Aquatic Macrophyte Survey: Point-intercept Method

Spooner Lake

Washburn County, Wisconsin

WBIC: 2685200

June/August 2018

Survey completed by Ecological Integrity Service, Amery Wisconsin

Abstract

In June and August 2018, a full lake point-intercept aquatic macrophyte survey was conducted on Spooner Lake, Washburn County Wisconsin. The results showed plants growing in 91% of the lake with a mean rake fullness of 1.9 (scale of 0-3). The species richness was 34 native species and 2 non-native species. A Simpson's Diversity index of 0.91 was calculated. The maximum depth with plants growing was 15.3 feet and a mean depth of plants growing was 5.3 feet. The floristic quality index (FQI) was 33.2. Two non-native invasive species, *Potamogeton crispus* and *Typha angustifolia*, were sampled. Two other non-native invasive species, *Phalaris arundinacea* and *Iris pseudacorus,* were observed in locations not part of the point intercept grid. Some areas had nuisance level filamentous algae floating on the surface during the August survey. Comparison with previous surveys in 2006 and 2012 using chi-square showed a statistically significant increase in 10 species from 2012 to 2018 and 12 species from 2006 to 2018. There was a statistically significant decrease in one species from 2012 to 2018 and in six species from 2006 to 2018.

Introduction

In June and August 2018, a full lake aquatic macrophyte survey was conducted using the point intercept (PI) method on Spooner Lake, Washburn County Wisconsin. Spooner Lake has an area of 1162 acres with a maximum depth of 17 feet and a mean depth of seven feet. It is a drainage lake with a mesotrophic trophic status.

This report presents a summary and analysis of data collected in a point intercept aquatic macrophyte survey. The primary goal of the survey is to compare this PI survey with ones conducted in 2012 and 2006 for the long-term monitoring of aquatic plant populations and allow for the evaluation of any changes that may occur long-term. These changes may be due to human activities such as management of *Potamogeton crispus* (curly-leaf pondweed), which has been occurring on Spooner Lake. In addition, invasive species presence and location monitoring is an integral part of this survey. This survey is acceptable for aquatic plant management planning.

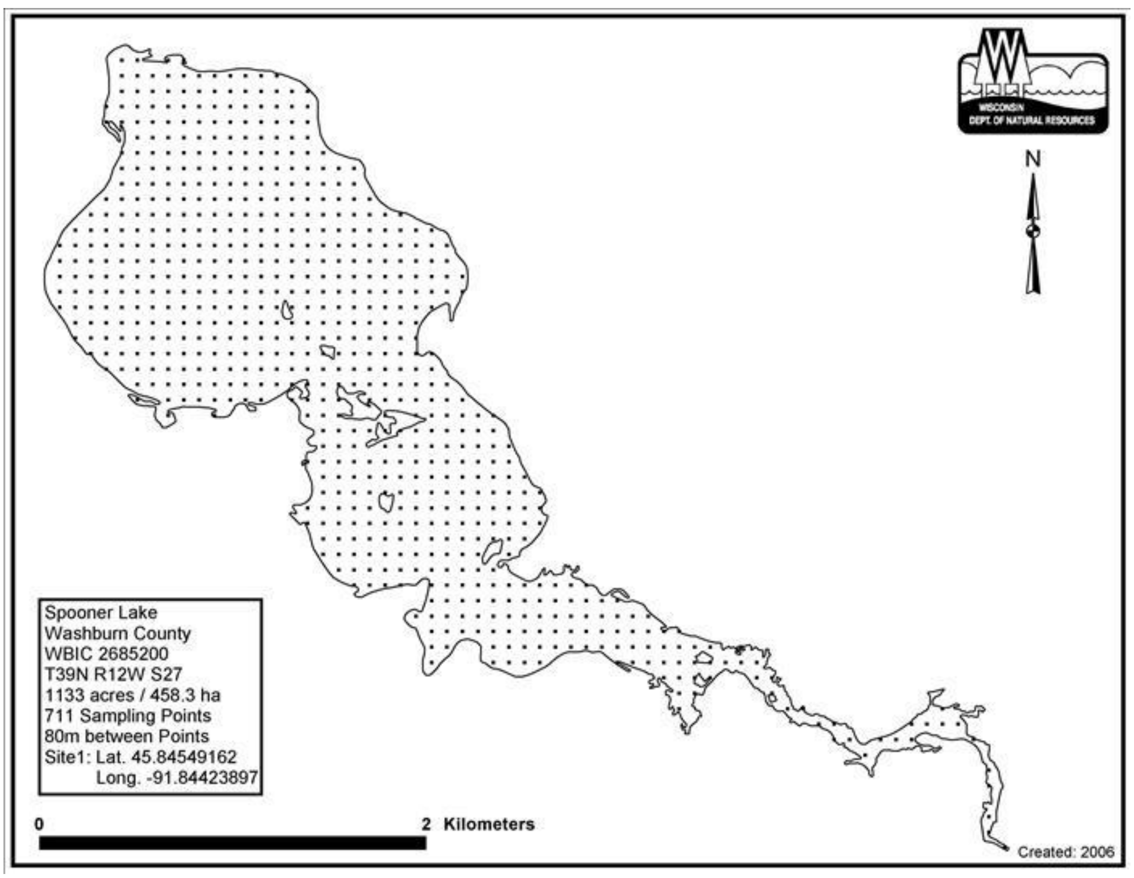

Figure 1: Point intercept grid for Spooner Lake aquatic macrophyte survey

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 the lake. All points were initially sampled for depth only. Once the maximum depth of plant growth was established, only points at that depth (or less) were sampled. If no plants were sampled, one point beyond that was sampled for plants. In areas such as bays that appear to be under-sampled, a boat or shoreline survey was conducted to record plants that may have otherwise been missed. This involved surveying that area for plants and recording the species viewed and/or sampled. The type of habitat is also recorded. These data are not used in the statistical analysis nor is the density recorded. Only plants sampled at predetermined points were used in the statistical analysis. In addition, any plant within 6 feet of the boat was recorded as "viewed." A Global Positioning System (GPS) located the sampling points in the field. The Wisconsin DNR guidelines for point location accuracy were followed with an 50-foot resolution window and the location arrow covering the point.

