Analysis of Herbicide Treatment-

Potamogeton crispus –curly leaf pondweed(CLP)

Big Lake

Polk County, WI

2019

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Amery, WI

Abstract

On May 2, 2019 8.4 acres of *Potamogeton crispus*-curly leaf pondweed (CLP) were treated with the herbicide endothall at a target concentration of 1.5-2.5 ppm. The water temperature at the time of treatment was 47 degrees F. A pretreatment survey was conducted on May 1 and a post treatment survey was conducted on June 11, 2019. A chi-square analysis was used to determine the significance of any reductions in frequency of occurrence. The frequency of occurrence from the pretreatment to the post treatment survey showed a statistically significant reduction (from 41.8% to 14.3%; p=0.002). A comparison of the post treatment survey of 2018 and the post treatment survey of 2019 showed an increase from 0% to 14.3% which was significant (p=0.009). Comparing the pretreatment survey of 2018 to the pretreatment survey of 2019, a decrease occurred from 43.4% to 36.4%, which was not statistically significant (p=0.24). A chi-square analysis revealed a statistically significant reduction in two native plant species and increases in two native species. A turion analysis resulted in a mean turion density of 13.8 turions/m^2, which is a small increase from 2018 (10.3 turions/m^2)

Introduction

On May 4, 2019 four beds totaling 8.4 acres of *Potamogeton crispus*-curly leaf pondweed (CLP) beds were treated with herbicide (endothall-K) 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.

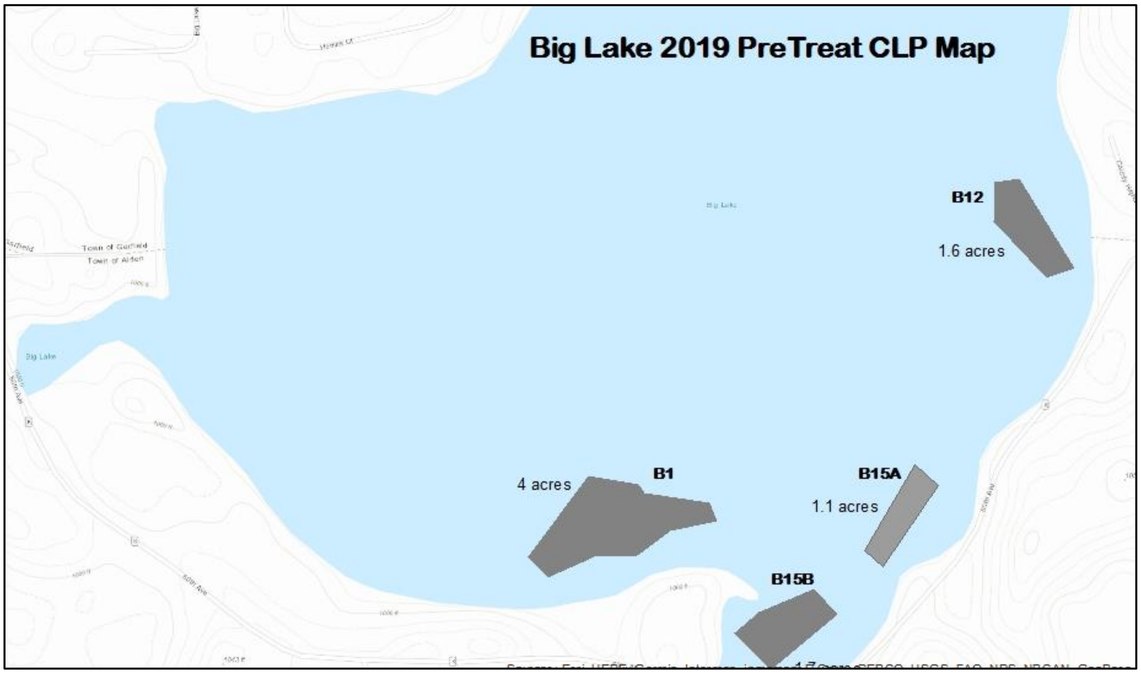

Figure 1: Map showing 2019 CLP treatment beds

Treatment date: Bed	*Acres*	*Mean depth*	*Acre-feet*	*Target Concentration**	*Water temp.**	*Wind/direction **
B1	4	6.3	28	**1.5 ppm**	**47**	**0-4/west**
B12	1.6	7	11.36	**1.5 ppm**	**47**	**0-4/west**
B15A	1.1	7.1	4.62	**2.5 ppm**	**47**	**0-4/west**
B15B	1.7	4.2	7.14	**2.5 ppm**	**47**	**0-4/west**
Total	8.4		51.12			

