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

## Deer Lake, Polk County Wisconsin

**WBIC: 2619400**

October, 2017

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

## *Abstract*

On May 5, 2017 22.6 acres of *Potamogeton crispus*-curly leaf pondweed (CLP) were treated with endothall(broad spectrum herbicide) 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 2017 to after treatment surveyed June 2017. There was also a significant reduction comparing the post treatment survey frequency in 2016 to the post treatment frequency in 2017. There was a slight reduction (not significant) from the 2016 to 2017 in pretreatment frequency. There was a significant reduction in three native species and an increase in one species. Only 0.04 acres of CLP were observed outside of the treatment areas in the entire lake. The turion analysis resulted in a mean turion density decrease in all beds from 84.7 turions/$m^2$ in 2016 to 41.7 turions/$m^2$ in 2017.

## Introduction

On May, 2017 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 22.6 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 51 degrees F and winds were reported as calm at the time of application.

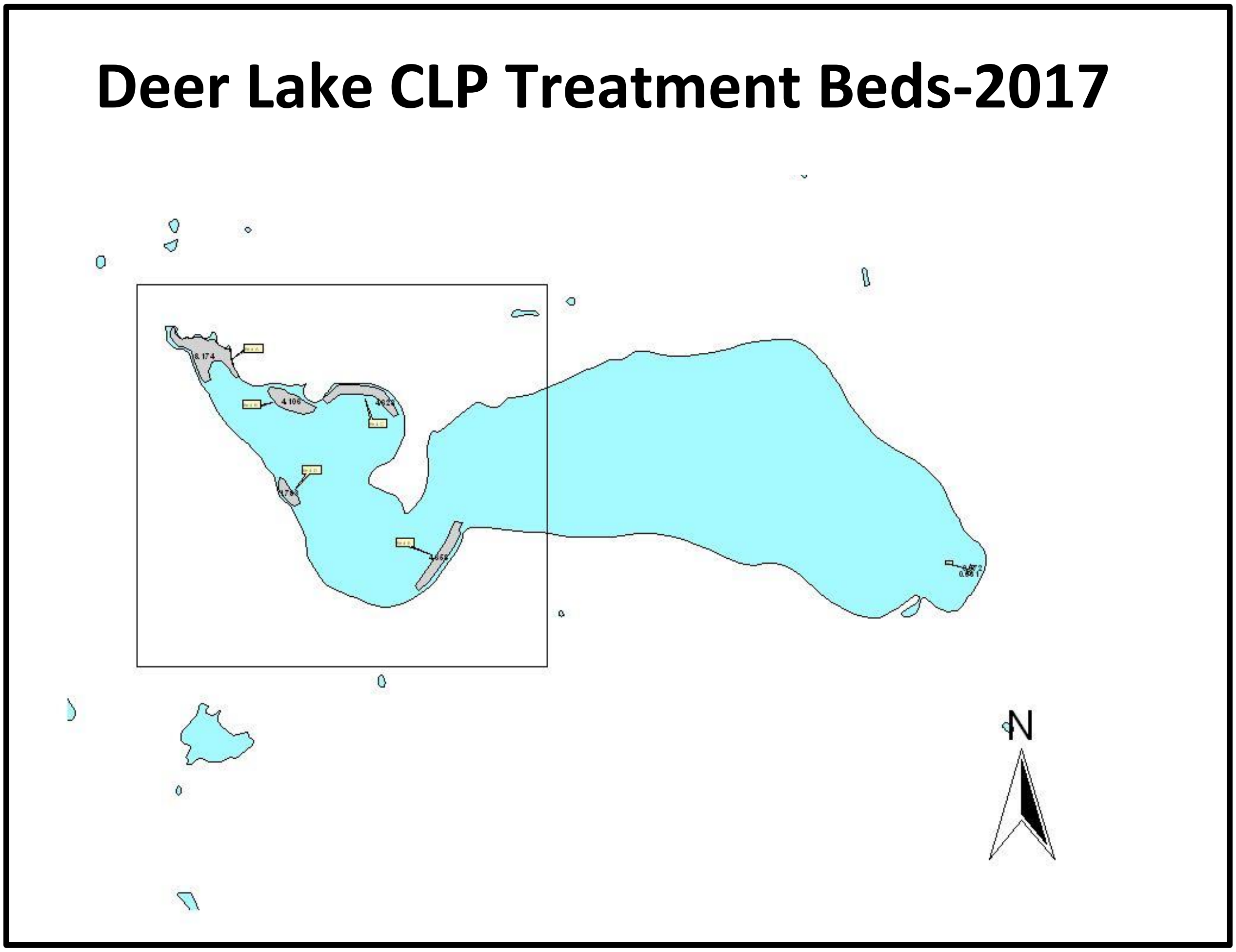



**Figure 1: Large map showing the location of the treatment beds relative to the remaining lake in 2017.**

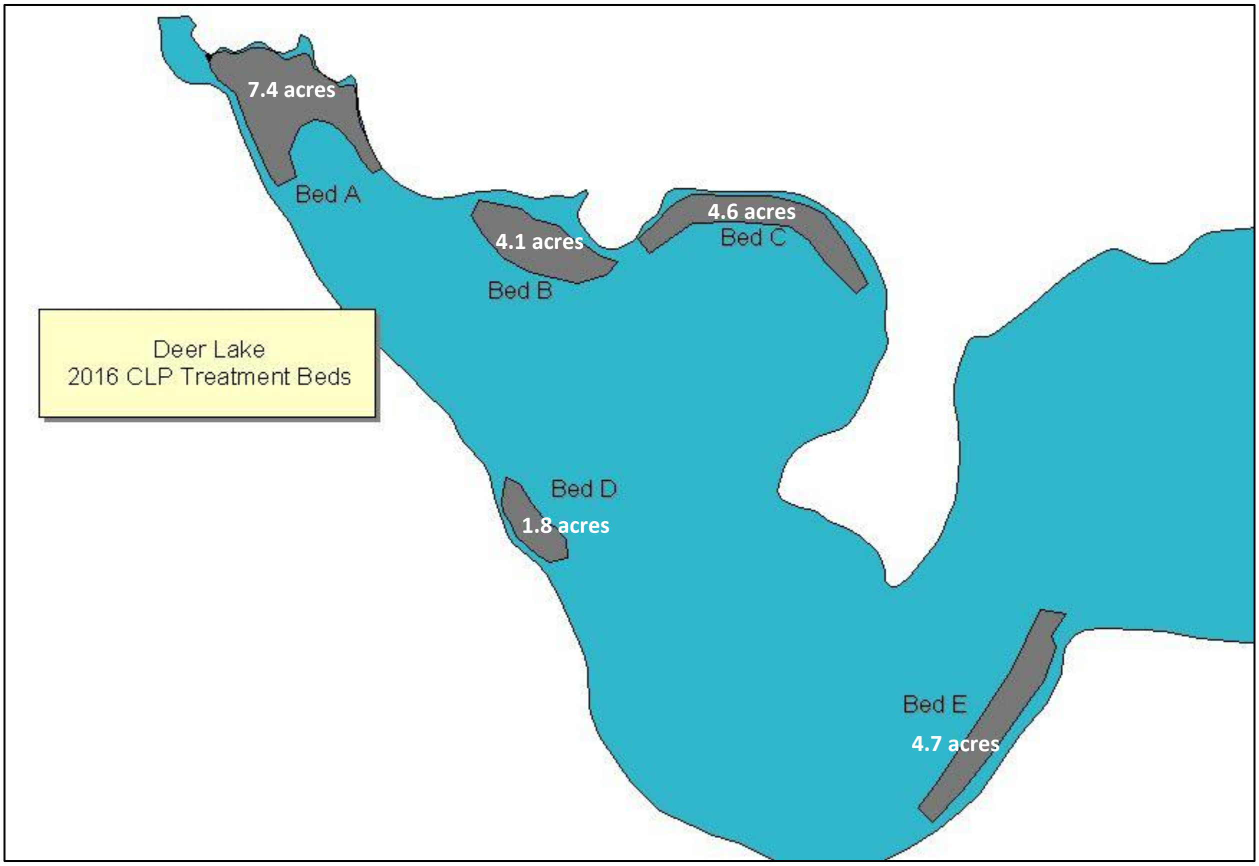



**Figure 2: Close map of 2017 CLP treatment beds.**

| Deer Lake CLP Beds (Treatment on May 5, 2017) | | | | | | |
|---|---|---|---|---|---|---|
| 2017 Beds | Area (acres) | Mean Depth | Acre-Feet | Application Rate*(ppm) | Wind conditions* | Water Temp*($^{o}$F) |
| Bed A | 7.4 | 5.2 | 38.48 | 2.0 | Calm | 51 |
| Bed B | 4.1 | 6.8 | 27.88 | 2.0 | Calm | 51 |
| Bed C | 4.6 | 7.8 | 35.88 | 2.0 | Calm | 51 |
| Bed D | 1.8 | 7.9 | 14.22 | 2.0 | Calm | 51 |
| Bed E | 4.7 | 8.1 | 38.07 | 2.0 | Calm | 51 |
| Total | 22.6 | | 154.53 | | | |

***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, 2013, 2014 and 2015. |
| **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, 2013, 2014 and 2015. 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, 2013, 2014 and 2015 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.

