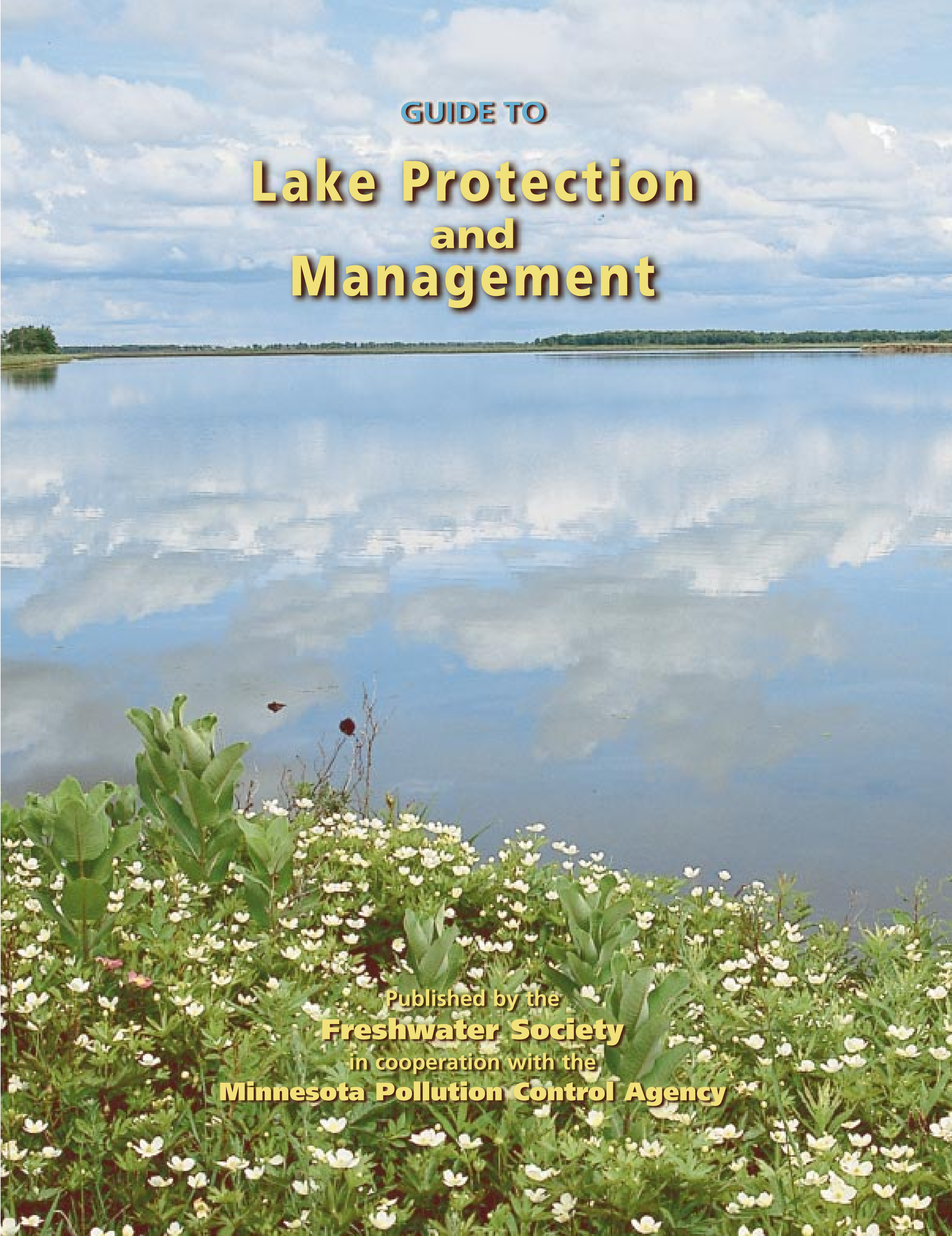
GUIDE TO

Lake Protection and Management



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in cooperation with the
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Forward

The need for a 2nd edition of a lake management and protection guide, after seven printings of the first edition, is testimonial to its acceptance and use to help conserve and wisely use our 15, 291 lakes and their millions of feet of shoreline. Proper management of such valuable natural resources is a duty of all of us.

But, two economic gains are easily forgotten while concentrating on the actual management of lakes and their shorelines. These are (1) the economic gain of proper lake management, and (2) the value of having congenial, satisfied, and compatible neighbors on adjacent shorelines.

Any of us who have owned shoreline on a Minnesota lake know the value of the property being "on the water", be it lake, pond, wetland, river, or stream. It is difficult to place a dollar amount on lakeshore, but land's value is often increased dramatically if it's located near water, especially pristine water. Properly-managed lake and shorelines will add to the value of the premium price of water-front property.

Then, there's the value of being a good neighbor and having good neighbors. Lake property with congenial, caring, and cooperative neighbors is "worth its price in gold" though difficult to quantify in dollars and cents, it's an added value to the property.

Be a good neighbor who shares in proper lake management and who manages his own shoreline as well. It does pay off.

Dick Gray
Founder, Freshwater Society

COVER PHOTO: RICHARD HAUG

ABOUT THIS PUBLICATION

Minnesota's famed 10,000 lakes have been a source of pride and enjoyment for countless generations, but the pressures of population, development, and pollution are threatening the health of these natural treasures.

This guide, now in its second edition, provides some of the basics and specifics that concerned citizens need to help lakes survive and thrive. It describes how lakes work, how various lake problems occur, what individuals and groups can do to protect and improve lakes, and where advice and assistance can be obtained.

FRESHWATER SOCIETY

Minnesota Pollution Control Agency

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I. What is a Lake?

A lake is a body of water, but it is also much more. A lake is an ecosystem, a biological community of interaction among animals, plants, and microorganisms, and as well as the physical and chemical environment in which they live. Water bodies are generally considered to be lakes when they are at least ten acres in surface area and greater than six feet deep at some point. Smaller and shallower water bodies are considered ponds or wetlands.

Lakes are interconnected with other water resources. Lakes receive much of their water from streams and ground water. Wetlands adjacent to the lakes, or connected to lakes by streams, often serve as spawning grounds for fish and habitat for diverse species of plants and animals. Protection of all of these natural resources as a whole is vital to the protection of lakes. A complex interdependence has evolved among the organisms in a lake community. If one part of the ecosystem is disturbed, it affects other parts. A road, a housing development, a drainage project, a forest fire, acid rain, or other such changes in the watershed can alter the delicate balance of the lake ecosystem.

Well-balanced lake ecosystems, however, do change from season to season and from year to year. Short-term events, such as an unusual or excessive algal bloom, may not necessarily signal a long-term problem. On the other hand, changes in land use in the watershed may not immediately have a visible effect on the lake. For example, it may take a decade or more for changes in agricultural practices or urbanization to result in weed problems or fish kills.

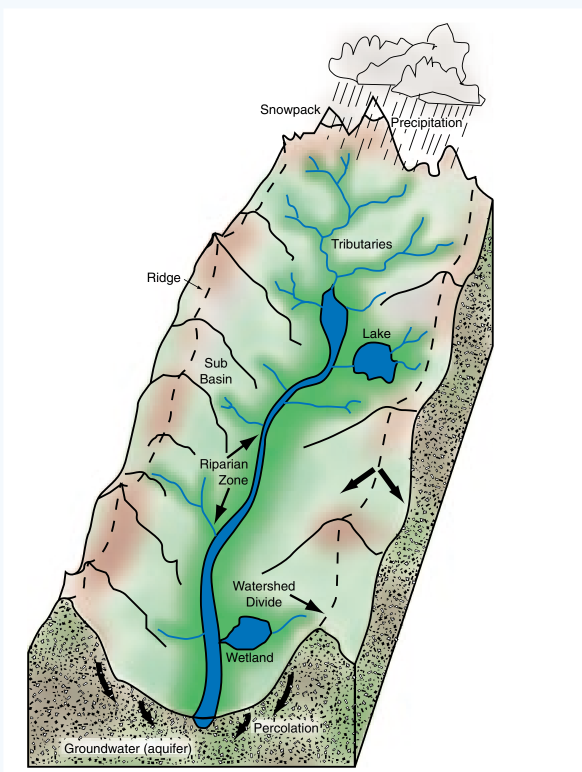
II. What is a Watershed?

Critical to any lake ecosystem is the lake's **watershed**, the surrounding land area that drains into that particular lake. Watersheds are defined by topography in which the high areas drain to the low areas. Water runs into a lake through direct **runoff** from the land, through a stream or ditch, or through a culvert or agricultural drain tile. In a more developed area, there may be multiple culverts that outlet to a lake. Water that runs off of yards, rooftops, parking lots, and driveways flows to the streets where it drains into underground **catch basins** and into the **storm sewers** that flow into lakes and rivers.

Lakes Begin...and End

Most lakes were created by past geological events. The vast lake and wetland-dotted landscapes found in North America were formed by glaciation in the relatively recent geologic past – 10,000 to 20,000 years ago. Glaciers formed lake basins by grooving holes in loose soil or bedrock, by depositing material across streambeds, or by leaving buried chunks of ice that melted and formed lake basins. More recently, humans and other animals have created lakes by damming rivers. Lakes constantly are undergoing slow evolutionary change, reflecting the changes that occur in their watersheds. Most lakes are destined to fill in with sand, silt, and topsoil washed in by floods and streams. These gradual changes in the physical, biological, and chemical environments of the lake affect the development, competition, and succession of many different plants and animals.

The natural process by which lakes form, evolve, and disappear takes thousands of years. Human activities, however, can change these lakes – for better or worse – in less than a single generation.



A lake is affected by its entire watershed.

III. How Do Lakes Work?

A necessary prerequisite for deciding how to protect a lake is developing a basic understanding of the physical, biological, and chemical properties of a lake. These properties – such as light, temperature, wind, precipitation, and nutrients – affect plants, animals, and the lake itself.

1. A Physical Look at Lakes

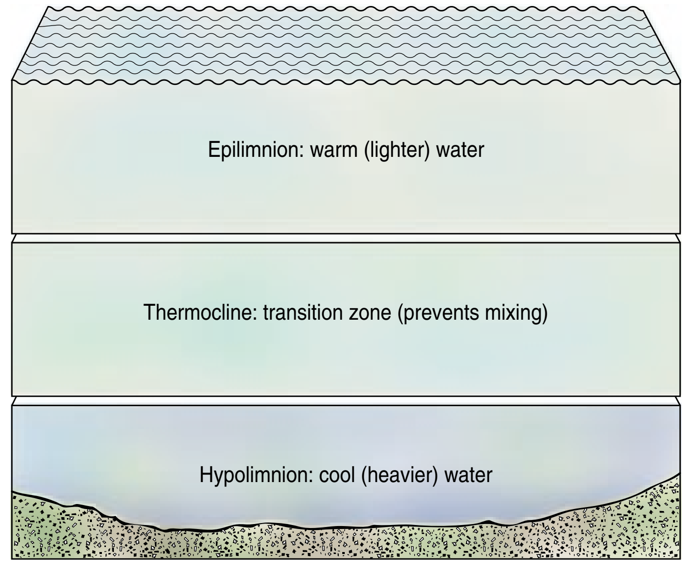
Lakes in temperate climates tend to stratify or form layers, especially during summer, because the density of water changes as its temperature changes. Water is most dense at 39°F. Both above and below that temperature, water expands and becomes less dense.

