Herbicide Treatment of *Potamogeton crispus* Analysis

Bone Lake, Polk County WI
2013

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Abstract

On June 7, 2013 seven beds totaling 30.46 acres of the invasive species Potamogeton crispus-curly leaf pondweed (CLP) was treated with endothall (concentration of 2ppm)for purposes of CLP reduction. A comparison of the pretreatment survey frequency with the post treatment frequency shows a significant reduction in CLP in all beds. A comparison of the 2012 post treatment survey with the 2013 post treatment survey also shows a significant reduction. An analysis of the native plants resulted in a significant reduction in one native species, but it is speculated that it is not due to the herbicide application. A turion density analysis shows a reduction in turion density in all beds that have been treated in prior years. The turion density is much higher in beds not treated in prior years. A 2013 bed delineation of CLP during peak growth resulted in 4.7 acres of lower density (<2) CLP and 48.4 acres of higher density (>2) CLP.

Introduction

On June 7, 2013 *Potamogeton crispus*-curly-leaf pondweed (CLP) was treated with the herbicide endothall (Aquatholl K). This was the 6th year of treatment on 3 of the 4 beds (Plots 2,3,4) and the 5th year in Plot 5. Three new beds (6,7, and 8) were treated this year. Figure 1 is a map showing the location of each bed treated and the acreage. Bed 6 and 7 were separated into parts to better determine mean depths for the applicator concentration calculation.

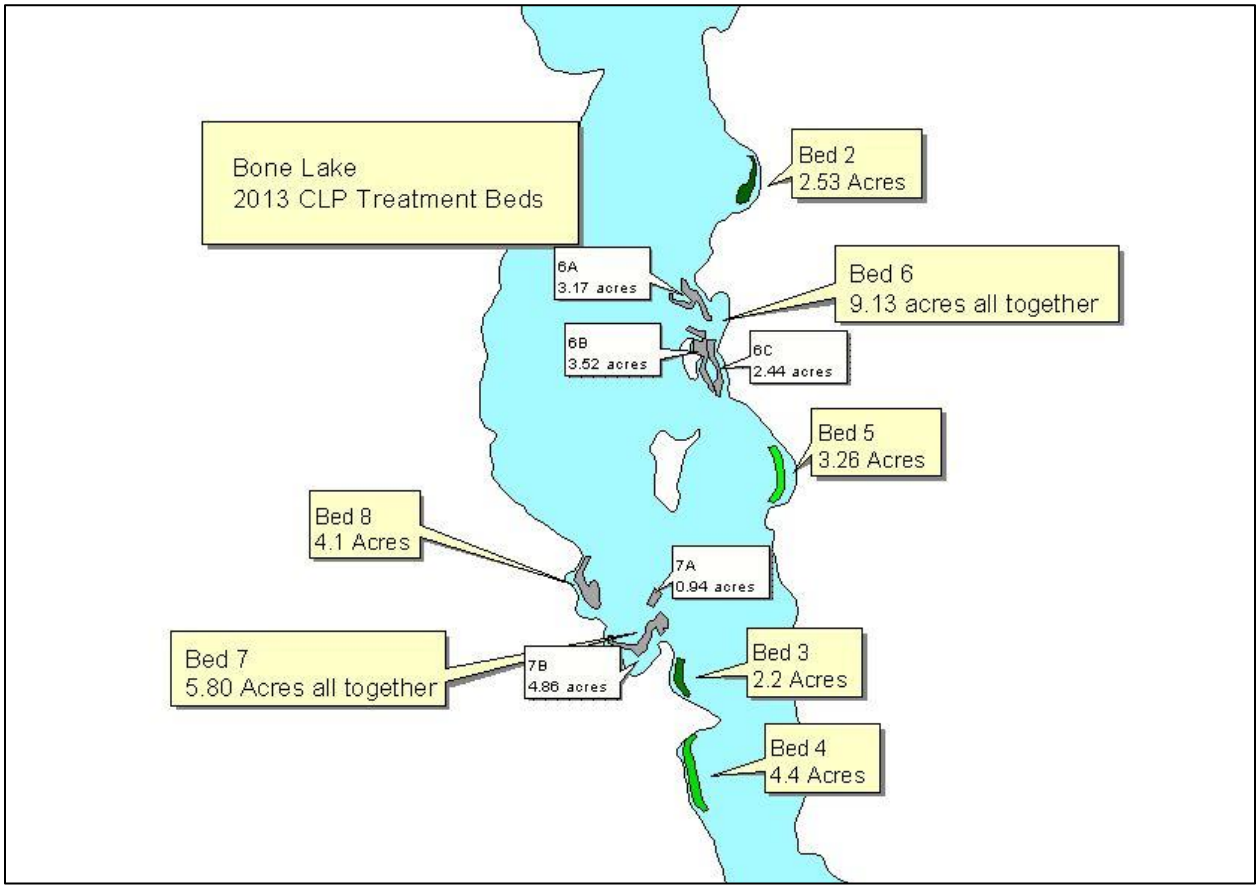


Figure 1: Map of CLP treatment beds for 2013.

The target concentration for each treatment bed was 2 parts per million (ppm). This was determined by using the acre feet of water within each bed. The treatment file prepared by the applicator stated that the 2ppm target was fulfilled. Table 1 outlines the treatment bed specifications.

Bed	Area (acres)	Mean Depth (ft)	Acre feet	Treatment Date	Target concentration	Wind conditions @ treatment
2	2.53	9.1	23.02	6/7/2013	2 ppm	Not logged
3	2.2	7.4	16.28	6/7/2013	2 ppm	Not logged
4	4.4	8.5	37.40	6/7/2013	2 ppm	Not logged
5	3.26	8.2	26.73	6/7/2013	2 ppm	Not logged
6	9.13	7.3	66.65	6/7/2013	2 ppm	Not logged
7	5.8	9.1	52.78	6/7/2013	2 ppm	Not logged
8	4.1	8.2	33.62	6/7/2013	2 ppm	Not logged
Total	**30.46**		**375.11**			

Table 1: Summary of treatment bed characteristics.

Bed	Description
2	Bed 2 lies to the north on the east shore. It is the second smallest bed. This bed has been treated for 5 years prior to 2013. The depth drops off quickly on the lake side and gets quite shallow near shore. The CLP has been most dense in the southern portion of the bed and quite sporadic in coverage on the north. The effectiveness of treatment has been most consistent in this bed, but only very effective the last two years.
3	Bed 3 lies on the western shore just north of Bed 4. This bed is the smallest but has a history of being very dense, especially in the northern half of the bed. Treatment results have been inconsistent, but effective the last two years.
4	Until 2013, Bed 4 was the largest bed, but is now third largest. This bed borders deep water and has been very inconsistent in response to treatment. It has been speculated that wind may be a factor in the results so treatment has been limited to winds below 5 mph. The middle portion of the bed has been the most dense, with the north and south end being more sporadic. There are a large number of piers bordering this bed on shore.
5	This bed has been treated one less year than beds 2,3 and 4. It lies on the east shore, south of bed 2. Bed 5 has been very dense in the southern half of the bed. The treatment has been very inconsistent in terms of effectiveness including last year, in which it responded the least of all beds to the herbicide. It also borders deep water.
6	Bed 6 is made up of three separate areas. This is one of the densest areas of CLP on Bone Lake. Historically navigation channels have been established within the area of this bed. Also, the bed borders a sensitive habitat area established many years ago by the Wisconsin DNR. To reduce adverse effects on this area, the bay to the north of the bed has been avoided. This bed lies adjacent (east) of eagle island. Much of the bed reaches the surface each year.
7	Bed 7 is divided into two parts. One is a small portion to the north of the main part of the bed. The bed lies on the west shore north of bed 3. The bed is most dense in the middle portion with the west arm being very narrow in coverage and reduced in density as move west. The small north portion that stands alone is dense, but in deep water (8-10 feet). Bed 7 historically has been very dense with CLP reaching the surface every year.
8	Bed 8 is just north of bed 7 on the west shore. It is relatively shallow and flat, but borders deep water on the lake side. This bed has been extremely dense in past years with CLP reaching the surface in most of the bed.

Table 3: Description of each treatment bed.

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 Figure 2 for reference). All other species are also recorded from the rake sample in order to verify no damage to the native plants. Since beds 6-8 were added in the winter before the 2013 treatment, there was no opportunity to collect density data from these beds before treatment. The density was estimated based upon bed delineation in June 2012.

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 create 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 show 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.

a

b

c.

Figure 3: Pictures showing turion density methods. A shows sediment sample; b shows separation; c Shows separated turions.

Results

The pretreatment survey showed a return of CLP growth from turion germination in beds 2-5. The post treatment survey in 2012 resulted in very little CLP growth in beds 2-5. In the spring, pretreatment survey in 2013, the frequency of CLP was extensive in beds 2-5. In beds 6-8, the CLP had not been treated in prior years and so the extensive coverage was expected.

The post treatment survey in June 2013 resulted in very little CLP sampled. This shows that the treatment was very effective. Table 2 shows the frequency data. All beds resulted in a significant reduction when comparing the pretreatment frequency to the post treatment frequency. In a 2012 post treatment frequency comparison to the 2013 post treatment frequency, a statistically significant reduction occurred in beds 2-5. Beds 6-8 were not treated in 2012, so that comparison is not applicable. The pretreatment frequency is assumed to be nearly the same so the comparison serves the same purpose.

Bed	2013 Pretreat	2013 posttreat	2012 posttreat	2013 pre to post Freq reduction significance	2012 post to 2013 post freq. reduction significance
2	77.7%	22.0%	35.0%	**Yes** (p=0.002)	No (p=0.28)
3	82.4%	11.8%	11.8%	**Yes** (p=0.0004)	n/c
4	61.8%	2.9%	6.0%	**Yes** ($p=1.12 \times 10^{-6}$)	No (p=0.55)
5	70.0%	0.0%	39.0%	**Yes** ($p=2.42 \times 10^{-7}$)	
6	93.5%	7.8%	not treated	**Yes** ($p=1.99 \times 10^{-26}$)	n/a
7	97.9%	8.5%	not treated	**Yes** (3.90×10^{-18})	n/a
8	100.0%	18.2%	not treated	**Yes** ($p=1.38 \times 10^{-11}$)	n/a
All beds (2-5)		**7.8%(beds 2-5)**	**22.0%**	**n/a**	**Yes** (p=0.008)
All beds (2-8)	**87.0%**	**9.3%(all beds)**		**Yes** ($p=3.86 \times 10^{-66}$)	n/a

Table 4: Summary of treatment results and statistics.

