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

Deer Lake, Polk County Wisconsin
WBIC: 2619400
2019

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

Abstract

On May 29, 2019 12.5 acres (four beds) 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 2019 to after treatment surveyed June 2019. There was a frequency increase (not significant) comparing the pretreatment survey frequency in 2018 to the pretreatment frequency in 2019. There was a frequency increase in post treatment CLP frequency from 2018 to 2019, which was statistically significant. There was no significant reduction in any native species from 2018 to 2019 post treatment surveys. Two small beds of CLP were observed in Deer Lake outside of the treatment areas. A turion density analysis in October showed a small increase in turion density in 2019 compared to 2018 (55.2 turions per square meter in 2018 compared to 78.6 turions per square meter in 2019).

Introduction

On May 28, 2019 an herbicide treatment targeting curly-leaf pondweed (*Potamogeton crispus*) was conducted using endothall in Deer Lake, Polk County WI. 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 four beds, labeled A-C, and E (totaling 12.45 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.

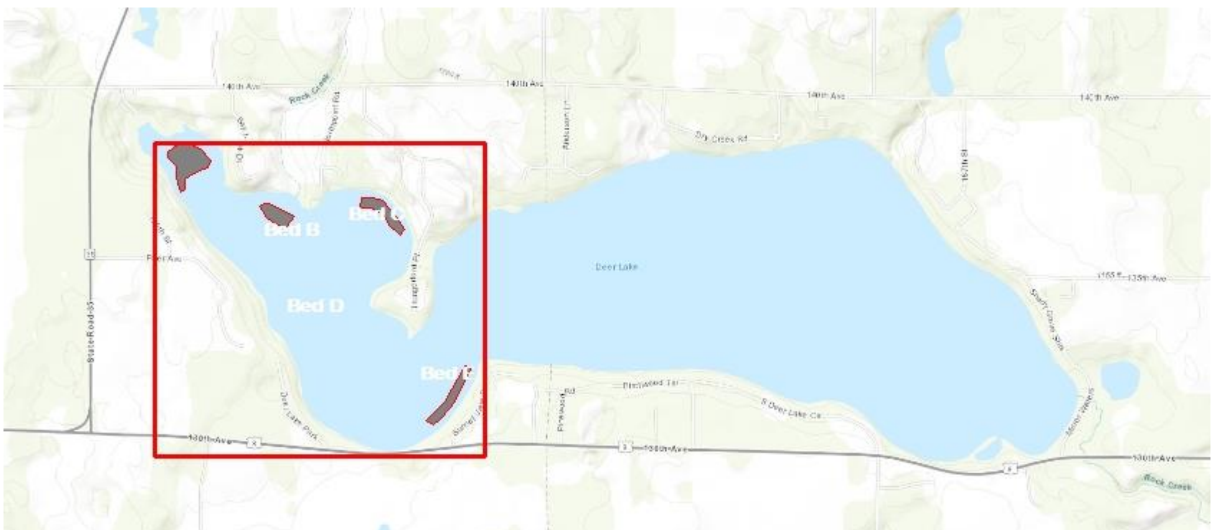

Figure 1: Large map showing the location of the treatment beds relative to the remaining lake in 2019.

Figure 2: Close map of 2019 CLP treatment beds.

Deer Lake CLP Beds (Treatment on May 28, 2019 with Aquatholl K)						
2019 Beds	**Area (acres)**	**Mean Depth**	**Acre-Feet**	**Application Rate*(ppm)**	**Wind conditions***	**Water Temp*(°F)**
Bed A	5.06	5.0	25.3	2.0	3-6	54.2
Bed B	2.09	5.6	11.7	2.0	3-6	54.2
Bed C	2.58	7.6	19.6	2.0	3-6	54.2
Bed D	NOT	TREATED	2019			
Bed E	2.72	7.0	19.04	2.0	3-6	54.2
Total	**12.45**		**75.65**			

Reported from applicator treatment records.

Table 1: Summary of treatment beds, 2019.

