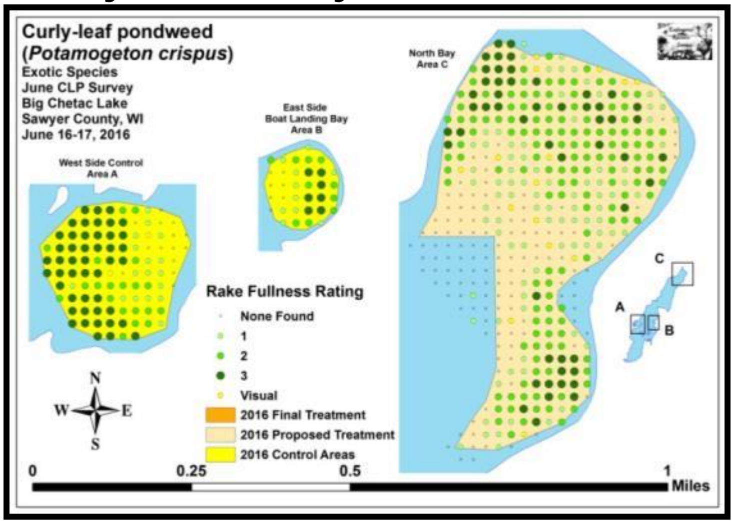
Curly-leaf pondweed (*Potamogeton crispus*)
April and June Surveys
Big Chetac Lake – WBIC: 2113300
Sawyer County, Wisconsin



June 2016 CLP Density and Distribution

2016 CLP in Western Control Bay 6/16/16

Project Funded by:

Grant ACEI-133-13 - Big Chetac Chain Lake Association, and the Wisconsin Department of Natural Resources

Canopied Mat of CLP in Northwest End of the North Bay 6/17/16

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April 29-30 and June 16-17, 2016

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ABSTRACT

Big Chetac Lake (WBIC 2113300) is a 1,920-acre stratified drainage lake in southwestern Sawyer Co., WI. The lake is eutrophic with a littoral zone that reached 12.5ft in the spring of 2016. From 2013-2015, following the acceptance of a three year Wisconsin Department of Natural Resources exotic species control grant to actively manage Curly-leaf pondweed (*Potamogeton crispus*) (CLP), the Big Chetac Chain Lake Association chemically treated the lake's north bay (90.8 acres in both 2013 and 2014, and 55.2 acres in 2015) where CLP nearly completely dominated the plant community. Although it was initially proposed to treat the same area in the north bay, a group **decision was ultimately made not to treat CLP anywhere on the lake in 2016**. Despite this, we were asked to do an early-spring survey on April 29-30th and a late-spring survey on June 16-17th to evaluate how CLP and native plants were responding in the absence of chemical control. So as to compare the same areas year-over-year, we again surveyed the original 550 point grid used each year from 2013-2015: 416 points in the north bay treatment area, 34 control points in the boat landing bay, and an additional 100 control points in a bay on the lake's west side. During the April 29-30, 2016 survey in the **north bay**, we found CLP at **80 of 416 total points (19.2% coverage) with a mean rake fullness of 1.36.** This was a **significant decline from 107 points (25.7%) with a mean rake fullness of 1.57 in 2015, and a further decline from 250 points (60.1%) in 2014, and 340 points (81.7%) in 2013**). In the boat landing bay, CLP was present at 18 of 34 points with a mean rake fullness of 1.72 (52.9% coverage). This was up from 15 points (44.1%) with a mean rake fullness of 1.20 in 2015, and comparable to 19 points (55.9%) in 2014, and 24 points (70.6%) in 2013. The western control bay had CLP present at 64 of 100 points (64% coverage) with a mean rake fullness of 1.94. This was a highly significant increase that was double the 32 points from April 2015, and a moderately significant increase from the 45 points it was found at in 2014; however, it was similar to the 70 points with CLP during the initial 2013 survey. We returned to the lake on June 16-17th, 2016 when CLP would have been at its peak density. In **the north bay**, we found **CLP at 278 points (66.8% coverage) with a mean rake fullness of 1.87 (up from 16 points (3.8%) with a mean rake fullness of 1.19 during the 2015 posttreatment survey). This was an increase in distribution of over 347% from the 80 points in the April survey, and it also represented a highly significant increase in total CLP, as well as rake fullness 3, 2, and 1.** In the boat landing bay, CLP experienced an overall significant increase to 27 points (79.4% coverage – 150% increase in distribution) with a mean rake fullness of 1.89. In the western control bay, we documented a moderately significant increase in CLP to 84 sites (84.0% coverage – 131% increase in distribution) with a mean rake fullness of 2.36. When comparing the April/June 2016 surveys in the north bay, in addition to CLP's highly significant expansion, we also found that Nitella (*Nitella* sp.) experienced a highly significant increase; Slender naiad (*Najas flexilis*), Clasping-leaf pondweed (*Potamogeton richardsonii*), and Wild celery (*Vallisneria americana*) each experienced significant increases; and filamentous algae demonstrated a highly significant decline. No native species demonstrated significant change in the boat landing control bay, but filamentous algae and Fries' pondweed (*Potamogeton friesii*) both experience significant increases in the western control bay. After comparing posttreatment 2013-2015/June 2016 data for the north bay, we noticed that most species that experienced significant increases over this time were late-growing/germinating species that tend to survive early-season herbicide treatments. It is unclear if the gains these native species have made will continue in light of the increase in CLP levels seen in 2016.

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INTRODUCTION:

Big Chetac Lake (WBIC 2113300) is a 1,920-acre stratified drainage lake in southwestern Sawyer County, Wisconsin in the Town of Edgewater (T37N R09W S19 NE NE). It reaches a maximum depth of 28ft in the narrows between the islands in the south basin and has an average depth of approximately 14ft (Busch et al. 1967). The lake is eutrophic (nutrient rich) in nature with summer Secchi readings averaging 2.94ft over the past 21 years in the north bay (WDNR 2016). This poor to very poor water clarity produced a littoral zone that extended to approximately 12.5ft in the spring of 2016. The bottom substrate is predominately muck in the lake's side bays and throughout the north and south ends, and a mixture of sand and rock along exposed shorelines, the mid-lake narrows, and around the islands (Busch et al. 1967).

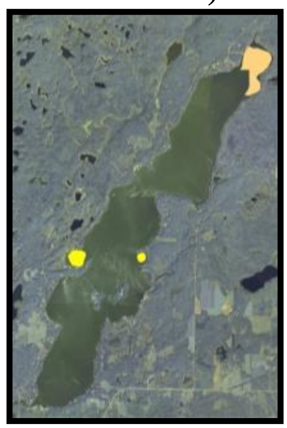


Figure 1: 2016 Proposed Spring CLP Treatment and Control Areas

Curly-leaf pondweed (*Potamogeton crispus*) (CLP), an exotic invasive species, is abundant in Big Chetac Lake. The 2008 spring point-intercept survey found CLP dominated approximately 30% of the lake's surface area, and, especially in the lake's muck bottom bays, almost always formed a solid canopy in up to 10ft of water, excluded most native plants, and often made boating difficult. Additionally, CLP's natural annual senescence in late June/early July contributes significantly to phosphorus loading (James et al. 2002) making it a factor in the lake's summer algae blooms that negatively impact water clarity and quality.

In 2013, after years of study and discussion among board members, residents, local businesses, and the WDNR, the Big Chetac Chain Lake Association applied for and received a three year WDNR exotic species control grant to begin actively managing CLP chemically and manually. After evaluating the 2008 maps, it was decided to treat 90 acres in the north bay in both 2013 and 2014; but, after the fall 2014 turion survey and the 2015 pretreatment survey revealed a significant decline in CLP distribution and density, the area treated was reduced to 55 acres in spring 2015. Because the 2015 fall turion survey suggested there would still be significant amounts of CLP in the north bay, it was proposed to treat the same area in 2016 (Figure 1); however, a group decision was ultimately made not to treat the north bay in 2016. Despite this, we were asked to do an early-spring survey on April 29-30th and a late-spring survey on June 16-17th to evaluate how CLP and native plants were responding in the absence of chemical control. This report is the summary analysis of these two field surveys.

METHODS:

We used the identical 550 point grid generated in 2013 so as to be able to make year-over-year comparisons in the treatment and control areas. The points were based on the size and shape of the initially proposed treatment areas and were just over the 4pts/acre threshold required by WDNR protocol for pre/post treatment sampling (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). In addition to plant data, we recorded the lake depth using a handheld sonar (Vexilar LPS-1) or the metered survey rake. We also noted the substrate type (bottom) when we could see it or reliably determine it with the rake.

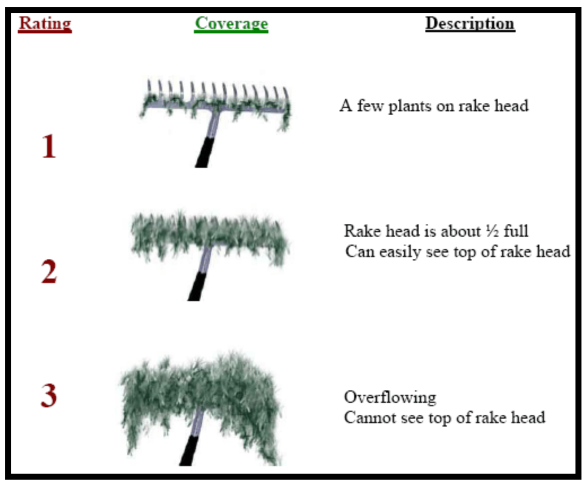


Figure 2: Rake Fullness Ratings

DATA ANALYSIS:

We entered all data collected into the standard APM spreadsheet (Appendix II). These data were then analyzed using the linked statistical summary sheet and the WDNR pre/post analysis worksheet (UWEX 2010). From this, we calculated the following:

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

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

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

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

> Frequency of occurrence example:
>
> Plant A is sampled at 70 out of 700 total points = 70/700 = .10 = 10%
> This means that Plant A's frequency of occurrence = 10% when considering the entire lake sample.
>
> Plant A is sampled at 70 out of 350 total points in the littoral zone = 70/350 = .20 = 20%
> This means that Plant A's frequency of occurrence = 20% when only considering the littoral zone.
>
> From these frequencies, we can estimate how common each species was throughout the lake, and how common the species was at depths where plants were able to grow. Note the second value will be greater as not all the points (in this example, only ½) occur at depths shallow enough for plant growth.

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

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

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

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

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

Species richness: This value indicates the number of different plant species found in and directly adjacent to (on the waterline) the survey site. Species richness alone only counts those plants found in the rake survey. **Note: Per WDNR protocol, filamentous algae, freshwater sponges, aquatic moss and the aquatic liverworts *Riccia fluitans* and *Ricciocarpus natans* are excluded from these totals.**

Mean rake fullness: This value is the average rake fullness of all species at all sites with vegetation. It excludes filamentous algae, and the other species not included in the species richness calculation as stated above (Table 2).

Relative frequency: This value shows a species' frequency relative to all other species. It is expressed as a percentage, and the total of all species' relative frequencies will add up to 100%. Organizing species from highest to lowest gives us an idea of which species are most important within the macrophyte community (Tables 3-8).

Relative frequency example:

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

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

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

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

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

Pre/Post Treatment and April/June Significance:
Data from the two surveys was compared using the linked statistical summary sheet and the WDNR pre/post analysis worksheet (UWEX 2010). April/June 2016, April/April 2015/2016, and May/June 2015/2016 differences were determined to be significant at $p < .05$, moderately significant at $p < .01$, and highly significant at $p < .005$ (Figures 9-11, 14-18).

RESULTS AND DISCUSSION:

Proposed Treatment:

Following analysis of the 2015 posttreatment survey and the fall 2015 turion survey, it was proposed to consider retreating the same 90.8 acre bed in the north bay that was treated in 2013-15 (Figure 3) (Appendix I). However, as previously mentioned, those plans were cancelled and **no herbicide treatment occurred anywhere on the lake in 2016** (Table 1).

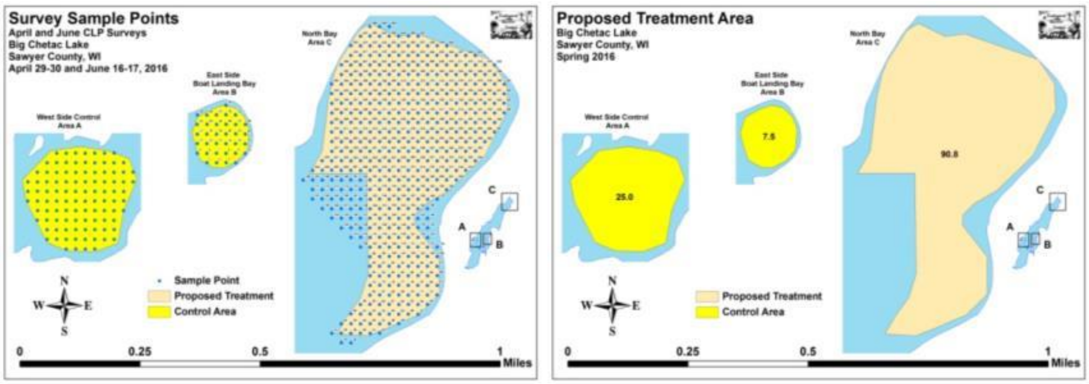


Figure 3: 2016 Survey Sample Points and Proposed Treatment Area

Table 1: Proposed CLP Treatment Summary
Big Chetac Lake – Spring 2016

CLP Bed Name	2016 Proposed Acreage	Final Acreage	Difference +/-
North Bay	90.8	0.0	-90.8
Boat Landing Bay	0.0	0.0	0.0
Control Bay	0.0	0.0	0.0
Total Acres	**90.8**	**0.00**	**-90.8**

CLP April/June Surveys:

Depths in the survey areas ranged from 2.5-14.5ft with most of the Curly-leaf pondweed established in 5-10.5ft of water and canopied or near canopy throughout this range. Although present in some sandy and rocky areas at low densities, most CLP was growing over thick organic muck (Figure 4) (Appendix III).

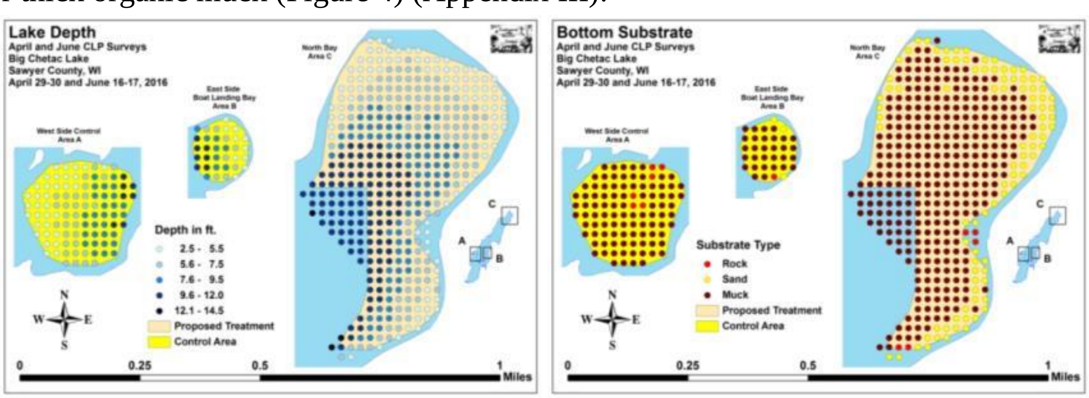


Figure 4: Study Area Depths and Bottom Substrate

The littoral zone for all three areas maxed out at 12.5ft during the April survey and 12.0ft during the June survey (Figure 5) (Appendix IV). In the north bay, mean and median depths for all plants rose sharply from 6.2ft and 6.0ft during the April survey to 7.9 and 8.0ft respectively in the June survey. In the boat landing and western control bays, these values also increased, but by lesser amounts (6.4ft and 6.5ft to 7.6ft and 7.5ft in the boat landing bay – 6.2ft and 6.0ft to 7.0ft and 6.5ft in the western bay) (Table 2). This increase appeared to be primarily due to additional late-germinating Curly-leaf pondweed plants in deep water.

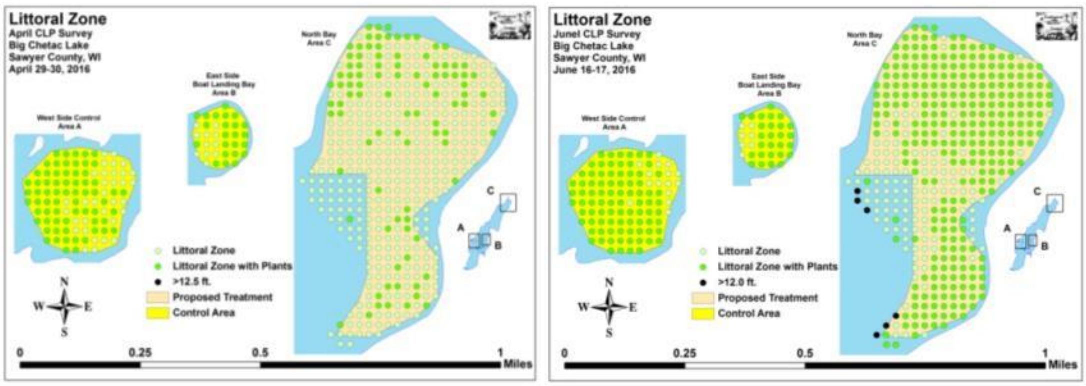


Figure 5: April/June Littoral Zone

Initial diversity within the north bay was very low with a Simpson Diversity Index value of 0.42 (up slightly from 0.39 in April 2015) (Table 2). This value decreased further to 0.32 in June (down significantly from 0.78 posttreatment in late May 2015). The boat landing bay had a moderate April index value of 0.68 (up from 0.43 in April 2015) that declined slightly to 0.59 in June (up from 0.53 in late May 2015). The western control bay also had a moderate starting value of 0.54 (down from 0.63 in April 2015), and it increased to 0.63 in June (similar to the 0.62 we found in late May 2015).

Mean native species richness was also low in all three areas. The north bay averaged 0.06 native species at littoral points in April and 0.15 in June (similar to 0.09 pretreatment/0.12 posttreatment in 2015). Even at sites that had natives present, only the western control bay (1.45) averaged more than 1.40 species/site during the June survey, and only two points in any area (both in the north bay) had more than three native species in any rake during either the April or June surveys (Figure 6) (Appendix IV).

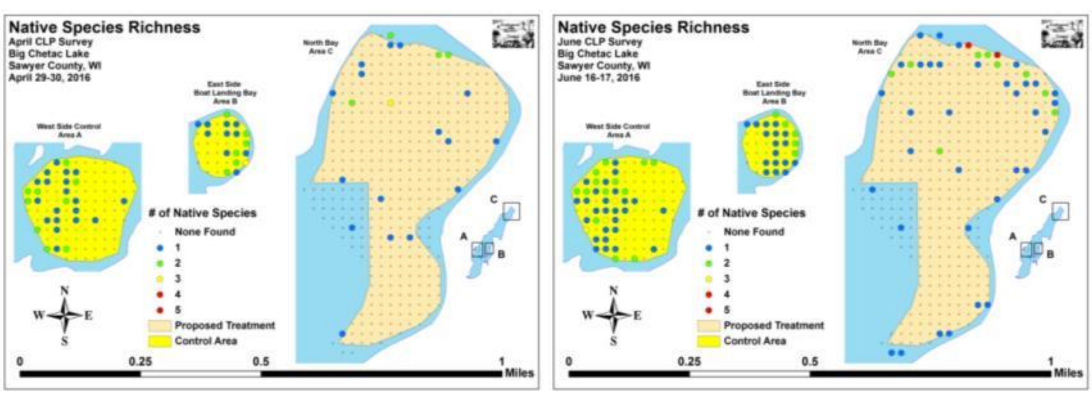


Figure 6: April/June Native Species Richness

Total species richness was low in all three areas with a combined 11 species found in April and 18 species found in June (up slightly from a combined nine species during the 2015 pretreatment, and 14 species during the posttreatment). The boat landing and western control bay each had six species in April; however, by June the boat landing bay had dropped to three species (compared to three in April/four in late May 2015) while the western bay had doubled to 12 (compared to five in April and six in late May 2015). The north bay had nine species in April 2016 (up from six pretreatment in 2015). By June, this had increased to 13 species (up from nine posttreatment 2015).

Mean total rake fullness from April to June increased significantly in all three areas with the majority of this biomass being attributed to CLP growth. In the north bay, mean rake fullness at points with vegetation jumped from 1.31 in April to 1.84 in June (compared to 1.54 pretreatment/1.06 posttreatment in 2015). In the boat landing control bay, this value increased from 1.61 to 2.15; and, in the western control bay, mean rake fullness values also increased from 1.96 to 2.38 (Figure 7) (Table 2) (Appendix IV).

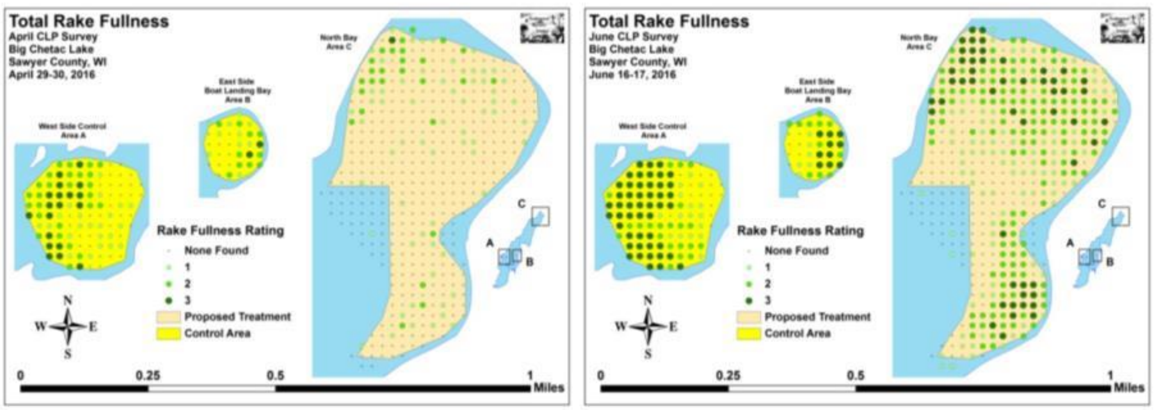
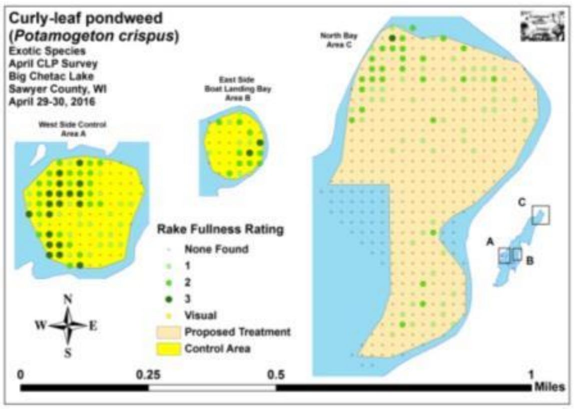


Figure 7: April/June Total Rake Fullness

Table 2: Initial 2013 Pretreatment and April/June 2016 Survey Summary Statistics
North Bay – Boat Landing Bay – Western Control Bay
Big Chetac Lake, Sawyer County
April 29-30 and June 16-17, 2016

Summary Statistics:	North Bay Former Treatment Area			Boat Landing Bay			Western Control Bay		
	Pre 2013	April 2016	June 2016	May 2013	April 2016	June 2016	May 2013	April 2016	June 2016
Total number of points sampled	416	416	416	34	34	34	100	100	100
Total number of sites with vegetation	354	93	293	26	23	27	97	67	85
Total number of sites shallower than the maximum depth of plants	414	416	410	31	33	28	100	97	94
Frequency of occurrence at sites shallower than maximum depth of plants	85.5	22.4	71.5	83.9	69.7	96.4	97.0	69.1	90.4
Simpson Diversity Index	0.41	0.42	0.32	0.51	0.68	0.59	0.73	0.54	0.63
Maximum depth of plants (ft)	13.0	12.5	12.0	11.5	11.5	10.5	12.0	10.0	10.5
Mean depth of plants (ft)	8.6	6.2	7.9	7.7	6.4	7.6	8.0	6.2	7.0
Median depth of plants (ft)	9.0	6.0	8.0	7.8	6.5	7.5	8.0	6.0	6.5
Number of sites sampled using pole rake (P)	416	416	416	34	34	34	100	100	100
Average number of all species per site (shallower than max depth)	1.09	0.26	0.83	1.26	1.30	1.93	1.70	1.04	1.54
Average number of all species per site (veg. sites only)	1.27	1.15	1.16	1.50	1.87	2.00	1.75	1.51	1.71
Average number of native species per site (shallower than max depth)	0.27	0.06	0.15	0.48	0.76	0.96	1.00	0.38	0.65
Average number of native species per site (veg. sites with natives only)	1.24	1.29	1.36	1.07	1.47	1.23	1.54	1.32	1.45
Species richness	8	9	13	4	6	3	5	6	12
Mean rake fullness (veg. sites only)	1.81	1.31	1.84	1.42	1.61	2.15	1.72	1.96	2.38
Mean Coefficient of Conservatism	5.9	5.9	5.9	6.0	5.4	7.5	6.0	5.8	5.7
Floristic Quality Index	15.5	16.6	20.5	10.4	12.1	10.6	12.0	13.0	19.0

During the April survey of the north bay, we found CLP at 80 of 416 points (19.2% coverage) (Figures 8) (Appendix V). This was a **significant decline from 107 points (25.7%) in 2015, and a further decline from 250 points (60.1%) in 2014, and 340 points (81.7%) in the original 2013 pretreatment survey**). Of these, one had a rake fullness rating of 3, 27 rated a 2, and 52 rated a 1 for a mean rake fullness of 1.36 (down from a mean rake of 1.57 in 2015). In **June, we found CLP at 278 sites (66.8% coverage – up from 16 points (3.8%) in the 2015 posttreatment survey)** with 52 rating a 3, 138 a 2, and the remaining 88 rating a 1 for a mean rake of 1.87 (up from 1.19 posttreatment in 2015). We also noted CLP as a visual at 15 points. Most CLP plants were either canopied or nearing canopy, and we noticed plants were expanding laterally via rhizomes. Our findings demonstrated a highly significant **increase** in total CLP **(347.5% increase in distribution from April)**, as well as in rake fullness 3, 2, and 1 (Figure 9) (Tables 3 and 4).



