Inland Lakes: Analysis and Action
Michigan State University
Cooperative Extension Service

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Illustration: Bill Thauer

Huron River Watershed Council
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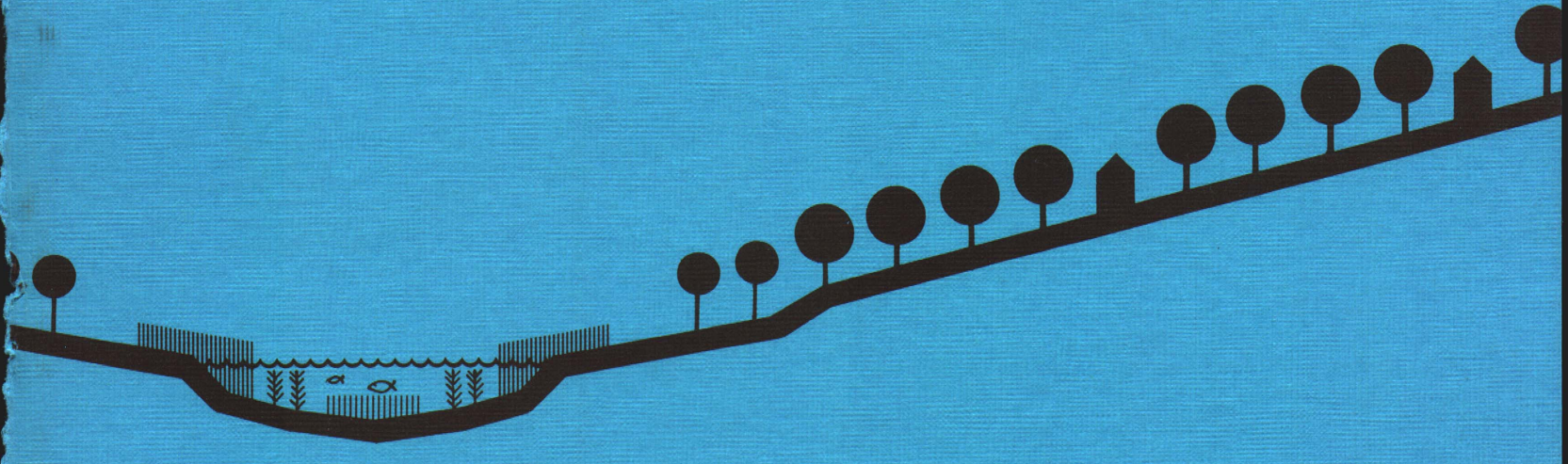
inland lakes

analysis and action



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Cooperative Extension Service
Michigan State University

MICHIGAN'S INLAND LAKES

Most of the basic characteristics of the Michigan landscape have resulted from glaciers and the geologic processes associated with them. Although most lakes in Michigan are of glacial origin, there is a wide range of lake types and sizes. Over 841,000 acres of the state's total area is lake surface. There are about 6,500 lakes larger than ten acres and over 35,000 lakes larger than one tenth of an acre.

Lakes in Michigan are used for recreation and leisure time activities and for year-round and vacation homesites. The lakes are a most important part of the natural environment. Especially in the north, wildlife, scenic and wilderness values need to be preserved and protected. Unfortunately many of Michigan's lakes, especially the highly developed ones in the south, are now used as "sinks" for the collection of silt, sewage and industrial waste.

Most of the people using Michigan's inland lakes live in the large metropolitan areas: Southeastern Michigan, Lansing, Grand Rapids, Flint, Bay City—Midland—Saginaw, and Muskegon. Many lake property owners and users also come from other states, especially Illinois, Indiana and Ohio. In areas near large cities, lake homes increasingly are used the year round. These lakes also are used intensively both by homeowners and their guests and by the public for active recreation: swimming, water skiing, sailing, and angling.

HURON RIVER WATERSHED COUNCIL

The Huron River Watershed Council is an organization of local governments, formed to encourage and assist the wise and orderly use of the Huron River as a natural resource. The Council was organized in 1965 under Michigan's "local river management act", which enables townships, cities, villages and counties, to undertake cooperative water resources planning and management activities. The Watershed Council may conduct studies and research on the water resources in the watershed; advise federal, state and local governmental agencies on water resources management issues; and conduct informational and educational programs.

