
# THE AQUATIC PLANT COMMUNITY OF PEPPERMILL LAKE, ADAMS COUNTY, WISCONSIN 2001-2021

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## I. INTRODUCTION

A study of the aquatic macrophytes (plants) in Peppermill Lake was conducted during the summer of 2021 by Reesa Evans, Certified Lake Manager, and Bill Pegler of the Peppermill Lake District. The survey used the Point Intercept Method currently required by the Wisconsin Department of Natural Resources. Six prior aquatic plant surveys have been done on this lake since 2001.

A study of the diversity, density, and distribution of aquatic plants is an essential component of understanding a lake ecosystem due to the important ecological role of aquatic vegetation in the lake 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 - the beginning of the food chain. Aquatic plants and algae provide food and oxygen for fish, wildlife, and the invertebrates that in turn provide food for other organisms. Plants provide habitat, improve water quality, protect shorelines and lake bottoms, add to the aesthetic quality of the lake and impact recreation.

**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).

The present study will provide ongoing information that is important for effective management of the lake, including fish habitat improvement, protection of sensitive habitat, aquatic plant management and water quality protection. It will also allow tracking of any significant changes in the aquatic plant community that may indicate changes in the lake's overall health, as well as permit evaluation of the management strategies set out in the approved lake management plan.

**Background and History:** Peppermill Lake is located in the Town of Jackson in Adams County. The impoundment is 65 surface acres in size. Maximum depth is 14 feet, with an average depth of about 5 feet. During the summer of 2016 when this aquatic plant survey was conducted, the lake was at slightly higher level than usual due to frequent rains in the spring and summer. There is a boat launch open to the public owned by the Town of Jackson. By the boat ramp is the Peppermill Dam, owned and managed by the Adams County Land & Water Conservatism Department. The Peppermill Lake District completed a lake management plan that was approved by the Wisconsin Department of Natural Resources. This plan is reviewed annually for needed updates.

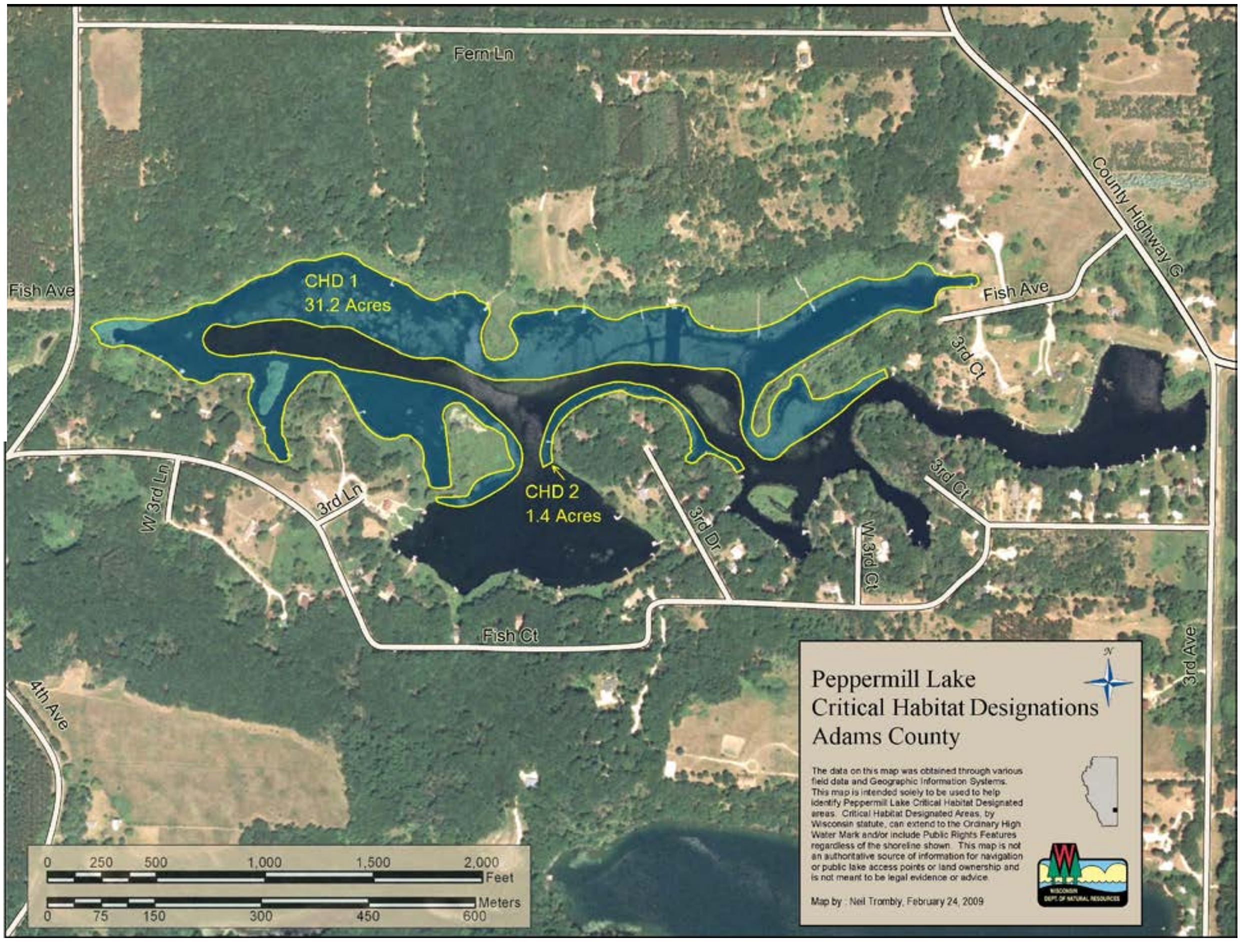
Residential development around the lake is found along most of the lakeshore, except the northwest end, which is in conservancy. There are no known endangered or threatened aquatic or terrestrial resources in or directly around the lake. There are no identified archeological or historical sites in either the surface or ground watersheds. Although much of the shore is inhabited, most of the buildings around Peppermill Lake are back from the shore, leaving landward near-shore areas usually covered with native vegetation.

Historically, efforts at controlling aquatic plant growth have included both chemical treatments and mechanical harvesting. Chemical treatment records go back to 1999. However, no chemical treatment has been done in Peppermill Lake for at least five years, as the population of Eurasian Watermilfoil diminished after several years of regular chemical treatment. The lake is evaluated regularly for any re-establishment of Eurasian Watermilfoil, but it has remained generally sparse. Another invasive aquatic plant, Reed Canarygrass (*Phalaris arundinacea),* has been found in Peppermill Lake, but has remained in low frequency occurrence. There has been a visual report of Curly-Leaf Pondweed (*Potamogeton crispus),* but none was observed during the 2021 survey.

Mechanical harvesting is done one to three times per summer, depending on aquatic plant growth, and is confined to making sure that navigational channels are open throughout the lake. This keeps *Chara* mounds and water lilies from blocking navigation through the lake. The most recent mechanical harvesting in the lake was done just before the 2021 aquatic plant survey.

Two areas in Peppermill Lake have been designated as "critical habitat." Area CH1 extends along approximately 7000 feet of the shoreline of about 2/3 of the northern shore of the lake and the southwest shore of the lake. Area CH2 runs along about 800 feet of shore along the middle south part of the lake. Much of the shore is wooded. The details of these areas have been discussed fully in other reports, so will not be repeated here.

