Loveless Lake Water Quality and Biological Assessment

Polk County, WI

LPL-1056-06

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Physical Characteristics of Loveless Lake and Watershed

Lake Area: 141 acres
Watershed Area: 450 acres
Watershed to Lake Ratio: 3:1

Mean Depth: 15 feet
Maximum Depth: 20 feet
Fetch: 1 mile
Miles of Shoreline: 2.5 miles

Littoral Area: 52 acres (up to 15 feet depth)
Surface Area Coverage of Aquatic Plants: roughly 28 acres
Number of plant species in survey: 18 species
Lake Type: Drainage Lake
Residence Time: 7.52 years

Average Total Phosphorus Concentration: 0.048 mg/L
TP:TN: 18:1

TSI $_{TP}$: 60

TSI $_{chloro\ a}$: 61

TSI $_{Secchi\ depth}$: 48

Water Quality and Human Influence

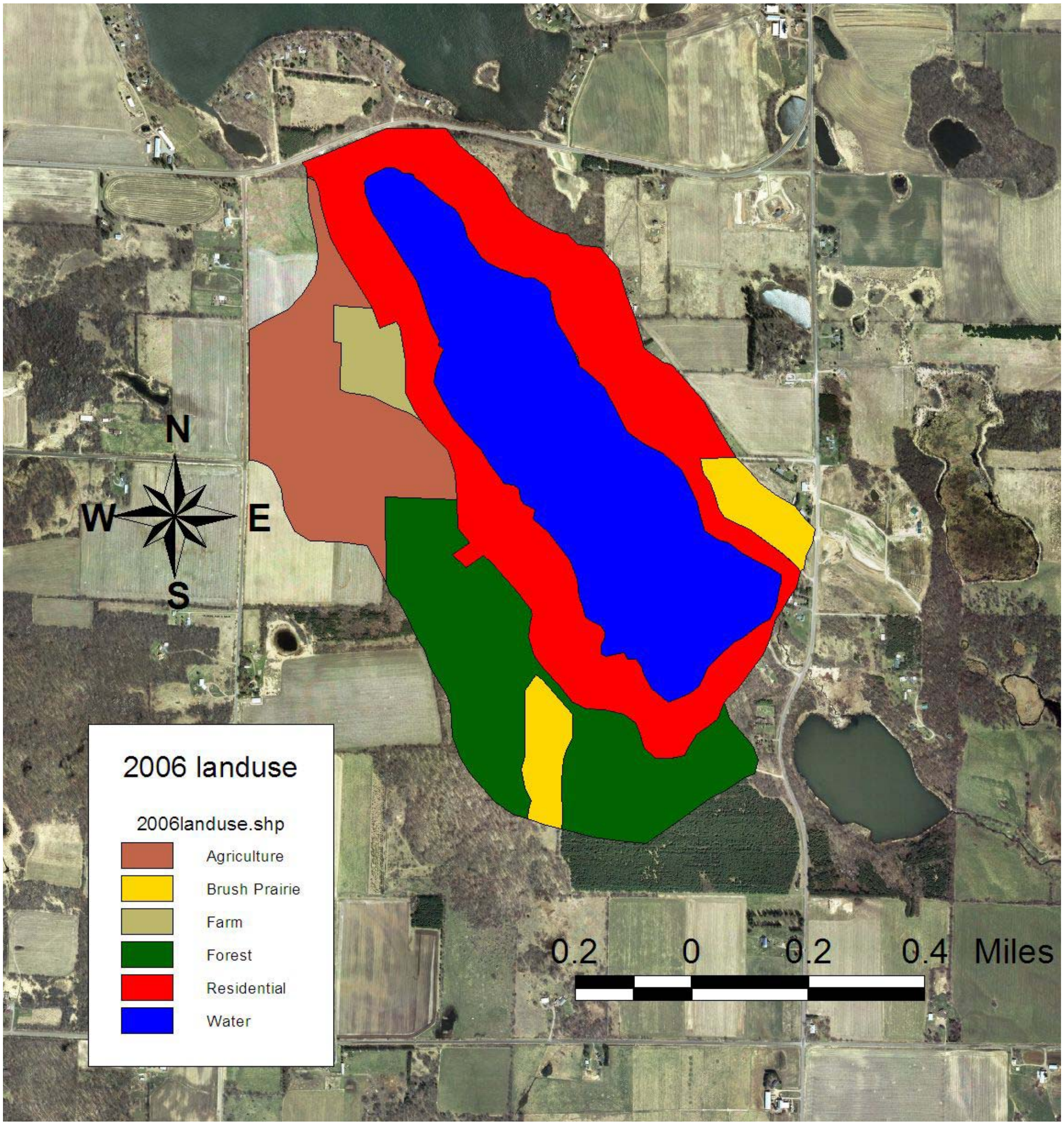
In the circle of life, water is an essential ingredient. Man can live up to 3 weeks without food, but only 3 days without clean water. As 65 percent of the human body, water is essential to people and animals. Most of us in this area use groundwater for drinking, but if you recall the hydrologic cycle, groundwater feeds and receives water from lakes. And from an animal point of view, lakes are the drinking source for wildlife.   So how we treat our lakes may have an impact on the groundwater quality in the future.

What do we do that impacts water quality of Loveless Lake? Because of the way that water travels, our actions both on the lake surface (while boating, water skiing, fishing, etc.), in the lake (dumping waste, pulling out water weeds, septic upkeep, etc.) and on the surrounding land (impervious area on our property, chemicals we use) will influence the quality of Loveless Lake water.

Water flows into Loveless Lake from rain events, traveling from high ground to low ground (the lake). As water travels over the land, it carries with it whatever is on surface, until it reaches its final destination. If the water reaches a puddle, it may stop and soak into the ground. But if the water is unimpeded by vegetation or shallow spots, it will bring to the lake whatever it found on the land. How humans treat the land is thus how water quality is impacted.

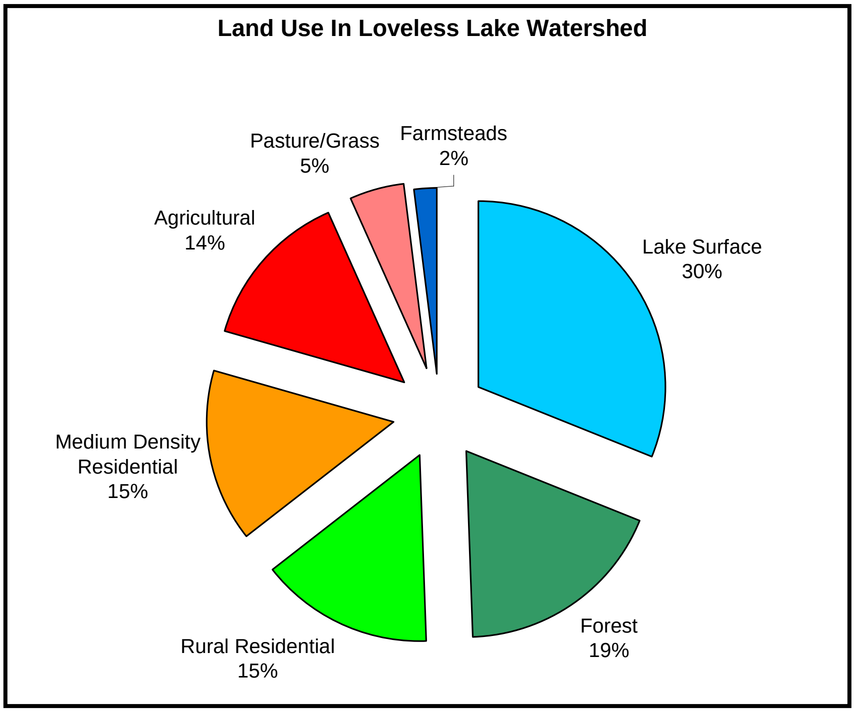
Land Use

What does the land look like surrounding Loveless Lake? The area of land that drains toward the lake is called the watershed (indicated by the white line on the front cover.) Four hundred fifty acres (450 acres) of land drain to Loveless Lake. Within this area, the land use can be broken into 7 categories.



Runoff from precipitation events carries nutrients, organic materials, and contaminants to Loveless Lake depending on the associated land use. For this reason, understanding the land use within the watershed is important to the study. The amount of nutrient pollution entering Loveless Lake from the watershed will be discussed in the Modeling Section of this report. Nutrient pollution and biological pollution (invasive species) are the main type that lake managers are concerned with. Here we will discuss the nutrient concentrations of Loveless Lake based on water samples collected during the summer of 2006.

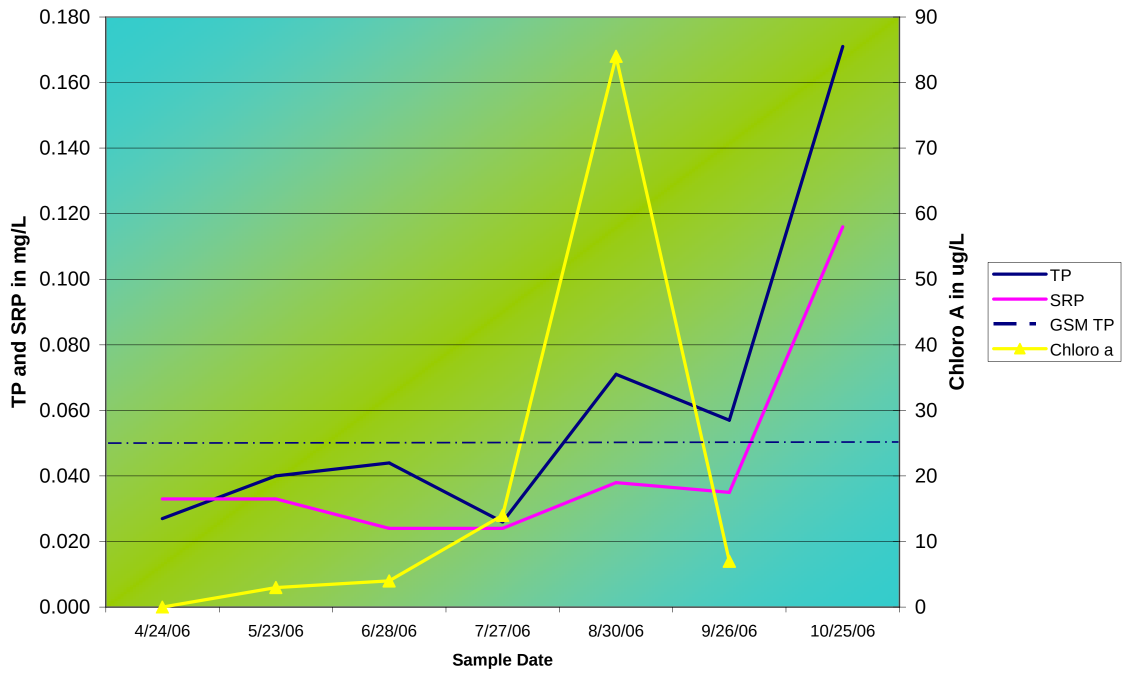
Water Quality



Phosphorus is an element that is necessary for plant and algae growth. Phosphorus occurs naturally in soils, and other sources of phosphorus include organic material, septic system discharge, agricultural runoff and manure, construction site runoff, and soil erosion induced from lawn runoff, development, and other human induced disturbances. While phosphorus is necessary for plant and animal growth, excessive amounts lead to an overabundance of growth, clogging our lakes and decreasing water clarity, thus polluting our lakes. **A "healthy" limit of phosphorus is set at 0.020 mg/L TP to prevent nuisance algal blooms.**

The total phosphorus concentration in Loveless Lake ranged from 0.024 mg/L to 0.171 mg/L from spring to fall. The growing season mean (GSM), which includes samples from May to September, was **0.048 mg/L**. A summer spike of phosphorus was noted in the August 30 sample, about the time aquatic plants senesce (grow old and die) and release nutrients into the water. An increase in chlorophyll a (an indicator of algae) was also observed at this sampling event. Total phosphorus includes both solid particles suspended in the water (sediment and organic material) and the dissolved fraction.

Loveless Lake Chemistry 2006



The soluble reactive phosphorus (SRP) is the dissolved portion of phosphorus that is readily available to plants and algae for uptake. The SRP in Loveless Lake follows the same trend as the total phosphorus, spiking in late summer. SRP cycles quite quickly because of its biological interaction. The SRP growing season average was **0.031 mg/L**. According to Shaw (2002), SRP concentrations **over 0.010 mg/L can stimulate an algal bloom**, which we have observed on Loveless Lake.

Nitrogen is another element necessary for plant growth that is divided into many components. All inorganic forms of nitrogen (NO_2+NO_3 and NH_4) can be used by aquatic plants and algae, and inorganic concentrations above 0.3 mg/L can support summer algae blooms. The average inorganic nitrogen concentration was 0.066 mg/L for the growing season. While nitrogen is the second most important nutrient for plant growth, it does not appear that nitrogen is contributing to excessive growths of plants or algae.

The total phosphorus to total nitrogen ratio is an indicator for which element the lake should be managed. Loveless Lake had a TN:TP ratio of 18:1, which means phosphorus inputs control the growth of plants or algae by allowing more to grow.

The samples collected in April and October are considered the "turnover" samples, when the change in water temperature and density cause the lake water to circulate. The following graph shows the concentrations found during the spring and fall turnovers of 2006 and 2002, when the last lake study was conducted. Turnover samples are collected when biological activity is minimal and should reflect the aquatic chemistry of lake components dissolved in the water.

Units in mg/L	TP	SRP	TKN	NH4	NO2+3	Cl
Spring 2006	**.027**	**.033**	**0.42**	**0.01**	**0.29**	**10.0**
Fall 2006	**.171**	**.116**	**1.19**	**0.30**	**0.11**	**11.5**
Winter 2007	**.024**	**.024**	**0.63**	**0.11**	**0.27**	**12.4**
Spring 2002	**.024**	**.010**	**0.40**	**0.05**	**0.54**	**9.5**
Fall 2002	**.053**	**.043**	**0.80**	**0.11**	**0.24**	**9.5**

In the four years between the two studies, it appears that the chloride concentration has increased slightly in the lake water. Chloride is a constituent of fertilizers, road salts, detergents, cleaners and household products, and septic effluent. Since chloride is not a biological necessity, the presence of chloride (above 2 mg/L) indicates human influence on lake water.

