Coon Lake

Polk County, Wisconsin

Biological Monitoring Study and Community Education Project, Phase 1 LPL-1340-10
Water Quality and Stormwater Management Study Project, Phase 2 LPL-1341-10

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Table of Contents

List of Figures

List of Tables

List of Appendices

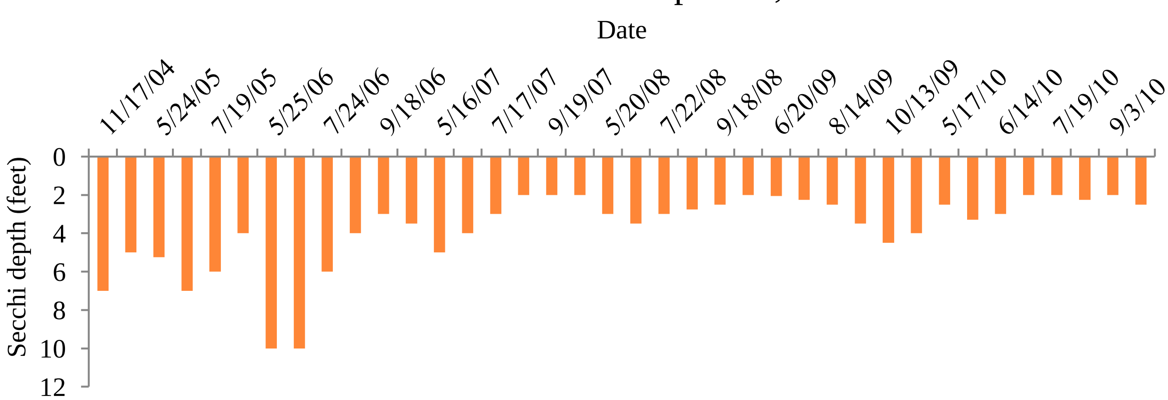
Executive Summary

Coon Lake is located at the headwaters of the Trade River Watershed, which drains to the St. Croix River Basin. The lake is located within the Village of Frederic and the shoreline is entirely in public ownership. Coon Lake receives water from three main sources: an inlet located on the north side of the lake, an inlet located on the south side of the lake, and a culvert located on the east side of the lake which receives the Village's stormwater. Precipitation and lake level monitoring data show that Coon Lake responds greatly to rainfall events, with the lake experiencing significant loss of volume in drought years.

Coon Lake is a shallow body of water with a maximum depth of 16 feet and a mean depth of 10 feet. The lake was man-made for the purpose of logging and totals 41.7 acres in size. Coon Lake does not stratify in the summer and remains well mixed throughout the year. Mixing allows oxygen (necessary for aquatic life) from the atmosphere to be mixed into the water column but allows for nutrients from the sediment to become re-suspended in the water column.

TSI data—which takes into account total phosphorus (important for algae growth), chlorophyll a (an indicator of the amount of algae present), and Secchi depth (an indicator of water clarity)—suggest that Coon Lake is eutrophic to hypereutrophic. Eutrophic lakes are high in nutrients and support a large biomass. As a result, they are usually either weedy or subject to frequent algae blooms and can experience oxygen depletion. Total phosphorus was greatly elevated over the entire 2010 growing season as compared to a healthy limit necessary to prevent algae blooms. Since 2004, Secchi depth in Coon Lake has decreased. The average 2010 summer Secchi depth (July 15-September 15) was 2.1 feet.

Coon Lake historic Secchi disk profile, 2004-2010.



Typically algae populations in lakes experience a seasonal succession of population dominance, shifting from diatoms, to green algae, to blue green algae, back to diatoms over the course of a growing season. However, the succession of populations in Coon Lake did not follow this pattern. Blue green algae and green algae dominated the phytoplankton community for the majority of the 2010 growing season. The algae community shifted to a diatom dominated state in September to a cryptomonad dominated state in October.

Cladocera are the group of zooplankton that are capable of reducing algae biomass. Although Caldocera populations made up less than 10% of the total zooplankton community in May, they composed over 90% of the total community by the end of July.

Coon Lake is almost devoid of submerged aquatic vegetation, with only one submerged aquatic plant, water smartweed, present. Two other emergent species were found, softstem bulrush and reed canary grass, a non-native species. Not surprisingly, Coon Lake had very low ratings for species richness (the number of plant species found in the lake), Simpson's Diversity Index, and the Floristic Quality Index (a measure designed to evaluate the closeness of the flora of an area to an undisturbed condition). Each parameter serves as an indicator of the health of the plant community in a lake.

Two invasive species, reed canary grass and narrow leaf cattail, were found at low densities around the lakeshore of Coon Lake. Additionally, numerous Japanese knotweed sites are known to exist in the Village of Frederic.

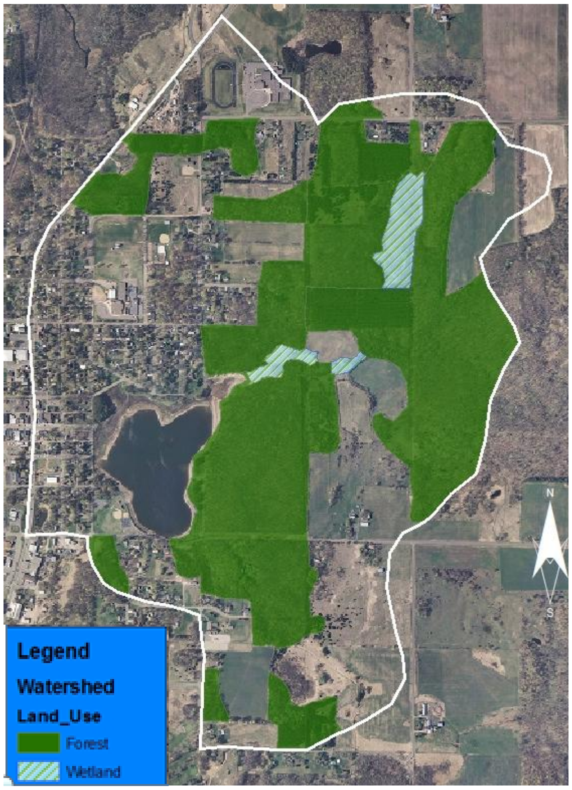
Phosphorus is a nutrient necessary for plant and animal growth. However, excessive amounts can result in an overabundance of plant growth and a decrease in water clarity. Phosphorus occurs naturally in soil, rocks, and the atmosphere and can make its way into lakes through a variety of sources, many of which are related to human activities. In approximately 80% of Wisconsin lakes phosphorus is the nutrient which most directly impacts the amount of algae and weed growth in a lake. As a result watershed phosphorus sources are often analyzed.

Based on average evaporation, precipitation, and runoff coefficients for Polk County soils the non-point source load was calculated to be 243.4 pounds of phosphorous annually. Since most of the agricultural land in the watershed is not actively row cropped, the model was re-run with this land use converted to grassland. In this scenario the total non-point source load was estimated to be 203.2 pounds of phosphorus annually. In both scenarios the land use that contributed the most non-point phosphorus was the Village, which contributes 46-121 pounds of phosphorus annually.

The average instantaneous load of phosphorus for the south inlet was 35.82 pounds of phosphorus per year. Stormwater Modeling found that three outlets contribute almost 24 pounds of phosphorus to Coon Lake annually.

The internal phosphorus load from the lake was estimated using in-situ data to quantify the increase of phosphorus concentrations in the fall. Using this method it was predicted that 126-

142 pounds of phosphorus (34.1 to 36.8% of the annual phosphorus budget) are released from the lake sediments.



Together the wetlands and forests make up approximately 54% of the land use in the Coon Lake Watershed but contribute only 15% of the total watershed phosphorus loading. These areas should be considered sensitive areas and preserved for the benefits they provide to Coon Lake.

The study also included an education component whereby a sociological survey was distributed within the Village of Frederic, updates were provided through Village Board Meetings and Village Parks Board Meetings, and a Coon Lake Fair was held that included a pontoon classroom, educational displays, and a Frederic Library Story Hour on amphibians.

The following goals were created for Coon Lake through collaborative efforts and take into account input gathered from Village Board Meetings, Village Parks Board Meetings, a 2011 sociological survey regarding the needs of Coon Lake stakeholders, and all relevant scientific data collected for Coon Lake.

1. Improve current water quality conditions in Coon Lake.
2. Reduce algae biomass in Coon Lake as a means to increase zooplankton communities and improve fisheries.
3. Reduce nutrient pollution to Coon Lake.
4. Maintain scenic beauty and enjoyment of Coon Lake through education.
5. Prevent the introduction of invasive species in Coon Lake and eradicate newly introduced aquatic invasive species.
6. Enhance the native plant community of Coon Lake for the benefits native plants provide in water clarity, fisheries health, and the prevention of AIS infestations.

Introduction

Coon Lake (WBIC 2642000) is located entirely within the Village of Frederic in Polk County, Wisconsin. A village park is located on the southeast side of the lake and a boardwalk is located on the south side of the lake. The shoreline of the lake is entirely in public ownership.

Coon Lake is at the headwaters of the Trade River Watershed, which drains to the St. Croix River Basin. At the time of this study the watershed area draining to Coon Lake had never been mapped but appeared to be large based off of USGS topographic maps. Coon Lake has a surface area of 41.7 acres and does not have a direct outlet. In addition to having two inflows, Coon Lake receives the Village's stormwater drainage. The north inlet drains from forest and the south inlet comes directly from an agricultural area. Storm sewers all flow to a culvert which enters Coon Lake on the east side off of Lake Avenue (Figure 1).

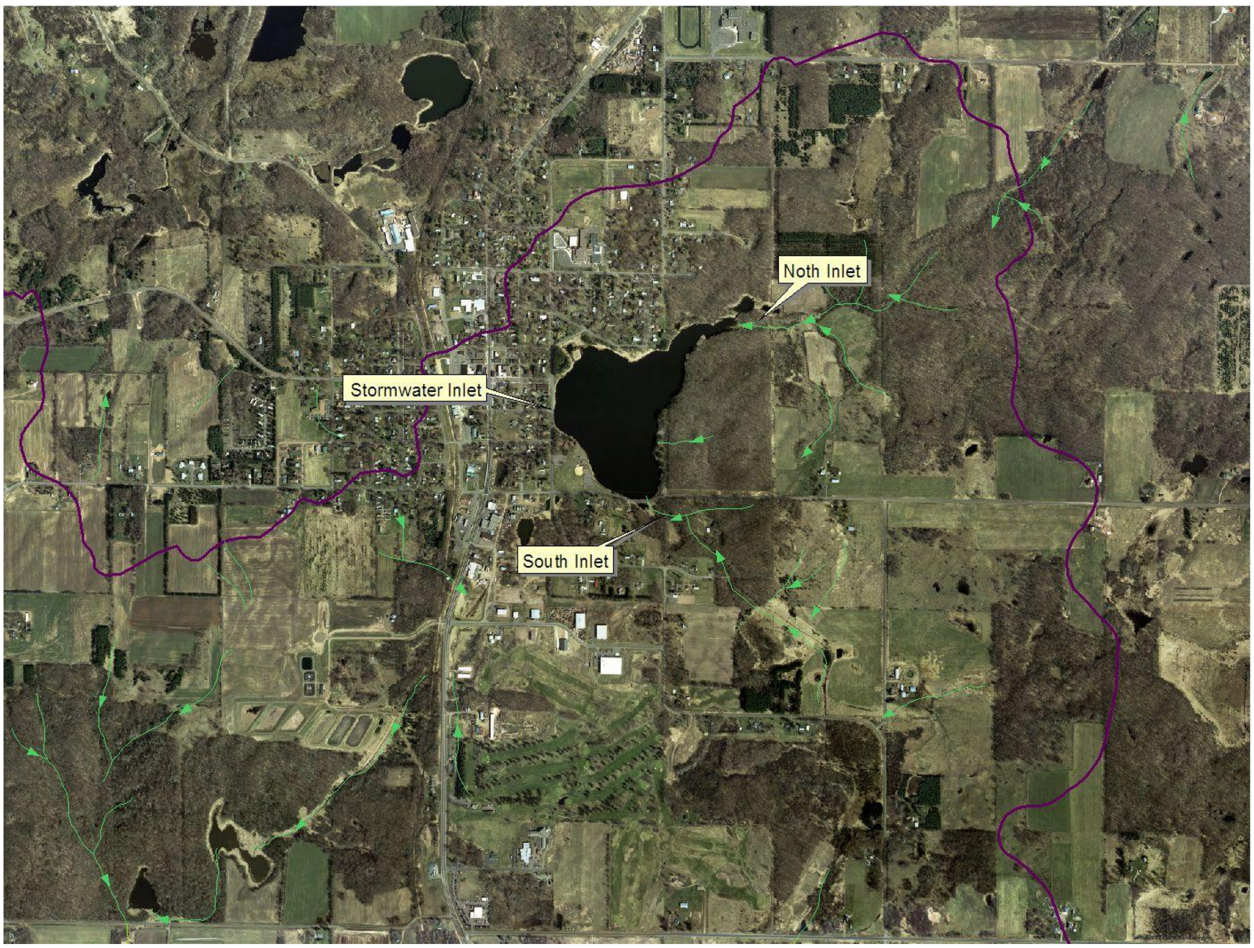


Figure 1. Map of Coon Lake depicting the north inlet, south inlet, and stormwater inlet.

Lake classification in Polk County is a relatively simple model that considers: lake surface area, maximum depth, lake type, watershed area, shoreline irregularity, and existing level of shoreline development. These parameters are then used to classify lakes as class one, class two, or class three lakes.

Class one lakes are large and highly developed.
Class two lakes are less developed and more sensitive to development pressure.
Class three lakes are usually small, have little or no development, and are very sensitive to development pressure.

Coon Lake is classified as a class three lake, meaning it is very sensitive to development pressure.

Very little qualitative or quantitative data has been collected on Coon Lake. Until this study, a lake planning grant had never been implemented to study water quality or the biotic components of Coon Lake. Additionally, data on water quality for Coon Lake was non-existent, with no phosphorus or other water quality information available with the exception of Secchi disk readings from 2005 to present.

Although the Village of Frederic was considering stormwater practices at the time this grant was written, a stormwater plan was not currently in place. This grant allowed for monitoring of urban runoff at culverts to help determine the areas of highest loading. Using this information allows the Village to adequately install lake protection programs.

The lack of past data pertaining to Coon Lake and the positive guidance data could provide for the Village, prompted the Village of Frederic and the Polk County Land and Water Resources Department to apply for a two phase lake planning grant in 2010. Additional factors which supported the need for a study included a significant loss of lake volume noted in mid-fall 2009 by DNR staff and a Polk County Board Supervisor and the fact that the Village of Frederic and the Village Parks Board was working on an Urban Forestry Plan. The study on Coon Lake was performed by the Polk County Land and Water Resources Department with assistance from the Village of Frederic/Village Parks Board and financial assistance from a two phase Department of Natural Resources Lake Planning Grant (LPL-1340-10 and LPL-1341-10). The majority of data was collected in the 2010 growing season. This report characterizes the data collected as pertains to the two phase grant.

Lake Characteristics from Wisconsin Department of Natural Resources

Name: Coon Lake
Area: 41.7 acres
Maximum depth: 16 feet
Mean depth: 10 feet
Bottom: 40% sand, 30% gravel, 0% rock, 30% muck
Hydrologic lake type: seepage
Shoreline: 13 miles
Trophic status: eutrophic

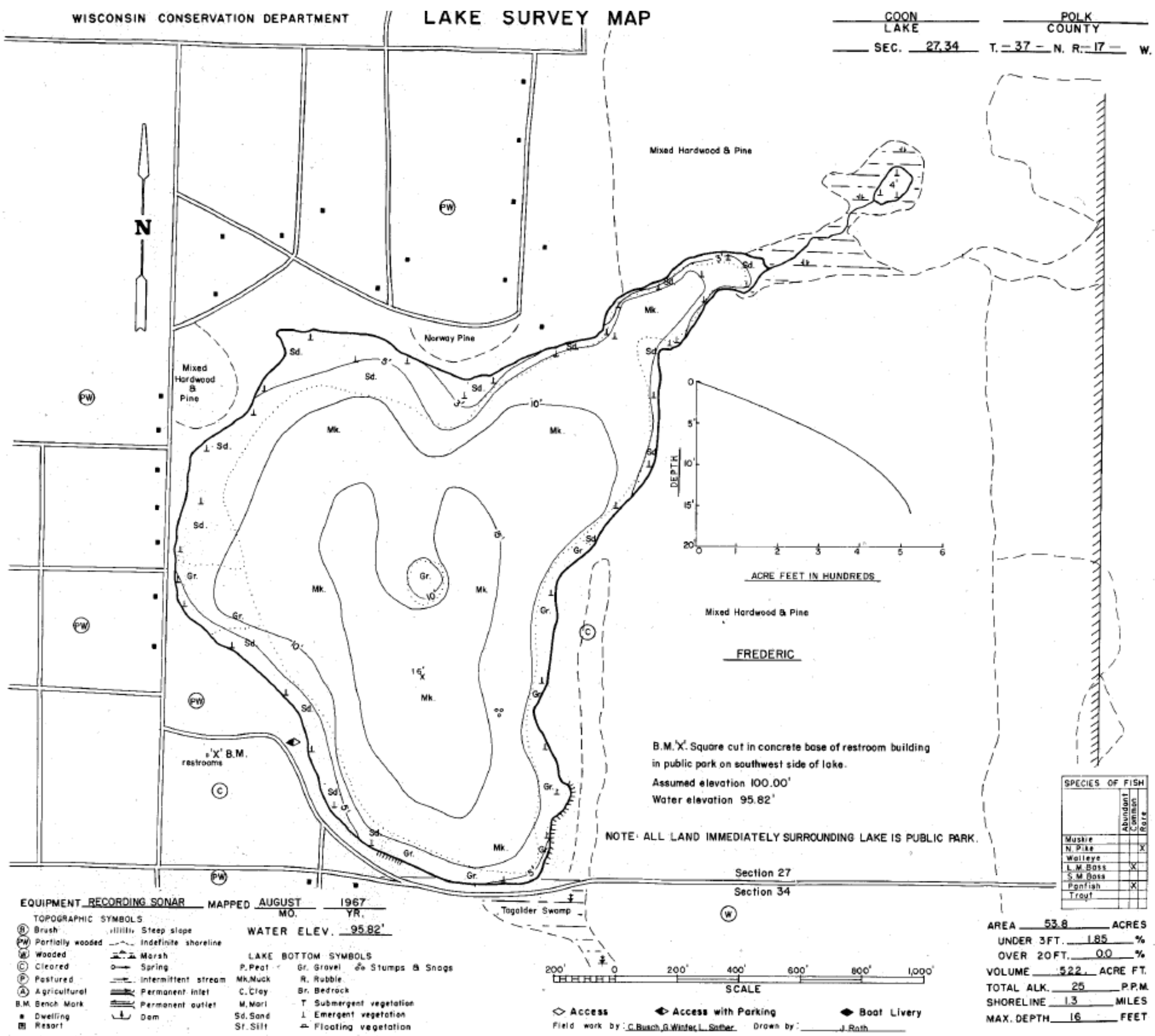


Figure 2. Coon Lake contour (bathymetric) map.

Lake Level and Precipitation Monitoring

In mid-fall 2009 a significant loss of lake volume was noted by DNR staff and a Polk County Board Supervisor. Annual Climatological Summary data from the U.S. Department of Commerce National Oceanic & Atmospheric Administration for Luck, Wisconsin (located 6 miles south of Frederic) showed an annual total rainfall of 25.99 inches in 2008, 22.18 inches in 2009, and 43.16 inches in 2010. The annual totals for 2008 and 2010 include one or more months which had 1 to 9 days that were missing.

In 2010 a staff gauge was placed in Coon Lake in the spring. However, as a result of a rapid rise in lake level the staff gauge was lost. As a result, daily lake level and precipitation data for Coon Lake do not exist for 2010.

However, lake level at the deep hole of Coon Lake was recorded by LWRD staff in 2010. Coon Lake maximum depth at the deep hole increased from 5.8 feet in mid-May to 7.8 feet by the end of July and 13.2 feet by mid-August. This increase is likely due to precipitation events given that the geographic area experienced nearly twice as much rainfall in 2010 as in 2009 and 2008.

Physical and Chemical Data

Physical and chemical data were collected in-lake at the deep hole of Coon Lake beginning on April 26th and ending on October 8th, 2010.

Integrated samples were collected from the water column once a month and analyzed at the Water and Environmental Analysis Lab (WEAL) at UW-Stevens Point for two types of phosphorus (total phosphorus and soluble reactive phosphorus), three types of nitrogen (nitrate/nitrite, ammonium, and total Kjeldahl nitrogen), chlorophyll a, sulfate, and total suspended solids. Additionally, spring and fall turnover samples were collected in April and October. Coon Lake in-lake chemical data can be found in Appendix A

Lake profile monitoring, which included dissolved oxygen, temperature, conductivity, pH, and Secchi depth was conducted bi-monthly. Dissolved oxygen, temperature, and conductivity readings were recorded at every meter within the water column using a YSI 85 multi-parameter probe. pH readings were recorded at every meter within the water column using a YSI 60 pH meter. Coon Lake in-lake physical data can be found in Appendix B. Secchi depth was recorded using a Secchi disk, which is an eight inch round disk with alternating black and white quadrants. To record Secchi depth the Secchi disk was lowered into the lake on the shady side of a boat until it just disappeared from sight. This depth is measured and recorded as the Secchi depth. Coon Lake in-lake historical Secchi data can be found in Appendix C.

Phosphorus

Phosphorus is an element present in lakes which is necessary for plant and algae growth. It occurs naturally in soil, rocks, and the atmosphere and can make its way into lakes through groundwater and soil erosion induced from construction site runoff or other human induced disturbances. Additional sources of phosphorus input into a lake can include fertilizer runoff from urban and agricultural settings and manure. While phosphorus is necessary for plant and animal growth, excessive amounts lead to an overabundance of growth which can decrease water clarity and lead to nutrient pollution in lakes. Phosphorus is present in lakes in several forms. This study measured two forms of phosphorus: total phosphorus and soluble reactive phosphorus.

Total phosphorus (TP) is a measure of all the phosphorus in a sample of water. In many cases total phosphorus is the preferred indicator of a lake's nutrient status because it remains more stable than other forms over an annual cycle.

Soluble reactive phosphorus (SRP) includes forms of phosphorus that are dissolved in the water and are readily available for uptake by algae and aquatic macrophytes (plants).

A "healthy" limit of phosphorus is set at 0.02 mg/l total phosphorus and 0.01 mg/l soluble reactive phosphorus to prevent nuisance algal blooms. Data collected in Coon Lake at each sampling date indicated elevated levels of both total phosphorus and soluble reactive phosphorus as compared to the "healthy" limit (Figure 3 and Figure 4 where the "healthy limit" is indicated by a red threshold line). The growing season (excludes turnover samples) averages for each parameter (TP = 0.17 mg/l and SRP = 0.08 mg/l) were also elevated as compared to the healthy limit.

Both TP and SRP reached peak levels on September 3rd. Summer spikes in phosphorus are typical and can arise from the release of nutrients when aquatic plants and algae senesce, or grow old and die. These data show a snapshot of Coon Lake over a year long period. However, historical data and trends can't be generalized due to a lack of data. Continued data collection related to phosphorus would be necessary to determine whether or not lake health is improving.

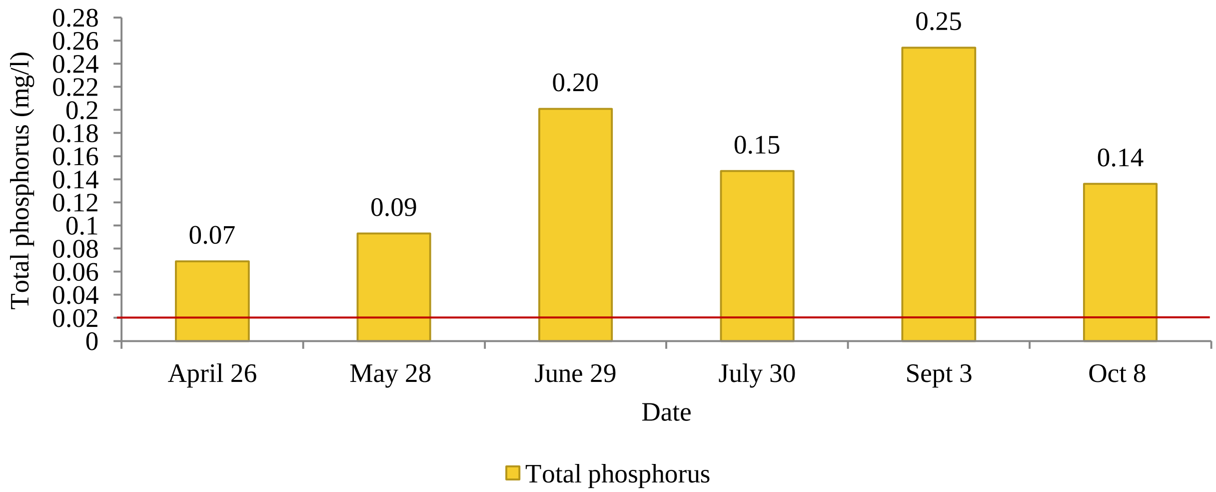


Figure 3. Coon Lake total phosphorus (mg/l), 2010. Red threshold line represents a healthy limit of total phosphorus, 0.02 mg/l.

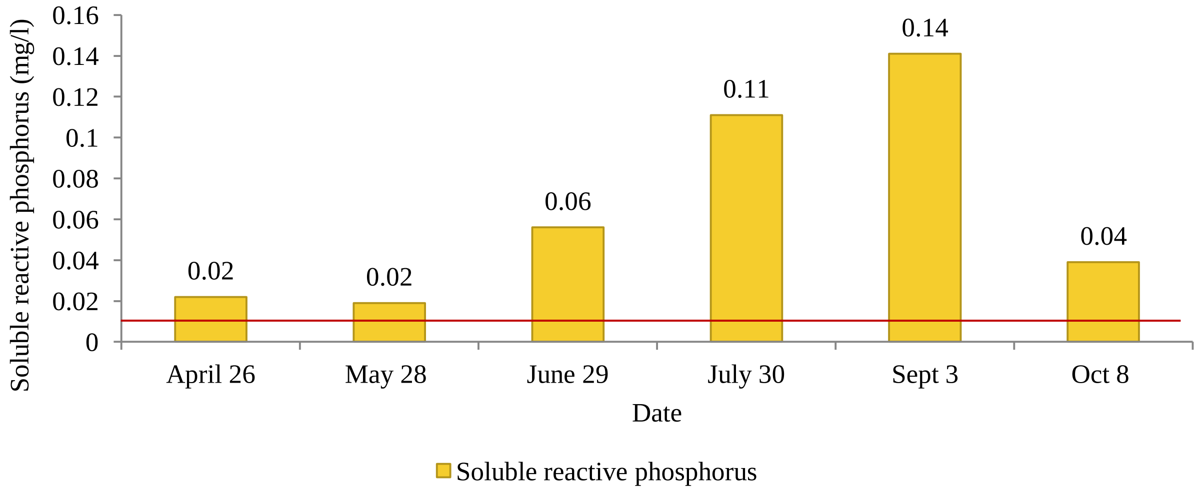


Figure 4. Coon Lake soluble reactive phosphorus (mg/l), 2010. Red threshold line represents a healthy limit of soluble reactive phosphorus, 0.01 mg/l.

Nitrogen

Nitrogen, like phosphorus, is an element necessary for plant growth. Nitrogen sources in a lake can vary widely. Although nitrogen does not occur naturally in soil minerals, it is a major component of all plant and animal matter. The decomposition of plant and animal matter releases ammonia, which is converted to nitrate in the presence of oxygen. This reaction accelerates when water temperatures increase. Nitrogen can also be introduced to a lake through rainfall, in the form of nitrate and ammonium, and through groundwater in the form of nitrate.

However, in most instances, the amount of nitrogen in a lake corresponds to land use. Nitrogen can enter a lake from surface runoff or groundwater sources as a result of fertilization of lawns and agricultural fields, animal waste, or human waste from septic systems or sewage treatment plants. During spring and fall turnover events, nitrogen is recycled back into the water column which can cause spikes in ammonia levels. Nitrogen can be lost from a lake system, through a process called denitrification, if oxygen is depleted. Under these conditions nitrate is converted to nitrogen gas. Additionally, nitrogen can be lost through permanent sedimentation.

Similar to phosphorus, nitrogen is divided into many components. In this study nitrate/nitrite (NO_3 and NO_2), ammonium (NH_4), and total Kjeldahl nitrogen (TKN) were analyzed.

Nitrate/nitrite and ammonium are all inorganic forms of nitrogen which can be used by aquatic plants and algae. Inorganic nitrogen concentrations above 0.3 mg/l can support summer algae blooms.

Total Kjeldahl nitrogen (TKN) is a measure of organic nitrogen plus ammonium. By subtracting the ammonium concentration from TKN, the organic nitrogen concentration found in plants and algal material can be found.

In Coon Lake the inorganic forms of nitrogen that are available for plant and algal uptake (NO_3+NO_2+NH_4) were below the threshold level of 0.3 mg/l which can support summer algae blooms in all the sample dates with the exception of September 3rd (Figure 5). The spike in inorganic nitrogen on September 3rd is possibly due to the release of nitrogen from algae when they senesce, or grow old and die. The concentration of organic nitrogen found in plants and algae was represented by a negative number on September 3rd, which supports this conclusion. This concentration increased to 1.37 mg/l on October 8th possibly representing an algae bloom (Figure 6).

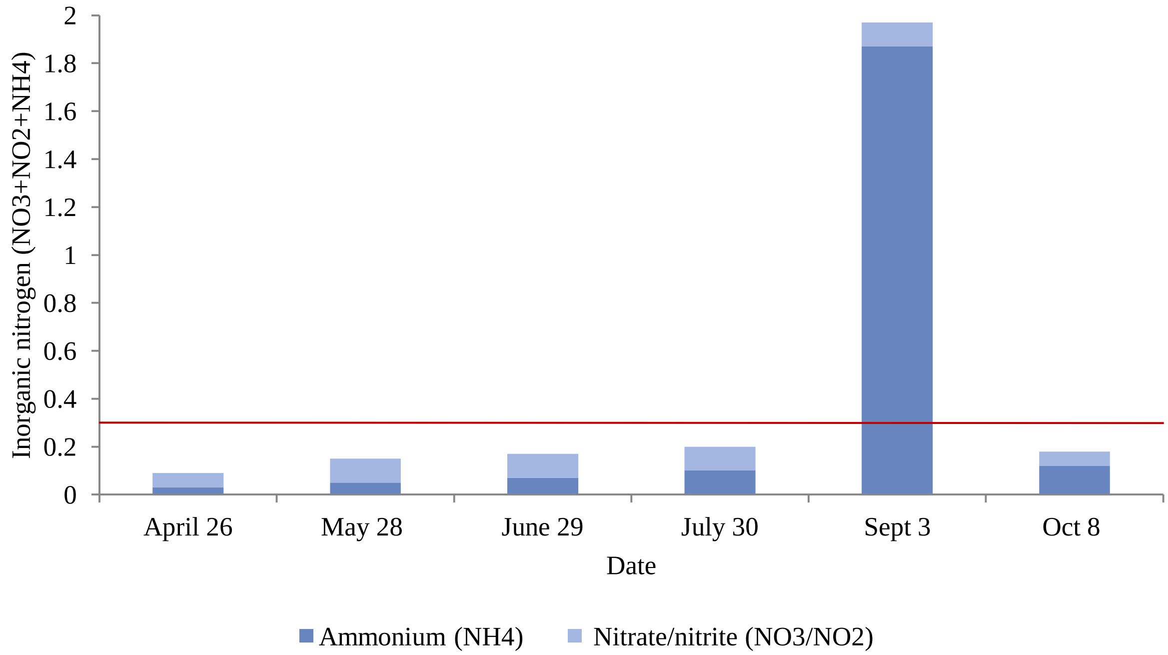


Figure 5. Coon Lake inorganic nitrogen (mg/l), 2010. Red threshold line represents a healthy limit of inorganic nitrogen, 0.3 mg/L. Nitrate/nitrite samples on May 28th, June 29th, July 30th, and September 3rd were less than 0.1 mg/l but are represented as 0.1.

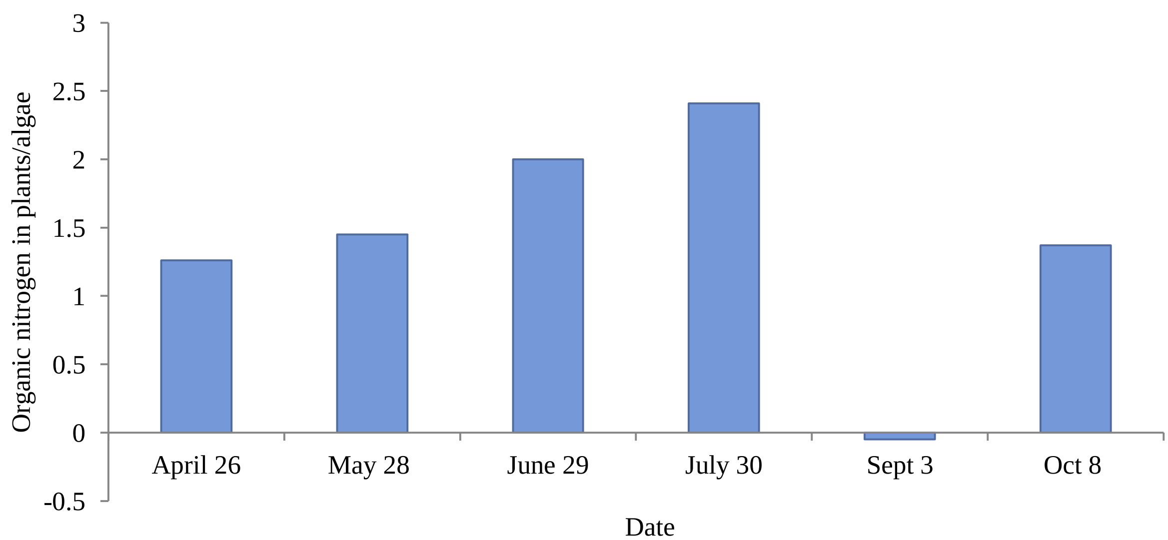


Figure 6. Coon Lake organic nitrogen in plants and algae (mg/l), 2010

Total Nitrogen to Total Phosphorus Ratio

The total nitrogen to total phosphorus ratio (TN:TP) is a calculation that depicts which nutrients limit algae growth in a lake. Lakes are considered nitrogen limited, or sensitive to the amount of nitrogen inputs into a lake, when TN:TP ratios are less than 10. Only about 10% of Wisconsin lakes are limited by nitrogen. In contrast, lakes are considered phosphorus limited, or sensitive to the amount of phosphorus inputs into a lake, when the TN:TP ratio is above 15. Lakes with values between 10 and 15 are considered transitional. In transitional lakes it is impossible to determine which nutrient, either nitrogen or phosphorus, is limiting algae growth.

In Coon Lake the total nitrogen to total phosphorus ratio varied throughout the 2010 growing season. Although half of the sample points indicate that the lake is phosphorus limited, the remainder of the sample points indicate that the lake is transitional or nitrogen limited (Figure 7). The point which represents a nitrogen-limited state occurred on September 3rd when inorganic nitrogen levels were elevated an order of magnitude above the remainder of sample points. The mean growing season (excludes turnover samples) total nitrogen to total phosphorus ratio is 13.5, which indicates a transitional state. Continued monitoring would provide more thorough analysis. For present, both nitrogen and phosphorus inputs into the lake should be minimized.

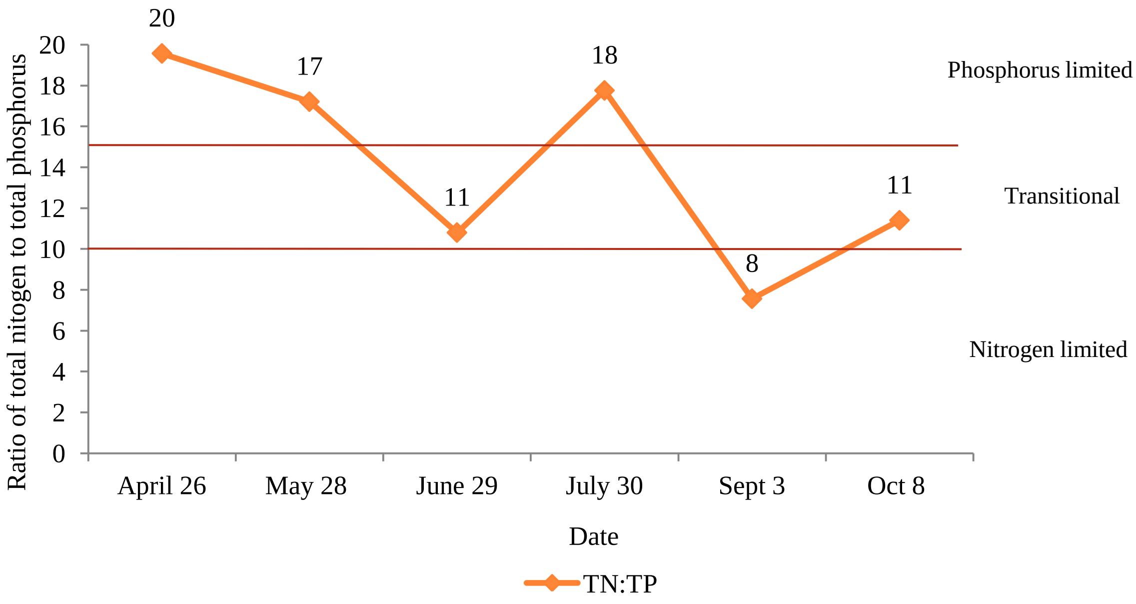


Figure 7. Coon Lake ratio of total nitrogen to total phosphorus, 2010. Values below 10 represent lakes which are nitrogen limited and values above 15 represent lakes which are phosphorus limited. Values between 10 and 15 are considered transitional.

Sulfate

Sulfate is a naturally occurring ion that is often associated with heavy mineral deposits and tends to accumulate in lake ecosystems unless removed. The amount of sulfate in lakes is primarily related to the types of minerals within the watershed and to acid rain. In Wisconsin, the highest levels of sulfate in lakes (over 40 mg/l) are found in the southeast portion of the state. In Polk County, lake sulfate levels are generally less than 10 mg/l. The mean growing season (excludes turnover samples) sulfate level in Coon Lake was 2.85 mg/l. Sulfate concentrations ranged from a high of 6.28 mg/l on May 28th to a low of to 2.2 mg/l on September 3rd (Figure 8).

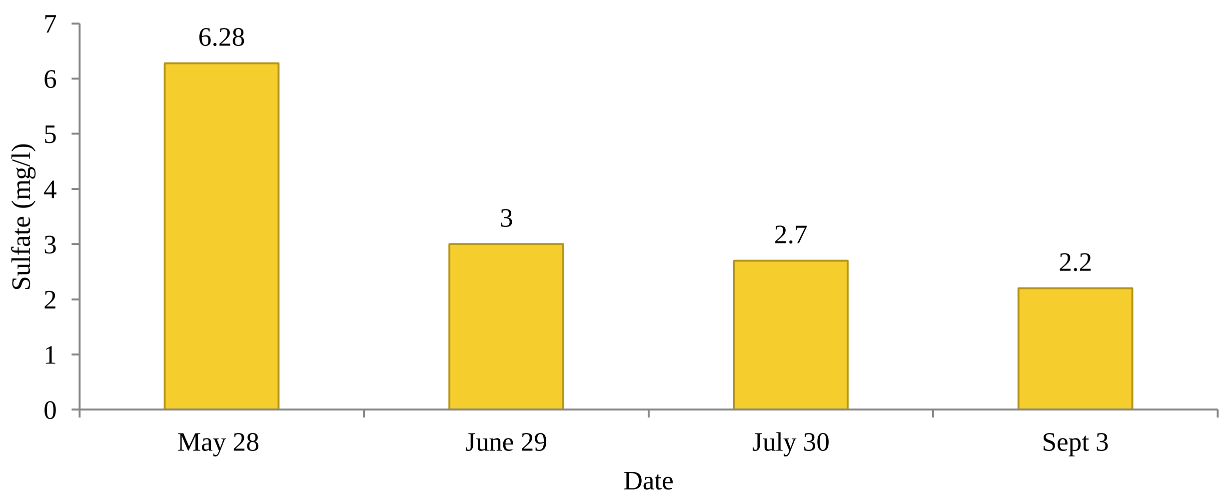


Figure 8. Coon Lake sulfate (mg/l), 2010.

Total Suspended Solids

Total suspended solids (TSS) quantify the amount of inorganic matter that is floating in the water column. Wind, waves, boats, and even some fish species can stir up sediments from the lake bottom re-suspending them in the water column. Fine sediments, especially clay, can remain suspended in the water column for weeks. These particles scatter light and decrease water transparency. The values for total suspended solids in Coon Lake are not outrageously high (Figure 9).

