Herbicide Treatment Analysis for *Potamogeton crispus* (Curly-leaf pondweed)

Deer Lake, Polk County Wisconsin
WBIC: 2619400
2018

Survey and analysis conducted by: Ecological Integrity Service, LLC
Amery, WI

Abstract

On May 21, 2018 18.8 acres of *Potamogeton crispus*-curly leaf pondweed (CLP) were treated with endothall (broad spectrum herbicide sold commercially as Aquatholl K®) to reduce the frequency and density of the CLP within 5 different beds. The treatment resulted in a significant reduction (based upon chi-square analysis) comparing the frequency of occurrence before treatment from April 2018 to after treatment surveyed June 2018. There was also a significant reduction comparing the pretreatment survey frequency in 2017 to the pretreatment frequency in 2018, reflecting some long term reduction. There was no change in post treatment CLP frequency from 2017 to 2018, but there was only one sample point with CLP after treatment each year, not allowing for a reduction. There was a significant reduction in three native species from 2017 to 2018. No beds of CLP were observed in Deer Lake outside of the treatment areas. Only a few single CLP plants were observed throughout the lake. A turion analysis in October showed a small increase in turion density from 2017 to 2018 (41.7 turions/m^2 to 55.2 turions/m^2).

Introduction

On May 21, 2018 an herbicide treatment targeting curly-leaf pondweed (*Potamogeton crispus*) was conducted using endothall. This analysis will outline the areas treated, describe the treatment protocol, and analyze the effectiveness of the treatment.

The treatment areas for Deer Lake were made up of five beds, labeled A-E (totaling 18.79 acres). Those beds, with their areas, are shown in figures 1 and 2. Portions or all of beds B, C and D have been treated annually since 2006, while beds A and E have been treated annually since 2010.

The herbicide endothall was used in the treatment of the CLP. The water temperature was 58 degrees F and winds were reported as 0-4 mph at the time of application.