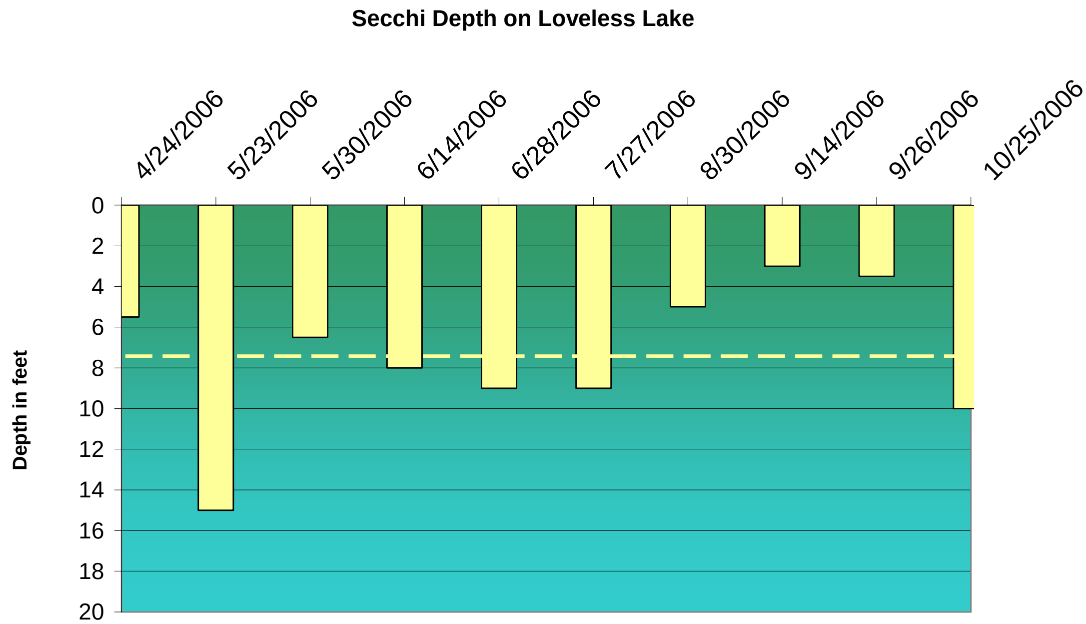
The total hardness of Loveless Lake was 96 mg/L $CaCO_3$ in 2006, classifying Loveless as a moderately hard water lake. The alkalinity was 84 mg/L as $CaCO_3$.

The total suspended solids (TSS) measured in the lake was ranged from 8 to 2 mg/L. Total suspended solids are a measure of particulate matter in a water sample.

Chlorophyll *a* is a pigment in plants and algae that is necessary for photosynthesis. It is an indicator of water clarity in a lake. The average growing season mean chlorophyll *a* in 2006 was **22.4 ug/L.** The average chlorophyll a in Loveless Lake collected through the Self Help program since 1994 was 15.52 ug/L.

Water Clarity

The water clarity of a lake is an indicator of water quality; it measures both color and turbidity of lake water. Natural tannic acids, silt, and algae can affect water clarity, which affects the aesthetics of a lake and plant growth. Water clarity is typically measured with a Secchi disk, an 8-inch round disc with alternating black and white quadrants. The Secchi disk is lowered into the lake on the shady side of a boat until it just disappears from sight. This depth is measured and recorded for a long-term record.

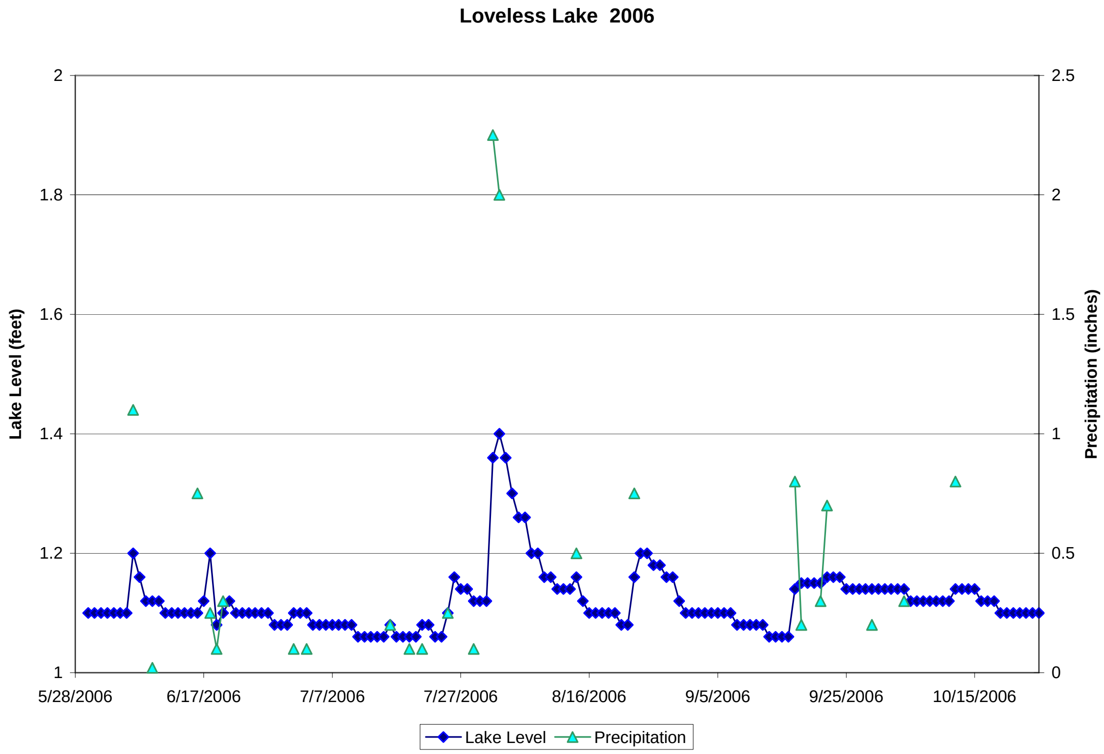


The average Secchi depth on Loveless Lake in 2006 was **7.5 feet**. This is an indication of "fair" water clarity on the water clarity index. **In 2002, the average Secchi depth was 9 feet.**

Lake Level Monitoring

Lake level and precipitation were monitored during 2006. The lake level varied only slightly by 0.36 of a foot. The lowest lake level was 1.06 feet and a lake high was reached on August 2, 2006, of 1.40. Two and a quarter (2.25) inches of rain were received on August 1 followed by 2 more inches on August 2 causing the lake level to rise.

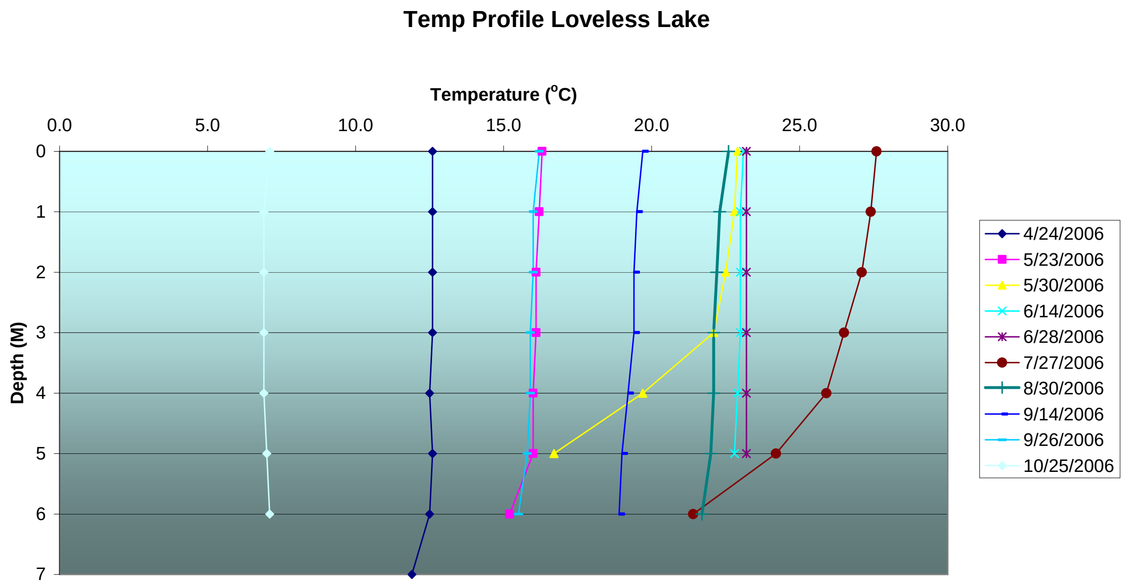
Besides this August rain event, the lake level did not rise of 1.2 feet and remained relatively constant. The lack of flashes in the chart indicates that Loveless Lake receives a large portion of water from groundwater sources.



Profiles

The temperature and dissolved oxygen in the water column of Loveless Lake were measured throughout the growing season. The YSI 85 probe was lowered at one-meter intervals, and results recorded. These profiles of the water column give a glimpse at what is happening throughout the lake with respect to interaction from the lake sediments and surface and atmospheric contribution.

The temperature of Loveless Lake during the growing season ranged from 16.3 °C to 27.6 °C at the surface. The lowest temperature recorded at the lake bottom was 15.2°C on May 23, 2006. In October, the water column was 7°C, and in April 12.6°C.

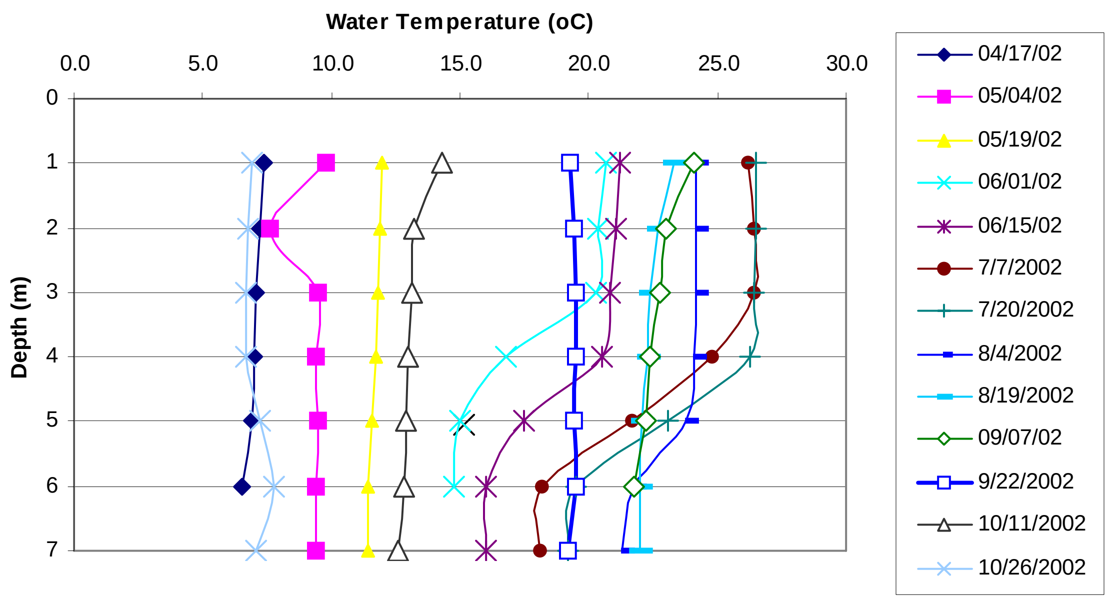


As water warms and cools, a distinct layer can form due to differences in density of water at different temperatures (this is why ice floats.) **These layers, or stratification, were only present to a mild extent on two sampling dates (5/30/06 and 7/27/06)**. Loveless Lake tends to be a mixed lake where the surface of the lake and bottom of the lake are in connection. Besides just heat exchange, this also has implications for nutrients that are shared in the lake and available throughout the water column. Riley & Prepas (1984) found that in mixed lakes, total phosphorus concentrations increased from spring to summer by 57%. In stratified lakes, that upper surface of lake water decreased TP concentration by 13%. Solid materials in the water column are able to drop to the lake bottom in stratified lakes, resulting in lower total phosphorus concentrations.

The lack of stratification may also be limiting the succession of algal community, keeping the water column constantly supplied with nutrients and limiting competition between species. Zooplankton could also be affected by lack of stratification because they take refuge in deeper parts of the lake by day to avoid predation by fish. Without this zonation, the zooplankton remain exposed.

In 2002, temperature profiles were collected 10 times during the growing season. Stratification was present during 5 sampling events in 2002.

Temperature Profile on Loveless Lake in 2002



Trophic State Indices

A large amount of data is often collected on lakes, involving many hours of volunteer and professional time, but often times not understood. Carlson (1977) developed a tropic state index based on three commonly collected parameters to standardize lake data for comparison. Using biomass-related characteristics of a lake, specific measurements of a lake can be aggregated to produce waterbody-level estimations of trophic state. The trophic scale is used to describe the biological condition of a waterbody and the amount of production in the lake. Comparing the three indices may tell some of the processes in-lake.

The three equations to calculate the TSIs are:

TSI (CHL) = 30.6 + 9.81 * Ln[CHL] (where CHL is in ug/L)

TSI (TP) = 14.42 * Ln [TP] + 4.15 (where TP is in ug/L)

TSI (SD) = 60 – 14.41 * Ln [SD] (where SD is in meters)

The TSI is theoretically from 0 to 100, with 0 having no biological activity and 100 being a polluted waterbody with a plethora of biological activity.

Year	TSI (CHL)	TSI (TP)	TSI (SD)
2006	**61**	**60**	**48**
2002			43
2001	53	57	47
2000	56	62	47
1999	61	61	47
1998	65	61	48
1997	49	62	44
1996	52	49	44
1995	51	49	42
1994	64	58	46
TO DATE AVERAGE	**57**	**58**	**46**

Many factors influence the TSI, including nutrient loading, climate, grazing, mixing depth, etc. TSIs can vary greatly year to year and it is best to have a long term comparison of values to determine the baseline of a lake's health. Based on 10 years of data, the 2006 TSI values are higher than the total averages. **It appears that the tropic status of Loveless Lake is moving towards an eutrophic lake where blue-green algae is dominant.** The section on Phytoplankton Section of this report will show this to be true.

The relationship between TSI [CHL] ~= TSI [TP] > TSI [SD] reveals that large algal particulates dominate the water column that zooplankton grazing is not able to control. Turbidity is not the light attenuating factor. Total phosphorus is driving the lake system in some form.

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 change 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 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.

Phytoplankton

Chlorophyll *a* is universal to all plants and algae, but certain flora also contain accessory pigments for photosynthesis. Universal statements about algal communities and quality based on chlorophyll *a* samples are difficult to make. For this reason, composite samples from a 6-foot water column were collected monthly and sent to the State Lab of Hygiene for identification and enumeration of algae present in Loveless Lake. Any species of concern can also be identified, if present.

