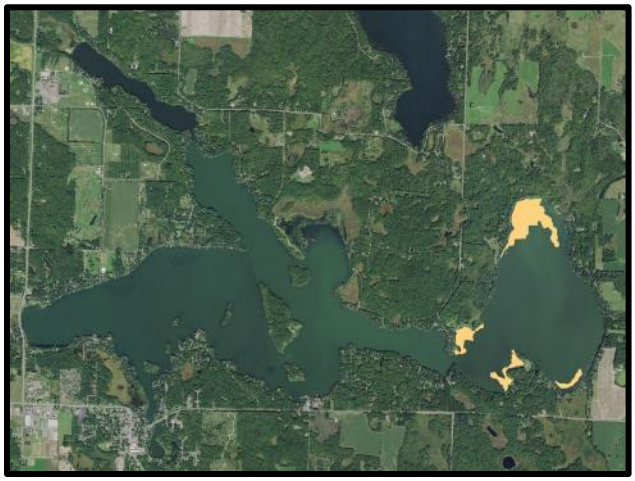
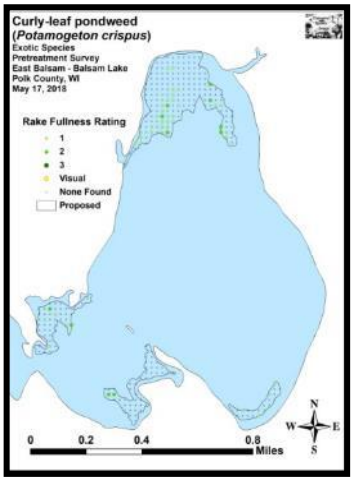
Curly-leaf Pondweed (*Potamogeton crispus*)
Pretreatment, Follow-up and Bed Mapping Surveys
Balsam Lake - WBIC: 2620600
Polk County, Wisconsin

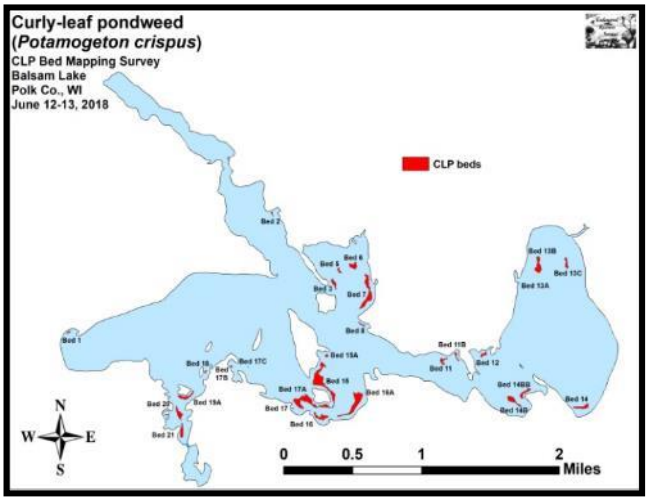


Proposed Spring 2018 CLP Treatment Areas



2018 CLP Pretreatment in East Balsam

Project Initiated by:
Balsam Lake Protection and Rehabilitation District and the
Wisconsin Department of Natural Resources – Grant ACEI21218



2018 CLP Beds

Surveys Conducted by and Report Prepared by:
Endangered Resource Services, LLC
Matthew S. Berg, Research Biologist
St. Croix Falls, Wisconsin
May 17, June 9, and June 12-13, 2018

TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

INTRODUCTION:

Balsam Lake (WBIC 2620600) is a 2,054 acre stratified drainage lake in central Polk County, Wisconsin in the Towns of Balsam Lake, Milltown, Georgetown, and Apple River (T34N R17W S10 NE NE). It reaches a maximum depth of 37ft north of Cedar Island in the western basin and has an average depth of 20ft (Hopke et al. 1964). The lake is mesotrophic bordering on eutrophic in nature, and water clarity is fair with historical summer Secchi readings averaging 6ft in East Balsam, 7ft in Little Balsam, and 8ft in the deep hole north of Cedar Island (WDNR 2018). Bottom substrate is variable with organic muck in most bays, and rock/sand in the Big and Little Narrows and around the lake's many islands.

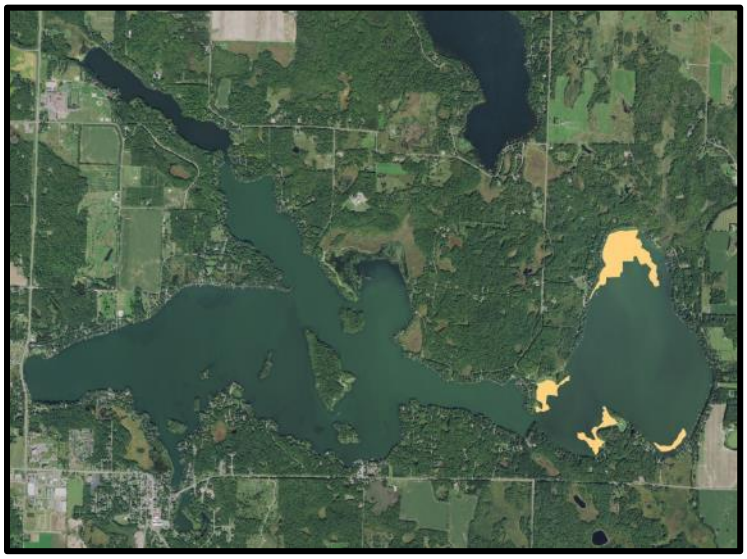


Figure 1: Balsam Lake with Proposed 2018 CLP Treatment Areas

BACKGROUND AND STUDY RATIONALE:

In the spring of 2018, the Balsam Lake Protection and Rehabilitation District (BLPRD) and the Wisconsin Department of Natural Resources (WDNR) authorized the herbicide treatment of 50.00 acres (2.43% of the lake's total surface area) within four Curly-leaf pondweed (*Potamogeton crispus*) (CLP) beds totaling 65.45 acres in East Balsam (Figure 1). These beds were selected based on the 2013 spring CLP bed mapping survey that found CLP in these areas was interfering with boat traffic and/or restricting resident access to the lake from their docks, and the fall 2017 turion survey which suggested there would still be CLP growth in this area in 2018.

Prior to the planned 2018 herbicide application, we conducted a pretreatment survey of the lake on May 17th to determine initial CLP levels and finalize treatment areas. Because this survey found little CLP, **it was decided to cancel the 2018 treatment**. However, in order to see how CLP and native plant populations responded to skipping treatment, it was requested that we do a follow-up survey on June 9th. We also returned to the lake on June 12-13th and mapped all CLP beds found within the visible littoral zone. These maps were used to guide mechanical harvesting in 2018, and they will also be used to help plan for future management in 2019. This report is the summary analysis of these three field surveys.

METHODS:

Pre/Follow-up Herbicide Survey:

Following a winter meeting of the BLPRD's Aquatic Plant Management Committee, it was decided to treat the same general areas in 2018 that were treated from 2014-17. In order to make year-over-year comparisons, we used the same 276 survey points that we established in 2014 (offset regular points at 31m resolution) for each subsequent survey. This sampling grid approximated to just over four points/acre and was based on the WDNR protocol's expected 4-10 survey pts/acre for pre/Follow-up herbicide surveys (Appendix I).

These points were uploaded to a handheld mapping GPS (Garmin 76CSx) and located on the lake. At each point, we recorded the depth and bottom substrate and used a rake to sample an approximately 2.5ft section of the bottom. CLP was assigned a rake fullness value of 1-3 as an estimation of abundance (Figure 2). We also recorded visual sightings of CLP within six feet of the sample point. Because visual sightings are not calculated into the pre/posttreatment statistical formulas, we only assigned a rake fullness value for non-CLP plants. A cumulative rake fullness value was also noted.

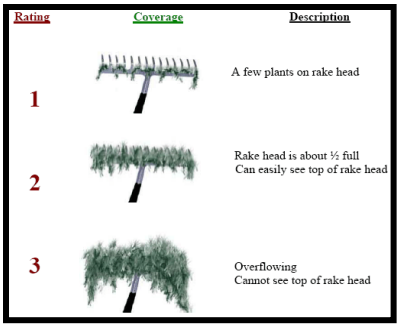


Figure 2: Rake Fullness Ratings

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). Pre/post differences were determined to be significant at $p<0.05$, moderately significant at $p<0.01$ and highly significant at $p<0.001$.

CLP Bed Mapping Survey:

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

RESULTS AND DISCUSSION:

Finalization of Treatment Areas:

The potential treatment areas covered 65.45 acres or approximately 3.19% of the lake's 2,054 total acres (Table 1). In 2018, northwest Wisconsin experienced near record late ice-out in late April/early May followed by a rapid warming of the water to over 60°F by the time of the pretreatment survey. These conditions appeared to negatively impact CLP growth as many area lakes also had unusually low overall CLP density and total biomass. In general, we observed the majority of CLP plants grew just a few feet and then topped off before they started to form turions. Following analysis of the pretreatment survey, there were just 12.04 acres that had regular CLP (Figure 3). After considering the cost/benefit, the BLPRD decided to cancel treatment in all areas in 2018 (Appendix I).

Table 1: 2018 Spring CLP Treatment Summary
Balsam Lake, Polk Co.

Bed Number	Proposed Bed Area (acres)	Potential Treatment Area (acres)	Final Treatment Area (acres)	Change from Proposed Acreage (+/-)
12	10.34	0.00	0.00	-10.34
13	40.83	12.04	0.00	-40.83
14	4.37	0.00	0.00	-4.37
14B	9.91	0.00	0.00	-9.91
	65.45	**12.04**	**0.00**	**-65.45**

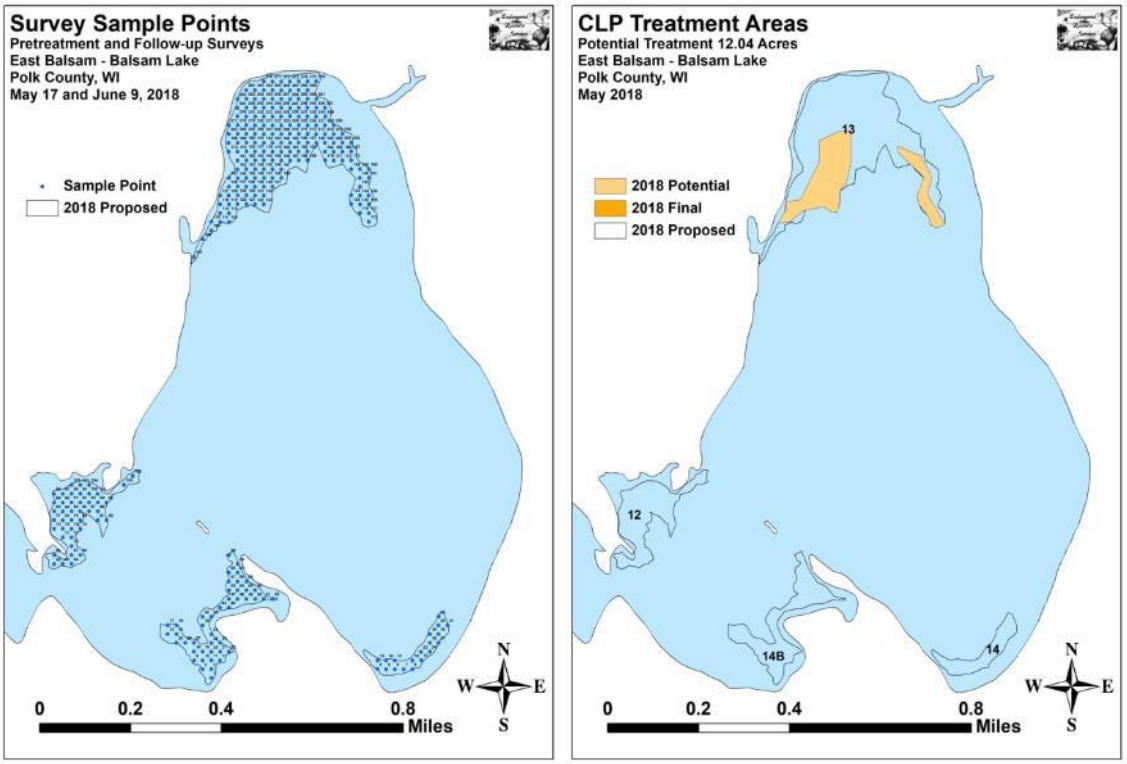


Figure 3: 2018 Pre/Follow-up Survey Points and CLP Treatment Areas

Pretreatment/Follow-up Surveys:

All beds occurred in areas between 2.5 and 11.0ft of water. During the pretreatment survey, we found the mean and median depth of plant growth was 7.1ft and 7.0ft respectively. By June, the mean had ticked up to 7.2ft, but the median remained 7.0ft (Table 2). Most CLP was established over organic muck, but we also found scattered plants in the sandy/rocky areas of Beds 13 and 14 (Figure 4) (Appendix III).

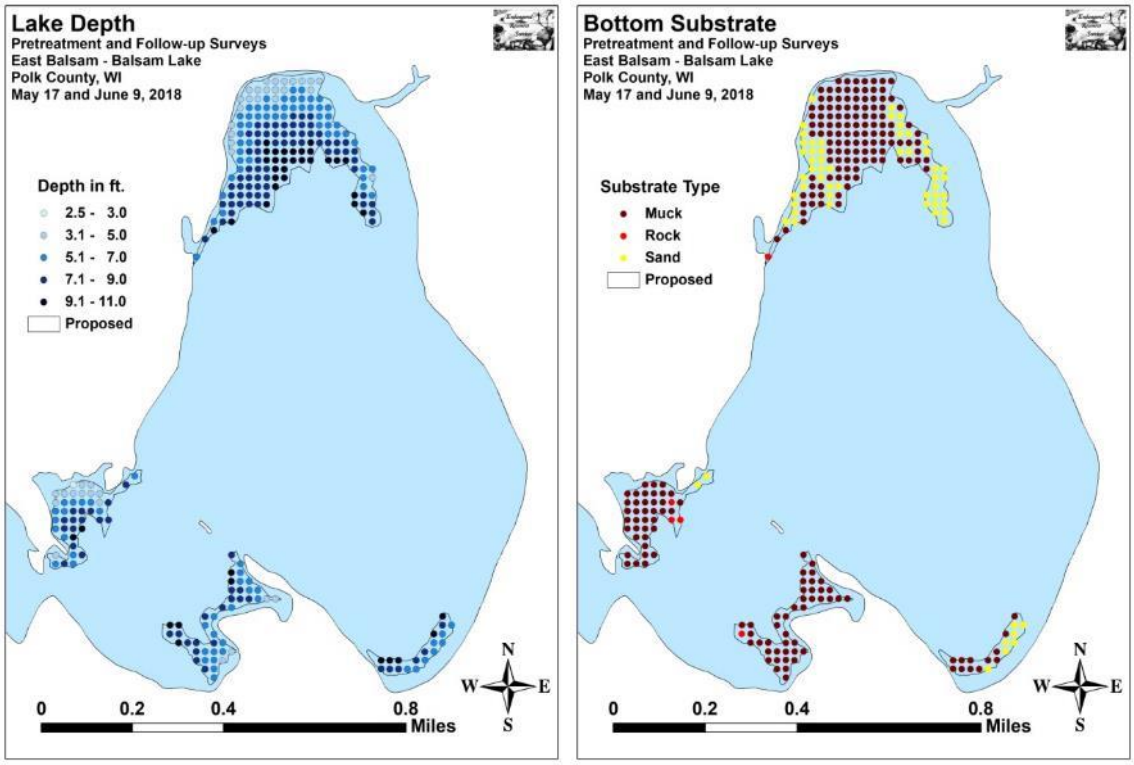


Figure 4: CLP Area Depths and Bottom Substrate

The littoral zone was unchanged at 11.0ft for both surveys; however, the frequency of plant occurrence at littoral points jumped from 81.5% during the pretreatment survey to 87.0% during the June follow-up (Figure 5) (Appendix IV). Species richness increased slightly from 11 pretreatment to 13 during the follow-up. The Simpson's Diversity Index also ticked up slightly from 0.72 in May to 0.74 in June; and the Floristic Quality Index (another measure of the native plant community health) increased from 19.0 pretreatment to 19.9 in June.

Table 2: Pre/Follow-up Survey Summary Statistics
Balsam Lake, Polk County
May 17 and June 9, 2018

Summary Statistics:	May	June
Total number of points sampled	276	276
Total number of sites with vegetation	225	240
Total number of sites shallower than the maximum depth of plants	276	276
Frequency of occurrence at sites shallower than maximum depth of plants	81.5	87.0
Simpson Diversity Index	0.72	0.74
Mean Coefficient of Conservatism	6.0	5.8
Floristic Quality Index	19.0	19.9
Maximum depth of plants (ft)	11.0	11.0
Mean depth of plants (ft)	7.1	7.2
Median depth of plants (ft)	7.0	7.0
Average number of all species per site (shallower than max depth)	1.43	1.43
Average number of all species per site (veg. sites only)	1.76	1.65
Average number of native species per site (shallower than max depth)	1.24	1.16
Average number of native species per site (sites with native veg. only)	1.63	1.51
Species Richness	11	13
Mean Rake Fullness (veg. sites only)	1.36	1.39

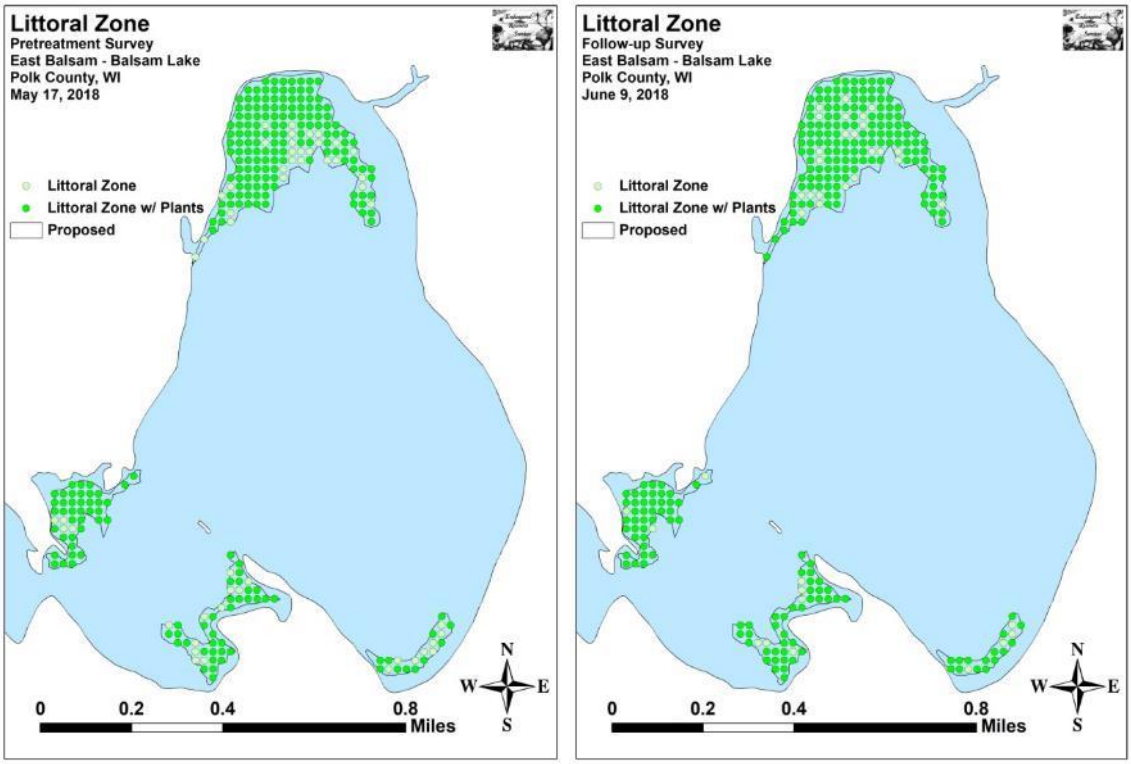


Figure 5: Pre/Follow-up Littoral Zone

Mean native species richness at points with native vegetation actually fell from 1.63 species/point pretreatment to 1.51 species/point during the follow-up (Figure 6). Total mean rake fullness pretreatment was an exceptionally low 1.36 that barely increased to 1.39 in June (Figure 7) (Appendix IV).

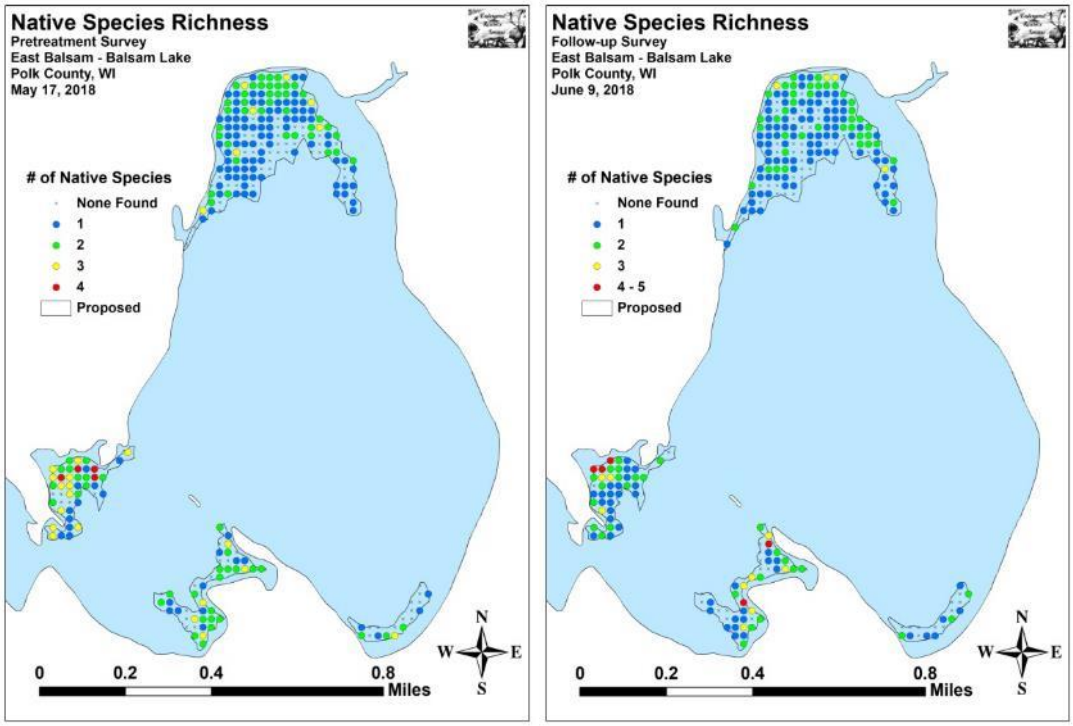


Figure 6: Pre/Follow-up Native Species Richness

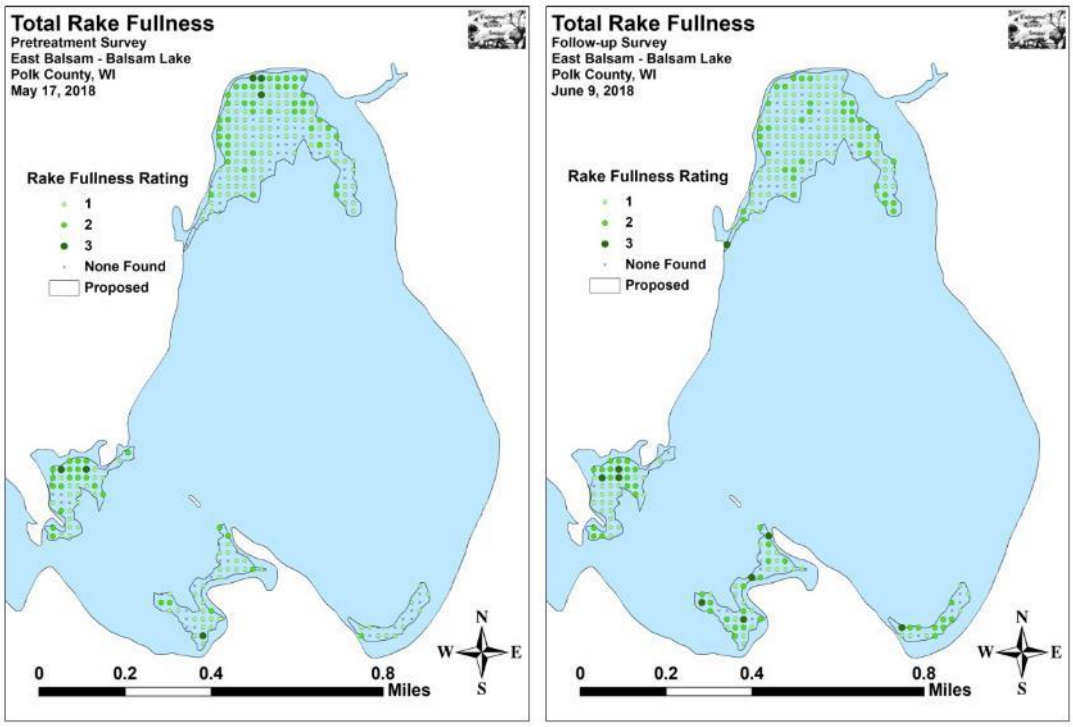


Figure 7: Pre/Follow-up Total Rake Fullness

We found Curly-leaf pondweed at 53 of 276 sites (19.2% coverage) during the pretreatment survey (Figure 8) – a highly significant decline from the 192 sites (69.6%) with CLP in 2017's pretreatment survey; 159 sites (57.6%) in 2016; and 208 sites (75.4%) in 2015. Of these, none had a rake fullness rating of 3, 11 rated a 2, and 42 were a 1. This produced a mean rake fullness for CLP of 1.21 and suggested just 4.0% of the beds had a significant infestation (rake fullness of 2 or 3). During the follow-up survey, we found CLP at 74 points (26.8% coverage) with two points rating a 3, 23 a two, and the remaining 49 a 1 for a mean rake fullness of 1.36. CLP was also recorded as a visual at six points (Appendix V). As expected without active management, **our results demonstrated a moderately significant increase in total CLP as well as significant increases in rake fullness 2 and visual sightings** (Figure 9). The 25 points (9.1%) with a significant infestation also represented a 127% increase over pretreatment values.

Despite these increases, the untreated June totals in 2018 were still significantly less than the pretreatment totals from 2017. Analysis of the follow-up survey map showed that CLP distribution remained patchy. We also noted that no CLP ever canopied in water over 5ft, and many plants at depths greater than this were already starting to fall over with few or often no turions visible.