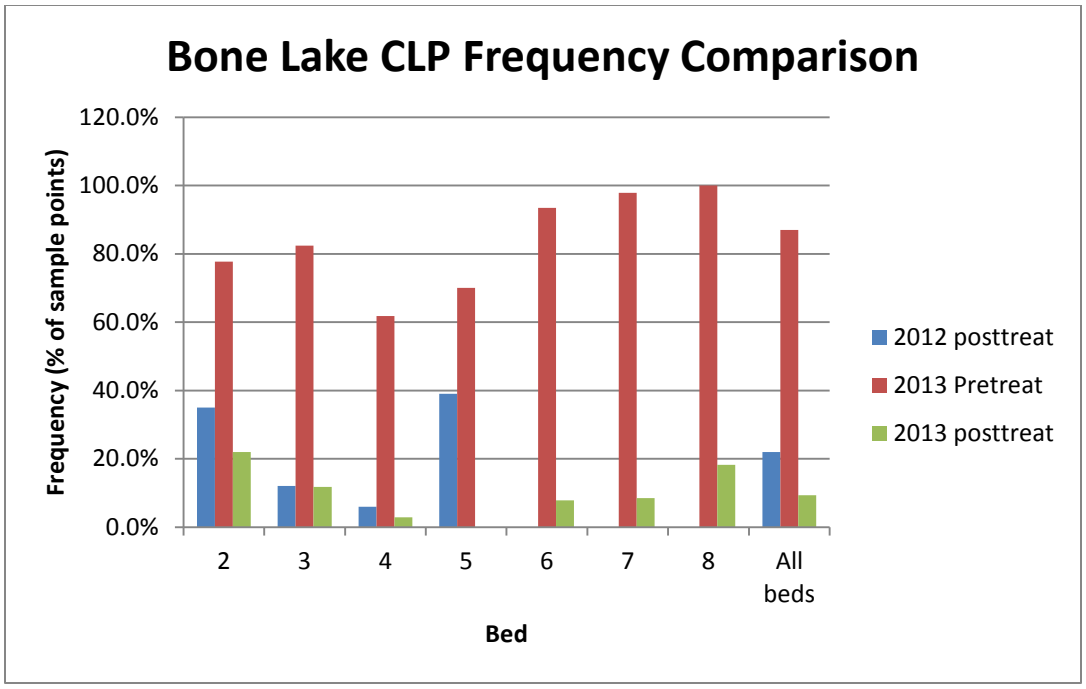


Figure 4: Graph showing comparison of the frequency of occurrences from surveys.

In addition to a reduction in frequency, a reduction in density was also achieved. This is expected since the growth was reduced extensively. Table 3 summarizes the density changes. The density for Beds 6-8 is an estimated mean. An overall density reduction was from a mean of 1.71 in 2012 to a mean of 0.10 in 2013. Figures 5 and 6 show the number of sample points with the density ratings.

Bed	2012 Mean Density	2013 Mean Density	Density change
2	0.35	0.22	-0.13
3	0.18	0.12	-0.06
4	0.06	0.03	-0.03
5	0.64	0.00	-0.64**
6	2.5*	0.08	-2.42**
7	2.5*	0.09	-2.41**
8	2.5*	0.23	-2.27**
All	1.71*	0.10	-1.61**

*Estimated based upon 2012 bed delineation.

**Significant decrease in density from ttest analysis ($p<0.05$)

Table 5: Mean density of each bed from 2012 and 2013 surveys showing change.

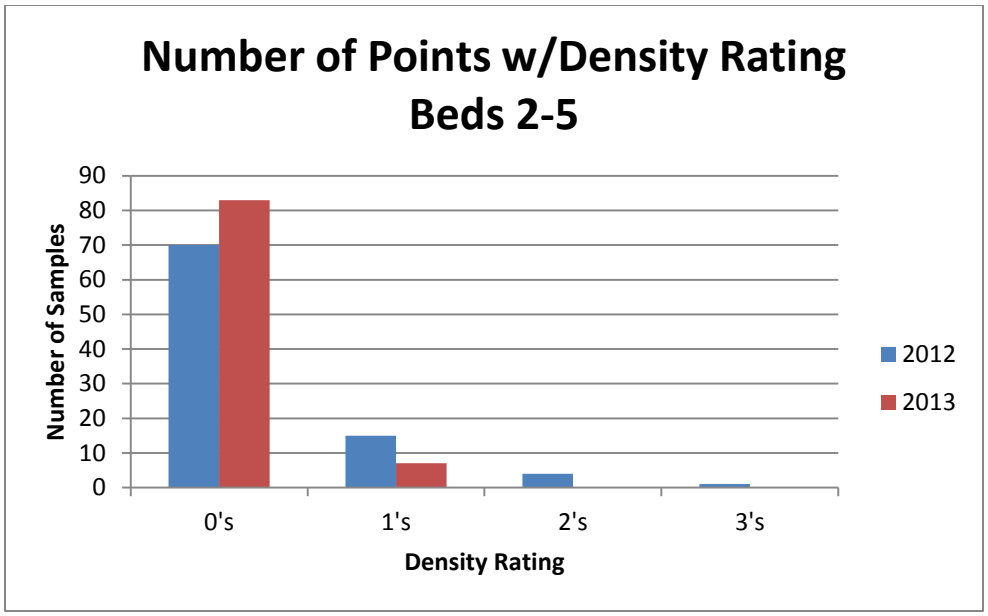


Figure 5: Graph with number of density ratings in beds 2-5 from 2012 and 2013 post survey.

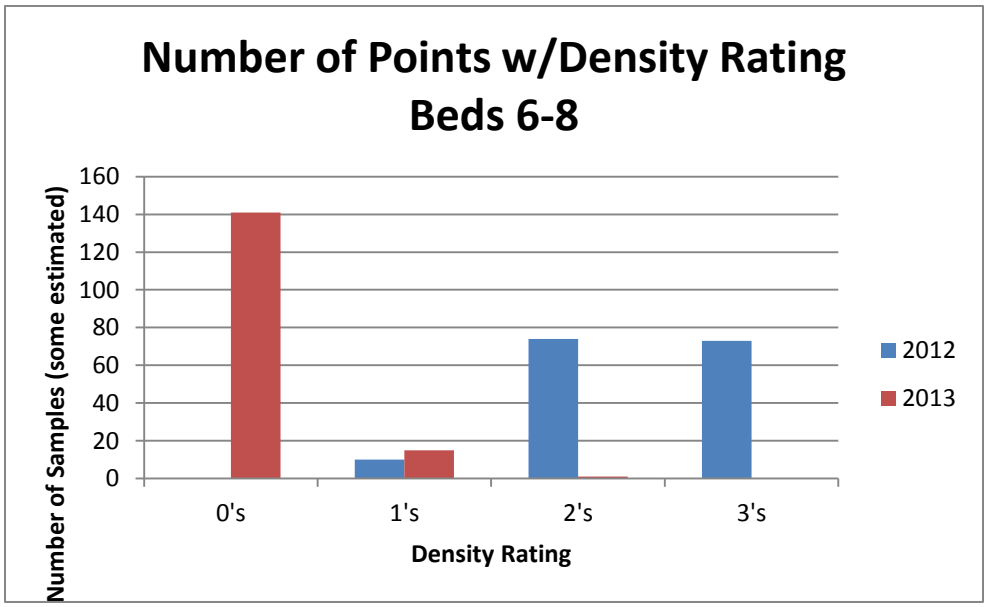


Figure 6: Graph with number of density ratings in beds 6-8 from 2012 (some estimated) and 2013.

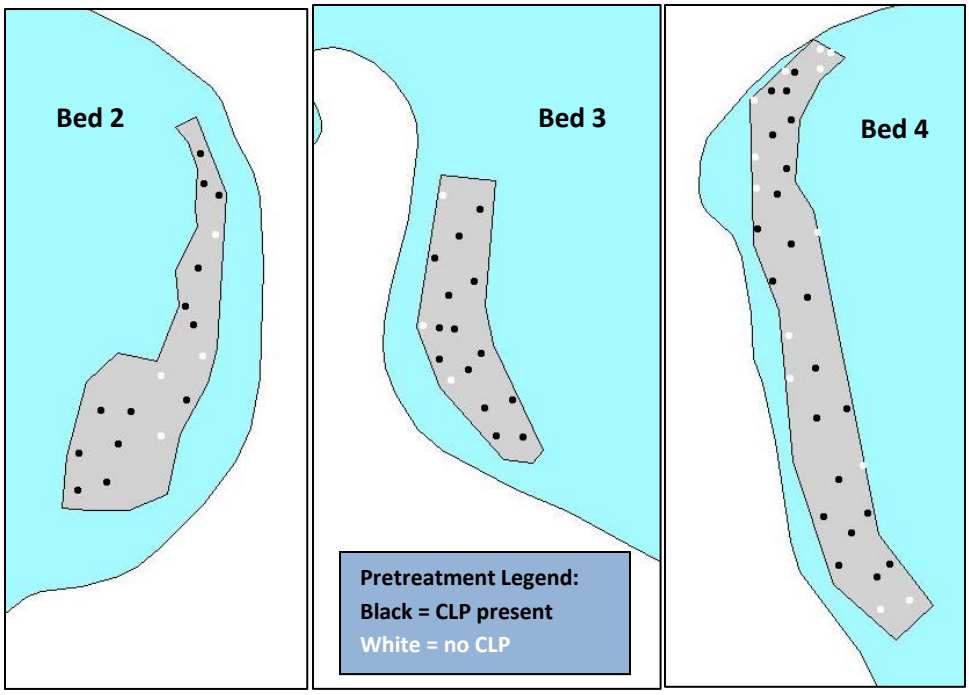


Figure 7: Map of beds 2-4 pretreatment presence of CLP prior to treatment 2013.

Figures 7 and 8 show the absence/ presence of CLP within the treatment polygons from the 2013 pretreatment survey. Figures 9-14 show the density of CLP within the treatment polygons from the 2012 and 2013 post treatment surveys. These figures allow for the comparison of coverage/density of CLP in the bed after treatment each of the two years.

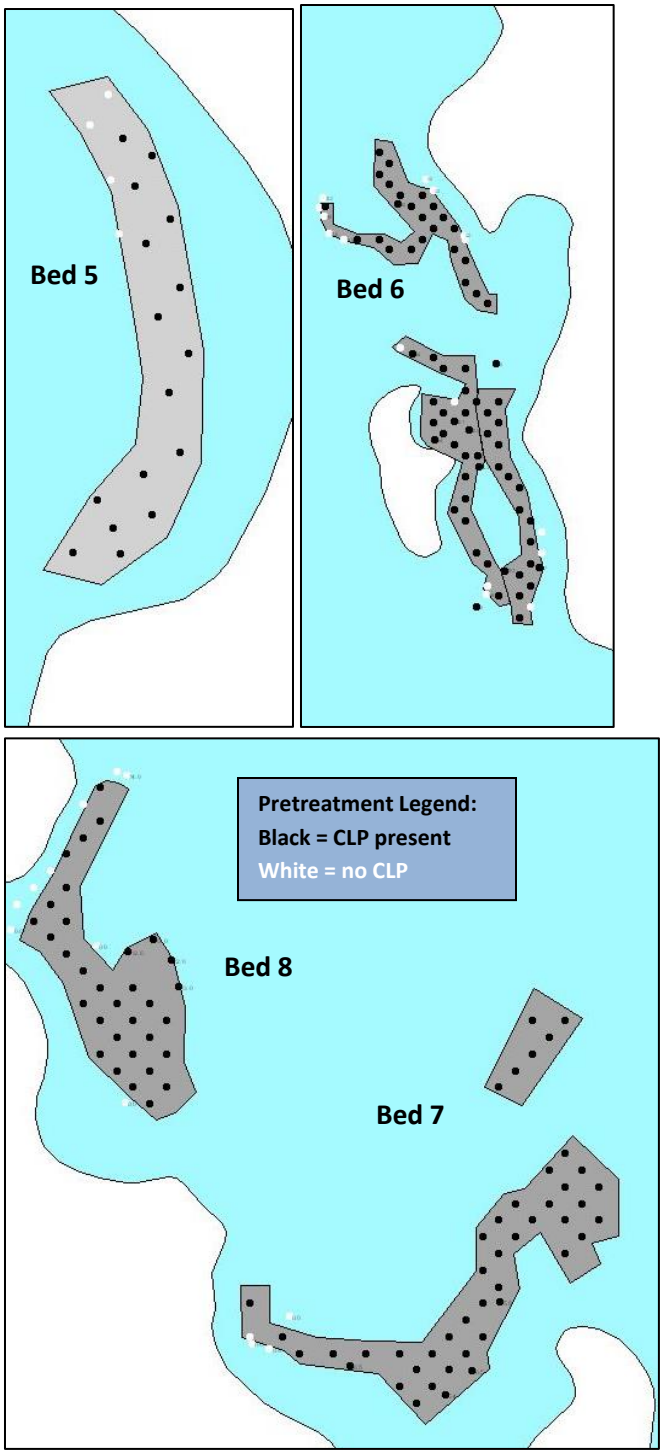


Figure 8: Map of beds 5-8 presence of CLP, prior to treatment 2013.