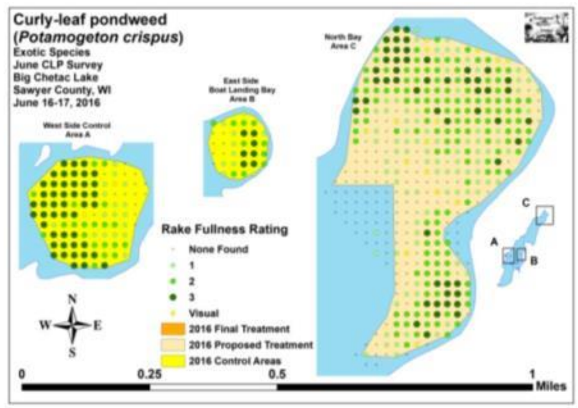
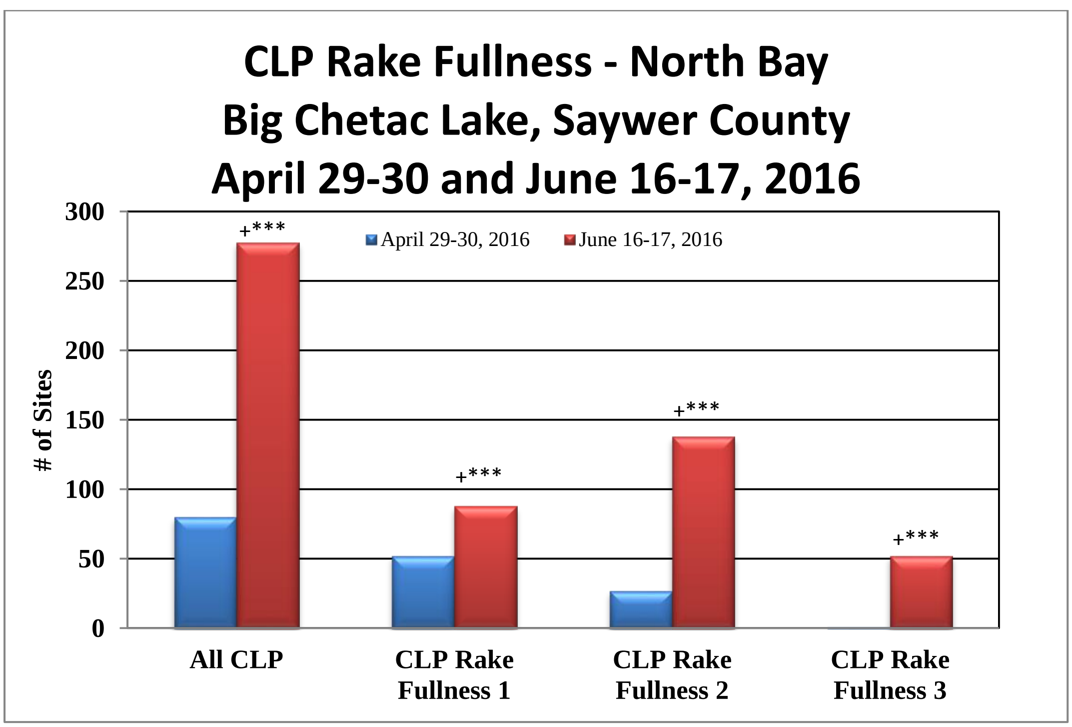


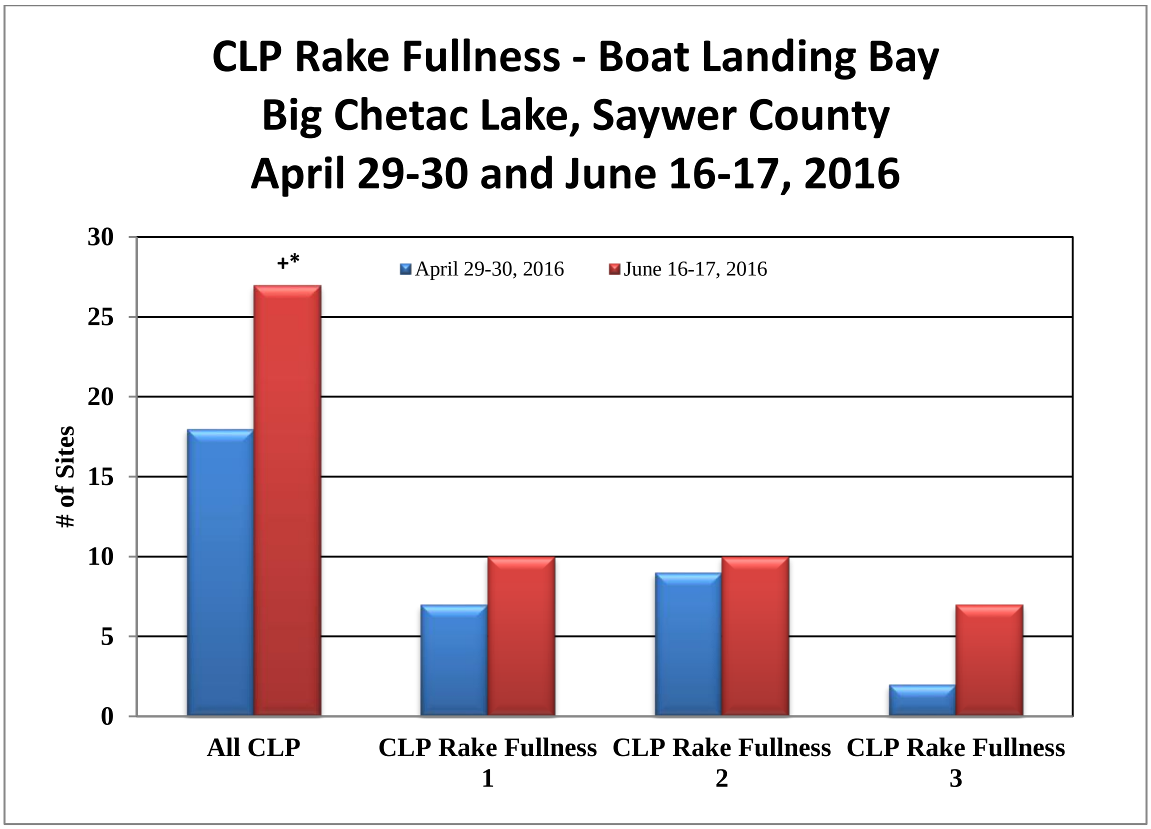
Figure 8: April/June CLP Density and Distribution



Significant differences = * *p* < .05, ** *p* < .01, * *p* < .005**

Figure 9: April/June Changes in CLP Rake Fullness – North Bay

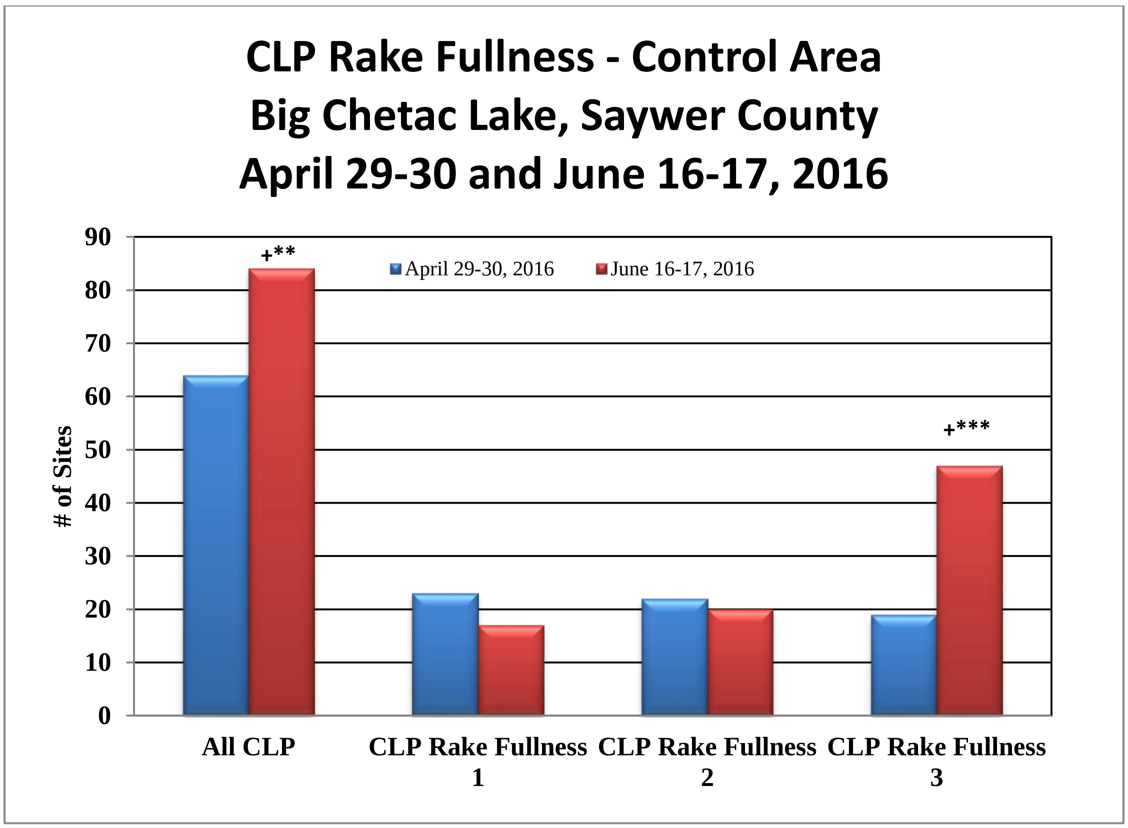
In the boat landing bay, the April survey found CLP at 18 of 34 points (52.9% coverage). Thus was up from 15 points in 2015 (44.1%) and comparable to 19 points (55.9%) in 2014, and 24 points (70.6%) in 2013. Of these, two had a rake fullness rating of 3, nine rated a 2, and seven were a 1 for a mean rake fullness of 1.72 (up from 1.20 in 2015). In June, CLP was present at 27 points (79.4%) with seven rating a 3, ten a 2, and the remaining ten a 1 for a mean rake of 1.89. Our findings demonstrated no significant change in any rake fullness class, but, overall, CLP did increase significantly from April. It was also nearly double the 14 points (41.2%) it was found at in late May 2015, and on the high end of all surveys from this area (19 points (55.9%) in June 2014 and 29 points (85.3%) in May of 2013) (Figure 10) (Tables 5 and 6).



Significant differences = * *p* < .05, ** *p* < .01, * *p* < .005**

Figure 10: April/June Changes in CLP Rake Fullness – Boat Landing Bay

We documented CLP at 64 (64.0% coverage) out of 100 points in the western control bay during the April survey (Figure 8). This highly significant increase was double the 32 points it was found at in April 2015; a moderately significant increase from the 45 points it was found at in 2014; but similar to the 70 points with CLP found during the initial 2013 survey. In 2016, 19 of the April points rated a 3, 22 were a 2, and 23 were a 1 producing a mean rake fullness value of 1.94 (up from 1.66 in 2015). By June, CLP had increased to 84 sites (84%) (up from 44 sites in 2015) with 47 sites rating a 3, 20 a 2, and the remaining 17 a 1 for a mean rake fullness of 2.36 (up from 1.77 in 2015). We also noted CLP as a visual at two points. The growing season changes in 2016 resulted in a moderately significant increase in overall CLP, and a highly significant increase in points with a mean rake fullness of 3 (Figure 11) (Tables 7 and 8).



Significant differences = * *p* < .05, ** *p* < .01, * *p* < .005**

Figure 11: April/June Changes in CLP Rake Fullness – Western Control Bay

When combining data from all three study areas, Coontail (*Ceratophyllum demersum*) (26 sites – mean rake of 1.23 in April/25 sites – mean rake of 1.00 in June) and Small pondweed (*Potamogeton pusillus*) (19 sites – mean rake of 1.11 in April/32 sites – mean rake of 1.22 in June) were the most common native species during both surveys (Tables 3-8) (Figures 12 and 13). Neither species experienced significant changes in any area, but, from April to June in the north bay, filamentous algae demonstrated a highly significant decline. This was likely due to the increased growth of CLP absorbing nutrients out of the water column/sediment making them unavailable for these algae. Native species that experienced growing season expansion included Nitella (*Nitella* sp.) with a highly significant increase; and Slender naiad (*Najas flexilis*), Clasping-leaf pondweed (*Potamogeton richardsonii*), and Wild celery (*Vallisneria americana*) each of which experienced significant increases (Figure 14).

Outside the north bay, with the exception of CLP, plants were little changed from April to June. In the boat landing bay, there were no significant changes (Figure 15), while in the western control bay, the only significant changes were a highly significant increase in filamentous algae, and a significant increase in Fries' pondweed (*Potamogeton friesii*) (Figure 16) (Maps for all native species pre and posttreatment are available in Appendixes VI and VII.)

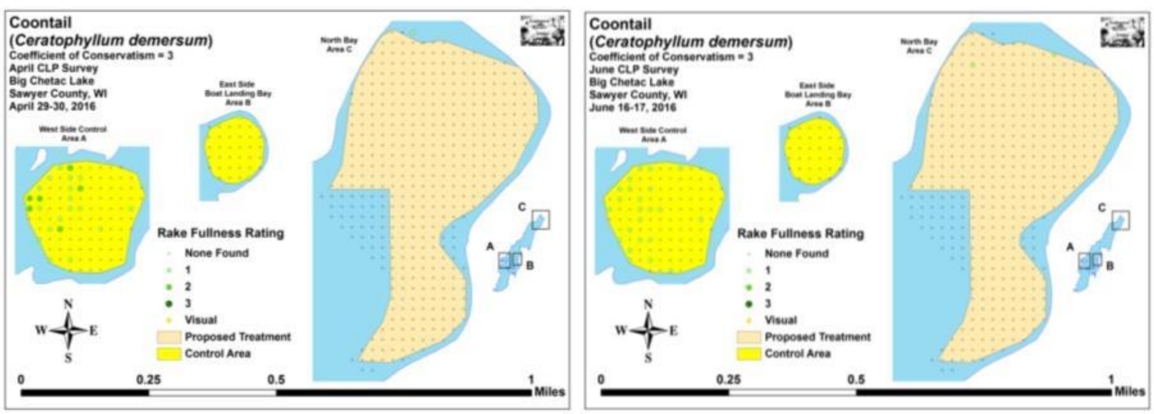


Figure 12: April/June Coontail Density and Distribution

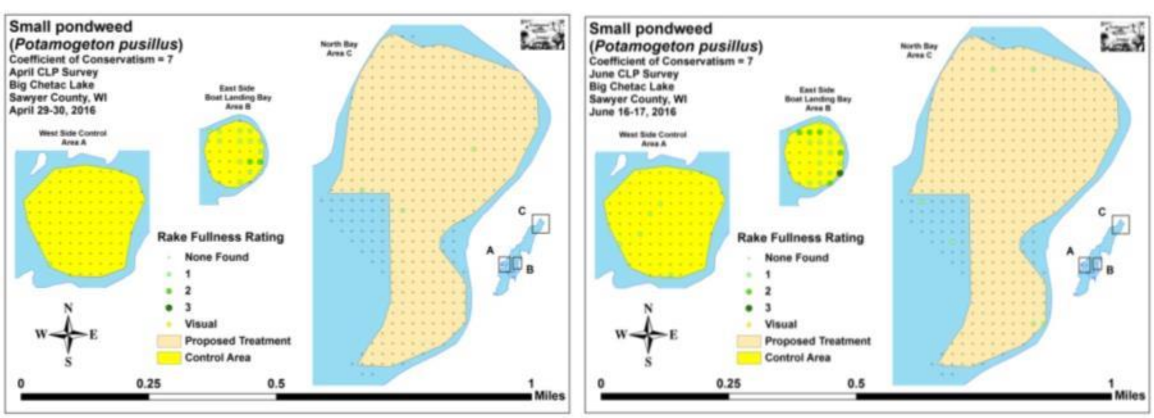
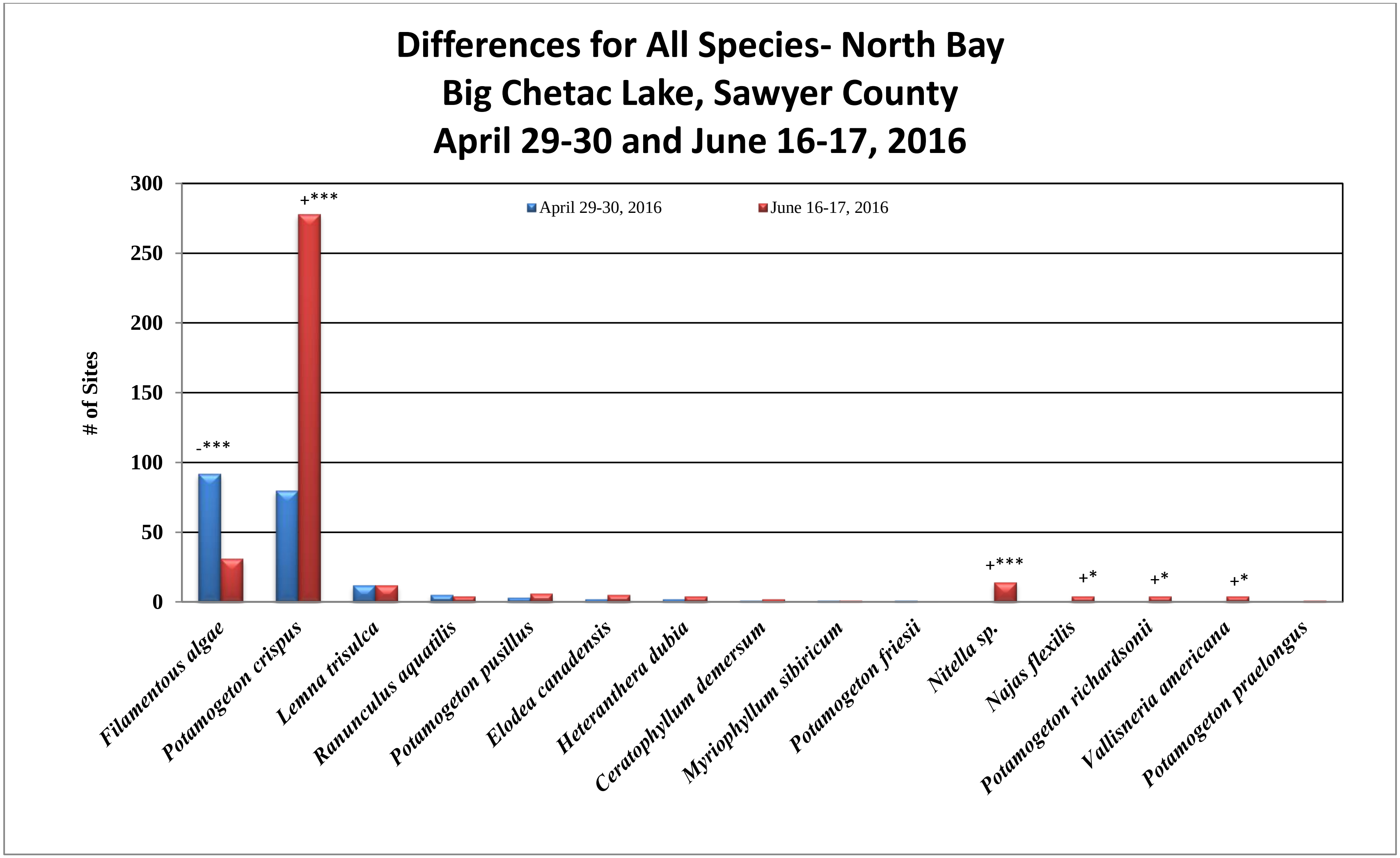
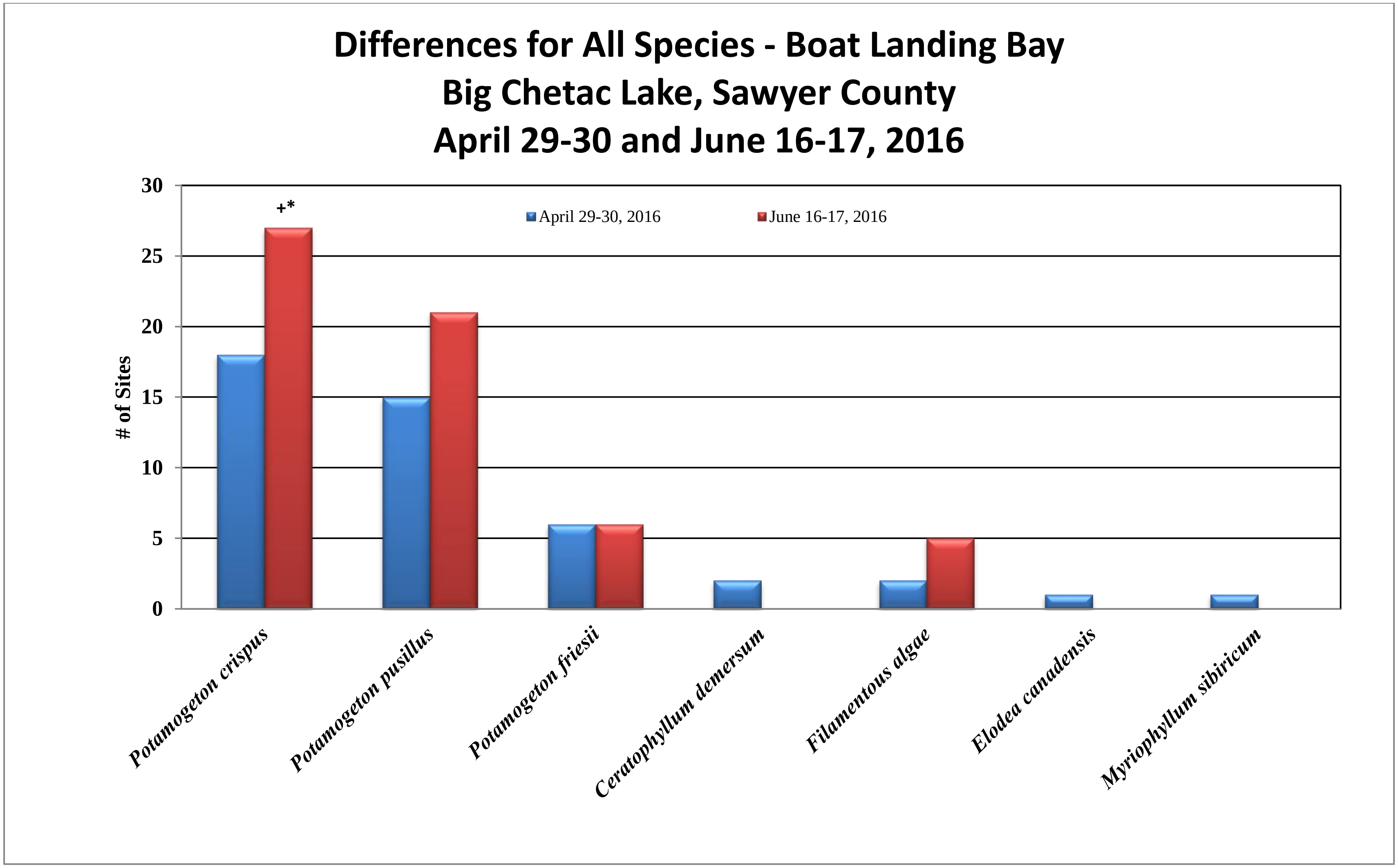


Figure 13: April/June Small Pondweed Density and Distribution



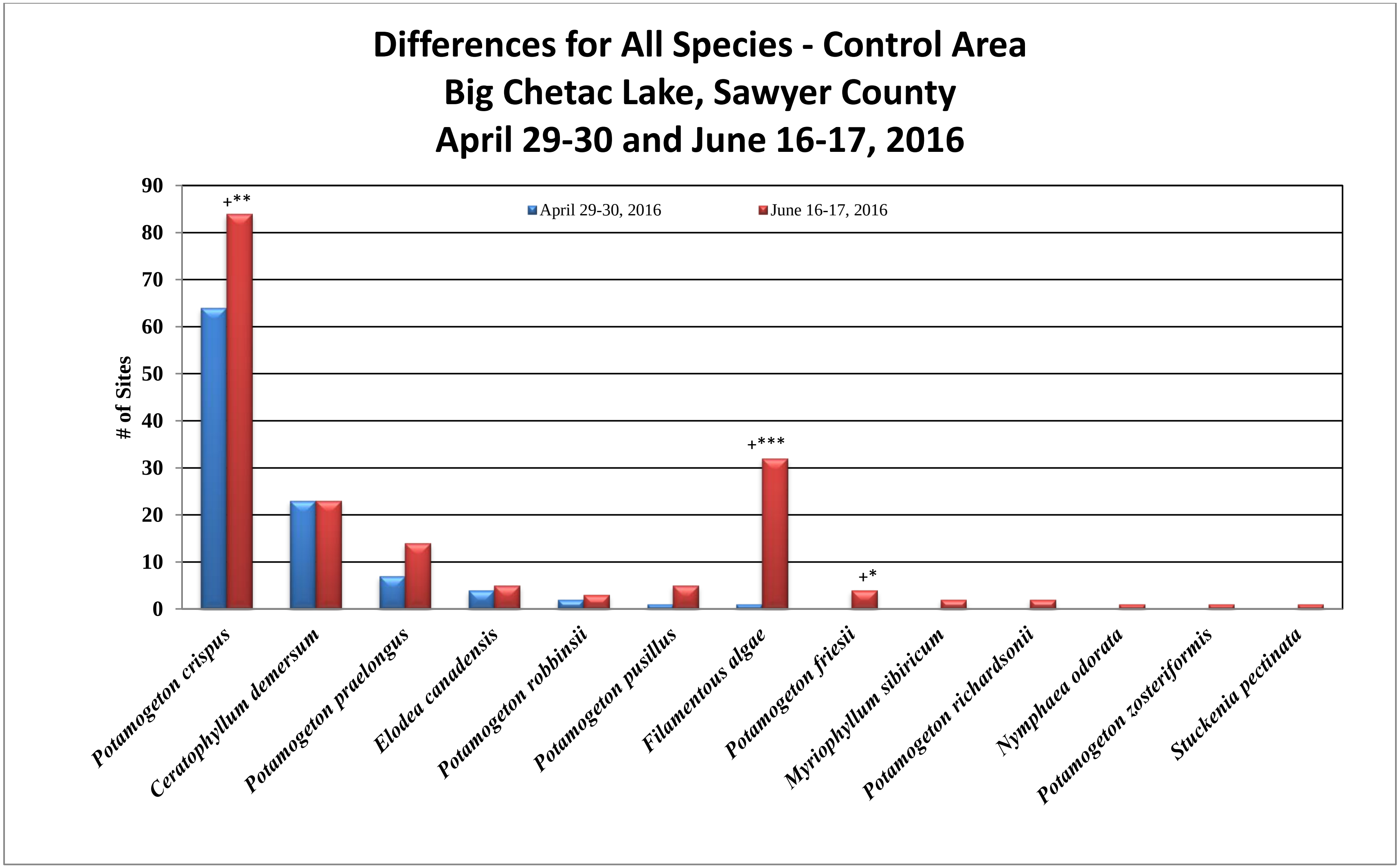
Significant differences = * *p* < .05, ** *p* < .01, * *p* < .005**

Figure 14: April/June Native Macrophyte Changes – North Bay



Significant differences = * $p < .05$, ** $p < .01$, *** $p < .005$

Figure 15: April/June Macrophyte Changes – Boat Landing Bay



Significant differences = * *p* < .05, ** *p* < .01, * *p* < .005**

Figure 16: April/June Macrophyte Changes – Western Control Bay

Table 3: Frequencies and Mean Rake Sample of Aquatic Macrophytes
April Survey – North Bay - Big Chetac Lake, Sawyer County
April 29-30, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
	Filamentous algae	92	*	98.92	22.12	1.00
Potamogeton crispus	Curly-leaf pondweed	80	74.77	86.02	19.23	1.36
Lemna trisulca	Forked duckweed	12	11.21	12.90	2.88	1.08
Ranunculus aquatilis	White water crowfoot	5	4.67	5.38	1.20	1.00
Potamogeton pusillus	Small pondweed	3	2.80	3.23	0.72	1.00
Elodea canadensis	Common waterweed	2	1.87	2.15	0.48	1.00
Heteranthera dubia	Water star-grass	2	1.87	2.15	0.48	1.00
Ceratophyllum demersum	Coontail	1	0.93	1.08	0.24	1.00
Myriophyllum sibiricum	Northern water-milfoil	1	0.93	1.08	0.24	1.00
Potamogeton friesii	Fries' pondweed	1	0.93	1.08	0.24	1.00

* Excluded from Relative Frequency Analysis

Table 4: Frequencies and Mean Rake Sample of Aquatic Macrophytes
June Survey – North Bay - Big Chetac Lake, Sawyer County
June 16-17, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
Potamogeton crispus	Curly-leaf pondweed	278	82.01	94.88	67.80	1.87
	Filamentous algae	31	*	10.58	7.56	1.10
Nitella sp.	Nitella	14	4.13	4.78	3.41	1.07
Lemna trisulca	Forked duckweed	12	3.54	4.10	2.93	1.08
Potamogeton pusillus	Small pondweed	6	1.77	2.05	1.46	1.00
Elodea canadensis	Common waterweed	5	1.47	1.71	1.22	1.00
Heteranthera dubia	Water star-grass	4	1.18	1.37	0.98	1.00
Najas flexilis	Slender naiad	4	1.18	1.37	0.98	1.00
Potamogeton richardsonii	Clasping-leaf pondweed	4	1.18	1.37	0.98	1.25
Ranunculus aquatilis	White water crowfoot	4	1.18	1.37	0.98	1.00
Vallisneria americana	Wild celery	4	1.18	1.37	0.98	1.00
Ceratophyllum demersum	Coontail	2	0.59	0.68	0.49	1.00
Myriophyllum sibiricum	Northern water-milfoil	1	0.29	0.34	0.24	2.00
Potamogeton praelongus	White-stem pondweed	1	0.29	0.34	0.24	2.00

* Excluded from Relative Frequency Analysis

Table 5: Frequencies and Mean Rake Sample of Aquatic Macrophytes
April Survey – Boat Landing Bay - Big Chetac Lake, Sawyer County
April 29-30, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
Potamogeton crispus	Curly-leaf pondweed	18	41.86	78.26	54.55	1.72
Potamogeton pusillus	Small pondweed	15	34.88	65.22	45.45	1.13
Potamogeton friesii	Fries' pondweed	6	13.95	26.09	18.18	1.17
Ceratophyllum demersum	Coontail	2	4.65	8.70	6.06	1.00
	Filamentous algae	2	*	8.70	6.06	1.00
Elodea canadensis	Common waterweed	1	2.33	4.35	3.03	1.00
Myriophyllum sibiricum	Northern water-milfoil	1	2.33	4.35	3.03	1.00

Table 6: Frequencies and Mean Rake Sample of Aquatic Macrophytes
June Survey – Boat Landing Bay - Big Chetac Lake, Sawyer County
June 16-17, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
Potamogeton crispus	Curly-leaf pondweed	27	50.00	100.00	96.43	1.89
Potamogeton pusillus	Small pondweed	21	38.89	77.78	75.00	1.33
Potamogeton friesii	Fries' pondweed	6	11.11	22.22	21.43	1.67
	Filamentous algae	5	*	18.52	17.86	1.20

* Excluded from Relative Frequency Analysis

Table 7: Frequencies and Mean Rake Sample of Aquatic Macrophytes
April Survey – Western Control Bay - Big Chetac Lake, Sawyer County
April 29-30, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
Potamogeton crispus	Curly-leaf pondweed	64	63.37	95.52	65.98	1.94
Ceratophyllum demersum	Coontail	23	22.77	34.33	23.71	1.26
Potamogeton praelongus	White-stem pondweed	7	6.93	10.45	7.22	1.00
Elodea canadensis	Common waterweed	4	3.96	5.97	4.12	1.00
Potamogeton robbinsii	Fern pondweed	2	1.98	2.99	2.06	1.00
Potamogeton pusillus	Small pondweed	1	0.99	1.49	1.03	1.00
	Filamentous algae	1	*	1.49	1.03	1.00

* Excluded from Relative Frequency Analysis

Table 8: Frequencies and Mean Rake Sample of Aquatic Macrophytes
June Survey – Western Control Bay - Big Chetac Lake, Sawyer County
June 16-17, 2016

Species	Common Name	Total Sites	Relative Freq.	Freq. in Veg.	Freq. in Lit.	Mean Rake
Potamogeton crispus	Curly-leaf pondweed	84	57.93	98.82	89.36	2.36
	Filamentous algae	32	*	37.65	34.04	1.16
Ceratophyllum demersum	Coontail	23	15.86	27.06	24.47	1.00
Potamogeton praelongus	White-stem pondweed	14	9.66	16.47	14.89	1.21
Elodea canadensis	Common waterweed	5	3.45	5.88	5.32	1.00
Potamogeton pusillus	Small pondweed	5	3.45	5.88	5.32	1.00
Potamogeton friesii	Fries' pondweed	4	2.76	4.71	4.26	1.00
Potamogeton robbinsii	Fern pondweed	3	2.07	3.53	3.19	1.00
Myriophyllum sibiricum	Northern water-milfoil	2	1.38	2.35	2.13	1.00
Potamogeton richardsonii	Clasping-leaf pondweed	2	1.38	2.35	2.13	2.00
Nymphaea odorata	White water lily	1	0.69	1.18	1.06	1.00
Potamogeton zosteriformis	Flat-stem pondweed	1	0.69	1.18	1.06	1.00

Looking back at the cumulative data from the posttreatment and June surveys in the north bay over the last four years (2013-2015 with treatment/2016 without), the most notable change was the highly significant jump in Curly-leaf pondweed (*Potamogeton crispus*) in 2016 following the cancellation of the herbicide application (Figure 17). CLP so completely dominated the bay in terms of distribution that it dwarfed all other species data. Because of this, we removed CLP from the graph to better see how native vegetation in the bay changed over this time (Figure 18).