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. The bed was reduced in size in 2019.
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 2012-2018.
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. This bed was reduced in size by nearly 50% in 2019.
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. Due to lack of CLP growth and turions, treatment did not occur in 2019.
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 2012-2018 treatments and has been treated since 2010. It was not changed due CLP growth in spring 2019.

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.

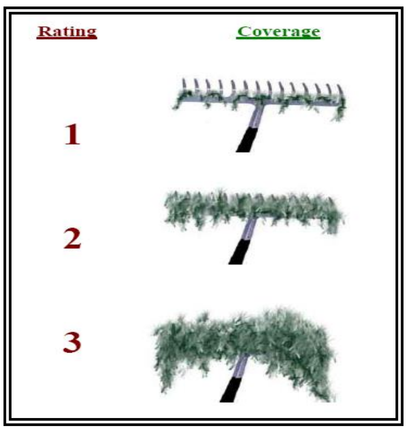

Figure 3: Density rating system and example CLP rake sample.

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.

c.

Figure 4: a shows sediment sample; b shows separation; c Shows separated turions.

Results

The pre and post treatment survey conducted in 2019 had the data reveal a statistically significant reduction in CLP frequency of occurrence (FOO) between before and after treatment. A table 3 shows the FOO and mean density from various surveys. Figure 5 is a map showing the presence/absence of CLP before treatment and figure 6 shows the density of CLP after treatment.

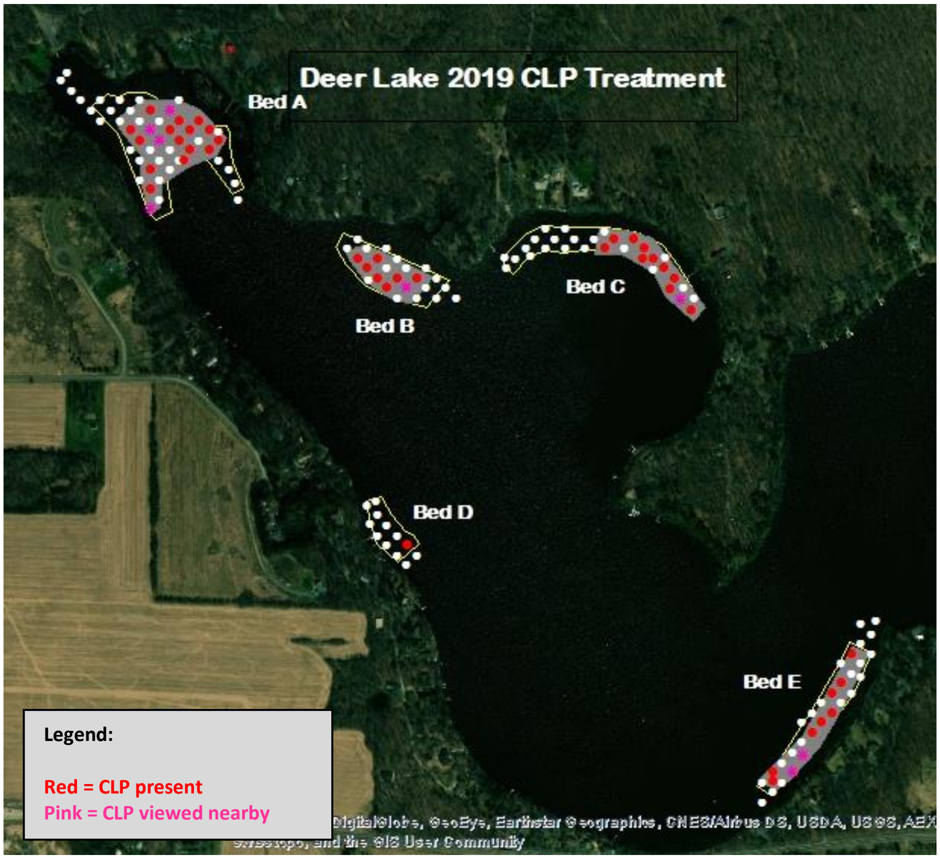

Figure 5: Map showing presence of CLP before treatment.