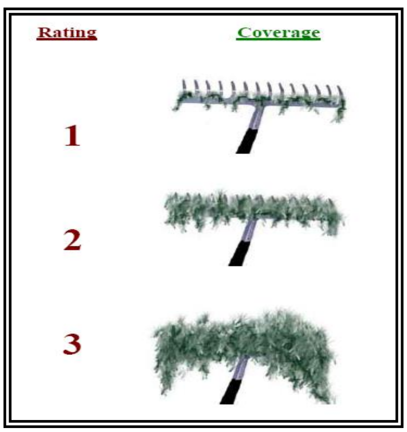



**Figure 3: Density rating system and example CLP rake sample.**

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*

*C*

**Figure 4: Pictures showing turion density methods. A shows sediment sample; b shows separation; c Shows separated turions.**

## Results

The results of the pretreatment and post treatment surveys from 2017 are summarized in table 3. The pretreatment survey was conducted on April 13, 2017 and the post treatment survey was conducted on June 9, 2017. CLP was dense in other area lakes when the post treatment survey was completed, thus demonstrating post survey was near peak CLP growth. The tables also contain information from 2016 to show changes between years of treatment.

| Treatment Bed | Pre-treat freq (2016) | Post treat freq (2016) | Pre treat freq (2017) | Post treat freq (2017) | Mean density 2016 | Mean density 2017 |
|---|---|---|---|---|---|---|
| **Bed A** | 60.4% | 4.6% | 48.9% | 0% | 0.05 | 0 |
| **Bed B** | 45.8% | 20.8% | 33.3% | 0% | 0.38 | 0 |
| **Bed C** | 38.7% | 19.4% | 41.9% | 3.0% | 0.32 | 0.03 |
| **Bed D** | 50.0% | 0.0% | 41.7% | 0% | 0.00 | 0 |
| **Bed E** | 37.9% | 20.7% | 56.7% | 0% | 0.28 | 0 |
| **All beds** | 47.5% | 13.7% | 45.8% | 0.7% | 0.2 | 0.007 |

**Table 3: Summary of CLP growth frequency pre and post treatment 2016-2017.**

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? | Chi-square result (reduction) |
|---|---|---|
| 2017 pretreatment freq/2016 post treatment freq. | Yes | $P=9.5 \times 10^{-10}$ |
| 2016 post treatment freq/2017 post treatment freq. | Yes | $P= 3.0 \times 10^{-5}$ |
| 2016 pretreatment freq/2017 pretreatment freq. | No (slight reduction) | P=0.81 |

**Table 4: Summary of frequency reduction and significance after treatment.**

The chi-square analysis shows a statistically significant reduction from before treatment to after treatment in 2017. There was also a statistically significant decrease from the post treatment frequency 2016 to post treatment frequency 2017. There was a slight decrease from pretreatment frequency 2016 to pretreatment frequency 20167, but was not significant. The overall density from 2016 to 2017 decreased. 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.

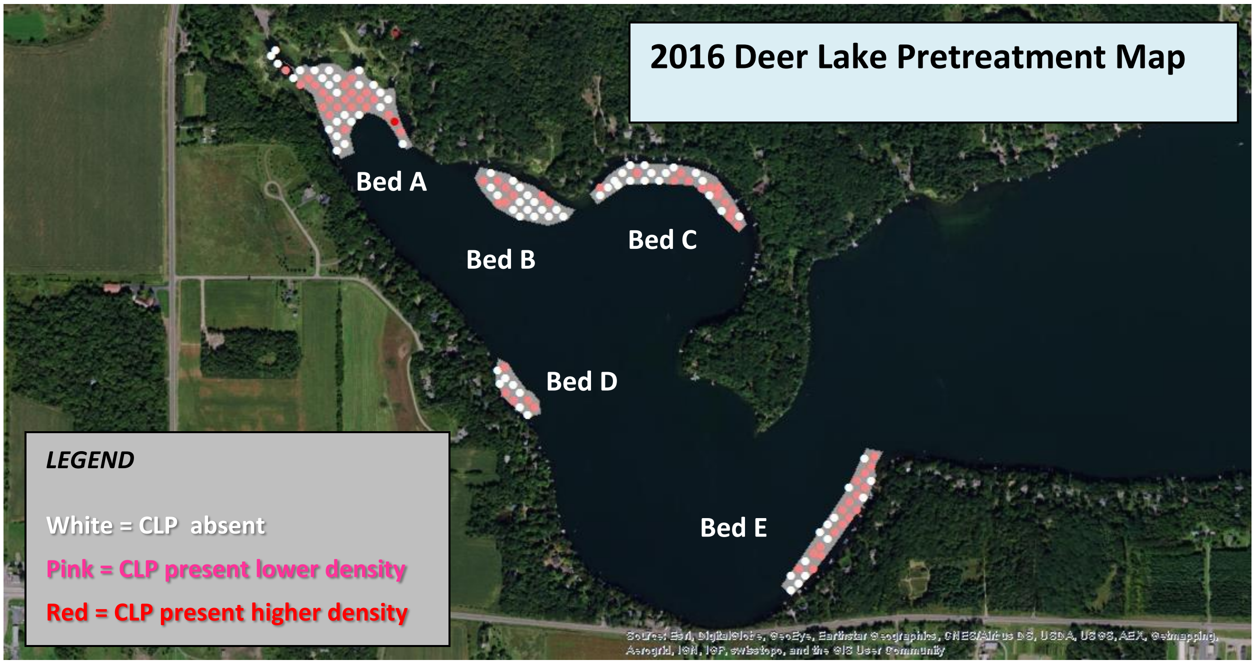



**Figure 5: Pre-treatment map from 2017 pretreatment survey showing presence/absence of CLP .**

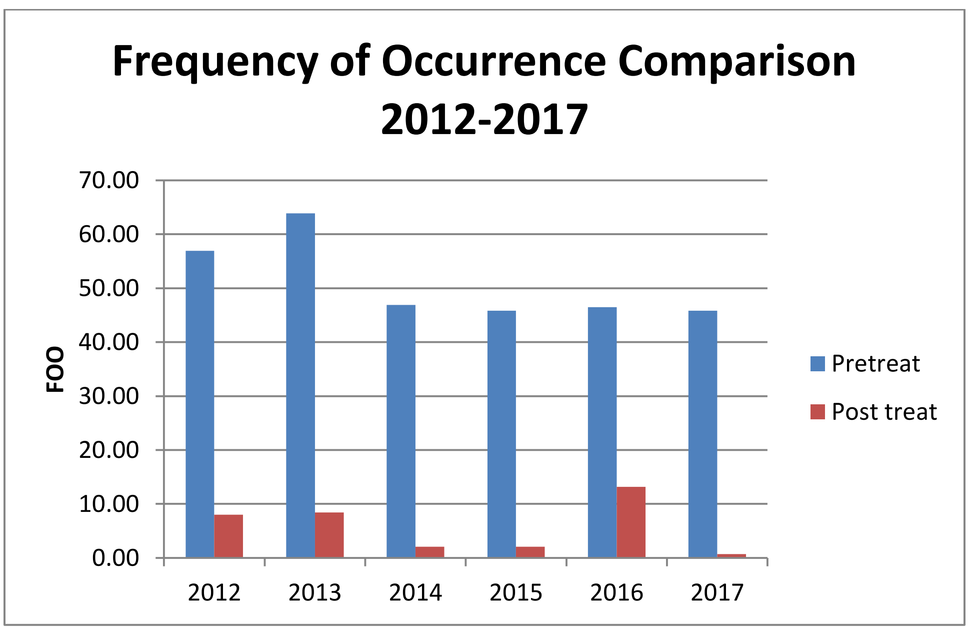



**Figure 6: Graph showing the pre/post treatment frequency comparison from 2012 and 2017-all beds treated.**

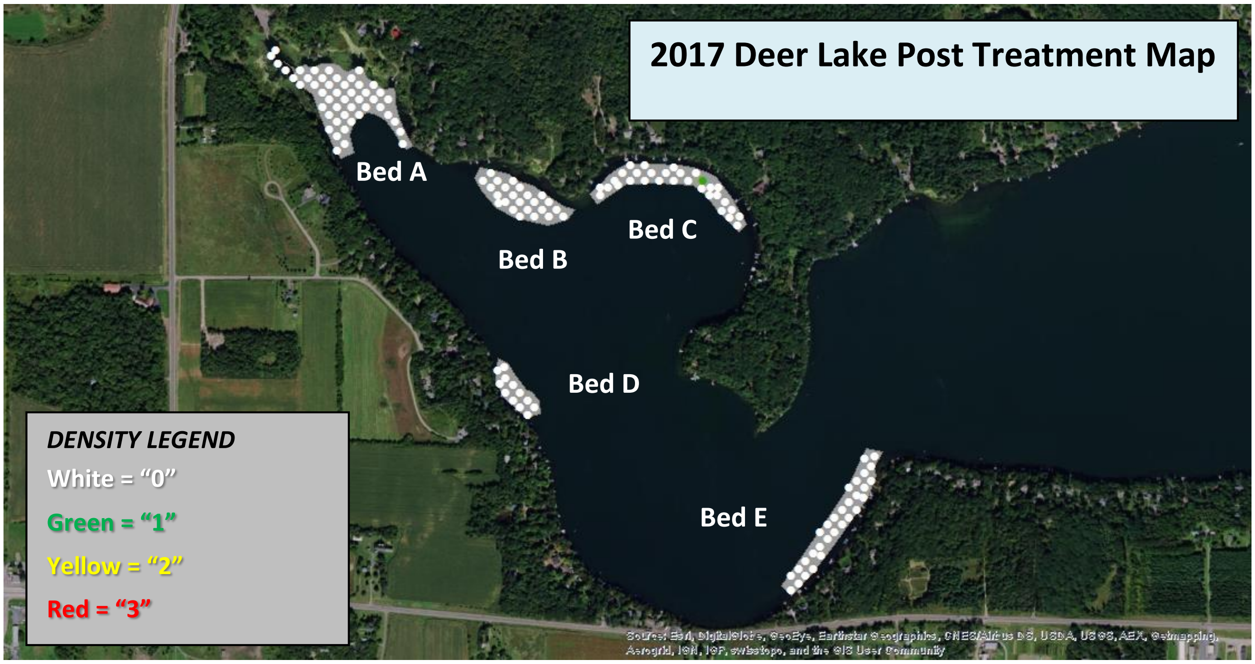



**Figure 7: Map showing CLP sampled and density in 2017 post treatment survey.**

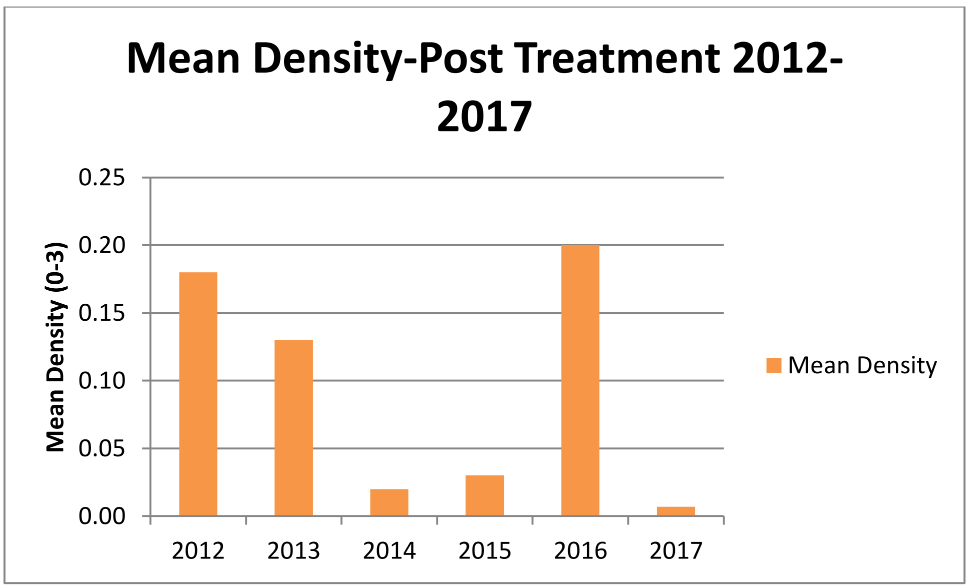



**Figure 8: Comparison of post treatment mean density all beds, 2012-2017.**

In conjunction with the frequency decreases, the mean density after treatment was very low. In 2016, the mean density had increased from 2015 to 0.2 (scale of 0-3). In 2017 the mean density was only 0.007, with only one location in all of the beds with CLP and that was a density of "1".

