

Aquatic Plant Community
Of
Cedar Lake
St. Croix County, Wisconsin
2012-2015

Wisconsin Department of Natural Resources
Eau Claire, Wisconsin
July, 2015

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Introduction

The aquatic plant community of a lake is full of complex interactions that contribute to the overall health of an aquatic ecosystem. Every level of the aquatic food chain from bacteria and invertebrates to fish and waterfowl are dependent upon aquatic plants to some degree for their survival (Engel, 1985; Wetzel, 2001). Photosynthesis and respiration are important in maintaining clear waters (Engel, 1990). Aquatic plants stabilize sediments and absorb wave action which in turn prevents turbidity caused by suspended sediments. Light penetration, excess nutrients from run-off, wave action and lake morphometry all affect the plant community of the littoral zone (Barko 1988; Duarte and Kalff, 1986). The importance of aquatic plants in an aquatic ecosystem creates the need to study the diversity, density and distribution of the aquatic plant community as well as an examination of the factors impacting the plant community. As a part of the Wisconsin Department of Natural Resources Long-Term Trends Monitoring program, an aquatic plant survey was conducted on Cedar Lake in July 2012, and July 2015, by water resources staff at the Wisconsin Department of Natural Resources.

Methods

Cedar Lake is a 1,100 acre lake located in St. Croix County in Wisconsin. The lake has 6.3 miles of shoreline and a maximum depth of 32 feet.

The plant surveys were conducted according to the Wisconsin Department of Natural Resources Guidelines using the Point-Intercept method that can be found at <http://www.uwsp.edu/cnr-ap/UWEXLakes/Pages/ecology/aquaticplants/default.aspx> (Hauwxell et al, 2010). A 69 meter grid of 956 points was established for Cedar Lake. At each Point-Intercept point one sample was collected using a steel thatching rake. The aquatic plant species present on the rake were identified and recorded. Each species was given a density rating based on the total coverage of the plant on the rake (1 – few, 2 – moderate, 3 – abundant). Visual inspections were done between points in order to record the presence of any species that did not occur at the sampling sites. Plant species present were collected and saved for preparation of voucher specimens. Nomenclature was according to Gleason and Cronquist (1991). Depth was recorded at each sample site. Depths were classified into four zones: zone 1 = 0 – 1.5 2ft; zone 2 = 2– 5 ft; zone 3 = 5.5 – 10 ft; zone 4 = 10.5 – 20 ft. Sediment data were collected at sites less than 15 feet. Sediments were classified as muck, sand or rock.

The percent frequency of occurrence of each plant species was calculated (number of sampling sites at which it occurred / total number of sampling sites). Relative frequency was calculated based on the number of occurrences of a species relative to all species' occurrences. A mean density where present was calculated for each species (sum of a species' density ratings / number of sampling sites at which it occurred). Relative rake fullness was calculated based on the total rake fullness of each species relative to all species rake fullness rankings. The relative frequency and relative rake fullness were summed to obtain a dominance value for each species.

The Floristic Quality Index (FQI) was used to assess each community's resemblance to an undisturbed condition. Coefficients of conservatism are values assigned to plant species based on their ties to a pre-settlement condition. Plants are given a value on a scale of 1 to 10 based on the probability that a species will occur in a disturbed habitat with higher values given to plants that are less likely to occur in a disturbed habitat (Nichols, 1999). Coefficient of conservatism values are assigned only to native species that would normally be found in a lake environment. $FQI = \text{Average Coefficient of conservatism} * \sqrt{\text{Number of species}}$.

The Aquatic Macrophyte Community Index (AMCI) was used to define the quality of the aquatic plant community based on seven parameters: the maximum rooting depth, the percentage of the littoral

zone vegetated, the relative frequencies of submerged species, sensitive species and exotic species, Simpson's Diversity Index and the total number of taxa. Each parameter was scaled from 1-10 with 10 representing the most desirable condition. The scaled values were then summed to obtain the AMCI (Nichols et al., 2000). The AMCI and FQI of Cedar Lake were compared to those of all Wisconsin Lakes and lakes in the North Central Hardwood region.

Simpson's Diversity Index (SDI) was used to measure the diversity of the plant communities in each survey. The formula measures the probability that two individuals from the same community will be the same species. Values for SDI range from 0-1 where a value of 0 indicates two individuals will always be the same species and a value of 1 indicates two individuals will always be different species. $SDI = 1 - (\text{Sum}(\text{frequency of occurrence of one species} / \text{sum frequency of all species}))$

Chi-square analysis was used to determine significant differences between consecutive surveys in the frequency of occurrence of each species.