Treatment Bed	Pre-treat freq (2018)	Post treat freq (2018)	Pre treat freq (2019) Historical sample pts	Pre treat freq (2019) Adjusted 2019 sample pts	Post treat freq (2019)	Mean density 2018 (post)	Mean density 2019 (post)
Bed A	30%	0%	35%	45.5%	0%	0	0
Bed B	25%	0%	31.8%	46.7%	6.25%	0	.063
Bed C	16.1%	0%	32.2%	64.7	6.25%	0	.063
Bed D	30%	0%	10%	n/a	No treat	0	n/a
Bed E	47.8%	4%	32%	32%	11.1%	0.04	0.11
All beds	28%	1%	34.7%	48.8%*	7.1%*	0.01	0.07

*Using fewer sample points than 9n 2018 due to bed size reduction.

Table 3: Pre and post treatment CLP survey frequency and density data.

Pre 2019/Post 2019	Reduction significant	P=6.4X10^{-9}
Pre 2018/Pre 2019	Increase (not significant)	P=0.41
Post 2018/Post 2019	Increase significant	P=0.03

Table 4: Chi-square analysis indicators for various surveys.

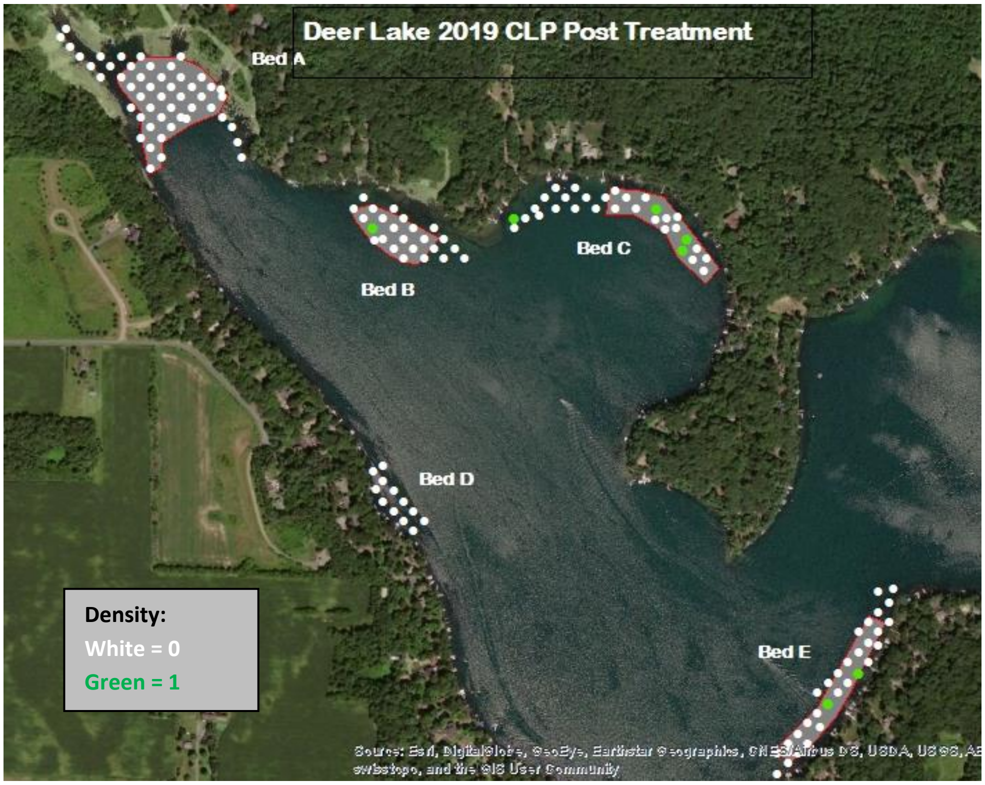

Figure 6: Post treatment CLP density and distribution within treatment beds.

In order to evaluate long term reduction in CLP, the pretreatment FOO can be compared from previous years. Since turions germinate and return growth of CLP each spring, decreases in FOO show that the return of CLP is diminishing as a result of successful reduction from herbicide treatment. Comparing the 2019 pretreatment survey to 2018 shows an increase in CLP FOO. This increase was not statistically significant, but it is not a desired result. It was a small increase, but still an increase.

