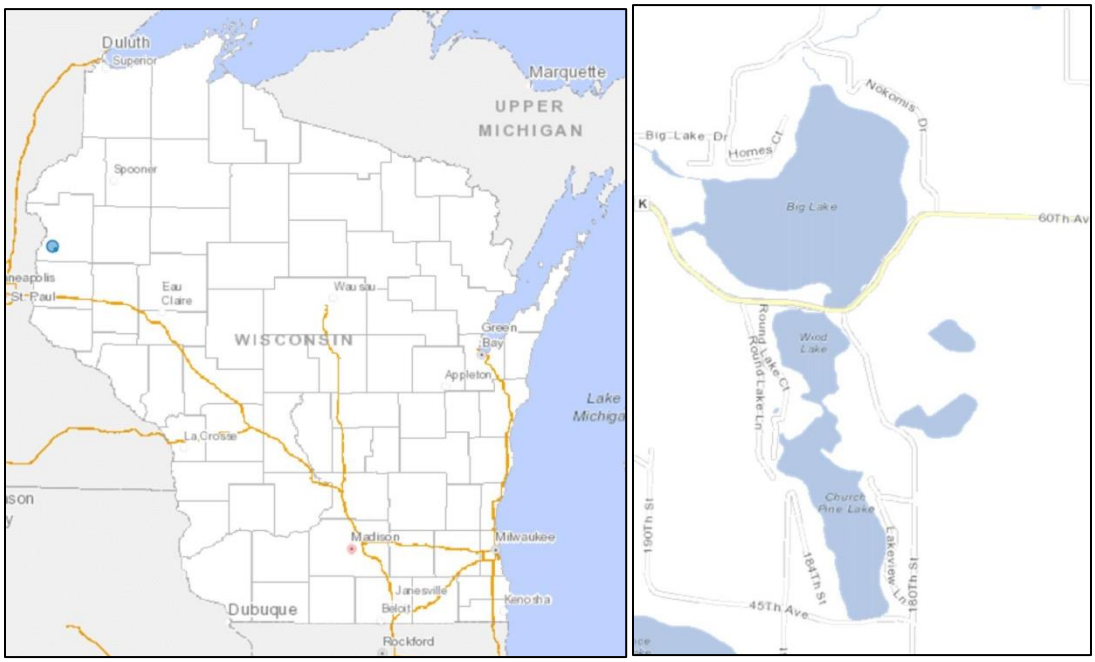
Abstract

A full lake, aquatic macrophyte point intercept survey was conducted on Big Lake, Churchpine Lake, and Round Lake Polk County Wisconsin in June and July, 2014. Big Lake had a species richness of 28 and a Simpson's diversity index of 0.87. The littoral zone had plants present in 64.58% of the sample points. Churchpine Lake has a species richness of 33 and a Simpson's diversity index of 0.92. The littoral zone had plants sampled in 84.14% of the sample points. Round Lake had a species richness of 37 with a Simpson's diversity index of 0.94. The littoral zone had plants present in 92.23% of the sample points. There were two invasive species sampled and/or observed on Big Lake and Round Lake. These species were *Potamogeton crispus*-curly leaf pondweed (one location only on each lake), *Lythrum salicaria* - Purple loosestrife (several locations in Big Lake and three locations on Round Lake). There was one invasive species observe*, Lythrum salicaria* -Purple loosestrife in one location only on Churchpine Lake. *Typha augustifolia*-narrow leaf cattail*,* which is a potential invasive species was observed in a few locations on each lake (could be extensive in two cattail beds in Churchpine Lake). In a comparison between the 2014 survey and a previous 2007 point intercept survey very small differences were found. Species richness, maximum depth of plants, Simpson's diversity index and FQI changed little or none. A chi-square analysis resulted in significant reduction in Potamogeton crispus (AIS) in Big Lake. Significant increases occurred in two native species in Big Lake, and six native species in both Churchpine Lake and Round Lake. Significant decreases occurred in one native species in Big Lake, four native species in Churchpine Lake and two native species in Round Lake. Causes were speculated to potentially be due to seasonal and/or sampling variation and field identification.

Introduction

In June and July 2014, a full lake aquatic macrophyte survey using the point intercept method was conducted on Big Lake, Churchpine Lake and Round Lake in Polk County, Wisconsin. Big Lake has an area of 245 acres with a maximum depth of 24 feet and a mean depth of 17 feet. It is classified as a seepage lake and has a trophic status of mesotrophic. Churchpine Lake is a drainage lake with an area of 87 acres. The maximum depth is 45 feet and a mean depth of 23 feet. It has a trophic status of mesotrophic. Round Lake is a drainage lake with an area of 68 acres. This mesotrophic lake has a maximum depth of 26 feet and a mean depth of 15 feet.

Figure 1: Map of Tomahawk Lake location in Wisconsin and Tomahawk Lake and surrounding lakes surveyed.



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 depth was sampled. 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 early June 2014 survey was conducted to determine if *Potamogeton crispus* was present.

Figure 2: Point intercept sample grid for Big Lake

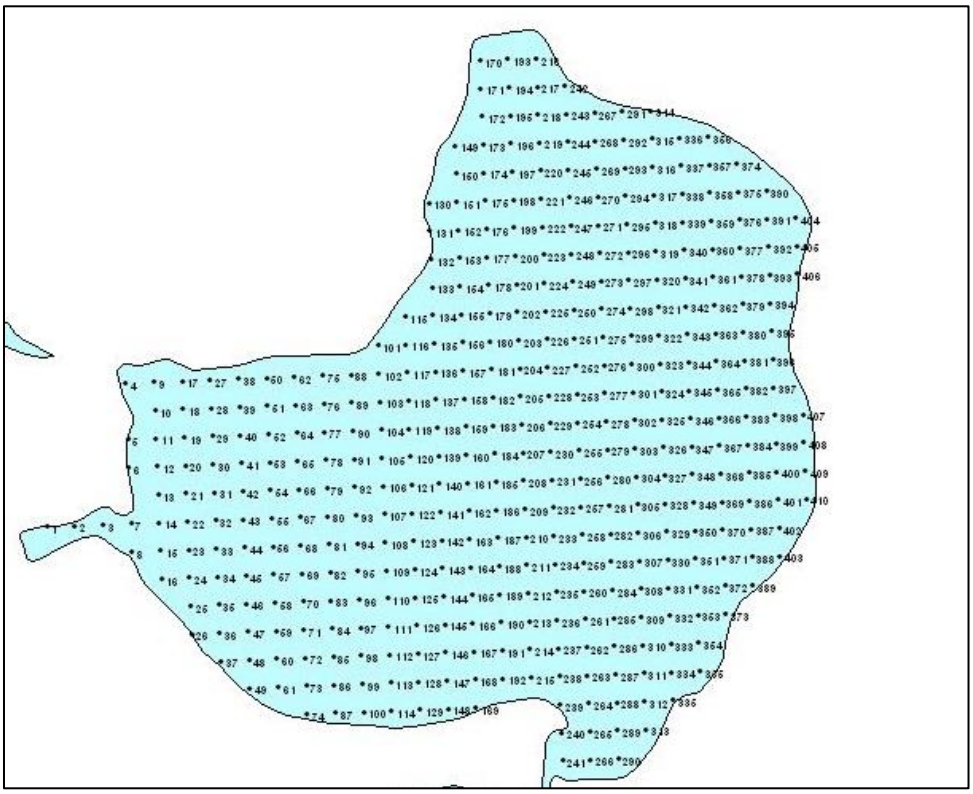


Figure 3: Point intercept sample grid Churchpine Lake.

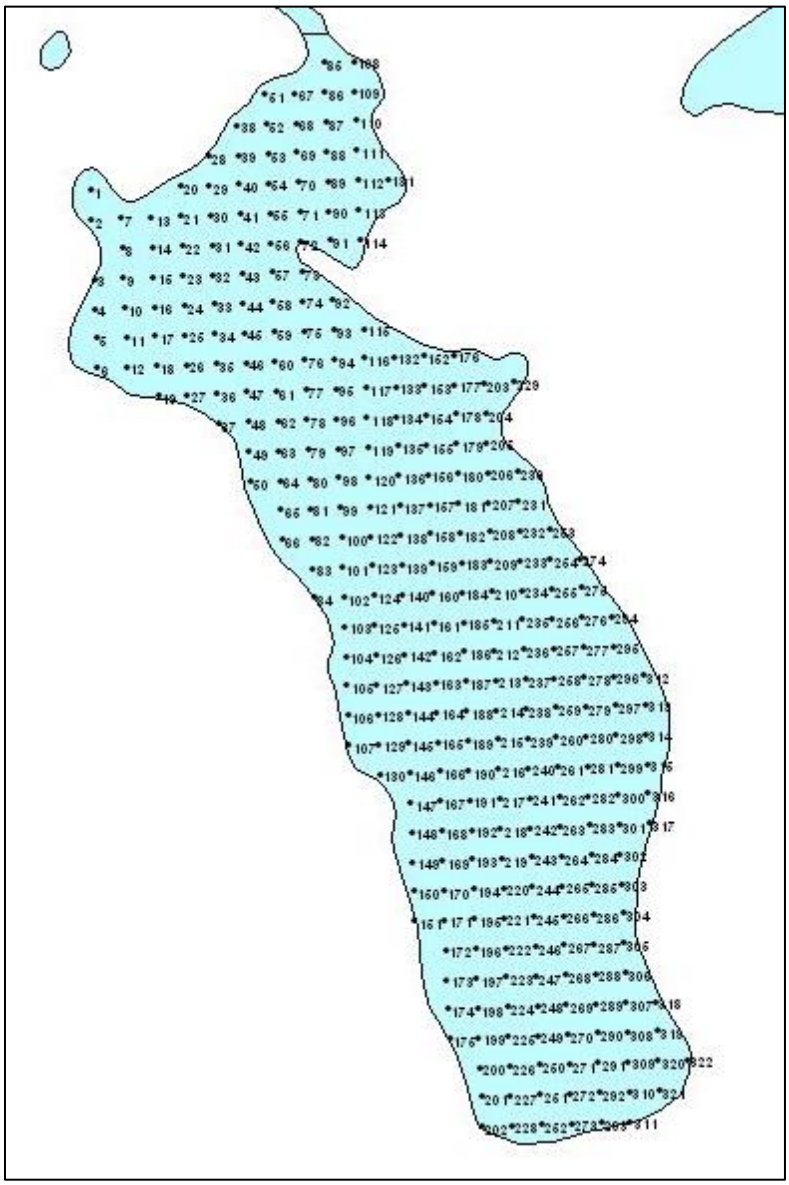
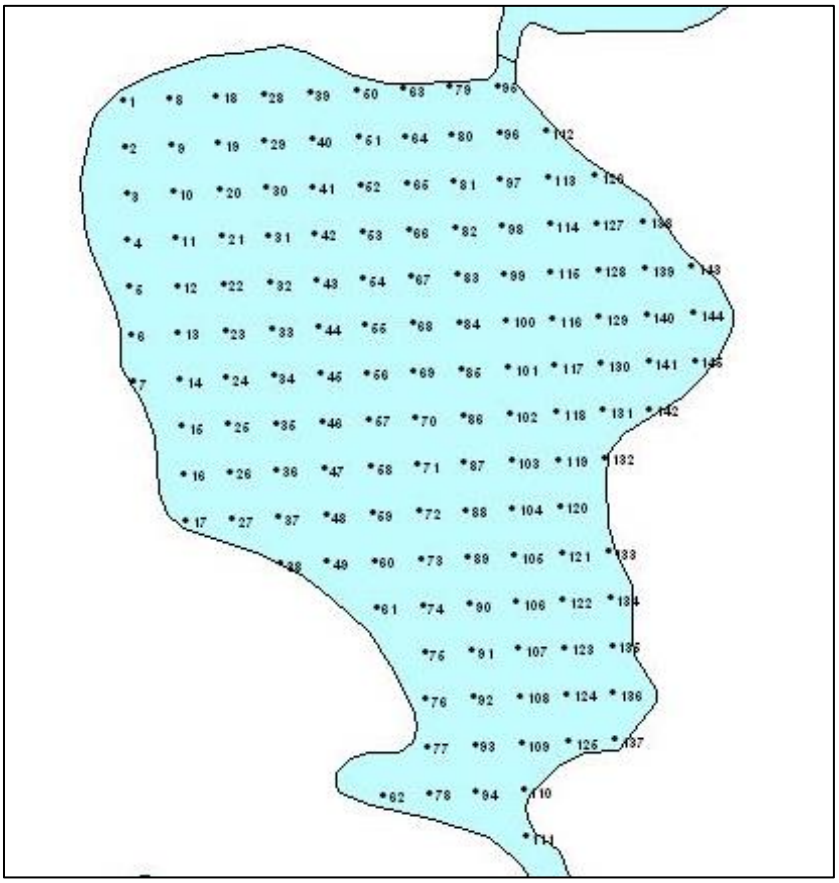
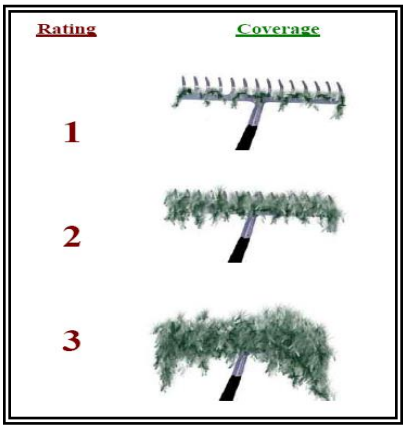