*As reported by applicator

Table 1: Summary of 2019 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. The pretreatment frequency is starting to go down, largely along the bed edges. Treatment of this bed needs to continue.
B2 **(not treated in 2019)**	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. This bed was eliminated for treatment in 2019 due to lack of CLP present.
B12	Bed B12 came about from combining B12 and B13 from previous treatment years. CLP growing between these beds that were 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 feet to 11 feet in depth. The most CLP growth in this bed is the outer ½ of the bed in 7-10 feet of water depth. This bed was reduced in size in 2019 due to lack of CLP in the shallow portions of the bed.
B15(A and B)	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. Due to distinct differences in CLP growth in this bed, it was labeled as two beds (A and B) in 2016 and completely separated in 2017. This continued in 2018. The CLP presence in 15A was small in 2019, but it was decided to proceed with treatment in 2019.

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.

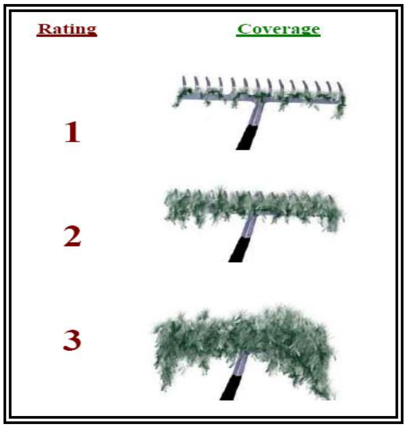

Figure 2: Density rating system and example CLP rake sample.

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 it is known 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

The 2019 herbicide treatment to target and reduce Potamogeton crispus (CLP) was successful at reducing the frequency of CLP before treatment to after treatment (pre and post treatment surveys). The reduction was statistically significant according to a chi-square analysis (P=0.002). Table 3 summarizes frequency of occurrence (FOO) from various surveys. Table 4 summarizes the significance of change from a chi-square analysis.

Bed	2018 Pre-FOO	2019 Pre-FOO	2018 Post-FOO	2019 Post-FOO	2018 Post Mean Density	2019 Post Mean Density
B1	46.7	40.5	0.0	21.6	0.0	0.22
B12	33.3	26.7	0.0	9.1	0.0	0.09
B15A	62.5	20.0	0.0	0.0	0.0	0.0
B15B	31.6	31.3	0.0	7.7	0.0	0.08
All Beds-only treated in 2019 (not bed 2)	39.4	41.8	0.0	14.3	0.0	0.14
All beds including no treat beds 2019 to compared pretreat (including bed 2)	43.4	36.4	n/a	n/a	n/a	n/a

Table 3: Frequency of occurrence and density data from 2018 and 2019 CLP surveys.

Bed	Pre to post (2019)reduction and significance	Post 2018 to Post 2019 reduction significance	Pre 2018 to Pre 2019 Reduction Significance (Bed 2 included)	Mean Density Change 2017-2018 (post)
All beds	Yes (p=0.002)	Increase is significant (p=0.009)	No (p=0.24)	Small Increase

Table 4: Chi-square analysis results comparing various surveys.

Figures 5 and 6 show the presence/density of CLP within the treatment beds before and after treatment. From 2018 to 2019, the CLP FOO in the pretreatment survey decreased slightly. Comparing the post treatment CLP FOO in 2018 to 2019 shows an increase. This increase was statistically significant (p=0.009). This is not a desirable result in a herbicide treatment. The cause for less effective frequency reduction is typically due to reduced contact time of the herbicide. The wind was recorded as 0-4 from the west at the time of application, which would be expected to cause very substantial currents in the water column. The water temperature was only 47 degrees F, but that too should not be a factor.

