Herbicide Treatment Analysis for *Potamogeton crispus* (CLP)

Big Lake/Round Lake
Polk County, WI

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Abstract

On May 21 2013, an endotholl herbicide treatment targeting Potamogeton crispus*-curly leaf pondweed (CLP) was conducted on Big Lake and Round Lake, Polk County Wisconsin. A total of 20.94 acres was treated (20.89 in Big Lake and 0.054 in Round Lake). 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 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=2.3X10-37) in frequency of occurrence of CLP in the post treatment compared to the pretreatment. The reduction from 2012 to 2013 was very small and not significant. The treatment was also effective in 2012, so the frequency was very low in that post treatment survey also. It was also determined that there was a significant reduction in three native plant species as compared to the 2012 survey. This could be due to the late spring, causing many native species to still be dormant in 2013 compared to this time in 2012. A turion analysis revealed that the turion density remained basically the same from 2012 to 2013, but is still much lower than 2011.*

Introduction

On May 21, 2013 a total of 20.94 acres of *Potamogeton crispus*-curly leaf pondweed (CLP) beds were treated with herbicide (endothall-K) for the third year on Big Lake and Round (Wind) 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 1.25 ppm to 2 ppm of endothall K. Table 1 shows the statistics for each treatment bed.

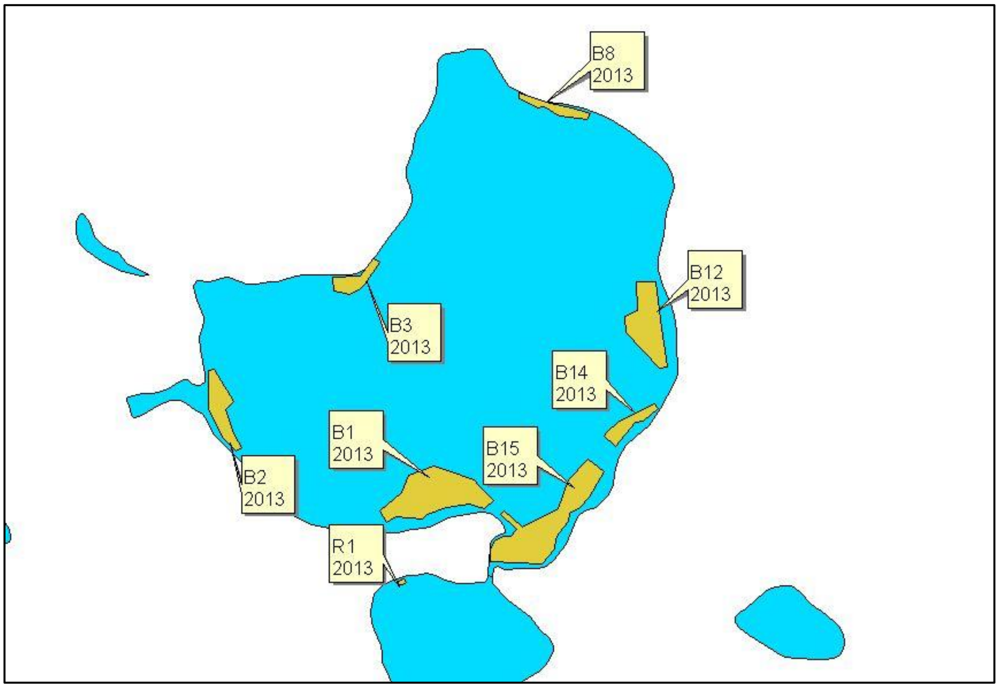


Figure 1: Map showing 2013 CLP treatment beds

Big Lake/Round Lake 2013 CLP					
Big Lake	**Acres**	**Mean Depth(ft)**	**Acre-feet**	**Gallons applied***	**Target conc.*** (ppm)
B1-2013	5.28	5.7	30.10	28.8	1.5
B2-2013	1.9	5.3	10.07	9.64	1.5
B3-2013	2.47	6.5	16.06	15.35	1.5
B8-2013	0.91	6.6	6.01	5.75	1.5
B12-2013	3.29	6	19.74	18.89	1.5
B14-2013	1.04	5.7	5.93	5.67	1.5
B15-2013	6	5.3	31.80	30.43	1.5
Big Lake Total	20.89	--	119.70	**--**	**--**
Round Lake					
R1-2013	0.054	4.2	0.23	0.36	2.5

*As reported by applicator

Table 1: Summary of 2013 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 density.
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	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
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	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.

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 3 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 two-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.

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.

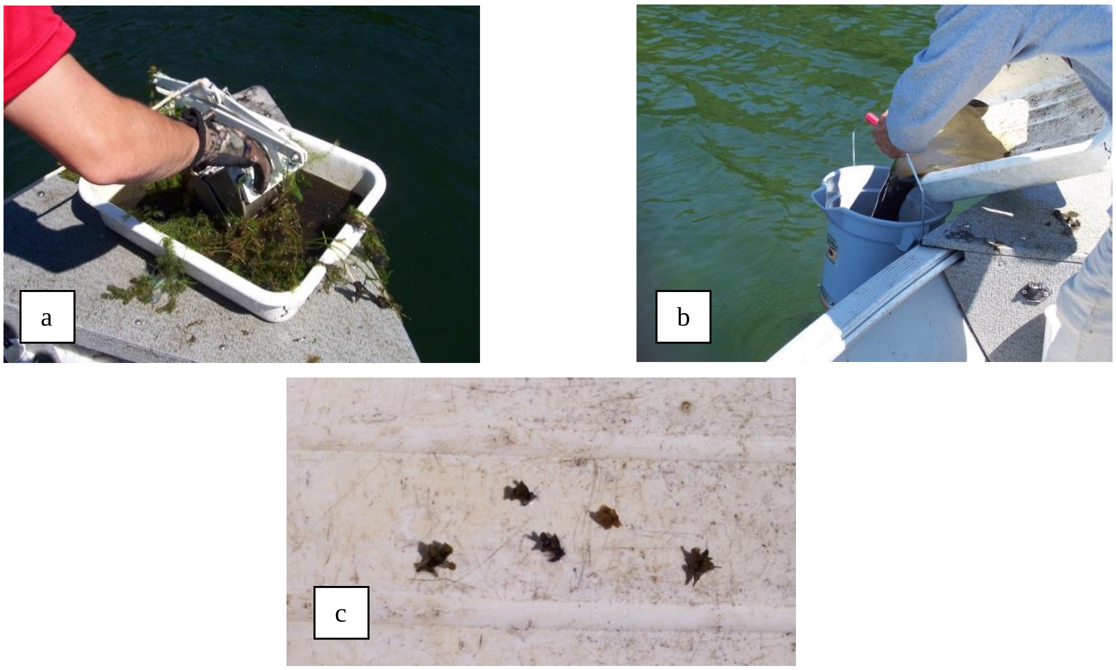


Figure 3: Pictures showing turion density methods. (a) shows sediment sample;(b) shows separation; (c) shows separated turions.

Results

CLP reduction

The pretreatment survey resulted in eliminating some treatment beds from 2012. With low turion density in 2012 and not finding any CLP growing in 2013, beds B4, B5, B6 and B7 from 2012 were eliminated for 2013. Also, beds B12 and B13 were combined and increased in size due to CLP growing between the beds. Some minor adjustments were made to beds B1 and B15 to reflect lack of growth in some areas and more growth in others. 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 2013 than the frequency in the post treatment survey of 2012. This shows that the CLP filled in the beds again, due to germination of turions.

Bed	2013 pretreat freq (0-100%)	2013 post treat freq (0-100%)	2012 post freq. (0-100%)	2013 mean density (0-3)
B1	73.7%	12.5%	13.0%	0.125
B2	92.8%	0.0%	6.7%	0
B3	80.0%	0.0%	12.5%	0
B8	75.0%	11.1%	14.3%	0.167
B12	82.6%	26.1%*	4.3%*	0.261
B14	62.5%	0.0%	14.3%	0
B15	72.7%	2.3%	6.5%	0.023
R1	33.3%	0.0%	0.0%	0
All beds	81.4%	9.3%	11.0%	0.093

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 12 showed the highest remaining CLP growth after treatment with 26% of the sample points having CLP present. All samples were of low density (1). Most all treatment beds showed a smaller frequency in 2013 than what was present in 2012. Overall, the cumulative effect was a slight reduction in frequency from 2012 to 2013.

The frequency reduction from the 2013 pretreatment CLP growth to the 2013 post treatment growth was significant. All beds showed a reduction, most of which were quite substantial. The overall reduction (all beds considered) was from a frequency of 81.4% to a frequency of 9.3%. This demonstrates an effective reduction of CLP growth from herbicide treatment.

Bed	Pre to post (2013)reduction significance	Post 2012 to Post 2013 reduction significance
B1	Yes ($p=1.02X10^{-7}$)	No
B2	Yes ($p=8.4X10^{-7}$)	No
B3	Yes (p=0.0003)	No
B8	Yes (p=0.004)	No
B12	Yes (p=0.003)	Increase
B14	Yes (p=0.007)	No
B15	Yes ($p=3.5X10^{-12}$)	No
R1	No (p=0.27)	No change
All beds	Yes ($p=2.3X10^{-37}$)	No (p=0.88)

Table 4: Summary of statistical analysis of CLP reduction.