At each sample location, a double-sided fourteen-tine rake was used to rake a 1meter tow off the bow of the boat. All plants present on the rake and those that were seen falling off the rake were identified and rated for rake fullness. The rake fullness value was used based on the criteria contained in the diagram and table below. Those plants that were within 6 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:

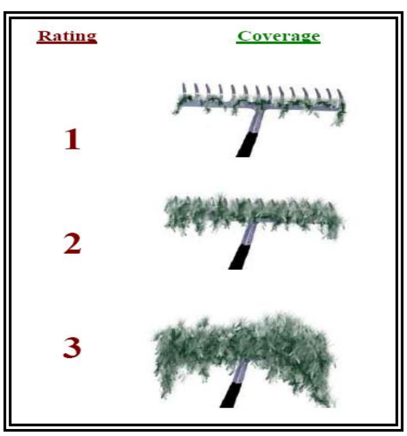

Figure 2: Rake fullness reference.

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

Table 1: Rake fullness description.

The depth and predominant sediment type were also recorded for each sample point. Caution must be used in using the sediment type since 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 crispus*-curly leaf pondweed) survey is completed to pick up any potential growth before native plants are robust. Curly leaf pondweed grows in the spring, only to senesce in early July before the main survey is typically conducted.

Data analysis methods

Data collected and analyzed resulting in the following information:

- The 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.

The 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, which calculates to two possible values. The first value is the percentage of all sample points that a particular plant was sampled at depths less than maximum depth plants (littoral zone), regardless of vegetation presence. The second is the percentage of sample points that a particular plant was sampled at only points containing vegetation. The first value shows how often the plant would be encountered in the defined littoral zone (by depth), while the second value shows how frequent the plant is only where plants grow. In either case, the greater this value, the more frequent the plant is present in the lake. When comparing frequency in the littoral zone, plant frequency is observed at maximum depth. This frequency value allows one to analyze the occurrence and location of plant growth based on depth. The 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.

<u>Relative frequency</u>-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 totals 100%. 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 compared to the other plants and thus 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 all frequencies are added (3+5+2+6), the sum is 16. The relative frequency calculated by dividing the individual frequencies by 16 in this case.

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 the plants can be compared 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 Plant D was sampled at 6 of 10 sites, many other plants were sampled too, thereby giving a lower frequency when compared to those other plants. This then gives a true measure of the dominant plants present.

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

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

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

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

Simpson's diversity example:

If a lake was sampled and observed just one plant, the Simpson's diversity would be "0" because if two plants were randomly sampled, 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 for a lake, the more likelihood two plants sampled are 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 value for the species richness of plants sampled, and another value 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 considers 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 a 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. 2007, 2012 and 2017 values from past aquatic plant surveys will also be compared in this analysis.

Summary of North Central Hardwood Forests for Floristic Quality Index:

(Nichols, 1999)

	Northern Lakes and Forests	Flowages
Median species richness	13	23.5
Median conservatism	6.7	6.2
Median Floristic Quality	24.3	28.3

*Floristic Quality has a significant correlation with area of lake (+), alkalinity(-),

conductivity(-), pH(-) and Secchi depth(+). In a positive correlation, as that value increases so will FQI, while with a negative correlation, as a value decreases, the FQI will decrease.

Results

Table 2 summarizes various data from the full lake point intercept survey on Spooner Lake. The survey results show that Spooner Lake has widespread, dense coverage of aquatic plants. The mean rake fullness was 1.9 (scale of 0-3; see methods section for reference). Within the defined littoral zone, 91.55% of the sample points had plants present.

Total number of sites visited	711
Total number of sites with vegetation	650
Total number of sites shallower than the maximum depth of plants	710
Frequency of occurrence at sites shallower than the maximum depth of plants	91.55
Simpson Diversity Index	0.91
Maximum depth of plants	15.30 ft
Mean Depth of Plants	5.30 ft
Average number of all species per site (shallower than max depth)	2.49
Average number of all species per site (vegetated sites only)	2.72
Mean rake fullness (scale 0-3)	1.9
Species Richness	36
Species Richness (including visuals)	38

Table 2: Spooner Lake point intercept data summary.

The maximum depth of plants was 15.3 feet. The mean depth of plants was 5.3 feet. This indicates moderate water clarity, allowing light penetration for growth at moderate depths.

Figure 3 shows the distribution of plants by depth. It shows that plants grow mostly in depths of 5-7 feet in Spooner Lake.

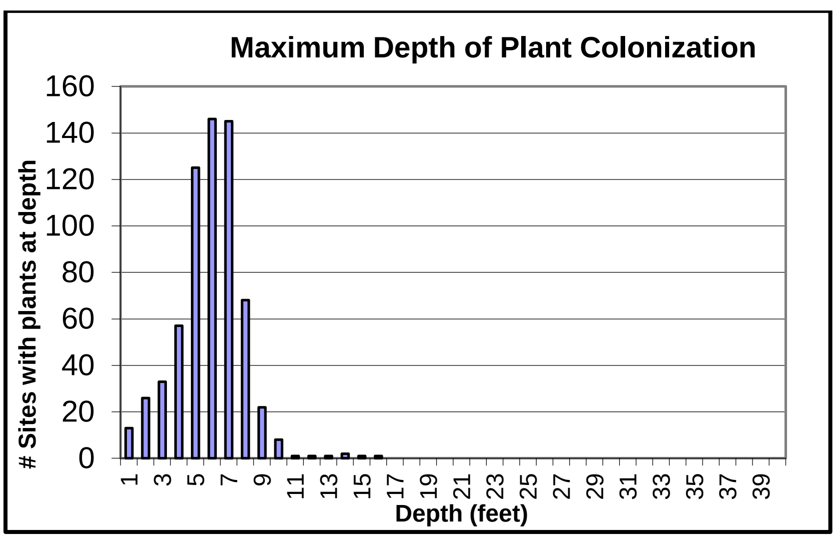

Figure 3: Graph showing depth distribution of aquatic plants sampled.

