Aquatic Macrophyte Survey

Deer Lake, Polk County Wisconsin
July 2016

Conducted by:
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Abstract

In April, June and July of 2016 a point intercept aquatic macrophyte survey was conducted on Deer Lake in Polk County Wisconsin. The spring survey was to evaluate the presence of Potamogeton crispus-curly leaf pondweed (CLP). CLP was sampled in six locations of the sample grid and located in numerous other locations outside of the grid. The later season survey in July found 31 species of native plant sampled. Four species of invasive species were observed but not sampled. The Simpson's diversity index was 0.90. The maximum depth of plants was 26.2 feet and the mean depth of plants was 10.7 feet. 87.8% of the defined littoral zone had aquatic plants present. The floristic quality index was 33.8 which is much higher than the ecoregion median of other lakes. Compared to a 2010 aquatic macrophyte survey, there was a statistically significant increase in four native species and a significant decrease in three native species. The floristic quality index was slightly higher in 2016. All other parameters were similar in both surveys.

Introduction

In April, June and July 2016, a full lake aquatic macrophyte survey using the point intercept method was conducted on Deer Lake, Polk County Wisconsin. Deer Lake covers 786 acres with a maximum depth of 46 feet and a mean depth of 26 feet. This lake is classified as mesotrophic, drainage lake. It has a narrow littoral zone with widespread plant growth within the littoral zone.

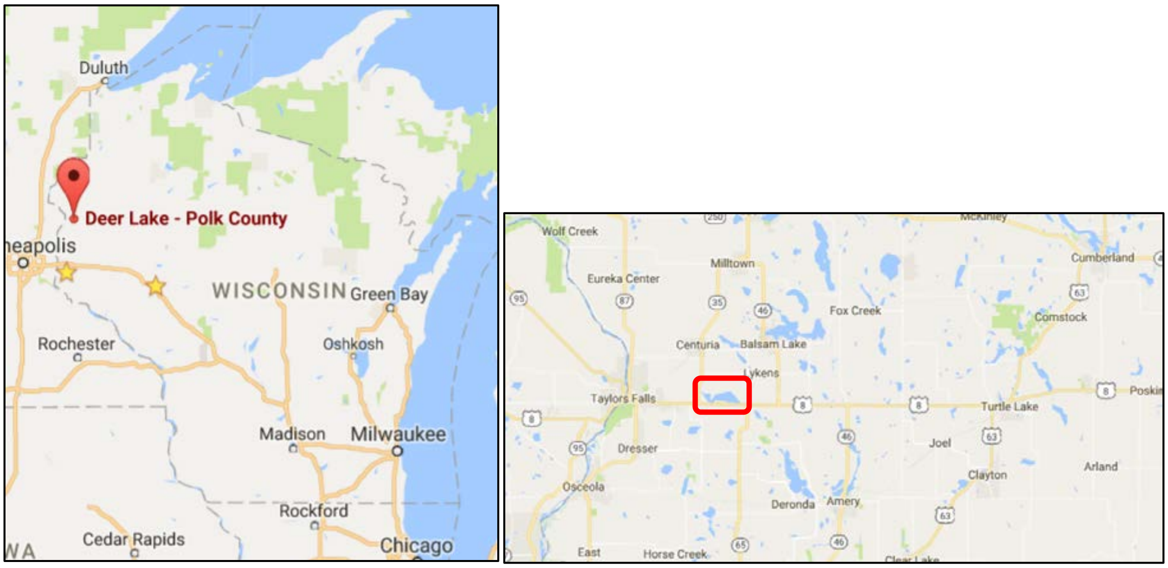
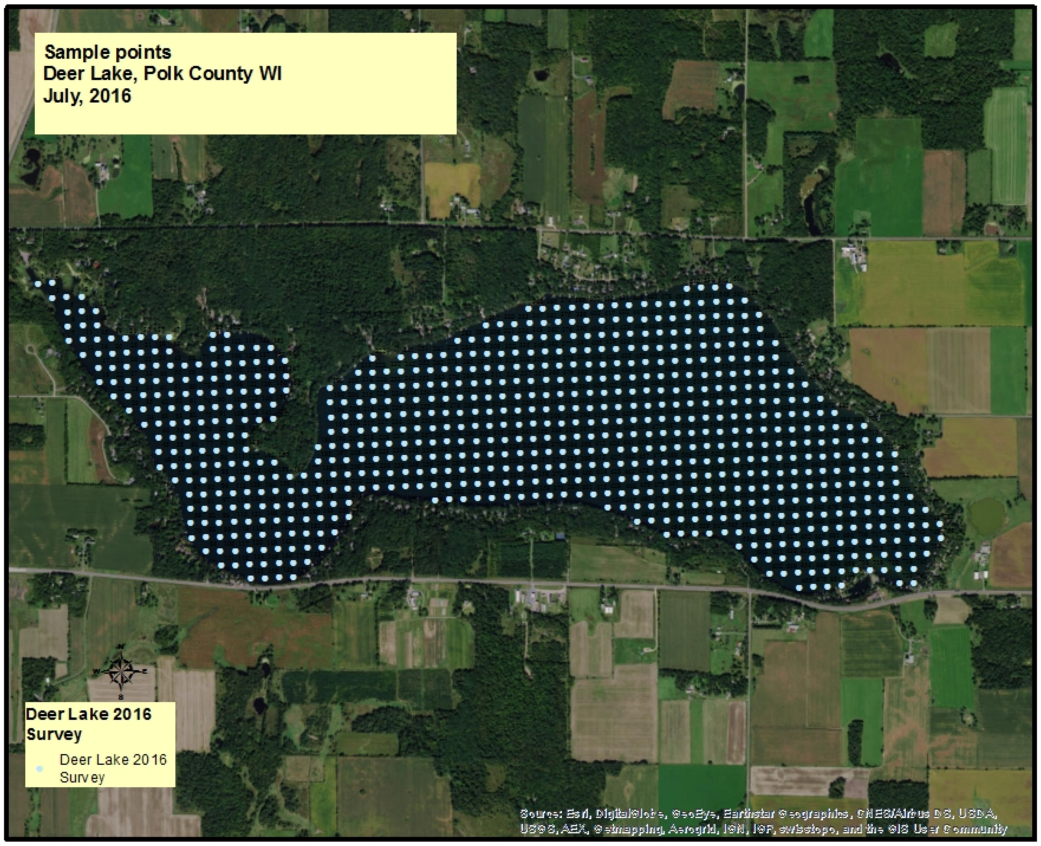


Figure 1: Map of Deer Lake location in Wisconsin.

Field Methods

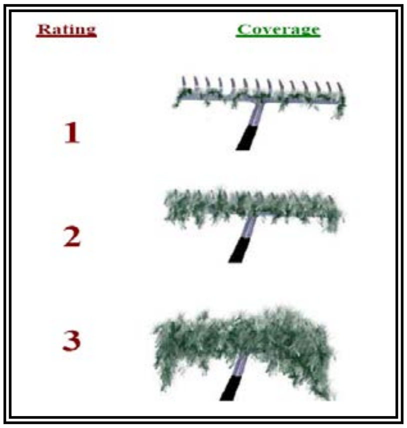
A point intercept method was employed for the aquatic macrophyte sampling. The Wisconsin Department of Natural Resources (Wisconsin DNR) generated the sampling point grids for each lake. All points were initially sampled for depth only. Once the maximum depth of plant growth was established, only sample points at that depth (or less) were sampled. If no plants were sampled, one sample point beyond that was sampled for plants. In areas such as bays that appear to be under-sampled, a boat or shoreline survey was conducted to record plants that may have otherwise been missed. This involved surveying that area for plants and recording the species viewed and/or sampled. The type of habitat is also recorded. These data are not used in the statistical analysis nor is the density recorded. Only plants sampled at predetermined sampled points were used in the statistical analysis. In addition, any plant within six feet of the boat was recorded as "viewed." A handheld Global Positioning System (GPS) located the sampling points in the field. The Wisconsin DNR guidelines for point location accuracy were followed with an 80 feet resolution window and the location arrow touching the point. An April and June 2016 survey was conducted to determine if *Potamogeton crispus*-curly leaf pondweed (CLP) was present. A portion of the CLP survey was conducted prior to herbicide application in April.

Figure 2: Point intercept sample grid for Deer Lake.



At each sample location, a double-sided fourteen-tine rake was used to rake a 1m tow off the bow of the boat. All plants present on the rake and those that fell off the rake were identified and rated for rake fullness. The rake fullness value was used based on the criteria contained in the diagram and table below. Those plants that were within six feet were recorded as “viewed,” but no rake fullness rating was given. Any under-surveyed areas such as bays and/or areas with unique habitats were monitored. These areas are referred to as a “boat survey or shoreline survey.”