Figure 4: Point intercept sample grid for Round Lake.



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 (density). 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. 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, and will 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)
- 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 than the 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)(listed as frequency in littoral zone). The second value shows how frequent the plant is where plants grow (listed as frequency in vegetated). In either case, the greater this value, the more frequent the plant is present in the lake. When comparing how frequency in the littoral zone, the frequency of all points below maximum depth with plants is evaluated. 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 only 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 given and used to locate the points using a GPS unit.

Sample sites less than maximum depth of plants-The maximum depth 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 lees than the maximum depth of plants. This is used to determine the percentage of points with vegetation.

Sample sites with vegetation- This is the number of sites where plants were actually sampled. This gives how extensive the plant coverage is 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 how diverse the plant community is, 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 is in a particular lake. 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 depth of plants-This depth indicates the deepest that plants were sampled. Generally, more clear lakes have a greater depth of plants, while lower water clarity limits light penetration and will reduce the depth at which plants are found.

Species richness-This is 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. Filamentous algae and aquatic moss are not part of the species richness which follows the Wisconsin DNR protocol.

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 = Mean C ·√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 Central Hardwood Forests 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 rises so will FQI, while with a negative correlation, as a value rises, the FQI will decrease.

Results

Big Lake

The 2014 point intercept survey showed that Big Lake has widespread aquatic plant coverage in the lake, with areas that reach fairly high density. The survey grid contained 410 survey points, of which 144 were within the littoral zone depth. The potential littoral zone depth is defined by the maximum depth of plant growth, which was 18.5 feet. Of the 144 littoral sample points, 93 had plants sampled, which is 64.58%. See table 1 for the survey statistic summary.

Table 1: Summary of survey statistics on Big Lake, 2014

SUMMARY STATS-Big Lake:	
Total number of sample points in grid	410
Total number of sites with vegetation	93
Total number of sites shallower than maximum depth of plants	144
Frequency of occurrence at sites shallower than maximum depth of plants	64.58%
Simpson Diversity Index	0.87
Maximum depth of plants (ft)	18.30
Average number of all species per site (shallower than max depth)	1.87
Average number of all species per site (veg. sites only)	2.89
Average number of native species per site (shallower than max depth)	1.86
Average number of native species per site (veg. sites only)	2.88
Species Richness	28
Species Richness (including visuals)	28

The plant community is fairly diverse, with a species richness of 28 aquatic plant species, and a Simpson's diversity index of 0.87. There was an average of 2.9 species of native plants sampled at each sample point. Table 2 lists the species sampled and the frequency data.

Figure 5: Maps of Big Lake littoral zone and plant density, 2014.

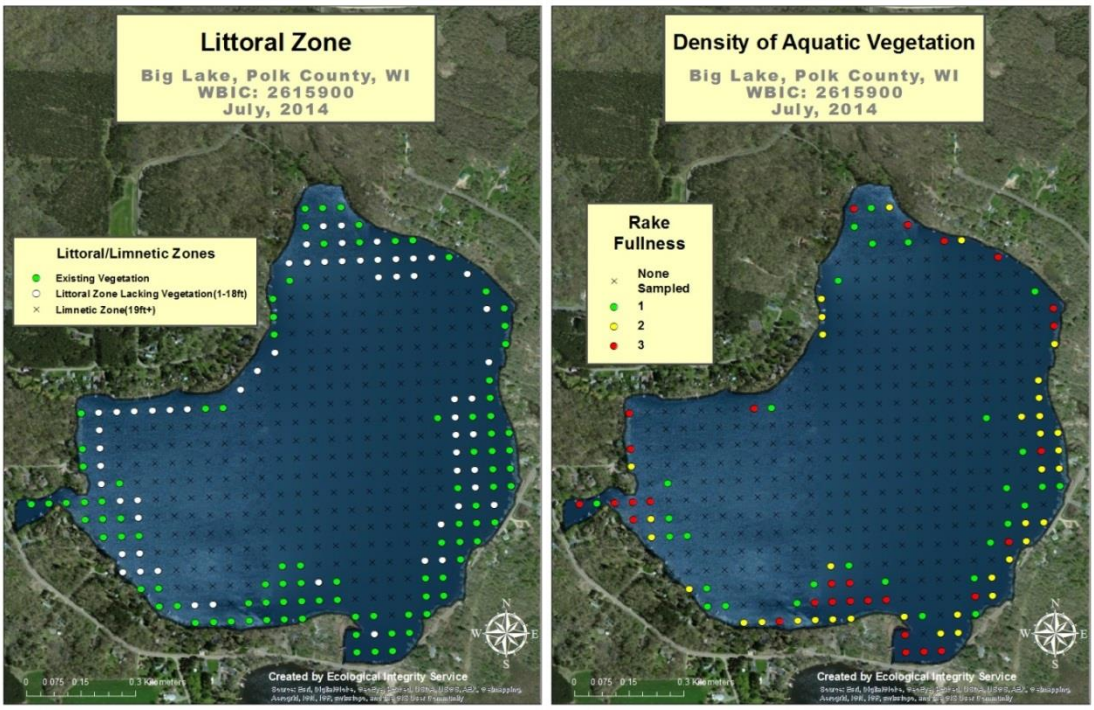


Table 2: Survey species list with frequency statistics Big Lake, 2014.

Species	Vegetated Freq	Littoral Freq	Rel Freq	# Sampled	Density	# Viewed
Ceratophyllum demersum, Coontail	82.80	53.47	28.50	77	1.60	
Vallisneria americana, Wild celery	39.78	25.69	13.75	37	1.08	
Lemna trisulca, Forked duckweed	27.96	18.06	9.60	26	1.08	
Elodea canadensis, Common waterweed	26.88	17.36	9.29	25	1.48	1
Myriophyllum sibiricum, Northern water-milfoil	18.28	11.81	6.32	17	1.00	7
Potamogeton illinoensis, Illinois pondweed	18.28	11.81	6.32	17	1.12	8
Heteranthera dubia, Water star-grass	13.98	9.03	4.83	13	1.08	1
Nymphaea odorata, White water lily	11.83	7.64	4.09	11	1.00	3
Stuckenia pectinata, Sago pondweed	10.75	6.94	3.72	10	1.00	2
Potamogeton richardsonii, Clasping-leaf pondweed	7.53	4.86	2.60	7	1.00	7
Lemna minor, Small duckweed	4.30	2.78	1.49	4	1.00	
Najas flexilis, Slender naiad	4.30	2.78	1.49	4	1.25	
Spirodela polyrhiza, Large duckweed	4.30	2.78	1.49	4	1.00	
Chara sp., Muskgrasses	2.15	1.39	0.74	2	1.00	
Ranunculus aquatilis, White water crowfoot	2.15	1.39	0.74	2	1.50	
Wolffia columbiana, Common watermeal	2.15	1.39	0.74	2	1.00	
Bidens beckii, Water marigold	1.08	0.69	0.37	1	1.00	

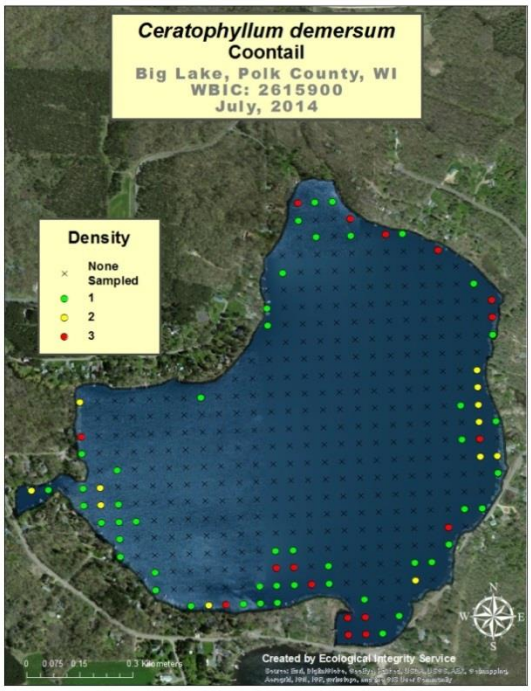
Species	Vegetated Freq	Littoral Freq	Rel Freq	# Sampled	Density	# Viewed
Nuphar variegata, Spatterdock	1.08	0.69	0.37	1	1.00	
Potamogeton amplifolius, Large-leaf pondweed	1.08	0.69	0.37	1		
Potamogeton foliosus, Leafy pondweed	1.08	0.69	0.37	1	1.00	
Potamogeton friesii, Fries' pondweed	1.08	0.69	0.37	1	1.00	
Potamogeton gramineus, Variable pondweed	1.08	0.69	0.37	1	1.00	
Potamogeton praelongus, White-stem pondweed	1.08	0.69	0.37	1	1.00	1
Potamogeton robbinsii, Fern pondweed	1.08	0.69	0.37	1	1.00	
Potamogeton zosteriformis, Flat-stem pondweed	1.08	0.69	0.37	1	1.00	
Sagittaria sp., Arrowhead	1.08	0.69	0.37	1	1.00	1
Schoenoplectus acutus, Hardstem bulrush	1.08	0.69	0.37	1	1.00	
*Potamogeton crispus,*Curly-leaf pondweed	1.08	0.69	0.37	1	1.00	1
Filamentous algae	26.88	17.36		25	1.20	