Analyzing the chart showed that most native species experienced minimal changes, but there were some variations. Forked duckweed (*Lemna trisulca*), a small rootless species that acts like an alga in that it proliferates in nutrient-rich environments and can respond quickly as local nutrient levels change, has been the dominant native species posttreatment in the north bay in terms of distribution since treatment began. From 2013-2014, it experienced a moderately significant increase; but this was followed by a highly significant decline in distribution from 2014-2015, and a nearly significant decline from 2015-2016 ($p = 0.057$). Despite these changes, its posttreatment/June mean rake fullness (1.03 in 2013, 1.02 in 2014, 1.00 in 2015, and 1.08 in 2016) was essentially unchanged as almost all rake samples over the four years were represented by a single individual. Small pondweed (*Potamogeton pusillus*), a fine-leaved early-growing species that showed significant declines following the initial treatment, demonstrated a significant rebound without treatment in 2016. Most other species that showed significant or near significant increases were either not seen prior to treatment such as Clasping-leaf pondweed (*Potamogeton richardsonii*), Slender naiad (*Najas flexilis*), Water star-grass (*Heteranthera dubia*), Nitella (*Nitella* sp.), and White water crowfoot (*Ranunculus aquatilis*); or were species that we found to be very rare prior to the treatments like Wild celery (*Vallisneria americana*). Point data as well as inter-point observations while on the water suggest all of these species were colonizing shallow vacant habitat that was formerly occupied by CLP. Based on our experience, because these are late-growing/germinating species, they also tend to survive early-season herbicide treatments. However, because CLP tends to canopy in late May just as their growth is normally starting to accelerate, it is unclear if the gains these native species have made will continue in light of the increase in CLP levels seen in 2016.

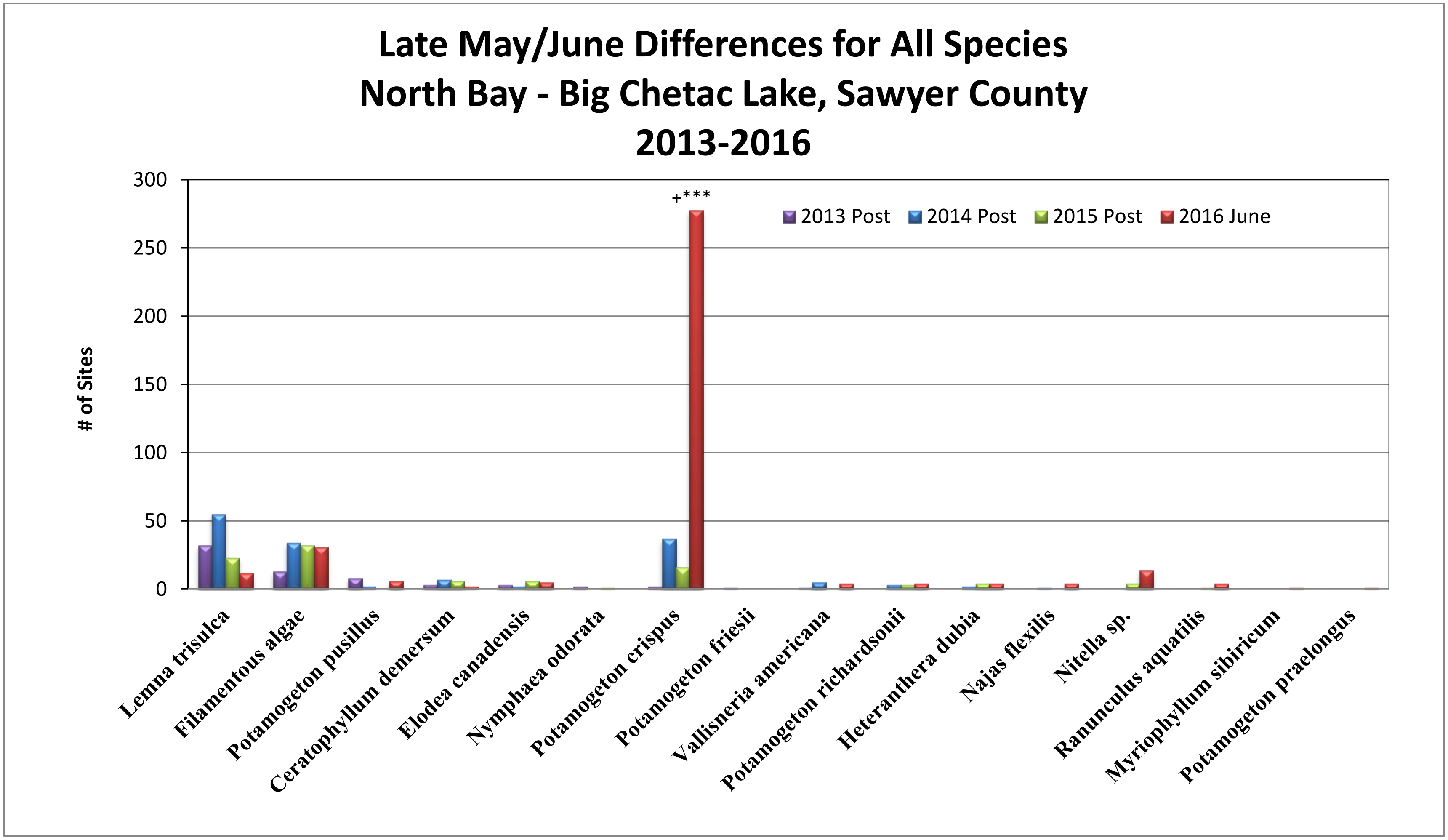


Figure 17: Late May/June 2013-2016 - Differences for All Species – North Bay

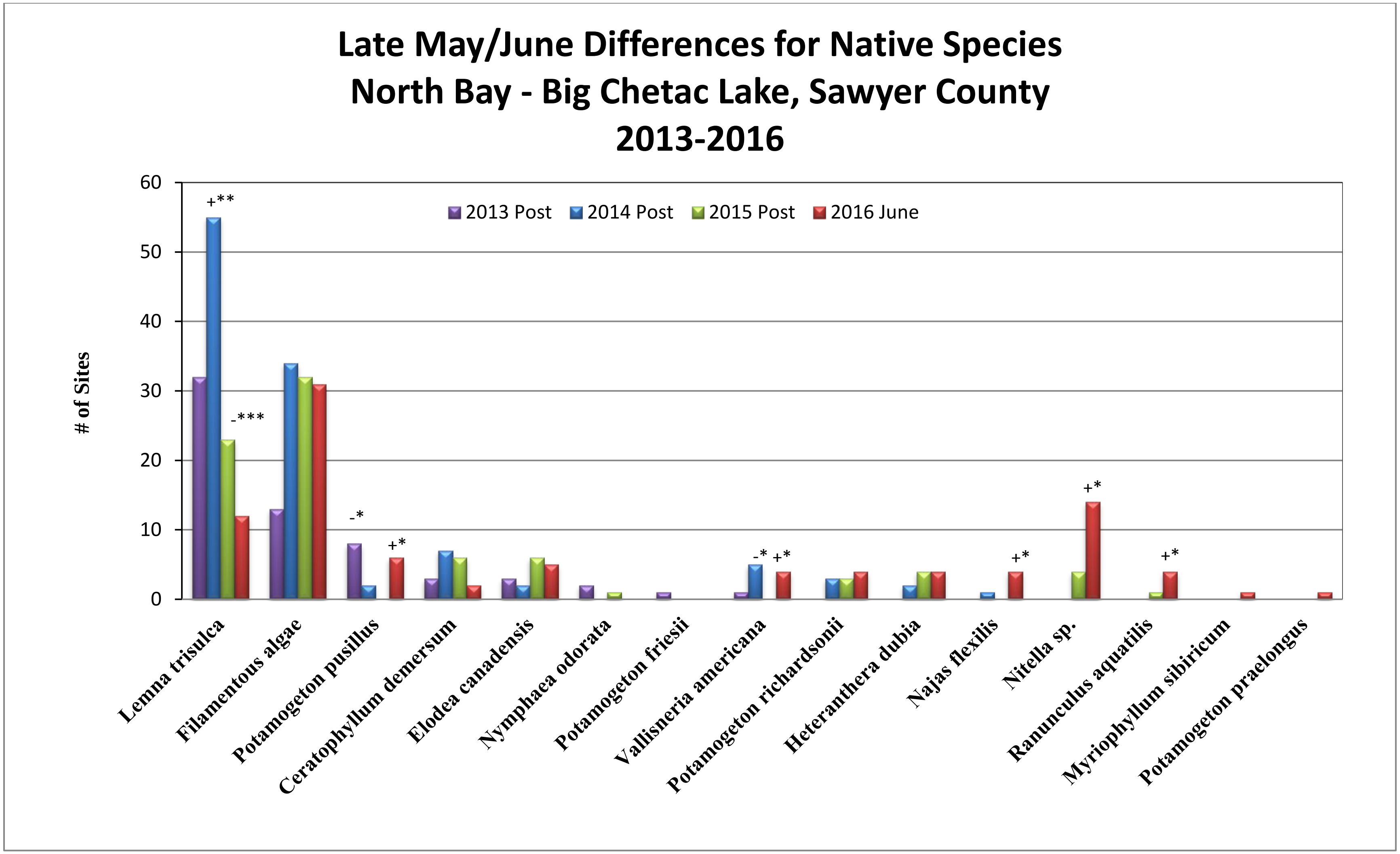


Figure 18: Late May/June 2013-2016 - Differences for Native Species – North Bay

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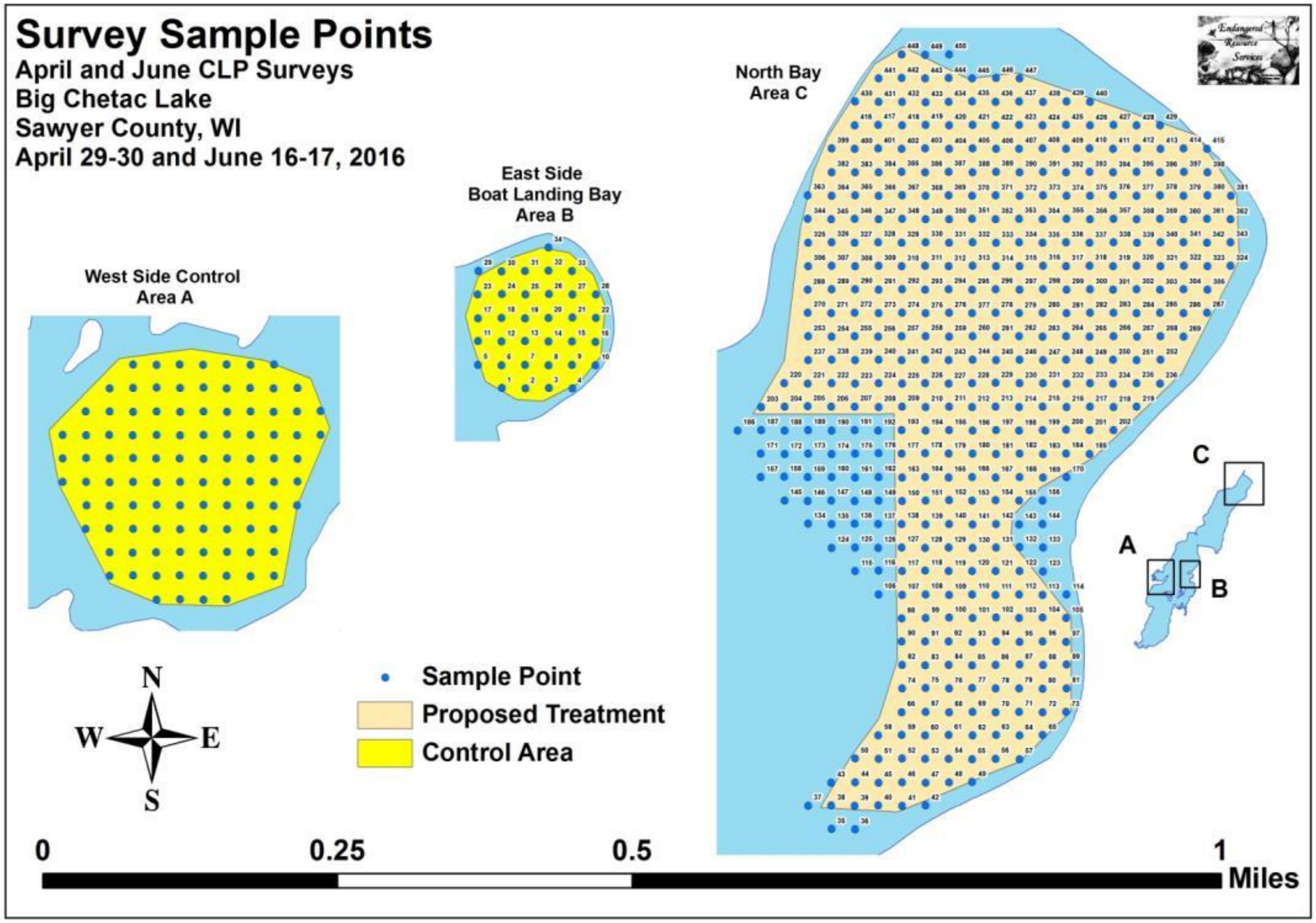
James, W.F., J.W. Barko, H.L. Eakin, and P.W. Sorge. 2002. Phosphorus budget and management strategies for an urban Wisconsin lake. Lake and Reserv. Manage. 18(2): 149-163

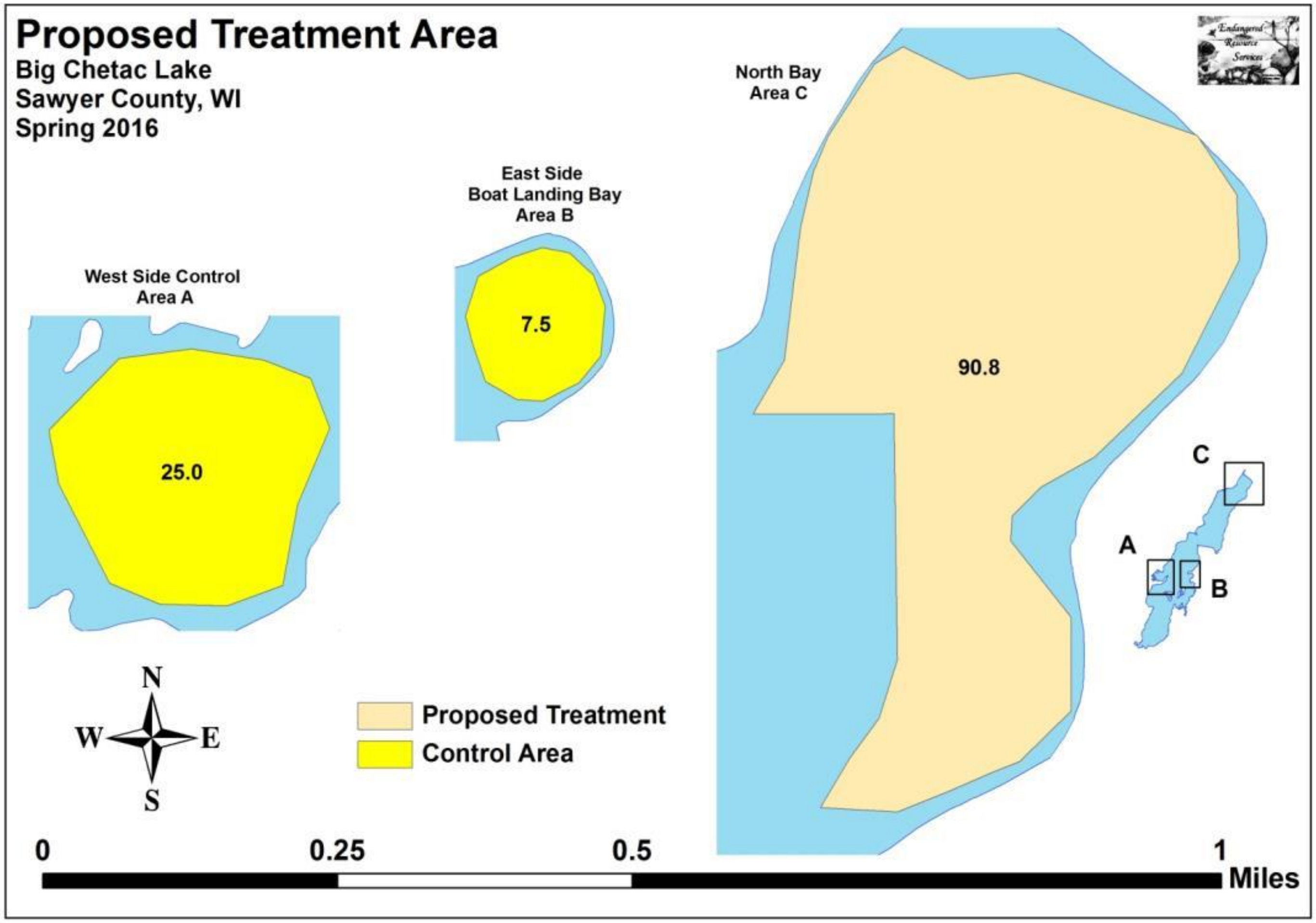
UWEX Lakes Program. [online]. 2010. Aquatic Plant Management in Wisconsin. Available from http://www.uwsp.edu/cnr/uwexlakes/ecology/APMguide.asp (2010, July).

WDNR. [online]. 2016. Big Chetac Lake - Citizen Lake Water Quality Monitoring Database. Available from http://dnr.wi.gov/lakes/lakepages/LakeDetail.aspx?wbic=2113300&page=waterquality 2016, November).

Appendix I: Survey Sample Points and Proposed CLP Treatment Area



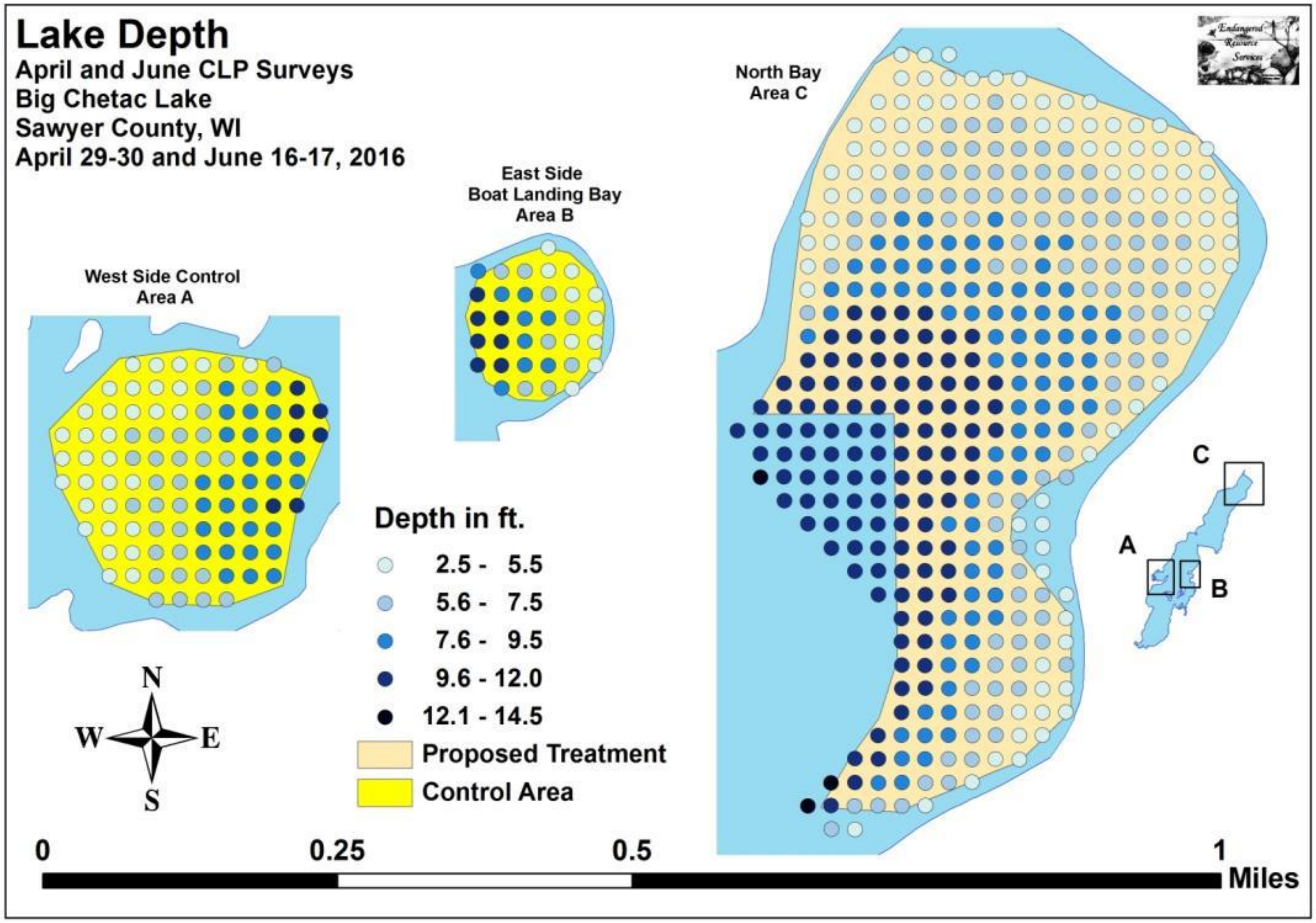
Survey Sample Points
April and June CLP Surveys
Big Chetac Lake
Sawyer County, WI
April 29-30 and June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
N
W
E
S
Sample Point
Proposed Treatment
Control Area
A
B
C
0
0.25
0.5
1
Miles

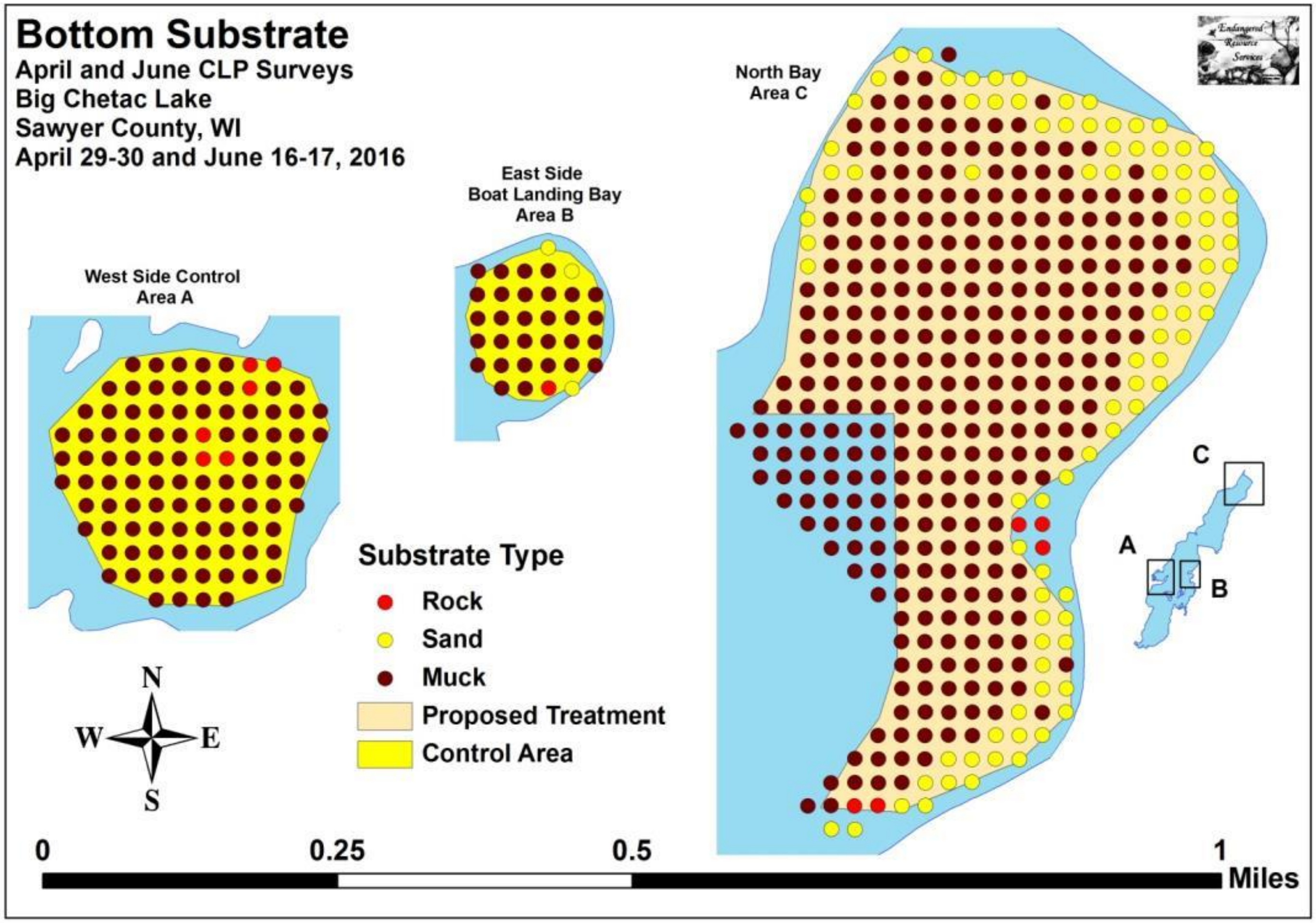

Proposed Treatment Area
Big Chetac Lake
Sawyer County, WI
Spring 2016
North Bay
Area C
East Side
Boat Landing Bay
Area B
West Side Control
Area A
7.5
90.8
25.0
C
A
B
N
W
E
S
Proposed Treatment
Control Area
0
0.25
0.5
1
Miles