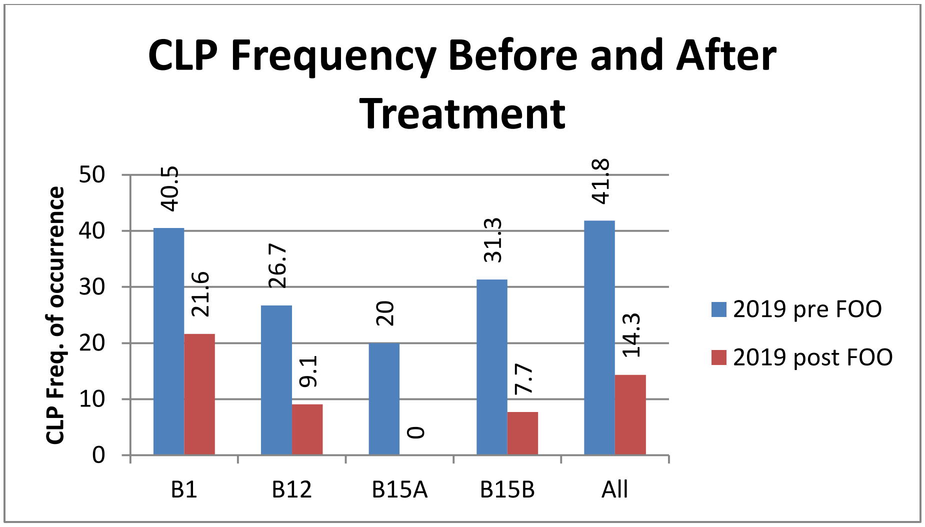

Figure 4: Frequency comparison before and after treatment for each bed and all beds combined.

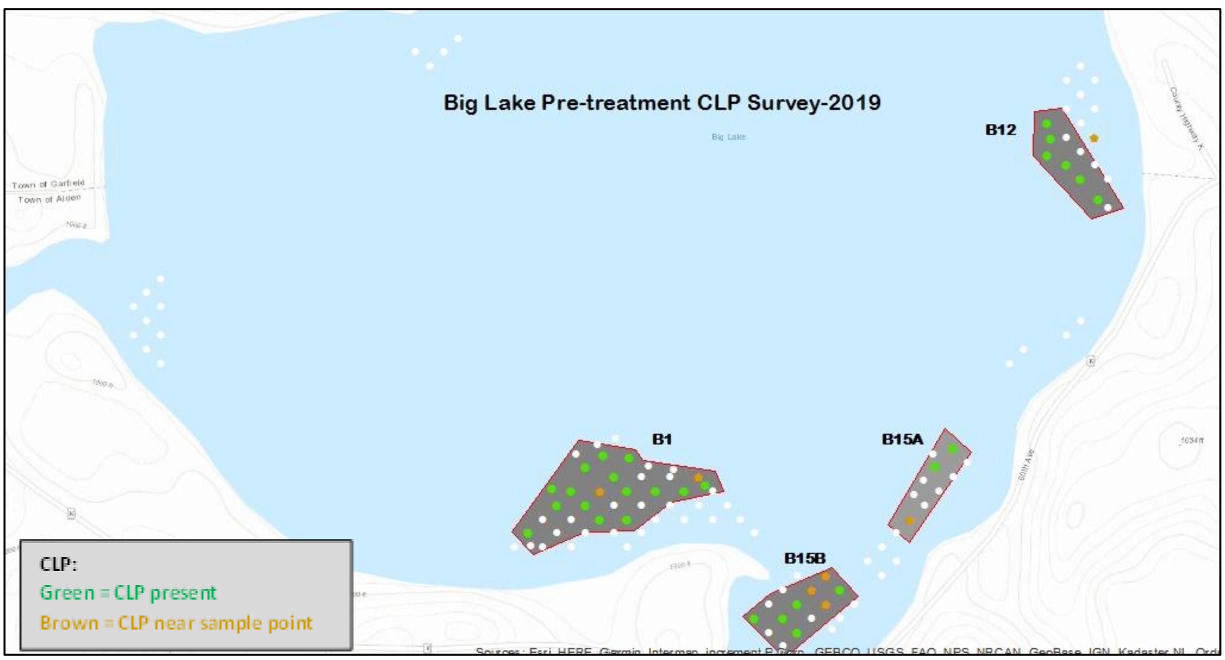

Figure 5: Map of CLP presence/absence before treatment May, 2019.

