Herbicide Treatment Analysis for *Potamogeton crispus* (CLP)

Big Lake
Polk County, WI

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Abstract

On May 22 2014, an endothall herbicide treatment targeting *Potamogeton crispus*-curly leaf pondweed (CLP) was conducted on Big Lake, Polk County Wisconsin. A total of 14.06 acres was treated. A pretreatment survey was conducted in May to determine/verify CLP growth in designated bed polygons which were mapped using GIS. A post treatment survey was conducted approximately three weeks after treatment (June 11) to determine the effectiveness. A chi-square analysis was used to determine the statistical significance of any reductions. The treatment was determined to be effective with a very significant reduction ($p=1.2 \times 10^{-24}$) in frequency of occurrence of CLP in the post treatment compared to the pretreatment, 2014. The reduction from 2013 to 2014 (post treatment) was small but found to be statistically significant ($p=0.04$). The treatment was also effective in 2012 and 2013, so the frequency has been consistently low in all post treatment surveys. There was also a slight reduction in frequency from the 2013 pretreatment frequency to the 2014 pretreatment frequency, reflecting long-term reduction. It was also determined that there was no significant reduction in any native plant species as compared to the 2013 post treatment survey. A turion analysis resulted in a reduction in an overall mean turion density from 13.6 turions/m^2(2013) to 6.4 turions/m^2(2014).

Introduction

On May 22, 2014 a total of 14.06 acres of *Potamogeton crispus*-curly leaf pondweed (CLP) beds were treated with herbicide (endothall-K) for the fourth year on Big Lake in Polk County Wisconsin (Township 32,33, Range 18 Section 36). Figure 1 shows the location of the beds.
The treatment comprised of concentrations ranging from 1.5-2.5 ppm of endothall K. Table 1 shows the statistics for each treatment bed.

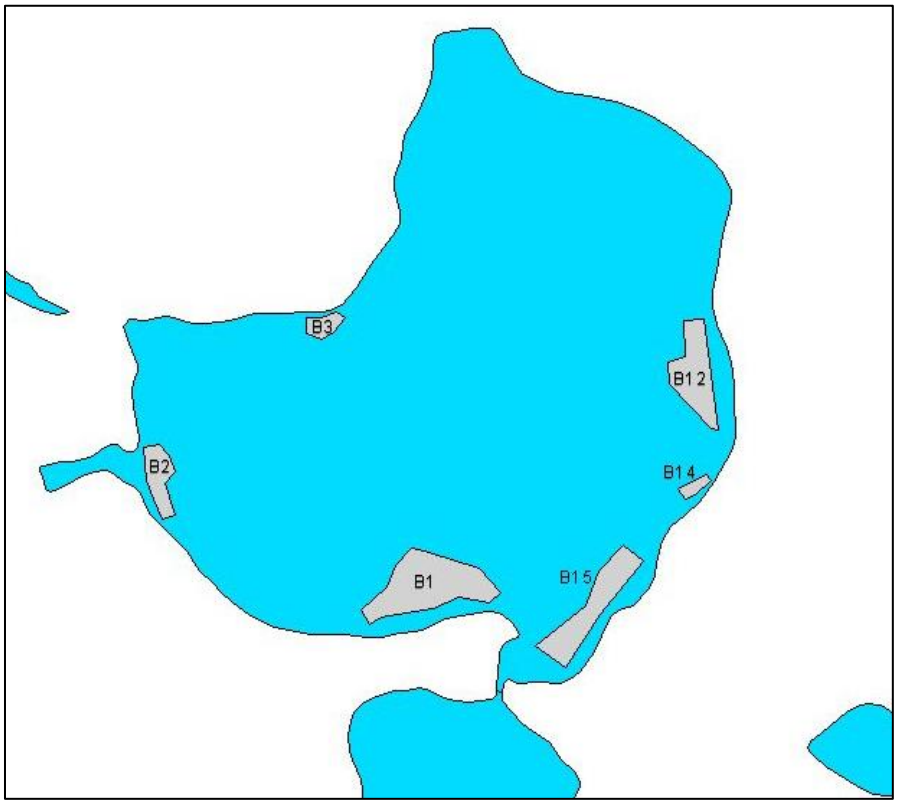


Figure 1: Map showing 2014 CLP treatment beds

Big Lake 2014 CLP					
Big Lake	**Acres**	**Mean Depth(ft)**	**Acre-feet**	**Gallons applied***	**Target conc.*** (ppm)
B1	5.18	5.87	30.41	30.4	1.5
B2	1.50	6.10	9.15	9.15	1.5
B3	0.65	6.95	4.52	7.23	2.5
B12	3.00	7.25	21.75	21.75	1.5
B14	0.36	6.13	2.21	3.54	2.5
B15	3.37	6.70	22.58	22.58	1.5
Big Lake Total	**14.06**		**90.61**	**--**	**--**

*As reported by applicator

Table 1: Summary of 2014 treatment bed statistics.

Bed	Description
B1	Bed B1 is just north of the narrows between Big Lake and Round Lake, This is the second largest bed and was very dense from the start of the treatment in 2011. The bed ranges from 3.5 feet to 11 feet in depth. The density/frequency has been declining each year but has had quite high turion densities. Pretreatment frequency is starting to go down, largely along the bed edges.
B2	This bed is on the western shoreline of Big Lake. It is 1.9 acres in size. The bed transitions quickly from a high nutrient, muck sediment to a hard, sandy substrate on the western edge of the bed. The CLP growth stops abruptly here. In 2010, this bed was quite dense in the middle portions of the bed, but has responded well to treatment.
B3	Bed B3 is on the northern shoreline of Big Lake. It originally had high density pockets of CLP with scattered growth between the pockets. The lake side edge borders very deep water and drops fast. There is no growth in this deeper water and defines the lake side boundary abruptly.
B8 ***(not treated 2014)***	B8 is a narrow bed on the northeast shore of Big Lake. It had medium density CLP which warranted treatment. It has responded to treatment, but turions keep showing up and providing CLP growth each year. It has the highest mean depth. No CLP was located in the pretreatment and only one point had CLP present in 2013, so it was not recommended for treatment in 2014.
B12	Bed B12 came about from combining B12 and B13 from previous treatment years. CLP growing between these beds that was observed in quite high density in May 2013 warranted changing this bed (it is back to its original size from 2011). This bed responded less to treatment than other beds and had the highest frequency of CLP in 2013. It is a wider bed than ½ of the beds and ranges from about 4 ft to 11 ft in depth. The most CLP growth in this bed is the outer ½ of the bed in 7-10 feet of water depth.
B14	B14 is on the eastern shore. This narrow bed has been responding to treatment well, but keeps having CLP return, warranting more treatment. It ranges from 4 ft to about 7.5 feet in depth.
B15	B15 is the largest bed treated. It encompasses much of the southeastern shoreline and extends out to Bed B1 and into the channel between Big Lake and Round Lake. This bed has a history of dense CLP and high turion production. The CLP density and turion density have both declined steadily.
R1*(not treated 2014)*	R1 is in Round Lake. It is a very small bed and was treated as it is the only CLP bed in Round Lake. It has been nearly eliminated, but keeps growing new CLP in very low amounts each year. Treatment has continued to try and eradicate this lone small bed in Round Lake. There was no CLP found in the pretreatment survey and have only had a couple of plants in the previous year, so no treatment was recommended for 2014.

Table 2: Description of treatment beds.

Methods

To conduct and analyze the treatment, two surveys are conducted following the Wisconsin DNR treatment protocol outlined in 2009 by the Wisconsin DNR. The first survey is referred to a pretreatment survey. This involves going to predetermined GPS coordinates within the proposed treatment area. A high definition underwater camera as well as a rake is used to determine the presence of CLP at that sample point. Density is not measured as the plants are typically very small and density is very subjective. The presence of CLP is simply determined. There are many points checked outside of the bed delineation to assure the boundary is correct.

The second survey is referred to as the post treatment survey. This survey involves going to the same GPS coordinates as the pre-treatment survey and doing a rake sample at the point. If any CLP is on the rake, the density of the CLP is recorded (see fig 2 for reference). All other species are also recorded from the rake sample in order to verify no damage to the native plants.

Figure 2: Density rating system and example CLP rake sample.

When the surveys are complete, the frequency of occurrence is determined as well as the mean density for each bed as well as all beds combined. The frequency of occurrence for each native plant species sampled is also calculated. A chi-square analysis is then used to determine if the change in frequency is statistically significant ($p<0.05$). The goal is to find the chi-square analysis show that the frequency of CLP is significantly reduced and the native plants are not significantly reduced.

The comparison for reduction is three-fold. First, the result from the previous year's post treatment survey is compared to the present year post treatment survey. This reflects a long-term effectiveness. As more treatments are done in annual succession, these frequency values can become very similar since the CLP growth is reduced so much. This can make it appear the treatment is not progressing successfully since the frequency appears to not be reduced. Each year, new turions can germinate in the fall/winter creating new growth. The result is a low frequency in the post treatment survey, but in the next spring the CLP has grown immensely, and results in a high frequency.
In order to reflect that new growth and the effect the treatment has on it, a second comparison is done. This compares the frequency of CLP in the spring, pre-treatment survey to the post treatment results in that same year. This shows what the CLP growth really was just before treating and the result after treatment. To show long-term reduction, the pretreatment frequency can be compared between treatment years. If the pretreatment frequency is going down from year to year, then the CLP is being reduced through turion reductions, thus resulting in less growth that spring.

In the end, we want to see a statistically significant reduction when comparing the pre-treatment frequency to the post treatment frequency. We would also like to see a consistent frequency reduction from year to year, depending on how low it is. If the

frequency in any post treatment survey is very low (less than 10% as an example), then lowering it even more may not be realistic, but is the goal. Turions can remain viable for several years, which can affect reduction amounts achieved.

In order to further reflect potential future growth and the cumulative success of treatments, a turion analysis is conducted. This analysis involves going to sample points near the middle of the CLP bed (assuming this will reflect the highest density). At each sample point a sediment sampler is lowered to the lake sediment and a sediment sample is obtained. Two samples are obtained from each side of the boat at each location. The samples are then separated with a screened bucket to isolate the turions. The turions are then counted and the density of turions is calculated in turions/square meter. Consistently successful treatments should so a trend of reduced turion density each year. This way we know the treatments are killing plants prior to turion production, resulting in overall reduction in CLP in those beds.

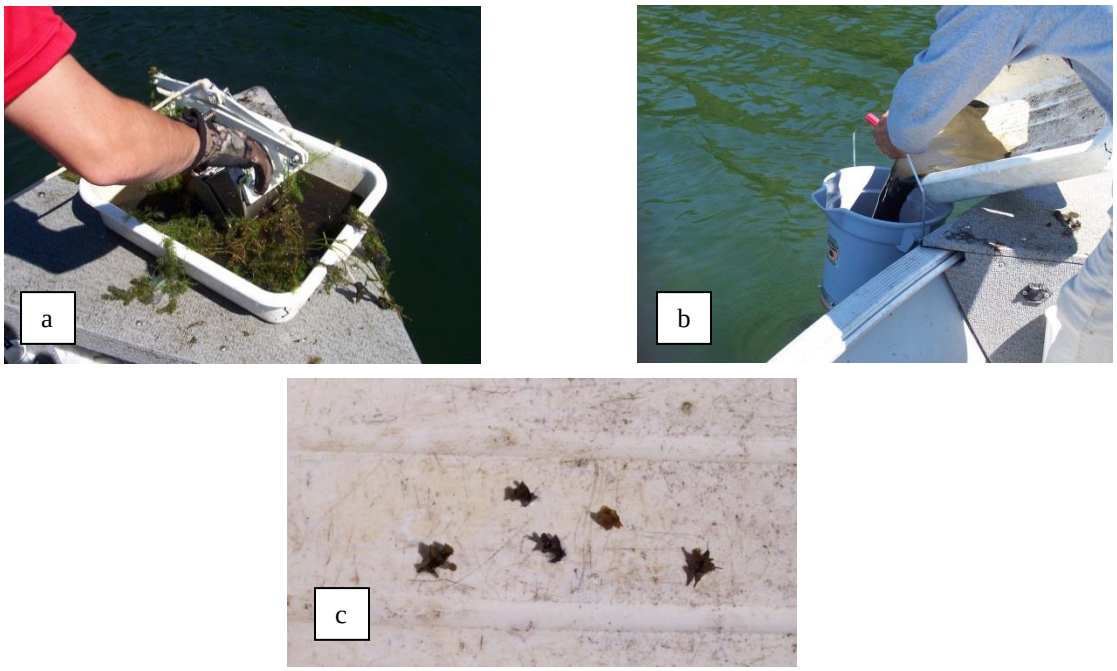


Figure 3: Pictures showing turion density methods. (a) shows sediment sample;(b) shows separation; (c) shows separated turions.

Results

CLP reduction

The pretreatment survey resulted in eliminating some treatment beds from 2013. With low turion density in 2013 and the lack of any CLP growth in 2013, beds B8 and R1 were eliminated for 2014. Some minor adjustments were made to beds B1 and B15 to reflect lack of growth in some areas . This is based upon the fact that if CLP is growing just outside the polygon border, these areas are included or added, while if an area is consistently not showing any CLP growth, that portion of the polygon is reduced.

The frequency of CLP in the treatment beds was much higher in the pretreatment survey of 2014 than the frequency in the post treatment survey of 2013. This shows that the CLP filled in the beds again, due to germination of turions.

Bed	2014 pre treat freq (0-100%)	2014 post treat freq (0-100%)	2013 post freq. (0-100%)	2013 pre freq. 0-100%)	2014 mean density (0-3)
B1	75.0%	0.0%	12.5%	73.7%	0.0
B2	81.8%	0.0%	0.0%	92.8%	0.0
B3	71.4%	0.0%	0.0%	80.0%	0.0
B8	0.0%	nt	11.1%	75.0%	nt
B12	63.6%	0.0%	26.1%	82.6%	0.0
B14	50.0%	0.0%	0.0%	62.5%	0.0
B15	66.7%	9.5%	2.3%	72.7%	0.1
All beds	**70.3%**	**2.0%**	**9.3%**	**81.4%**	**0.02**

Table 3: Frequency changes reflected in pre and post treatment surveys.

