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[OSPREY LAKE 2015 AQUATIC PLANT SURVEY AND COMPARISON TO 2006 SURVEY]

This report is a summary and analysis of the data which was collected in a baseline macrophyte survey of Osprey Lake, Sawyer County WI. The macrophyte survey took place from 9/14/15 – 9/16/15 and followed WI DNR protocol for a point-intercept survey. The results of this current survey were then compared to the previous plant survey conducted in 2006 to determine if control methods for Eurasian Water Milfoil (EWM) over the course of time have had an impact on the native plant community.

Field Methods
A point intercept method for the macrophyte sampling was used. The Wisconsin Department of Natural Resources (WDNR) generated the sampling point grid. This grid consisted of 535 points (Figure 1). Only points shallower than 25 feet were initially sampled until the maximum depth of plants could be established. It was determined that the maximum depth of plants was 23 feet. A total of 267 points were sampled. From those 267 points, 260 points were at depths of 23 feet or less and 237 (91%) of them contained vegetation.

If no plants were sampled at a specific depth, one sample point beyond that depth was sampled for plants until the maximum depths of plants could be established. In addition, any plant within six feet of the boat was recorded. The visually surveyed plant data is not used in the statistical analysis nor is the density recorded. Only results from the predetermined sample points were used in the statistical analysis. 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-foot resolution and the location arrow touching the point.

At each sample location, a double-sided fourteen-tine rake was used to rake a 1 meter tow from off the bow of the boat. All plants contained on the rake and those that fell off of the rake were identified to the lowest practical taxonomic level (e.g., typically genus or species) and rated as to rake fullness and recorded on field data sheets. The rake fullness value was used based on the criteria contained in the diagram below. Those plants that were within six feet were recorded as "viewed," but no rake fullness rating was given.

