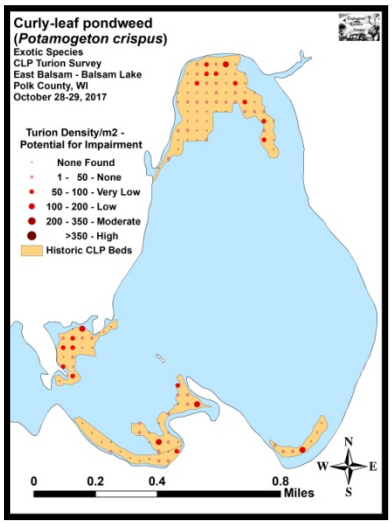
Curly-leaf Pondweed (*Potamogeton crispus*)
Post Herbicide Turion Survey
Balsam Lake – WBIC: 2620600
Polk County, Wisconsin

B. Collins with Ponar Dredge – East Balsam (10/29/17)



2017 Posttreatment Turion Density

Project Funded by:

Balsam Lake Protection and Rehabilitation District and the
Wisconsin Dept. of Natural Resources - Grant AEPP-430-14

Clearing off snow to get started (10/28/17)

Survey Conducted by and Report Prepared by:

Endangered Resource Services, LLC
Matthew S. Berg, Research Biologist
St. Croix Falls, Wisconsin
October 28-29, 2017

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INTRODUCTION:

Balsam Lake (WBIC 2620600) is a 2,054 acre stratified drainage lake in central Polk County, Wisconsin in the Towns of Balsam Lake, Milltown, Georgetown, and Apple River (T34N R17W S10 NE NE). The lake reaches a maximum depth of 37ft north of Cedar Island in the western basin and has an average depth of 20ft (Hopke et al. 1964). Balsam Lake is mesotrophic bordering on eutrophic in nature, and water clarity is fair with historical summer Secchi readings averaging 6ft in East Balsam, 7ft in Little Balsam, and 8ft in the deep hole north of Cedar Island (WDNR 2017). Bottom substrate is variable with muck bottoms in most bays, and rock/sand bars in the Big and Little Narrows and around the lake's many islands.

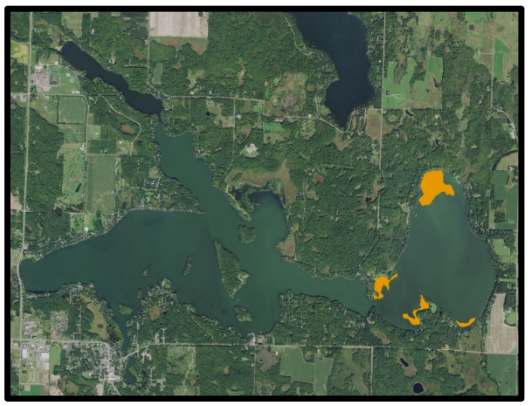

Figure 1: Balsam Lake with 2017 CLP Treatment Areas

Curly-leaf pondweed (*Potamogeton crispus*) (CLP) is an invasive exotic plant that is common to abundant in parts of Balsam Lake. In their 2010 Wisconsin Department of Natural Resources (WDNR) approved Aquatic Plant Management Plan (APMP), the Balsam Lake Protection and Rehabilitation District's (BLPRD) identified a) reducing overall lake coverage of CLP to <20 acres and b) relieving navigation impairment caused by canopied CLP beds as management goals (Clemens 2010). As part of their continuing efforts to meet these goals, in May 2014, 2015, and 2016, the BLPRD and the WDNR authorized the herbicide treatment of five CLP beds in East Balsam Lake. These beds were selected based on the 2013 spring CLP bed mapping survey that found they were the largest areas of CLP on the lake, and because they were interfering with boat traffic and/or restricting resident access to the lake from their docks. Although no CLP beds were found in East Balsam following the treatments, the fall 2016 turion survey suggested there would again be significant amounts of CLP in East Balsam. Because of this, in spring 2017, 54.18 acres (down from 65.49 acres treated in 2014/2015 and 58.27 acres in 2016) or approximately 2.64% of the lake's total surface area were again treated (Figure 1).

Following the herbicide application on May 2nd, we completed a May 25th posttreatment survey to evaluate the effectiveness of this control effort. On May 31st, we also searched the lake's visible littoral zone and mapped all CLP beds found. As in 2014, 2015, and 2016, these surveys showed that CLP plants were all but eliminated from East Balsam by the treatment. Knowing there was still the potential for the beds to return in 2018, the BLPRD requested a late fall CLP turion survey to determine the level of any latent turions remaining in the lake's substrate. This report is the summary analysis of that survey conducted on October 28-29, 2017.

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 Turion

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).

Following the May herbicide application and the 2017 summer growing season, we conducted a posttreatment turion survey on October 28-29th. The goals of the survey were to determine if there were still CLP turions in any of the East Balsam treatment areas, and, if there were, whether their numbers suggested there would likely be enough to cause navigation issues in 2018. This report is the summary analysis of that field survey.

METHODS:

Ponar Dredge Turion Survey:

After merging the 2014 treatment areas and the 2009 treatment of Bed 14C into a single shapefile, we used Hawth's Analysis Tools Extension to ArcGIS 9.3.1 to generate regular points at the rate of approximately 1.7 points/acre. This produced a 120 point sampling grid of which 18 were in Bed 12, 65 were in Bed 13, 7 were in Bed 14, and the remaining 30 were in the combined area of Beds 14B and 14C. This same sampling grid was also used in 2015, 2016, and 2017 to allow for the most accurate comparisons possible (Figure 3) (Appendix I). For ease in determining the total impact of the current treatment program, we also left the 2014, 2015, and 2016 narratives in the results section of this report.

