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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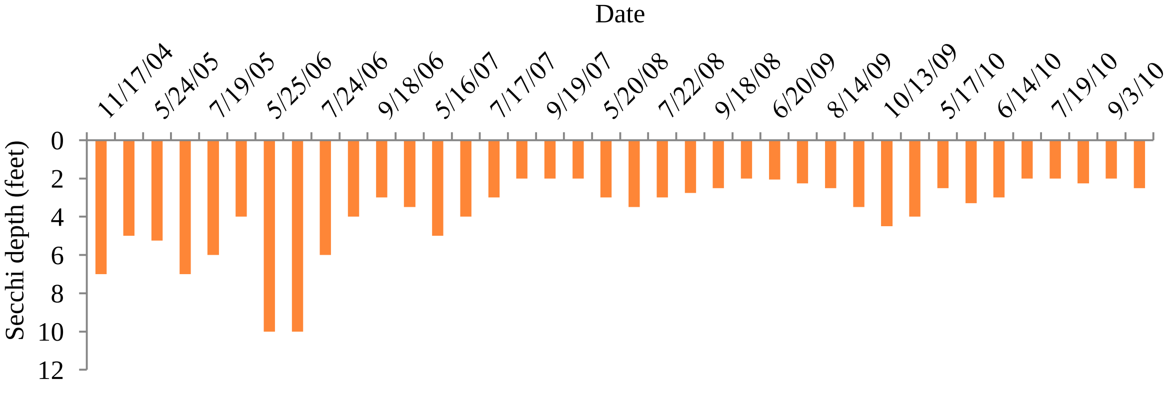
Executive Summary

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.

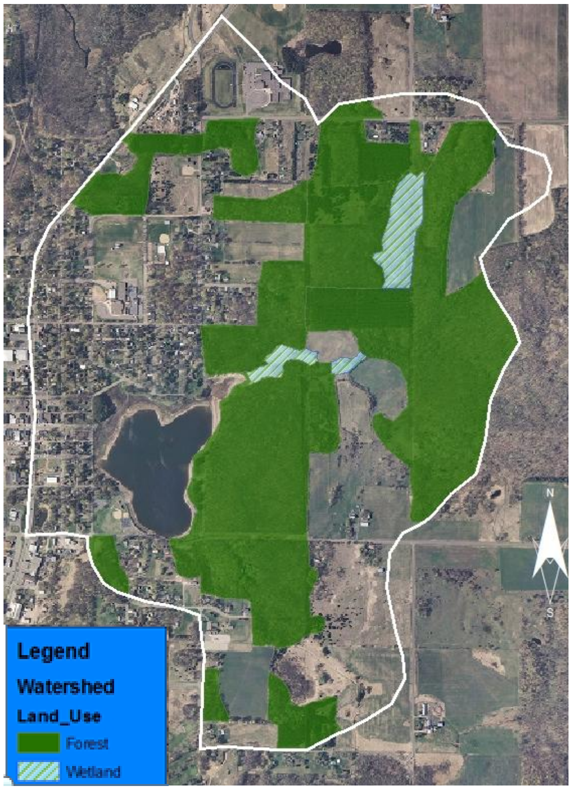
Phosphorus is a nutrient necessary for plant and animal growth. However, excessive amounts can result in an overabundance of plant growth and a decrease in water clarity. Phosphorus occurs naturally in soil, rocks, and the atmosphere and can make its way into lakes through a variety of sources, many 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).

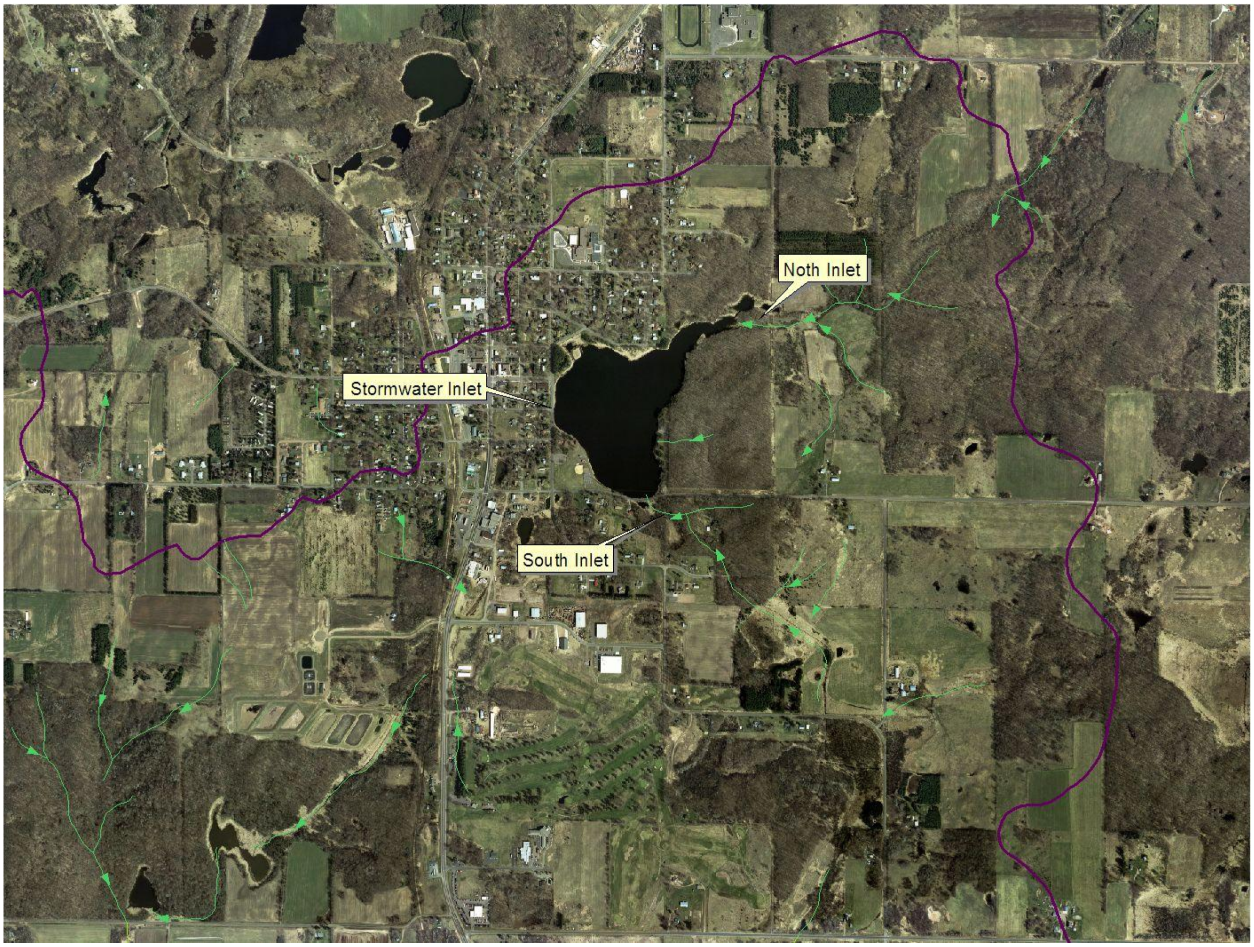


Figure 1. Map of Coon Lake depicting the north inlet, south inlet, and stormwater inlet.

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.

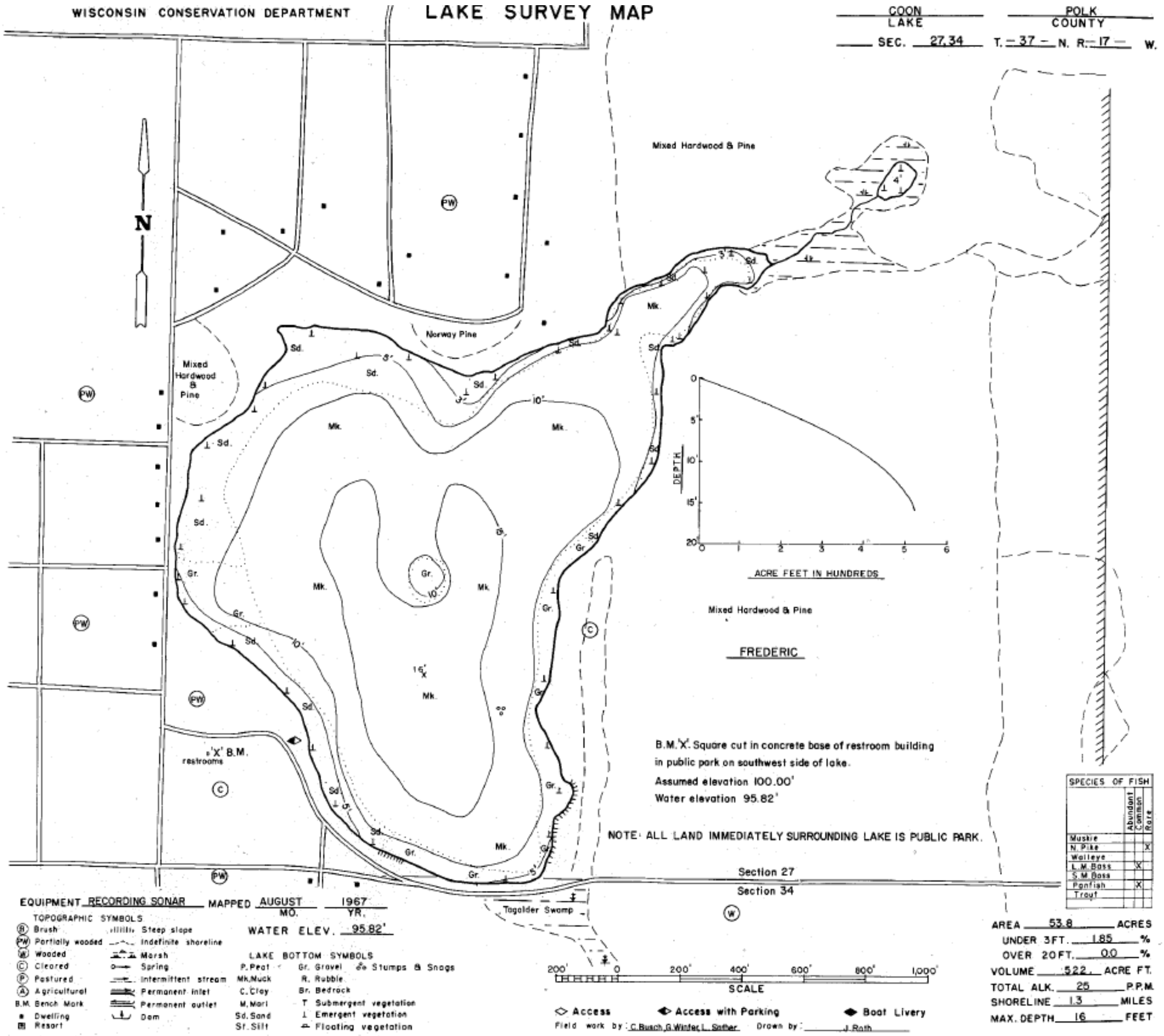
Very little qualitative or quantitative data has been collected on Coon Lake. Until this study, a lake planning grant had never been implemented to study water quality or the biotic components of Coon Lake. Additionally, data on water quality for Coon Lake was non-existent, with no phosphorus or other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



B.M. 'X'. Square cut in concrete base of restroom building in public park on southwest side of lake.
Assumed elevation 100.00'
Water elevation 95.82'

NOTE: ALL LAND IMMEDIATELY SURROUNDING LAKE IS PUBLIC PARK.