Comparing post treatment survey FOO allows for the reflection of CLP increases from one year to the next. It can reflect the effectiveness of that year's herbicide treatment. From 2018 to 2019 there was a significant increase in the post treatment survey FOO. This was not a strong significance with p=0.03. The mean density also increase from 2018 to 2019. Figure 7 graphically shows the FOO from 2019 and previous surveys for comparison. Figure 8 shows the historical mean densities in all beds combined. Table 4 summarizes the chi-square analysis results.

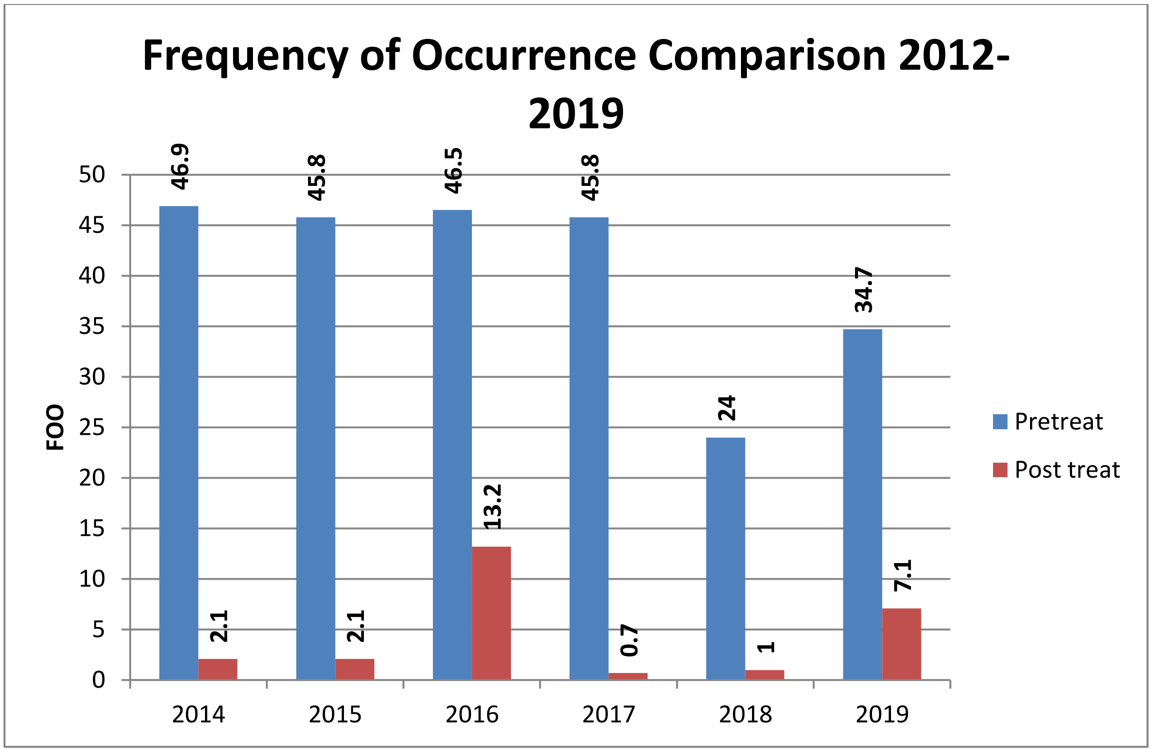

Figure 7: Graph comparing frequency of occurrence (FOO) for pre and post treatment CLP from 2014-2019.