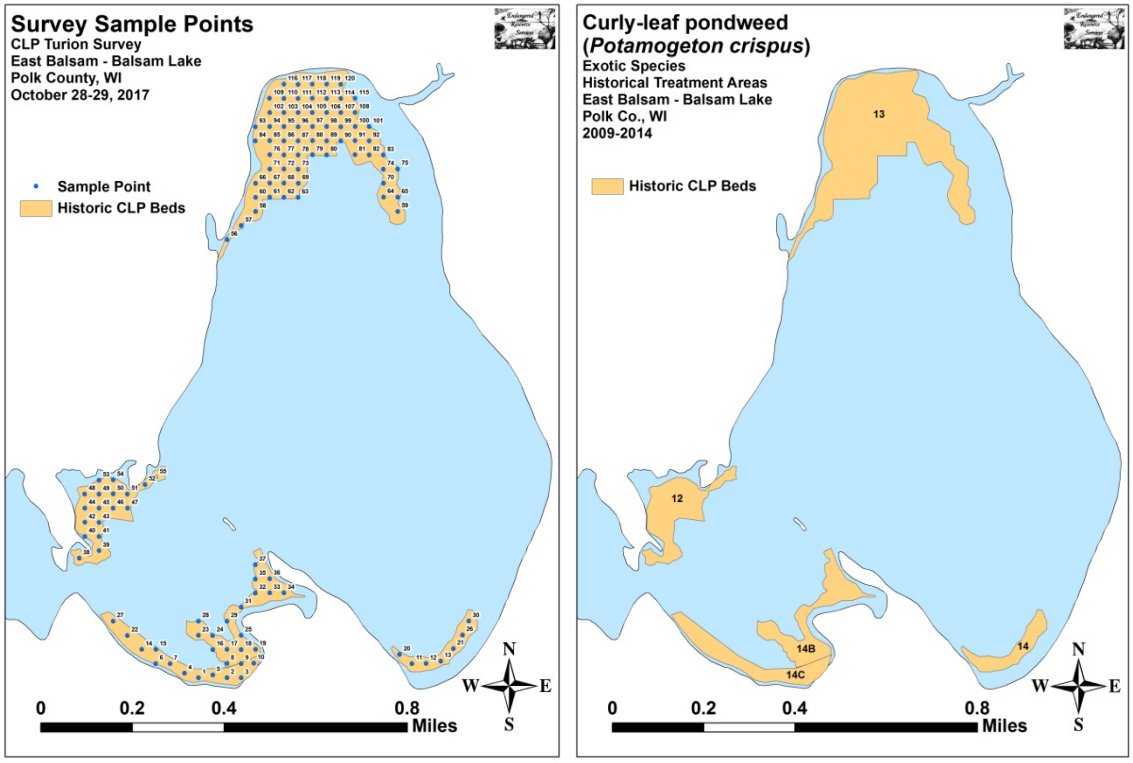

Figure 3: Turion Survey Sample Points in Historical Treatment Areas

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 or significant amounts 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 during the 2018 growing season.

Figure 4: East Balsam 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:

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

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

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

Frequency of occurrence: 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 the following year.

Points at or above nuisance level: This value gives the number of survey sites within the study area that were above the predicted nuisance threshold (Figure 5). Research suggests that when the turion density is at or above 200/m^2, the following year's CLP growth has the potential to at least moderately impair navigation (Johnson 2012).

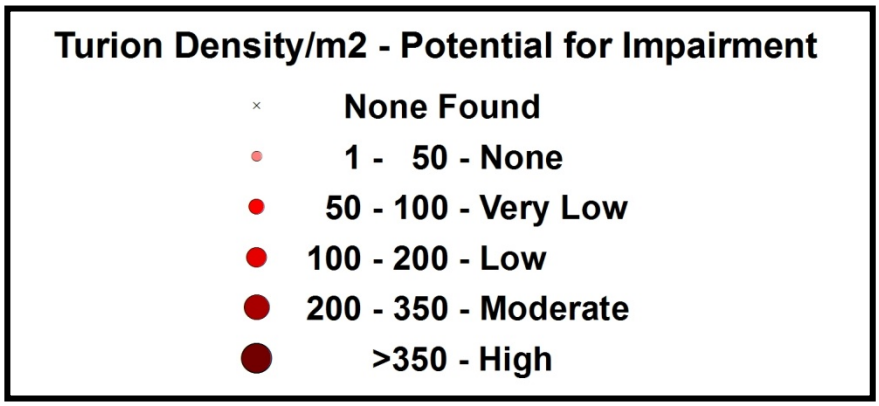

Figure 5: Predicted Navigation Impairment Based on Turion Density

Percent nuisance level: The percentage of nuisance points divided by the total number of survey points can be extrapolated to determine what percent of the study area has the potential to have at least moderate navigation impairment during the next growing season.

Mean turions/m^2: 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.

Standard deviation of turions/m^2: 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.

2014-2015, 2015-2016, and 2016-2017 Significant Differences:
Data from the 2014, 2015, 2016, and 2017 surveys was compared using paired t-tests as we returned to the same sites during each survey. Year-over-year differences were determined to be significant at $p < .05$, moderately significant at $p < .01$, and highly significant at $p < .001$ (Tables 1-3).

RESULTS AND DISCUSSION:

2014 Fall Ponar Dredge Turion Survey:

The November 8-9, 2014 survey revealed CLP turions were present throughout much of the 2014 treatment areas with 92 of 120 points having live turions (76.67%) (Figure 6) (Appendix II). Despite this, only six points (5.00%) suggested CLP growth in 2015 had the potential to exceed the nuisance threshold with densities >200 turions/m^2 (Table 1). When broken down by area, Bed 12 had the highest rate with over 22% of the bed projected to exceed this level. Bed 13 was the only other area with any nuisance points, and both of them were located at the very northern edge of the bed. All of the nuisance points were in areas with shallow water (<5ft) that historically have also had dense canopied CLP.

The overall mean turion density was 61.53 turions/m^2. This value suggested that the average potential for impairment would be very low. Turion densities were somewhat variable with all standard deviations values being greater than the mean. However, only Bed 12 was more than 25% higher than the mean, and none were double the mean.

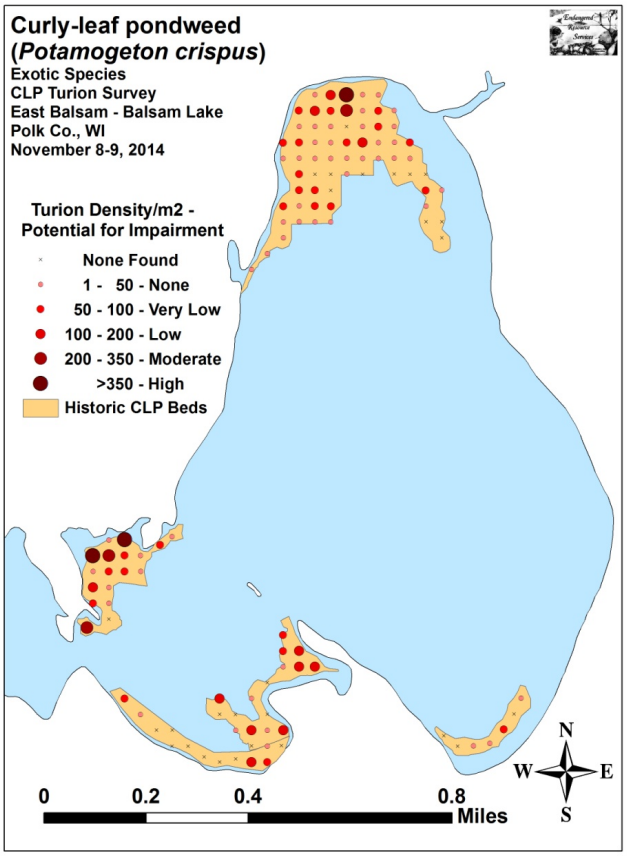

Figure 6: 2014 Fall CLP Turion Survey Density and Distribution

2015 Fall Ponar Dredge Turion Survey:

During the October 31- November 1, 2015 survey, we found live CLP turions at 67 of 120 points (55.83%) (Figure 7) (Appendix II). This was a decline in distribution of 27.17% from the 92 points with turions in 2014. When broken down by area, all beds showed a decline in distribution except for Bed 14B/C which increased from 56.67% coverage in 2014 to 60.00% coverage in 2015 (Table 1).