The 125 mile long Huron River, a tributary of Lake Erie, drains a 900 square mile area of Southeastern Michigan, on the western fringe of the Detroit Metropolitan region. There are more than 300 lakes in the watershed, most of which have heavily developed shorelines.

Huron River Watershed Council
415 West Washington Street
Ann Arbor, Michigan 48103

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The Office of Water Resources Research was authorized by the Congress in 1964 (the Water Resources Research Act, P.L. 88-379) to undertake a cooperative water resources research and training program. Title I of the Act provides for the support of Water Resources Research Institutes at the land grant colleges in the fifty states and Puerto Rico. These Institutes support a program of research and manpower training in all areas of the water resources field. Title II of the Act provides for grants and contracts to public or private agencies in selected water resources research areas.

The INLAND LAKES PROJECT of the HURON RIVER WATERSHED COUNCIL is a Title II research project. In addition, the Office of Water Resources Research sponsors an annual research conference, and supports the Water Resources Scientific Information Center in publishing an annual research catalog and selected Water Resources Abstracts.

U.S. Department of the Interior
Office of Water Resources Research
Washington, D.C. 20240

MICHIGAN COOPERATIVE EXTENSION SERVICE

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SUPPORTED BY A GRANT FROM THE U.S. DEPARTMENT OF THE INTERIOR,
OFFICE OF WATER RESOURCES RESEARCH.

about this booklet:

This booklet is intended to give individuals concerned about the protection and management of inland lakes some basic information on the issues which must be considered in planning for the future of lakes and lake communities. The booklet is not intended to serve as a complete reference manual, with answers to all lake management problems. Rather, its purpose is to expose the reader to some of the basic issues and problems which should be considered, and to outline some of the ways in which desired goals can be achieved.

The booklet is written in layman's language, in an attempt to bridge the information gap between the trained technician or "expert" (who knows about the scientific and technical problems and their possible solutions) and the citizen, who must be responsible for initiating the necessary action to preserve what is good, and to correct what is not so good.

Most of the material in this booklet is applicable to practically any developed inland lake in the temperate regions of the northern hemisphere. The orientation in much of the booklet, however, is towards the problems of small and medium-size lakes in those parts of North America once covered by glaciers: the Great Lakes States and Provinces, and New England. The unique features and problems of man-made lakes, such as are common in the arid regions of the western United States, are covered in a separate section. The natural processes and many of the lake management issues and concepts, however, apply to all lakes, whether natural or man-made.

Special emphasis has been given to developed lakes—that is, lakes which have populated shorelines. Inland lakes in wilderness areas and those managed primarily for wildlife and public recreation values—along which lake communities are unlikely to develop—have special management problems, and are beyond the scope of this booklet.

Inland Lakes: Analysis and Action is a revised version of an earlier manual of the same title, developed as part of an Inland Lakes and Shoreland Management Project. This research project was conducted during 1969-1971 by the Huron River Watershed Council, Ann Arbor, Michigan, and funded in large part by a Title II grant from the U.S. Department of the Interior, Office of Water Resources Research.

The project was designed as a cooperative effort for lake study and improvement, involving the residents of inland lake communities located in the Huron River watershed. A major goal was to provide the residents information on lake management appropriate to their attitudes and understanding of lake problems. Similar techniques of information dissemination and response feedback could be applied in many lake communities, to help citizens and their local governments work together to halt the deterioration and mismanagement of their lakes and shorelands, as well as establish sound cooperative water resources management programs.

acknowledgements

The authors wish to express their sincere appreciation to the many people and organizations whose contributions made this booklet possible. Special thanks are due John H. Dillon, member of the Executive Committee and former Chairman of the Huron River Watershed Council, and Spenser W. Havlick and William B. Stapp of the University of Michigan School of Natural Resources, who made invaluable suggestions at many stages of the project. Several hundred resource experts across the country and the Executive Committee and membership of the Huron River Watershed Council reviewed the original version of the booklet and supplied many new ideas which are included in this revision. C. Franklin Waite, Introl Division, Chrysler Corporation, reviewed the final version of the revised booklet. The late William D. McCool supervised the printing of the original booklet; the results of his thoughtful advice on graphic design and printing technology can be found in this revision. Jane Read, Ellen Rosenthal, and Linda Randell provided invaluable assistance in data analysis, as well as in typing the many versions of the manuscript for the booklet. The original concept of the booklet was derived from the results of information surveys of the residents of the communities surrounding Cavanaugh, Gallagher, Portage, Sherwood, Wolverine and Woodland Lakes, Michigan, without whose participation the Inland Lakes Project would not have been possible. The work upon which this publication is based was supported in part by funds provided by the United States Department of the Interior as authorized under the Water Resources Research Act of 1964, as amended.