Figures 9 and 10 show the maps of the pretreatment and post treatment surveys from 2016 for comparison to 2017 maps.

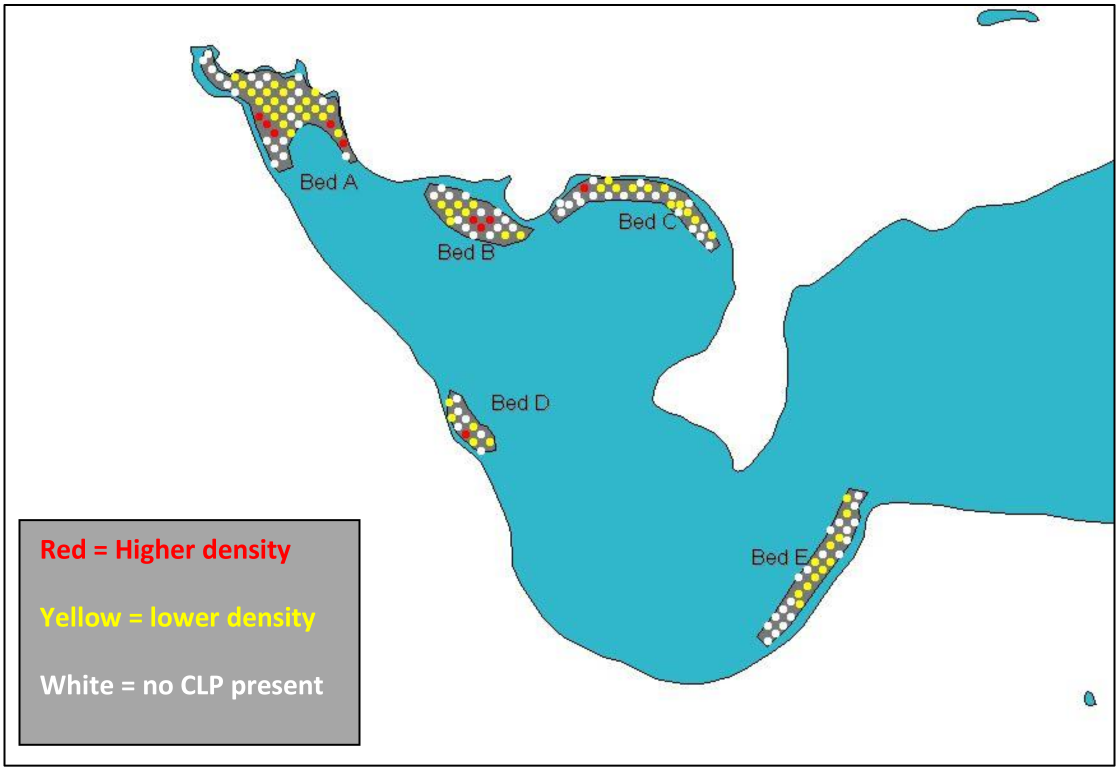



**Figure 9: Pretreatment survey map, 2016**

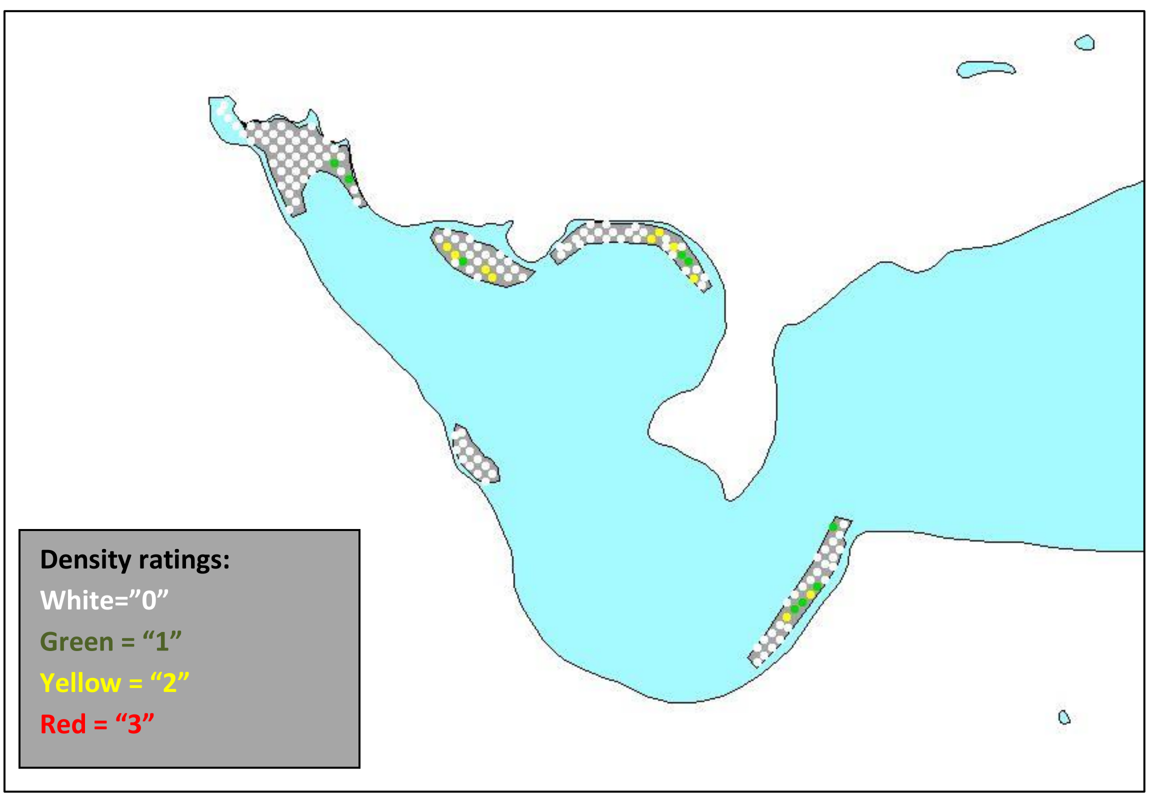



**Figure 10: Post treatment survey map, 2016.**

## 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 to herbicide exposure from the 2017 treatment.

| Native species | Frequency 2016 | Frequency 2017 | P value | Significant reduction |
|---|---|---|---|---|
| *Lemna trisulca*,forked duckweed | 0.12 | 0.11 | 0.85 | No |
| *Potamogeton praelongus*,White-stem pondweed | 0.03 | 0.11 | 0.005 | n/a (increase) |
| *Ceratophyllum demersum*, Coontail | 0.51 | 0.58 | 0.15 | n/a |
| *Myriophyllum sibiricum*, Northern milfoil | 0.43 | 0.19 | $2X10^{-5}$ | Yes |
| *Potamogeton richardsonii*, Clasping pondweed | 0.24 | 0.10 | 0.002 | Yes |
| *Elodea canadensis*, elodea | 0.22 | 0.19 | 0.66 | No |
| *Heteranthera dubia*, water stargrass | 0.17 | 0.09 | 0.05 | No |
| *Ranunculus aquatilis*, stiff water crowfoot | 0.11 | 0.11 | 1.0 | No |
| *Chara sp.,* muskgrasses | 0.09 | 0.13 | 0.25 | n/a |
| *Nymphaea odorata*, white lily | 0.05 | 0.07 | 0.45 | n/a |
| *Stuckenia pectinata, sago pondweed* | 0.05 | 0.06 | 0.79 | n/a |
| *Nitella sp.,* Stonewort | 0.01 | 0.0 | 0.32 | No |
| *Bidens beckii,*Water marigold | 0.05 | 0.0 | 0.007 | Yes |
| *Potamogeton epihydrous,* ribbon pondweed | 0.0 | 0.01 | 0.32 | n/a |
| *Spirodela polyrhiza,*Large duckweed | 0.0 | 0.01 | 0.32 | n/a |
| *Lemna minor,* small duckweed | 0.0 | 0.01 | 0.32 | n/a |

**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 richardsonii*-clasping pondweed, *Myriophyllum sibiricum*-northern water milfoil, and *Bidens beckii*-water marigold). The source of this reduction is unknown. It could be due to natural variation, sampling variation or herbicide application. There was also a statistically significant increase in one native species (*Potamogeton praelongus)* so this may indicate it isn't due to herbicide since the broad spectrum herbicide used can kill all plants. *Potamogeton praelongus* had a significant reduction from 2015 to 2016, so it appears to have rebounded. If the native plants are out of dormancy at the time of 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. 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. In order to be delineated by sight, the CLP must be growing at or near the lake surface. There were three CLP beds seen outside of treatment and no beds within the treatment areas. Figure 11 showa the location of the CLP observed out of the treatment beds. Figure 12 and 13 are the maps of the CLP beds observed on the north shoreline and in the lagoon. These beds totaled 0.04 acres. There was no other CLP observed in the lake.