SPECIES OF FISH	Abundant	Common	Rare
Muskie			
N. Pike			X
Walleye			
L.M. Bass		X	
S.M. Bass			
Panfish		X	
Trout			

AREA 53.8 ACRES
UNDER 3FT. 1.85 %
OVER 20FT. 0.0 %
VOLUME 522. ACRE FT.
TOTAL ALK. 25 P.P.M.
SHORELINE 1.3 MILES
MAX. DEPTH 16 FEET

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.

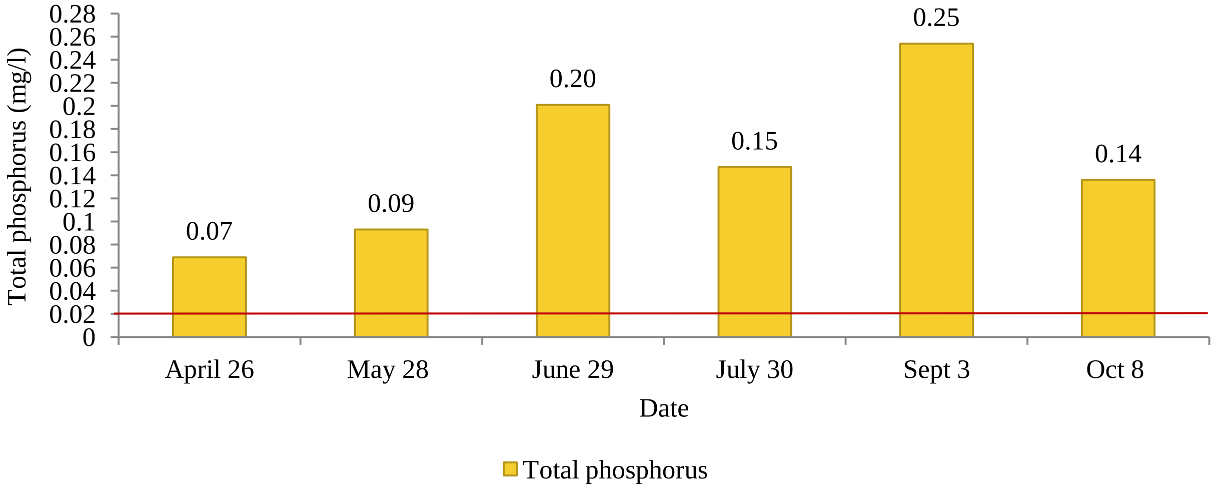


Figure 3. Coon Lake total phosphorus (mg/l), 2010. Red threshold line represents a healthy limit of total phosphorus, 0.02 mg/l.

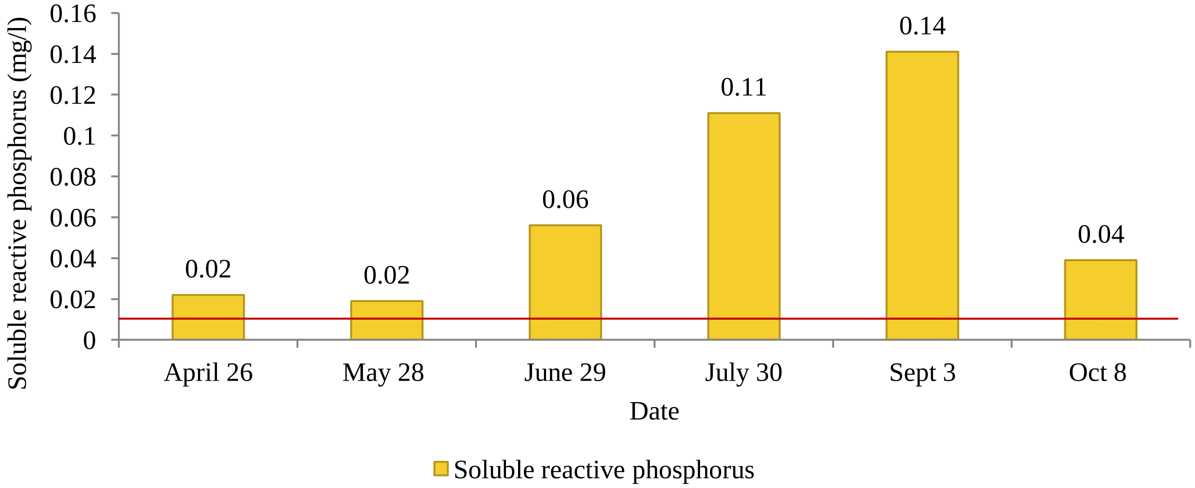


Figure 4. Coon Lake soluble reactive phosphorus (mg/l), 2010. Red threshold line represents a healthy limit of soluble reactive phosphorus, 0.01 mg/l.

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).

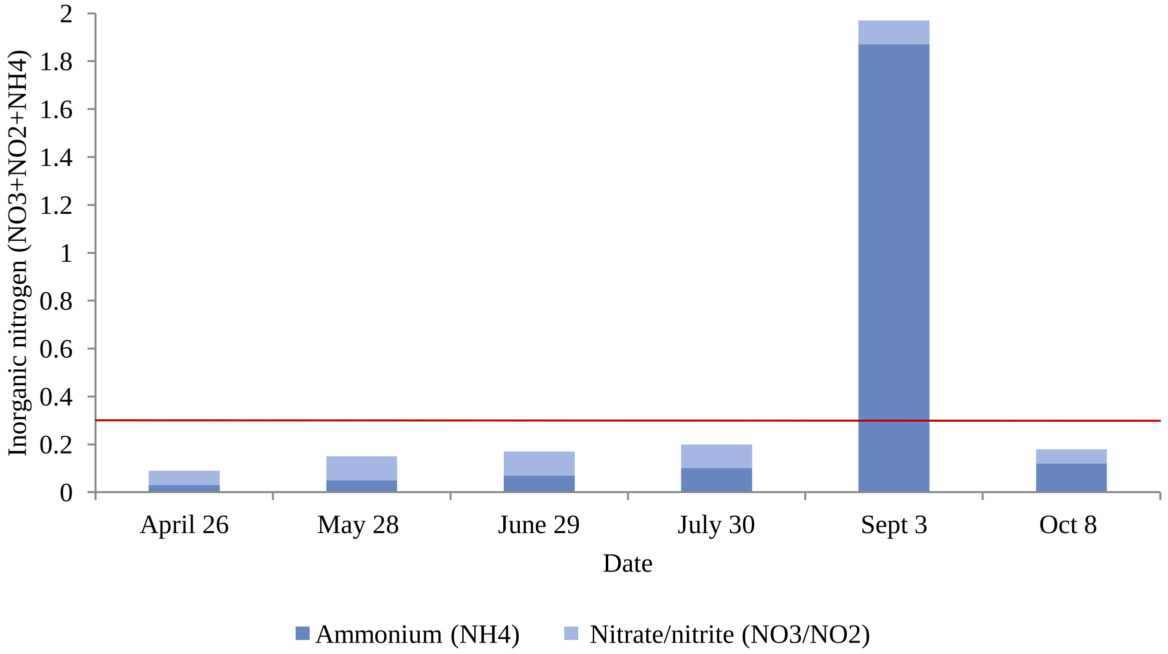


Figure 5. Coon Lake inorganic nitrogen (mg/l), 2010. Red threshold line represents a healthy limit of inorganic nitrogen, 0.3 mg/L. Nitrate/nitrite samples on May 28th, June 29th, July 30th, and September 3rd were less than 0.1 mg/l but are represented as 0.1.

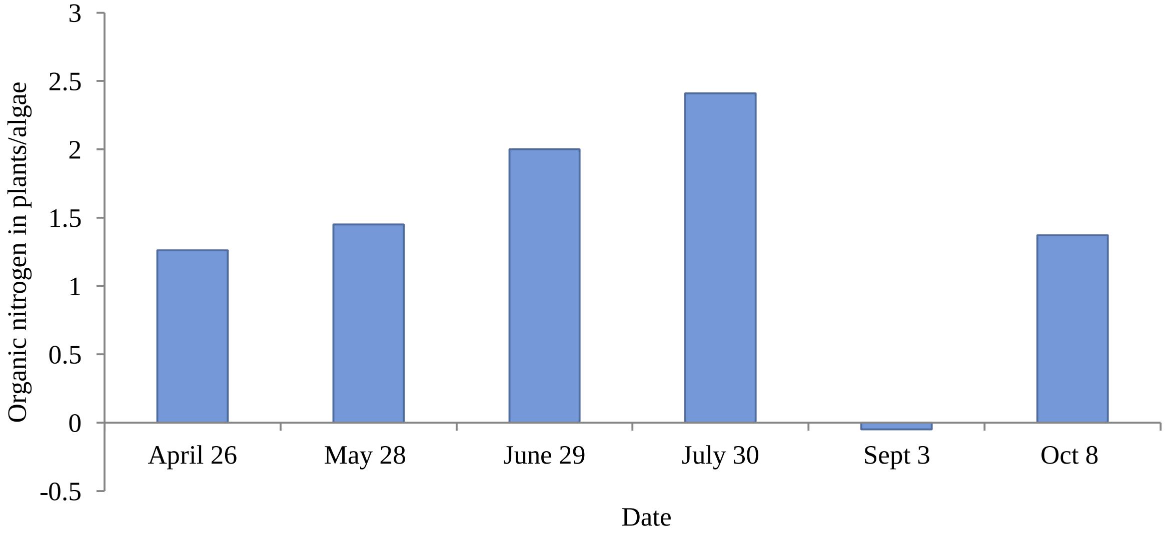


Figure 6. Coon Lake organic nitrogen in plants and algae (mg/l), 2010

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.

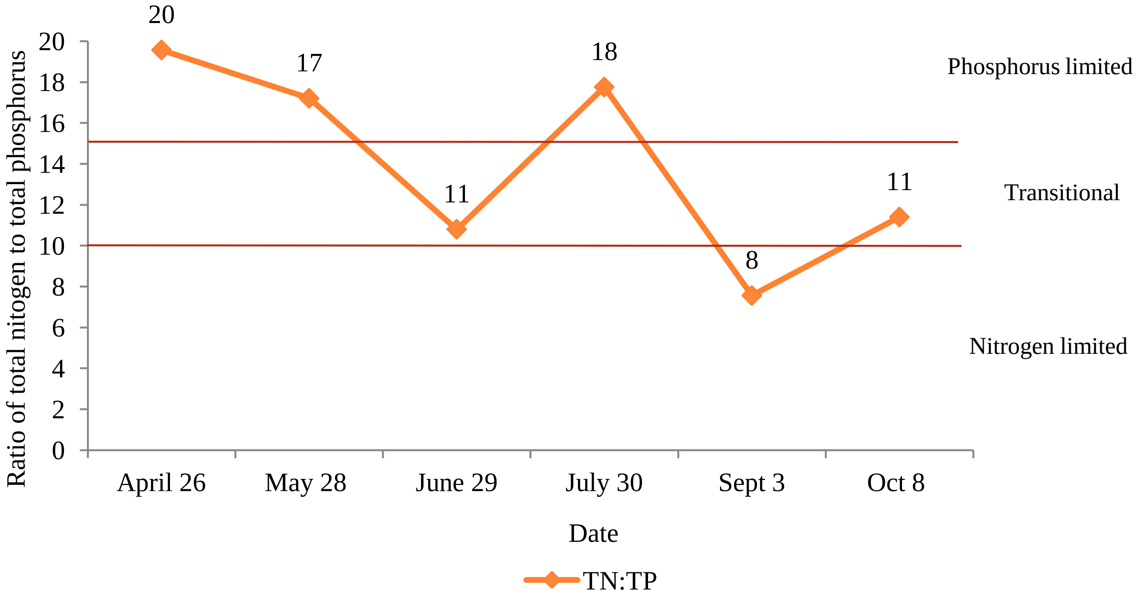


Figure 7. Coon Lake ratio of total nitrogen to total phosphorus, 2010. Values below 10 represent lakes which are nitrogen limited and values above 15 represent lakes which are phosphorus limited. Values between 10 and 15 are considered transitional.

