Aquatic Macrophyte Survey-Point Intercept Method

Connors Lake, Sawyer County Wisconsin

WBIC: 2275100

August, 2021

Survey and analysis conducted by: Ecological Integrity Service, LLC

Survey Summary

An aquatic macrophyte survey using the point intercept method was conducted on Connors Lake, Sawyer County Wisconsin in August 2021. The survey resulted in species richness of 34 and a Simpson's diversity index of 0.92. Of the 34 species, 33 are native and one is non-native and invasive (*Myriophyllum spicatum*). The plant coverage was 72.8% within the depth-defined littoral zone (very small littoral zone) and 14.4% of the entire lake (of sample point grid). The maximum depth with plants was 15.7 feet and a mean of 3.9 feet. The calculated floristic quality index (FQI) for 2021 was 38.9. A chi-square analysis resulted in statistically significant increases in two species since the 2019 survey and six species since the 2005 survey. There was a statistically significant decrease in no species since 2019 and in six species since 2005, including *Myriophyllum spicaturm*. Most of the survey parameters since 2005 have changed little.

Introduction

In August 2021, an aquatic macrophyte survey was conducted on Connors Lake (WBIC: 2275100), in Sawyer County Wisconsin using the point intercept method developed by the Wisconsin Department of Natural Resources. Connors Lake is a 410-acre lake with a maximum depth of 82 feet and a mean depth of 38 feet. The lake is designated as a drainage lake and has a mesotrophic trophic status. Development around the lakes is moderate.

This report summarizes and analyzes data collected in 2021 and compares the most recent survey in 2019 and the 2005 baseline aquatic macrophyte survey. The survey's primary goal is to conduct long-term monitoring of aquatic plant populations and evaluate any changes that may occur from human impact. Invasive species presence and locations are critical components to a survey of this type. This survey is acceptable for aquatic plant management planning purposes in Wisconsin.

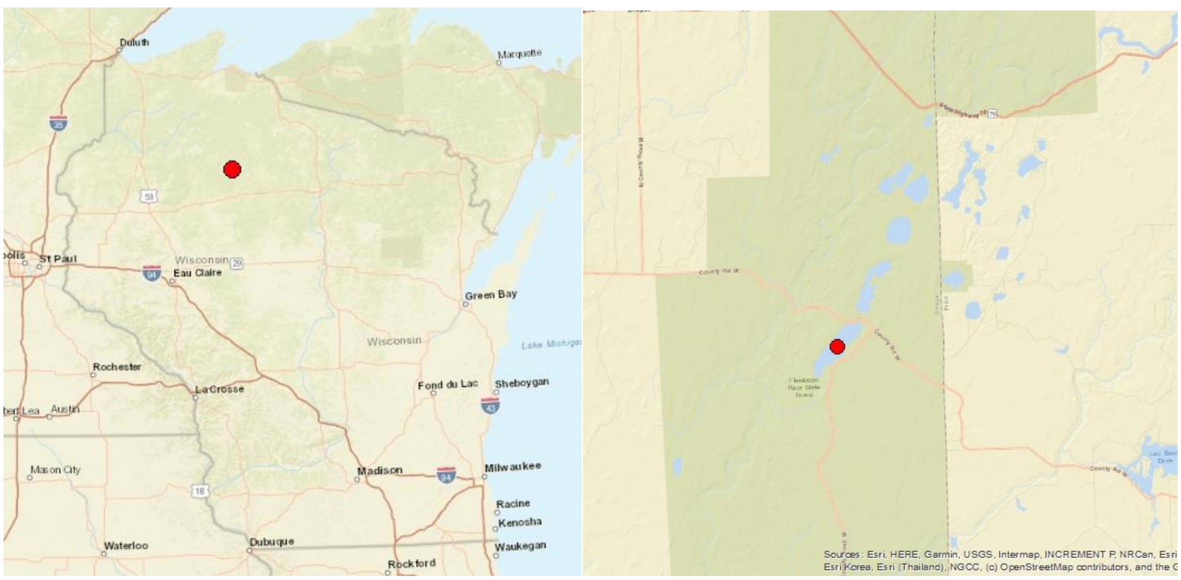


Figure 1: Map of Connors Lake located within Wisconsin and closer location.

Field Methods

A point intercept method was employed for the aquatic macrophyte sampling. The Wisconsin Department of Natural Resources (Wisconsin DNR) generated the sampling point grids for each lake. All points were initially sampled for depth only. Once the maximum depth of plant growth was established, only points at that depth (or less) were sampled. If no plants were sampled, one point beyond that was sampled. In areas such as bays that appear to be under-sampled, a boat or shoreline survey was conducted to record plants that may have otherwise been missed. The process involved surveying that area for plants and recording the species viewed 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. Any plant within 6 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 followed a 50-foot resolution window and the location arrow touching the point.

