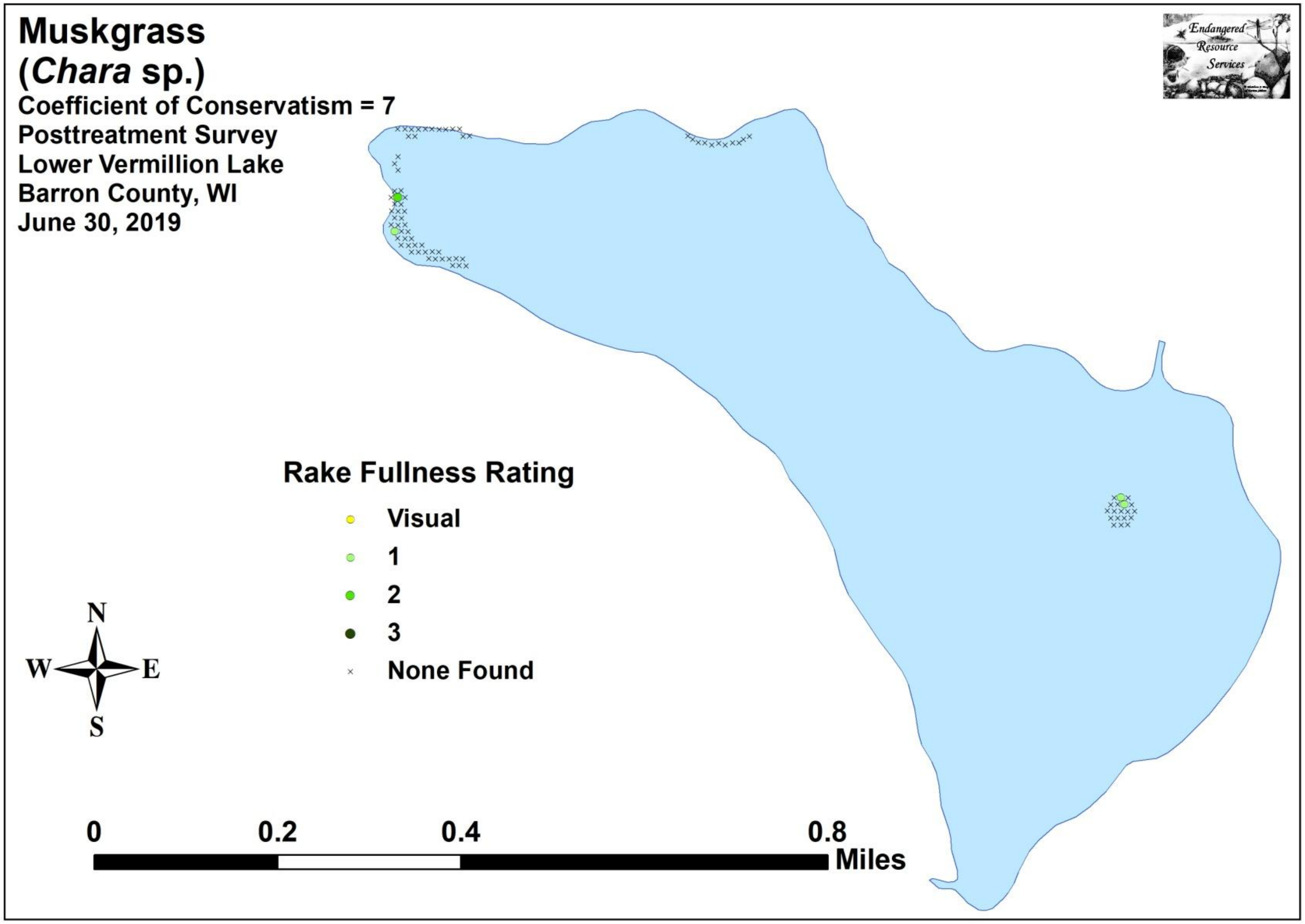

Flat-stem pondweed
(Potamogeton zosteriformis)
Coefficient of Conservatism = 6
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

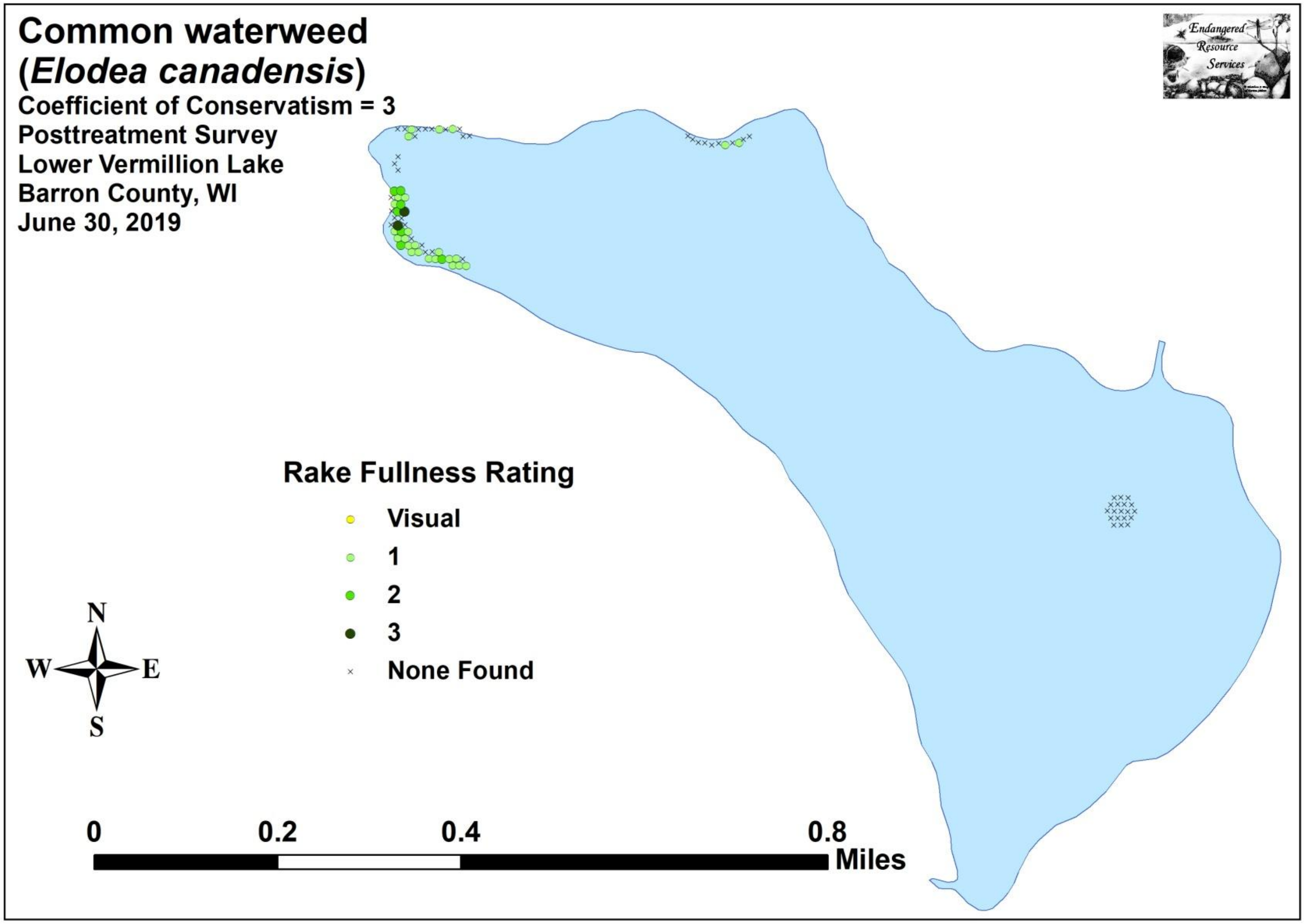

White water crowfoot
(Ranunculus aquatilis)
Coefficient of Conservatism = 8
Pretreatment Survey
Lower Vermillion Lake
Barron County, WI
May 14, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