Appendix II: Vegetative Survey Data Sheet

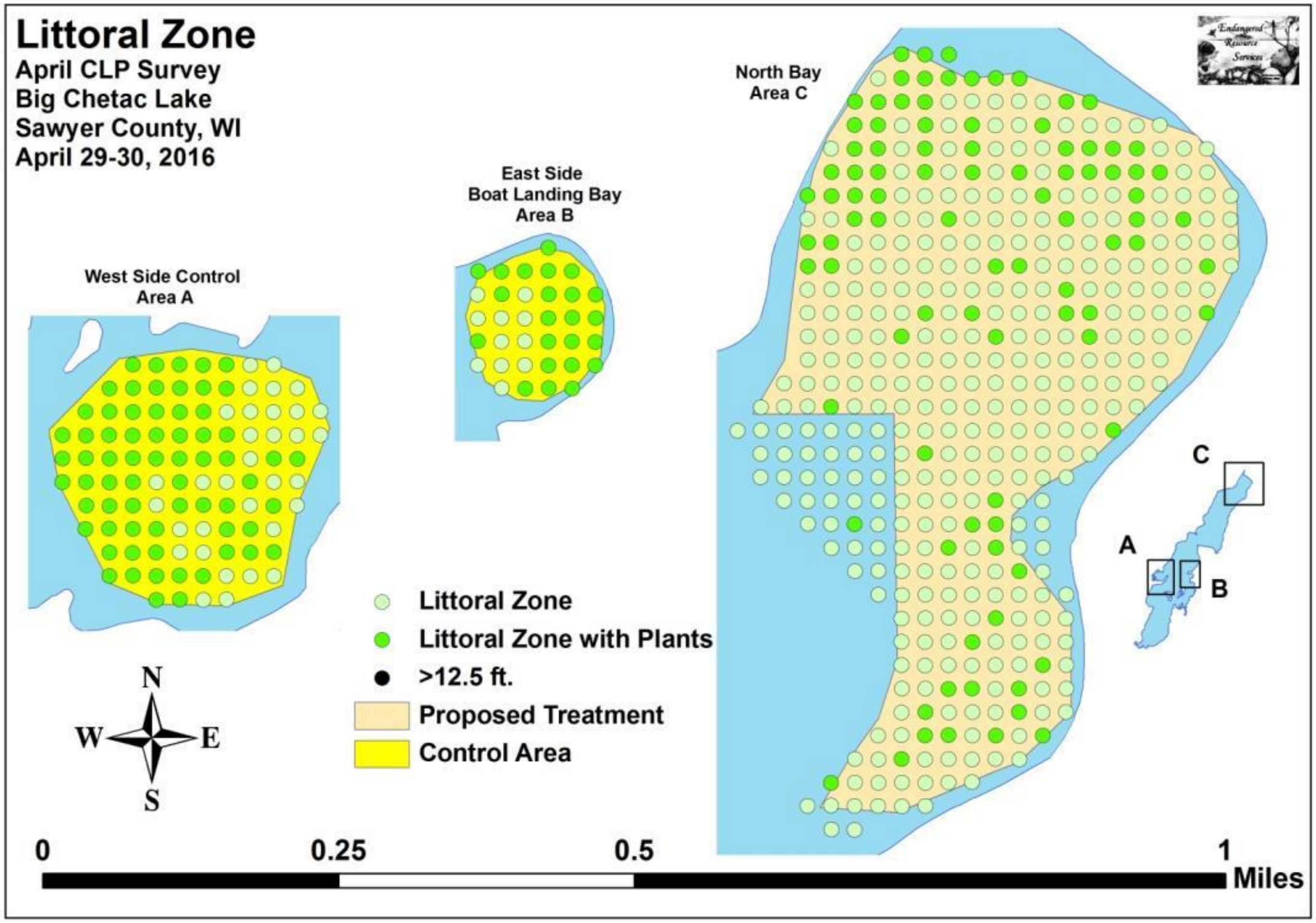
Lake:								WBIC									County						Date:	
Site #	**Depth (ft)**	**Muck (M), Sand (S), Rock (R)**	**Rake pole (P) or rake rope (R)**	**Total Rake Fullness**	**CLP**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
1								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

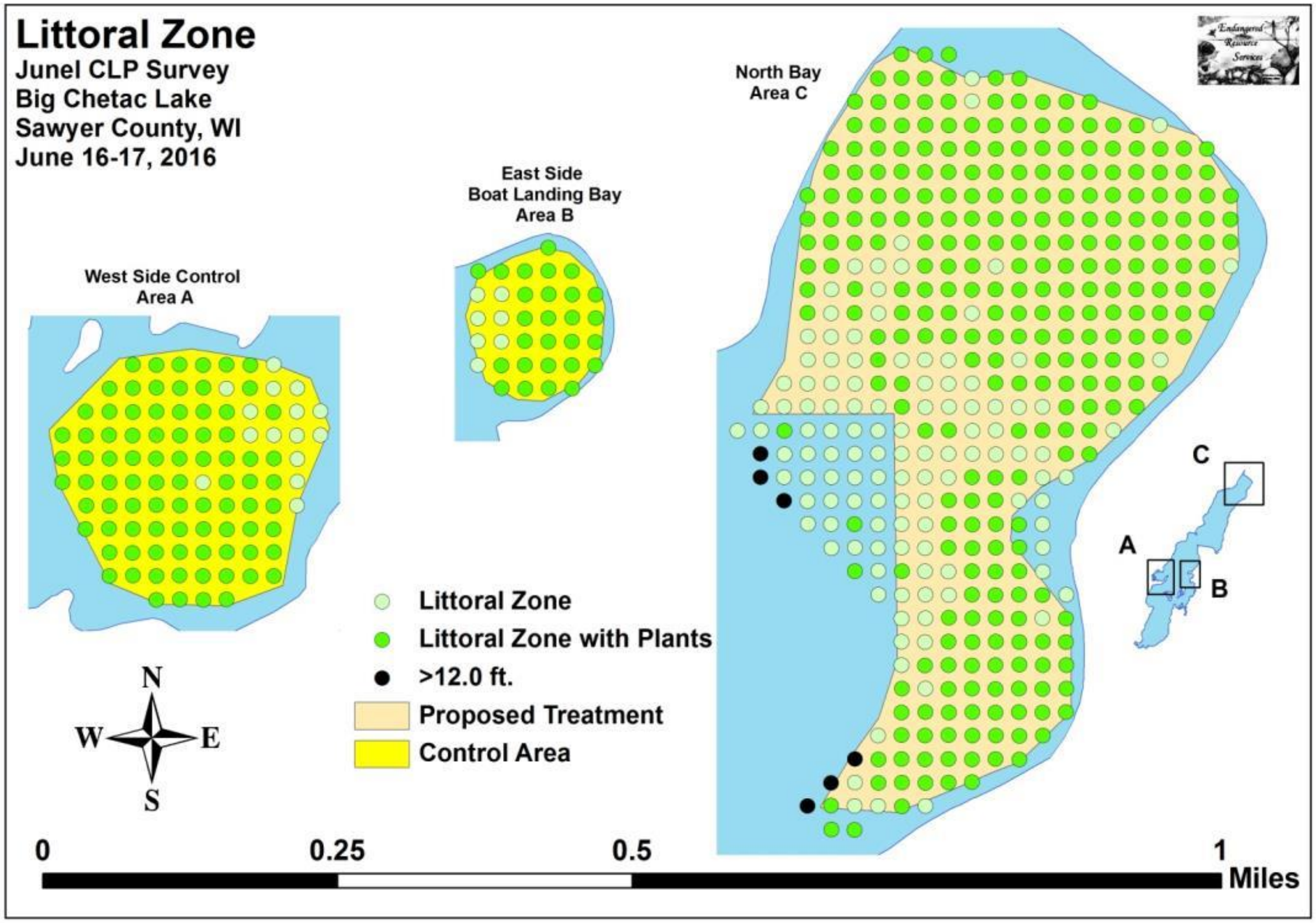
Appendix III: April/June Habitat Variable Maps

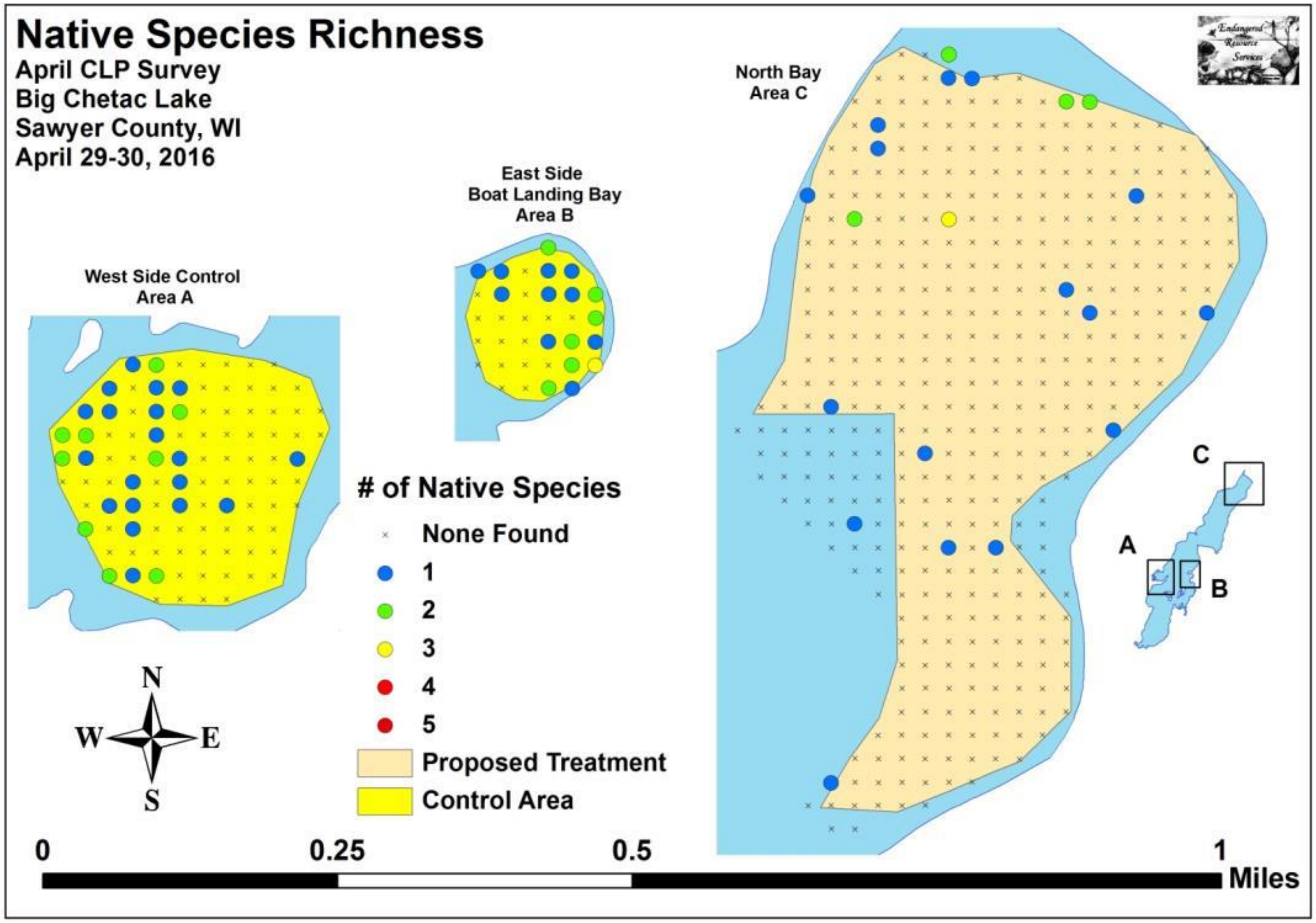

Lake Depth
April and June CLP Surveys
Big Chetac Lake
Sawyer County, WI
April 29-30 and June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Depth in ft.
2.5 - 5.5
5.6 - 7.5
7.6 - 9.5
9.6 - 12.0
12.1 - 14.5
Proposed Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles


Bottom Substrate
April and June CLP Surveys
Big Chetac Lake
Sawyer County, WI
April 29-30 and June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Substrate Type
Rock
Sand
Muck
Proposed Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles

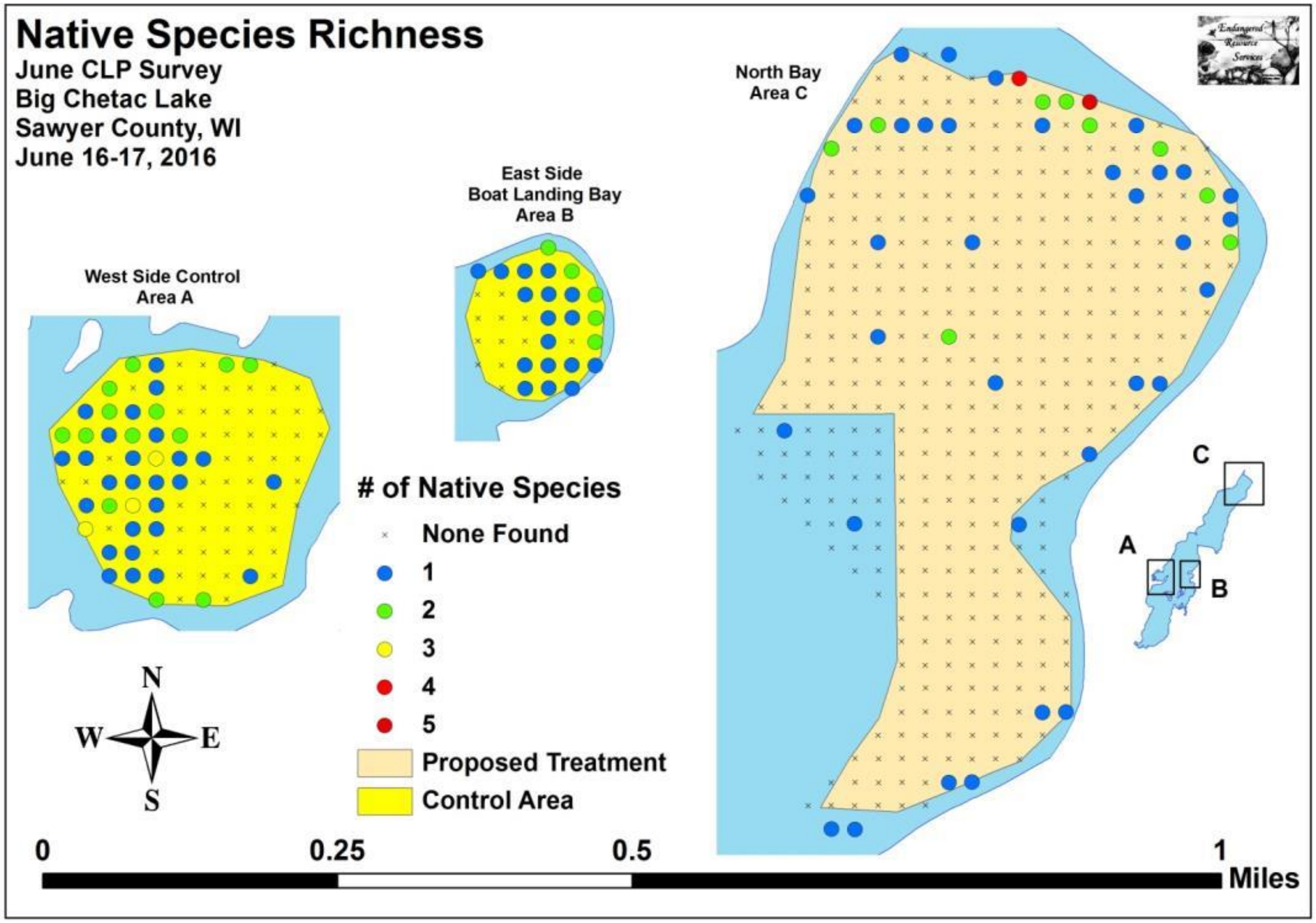
Appendix IV: April/June Littoral Zone, Native Species Richness, and Total Rake Fullness


Littoral Zone
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Littoral Zone
Littoral Zone with Plants
>12.5 ft.
Proposed Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles

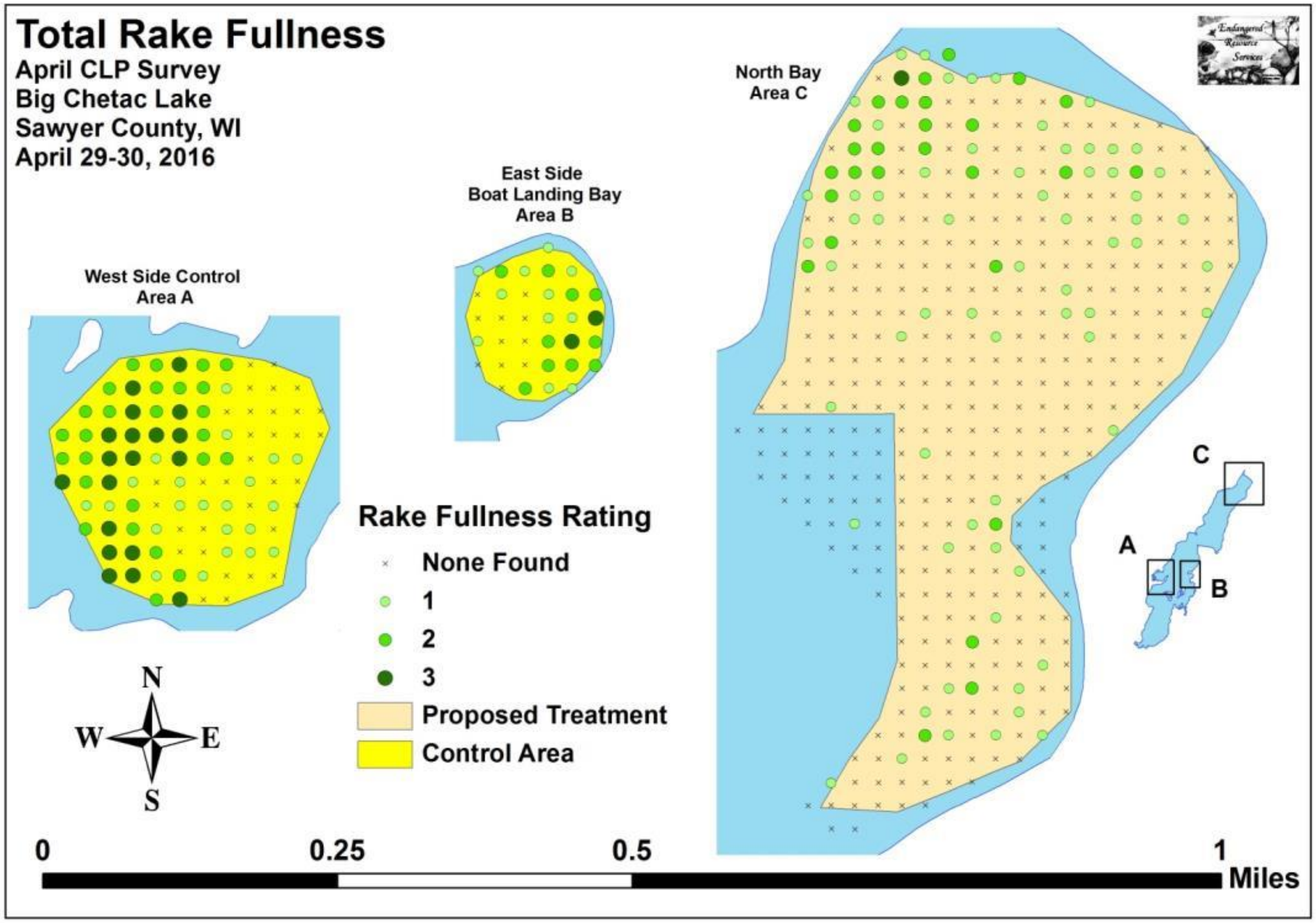

Littoral Zone
Junel CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
North Bay
Area C
East Side
Boat Landing Bay
Area B
West Side Control
Area A
Littoral Zone
Littoral Zone with Plants
>12.0 ft.
Proposed Treatment
Control Area
N
W
E
S
C
A
B
0
0.25
0.5
1
Miles



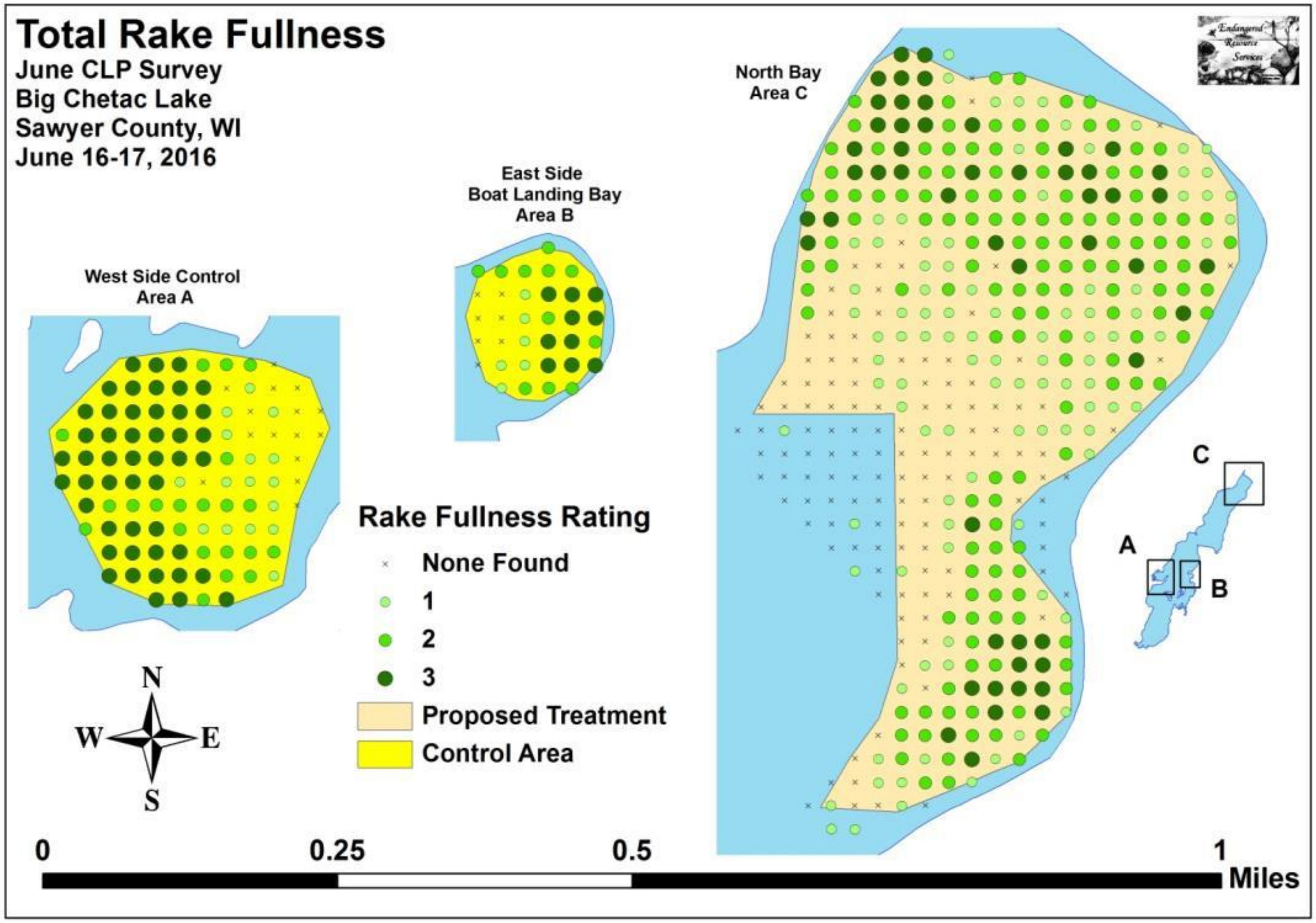
Native Species Richness
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
# of Native Species
None Found
1
2
3
4
5
Proposed Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles



Native Species Richness
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
North Bay
Area C
East Side
Boat Landing Bay
Area B
West Side Control
Area A
# of Native Species
None Found
1
2
3
4
5
Proposed Treatment
Control Area
N
W
E
S
C
A
B
0
0.25
0.5
1
Miles

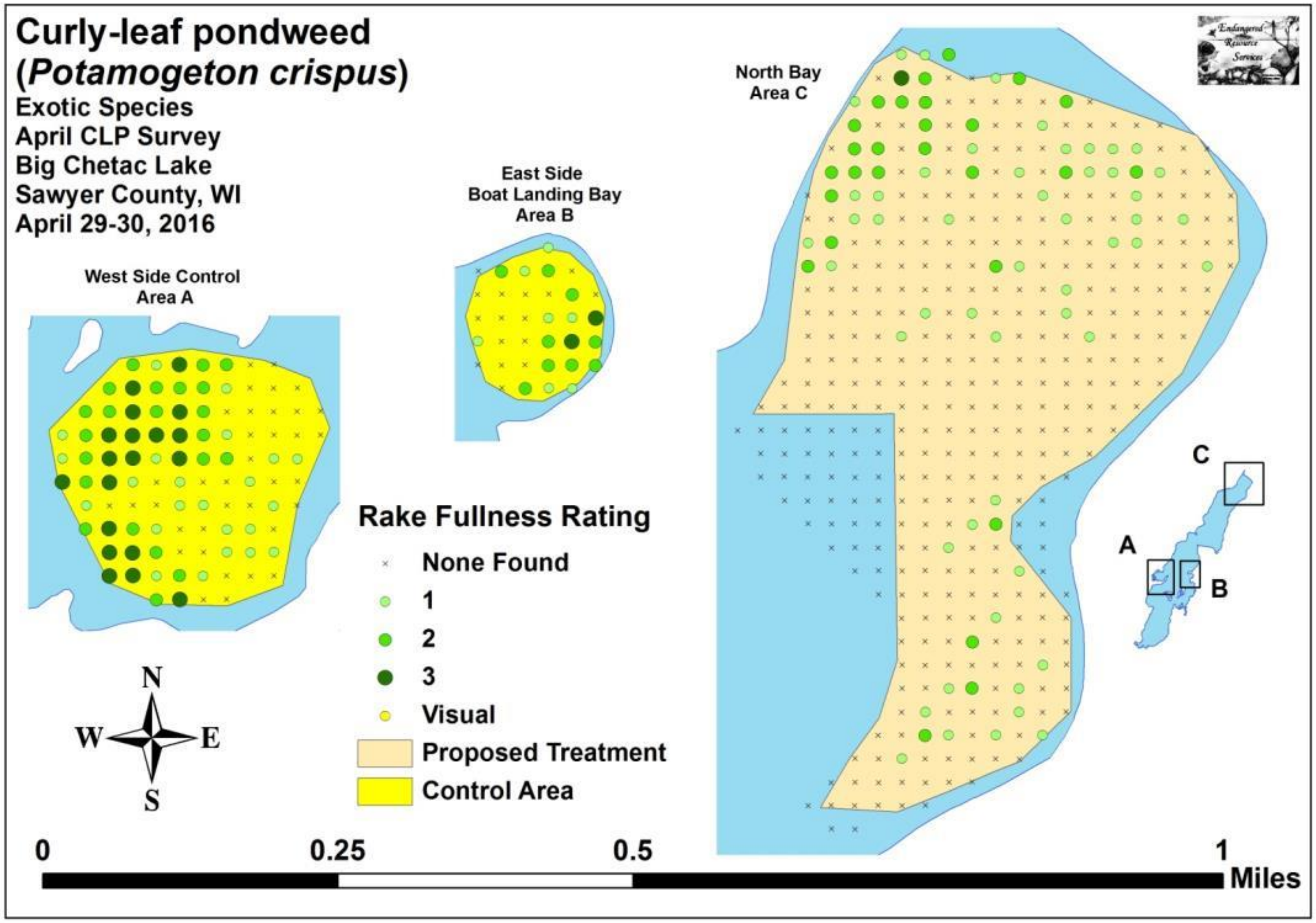


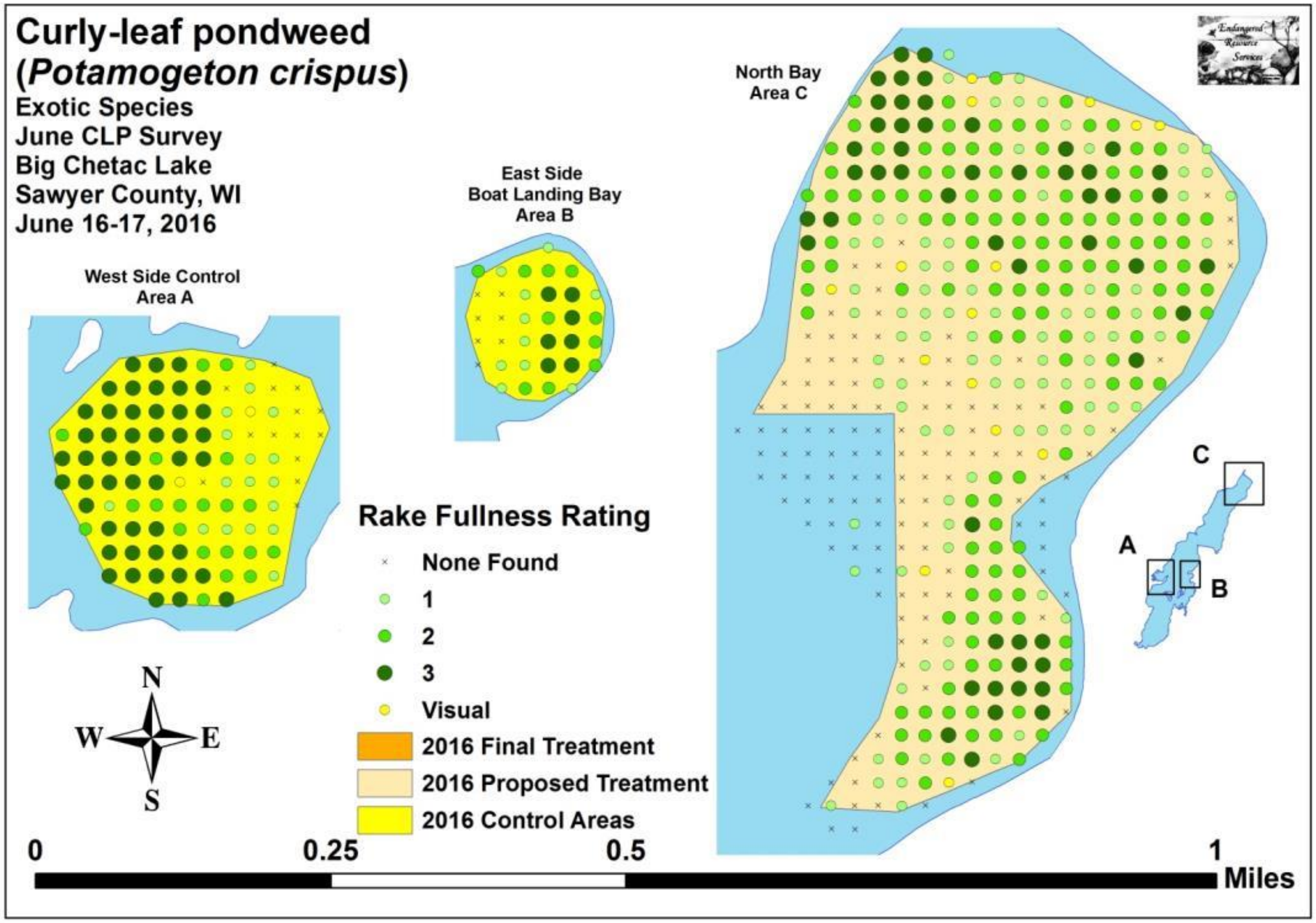
Total Rake Fullness
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
North Bay
Area C
East Side
Boat Landing Bay
Area B
West Side Control
Area A
Rake Fullness Rating
None Found
1
2
3
Proposed Treatment
Control Area
N
W
E
S
C
A
B
0
0.25
0.5
1
Miles