The rake density criteria used:



Rake fullness rating	Criteria for rake fullness rating
1	Plant present, occupies less than ½ of tine space
2	Plant present, occupies more than ½ tine space
3	Plant present, occupies all or more than tine space
v	Plant not sampled but observed within 6 feet of boat

The depth and predominant sediment type was also recorded for each sample point. Caution must be used in determining the sediment type in deeper water as it is difficult to discern between muck and sand with a rope rake. All plants needing verification were bagged and cooled for later examination. Each species was mounted and pressed for a voucher collection and submitted to the Freckmann Herbarium (UW-Stevens Point) for review if new from previous surveys. On rare occasions a single plant may be needed for verification, not allowing it to be used as a voucher specimen and may be missing from the collection.

An early season, aquatic invasive species (AIS) (emphasis on *Potamogeton crispsus*-curly leaf pondweed) survey is completed to pick up any potential growth before native plants are robust. Curly leaf pondweed grows in the spring, only to senesce in early July before the main survey is typically conducted.

Data analysis methods

Data collected was entered into a spreadsheet for analysis. The following statistics were generated from the spreadsheet:

- Frequency of occurrence in sample points with vegetation (littoral zone)

- Frequency of occurrence in sample points less than the maximum depth of plants (defined littoral zone).
- Relative frequency
- Total points in sample grid
- Total points sampled
- Sample points with vegetation
- Simpson's diversity index
- Maximum plant depth
- Species richness
- Floristic Quality Index

An explanation of each of these data is provided below.

Frequency of occurrence for each species- Frequency is expressed as a percentage by dividing the number of sites the plant is sampled by the total number of sites. There can be two values calculated for this. The first value is the percentage of all sample points that a particular plant was sampled at depths less then maximum depth plants (littoral zone), regardless if vegetation was present. The second is the percentage of sample points that a particular plant was sampled at only points containing vegetation. The first value shows how often the plant would be encountered in the defined littoral zone (by depth), while the second value shows how frequent the plant is where plants grow. In either case, the greater this value, the more frequent the plant is present in the lake. When comparing frequency in the littoral zone, we look at the frequency of all points below maximum depth with plants. This frequency value allows the analysis of how common plants are and where they could grow based upon depth. When focusing only where plants are actually present, we look at frequency at points in which plants were found. Frequency of occurrence is usually reported using sample points where vegetation was present.

Frequency of occurrence example:

Plant A sampled at 35 of 150 littoral points = 35/150 = 0.23 = 23%

Plant A's frequency of occurrence = 23% considering littoral zone depths.

Plant A sampled at 12 of 40 vegetated points = 12/40 = 0.3 = 30%

Relative frequency-This value shows, as a percentage, the frequency of a particular plant relative to other plants. This is not dependent on the number of points sampled. The relative frequency of all plants will add to 100%. This means that if plant A had a relative frequency of 30%, it occurred 30% of the time compared to all plants sampled or makes up 30% of all plants sampled. This value allows us to see which plants are the dominant species in the lake. The higher the relative frequency, the more common the plant is compared to the other plants and therefore, more frequent in the plant community.

Relative frequency example:

Suppose we were sampling 10 points in a very small lake and got the following results:

	Frequency sampled
Plant A present at 3 sites	3 of 10 sites
Plant B present at 5 sites	5 of 10 sites
Plant C present at 2 sites	2 of 10 sites
Plant D present at 6 sites	6 of 10 sites

So one can see that Plant D is the most frequent sampled at all points with 60% (6/10) of the sites having plant D. However, the relative frequency allows us to see what the frequency is compared the other plants, without taking into account the number of sites. It is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. If we add all frequencies (3+5+2+6), we get a sum of 16. We can calculate the relative frequency by dividing by the individual frequency.

Plant A = 3/16 = 0.1875 or 18.75%

Plant B = 5/16 = 0.3125 or 31.25%

Plant C = 2/16 = 0.125 or 12.5%

Plant D = 6/16 = 0.375 or 37.5%

Now we can compare the plants to one another. Plant D is still the most frequent, but the relative frequency tells us that of all plants sampled at those 10 sites, 37.5% of them are Plant D. This is much lower than the frequency of occurrence (60%) because although we sampled Plant D at 6 of 10 sites, we were sampling many other plants too, thereby giving a lower frequency when compared to those other plants. This then gives a true measure of the dominant plants present.

Total points in sample grid- The Wisconsin DNR establishes a sample point grid that covers the entire lake. Each GPS coordinate is mapped and used to locate the points.

Sample sites less than maximum depth of plants-The maximum depth at which a plant is sampled is recorded. This defines the depth plants can grow (potential littoral zone). Any sample point with a depth less than, or equal to this depth is recorded as a sample point less than the maximum depth of plants. This depth is used to determine the potential littoral zone and is referred to as the littoral zone.

Sample sites with vegetation- This is the number of sites where plants were actually sampled. This gives a good projection of plant coverage on the lake. If 10% of all sample points had vegetation, it implies about 10% coverage of plants in the whole lake, assuming an adequate number of sample points have been established. We also observe the number of sample sites with vegetation in the littoral zone. If 10% of the littoral zone had sample points with vegetation, then the plant coverage in the littoral zone would be estimated at 10%.

Simpson's diversity index-To measure the diversity of the plant community, Simpson's diversity index is calculated. This value can run from 0 to 1.0. The greater the value, the more diverse the plant community. In theory, the value is the chance that two species sampled are different. An index of "1" means that the two will always be different (very diverse) and a "0" would indicate that they will never be different (only one species found). The higher the diversity in the native plant community, the healthier the lake ecosystem.

Simpson's diversity example:

If one sampled a lake and found just one plant, the Simpson's diversity would be "0." This is because if we randomly sampled two plants, there would be a 0% chance of them being different, since there is only one plant.

If every plant sampled were different, then the Simpson's diversity would be "1." This is because if two plants were randomly sampled, there would be a 100% chance they would be different since every plant is different.

Maximum and mean depth of plants-This depth indicates the deepest that plants were sampled. The mean depth is the average depth all plants were sampled. Generally, more clear lakes have a greater depth of plants, while lower water clarity limits light penetration and reduce the depth at which plants are found.

Species richness-The number of different individual species found in the lake. There is a number for the species richness of plants sampled, and another number that takes into account plants viewed but not actually sampled during the survey.

Floristic Quality Index-The Floristic Quality Index (FQI) is an index developed by Dr. Stanley Nichols of the University of Wisconsin-Extension. This index is a measure of the plant community in response to development (and human influence) on the lake. It takes into account the species of aquatic plants sampled and their tolerance for changing water quality and habitat quality. The index uses a conservatism value assigned to various plants ranging from 1 to 10. A higher conservatism value indicates that a plant is intolerant, while a lower value indicates tolerance. Those plants with higher values are more apt to respond adversely to water quality and habitat changes, largely due to human influence (Nichols, 1999). The FQI is calculated using the number of species and the average conservatism value of all species used in the index.

The formula is: $FQI = \text{Mean } C \cdot \sqrt{N}$

Where C is the conservatism value and N is the number of species (only species sampled on rake).

Therefore, a higher FQI indicates a healthier aquatic plant community, which is an indication of better plant habitat. This value can then be compared to the median for other lakes in the assigned eco-region. There are four eco-regions used throughout Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area, and Southeastern Wisconsin Till Plain. The 2006 and 2008 values from past aquatic plant surveys will also be compared in this analysis.

Summary of Northern Lakes and Forests and Flowages Median Values for Floristic Quality Index:

(Nichols, 1999)

	Northern Central Hardwood Forests
Median species richness	14
Median conservatism	5.6
Median Floristic Quality	20.9

*Floristic Quality has a significant correlation with area of lake (+), alkalinity(-), conductivity(-), pH(-) and Secchi depth(+). In a positive correlation, as that value increases so will FQI, while with a negative correlation, as a value decreases, the FQI will decrease.

Results

The results of the full lake point intercept survey conducted in April, June and July 2016 show a healthy plant community. Within the littoral zone (areas that plants live in the lake), 87.8% of that area has plants growing. The littoral zone is quite limited in coverage, with approximately 34% of the lake is included within the depths plants are found growing. The plant coverage within the entire lake area is 29.6%. See figure 3 for the defined littoral zone map.