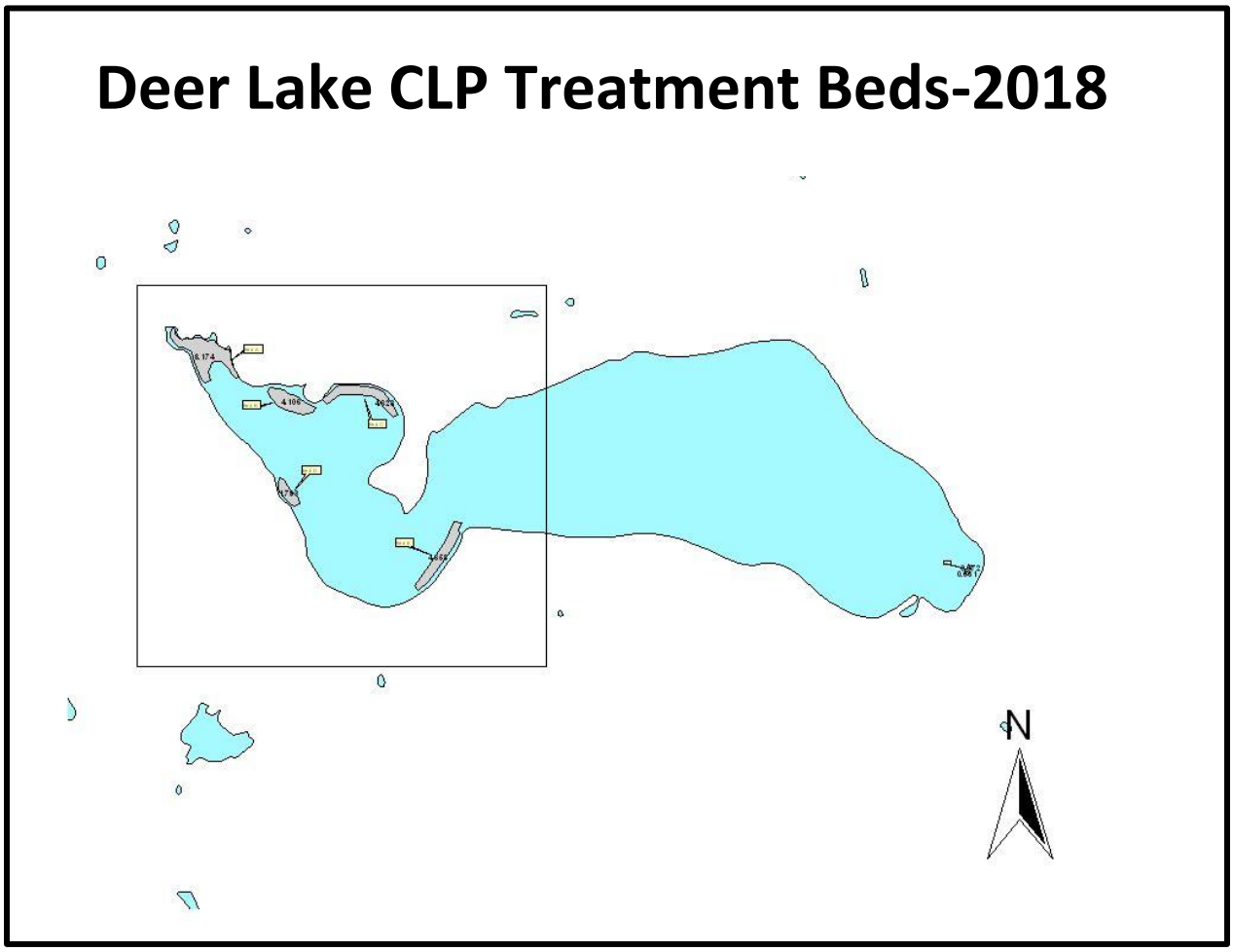

Figure 1: Large map showing the location of the treatment beds relative to the remaining lake in 2018.

Figure 2: Close map of 2018 CLP treatment beds.

Deer Lake CLP Beds (Treatment on May 21, 2018 with Aquatholl K)						
2018 Beds	**Area (acres)**	**Mean Depth**	**Acre-Feet**	**Application Rate*(ppm)**	**Wind conditions***	**Water Temp*(°F)**
Bed A	6.86	5.2	35.67	2.0	0-4	58
Bed B	3.1	6.8	21.08	2.0	0-4	58
Bed C	4.31	7.8	33.62	2.0	0-4	58
Bed D	1.32	7.9	10.43	2.0	0-4	58
Bed E	3.2	8.1	25.92	2.0	0-4	58
Total	**18.79**		**126.72**			

Reported from applicator treatment records.

Table 1: Summary of treatment beds, 2017.

Treatment Bed	Description
Bed A	Bed A is near the landing and extends out from the landing quite a distance. The area in the middle is too deep causing the CLP to spit the bed into two forks. The CLP has been quite dense except for the area just near the landing. The eastern fork of the bed has quite a large amount of floating vegetation. The bed had successful treatment in 2012, 2013, 2014 and 2015. It has been treated since 2010. The bed was reduced in 2016 adjacent to boat landing as no CLP has been found for 2 years.
Bed B	Bed B is located on the east shoreline just south of Bed A. This bed has been notoriously dense and has been treated since 2006. The bed has white-stem pondweed, forked duckweed and coontail in fairly high frequency. The bed gets quite scattered with CLP in the more shallow areas and is then quite dense in deeper water. The boundary has been very well defined. The treatment was successful in 2012-2017.
Bed C	This bed is south and east of Bed B. The bed is quite long curving along the shoreline to the north and west. This bed is narrow but long, bordered on the lake side by deeper water, creating a well-defined boundary. The bed has been very dense in the 6-8 ft depths, with less density on the shore side of the bed. The ends have been sporadic, but very dense just inside. The treatment was successful on Bed C in 2012-2015. This bed has been treated since 2006 in half of the bed and then the bed was increased in size and treated in 2010.
Bed D	This is a small bed on the western shore, just south of the landing. It changes in depth greatly over a rather short distance across the bed. It has been very dense in the middle and toward the north portion of the bed. The treatment was successful in 2012-2017. This bed was one of the original beds treated starting in 2006.
Bed E	Bed E is a long and very narrow bed that changes from 2.5 feet to 12+ feet on the lake side boundary. The highest density has been on the eastern ½ of the bed, but it is quite dense throughout. This bed has a fairly large amount of northern milfoil present throughout the bed. This bed had successful 2012-2017 treatments and has been treated since 2010.

Table 2: Treatment bed descriptions.

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 subjective, but is rated low/high density based upon relative number of CLP plants. 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 3 for reference). All other species are also recorded from the rake sample in order to verify no damage to the native plants.

Figure 3: 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 can involve three evaluations. 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 and create new growth. The result from turion germination 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 was just before treating and the result after treatment.

The third method is to evaluate the pretreatment survey frequency from year to year. Since the pretreatment survey frequency reflects new growth from turion germination, a reduction from year to year in this frequency can show long-term reduction since it reflects the new CLP growth resulting from turions. If the CLP frequency goes down each year, there must be less turions germinating each year.

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, in the pre and post treatment surveys in successive years. 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. Comparing the pretreatment surveys from year to year can show the progress being made as it reflects growth after turion germination, thus reflecting potential overall reduction. 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.

a shows sediment sample; b shows separation; c Shows separated turions.

c.