The post treatment survey showed that the frequency of CLP growth was very small in all treatment beds. Bed 15 showed the only remaining CLP growth after treatment with 9.5% of the sample points having CLP present. All samples were of low density (1). This frequency is a small increase from 2013 (9.3% vs 2.3%). Treatment beds B1 and B12 showed a smaller frequency in 2014 than what was present in 2013. Overall, the cumulative effect was a slight reduction in frequency from 2013 to 2014, but was found to be significant ($p=0.04$).

The frequency reduction from the 2014 pretreatment CLP growth to the 2014 post treatment growth was significant ($p=1.2 \times 10^{-24}$). All beds showed a reduction, most of which were quite substantial. The overall reduction (all beds considered) was from a frequency of 70.3% to a frequency of 2.0%. This demonstrates an effective reduction of CLP growth from herbicide treatment.

Bed	Pre to post (2014)reduction and significance?	Post 2013 to Post 2014 reduction significance?	Pre 2013 to Pre 2014 Reduction Significance?
B1	-75%	-12.5%	+1.3%
B2	-81.8%	n/c	-11.0%
B3	-71.4%	n/c	-8.6%
B12	-63.6%	-26.1%	-19.0%
B14	-50.0%	n/c	-12.5%
B15	-57.2%	+7.2	6.0%
All beds	-68.3% Yes ($p=1.2X10^{-24}$)	-7.3% Yes (p=0.04)	-11.1% Yes (p=0.04)

Table 4: Summary of statistical analysis of CLP reduction.

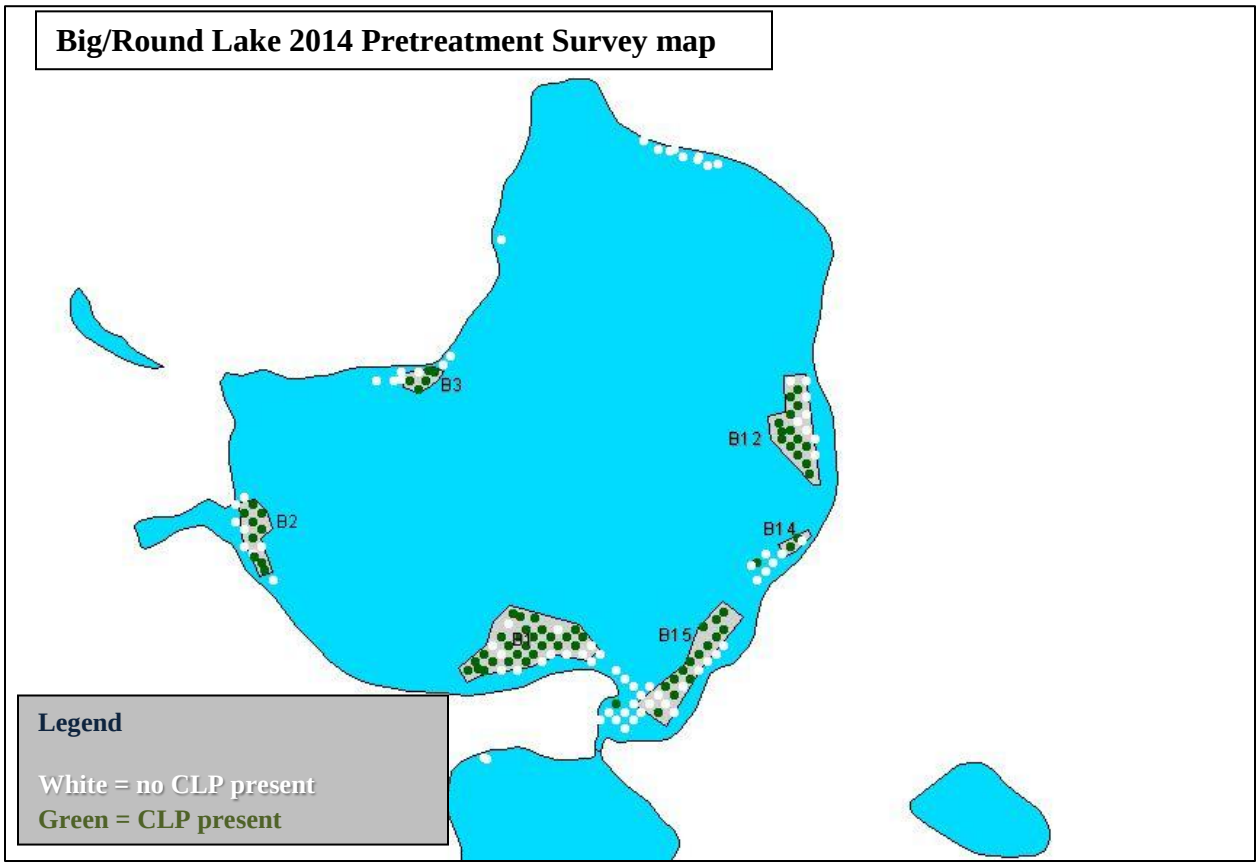


Figure 4: Map showing absence and presence of CLP growth from pretreatment survey, May 2014.

In addition, a frequency reduction occurred from the pretreatment survey in 2013, to the pretreatment survey in 2014. This reduction was quite small, but the chi-square analysis

indicates it was statistically significant (p=0.04). This is a good indication of long-term CLP reduction.

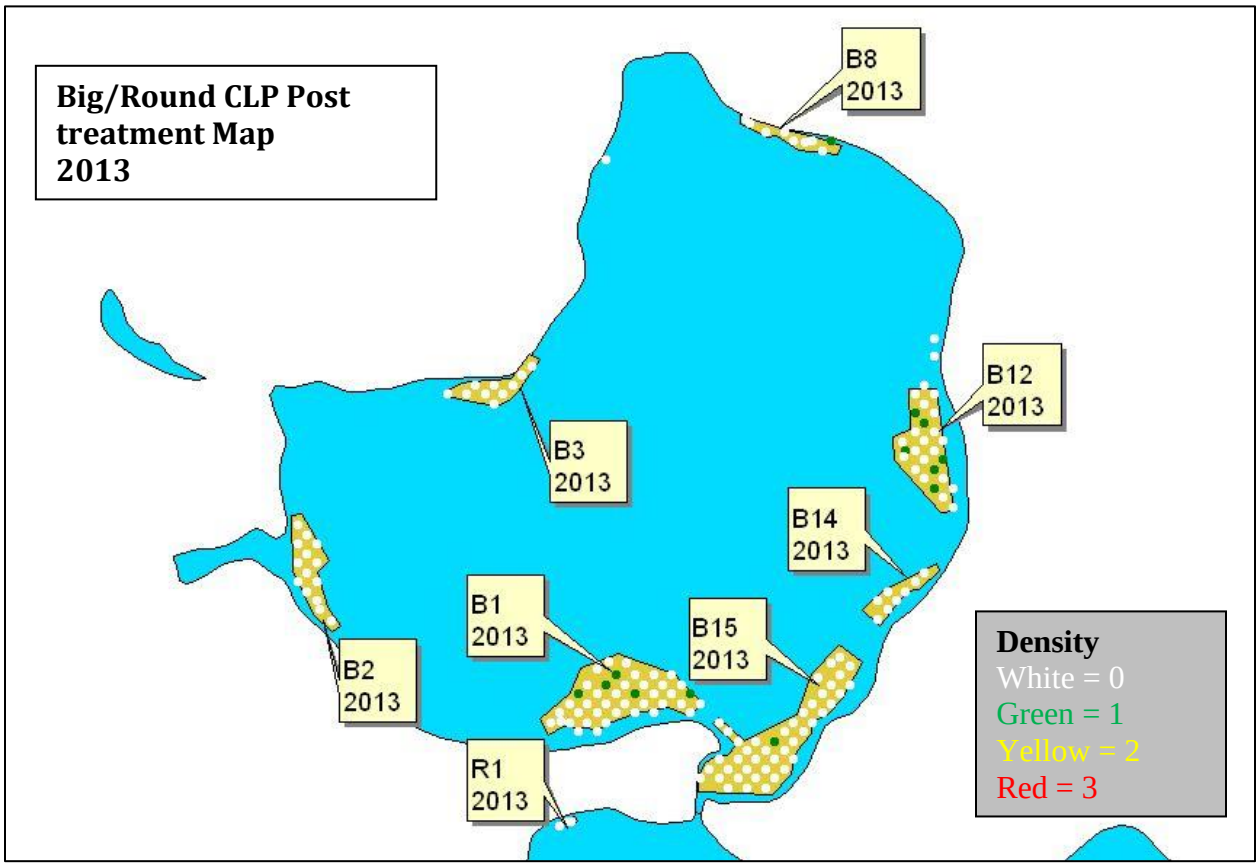


Figure 5: Map showing CLP density from post treatment survey June 2013.

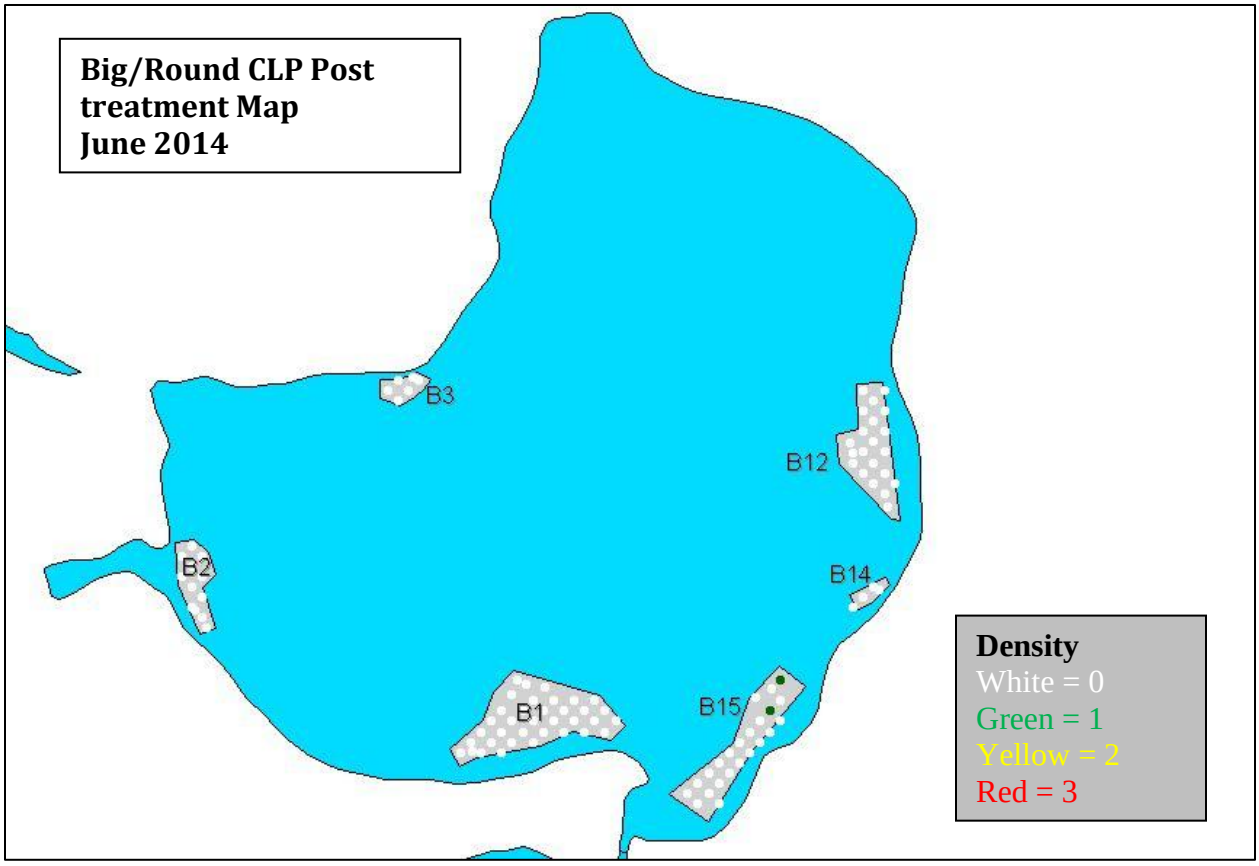
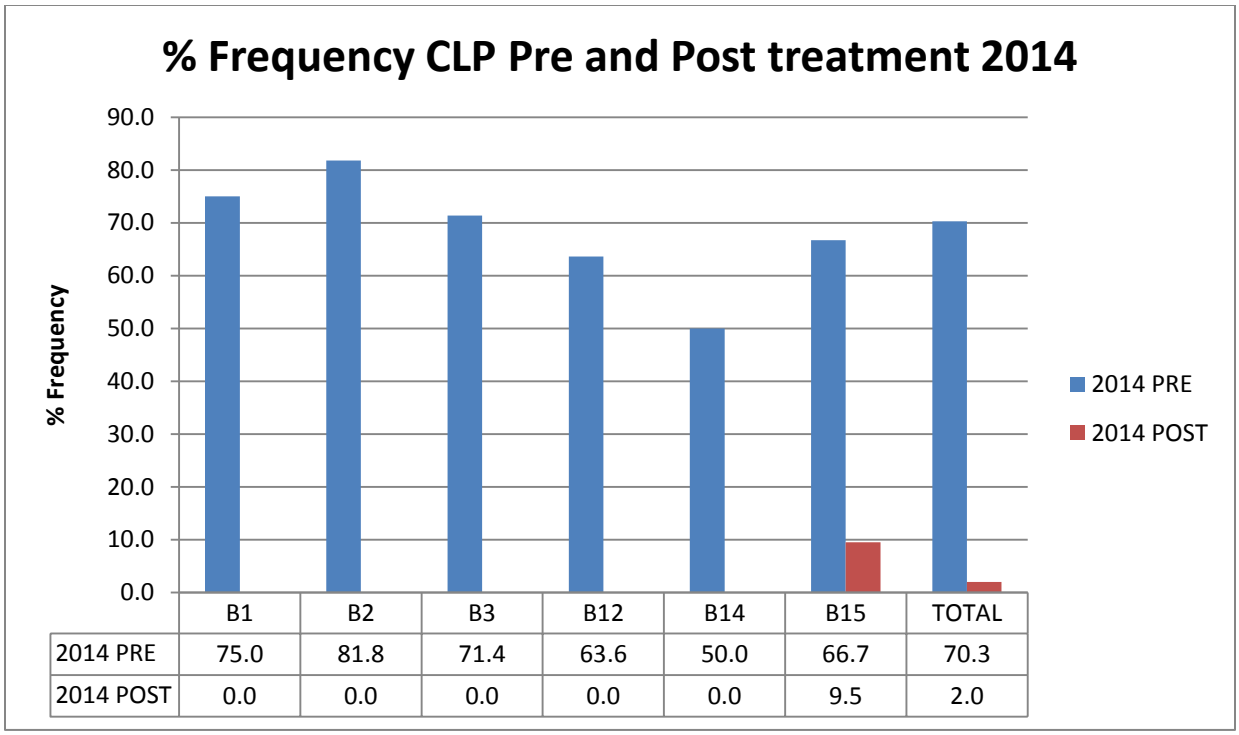
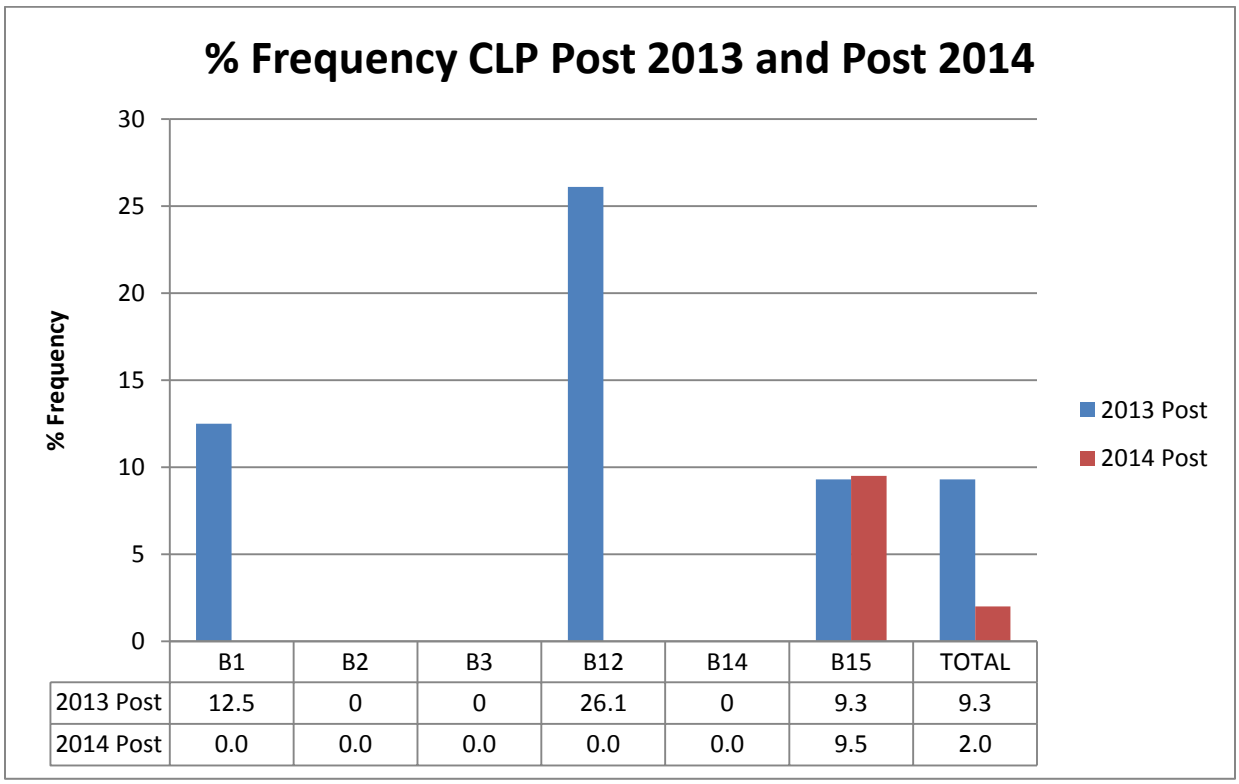