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it's up to you

Throughout North America are hundreds of thousands of lakes, ranging in size from less than an acre to the Great Lakes. These lakes constitute one of our greatest water resources. As inland lakes increasingly have felt the impact of man, their natural environment has undergone change, and they have become susceptible to new and different pressures on the natural systems which create and sustain life in them.

Twentieth century technology has given man a great capacity for changing nature and affecting natural processes and events. The result can either disrupt the natural environment or help repair damage already caused. But regardless of whether the outcome is desirable or not, all these changes affect in some way a complex, carefully balanced series of interdependent relationships in the natural ecosystem. It is within this framework of actual and potential conflict between man and nature that the subject of this booklet—inland lake management—must be viewed.

Inland lakes can be managed successfully for preservation and improvement. But those who do so must understand the natural processes of the lake environment itself and be sensitive to its complex and delicate balance. It is also important that the rights and desires of other people are respected, and their use and enjoyment of water and related natural resources continue unimpaired. These rights of use and enjoyment apply, of course, to future generations, as well as to those of us now living.

We live in a democracy. Fundamental to this concept of government is the right of we, the people, to govern ourselves—to decide what we want, and how to achieve it. While there is much that we as individuals, acting alone, can do to improve our lakes, much of what needs to be done to protect and manage them requires cooperative, community-wide action. Some of these actions can be done by private citizens, working together informally. Many more require some type of formal governmental involvement. Our elected and appointed governmental officials are only as responsive to and informed about our needs and desires as we want them to be. It is incumbent upon us to support—even demand—sensitive and enlightened action by our leadership. The responsibility for appropriate action must be shared by all concerned: the public officials; the trained experts who advise us on what to do, and how; and the citizenry for whom the action is taken. The ultimate responsibility for government's action or inaction, though, lies with the citizens for whom the officials and the experts act.

Thus the purpose of this booklet: to help citizens, particularly those living in lake communities, become informed: about their natural surroundings—their environment—and its limitations; about the possibilities for action; and about their responsibilities, individually and collectively, to accomplish what should be done.

concerns and goals

concerns:

Lake property owners, professional resource planners and managers agree that there are many problems of inland lakes and their use which concern them greatly. The following list, developed from information provided by homeowners in selected lake communities in Michigan and from interviews and correspondence with experts in lake management, includes the items or problems of greatest concern. It must be remembered that the ranking of the concerns will vary from lake to lake and from region to region.

- Motorboat Operation
- Water Quality/Water Pollution
- Nuisance Algae and Aquatic Weeds
- Public Access
- Preservation of Natural Beauty
- Fish and Wildlife Protection (including wetland preservation)
- Taxes and Property Values
- Shoreline Development— filling, dredging and housing
- Insect Pests
- Lake Level Fluctuations— flooding and low water.

goals:

Lake area residents and resource managers recognize that the more important of these concerns must be selected and established as goals which must be achieved in order to preserve the worth of the lake community. Several measures must be taken: some practices will have to be more closely *regulated* (motorboat operation and land use for example) and others *eliminated* (use of persistent pesticides); some will have to be *altered* (type of sewage disposal); and others *begun,* such as community planning and the deliberate, permanent conservation of natural areas, wildlife, and scenic beauty.

Once goals are set, criteria for achieving them must be established. These standards can be developed with a minimum of effort. They can become very important tools in measuring progress toward attaining the stated goals.

Because lakes are "common assets" shared by private landowners and in most cases the general public, cooperative action is required. Improvement or deterioration of any aspect of the lake or its shore will affect directly all property owners and the public.

Lakes are very delicate natural assets. Uninformed or exploitative action will destroy them quickly. Since a basic understanding of the environment and man's effect on it must guide a successful course of action, the next section provides environmental information that will be useful in preserving and protecting lake communities.