Total number of sample points	752
Total number of sites shallower than maximum depth of plants	254
Total number of sites with vegetation	223
Frequency of occurrence at sites shallower than maximum depth of plants	87.80
Simpson Diversity Index	0.90
Maximum depth of plants	26.20 ft
Mean depth of plants	10.72 ft
Average number of all species per site (shallower than max depth)	2.37
Average number of all species per site (veg. sites only)	2.70
Average number of native species per site (shallower than max depth)	2.37
Average number of native species per site (veg. sites only)	2.70
Species Richness	32
Species Richness (including visuals)	33

Table 1: Summary of point intercept survey statistics, Deer Lake 2016.

The diversity of plants within the littoral zone is high, with a Simpson's diversity index of 0.90 and 32 species of plants being sampled. Of these 32 species, 31 are native with two species of algae and 29 species of vascular plants. Figure 5 shows where the highest diversity occurs. These areas largely occur in bays with high nutrient sediments and little boat traffic.

Plant growth is not overly dense with a mean rake fullness of 1.61 (on a scale of 0-3 (see methods section for reference)). Figure 4 shows the rake fullness at each sample point that had plants.

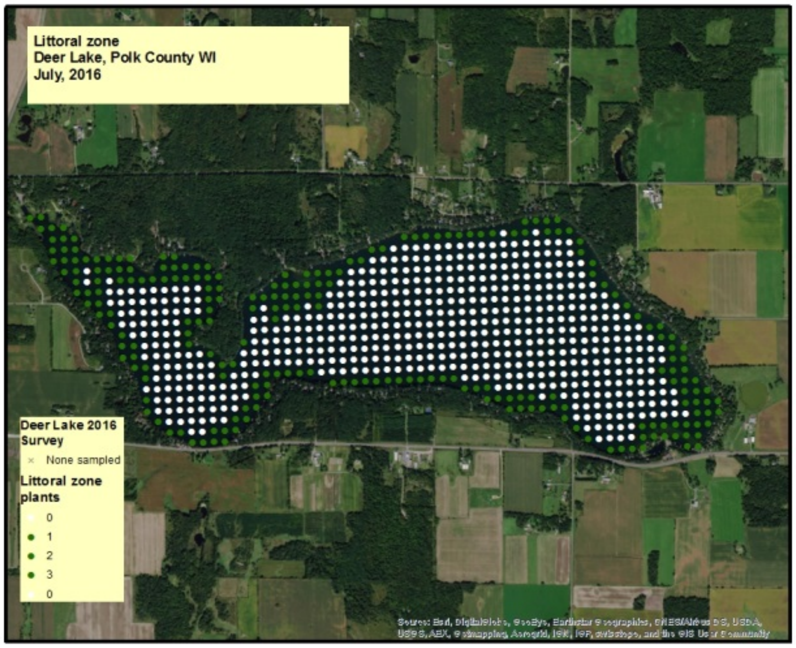


Figure 3: Map designating the littoral zone based upon plant growth locations on Deer Lake-2016.

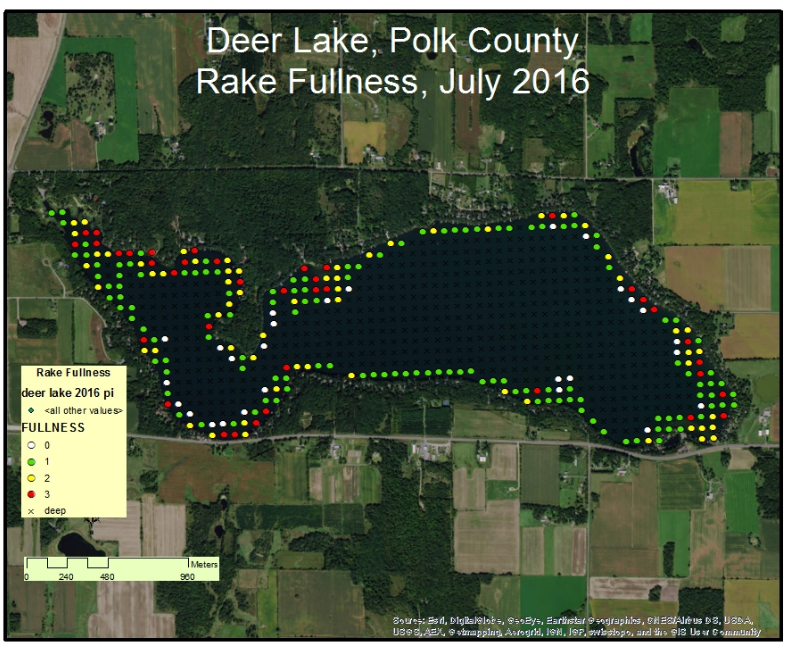


Figure 4: Map of rake fullness to show plant density distribution on Deer Lake-2016.

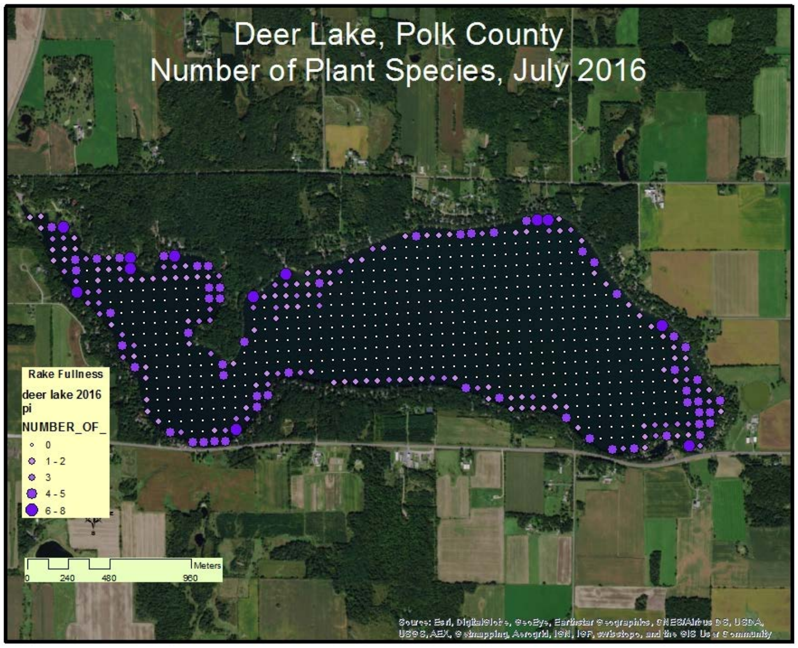


Figure 5: Map of Deer Lake showing the number of species (species richness) at each sample point with plants.

The maximum depth of plants was 26.2 feet. Figure 6 shows that plants growing at a wide range of depths, which may be due to the high water clarity in Deer Lake. This is reinforced by the mean plant growth of 10.72 feet. The graph only goes up to 22 feet but forked duckweed was sampled in 26 feet.

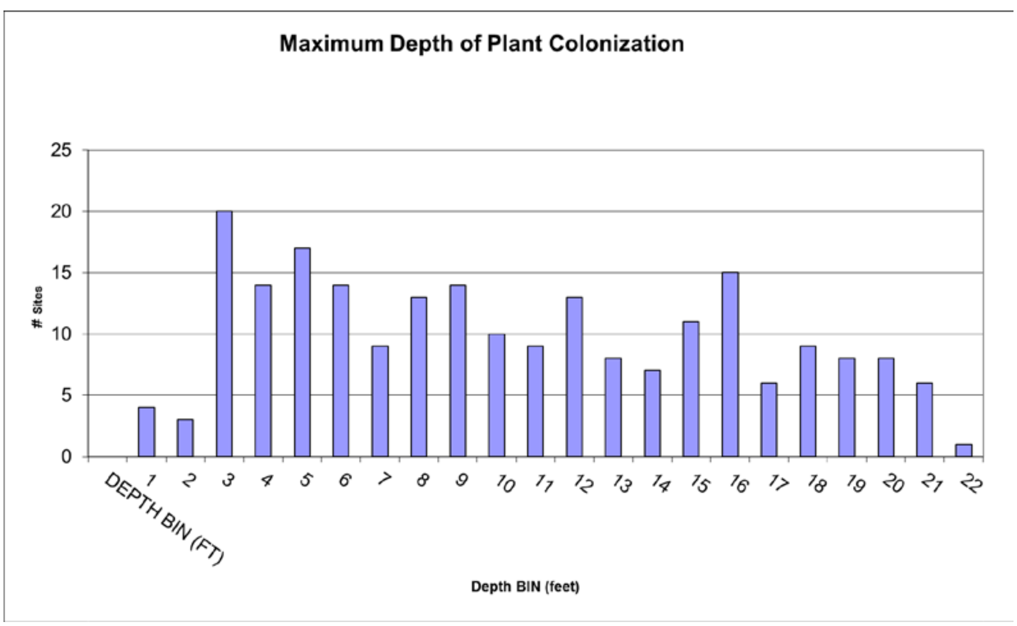


Figure 6: Graph showing the number of sites with plants at a particular depth. Note the wide spread growth throughout many depths.