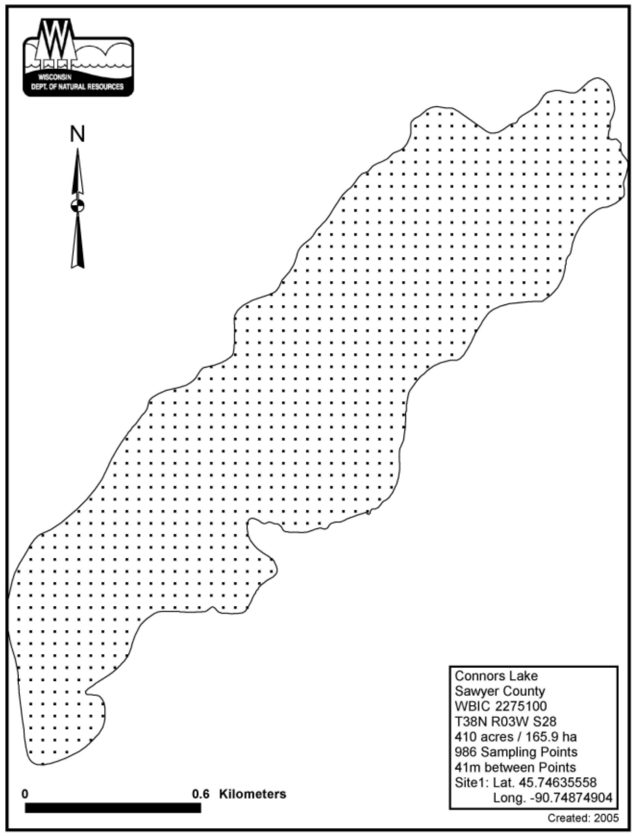


***Figure 2: Point-intercept sample grid for Connors Lake*.**[1]

A double-sided fourteen-tine rake was used at each sample location to rake a 1-meter tow off the boat's bow. All plants present on the rake and those that fell off the rake were identified and rated for rake fullness. The rake fullness value was used based on the criteria contained in figure 3 and table 1 below. The plants within 6 feet were recorded as "viewed," but no rake fullness rating was given. Any under-surveyed areas, such as bays and areas with unique habitats, were monitored. These areas are referred to as a "boat survey or shoreline survey."

[1] Sampling grid was generated by the Wisconsin Dept. of Natural Resources.

The rake density criteria used:

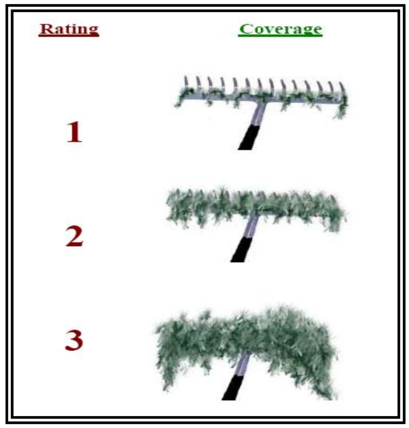


Figure 3: Rake fullness diagram

Rake fullness rating	Criteria for rake fullness rating
1	Plant present occupies less than ½ of tine space
2	Plant presence 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 criteria descriptions.

The depth and predominant sediment types were also recorded for each sample point. Caution must be used in determining the sediment type data 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.

Data analysis methods

Data collected and analyzed resulted in the following information:

- Frequency of occurrence (FOO) in sample points with vegetation (littoral zone)
- Relative frequency
- Total points in sample grid
- Total points sampled
- Sample points with vegetation
- Simpson's diversity index

- Maximum plant depth
- Species richness
- Floristic Quality Index

An explanation of each of these data is provided below.

Frequency of occurrence for each species- Frequency is expressed as a percentage by dividing the number of sites the plant is sampled by the total number of sites, which calculates to two possible values. The first value is the percentage of all sample points of a particular plant that were sampled at depths less than maximum depth plants (littoral zone), regardless of vegetation was present. The second is the percentage of sample points of a particular plant at only points containing vegetation. The first value shows how often the plant would be present in the defined littoral zone (by depth), while the second value indicates the frequency of the plant in vegetated areas. The greater this value, the more frequent the plant is present in the lake in either case. When comparing frequency in the littoral zone, plant frequency is observed at maximum depth. This frequency value is used 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%

These two frequencies will show 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 (FOO) in most cases.