Results

The results of the pretreatment and post treatment surveys from 2018 are summarized in table 3. The pretreatment survey was conducted on April 13, 2018 and the post treatment survey was conducted on June 9, 2018. CLP was dense in other area lakes when the post treatment survey was completed, thus demonstrating post survey was near peak CLP growth. There was a late ice out on the areas lakes, including Deer Lake, which could have affected the CLP growth for 2018. The tables also contain information from 2018 to show changes between years of treatment.

Treatment Bed	Pre-treat freq (2017)	Post treat freq (2017)	Pre treat freq (2018)	Post treat freq (2018)	Mean density 2017	Mean density 2018
Bed A	48.9%	0%	30%	0%	0	0
Bed B	33.3%	0%	25%	0%	0	0
Bed C	41.9%	3.0%	16.1%	0%	0.03	0
Bed D	41.7%	0%	30%	0%	0	0
Bed E	56.7%	0%	47.8%	4%	0	0.04
All beds	45.8%	0.7%	28%*	1%	0.007	0.01

Table 3: Summary of CLP growth frequency pre and post treatment 2017-2018.

As stated in the methods, a chi-square analysis is conducted on the frequency data. The results of this are summarized in table 4 (all beds combined).

Survey Comparison	Statistically significant reduction in FOO?	Chi-square result (reduction)
2018 pretreatment freq/2018 post treatment freq.	Yes	$P=3.5 \times 10^{-9}$
2017 post treatment freq/2018 post treatment freq.	No change *(only one CLP sample each year)*	n/a
2017 pretreatment freq/2018 pretreatment freq.	Yes	P=0.004

Table 4: Summary of FOO (frequency of occurrence) reduction and significance after treatment.

The chi-square analysis shows a statistically significant reduction from before treatment to after treatment in 2018. There was also a statistically significant decrease from the pretreatment frequency 2017 to pretreatment frequency 2018. There was no change from post treatment frequency 2017 to post treatment frequency 2018. The overall density from 2017 to 2018 was also unchanged. There was only one location in all of the beds that had CLP growth. Based upon these data, the herbicide treatment seems to have effectively reduced the CLP growth.

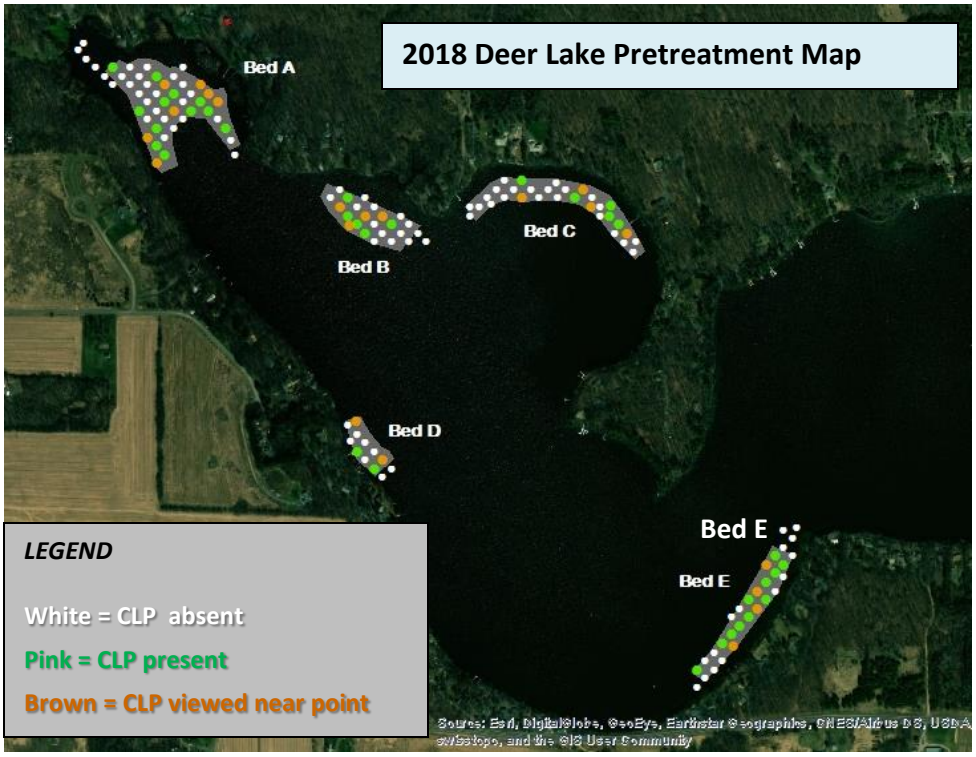

Figure 5: Pre-treatment map from 2018 pretreatment survey showing presence/absence of CLP .