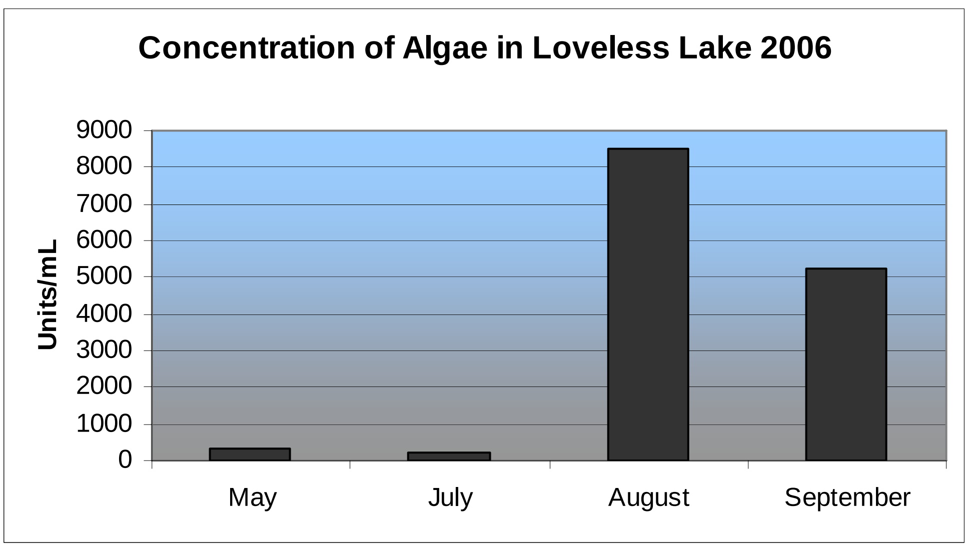
The algae samples were identified to genus and the relative concentration and natural unit count was made to describe the assemblage throughout the summer. Great variability in algal species exist in quantity, time, and between lakes. Because algae are an important component of a lake's food web, we describe Loveless Lake's algal composition here.

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 the aquatic ecosystem and respond quickly to changes in water chemistry. The size of different types of algae is also 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 identification of management strategy.

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 the nutrient dynamics. Algae can live on bottom sediments and substrate, in the water column, and on plants and leaves. The genus and species present are influenced by environmental factors like climate, phosphorus, nitrogen, silica and other nutrient content, carbon dioxide, grazing, substrate, and other factors in the lake (Wehr and Sheath, 2003). When high nutrients are available, blue green algae often becomes predominant.

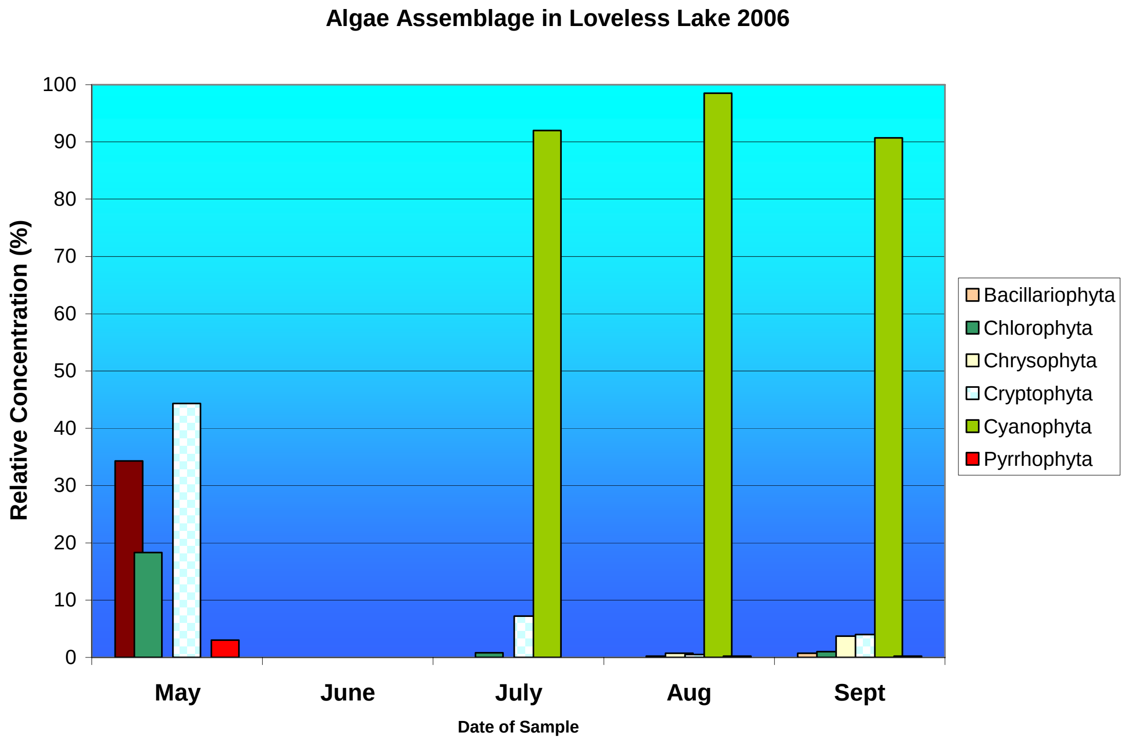
The concentration of algae in the water samples was measured in units/ml. As described, algae morphologies can be unicellular (one) or colonial (many), depending on the type of algae. The concentration analysis measured the algae in the natural units that they take. This measurement does not describe biomass in the lake. Biomass is the weight of all living material in a unit area at a given instant in time. This is a measure of the amount of production in the lake by phytoplankton. The following graph is shown for comparison of algae units throughout the season, but is not indicative of the biomass in Loveless Lake, just the number of algal units per milliliter of water.



There are 12 classes of algae found in typical lakes of Wisconsin. Six classes were found in Loveless Lake:

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, see a decrease in diatoms. 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 used to feed 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
Chrysophyta	Golden Brown Algae	Organisms which bear two unequal flagella. A genus of single-celled algae in which the cells are ovoid. Contain chlorophyll a, c_1 and c_2, generally masked by abundant accessory pigment, fucoxanthin, imparting distinctive golden color to cells.



A June algal sample was not collected. No non-native species were found in any of the samples. The May algal sample was dominated by Chryptomonads and diatoms (Bacillariophyta). Chryptomonads and diatoms provide a good food source for zooplankton and small fish fry. The increase of zooplankton <u>grazing</u> as water temperatures rise, and an increase in <u>nutrient enrichment</u> (phosphorus) causing a growth of blue greens could be restricting the diatoms and Chryptomonads in later months. Some blue green algae (*Microcystis*) have allelopathic characteristics which releases a chemical to restrict growth of other algae and proliferate their own growth.

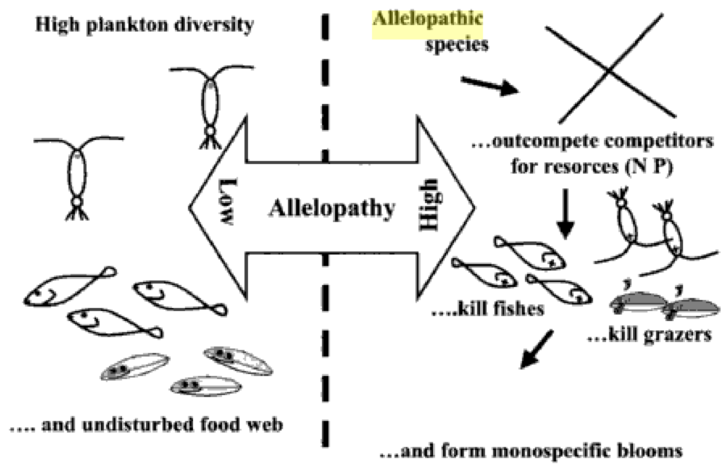


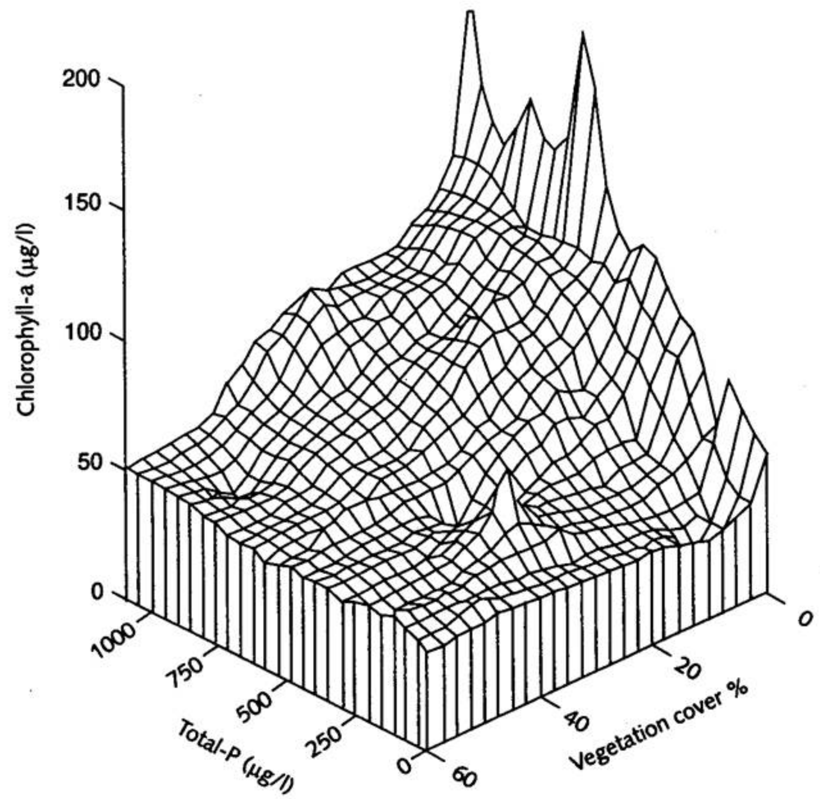
Figure 2. The pathways in which the increase in the production of allelochemicals by phytoplankton can alter the entire marine food web (right side).

The dominant type of algae observed in the samples was blue green algae during the months of July, August and September. The increase in phosphorus concentration in the lake water could stimulate an increase in blue green. The monotypic assemblage of algae in Loveless Lake is quite alarming. Not only is the blue green algae dominant, but the species ***Aphanizomenon flos-aquae* is the dominant species in July (45.6% relative concentration), August (88.6%), and September (69.1%**). *Aphanizomenon flos-aquae* are known to produce hepatotoxins.

Aphanizomenon flos-aquae resembles cut grass clippings during a bloom.

A lack of copepods and Daphnia (zooplankton) to graze on blue green will also proliferate the blooms. A forward switch to move Loveless Lake to an algae-dominated lake would be to continue to destroy the macrophyte community.

As lakes become more eutrophic, a greater proportion of the phytoplankton biomass and productivity often results from large algae (mostly colonial or filamentous). The larger algae interfere with zooplankton's ability to collect food to a greater extent.



This graphic, taken from Scheffer (1998), shows that a chlorophyll *a* concentration increase occurs with an increase in phosphorus concentration and a decrease in the aquatic vegetation cover. A decrease in aquatic vegetation is often viewed by riparians as a recreational benefit. However, the transition may be irreversible and less desireable than the current conditions.

Zooplankton

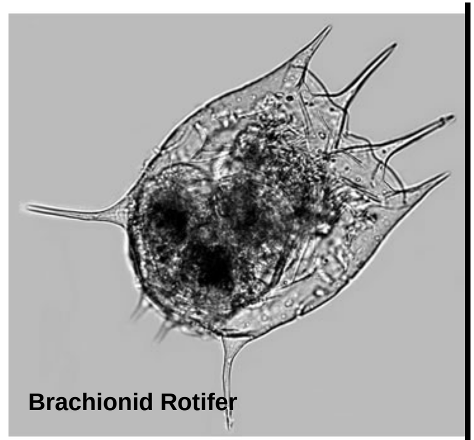
Zooplankton analysis was done on Loveless Lake on four dates throughout the summer. Zooplankton is assessed to monitor the top-down control effect on phytoplankton and determine biodiversity and other food-web parameters.

Zooplankton are microscopic animals that are an essential part of the lake food web. Zooplankton can be herbivores (eating algae and bacteria) or carnivores (eating other zooplankton). Fish and macroinvertebrates feed on zooplankton. **Zooplankton population can have a profound effect on the water clarity of a lake because of its grazing**, given the type of algae in a lake (green, blue green, etc.). Blue green algae are undigestable by zooplankton and rarely consumed.

Since they are not part of the food web, their population can increase unchecked by the food chain. Many species of zooplankton are mobile, controlling their buoyancy to move up or down in the water column, or being able to move by propulsion or oaring. They take refuge in aquatic plants and the hypolimnion from predation by fish species and other invertebrates.

Inclusion of zooplankton community analysis can help provide a more thorough understanding of water quality. The relative abundance of zooplankton species or types can be an indicator of water quality. Some species are limited by physicochemical variables such as oxygen, temperature, or salinity. Zooplankton are also affected by competition between species, predation by other species, and food availability.

Continuous, long-term monitoring of community structure can be useful in detecting patterns and changes in species composition that may be related to changes in water quality. A routine monitoring program will help to separate the ordinary effects of seasonal changes in the zooplankton community from other influences. The species composition in a particular water body usually remains somewhat stable over time, and the sudden appearance of new species or disappearance of existing species could indicate a change in water quality due to toxic substances, eutrophication, or imbalance between piscivorous (fish-eating) and planktivorous (plankton-eating) fish or in increase in *Chaoborous* in fishless lakes.


Brachionid Rotifer

Rotifers were the most abundant zooplankton in Loveless Lake. There are several species present, with average concentration of 31 animals per liter of water. Rotifers are microscopic aquatic animals that live in freshwater environments and are usually found in lakes, rivers, or streams, but can also be found in diverse areas such as rain gutters, puddles, soil or leaf litter, in sewage tanks, and on freshwater crustaceans and aquatic insect larvae. There are approximately 2,000 different species of rotifers. The name "rotifer" comes from the Latin word meaning "wheel-bearer," referring to the crown of cilia around the mouth of the rotifer. Cilia are hair-like projections that aid in movement and trapping food. **Most rotifers are omnivorous with a diet consisting mostly of dead or decomposing organic materials, unicellular algae, and other phytoplankton**, but some species are cannibalistic. **Rotifers are often preyed upon by other zooplankton and invertebrates.** Rotifers may reproduce asexually or sexually. Rotifers do not typically reduce the frequency of algal blooms as they tend to eat species with a small cell size and, hence, do not decrease the total algal biomass.

Daphnia

Daphnia**,** which tend to be a large bodied zooplankton capable of reducing algal biomass is **quite rare in Loveless Lake** (11.24 animal/L, however, May sample was 22.24 animals/L, skewing the average). *Daphnia* are small, mostly planktonic, crustaceans, between 0.2 and 5 mm in length. *Daphnia* are members of the order Cladocera, and are one of the several small aquatic crustaceans commonly called water fleas because of their saltatory swimming style (although fleas are insects and thus only very distantly related). They live in various aquatic environments ranging from acidic swamps to freshwater lakes, ponds, streams and rivers. **The low number of Daphnia is likely due to a lack of habitat to avoid fish predation**. In unstratified lakes such as Loveless, *Daphnia* tend to migrate horizontally into the litoral zone rather than vertically below the thermocline. Because of the "Dires Straights" condition of the Loveless Lake littoral zone it is unlikely to have a desireable increase in *Daphnia* numbers.

Other non-daphiniidae diplostraca (order in which *Daphnia* and other families are placed), such as Bosmina, were also found in Loveless Lake. These animals were not as abundant as may be desired (2.6 animals/L). Although they do not have the drastic effect on primary production (many are benthic, or bottom dwelling) as *Daphnia*, they can reduce algal biomass. However, they are not likely the "clear up" the water column.