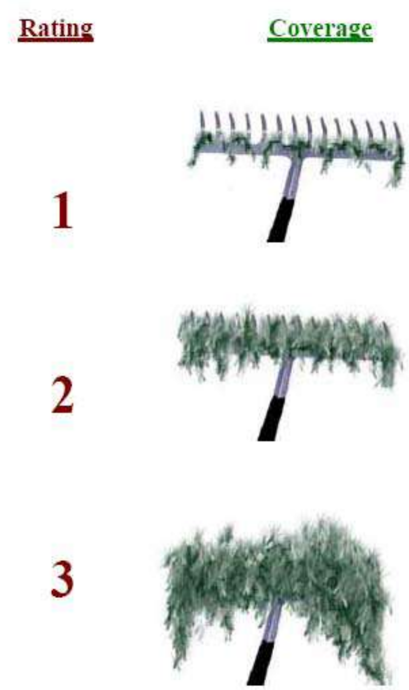
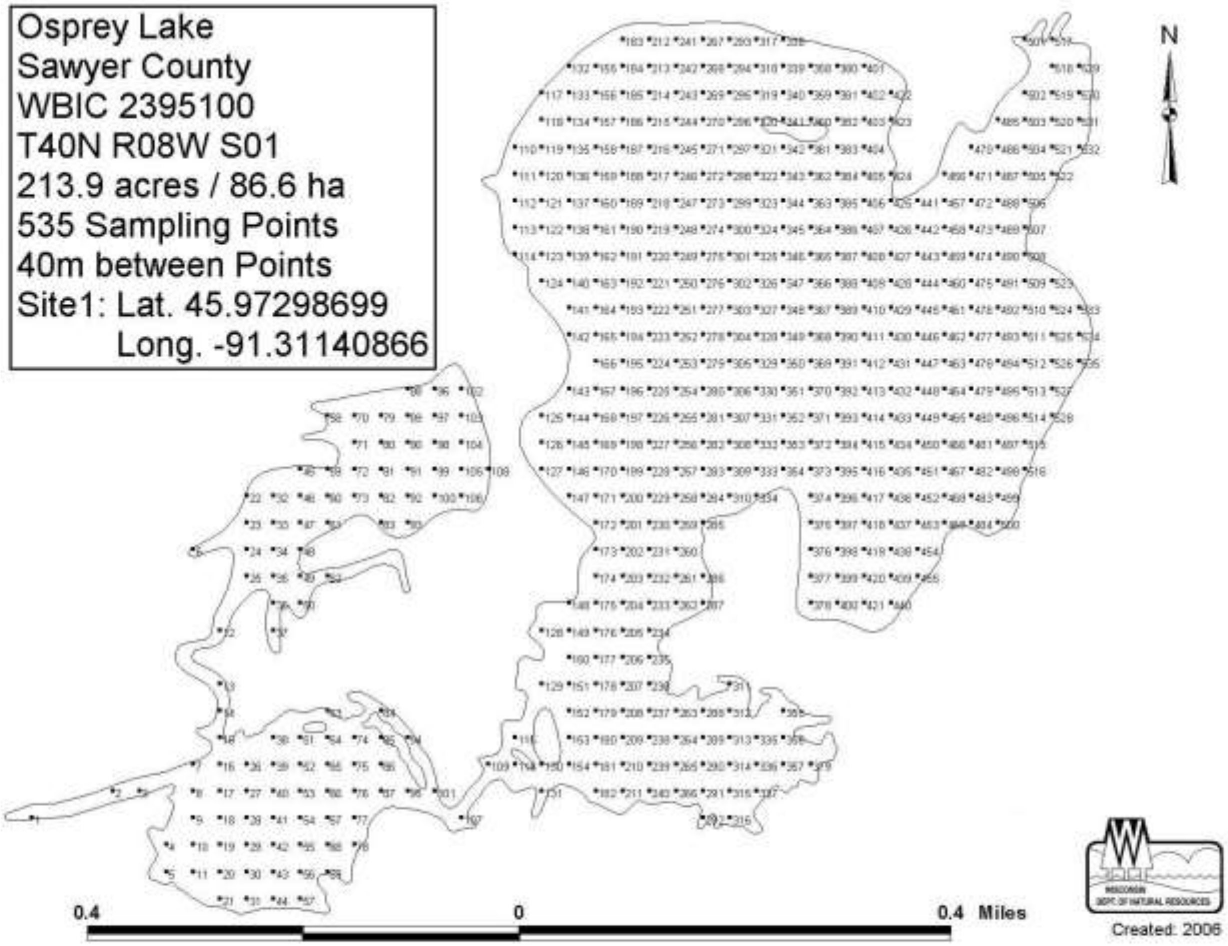


Figure 1: Osprey Lake Sampling Point Grid



The depth and predominant bottom type were also recorded for each sample point. All plants needing verification were bagged and cooled for later examination.

Data Analysis Methods

The 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 sample points
- 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 total sites. There are two frequency values calculated. The first is the percentage of all sample points that a plant was sampled at depths less than the 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 out of only points containing vegetation. The first value shows how often the plant would be encountered in the defined littoral zone (23 feet deep or less), while the second value considers only points that contain plants. In either case, the greater this value, the more frequently the plant occurs in the lake. If one wants to compare plants within 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 in areas where they could grow. If one wants to focus only on 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.

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.

Total Sample Points
This is the total number of points created for sampling on the lake. This may not be the same as the actual points sampled. When doing a survey, samples aren't taken 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 points with vegetation
This is the number of sites where plants were actually sampled. It gives a good idea of the plant coverage of the lake. If 20% of all grid sample points had vegetation, it implies about 20% coverage of plants in the whole lake. We also look at the number of sample sites with vegetation in the littoral zone. If 20% of the littoral zone had sample points with vegetation, then the plant coverage in the littoral zone would be estimated at 20%.

Simpson's diversity index
Simpson's diversity index is calculated to measure how diverse the plant community is. 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.

Maximum depth of plants
This depth indicates the deepest that plants were sampled. Generally lakes with higher water clarity 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. Results include 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 found 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. Not all plants have a conservatism value. A high conservatism value (7-10) indicates that a plant is intolerant to disturbance while a lower value (0-3) indicates a plant is very tolerant to disturbance. Intermediate C values (4-6) indicate plant species that can tolerate moderate disturbance. Those plants with higher values are more apt to respond adversely to water quality and habitat changes, largely due to human influence.