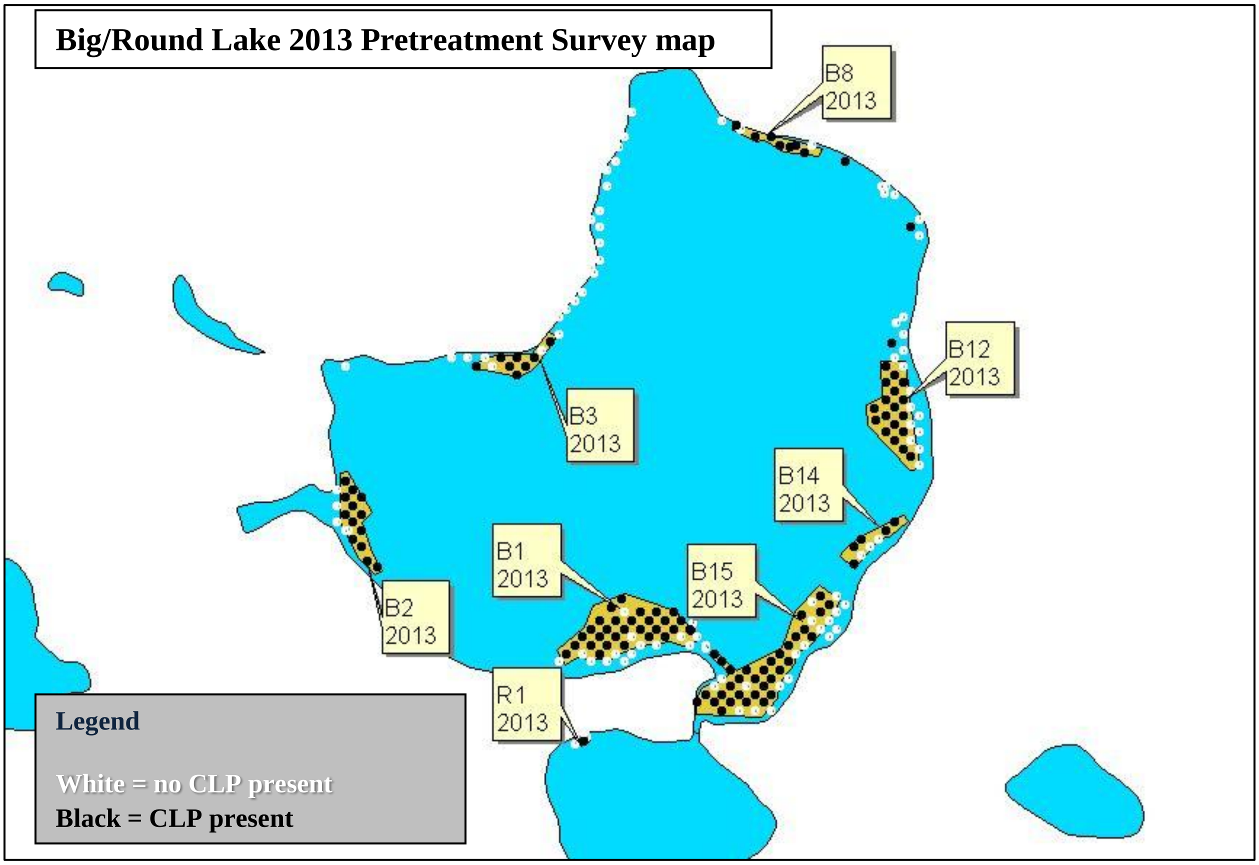


Figure 4: Map showing absence and presence of CLP growth from pretreatment survey, May 2013.

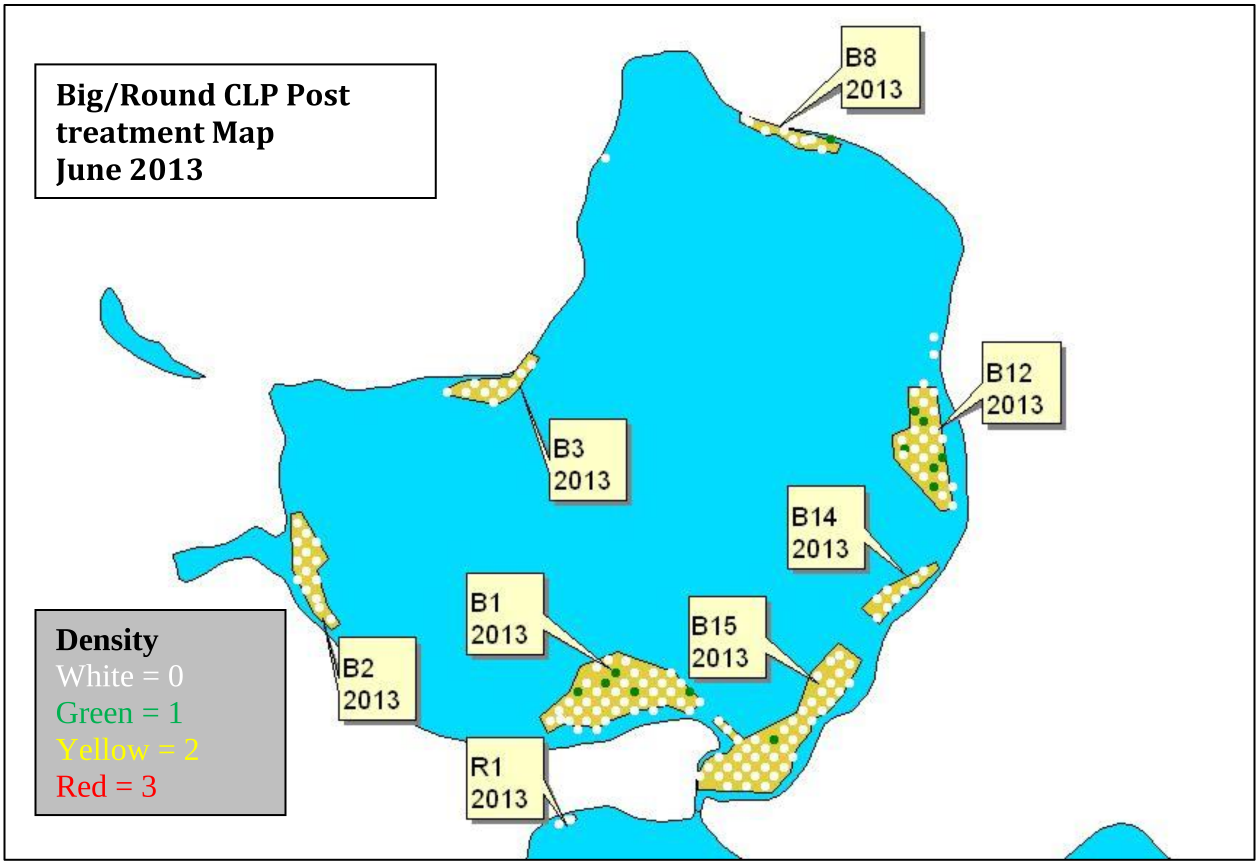


Figure 5: Map showing CLP density from post treatment survey June 2013.

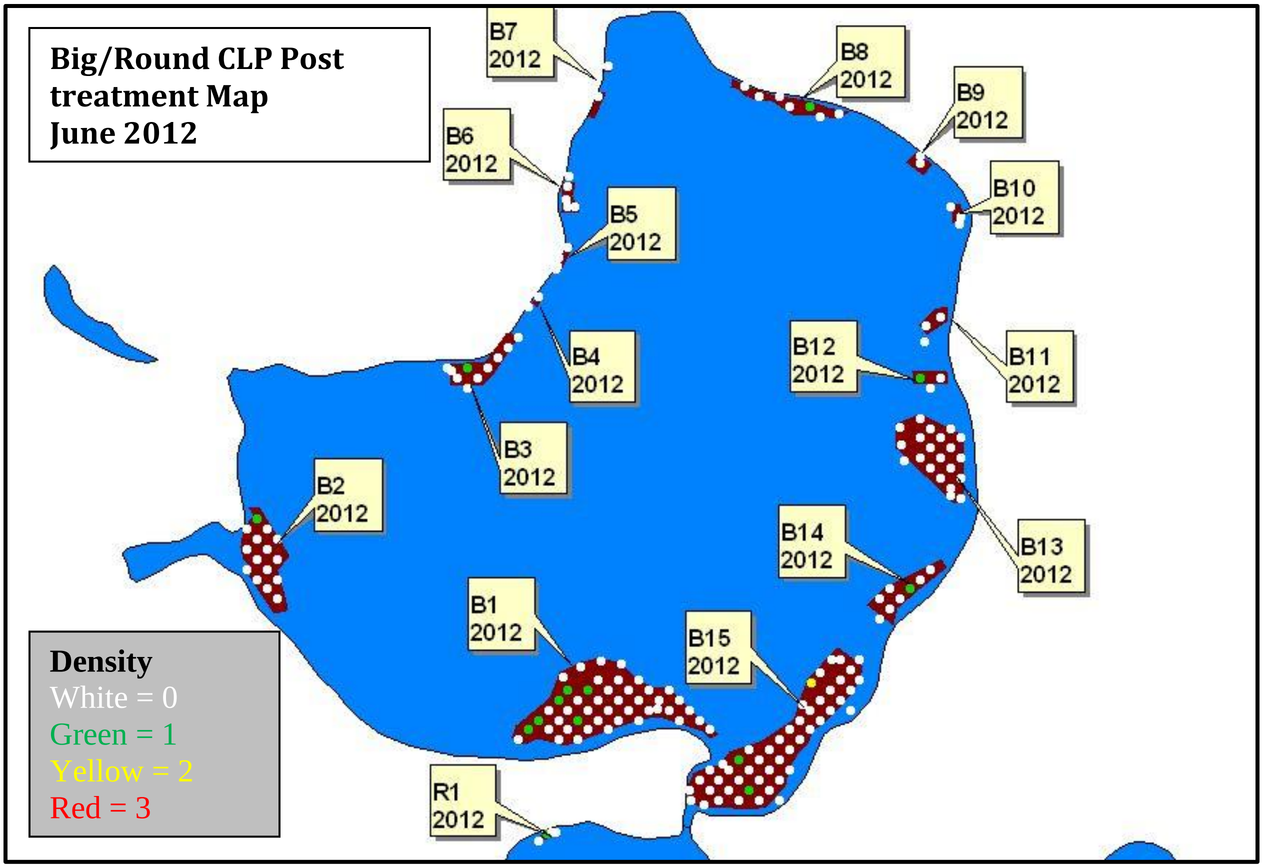


Figure 6: Map showing CLP density from post treatment survey June 2012.