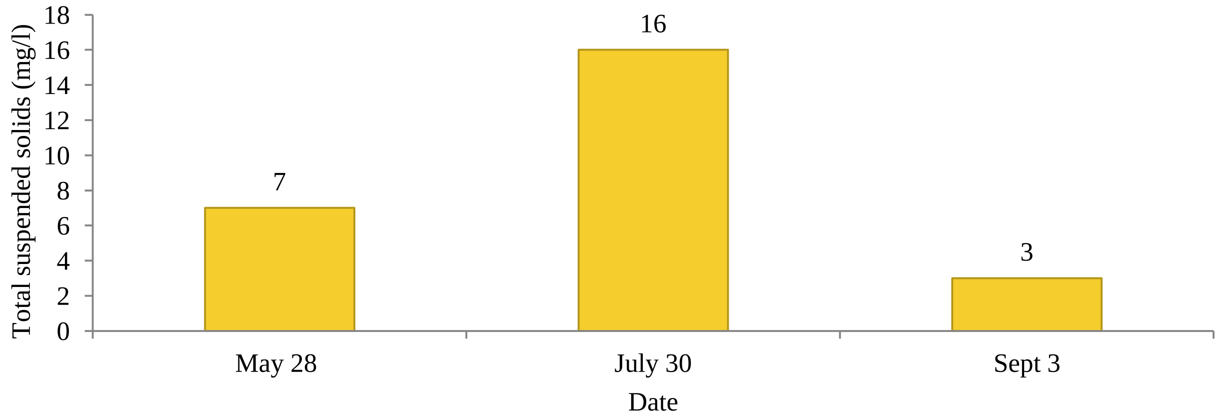


Figure 9. Coon Lake total suspended solids (mg/l), 2010.

Chlorophyll a

Chlorophyll a is a pigment in plants and algae that is necessary for photosynthesis and is an indicator of water quality in a lake. While chlorophyll a gives a general indication of the amount of algae growth in the water column, it is not directly correlated with algae biomass. Chlorophyll a seems to have the greatest impact on water clarity when levels exceed 0.03 mg/l. Lakes which appear clear generally have chlorophyll a levels less than 0.015 mg/l.

On May 28th chlorophyll a concentrations were 0.027 mg/l and on June 29th chlorophyll a concentrations were 0.071 mg/l.

Dissolved Oxygen

Oxygen is required by all aquatic organisms for survival. The amount of oxygen dissolved in water depends on water temperature, the amount of wind mixing that brings water into contact with the atmosphere, the biological activity that consumes or produces oxygen within a lake, and the composition of groundwater and surface water entering a lake. The 2010 growing season oxygen profile for Coon Lake is graphed in Figure 10. The concentration of dissolved oxygen ranged from 10.85 to 3.53 mg/l at the surface of the lake and from 8.36 to 0.02 mg/l at the bottom of the lake. As temperature rises, the ability for a gas to remain in a dissolved state declines. Generally, dissolved oxygen concentrations are higher in spring and late summer/fall when water temperatures are cooler.

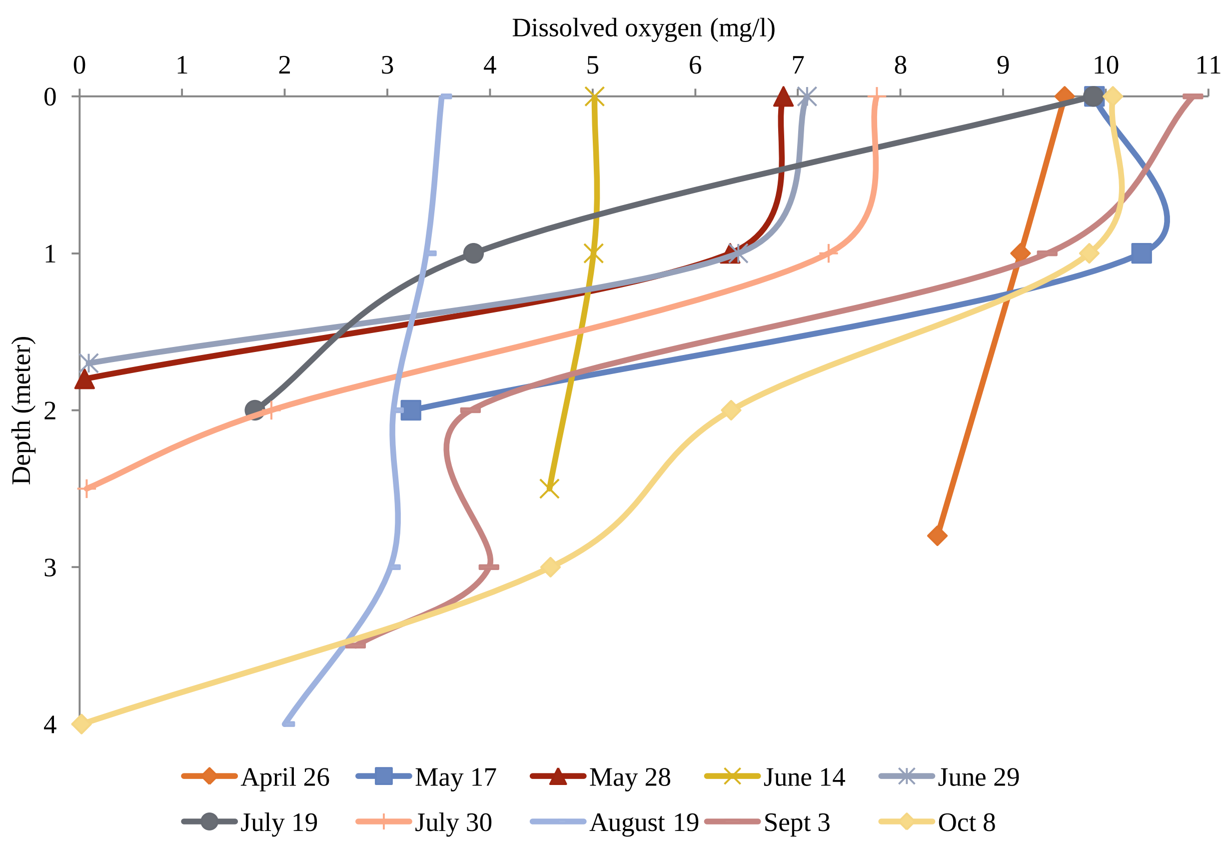


Figure 10. Coon Lake dissolved oxygen (mg/l) profile, 2010.

Temperature

The 2010 growing season temperature profile for Coon Lake is show in Figure 11. The warmest water temperature on the surface of Coon Lake was 26.1 °C on July 30th, 2010. The coldest water temperature on the surface of Coon Lake was 13.4 °C on April 26th, 2010. The water temperature on any given day was only about 1-3°C different at the bottom of the lake as compared to at the top.

Coon Lake has a mixed water column that does not stratify throughout the summer. The lake does not develop water temperature (thus density) differences that create distinct layers in the water column. Instead wind and wave action are able to mix the water of the lake. The constant mixing of the lake water allows oxygen from the atmosphere to be mixed into the water column of most of the lake, but also allows nutrients from the sediments to become re-suspended in the water column thereby adding to the lakes fertility.

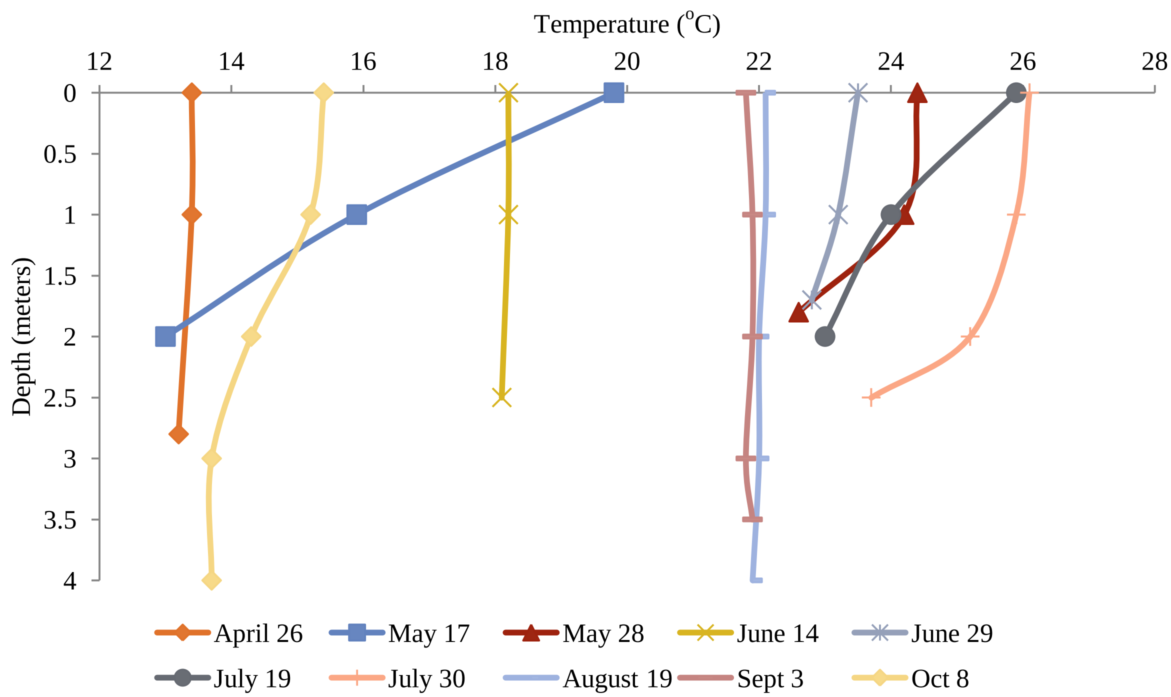


Figure 11. Coon Lake temperature (°C) profile, 2010.

Conductivity

Conductivity is a measure of the ability of water to conduct an electrical current and serves as an indicator of the concentration of dissolved solids in the water. Since conductivity is temperature related, reported values are normalized at 25^{0}C and termed specific conductance. Specific conductance increases as the concentration of dissolved minerals in a lake increase.

The 2010 growing season specific conductance profile of Coon Lake is show in Figure 12. Specific conductance at the surface ranged from a high of 87.6 uS/cm on May 28th to a low of 58.6 uS/cm on August 19th.

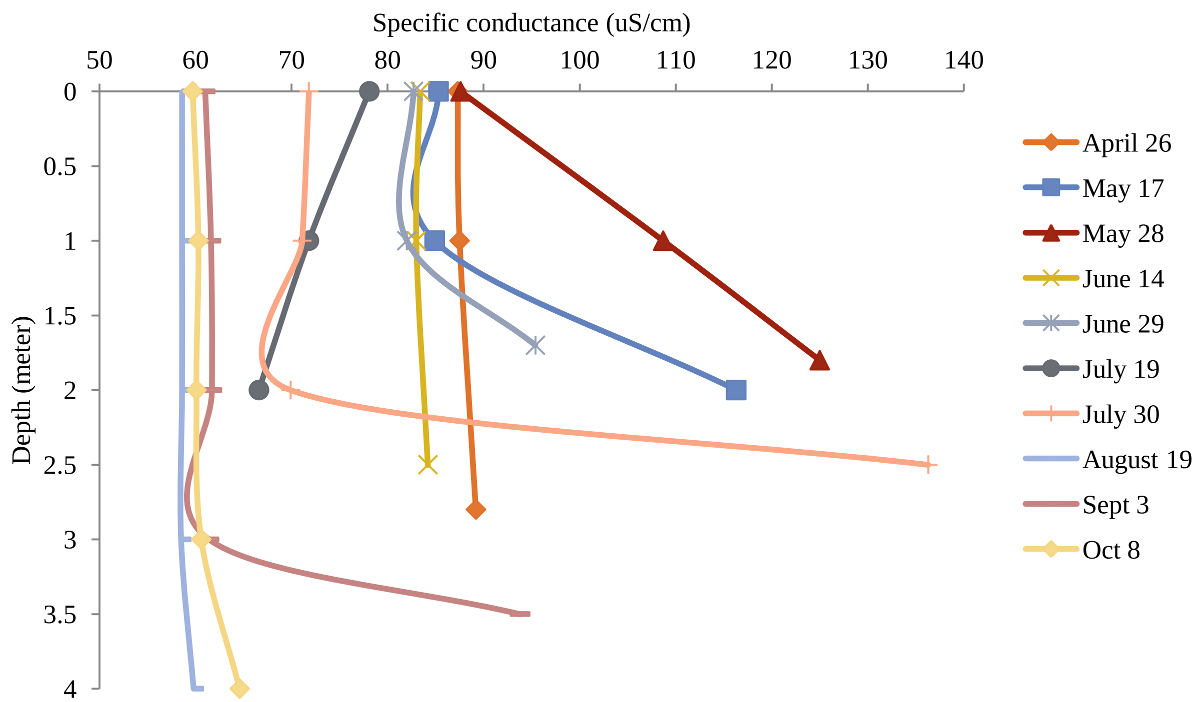


Figure 12. Coon Lake specific conductance (uS/cm) profile, 2010.

pH

pH is a measure of the acidity of the lake. A pH value of 7 is considered neutral. Values less than 7 indicate acidic conditions; whereas, values greater than 7 indicate alkaline conditions. Algae can cause the pH in a lake to increase as they deplete bicarbonate.

Surface pH levels ranged from a high of 8.33 on April 26th to a low of 7.08 on June 14th. pH levels were highest on April 26th and May 17th (Figure 13). Although no algae data exists for April 26th, on May 17th algae populations were at their peak and on June 14th algae populations were at their lowest.

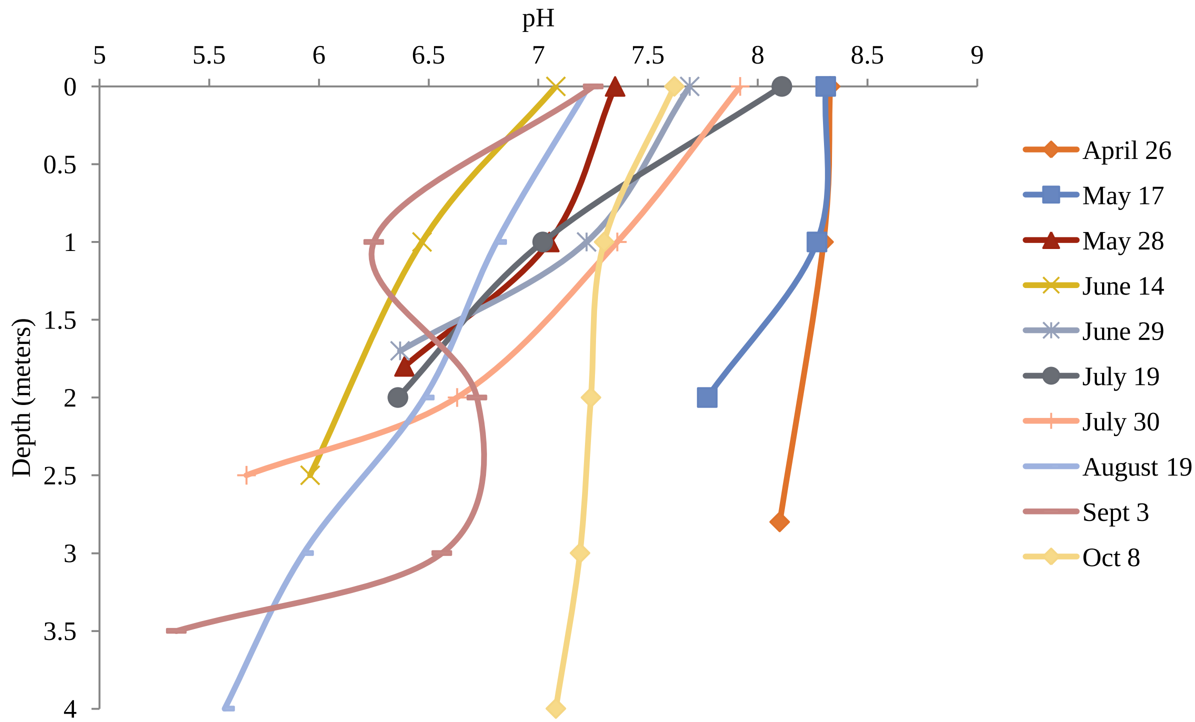


Figure 13. Coon Lake pH profile, 2010.

Secchi Depth

Secchi depth is a measure of the amount of light that can penetrate the water column and serves as a measure of water clarity. Secchi depth is affected by dissolved and suspended materials in the water column, as well as phytoplankton (algae).

Secchi depth ranged from a high of 4 feet on April 26th to a low of 2 feet on both June 29th and July 19th (Figure 14). The average summer Secchi depth (July 15-Septebmer 15) was 2.1 feet.

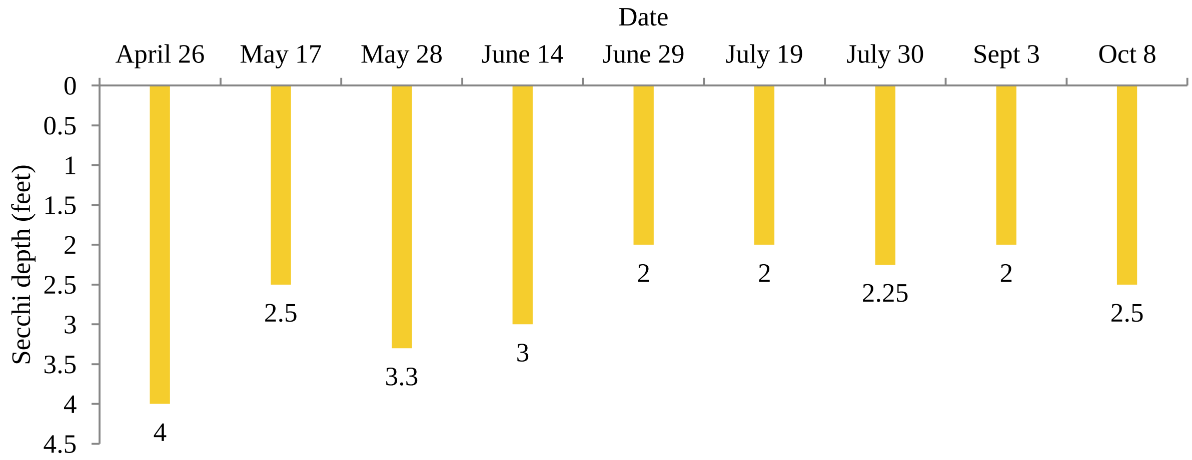


Figure 14. Coon Lake Secchi disk profile, 2010.

Although Secchi depth varies from year to year, summer Secchi depth has been decreasing since 2005 (Figure 15).

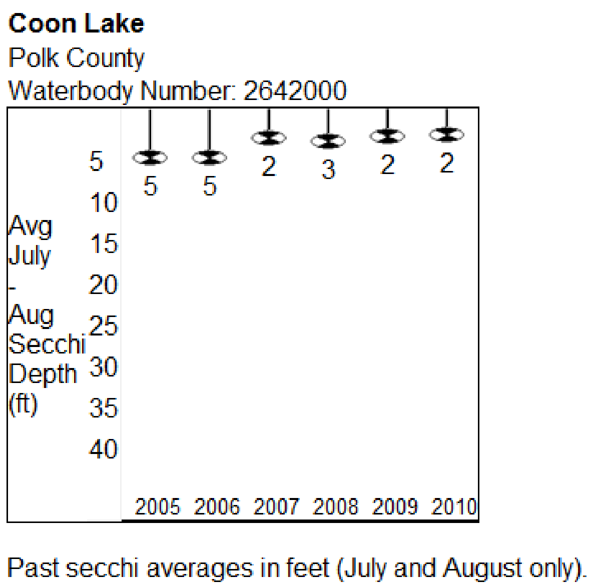


Figure 15. Coon Lake historic Secchi disk profile, 2005-2010.

Trophic State Index (TSI)

Lakes can be divided into three categories based on their trophic states: oligotrophic, eutrophic, and mesotrophic. These categories reflect a lake's nutrient and clarity level and serve as an indicator of water quality. Each category is designed to serve as an overall interpretation of a lake's primary productivity (Figure 16).

Oligotrophic lakes are generally clear, deep, and free of weeds and large algae blooms. These types of lakes are often poor in nutrients and are therefore unable to support large populations of fish. However, oligotrophic lakes can develop a food chain capable of supporting a desirable population of large game fish.

Eutrophic lakes are generally high in nutrients and support a large number of plant and animal populations. They are usually weedy and subject to frequent algae blooms. Eutrophic lakes often support large fish populations but are susceptible to oxygen depletion.

Mesotrophic lakes lie between oligotrophic and eutrophic lakes. They usually have good fisheries and occasional algae blooms.

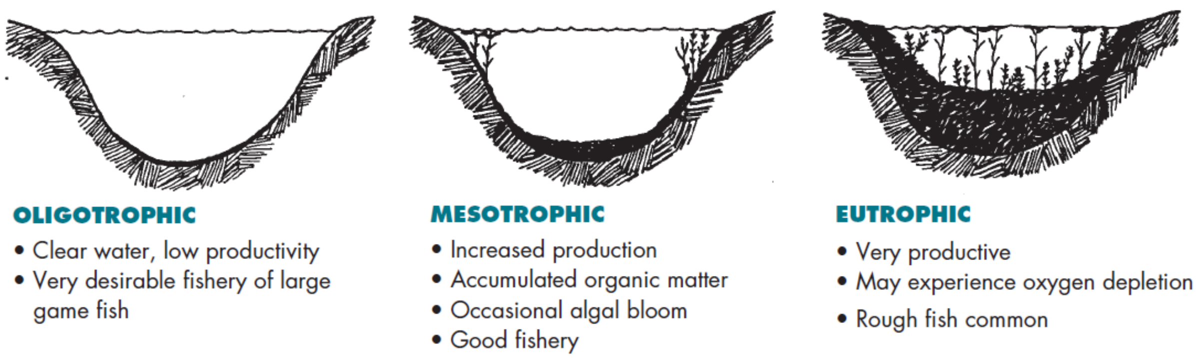


Figure 16. Lake aging process. *Figure from Understanding Lake Data (G3582).*

A common method of determining a lake's trophic state is to compare total phosphorus concentration (important for algae growth), chlorophyll a concentration (an indicator of the amount of algae present), and Secchi disk readings (an indicator of water clarity). Although many factors influence these relationships, the link between phosphorus concentration, chlorophyll a concentration, and Secchi disk readings is the basis of comparison for the Trophic State Index (TSI).

Two equations for summer TSI (July 15-September 15) were examined for Coon Lake. Chlorophyll was not used in the TSI calculation due to a lack of summer data for this parameter.

TSI (P) = 14.42 * Ln [TP] + 4.15 (where TP is in ug/l) = Coon Lake 81
TSI (S) = 60-14.41 * Ln [Secchi] (where the Secchi depth is in meters) = Coon Lake 66

By finding an average of the three values for the TSI equations an overall TSI rating of 73.5 was found for Coon Lake, which indicates that Coon Lake is eutrophic to hypereutrophic (Table 1).

TSI	General Description
<30	Oligotrophic; clear water, high dissolved oxygen throughout the year throughout the lake
30-40	Oligotrophic; clear water, possible periods of oxygen depletion in the lower depths of the lake
40-50	Mesotrophic; moderately clear water, increasing chance of anoxia near the bottom of the lake in summer, fully acceptable for all recreation/aesthetic uses
50-60	Mildly eutrophic; decreased water clarity, anoxic near the bottom, may have a macrophyte problem; warm-water fisheries only.
60-70	Eutrophic; blue-green algae dominance, scums possible, prolific aquatic plant growth. Full body recreation may be decreased
70-80	Hypereutrophic; heavy algal blooms possible throughout the summer, dense algae and macrophytes
>80	Algal scums, summer fish kills, few aquatic plants due to algal shading, rough fish dominate.

Coon Lake TSI Ratings (70-80)

Table 1. Trophic State Index values and descriptions, including Coon Lake's rating.

Sociological Survey

A DNR approved sociological survey was mailed out to four hundred twenty residents in the Village of Frederic in July 2011. The survey was designed to gather information from residents owning property near Coon Lake concerning land use, lake use, lake condition, and the lake's intended use as a guide for future management decisions. The Coon Lake Watershed survey can be found in Appendix D. Sixty-one surveys were returned (response rate = 15%) and data was entered and analyzed. The results of the Coon Lake Watershed survey can be found in Appendix E. The average age of respondents was 62.58 years.

Property Ownership

Respondents have owned property in Frederic, Wisconsin for an average of 22 years, with the majority (89%) living on their property year round. On average, respondents occupy their property 333 days per year.

Land Use

Survey respondents were asked to classify the amount of open space (lawns or mowed areas), shrub/grass/sedge community, woods, and impervious surfaces (buildings, driveways, sidewalks, patios, gravel paths, and driveways) on their property to gauge land use in the area surrounding Coon Lake. On average, 53% of properties are occupied by open space (lawns or mowed areas) and 31% are occupied by impervious surfaces. In general, lawns and mowed areas have compacted soils and plant life with shallow root systems. These areas often have limited infiltration and water holding capacities and are more susceptible to erosion and nutrient runoff. Conversely, on average 9% of properties are occupied by woods and 6% are occupied by shrub/grass/sedge communities. These types of land use generally consist of plants with deep root systems and less compacted soils which allows for greater infiltration, greater nutrient uptake, and in effect less nutrient runoff.

Usage of Coon Lake

Coon Lake is viewed as an asset by the community of Frederic. In the spring and summer months (April-September) survey respondents visit Coon Lake an average of 6.3 times per month. Additionally, in the fall and winter months (October-March) survey respondents visit Coon Lake an average of 3.9 times per month. Coon Lake is surrounded by public land in its entirety and possesses two areas with pavilions and picnic tables, a public park, and a boardwalk. Over half of respondents have used Coon Lake for fishing (56%) and non-motorized water sports such as birding, canoeing, and hiking (51%) within the past year. Eighteen percent of respondents use the public park and picnic areas surrounding Coon Lake (Table 2).

Respondents keep a total of ten canoes/kayaks, nine motorboats/pontoons (1-20 HP), four motorboats/pontoons (21-50 HP), and three paddleboats/rowboats on their property for use on/in Coon Lake.

Activity	Number of respondents	Percent of respondents
Fishing	32	56%
Non-motorized water sports *(birding, canoeing, hiking)*	29	51%
Non-motorized winter activities *(skiing, snowshoeing)*	11	19%
Other, please specify *(Public park/picnic area)*	10	18%
Swimming	6	11%
Motorized water sports *(PWC, boating, water skiing)*	5	9%
Motorized winter activities *(ATV, snowmobile)*	4	7%
Have not been to Coon Lake in the past year	4	7%
Hunting	0	0%

Table 2. Activities survey respondents have done along the shoreline or in Coon Lake within the past year.

Concerns for Coon Lake

Survey respondents were asked to rank their top three concerns for Coon Lake. To analyze this data each concern that ranked first received 3 points, each concern that was ranked 2nd received 2 points, and each concern that ranked third received 1 point. Total points were then added to determine the ranking of concerns for Coon Lake. Pollution (chemical inputs, septic systems, agriculture, erosion, storm water runoff) ranked as the 1st concern for Coon Lake, followed by water levels (loss of lake volume) in 2nd, and invasive species in 3rd (Table 3).

Concerns for Coon Lake	Rank	Points
Pollution *(chemical inputs, septic systems, agriculture, erosion, stormwater runoff)*	1st	98
Water levels (*loss of lake volume*)	2nd	58
Invasive species *(Eurasian water milfoil, zebra mussels, buckthorn, purple loosestrife)*	3rd	33
Quality of fisheries	4th	30
Water clarity *(visibility)*	5th	28
Development *(population density, loss of wildlife)*	6th	16
Aquatic plants *(not including algae)*	7th	14
Property value and/or taxes	7th	14
Harmful algae blooms	9th	10
Quality of life	10th	8
Water recreation safety *(boat traffic, no wake zone)*	11th	7
Other, please specify *(park cleaned/maintained, lack of beach/swimming area)*	11th	7

Table 3. Ranking of concerns for Coon Lake.

Coon Lake Water Quality and Vegetation

Approximately half of respondents (48%) were unsure how to describe the current water quality of Coon Lake. A third of respondents (33%) described the current water quality as good, 18% described the water quality as fair, and 2% described the water quality as poor. Zero respondents described the water quality as excellent.

Respondents were also asked to describe how the water quality in Coon Lake has changed in the time they've owned their property. Approximately half (52%) felt the water quality has remained unchanged. A quarter of respondents felt the water quality has somewhat improved and 8% felt the water quality was greatly improved. On the other side of the spectrum, 13% of respondents felt the water quality has somewhat degraded, and 2% felt that the water quality has severely degraded. A 1961 report on Surface Water Resources of Polk County (Wisconsin Conservation Department) cited that swimming use is limited in Coon Lake by existing conditions and that algae blooms are a particular problem. This information supports the possibility that water quality may have improved over the past fifty years. However, quantitative data does not exist to support his conclusion.

In addition to being asked about water quality, survey respondents were also asked to categorize information regarding terrestrial and aquatic vegetation. Approximately half of respondents (49%) described the amount of current shoreline vegetation at the park on Coon Lake as being just right. Twenty two percent of respondents described the amount of vegetation as too much and 3% described the amount as not enough. A quarter of respondents (25%) were unsure of how to describe the amount of current shoreline vegetation.

Survey respondents were also asked how often aquatic plant growth, including algae, negatively impact their enjoyment of Coon Lake during the open water season. Approximately a third of respondents (35%) stated that plant growth rarely impacts their enjoyment of Coon Lake, approximately a quarter (27%) stated that plant growth never impacts their enjoyment of Coon Lake, and approximately a quarter (27%) stated that plant growth sometimes impacts their enjoyment of Coon Lake. Nine percent of respondents stated that plant growth often impacts their enjoyment of Coon Lake and 2% stated that plant growth always impacts their enjoyment of Coon Lake.

In lieu of the previous question, forty-one percent of respondents are unsure whether aquatic plant control is needed on Coon Lake. On either side of the spectrum, 21% of respondents believe that yes, control is probably necessary and 21% of respondents believe that no, control is probably not necessary. Thirteen percent of respondents believe that aquatic plant control is definitely needed and 5% of respondents believe that aquatic plant control is definitely not needed.

Survey respondents were also asked to describe the importance of wetlands to Coon Lake's water quality. Forty-three percent of respondents described wetlands as very important to Coon

Lake's water quality and 16% described wetlands as somewhat important to Coon Lake's water quality. Slightly more than a third (36%) of respondents were unsure of how to describe the importance of wetlands to Coon Lake's water quality. A mere 3% of respondents described wetlands as not too important to Coon Lake's water quality and 0% of respondents described wetlands as not at all important to Coon Lake's water quality.

Management Practices

From a list of practices, survey respondents were asked to check all the management practices, if any, they do which help protect the Coon Lake Watershed. Over a quarter (27%) of respondents don't implement any management practices to help protect the Coon Lake Watershed (Table 4). Forty-six percent of respondents don't use fertilizer, 44% of respondents partake in roadside cleanup or other attempts to stop pollution, 23% of respondents plant natural grassland and flower species, and 21% of respondents remove plant material from boats after leaving a lake (Table 4). The management practices that survey respondents implement draw a parallel with the 1st (Pollution) and 3rd (Invasive species) ranking concerns for Coon Lake.

Management practice	Number of respondents	Percent of respondents
Not using fertilizer	26	46%
Installing rain gardens	2	4%
Planting natural grassland and flower species	13	23%
Implementing projects to slow runoff	3	5%
Roadside cleanup or other attempts to stop pollution	25	44%
Using no wake near shorelines	6	11%
Removing plant material from boats after leaving a lake	12	21%
Other, please describe (check Coon Lake condition)	1	2%
I do not do any of the above	19	27%

Table 4. Management practices that survey respondents do which help protect the Coon Lake Watershed.

Approximately half (56%) of survey respondents are aware that there is a ban on using fertilizers containing phosphorus within shoreland areas (1000 feet from a lake or 300 feet from a stream) in Polk County. The remainder of survey respondents (44%) are not aware that such a ban exists.

Stormwater Runoff

Survey respondents were given information regarding the fact that stormwater runoff can become a problem when rain water does not soak into the ground after rainfall events. Respondents were then asked how much of a problem, if at all, stormwater runoff is in the Village of Frederic. Thirty-eight percent of respondents were unsure if stormwater runoff is a problem in the Village of Frederic. Twenty-one percent of respondents said stormwater runoff is a moderate problem and 10% of respondents said that stormwater runoff is a large problem.

Conversely, 26% of respondents said that stormwater runoff was a little problem and 5% of respondents said that stormwater runoff in the Village of Frederic is no problem at all.

Financial Support

The last section of the survey regarded the willingness of survey respondents to provide financial support to improve the quality of Coon Lake and its associated land resources. Nearly two thirds (60%) of respondents were unsure if they would be willing to provide financial support and would like more information before making a decision. Approximately a quarter (26%) of respondents were not willing to provide financial support and 14% of respondents were willing to provide financial support to maintain or improve the quality of Coon Lake and its associated land resources.

The survey respondents who noted they would be willing to provide financial support were also asked approximately how much they would be willing to contribute each year. The survey stated that the question was only designed to give an indication of possible support and that it was not intended to act as a commitment for financial support. The survey respondents who would be willing to provide financial support to maintain or improve the quality of Coon Lake and its associated land resources were willing to contribute an average of $77.50 per year. Respondents were willing to contribute a range of $20-200 per year.

Phytoplankton

Algae, also called phytoplankton, are microscopic plants that convert sunlight and nutrients into biomass, which may or may not be consumable. They are the primary producer in an aquatic ecosystem and respond quickly to changes in water chemistry. The size of different types of algae is an important determination of what types of zooplankton can graze upon them. Because of their short life cycle, changes in water quality are often reflected by changes in the algal community within a few days or weeks. Determination of the numbers and types of algae present in a water body is useful in environmental monitoring programs, impairment assessments, and the identification of management strategies.

Algal morphologies can be unicellular, planktonic, colonial, pseudo filamentous, filamentous, or take other forms. Algae are classified by a combination of their characteristics including photosynthetic pigments (like chlorophyll a), starch-like reserve products, cell covering, and other aspects of cellular organization.

The types of algae in a lake will change over the course of a year. Typically there is less biological activity in winter and spring because of ice cover and cold temperatures. As the lake warms up and gains access to more sunlight, algae communities begin to grow. Their short life span quickly cycles the nutrients in a lake and affects nutrient dynamics. Algae can live on bottom sediments and substrate, in the water column, and on plants and leaves. The genus and species present in a lake are influenced by environmental factors like climate, phosphorus, nitrogen, silica and other nutrient content, carbon dioxide, grazing, substrate, and other factors in the lake. When high levels of nutrients are available, blue green algae often become predominant.

Chlorophyll a is a pigment in plants and algae this is necessary for photosynthesis. While chlorophyll a gives a general indication of the amount of algae growth in the water column, it is not directly correlated with algae biomass. Certain flora also contain accessory pigments for photosynthesis making universal statements about algal communities and quality based on chlorophyll a samples difficult to make. For this reason, composite samples from a 2 meter water column were collected monthly and sent to the State Lab of Hygiene for identification and enumeration of algae species present in Coon Lake. Algae from the samples were identified to genus and a relative concentration and natural unit count was made to describe the assemblage throughout the growing season. Coon lake phytoplankton data can be found in Appendix F. This method of sampling also allows the identification of any species of concern which might be present.

There are 12 classes of algae found in typical lakes of Wisconsin. Five classes were found in Coon Lake (Table 5):

Algal Class	Common Name	Characteristics
Chlorophyta	Green Algae	Have a true starch and provide high nutritional value to consumers. Can be filamentous and intermingle with macrophytes.
Bacillariophyta	Diatoms	Have a siliceous frustule that makes up the external covering. Sensitive to chloride, pH, color, and total phosphorus (TP) in water. As TP increases, a decrease in diatoms is seen. Generally larger in size. Tend to be highly present in spring and late spring. Can be benthic or planktonic.
Cryptophyta	Cryptomonads	Have a true starch. Planktonic. Bloom forming, are not known to produce any toxins and are consumed by small zooplankton. Cryptomonads frequently dominate the phytoplankton assemblages of the Great Lakes.
Cyanophyta	Blue Green Algae	Prevail in nutrient-rich standing waters. Blooms can be toxic to zooplankton, fish, livestock, and humans. Can be unicellular, colonial, planktonic, or filamentous. Can live on almost any substrate. More prevalent in late to mid-summer.
Pyrrhophyta	Dinoflagellates	Have starch food reserves and serve as food for grazers

Table 5. Characteristics of the five classes of algae found in Coon Lake, 2010.

The highest algae counts (natural units/ml) were on May 17th as a result of a drastic spike in the cyanophyta population (Figure 17). After this peak, the algae population crashed to a low on June 14th and began to recover and reach a somewhat steady state (Figure 18).

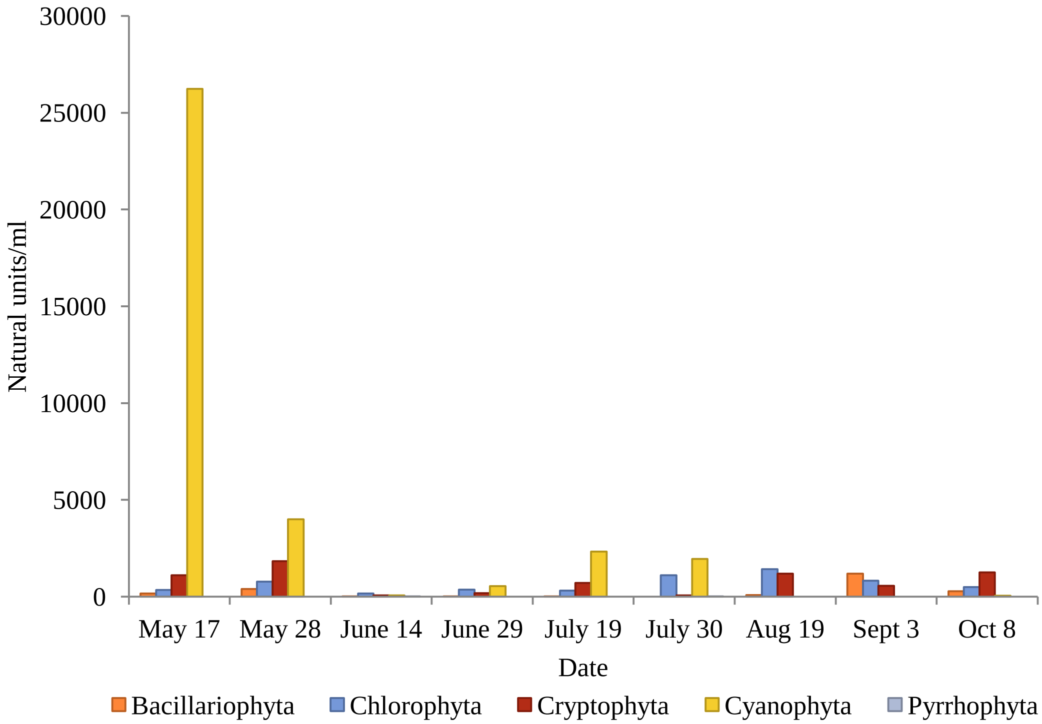


Figure 17. Natural units/ml of each algae division, Coon Lake, 2010.

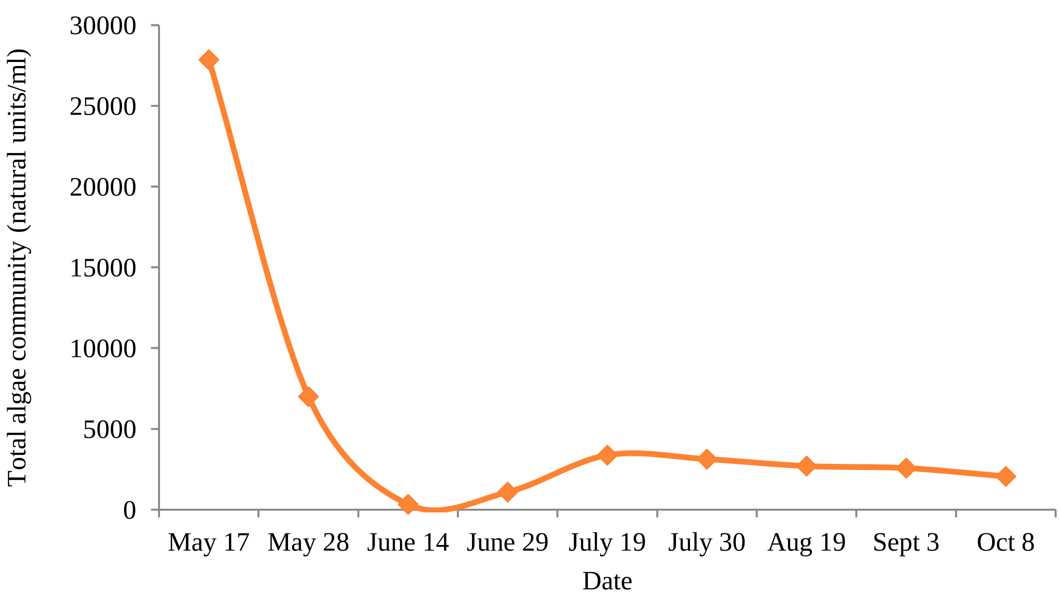


Figure 18. Total algae community (natural units/ml), Coon Lake, 2010.

