Herbicide Treatment Analysis on *Potamogeton crispus*

Deer Lake, Polk County Wisconsin

WBIC: 2619400

2014

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Amery, WI

Abstract

An herbicide treatment (endothall) of *Potamogeton crispus*-curly leaf pondweed (CLP) was conducted on Deer Lake, Polk County Wisconsin on May28, 2014. The herbicide was applied at a rate of 1.5 ppm on 5 different beds totaling 23.4 acres. A pretreatment and post treatment survey analysis showed that the treatment was effective. The frequency of occurrence of CLP was reduced from the 2014 pretreatment survey to the 2014 post treatment survey (46.9% to 2.1%), with that reduction being statistically significant. The 2013 post treatment frequency was also reduced in the 2014 post treatment frequency (8.4% to 2.1%) and was also statistically significant. There was also a frequency reduction from the 2013 pretreatment survey to the 2014 pretreatment survey (63.9% to 46.9%), which was statistically significant. The post treatment mean density was also reduced from 2014 to 2013 from 0.13 to 0.02 (scale of 0-3). A native species evaluation indicated that the native species were not significantly reduced by the herbicide. No CLP was observed or sampled outside of the treatment areas on Deer Lake in June 2014. The turion analysis showed a mean turion density reduction from 88.8 turions/m^2 in 2013, to 52 turions/m^2 in 2014.

Introduction

On May 29 2014, an herbicide treatment targeting curly-leaf pondweed (*Potamogeton crispus*) was conducted using endothall. This analysis will outline the areas treated, 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. Those beds with their areas are shown in figures 1 and 2. Portions or all of beds B, C and D have been treated since 2006, while beds A and E have been treated since 2010.

The herbicide endothall was used in the treatment of the CLP. Water temperature and wind conditions have not been provided by applicator.

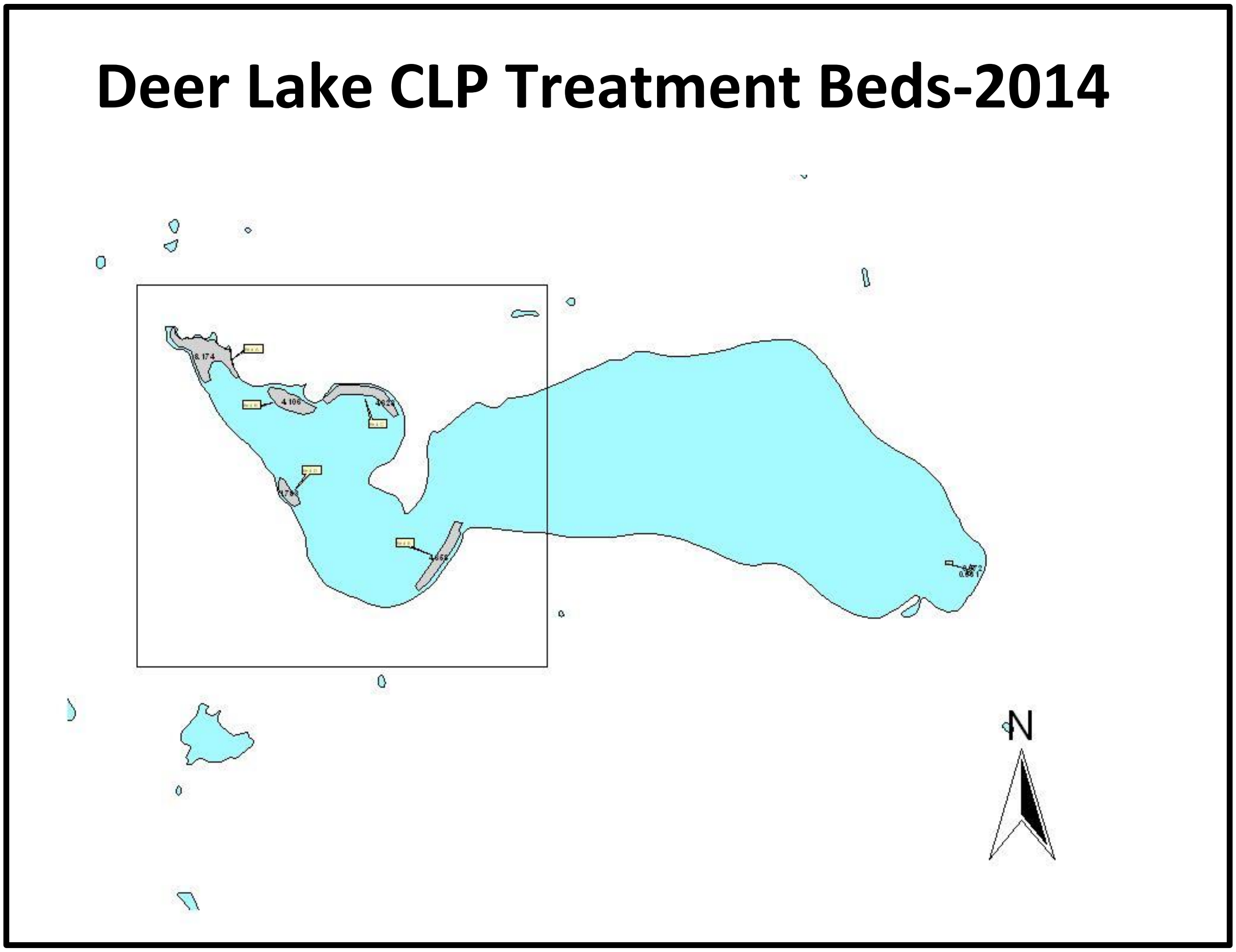


Figure 1: Large map showing the location of the treatment beds relative to the remaining lake.

Deer Lake CLP Treatment Beds-2014

Close-up view

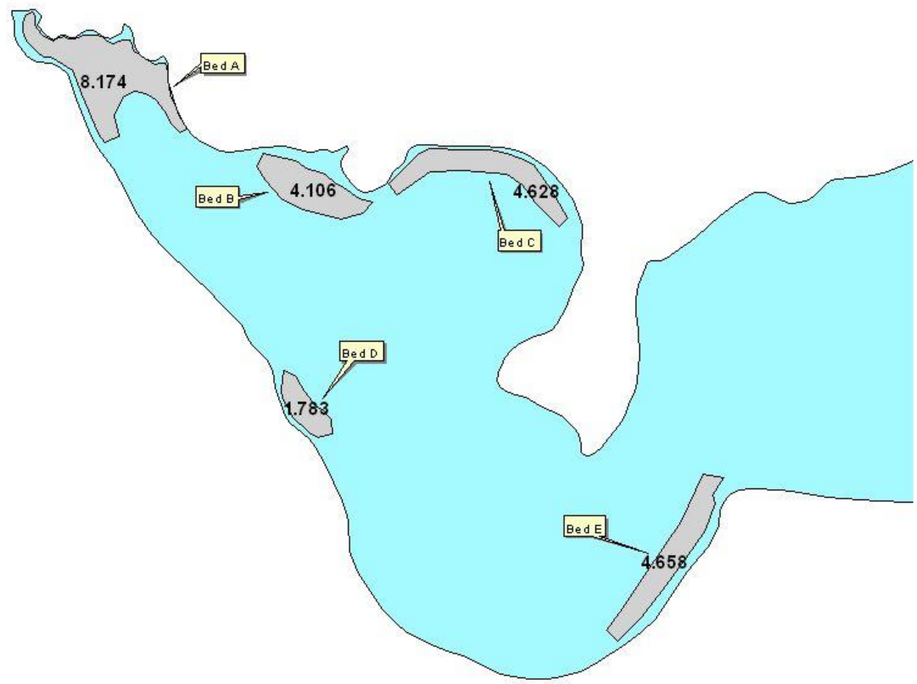


Figure 2: Close map of 2014 CLP treatment beds.

Deer Lake CLP Beds					
2014	**Area**	**Mean Depth**	**Acre-Feet**	**Application Rate**	**Wind conditions**
Bed A	8.2	5.2	42.64	1.5 ppm (42.64 gal)	??
Bed B	4.1	6.8	27.88	1.5 ppm (27.88 gal)	
Bed C	4.6	7.8	35.88	1.5 ppm (35.88 gal)	
Bed D	1.8	7.9	14.22	1.5 ppm (14.22 gal)	
Bed E	4.7	8.1	38.07	1.5 ppm (38.07 gal)	
Total	23.4		158.69	1.5 ppm (158.69 gal)	

Table 1: Summary of treatment beds, 2013.

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 has successful treatment in 2012, 2013 and has been treated since 2010.
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 and 2013.
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 rather deep water, creating a rather 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. 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 and in 2013. 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 quite dense throughout. This bed has a fairly large amount of northern milfoil mixed in with not floating vegetation. This bed had successful 2012 and 2013 treatments and has been treated since 2010.
Bed F	Bed F is a very small, two part bed. It is in very deep water (from 10-13 feet). Since very little CLP has been seen here, it was recommended to not treat in 2013 or 2014 (which it was not).

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 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 3 for reference). All other species are also recorded from the rake sample in order to verify no damage to the native plants.

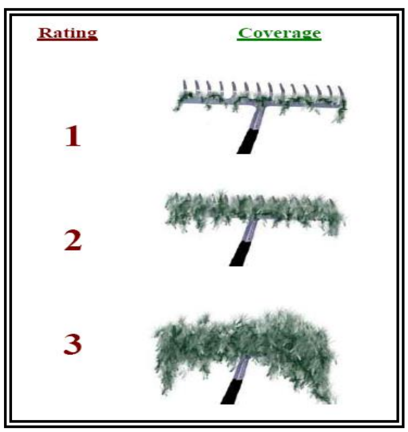


Figure 3: Density rating system and example CLP rake sample.

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 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.

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 so 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 2014 and 2013 are summarized in table 3. Also the frequency result from the 2012 post treatment survey is included for comparison. The graph in figure 6 shows these changes also.

Treatment Bed	Pre-treat freq (2014)	Post treat freq (2014)	Pre treat freq (2013)	Post treat freq (2013)
Bed A	50.0%	0.0%	73%	0%
Bed B	45.8%	4.2%	69%	8.6%
Bed C	51.6%	0.0%	57%	7.1%
Bed D	41.7%	0.0%	62.5%	25%
Bed E	43.3%	6.7%	54%	11.4%
All beds	46.9%	2.07%	63.9%	8.4%

Table 3: Summary of CLP growth frequency pre and post treatment 2013-2014.

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

Treatment Bed	2014 pre/2014 post freq reduction	Statistically significant reduction	2013 post/2014 post freq reduction	Statistically significant reduction
Bed A	-50.0%		-0.0%	
Bed B	-41.6%		-4.4%	
Bed C	-51.6%		-7.1%	
Bed D	-41.7%		-25%	
Bed E	-36.6%		-4.7%	
All Beds	**-44.8%**	**Yes ($p=2.9 \times 10^{-19}$)**	**-6.3%**	**Yes($p=0.015$)**

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

Treatment Bed	2013 pre/2014 pre freq reduction	Statistically significant reduction
Bed A	-23.0%	
Bed B	-23.2%	
Bed C	-5.4%	
Bed D	-20.8%	
Bed E	-10.7%	
All Beds	**-17.0%**	**Yes ($p=0.0045$)**

Table 5: Summary of frequency change between 2013 and 2014 pretreatment suveys.

The chi-square analysis shows a statistically significant reduction from before treatment to after treatment in 2014. There was also a statistically significant reduction from 2013 post to 2014 post. Also, as table 5 shows, there was a statistically significant reduction in CLP frequency from the 2013 pretreatment survey to the 2014 pretreatment survey.

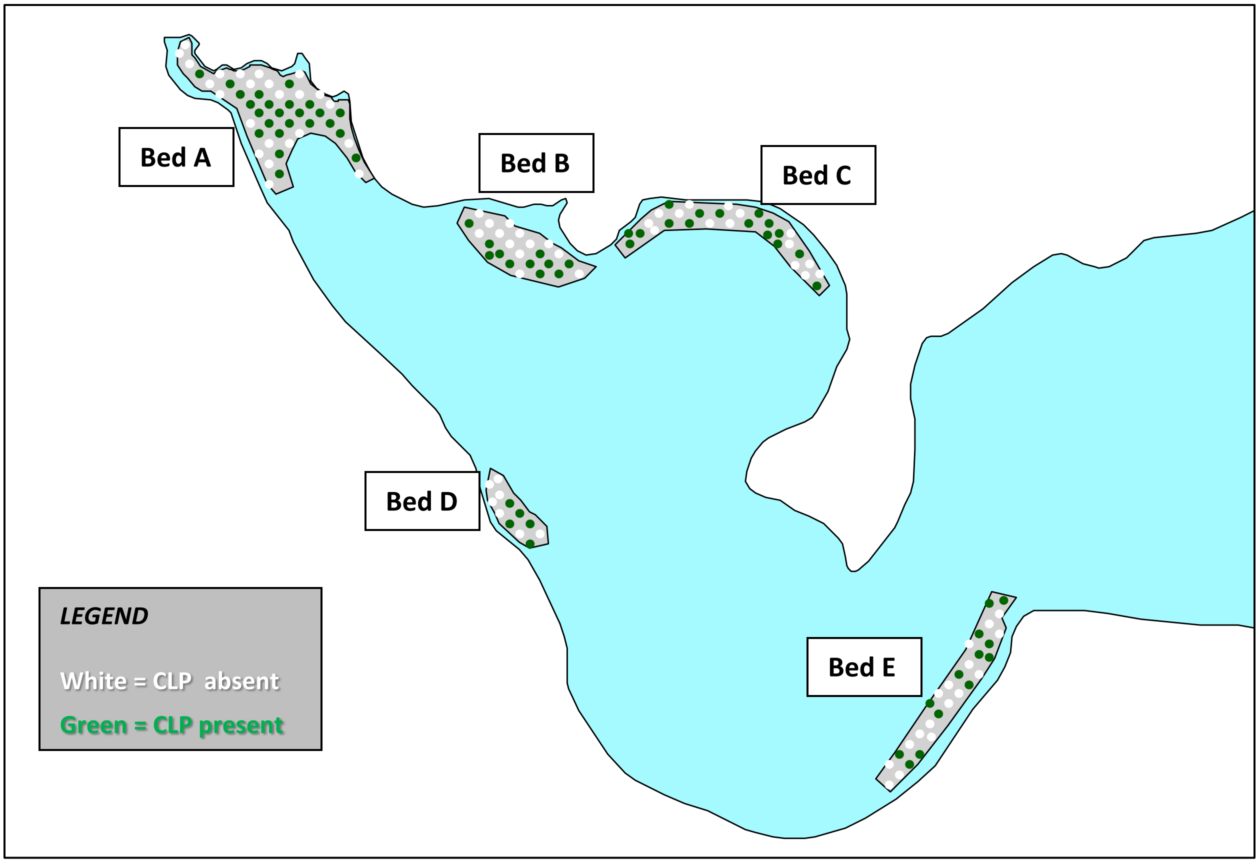


Figure 5: Pre-treatment map from 2014 pretreatment survey.

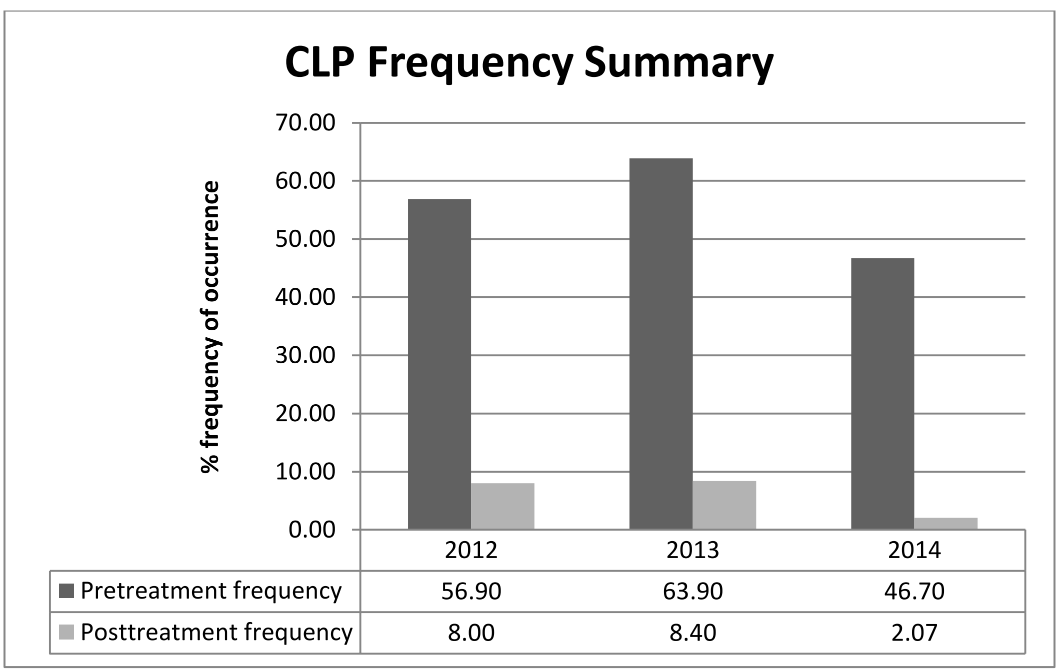


Figure 6: Graph showing the frequency comparison from 2012 and 2014-all beds treated.