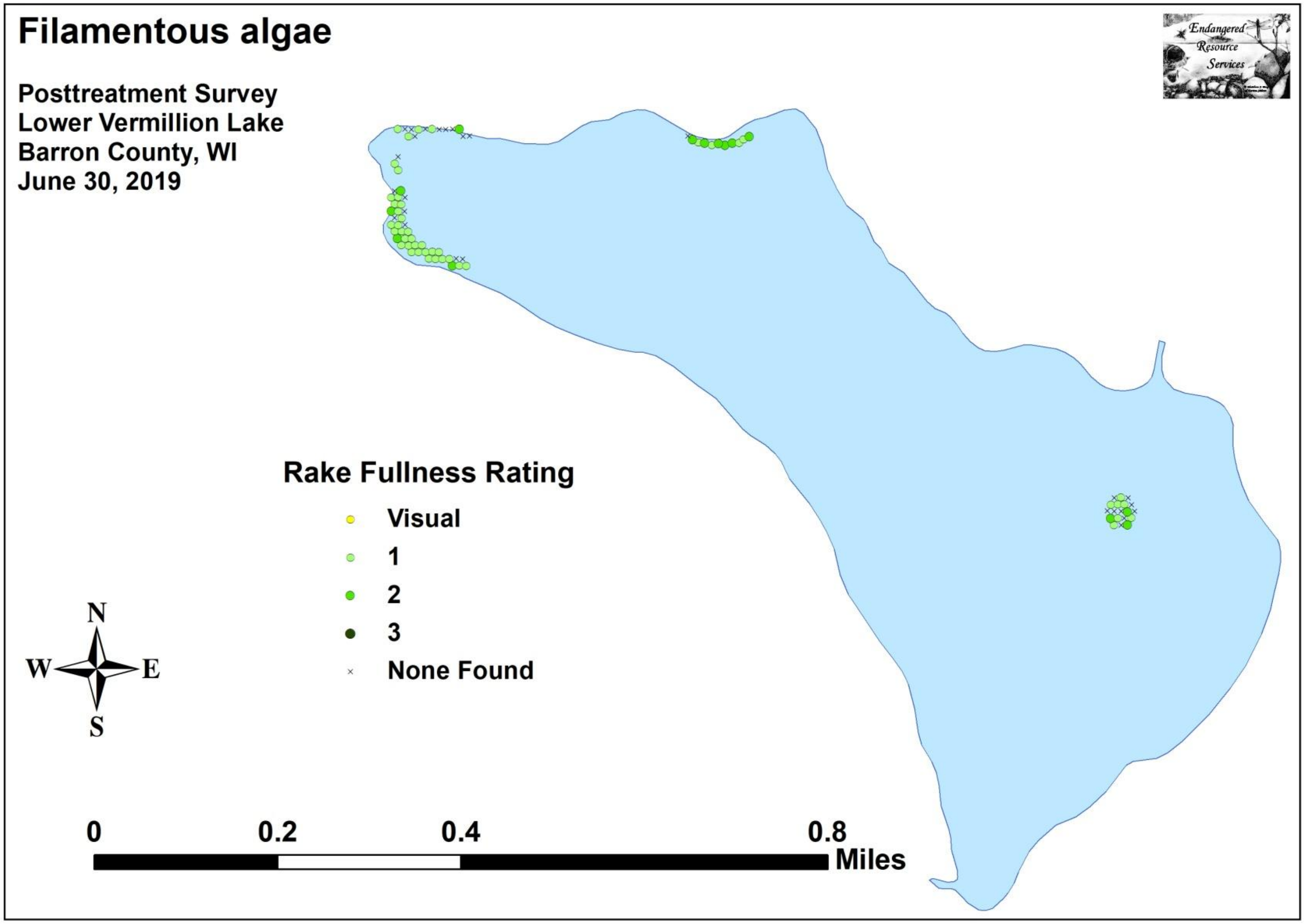
Appendix VII: Posttreatment Native Species Density and Distribution

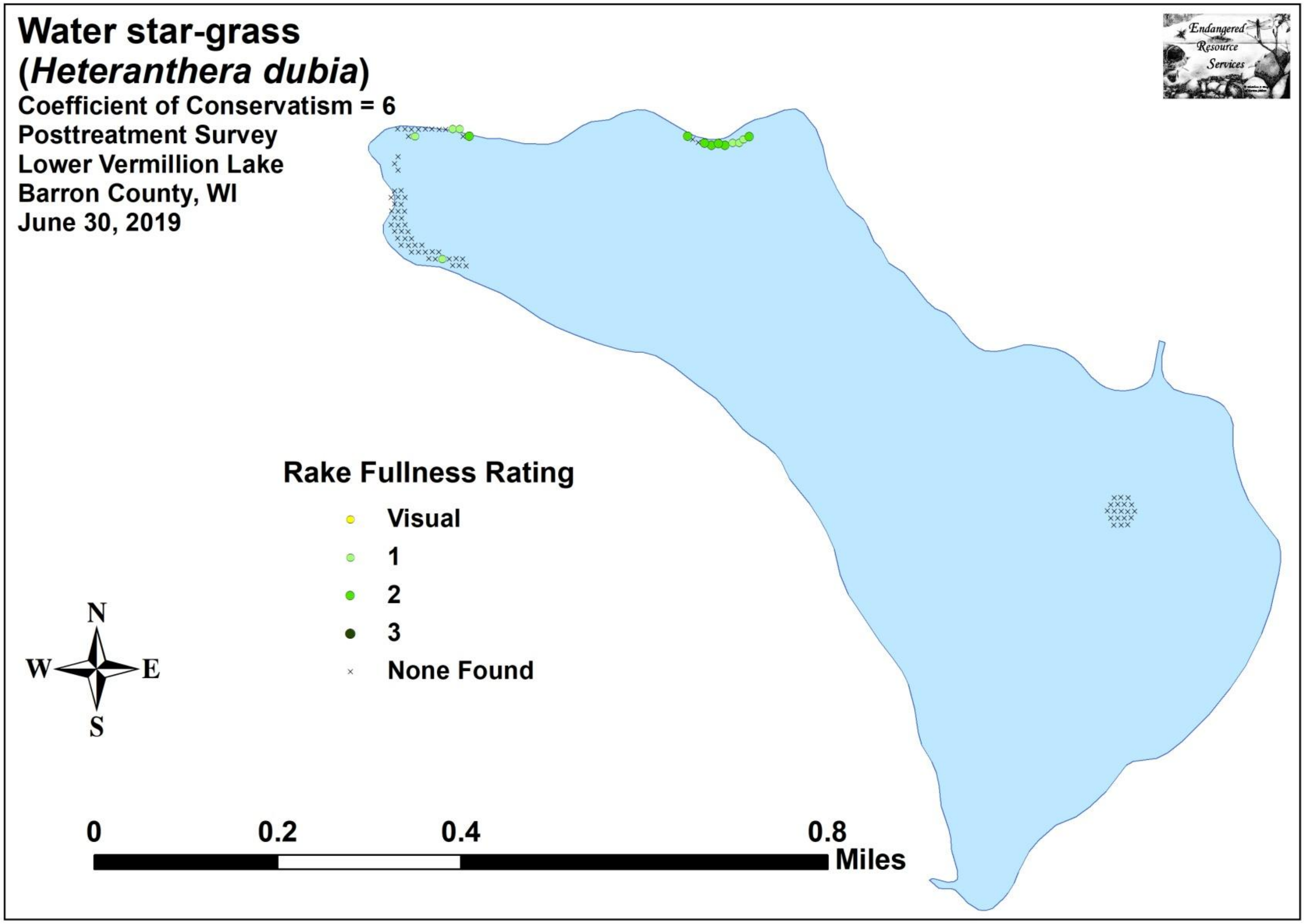


Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

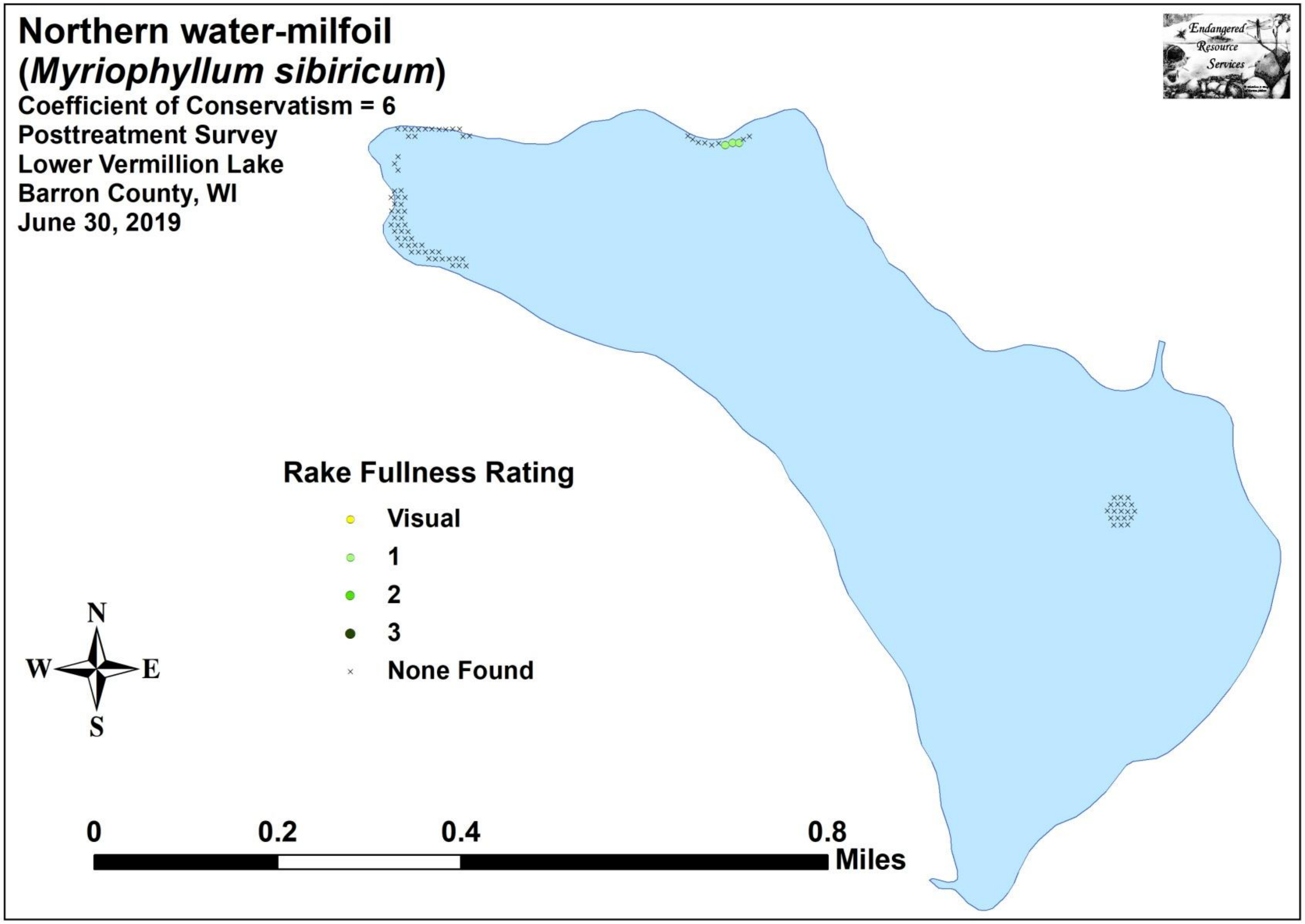

Muskgrass
(*Chara* sp.)
Coefficient of Conservatism = 7
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