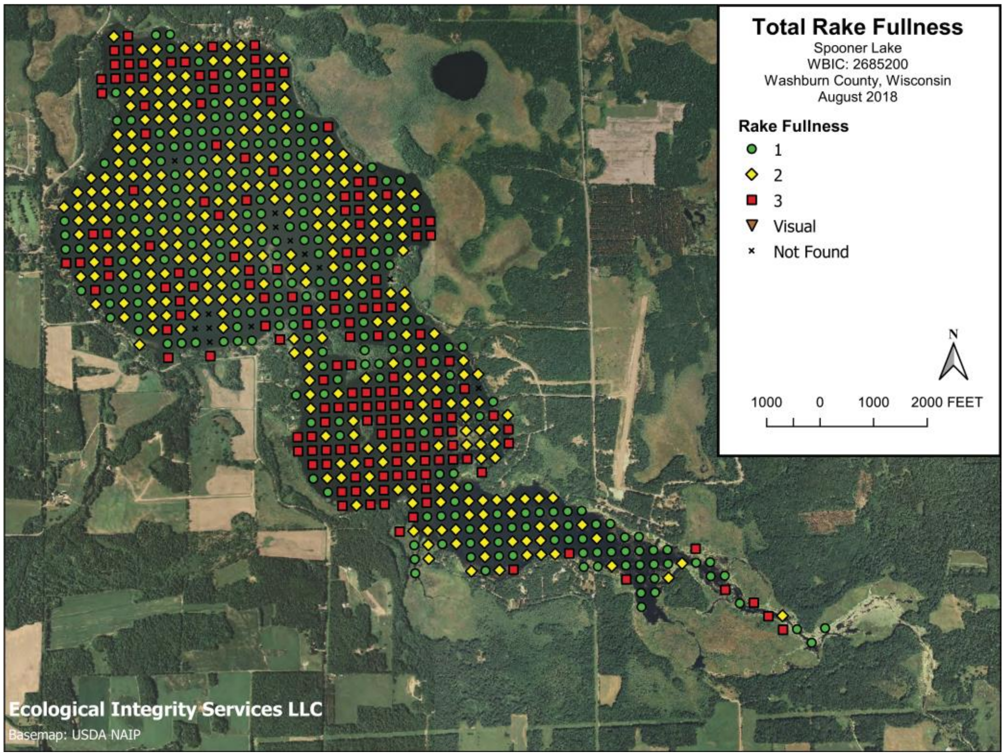

Figure 4: Map showing rake fullness at each sample point on Spooner Lake August 2018.

The diversity of plants present in Spooner Lake is moderately high, with a species richness of 36 species (34 native species and 2 non-native species). The Simpson's Diversity Index was 0.91 which is relatively high, indicating that most species sampled were different in most samples. The highest diversity sampling regions within Spooner Lake did not show any trends. High diversity areas occurred in various locations around the lake (see figure 5 for species richness map).

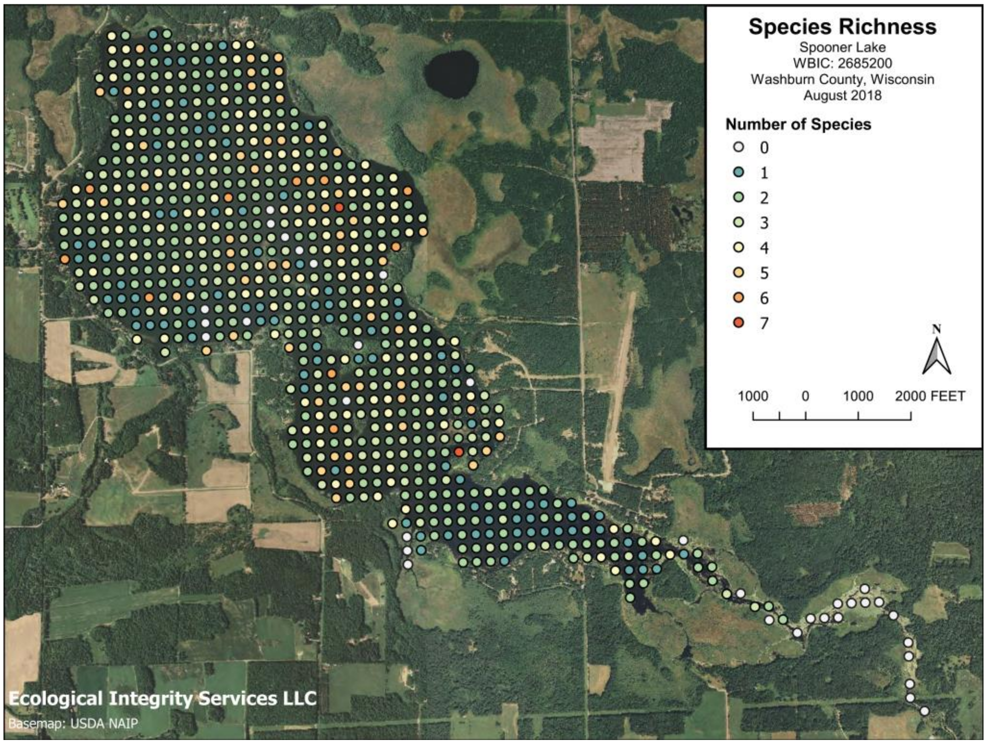

Figure 5: Map showing species richness at each sample point in Spooner Lake August 2018.

These data indicate that Spooner Lake has substantial plant growth coverage with good diversity of native plants at any location. Habitat conducive for plant growth occurs nearly everywhere in Spooner Lake.

The species frequency shows that the three most common plants have high relative frequency, showing that these three plants are dominant. There is no one plant completely dominating the plant community. Table 3 contains the frequency data for each species sampled.

Table 3: Species list with the frequency of occurrence (FOO) data as well as density (rake fullness).