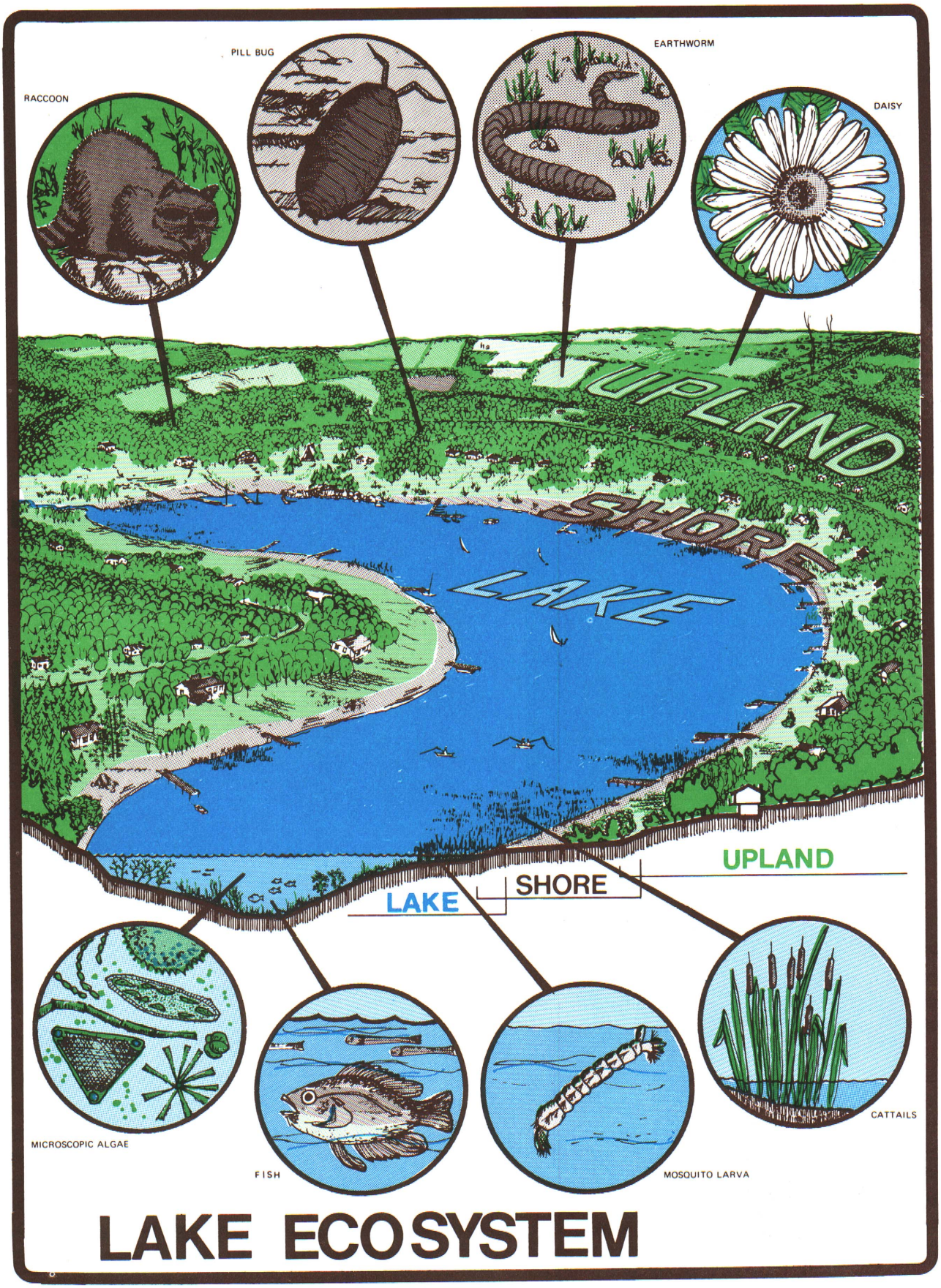
environmental concepts and terms

Information about the natural history and the environment of inland lakes is both interesting and useful. If inland lakes are to be used without abuse and managed with wisdom and care, those who use the lakes and are responsible for their management should have some understanding of them.

the ecosystem
the natural unit

A lake and the land around it form a natural unit of land, water, and living things. Within this area there are three different types of environments—the lake, the beach or shore, and the upland. The lake environment consists of water, aquatic plants and animals both large and microscopic, the lake bottom, and nonliving materials dissolved or suspended in the water. The beach or the shore is the junction of the upland and the lake environments and has characteristics of both. The upland environment is the one that we are most familiar with, consisting of soil, trees, grass, bushes, and small and large animals including man. Taken together these three environments form an interdependent system—an ecosystem.

