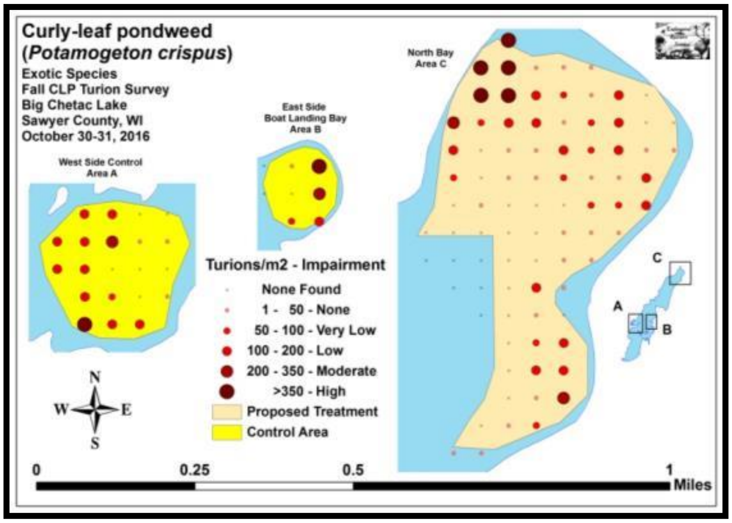
Curly-leaf pondweed (*Potamogeton crispus*)
Fall Turion Survey
Big Chetac Lake – WBIC: 2113300
Sawyer County, Wisconsin



2016 - Fall Turion Density

Germinating CLP in Sieve 10/30/16

Project Funded by:

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

Tamaracks in the North Bay – Big Chetac 10/30/16

Survey Conducted by and Report Prepared by:

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October 30-31, 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. Following the acceptance of a three year exotic species control grant to actively manage Curly-leaf pondweed (*Potamogeton crispus*), the Big Chetac Chain Lake Association and the WDNR chemically treated 90 acres on the lake in both 2013 and 2014, and 55 acres in 2015. All of these treatments occurred in the north bay – an area where CLP had nearly completely dominated the plant community. Although **no treatment occurred in 2016**, we were asked to conduct a Petite Ponar dredge survey in both the north bay and boat landing bay/western control bay areas to see how CLP had responded following a year without management. The survey found CLP turions at 56 of 85 survey points (65.88% coverage) in the north bay. This was an **increase in coverage of 51.35% from 2015** when we found turions at 37 points (43.53% coverage); however, it was still 23.29% lower than the 73 points (85.88% coverage) they were found at prior to the 2013 treatment. Along with the moderately significant increase in overall coverage **(p = 0.002)**, the **mean turion density in the north bay also increased by nearly 33%** from 64.50 turions/m^2 with a standard deviation of +/-203.48 turions/m^2 in 2015to 85.75 turions/m^2 with a standard deviation of +/-157.70 turions/m^2 in 2016. This represented the highest density of turions found in the north bay during any of the four fall surveys. In the control bays, turions coverage dropped from 24 of 29 points (82.76%) in 2015 to 20 points (68.97%) in 2016 – a decrease of 16.67%. Most of this drop in coverage in 2016 occurred in previously low density areas on the outer edge of the littoral zone. This, coupled with an increase in the number of shallow water turions, produced a mean density of 127.52 turions/m^2 and a standard deviation of +/-235.02 turions. Both of these values were higher than 2015 when we found an average of 69.69 turions/$m^2$with a standard deviation of +/-91.88. When comparing densities from 2015 to 2016, **these results demonstrated a non-significant increase in mean turion density in the north bay area (t = +0.96, p = 0.17)**, and a **significant increase in the control bays (t = +1.24, p = 0.04)**. Within the north bay, the number of points predicted to be at the nuisance level (densities >200 turions/m^2) also increased 83% from four in 2015 to seven in 2016; although this was still well below the 26 predicted nuisance points (30.59% of all points) found during the 2013 pretreatment survey. In the control bays, there were four nuisance points which was identical to the pretreatment baseline.

LIST OF FIGURES AND TABLES

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).

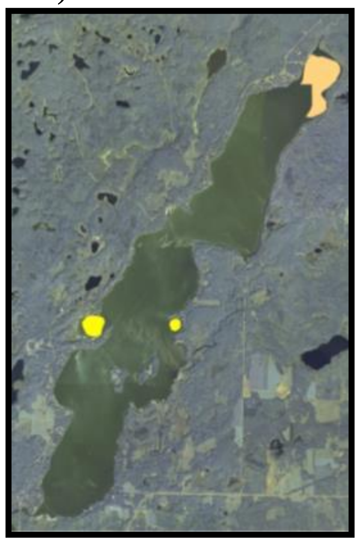

Figure 1: 2016 Proposed Spring CLP Treatment and Control Areas

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 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.

CLP LIFE HISTORY AND STUDY OBJECTIVES:

Although Curly-leaf pondweed occasionally reproduces by seed, the vast majority of plants resprout from stiff overwintering buds called turions that are normally produced in number by the plants prior to their late June/early July senescence (Figure 2). After the pinecone-like turions germinate in late fall or early winter, plants continue to grow slowly under the ice. Following ice out, growth accelerates, and plants rapidly canopy allowing them a competitive advantage over slower growing native species (Capers 2005).

Figure 2: Germinating CLP Turions – North Bay of Big Chetac

Research suggests approximately 50% of turions germinate in a growing season while the rest remain dormant until the following growing season when another 50% will germinate (Johnson 2012). Depending on the level of turions at a given location, and knowing that latent turions may be able to survive for over 5 years in the sediment, it may take several years of control to exhaust the "turion bank" (R. Newman – U of M unpublished data).

In 2013, we conducted a baseline Ponar dredge turion survey in the scheduled treatment and control areas, and a follow-up turion survey after the treatment and summer growing season. This survey demonstrated a highly significant reduction in turions in the north bay treatment area, but no significant change in the two control areas. Following the 2014 treatment and summer growing season, our fall survey found the turion density had experienced a further significant decline, while the two control areas had a significant increase. The fall 2015 turion survey found that, despite the total coverage declining, turion density unexpectedly showed a non-significant increase in the treatment area while the control areas had a non-significant decline. Although no treatment occurred in 2016, we were again asked to conduct a fall survey to see not treating the north bay had impacted the turion "bank". This report is the summary analysis of that survey completed on October 30-31, 2016. For ease in understanding the changes that have taken place in the bay, we have included data from all five turion surveys.

METHODS:
Ponar Dredge Turion Survey:

Within the initial 2013 proposed treatment and control area shapefiles, we used Hawth's Analysis Tools Extension to ArcGIS 9.3.1 to generate regular points at the rate of approximately 1 point for every 1.25 acres. This resulted in a sampling grid totaling 114 points of which 85 were in the 97.5 acre north bay, 21 were in the 25 acre western control bay, and 8 were in the 7.5 acre boat landing control bay (Figure 3) (Appendix I). This same sampling grid was used for each of the five surveys to allow for the most accurate comparison possible.