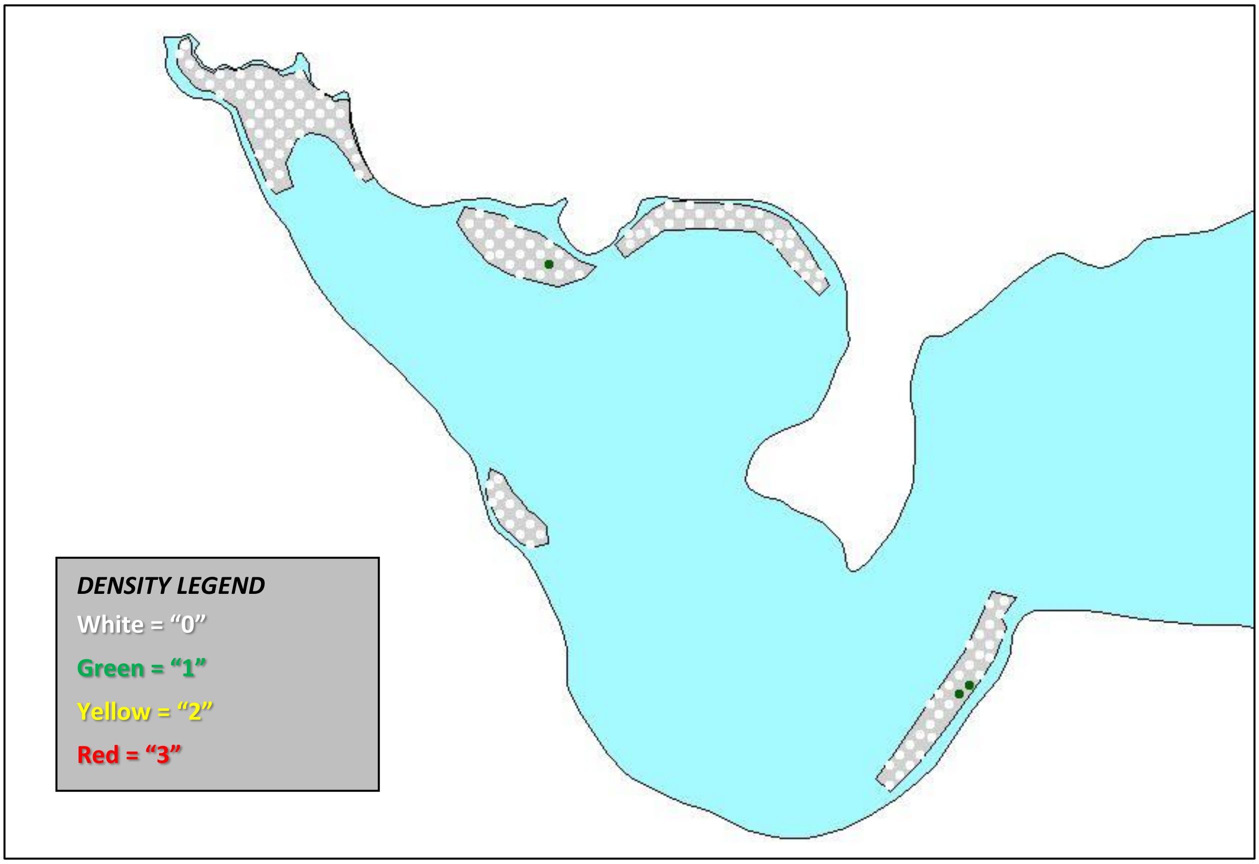


Figure 7: Map showing CLP density in 2014 post treatment survey.

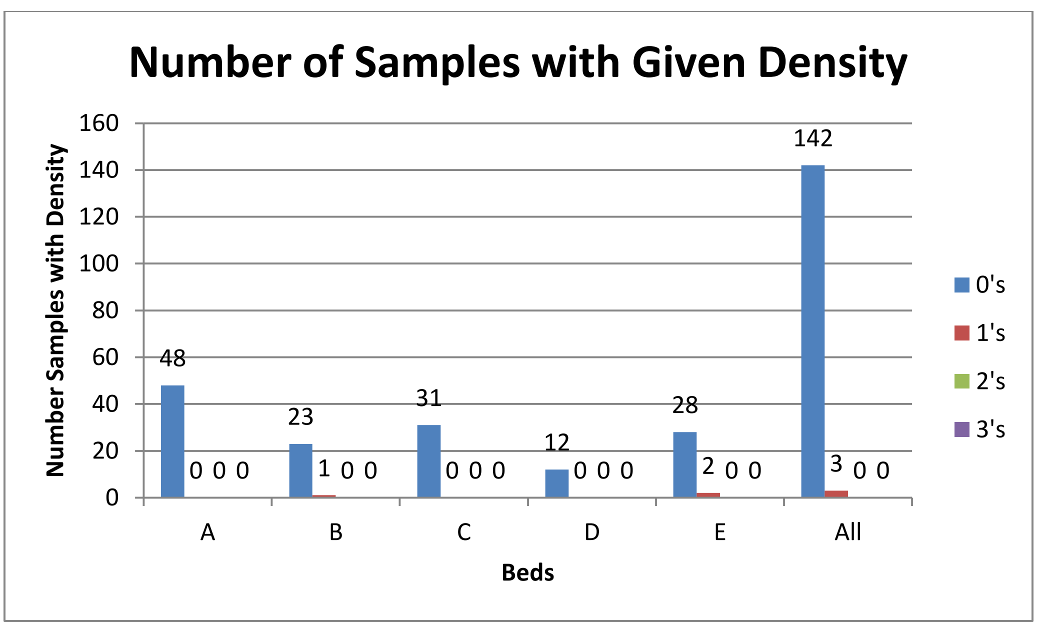


Figure 8: Graph showing density ratings by number of points with density ratings 0-3, 2014 post survey.

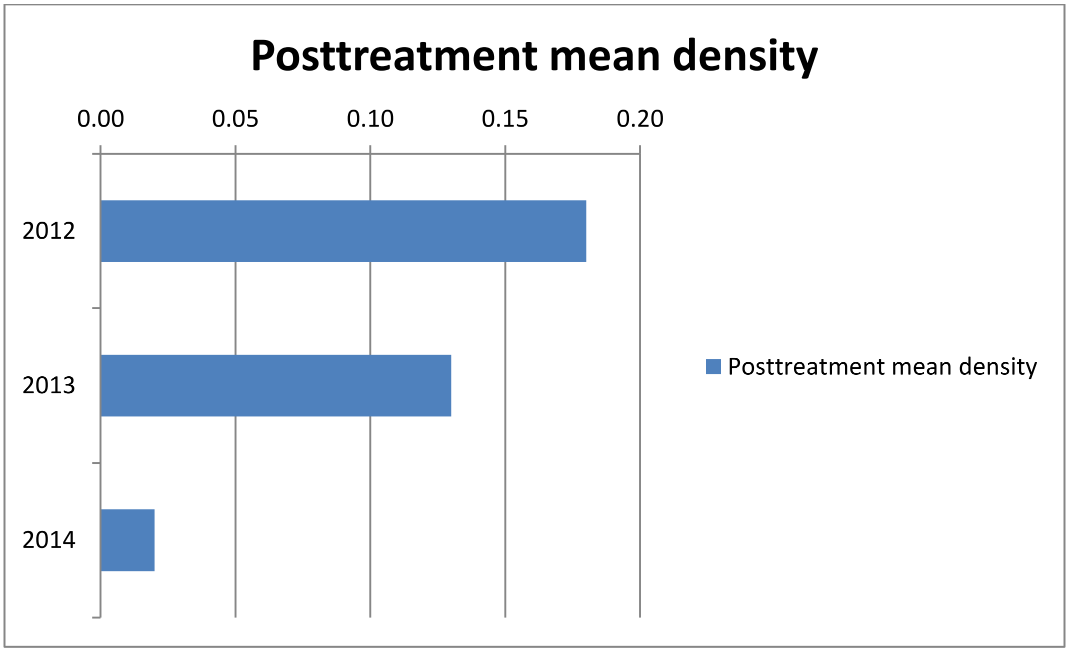


Figure 9: Comparison of post treatment mean density all beds, 2012-2014.

In addition to a frequency reduction, the mean density was also reduced. Figure 8 shows that only 3 samples of CLP occurred within the treatment beds, with all being a density of "1". Figure 9 shows that the mean density has declined since 2012, with a dramatic decline from 2013 to 2014.

Figures 10-13 show the maps of the pretreatment and post treatment surveys from 2013 and 2014. These maps indicate the presence of CLP before treatment each year and the density of CLP after treatment each year.

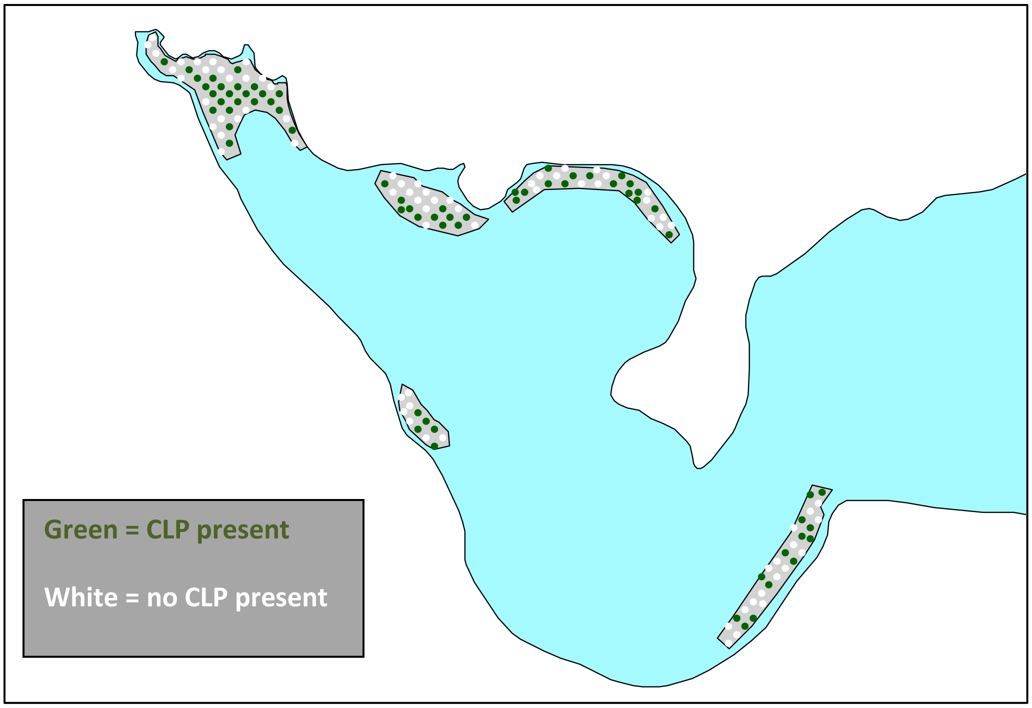


Figure 10: Pretreatment survey map, 2014

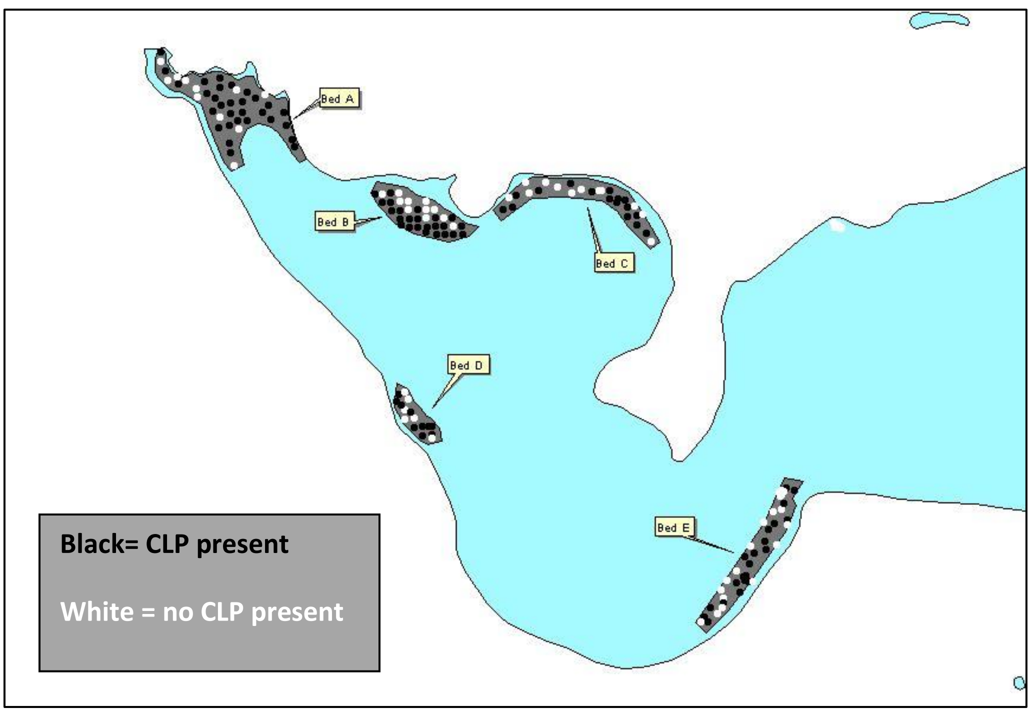


Figure 11: Pretreatment survey map, 2013.

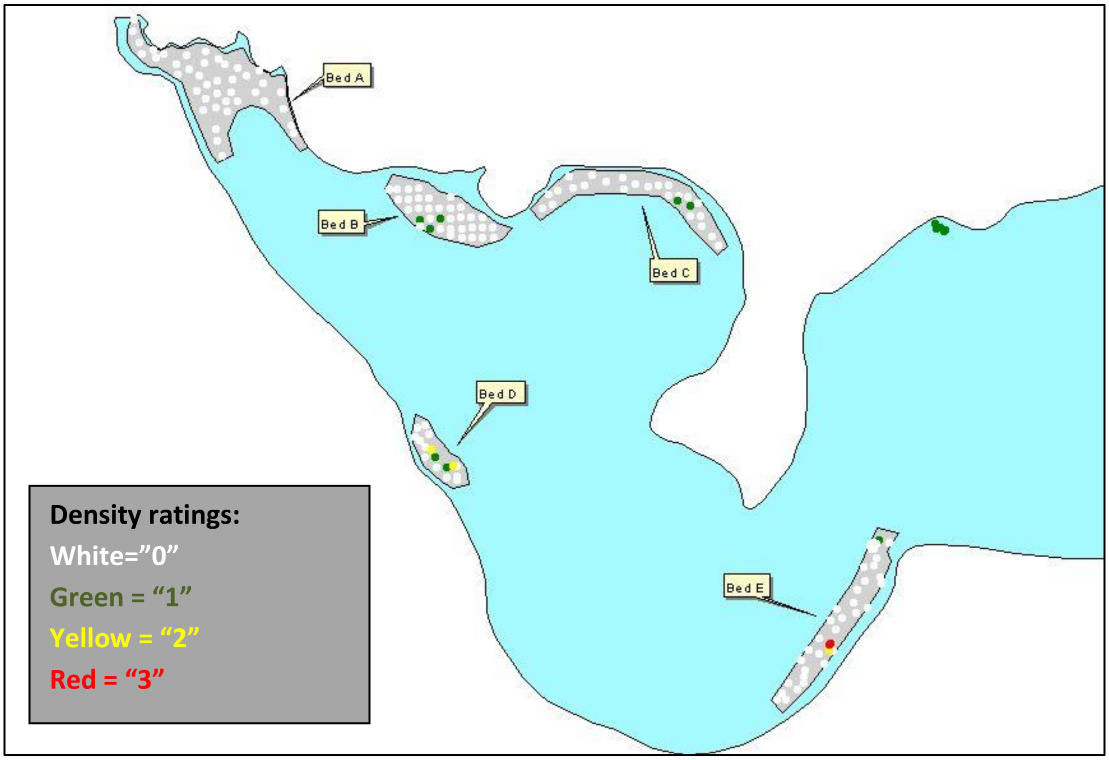


Figure 12: Post treatment survey map, 2013.