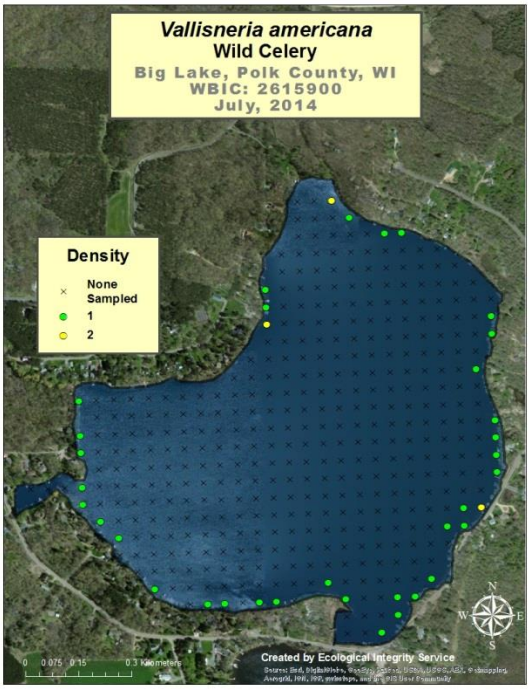
Table 4: Boat survey shoreline species observed Big Lake, 2014.

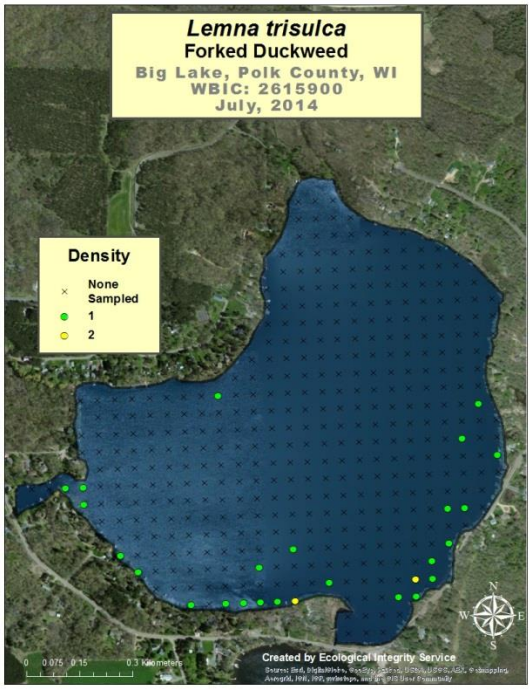
Boat/Shoreline Survey Species	Near Sample Point
Lythrum salicaria -Purple loosestrife	Several see map
Typha latifolia-Broad cattail	3, 355
Bolboschoenus fluviatilis-River bulrush	170
Typha augustifolia-Narrow cattail	170
Rumex orbiculatus-Water dock	2
Calla palustris-Wild calla	2
Cicuta bulbifera-Bulb bearing rush	2
Carex comosa-bottle brush sedge	2
Iris versicolor-Blue flag iris	3
Potamogeton natans-Floating pondweed	1
Eleocharis palustris-Creeping spikerush	1

The most common plants sampled in Big Lake in July 2014 were *Ceratophyllum demersum*- coontail, *Vallisneria americana*-wild celery, and *Lemna trisulca*-forked duckweed (in order of relative frequency). Coontail is a common and widespread aquatic plant found in Wisconsin lakes. This plant provides good habitat for invertebrates and foraging for fish. Coontail can withstand low light conditions; therefore it is able to grow at greater depths than many plants and often overwinters. This can provide much needed oxygen in the lake, especially in winter. Coontail also is often associated with high nutrient lakes and can absorb a great deal of nutrients.

Figure 6: Most abundant plant species sampled on Big Lake, 2014.





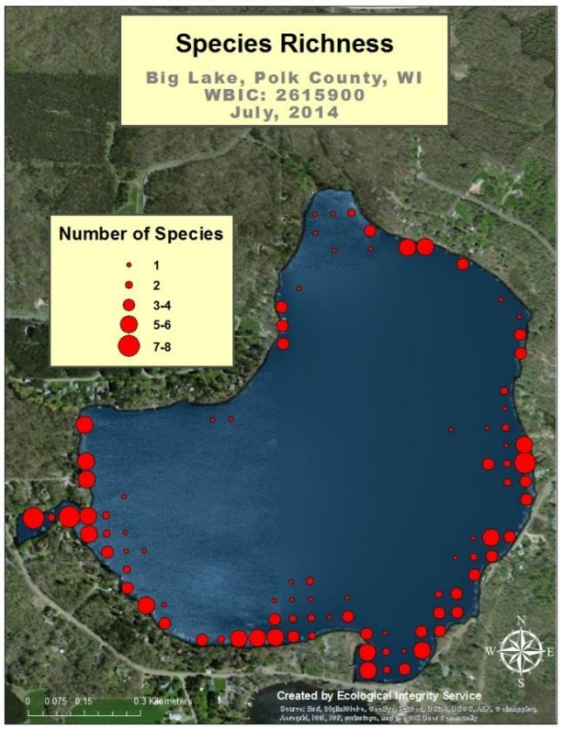


Wild celery is a common aquatic plant, found throughout Wisconsin. This plant grows in a wide range of depths, typically in firm substrates. It is tolerant of a wide range of water quality. Wild celery provides

food for a wide array of waterfowl and mammals such as muskrats. Fish also rely on clumps of wild celery for habitat, providing shade and shelter.

Forked duckweed is another common plant found in Wisconsin. It is not rooted, but lives as a free floating plant (typically on or near the lake bottom). Forked duckweed does not rely on sediment or water clarity, but does need adequate nutrients. Waterfowl use forked duckweed for food and large masses of forked duckweed can provide cover for invertebrates and fish.

Figure 7: Map of number of species sampled at each sample point, Big Lake 2014.



Big Lake has a few different areas that have high diversity. The bay and lagoon to the west have sample points with up to 8 different species sampled. The southern-most bay by the landing and some areas along the eastern shore also have high diversity. See figure 7 that shows the number of species per sample point.

Table 5: Big Lake Floristic Quality Index values and ecoregion median.

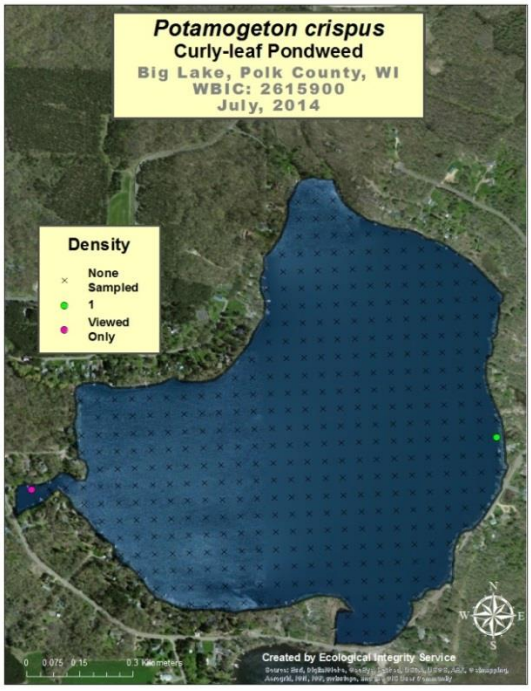
Floristic Quality Index Data	Big Lake, Polk County	Ecoregion median (other lakes studied)
Number of species	26	14
Mean conservatism	5.96	5.6
FQI	30.40	20.9

The floristic quality index (FQI) for Big Lake is much higher than the ecoregion median (30.4 in Big Lake vs 20.9 for ecoregion median). The FQI can demonstrate the health of the plant community in

relationship to the response to human activities. As habitat changes, plants with high conservatism values tend to decrease in frequency and even disappear. This can be reflected in the FQI. The mean conservatism value in Big Lake is higher than the ecoregion median as well.

There was one invasive species sampled in Big Lake and two observed. The invasive species sampled was *Potamogeton crispus*-curly leaf pondweed or CLP. Curly-leaf pondweed has been managed in Big Lake the past 5 years and the frequency and coverage of this AIS has significantly reduced. There was only one location CLP was sampled (and was not viewed or observed anywhere else).

Figure 8: CLP distribution map for Big Lake, 2014.



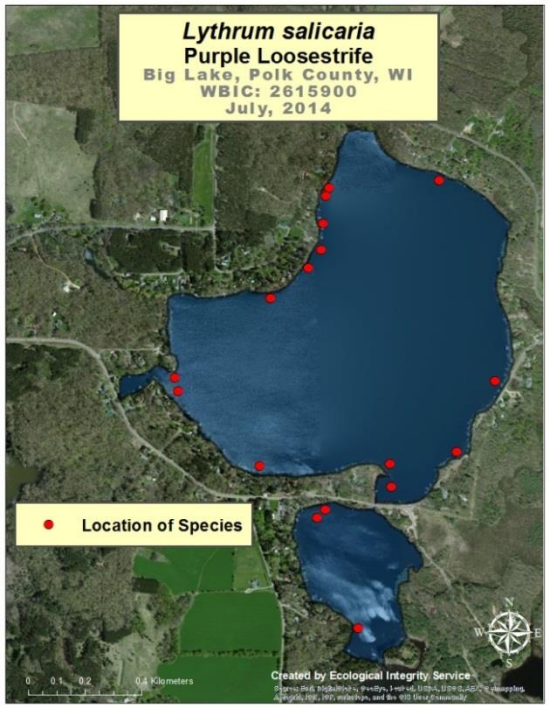
Another invasive plant observed as purple loosestrife. This plan was observed in near-shore areas around the lake. No purple loosestrife was growing within the ordinary high water mark. Figure 9 marks the locations purple loosestrife was observed. The locations are the boat locations, but he plants were only near or upland from the shore.

The other potentially invasive plant observed as *Typha augustifolia*-narrow leaf cattail. Narrow leaf cattail is an introduced species and according to the Wisconsin DNR, is potentially invasive[1]. Some literature suggests the narrow leaf cattail does not act invasively when competing with broad leaf cattail. It can tend to be more common than broad leaf cattail because narrow leaf cattail is more tolerant in deeper water. One study suggests that in more shallow water, which broad leaf cattail

[1] Susan Knight, Wisconsin DNR personal communication, 2014.

prefers, the narrow cattail remained the same or declined slightly[2]. Narrow leaf cattail can also tend to hybridize with broad cattail, and this hybrid tends to spread more quickly than narrow cattail. The narrow leaf cattail could be monitored if it is a concern for Big Lake. It is not known if the cattail in Big Lake has been changing over from broad leaf to narrow leaf cattail.