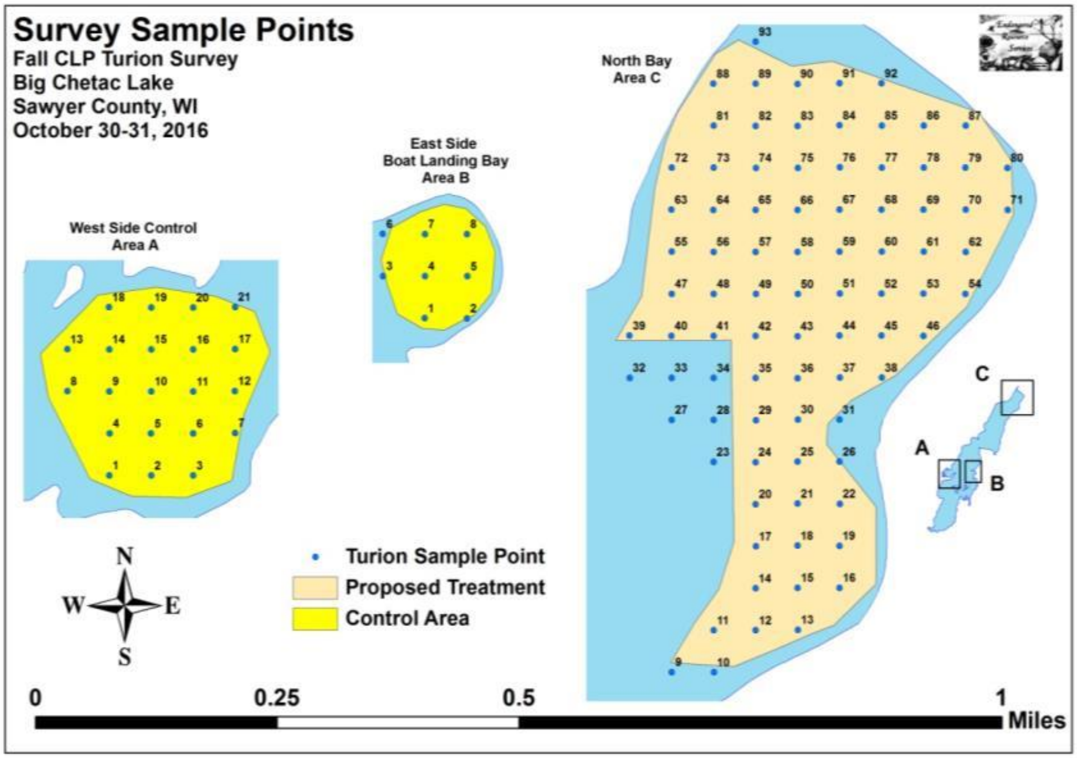

Figure 3: 2016 Turion Survey Sample Points

During the surveys, we located each point with a handheld mapping GPS unit (Garmin 76CSx) and used a Petite Ponar dredge with a 0.0232m^2 (36in^2) sample area to take a bottom sediment grab from each side of the boat at each location. These samples were then rinsed in a fine sieve to separate out the sediment (Figure 4). Samples with high numbers of turions/levels of detritus were bagged for later analysis at which time we discarded all rotten turions, tallied all live turions, and multiplied the combined total live turions from the two samples by 21.53 to estimate turions/m^2 at each location. This value gives an idea of how many CLP plants will germinate in an area in 2017.

Figure 4: Ponar Grab and Turion Sieving

DATA ANALYSIS:

We entered all data collected into an Excel spreadsheet and used standard formulas in the data analysis tool pack to calculate the following:

<u>Total number of points sampled:</u> This value is the total number of points on the lake within each study area. We took two Ponar samples at each sample point during each survey.

<u>Total number of live turions:</u> This value includes all live turions found at all sites within a study area.

<u>Total number of points with live turions:</u> This number includes all survey sites that had at least one turion in **either** of the Ponar samples taken at the site.

<u>Frequency of occurrence:</u> The frequency of turions is generally reported as a percentage of occurrences at all sample points. The value is used to extrapolate coverage within the study area. For example, if 20% of all sample sites have turions, it suggests that 20% of the study area will have at least some Curly-leaf pondweed coverage.

<u>Points at or above nuisance level:</u> This value gives the number of survey sites within the study area that were above the moderate nuisance threshold (Figure 5). Research suggests that when the turion density is at or above 200/m^2, the resulting CLP growth is likely to at least moderately impair navigation (Johnson 2012).

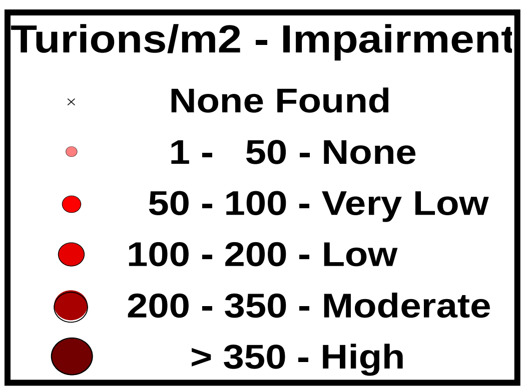

Figure 5: Predicted Navigation Impairment Based on Turion Density

<u>Percent nuisance level:</u> The percentage of nuisance points divided by the total survey points can be extrapolated to determine what percent of the study area is likely to have at least moderate navigation impairment during the coming growing season.

<u>Mean turions/m^2:</u> This value is the average number of turions/m^2 when pooling the data from all survey sites regardless of whether or not they had turions present.

<u>Standard deviation of turions/m^2:</u> This value tells us how far apart the data is from the mean. A low standard deviation suggests most points have a turion density that was similar to the mean, while a high value suggests there was greater variability in turion density within the sample area.

Pre/Post Treatment, Spring/Fall, and Year/Year Significance:
Density data from the five surveys was analyzed using paired t-tests as we returned to the same sites during each survey (Table 1). For total distribution comparisons in 2016, we also used Chi-square analysis. All differences (Pre/posttreatment, spring/fall, and year/year) were determined to be significant at $p < .05$, moderately significant at $p < .01$, and highly significant at $p < .005$.

RESULTS AND DISCUSSION:

May 2013 Ponar Dredge Turion Survey:

During the initial May 11-12, 2013 pretreatment turion survey, we found Curly-leaf pondweed turions at 73 of 85 survey points (85.88%) in the north bay treatment area, and in 23 of 29 points (79.31%) in the control bays (Table 1). In the north bay treatment area, 26 points had densities of 200 turions/m^2 or higher suggesting that over 30% of the north bay would have experienced moderate to severe navigation impairment without management (Figure 6) (Appendix II). Results from the control bays suggested lower overall CLP densities with only four points or approximately 14% of the area reaching the nuisance level.

We found that initial turion densities were highly variable as the standard deviation in the north bay was +/- 151.88 around a mean density of 158.59 turions/m^2. In general, CLP in the deeper water areas in the south-central parts of the bed and over sandy shoreline areas on the north and east sides of the bed had lower densities while areas over organic muck in the 4-8ft range had the highest densities (Figure 6). Mean densities in the control bays were 43% lower than in the north bay with an average of 68.21 turions/m^2; however, as in the north bay, turions densities varied widely as the standard deviation was +/- 71.32. In the boat landing bay, density appeared to be primarily a function of depth, while in the western bay, both the eastern and western sides of the bed had reduced densities. This is likely related to increasing depth on the east, and, potentially, competition from a diverse native plant community on the western edge.

September 2013 Ponar Dredge Turion Survey:

The September 28-29, 2013 posttreatment turion survey revealed an approximately 23% reduction in overall turion coverage in the north treatment area with 56 of 85 points having live turions present (65.88%) (Figure 7) (Appendix II). Coverage in the control bays was also down 8% with 21 of 29 sites having turions. Although a majority of points in the treatment area still had viable turions, the nuisance level was reduced almost 75% with only seven points still having densities >200 turions/m^2. Interestingly, the control bays also experienced a 75.0% reduction in predicted nuisance coverage with a single point exceeding this threshold.

Overall mean turion density in the treatment area decreased 55.0% to 71.33 turions/m^2. Although a decline in density was not surprising, this was greater than the expected reduction of 50% based on predicted germination rates. Furthermore, this value suggests there was minimal survival or regrowth of CLP plants following treatment. In the control areas, mean density declined nearly 7% indicating that CLP plants produced turions at a rate slightly below replacement level. Densities continued to be highly variable in the treatment area as the standard deviation of +/- 142.93 was twice as high as the mean. The control areas' standard deviation of +/- 88.07 was also above the mean density of 63.02 turions/m^2.

