Aquatic Macrophyte Survey

Big Lake
Churchpine Lake
Wind Lake

Polk County, Wisconsin
2009

Sponsored by: Churchpine/Round (Wind)/Big Lake P&R District and Wisconsin Dept. of Natural Resources

Conducted by: Ecological Integrity Service, LLC Amery, Wisconsin

Abstract

In June and August of 2009 an aquatic macrophyte survey was conducted on Big Lake, Churchpine Lake, and Wind Lake in Polk County Wisconsin. These three lakes are connected as a chain of lakes. A point intercept method was used based on the Wisconsin DNR aquatic macrophyte survey protocol. All three lakes had good plant coverage with Big Lake being the most limited and Wind Lake have the most plant coverage. All lakes had quite high diversity with Big Lake having a species richness (sampled and viewed combined of 32, Churchpine Lake with 38 species and Wind Lake with 40 species. Two species of non-native plants were found on Big Lake and Wind Lake. These were curly leaf pondweed and purple loosestrife. Churchpine Lake did not have any non-native species sampled or viewed. A FQI was also calculated with all three lakes having the number of species, mean conservatism and FQI higher than the median for lakes in the ecoregion as determined by Stanley Nichols' FQI research. Churchpine Lake had the highest mean conservatism at 6.3 and Wiind Lake had the highest FQI at 36.7.

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Introduction

In June and August 2009, an aquatic macrophyte survey was conducted on Big Lake (WBIC: 2615900), Churchpine Lake (WBIC: 2616100) and Wind Lake (sometimes referred to as Round Lake[1]) (WBIC: 2616000), in Polk County Wisconsin. Big Lake is a 259-acre lake with a maximum depth of 24 feet. Churchpine Lake is a 107-acre lake with a maximum depth of 45 feet. Wind Lake is a 38-acre lake and has a maximum depth of 24^{+} feet[2]. Development around the lakes is moderate to heavy with much of the lakeshore developed and/or disturbed from an original native riparian zone.

This report presents a summary and analysis of data collected in a point intercept, baseline aquatic macrophyte survey. The primary goal of the survey is to establish a baseline for long-term monitoring of aquatic plant populations and allow for the evaluation of any changes that may occur long-term. In addition, invasive species presence and locations are key components to a survey of this type. This survey is acceptable for aquatic plant management purposes.

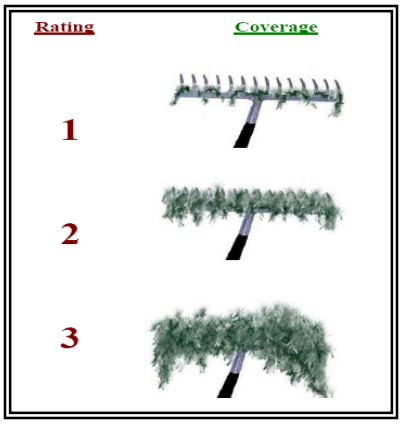
Field Methods

A point intercept method was employed for the macrophyte sampling. The Wisconsin Department of Natural Resources (Wisconsin DNR) generated the sampling point grid of 410 points for Big Lake, 322 points for Churchpine Lake, and 145 points for Wind Lake. Only points shallower than 25 feet were initially sampled on Big Lake and Wind Lake and 30 feet on Churchpine Lake (due to high water clarity), until the maximum depth of plants could be established. 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 survey was conducted. This involved going to the area and surveying that area for plants, 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 ft resolution window and the location arrow touching the point.

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 contained on the rake and those that fell off of rake were identified and rated as to 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.

[1] The request for surveying was for Round Lake but the Wisconsin Hydrography GIS layer names this lake Wind Lake.

[2] Listed on Wisconsin DNR Lake Maps as 7 feet deep. The maximum depth recorded during survey was in excess of 24 feet.



	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 bottom type was also recorded for each sample point. Caution must be used in using 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 Wisconsin DNR 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.

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 number of sites. There can be two values calculated for this. The first is the percentage of all sample points that this plant was sampled at depths less then maximum depth plants were found (littoral zone), regardless if vegetation was present. The second is the percentage of sample points that the 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 if considered where points contain plants. In either case, the greater this value, the more frequent the plant is in the lake. If one wants to compare how frequent 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 where they could grow based upon depth. If one wants to focus only where plants are actually present, then one would 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%
Plant A's frequency of occurrence = 30% in vegetated areas

These two frequencies can tell us how common the plant was sampled in the littoral zone or how common the plant was sampled at points plants actually grow. Generally the second will have a higher frequency since that is where plants are actually growing as opposed to where they could grow. This analysis will consider vegetated sites for frequency of occurrence only.

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 of the 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 the 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 point 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.

Number of points sampled- This may not be the same as the total points in the sample grid. When doing a survey, we don't sample at depths outside of the littoral zone (the area where plants can grow). Once the maximum depth of plants is established, many of the points deeper than this are eliminated to save time and effort.

Sample sites with vegetation- The number of sites where plants were actually sampled. This gives a good idea of the plant coverage of the lake. If 10% of all sample points had vegetation, it implies about a 10% coverage of plants in the whole lake, assuming an adequate number of sample points have been established. We also look at 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 more diverse the plant community, the better 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.

These are extreme and theoretical scenarios, but they demonstrate how this index works. The greater the Simpson's index is for a lake, the greater the diversity since it represents a greater chance of two randomly sampled plants being 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 reduces 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 high 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:

$$\mathbf{FQI = Mean\ C \cdot \sqrt{N}}$$

Where C is the conservatism value and N is the number of species.

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. These are Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area and

Southeastern Wisconsin Till Plain. Big Lake, Churchpine Lake and Wind Lake are in the Northern Central Hardwood Forests ecoregion.

Summary of Northern Lakes and Forests Median Values for Floristic Quality Index:
(Nichols, 1999)

Mean species richness = 14

Mean conservatism = 5.6

Mean 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.

Survey Results

Big Lake

The survey of Big involved utilizing a grid of 410 points set by the Wisconsin DNR. Of these 410 points, 84 of them had vegetation growing. This is a rather low coverage of plants in a lake. The littoral zone is rather small in Big Lake leading to less area that can grow plants. It is also possibly due to limited water clarity in the later part of summer, thus reducing light penetration. Much of the littoral zone is deep enough to reduce plant growth. The greatest depth that had plants sampled was 16 feet. Most areas deeper than 12 feet had no plants. There was one sample point with a small plant sample at 16 feet, but growth at depths between 12 and 16 feet was not consistent.

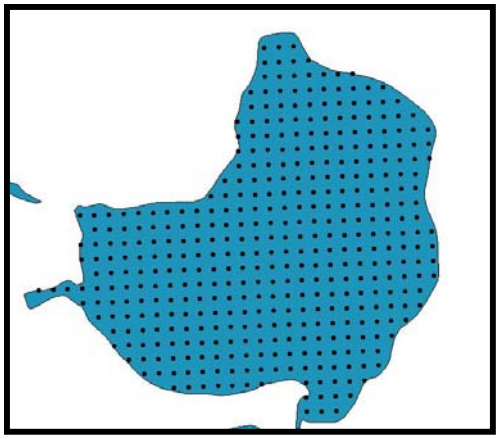


Figure 1: Map of sample point grid for Big Lake.

Survey Statistic Summary- Big Lake	
Total number of points in lake grid	410
Total number of points sampled	178
Total number of sites with vegetation	84
Total number of sites shallower than max. depth of plants (littoral zone)	114
Frequency of occurrence at sites shallower than maximum depth of plants	73.68%
Frequency of occurrence at all lake sites	20.49%
Simpson Diversity Index	0.91
Maximum depth of plants (ft)	16
Average number of all species per site (veg. sites only)	3.64
Average number of native species per site (veg. sites only)	3.52
Species Richness	27
Species Richness (including visuals)	32

Table 1: Plant survey statistic summary for Big Lake

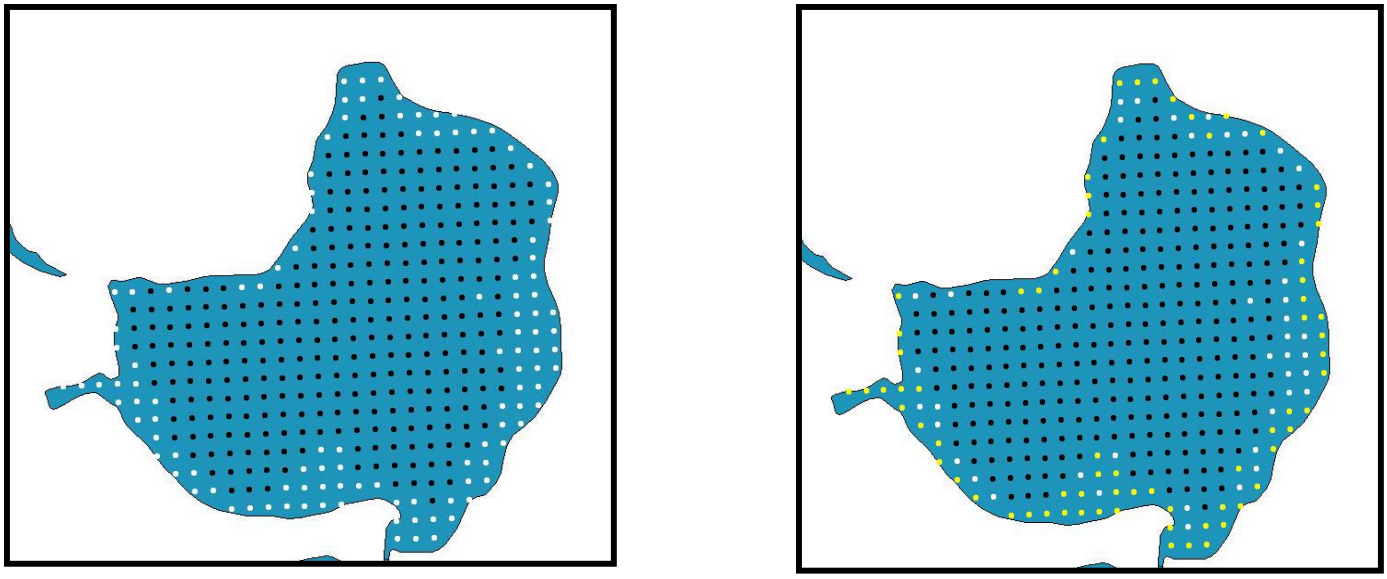


Figure 2: Map of littoral zone in Big Lake and map of plants in littoral zone. Black dots are points deeper than depth of plants. White dots are points within littoral zone and yellow dots are plants present within littoral zone.