Species (in order of highest frequency) August 2018 FOO="frequency of occurrence"	**FOO-Veg.**	**FOO-Littoral**	**Relative Freq.**	**# sampled**	**Mean rake fullness**
Elodea canadensis, Common waterweed	48.92	44.79	17.97	318	1.17
Potamogeton zosteriformis, Flat-stem pondweed	34.00	31.13	12.49	221	1.23
Myriophyllum sibiricum, Northern water-milfoil	33.54	30.70	12.32	218	1.20
Ceratophyllum demersum, Coontail	25.85	23.66	9.49	168	1.25
Heteranthera dubia, Water star-grass	20.62	18.87	7.57	134	1.56
Potamogeton robbinsii, Fern pondweed	19.38	17.75	7.12	126	1.16
Potamogeton praelongus, White-stem pondweed	14.31	13.10	5.25	93	1.02
Stuckenia pectinata, Sago pondweed	13.23	12.11	4.86	86	1.08
Potamogeton friesii, Fries' pondweed	13.08	11.97	4.80	85	1.05
Vallisneria americana, Wild celery	9.85	9.01	3.62	64	1.08
Najas flexilis, Slender naiad	9.54	8.73	3.50	62	1.05
Chara sp., Muskgrasses	7.38	6.76	2.71	48	1.38
Potamogeton richardsonii, Clasping-leaf pondweed	6.77	6.20	2.49	44	1.11
Potamogeton amplifolius, Large-leaf pondweed	2.62	2.39	0.96	17	1.06
Potamogeton pusillus, Small pondweed	2.62	2.39	0.96	17	1.06
Nymphaea odorata, White water lily	1.69	1.55	0.62	11	1.00
Nitella sp., Nitella	1.08	0.99	0.40	7	1.43
Sagittaria rigida, Sessile-fruited arrowhead	1.08	0.99	0.40	7	1.14
Lemna minor, Small duckweed	0.92	0.85	0.34	6	1.00
Nuphar variegata, Spatterdock	0.92	0.85	0.34	6	1.00
Pontederia cordata, Pickerelweed	0.77	0.70	0.28	5	1.20
Potamogeton crispus,Curly-leaf pondweed	0.46	0.42	0.17	3	1.00
Spirodela polyrhiza, Large duckweed	0.46	0.42	0.17	3	1.00
Wolffia columbiana, Common watermeal	0.46	0.42	0.17	3	1.00
Eleocharis acicularis, Needle spikerush	0.31	0.28	0.11	2	1.00
Eleocharis palustris, Creeping spikerush	0.31	0.28	0.11	2	1.00
Ranunculus aquatilis, White water crowfoot	0.31	0.28	0.11	2	1.00
Schoenoplectus acutus, Hardstem bulrush	0.31	0.28	0.11	2	1.00
Typha angustifolia, Narrow-leaved cattail	0.31	0.28	0.11	2	1.00
Typha latifolia, Broad-leaved cattail	0.31	0.28	0.11	2	1.00
Bidens beckii , Water marigold	0.15	0.14	0.06	1	1.00
Carex comosa, Bottle brush sedge	0.15	0.14	0.06	1	1.00
Decodon verticillatus, Swamp loosestrife	0.15	0.14	0.06	1	3.00
Isoetes echinospora, Spiny spored-quillwort	0.15	0.14	0.06	1	1.00
Potamogeton natans, Floating-leaf pondweed	0.15	0.14	0.06	1	1.00
Sagittaria sp., Arrowhead rosette	0.15	0.14	0.06	1	1.00
Freshwater sponge	0.31	0.28	n/a	2	1.00
Filamentous algae	19.38	17.75	n/a	126	1.21

Species (in order of highest frequency) August 2018 FOO="frequency of occurrence"	FOO-Veg.	FOO-Littoral	Relative Freq.	# sampled	Mean rake fullness
Sparganium eurycarpum, common bur-reed	Viewed	only			
Sagittaria latifolia, common arrowhead	Viewed	only			

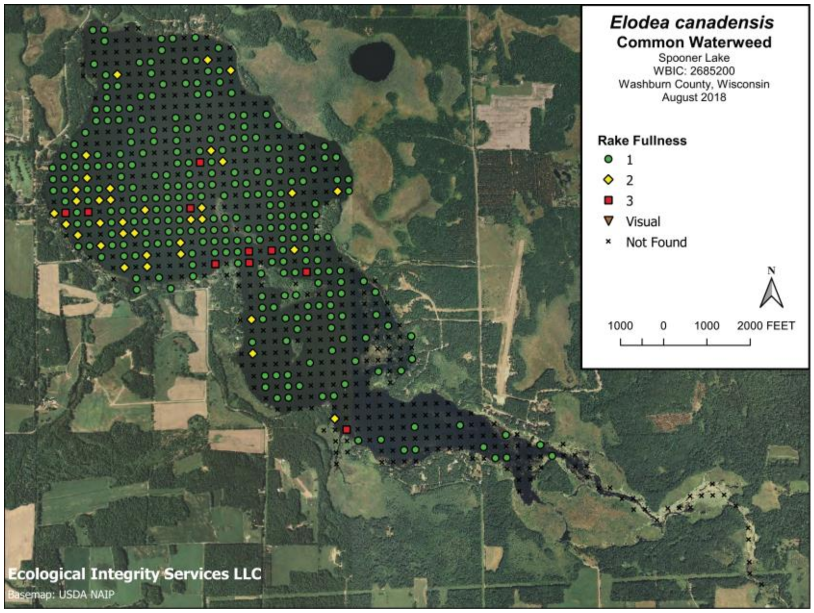

Figure 6: Distribution of most common plant sampled, Elodea Canadensis (common waterweed).

The three most common species sampled (highest relative frequency) were *Elodea Canadensis* (common waterweed), *Potamogeton zosteriformis* (flat-stem pondweed), and *Myriophyllum sibiricum* (northern watermilfoil). All three of these plants are common plants found in Wisconsin lakes and are all desirable, providing key habitat for invertebrates and fish.