Figure 6: Map showing CLP density from post treatment survey June 2014.



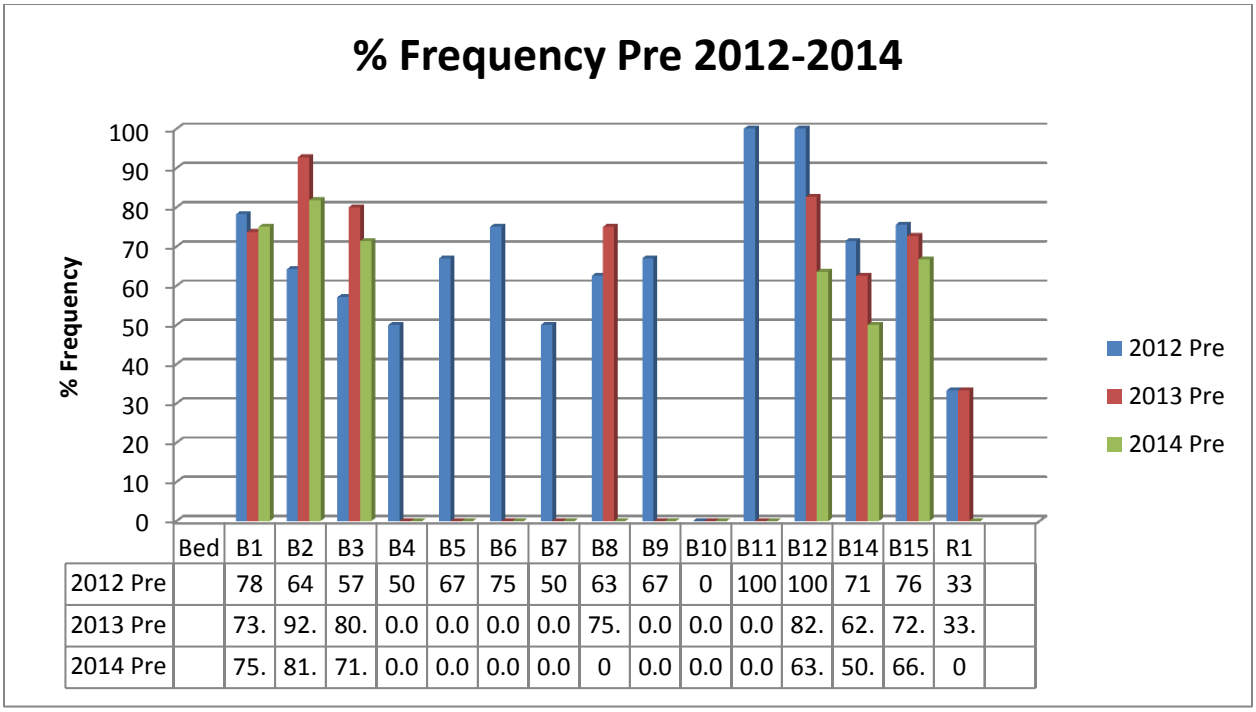
	B1	B2	B3	B12	B14	B15	TOTAL
2014 PRE	75.0	81.8	71.4	63.6	50.0	66.7	70.3
2014 POST	0.0	0.0	0.0	0.0	0.0	9.5	2.0

Figure 7: Graph depicting the reduction in CLP growth from pre to post treatment 2014.



	B1	B2	B3	B12	B14	B15	TOTAL
2013 Post	12.5	0	0	26.1	0	9.3	9.3
2014 Post	0.0	0.0	0.0	0.0	0.0	9.5	2.0

Figure 8: Graph depicting the change in CLP frequency from 2013 to 2014, post treatment.



Bed	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B14	B15	R1
2012 Pre	78	64	57	50	67	75	50	63	67	0	100	100	71	76	33
2013 Pre	73.	92.	80.	0.0	0.0	0.0	0.0	75.	0.0	0.0	0.0	82.	62.	72.	33.
2014 Pre	75.	81.	71.	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	63.	50.	66.	0

Figure 9: Graph showing the pretreatment CLP frequency in each bed, 2012-2014. Note the lack of frequency of beds in 2013 and 2014. This shows the CLP has been significantly reduced in those beds.

Native plant species

Another goal of the herbicide treatment is to target the CLP with little or no detrimental effect on the native plant community. In order to determine if there was potential impact on the native plants, a comparison in native plant frequencies is done from one year to the next; in this case 2013 to 2014. A chi-square analysis is then conducted to determine if the change is statistically significant and not just from chance or random variation.

The post treatment survey resulted in no reduction in native plant frequency from 2013 to 2014. This shows that the CLP was targeted with little or no effect on the native plant community. This is the goal of any AIS treatment; target the AIS without harming the native plants. Table 5 summarizes the native plant data and distribution maps are at the end of this analysis.

Species	2013 freq	2014 freq	change	Significant Reduction?
Ceratophyllum demersum(coontail)	0.89	0.95	+	n/a
Elodea canadensis(waterweed)	0.18	0.30	+	n/a
Heteranthera dubia(stargrass)	0.00	0.04	+	n/a
Lemna triscula(forked duckweed)	0.01	0.12	+	n/a
Myriophyllum sibiricum(northern water-milfoil)	0.04	0.01	-	No(p=0.15)
Nymphae odorata(white lily) sim	0.04	0.02	-	No(p=0.24)
Potamogeton gramineus(variable pondweed)	0.01	0.00	-	No(p=0.40)
Potamogeton illinoensis(Illinois pondweed)	0.02	0.05	+	n/a
Potamogeton praelongus(whitestem pondweed)	0.06	0.05	-	No(p=0.68)
Potamogeton richardsonii(clasping pondweed)	0.01	0.01	n/c	n/a
Potamogeton robbinsii(fern pondweed)	0.01	0.00	-	No(p=0.40)
Potamogeton zosteriformis(flat-stem pondweed)	0.01	0.00	-	No(p=0.04)
Vallesnaria americana(wild celery)	0.00	0.01	+	n/a

Table 5: Summary of native plant changes from 2013 to 2014, post treatment.

Turion Analysis

The 2014 turion analysis showed that the turion density declined from 2013 to 2014. The mean turion density for all treated areas was 13.6 turions per m^2 in 2013 and was 6.4 turions per m^2 in 2014. There were slight increases in beds B2 and B3. This is likely due to sampling variation since there was no CLP observed in these areas in the post treatment survey to produce and release turions. The reduction likely occurs because the 2014 CLP growth resulted from germinated turions. Effective treatment kills the CLP plants prior to turion production, thus resulting in no net turions added. This is the desired result in treatment and should result in even less CLP growth in spring, 2015.

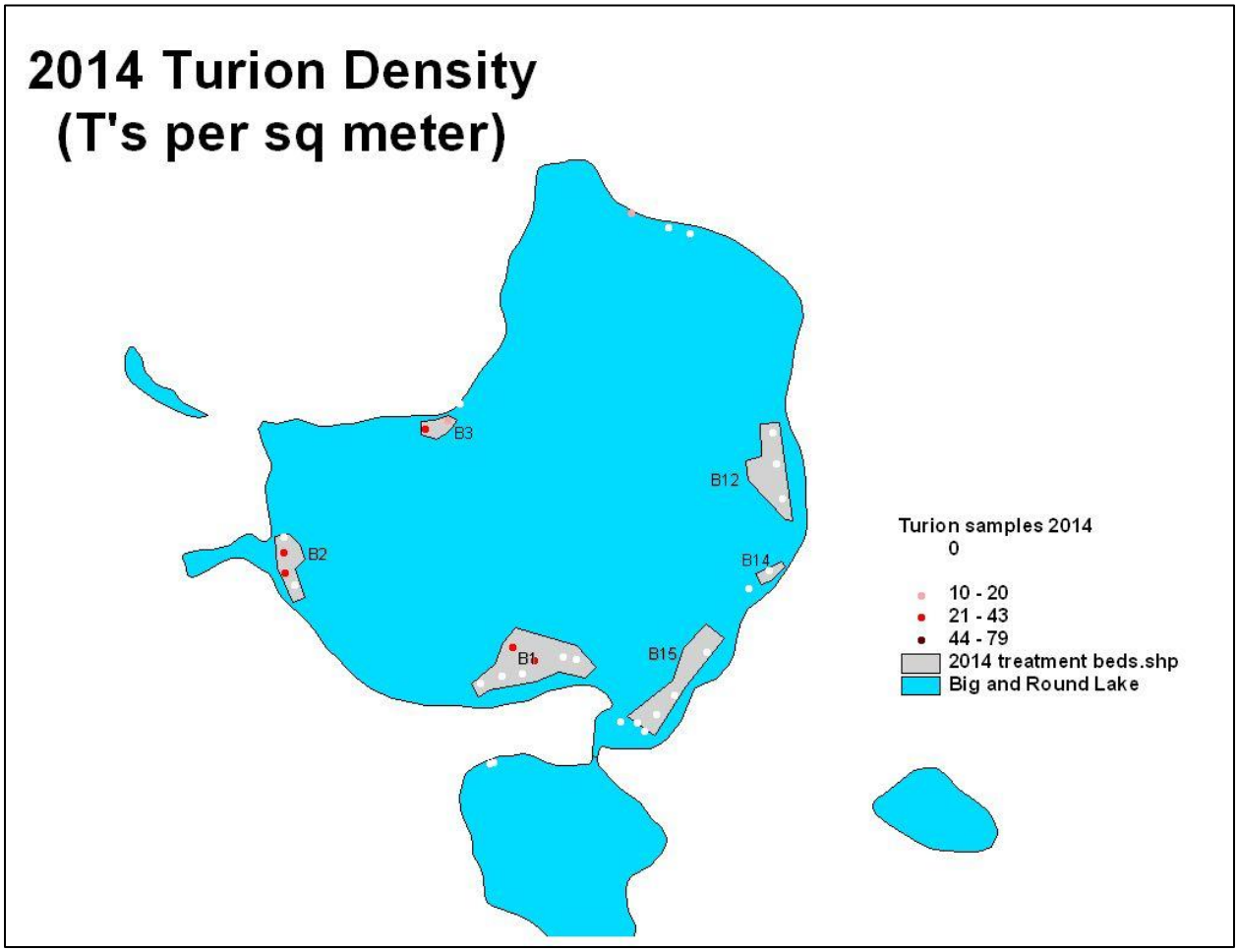


Figure 10: Map of turion density in treatment beds-2014.