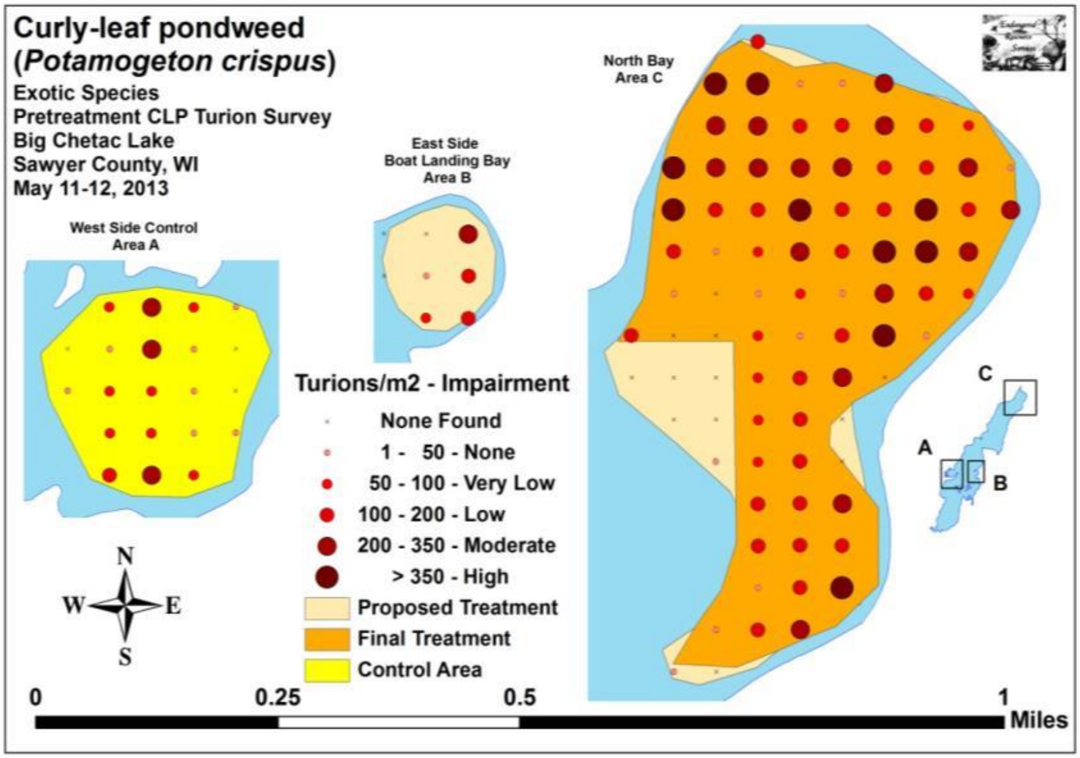

Figure 6: 2013 Pretreatment CLP Turion Density and Distribution

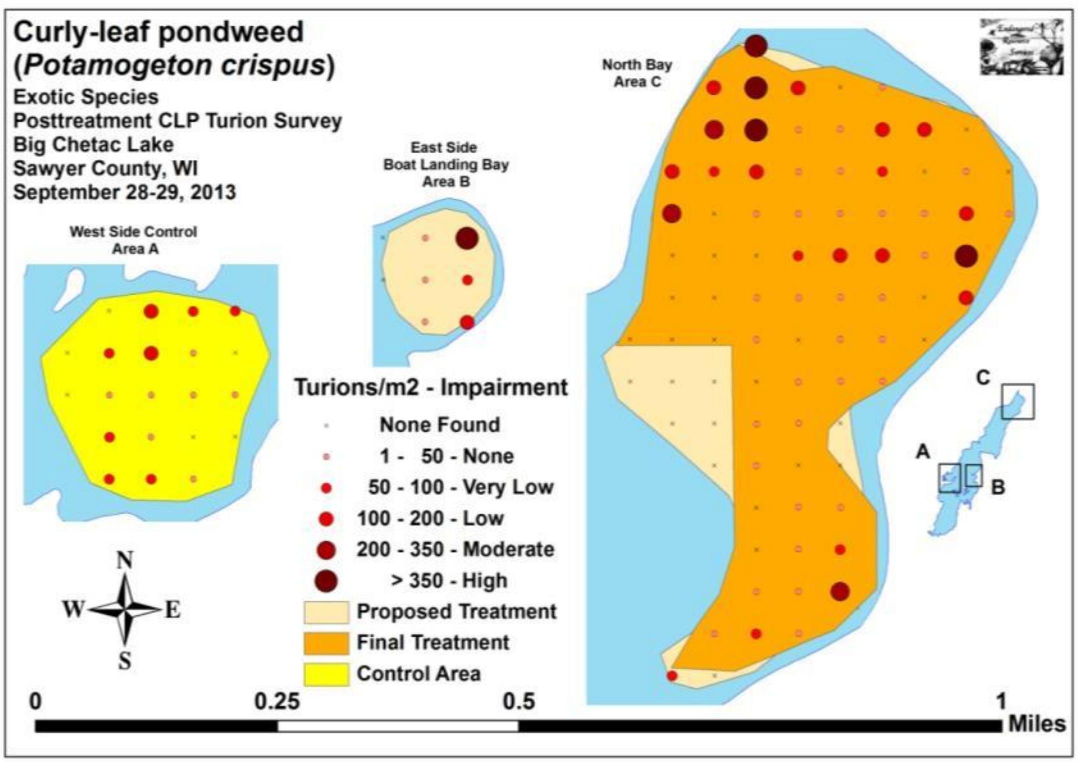

Figure 7: 2013 Posttreatment CLP Turion Density and Distribution

November 2014 Ponar Dredge Turion Survey:

When compared to September 2013, the November 2014 survey demonstrated a 12.50% reduction in overall turion coverage in the north treatment area with 49 of 85 points having live turions present (57.65%) (Figure 8) (Appendix II). This was also a nearly 33% reduction from the 73 points turions were found at during the original 2013 baseline pretreatment survey. In the control bays where coverage fell 8.7% in 2013, we found turions at 19 points suggesting a further 9.5% decline (17.5% overall when compared to the original survey). As in fall 2013, we found that the majority of points in the treatment area still had viable turions. However, only five points (5.88%) were predicted to be at the nuisance level with densities >200 turions/m^2. This was a reduction of over 80% when compared to the 26 nuisance points (30.59%) in the original pretreatment survey. The control bays, which had experienced a 75% reduction in predicted nuisance coverage in 2013, jumped back to their baseline total of four points (13.79%).

Overall mean turion density in the treatment area decreased by 35.1% (46.29 turions/m^2) when compared to fall 2013 (71.33 turions/m^2), and by 70.8% when compared to the pretreatment baseline (158.59 turions/m^2). Despite this positive outcome, we noted that it was less than the 50% decline we would have expected if the treatment had killed all turions that should have germinated. This may mean that some turions germinated after the treatment due to the late spring, or it could mean that conditions allowed for a "second crop" in late summer when additional CLP plants germinated, grow, and set turions. In the control areas, mean density increased 37.6% over fall 2013 levels to 86.74 turions/m^2. Densities in the treatment area were much less variable (+/-74.52) compared to fall 2013 (+/-142.93). The control areas' standard deviation jumped sharply to +/-138.68 (up from +/- 88.07 in fall 2013).

October 2015 Ponar Dredge Turion Survey:

When compared to November 2014, the October 2015 survey demonstrated a further 24.49% reduction in overall turion coverage in the north treatment area with 37 of 85 points having live turions present (43.53%) (Figure 9) (Appendix II). This was also a nearly 50% reduction from the 73 points turions were found at during the original 2013 baseline pretreatment survey. In the control bays, coverage was the highest we have ever documented with live turions present at 24 points (82.76%). This was an increase of over 26% from November 2014 when we found turions at 19 points (65.52% coverage), and almost identical to the initial coverage in 2013 of 23 points (79.31%). In the north treatment area, four points (4.71%) (down from five points (5.88%) in 2014) were predicted to be at the nuisance level with densities >200 turions/m^2. This was a reduction of almost 85% when compared to the 26 nuisance points (30.59%) in the original pretreatment survey. In fall 2015, the control bays were again at their 2013 baseline total of four points (13.79%).