The FQI is calculated using the number of species and the average conservatism value of all species used in the index. It should be noted that some species such as filamentous algae and invasive species (such as EWM) do not have assigned C values, and therefore are not included in calculating the FQI.

The formula for calculating the FQI is:

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

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

A higher FQI, indicates a healthier aquatic plant community. This value can then be compared to the mean for other lakes in the assigned eco-region as well as to previous years within the lake to gauge the response to plant stressors such as chemical treatments to control invasive species. 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. Osprey Lake is located in the Northern Lakes and Forest eco-region. Below is a summary of the FQI median values for the Northern Lakes and Forest eco-region which Osprey Lake is located in:

Mean species richness = 13
Mean conservatism = 6.7

Mean Floristic Quality = 24.3[1]

Results and Comparison to 2006

The goal of the Osprey Lake Aquatic Plant Management Plan is to protect the native lake ecosystem and native plant populations while guiding efforts to control Eurasian watermilfoil. Statistical analysis can be used to help assess if the chemical treatments being used to control the EWM in Osprey Lake are having an impact on the native plant species. Table 1 outlines the EWM treatment history for Osprey Lake since it was first discovered in 2005.

Table 1: Osprey Lake EWM Control History

Year	Acres Treated	Herbicide	Rate (lbs/acre)
2006	8	2,4-D	125
2007	6	2,4-D	100-125
2008	4	2,4-D	100-125
2009	1	2,4-D	150
2010	5	2,4-D	150
2011	8.5	2,4-D	?
2012	12	2,4-D	?
2013	9	2,4-D	262
2014	N/A	N/A	N/A
2015	6	2,4-D	300

To gauge an initial response to the effects of herbicide treatment the point-intercept survey statistics for 2006 and 2015 can be looked at. See Table 2 for a comparison of the summaries of the point-intercept survey statistics for 2006 and 2015.

[1] Floristic Quality Assessment of Wisconsin Lake Plant Communities with Example Applications. Journal of Lake and Reservoir Management 15 (2): 133-144. 1999.

Table 2: Osprey Lake Aquatic Plant Survey Statistics

SUMMARY STATS:	2006	2015
Total number of points sampled	319	267
Total number of sites with vegetation	208	237
Total number of sites shallower than maximum depth of plants	292	260
Frequency of occurrence at sites shallower than maximum depth of plants	71.2	91.15
Simpson Diversity Index	0.93	0.93
Maximum depth of plants (ft)	25	23.00
Number of sites sampled using rake on Rope (R)	88	124
Number of sites sampled using rake on Pole (P)	191	142
Average number of all species per site (shallower than max depth)	2	2.87
Average number of all species per site (veg. sites only)	1.48	3.15
Average number of native species per site (shallower than max depth)	1.8	2.71
Average number of native species per site (veg. sites only)	1.48	3.15
Species Richness	35	33
Species Richness (including visuals)	37	37

Several changes stand out when comparing the aquatic plant survey statistics. The first is the frequency of occurrence at sites shallower than the maximum depths of plants. The percent coverage of plants in the littoral zone increased from approximately 71% in 2006 to approximately 91% in 2015. This is a 20% increase in the coverage of plants in the littoral zone. The average number of species per vegetated site also more than doubled from 1.48 to 3.15 in 2015. The EWM treatments do not appear to be limiting spatial coverage or number of species at the sampled sites since both of these are increasing.

To compare the individual species populations between the years, a statistical analysis was completed using a Chi-square test with a 5% Type-1 error rate. This error rate is standard in ecological studies and equals that there is a 5% chance of claiming statistically significant change when no real change occurred. Only those species that display a p-value of 0.05 or lower changed significantly population-wise between the years. To calculate these values, the total number of sample locations each species was found at is compared between the years (2006 vs 2015). Table 3 displays the statistical changes, if any, for each species sampled in 2015 versus the 2006 survey.