Figure 9: Locations where purple loosestrife was observed, Big Lake shoreline 2014.



[2] James B Gracea, Robert G Wetzelb Long-term dynamics of *Typha* populations Aquatic Botany, Volume 61, Issue 2, 1 June 1998, Pages 137–146.

Churchpine Lake

The point intercept survey of 2014 showed Churchpine Lake has aquatic plants growing at deep depths with a maximum depth with plants at 24.9 feet. This results in 132 sample points, out of 322 total sample points, that are at or shallower than the 24.9 feet. Of these 132 points, 117 had plants sampled which is 88.64% of the littoral zone with plants.

Table 6: Survey statistics summary for Churchpine Lake, 2014.

SUMMARY STATS-Churchpine Lake 2014:	
Total number of sample points in grid	322
Total number of sites with vegetation	122
Total number of sites shallower than maximum depth of plants	145
Frequency of occurrence at sites shallower than maximum depth of plants	84.14%
Simpson Diversity Index	0.92
Maximum depth of plants (ft)	25.60
Average number of all species per site (shallower than max depth)	3.11
Average number of all species per site (veg. sites only)	3.58
Average number of native species per site (shallower than max depth)	3.11
Average number of native species per site (veg. sites only)	3.58
Species Richness	33
Species Richness (including visuals)	37

The diversity of aquatic plants in Churchpine Lake is quite high. The species richness is 33 species, with four more species viewed during the survey (within six feet of sample point). The Simpson's diversity index was 0.92, which is high. Within sample points that had plants, there was a mean of 3.58 species of plants sampled at each point. Table 7 lists the species of plants sampled and viewed, with frequency and density data.

Figure 9: Littoral zone and plant density maps, Churchpine Lake 2014.

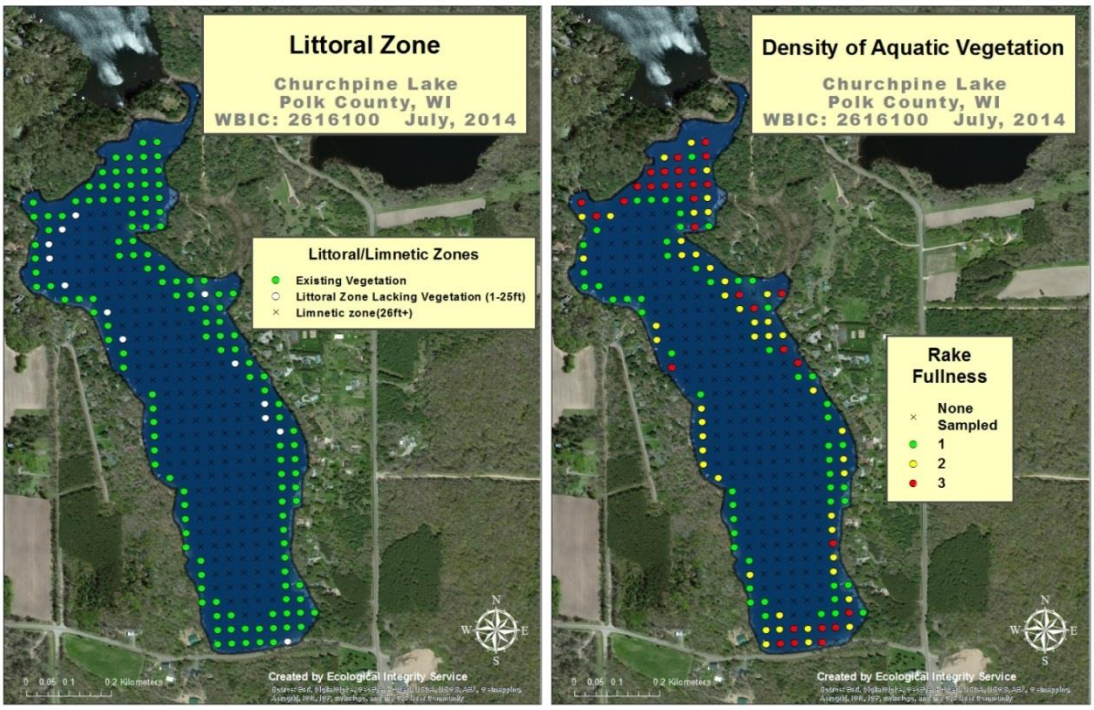


Table 7: Species list with frequency data, Churchpine Lake 2014.

Churchpine Lake Species	Vegetated Freq	Littoral Freq	Rel Freq	# Sampled	Density	# Viewed
Potamogeton robbinsii, Fern pondweed	46.72	39.31	13.38	57	1.51	1
Vallisneria americana, Wild celery	45.90	38.62	13.14	56	1.07	2
Potamogeton gramineus, Variable pondweed	44.26	37.24	12.68	54	1.19	
Myriophyllum sibiricum, Northern water-milfoil	38.52	32.41	11.03	47	1.13	
Najas flexilis, Slender naiad	22.13	18.62	6.34	27	1.07	1
Ceratophyllum demersum, Coontail	21.31	17.93	6.10	26	1.13	
Potamogeton illinoensis, Illinois pondweed	15.57	13.10	4.46	19	1.00	
Potamogeton zosteriformis, Flat-stem pondweed	15.57	13.10	4.46	19	1.05	
Lemna trisulca, Forked duckweed	9.84	8.28	2.82	12	1.00	
Nymphaea odorata, White water lily	9.02	7.59	2.58	11	1.00	
Chara sp., Muskgrasses	9.02	7.59	2.58	11	1.18	
Nitella sp., Nitella	9.02	7.59	2.58	11	1.09	
Potamogeton friesii, Fries' pondweed	8.20	6.90	2.30	10	1.30	
Potamogeton pusillus, Small pondweed	8.20	6.90	2.30	10	1.11	
Heteranthera dubia, Water star-grass	7.38	6.21	2.11	9	1.11	
Brasenia schreberi, Watershield	5.74	4.83	1.64	7	1.00	1
Potamogeton natans, Floating-leaf pondweed	4.92	4.14	1.41	6	1.00	
Potamogeton foliosus, Leafy pondweed	4.10	3.45	1.17	5	1.20	

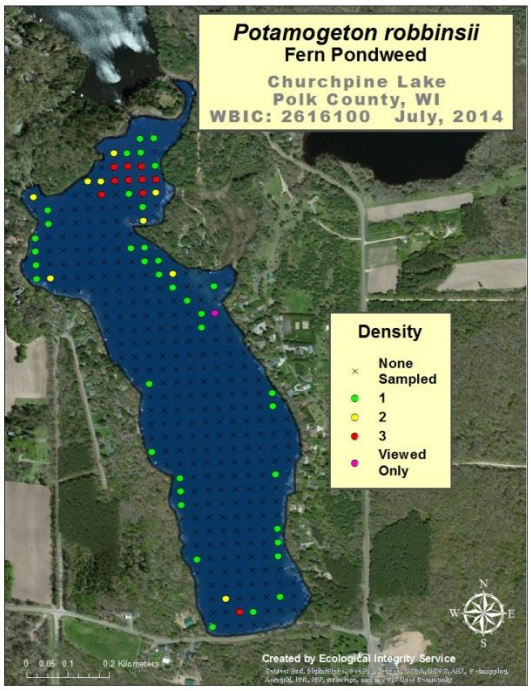
Churchpine Lake Species	Vegetated Freq	Littoral Freq	Rel Freq	# Sampled	Density	# Viewed
Potamogeton praelongus, White-stem pondweed	3.28	2.76	0.94	4	1.00	
Eleocharis acicularis, Needle spikerush	2.46	2.07	0.70	3	1.00	
Elodea canadensis, Common waterweed	2.46	2.07	0.70	3	1.00	
Bidens beckii, Water marigold	1.64	1.38	0.47	2	1.00	
Juncus pelocarpus f. submersus, Brown-fruited rush	1.64	1.38	0.47	2	1.00	
Pontederia cordata, Pickerelweed	1.64	1.38	0.47	2	1.00	
Potamogeton amplifolius, Large-leaf pondweed	1.64	1.38	0.47	2	1.00	
Typha augustifolia, Narrow-leaved Cattail	1.64	1.38	0.47	2	1.00	1
Eleocharis palustris, Creeping spikerush	0.82	0.69	0.23	1	1.00	
Myriophyllum tenellum, Dwarf water-milfoil	0.82	0.69	0.23	1	1.00	
Potamogeton richardsonii, Clasping-leaf pondweed	0.82	0.69	0.23	1	1.00	
Sagittaria cristata, Crested arrowhead	0.82	0.69	0.23	1	1.00	
Schoenoplectus subterminalis, Water bulrush	0.82	0.69	0.23	1	1.00	
Stuckenia pectinata, Sago pondweed	0.82	0.69	0.23	1	1.00	
Utricularia intermedia, Flat-leaf bladderwort	0.82	0.69	0.23	1	1.00	1
Aquatic moss	1.64	1.38	n/a	2	1.00	
Freshwater sponge	0.82	0.69	n/a	1	1.00	
Filamentous algae	18.85	15.86	n/a	23	1.04	
Isoetes echinospora, Spiny spored-quillwort	Viewed	only				1
Schoenoplectus acutus, Hardstem bulrush	Viewed	only				1
Sparganium eurycarpum, Common bur-reed	Viewed	only				1
Utricularia vulgaris, Common bladderwort	Viewed	only				1

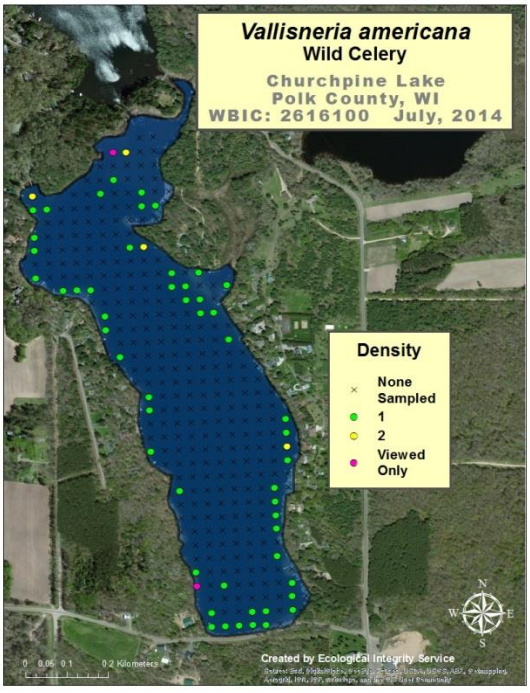
Table 8: Boat survey shoreline species observed, Churchpine Lake 2014.