Bed	2012	2013	2014
B1	30.7	27	12.4
B2	32.28	4	10.9
B3	7.1	15	21.7
B8	0	6.7	n/a
B12	28.7	39.7	0
B14	0	20	0
B15	30.7	16.7	0
R1	0	20	n/a
All Treated	**12.8**	**13.6**	**6.4**

Table 6: Mean turion density by beds, 2012 through 2014.

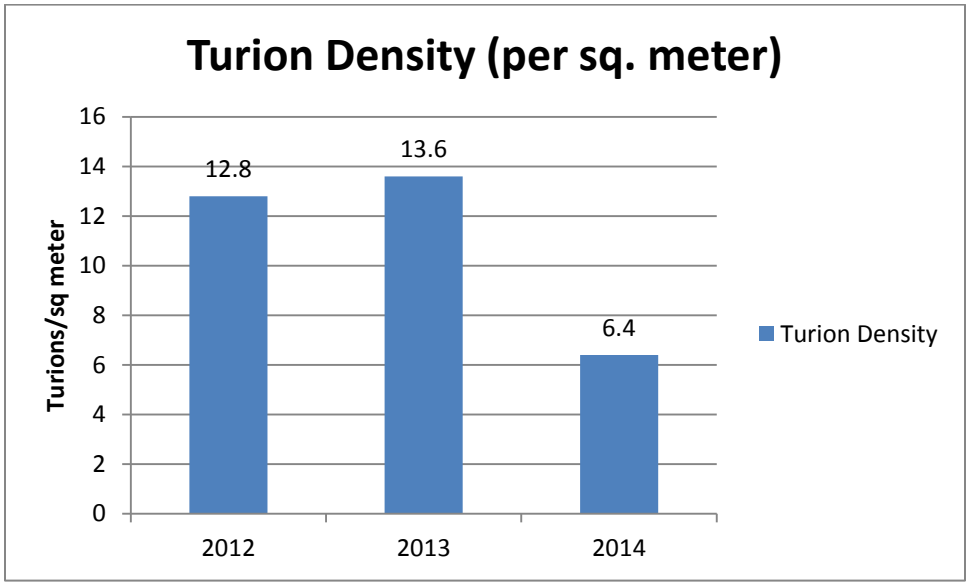


Figure 11: Graph of mean turion density (all treated beds) 2012-2014.

Discussion

A statistical analysis of the CLP growth data from pre and post treatment surveys show that the herbicide treatment was effective in reducing the CLP growth. The reduction occurred from the spring growth before treatment (reflected in pretreatment survey 2014) to the growth after treatment (reflected in the post treatment survey 2014).

Analysis shows a small reduction in growth after treatment 2014 as compared to after treatment in 2013. This reduction was small, but was statistically significant. There was also a significant reduction in the 2013 pretreatment frequency compared to the 2014 pretreatment frequency. This supports another effective treatment in 2014, in addition to previous years having effective treatments. Figure 10 shows the areal coverage of the CLP treatment beds each spring before treatment. These areas have been corrected using the frequency of occurrence, thus reducing the area the treated area actually covered with CLP.

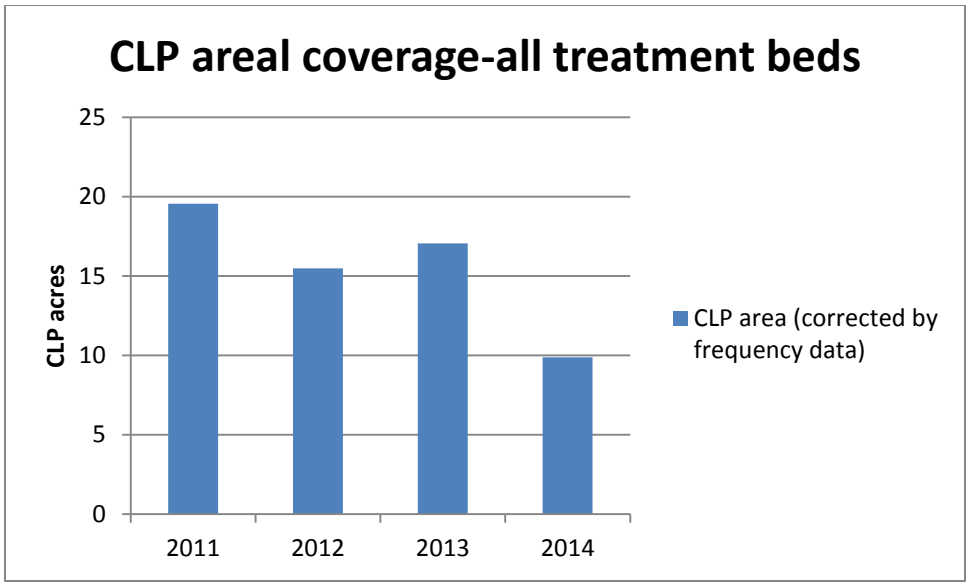


Figure 10: CLP areal coverage of all beds for each year 2011-2014.

The turion analysis shows that the decline in CLP appears to continue. The reduced turion density should result in less CLP growth in spring, 2015. Continued declines in turion density reflect long-term successful CLP reduction.

It is recommended that treatment of the beds continue based upon the early spring CLP coverage. Since turions can remain viable for many years future treatment may be needed. The turion analysis results, coupled with the pretreatment maps can be used to determine treatment in a particular year. The response to treatment and the resulting reduction in CLP in Big Lake and Round Lake has been excellent.

References

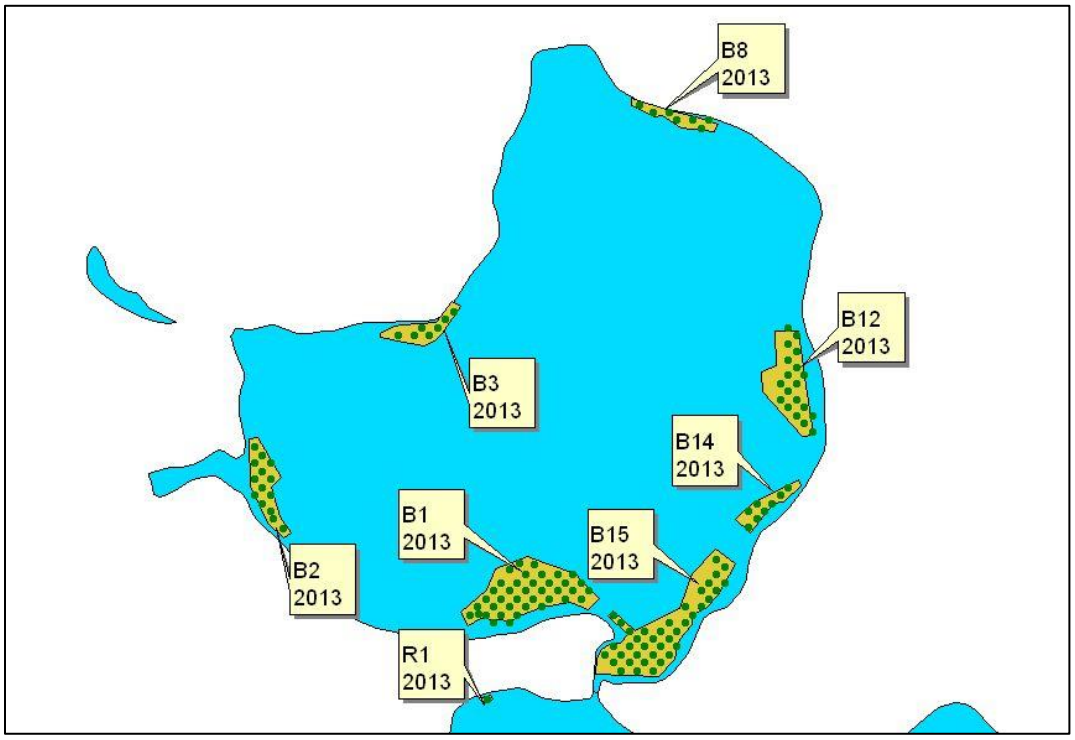
Borman, Susan, Robert Korth and Jo Tempte. *Through the Looking Glass.* University of Wisconsin-Extension. Stevens Point, Wisconsin. 1997. 248 p.

Crow, Garrett E. and C. Barre Hellquist. *Aquatic and Wetland Plants of Northeastern North America*. The University of Wisconsin Press. Madison, Wisconsin. Volumes 1 and 2. 2000. 880p.

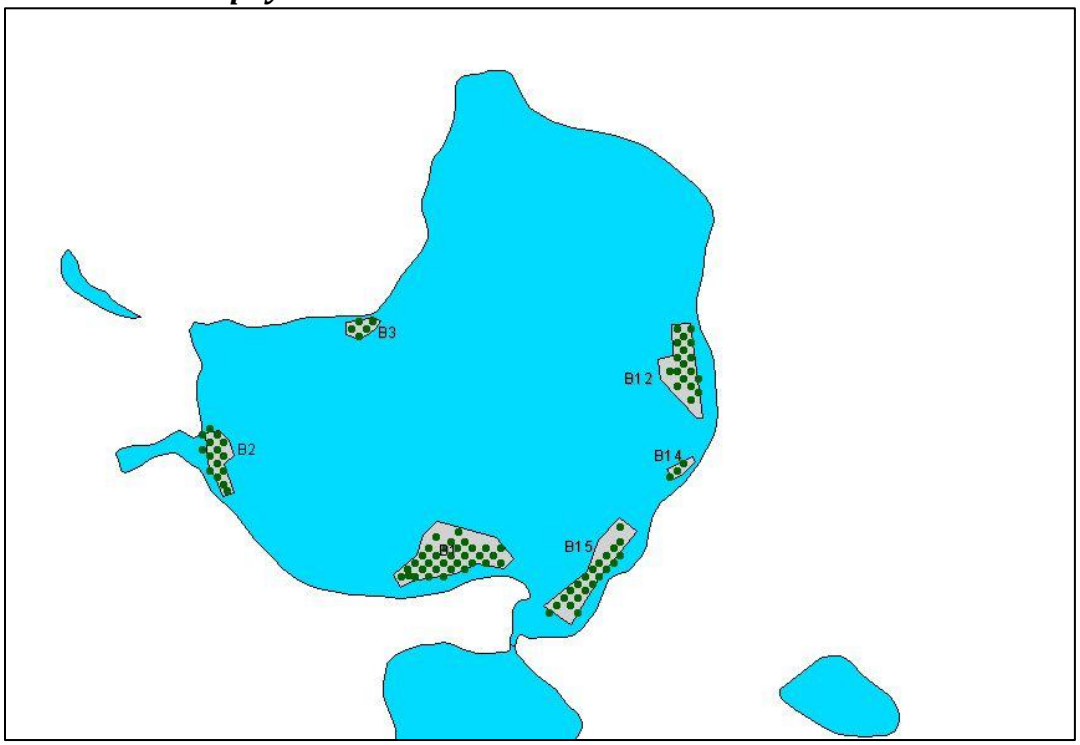
University of Wisconsin-Extension. *Aquatic Plant Management in Wisconsin*. April 2006 Draft. 46 p.

UW-Extension. Aquatic Plant Management website. http://www4.uwsp.edu/cnr/uwexlakes/ecology/apmguide.asp appendix d.