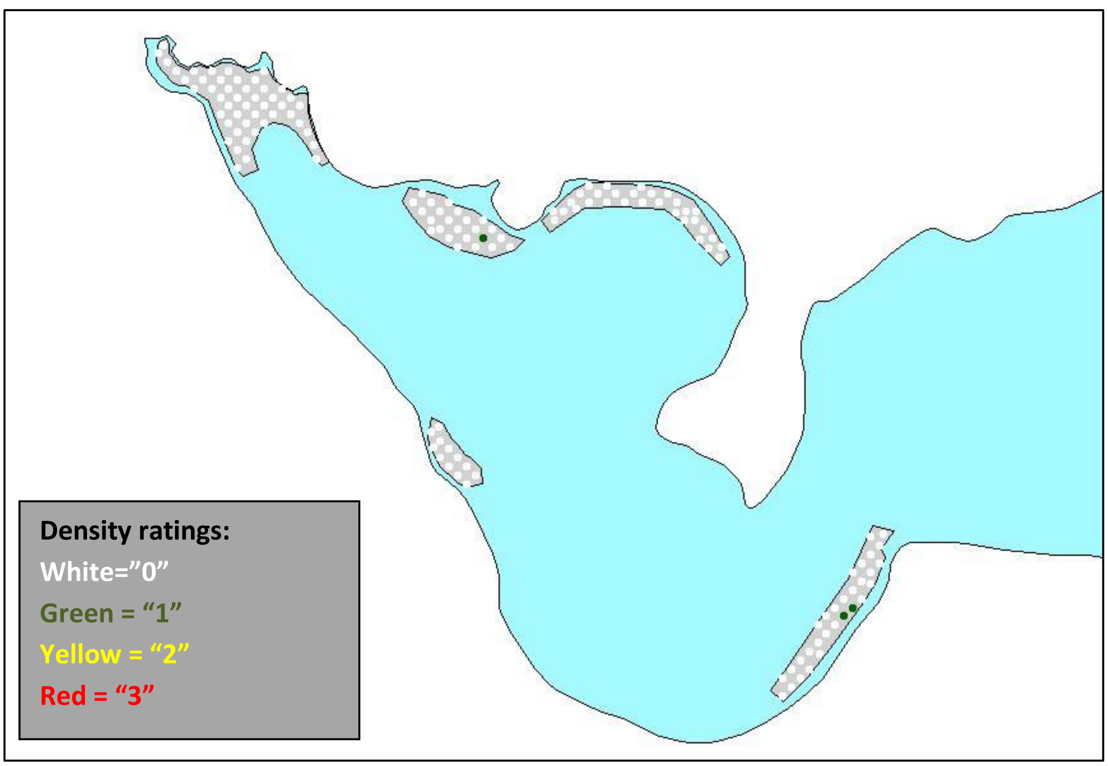


Figure 13: Post treatment survey map, 2014.

Native species	Frequency 2013	Frequency 2014	P value	Significant reduction	Change
Lemna trisulca,forked duckweed	**0.13**	**0.14**	**0.82**	**no**	**-**
Potamogeton. robbinsii, Fern pondweed	**0.00**	**0.01**	**0.30**	**no**	**+**
Potamogeton praelongus,White-stem pondweed	**0.22**	**0.13**	**0.045**	**yes**	**-**
Ceratophyllum demersum, Coontail	**0.65**	**0.66**	**0.67**	**n/a**	**+**
Myriophyllum sibiricum, Northern milfoil	**0.09**	**0.08**	**0.65**	**no**	**-**
Potamogeton richardsonii, Clasping pondweed	**0.03**	**0.09**	**0.02**	**n/a**	**+**
Vallisneria americana, Wild celery	**0.00**	**0.03**	**0.04**	**n/a**	**+**
filamentous algae	**0.58**	**0.65**	**0.19**	**n/a**	**+**
Elodea canadensis, elodea	**0.20**	**0.14**	**0.26**	**no**	**-**
Heteranthera dubia, water stargrass	**0.09**	**0.17**	**0.03**	**n/a**	**+**
Ranunculus aquatilis, stiff water crowfoot	**0.08**	**0.03**	**0.07**	**no**	**-**
Chara sp., muskgrasses	**0.03**	**0.02**	**0.77**	**no**	**-**
Nymphaea odorata, white lily	**0.05**	**0.03**	**0.64**	**no**	**-**
Stuckenia pectinata, sago pondweed	**0.00**	**0.03**	**0.04**	**n/a**	**+**
Potamogeton amplifolius-large leaf pondweed	**0.00**	**0.01**	**0.3**	**n/a**	**+**
Nitella sp., Stonewort	**0.01**	**0.00**	**0.33**	**no**	**-**
Lemna minor, Small duckweed	**0.01**	**0.00**	**0.33**	**no**	**-**
Potamogeton zosteriformis-Flatstem pondweed	**0.01**	**0.00**	**0.33**	**no**	**-**
*Bidens beckii,*Water marigold	**0.00**	**0.02**	**0.07**	**n/a**	**+**

Table 6: Native species frequency and chi-square analysis-2013 to 2014.

The native plant survey data shows a reduction in one native species, of which it was significant (*Potamogeton praelongis*-whitestem pondweed). There was also an increase in frequency of 7 (four were statistically significant) native species (filamentous algae is not considered). When considering the one significant reduction with the several increases in native species, it is valid to state that the herbicide did not have an adverse effect on the native species. The one reduction is likely due to seasonal variation. It is not definitive that it was not due to the herbicide, but the data is no cause for concern.

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 no CLP beds to delineate. The only places CLP was observed after treatment, were the three locations it was sample within the treatment beds. There is no CLP to map for 2014.

Turion Analysis

The turion density analysis shows moderate density remaining in Beds A,B and C. This is an indication that there is still the potential for dense CLP growth in the next year in many portions of most beds. The turion density was reduced in all beds from 2013 to 2014. In beds A, C and D, the reduction was small. In beds B and E, the reduction was large. The mean turion density in all beds was reduced from 88.8 turions/m^2 in 2013 to 52 turions/m^2 in 2014. This reduction supports effective treatment since the spring 2014 CLP growth was from germinated turions. If the CLP is killed prior to turion development, then no new turions will be added that year. Continued successful treatment should result in annual reductions in turions, thus reflecting long-term CLP reduction.

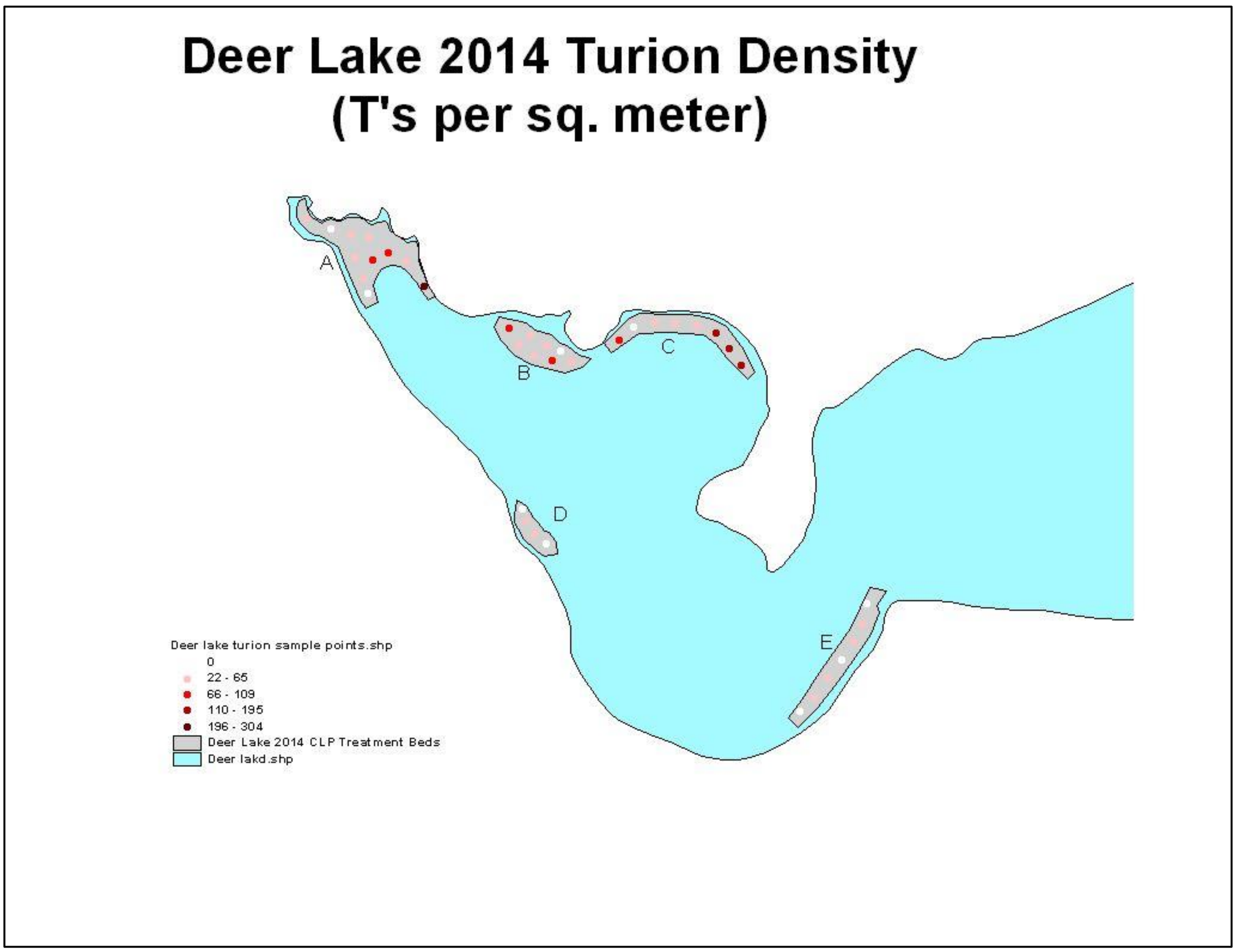
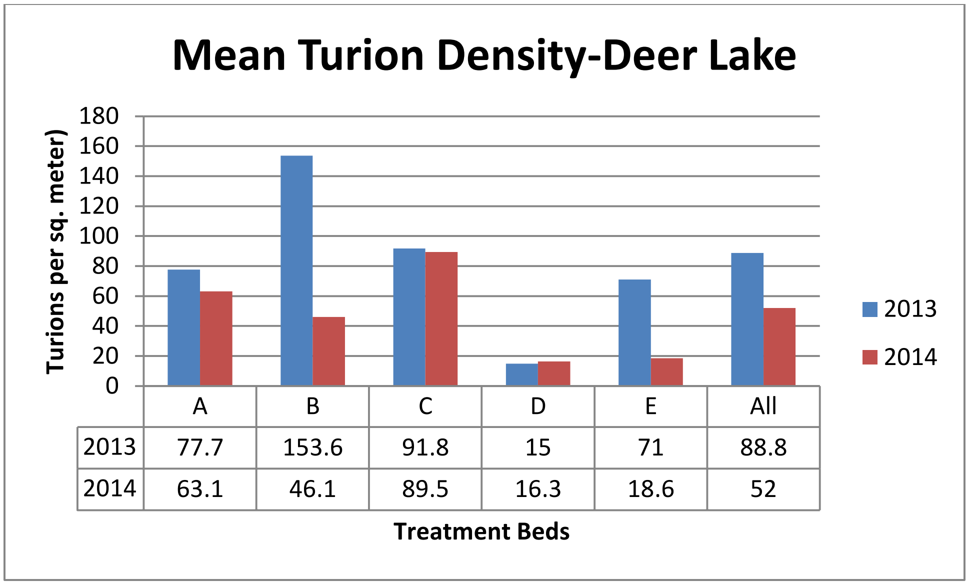


Figure 14: Map of turion density at each turion sample point within each treatment bed-2014.



	A	B	C	D	E	All
2013	77.7	153.6	91.8	15	71	88.8
2014	63.1	46.1	89.5	16.3	18.6	52

Figure 15: Graph and data of mean turion density within each treatment bed and all beds combined-2013 and 2014.

Discussion

The 2014 CLP herbicide treatment was very successful. The frequency of occurrence of CLP was significantly reduced in each bed of CLP treated. When comparing the frequency of CLP just before treatment (pre -treatment survey 2014) it was much higher than after treatment (post treatment survey 2014). The reduction was substantial, with an overall frequency reduction of 44.8%. See figure 6 for graphic representation.

When comparing the post treatment frequency in 2013 to the post treatment frequency in 2014, there was a smaller change, but it too was statistically significant. This shows that overall reduction was achieved. Since the treatment in 2013 was also very effective, the post treatment frequency in 2013 was very low, thus giving little room for improvement. However, the pretreatment frequency in early spring 2014 shows that the beds filled back in with CLP due to turion germination. There was also density reduction from 2013 to 2014. Density is not determined in the pretreatment survey so that is not comparable.

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. The pretreatment frequency in 2014 was significantly reduced from the pretreatment frequency of 2013 (17% reduction), further demonstrating successive effective treatments.

The five beds that are being treated total 23.4 acres based upon their original areal coverage. If the areal coverage is estimated using the frequency on CLP in the pretreatment survey 2014, the area of the five beds totals approximately 10.65 acres. This is a 54.5% decrease in CLP coverage. Figure 14 shows this change graphically and demonstrates a successful reduction in CLP coverage.

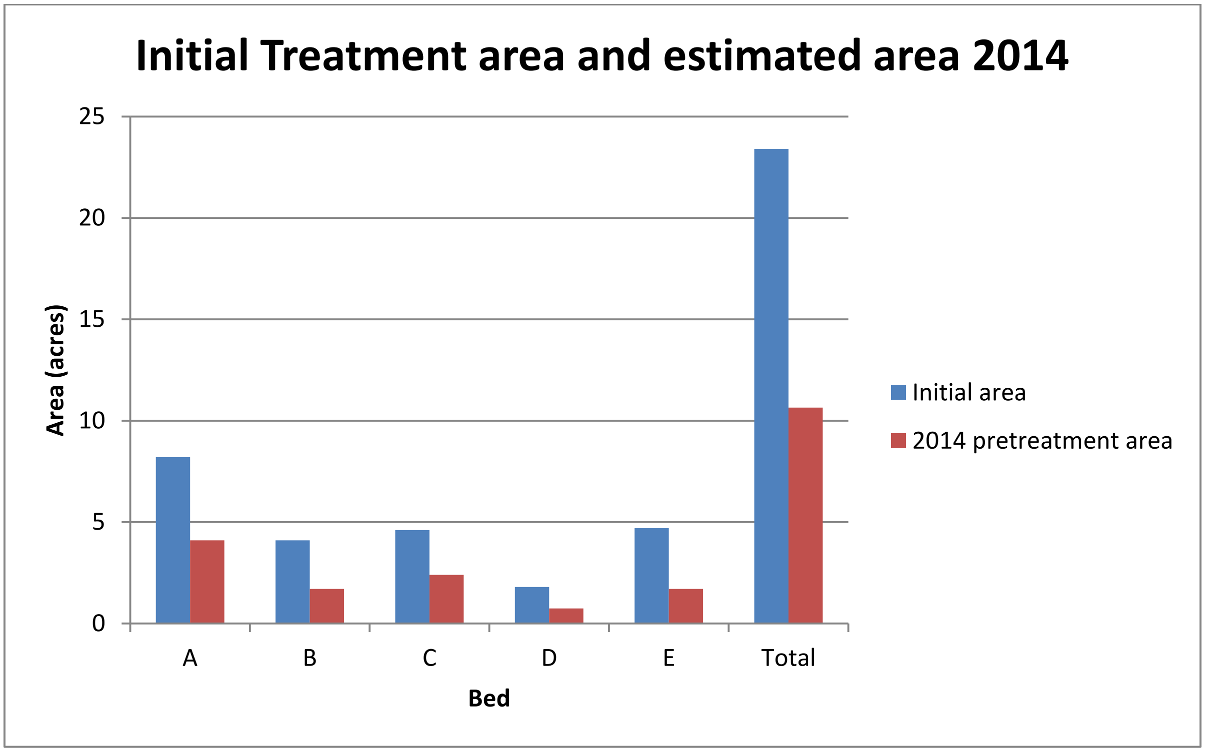


Figure 14: Estimated areal coverage from 2014 pretreatment survey compared to the original areal coverage of each bed and all beds combined (total).

The native plant species did show a reduction in one species (*Potamogeton praelongis*-white-stem pondweed). However, this could be due to seasonal variation since there was an increase in the frequency of 7 native species. If the herbicide had an effect on the native plants, one would assume others species would be affected.

The turion density decreased a fairly large amount from 2013 to 2014 (88.8 to 52 turions/m^2). This supports long-term CLP reduction.

Reduction in CLP in the treatment beds is progressing very well. Continued treatments should continue to reduce the CLP growth and turion density. A spring, pretreatment survey should be used to determine the treatment area in 2015.

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.