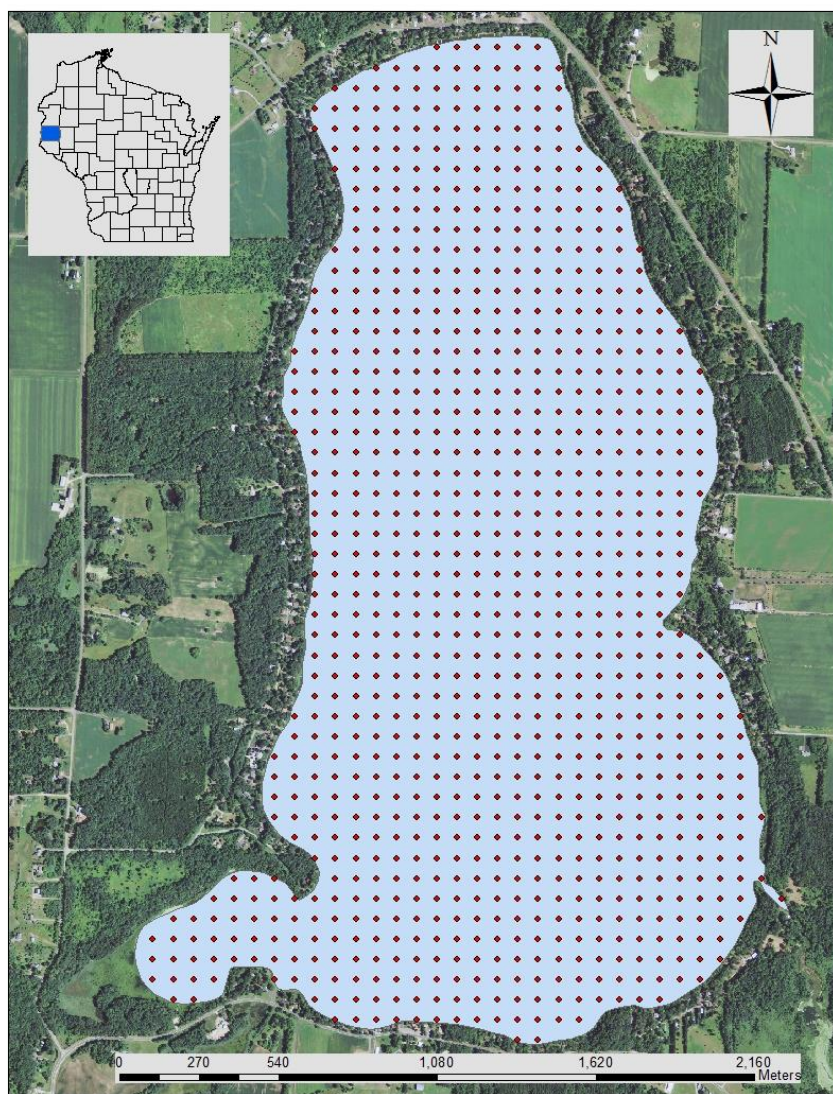


Figure 1. Map – Sampling grid

Results

Table 1. Trophic status

	Quality Index	Phosphorus ug/L	Chlorophyll ug/L	Secchi Disc feet
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1-10	1-5	8-19
Mesotrophic	Good	10-30	5-10	6-8
	Fair	30-50	10-15	5-6
Eutrophic	Poor	50-150	15-30	3-5
Hypereutrophic	Very Poor	>150	>30	<3
Cedar Lake 2014	Poor	100.35	40.9	5.24