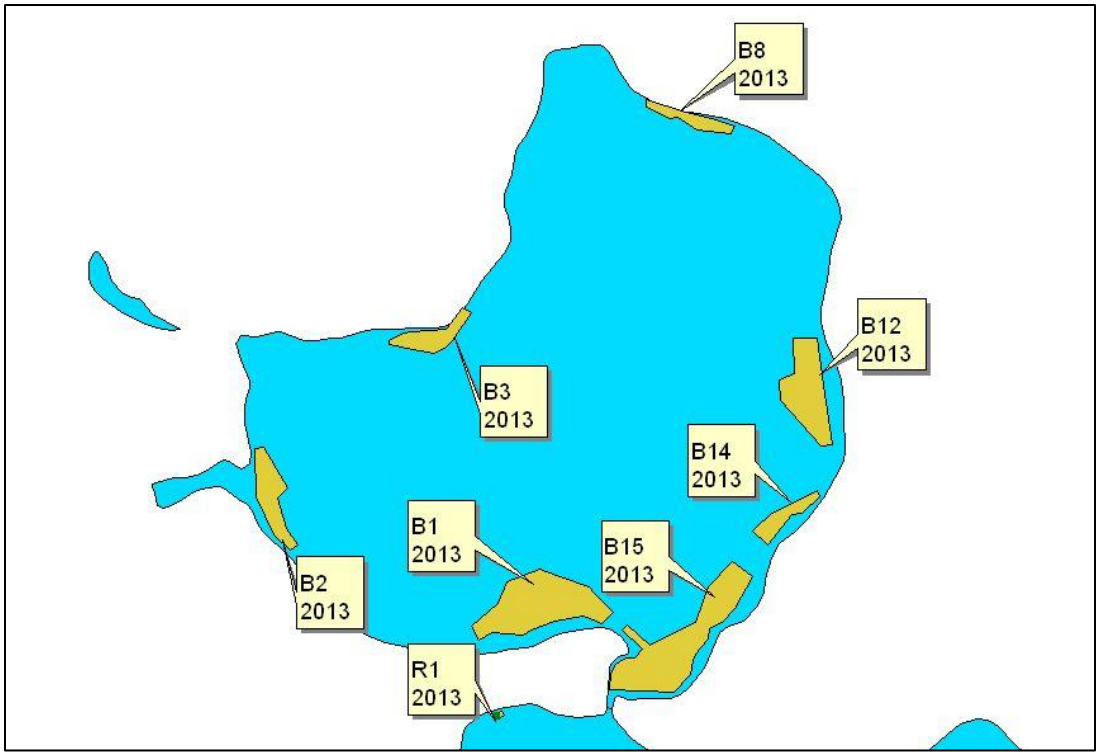
Appendix-native plant maps-2013



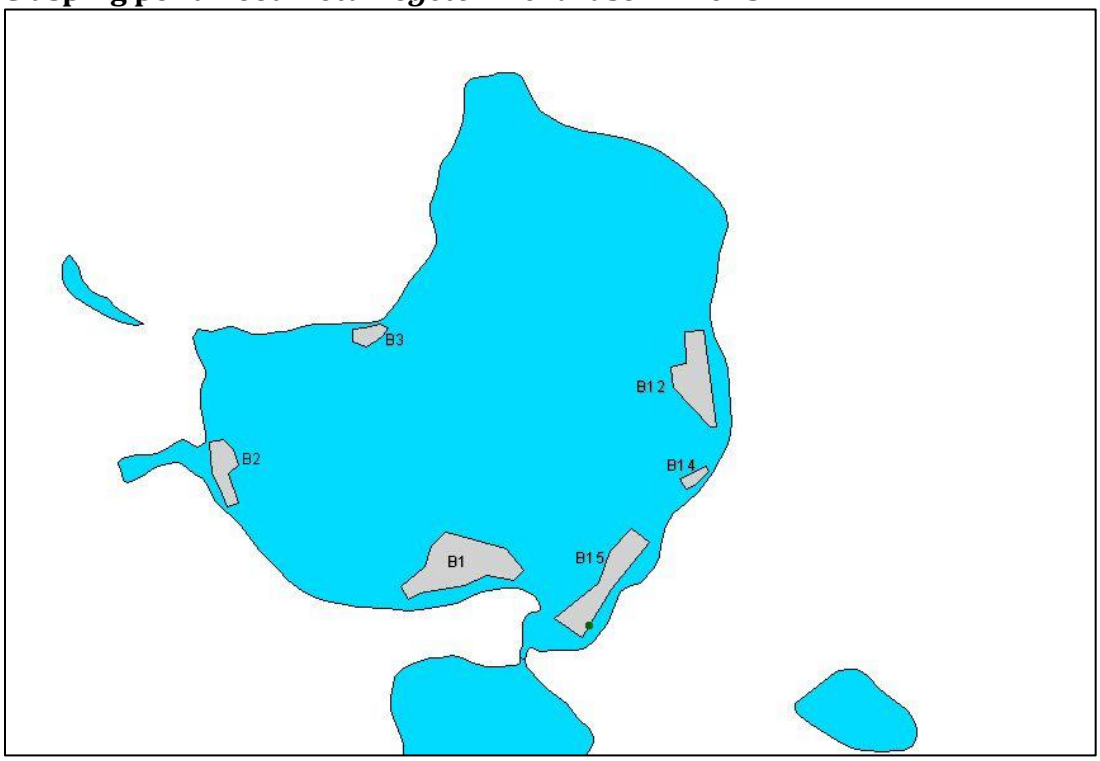
Coontail-*Ceratophyllum demersum*-2013



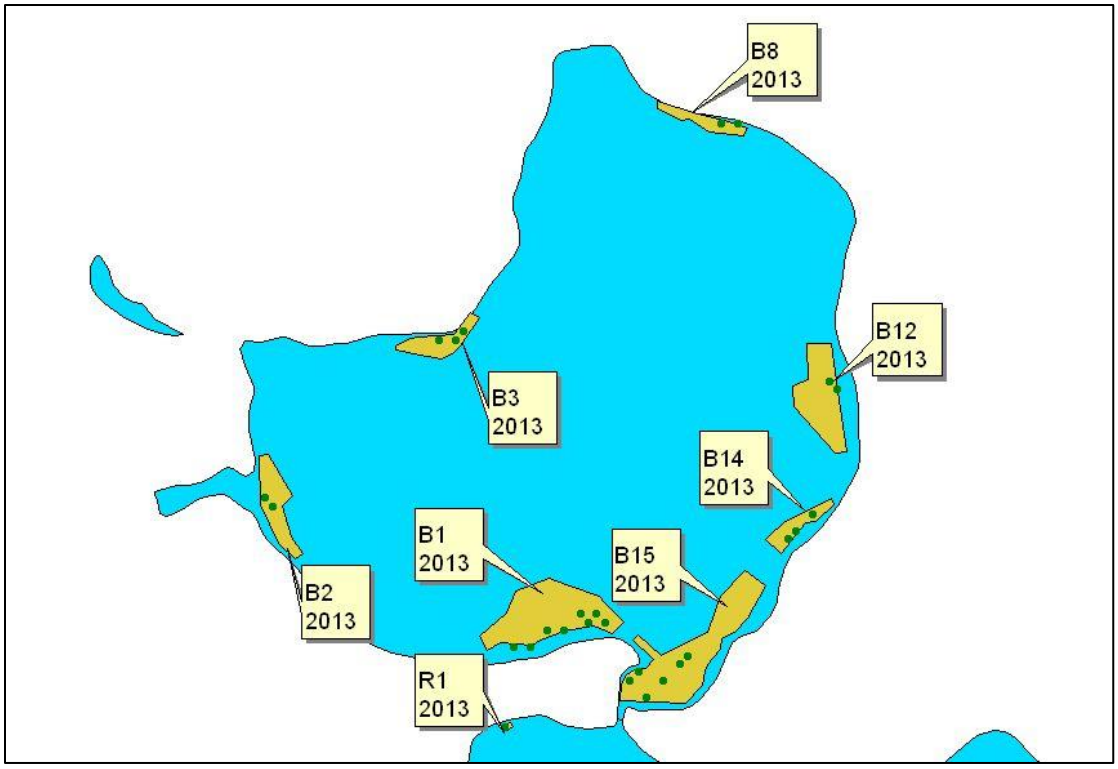
Coontail-*Ceratophyllum demersum*-2014



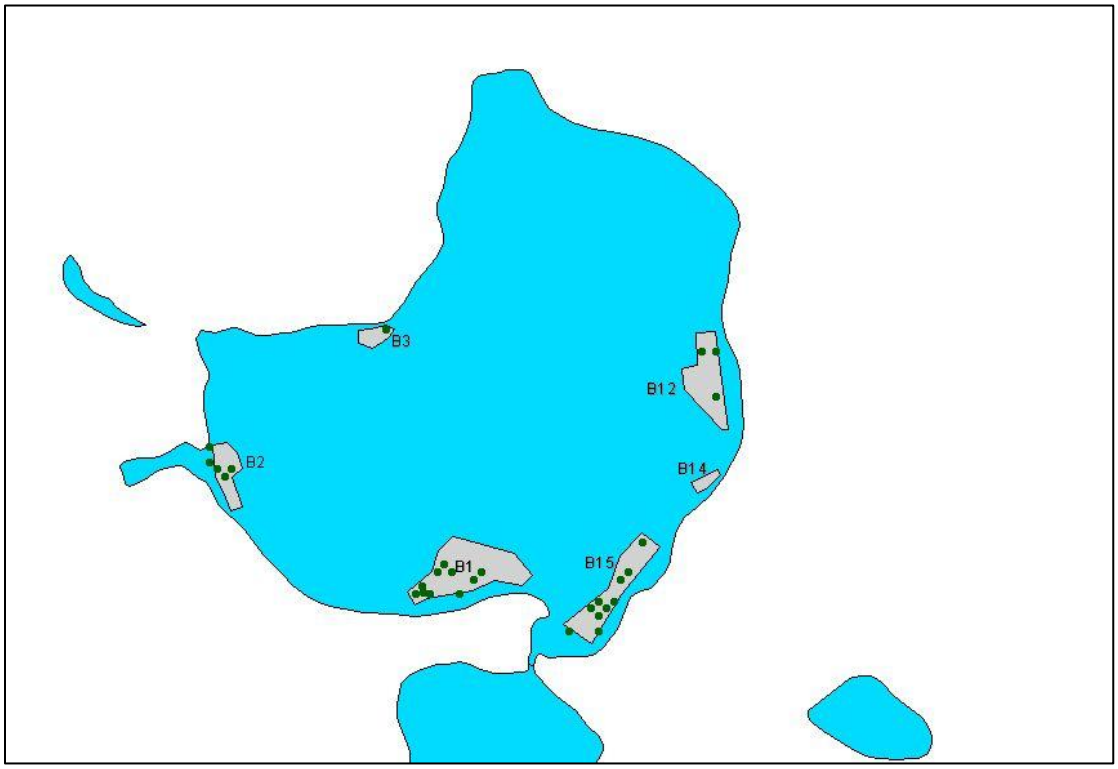
Clasping pondweed-*Potamogeton richardsonii*-2013



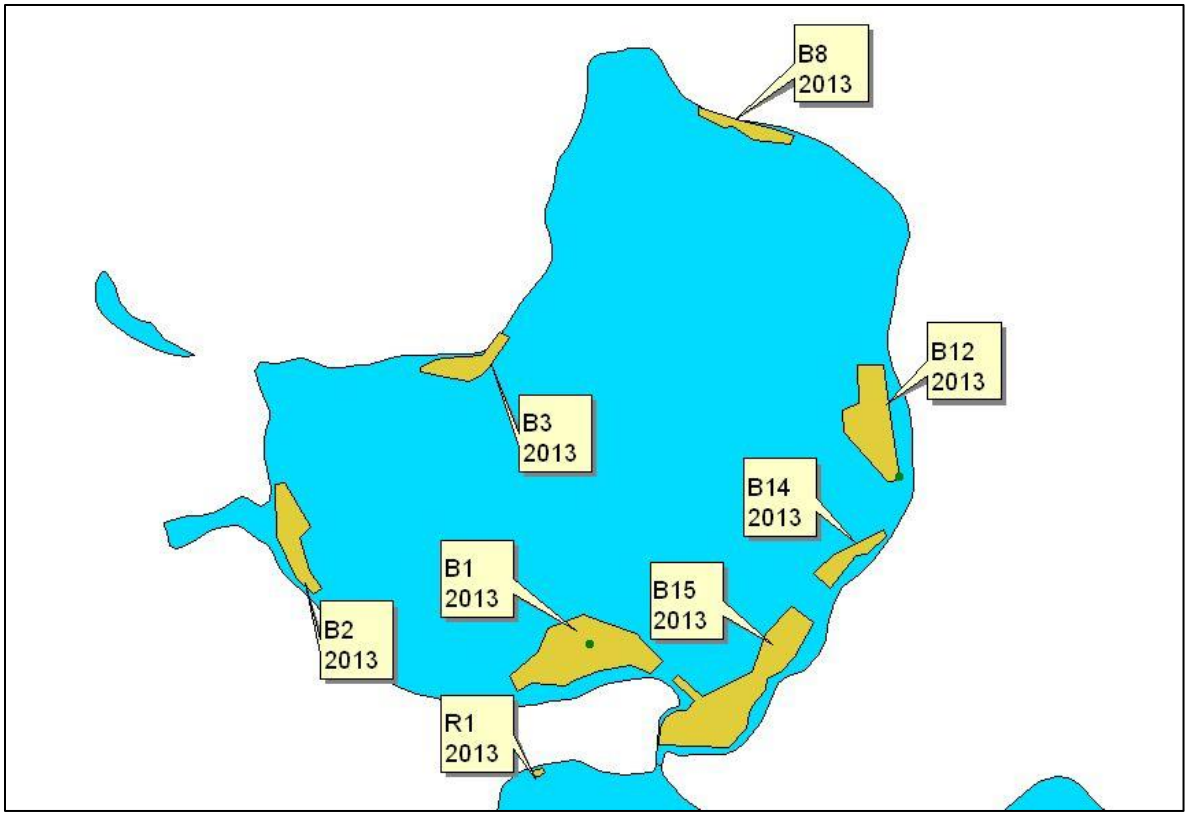
Clasping pondweed-*Potamogeton richardsonii*-2014