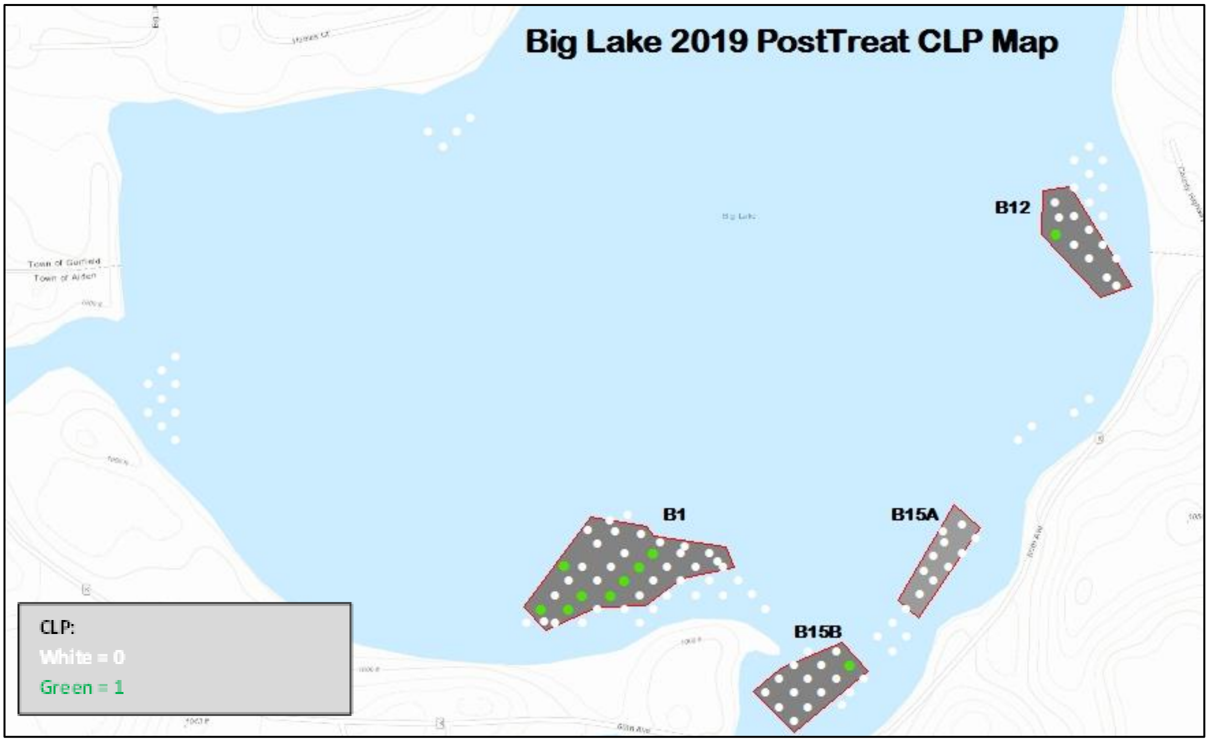

Figure 6: Map of CLP density after treatment in June, 2019.