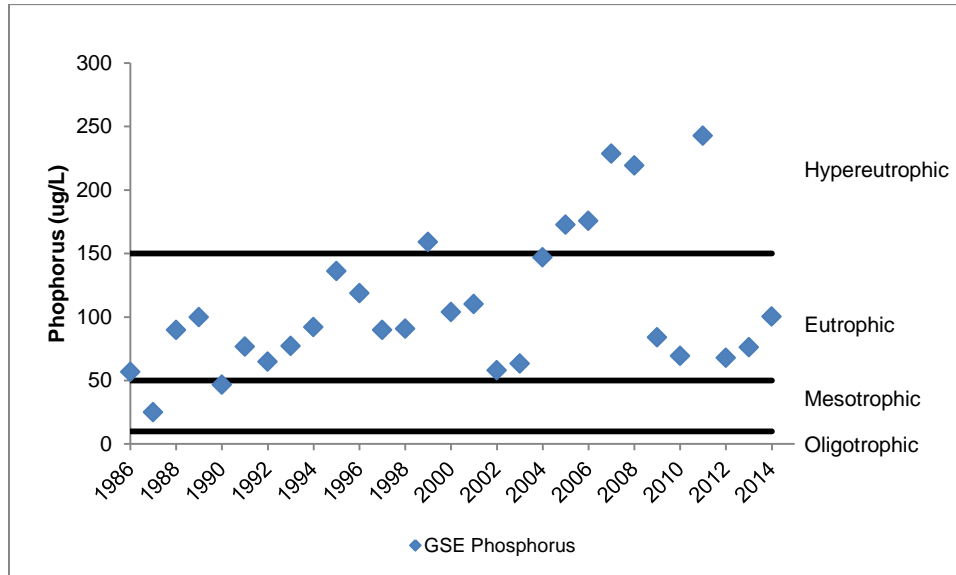


Figure 2. Phosphorus ug/L

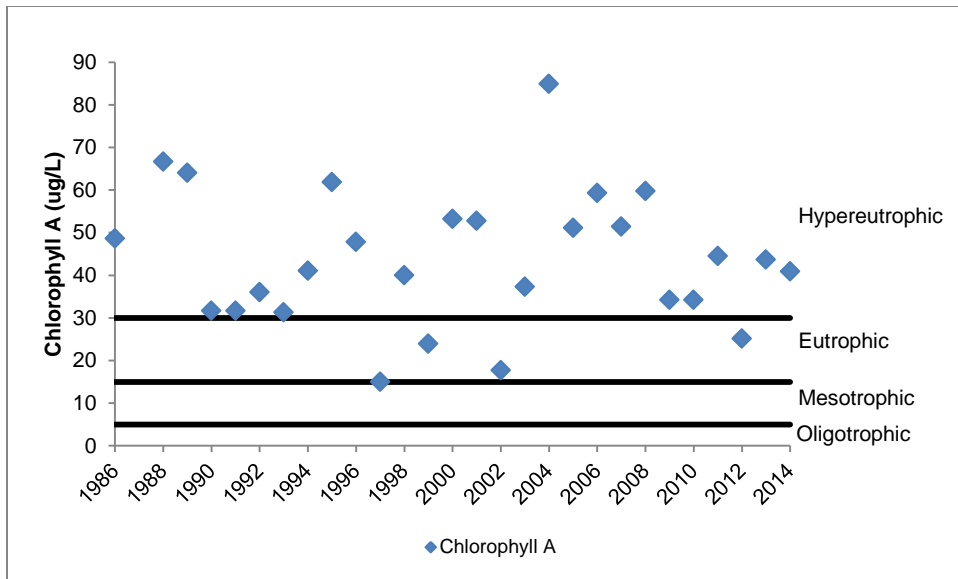


Figure 3. Chlorophyll ug/L

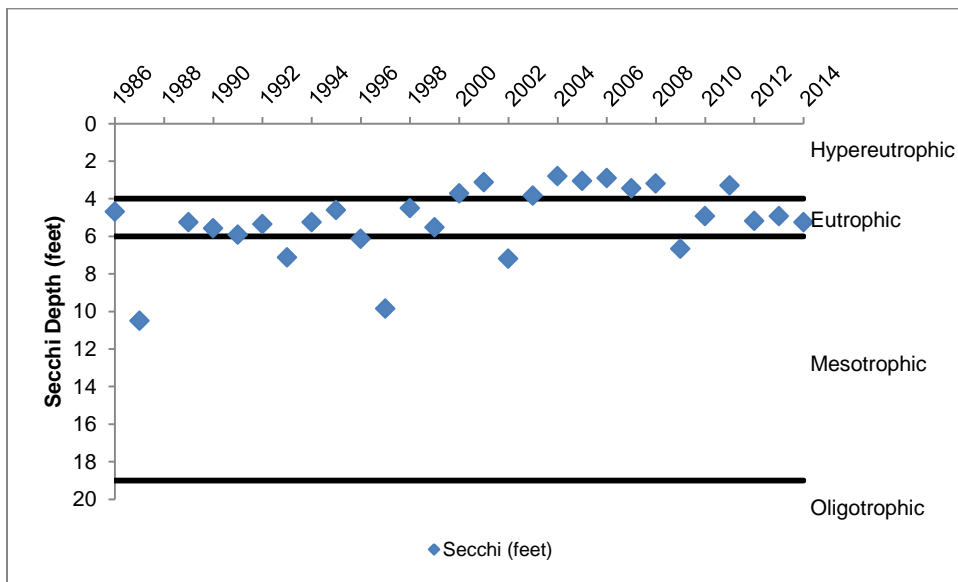


Figure 4. Secchi Disc

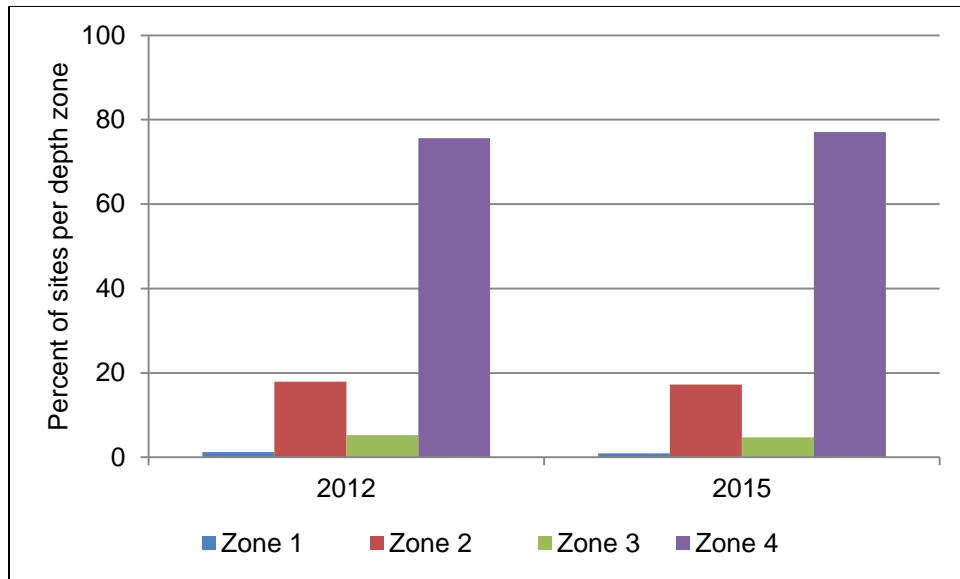


Figure 5. Percent of sites sampled per depth zone

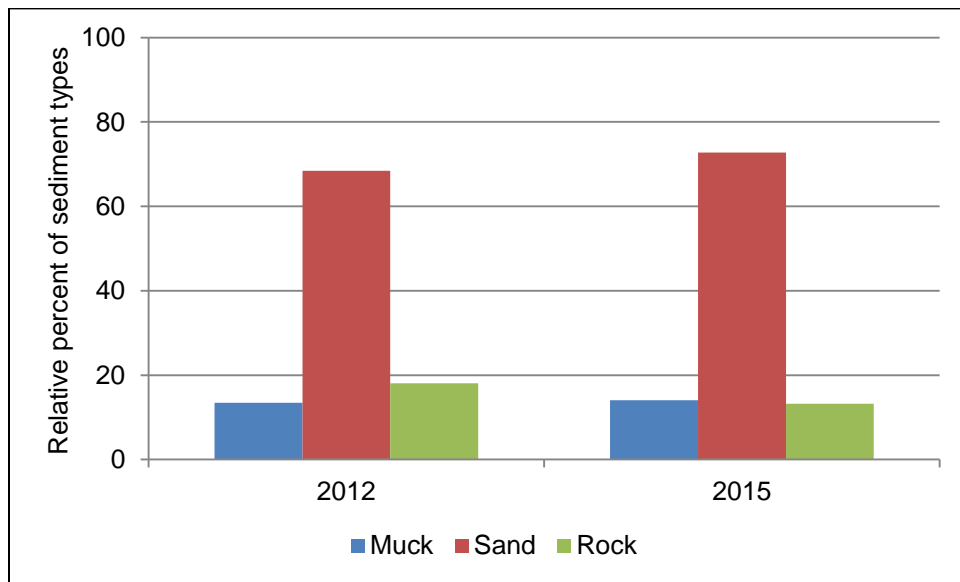


Figure 6. Relative frequency of sediment types

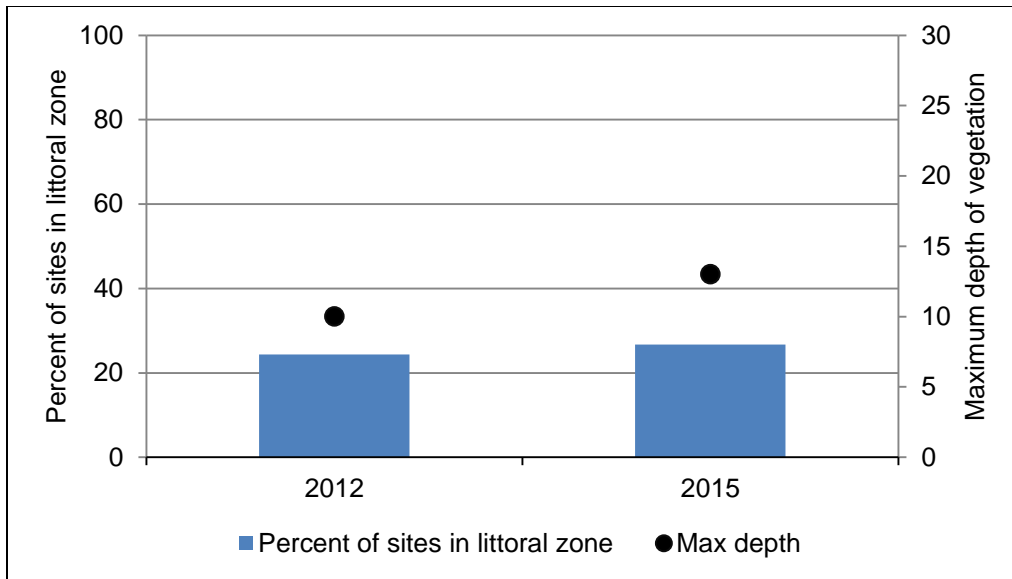


Figure 7. Percent of survey area in littoral zone and maximum depth of vegetation