Table 2: Species richness with frequency and density data.

Species	**Freq veg**	**Freq littoral**	**Relative freq**	**# of pts sampled**	**Mean density**	**# Viewed**
Ceratophyllum demersum, Coontail	59.19	51.97	21.5	132	1.3	
Lemna trisulca, Forked duckweed	34.98	30.71	12.7	78	1.0	
Myriophyllum sibiricum, Northern water-milfoil	25.11	22.05	9.1	56	1.1	3
Chara sp., Muskgrasses	21.52	18.90	7.8	48	1.4	
Vallisneria americana, Wild celery	21.08	18.50	7.7	47	1.1	1
Potamogeton richardsonii, Clasping-leaf pondweed	17.49	15.35	6.4	39	1.1	2
Elodea canadensis, Common waterweed	12.56	11.02	4.6	28	1.1	
Heteranthera dubia, Water star-grass	11.21	9.84	4.1	25	1.1	
Potamogeton gramineus, Variable pondweed	10.76	9.45	3.9	24	1.1	1
Potamogeton robbinsii, Fern pondweed	7.62	6.69	2.8	17	1.0	
Stuckenia pectinata, Sago pondweed	7.62	6.69	2.8	17	1.0	
Nitella sp., Nitella	7.17	6.30	2.6	16	1.3	
Potamogeton praelongus, White-stem pondweed	6.73	5.91	2.4	15	1.0	1
Potamogeton zosteriformis, Flat-stem pondweed	6.73	5.91	2.4	15	1.0	1
Ranunculus aquatilis, White water crowfoot	4.93	4.33	1.8	11	1.0	
Najas flexilis, Slender naiad	4.04	3.54	1.5	9	1.0	
Bidens beckii, Water marigold	2.69	2.36	1.0	6	1.0	
Potamogeton crispus,Curly-leaf pondweed	2.69	2.36	1.0	6	1.0	
Potamogeton friesii, Fries' pondweed	1.79	1.57	0.6	4	1.0	
Lemna minor, Small duckweed	1.35	1.18	0.5	3	1.0	
Nymphaea odorata, White water lily	1.35	1.18	0.5	3	1.0	1
Spirodela polyrhiza, Large duckweed	1.35	1.18	0.5	3	1.0	
Wolffia columbiana, Common watermeal	1.35	1.18	0.5	3	1.0	
Elatine minima, Waterwort	0.90	0.79	0.3	2	1.0	
Eleocharis acicularis, Needle spikerush	0.90	0.79	0.3	2	1.0	
Potamogeton alpinus, Alpine pondweed	0.90	0.79	0.3	2	1.0	
Potamogeton amplifolius, Large-leaf pondweed	0.90	0.79	0.3	2	1.0	
Sagittaria sp., Arrowhead rosette	0.90	0.79	0.3	2	1.0	
Potamogeton foliosus, Leafy pondweed	0.45	0.39	0.2	1	1.0	
Potamogeton illinoensis, Illinois pondweed	0.45	0.39	0.2	1	1.0	
Potamogeton pusillus, Small pondweed	0.45	0.39	0.2	1	1.0	
Sparganium eurycarpum, Common bur-reed	0.45	0.39	0.2	1	1.0	
Aquatic moss	0.45	0.39		1	1.0	
Filamentous algae	26.01	22.83		58	1.0	
Isoetes echinospora, Spiny spored-quillwort						1

The most common plants sampled were coontail (*Ceratophyllum demersum*), forked duckweed (*Lemna triscula*) and northern water mifoil (*Myriophyllum sibiricum*). Figures 7 to 9 show the distribution of these three plants.

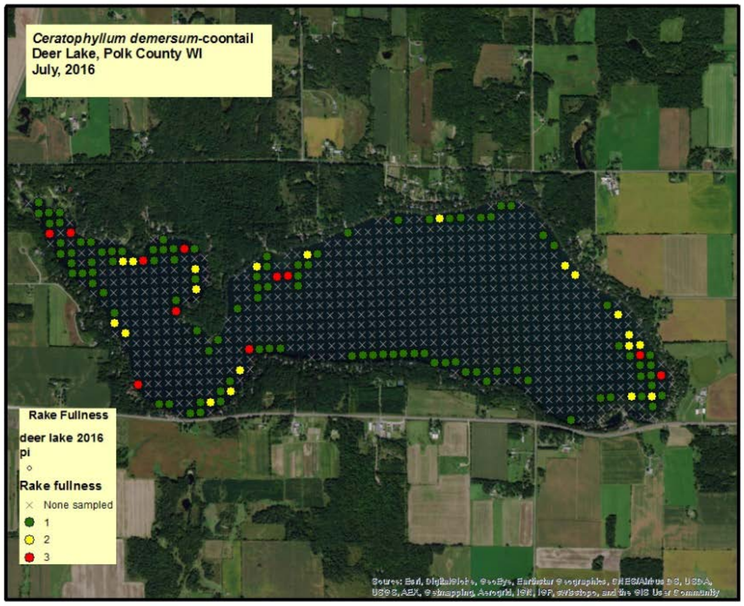


Figure 7: Distribution map of *Ceratophyllum demersum* (coontail) which is most common plant sampled.

Coontail is a very common aquatic plant in Wisconsin lakes. The plant has many fine leaves whorled around the petiole that provide excellent habitat for plankton and invertebrates. This provides good forage areas for small fish and larger fish. Coontail also can absorb nutrients directly from the water column.

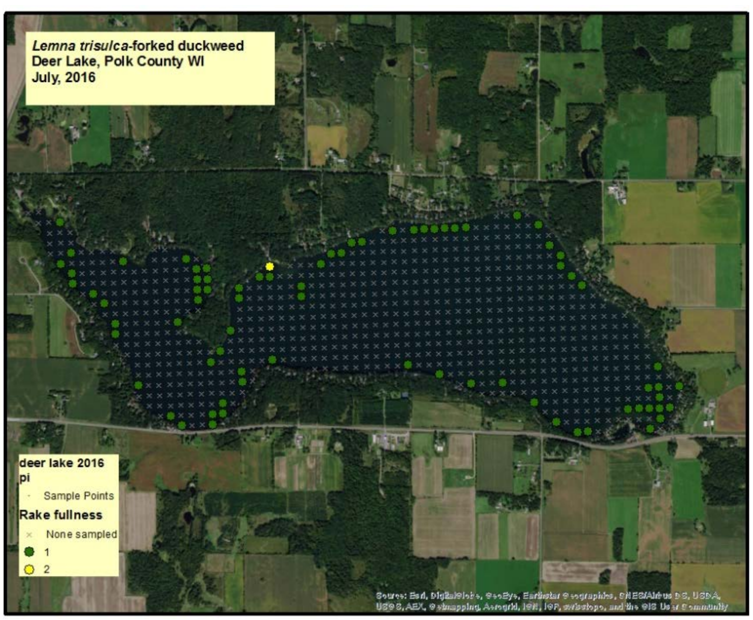


Figure 8: Distribution map of *Lemna trisulca* (forked duckweed) which is the second most common plant sampled.

Forked duckweed is a free floating (not rooted but tends to live on the bottom or on other plant material). It is a common plant in Wisconsin lakes and is desirable. Forked duckweed provides good food for waterfowl and in high enough density, it can provide cover for fish and invertebrates. Since it if free floating, it absorbs nutrients directly from water and can only grow if nutrient content of the water is adequate.

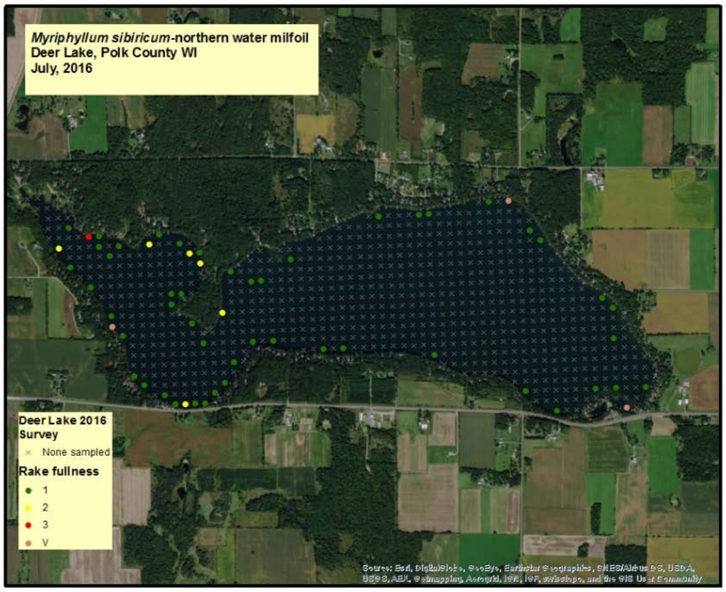


Figure 9: Distribution map of *Myriophyllum sibiricum* (northern water milfoil) which is the third most common plant sampled.