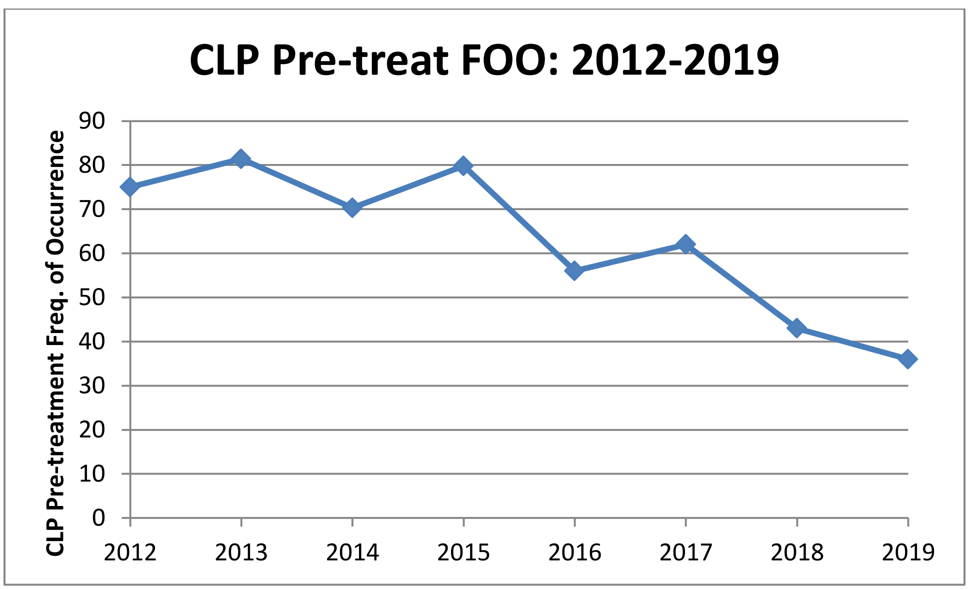

Figure 7: Graph of CLP frequency from pretreatment surveys 2012-2019.

A long-term, desirable trend is for the pretreatment FOO to decrease each year. This is because the CLP growth typically returns each spring due to turion germination. As plants are killed before turion production, the frequency of the return CLP growth should go down. Figure 7 shows that the pretreatment CLP FOO has been declining since 2012.

In addition, beds of herbicide treatment have been reduced in size and some have been eliminated. The CLP aerial coverage in 2012 was 20.66 acres. That has gone down to approximately 5.7 acres (estimated based on sampled CLP) in 2019.

Year	Area coverage of CLP (pre-treat estimate)
2012	20.66 acres
2019	5.7 acres

Table 5: Aerial coverage of CLP from 2012 to 2019.

Native plant evaluation

A successful treatment not only results in the reduction of the target species, but no reduction in native species. The frequency of each native species from the post treatment survey the previous year is compared to the treatment year frequency. A chi-square analysis is used to determine the statistical significance of any changes. The desire is to have no significant reduction in native species.

The chi-square analysis resulted in a statistically significant reduction in two native species. One species, coontail (*Ceratophyllum demersum*), had a high frequency so its reduction could be due to herbicide use. The other species, forked duckweed (*Lemna trisulca*), had a low frequency so this could be due to herbicide use or sampling variation. There were two significant increases in native plant frequency. One of these, southern naiad (*Najas guadulupensis*), was growing in large, dense clumps. Its coverage was widespread and its dense growth may have adversely affected the growth of coontail and/or other native plants. The other increase to note was common waterweed (*Elodea candensis*). This increase would indicate no adverse effects from herbicide use.

Species	2018 freq	2019 freq	change	Significant Reduction?
Ceratophyllum demersum(coontail)	0.89	0.50	**decrease**	Yes P=3.8 X 10^{-7}
Elodea canadensis(waterweed)	0.45	0.73	**increase**	Yes P=0.001
Heteranthera dubia(stargrass)	0.01	0.02	**increase**	n/a
Lemna trisulca(forked duckweed)	0.09	0.0	**decrease**	Yes P=0.01
Myriophyllum sibiricum(northern water-milfoil)	0.08	0.13	**increase**	No
Nymphae odorata(white lily)	0.05	0.02	**decrease**	No
Potamogeton praelongus(whitestem pondweed)	0.03	0.1	**decrease**	No
Najas guadulupensis (southern naiad)	0.07	0.61	**increase**	Yes P=7 X 10^{-12}
Stuckenia pectinata(sago pondweed)	0.0	0.02	**increase**	No
Potamogeton gramineus (variable pondweed)	0.0	0.02	**increase**	No
Potamogeton richardsonii (clasping pondweed)	0.0	0.03	**increase**	No
Schoenoplectus acutus (hardstem bulrush)	0.0	0.02	**increase**	No

Table 6: Native plant species frequency from post treatment survey with chi-square results.