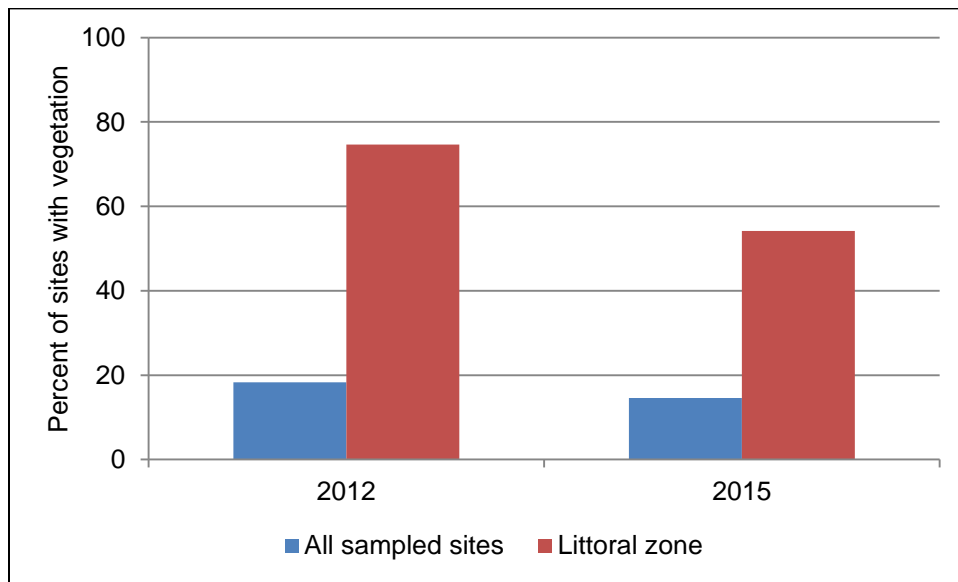


Figure 8. Percent frequency of sampled sites with vegetation

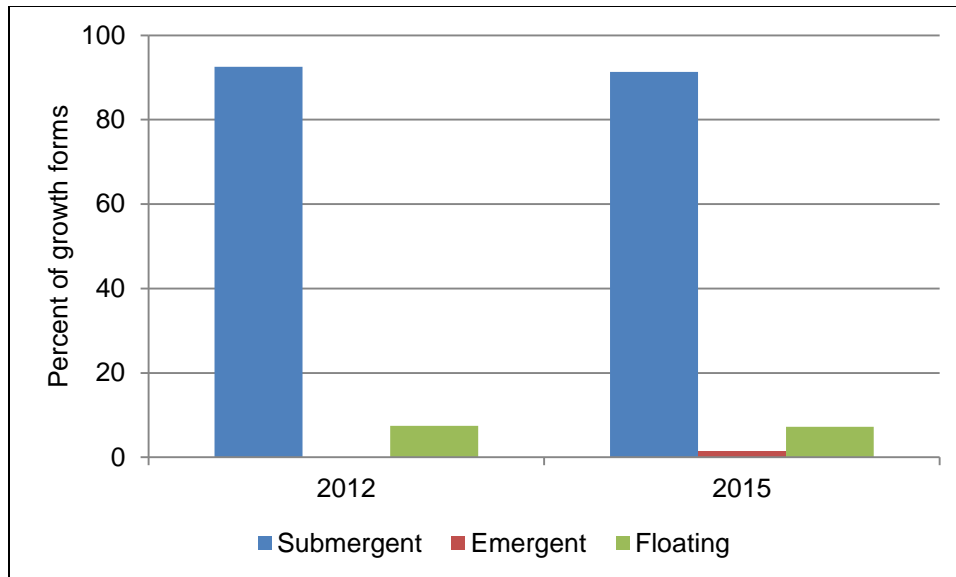


Figure 9. Relative percent frequency of plant growth forms

Table 2. Species list – values indicate number of occurrence at all sampled sites + visual sightings

SCIENTIFIC NAME	COMMON NAME	2012	2015
<i>Ceratophyllum demersum</i>	Coontail	37	24
<i>Chara</i> sp.	Chara		15
<i>Elodea canadensis</i>	Common waterweed	1	1
<i>Heteranthera dubia</i>	Water star-grass		2
<i>Lemna minor</i>	Small duckweed	6	2
<i>Lemna trisulca</i>	Forked duckweed	3	7
<i>Myriophyllum sibiricum</i>	Northern milfoil	4	16
<i>Myriophyllum spicatum</i>	Eurasian water milfoil		6
<i>Najas flexilis</i>	Slender naiad	73	5
<i>Nuphar X rubrodisca</i>	Intermediate pond lily	2	1
<i>Nymphaea odorata</i>	White water lily	14	6
<i>Potamogeton crispus</i>	Curly-leaf pondweed	25	31
<i>Potamogeton illinoensis</i>	Illinois pondweed	3	2
<i>Potamogeton pusillus</i>	Small pondweed	57	87
<i>Potamogeton richardsonii</i>	Clasping-leaf pondweed	25	13
<i>Potamogeton robbinsii</i>	Fern pondweed	1	2
<i>Potamogeton zosteriformis</i>	Flat-stem pondweed	22	18
<i>Sagittaria</i> sp.	Arrowhead		1
<i>Sparganium</i> sp.	Bur-reed		1
<i>Spirodela polyrhiza</i>	Large duckweed	6	2
<i>Stuckenia pectinata</i>	sago pondweed	55	9
<i>Typha</i> sp.	Cattail		2
<i>Vallisneria americana</i>	Wild celery	81	27
<i>Wolffia columbiana</i>	Common watermeal		2

Table 3. Chi-square analysis of differences in aquatic plant frequency of occurrence. Directionality of significant changes is indicated with \wedge (increase) and \vee (decrease). Directionality of non-significant changes is indicated with + (increase) and – (decrease).