Where there were plants growing, the coverage was quite dense. A map below (figure 3) shows the density of plants sampled at points with plants. Many of these sample points have total rake density ratings of 3, which is the highest.

Figure 3: Map of total rake density at points with plants sampled in Big lake.

Big Lake does have a fairly diverse plant community. The species richness was 27 plants sampled and 32 species if all plants viewed but not sampled are included. The highest number of species at any sample point was seven. Another good measure of diversity is the Simpson's diversity index. The Simpson's diversity index from this survey was 0.91. This demonstrates high diversity as there is a 91% two plants sampled at a point are different.

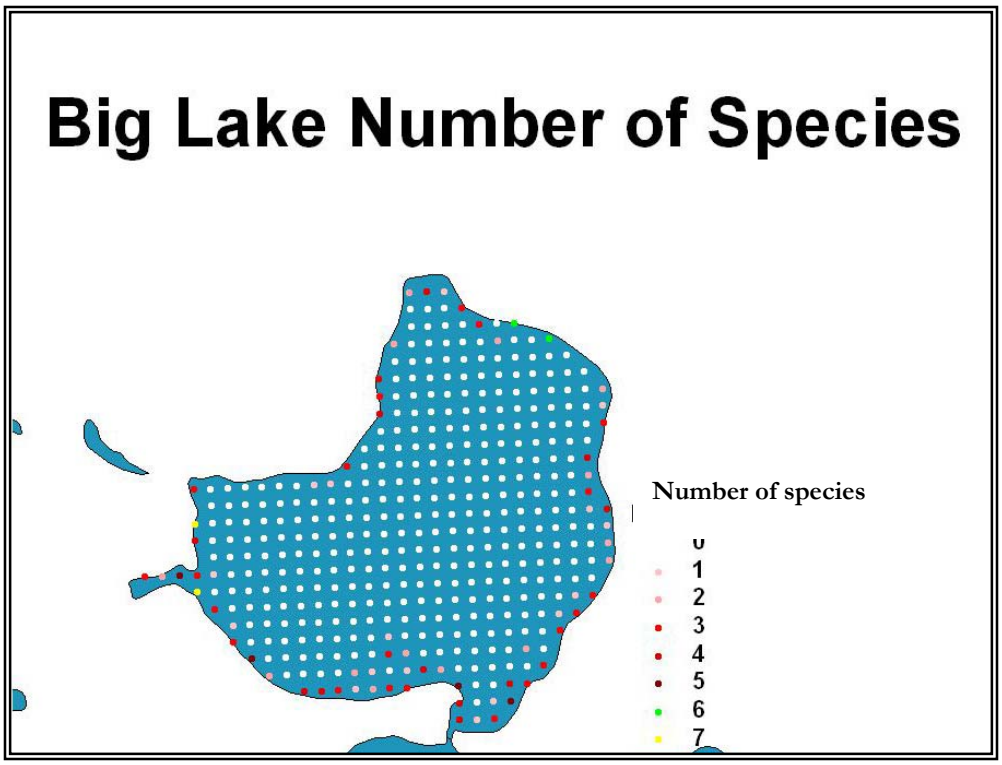


Figure 4: Map of number of different plant species sampled at each sample point with plants on Big Lake.

Species-Big Lake	Freq of occ	Freq	Rel freq	Number	Mean den	Viewed
***Ceratophyllum demersum,*Coontail**	75.00	55.26	20.59	63	1.78	
***Vallisneria americana,*Wild celery**	45.24	33.33	12.42	38	1.37	
***Potamogeton zosteriformis,*Flat-stem pondweed**	38.10	28.07	10.46	32	1.09	2
***Myriophyllum sibiricum,*Northern water milfoil**	32.14	23.68	8.82	27	1.15	6
***Lemna trisulca,*Forked duckweed**	22.62	16.67	6.21	19	1.00	
filamentous algae	19.05	14.04	5.23	16	1.13	
***Heteranthera dubia,*Water star-grass**	16.67	12.28	4.58	14	1.14	1
***Elodea canadensis,*Common waterweed**	14.29	10.53	3.92	12	1.17	
***Potamogeton crispus*,Curly-leaf pondweed**	11.90	8.77	3.27	10	1.00	
***Potamogeton richardsonii,*Clasping-leaf pondweed**	11.90	8.77	3.27	10	1.00	1
***Stuckenia pectinata,*Sago pondweed**	10.71	7.89	2.94	9	1.22	7
***Nymphaea odorata,*White water lily**	7.14	5.26	1.96	6	1.00	3
***Potamogeton praelongis,*White-stem pondweed**	7.14	5.26	1.96	6	1.00	
***Najas flexilis,*Bushy pondweed**	5.95	4.39	1.63	5	1.40	3
***Potamogeton amplifolius,*Large-leaf pondweed**	5.95	4.39	1.63	5	1.00	2
***Potamogeton illinoensis,*Illinois pondweed**	5.95	4.39	1.63	5	1.00	2
***Potamogeton pusillus,*Small pondweed**	5.95	4.39	1.63	5	1.20	
***Potamogeton foliosus,*Leafy pondweed**	4.76	3.51	1.31	4	1.00	
***Potamogeton friesii,*Frie's pondweed**	3.57	2.63	0.98	3	1.00	
***Potamogeton robbinsii,*Robbins pondweed**	3.57	2.63	0.98	3	1.33	1
***Spirodela polyrhiza,*Large Duckweed**	3.57	2.63	0.98	3	1.00	
***Chara* ,Muskgrasses**	2.38	1.75	0.65	2	1.00	
***Megalodonta beckii,*Water marigold**	2.38	1.75	0.65	2	1.50	
***Ranunculus aquatilis,*Stiff water crowfoot**	2.38	1.75	0.65	2	1.50	1
***Eleocharis acicularis,*needle spikerush**	1.19	0.88	0.33	1	1.00	
***Schoenoplectus acutus,*Hardstem bulrush**	1.19	0.88	0.33	1	1.00	
***Wolffia columbiana,*Common watermeal**	1.19	0.88	0.33	1	1.00	
***Decodon verticillatus,*Swamp loosestrife**	Viewed	Only	No	stats		1
***Iris versicolor,* Northern Blue flag**	Viewed	Only	No	stats		1
***Lythrum salicaria,*Purple loosestrife**	Viewed	Only	No	stats		6
***Nuphar variegata,*Spatterdock**	Viewed	Only	No	stats		2
***Typha latifolia,*Broad-leaved cattail**	Viewed	Only	No	stats		2

Table 2: Species richness with frequency data, density and number of points sampled and view for each species in Big Lake.

Of the 32 species sampled or viewed, two are algae, two non-native and 28 native vascular plants. The four most frequent plants sampled are coontail (*Ceratophyllum demersum*), wild celery (*Vallisneria Americana*), flat-stem pondweed (*Potamogeton zosteriformis*) and northern water milfoil (*Myriophyllum sibiricum*) (this a native milfoil). All of these plants are native and common in Wisconsin lakes. They are desirable plants and serve very important roles in the lake ecosystem. Coontail has a relative frequency of 20.29%. This means one in every five plants sampled were coontail. This may indicate high nutrients in the lake and reduced water clarity. Coontail can live in lower light conditions and can absorb high amounts of nutrients directly from the water.

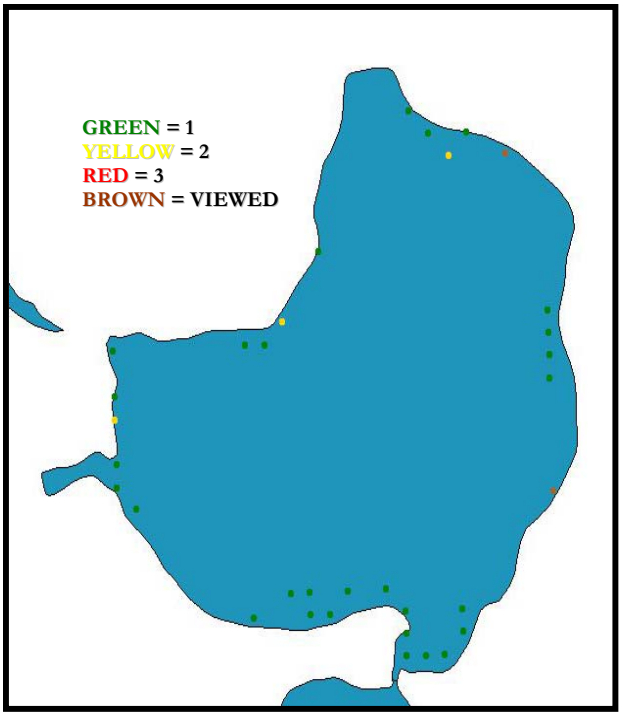


Figure 5: Distribution map of coontail.