Turion analysis

In October, 2019 a turion analysis was conducted in Big Lake using the same sample points as in past years. Table 7 summarizes the mean turion density with each treatment bed treated in 2019. Past turion sample locations that occurred in beds not treated in 2019 were included in the overall turion density to allow for valid comparison to previous years.

Bed	2012	2013	2014	2015	2016	2017	2018	2019
B1	30.7	27	12.4	18.4	6.2	6.1	6.1	15.4
B12	28.7	39.7	0	129	34.4	4.4	43	48.4
B15	30.7	16.7	0	8.6	17.2	17.7	0	4.3
All	12.8	13.6	6.4	24.3	18.7	7.5	10.3	13.8

Table 7: Mean turion density by bed and all points (turions/square meter).

Turion data shows a small increase in turion density. Since there was some CLP growth after treatment in 2019, these plants may have developed turions and contributed to the increase. Also, turion distribution is likely not uniform, so sampling variation can contribute to small changes in density when the density has not actually changed from plant production.

Figure 8 shows the overall changes in turion density over the past several years. This shows a small increase over the last couple of years (2017-2019), after a substantial decrease from 2015 to 2017.

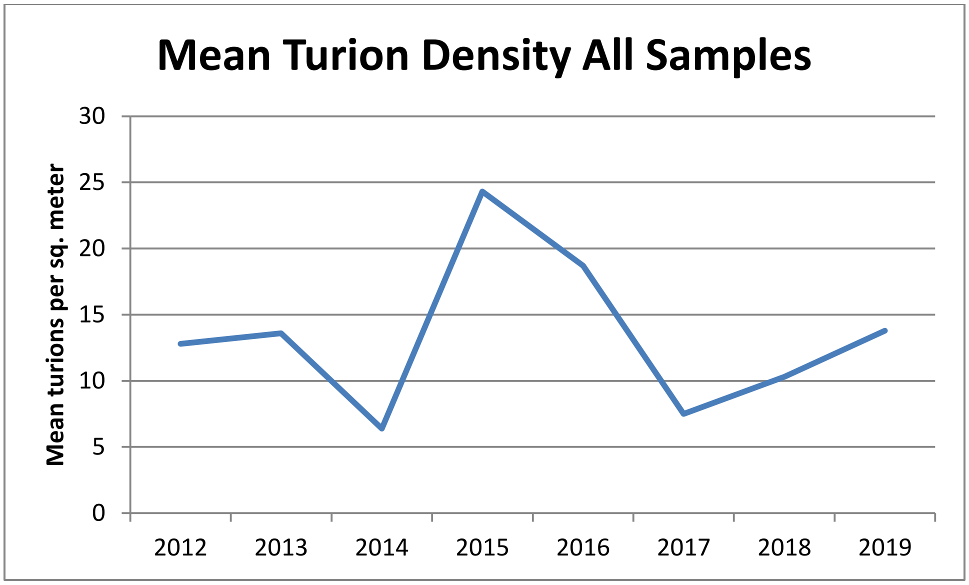

Figure 8: Graph of mean turion density at all sample points, 2012-2019.

