

A Citizen's Guide to Lake Protection

What Is a Lake?

It's not as simple as it may sound. A lake is a body of water, but it is also much more. A lake is an ecosystem, a community of interaction among animals, plants, microorganisms, and the physical and chemical environment in which they live. Critical to any lake ecosystem is the lake's watershed, the surrounding land area that drains into that particular lake.

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, like a single algal bloom (an unusual or excessive abundance of algae), 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. It may take a decade or more, for example, for changes in agricultural practices or urbanization to result in weed problems or fish kills.

Lakes Begin...And End

Most lakes were created by past geologic events. The vast lake-dotted and marshy 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 gouging holes in loose soil or bedrock, by depositing material across streambeds or by leaving buried chunks of ice whose melting shaped 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 are destined to fill in with sand, silt and topsoil washed in by floods and streams. These gradual changes in the physical and chemical components of the lake affect the development, competition and succession of many different plants and animals.

[How do lakes work?](#)

[What can go wrong in lakes?](#)

[What can you do to take care of your lake?](#)

[Lake stewardship](#)

[Lake management: what is it?](#)

[Lake management: what can be done?](#)

[Lake restoration: what's involved?](#)

[Lake restoration: what can be done?](#)

[What are the benefits of lake protection?](#)

[Glossary](#)

[Appendix](#)

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.

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 physical, biological and chemical properties-such as light, temperature, wind, precipitation and nutrients-affect plants, animals and the lake itself.

1. A Physical Look at Lakes

Lakes Form Layers

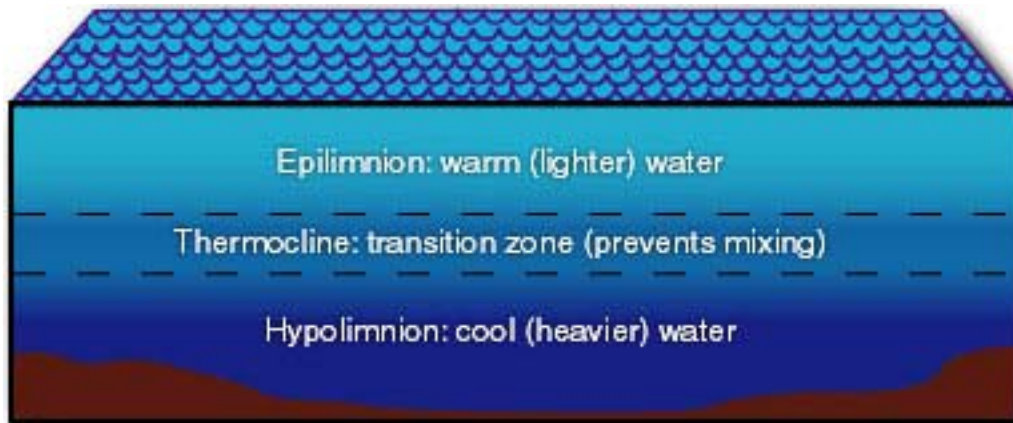
Lakes in temperate climates tend to stratify or form layers, especially during summer. This happens because the density of water changes as its temperature changes. Water is most dense at 39°F. Both above and below that temperature, water expands and becomes less dense. This means that in the spring, just before the ice melts, the water near the bottom will be at 39°F. Water above that 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 density cause this surface water to sink and mix with the deeper water, a process called spring turnover.

As summer progresses, the temperature difference (and thus density difference) between upper and lower water becomes more distinct, and most lakes form three separate layers. The upper layer, the epilimnion, is characterized by warmer (lighter) water. The epilimnion is roughly equivalent to the zone of light penetration, where the bulk of productivity, or growth, occurs.

Below the epilimnion is another layer, the thermocline, in which the temperature declines rapidly. The thermocline is a narrow band of transition which 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.

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.



Lakes in the temperate 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.