	2012-2015	
	Significance	Direction
<i>Ceratophyllum demersum</i>	n.s.	-
<i>Chara</i> sp.	***	\wedge
<i>Elodea canadensis</i>	n.s.	+
<i>Heteranthera dubia</i>	n.s.	+
<i>Lemna minor</i>	n.s.	-
<i>Lemna trisulca</i>	n.s.	+
<i>Myriophyllum sibiricum</i>	**	\wedge
<i>Myriophyllum spicatum</i>	n.s.	+
<i>Najas flexilis</i>	***	\vee
<i>Nuphar variegata</i>	n.s.	-
<i>Nymphaea odorata</i>	n.s.	-
<i>Potamogeton crispus</i>	n.s.	+
<i>Potamogeton illinoensis</i>	n.s.	-
<i>Potamogeton pusillus</i>	**	\wedge
<i>Potamogeton richardsonii</i>	n.s.	-
<i>Potamogeton robbinsii</i>	n.s.	+
<i>Potamogeton zosteriformis</i>	n.s.	-
<i>Sagittaria</i> sp.	n.s.	+
<i>Sparganium</i> sp.	n.s.	+
<i>Spirodela polyrhiza</i>	n.s.	-
<i>Stuckenia pectinata</i>	***	\vee
<i>Typha</i> sp.	n.s.	+
<i>Vallisneria americana</i>	***	\vee
<i>Wolffia columbiana</i>	n.s.	+

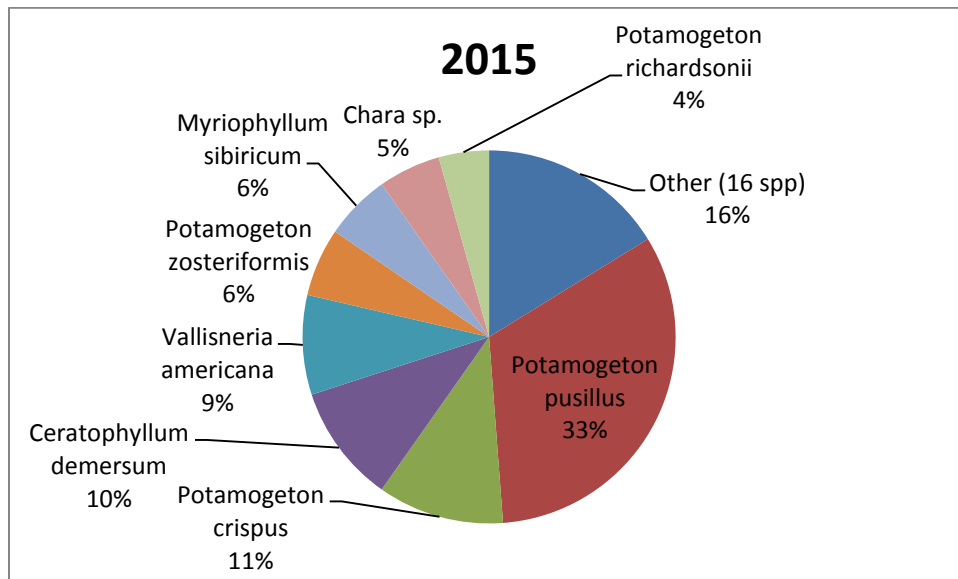
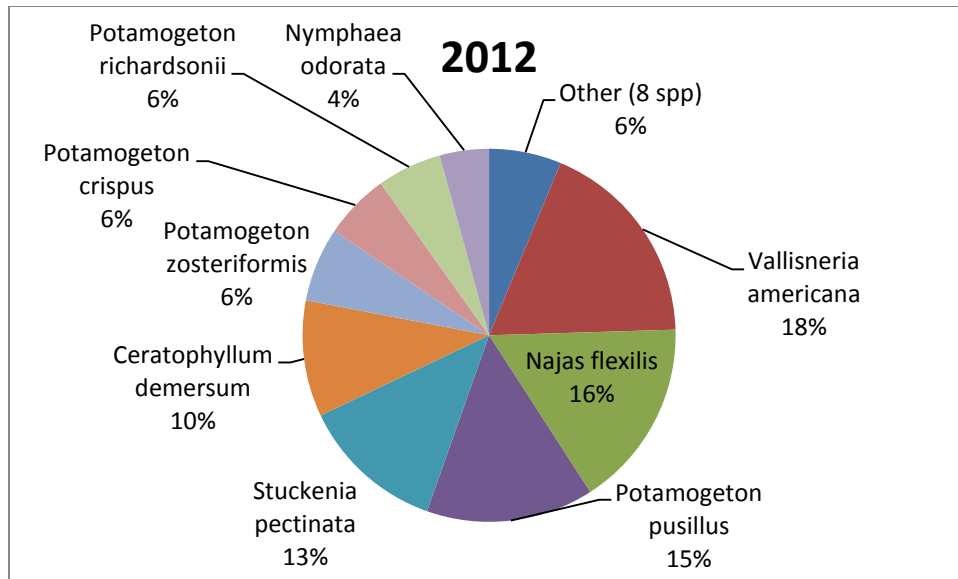


Figure 10. Dominance values of aquatic plant community

Cedar Lake's AMCI and FQI values were compared to all lakes in Wisconsin, and lakes in the North Central Hardwood region. Box plots illustrate where Cedar Lake falls on the continuum of values. The graphic to the right illustrates the box plot. The minimum and maximum represent the lowest and highest values. 25% of lakes fall above and below the upper and lower quartile marks and 50% of lakes fall above and below the median value.