**Figure 11: Map of the CLP bed locations outside of the treatment area.**

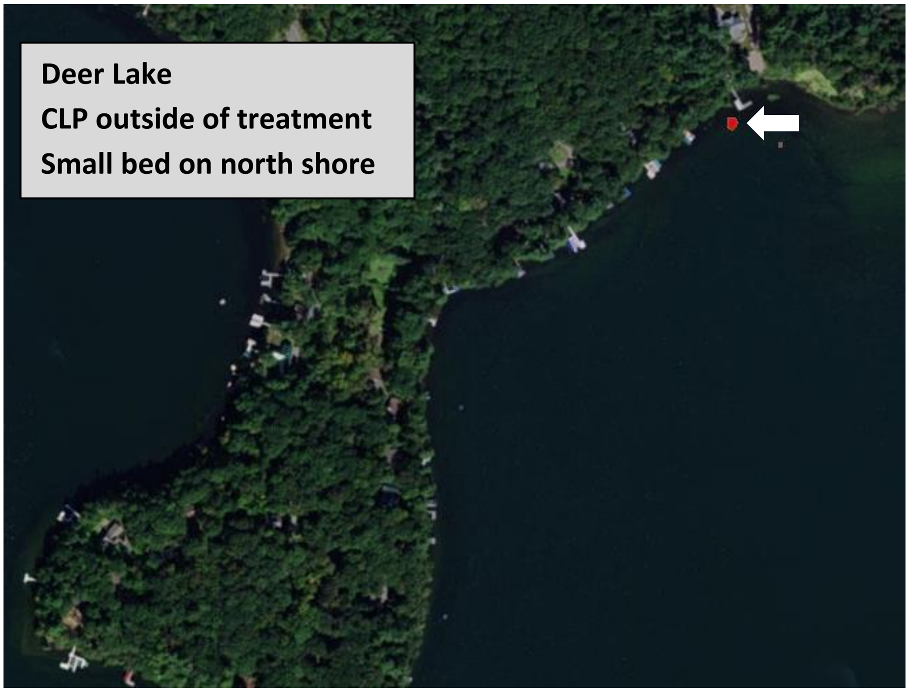



**Figure 12: Small CLP bed observed on the north shoreline Deer Lake-June, 2017.**


**Figure 13: CLP beds observed in the lagoon area of Deer Lake-June, 2017.**

## Turion Analysis

The turion analysis was conducted on October 7, 2017. 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 ($T/m^2$) |
|---|---|---|---|---|---|
| **A** | 77.7 | 63.1 | 39.1 | 83 | 47.8 |
| **B** | 153.6 | 46.1 | 96.75 | 122 | 49 |
| **C** | 91.8 | 89.5 | 75.25 | 136 | 67.75 |
| **D** | 15.0 | 16.3 | 32.25 | 5 | 16.25 |
| **E** | 71.0 | 18.6 | 55.3 | 31 | 9.3 |
| **All Beds** | 88.8 | 52.0 | 61.1 | 84.7 | 41.7 |

**Table 6: Turion density in each bed 2013 through 2017.**

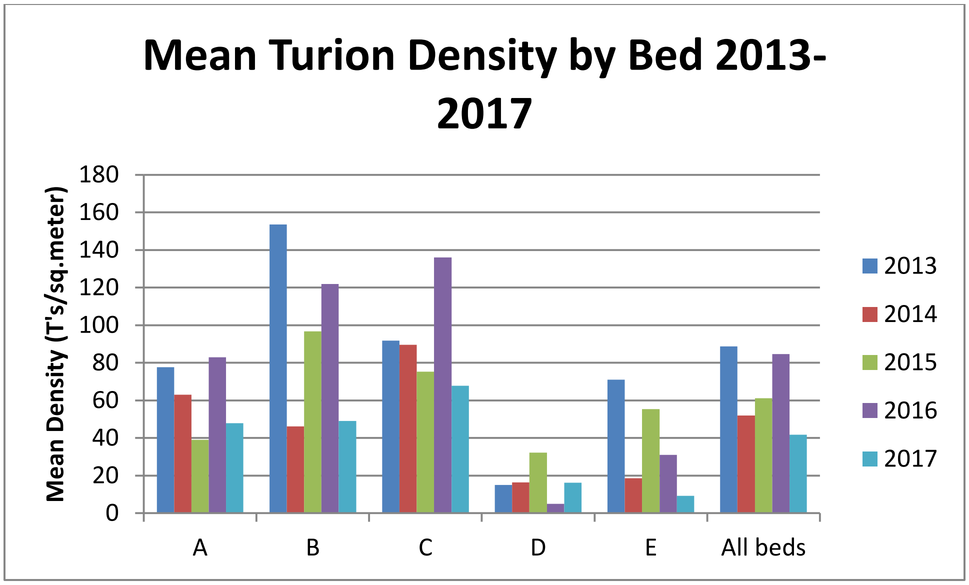



**Figure 14: Turion densities by bed for comparison 2013 through 2017.**

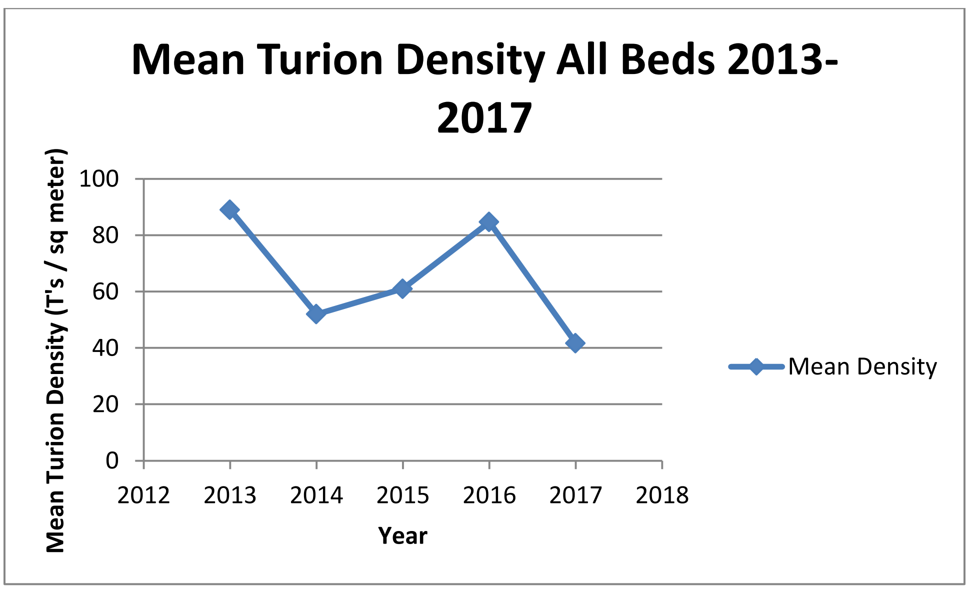



**Figure 15: Change in turion density, all beds 2013 through 2017.**

As the data shows, the mean turion density in all beds combined declined from 2016 to 2017. This follows increases in 2015 and 2016. 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. The mean turion density did increase slightly in bed D.

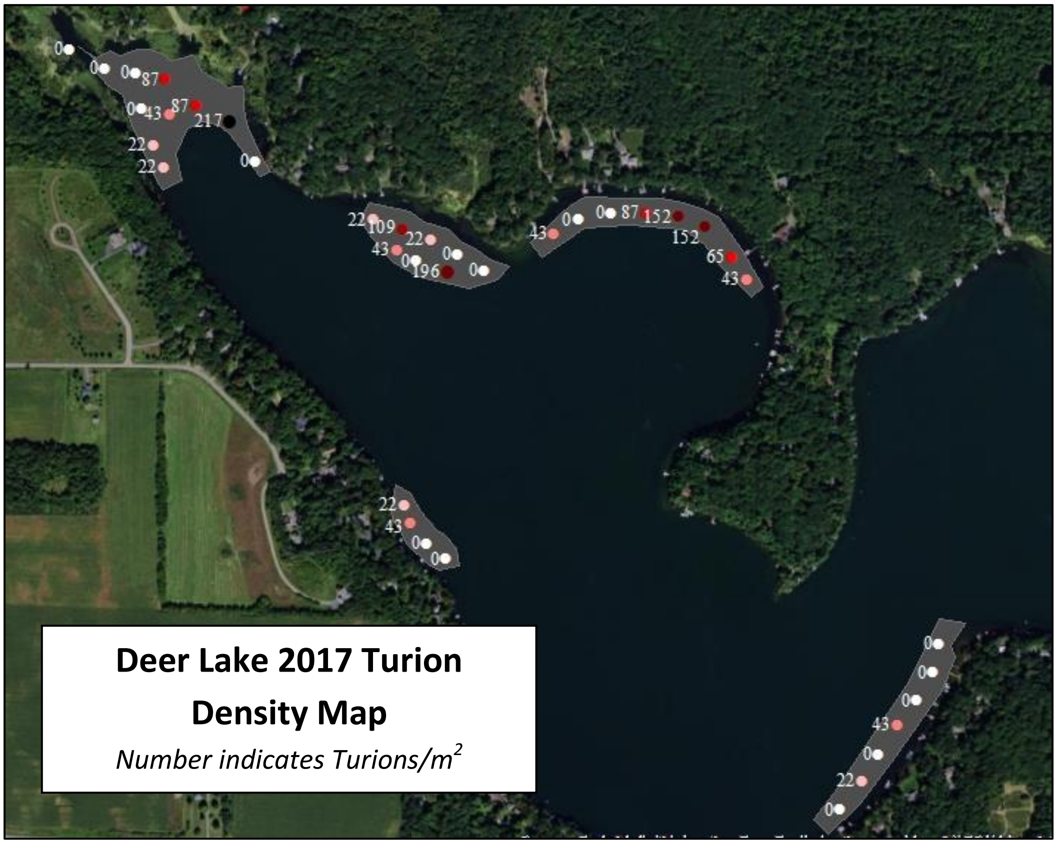



**Figure 16: Map of turion density by bed, 2017.**

## Discussion

The 2017 CLP herbicide treatment was very successful at reducing CLP growth occurring in 2017. 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 2017) it was much higher than after treatment (post treatment survey 2017) with a reduction of from 45.8% to 0.7%. See Figure 6 for graphic representation.