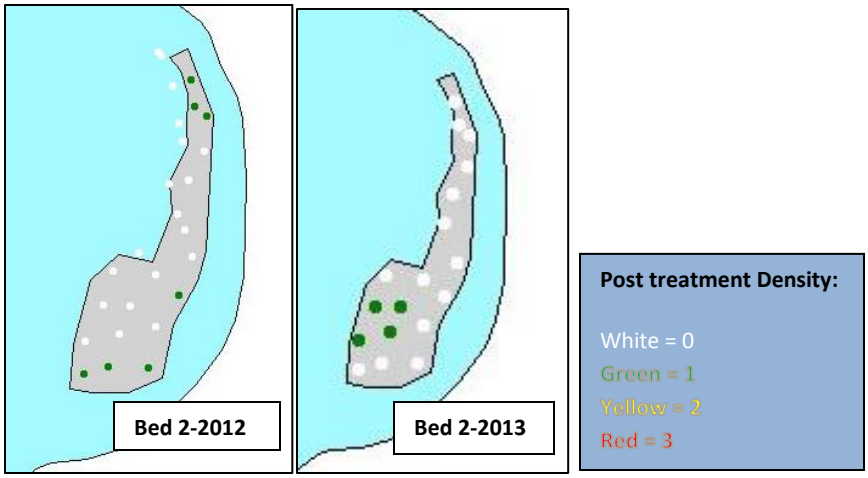


Figure 9: Density map of CLP in bed 2, post treatment 2012 and 2013.

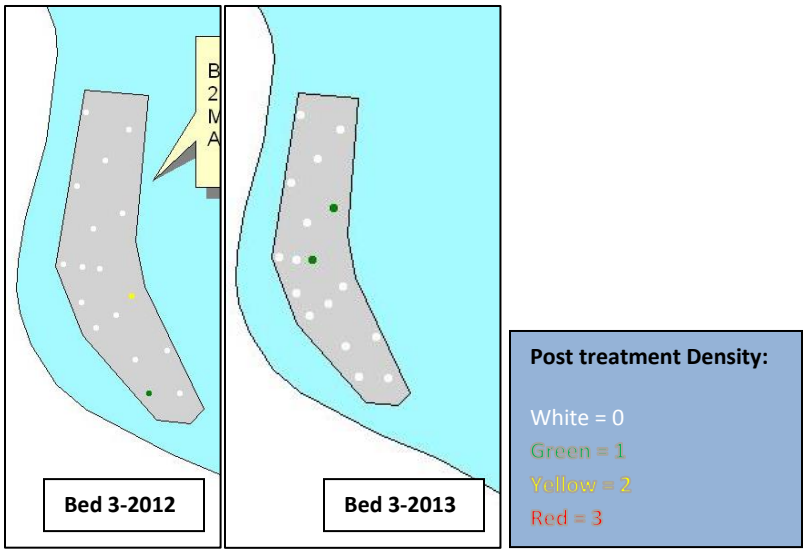


Figure 10: Density map of CLP in bed 3, post treatment 2012 and 2013.

Figure 11: Density map of CLP in bed 4, post treatment 2012 and 2013.

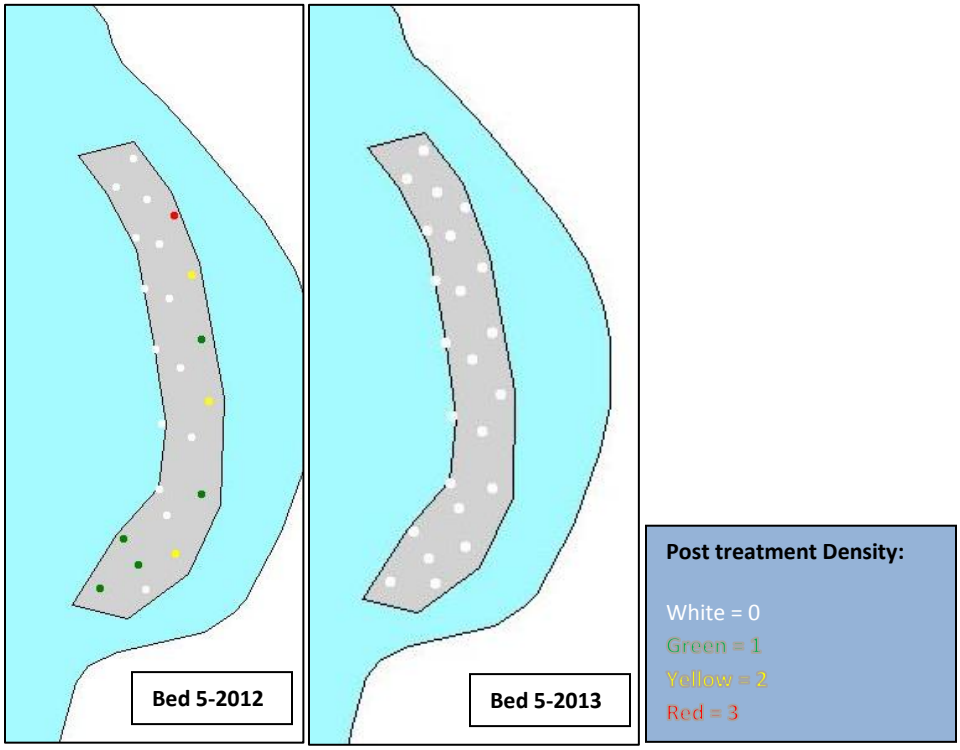


Figure 12: Density map of CLP in bed 5, post treatment 2012 and 2013.

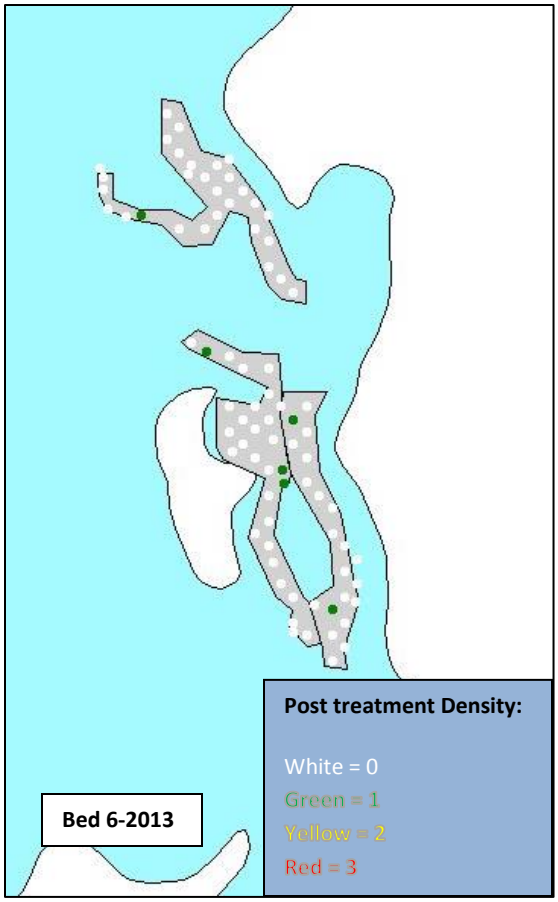


Figure 13: Density map of CLP in bed 6, post treatment 2013.

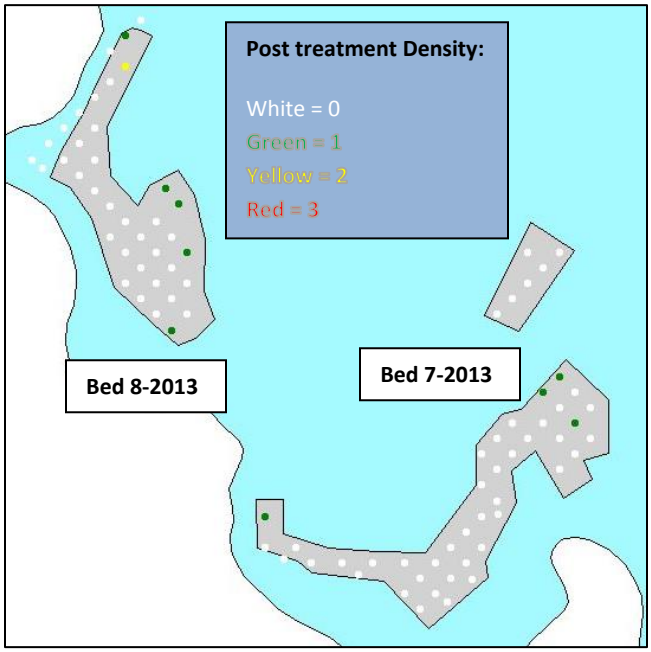


Figure 14: Density map of CLP in beds 7-8, post treatment 2013.

The frequency of native plants is also compared between the post treatment results to the previous year's post treatment results. This is to verify that the CLP was targeted with little or no adverse effects on the native plant community. Table 6 shows that there was a significant reduction in one native plant, northern water milfoil (*Myriophyllum sibiricum*) as the chi-square analysis p value was < 0.02. This is likely due to the plant still being dormant during the survey as the spring was very late and many plants remained dormant. Also, coontail is the most dominant species and its frequency did not change. If the herbicide had affected native plants, one would expect the coontail frequency to have been significantly reduced, which it was not. It appears the CLP was targeted with little effect on the native plants.

YEAR	*Potamogeton zosteriformis*	*Nitella sp.*	*Lemna trisculca*	*Heterantehra dbuia*	*Ceratophyllum demersum*	*Bidens beckii*	*Ranunculus aquatilis*	*Vallisneria americana*	*Myriophyllum sibiricum*	*Stuckenia pectinatus*	*Potamogeton robbinsii*
2012	0.00	0.01	0.06	0.03	0.38	0.03	0.00	0.02	0.14	0.01	0.00
2013	0.02	0.00	0.02	0.02	0.39	0.00	0.01	0.00	0.02	0.00	0.01
Change	**+**	**-**	**-**	**-**	**+**	**-**	**+**	**-**	**-**	**-**	**+**
Significance	No	No	No	No	No	No	No	No	Yes (p=0.003)	No	No

Table 6: Summary of native species frequency changes from 2012 to 2013 (from post treatment surveys).

The turion analysis revealed a further reduction in turion density in beds 2-5 as they have been previously treated. Table 7 shows that the turion density has decreased immensely in these beds from the initial analysis in 2011. The turion density in beds 6-8 shows a very high density and allows a comparison of how much of a reduction may have occurred in the treated areas of beds 2-5. As more successful treatments occur in the future, the turion density should decrease, resulting in less CLP growth each spring (in the treatment areas).

Bed	2011 Turions/m^2	2012 Turions/m^2	2013 Turions/m^2
2	**75**	27	35
3	269	65	79
4	512	47	30
5	274	161	65
All(2-5)	**296**	**75**	**50**
6	*n/a*	*n/a*	422
7	*n/a*	*n/a*	165
8	*n/a*	*n/a*	489
All (2-8)	*n/a*	*n/a*	**259**

Table 7: Turion density data from 2011 through 2013.

