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**The Aquatic Plant Community in Little Falls Lake**

**1993-2000**

**I. INTRODUCTION**

A study of the aquatic macrophytes (plants) in Little Falls Lake was conducted during August of 1993 and 2000 by Water staff in the West Central Region - Department of Natural Resources (DNR).

A study of the diversity, density, and distribution of aquatic plants is an essential component of understanding a lake due to the important ecological role of aquatic vegetation and the ability of the vegetation to characterize the water quality (Dennison et al. 1993).

 **Ecological Role:** All other life in the lake depends on the plant life (including algae) - the beginning of the food chain. Aquatic plants provide food and shelter for fish, wildlife, and the invertebrates that in turn provide food for other organisms.

 **Characterize Water Quality:** Aquatic plants serve as indicators of water quality because of their sensitivity to water quality parameters, such as water clarity and nutrient levels (Dennison et. al. 1993).

In addition, plants can improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake and impact recreation.

The present study will provide information that is important for effective management of the lake, including: fish habitat improvement, protection of sensitive wildlife areas, aquatic plant management, and water resource regulations. The added data that it provides will be compared to past and future plant inventories to track any changes occurring in the lake.

**Background:** Little Falls Lake is a 172-acre impoundment on the Willow River in St. Croix County, Wisconsin. The maximum depth of Little Falls Lake is 18 feet. As part of Willow River State Park, Little Falls Lake is an important recreational resource.

**II.METHODS**

Field Methods

The 1993 study design was based primarily on the rake-sampling method developed by Jessen and Lound (1962) and repeated in 2000. Transects (13) were place equidistant along the shoreline, 1700 ft. apart, perpendicular to the shoreline.

One sampling site was randomly located in each depth zone (0-1.5ft., 1.5-5ft., 5-10ft., and 10-20ft.) along each transect. Using a long-handled steel, thatching rake, four rake samples were taken at each sampling site. The four samples were taken from each quarter of a 6-foot diameter quadrat. The aquatic plant species that were present on each rake sample were recorded. Each species was given a density rating (0-5) based on the number of rake samples on which it was present at each sampling site. (A rating of 1 indicates that a species was present on one rake sample...a rating of 4 indicates that the species was present on all four rake samples and a rating of 5 indicates that the species was abundantly present on all rake samples at that sampling site.) The exact depth and sediment type at each sampling site was also recorded.

The type of shoreline cover was recorded at each transect. A section of shoreline, 50 feet on either side of the transect intercept with the shore and 30 feet back from the shore, was evaluated. The percentage of each cover type within this 100' x 30' rectangle was visually estimated.

Visual inspection and periodic samples were taken between transect lines in order to record additional species. Specimens of all plant species present were collected and saved in a cooler for later preparation of voucher specimens. Nomenclature was according to Gleason and Cronquist (1991).

Data Analysis

Data from each survey (1993 and 2000) were analyzed separately and compared. The percent frequency of each species was calculated (number of sampling sites at which it occurred / total number of sampling sites) (Appendix I, II). Relative frequency was calculated based on the number of occurrences of a species relative to total occurrence of all species (Appendix I, II). The mean density was calculated for each species (sum of a species' density ratings / number of sampling sites) (Appendix III, IV). Relative density was calculated based on a species density relative to total plant densities. A "mean density where present" was calculated for each species (sum of a species' density ratings / number of sampling sites at which the species occurred) (Appendix III, IV). The relative frequency and relative density was summed to obtain an importance value (Appendix V, VI). Simpson's Diversity Index was calculated (Appendix I, II).

**III. RESULTS**

 **PHYSICAL DATA**

Many physical parameters are important determinants of the type of macrophyte community that will ultimately inhabit a lake. Water quality (nutrient levels, algae levels, clarity, pH) impact the macrophyte community as the macrophyte community can in turn modify these parameters. Other physical factors, such as lake morphology, sediment composition and shoreline use, also impact the macrophyte community.

 **WATER QUALITY** - The trophic state of a lake is an indication of its water quality. Eutrophic lakes are high in nutrients and support a large biomass. Oligotrophic lakes are low in nutrients and support limited plant growth and smaller fish populations. Mesotrophic lakes have intermediate levels of nutrients and biomass. Phosphorus, chlorophyll, and water clarity data are collected and combined to determine the trophic state of a lake.

 **Nutrients**

Phosphorus is a limiting nutrient in many Wisconsin lakes. Increased inputs of phosphorus into a lake can feed algae blooms and excess plant growth.

**1993 mean summer phosphorus in Little Falls Lake was 71 ug/l.**

**2000 summer phosphorus in Little Falls Lake was 58 ug/l.**

These levels of phosphorus indicate that Little Falls Lake was a eutrophic lake in both years, although slightly decreased in 2000 (Table 1).