When comparing the post treatment frequency in 2016 to the post treatment frequency in 2017, there was a significant reduction from 13.7% to 0.7%. This shows that overall reduction from the previous year did occur, with more CLP growing after treatment in 2016 than in 2017. The density also decreased from 0.3 in 2016 to 0.007 in 2017.

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 2016 to 2017 showed a small decrease but was not significant. The CLP is returning each spring, but the frequency is staying lower. 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 2017 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, 2016, more CLP was observed than in previous years, resulting in the delineation of four beds outside of the treatment areas. In 2017, there were only three small beds, totaling 0.04 acres observed. No CLP beds were present within the treatment areas. There was very little CLP observed in Deer Lake in 2017.

The turion data analysis shows that the turion density decreased from 2016 to 2017. The density is the lowest it has been in collected turion data in 2013. This shows long term reduction in CLP and should result in lower CLP growth in spring 2018.

## References

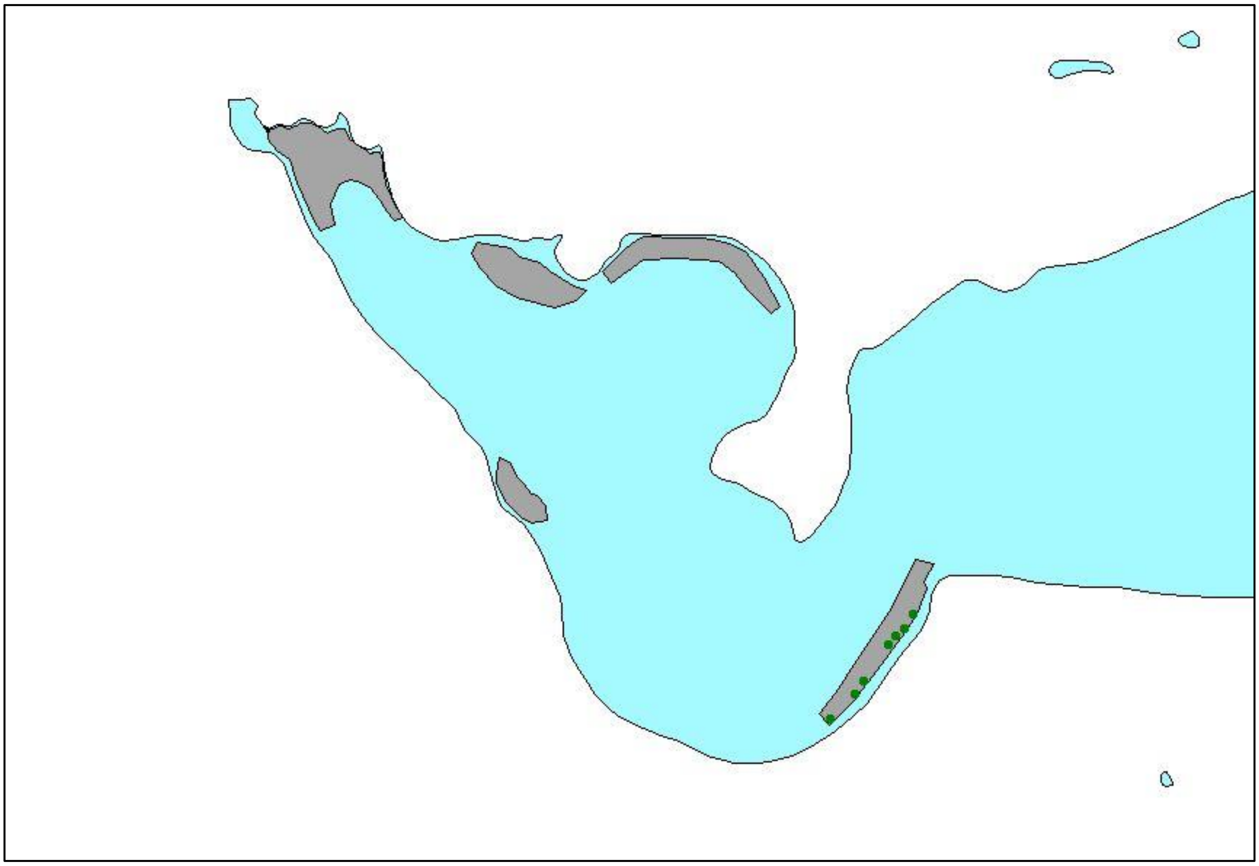
Borman, Susan, Robert Korth and Jo Tempte. *Through the Looking Glass.* University of Wisconsin-Extension. Stevens Point, Wisconsin. 1997. 248 p.

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.

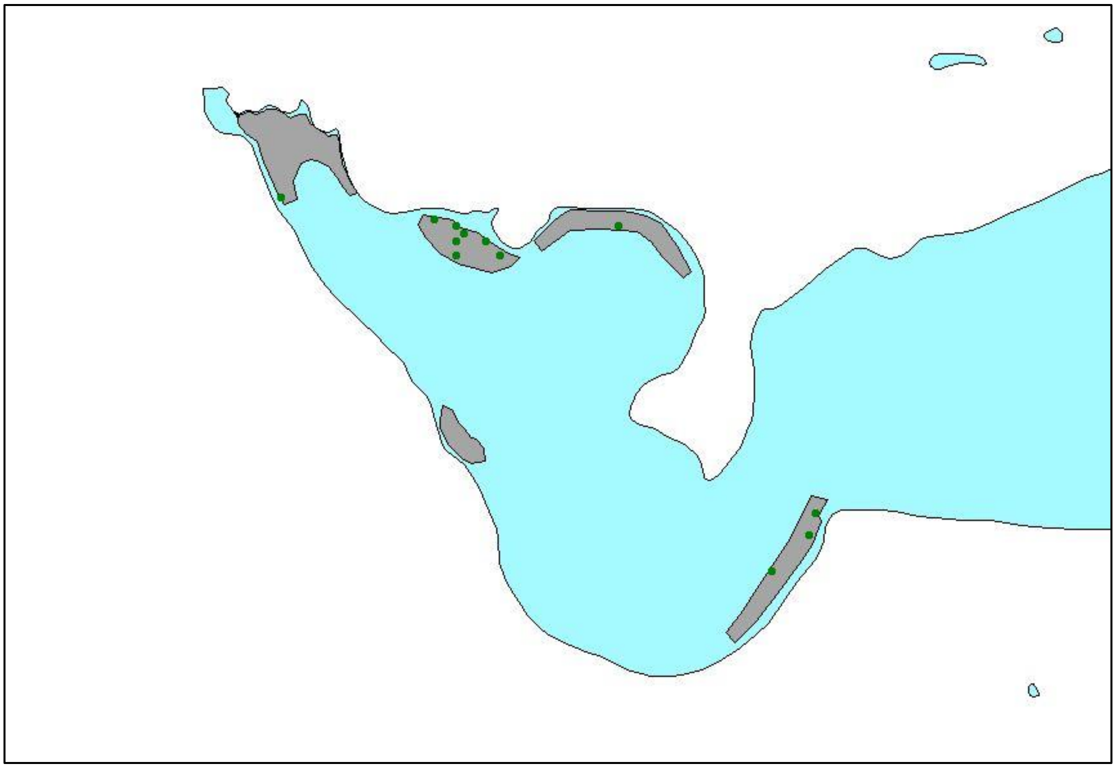
UW-Extension. Aquatic Plant Management website.
http://www4.uwsp.edu/cnr/uwexlakes/ecology/apmguide.asp appendix d.