During May, the algae community was dominated by cyanophyta, or blue green algae. This class of algae also dominated the community in July and to a lesser extent on June 29th. June 14th and July 30th were the only sampling dates where pyrrhophyta, or dinoflagellates, were present. Bacillariophyta, or diatoms, made up a very small percentage of the algal community on all samplings dates, with the exception of September 3rd where they make up over 40% of the algal community. Chlorophyta, or green algae exhibit a pattern of increases and decreases in dominance over the course of the year. Cryptophyta, or cryptomonad, dominance of the community remained fairly constant but increased to 44.1% of the total community on August 19th and 60.8% on October 8th (Figure 19).

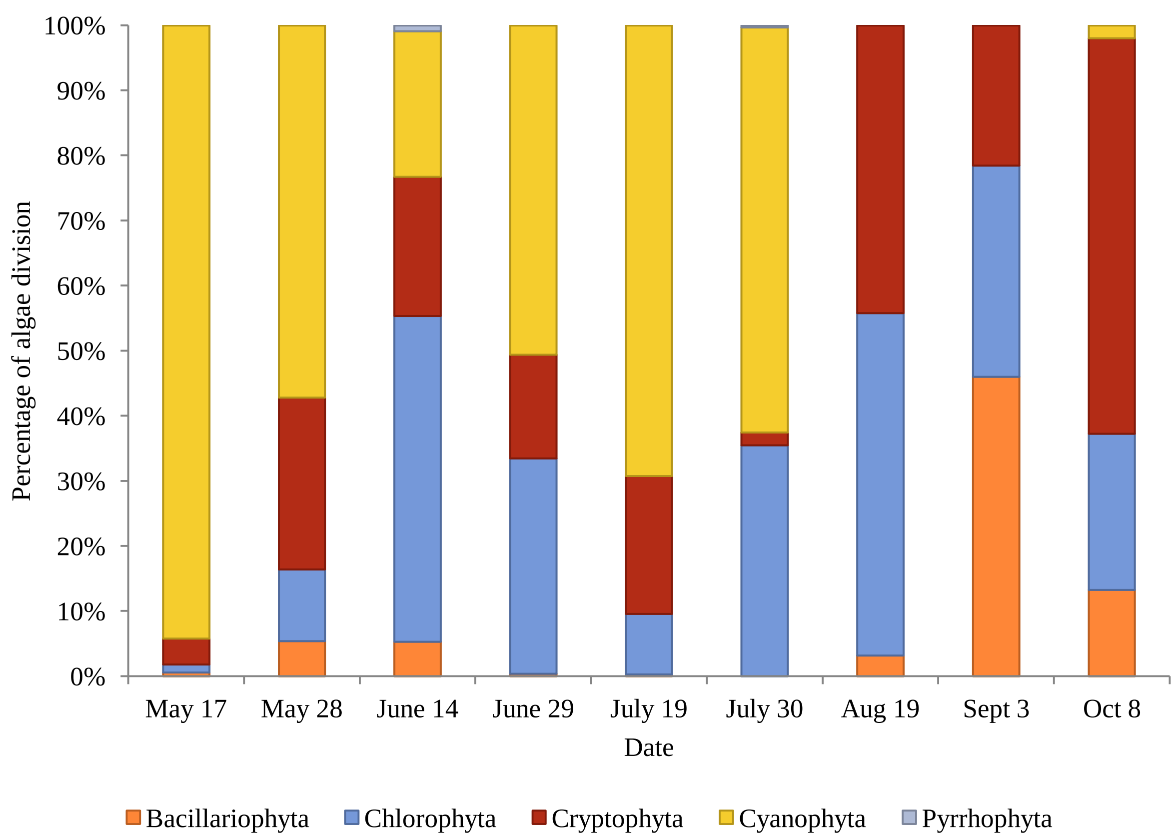


Figure 19. Percentage of each algae division, Coon Lake, 2010.

While blue-green algae, also called cyanophyta or cyanobacteria, have been around for billions of years and typically do bloom each summer, blue-green algae blooms may be more frequent because of the increased nutrients reaching our waters or being released from the sediments themselves, which occurs in mixed lakes such as Coon Lake. One of the primary concerns with cyanobacteria beyond aesthetics stems from the production of cyanotoxins.

Cyanotoxins are naturally produced chemical compounds that are sometimes found inside the cells of certain blue green algae species. Depending on the type of toxin that an algae species produces, these chemicals can affect the skin and mucous membranes with an allergy-like reaction, cause damage to the liver or internal organs, or affect the central nervous system. It is not know which environmental conditions cause the production of cyanotoxins, but scientists have found that when blue green algae is present in concentrations over 100,000 cells/ml toxin production is more likely to occur. The difference between the algae units of cells/ml and units/ml depends on how the algae live, either as a free cell or colonial. The blue green algae species that are capable of producing toxins were counted as individual units/ml of sample (in addition to the natural units that they occur in) to determine their ultimate concentration.

On Coon Lake, there were no samples where blue green algae concentrations were above 100,000 units/ml, or the concentration at which algae are capable of producing toxins. The highest concentration occurred on May 17th with a value of 26,229 natural units/ml (Figure 20).

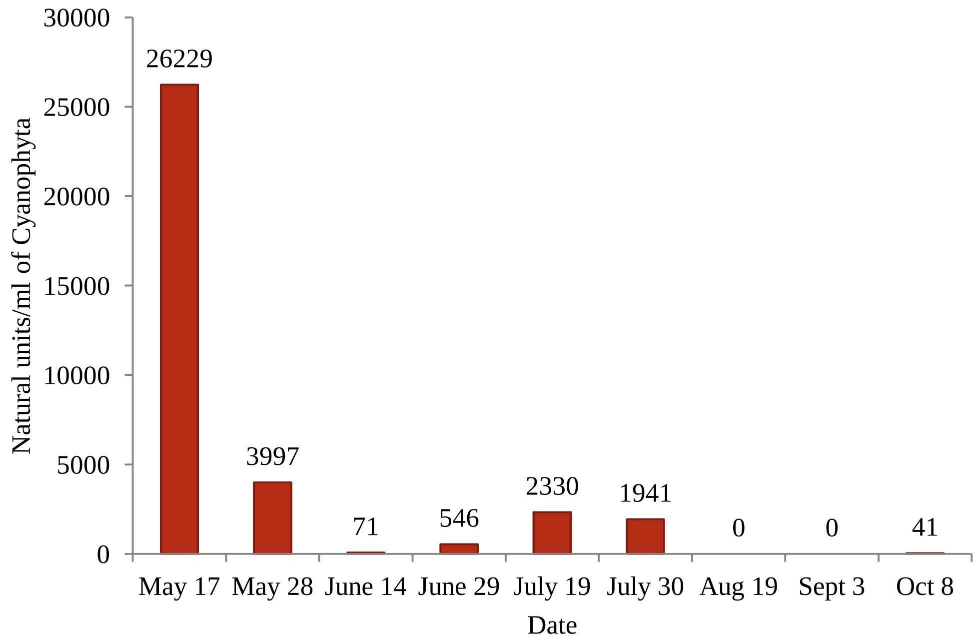


Figure 20. Natural units/ml of Cyanophyta, Coon Lake, 2010.

Zooplankton

Zooplankton are small aquatic animals which range in size from 0.03 to 3 mm long. The three primary components of the zooplankton community are rotifers, copepods, and cladocerans.

Rotifers are size selective omnivores that eat algae, zooplankton, and sometimes each other. However, due to their small size rotifers are not capable of significantly reducing algal biomass although they are able to shift the algae community to favor larger species.

Copepods are size selective omnivores which feed on algae and other plankton. They are eaten by larger plankton and are preyed heavily upon by planktivores like pan fish and minnows and the fry of larger fish.

Cladocerans are filter feeders that play an important part in the food web. Species of cladocerans (particularly *Daphnia*) are well known for their ability to reduce algal biomass and help maintain a clear water regime in lake ecosystems.

Zooplankton are often overlooked as a component of aquatic systems, but their role in ecosystem function is extremely important. Lake systems are valued primarily for water clarity, fishing, or other recreation, all of which are strongly linked to water quality and ecosystem health. Zooplankton are the primary link between the "bottom up" processes and "top down" processes of the lake ecosystem.

"Bottom up" processes include factors such as increased nutrients which can cause noxious algal blooms. Zooplankton have the ability to mediate algae blooms by heavy grazing. Conversely, shifts in algal composition, which can be caused by increased nutrients, can change the composition of the zooplankton community. If the composition shifts to favor smaller species of zooplankton, for example, algal blooms can be intensified, planktivorous fish can become stressed, and the development of fry can be negatively impacted.

"Top down" processes include factors such as increased fish predation. Increases in planktivorous fishes (pan fish) can dramatically reduce zooplankton populations and lead to algal blooms. In some lakes biomanipulation is utilized to manage this effect and improve water clarity. Picivorous fish (fish that eat other fish) are used to reduce planktivorous fish. This in turn increases zooplankton populations and ultimately reduces algae populations.

Zooplankton also respond to changes to lakeshore and the littoral zone communities. Changes in the aquatic plant community and shoreland habitat impact plankton populations both directly and indirectly. This occurs especially in shallow lakes where zooplankton are more likely to have the ability to migrate horizontally to avoid predation from fish and other invertebrates.

Zooplankton were sampled from Coon Lake during the 2010 ice free season. Samples were collected mid-lake on a monthly basis beginning in late May and ending in early October and counted and identified at the St. Croix Watershed Research Station of the Science Museum of

Minnesota. This analysis shows the abundance of the major zooplankton groups: cladocera, copepoda, and rotifer in Coon Lake. The Coon lake zooplankton data and report can be found in Appendix G.

In both May samples the zooplankton community was dominated by rotifers in terms of abundance and biomass. In June and July the community shifted to a dominance of cladocera in terms of abundance and biomass. In August, cladoceran dominated the community in terms of abundance; whereas rotifer dominated the community in terms of biomass. In August and September zooplankton populations reached their peak with regard to abundance and biomass which was followed by a decline (Figure 21, Figure 22, Figure 23, and Figure 24).

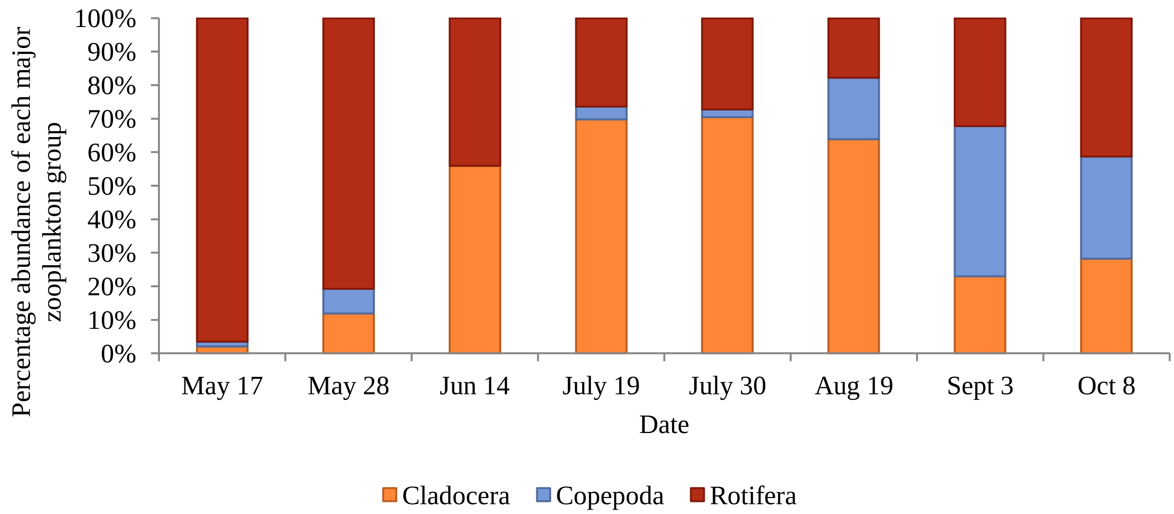


Figure 21. Percent abundance of the major zooplankton groups, Coon Lake, 2010.

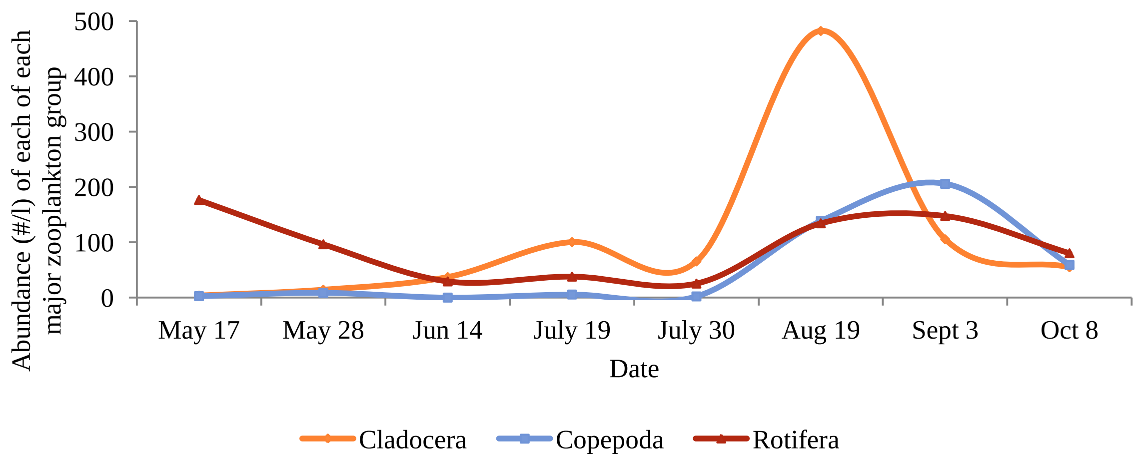


Figure 22. Abundance (#/l) of the major zooplankton groups, Coon Lake, 2010.

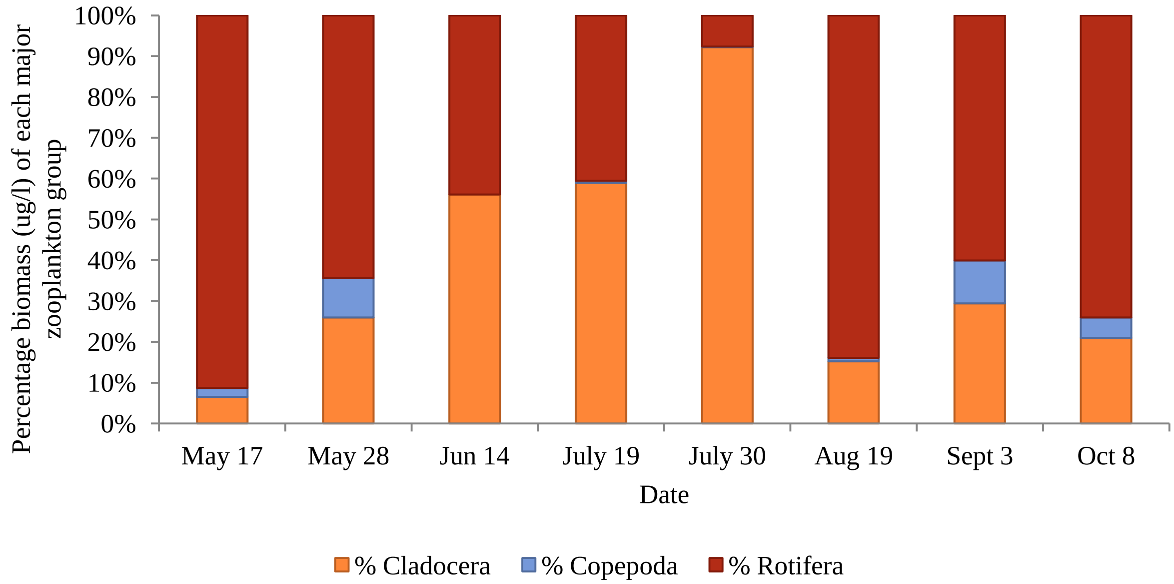


Figure 23. Percentage biomass of the major zooplankton groups, Coon Lake, 2010.

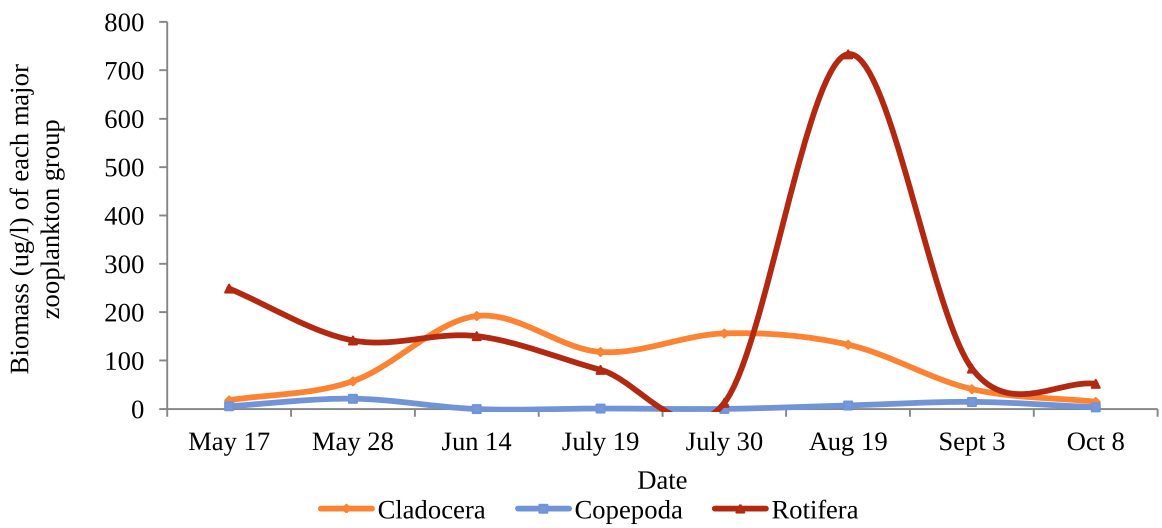


Figure 24. Biomass (ug/l) of the major zooplankton groups, Coon Lake, 2010.

Point Intercept Macrophyte Survey

An aquatic macrophyte survey was carried out on Coon Lake on September 13th, 2010. One hundred thirty eight sampling points were established in and around the lake using a standard formula that takes into account the shoreline shape and distance, islands, water clarity, depth, and total lake acres (Figure 25). Points were generated in ArcView (a GIS program) and downloaded to a GPS unit. These points were then sampled in field.

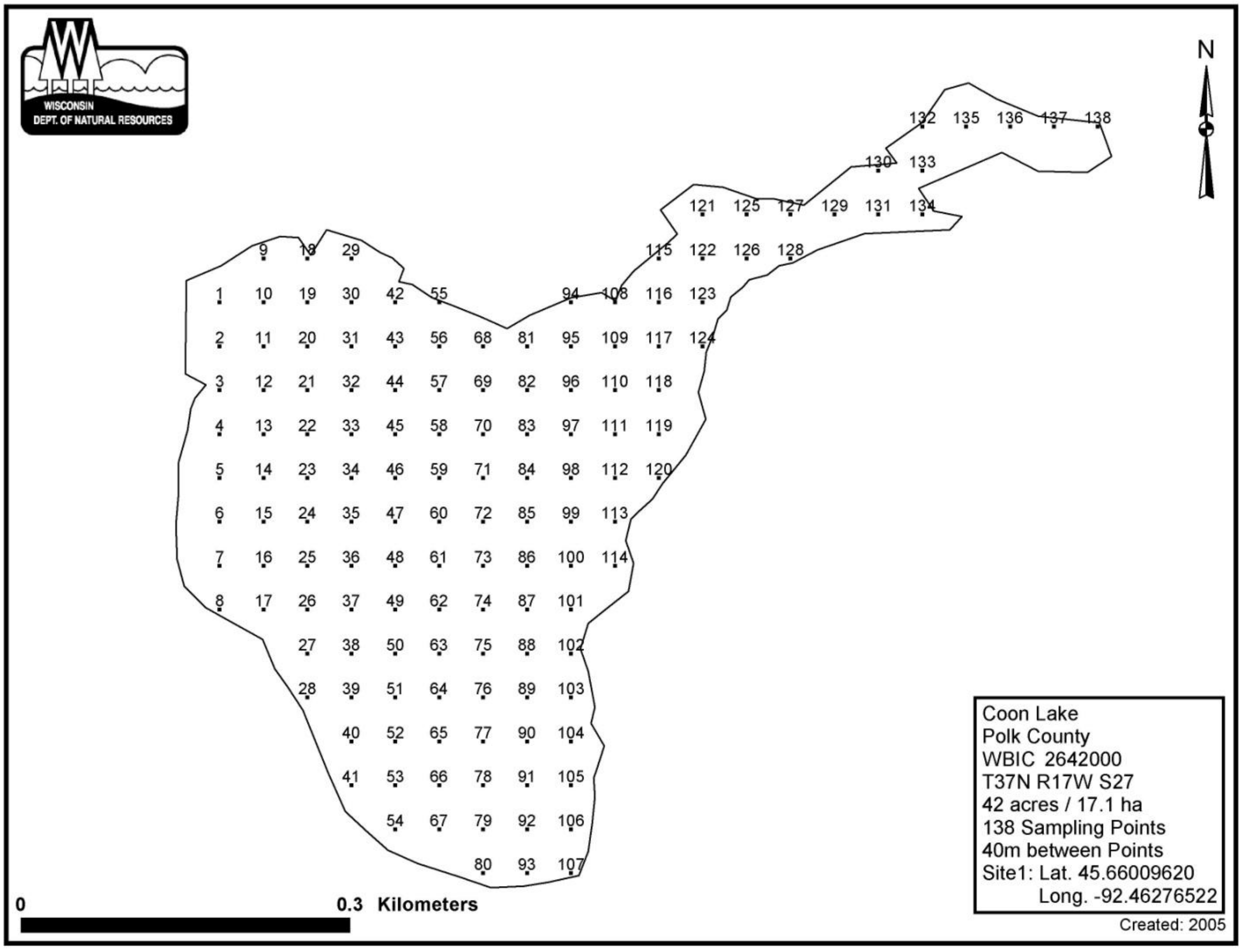


Figure 25. Coon Lake sampling points for point intercept macrophyte survey, 2010.

During the point intercept survey, each sampling point was located using a handheld mapping GPS unit. The depth at each sampling point was recorded using a handheld depth finder. At each sampling point a rake, either on a pole or throw line depending on depth, was used to sample the plant community of an approximately 1 meter section of the benthos. All plants on the rake, as well as any that were dislodged by the rake, were identified to species and assigned a rake fullness value of 1 to 3 to estimate abundance (Table 6). Visual sightings of plants within six feet of the sample point were also recorded. The lake bottom type, or substrate, was also assigned at each sampling point where the bottom was visible or it could be reliably determined using the rake. Data was collected at each sampling point, with the exception of those that were too shallow or terrestrial. Shallow communities were characterized visually. Although one hundred and thirty eight sampling points were established in Coon Lake it was only possible to sample ninety-eight sampling points due to decreased water levels. Coon Lake point intercept aquatic macrophyte results can be found in Appendix H.

Rating	Coverage	Description
1		A few plants on rake head
2		Rake head is about ½ full Can easily see top of rake head
3		Overflowing Cannot see top of rake head

Table 6. Rake fullness ratings as an estimation of abundance.

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

- Frequency of occurrence for all sample points in lake
- Relative frequency
- Sample points with vegetation
- Species richness
- Simpson's diversity index
- Maximum plant depth
- Floristic Quality Index

The following are explanations of the various analysis values with data from Coon Lake:

Frequency of Occurrence

Two values are computed for frequency of occurrence. The first value is a percentage of all sample points that a specific species was found at and is used to compare the frequency of occurrence across an entire lake. The second value is a percentage of all littoral sample points that a specific species was found at and is used to compare the frequency of occurrence only where plants are probable. The first value shows how often the plant would be encountered *everywhere in the lake*; whereas, the second value shows how often the plant would be encountered *only within the depths plants potentially grow*. In both instances, the greater the value, the more frequently the plant would be encountered in the lake.

Frequency of occurrence example:
Plant A sampled at 35 of 150 total points = 35/150 = 0.23 = 23%
Plant A's frequency of occurrence = 23% considering whole lake sample.
This frequency can tell us how common the plant was sampled in the entire lake.

In Coon Lake the frequency of occurrence values within the entire lake and within the littoral zone were highest for filamentous algae, followed by reed canary grass, a non-native species (Table 7).

Relative Frequency

Relative frequency is the frequency of a particular plant species relative to other plant species. This value is in-dependent of the number of points sampled. Relative frequency can be used to show which plants are the dominant species in a lake. The higher the value a species has for relative frequency, the more common the species is compared to others. The relative frequency of all plants will always add up to 100%. If species A had a relative frequency of 30%, this species occurred 30% of the time compared to all the species sampled or makes up 30% of all species sampled.

Relative frequency example:
Suppose we were sampling 10 points in a very small lake and got the following results:
Plant A present at 3 of 10 sites
Plant B present at 5 of 10 sites
Plant C present at 2 of 10 sites
Plant D present at 6 of 10 sites

Plant D is the most frequently 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 of Plant D is compared to other plants, without taking into account the number of sites. This value 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.

The relative frequency values in Coon Lake were highest for filamentous algae (77.8%), followed by reed canary grass (11.1%), an invasive species (Table 7).

Species scientific name	Species common name	Frequency of occurrence in entire lake	Frequency of occurrence in littoral zone	Relative frequency
Filamentous algae	Filamentous algae	82.35%	31.82%	77.8%
Phalaris arundinacea	Reed canary grass	11.76%	4.55%	11.1%
Polygonum amphibium	Water smartweed	5.88%	2.27%	5.6%
Schoenoplectus tabernaemontani	Softstem bulrush	5.88%	2.27%	5.6%

Table 7. Coon Lake aquatic macrophyte frequency of occurrence and relative frequency, 2010.

Sample Points with Vegetation

This value shows the number of sites where plants were actually collected and gives an approximation of the plant coverage of a lake. If 10% of all sample points had vegetation, then it is implied that approximately 10% of the lake is covered with plants.

Seventeen sites out of a total of ninety-eight sites had vegetation. This implies that approximately 17.35% of Coon Lake is vegetated.

Species Richness

Species richness is a measure of the number of different individual species found in a lake. Species richness can be computed based on plants sampled or based on plants sampled/visually seen during the survey.

Coon Lake has an extremely low value for species richness, with only four species being sampled or visually seen during the survey. One of these species was filamentous algae and another was reed canary grass which is a non-native species. In effect, only the two remaining species (water smartweed and softstem bulrush) could be considered desirable.

Simpson's Diversity Index

Simpson's Diversity Index (D) is used to determine how diverse the plant community in a lake is by measuring the probability that two individuals randomly selected from a sample will belong to the same species (or some category other than species). This value ranges from zero to one, with greater values representing more diverse plant communities. In theory the value for Simpson's diversity index is the chance that two species that are sampled will be different. An index of one means that the two plants sampled will *always* be different (very diverse) and an index of zero means that the two plants sampled will *never* be different. Simpson's diversity index can be calculated by using the equation

$$D = \frac{\sum n(n-1)}{N(N-1)};$$

Where: D = Simpson's Diversity Index;
n= the total number of organisms of a particular species; and
N=the total number of organisms of all species.

Simpson's Diversity Index example:

If one went into a lake and found just one plant, the Simpson's Diversity Index would be "0." This is because if two plants were sampled randomly, 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 Index would be "1." This is because if two plants were sampled randomly, there would be a 100% chance they would be different since every plant is different.

These are extreme and theoretical scenarios, but they do make the point. The greater the Simpson's Diversity Index is for a lake, the greater the diversity since it represents a greater chance of two randomly sampled plants being different.

The Simpson's Diversity Index on Coon Lake was calculated to be 0.38, which is extremely low and likely results from Coon Lake being a man-made waterbody.

Floristic Quality Index

The Floristic Quality Index (FQI)is designed to evaluate the closeness of the flora in an area to that of an undisturbed condition. It can be used to identify natural areas, compare the quality of different sites or locations within a single lake, monitor long-term floristic trends, and monitor habitat restoration efforts. This is an important assessment in Wisconsin because of the demand by the Department of Natural Resources (DNR), local governments, and riparian landowners to consider the integrity of lake plant communities for planning, zoning, sensitive area designation, and aquatic plant management decisions.

The Floristic Quality Index takes into account the species of aquatic plants found and their tolerance for changing water quality and habitat modification using the equation $I = \overline{C}\sqrt{N}$

Where I is the Floristic Quality Index;
$\overline{C}$ is the average coefficient of conservation (obtainable from http://www.botany.wisc.edu/wisflora/FloristicR.asp); and
$\sqrt{N}$ is the square root of the number of species.

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 of change while a lower value indicates a plant is tolerant of change. Those plants with higher values are more apt to respond adversely to water quality and habitat changes. The FQI is calculated using the number of species and the average conservatism value of all species used in the Index. Therefore, a higher FQI, indicates a healthier lake plant community. It should be noted that invasive species have a conservatism value of 0.

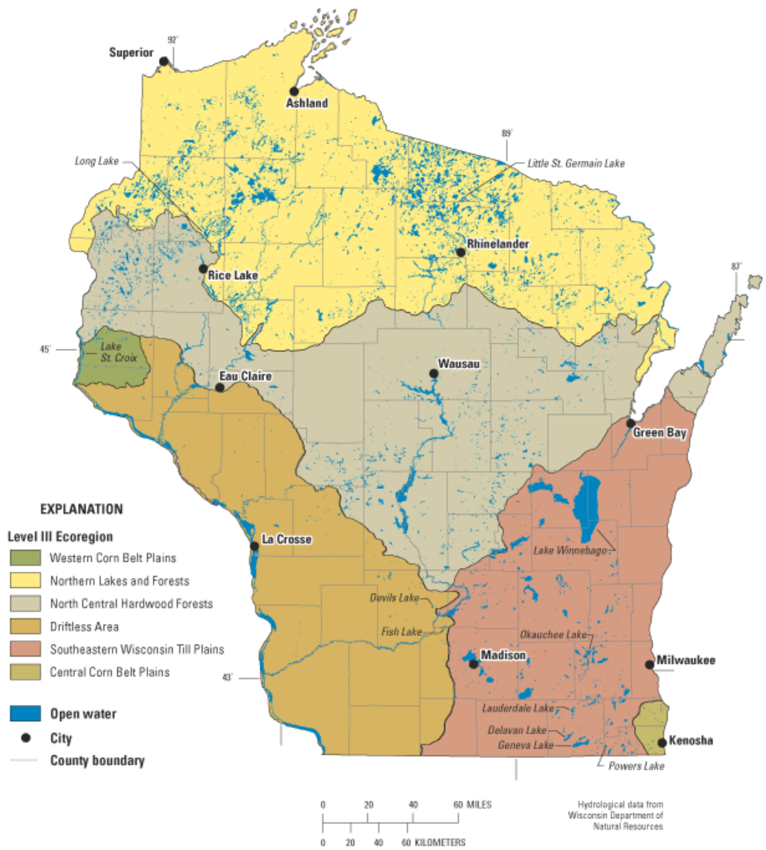


Figure 26. Wisconsin Eco-regions map. (USGS, 2003).

Summary of North Central Hardwood Forest values for Floristic Quality Index:

Mean species richness = 14
Mean average conservatism = 5.6
Mean Floristic Quality = 20.9*

**Floristic Quality has a significant correlation with area of lake (+), alkalinity (-), conductivity (-), pH (-) and Secchi depth (+). With a positive correlation, as that value rises so will FQI. With a negative correlation, as a value rises, the FQI will decrease.*

Summary of Coon Lake values for Floristic Quality Index:

Mean species richness = 2
Mean average conservatism = 4.5
Mean Floristic Quality = 6.36

Coon Lake Floristic Quality Index data can be found in Appendix I.

Exotic Species Inventory

In 2010 and 2011 an exotic species inventory was conducted in and around Coon Lake. The 2011 exotic species inventory was conducted as part of the WDNR Smart Prevention Protocol. The only aquatic invasive species found in 2011 were narrow leaf cattail and reed canary grass, which were both at low densities around the lakeshore. Japanese knotweed was not located on the shoreline of Coon Lake; however, numerous know sites exist in the Village of Frederic, Wisconsin (Figure 27).

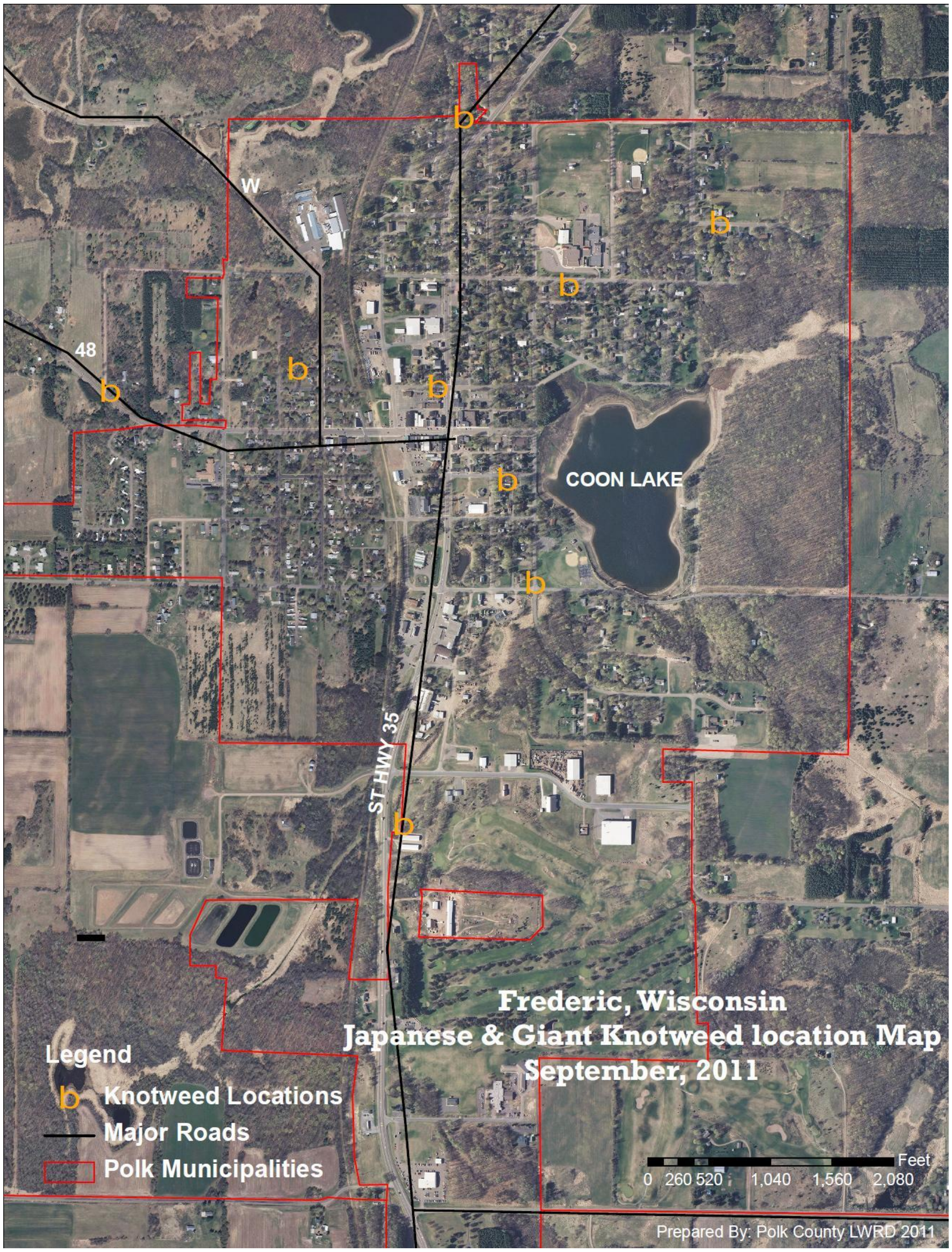


Figure 27. Japanese knotweed sites in Frederic, Wisconsin, as of September 2011.

The following information on Japanese knotweed is taken from the Wisconsin DNR website:

Japanese Knotweed

(*Polygonum cuspidatum.; syn. Polygonum zuccarini, Fallopia japonica, or Reynoutria japonica*)

Figure 28. Japanese knotweed.

Also known as Japanese bamboo, Japanese fleece-flower, and Mexican bamboo.

Description: Japanese knotweed, in the buckwheat family, is a perennial that grows to heights of 5-10 feet in large clones up to several acres in size. The arching stems are hollow and bamboo-like, a reddish-brown to tan color; they die, but remain upright through the winter. Mature leaves are 3-5" wide and 4-9" long, lighter on the lower surface, and egg to spade shaped; young leaves are heart-shaped. Lacy 2 inch long clusters of tiny greenish-white flowers are produced in late summer and held upright at the leaf base. Japanese knotweed reproduces occasionally by seed, but spreads primarily by extensive networks of underground rhizomes, which can reach 6 feet deep, 60 feet long, and become strong enough to damage pavement and penetrate building foundations.

Look-alikes: Another much less widespread invasive species, giant knotweed (Polygonum sachalinense), is similar, but can grow taller and has much larger leaves (up to 12" long). The upper surface of Japanese knotweed has an extremely fine-sandpaper feel in contrast to the fine-leather feel of giant knotweed.

Impacts & Habitat: Introduced in the late 1800s, Japanese knotweed is now found throughout much of North America. It is especially widespread in the coastal Pacific Northwest, in the East from Newfoundland to North Carolina, and in the Midwest. It is often considered to be the most troublesome weed in Great Britain. It grows in a variety of habitats, in many soil types, and a range of moisture conditions. Of particular concern is its tendency to invade valuable wetland habitat and line the banks of creeks and rivers where it often forms an impenetrable wall of stems, crowding out native vegetation and leaving banks vulnerable to erosion when it dies in winter. It is also found along roads, railroads, utility pathways, and strip-mining areas. In addition to spreading by rhizomes and seed, it is often spread by streams, by transportation of fill dirt, or through roadside plowing.

Control: Attempting to remove Japanese knotweed by pulling or digging is generally ineffective due to its extensive underground rhizome network; it may even promote further spreading if pieces of the plant are not disposed of properly. Herbicide application has been effective, when the entire clone is treated repeatedly. Applications of herbicides containing glyphosate are typically used after spring leaf out and on resprouts emerging after cutting.

Land Use

The area of land that drains towards a lake is called the watershed. The watershed area of Coon Lake, including the lake itself is approximately 858 acres. The lake itself is 42 acres, and is represented in Figure 29 as 5% of the total land use in the Coon Lake Watershed. The majority of the Coon Lake Watershed is forest (41%) followed by medium density residential (1/4 acre per person, 20%), pasture/grass (13%), and row crop (7%). The remainder of land use is made up of commercial (3%), open space (3%), rural residential (more than 1 acre per person, 3%), school grounds (3%), and wetland (2%).

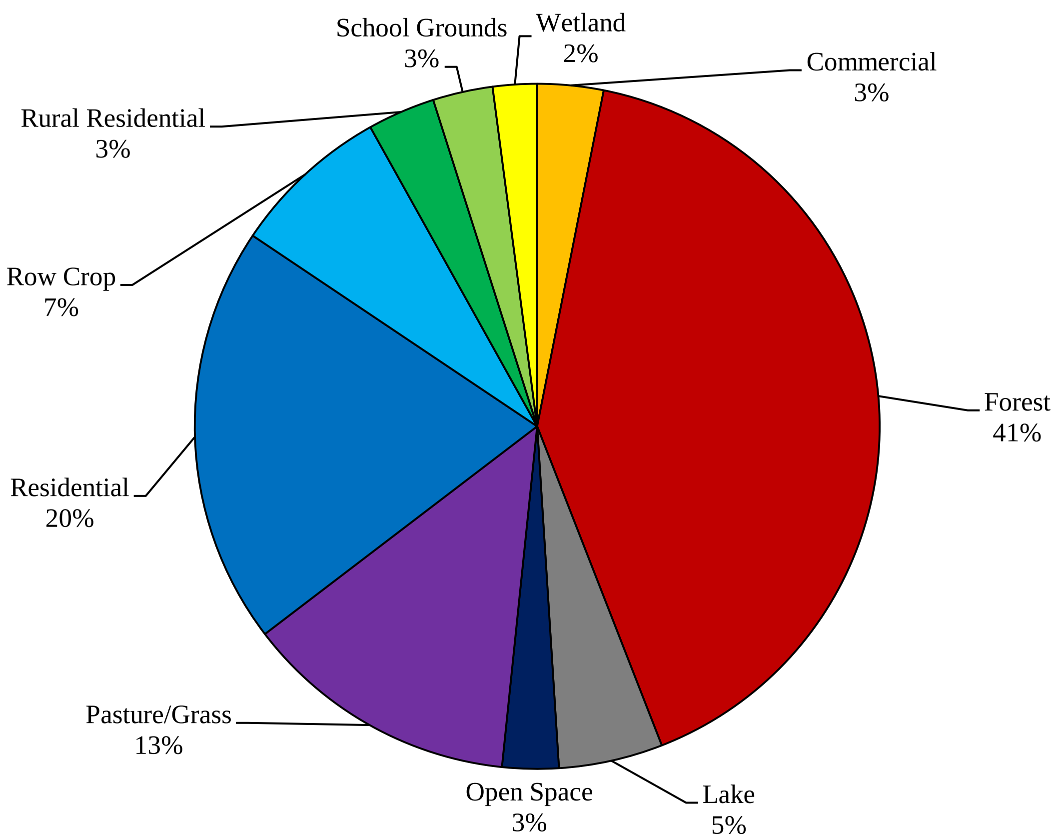


Figure 29. Land use (%) in Coon Lake Watershed.