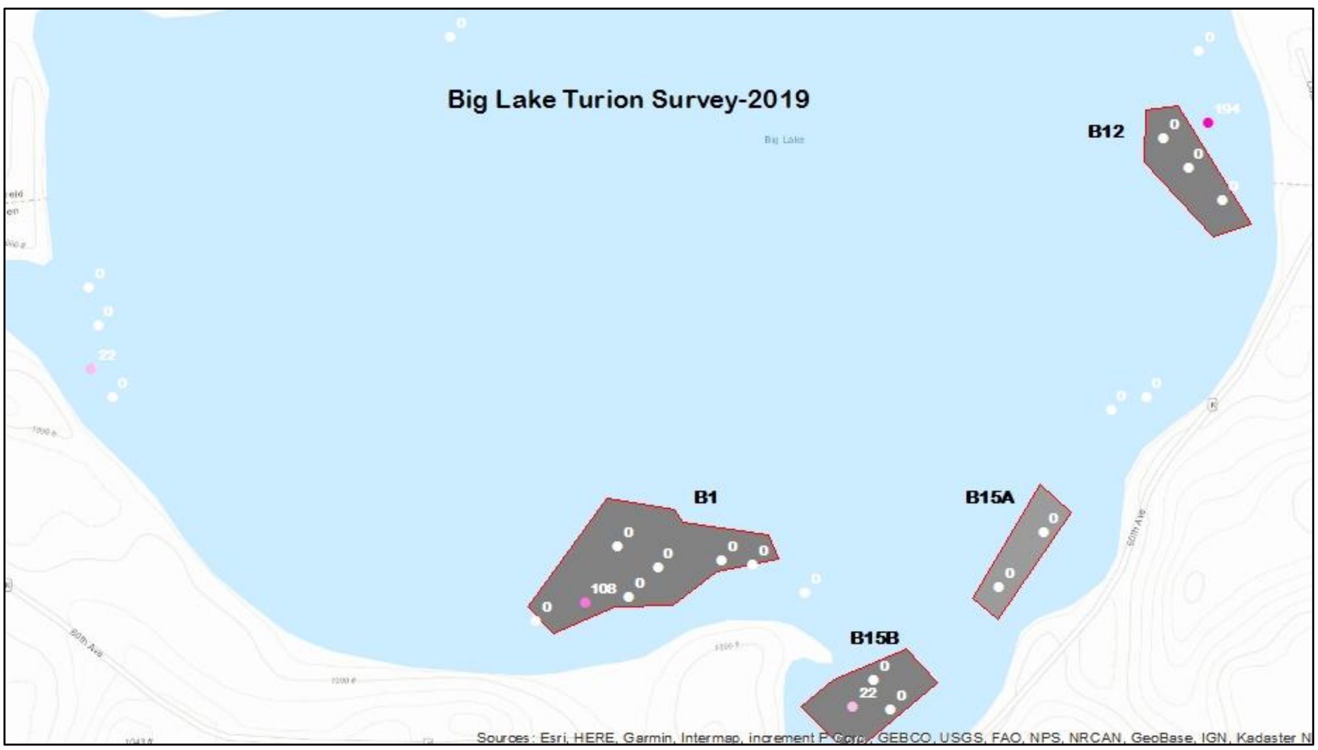

Figure 9: Map of turion density within each bed and in sample points in historically treated areas, but not 2019.

Figure 9 is a map of the turion density. As can be observed, turions were only sampled in single locations within any bed that had turions. So the turion coverage is not widespread, so the mean density can be somewhat misleading. Also, Bed B1 (west shore) was not treated, but a small sample of turions (22 turions/sq. meter) was sampled. Also, Bed B12 was reduced in size in 2019, but a rather large turion sample occurred outside of the 2019 treatment border.

Discussion

The 2019 herbicide treatment was statistically effective, but less than in all previous years (treatment has occurred since 2011). The fact there was some CLP growth after treatment could lead to more turion production, increasing CLP growth in spring 2020. Two native plants were reduced with statistical significance during the 2019 treatment.

Treatment has occurred for nine years, with the first eight highly effective. The ninth year of treatment (2019) has been the least effective, resulting in some (limited) growth of CLP in the treatment beds (14.3% FOO), mainly in bed B1.

The turion density has been increasing slightly the last two years. This may be due to some CLP growth after treatment, but could also be due to sampling variation. Regardless, even after many years of successful treatment, turions are still be sampled in most beds. The turions were sampled in only a few locations, so they are not widespread in the beds. This indicates CLP will return in spring 2020 in some areas.

The amount of CLP coverage over the past nine years has decreased immensely. The CLP continues to return each spring (with less frequency) mainly in beds B1, B12 and B15. The other beds where herbicide treatment has ceased does not appear to have CLP returning at this time. This could change and should continue to be monitored. Decisions for future treatment will need to be reviewed. However, if treatment does occur in 2020, it would likely be in beds B1 and possibly in B12 and B15, depending on spring CLP growth.

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