For our purposes, the word "ecosystem" describes a land and water area and also the natural processes that take place in this physical area. The flow of energy and the cycling of materials is just as much a part of the lake ecosystem as fish and plants, or soil and water. All of the processes described in the following pages occur in the lake ecosystem and are part of it.

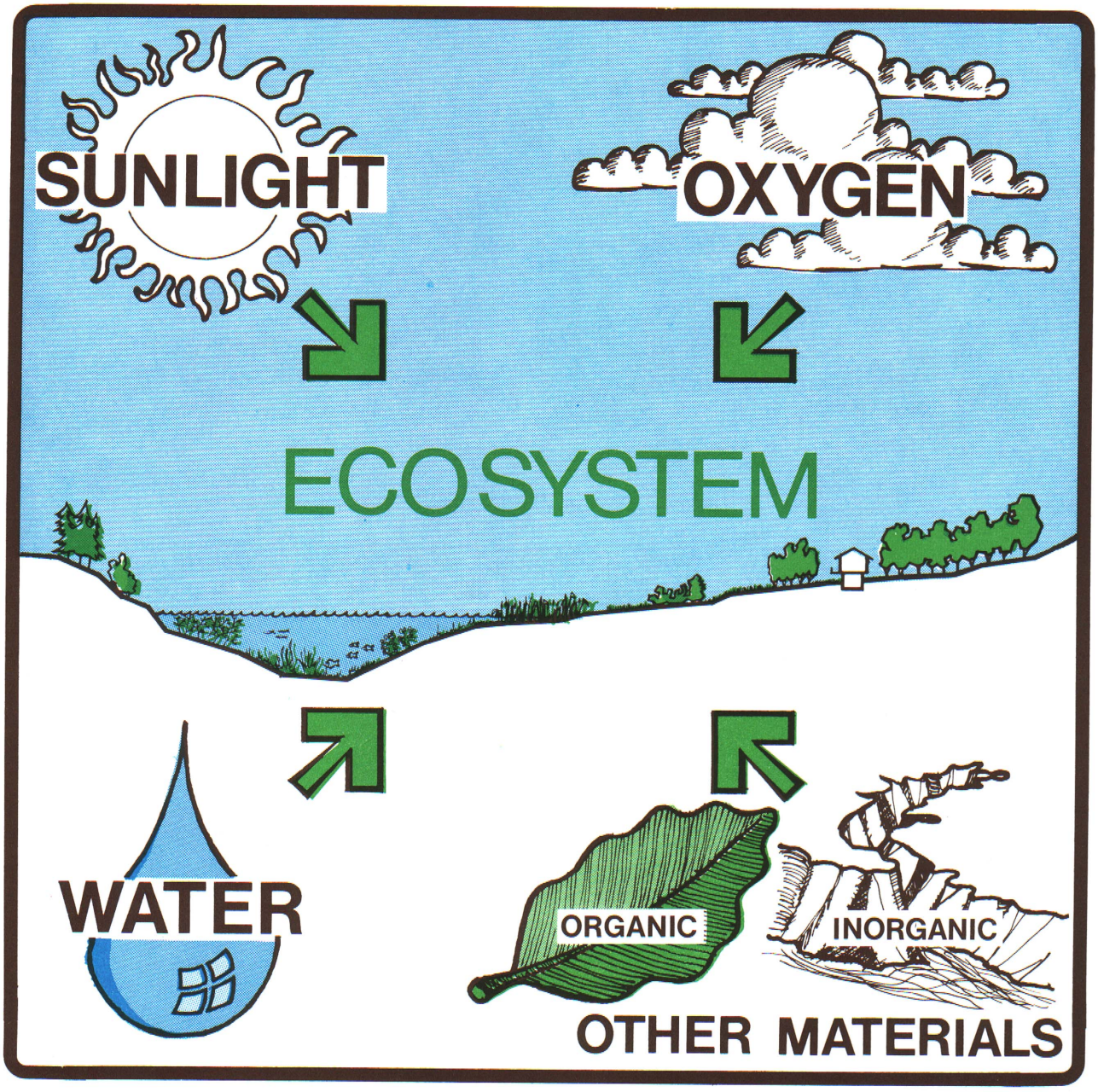


LAKE ECOSYSTEM

The lines point to the lake, shore and upland habitats of the living things pictured in the circles. Plants and animals, including man, are part of the lake ecosystem.