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).

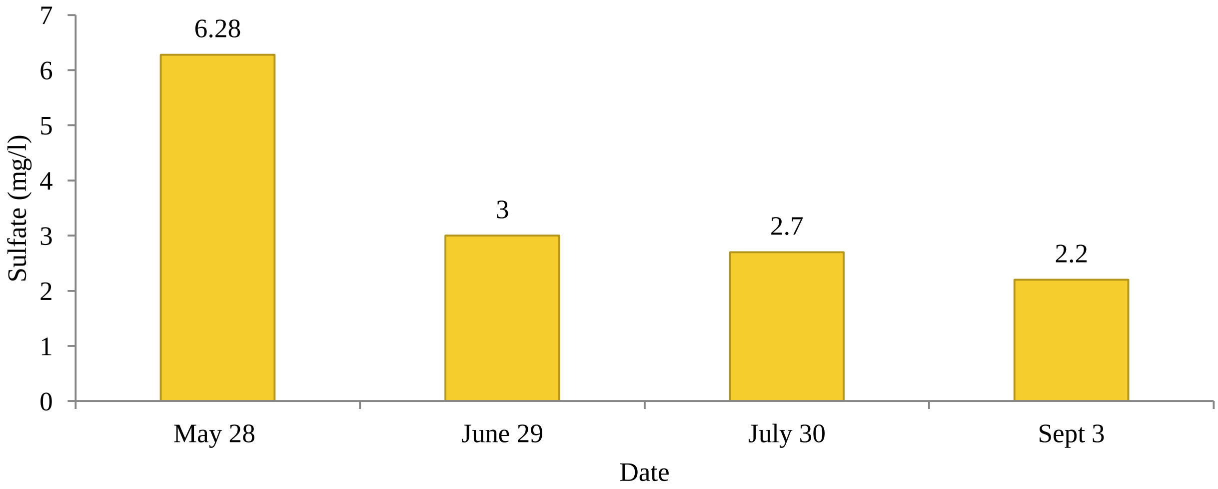


Figure 8. Coon Lake sulfate (mg/l), 2010.

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).

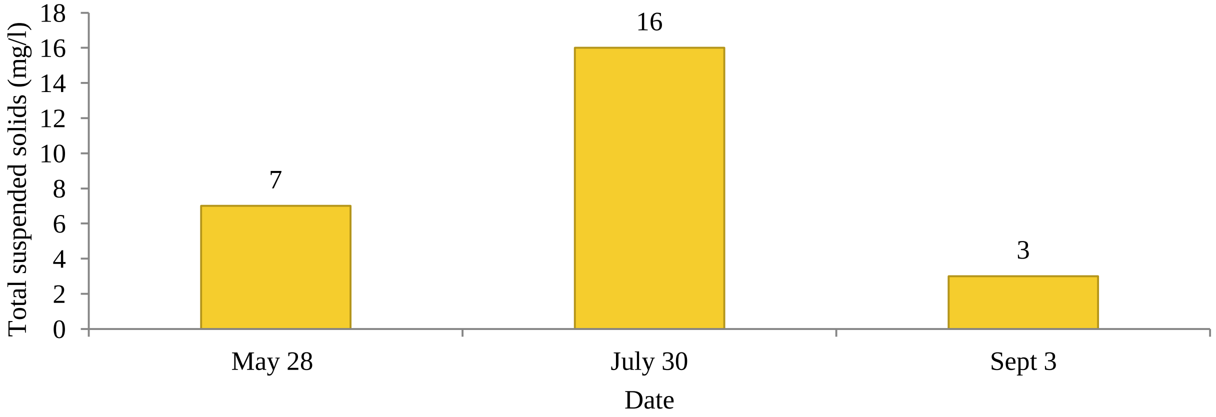


Figure 9. Coon Lake total suspended solids (mg/l), 2010.

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.

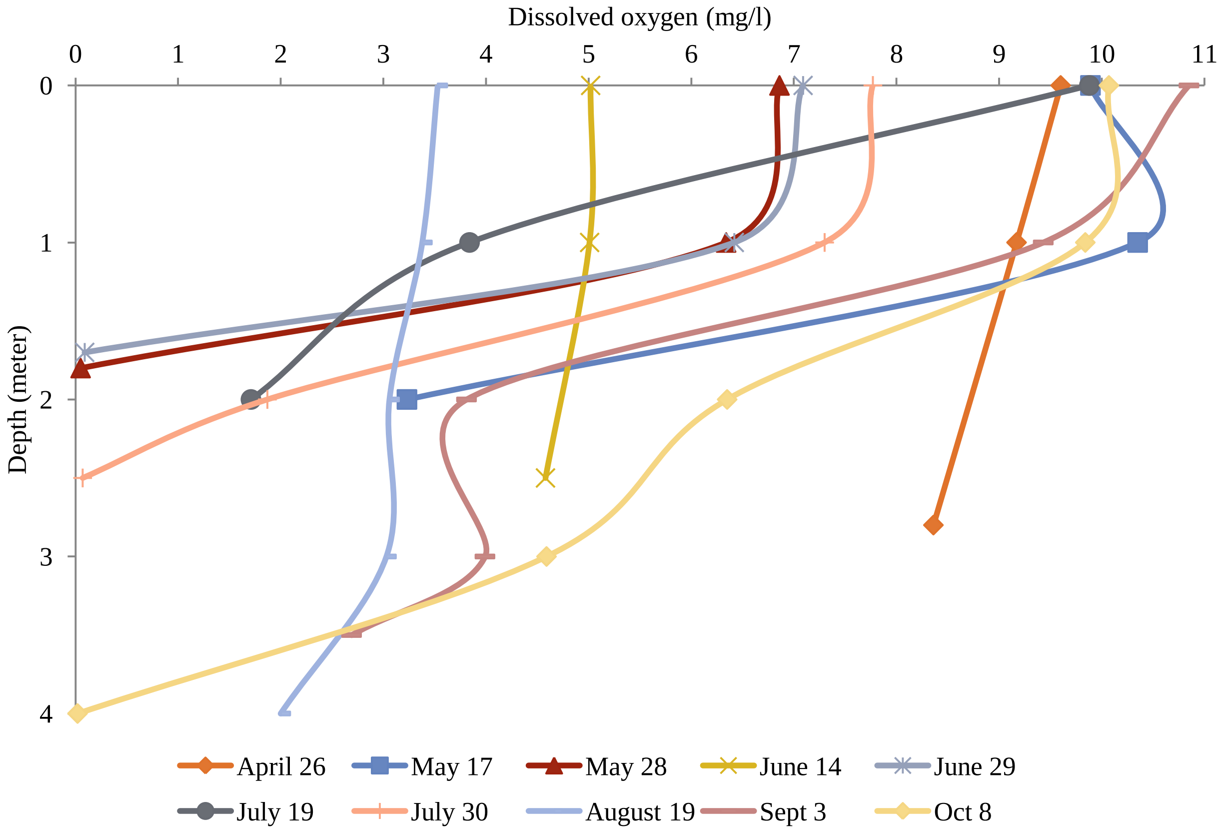


Figure 10. Coon Lake dissolved oxygen (mg/l) profile, 2010.

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.

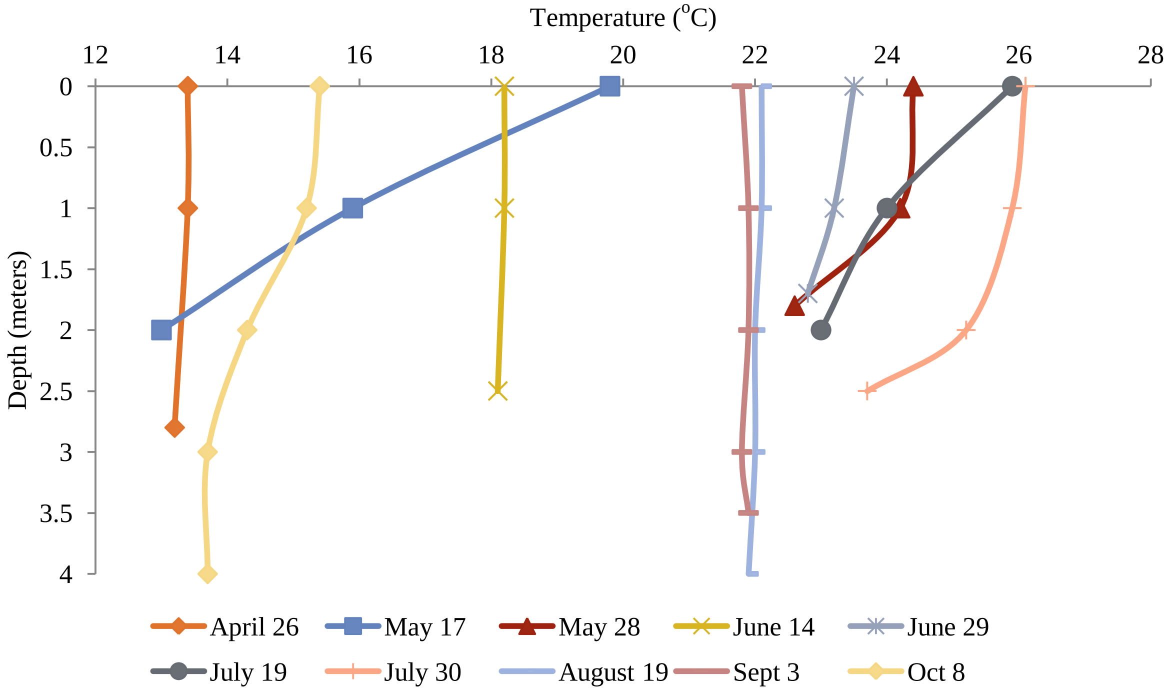


Figure 11. Coon Lake temperature (°C) profile, 2010.

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.