## Figure 1: Critical Habitat Map for Peppermill Lake




## Figure 2: Fish & Wildlife Uses of Aquatic Plants

| | Fish | Water Fowl | Shore Birds | Upland Birds | Muskrat | Beaver | Deer |
|---|---|---|---|---|---|---|---|
| *Carex spp* | | F | F,I | - | | | |
| *Chara* | F,S | F,I,C | | | | | |
| *Lemna minor* | F,I,C,S | F | F | | F | F | |
| *Myriophyllum spp* | F,I,C,S | F,I | F | | F | | |
| *Najas spp* | F,C,I | F | F | F | F | | |
| *Nuphar variegataa* | F,I,C,S | F | F | | F | F | F |
| *Nymphaea odoratoa* | F,I,C,S | F | F | | F | F | |
| *Potamogeton spp* | F,I,C.S | F,I | F | | F | F | F |
| *Spirodela polyrhiza* | F,I,C,S | F | F | | F | F | |

F = Food; I = Shelters Invertebrates; C = Cover; S = Spawning; N = Nesting

# II. METHODS

## Field Methods

The 2021 survey used the Point Intercept Method. This method involves calculating the surface area of a lake and dividing it (using a formula developed by the WDNR) into a grid of several points, always placed at the same interval from the next one(s). These points are related to a particular latitude and longitude reading. At each geographic point, the depth is noted, and one rake is taken, with a score given between 1 and 3 to each species on the rake.

A rating of 1 = a small amount present on the rake;
A rating of 2 = moderate amount present on the rake;
A rating of 3 = large amount present on the rake.

A visual inspection was done between points to record the presence of any species that didn't occur at the raking sites. Gleason and Cronquist (1991) nomenclature was used in recording plants found. Some near shore sites were added to the original grid to be sure shallow water vegetation was adequately evaluated.

## Data Analysis

The percent frequency of each species was calculated (number of sampling sites at which it occurred/total number of sampling sites). Relative frequency was calculated (number of occurrences of a species/sum of all species occurrences). The mean density was calculated for each species (sum of a species' density ratings/number of sampling sites). Relative density was calculated (sum of a species density/sum of all plant densities). The relative frequency and relative density of each species were summed to obtain a dominance value for each species. Species diversity was measured by Simpson's Diversity Index.

The Aquatic Macrophyte Community Index (AMCI) developed by Nichols (Nichols et al., 2000) was applied to Peppermill Lake results. Measures for each of seven categories that characterize a plant community are converted to values between 0 and 10 and summed to measure the quality of the plant community.

The Average Coefficient of Conservatism and Floristic Quality Index were calculated, as outlined by Nichols (1998), to measure disturbance in the plant community. A coefficient of conservatism is an assigned value, 0-10, the probability that a species will occur in an undisturbed habitat. The Average Coefficient of Conservatism is the mean of the coefficients for all species found in the lake. The Floristic Quality Index is calculated from the Coefficient of Conservatism (Nichols, 1998) and is a measure of a plant community's closeness to an undisturbed condition.

The conditions of the 2021 survey were not optimum. The survey was conducted during the first week of September with the permission of the WDNR. Optimum survey time would have been earlier in the growing season; however, the COVID pandemic prevented that timing. Some of the plants on the survey rake were already starting to senesce towards winter conditions; it is possible that some of the more sensitive plants previously found—for example, some of the Utricularia species and *Potamogeton pusillus* may have already died off. Third, mechanical harvesting had been done earlier in the week of the survey, resulting in a number of “floaters” that were not found in their original site.

Peppermill Lake has a long history of varied and lush emergent plant population. The 2021 survey was initially going to be conducted on a small pontoon that would allow the near-shore plants to be evaluated; however, after three points, the motor on that boat gave out, so a larger boat had to be used. The size of this boat did not allow a specific evaluation of the emergent plants at the shallow sites. Most of the emergent plants thus could only be evaluated visually from a distance that didn't allow examination of flowers or fruits.

## III. RESULTS

### <u>PHYSICAL DATA</u>

Many physical parameters impact the aquatic plant community. Water quality (nutrients, algae, water clarity and water hardness) influence the plant community as the plant community can in turn modify these parameters. Lake morphology, sediment composition and shoreline use also impact the aquatic plant community.

**WATER QUALITY -** The trophic state of a lake is a classification of its water quality. Phosphorus concentration, chlorophyll concentration and water clarity data are collected and combined to determine the trophic state. Peppermill Lake has water quality records for a number of years. Water clarity, total phosphorus, and chlorophyll-a readings go back to 1992. After a gap of several years, regular collection began again in 1999 and has continued through 2016. There are 4 monitoring sites for collection: the deep hole, funded by the WDNR, and 3 additional sites funded by the Peppermill Lake District.

### Phosphorus

Phosphorus is a limiting nutrient in many Wisconsin lakes, including Peppermill Lake. Increases in phosphorus in a lake can feed algae blooms and, occasionally, excess plant growth. Starting from 2004, the average growing season (May through September) through 2021 for total phosphorus levels is 29.4 micrograms/liter, which is in the "good" category. Total phosphorus levels have increased slightly in the last 10 years, resulting in an average of 31.1 micrograms/liter.

## Algae/Chlorophyll-a

Chlorophyll-a concentrations provide a measure of the amounts of algae in lake water, although not the species. Algae are natural and essential in lakes, but high algae populations can increase turbidity and reduce the light available for plant growth. The 2004-2021 mean summer chlorophyll-a concentration in Peppermill Lake was 6.7 micrograms/liter, in the “good” range for chlorophyll-a levels.

**Figure 3: Trophic Status of Peppermill Lake**

| | 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 |
| | Fair | 30-50 | 10-15 | 5-6 |
| Eutrophic | Poor | 50-150 | 15-30 | 3-4 |
| Peppermill Lake Growing Season 2004-2021 | | **29.4** | **6.7** | **8.3** |

## Overall Water Quality

The combination of phosphorus and chlorophyll-a concentrations and water clarity indicate that Peppermill Lake is a borderline oligotrophic/mesotrophic impoundment with good-to-very good water quality and clarity. This trophic state should favor only moderate plant growth and occasional localized summer algal blooms.