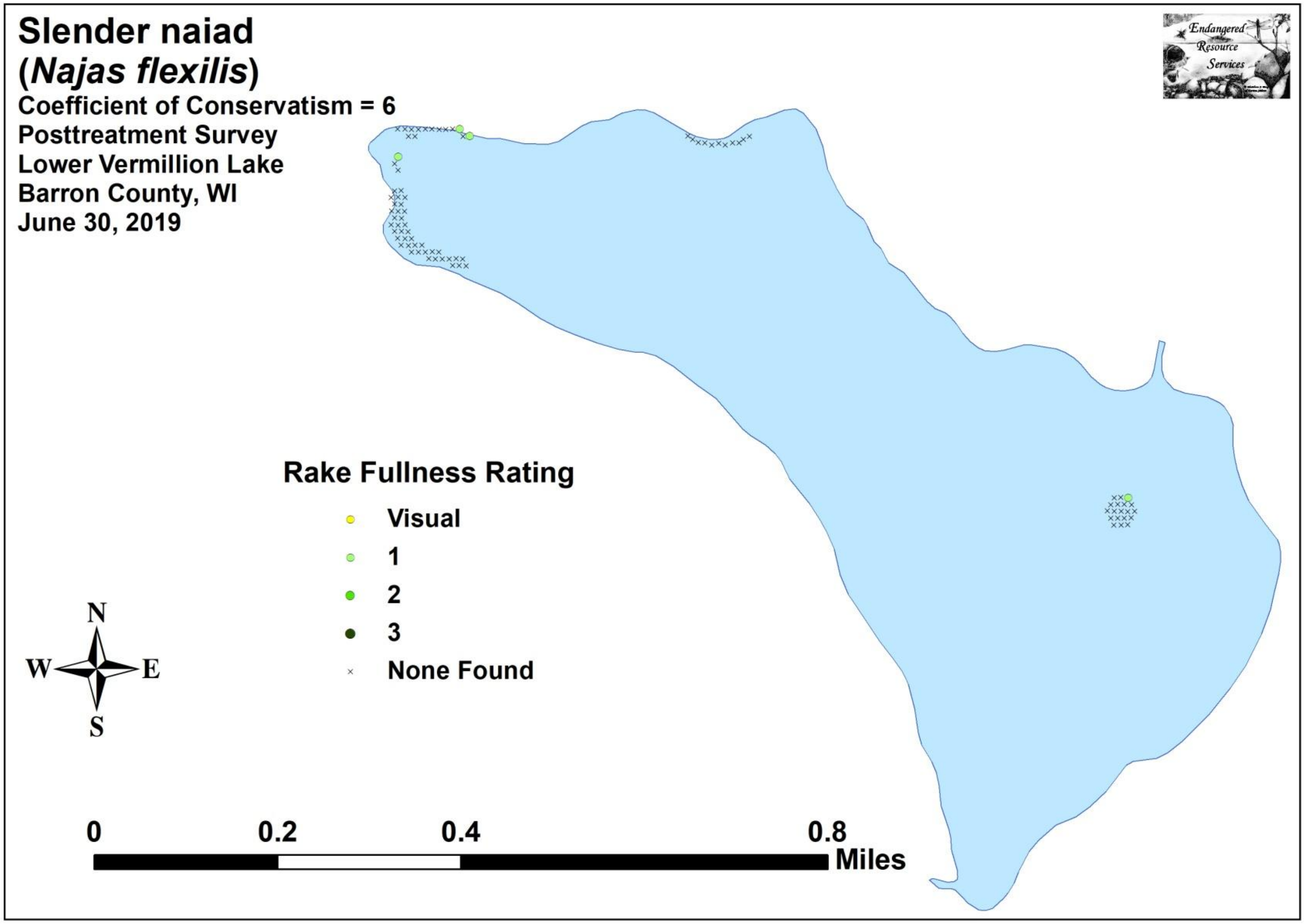

Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

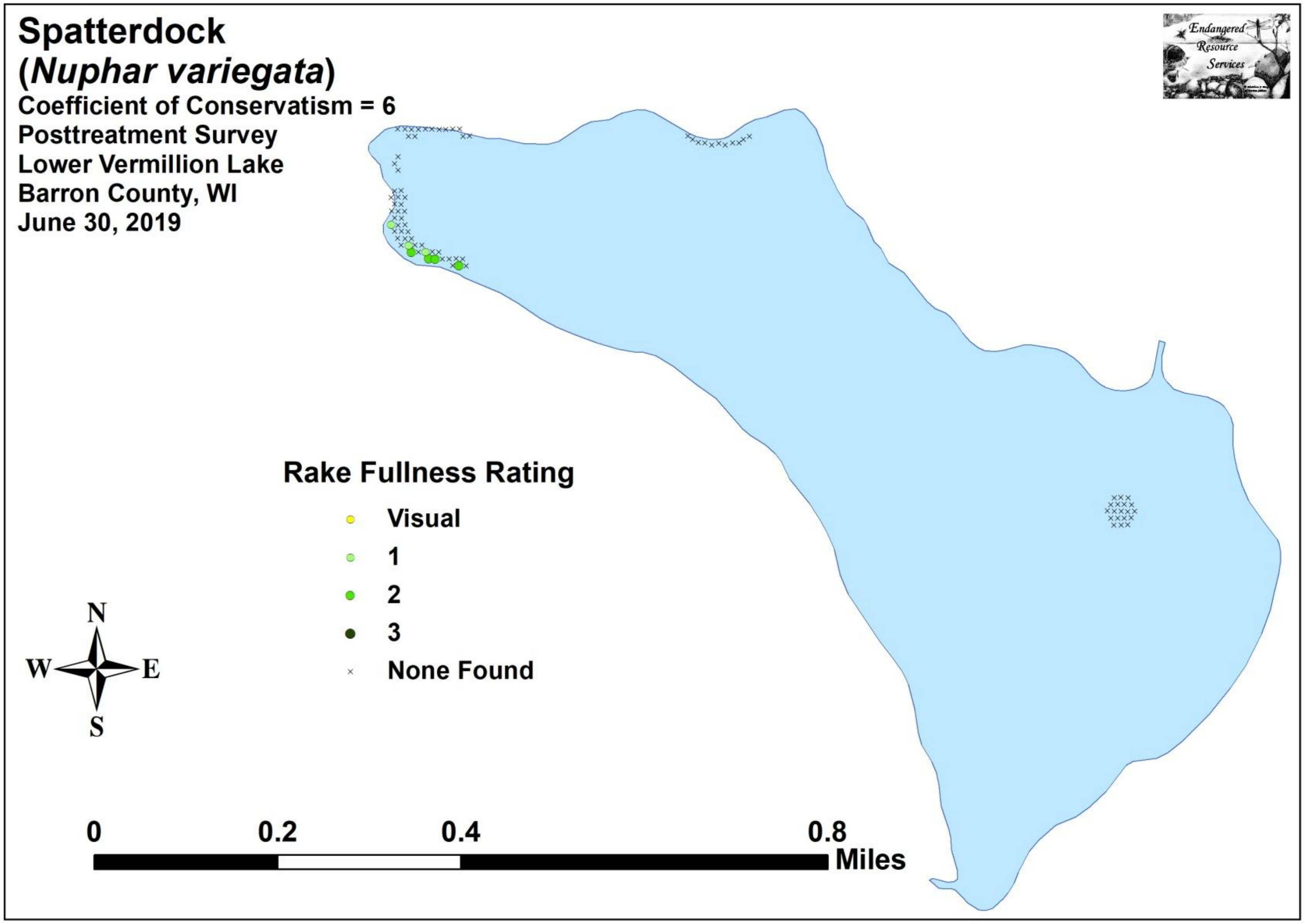

Filamentous algae
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

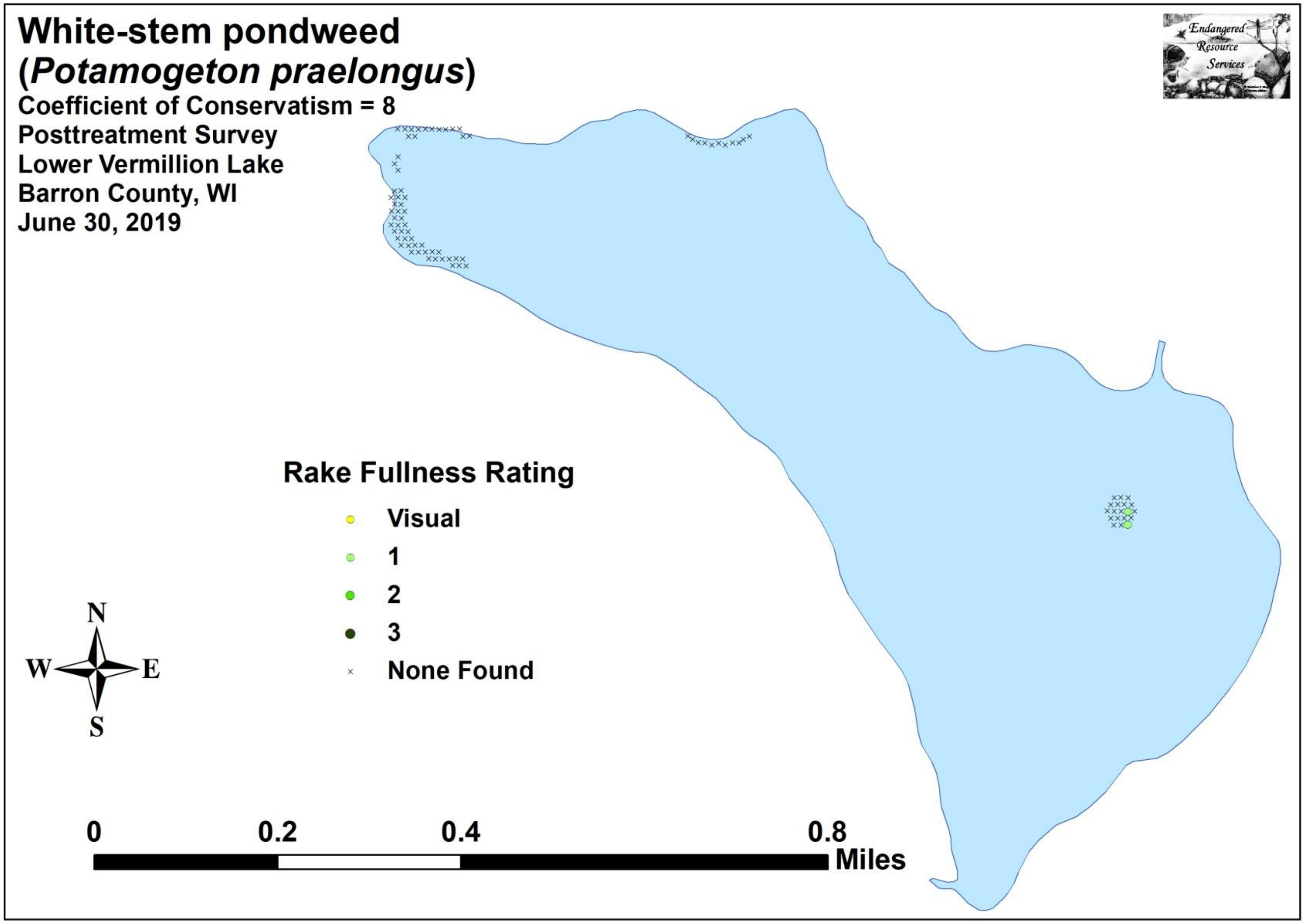


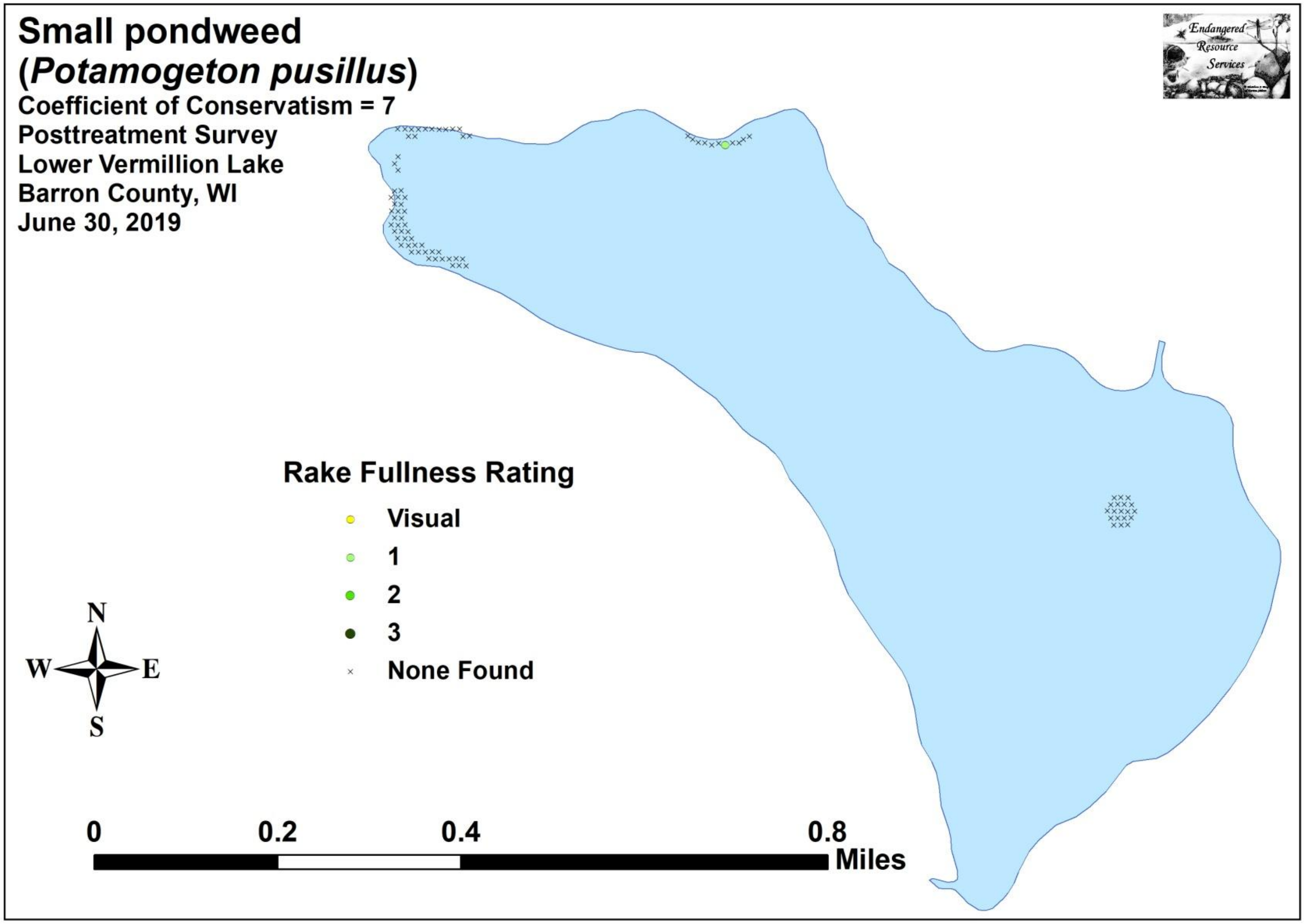
Water star-grass
(*Heteranthera dubia*)
Coefficient of Conservatism = 6
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