Relative frequency-This value shows a percentage of 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 or made up 30% of all plants sampled. This value demonstrates which plants are the dominant species in the lake. The higher the relative frequency, the more frequent the plant is compared to the other plants.

Relative frequency example:

Suppose 10 points were sampled 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

Results show Plant D is the most frequent sampled plant at all points with 60% (6/10) of the sites having plant D. However, the relative frequency displays 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. In this case, the relative frequency calculated by dividing the individual frequencies by 16.

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%

In comparing plants, 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 shows the true value of the dominant plants present.

<u>Total points in the sample grid- The Wisconsin DNR establishes a sample point grid covering</u> the entire lake. Each GPS coordinate is mapped and used to locate the points.

<u>Sample sites less than the maximum depth of plants</u>-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 is recorded as a sample point less than the maximum depth of plants. This depth is used to determine the potential littoral zone.

Sample sites with vegetation- The number of sites where plants were sampled gives a projection of plant coverage on the lake. Vegetation in 10% of all sample points implies about 10% coverage of plants in the whole lake, assuming an adequate number of sample points have been established. The littoral zone is observed for the number of sample sites with vegetation. If 10% of the littoral zone had sample points with vegetation, then the estimated plant coverage in the littoral zone 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 index value, the more diverse the plant community. In theory, the value is the chance that two species sampled are different. An index of "1" indicates that the two will always be different (diverse), and a "0" means that the species will never be other (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 greatest depth that plants were sampled. Generally, 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 documents plants viewed but not sampled during the survey.

Floristic Quality Index- The Floristic Quality Index (FQI) was developed by Dr. Stanley Nichols of the University of Wisconsin-Extension. This index measures 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, mainly 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: $FQI = \text{Mean } C \cdot \sqrt{N}$

Where C is the conservatism value, and N is the number of species (sampled on rake only).

Therefore, a higher FQI indicates a healthier aquatic plant community, which means a better plant habitat. This value can then be compared to the median for other lakes in the assigned eco-region. Four eco-regions are used throughout Wisconsin: Northern Lakes and Forests, Northern Central Hardwood Forests, Driftless Area, and Southeastern Wisconsin Till Plain. This analysis also compares the 2013 and 2019 macrophyte surveys.

Summary of Northern Lakes and Forests for Floristic Quality Index:

(Nichols, 1999)

	Northern Lakes and Forests
Median species richness	13
Median conservatism	6.7
Median Floristic Quality	24.3

*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

The 2019 aquatic macrophyte survey on Connors Lake resulted in species richness of 34 species, 33 of which were native and one non-native, invasive species. The Simpson's diversity index was 0.90, which indicates the high diversity of plants at any given sample point. The maximum depth with plants was 15.7 feet and a mean depth with plants at 3.94 feet.

Total number of sites in entire lake	986
Total number of sites with vegetation	142
Total number of sites shallower than maximum depth of plants	195
Frequency of occurrence at sites shallower than maximum depth of plants	72.82%
Frequency of occurrence in entire lake	14.44%
Simpson Diversity Index	0.92
Maximum depth of plants	15.70 ft
Mean depth of plants	3.94 ft
Average number of all species per site (shallower than max depth)	1.81
Average number of all species per site (veg. sites only)	2.49
Average number of native species per site (shallower than max depth)	1.76
Average number of native species per site (veg. sites only)	2.45
Species Richness	34
Species Richness (including visuals)	38

Table 2: Summary of 2021 survey stats.

The coverage of plants in Connors Lake is limited. The littoral zone defined by depth contained plant growth at 72.8% of the sample points. However, the littoral zone is small in Connors Lake, resulting in plant coverage in only 14.4% of the entire lake sample point grid. Most of the plant growth in Connors Lake is limited to two bays in the lake; the northeast end and Musky Bay (east/central).

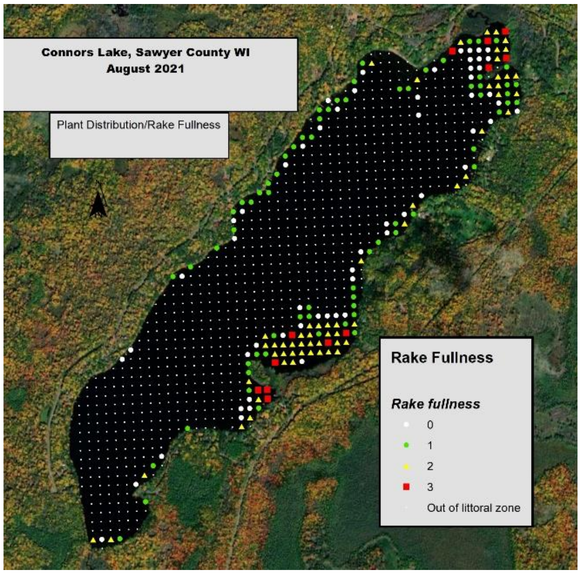


Figure 4: Rake fullness/plant distribution map of all sites with plants.