Northern water milfoil is another common aquatic plant in Wisconsin lakes that has fine leaflets making up each leaf. This provides excellent areas for plankton to grow, leading to great forage areas for fish. Northern water milfoil is closely related to the non-native Eurasian water milfoil. The native northern water milfoil is desirable in a lake and can help (along with other native plants) keep invasive species such as Eurasian water milfoil from becoming established.

A survey was done in areas not represented by the sample point grid, largely to see if any plants in these areas are present such as invasive species or rare plants. Numerous species were observed in this part of the survey not sampled in the sample grid points.

Calla palustris-wild calla
Iris pseudacorus-yellow iris
Myosotis scorpioides-aquatic forget me not
Nuphar variegata-spatterdock
Phalaria arundincea-reed canary grass
Sagittaria latifolia-common arrowhead
Sagittaria rigida-sessile fruited arrowhead
Schoenoplectus tabernaemontani-softstem bulrush
Typha augustifolia-narrow leaf cattail
Typha latifolia-broad leaf cattail

FQI

The floristic quality index can indicate changes that have occurred in the habitat for aquatic plants. This change is compared to pre-development of the lake and therefore attributed to human activity. The higher the FQI, the less affected he plant community has been affected by human activity in and around the lake. The FQI of a lake can be compared to the median of lakes from the same ecoregion and to previous point intercept surveys.

FQI Parameter	Deer Lake 2016	Ecoregion median
Number of species in FQI	30	14
Mean conservatism	6.17	5.6
FQI	33.8	20.9

Table 3: Floristic quality data from Deer Lake 2016 macrophyte survey and comparison to ecoregion median values.

Non-native/invasive species

There were five invasive species sampled or observed on Deer Lake during the spring and summer surveys. The species include:

- *Potamogeton crispus* (curly leaf pondweed)-sampled
- *Typha augustifolia* (narrow leaf cattail)-observed only
- *Phalaria arundincea* (reed canary grass)-observed only
- *Myosotis scorpioides* (aquatic forget me not)-observed only
- *Iris psuedacorus* (yellow iris)-observed only

Potamogeton crispus-curly leaf pondweed (CLP) has been managed on Deer Lake for several years. A survey for CLP was conducted in April (prior to herbicide treatment), and June when this plant is at peak growth. All point intercept locations were sampled for CLP. Figure 10 shows the point intercept distribution result from 2016.

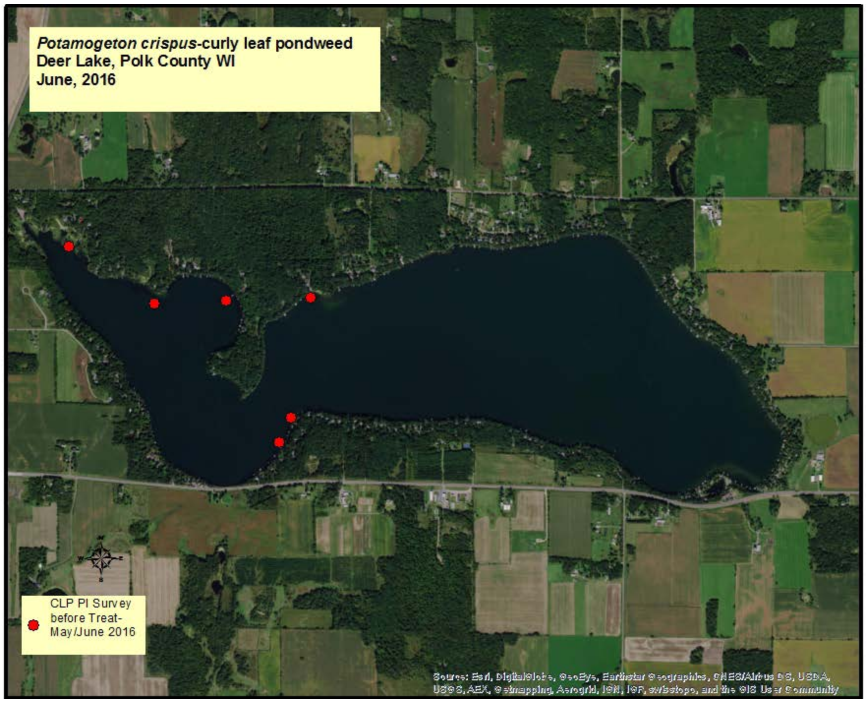


Figure 10: Distribution map of *Potamogeton crispus* (CLP) from a spring PI survey, 2016.

Following the point intercept survey, the entire littoral zone was surveyed for CLP. Figure 11 shows the location of all CLP in May/June 2016.

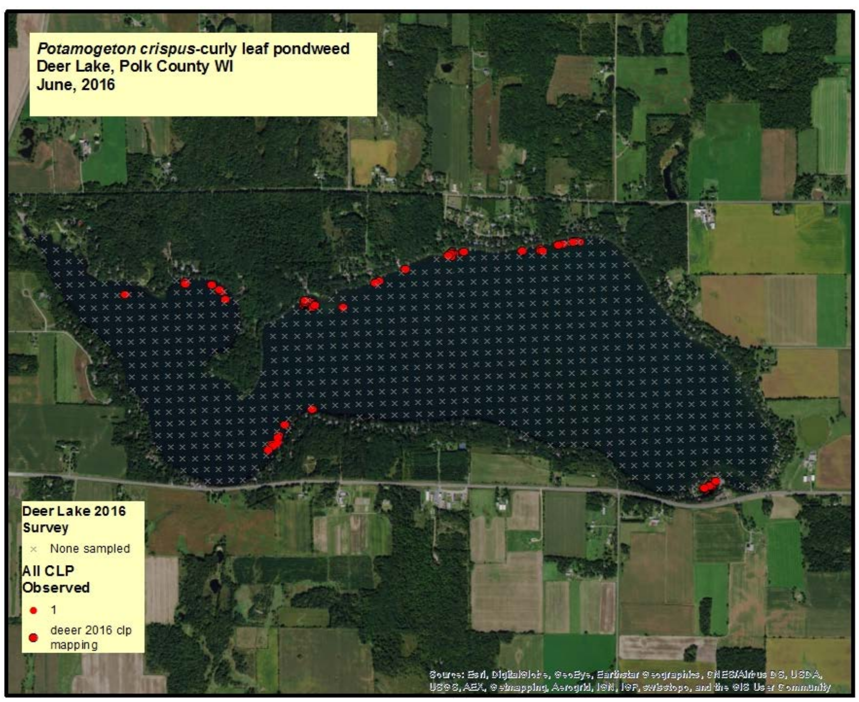


Figure 11: Map showing locations of all CLP observed in PI survey and littoral zone survey where CLP was viewed from surface.

Another non-native species observed was narrow leaf cattail. Narrow leaf cattail is considered invasive in Wisconsin and is restricted. Cattail is very limited in and around Deer Lake. Of that cattail present, most is narrow leaf cattail, with limited amounts of the native broad leaf cattail present. Most of the narrow leaf cattail is near the landing and in a couple of bays around the lake. Figure 12 shows the two locations of the predominant narrow leaf cattail was observed during survey (not at sample points.