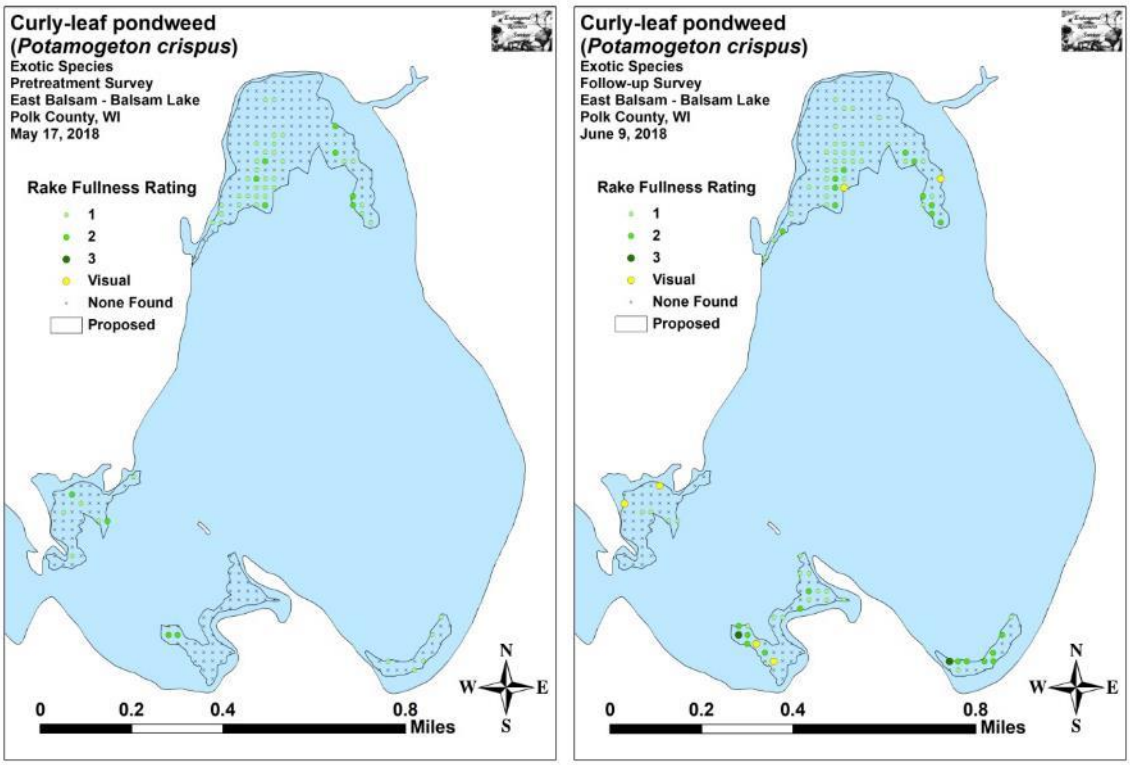
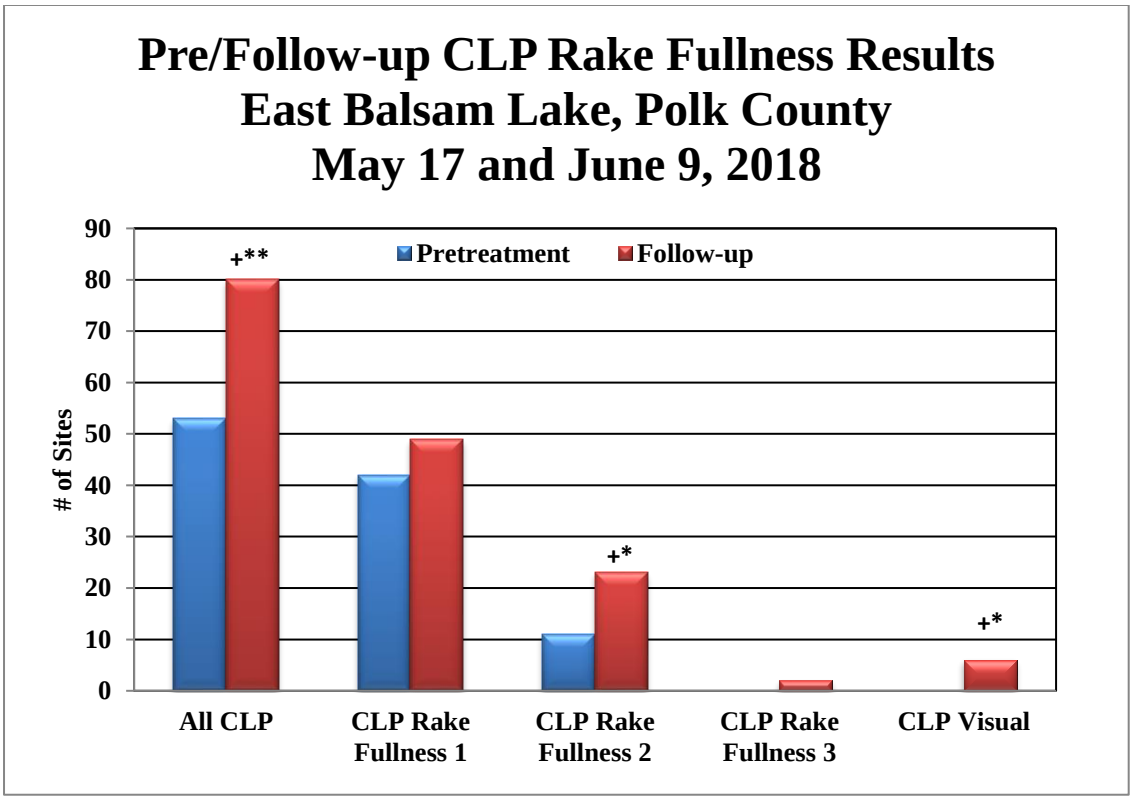


Figure 8: Pre/Follow-up CLP Density and Distribution



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

Figure 9: Changes in CLP Rake Fullness

Forked duckweed (*Lemna trisulca*) and Coontail (*Ceratophyllum demersum*) were the most common native species in both the pretreatment and follow-up surveys (Figures 10 and 11) (Tables 3 and 4). Both species showed a non-significant decline in distribution with Forked duckweed falling from 175 points in May to 167 points in June, and Coontail dropping from 94 sites in May to 84 sites in June (Figure 12).

Interestingly, despite no treatment having occurred, Common waterweed (*Elodea canadensis*) and aquatic moss experienced moderately significant declines, and Nitella (*Nitella* sp.) saw a significant decline. Conversely, in addition to Curly-leaf pondweed, Northern water-milfoil (*Myriophyllum sibiricum*) and Spatterdock (*Nuphar variegata*) both demonstrated significant increases (Maps of all native species from the pretreatment and follow-up surveys can be found in Appendixes VI and VII).

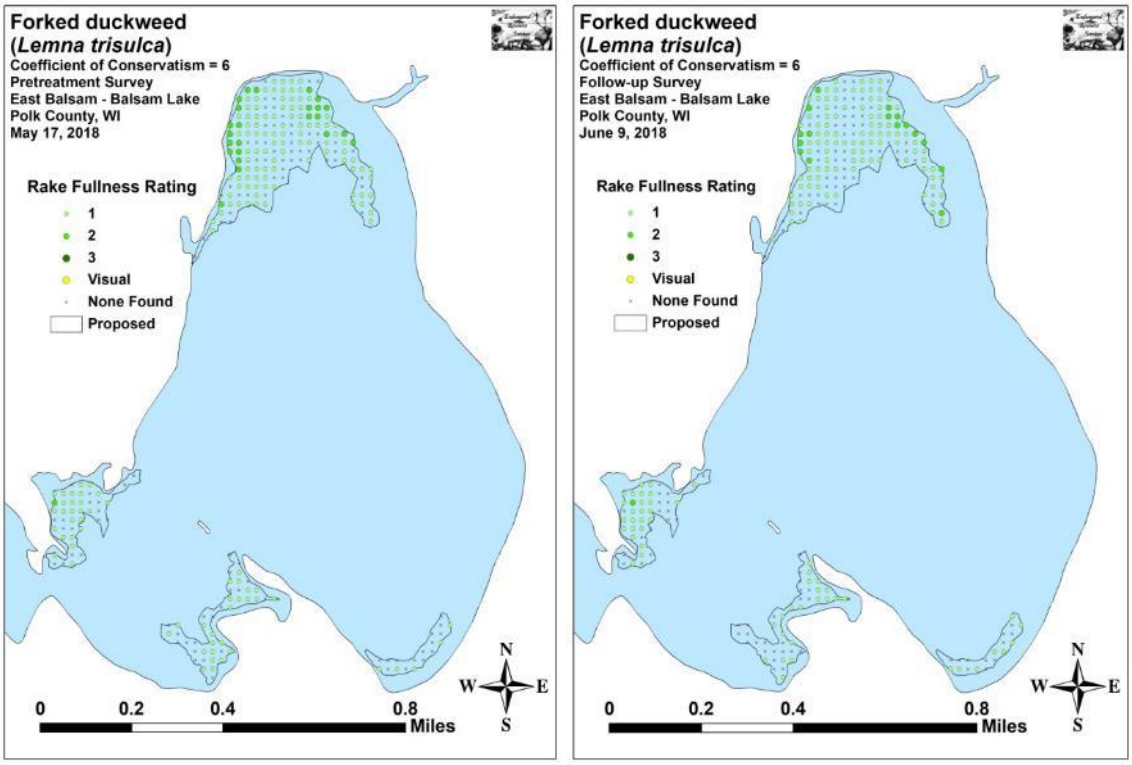


Figure 10: Pre/Follow-up Forked Duckweed Density and Distribution

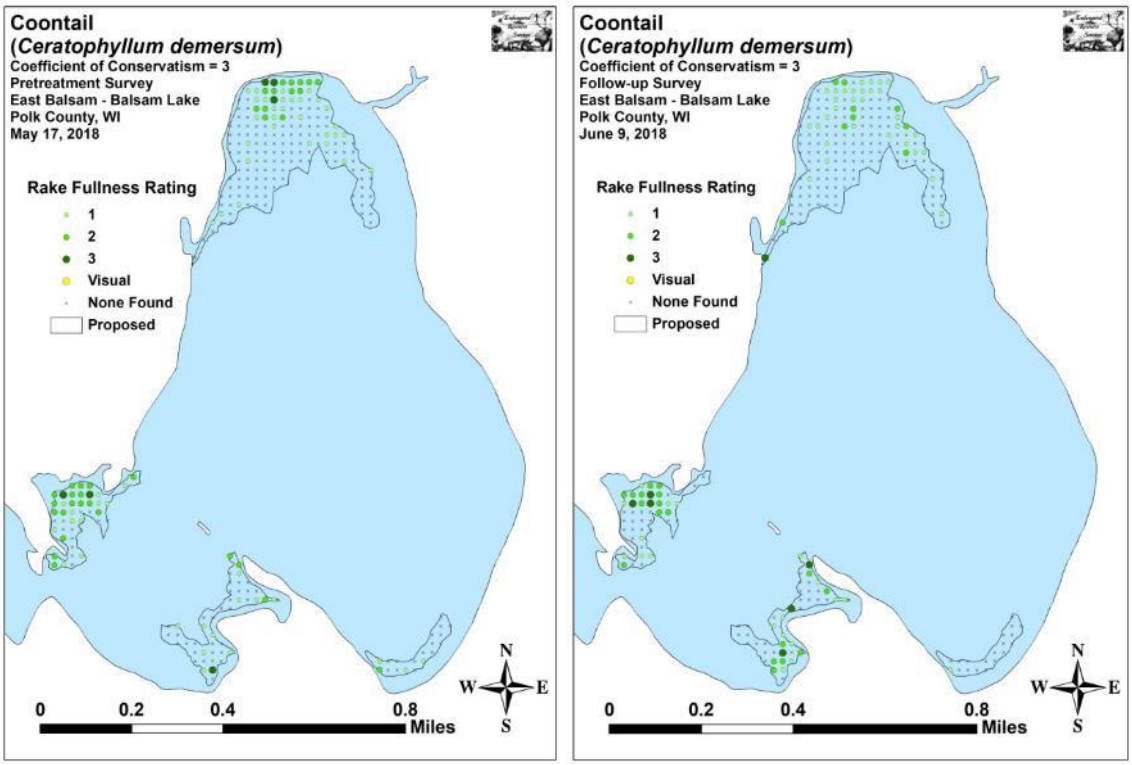


Figure 11: Pre/Follow-up Coontail Density and Distribution

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Pretreatment Survey - Balsam Lake, Polk County
May 17, 2018

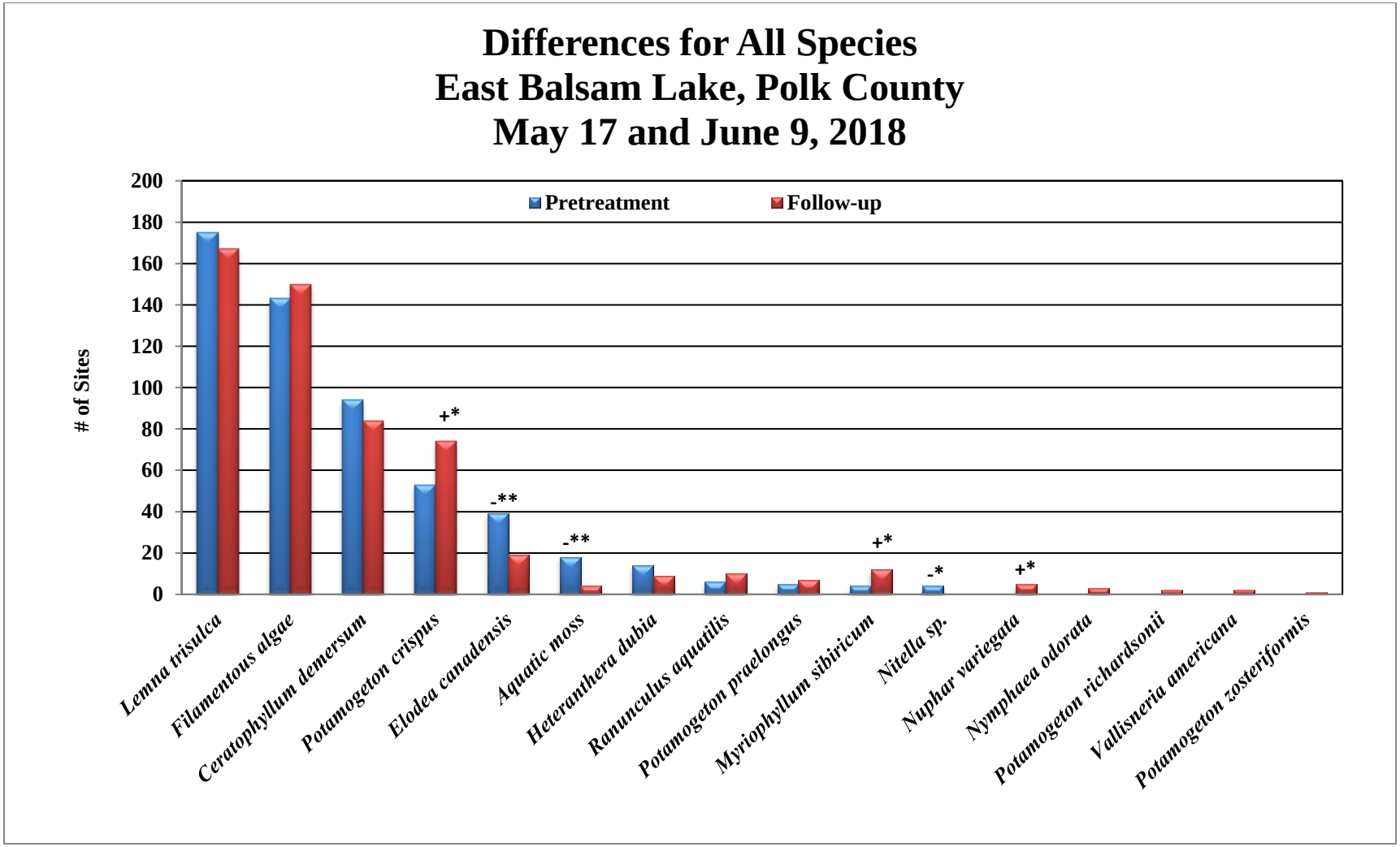
Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
Lemna trisulca	Forked duckweed	175	44.19	77.78	63.41	1.14
	Filamentous algae	143	*	63.56	51.81	1.22
Ceratophyllum demersum	Coontail	94	23.74	41.78	34.06	1.49
Potamogeton crispus	Curly-leaf pondweed	53	13.38	23.56	19.20	1.21
Elodea canadensis	Common waterweed	39	9.85	17.33	14.13	1.08
	Aquatic moss	18	*	8.00	6.52	1.39
Heteranthera dubia	Water star-grass	14	3.54	6.22	5.07	1.00
Ranunculus aquatilis	White water crowfoot	6	1.52	2.67	2.17	1.00
Potamogeton praelongus	White-stem pondweed	5	1.26	2.22	1.81	1.00
Myriophyllum sibiricum	Northern water-milfoil	4	1.01	1.78	1.45	1.00
Nitella sp.	Nitella	4	1.01	1.78	1.45	1.00
Nuphar variegata	Spatterdock	1	0.25	0.44	0.36	1.00
Potamogeton pusillus	Small pondweed	1	0.25	0.44	0.36	1.00

* Excluded from Relative Frequency Analysis

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
Follow-up Survey - Balsam Lake, Polk County
June 9, 2018

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
Lemna trisulca	Forked duckweed	167	42.28	69.58	60.51	1.10
	Filamentous algae	150	*	62.50	54.35	1.13
Ceratophyllum demersum	Coontail	84	21.27	35.00	30.43	1.49
Potamogeton crispus	Curly-leaf pondweed	74	18.73	30.83	26.81	1.36
Elodea canadensis	Common waterweed	19	4.81	7.92	6.88	1.00
Myriophyllum sibiricum	Northern water-milfoil	12	3.04	5.00	4.35	1.25
Ranunculus aquatilis	White water crowfoot	10	2.53	4.17	3.62	1.10
Heteranthera dubia	Water star-grass	9	2.28	3.75	3.26	1.11
Potamogeton praelongus	White-stem pondweed	7	1.77	2.92	2.54	1.43
Nuphar variegata	Spatterdock	5	1.27	2.08	1.81	1.60
	Aquatic moss	4	*	1.67	1.45	1.75
Nymphaea odorata	White water lily	3	0.76	1.25	1.09	1.33
Potamogeton richardsonii	Clasping-leaf pondweed	2	0.51	0.83	0.72	1.50
Vallisneria americana	Wild celery	2	0.51	0.83	0.72	1.00
Potamogeton zosteriformis	Flat-stem pondweed	1	0.25	0.42	0.36	1.00

* Excluded from Relative Frequency Analysis



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

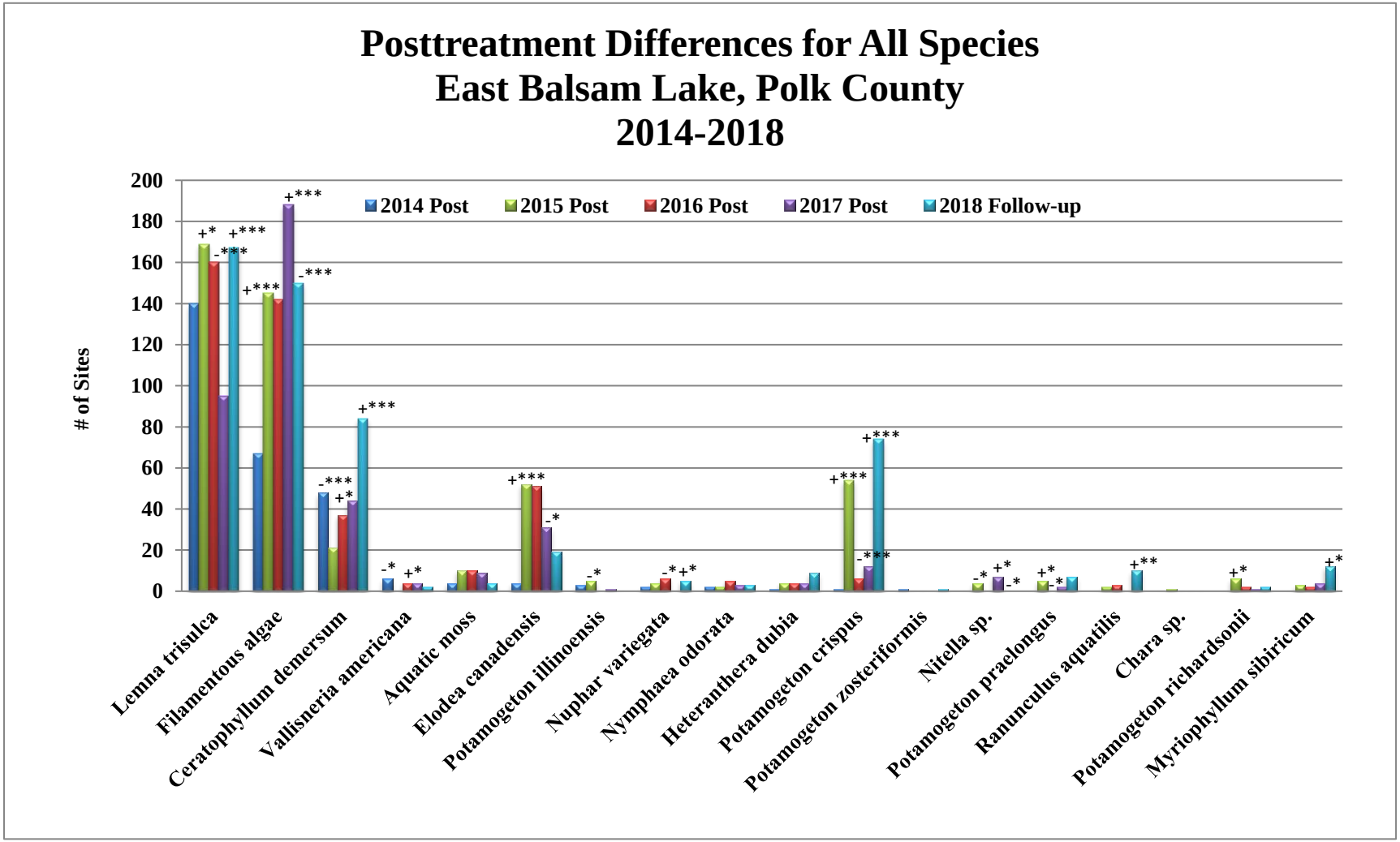
Figure 12: Pre/Follow-up Macrophyte Changes

Looking back at the cumulative data from the posttreatment and follow-up surveys in East Balsam over the last five years (2014-2018) showed many species experienced significant changes (Figure 13). Following a relatively late treatment in 2014, Small pondweed (*Potamogeton pusillus*), a previously abundant fine-leaved early-growing species, showed highly significant declines and seen again until we found a single individual during the 2018 pretreatment survey.

In 2015, although it produced a highly significant reduction from the pretreatment survey, a relatively early treatment proved to be much less effective as Curly-leaf pondweed experienced a highly significant year-over-year increase – a change which was, based on our posttreatment observations, potentially due to latent turions sprouting after the treatment. The 2015 treatment also produced a highly significant year-over-year decrease in Coontail. Conversely, filamentous algae and Common waterweed experienced highly significant year-over-year increases; and Forked duckweed had a significant increase. All three of these species maintained these increases following the 2016 treatment. Other species that showed year-over-year increases in 2015 such as Nitella, Illinois pondweed (*Potamogeton illinoensis*), and White-stem pondweed (*Potamogeton praelongus*), dropped back to very low levels in 2016. Wild celery, a species that seems to exploit vacant habitat in the sandy shallows of East Balsam, inversely mirrored the changes in these broad-leaved pondweeds by significantly declining in 2015 before significantly rebounding in 2016. Coontail, a species that seems to be a competitor of CLP over muck in deeper water, experienced a significant rebound in 2016 that inversely mirrored the highly significant reduction in CLP.

Following the treatment in 2017, Forked duckweed experienced a highly significant reduction that mirrored the highly significant increase in filamentous algae and the moderately significant increase in the colonial algae Nitella. It may be that these species were competing for the same suspended nutrients. Common waterweed and Spatterdock also experienced significant year-over-year declines.

With no treatment in 2018, many species showed significant year-over-year changes. Filamentous algae suffered a highly significant decline, and Nitella saw a significant decline – again potentially because these colonial algae absorb nutrients from the water column that may not have been as readily available as they would be following a treatment when other plants are decomposing. Conversely, CLP, Forked duckweed, and Coontail enjoyed highly significant increases; White water crowfoot (*Ranunculus aquatilis*) had a moderately significant increase, and both Spatterdock and Northern water-milfoil saw significant increases.



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

Figure 13: Late May/June 2014-2018 - Differences for All Species – East Balsam

Curly-leaf Pondweed Bed Mapping Survey:

In 2017, the early ice-out followed by much below average temperatures throughout the rest of April and May appeared to have produced ideal growing conditions for Curly-leaf pondweed. Similar to other area lakes, we found higher densities and wider distributions of CLP than during any previous survey we've conducted dating back to 2011. In total, we located and mapped 21 beds in 2017 (identical to 2016, but up from 14 beds in both 2014/2015, 13 beds in 2013, 20 beds in 2012, and seven beds in 2011). They ranged in size from 0.17 acre (Bed 1A in Little Balsam) to 40.63 acres (Merged Beds 3-8 in Stump Bay) (Figure 14) (Appendix VIII); and, collectively, they covered a total of 97.73 acres or 4.76% of the lake's 2,054 total acres (Table 5). This represented a 56.82 acre increase (+138.9%) over the 40.91 acres mapped in 2016, and was a further increase over the 16.32 acres mapped in 2015, and the 4.54 acres mapped in 2014. It was also well above the previous maximum value of 80.58 acres mapped in 2013. This is even more significant considering the 2013 survey included over 60 acres in East Balsam that were eliminated by the 2017 spring herbicide treatment (Table 6). Most of the acreage expansion seen in 2017 occurred in Stump Bay, around Paradise Island, and in the channel leading north of the village beach landing; however, all beds increased in area from 2016, and we found that many formerly isolated beds had joined together to form "super beds".

Following a historically late ice-out and subsequent rapid warming of the lake, our June 2018 bed-mapping survey found Curly-leaf pondweed was dramatically reduced - despite 2017's record acreage and the cancellation of the 2018 herbicide treatment in East Balsam. Collectively, we mapped 27 beds ranging in size from 0.01 acre (Bed 17C – at the Raskin Bay outlet) to 7.04 acres (Bed 15 around Paradise Island) and totaling 35.41 acres (1.72% of the lake's surface area). This 63.8% decline in acreage from 2017 was even more dramatic considering most "beds" in 2018 never actually canopied despite our waiting until as late as possible in the growing season to do the survey. We also noted that many of the plants showed no evidence of turion formation and were turning lime green suggesting they were beginning to senesce. Based on these collective observations from all three surveys, it appears deciding not to treat in 2018 was a very positive decision from both an economic and ecological perspective.