The majority of the shoreline of Coon Lake is forest and open space (Figure 30). The amount of runoff which reaches a lake depends largely on the associated land use. This is important because runoff from precipitation events carry nutrients, organic material, and contaminants to Coon Lake. Natural communities, such as forests and wetlands, allow for more infiltration of precipitation when compared with developed residential sites containing lawn, rooftops, sidewalks, and driveways. Median surface runoff estimates from wooded catchments are an order of magnitude less than those from lawn catchments. Additionally, the increased water volumes from the lawn catchments resulted in greater nutrients loads from the developed sites.

The forest and wetland areas in the Coon Lake watershed are sensitive areas that should be preserved for their ability to protect water quality. Wetlands provide extensive ecosystem services by filtering nutrients and slowing the flow of water and the impacts of erosion.

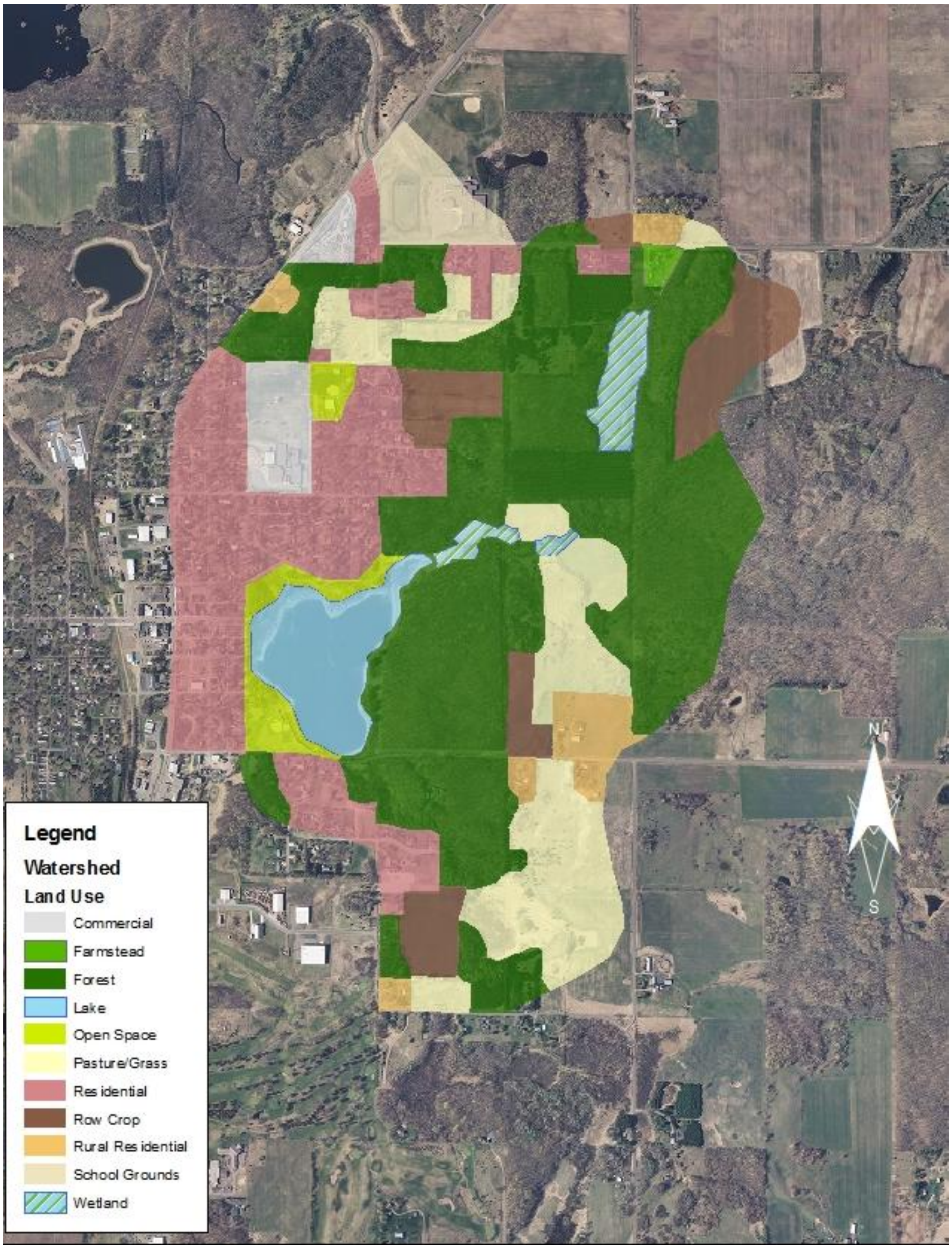


Figure 30. Land use in Coon Lake Watershed. Grey = commercial, green = farmstead, dark green = forest, blue = lake, light green = open space, light yellow = pasture/grass, pink = medium density residential, brown = row crop, tan = rural residential, light brown = school grounds, and hash blue = wetland.

WiLMS was used to model percent loading from each land use (i.e. nutrient budget). Medium density residential (43%), row crop (33%) and forest (16%) contribute the greatest percentage of phosphorus loading to Coon Lake. To a lesser extent, pasture/grass (2%), mixed agriculture (2%), the lake surface (2%), wetlands (1%) and rural residential (1%) also contribute to the total watershed phosphorus loading (Table 8). Other residential land uses contribute the remainder of phosphorus loading (28.1%).

Land Use	**Acres**	**Percent acreage**	**Percent phosphorus loading**
Row crop	64.4	9%	23.6%
Mixed agriculture	3.24	0%	1%
Pasture/grass	11.45	2%	1.3%
MD residential	169.61	25%	31.1%
Rural residential	27.38	4%	1%
Wetlands	17.855	3%	0.7%
Forest	351.44	51%	11.6%
Lake surface	42.2	6%	1.6%

Table 8. Land use, acres, percent acreage, and percent phosphorus loading for the Coon Lake Watershed.

Since none of the row crop is currently being utilized for field crops, this land use was converted to grass/pasture and the model was re-run. In this scenario, medium density residential (53%), forest (20%), and pasture/grass (14%) contribute the greatest percentage of phosphorus loading to Coon Lake. To a lesser extent, the lake surface (8%), rural residential (2%), mixed agriculture (2%), and wetlands (1%) also contribute to the total watershed phosphorus loading (Table 9). Other residential land uses contribute the remainder of phosphorus loading (29.9%).

Land Use	**Acres**	**Percent acreage**	**Percent phosphorus loading**
Mixed agriculture	3.2	0%	1.1%
Pasture/grass	75.8	11%	10%
MD residential	169.6	25%	37.2%
Rural residential	27.4	4%	1.2%
Wetlands	17.9	3%	0.8%
Forest	351.4	51%	13.9%
Lake surface	42.2	6%	5.9%

Table 9. Land use, acres, percent acreage, and percent phosphorus loading for the Coon Lake Watershed with row crop converted to pasture/grass.

Although forest makes up over 51% of the watershed acreage for Coon Lake, this land use contributes only 13.9% of the watershed phosphorus loading. Medium density residential, which makes up 25% of the watershed acreage, contributes the greatest amount of phosphorus loading (37.2%). Therefore, best management practices which focus on reducing the phosphorus loading from high density residential areas (such as increasing native vegetation, rain gardens, and demonstration sites on public property) will likely be most effective in improving water quality in Coon Lake.

Although forest also contributes phosphorus loading to Coon Lake, this land use keeps vegetation in a natural state, making best management practices associated with forests unnecessary. Additionally, since the percent loading from the forest corresponds with over half of the land use acreage, the associated phosphorus loading is likely background phosphorus.

Areas Providing Water Quality Benefits to Coon Lake

Together the wetlands and forests make up approximately 54% of the land use in the Coon Lake Watershed but contribute only 15% of the total watershed phosphorus loading. The wetlands and forest in the Coon Lake Watershed should be considered sensitive areas and preserved for the benefits they provide to Coon Lake (Figure 31).

Natural areas such as forests and wetlands allow for more infiltration of precipitation when compared with developed residential sites which include lawns, rooftops, sidewalks, and driveways. This arises because dense vegetation slows the velocity of rain drops before they reach the soil interface, thereby reducing erosion and allowing for greater infiltration. Additionally, wetlands provide extensive ecosystem services by allowing for the sedimentation of particles and filtering of nutrients.

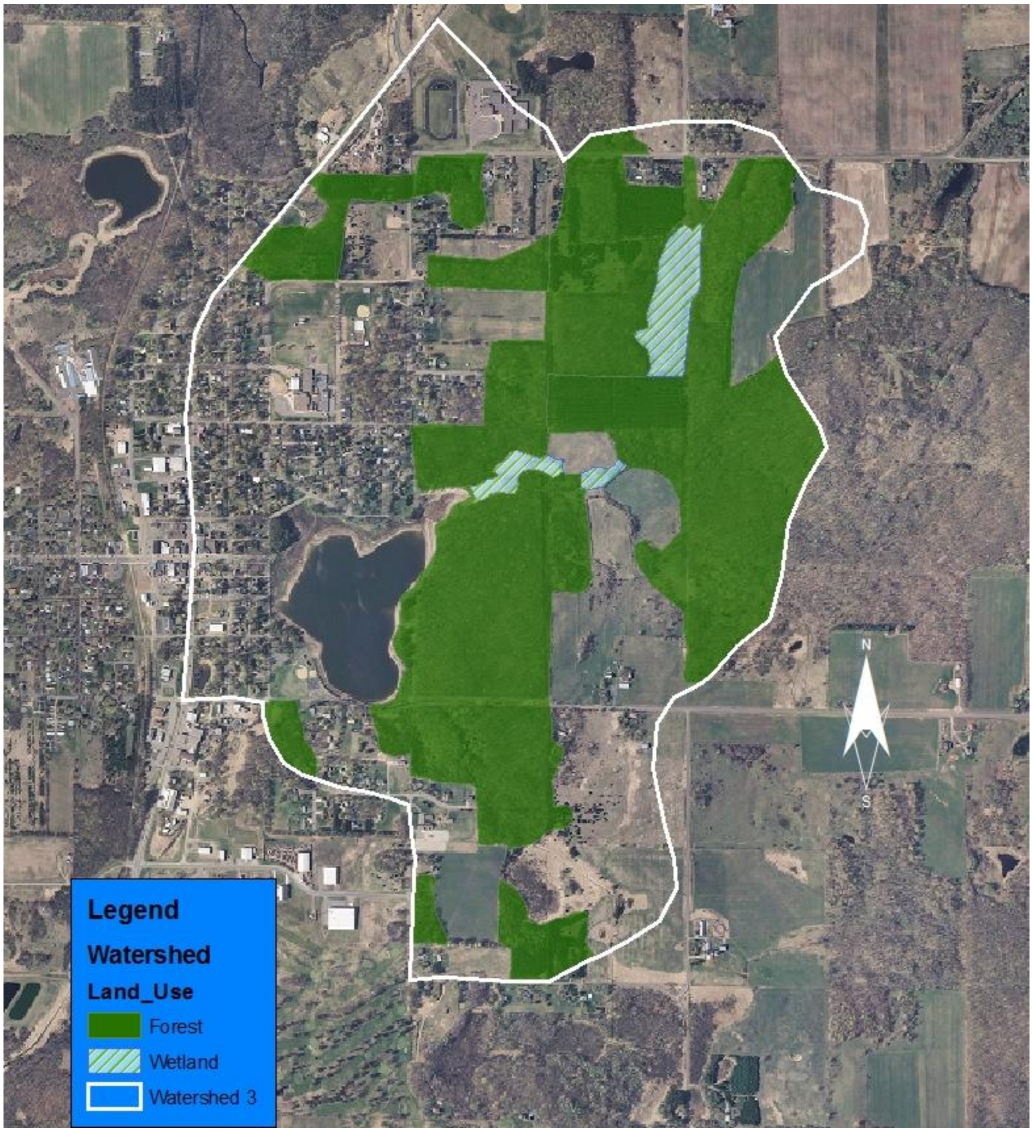


Figure 31. Areas in the Coon Lake Watershed that provide benefits for the water quality of Coon Lake. (Green = forest and hash blue = wetlands).

Watershed Modeling

The Wisconsin Lake Modeling Suite (WiLMS) was used to model current conditions for Coon Lake, verify monitoring, and estimate in-lake nutrient loading. Phosphorous is the key parameter in the modeling scenarios used in WiLMS because it is the limiting nutrient for algal growth in most lakes.

Based on average evaporation, precipitation, and runoff coefficients for Polk County soils the non-point source load was calculated to be 232.1 pounds of phosphorous annually. Because most of the agricultural land in the watershed is not actively row cropped, the row crop land use was converted to grassland and the watershed was modeled in a different scenario. In this scenario the total non-point source load was estimated to be 191.9 pounds of phosphorus.

In both scenarios the land-use that contributed the most non-point phosphorus in the model was the Village. The model estimates that the Village itself contributes 46-121 pounds of phosphorus annually.

The internal load of the lake was estimated using in-situ data. This model quantifies the increase of phosphorous concentrations in the fall. Using this method it was predicted that 126 to 142 pounds of phosphorous are released from the sediment. That is 34.1% to 36.8% of the annual phosphorous budget. Continuous nutrient data should be taken in order to continue a trend and update the lakes nutrient budget as needed (especially as land-use changes and practices are implemented).

This data was used to select the 1977 Rechow Anoxic lake model: $P = \dfrac{L}{0.17z + 1.13\, z/T_w}$

Where P = the predicted mixed lake total phosphorous concentration in mg/m^3,
L = the areal total phosphorus load in mg/m^2 of lake,
z = the lake mean depth and
T_w = the lakes hydraulic retention time in years.

This model was the best fit for Coon Lake as it predicted the total phosphorous to be 143 mg/m^3; relatively close to the observed 166 mg/m^3 in the growing season.

This indicates that the effectiveness of traditional watershed and urban stormwater practices may work very well to reduce phosphorus and the potential for algae blooms in Coon Lake. As such, the Frederic Parks Board and the Village of Frederic should pursue policies and grant dollars to reduce the stormwater runoff from the Village.

Traditional lake models do not predict water column phosphorous in shallow lakes well. However, WiLMS does have an expanded trophic response module that allows the prediction of nuisance algal bloom frequency. Based on the data collected, it is predicted that Coon Lake will have nuisance blue-green algae blooms between 84-88% of the growing season. This is typical of the phytoplankton dominated state in lake ecosystems. However because of the opportunities to reduce the phosphorus load from the Village there should be visible results when practices and policies are put in place.

Coon Lake Tributaries

Coon Lake has two unnamed inlets. One is located on the north-east side of the lake and the other is located on the south side of the lake (Figure 32). The inlet located on the north-east side of the lake was filled with reed canary grass and never exhibited flow. This is likely because of the drought conditions in 2010, the low water levels in Coon Lake, and the fact that the inlet flows directly from a wetland, which would have needed to become saturated and filled before flow reached the inlet. The south inlet was also dry for the majority of the summer but did begin to flow in early September.

Figure 32. Coon Lake Inlets.

Flow data was collected biweekly on the south inlet with a Marsh McBirney Flo-Mate™ velocity flowmeter. Grab samples were collected once monthly on the south inlet and analyzed at the Water and Environmental Analysis Laboratory for total phosphorus and soluble reactive phosphorus. When sites were dry or without flow, samples were not collected.

The phosphorus data collected is specific to date and location and can be used to theoretically determine how much phosphorus is entering the lake. Values for phosphorus influxes are established by multiplying the phosphorus concentration at a specific location by the volume of water that moves through a specific location, or the discharge in cubic feet per second. To determine the average instantaneous load of phosphorus (in mg/s), the average phosphorus concentration is multiplied by the average season discharge. Units are then converted and expressed as lb/yr.

This data allows for a phosphorus gradient and nutrient loading budget for the lake to be generated. The analysis of this data allows for areas of highest phosphorus loading to be identified. Once areas of highest phosphorus loading are identified, the land use and geology of these areas can be investigated for their total phosphorus contribution and best management recommendations can be made.

Due to drought conditions, only two data sets (9/3/10 and 10/8/10) were able to be collected for the south inlet and none were collected for the north-east inlet. As a result, continued monitoring by the Village should be initiated to gain a more accurate snapshot of nutrient loading to Coon Lake.

The average instantaneous load for the south inlet was 35.82 lb total phosphorus/year (Table 10).

Site	Total phosphorus (mg/l)	Discharge (l/s)	Instantaneous load (mg/s)	Instantaneous load (lb/yr)
South inlet	0.3135	1.642393	0.51489	35.82148

Table 10. Average total phosphorus, discharge, and instantaneous load for Coon Lake south inlet site.

Stormwater Phosphorus Concentration

In 2010 and 2011, stormwater samples were taken throughout the summer by volunteers from the Village Parks Board and workers from the Village Crew. Samples were collected after rainfall events at three locations where stormwater enters Coon Lake (Figure 33). Samples were analyzed at the Water and Environmental Analysis Lab (WEAL) at UW-Stevens Point for two types of phosphorus (total phosphorus and soluble reactive phosphorus) and three types of nitrogen (nitrate/nitrite, ammonium, and total Kjeldahl nitrogen).

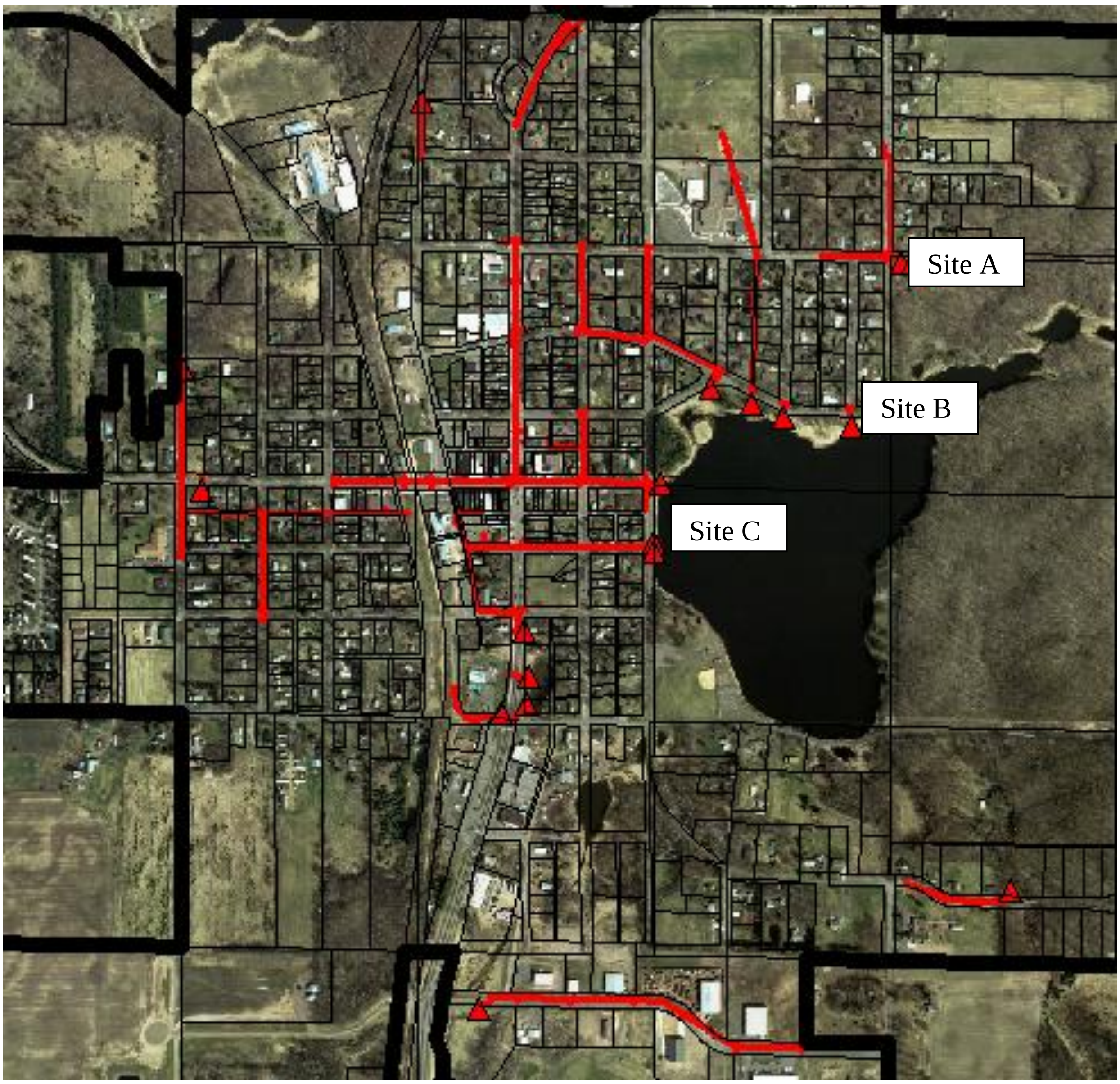


Figure 33. Stormwater sample sites.

Concentrations of phosphorus varied between sites, and samples were not always able to be taken due to a lack of flow (Figure 34). It would be recommended that the Village continue sampling inlets to set priority areas for best management practice installation.

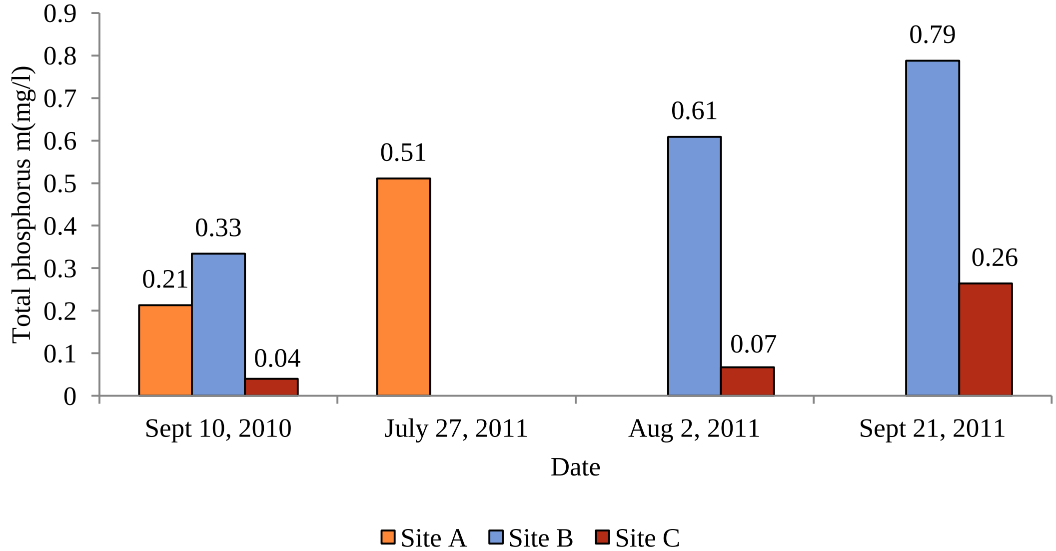


Figure 34. Coon Lake inflow total phosphorus concentration (mg/l), 2010 and 2011.

P8 Urban Catchment Model for Stormwater

The P8 Urban Catchment Model was used to determine loads of phosphorus entering Coon Lake from each watershed outlet. This model was developed for the Wisconsin DNR, Minnesota Pollution Control Agency, and the United States Environmental Protection Agency. The model uses a 30 year precipitation and temperature average to calculate a mass balance of phosphorus using curve numbers from the USDA Technical Release 55 Urban Hydrology for Small Watersheds (TR-55).

The model predicted that Site C had an elevated phosphorus load. However, continued sampling should be undertaken by the Village. The model showed that the portion of the Village that contributes directly to these three outlets contributes almost 24 pounds of phosphorus to Coon Lake annually (Figure 35). This is probably accurate as the default concentration values used by the model are relatively consistent with that data that was actually collected. Likely the model predicts less phosphorus than what the Village actually contributes because other stormwater sewers which were not sampled, are indirectly connected to Coon Lake.

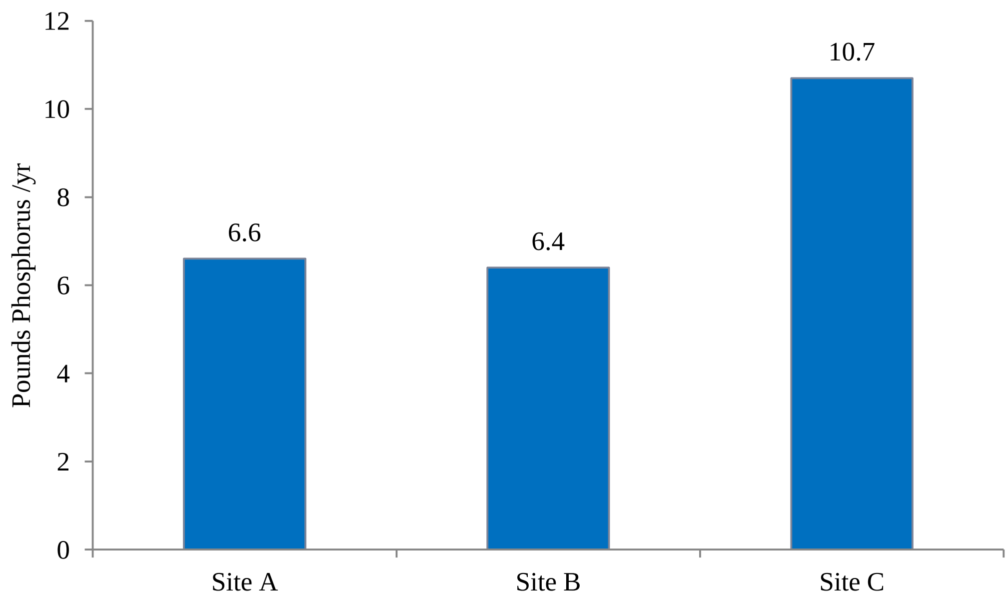


Figure 35. Coon Lake pounds phosphorus/year for stormwater sites, 2010.

Likely creating a stormwater ordinance, conducting engineering feasibility studies, and installing urban Best Management practices would have a very positive impact on Coon Lake’s nutrient budget (see the Watershed Modeling Section of this report).

Nutrient Budget Summary

Non-point source load: 191.9 pounds of phosphorus

** Row crop converted to grass scenario*

- Mixed agriculture: 1.1%
- Pasture/grass: 10%
- MD residential: 37.2%
- Rural residential: 1.2%
- Wetlands: 0.8%
- Forest: 13.9%
- Lake surface: 5.9%

Internal load: 126-142 pounds of phosphorus

South inlet instantaneous load: 26 pounds of phosphorus/year

Stormwater: 23.7 pounds of phosphorus/year

- Site A: 6.6 pounds of phosphorus/year
- Site B: 6.4 pounds of phosphorus/year
- Site C: 10.7 pounds of phosphorus/year

Currently, the TSI(P) for Coon Lake is 78, which indicates that the lake is hypereutrophic. A realistic goal would be to reduce the water column phosphorus between 15 and 30%. The 1977 Rechow Anoxic lake model predicted the total phosphorus to be 143 mg/m^3 which is relatively close to the growing season average of 150 mg/m^3. This model was used to determine the impacts of installing various best management practices to reduce phosphorus concentrations.

Controlling all stormwater would achieve a growing season average of 133.14 mg/m^3 (11.24% decrease)

Removing internal load would achieve a growing season average of: 103.97 mg/m^3 (30.69% decrease)

Reducing 60% of stormwater and reducing internal load by 60% would achieve a growing season average of: 95.10 mg/m^3 (36.6% decrease)

Reducing 30% of stormwater and reducing internal load by 30% would achieve a growing season average of: 129.34 mg/m^3 (13.8% decrease)

**Controlling stormwater can be achieved through shoreline restoration, installing rain gardens, and professional engineered projects (ie sediment ponds). Internal load can be reduced through the introduction of native aquatic macrophytes.*

Education Summary

A number of educational programs were planned to accompany both lake studies. The educational programs offered included:

- A pontoon classroom at the Coon Lake Fair. The opportunity provided two adults and three children with a hands-on learning experience regarding lake ecology and lake monitoring techniques. Participants questions were also answered (Figure 36).
- Educational display boards regarding aquatic invasive species at the Coon Lake Fair (Figure 37).
- Monthly update meetings with the Village Board and Parks Board.
- Frederic Library Story Hour on amphibians with Randy Korb at the Coon Lake Fair (Figure 38).

Figure 36. Pontoon classroom at Coon Lake Fair.

Figure 37. Educational display at Coon Lake Fair.

Figure 38. Frederic Library story hour with Randy Korb.

Discussion

Coon Lake is a man-made lake that was created for the logging industry, and therefore does not appear to go through seasonal changes in the same way that a natural lake does. However, it does appear that the lake is phosphorus limited on an annual and multi-annual basis.

Algae in lakes usually goes through a seasonal succession where diatoms are the dominant group of algae in the spring, followed by green algae in the early summer, blue-green algae in the late summer and early fall, and diatoms in the late fall. This is due to many factors including the availability of light, inorganic nutrients, temperature, and grazing by zooplankton.

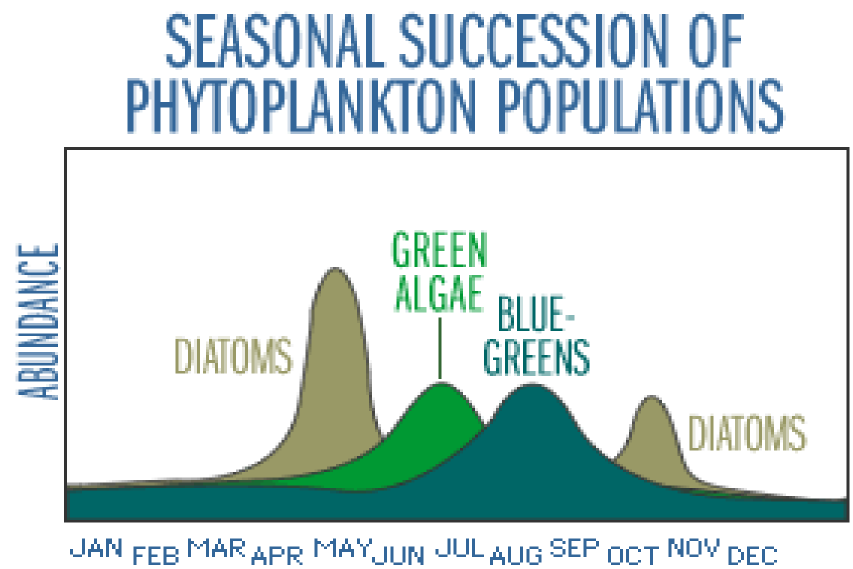


Figure 39. Seasonal succession of phytoplankton populations. *Figure from Water on the Web.*

In Coon Lake the typical seasonal succession for algae populations did not occur. Blue-green algae (cyanobacteria) *Limnothrix sp.* was the dominant species composing over 93% of the total algae biomass in mid-May, which was the highest population of cyanobacteria the entire season. *Limnothrix sp*. is a planktic or tychoplanktic filamentous species that is capable of using vacuoles filled with air to maintain buoyancy. The green and blue-green algae remain the dominant groups until September when the diatoms finally become the most dominant group.

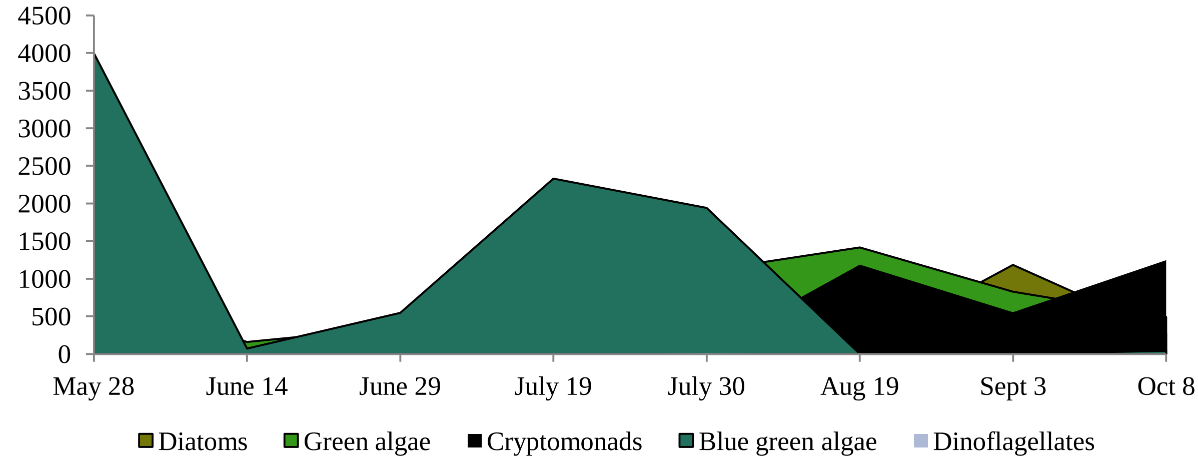


Figure 40. Coon Lake seasonal succession of phytoplankton populations.

The abnormal seasonal succession of phytoplankton populations in Coon Lake could be a result of the fluctuation in different zooplankton groups. The Cladocera are the group of zooplankton that are capable of reducing algae biomass, particularly the genus daphnia. Cladocera where not very abundant early in the season, composing a little less than 10% of the total zooplankton biomass, but were very abundant by July 30th, composing over 90% of the zooplankton biomass. This may explain the odd algae seasonality; however, the algae may influence the zooplankton rather than vice versa.

In addition to the unconventional algae and zooplankton dynamics, it should be noted that Coon Lake is almost devoid of submerged aquatic vegetation. In fact, the only submerged species present was *Polygonum amphibium* which is an annual plant that needs to produce seed in order to persist within a lake because it does not make vegetative reproduction structures like many other aquatic macrophyte species. The other truly aquatic plant present in Coon Lake was the emergent species *Schoenoplectus tabernaemontani* which is quite important for gas exchange within the water column.

The lack of aquatic vegetation has major implications for in-lake water quality. The total phosphorus content in Coon Lake is quite elevated ranging from 70 µg/l to 250 µg/l. This indicates that the lake is quite eutrophic and could experience extreme algae blooms if the conditions are right.

The watershed modeling indicates that the internal load of phosphorus to Coon Lake is between 34-37% of the total load of phosphorus. Because there are virtually no rooted aquatic plants in the lake, algae are the dominant autotroph present. Algae likely shade the sediment surface and raise the redox potential of the sediment. As the redox potential of the sediment increases, phosphorus that is bound to iron, magnesium, and sulfur are released into the water column. Increasing the aquatic plants present in Coon Lake should help mitigate this effect.

In addition to mitigating the internal load of nutrients, the external load needs to be addressed by means of a stormwater ordinance for the Village and urban best management practices. The watershed modeling done using 2010 land use strongly indicated that the Village of Frederic was the highest contributor of external nutrients to the lake. By implementing practices to infiltrate water into the soil, Frederic can essentially "shut of the tap" of external nutrients being exported from the village.

Areas that are of high value to protect water quality such as forested land and wetlands should be protected through the use of easements or purchasing land in order to maintain the ecosystem services that these lands provide.

Implementation Plan Including Goals for Aquatic Plant Management

Lake Management Plans help protect natural resource systems by encouraging partnerships between concerned citizens, lakeshore residents, watershed residents, agency staff, and diverse organizations. Lake Management Plans identify concerns of importance and set realistic goals, objectives, and actions to address concerns of importance. Additionally, Lake Management Plans identify roles and responsibilities for meeting each goal and provide a timeline for implementation.

Lake Management Plans are living documents that are under constant review and adjustment depending on the condition of a lake, available funding, level of volunteer commitment, and the needs of lake stakeholders.

The implementation plan presented below was created through collaborative efforts and takes into account input gathered from Village Board Meetings, Village Parks Board Meetings, and a 2011 sociological survey regarding the needs of Coon Lake stakeholders. The goals presented below are realistic based upon the findings of this project and the needs of Coon Lake and the stakeholders that represent the lake.

Plan for Coon Lake available for public review and comment

FREDERIC - The public is invited to review and provide comments on the Implementation Plan and Aquatic Plant Management Plan for Coon Lake.

A hard copy of the plan is available at the Frederic Public Library and an online version is available on the village of Frederic Web site.

Comments and suggestions should be submitted in writing or e-mail and received by Friday, March 23, to ensure that they are given proper consideration in the final plan. No telephone messages will be considered. Anyone interested in providing input should contact Jeremy Williamson or Katelin Holm at 100 Polk County Plaza, Ste. 120, Balsam Lake, WI 54810; jeremyw@co.polk.wi.us; or katelin.holm@.polk.wi.us. - *submitted*

Figure 41. Excerpt from the February 15th Inter County Leader, Section A, Page 3.

On February 13th 2012 a summary of the Coon Lake Water Quality Study was presented to the Village Board by the Polk County LWRD. This meeting reviewed the Implementation Plan and allowed for public comment to be made. LWRD also presented the Implementation Plan to the Frederic Parks Board on March 23rd, 2012 for review. The final report and Implementation Plan was posted on the Village of Frederic website on February 15th, 2012 for public review. The same day a notice was posted in the Inter-County Leader, the County paper, directing the public to review and comment on the plan. The plan was open for comment through March 23rd. No comments were made during the timeframe from February 15th through March 23rd.

The plan below also includes a specific Aquatic Plant Management Goal for Coon Lake.

Management Goal 1. Improve current water quality conditions in Coon Lake.

Objective: Continue to monitor water quality through WDNR Citizens Lake Monitoring Network.

Action: Maintain current volunteers and recruit additional volunteers if necessary.

Action: If necessary contact Kris Larsen, WDNR (715-635-4072, kris.larsen@wisconsin.gov) to arrange for training and equipment.

Action: Volunteers collect data and report results to WDNR through the SWIMS database and present data at Village Meetings.

Objective: Reconstruct past water quality conditions as a means to set future water quality goals and objectives.

Action: Collect lake sediment cores for analysis.

Action: Research possible funding sources to assist with costs of sediment cores.

Objective: Promote shoreline restoration through information and education.

Action: Identify public property for shoreline restoration demonstration sites.

Action: Research cost sharing opportunities for installation of demonstration sites.

Management Goal 2. Reduce algae biomass in Coon Lake as a means to increase zooplankton communities and improve fisheries.

Objective: Gain an understanding of algae population dynamics, zooplankton population dynamics, and nutrient availability in Coon Lake.

Action: Recruit volunteers to collect algae samples, zooplankton samples, and in-lake water samples to analyze for nitrogen and phosphorus.

Action: Conduct a fisheries population analysis.

Action: If necessary, retain a consultant to coordinate a monitoring strategy.

Action: If necessary, obtain a WDNR grant to fund monitoring activities.

Objective: Increase algae grazing by zooplankton.

Action: Increase coarse woody habitat.

Action: Provide education regarding the important role of coarse woody habitat for algae grazing and fishery improvement.

Management Goal 3. Reduce nutrient pollution to Coon Lake.

Objective: Develop a stormwater management strategy.

Action: Adopt an appropriate stormwater ordinance (see City of Amery).

Action: Implement an engineering feasibility study to determine best management practices for stormwater management.

Action: Research Lake Protection Grant and Stormwater Grant funding opportunities.

Action: Initiate a stormwater runoff information and education campaign which focuses on the impact of stormwater on lake health.

Objective: Promote the adoption of infiltration practices through information and education.

Action: Recruit property owners or identify public property for demonstration sites for infiltration practices.

Action: Research cost sharing opportunities for installation of demonstration sites.

Action: Consider purchasing conservation easements or properties that have a conservation element and potentially use as an outdoor classroom site.

Management Goal 4. Maintain scenic beauty and enjoyment of Coon Lake through education.

Objective: Create an Education and Communication Committee to communicate information and education.

Action: Recruit volunteer committee members.

Action: Identify topics of focus for education and information based on priority and feasibility.

Example educational topics: water safety, shoreline restoration, water quality, noise pollution, septic system maintenance, minimizing pollution, benefit of aquatic plants, invasive species, stormwater runoff etc.

Objective: Provide users of Coon Lake with important and timely information to assist with minimizing their impact on the lake.

Action: Develop a website where information can be communicated.

Action: Utilize multiple media types to communicate information such as newsletters, newspaper articles, signage at public boat landings and the public beach, demonstration sites, events, posters, etc.

Management Goal 5. Prevent the introduction of invasive species in Coon Lake and eradicate newly introduced aquatic invasive species.

Objective: Prevent AIS introductions.

Action: Ensure that residents, renters, and visitors understand the impacts of AIS and the actions they can take to prevent their establishment.

Action: Consider and potentially implement new technologies, such as remote cameras and monitoring of boat landings, as they become available.

Objective: If AIS introductions occur, ensure that they are discovered early.

Action: Implement an AIS monitoring protocol in early spring and August to monitor for species such as zebra mussels, Eurasian water milfoil, curly leaf pondweed, and purple loosestrife.

Action: If new AIS are discovered, notify the WDNR, apply for a WDNR rapid response grant, and follow approved treatment methods

Management Goal 6. Enhance the native plant community of Coon Lake for the benefits native plants provide in water clarity, fisheries health, and the prevention of AIS infestations.

Objective: Maintain current native plant community.

Action: Prevent disturbance of native plants from watercraft.

Objective: Enhance native plant community.

Action: Consider transplanting *Vallisneria* (water celery) or other native plants is areas that do not impede navigation (i.e. boat landing).