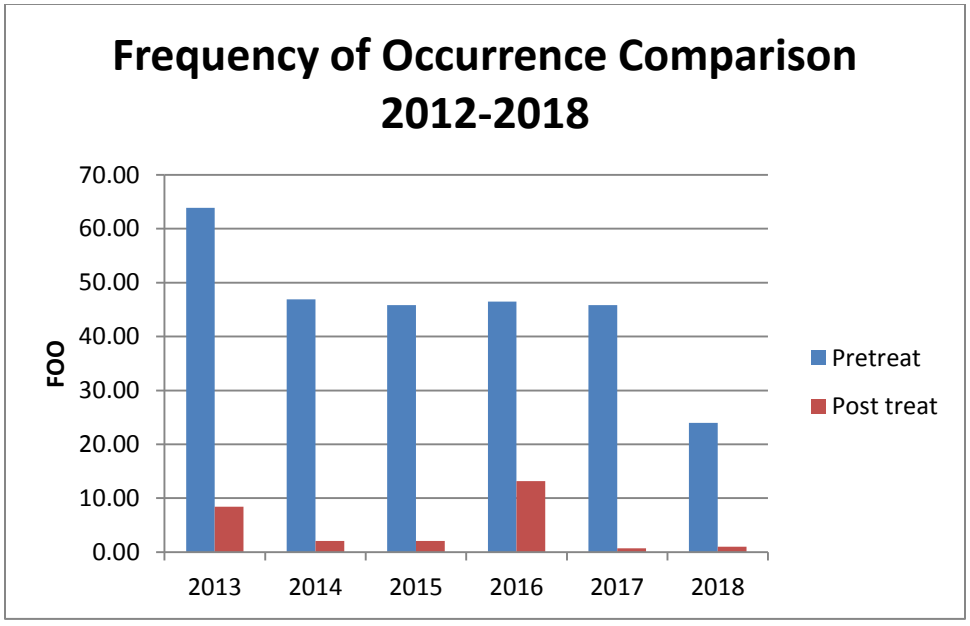

Figure 6: Graph showing the pre/post treatment frequency comparison from 2012 and 2018-all beds treated.

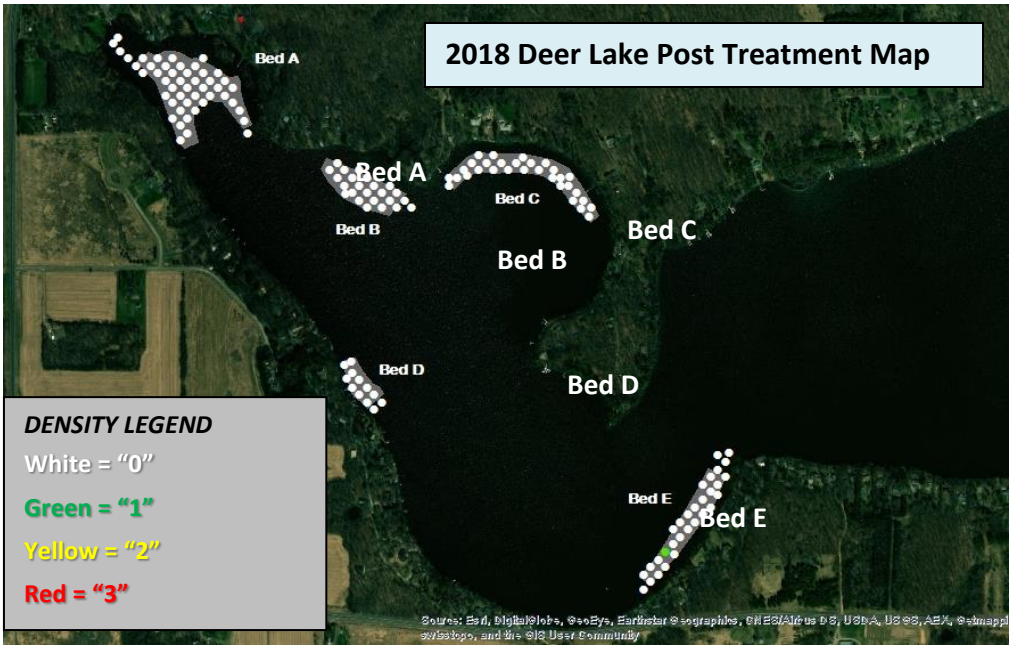

Figure 7: Map showing CLP sampled and density in 2018 post treatment survey.