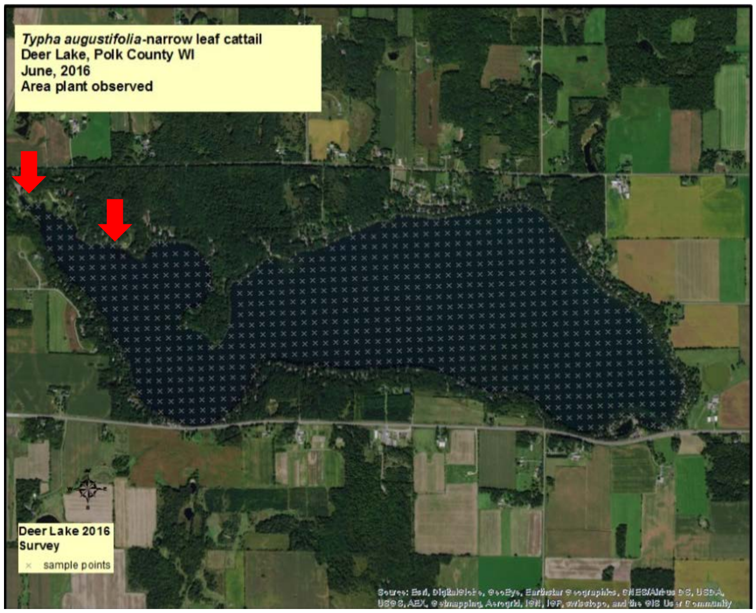


Figure 12: Locations that narrow leaf cattail (*Typha augustifolia*) was observed. None were sample points.

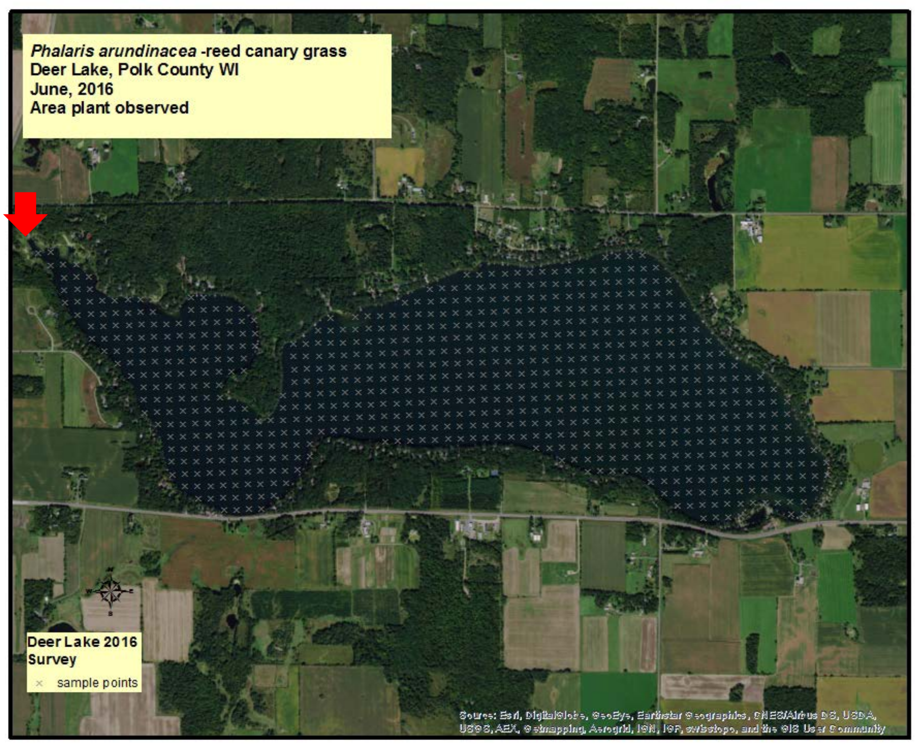


Figure 13: Location of predominant reed canary grass (*Phalaria arundincea*) growth. Reed canary grass occurs in many places around Deer Lake on or near shore.

Reed canary grass cultivar (aka ribbon grass) is restricted in Wisconsin. Reed canary grass has been considered native in North America, but most populations have interbred with the non-native European strain. There is a dense area of reed canary grass around the boat landing (see figure 13 with red arrow).

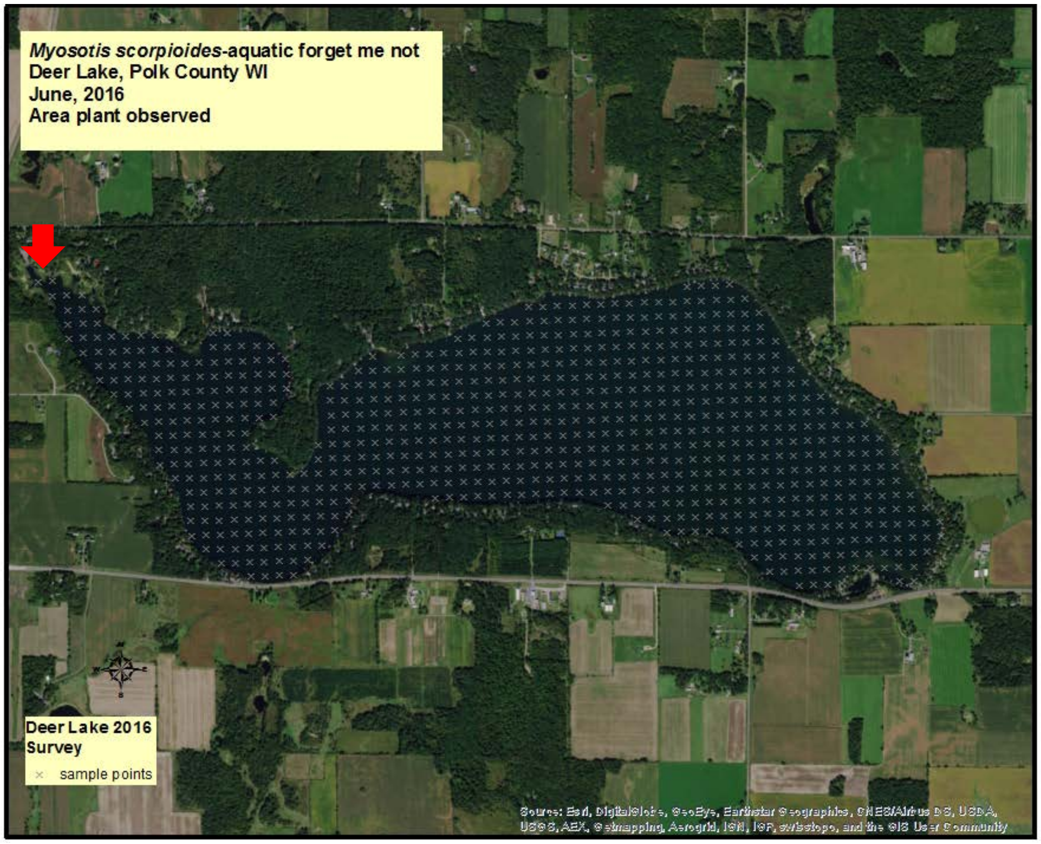


Figure 14: Location of aquatic forget me not observed in Deer Lake survey. The red arrow marks a rather extensive stand of this invasive species.

Aquatic forget me not (*Myosotis scorpioides*) is a restricted invasive species in Wisconsin. There was rather extensive coverage of this plant near the landing (both east and west of the ramp). See figure 14 for location as indicated by the red arrow.

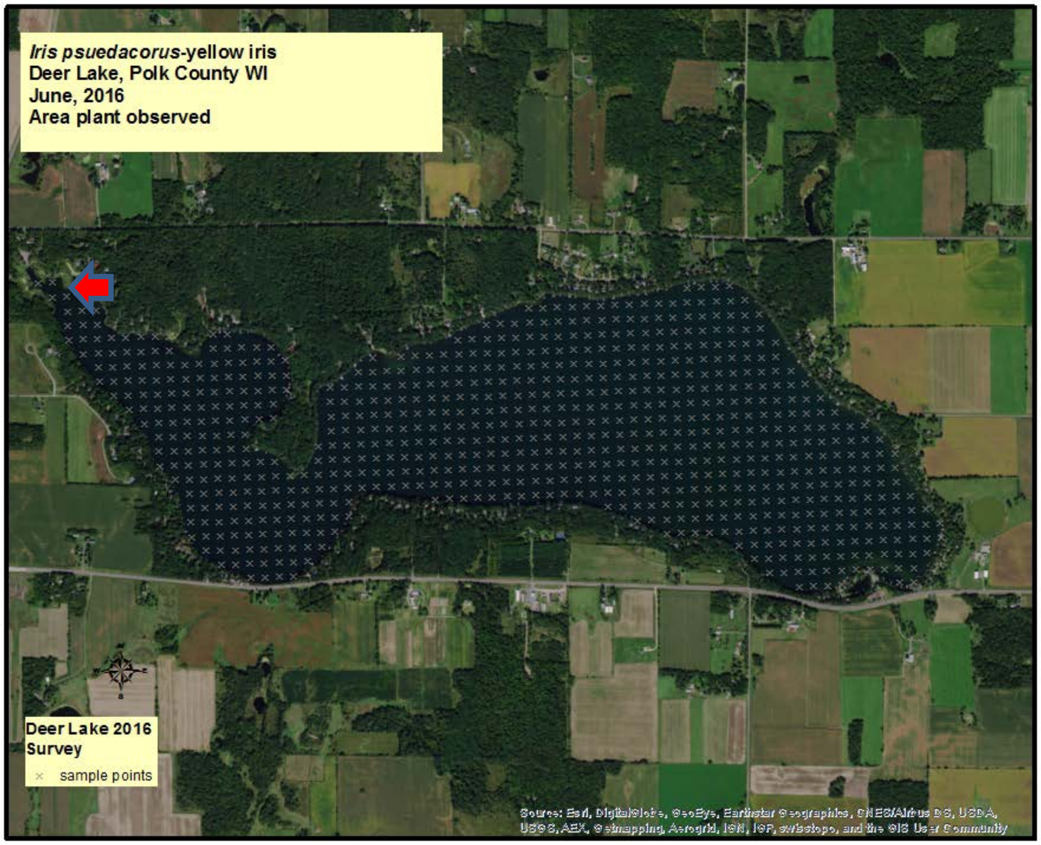


Figure 15: Map designating location of yellow iris observed flowering in June, 2016. There were only a few plants observed along the shoreline.