Action Items	Timeline	Responsible Parties
Management Goal 1. Improve current water quality conditions in Coon Lake.		
Maintain current volunteers and recruit additional volunteers if necessary.	Ongoing	Village Parks Board
If necessary contact Kris Larsen, WDNR (715-635-4072, kris.larsen@wisconsin.gov) to arrange for training and equipment.	Ongoing	Village Parks Board, WDNR
Volunteers collect data and report results to WDNR through the SWIMS database and present data at Village Meetings.	Ongoing	Village Parks Board, WDNR
Collect lake sediment cores for analysis.	When funds available	Village Parks Board, LWRD, SCWRS

Research possible funding sources to assist with costs of sediment cores.	Ongoing	Village Parks Board, LWRD
Identify public property for shoreline restoration and rain garden demonstration sites.	When funds available	Village Parks Board
Research cost sharing opportunities for installation of shoreline restorations and rain gardens.	Ongoing	Village Parks Board, LWRD
Management Goal 2. Reduce algae biomass in Coon Lake as a means to increase zooplankton communities and improve fisheries.		
Recruit volunteers to collect algae samples, zooplankton samples, and in-lake water samples to analyze for nitrogen and phosphorus.	When funds available	Village Parks Board
Conduct a fisheries population analysis.	When funds available	WDNR
If necessary, retain a consultant to coordinate a monitoring strategy.	Spring	LWRD, consultant
If necessary, obtain a WDNR grant to fund monitoring activities.	Ongoing	Village Parks Board, LWRD
Increase coarse woody habitat.	Ongoing	Village Parks Board
Provide education regarding the important role of coarse woody habitat for algae grazing and fishery improvement.	Ongoing	Village Parks Board
Management Goal 3. Reduce nutrient pollution to Coon Lake.		
Adopt an appropriate stormwater ordinance (see City of Amery).	As soon as possible	Village Parks Board
Implement an engineering feasibility study to determine best management practices for stormwater management.	When funds available	Village Parks Board, Consultant
Research Lake Protection Grant and Stormwater Grant funding opportunities.	Ongoing	Village Parks Board
Initiate a stormwater runoff information and education campaign which focuses on the impact of stormwater on lake health.	Ongoing	Village Parks Board
Recruit property owners or identify public property for demonstration sites for infiltration practices.	Ongoing	Village Parks Board
Research cost sharing opportunities for installation of demonstration sites.	Ongoing	Village Parks Board, LWRD
Consider purchasing conservation easements or properties that have a conservation element and potentially use as an outdoor classroom site.	When funds available	Village Parks Board
Management Goal 4. Maintain scenic beauty and enjoyment of Coon Lake through education.		
Recruit volunteer committee members.	Ongoing	Village Parks Board

Identify topics of focus for education and information based on priority and feasibility.	Ongoing	Education committee, Village Parks Board
Develop a website where information can be communicated.	Ongoing	Education committee, Village Parks Board
Utilize multiple media types to communicate information such as newsletters, newspaper articles, signage at public boat landings and the public beach, demonstration sites, events, posters, etc.	Ongoing	Education committee, Village Parks Board
Management Goal 5. Prevent the introduction of invasive species in Coon Lake and eradicate newly introduced aquatic invasive species.		
Ensure that residents, renters, and visitors understand the impacts of AIS and the actions they can take to prevent their establishment.	Ongoing	Village Parks Board
Consider and potentially implement new technologies, such as remote cameras and monitoring of boat landings, as they become available.	When funds available	Village Parks Board
Implement an AIS monitoring protocol in early spring and August to monitor for species such as zebra mussels, Eurasian water milfoil, curly leaf pondweed, and purple loosestrife.	Spring, August	Village Parks Board, LWRD
If new AIS are discovered, notify the WDNR, apply for a WDNR rapid response grant, and follow approved treatment methods.	Ongoing	Village Parks Board, WDNR
Management Goal 6. Enhance the native plant community of Coon Lake for the benefits native plants provide in water clarity, fisheries health, and the prevention of AIS infestations.		
Prevent disturbance of native plants from watercraft.	Ongoing	Village Parks Board
Consider transplanting *Vallisneria* (water celery) or other native plants is areas that do not impede navigation (i.e. boat landing).	When funds available	Village Parks Board

Table 11. Timeline and responsible parties for Coon Lake Implementation Plan action items.

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Coon Lake Management Plan

Coon Lake In-lake Chemical Data

Appendix A

Polk County Land and Water Resources Department
12/31/2011

Date	Site	Conductivity	Soluble Reactive Phosphorus	Total Phosphorus	Ammonium	Nitrate/ Nitrite	Total Kjeldahl Nitrogen	Chloride	Sulfate	Total suspended solids
4/26/10	Mid Lake	70	0.022	0.069	0.03	0.06	1.29	11.5		
5/28/10	Mid Lake		0.019	0.093	0.05	<0.1	1.5		6.28	7
6/29/10	Mid Lake	67	0.056	0.201	0.07	<0.1	2.07	9.3	3	
7/30/10	Mid Lake	49	0.111	0.147	0.1	<0.1	2.51	7.3	2.7	16
9/3/10	Mid Lake	48	0.141	0.254	1.87	<0.1	1.82	4.1	2.2	
-9/10/10	Coon Lake Inlet		0.307	0.458	0.52	<0.1	2.11	6.5		3
	Site A		0.184	0.213	0.21	<0.1	0.69	1		9
	Site B		0.256	0.334	0.09	<0.1	0.93	<0.5		25
	Site C		0.051	0.04	0.35	0.1	0.49	<0.5		<2
	Site D		0.119	0.116	0.06	<0.1	0.37	<0.5		<2
	Site E		0.198	0.233	0.12	<0.1	0.55	<0.5		2
10/8/10	Mid Lake	49	0.039	0.136	0.12	0.06	1.49	3.9		
	S inlet	57	0.152	0.169	0.07	0.03	1.51	3.5		7

Date	Site	Chlorophyll -a	pH	Alkalinity	Total Hardness	Calcium Hardness	Sodium	Potassium	Color	Turbidity (NTU)
4/26/10	Mid Lake									
5/28/10	Mid Lake	27								
6/29/10	Mid Lake	71								
7/30/10	Mid Lake		6.98	24	24	12	3.9	3	81.5	
9/3/10	Mid Lake		6.85	28	21	14	2.2	3.1	100	9.6
-9/10/10	Coon Lake Inlet									
	Site A									
	Site B									
	Site C									
	Site D									
	Site E									
10/8/10	Mid Lake									
	S inlet		6.65							

Coon Lake Management Plan

Coon Lake In-lake Physical Data

Appendix B

Polk County Land and Water Resources Department
12/31/2011

Date	Depth	DO	Condo	SpCon	Temp	Sal	pH	Secchi	Comments
4/26/10	0	9.6	67.8	87.3	13.4	0	8.33	4	Windy and sunny (66)
	1	9.17	68	87.5	13.4	0	8.3	4	
	2.8	8.36	69.4	89.2	13.2	0	8.1	4	
5/17/10	0	9.89	77.1	85.3	19.8	0	8.31	2.5	Sunny and Warm (75)
	1	10.35	70.1	84.9	15.9	0	8.27	2.5	Zoops and Algae Taken
	2	3.23	90.3	116.3	13	0.1	7.77	2.5	Zoops 5.5' verticle tow
									Algae whole water column composite
5/28/10	0	6.86	86.6	87.6	24.4	0	7.35	3.3	Sunny, warm, slight breeze
	1	6.34	106.7	108.7	24.2	0.1	7.05	3.3	Zoop, verticle tow
	1.8	0.05	120.1	125	22.6	0.1	6.39	3.3	Algae, composite sampler
6/14/10	0	5.02	72.6	83.4	18.2	0	7.08	3	Cloudy and cool
	1	5.01	72.2	83	18.2	0	6.47	3	Mixing event? Storms past 48 hours
	2.5	4.58	73	84.2	18.1	0	5.96	3	
6/29/10	0	7.09	80.6	82.7	23.5	0	7.69	2	Sunny, breezy, warm
	1	6.42	79.2	82	23.2	0	7.22	2	lake is quite green (aphanizominon?)
	1.7	0.09	91.5	95.4	22.8	0	6.37	2	
7/19/10	0	9.88	81	78.1	25.9	0	8.11	2	Lake up 2 feet (7.7), inlet flowing
	1	3.84	70.3	71.8	24	0	7.02	2	Green-microcys.
	2	1.71	63.6	66.6	23	0	6.36	2	Cloudy, warm
7/30/10	0	7.77	73.3	71.8	26.1	0	7.92	2.25	Cloudy, breezy, warm
	1	7.3	72.2	71.1	25.9	0	7.36	2.25	H2O Brown-bloom
	2	1.87	70.4	69.9	25.2	0	6.63	2.25	
	2.5	0.07	130.1	136.3	23.7	0.1	5.67	2.25	
8/19/10	0	3.53	55.4	58.6	22.1	0	7.23		Depth at 13.2 ft
	1	3.38	55.3	58.6	22.1	0	6.81		Overcast 70, calm
	2	3.06	55.2	58.6	22	0	6.48		micro-bloom @ boat landing
	3	3.03	55.2	58.5	22	0	5.93		
	4	2	56.3	59.8	21.9	0	5.57		
9/3/10	0	10.85	57.3	61	21.8	0	7.25	2	Depth 11.3 ft
	1	9.43	58	61.6	21.9	0	6.25	2	Rain, Cold, Windy
	2	3.81	58	61.7	21.9	0	6.72	2	
	3	3.99	57.8	61.4	21.8	0	6.56	2	
	3.5	2.69	88.2	93.8	21.9	0	5.35	2	
10/8/10	0	10.07	48.7	59.7	15.4	0	7.62	2.5	
	1	9.84	48.9	60.3	15.2	0	7.3	2.5	
	2	6.35	47.9	60.1	14.3	0	7.24	2.5	
	3	4.59	47.5	60.6	13.7	0	7.19	2.5	
	4	0.02	51	64.6	13.7	0	7.08	2.5	

Coon Lake Management Plan

Coon Lake In-lake Historical Secchi Data

Appendix C

Polk County Land and Water Resources Department
12/31/2011

Start Date	Secchi (Feet)
11/17/04	7
4/21/05	5
5/24/05	5.25
6/25/05	7
7/19/05	6
8/20/05	4
5/25/06	10
6/23/06	10
7/24/06	6
8/24/06	4
9/18/06	3
10/11/06	3.5
5/16/07	5
6/13/07	4
7/17/07	3
8/13/07	2
9/19/07	2
10/16/07	2
5/20/08	3
6/15/08	3.5
7/22/08	3
8/24/08	2.75
9/18/08	2.5
10/15/08	2
6/20/09	2.05
7/8/09	2.25
8/14/09	2.5
9/27/09	3.5
10/13/09	4.5
4/26/10	4
5/17/10	2.5
5/28/10	3.3
6/14/10	3
6/29/10	2
7/19/10	2
7/30/10	2.25
9/3/10	2
10/8/10	2.5

Coon Lake Management Plan

Coon Lake Watershed Survey

Appendix D

Polk County Land and Water Resources Department
12/31/2011

2011 Coon Lake Watershed Survey

The Land and Water Resources Department (LWRD) obtained a grant from the DNR to conduct a water quality and biological integrity study on Coon Lake. The watershed was sampled and surveyed in 2010. To meet the goals of this study we would like to have your input on the lake and invite you to participate in future activities related to Coon Lake. Following is a survey designed to gather information about residents owning property near Coon Lake, the lake's current condition, and its intended use to direct future management decisions. The survey should take approximately 5-10 minutes to complete. For every question, please check only one response unless directed to "check all that apply." Please fill out this survey and return it to LWRD. The results will be compiled in the final lake report available in 2011 from LWRD. If you have questions, feel free to contact Katelin Holm, Information and Education Coordinator and Water Quality Specialist at LWRD, at 485-8637 or katelin.holm@co.polk.wi.us. Surveys should be returned by August 1st, 2011 to:

LWRD
100 Polk County Plaza- Suite 120
Balsam Lake, WI 54810

The results of this survey will help guide future land and lake management decisions. Thank you again for your participation in this survey!

---

1. How many years have you owned property in Frederic, Wisconsin? If less than 1 year, please write 1. *Note: If you own more than one property, please answer all questions for the property you have owned the longest.*

   ________ years

2. What type of property do you own in Frederic (from question 1 above)?
   - ❑ Year-round residence
   - ❑ Seasonal residence (summer only)
   - ❑ Weekends throughout the year
   - ❑ Undeveloped land
   - ❑ Rental property
   - ❑ Resort
   - ❑ Other (please specify) ____________________

3. How many days in a typical year is your property used by you or others? Just provide your best estimate.

   ________ days per year

4. Land use generally falls into one of the following four categories: open space, shrub/grass/sedge community, woods, and impervious (hard) surfaces. Please use **estimated percentages** to describe the amount of each land use on your property. (The total should equal 100%.)
   ____% Open space (lawns or mowed areas)
   ____% Shrub/grass/sedge community
   ____% Woods
   ____% Impervious surfaces (buildings, driveways, sidewalks, patios, gravel paths and driveways)

5. Using your best guess, how many days per month during the **spring/summer months** (April-September) do you and/or your family visit Coon Lake? If you never visit Coon Lake, please write "0".
   Visit Coon Lake ________ **times per month** from April through September

6. Using your best guess, how many days per month during the **fall/winter months** (October-March) do you and/or your family visit Coon Lake? If you never visit Coon Lake, please write "0".
   Visit Coon Lake ________ **times per month** from October through March

7. Which activities have you and/or your family done along the shoreline or in Coon Lake within the past year? Please check all that apply.
   - ☐ Fishing (any season)
   - ☐ Swimming
   - ☐ Non-motorized water sports (birding, canoeing, hiking)
   - ☐ Motorized water sports (PWC, boating, water skiing)
   - ☐ Non-motorized winter activities (skiing, snowshoeing)
   - ☐ Motorized winter activities (ATV, snowmobile)
   - ☐ Hunting
   - ☐ I have not been to Coon lake within the past year
   - ☐ Other, please describe____________________________

8. How many of the following watercraft are kept on your property for use on/in Coon Lake? If none, please write 0.
   ____Jet skis
   ____Motorboats/pontoons between 1-20 HP
   ____ Motorboats/pontoons between 21-50 HP
   ____ Motorboats/pontoons more than 50 HP
   ____ Canoes and kayaks
   ____ Paddleboats/rowboats
   ____ Sailboats/ windsurfing
   ____ Other, please describe______________________

9. From the list below, please rank your top three concerns for Coon Lake.
(Please list your top three concerns in order of importance, with 1st being most important)

1st ___
2nd ___
3rd ___

A. **Pollution** (chemical inputs, septic systems, agriculture, erosion, storm water runoff)
B. **Development** (population density, loss of wildlife habitat)
C. **Quality of life**
D. **Property values and/or taxes**
E. **Water recreation safety** (boat traffic, no wake zone)
F. **Water clarity** (visibility)
G. **Aquatic plants** (not including algae)
H. **Invasive species** (Eurasian water milfoil, zebra mussels, buckthorn, purple loosestrife)
I. **Harmful algae blooms**
J. **Quality of fisheries**
K. **Water levels** (loss of lake volume)
L. **Other**, please describe____________________________

10. How would you describe the current water quality of Coon Lake?
- ❑ Poor
- ❑ Fair
- ❑ Unsure
- ❑ Good
- ❑ Excellent

11. How has the water quality changed in Coon Lake in the time you've owned your property?
- ❑ Severely degraded
- ❑ Somewhat degraded
- ❑ Remained unchanged
- ❑ Somewhat improved
- ❑ Greatly improved

12. How would you describe the amount of current shoreline vegetation at the park on Coon Lake (starting at the water and going landward)?
- ❑ Too much
- ❑ Just right
- ❑ Not enough
- ❑ Unsure

13. During open water season, how often does aquatic plant growth, including algae, negatively impact your enjoyment of Coon Lake?
    - ❑ Never
    - ❑ Rarely
    - ❑ Sometimes
    - ❑ Often
    - ❑ Always

14. Considering you answer to the above question, do you believe aquatic plant control is needed on Coon Lake?
    - ❑ Definitely yes
    - ❑ Probably yes
    - ❑ Unsure
    - ❑ Probably no
    - ❑ Definitely no

15. How would you describe the importance of wetlands to Coon Lake's water quality?
    - ❑ Not at all important
    - ❑ Not too important
    - ❑ Unsure
    - ❑ Somewhat important
    - ❑ Very important

16. From the list below, please check all of the management practices, if any, that you do which help protect the Coon Lake watershed. (Please check all that apply.)
    - ❑ Not using fertilizer
    - ❑ Installing rain gardens
    - ❑ Planting natural grassland and flower species
    - ❑ Implementing projects to slow runoff
    - ❑ Roadside cleanup or other attempts to stop pollution
    - ❑ Using no wake near shorelines
    - ❑ Removing plant material from boats after leaving a lake
    - ❑ Other, please describe____
    - ❑ I do not do any of the above

17. Are you aware that there is a ban on using fertilizers containing phosphorus within shore land areas (1000 feet from a lake or 300 feet from a stream) in Polk County?
    - ❑ Yes
    - ❑ No

18. Stormwater runoff can become a problem when it does not soak into the ground after rain events. How much of a problem, if at all, would you say stormwater runoff is in the Village of Frederic?
    - ❑ No problem at all
    - ❑ Little problem
    - ❑ Unsure
    - ❑ Moderate problem
    - ❑ Large problem

19. Would you be willing to provide financial support to maintain or improve the quality of Coon Lake and its associated land resources?
    - ❑ Yes
    - ❑ No
    - ❑ Unsure, I would need more information

20. **<u>If you answered yes to question 19</u>**, how much would you be willing to contribute each year? *This question is only designed to give an indication of possible support. It is <u>not</u> intended to act as a commitment for financial support.*

    $__________

21. Please provide your age. I am ________ years old.

Thank you for your participation in this survey!

Please use the remaining space to add any additional comments or concerns you have regarding Coon Lake and its surrounding land resources.

Coon Lake Management Plan

2011 Coon Lake Watershed Survey Results

Appendix E

Polk County Land and Water Resources Department
12/31/2011

<u>**2011 Coon Lake Watershed survey results**</u>

Surveys mailed: 420
Surveys returned: 61
Response rate: 14.5%

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1. How many years have you owned property in Frederic, Wisconsin? If less than 1 year, please write 1. *Note: If you own more than one property, please answer all questions for the property you have owned the longest.* **60 respondents**

   Average years: 22

2. What type of property do you own in Frederic (from question 1 above)? **59 respondents**
   - ☐Year-round residence **53 respondents, 90%**
   - ☐Seasonal residence (summer only) **1 respondent, 2%**
   - ☐Weekends throughout the year **0 respondents, 0%**
   - ☐Undeveloped land **0 respondents, 0%**
   - ☐Rental property **1 respondent, 2%**
   - ☐Resort **0 respondents, 0%**
   - ☐Other (please specify) **4 respondents, 7%**

     School district
     Commercial rental
     Business
     Business

3. How many days in a typical year is your property used by you or others? Just provide your best estimate. **59 respondents**

   Average days per year: 333

4. Land use generally falls into one of the following four categories: open space, shrub/grass/sedge community, woods, and impervious (hard) surfaces. Please use <u>**estimated percentages**</u> to describe the amount of each land use on your property. (The total should equal 100%.) **55 respondents**
   - ☐Average Open space (lawns or mowed areas) **52.7%**
   - ☐Average_Shrub/grass/sedge community **6.2%**
   - ☐Average Woods **9.4%**
   - ☐Average Impervious surfaces (buildings, driveways, sidewalks, patios, gravel paths and driveways) **30.8%**

5. Using your best guess, how many days per month during the <u>**spring/summer months** (April-September)</u> do you and/or your family visit Coon Lake? If you never visit Coon Lake, please write "0". **60 respondents**

   Visit Coon Lake an average of 6 times per month from April through September

6. Using your best guess, how many days per month during the **fall/winter months** (October-March) do you and/or your family visit Coon Lake? If you never visit Coon Lake, please write "0". **59 respondents**

   Visit Coon Lake an average of 4 times per month from October through March

7. Which activities have you and/or your family done along the shoreline or in Coon Lake within the past year? Please check all that apply. **57 respondents**

   - Fishing (any season) **32 respondents, 56%**
   - Swimming **6 respondents, 11%**
   - Non-motorized water sports (birding, canoeing, hiking) **29 respondents, 51%**
   - Motorized water sports (PWC, boating, water skiing) **5 respondents, 9%**
   - Non-motorized winter activities (skiing, snowshoeing) **11 respondents, 19%**
   - Motorized winter activities (ATV, snowmobile) **4 respondents, 7%**
   - Hunting **0 respondents, 0%**
   - I have not been to Coon lake within the past year **4 respondents, 7%**
   - Other, please describe **10 respondents, 18%**

     Schools
     Picnic (3)
     Playing at the park (2)
     Driving past
     Family days (2)
     Use of shelter

8. How many of the following watercraft are kept on your property for use on/in Coon Lake? If none, please write 0. **50 respondents**

   0 Jet skis
   9 Motorboats/pontoons between 1-20 HP
   4 Motorboats/pontoons between 21-50 HP
   0 Motorboats/pontoons more than 50 HP
   10 Canoes and kayaks
   3 Paddleboats/rowboats
   0 Sailboats/ windsurfing
   0 Other, please describe

9. From the list below, please rank your top three concerns for Coon Lake.

(Please list your top three concerns in order of importance, with 1st being most important)

1st Pollution
2nd Water levels
3rd Invasive species

A. **Pollution** (chemical inputs, septic systems, agriculture, erosion, storm water runoff) **98 points**
B. **Development** (population density, loss of wildlife habitat) **16 points**

C. **Quality of life 8 points**
D. **Property values and/or taxes 14 points**
E. **Water recreation safety** (boat traffic, no wake zone) **7 points**
F. **Water clarity** (visibility) **28 points**
G. **Aquatic plants** (not including algae) **14 points**
H. **Invasive species** (Eurasian water milfoil, zebra mussels, buckthorn, purple loosestrife) **33 points**
I. **Harmful algae blooms 10 points**
J. **Quality of fisheries 30 points**
K. **Water levels** (loss of lake volume) **58 points**
L. **Other**, please describe **7 points**
   Less rain/other drainage
   Clean park, at a swimming pool at the park to make the park a focal point
   Currently no beach/swimming area
   Surround area maintained
   Runoff/dirty, would love a path around entire lake—would use more park, new safer play area for children
   Would like to see more fish/would like to see no skidoos, etc.

10. How would you describe the current water quality of Coon Lake? **60 respondents**
   □Poor **1 respondent, 2 %**
   □Fair **11 respondents, 18%**
   □Unsure **29 respondents, 48%**
   □Good **20 respondents, 33%**
   □Excellent **0 respondents, 0%**

11. How has the water quality changed in Coon Lake in the time you've owned your property? **52 respondents**
   □Severely degraded **1 respondents, 2%**
   □Somewhat degraded **7 respondents, 13%**
   □Remained unchanged **27 respondents, 52%**
   □Somewhat improved **13 respondents, 25%**
   □Greatly improved **4 respondents, 8%**

12. How would you describe the amount of current shoreline vegetation at the park on Coon Lake (starting at the water and going landward)? **59 respondents**
   □Too much **13 respondents, 22%**
   □Just right **29 respondents, 49%**
   □Not enough **2 respondents, 3%**
   □Unsure **15 respondents, 25%**

13. During open water season, how often does aquatic plant growth, including algae, negatively impact your enjoyment of Coon Lake? **55 respondents**
   □Never **15 respondents, 27%**

☐Rarely **19 respondents, 35%**
☐Sometimes **15 respondents, 27%**
☐Often **5 respondents, 9%**
☐Always **1 respondent, 2%**

14. Considering you answer to the above question, do you believe aquatic plant control is needed on Coon Lake? **56 respondents**
☐Definitely yes **7 respondents, 13%**
☐Probably yes **12 respondents, 21%**
☐Unsure **23 respondents, 41%**
☐Probably no **12 respondents, 21%**
☐Definitely no **3 respondents, 5%**

15. How would you describe the importance of wetlands to Coon Lake's water quality? **58 respondents**
☐Not at all important **0 respondents, 0%**
☐Not too important **2 respondents, 3%**
☐Unsure **21 respondents, 36%**
☐Somewhat important **9 respondents, 16%**
☐Very important **25 respondents, 43%**

16. From the list below, please check all of the management practices, if any, that you do which help protect the Coon Lake watershed. (Please check all that apply.) **57 respondents**
☐Not using fertilizer **26 respondents, 46%**
☐Installing rain gardens **2 respondents, 4%**
☐Planting natural grassland and flower species **13 respondents, 23%**
☐Implementing projects to slow runoff **3 respondents, 5%**
☐Roadside cleanup or other attempts to stop pollution **25 respondents, 44%**
☐Using no wake near shorelines **6 respondents, 11%**
☐Removing plant material from boats after leaving a lake **12 respondents, 21%**
☐Other, please describe **1 respondents, 2%**
Check Coon Lake Condition
☐I do not do any of the above **19 respondents, 27%**

17. Are you aware that there is a ban on using fertilizers containing phosphorus within shore land areas (1000 feet from a lake or 300 feet from a stream) in Polk County? **59 respondents**
☐Yes **33 respondents, 56%**
☐No **26 respondents, 44%**

18. Stormwater runoff can become a problem when it does not soak into the ground after rain events. How much of a problem, if at all, would you say stormwater runoff is in the Village of Frederic? **58 respondents**
☐No problem at all **3 respondents, 5%**
☐Little problem **15 respondents, 26%**

☐Unsure **22 respondents, 38%**
☐Moderate problem **12 respondents, 21%**
☐Large problem 6 **respondents, 10%**

19. Would you be willing to provide financial support to maintain or improve the quality of Coon Lake and its associated land resources? **58 respondents**
☐Yes **8 respondents, 14%**
☐No **15 respondents, 26%**
☐Unsure, I would need more information **35 respondents, 60%**

20. **If you answered yes to question 19**, how much would you be willing to contribute each year? *This question is only designed to give an indication of possible support. It is not intended to act as a commitment for financial support.*
Average $57

21. Please provide your age. I am ________ years old.

Average age: 63

Thank you for your participation in this survey!

Please use the remaining space to add any additional comments or concerns you have regarding Coon Lake and its surrounding land resources.

I live on west side of village.
There is very little that can be done to minimize runoff from areas around Coon Lake.
You just spent $250,000 on only walk way that should not be. Use your head!
Unsure about water quality change in Coon Lake since owned property one year.
Large problem with runoff in Village especially in front of our home at Lake Ave So.
Way too much buckthorn around lake & on village property. Also on Gandy Dancer corridor owned by DNR.
When my son swims in the lake he smells like fish BAD! Water seems dirty. It would be nice to have a nice swimming area.
I think the waterskip event was a terrible thing for our lake. It disturbs fish and their beds, pollutes and is noisy.
The park at Coon lake is a great asset to the village, I think it's being used more often than ever, so many fisherman - boats, from bridge - dock and the shore, especially wonderful to see so many youth there, also the covered shelter has been busy with celebrations often.
Since there isn't a pool in town any longer, it would be nice to have a swimming beach.
Please extend trail around lake, handicap accessible too; please do not turn into campground for campers; please do not sell to homeowners to build on; please provide water on east side.
In Wisconsin it is nice having a lake nearby.
I truly wish that my family and other families in Frederic could use Coon Lake to safely swim with children. We desperately need a beach and a lake clean enough to swim in.

Coon Lake Management Plan

Coon Lake Phytoplankton Data

Appendix F

Polk County Land and Water Resources Department
12/31/2011

Collection date	Taxa	Division	Natural Units/ML	Percentage
5/17/2010	AULACOSEIRA SP.	Bacillariophyta	170	0.6
	SCENEDESMUS SP.	Chlorophyta	341	1.2
	CRYPTOMONAS SP.	Cryptophyta	1107	4
	APHANIZOMENON FLOS-AQUAE	Cyanophyta	255	0.9
	LIMNOTHRIX SP.	Cyanophyta	25974	93.3
5/28/2010	AULACOSEIRA SP.	Bacillariophyta	136	1.9
	CYCLOTELLA SP.	Bacillariophyta	23	0.3
	FRAGILARIA SP.	Bacillariophyta	227	3.2
	DYSMORPHOCOCCUS SP.	Chlorophyta	159	2.3
	GLOEOCYSTIS SP.	Chlorophyta	136	1.9
	PEDIASTRUM SP.	Chlorophyta	68	1
	SCENEDESMUS SP.	Chlorophyta	363	5.2
	SCHROEDERIA SP.	Chlorophyta	45	0.6
	CRYPTOMONAS SP.	Cryptophyta	1453	20.8
	KOMMA CAUDATA	Cryptophyta	386	5.5
	APHANIZOMENON FLOS-AQUAE	Cyanophyta	45	0.6
	APHANOTHECE SP.	Cyanophyta	91	1.3
	LIMNOTHRIX SP.	Cyanophyta	3861	55.2
6/14/2010	AULACOSEIRA SP.	Bacillariophyta	17	5.3
	CLOSTERIUM SP.	Chlorophyta	3	0.9
	DYSMORPHOCOCCUS SP.	Chlorophyta	14	4.4
	GLOEOCYSTIS SP.	Chlorophyta	24	7.5
	PEDIASTRUM SP.	Chlorophyta	20	6.3
	SCENEDESMUS SP.	Chlorophyta	27	8.5
	SCHROEDERIA SP.	Chlorophyta	68	21.4
	STAURASTRUM SP.	Chlorophyta	3	0.9
	CRYPTOMONAS SP.	Cryptophyta	65	20.4
	KOMMA CAUDATA	Cryptophyta	3	0.9
	ANABAENA SP.	Cyanophyta	7	2.2
	APHANIZOMENON FLOS-AQUAE	Cyanophyta	3	0.9
	APHANOTHECE SP.	Cyanophyta	61	19.2
	CERATIUM HIRUNDINELLA	Pyrrhophyta	3	0.9
6/29/2010	AULACOSEIRA SP.	Bacillariophyta	4	0.4
	COSMARIUM SP.	Chlorophyta	7	0.6
	DYSMORPHOCOCCUS SP.	Chlorophyta	39	3.6
	GLOEOCYSTIS SP.	Chlorophyta	50	4.6
	OOCYSTIS SP.	Chlorophyta	7	0.6
	PEDIASTRUM SP.	Chlorophyta	7	0.6
	SCENEDESMUS SP.	Chlorophyta	32	3
	SCHROEDERIA SP.	Chlorophyta	183	17
	STAURASTRUM SP.	Chlorophyta	32	3
	CRYPTOMONAS SP.	Cryptophyta	147	13.6
	KOMMA CAUDATA	Cryptophyta	25	2.3
	ANABAENA SP.	Cyanophyta	7	0.6
	APHANIZOMENON FLOS-AQUAE	Cyanophyta	488	45.2
	APHANOTHECE SP.	Cyanophyta	7	0.6
	COELOSPHAERIUM SP.	Cyanophyta	7	0.6
	MICROCYSTIS SP.	Cyanophyta	29	2.7
	PLANKTOLYNGBYA SP.	Cyanophyta	4	0.4
	PLANKTOTHRIX SP.	Cyanophyta	4	0.4
7/19/2010	AULACOSEIRA SP.	Bacillariophyta	11	0.3
	COELASTRUM SP.	Chlorophyta	110	3.3
	COSMARIUM SP.	Chlorophyta	22	0.7
	DYSMORPHOCOCCUS SP.	Chlorophyta	66	2

	GLOEOCYSTIS SP.	Chlorophyta	22	0.7
	PEDIASTRUM SP.	Chlorophyta	11	0.3
	SCENEDESMUS SP.	Chlorophyta	44	1.3
	SCHROEDERIA SP.	Chlorophyta	11	0.3
	STAURASTRUM SP.	Chlorophyta	22	0.7
	CRYPTOMONAS SP.	Cryptophyta	626	18.6
	KOMMA CAUDATA	Cryptophyta	88	2.6
	ANABAENA SP.	Cyanophyta	99	2.9
	APHANIZOMENON FLOS-AQUAE	Cyanophyta	2077	61.8
	MICROCYSTIS SP.	Cyanophyta	110	3.3
	PLANKTOTHRIX SP.	Cyanophyta	44	1.3
7/30/2010	COELASTRUM SP.	Chlorophyta	372	11.9
	COSMARIUM SP.	Chlorophyta	10	0.3
	DYSMORPHOCOCCUS SP.	Chlorophyta	124	4
	GLOEOCYSTIS SP.	Chlorophyta	351	11.3
	OOCYSTIS SP.	Chlorophyta	103	3.3
	PEDIASTRUM SP.	Chlorophyta	21	0.7
	SCENEDESMUS SP.	Chlorophyta	62	2
	SCHROEDERIA SP.	Chlorophyta	10	0.3
	STAURASTRUM SP.	Chlorophyta	52	1.7
	CRYPTOMONAS SP.	Cryptophyta	52	1.7
	KOMMA CAUDATA	Cryptophyta	10	0.3
	APHANIZOMENON FLOS-AQUAE	Cyanophyta	21	0.7
	COELOSPHAERIUM SP.	Cyanophyta	10	0.3
	MICROCYSTIS SP.	Cyanophyta	1848	59.3
	PLANKTOTHRIX SP.	Cyanophyta	62	2
	CERATIUM HIRUNDINELLA	Pyrrhophyta	10	0.3
8/19/2010	AULACOSEIRA SP.	Bacillariophyta	87	3.2
	CLOSTERIUM SP.	Chlorophyta	498	18.5
	COELASTRUM SP.	Chlorophyta	297	11
	COSMARIUM SP.	Chlorophyta	17	0.6
	DYSMORPHOCOCCUS SP.	Chlorophyta	201	7.5
	GLOEOCYSTIS SP.	Chlorophyta	44	1.6
	OOCYSTIS SP.	Chlorophyta	70	2.6
	PEDIASTRUM SP.	Chlorophyta	35	1.3
	SCENEDESMUS SP.	Chlorophyta	192	7.1
	SCHROEDERIA SP.	Chlorophyta	17	0.6
	STAURASTRUM SP.	Chlorophyta	44	1.6
	CRYPTOMONAS SP.	Cryptophyta	1170	43.5
	KOMMA CAUDATA	Cryptophyta	17	0.6
9/3/2010	AULACOSEIRA SP.	Bacillariophyta	749	29.2
	FRAGILARIA SP.	Bacillariophyta	434	16.9
	CLOSTERIUM SP.	Chlorophyta	9	0.4
	COELASTRUM SP.	Chlorophyta	51	2
	COSMARIUM SP.	Chlorophyta	17	0.7
	DYSMORPHOCOCCUS SP.	Chlorophyta	434	16.9
	GOLENKINIA SP.	Chlorophyta	17	0.7
	OOCYSTIS SP.	Chlorophyta	60	2.3
	PANDORINA SP.	Chlorophyta	9	0.4
	PEDIASTRUM SP.	Chlorophyta	136	5.3
	SCENEDESMUS SP.	Chlorophyta	68	2.7
	SCHROEDERIA SP.	Chlorophyta	17	0.7
	STAURASTRUM SP.	Chlorophyta	9	0.4
	CRYPTOMONAS SP.	Cryptophyta	554	21.6
10/8/2010	AULACOSEIRA SP.	Bacillariophyta	245	12
	FRAGILARIA SP.	Bacillariophyta	27	1.3

	CLOSTERIUM SP.	Chlorophyta	34	1.7
	COELASTRUM SP.	Chlorophyta	61	3
	COSMARIUM SP.	Chlorophyta	7	0.3
	DYSMORPHOCOCCUS SP.	Chlorophyta	75	3.7
	GLOEOCYSTIS SP.	Chlorophyta	7	0.3
	GOLENKINIA SP.	Chlorophyta	75	3.7
	OOCYSTIS SP.	Chlorophyta	48	2.3
	PANDORINA SP.	Chlorophyta	20	1
	PEDIASTRUM SP.	Chlorophyta	55	2.7
	SCENEDESMUS SP.	Chlorophyta	48	2.3
	STAURASTRUM SP.	Chlorophyta	61	3
	CRYPTOMONAS SP.	Cryptophyta	1076	52.5
	KOMMA CAUDATA	Cryptophyta	170	8.3
	COELOSPHAERIUM SP.	Cyanophyta	20	1
	MICROCYSTIS SP.	Cyanophyta	14	0.7
	PLANKTOLYNGBYA SP.	Cyanophyta	7	0.3

Coon Lake Management Plan

Coon Lake Zooplankton Data and Report

Appendix G

Toben Lafrançois
12/31/2011

Date	Taxa	Abundance	Biomass (ug/l)	Calcs abundance	Raw numbers
5/17/09	Chydorus spp.	1.1	0.1918	1.1	2
	Total Daphnia spp.			2.7	
	Daphnia spp.	2.7	17.6662		
	Daphnia mendotae	2.7	17.6662		5
	total Cyclopoid spp.			2.7	
	Cyclopoid spp.	1.6	0.4212		
	total Calanoid spp.			1.6	
	Calanoid spp.	1.1	5.3842	1.1	
	total nauplii and copepodids (not included in copepoda total)	9.0	5.5193	9.0	
	Calanoid female- Diaptomidae	1.1	5.3842	1.1	2
	Cyclopoid nauplius	6.4	5.3102	6.4	12
	copepodid	2.7	0.2091	2.7	5
	(Homocyclops sp.)	1.1	0.3945	1.1	2
	Microcyclops (rubellus)	0.5	0.0267	0.5	1
	Asplanchna priodonta	4.2	190.1030	4.2	8
	Keratella spp (sum)		58.2855		
	Keratella cochlearis	168.5	58.2855	168.5	318
	Trichocerca pusilla	3.7	0.7385	3.7	7
	testate protozoa	63.6	18.5302		
	testate amoebae			63.6	
	testate 1 (sphere)			63.6	120
	Cucurbitella sp.	63.6	18.5302		
5/28/09	Chydorus spp.	3.2	0.5719	3.2	4
	Total Daphnia spp.			7.9	
	Daphnia spp.	7.9	52.6654		
	Daphnia mendotae	7.9	52.6654	7.9	10
	Diaphanosoma brachyurum	3.2	4.0579	3.2	4
	total Cyclopoid spp.			4.7	
	Cyclopoid spp.	4.7	1.1454		
	total Calanoid spp.			4.0	
	Calanoid spp.	4.0	20.0639		
	total nauplii and copepodids (not included in copepoda total)	12.6	9.9844	12.6	
	Calanoid female- Diaptomidae	4.0	20.0639	4.0	5
	Calanoid nauplius	2.4	2.6041	2.4	3
	Cyclopoid nauplius	8.7	7.2557	8.7	11
	copepodid	1.6	0.1246	1.6	2
	Diacyclops spp.	1.6	0.2236	1.6	2
	(Homocyclops sp.)	2.4	0.8821	2.4	3
	Microcyclops (rubellus)	0.8	0.0397	0.8	1
	Asplanchna priodonta	2.4	106.2604	2.4	3
	Keratella spp (sum)		30.8719		
	Keratella cochlearis	89.3	30.8719	89.3	113
	Polyarthra spp. (sum)	2.4	4.2210	2.4	
	Polyarthra euryptera	2.4	4.2210	2.4	3
	Trichocerca pusilla	2.4	0.4718	2.4	3
	testate protozoa	174.6	50.8678		
	Cucurbitella sp.	174.6	50.8678		
	testate amoebae			174.6	
	testate 1 (sphere)			174.6	221
6/14/09	Bosminidae(Bosmina longirostrus and possibly others)	1.6	0.3560	1.6	2

	Chydorus spp.	4.7	0.8578	4.7	6
	Total Daphnia spp.			32.0	
	Daphnia spp.	30.0	190.1127		
	Daphnia ambigua	2.4	5.7839	2.4	3
	Daphnia mendotae	27.7	184.3288	27.7	35
	Diaphanosoma brachyurum	0.8	1.0145	0.8	1
	total nauplii and copepodids (not included in copepoda total)	1.6	0.9303	1.6	
	Calanoid nauplius	0.8	0.8680	0.8	1
	copepodid	0.8	0.0623	0.8	1
	Asplanchna priodonta	3.2	141.6805	3.2	4
	Keratella spp (sum)		9.0157		
	Keratella cochlearis	26.1	9.0157	26.1	33
7/19/09	Bosminidae(Bosmina longirostrus and possibly others)	20.5	4.6280	20.5	26
	Chydorus spp.	57.7	10.4369	57.7	73
	Total Daphnia spp.			18.2	
	Daphnia spp.	18.2	97.7605		
	Daphnia ambigua	5.5	13.4959	5.5	7
	Daphnia mendotae	12.6	84.2646	12.6	16
	Diaphanosoma brachyurum	4.0	5.0723	4.0	5
	total Cyclopoid spp.			5.5	
	Cyclopoid spp.	5.5	1.0410		
	total nauplii and copepodids (not included in copepoda total)	14.2	7.0946	14.2	
	Cyclopoid nauplius	7.9	6.5961	7.9	10
	copepodid	6.3	0.4986	6.3	8
	(Homocyclops sp.)	2.4	0.8821	2.4	3
	Microcyclops (rubellus)	3.2	0.1589	3.2	4
	Ascomorpha saltans	19.8	32.7996	19.8	25
	Asplanchna priodonta	0.8	35.4201	0.8	1
	Brachyonus havanaensis	0.8	0.4170	0.8	1
	Filinia longiseta	0.8	0.3823	0.8	1
	Gastropus sp.	2.4	2.6177	2.4	3
	Keratella spp (sum)		2.1856		
	Keratella cochlearis	6.3	2.1856	6.3	8
	Lecane ungulata	0.8	1.2637	0.8	1
	Polyarthra spp. (sum)	2.4	4.2210	2.4	
	Polyarthra euryptera	2.4	4.2210	2.4	3
	Trichocerca cylindrica	4.0	1.7528	4.0	5
7/30/09	Bosminidae(Bosmina longirostrus and possibly others)	14.8	3.3279	14.8	7
	Chydorus spp.	23.2	4.2004	23.2	11
	Total Daphnia spp.			21.1	
	Daphnia spp.	21.1	140.6632		
	Daphnia mendotae	21.1	140.6632	21.1	10
	Diaphanosoma brachyurum	6.3	8.1285	6.3	3
	Cyclopoid spp.	2.1	0.2986	2.1	
	total nauplii and copepodids (not included in copepoda total)	38.0	31.7112	38.0	
	Cyclopoid nauplius	38.0	31.7112	38.0	18
	Diacyclops spp.	2.1	0.2986	2.1	1
	Anuraeopsis sp.	6.3	5.4002	6.3	3
	Conochilus sp.	2.1	1.4816	2.1	1
	Keratella spp (sum)		5.1078		