Despite the decline in overall coverage, mean turion density in the treatment area **increased** by 39.3% (64.50 turions/m^2) when compared to fall 2014 (46.29 turions/m^2). However, it was still almost 60% below 2013 pretreatment baseline (158.59 turions/m^2). Although this was disappointing, it should be noted that two sites (point 62 – 43 turions and point 82 – 74 turions) accounted for 46% of all turions. In the control areas, mean density declined almost 20% over fall 2014 levels (86.74 turions/m^2) to 69.69 turions/m^2. Densities in the treatment area were highly variable (+/-203.48) when compared to fall 2014 (+/-74.52). The control areas' standard deviation dropped to +/-91.88 (down from +/- 138.68 in fall 2014).

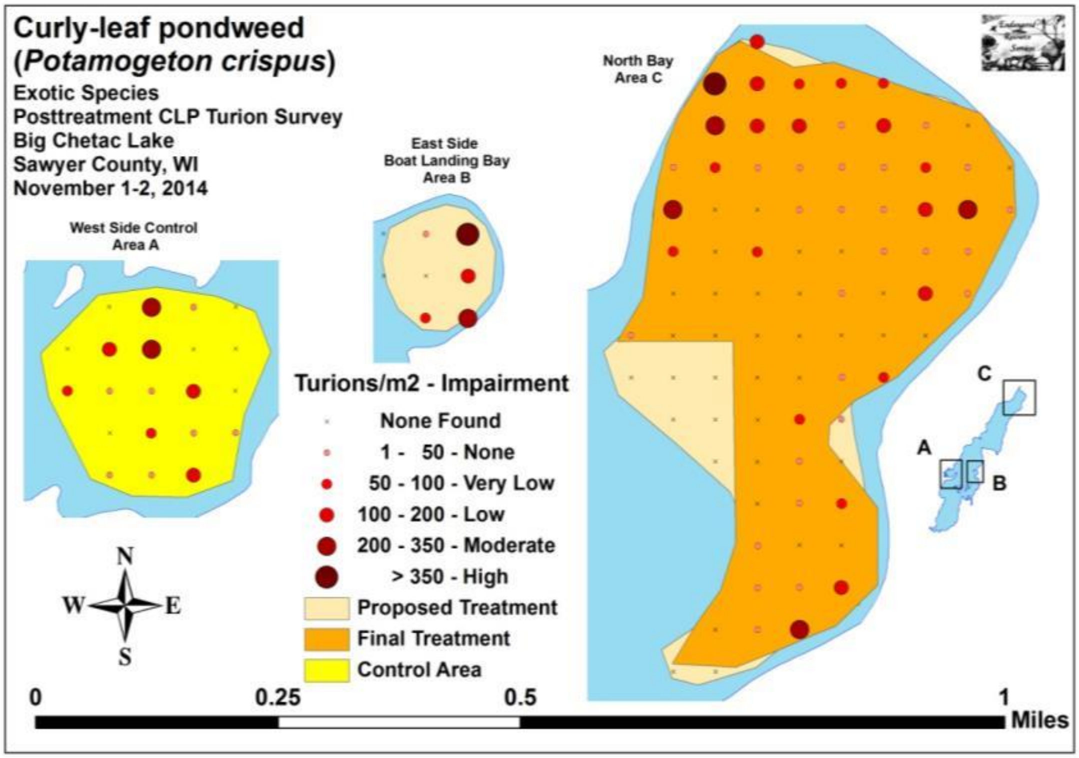

Figure 8: 2014 Posttreatment CLP Turion Density and Distribution

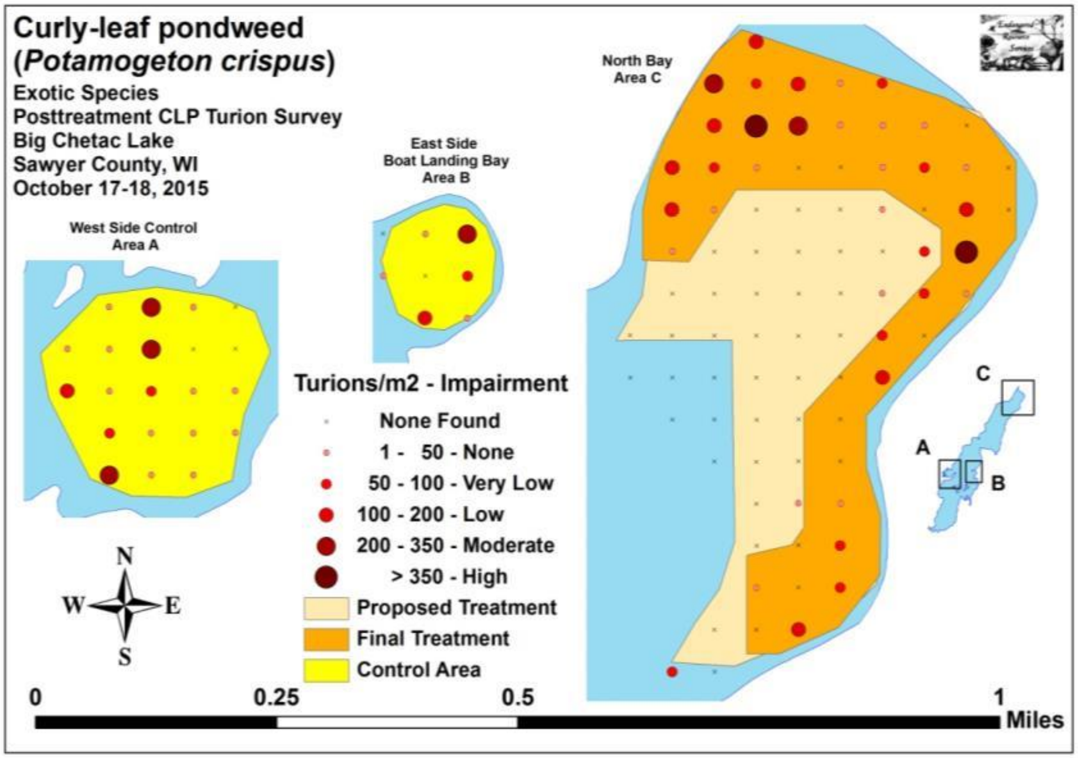

Figure 9: 2015 Posttreatment CLP Turion Density and Distribution

October 2016 Ponar Dredge Turion Survey:

Live turions were present at 56 of 85 points (65.88% coverage) in the north bay. This was a **51.35% increase in distribution compared to October 2015** when we found turions at 37 of 85 points (43.53% coverage) (Figure 10) (Appendix II). This total was 23.29% lower than the 73 points with turions (85.88% coverage) found during the original 2013 baseline pretreatment survey, and was equal to the 2013 posttreatment distribution when we also found turions at 56 points. In the control bays, coverage dropped from 24 points (82.76%) in 2015 to 20 points (68.97%) in 2016. This 16.67% reduction brought the distribution back in-line with the September 2013 and November 2014 totals when we found turions at 21 points (72.41% coverage) and 19 points (65.52% coverage) respectively. In the north treatment area, seven points (8.24% coverage) (up from four points (4.71% coverage) in 2015) were predicted to be at the nuisance level with densities >200 turions/m^2. This was a 75.00% increase when compared to fall 2015, but was still 73.08% below the 26 nuisance points (30.59% coverage) in the original pretreatment survey. In fall 2016, the control bays were again at their 2013 baseline total of four nuisance points (13.79%).