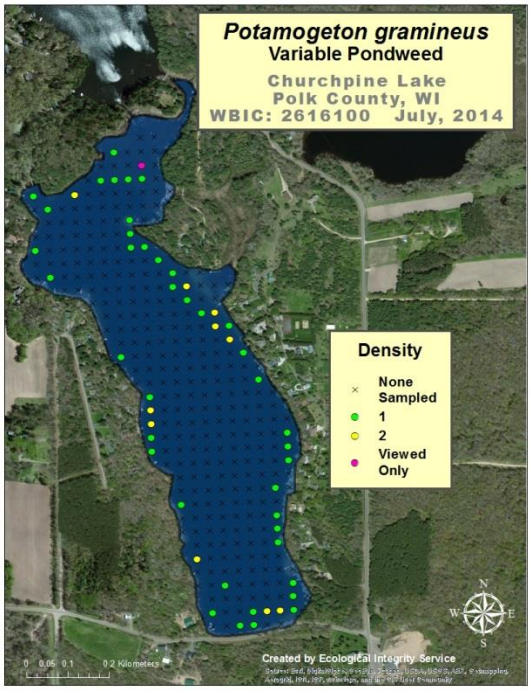
Boat/Shoreline Survey Species	Near Sample Point
Typha latifolia-Broad cattail	13 and 114
Typha augustifolia-Narrow cattail (in addition to sampled)	114, 177, 312
Iris versicolor-Blue flag iris	149
Lythrum salicaria -Purple loosestrife	3

The most common plants sampled in Churchpine Lake were *Potamogeton robbinsii*-fern pondweed, *Vallisneria americana*-wild celery, and *Potamogeton gramineus*-variable pondweed (in order of relative frequency).

Figure 10: Distribution maps for most abundant species sampled on Churchpine Lake, 2014.







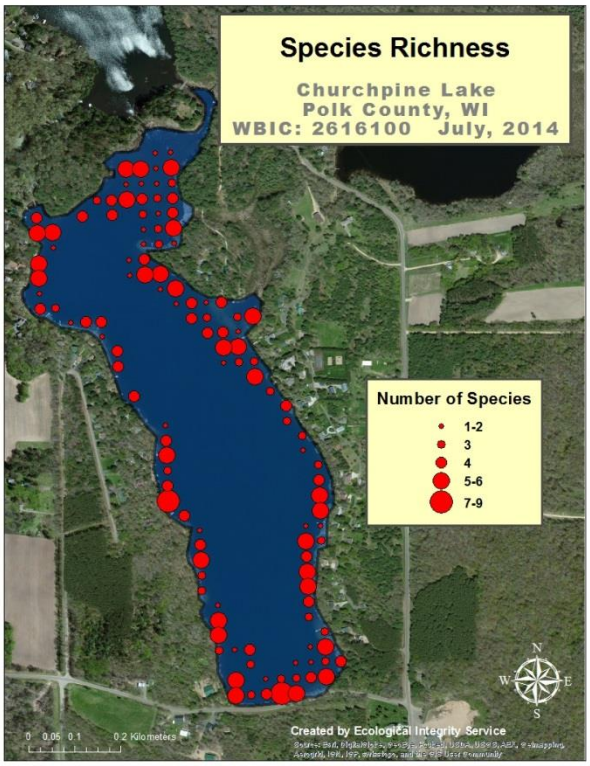
Fern pondweed is a very common aquatic plant in northern Wisconsin. It has the ability to grow in deep water and can overwinter. This can provide oxygen in areas of the lake that may be deprived of oxygen, through photosynthesis. Fern pondweed provides habitat for invertebrates and good foraging for fish.

As outlined earlier, wild celery provides food for waterfowl as well as shelter and shade for fish.

Variable pondweed is widely distributed in Wisconsin. It is typically found in firm sediment ranging in depth from very shallow to several meters deep. Waterfowl feed on fruits and tubers. Muskrat, beaver, and deer are known to feed on foliage and fruit. Often the plants have extensive branching of small leaves that provides excellent habitat for invertebrates and fish.

There are numerous areas around Churchpine Lake that have high plant diversity. Many of the bays had sample points that had up to eight species of plant with one rake sample. The high diversity areas are scattered throughout the lake, with most of these areas in more shallow bays.

Figure 11: Number of species sampled at each sample point, Churchpine Lake 2014.



The FQI on Churchpine Lake in 2014 was substantially higher than the ecoregion median (35.71 for Churchpine and 20.9 for the ecoregion median). This shows that Churchpine Lake has a healthy, diverse plant community that includes a large number of sensitive plants. The mean conservatism is much higher than the ecoregion median, which suggests the presence of more sensitive plants.

Table 9: Floristic Quality Index values, Churchpine Lake 2014.

Floristic Quality Index Data	Churchpine Lake, Polk County	Ecoregion median (other lakes studied)
Number of species	32	14
Mean conservatism	6.31	5.6
FQI	35.71	20.9

There was one invasive species observed and one potentially invasive species sampled. There was one location that purple loosestrife was observed, but not sampled along the shore on Churchpine Lake. Purple loosestrife is an invasive wetland plant. Narrow leaf cattail, which is potentially invasive was sampled and observed in a few different locations. The north end of Churchpine Lake, near the outlet to Round Lake has two extensive cattail beds. These beds have a mixture of some broad leaf cattail and a large amount of narrow leaf cattail and potentially a hybrid of the two species. These beds were not evaluated as to the dominance of narrow leaf cattail or the hybrid (if present).

Round Lake

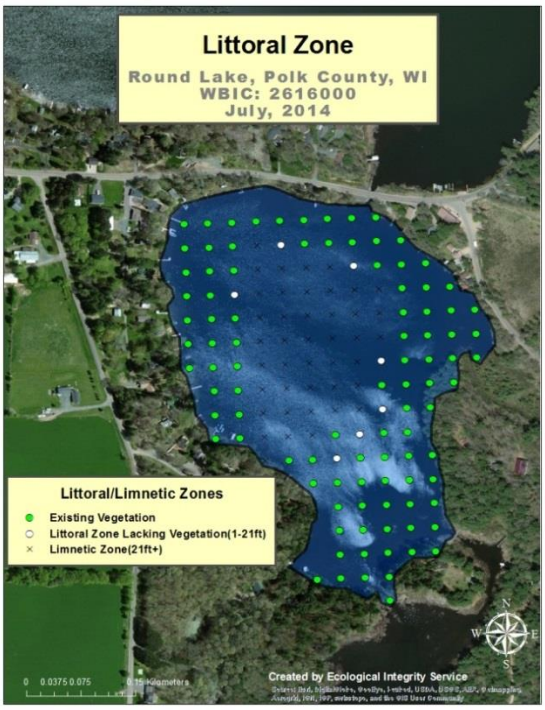
The 2014 point intercept shows Round Lake has an extensive, diverse plant community. Of the 145 sample points, 103 were at depths less than 20.9 feet (maximum depth of plants) with plants present in 95 sample points. The frequency of occurrence within the littoral zone (less than 20.9 feet) was 92.23%. There are numerous areas in Round Lake with high density of plant growth.

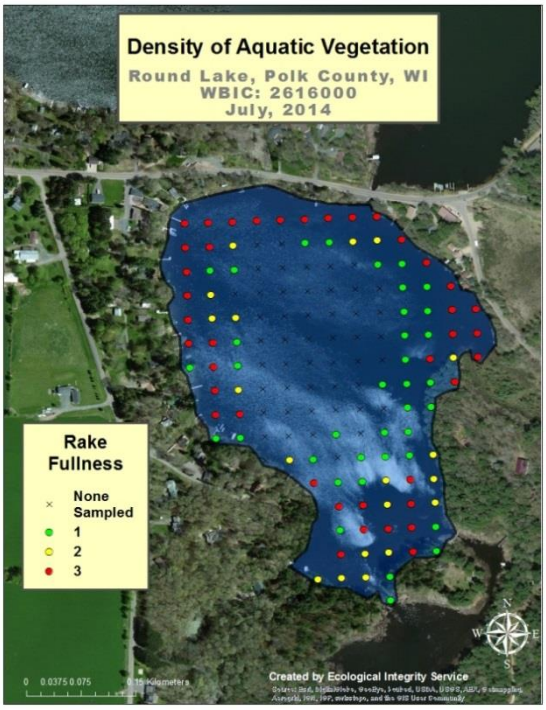
Table 10: Survey statistic summary, Round Lake 2014.

SUMMARY STATS-Round Lake 2014:	
Total number of sample points in grid	145
Total number of sites with vegetation	95
Total number of sites shallower than maximum depth of plants	103
Frequency of occurrence at sites shallower than maximum depth of plants	92.23%
Simpson Diversity Index	0.94
Maximum depth of plants (ft)**	20.90
Average number of all species per site (shallower than max depth)	4.04
Average number of all species per site (veg. sites only)	4.38
Average number of native species per site (shallower than max depth)	4.03
Average number of native species per site (veg. sites only)	4.37
Species Richness	37
Species Richness (including visuals)	38

Round lake has a high diversity, the highest of the three lakes at 37 species sampled. The Simpson's diversity index was 0.94, which is very high and reflects tremendous diversity at each sample point. There was an average of 4.37 native species sampled at each sample point.

Figure 12: Littoral zone and plant density maps, Round Lake 2014.





The most common plants sampled in Round Lake in 2014 were *Ceratophyllum demersum*-coontail, *Nymphaea odorata*-white water lily, and *Potamogeton zosteriformis*-flat-stem pondweed respectively.

Table 11: Species list and frequency data, Round Lake 2014.

Round Lake Species	Vegetated Freq	Littoral Freq	Rel Freq	# Sampled	Density	# Viewed
Ceratophyllum demersum, Coontail	65.26	60.19	14.9	62	1.50	
Nymphaea odorata, White water lily	34.74	32.04	7.9	33	1.00	5
Potamogeton zosteriformis, Flat-stem pondweed	30.53	28.16	7.0	29	1.00	1
Najas flexilis, Slender naiad	29.47	27.18	6.7	28	1.21	1
Potamogeton robbinsii, Fern pondweed	29.47	27.18	6.7	28	1.25	1
Myriophyllum sibiricum, Northern water-milfoil	22.11	20.39	5.0	21	1.00	2
Elodea canadensis, Common waterweed	18.95	17.48	4.3	18	1.00	
Heteranthera dubia, Water star-grass	18.95	17.48	4.3	18	1.06	
Lemna minor, Small duckweed	18.95	17.48	4.3	18	1.11	
Potamogeton illinoensis, Illinois pondweed	17.89	16.50	4.1	17	1.06	
Potamogeton friesii, Fries' pondweed	16.84	15.53	3.8	16	1.06	