Table 3: Statistical significance of Species between Sampling Events

Specie	2006 points	2015 points	+/-	p-value	Significance
Eurasian water-milfoil	present	present	#VALUE!	#VALUE!	#VALUE!
filamentous algae	0	42	+	1.77276E-10	***
Watershield	9	39	+	3.86909E-05	***

Specie	2006 points	2015 points	+/-	p-value	Significance
Coontail	3	0	-	0.063579095	n.s.
bottle brush sedge	0	present	no change	#DIV/0!	#DIV/0!
Muskgrasses	65	72	-	0.842712764	n.s.
needle spikerush	10	9	-	0.598941923	n.s.
Creeping spikerush	present	0	no change	#DIV/0!	#DIV/0!
Robbins spikerush	1	6	+	0.082783433	n.s.
Common waterweed	59	38	**-**	0.001668688	**
Pipewort	1	2	+	0.640470217	n.s.
Water star-grass	4	3	-	0.578247342	n.s.
Small duckweed	0	present	#VALUE!	#VALUE!	#VALUE!
Water marigold	15	19	+	0.74966322	n.s.
moss	3	17	**+**	0.003599576	**
Northern water milfoil	7	1	**-**	0.01972123	*
Dwarf watermilfoil	9	0	**-**	0.001215595	**
Bushy pondweed	51	3	**-**	6.61628E-14	***
Nitella	40	57	+	0.219185098	n.s.
Spatterdock	6	12	+	0.244450866	n.s.
White water lily	13	41	**+**	0.000368589	***
Water smartweed	1	1	-	0.926247712	n.s.
Pickerelweed	1	2	+	0.640470217	n.s.
Large-leaf pondweed	7	25	**+**	0.00342788	**
Variable pondweed	28	61	**+**	0.001236275	**
Floating-leaf pondweed	10	28	**+**	0.008319853	**
White-stem pondweed	1	7	+	0.050135123	n.s.
Small pondweed	39	12	**-**	6.11944E-06	***
Clasping-leaf pondweed	17	3	**-**	0.000449816	***
Robbins pondweed	58	90	**+**	0.024190634	*
Flat-stem pondweed	14	0	**-**	4.94238E-05	***
Sagittaria sp.	11	3	**-**	0.015288975	*
Water bulrush	13	30	**+**	0.022439466	*
Soft stem bulrush	1	2	+	0.640470217	n.s.
Narrow-leaved bur-reed	0	1	+	0.348307481	n.s.
Common bur-reed	4	2	-	0.324689041	n.s.
Flat-leaf bladderwort	2	44	**+**	1.15802E-09	***
Wild celery	18	70	**+**	3.4285E-08	***
Short-stem Burr Reed	0	1	+	0.348307481	n.s.
Freshwater sponge	2	4	+	0.507491102	n.s.
cattail	present	present	no change	#DIV/0!	#DIV/0!

*,**,*** - *Levels of significance*
n.s. – change not significant

A total of eleven species increased significantly from 2006 to 2015 (highlighted in **green**) and eight species decreased significantly (highlighted **red**).

Species Richness

Thirty-three species of aquatic macrophytes were directly sampled and four additional species were visually observed for a total of 37 species in Osprey Lake during the 2015 whole lake survey. In the 2006 survey, 35 species were sampled with 2 more observed for a total of 37 species also. Table 4 lists all of the species that were sampled or observed in 2015 along with their frequency and average rake density.