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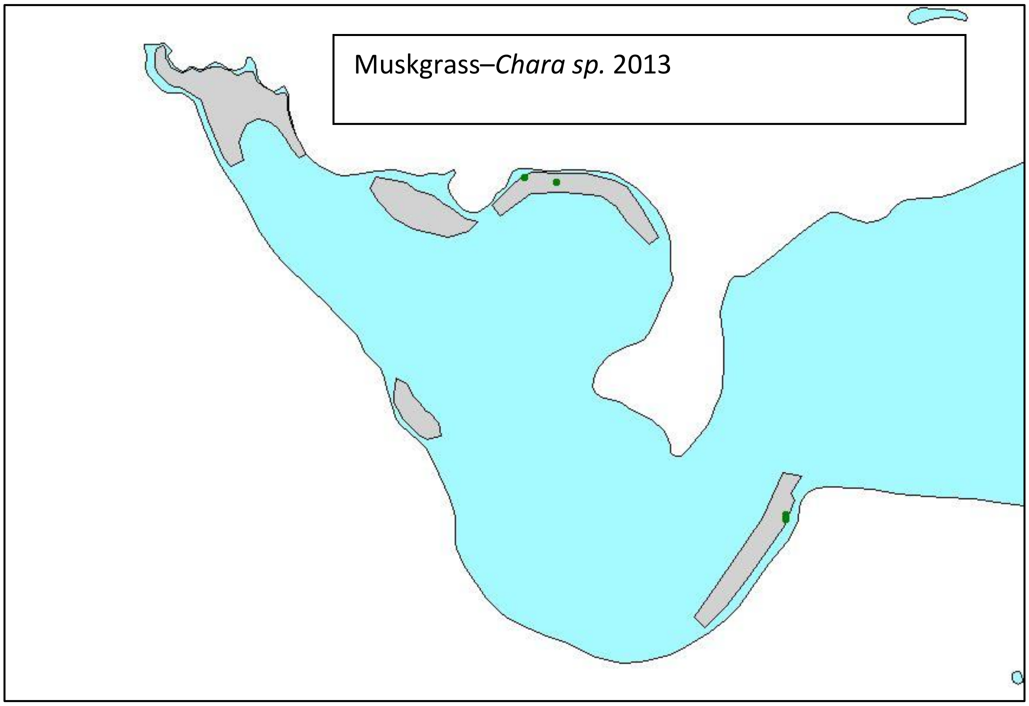
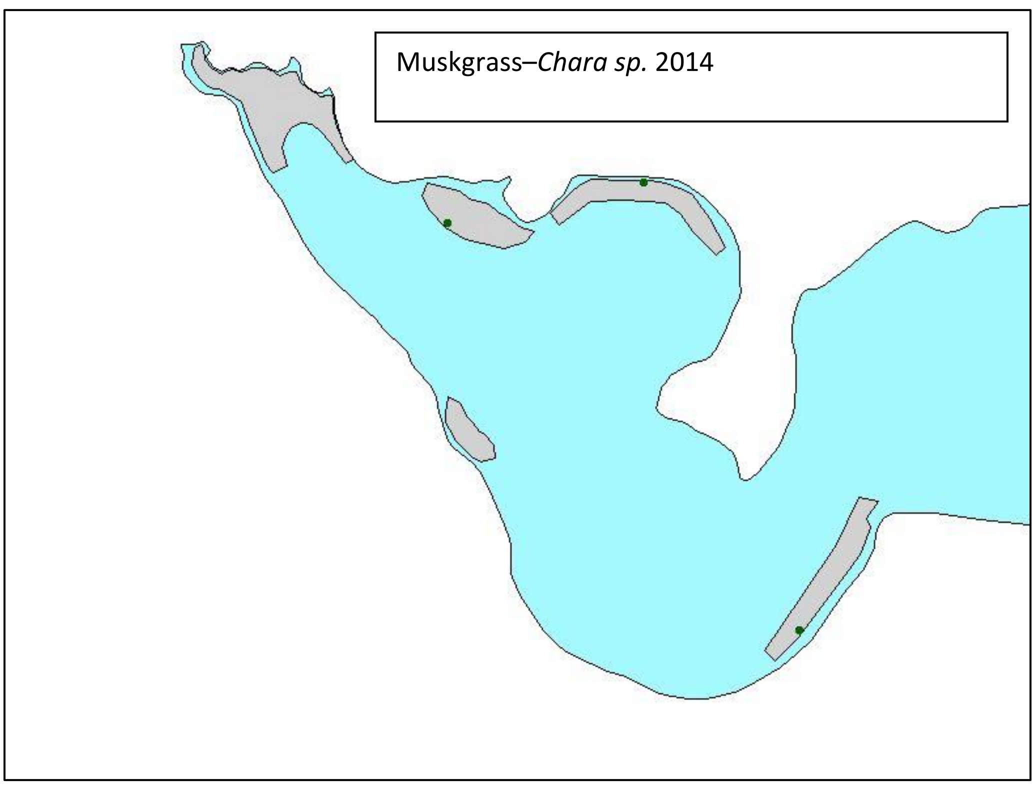
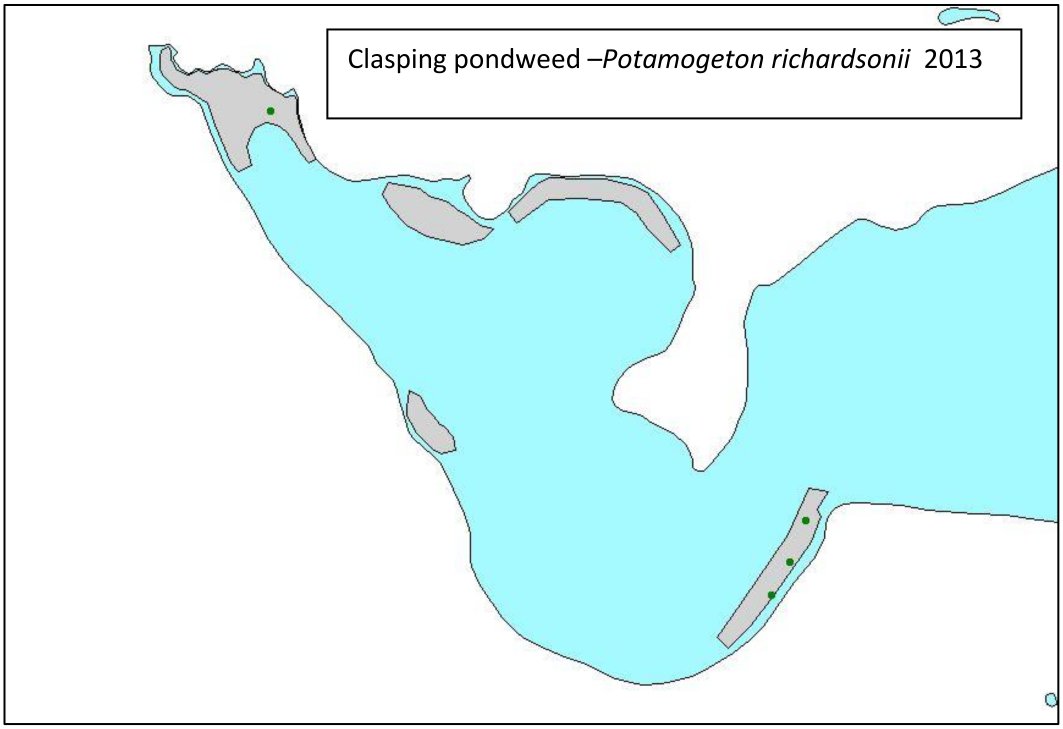
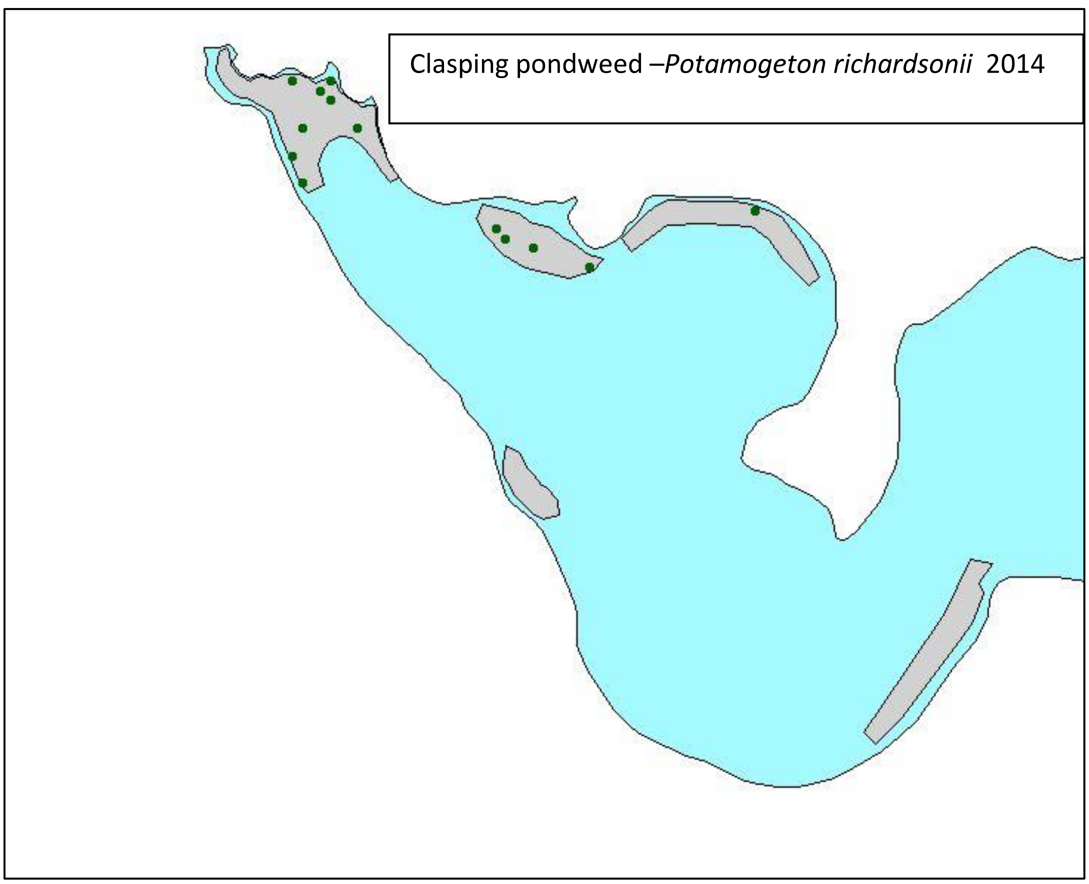
UW-Extension. Aquatic Plant Management website. http://www4.uwsp.edu/cnr/uwexlakes/ecology/apmguide.asp appendix d.

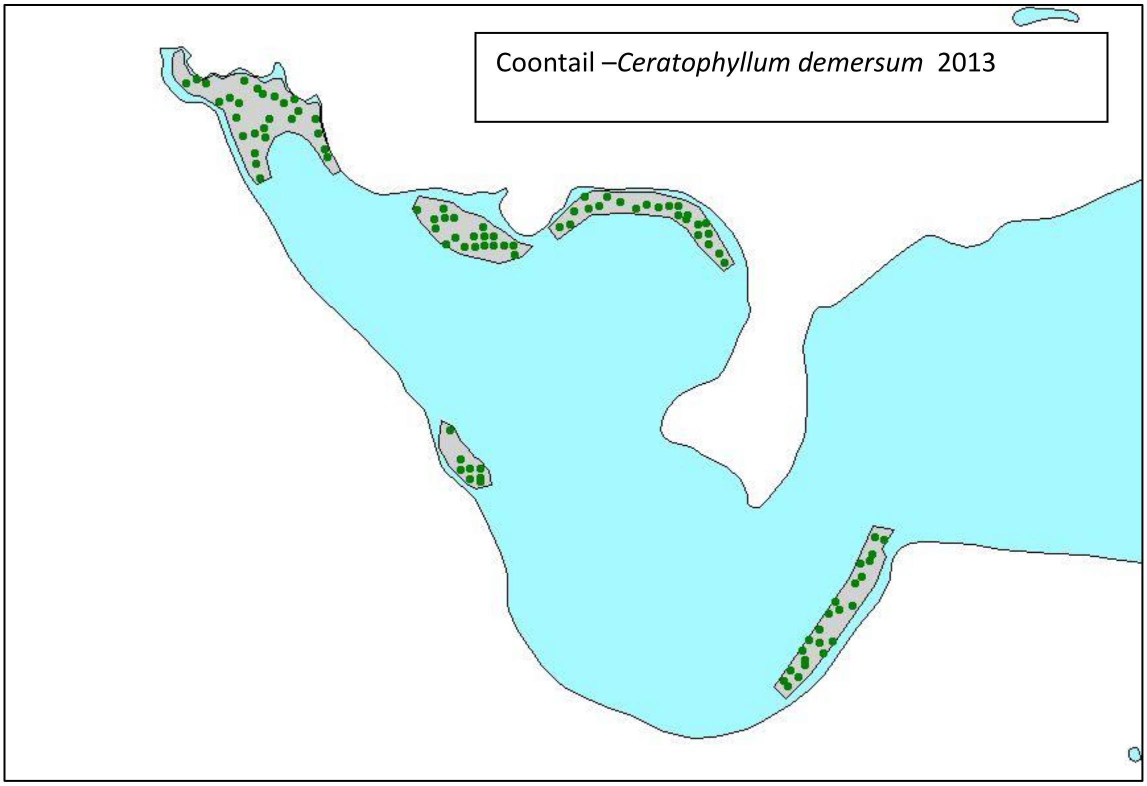
Appendix-Native plant maps from 2013 and 2014.