**Figure 4: Average Total Phosphorus Levels in Peppermill Lake 2004-2021**

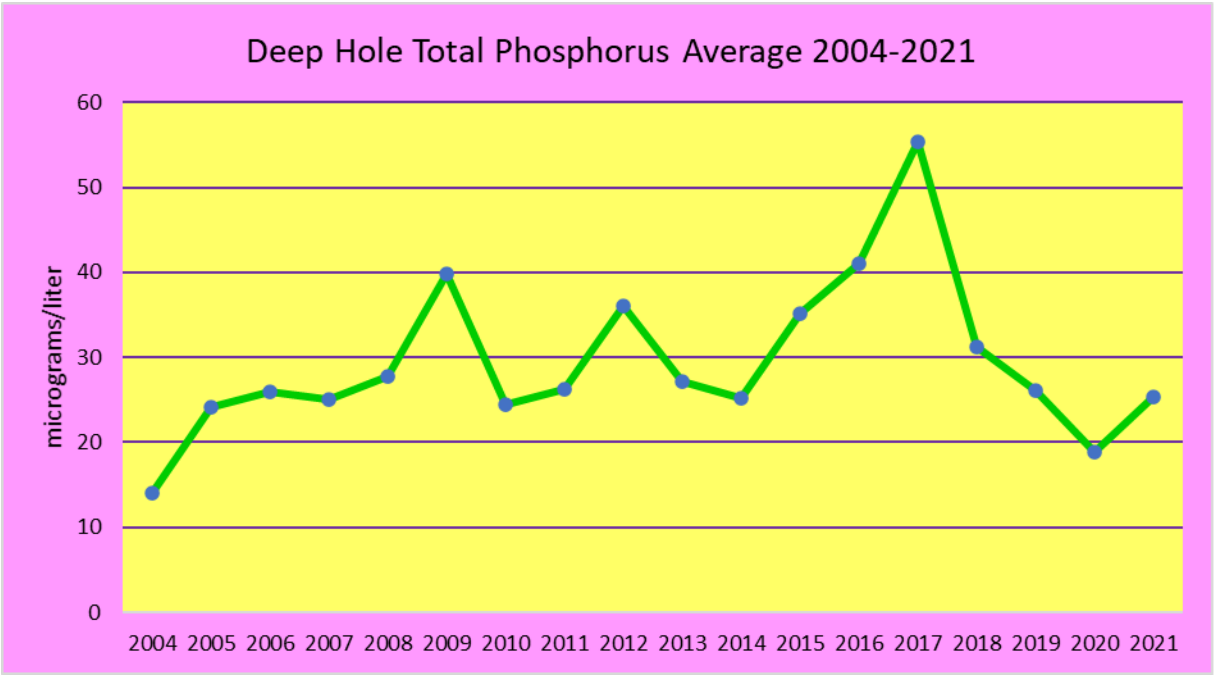
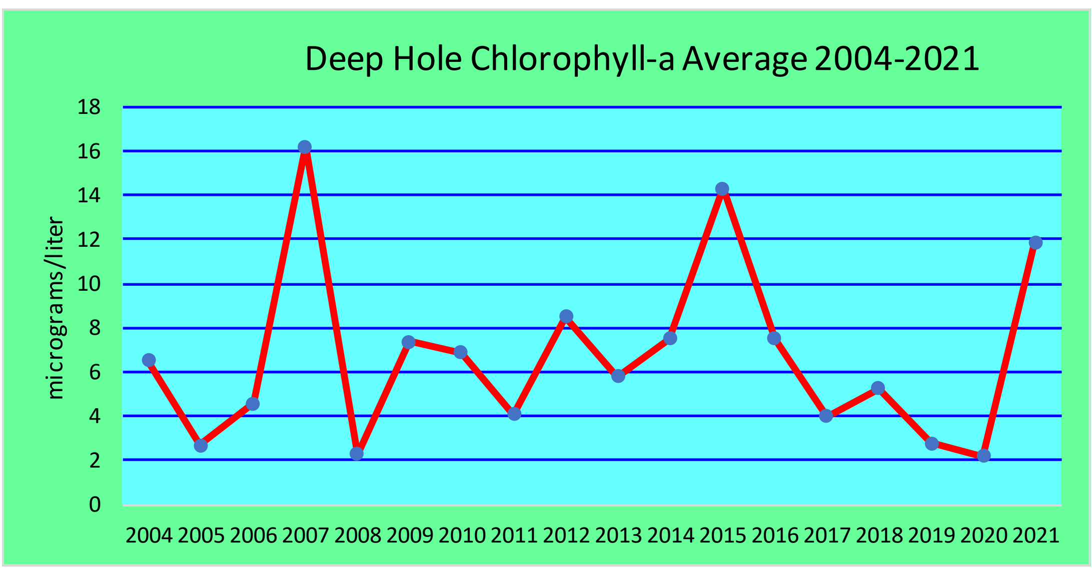



**Figure 5: Average Chlorophyll-a Levels in Peppermill Lake 2004-2021**



**Water Clarity**

Water clarity is a critical factor for aquatic plants, since they need more than 2% surface illumination, or they won't survive (Chambers and Kalff, 1985; Duarte et al., 1986; Kampa, 1994). Water clarity is reduced by turbidity (suspended materials like algae and silt) and dissolved organic chemicals that color the water. Water clarity is measured with a Secchi disc. The 1992-2021 average summer Secchi disc clarity in Peppermill Lake was 9.3 feet. This falls in the "very good" category. The average for the last 10 years is down slightly to 8.6 feet, but still in the 'very good' category.

**Overall Water Quality**

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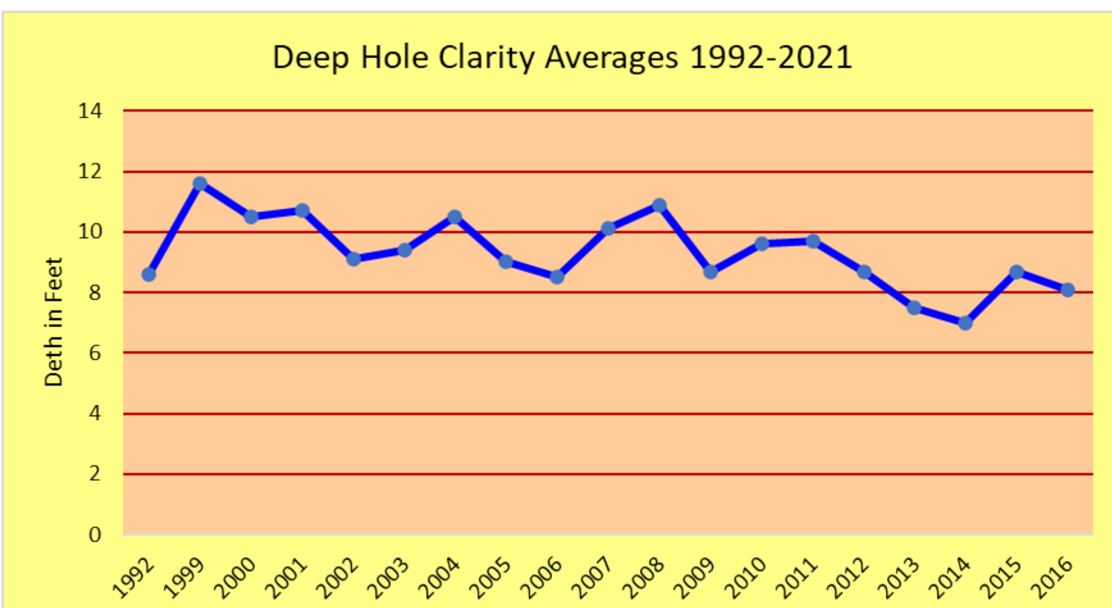
**Figure 6: Peppermill Average Growing Season Secchi Depth 1992-2021**



## SHORELINE LAND USE

Land use can strongly impact the aquatic plant community and therefore the entire aquatic community. Land use in both rural and urban settings can directly impact the plant community through increased erosion and sedimentation and increased run-off of nutrients, fertilizers and toxics applied to the land.

Native herbaceous cover is the most frequently occurring shoreline on Peppermill Lake. Shrubs and trees are also common. Woody debris by the shore is abundant in the lake. Cultivated lawn and hard structure (boat docks, patios, retaining walls, etc.) are less frequently occurring than on any other man-made lakes in Adams County.

## MACROPHYTE DATA

### SPECIES PRESENT

In the 2021 survey, 33 species of aquatics were found. Of these, 31 were native: 6 emergent species, 3 free-floating species, 4 rooted floating-leaf plants, and 18 submergents. Two invasive aquatic plants were found: the emergent Reed Canarygrass (*Phalaris arundinacea*) and the submergent Eurasian Watermilfoil (*Myriophyllum spicatum*).

### FREQUENCY OF OCCURRENCE

In 2021, members of the *Charophyte* family were the most frequently-occurring aquatic species. These species play multiple roles in an aquatic ecosystem as part of the food web, in providing habitat, and in increasing water quality. Almost all groups in an aquatic food web benefit from the presence of *Charophytes.* This vegetation is especially important in the winter when it provides habitat for the invertebrates that support good fisheries.