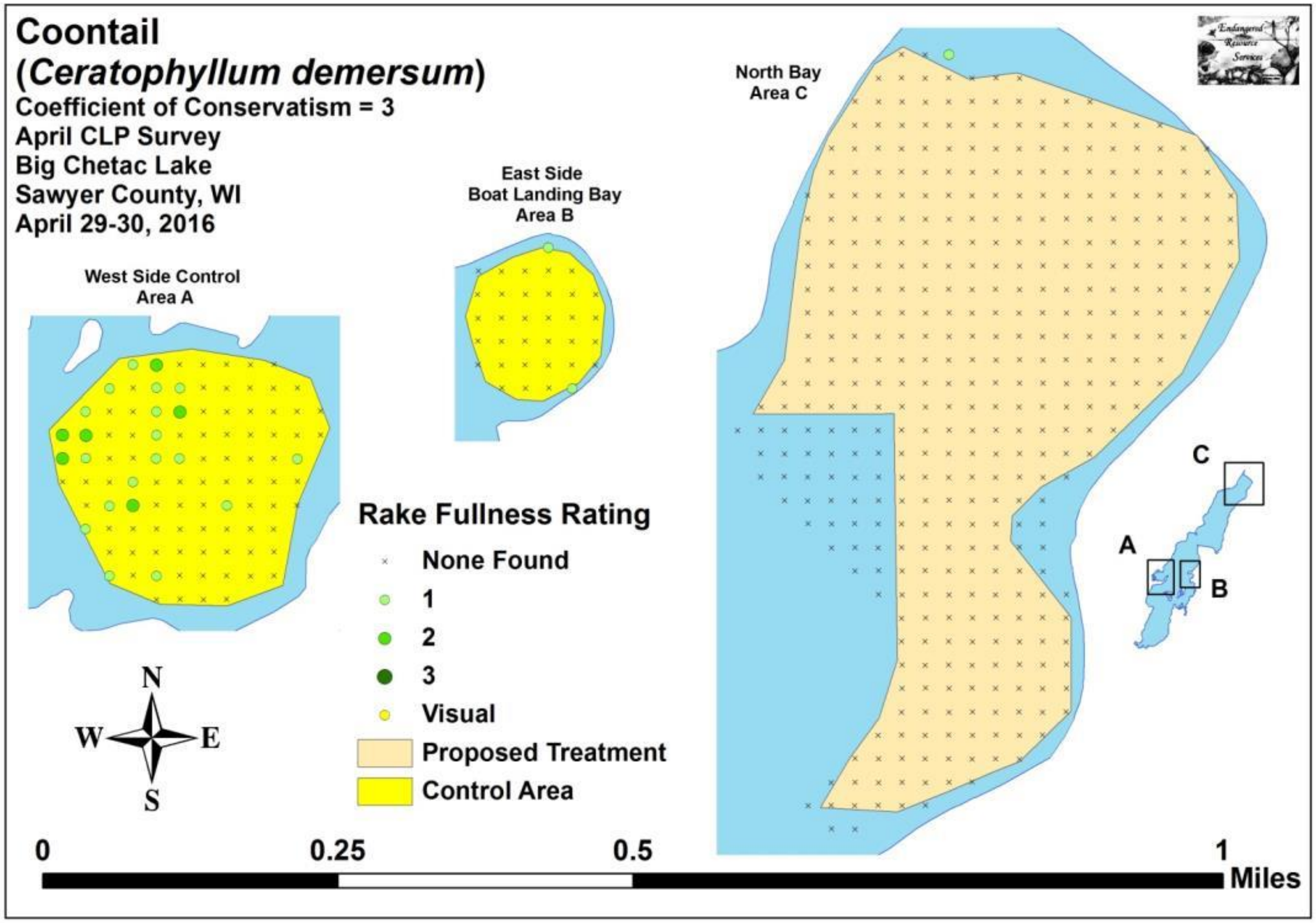
Total Rake Fullness
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
North Bay
Area C
East Side
Boat Landing Bay
Area B
West Side Control
Area A
Rake Fullness Rating
None Found
1
2
3
Proposed Treatment
Control Area
N
W
E
S
C
A
B
0
0.25
0.5
1
Miles

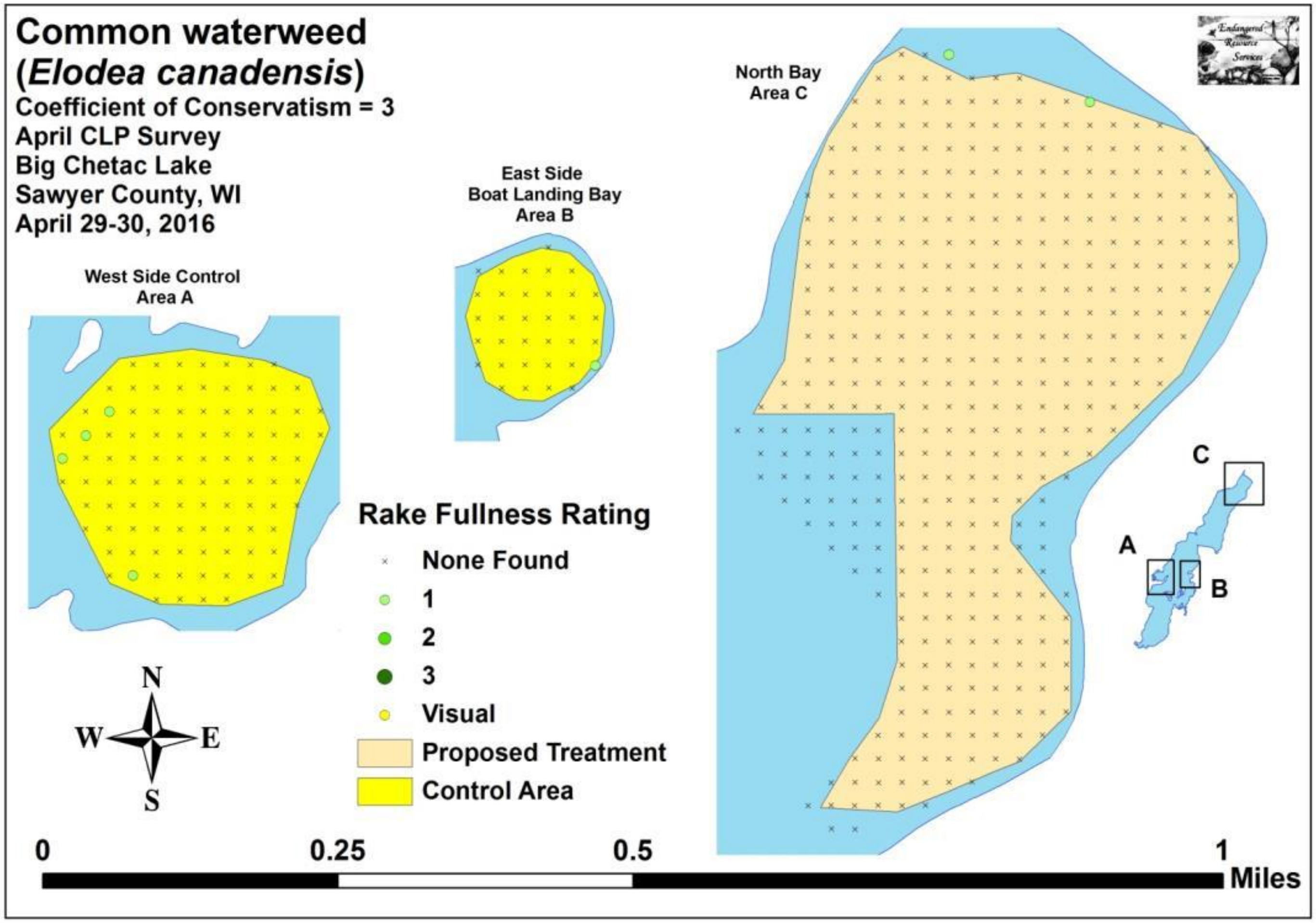
Appendix V: CLP April/June Density and Distribution

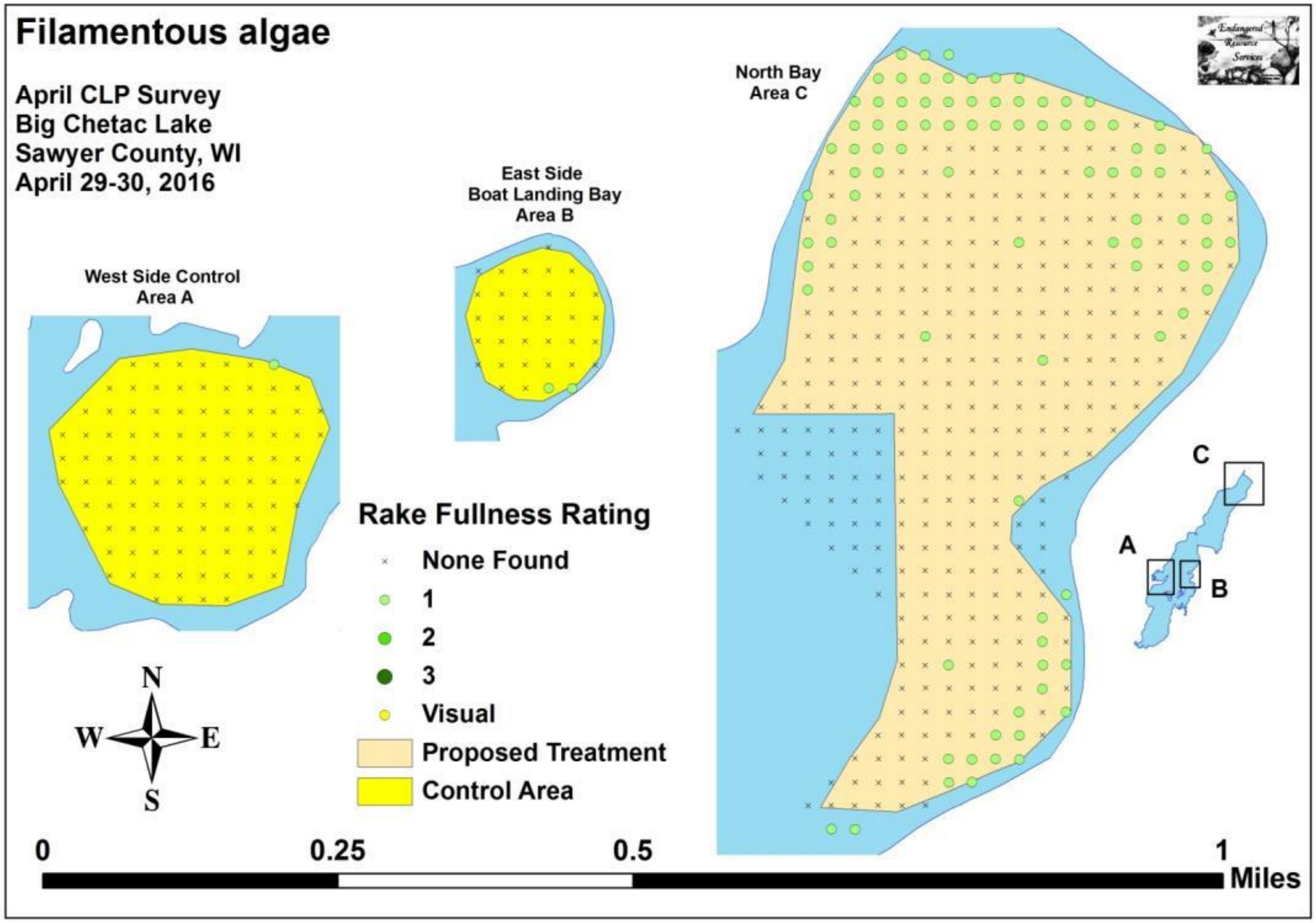

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
1
2
3
Visual
Proposed Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles

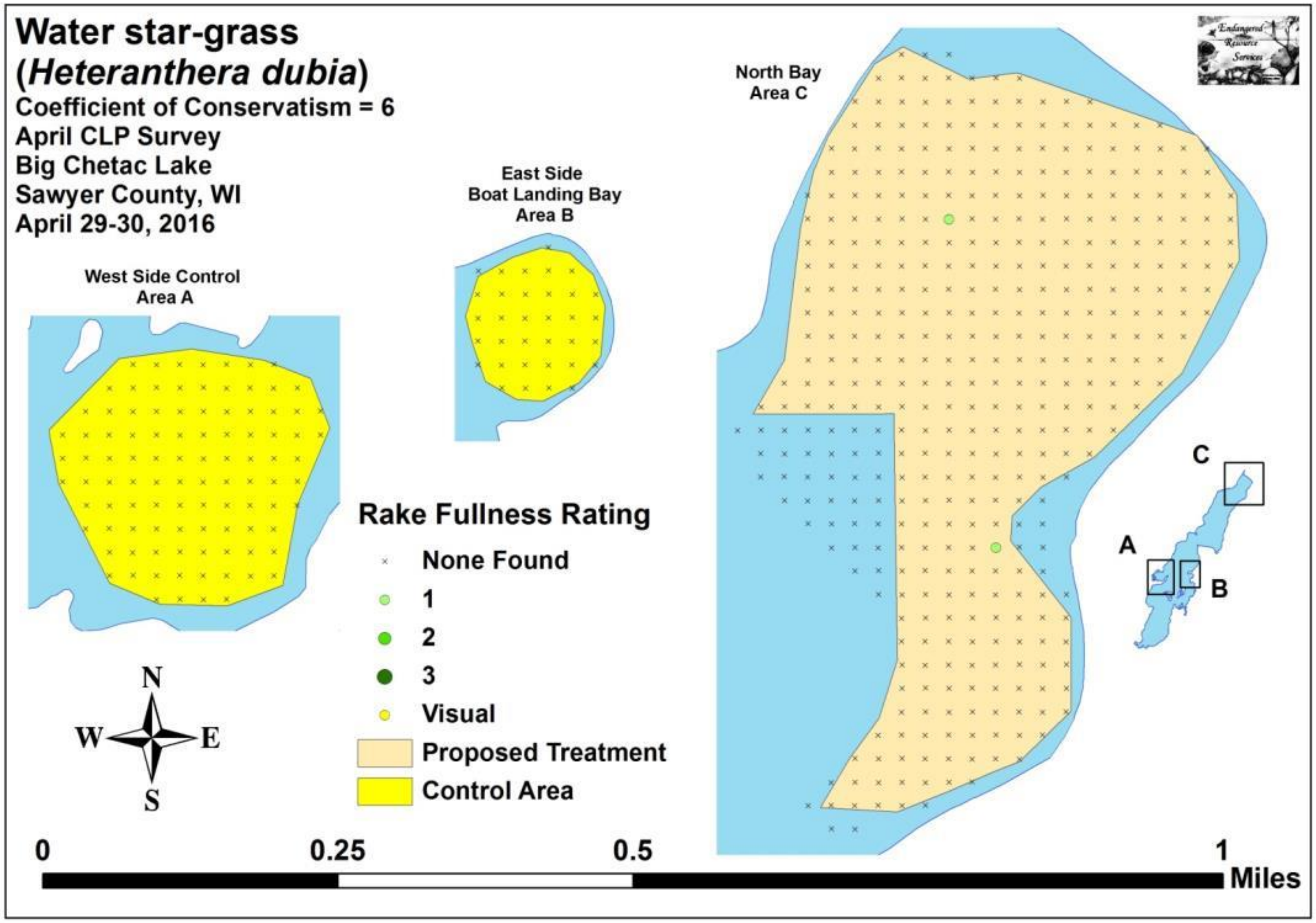

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
1
2
3
Visual
2016 Final Treatment
2016 Proposed Treatment
2016 Control Areas
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles

Appendix VI: April Native Species Density and Distribution


Coontail
(*Ceratophyllum demersum*)
Coefficient of Conservatism = 3
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
1
2
3
Visual
Proposed Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles


Common waterweed
(Elodea canadensis)
Coefficient of Conservatism = 3
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
1
2
3
Visual
Proposed Treatment
Control Area
N
W
E
S
0
0.25
0.5
1
Miles
A
B
C


Filamentous algae
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
Endangered Resource Services
North Bay
Area C
East Side
Boat Landing Bay
Area B
West Side Control
Area A
Rake Fullness Rating
None Found
1
2
3
Visual
Proposed Treatment
Control Area
N
W
E
S
C
A
B
0
0.25
0.5
1
Miles


Water star-grass
(*Heteranthera dubia*)
Coefficient of Conservatism = 6
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
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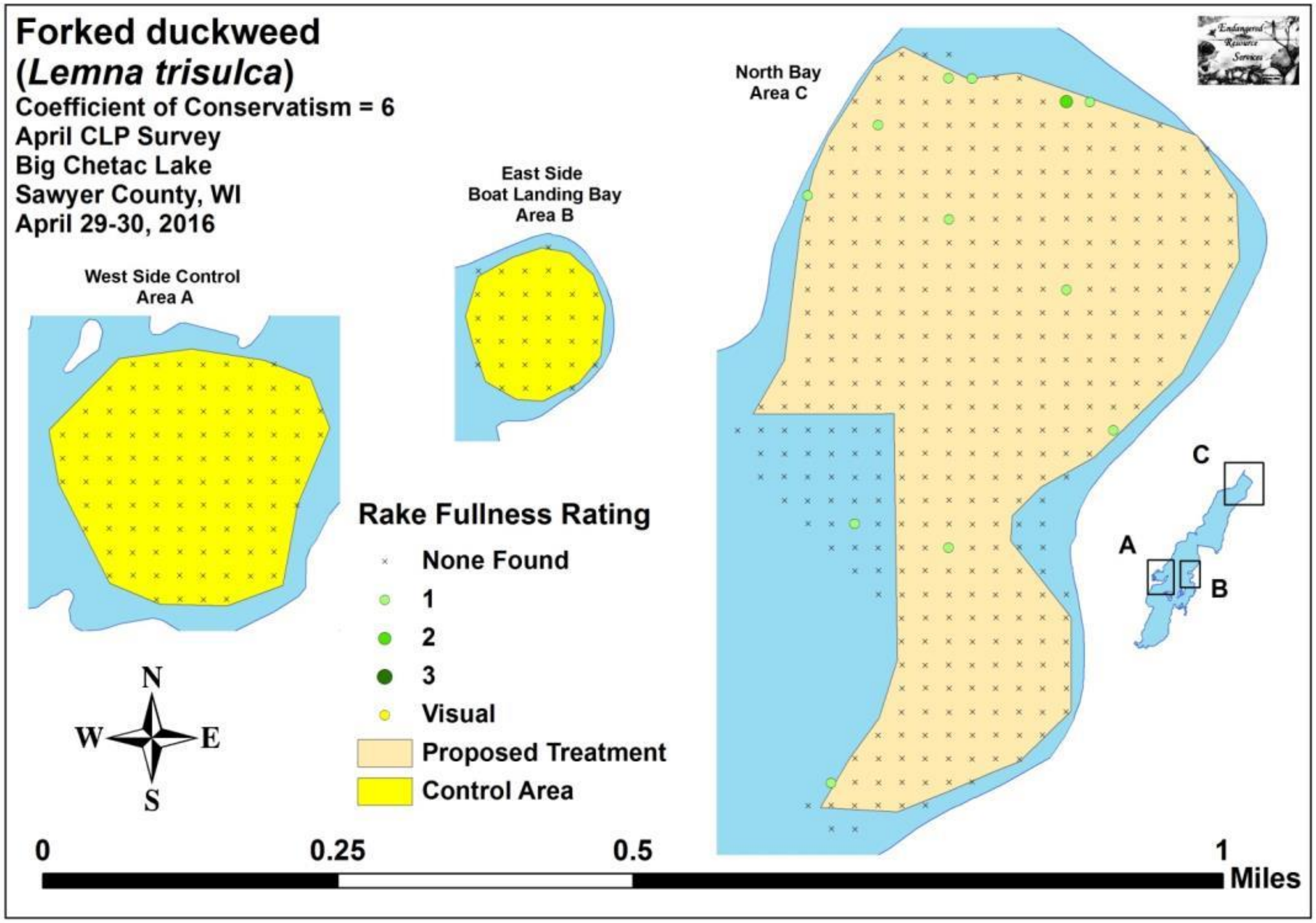