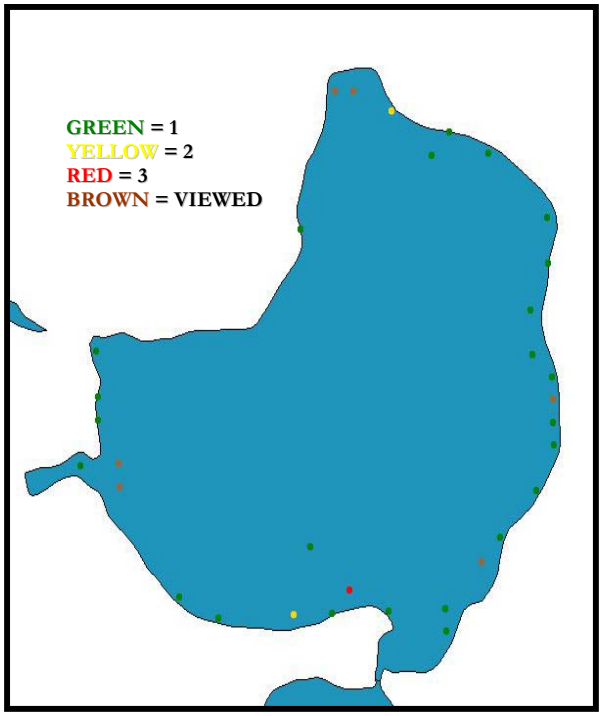


Figure 6: Distribution map of wild celery.

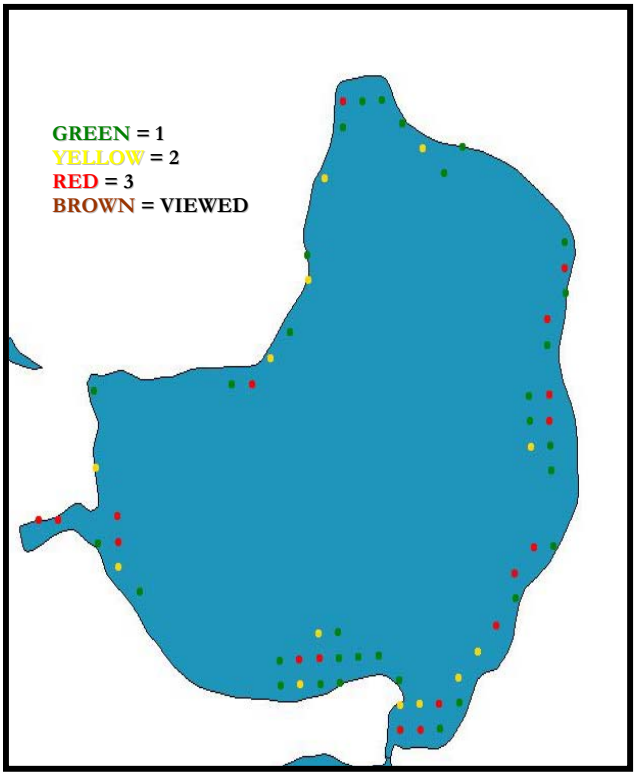


Figure 7: Distribution map of flatstem pondweed

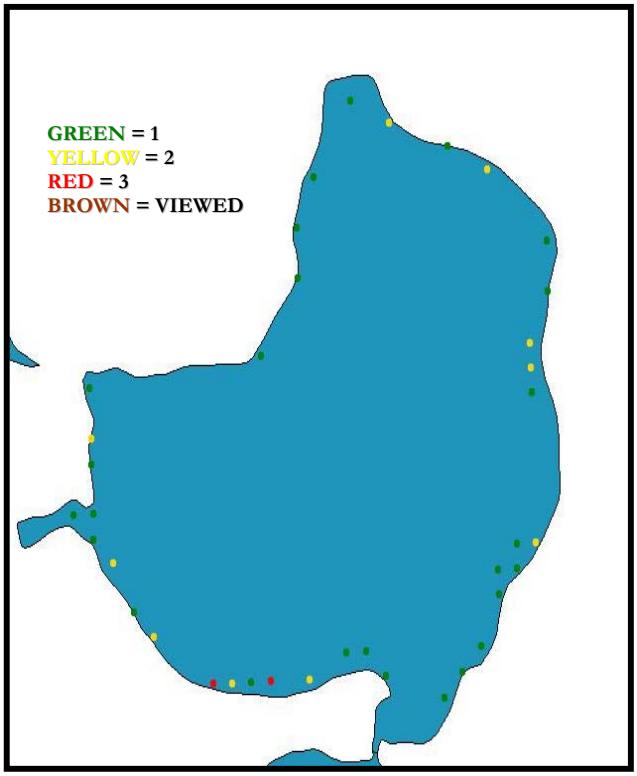


Figure 8: Distribution map of northern water milfoil

Churchpine Lake

The survey in Churchpine utilized a sample grid of 322 points. Of these 322 points 132 (42.86%) had vegetation. The greatest depth with plants was 25.7 feet, with 92.62% of depths less than 25.7 feet having plants. This indicates that Churchpine Lake has very high water clarity throughout the summer. A depth of 25.7 feet is quite deep to have plants growing. In addition, most all depths less than this consistently had plants. It is evident that many deep areas contain plants showing there is excellent light penetration throughout the growing season.

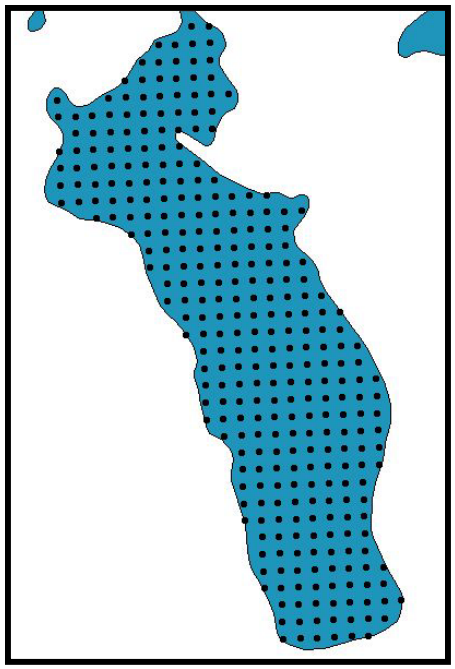


Figure 9: Map of sample point grid Churchpine Lake.

Survey Statistic Summary- Churchpine Lake	
Total number of points in lake grid	322
Total number of points sampled	179
Total number of sites with vegetation	138
Total number of sites shallower than max. depth of plants (littoral zone)	149
Frequency of occurrence at sites shallower than maximum depth of plants	92.62%
Frequency of occurrence at all sites	42.86%
Simpson Diversity Index	0.91
Maximum depth of plants (ft)	25.7
Average number of all species per site (veg. sites only)	3.41
Average number of native species per site (veg. sites only)	3.41
Species Richness	33
Species Richness (including visuals)	38

Table 3: Plant survey statistic summary for Churchpine Lake.

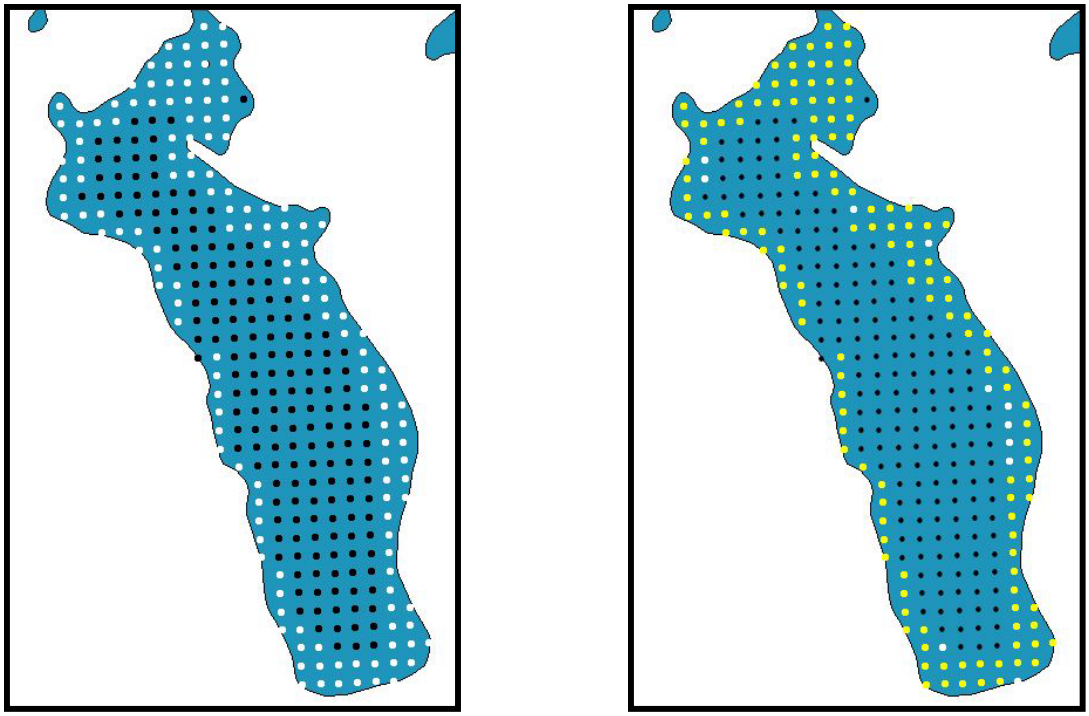


Figure 10: Map of littoral zone points and points within littoral zone with plants. Black dots are points deeper than littoral zone, white dots are points within littoral zone and yellow dots are points within littoral zone with plants.

Some of the more shallow areas had fairly dense plant growth. However, most of the plant growth at sample points was moderate. The lake gets very deep and plant growth stops very abruptly. The map below shows the total rake density at each sample point.

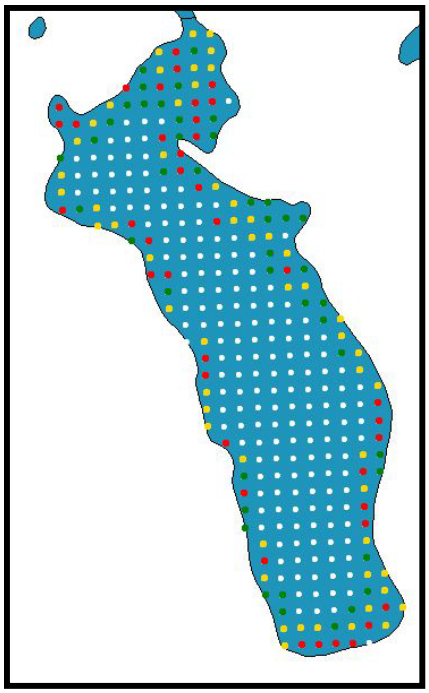


Figure 11: Map of total rake density at points with plants on Churchpine Lake.