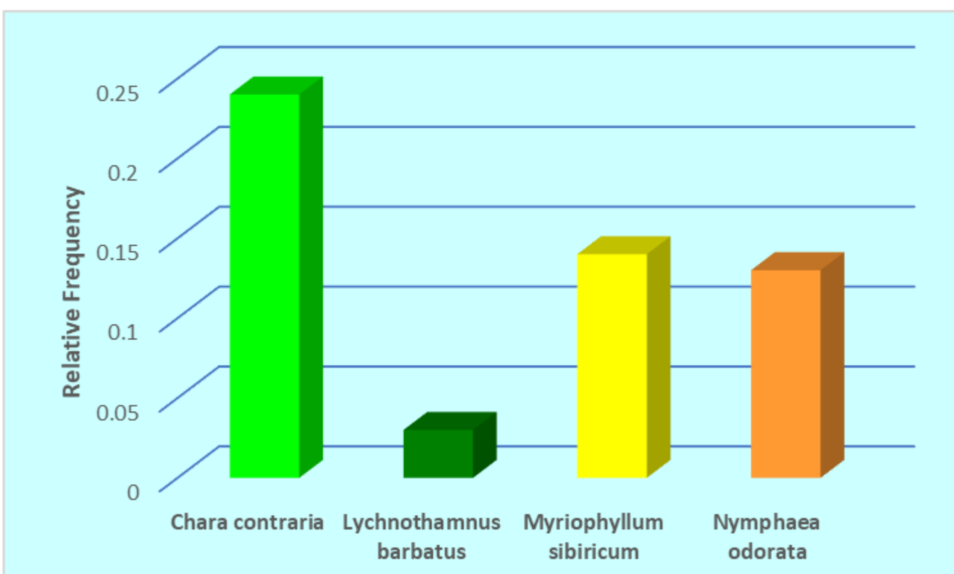
### Figure 7: Species Found in Peppermill Lake 2021

| Scientific Name | Common Name | Type |
|---|---|---|
| *Carex spp* | Sedge | Emergent |
| *Carex comosa* | Bristly Sedge | Emergent |
| *Ceratophyllum demersum* | Coontail | Submergent |
| *Chara contraria* | Common Muskgrass | Submergent |
| *Elodea canadensis* | Common Waterweed | Submergent |
| *Heteranthia dubia* | Water Stargrass | Submergent |
| *Impatiens capensis* | Jewelweed | Emergent |
| *Iris versicolor* | Blue-Flag Iris | Emergent |
| *Lemna minor* | Lesser Duckweed | Free-Floating |
| *Lycnothamnus barbatus* | Bearded Stonewort | Submergent |
| *Myriophyllym heterophyllum* | Variable-Leaf Milfoil | Submergent |
| *Myriophyllum sibiricum* | Northern Milfoil | Submergent |
| *Myriophyllum spicatum* | Eurasian Watermilfoil | Submergent |
| *Myriophyllum verticillatum* | Whorled Milfoil | Submergent |
| *Najas flexlis* | Slender Naiad | Submergent |
| *Nuphar variegata* | Yellow Pond Lily | Floating-Leaf |
| *Nymphaea odoratus* | White Water Lily | Floating-Leaf |
| *Phalaris arundinacea* | Reed Canarygrass | Emergent |
| *Polygonum amphibium* | Water Smartweed | Floating-Leaf |
| *Potamogeton amplifolius* | Large-Leaf Pondweed | Submergent |
| *Potamogeton gramineus* | Variable Pondweed | Submergent |
| *Potamogeton illinoensis* | Illinois Pondweed | Submergent |
| *Potamogeton natans* | Floating-Leaf Pondweed | Submergent |
| *Potamogeton praelongus* | White-Stemmed Pondweed | Submergent |
| *Potamogeton pusillus* | Small Pondweed | Submergent |
| *Potamogeton zosteriformis* | Flat-Stemmed Pondweed | Submergent |
| *Ranunculus aquatilis* | White Water Crowfoot | Submergent |
| *Schoenoplectus tabernaemontani* | Soft-Stemmed Bulrush | Emergent |
| *Spirodela polyrhiza* | Greater Duckweed | Free-Floating |
| *Stuckenia pectinata* | Sago Pondweed | Submergent |
| *Typha spp* | Cattail | Emergent |
| *Utricularia vulgaris* | Greater Bladderwort | Submergent |
| *Wolffia columbiana* | Watermeal | Free-Floating |

Besides providing habitat for important invertebrates and food for fish and wildlife, *Charophytes* also serve as protection and cover for young fish. They are important in the predator-prey ratio. Their presence has even been known to inhibit the survival of mosquito larvae.

Perhaps the most important role in an aquatic ecosystem that *Charophytes* serve is in water quality. These plant-like algae naturally filter the water and play an important part in nutrient cycling. They hold massive amounts of phosphorus, thus serving as a phosphorus sink. This results in reducing and/or and blocking the availability of phosphorus for other less desirable algae and aquatic vegetation. In hard water systems, like those in Adams County, the calcification on *Charophytes* ties up even more phosphorus.

**Figure 8: Relative Frequency of Most Common Species in 2021**




They deliver oxygen to sediments, enhancing the nitrogen cycle and preventing iron-bound phosphorus from being released into the water column. Besides holding phosphorus, they also hold a lot of nitrogen, which is the second most influential factor in the presence of nuisance aquatic plant and excessive algae production.

*Charophytes* are known to play important roles in forming habitat and shaping an aquatic environment, influencing both abiotic (pH, water clarity) and biologic (structure of phytoplankton) factors. Studies have shown that *Charophytes* restrict the resuspension of sediments up to 100 times more than other aquatic vegetation.

The most frequently-occurring aquatic plants in the 2021 survey were Northern Milfoil, a submergent, and White Water Lily, a rooted floating-leaf plant. Both are native plants found in many of the lakes in Adams County.

As is common in the Adams County lakes, submergent plants were the most frequently-occurring aquatic type in Peppermill Lake in 2021, comprising over 79% of the aquatic community.

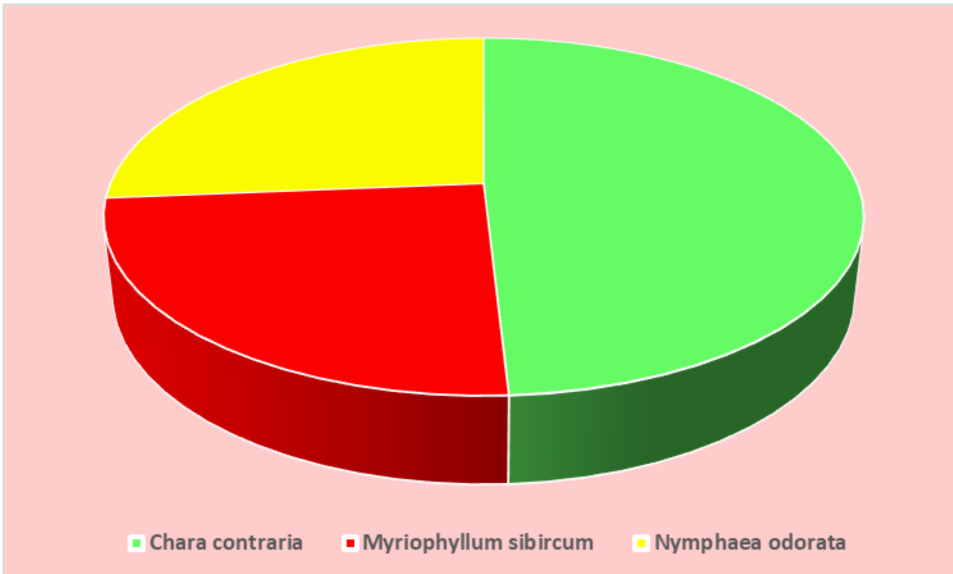
**DENSITY**

Besides the frequency at which species occur, the density of growth for each plant type is also evaluated. Some plants occur mostly in beds of growth with their own kind—those would have a considerably higher growth density where present than in the lake overall. In other instances, a specie is found scattered throughout the lake, mixed with other species. The most densely-growing aquatic species in the lake overall in 2021 were the *Charophyte* species, the water lily species, and the Milfoil species.