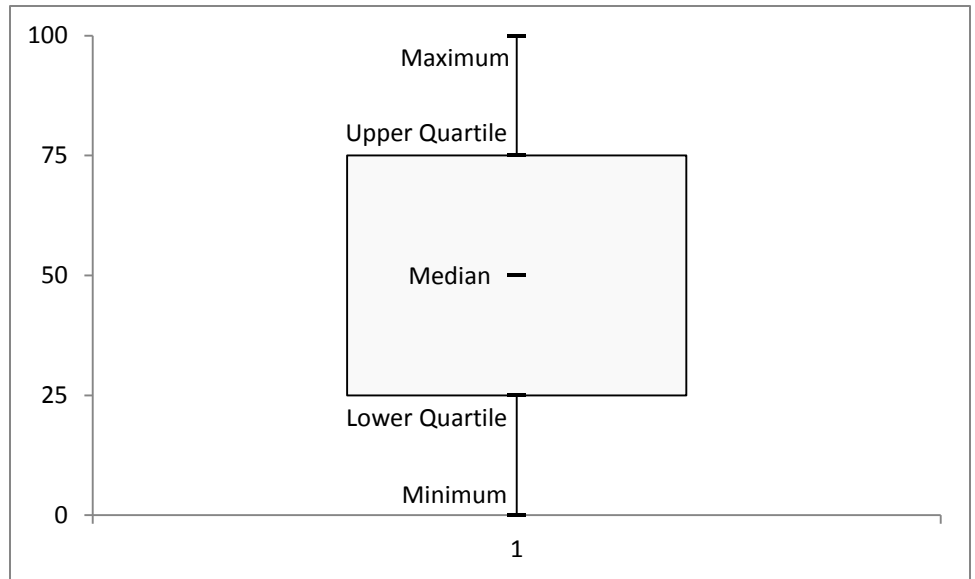


Table 4. FQI

	2012	2015
Species	16	20
Average C	5.38	5.25
FQI	21.50	23.48

Table 5. AMCI

	2012		2015	
	Value	Scaled	Value	Scaled
Maximum Rooting Depth (ft)	10.0	5	13.0	7
# Species	17	8	24	9
Littoral Zone Vegetated (%)	74.68	10	54.15	10
Submergent Species (%)	92.53	7	91.34	8
Sensitive Species (%)	6.27	5	7.94	5
Exotic Species (%)	6.02	5	11.55	4
Simpson's Diversity	83.85	6	85.49	6
AMCI		46		49

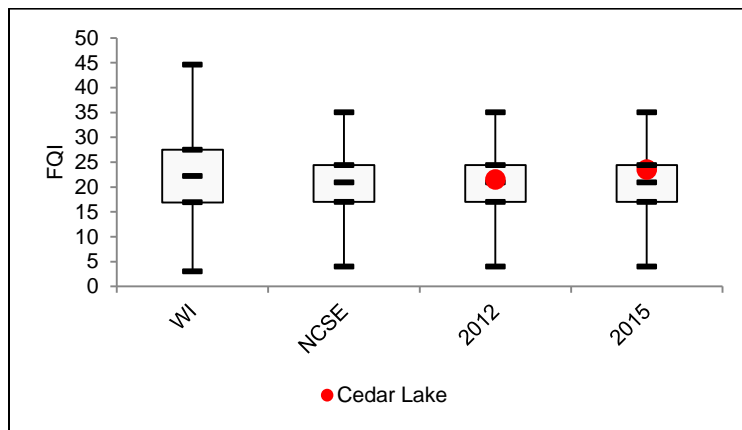
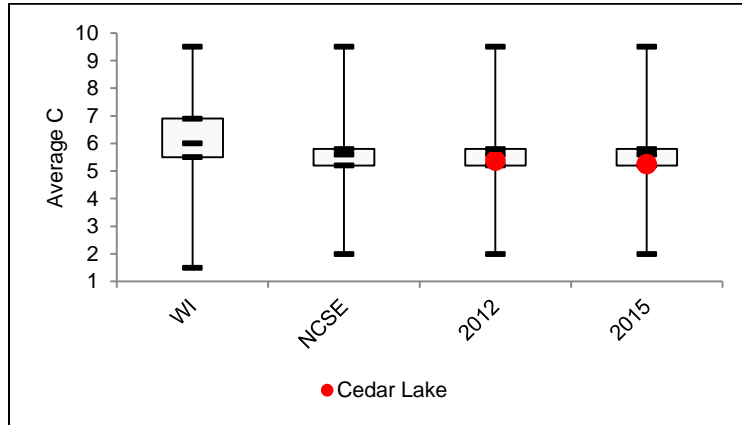
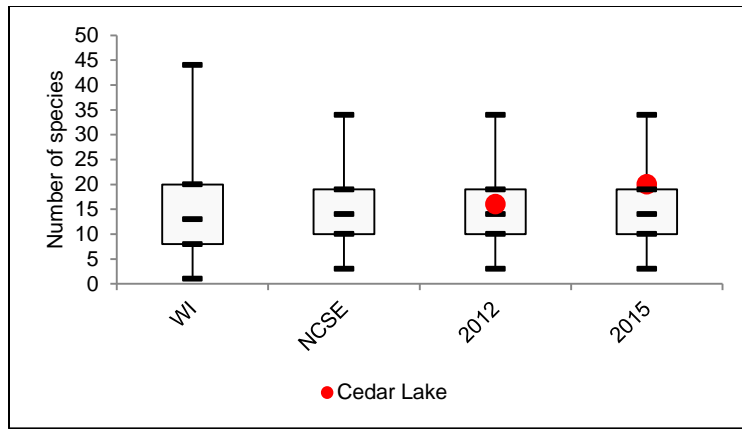