Species-Churchpine Lake	Freq of occurrence	Relative Frequency	Number sampled	Mean Density	Number viewed
Potamogeton robbinsii,Robbins pondweed	61.59	18.09	85	1.58	
Vallisneria americana,Wild celery	50.00	14.68	69	1.09	2
Potamogeton illinoensis,Illinois pondweed	37.68	11.06	52	1.33	7
Najas flexilis,Bushy pondweed	29.71	8.72	41	1.02	1
Ceratophyllum demersum,Coontail	21.74	6.40	30	1.07	
Elodea canadensis,Common waterweed	18.84	5.53	26	1.04	
Myriophyllum sibiricum,Northern water milfoil	17.39	5.11	24	1.04	6
Chara ,Muskgrasses	12.32	3.62	17	1.18	
Potamogeton praelongis,White-stem pondweed	12.32	3.62	17	1.00	1
Potamogeton gramineus,Variable pondweed	10.87	3.19	15	1.00	
Nitella sp.,Nitella	7.97	2.34	11	1.36	
Nymphaea odorata,White water lily	7.97	2.34	11	1.00	6
Potamogeton zosteriformis,Flat-stem pondweed	7.97	2.34	11	1.00	3
filamentous algae	7.25	2.13	10	1.00	
Brasenia schreberi,Watershield	5.80	1.70	8	1.13	4
Potamogeton amplifolius,Large-leaf pondweed	5.07	1.49	7	1.00	6
Potamogeton natans,Floating-leaf pondweed	4.35	1.28	6	1.00	1
Potamogeton pusillus,Small pondweed	3.62	1.06	5	1.00	3
Aquatic moss	2.90	0.85	4	1.00	
Eleocharis acicularis,needle spikerush	2.17	0.64	3	1.00	1
Lemna trisulca,Forked duckweed	1.45	0.43	2	1.00	
Megalodonta beckii,Water marigold	1.45	0.43	2	1.00	3
Myriophyllum tenellum,Dwarf water milfoil	1.45	0.43	2	1.00	1
Potamogeton richardsonii,Clasping-leaf pondweed	1.45	0.43	2	1.00	3
Sagittaria cuneata ,Arum-leaved arrowhead	1.45	0.43	2	1.00	
Sagittaria rigida, Stiff arrowhead	1.45	0.43	2	1.00	
Isoetes echinospora, Spinyspored quillwort	0.72	0.21	1	1.00	
Lemna minor,Small duckweed	0.72	0.21	1	1.00	
Nuphar variegata,Spatterdock	0.72	0.21	1	1.00	
Pontederia cordata,Pickerelweed	0.72	0.21	1	1.00	2
Schoenoplectus subterminalis,Water bulrush	0.72	0.21	1	1.00	
Typha latifolia,Broad-leaved cattail	0.72	0.21	1	1.00	
Utricularia intermedia,Flat-leaf bladderwort	0.72	0.21	1	1.00	
Utricularia gibba, Creeping bladderwort	Viewed	Only	No stats		1
Heteranthera dubia,Water star-grass	Viewed	Only	No stats		2
Schoenoplectus acutus,Hardstem bulrush	Viewed	Only	No stats		1
Sparganium eurycarpum,Common bur-reed	Viewed	Only	No stats		1
Stuckenia pectinata,Sago pondweed	Viewed	Only	No stats		1

Table 4: Species richness with frequency data and density of each species on Churchpine Lake.

Churchpine Lake has a very diverse plant community. The highest number of species sampled at any sample point was 9. The species richness is 33 species sampled and 38 species when including visually observed plants. The Simpson's diversity index is 0.91, which is also high and indicates a large amount of diversity in Churchpine Lake.

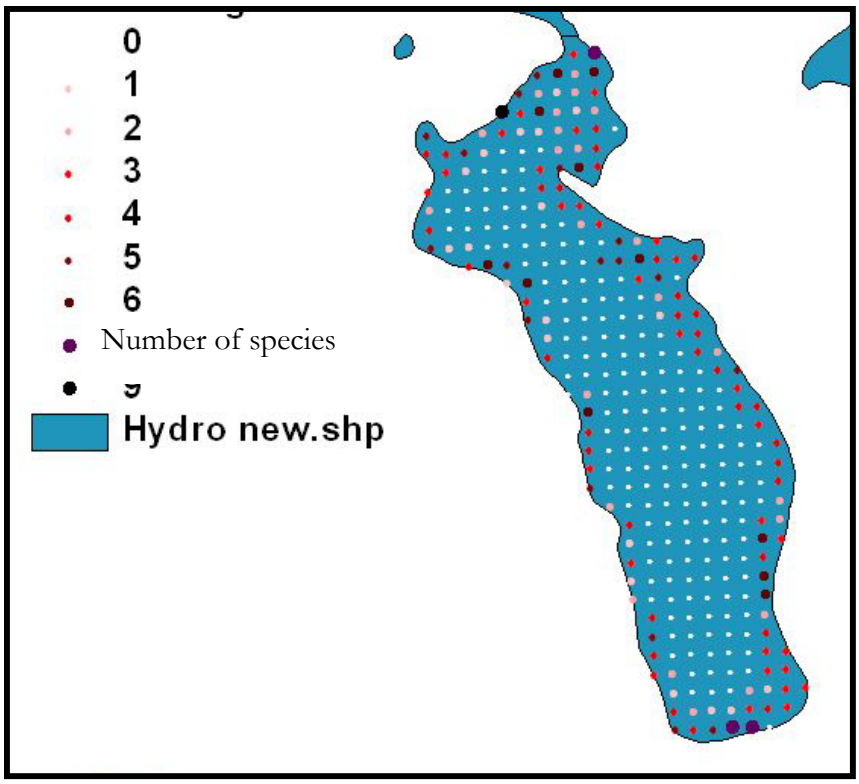


Figure 12: Map of number of species sampled at each sample point with plants on Churchpine Lake.

Of the 38 species sampled or viewed three are algae and 35 are native vascular plants. No non-native species were sampled or viewed in or near Churchpine Lake. The most common plants sampled were Robbin's pondweed (*Potamogeton robbinsii)*, wild celery (*Vallisneria Americana*), Illinois pondweed (*Potamogeton illinoensis*), and bushy pondweed (*Najas flexilis*). All of these are common native species found in Wisconsin Lakes. Each of these plant species (as well as others sampled) is desirable and serve important roles or niches in the lake ecosystem.