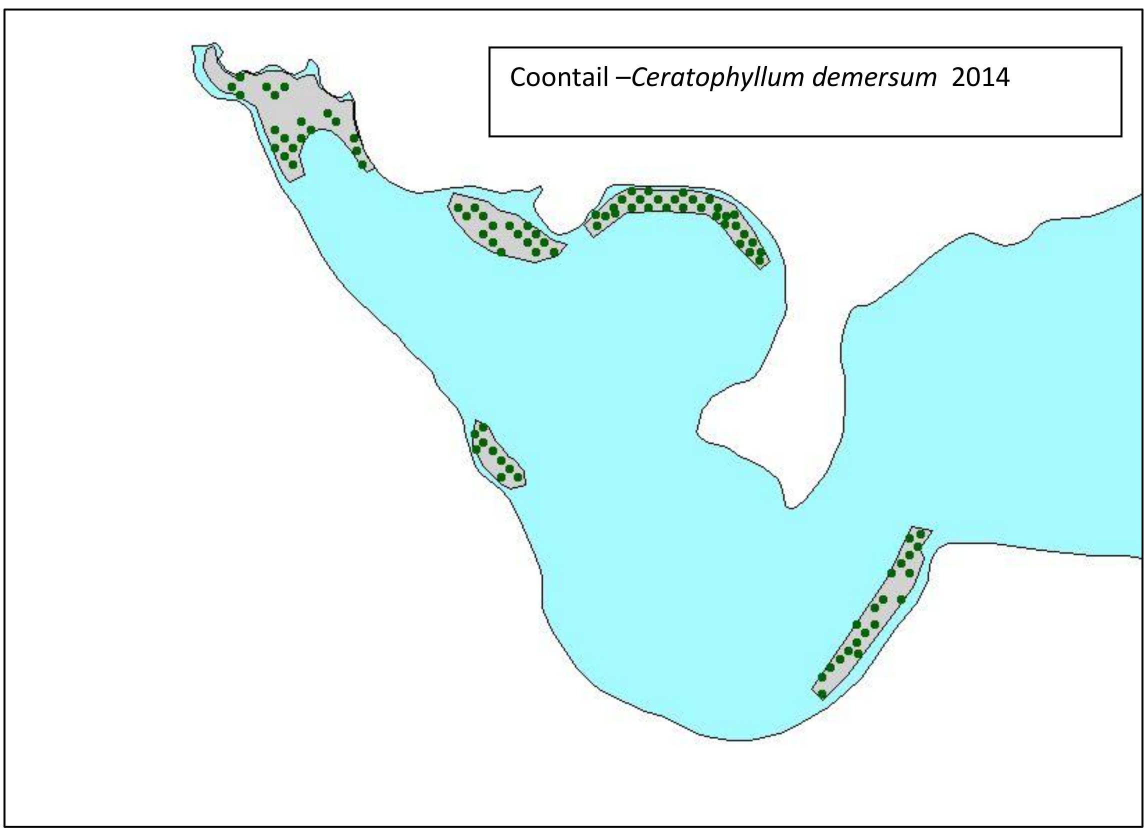


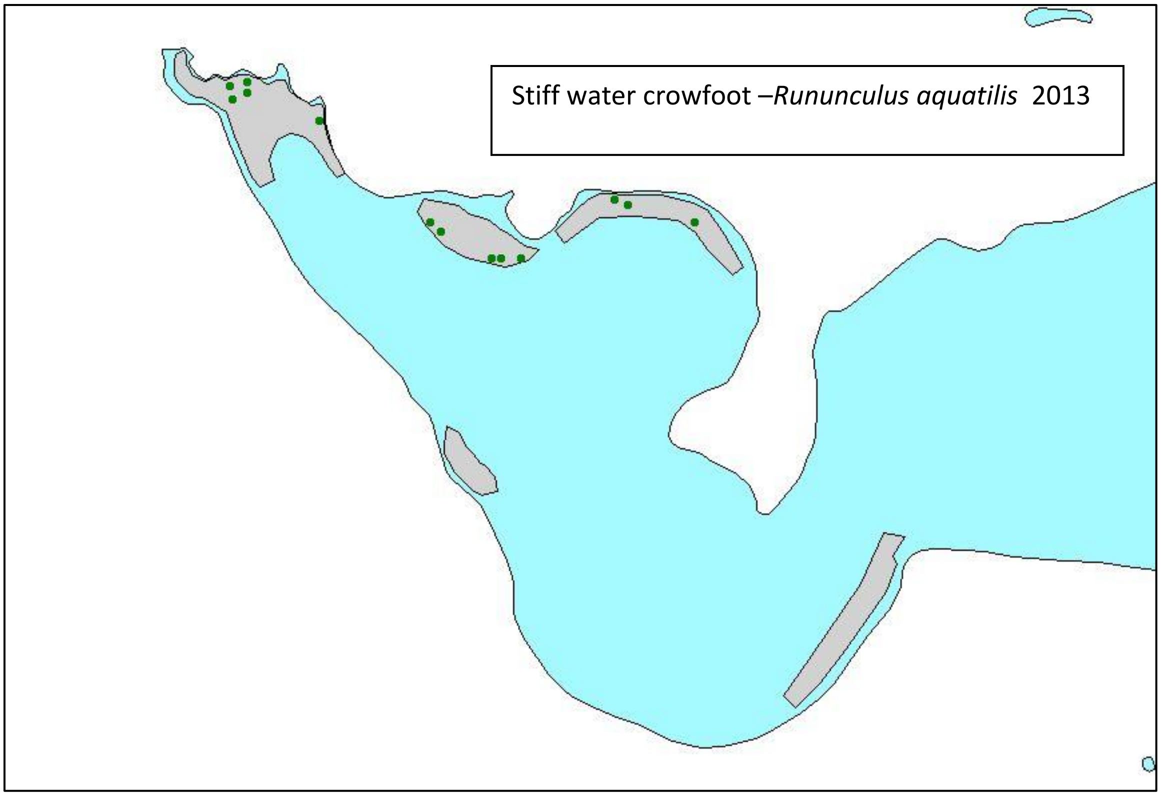


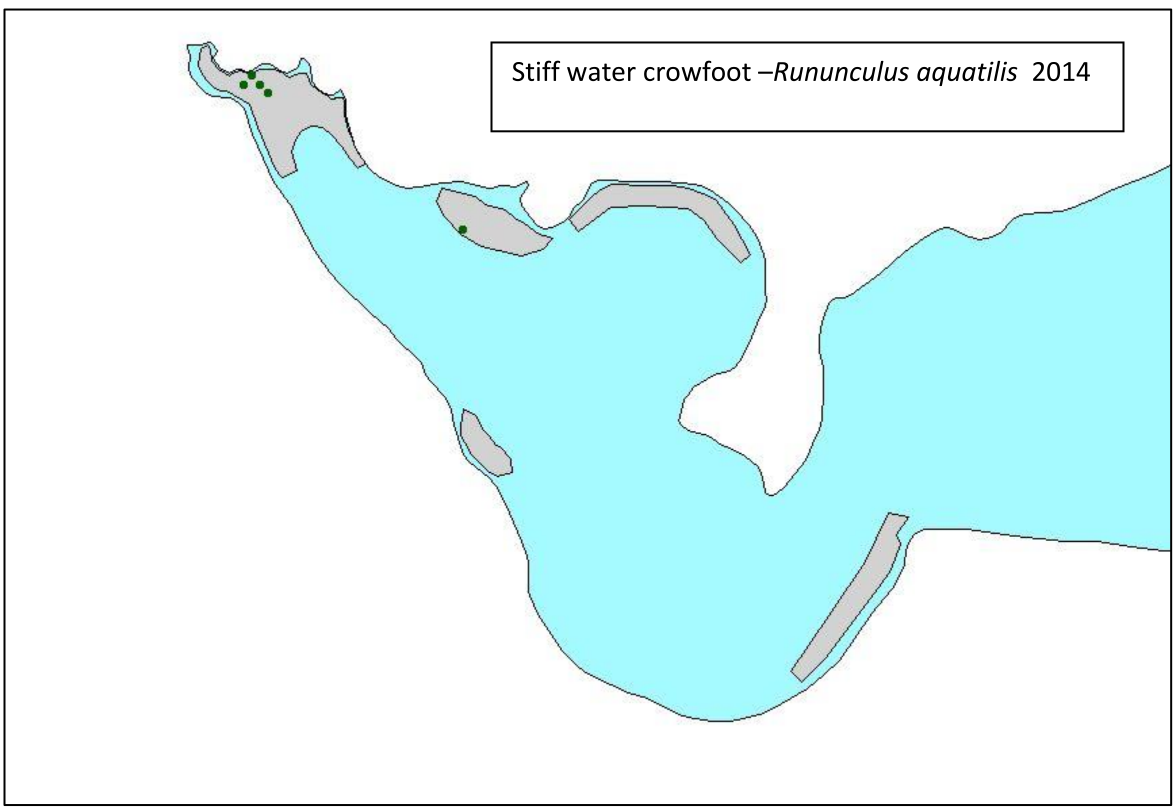

Clasping pondweed –*Potamogeton richardsonii* 2013

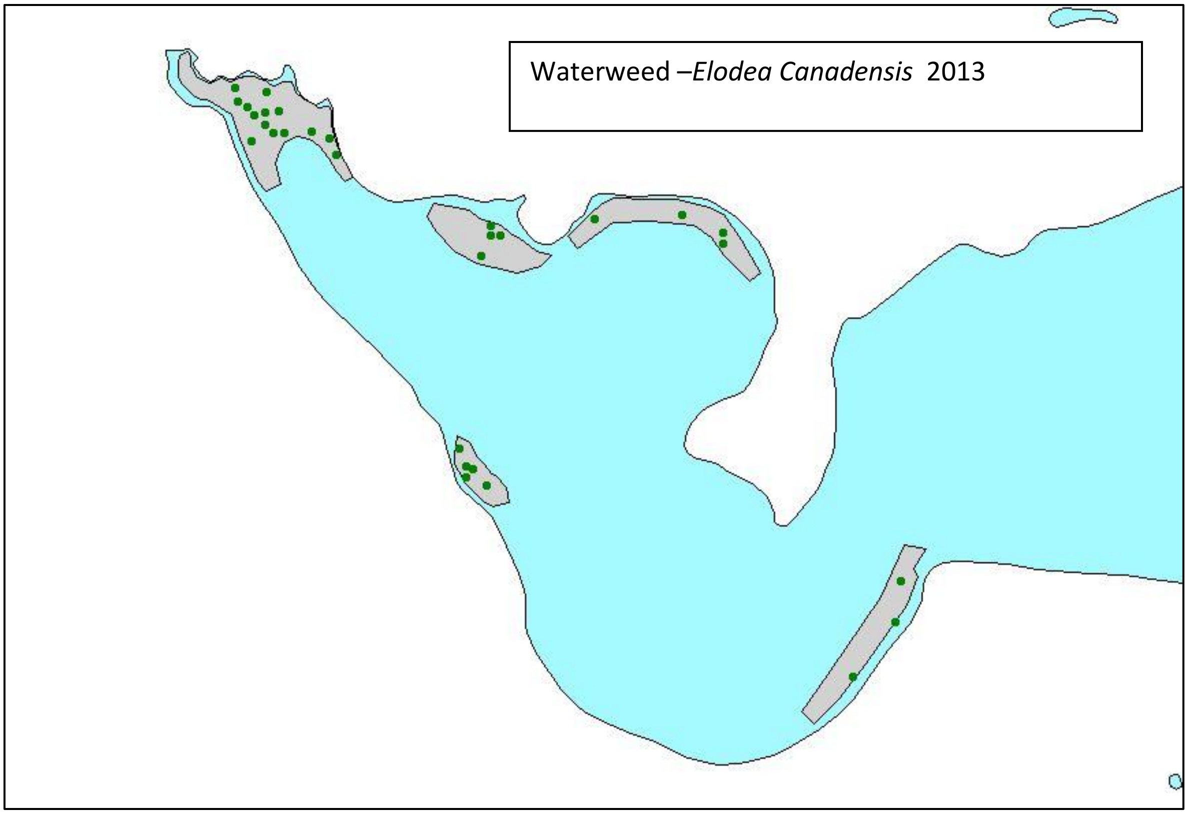

Clasping pondweed –*Potamogeton richardsonii* 2014

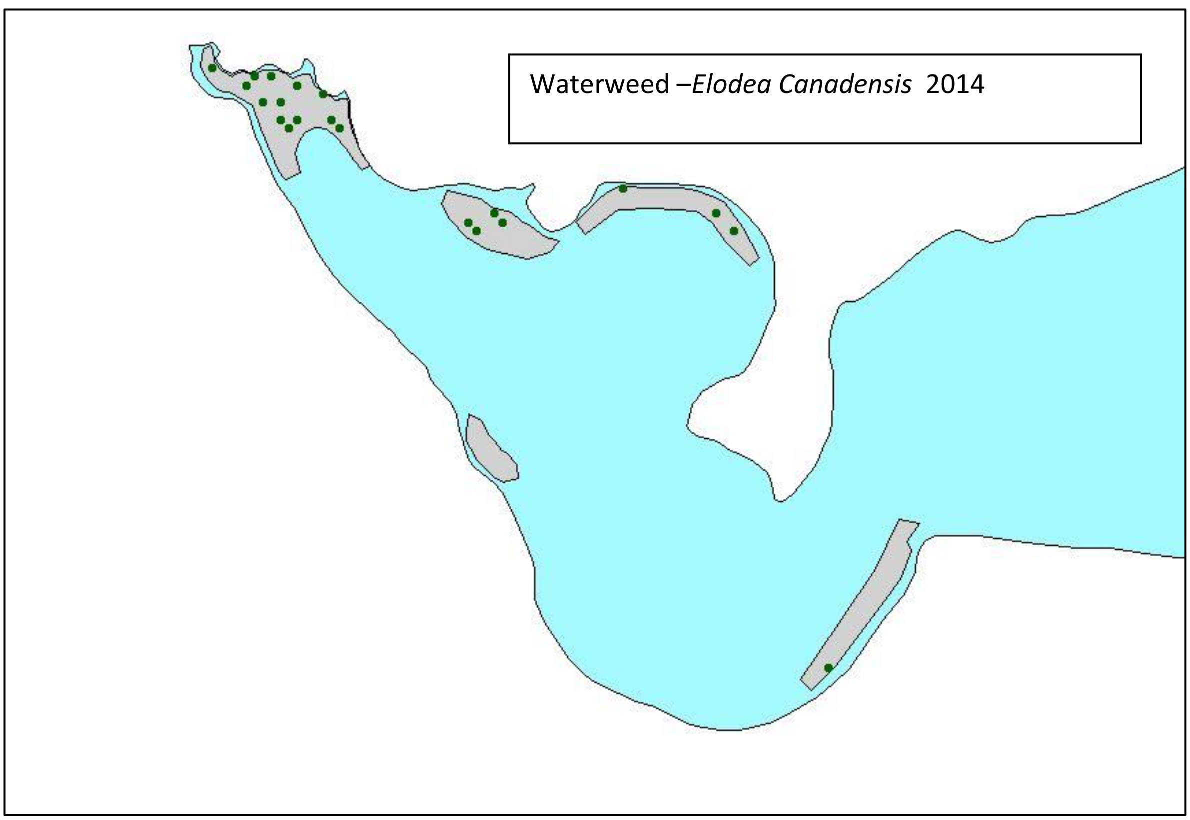

Coontail –*Ceratophyllum demersum* 2013

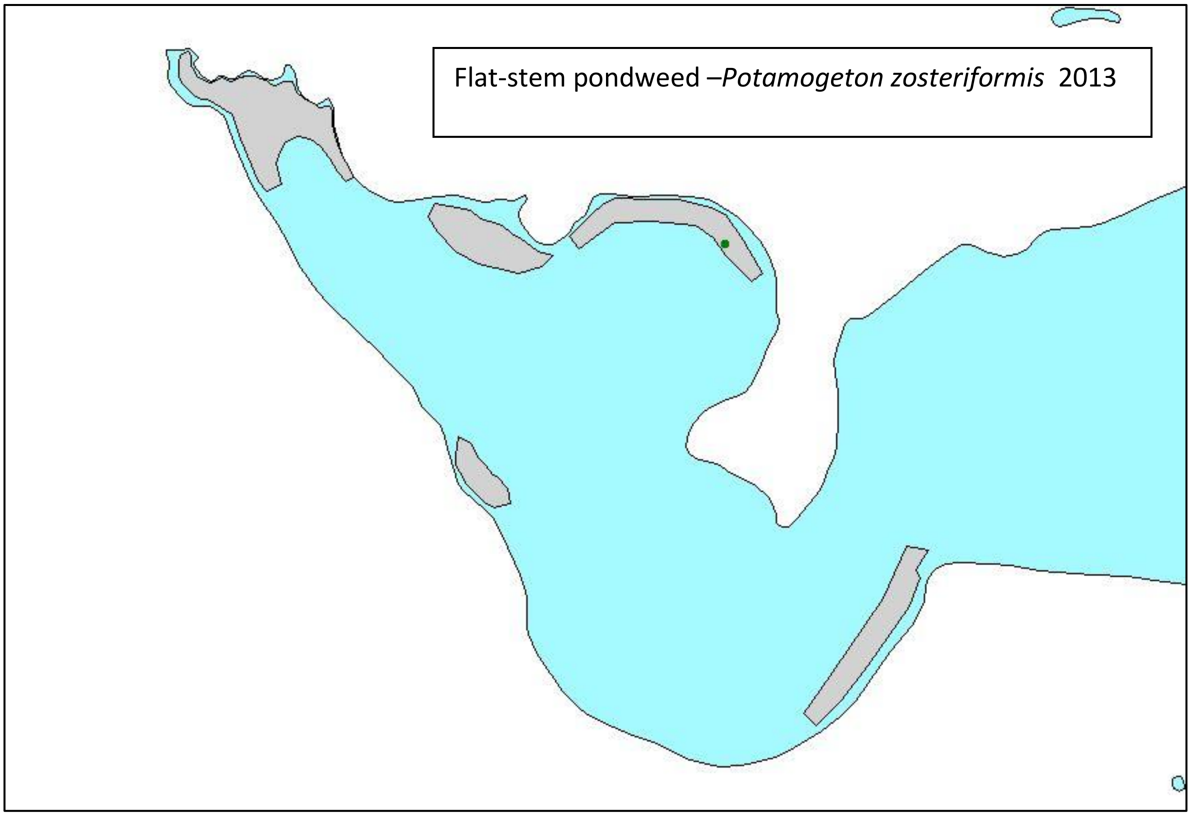