The number of high density "predictive nuisance" locations also declined fractionally from six points (5.00%) in 2014 to five points (4.17%) in 2015. As in 2014, Bed 12 had the highest percentage of high density points (11.11%). Outside this area, no other bed had more that 3.33% (Bed 14B/C). The majority of the highest density turion points again occurred in areas with shallow water (<5ft) that historically have had dense canopied CLP growth in the spring as well as moderate levels later in the summer. These areas may be producing a "second crop" of plants that sprout from latent turions after the treatment and, consequently, are able to produce turions/maintain the bank at these locations.

We calculated the overall mean density within the study areas at 44.13 turions/m^2 with a standard deviation of 75.04 turions/m^2. This was a nearly significant decline from 2014 (***p*=0.057**) when we found a mean of 61.53turions/m^2 with a standard deviation of 114.47 turions/m^2. Visual analysis of the 2014 and 2015 maps suggested the turion bank has been nearly exhausted in most deep water areas over 8ft while shallow areas continue to have regular turions present. Densities continued to be variable with all standard deviations values being greater than the mean. With the exception of Bed 14 (southeast bay) which showed a slight increase, all other areas declined; although none of these changes were significant.

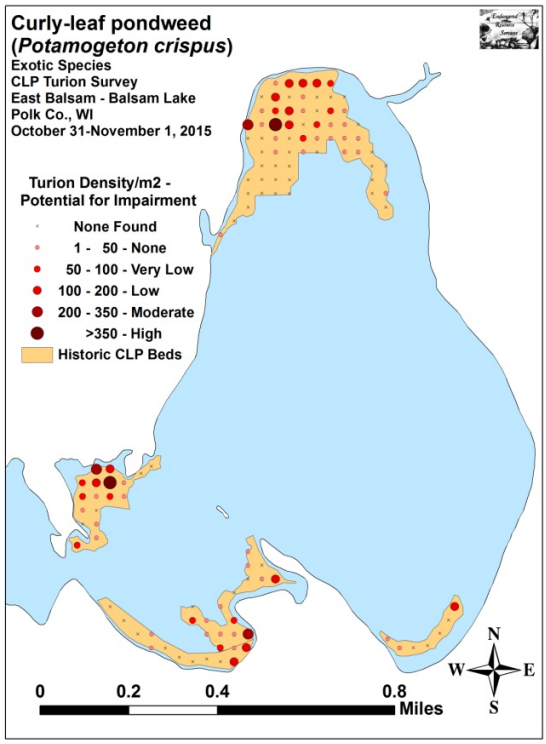

Figure 7: 2015 Fall CLP Turion Survey Density and Distribution

Table 1: CLP Turion Surveys - Summary Statistics
East Balsam Lake, Polk County
November 8-9, 2014 and October 31-November 1, 2015

	2014					2015				
Summary Statistics:	Total	Bed 12	Bed 13	Bed 14	Bed 14B/C	Total	Bed 12	Bed 13	Bed 14	Bed 14B/C
Total number of points sampled	120	18	65	7	30	120	18	65	7	30
Total live turions	343	127	142	7	67	246	69	111	10	56
Total number of points with live turions	92	17	54	4	17	67	14	32	3	18
Frequency of occurrence (in percent)	76.67	94.44	83.08	57.14	56.67	55.83	77.78	49.23	42.86	60.00
Points at or above nuisance level (+200/m^2)	6	4	2	0	0	5	2	2	0	1
% nuisance level	5.00	22.22	3.08	0.00	0.00	4.17	11.11	3.08	0.00	3.33
Maximum turions/m^2	1,012	1,012	388	65	194	431	409	431	172	258
Mean turions/m^2	61.53	151.89	47.03	21.53	48.08	44.13	82.52	36.76	30.75	40.19
Standard deviation/m^2	114.47	249.58	58.70	24.86	58.39	75.04	107.58	71.07	63.20	57.02
Standard error of the paired difference						0.51	2.70	0.47	1.23	0.58
Degrees of freedom						119	17	64	6	29
t-statistic						-1.59	-1.19	-1.01	0.34	-0.63
p - value						0.057	0.12	0.15	0.37	0.27

Significant differences = * $p < .05$, ** $p < .01$, *** $p < .001$

2016 Fall Ponar Dredge Turion Survey:

During the October 29-30, 2016 survey, we found live CLP turions at 45 of 120 points (37.50%) (Figure 8) (Appendix II). This 32.84% decline in distribution from the 67 points with turions (55.83%) in 2015 and a further decline from the 92 points with turions in 2014 (76.67%) suggests the current treatment program has significantly reduced the "turion bank". When broken down by area, all beds showed a decline except for Bed 12 which remained at 77.78%. No other bed had coverage higher than 33.33% (Table 2).

The total number of high density "predictive nuisance" locations ticked back up to six points (5.00%) from five points in 2015 (4.17%) with all but one occurring in Bed 12. Although Bed 12 has always had the largest percentage of high density points (27.78% of the bed in 2016), the nearly significant increase in density (82.52/m^2 in 2015 to 145.91/m^2 in 2016 (***p*=0.057**), and the more than doubling of the number of high density points from two (11.11% of bed) in 2015 to five in 2016 was unexpected based on the successful treatments in this area from 2014-2016.

We calculated the overall mean density within the study areas at 35.70 turions/m^2 with a standard deviation of 85.86 turions/m^2. This was a further decline (p=0.17) from the 44.13 turions/m^2 with a standard deviation of 75.04 turions/m^2 in 2015 and the 61.53turions/m^2 with a standard deviation of 114.47 turions/m^2 in 2014. Visual analysis of the 2016 map continues to show that the turion bank appears to have been nearly exhausted in most deep water areas over 8ft, and many shallow areas now have only scattered turions present. Densities continue to be variable with all beds having standard deviations values that were greater than the mean. With the exception of Bed 12 (southwest bay), all other area mean densities declined with Bed 14B/C showing a moderately significant decline (***p*=0.002**), and Bed 13 (north bay) a nearly significant decline (***p*=0.06**).

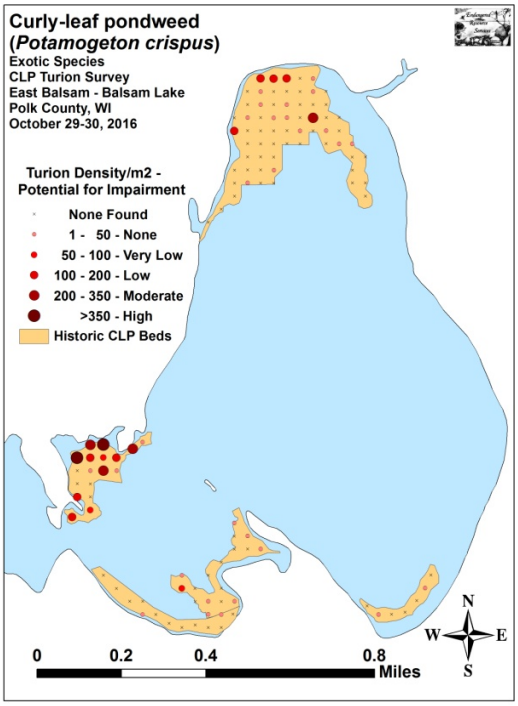

Figure 8: 2016 Fall CLP Turion Survey Density and Distribution

Table 2: CLP Turion Surveys - Summary Statistics
East Balsam Lake, Polk County
October 31-November 1, 2015 and October 29-30, 2016