Yellow iris (*Iris pseudacorus*) was observed in the bay just south and east of the boat landing. A few plants were seen flowering right on the shoreline line in this area. Yellow iris is a restricted plant in Wisconsin. See figure 15 for the location as indicated by the red arrow.

Comparison between 2010 and 2016 point intercept surveys

A full lake, point intercept survey was conducted on Deer lake in 2010. In order to evaluate the plant community, the results of the 2016 survey were compared to the 2010 results. The purpose for this comparison is to determine if there were changes in the frequency of various species of plants, a change in diversity and if any changes in the FQI occurred over the past seven years. Increases in native species are typically not a concern. If a plant increases to major dominance due to adverse conditions, such as reduced water clarity, then an increase would be a concern. Substantial decreases in various native species are a concern, especially if not coupled with an increase in a different native species.

Table 4 shows a comparison of some of the major statistics from the surveys.

Parameter	2010 survey	2016 survey
Sample points with vegetation	225	223
Greatest depth with plant growth	28.0	26.2
Simpson's diversity index	0.89	0.90
Native plants per sample	3.42	2.75
Species richness	29	32
Dominant species (relative freq.)	*Lemna trisulca* (20.4)	*Ceratophyllum demersum* (21.5%)

Table 4: Comparison of some data from 2010 and 2016 macrophyte surveys.

The only major difference is in the number of native plants per sample point. Although other parameters don't show a change in diversity, this parameter shows a small decrease in plant diversity. All other parameters are very similar in the two surveys.

The potential sources of native plant reductions over the course of several years are as follows:

1. Management practices such as herbicide treatments. Typically if herbicide treatments of invasive species are utilized, a pre and post treatment analysis is done in those specific areas. To determine if this is a cause of a reduction in the full lake survey, the treatment areas would need to be evaluated using the point intercept sample grid. Furthermore, if herbicide reduces the native species, it is dependent upon the type and concentration of the herbicide. A single species reduction is unlikely and more likely multiple species would be affected.
2. Sample variation can also occur. The sample grid is entered into a GPS unit. The GPS will allow the surveyors to get close to the same sample point each time, but there could easily be a difference 20 feet or more (the arrow icon is 16 feet in real space). Since the distribution of various plants is not typically uniform but more likely clumped, sampling variation could easily result in that plant not being sampled in a particular survey. Plants with low frequency could easily give significantly different values with surveys conducted within the same year.
3. Each year, the timing for aquatic plants coming out of dormancy can vary widely. A late or early ice-out could greatly affect the size of plants during a survey from one year to the next. A lake may have high density of a plant one year, only to have a very low density another year. The type of plant reproduction can affect this immensely. If the plant grows from seed or a rhizome each year, the timing can be paramount as to the frequency and density shown in a survey.
4. Identification differences can lead to frequency changes. The small pond weeds such as *Potamgeton pusillus, Potamogeton foliosus, Potamogeton friesii*, and *Potamogeton strictifolious* can easily be mistaken for one plant or another. It may be best to look at the overall frequency of all of the small pondweeds to determine if a true reduction has occurred. All small pondweeds collected were magnified and closely scrutinized in the 2016 survey. The same surveyor conducted both surveys so this discrepancy is less likely.
5. Habitat changes and plant dominance changes can lead to plant declines. If an area received a large amount of sediment from human activity the plant community may respond. For

this to occur in 5-7 years may be unlikely. If a plant emerges as a more dominant plant over time, that plant may reduce the other plant's frequency and /or density.

6. Very large plant coverage reduction that is not species specific can occur from an infestation in the non-native rusty crayfish or common carp.

In order to determine if a change is statistically significant, a chi-square analysis is calculated. This analysis compares the frequency of both surveys and determines if the change is due to chance variation or something other than chance. The cutoff for significance is P<0.05, with the lower P value indicating more significance. Table 5 summarizes the chi-square analysis that shows the changes in the plant frequencies from 2010 to 2016. Yellow designates a statistically significant decrease and green a statistically significant increase.

Table 5: Chi-square analysis for 2010 and 2016 plant frequencies. P<0.05 is a significant change.

Species	2010	2016	P value	Significant change	Change
Ceratophyllum demersum, Coontail	120	132	0.21	n.s.	+
Lemna trisulca, Forked duckweed	104	78	0.015	yes*	-
Myriophyllum sibiricum, Northern water-milfoil	61	56	0.63	n.s.	-
Chara sp., Muskgrasses	28	48	0.01	yes*	+
Vallisneria americana, Wild celery	74	47	0.005	yes**	-
Potamogeton richardsonii, Clasping-leaf pondweed	18	39	0.002	yes**	+
Elodea canadensis, Common waterweed	33	28	0.51	n.s.	-
Heteranthera dubia, Water star-grass	36	25	0.14	n.s.	-
Potamogeton gramineus, Variable pondweed	4	24	0.00009	yes***	+
Potamogeton robbinsii, Fern pondweed	27	17	0.12	n.s.	-
Stuckenia pectinata, Sago pondweed	0	17	0.00002	yes***	+
Nitella sp., Nitella	17	16	0.88	n.s.	-
Potamogeton zosteriformis, Flat-stem pondweed	25	15	0.10	n.s.	-
Ranunculus aquatilis, White water crowfoot	8	11	0.47	n.s.	+
Najas flexilis, Slender naiad	12	9	0.52	n.s.	-
Potamogeton praelongus, White-stem pondweed	42	15	0.00015	yes***	-
Bidens beckii, Water marigold	1	6	0.055	n.s.	+
Potamogeton friesii, Fries' pondweed	1	4	0.17	n.s.	+
Nymphaea odorata, White water lily	3	3	0.99	n.s.	+
Elatine minima, Waterwort	1	2	0.56	n.s.	+
Eleocharis acicularis, Needle spikerush	6	2	0.16	n.s.	-
Potamogeton alpinus, Alpine pondweed	0	2	0.15	n.s.	+
Potamogeton amplifolius, Large-leaf pondweed	2	2	0.99	n.s.	+
Sagittaria sp., Arrowhead rosette	1	2	0.56	n.s.	+

Species	2010	2016	P value	Significant change	Change
Potamogeton crispus,Curly-leaf pondweed	6	1	0.06	n.s.	-
Lemna minor, Small duckweed	2	3	0.64	n.s.	+
Potamogeton foliosus, Leafy pondweed	0	1	0.31	n.s.	+
Potamogeton illinoensis, Illinois pondweed	3	1	0.32	n.s.	-
Potamogeton pusillus, Small pondweed	4	1	0.18	n.s.	-
Sparganium eurycarpum, Common bur-reed	0	1	0.31	n.s.	+
Spirodela polyrhiza, Large duckweed	2	3	0.64	n.s.	+
Wolffia columbiana, Common watermeal	2	3	0.64	n.s.	+
Significant increase					
Significant decrease					

As table 5 shows, there was a significant increase in four native species and a significant decrease in three native species. The concern in frequency changes are the significant decreases. The cause of the decreases is not known, but potential reduction due to herbicide use in curly leaf pondweed management is of concern. Since the herbicide is broad spectrum, all plants may be susceptible to the herbicide. The fact that there were four species with significant increases, the potential of the decrease being due to herbicide use is low. Also, most native plants in Deer Lake did not appear to form widespread beds, but rather small clumps of different species. Just a minor fluctuation in sampling location can change the possibility of sampling or not sampling plant, causing frequency data changes. Figures 16 to 18 show the comparison with the CLP management beds (herbicide applied) over the past several years. Keep in mind that the herbicide will travel outside of the treatment areas, but residual monitoring has shown the concentration decreases rapidly even within the treatment area.