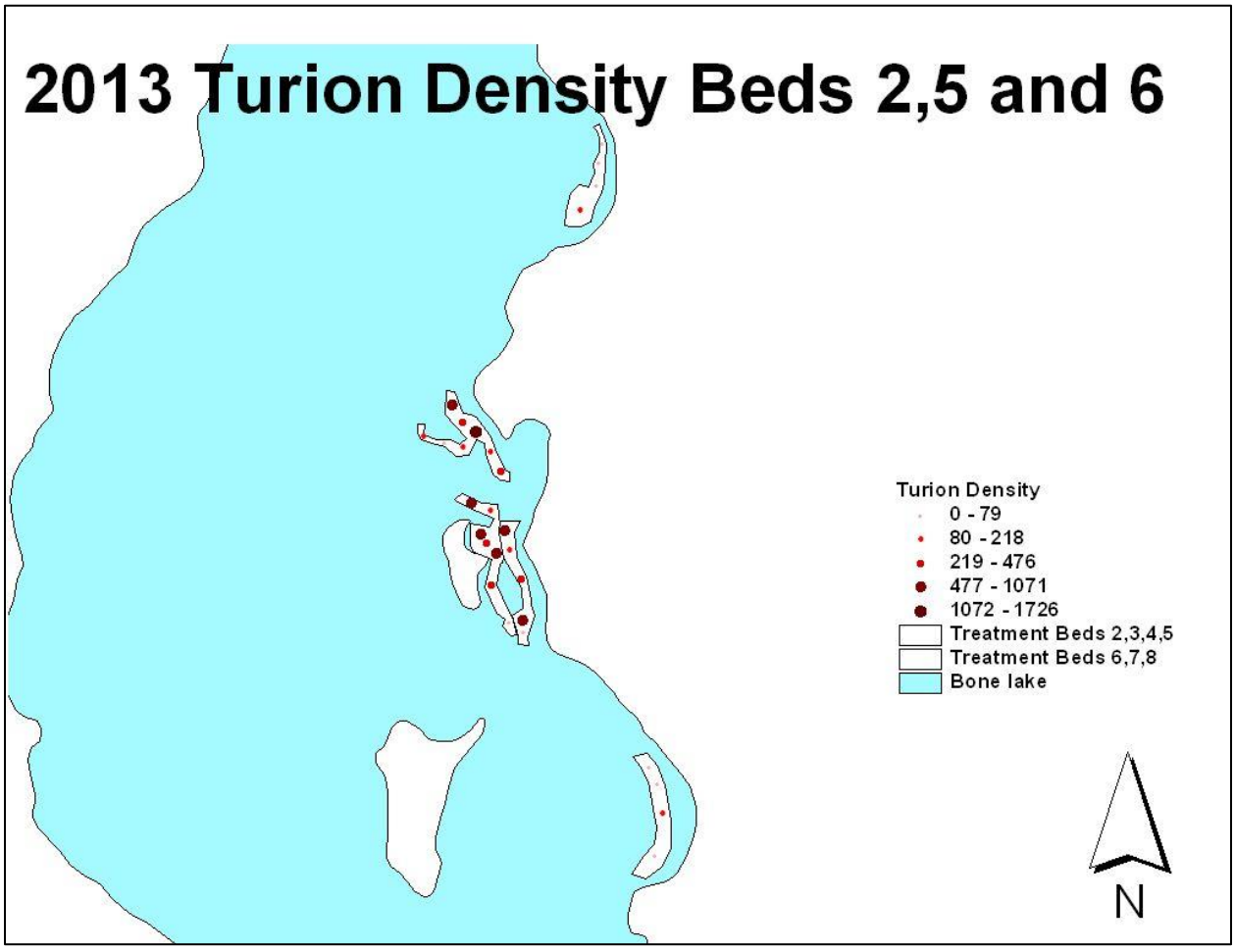


Figure 15: Turion density map from 2013 turion analysis,, beds 2,5 and 6.

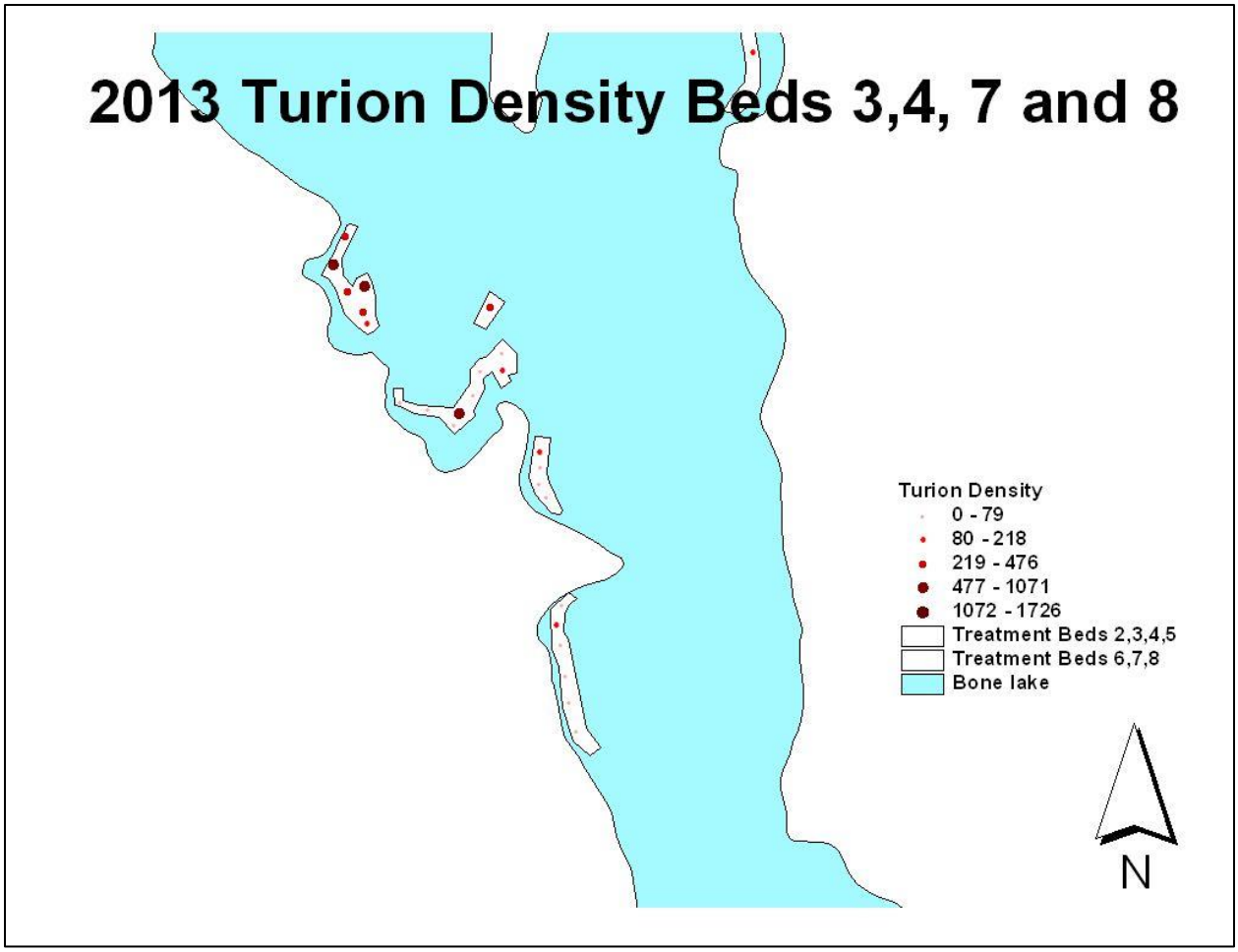


Figure 16: Turion density from 2013 turion analysis, beds 3,4,7 and 8.

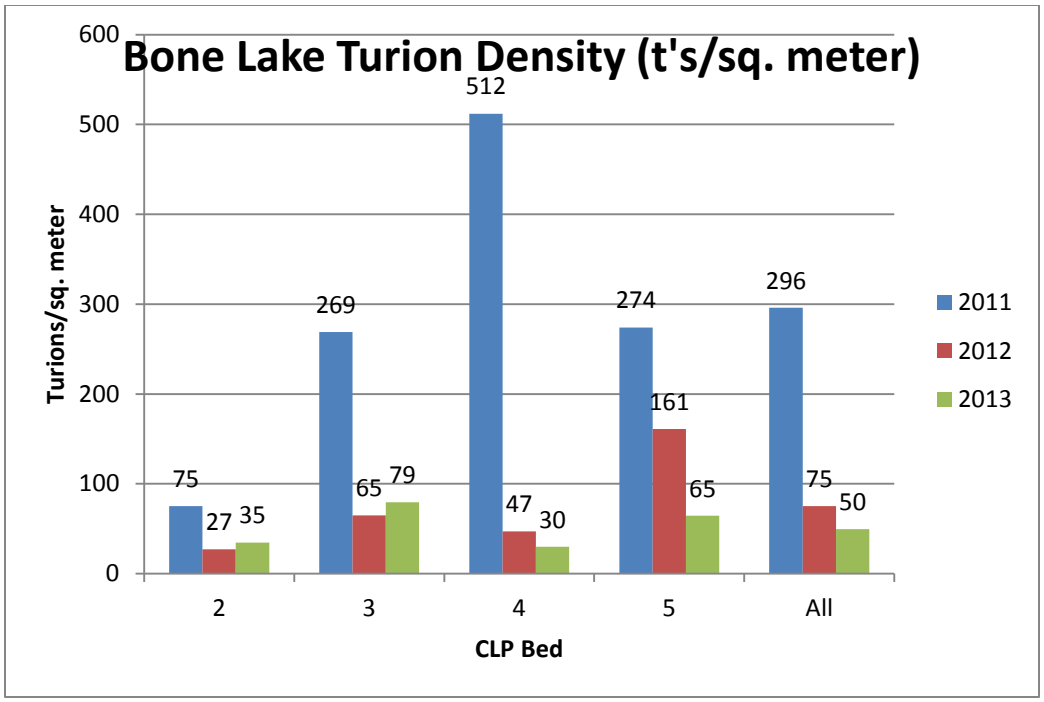


Figure 17: Graph comparing turion density from 2011 through 2013 in beds 2-5. Beds 6-8 have no turion data prior to 2013.

Each year after the post treatment survey is conducted the CLP on Bone Lake is mapped. The beds that have estimated mean CLP density of 2+ and growth of CLP at or near the surface (allowing the CLP to be viewed from the surface) are delineated and mapped in GIS as "dense" beds. Those beds that have CLP at or near the surface, but the coverage is more sporadic and the mean density is estimated to be less than 2 are mapped as "less dense" beds. All of the CLP in the lake is not mapped, only the beds that are dense and clearly near the surface. If these areas should occur in a treatment bed, the delineated area is included in the map. Figure 18 shows the resulting map from 2013. The red areas are dense beds (density >2) and the yellow areas are less dense beds (density <2).