Forked duckweed
(Lemna trisulca)
Coefficient of Conservatism = 6
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
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North Bay
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Proposed Treatment
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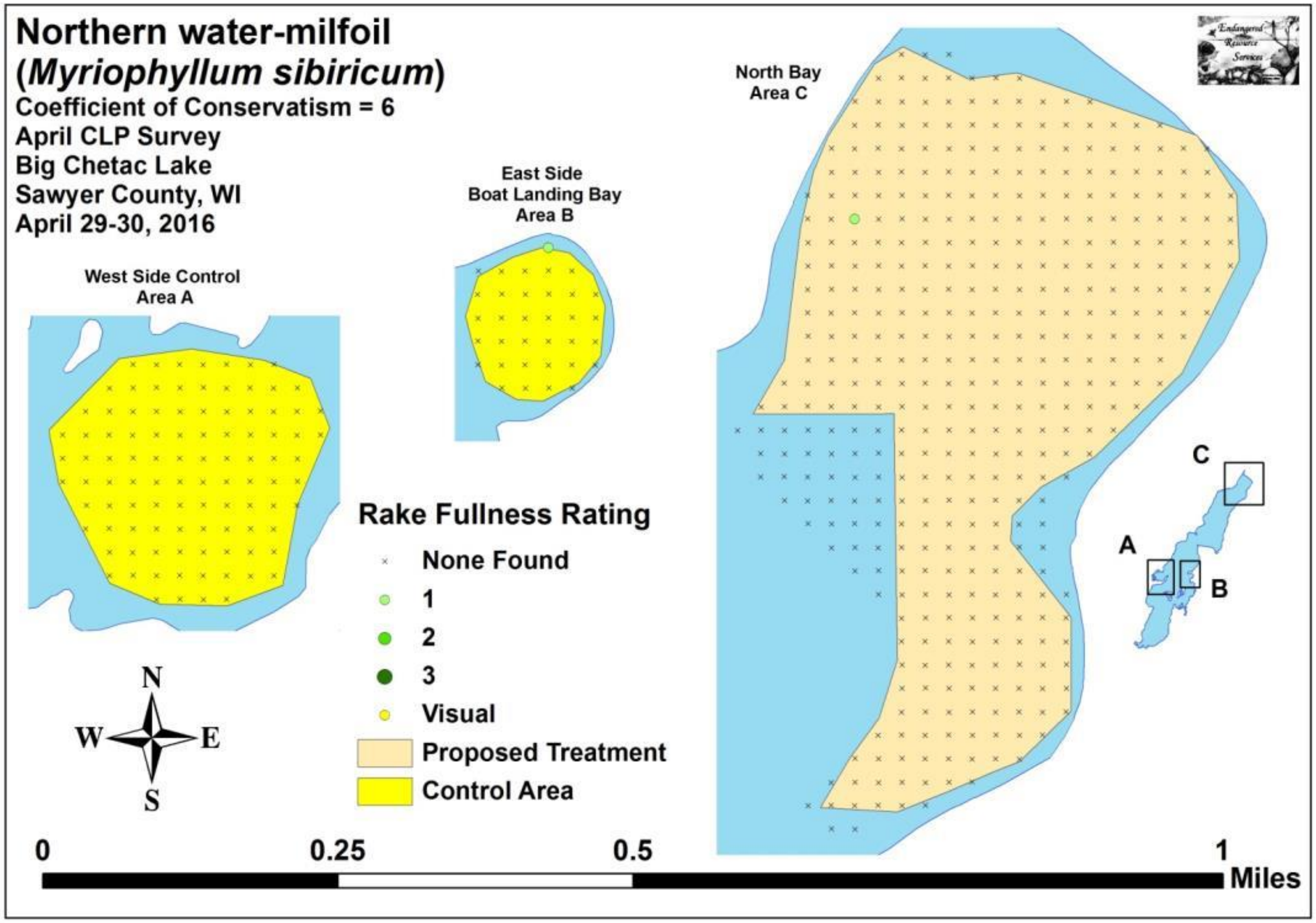
Northern water-milfoil
(Myriophyllum sibiricum)
Coefficient of Conservatism = 6
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
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Area B
North Bay
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Proposed Treatment
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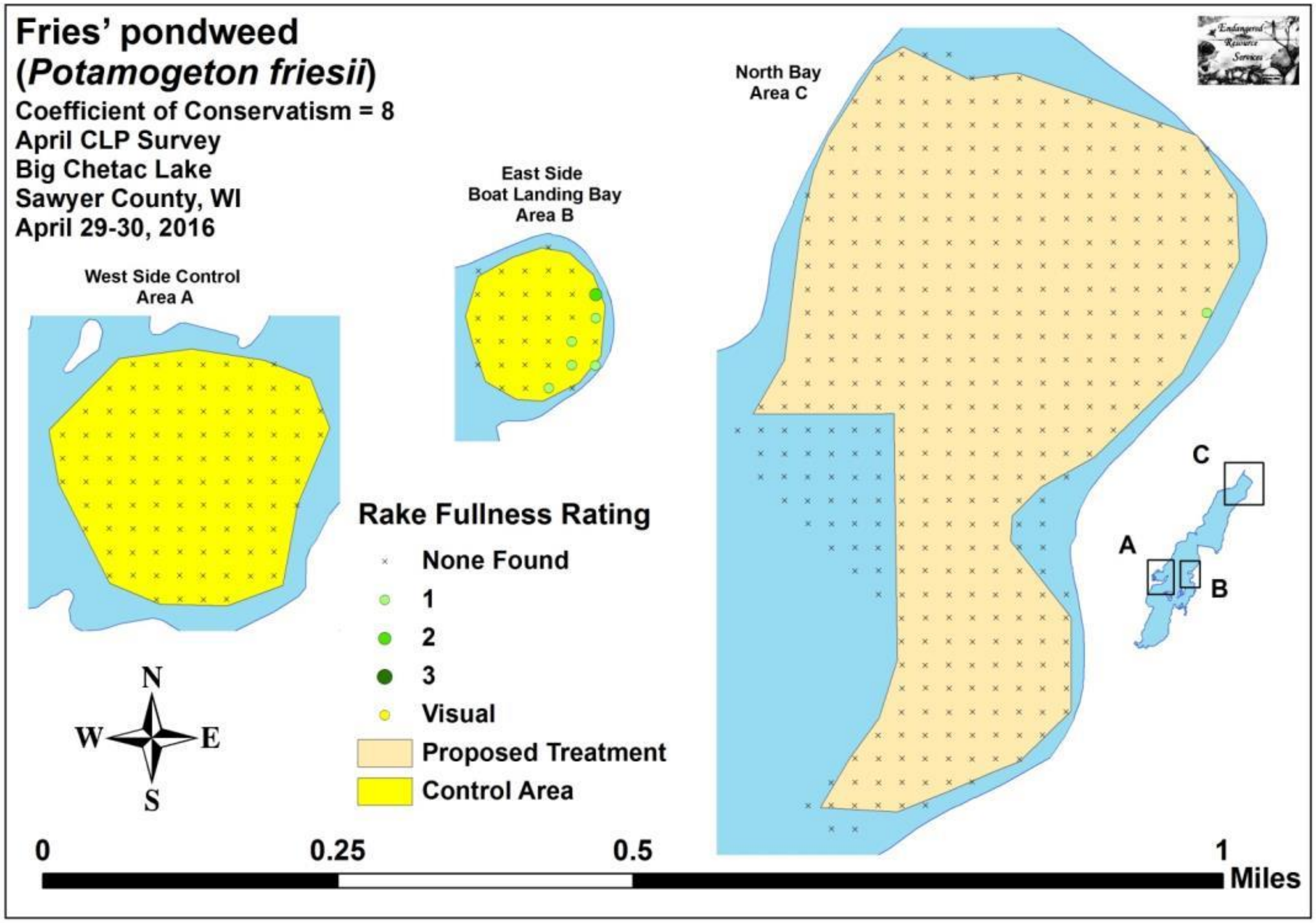
Fries' pondweed
(Potamogeton friesii)
Coefficient of Conservatism = 8
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
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Proposed Treatment
Control Area
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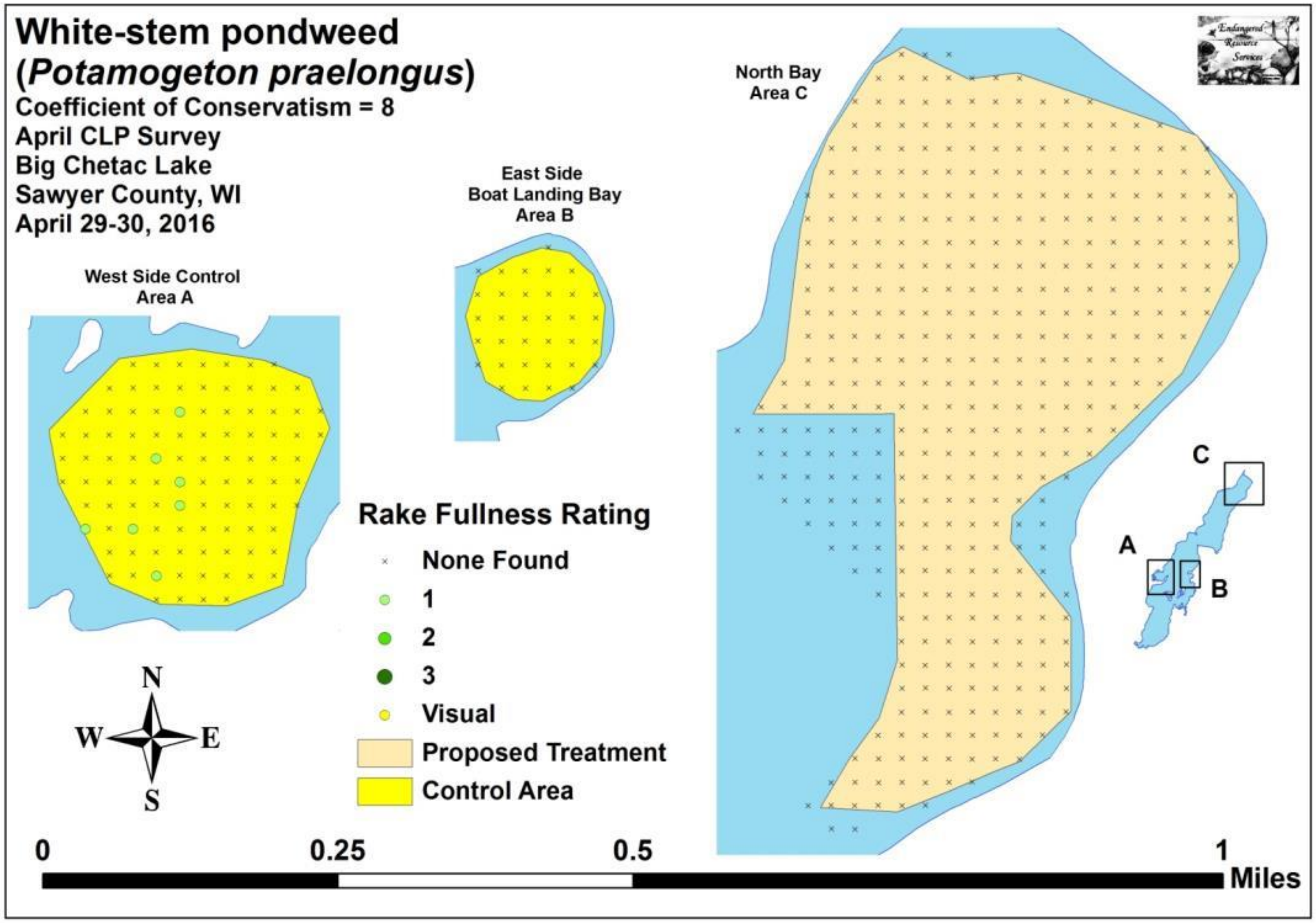
White-stem pondweed
(*Potamogeton praelongus*)
Coefficient of Conservatism = 8
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
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Rake Fullness Rating
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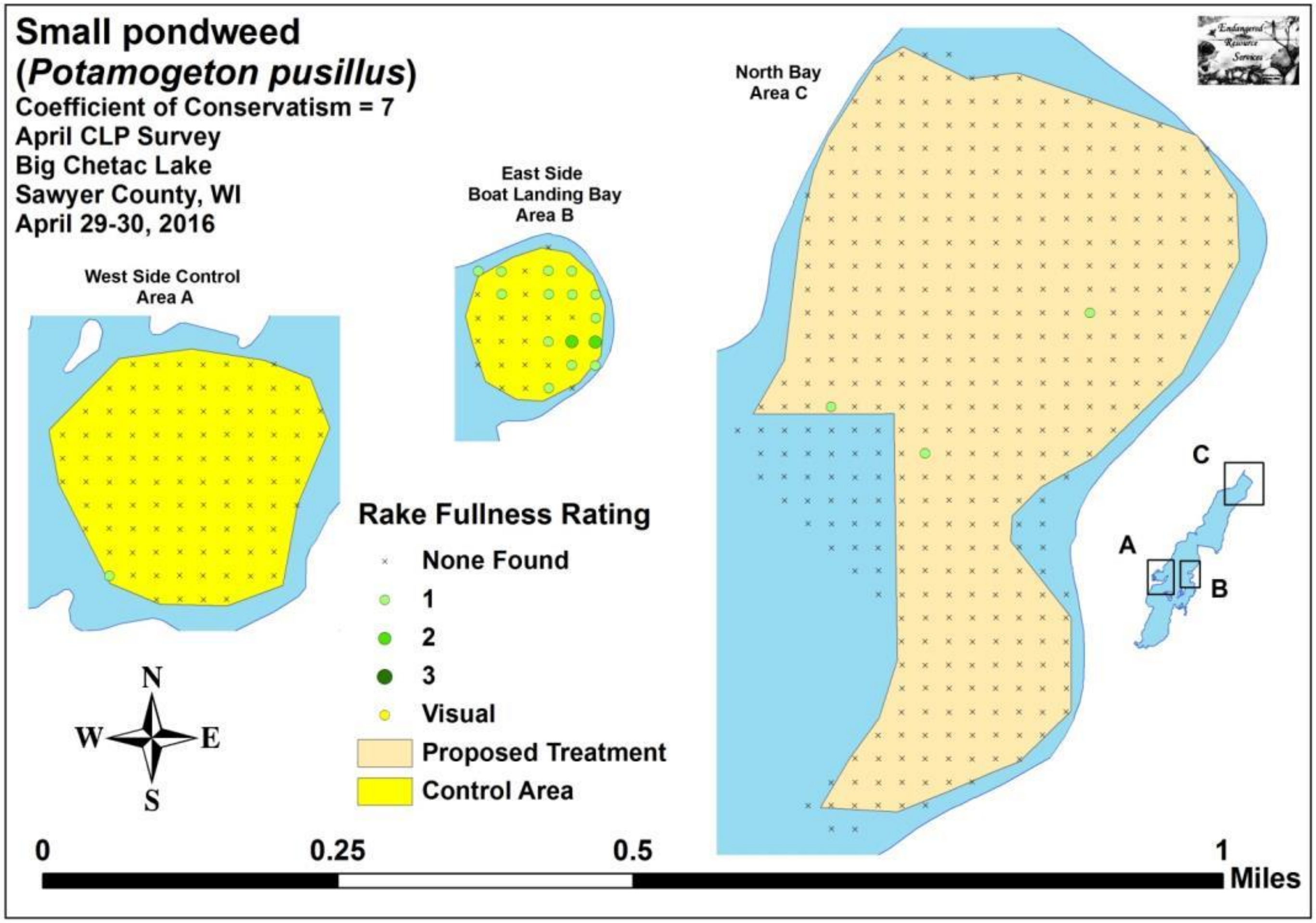

Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
Area A
East Side
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Area B
North Bay
Area C
Rake Fullness Rating
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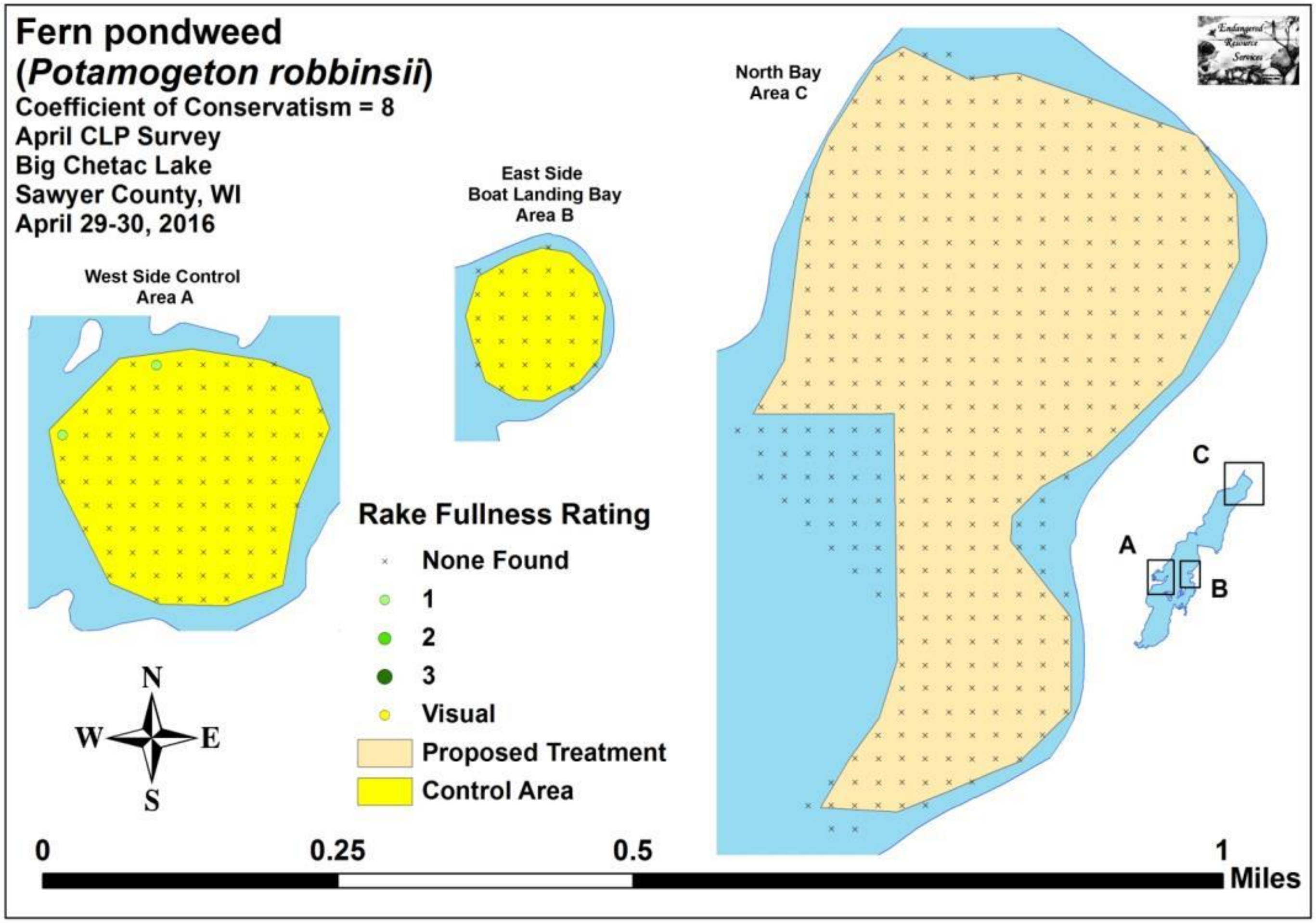

Fern pondweed
(*Potamogeton robbinsii*)
Coefficient of Conservatism = 8
April CLP Survey
Big Chetac Lake
Sawyer County, WI
April 29-30, 2016
West Side Control
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East Side
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North Bay
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Rake Fullness Rating
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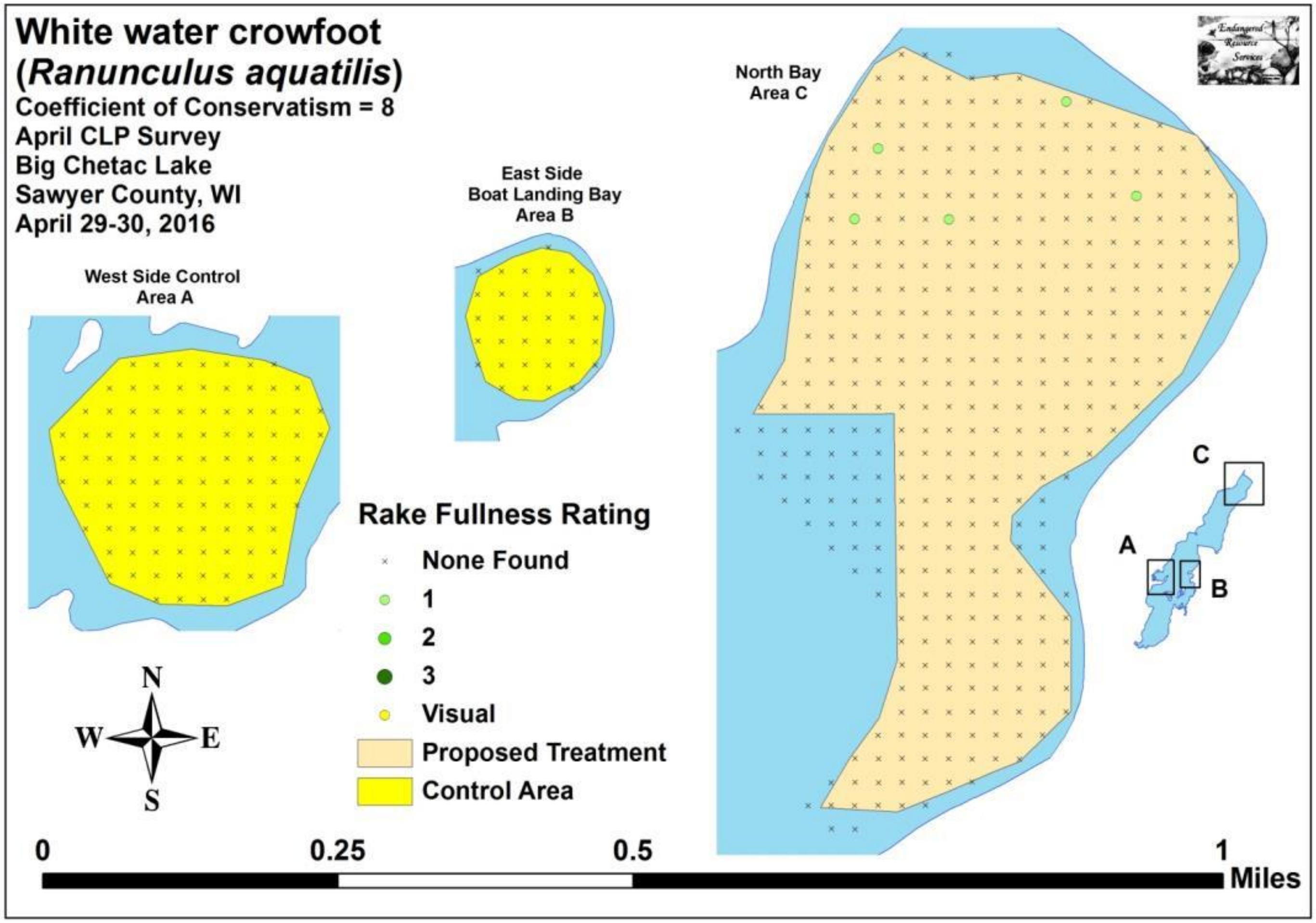

White water crowfoot
(Ranunculus aquatilis)
Coefficient of Conservatism = 8
April CLP Survey
Big Chetac Lake
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April 29-30, 2016
West Side Control
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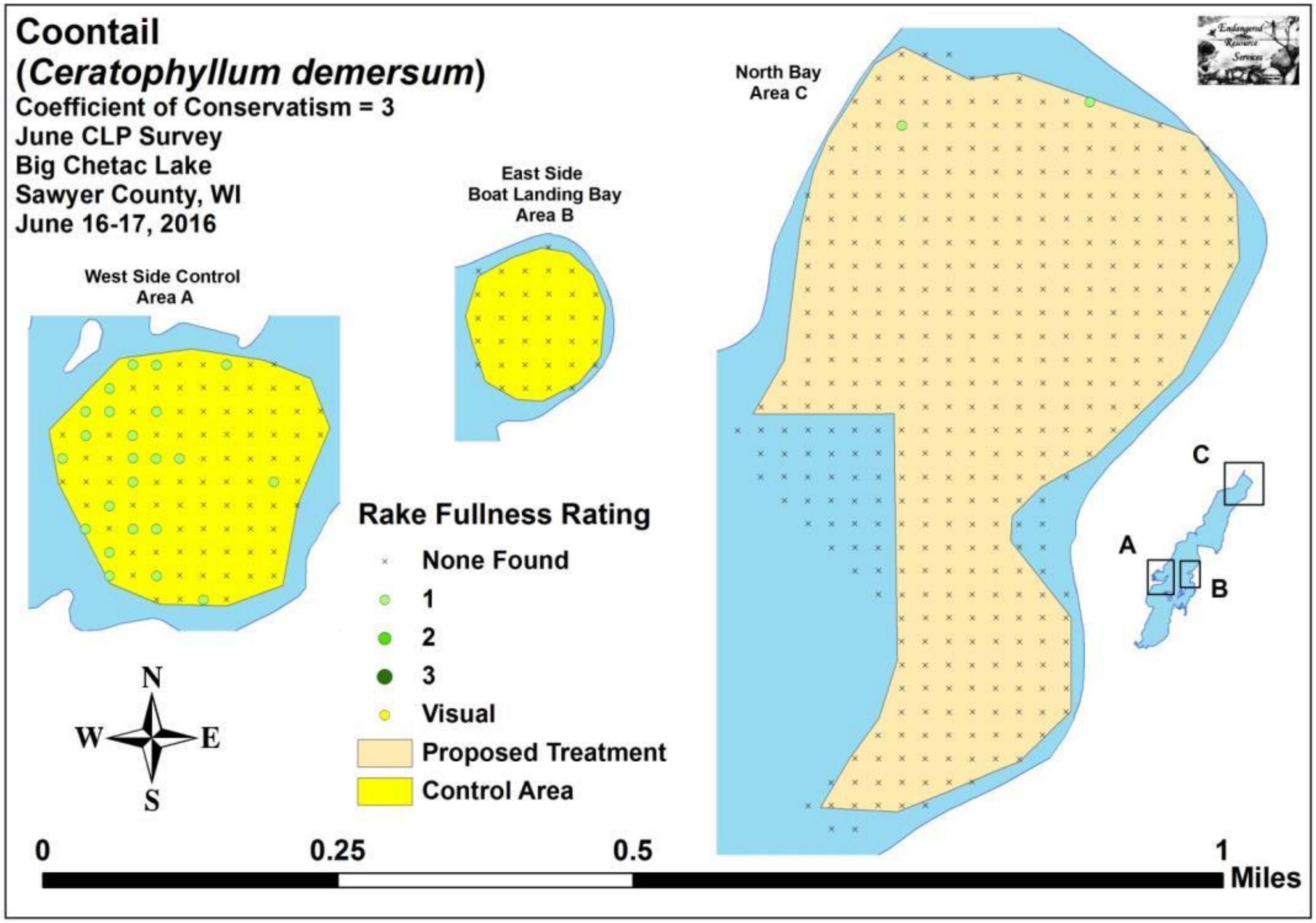
Appendix VII: June Native Species Density and Distribution



Coontail
(*Ceratophyllum demersum*)
Coefficient of Conservatism = 3
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
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East Side
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North Bay
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Rake Fullness Rating
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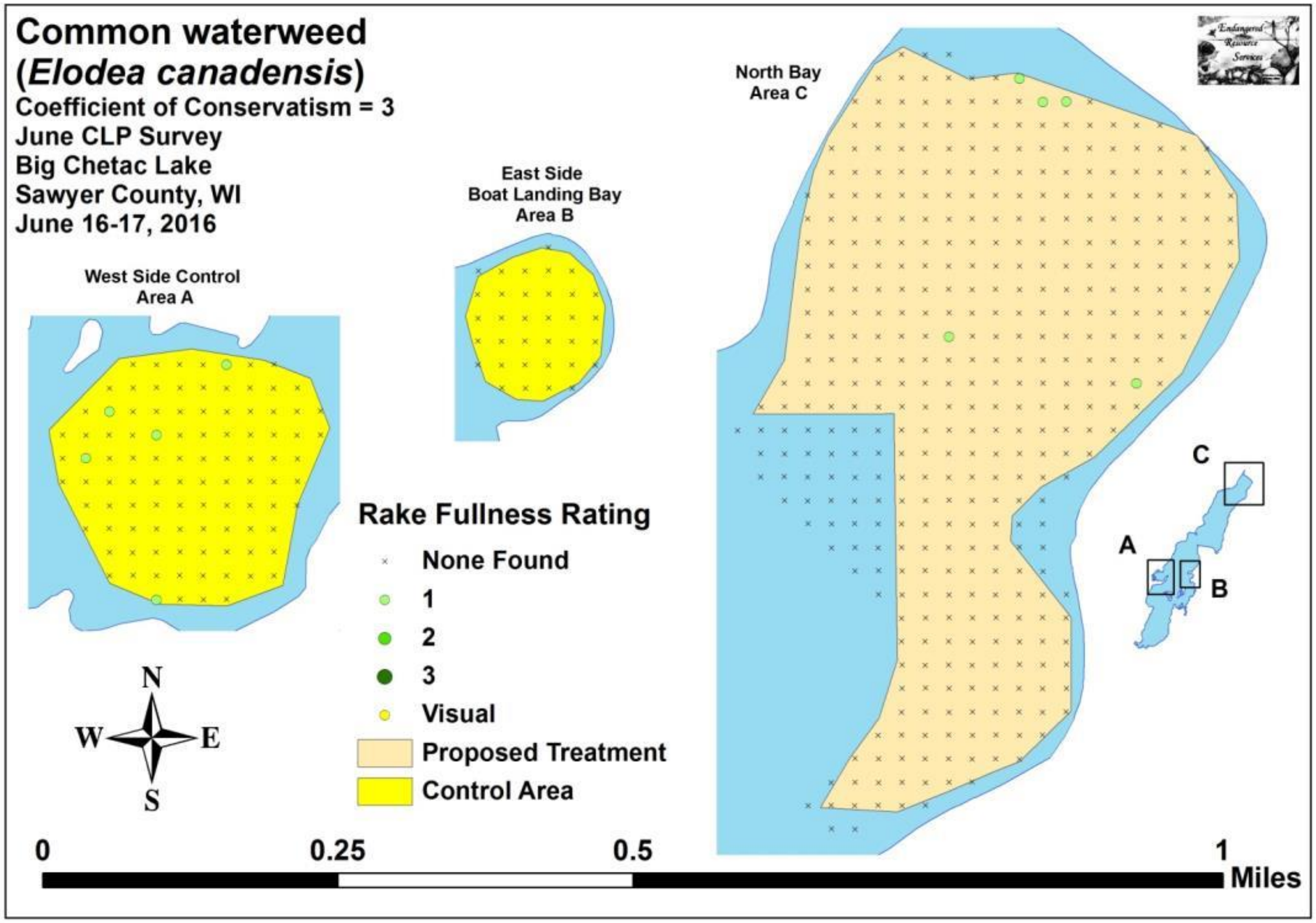
Common waterweed
(*Elodea canadensis*)
Coefficient of Conservatism = 3
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
East Side
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North Bay
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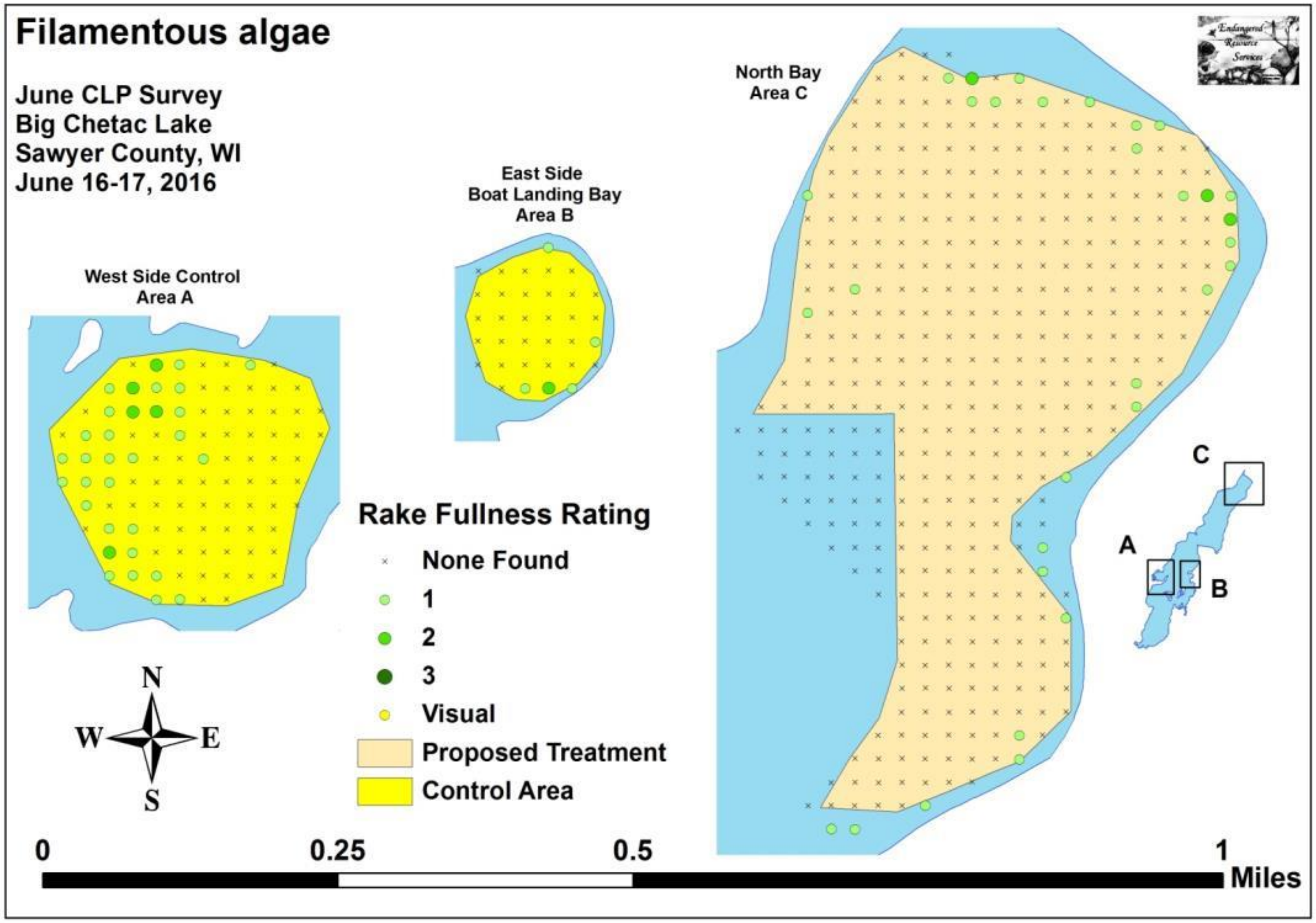
Miles



