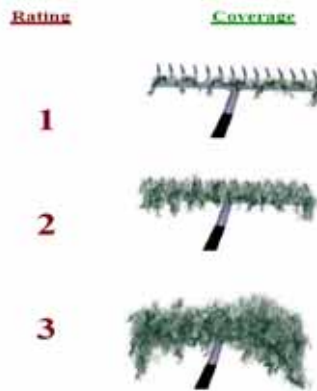


Aquatic Plant Survey Methods

Field Methods

Harmony Environmental employed a point intercept method for the macrophyte sampling. The Wisconsin Department of Natural Resources (Wisconsin DNR) generated the sampling point grid. Only points shallower than 25 feet were initially sampled until the maximum depth of plants could be established. If no plants were sampled at a specific depth, one sample point beyond that depth was sampled for plants. In areas such as bays that appear to be under-sampled, a boat survey was conducted. This involved going to the area and surveying that area for plants, 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 results from predetermined sample points were used in the statistical analysis. In addition, any plant within six feet of the boat was recorded. 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 off the bow of the boat. All plants contained on the rake and those that fell off of the rake were identified and rated as to rake fullness. The rake fullness value was used based on the criteria contained in the diagram and table below. Those plants that were within six feet were recorded as “viewed,” but no rake fullness rating was given.



Rake fullness rating	Criteria for rake fullness rating
1	Plant present, occupies less than 1/2 of tine space
2	Plant present, occupies more than 1/2 tine space
3	Plant present, occupies all or more than tine space
v	Plant not sampled but observed within 6 feet of boat

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

and pressed for a voucher collection. A voucher specimen and may be missing from the collection on rare occasions where a single plant is needed for verification.

Data Analysis Methods

Data collected was entered into a spreadsheet for analysis. The following statistics were generated from the spreadsheet:

- Frequency of occurrence in sample points with vegetation (littoral zone)
- Relative frequency
- Total 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 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, while the second value shows if only points that contain plants were considered. In either case, the greater this value, the more frequent 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 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.

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 frequently the plant was sampled in the littoral zone or how frequently the plant was sampled at points where plants actually grow. Generally the second will have a higher frequency since there are fewer points where plants grow than points in the entire littoral zone.

Relative frequency

This value shows, as a percentage, the frequency of a particular plant relative to other plants. This is not dependent on the number of points sampled. The relative frequency of all plants will add to 100%. This means that if plant A had a relative frequency of 30%, it occurred 30% of the time compared to all plants sampled or makes up 30% of all plants sampled. This value allows us to see which of the plants are the dominant species in the lake. The higher the relative frequency, the more common the plant is compared to the other plants.

Total point grid

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, we don't sample at depths outside of the littoral zone (the area where plants can grow). Once the maximum depth of plants is established, many of the points deeper than this are eliminated to save time and effort.

Relative frequency example:

Suppose we were sampling 10 points in a very small lake and got the following results:

	<u>Frequency sampled</u>
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 plant sampled at all points with 60% (6/10) of the sites having plant D. However, the relative frequency allows us to see what the frequency is compared the other plants, without taking into account the number of sites. It is calculated by dividing the number of times a plant is sampled by the total of all plants sampled. If we add all frequencies (3+5+2+6), we get a sum of 16. We can calculate the relative frequency by dividing by the individual frequency.

Plant A = $3/16 = 0.1875$ or 18.75%

Plant B = $5/16 = 0.3125$ or 31.25%

Plant C = $2/16 = 0.125$ or 12.5%

Plant D = $6/16 = 0.375$ or 37.5%

Now we can compare the plants to one another. Plant D is still the most frequent, but the relative frequency tells us that of all plants sampled at those 10 sites, 37.5% of them are Plant D. This is much lower than the frequency of occurrence (60%) because although we sampled Plant D at 6 of 10 sites, we were sampling many other plants too, thereby giving a lower frequency when compared to those other plants. This then gives a true measure of the dominant plants present.

Sample sites with vegetation

The number of sites where plants were actually sampled. This gives a good idea of the plant coverage of the lake. If 10% of all grid sample points had vegetation, it implies about a 10% coverage of plants in the whole lake, assuming an adequate number of sample points have been established. We also look at the number of sample sites with vegetation in the littoral zone. If 10% of the littoral zone had sample points with vegetation, then the plant coverage in the littoral zone would be estimated at 10%.

Simpson's diversity index

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.

Simpson's diversity example:

If one sampled a lake and found just one plant, the Simpson's diversity would be "0." This is because if we randomly sampled two plants, there would be a 0% chance of them being different, since there is only one plant.

If every plant sampled were different, then the Simpson's diversity would be "1." This is because if two plants were randomly sampled, there would be a 100% chance they would be different since every plant is different.

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

Maximum depth of plants

This depth indicates the deepest that plants were sampled. Generally more clear lakes have a greater depth of plants while lower water clarity limits light penetration and reduces the depth at which plants are found.

Species richness

The number of different individual species found in the lake. 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. A high conservatism value indicates that a plant is intolerant to disturbance 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. 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.

Therefore, 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. 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.

Summary of Northern Lakes and Forest Median Values for Floristic Quality Index:

Mean species richness = 13

Mean conservatism = 6.7

Mean 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 rises so will FQI, while with a negative correlation, as a value rises, the FQI will decrease.

Table 3. List of species used for FQI and conservatism values

Species	Common Name	C
<i>Dulichium arundinaceum</i>	Three-way sedge	9
<i>Pontederia cordata</i>	Pickerelweed	9
<i>Isoetes</i> sp.	Quillwort	8
<i>Potamogeton epihydrus</i>	Ribbon-leaf pondweed	8
<i>Potamogeton praelongis</i>	White-stem pondweed	8
<i>Potamogeton robbinsii</i>	Robbins pondweed	8
<i>Potamogeton spirillus</i>	Spiral-fruited pondweed	8
<i>Sagittaria rigida</i>	Stiff arrowhead	8
<i>Brasenia schreberi</i>	Watershield	7
<i>Chara</i> sp.	Muskgrasses	7
<i>Equisetum fluviatile</i>	Water horsetail	7
<i>Myriophyllum sibiricum</i>	Northern water-milfoil	7
<i>Nitella</i> sp.	Nitella	7
<i>Potamogeton amplifolius</i>	Large-leaf pondweed	7
<i>Potamogeton gramineus</i>	Variable pondweed	7
<i>Potamogeton pusillus</i>	Small pondweed	7
<i>Ranunculus aquatilis</i>	Stiff water crowfoot	7
<i>Najas flexilis</i>	Bushy pondweed	6
<i>Nuphar variegata</i>	Spatterdock	6
<i>Nymphaea odorata</i>	White water lily	6
<i>Potamogeton foliosus</i>	Leafy pondweed	6
<i>Potamogeton illinoensis</i>	Illinois pondweed	6
<i>Potamogeton zosteriformis</i>	Flat-stem pondweed	6
<i>Vallisneria americana</i>	Wild celery	6
<i>Zosterella dubia</i>	Water star-grass	6
<i>Carex comosa</i>	Bottle brush sedge	5
<i>Polygonum amphibium</i>	Water smartweed	5
<i>Potamogeton richardsonii</i>	Clasping-leaf pondweed	5
<i>Schoenoplectus acutus</i>	Hardstem bulrush	5
<i>Schoenoplectus tabernaemontani</i>	Softstem bulrush	4
<i>Ceratophyllum demersum</i>	Coontail	3
<i>Elodea canadensis</i>	Common waterweed	3
<i>Sagittaria latifolia</i>	Common arrowhead	3

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