This means that in the spring, just before the ice melts, the water near the lake bottom will be at 39°F. Water above the lake bottom will be cooler, approaching 32°F just under the ice. As the weather warms, the ice melts and the surface waters begin to heat up. Wind action and increasing water density causes this surface water to sink and mix with the deeper water, a process called **spring turnover**.

As summer progresses, the temperature and density difference between the upper and lower lake water becomes more distinct, and most deep lakes form three separate layers. The upper layer, the **epilimnion**, is characterized by warmer water. The epilimnion is roughly equivalent to the zone of light penetration, where the bulk of productivity, or growth, occurs. Much of the plant and fish life is found in this zone.

Below the epilimnion is another layer, the **thermocline**, in which the temperature declines rapidly. The thermocline is a narrow transitional band between the warmer, upper and lower, cooler layers that helps to prevent mixing between the layers. Below the thermocline lies water much colder than the epilimnion, called the **hypolimnion**. The hypolimnion is the zone of decomposition, where plant material either decays or sinks to the bottom and accumulates. **Dissolved oxygen** levels are often very low in this layer.

Stratification: Lakes Form Layers



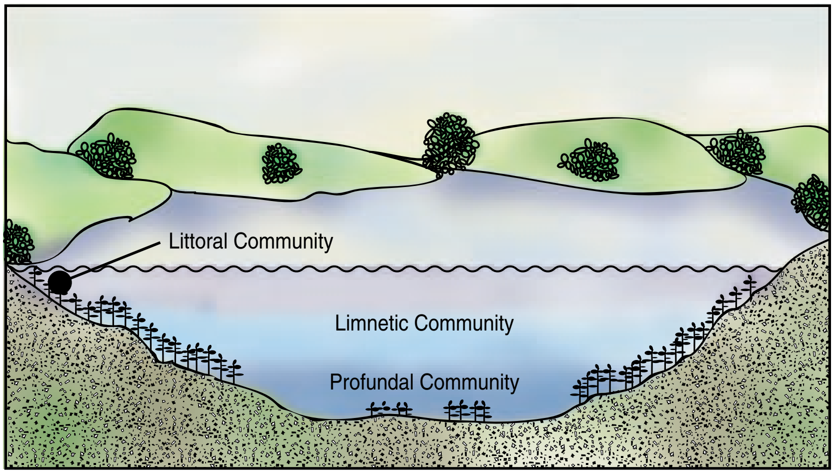
Lakes in the temperature climates tend to form layers. The epilimnion is roughly equivalent to the zone of light penetration where the bulk of productivity, or growth, occurs. The thermocline is a narrow band of transition which helps to prevent mixing between the layers. The hypolimnion is the zone of decomposition, where plant material either decays or sinks to the bottom and accumulates.

These temperature conditions will continue until fall. Then surface waters cool until they are as dense as the bottom waters and wind action mixes the lake. This is the **fall turnover.**

2. A Biological Look at Lakes

A lake can be divided into zones, or communities, of plants and animals. Extending from the shoreline is the **littoral** community, where aquatic plants are dominant. The size of this community depends on the extent of shallow areas around the lake and the clarity of the water for light penetration. Water lilies, duckweed, and submerged plants are abundant. These plants play an important role in the overall aquatic community by producing oxygen and providing food and shelter for insects, crustaceans, frogs, turtles, and fish. Maintaining the health and integrity of this zone is critical to the overall health of the lake.

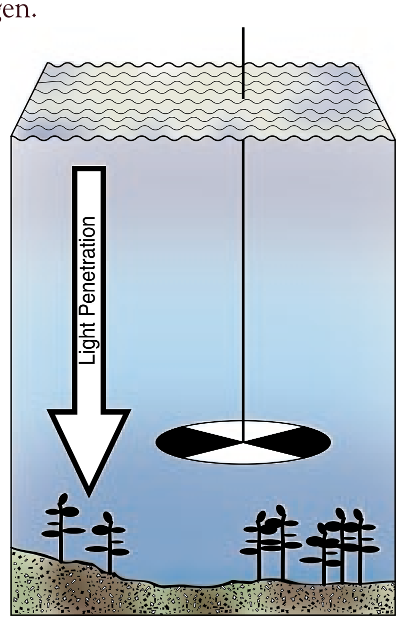
Lake Communities



A lake can be divided into zones or communities. Extending from the shoreline is the **littoral community**, where aquatic plants are dominant. The area of open water is the **limnetic community**, the habitat of algae, microscopic animals and fish. The **profundal community**, where light does not penetrate, is the habitat of bacteria and fungi.

The area of open water is the **limnetic** community. This area is the habitat of **phytoplankton** (algae), **zooplankton** (microscopic animals), and fish. Phytoplankton are very important, serving as the base of the lake's food chain and producing oxygen.

The process by which green plants, including algae, produce oxygen from sunlight, water, and carbon dioxide is photosynthesis. **Chlorophyll** is a pigment produced by the plants, which is essential for this process. Since sunlight is very important for photosynthesis, oxygen will be produced only as deep as the sunlight penetrates. The depth of light penetration can be measured using a **Secchi disk**.



Secchi disk measurement.

Below the limnetic zone is the **profundal** community, where light does not penetrate. This zone or community is dominated by respiration, or oxygen consumption, rather than oxygen production. This zone corresponds roughly to the hypolimnion layer. The community in this zone consists of such organisms as bacteria and fungi. These organisms decompose dead plants and animals that descend from the waters above. This process consumes oxygen.

Oxygen: The Key Ingredient for Lake Life

The presence or absence of oxygen in the different water zones determines where organisms will be found. Organisms such as fish, zooplankton, and aerobic bacteria all require oxygen. In the spring, when the water in the lake is well mixed, oxygen is usually present at all depths and thus the organisms may be distributed throughout the lake. In the summer, under layering conditions, little or no oxygen is produced in the hypolimnion. As oxygen is consumed through decomposition, levels may become too low for fish and zooplankton, and these organisms must occupy the upper waters or epilimnion.

If these conditions are prolonged and the upper waters become very warm, species such as trout, walleye and whitefish, which require cooler temperatures, may die.

With the onset of cooler temperatures and wind activity in the fall, a lake's thermal layers break down and turnover, replenishing oxygen to the bottom waters.

The formation of ice in winter severs the atmospheric supply of oxygen to the lake. If sunlight can penetrate through the snow and ice, algae and aquatic plants will continue to produce oxygen. If the snow cover is too great, this process will be inhibited. Since respiration and decomposition continue, the amount of oxygen consumed may exceed the amount produced. This is quite common in lakes that have large amounts of weeds, leaves, and other organic debris available for decomposition in the sediment. If oxygen levels fall too low, fish and other aquatic life may die, with game fish such as walleye and bass often being among the first to succumb.

3. A Chemical Look at Lakes

Plants require various substances for growth, including phosphorus, carbon, oxygen, and nitrogen. The concentrations of these substances in water control the total amount of plant matter that can grow. The quantity of each required substance varies. For example, a high percentage of all plant matter is carbon and a very small percentage is phosphorus. If any one of these substances is absent, plants cannot grow, even if the other substances are abundantly available.

In many lakes, phosphorus is the least available nutrient; therefore, its quantity controls the extent of algal growth. If more phosphorus is added to the lake from sewage treatment plants, urban or farmland **runoff**, septic tanks, or even from phosphorus-rich sediments stirred up from the lake bottom, more algae will grow.

In turn, the amount of algae in the water will determine how deep light penetrates as measured by the Secchi disk. Combined measurements of phosphorus level, algae abundance (expressed in terms of chlorophyll a), and Secchi disk transparency are used to identify the **trophic status** or the level of growth of a lake.

A **eutrophic** or nutrient-rich lake tends to be shallow, “green,” and has limited oxygen in the hypolimnion. An **oligotrophic** lake is relatively nutrient-poor, is clear and deep, and has a hypolimnion high in dissolved oxygen. A **mesotrophic** lake is intermediate between the two. Factors vary, however, from lake to lake, and assessments are necessarily subjective.

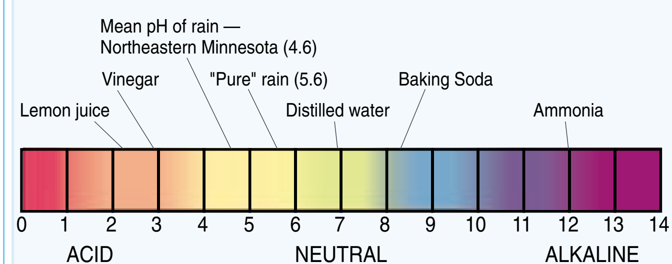
Other chemical factors also play an important role in lake ecology. The acidity of water, measured by the pH scale, is an important consideration for aquatic life. A desirable range in pH for aquatic life is 6.5 to 9.0. Values either higher or lower may interfere with reproduction, respiration, and other biological functions of aquatic life. Alkalinity, or buffering capacity, determines the ability of water to withstand great fluctuations in pH. The alkalinity of a lake generally depends on minerals, such as lime, in its watershed. Watersheds with soils rich in lime and related materials will provide much buffering to lakes, while those poor in lime, such as the bedrock region of northeastern Minnesota, will provide very little buffering capacity to lakes. These poorly buffered lakes are more susceptible to changes in pH and acid deposition or acid runoff.

The pH scale

The acidity of substances is measured by the pH scale of 0 to 14. Substances with a pH of 7, such as distilled water, are neutral. If a substance has a pH greater than 7, it is alkaline; if it is less than 7, it is acidic. Because the pH scale is logarithmic, each descending whole number represents a ten-fold increase in acidity. For example, a lake with a pH of 6 is ten times more acidic than distilled water, which is neutral at pH 7. Vinegar, at pH 3, is 10,000 times more acidic than distilled water.

“Pure” rain – that is, rain unaffected by any pollutants – is slightly acidic (pH 5.6-5.7), because it combines with carbon dioxide, a gas naturally present in the atmosphere.

But monitoring in northeastern Minnesota has shown that the average pH of rain is about 4.6 – ten times more acidic than pure rain. More recent data from the area indicates that the average rain pH may be even lower, or more acidic.



Lake color may result not only from algae growth but also from wetland drainage, which lends a "coffee-stained" appearance to the water. Suspended soil or clay particles can make water look "muddy." Coffee-coloring is common in northern Minnesota lakes, which receive naturally acidic drainage from wetlands. The muddy color is common in lakes with major inflowing streams. Both of these influences reduce the light penetration or transparency in a lake, and must be considered when assessing a lake's trophic status.

There's more to a lake than meets the eye! The physical, biological, and chemical factors that influence the workings of a lake provide the foundation needed to understand what can go wrong in a lake, and what to do about it.

IV. How Do Watersheds Work?

It has been said that a lake is a reflection of its watershed. In other words, a lake's quality depends upon what is carried into it from its watershed. The watershed not only carries water to the lake, but also pollutants of all types that can adversely impact the lake.

1. Hydrology

Hydrology is a technical term for water input and output. A lake receives water from precipitation, groundwater, and runoff from the surrounding watershed. Depending upon the lake setting, the runoff generated from rainfall is carried into the lake through streams, ditches, agricultural tile lines, and storm sewer culverts.