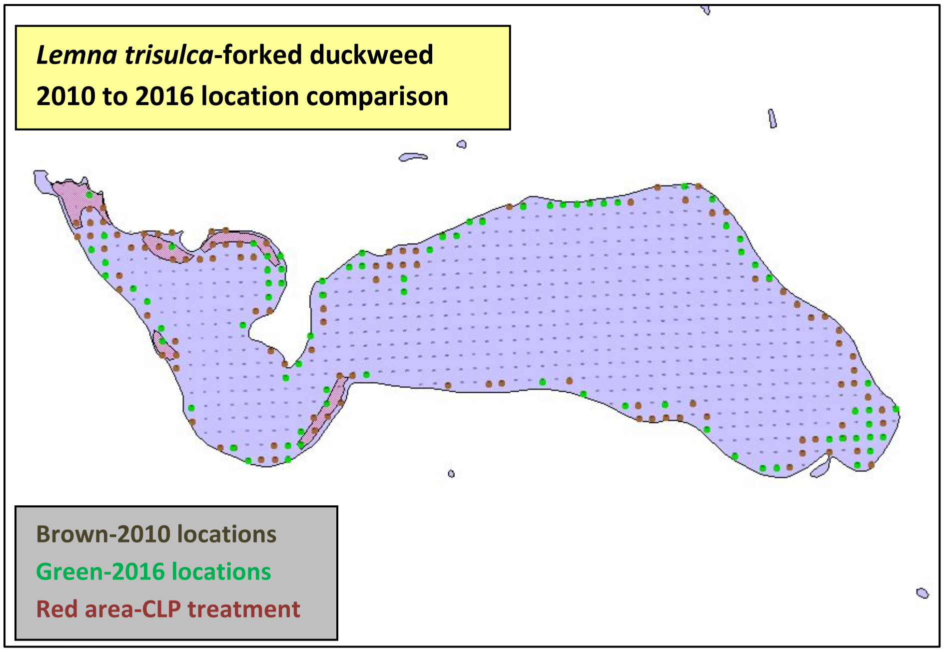


Figure 16: 2010 to 2016 comparison of forked duckweed which showed a significant reduction in 2016.

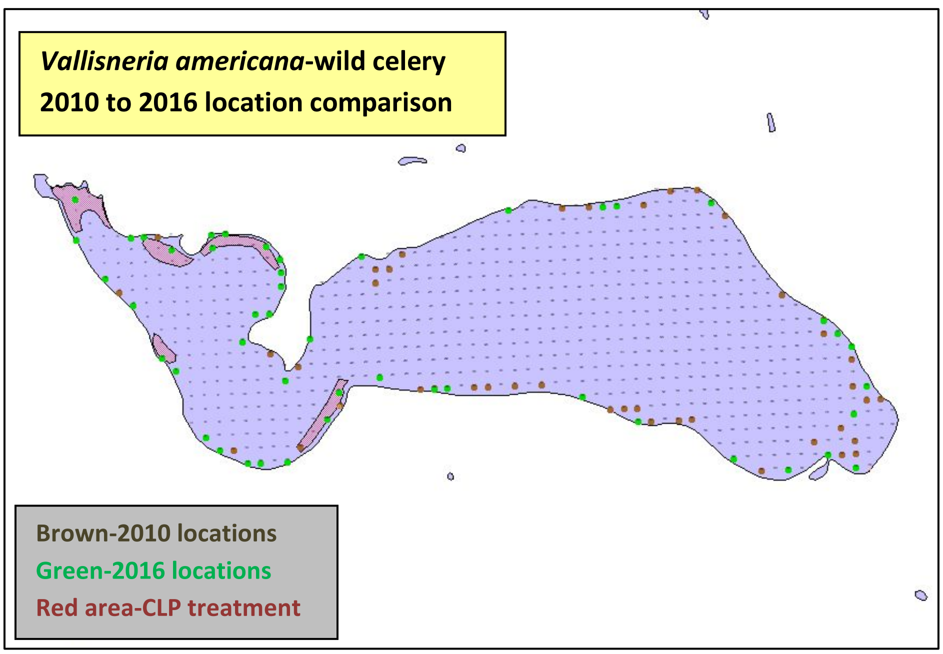


Figure 17: 2010 to 2016 comparison of wild celery distribution which showed a significant reduction in 2016.

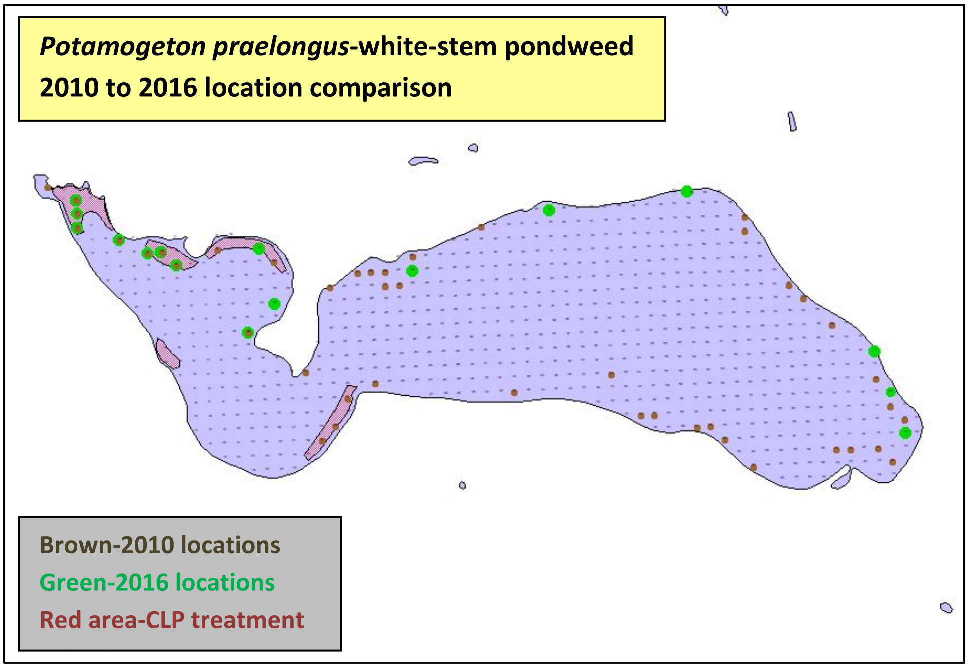


Figure 18: 2010 to 2016 distribution map of white-stem pondweed which showed a reduction in 2016.

FQI Parameter	2010	2016
Number of species in FQI	28	30
Mean conservatism	6.32	6.17
FQI	33.45	33.8

Table 6: FQI comparison between 2010 and 2016. Note very little change.

The FQI can change with a change in habitat. The FQI is used to compare the plant community to pre-development times (due to human activity). If human activity affects the habitat for plants, the FQI may change (go down).

Table 6 shows the FQI has changed little from 2010 to 2016. The mean conservatism value decreased slightly, but with two more species sampled, the FQI is slightly higher in 2016. This data indicates that the plant community does not appear to have changed in six years from human activities or influence.

Discussion

The 2016 aquatic macrophyte on Deer Lake showed a moderately diverse plant community with 32 species sampled (31 native species). The Simpson's diversity index of 0.90 shows a diversity that is relatively high. In addition, the floristic quality index was high showing a healthy plant community. There were no rare plant or species of special concern sampled or observed.

There was one invasive species sampled, *Potamogeton crispus*-curly leaf pondweed (CLP). This plant has been managed through herbicide application over the past several years. The point intercept survey resulted in six sample locations with CLP. There were several more locations added when a visual survey was conducted. The frequency cannot be compared to the 2010 survey as a point intercept was not conducted for CLP (needs to be completed in spring as CLP dies in early August) in 2010.

Other non-native species were observed but not sampled. These include yellow iris, reed canary grass, aquatic forget me not, and narrow leaved cattail. Yellow iris, narrow cattail and aquatic forget me not are restricted invasive species. Reed canary grass cultivars are restricted. Yellow iris and narrow cattail were not observed in the 2010 survey.

The 2010 survey was compared to the 2016 survey through a chi-square analysis. A statistically significant increase occurred in four native species. A statistically significant reduction occurred in three native species. The other survey parameters showed little change, including floristic quality index. These comparisons show the plant community has changed little since 2010.

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