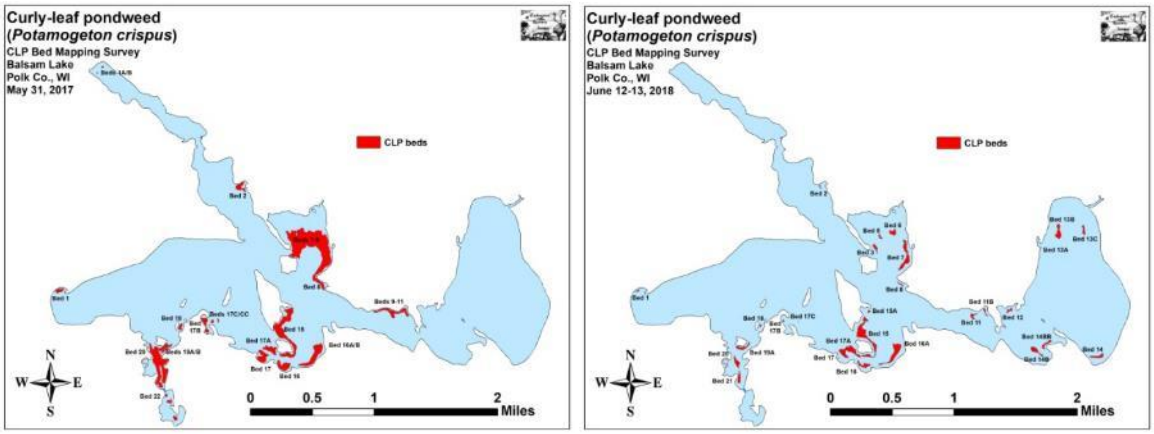


Figure 14: 2017 and 2018 Balsam Lake Late May/June CLP Beds

Table 5: CLP Bed Summary - Balsam Lake, Polk Co. June 12-13, 2018

Bed #	Location	2018 Area (Acres)	2017 Area	2017-18 Change in Area	Est. Range and Mean Rake-full	Depth Range and Mean Depth	Navigation Impairment	Field Notes
1	HWY 46 Landing	0.14	1.00	-0.86	<<1-2; 1	4-7; 5	Minor	Patchy – mixed with natives
1A, 1B	Rice Creek Inlet	0.00	0.17	-0.17	<<<1-1; <<<1	4-6; 5	None	A few scattered plants
2 and 2A	Boston Bay	0.13	2.02	-1.89	<<1-2; 1	4-6; 5	Minor	Most of former bed barren
3-8	Stump Bay	6.41	40.63	-34.22	<<1-3; 2	3-7; 5	Minor	Most narrow in front of residences
9-11	Bay NW of Big Narrows	1.03	4.15	-3.12	<1-3; 2	4-8; 6	Minor	Mixed with natives; esp. crowfoot
12	Bay NE of Big Narrows	0.52	0.00	0.52	<1-3; 2	3-5; 4	Moderate	Canopied at edge of lilypads
13, A, B, C	N. Bay of East Balsam	2.73	0.00	2.73	<1-3; 2	5-10; 9	None	Plants unlikely to canopy
14	SE Bay of East Balsam	1.06	0.00	1.06	<1-3; 2	6-11; 9	Minor	Deep areas not likely to canopy
14B-BB, 14C	Bay SE of Big Narrows	2.37	0.00	2.37	<1-3; 1	6-9; 8	Minor	Regular low density plants
15, A, B	E. and SE of Big Island	7.26	13.28	-6.02	<<1-3; 2	3-10, 8	Moderate	Deep areas likely won't canopy
16	Bay S. of Paradise Island	1.45	3.28	-1.83	<<1-3; 2	4-8; 7	Moderate	Narrow channels around
16A + B	E. of Paradise Landing	4.33	6.46	-2.13	<1-3; 2	5-11; 8	Moderate	Near canopy with prop trails.
17	Bay SW of Paradise Island	0.04	3.39	-3.35	<1-2; 1	3-5; 4	Minor	Couple of patches; barely a bed
17A	West of Paradise Island	4.27	2.59	1.68	<<1-3; 2	5-11; 9	Minor	Unlikely to canopy; deep water bed
17B+D	Raskin Bay	0.11	1.94	-1.83	<1-2; 1	2-4; 3	Minor	Low density; scattered plants
17C and CC	Raskin Bay Outlet	0.01	0.50	-0.49	1-2; 1	5-8; 7	Minor	Low density cluster of plants
18	Channel E. of Pine Island	0.13	0.72	-0.59	<<1-3; 1	4-7; 6	Minor	Low density; scattered plants
19A , B	Channel S/E. of First Island	1.18	2.03	-0.85	<<1-3; 2	2-8; 5	Moderate	Boats keeping channel open
20 and 20A	East of Idlewild Bay	1.23	14.18	-12.95	<<1-2; 1	4-7; 6	Minor	Boats keeping channel open
21	N. of Village Beach	1.02	0.00	1.02	<1-3; 1	4-8; 6	Minor	Heavily prop-clipped but low dens.
22	Northwest Mill Pond	0.00	0.25	-0.25	<<<1	4-6; 5	None	Scattered CLP – native dominated
23	Northeast Mill Pond	0.00	0.00	0	<<<1	4-6; 5	None	Scattered CLP – native dominated
24	Mill Pond Point	0.00	0.57	-0.57	<<<1	4-6; 5	None	Scattered CLP – native dominated
25	Southeast Mill Pond	0.00	0.56	-0.56	<<<1	4-6; 5	None	Scattered CLP – native dominated
	Total	**35.41**	**97.73**	**-62.32**				

Table 6: Historical CLP Bed and Treatment Summary - Balsam Lake, Polk Co. 2009-2018

Bed #	Location	2018 Area (Acres)	2017 Area	2016 Area	2015 Area	2014 Area	2013 Area	2012 Area	2011 Area	Years Treated	Acreage Treated
1	HWY 46 Landing	0.14	1.00	0.15	0.00	0.07	0.00	0.58	0.00	2011	1.81
1A, 1B	Balsam Branch Inlet	0.00	0.17	0.01	0.01	0.04	0.00	0.00	0.00	-	-
2 and 2A	Boston Bay	0.13	2.02	0.28	0.03	0.15	0.64	1.23	0.08	-	-
3-5	Stump Bay	1.08	Merged	1.38	0.42	0.00	0.00	0.67	0.00	-	-
6-8	East Shore Stump Bay/Outlet	5.33	Merged	9.61	0.42	0.08	3.08	4.91	0.00	-	-
3-8	Stump Bay (Merged)	(6.41)	40.63	-	-	-	-	-	-	-	-
9	NW of Big Narrows	0.00	Merged	Merged	0.00	0.00	0.00	0.19	0.00	2011	0.11
10	NW of Big Narrows	0.00	Merged	Merged	0.00	0.00	0.18	0.00	0.00	2011	0.22
11	Bay NW of Big Narrows	1.03	4.15	3.54	0.56	0.00	2.70	4.72	1.04	2013, 11, ‘10	4.71, 2.80, 2.85
12	Bay NE of Big Narrows	0.52	0.00	0.00	0.00	0.00	10.34	0.00	5.91	2017,’16, ’15, ‘14, ‘12	10.34, 10.34,10.34,10.37, 5.91
13	N. Bay of East Balsam	2.73	0.00	0.00	0.00	0.00	40.83	0.00	43.14	2017,’16, ’15, ‘14, ‘12	32.08, 35.37,40.83, 38.66, 43.14
14	SE Bay of East Balsam	1.06	0.00	0.00	0.00	0.00	4.37	0.00	6.95	2017,’16, ’15, ‘14, ‘12	3.09, 3.27,4.37, 4.37, 6.95
14B, 14C	Bay SE of Big Narrows	2.37	0.00	0.00	0.00	0.00	9.92	0.00	0.00	2017,’16, ’15,‘14,‘11,‘09	8.66, 9.29,9.91, 9.92, 3.07, 11.38
15, A, B	E. and SE of Big Island	7.26	13.28	12.49	6.75	1.68	8.22	8.78	3.80	2013	8.70
16	Bay S. of Paradise Island	1.45	3.28	1.56	0.46	0.00	0.00	0.65	0.00	2011	1.26
16A + B	E. of Paradise Landing	4.33	6.46	6.22	4.65	0.53	0.00	0.00	0.00	-	-
17	Bay SW of Paradise Island	0.04	3.39	0.59	0.00	0.08	0.00	0.00	0.00	-	-
17A	West of Paradise Island	4.27	2.59	0.27	0.16	0.13	<0.01	1.86	0.00	-	-
17B+D	Raskin Bay	0.11	1.94	0.45	0.24	0.00	0.00	0.00	0.26	-	-
17C and CC	Raskin Bay Outlet	0.01	0.50	0.33	<0.01	0.00	<0.01	1.04	0.00	-	-
18	Channel E. of Pine Island	0.13	0.72	0.31	0.00	0.00	0.00	0.00	0.00	2011, ‘10	0.59, 0.57
19A , B	Channel S/E. of First Island	1.18	2.03	0.49	0.19	0.00	0.00	0.98	0.00	2011, ‘10	4.87, 4.55
20, 20A	East of Idlewild Bay	1.23	14.18	3.22	2.43	1.58	0.30	0.10	0.00	2011	4.26
21	N. of Village Beach	1.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-	-
22	Northwest Mill Pond	0.00	0.25	0.00	0.00	0.00	0.00	0.40	0.00	-	-
23	Northeast Mill Pond	0.00	0.00	0.00	0.00	0.05	0.00	0.43	0.00	-	-
24	Mill Pond Point	0.00	0.57	0.00	0.00	0.15	0.00	1.37	0.00	-	-
25	Southeast Mill Pond	0.00	0.56	0.00	0.00	0.00	0.00	0.30	0.00	-	-
	Total	**35.41**	**97.73**	**40.91**	**16.32**	**4.54**	**80.58**	**28.21**	**61.18**		

Description of Past and Present Curly-leaf Pondweed Beds:

Bed 1 – The small Curly-leaf pondweed bed near Ward's resort was, at worst, only a minor impairment to navigation due to its narrow width. Much of the surrounding area was dominated by natives species; especially Coontail, Northern water-milfoil, and Flat-stem pondweed (*Potamogeton zosteriformis*).

Bed 1A – We saw only a handful of CLP plants and clusters near the Rice Creek Inlet adjacent to the lake's largest Northern wild rice (*Zizania palustris*) bed.

Beds 2A and 2 – The bed in Boston Bay was patchy and mixed with natives. Most of the area covered by CLP in 2017 was a barren flat in 2018 with almost no plant growth at all other than a layer of filamentous algae and Forked duckweed. The bed itself was likely only a minor navigation impairment as it was easily avoided.

Beds 3-8 – In 2017, CLP formed a canopied mat throughout much of Stump Bay. This "super bed" fragmented back to historical norms in 2018 with five separate beds ringing the bay and extending east of the outlet. Most of the densest areas were back in the stumps where they were unlikely to be an issue. On the eastern shoreline of the bay where most residences occur, the Bed 7 was patchy and mixed with significant numbers of native pondweeds. As in the past, we encourage limiting management to the minimal amount needed for residents to access the lake; thereby preserving the area's critical fish habitat.

Beds 9, 10 and 11 – In 2017, the three beds northwest of the Big Narrows essentially merged into a single continuous bed. However, in 2018, we found most of the area had almost no CLP at all. The only beds occurred on the rock bar projecting to the south and in the northeast bay. Even here, CLP levels were only low to moderate and likely didn't cause more than minor impairment.

Bed 12 – The bed just northeast of the Big Narrows only had CLP in very shallow water at the edge of the lilypads in front of the residences with fountains. This area has benefited from mechanical harvesting even after herbicide applications have happened in the past, and a few passes will likely be all that's required to keep it open again in 2018.

Beds 13A, 13B, and 13C – Despite not being treated, the former giant bed that dominated the north bay of East Balsam was little more than a few patches in 2018. We noted that almost no plants made it to canopy, and those that did occurred at such low densities that they likely wouldn't have caused more than minor impairment. Interestingly, these deep water CLP plants in East Balsam showed almost no evidence of turions.

Bed 14 – In the technical sense, this area wasn't a true bed as most plants didn't canopy. However, we found such high densities during the follow-up survey that we raked around the perimeter to establish the boundaries for this area. Plants appeared to already be senescing, and some had moderate amounts of turions.

Beds 14B, 14BB, and 14C – We found CLP was present throughout these former beds, but it occurred at such low levels that only the core areas on the rock bar in 14B and the bay in 14BB had enough plants to be worth harvesting.

Beds 15 and 15A – This bed wrapped around the east side of Big Island and the north, east, and south sides of Paradise Island. Although it was canopied, it was much less dense than in the past and didn't appear to be more than a moderate impairment. In the gap between the islands, regular boat traffic was keeping a channel open.

Bed 16 – The bed was canopied, dense, and likely at least a moderate navigation impairment for those residents living in the bay due west of Sunnyside Marina. Fortunately, there were navigation channels around it.

Beds 16A and 16B – These areas again merged into a single large bed that was one of the worst on the lake. We noted it was less dense than in 2017 and not canopied; however, it was wide enough that it would likely have been a moderate impairment, and we could see numerous prop trails cut through it.

Bed 17 – This bed shrank to just a tiny canopied patch. The rest of the bay was full of native species, but they weren't canopied, and didn't appear to be causing any issues.

Bed 17A – As in the past, 17A was situated next to a Hardstem bulrush (*Schoenoplectus acutus*) bed that provides important spawning habitat for the lake's panfish (pers. obs.). Because of this, even harvesting in this area may be better off avoided as the bed occurs on an isolated rock island. Unlike most other areas outside East Balsam, Bed 17A actually saw expansion in 2018 as it nearly linked up with Bed 15 south of Paradise Island.

Beds 17B, 17C, 17CC, and 17D – Raskin Bay was the usual collection of dense canopied vegetation, but there was little CLP. Most of the bay was dominated by Coontail and White water lilies.

Beds 18 and 19A/B – Although many plants were prop-clipped or uprooted and there were trails cut throughout, we found the CLP around Pine Island was quite patchy and likely causing only minor navigation impairment. The bed near First Island was somewhat thicker and may have been a moderate issue – at least outside of the very center of the channel.

Bed 20 – CLP again filled much of the channel east of Idlewild Bay and beyond the "No Wake Zone" buoy to the north. As usual, we noted that many plants were prop-clipped or had been ripped out of the sediment by boat traffic. However, it was much less dense than in the past, and we estimated it was only a minor impairment to navigation.

Bed 21 – CLP was scattered but more or less continuous north of the village beach. Although it occurred at low densities, this was at least partially due to the high number of prop trails leading away from the main public landing.

Beds 22-25 – The Mill Pond had very low levels of CLP and none that were high enough to deserve being mapped. Most areas within the former beds were dominated by Coontail and Northern water milfoil.

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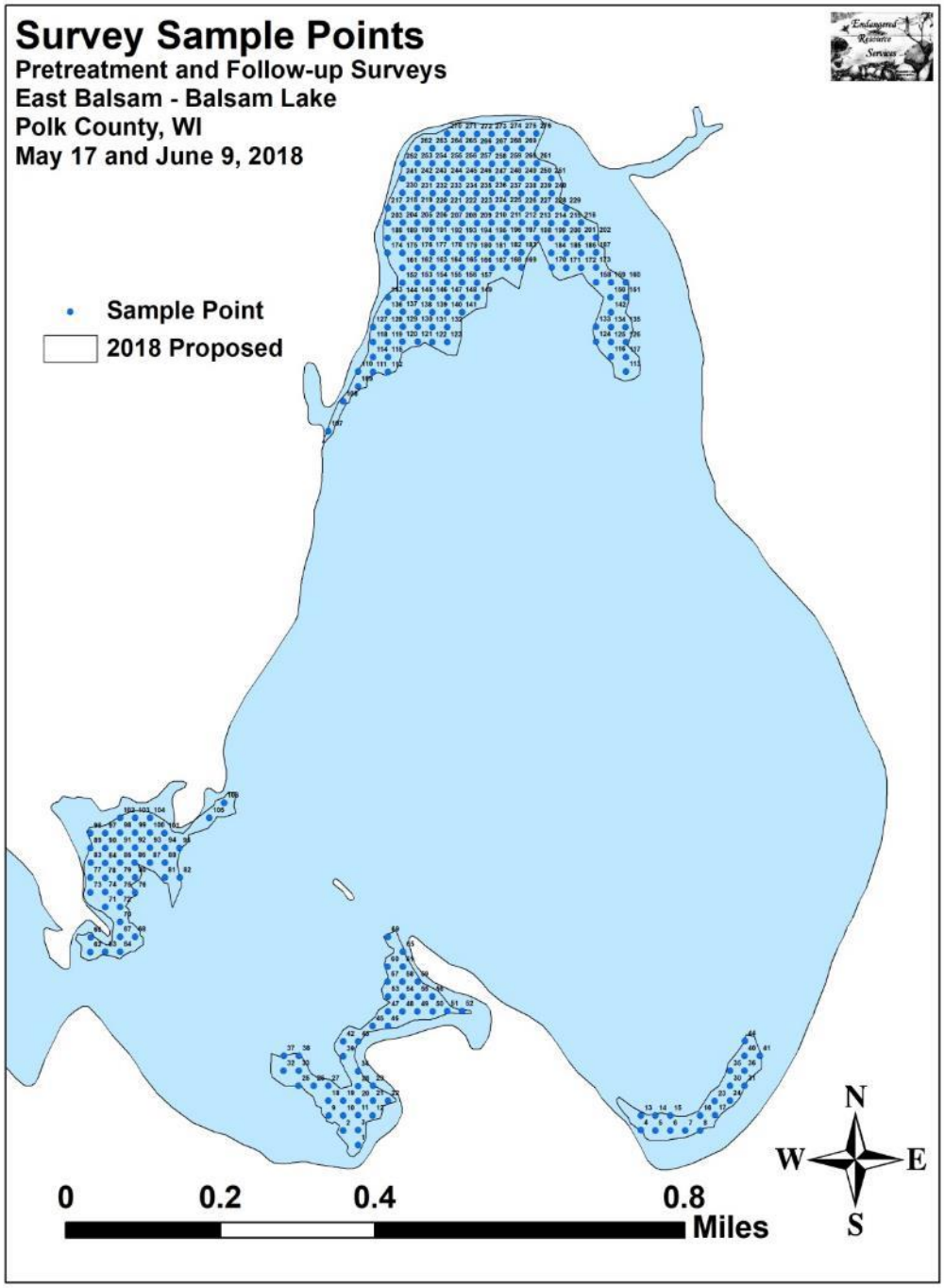
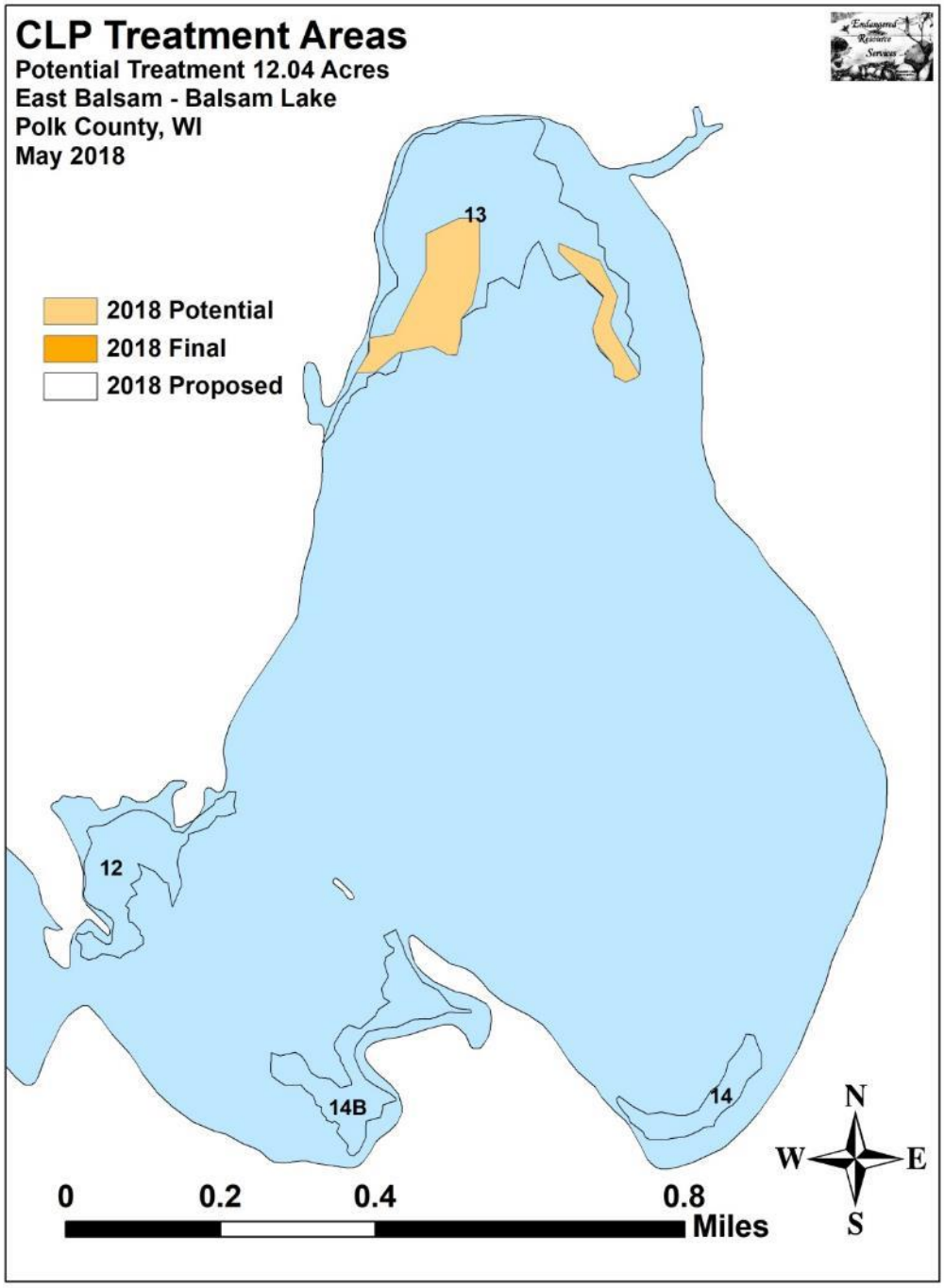
UWEX Lakes Program. [online]. 2010. Aquatic Plant Management in Wisconsin. Available from http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/aquaticplants/default.aspx (2018, November).

UWEX Lakes Program. [online]. 2010. Pre/Follow-up Herbicide Comparison. Available from http://www.uwsp.edu/cnr-ap/UWEXLakes/Documents/ecology/Aquatic%20Plants/Appendix-D.pdf (2018, November).

WDNR. [online]. 2018. Balsam Lake Citizen Monitoring Water Quality Database. Available from http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2620600&page=waterquality (2018, November)

Appendix I: CLP Pre/Follow-up Survey Sample Points and Proposed Treatment Areas

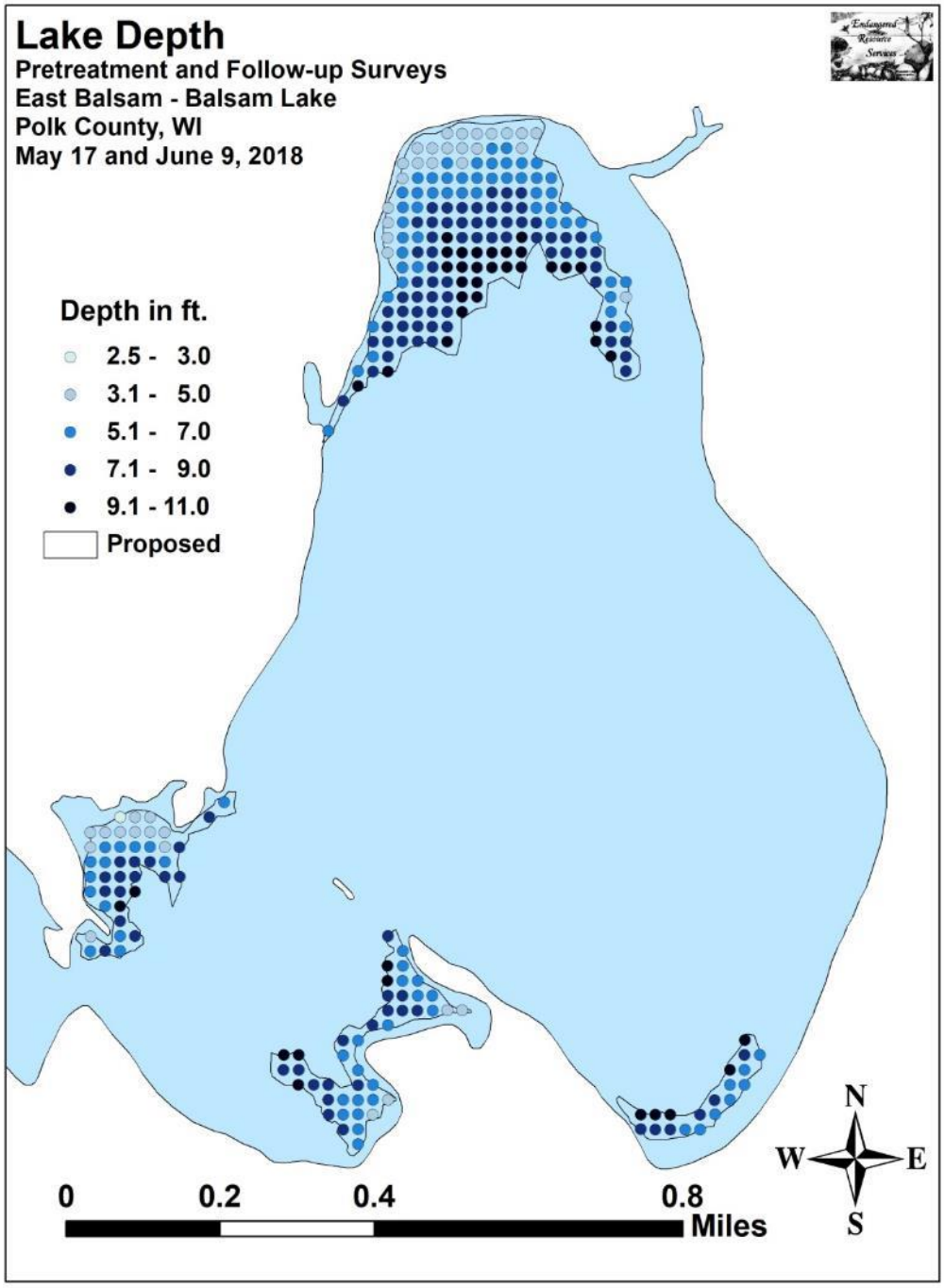

Survey Sample Points
Pretreatment and Follow-up Surveys
East Balsam - Balsam Lake
Polk County, WI
May 17 and June 9, 2018
Sample Point
2018 Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

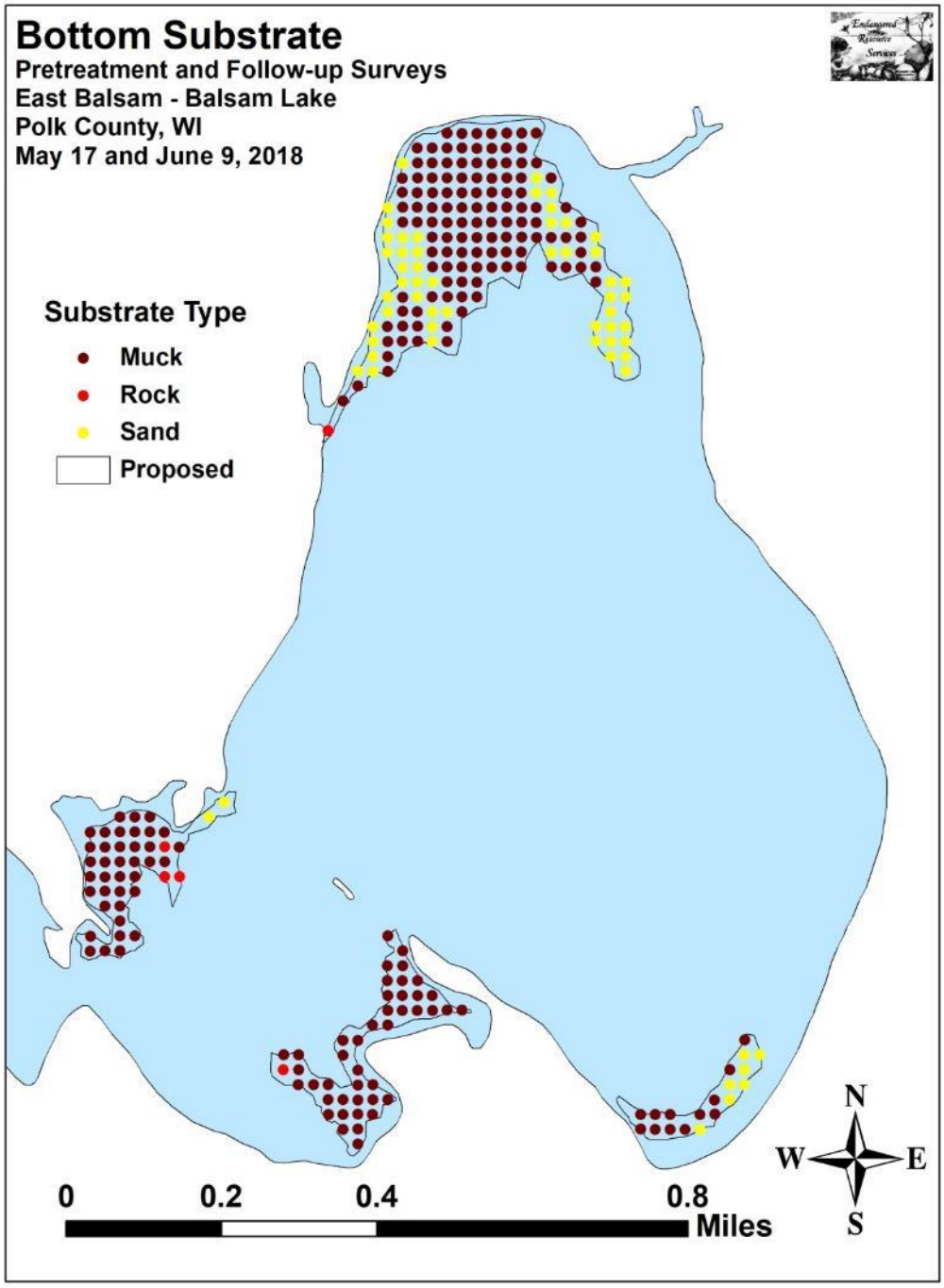

CLP Treatment Areas
Potential Treatment 12.04 Acres
East Balsam - Balsam Lake
Polk County, WI
May 2018
2018 Potential
2018 Final
2018 Proposed
13
12
14B
14
N
W
E
S
0
0.2
0.4
0.8
Miles