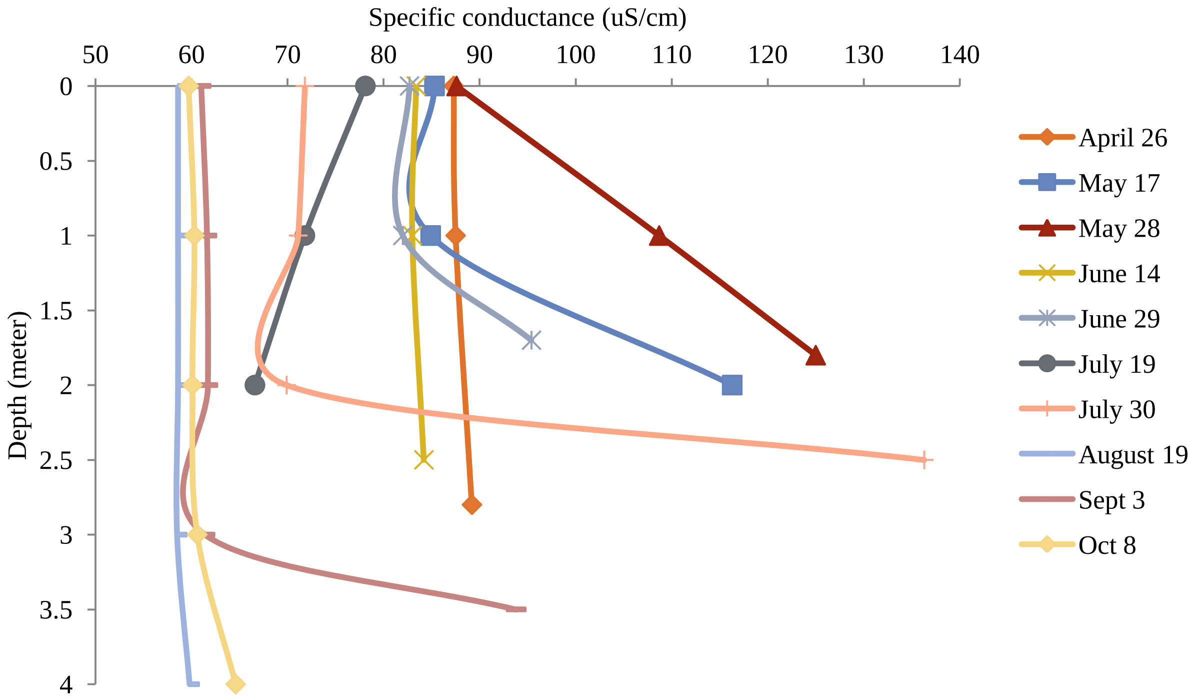


Figure 12. Coon Lake specific conductance (uS/cm) profile, 2010.

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.

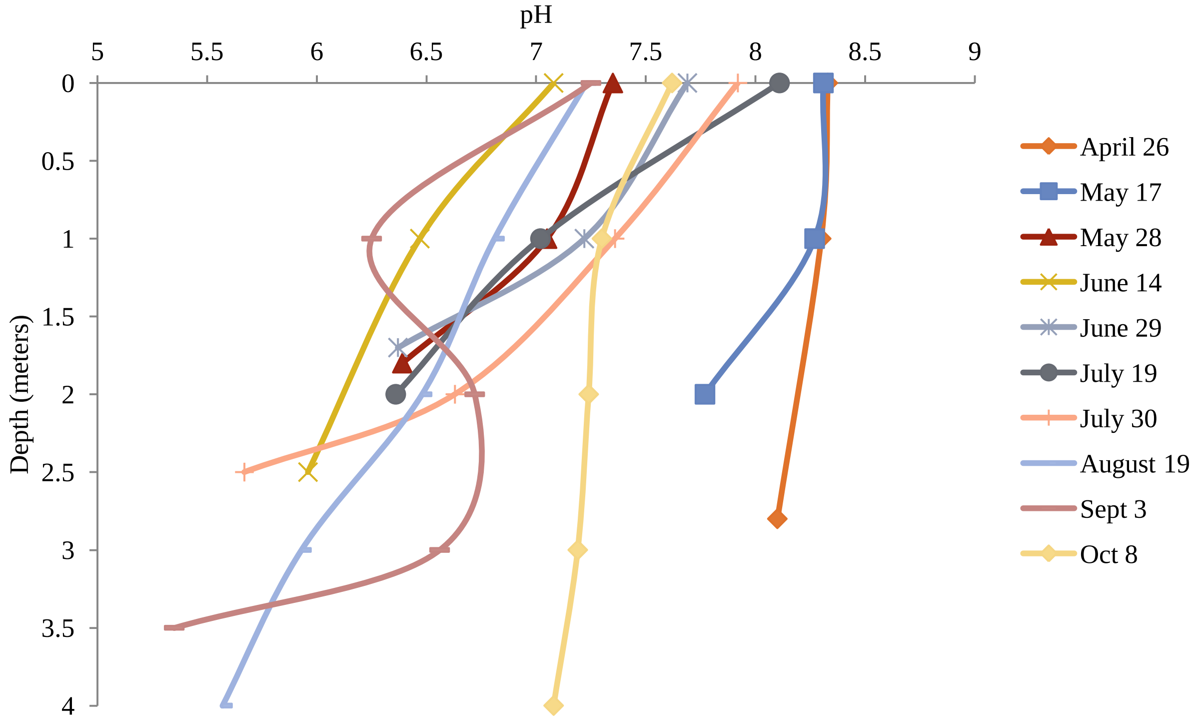


Figure 13. Coon Lake pH profile, 2010.

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.

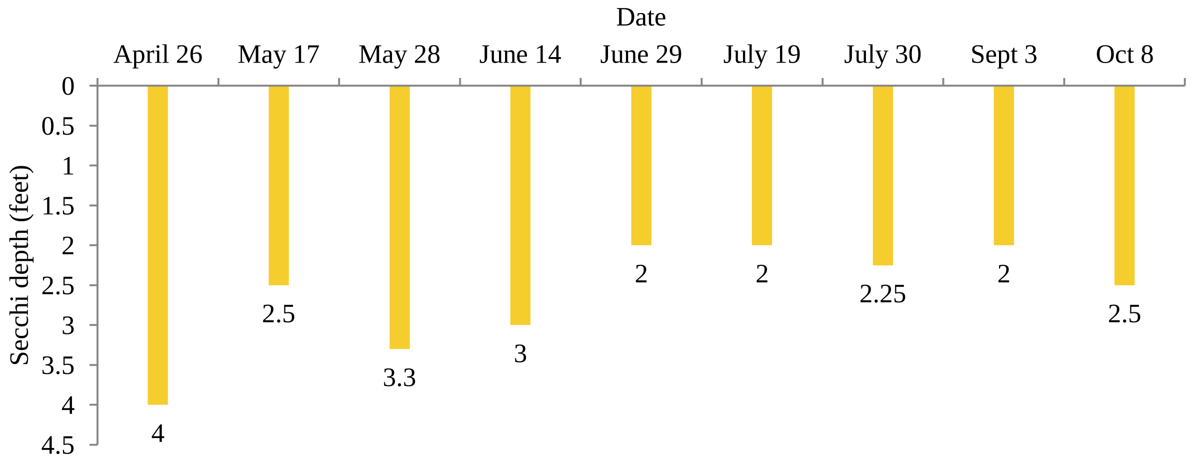


Figure 14. Coon Lake Secchi disk profile, 2010.

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

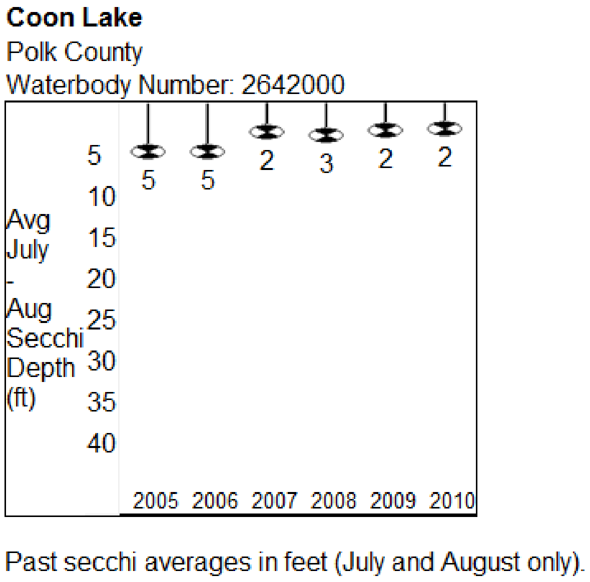


Figure 15. Coon Lake historic Secchi disk profile, 2005-2010.

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.

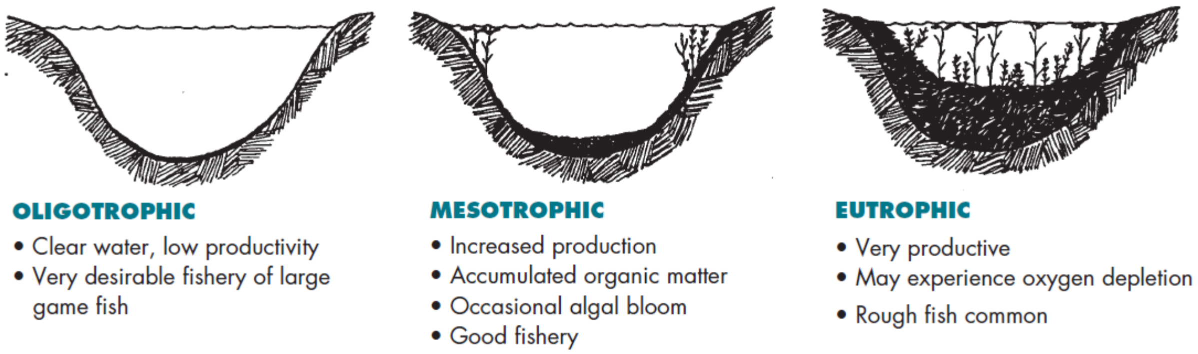


Figure 16. Lake aging process. *Figure from Understanding Lake Data (G3582).*

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).

Coon Lake TSI Ratings

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.

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).

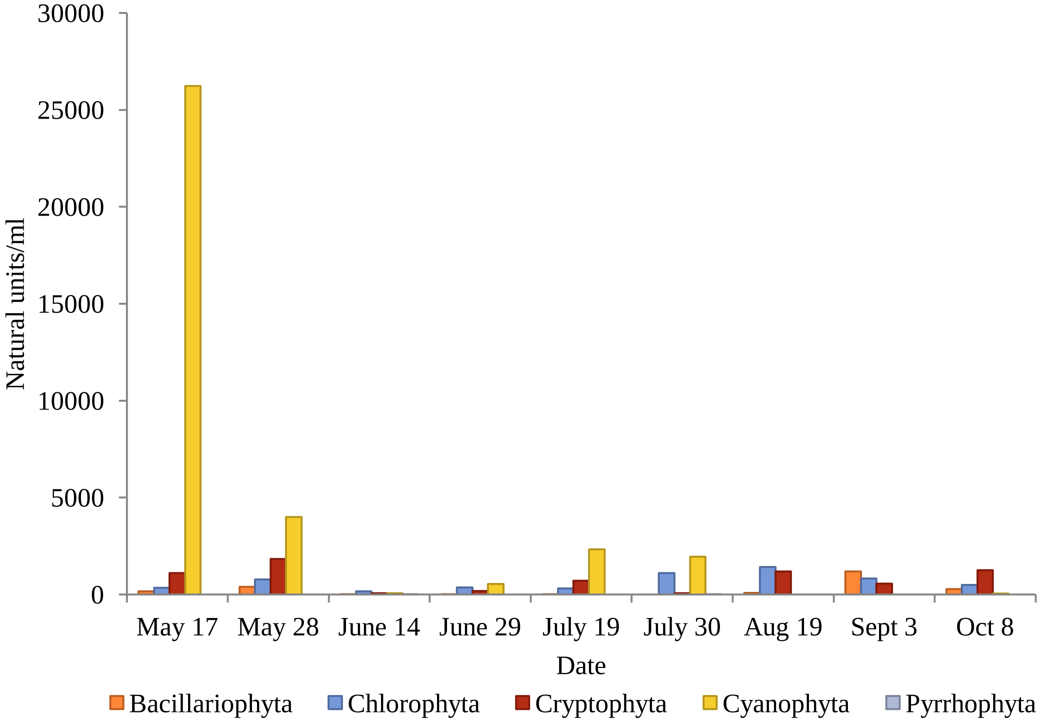


Figure 17. Natural units/ml of each algae division, Coon Lake, 2010.