	Keratella cochlearis	14.8	5.1078	14.8	7
	Trichocerca cylindrica	2.1	0.9363	2.1	1
	testate protozoa	2.1	0.6148		
	Cucurbitella sp.	2.1	0.6148		
	testate amoebae			2.1	
	testate 1 (sphere)			2.1	1
8/19/09	Bosminidae(Bosmina longirostrus and possibly others)	442.4	99.6794	442.4	112
	Chydorus spp.	11.9	2.1446	11.9	3
	Ceriodaphnia lacustris	11.9	5.0464	11.9	3
	Daphnia spp.	4.0	10.8658		
	Total Daphnia spp.			4.0	
	Daphnia longiremus	4.0	10.8658	4.0	1
	Diaphanosoma brachyurum	11.9	15.2169	11.9	3
	total Cyclopoid spp.			138.3	
	Cyclopoid spp.	138.3	7.3124		
	total nauplii and copepodids (not included in copepoda total)	367.4	291.7846	367.4	
	Cyclopoid nauplius	347.6	290.2265	347.6	88
	copepodid	19.8	1.5580	19.8	5
	Diacyclops spp.	4.0	0.5590	4.0	1
	Microcyclops (rubellus)	134.3	6.7534	134.3	34
	Asplanchna brightwelli	7.9	652.3979		2
	Conochiloides sp.	7.9	9.9410	7.9	2
	Kellicottia bostoniensis	43.5	10.5257	43.5	11
	Keratella spp (sum)		8.1961		
	Keratella cochlearis	23.7	8.1961	23.7	6
	Polyarthra spp. (sum)	35.6	21.1048	35.6	
	Polyarthra euryptera	11.9	21.1048	11.9	3
	Pompholyx sulcata	23.7	21.5877	23.7	6
	Synchaeta oblonga	4.0	4.2649	4.0	1
	Trichocerca cylindrica	11.9	5.2584	11.9	3
	testate protozoa	31.6	4.1645		
	tintinnid ciliate *Codonella* sp.	31.6	4.1645		
	testate amoebae			31.6	
	testate 2 (amphora)			31.6	8
9/3/09	Bosminidae(Bosmina longirostrus and possibly others)	79.1	17.8112	79.1	15
	Ceriodaphnia lacustris	21.1	8.9770	21.1	4
	Holopedium gibberum	5.3	14.1542	5.3	1
	total Cyclopoid spp.			205.5	
	Cyclopoid spp.	205.5	14.6629		
	total nauplii and copepodids (not included in copepoda total)	363.6	275.7197	363.6	
	Cyclopoid nauplius	326.7	272.8096	326.7	62
	copepodid	36.9	2.9101	36.9	7
	Diacyclops spp.	47.4	6.7127	47.4	9
	Microcyclops (rubellus)	158.1	7.9502	158.1	30
	Conochilus sp.	26.4	18.5019	26.4	5
	Kellicottia bostoniensis	68.5	16.5965	68.5	13
	Keratella spp (sum)		3.6450		
	Keratella cochlearis	10.5	3.6450	10.5	2
	Polyarthra spp. (sum)	42.2		42.2	
	Pompholyx sulcata	26.4	24.0015	26.4	5
	Polyarthra vulgaris	15.8	20.9436	15.8	3

	testate protozoa	448.0	60.7159		
	Cucurbitella sp.	10.5	3.0709		
	tintinnid ciliate *Codonella* sp.	437.4	57.6450		
	testate amoebae			448.0	
	testate 1 (sphere)			10.5	2
	testate 2 (amphora)			437.4	83
10/8/09	Bosminidae(Bosmina longirostrus and possibly others)	44.3	9.9837	44.3	21
	Chydorus spp.	6.3	1.1456	6.3	3
	Ceriodaphnia lacustris	2.1	0.8985	2.1	1
	Diaphanosoma brachyurum	2.1	2.7095	2.1	1
	total Cyclopoid spp.			59.1	
	Cyclopoid spp.	59.1	3.5485		
	total nauplii and copepodids (not included in copepoda total)	84.4	67.2787	84.4	
	Cyclopoid nauplius	80.2	66.9458	80.2	38
	copepodid	4.2	0.3329	4.2	2
	Diacyclops spp.	6.3	0.8959	6.3	3
	Microcyclops (rubellus)	52.8	2.6526	52.8	25
	Conochilus sp.	46.4	32.5942	46.4	22
	Kellicottia bostoniensis	23.2	5.6226	23.2	11
	Polyarthra spp. (sum)	10.6		10.6	
	Polyarthra vulgaris	10.6	13.9756	10.6	5
	testate protozoa	57.0	15.5950		
	tintinnid ciliate *Codonella* sp.	21.1	2.7807		
	Difflugia sp.	35.9	12.8143		
	testate amoebae			57.0	
	testate 2 (amphora)			21.1	10
	testate 3 (vase)			35.9	17

	5/17/09	**5/28/09**	**6/14/09**	**7/19/09**	**7/30/09**	**8/19/09**	**9/3/09**	**10/8/09**
Diversity (genera)	9	12	8	16	10	16	11	10
Diversity (taxa)	10	14	10	18	11	17	14	12
Cladocera abundance	3.7	14.2	37.1	100.3	65.4	481.9	105.4	54.9
Cladocera abundance calculations	3.7	14.2	37.1	100.3	65.4	481.9	105.4	54.9
Copepoda abundance	2.7	8.7	0.0	5.5	2.1	138.3	205.5	59.1
Copepoda abundance calculations	2.7	8.7	0.0	5.5	2.1	138.3	205.5	59.1
Rotifera abundance	176.5	96.4	29.2	37.9	25.3	134.3	147.6	80.2
Rotifera abundance calculations	176.5	96.4	29.2	37.9	25.3	134.3	147.6	80.2
Total number abundance	182.9	119.3	66.4	143.8	92.8	754.5	458.5	194.1
Cladocera biomass	17.9	57.3	192.3	117.9	156.3	133.0	40.9	14.7
Copepoda biomass	5.8	21.2	0.0	1.0	0.3	7.3	14.7	3.5
Rotifera biomass	249.1	141.8	150.7	81.1	12.9	733.3	83.7	52.2

Species List by Taxa for Coon Lake
Bosminidae (*Bosmina longirostrus* confirmed)
Chydorus spp.
Ceriodaphnia lacustris
Daphnia spp.
Daphnia ambigua
Daphnia longiremus
Daphnia mendotae
Diaphanosoma brachyurum
Holopedium gibberum
Calanoid female- Diaptomidae
Calanoid nauplius
Cyclopoid nauplius
copepodid
Diacyclops spp.
(*Homocyclops* sp.)
Microcyclops (*rubellus*)
Anuraeopsis sp.
Ascomorpha saltans
Asplanchna brightwelli
Asplanchna priodonta
Brachyonus havanaensis
Conochilus sp.
Conochiloides sp.
Kellicottia bostoniensis
Keratella spp.
Keratella cochlearis
Lecane ungulata
Polyarthra spp.
Polyarthra euryptera
Polyarthra vulgaris
Pompholyx sulcata
Synchaeta oblonga
Trichocerca cylindrica
Trichocerca pusilla
testate protozoa
Cucurbitella sp.
tintinnid ciliate *Codonella* sp.
Difflugia sp.

Zooplankton abundance and biomass estimates for Big Butternut and Coon Lakes, Polk Co., WI, 2009 with taxonomic and ecological notes.

Cladoceran (Bosmina sp.) from Coon Lake, Polk Co., WI.

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Contents

List of figures

List of tables

1. Summary

Zooplankton form a critical link between bottom-up and top-down processes in lakes. They are voracious consumers of algae and bacteria, and are also a favorite fish food of planktivorous pan fish, minnows and fry of larger fish. In this way, zooplankton connect two of the most important features of lake management- water clarity and fishing. Examining zooplankton community composition, abundances, and presence of sensitive or tolerant organisms is like looking under the hood of a car because it shows how important lake processes are mechanically connected.

Zooplankton were sampled from Big Butternut and Coon Lakes during the 2009 ice free season by Polk County Land and Water Resources Department. Samples were counted and identified at the St. Croix Watershed Research Station of the Science Museum of Minnesota. Results are reported below and data are included in an attached Microsoft Excel file (including all graphs and tables). In the absence of other data regarding fish presence or trophic status, some of the zooplankton phenology is difficult to interpret, but the patterns within each lake and the comparison between them are by themselves very informative. Basic information is summarized below, correlation with other environmental factors to explain differences in water quality will require further analysis.

Big Butternut Lake shows a clear pattern of large cladoceran biomass (primarily Daphnia mendotae) dominating the early season, followed by a precipitous decline. Other community data does not suggest interspecific competition or invertebrate predation as the cause. Neither is it likely the result of normal phenology, which leaves a fish predation event (stocking of fry or pan fish) as a primary cause. This decline represents a large reduction in grazing capacity of the zooplankton community. Conclusions must be corroborated with data on other aspects of the community (fish, temperature, nutrients, algae).

Coon Lake zooplankton follow a complicated phenology that includes competetive replacement and several shifts in biomass. It is difficult from the zooplankton data alone to make any inferences about lake processes in Coon Lake, but when incorporated with other data the zooplankton community data should be illuminating. In general, Coon Lake supported an order of magnitude less biomass of zooplankton than Big Butternut Lake and showed greater fluctuation in species composition, biomass, and diversity over the sampling year.

2. Laboratory methods

Zooplankton were identified at the St. Croix Watershed Research Station, Marine on St. Croix MN (a non-profit research branch of the Science Museum of Minnesota). Samples were rinsed in a 35um net and placed in Falcon centrifuge tubes with 30 to 35 ml of 80% ETOH (depending on the density of sample). The Falcon tube was vigorously agitated and sub-sampled with a 1ml Hempsten-Stempel pipette. This subsample was placed in a Sedgwick rafter cell for counting. The portion of the subsample counted (number of rows within the rafter) was determined on a per sample basis relative to the density of the sample. Numbers were then converted to back to lake density (numbers per liter) based on the Falcon tube volume and vertical tow volume. The methods listed here reflect the particular conditions of these lakes and sampling design. They were tested for sufficiency but should not be reproduced in other systems without re-testing adequacy.

An Olympus BX50F4 Microscope was used for counting and digital pictures of whole organisms. The most widely accepted taxonomic keys were used (Balcer et al., 1984; Thorp et al., 1997; Smith et al., 2001) as well as the most recent or most informative species accounts (Stemberger 1979, De Melo et al. 1994, Hebert 1995, Kotov et al. 2009). It should be noted that available keys are not always in agreement, and many contain errors (particularly Torke 1976). Results from the present analysis should be consistent with other studies of zooplankton because these keys represent the best available taxonomy to date. Biomass estimates follow Doohan 1973, Dumont et al. 1975, Bottrell et al. 1976, Pace et al. 1981, and McCauley 1984.

3. Big Butternut Lake Zooplankton Ecology, 2009

Zooplankton taxa found in Butternut Lake in 2009 are listed in Table 1. Analyzed and raw data are included in an attached Microsoft Excel file "PolkCoZoop2009". In 2009, the densities of cladocerans and copepods remained fairly stable with a mid-July increase, while rotifers increased dramatically in mid-July (Figure 1). The biomass estimates tell the real story here, however (Figure 2). Rotifer biomass followed density very closely, which is no surprise since body size within most species and between many of the species present is relatively similar. Copepod biomass also tracks density.

Cladoceran biomass, however, shows the opposite trend as cladoceran density, crashing from very high levels in spring and climbing again in fall. This strongly indicates a size selective predation event. In the absence of large copepods and no evidence of chaoboridae or other invertebrate predators in the samples, it seems very likely that this is a major fish predation event rather than competition or invertebrate predation. The change in cladoceran biomass results in a very strong drop in algal grazing capacity in July. Taking the rotifers out of the graph shows this trend in much greater detail. Cladoceran and copepod numbers track each other, increasing over summer and dropping of in late summer to early fall (Figure 3). Cladoceran biomass, on the other hand, follows a different pattern, indicating fewer, larger species in spring followed by a rapid decline in numbers and size, with some late summer recovery (Figure 4).

A closer look at the most common species from each group shows that *Daphnia mendotae* is the cladoceran responsible both for the high numbers and biomass in spring to early summer and late fall (Figures 5 and 6). However, not all the autumn recovery of cladoceran biomass is *D. mendotae*, but includes other, smaller cladocerans. This pattern confirms the hypothesis that fish predation in midsummer is responsible for the major loss in cladoceran biomass, as *D. mendotae* are favorite prey of pan fishes. Given the late occurrence, it is unlikely to be fry predating on the plankton (which would normally produce a dip in spring rather than midsummer) unless stocking of fry or more pan fish took place. It is also possible that a major algal bloom good knock *Daphnia* back if it there was a corresponding algal species shift away from the normal grazing preferences of the species.

4. Coon Lake Zooplankton Ecology, 2009 with comparison between Big Butternut and Coon Lakes

Zooplankton taxa found in Coon Lake in 2009 are listed in Table 1. Analyzed and raw data are included in an attached Microsoft Excel file "PolkCoZoop2009". The abundance of the three major zooplankton groups follow a different and more complex pattern than shown in Big Butternut Lake. Cladoceran abundance shows an inverse pattern to Big Butternut- low throughout the year but peaking in mid-August (Figure 7). Rotifers and copepods follow each other, with relatively low numbers that peak in fall. Rotifer and copepod biomass follow similar trends as their abundance, while like Big Butternut the cladocera biomass follows an inverse patter to abundance (Figure 8). The high cladoceran numbers and biomass in August are due to an increase in *Bosmina* spp. and *Chydorus* sp. (Figures 9 and 10), while spring and midsummer cladoceran numbers are dominated by *Daphnia* species and to some extent *Diaphanosoma brachyurum* (Figures 11 and 12). Taken together the data show a shift from spring dominance of zooplankton biomass (but not density) by *Daphnia* replaced by greater numbers of smaller cladocerans in late summer and fall. Looking more closely at the relationship among the cladoceran groups shows low densities of all cladocerans until August, when *Bosmina* species increase remarkably (Figure 13). Large *Daphnia* species dominate the biomass of the cladocera (as well as the entire zooplankton assemblage) in spring and early summer, to be replaced by *Bosmina* spp. in August (Figure 14), with a net reduction in cladoceran biomass (and consequently grazing capacity of the zooplankton community).

It is difficult to interpret these patterns as a top-down or bottom-up response without other information. However, it is likely a combination of fish predation and competition between cladoceran groups. This is indicated (but not proven) by the relationship of *Daphnia* being replaced by *Ceriodaphnia* in August (Figures 15 and 16). The replacement looks very much like a competitive shift looking at densities, and this shift has large consequences on the grazing capacity as shown by changes in biomass. This is a complex system and further work on the zooplankton dynamics is necessary to untangle the relationship between food web changes and water quality.

There are more differences between the two study lakes that are important to note. First, Coon lake supports far lower (almost two orders of magnitude) densities of zooplankton with the exception of the bosminid bloom in August (Figure 17). This relationship is made more distinct when looking at biomass, with an order of magnitude difference in spring biomass (Big Butternut supporting the larger zooplankton mass) with a startling reversal in mid-August (Figure 18). The two lakes support similar numbers of cladocerans, with Coon lake showing a leap in cladoceran numbers in August due to the bosminid bloom (Figure 19).

Raw species richness is more stable in Big Butternut than Coon (Figure 20). The fluctuations in Coon can be from several factors that are not identifiable with this data set. Number of genera (Figure 21) show a similar pattern as species for Coon Lake, reflecting the complex phenology. The pattern for Big Butternut Lake is more exaggerated than the species pattern in large part due to a shifts between species rich genera like *Daphnia* and genera-rich groups like the rotifers.

Looking just at the zooplankton data, it can be concluded that Big Butternut in general supports more and larger zooplankton. However, some event in mid-summer dramatically changes the zooplankton community in Big Butternut and this event does not seem to be competition or invertebrate predation. Coon lake supports far fewer zooplankton as well as smaller species, but the community seems far more stable other than what appear to be changes expected from normal community phenology.

5. Taxonomic notes

The calanoid copepods were not identifiable as species due to a lack of male specimens. Cyclopoids did not always key very well for several reasons. It is a rare and happy occasion to obtain a regionally specific guide to these groups, but TORKE contains several errors and omissions that are not easily corrected with other keys. Generic attributions of the cyclopoids are made with confidence, but species names used only when certain (otherwise they are in parentheses).

Testate and ciliate species were not discussed here, but my provide useful clues to the ecology of these lakes. Identifications were confirmed with the help of Dr. Stephen Wickham, Dept. of Organismic Biology, University of Salzburg, Austria.

Finally, despite the major role bosminidae play and the taxonomic patience of the author, it was very difficult to identify the bosminidae of these two lakes. *Bosmina longirostrus* was present (with certainty) but several characters of other genera and genera were seen but the specimens were not fully intact so complete identification was not possible. It does not help that there is much disagreement in the recent literature (reviewed in Kotov et al. 2009). Digital images of taxonomic characters were taken when possible, particularly some shots of several lateral pores and pectin fringes. These images will be archived at the SCWRS. No genera or species that are different from *Bosmina longirostrus* in ecologically meaningful ways were found (such as *E. coregoni*).

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7. Figures

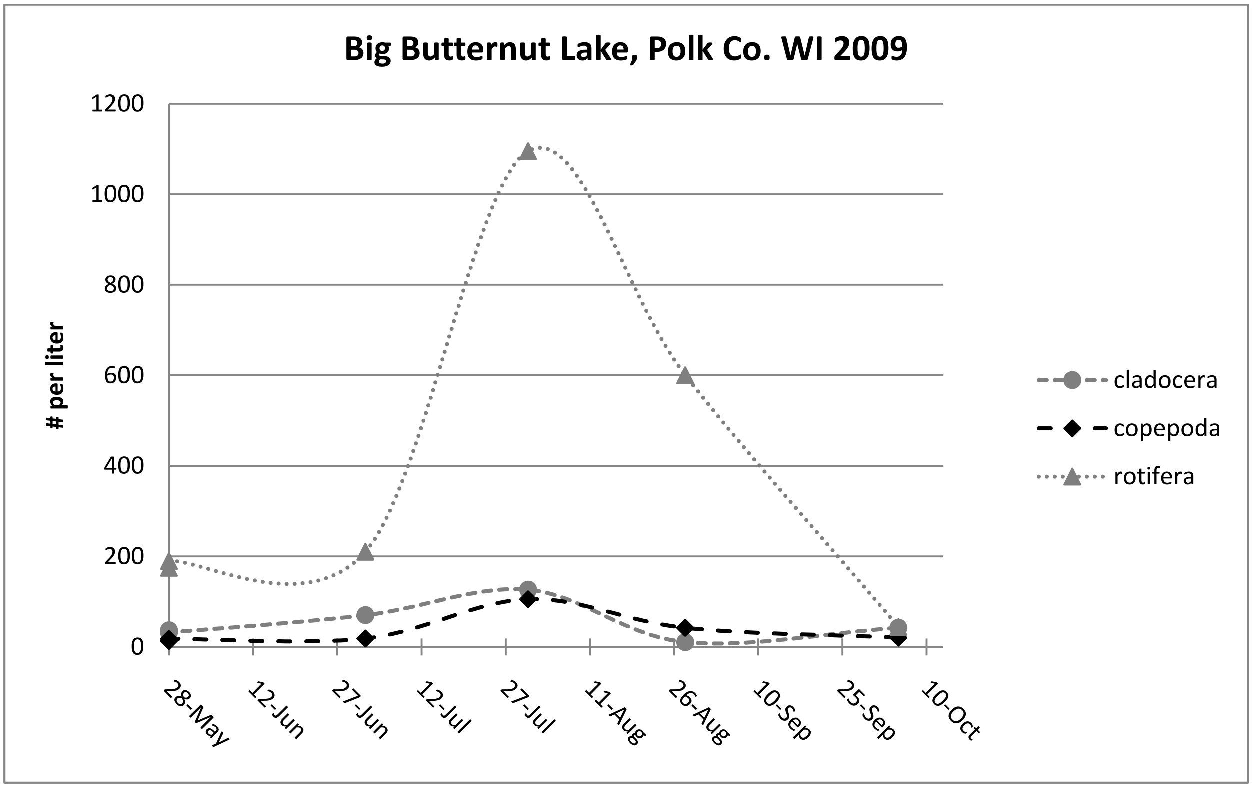

Figure 1. Abundance (#/l) of major zooplankton groups, Big Butternut Lake, Polk Co. WI, 2009. May sample shows lab duplicate.

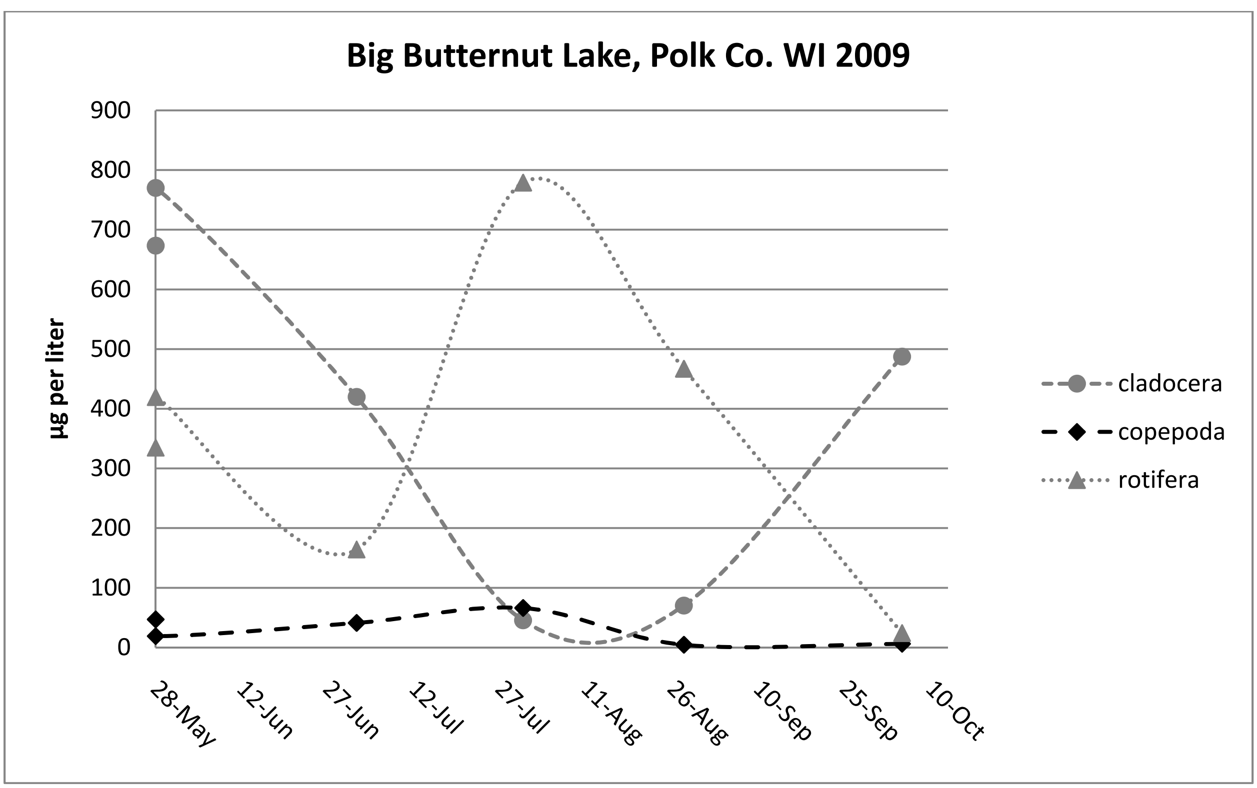

Figure 2. Biomass estimates (µg/l) of major zooplankton groups, Big Butternut Lake, Polk Co. WI, 2009. May sample shows lab duplicate.

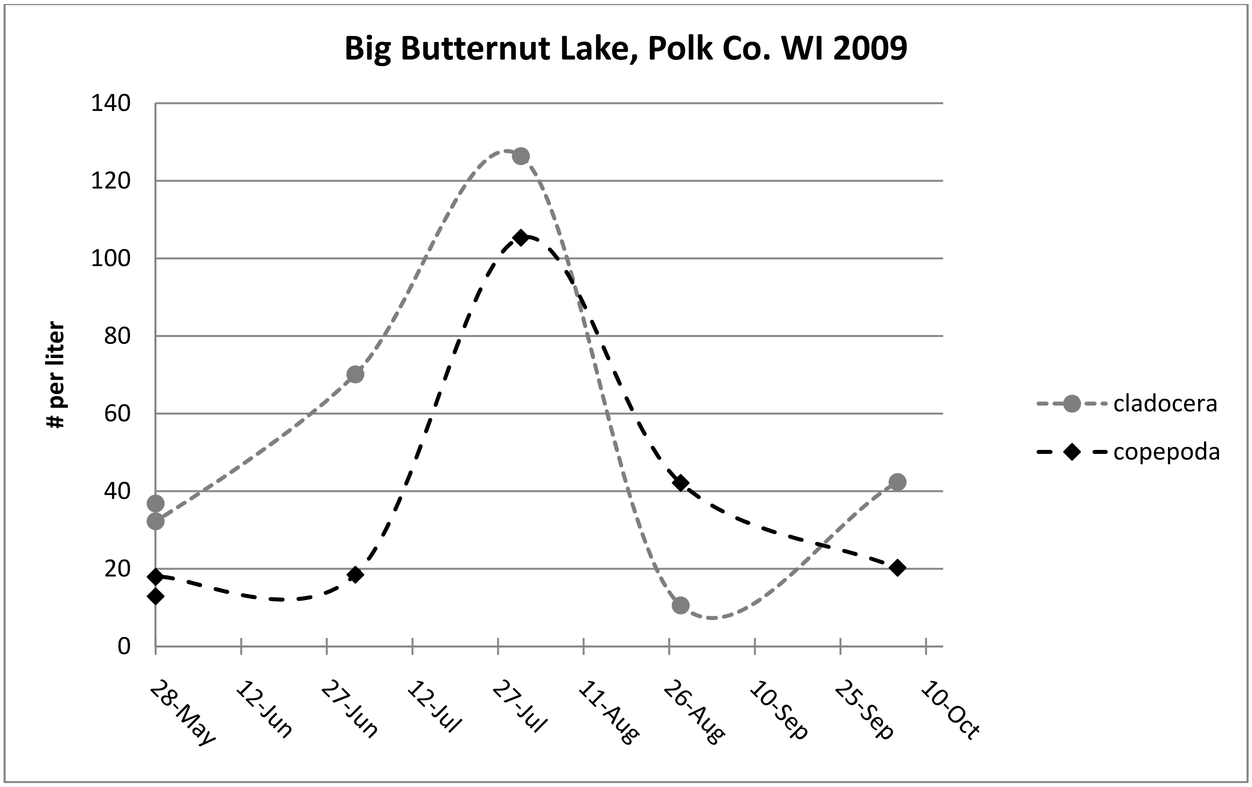

Figure 3. Abundance (#/l) of cladocera and copepoda, Big Butternut Lake, Polk Co. WI, 2009. May sample shows lab duplicate.

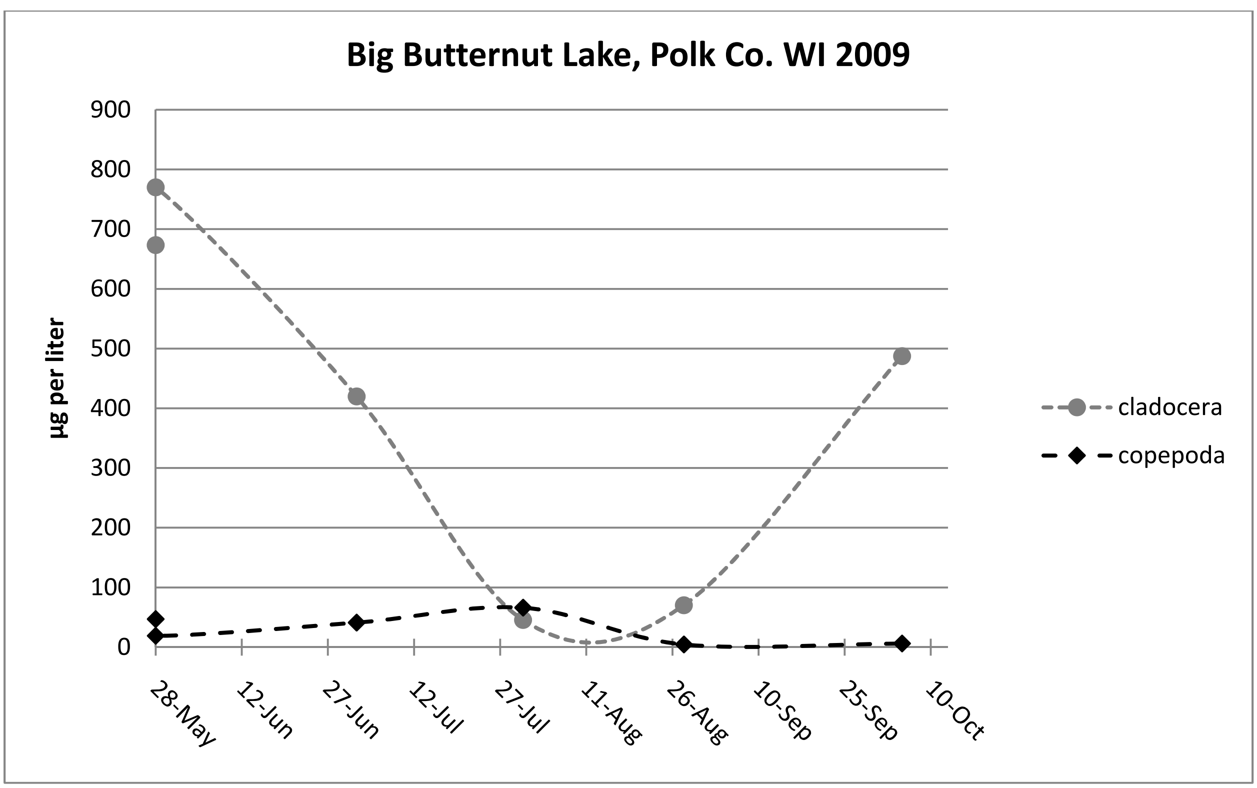

Figure 4. Biomass estimates (µg/l) of cladocera and copepoda, Big Butternut Lake, Polk Co. WI, 2009. May sample shows lab duplicate.

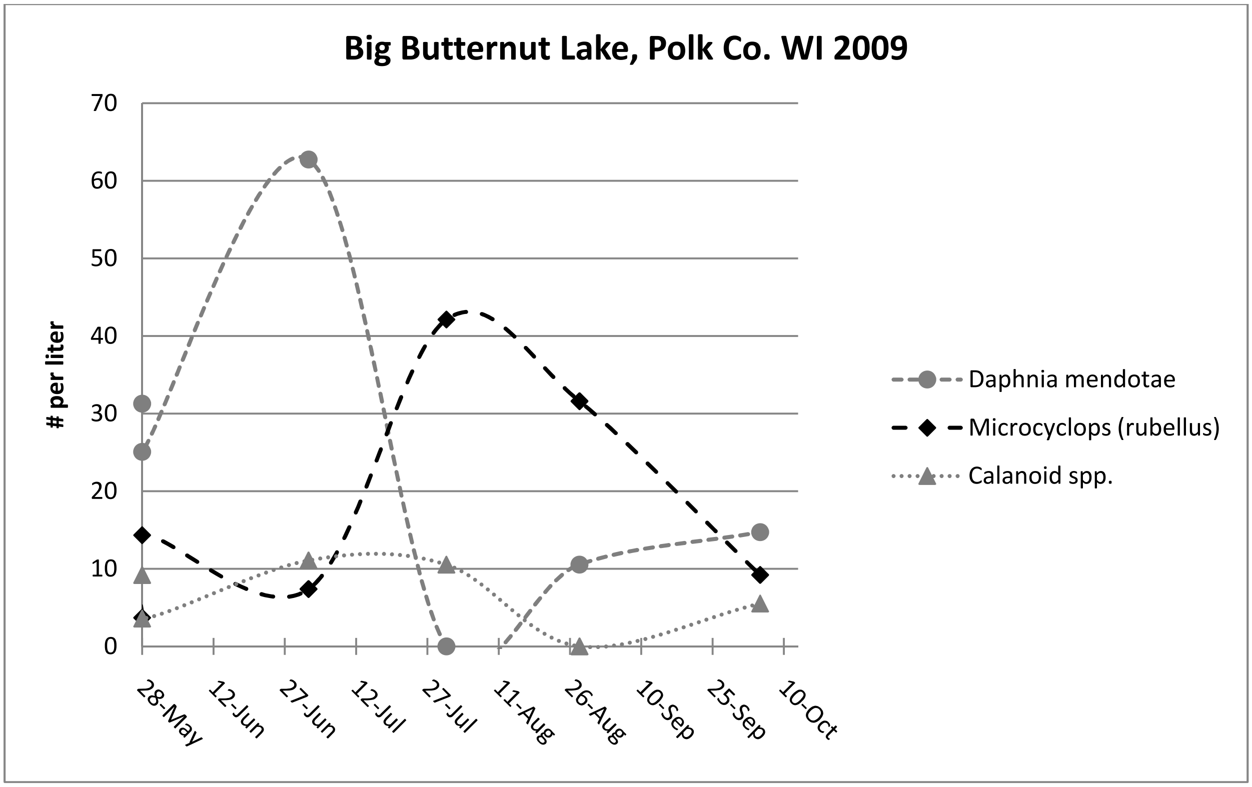

Figure 5. Abundance (#/l) of three key taxa, Big Butternut Lake, Polk Co. WI, 2009. May sample shows lab duplicate.

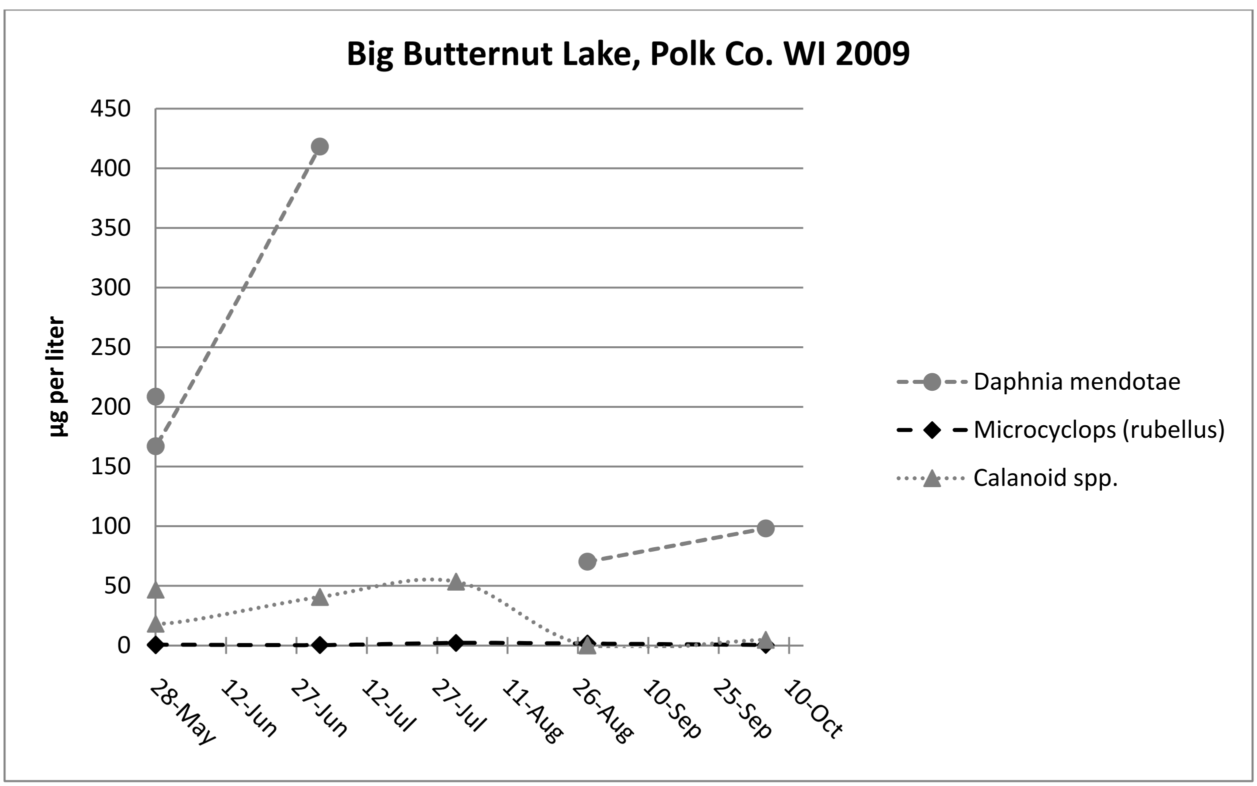

Figure 6. Biomass estimates (µg/l) of three key taxa, Big Butternut Lake, Polk Co. WI, 2009. May sample shows lab duplicate.

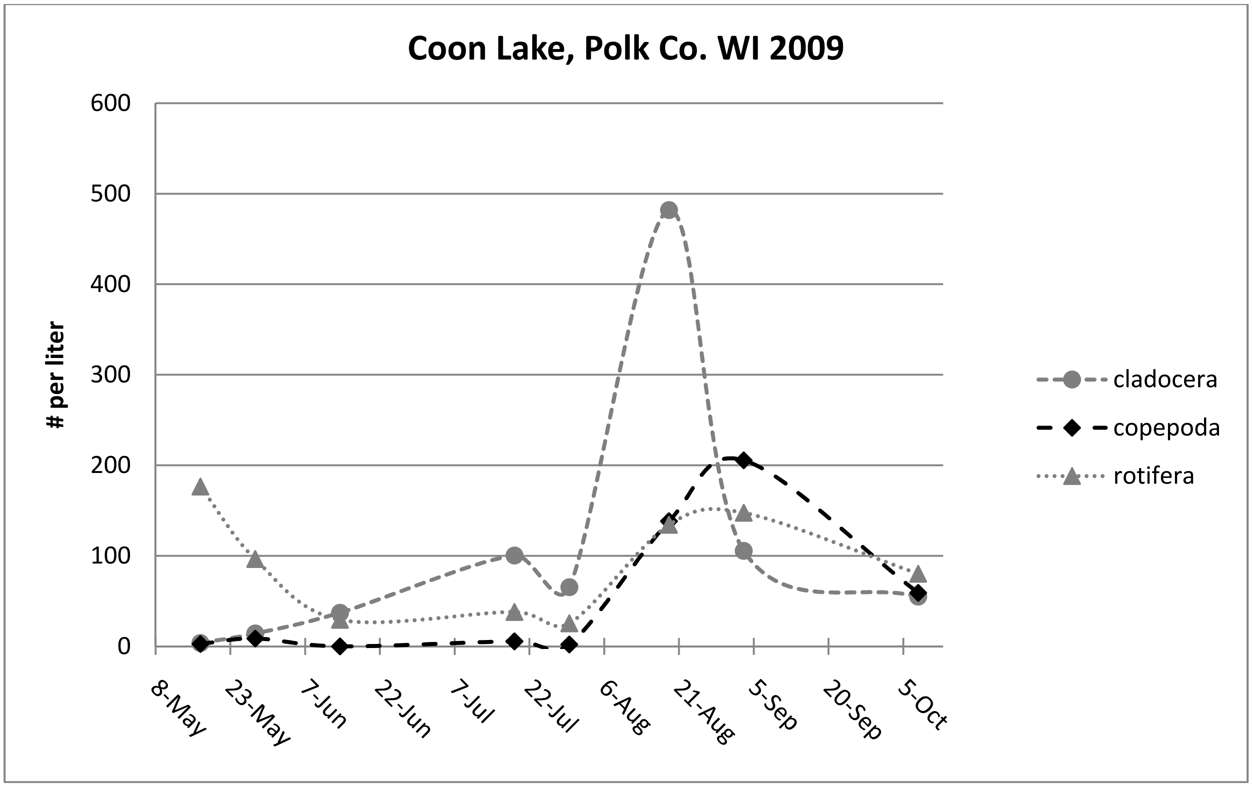

Figure 7. Abundance (#/l) of major zooplankton groups, Coon Lake, Polk Co. WI, 2009.