	2015					2016				
Summary Statistics:	Total	Bed 12	Bed 13	Bed 14	Bed 14B/C	Total	Bed 12	Bed 13	Bed 14	Bed 14B/C
Total number of points sampled	120	18	65	7	30	120	18	65	7	30
Total live turions	246	69	111	10	56	199	122	61	2	14
Total number of points with live turions	67	14	32	3	18	45	14	19	2	10
Frequency of occurrence (in percent)	55.83	77.78	49.23	42.86	60.00	37.50	77.78	29.23	28.57	33.33
Points at or above nuisance level (+200/m^2)	5	2	2	0	1	6	5	1	0	0
% nuisance level	4.17	11.11	3.08	0.00	3.33	5.00	27.78	1.54	0.00	0.00
Maximum turions/m^2	431	409	431	172	258	560	560	323	22	65
Mean turions/m^2	44.13	82.52	36.76	30.75	40.19	35.70	145.91	20.20	6.15	10.05
Standard deviation/m^2	75.04	107.58	71.07	63.20	57.02	85.86	157.26	54.21	10.50	16.71
Standard error of the paired difference						0.41	1.77	0.50	1.16	0.46
Degrees of freedom						119	17	64	6	29
t-statistic						-0.95	1.66	-1.54	-0.98	-3.07
p - value						0.17	0.057	0.06	0.18	****0.002**

Significant differences = * $p < .05$, ** $p < .01$, *** $p < .001$

2017 Fall Ponar Dredge Turion Survey:

During the October 28-29, 2017 survey, we found live CLP turions at 59 of 120 points (49.17%) (Figure 9) (Appendix II). This 31.11% increase from 45 points with turions (37.50%) in 2016 was the first expansion in distribution since treatment began. However, it was still below the 67 points with turions (55.83%) in 2015 and 92 points with turions in 2014 (76.67%). When broken down by area, only Bed 12 (northeast of the Big Narrows) showed a decline in points with turions (Table 3).

We calculated the overall mean density within the study areas at 23.32 turions/m^2 with a standard deviation of 33.33turions/m^2. This was a nearly significant decline **(p=0.06)** from 35.70 turions/m^2 with a standard deviation of 85.86 turions/m^2 in 2016. It was also a further decline (p=0.17) from the 44.13 turions/m^2 with a standard deviation of 75.04 turions/m^2 in 2015, and the 61.53turions/m^2 with a standard deviation of 114.47 turions/m^2 in 2014. This means that, despite the uptick in distribution, the mean density was the lowest it has been since treatment started. We also noted that, for the first time ever, there were no high density "predictive nuisance" points in any of the beds.

Visual analysis of the 2017 map showed that most of the expansion in distribution occurred in deep water areas that were not treated in 2017 because they did not have any turions in fall 2016 and few CLP plants during the 2017 pretreatment survey. In the past, when these low density areas were trimmed from the treatment plan, they still appeared to have experienced residual control; however; that doesn't seem to have been the case in 2017. This may be because, for whatever reason, the 2017 treatment wasn't as effectively as in years past when plants immediately and completely disintegrated. Rather, CLP was only severely burned by the herbicide, and, based on several follow-up visits we did in June, took up to five weeks posttreatment to fall over/decompose. Fortunately, none of these "slow dying" CLP plants were ever found to have produced turions.

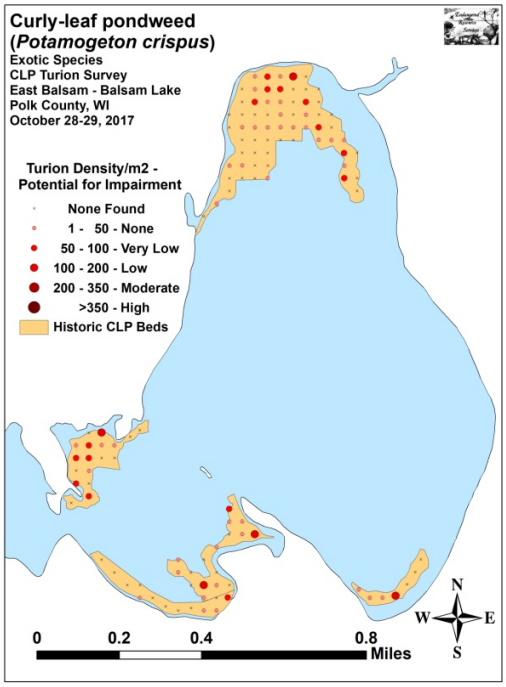

Figure 9: 2017 Fall CLP Turion Survey Density and Distribution

Table 3: CLP Turion Surveys - Summary Statistics
East Balsam Lake, Polk County
October 29-30, 2016 and October 28-29, 2017

	2016					2017				
Summary Statistics:	Total	Bed 12	Bed 13	Bed 14	Bed 14B/C	Total	Bed 12	Bed 13	Bed 14	Bed 14B/C
Total number of points sampled	120	18	65	7	30	120	18	65	7	30
Total live turions	199	122	61	2	14	130	26	58	11	35
Total number of points with live turions	45	14	19	2	10	59	10	30	4	15
Frequency of occurrence (in percent)	37.50	77.78	29.23	28.57	33.33	49.17	55.56	46.15	57.14	50.00
Points at or above nuisance level (+200/m^2)	6	5	1	0	0	0	0	0	0	0
% nuisance level	5.00	27.78	1.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum turions/m^2	560	560	323	22	65	194	108	108	129	194
Mean turions/m^2	35.70	145.91	20.20	6.15	10.05	23.32	31.10	19.21	33.83	25.12
Standard deviation/m^2	85.86	157.26	54.21	10.50	16.71	33.33	34.02	27.21	46.27	41.19
Standard error of the paired difference						0.37	1.70	0.34	0.89	0.34
Degrees of freedom						119	17	64	6	29
t-statistic						-1.53	**-3.13**	-0.13	+1.44	**+2.08**
p - value						0.06	****0.003**	0.44	0.10	***0.02**

Significant differences = * $p < .05$, ** $p < .01$, *** $p < .001$

CONSIDERATIONS FOR FUTURE MANAGMENT:

The 2017 turion survey suggests there will again be CLP throughout much of East Balsam Lake in 2018; however, there were no areas that had moderate or high densities that suggest CLP would likely cause navigation impairment. When considering the total number of turions found during the fall surveys, the decline in numbers appears to be progressing in a generally linear fashion both throughout East Balsam as well as within most of the individual beds (Figure 10). Interestingly, when a late-season mechanical harvest was coupled with the herbicide treatment in Bed 12, there was a greater than expected drop in the number of turions. Continuing this strategy in all the beds during either July or August may help eliminate the "second crop" of CLP we have observed in the shallower parts of these bays and hasten the overall decline in surviving turions. Ultimately, the results of the pretreatment survey coupled with the level of CLP growth the board is comfortable with will determine how much of East Balsam is treated and/or mechanically harvested in 2018.