Filamentous algae
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
North Bay
Area C
East Side
Boat Landing Bay
Area B
West Side Control
Area A
Rake Fullness Rating
None Found
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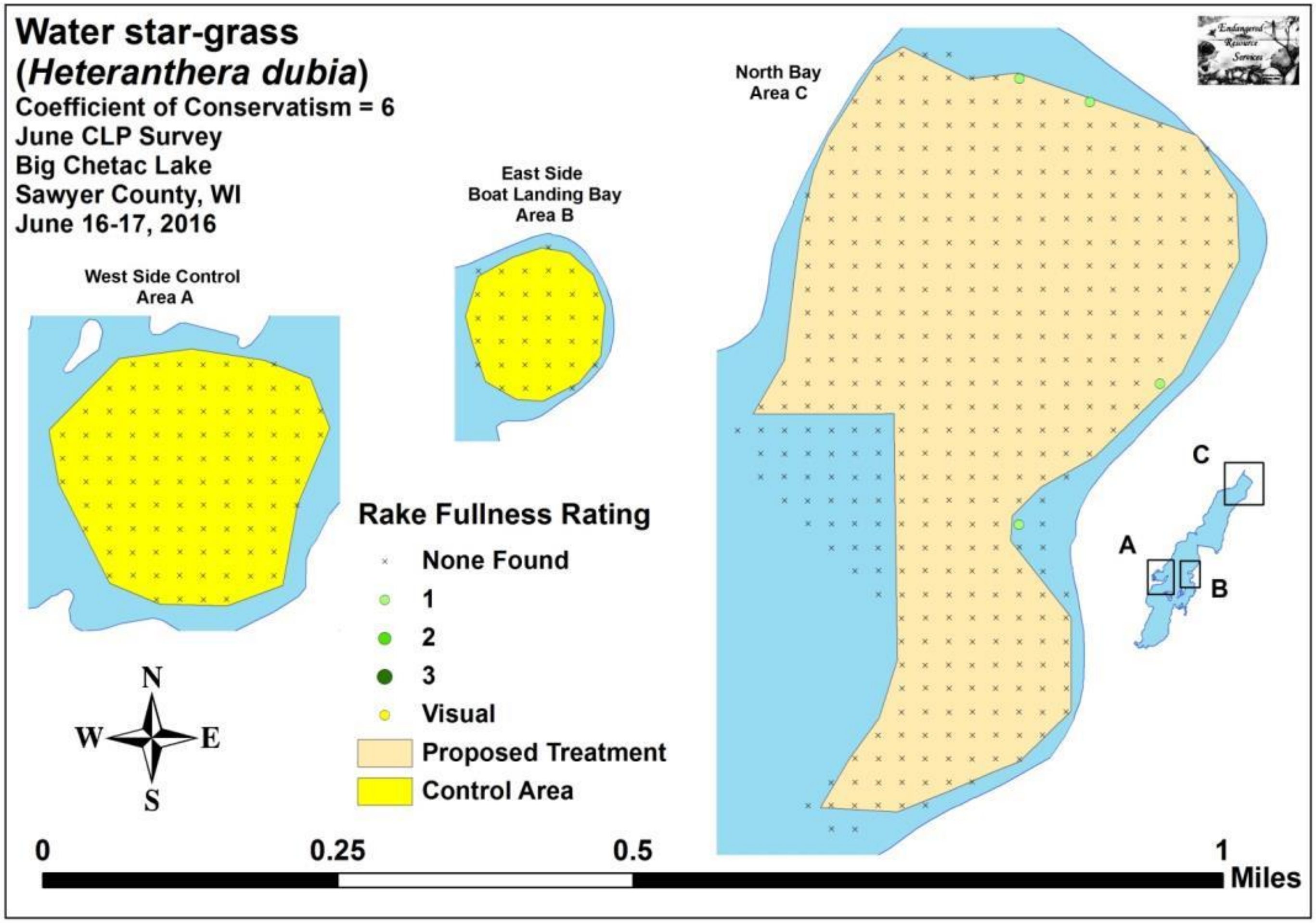

Water star-grass
(Heteranthera dubia)
Coefficient of Conservatism = 6
June CLP Survey
Big Chetac Lake
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June 16-17, 2016
West Side Control
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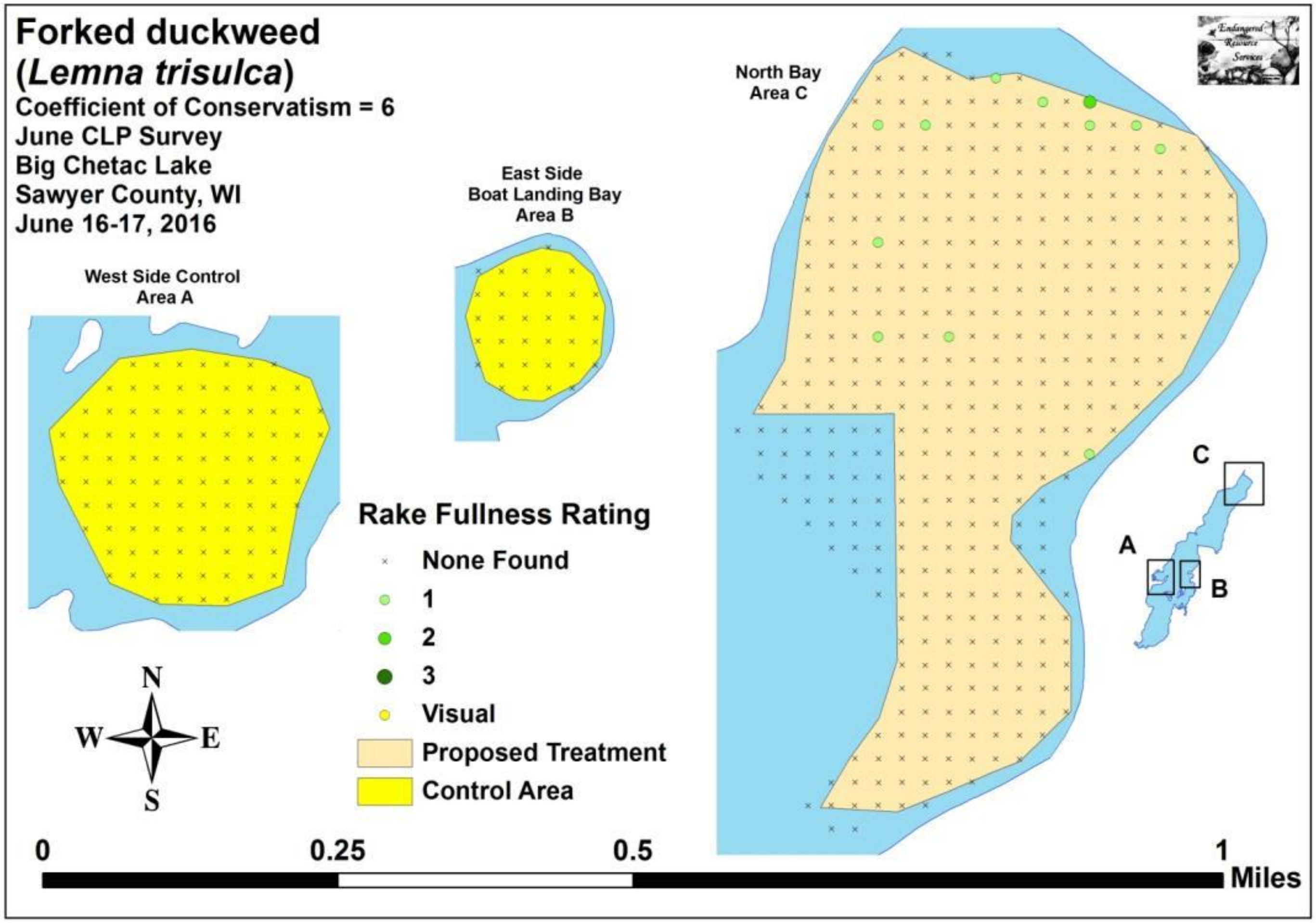
Forked duckweed
(Lemna trisulca)
Coefficient of Conservatism = 6
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
East Side
Boat Landing Bay
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West Side Control
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Rake Fullness Rating
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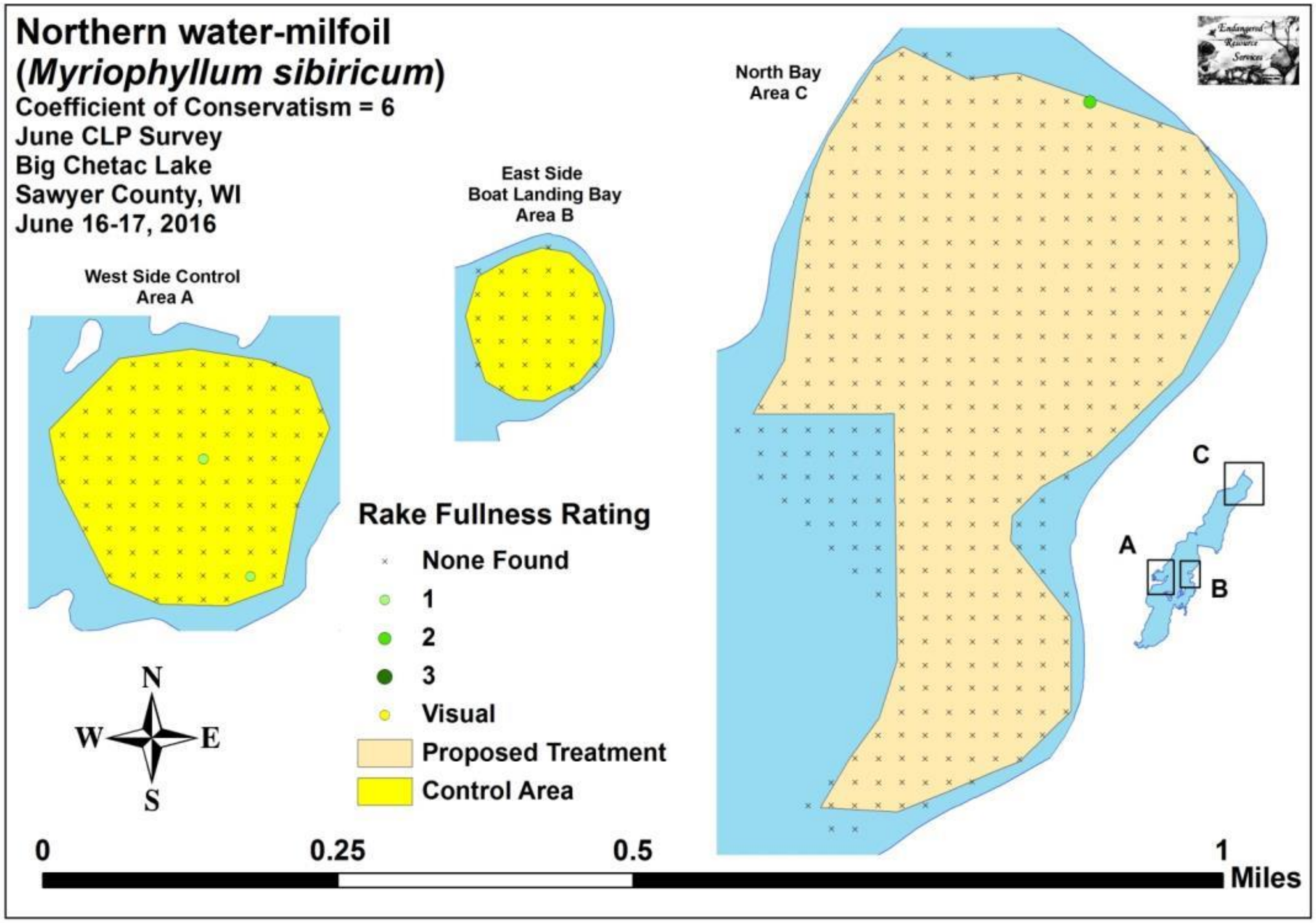
Northern water-milfoil
(*Myriophyllum sibiricum*)
Coefficient of Conservatism = 6
June CLP Survey
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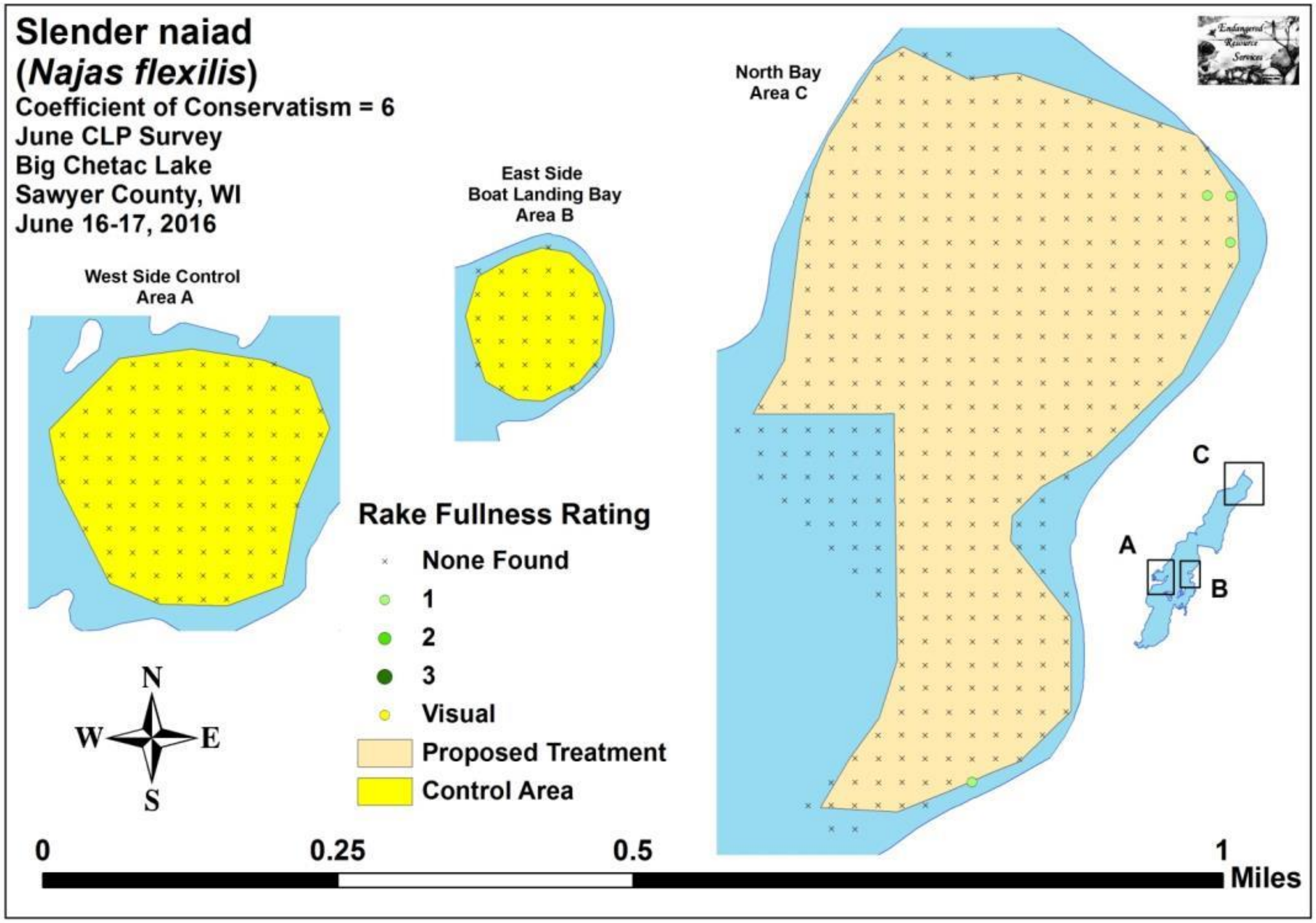
Slender naiad
(Najas flexilis)
Coefficient of Conservatism = 6
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
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North Bay
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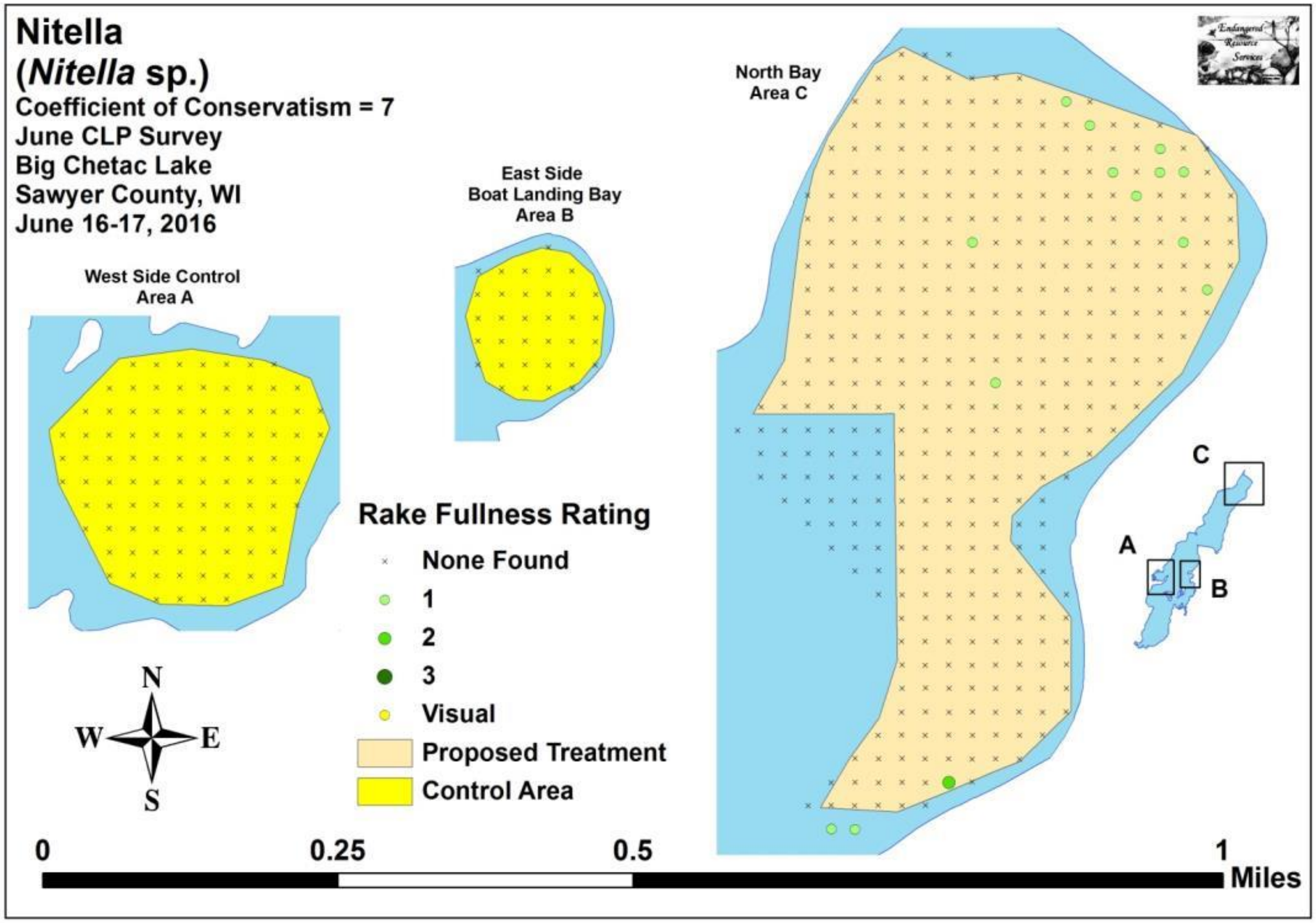

Nitella
(*Nitella* sp.)
Coefficient of Conservatism = 7
June CLP Survey
Big Chetac Lake
Sawyer County, WI
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West Side Control
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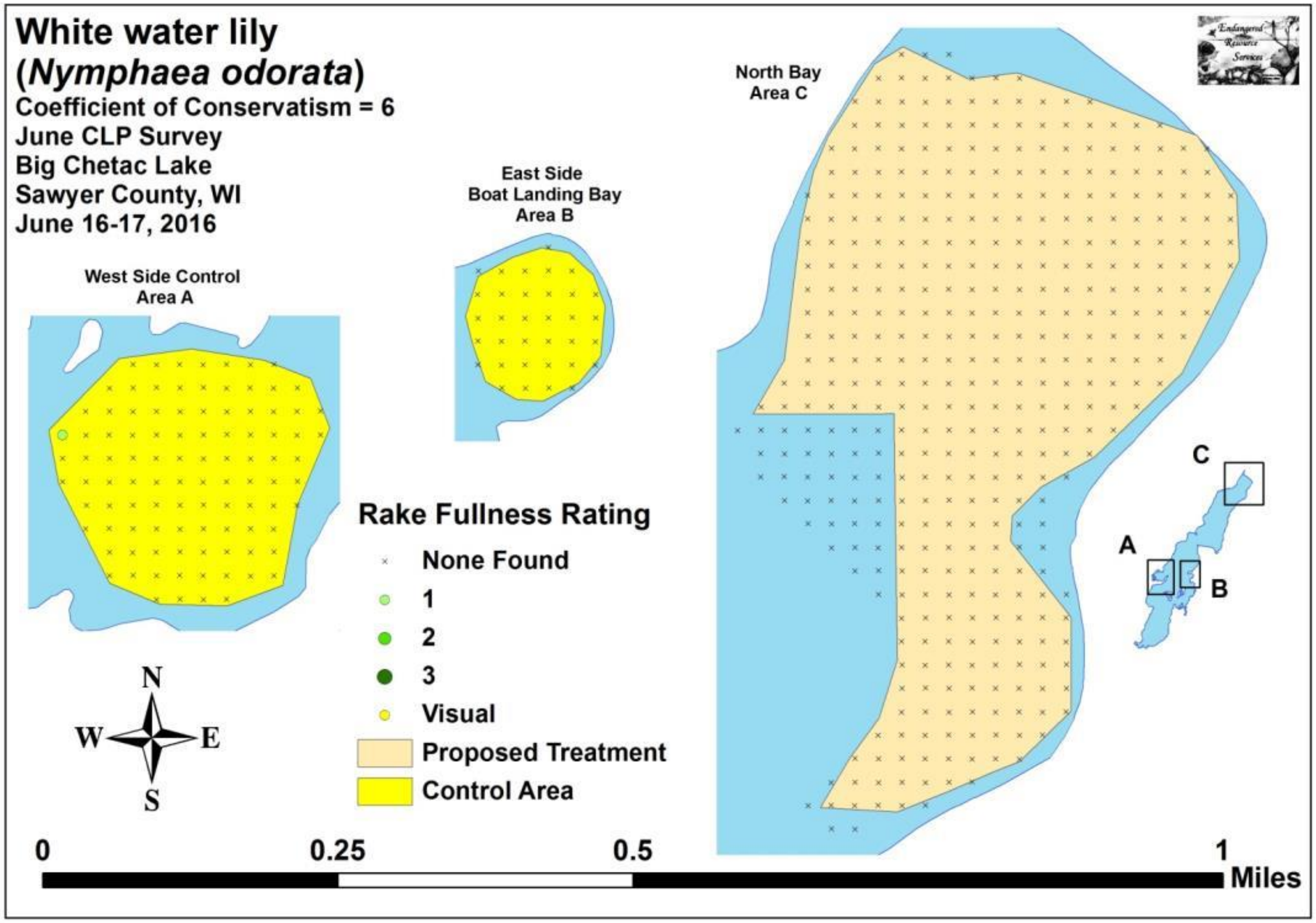
White water lily
(*Nymphaea odorata*)
Coefficient of Conservatism = 6
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
East Side
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Area B
North Bay
Area C
Rake Fullness Rating
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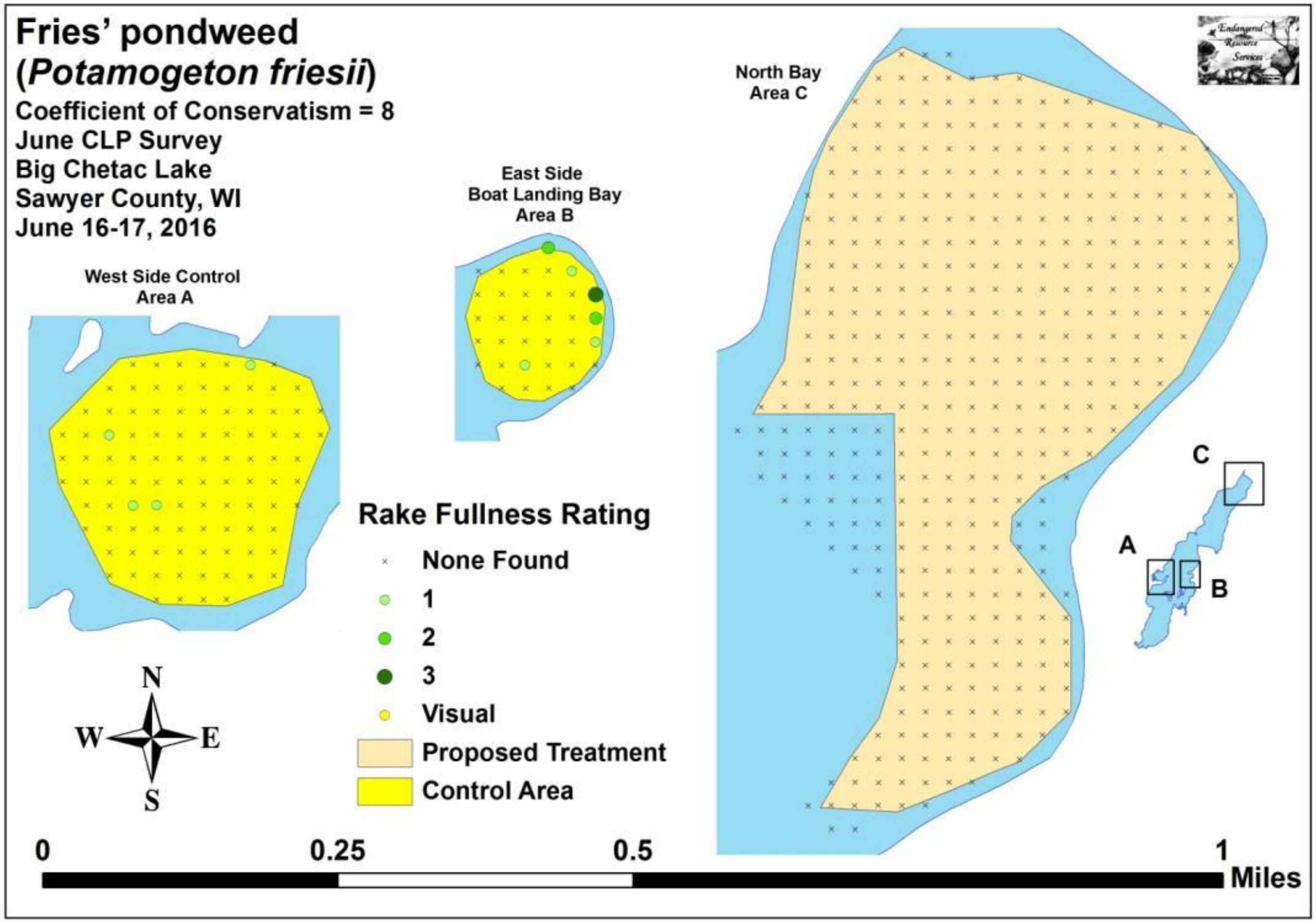
Fries' pondweed
(Potamogeton friesii)
Coefficient of Conservatism = 8
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
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North Bay
Area C
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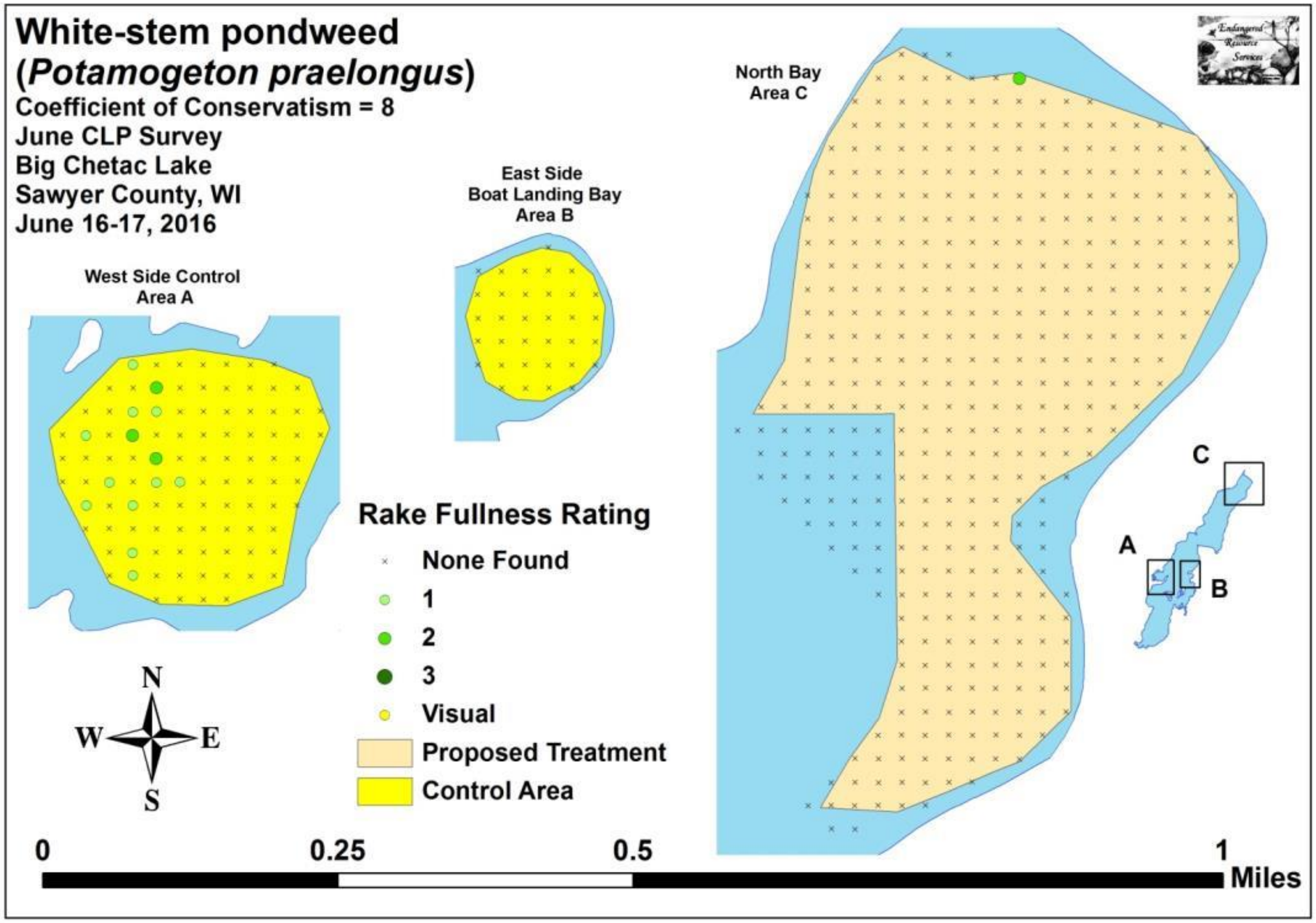
White-stem pondweed
(Potamogeton praelongus)
Coefficient of Conservatism = 8
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
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Boat Landing Bay
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Rake Fullness Rating
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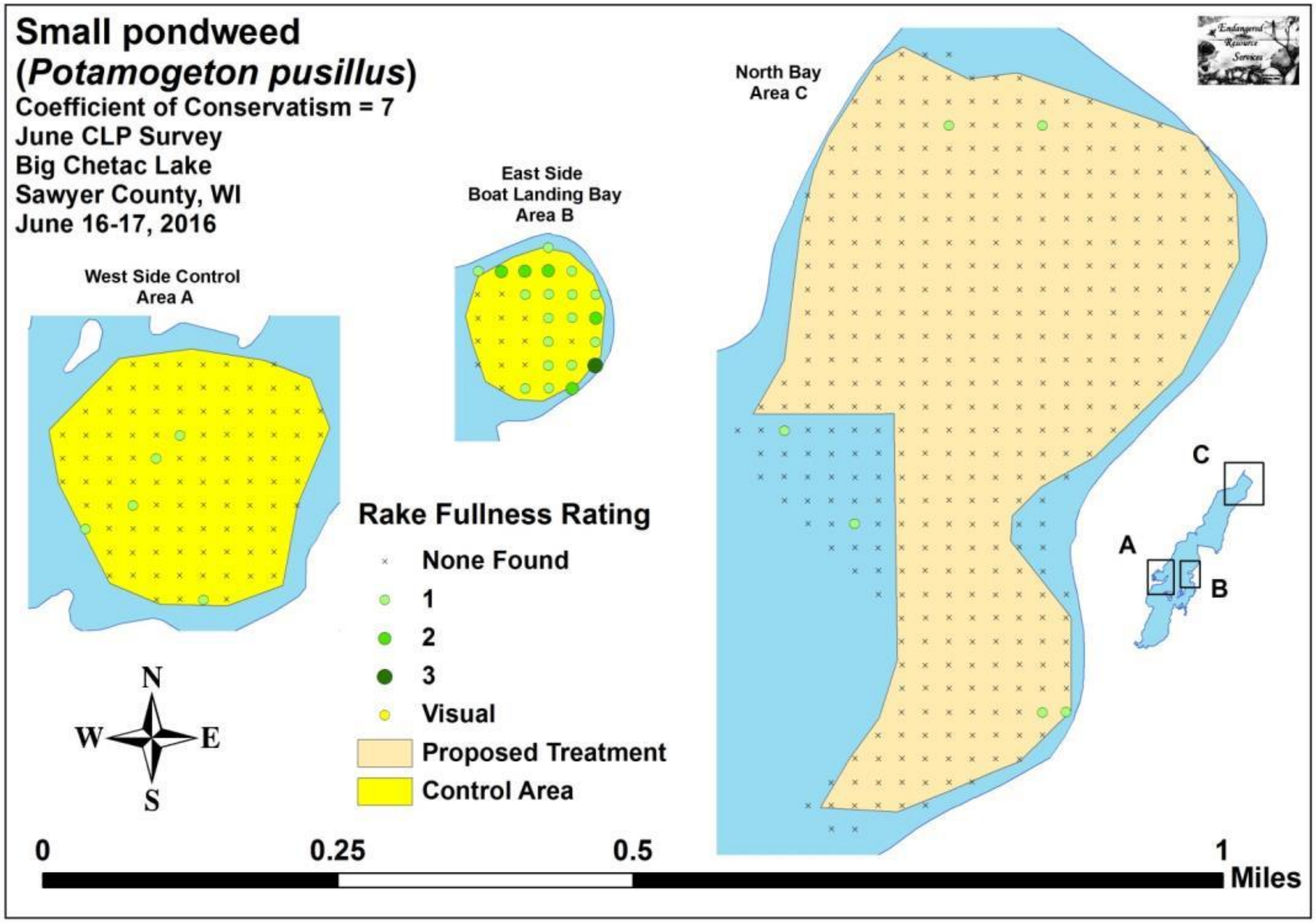