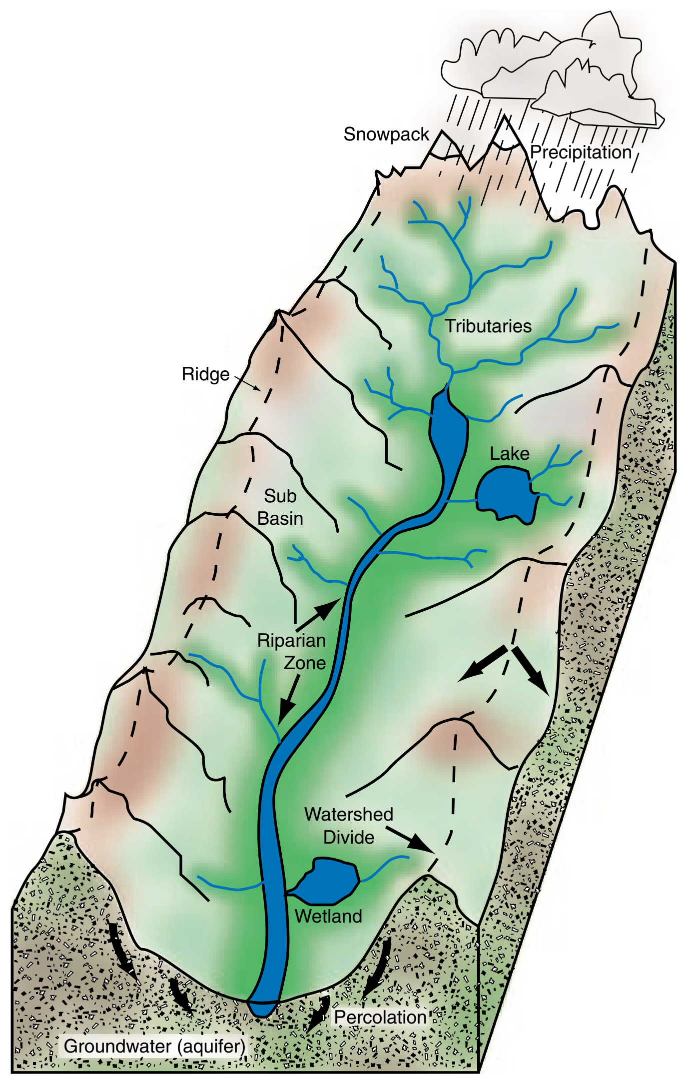
2. Pollutant Loading

Pollutants such as phosphorus and sediment, either suspended or dissolved, are carried into a lake along with the water. The amount of pollutants delivered to the lake is referred to as the pollutant load.

Pollutant load is the product of the volume of water multiplied by the concentration of the pollutant.

Pollutant Load = water volume x pollutant concentration

If the pollutant is in high concentration, the loading will be greater. If there is very little water entering the lake, the loading will be lower. For example, when a building is under construction, soil from the site can erode and be carried in runoff to a lake. The resulting sediment load is equal to the concentration of sediment in the water multiplied by the volume of water flowing into the lake carrying the sediment.



A lake is affected by its entire watershed.

V. What Can Go Wrong In Lakes?

1. Eutrophication: The Weeds Take Over

Eutrophication is the process by which lakes are fertilized with nutrients, which are chemicals absorbed by plants and used for growth. It is a natural aging process, but human activities can speed it up – with more algae and aquatic plants, often called weeds, the result.

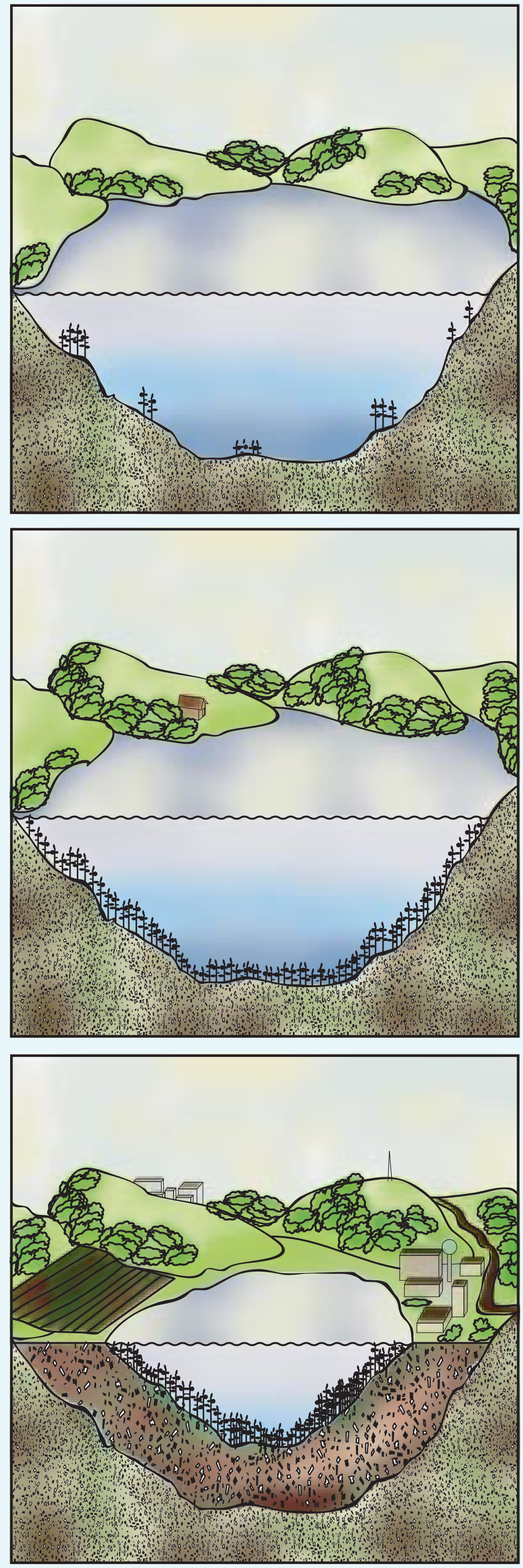
As nutrients such as nitrogen, phosphorus, and potassium, wash into lakes in runoff water or by soil erosion, these chemicals fertilize the lake, allowing algae and weeds to grow. As plants die and decompose, they accumulate on the lake bottom as muck. After hundreds or thousands of years of plant growth and decomposition, the character of a lake may more closely resemble a wetland. This aging is called **natural eutrophication**.

Lakes can also obtain nutrients from various human activities, which can literally make a lake "old" before its time. This accelerated aging is called **cultural eutrophication**. Nutrients washed from agricultural areas, stormwater runoff from urban areas, municipal and industrial wastewater, runoff from construction projects, and even recreational activities contribute to cultural eutrophication. When human activities increase the rate of nutrient and sediment enrichment of a lake, pollution is occurring.

Nutrient and other pollution sources discharged to a lake from specific locations, such as municipal and industrial wastewater outlets, urban stormwater outlets, or other point sources are easy to identify. This type of pollution is also relatively easy to control through treatment projects and has been the focus of much of the water pollution control work to date.

Nutrients and pollution sources that are not discharged from a specific pipe, but instead are washed off the land or seep into ground water, are known as **nonpoint sources** of pollution or polluted runoff. These include runoff from agricultural fields and feedlots, leakage from septic tanks, nutrients from wetland drainage and stormwater runoff, and others. Polluted runoff is best controlled through wise land use practices, also known as **best management practices (BMP's)**.

Lake Eutrophication



The natural process by which lakes form, evolve, and disappear takes thousands of years. Human activities, however, can change these lakes – for better or worse – in less than a single generation.

2. Sedimentation: The Lake Fills In

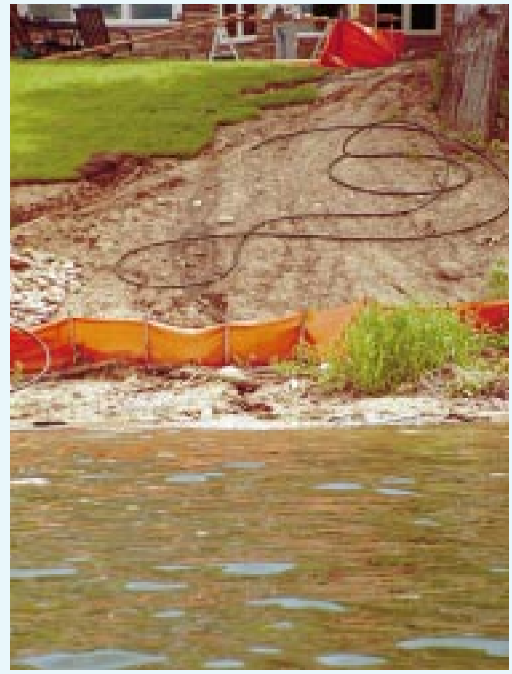
Closely associated with eutrophication is **sedimentation**. Wind and water move soils from the surrounding watershed into a lake, a process known as **erosion**. These soils settle on the bottom of the lake causing the lake to become increasingly shallow. This process is a natural part of lake aging, governed by gravity and the forces of rain and wind. Erosion and sedimentation can be greatly accelerated by human activities that leave the soil without vegetation for extended periods. Construction activities that cause soils to be bare and intensive agricultural activities, such as plowing near lakes and streams or farming steep slopes, leave soils vulnerable to erosion.

This problem is best controlled through soil and water conservation practices and maintaining vegetation on soils.

3. Acidification: Air Pollution Affects Lakes

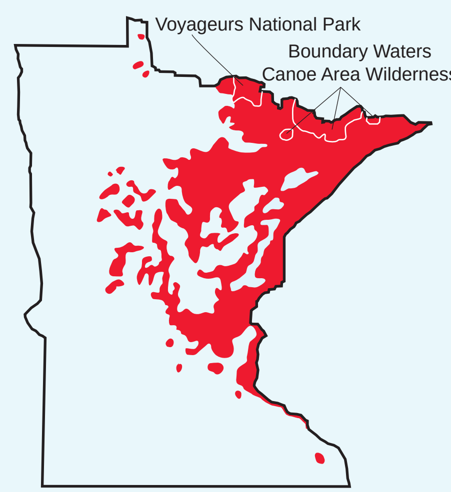
Acid rain occurs when air pollution, sulfur, and nitrogen oxides from power plants, factories, and cars mix with cloud moisture to form acidic compound which eventually fall to earth in rain, snow, or dust. Acid rain can change the chemical balance of a lake, sometimes with severe consequences. In Canada, New England, and Scandinavia, thousands of lakes are now too acidic to support fish and other aquatic life. In Minnesota, lakes in the northeastern part of the state are considered the most sensitive to acid rain because of their very low alkalinity, or ANC (acid neutralizing capacity). The concern raised about acid rain in the 1980s lead to the creation of state and federal emission control laws that reduced emissions and virtually eliminated the potential for acidification of Minnesota's lakes.

Another reason that Minnesota lakes never were acidified is that natural bacteria convert the sulfate from sulfuric acid to hydrogen sulfide, a process that consumes the acid. This would be entirely good news, except that new research has shown that these are the same bacteria that produce methylate mercury. Methylmercury is the only form of mercury that accumulates in fish. Therefore, it is probable that acid rain has contributed to increased mercury contamination of fish, even in the absence of acidification.



Properly maintained silt fences can minimize erosion caused by construction activities.