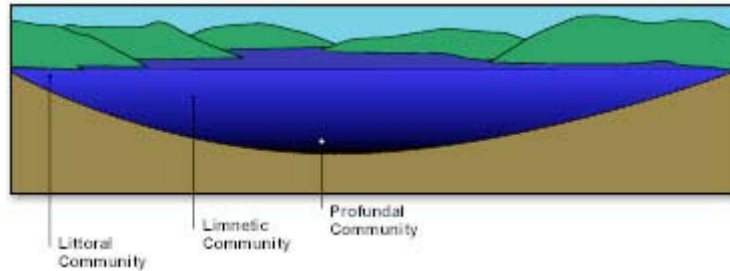
2. A Biological Look at Lakes

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. 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.

The area of open water is the limnetic community. This area is the habitat of phytoplankton (algae), zooplankton (microscopic animals), and fish. The 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. A pigment produced by the plants, chlorophyll, speeds this process. Since sunlight is very important to photosynthesis, oxygen will be produced only as deep as the sunlight penetrates. The depth of light penetration can be measured using a secchi disc.

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 break down or consume (decompose) dead plants and animals that settle out of the waters above. This process consumes oxygen.



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.

What can go Wrong in Lakes?

1. Eutrophication: The Weeds Take Over

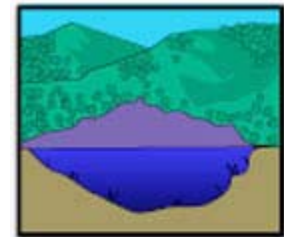
Eutrophication is the process by which lakes are fertilized with nutrients (chemicals absorbed by plants and used for growth). It is a natural aging process, but human activities can speed it up, with more algae and weeds the result.

As nutrients such as nitrogen, phosphorus and potassium wash into lakes in runoff water or by soil erosion, they 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 marsh or a bog. This aging is called natural eutrophication.

Lakes also can 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, storm water 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 taking place.

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

Nutrients and pollution sources that are not discharged from a pipe, but instead are washed off the land or seep into groundwater, are known as nonpoint sources of pollution or polluted runoff. These include runoff from agricultural fields and feedlots, leakage



Centuries



Decades



from septic tanks, nutrients from wetland drainage and storm water runoff, and others. Polluted runoff is best controlled through wise land use practices.

As shown in the diagram in the upper right, 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 down into a lake. These soils settle on the bottom of the lake, and the lake becomes increasingly shallow. This process is again a natural part of lake aging, governed by gravity and the forces of rain and wind.

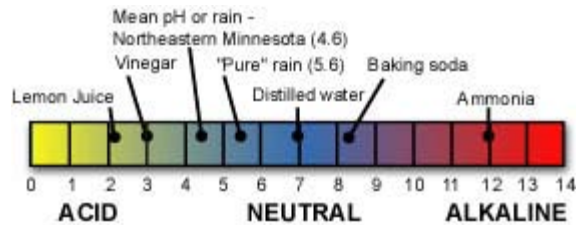
Sedimentation is greatly accelerated, however, by human activities that leave the soil exposed without vegetation for extended periods. Construction activities that leave soils bare, and intensive agricultural activities, such as plowing near lakes and streams of farming steep slopes, leave soils vulnerable 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 from power plants, factories and cars mixes with cloud moisture to form acidic compounds, which eventually fall to earth as 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.



The rain in northeastern Minnesota, the region of the state containing the majority of acid-sensitive lakes, is about 10 times more acidic than "normal" rain. Although no "acid-dead" lakes have been found yet in Minnesota, some appear to be showing the early effects of acidification. Approximately 2,500 to 3,700 Minnesota lakes are considered sensitive to acid rain. Of these lakes, 500 to 1,000 are extremely sensitive due to their very low alkalinities. (For more information on acid rain, contact the Minnesota Pollution Control Agency.)



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

Several types of toxic substances may contaminate lakes: (1) industrial chemicals such as PCBs (polychlorinated biphenyls), metals, and solvents from point sources or runoff; (2) pesticides from agricultural runoff; (3) urban storm runoff containing metals and pesticides; and (4) air-deposited chemicals.