Appendix II: Vegetative Survey Datasheet

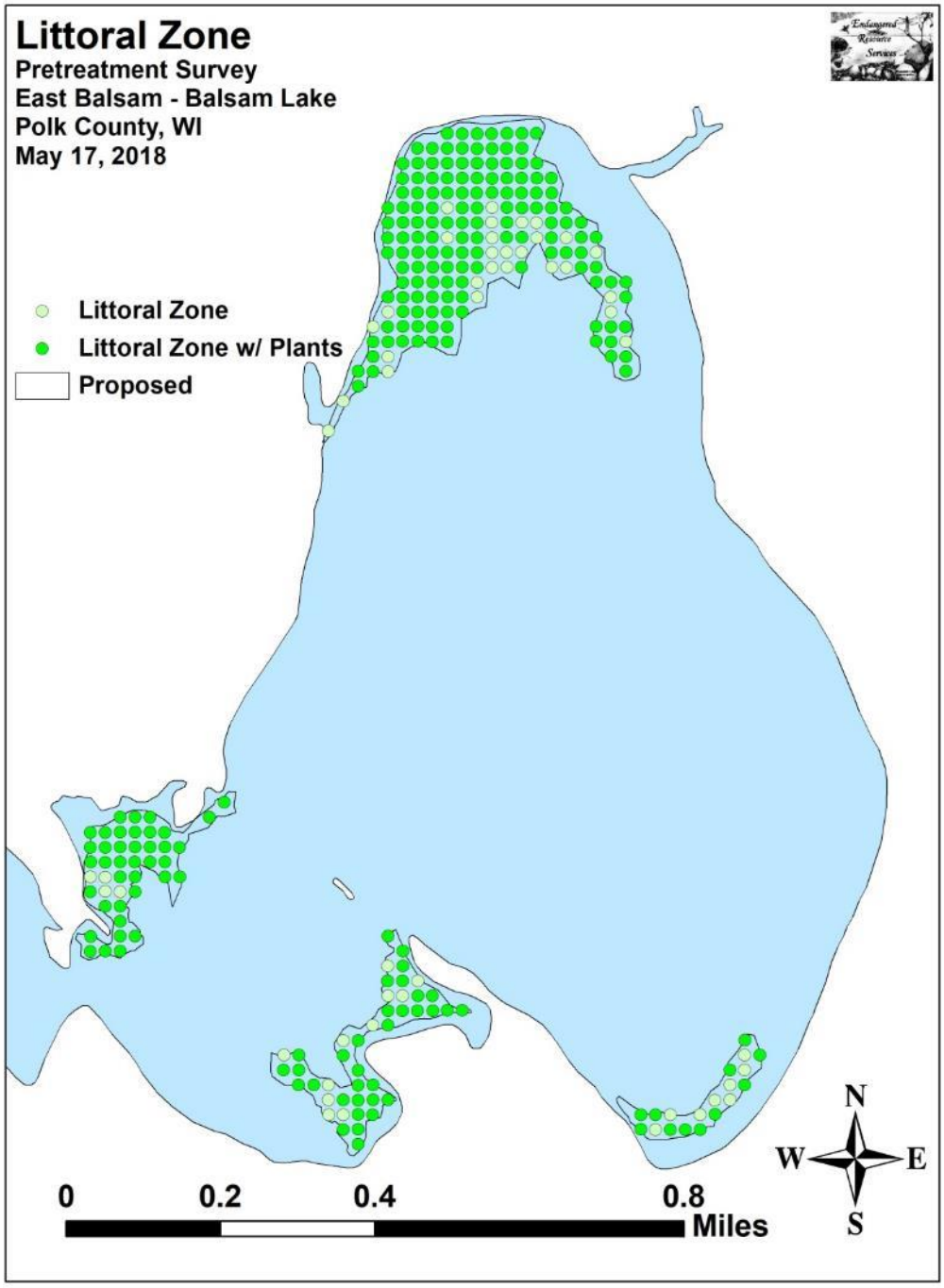
Observers for this lake: names and hours worked by each:																										
Lake:									WBIC									County						Date:	
Site #	Depth (ft)	Muck (M), Sand (S), Rock (R)	Rake pole (P) or rake rope (R)	Total Rake Fullness	CLP	CLP	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1																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

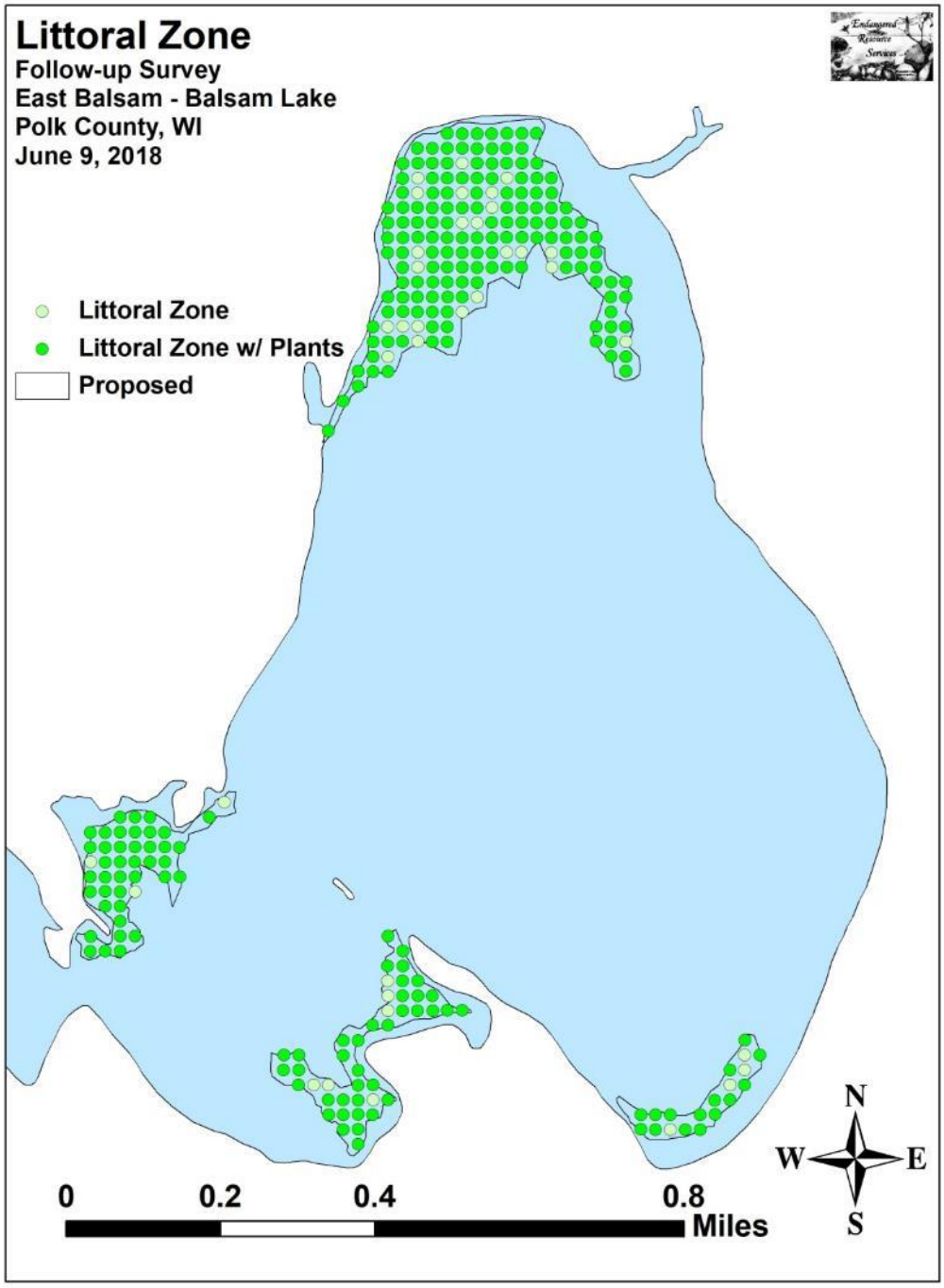
Appendix III: Pre/Follow-up Habitat Variables

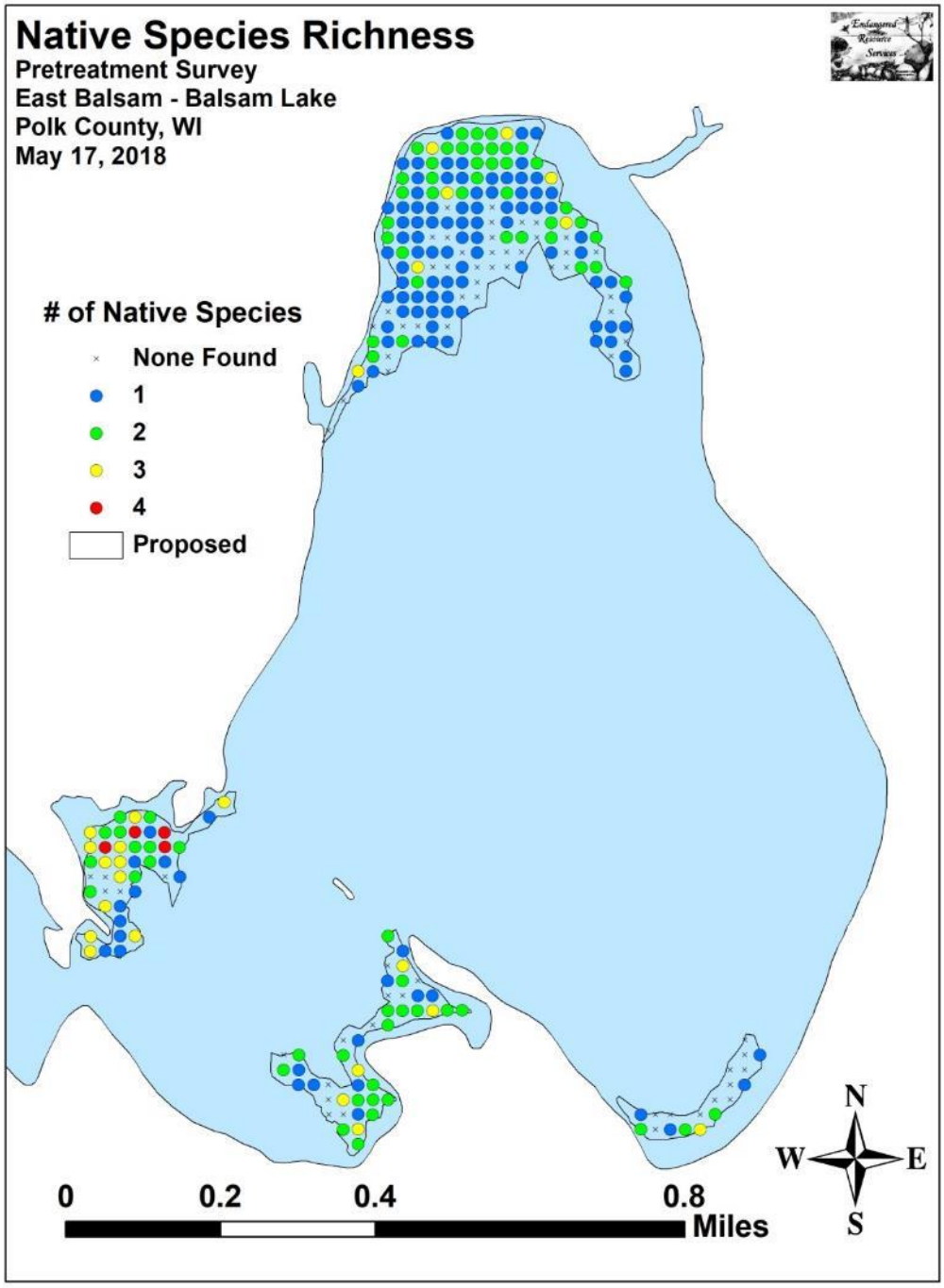

Lake Depth
Pretreatment and Follow-up Surveys
East Balsam - Balsam Lake
Polk County, WI
May 17 and June 9, 2018
Depth in ft.
2.5 - 3.0
3.1 - 5.0
5.1 - 7.0
7.1 - 9.0
9.1 - 11.0
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

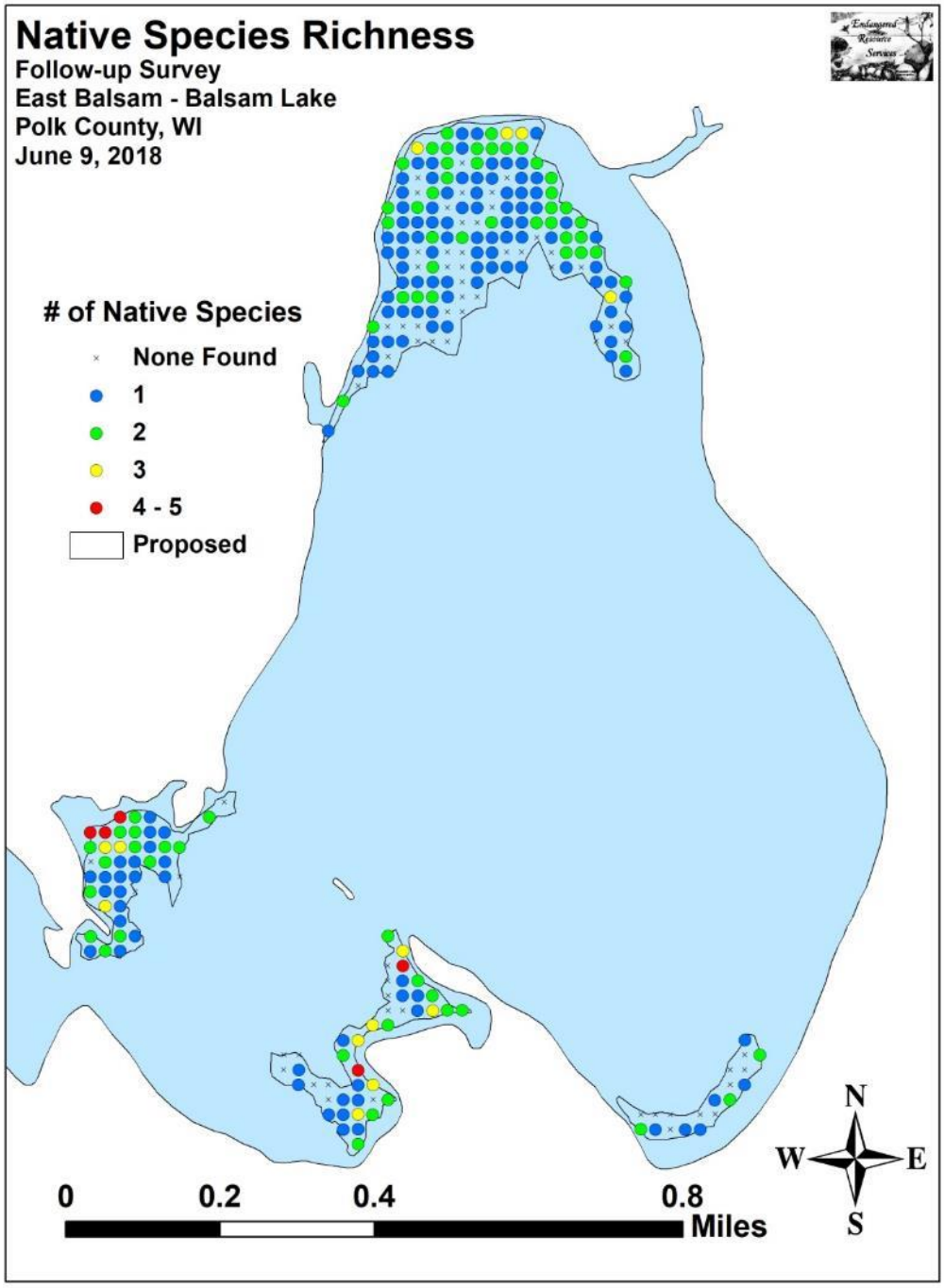

Bottom Substrate
Pretreatment and Follow-up Surveys
East Balsam - Balsam Lake
Polk County, WI
May 17 and June 9, 2018
Substrate Type
Muck
Rock
Sand
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

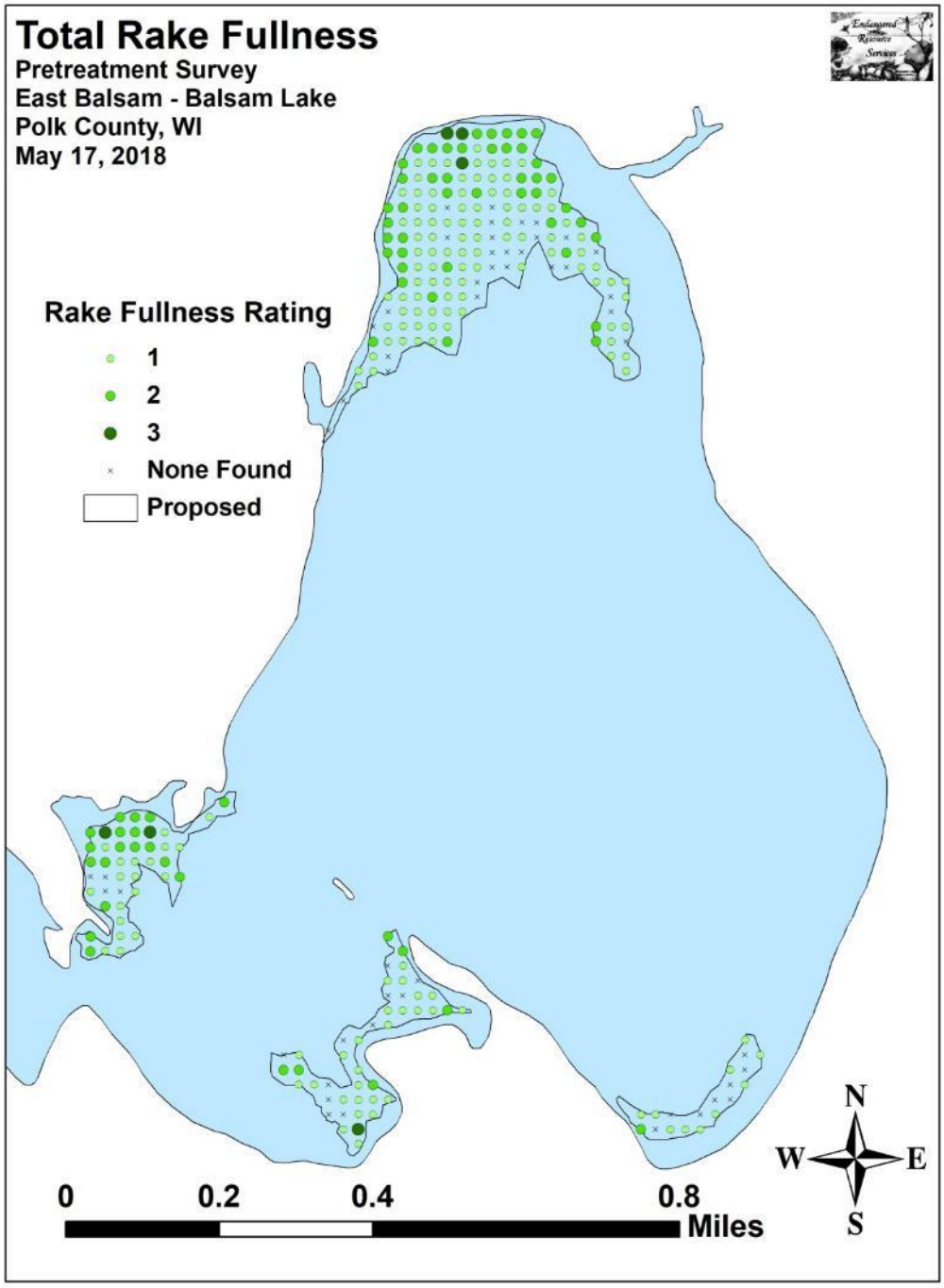
Appendix IV: Pre/Follow-up Littoral Zone, Native Species Richness and Total Rake Fullness

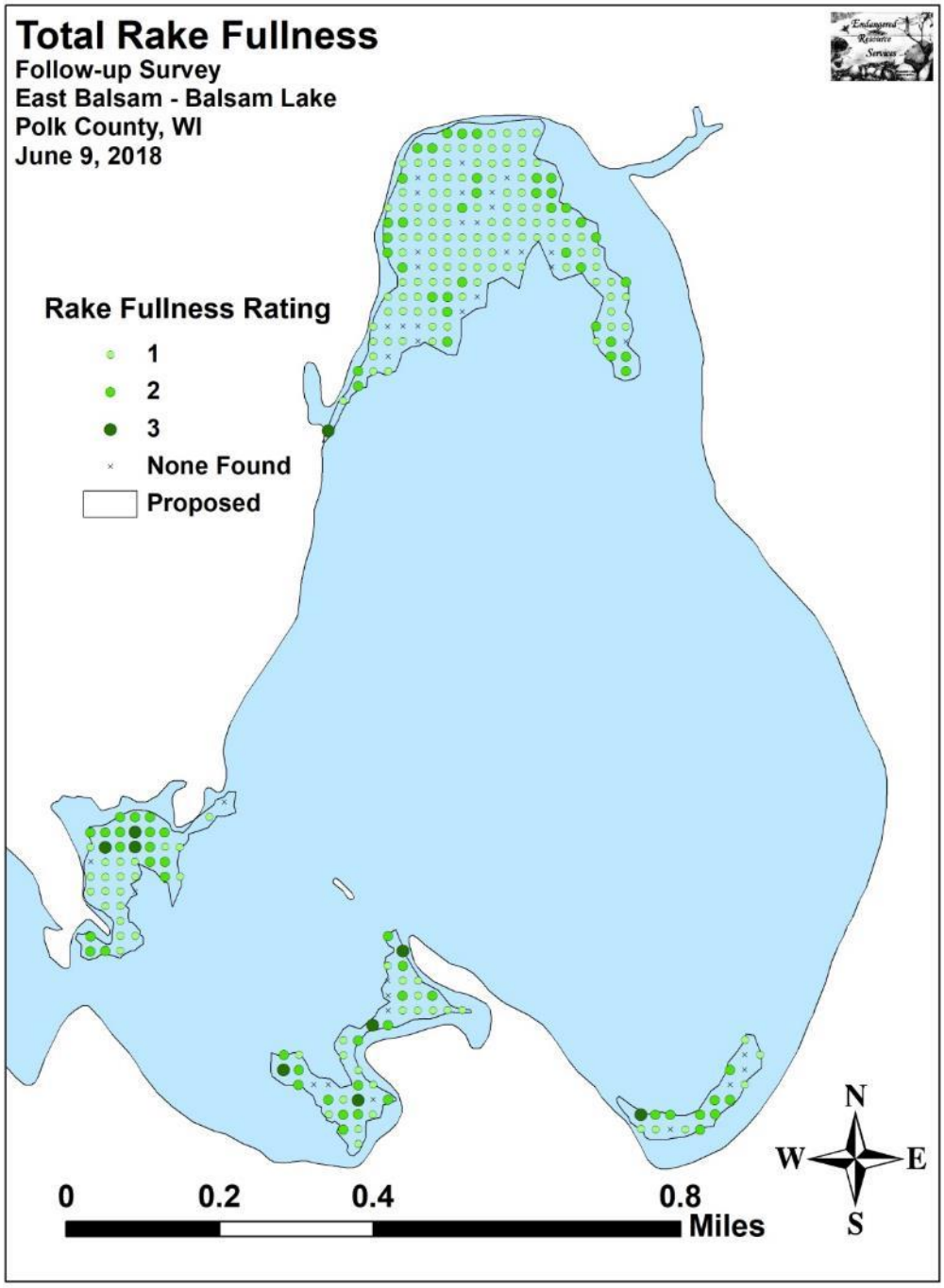

Littoral Zone
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Littoral Zone
Littoral Zone w/ Plants
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S


Littoral Zone
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Littoral Zone
Littoral Zone w/ Plants
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

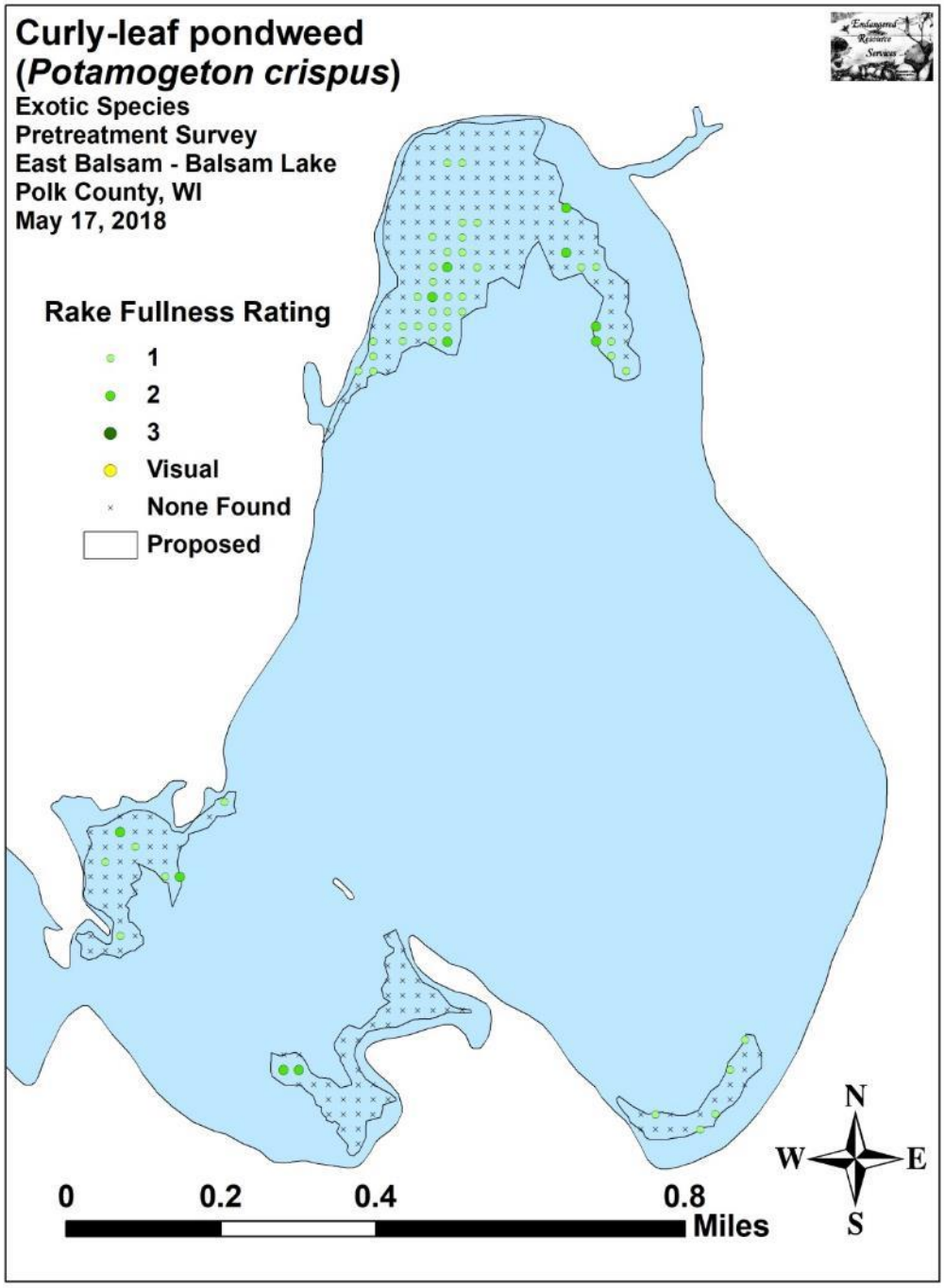

Native Species Richness
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
# of Native Species
None Found
1
2
3
4
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

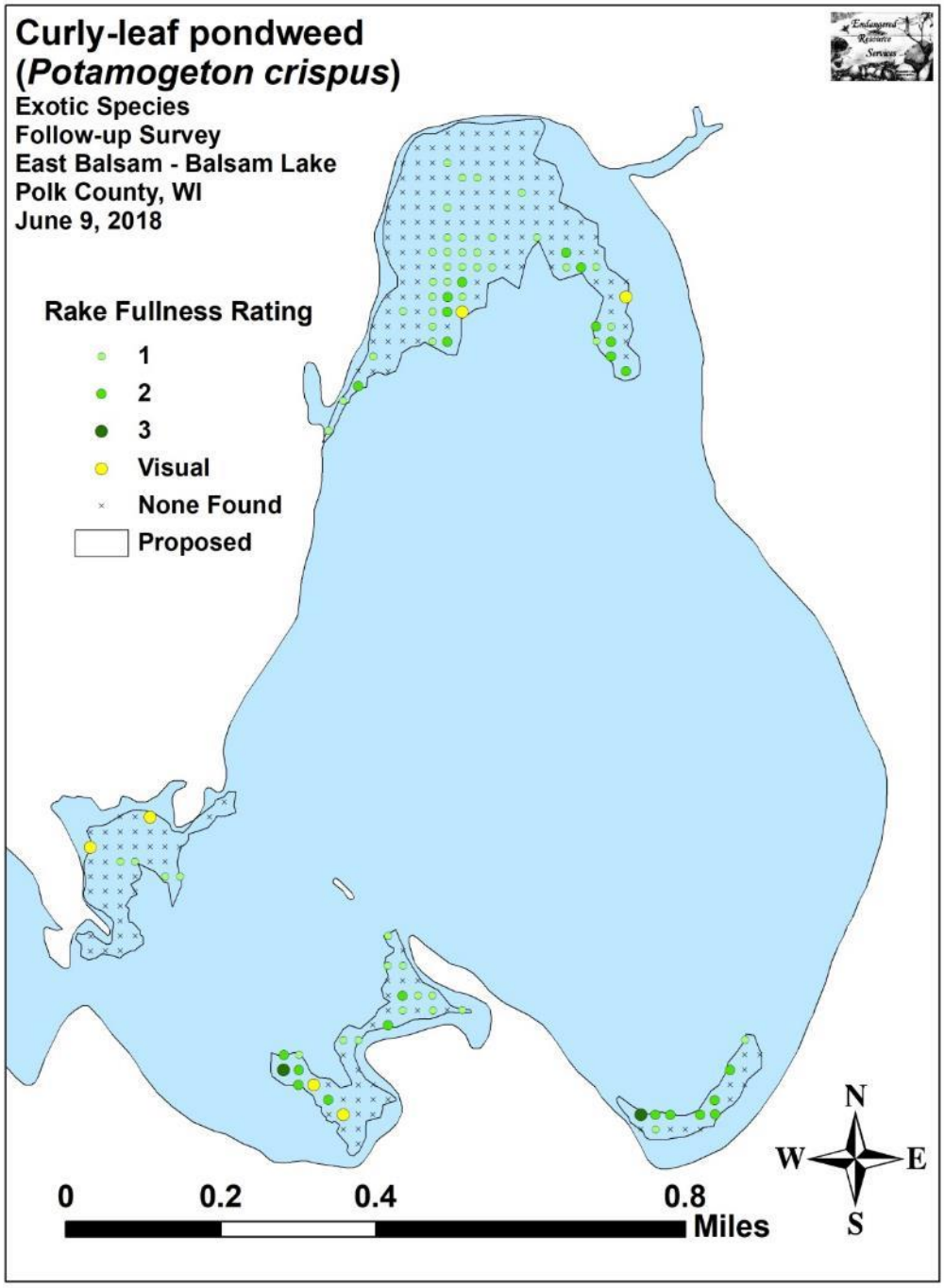

Native Species Richness
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
# of Native Species
None Found
1
2
3
4 - 5
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S