Acid-sensitive areas of Minnesota



As a result of the state's glacial history, much of northeastern Minnesota and parts of north central Minnesota have thin soils and exposed bedrock. Most of the state's acid-sensitive lakes are in these areas. Moreover, these areas receive an average rainfall of pH 4.6, ten times more acidic than normal rain (pH 5.6). In contrast, agricultural lands in southern and western Minnesota receive rain with a close-to-normal pH and also have a low sensitivity to acid rain.

4. Toxic Contamination: Excess Chemicals Contaminate Lakes

Toxic chemicals may enter and contaminate lakes from a variety of sources:

(1) industries use chemicals that may enter lakes from direct discharge or runoff from their facility;
(2) farmers use pesticides or herbicides that may runoff into lakes;
(3) urban storm runoff containing metals, salts, and pesticides may enter lakes;
(4) wastewater discharge may contain pharmaceuticals that can enter lakes; and,
(5) chemicals in the air, in particular mercury, may enter lakes in rain and snow.

Toxic contamination may be dramatic – such as fish kills that eliminate part or all of a lake's fish population. Less obvious impacts may include decreased reproduction or slower growth rates in fish and other aquatic life.

One particularly dangerous impact is the bioaccumulation or build-up of toxic substances in fish at the top of the food chain. The most widespread example of this concern is mercury contamination of **piscivorous fish**, which occurs in virtually every lake because of air pollution. Not only may these fish experience effects on their ability to reproduce, but the toxic effects may be passed on to humans and wildlife eating the fish. Because of potential health effects, Minnesota has fish consumption advisories for mercury on virtually every lake in the state and for PCBs (polychlorinated biphenyls) on a few lakes. Fortunately, PCBs are no longer manufactured, therefore the concentration of PCBs in Minnesota fish has declined markedly over the past decade. There is some evidence that efforts to reduce mercury use and emissions are also resulting in fish with lower levels of contaminants.

5. Exotic Species Infestation: The Aliens Have Arrived

Another threat to lakes is the infestation of the lake by exotic species. Several exotic species have caused considerable harm to our lake ecosystems. Because these species are imported from another area or country, they do not have natural predators. This allows them to grow and out-compete many of our native species. Scientists are working to develop methods to control these exotic species. The best control is preventing introduction of the plant or animal species to a lake. Educational efforts to teach the public about preventing introduction of these species are ongoing. Learn to recognize these species. Some of the exotics found in Midwestern lakes include:

- Curlyleaf Pondweed
- Yellow Water iris
- Purple Loosestrife
- Rusty Crayfish
- Eurasian Watermilfoil
- Spiny Water flea
- Water Lilies, non-native
- Zebra Mussels
- Flowering Rush

Rusty Crayfish

Zebra Mussels

VI. What Can You Do To Take Care Of Your Lake?

Taking care of your lake may require lake and watershed stewardship, lake management, lake restoration, or a combination of all three. These three terms – stewardship, management, and restoration – are related but not interchangeable.

1. Lake and Watershed Stewardship: An Attitude

> "Treat the Earth well. It was not given to you by your parents; it was loaned to you by your children."
>
> Ecologist Lee Talbot

Lake and watershed stewardship really is an attitude – and it is the first important step in protecting a lake. Stewardship reflects an understanding that what we do on land and in the water affects the lake.

Stewardship centers on thoughtful consideration of the intricate lake ecosystem and the interdependence between the lake and its surrounding watershed. Stewards understand the need to better balance our lives and lifestyles with the needs of our lakes.

In short, it is a recognition that lakes are vulnerable – that in order to make them thrive, citizens, both individually and collectively, must assume responsibility for their care.

2. Lake Management: A Process

Lake management is a process. A lake manager displays a willingness to study a lake, to assess its status and its needs, and to determine how best to maximize the lake's potential as a thriving ecosystem.

Lake management can be as simple as fostering the practices of stewardship among lake homeowners and other interested individuals. It can also include taking an active role in altering specific ecological relationships within the lake and its watershed to make a lake healthy and keep it healthy. Lake management can also include protecting the health of a lake ecosystem through a plan of preventive action.

Lake management, to be effective, requires the coordinated efforts of a group of individuals in the form of a lake association, sporting or conservation club, or another organization or group of stewards.

Storm sewers carry rain water and debris to nearby water sources.

3. Lake Restoration: Corrective Action

Lake restoration, also referred to as rehabilitation, is an action directed toward a lake to "make it better." It is one example of a lake management technique. The complexity and expense of this activity requires an organization with some authority over the lake and its watershed, such as a lake improvement district or watershed district. It can also be accomplished through a cooperative effort of many groups, such as the lake association, city, watershed organization, or state agency. Lake restoration is sometimes associated with chemical treatment of a lake. Usually, lake restoration is much more than this. Treating the lake with chemicals is like putting a bandage on the injury; it does not stop the harming event from happening again and will only be temporarily effective in masking the problem.

VII. Lake and Watershed Stewardship: What Can An Individual Do?

"Never doubt that a small group of thoughtful, committed citizens can change the world; indeed, it is the only thing that ever has."

Margaret Mead

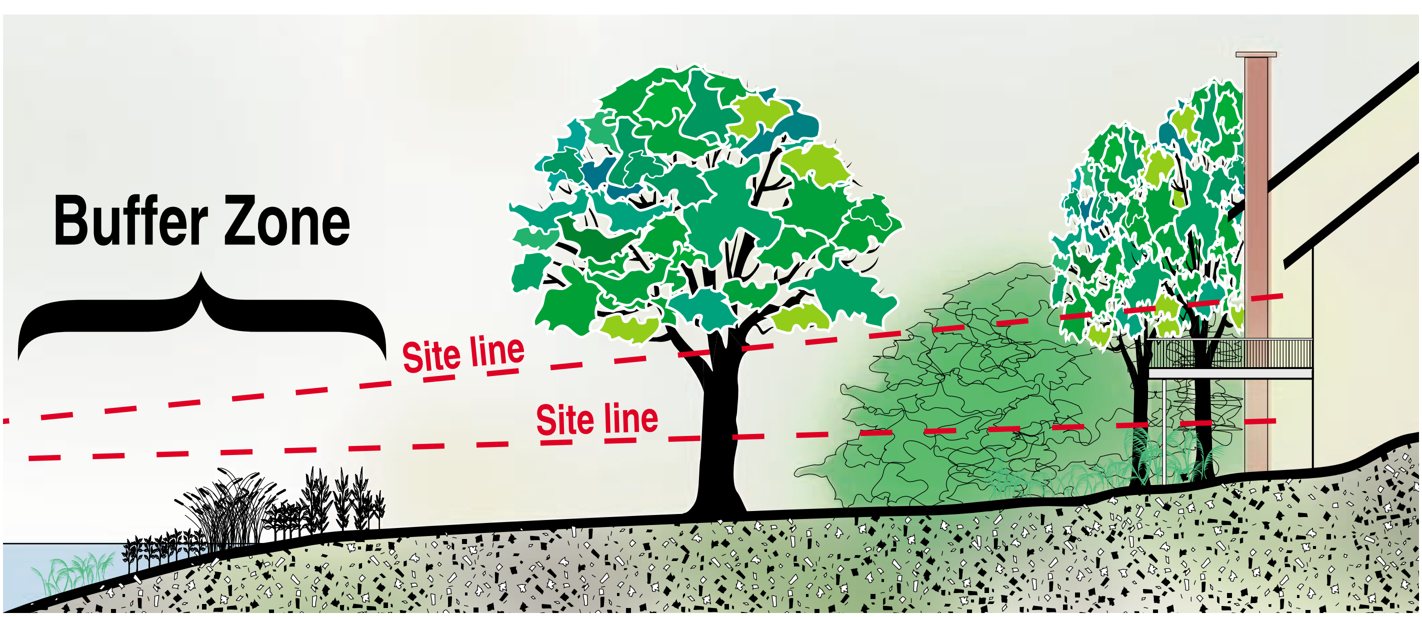
Good stewardship by the individual, whether a lake homeowner or simply a lake user, can do much to enhance the lake environment and serve as a beginning for sound lake management. Although most of the following comments are directed to lake homeowners, many also apply to those who live anywhere within a watershed. One of the most important things an individual can do is to get involved with other concerned citizens. Collective efforts will yield the greatest dividends for you and the lake.

Here's what you can do to protect and improve a lake by minimizing polluted runoff into the lake. Many of these suggestions are based on shoreland management laws, such as those in Minnesota. Local and state regulations are in place to help protect our lakes, stream, and wetlands. Be sure to check with your state natural resource agency and local planning and zoning authority before doing any work near a lake, stream, or wetland. In many cases a permit is required.

1. Plan Wisely Before Building

The location of a house or cabin and septic system can negatively affect the lake if not sited properly. Minimize any impacts by following these guidelines.

- Don't let the house intrude upon the lake. Position a new house and any future additions to meet horizontal setbacks and vertical elevation requirements and to avoid damage if the lake rises dramatically in the future. Preserve as much natural vegetation as possible between the house and the lake to filter sediments and nutrients from surface runoff.
- Consider other facilities, particularly wells and septic systems, when siting the house. The septic system should receive priority since adequate soil conditions are necessary for its proper functioning. Site evaluators and many sewage system installers can conduct soil borings and percolation tests and consult soil maps and data to determine the best location on the lot. Wells should be located upslope from sewage systems and be deep and cased whenever possible. A site sketch of the lot, drawn to scale, will help to decide the best locations for all facilities and is often required when obtaining permits.
- Contact a county zoning officer or city to determine what permits will be needed and what standards must be met. Take a personal interest in meeting the regulations. Don't leave the arrangements entirely to the contractors.



- If a standard septic tank and drainfield system is unsuited for the lot, an approved alternative system, such as a mound system, may be used. On some lots a holding tank may be the only feasible system. A composting toilet or community mound system are other options to consider.
- Make sure the contractors know which trees should be saved. Fence off areas to protect trees and roots from construction damage.
- Don't place a road or wide path down to the lake. This creates a direct route for runoff. Make the path narrow and curvilinear. If access along a steep slope is needed, consider a wooden stairway rather than a path. This will help reduce runoff to the lake.

2. Minimize Waterfront Alterations

To protect the lake, minimize any changes to the waterfront. It is important that homeowners check local and state regulations before beginning any alteration work.

- If a sandy beach is desired, try to buy a lot with a natural sand beach. Sand dumped on the shore to create a beach can seriously affect the habitat of fish, birds, frogs, and aquatic insects. If the beach was not originally sandy, adding sand usually is only temporary. It often washes away or is quickly overlain with organic matter.
- Make waterfront equipment such as docks and boat houses as unobtrusive as possible. Avoid structures that require much tree clearing, excavating, or filling. Think about the view from the lake.
- Think twice before putting in a lawn down to the lake. A short turf may attract nuisance geese. Maintain as wide a buffer zone of natural vegetation as possible between the lawn and the water's edge. Determine how much area is really needed for recreation. For example, on a 100 foot lot, maybe a 25 foot wide strip of lawn for access to the dock and swimming area would be adequate. Leave the rest in natural vegetation. If it has already been removed, replant the area in native grasses, wildflowers, trees, and shrubs. Additional resources on shoreline restoration can be found in the reference section of this publication.

3. Modify Yard Care

Yard management can have a positive or negative effect on the lake ecosystem. Whether the property is on the water or not, there are many simple practices homeowners can do to reduce pollution to their watershed.