Waterweed or elodea-*Elodea Canadensis*-2013

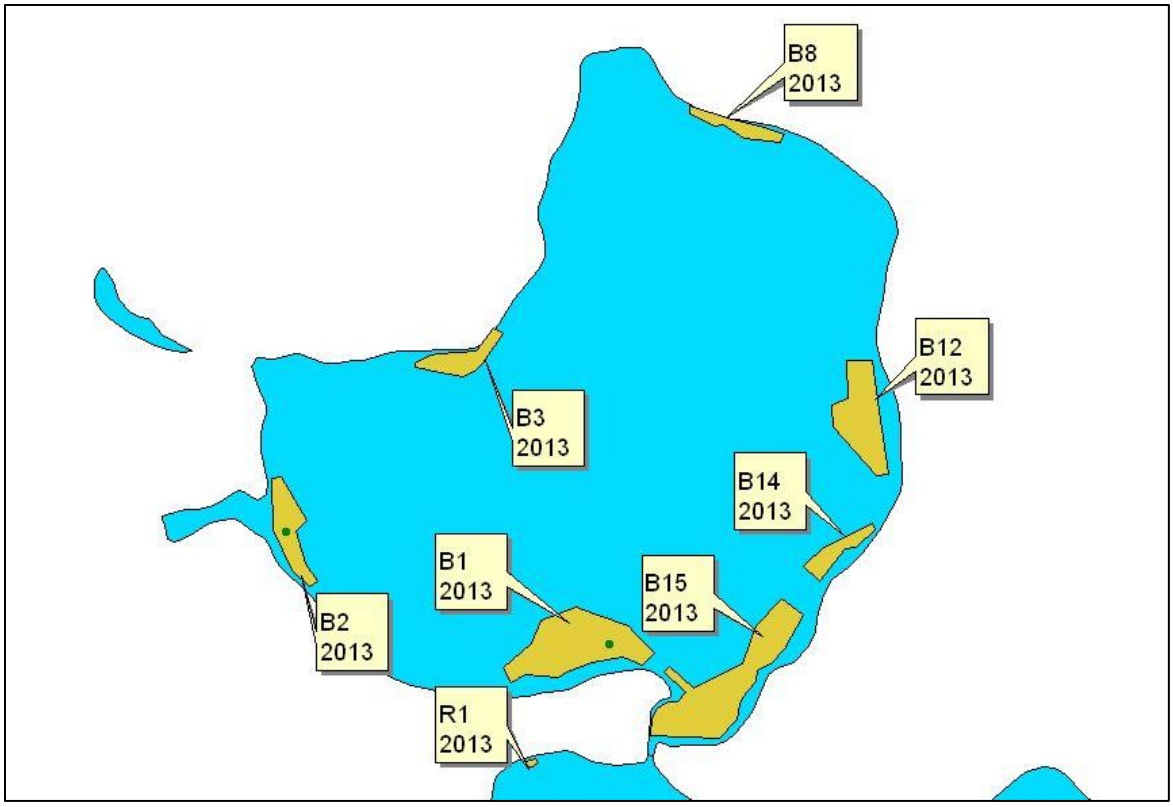


Waterweed or elodea-*Elodea Canadensis*-2014



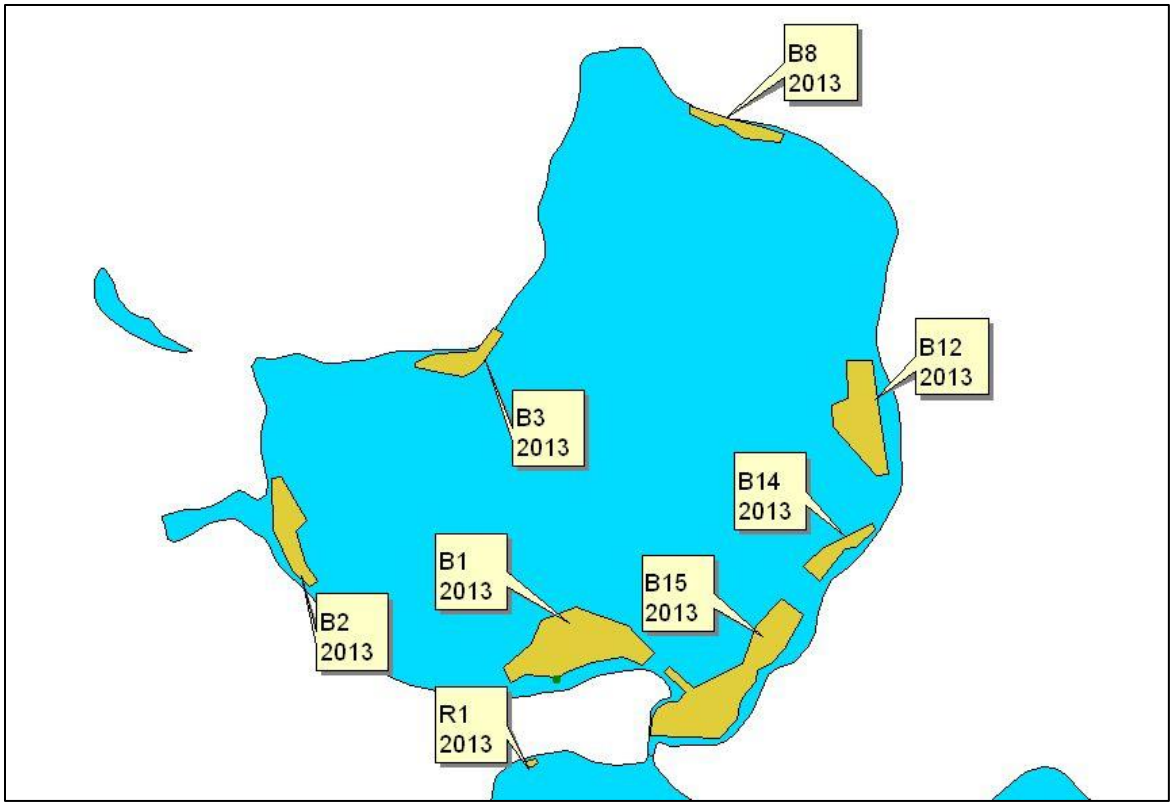
Fern pondweed-*Potamogeton robbinsii*-2013

None sampled in 2014.

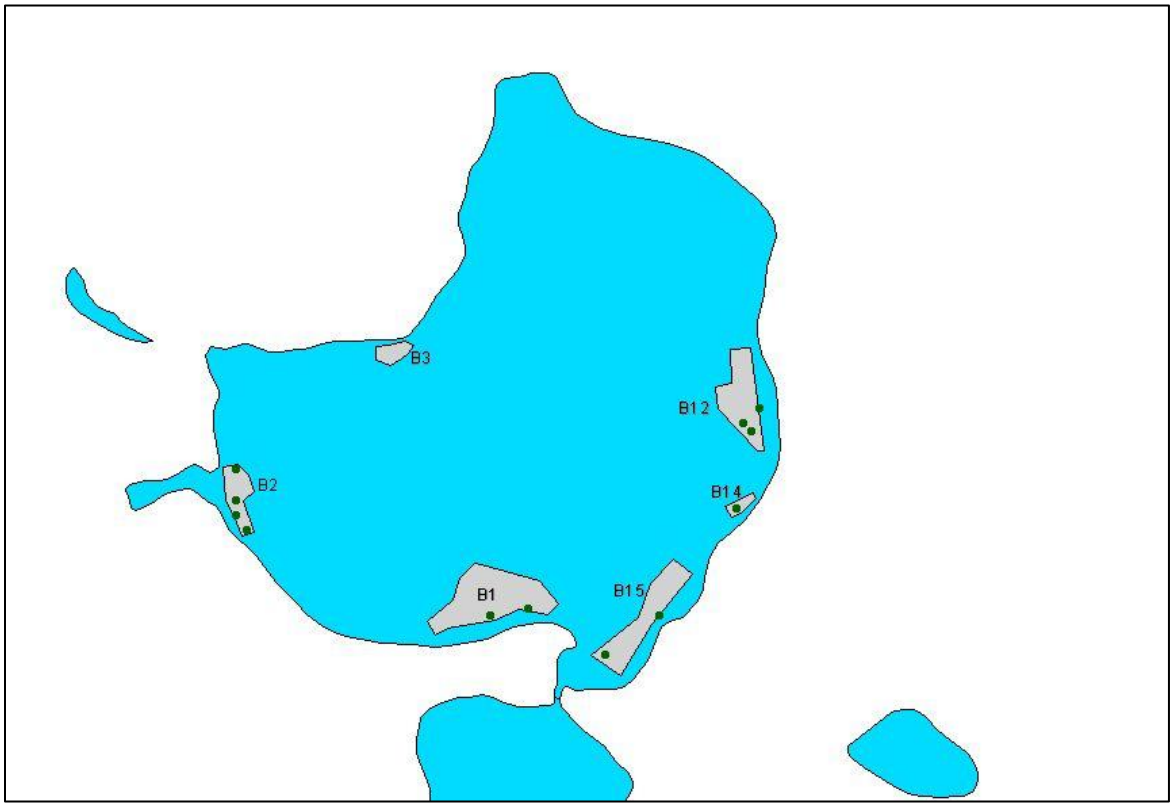


Flat-stem pondweed-*Potamogeton zosteriformis*-2013

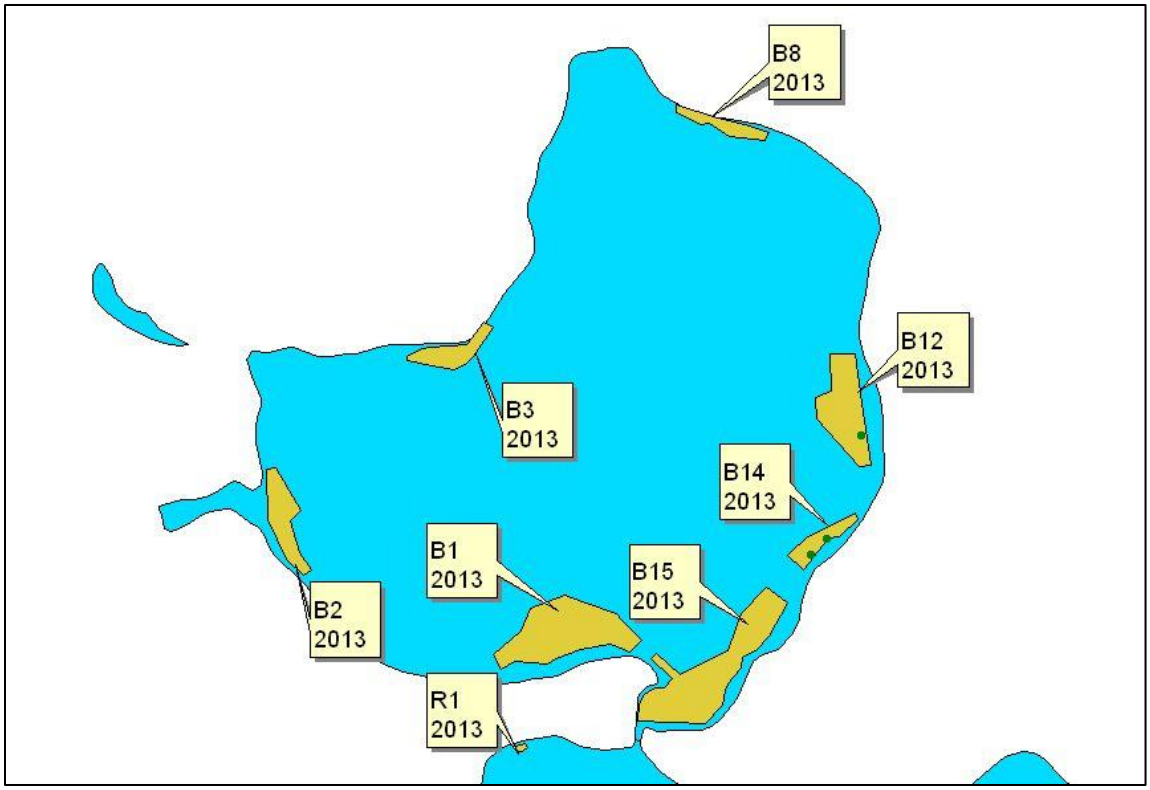
None sampled in 2014.