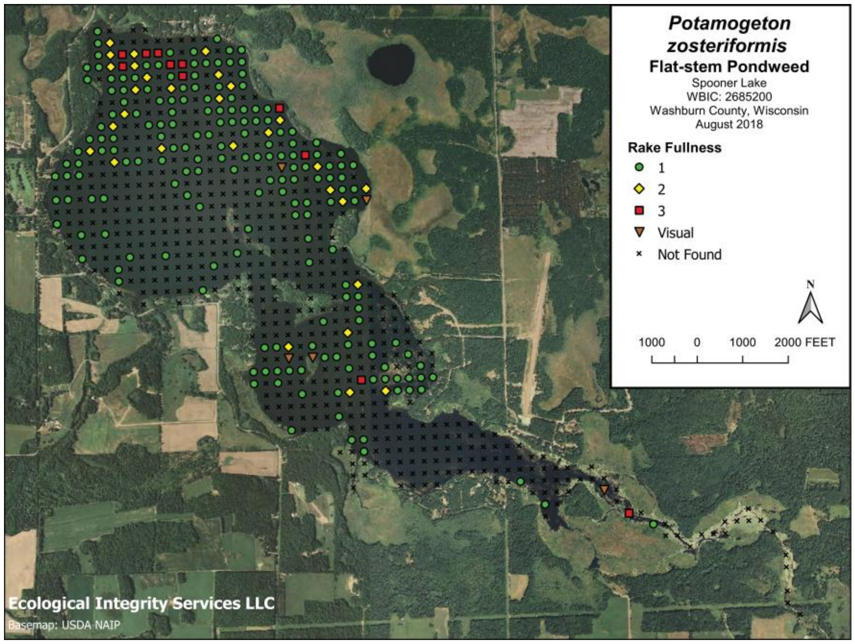

Figure 7: Distribution maps of second most common plant sampled, *Potamogeton zosteriformis* (flat- stem pondweed)

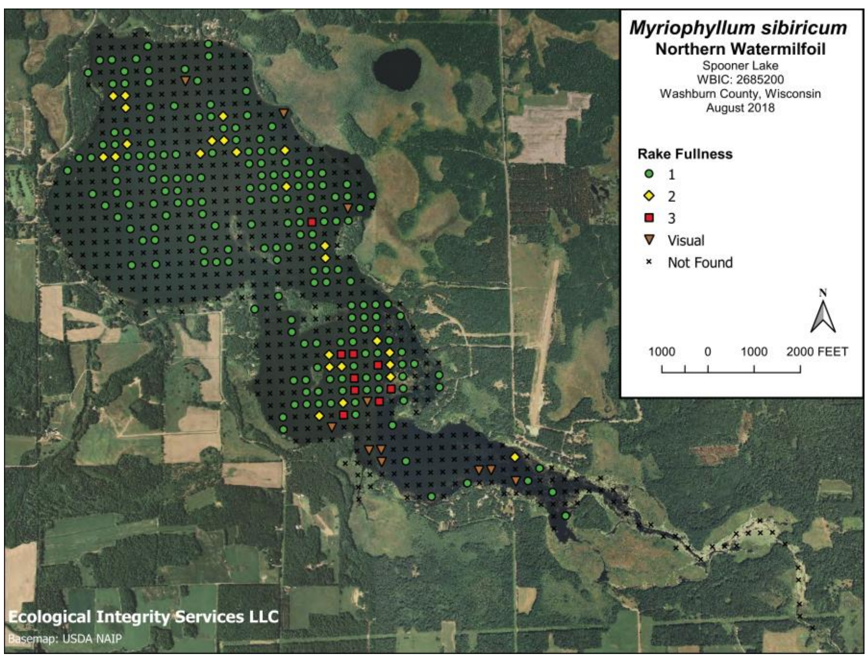

Figure 8: Distribution map of third most common plant sampled, *Myriophyllum sibiricum* (northern watermilfoil).

Species observed in boat survey
Bidens sp.
Calla palustris, Wild calla
Cicuta bulbifera, Bulb bearing water hemlock
Iris pseudacorus, Yellow iris
Phalaris arundinacea, Reed canary grass
Schoenoplectus tabernaemontani, Soft-stem bulrush

Table 4: List of plant species observed in the boat survey. These are not used in any statistical analysis.

A boat survey was conducted to view areas that were under-represented by the point grid. Table 4 summarizes species observed in the boat survey that were not sampled or viewed at the sample points. Yellow iris and reed canary grass are invasive species.

Floristic Quality Index

The floristic quality index is a calculation based upon species richness and means conservatism values assigned to various plants. The FQI can indicate the adverse effects of human activity around the lake that can lead to habitat degradation. The FQI for Spooner Lake was higher than the eco-region median for lakes within the region. The mean conservatism was lower than the eco-region median. This indicates that the plants in Spooner Lake are less sensitive on average, but due to the higher species richness the FQI is higher. The plant community appears minimally affected by human activity.

FQI Values	Spooner Lake 2018	Eco-region median
N	33	13
mean C	5.8	6.7
FQI	33.2	24.3

Table 5: Floristic quality index data from Spooner Lake August 2018.

Invasive Species

Two invasive species were sampled in Spooner Lake. These two species are *Potamogeton crispus* (curly leaf pondweed) and *Typha angustifolia* (narrow leaf cattail). Two species were observed in the boat survey. Those species are *Phalaris arundinacea* (reed canary grass) and *Iris pseudacorus* (yellow iris). Curly leaf pondweed has been sampled in the past in Spooner Lake and has been managed for several years. Narrow-leaf cattail occurs in various cattail beds around the lake. This plant is typically found in similar habitat as the native broad-leaf cattail and serve similar roles, except the narrow leaf is not native. Narrow-leaf can tend to occur in deeper water than broad-leaf cattail.

Reed canary grass is a very common invasive species. There are some scattered areas of reed canary grass occurring in mostly disturbed areas. There was no evidence of reed canary grass dominating entire wetland areas around the lake.