The most common plant sampled was *Potamogeton robbinsii* (fern pondweed), making up 18.08% of all the plants sampled. This was followed by *Potamogeton gramineus* (variable pondweed), *Vallisneria americana* (wild celery), and *Potamogeton amplifolius* (large-leaf pondweed) respectively. Table 3 lists all species sampled and the frequencies.

Table 3: Species list with the frequency of occurrence data and rake fullness.

Species	**FOO-vegetated**	**FOO-Littoral depth**	**Relative Freq**	**# sampled**	**Mean fullness**	**# viewed**
Potamogeton robbinsii, Fern pondweed	45.07	32.82	18.08	64	1.50	
Potamogeton gramineus, Variable pondweed	33.80	24.62	13.56	48	1.00	3
Vallisneria americana, Wild celery	20.42	14.87	8.19	29	1.03	
Potamogeton amplifolius, Large-leaf pondweed	19.01	13.85	7.63	27	1.11	8
Najas flexilis, Slender naiad	18.31	13.33	7.34	26	1.00	
Schoenoplectus acutus, Hardstem bulrush	16.90	12.31	6.78	24	1.00	1
Eleocharis palustris, Creeping spikerush	12.68	9.23	5.08	18	1.00	
Potamogeton richardsonii, Clasping-leaf pondweed	10.56	7.69	4.24	15	1.20	3
Heteranthera dubia, Water star-grass	9.86	7.18	3.95	14	1.00	
Myriophyllum sibiricum, Northern water-milfoil	9.86	7.18	3.95	14	1.00	
Ceratophyllum demersum, Coontail	7.04	5.13	2.82	10	1.00	
Myriophyllum spicatum,Eurasian water milfoil	6.34	4.62	2.54	9	1.44	1
Potamogeton zosteriformis, Flat-stem pondweed	5.63	4.10	2.26	8	1.00	1
Elodea canadensis, Common waterweed	4.23	3.08	1.69	6	1.17	
Myriophyllum tenellum, Dwarf water-milfoil	4.23	3.08	1.69	6	1.00	
Equisetum fluviatile, Water horsetail	2.11	1.54	0.85	3	1.00	
Eriocaulon aquaticum, Pipewort	2.11	1.54	0.85	3	1.00	
Lobelia dortmanna, Water lobelia	2.11	1.54	0.85	3	1.00	1
Nuphar variegata, Spatterdock	2.11	1.54	0.85	3	1.00	1
Nymphaea odorata, White water lily	2.11	1.54	0.85	3	1.00	1
Potamogeton illinoensis, Illinois pondweed	2.11	1.54	0.85	3	1.00	
Bidens beckii, Water marigold	1.41	1.03	0.56	2	1.00	
Pontederia cordata, Pickerelweed	1.41	1.03	0.56	2	1.00	1
Ranunculus flammula, Creeping spearwort	1.41	1.03	0.56	2	1.00	
Sagittaria rigida, Sessile-fruited arrowhead	1.41	1.03	0.56	2	1.00	
Sagittaria sp., Arrowhead	1.41	1.03	0.56	2	1.00	
Chara sp., Muskgrasses	0.70	0.51	0.28	1	1.00	
Potamogeton epihydrus, Ribbon-leaf pondweed	0.70	0.51	0.28	1	1.00	
Potamogeton friesii, Fries' pondweed	0.70	0.51	0.28	1	1.00	
Potamogeton pusillus, Small pondweed	0.70	0.51	0.28	1	2.00	
Potamogeton spirillus, Spiral-fruited pondweed	0.70	0.51	0.28	1	1.00	
Ranunculus aquatilis, White water crowfoot	0.70	0.51	0.28	1	1.00	
Schoenoplectus pungens, Three-square bulrush	0.70	0.51	0.28	1	1.00	
Utricularia vulgaris, Common bladderwort	0.70	0.51	0.28	1	1.00	

Species	FOO-vegetated	FOO-Littoral depth	Relative Freq	# sampled	Mean fullness	# viewed
Filamentous algae	4.93	3.59		7	1.00	
Freshwater sponge	0.70	0.51		1	1.00	
Decodon verticillatus, Swamp loosestrife						1
Isoetes echinospora, Spiny spored-quillwort						1
Juncus pelocarpus f. submersus, Brown-fruited rush						1
Sparganium eurycarpum, Common bur-reed						1

Figures 5 and 6 show the distribution of these plants. They are all common aquatic plants in Wisconsin lakes and serve important roles in the lake ecosystem. This includes providing important habitat for invertebrates and fish, providing cover for important components of the lake food web.