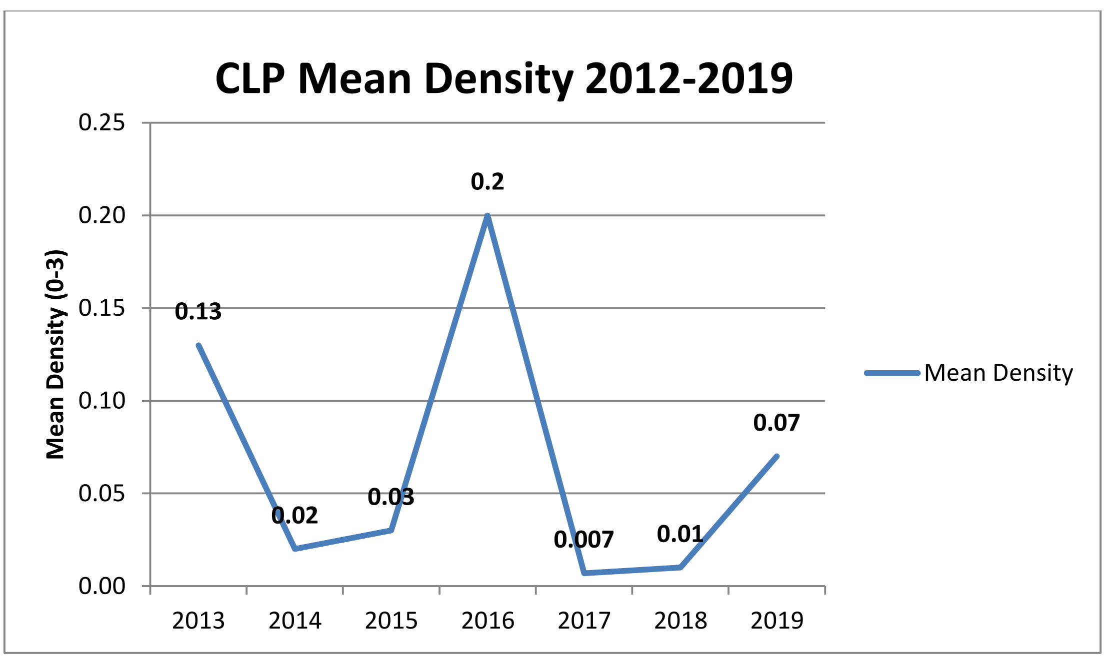

Figure 8: Graph showing mean CLP density in post treatment surveys.

Overall, there has been a decrease in CLP coverage in the treatment areas likely due to repeated successful herbicide treatments. Long term, the area of CLP treated has decreased from 23.6 acres in 2010 to 12.45 acres in 2019 (see table 5).

Year	Acres treated on Deer Lake
2010	23.6
2019	12.45

Table 5: Acres of CLP treated 2010 and 2019.

Native species analysis

An important aspect of effective herbicide is to target the AIS without harming the native plant species. There were no statistically significant reductions in native plant species, based upon a chi-square analysis comparing the FOO of each species from 2018 to 2019. Table 6 shows the native plant species frequencies and the chi-square analysis results.

Native species	Frequency 2018	Frequency 2019	Reduction significant	P value
Lemna trisulca, forked duckweed	0.10	0.15	increase	
Potamogeton praelongus, White-stem pondweed	0.03	0.14	increase	
Ceratophyllum demersum, Coontail	0.62	0.57	No	0.47
Myriophyllum sibiricum, Northern milfoil	0.07	0.13	increase	
Potamogeton richardsonii, Clasping pondweed	0.04	0.05	increase	
Elodea canadensis, Common waterweed	0.26	0.21	No	0.47
Heteranthera dubia, water stargrass	0.15	0.13	No	0.65
Ranunculus aquatilis, stiff water crowfoot	0.10	0.14	increase	
Chara sp., muskgrasses	0.19	0.27	increase	
Potamogeton amplifolius, large leaf pondweed	0.01	0.00	No	0.22
Nymphaea odorata, white lily	0.06	0.04	No	0.36
Stuckenia pectinata, sago pondweed	0.01	0.04	increase	
Potamogeton zosteriformis, Flatstem pondweed	0.01	0.00	No	0.22
Potamogeton epihydrous, ribbon pondweed	0.00	0.01	increase	
Bidens beckii, water marigold	0.00	0.02	increase	
Lemna minor, small duckweed	0.00	0.01	increase	

Table 6: Post treatment survey native species frequency and change significance based upon chi-square analysis.