Total Rake Fullness
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

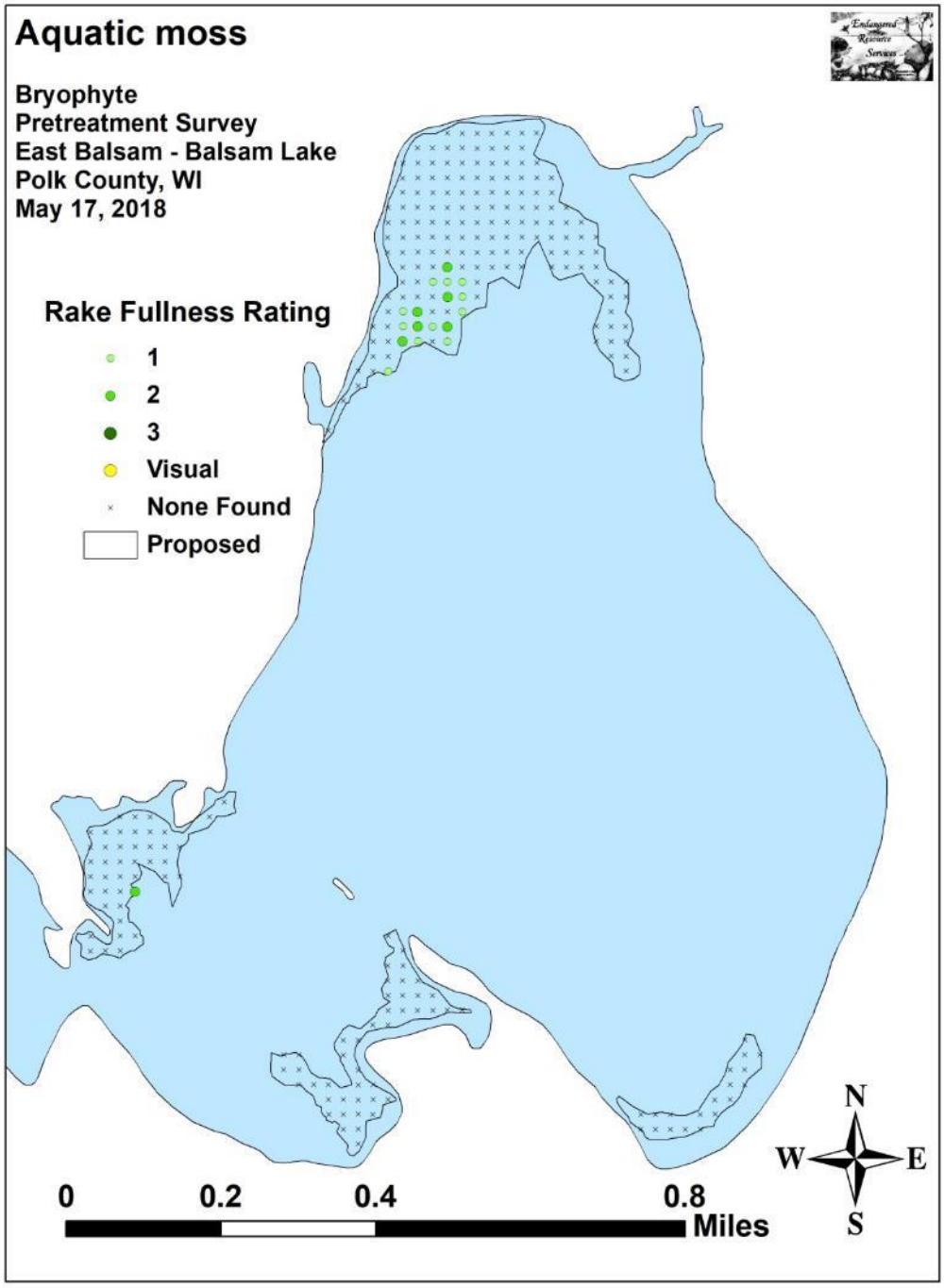

Total Rake Fullness
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

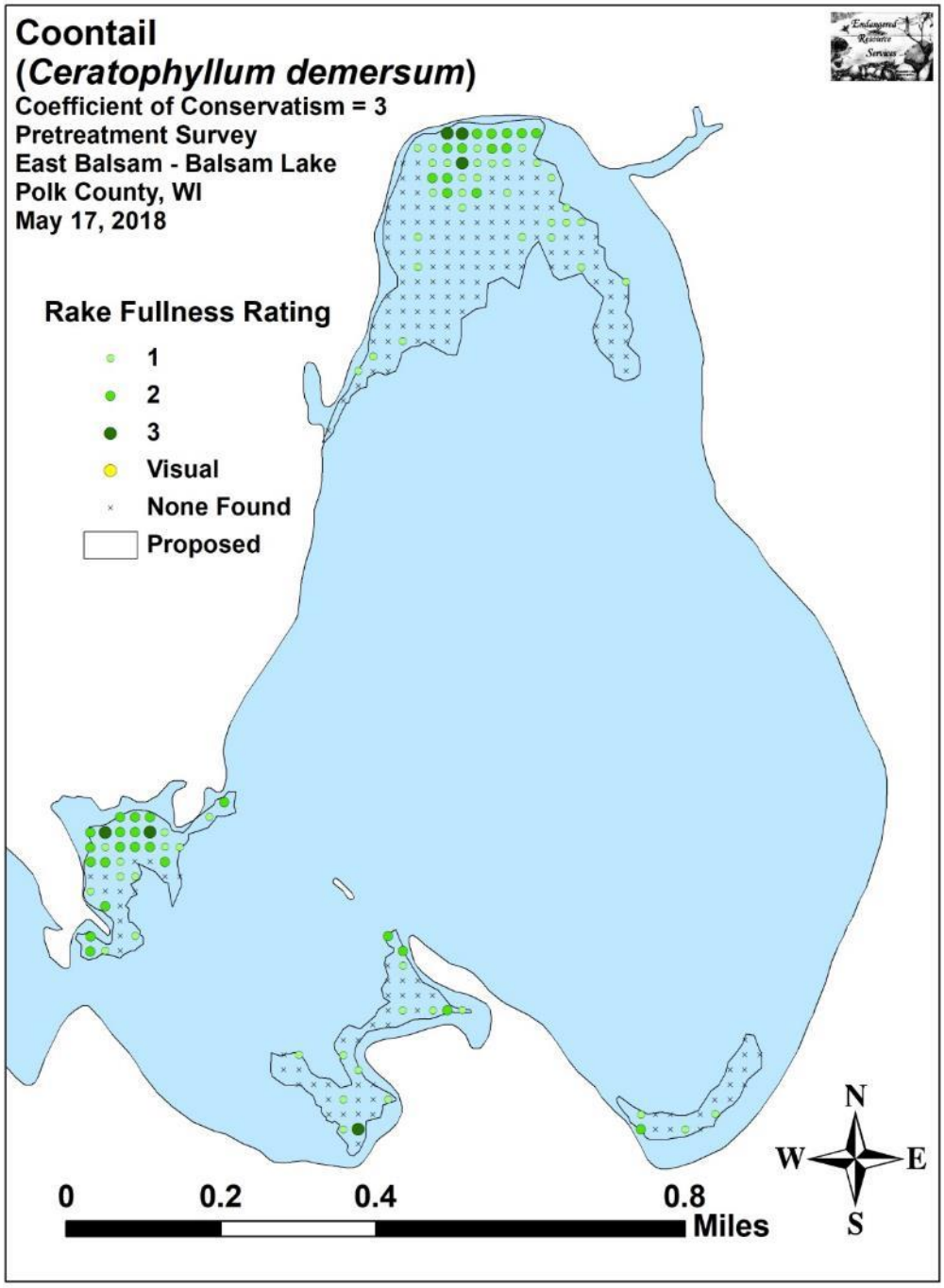
Appendix V: CLP Pre/Follow-up Density and Distribution

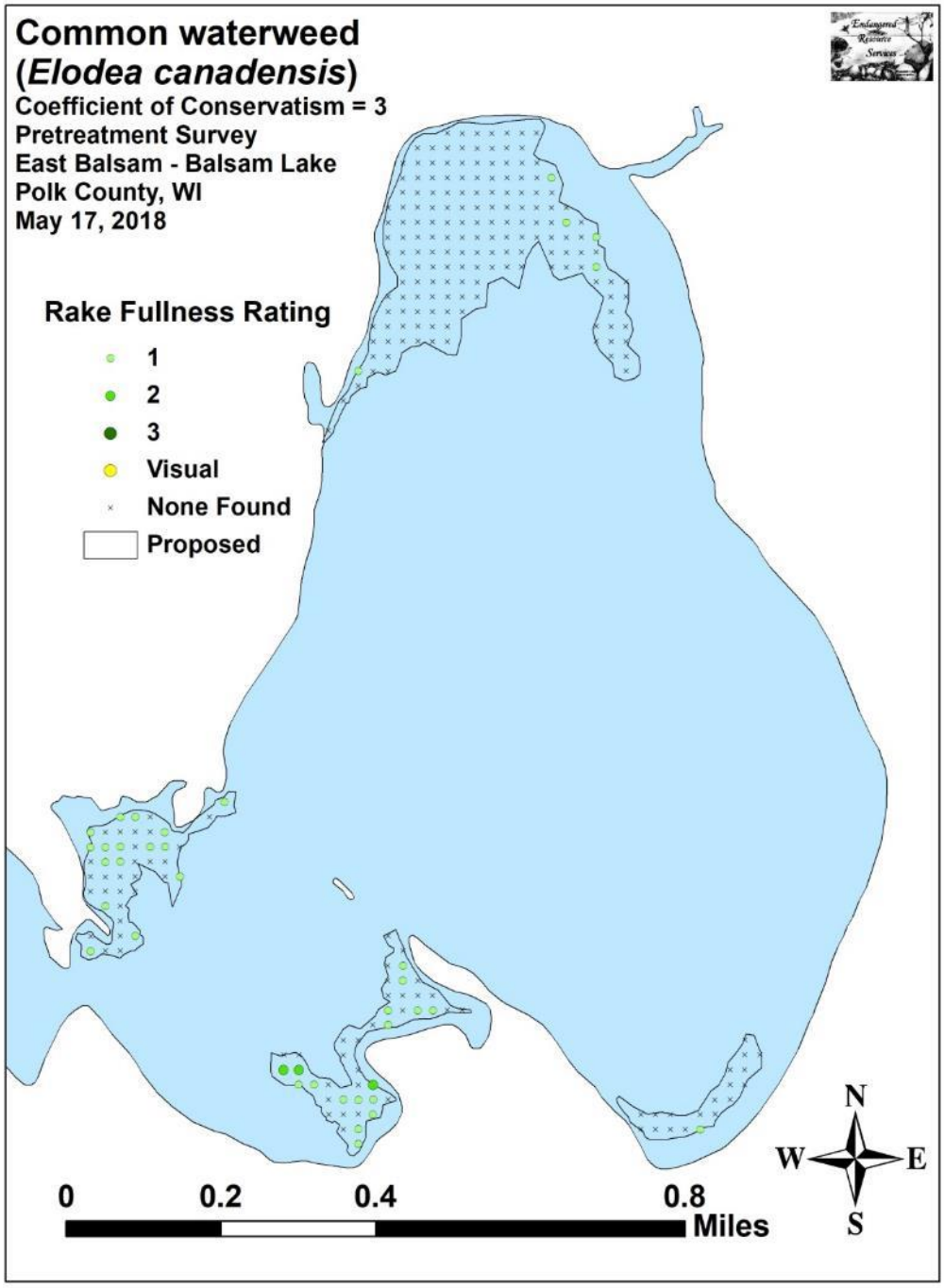

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

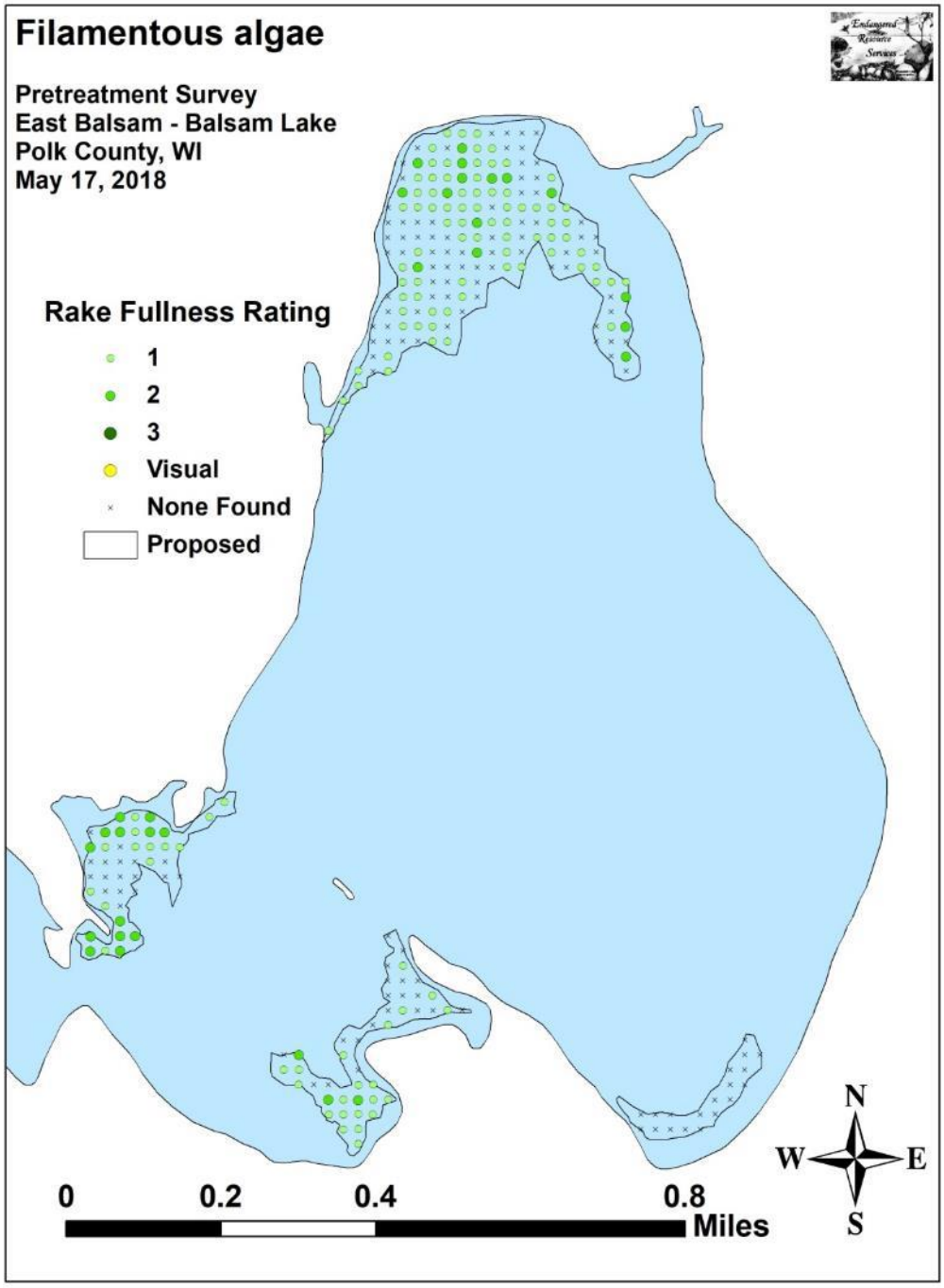

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

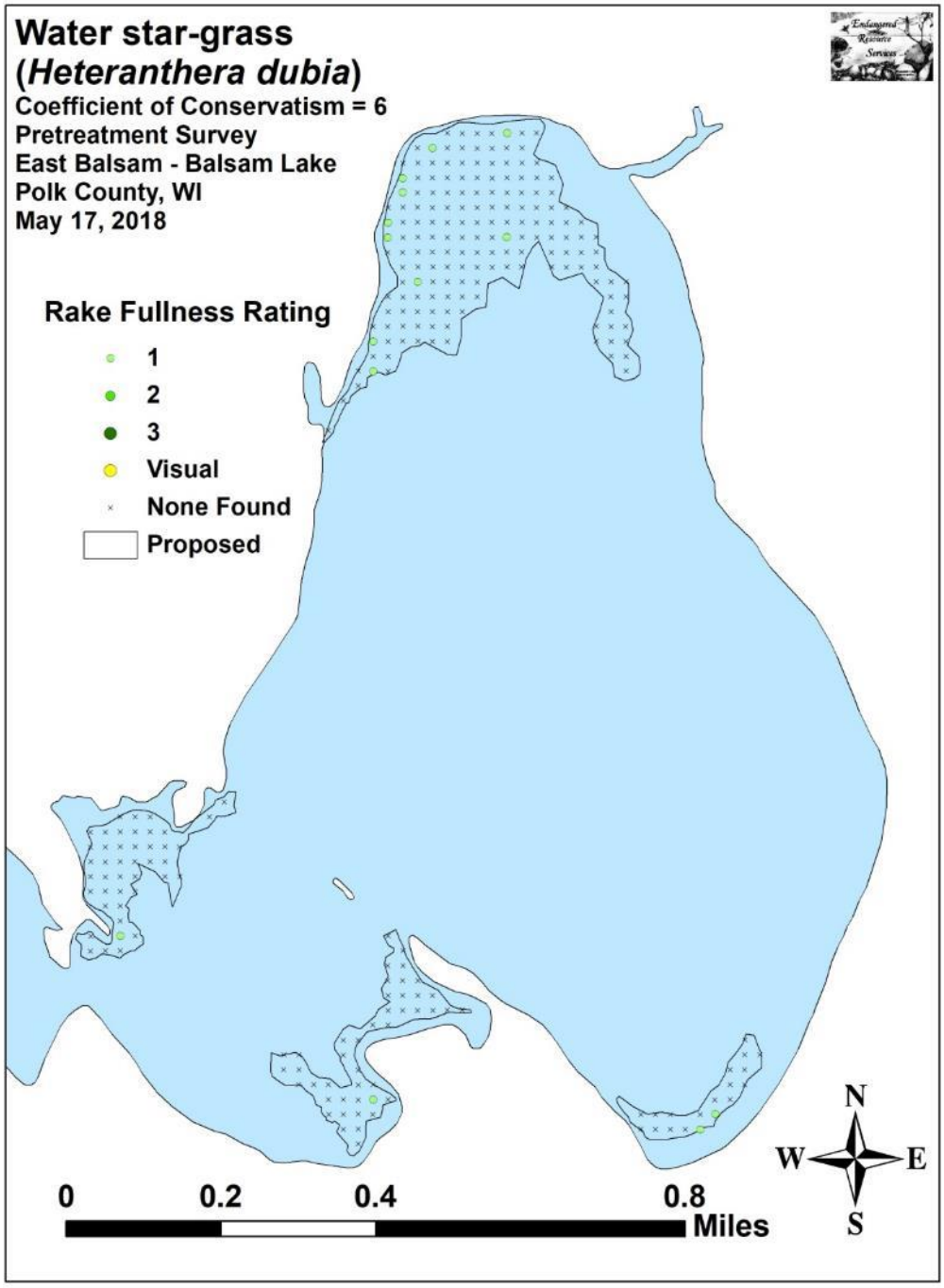
Appendix VI: Pretreatment Native Species Density and Distribution