## *Appendix-Native plant maps from 2015 and 2016.*



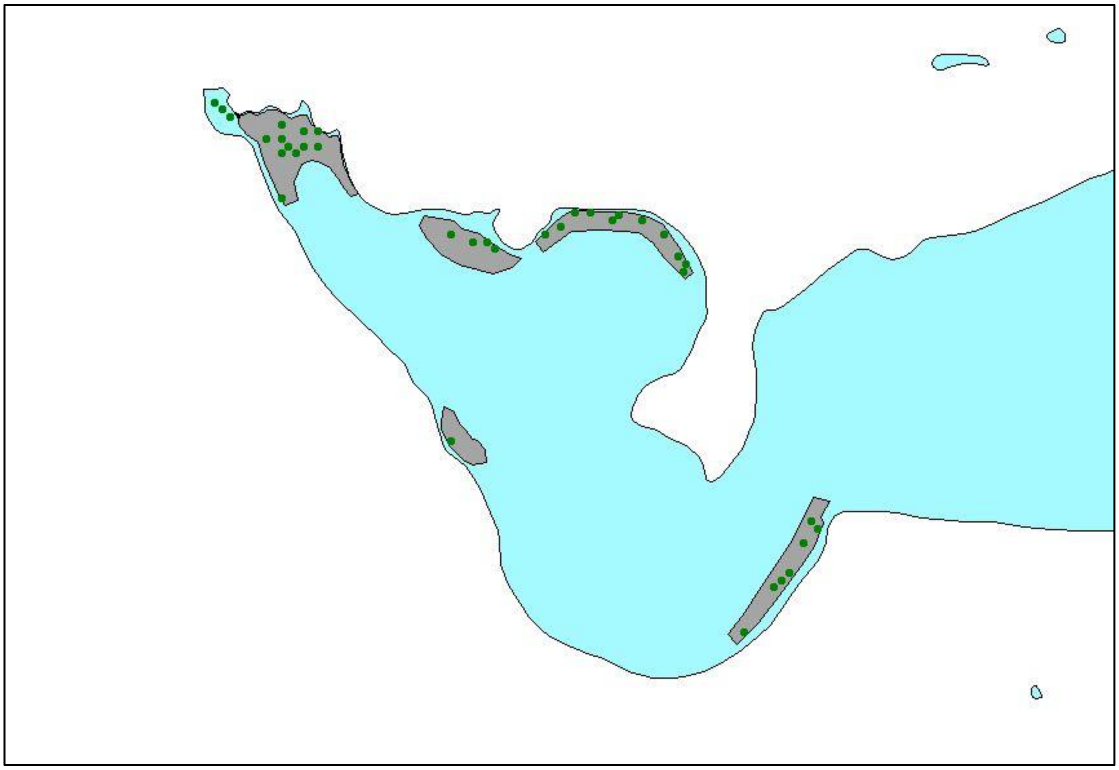
*Bidens beckii*-Water marigold-2016

Not sampled in 2017



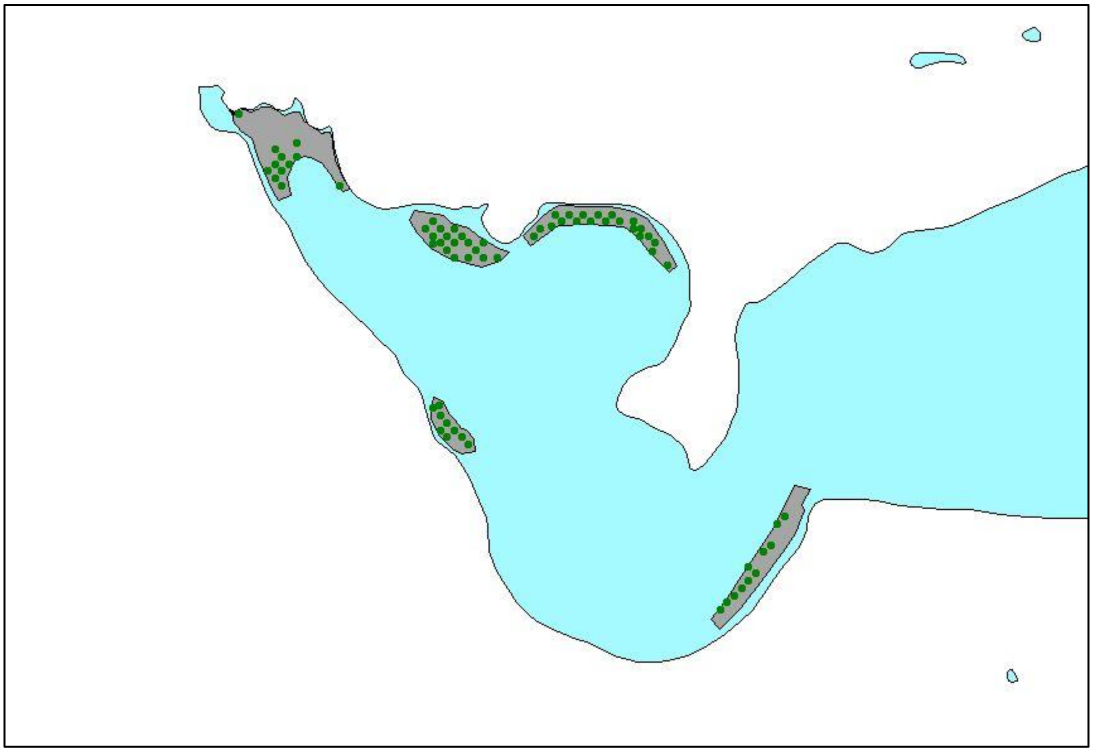
*Chara sp*.-Muskgrass-2016

*Chara sp*.-Muskgrass-2017



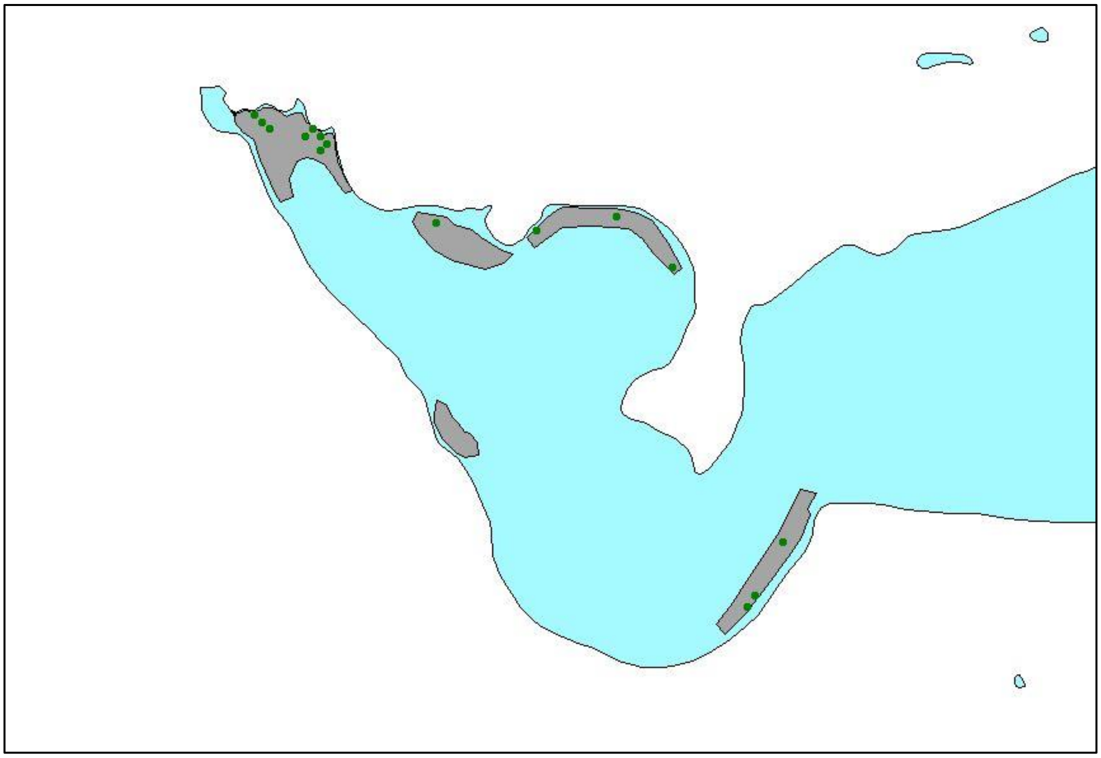
*Potamogeton richardsonii*-Clasping pondweed-2016

*Potamogeton richardsonii*-Clasping pondweed-2017



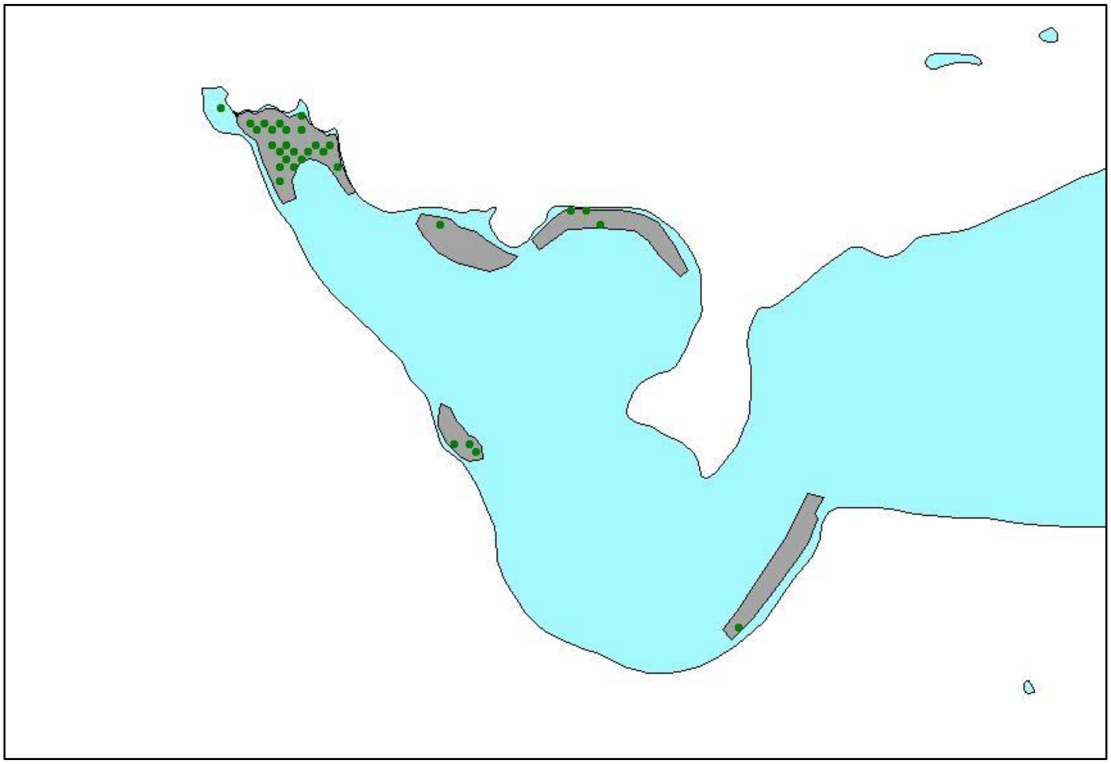
*Ceratophyllum demersum*-Coontail-2016

*Ceratophyllum demersum*-Coontail-2017



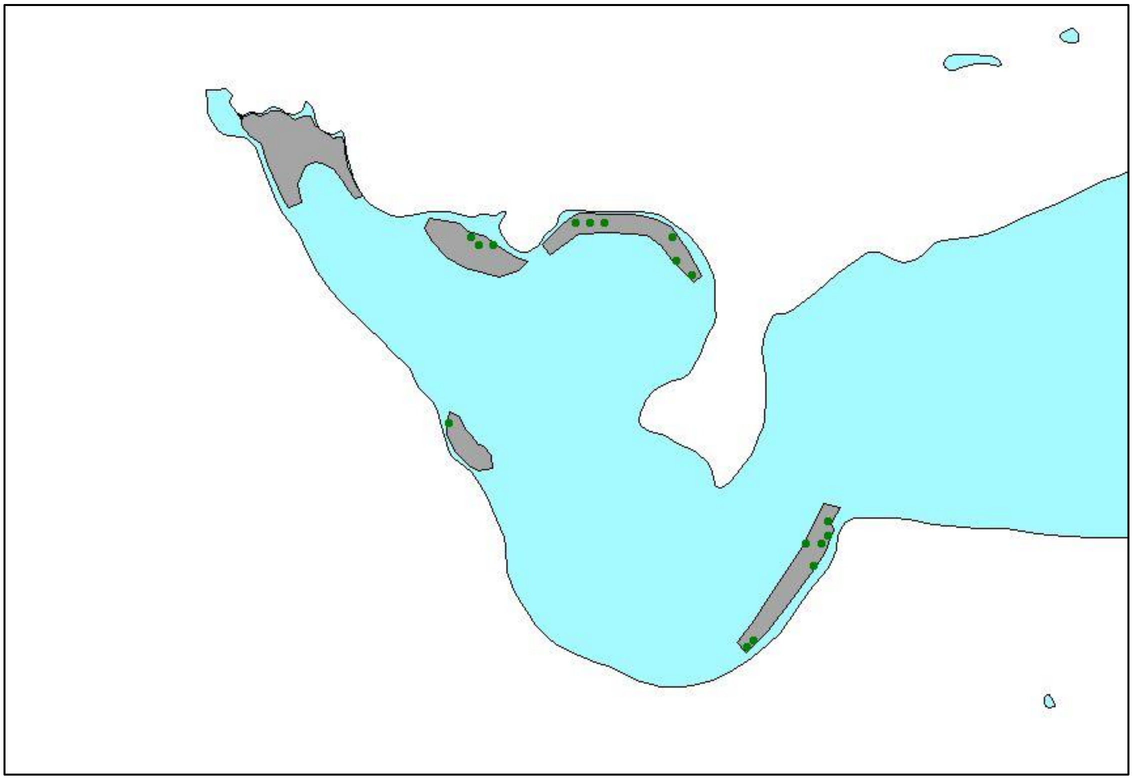
*Rununculus aquatilis*-Whitewater Crowfoot-2016