- Minimize the amount of turf. Leave or plant more of the yard in native grasses, wildflowers, shrubs, and trees.
- Minimize the use of pesticides, herbicides, and fertilizers, which can harm the lake.
- Don't burn brush or leaves on a slope from which ashes can wash into the lake.
- Use a broom to sweep up the driveway rather than hosing it down to the storm sewers.
- Sweep up leaves and grass clippings out of the street to prevent them from being carried into the lake where they decompose and use oxygen.
- Cut turf grass at a height of 2 1/2 - 3". Aerate the lawn to promote infiltration.

4. Take Care of On-Site Wastewater Treatment System

Most homes that are not on a public wastewater treatment system are equipped with individual on-site septic systems. Even a properly operating septic system isn't entirely efficient in removing pollutants from waste. Inadequate treatment of wastewater may be a risk to human and animal health. Untreated wastewater contains viruses, bacteria, and other disease-causing pathogens that can enter ground or surface water and make drinking water or beaches unfit for use. Wastewater also contains nutrients that contribute to lake **eutrophication**. Wastewater discharged from the septic tank contains nitrogen and phosphorus. Much of the phosphorus is adsorbed or attached to the soil particles while the nitrogen is carried in the water through the soil. Some of the nutrients are used by trees, grass, and other plants or converted to gas by bacteria. Some remain in the groundwater where they can be discharged into a nearby lake or stream.

Improve the treatment of wastewater from the home by taking the following actions:

- Consider an alternative wastewater treatment system such as a composting toilet, gray water system, or holding tank. These systems do not pollute the soil or groundwater and should be considered for new or upgraded construction adjacent to surface waters or in areas with high water tables.
- Don't let the septic system pollute the lake. Proper maintenance is vital to keep the system working properly. Have the septic tank checked every other year and pumped when necessary, at least every three years.
- Replace failing septic systems or those that are not in compliance with current rules.
- Use non-phosphate detergents, wash only full loads of clothes, and use water-saving showers and toilets to avoid stressing the septic system. In Minnesota, phosphates in household laundry detergents have been banned since 1977. However, they are still allowed in water-softening products and dishwashing detergents.
- Do not use a garbage disposal, and keep solvents, plastics, paper, diapers, and other similar products out of your septic system. These may harm the septic system or plug the drainfield. Use only minimal amounts of mild drain cleaners and cleansers.
- Don't use septic system additives. They are not needed and may do more harm than good.

5. Reduce Runoff From The Yard

Reducing the amount of water leaving the property reduces the pollutant load reaching the lake. Here are some ways to reduce runoff.

- Limit the amount of impervious areas such as driveways, sidewalks, patios, and plastic under landscape rock so that water can soak into the ground rather than run off.
- Direct downspouts onto a vegetated area rather than the driveway or sidewalk.
- Have the lawn aerated regularly to reduce compaction of the soils and improve infiltration.
- Install rain gardens or rain barrels to collect water that would normally run off into the street.
- Grade areas and direct runoff so that it spreads out into a larger area rather than flowing in a concentrated stream.
- Replace lawn with long, fibrous-rooted, native plants to promote infiltration and transpiration of water.
- Direct drainage from the sump pump to a vegetated area where it can infiltrate.

6. Modify Boating, Swimming, and Fishing Practices

Our lakes are wonderful recreational areas. Help keep them safe for humans and wildlife by following these practices.

- When purchasing a boat motor, choose a 4-cycle rather than 2-cycle engine. A 2-cycle engine loses approximately 30% of the gasoline to the air and water. A 4-cycle is much more efficient and less polluting.
- Replace your lead sinkers and tackle with non-lead alternatives. The lead is toxic to loons and other waterfowl that ingest it when feeding.
- Practice slow-no-wake boating in the near-shore areas. Waves produced by boats or powered water bikes contribute to shoreline erosion and churning up of the bottom sediments.
- When entering or leaving a lake, check the boat, trailer, anchor, and bait buckets for exotic species such as Eurasian watermilfoil and remove all aquatic plants and animals. Notify the local natural resources department if a questionable species is found.
- Don't use the lake as a toilet. This applies to ice fishing as well as open water fishing. Dispose of wastewater properly.
- Don't use the lake as a bathtub. Soaps and shampoos contain nutrients and pollutants that are harmful to the lake and animal species. Wash and rinse on the land, not in the lake.

VIII. Lake and Watershed Management: What Is It?

Lake management requires a general knowledge of lake ecology, the causes of natural and cultural water quality problems, the techniques for restoring and protecting the lake, the legal and financial realities to be considered, and the resources available to concerned citizens.

Lake management begins with ecological awareness. Just as the art of the landscape painter begins with an understanding of the relationship between elements in the landscape, so must a lake be seen as part of an interdependent system of surface and subsurface flowing water and plant and animal habitats that relate to, and rely on, each other.

'preventative action should be the first priority'

Two Philosophies of Lake Management

Lake management approaches can be divided into two categories. One is the "quick-fix" approach. The other is long-term environmental management.

1. The "Quick-Fix" Approach

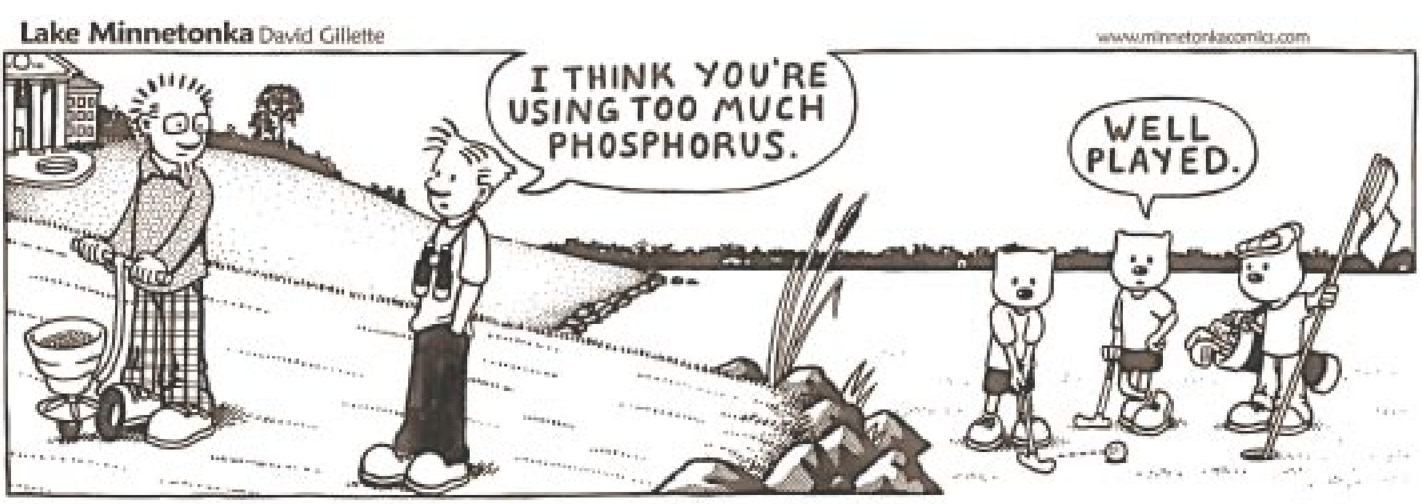
The "quick fix" in lake management is a short-term solution, such as the application of aquatic herbicides to quickly kill unwanted algae. Such chemical applications can go on year after year, becoming increasingly less effective if the underlying causes of the algal growth are ignored.

The "quick fix" treats the biological symptoms of a lake problem, but plant and fish productivity are directly dependent on the chemical and physical processes going on in and around the lake as well. These underlying factors must be the principle consideration in any plan to change the biology of a lake.

2. Long-Term Lake Management

Long-term lake management considers all of the environmental, cultural, and biological factors affecting the lake and sets a higher priority on finding lasting solutions than on pursuing quick, cosmetic treatment of symptoms.

A high quality, financially efficient, environmental project takes time and begins with long-range planning. If immediate in-lake rehabilitation techniques are necessary, the community will need to be sure that such immediate rehabilitation efforts are followed by appropriate long-term management techniques.



One pound of phosphorus can grow up to 500 lbs of plants or algae.

IX. Lake and Watershed Management: Taking Action

> "When it comes to the future, there are three kinds of people: those who let it happen, those who make it happen, and those who wonder what happened."
>
> Carol Christensen

Lake management often begins with concern for a particular lake. The lake may no longer live up to someone's expectations, whatever they might be.

Deteriorated lakes can be rehabilitated, but the task is difficult. Understanding of lake ecosystems is incomplete, and even when technical answers are available, they may be expensive to apply. Further, the results of a lake restoration project may not be apparent for years.

Action to protect and restore a lake may be taken by individual lake property owners and by lake associations, usually with the assistance of one or more governmental units.
A group of concerned citizens uniting as a lake association is the first step toward resolving lake problems. The association may already exist as a local conservation club, a rod-and-gun club, the chamber of commerce, or another concerned group. An effective lake association includes not only lakeshore property owners but also people who have various other interests in the lake. If lake management is initiated by a municipality or other governmental unit, it is a good idea to form an advisory group of interested citizens by seeking volunteers from the association or other concerned civic groups.

Four Initial Steps

1. Set Goals

Where does a lake association begin? The first order of business is to set goals. The goals of a lake management program are set according to what the members of the association expect the lake to be. These goals are usually based on social judgments and definitions of values. Throughout the planning process, these expectations require continual review and modification as information is gathered and as environmental, technical, institutional, and financial realities become clearer. Expert advice should be sought to determine if the goals are realistic. For example, a clear, blue, oligotrophic lake may not be attainable due to various factors such as its location and depth.

2. Find Partners and Assess Levels of Commitment

Identify people and resources that can provide help. Local, county, state, and federal agency staff may be willing to assist you with part of your lake management program. Statewide organizations, such as the Minnesota Lakes Association, provide a forum for sharing experiences and information about lakes and lake management. Know what financial and time commitments the group is willing and able to make. It is easy to overlook these factors in an initial eagerness to get results, but realistic assessments of available time and finances are critical to success.

3. Acquire Background Knowledge

Get acquainted with the principles of lakes. Understand the direct and critical relationship between a lake and its surrounding shoreline. The better the understanding of the relationship of a lake to its watershed, the more likely effective management choices will be made. Help is available in local communities. A high school or community college science teacher may be able to help residents better understand the lake. The county planning and zoning office can provide information on present and future land use in the watershed. The soil and water conservation district can provide information on soils and assist in mapping the area draining into the lake. The Freshwater Society and state natural resource agencies can help increase the understanding of the interdependence of land use practices and lake protection.

4. Determine the Current Status of the Lake

It is important to determine the current water quality or trophic status of the lake. This will provide a baseline for assessing changes in water quality over time and determining the effectiveness of management practices. This may be as simple as getting involved in a citizen's lake-monitoring program. Or, if major management choices are to be made, a complete water quality study of the lake and its watershed may be necessary.

This is a good point at which to seek professional advice. Water quality data may be available from the Minnesota Pollution Control Agency (MPCA), Minnesota Department of Natural Resources (MDNR) or your watershed, county, or city. Data summaries are now widely available on the web. See the Appendix for some of these web addresses.