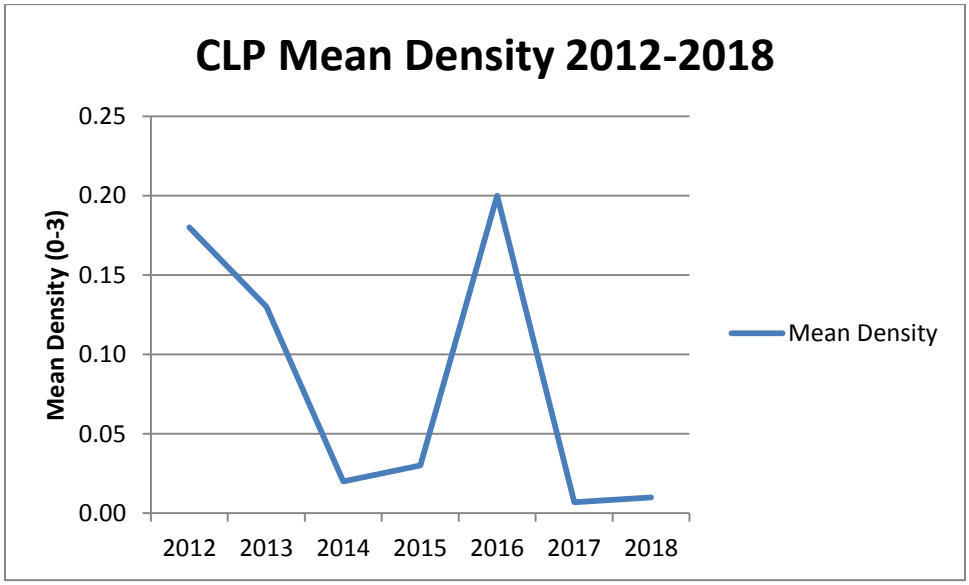

Figure 8: Comparison of post treatment mean density all beds, 2012-2018.

In conjunction with the frequency decreases, the mean density after treatment was very low. In 2017 the mean density was only 0.007, and in 2018 it was 0.01, indicating no real change. In both years there was only CLP present at one point within the treatment beds after treatment.

Figure 9 and figure 10 show the maps of the pretreatment and post treatment surveys from 2017 for comparison to the 2018 survey maps.