The remaining portions of Deer Lake were surveyed for CLP (outside of treatment areas). Figure 9 shows those locations. Two small beds of CLP were delineated in the northeast shore of the lake. Small CLP beds have occurred in this area in the past. Treatment has never been implemented in this area, partly due to the small bed size and inconsistent growth from year to year.

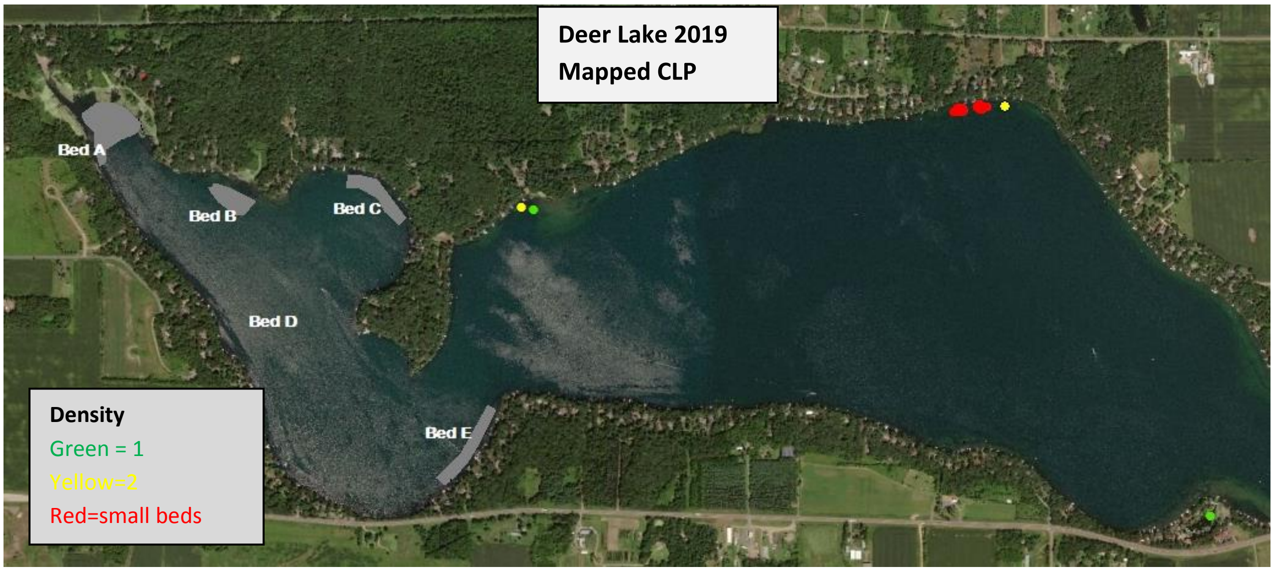

Figure 9: Map of CLP location and density outside of treatment beds on Deer Lake, June 2019.

Turion Analysis

Turions are the reproductive structures on CLP plants. If the plant reaches maturity, the turions are created on the nodes and apex of the plant. When the plant dies, the turions settle into the sediment which can germinate in the future to create new CLP plants.

Turion density is analyzed each year to evaluate long-term trends on CLP management. With successful treatment, plants should not reach maturity and therefore will not create turions. Over time, the density of turions in the sediment should decrease. If the turion density does not decrease, it indicates the potential for more CLP growth. Even what appears to be successful treatment may not lower turion density if CLP growth occurred in the bed (or area) and was not observed, resulting in unsuspecting turion development. Table 7 shows the turion density in each bed (Bed D was not treated in 2019). Figure 10 shows the mean turion density in all beds over several years. Figure 11 is a map showing the turion density at various locations in the beds.