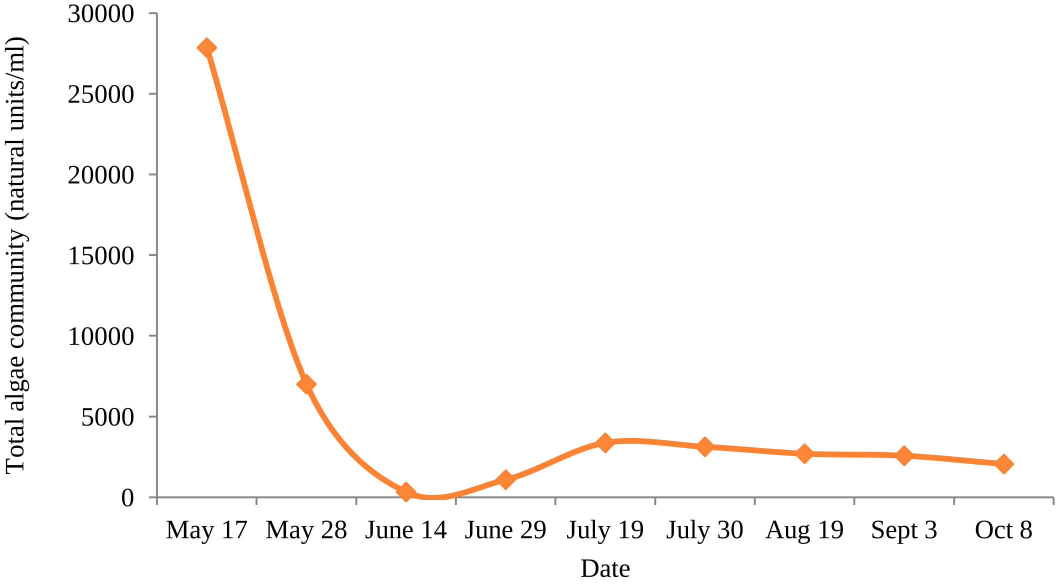


Figure 18. Total algae community (natural units/ml), Coon Lake, 2010.

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).

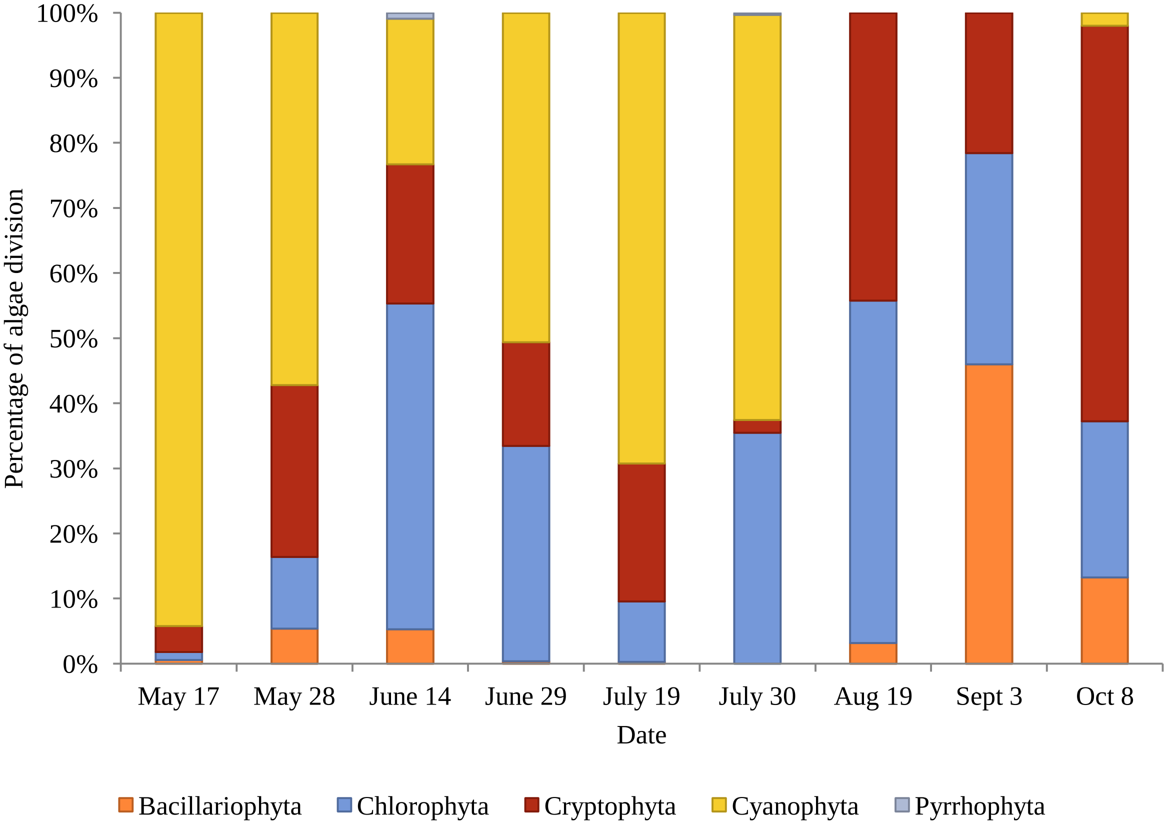


Figure 19. Percentage of each algae division, Coon Lake, 2010.

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).

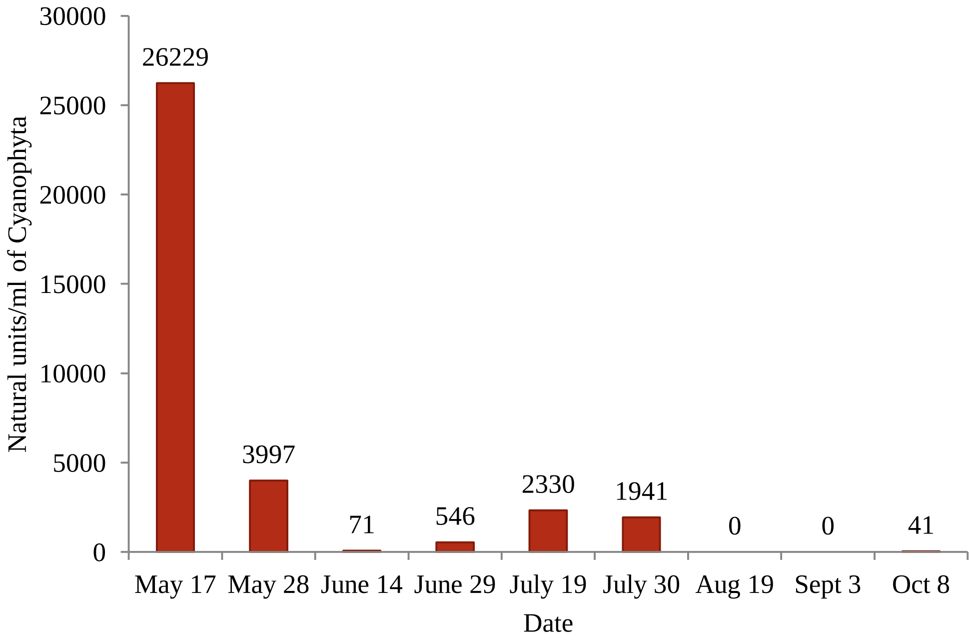


Figure 20. Natural units/ml of Cyanophyta, Coon Lake, 2010.

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).

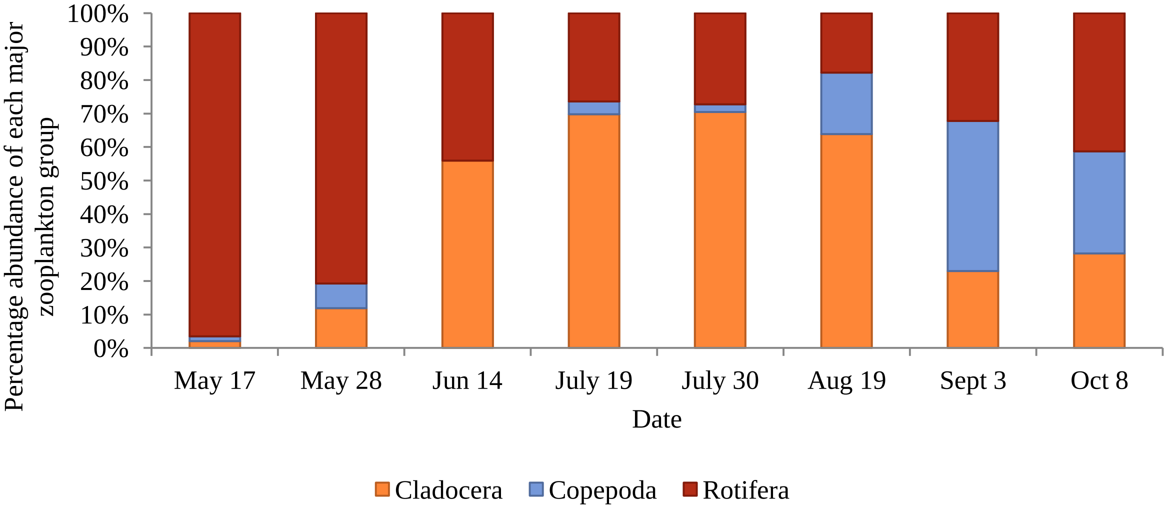


Figure 21. Percent abundance of the major zooplankton groups, Coon Lake, 2010.

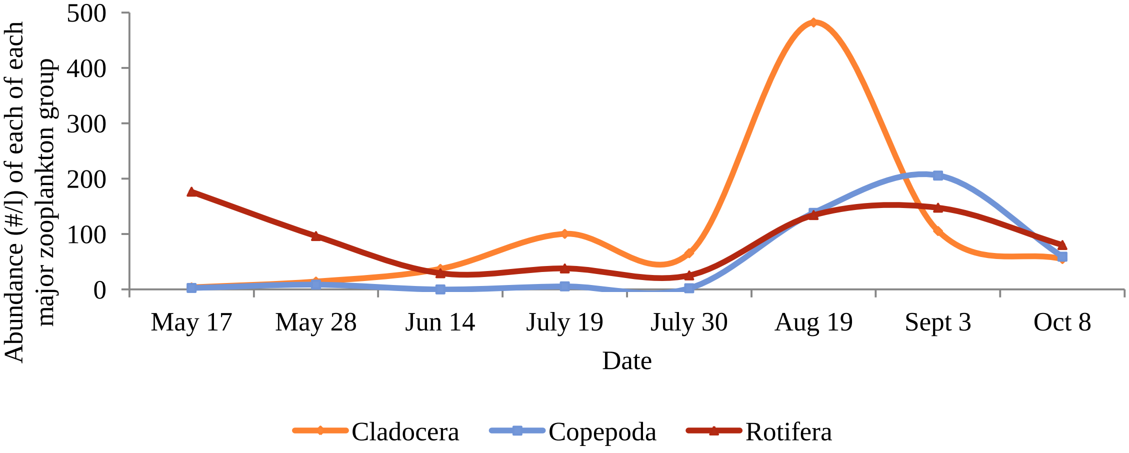


Figure 22. Abundance (#/l) of the major zooplankton groups, Coon Lake, 2010.