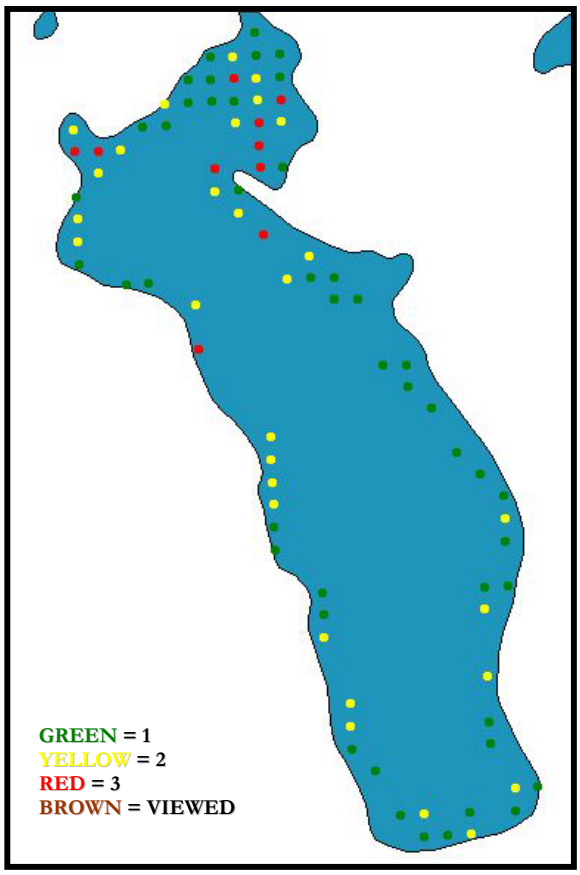


Figure 13: Distribution map of Robbin's pondweed

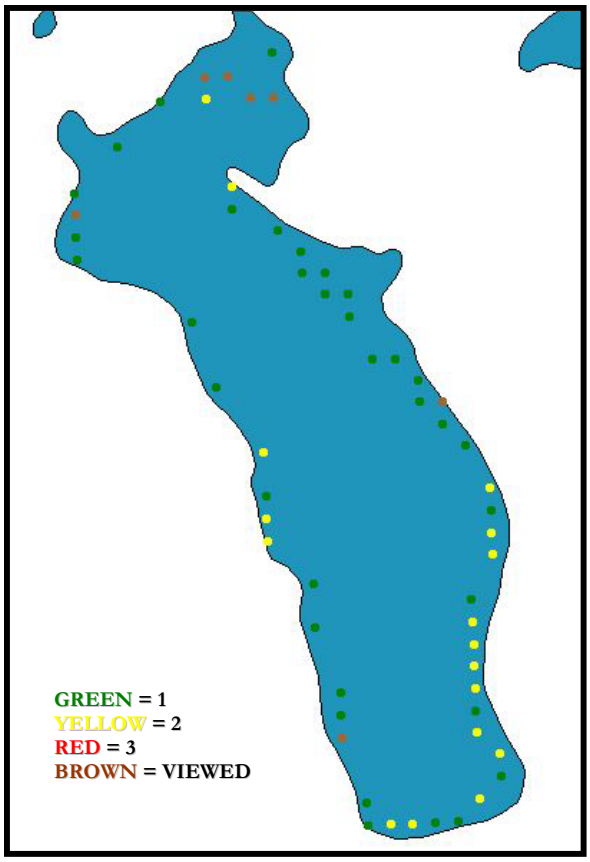


Figure 14: Distribution map of wild celery

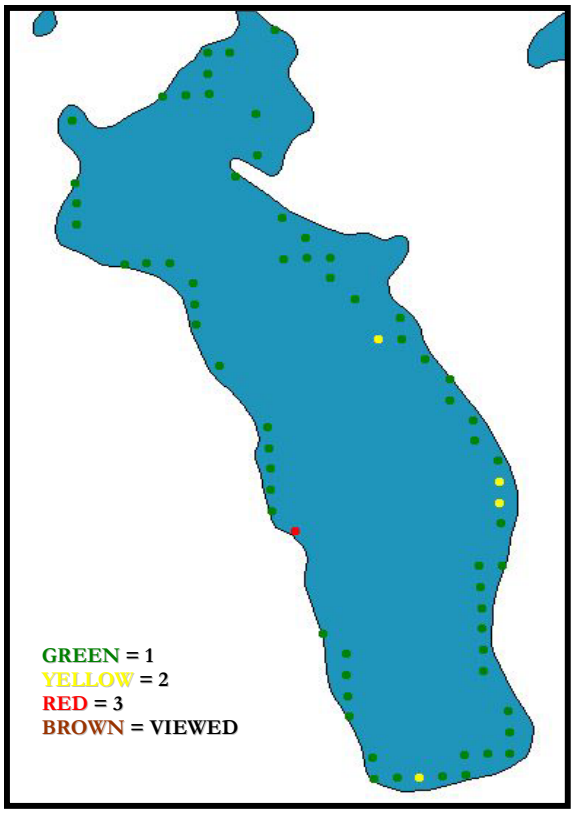


Figure 15: Distribution map of Illinois pondweed

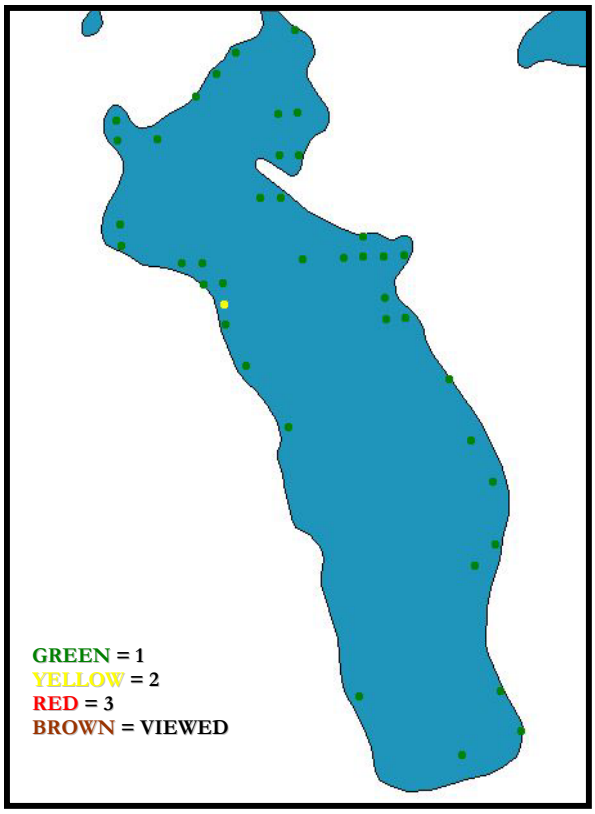


Figure 16: Distribution map of bushy pondweed

Wind Lake

The survey for Wind Lake utilized a 145 point grid that was generated by the Wisconsin DNR. Of the 145 points, 86 (59.31%) had vegetation growing. The greatest depth with plants sampled was 21.1 feet. A majority of the sample points (108) were at or less than the depth plants were sampled. This defines the littoral zone. In this area, 79.63% of the sample points had vegetation growing. This indicates that plant growth is widespread in Wind Lake.

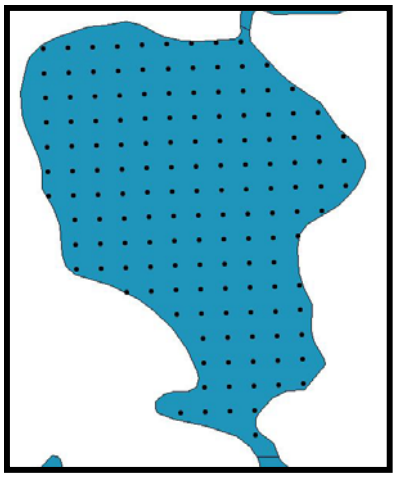


Figure 17: Map of sample point grid for Wind Lake

Survey Statistic Summary- Wind Lake	
Total number of point in lake grid	145
Total number of points sampled	135
Total number of sites with vegetation	86
Total number of sites shallower than max. depth of plants (littoral zone)	108
Frequency of occurrence at sites shallower than maximum depth of plants	79.63%
Frequency of occurrence at all sites	59.31%
Simpson Diversity Index	0.91
Maximum depth of plants (ft)	21.1
Average number of all species per site (veg. sites only)	3.95
Average number of native species per site (veg. sites only)	3.95
Species Richness	37
Species Richness (including visuals)	40

Table 5: Plant survey statistic summary for Wind Lake

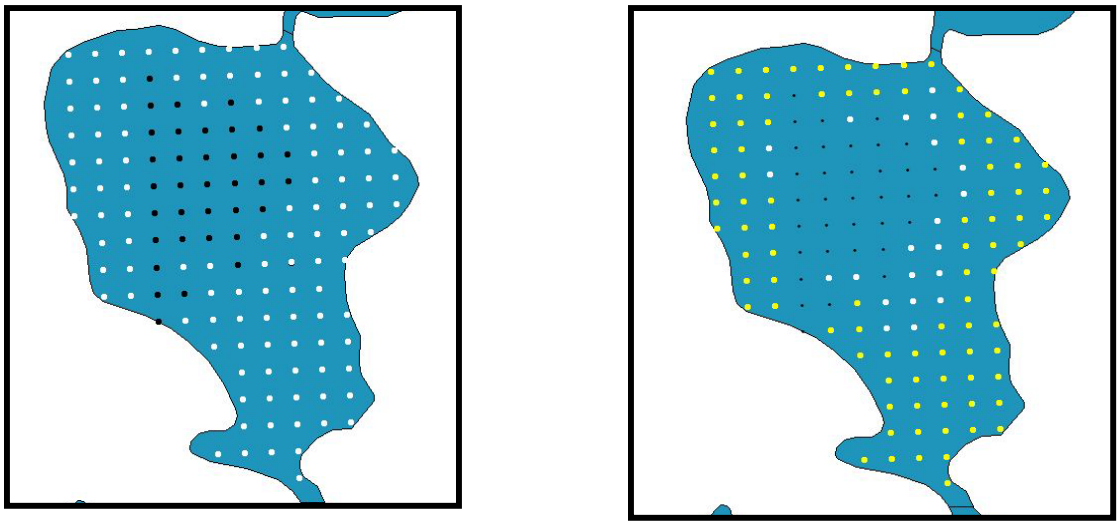


Figure 18: Map of littoral zone and points with plants within the littoral zone. Black dots are points deeper than littoral zone, white dots are points within littoral zone, and yellow dots are points within littoral zone with plants.

Where plants were growing in Wind Lake, the density was quite high. The map below shows the total rake density at sites with plants. Many of these sites have a rake density of three, which is the highest density rating.

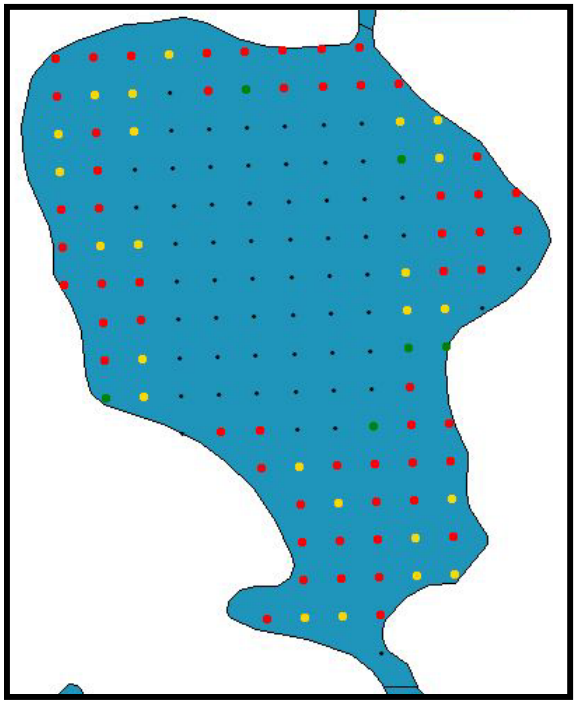


Figure 19: Map of total rake density of points with plants on Wind Lake

The plant community in Wind Lake is diverse and healthy. There were 37 species of plants sampled on the rake and 3 more viewed (for a total of 40). Of these 40 species, 3 are algae species, 35 are native vascular plants and 2 are non-native vascular plants. The most common plants sampled were Robbin's pondweed (*Potamogeton robbinsii)*, coontail (*Ceratophyllum demersum*), white water lily (*Nymphaea odorata*), and common waterweed (*Elodea canadensis*). No plant dominated the plant population with Robbin's pondweed having the highest relative density of 19.7%. This is followed by coontail at 17.9%, white water lily at 7.65% and common waterweed at 5.6%. All of the native plants are quite balanced in frequency and are desirable plants to have in a lake ecosystem.