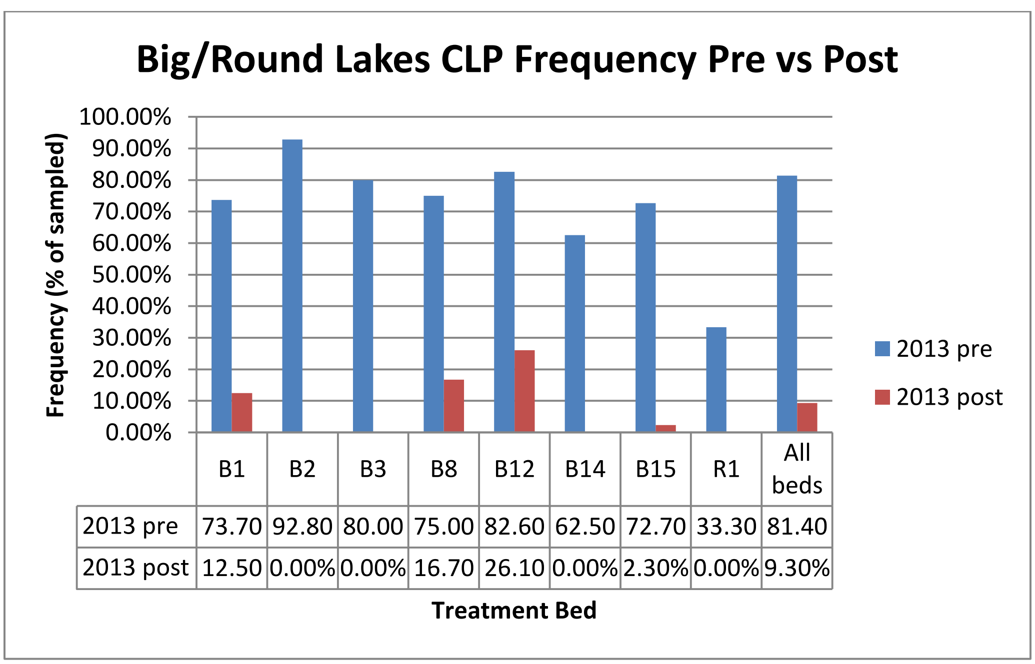


Figure 7: Graph depicting the reduction in CLP growth from pre to post treatment 2013.

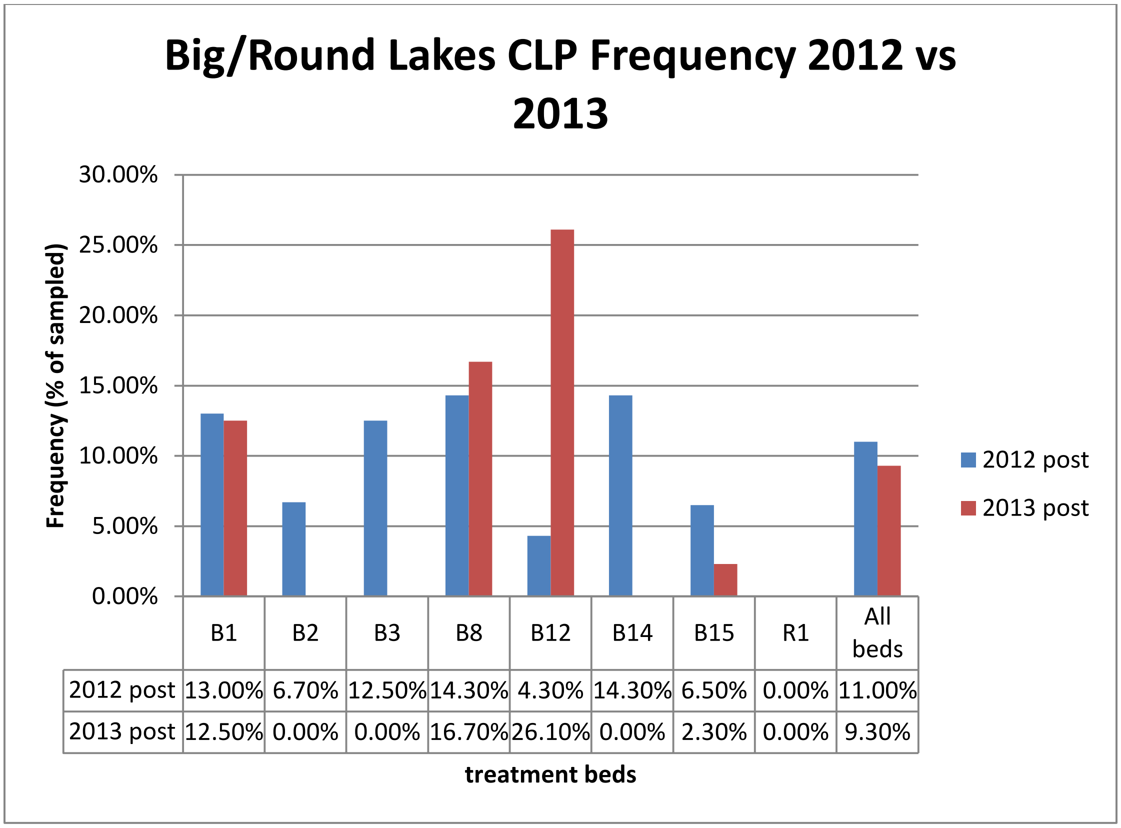


Figure 8: Graph depicting the change in CLP frequency from 2012 to 2013, post treatment.

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 2012 to 2013. A chi-square analysis is then conducted to determine if the change is statistically significant and not just from chance or random variation.

The native plant analysis shows a statistically significant reduction in three native species (see Table 5). This could be due to adverse effects of the herbicide. It could also be due to the late spring which caused native to be dormant at survey time. Since coontail actually increase slightly and is the most common plant within the polygons, one would assume that if the herbicide reduced other native plants, that reduction would have been reflected in the coontail frequency as well. One reduced native was wild celery, of which none was sampled during the 2013 post treatment survey. During the turion analysis in August 2013, wild celery was sampled in some of the polygons. This shows that wild celery was likely dormant during the post treatment survey. There were similar observations in other area lakes.

Species	2012 freq	2013 freq	change	significant
Chara sp.(muskgrass)	0.01	0	-	No
Elodea canadensis(waterweed)	0.25	0.18	-	No
Heteranthera dubia(stargrass)	0.17	0	-	Yes ($p=1.5X10^{-7}$)
Potamogeton zosteriformis(flat-stem pondweed)	0.01	0.01	**nc**	N/A
Vallesnaria americana(wild celery)	0.1	0	-	Yes ($p=7.4X10^{-5}$)
Ceratophyllum demersum(coontail)	0.88	0.89	+	No
Lemna triscula(forked duckweed)	0.04	0.01	-	No
Potamogeton richardsonii(clasping pondweed)	0	0.01	+	No
Potamogeton robbinsii(fern pondweed)	0.01	0.01	**nc**	N/A
Potamogeton praelongus(whitestem pondweed)	0.01	0.06	+	Yes (p=0.023)
Myriophyllum sibiricum(northern water-milfoil)	0.09	0.04	-	No
Potamogeton pusillus(small pondweed)	0.01	0	-	No
Stuckenia pectinatus(sago pondweed)	0.02	0	-	No
Nymphae odorata(white lily) sim	0.04	0.04	**nc**	N/A
Potamogeton gramineus(variable pondweed)	0	0.01	-	No
Potamogeton illinoensis(Illinois pondweed)	0.06	0.02	-	No
Potamogeton amplifolius(large-leaf pondweed)	0.01	0	-	No
Sagittaria rosette(arrowhead)	0.01	0	-	No

Table 5: Summary of native plant changes from 2012 to 2013, post treatment.

Turion reduction

The 2013 turion analysis showed that the turion density remained basically unchanged from 2012. The mean turion density in 2013 appears to be quite a bit higher than 2012. However, four of the treatment beds in 2012 were eliminated in the 2013 treatment, thus reducing the number of sample points used in the turion density calculation. The same points were sampled each year, so if the density is recalculated including all turion sample points from previous years, it goes from 21.3 to 13. 6 turions per square meter in 2013. This is compared to 12.8 turions per square meter in 2012. See figures 9 and 10 for a map of the turion densities.