5. Develop a Lake Management Plan

A lake management plan is a written document that lists known information about a lake, defines existing conditions and problems, and lays out instruction for short and long-term management of the lake. This may include a section on managing the excessive weeds and algae, an exotic species control plan, a plan for lake use and hours for boating, a monitoring plan, a plan for surveying septic systems, an education plan, a fisheries management plan, and other plans that address issues specific to your lake. The lake management plan provides direction for the future activities of the lake association and others concerned about the lake. It helps define a path to reach the goals set by the lake association. Guidance on developing a lake management plans is available on the web as listed in the Appendix.

6. Voice Your Concerns

Let local officials know that there is interest in the lake. When a change in land use is proposed, such as a development or feedlot, attend the meetings where decisions are made and voice concerns. Become informed about the affects of land use changes on lakes and methods to reduce impacts. Educate local officials about the value of the lake to the community.

7. Decide How to Proceed

After the association has gone through these initial steps, it will have a basis for determining the level of management that is reasonable for the group to try to attain. This management may be as basic as fostering the concepts of stewardship among its members and others who live near the lake. To be effective may require that the association work closely with city, county, or state officials to seek enforcement of any existing regulations protecting the lake, as the association has no statutory authority of its own. This level of management may be adequate for preserving the existing quality of the lake.

In cases where the existing quality of a lake is not acceptable, more direct measures may be necessary. Many times these measures are directed at the biological symptoms of the problem such as algal blooms or excessive weed growth, with chemical treatments and weed harvesting being common responses. While these treatments do provide short-term relief from these symptoms, they do not address the underlying cause, which is generally tied to land-use activities in the watershed that promote excess runoff of nutrients and sediment. The association should seek to address the causes as well as the symptoms of such problems.

Even with good stewardship and concerted efforts by a lake association, the water quality of a lake may have deteriorated to the point where basic management of the lake and its shoreline is insufficient to create acceptable conditions. Lakes at this advanced stage of eutrophication are often characterized by fish kills, excessive weed growth, and frequent algal blooms. At this point, restoration may be necessary.

X. Lake Restoration: What's Involved?

At some point a lake association may need additional help to effectively manage a serious water quality problem. In some instances, responsible management and preventive action may not be enough. Lake restoration, a more complex challenge, involves restoring a lake to a previous – and presumably better – state.

The financial resources of the association and the willingness of its members to participate are critical considerations in making a decision to pursue lake restoration. Lake restoration is not just a yearly process of adding chemicals to an affected lake. Restoration is complex and expensive, usually requiring financial capabilities and statutory authority beyond those available to a lake association.

Four initial steps in considering lake restoration should help prepare an association to decide how – or whether – to proceed.

1. Re-evaluate Goals

Before beginning lake restoration efforts, the lake association should complete a re-evaluation of the mission, including an assessment of the following:

- What are the goals of the association?
- What is the level of commitment of the members?
- What are the financial resources of the association?
- What does the available information tell us about the lake and its watershed?

2. Pursue a Higher Level of Organization

Sometimes a thorough search will reveal that data and possibly reports already exist for a lake. Check with the state natural resource agencies, county, city or township, watershed management organization, or nearby college. Some of this data is available on the web. It may be wise at this time to seek professional advice both to evaluate the data collected and to suggest how the association should proceed. Depending on the answers to these questions, a higher level of organization may be necessary to carry out the lake management process.

A variety of local governmental units exists that can help with lake and watershed management, including lake improvement districts, sanitary districts, watershed districts, and soil and water conservation districts. In addition, cities and counties may play a very important role either directly by taking the responsibility for this work, or indirectly by sponsoring or assisting in the establishment of a special-purpose local governing unit.

Once the association has decided that a higher level of organization may be necessary to manage the lake, a first step should be to contact local authorities (city and county) to determine whether any organization already exists to fulfill this task. If these local governing units exist, the lake association should seek to work with them closely, since they will likely have the statutory authority and serve as an additional source of funding to carry out a more complex study or project. Consultation with professionals at the MPCA and MDNR may also be helpful at this point.

3. Explore Financing Sources

Funding cannot be addressed in depth in this publication because the outside sources of funds, such as state and federal aid, are continually changing. It is important, however, to distinguish between the funds available to lake associations and those available to organizations such as lake improvement districts. The primary sources of funding for lake associations are generally voluntary contributions and fund-raisers. In contrast, such organizations as lake improvement districts and watershed districts have taxing authority and also are considered "grant-eligible bodies." This simply means that if state or federal funds are available for lake and watershed work, these organizations are eligible to apply for these funds. Among other recognized grant-eligible bodies are cities, counties, and regional planning agencies.

Consult with local and state officials, such as the MPCA and MDNR, to identify the current status of these programs and identify other programs that may be available for cost-sharing of projects. The list of funding sources and web sites at the end of this publication will be helpful.

4. Conduct a Lake Study

Before any lake restoration can take place, the lake and its watershed should be studied in detail. Such studies are often termed "diagnostic-feasibility" or "feasibility" studies. The study's purpose is to accurately characterize the chemistry, biology, and hydrology of the lake and determine the amount and character of runoff from its watershed. Only after such a study is conducted can an assessment be made as to which restorative techniques, if any, may improve the quality of the lake. The study diagnoses the lakes problems and causes, much as a medical doctor diagnoses health problems. Typical elements of a diagnostic-feasibility study include the following:

In the lake

- Water chemistry, in particular phosphorus and nitrogen levels
- Dissolved oxygen and temperature
- Secchi disk transparency
- Chlorophyll a
- Phytoplankton (algae) and zooplankton identification
- Macrophyte (large aquatic plants) study
- Sediment characteristics
- Fish population

In the watershed

- Inlet and outlet flow
- Inlet water chemistry
- Land use – past, present, and future
- Soil erosion inventory
- Precipitation
- Vegetative cover
- Wastewater disposal system survey

Contact the MPCA or the Freshwater Society for information on conducting feasibility studies.

5. Prepare an Implementation Plan

After a diagnostic-feasibility study is conducted, information is available to prepare an implementation plan. The diagnostic study identifies sources and the magnitude of pollutants. An implementation plan is prepared to address prioritizing and reducing the sources of pollutants. Examples of implementation activities are included in Chapter XI.

XI. Lake Restoration: What Can Be Done?

Lake restoration includes both in-lake treatment techniques and watershed techniques for the purpose of "restoring" a lake. It is critical to remember, though, that the watershed is usually the key to helping a lake recover its long-range vitality. The term "restoration" is probably a misnomer. A lake can never be completely restored to its original complex physical, chemical, and biological conditions. However, lake conditions can be improved.

The selection of restoration techniques will vary from lake to lake depending on results from the feasibility study and available funding. In general, a well-designed restoration plan will include at least some work in the watershed to stem the flow of nutrients and sediment to the lake. In fact, in-lake techniques may not be necessary since the lake may filter itself over time if external nutrient sources are reduced. In-lake techniques, though, may speed up the natural process.

It is important to remember that most if not all of the techniques mentioned require a permit and in some cases will require working directly with MPCA, MDNR, watershed district, or other government agencies.

In-Lake Techniques

In-lake techniques are those that are conducted in the lake itself and may include physical, chemical, and biological measures.

1. Physical Measures

Aeration and circulation are techniques that involve moving the water and adding oxygen, which increases dissolved oxygen levels. This may prevent fish kills and create a larger habitat for fish and microscopic animal communities. Aeration can also slow the tapping of phosphorus from bottom sediments. Results, however, are not always predictable.

Dredging removes sediment, which can be a major source of phosphorus in the water and can hinder recreational use of the lake. Sediment removal, however, is costly. Disposal of the dredged sediment is often a problem.

Dilution and flushing introduces nutrient-poor water and flushes out nutrient-rich water, decreasing the concentration of pollutants and thus the potential for algal growth.

On-shore treatment techniques involve pumping water on-shore, water treatment, and then allowing the treated water to re-enter the lake. Options for such treatment include artificial waterfalls for aeration and using the water to irrigate and fertilize field crops or wetlands, which removes nutrients from the water before it drains back into the lake.

Drawdown lowers water in an impoundment and can sometimes control weeds by exposing them to drying or freezing. Exposing the littoral zone may also result in shrinkage of soft muck, thus deepening the lake without expensive dredging. This process may also cause erosion of the shoreline. Drawdown can be useful in encouraging growth of plants beneficial to waterfowl.

Harvesting removes nutrients from the system by eliminating algae, plants, and fish. In eutrophic lakes, however, only relatively small amounts of nutrients are removed by mechanical harvesting. It is primarily considered a cosmetic improvement, like mowing a lawn.

Bottom sealing cuts off sediment as a potential source of nutrients through the application of such chemicals as alum (aluminum sulfate) or calcium nitrate.

Shading uses a dye to color the water and prevent penetration of light into the water column. The light limitation may inhibit the growth of plants and algae. Dye must be reapplied periodically. This method is used mainly in ponds or very small lakes.

2. Chemical Measures

Algal toxins (algaecides and barley straw) are a means of quickly and briefly controlling severe nuisances, such as algal blooms, that interfere with recreation. The treatment does not remove nutrients from the lake, and repeated treatment may be necessary in the same season. After repeated treatments, chemicals and metals such as copper may build up in the sediments and fish.

Algaecides, pesticides that are effective on algae, are usually broad-spectrum, killing many plants and animals in the lake as well as the algae. Use of the water by humans is restricted for a time following the application of such chemicals.

Barley straw has been used to treat small lakes and ponds. Natural toxins in the straw inhibit the growth of algae in the water. The straw is placed in netting bags and staked in multiple locations around the lake.

Application of algal toxins, treats the symptoms inadequately, does little to solve the problem, and may lead to a buildup of undesirable chemicals and metals in the lake. These techniques are seldom incorporated into a comprehensive lake restoration plan and should be considered only for short-term treatment of symptoms. However, in some cases these procedures may be the only feasible approach.

Direct nutrient control reduces internal loading of phosphorus by binding the phosphorus in the sediments. Chemicals used for this process include ferric chloride or, more commonly, alum or calcium nitrate. These chemicals are expensive to apply and their effect is limited in duration.

Plant control uses herbicides (plant-killing chemicals) toxic either to a broad group of plants or to specific plants, but not to other non-targeted plants or animals. This is a temporary treatment that must be repeated annually or more frequently.

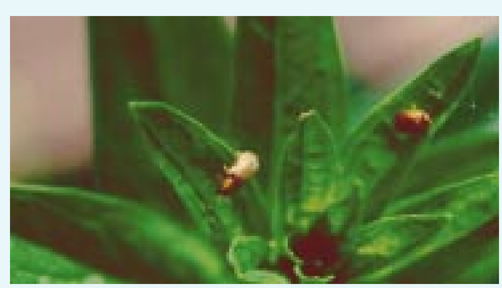
Fish control uses pesticides such as rotenone that are toxic to fish. These toxins are usually specific for fish. This may be conducted by the MDNR when a lake has become dominated by undesirable fish. Restocking with game fish generally follows.

3. Biological Measures

Biological controls represent a relatively new effort to control the growth of algae and weeds through manipulation of the lake's ecological inter-connections. Although great potential exists in this area, the ecology of lakes is not yet sufficiently understood for such approaches to be used routinely.

Biomanipulation is the term used for a restoration technique that shows some promise. In this technique, attempts are made to adjust the fish species composition of a lake in order to encourage the growth of the **zooplankton** population. If successful, these tiny animals are able to reduce algae by eating them. This technique is often coupled with aeration, which creates a larger zone for the zooplankton, and the destruction of the existing fish population with a subsequent restocking of fish species that do not generally feed on zooplankton, such as largemouth bass.