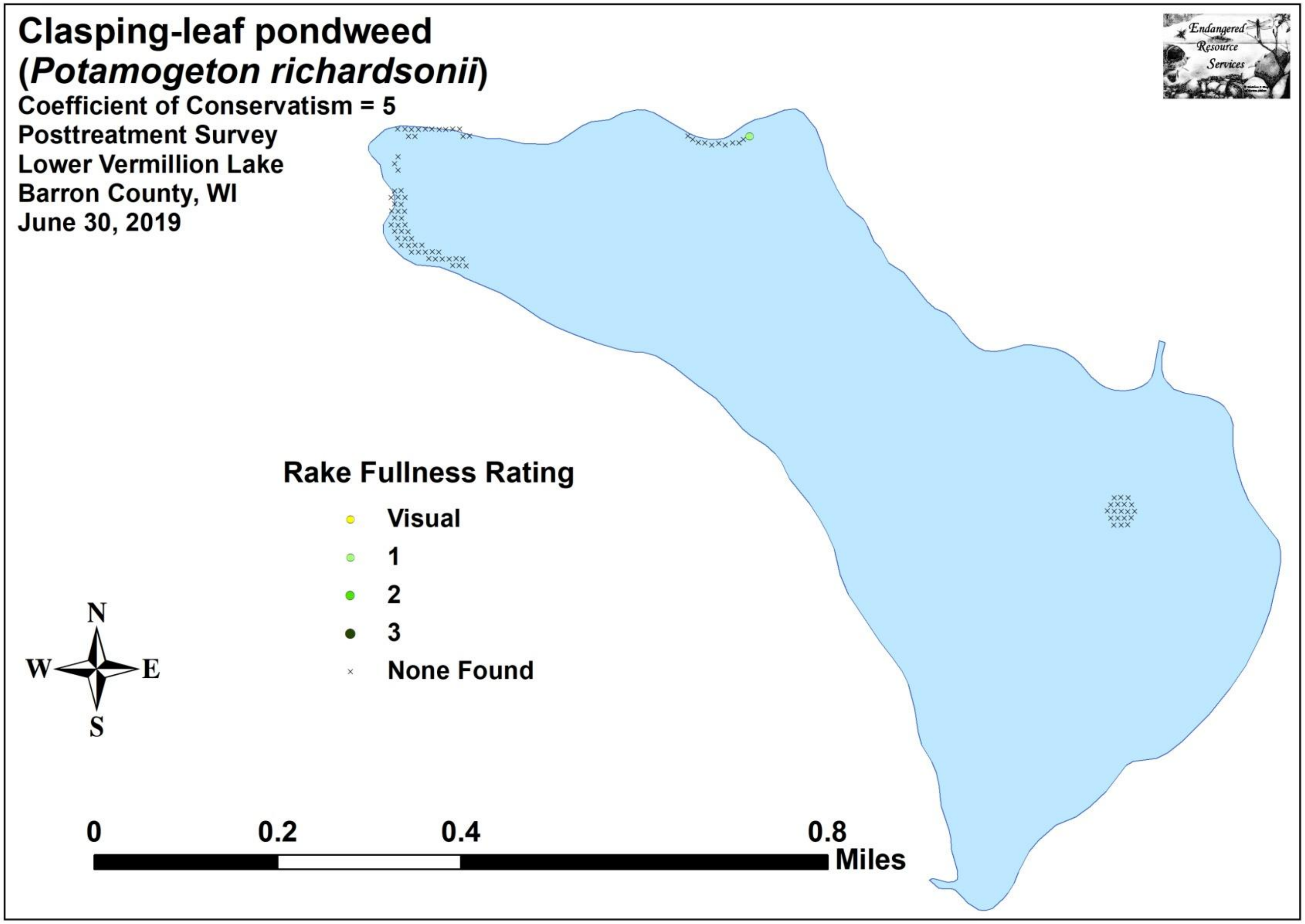

Northern water-milfoil
(*Myriophyllum sibiricum*)
Coefficient of Conservatism = 6
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