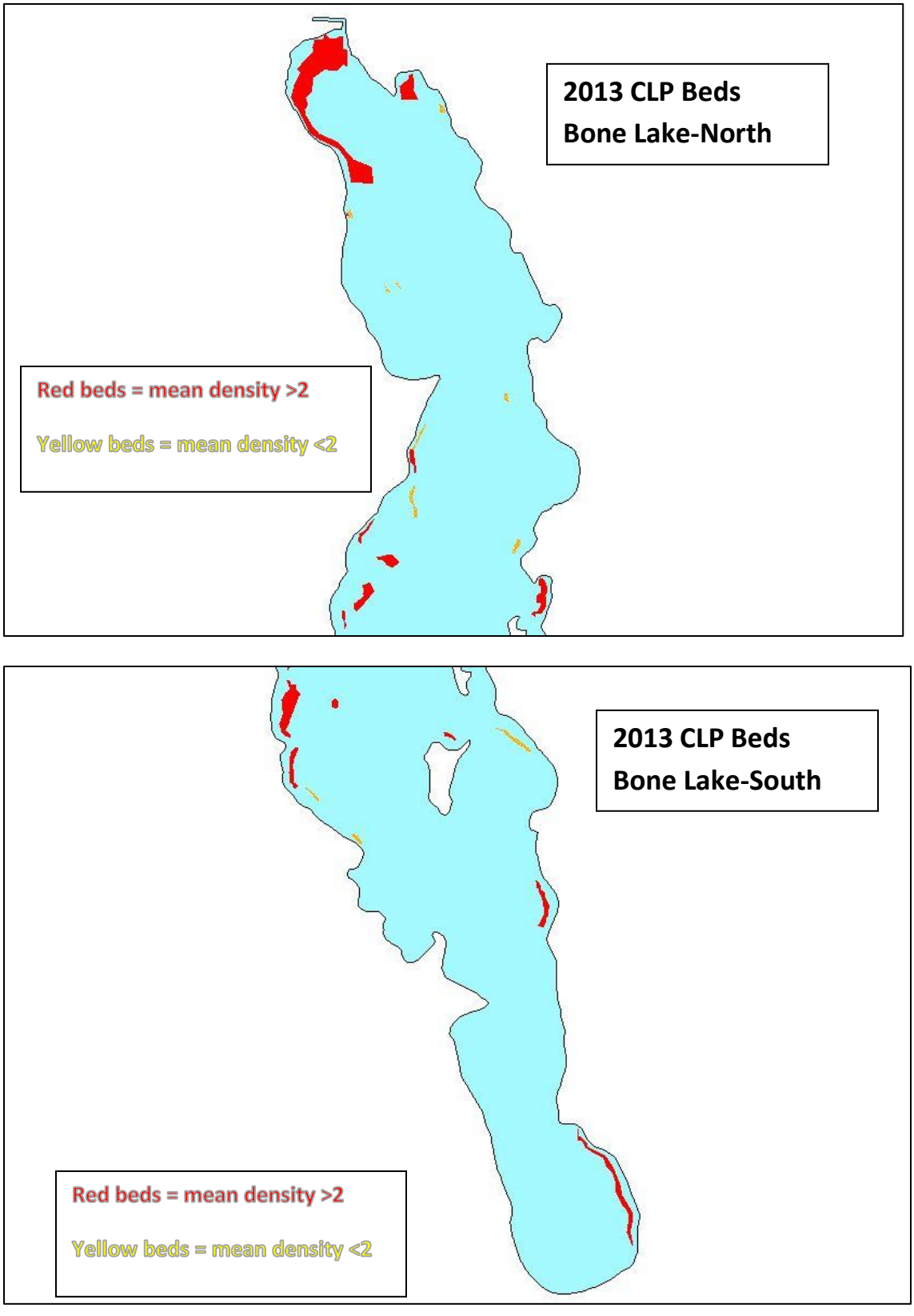


Figure 18: Map of CLP beds delineated in June 2013 during estimated peak growth.

The CLP mapping resulted in an area of 48.4 acres of dense beds and 4.7 acres of less dense beds. Historically the CLP coverage has varied immensely from year to year. In past years more than 80 acres were mapped, while other years had around 50 acres mapped. This year had a total of 53.1 acres mapped. The reduction in the treatment beds (through an effective treatment resulted in much less coverage since the treatment areas totaled about 30.5 acres.

Discussion

The CLP herbicide treatment for 2013 was effective. The 30.45 acres of CLP treated went from high frequency, extensive coverage to only a small number of locations that CLP was sampled after treatment. The reduction in frequency of occurrence was found to be statistically significant through a chi-square analysis. The density was also reduced immensely. The survey also showed a significant reduction in one native species, but it is speculated that this is due to the late spring and not the herbicide application.

The turion analysis supports another reduction in turion density in the treatment beds. The beds that have been treated in past years also have a significantly lower density than the beds there were treated for the first time in 2013. The goal is to see continued reduction in turion density with future effective treatments. Due to the continued presence of turions in all beds, it is recommended that treatment continue in all treatment beds, with adjustments being made in the spring pretreatment survey based upon growth of CLP at that time.

References

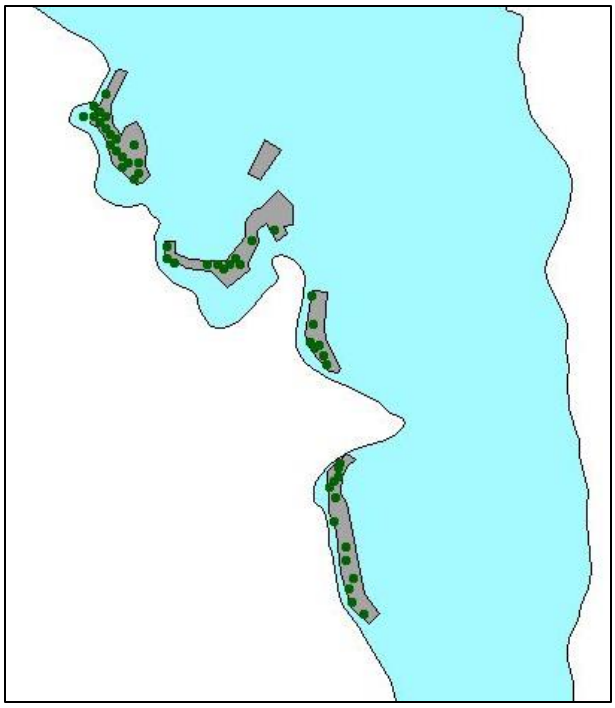
Borman, Susan, Robert Korth and Jo Tempte. *Through the Looking Glass.* University of Wisconsin-Extension. Stevens Point, Wisconsin. 1997. 248 p.

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.

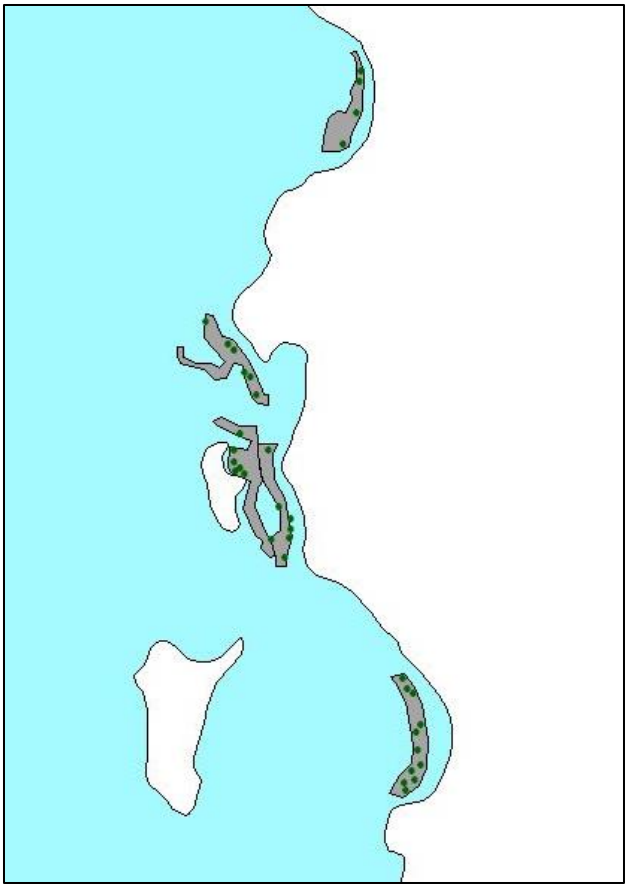
University of Wisconsin-Extension. *Aquatic Plant Management in Wisconsin*. April 2006 Draft. 46 p.

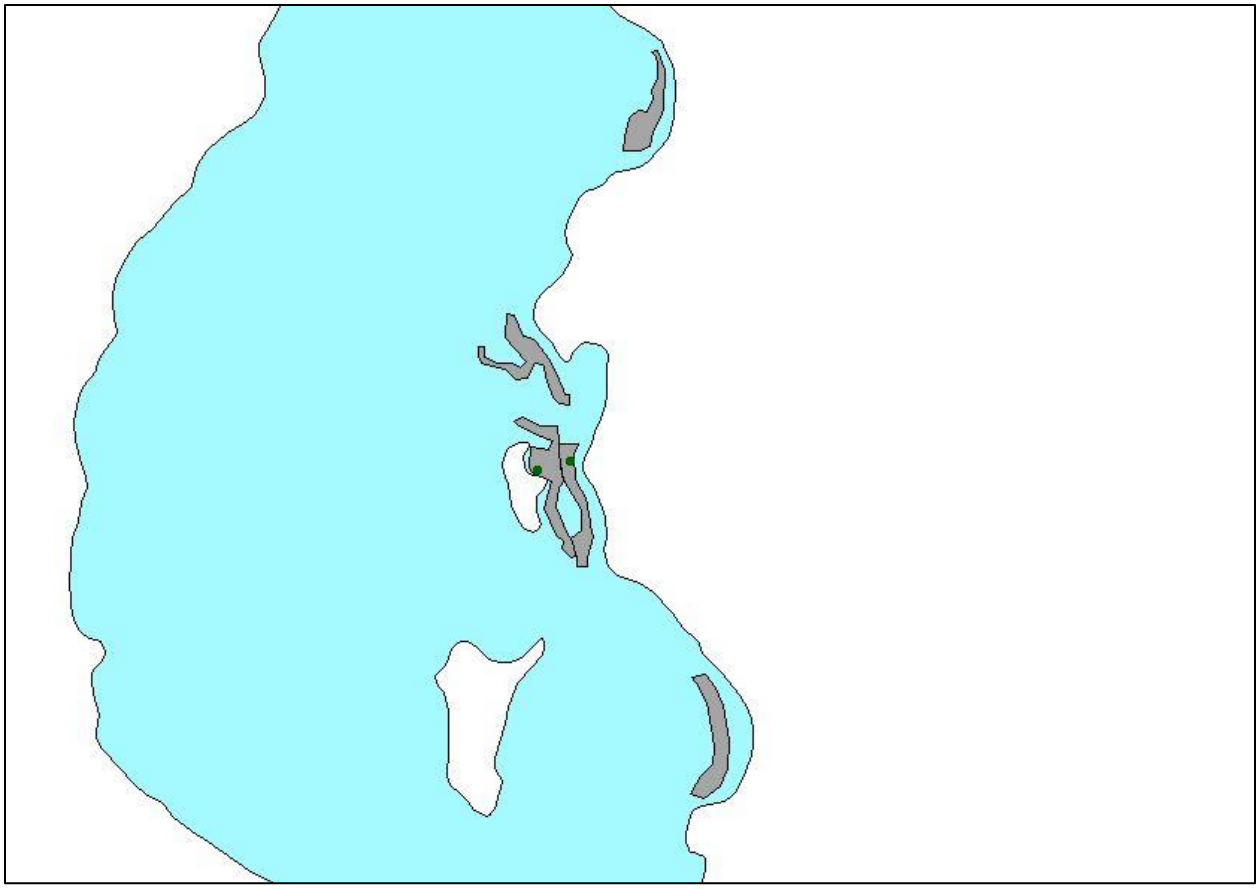
UW-Extension. Aquatic Plant Management website. http://www4.uwsp.edu/cnr/uwexlakes/ecology/apmguide.asp appendix d.