*Rununculus aquatilis*-Whitewater Crowfoot-2017



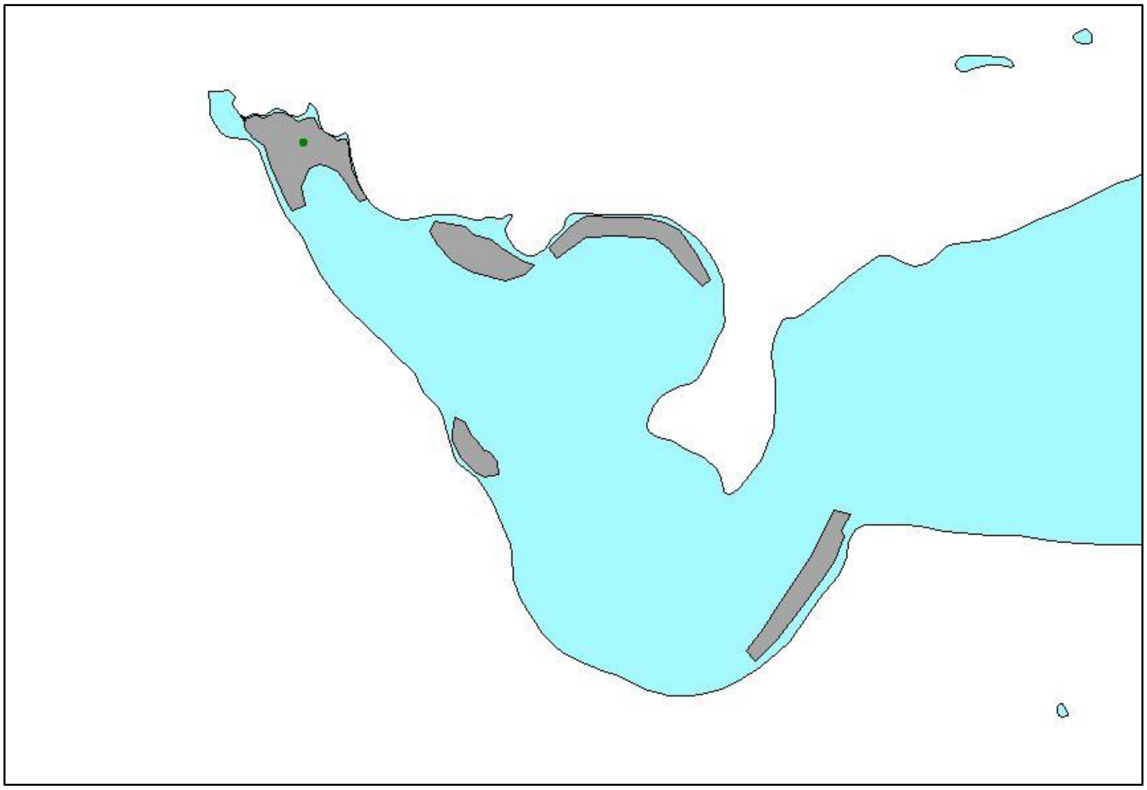
*Elodea canadensis*-Common waterweed-2016