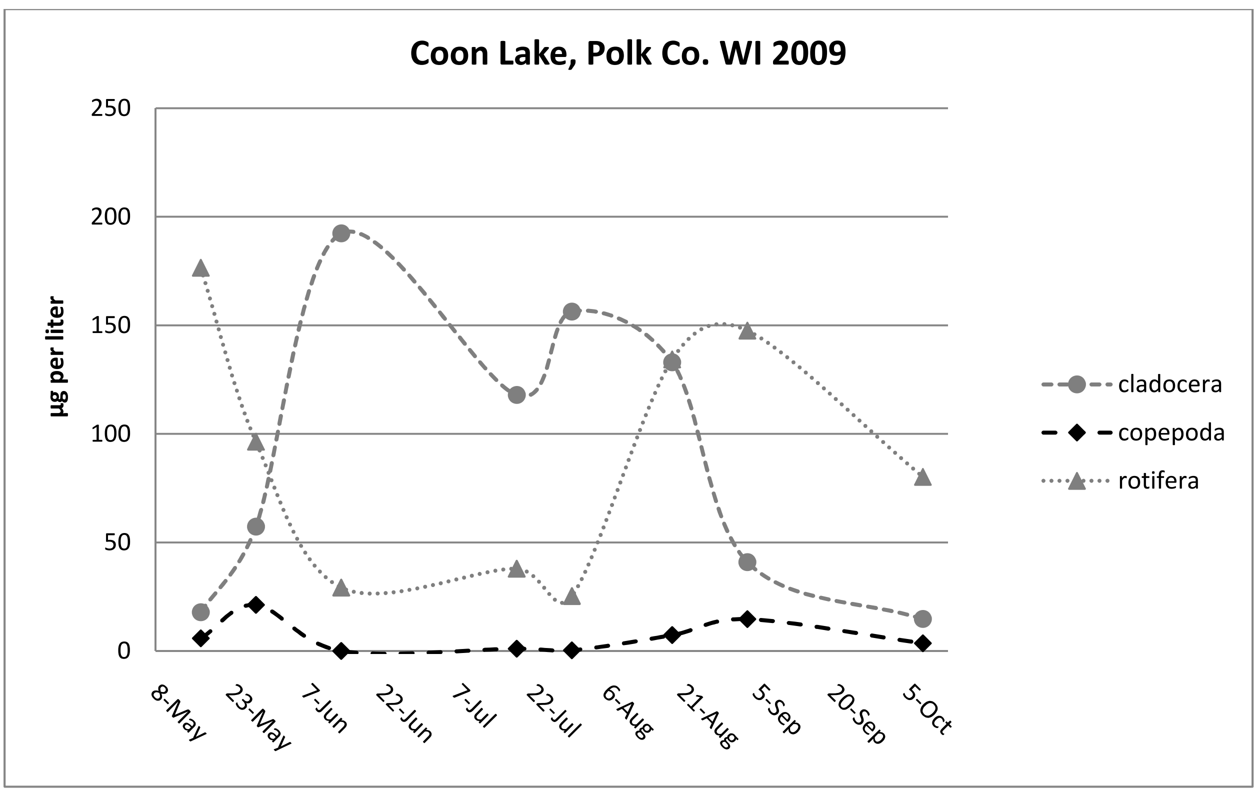

Figure 8. Biomass estimates (µg/l) of major zooplankton groups, Coon Lake, Polk Co. WI, 2009.

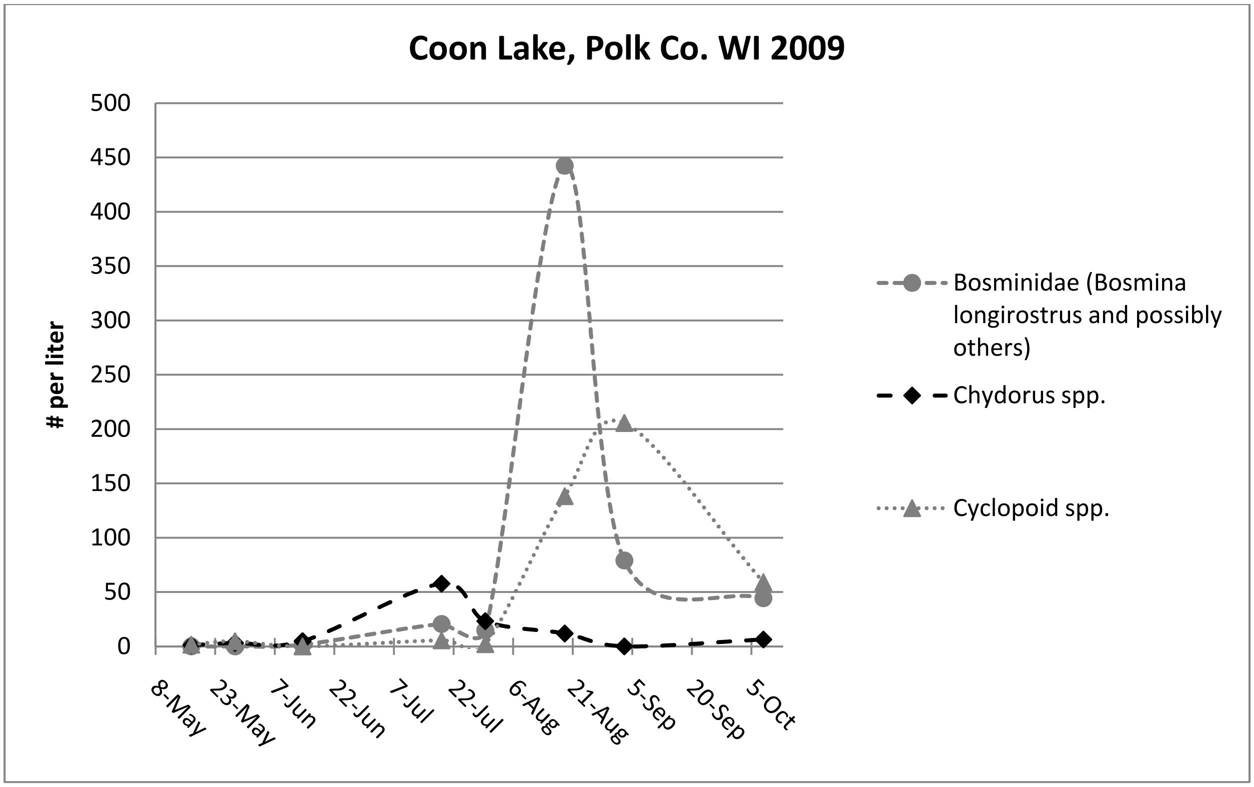

Figure 9. Abundance (#/l) of key taxa (group 1), Coon Lake, Polk Co. WI, 2009.

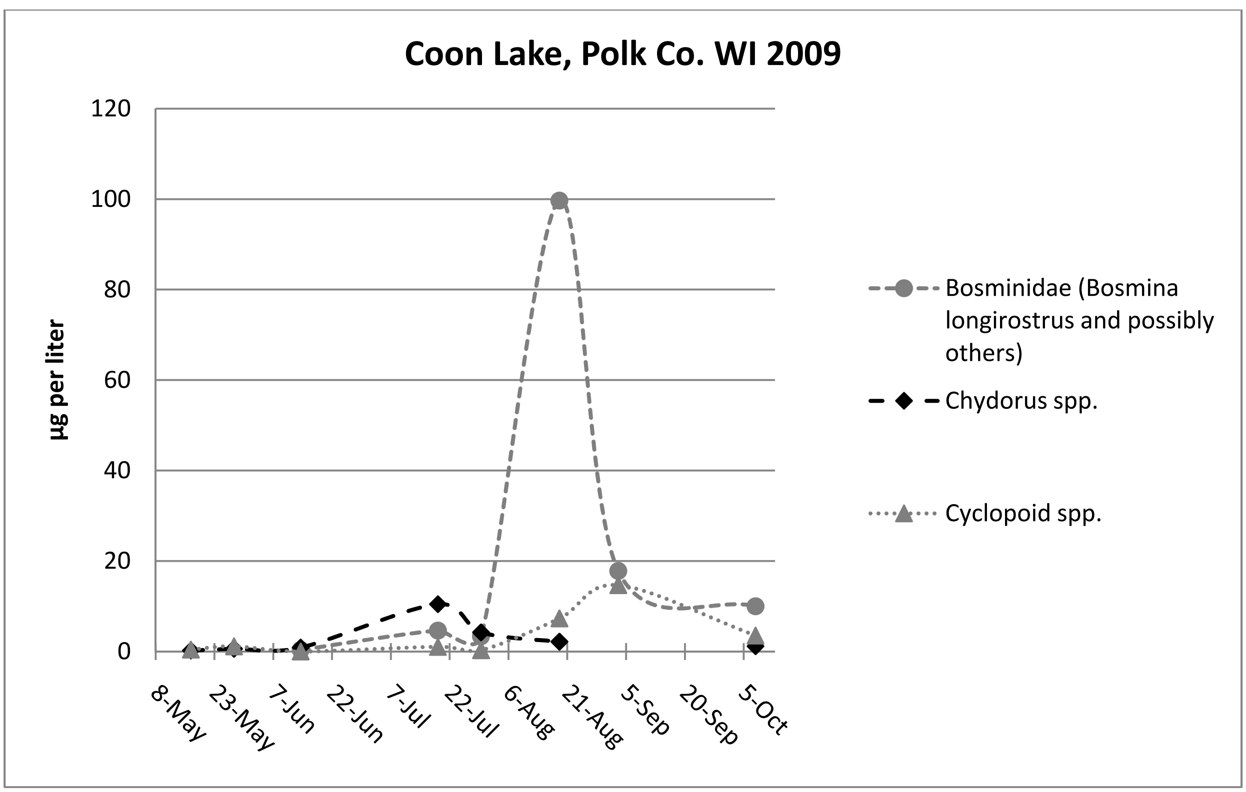

Figure 10. Biomass estimates (µg/l) of key taxa (group 1), Coon Lake, Polk Co. WI, 2009.

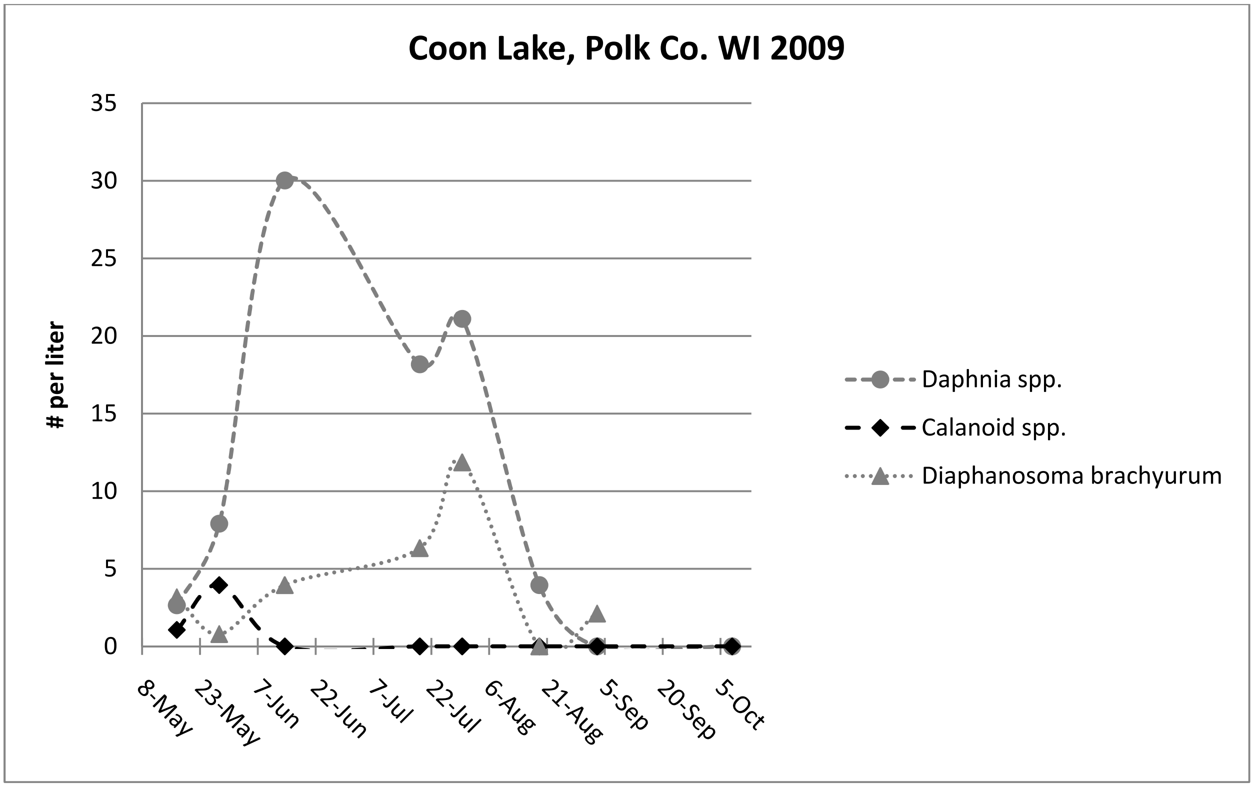

Figure 11. Abundance (#/l) of key taxa (group 2), Coon Lake, Polk Co. WI, 2009.

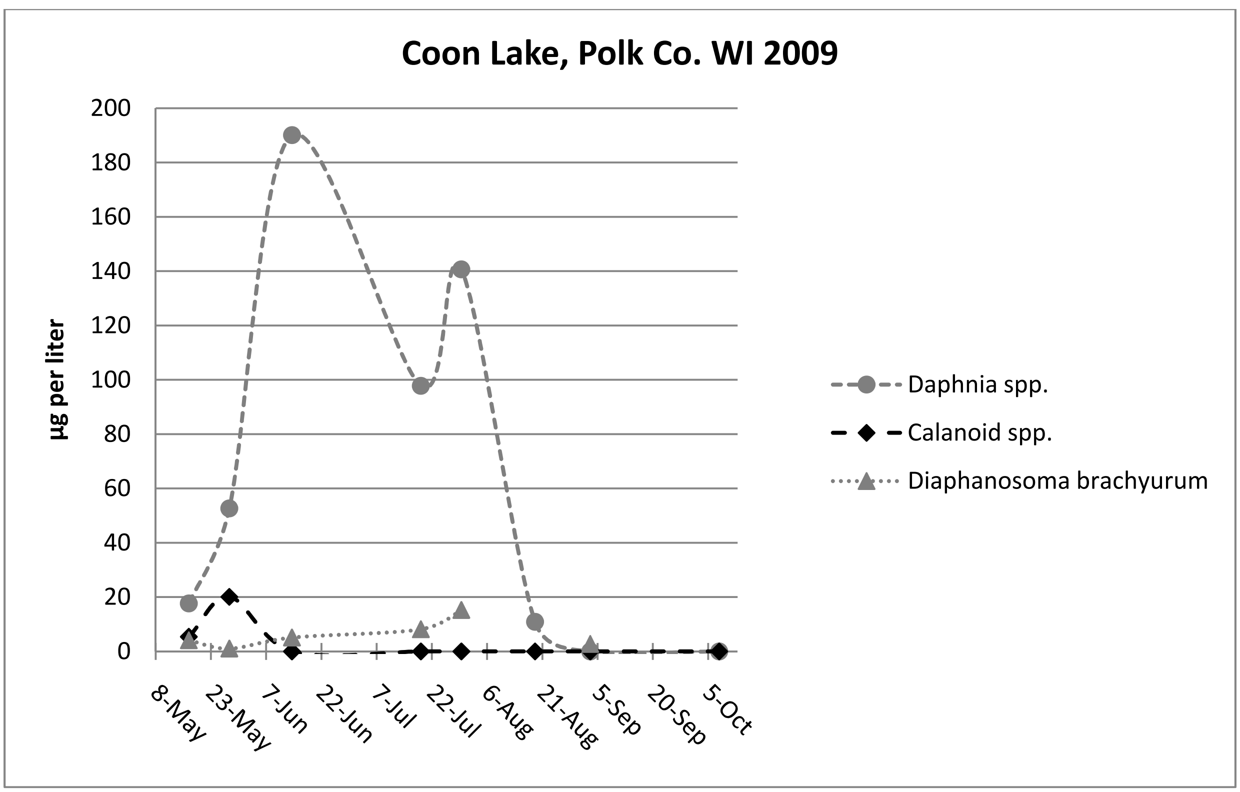

Figure 12. Biomass estimates (µg/l) of key taxa (group 2), Coon Lake, Polk Co. WI, 2009.

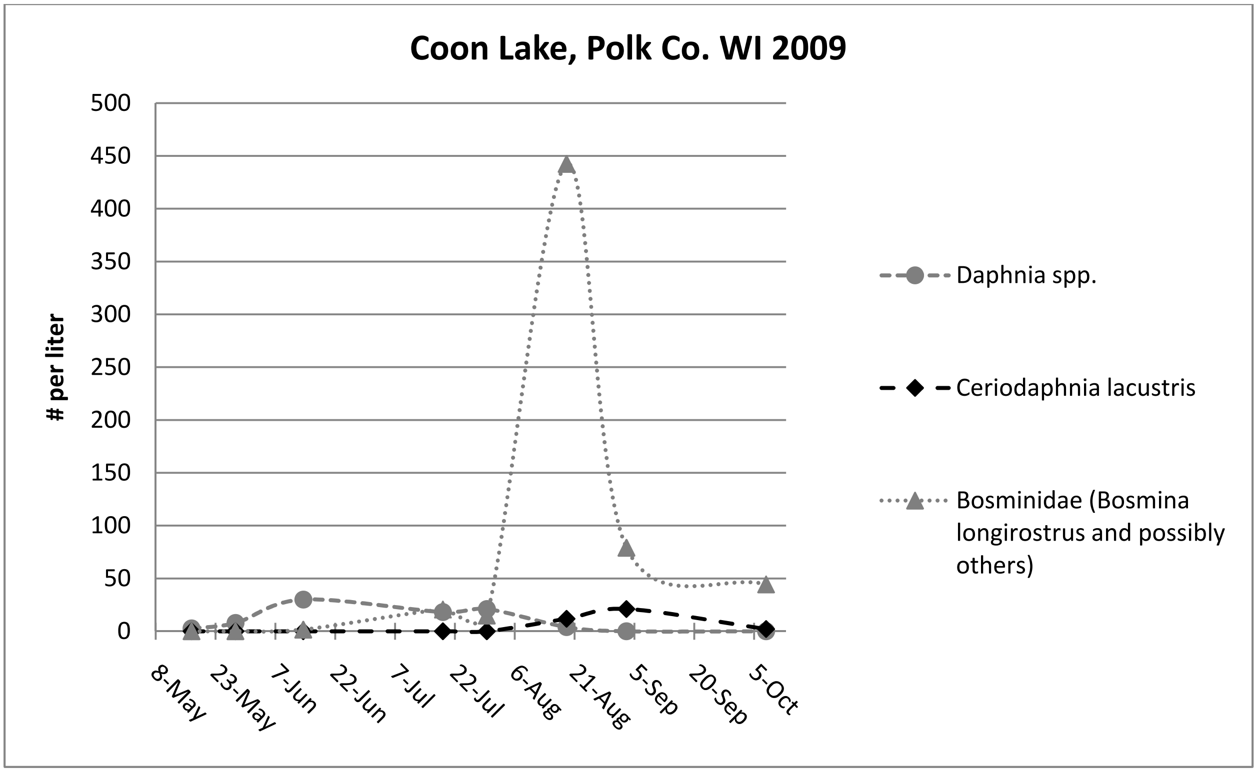

Figure 13. Abundance (#/l) of three cladoceran groups, Coon Lake, Polk Co. WI, 2009.

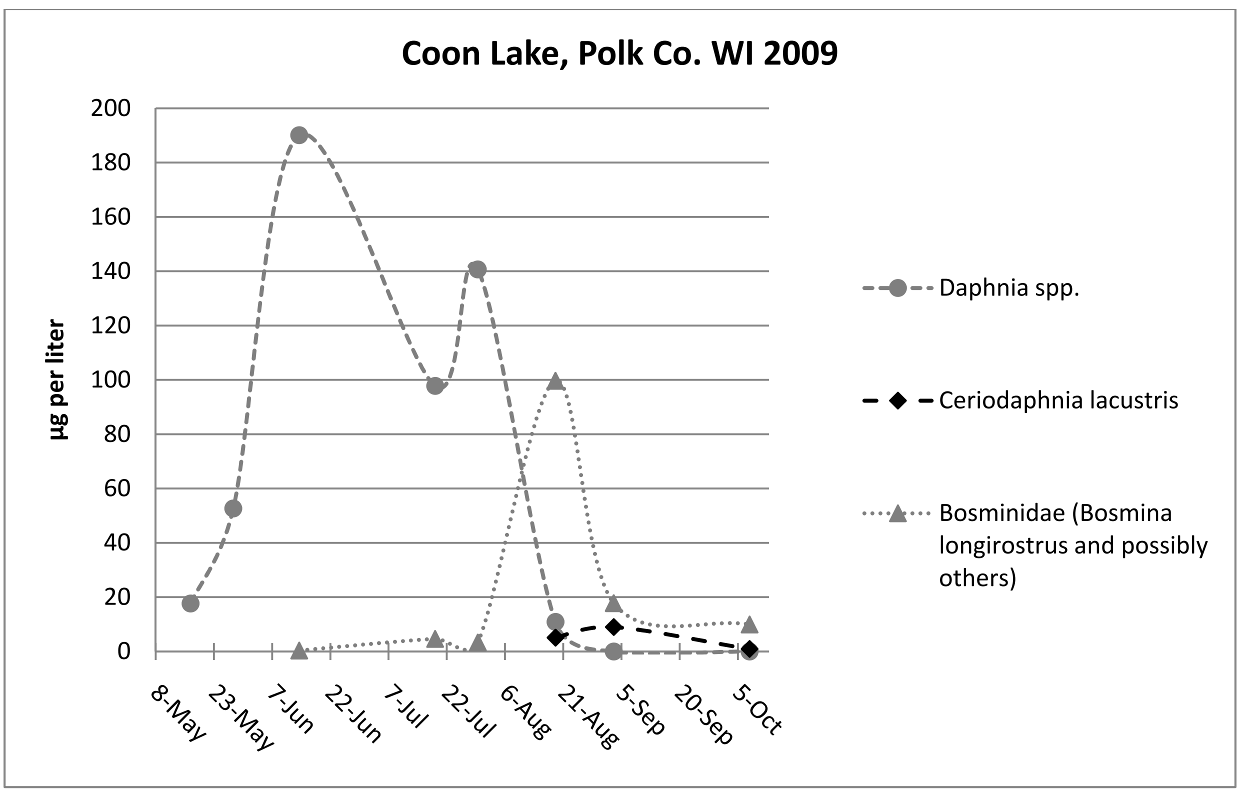

Figure 14. Biomass estimates (µg/l) of three cladoceran groups, Coon Lake, Polk Co. WI, 2009.

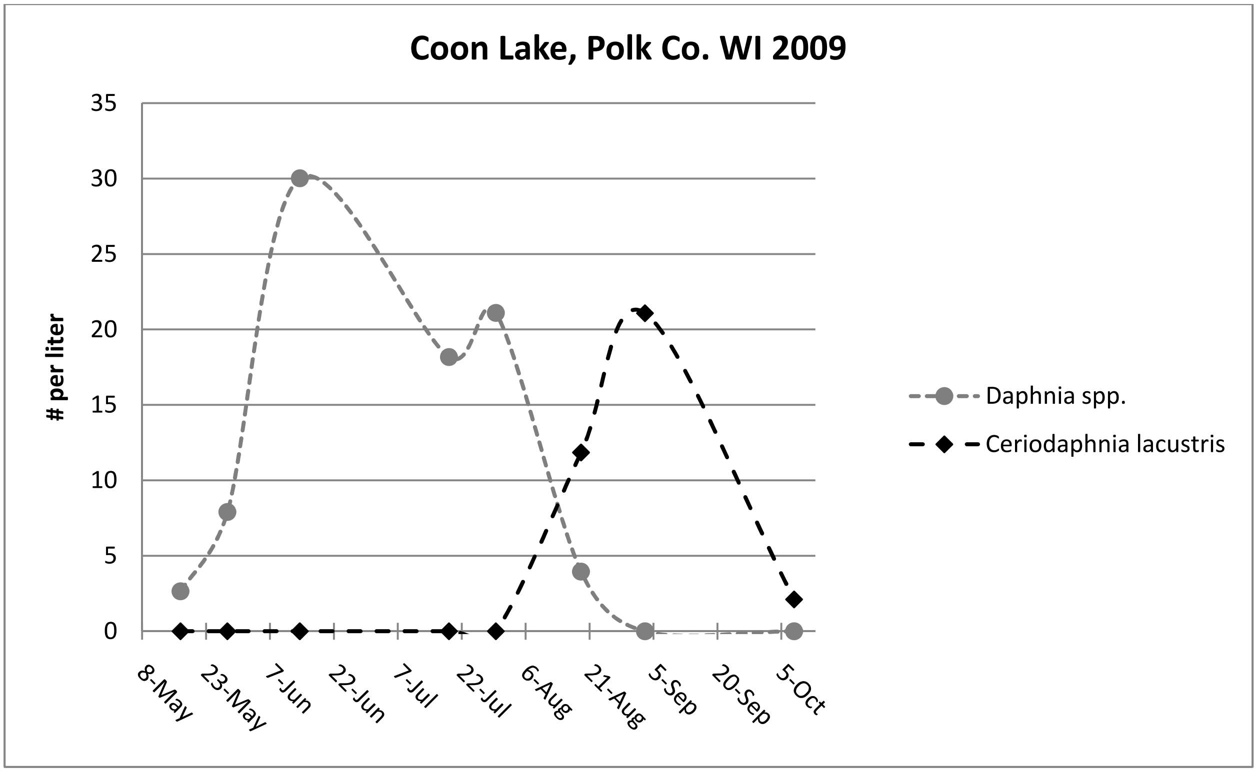

Figure 15. Detail of (Figure 14), abundance (#/l) of two cladoceran groups, Coon Lake, Polk Co. WI, 2009.

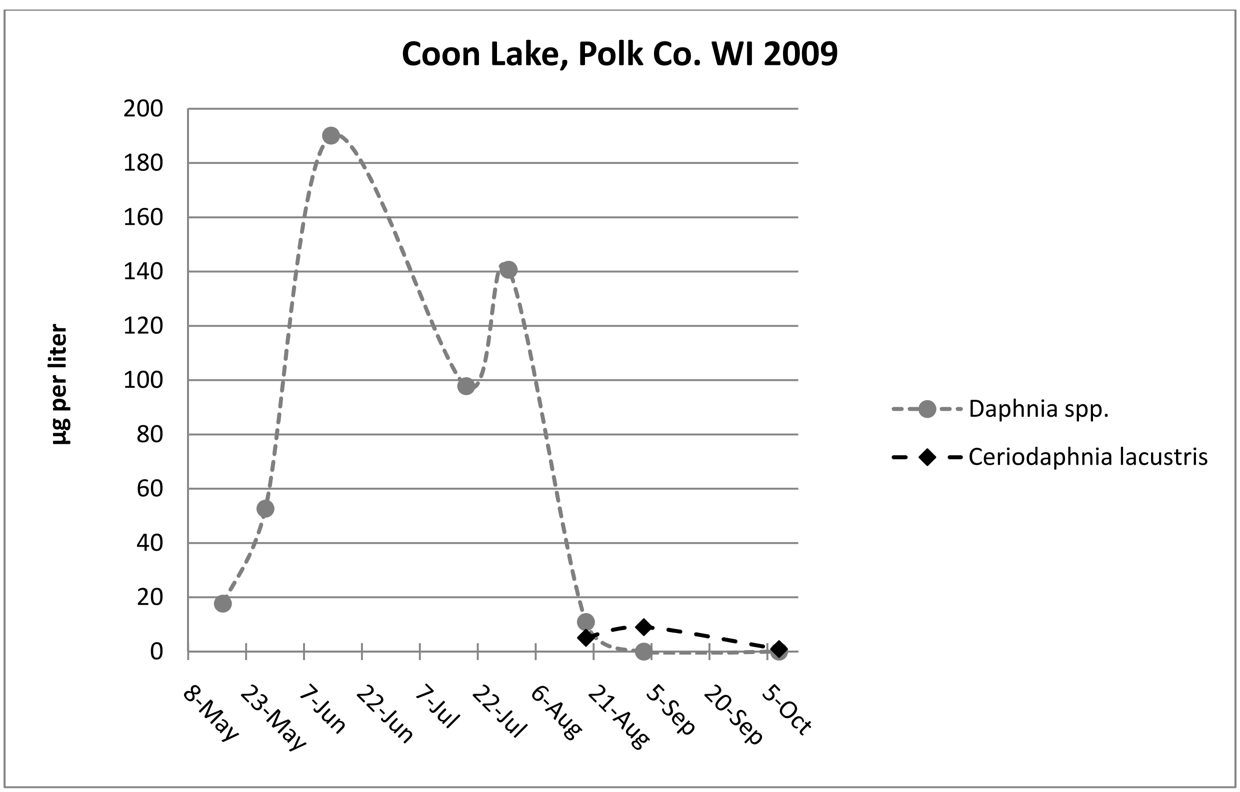

Figure 16. Detail of (Figure 14), biomass estimates (µg/l) of two cladoceran groups, Coon Lake, Polk Co. WI, 2009.

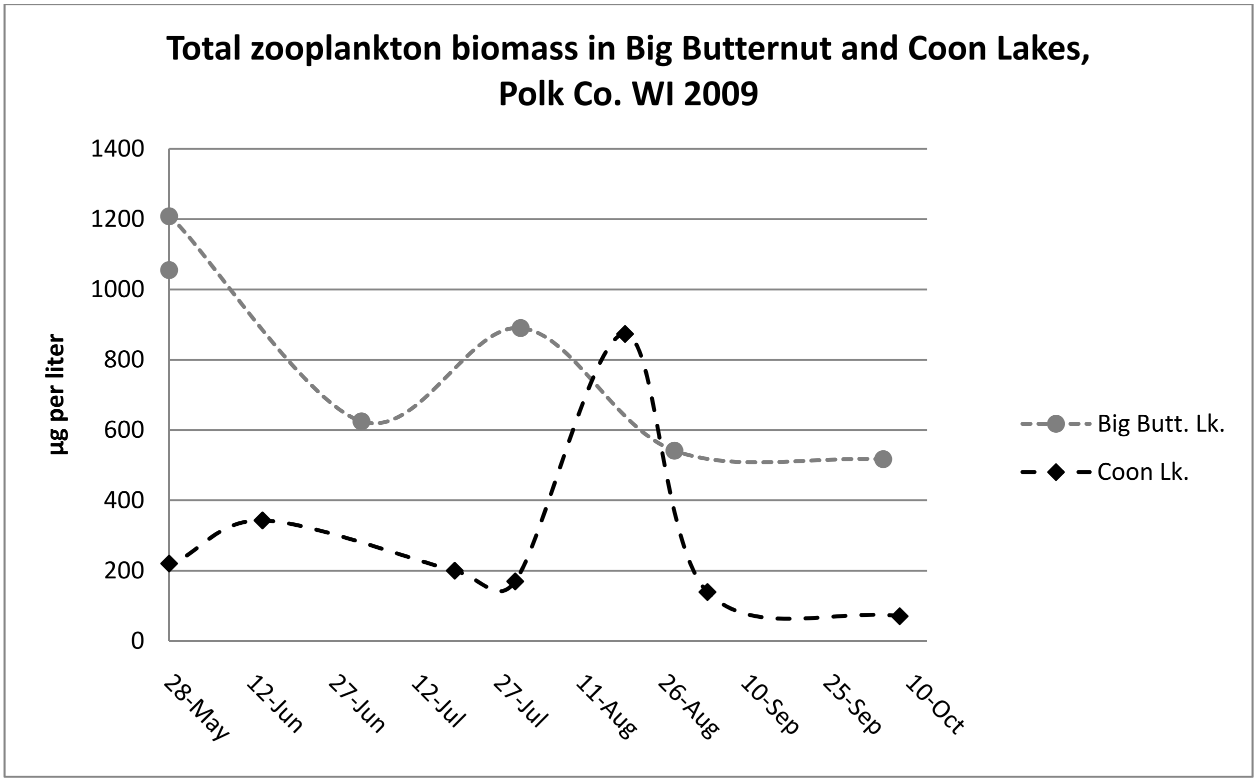

Figure 17. Comparison of total zooplankton biomass between Big Butternut and Coon Lakes, Polk Co. WI, 2009.

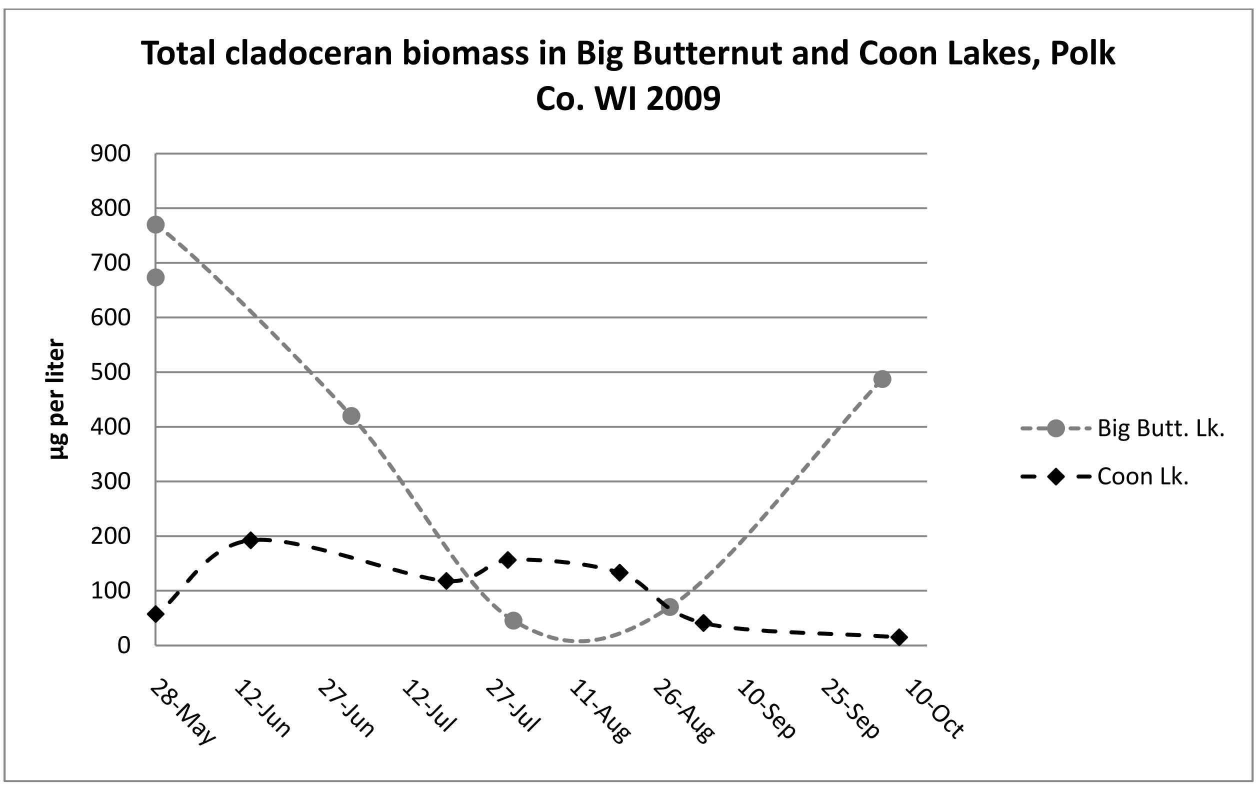

Figure 18. Comparison of total cladoceran biomass between Big Butternut and Coon Lakes, Polk Co. WI, 2009.

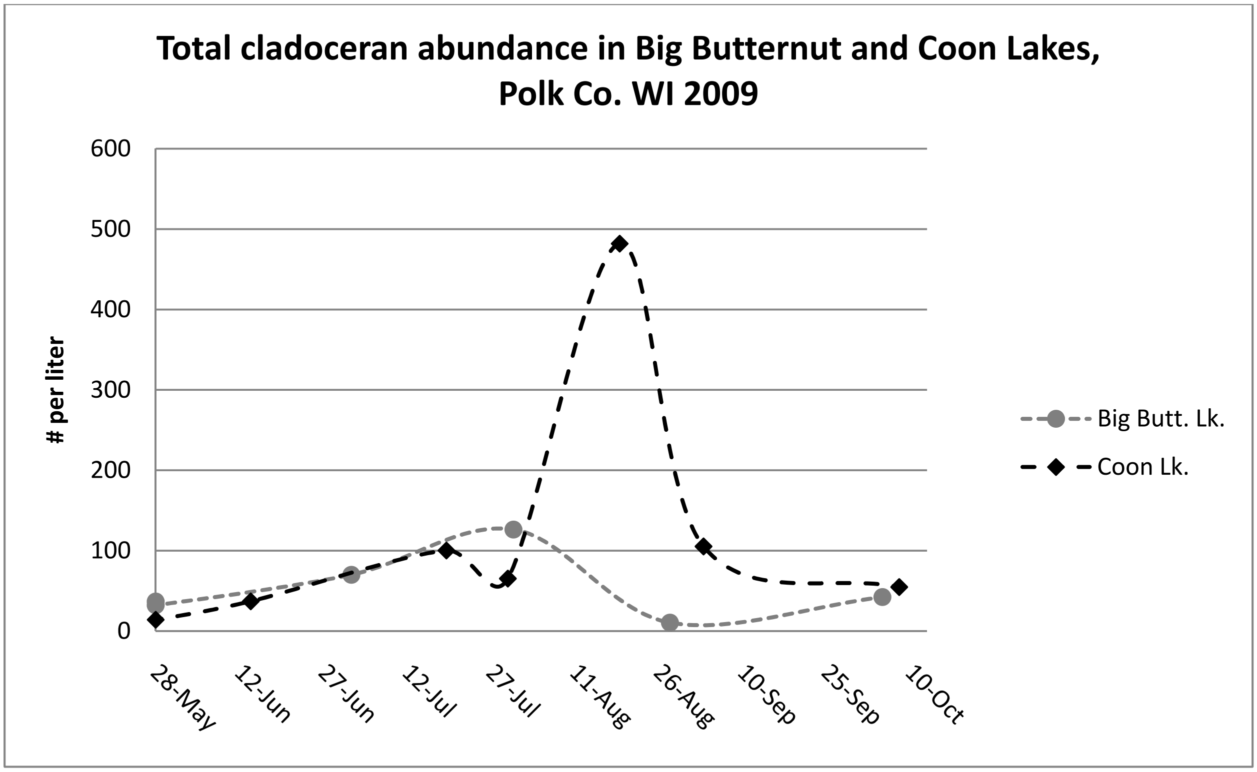

Figure 19. Comparison of cladoceran density between Big Butternut and Coon Lakes, Polk Co. WI, 2009.

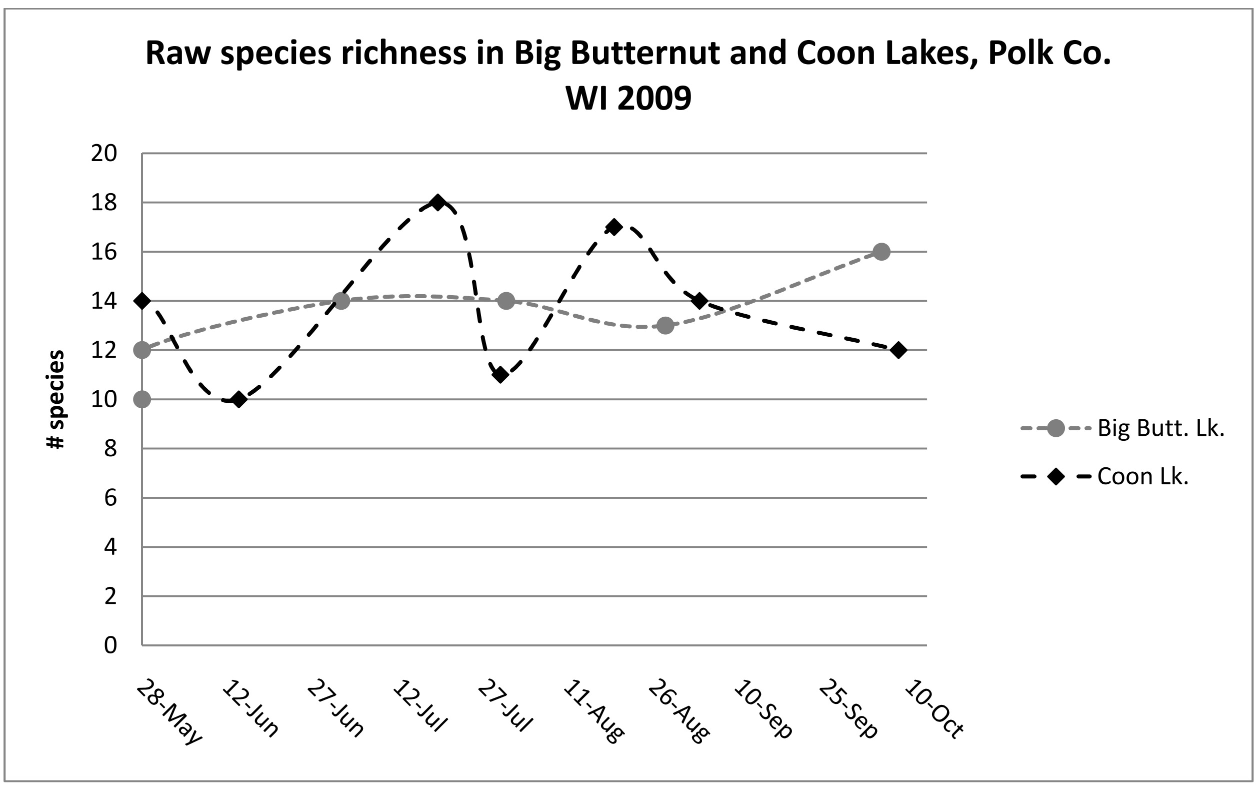

Figure 20. Comparison of total number of zooplankton species between Big Butternut and Coon Lakes, Polk Co. WI, 2009.