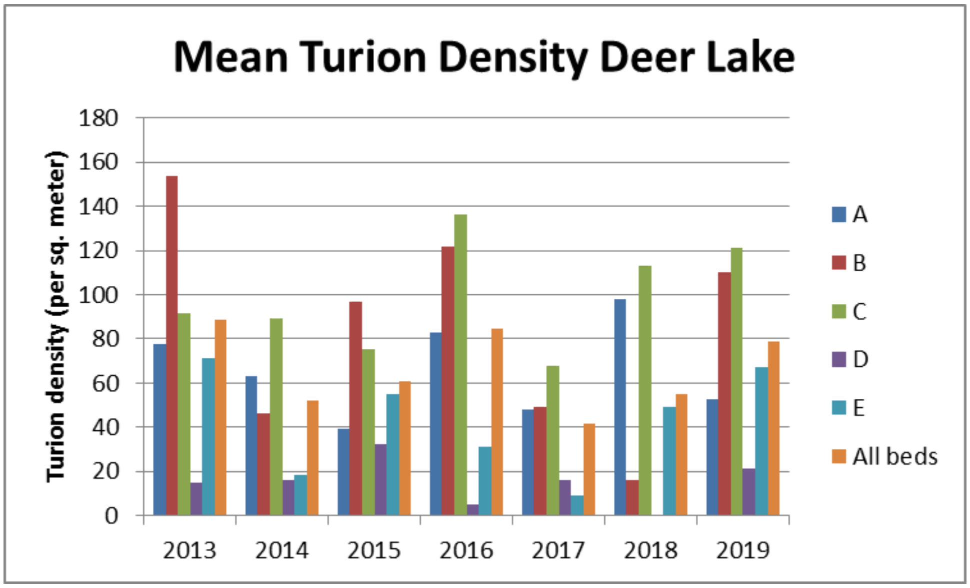

Figure 10: Graph of mean turion density in each bed and all beds 2013-2019.

The 2019 turion analysis resulted in a turion density increase in each bed except Bed A, of which there was a decrease. There was an increase mean turion density in all combined beds in 2019, compared to 2018. This increase is likely due to some CLP growth that occurred after herbicide treatment in 2019. An increase in turion density is not desirable and indicates that there could likely be an increase in CLP growth in 2020. Figure 12 shows the mean turion changes from year to year.

Bed	2013	2014	2015	2016	2017	2018	2019
A	77.7	63.1	39.1	83	47.8	97.7	52.8
B	153.6	46.1	96.75	122	49	16.1	110.2
C	91.8	89.5	75.25	136	67.75	112.9	120.9
D	15	16.3	32.25	5	16.25	0	21.5
E	71	18.6	55.3	31	9.3	49.1	67.5
All beds	88.8	52	61.1	84.7	41.7	55.16	78.6

Table 7: Mean turion density in T's per square meter in each treatment bed.