Figure 11. FQI box plots

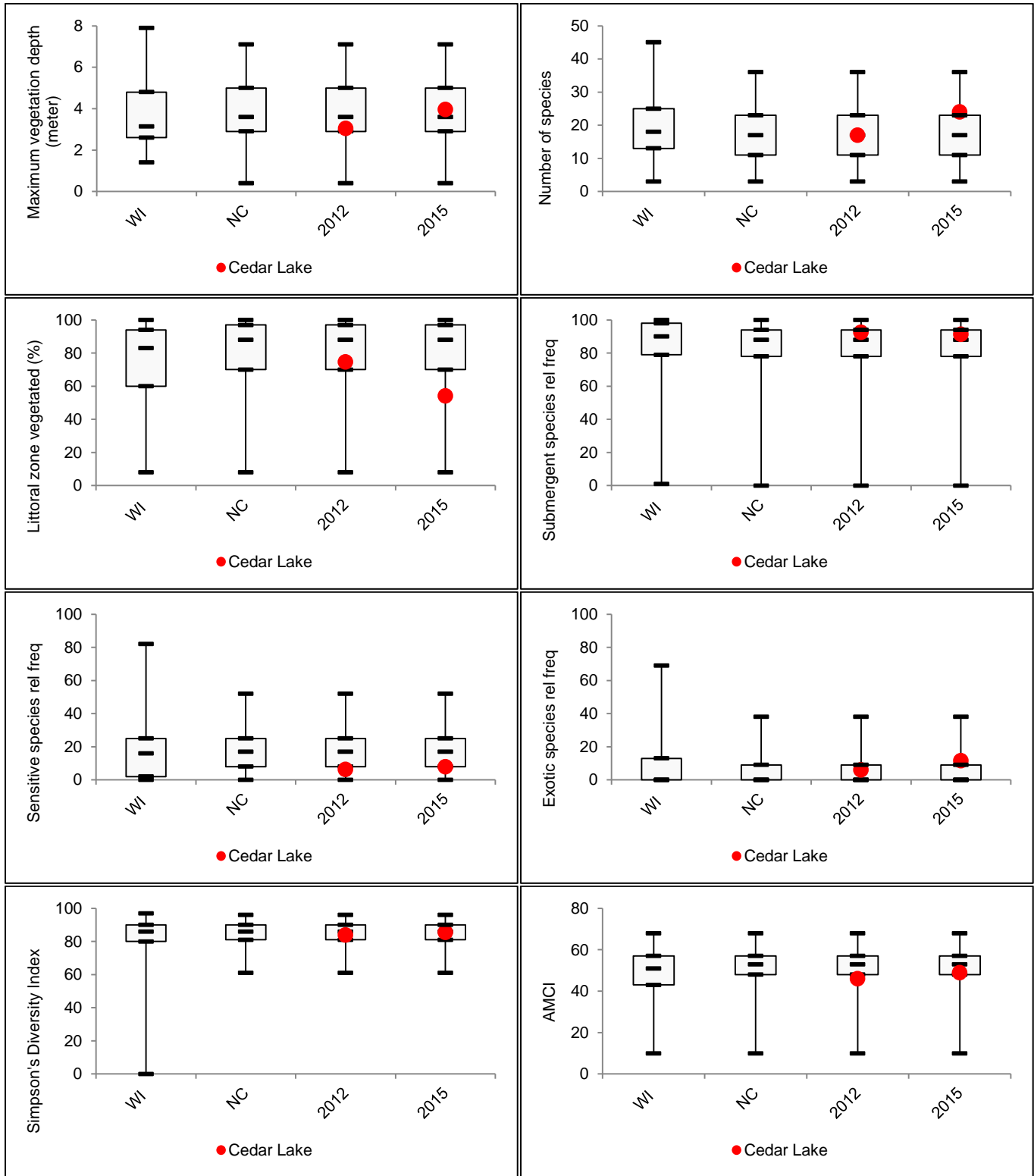


Figure 12. AMCI box plots

Table 6. Community comparisons

	1988	1991	1994	1997	2000	2004	2012	2015
Number of Species	17	22	23	23	17	18	17	24
Maximum Rooting Depth	12.0	11.5	13.0	13.0	11.0	7.0	10	13
Simpson's Diversity Index	0.87	0.88	0.87	0.90	0.88	0.86	0.84	0.85
FQI	20.5	23.2	24.1	23.6	19.7	19.3	21.5	20
Average Coefficient of Conservatism	4.8	5.0	5.1	4.9	4.8	4.6	5.7	5.25
AMCI	46	49	45	45	43	38	46	49

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Appendix 1. Individual Species Statistics

2012 Aquatic Plant Frequency	Total Occur.	Occur. Zone 1	Occur. Zone 2	Occur. Zone 3	Occur. Zone 4	Frequency of Occurrence (FOO)	FOO Littoral	FOO Zone 1	FOO Zone 2	FOO Zone 3	FOO Zone 4	Relative Freq
<i>Ceratophyllum demersum</i> , Coontail	37	1	19	17		3.87	15.88	8.33	11.11	34.00		8.92
<i>Elodea canadensis</i> , Common waterweed	1			1		0.10	0.43			2.00		0.24
<i>Lemna minor</i> , Small duckweed	6		6			0.63	2.58		3.51			1.45
<i>Lemna trisulca</i> , Forked duckweed	3		3			0.31	1.29		1.75			0.72
<i>Myriophyllum sibiricum</i> , Northern water-milfoil	4		1	3		0.42	1.72		0.58	6.00		0.96
<i>Najas flexilis</i> , Slender naiad	73	10	61	2		7.64	31.33	83.33	35.67	4.00		17.59
<i>Nuphar variegata</i> , Spatterdock	2		2			0.21	0.86		1.17			0.48
<i>Nymphaea odorata</i> , White water lily	14		13	1		1.46	6.01		7.60	2.00		3.37
<i>Potamogeton crispus</i> , Curly-leaf pondweed	25		15	10		2.62	10.73		8.77	20.00		6.02
<i>Potamogeton illinoensis</i> , Illinois pondweed	3		3			0.31	1.29		1.75			0.72
<i>Potamogeton pusillus</i> , Small pondweed	57	1	45	11		5.96	24.46	8.33	26.32	22.00		13.73
<i>Potamogeton richardsonii</i> , Claspig-leaf pondweed	25		24	1		2.62	10.73		14.04	2.00		6.02
<i>Potamogeton robbinsii</i> , Fern pondweed	1		1			0.10	0.43		0.58			0.24
<i>Potamogeton zosteriformis</i> , Flat-stem pondweed	22	2	14	6		2.30	9.44	16.67	8.19	12.00		5.30
<i>Spirodela polyrhiza</i> , Large duckweed	6		6			0.63	2.58		3.51			1.45
<i>Stuckenia pectinata</i> , Sago pondweed	55	8	46	1		5.75	23.61	66.67	26.90	2.00		13.25
<i>Vallisneria americana</i> , Wild celery	81	4	74	3		8.47	34.76	33.33	43.27	6.00		19.52
Total	415	26	333	56	0	43.41	178.11	216.67	194.74	112.00	0.00	100.00