Along with the increase in overall coverage, **mean turion density in the north bay increased** by nearly 33% (85.75 turions/m^2) when compared to fall 2015 (64.50 turions/m^2) and was the highest of any fall survey. However, it was still approximately 54% below the 2013 pretreatment baseline (158.59 turions/m^2). In the control areas, the mean density nearly doubled to 127.52 turions/m2. This was an 82.98% increase over fall 2015 levels when we found 69.69 turions/m^2. As in the past, densities in both the north bay and the control areas were highly variable with both having standard deviations that were nearly twice the mean. In the north bay, the deviation declined from +/-203.48 turions in fall 2015 to +/-157.70 turions in fall 2016, while the control areas' increased sharply from +/-91.88 turions in fall 2015 to +/- 235.02 in fall 2016.

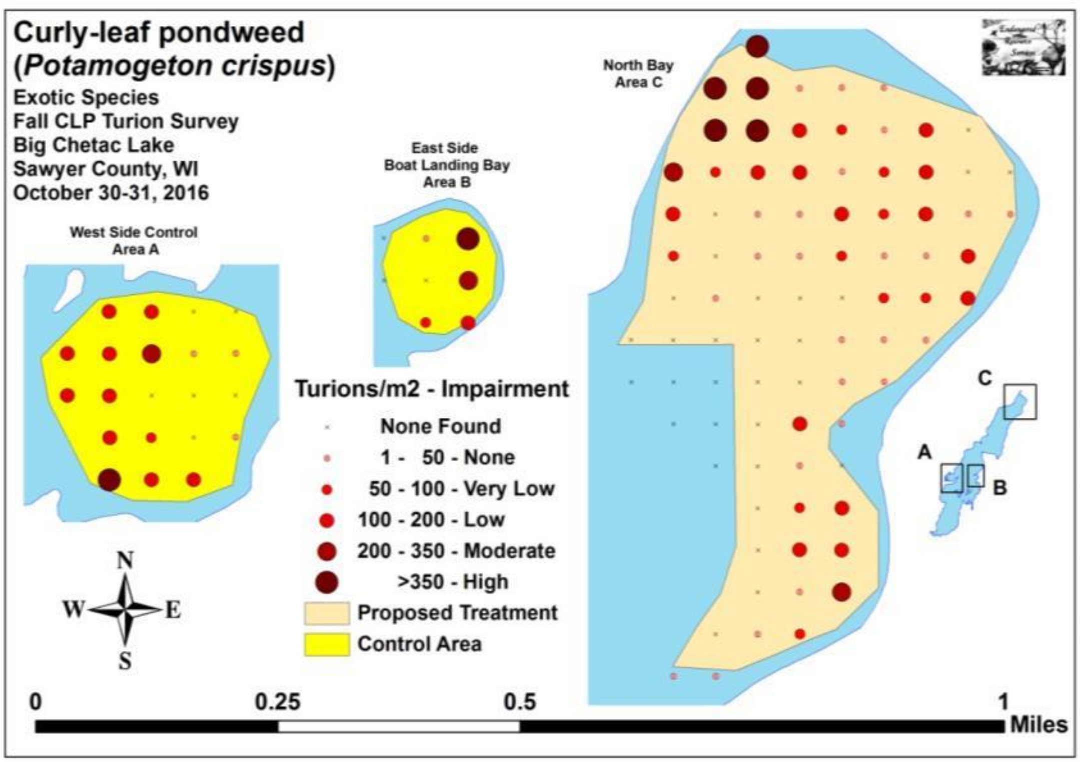

Figure 10: 2016 Fall CLP Turion Density and Distribution

Table 1: CLP Turion Surveys - Summary Statistics
Big Chetac Lake, Sawyer County
May 11-12 and September 28-29, 2013, November 1-2, 2014,
October 17-18, 2015, and October 30-31, 2016

Summary Statistics:	North Bay Treatment Area					Boat Landing and Western Control Bays				
	2013 Pre	2013 Post	2014 Post	2015 Post	2016 Fall	2013 May	2013 Sept.	2014 Nov.	2015 Oct.	2016 Oct.
Total number of points sampled	85	85	85	85	85	29	29	29	29	29
Total live turions	627	282	183	255	339	92	85	117	94	172
Total number of points with live turions	73	56	49	37	56	23	21	19	24	20
Frequency of occurrence	85.88%	65.88%	57.65%	43.53%	65.88%	79.31%	72.41%	65.52%	82.76%	68.97%
Points at or above nuisance level (+200/m^2)	26	7	5	4	7	4	1	4	4	4
% nuisance level	30.59%	8.24%	5.88%	4.71%	8.24%	13.79%	3.45%	13.79%	13.79%	13.79%
Maximum turions/m^2	731	1,011	387	1,591	1,011	237	430	645	344	1,247
Mean turions/m^2	158.59	71.33	46.29	64.50	85.75	68.21	63.02	86.74	69.69	127.52
Standard deviation/m^2	151.88	142.93	74.52	203.48	157.70	71.32	88.07	138.68	91.88	235.02
Standard error of the paired difference		0.72	0.67	0.98	1.02		0.46	0.57	0.92	1.56
Degrees of freedom		84	84	84	84		28	28	28	28
t-statistic		-5.65	-1.74	+0.87	+0.96		-0.51	+1.91	-0.87	+1.24
p-value		***<.001	***0.04**	0.19	0.17		0.30	***0.03**	0.20	***0.04**

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

Statistical Analysis of Surveys:

Using a paired t-test to compare the results of the 2015 and 2016 October surveys, we found that the **increase in the north bay turion densities was not significant** ($p = 0.17$) (Table 1). However, the Chi-square analysis showed a **moderately significant increase in distribution** (***p* =0.003**). The reason for the lack of significance in the overall increase in the north bay's turion density seems to be the large number of low density points in deep water areas where CLP appeared to be recolonizing. Although these points contributed to the significant expansion value, they tended to dampen the larger density increases seen in shallow waters. This resulted in a p-value that was only suggestive of a positive increase in the overall mean density.

In the control areas, we found **the increase in turion densities was significant** ($p = 0.04$), but, **the decline in distribution was not** ($p = 0.22$). Analysis of the 2015 and 2016 maps in these areas revealed that the decline in distribution primarily occurred along the deepwater edge. This, coupled with a few very high density points (maximum of 1,247 turions/m^2) in shallow water, produced the significant increase in mean densities seen in the control areas.