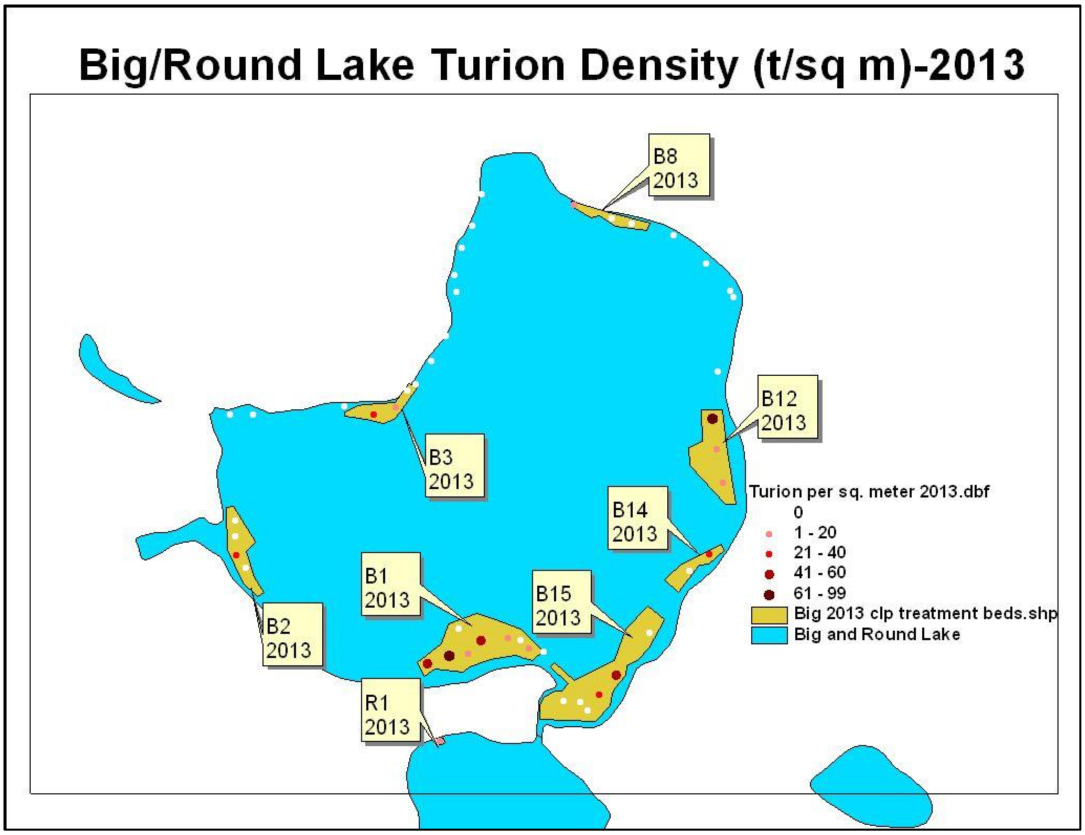


Figure 9: Map showing turion density in polygons (and areas previously treated) in August 2013.

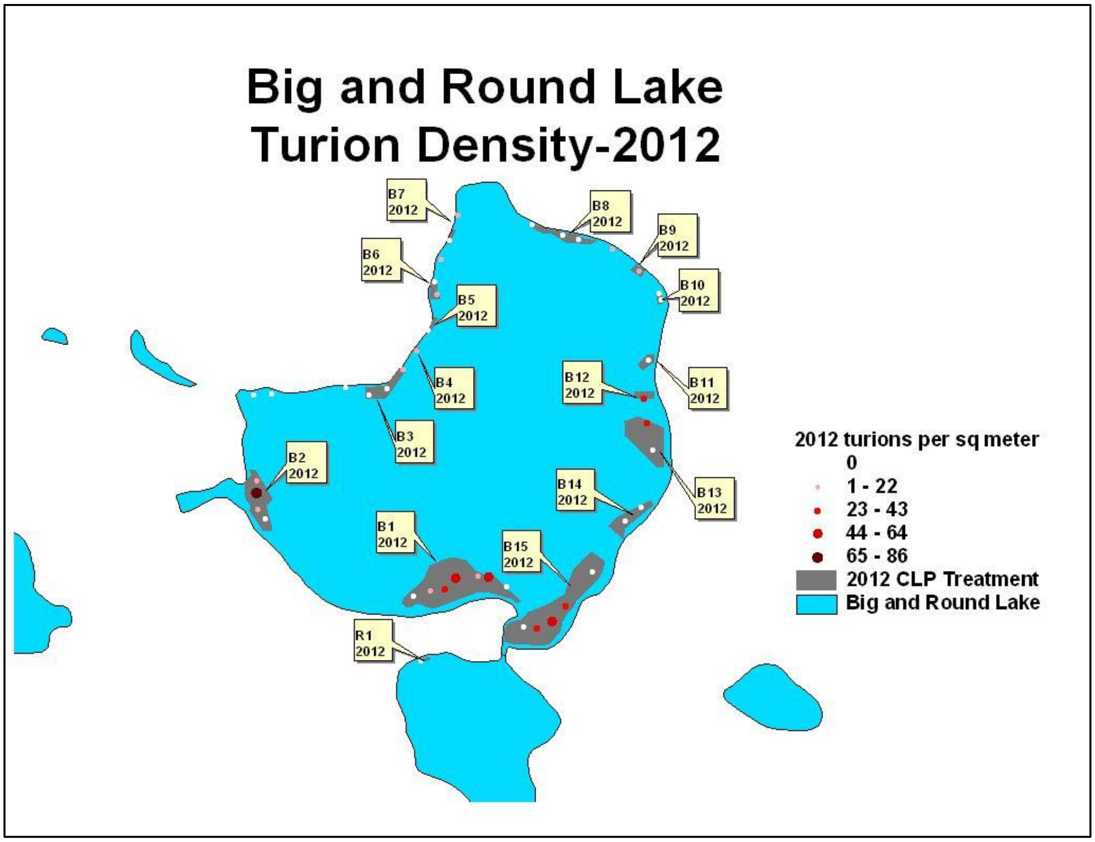


Figure 10: Map showing turion density within treatment beds, August 2012.

Bed	Mean turion density 2012	Mean turion density 2013
B1	30.7	27
B2	32.28	4.0
B3	7.1	15.0
B8	0.0	6.7
B12*	28.7	39.7 *(combines 12 and 13 from 2012)*
B14	0.0	20.0
B15	30.7	16.7
R1	0.0	20.0
All beds (just treated)	12.8 *(includes beds not treated 2013)*	21.3*(13.6 using all 2012 points)*

*Bed 12 in 2013 is the combination of Bed 12 and 13 from the 2012 treatment.

Table 6: Turion analysis summary for each treatment bed, 2012 and 2013.

Year	Mean turion density (turions/sq. meter)
2011	44
2012	12.8
2013	21.3 (13.6 with all pts)

Table 7: Overall turion densities 2011-2013.

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 2013) to the growth after treatment (reflected in the post treatment survey 2013).

Analysis shows a slight reduction in growth after treatment 2013 as compared to after treatment in 2012. This reduction is slight and can't be attributed to treatment. However, since the frequency of occurrence of CLP was so low after treatment in 2012, a further reduction is difficult, short of eradication of the CLP. This then supports another effective treatment in 2013.

Annual successful reduction of CLP should be reflected in a reduction of turion density each year. Since turions may remain viable for several years, it takes time to reduce the turion density. If most all of the CLP plants are killed prior to turion formation, there should be no new turions added to the bed. The turion density from 2012 to 2013 remained virtually unchanged. The mean turion density is lower than 2011 and should remain low if treatments continue to work well.

It is recommended that treatment of the beds continue in the future, pending pretreatment survey results. Since turions can remain viable for many years and the fact that turion densities are the same as in 2012, it is likely most of these beds will have CLP growth next spring (2014).

References

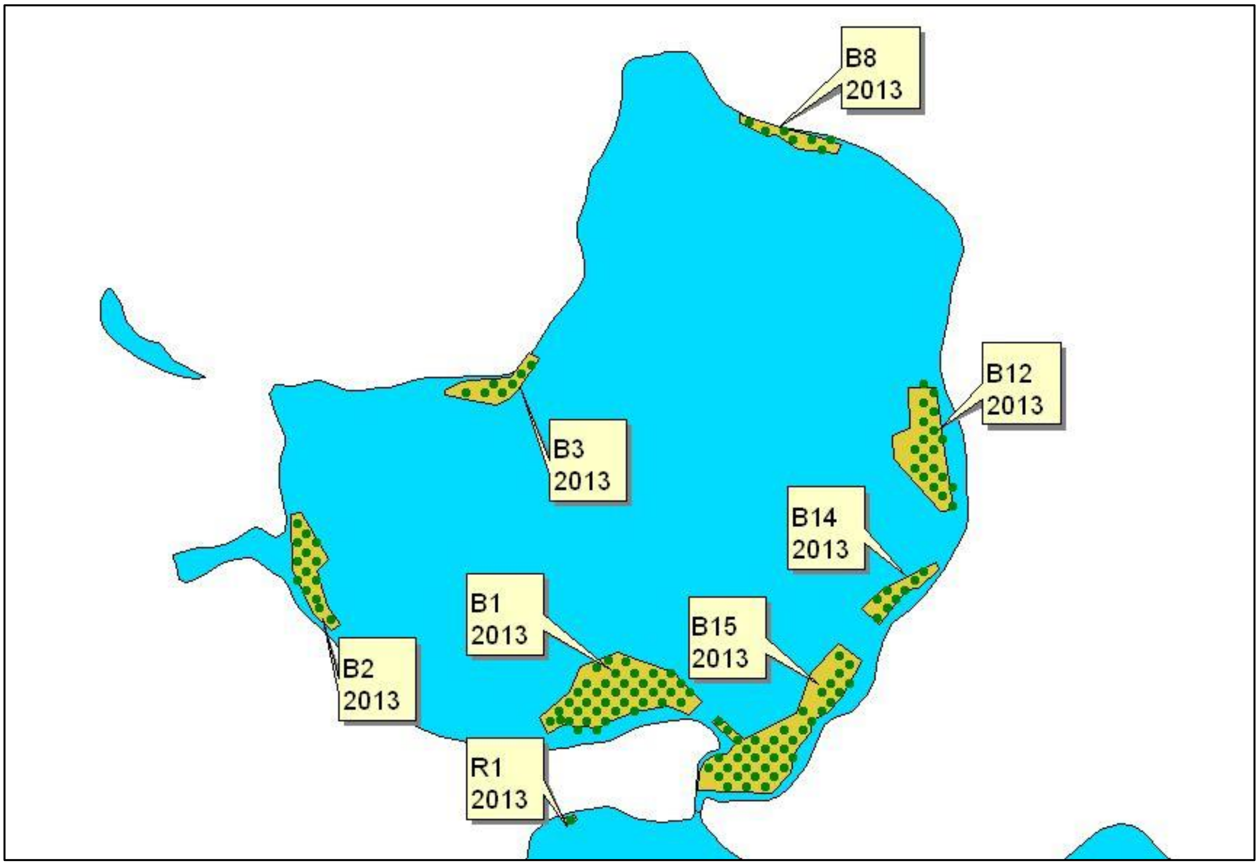
Borman, Susan, Robert Korth and Jo Tempte. *Through the Looking Glass.* University of Wisconsin-Extension. Stevens Point, Wisconsin. 1997. 248 p.