Copepods were common throughout the summer (7.7 animals/L). Copepods are common predators which eat other zooplankton. These aquatic crustaceans are very diverse and are the most numerous metazoans in the water community ("metazoan" means all multi-celled animals). Copepods may be free-living, symbiotic, or internal or external parasites on almost every phylum of animals in water. The usual length of adults is 1-2 mm, but adults of some species

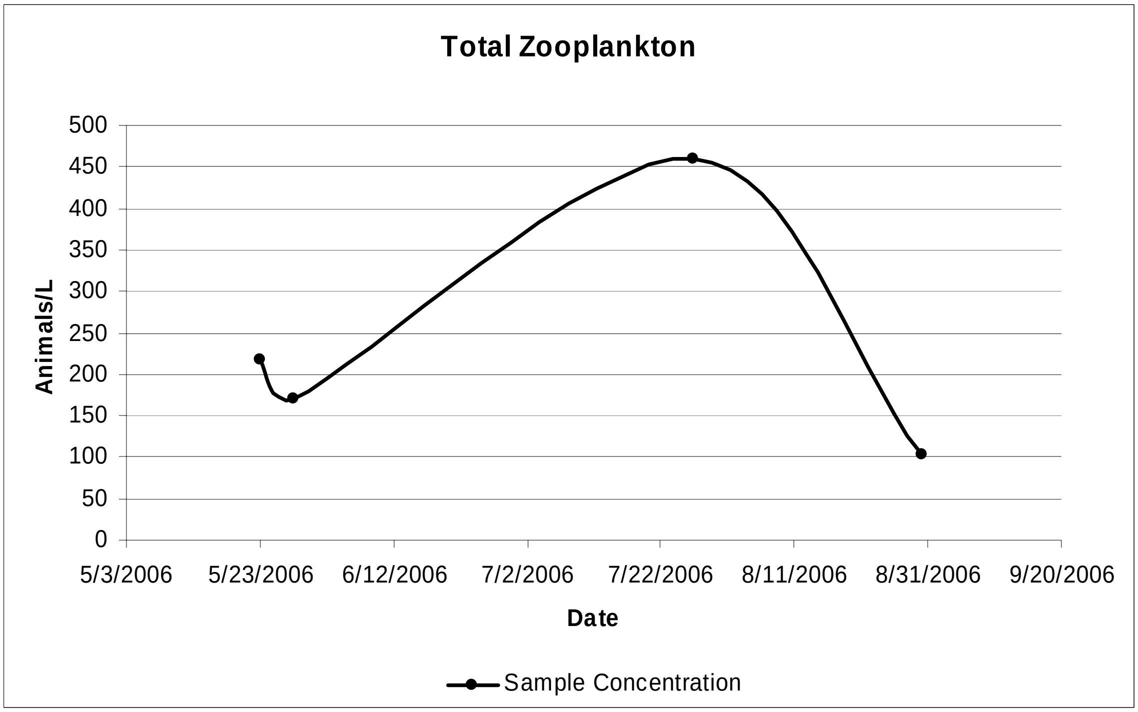
Centropyxis

may be as short as 0.2mm and others may be as long as 10mm.

Ecologically they are important links in the food chain linking microscopic algal cells to juvenile fish.

The last groups of common zooplankton in the Loveless Lake summer samples were a group of **testate amoebas called *Centropyxis***. The testate amoebae produce shells, or tests, either by secreting them, or by accreting them from appropriately sized particles encountered on their travels. The structural details of the test are the usual means of identifying them. Often this group of animals is found in the neuston (or surface film), or are benthic (or bottom dwelling). However, many members of this family do have some pelagic stages. Recently researchers at the Institute of Hydrobiology, Jinan University, in China and the Department of Animal Ecology, Ghent University, in Belgium have discovered that *Difflugia tuberspinifera*, a testate amoeba and a close relative of *Centropyxis*, found in the open water plankton of southern Chinese reservoirs during summer. They suggest that its incentive to leave the bottom might be the abundance of food in the water column rather than temperature. This *Difflugia* (and perhaps the other pelagic species as well) is indeed an **actively hunting carnivore** that catches small rotifers and other prey in the same size range. This could be a likely explanation for the high number of these animals in Loveless Lake in July (218.04 animals/L or 47.44% of the entire sample) as there is a high number of Rotifers throughout the season.

The total number of zooplankton in Loveless Lake follows the ebb and flow of the seasonal dynamics of algal species composition (see figure below). **The lack of stratification and the poor littoral zone coverage allows planktivorous fish to consume the large Cladocera that are capable of reducing biomass and frequency of nuisance blooms. In order for Loveless Lake to maintain the current level of water clarity and, indeed, improve it, the littoral zone must be enhanced and the water column should be less disturbed to allow periods of stratification.** If the littoral zone continues to be degraded, the future of Loveless Lake is grim. There will likely be a complete collapse of the Cladoceran (*Daphnia*) population **allowing for cyanobacteria (blue-green algae) to proliferate, changing the whole food-web structure of Loveless Lake.**



Total number of zooplankton per sample throughout the 2006 sampling period

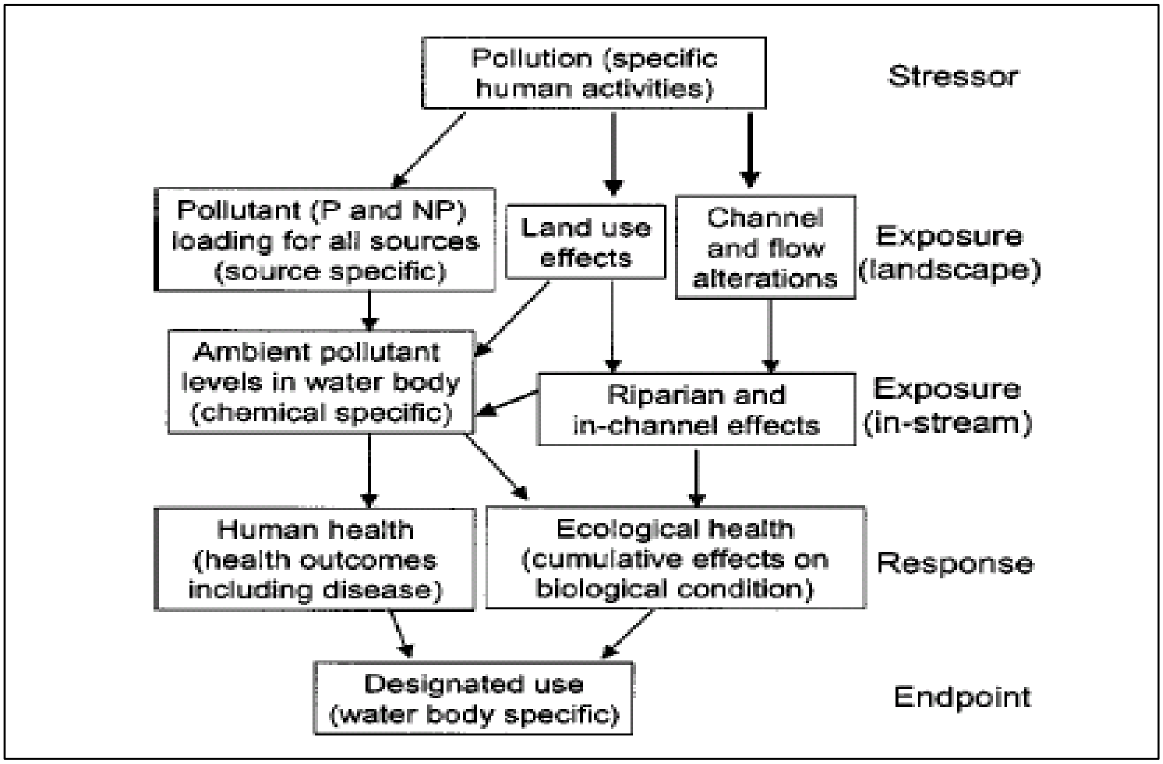
Macroinvertebrates

Loveless Lake invertebrate samples were collected May 30 and October 27,, 2006. **The objective of this monitoring was to assess how riparian land use affects the functional feeding ecology of benthic macroinvertebrates and hence the entire food web of the lake.**

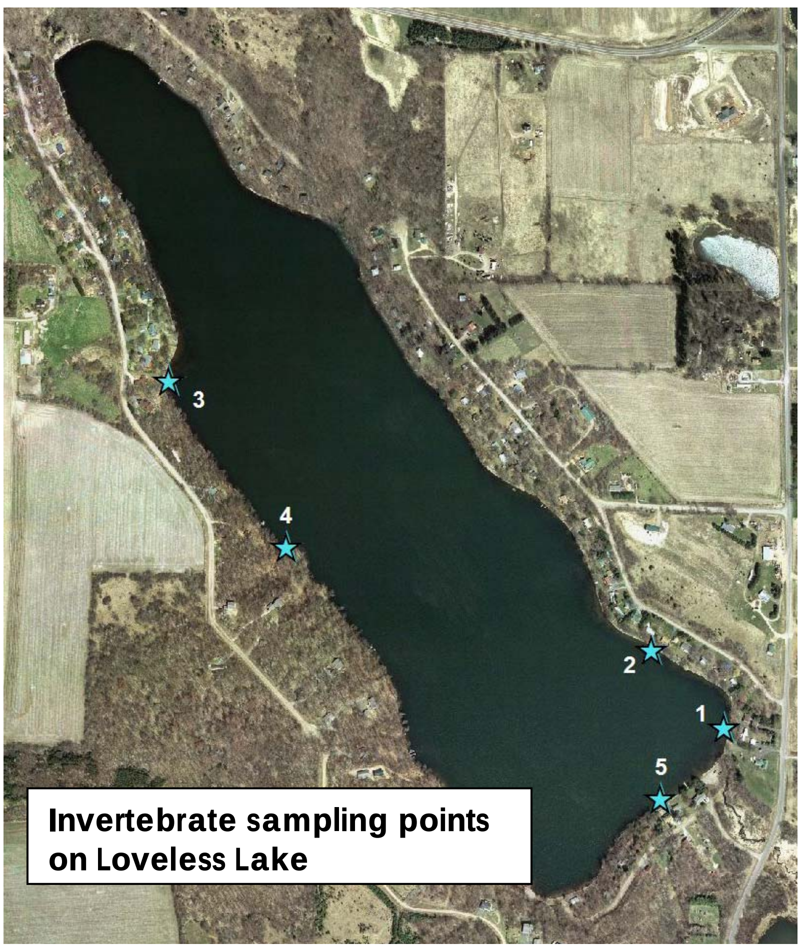
The near shore zone invertebrate community reflects the complexity of aquatic systems and how land and water is interconnected. The bottom tier of the following figure illustrates how the ecology, not chemical endpoints, show the cumulative effects of human activities. Such is the LWRD focus of sampling differences in land use.

To this end, current research has greatly increased our knowledge of lake organisms and how they respond to eutrophication (degradation of water quality). Along with exotic species, eutrophication is probably the greatest environmental hazard in many inland lakes. If we can associate communities of organisms in past and present times with nutrient concentrations and land uses, an IBI type approach can be used not only to set realistic goals but also to evaluate the progress of restoration and management.

This type of approach can be used to develop IBI's (index of biotic integrity) that reflect lake classification and current land use conditions and associate them with designated uses and nutrient criteria to set realistic restoration goals.

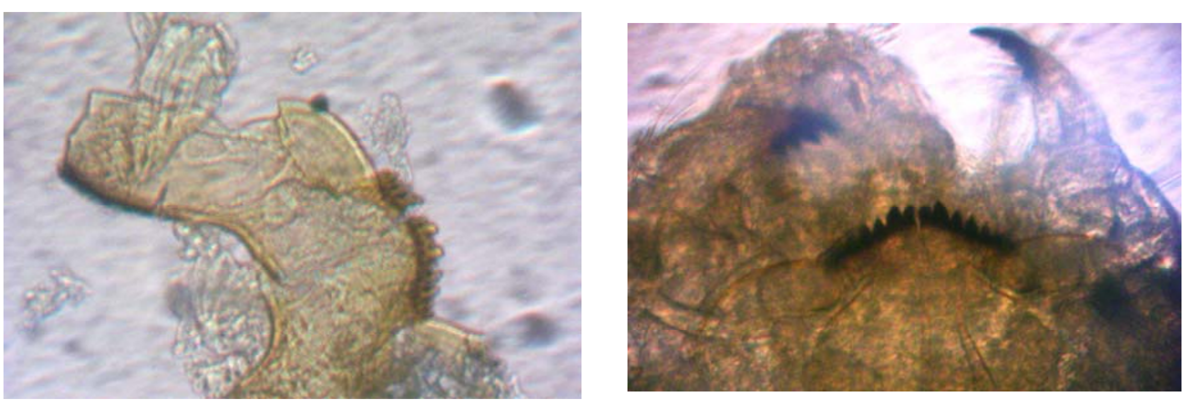


Biologic response to stressors, *taken from Karr and Yoder* 2004



Five study sites were chosen and sampled based on adjacent land use. Site one was a restoration area with the native vegetation installed in 2004. In the past it was turf grass to the lake, but is recolonizing with native vegetation. There was very little embeddedness at this site. Embeddedness is a term that describes the extent to which the rock surfaces found on the stream bottom are filled in with sand, silts and clay. In a healthy stream, the interstitial pores between cobbles, rock and gravel generally lack fine sediments, and are an active habitat zone and detrital processing area. The increased sediment transport in urban streams can rapidly fill up these pores in a process known as embedding. Site two was lawn, with a 2-3' buffer at the lakeshore with some tree cover. There was about 25% embeddedness at this site and a high number of *Chironomus* larvae (an indicator of disturbance). For practical classification, there is no native vegetation at this site; the small buffer is composed mostly of reed canary grass, which has little or no wildlife or habitat value. Site three was all lawn all the way to the lakeshore with no tree cover for shade. There was a rail road tie retaining wall at this site (high potential for toxins to affect macroinvertebrates and fish). There was a sandy bottom, but most of the larger stones were 99% embedded. Site four was a forested site with coarse woody habitat present and is probably indicative of the habitat that surrounded the whole lake before the riparian area was settled. Site five was sampled near recent excavation with no erosion control and is hence 75% embedded. This site has a high potential for erosion that would be extremely detrimental to the benthic fauna at this site. The historical littoral zone of Loveless Lake was likely a rocky windswept habitat with a high diversity of benthic macroinvertebrates.

Benthic invertebrates were sampled using an aquatic D-frame kick-net as suggested in Merritt and Cummins (1996). Samples were taken in triplicate and preserved in 95% ethanol for identification at the lab. Samples were sorted under a dissecting microscope at 20-40x magnification and identified under a compound scope when necessary at up 400x.