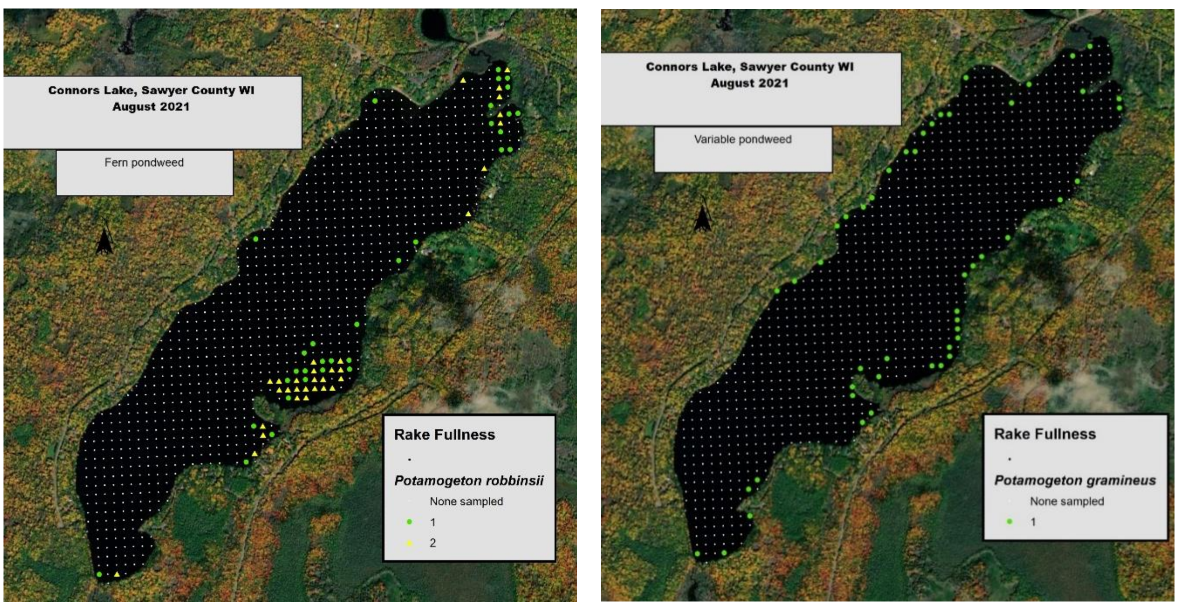
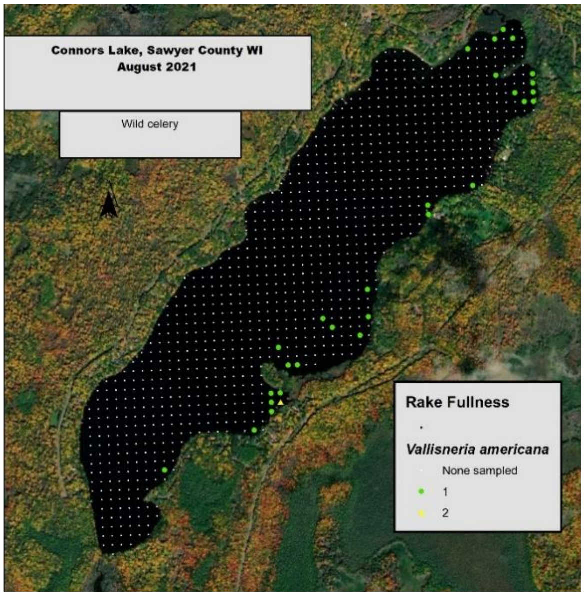


Figure 5: Distribution maps of the two most common species sampled in 2021.