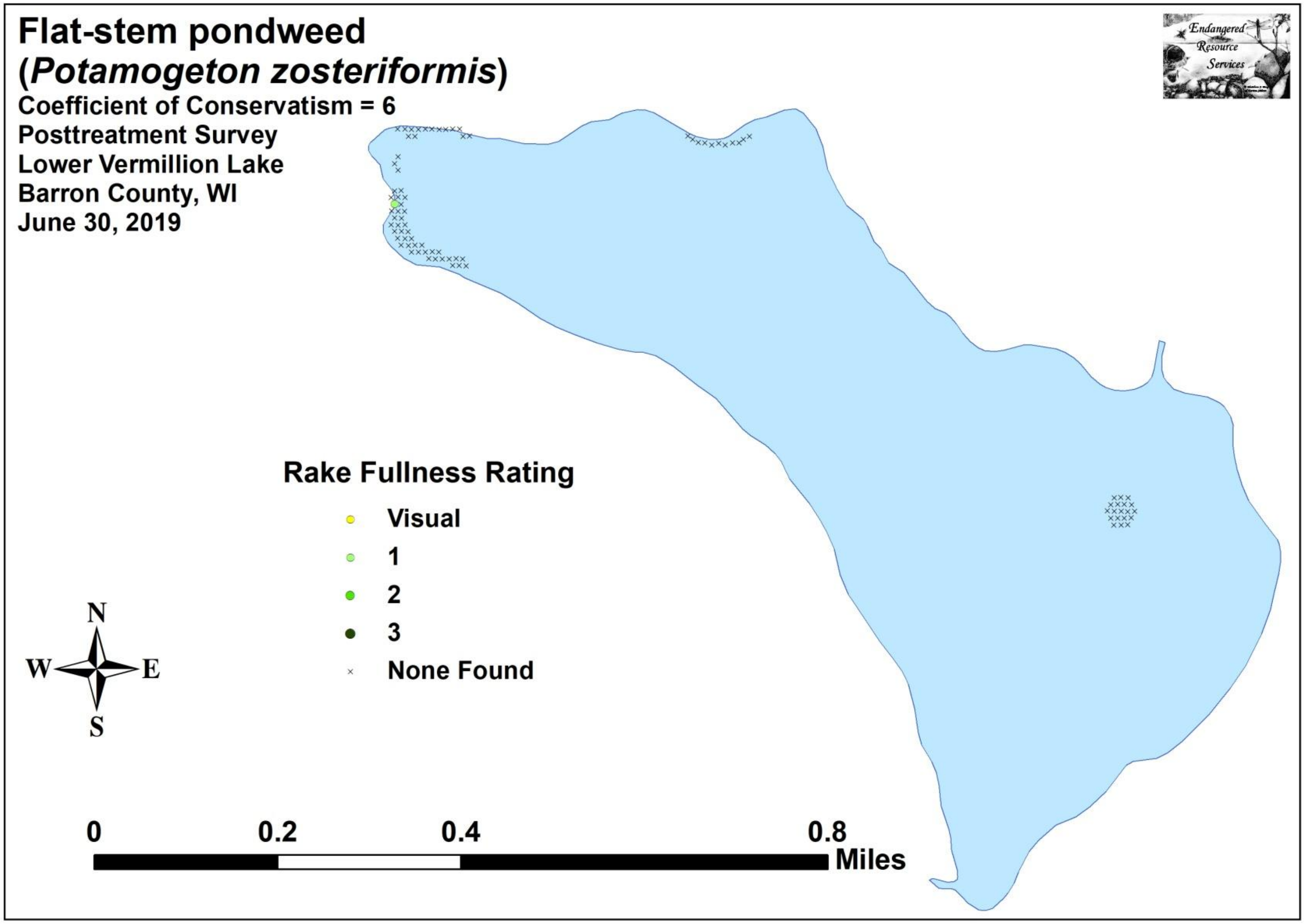

Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

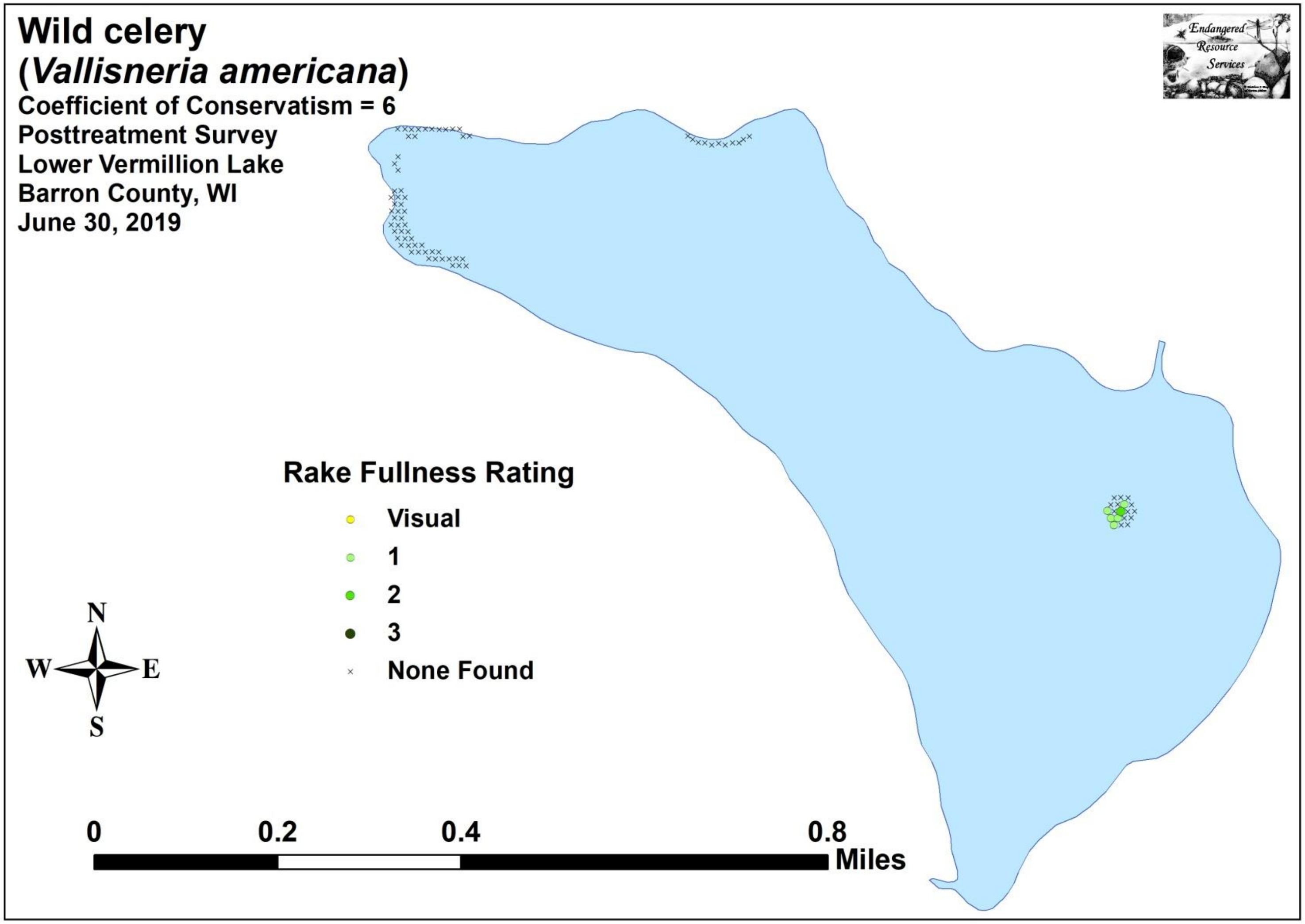

Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles


White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