Coontail –*Ceratophyllum demersum* 2014


Stiff water crowfoot –*Rununculus aquatilis* 2013

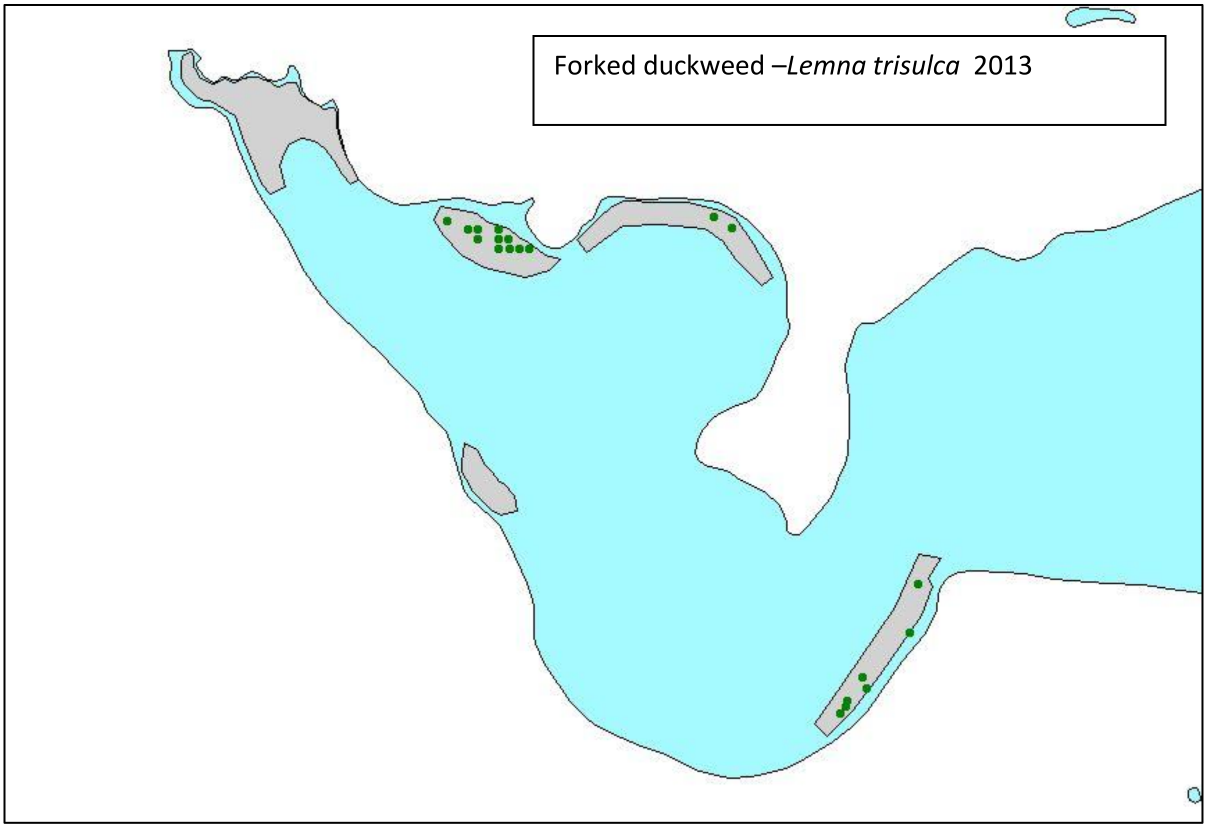

Stiff water crowfoot –*Rununculus aquatilis* 2014

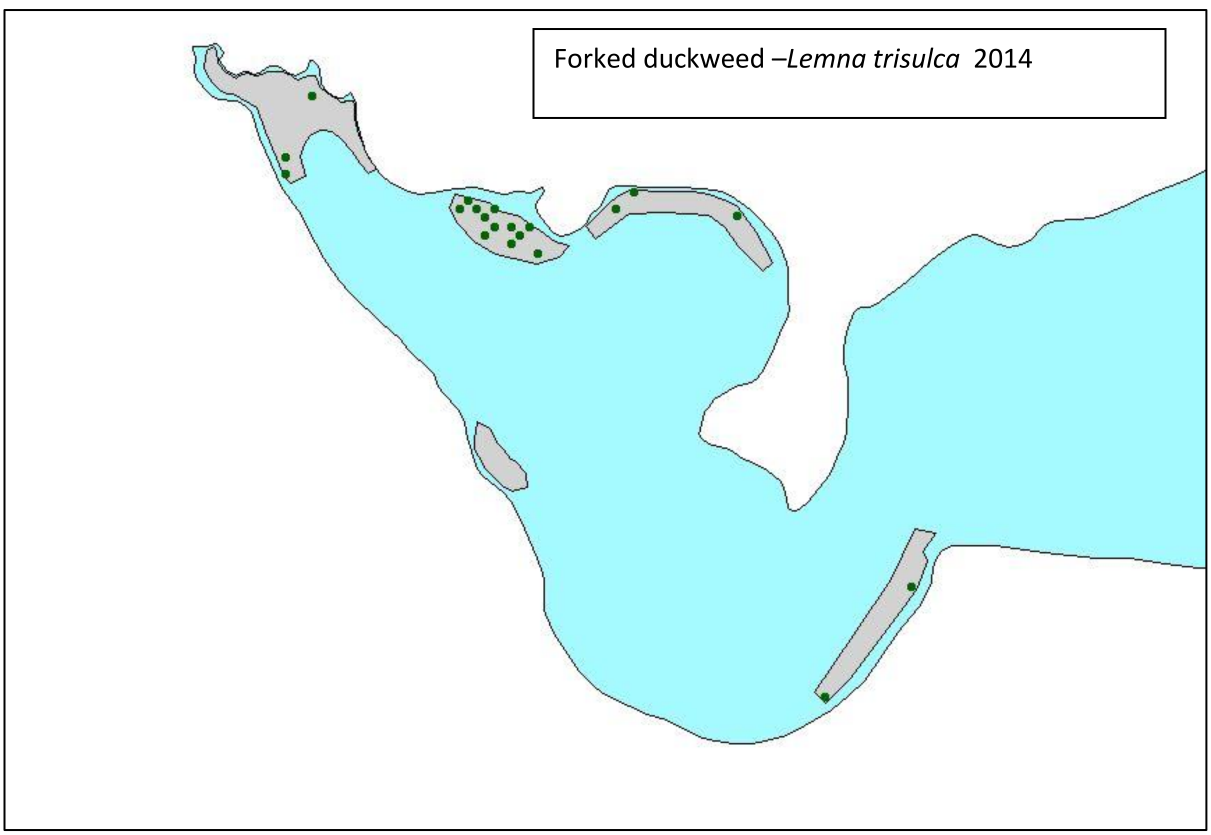

Waterweed –*Elodea Canadensis* 2013

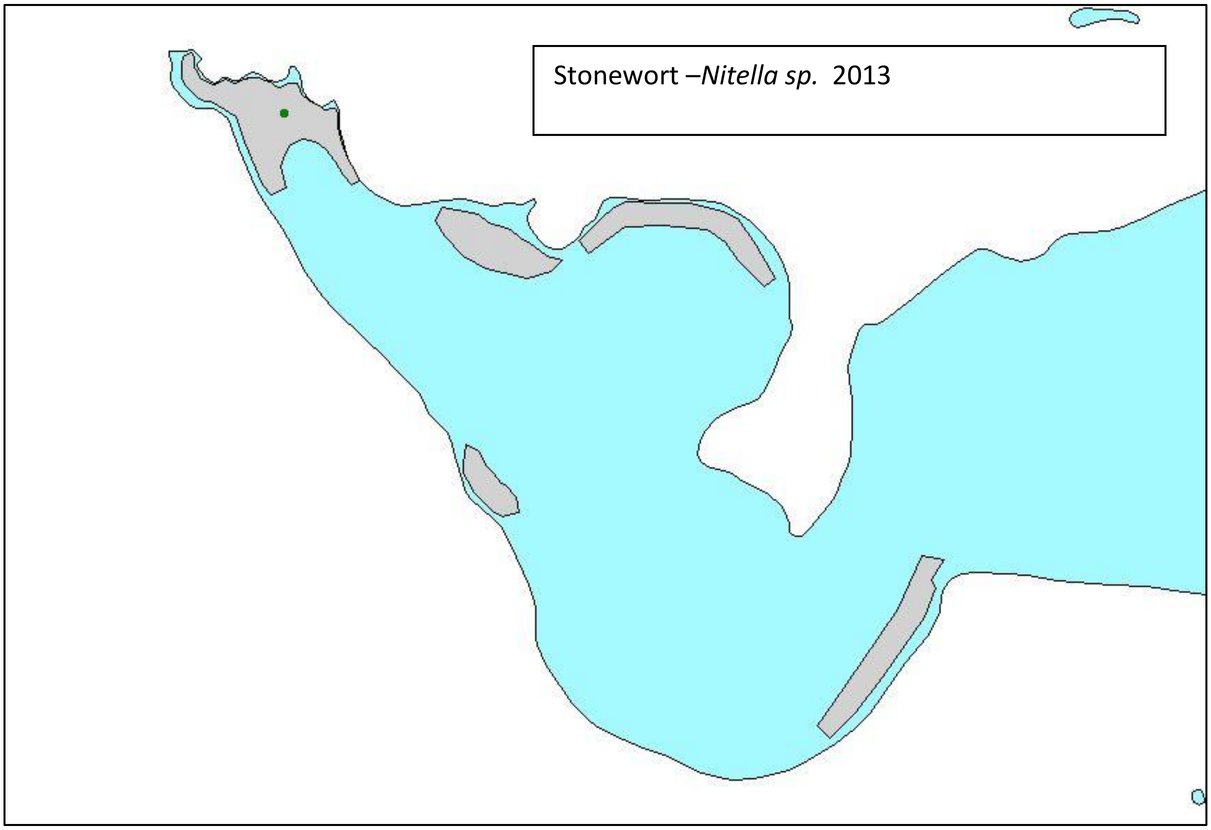

Waterweed –*Elodea Canadensis* 2014



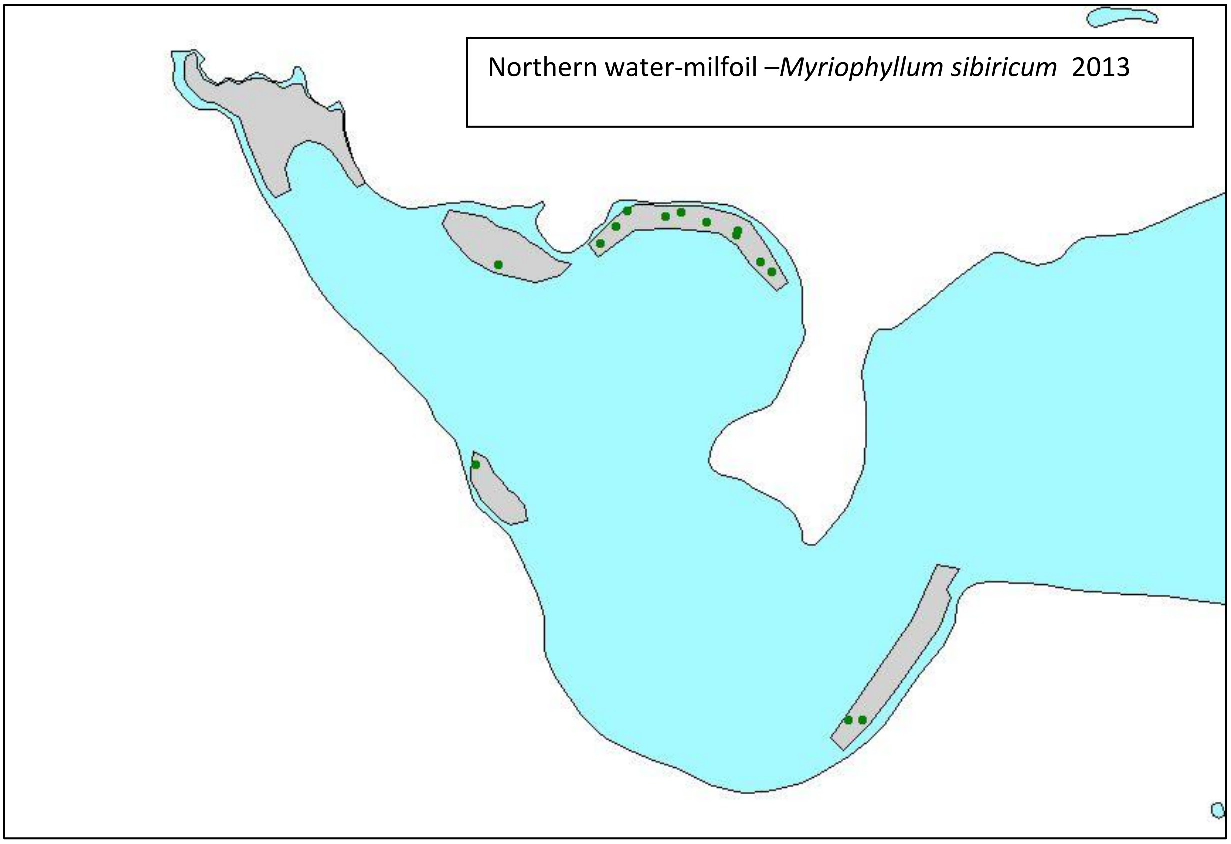
Flat-stem pondweed not present in 2014.