**Table 1. Trophic Status**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Quality Index** | **Phosphorus ug/l** | **Chlorophyll ug/l** | **Secchi Disc ft.** |
| Oligotrophic | Excellent | <1 | <1 | > 19 |
|  | Very Good | 1-10 | 1-5 | 8-19 |
| Mesotrophic | Good | 10-30 | 5-10 | 6-8 |
| Eutrophic | Fair | 30-50 | 10-15 | 5-6 |
|  | Poor | **50-150** | 15-30 | **3-4** |
| Hypereutrophic | Very Poor | >150 | **>30** | >3 |
| Little Falls Lake 1993 | Poor | 71 | 39 | 3.7 |
| Little Falls Lake 2000 | Poor | 58 | 50 | 4.6 |

After Lillie & Mason (1983)

 Shaw et. al. (1993)

Nitrogen is another important nutrient. The ratio of phosphorus to nitrogen in Little Falls Lake suggests that Little Falls Lake may be transitional between a phosphorus-limited and nitrogen-limited lake. This means that, at times, the addition of either nitrogen or phosphorus can feed excess algae growth.

 **Algae**

Algae is natural and essential in lakes, but high algal levels can increase turbidity and reduce the light available for plant growth. Measuring the amount of chlorophyll in the water gives an indication of algal levels.

**1993 mean summer chlorophyll in Little Falls Lake was 39 ug/l**.

**2000 summer chlorophyll in Little Falls Lake was 50 ug/l**.

The chlorophyll concentration in Little Falls Lake indicates that it was a hypereutrophic lake (Table 1).

 **Water Clarity**

Water clarity is a critical factor for plants. When plants receive less than 1 - 2% of the surface illumination, they can not survive. Water clarity is reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color the water. Water clarity can be measured with a Secchi disc that shows the combined effect of turbidity and color.

**1993 Mean summer Secchi Disc Clarity was 3.6 ft.**

**2000 Summer Secchi Disc Clarity was 4.5 ft.**

The water clarity in Little Falls Lake also places the lake in the eutrophic range, with poor water clarity (Table 1).

Secchi disc data can be used to calculate a predicted maximum rooting depth for plants in a lake (Dunst 1982).

**Based on the clarity, the predicted maximum rooting depth in Little Falls was 7.2 in 1993 and 8.3 ft in 2000.**

The combination of the phosphorus levels, chlorophyll levels, and clarity values indicates the trophic status of the lake. These values for Little Falls Lake indicate that it was a eutrophic lake with poor water quality. This trophic state favors abundant levels of plant and algae growth.

 **pH**

The pH of a lake indicates the acidity or alkalinity of the water.

**The 1993 and 2000 mean summer pH of the surface water in Little Falls Lake was 8.9.**

This would favor plants adapted to neutral to slightly alkaline conditions.

 **Hardness**

The hardness (mineral content) of a body of water can also determine plant growth.

The level of hardness in Little Falls Lake in 1993 and 2000 varied between 167-190 mg/lCaCO3.

Total hardness in the range of 121-180 mg/lCaCO3 indicates a hard water lake. Hard water favors plant growth.

 **LAKE MORPHOMETRY** - The morphometry of a lake is an important factor in determining the distribution of aquatic plants. Duarte and Kalff (1986) found that the slope of the littoral zone could explain 72% of the observed variability in the growth of submerged plants. Gentle slopes support more plant growth than steep slopes (Engel 1985).

Little Falls Lake has a maximum depth of 18 ft. and a mean depth of 8 feet. Most of the basin has a gradually sloped littoral zone. The gradual slope and shallow depths of Little Falls Lake should favor plant growth.

 **SEDIMENT COMPOSITION** - Silt, a soft (low density) sediment was the predominant sediment in Little Falls Lake. Silt occurred at more than half of the sample sites greater than 1.5 ft. deep in 1993 and about half the sample sites in the 5-20 ft. depth zone in 2000 (Table 2, 3).

Sediments with gravel and rock mixed with sand were the predominant sediment in the 0-1.5 ft. depth zone in 1993 and 2000. Rock and gravel were found in the west half of the lake and at the inflow of the Willow River.

Sand was predominant at the sample sites in the 1.5-5 ft. depth zone in 2000. The occurrence of sand increased from 1993 to 2000.

Sites with organic muck were also found near the inflow of the Willow River. Sand was more common along the north shore and silt was more common along the south shore.

**Table 2. 1993 Sediment Composition**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | **0-1.5 ft.** | **1.5-5 ft.** | **5-10 ft.** | **10-20 ft.** | **Overall** |
| **Hard**  | Rock |  | 15% | 33% | 43% | 20% |
| **Sediments** | Sand/Rock | 38% | 15% |  |  | 16% |
|  | Sand | 23% | 15% |  |  | 11% |
| **Mixed**  | Sand/Silt | 8% |  | 17% |  | 7% |
| **Sediments** | Silt/rock | 8% |  |  |  | 2% |
| **Soft** | Silt | 23% | 54% | 50% | 57% | 44% |
| **Sediments** | Muck |  |  |  |  |  |

**Table 3. 2000 Sediment Composition**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | **0-1.5 ft.** | **1.5-5 ft.** | **5-10 ft.** | **10-20 ft.** | **Overall** |
| **Hard**  | Sand | 12% | 38% | 20% | 33% | 29% |
| **Sediments** | Sand/rock | 33% | 8% | 1% |  | 15% |
| **Mixed Sediments** | Sand/Silt | 8% | 23% | 20% |  | 15% |
| **Soft**  | Silt | 12% | 23% | 40% | 67% | 34% |
| **Sediments** | Muck | 8% | 8% | 10% |  | 7% |

 **SHORELINE LAND USE** - There has been an increasing awareness that land use practices strongly impact the aquatic plant community and, therefore, the entire aquatic community. Practices on shore can directly impact the plant community through increased sedimentation from erosion, increased nutrient levels from fertilizer run-off and soil erosion and increased toxics from farmland, suburban and urban run-off.