Appendix-Maps of native species, 2013 post treatment

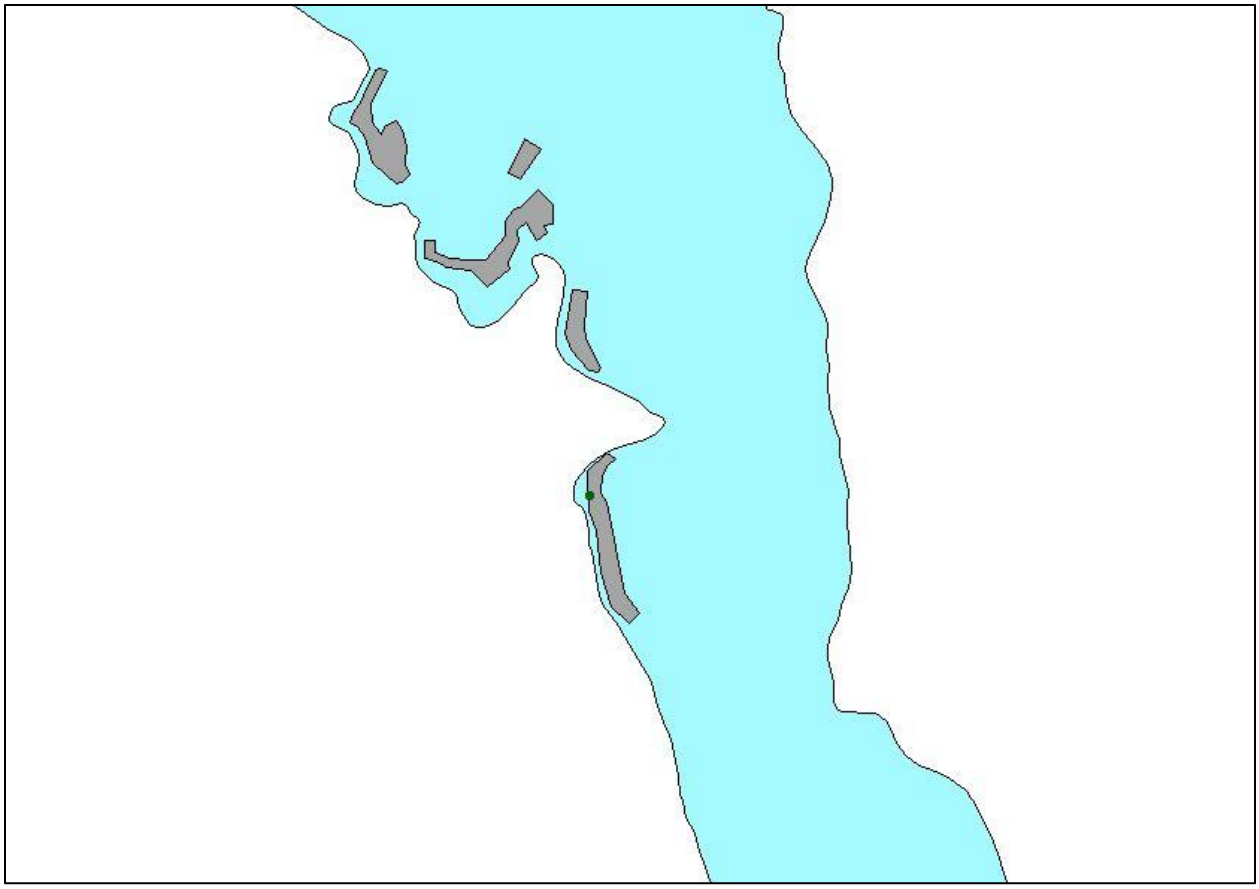


Coontail-*Ceratophyllum demersum*

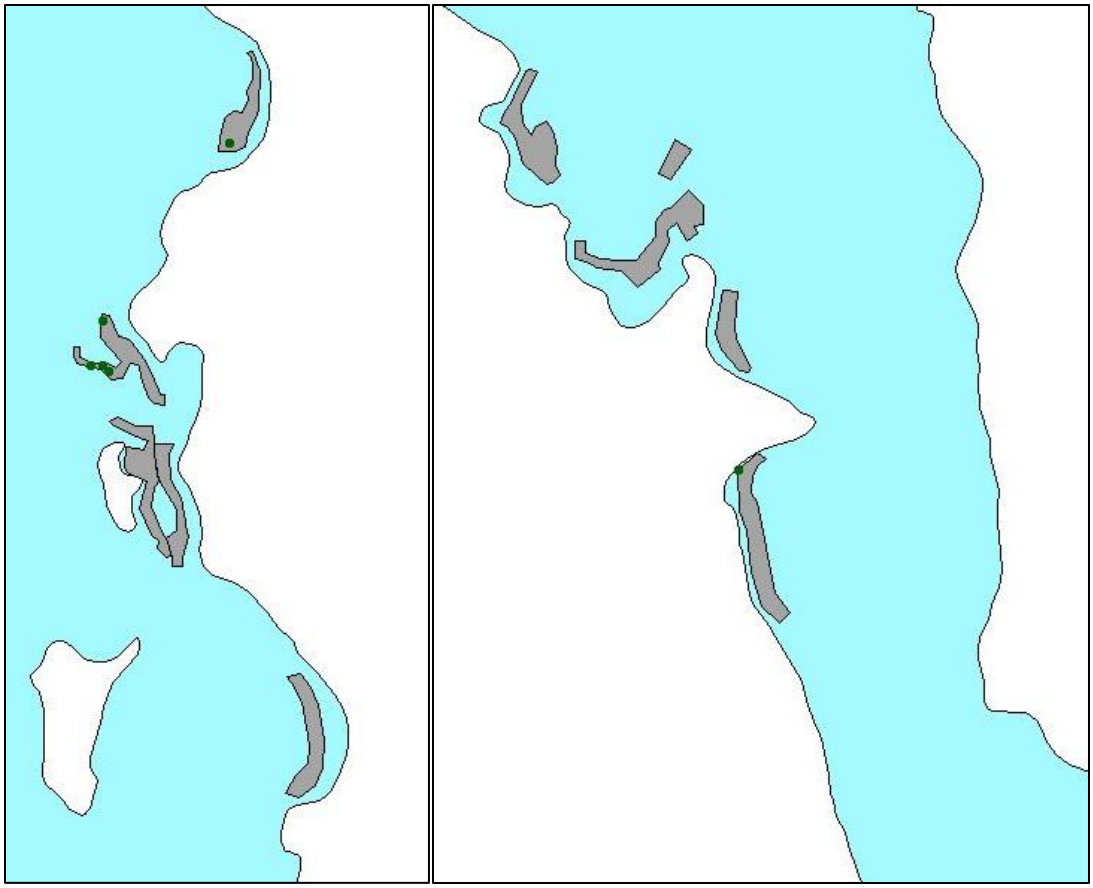




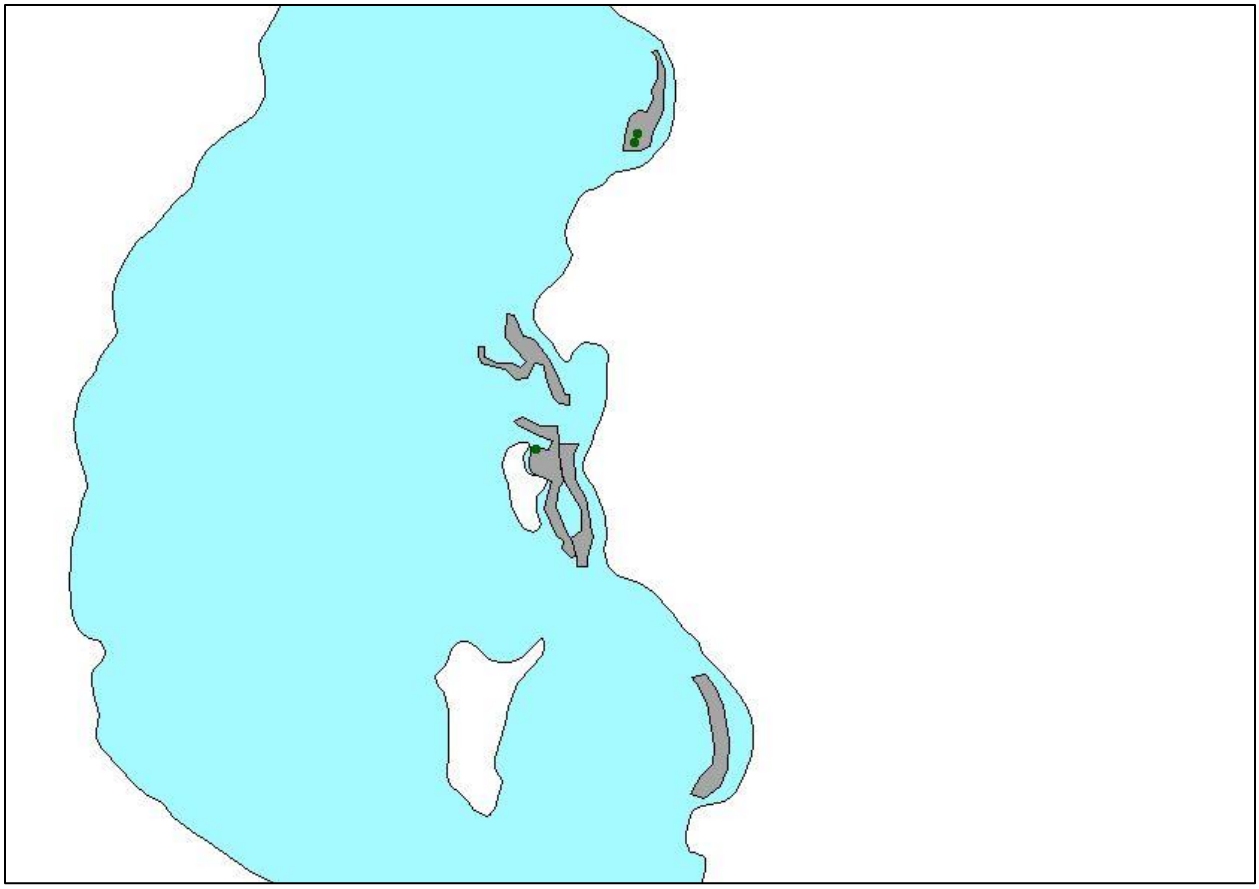
Arrowhead rosette-*Sagittaria sp.*