The most densely-growing aquatic "plant" was *Chara contraria*. In some area of

Peppermill Lake, this plant is so dense that travel through the beds is nearly impossible, especially in boggy areas.

**Figure 9: Relative Density of Aquatic Plants in Peppermill Lake**




## DOMINANCE

Combining the relative frequency and relative density of a species into a Dominance Value illustrates how dominant that species is within the aquatic plant community. Based on the Dominance Value, *Chara contraria*, *Myriophyllum sibircum*, and *Nymphaea odorata* were the dominant aquatic species in Peppermill Lake in 2021.

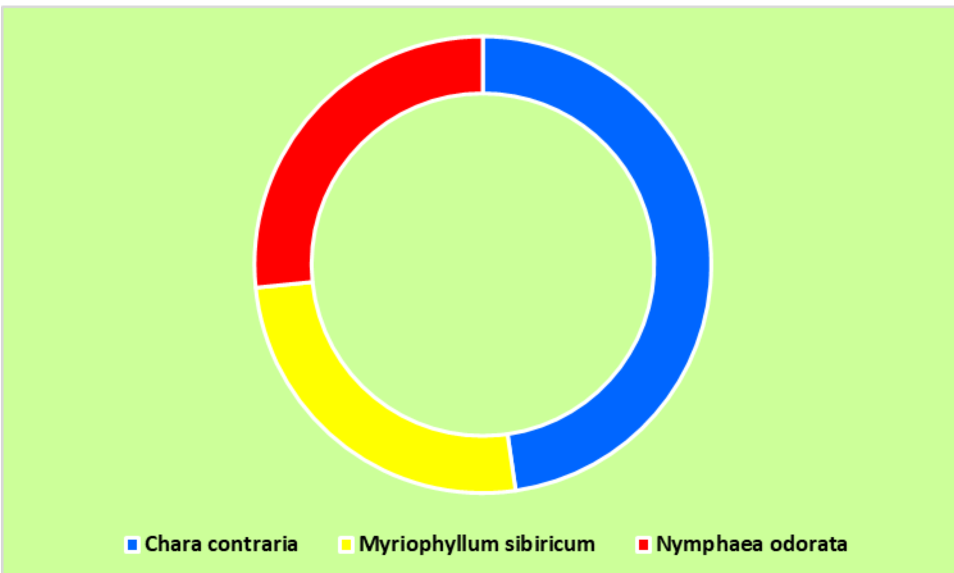
## DISTRIBUTION

Aquatic plants were found throughout Peppermill Lake in all the recorded surveys. Except for a few sites, aquatic plants were found throughout the lake. Eurasian Watermilfoil has been consistently found in Peppermill Lake for many years. After several years of chemical treatment, it seemed to disappear from the lake for a while.

In the last several surveys, as in this survey, it has only been found as isolated plants. Spring and fall monitoring will continue for the near future. It comprised only 2% of the aquatic plant community in 2021.

Peppermill Lake continues to be a "hot spot" for the presence of *Lychnothamnus barbatus* (Bearded Stonewort), the rarest *Charophyte* species in the world. In a few areas of the lake, it was thick enough that it was a like a carpet.

**Figure 10: Dominance in 2021 in Peppermill Lake**



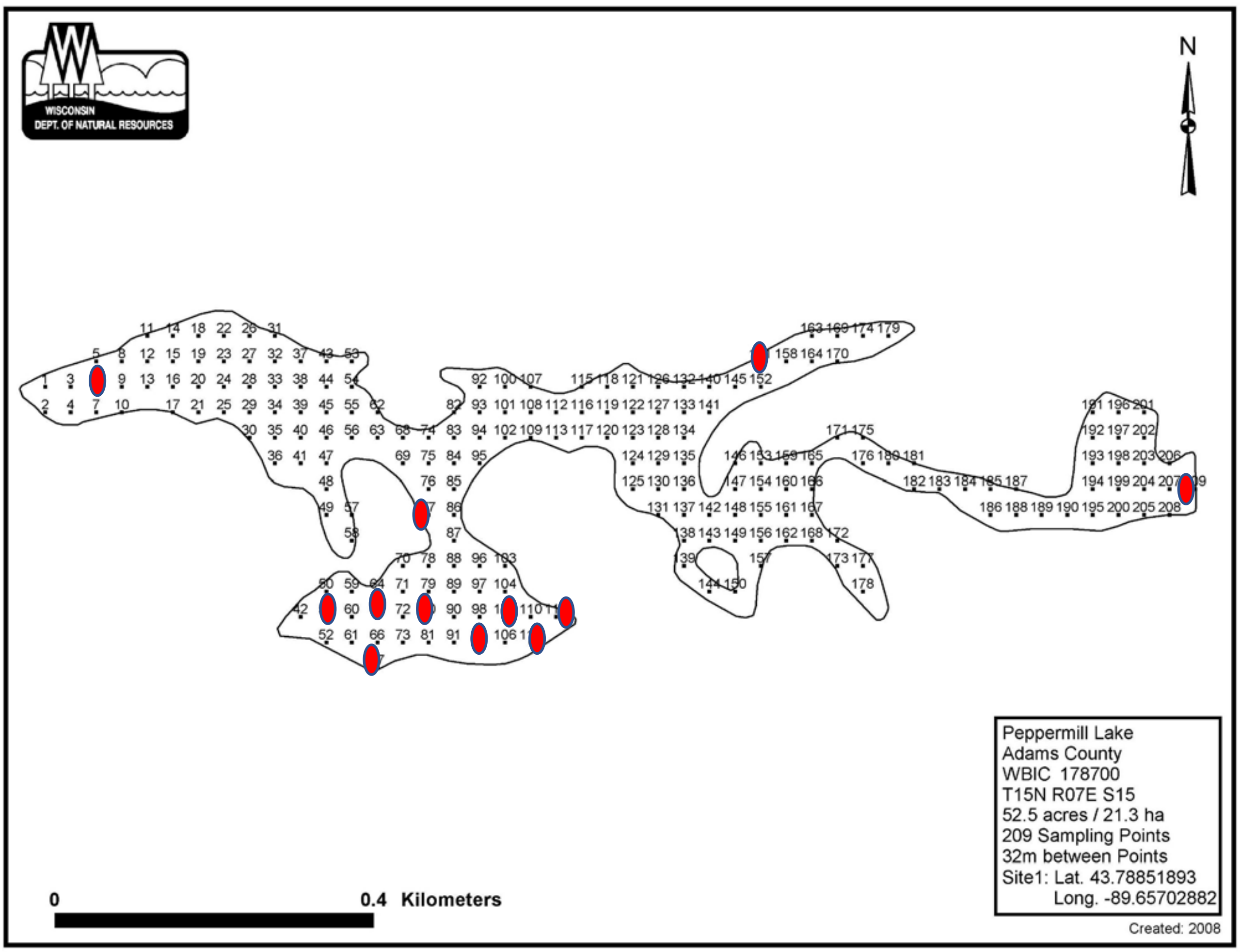

Reed Canarygrass, the other invasive found at Peppermill Lake, has never comprised a large part of the aquatic community. Although it has been found for many years at Peppermill Lake, it continues to be found in low frequency of occurrence and low density of growth.