Wooded cover was the most frequently encountered shoreline cover at the transects (Table 4). Native herbaceous plant growth had a high occurrence and the highest mean coverage. Shrub cover was also commonly encountered.

**Table 4. Shoreline Land Use**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Cover Type** | **Frequency of Occurrences at Transects**  | **Mean % Coverage** |
| Natural Shoreline | Wooded | 85% | 35% |
| Native Herbaceous | 77% | 44% |
| Shrub | 54% | 8% |
| DisturbedShoreline | Cultivated Lawn | 15% | 10% |
| Eroded soil | 15% | 3% |

Natural shoreline (wooded, native herbaceous, shrub) was found at 100% of the sites and covered 87% of the shoreline.

Disturbed shoreline (cultivated lawn and eroded soil) was found at 31% of the sites and covered 13% of the shoreline.

 **MACROPHYTE DATA**

 **SPECIES PRESENT**

A total of 14 species was found in Little Falls Lake. Of the 14 species, 1 was an emergent species, 3 were a floating-leaf species, and 10 were submergent species (Table 5).

No endangered or threatened species were found.

Two non-native species were found: *Potamogeton crispus* and *Myriophyllum spicatum*.

**Table 5. Little Falls Lake Aquatic Plant Species**

Scientific Name Common Name I. D. Code

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Emergent Species

1) *Iris versicolor* L. northern blue flag irive

Floating-leaf Species

2) *Lemna minor* L. small duckweed lemmi

3) *Spirodela polyrhiza* (L.) Schleiden.

 greater duckweed spipo

4) *Wolffia columbiana* Karsten. common watermeal wolco

# Submergent Species

5) *Ceratophyllum demersum* L. coontail cerde

6) *Elodea canadensis* Michx. common water-weed eloca

7) *Myriophyllum spicatum* L. Eurasain watermilfoi myrsp

8) *Najas flexilis* (Willd.) R. & S. northern water-nymph najfl

9) *Potamogeton crispus* L. curly-leaf pondweed potcr

10) *Potamogeton foliosus* Raf. leafy pondweed potfo

11) *Potamogeton nodosus* Poiret. long-leaf pondweed potno

12) *Potamogeton pectinatus* L. sago pondweed potpe

13) *Potamogeton pusillus* L. slender pondweed potpu

14) *Zosterella dubia* (Jacq.) Small water strawgrass zosdu

Not all species occurred at the sample sites in both years. In 1993, 11 species occurred at the transect sites and in 2000, 13 species occurred at the transect sites.

 **FREQUENCY OF OCCURRENCE**

The species with the highest frequency of occurrence in 1993 was *Zosterella dubia* (44%). Between 1993 and 2000, *Z. dubia* decreased in frequency and *E. canadensis* increased in frequency. In 2000, *Elodea canadensis* had the highest frequency of occurrence (54%) in Little Falls Lake (Figure 1).

**Figure 1. Frequency of macrophyte species in Little Falls Lake.**

The occurrence of filamentous algae has increased from 6.7% of the sample sites in 1993 to 43.9% of the sample sites in 2000. The filamentous algae was found in the 0-5 ft. depth zone in both sample years. In 2000, filamentous algae occurred at:

 91.7% of the sites in the 0-1.5 ft. depth zone

 53.8% of the sites in the 1.5-5 ft. depth zone.

 **DENSITY**

*Zosterella dubia* was the species with the had the highest mean density in 1993 in Little Falls Lake. *Elodea canadensis* increased in density between 1993 and 2000; in 2000, *Elodea canadensis* had the highest mean density (1.32 on a density scale of 1-4) of any species in Little Falls Lake (Figure 2).

**Figure 2. Mean density of macrophytes in Little Falls Lake, 1993**

 **and 2000**

Species with a high “mean density where present” are those species with a more aggregated, or more dense growth form. Species with an above average aggregation in Little Falls in 1993 were *Lemna minor*; in 2000 were *Potamogeton pusillus, Wolffia columbiana, Zosterella dubia*.

 **DOMINANCE**

Combining relative frequency and relative density into an importance value indicates the dominance of species within the macrophyte community (Appendix V-VI). Based on the importance values, in 1993, *Zosterella dubia* was the dominant species; *Elodea canadensis, Ceratophyllum demersum* were the sub-dominant species within the macrophyte community (Figure 3). The dominance of *E. canadensis* increased from 1993 to 2000. In 2000, *E.* canadensis was the dominant species; *Ceratophyllum demersum* and *Zosterella dubia* were dub-dominant.