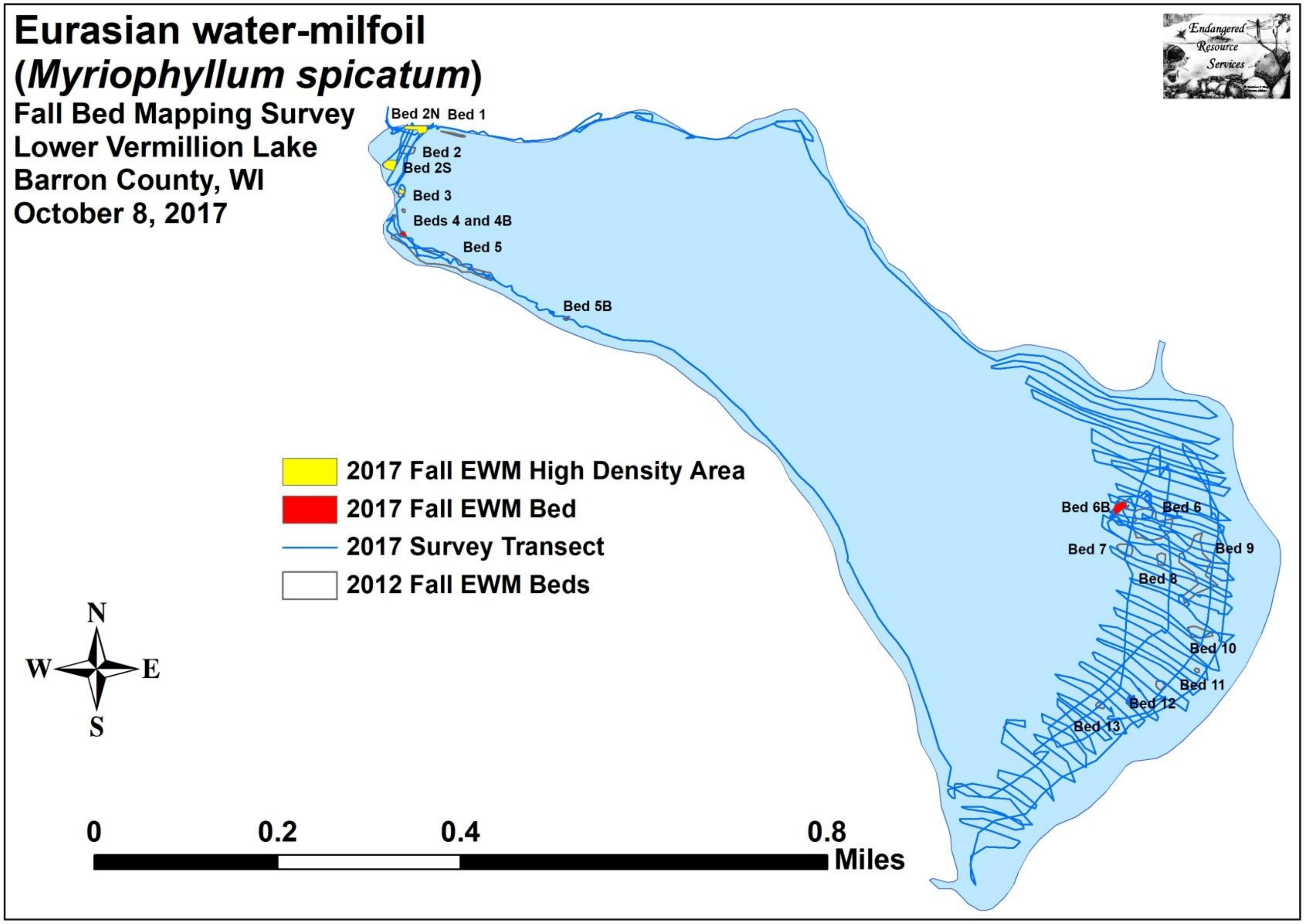

Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

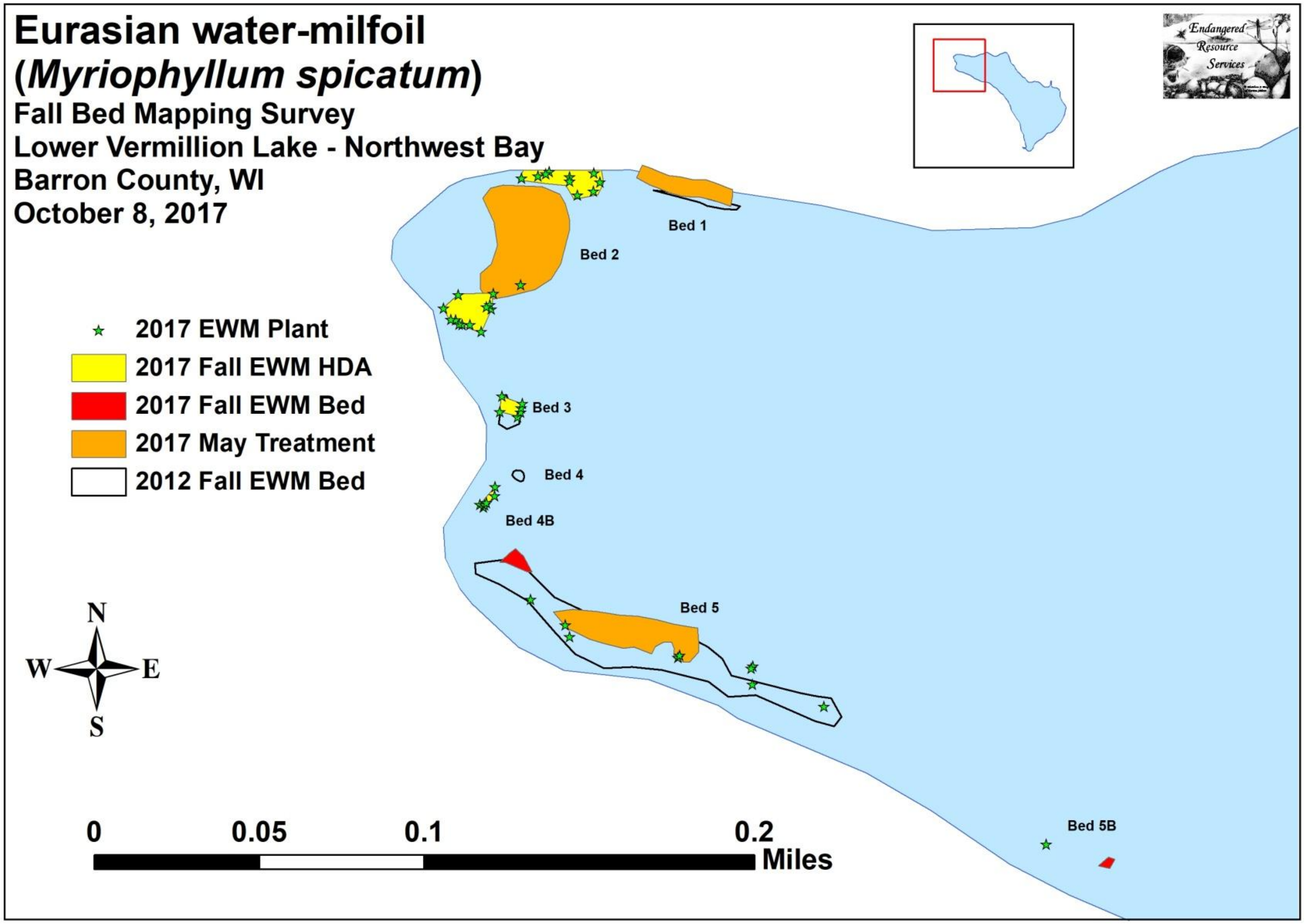

Clasping-leaf pondweed
(Potamogeton richardsonii)
Coefficient of Conservatism = 5
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