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.

One particularly dangerous impact is the bioaccumulation or build-up of toxic substances in fish flesh. The toxic effects may be passed on to humans eating the fish.

What Can You do to Take Care of Your Lake?

"Taking care of" your lake may require lake 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 Stewardship: An Attitude

Lake stewardship really is an attitude-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. It takes into account 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, we, both individually and collectively, must assume responsibility for their care.

2. Lake Management: A Process

Lake management is a process, and the second major step in lake protection. It reflects a willingness to study a lake, to assess its status and its needs, and to determine how best to maximize its potential as a thriving ecosystem.

Lake management can be as simple as fostering the practices of stewardship among lake homeowners and other interested individuals. Or it can include taking an active role in altering certain 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, sportsmen's or conservation club, or some other organization.

3. Lake Restoration: Corrective Action

Lake restoration 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 lake improvement district or watershed district.

Lake Stewardship: What can an Individual do?

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 lake's watershed. One of the most important things an individual can do is to get involved with other concerned citizens. Your 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.

1. Siting the House and Other Facilities

- Don't let your house intrude upon the lake. Locate a new house and any future additions to meet horizontal setback 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 out of surface runoff.
- You'll also need to consider other facilities, particularly wells and septic systems, when siting your 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 your lot. Wells should be located upslope from sewage systems and be deep and cased whenever possible. A site sketch of your lot, drawn to scale, will help you decide the best locations for all facilities and is often required when obtaining permits.

- Contact your county zoning officer 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 your contractors.
- If a standard septic tank and drainfield system is unsuited for your lot, you may have to use an approved alternative system such as a mound system. On some lots a holding tank may be the only feasible system.
- Make sure your contractors know which trees you want to save. Fence off areas to protect trees and roots from construction damage.
- Don't put a road or wide path down to the lake. Curve any path you do build to the lake. Consider a wooden stairway rather than a road if you need access along a steep slope.

2. Altering the Waterfront

- If you want a sandy beach for swimming, try to buy a lot with a natural beach. Sand dumped on the shore to create a beach can seriously affect the habitat of fish, birds, frogs and aquatic insects.
- Make waterfront equipment such as docks and boat houses as unobtrusive as possible. Avoid structures that require much tree clearing, excavating or filling.

3. Modifying Yard Care

- Think twice before putting in a lawn—you may not need one in a lake setting. Maintain as wide a buffer zone of natural vegetation as possible between the lawn and the water's edge.
- 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.

4. Taking Care of Your Septic System

- Don't let your septic system pollute the lake. Have your septic tank checked every other year and pumped when necessary.
- Use nonphosphate detergents, wash only full loads of clothes, and use water-saving showers and toilets to avoid stressing your septic system. (In Minnesota, phosphates in household laundry detergents have been banned since 1977.)
- Do not use a garbage disposal, and keep solvents, plastics, paper diapers and other similar products out of your septic system.

Lake 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 administrative and technical 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 of plant and animal habitats that relate to, and rely on, each other.

Two Areas of Concern

Every lake is ecologically unique. Every management group will have a unique set of management objectives and a unique strategy for attaining them.

Lake management planners seeking the most effective way to arrest or reverse eutrophication face two general areas of concern:

The first addresses biological symptoms that arise in the lake-primarily from activities in the lake's watershed. "Nutrient-rich" lakes can be made less "productive" through the use of watershed management practices. The cost depends on the extent of the problem.

In the second area of concern, the lake has reached a critical level. Nutrients accumulated in the lake continue to maintain excess productivity even with watershed management. The restoration of such a lake may require in-lake treatment as well as watershed management. The cost may be high.

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 principal 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.

Lake Management: What Can Be Done?

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

Deteriorated lakes can be restored, 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.

For these reasons, preventive action should be the first priority of most lake communities. If the lake is a valuable recreational asset, the primary objective should be to prevent further deterioration. Lake deterioration can be prevented by managing the watershed and by protecting the shoreline.