Introduction of control species has been used to control exotic plant species. One example of this is use of the Galerucella beetle to control purple loosestrife. The beetles feed on the leaves and affect the growth and seed production of the plants. Similarly, a species of weevil feeds on *Eurasian watermilfoil* and is a potential control species for introduction to lakes to control this nuisance plant.



Galerucella beetle feeds on purple loosestrife.

Watershed Management Techniques

Watershed management techniques focus on best management practices and include on-site best management practices, off-site techniques, and non-structural practices.

A lake is fed by its watershed, so it is very important that restoration efforts also address the surrounding land areas. In the recent past, visual surveys were relied upon to identify obvious problems like gullies or feedlots. Today, computerized pollution models are available to identify the less obvious but important problems. Once problem spots are inventoried, it is possible to identify the best management practices necessary to protect the lake. Best management practices are the most effective and practical means of preventing and abating non-point polluted runoff. These management practices can stop pollutants at the site or at strategic points in the watershed.

1. On-site Best Management Practices

On-site BMPs are those that take place at the site where the pollution originated.

a. Agricultural Pollutants

BMPs for controlling agricultural pollutants are directed at keeping soil and nutrients on farms and out of our lakes, where they are pollutants. Practices include:

- Conservation tillage
- Crop rotations
- Manure management
- Grassed waterways
- Terracing
- Contour farming
- Fencing
- Fertilizer and pesticide management
- Animal feedlot runoff controls
- Rotational grazing
- Nutrient management
- Filter strips and vegetated buffers
- Water and sediment control basin
- Livestock exclusion (fencing out of waterways and lakes)

b. Urban Pollutants

Best management practices for controlling urban pollution are directed at controlling runoff from streets, parking lots, and other paved areas from which leaves, chemicals, oils, sediment, and nutrients are washed into lakes. Practices include:

- Detention and infiltration basins to collect runoff from paved areas
- Yard waste cleanup
- Storm sewer and catch basins cleaning
- Rain gardens or native plantings
- Catch basin filters
- In-line stormwater treatment devices
- Pet waste clean up
- Lawn aeration
- Impervious surface reduction or disconnection
- Low impact development
- Septic system upgrades for rural homes

c. Erosion and Sedimentation

Best management practices for controlling erosion from construction sites are directed at keeping the exposed soil and attached pollutants out of lakes. Practices include:

- Planning, implementing, and maintaining erosion control practices on construction sites
- Limiting the area exposed and stabilizing it with surface cover
- Directing runoff to temporary or permanent holding areas to prevent sediment and other pollutants from leaving the site
- Inspection and reporting program

Watershed management techniques rely on stewardship and cooperation of all individuals in a lake watershed. Frequently, individuals are unaware that their activities are causing water problems. They may be quite willing to take corrective action if they understand what to do and why. Education is an important part of watershed management – it can encourage land use practices that will preserve and protect our lakes.

RON WINCH

2. Off-site Watershed Management Techniques

Off-site watershed management techniques are best management practices that intercept pollutants between their origin and the lake.

a. Wetland Protection

Wetlands should not be altered or drained. Wetlands are now commonly recognized as serving a vital role not only for fish and wildlife, but also for pollution filtration and flood control. When runoff water carrying nutrients and sediment circulates through a wetland, the sediment settles and the plants take up and use the nutrients before they can run into a lake.

b. Wetland Restoration

In some watersheds it may be valuable to re-establish wetlands that have been drained in the past or even create new wetlands to treat water before it enters the lake. Such projects will require specific engineering plans, funds to buy the land or to purchase an easement, and an organization to manage the wetland.

c. Stormwater treatment ponds

Stormwater treatment ponds are designed and constructed specifically to allow water carrying a suspended load of fine particles to reduce speed and allow the solid particles and nutrients to settle out.

d. Alum injection

Alum injection has been used to remove phosphorus from the water (e.g. storm water) before it enters the lake. An physical alum injection device is constructed and a specific dose of alum is injected into the water as it flows by to bind and remove the phosphorus. From there the water often flows to a sedimentation basin to allow the alum to settle prior to entering the lake. This basin may need to be periodically dredged to remove accumulated sediment.

The capacity of a wetland or sediment basin to handle pollutants is limited. If either is overburdened by sediment and nutrients, it may not improve water quality and may even fill in. That is why on-site best management practices must be used in conjunction with the off-site management techniques to maximize lake protection.

> "If you are thinking one year ahead, sow seed. If you are thinking 10 years ahead, plant a tree. If you are thinking 100 years ahead, educate people."
>
> Chinese proverb

3. Non-structural Best Management Practices

a. Education efforts

In the long term, education of the general public, lake association members, local officials, and children will be helpful to improve the way we manage our lakes and land. Some examples of education efforts include:

- Storm drain marking
- Newsletters
- Newspaper articles
- Workshops, conferences, and presentations
- Events such as watershed festivals
- Web sites

b. Ordinances and regulations

Often a combination of ordinances and education is needed to positively change land management practices. Whether local, state, or federal, these ordinances or regulations set minimum standards for land and water protection. Ordinances may include:

- Erosion and sediment control
- Stormwater management
- Vegetated buffers
- Shoreland setbacks
- Feedlot regulations
- Limitations on the use of phosphorus in fertilizers

c. Conservation Easements and Land Protection programs

Sometimes the best way to prevent a site from continuing to contribute pollutants to a lake, or increase pollutant loading due to a change in land use, is to take the land out of use. Land protections programs such as easements and purchases can permanently maintain the land in a non-degrading land use. These programs should target the ecologically high priority sites and those most beneficial to the lake, such as undeveloped shoreline. For new developments or redevelopments, encourage use of plans that minimize pollutant loading by limiting impervious surfaces, keeping open space, reducing runoff, etc.

- Perpetual or long-term easements or set-aside programs
- Purchase or transfer of development rights (PDR & TDR) programs
- Low impact development

XII. What Are the Benefits of Lake Protection?

Clean Water – and More

The benefits of lake management differ from community to community. Some benefits may spread across more than one generation. For these reasons, the actual value of a lake management project can't be calculated.

Many communities were built around a lake or mill pond. The visual quality of these communities is highly dependent on the condition of the water body and the lakeshore. The natural beauty of the lake is part of the quality of life for lakeshore property owners and the entire community.

A properly managed lake provides recreational opportunities for fishing, swimming, and boating. A lake and its adjacent wetlands provide habitat for game fish and other wildlife. The quality of a lake directly affects community property values and, therefore, the local tax base. A study conducted on northern Minnesota Lakes confirmed that lake water quality affects property values. For a one meter decrease in water clarity, prices were reduced up to $594 per shoreline foot. For a one meter increase in clarity, prices increased up to $423 per shoreline foot (Krysel et. al., 2002). Studies conducted elsewhere in the country show similar results. This can be a significant financial loss or gain to a community as well as the individual homeowner.

Effective, long-term lake management is a complex undertaking that must deal with sociology as well as biology. It is an exercise in compromise, balancing the needs of nature with the needs of civilization. Lake management requires choices: between sandy bottoms for swimmers and weed beds for fishermen; between groomed lawns and control of nutrients and pesticides in the lake; and, among the needs of agriculture, industry, taxpayers and the tourist bureau.

The future of some lakes is better left to nature. The natural process by which lakes evolve into marshes and wetlands creates much needed wildlife habitat. The decision to restore or protect a particular lake must be based on a thorough study of the lake, its watershed, and the commitment of time and money necessary for long-term management.

Protection of a lake may be as simple as the care exercised by lake property owners and others who use and enjoy the lake. Lake restoration, on the other hand, can be a complex, expensive, time-consuming, and often frustrating effort.

The reasons for undertaking lake management programs are as varied as the concerns of the citizens who undertake them. Each lake is unique, and each management process is as complex as the concerns it addresses. But the ecological, social, and economic benefits of a well-managed lake can span generations. And a commitment to stewardship of our water resources makes us responsible for protecting and preserving our lakes – not only for ourselves, but for those who follow as well.

CATHERINE PECHACEK

GLOSSARY

Acid rain: rain with a pH below the normal range of 5.0 – 5.6 due to sulfur sulfuric and nitrogen nitric acids, which, mixing with cloud moisture can make lakes devoid of fish Atmospheric deposition of sulfuric acid may increase mercury contamination of fish even when the lake is not acidified.

Algal bloom: an unusual or excessive abundance of algae

Alkalinity: capacity of a lake water to neutralize acid

Best Management Practices (BMPs): actions taken or structures installed to prevent or reduce nonpoint source pollution

Bioaccumulation: build-up of toxic substances in fish flesh, may be passed on to humans eating the fish

Biomanipulation: adjusting the fish species composition in a lake as a restoration technique

Catch basin: a structure with a surface grate inlet, installed along the curbs to capture stormwater runoff and deliver it to the stormsewer system

Cultural eutrophication: is the accelerated aging of a lake as a result of human activities

Dimictic: lakes that thermally stratify and mix (turnover) once in spring and fall.

Dissolved oxygen: amount of oxygen in water

Ecoregion: areas of relative homogeneity, EPA ecoregions have been defined for Minnesota based on land use, soils, landform, and potential natural vegetation

Ecosystem: a community of interaction among animals, plants, and microorganisms, and the physical and chemical environment in which they live

Epilimnion: the upper layer of a lake characterized by warmer and lighter water

Erosion: erosion is the wearing away of land surfaces due to water, wind, or ice action

Eutrophication: the aging process by which lakes are fertilized with nutrients

Eutrophic lake: a nutrient-rich lake, usually shallow, "green" and with limited oxygen in the bottom layer of water

Fall turnover: cooling surface waters, activated by wind action, sink to mix with lower levels of water, all water is now at the same temperature

Hydraulic Residence Time: the amount of time it takes to exchange the entire volume of lake water with new inflowing water

Hypolimnion: the bottom layer of lake water during the summer months, much denser and colder than the water in the upper two layers

Internal loading: release of pollutants, such as phosphorus, from the lake sediments and into the water

Lake management: a process that involves study, assessment of problems, and decisions on how to maintain a lake as a thriving ecosystem

Lake restoration: actions directed toward improving the quality of a lake

Lake stewardship: an attitude that recognizes the vulnerability of lakes and the need for citizens, both individually and collectively, to assume responsibility for lake care

Limnetic community: the area of open water in a lake providing the habitat for phytoplankton, zooplankton, and fish

Littoral community: the shallow areas around a lake's shoreline, dominated by aquatic plants which produce oxygen and provide food and shelter for animal life

Mesotrophic lake: midway in nutrient levels between the eutrophic and oligotrophic lakes

Natural eutrophication: will very gradually change the character of a lake over thousands of years

Nonpoint source: nutrients and pollution sources not discharged from a single point: e.g. runoff from agricultural fields or feedlots

Oligotrophic lake: a relatively nutrient- poor lake, clear and deep with bottom waters high in dissolved oxygen

pH scale: a measure of acidity or alkalinity based on the concentration of hydrogen ions, ranges from 1 – 14. Anything below 7 is acidic and above 7 is alkaline.