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.

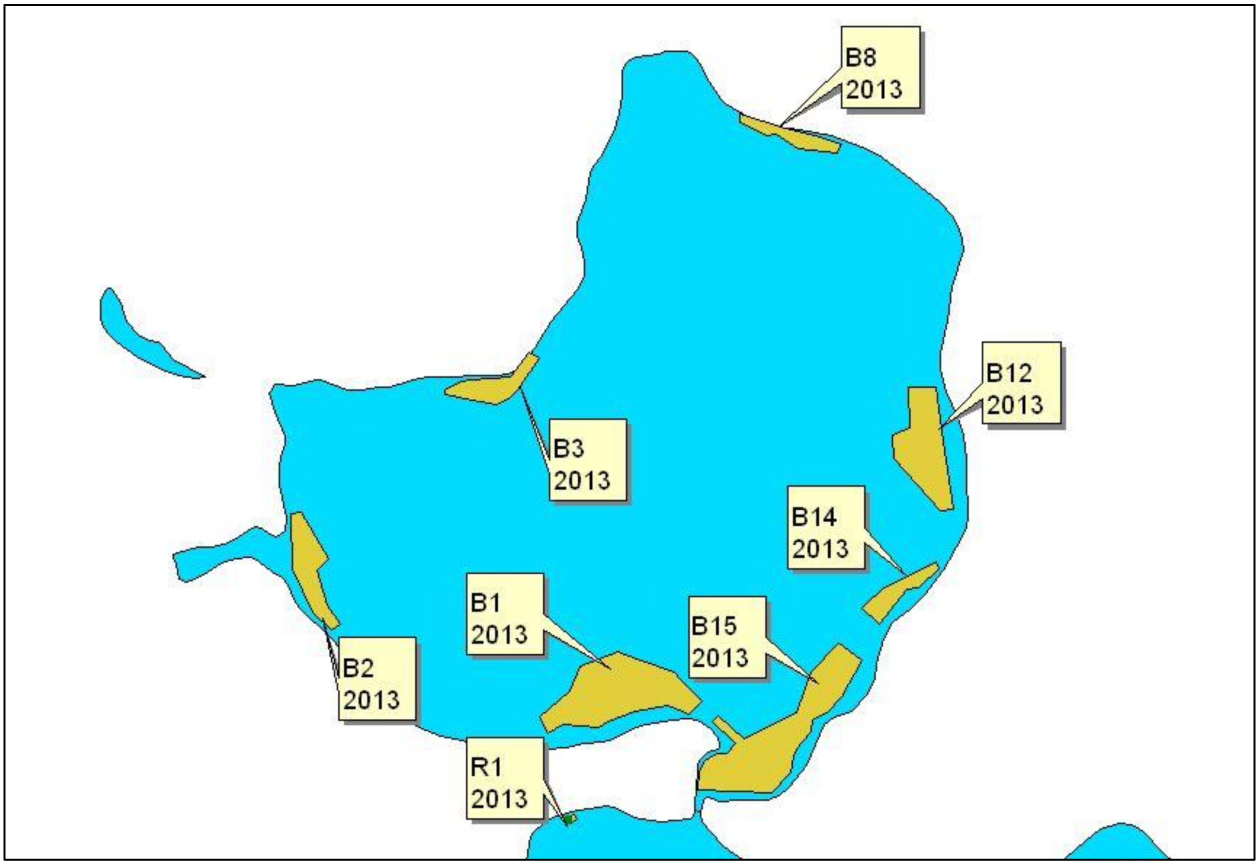
University of Wisconsin-Extension. *Aquatic Plant Management in Wisconsin*. April 2006 Draft. 46 p.