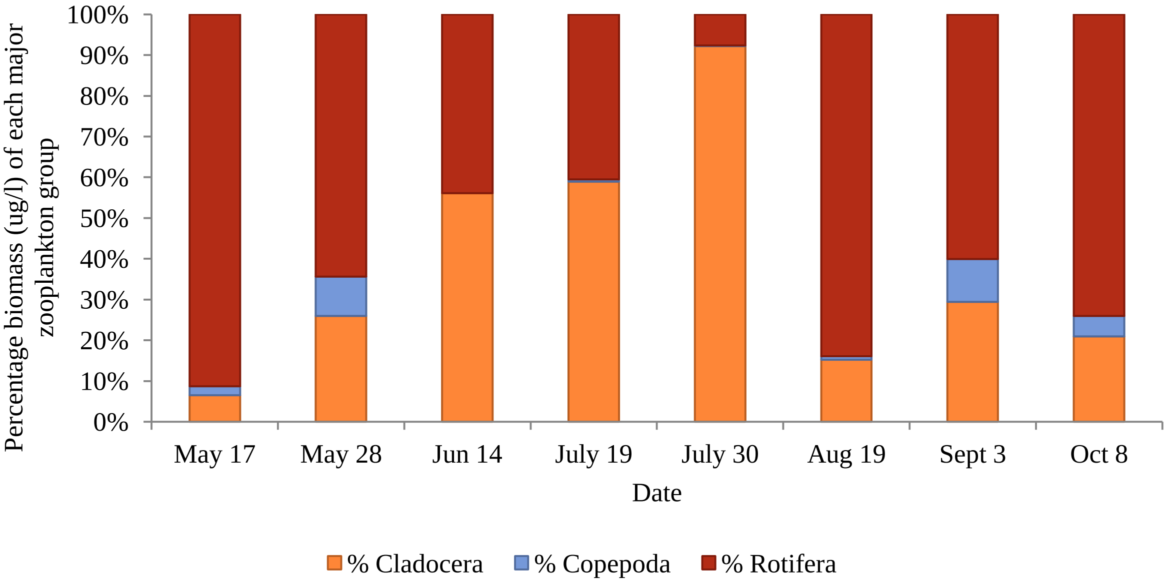


Figure 23. Percentage biomass of the major zooplankton groups, Coon Lake, 2010.

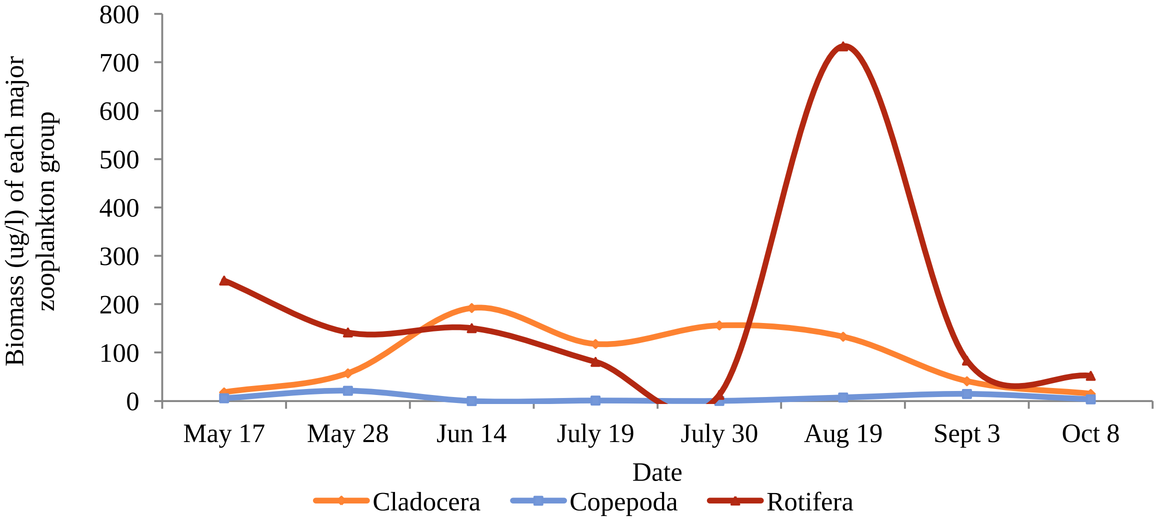


Figure 24. Biomass (ug/l) of the major zooplankton groups, Coon Lake, 2010.

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.

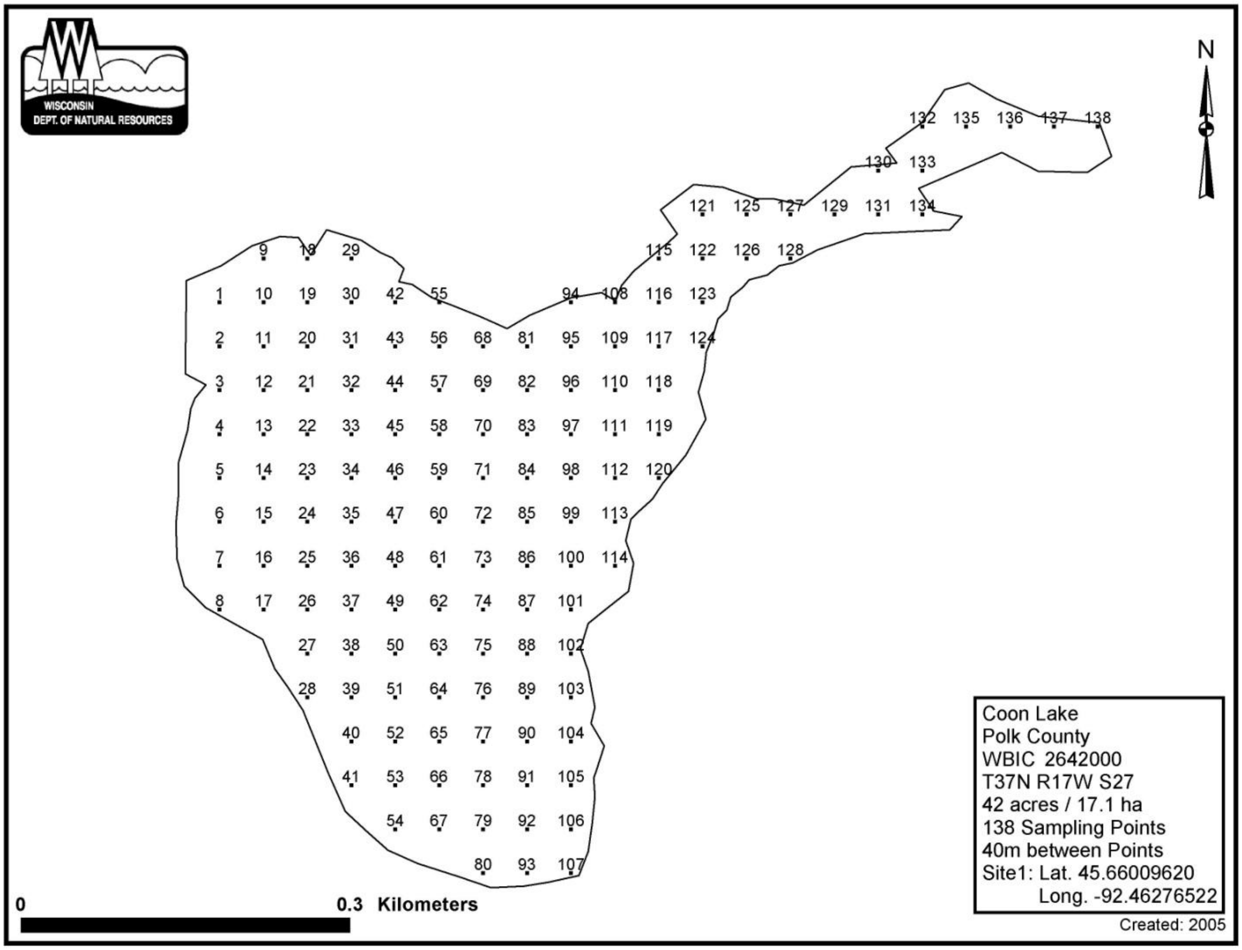


Figure 25. Coon Lake sampling points for point intercept macrophyte survey, 2010.

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.

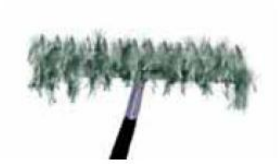
Rating	Coverage	Description
1		A few plants on rake head
2		Rake head is about ½ full Can easily see top of rake head
3		Overflowing Cannot see top of rake head

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.

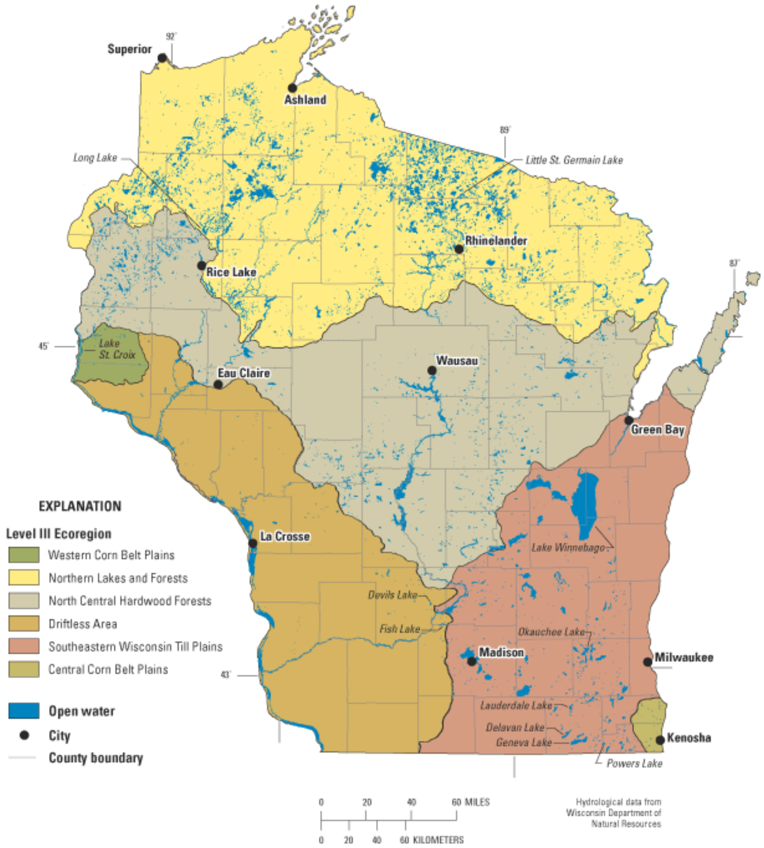


Figure 26. Wisconsin Eco-regions map. (USGS, 2003).

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).