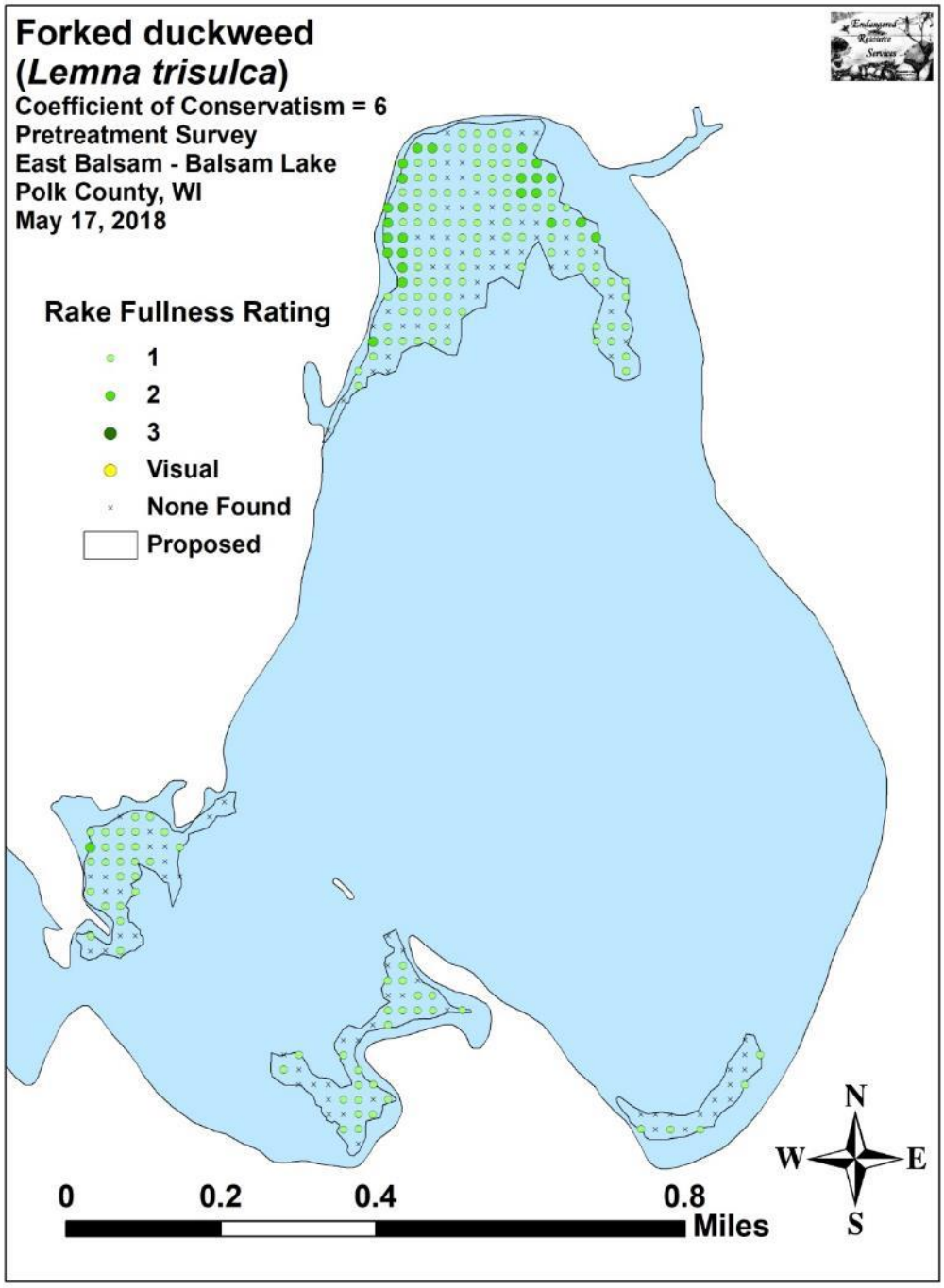

Aquatic moss
Bryophyte
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

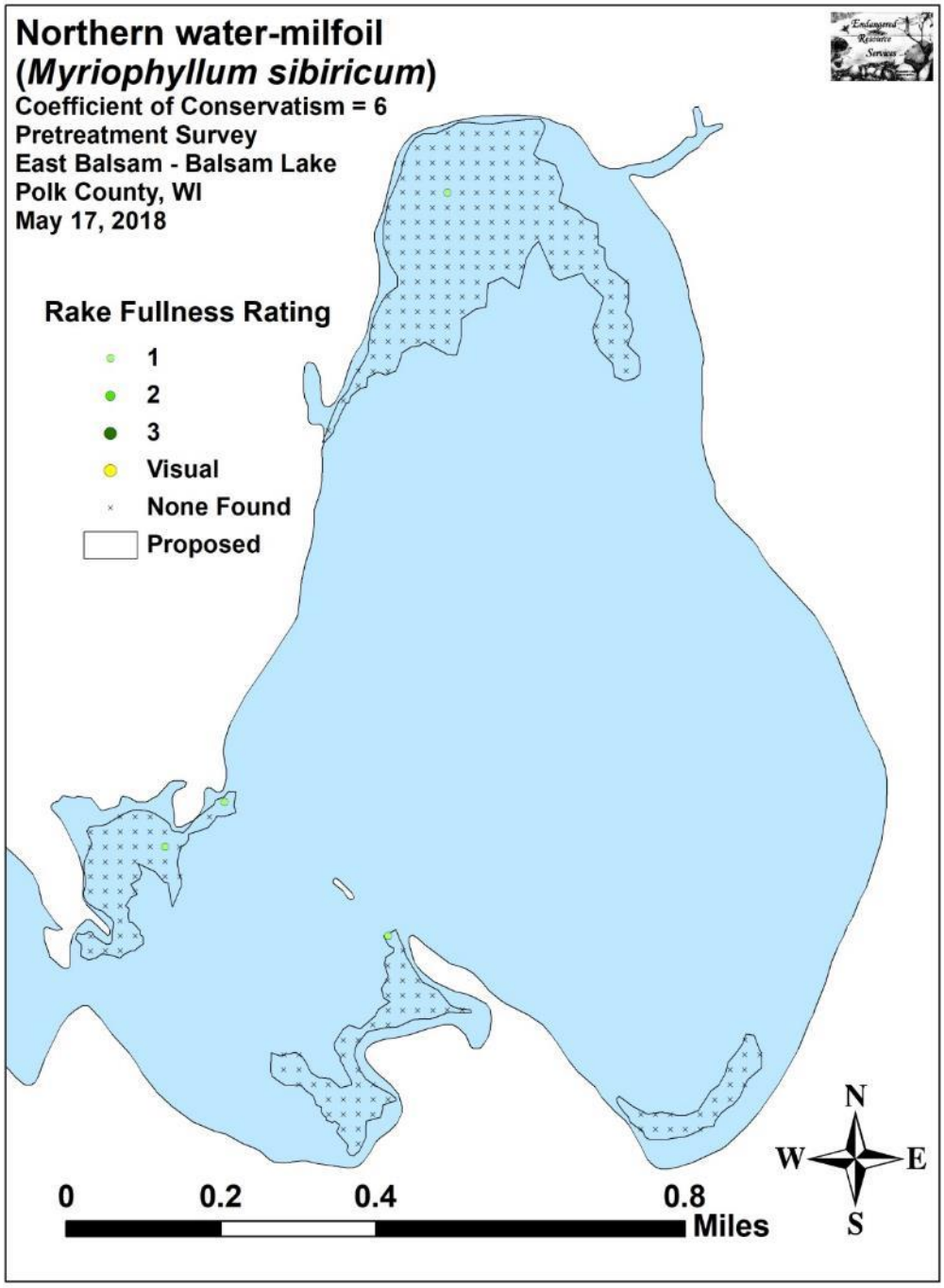

Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

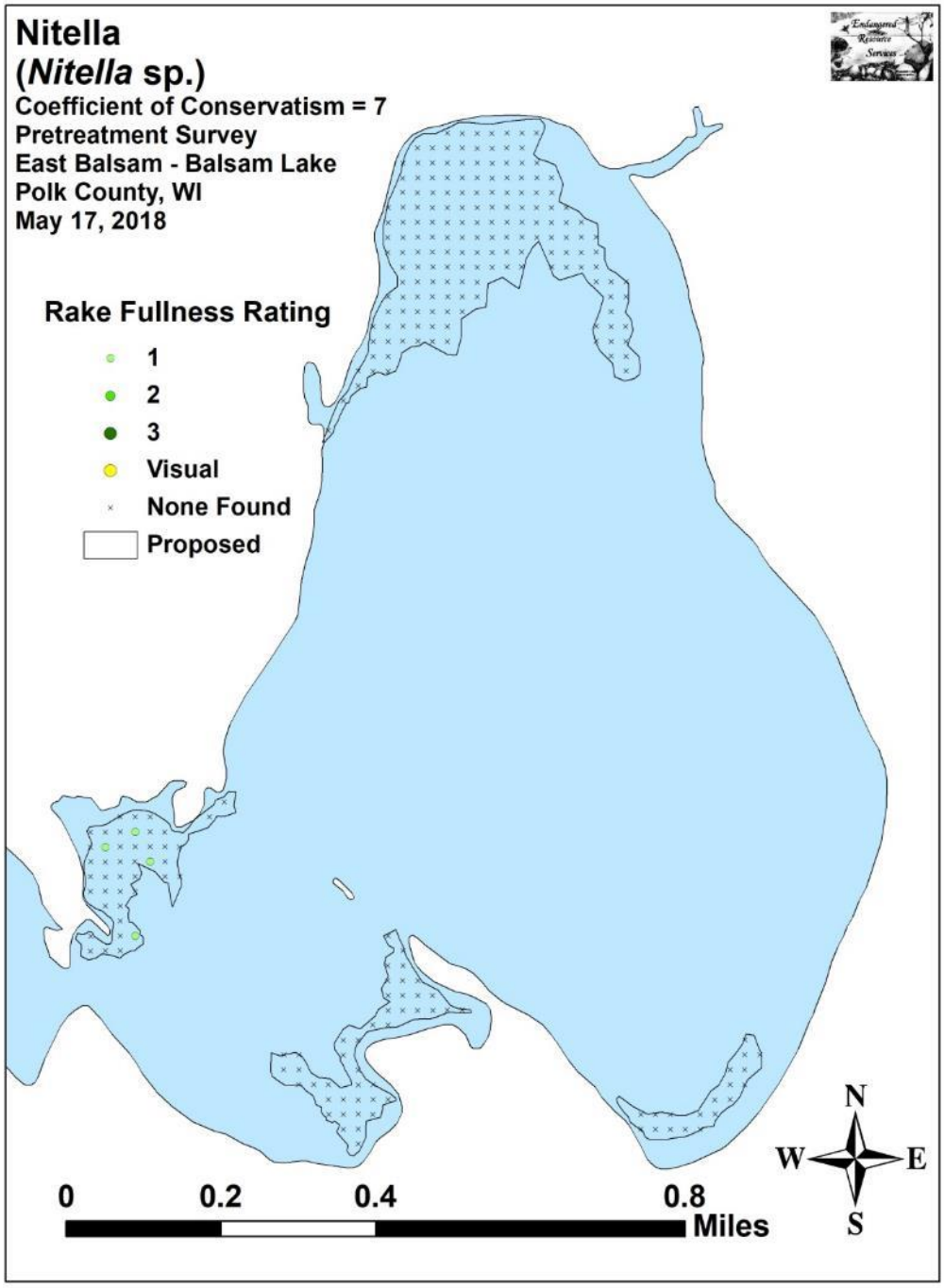

Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

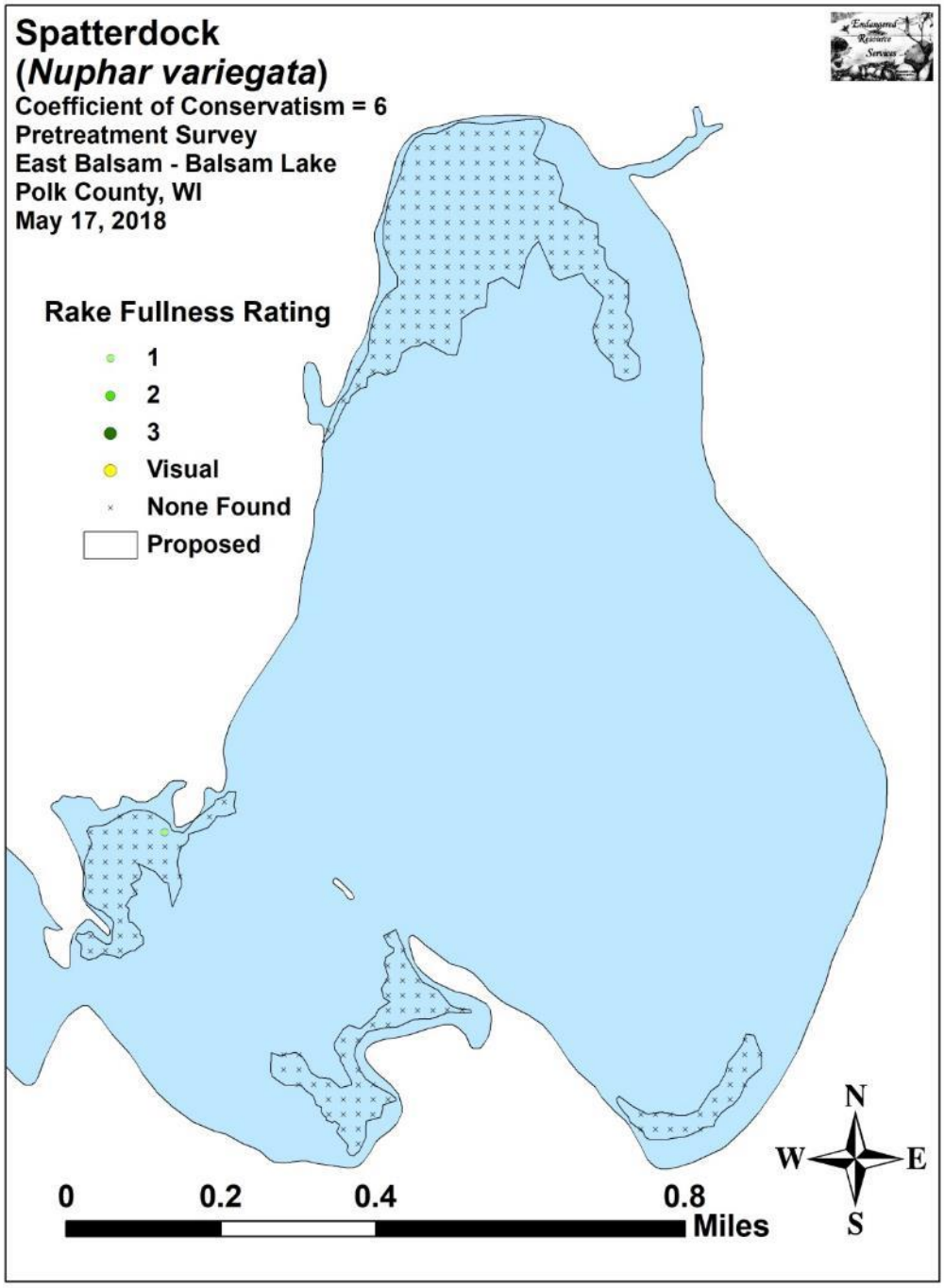

Filamentous algae
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

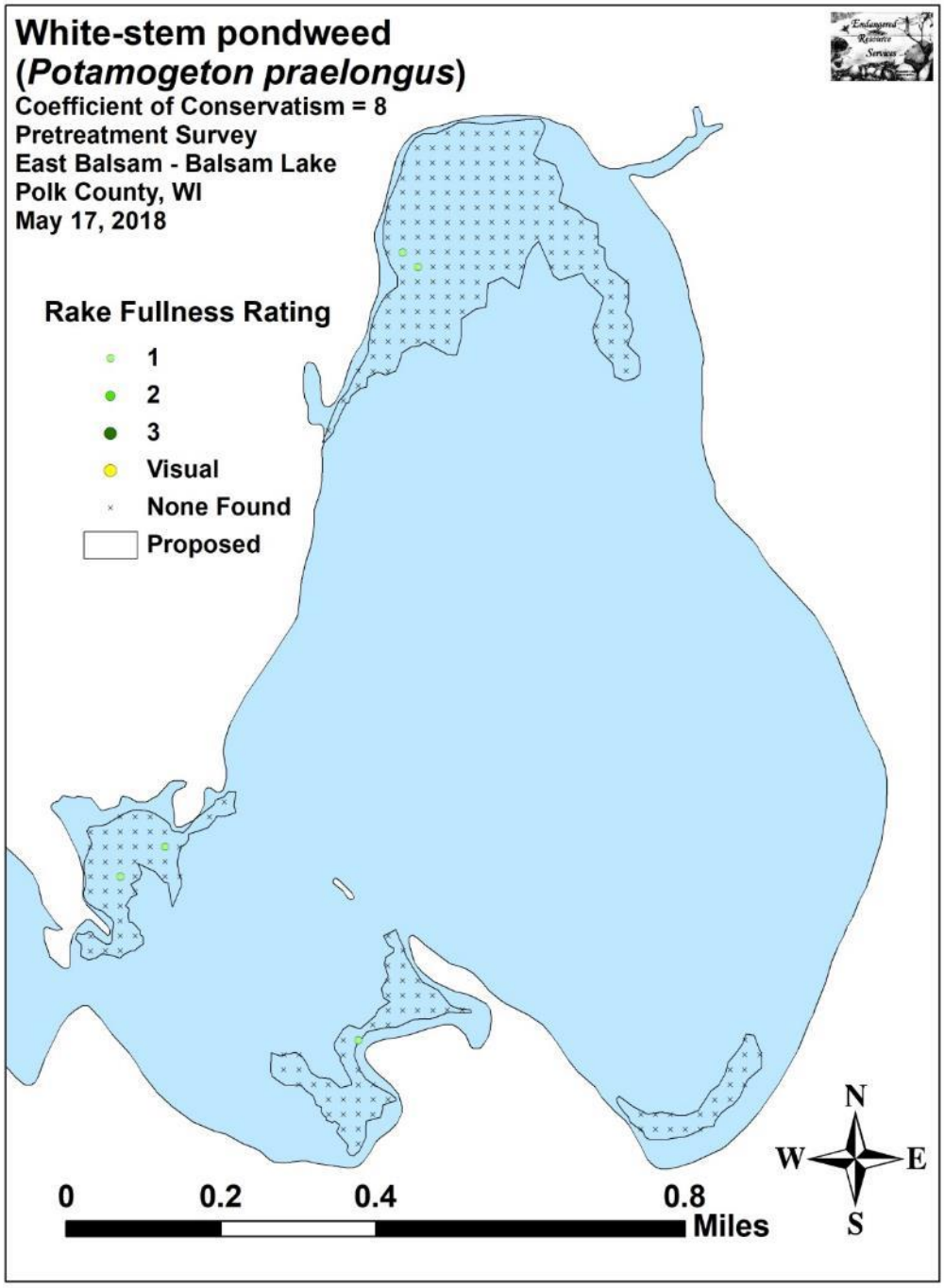

Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

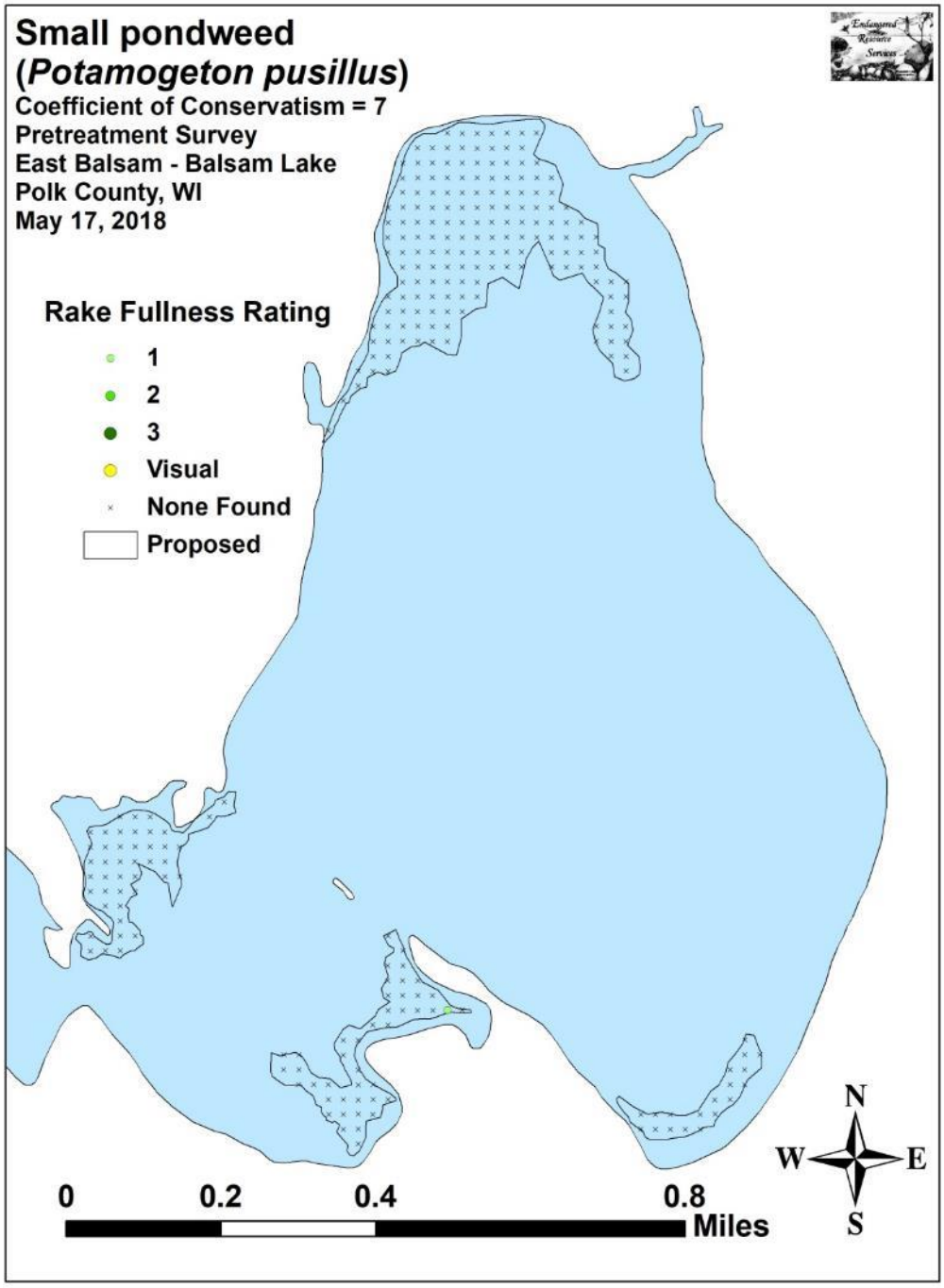

Forked duckweed
(Lemna trisulca)
Coefficient of Conservatism = 6
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

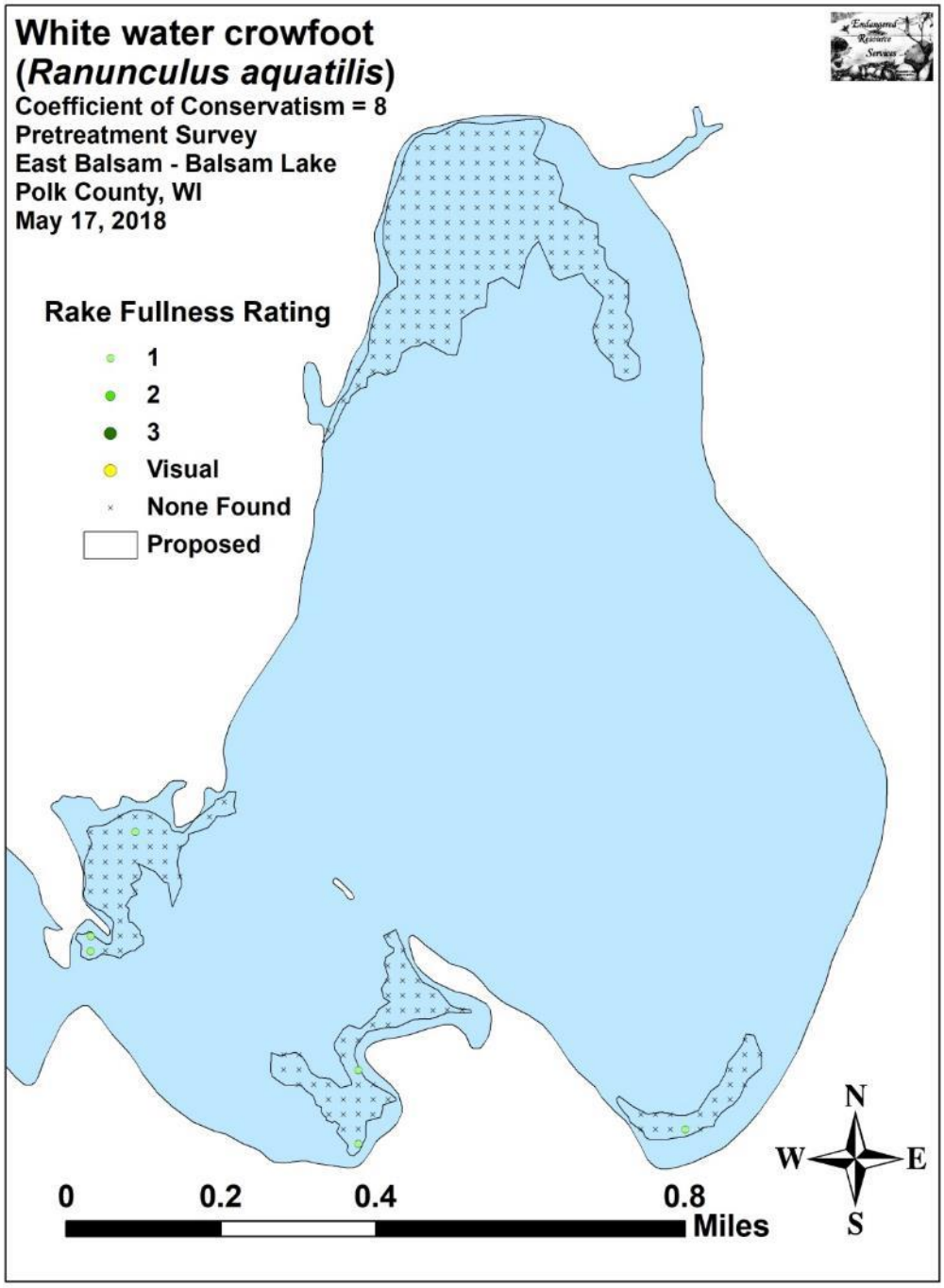

Northern water-milfoil
(Myriophyllum sibiricum)
Coefficient of Conservatism = 6
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S


Nitella
(Nitella sp.)
Coefficient of Conservatism = 7
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

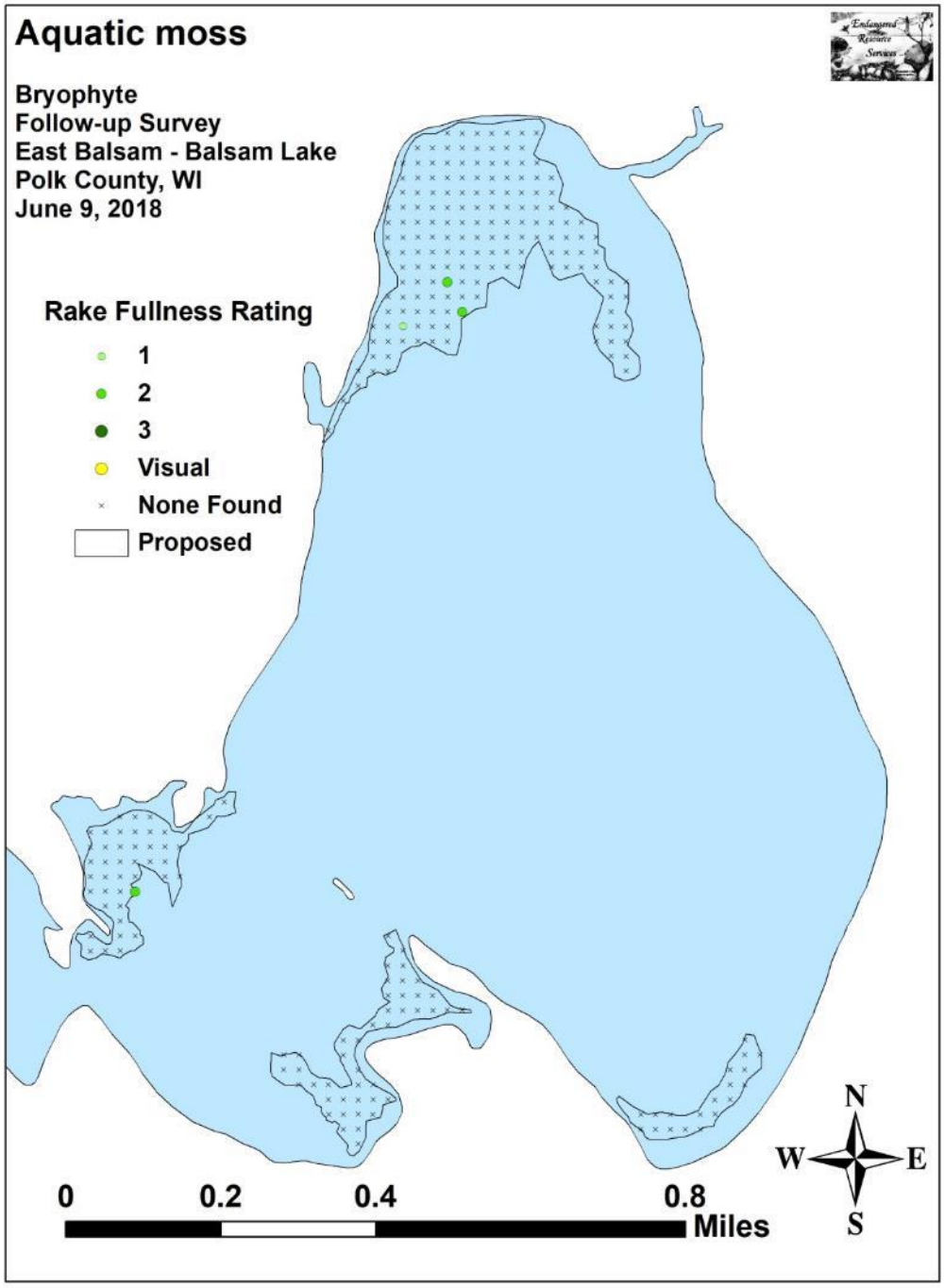

Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

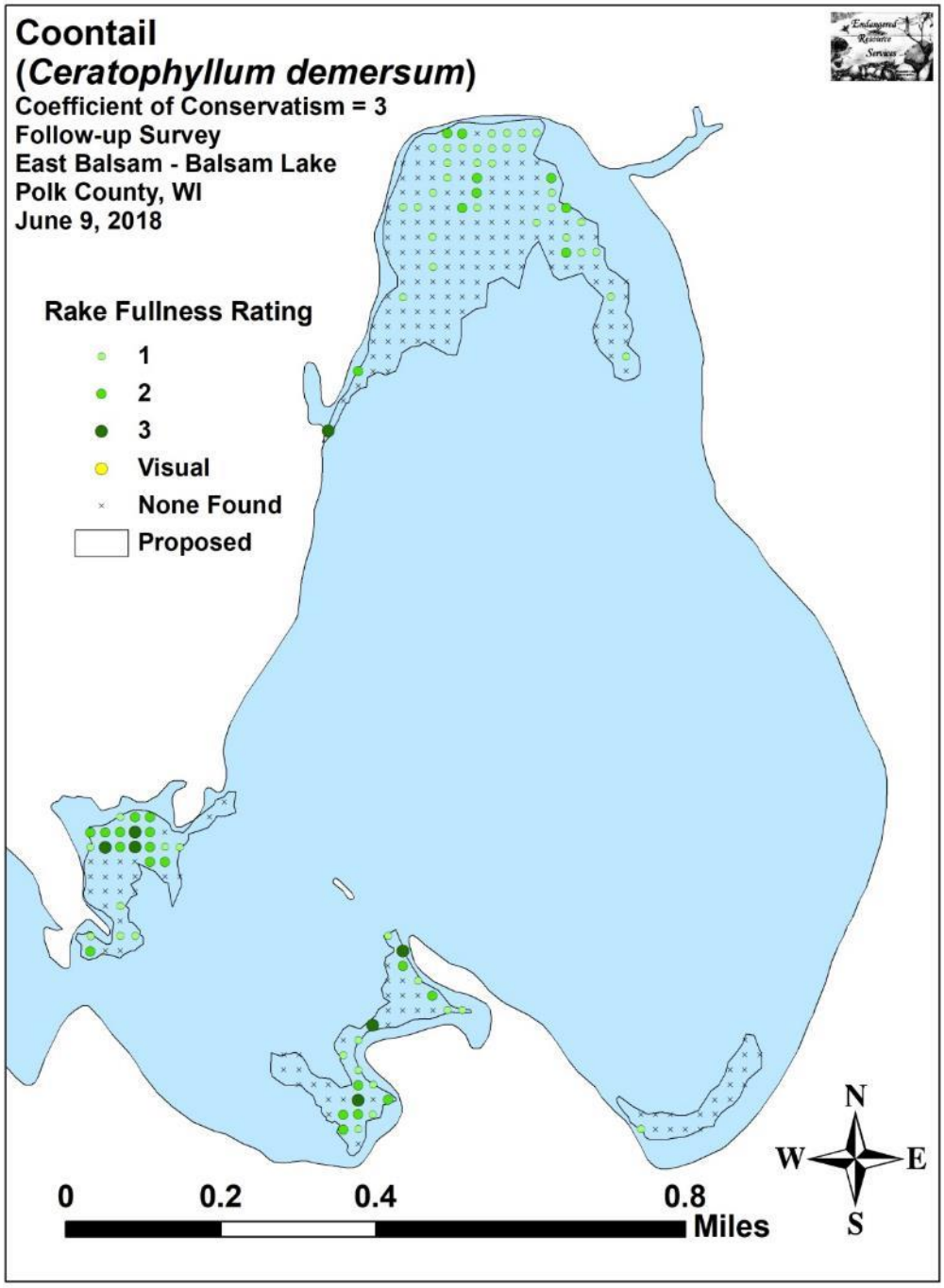

White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

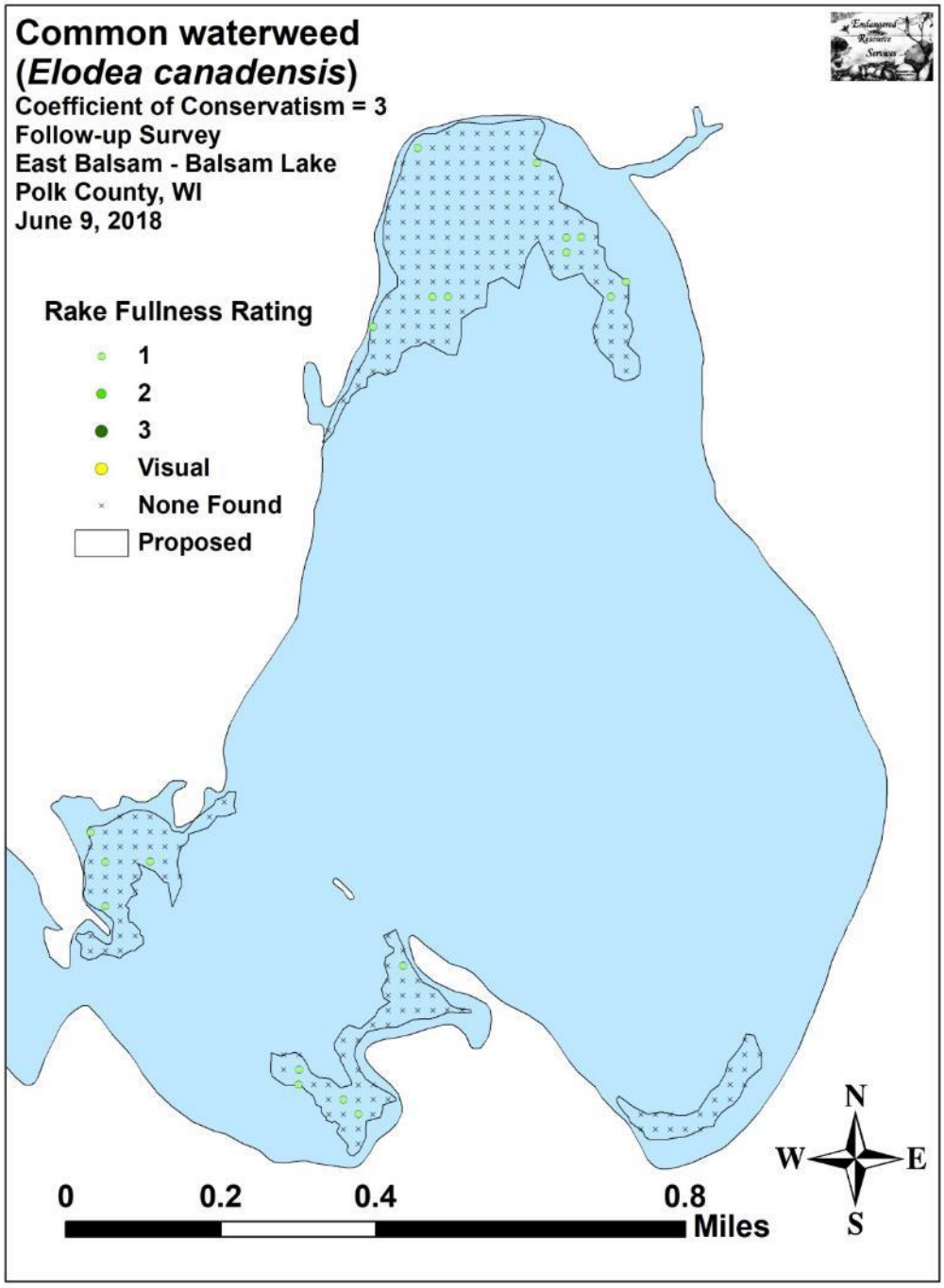

Small pondweed
(Potamogeton pusillus)
Coefficient of Conservatism = 7
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