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

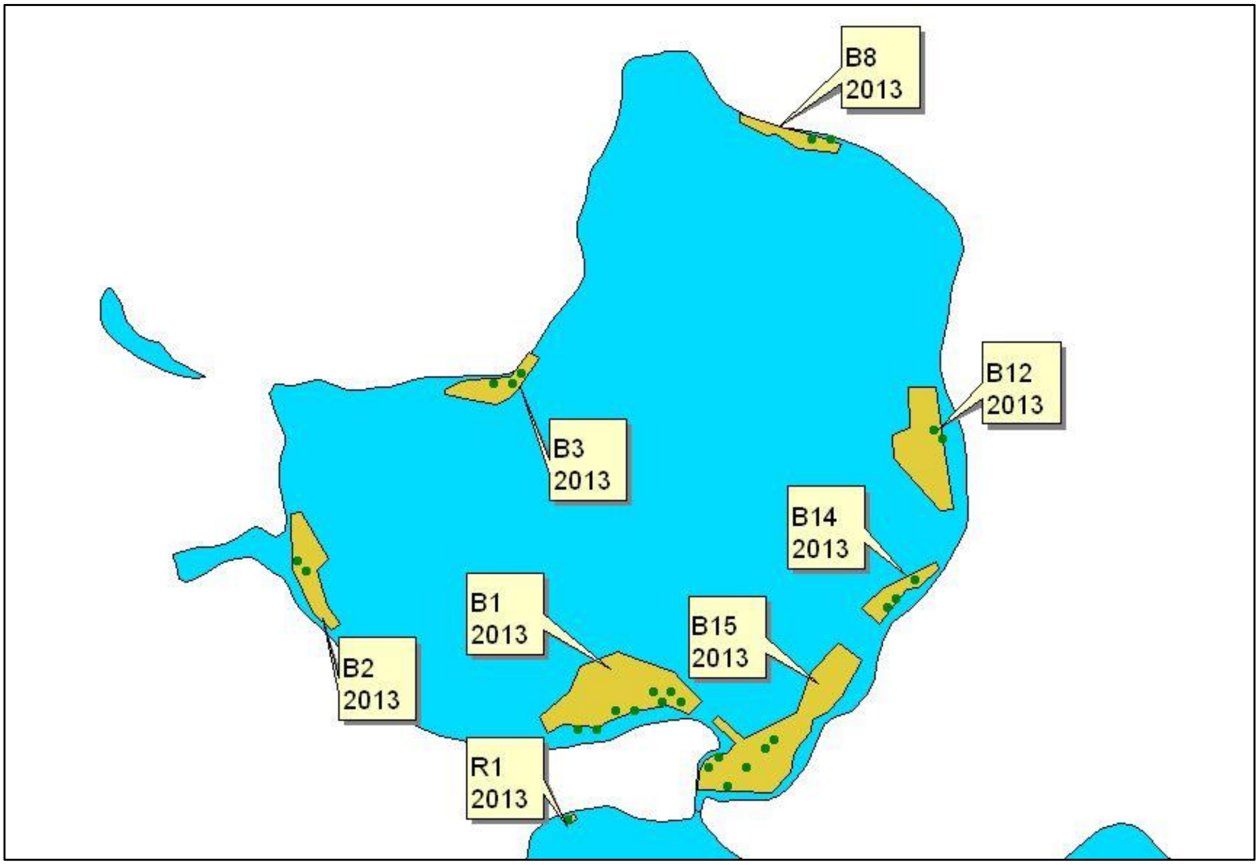
Appendix-native plant maps-2013



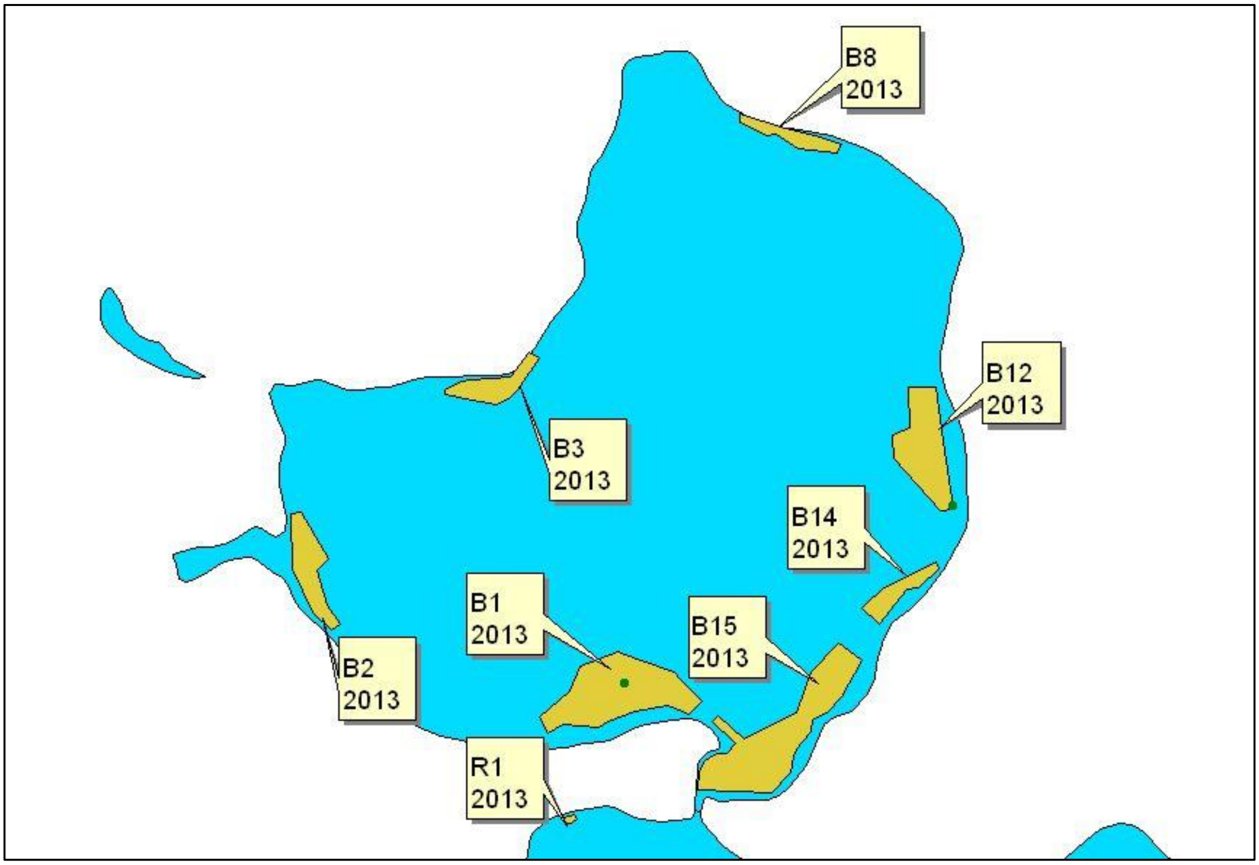
Coontail-*Ceratophyllum demersum*



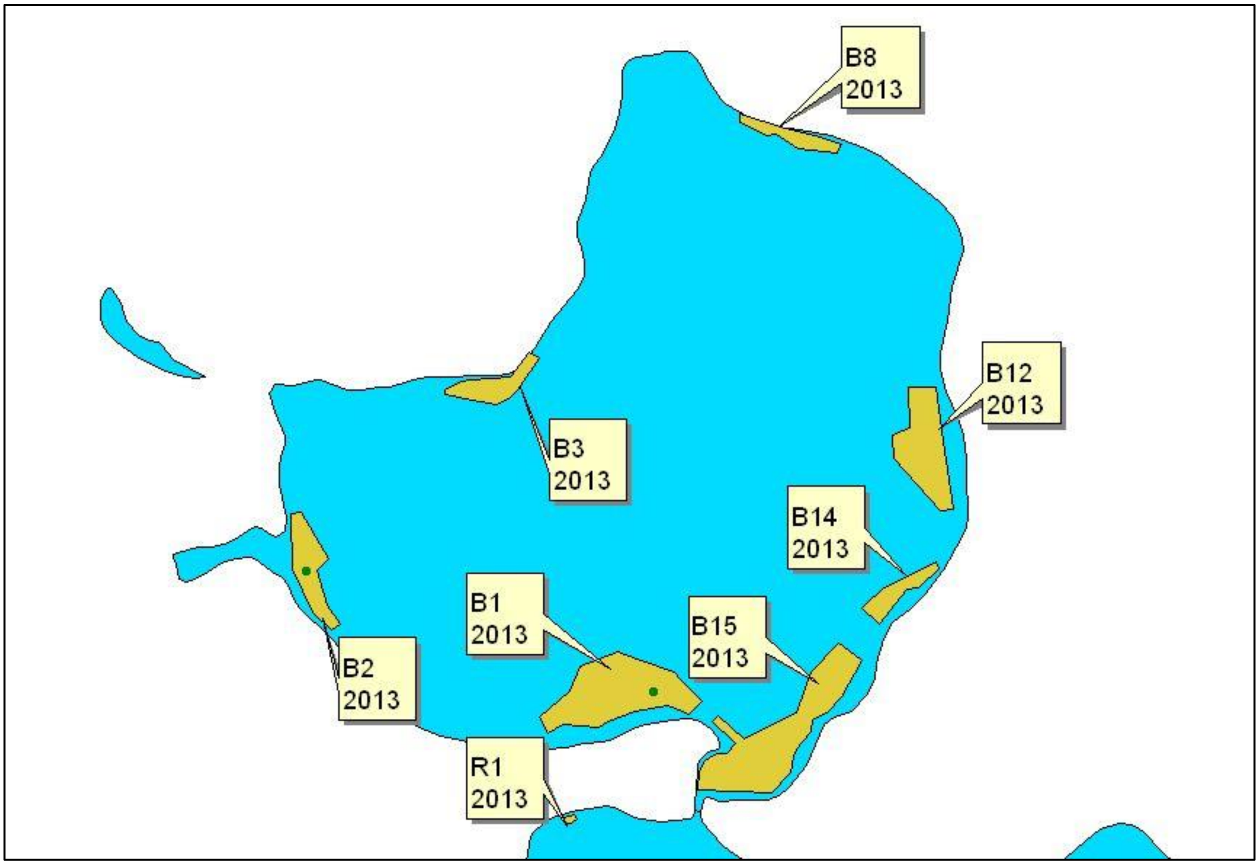
Clasping pondweed-*Potamogeton richardsonii*