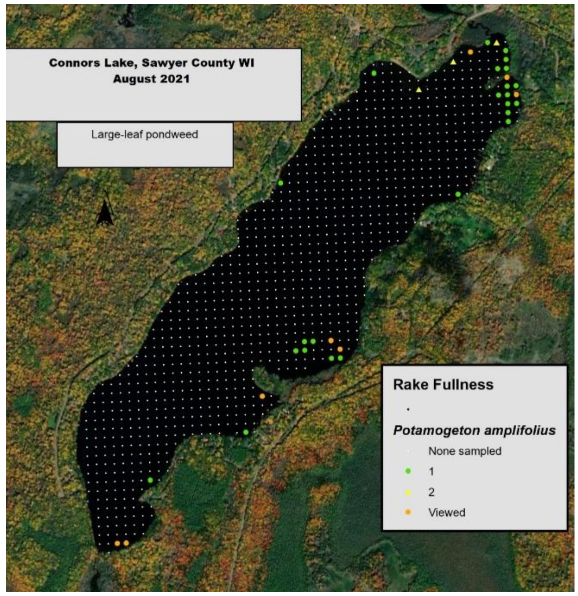


Figure 6: Distribution maps of third and fourth most common sampled plants in 2021.

Invasive species-Eurasian watermilfoil

One species of invasive species was sampled, *Myriophyllum spicatum* (Eurasian water-milfoil or EWM). This plant has been present in Connors Lake for several years. Numerous herbicide treatments have been utilized over several years to manage this invasive plant. Figure 7 is a map showing the distribution and density of EWM in Connors Lake in August 2021. EWM had a frequency of occurrence of 4.62% within the littoral zone defined by the depth of plants and 6.34% in the vegetated zone.

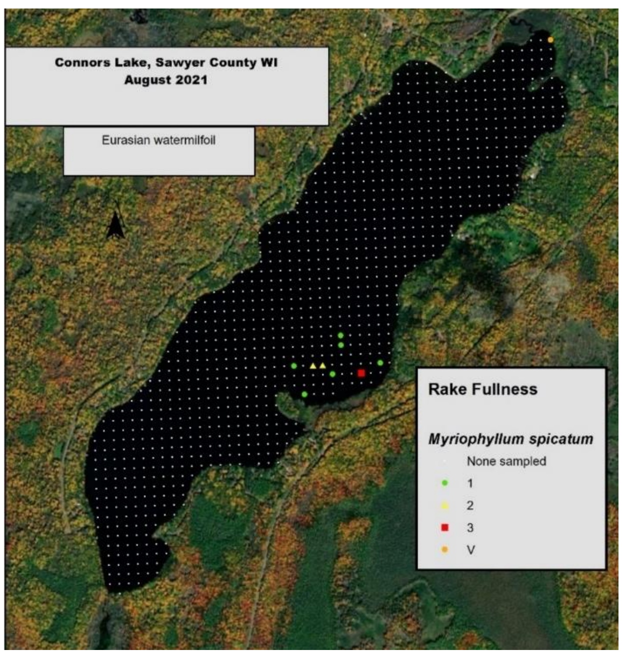


Figure 7: Distribution map of Eurasian watermilfoil (EWM).

Floristic Quality Index

The floristic quality index (FQI) gives a value that reflects the status of the plant community as it relates to degradation due to human activity. The basis is that if the lake plant habitat degrades from human activity in and around the lake, more sensitive plants (those with high conservatism values) will decrease or even disappear in the ecosystem. The desire is for a higher mean conservatism value and thus a higher FQI for the lake.

Floristic Quality Index Parameter	Connors Lake	Eco-region median
Number of species in FQI	30	13
Mean conservatism	6.9	6.7
FQI Value	38.9	24.3

Table 4: Floristic quality index information, Connors Lake 2021.

Connors Lake had a high mean conservatism value and a high FQI. The FQI was much higher than the median for the eco-region that Connors Lake is contained within. This indicates that there numerous sensitive plants and a high diversity of plants growing in Connors Lake.

Sensitive plant species

Species of native plants are assigned a coefficient of conservatism. The coefficients follow a scale of 0-10, with a 10 being the most sensitive. This coefficient measures the susceptibility of a species to disturbance, or its tendency to occur in a specific habitat type. Table 5 lists the plants that were found in Connors Lake that have a coefficient of conservatism of 9 or 10.

Sensitive species	Coefficient of conservatism	Number sampled and/or viewed
Myriophyllum tenellum-dwarf watermilfoil	10	6
Lobelia dortmanna-water lobelia	10	3
Eriocaulon aquaticum-pipewort	9	3

Table 5: List of sensitive species with a coefficient of the conservatism of 9-10.

Species of special concern are species that are becoming less common throughout their range and there is a risk of them becoming threatened. There were no species of special concern, threatened or endangered species sampled or viewed.

Comparison to previous surveys

A key rationale for conducting routine aquatic macrophyte surveys is to compare the surveys and evaluate any changes that occur in the plant community. This is especially beneficial when management practices such as herbicide treatments have been utilized. The 2021 survey results were compared to the most recent survey in 2019 and to the oldest survey provided from 2005.