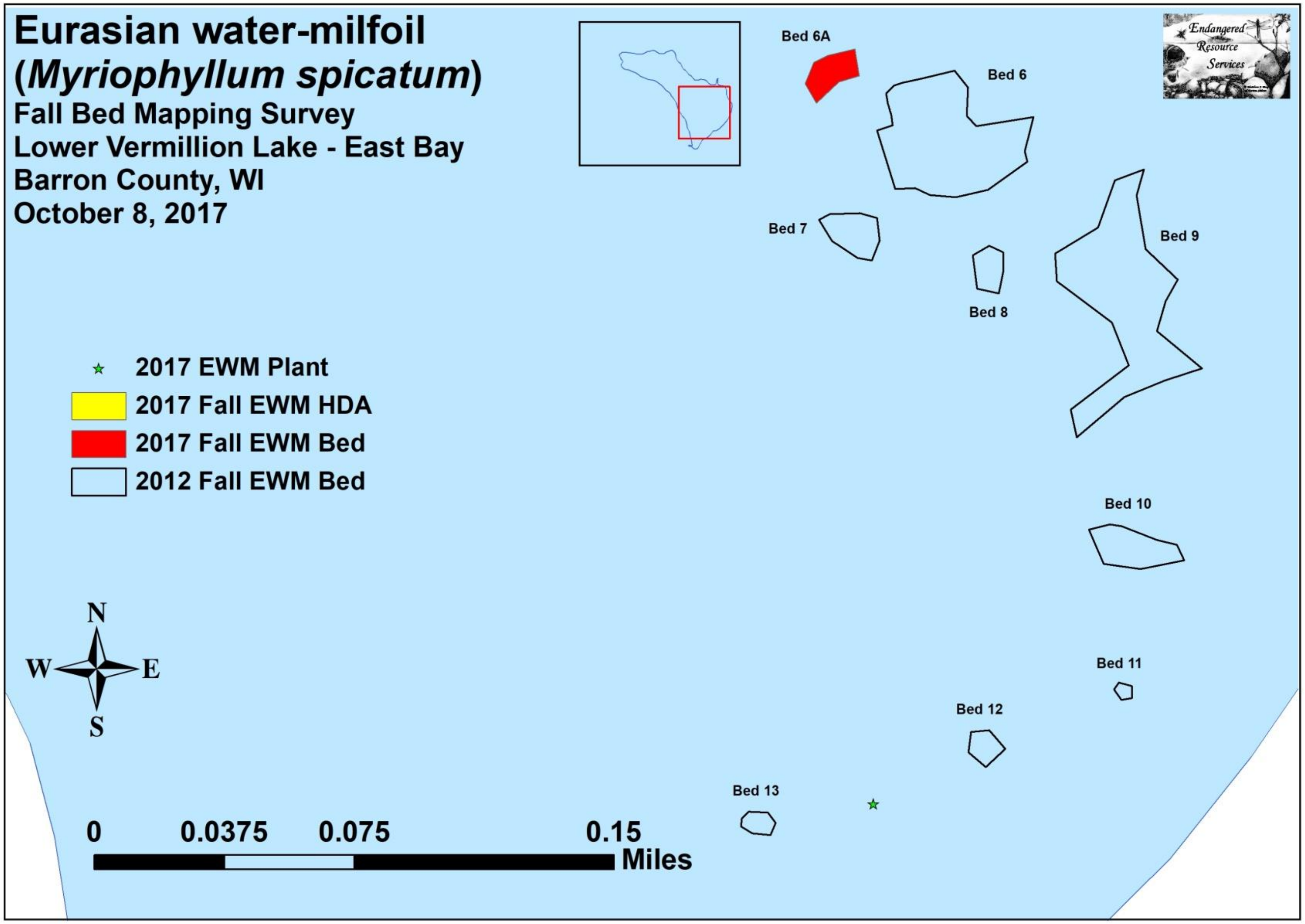

Flat-stem pondweed
(Potamogeton zosteriformis)
Coefficient of Conservatism = 6
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

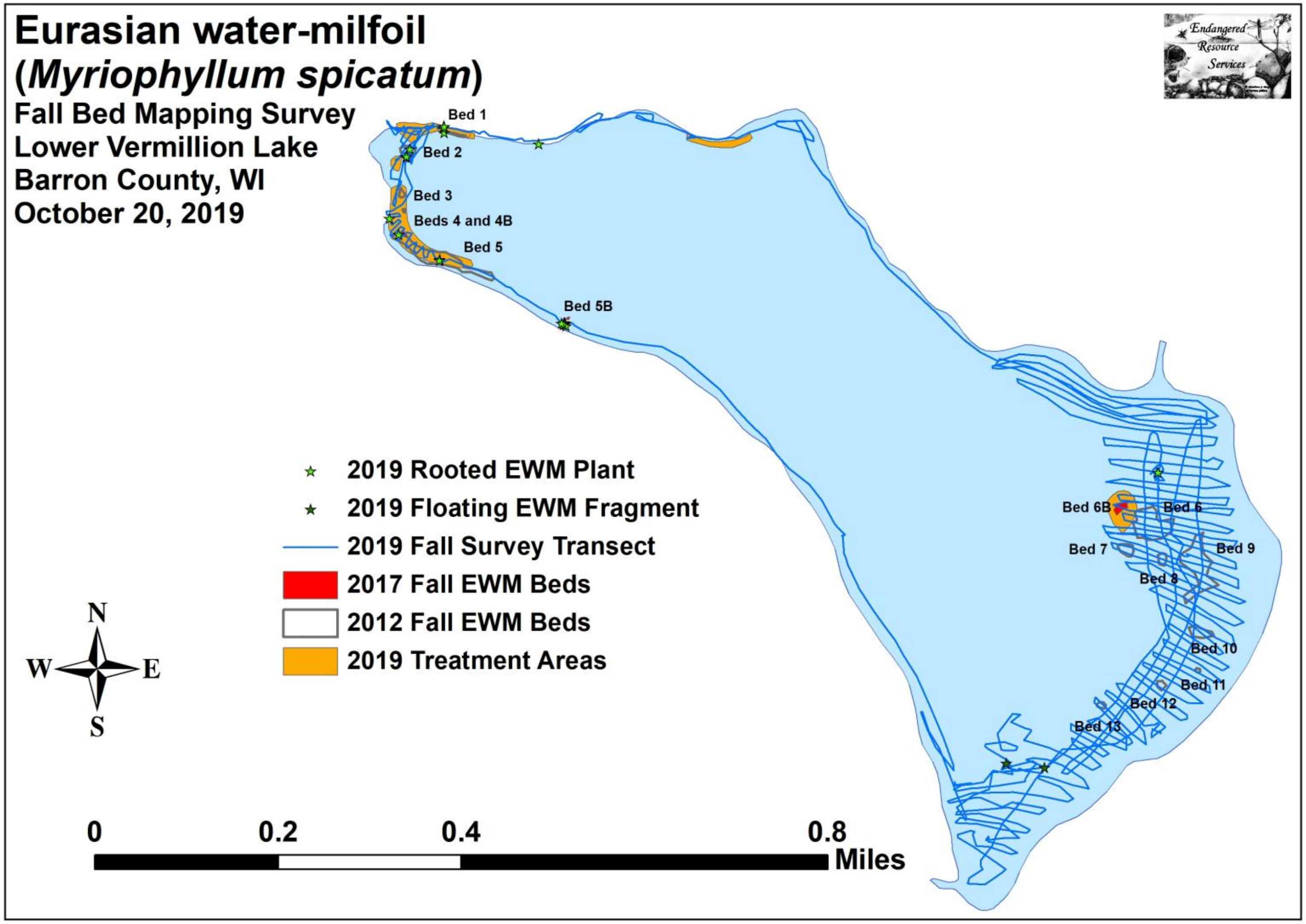

Wild celery
(*Vallisneria americana*)
Coefficient of Conservatism = 6
Posttreatment Survey
Lower Vermillion Lake
Barron County, WI
June 30, 2019
Endangered Resource Services
Rake Fullness Rating
Visual
1
2
3
None Found
N
W
E
S
0
0.2
0.4
0.8
Miles

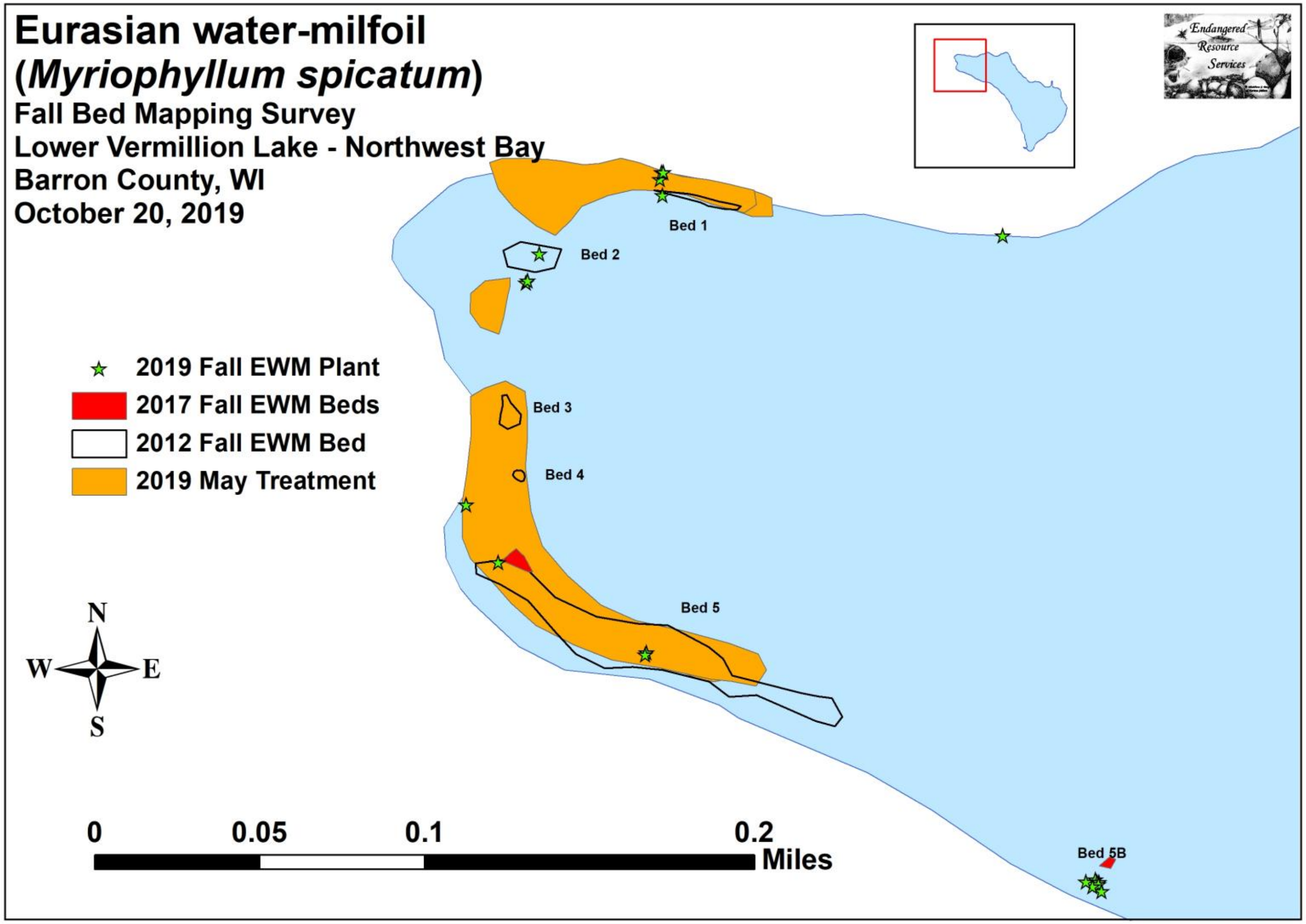
Appendix VIII: Fall 2017 and 2019 EWM Bed Maps