Round Lake Species	Vegetated Freq	Littoral Freq	Rel Freq	# Sampled	Density	# Viewed
Vallisneria americana, Wild celery	15.79	14.56	3.6	15	1.00	
Brasenia schreberi, Watershield	11.58	10.68	2.6	11	1.18	2
Lemna trisulca, Forked duckweed	11.58	10.68	2.6	11	1.00	
Nitella sp., Nitella	11.58	10.68	2.6	11	1.00	
Potamogeton pusillus, Small pondweed	10.53	9.71	2.4	10	1.00	
Spirodela polyrhiza, Large duckweed	8.42	7.77	1.9	8	1.00	
Potamogeton amplifolius, Large-leaf pondweed	7.37	6.80	1.7	7	1.00	2
Nuphar variegata, Spatterdock	6.32	5.83	1.4	6	1.00	
Potamogeton richardsonii, Clasping-leaf pondweed	6.32	5.83	1.4	6	1.00	3
Potamogeton gramineus, Variable pondweed	5.26	4.85	1.2	5	1.00	
Sagittaria sp., Arrowhead	5.26	4.85	1.2	5	1.00	1
Bidens beckii, Water marigold	4.21	3.88	1.0	4	1.00	
Chara sp., Muskgrasses	4.21	3.88	1.0	4	1.00	
Schoenoplectus acutus, Hardstem bulrush	4.21	3.88	1.0	4	1.00	1
Pontederia cordata, Pickerelweed	3.16	2.91	0.7	3	1.00	2
Sagittaria rigida, Sessile-fruited arrowhead	3.16	2.91	0.7	3	1.00	3
Wolffia columbiana, Common watermeal	3.16	2.91	0.7	3	1.00	
Potamogeton natans, Floating-leaf pondweed	2.11	1.94	0.5	2	1.00	
Potamogeton praelongus, White-stem pondweed	2.11	1.94	0.5	2	1.00	2
Utricularia intermedia, Flat-leaf bladderwort	2.11	1.94	0.5	2	1.00	
Eleocharis acicularis, Needle spikerush	1.05	0.97	0.2	1	1.00	
Isoetes echinospora, Spiny spored-quillwort	1.05	0.97	0.2	1	1.00	
Potamogeton crispus,Curly-leaf pondweed	1.05	0.97	0.2	1	1.00	
Potamogeton foliosus, Leafy pondweed	1.05	0.97	0.2	1	1.00	
Stuckenia pectinata, Sago pondweed	1.05	0.97	0.2	1	1.00	1
Utricularia vulgaris, Common bladderwort	1.05	0.97	0.2	1	1.00	
Aquatic moss			n/a			
Filamentous algae	13.68	12.62	n/a	13	1.00	
Sparganium eurycarpum, Common bur-reed	Viewed	only				2

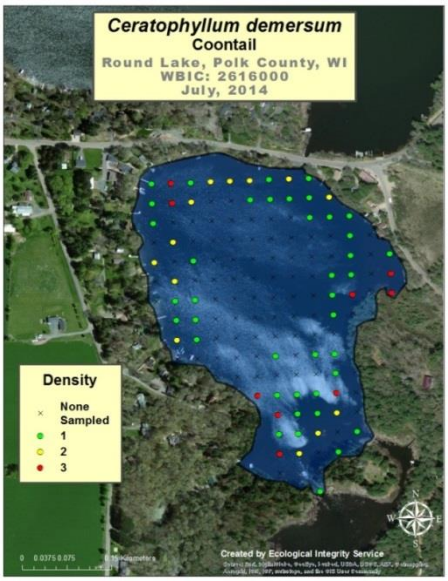
Table 12: Boat survey shoreline species observed, Round Lake 2014.

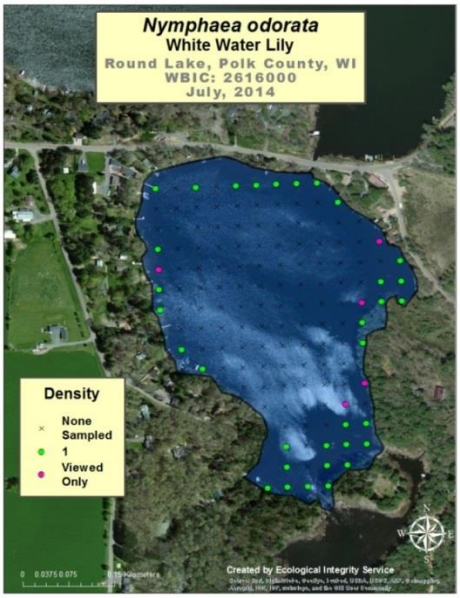
Boat/Shoreline Survey Species	Near Sample Point
Polygonum amphibium-Water smartweed	49
Typha augustifolia-Narrow cattail	112, 125

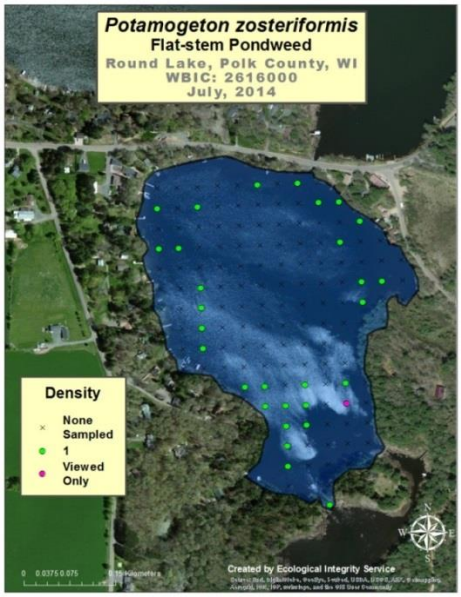
Coontail is a very common in Wisconsin and provides great habitat for invertebrates and fish. This plant can overwinter, thus providing habitat and oxygen during the winter months.

White water lily is also widespread throughout Wisconsin. This plant has a round, floating leaf with a long petiole. The floating leaves provide shade and cover for fish. The extensive rhizome networks of white lily beds stabilize bottom sediments.

Figure 13: Distribution maps of most abundant species sampled on Round Lake, 2014.

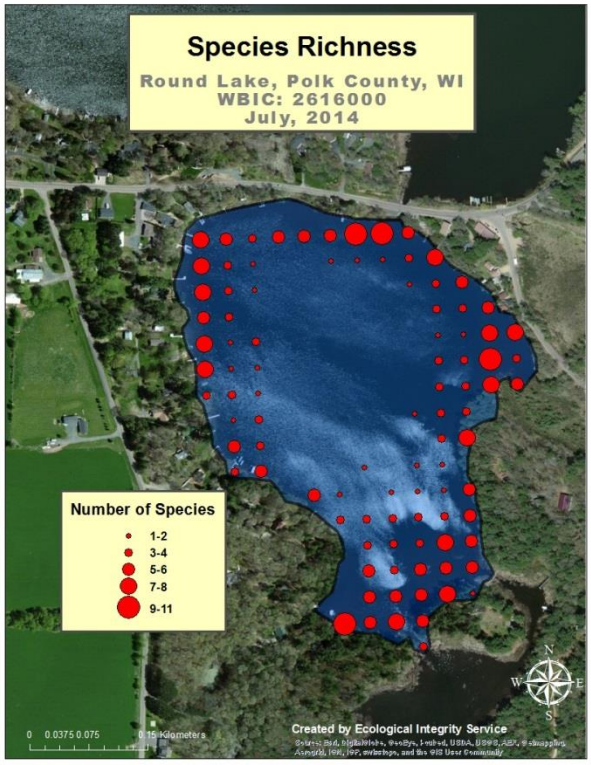






Flat-stem pondweed is a common Wisconsin aquatic plant. It grows in a wide variety of water depths and tends to be found in soft sediment. Flat-stem pondweed is a food source for waterfowl. It is also grazed by muskrat, deer, and beaver. Invertebrates and fish will use flat-stem pondweed for cover.

Figure 14: Number of species sampled at each sample point, Round Lake 2014.



There are numerous sample points around Round Lake that have high diversity. Several sample points had over 10 species sampled at a single location. The eastern most bay and the bays in the south have consistently high diversity and density.

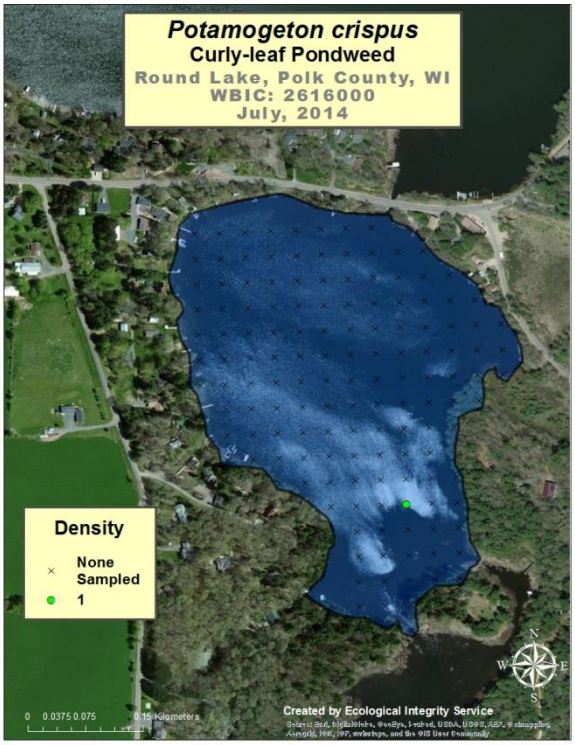
Table 13: Floristic Quality Index values, Round Lake 2014.

Floristic Quality Index Data	Round Lake, Polk County	Ecoregion median (other lakes studied)
Number of species	35	14
Mean conservatism	6.2	5.6
FQI	36.68	20.9

The FQI in Round Lake was significantly higher than the ecosystem median (36.68 vs 20.9). The mean conservatism value is also higher (6.2 vs 5.6). This shows the plant community is healthy and has a number of more sensitive plants. The plants do not indicate adverse response to human activity.

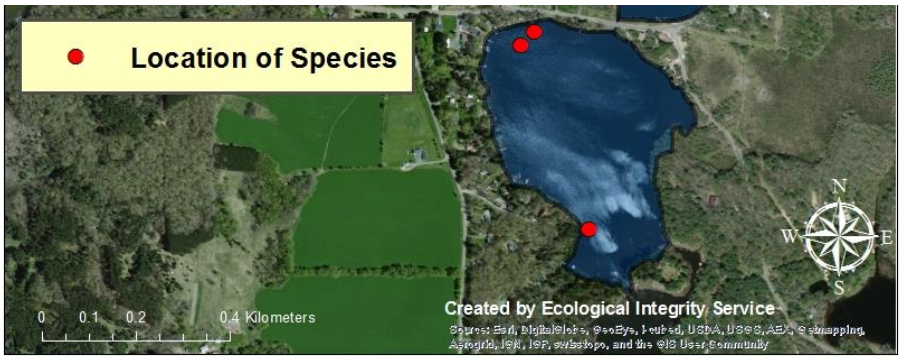
There was one invasive species sampled and two observed. The invasive species sampled was *Potamogeton crispus*-curly leaf pondweed. This plant was only sampled, viewed and/or observed at only this one location.

Figure 15: Distribution map of CLP, Round Lake 2014.



Purple loostrife was observed in a few locations along the shoreline on Round Lake. Those locations are marked from the lake for reference to the shoreline location.

Figure 16: Round Lake shoreline locations with purple loosestrife, 2014.



The narrow leaf cattail, which is a potential invasive plant, was observed along the shoreline near points 112 and 125. See appendix for those locations on a map.

Comparison to 2009 survey

A full lake, point intercept survey was conducted on these lakes in 2009. In order to evaluate the plant community, the results of the 2014 survey were compared to the 2009 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 five years. Increases in native species are not a concern. Substantial decreases in various native species are a concern, especially if not coupled with an increase in a different native species.