**Figure 3. Dominance within the macrophyte community, of the most prevalent species in Little Falls Lake.**

The frequencies and densities of individual species varied with depth zone and year of study. *Zosterella dubia,* the dominant species in 1993, was the most frequent and dense species in the 0-5 foot depth zone in 1993 (Figure 4). The frequency of *Z. dubia* declined in 2000, especially in the 0-5 ft. depth zone (Figure 4).

**Figure 4. Frequency and density of *Zosterella dubia* by depth**

 **zone.**

*Elodea canadensis* was the species with the highest frequency and density in the 0-5 foot depth zone in 2000 (Figure 5). Its frequency and density had increased since 1993, especially in the 0-5 foot depth zone.

**Figure 5. Frequency and density of *Elodea canadensis* by depth.**

*Ceratophyllum demersum* occurred at its highest frequency and density in the 0-1.5 foot depth zone (Figure 6), but it was also the species with the highest frequency and density in the 5-10 foot depth zone during 1993. The density of *C. demersum* has remained constant from 1993 to 2000, but its frequency has decreased in the deeper part of the littoral zone (Figure 6).

**Figure 6. Frequency and density of *Ceratophyllum demersum* by**

 **depth zone.**

The frequency and density of *Najas flexilis* decreased from 1993 to 2000, especially its frequency in the 0-5 foot depth zone (Figure 7) and its density in the 0-1.5 ft. depth zone.

**Figure 7. Frequency and density of *Najas flexilis* by depth zone.**

*Elodea canadensis* was found throughout the lake; *Ceratophyllum demersum* was found in the east end of the lake; *Zosterella dubia* was found along the north shore.

 **DISTRIBUTION**

Aquatic plant growth was found throughout Little Falls Lake to a maximum depth of 6 feet in 1993 and 7.5 feet in 2000. This is less than the predicted maximum rooting depth for 1993 and 2000 (7.2 feet and 8.3 feet). *Elodea canadensis* occurred at the maximum depth in both studies.

Aquatic vegetation occurred at 71% and 66% of the sample sites in 1993 and 2000. The 0-5 ft depth zone had the highest percentage of vegetated sites (Figure 8). The decrease in vegetated sites from 1993 and 2000 occurred in the 5-10 ft. depth zone (Figure 8)

**Figure 8. Percentage of vegetated sites by depth zone in Little Falls Lake.**

The 0-1.5 ft. depth zone had the highest total occurrence of plants, highest total density of plants and greatest mean number of species per sample site (Figure 9, 10, 11). The total occurrence, total density and mean number of species decreased rapidly with increasing depth. The total occurrence, density and species per site were similar in 1993 and 2000, however, all three were slightly decreased in the 0-1.5 ft. and 5-10 ft. depth zone (Figure 8, 9, 10).

**Figure 9. Total Occurrence of aquatic plants by depth zone**

**Figure 10. Total density of aquatic plants by depth zone.**

**Figure 11. Mean number of species per site, by depth zone.**

 **SEDIMENT INFLUENCE** - Many plants depend on the sediment in which they are rooted for their nutrients. The richness or sterility of the sediment will determine the type and abundance of macrophyte species that can survive in a location.

The availability of mineral nutrients for growth is highest in sediments of intermediate density, such as silt (Barko and Smart 1986). Highly organic muck sediments are low density; sand, gravel and rock are high density sediments.

Silt was the predominant sediment found in Little Falls Lake. All types of sediments had high percentages of vegetation (Table 6). The depth zone appeared to be a more important determinant of plant growth in Little Falls Lake than sediment.

**Table 6. Sediment Influence**

|  |  |  |
| --- | --- | --- |
|  | **1993** | **2000** |
| **Percent of sites** | **Percent vegetated** | **Percent of sites** | **Percent vegetated** |
| **Hard**  | Rock | 20% | 44% |  |  |
| **Sediments** | Sand/Rock | 16% | 100% | 15% | 67% |
|  | Sand | 11% | 100% | 29% | 75% |
| **Mixed Sediments** | Sand/Silt | 7% | 33% | 15% | 100% |
| **Soft**  | Silt/rock | 2% | 100% |  |  |
| **Sediments** | Silt | 44% | 70% | 34% | 43% |
|  | Muck |  |  | 7% | 67% |

 **THE COMMUNITY**

Many indices can be used to determine changes in the plant community. A few small changes have occurred in the plant community of Little Falls Lake between 1993 and 2000 (Table 7).

The number of species at the sampling sites has increased slightly, as has the maximum rooting depth of aquatic plants.

The percent of the littoral zone that is vegetated has decreased 7%, the coverage of free-floating species decreased 16% and the coverage of submerged species decreasing 2% (Table 7).

Simpson's Diversity decreased 3.5%, from a good diversity to fair diversity. An index of 1.0 would mean that each species in the lake would be a different species (the most diversity achievable).