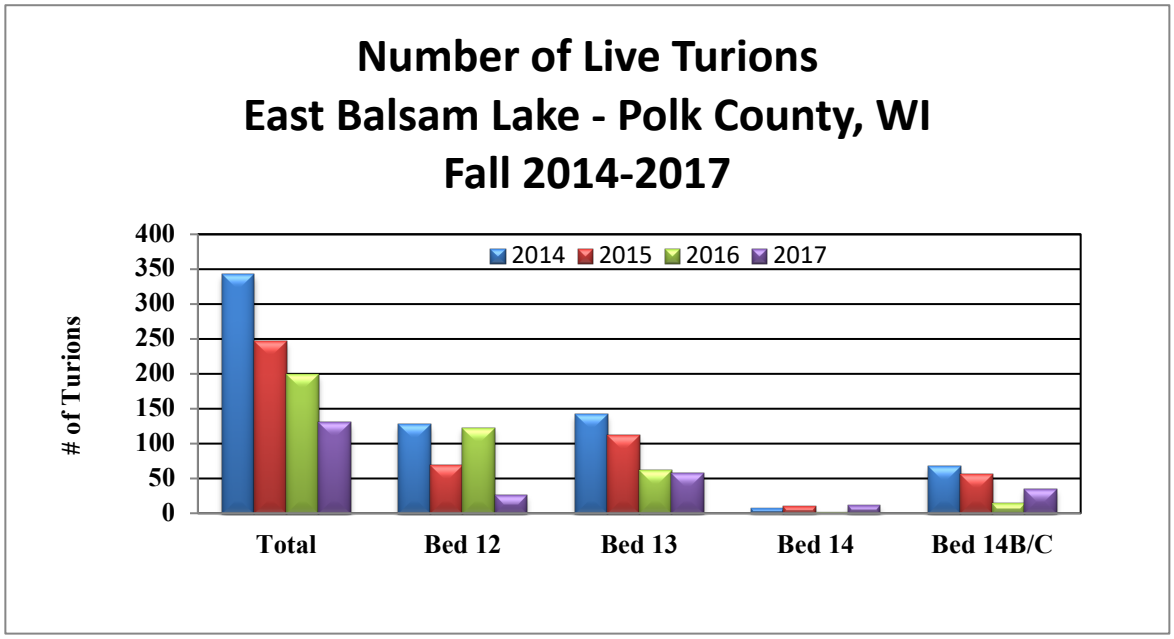

Figure 10: Total Live Turions Found – Fall 2014-2017

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