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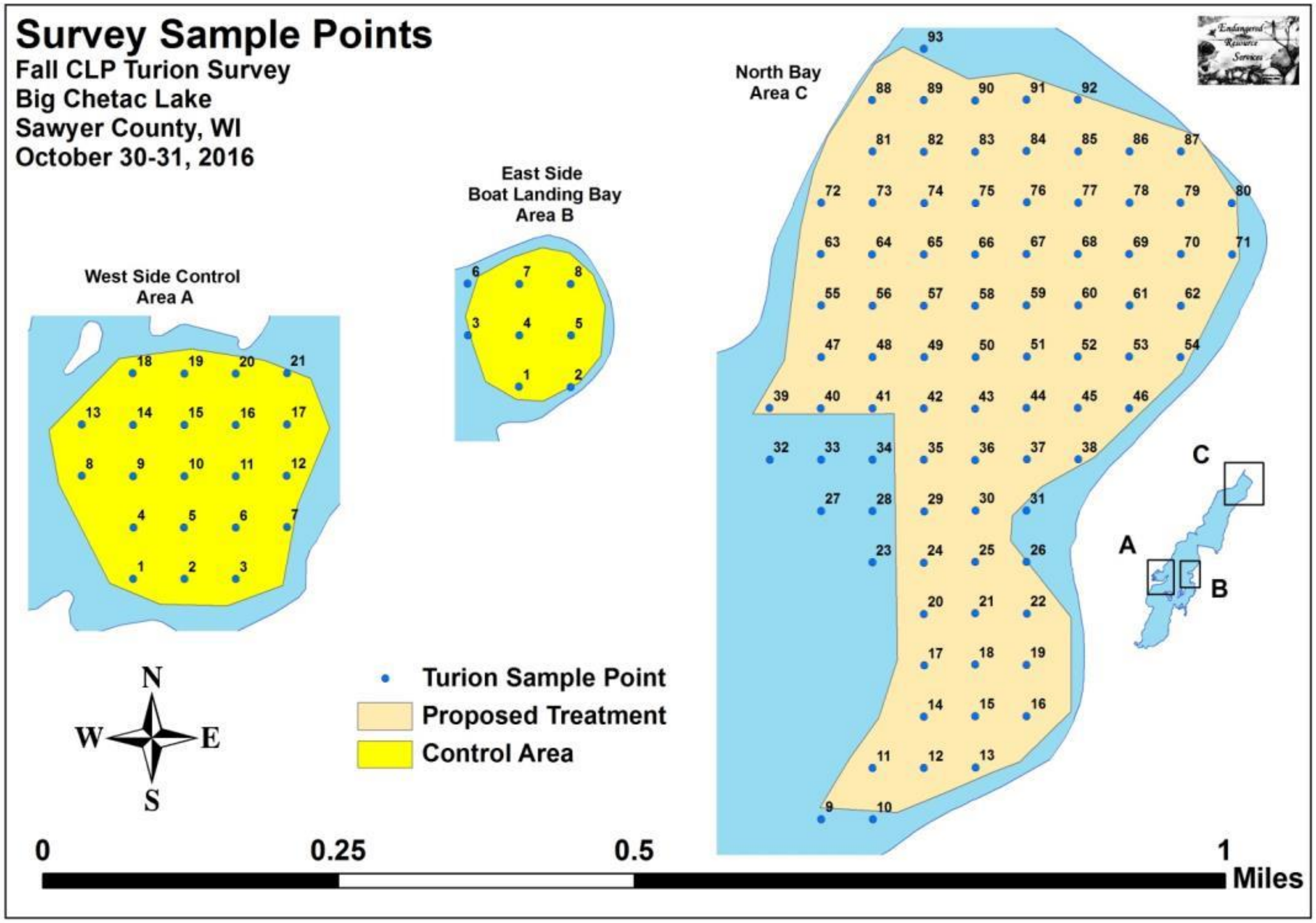
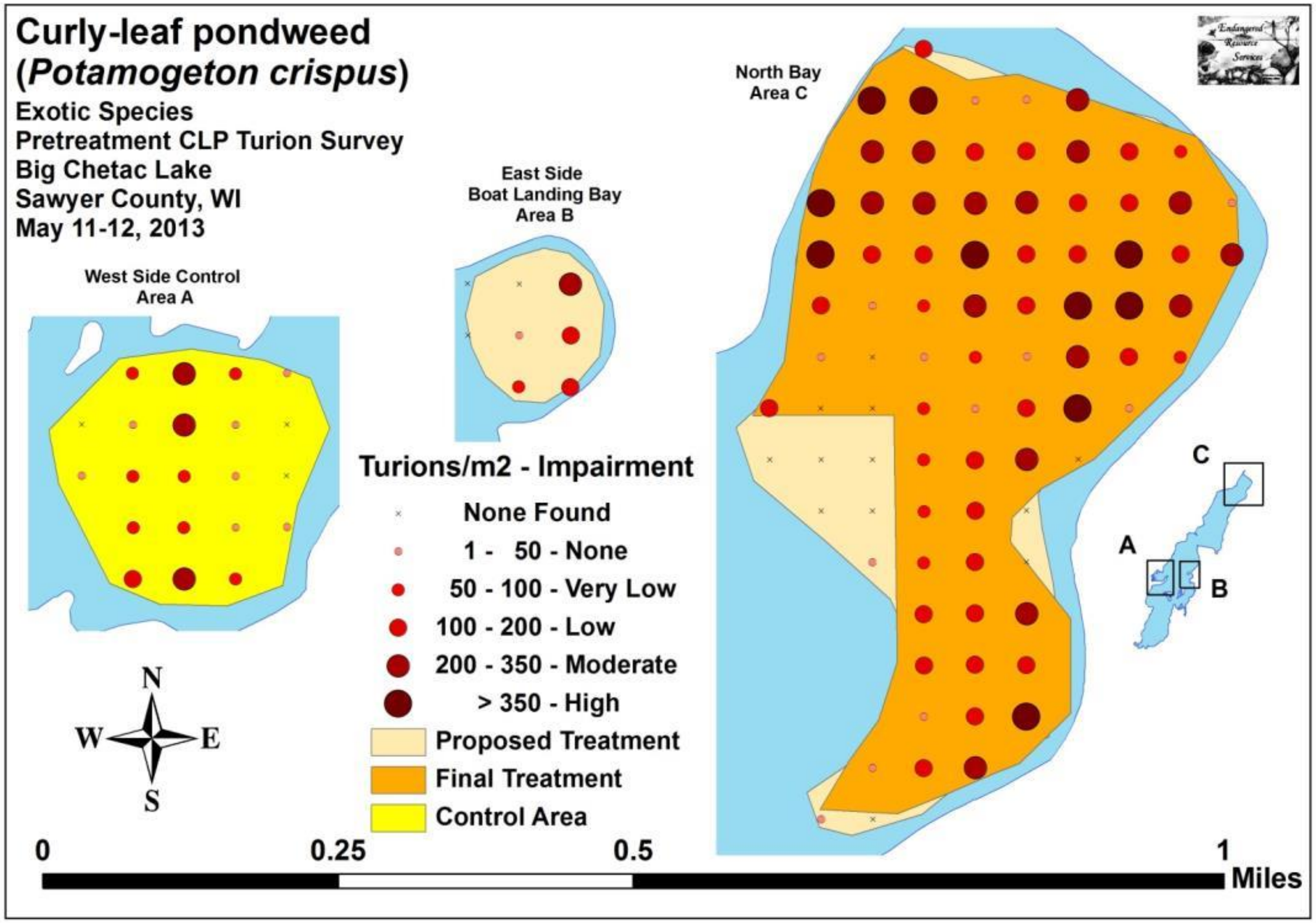
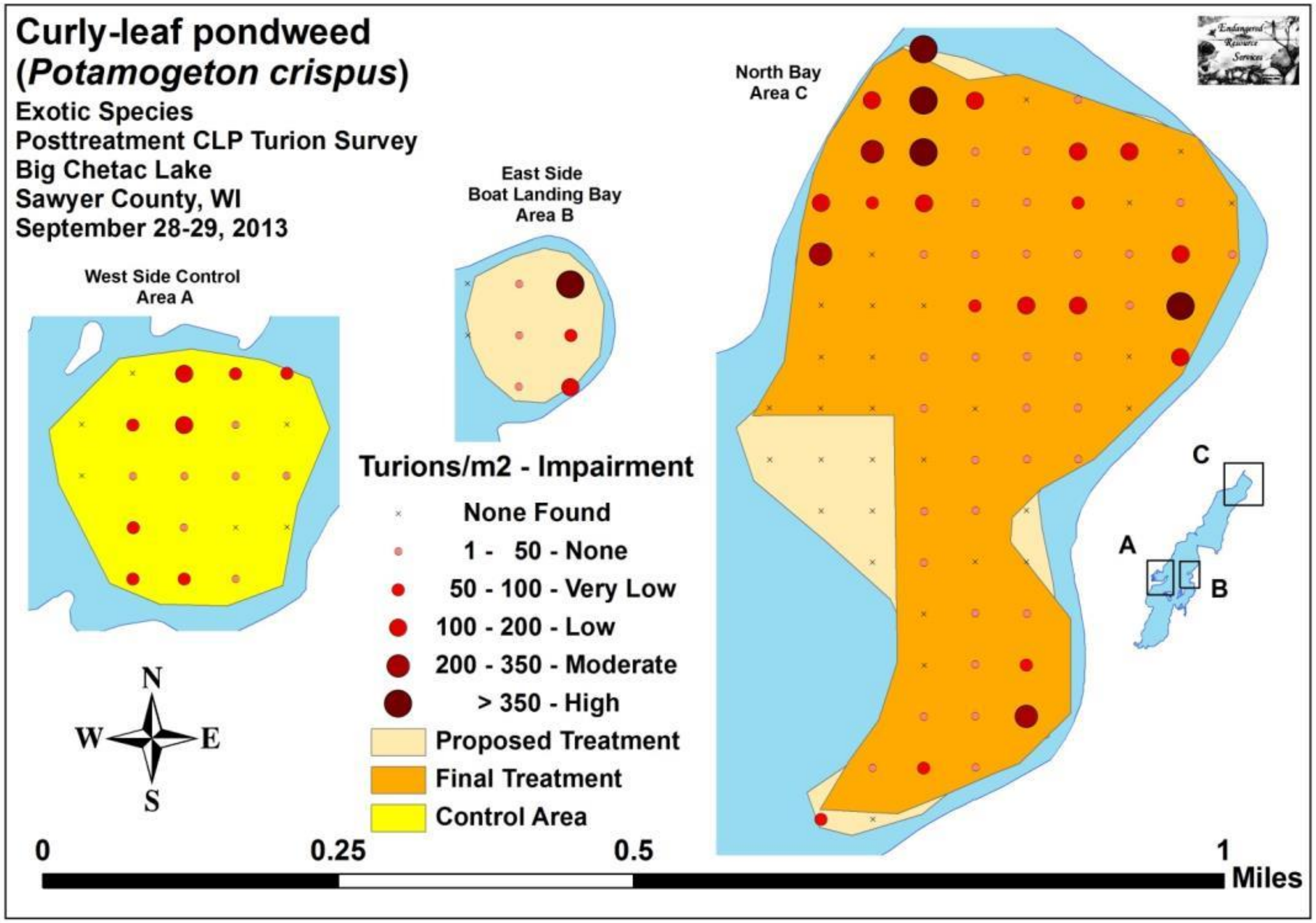
Appendix I: Turion Survey Sample Points