Table 4: 2015 Osprey Lake Aquatic Macrophytes

Scientific Name	***Common Name***	***Frequency within vegetated areas (%)***	***Freq. at sites shallower than max depth of plants (%)***	***Relative Frequency (%)***	***Average Rake Fullness***
Myriophyllum spicatum	Eurasian water-milfoil				present
filamentous algae		17.72	16.15	5.62	1
Brasenia schreberi	Watershield	16.46	15.00	5.22	1
Carex comosa	bottle brush sedge				present
Chara	Muskgrasses	30.38	27.69	9.64	1
Eleocharis acicularis	needle spikerush	3.80	3.46	1.20	1
Eleocharis robbinsii	Robbins spikerush	2.53	2.31	0.80	1
Elodea canadensis	Common waterweed	16.03	14.62	5.09	1
Eriocaulon aquaticum	Pipewort	0.84	0.77	0.27	1
Heteranthera dubia	Water star-grass	1.27	1.15	0.40	1
Lemna minor	Small duckweed				present
Megalodonta beckii	Water marigold	8.02	7.31	2.54	1
moss		7.17	6.54	2.28	1
Myriophyllum sibiricum	Northern water milfoil	0.42	0.38	0.13	1
Najas flexilis	Bushy pondweed	1.27	1.15	0.40	1
Nitella sp.	Nitella	24.05	21.92	7.63	1
Nuphar variegata	Spatterdock	5.06	4.62	1.61	1
Nymphaea odorata	White water lily	17.30	15.77	5.49	1
Polygonum amphibium	Water smartweed	0.42	0.38	0.13	1
Pontederia cordata	Pickerelweed	0.84	0.77	0.27	1
Potamogeton amplifolius	Large-leaf pondweed	10.55	9.62	3.35	1
Potamogeton gramineus	Variable pondweed	25.74	23.46	8.17	1
Potamogeton natans	Floating-leaf pondweed	11.81	10.77	3.75	1
Potamogeton praelongis	White-stem pondweed	2.95	2.69	0.94	1

Scientific Name	Common Name	Frequency within vegetated areas (%)	Freq. at sites shallower than max depth of plants (%)	Relative Frequency (%)	Average Rake Fullness
Potamogeton pusillus	Small pondweed	5.06	4.62	1.61	1
Potamogeton richardsonii	Clasping-leaf pondweed	1.27	1.15	0.40	1
Potamogeton robbinsii	Robbins pondweed	37.97	34.62	12.05	1
Sagittaria sp.		1.27	1.15	0.40	1
Schoenoplectus subterminalis	Water bulrush	12.66	11.54	4.02	1
Schoenoplectus tabernaemontani	Soft stem bulrush	0.84	0.77	0.27	2
Sparganium angustifolium	Narrow-leaved bur-reed	0.42	0.38	0.13	1
Sparganium eurycarpum	Common bur-reed	0.84	0.77	0.27	1
Utricularia intermedia	Flat-leaf bladderwort	18.57	16.92	5.89	1
Vallisneria americana	Wild celery	29.54	26.92	9.37	1
sparganium chlorocarpum	Short-stem Burr Reed	0.42	0.38	0.13	2
Freshwater sponge		1.69	1.54	0.54	1
Typha sp.	cattail				Present

Frequency of occurrence within vegetated areas (%): *Number of times a species was seen in a vegetated area divided by the total number of vegetated sites.*
Frequency of occurrence at sites shallower than maximum depth of plants: *Number of times a species was seen divided by the total number of sites shallower than maximum depth of plants (whole lake value-how often it occurs within the entire littoral zone)*

Some species were present in 2015 that weren't present in the 2006 survey as well as some species that were present in 2006 weren't sampled in the 2015 survey. Table 5 notes the differences in the plant species that were present/absent between 2006 and 2015.

Table 5: Plant Species Present/Absent 2006 vs 2015 Surveys

Scientific Name	Common Name	2006	2015
Ceratophyllum demersum	Coontail	Present	Absent
Carex comosa	bottle brush sedge	Absent	Present
Eleocharis palustris	Creeping spikerush	Present	Absent
Lemna minor	Small duckweed	Absent	Present
Myriophyllum tenellum	Dwarf watermilfoil	Present	Absent
Potamogeton zosteriformis	Flat-stem pondweed	Present	Absent
Sparganium angustifolium	Narrow-leaved bur-reed	Absent	Present
sparganium chlorocarpum	Short-stem Burr Reed	Absent	Present