2012 Aquatic Plant Rake Fullness	Total rake fullness	Rake fullness Zone 1	Rake fullness Zone 2	Rake fullness Zone 3	Rake fullness Zone 4	Total Mean rake fullness	Mean rake fullness Zone1	Mean rake fullness Zone2	Mean rake fullness Zone3	Mean rake fullness Zone 4	Relative rake fullness
Ceratophyllum demersum, Coontail	61.00	1.00	28.00	32.00		1.65	1.00	1.47	1.88		11.25
Elodea canadensis, Common waterweed	1.00			1.00		1.00			1.00		0.18
Lemna minor, Small duckweed	8.00		8.00			1.33		1.33			1.48
Lemna trisulca, Forked duckweed	3.00		3.00			1.00		1.00			0.55
Myriophyllum sibiricum, Northern water-milfoil	4.00		1.00	3.00		1.00		1.00	1.00		0.74
Najas flexilis, Slender naiad	82.00	14.00	66.00	2.00		1.12	1.40	1.08	1.00		15.13
Nuphar variegata, Spatterdock	6.00		6.00			3.00		3.00			1.11
Nymphaea odorata, White water lily	28.00		27.00	1.00		2.00		2.08	1.00		5.17
Potamogeton crispus, Curly-leaf pondweed	29.00		18.00	11.00		1.16		1.20	1.10		5.35
Potamogeton illinoensis, Illinois pondweed	3.00		3.00			1.00		1.00			0.55
Potamogeton pusillus, Small pondweed	83.00	2.00	64.00	17.00		1.46	2.00	1.42	1.55		15.31
Potamogeton richardsonii, Claspig-leaf pondweed	28.00		27.00	1.00		1.12		1.13	1.00		5.17
Potamogeton robbinsii, Fern pondweed	1.00		1.00			1.00		1.00			0.18
Potamogeton zosteriformis, Flat-stem pondweed	41.00	2.00	27.00	12.00		1.86	1.00	1.93	2.00		7.56
Spirodela polyrhiza, Large duckweed	8.00		8.00			1.33		1.33			1.48
Stuckenia pectinata, Sago pondweed	64.00	8.00	55.00	1.00		1.16	1.00	1.20	1.00		11.81
Vallisneria americana, Wild celery	92.00	4.00	85.00	3.00		1.14	1.00	1.15	1.00		16.97
Total	542.00	31.00	427.00	84.00	0.00	23.34	7.40	22.32	13.53	0.00	100.00

2012 Aquatic Plant Frequency	Total Occur.	Occur. Zone 1	Occur. Zone 2	Occur. Zone 3	Occur. Zone 4	Frequency of	FOO Littoral	FOO Zone 1	FOO Zone 2	FOO Zone 3	FOO Zone 4	Relative Freq
						Occurrence (FOO)						
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Lemna trisulca, Forked duckweed	3		3			0.31	1.29		1.75			0.72
Myriophyllum sibiricum, Northern water-milfoil	4		1	3		0.42	1.72		0.58	6.00		0.96
Najas flexilis, Slender naiad	73	10	61	2		7.64	31.33	83.33	35.67	4.00		17.59
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Nymphaea odorata, White water lily	14		13	1		1.46	6.01		7.60	2.00		3.37
Potamogeton crispus, Curly-leaf pondweed	25		15	10		2.62	10.73		8.77	20.00		6.02
Potamogeton illinoensis, Illinois pondweed	3		3			0.31	1.29		1.75			0.72
Potamogeton pusillus, Small pondweed	57	1	45	11		5.96	24.46	8.33	26.32	22.00		13.73
Potamogeton richardsonii, Claspig-leaf pondweed	25		24	1		2.62	10.73		14.04	2.00		6.02
Potamogeton robbinsii, Fern pondweed	1		1			0.10	0.43		0.58			0.24
Potamogeton zosteriformis, Flat-stem pondweed	22	2	14	6		2.30	9.44	16.67	8.19	12.00		5.30
Spirodela polyrhiza, Large duckweed	6		6			0.63	2.58		3.51			1.45
Stuckenia pectinata, Sago pondweed	55	8	46	1		5.75	23.61	66.67	26.90	2.00		13.25
Vallisneria americana, Wild celery	81	4	74	3		8.47	34.76	33.33	43.27	6.00		19.52
Total	415	26	333	56	0	43.41	178.11	216.67	194.74	112.00	0.00	100.00

2015 Aquatic Plant Rake Fullness	Total rake fullness	Rake fullness Zone 1	Rake fullness Zone 2	Rake fullness Zone 3	Rake fullness Zone 4	Total Mean rake fullness	Mean rake fullness Zone1	Mean rake fullness Zone2	Mean rake fullness Zone3	Mean rake fullness Zone 4	Relative rake fullness
Ceratophyllum demersum, Coontail	44.00		6.00	36.00	2.00	1.83		1.20	2.12	1.00	11.80
Chara sp., Muskgrasses	20.00		20.00			1.33		1.33			5.36
Elodea canadensis, Common waterweed	1.00			1.00		1.00			1.00		0.27
Heteranthera dubia, Water star-grass	2.00			2.00		1.00			1.00		0.54
Lemna minor, Small duckweed	2.00		2.00			1.00		1.00			0.54
Lemna trisulca, Forked duckweed	7.00		3.00	4.00		1.00		1.00	1.00		1.88
Myriophyllum sibiricum, Northern water-milfoil	21.00	1.00	10.00	9.00	1.00	1.31	1.00	1.25	1.50	1.00	5.63
Myriophyllum spicatum, Eurasian water-milfoil or Hybrid water-milfoil	1.00		1.00			1.00		1.00			0.27
Najas flexilis, Slender naiad	6.00		6.00			1.20		1.20			1.61
Nuphar variegata, Spatterdock	3.00		3.00			3.00		3.00			0.80
Nymphaea odorata, White water lily	13.00		13.00			2.17		2.17			3.49
Potamogeton crispus, Curly-leaf pondweed	40.00		20.00	19.00	1.00	1.29		1.18	1.46	1.00	10.72
Potamogeton illinoensis, Illinois pondweed	2.00		2.00			1.00		1.00			0.54
Potamogeton pusillus, Small pondweed	126.00	3.00	93.00	27.00	3.00	1.45	3.00	1.41	1.59	1.00	33.78
Potamogeton richardsonii, Claspig-leaf pondweed	15.00		14.00	1.00		1.15		1.17	1.00		4.02
Potamogeton robbinsii, Fern pondweed	2.00		2.00			1.00		1.00			0.54
Potamogeton zosteriformis, Flat-stem pondweed	20.00		7.00	13.00		1.11		1.17	1.08		5.36
Sagittaria sp., Arrowhead	1.00		1.00			1.00		1.00			0.27
Sparganium sp., Bur-reed	1.00		1.00			1.00		1.00			0.27
Spirodela polyrhiza, Large duckweed	2.00		2.00			1.00		1.00			0.54
Stuckenia pectinata, Sago pondweed	12.00	1.00	11.00			1.33	1.00	1.38			3.22
Typha sp., Cattail	2.00		2.00			1.00		1.00			0.54
Vallisneria americana, Wild celery	28.00		26.00	2.00		1.04		1.04	1.00		7.51
Wolffia columbiana, Common watermeal	2.00		2.00			1.00		1.00			0.54
Total	373.00	5.00	247.00	114.00	7.00	30.22	5.00	27.48	12.75	4.00	100.00

Appendix 2: Maps