Action to protect and restore a lake may be taken by individual lake property owners and by lake association, usually with the assistance of one or more government units.

When concern over a lake's condition leads to a meeting of concerned citizens, the first step has been taken: formation of a lake association. 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 government unit, it is a good idea to form an advisory group on 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 more clear.

2. Assess Levels of Commitment

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 you understand the relationship of a lake to its watershed, the more likely you'll be to make effective management choices. You can find help with this in your local community. 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 the Gray Freshwater Biological Institute can help you better understand 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 the [Citizen 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 either the Minnesota Pollution Control Agency (MPCA) or Minnesota Department of Natural Resources (MDNR). The MPCA can help determine if an extensive study is needed. In such cases a professional consultant may need to be retained.

Deciding 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 it 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 treatment 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 of a lake 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.

Lake Restoration: What's Involved?

At some point a lake association may need more 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. 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-evaluating Goals

This would be a good time for re-evaluation of the mission of the lake association, 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. Pursuing a Higher Level of Organization

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, it may be decided that a higher level of organization is 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 exist 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. Exploring Financing Sources

Funding cannot be addressed in depth in this publication because the outside sources of funds (such as state and federal aid) and funding levels are continually changing. It is important, however, to distinguish between the funding available to lake associations and that 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 would be eligible to apply for these funds. Among other recognized grant-eligible bodies are cities, counties and regional planning agencies.

Consult with local and state official (such as the MPCA and MDNR) to identify the current status of these programs that may be available for cost-sharing of projects.

4. Conducting 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 "feasibility" studies. Their 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 one assess which restorative techniques, if any, may improve the quality of the lake. Typical elements of a feasibility study include the following:

In the Watershed

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

In the Lake: Biological Productivity

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

Contact the MPCA or the Gray Freshwater Biological Institute for information on conducting feasibility studies.

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 selection of 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 "cleanse" 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, or other government agencies.

In-Lake Techniques

In-lake techniques include physical measures, chemical measures and biological measures.

1. Physical Measures

Aeration and circulation increase dissolved oxygen levels, prevent fish kills and create a larger zone of habitation for fish and microscopic animal communities. Aeration can also slow the tapping of phosphorus from bottom sediments. Results, however, are not always predictable.

Dredging is used to remove 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 dredge spoils is often a problem.

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

Onshore treatment techniques involve pumping water onshore, treating it and then allowing it 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 marshlands (which will remove nutrients from the water before it drains back into the lake).

Drawdown (lowering water in an impoundment) 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. It may also cause slumping of the shoreline. Drawdown can also be useful in encouraging growth of plants beneficial to waterfowl.

Harvesting removes nutrients from the system by removing 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.

2. Chemical Measures

Algal toxins (algicides) 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 treatment, chemical and metals such as copper may build up in the sediments and fish. Such chemicals 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.

Application of algicides treats the symptoms inadequately, does little to solve the problem, fails to address the underlying causes, and may lead to buildup of undesirable chemicals and metals in the lake. This technique is seldom incorporated into a lake restoration and should be considered only for short-term treatment of symptoms.

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.

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.

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 rough 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 ecological connections within a lake. Although great potential exists in this area, the ecology of lakes is not yet sufficiently understood for such approaches to be used routinely.

Bio-manipulation 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 (or refuge) 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.

Watershed Management Techniques

Watershed management techniques focus on best management practices and include on-site techniques and off-site 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 nonpoint polluted runoff. These management practices can stop pollutants at the site or at strategic points in the watershed.

1. On-Site Best Management Practices

Agricultural Pollutants

Best management practices for controlling agricultural pollutants are directed at keeping soil and nutrients of farms, where they are important components of production, 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

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
- Sweeping leaves and dirt from streets
- Cleaning storm sewers and catch basins

Erosion and Sedimentation

Best management practices for controlling erosion from construction sites where natural land cover is removed are directed at controlling erosion and sedimentation to lakes. Practices include:

- Erosion control practices as part of the planned construction project required before a building permit is issued.
- Limiting the area exposed and stabilizing it with surface cover.
- Directing runoff to holding areas to prevent sediment and other pollutants from leaving the site.