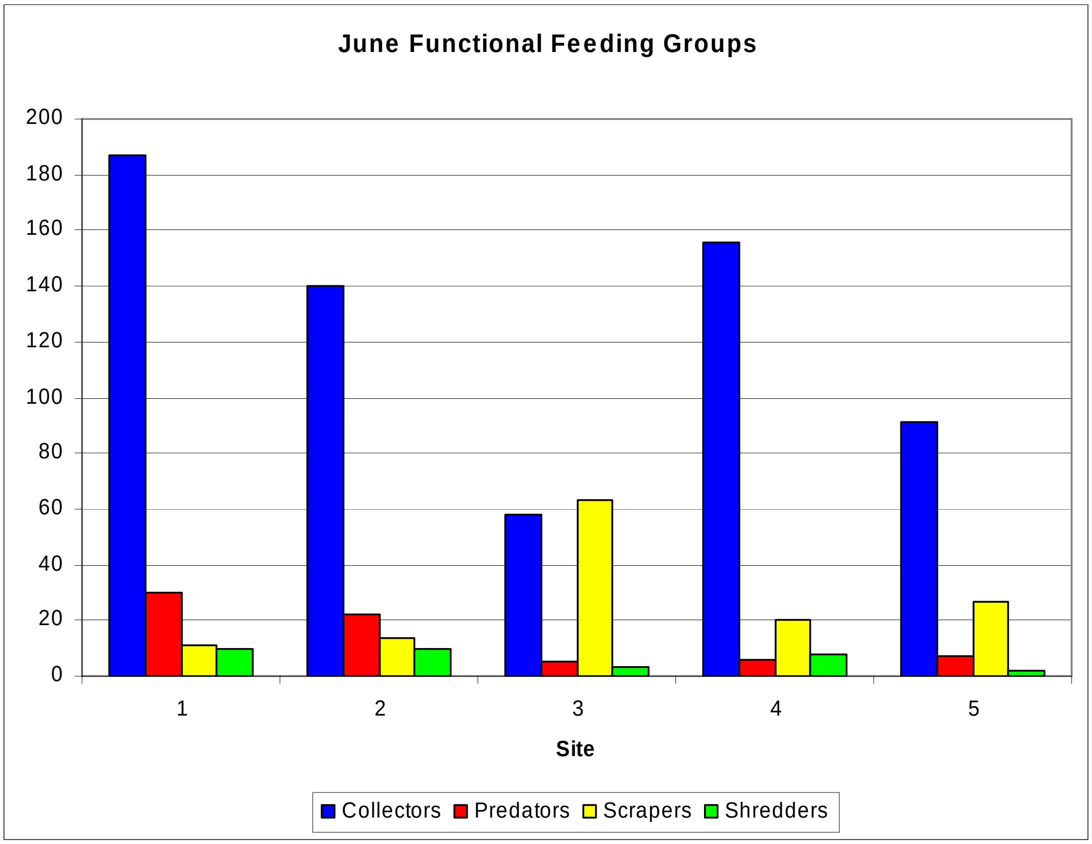


View of different Chironomidae larval head capsules through a microscope.

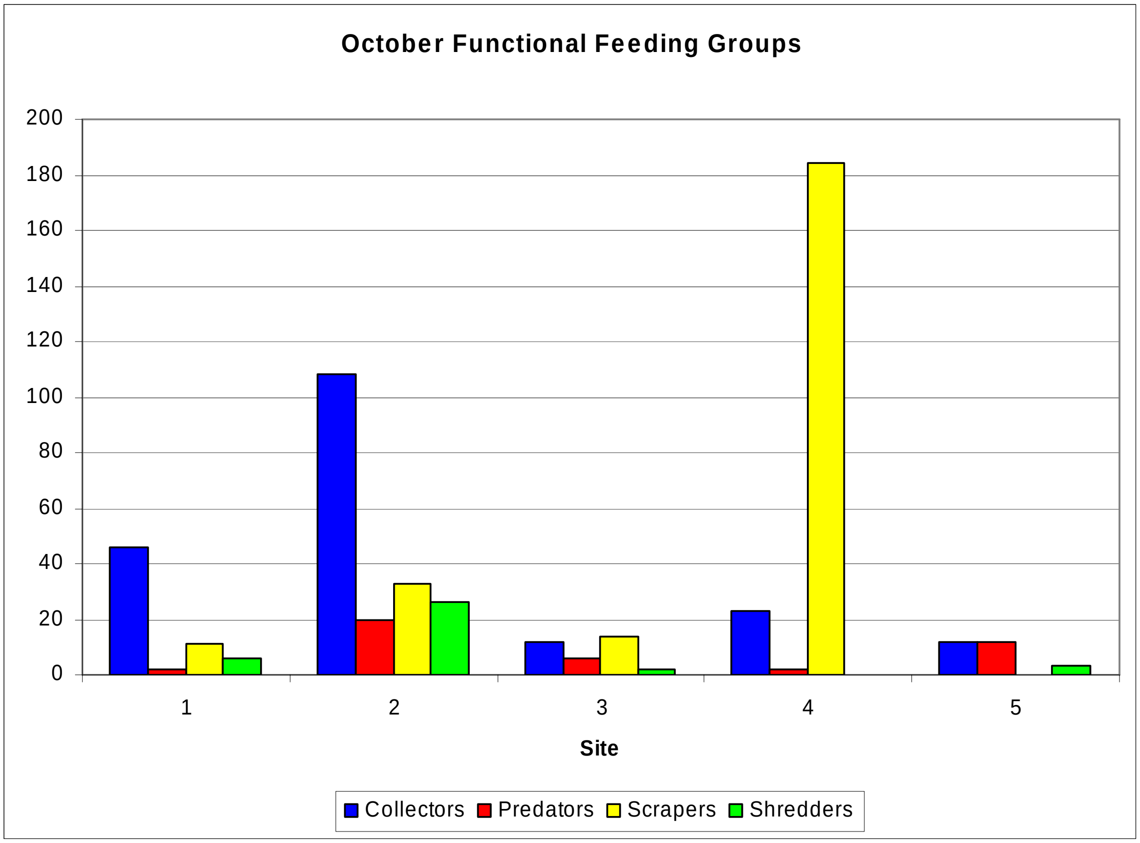
Statistical Analysis

All five sites were used for the analysis (See data in the Appendix). For each sample the abundance of functional feeding groups was tabulated and graphed and a one-way ANOVA (analysis of variance) was run. In

May there was a significant difference between the collector/gatherers group and every other group. This is likely because of the high number of oligochaetes at every site. In October there were no significant differences (for a discussion on functional feeding groups, see the Appendix). It should be noted however that site four in the October samples had an extremely high number of scrappers. This is due to the large number of Hydrobiid snails found at this site in the dense periphyton cover.



Abundance of functional feeding groups per site in May.



Abundance of functional feeding groups per site in October.

Seasonal and annual variability could be overcome by using recent death assemblages of chironomidae (midge) head capsules and other easily fossilized fauna, which could also be tied back into future paleolimnology studies. There was not a statistical significance between sites in May or October. However, **in both sampling periods there are a very low number of shredders.** It should also be noted that the scrappers found in May were mostly insect larvae, which have specific habitat and diet requirements. In October there is a dense cover of periphyton in many sites and the scrapers **shift to a less-selective snail-dominated community**.

Diversity

The biological diversity of the macroinvertebrates was also calculated based upon the taxa that were sampled in our regime. The biological diversity was calculated using the Shannon-Wiener equation:

$H = \mathrm{S\overset{s}{\underset{i=1}{U}}M}\,(pi)(\log 2\,pi)$ where *H* = Shannon-Wiener Diversity, *SUM* represents a capitol epsilon, *s* = the number of species, *pi* = the proportion of individuals of the total sample belonging to the *ith* species calculated as *ni/N* for each *ith* species with ni being the number in species *i* and *N* being the total number of individuals in the sample. The Shannon-Wiener score for June was calculated to be 1.81 in May and 1.98 in October. The score in October is likely higher because there were not a single dominant species like the oligochaetes were in May. However, the number of different taxa in May was higher per site with an average of 18.4 different taxa in May and 13.2 in October. As stated before the high number of oligochaetes in May makes the sites less diverse on the index. This also shows in the number of individuals per site with an average of 175.8 individuals in May and 104.6 in October.

From the samples collected, it is evident how important a native riparian community is for the entire lake food web based off the benthic invertebrate community. **Shredders and insect scrapers are utterly important in the cycling of nutrients in a lake and the breakdown of external inputs**. Leaves from trees are easily colonized by diatoms and bacteria which aids in invertebrate digestion of these material whereas grass is not. The community composition in Loveless Lake clearly shows this. In order to improve the efficiency of nutrient uptake, any unnatural shorelines should be restored to a forested state and the near shore zone should remain relatively undisturbed in order for nutrients to be utilized by the natural community rather than have it become available in the water column.

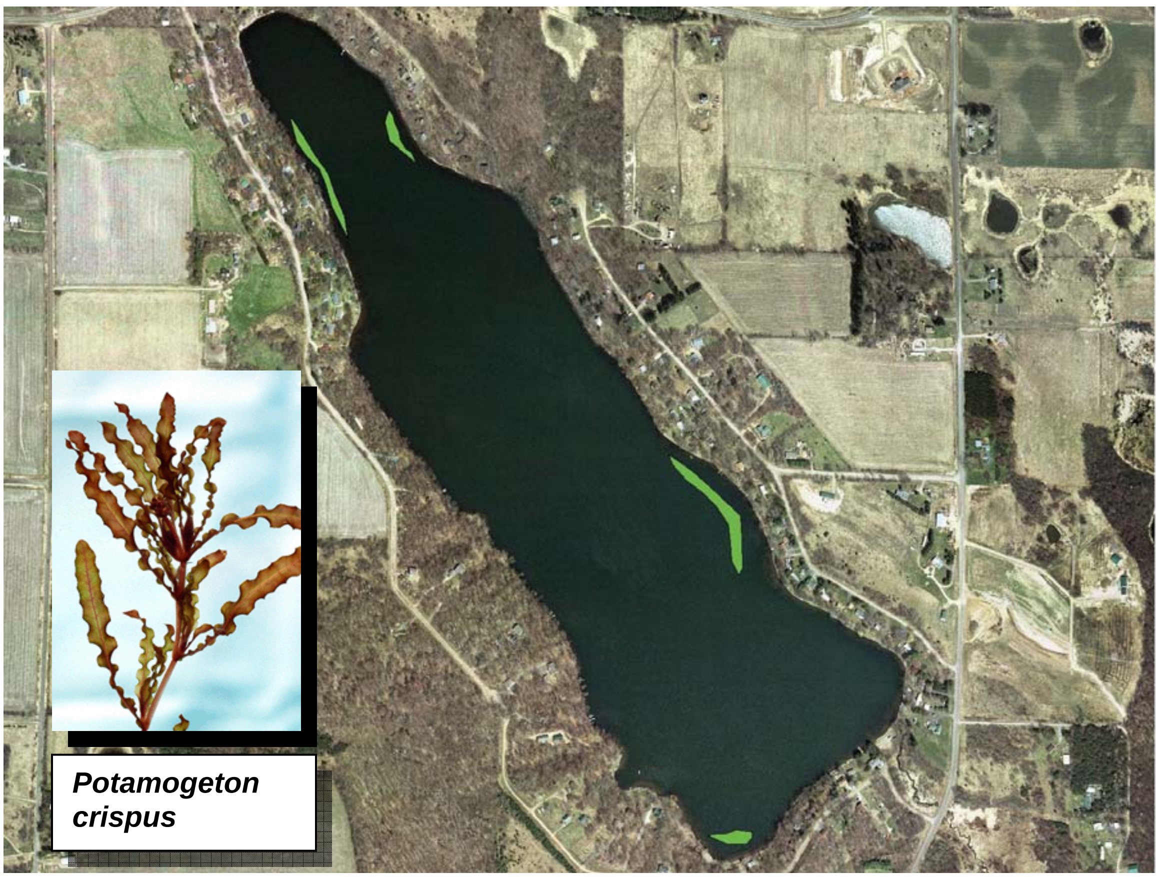
Also **based on the oligochaete and abundant snail scraper community of the lake, it is evident that Loveless Lake is on the cusp of becoming eutrophied. Oligochaetes and snails are considered pollution-tolerant invertebrates** and dominated Site 4. Efforts should be made throughout the watershed to reduce stormwater runoff and lake residents should be educated on proper boating and recreational activities on small lakes. Along with BMP measures, the macroinvertebrate community should continue to be monitored to measure success of implementation programs.

Macrophytes and Exotic Species

Two types of macrophyte surveys were conducted on Loveless Lake in 2006. On May 10th, 2006, ***Potamogeton** crispus* (curly-leaf pondweed) was mapped to determine the extent of its presence on Loveless Lake. A point intercept survey was carried out on August 16th, 2006, to assess the plant community within the whole lake.

Curlyleaf pondweed is a nonnative plant species that has been present in Wisconsin since early 1900's. In very disturbed lakes, curlyleaf pondweed is the dominant plant and can grow to nuisance levels. Curlyleaf pondweed can destroy the native plant community, impede recreation on a lake, and alter the nutrient dynamics in a lake system. For more information on curlyleaf pondweed, visit the Department of Natural Resources' website at http://dnr.wi.gov/invasives/plants.htm

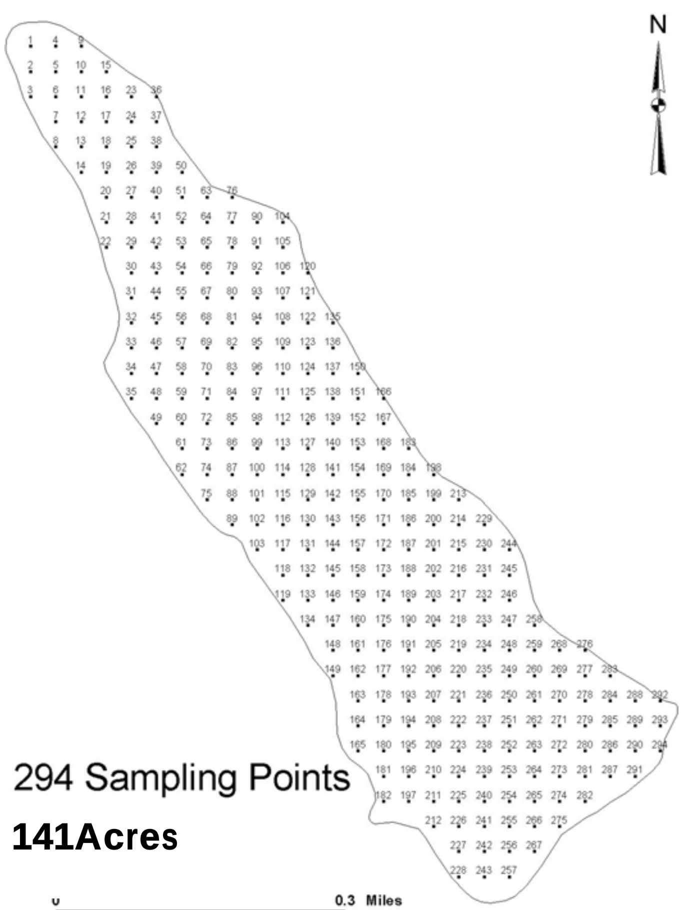
The curlyleaf pondweed on Loveless Lake was mapped using an Aqua-scope for viewing in the water and a GPS unit to document the plant beds. Curly-leaf pondweed does not appear to be at nuisance levels at this time, with about 2.27 acres of coverage. However, *P. crispus* should continue to be monitored and mapped in order to protect the integrity of the already-stressed aquatic plant community of Loveless Lake. No other aquatic exotic species were found on Loveless Lake in 2006.