Floristic Quality (which will be discussed later) also decreased.

**Table 7. Changes in the Macrophyte Community in Little Falls Lake, 1993-2000.**

The Coefficients of Community Similarity is a measure of the percent similarity between two communities. Coefficients less than 75% indicate that the two communities are only 75% similar and considered to be significantly different. The coefficients for Little Falls Lake indicate that the 1993 and 2000 aquatic plant communities were not significantly different (Table 8). The two communities have a coefficient of 0.778-0.784 which indicate that they are 78% similar.

**Table 8. Coefficients of Community Similarity**

Plant communities change due to changes in individual species. *Elodea canadensis* underwent the largest increase, from

**27% frequency and 0.67 mean density in 1993 to**

**54% frequency and 1.32 mean density in 2000** (Appendix VII).

*Myriophyllum spicatum* had the largest percentage increase, quadrupling in frequency and density;

**2% frequency and 0.02 mean density in 1993 to**

**10% frequency and 0.10 mean density in 2000.**

Other than *Spirodela polyrhiza*, which was not found in 2000, *Najas flexilis* underwent the greatest decrease. *N. flexilis* decreased 81-83%, decreasing from

**27% frequency and 0.42 mean density in 1993 to**

5% frequency and 0.07 mean density in 2000.

The Aquatic Macrophyte Community Index (AMCI) developed by Weber et. al. (1995) to evaluate the quality of an aquatic plant community, was applied to Little Falls Lake (Table 9). Values between 0 and 10 are given for each of six important measures of a plant community. The highest value for this index is 60. Little Falls Lake was below the average of 40 for lakes in Wisconsin in 1993 and 2000. The quality in 2000 was slightly higher, but still below average.

**Table 9. Aquatic Macrophyte Community Index**

|  |  |  |
| --- | --- | --- |
| Category | 1993 | 2000 |
| Maximum Rooting Depth | 2 | 4 |
| % Littoral Zone Vegetated | 10 | 10 |
| Simpson's Diversity | 8 | 9 |
| # of Species | 2 | 2 |
| % Submersed Species | 6 | 6 |
| % Sensitive Species | 0 | 0 |
| Totals | 28 | 31 |

Nichols (1998) recently outlined a method for evaluating the closeness of an aquatic plant community to an undisturbed condition using Coefficients of Conservatism.

A Coefficient of Conservatism (C) is an assigned value, 0-10, based on the probability that a species will occur in a relatively undisturbed habitat. The Average Coefficient of Conservatism (ĉ)is the mean of the coefficient of conservatism for each species found in a lake.

Floristic quality (I), calculated from the coefficients, is a measure of plant community’s closeness to an undisturbed condition.

When Nichols applied this metric to a sample of 554 lakes throughout Wisconsin, the Average Coefficient of Conservatism for all Wisconsin lakes ranged from a low of 2.0 (the most disturbance tolerant), a mean of 6.0, an upper quartile of 6.9 and to a high of 9.5 (least disturbance tolerant). The lowest Floristic Quality was 3.0 (the most disturbance tolerant), the mean was 22.2, the upper quartile was 27.5 and the high was 44.6 (the least disturbed) (Table 10).

In the North Central Hardwood Forest Region (NCHF), the region in which Little Falls Lake is located, the Average Coefficient of Conservatism lower quartile limit was 5.2, the mean was 5.6 and the upper quartile was 5.8 (Table 10). The Floristic Quality lower quartile was 17, the mean was 20.9 and the upper quartile was 24.4.

Table 10. Mean Coefficient of Conservatism and Floristic Quality of Little Falls Lake, Compared to Wisconsin Lakes and Region Lakes.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | (ĉ)Average Coefficient of Conservatism | (I)Floristic Quality | (I)Based on Relative Frequency | (I)Based on Dominance Values |
| Wisconsin Lakes | 5.5, 6.0, 6.9**\*** | 16.9, 22.2, 27.5**\*** |  |  |
| NCHF | 5.2, 5.6, 5.8**\*** | 17.0, 20.9, 24.4**\*** |  |  |
| Little Falls Lake, 1993-2000 |
| 1993 | 4.09 | 13.57 | 14.03 | 13.80 |
| 2000 | 4.25 | 14.72 | 12.85 | 13.48 |

**\*** upper limit of lower quartile, mean, lower limit of upper quartile

The 1993 and 2000 Average Coefficient of Conservatism and Floristic Quality Index for Little Falls Lake was in the lowest quartile for all Wisconsin lakes and lakes in the North Central Hardwood Region (Table 10). This suggests that the plant community in Little Falls Lake is among those lakes most tolerant of disturbance, probably the result of being subjected to disturbance.

**V. DISCUSSION**

Based on 1993 and 2000 water quality data, Little Falls Lake is a eutrophic lake, with poor water clarity. The poor water clarity could limit plant growth. On the other hand, high nutrient levels, hard water, high frequency of silt sediments, a gradually-sloped littoral zone and shallow depths over much of the lake would favor plant growth.