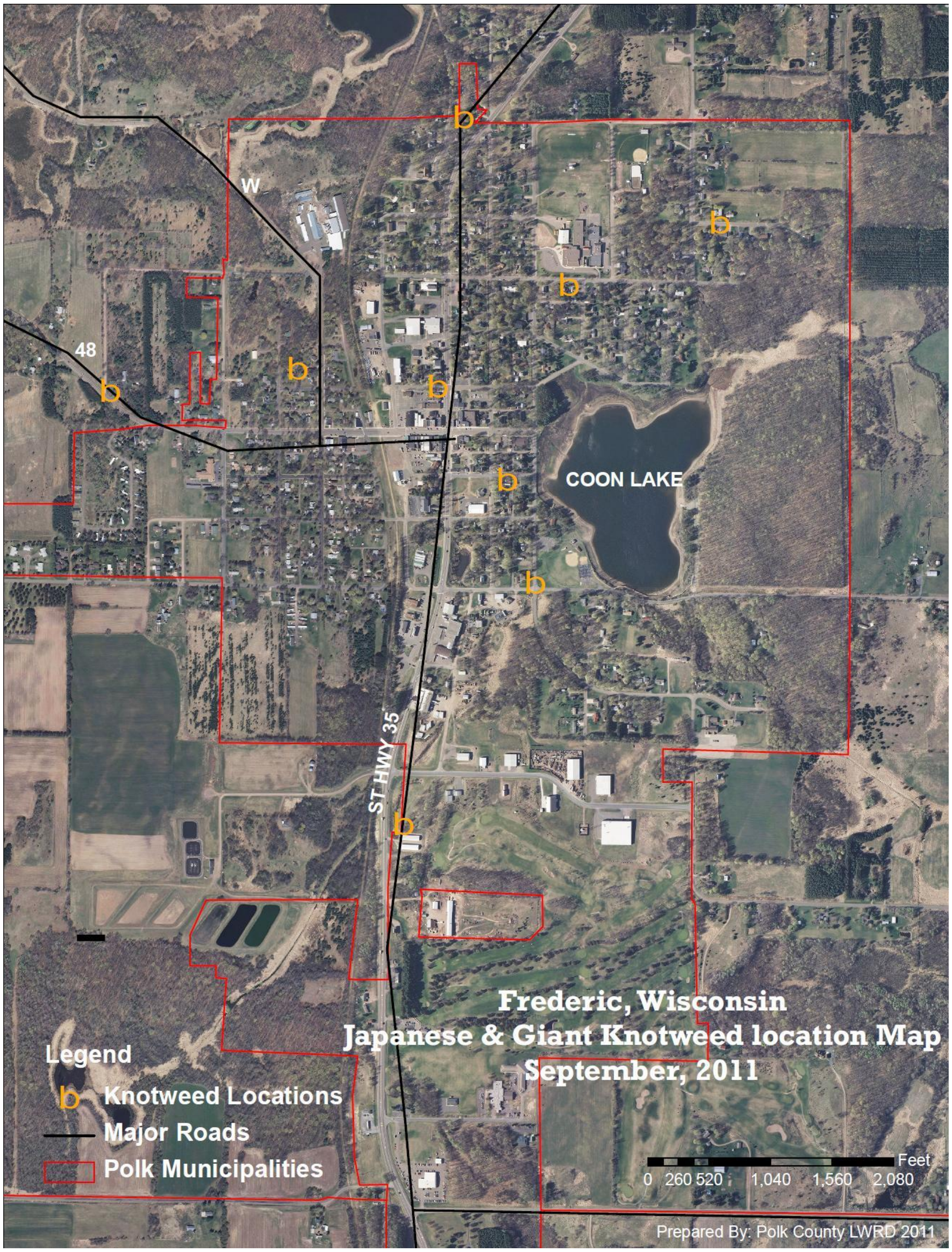


Figure 27. Japanese knotweed sites in Frederic, Wisconsin, as of September 2011.

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

Figure 28. Japanese knotweed.

Japanese Knotweed

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

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%).

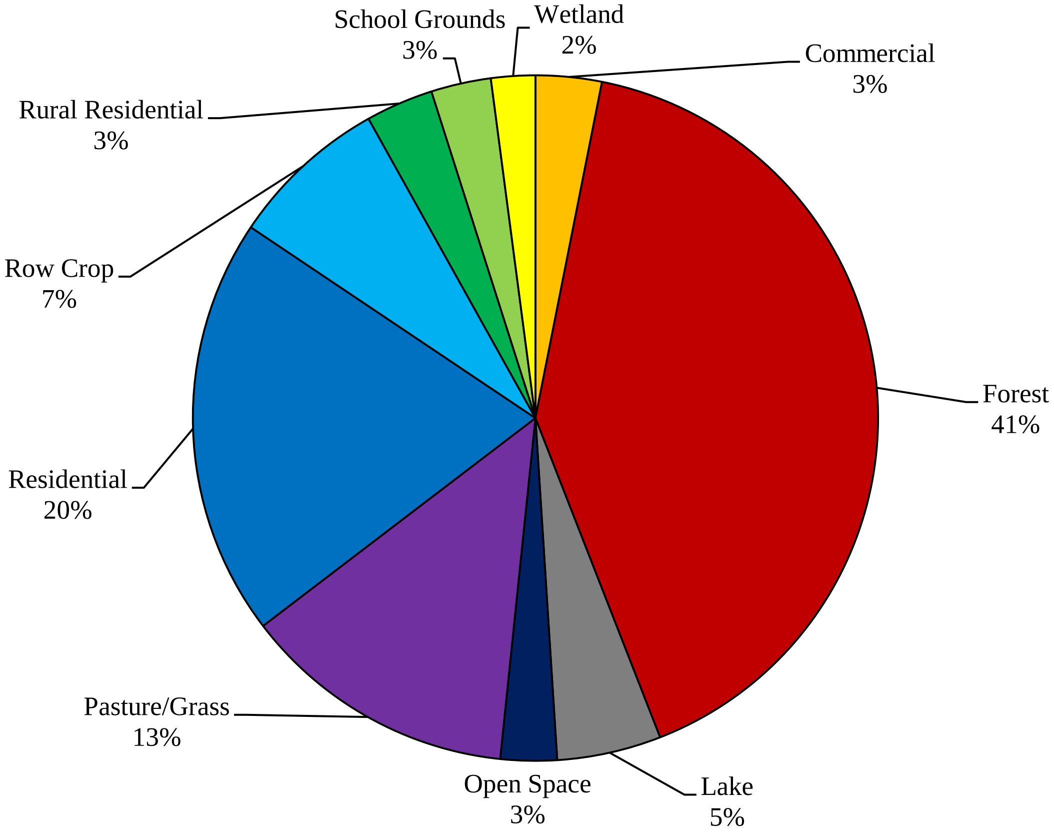


Figure 29. Land use (%) in Coon Lake Watershed.

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.

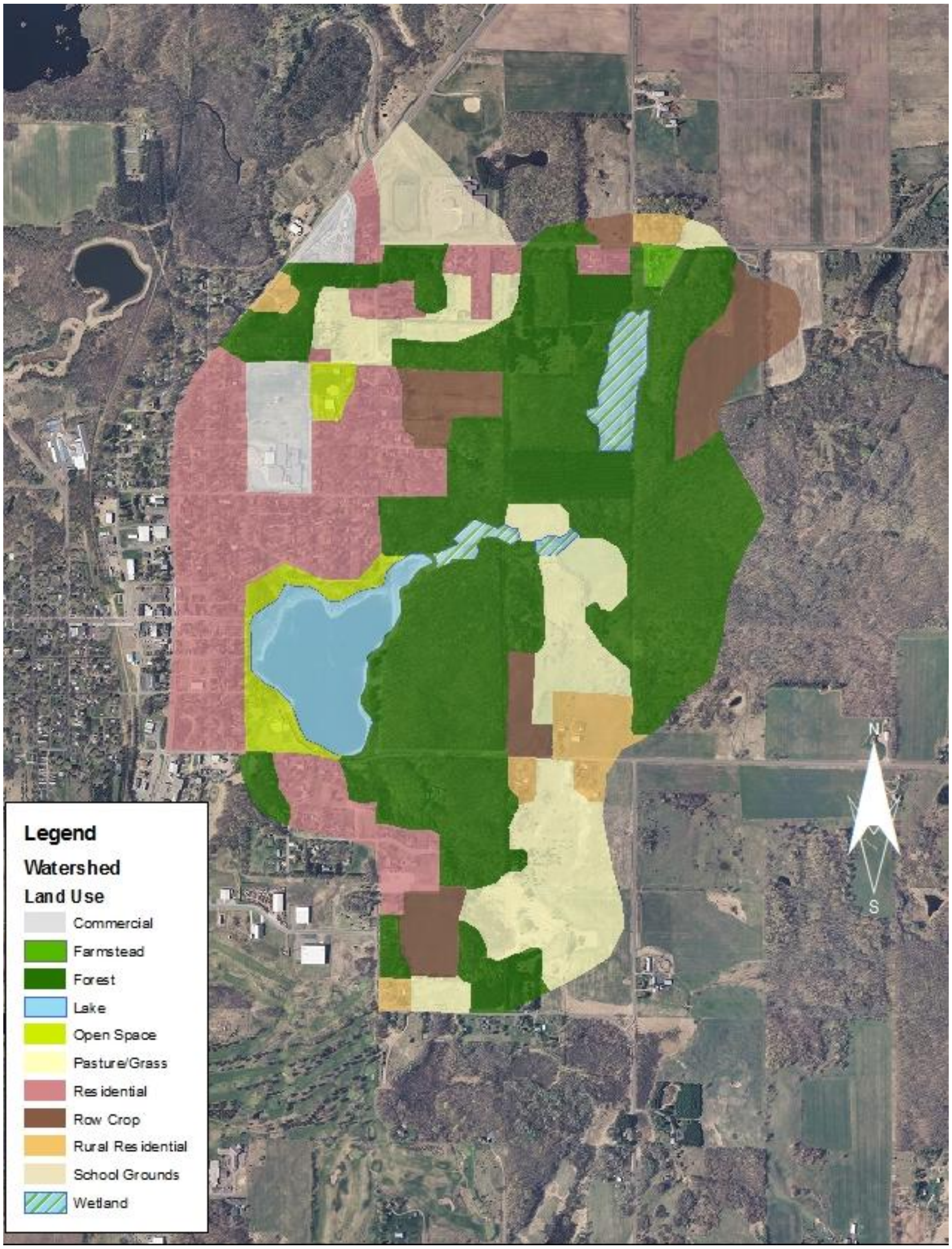


Figure 30. Land use in Coon Lake Watershed. Grey = commercial, green = farmstead, dark green = forest, blue = lake, light green = open space, light yellow = pasture/grass, pink = medium density residential, brown = row crop, tan = rural residential, light brown = school grounds, and hash blue = wetland.

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.