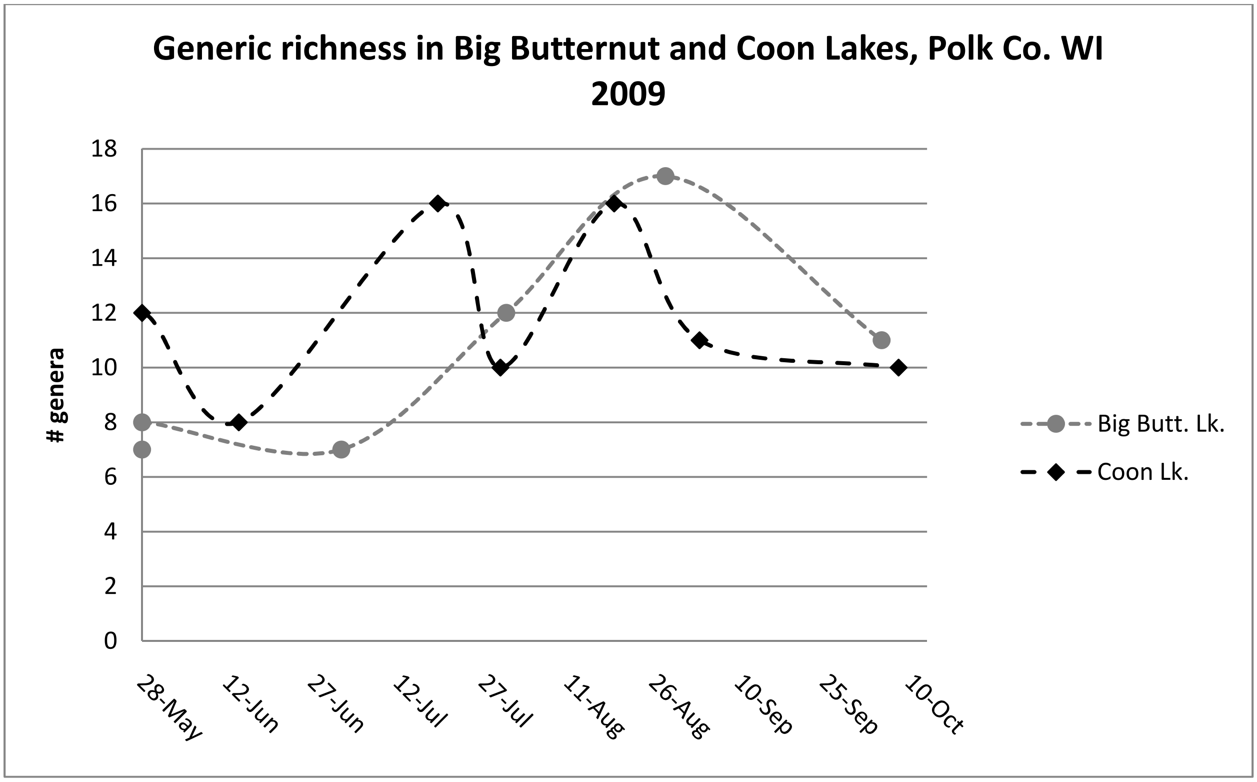

Figure 21. Comparison of total zooplankton genera between Big Butternut and Coon Lakes, Polk Co. WI, 2009.

8. Tables

Table 1. Taxa present in 2009 sampling of Big Butternut and Coon Lakes, Polk Co., WI (2 pages).

Taxa	Big Butternut Lake	Coon Lake
Bosminidae (*Bosmina longirostrus* confirmed)	X	X
Chydorus spp.		X
Ceriodaphnia lacustris	X	X
Daphnia spp.	X	X
Daphnia ambigua		X
Daphnia catawba	X	
Daphnia longiremus		X
Daphnia mendotae	X	X
Daphnia retrocurva	X	
Diaphanosoma brachyurum		X
Holopedium gibberum		X
Calanoid female- Diaptomidae	X	X
Calanoid female- Epischura	X	
Calanoid nauplius	X	X
Cyclopoid nauplius	X	X
copepodid	X	X
Acanthocyclops (*venustoides* or *brevispinosus*)	X	
Diacyclops albus	X	
Diacyclops spp.	X	X
(*Homocyclops* sp.)		X
Microcyclops (*rubellus*)	X	X
Anuraeopsis sp.	X	X
Ascomorpha saltans	X	X
Asplanchna brightwelli		X
Asplanchna priodonta	X	X
Brachyonus havanaensis		X
Conochilus sp.	X	X
Conochiloides sp.	X	X
Euchlanis sp.	X	
Filinia longiseta	X	
Gastropus sp.	X	
Kellicottia bostoniensis		X
Keratella spp.	X	X
Keratella cochlearis	X	X
Keratella earlinae	X	
Lecane ungulata		X
Monostyla bulla	X	
Polyarthra spp.	X	X

Polyarthra dolichoptera	x	
Polyarthra euryptera	x	x
Polyarthra remata	x	
Polyarthra vulgaris	x	x
Pompholyx sulcata	x	x
Synchaeta oblonga		x
Trichocerca cylindrica	x	x
Trichocerca lata	x	
Trichocerca pusilla		x
unidentifiable rotifer	x	
testate protozoa	x	x
Cucurbitella sp.	x	x
tintinnid ciliate *Codonella* sp.	x	x
Difflugia sp.		x

9. Appendix: Zooplankton background information

(from Lafrançois, T. 2009. Zooplankton of Wild Goose and Ward Lakes, Polk Co. WI, 2008. Final report to Polk County Land and Water Resources Dept., March 2009.)

Zooplankton are small aquatic animals (specimens from this study range from 0.03 mm long to 3 mm long). Three primary components of the zooplankton community are rotifers, copepods, and cladocerans. Single celled organisms were not found in this survey, most likely due to over-desiccation in sample preservative. Organisms of the phylum Rotifera are either soft-bodied or have a hard lorica (shell). All rotifers have mouthparts with bristles that undulate like two little wheels, giving this group their name. Rotifers are small, ranging from 0.03 mm to 1.00 mm long, depending on the species. They are size-selective omnivores that eat algae, protozoa, and sometimes each other. Rotifers are preyed on by other plankton but only incidentally by fish. Some have long spines or gelatinous sheaths to deter predators.

Copepods are crustaceans (phylum Arthropoda, subphylum Crustacea) of two orders (Calanoida and Cyclopoida). Other orders of copepods are benthic (live in the sediments) or parasitic on fish and are not usually included in studies of plankton. Copepods are multi-segmented animals that are size selective omnivores, eating algae and other plankton. Some have more specific feeding habits. Copepods are highly variable in size, depending on the species, ranging from 0.3 mm to 3.0 mm long (and even larger in some cases). They can be eaten by larger plankton and are a favorite fish food (either planktivores like pan fish and minnows or fry of larger fish).

Cladocerans are also crustaceans (phylum Arthropoda, subphylum Crustacea) of similar size range than copepods but very distinct morphologically. Cladocerans filter-feed by creating a current with fan-like legs protected by a hard but un-segmented carapace. Most cladocerans are parthogenetic, females producing clonal eggs. Males are produced in times of environmental stress and sexual reproduction occurs for one or two generations. Cladocerans are voracious consumers of algae and are also a favorite food of fish.

Zooplankton are often an overlooked component of aquatic systems, but their role in ecosystem function is extremely important. Lake systems are valued primarily for water clarity and fishing or other recreation. Both of these values are strongly linked to water quality and ecosystem health. Zooplankton are the primary link between the 'bottom up' processes and 'top down' processes of the ecosystem. Bottom up processes, like increased nutrients, can cause noxious algal blooms. Zooplankton can mediate these blooms by heavy grazing. On the other hand, shifts in algal composition caused by increased nutrients can change zooplankton community composition, exacerbating algal blooms and stressing planktivorous fish and / or the development of fry. Top down processes include fish predation, where increased planktivorous fishes (e.g. pan fish) can drastically reduce zooplankton populations and lead to algal blooms. In some lakes a trophic cascade is used to manage this effect, using piscivorous fish to reduce planktivorous fish populations, increasing plankton to reduce algae— and consequently improving water clarity.

Zooplankton also respond to changes in watershed and lakeshore management. Changes in aquatic plants, landscape use in the watershed, and buffer zones around a lake impact plankton directly or indirectly. Understanding the plankton in a lake (both algae and zooplankton) is like looking under the hood of a car, showing the mechanisms that connect lake management, ecosystem effects, water clarity, and fishing.

Coon Lake Management Plan

Coon Lake Point Intercept Aquatic Macrophyte Survey Results

Appendix H

Polk County Land and Water Resources Department
12/31/2011

Coon Lake, Polk County, 9/13/10, JW, EW, AM	Total # Species at Site	Total # Species veg sites only includes exotics	Total # Species veg sites only No exotics	Total # Species at Site (shallower than max depth) includes exotics	Total # Species at Site (shallower than max depth), no exotics	Depth w/ some plants	Depths w/in vegetated range	sampling point	Latitude	Longitude	Depth (ft)	Dominant sediment type (M=muck, S=Sand, R=Rock)	Sampled holding rake pole (P) or rake rope (R)?	comments	filamentous algae	Phalaris arundinacea,Reed canary grass	Polygonum amphibium,Water smartweed	Schoenoplectus tabernaemontani,Softstem bulrush
	0							1	45.6600962	92.46276522				Shore				
	0							2	45.6597365	92.46274944				Shore				
	2	2	2	2	1	0.5	1	3	45.6593768	92.46273367	0.5			Wild Rice (v) not w/in 6 ft	1	1		
	0			0	0		1	4	45.6590171	92.46271789	3						v	v
	0			0	0		1	5	45.6586574	92.46270211	3				v			
	0			0	0		1	6	45.65829769	92.46268633	4	s						
	1	1	1	1	0	7	1	7	45.65793799	92.46267055	7				2			
	0							8	45.65757829	92.46265477				Shore				
	0							9	45.66046697	92.46226803				Shore				
	0							10	45.66010727	92.46225225				Shore				
	0							11	45.65974757	92.46223648				Shore				
	0							12	45.65938786	92.4622207				Shore				
	0			0	0		1	13	45.65902816	92.46220493	3.7				v			
	0			0	0		1	14	45.65866846	92.46218915	8.9	s						
	0							15	45.65830876	92.46217338	10.5							
	0			0	0		1	16	45.65794905	92.4621576	10.1							
	1	1	1	1	0	6.9	1	17	45.65758935	92.46214183	6.9				1			
	0							18	45.66047803	92.46175506				Shore				
	0							19	45.66011833	92.46173928				Shore				
	1	1	1	1	0	4	1	20	45.65975863	92.46172351	4	s			1			
	1	1	1	1	0	6.9	1	21	45.65939892	92.46170774	6.9				1			
	0			0	0		1	22	45.65903922	92.46169196	10.1							
	0							23	45.65867952	92.46167619	11.6							
	0							24	45.65831982	92.46166042	11.8							
	0							25	45.65796011	92.46164465	11.7							
	0							26	45.65760041	92.46162888	11.1							
	1	1	1	1	0	7.2	1	27	45.65724071	92.46161311	7.2				1			
	0							28	45.65688101	92.46159734				Shore				
	0							29	45.66048909	92.46124208				Shore				
	0							30	45.66012939	92.46122631				Shore				

	0			0	0		1	31	45.65976969	92.46121054	5	r			v			
	0							32	45.65940998	92.46119477	11							
	0							33	45.65905028	92.461179	12.2							
	0							34	45.65869058	92.46116323	13							
	0							35	45.65833087	92.46114747	12.6							
	0							36	45.65797117	92.4611317	13.2							
	0							37	45.65761147	92.46111593	12.8							
	0							38	45.65725177	92.46110016	12.8							
	0							39	45.65689206	92.4610844	12.5							
	1	1	1	1	0	10.1	1	40	45.65653236	92.46106863	10.1				1			
	1	1	1	1	0	7.3	1	41	45.65617266	92.46105286	7.3				1			
	0							42	45.66014045	92.46071334				Shore				
	0			0	0		1	43	45.65978074	92.46069757	7.1							
	0			0	0		1	44	45.65942104	92.46068181	9.1							
	0							45	45.65906134	92.46066604	14							
	0							46	45.65870163	92.46065028	13.1							
	0							47	45.65834193	92.46063451	12.8							
	0							48	45.65798223	92.46061875	12.2							
	0							49	45.65762253	92.46060298	12.8							
	0							50	45.65726282	92.46058722	13.2							
	0							51	45.65690312	92.46057145	13.5							
	0							52	45.65654342	92.46055569	13.8							
	0							53	45.65618371	92.46053993	12.5							
	1	1	1	1	0	8.1	1	54	45.65582401	92.46052416	8.1				1			
	0							55	45.6601515	92.46020037				Shore				
	1	1	1	1	0	6.6	1	56	45.6597918	92.46018461	6.6				2			
	0			0	0		1	57	45.65943209	92.46016884	8.3	r						
	0							58	45.65907239	92.46015308	11.9							
	0							59	45.65871269	92.46013732	12.7							
	0							60	45.65835298	92.46012156	12.4							
	0			0	0		1	61	45.65799328	92.46010579	9.6							
	0							62	45.65763358	92.46009003	12.5							
	0							63	45.65727388	92.46007427	13.4							
	0							64	45.65691417	92.46005851	13.5							
	0							65	45.65655447	92.46004275	13.4							
	0							66	45.65619477	92.46002699	13.9							
	0			0	0		1	67	45.65583506	92.46001123	9.9							
	1	1	1	1	1	1.4	1	68	45.65980285	92.45967164	1.4							1
	1	1	1	1	0	4.7	1	69	45.65944315	92.45965588	4.7				1			
	0							70	45.65908344	92.45964012	12.4							
	0							71	45.65872374	92.45962436	13.1							
	0							72	45.65836404	92.4596086	12.4							
	0							73	45.65800433	92.45959284	11.8							
	0							74	45.65764463	92.45957708	12.6							
	0							75	45.65728493	92.45956133	13							
	0							76	45.65692522	92.45954557	13.3							
	0							77	45.65656552	92.45952981	13.5							
	0							78	45.65620582	92.45951406	13.2							
	0							79	45.65584611	92.4594983	11.9							
	0			0	0		1	80	45.65548641	92.45948254	4.2							
	1	1	1	1	1	1	1	81	45.6598139	92.45915867	1					1		
	0							82	45.6594542	92.45914291	10.5							
	0							83	45.65909449	92.45912716	12.2							

	0							84	45.65873479	92.4591114	12.6							
	0							85	45.65837509	92.45909564	12.1							
	0			0	0		1	86	45.65801538	92.45907989	9.1	s						
	0							87	45.65765568	92.45906414	10.8							
	0							88	45.65729598	92.45904838	12.7							
	0			0	0		1	89	45.65693627	92.45903263	9.7							
	0							90	45.65657657	92.45901687	12.6							
	0							91	45.65621687	92.45900112	12.2							
	0							92	45.65585716	92.45898537	10.7							
	0			0	0		1	93	45.65549746	92.45896961	3.3							
	0							94	45.66018465	92.45866145				Shore				
	0			0	0		1	95	45.65982495	92.4586457	7.9							
	0							96	45.65946524	92.45862995	11.1							
	0							97	45.65910554	92.45861419	11.6							
	0							98	45.65874584	92.45859844	11.9							
	0							99	45.65838613	92.45858269	11.3							
	0			0	0		1	100	45.65802643	92.45856694	7.6							
	0			0	0		1	101	45.65766673	92.45855119	5.7							
	0			0	0		1	102	45.65730702	92.45853543	5.1							
	0							103	45.65694732	92.45851968				Shore				
	0			0	0		1	104	45.65658761	92.45850393	4.2	r						
	1	1	1	1	0	6.7	1	105	45.65622791	92.45848818	6.7	r			1			
	1	1	1	1	1	1.5	1	106	45.65586821	92.45847243	1.5						1	
	0							107	45.6555085	92.45845668				Shore				
	0							108	45.66019569	92.45814848				Shore				
	0			0	0		1	109	45.65983599	92.45813273	7.5							
	0			0	0		1	110	45.65947629	92.45811698	8.5							
	0							111	45.65911658	92.45810123	10.7							
	0			0	0		1	112	45.65875688	92.45808548	8.9	s						
	0							113	45.65839718	92.45806973				Shore				
	0							114	45.65803747	92.45805398				Shore				
	0							115	45.66056644	92.45765125				Shore				
	0							116	45.66020674	92.45763551				Shore				
	1	1	1	1	0	5.7	1	117	45.65984703	92.45761976	5.7	s			1			
	0			0	0		1	118	45.65948733	92.45760401	7.1	s						
	0			0	0		1	119	45.65912763	92.45758827	7.2	s						
	0							120	45.65876792	92.45757252				Shore				
	0							121	45.66093719	92.45715402				Shore				
	1	1	1	1	0	3.2	1	122	45.66057748	92.45713828	3.2				1			
	0							123	45.66021778	92.45712253				Shore				
	0							124	45.65985807	92.45710679				Shore				
	0							125	45.66094822	92.45664104				Shore				
	0							126	45.66058852	92.4566253				Shore				
	0							127	45.66095926	92.45612806				Shore				
	0							128	45.66059956	92.45611232				Shore				
	0							129	45.66097029	92.45561508				Shore				
	0							130	45.66134103	92.45511783				Shore				
	0							131	45.66098133	92.4551021				Shore				
	0							132	45.66171176	92.45462057				Shore				
	0							133	45.66135206	92.45460484				Shore				
	0							134	45.66099236	92.45458911				Shore				
	0							135	45.66172279	92.45410758				Shore				
	0							136	45.66173382	92.45359459				Shore				
	0							137	45.66174484	92.4530816				Shore				

Coon Lake, Polk County, 9/13/10	Total vegetation	Filamentous algae	Phalaris arundinacea, Reed canary grass	Polygonum amphibium, Water smartweed	Schoenoplectus tabernaemontani, Softstem bulrush
INDIVIDUAL SPECIES STATS:					
Frequency of occurrence w/in vegetated areas (%)		82.35	11.76	5.88	5.88
Frequency of occurrence at sites shallower than max depth of plants		31.82	4.55	2.27	2.27
Relative Frequency (%)		77.78	11.11	5.56	5.56
Relative Frequency (squared)	0.62	0.60	0.01	0	0
# of sites where species found		14	2	1	1
Average Rake Fullness		1.14	1	1	1
# visual sightings		3		1	1
Present (visual or collected)		present	present	present	present
SUMMARY STATS:					
Total # of points sampled	98				
Total # of sites with vegetation	17				
Total # of sites shallower than max depth of plants	44				
Frequency of occurrence at sites shallower than max depth of plants	38.64				
Simpson Diversity Index	0.38				
Max depth of plants (ft)	10.10				
# of sites sampled using rake on Rope (R)	0				
# of sites sampled using rake on Pole (P)	0				
Ave # of all species per site (shallower than max depth)	0.41				
Ave # of all species per site (veg. sites only)	1.06				
Ave # of native species per site (shallower than max depth)	0.09				
Ave # of native species per site (veg. sites only)	1.06				
Species Richness	4				
Species Richness (including visuals)	4				

Coon Lake Management Plan

Coon Lake Floristic Quality Index (FQI)

Appendix I

Polk County Land and Water Resources Department
12/31/2011

Coon Lake

Species	Common name	C	Species present=1	
Acorus calamus	Sweet flag	7		0
Alisma triviale	Water plantains	4		0
Bolboschoenus fluviatilis	River bulrush	5		0
Brasenia schreberi	Watershield	7		0
Calla palustris	Wild calla	9		0
Callitriche hermaphroditica	Autumnal water starwort	9		0
Callitriche heterophylla	Large water starwort	9		0
Callitriche palustris	Common water starwort	8		0
Carex comosa	Bottle brush sedge	5		0
Catabrosa aquatica	Brook grass	10		0
Ceratophyllum demersum	Coontail	3		0
Ceratophyllum echinatum	Spiny coontail	10		0
Chara	Muskgrasses	7		0
Dulichium arundinaceum	Three-way sedge	9		0
Elatine minima	Waterwort	9		0
Elatine triandra	Matted waterwort	9		0
Eleocharis acicularis	Needle spikerush	5		0
Eleocharis erythropoda	Bald spike-rush	3		0
Eleocharis palustris	Creeping spikerush	6		0
Elodea canadensis	Common waterweed	3		0
Elodea nuttallii	Slender waterweed	7		0
Equisetum fluviatile	Water horsetail	7		0
Eriocaulon aquaticum	Pipewort	9		0
Glyceria borealis	Northern manna grass	8		0
Gratiola aurea	Dwarf hyssop	10		0
Isoetes echinospora	Spiny-spored quillwort	8		0
Isoetes lacustris	Large quillwort	8		0
Juncus palocarpus f. submersus	Brown-fruited rush	8		0
Juncus torreyi	Torrey's rush	4		0
Lemna minor	Small duckweed	5		0
Lemna perpusilla	Least duckweed	10		0
Lemna trisulca	Forked duckweed	6		0
Littorella americana	Littorella	10		0
Lobelia dortmanna	Water lobelia	10		0
Ludwigia palustris	Marsh purslane	4		0
Megalodonta beckii	Water marigold	8		0
Myriophyllum alterniflorum	Alternate-flowered water-milfoil	10		0
Myriophyllum farwellii	Farwell's water-milfoil	9		0
Myriophyllum heterophyllum	Various-leaved water-milfoil	7		0
Myriophyllum sibericum	Northern water-milfoil	7		0
Myriophyllum tenellum	Dwarf water-milfoil	10		0
Myriophyllum verticillatum	Whorled water-milfoil	8		0
Najas flexilis	Bushy pondweed	6		0
Najas gracillima	Slender water-nymph	7		0
Najas guadalupensis	Southern water-nymph	7		0
Nelumbo lutea	American lotus-lily	8		0
Nitella	Nitella	7		0
Nuphar advena	Yellow pond lily	8		0
Nuphar microphylla	Small pond lily	9		0
Nuphar x rubrodisca	Intermediate pond lily	9		0
Nuphar variegata	Spatterdock	6		0
Nymphaea odorata	White water lily	6		0
Phragmites australis	Common reed	1		0
Polygonum amphibium	Water smartweed	5	1	5

Polygonum punctatum	Dotted smartweed	5		0
Pontederia cordata	Pickerelweed	9		0
Potamogeton alpinus	Alpine pondweed	9		0
Potamogeton amplifolius	Large-leaf pondweed	7		0
Potamogeton confervoides	Algal-leaved pondweed	10		0
Potamogeton diversifolius	Common snail-seed pondweed	8		0
Potamogeton epihydrus	Ribbon-leaf pondweed	8		0
Potamogeton foliosus	Leafy pondweed	6		0
Potamogeton friesii	Frie's pondweed	8		0
Potamogeton gramineus	Variable pondweed	7		0
Potamogeton hillii	Hill's pondweed	9		0
Potamogeton illinoensis	Illinois pondweed	6		0
Potamogeton natans	Floating-leaf	5		0
Potamogeton nodosus	Long-leaf pondweed	7		0
Potamogeton oakesianus	Oake's pondweed	10		0
Potamogeton obtusifolius	Blunt-leaf pondweed	9		0
Potamogeton praelongis	White-stem pondweed	8		0
Potamogeton pulcher	Spotted pondweed	10		0
Potamogeton pusillus	Small pondweed	7		0
Potamogeton richardsonii	Clasping-leaf pondweed	5		0
Potamogeton robbinsii	Robbins pondweed	8		0
Potamogeton spirillus	Spiral-fruited pondweed	8		0
Potamogeton strictifolius	Stiff pondweed	8		0
Potamogeton vaseyi	Vasey's pondweed	10		0
Potamogeton zosteriformis	Flat-stem pondweed	6		0
Ranunculus aquatilis	Stiff water crowfoot	7		0
Ranunculus flabellaris	Yellow water buttercup	8		0
Ranunculus flammula	Creeping spearwort	9		0
Riccia fluitans	Slender riccia	7		0
Ruppia maritima	Ditch grass	8		0
Sagittaria brevirostrata	Arum-leaved arrowhead	9		0
Sagittaria cuneata	Midwestern arrowhead	7		0
Sagittaria graminea	Grass-leaved	9		0
Sagittaria latifolia	Common arrowhead	3		0
Sagittaria rigida	Stiff arrowhead	8		0
Schoenoplectus acutus	Hardstem bulrush	5		0
Schoenoplectus heterochaetus	Slender bulrush	10		0
Schoenoplectus pungens	3-square	5		0
Schoenoplectus subterminalis	Water bulrush	9		0
Schoenoplectus tabernaemontani	Softstem bulrush	4	1	4
Sparganium americanum	American bur-reed	8		0
Sparganium androcladum	Branched bur-reed	8		0
Sparganium angustifolium	Narrow-leaved bur-reed	9		0
Sparganium emersum	Short-stemmed bur-reed	8		0
Sparganium eurycarpum	Common bur-reed	5		0
Sparganium fluctuans	Floating-leaf-bur-reed	10		0
Spirodela polyrhiza	Large duckweed	5		0
Stuckenia filiformis	Thread-leaf pondweed	8		0
Stuckenia pectinata	Sogo pondweed	3		0
Stuckenia vaginata	Sheathed pondweed	9		0
Typha angustifolium	Narrow-leaved cattail	1		0
Typha latifolia	Broad-leaved cattail	1		0
Utricularia cornuta	Horned bladderwort	10		0
Utricularia geminiscapa	Twin-stemmed bladderwort	9		0
Utricularia gibba	Creeping bladderwort	9		0
Utricularia intermedia	Flat-leaf bladderwort	9		0

Utricularia minor	Small bladderwort	10	0
Utricularia purpurea	Large purple bladderwort	9	0
Utricularia resupinata	Small purple bladderwort	9	0
Utricularia vulgaris	Common bladderwort	7	0
Vallisneria americana	Wild celery	6	0
Wolffia columbiana	Common watermeal	5	0
Wolffia punctata	Northern water-meal	6	0
Zannichellia palustris	Common water-meal	7	0
Zizania aquatica	Zizania aquatica	8	0
Zizania palustris	Northern wild rice	8	0
Zosterella dubia	Water star-grass	6	0
N		**2**	
Mean C			**4.5**
FQI			**6.363961031**

Coon Lake Management Plan

Coon Lake Watershed Modeling Data

Appendix J

Polk County Land and Water Resources Department
12/31/2011

Date: 12/9/2011   Scenario: Coon Lake 2010 Landuse

Lake Id: Coon Lake
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 719.2 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 479.5 acre-ft
Lake Surface Area <As>: 42.18 acre
Lake Volume <V>: 421 acre-ft
Lake Mean Depth <z>: 10.0 ft
Precipitation - Evaporation: 3.00 in.
Hydraulic Loading: 490.0 acre-ft/year
Areal Water Load <qs>: 11.6 ft/year
Lake Flushing Rate <p>: 1.16 1/year
Water Residence Time: 0.86 year
Observed spring overturn total phosphorus (SPO): 69 mg/m^3
Observed growing season mean phosphorus (GSM): 166.2 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	64.40	0.50	1.00	3.00	23.6	13	26	78
Mixed AG	3.24	0.30	0.80	1.40	1.0	0	1	2
Pasture/Grass	11.45	0.10	0.30	0.50	1.3	0	1	2
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	169.61	0.30	0.50	0.80	31.1	21	34	55
Rural Res (>1 Ac)	27.38	0.05	0.10	0.25	1.0	1	1	3
Wetlands	17.855	0.10	0.10	0.10	0.7	1	1	1
Forest	351.44	0.05	0.09	0.18	11.6	7	13	26
Lake Surface	42.2	0.10	0.30	1.00	4.6	2	5	17

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.3	0.5	0.8	
# capita-years	0.0				
% Phosphorus Retained by Soil		98	90	80	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	137.8	243.4	489.3	100.0
Total Loading (kg)	62.5	110.4	221.9	100.0
Areal Loading (lb/ac-year)	3.27	5.77	11.60	0.0
Areal Loading (mg/m^2-year)	366.15	646.79	1300.19	0.0
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	134.0	232.1	451.6	100.0
Total NPS Loading (kg)	60.8	105.3	204.9	100.0

Wisconsin Internal Load Estimator

Date: 12/9/2011   Scenario: 2

Method 1 - A Complete Total Phosphorus Mass Budget

Method 1 - A Complete Total Phosphorus Mass Budget 150 mg/m^3
Phosphorus Inflow Concentration: 182.7 mg/m^3
Areal External Loading: 646.8 mg/m^2-year
Predicted Phosphorus Retention Coefficient: 0.70
Observed Phosphorus Retention Coefficient: 0.18
Internal Load: 126 Lb   57 kg

Method 2 - From Growing Season In Situ Phososphorus Increases

Start of Anoxia

Average Hypolimnetic Phosphorus Concentration: mg/m^3
Hypolimnetic Volume: acre-ft
Anoxia Sediment Area: acres

Just Prior To The End of Stratification

Average Hypolimnetic Phosphorus Concentration: 0 mg/m^3
Hypolimnetic Volume: 30 acre-ft
Anoxia Sediment Area: 5 acres
Time Period of Stratification: 14 days
Sediment Phosphorus Release Rate: 0 mg/m^2-day   0 lb/acre-day
Internal Load: -2 Lb   -1 kg

Method 3 - From In Situ Phososphorus Increases In The Fall

Start of Anoxia

Average Hypolimnetic Phosphorus Concentration: 174 mg/m^3
Hypolimnetic Volume: 30 acre-ft

Anoxia Sediment Area: 5 acres

Just Prior To The End of Stratification

Average Water Column Phosphorus Concentration: 136 mg/m^3
Lake Volume: 421.0 acre-ft
Anoxia Sediment Area Just Before Turnover: 5 acres
Time Period Between Observations: 30 days
Sediment Phosphorus Release Rate: 105.7 mg/m^2-day   2.88E-001 lb/acre-day
Internal Load: 142 Lb   64 kg

Method 4 - From Phososphorus Release Rate and Anoxic Area

Start of Anoxia Anoxic Sediment Area: 5 acre
End of Anoxia Anoxic Sediment Area: 5 acre
Phosphorus Release Rate As Calculated In Method 2: -3.5 mg/m^2-day
Phosphorus Release Rate As Calculated In Method 3: -3.5 mg/m^2-day
Average of Methods 2 and 3 Release Rates: 51.1 mg/m^2-day
Period of Anoxia: 56 days
Default Areal Sediment Phosphorus Release Rates:

	Low	Most Likely	High
	6	14	24
Internal Load: (Lb)	5	11	18
Internal Load: (kg)	2	5	8

Internal Load Comparison (Percentanges are of the Total Estimate Load)

Total External Load: 243 Lb   110 kg

	Lb	kg	%
From A Complete Mass Budget:	126	57	34.1
From Growing Season In Situ Phosphorus Increases:	-2	-1	-0.9
From In Situ Phososphorus Increases In The Fall:	142	64	36.8
From Phososphorus Release Rate and Anoxic Area:	11	5	4.2

Predicted Water Column Total Phosphorus Concentration (ug/l)

	Low	Most Likely	High
Nurnberg+ 1984 Total Phosphorus Model:	126	108	119

Osgood, 1988 Lake Mixing Index: 7.4

Phosphorus Loading Summary:

	Low	Most Likely	High
Internal Load (Lb):	126	69.7	11
Internal Load (kg):	57	31.6	5
External Load (Lb):	138	243	489
External Load (kg):	63	110	222
Total Load (Lb):	264	313	500
Total Load (kg):	120	142	227

Phosphorus Prediction and Uncertainty Analysis Module

Date: 12/9/2011   Scenario: 1
Observed spring overturn total phosphorus (SPO): 69.0 mg/m^3
Observed growing season mean phosphorus (GSM): 166.2 mg/m^3
Back calculation for SPO total phosphorus: 132.69 mg/m^3
Back calculation GSM phosphorus: 319.62 mg/m^3
% Confidence Range: 70%
Nurenberg Model Input - Est. Gross Int. Loading: 108 kg

Lake Phosphorus Model	**Low** Total P (mg/m^3)	**Most Likely** Total P (mg/m^3)	**High** Total P (mg/m^3)	**Predicted** -Observed (mg/m^3)	**% Dif.**
Walker, 1987 Reservoir	35	63	126	-103	-62
Canfield-Bachmann, 1981 Natural Lake	46	70	114	-96	-58
Canfield-Bachmann, 1981 Artificial Lake	39	55	82	-111	-67
Rechow, 1979 General	23	41	82	-125	-75
Rechow, 1977 Anoxic	81	143	288	-23	-14
Rechow, 1977 water load<50m/year	45	80	161	-86	-52
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	58	103	208	34	49
Vollenweider, 1982 Combined OECD	41	65	115	-53	-45
Dillon-Rigler-Kirchner	28	50	100	-19	-28
Vollenweider, 1982 Shallow Lake/Res.	34	56	104	-62	-53
Larsen-Mercier, 1976	54	95	191	26	38
Nurnberg, 1984 Oxic	210	234	290	68	41

Lake Phosphorus Model	**Confidence** Lower Bound	**Confidence** Upper Bound	**Parameter** Fit?	**Back** Calculation (kg/year)	**Model** Type
Walker, 1987 Reservoir	39	108	FIT	564	GSM
Canfield-Bachmann, 1981 Natural Lake	22	202	FIT	1081	GSM
Canfield-Bachmann, 1981 Artificial Lake	17	158	FIT	3700	GSM
Rechow, 1979 General	24	71	FIT	865	GSM
Rechow, 1977 Anoxic	90	243	FIT	247	GSM
Rechow, 1977 water load<50m/year	48	139	P	441	GSM
Rechow, 1977 water load>50m/year	N/A	N/A	N/A	N/A	N/A
Walker, 1977 General	54	191	FIT	142	SPO
Vollenweider, 1982 Combined OECD	33	118	FIT	509	ANN

Dillon-Rigler-Kirchner	31	85	P	295	SPO
Vollenweider, 1982 Shallow Lake/Res.	29	103	FIT	550	ANN
Larsen-Mercier, 1976	61	160	P Pin	155	SPO
Nurnberg, 1984 Oxic	147	361	P	281	ANN

Expanded Trophic Response Module
Date: 12/9/2011   Scenario: 1
Total Phosphorus: 166.2 mg/m^3
Growing Season
Chorophyll a: 49 mg/m^3
Secchi Disk Depth: 0.74 m
Cholorphyll a Nuisance Frequency
Chla Mean Min: 5
Chla Mean Max: 100
Chla Mean Increment: 5
Chla Temporal CV: 0.62
Chla Nuisance Criterion: 20

Mean	Freq %	ml	z	v	w	x
5	0.5	1.4	2.546	0.016	0.541	0.005
10	7.7	2.1	1.428	0.144	0.678	0.077
15	21.9	2.5	0.774	0.296	0.795	0.219
20	37.8	2.8	0.310	0.380	0.907	0.378
25	52.0	3.0	-0.050	0.398	0.984	0.480
30	63.5	3.2	-0.344	0.376	0.897	0.365
35	72.3	3.4	-0.593	0.335	0.835	0.277
40	79.0	3.5	-0.808	0.288	0.788	0.210
45	84.1	3.6	-0.998	0.242	0.751	0.159
50	87.9	3.7	-1.168	0.202	0.720	0.121
55	90.7	3.8	-1.322	0.167	0.695	0.093
60	92.8	3.9	-1.462	0.137	0.673	0.072
65	94.4	4.0	-1.591	0.112	0.654	0.056
70	95.6	4.1	-1.711	0.092	0.637	0.044
75	96.6	4.1	-1.822	0.076	0.623	0.034
80	97.3	4.2	-1.926	0.062	0.609	0.027
85	97.8	4.3	-2.024	0.051	0.598	0.022
90	98.3	4.3	-2.116	0.043	0.587	0.017
95	98.6	4.4	-2.203	0.035	0.577	0.014
100	98.9	4.4	-2.286	0.029	0.568	0.011

Lake Id: Coon Lake Conversion from Ag to pasture/grass
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 719.1 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 479.4 acre-ft
Lake Surface Area <As>: 42.2 acre
Lake Volume <V>: 421.0 acre-ft
Lake Mean Depth <z>: 10.0 ft
Precipitation - Evaporation: 3.0 in.
Hydraulic Loading: 489.9 acre-ft/year
Areal Water Load <qs>: 11.6 ft/year
Lake Flushing Rate <p>: 1.16 1/year
Water Residence Time: 0.86 year
Observed spring overturn total phosphorus (SPO): 69.0 mg/m^3
Observed growing season mean phosphorus (GSM): 166.2 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	0.0	0.50	1.00	3.00	0.0	0	0	0
Mixed AG	3.2	0.30	0.80	1.40	1.1	0	1	2
Pasture/Grass	75.8	0.10	0.30	0.50	10.0	3	9	15
HD Urban (1/8 Ac)	0.0	1.00	1.50	2.00	0.0	0	0	0
MD Urban (1/4 Ac)	169.6	0.30	0.50	0.80	37.2	21	34	55
Rural Res (>1 Ac)	27.4	0.05	0.10	0.25	1.2	1	1	3
Wetlands	17.9	0.10	0.10	0.10	0.8	1	1	1
Forest	351.4	0.05	0.09	0.18	13.9	7	13	26
Lake Surface	42.2	0.10	0.30	1.00	5.6	2	5	17

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	0.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	114.8	203.2	345.6	100.0
Total Loading (kg)	52.1	92.2	156.8	100.0
Areal Loading (lb/ac-year)	2.72	4.81	8.19	
Areal Loading (mg/m^2-year)	304.93	539.63	918.03	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	111.0	191.9	308.0	100.0
Total NPS Loading (kg)	50.4	87.0	139.7	100.0

Date: 12/9/2011 Scenario: Development - Coon Lake

Lake Id: Coon Lake
Watershed Id: 0

Hydrologic and Morphometric Data

Tributary Drainage Area: 719.1 acre
Total Unit Runoff: 8.00 in.
Annual Runoff Volume: 479.4 acre-ft
Lake Surface Area <As>: 42.2 acre
Lake Volume <V>: 421.0 acre-ft
Lake Mean Depth <z>: 10.0 ft
Precipitation - Evaporation: 3.0 in.
Hydraulic Loading: 489.9 acre-ft/year
Areal Water Load <qs>: 11.6 ft/year
Lake Flushing Rate <p>: 1.16 1/year
Water Residence Time: 0.86 year
Observed spring overturn total phosphorus (SPO): 69.0 mg/m^3
Observed growing season mean phosphorus (GSM): 166.2 mg/m^3
% NPS Change: 0%
% PS Change: 0%

NON-POINT SOURCE DATA

Land Use	Acre (ac)	Low	Most Likely	High	Loading %	Low	Most Likely	High
		|---- Loading (kg/ha-year) ----|				|----- Loading (kg/year) ----|		
Row Crop AG	64.4	0.50	1.00	3.00	18.0	13	26	78
Mixed AG	3.2	0.30	0.80	1.40	0.7	0	1	2
Pasture/Grass	11.4	0.10	0.30	0.50	1.0	0	1	2
HD Urban (1/8 Ac)	84.8	1.00	1.50	2.00	35.6	34	51	69
MD Urban (1/4 Ac)	84.8	0.30	0.50	0.80	11.9	10	17	27
Rural Res (>1 Ac)	27.4	0.05	0.10	0.25	0.8	1	1	3
Wetlands	17.9	0.10	0.10	0.10	0.5	1	1	1
Forest	351.4	0.05	0.09	0.18	8.8	7	13	26
Lake Surface	42.2	0.10	0.30	1.00	3.5	2	5	17

POINT SOURCE DATA

Point Sources	Water Load (m^3/year)	Low (kg/year)	Most Likely (kg/year)	High (kg/year)	Loading %

SEPTIC TANK DATA

Description		Low	Most Likely	High	Loading %
Septic Tank Output (kg/capita-year)		0.30	0.50	0.80	
# capita-years	0.0				
% Phosphorus Retained by Soil		98.0	90.0	80.0	
Septic Tank Loading (kg/year)		0.00	0.00	0.00	0.0

TOTALS DATA

Description	Low	Most Likely	High	Loading %
Total Loading (lb)	190.7	319.1	580.1	100.0
Total Loading (kg)	86.5	144.7	263.1	100.0
Areal Loading (lb/ac-year)	4.52	7.56	13.75	
Areal Loading (mg/m^2-year)	506.64	847.44	1540.74	
Total PS Loading (lb)	0.0	0.0	0.0	0.0
Total PS Loading (kg)	0.0	0.0	0.0	0.0
Total NPS Loading (lb)	187.0	307.8	542.4	100.0
Total NPS Loading (kg)	84.8	139.6	246.0	100.0