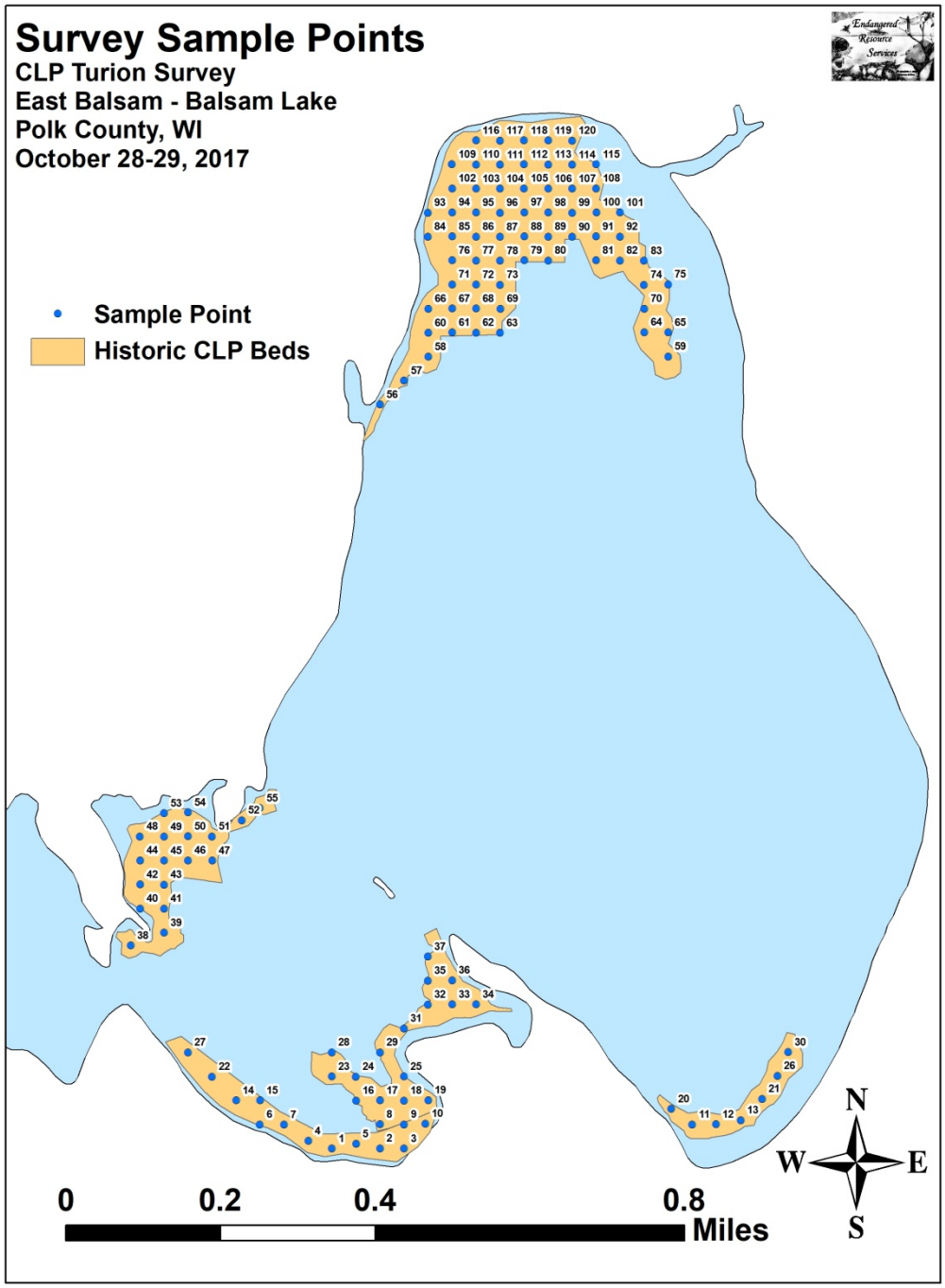
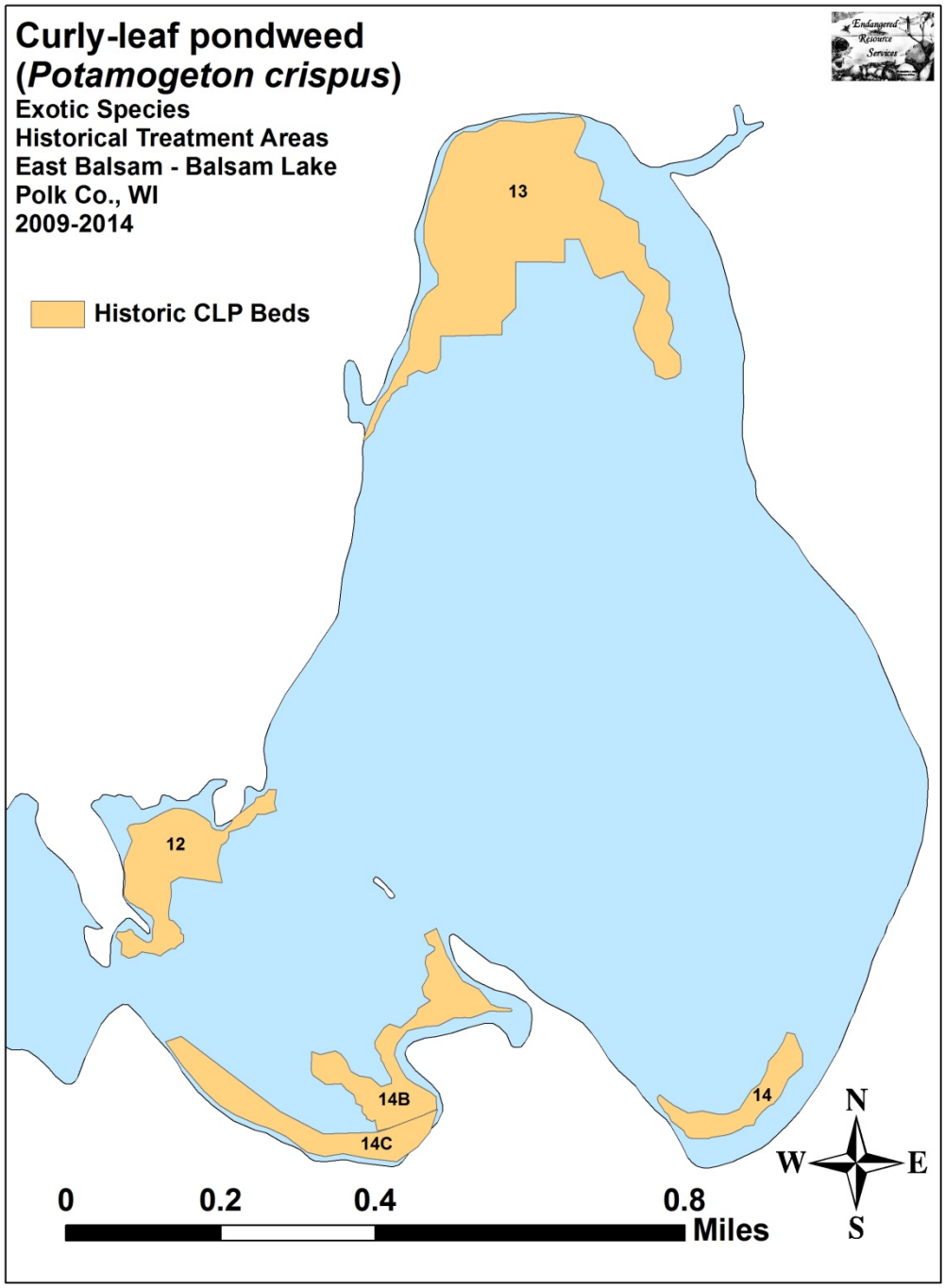
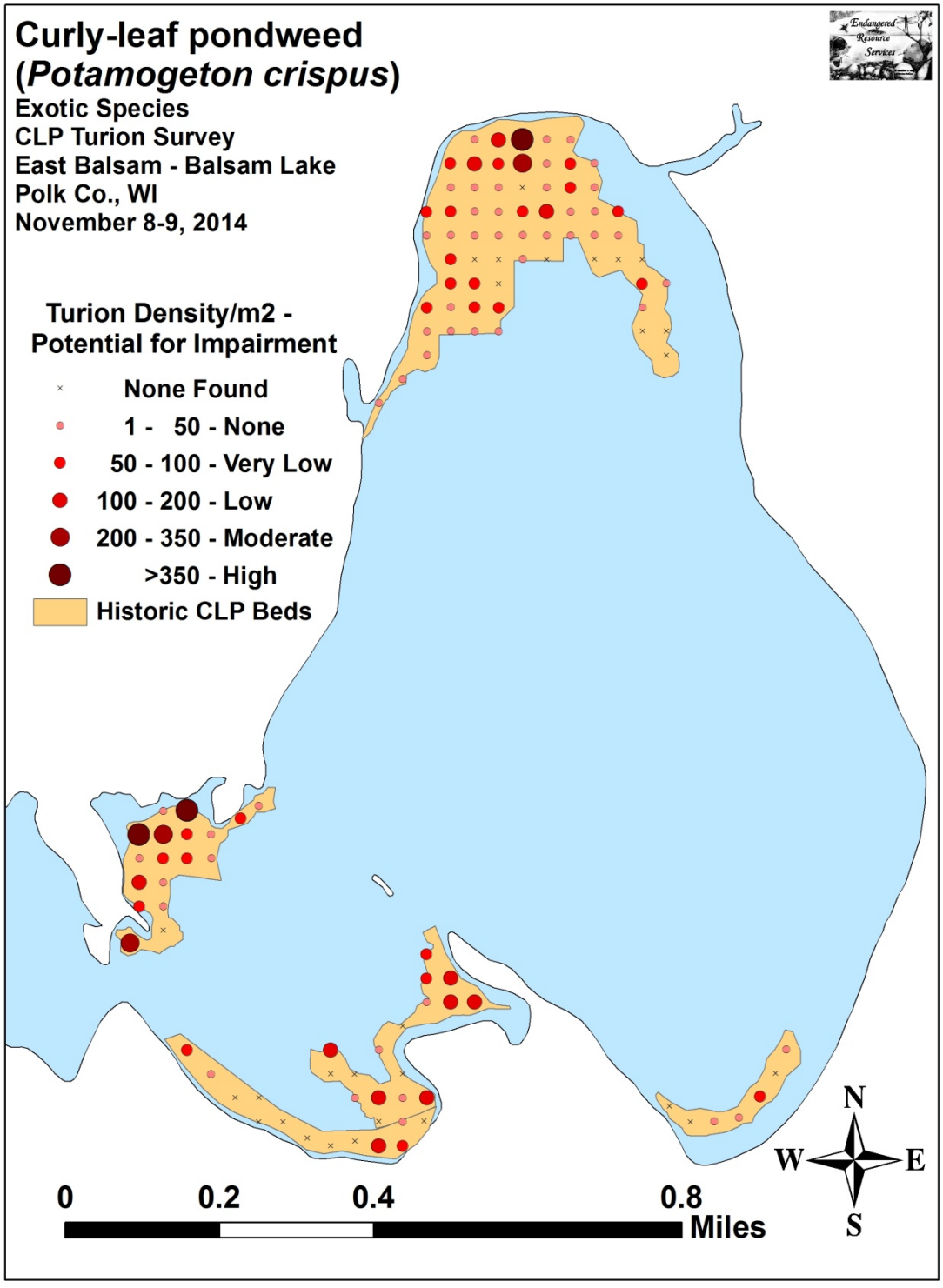