Algae growth in Little Falls Lake is in the hypereutrophic range. The frequency of filamentous algae increased from 7% of the sites in 1993 to 44% of the sites in 2000.

Little Falls may be borderline between a phosphorus-limited and nitrogen-limited lake. This means that the addition of either nutrient can trigger algae growth.

Simpson's Diversity Index indicates that the plant community had a good diversity in 1993 that declined slightly to fair diversity in 2000. The Aquatic Plant Community Index (AMCI) indicates that the plant community in Little Falls Lake is below average for Wisconsin lakes, even with a slightly increased quality in 2000.

The Floristic Quality Index indicates the closeness of a plant community to an undisturbed condition. The Floristic Quality in Little Falls Lake is in the lowest quartile of Wisconsin lakes and lakes in the North Central Hardwoods Region. This means that Little Falls is within the group of lakes that are most disturbance tolerant, likely due to being subjected to disturbance.

*Zosterella dubia* was the dominant plant species in 1993, epecially in the 0-5 ft, depth zone.  *Elodea canadensis* (common waterweed) increased in its dominance between 1993 and 2000, becoming the dominant plant species in 2000, espcially in the 0-5 ft. depth zone. *Elodea canadensis* is adapted to low water clarity due to the placement of its chloroplasts near the leaf surface. *Z. dubia* and *Ceratophyllum demersum* were sub-dominant species in 2000.

*Myriophyllum spicatum* has also increased substantially from 1993 to 2000.

*Najas flexilis* has decreased noticeably (81-83% decrease) from 1993-2000 as has *Potamogeton cripsus* (63-77% decrease)*.*

However, the Coefficient of Community Similarity does not indicate a significant change between the 1993 and 2000 aquatic plant communities.

Most of the species in Little Falls Lake (*Ceratophyllum demersum, Elodea canadensis, Lemna minor, Potamogeton crispus, P. foliosus, P.nodosus, P pectinatus, P. pusillus, Spirodela polyrhiza, Wolfia columbiana, Zosterlla dubia*) are tolerant of lower water clarity. *Ceratophyllum demersum, Elodea canadensis, Lemna minor, Potamogeton crispus, P. pectinatus,* *Spirodela polyrhiza* and *Zosterella dubia* can grow to over-abundance when there is an excess of nutrients in the lake (Nichols and Vennie 1991).

Plant growth occurred in 71% of the littoral zone in 1993 and 66% of the littoral zone in 2000. However, the highest occurrence and density of plants and the greatest number of species per site were found in the 0-1.5 foot depth zone in both years. The highest percentage of vegetated sites was in the 0-5 ft. depth zone. Although the total occurrence and density of plant growth increased from 1993 to 2000, the percent of the littoral zone that was vegetated decreased. Much of this decrease may be due to the decreased coverage of free-floating duckweeds and the decrease in plant growth in the 5-10 ft. depth zone.

The actual maximum rooting depth (6ft. and 7.5 ft.) is less than the predicted maximum rooting depth (7.2 ft. and 8.3 ft.). This suggests that factors other than water clarity are influencing plant growth.

Species with a dense or agreggated growth form have a high density at the sites in which they grow, although their mean density throughout the lake may be low. One species had a dense growth form in 1993 and 3 species had increased to have a dense growth form in 2000.

The occurrence and mean coverage of natural shoreline (wooded, shrub and native herbaceous growth) on Little Falls Lake was high. Preserving this buffer of natural vegetation along the shore will protect the water quality of the lake from erosion and nutrient/chemical run-off that could feed algal blooms and increase sedimentation. Although natural shoreline was abundant, cultivated lawn and eroded sites were common (31% frequency) and had a mean coverage of 13%. Cultivated lawn and eroded areas can result in increased run-off of fertilizers and other nutrients and increased sedimentation if there is not an adequate buffer zone.

**VI. CONCLUSIONS**

Little Falls Lake is a eutrophic lake with poor water clarity. The occurrence of filamentous algae appears to be increasing to high levels.

The plant community in Little Falls Lake is below average for Wisconsin lakes and is characterized by fair diversity and abundant plant growth in the 0-5 ft. depth zone. The aquatic plant community in Little Falls Lake is in the quartile of the lake with the most disturbance tolerant plant communities in Wisconsin and the North Central Hardwoods Region.

In 2000, *Elodea canadensis* was the dominant species within the plant community and *Ceratophyllum demersum* and *Zosterella dubia* were sub-dominant. *Z. dubia* had been dominant in 1993 with *C. demersum* and *E. canadensis* as sub-dominants. These species and nearly all other species found in Little Falls Lake are tolerant of poor water clarity.

There has not been a significant change in the plant community in Little Falls Lake from 1993 to 2000. Besides changes in the dominant species, *Myriophyllum spicatum* has increased and *Najas flexilis* and *Potamogeton crispus* have decreased.