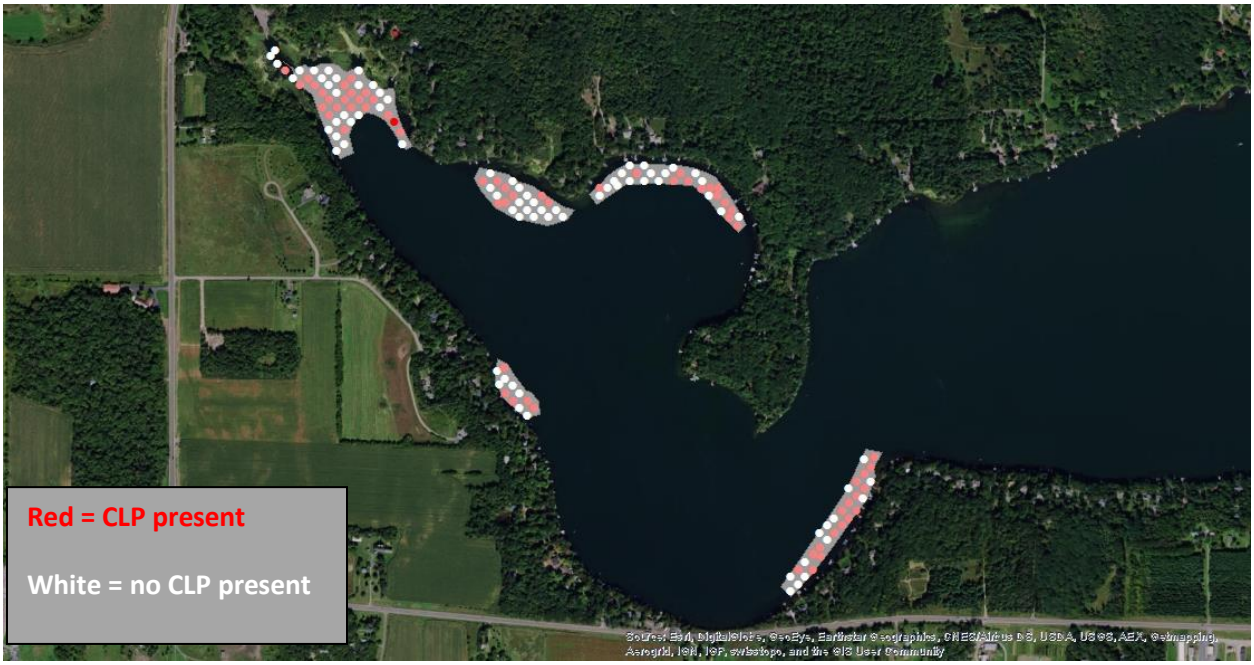

Figure 9: Pretreatment survey map, 2017

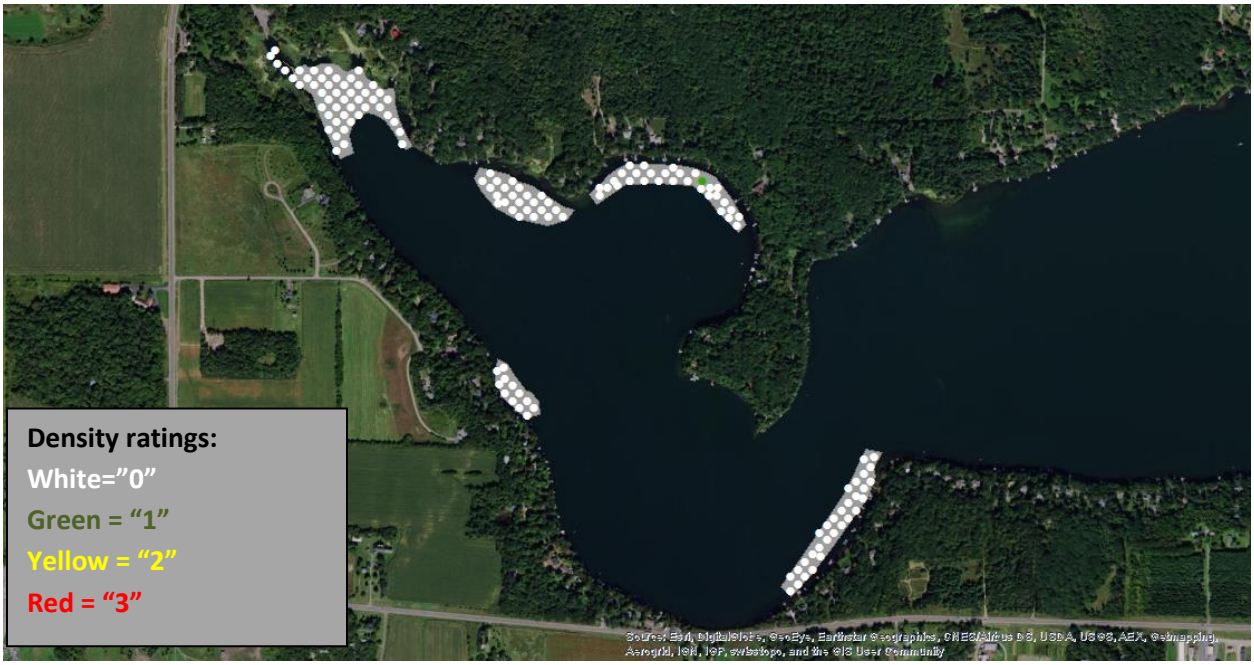

Figure 10: Post treatment survey map, 2017.

Native Plant Changes

The native plant frequencies were evaluated during the post treatment survey. Table 5 summarizes those results and the chi-square analysis that determines the significance of any reductions, potentially due to herbicide exposure from the 2018 treatment.

Native species	Frequency 2017	Frequency 2018	P value	Significant reduction
Lemna trisulca,forked duckweed	0.11	0.10	0.84	No
Potamogeton praelongus,White-stem pondweed	0.11	0.03	0.013	Yes
Ceratophyllum demersum, Coontail	0.58	0.62	0.54	No
Myriophyllum sibiricum, Northern milfoil	0.19	0.07	.005	Yes
Potamogeton richardsonii, Clasping pondweed	0.10	0.04	0.07	No
Elodea canadensis, elodea	0.19	0.26	0.18	No
Heteranthera dubia, water stargrass	0.09	0.15	0.12	No
Ranunculus aquatilis, stiff water crowfoot	0.11	0.10	0.81	No
Chara sp., muskgrasses	0.13	0.19	0.14	No
Potamogeton amplifolius, large leaf pondweed	0.00	0.01	0.28	No
Nymphaea odorata, white lily	0.07	0.06	0.85	No
Stuckenia pectinata, sago pondweed	0.06	0.01	0.03	Yes
Potamogeton zosteriformis, Flatstem pondweed	0.0	0.01	0.28	No
Potamogeton epihydrous, ribbon pondweed	0.01	0.00	0.28	No
*Spirodela polyrhiza,*Large duckweed	0.01	0.00	0.28	No
Lemna minor, small duckweed	0.01	0.00	0.28	No

Table 5: Native species frequency and chi-square analysis-2016 to 2017.

The native plant survey data shows a reduction in three native species, which were significant (*Potamogeton praelongis,* white-stem pondweed, *Myriophyllum sibiricum*, northern water milfoil, and *Stuckenia pectinate,* sago pondweed). The source of this reduction is unknown. It could be due to natural variation, sampling variation or herbicide application. There was an increase in frequency in five native species, but none of the increases were significant. If the native plants are out of dormancy at the time of herbicide application, they are more susceptible to the herbicide.