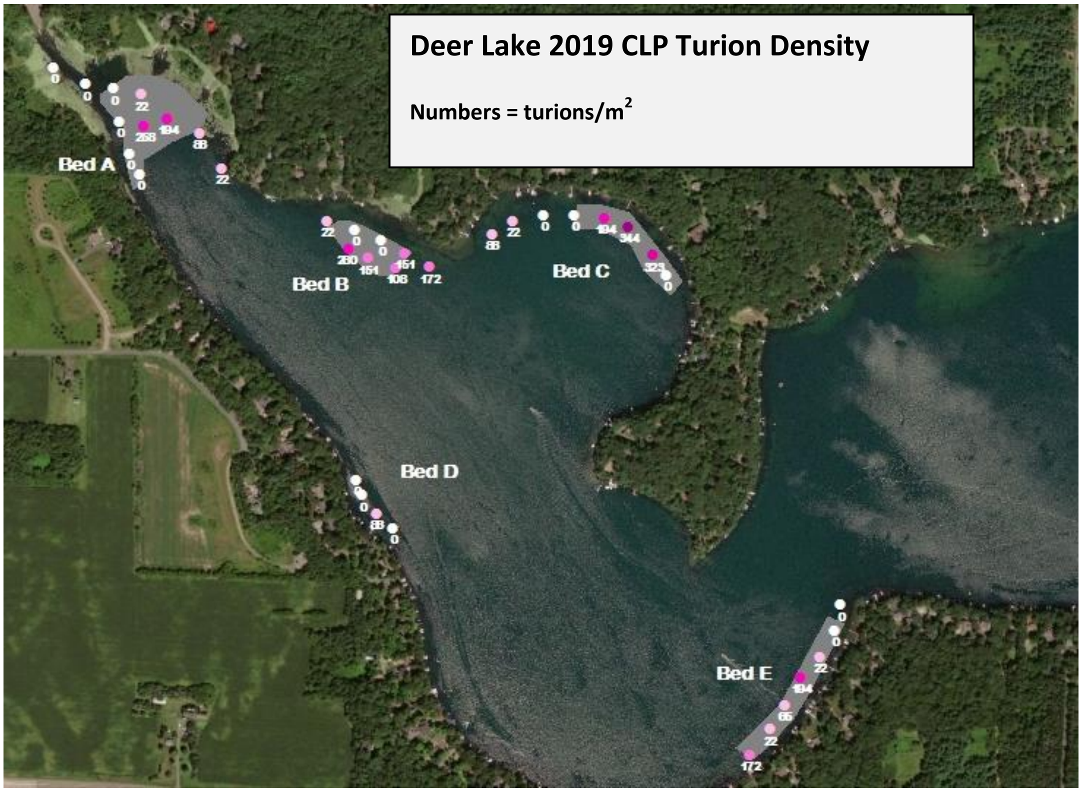

Figure 11: Turion density map with each treatment bed (Bed D was not treated in 2019).

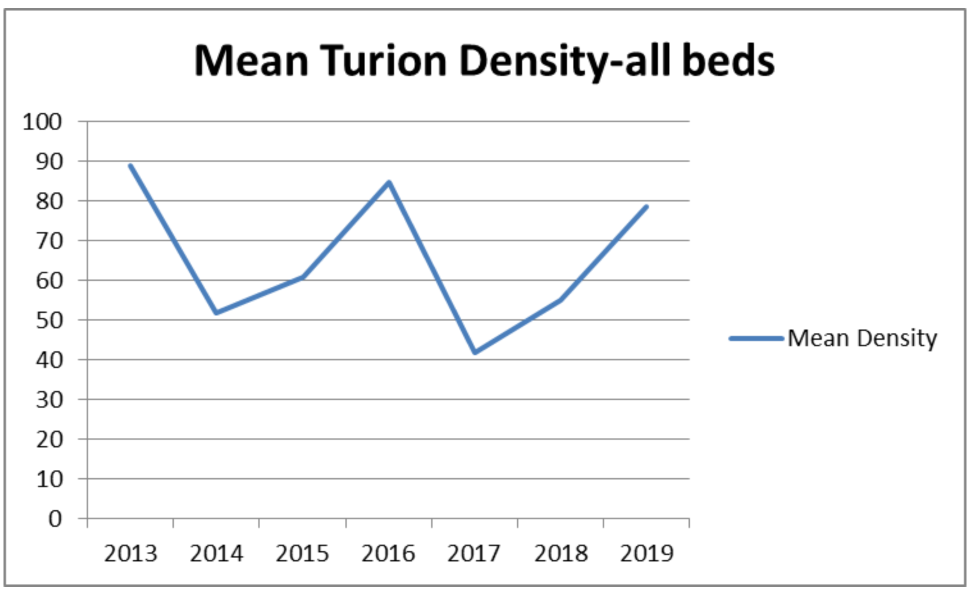

Figure 12: Mean turion density for all beds combined 2013-2019.

Summary

The 2019 herbicide treatment was successful in reducing the growth that was present before treatment in spring 2019 as compared to after treatment. However, comparing the surveys from 2019 to 2018 showed that some increase in CLP occurred. Herbicide effectiveness can vary, largely due to contact time of the herbicide. The reported wind was 3-6 mph from the north/north east. It is possible that this could cause currents reducing the contact time. Furthermore, the area in Bed C was reduced which could reduce coverage of herbicide reducing concentration and contact time. The CLP growth in the post treatment survey was not extensive, but was higher than the previous year.

The turion density increased as well. This may be due to the CLP growth that occurred after treatment. The CLP frequency was not high, but CLP may have grown between sample points (the hole bed is monitored and none was observed from surface but still could have been present). These plants could then give rise to turions. This increase causes a prediction of potentially higher CLP growth in spring 2020.

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.