A healthy aquatic plant community plays a vital role within the lake community. This is due to the benefits plants provide in

1) improving water quality 2) providing valuable resources for fish and wildlife 3) resisting invasions of non-native species and 4) checking excessive growth of tolerant species that could crowd out the more sensitive species, therefore reducing the diversity.

1) Plant communities improve water quality in many ways: they trap nutrients, debris, and pollutants entering a water body; they absorb and break down some pollutants; they reduce erosion by damping wave action and stabilizing shorelines and lake bottoms; they remove nutrients that would otherwise be available for algae blooms (Engel 1985).

2) Aquatic plant communities provide important fishery and wildlife resources. Plants (including algae) start the food chain that supports many levels of wildlife, and at the same time produce oxygen needed by animals. Plants are used as food, cover and nesting/spawning sites by a variety of wildlife and fish (Table 11).

Compared to non-vegetated lake bottoms, plant beds support larger, more diverse invertebrate populations that in turn will support larger and more diverse fish and wildlife populations (Engel 1985). Additionally, mixed stands of plants support 3-8 times as many invertebrates and fish as monocultural stands (Engel 1990). Diversity in the plant community creates more microhabitats for the preferences of more species. Plant beds of

**Table 11. Wildlife Uses of Aquatic Plants in Little Falls Lake**

| **Aquatic Plants** | **Fish** | **Water****Fowl** | **Shore****Birds** | **Upland****Birds** | **Muskrat** | **Beaver** | **Deer** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Submergent Plants** |  |  |  |  |  |  |  |
|  *Ceratophyllum demersum* | F,I\*, C, S | F(Seeds\*), I, C |  |  | F |  |  |
|  *Elodea canadensis* | C, F, I | F(Foliage) I |  |  |  |  |  |
|  *Najas flexilis* | F, C | F\*(Seeds, Foliage) | F(Seeds) |  |  |  |  |
|  *Potamogeton crispus* | F, C, S | F(Seeds, Tubers) |  |  |  |  |  |
|  *Potamogeton foliosus* | F, I, S\*,C | F\*(All) |  |  | F\* | F | F |
|  *Potamogeton nodosus* | F, I, S\*,C | F\*(Seeds) |  |  | F\* | F | F |
|  *Potamogeton pectinatus* | F, I, S\*,C | F\* |  |  | F\* | F | F |
|  *Potamogeton pusillus* | F, I, S\*,C | F\*(All) |  |  | F\* | F | F |
|  *Zosterella dubia* | F, C, S | F(Seeds) |  |  |  |  |  |
|  |  |  |  |  |  |  |  |
| Floating-leaf Plants |  |  |  |  |  |  |  |
|  *Lemna minor* | F | F\*, I | F | F | F | F |  |
|  *Spirodela polyrhiza* | F | F |  | F |  |  |  |
|  *Wolffia columbiana* |  | F |  |  | F |  |  |
|  |  |  |  |  |  |  |  |
| **Emergent Plants** |  |  |  |  |  |  |  |
|  *Iris versicolor* |  | F, C | F |  | F |  |  |

**F=Food, I= Shelters Invertbrates, a valuble food source C=Cover, S=Spawning**

**\*=Valuable Resource in this category**

 \*Current knowledge as to plant use. Other plants may have uses that have not been determined.

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moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel 1990).

Cover within the littoral zone should be about 25-85% to support a healthy fishery. The plant growth in Little Falls Lake in 2000 provided 66% cover within the littoral zone

**Management**

Protecting and improving the water quality in Little Falls Lake will require efforts on the lake and in the watershed.

1) Preserving the natural buffer zones of native vegetation around the lake will be beneficial to the water quality and wildlife habitat.

2) Managing nutrient inputs from watershed sources by:

1. reducing nutrient run-off from lawn and agricultural fertilizer applications
2. reducing erosion in the watershed and around the lake

3) Protecting wetlands in the watershed.

Little Falls Lake's location in a State Park and proximity to urban areas make it an important resource that deserves protection. These practices will protect the water quality and wildlife habitat in the lake.

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**Appendix VIII. Little Falls Lake Data - August 31, 1993**

**Species Found at Transects and Density Ratings**

(Density rating range: 1=sparse; 5=abundant)