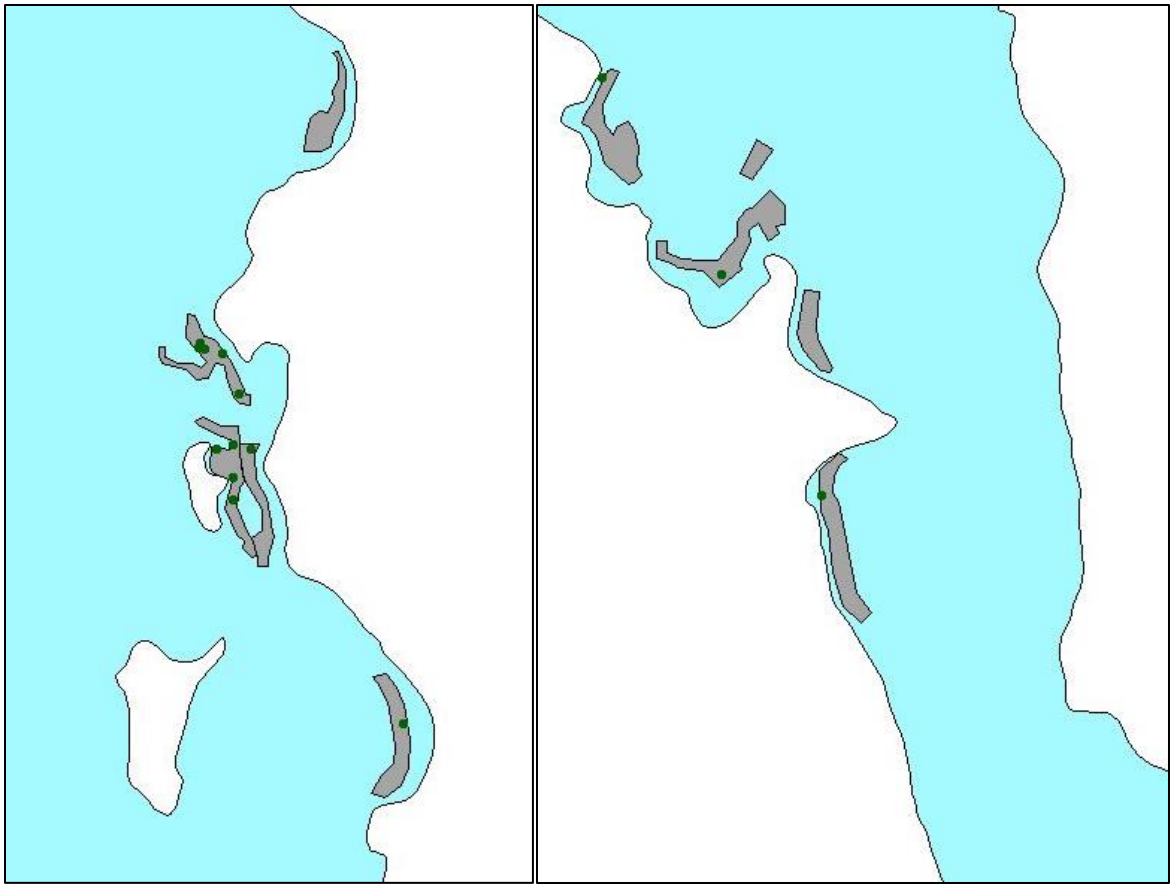
Stiff water crowfoot-*Rununculus aquatilis*



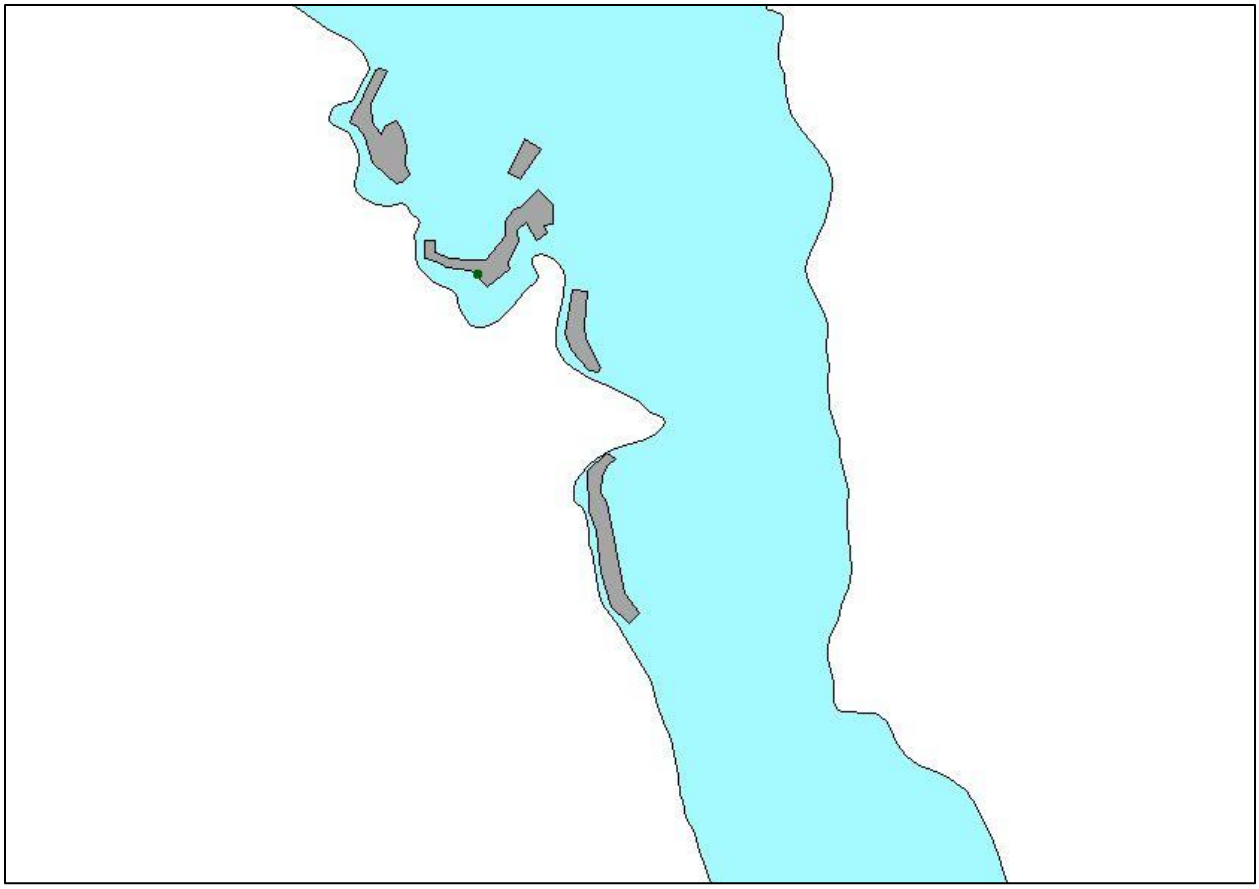
Fern pondweed-*Potamogeton robbinsii*



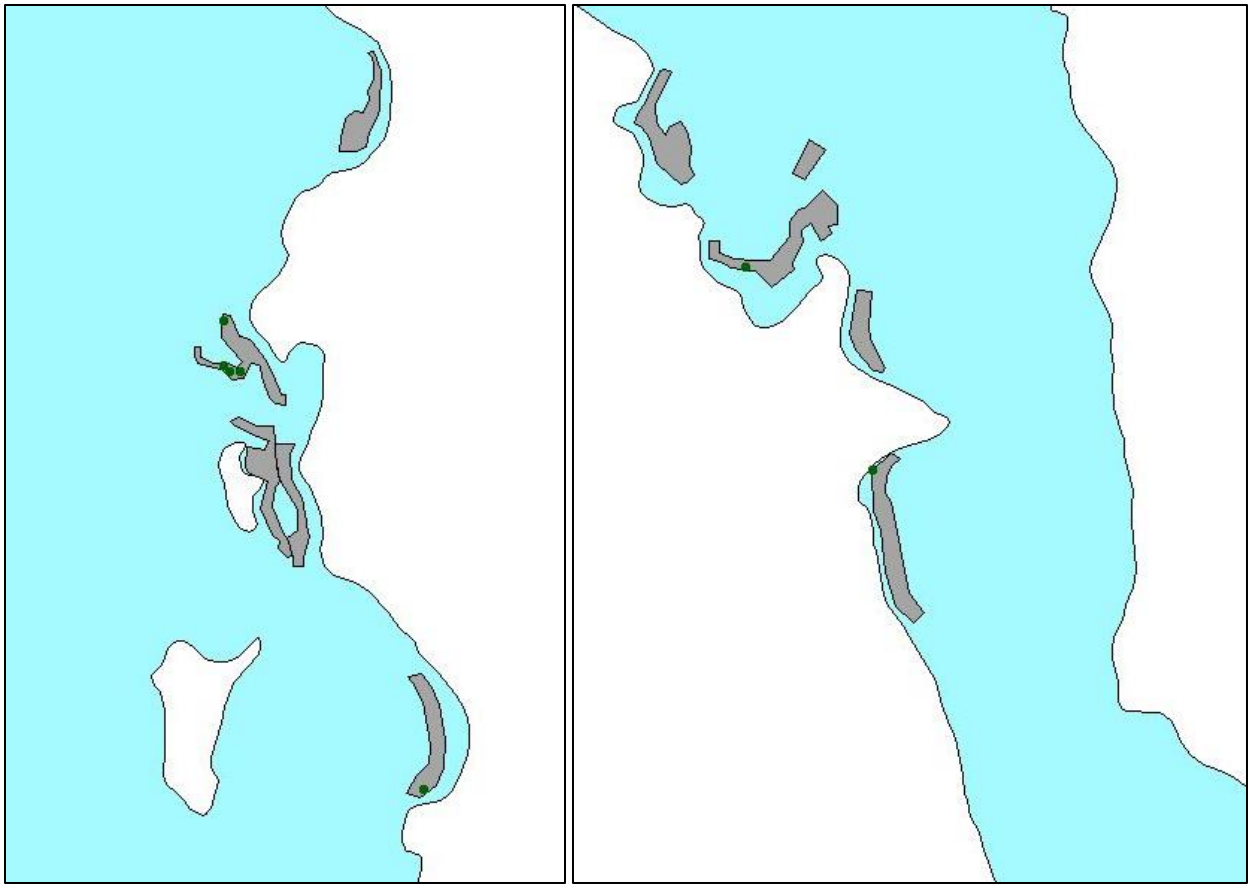
Flatstem pondweed-*Potamogeton zosteriformis*