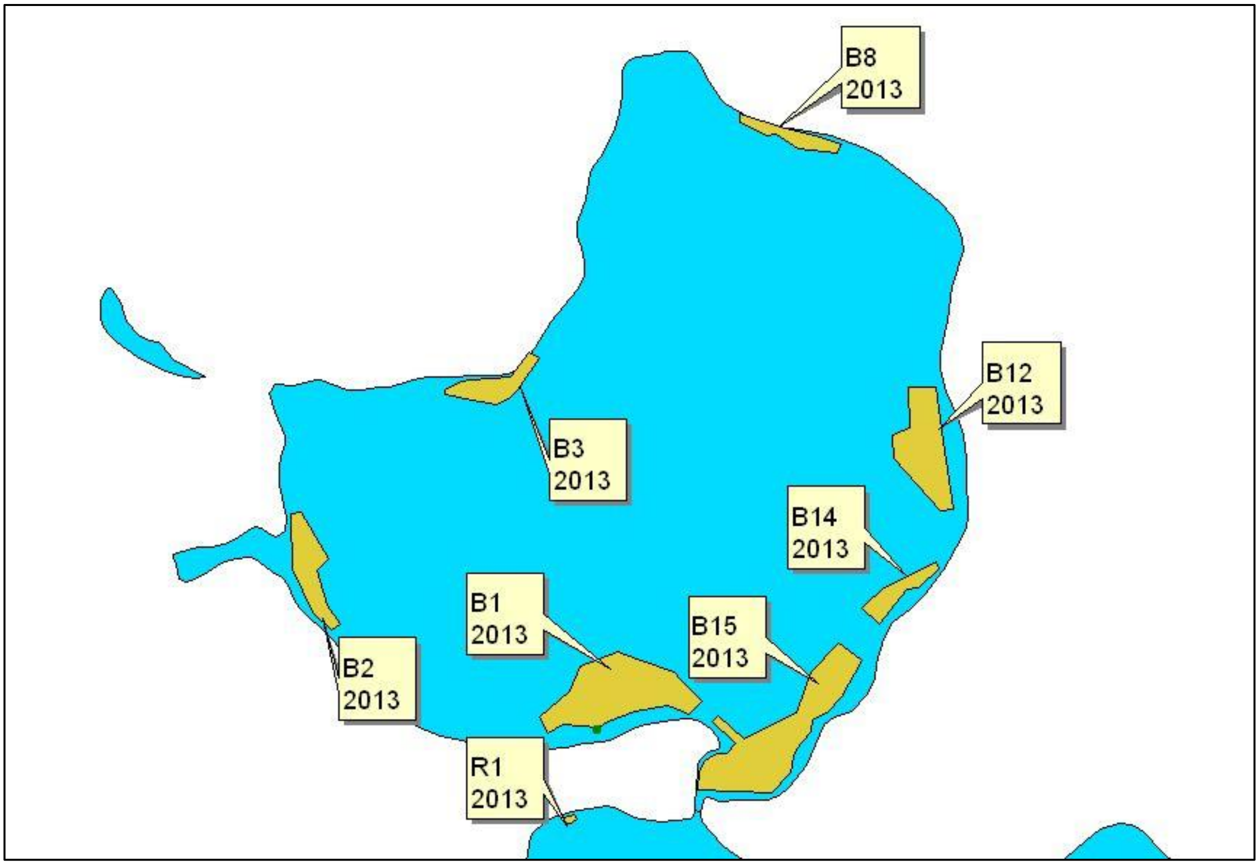
Waterweed or elodea-*Elodea canadensis*



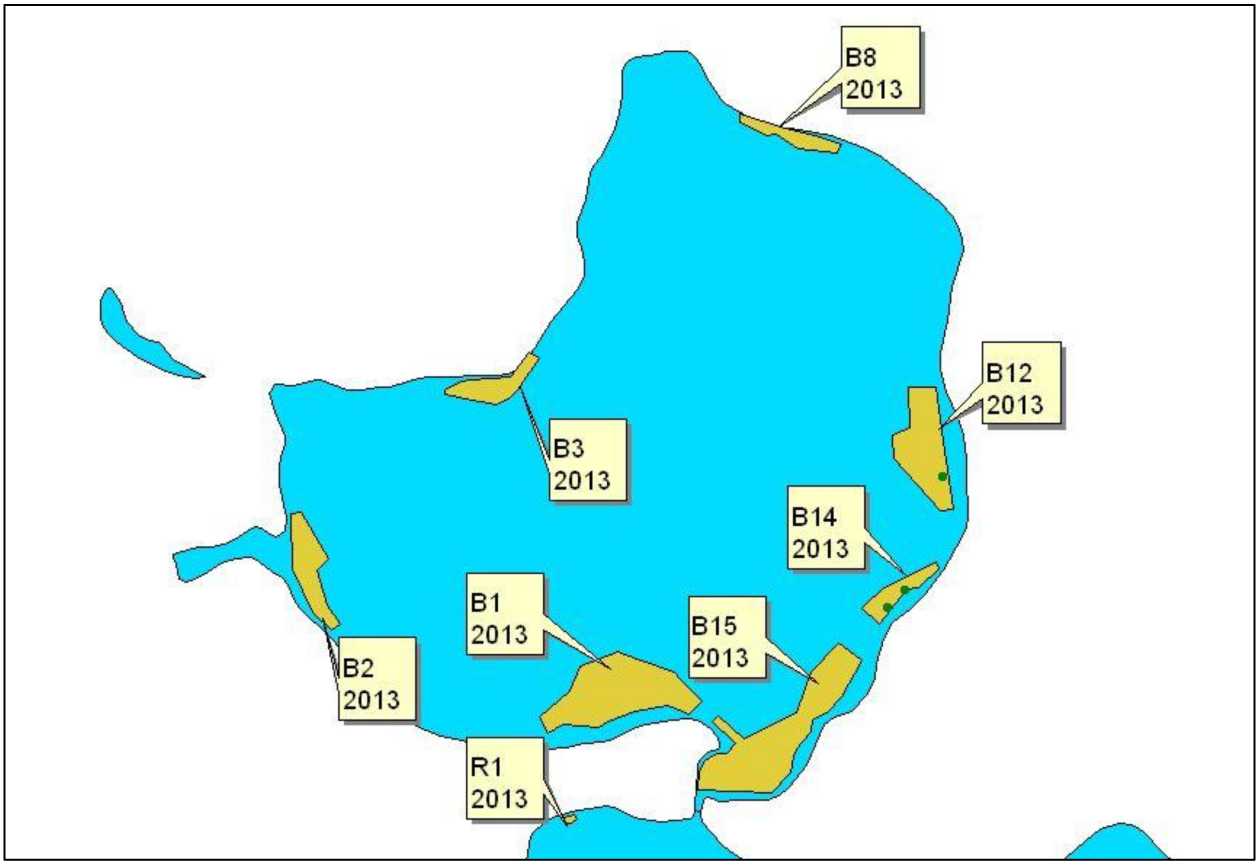
Fern pondweed-*Potamogeton robbinsii*



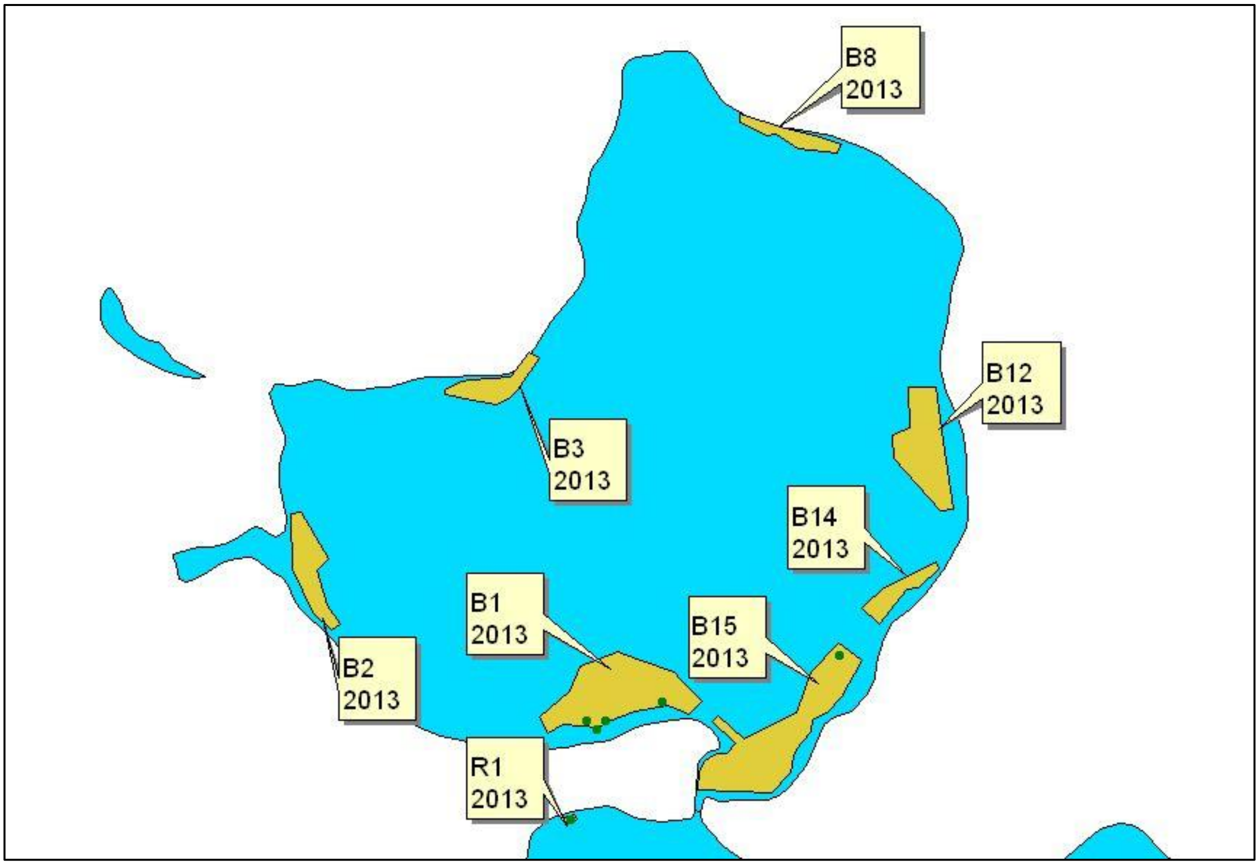
Flat-stem pondweed-*Potamogeton zosteriformis*