On-site 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.

2. Off-Site Watershed Management Techniques

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

- Where wetlands exist, they should not be altered or drained. It is now recognized that wetlands serve 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 out and the plants take up and use the nutrients before they can run into a lake.
- 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 and an organization to manage the wetland.

- Sediment basins are important to allow water carrying a suspected load of fine particles to reduce speed and allow the solid particles and nutrients to settle out.

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.

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 into one neat number.

Many communities were built around a lake or millpond. 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. The quality of a lake directly affects community property values and, therefore, the local tax base. Effectively managed, a lake and its adjacent wetlands provide habitat for game fish and other wildlife.

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 wildlife with the needs of civilization. Lake management requires choices: between sandy bottoms for swimmers and weedbeds for fishermen; between groomed lawns and control nutrients and pesticides in the lake; 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 up responsible for protecting and preserving our lakes-not only for ourselves, but for those who follow as well.

Glossary

Acid Rain: Rain with a higher than normal acid range. Caused when polluted air mixes with cloud moisture. Can make lakes devoid of fish.

Algal bloom: An unusual of excessive abundance of algae.

Alkalinity: Capacity of a lake to neutralize acid.

Bioaccumulation: Build-up of toxic substances in fish flesh. Toxic effects may be passed on to humans eating the fish.

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

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

Epilimnion: Most lakes form three distinct layers of water during summertime weather. The epilimnion is the upper layer and is characterized by water and lighter water.

Eutrophication: The aging process by which lakes are fertilized with nutrients. Natural eutrophication will very gradually change the character of a lake. Cultural eutrophication is the accelerated aging of a lake as a result of human activities.

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. As in spring turnover, all water is now at the same temperature.

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

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 recognized the vulnerability of lakes and the need for citizens, both individually and collectively, to assume responsibility for their 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. The plants produce oxygen and provide food and shelter for animal life.

Mesotrophic Lake: Midway in nutrient levels between the eutrophic and oligotrophic lakes.

Nonpoint Source: Polluted runoff-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, it is clear and deep with bottom waters high in dissolved oxygen.

pH Scale: A measure of acidity.

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

Phytoplankton: Algae-the base of the lake's food chain, it also produces oxygen.

Point Sources: Specific sources of nutrient or polluted discharge to a lake: e.g. stormwater outlets.

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

Secchi Disc: A device measuring the depth of light penetration in water.

Sedimentation: The addition of soils to lakes, a part of the natural aging process, makes lakes shallower. The process can be greatly accelerated by human activities.

Spring Turnover: After ice melts in spring, warming surface water sinks to mix with deeper water. At this time of year, all water is the same temperature.

Thermocline: During summertime, the middle layer of lake water. Lying below the epilimnion, this water rapidly loses warmth.

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

Water Density: Water is most dense at 39°F 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

Appendix

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

- **Minnesota Pollution Control Agency (MPCA)**
Lake management and restoration, lake studies, pollution, how to form a lake association, acid rain
520 Lafayette Road, St. Paul, Minnesota 55155
651-296-6300
- **Freshwater Foundation**
Water quality assessment, lake management practices
2500 Shadywood Road, Box 90, Navarre, Minnesota 55392
651-471-8407
- **Freshwater Foundation Spring Hill Center**
Water quantity and quality concerns, lake management, lake stewardship, public information/education materials
725 County Road 6, Wayzata, Minnesota 5391
651-449-0092
- **Minnesota Department of Natural Resources (MDNR)**
Shoreland management laws, fisheries management, aquatic nuisance control, lake aeration, lake survey information, lake mapping, lake level management
500 Lafayette Road, St. Paul, Minnesota 55146
651-296-6157