CLP mapping

After the post treatment survey is completed, the entire lake is surveyed looking for CLP beds outside of the treatment areas. A bed is defined as an area of CLP that is dominated by CLP, has a mean CLP density >2, and can be delineated by sight due. In order to be delineated by sight, the CLP must be growing at or near the lake surface. There were no beds of CLP observed throughout Deer Lake in June. There were only a few plants observed in the lagoon area.

Turion Analysis

A turion analysis was conducted on October 7, 2018. Table 6 summarizes the turion density comparison from 2013 to 2017. Figures 14 and 15 graphically show the changes.

Bed	2013 Mean (T/m^2)	2014 Mean (T/m^2)	2015 Mean (T/m^2)	2016 Mean (T/m^2)	2017 Mean (T/m^2)	2018 Mean (T/m^2)
A	77.7	63.1	39.1	83	47.8	97.7
B	153.6	46.1	96.75	122	49	16.1
C	91.8	89.5	75.25	136	67.75	112.9
D	15.0	16.3	32.25	5	16.25	0.0
E	71.0	18.6	55.3	31	9.3	49.1
All Beds	88.8	52.0	61.1	84.7	41.7	55.16

Table 6: Turion density in each bed 2013 through 2018.

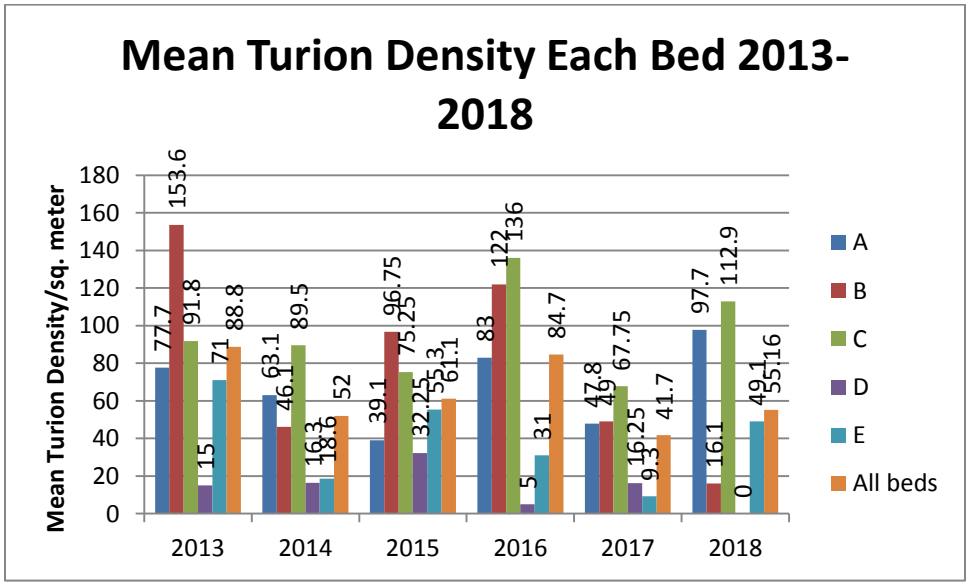

Figure 14: Turion densities by bed for comparison 2013 through 2018.

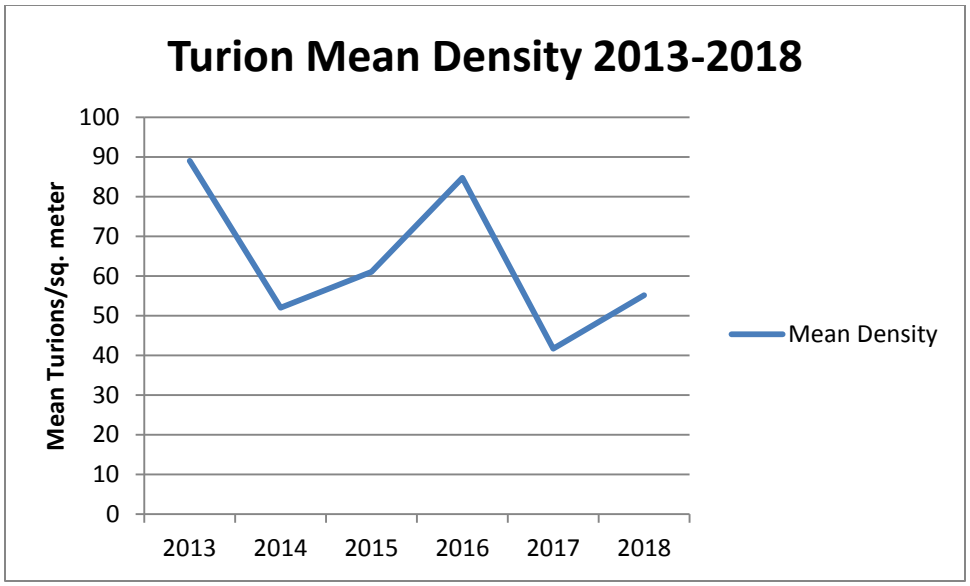

Figure 15: Change in turion density, all beds 2013 through 2018.