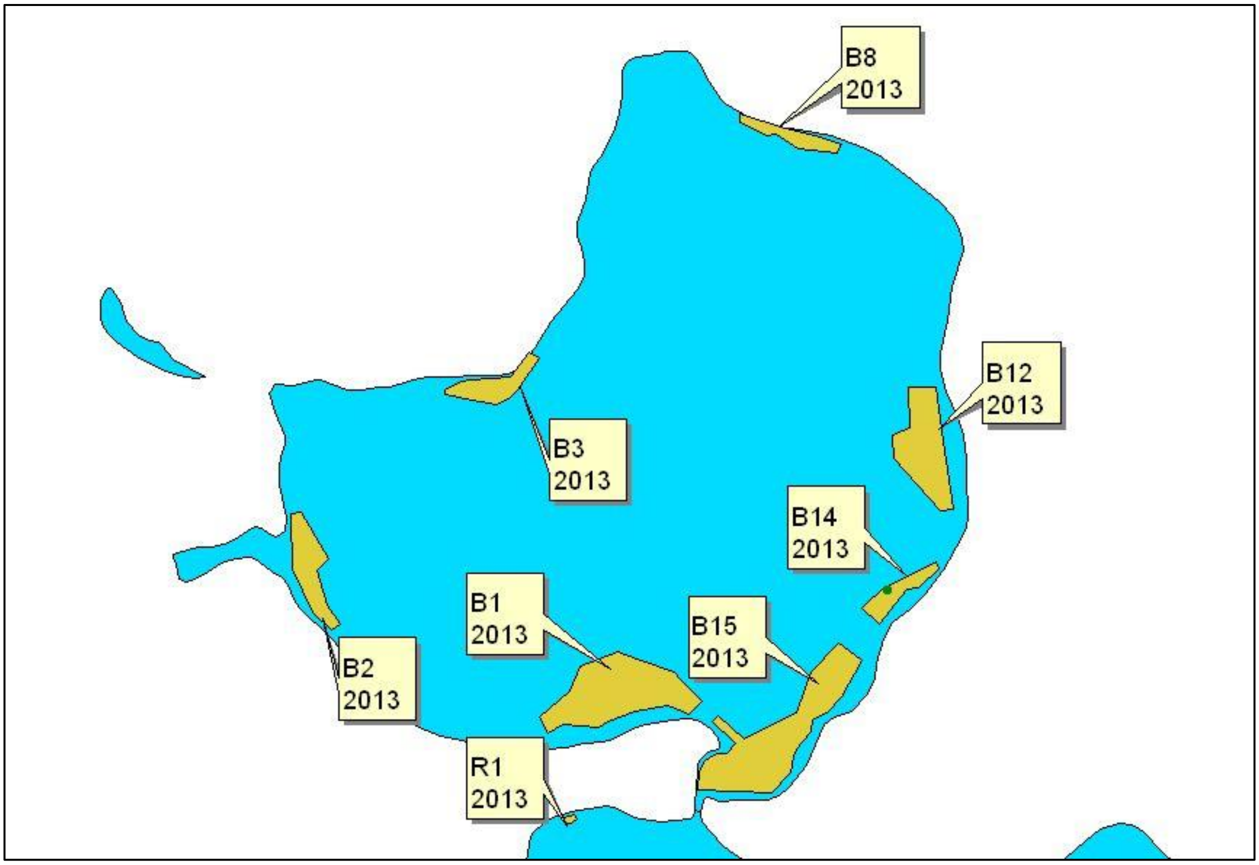
Forked duckweed-*Lemna trisulca*



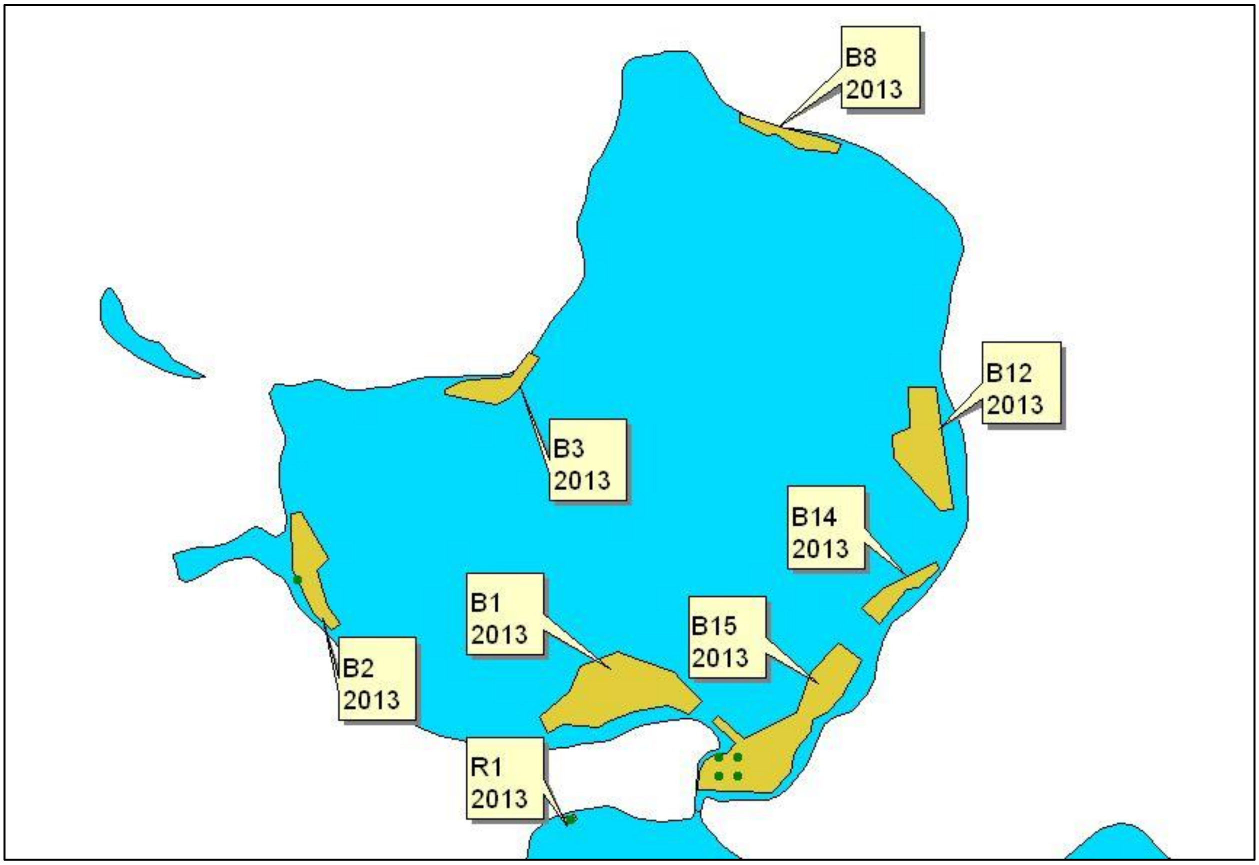
Illinois pondweed-*Potamogeton illinoensis*



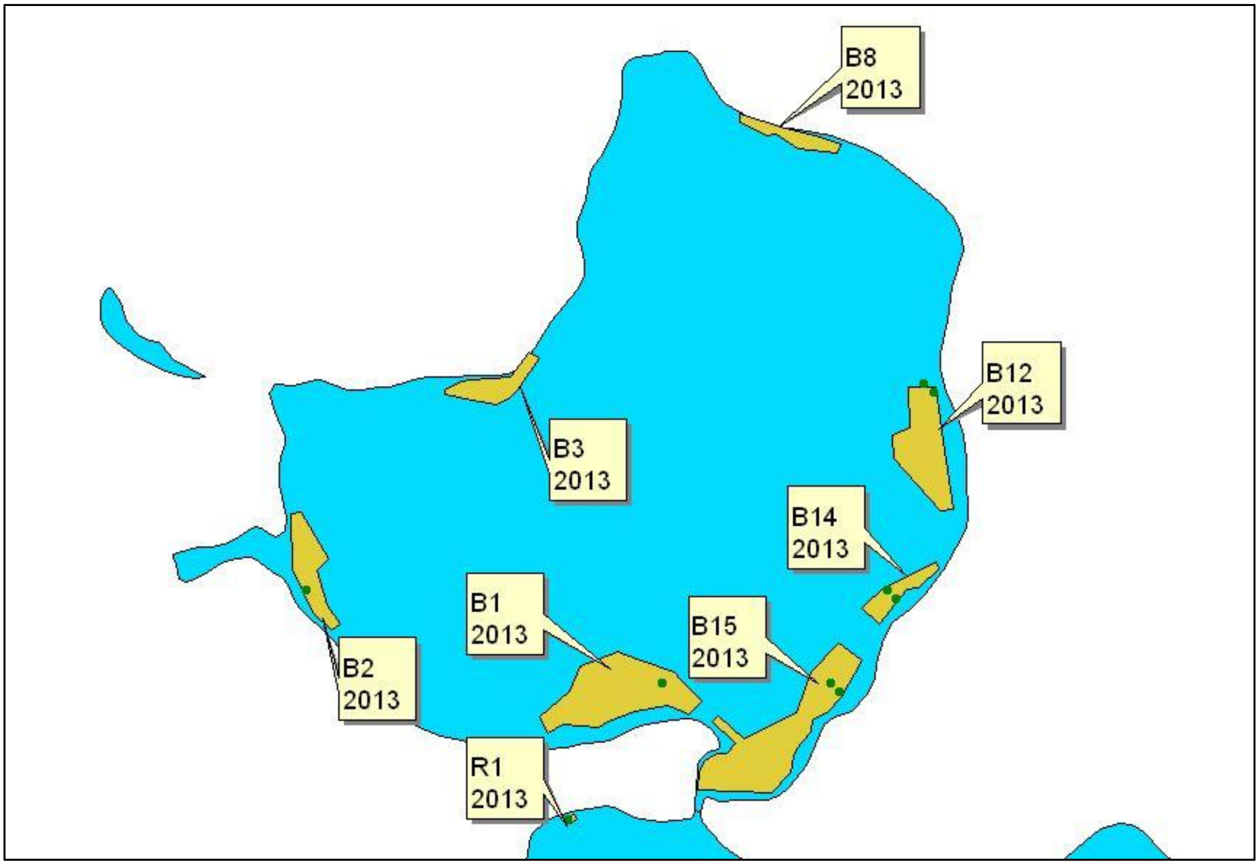
Northern water-milfoil-*Myriophyllum sibiricum*



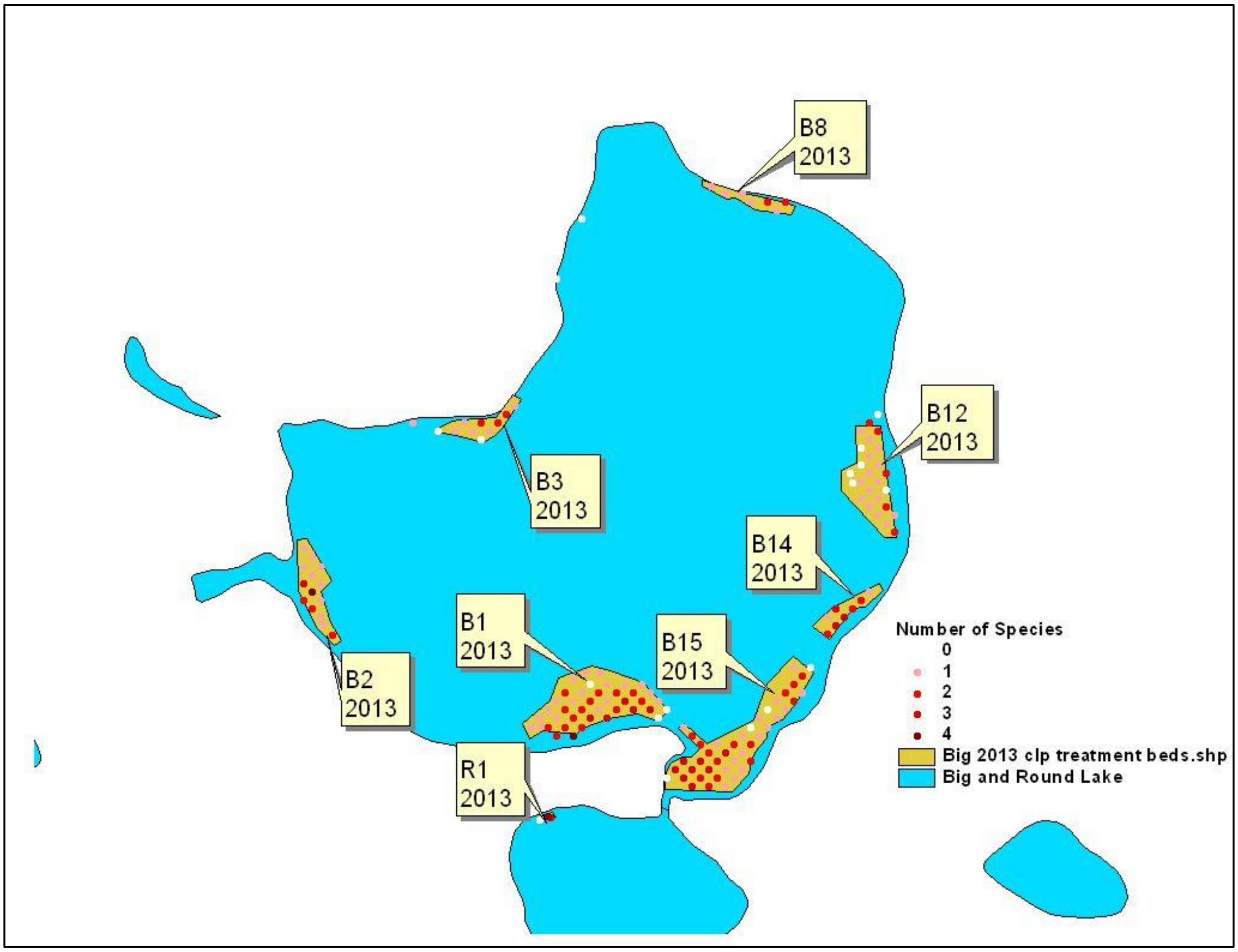
Variable pondweed-*Potamogeton gramineus*



White water lily-*Nymphaea odorata*



Whitestem pondweed-*Potamogeton praelongus*



Number of species per sample point (native species).