Survey Sample Points
Fall CLP Turion Survey
Big Chetac Lake
Sawyer County, WI
October 30-31, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Turion Sample Point
Proposed Treatment
Control Area
N
S
E
W
A
B
C
0
0.25
0.5
1
Miles

Appendix II: 2013 Pre and Posttreatment, 2014 and 2015 Posttreatment, and 2016 Fall CLP Turion Density and Distribution Maps



Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
Pretreatment CLP Turion Survey
Big Chetac Lake
Sawyer County, WI
May 11-12, 2013
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Turions/m2 - Impairment
None Found
1 - 50 - None
50 - 100 - Very Low
100 - 200 - Low
200 - 350 - Moderate
> 350 - High
Proposed Treatment
Final Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles


Curly-leaf pondweed
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Exotic Species
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Area A
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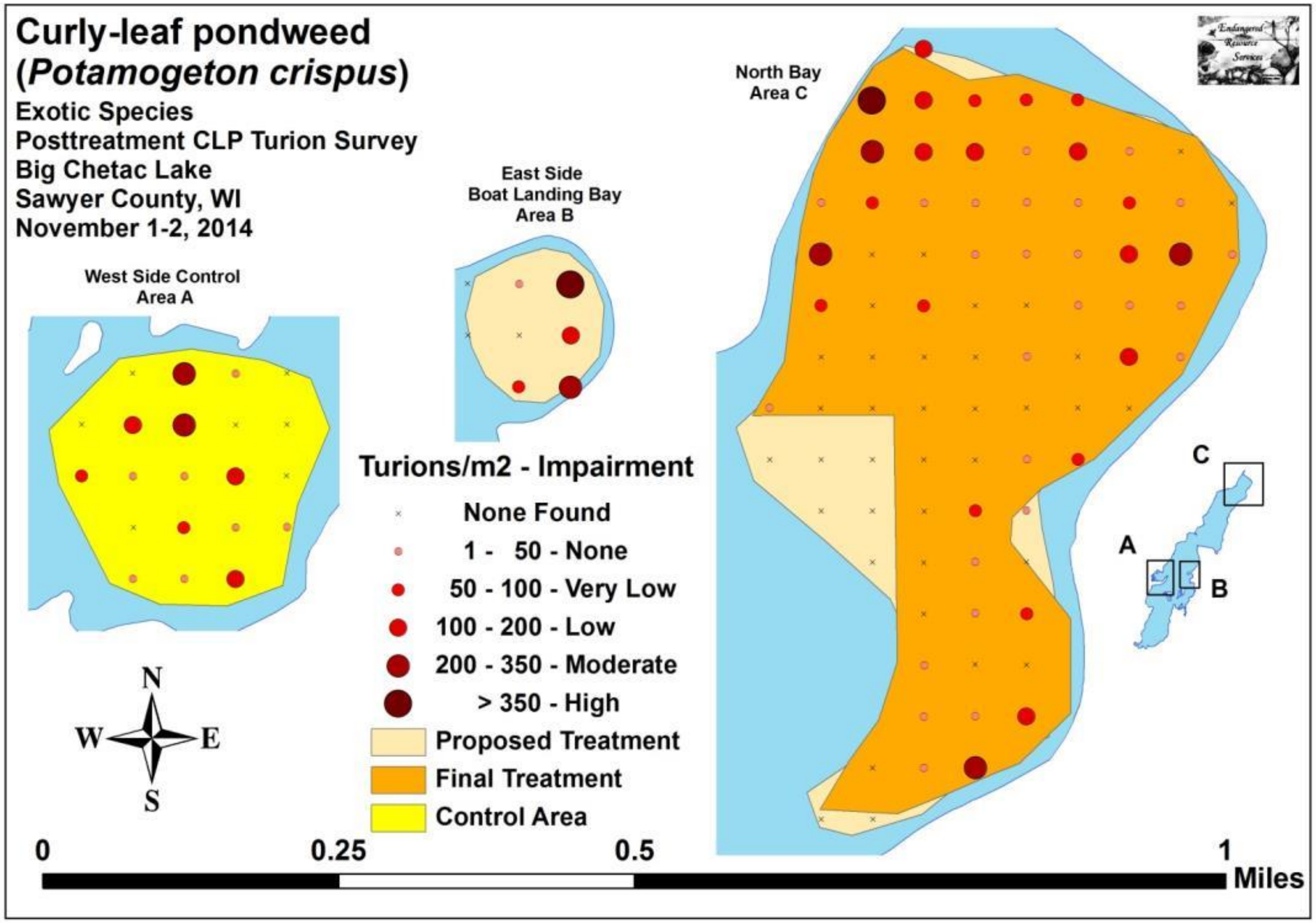
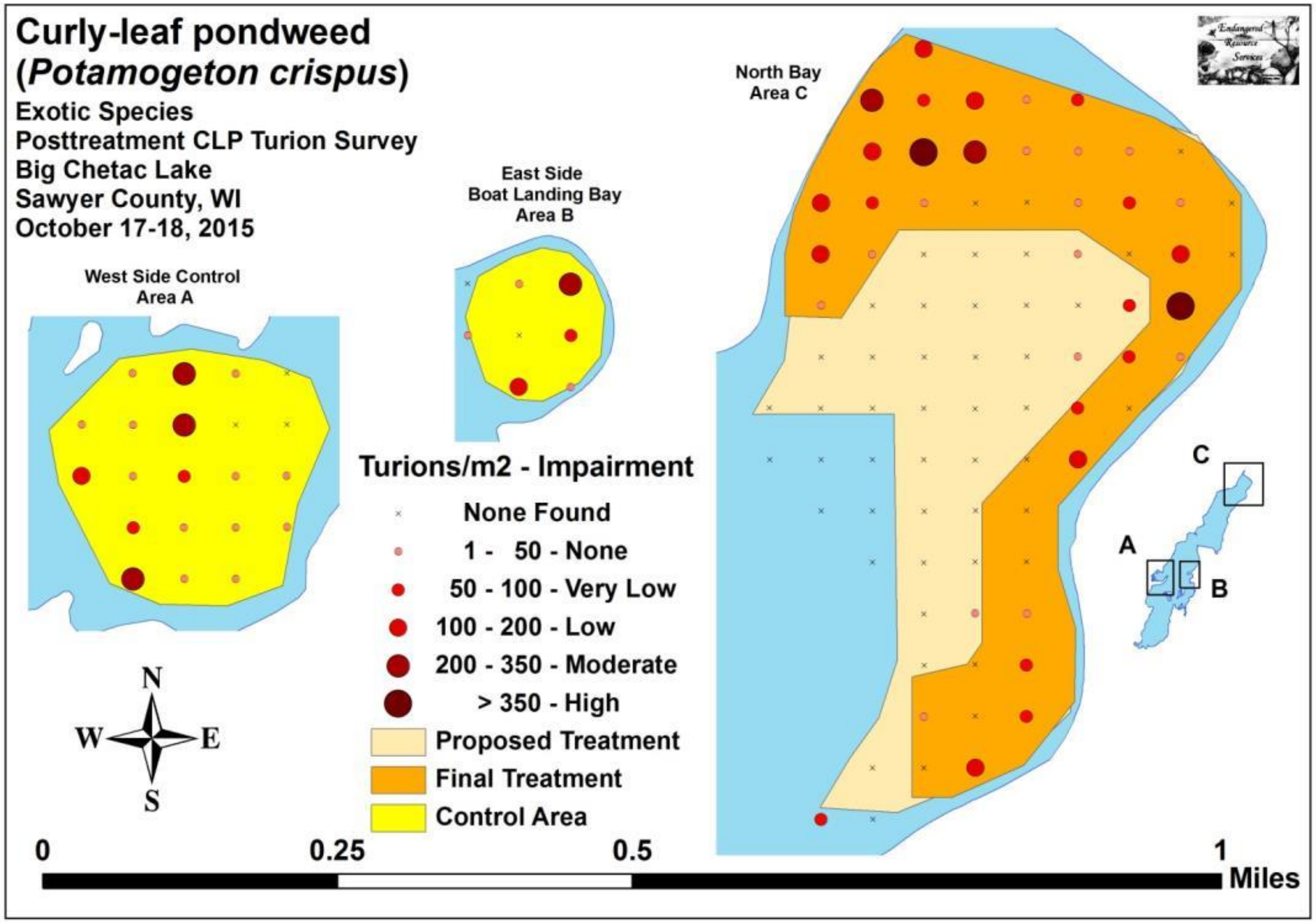
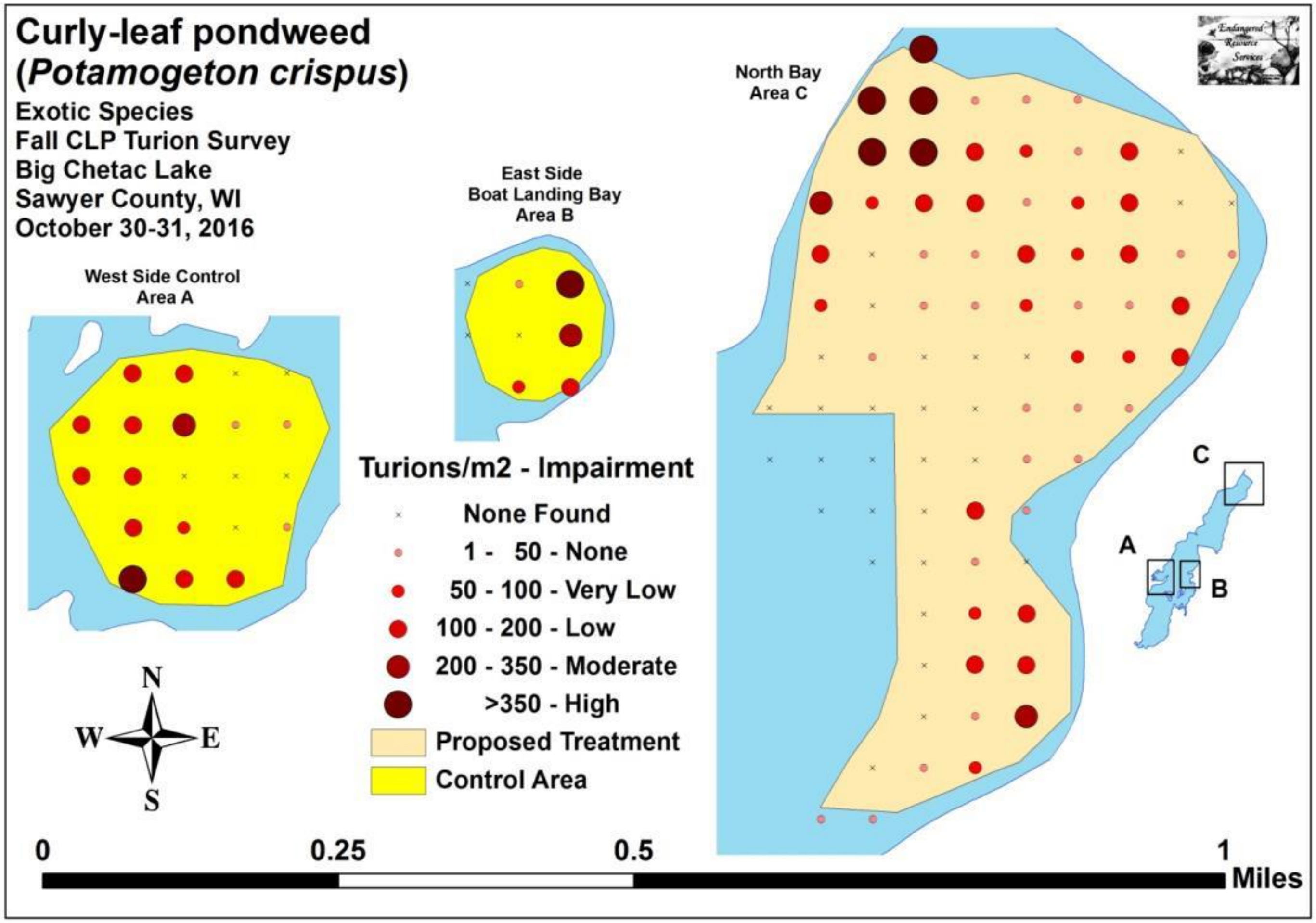
Area B
North Bay
Area C
Turions/m2 - Impairment
None Found
1 - 50 - None
50 - 100 - Very Low
100 - 200 - Low
200 - 350 - Moderate
> 350 - High
Proposed Treatment
Final Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
Posttreatment CLP Turion Survey
Big Chetac Lake
Sawyer County, WI
November 1-2, 2014
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Turions/m2 - Impairment
None Found
1 - 50 - None
50 - 100 - Very Low
100 - 200 - Low
200 - 350 - Moderate
> 350 - High
Proposed Treatment
Final Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles



Curly-leaf pondweed
(*Potamogeton crispus*)
Exotic Species
Posttreatment CLP Turion Survey
Big Chetac Lake
Sawyer County, WI
October 17-18, 2015
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Turions/m2 - Impairment
None Found
1 - 50 - None
50 - 100 - Very Low
100 - 200 - Low
200 - 350 - Moderate
> 350 - High
Proposed Treatment
Final Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
Fall CLP Turion Survey
Big Chetac Lake
Sawyer County, WI
October 30-31, 2016
West Side Control
Area A
East Side
Boat Landing Bay
Area B
North Bay
Area C
Turions/m2 - Impairment
None Found
1 - 50 - None
50 - 100 - Very Low
100 - 200 - Low
200 - 350 - Moderate
>350 - High
Proposed Treatment
Control Area
N
W
E
S
A
B
C
0
0.25
0.5
1
Miles