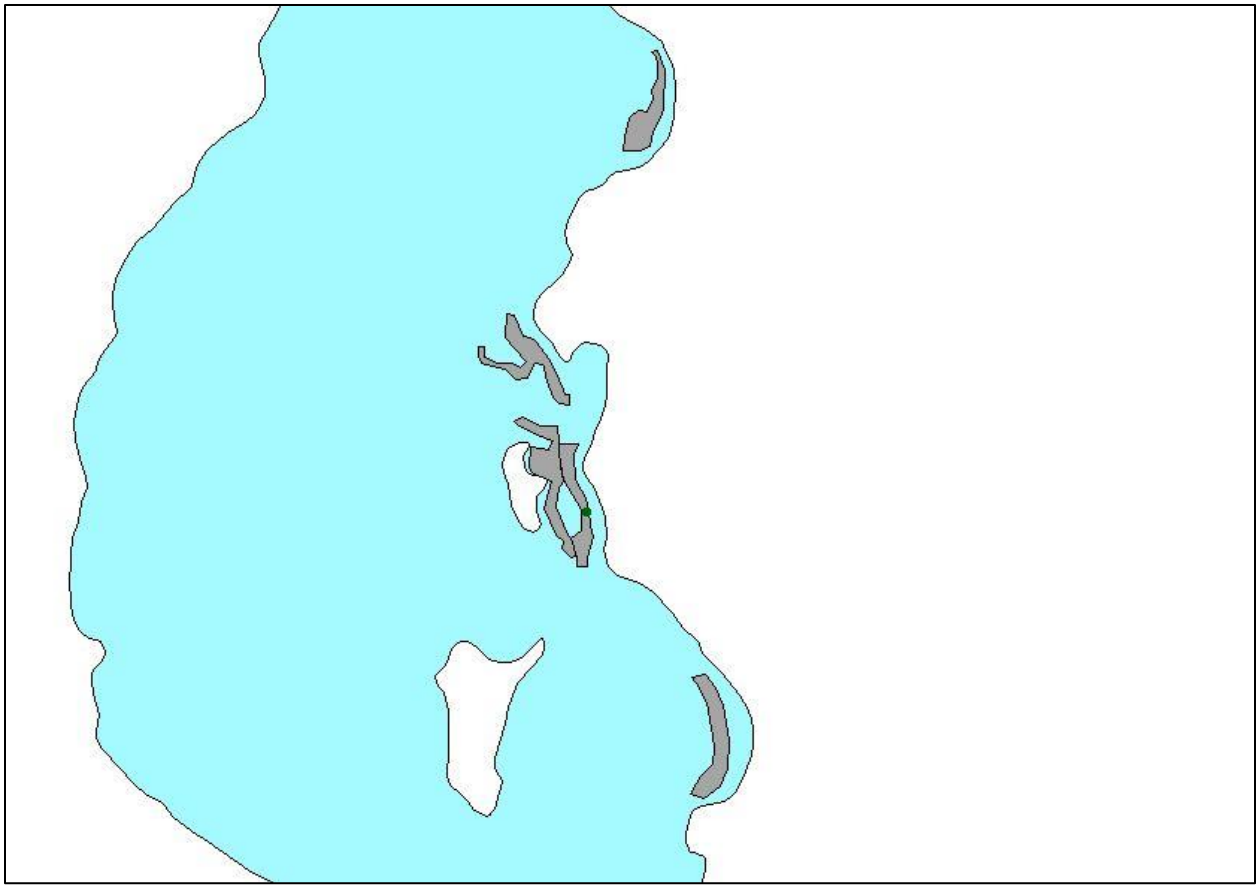
Forked duckweed-*Lemna trisulca*



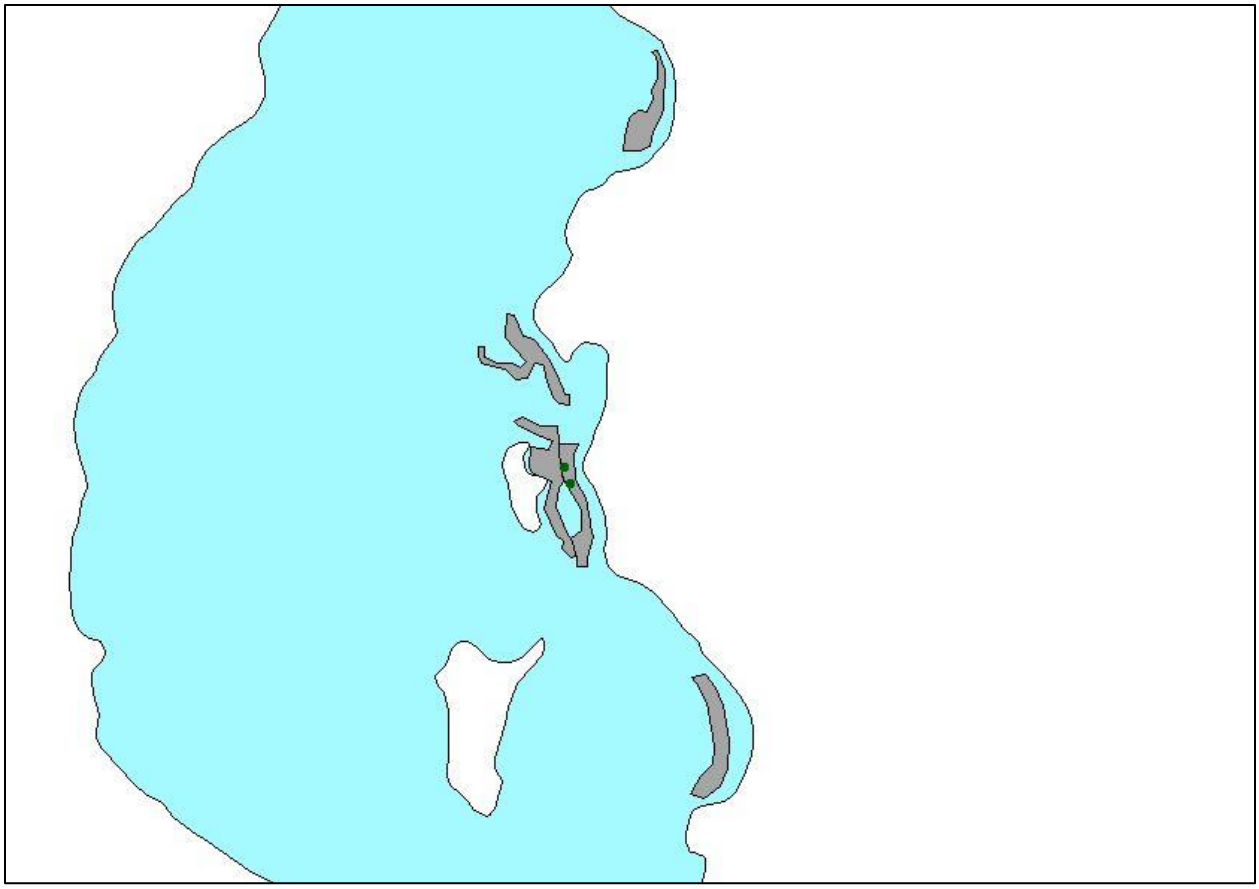
Water marigold-*Bidens beckii*



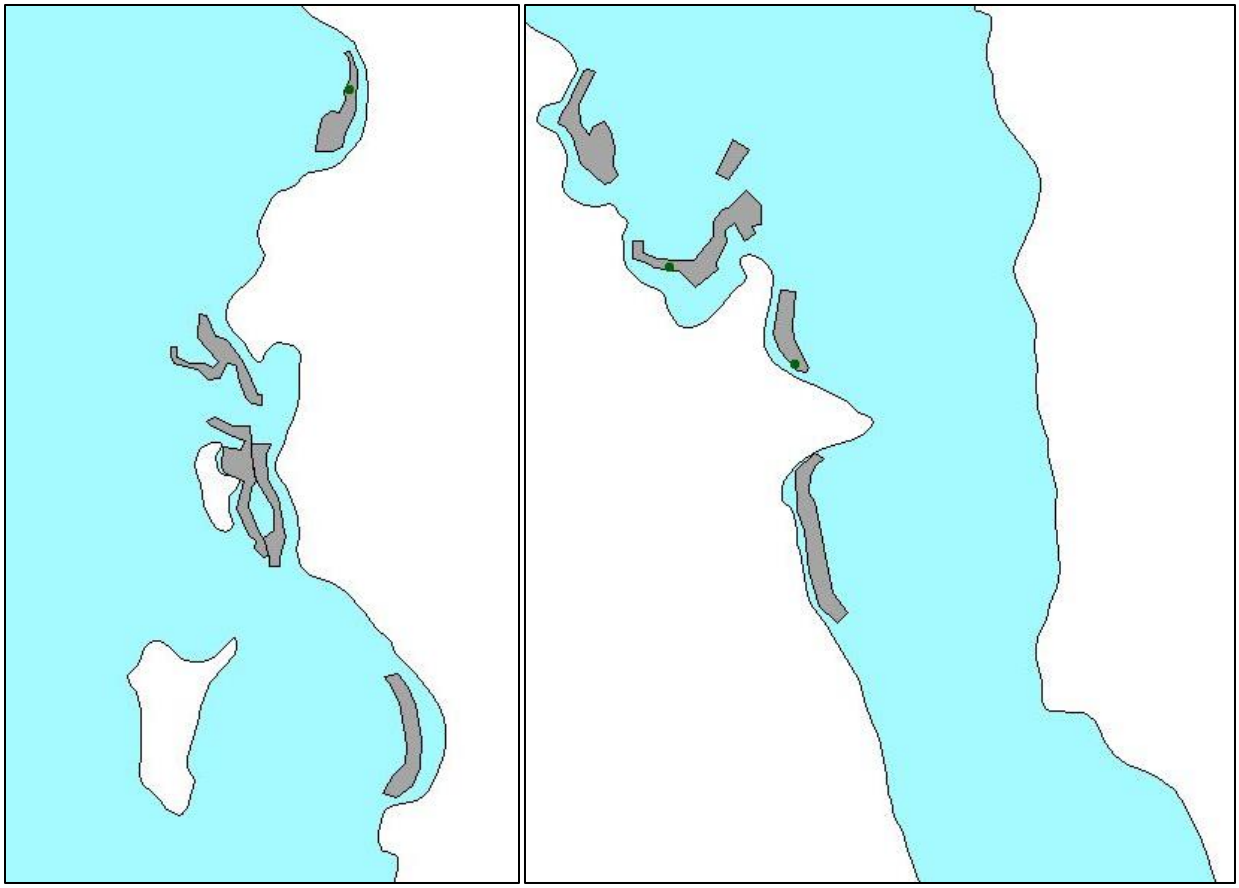
Northern water-milfoil-*Myriophyllum sibiricum*



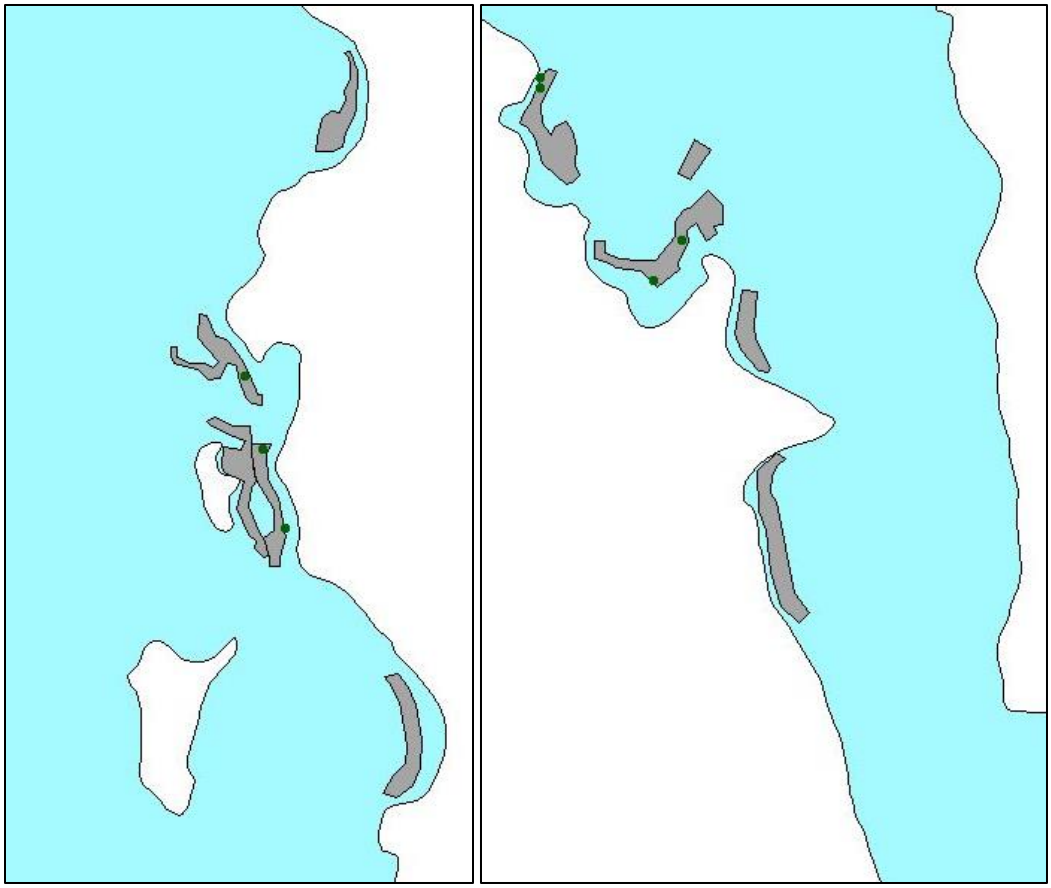
Bushy pondweed-*Najas flexilis*



Stonewort-*Nitella sp.*



Water stargrass-*Heteranthera dubia*



White-stem pondweed – *Potamogeton praelongus*