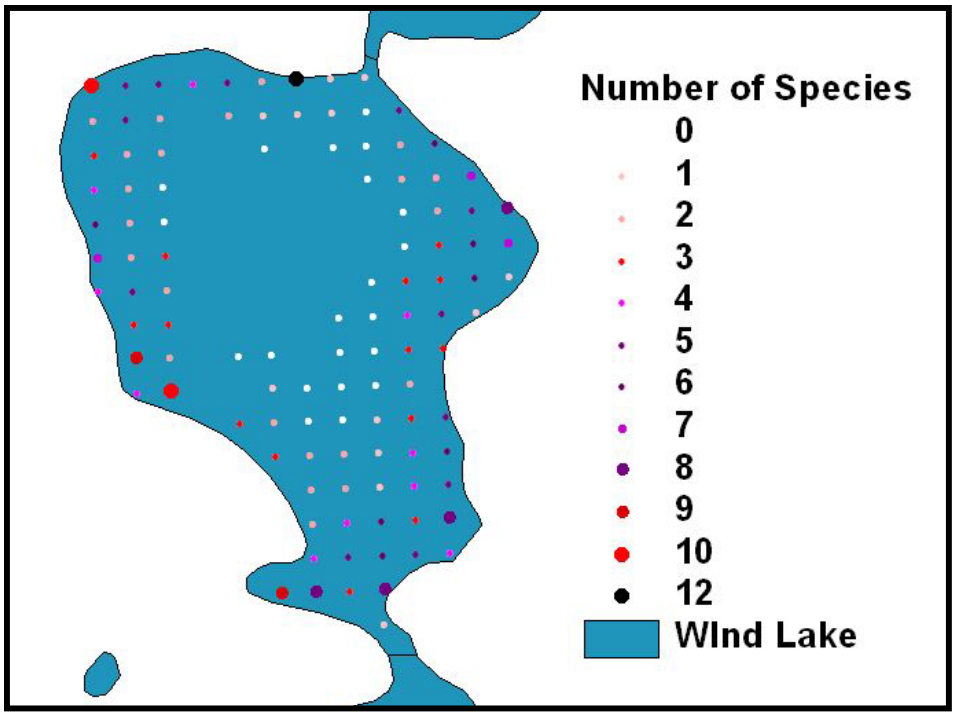


Figure 20: Map of number of species sampled at each point with plants on Wind Lake.

Species-Wind Lake	Freq of occurrence	Relative frequency	Number sampled	Mean density	Number Viewed
***Potamogeton robbinsii,*Robbins pondweed**	77.91	19.71	67	1.76	
***Ceratophyllum demersum,*Coontail**	70.93	17.94	61	1.62	
***Nymphaea odorata,*White water lily**	30.23	7.65	26	1.00	14
***Elodea canadensis,*Common waterweed**	22.09	5.59	19	1.21	
***Brasenia schreberi,*Watershield**	20.93	5.29	18	1.00	2
***Potamogeton illinoensis,*Illinois pondweed**	20.93	5.29	18	1.11	4
***Myriophyllum sibiricum,*Northern water milfoil**	19.77	5.00	17	1.00	8
***Vallisneria americana,*Wild celery**	17.44	4.41	15	1.27	2
***Megalodonta beckii,*Water marigold**	13.95	3.53	12	1.00	1
***Najas flexilis,*Bushy pondweed**	9.30	2.35	8	1.13	
***Potamogeton amplifolius,*Large-leaf pondweed**	9.30	2.35	8	1.00	3
***Heteranthera dubia,*Water star-grass**	8.14	2.06	7	1.00	6
***Potamogeton pusillus,*Small pondweed**	8.14	2.06	7	1.00	1
***Spirodela polyrhiza,*Large Duckweed**	8.14	2.06	7	1.00	1
***Chara sp.* ,Muskgrasses**	4.65	1.18	4	1.00	
***Nitella sp.,*Nitella**	4.65	1.18	4	1.00	
***Nuphar variegata,*Spatterdock**	4.65	1.18	4	1.00	
***Potamogeton gramineus,*Variable pondweed**	4.65	1.18	4	1.00	
***Potamogeton zosteriformis,*Flat-stem pondweed**	4.65	1.18	4	1.00	3
***Potamogeton praelongis,*White-stem pondweed**	3.49	0.88	3	1.00	
***Sagittaria cuneata* ,Arum-leaved arrowhead**	3.49	0.88	3	1.00	1
***Utricularia vulgaris,*Common bladderwort**	3.49	0.88	3	1.00	1
***Lemna trisulca,*Forked duckweed**	2.33	0.59	2	1.00	
***Potamogeton natans,*Floating-leaf pondweed**	2.33	0.59	2	1.00	1
***Potamogeton richardsonii,*Clasping-leaf pondweed**	2.33	0.59	2	1.00	
***Sagittaria rigida,* Stiff arrowhead**	2.33	0.59	2	1.00	
***Schoenoplectus acutus,*Hardstem bulrush**	2.33	0.59	2	1.00	3
***Typha latifolia,*Broad-leaved cattail**	2.33	0.59	2	1.00	
***Utricularia intermedia,*Flat-leaf bladderwort**	2.33	0.59	2	1.00	
Filamentous algae	1.16	0.29	1	1.00	
***Eleocharis acicularis,*needle spikerush**	1.16	0.29	1	1.00	
***Isoetes echinospora,* Spinyspore quillwort**	1.16	0.29	1	1.00	
***Lemna minor,*Small duckweed**	1.16	0.29	1	1.00	
***Pontederia cordata,*Pickerelweed**	1.16	0.29	1	1.00	1
***Sparganium eurycarpum,*Common bur-reed**	1.16	0.29	1	1.00	1
***Stuckenia pectinata,*Sago pondweed**	1.16	0.29	1	1.00	
***Utricularia gibba,*Creeping bladderwort**	1.16	0.29	1	1.00	1
***Eleocharis palustris,*creeping spikerush**	Viewed only		No stats		1
***Potamogeton crispus,*Curly-leaf pondweed**	Viewed only		No stats		1
***Lythrum salicaria,*Purple loosestrife**	Viewed only		No stats		13
***Calla palustris,* Wild calla**	*Boat survey*				

Table 6: Species richness with frequency and density of each species on Wind Lake

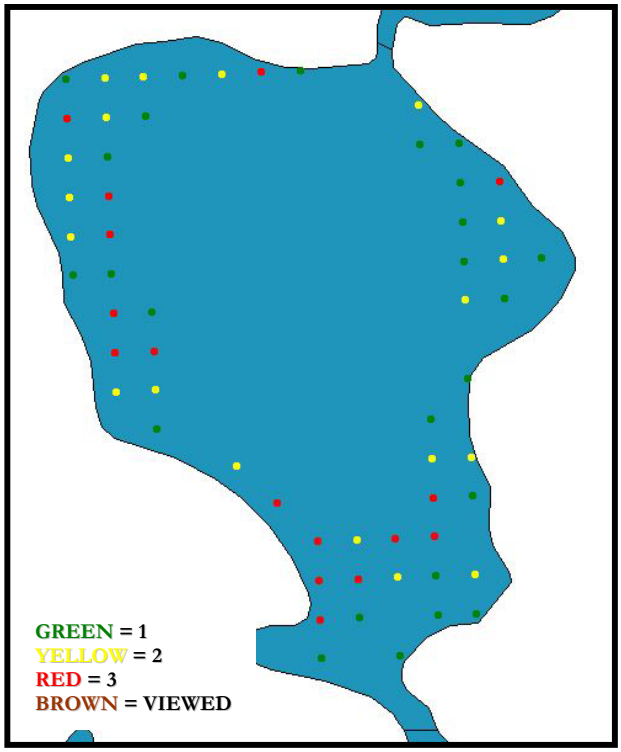


Figure 21: Distribution map of Robbin's pondweed

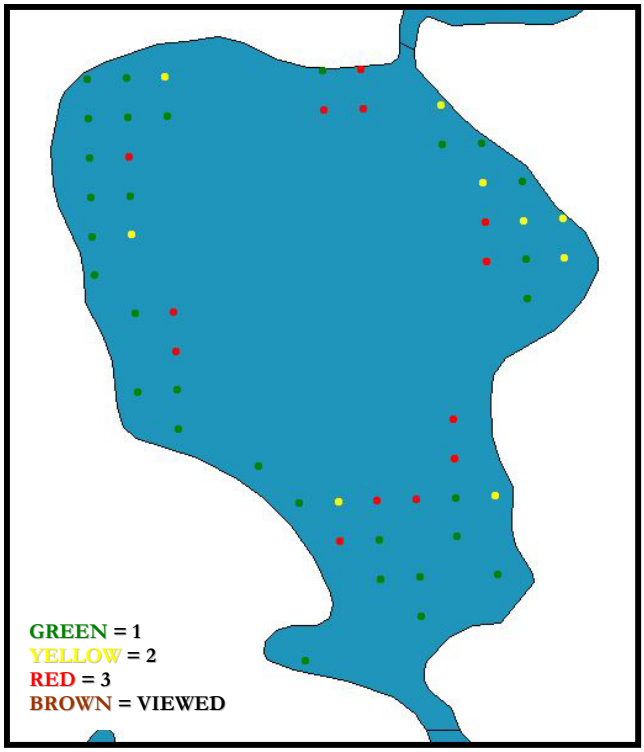


Figure 22: Distribution map of coontail

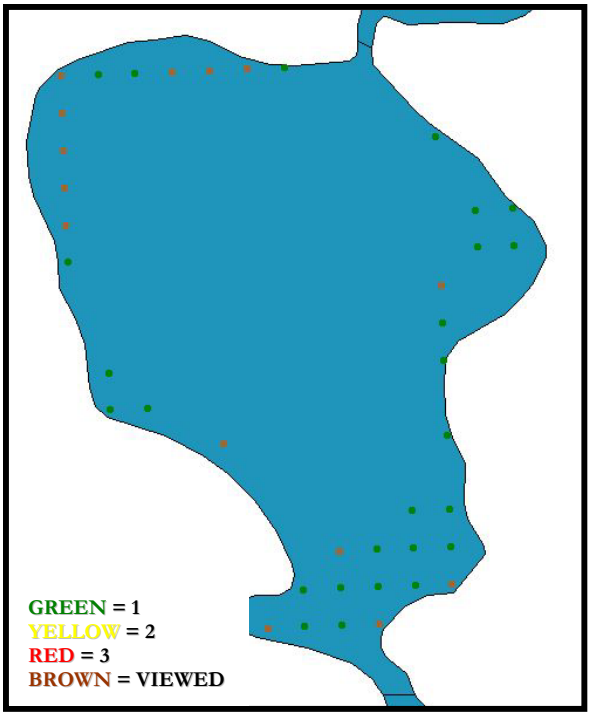


Figure 23: Distribution map of white water lily

Figure 24: Distribution map of common waterweed

Non-native aquatic species

Big Lake

Two non-native species were surveyed in or around Big Lake. The species are:

Curly leaf pondweed (CLP)-*Potamogeton crispus*
Purple loosestrife- *Lythrum salicaria*

CLP

The curly leaf pondweed was surveyed and mapped in June. The following maps show the coverage of the dense beds where the mean density is > 2 and the plants can be easily viewed from the surface.