Parameter	2005	2019	2021
Species richness	27	30	34
Simpson's diversity index	0.92	0.90	0.92
Native species per sample site	1.5	2.69	2.45
Maximum depth with plants	15.5	10.6	15.7
Mean conservatism value	7.4	6.6	6.9
Floristic Quality Index	35.4	35.5	38.9
% of the littoral zone with plants	71.4	92.76*	72.8

Table 6: Summary of various stats from 2005, 2019, and 2021 surveys.

As table 5 shows, the diversity of aquatic plants in Connors Lake has remained consistent. The 2019 survey had the highest species richness of the three surveys, with 2015 having the lowest species richness. Simpson's diversity index is nearly the same in all three surveys. The FQI in 2019 and 2017 were the same. In all, the changes in the plant community appear to be minimal based upon these broad parameters mentioned.

A more in-depth analysis of the data consists of conducting a chi-square analysis on the frequency of occurrence of individual species sampled in Connors Lake. The chi-square analysis determines if any changes in the frequency are statistically significant ($p<0.05$). Table 6 is a list of the species sampled in any of the three surveys compared, with the number of sample points that plant was present. Tables 8-10 summarize the species with significant increases and significant decreases. The changes are separated by comparing the 2021 survey to the 2019 survey and then the 2005 survey results.

Changes in frequency of various species-chi square analysis

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 2019 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 Eurasian watermilfoil 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.

Species	Number sampled 2005	Number sampled 2019	Number sampled 2021
Potamogeton robbinsii, Fern pondweed	4	76	64
Potamogeton gramineus, Variable pondweed	3	54	48
Vallisneria americana, Wild celery	15	41	29
Potamogeton amplifolius, Large-leaf pondweed	39	35	27
Najas flexilis, Slender naiad	35	32	26
Heteranthera dubia, Water star-grass	12	20	14
Myriophyllum sibiricum, Northern water-milfoil	22	18	14
Ceratophyllum demersum, Coontail	20	17	10
Schoenoplectus acutus, Hardstem bulrush	12	17	24
Potamogeton richardsonii, Clasping-leaf pondweed	5	11	15
Myriophyllum spicatum, Eurasian water milfoil	38	10	9
Elodea canadensis, Common waterweed	34	8	6
Chara sp., Muskgrasses	1	6	1
Potamogeton illinoensis, Illinois pondweed	13	0	3
Eleocharis palustris, Creeping spikerush	0	6	18
Potamogeton pusillus, Small pondweed	0	5	1
Nymphaea odorata, White water lily	2	4	3
Isoetes echinospora, Spiny spored-quillwort	1	3	0
Nuphar variegata, Spatterdock	3	3	3
Potamogeton praelongus, White-stem pondweed	0	3	0
Potamogeton spirillus, Spiral-fruited pondweed	2	3	1
Eleocharis acicularis, Needle spikerush	2	2	0
Eriocaulon aquaticum, Pipewort	0	2	3
Lobelia dortmanna, Water lobelia	0	2	3
Nitella sp., Nitella	19	2	0
Potamogeton obtusifolius, Blunt-leaf pondweed	3	2	0
Potamogeton zosteriformis, Flat-stem pondweed	40	2	8
Potamogeton crispus, curly-leaf pondweed	1	0	0
Sagittaria graminea, Grass-leaved arrowhead	1	0	0
Schoenoplectus pungens, Three-square bulrush	0	2	1
Bidens beckii , Water marigold	0	1	2
Pontederia cordata, Pickerelweed	0	1	2
Sparganium eurycarpum, Common bur-reed	0	1	0
Equisetum fluviatile, water horsetail	2	0	2
Ranunculus flammula, creeping spearwort	0	0	2
Myriophyllum tenellum, dwarf milfoil	2	0	6
Sagittaria sp., arrowhead	1	0	4
Ranunculus aquatilis, whitewater crowfoot	0	0	1
Potamogeton epihydrous, ribbon-leaf pondweed	0	0	1
Potamogeton friesii, Fries' pondweed	0	0	1
Utricularia vulgaris, Common bladderwort	0	0	1

Table 7: Number of each species sampled in 2005, 2019 and 2021 surveys.

Species with a statistically significant increase 2005-2021	P-value
Potamogeton robbinsii (fern pondweed)	$1.2X10^{-16}$
Potamogeton gramineus (variable pondweed)	$5.0X10^{-12}$
Eleocharis palustris (creeping spikerush)	$1.0X10^{--5}$
Potamogeton richardsonii (clasping pondweed)	0.022
Vallisneria americana (wild celery)	0.025
Schoenoplectus acutus (hard-stem bullrush)	0.036

Table 8: List of species with a statistically significant increase in frequency between the 2005 and the 2021 surveys.