Yellow iris is a bright yellow flower bearing plant, often planted as an ornamental. This plant has begun to spread beyond flower gardens on many lakes. It can expand in wetland areas and therefore should be removed from the few locations it was observed. The yellow iris observed as located on the west shoreline in the southeastern portion of Spooner Lake. These locations are recorded and should be checked in June, 2019 with a removal program implemented.

Figures 9-11 show the locations of the sampled invasive species curly leaf pondweed in June and August, and narrow leaf cattail in August.

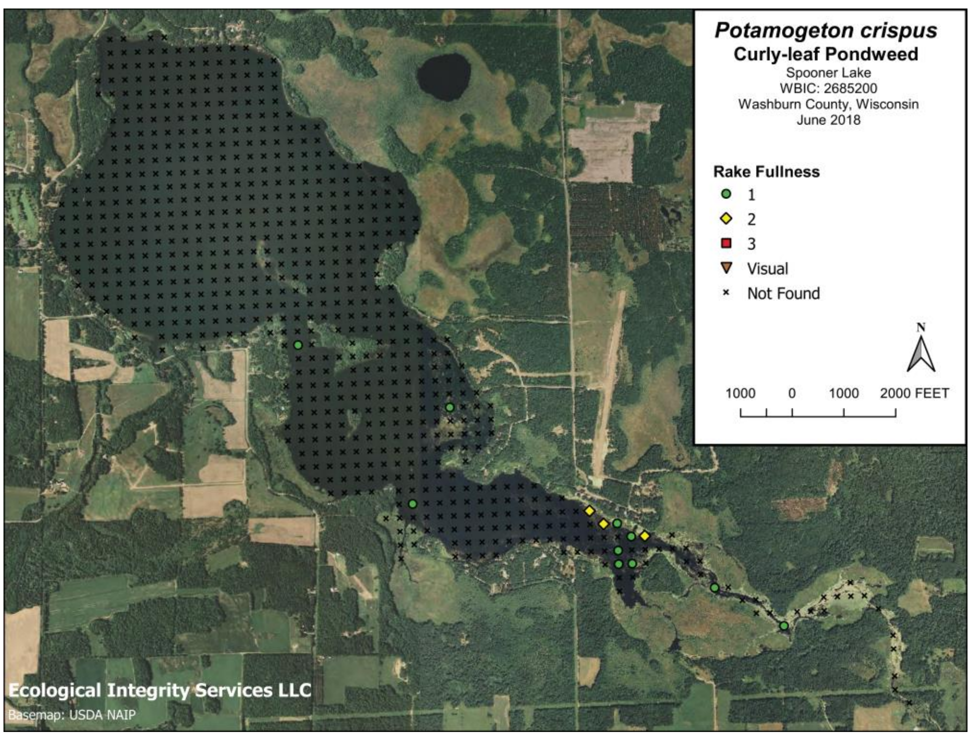

Figure 9: Distribution map of *Potamogeton crispus*-curly leaf pondweed (CLP) in June 2018. This survey was completed during the time of peak growth of CLP in area lakes.

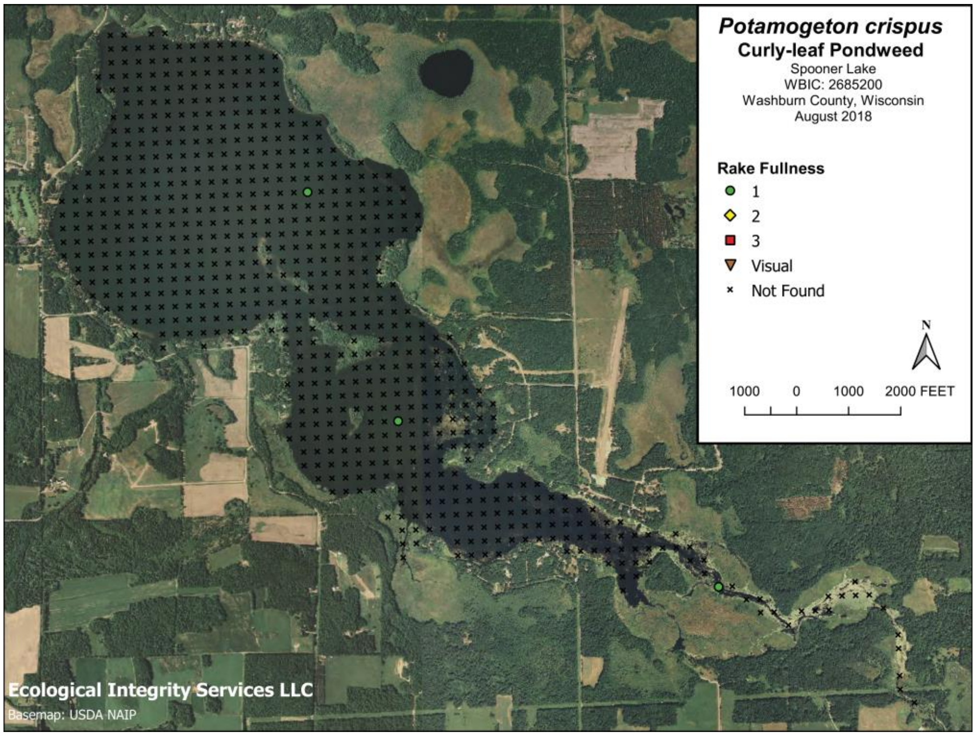

Figure 10: Distribution map of *Potamogeton crispus* (CLP) during August survey.