Small pondweed
(*Potamogeton pusillus*)
Coefficient of Conservatism = 7
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
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East Side
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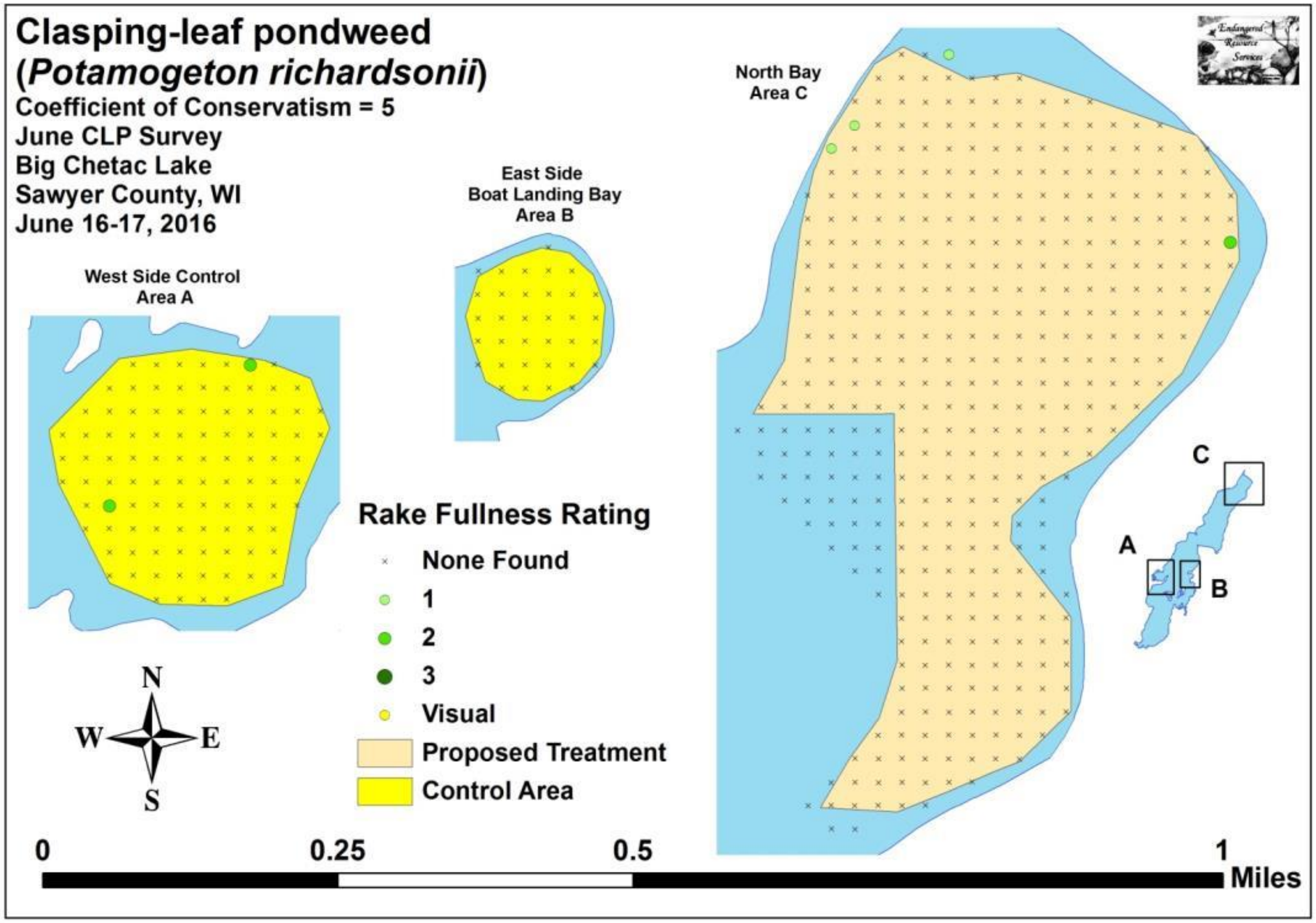

Clasping-leaf pondweed
(Potamogeton richardsonii)
Coefficient of Conservatism = 5
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
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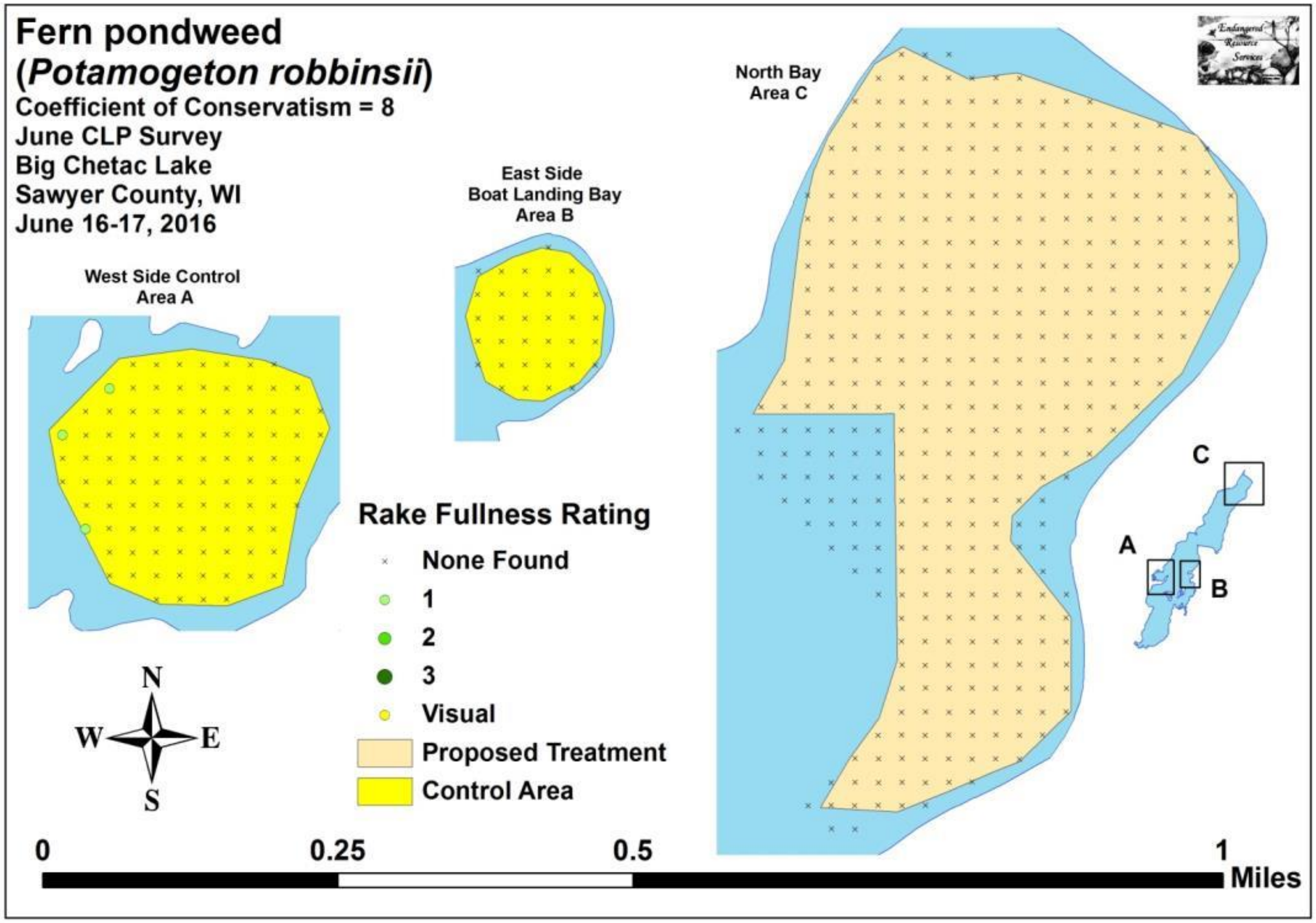

Fern pondweed
(*Potamogeton robbinsii*)
Coefficient of Conservatism = 8
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
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Control Area
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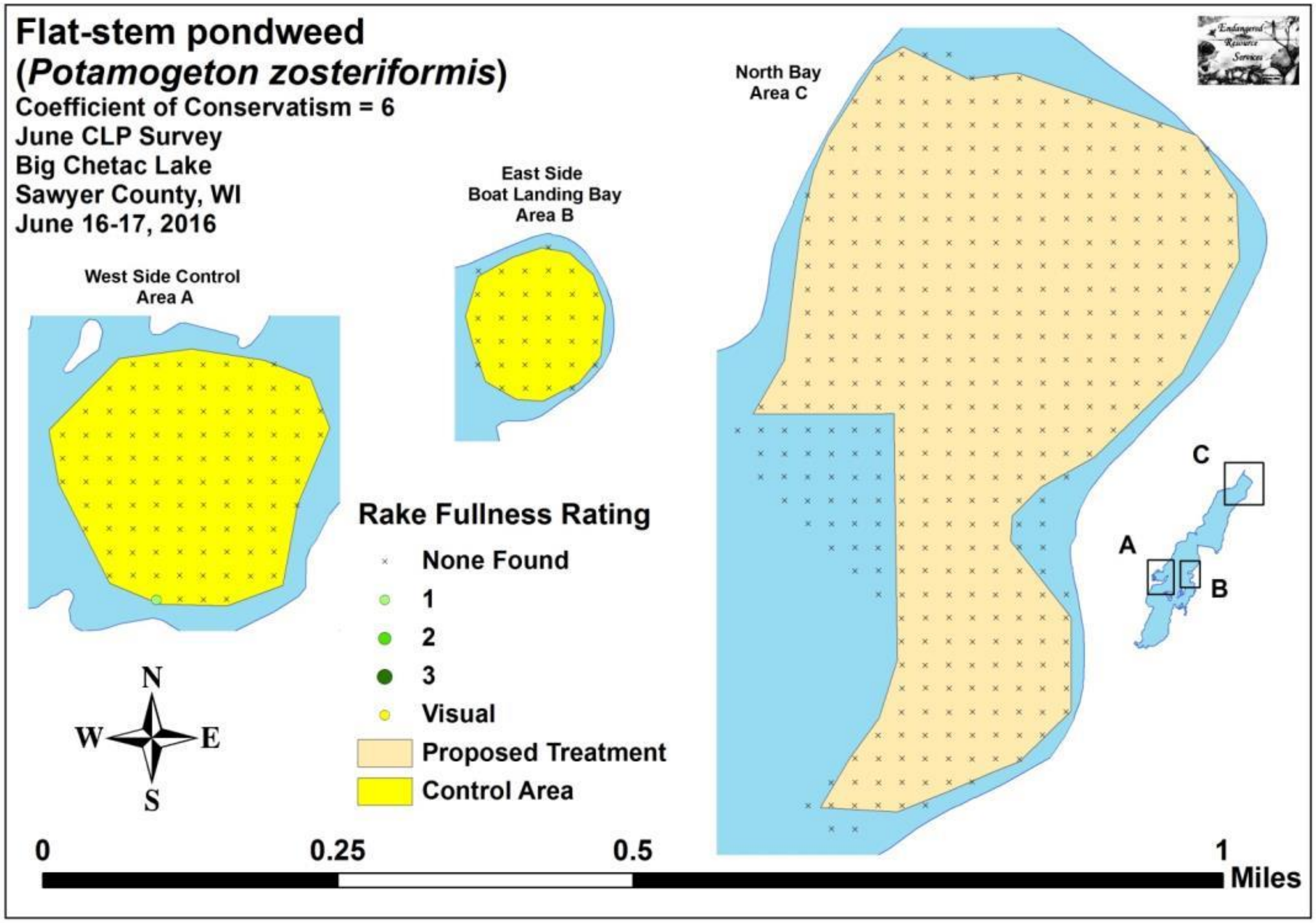

Flat-stem pondweed
(*Potamogeton zosteriformis*)
Coefficient of Conservatism = 6
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
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Proposed Treatment
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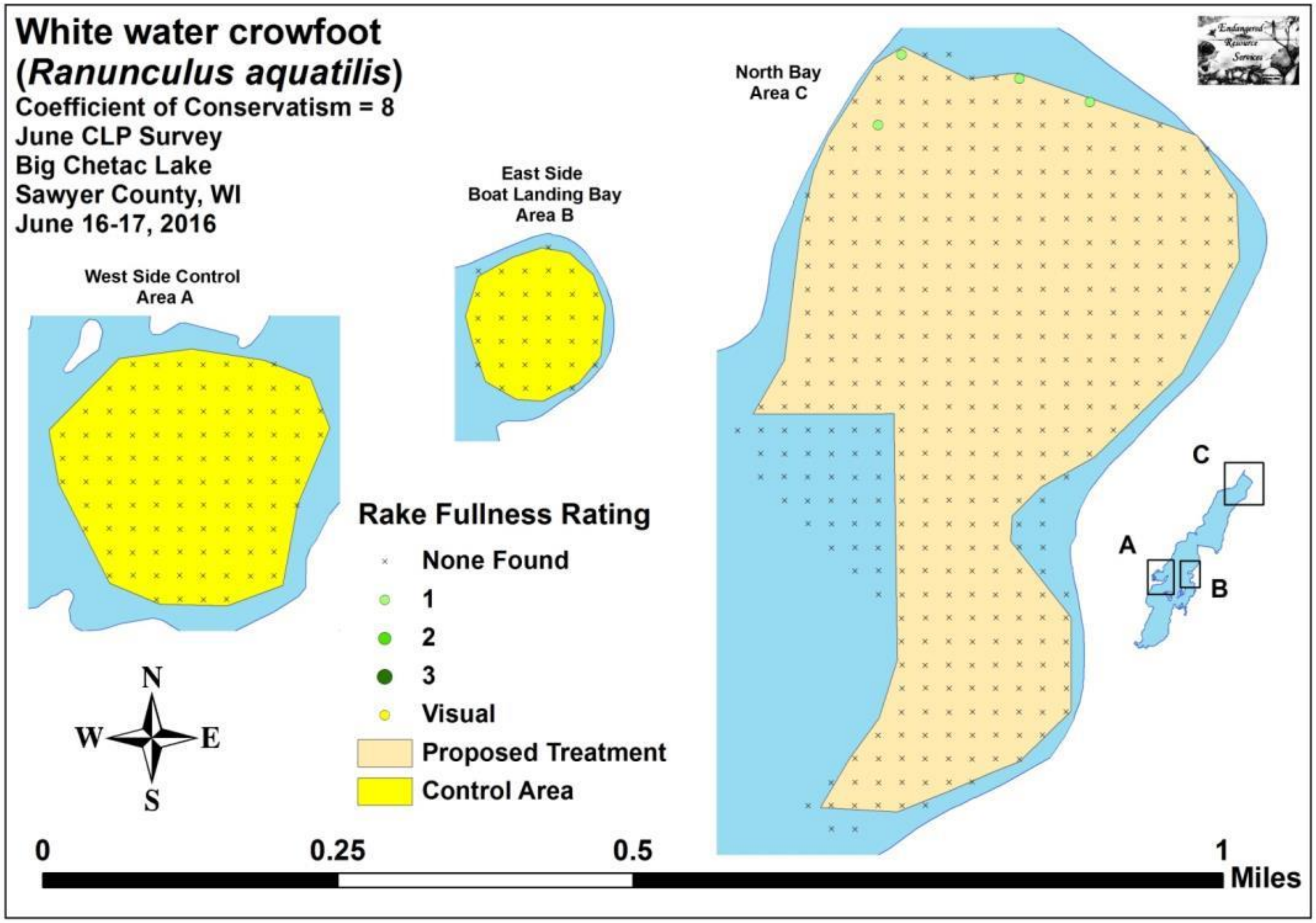
White water crowfoot
(Ranunculus aquatilis)
Coefficient of Conservatism = 8
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
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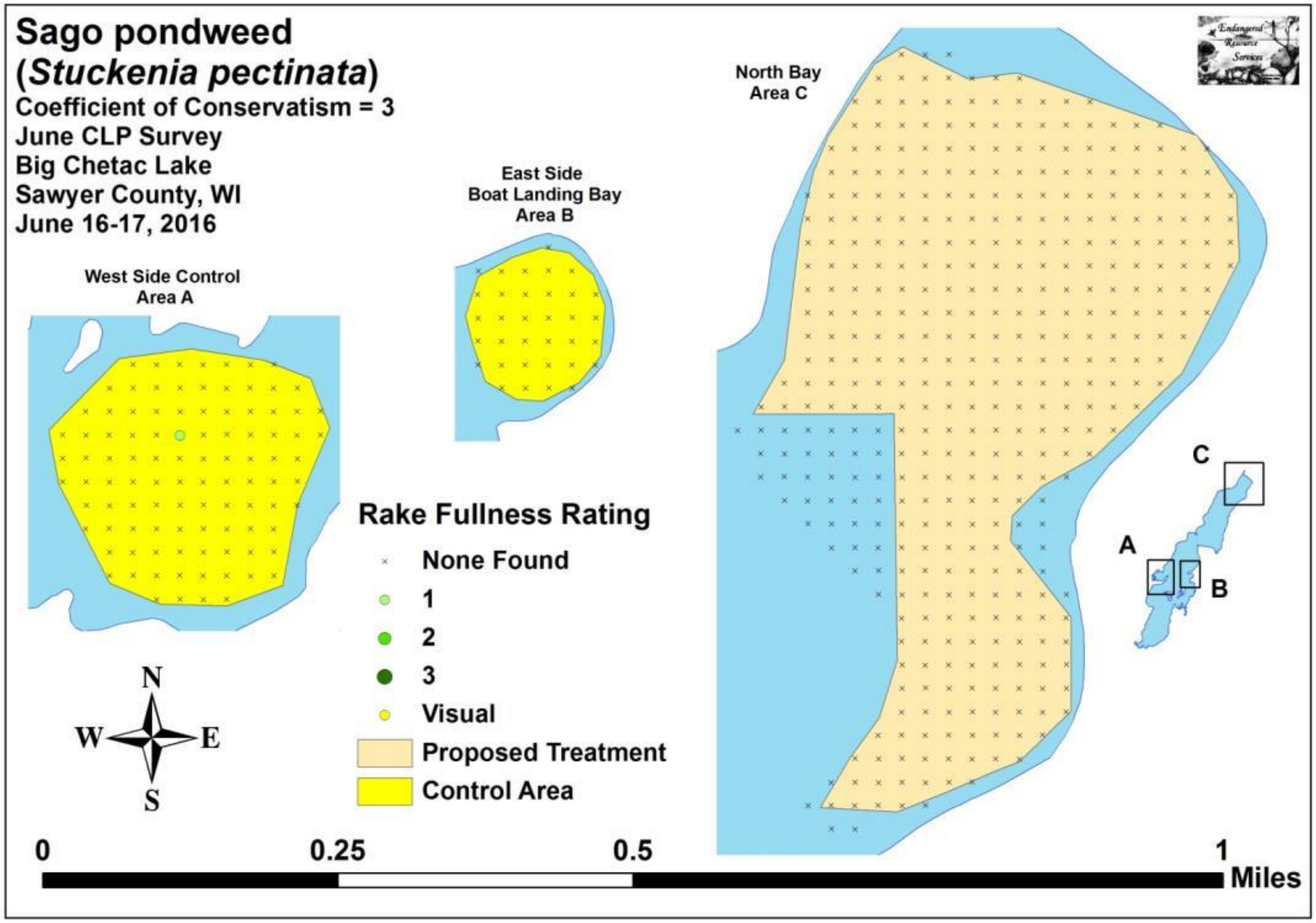
Sago pondweed
(*Stuckenia pectinata*)
Coefficient of Conservatism = 3
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
None Found
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Proposed Treatment
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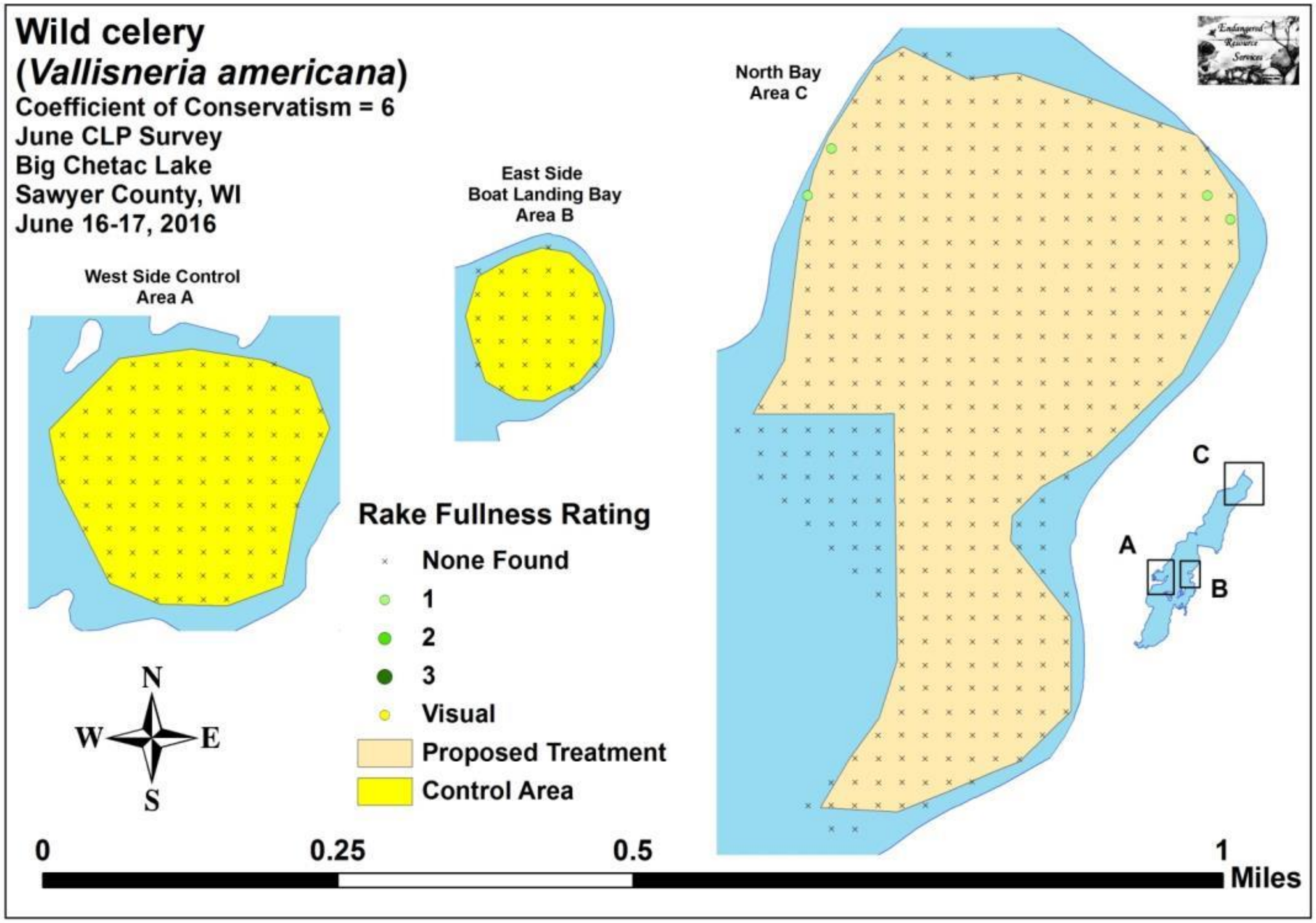
Wild celery
(Vallisneria americana)
Coefficient of Conservatism = 6
June CLP Survey
Big Chetac Lake
Sawyer County, WI
June 16-17, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Rake Fullness Rating
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Appendix VIII: Glossary of Biological Terms (UWEX 2010)

Aquatic:
: organisms that live in or frequent water.

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

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

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

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

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

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

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

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

Limnology:
: the study of inland lakes and waters.

Littoral:

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

Macrophytes:

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

Nutrients:

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

Organic Matter:

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

Photosynthesis:

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

Phytoplankton:

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

Plankton:

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

ppm:

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

Richness:

number of species in a particular community or habitat.

Rooted Aquatic Plants:

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

Runoff:

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

Secchi Disc:

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

Seepage lakes:

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

Turbidity:

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

Watershed:

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

Zooplankton:

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