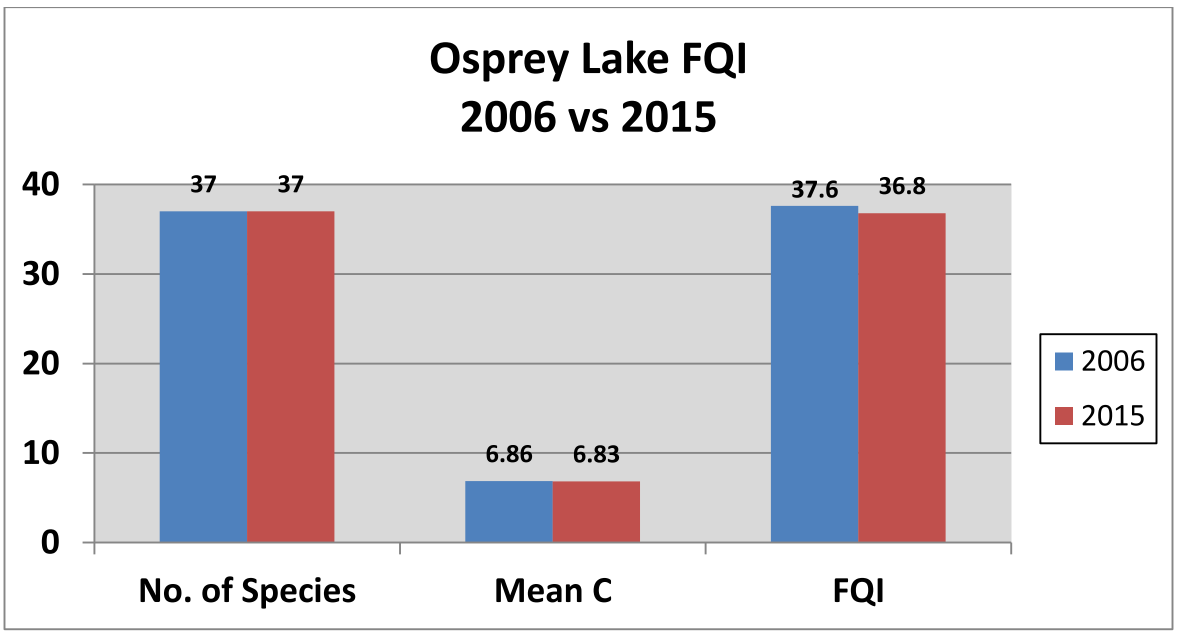
Plant Diversity
Osprey Lake continues to have a very diverse plant community. The Simpson's diversity index remained unchanged from 2006 (.93) indicating once again a healthy ecosystem and a high degree of diversity. The most abundant plant species surveyed in 2015 were Robbins Pondweed

938%), Muskgrass (30%) and wild celery (30%). The most abundant species in 2006 were Muskgrass (31%), common waterweed (28%) and Robbins pondweed (28%). No single plant dominated the lake in either year and the plant species abundance is balanced between several different types.

Floristic Quality Index

As seen in Figure 3, Osprey Lake continues to have a very high FQI (36.8). The mean conservatism value remained relatively unchanged also. The number of species, conservatism value and the FQI are essentially the same as they were in 2006 and continue to be well above the median values for lakes in the same eco-region (Northern Lakes and Forests). This high FQI is indicative of a plant community that is intolerant to development and other human disturbances in the watershed. It indicates that the plant community is healthy and likely has changed little in response to human impact on water quality and habit (sediment) changes.

Figure 2: Osprey Lake FQI Comparison 2006 vs 2015



Assessment of EWM Management on the Native Plant Community

Once again the goal of the Osprey Lake Aquatic Plant Management Plan is to protect the native lake ecosystem and native plant populations while guiding efforts to control Eurasian watermilfoil. The goal set out appears to be being achieved. Only 4 visuals of EWM were noted in the 2015 survey and none was sampled at any of the points. The native plant community also continues to be thriving as is evident by the relatively unchanged mean C value and FQI. Some species have declined but others have increased with the total number of different species unchanged. In fact overall plant density and the number of species per site has actually increased in the lake. Future EWM control efforts if conducted in a similar manner appear to be effective and are having no detrimental impacts on the native plant community.