*Rununculus aquatilis*-Whitewater Crowfoot-2017



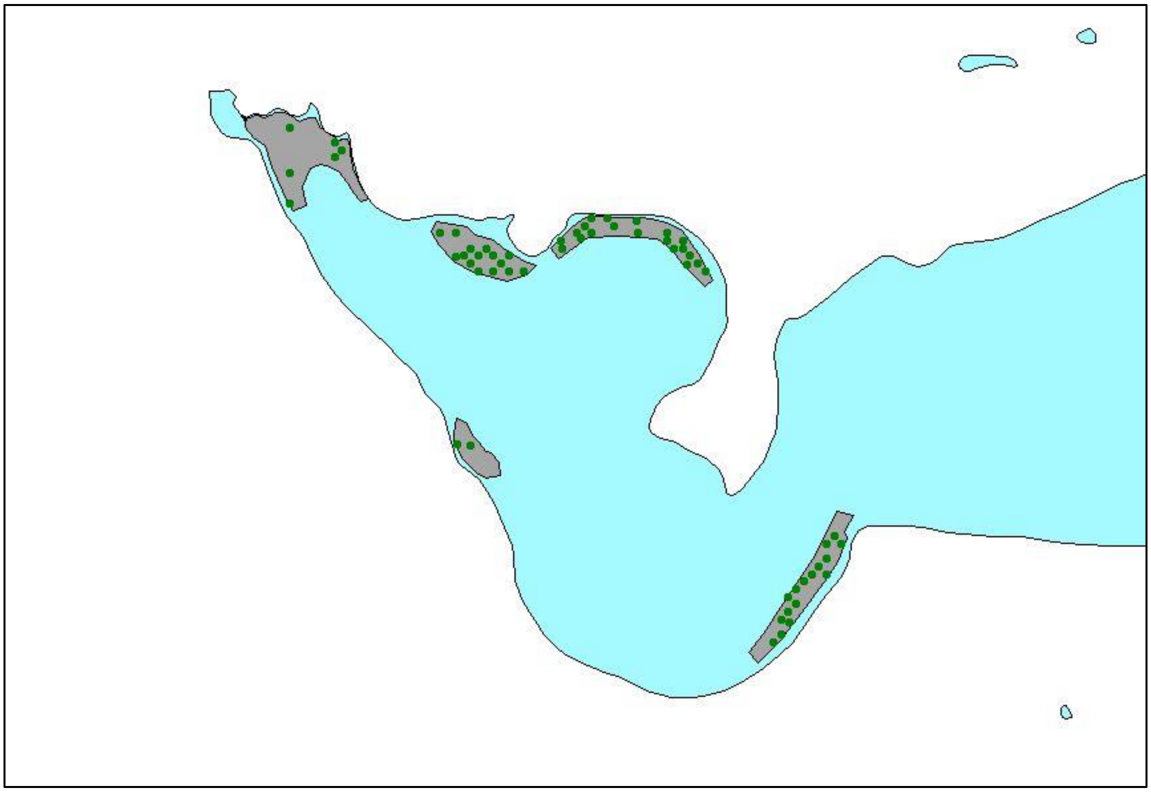
*Lemna triscula*-Forked duckweed-2016

*Lemna triscula*-Forked duckweed-2017



*Nitella sp*.-Stonewort-2016

Nitella not sampled in 2017

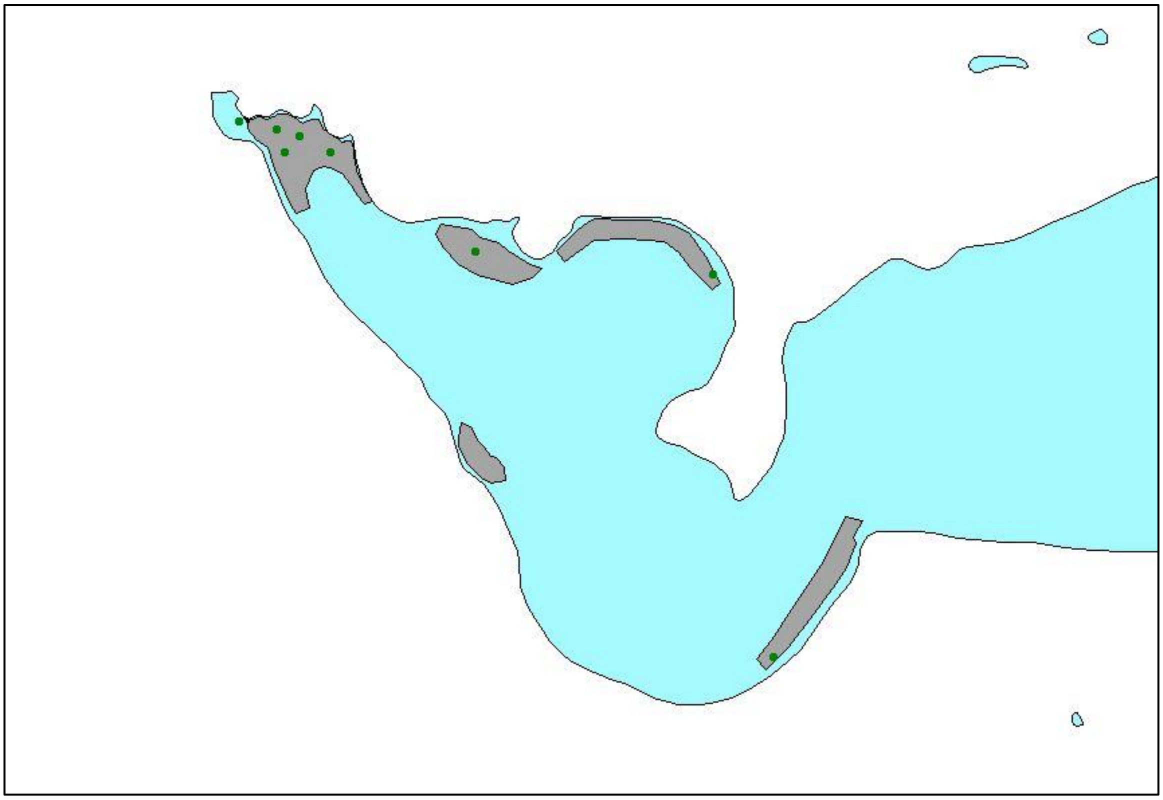


*Myriophyllum sibiricum*-Northern water milfoil-2016

*Myriophyllum sibiricum*-Northern water milfoil-2017

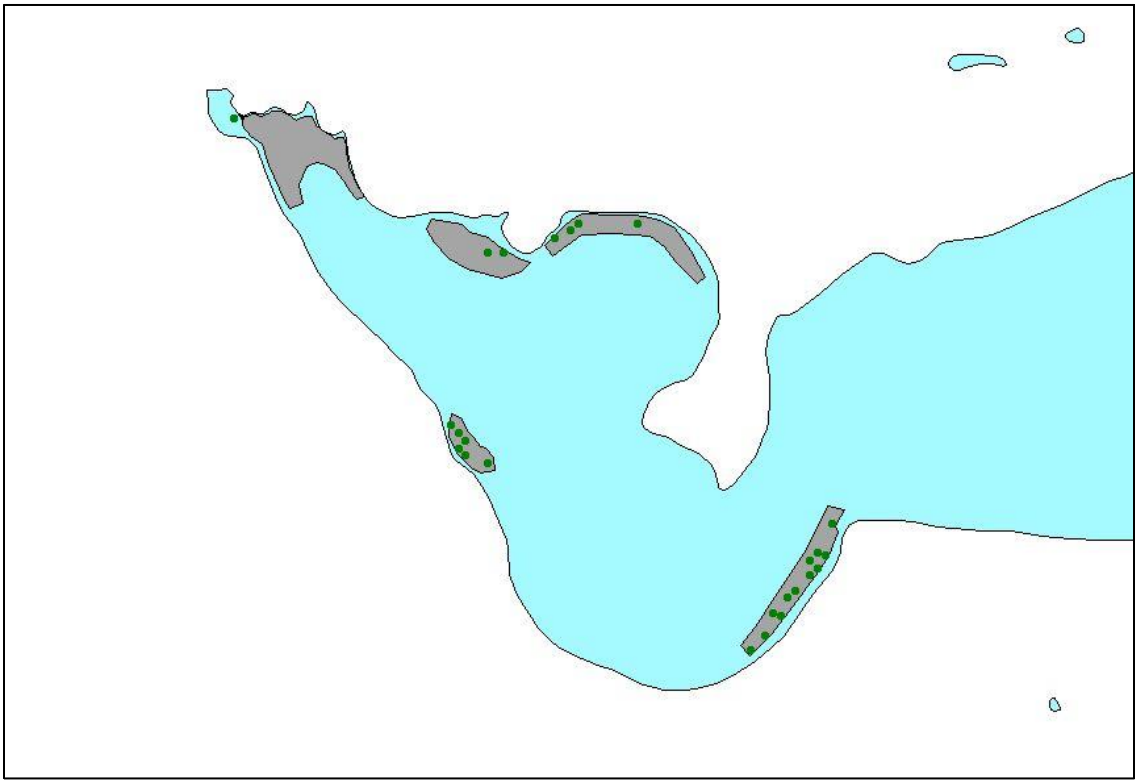
*Potamogeton epihydrous*-Ribbon leaf pondweed not sampled in 2016

*Potamogeton epihydrous*-Ribbon leaf pondweed-2017



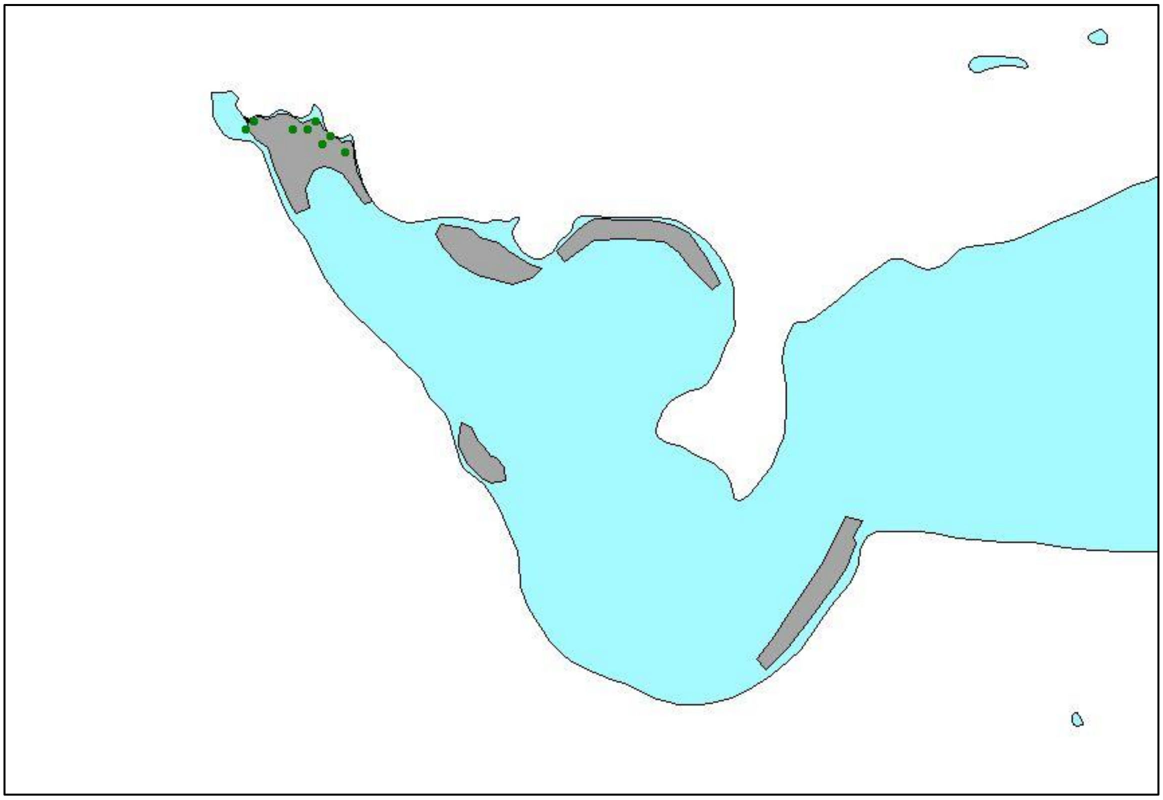
*Stuckenia pectinate*-Sago pondweed-2016

*Stuckenia pectinate*-Sago pondweed-2017



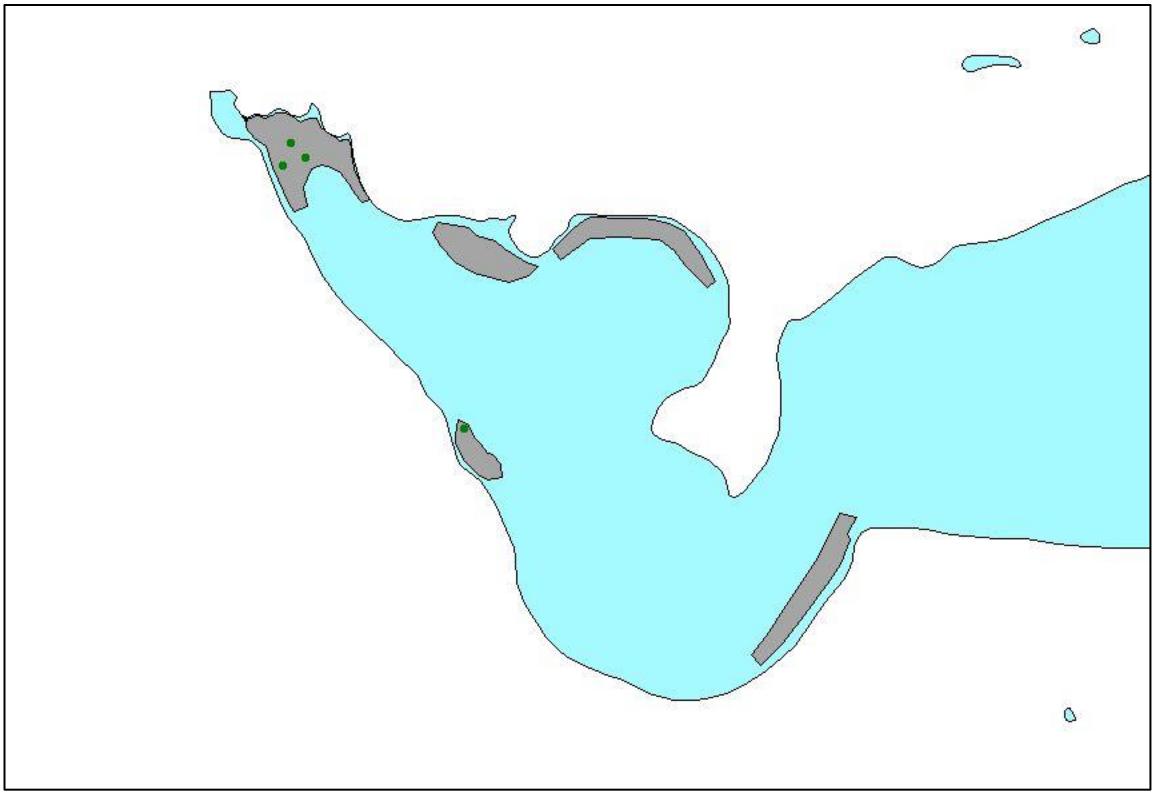
*Heteranthera dubia*-Water Stargrass-2016

*Heteranthera dubia*-Water Stargrass-2017



*Nymphaea odorata*-White water lily-2016

*Nymphaea odorata*-White water lily-2017



*Potamogeton praelongus*-Whitestem pondweed-2016

*Potamogeton praelongus*-Whitestem pondweed-2017

*Lemna minor*-small duckweed-2017 (not sampled in 2016)

Spirodela polyrhiza-large duckweed-2017 (not sampled in 2016)