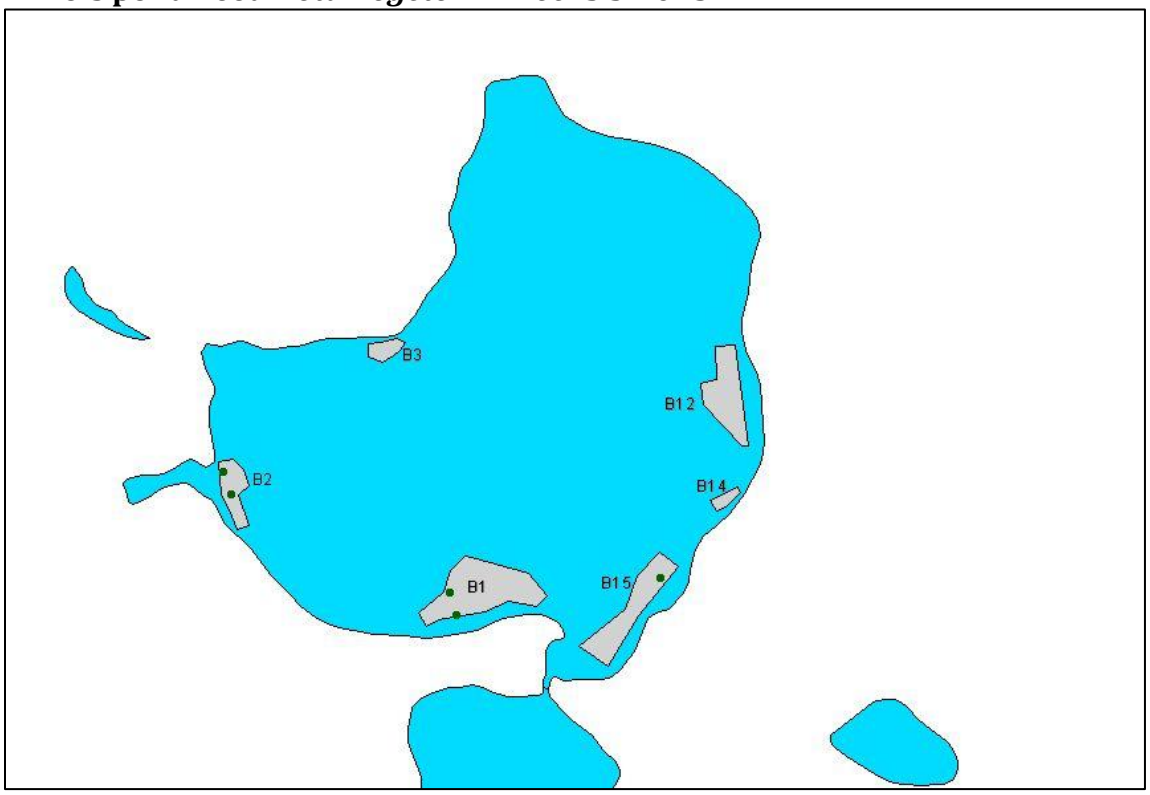
Forked duckweed-*Lemna trisulca*-2013



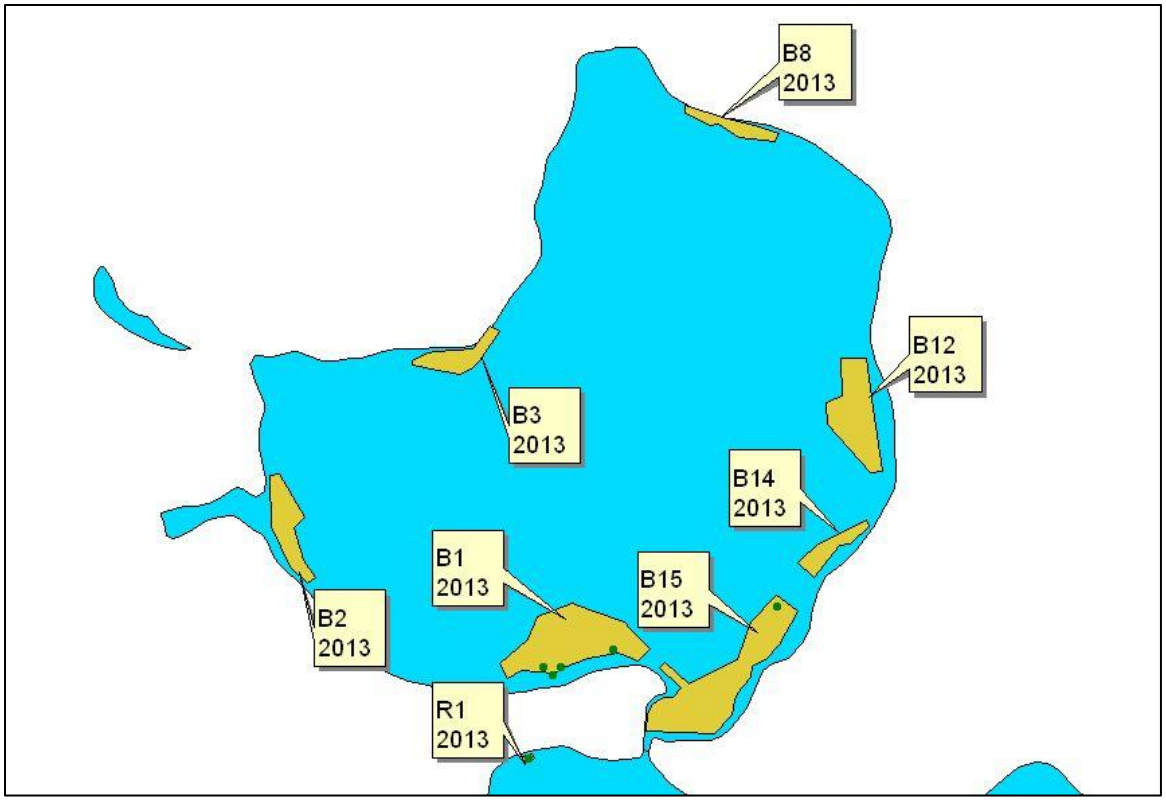
Forked duckweed-*Lemna trisulca*-2014



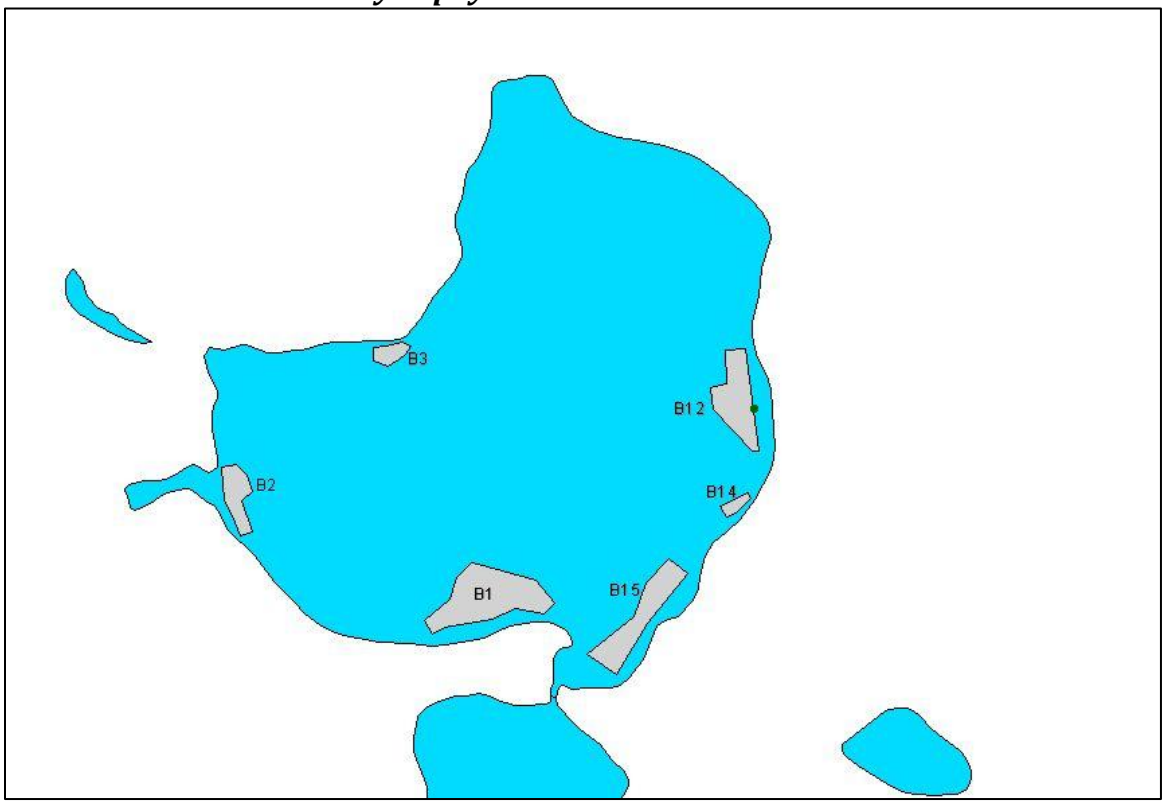
Illinois pondweed-*Potamogeton illinoensis*-2013



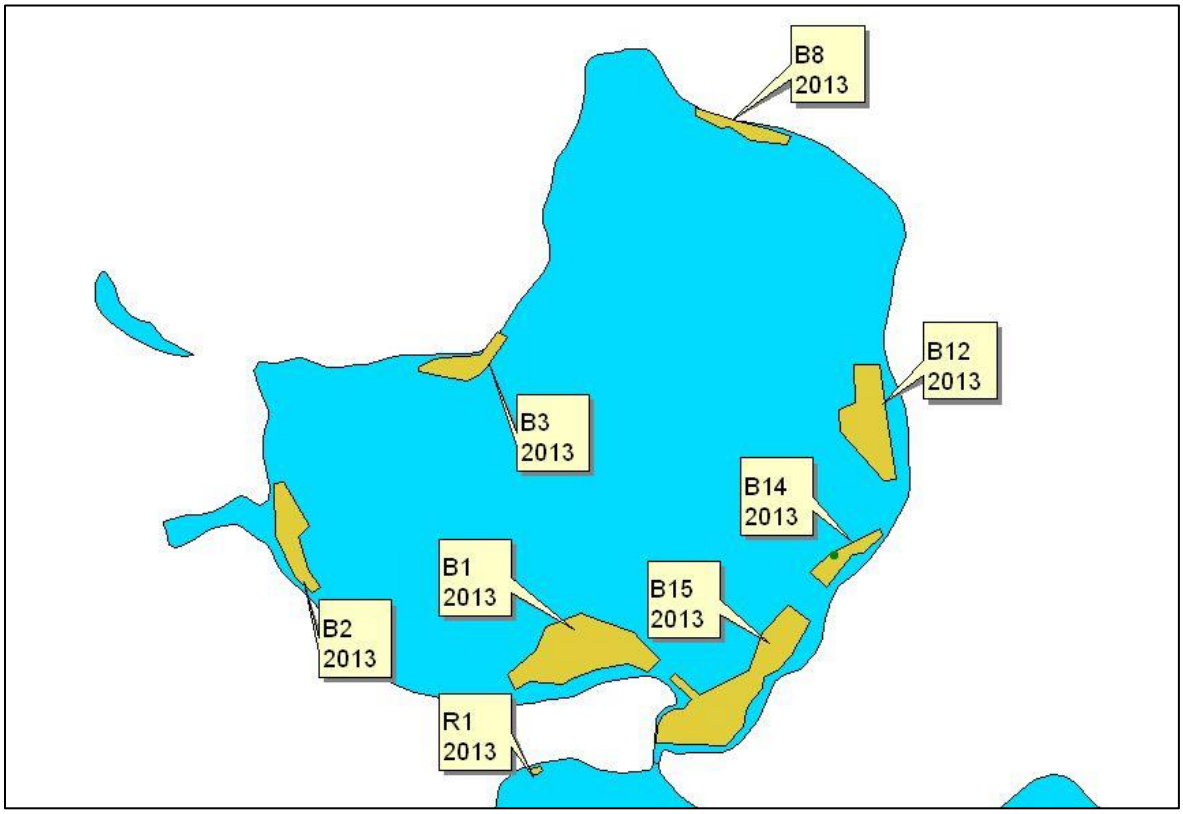
Illinois pondweed-*Potamogeton illinoensis*-2014