## THE COMMUNITY

The Simpson's Diversity Index (SI) for the 2021 survey was 0.88. A rating of 1.0

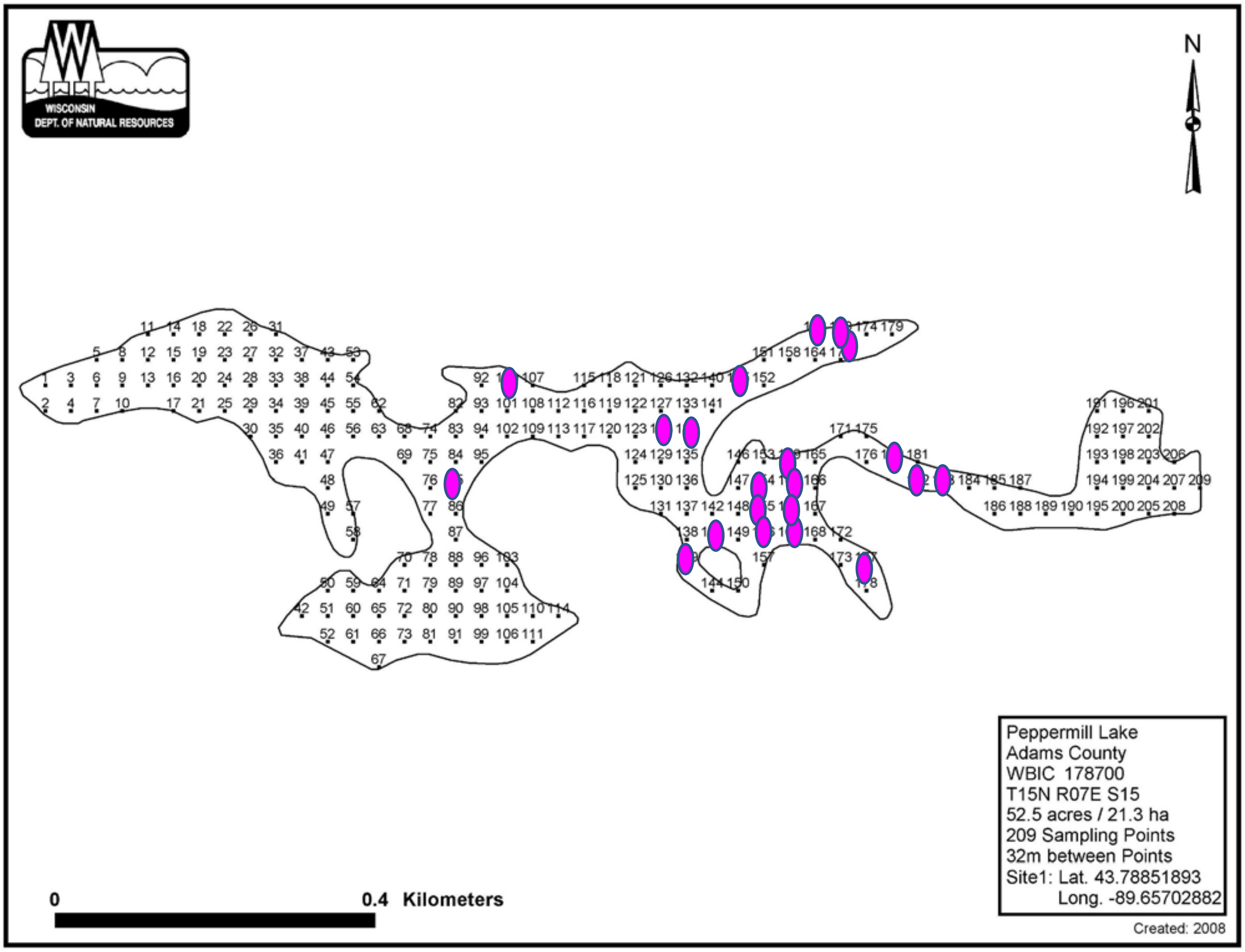
would mean that each plant in the lake was a different species (the most diversity achievable). This score places Peppermill Lake in the upper quartile for diversity for all the lakes in Wisconsin and for the North Central Hardwoods Region.

**Figure 11: Distribution of Eurasian Watermilfoil 2021**




Species richness is the number of species at a particular area. When looking at aquatic survey results, higher species richness usually indicates a higher quality aquatic plant community. The 2012 PI species richness was 3.24. The score for 2016 was 3.98. In 2021, it was 3.54. This suggests the species richness in Peppermill Lake is basically stable.

**Figure 12: Locations of *Lychnothamnus barbatus* in 2021**




The Average Coefficient of Conservation and Floristic Quality Index were calculated as outlined by Nichols (1998) to measure plant community disturbance. A coefficient of conservation is an assigned value between 0 and 10 that measures the probability that the species will occur in an undisturbed habitat. The Average Coefficient of Conservationism is the mean of the coefficients for the species found in the lake. The Average Coefficient of Conservatism for Peppermill Lake in 2021 was 5.7. This figure would put Peppermill Lake in the median of lakes in Wisconsin and in median range for the North Central Hardwoods Region.

The coefficient of conservatism is used to calculate the Floristic Quality Index (FQI), a measure of a plant community's closeness to an undisturbed condition. The Floristic Quality Index is also a tool that can be used to identify areas of high conservation value, monitor sites over time, assess the anthropogenic (human-caused) impacts affecting an area and measure the ecological condition of an area (M. Bourdaghs et al, 2006).

The FQI for the 2021 PI survey was 30.5. This score places Peppermill Lake in the highest quartile for Wisconsin lakes and the North Central Hardwood Region lakes. These figures indicate that the plant community in Peppermill Lake is closer to an undisturbed condition than the average lake in Wisconsin and within the group of lakes in the region closest to an undisturbed condition.

These results may at first seem contradictory, with one score in the median range and one in the highest quartile. However, the Average Coefficient of Conservatism doesn't include considering the frequency or density of the species involved, unlike the FQI.

Disturbances can be of many types:

1) Physical disturbances to the plant beds from activities such as boat traffic, plant harvesting, chemical treatments, the placement of docks and other structures and fluctuating water levels.
2) Indirect disturbances that impact water clarity and stress species that are more sensitive: resuspension of sediments, sedimentation from erosion, or increased algae growth due to nutrient inputs.

3) Biological disturbances like the introduction of a non-native or invasive plant species, grazing from an increased population of aquatic herbivores and destruction of plant beds by a fish or wildlife population.

**Figure 13: Floristic Quality and Coefficient of Conservatism of Peppermill Lake, Compared to Wisconsin Lakes and Northern Wisconsin Lakes.**

| | Average Coefficient of Conservatism † | Floristic Quality ‡ |
|---|---|---|
| Wisconsin Lakes | 5.5, 6.0, 6.9 * | 16.9, 22.2, 27.5 |
| NCHR | 5.2, 5.6, 5.8 * | 17.0, 20.9, 24.4 |
| Peppermill Lake 2021 | 5.7 | 30.5 |

* - Values indicate the highest value of the lowest quartile, the mean and the lowest value of the upper quartile.