Photosynthesis: process by which green plants produce oxygen from sunlight, water, and carbon dioxide

Phytoplankton: algae – the base of the lake's food chain, also produces oxygen

Piscivorous fish: fish that feed on other fish

Point sources: specific sources of nutrient or polluted discharge to a lake: e.g. wastewater treatment plant discharges

Polymictic: a lake that does not thermally stratify in the summer, but tends to mix periodically throughout summer via wind and wave action

Profundal community: the area below the limnetic zone where light does not penetrate This area roughly corresponds to the hypolimnion layer of water and is home to organisms that break down or consume organic matter.

Respiration: oxygen consumption by living plants and animals

Runoff: water that flows off the land after a precipitation event or snowmelt

Secchi disk: a device measuring the depth of light penetration in water

Sedimentation: the deposition of soils in lakes and waterways, part of the natural aging process that makes lakes shallower, but can be greatly accelerated by human activities

Spring turnover: warming surface water sinks to mix with deeper water. At this time of year all water is the same temperature.

Storm sewer: a system of pipes that carry water, that flows off of the land, to a downstream water resource

Stormwater: water resulting from a precipitation event

Trophic status: the level of growth or productivity of a lake as measured by phosphorus content, algae abundance, and depth of light penetration

Transpiration: the passing of water vapor into the atmosphere from living plants

Thermocline: during summertime, the middle layer of a lake

Turbidity: particles in solution (e.g. soil or algae) which scatter light and reduce transparency

Water density: water is most dense at 39º F (4º C) and expands (becomes less dense) at both higher and lower temperatures

Watershed: the surrounding land area that drains into a lake, river, or river system

Zooplankton: microscopic animals living in the water

Appendix

Checklist of Stewardship Practices for Lake Protection

Use this checklist to test how you are doing as a lake steward. Check the practices you use. Review those that you don't use and think about adding them. Periodically review this list to see if you have improved as a lake steward.

Boating and other Recreation

____ Use a 4-cycle boat engine or a non-motorized boat.

____ Use lead-free weights and tackle.

____ Limit clearing of shoreline to only the area needed for access and recreation.

____ Adjust boat speed to reduce wake and minimize wave damage to shore.

____ Stop washing dishes, laundry, and self in lake while camping.

____ Properly dispose of wastewater when boating and ice fishing.

Runoff Reduction

____ Reduce paved areas (e.g. use paving stones rather than concrete).

____ Sweep driveways and walks instead of washing them with water.

____ Redirect downspouts away from paved areas.

____ Drain your sump pump through the lawn rather than directly out to the street.

____ Re-establish or preserve a vegetative buffer along the shore and on top of bluffs.

____ Do not remove ice ridges that form along the shoreline.

Yard Care

____ Use 0 phosphorus fertilizer unless soil test results show phosphorus is needed.

____ Don not use fertilizers within 10 feet of a lake, wetland, stream, or storm drain.

____ Sweep fertilizer, grass clippings and soil off of your driveway and the street.

____ Replace lawn with native trees, shrubs, grasses, sedges, and wildflowers.

____ Pick up pet waste.

____ Minimize use of salt and sand on walkways and driveways during the winter.

Exotic Species

____ Learn how to identify and control exotic species.

____ Inspect boats and equipment for exotics before taking them to other waters.

____ Never dump bait buckets or live fish from one water body into another.

Septic Systems

____ Eliminate use of garbage disposal when using an on-site septic system.

____ Pump septic tank annually, through the manhole, not through inspection port.

____ Don't use septic tank additives.

References and Additional Sources of Information

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Minnesota Extension Service. 1998. Protecting Our Waters: Shoreland Best Management Practices. Publication number MI-6946.

Minnesota Lakes Association & University of Minnesota Center for Urban and Regional Affairs. 2000. Sustainable Lakes Planning Workbook: A Lake Management Model. Available through MLA as hard copy or on their web site: www.mnlakes.org.

Minnesota Pollution Control Agency. 2002. Acid Rain in Minnesota. Air Quality Fact Sheet #1.11, January 2002.

Web Sites

Board of Soil and Water Resources:
www.bwsr.state.mn.us

Environmental Protection Agency:
www.epa.gov

Water: www.epa.gov/ebtpages/water.html
Surf Your Watershed: www.epa.gov/surf3
Volunteer Monitoring:
www.epa.gov/owow/monitoring/vol.html

Freshwater Society: www.freshwater.org

MN Shoreland Management Resource Guide:
www.shorelandmanagement.org

Minnesota Lakes Association: www.mnlakes.org
Sustainable Lakes Workbook

Minnesota Pollution Control Agency:
www.pca.state.mn.us/water/

Environmental Data:
www.pca.state.mn.us/data/eda/
Volunteer Surface Water Monitoring Guide:
www.pca.state.mn.us/water/monitoring-guide.html

Minnesota Department of Natural Resources:
www.dnr.state.mn.us

Lake data:
www.dnr.state.mn.us/lakefind/index.html
Shoreland management:
www.dnr.state.mn.us/shorelandmgmt/index.html

Minnesota Extension Service:
www.extension.umn.edu

Understanding your Septic System:
www.extension.umn.edu/distribution/naturalresources/dd7439.html
Shoreland Best Management Practices:
www.extension.umn.edu/distribution/naturalresources/DD6946.html

Minnesota Sea Grant-Exotic Species Resources:
www.seagrant.umn.edu/exotics/index.html

Natural Resources Research Institute:
Understanding Lake Ecology:
www.wow.nrri.umn.edu/wow/under/primer

North American Lake Management Society:
www.nalms.org

Rivers Council of Minnesota: www.riversmn.org

University of Minnesota Water Resources Center:
www.wrc.coafes.umn.edu

Organizations

Need more information or assistance? Here are some organizations that can help.

Board of Water and Soil Resources (BWSR), One West Water Street, Suite #200, St. Paul, MN 55107. (651) 297-3767.

Freshwater Society, 2500 Shadywood Road, Excelsior, Minnesota, 55331, 952-471-9773. Email: freshwater@freshwater.org.

Minnesota Lakes Association (MLA), 19519 Highway 371 N, Brainerd, Minnesota 56401. 800-515-5253, 218-824-5565, Email: lakes@mnlakes.org.

Minnesota Department of Natural Resources (MDNR), 500 Lafayette Road, St. Paul, Minnesota, 55155, 612-296-6157.

Minnesota Pollution Control Agency (MPCA), 520 Lafayette Road, St. Paul, Minnesota, 55155-4194, 612-296-6300 or 1-800-657-3864.

North American Lake Management Society (NALMS), PO Box 5443, Madison, Wisconsin, 53705. (608) 233-2836. Email: nalms@nalms.org.

Watershed Management Organizations and Soil and Water Conservation Districts – find you local organization through the Board of Soil and Water Resources.

Funding Sources

Funding sources will vary from year to year. There are public agencies that offer funding as well as private foundations and non-profit organizations. Funding can be in the form of a grant, loan or in-kind services.

Minnesota Pollution Control Agency offers Clean Water Partnership Grants.

Department of Natural Resources offers Environmental Partnership Grants.

Board of Water and Soil Resources offers cost-share funds for lake management plans, feedlot improvements and other conservation efforts. These are usually administered through Soil and Water Conservation District's and Counties.

Natural Resource Conservation Service

Soil and Water Conservation Districts offer cost-share programs for erosion control and other projects.

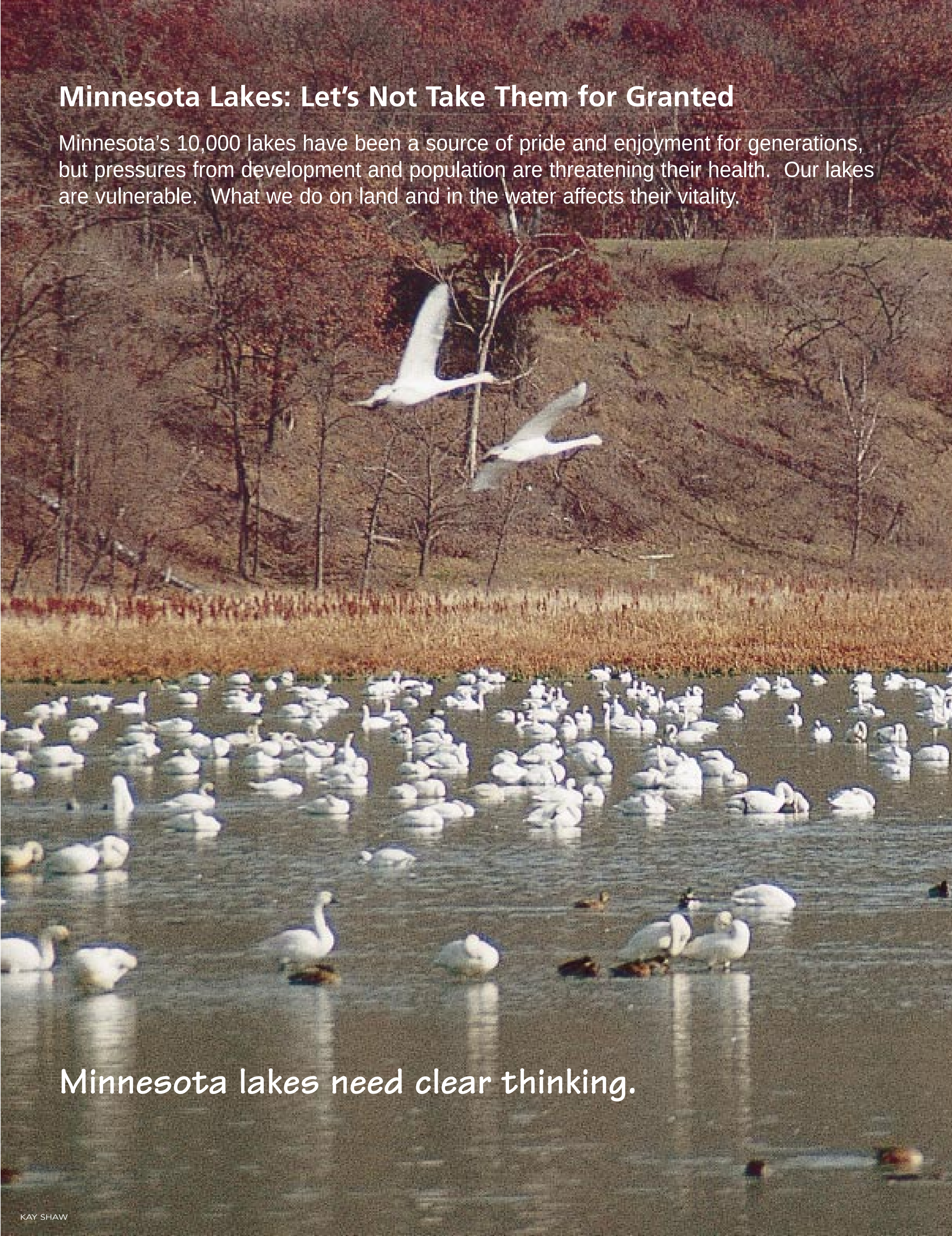
U.S. EPA

Watershed Management Organizations – Often local watershed districts may have funds for education efforts or implementation projects.

Other potential sources of funding include private foundations, non-profits, and state organizations.

Minnesota Lakes: Let's Not Take Them for Granted

Minnesota's 10,000 lakes have been a source of pride and enjoyment for generations, but pressures from development and population are threatening their health. Our lakes are vulnerable. What we do on land and in the water affects their vitality.



Minnesota lakes need clear thinking.

KAY SHAW