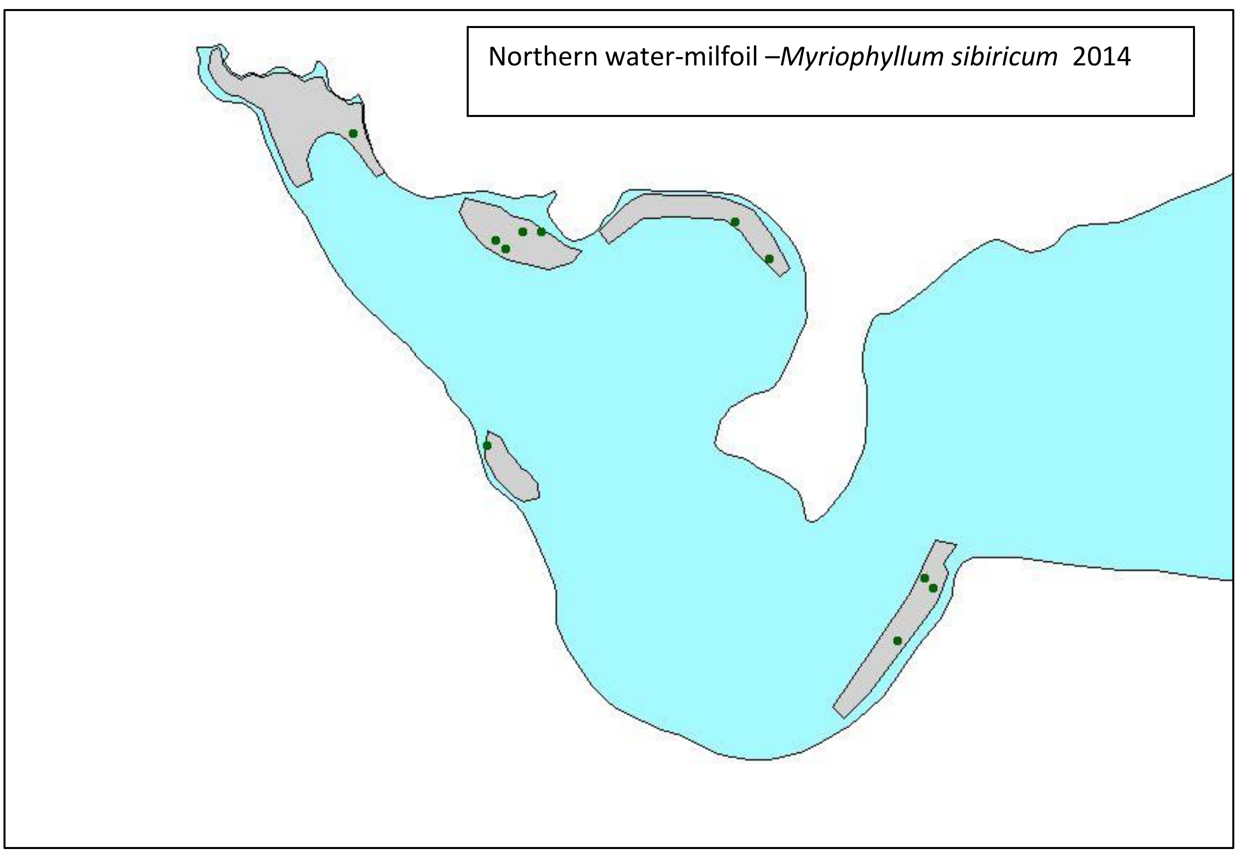

Forked duckweed –*Lemna trisulca* 2013

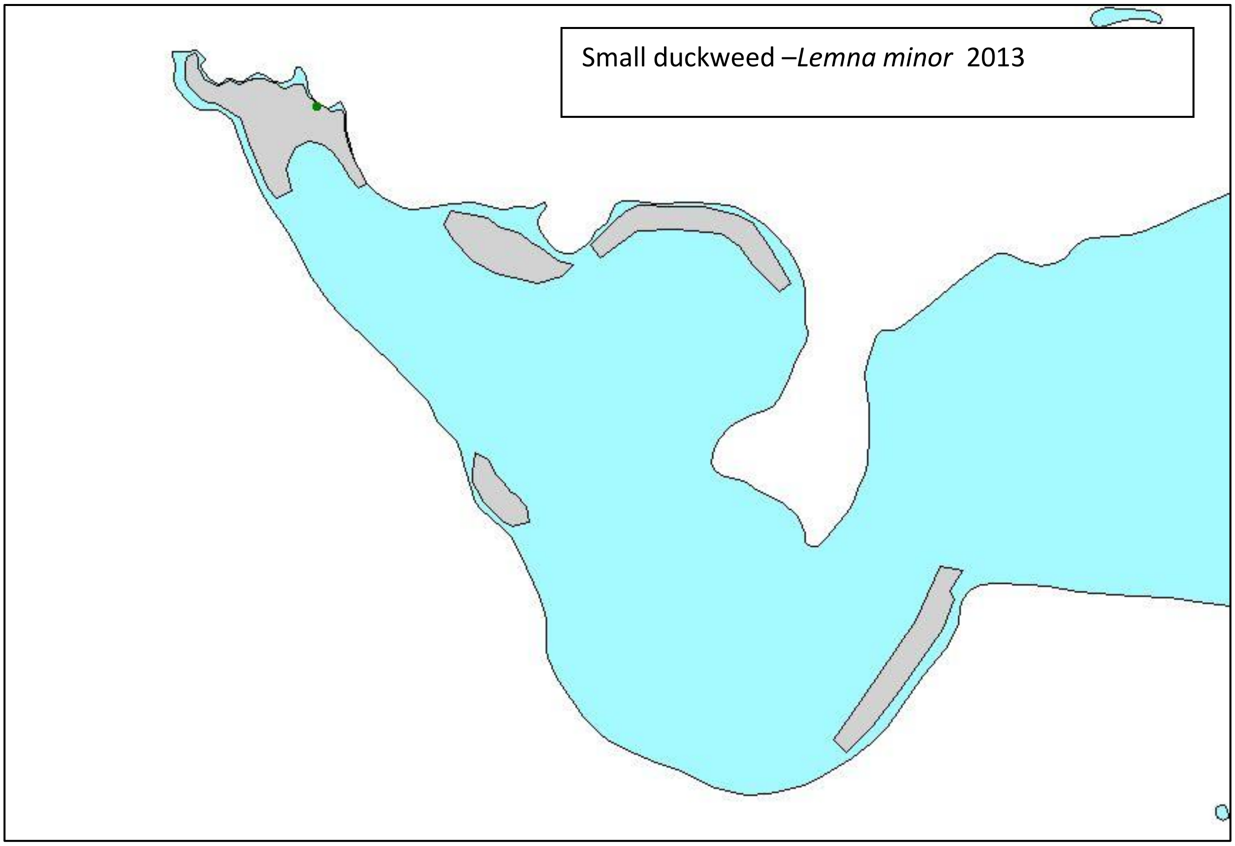

Forked duckweed –*Lemna trisulca* 2014



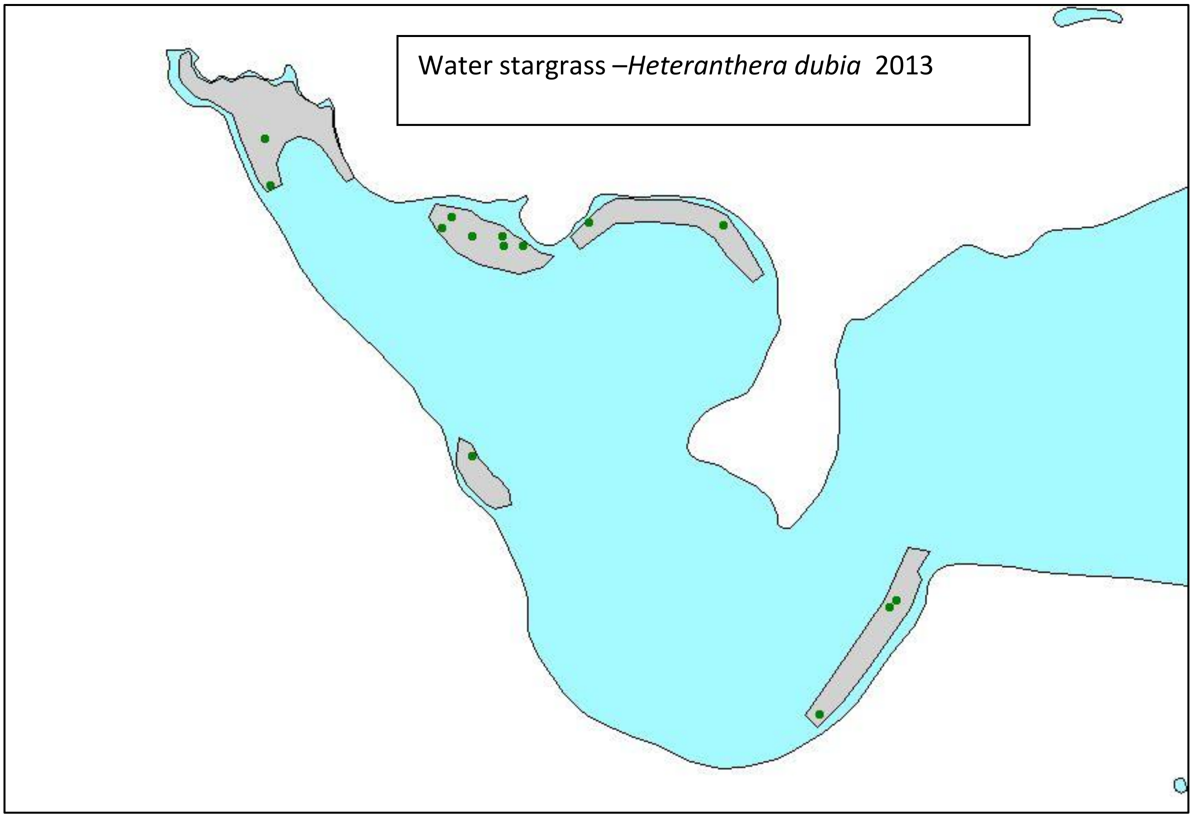
Nitella sp. not present in 2014

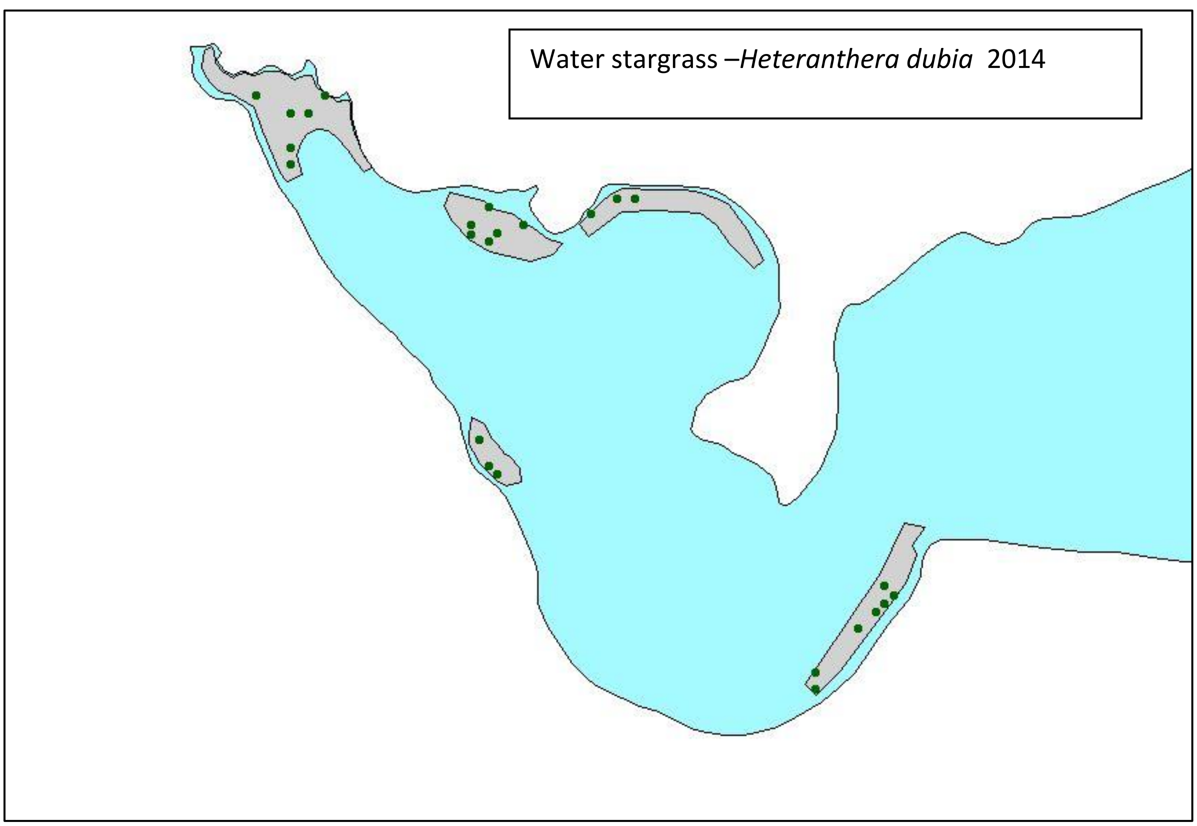

Northern water-milfoil –*Myriophyllum sibiricum* 2013

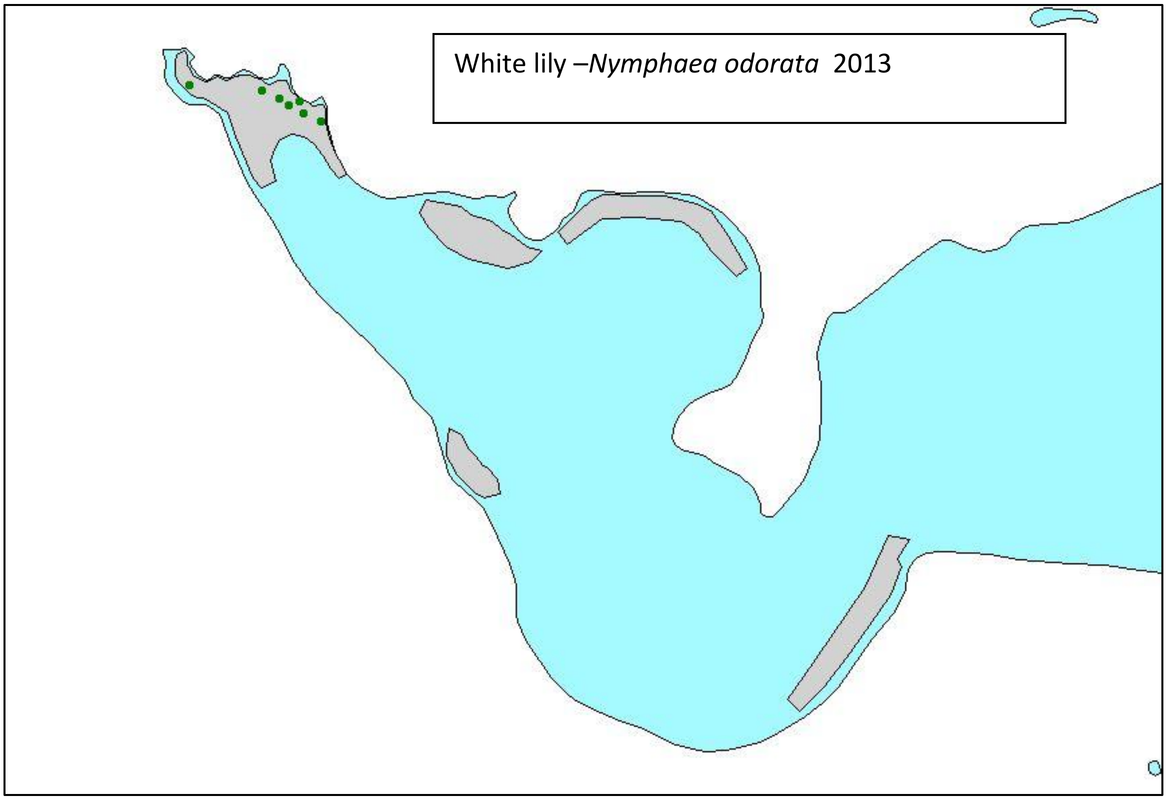

Northern water-milfoil –*Myriophyllum sibiricum* 2014

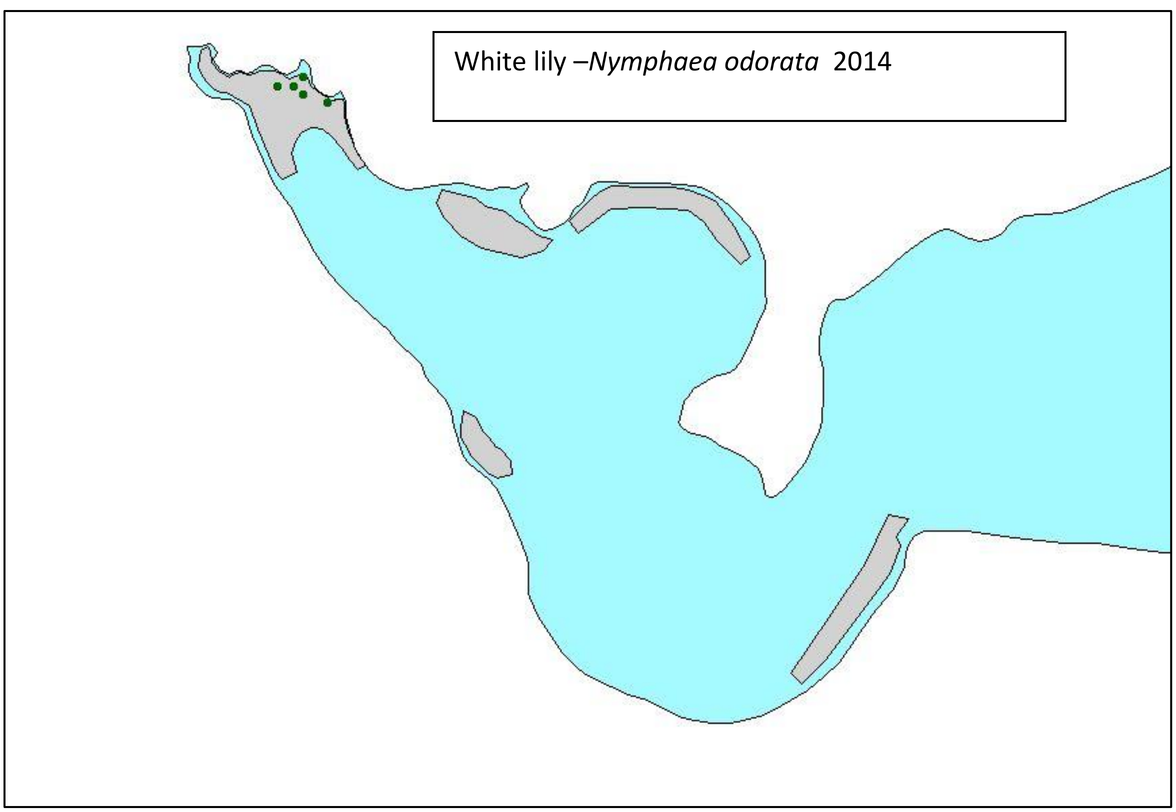


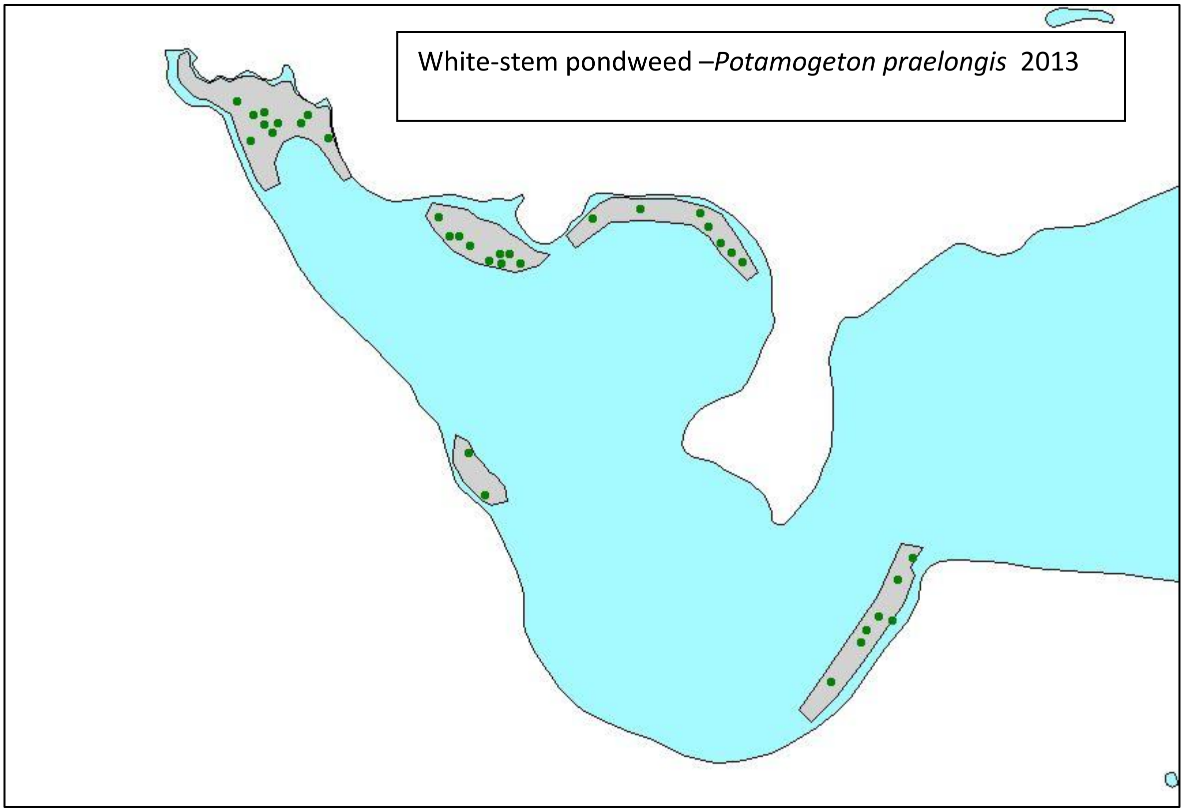
Small duckweed not present in 2014.