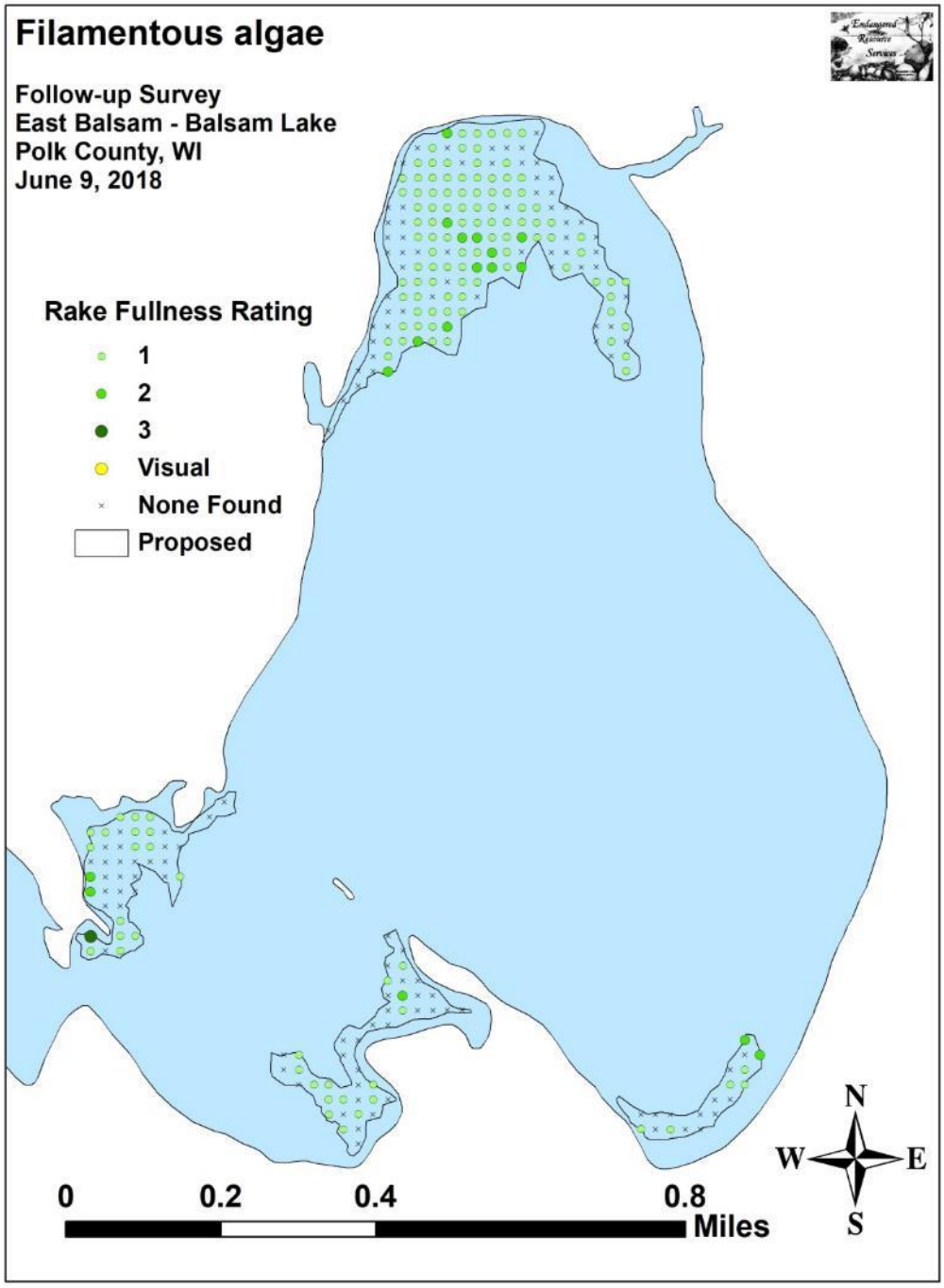

White water crowfoot
(Ranunculus aquatilis)
Coefficient of Conservatism = 8
Pretreatment Survey
East Balsam - Balsam Lake
Polk County, WI
May 17, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

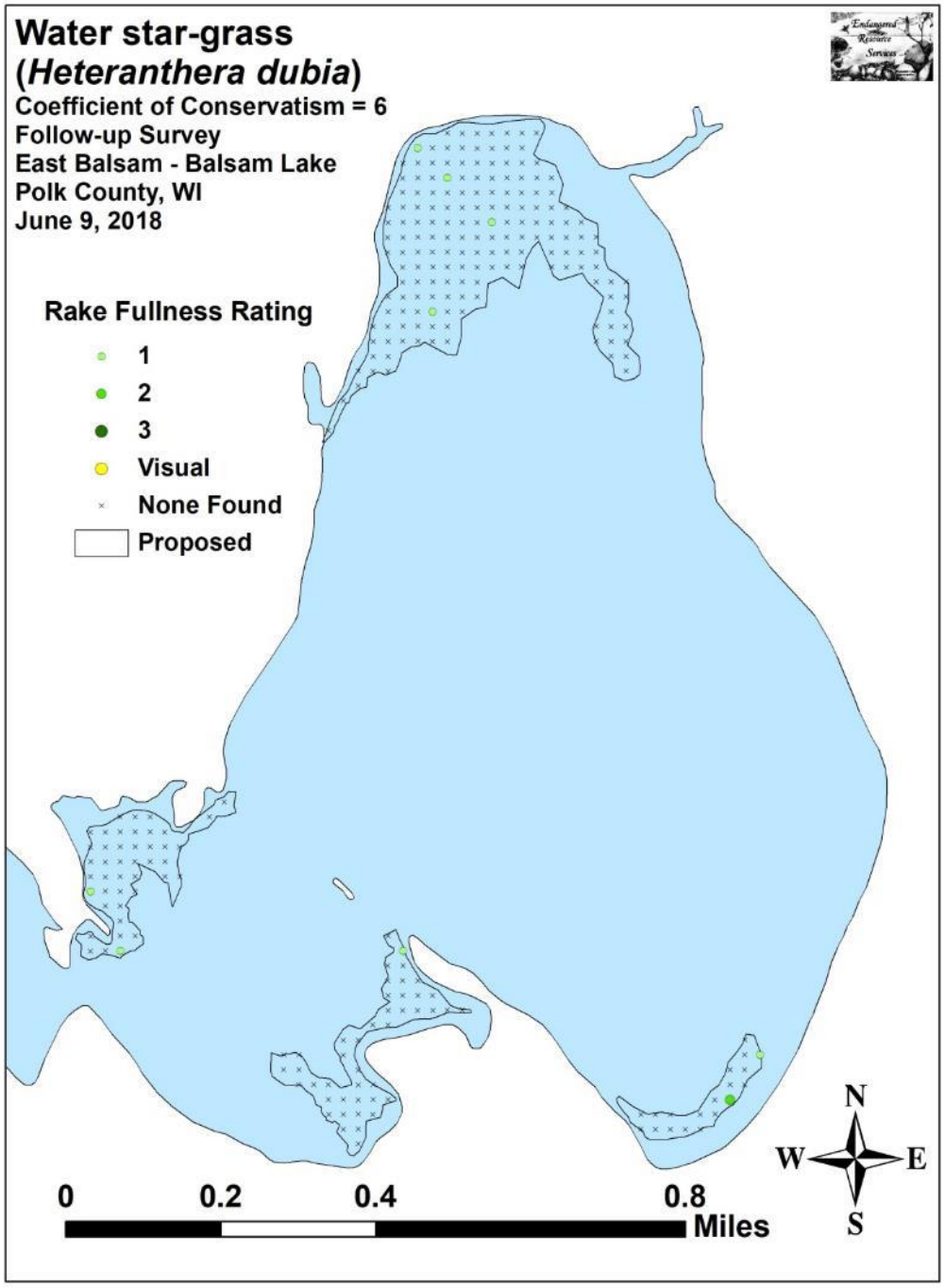
Appendix VII: Follow-up Native Species Density and Distribution

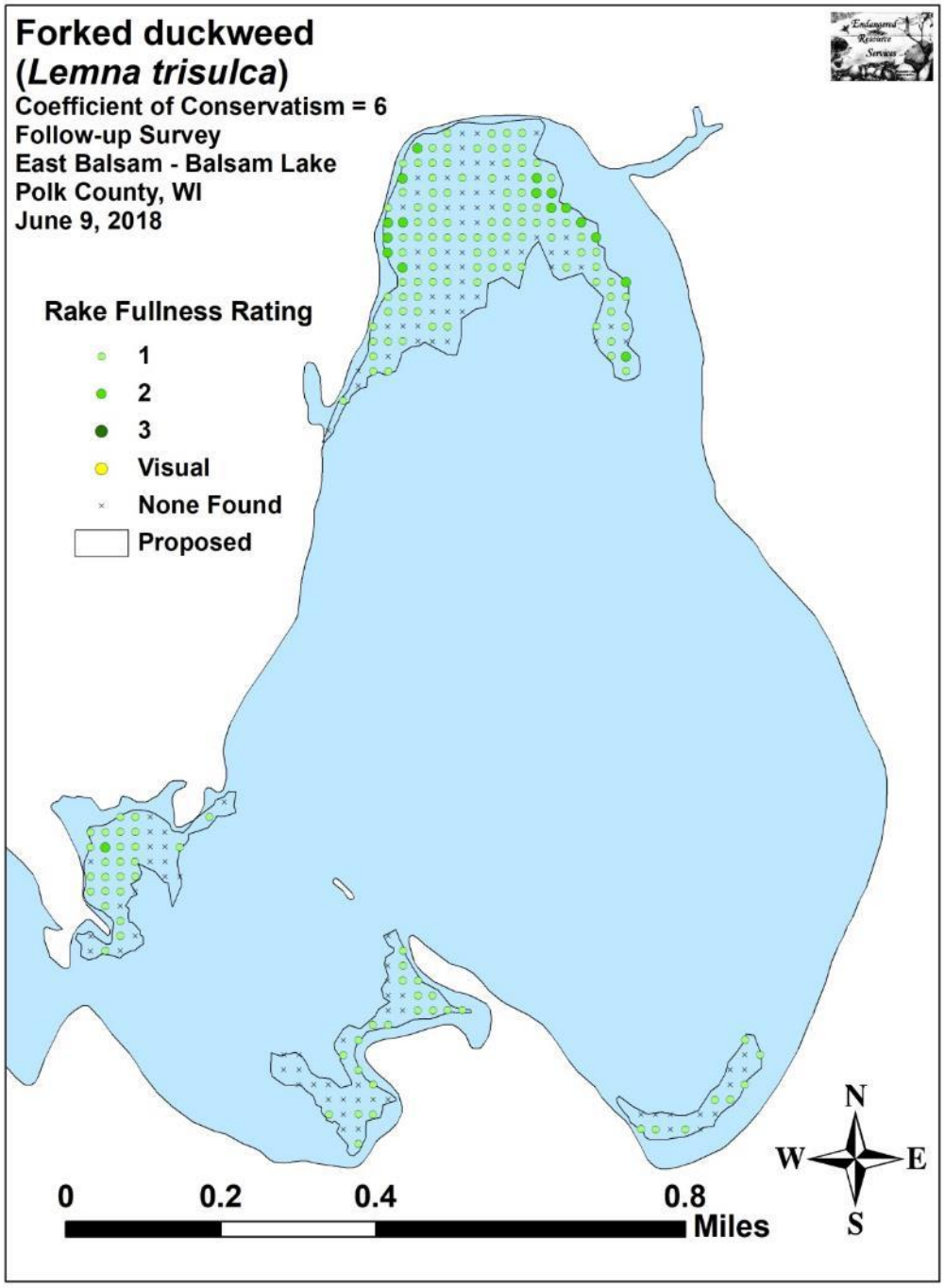

Aquatic moss
Bryophyte
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

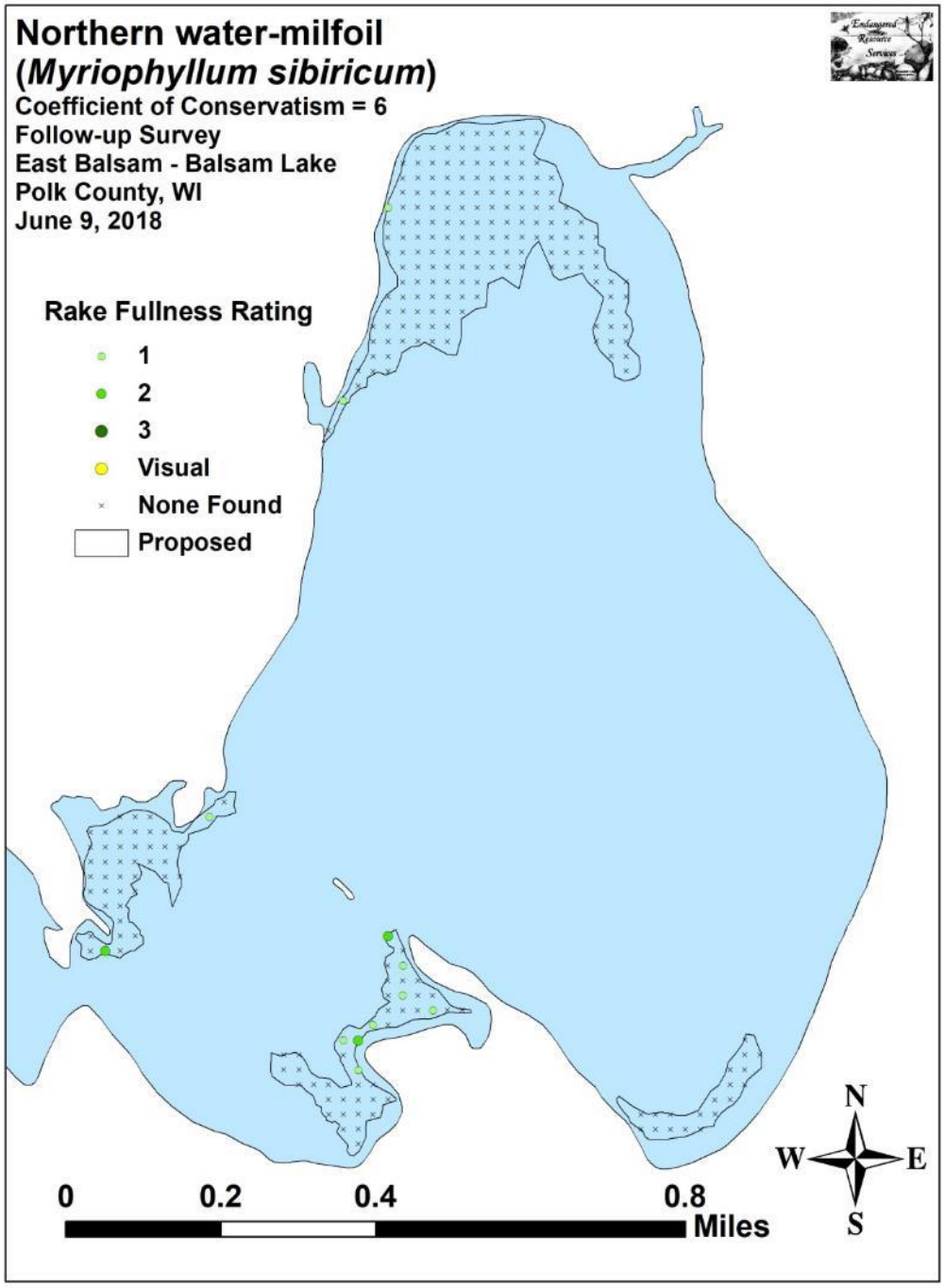

Coontail
(Ceratophyllum demersum)
Coefficient of Conservatism = 3
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

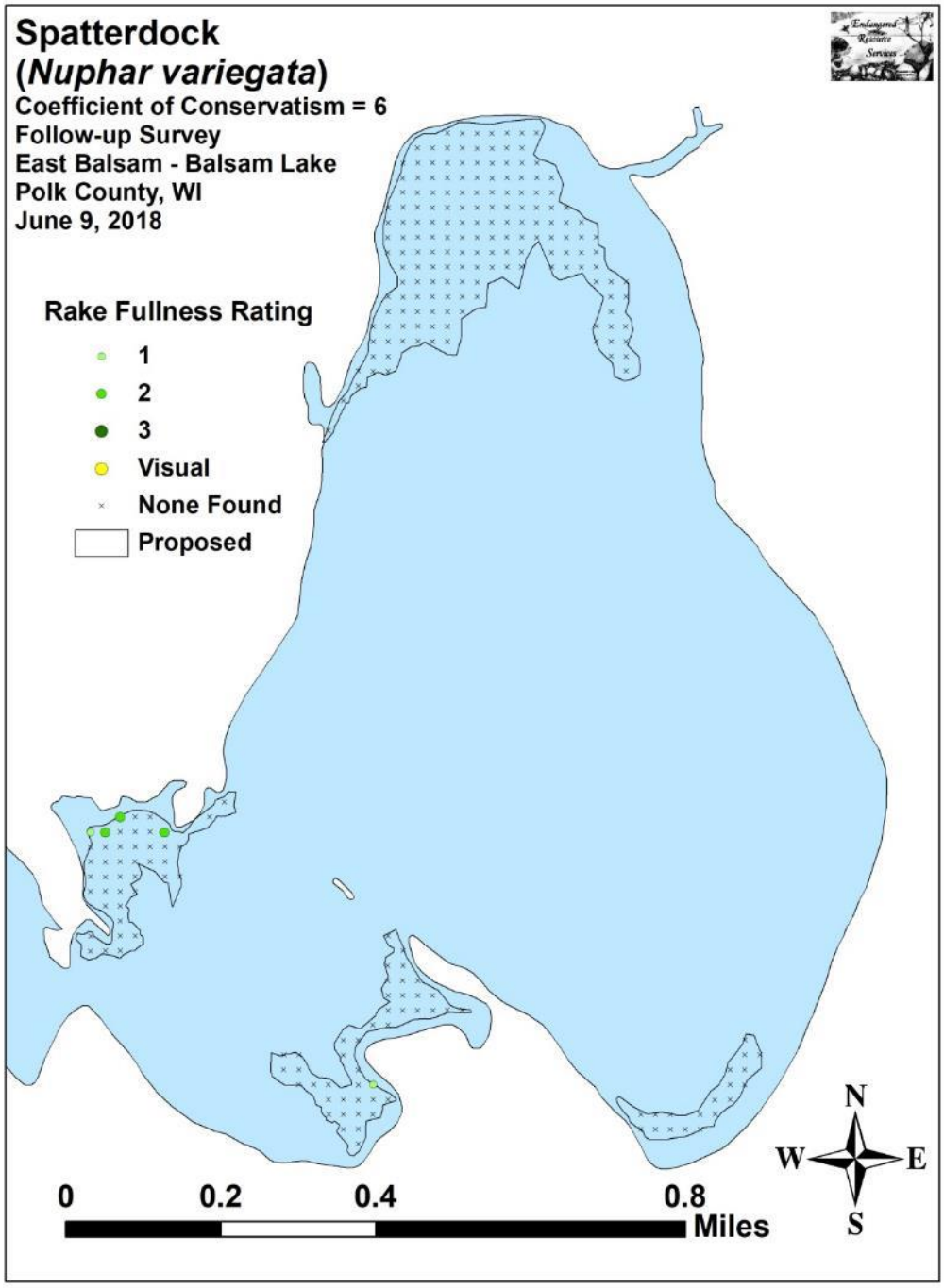

Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

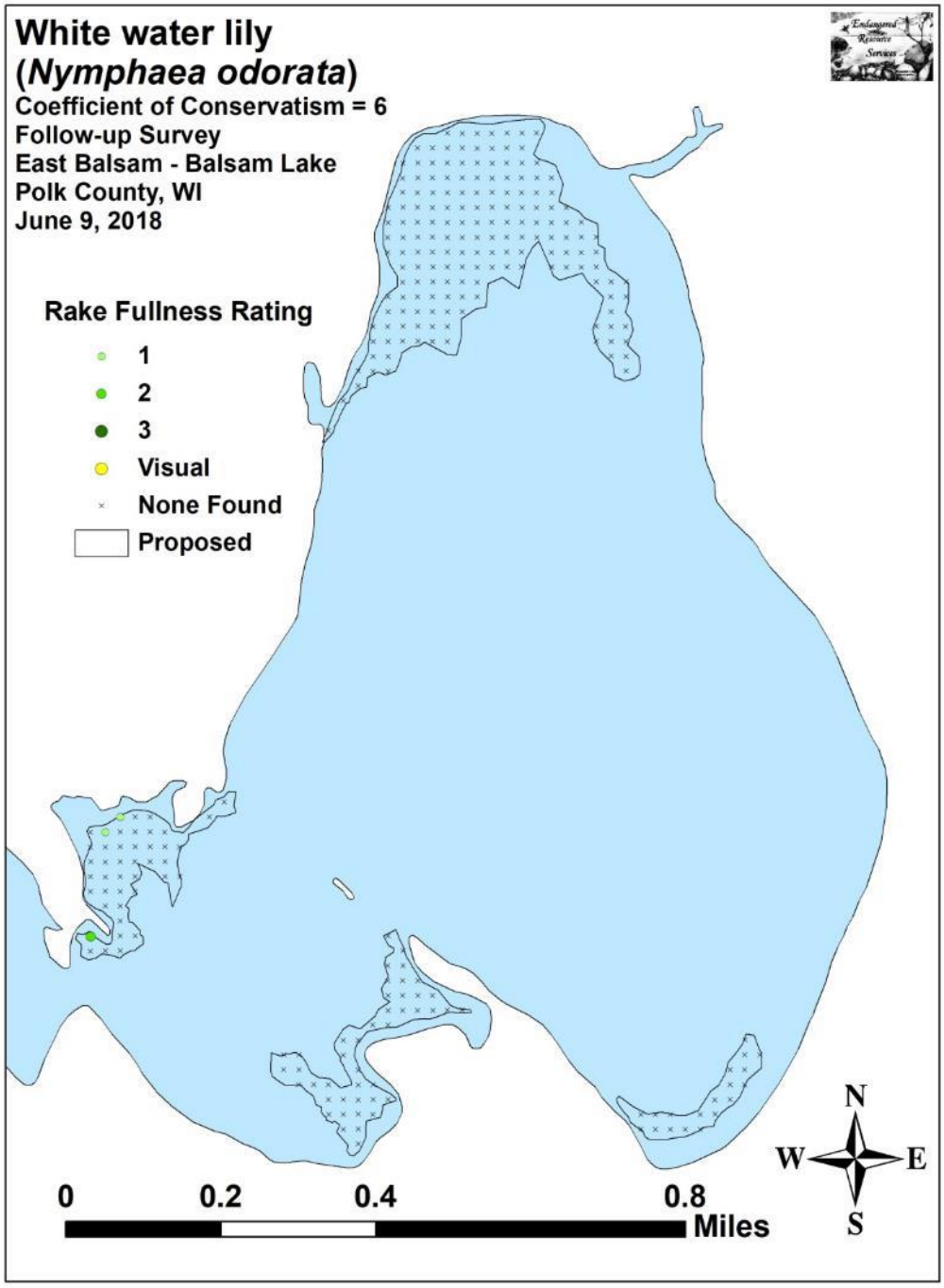

Filamentous algae
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

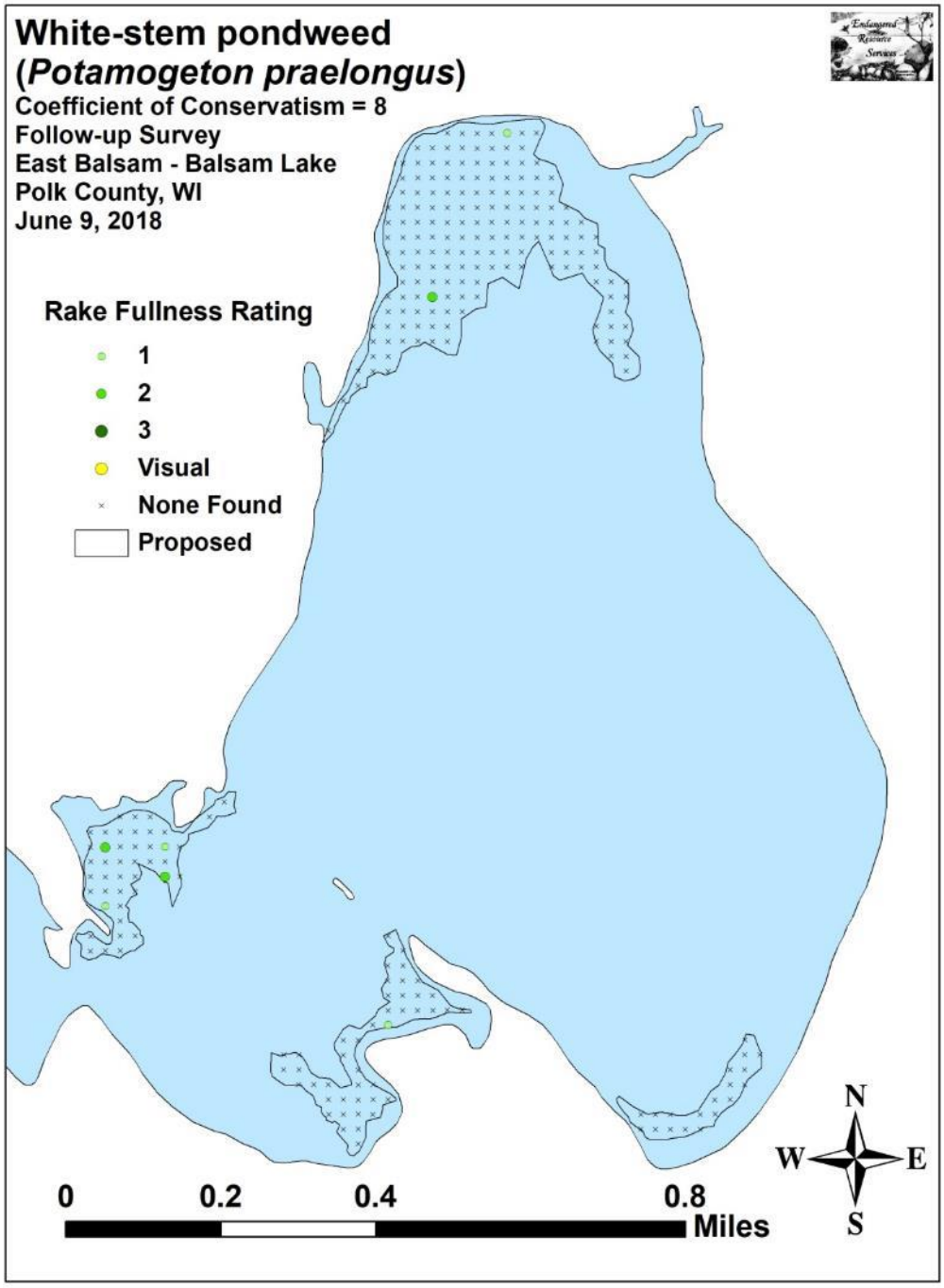

Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

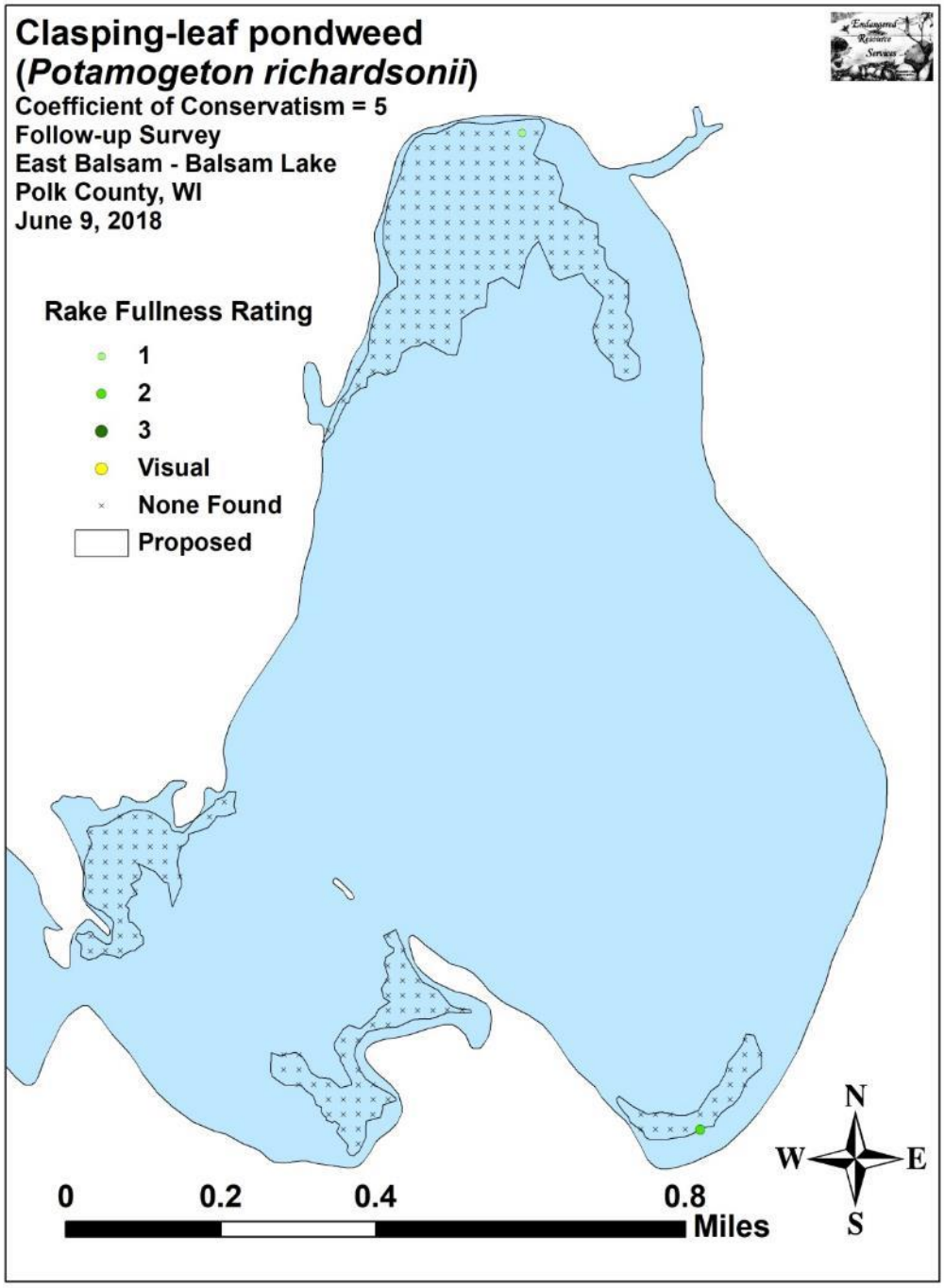

Forked duckweed
(Lemna trisulca)
Coefficient of Conservatism = 6
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