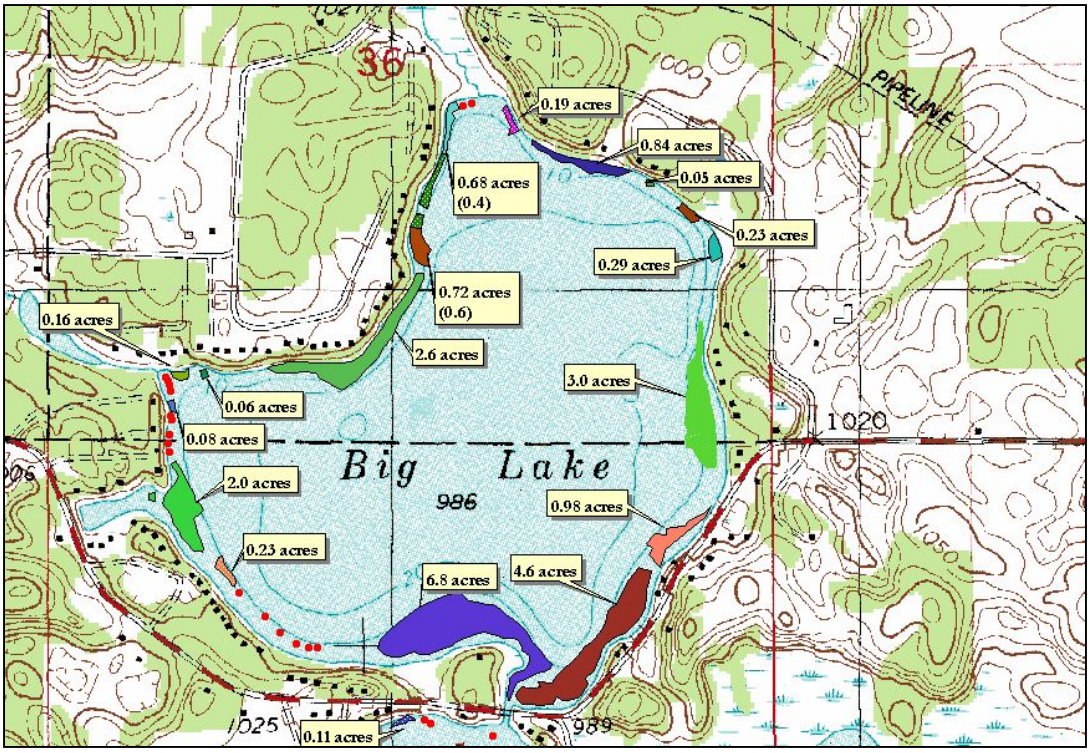


Figure 25: Map of curly leaf pondweed (CLP) beds on Big Lake-2009.

As can be seen from the map, the coverage of dense CLP is quite extensive. There are approximately 23 total acres of dense CLP beds in Big Lake. There are numerous small clumps (red dots on map) that are not big enough to navigate and delineate as a bed. Many of the beds have plants at or near the surface and were reaching nuisance levels during the June survey in 2009.

Purple loosestrife

Big Lake has a few locations where purple loosestrife was observed. Two of these locations are large and quite dense. Near the landing there is a bay that has fairly extensive coverage and rather high density. Removal by hand may not be possible. Another area is across the road from Big Lake on the east shore. This is a very large and dense bed of loosestrife. Hand removal is most likely not possible. A more extensive management practice will be needed here. This could be herbicide application or the introduction of the *Galerucella sp.* beetle. This management should be determined in an aquatic plant management plan.

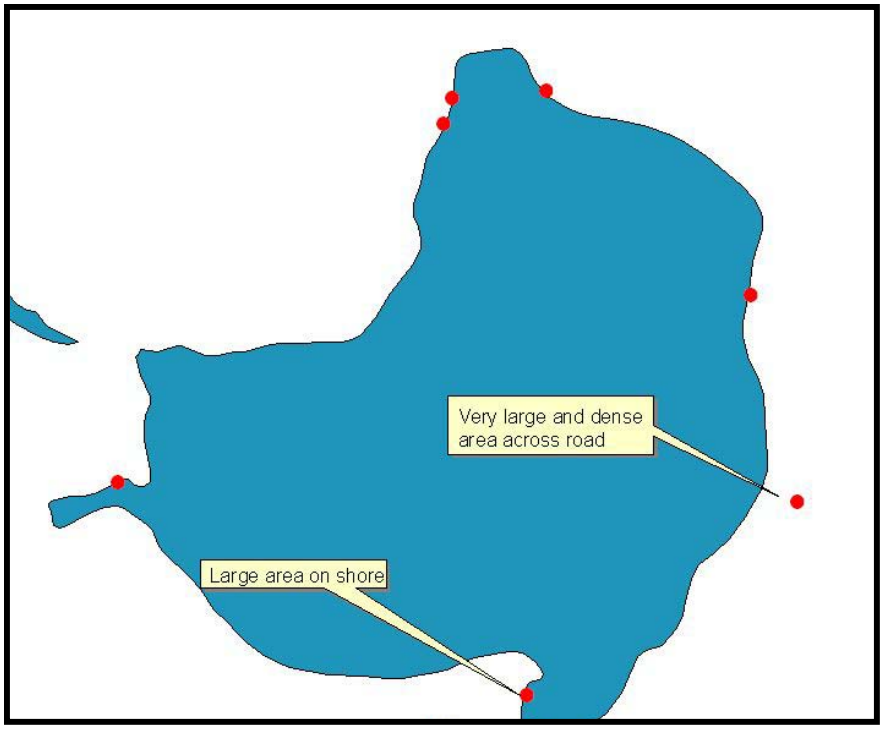


Figure 26: Map of purple loosestrife locations on and near Big Lake-2009

Churchpine Lake

The June survey found no CLP in Churchpine Lake. Also, Churchpine Lake did not have an purple loosestrife observed. All plants were native.

Wind Lake

Two non-native species were surveyed in or around Wind Lake. The species are:

Curly leaf pondweed (CLP)-*Potamogeton crispus*
Purple loosestrife- *Lythrum salicaria*

CLP

In Wind Lake, several single plants or small clumps of CLP were sampled or viewed. On area that is 0.11 acres in size had several sporadic clumps. The mean density of this area is

much less than 2, but was an area the had a more consistent growth of CLP so was delineated. This "bed" did not have extensive growth and would not be regarded as a nuisance level.

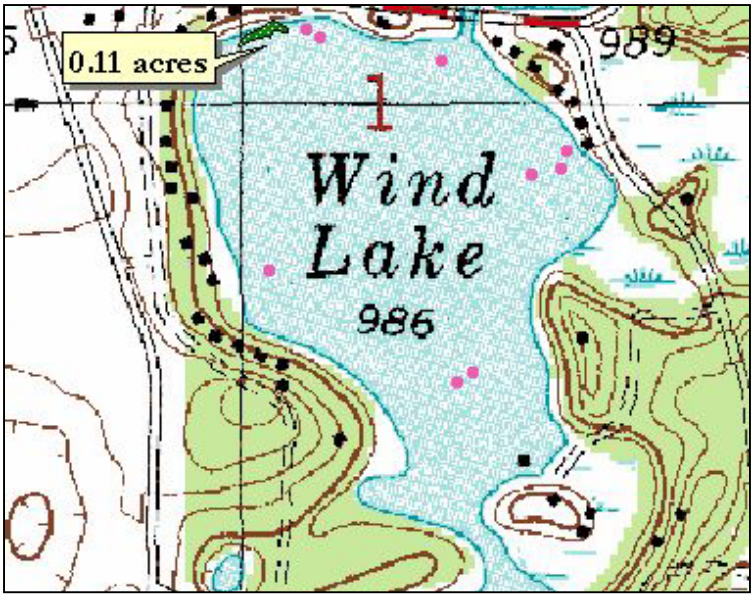


Figure 27: Map of CLP locations on Wind Lake-2009.

Purple loosestrife

There were numerous locations along the shoreline on Wind Lake that purple loosestrife was observed. All of the locations were single plants or very few plants in small clumps. However, this plant can spread and there are some shallow bays in Wind Lake that this plant could spread to rapidly. All single plants and small clumps should be removed by hand and disposed of properly. This removal should take place as soon as possible.

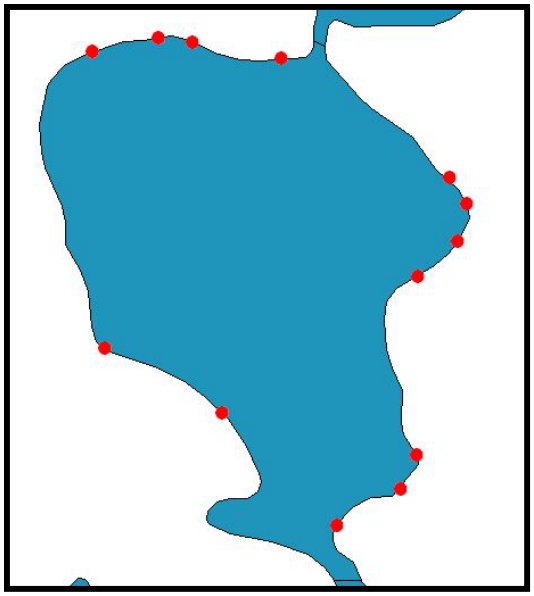


Figure 28: Map of purple loosestrife location on Wind Lake-2009

Floristic Quality Index for Big Lake, Churchpine Lake and Wind Lake

The Floristic Quality Index (FQI) was calculated for each lake. Only species sampled on the rake and listed in the Nichols FQI are used in determining the FQI. This is the reason the FQI species list may differ from the species richness list for each lake. The following tables list the species used and the conservatism value in each lake.