† - Average Coefficient of Conservatism for all Wisconsin lakes ranged from a low of 2.0 (the most disturbance tolerant) to a high of 9.5 (least disturbance tolerant).

‡ - lowest Floristic Quality was 3.0 (farthest from an undisturbed condition) and the high was 44.6 (closest to an undisturbed condition).

Disturbances can be of many types:

4) Physical disturbances to the plant beds from activities such as boat traffic, plant harvesting, chemical treatments, the placement of docks and other structures and fluctuating water levels.
5) Indirect disturbances that impact water clarity and stress species that are more sensitive: resuspension of sediments, sedimentation from erosion, or increased algae growth due to nutrient inputs.
6) Biological disturbances like the introduction of a non-native or invasive plant species, grazing from an increased population of aquatic herbivores and destruction of plant beds by a fish or wildlife population.

The major disturbances in Peppermill Lake are likely:

1) the introduction of non-native aquatic plant species;

2) damage by motor boats in the shallow water areas.

The Aquatic Macrophyte Community Index (AMCI) for Peppermill Lake was 52 in 2021. This value is in the average for lakes in the North Central Hardwoods Region (48 to 57) and Wisconsin (45 to 57) and indicate that the aquatic plant community in Peppermill Lake is of at least average quality.

## COMPARISON TO PRIOR RESULTS

In 2006, 31 aquatic species were found in Peppermill Lake, using the transect method. In 2012, the transect survey method found 41 species and the PI survey yielded 51 species. During the summer of 2012, the lake level of Peppermill Lake was reduced, down in depth due to the hot dry weather and drought. Despite this variance in water level, the aquatic plant community found in the 2012 transect community was much the same as that in the 2006 survey, with a small change in percentages between emergent, rooted floating-leaf, and submergent species. By 2016, 43 species were located and identified. The 2016 survey produced 44 aquatic plant species found. Fewer species were found in the 2021 species, likely due to the issues discussed earlier in this report.

### Figure 14: Plant List Comparisons

| Scientific Name | 2001(t) | 2006(t) | 2012(t) | 2012(pi) | 2016(pi) | 2021(PI) |
|---|---|---|---|---|---|---|
| *Acorus americana* | | x | | x | | |
| *Alisma spp* | | | | | **x** | |
| *Angelica atropurpurea* | | | | x | | |
| *Asclepias incarnata* | | x | x | x | | |
| *Bidens beckii* | | | | | **x** | |
| *Bidens frondosus* | | | | x | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Bromus ciliatus* | | | | x | | |
| *Calamagrostis canadensis* | | | x | x | | |
| *Carex spp* | | x | x | x | x | x |
| *Carex aquatilis* | | | x | | | |
| *Carex comosa* | | x | | x | x | x |
| *Carex prairea* | | | | x | | |
| *Cornus stolonifera* | | | | x | | |
| *Ceratophyllum demersum* | x | x | x | x | x | x |
| *Chara spp* | x | x | x | x | x | x |
| *Chelone glabra* | | | x | | x | |
| *Cicuta bulbifera* | x | x | x | x | x | |
| *Cornus stolonifera* | x | x | x | x | | |
| *Cyperus odoratus* | | | | | **x** | |
| *Eleocharis erythropoda* | | | | x | x | |
| *Elodea canadensis* | x | x | x | x | x | x |
| *Eupatorium maculatum* | | | x | x | x | |
| *Eupatorium perfoliatum* | | | x | x | | |
| *Galium asperellum* | | | | x | | |
| *Impatiens capensis* | | x | x | x | | x |
| *Iris versicolor* | | | x | x | x | x |
| *Leersia oryzoides* | | x | | | | |
| *Lemna minor* | x | x | x | x | x | x |
| *Lycopus uniflorus* | | | x | x | x | |
| *Lycnothamnus barbatus* | | | | | x | x |
| *Myriophyllym heterophyllum* | | x | x | x | x | x |
| *Myriophyllum sibiricum* | x | x | x | x | x | x |
| *Myriophyllum spicatum* | x | x | x | x | x | x |
| *Myriophyllum verticillatum* | | | x | x | x | x |
| *Najas flexilis* | x | x | x | x | x | x |
| *Nuphar variegata* | x | x | x | x | x | x |
| *Nymphaea odorata* | x | x | x | x | x | x |
| *Onoclea sensibilis* | | x | | x | | |
| *Phalaris arundinacea* | | x | x | x | x | x |
| *Physiocoarpus opulifolis* | | x | | | | |
| *Polygoncum amphibium* | | x | | x | x | x |
| *Potamogeton amplifolious* | x | x | x | x | x | x |
| *Potamogeton foliosus* | | x | x | x | | |
| *Potamogeton friesii* | | x | x | x | | |
| *Potamogeton gramineus* | | | | | **x** | x |
| *Potamogeton illinoensis* | x | x | x | x | x | x |
| *Potamgeton natans* | | x | x | x | x | x |
| *Potamogeton praelongus* | | | x | x | x | x |
| *Potamogeton pusillus* | | | | | x | x |
| *Potamogeton richardsonii* | x | | | x | | |
| **Scientific Name** | **2001(t)** | **2006(t)** | **2012(t)** | **2012(pi)** | **2016(pi)** | |
| *Potamogeton zosteriformis* | | x | | x | x | x |
| *Ranunculus aquatilis* | | | | | x | x |
| *Rumex spp* | | x | | | | |
| *Sagittaria spp* | | x | x | x | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Salix spp* | | | x | x | | |
| *Schoenoeplectus tabernaemontani* | z | x | x | x | x | x |
| *Scutellaria laterifolia* | | x | | | | |
| *Scirpus cyperinus* | | | | x | | |
| *Sium suave* | | | | x | | |
| *Solanum dulcamara* | | | x | | x | |
| *Sparganium eurycarpum* | | x | x | x | | |
| *Spirodela polyrhiza* | | x | x | x | x | x |
| *Stuckenia pectinata* | x | x | x | x | x | x |
| *Typha spp* | x | | x | x | x | x |
| *Utricularia gemniscapa* | | | | x | x | |
| *Utricularia gibba* | | | | x | x | |
| *Utricularia minor* | | | | | **x** | |
| *Utricularia vulgaris* | x | x | | x | x | x |
| *Zosterella (Heteranthia) dubia* | | x | | x | x | x |

The aquatic communities of 2016 and 2021 were compared by calculating coefficients of similarity (developed by Jaccard in 1901), using both actual frequency of occurrence and relative frequency of occurrence, based on a finding that any figure over 75% suggests a stable community. Using the actual frequency of occurrence, the communities were 82.5% similar. However, using relative frequency, they were only 65.3% similar. It may be that the lack of information about the near-shore community and its composition accounts for the difference in the relative frequency calculations. Historically, the aquatic plant community at Peppermill Lake has remained relatively stable in the last fifteen-plus years, despite some variances in species occurrence or density.

## V. DISCUSSION

Based on water clarity, chlorophyll-a, and phosphorus data, Peppermill Lake is a borderline oligotrophic/mesotrophic lake with very good water clarity and good water quality. Adequate nutrients (including sediments), good water clarity, hard water, and the large shallow areas in the lake would favor plant growth. Fairly high traffic and a significant presence of aquatic invasive plants, especially Eurasian Watermilfoil, have disturbed the aquatic plant community in the past, although overall the aquatic plant community has remained fairly stable. When the Eurasian Watermilfoil (EWM) was significantly reduced, *Chara* (muskgrass) moved in to many of the areas formerly occupied by EWM.