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

1. Management practices such as herbicide treatments can reduce frequency. 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 would more likely be multiple species.
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 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 plant 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. There are times when a lake may have high density of a plant one year, followed by 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, and Potamogeton friesii*, can easily be mistaken for one plant or another in the field. 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 2014 survey.
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 five years may be unlikely. If a plant emerges as a more dominant plant over time, that plant may compete for space in that area, thus reducing 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 carp.

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).

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.

Big Lake

Table 14: Big Lake survey statistics comparison, 2009 and 2014.

Survey Data	2009	2014
Species Richness	26	28
Simpson's diversity index	0.91	0.87
Maximum depth of plants	16.00 ft	18.30 ft
% Littoral coverage	73.68%	64.58%
FQI	29.19	30.40

The survey statistics were very similar between the 2009 survey and the 2014 survey. The species richness is different by only one species. The maximum depth of plants was greater in 2014, which resulted in a lower littoral zone coverage (this is because the deeper value adds more points to the potential littoral zone, many of which are deep and likely may not have plants). The FQI for both surveys are virtually the same.

Table 15: Chi-square analysis for Big Lake frequency data, 2009 and 2014.

Species	2009	2014	P value	Significant change	Change from 2009 to 2014
Ceratophyllum demersum, Coontail	63	77	0.19	**n.s.**	**+**
Vallisneria americana, Wild celery	38	37	0.90	**n.s.**	**-**
Lemna trisulca, Forked duckweed	19	26	0.28	**n.s.**	**+**
Elodea canadensis, Common waterweed	12	25	0.029	*****	**+**
Myriophyllum sibiricum, Northern water-milfoil	27	17	0.12	**n.s.**	**-**
Potamogeton illinoensis, Illinois pondweed	5	17	0.009	******	**+**
Heteranthera dubia, Water star-grass	14	13	0.84	**n.s.**	**-**
Nymphaea odorata, White water lily	6	11	0.22	**n.s.**	**+**
Stuckenia pectinata, Sago pondweed	9	10	0.82	**n.s.**	**+**

Species	2009	2014	P value	Significant change	Change from 2009 to 2014
Potamogeton richardsonii, Clasping-leaf pondweed	10	7	0.46	**n.s.**	**-**
Lemna minor, Small duckweed	5	4	0.74	**n.s.**	**-**
Najas flexilis, Slender naiad	5	4	0.74	**n.s.**	**-**
Spirodela polyrhiza, Large duckweed	3	4	0.70	**n.s.**	**+**
Chara sp., Muskgrasses	2	2	1.00	**n.s.**	**no change**
Ranunculus aquatilis, White water crowfoot	2	2	1.00	**n.s.**	**no change**
Wolffia columbiana, Common watermeal	1	2	0.56	**n.s.**	**+**
Bidens beckii, Water marigold	2	1	0.56	**n.s.**	**-**
Nuphar variegata, Spatterdock	0	1	0.32	**n.s.**	**+**
Potamogeton foliosus, Leafy pondweed	4	1	0.18	**n.s.**	**-**
Potamogeton friesii, Fries' pondweed	3	1	0.32	**n.s.**	**-**
Potamogeton gramineus, Variable pondweed	0	1	0.32	**n.s.**	**+**
Potamogeton praelongus, White-stem pondweed	6	1	0.06	**n.s.**	**-**
Potamogeton robbinsii, Fern pondweed	3	1	0.32	**n.s.**	**-**
Potamogeton zosteriformis, Flat-stem pondweed	32	1	0.00000	***	**-**
Sagittaria sp., Arrowhead	0	1	0.32	**n.s.**	**+**
Schoenoplectus acutus, Hardstem bulrush	1	1	1.00000	**n.s.**	**no change**
Potamogeton crispus,Curly-leaf pondweed	10	1	0.006	**	**-**
Potamogeton amplifolius, Large leaf pondweed	5	1	0.10	**n.s.**	**-**
Eleocharis acicularis, needle spikerush	1	0	0.32	**n.s.**	**-**

Significant native increase

Significant native decrease

***AIS decrease** (late season survey)*

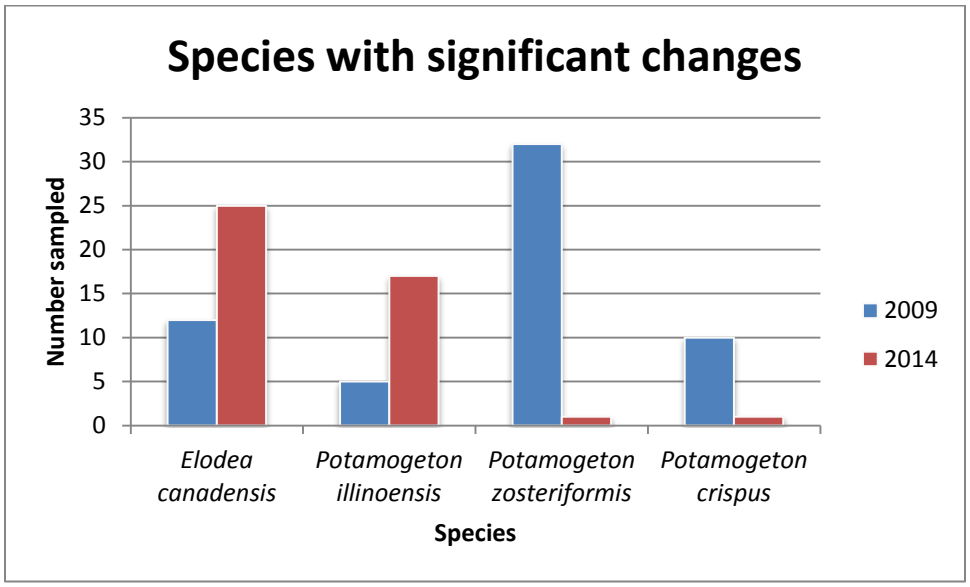
A chi-square analysis is done to evaluate any changes in the frequency of individual plant species and if that change is significant or not (or due to chance). In Big Lake, there were two species that increased in frequency that was significant. These species were *Elodea canadensis* and *Potamogeton illinoensis*.

One species of native plant and one species of AIS decreased (significant). The native species was *Potamogeton zosteriformis*-flat-stem pondweed. The cause of this is unknown. It is not likely due to

herbicide treatments as other species would likely have been reduced also. Furthermore, previous surveys evaluating herbicide treatments did not show a decline in flat-stem pondweed. This decrease is not a concern as it is likely due to seasonal growth and/or sampling variation.

Potamogeton crispus-curly leaf pondweed is the AIS that significantly decreased. This plant has been actively managed in Big Lake and this reduction is a desirable outcome of the management (herbicide applications).

Figure 17: Graph showing species with statistically significant changes on Big Lake, 2009 to 2014.



Overall, it appears the Big Lake plant community has changed very little in five years.

Churchpine Lake

Table 16: Comparison of survey statistics Churchpine Lake, 2009 and 2014.

Survey Data	2009	2014
Species Richness	31	33
Simpson's diversity index	0.91	0.92
Maximum depth of plants	25.70 ft	25.60 ft
% Littoral coverage	92.62%	84.14%
FQI	35.78	35.71

The survey comparison for Churchpine Lake show few differences. The species richness is different by two species. All other values are nearly identical except for the littoral plant coverage. It appears that this coverage decreased slightly from 2009 to 2014.

Table 17: Chi-square analysis of species frequency data for Churchpine Lake, 2009 to 2014.

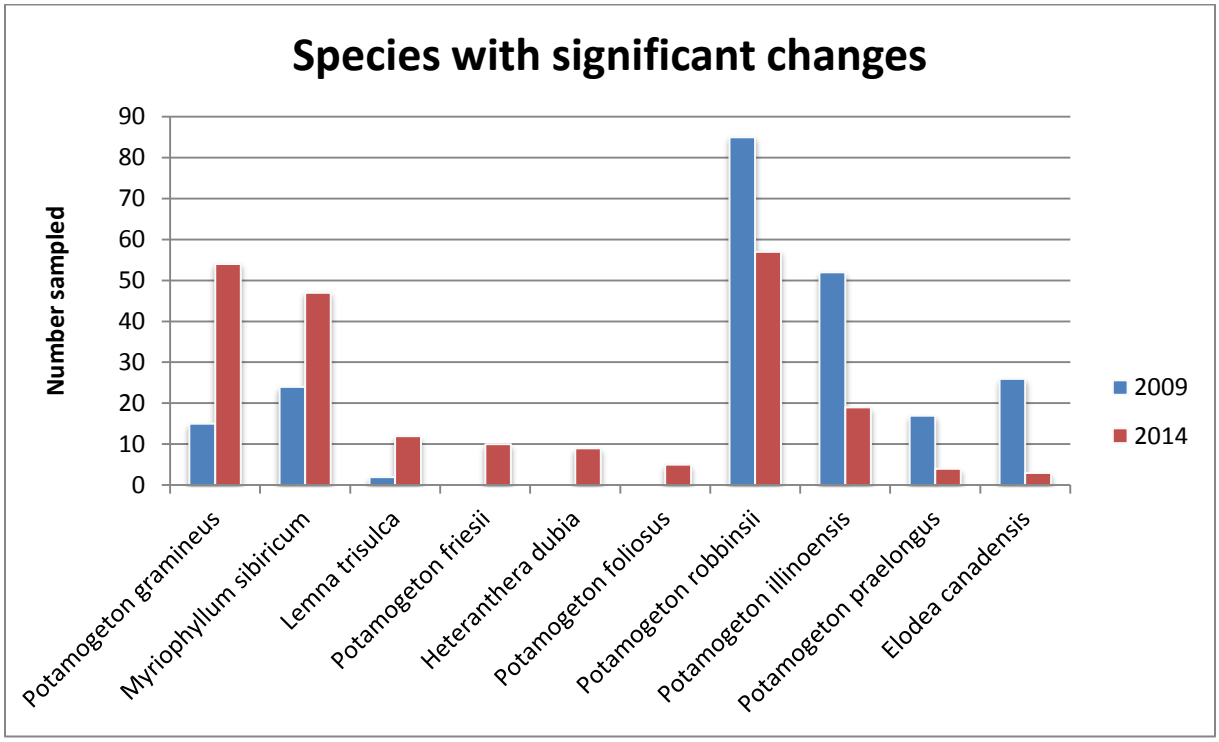
Species	2009	2014	p	Significant change	Change from 2009 to 2014
Potamogeton robbinsii, Fern pondweed	85	57	0.008	**	-
Vallisneria americana, Wild celery	69	56	0.20	n.s.	-
Potamogeton gramineus, Variable pondweed	15	54	0.0000	***	+
Myriophyllum sibiricum, Northern water-milfoil	24	47	0.004	**	+
Najas flexilis, Slender naiad	41	27	0.07	n.s.	-
Ceratophyllum demersum, Coontail	30	26	0.58	n.s.	-
Potamogeton illinoensis, Illinois pondweed	52	19	0.00003	***	-
Potamogeton zosteriformis, Flat-stem pondweed	11	19	0.13	n.s.	+
Lemna trisulca, Forked duckweed	2	12	0.007	**	+
Nymphaea odorata, White water lily	11	11	0.83	1.00	n/c
Chara sp., Muskgrasses	17	11	0.25	n.s.	-
Nitella sp., Nitella	11	13	0.68	n.s.	+
Potamogeton friesii, Fries' pondweed	0	10	0.001	**	+
Heteranthera dubia, Water star-grass	0	9	0.002	**	+
Potamogeton pusillus, Small pondweed	5	10	0.19	n.s.	+