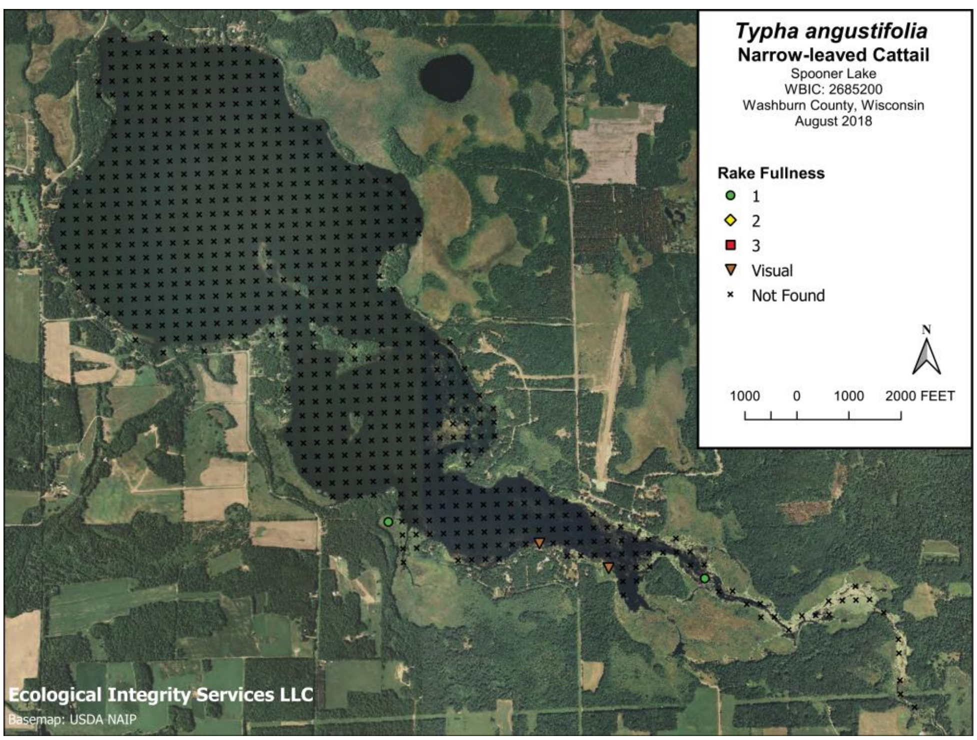

Figure 11: Distribution of *Typha angustifolia* (narrow-leaved cattail).

Filamentous algae

Filamentous algae are a class of algae that grow into long, entangled stands. These algae can blanket the bottom and aquatic plants. During certain periods, the mats of algae can build up gas and float to the surface, creating nuisance mats of algae. Spooner Lake has a history of rather extensive filamentous algae in various regions within the lake. Figure 12 shows the map of filamentous algae from the 2018 survey.

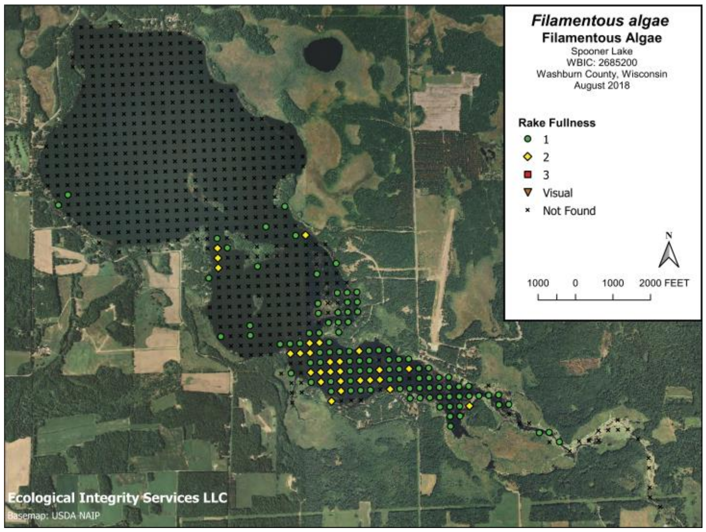

Figure 12: Distribution map for filamentous algae in Spooner Lake, 2018.

The map shows that most filamentous algae are located in the southeastern portion of Spooner Lake. During the survey, some bays in this area were inundated with floating mats of filamentous. Some residents on the lake have indicated that chemical treatment had occurred on filamentous algae, which is not known for this document. However, this could have been the cause of these dying mats of algae, or it may have naturally senesced and was floating. Regardless, it was hampering navigation immensely in these areas as well as degrading aesthetics of lake.

Sensitive plants

No endangered, threatened or species of special concern were sampled, viewed or observed in Spooner Lake. Most of the plants sampled has a conservatism value assigned to them and this is used to calculate the floristic quality index. Table 5 is a list of the plants sampled that have the highest conservatism values (>"8") as well as the frequency of occurrence (FOO) of the plant.

Species	Conservatism value	FOO
Bidens beckii	8	0.15%
Isoetes echinospora	8	0.15%
Pontederia cordata	8	0.77%
Potamogeton friesii	8	13.08%
Potamogeton praelongus	8	14.31%
Potamogeton robbinsii	8	19.38%
Ranunculus aquatilis	8	0.31%
Sagittaria rigida	8	1.08%

Table 5: List of most sensitive plants and their sampling frequency.

Comparison with previous surveys

Management practices, as well as human activities, can change the aquatic macrophyte community over time. To evaluate these changes, a chi-square analysis is conducted to compare the frequency of occurrences of plants sampled (not viewed or observed) between previous year's surveys. The baseline survey was in 2006. A subsequent survey was conducted in 2012 and now in 2018.

Parameter	2006	2012	2018
% of littoral with plants	99.56	96.72	91.55
Species richness	20	32	36
Dominant species	1. *Potamogeton zosteriformis* 2. *Myriophyllum sibiricum-* 3. *Ceratophyllum demersum*	1. *Ceratophyllum demersum* 2. *Potamogeton zosteriformis* 3. *Potamogeton robbinsii*	1. *Elodea canadensis,* 2. *Potamogeton zosteriformis* 3. *Myriophyllum sibiricum*
Simpson's diversity index	0.86	0.84	0.91
Maximum depth of plants	16.5	13.7	15.3

Table 6: Survey comparison data from 2006, 2012 and 2018 macrophyte surveys.

As table 6 shows, the changes in the plant community in regard to diversity is a positive one. 2018 showed the highest species richness and Simpson's diversity index of all the survey years. The plant coverage has decreased slightly, but there is still vast coverage of plants in nearly the entire lake. The depth of plants has varied somewhat, but there were no major changes in this regard.