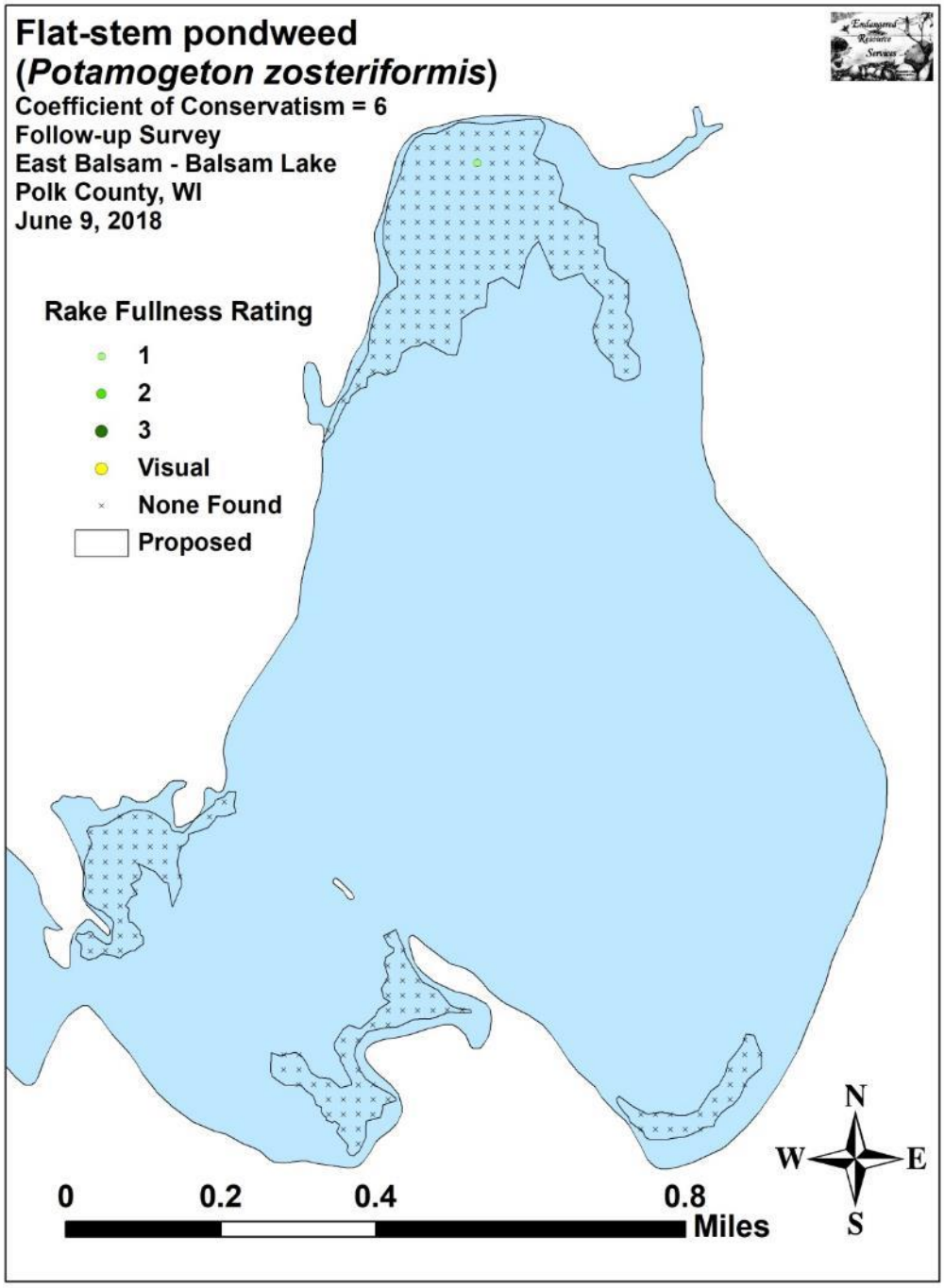

Northern water-milfoil
(Myriophyllum sibiricum)
Coefficient of Conservatism = 6
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

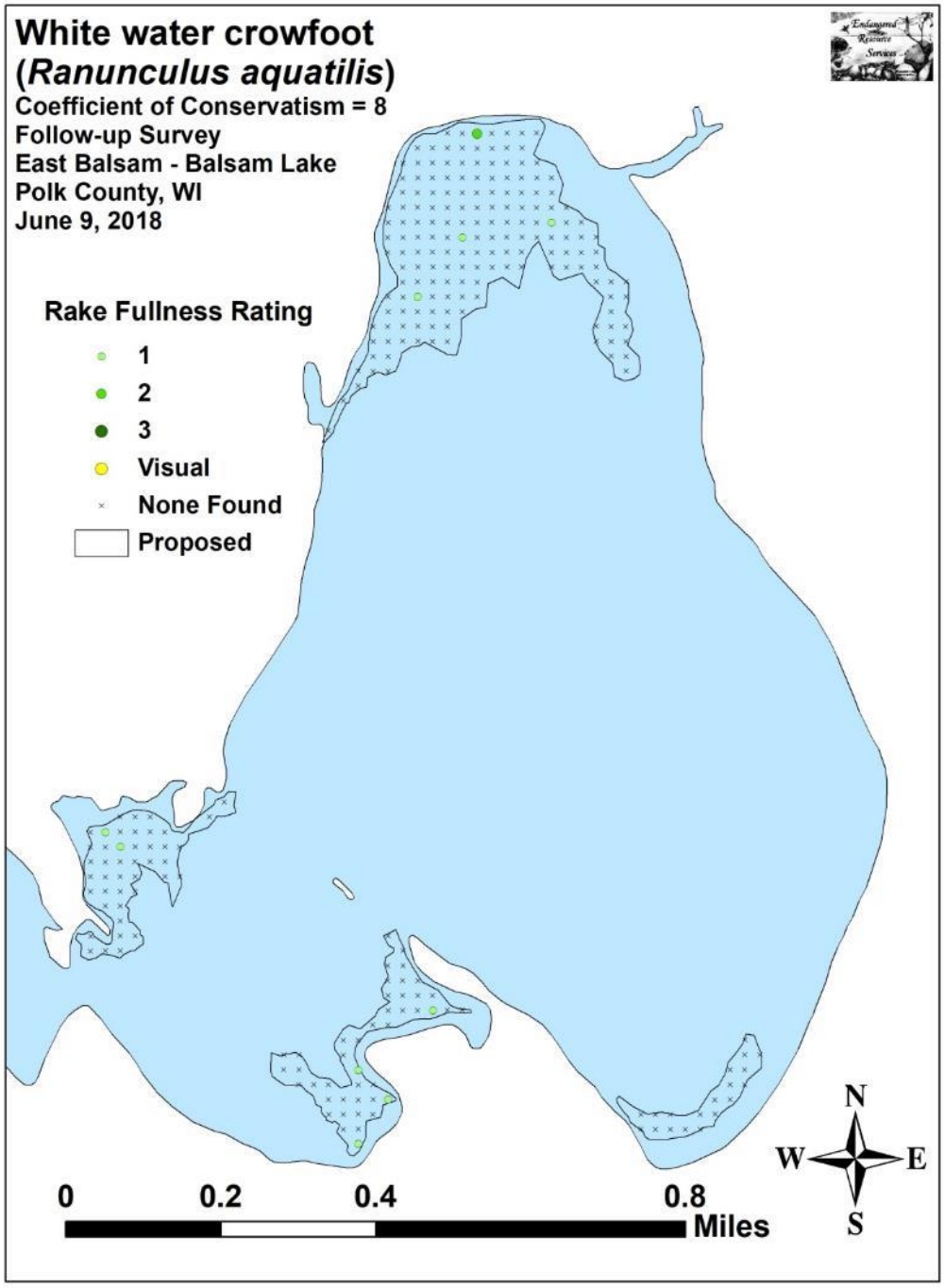

Spatterdock
(Nuphar variegata)
Coefficient of Conservatism = 6
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

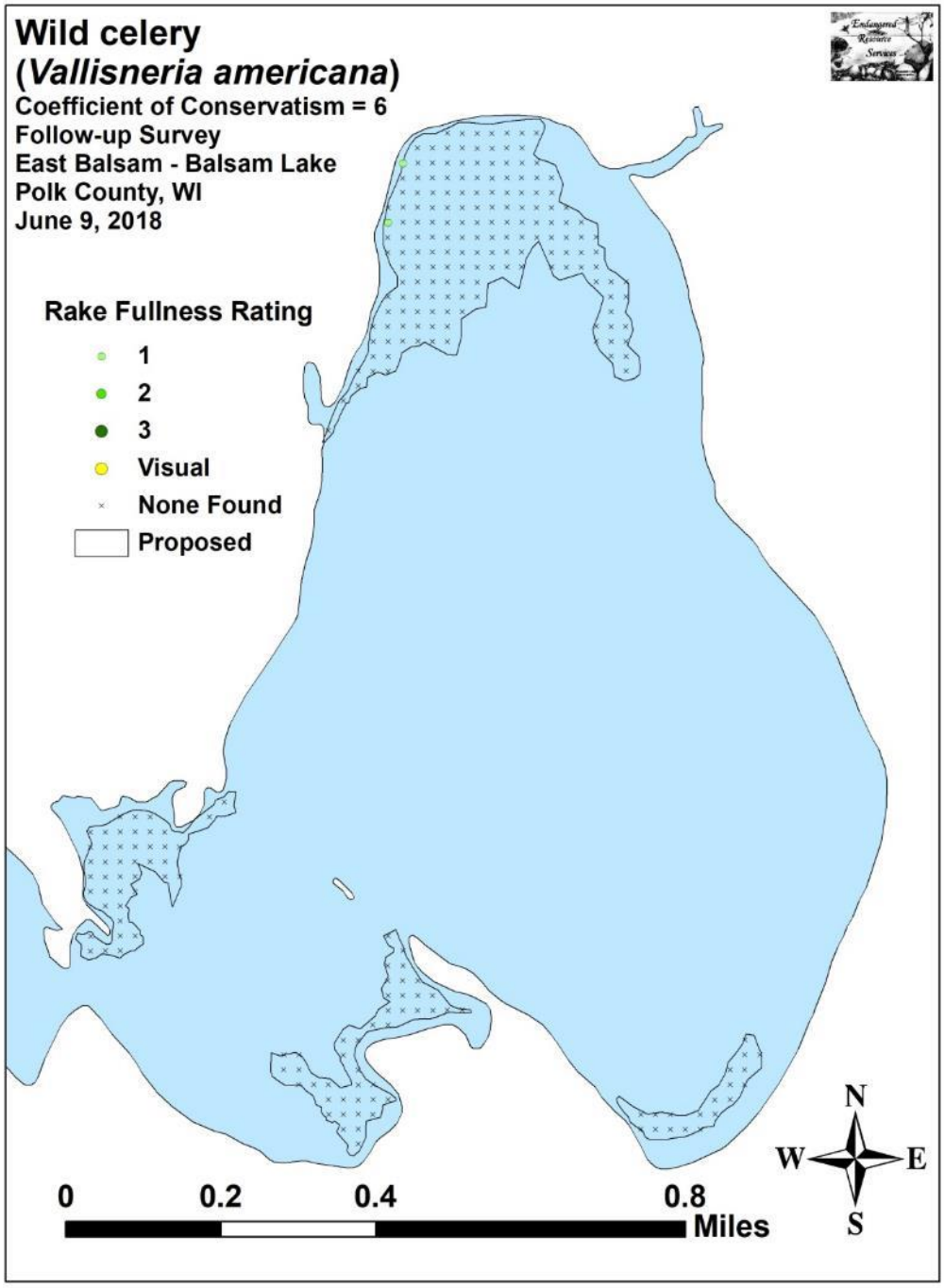

White water lily
(Nymphaea odorata)
Coefficient of Conservatism = 6
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S


White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

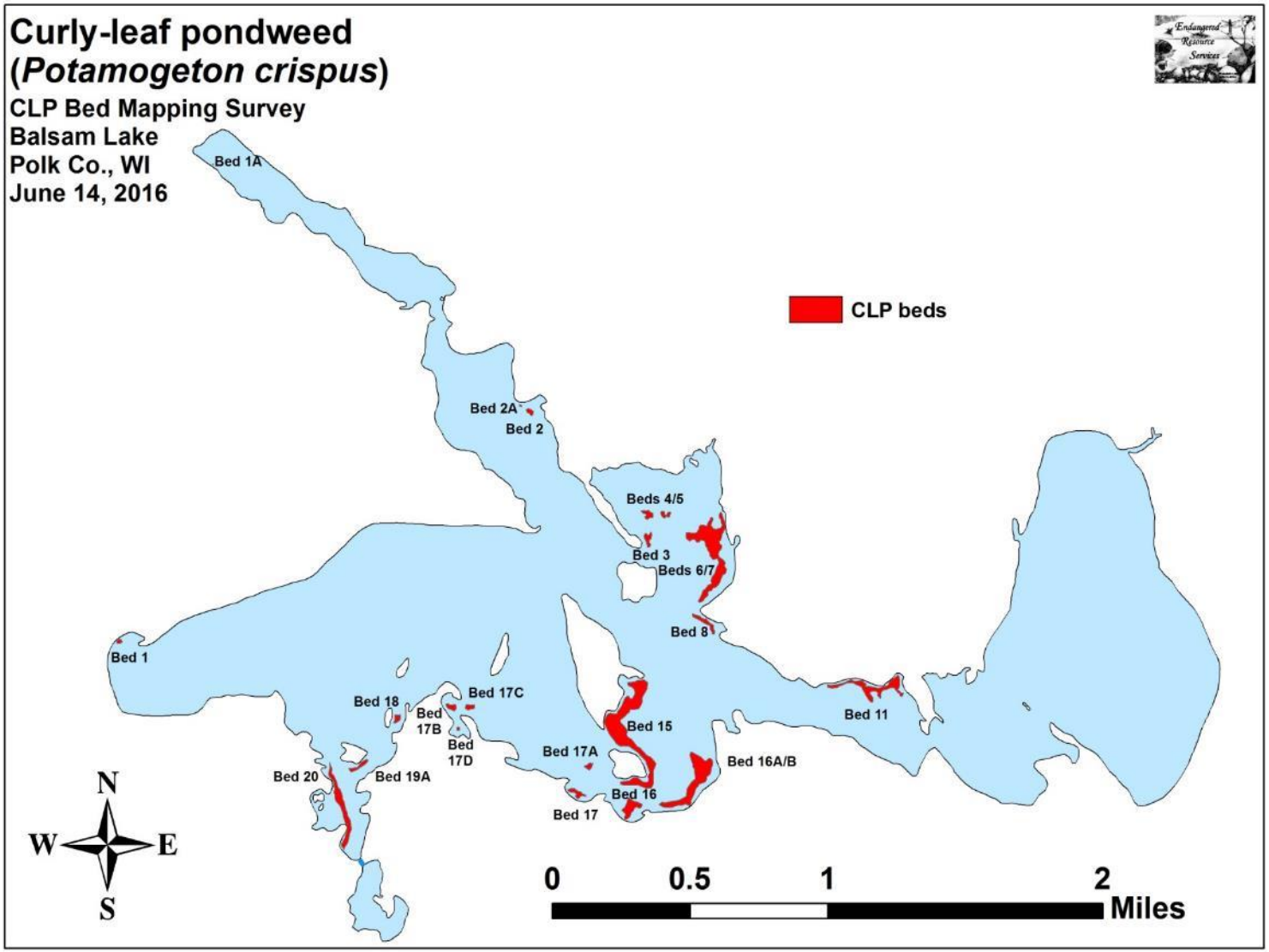

Clasping-leaf pondweed
(Potamogeton richardsonii)
Coefficient of Conservatism = 5
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

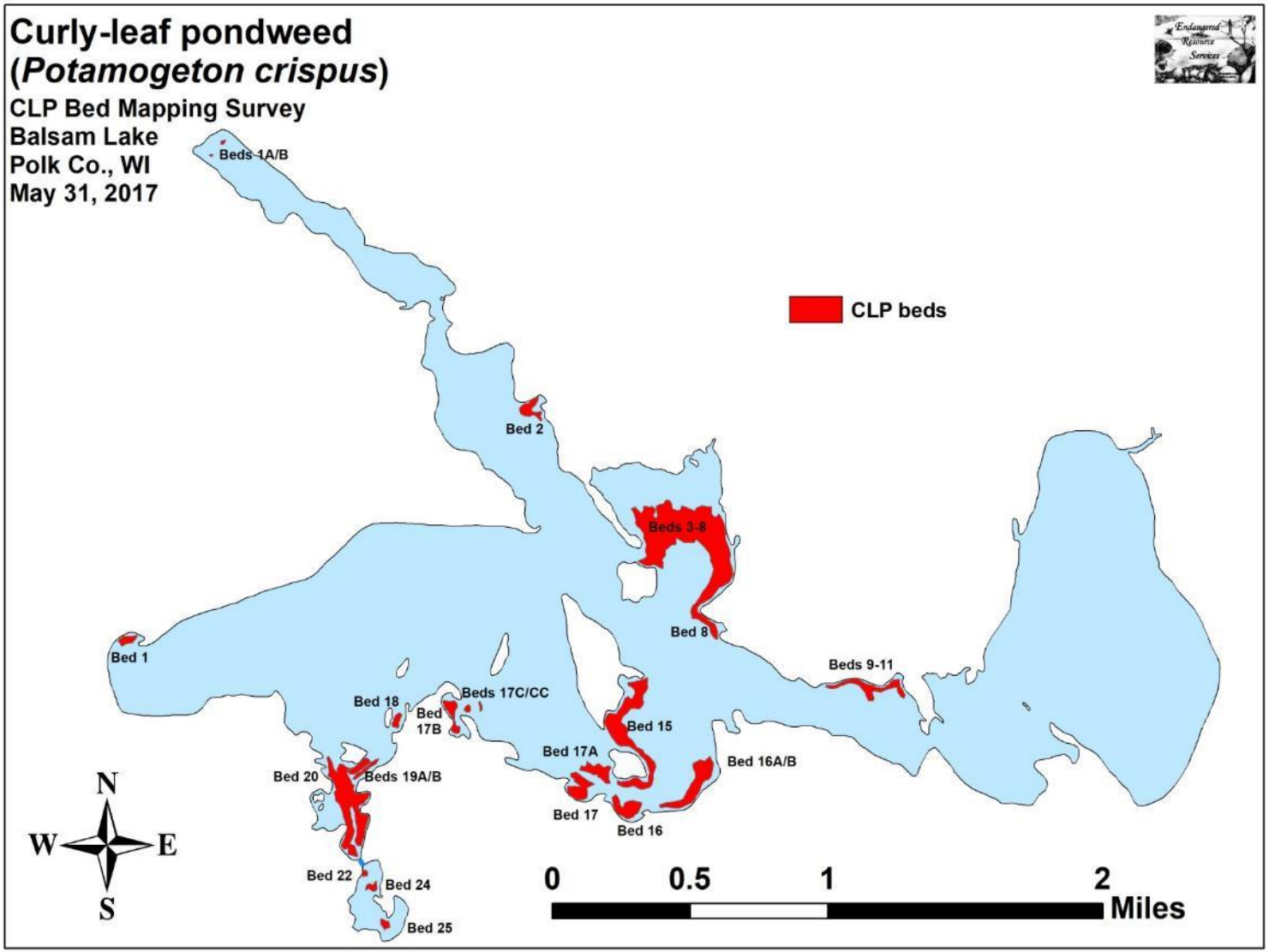

Flat-stem pondweed
(Potamogeton zosteriformis)
Coefficient of Conservatism = 6
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

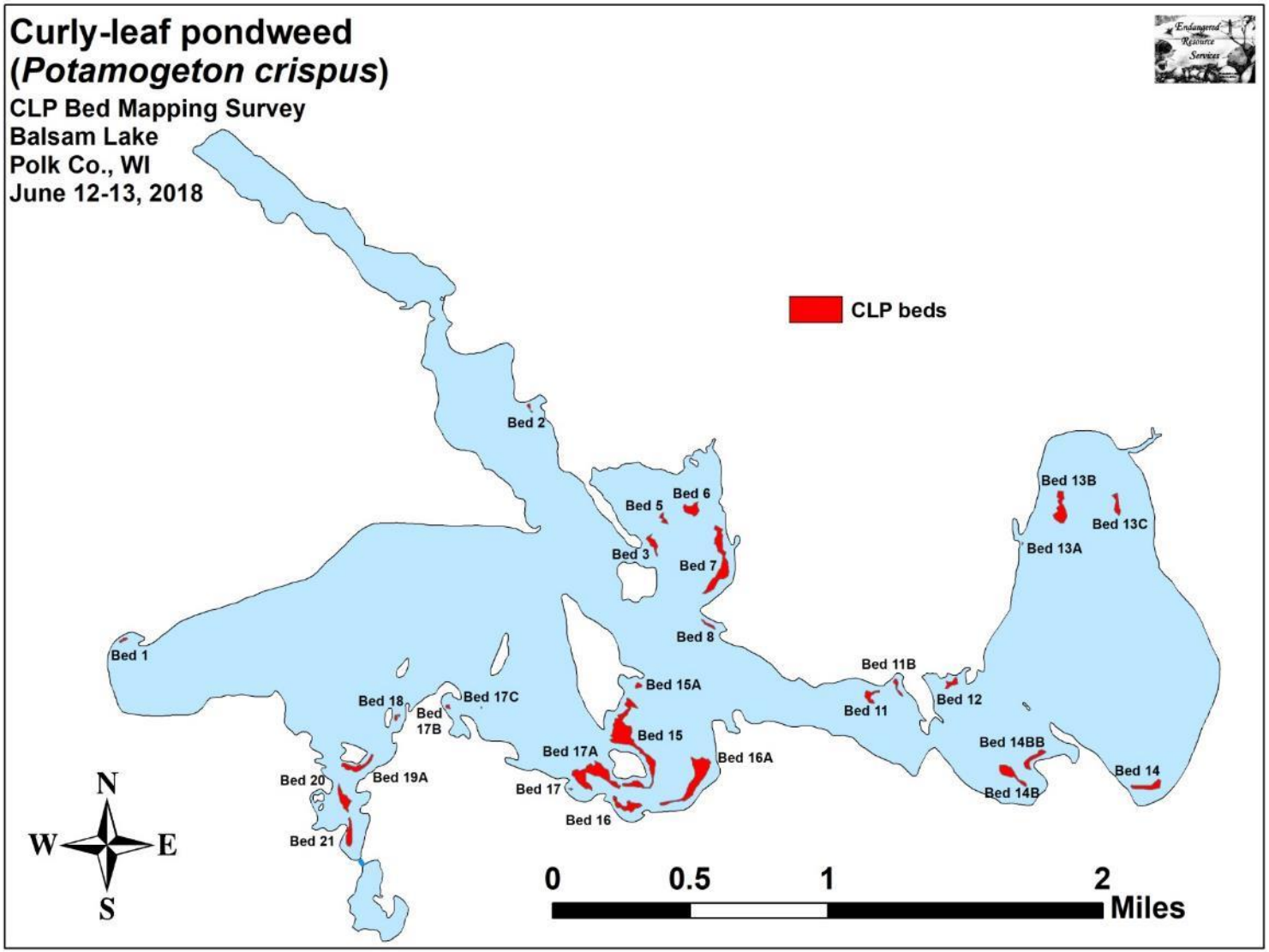

White water crowfoot
(Ranunculus aquatilis)
Coefficient of Conservatism = 8
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S


Wild celery
(Vallisneria americana)
Coefficient of Conservatism = 6
Follow-up Survey
East Balsam - Balsam Lake
Polk County, WI
June 9, 2018
Rake Fullness Rating
1
2
3
Visual
None Found
Proposed
0
0.2
0.4
0.8
Miles
N
W
E
S

Appendix VIII: 2016, 2017, and 2018 Spring CLP Bed Maps


Curly-leaf pondweed
(Potamogeton crispus)
CLP Bed Mapping Survey
Balsam Lake
Polk Co., WI
June 14, 2016
Endangered Resource Services
CLP beds
Bed 1A
Bed 2A
Bed 2
Beds 4/5
Bed 3
Beds 6/7
Bed 8
Bed 1
Bed 18
Bed 17C
Bed 17B
Bed 17D
Bed 15
Bed 11
Bed 17A
Bed 16A/B
Bed 20
Bed 19A
Bed 16
Bed 17
N
W
E
S
0
0.5
1
2
Miles


Curly-leaf pondweed
(Potamogeton crispus)
CLP Bed Mapping Survey
Balsam Lake
Polk Co., WI
May 31, 2017
Endangered Resource Services
CLP beds
Beds 1A/B
Bed 2
Beds 3-8
Bed 8
Beds 9-11
Bed 1
Bed 18
Bed 17B
Beds 17C/CC
Bed 15
Bed 17A
Bed 16A/B
Bed 20
Beds 19A/B
Bed 17
Bed 16
Bed 22
Bed 24
Bed 25
N
W
E
S
0
0.5
1
2
Miles


Curly-leaf pondweed
(Potamogeton crispus)
CLP Bed Mapping Survey
Balsam Lake
Polk Co., WI
June 12-13, 2018
Endangered Resource Services
CLP beds
Bed 1
Bed 2
Bed 3
Bed 5
Bed 6
Bed 7
Bed 8
Bed 11
Bed 11B
Bed 12
Bed 13A
Bed 13B
Bed 13C
Bed 14
Bed 14B
Bed 14BB
Bed 15
Bed 15A
Bed 16
Bed 16A
Bed 17
Bed 17A
Bed 17B
Bed 17C
Bed 18
Bed 19A
Bed 20
Bed 21
N
W
E
S
0
0.5
1
2
Miles