Northern water-milfoil-*Myriophyllum sibiricum*-2013

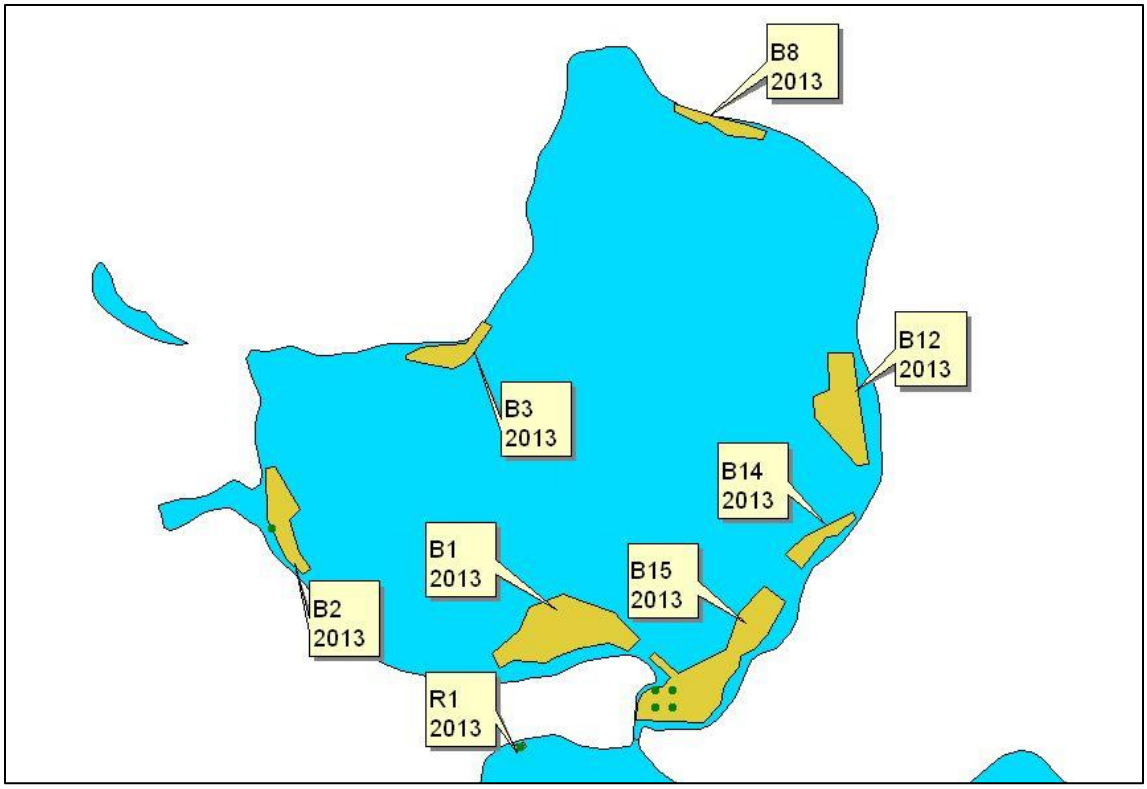


Northern water-milfoil-*Myriophyllum sibiricum*-2014

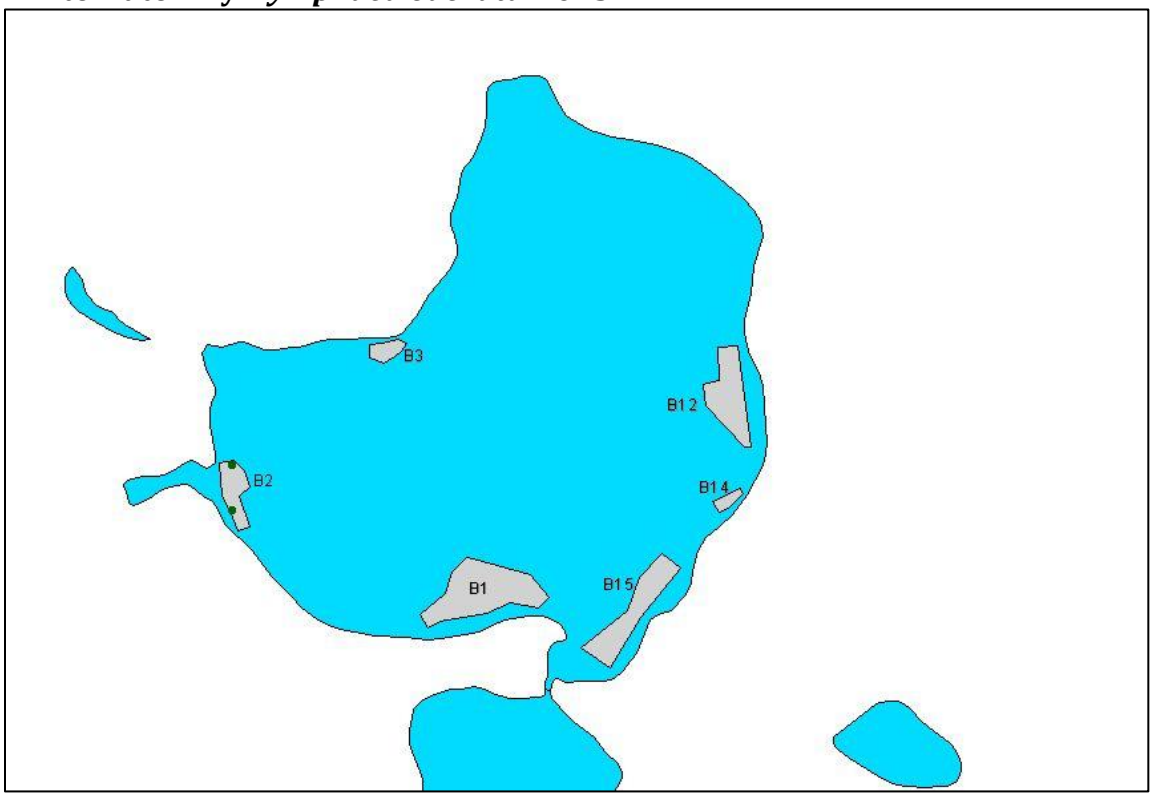


Variable pondweed-*Potamogeton gramineus*-2013

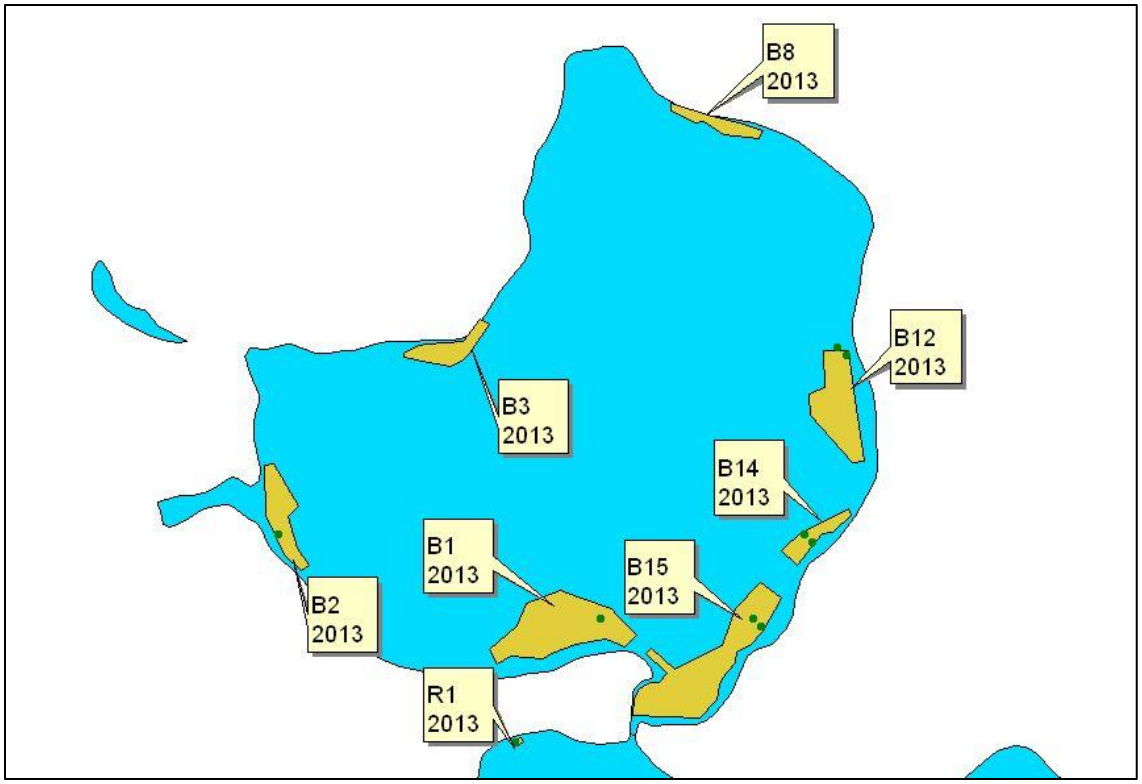
None sampled in 2014.



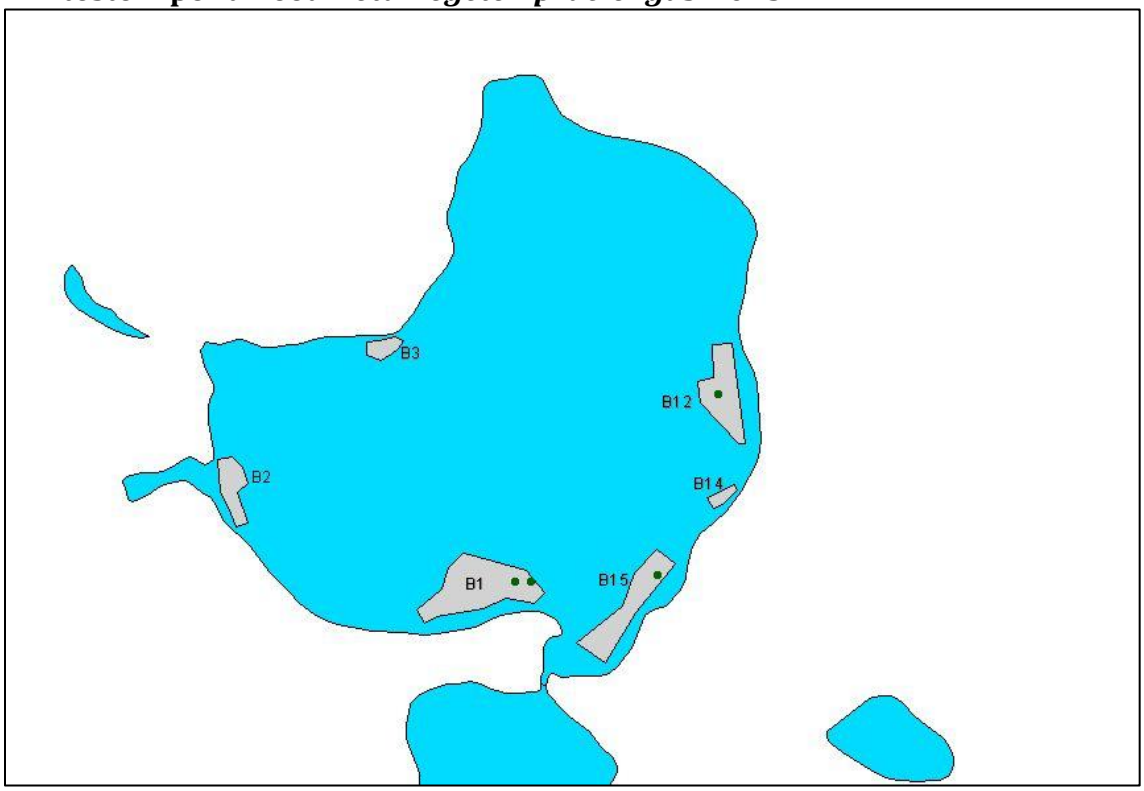
White water lily-*Nymphaea odorata*-2013



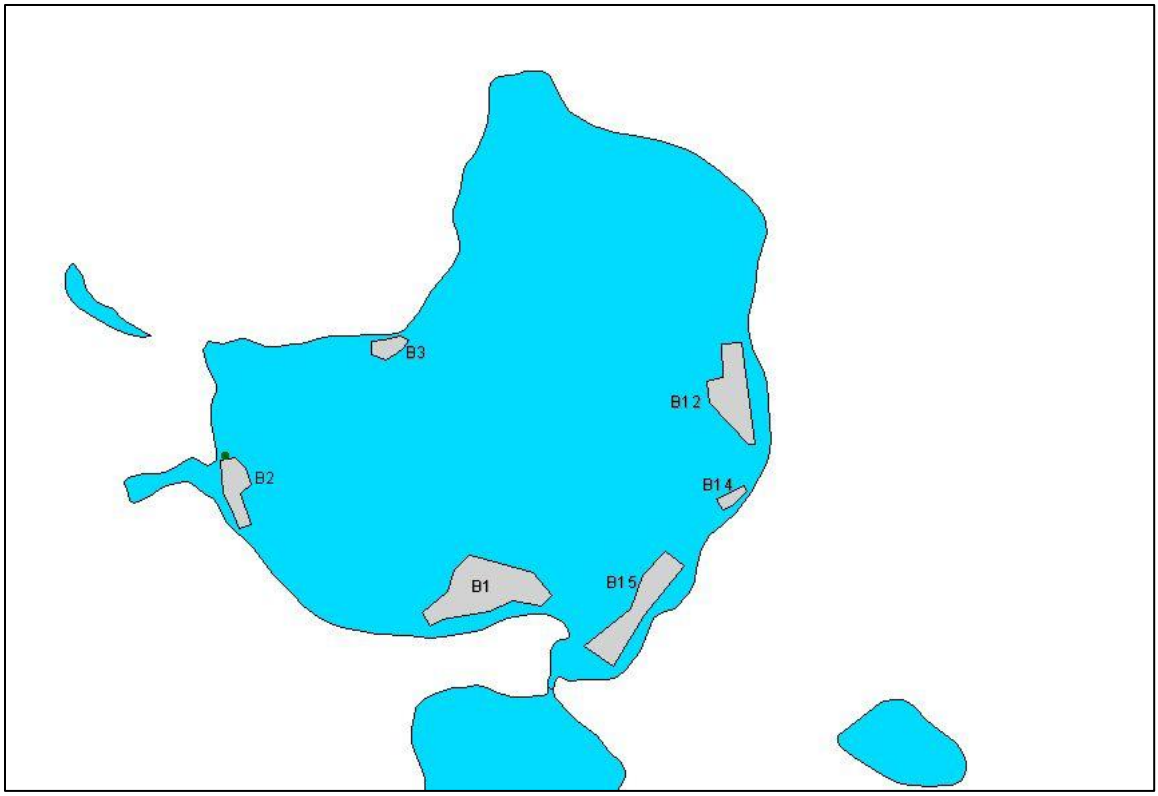
White water lily-*Nymphaea odorata*-2014



Whitestem pondweed-*Potamogeton praelongus*-2013

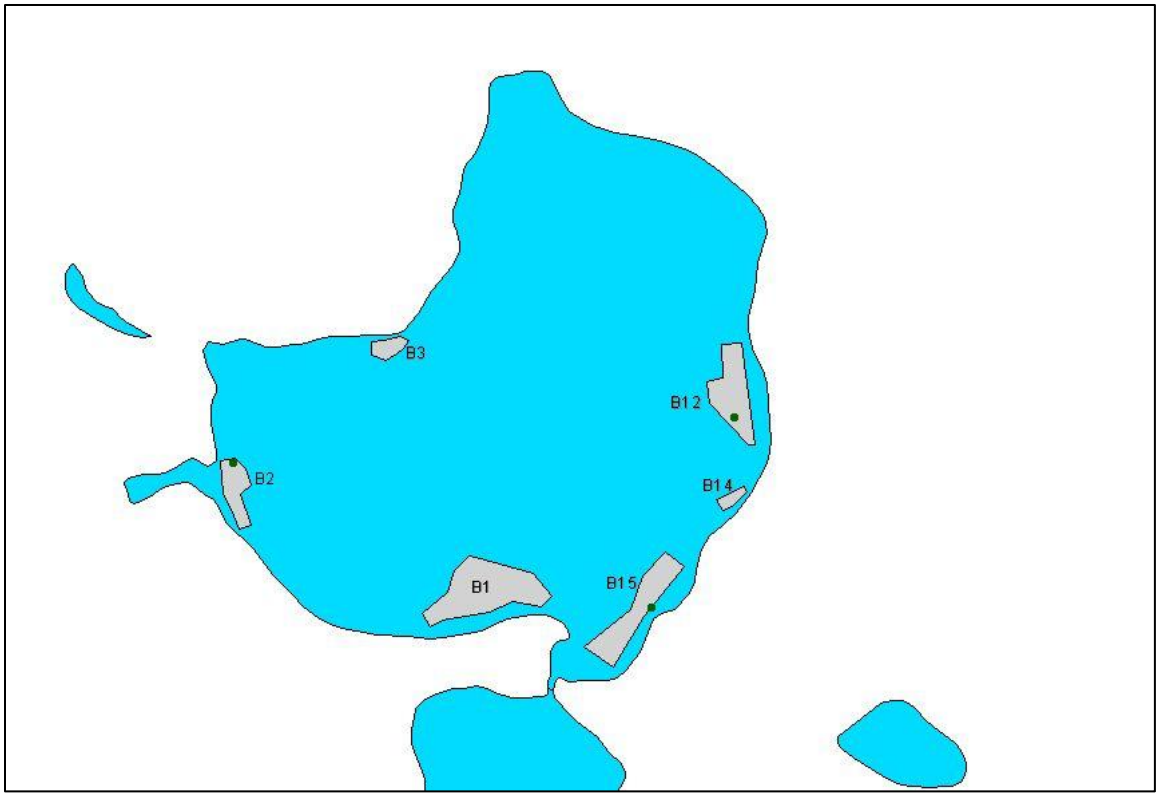


Whitestem pondweed-*Potamogeton praelongus*-2014



Wild celery-*Vallisneria americana*-2014

None sampled in 2013.



Water stargrass-*Heteranthera dubia*-2014

None sampled in 2013.