Species with a statistically significant decrease 2005-2021	P-value
Myriophyllum spicatum (Eurasian watermilfoil)	$2.8X10^{-6}$
Elodea canadensis (common waterweed)	$1.4X10^{-6}$
Potamogeton zosteriformis (flat-stem pondweed)	$3.0X10^{-7}$
Nitella sp.	$1.0X10^{-5}$
Potamogeton illinoensis (Illinois pondweed)*	0.009
Certatophyllum demersum (coontail)	0.049

Table 9: List of species with a statistically significant decrease in frequency between the 2005 and the 2021 surveys.

Species with a statistically significant increase from 2019-2021	P-value
Eleocharis palustris (creeping spikerush)	0.011
Myriophyllum tenellum (dwarf watermilfoil)	0.014

Table 10: List of species with a statistically significant increase in frequency between the 2019 and the 2021 surveys.

<u>There were no statistically significant decreases from 2019-2021</u>

The reduction in EWM is good and reflects management may have been effective. However, long-term reductions in native species are not desired. The cause of these reductions is unknown. Since there was the same number of increases, much of the variation may be natural. However, future management decisions need to consider impacts on native species, through timing and targeting of AIS as precisely as possible.

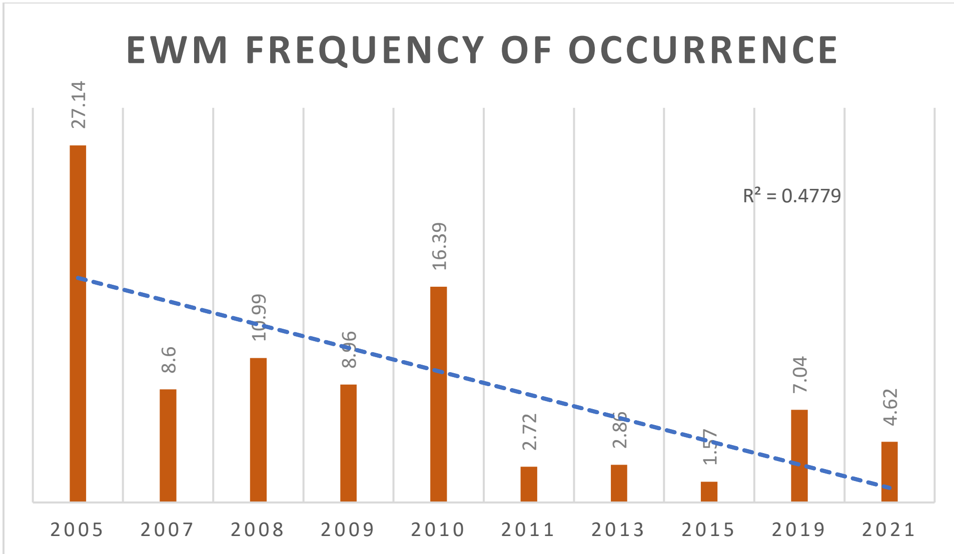


Figure 8: Graph showing the frequency of occurrence of EWM since 2005.

The EWM in 2021 is still mostly limited to Musky Bay. In years, past the EWM was scattered into other locations on the lake. The EWM frequency of occurrence has ranged from a high in 2005 (27.14%) to a low in 2015 (1.57%). A weak trend indicates a potential overall decline in frequency since 2005.

Discussion

The 2021 full lake point intercept aquatic macrophyte survey on Connors Lake revealed a healthy plant community. The species sampled included some very sensitive plants. The coverage of plants on Connors Lake is limited as the littoral zone is narrow with the depth of the lake increasing rapidly near shore in most areas. The majority of the plant growth is contained in two large bays in the lake. Due to the limited plant coverage, management decisions need to emphasize the preservation of the native plant community.

Comparisons with other plant surveys show the plant community has changed somewhat but remained quite constant for the most part. The invasive species *Myriophyllum spicatum* (EWM) remained the same in frequency from 2019 to 2021 but decreased (statistically significant) from 2005 to 2021 (overall). There were no significant decreases in one native species from 2019 to 2021, but in six native species from 2005 to 2021. However, this was coupled with significant increases in two native species since 2019 and six native species since 2005. Since management of EWM with herbicide has occurred several times, decreases are a concern. However, it has been several years since EWM with herbicide has occurred (most recent was in 2016). The data does not appear to indicate major changes resulting from herbicide use but should continue to be monitored closely, especially if herbicide is used again in the future.

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