Species	2009	2014	p	Significant change	Change from 2009 to 2014
Brasenia schreberi, Watershield	8	7	0.79	**n.s.**	**-**
Potamogeton natans, Floating-leaf pondweed	6	6	1.00	**n.s.**	**no change**
Potamogeton foliosus, Leafy pondweed	0	5	0.02	*	**+**
Potamogeton praelongus, White-stem pondweed	17	4	0.004	**	**-**
Eleocharis acicularis, Needle spikerush	3	3	1.00	**n.s.**	**no change**
Elodea canadensis, Common waterweed	26	3	0.00001	***	**-**
Bidens beckii, Water marigold	2	2	1.00	**n.s.**	**no change**
Juncus pelocarpus f. submersus, Brown-fruited rush	0	2	0.16	**n.s.**	**+**
Pontederia cordata, Pickerelweed	1	2	0.56	**n.s.**	**+**
Potamogeton amplifolius, Large-leaf pondweed	7	2	0.09	**n.s.**	**-**
Typha augustifolia, Narrow-leaved Cattail	0	2	0.16	**n.s.**	**+**
Eleocharis palustris, Creeping spikerush	0	1	0.32	**n.s.**	**+**
Myriophyllum tenellum, Dwarf water-milfoil	2	1	0.56	**n.s.**	**-**
Potamogeton richardsonii, Clasping-leaf pondweed	2	1	0.56	**n.s.**	**-**
Sagittaria sp., Arrowhead	2	1	0.56	**n.s.**	**-**
Schoenoplectus subterminalis, Water bulrush	1	1	1.00	**n.s.**	**no change**
Stuckenia pectinata, Sago pondweed	0	1	0.32	**n.s.**	**+**
Utricularia intermedia, Flat-leaf bladderwort	1	1	1.00	**n.s.**	**no change**
Isoetes sp.	1	0	0.32	**n.s.**	**-**
Lemna minor, Small duckweed	1	0	0.32	**n.s.**	**-**
Nuphar variegate, Spatterdock	1	0	0.32	**n.s.**	**-**
Typha latifolia, broad cattail	1	0	0.32	**n.s.**	**-**
Significant native increase					
Significant native decrease					

The chi-square analysis shows there were a significant increase in six native species and a significant decrease in four native species. Since there was no plant management occurring over the past five years, the decreases cannot be attributed to herbicide or other management practices. The decrease in *Potamogeton illinoensis*-Illinois pondweed and increase in *Potamogeton gramineus*-variable pondweed

may be due to identification issues. The larger version of variable pondweed can be easily mistaken for smaller versions of Illinois pondweed. If these two species sample numbers are combined they are very similar in both surveys (2009 and 2014). All other differences are likely due to seasonal and/or sampling variation.

Figure 18: Graph showing species with statistically significant changes on Churchpine Lake, 2009 to 2014.



Round Lake

Table 18: Comparison of survey statistics Round Lake, 2009 to 2014.

Survey Data	2009	2014
Species Richness	36	37
Simpson's diversity index	0.91	0.94
Maximum depth of plants	21.1 ft	20.9 ft
% Littoral coverage	79.63%	92.23%
FQI	36.68	36.68

The comparison of the Round Lake survey statistics show very little change. The species richness is different by one species. The Simpson's diversity index increased a small amount as did the littoral zone plant coverage. The FQI values are exactly the same. The based upon these values, the plant community changed very little in the past five years.

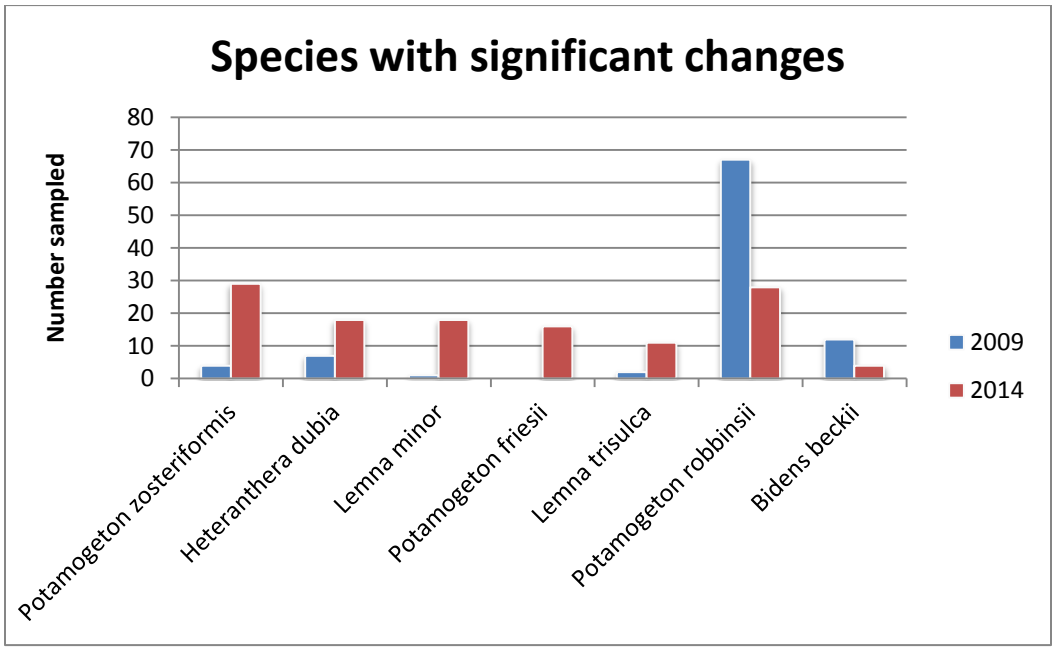
Table 19: Chi-square analysis of species frequency data for Round Lake, 2009 to 2014.

Species	2009	2014	P value	Significant change	Change from 2009 to 2014
Ceratophyllum demersum, Coontail	61	62	0.90	**n.s.**	**+**
Nymphaea odorata, White water lily	26	33	0.31	**n.s.**	**+**
Potamogeton zosteriformis, Flat-stem pondweed	4	29	0.0000	***	**+**
Najas flexilis, Slender naiad	8	28	0.0004	***	**+**
Potamogeton robbinsii, Fern pondweed	67	28	0.0000	***	**-**
Myriophyllum sibiricum, Northern water-milfoil	17	21	0.49	**n.s.**	**+**
Elodea canadensis, Common waterweed	18	18	1.00	**n.s.**	**no change**
Heteranthera dubia, Water star-grass	7	18	0.02	*	**+**
Lemna minor, Small duckweed	1	18	0.00005	***	**+**
Potamogeton illinoensis, Illinois pondweed	18	17	0.86	**n.s.**	**-**
Potamogeton friesii, Fries' pondweed	0	16	0.00004	***	**+**
Vallisneria americana, Wild celery	15	15	1.00	**n.s.**	**no change**
Brasenia schreberi, Watershield	18	11	0.17	**n.s.**	**-**
Lemna trisulca, Forked duckweed	2	11	0.01	*	**+**
Nitella sp., Nitella	4	11	0.06	**n.s.**	**+**
Potamogeton pusillus, Small pondweed	7	10	0.45	**n.s.**	**+**
Spirodela polyrhiza, Large duckweed	7	8	0.79	**n.s.**	**+**
Potamogeton amplifolius, Large-leaf pondweed	8	7	0.79	**n.s.**	**-**
Nuphar variegata, Spatterdock	4	6	0.52	**n.s.**	**+**
Potamogeton richardsonii, Clasping-leaf pondweed	2	6	0.15	**n.s.**	**+**
Potamogeton gramineus, Variable pondweed	4	5	0.73	**n.s.**	**+**
Sagittaria sp., Arrowhead	5	5	1.00	**n.s.**	**no change**
Bidens beckii Water marigold	12	4	0.04	*	**-**

Chara sp., Muskgrasses	4	4	1.00	**n.s.**	**no change**
Schoenoplectus acutus, Hardstem bulrush	2	4	0.41	**n.s.**	**+**
Pontederia cordata, Pickerelweed	1	3	0.31	**n.s.**	**+**
Sagittaria rigida, Sessile-fruited arrowhead	0	3	0.08	**n.s.**	**+**
Wolffia columbiana, Common watermeal	0	3	0.08	**n.s.**	**+**
Potamogeton natans, Floating-leaf pondweed	2	2	1.00	**n.s.**	**no change**
Potamogeton praelongus, White-stem pondweed	3	2	0.65	**n.s.**	**-**
Utricularia intermedia, Flat-leaf bladderwort	2	2	1.00	**n.s**	**no change**
Eleocharis acicularis, Needle spikerush	1	1	1.00	**n.s.**	**no change**
Isoetes echinospora, Spiny spored-quillwort	1	1	1.00	**n.s.**	**no change**
Potamogeton crispus,Curly-leaf pondweed	1	1	1.00	**n.s.**	**no change**
Potamogeton foliosus, Leafy pondweed	0	1	0.32	**n.s.**	**+**
Stuckenia pectinata, Sago pondweed	1	1	1.00	**n.s.**	**no change**
Utricularia vulgaris, Common bladderwort	3	1	0.31	**n.s.**	**-**
Utricularia gibba, Creeping bladderwort	1	0	0.32	**n.s**	**-**
Sparganium eurycarpum, Common bur-reed	1	0	0.32	**n.s.**	**-**
Typha latifolia	1	0	0.32	**n.s.**	**-**
Significant native increase					
Significant native decrease					

The chi-square analysis shows there was a significant increase in six native species and a significant decrease in two native species. The decrease in the two species is not a concern and is likely due to natural, seasonal variation and/or sampling variation. The plants that decreased (*Potamogeton robbinsii* and *Bidens beckii*) are fairly sensitive plants and would tend to respond to adverse habitat changes. However, there are a number of other sensitive plants that did not change significantly.

Figure 19: Graph of species with statistically significant changes on Round Lake, 2009 to 2014.



Discussion

Big Lake, Churchpine Lake and Round Lake were found to have fairly high to high diversity (Round Lake was the highest). All lake's FQI were higher than the ecoregion median, indicating the plant communities have not been adversely affected through human activity.

From 2009 to 2014, the surveys show very little changes, with more increases in frequency of occurrence than decreases (that were statistically significant). No decrease appear to indicate human caused reductions, especially through CLP management.

CLP management success is indicated in the 2014 survey. There was a significant decrease in CLP frequency of occurrence, and CLP was only sampled, viewed and/or observed in 2 locations (one in Big Lake and one in Round Lake.

Monitoring of AIS should be continued as well as boat landing monitoring. Efforts to avoid any introduction of new AIS should be top priority. Continued monitoring of CLP, purple loosestrife and narrow cattail is important. If the spread of narrow cattail within larger cattail beds is a concern, a population survey of each cattail species may be considered.

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