Mapped beds of *P. crispus* on Loveless Lake, Polk County, WI

The whole lake macrophyte survey employed the point intercept method suggested by the Wisconsin DNR. Two hundred ninety-four (294) sampling points were established in the lake by ArcView. The grid of points was downloaded to a GPS unit to locate in the field. Each sampling point was visited on August 16, 2006.

Collecting aquatic macrophytes



Macrophyte collection sites on Loveless Lake, Polk County, WI

The Jessen and Lound rake method was used to sample the macrophytes. Once the boat is maneuvered to the sample location, a rake is lowered to the bed of the lake, head down. The depth and substrate at the sample point is noted. A figure eight is made with the handle of the rake in an area that is approximately 1 m^2. The rake is then inverted and brought to the surface to assess the sample.

Each species on the rake head is identified and noted on a field log along with the approximate density of each species, on a scale of 1 to 3. This can be used to determine species composition or dominance of a species at a site or certain water depth. The results were then evaluated using three different indices or metrics: the Floristic Quality Index, Simpson's Diversity Index, and the Frequency of Occurrence for each species.

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

Of the 294 sampling points, **58 sites had vegetation**. This very roughly equates to 28 acres of the lake or 20% of the lake surface has aquatic vegetation. This is a very narrow band of plant growth for fish and other aquatic organisms, for substrate stabilization on such a highly used lake, and for nutrient utilization, among the other benefits macrophytes provide. Given the bathymetry (underwater contours) and the water clarity (average light penetration of 7.5 feet) of Loveless Lake, aquatic plants should grow at a minimum to a rooting depth of 15 feet. Fifty-two (52) acres of the lake are 15 feet of depth or less, which should comprise the littoral zone. Plant growth only occurs on half of this area. Other points in the survey were beyond rooting depth (too deep for light penetration) or the substrate did not support macrophytes (rather microphytes such as diatoms), but likely disturbance is another reason for a decline in macrophyte growth.

Current Littoral Zone of 28 acres

Optimal Plant Growth to 15 feet of water depth (52 acres)

The lake, as a whole, was not very rich as compared to most lakes in the region. Only **18 species of macrophytes** were observed. Most of the regional lakes have between 30 and 50 different species present. The lack of species richness raises concern about activities on the lake and watershed that are affecting the macrophyte community.

Ceratophyllum demersum

The Frequency of Occurrence (FO) is defined as the number of sites that the species occurred divided by the total number of sampling sites in the lake with vegetation, expressed as a percent. *Ceratophyllum demersum* (Coontail) was the most abundant submerged species in Loveless Lake occurring at 81% of the sites. The relative frequency of coontail (how often the plant occurred compared to other species) was 24%. Coontail is on the beginning of dominating Loveless Lake's plant community. However, Coontail is not a rooted plant species and may have floated into sampling areas during the survey. *Potamogeton zostriformis* (Flatstem pondweed) was the most common rooted species. Flatstem pondweed had an FO of 70.7% and relative frequency of 21%. Other species with a large presence in Loveless Lake include Forked Duckweed (*Lemna trisulca*), native Northern water milfoil (*Myriophyllum sibiricum*), and Small Pondweed (*Potamogeton pusillus*). Curlyleaf pondweed was found at two sites during the August survey, but no other exotic species.

The Simpson's Diversity Index was calculated for the lake**.** Simpson's Index **(**D**)** measures the probability that two individuals randomly selected from a sample will be of the same species (or some category other than species). $D = \frac{\sum n(n-1)}{N(N-1)}$ where D = Simpson's Diversity, n= the total number of organisms of a particular species, N=the total number of organisms of all species.

The Simpson's diversity index for Loveless Lake was calculated to be 0.84 as compared to 0.83 in 2002. A number close to 1 indicates that two individual samples selected will be the same. Again, the lack of species diversity is disturbing. **The methods used in 2007** (the 2002 survey used the transect method versus the point intercept method) **should expand the sampling of microhabitats, which in turn increases the diversity, but this was not the case**.

The Floristic Quality Index was also determined to assess the quality of the macrophyte community in Loveless Lake. The Floristic Quality Index 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 (Nichols, 1999).

Using the equation $I = \overline{C}\sqrt{N}$ (where *I* is the floristic quality, $\overline{C}$ 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 floristic quality of Loveless Lake was determined to be 22.18** as opposed to 14.50 in 2002. The average for this area of the state (North Central Hardwood Forest) is 17 to 24.4 with a median of 20.9. Loveless Lake appears to be average in the region, but faltering. Again, the difference in sampling techniques used may account for the increase in Floristic Quality Index. Future monitoring will be more telling after this whole lake point intercept survey. This shows that the new point intercept method picked up on some of the more sensitive species, but raises more alarm to the low richness.

The aquatic plant community of Loveless Lake is an invaluable part of the lake's ecosystem, particularly to invertebrates and fish. In order to protect the lake, the aquatic plant community needs to be improved by increasing the diversity and coverage. By increasing the diversity, the macrophyte structure and in-lake architecture will also improve to provide more habitat for desirable fish species and invertebrates. This can be achieved by reducing the impact of recreation and a reduction in the sediment that reaches the lake. **The aquatic plant community should continue to be monitored to ensure a healthy ecosystem** and gauge the effectiveness of lake management techniques. A major disturbance to the native macrophyte community of Loveless Lake could be detrimental to its ecosystem and fishery. If the macro-plants that are currently in Loveless Lake become destroyed, the system could shift to a micro flora system with algae becoming dominant. Sedimentation from road runoff, aggressive recreation, and non-native lakeshore landscaping are topics that should be addressed.

Shoreline Assessment

As waterfront property becomes more attractive to the human population, the effects of human presence takes its toll on water quality. Indicator species are a group of animals that are a key link in the native community. Because of their interaction with prey and predators, plant species and habitat, the monitoring of an indicator species can show a change in the quality of a native community. A decline in the species shows that the whole community is being affected. Limnologists have identified numerous aspects of aquatic habitats that are indicators of aquatic ecosystem health. Some of these include the presence of exotic species, terrestrial vegetation, Imperviousness around a lake, and coarse woody debris in a lake.

Terrestrial Vegetation

A survey of the terrestrial vegetation surrounding Loveless Lake was taken on October 25, 2006. The riparian zone is an incredibly important ecosystem both ecologically and hydrologically. Shoreline observations were made to document the habitat type and then generalize the conditions around the lake. In this part of Wisconsin, Northern Hardwood Forests are the native eco-type. The surrounding lakeshore vegetation has more significance than just for birds, mammals, and reptiles. **The type of food sources entering the lake from the lakeshore, called allochtonous matter, influences the bacteria, macroinvertebrates, immature insects, algae, and zooplankton in the littoral zone; hence the basis of the foodweb in Loveless Lake.**

The organic carbon derived from the land sources of vegetation can be easily dissolved or somewhat resistant to decay. The rate of decomposition determines the rate of nutrients entering the water column. It takes weeks for leaves to decompose and years for woody material (Wetzel, 1983). The animals have adapted with symbiotic gut microflora to utilize the particulate plant material. Grasses and turf have less cellulose than woody material (why they are less rigid) and can be digested easier by microflora, cycling nutrients quicker.

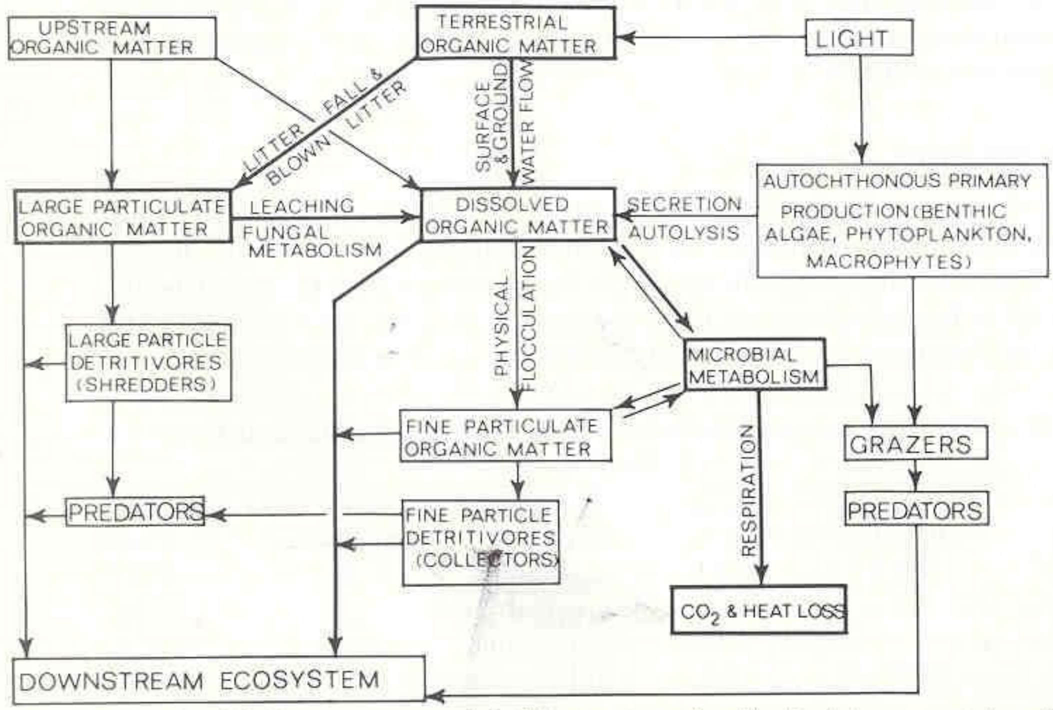


Figure 22-1. Simplified compartment model of the structure of an idealized stream ecosystem. Heavier lines indicate dominant transport and metabolic pathways of organic matter. (Composite of modified figures after Fisher and Likens, 1973, and Cummins, et al., 1973.)

Fate of terrestrial organic matter entering an aquatic ecosystem. *(taken from Wetzel, 1983).*

As you can see from the model depicted above, organic matter originating from terrestrial sources follows a complex system. However, this is what feeds the food web, and its preservation can be ensured by keeping lakeshore landscaping **native** and other best management practices.

The landscape around Loveless Lake is choppy, with exception to the west shore where a large portion of in-tact woods remains. The northwest portion of Loveless also sustains mostly native vegetation. This offers protection from erosion on the steep slopes and also provides **coarse woody habitat** in the water that is necessary for fish, reptiles, amphibians, macroinvertebrates, and microflora. These areas should be protected from any future development as they provide numerous benefits to Loveless Lake. Other areas of the lake had wooded lots interspersed with lawns and impacted sites.

Some of the worst examples of stewardship observed were artificial sandy beaches, retaining walls built of railroad ties and tires, and mowed grass to the shoreline. Nonconforming structures were also noted. (Loveless is a Class 1 lake.) Land use surround Loveless Lake is dominated by residential dwellings, followed by forest, agricultural lands, and grassland. Please see the Modeling Section of the report for more information on phosphorus loading to Loveless Lake based on land use in the watershed.

Retaining walls are mainly used for aesthetic landscaping purposes; they retain little, if any, water runoff and segment habitat for wildlife. Native hardwoods and shrubs can be used to stabilize slopes, prevent erosion, and intercept stormwater by increasing soils field capacity. **Ice berms** should be left in tact on shorelines. The force of winter ice from the lake creates a natural ridge on lake which retains water and allows infiltration of snowmelt in spring. Lakeshores should be allowed to **recolonize with Northern Hardwood species**. The easiest way would be to ceasing lawn mowing, or additional effort can be made to replant a shoreline restoration. Given the presence of wooded areas around the lake, seeds and roots should move quickly to undisturbed areas to revegetate the property. The restoration should be attended to remove any invasive plants, such as **buckthorn or reed canary grass**. These species were noted around Loveless Lake in the terrestrial survey.

The plant community of Lotus Lake's watershed is an invaluable part of the lake's ecosystem to microfauna and macrofauna. In order to protect the lake, the riparian community needs to be protected and enhanced through activities such as shoreline restoration. The watershed plant community should continue to be monitored to ensure a healthy ecosystem and gauge the effectiveness of management techniques. A major disturbance to the natural community of Loveless Lake could be detrimental to its ecosystem and the surface and groundwater quality of Loveless Lake.

Coarse Woody Debris

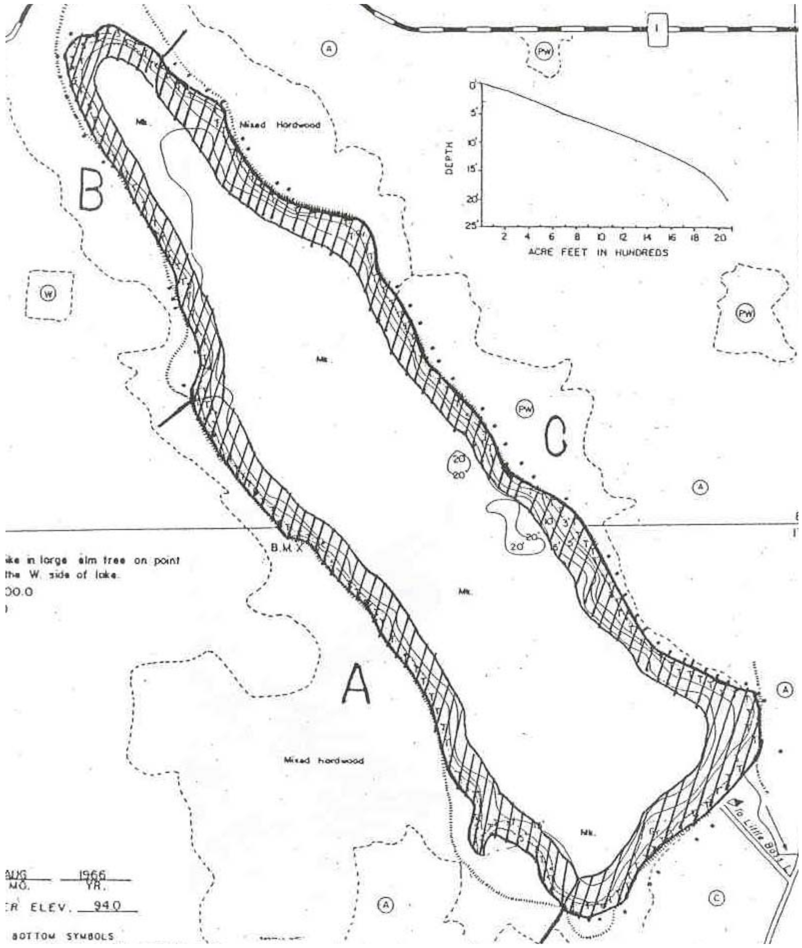
Coarse woody debris was noted in several areas along the western shore of Loveless Lake and in one shallow bay. The northeast corner of Loveless Lake also upheld some woody material in the lake. It is no coincidence that the upland land use at these sites is forested. Trees and shrubs should not be cut down even when they die because they provide important woody debris habitat within the buffer zone as well as the littoral zone when they fall into the lake. **More areas around the lake should leave fallen trees, logs and branches intact to provide underwater structure and habitat**. Various sizes, locations, densities, and vegetation makeup offer many habitat types (Roth, et al., 2007 and Marburg, et al., 2006).