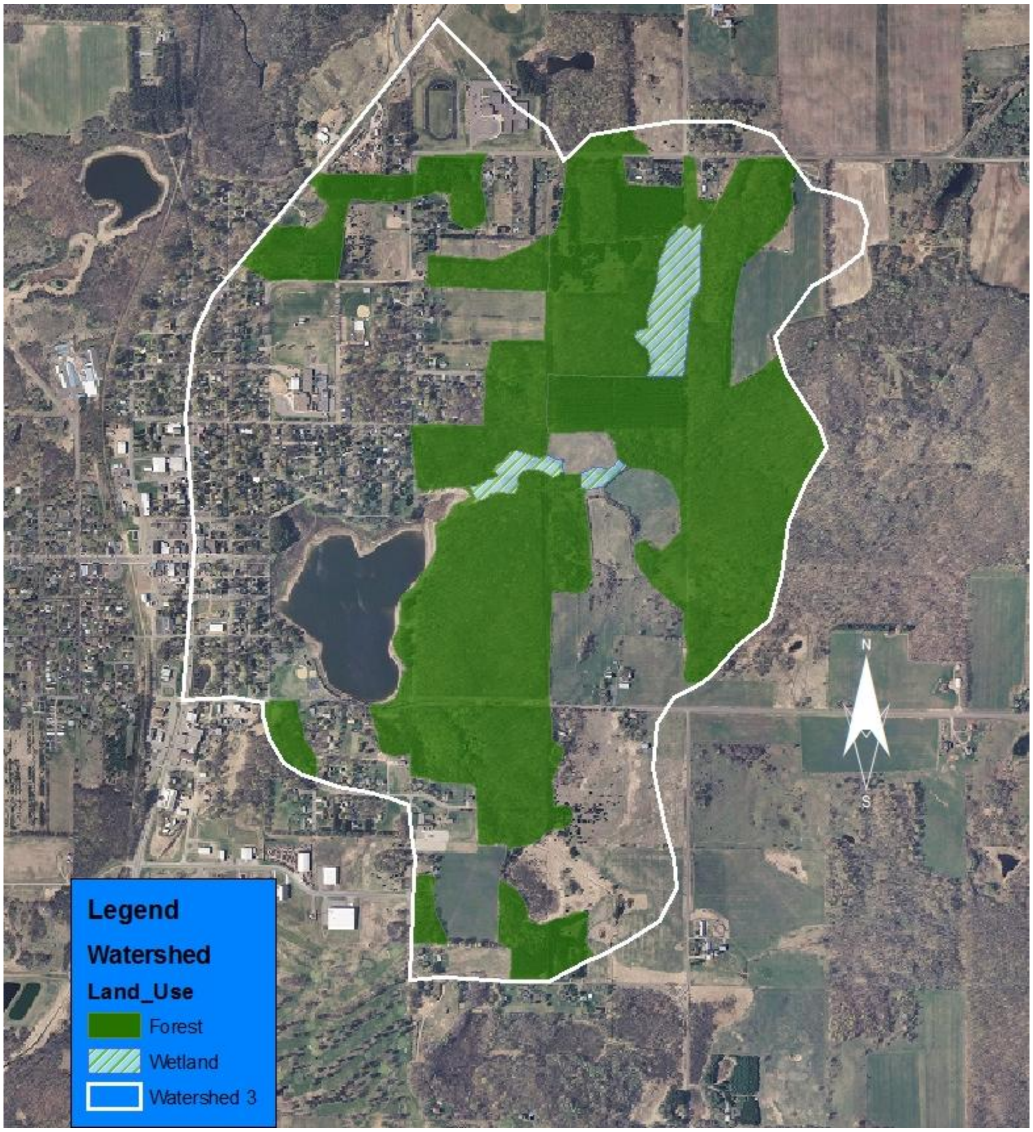


Figure 31. Areas in the Coon Lake Watershed that provide benefits for the water quality of Coon Lake. (Green = forest and hash blue = wetlands).

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: $P = \frac{L}{0.17z + 1.13\, z/T_w}$

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^{TM} 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.

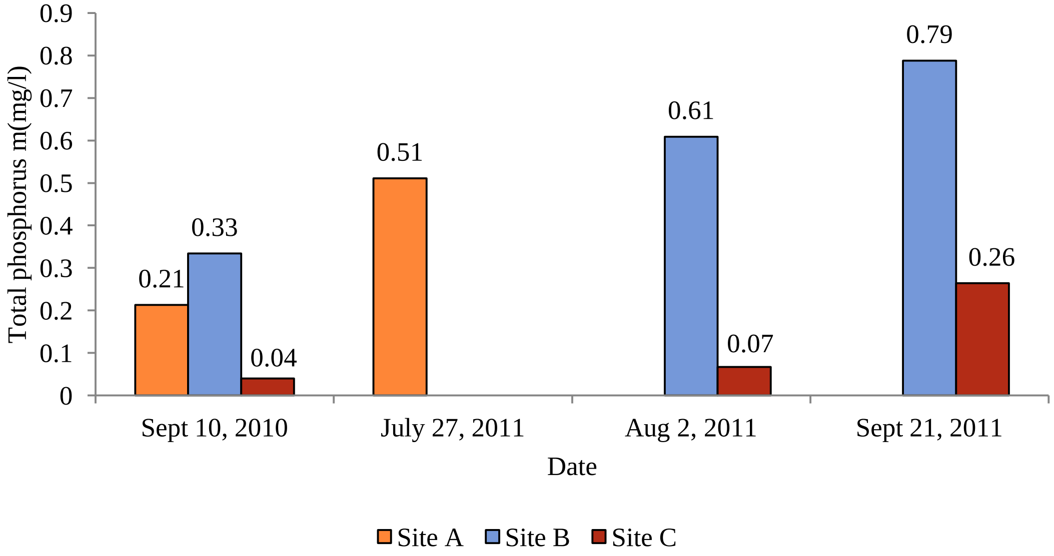


Figure 34. Coon Lake inflow total phosphorus concentration (mg/l), 2010 and 2011.

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.

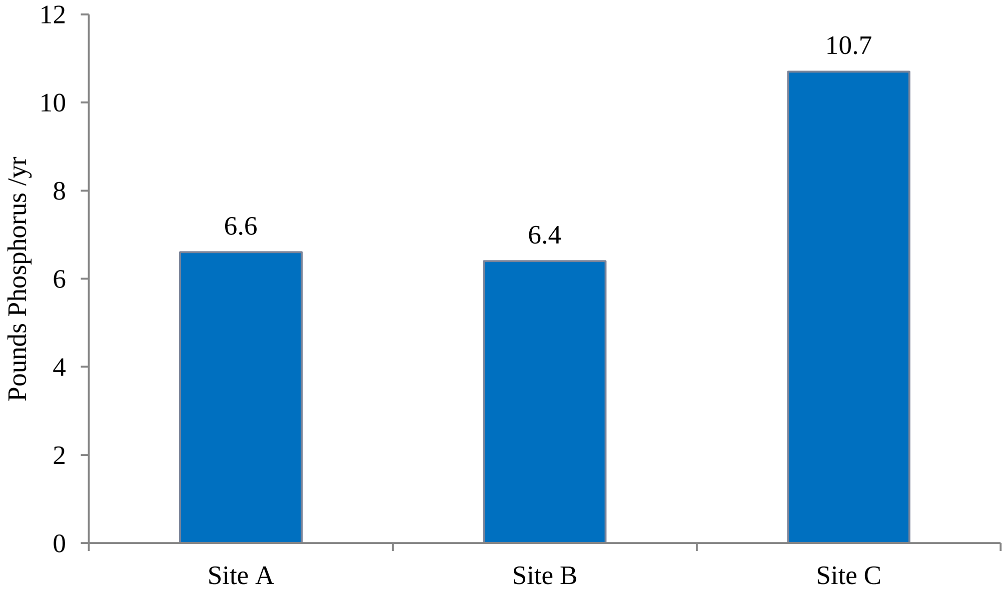


Figure 35. Coon Lake pounds phosphorus/year for stormwater sites, 2010.

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.

08/21/2010

Figure 37. Educational display at Coon Lake Fair.

08/21/2010

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.

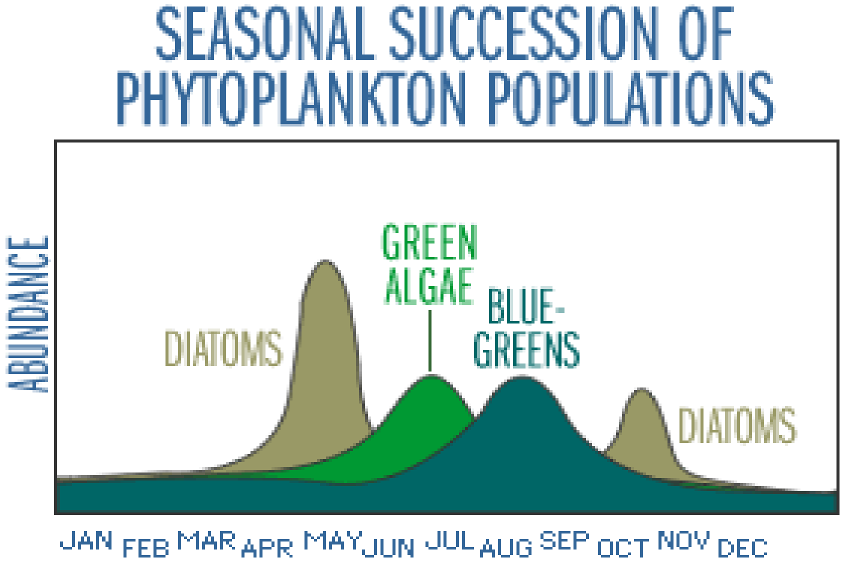


Figure 39. Seasonal succession of phytoplankton populations. *Figure from Water on the Web.*

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.

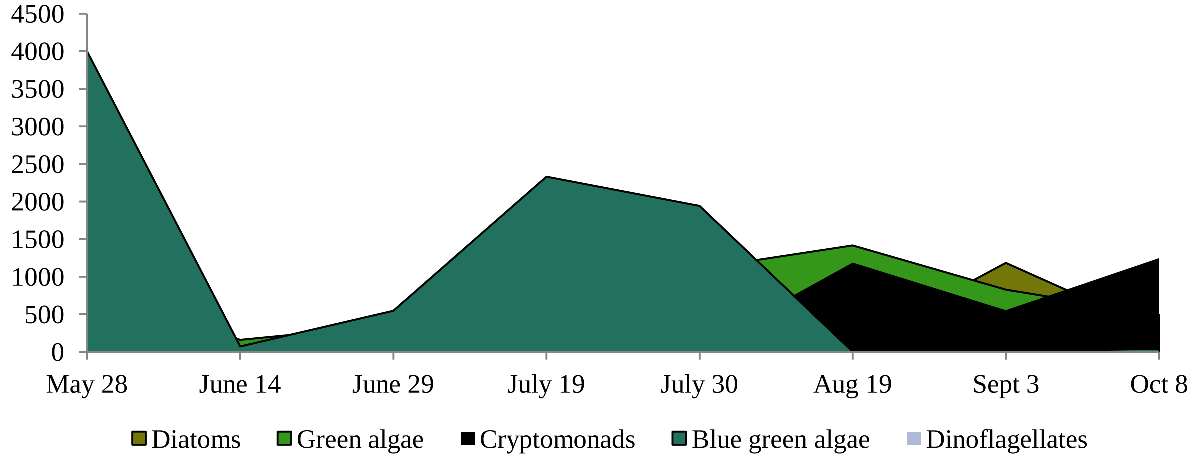


Figure 40. Coon Lake seasonal succession of phytoplankton populations.

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.

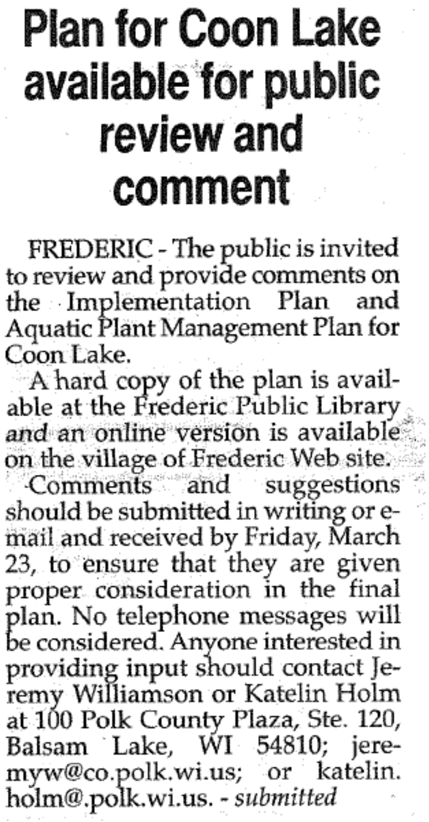
Areas that are of high value to protect water quality such as forested land and wetlands should be protected through the use of easements or purchasing land in order to maintain the ecosystem services that these lands provide.

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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