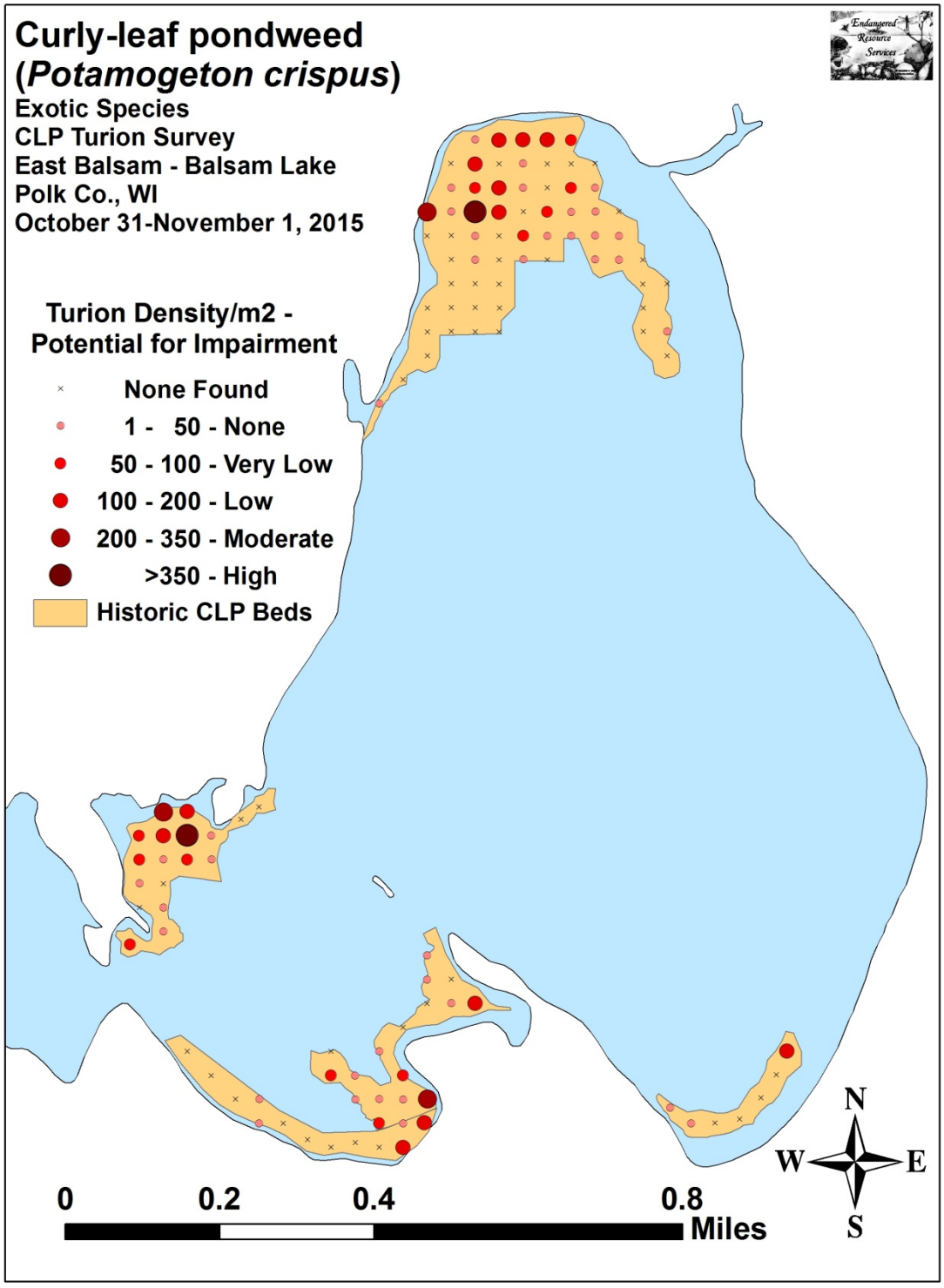
Appendix I: Survey Sample Points and Historic CLP Treatment Areas