The following conclusions were noted by Jack Sullivan, Director of Wisconsin DNR Bureau of Integrated Science Services, and Dr. Greg Sass, Center for Limnology, UW-Madison on an ongoing research project of Little Rock Lake in Vilas County, Wisconsin.

1. A strong, negative relationship exists between the amount of coarse woody habitat (CWH) (i.e. logs, sticks, and branches in the water) found in the littoral zones of lakes and the amount of lakeshore residential development.
2. Loss of coarse woody habitat (CWH) from nutrient-poor lakes, such as those found in northern Wisconsin, can cause declines in fish growth rates and the amount of fish a lake can support.
3. Coarse woody habitat provides refuge for small fishes and serves as a spawning substrate for many species of fish.
4. Therefore, loss of coarse woody habitat can lead to rapid and persistent declines in fish populations that rely on CWH for refuge and spawning.
5. Removal of coarse woody habitat can lead to elevated levels of methyl mercury in fishes because physical removal of CWH reintroduces buried mercury into a lake.
6. The rapid removal of coarse woody habitat by people (over days to years) and the slow rates of natural replacement and degradation (centuries to millennia) suggest that CWH loss can have long-lasting or permanent consequences for fish populations and fisheries.

Sensitive Area Survey

A sensitive area survey was conducted on Loveless Lake on August 12, 1993, by the Wisconsin Department of Natural Resources. Areas that merit special protection of aquatic habitat were identified, which provide the necessary seasonal or life stage requirements of the associated fisheries, and the aquatic vegetation offers water quality or erosion control benefits to the body of water. **The entire littoral zone of Loveless Lake is considered a sensitive area.**



Sensitive area survey of Loveless Lake, 1993 by Rick Cornelius, WDNR

Landuse Runoff / Impervious Assessment

Loveless Lake is a groundwater drainage lake. This means there is no stream or river feeding Loveless, but rather water enters via groundwater discharge (springs), precipitation that falls on the lake, and surface water runoff from nearby land. As described earlier in this report, water that flows over the surface of the earth carries with it minerals, oils, debris, and other dissolved substances that it picks up until the water enters the lake. The faster water travels, the more power it has to carry things with it, or erosivity.

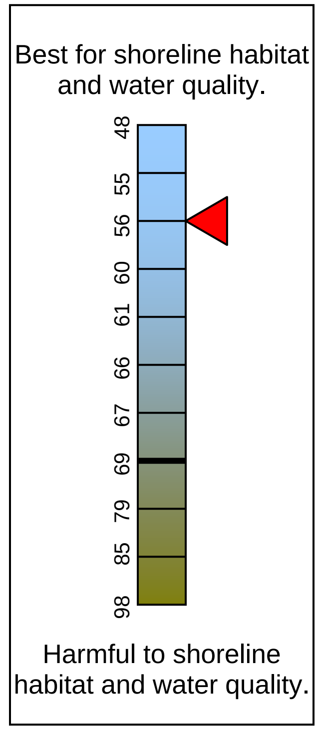
A slow trickle of water can create a small rill where water travels. A large rain can make sheet flow.

Erosion on a farm field with bare soil. Notice the small rills and gullies that form where water concentrates to flow.

The way to slow down water (and therefore reduce erosion potential) is to allow it to soak into the ground before it reaches the lake. Vegetation (trees, tall grasses, leaf litter on the ground, shrubs) soak up water like a sponge, slow down the flow of water, and help water infiltrate into the ground by releasing moisture slowly. Hard impervious surfaces like rooftops, driveways, sidewalks, patios, etc. divert water and cause the water to **concentrate into high flow areas.**

Stormwater off Niles Lane. The short, sparse vegetation does little to slow down runoff into Loveless Lake.

The land use runoff has been studied extensively. The United States Department of Agriculture developed an Urban Hydrology for Small Watersheds model (1986) which determines runoff from various land uses. This is the basis for the Land Use Runoff Rating used in the Polk County Shoreland Protection Zoning Ordinance. (See http://www.co.polk.wi.us/landinfo/ordinances.asp) Stormwater runoff is defined as precipitation that is not intercepted by vegetation, absorbed by the soil, or evaporated and thus moves directly from the land to surface water bodies. Stormwater runoff from residential development is high in pollutants, which are harmful to lakes, rivers, and wetlands. For more than 10 years the Environmental Protection Agency (EPA) has considered stormwater runoff as the primary threat to surface waters of the United States.



We asked Loveless Lake residents to evaluate their property for imperviousness to determine runoff potential. This was to be an educational exercise to assess one's impact on Loveless Lake. The request was made at the spring association meeting, through board members, and via e-mail. Four responses were received from residents who took time to determine their curve number. The calculation is timely to complete. Our hope is that although many did not complete the exercise, in determining not to, they at least did a visual evaluation of their property and looked for erosion and runoff potential.

Of the four land use assessments received, the curve numbers were 57, 63, and 67. One calculation was partially completed and the curve number not determined. The properties evaluated were 2 acres, 1 acre, and 0.5 acre in size, respectively, which indicates that larger parcels of land with larger tracts of native vegetation are more beneficial for water quality. Regardless of lot size, **riparian owners should try to reduce the impact of their housing footprint by limiting imperviousness, mitigating with rain garden, rain barrels, and infiltration swales, and keeping native cover on the land**. The impacts of impervious surfaces due to suspended sediments on aquatic systems are summarized below. *(Taken from Impacts of Impervious Runoff, 2003, Center for Watershed Protection, Maryland.)*

- Abrades and damages fish gills, increasing risk of infection and disease
- Scouring of periphyton from stream (plants attached to rocks)
- Loss of sensitive or threatened fish species when turbidity exceeds 25 NTU

- o Decline in sunfish, bass, chub and catfish when month turbidity exceeds 100 NTU and shift in fish community toward more sediment-tolerant species
- o Reduces light penetration causing reduction in plankton and aquatic plant growth
- o Adversely impacts aquatic insects, which are the base of the food chain
- o Slightly increases the stream temperature in the summer
- o Reduces anglers chances of catching fish
- o Physical smothering of benthic aquatic insect community
- o Reduced survival rates for fish eggs
- o Destruction of fish spawning areas and eggs
- o Embeddedness of stream bottom reduced fish and macroinvertebrate habitat value
- o Increase in sediment oxygen demand can deplete dissolved oxygen in streams
- o Deposits diminish scenic and recreational values of waterways

Modeling

The Wisconsin Lake Modeling Suite (WiLMS) was used to model phosphorus export to Loveless Lake using current land use conditions, a forested watershed condition, and projected development conditions for Loveless Lake. The WiLMS model is a lake management tool that can predict water column phosphorus concentrations, turnover phosphorus concentrations, and frequency of algal blooms based on phosphorus loading. Phosphorus is the key parameter in the modeling scenarios because it is the limiting nutrient for algal growth in most Wisconsin lakes and affects water quality.

The following table was based on annual external source loading estimates and the Nurnberg model for estimating gross internal loading. The model that appeared to be the best "fit" for Loveless Lake was the Vollenweider Shallow Lake Model (1982). The Vollenweider model calculates a spring turnover and growing season average. The model also calculates an estimated phosphorous concentration in the water column (mg/m^3).

The table below indicates that the watershed loading for Loveless Lake has a significant increase causing a phosphorus concentration of 38 µg/l versus the modeled 2002 data of 33 µg/l and observed concentration today of 58.0 µg/l. The Concentration in 2002 was observed to be 42.1 µg/l. An overall in-lake phosphorus concentration of less than18 µg/l is a potential management goal (however unlikely as described below).

This is the modeled concentration for a forested watershed, such a level would likely increase water clarity and ensure a quality lake for generations.

Condition	**Total P loading (lbs)**	**Water Column Concentration (P in mg/m^3 or ug/l)**
2002	129.5	33
2006	168.0	38
2002-predicted	124.0*	38

*Total P loading may be reduced in the model because of the poor assumption of paved surface concentration, however the water column concentration is still affected by the increased volume of runoff.

The 2002 projected development condition boded grim for Loveless Lake, and in fact, based on the model came true. The predicted 38 ug/l in-lake phosphorus concentration brought more algal blooms and consequently more internal loading due to reduced O_2 at the water/sediment interface as plant matter decays.

Restoring the watershed to a forested condition and reducing the in-lake phosphorus concentration to18 µg/l is an unlikely scenario based on both environmental and economic restraints. (*However it is heartening to know that limiting nutrient inputs to the lake will likely result in improvements*.) Therefore, the lake was modeled at 12%, 20% and 45% reductions in external phosphorus loading.

Such reductions may be possible through the implementation of best management practices (BMPs), shoreline restoration, wetland restoration, or some combination of these management options. Limiting horsepower and/or speed limits on the lake, as well as educating lake residents on proper recreational activities on small lakes, could also further reduce internal phosphorus loading. Targeted Runoff Management Grants should also be pursued for the repair of Reidner and Niles Lanes as the roads contribute much sediment.

Aerial view of sediment
from Niles Lane.

A 45% reduction of phosphorous loading from external sources would significantly affect total phosphorous concentrations in Loveless Lake (89.8 lbs of loading and a water column concentration of 24 ug/l). Such a reduction would classify the lake as mesotrophic. A perceived improvement in water clarity may be noticeable as the watershed shifts towards a forested conditions.

Phosphorus may be further reduced within the water column reducing internal loading through more appropriate recreational activities, such as canoeing and fishing, as opposed to wakeboarding and waterskiing on such a small, narrow lake. Such activity resuspends sediment, erodes the shoreline and, consequently, nutrients and makes them available to plants and algae.

The empirical models in WiLMS estimate that internal loading makes up approximately 7.7% of the total phosphorous in the water column. This model does not take into account the presence of *P. crispus* or resuspension of sediment from motorized activity. CLP emerges from the lake bottom earlier than native species, and therefore dies and decays earlier in the year depriving the lake of dissolved oxygen. Because of this and the boat traffic on the lake resuspending sediment, the internal loading of Loveless Lake is likely higher than the model indicates and should be further investigated.

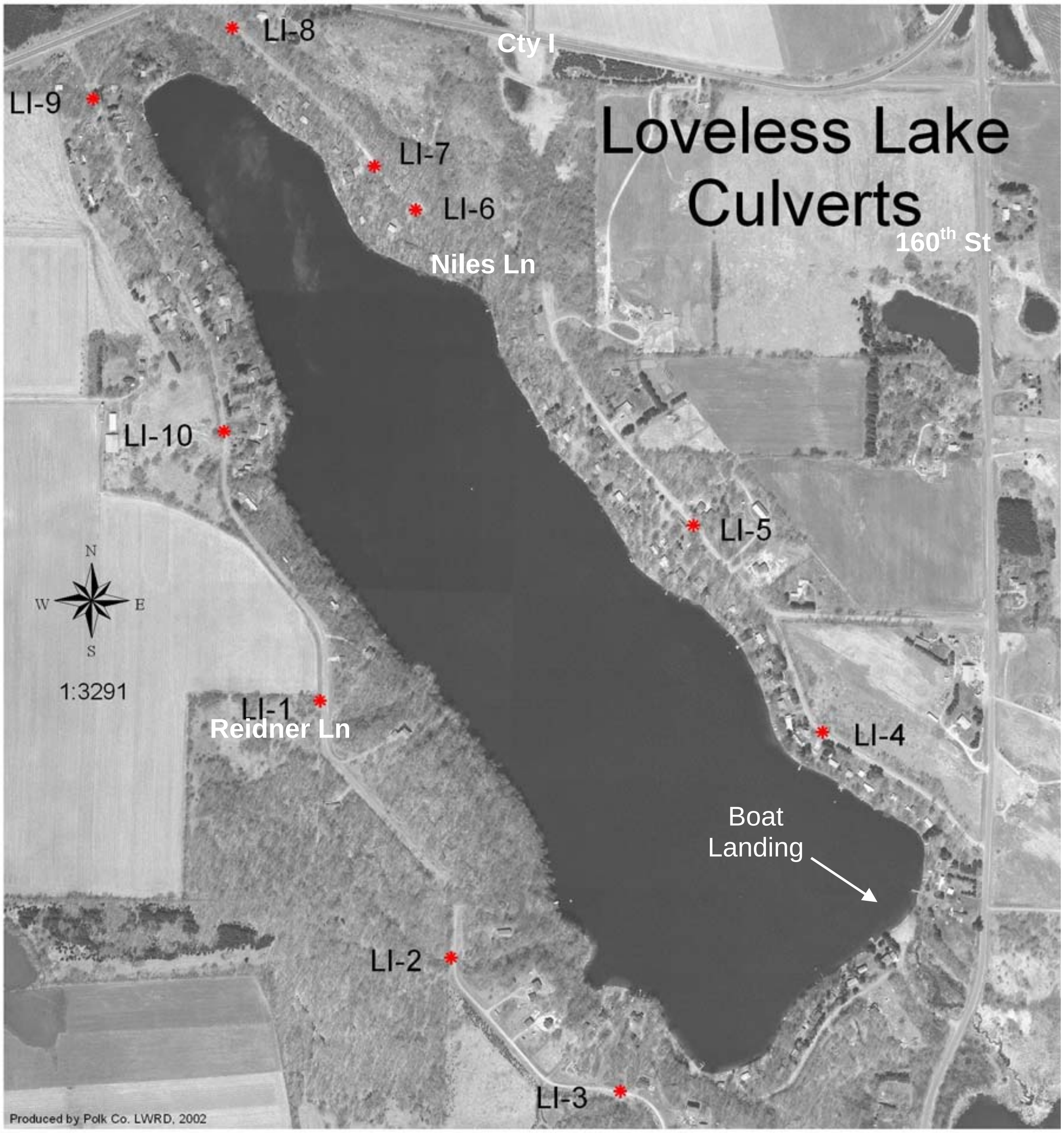
The summary trophic response based on the entered data shows Loveless Lake as mildly eutrophic; this is the same as modeled in 2002.

In the expanded trophic response module of the WiLMS model it is predicted that the nuisance algal bloom frequency (based on collected data) will occur 44.9% of the time, up from 40% in 2002. A frequency of this nature will shift the algal species composition, and affect the whole food-web from zooplankton to game fish.