FQI Species-Big Lake	Common Name	C
Ceratophyllum demersum	Coontail	3
Chara	Muskgrasses	7
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Lemna trisulca	Forked Duckweed	6
Megalodonta beckii	Water marigold	8
Myriophyllum sibericum	Northern water-milfoil	7
Najas flexilis	Bushy pondweed	6
Nymphaea odorata	White water lily	6
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton foliosus	Leafy pondweed	6
Potamogeton friesii	Frie's pondweed	8
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton praelongis	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Robbins pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Ranunculus aquatilis	Stiff water crowfoot	7
Schoenoplectus acutus	Hardstem bulrush	5
Spirodela polyrhiza	Large Duckweed	5
Stuckenia pectinata	Sogo pondweed	3
Vallisneria americana	Wild celery	6
Wolffia columbiana	Common watermeal	5

Table 7: FQI species list and conservatism values for Big Lake

FQI Species-Churchpine	Common Name	C
Brasenia schreberi	Watershield	7
Ceratophyllum demersum	Coontail	3
Chara	Muskgrasses	7
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Isoetes echinospora	Spiny-spored quillwort	8
Lemna minor	Small duckweed	5
Lemna trisulca	Forked Duckweed	6
Megalodonta beckii	Water marigold	8
Myriophyllum sibericum	Northern water-milfoil	7
Myriophyllum tenellum	Dwarf water-milfoil	10
Najas flexilis	Bushy pondweed	6
Nitella	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	9
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton gramineus	Variable pondweed	7
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton natans	Floating-leaf	5
Potamogeton praelongis	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Robbins pondweed	8
Sagittaria cuneata	Midwestern arrowhead	7
Sagittaria rigida	Stiff arrowhead	8
Schoenoplectus subterminalis	Water bulrush	9
Typha latifolia	Broad-leaved cattail	1
Utricularia intermedia	Flat-leaf bladderwort	9
Vallisneria americana	Wild celery	6

Table 8: FQI list of species and conservatism values for Churchpine Lake

FQI Species-Wind Lake	Common Name	C
Brasenia schreberi	Watershield	7
Ceratophyllum demersum	Coontail	3
Chara	Muskgrasses	7
Eleocharis acicularis	Needle spikerush	5
Elodea canadensis	Common waterweed	3
Isoetes echinospora	Spiny-spored quillwort	8
Lemna minor	Small duckweed	5
Lemna trisulca	Forked Duckweed	6
Megalodonta beckii	Water marigold	8
Myriophyllum sibericum	Northern water-milfoil	7
Najas flexilis	Bushy pondweed	6
Nitella	Nitella	7
Nuphar variegata	Spatterdock	6
Nymphaea odorata	White water lily	6
Pontederia cordata	Pickerelweed	9
Potamogeton amplifolius	Large-leaf pondweed	7
Potamogeton gramineus	Variable pondweed	7
Potamogeton illinoensis	Illinois pondweed	6
Potamogeton natans	Floating-leaf	5
Potamogeton praelongis	White-stem pondweed	8
Potamogeton pusillus	Small pondweed	7
Potamogeton richardsonii	Clasping-leaf pondweed	5
Potamogeton robbinsii	Robbins pondweed	8
Potamogeton zosteriformis	Flat-stem pondweed	6
Sagittaria cuneata	Midwestern arrowhead	7
Sagittaria rigida	Stiff arrowhead	8
Schoenoplectus acutus	Hardstem bulrush	5
Sparganium eurycarpum	Common bur-reed	5
Spirodela polyrhiza	Large Duckweed	5
Stuckenia pectinata	Sogo pondweed	3
Typha latifolia	Broad-leaved cattail	1
Utricularia gibba	Creeping bladderwort	9
Utricularia intermedia	Flat-leaf bladderwort	9
Utricularia vulgaris	Common bladderwort	7
Vallisneria americana	Wild celery	6

Table 9: FQI species list and conservatism values for Wind Lake

The FQI for each lake is higher than the median values for other lakes within the same ecoregion. In Big Lake, this is largely due to the higher number of species since the mean conservatism of the plants sampled is just slightly higher than the median within the ecoregion. In both Churchpine Lake and Wind Lake all of the values (species, mean conservatism, and FQI) are substantially higher than the median within the ecoregion.

These values show the plant community is diverse with a large number of intolerant plants present. The habitat for plants is good and may show human disturbance have had little impact on the plant community, especially in Churchpine Lake.

Lake	Species used FQI	Mean Conservatism	FQI
Big Lake	24	5.96	29.19
Churchpine Lake	30	6.53	35.78
Wind Lake	35	6.2	36.68
EcoRegion median	14	5.6	20.9

Table 10: FQI comparison of Big Lake, Churchpine Lake and Wind Lake to the median of lakes in ecoregion

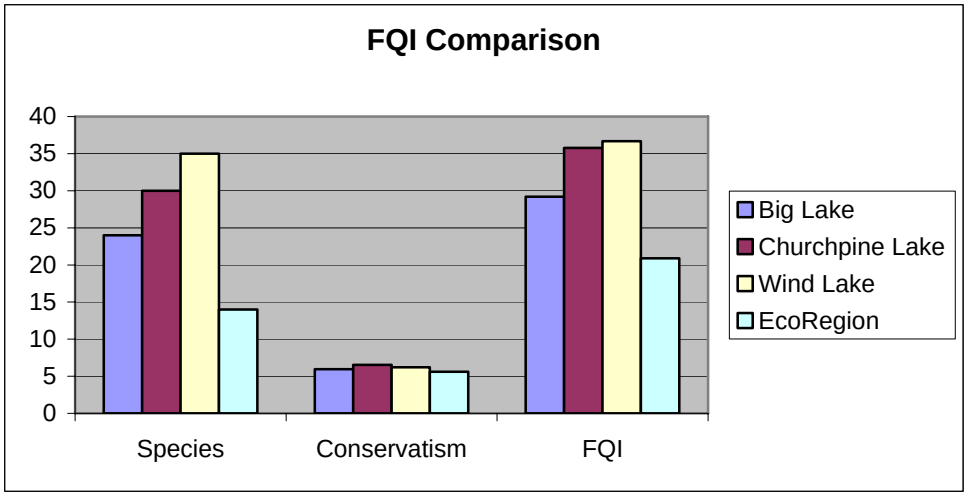


Figure 29: FQI comparison graph

Summary

Big Lake has a fairly diverse plant community but is limited in plant coverage throughout the lake. The lower water clarity may be affecting growth of plants as the maximum depth of plants was 16 feet, with most depths above 12 feet in depth lacking plant growth. The FQI is higher than the median for other lakes studied in this ecoregion. This indicates that Big Lake's plant community is quite healthy. There are a couple of areas that are thick plant growth that could adversely affect navigation to and from boating piers.

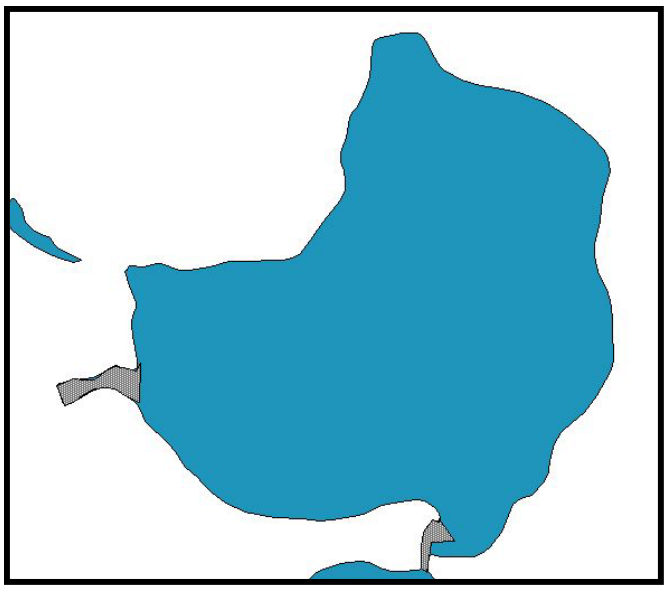


Figure 30: Map of potential nuisance plant growth Big Lake

Big Lake has two non-native plants. One is curly leaf pondweed and has extensive coverage of this plant with 23 acres of dense growth in many different beds. The other plant is purple loosestrife. One area on the lake has a rather large dense bed. Another area occurs adjacent to the lake across the road on the east shoreline. This bed is large and very dense. Both of these areas should be managed soon. In addition, the other locations have single or a few plants and should be removed by hand.

Churchpine Lake has an extremely healthy plant community. It is very diverse and had the highest mean conservatism of the three lakes. This is probably due to the good water quality Churchpine Lake has throughout the year. Plants were found at 26 feet and most points more shallow than this depth had plants. This indicates that the water clarity is good throughout the growing season. The FQI was substantially higher than the ecoregion median. Churchpine Lake had no non-native species sampled or viewed.

Wind Lake also has a very healthy plant community. The survey showed that there is high diversity and many plants with low tolerance to habitat changes (high conservatism values). As a result, the FQI is much higher for Wind Lake than the median for lakes in the ecoregion. Wind Lake had plants growing in depths of 21 feet and less. This shows that the water clarity remains high in Wind Lake. Both curly leaf pondweed and purple loosestrife occur in Wind Lake, but neither have any large, dense beds of either plant.

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