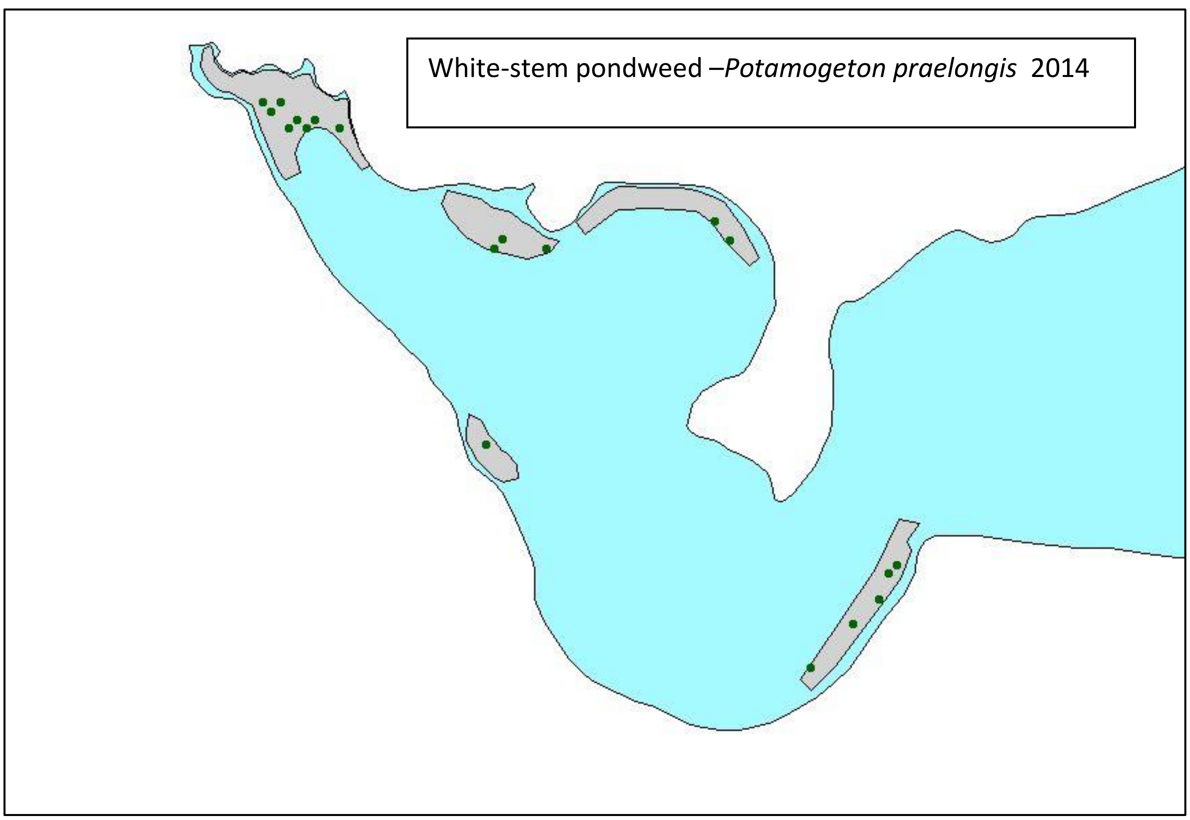

Water stargrass –*Heteranthera dubia* 2013

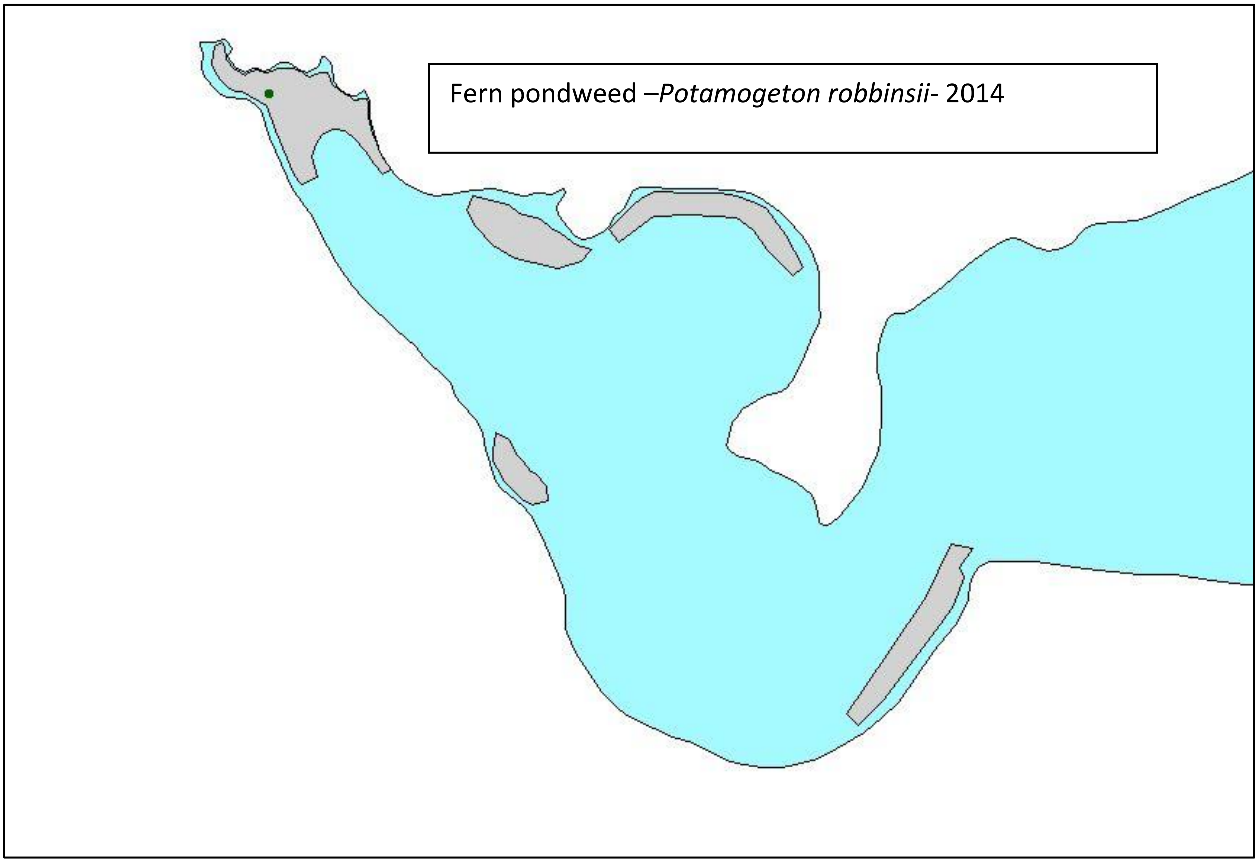

Water stargrass –*Heteranthera dubia* 2014


White lily –*Nymphaea odorata* 2013

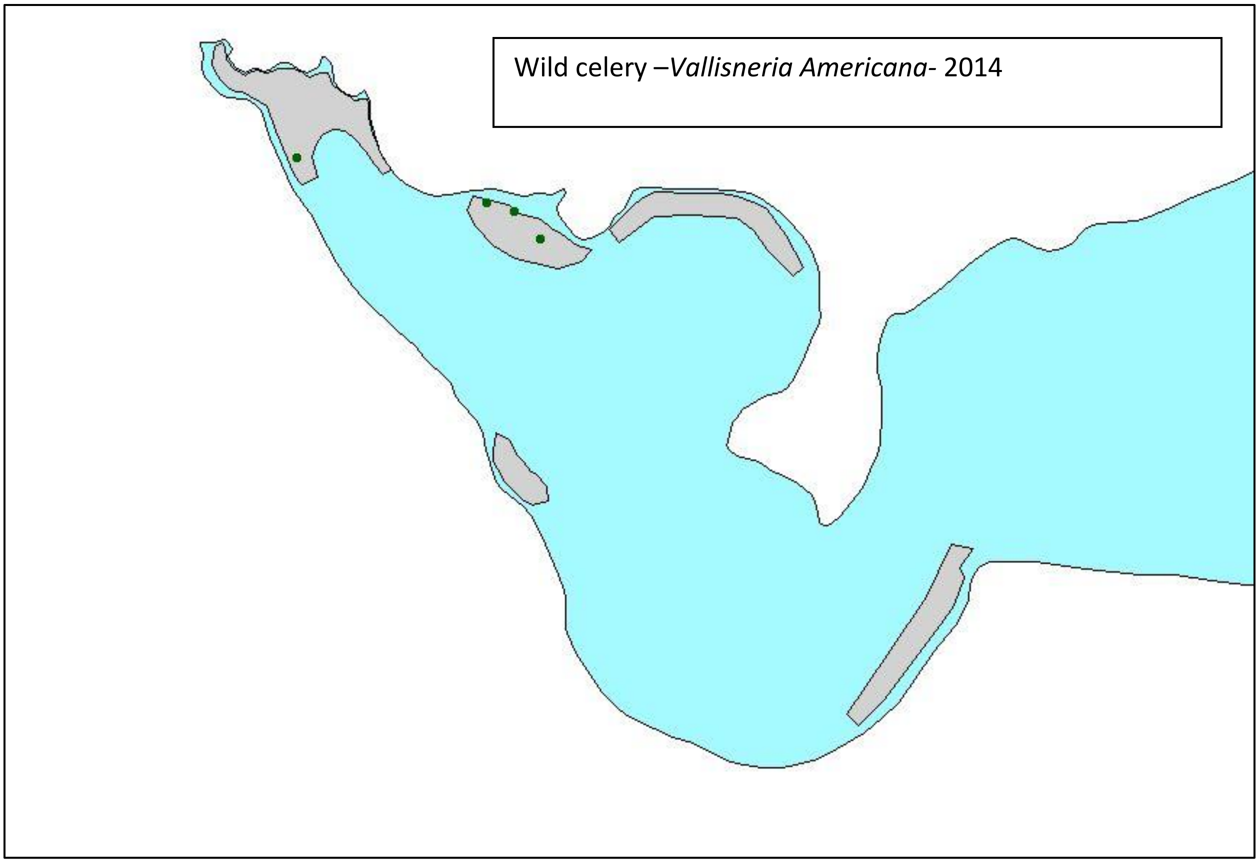

White lily –*Nymphaea odorata* 2014


White-stem pondweed –*Potamogeton praelongis* 2013

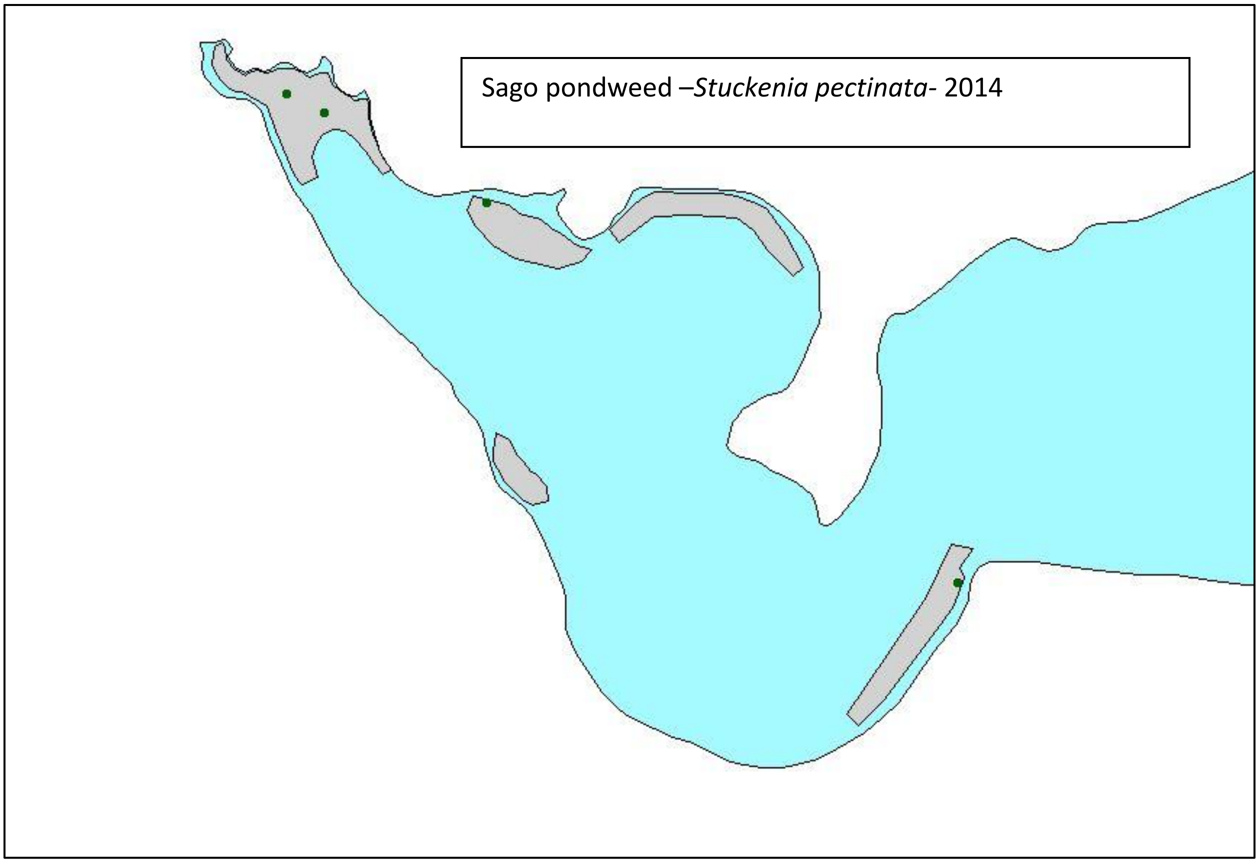

White-stem pondweed –*Potamogeton praelongis* 2014



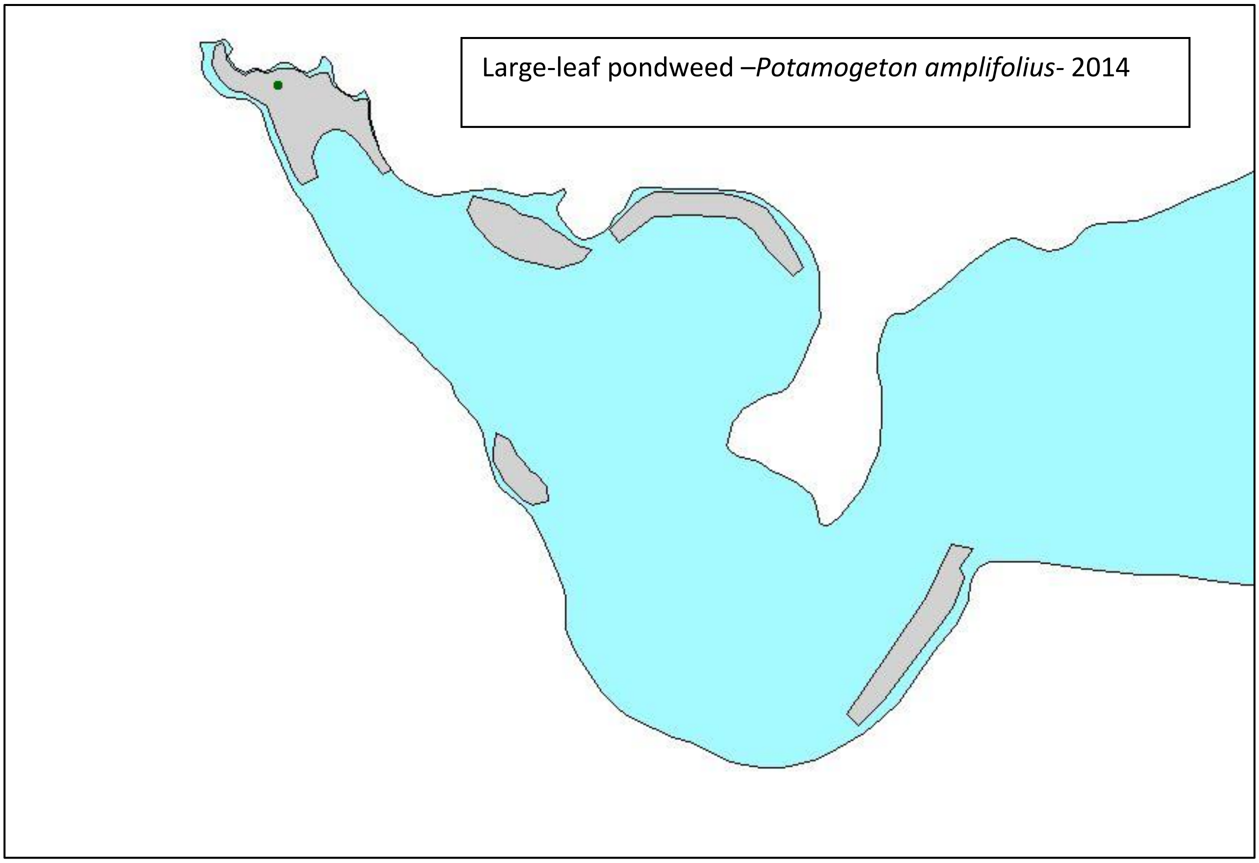
Fern pondweed not present in 2013.



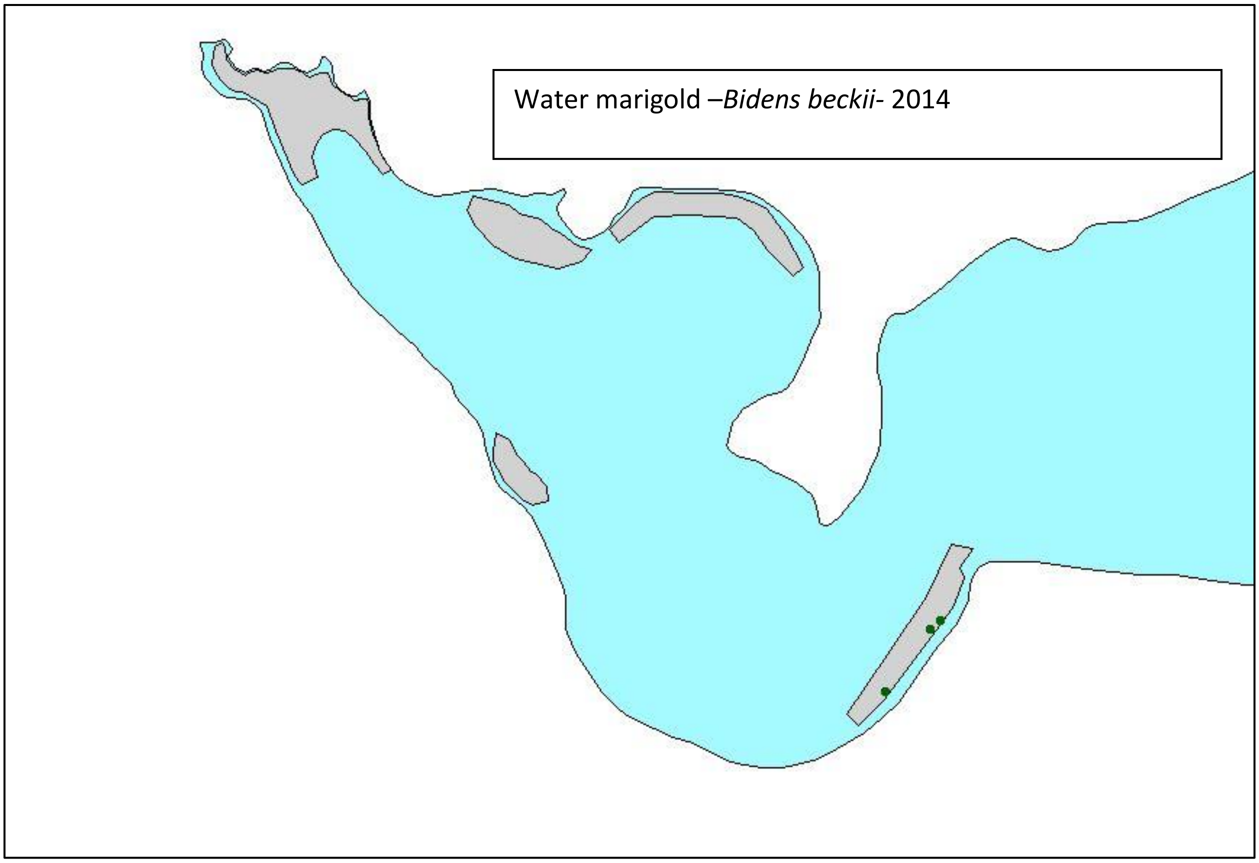
Wild celery not present in 2013



Sago pondweed not present in 2013.



Large-leaf pondweed not present in 2013.



Not present in 2013.