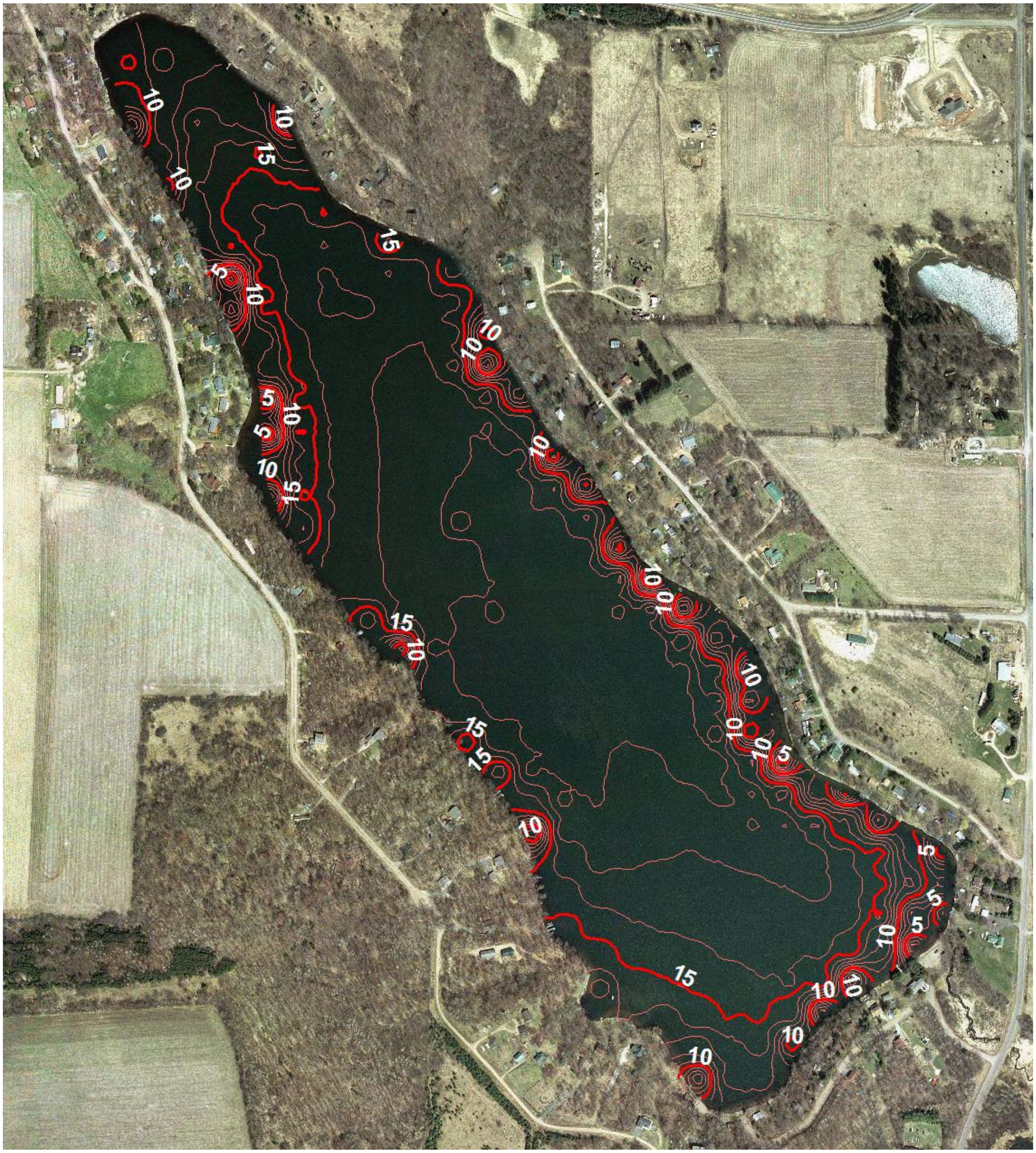
Sediment washing in from boat landing at South Loveless Lake Lane during a rain event (9/18/07).

Bathymetric Map

Sedimentation, motorized activity, changes in water level, and riparian vegetation manipulation can all have an impact on the depth and composition of Loveless Lake. Lake depth and bathymetry is a predictor of macrophyte growth, shoreline habitat, and areas of erosion. The depth from lake surface to lake bottom was recorded to develop a bathymetric map on Loveless Lake. The image shows one foot contour lines. Loveless Lake is very bowl-like in shape with a deep center and sloping sides. **Shallow areas along the perimeter of the lake are an indicator of sedimentation and should be investigated upslope to see if any erosion is occurring**.



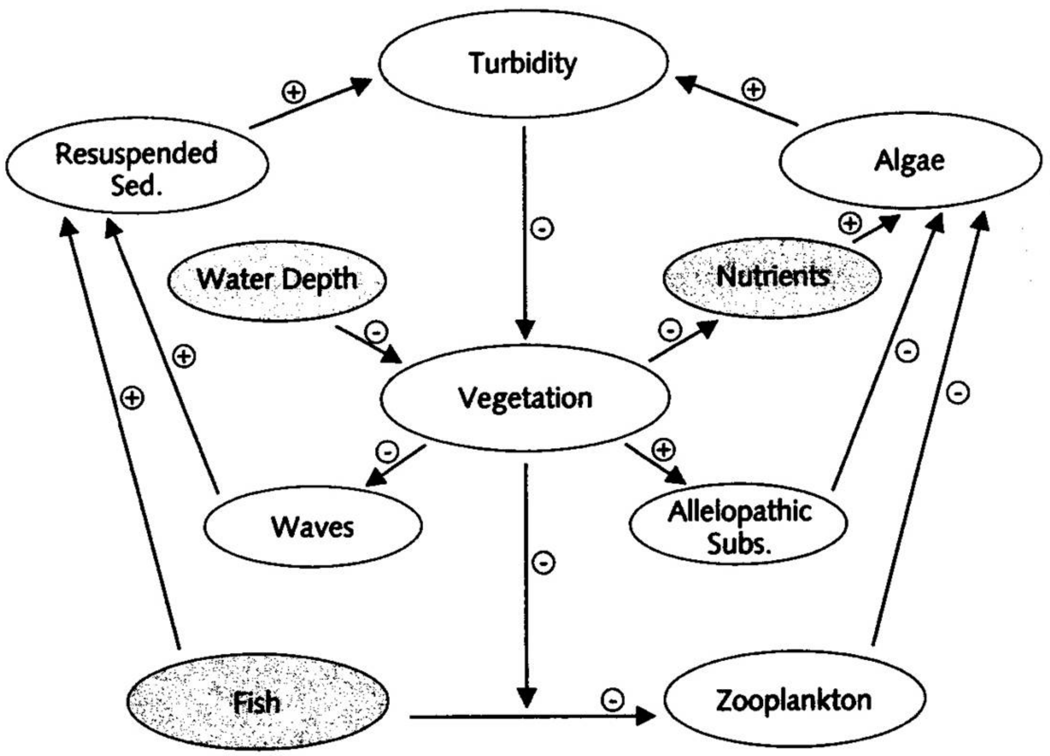
The red dots indicate the location of culverts around Loveless Lake.



Bathymetric map generated of Loveless Lake with 1 foot contour lines. Shallow areas along shore shows areas of sedimentation.

Recreational Survey

Local and visitors alike flock to Loveless Lake in the summer time to fish, boat, tube, and waterski. The parking lot is often full. Loveless is a quaint lake centrally located in the county. It receives much activity. For capacity and user issues as well as enumerating the hours of use, a recreation survey was designed. Tuesday, Thursday, Saturday and Sunday counts of boats and activity would be logged. Three lake residents volunteered to monitor activity, but no data was collected from them. At this time, we have no data on recreational use of Loveless Lake other than antidotal.



Waves are an integral part of the dynamics of a shallow lake. The interconnectedness of ecosystems to the physical, chemical, and biological characteristics of a lake can easily cause a cascading effect. Waves generated by boats and artificial mixing of the lake can affect the ecosystem and water clarity of Loveless Lake.

Management Recommendations

Loveless Lake truly appears to be on the verge of a tropic state shift. All biological and chemical parameters measured indicate that the ecosystem and water quality are worsening. The exact cause of this shift is not known, but there are several options that should be pursued immediately to prevent further degradation of this wonderful resource. Nutrient limitation, water column disturbance, and aquatic vegetation manipulation should be kept minimal. Specific projects for Loveless Lake also include:

1. WORK WITH BALSAM LAKE TOWNSHIP TO PURSUE A TARGETED RUNOFF MANAGEMENT (TRM) GRANT OR LAKE PROTECTION GRANT TO FIX REIDNER LANE, NILES LANE, AND SOUTH LOVELESS LAKE LANE AT THE BOAT LANDING. (See photos on previous page.) Sedimentation from the road culverts is occurring.

2. Educate public and citizenry to adopt lake stewardship practices, advocate for water quality, and engage in water management.

3. The aquatic plant community of any shallow lake is an invaluable part of the lake's ecosystem, particularly to invertebrates and fish. In order to protect these lakes, the aquatic plant community needs to be protected and/or enhanced. Aquatic plant communities should continuously to be monitored to ensure a healthy ecosystem and gauge the effectiveness of management techniques. A major disturbance to the macrophyte community of Loveless Lake could be detrimental to its ecosystem. Enhancement would enrich the water quality and fisheries.

4. Maintain native vegetation in riparian areas with a minimum buffer of 35 feet and the smallest viewing corridor.

5. Clear road ditches of leaf debris and organic matter which could enter the lake.

6. Given the teetering of the zooplankton community, it would be our recommendation that a complete analysis of food web should be conducted by the DNR before any fish stocking potentially biomanipulates the water clarity.

7. Become organized within association to do volunteer monitoring – macrophytes, shoreline vegetation surveys, Clean Boats/Clean Water inspections, water chemistry, and exotic species watch.

8. Pursue a recreational survey to determine the extent of boating impact. Recreational boating should be moderated on small, shallow lakes. Non-motorized sports will have less impact on water quality and turbidity than PWC and motorized boats. At a minimum, slow-no-wake speeds should be implemented and the 100-foot from piers, docks and other boats law upheld. Work with Township to develop recreational ordinance, if necessary.

9. Watershed residents should limit the amount of impervious surfaces on their property to allow for water infiltration and reduce runoff. Rain gardens and native vegetation are beneficial to reduce stormwater runoff and for wildlife habitat. Grassy pavers and porous cement are better alternatives than blacktop. Rain barrels also help reduce runoff from entering Loveless Lake. Ice berms that form at the lake edge should be kept in tact to facilitate spring infiltration.

10. Be aware of and follow VHS rules. http://dnr.wi.gov/fish/pages/vhs.html

11. Any new construction in the watershed shall have proper erosion control measures in place. Sediment loading from construction sites is a major polluter to our waterways. ***Properly installed*** silt fences, erosion control blankets and other BMPs are required under the Uniform Dwelling Code, Stormwater and Erosion Control Ordinance, and Shoreland Protection Zoning Ordinance.

12. Riparian vegetation, aquatic plants, and coarse woody debris (fallen trees and logs) should be left where it stands or falls to preserve the water quality of Loveless Lake. Designated Sensitive Areas should be protected.

13. Agricultural and other best management practices should be utilized in the watershed to reduce phosphorus and other pollution reaching surface waters.

14. Residents should continue their relationship with the Polk County Association of Lakes and Rivers, Wisconsin Association of Lakes, the Lakes Partnership, and Land and Water Resources Department. An informed citizenry will be the best advocate for the lake.

Newsletters and conferences will be valuable educational material for Loveless Lake residents.

15. Continued monitoring of Loveless Lakes' biological community and water quality is important for establishing a baseline. Citizens should continue the Self Help program and Adopt a Stream.

16. New residents should be alerted of local Zoning laws to prevent misunderstandings and violations.

17. No phosphorus fertilizers shall be applied in shoreland areas of Polk County.

18. Septic systems should regularly be maintained and checked on to prevent pollution from entering the lake.

19. Area residents and fisherman should inspect boating and fishing equipment to prevent the introduction of an invasive specie into Loveless Lake. Unused fishing bait should be disposed of in the trash. Tackle and sinkers should be lead free. Aquatic plants should be removed from the trailer and axles before and after launching.

References

Carlson, R.E. 1977. A trophic state index for lakes. Limnology and Oceanography. 22:361-369.

Cummins, K. W., M. J. Klug. 1979. Feeding Ecology of Stream Invertebrates. Annual Review of Ecology and Systematics 10:147–172.

Ferrington, L. C., N. H. Crisp, J. L. Kavanaugh, and F. J. Schmidt. 1999. A Protocol for Using Surface-Floating Exuviae of Chironomidae for Rapid Bioassessment of Changing Water Quality. 181-190. In: Sediment and Stream Water uality in a Changing Environment: Trends and Explanation. IAHS Publication Number 203. 374pp.

Karr, J. and C. Yoder. 2004. Biological assessment and criteria improve total maximum daily load decision making. Journal of Environmental Engineering 130(6):594-604.

Marburg, A.E., M. G. Turner, and T. K. Kratz. 2006. Natural and anthropogenic variation in coarse wood among and within lakes. Journal of Ecology 94:558-568.

Merritt, R.W. & K.W. Cummins. 1996. An introduction to the aquatic insects of North America, 3rd ed. Kendall/Hunt. Dubuque. 862 pp.

Merritt, R. W., K. W. Cummins, M. B. Berg, J. A. Novak, M. J. Higgins, K. J. Wessell, and J. L. Lessard. 2002. Development and application of macroinvertebrate functional group approach in the bioassessment of remnant river oxbows in southwest Florida. J. North American Benthological Society 21:290-31.

Novotny, V., A. Bartosova, N. O'Reilly, and T. Ehlinger. 2005. Unlocking the relationship of biotic integrity of impaired waters to anthropogenic stress. Water Research 39:184-198.

Riley, E.T. And E.E. Prepas. 1984. Role of internal phosphorus loading in two shallow, productive lakes in Alberta, Canada. Can. J. Fish. Aquat. Sci. 41:845-855.

Roth, B. M., I. C. Kaplan, G. G. Sass, P. T. Johnson, A. E. Marburg, A. C. Yannarell, T. D. Havlicek, T. V. Willis, M. G. Turner, and S. R. Carpenter. 2007. Linking terrestrial and aquatic ecosystems: the role of woody habitat in lake food webs. Ecological Modelling 203:439-52.

Rosenberg, D. M. 1992. Freshwater Biomonitoring and Chironomidae. Netherlands Journal of Aquatic Ecology 26(2-4):101-122.

Ruse, L. 2002. Chironomid pupal exuviae as indicators of lake status. Arch. Hydrobiol. 153(3): 367-390.

Saether, O. 1975. Chironomid communities as water quality indicators. Holarctic Ecology 2: 65-74.

Scheffer, M., 1998. Ecology of Shallow Lakes. Chapman and Hall. London. 357 pp.

Shaw, B., C. Mechenich, and L. Klessig. Understanding Lake Data. UW Extension SR-02 / 2002-1M-525. 2002

United States Environmental Protection Agency. 1998. Lake and Reservoir Bioassessment and Biocriteria: Technical Guidance Document. EPA 841-B-98-007.

Wetzel, R. Limnology. 3rd Edition, CBS College Publishing. 2001.