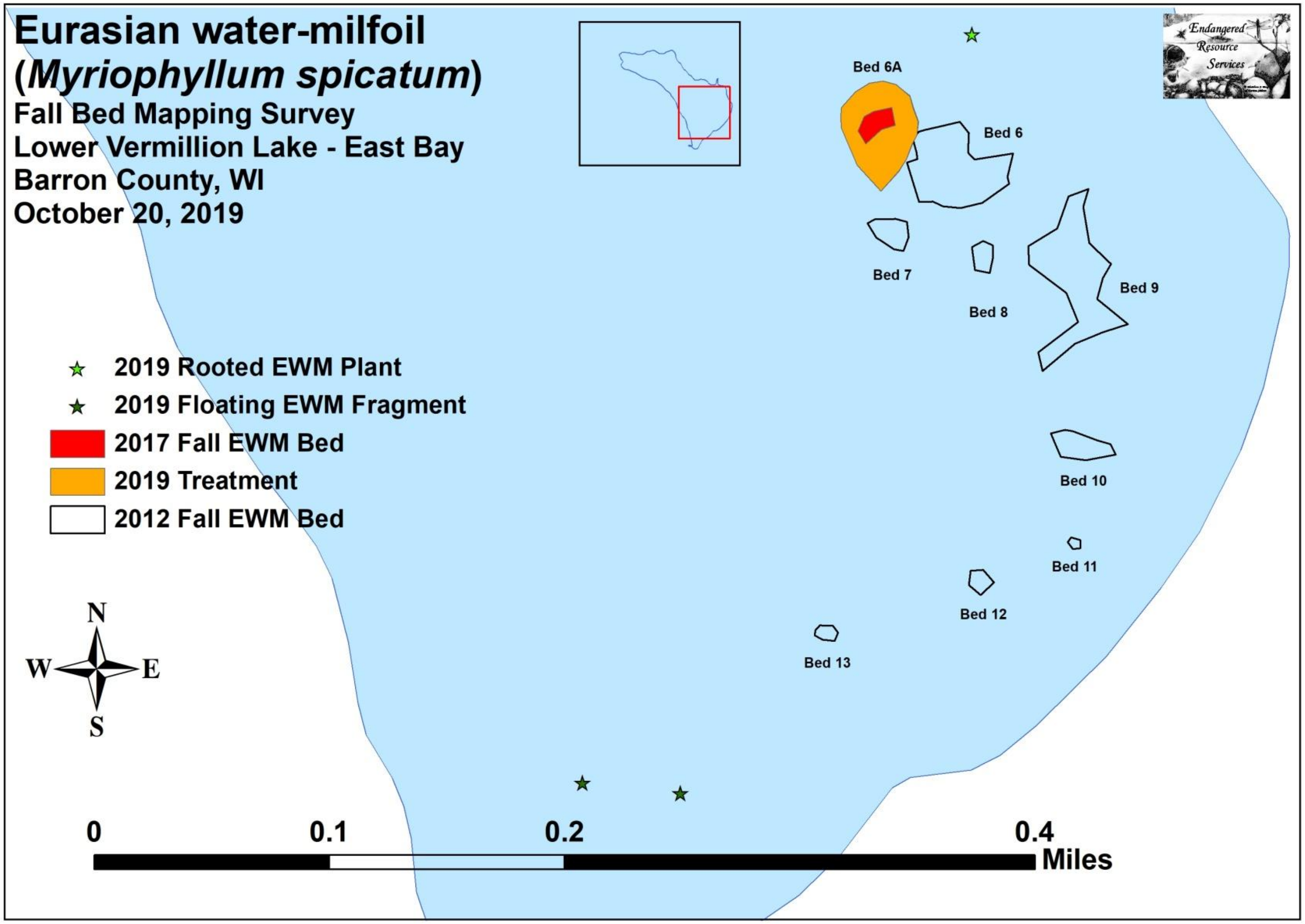

Eurasian water-milfoil
(*Myriophyllum spicatum*)
Fall Bed Mapping Survey
Lower Vermillion Lake
Barron County, WI
October 8, 2017
Endangered Resource Services
Bed 2N
Bed 1
Bed 2
Bed 2S
Bed 3
Beds 4 and 4B
Bed 5
Bed 5B
Bed 6B
Bed 6
Bed 7
Bed 9
Bed 8
Bed 10
Bed 11
Bed 12
Bed 13
2017 Fall EWM High Density Area
2017 Fall EWM Bed
2017 Survey Transect
2012 Fall EWM Beds
N
W
E
S
0
0.2
0.4
0.8
Miles


Eurasian water-milfoil
(*Myriophyllum spicatum*)
Fall Bed Mapping Survey
Lower Vermillion Lake - Northwest Bay
Barron County, WI
October 8, 2017
Endangered Resource Services
Bed 1
Bed 2
Bed 3
Bed 4
Bed 4B
Bed 5
Bed 5B
2017 EWM Plant
2017 Fall EWM HDA
2017 Fall EWM Bed
2017 May Treatment
2012 Fall EWM Bed
N
W
E
S
0
0.05
0.1
0.2
Miles


Eurasian water-milfoil
(*Myriophyllum spicatum*)
Fall Bed Mapping Survey
Lower Vermillion Lake - East Bay
Barron County, WI
October 8, 2017
Bed 6A
Bed 6
Bed 7
Bed 8
Bed 9
Bed 10
Bed 11
Bed 12
Bed 13
2017 EWM Plant
2017 Fall EWM HDA
2017 Fall EWM Bed
2012 Fall EWM Bed
N
W
E
S
0
0.0375
0.075
0.15
Miles
Endangered Resource Services


Eurasian water-milfoil
(*Myriophyllum spicatum*)
Fall Bed Mapping Survey
Lower Vermillion Lake
Barron County, WI
October 20, 2019
Endangered Resource Services
Bed 1
Bed 2
Bed 3
Beds 4 and 4B
Bed 5
Bed 5B
Bed 6B
Bed 6
Bed 7
Bed 9
Bed 8
Bed 10
Bed 11
Bed 12
Bed 13
2019 Rooted EWM Plant
2019 Floating EWM Fragment
2019 Fall Survey Transect
2017 Fall EWM Beds
2012 Fall EWM Beds
2019 Treatment Areas
N
W
E
S
0
0.2
0.4
0.8
Miles


Eurasian water-milfoil
(Myriophyllum spicatum)
Fall Bed Mapping Survey
Lower Vermillion Lake - Northwest Bay
Barron County, WI
October 20, 2019
Endangered Resource Services
Bed 1
Bed 2
Bed 3
Bed 4
Bed 5
Bed 5B
2019 Fall EWM Plant
2017 Fall EWM Beds
2012 Fall EWM Bed
2019 May Treatment
N
W
E
S
0
0.05
0.1
0.2
Miles


Eurasian water-milfoil
(*Myriophyllum spicatum*)
Fall Bed Mapping Survey
Lower Vermillion Lake - East Bay
Barron County, WI
October 20, 2019
Endangered Resource Services
Bed 6A
Bed 6
Bed 7
Bed 8
Bed 9
Bed 10
Bed 11
Bed 12
Bed 13
2019 Rooted EWM Plant
2019 Floating EWM Fragment
2017 Fall EWM Bed
2019 Treatment
2012 Fall EWM Bed
N
W
E
S
0
0.1
0.2
0.4
Miles