| **Transect** | **Species Density Depth: 0-1.5'** | **Species Density Depth: 1.5-5'** | **Species Density Depth: 5-10'** | **Species Dens.** **Depth:10-20'** |
| --- | --- | --- | --- | --- |
| 1 | **1' sand/gravel**zosdu1 | **4' sand**zosdu2 | **7' sand/silt**no vegetation | **12’ silt**no vegetation |
| 2 | **1' sand/rock**najfl4 potpe1 zosdu2 | **4' sand**najfl1 zosdu1 | **7.5' sand/silt**no vegetation | **11’ silt**no vegetation |
| 3 | **1' sand**cerde2 najfl3 potno1  | **4' silt**eloca1 zosdu1 | **7' silt**cerde1 | No depth > 10’ |
| 4 | **1' sand**cerde3 eloca3 lemmi4 spipo1 (fa) | **4' silt**eloca3 lemmi3 potcr4 potpe1 spipo1 (fa) | No depth > 5’ | No depth > 5’ |
| 5 | **1' silt**cerde1 eloca4 lemmi3 potcr3 potno3 spipo1 zosdu1 (fa) | **4' silt**cerde1 eloca3 potpe2  | **5.5’ silt**cerde1 eloca1 potcr1 | No depth > 10’ |
| 6 | **1' silt/gravel**cerde2 eloca4 lemmi3 potcr2 spipo1 zosdu1 | **3.5' silt**cerde3 eloca4 potcr3  | **6' silt** eloca1 | No depth > 10’ |
| 7 | **1' sand/silt**cerde3 eloca4 lemmi1 najfl1 potcr1 potpe1 potpu2 spipo1 zosdu1  | **3' silt**eloca1 najfl1 | **6' silt**no vegetation | No depth > 10’ |
| 8 | **1' silt**no vegetation | **3' silt**cerde1 eloca1  | **8' silt**cerde1 | No depth > 10’ |
| 9 | **1’ sand**cerde1 najfl1 zosdu3 | **3' sand/gravel**najfl1 zosdu2 | **7' gravel**no vegetation | **11.5' silt**no vegetation |
| 10 | **1' sand/gravel**najfl2 zosdu1 | **4' sand/gravel**potpe1 zosdu1 | **8' gravel**zosdu1 | **11' gravel**no vegetation |
| 11 | **1’ silt/gravel**cerde2 najfl1 zosdu1 | **3' gravel**no vegetation | **6.5' gravel**cerde1 | **11' gravel**no vegetation |
| 12 | **1' sand/rock**myrsp1 zosdu1 | **3' gravel**najfl1 zosdu2 | **6' gravel**cerde1 zosdu1 | **11' gravel**no vegetation |
| 13 | **1’ silt**najfl2 potpe1 zosdu4 | **3' silt**najfl1 zosdu4 | **6’ silt**cerde1 zodu1 | **11’ silt**no vegetation |

fa = filamentous algae

**Appendix IX. Little Falls Lake Data August 15, 2000**

**Species Found at Transects and Density Ratings**

(Density rating range: 1=sparse; 5=abundant)

| **Transect** | **Species Density Depth: 0-1.5'** | **Species Density Depth: 1.5-5'** | **Species Density Depth: 5-10'** | **Species Dens.** **Depth:10-20'** |
| --- | --- | --- | --- | --- |
| 1 | **1' sand/rock**eloca1 lemmi2 (fa) | **4' sand/silt**eloca1 | **6.5' silt**no vegetation | **14’ silt**no vegetation |
| 2 | **0.5' sand/silt**cerde2 eloca1 potno3 (fa) | **4.5' sand/silt**cerde2 eloca1 (fa) | **7.5' sand/silt**cerde1 | No depth > 10’ |
| 3 | **0.5' sand**cerde3 eloca3 lemmi1 zosdu5 (fa) | **4.5' sand/silt**cerde1 eloca4 zosdu5 (fa) | **6.5' silt**no vegetation | No depth > 10’ |
| 4 | **1' silt**eloca3 potpu2 (fa) | **2' silt**eloca3 (fa) | No depth > 5’ | No depth > 5’ |
| 5 | **0.5' silt**eloca4 potcr2 potpu4 (fa) | **2' silt**eloca4 lemmi1 potpe1 (fa) | No depth > 5’ | No depth > 5’ |
| 6 | **1' muck**cerde4 eloca4 lemmi5 wolco4 (fa) | **1.75' muck**cerde1 eloca4 potcr1 potpe1 (fa) | No depth > 5’ | No depth > 5’ |
| 7 | **1' silt**cerde4 eloca5 lemmi2 myrsp1 potfo1 (fa) | **3' silt**cerde3 eloca4 (fa) | **6' silt/muck**no vegetation | No depth > 10’ |
| 8 | **1' sand**eloca1 zosdu1 (fa) | **4' sand**cerde1 eloca3 myrsp1 zosdu3 | **7' silt**no vegetation | No depth > 10’ |
| 9 | **1.5’ sand/gravel**zosdu1 | **3.5' sand/rock**myrsp1 zosdu3 (fa) | **6' sand/rock**no vegetation | **10' sand**no vegetation |
| 10 | **1' sand/gravel**eloca1 irive2 potpe4 zosdu2 (fa) | **4' sand**zosdu4 | **9.5' sand**no vegetation | **13' silt**no vegetation |
| 11 | **1’ sand**cerde1 eloca2 potno1 potpe1 zosdu3 (fa) | **2.5' sand**eloca1 myrsp1 najfl1 potno3 potpe1 zosdu3 | **8' sand**zosdu1 | **15' sand**no vegetation |
| 12 | **1' sand/rock**no vegetation (fa) | **3.5' sand**eloca1 najfl2 | **7.5' sand/silt**eloca1 | **16' silt**no vegetation |
| 13 | No depth < 1.5’ | **3' sand**eloca2 | **8’ silt**no vegetation | **12.5’ silt**no vegetation |

fa = filamentous algae