As the data shows, the mean turion density in all beds combined increased a small amount from 2017 to 2018. This follows a decrease from 2016 to 2017. It is desired to see annual reduction in turion density. If any treatment areas are not successful in killing the CLP, these plants can produce turions, which can germinate the following year. Since there was little or no CLP growing after treatment in both 2017 and 2018, there should not have been an increase in turion density. This increase may be due to sampling location variation or there was some CLP growth that was no observed in those years.

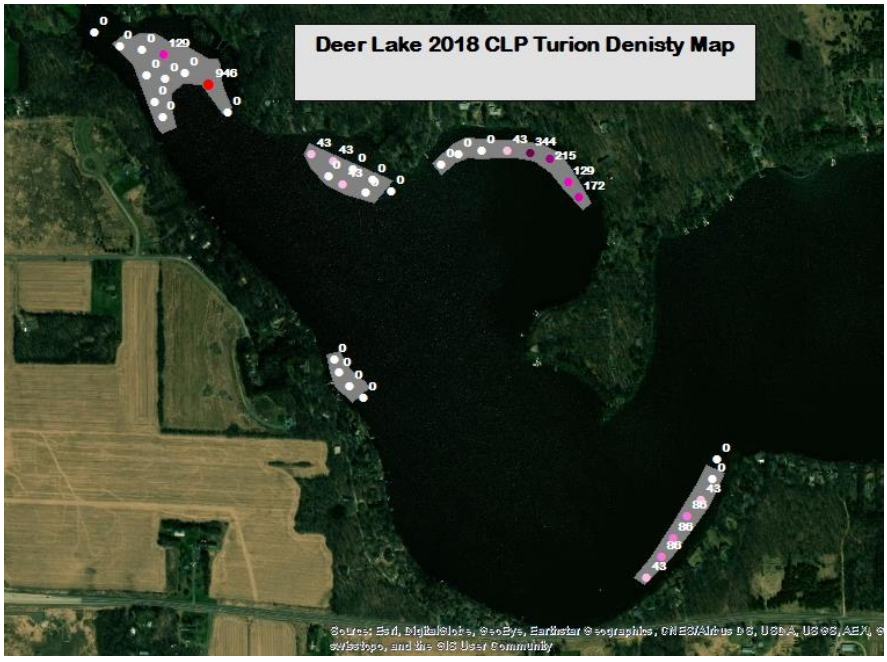

Figure 16: Map of turion density by bed, 2017.

Discussion

The 2018 CLP herbicide treatment was successful at reducing CLP growth occurring in 2018. The frequency of occurrence of CLP was significantly reduced according to a chi-square analysis. When comparing the frequency of CLP just before treatment (pre -treatment survey 2018) it was higher than after treatment (post treatment survey 2018) with a reduction of from 28% to 1%. See Figure 6 for graphic representation.

The post treatment surveys from 2017 and 2018 showed no decrease in frequency of occurrence. However, the frequency is so low both years, there is no reduction that can really occur.

Since the beds tend to fill in from turion germination, comparing the pretreatment surveys from year to year can reflect the progress that is being made. If the CLP frequency is reduced from pretreatment to pretreatment survey, then overall reduction of CLP is occurring. Comparing the pretreatment frequency in 2017 to 2018 showed a decrease but was significant. Pretreatment frequency decreases show long-term reduction in CLP and the goal is for this to continue to decrease.

The native plant species did show a reduction in three species. This reduction could be due to the herbicide application, sample location variation and/or natural variation. There was one significant increase in native species. The goal is for no species to decrease and the main concern is reduction due to herbicide. This cause cannot be ruled out in 2018 and continued monitoring of native species with full lake surveys every 5 years should continue.

Following the post treatment survey of the treatment beds, the CLP was mapped in all areas. Any areas that constituted a bed, the area was delineated. In years past, very little to no CLP was observed outside of the treatment area. In June, 2018, no CLP beds were observed with only a few CLP plants located.

The turion data analysis shows that the turion density increased a small amount from 2017 to 2018. The overall trend over the last two years is a decrease. This shows long term reduction in CLP and should result in relatively low CLP growth in spring 2019.

The CLP coverage in the treatment beds is decreasing. Decisions will need to be made as to how long treatments should continue. Some beds may be reduced in area based upon the spring survey, as long as the coverage is large enough for successful treatment. Bed D may be considered for elimination from treatment as there has been no CLP present the last two years, and no turions were sampled in 2018.

References

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