There are various sources for the frequency of occurrence change. Those possible sources are as follows:

1. Management practices such as herbicide treatments can cause reductions. Typically if herbicide treatments of invasive species are utilized, a pretreatment and post-treatment analysis is conducted in those specific areas. To determine if this is a cause of a reduction in the full lake survey, the treatment areas would need to be evaluated using the point-intercept sample grid. Furthermore, if herbicide reduces the native species, it is dependent upon the type and concentration of the herbicide. A single species reduction is unlikely and more likely multiple species would be affected.

2. Sample variation can also occur. The sample grid is entered into a GPS unit. The GPS allows the surveyor to get close to the same sample point each time, but there is a possible error of 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 result in that plant not being sampled in a particular survey. Plants with low frequency could give significantly different values with surveys conducted within the same year.

3. Each year, the timing for aquatic plants coming out of dormancy can vary widely. A late or early ice-out may affect the size of plants during a survey from one year to the next. For example, a lake with a high density of a plant one year could have a very low density another year. The type of plant reproduction can affect this immensely. If the plant grows from seed or a rhizome each year, the timing can be paramount as to the frequency and density are shown in a survey.

4. Identification differences can lead to frequency changes. The small pond weeds such as *Potamogeton pusillus, Potamogeton foliosus, Potamogeton friesii,* and *Potamogeton strictifolious* can easily be mistaken for one plant or another. It may be best to look at the overall frequency of all of the small pondweeds to determine if a true reduction has occurred. All small pondweeds collected were magnified and closely scrutinized in the 2017 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 5-7 years may be unlikely. If a plant emerges as a more dominant plant over time, that plant may reduce another plant's frequency and /or density.

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

Management of curly leaf pondweed has been taking place for many years. This reason, any reduction in frequency could be due to herbicide use. There is no conclusive evidence that herbicide is the only source of any reductions. Also, there were numerous significant increases as well.

One potential concerning indication from some of the reductions is that some of the species have high frequencies with widespread distribution. Therefore, these are not likely due to sampling variation due to their historical overall distribution in Spooner Lake.

Table 7 summarizes the statistically significant increases and decreases (based upon the chi-square analysis). Special notes are added as some are small frequencies or potential identification differences.

2012-2018 significant decrease	2012-2018 significant increase	2006-2012 significant decrease	2006-2018 significant increase
1 species	**10 species**	**6 species**	**12 species**
Ceratophyllum demersum-coontail	*Elodea Canadensis*-common waterweed	*Potamogeton zosteriformis,* Flat-stem pondweed	*Elodea canadensis,* Common waterweed
	Myriophyllum sibiricum, Northern water-milfoil	*Myriophyllum sibiricum,* Northern water-milfoil	Heteranthera dubia, Water star-grass
	Heteranthera dubia, Water star-grass	*Ceratophyllum demersum,* Coontail	*Potamogeton praelongus,* White-stem pondweed
	Potamogeton praelongus, White-stem pondweed	*Potamogeton robbinsii,* Fern pondweed	*Stuckenia pectinata,* Sago pondweed
	Stuckenia pectinata, Sago pondweed	*Potamogeton friesii,* Fries' pondweed	*Najas flexilis,* Slender naiad
	Potamogeton friesii, Fries' pondweed	*Potamogeton* crispus, Curly-leaf pondweed **(AIS)**	*Chara sp.,* Muskgrasses
	Vallisneria americana, Wild celery		*Potamogeton richardsonii,* Clasping-leaf pondweed
	Chara sp., Muskgrasses		*Nymphaea odorata,* White water lily
	Potamogeton pusillus, Small pondweed		*Nitella sp.,* Nitella
	Nitella sp., Nitella		*Sagittaria rigida,* Sessile-fruited arrowhead
			Nuphar variegata, Spatterdock
			Pontederia cordata, Pickerelweed

Table 7: List of species with statistically significant increases and decreases between surveys.

As the frequency table shows, there was a statistically significant decline in one native species from 2012 to 2018. From 2006 to 2018, there was a decline in five native species and one invasive species. Some of the declines occurred within widespread, high-frequency species such as *Ceratophyllum demersum*- coontail (2006-2012 and 2012-2018) and *Potamogeton zosteriformis*- flat-stem pondweed (2006-2012) .

From 2006 to 2012 as well as 2012 to 2018, there was a statistically significant increase in 12 species and 10 species respectively. This data indicates that the plant community in Spooner is remaining healthy. The changes do not indicate adverse effects of human activities in Spooner Lake.

The floristic quality index is an indicator of human impact on the plant community. Table 8 compares the FQI data from each survey. This data indicates that the plant community is not getting adversely affected by human activities.

FQI Comparison	**2006**	**2012**	**2018**
N	19	32	33
Mean conservatism	5.7	5.4	5.8
FQI	25.0	30.8	33.2

Table 8: Floristic quality index comparison between 2018 and previous surveys.

Management Implications

The plant coverage in Spooner Lake is widespread and quite dense. These plants are likely absorbing excess nutrients and helping maintain water clarity. Excess nutrients can typically lead to macrophyte dominated or algae dominated lakes. Spooner Lake is a macrophyte-dominated lake, in addition to the quite dense growth of filamentous algae in various regions of the lake. Maintaining these plants could be important for maintaining water clarity in Spooner Lake. The filamentous algae are also absorbing excess nutrients and if not present could lead to unicellular algae that would reduce present water clarity.

The invasive species *Potamogeton crispus*-curly leaf pondweed (CLP) in Spooner Lake was much less prevalent than in years past. The CLP has declined since 2006. There was a rather large number of acres of CLP treated with herbicide in 2018. However, the CLP, although quite variable from year to year, has declined in areas of the lake not treated. This change could be affected by the density of filamentous algae growth. This may need to be considered in future management. If CLP returns, it may be worthwhile to make sure the CLP consistently grows for more than one year before being managed.

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