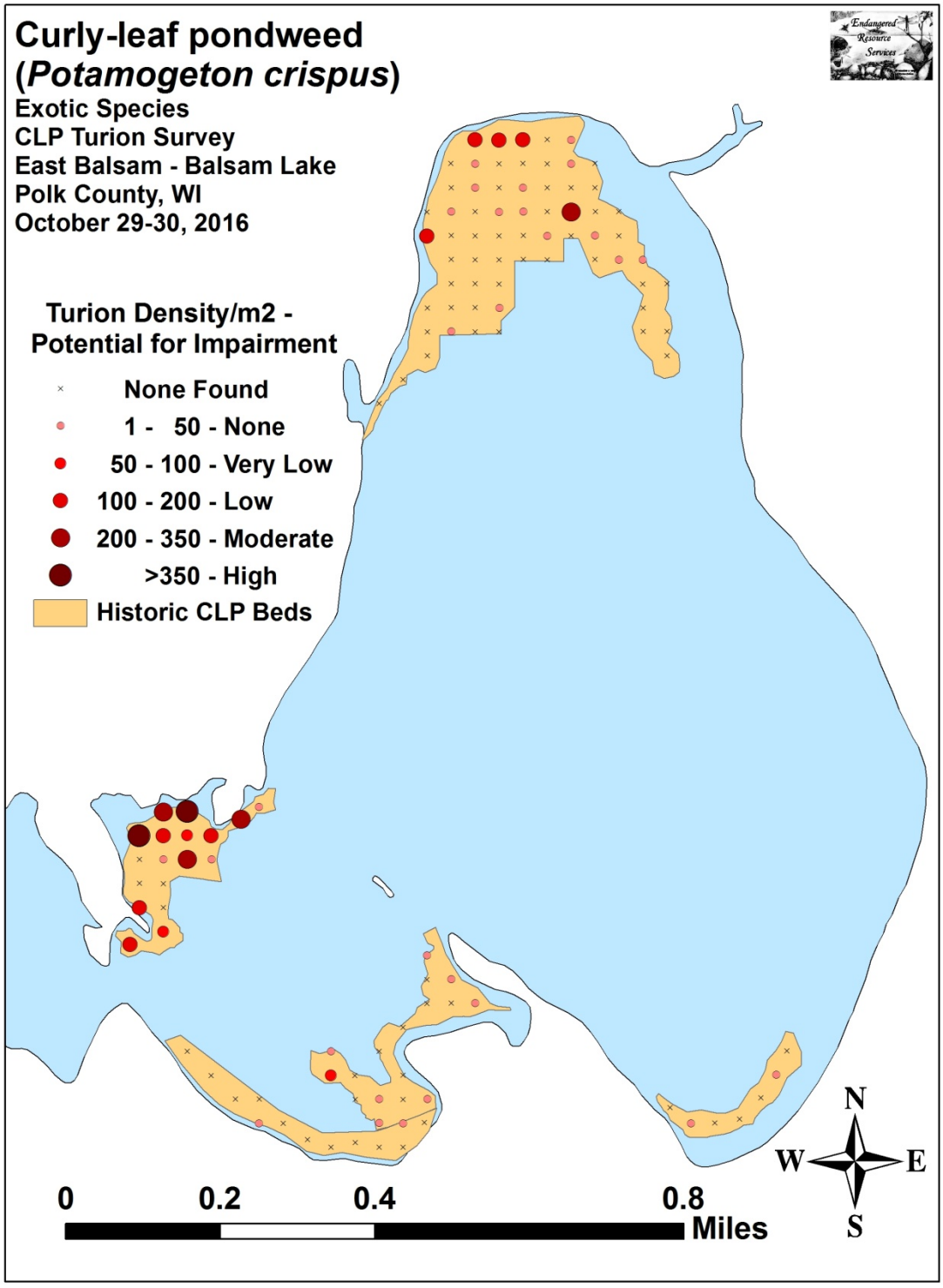

Survey Sample Points
CLP Turion Survey
East Balsam - Balsam Lake
Polk County, WI
October 28-29, 2017
Sample Point
Historic CLP Beds
0
0.2
0.4
0.8
Miles
N
W
E
S

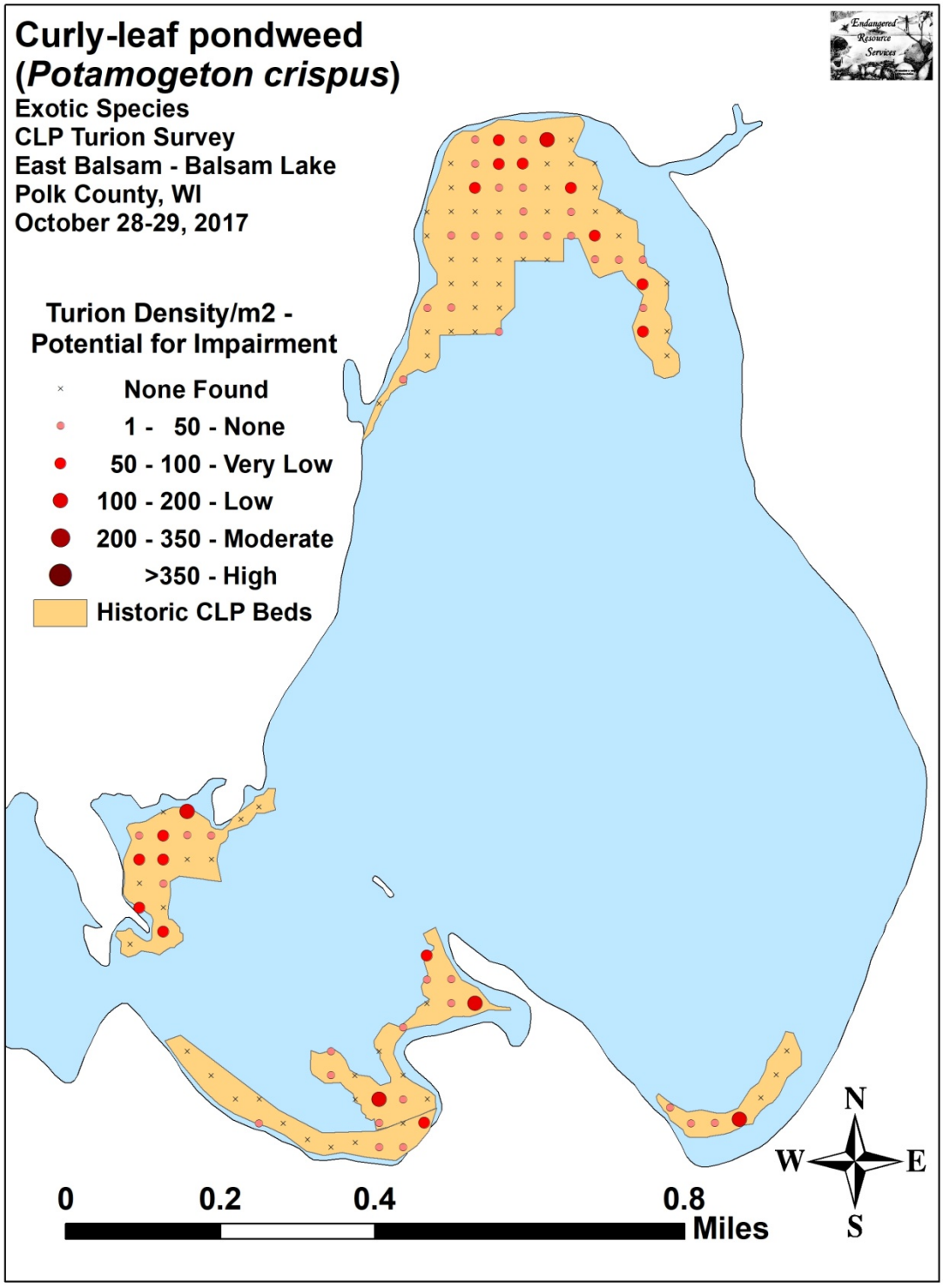

Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
Historical Treatment Areas
East Balsam - Balsam Lake
Polk Co., WI
2009-2014
Historic CLP Beds
13
12
14B
14C
14
N
W
E
S
0
0.2
0.4
0.8
Miles

Appendix II: 2014, 2015, 2016, and 2017 Fall CLP Turion Density and Distribution Maps


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Turion Survey
East Balsam - Balsam Lake
Polk Co., WI
November 8-9, 2014
Endangered Resource Services
Turion Density/m2 -
Potential for Impairment
None Found
1 - 50 - None
50 - 100 - Very Low
100 - 200 - Low
200 - 350 - Moderate
>350 - High
Historic CLP Beds
N
W
E
S
0
0.2
0.4
0.8
Miles


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Turion Survey
East Balsam - Balsam Lake
Polk Co., WI
October 31-November 1, 2015
Endangered Resource Services
Turion Density/m2 -
Potential for Impairment
None Found
1 - 50 - None
50 - 100 - Very Low
100 - 200 - Low
200 - 350 - Moderate
>350 - High
Historic CLP Beds
0
0.2
0.4
0.8
Miles
N
W
E
S


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Turion Survey
East Balsam - Balsam Lake
Polk County, WI
October 29-30, 2016
Endangered Resource Services
Turion Density/m2 -
Potential for Impairment
None Found
1 - 50 - None
50 - 100 - Very Low
100 - 200 - Low
200 - 350 - Moderate
>350 - High
Historic CLP Beds
0
0.2
0.4
0.8
Miles
N
W
E
S


Curly-leaf pondweed
(Potamogeton crispus)
Exotic Species
CLP Turion Survey
East Balsam - Balsam Lake
Polk County, WI
October 28-29, 2017
Endangered Resource Services
Turion Density/m2 -
Potential for Impairment
None Found
1 - 50 - None
50 - 100 - Very Low
100 - 200 - Low
200 - 350 - Moderate
>350 - High
Historic CLP Beds
0
0.2
0.4
0.8
Miles
N
W
E
S