**Figure 15: Comparisons in Aquatic Communities Peppermill 2001-2021**

| **Peppermill** | 2001(T) | 2006(T) | 2012(T) | 2012(PI) | 2016(PI) | 2021(PI) |
|---|---|---|---|---|---|---|
| Number of Species | 19 | 31 | 39 | 49 | 44 | 33 |
| Maximum Rooting Depth | 10.0 | 8.0 | 7.5 | 9.5 | 9 | 9.0 |
| % of Littoral Zone Unvegetated | 0 | 0 | 0 | 0 | 0.4 | 0.5 |
| Simpson's Diversity Index | 0.90 | 0.93 | 0.93 | 0.87 | 0.92 | 0.88 |
| Species Richness | 3.50 | 5.05 | 4.70 | 3.24 | 3.98 | 3.54 |
| Floristic Quality | 36.02 | 28.28 | 29.52 | 36.81 | 36.21 | 30.5 |
| Average Coefficient of Conservatism | 4.8 | 5 | 4.8 | 5.3 | 5.7 | 5.7 |
| AMCI Index | 43 | 56 | 49 | 51 | 51 | 52 |

## V. CONCLUSIONS

Peppermill Lake is a mesotrophic/oligotrophic lake with aquatic plants all through the lake. Depths of less than 5 feet supported the most abundant aquatic plant growth. Rooted aquatic plants were found as deep as 9.0 feet. *Charophytes (Chara contraria* and *Lychnothamnus barbartus)* were the dominant species found in the 2021 survey. Northern Milfoil and White Water Lily, both native, were also common. All other species were found much less frequently and occurred in relatively low density of growth. No endangered or threatened species were found in Peppermill Lake in 2016.

Two invasive aquatic plant species have been present in Peppermill Lake for some time. One of them, Reed Canarygrass, has continued to be present only in low numbers. However, the second, Eurasian Watermilfoil, has been a problem treated with chemicals in the past, but seems at least temporarily to be reduced in presence and occurrence, found only in scattered spots.

A few years ago, a Shoreline and Shallows Habitat survey was conducted on Peppermill Lake using the sample protocol developed by the WDNR. 93 waterfront lots were evaluated. The average canopy cover in the riparian (35 feet landward of the ordinary high water mark) was 33.0% on the lake. 13 lots (14.0%) had no canopy at all; another 26 (28.0%) had 10% or less canopy. Canopy creates a micro-climate that offers habitat to species looking for cooler land and/or water. Vegetation dominated bank/water interface on Peppermill Lake, found, to some extent, on all waterfront lots. 40 lots (19.7%) had bare soil and/or sand at the interface. Hard structure (seawall, rock riprap, etc.) was found on only 6 lots (6.4%) in this bank area.

During this survey active erosion was found to be almost non-existent on Peppermill Lake. Although there were several areas where the property sloped towards the lake, the areas were usually covered with vegetation that would likely intercept and filter any potential runoff. Non-lawn vegetation covered 85.2% of Peppermill Lake shore riparian areas. This is substantially more than the state-mandated 65-70%. This kind of riparian cover may contribute to the high-level water quality found in Peppermill Lake as compared to other impoundments in Adams County. Cultivated lawn did cover about 14.2% of the riparian areas on Peppermill Lake. There were also a few small areas of rock at the shore.

The littoral (shallow) zone and its plant communities provide essential habitat for fish, wildlife, and the invertebrates that feed on them, but also provide erosion protection and water quality protection. Peppermill Lake has abundant aquatic plants of all four types: emergent; rooted floating-leaf; free-floating; and submergent. 43.0% of the lots had emergent species in this area; 51.6% had rooted floating-leaf plants; 54.9% had submergent species; 6.4% had free-floating plants.

Part of the protocol included GPSing all woody debris in the water near the shores. This protocol only enumerates "large wood," defined as greater than 4 inches in diameter somewhere along its length and at least 5 feet long. Using these requirements, Peppermill Lake had 160 pieces of woody debris in this area, divided between 58 sites. In some instances, only one piece was present; at several others, there were multiple pieces. The lake is well-stocked with woody debris for both habitat and shore protection.

The Peppermill Lake aquatic plant community is characterized by at least average quality and good species diversity. Depending on the indices used, the plant community is either in the top quartile or median of lakes in the region, with an above average tolerance to disturbance.

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in: 1) improving water quality; 2) providing valuable habitat 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, thus reducing diversity. Aquatic plant communities improve water quality in many ways (Engel, 1985):

- 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.

Aquatic plant communities provide important fishery and wildlife resources. Plants and 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 and are an essential part of the ecological web of a lake.

Lakes with diverse aquatic plant beds support larger, more diverse invertebrate populations. These in turn support larger and more diverse fish and wildlife populations (Engel 1985). Additionally, mixed stands of aquatic 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. Aquatic plant beds of moderate density support adequate numbers of small fish without restricting the movement of predatory fish (Engel, 1990). Peppermill Lake, with a diversity of aquatic vegetation species and varied aquatic plant structure, should support diverse invertebrate and fish populations.

**MANAGEMENT RECOMMENDATIONS**

1) All lake residents should practice best management on their lake properties. Peppermill Lake is borderline between oligotrophic and mesotrophic. A small increase in nutrients could push the lake into another trophic state, resulting in

noticeably worse water quality. Conversely, reducing nutrients could have a noticeable favorable impact on water quality.

- Keep septic systems cleaned and in proper condition;
- Use no lawn fertilizers;
- Clean up pet wastes;
- No composting should be done near the water nor should yard wastes & clippings be allowed to enter the lake (Do not compost near the water or allow yard wastes and clippings to enter the lake).

2) Continued involvement in regular water quality monitoring (through the Citizen Lake Monitoring Program) and aquatic invasive species monitoring should occur. This is important for keeping track of changes in the lake and for evaluating the effect of the management plan activities.

3) Peppermill Lake is heavily used by the public, especially for fishing. The Clean Boats, Clean Waters Program should be reactivated. Non-competitive grants are available specifically to help with Clean Boats, Clean Waters activities. The Peppermill Lake District could consider applying for this grant.

4) A few years ago, a small pier was installed for fishing that could also be used to launch canoes and kayaks. However, the path to this pier is frequently so overgrown that it is impossible to reach the pier from the parking area. Perhaps a volunteer program could be set in place with regular clearing of the path, so that easier access is available.

5) With critical habitat areas designated, a map of these areas should be posted at the public access points with a sign encouraging avoidance of motorboat

disturbance to these areas. Education about what these areas mean to the lake would also be a good idea. Landowners on the lake should watch for disturbance of these areas and report any violations. These areas are very important for habitat, the high value aquatic plant community, maintaining the positive water quality, and for preserving endangered and rare species.

6) Regular monitoring for the presence of aquatic invasives should continue, especially for the presence of Eurasian Watermilfoil. Pre-and-post treatment monitoring for the presence of aquatic invasives should also be scheduled if chemical treatment begins again.

7) The Peppermill Lake District should continue to regularly review and, if necessary, update its lake management plan.

11) All lake users should protect the aquatic plant community in Peppermill Lake. The standing-water emergent community, floating-leaf community, and submergent plant community are all unique plant communities. Each of these plant communities provides their own benefits for fish and wildlife habitat and water quality protection.

12) An aquatic plant survey should be repeated in 3 to 5 years in order to continue to track any changes in the community and the lake's overall health.

13) The Peppermill Lake District should consider approaching the landowners who own the undeveloped waterfront property on the lake and see if those landowners would be interested in conservation easements. If so, the Peppermill Lake District Lake could apply for a WDNR grant to gain these easements.

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