inputs

The most important natural ingredients which enter the lake ecosystem are energy (mainly sunlight); oxygen, carbon dioxide and nitrogen (mainly from the atmosphere); water; and other materials, such as eroding soil carried into the lake by running water or wind. Farming, logging, mining, housing development and other activities of man can change drastically the amounts and types of these inputs.

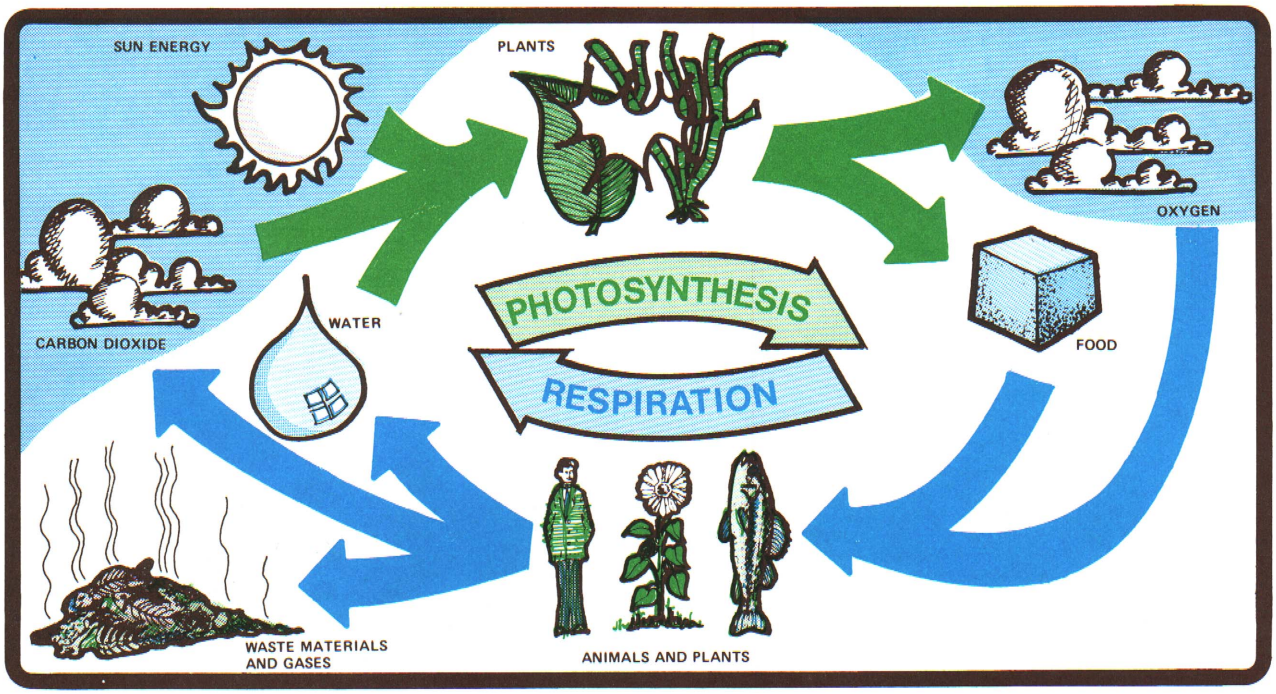


photosynthesis and respiration
vital life processes

Energy from the sun is the driving force in this natural system. Algae use this energy to transform carbon dioxide and water into more algae cells and into food just as garden vegetables or farm crops grow and bear fruit. As algae and other plants grow they use sunlight to transform water, carbon dioxide and other materials into living plant cells and into food (fats, sugars and proteins) needed to maintain life. This process is called "photosynthesis." Green plants are called producers because only they can make food by this process. The oxygen in the air we breathe is a by-product of photosynthesis—if there were no green plants eventually there would be no available oxygen.

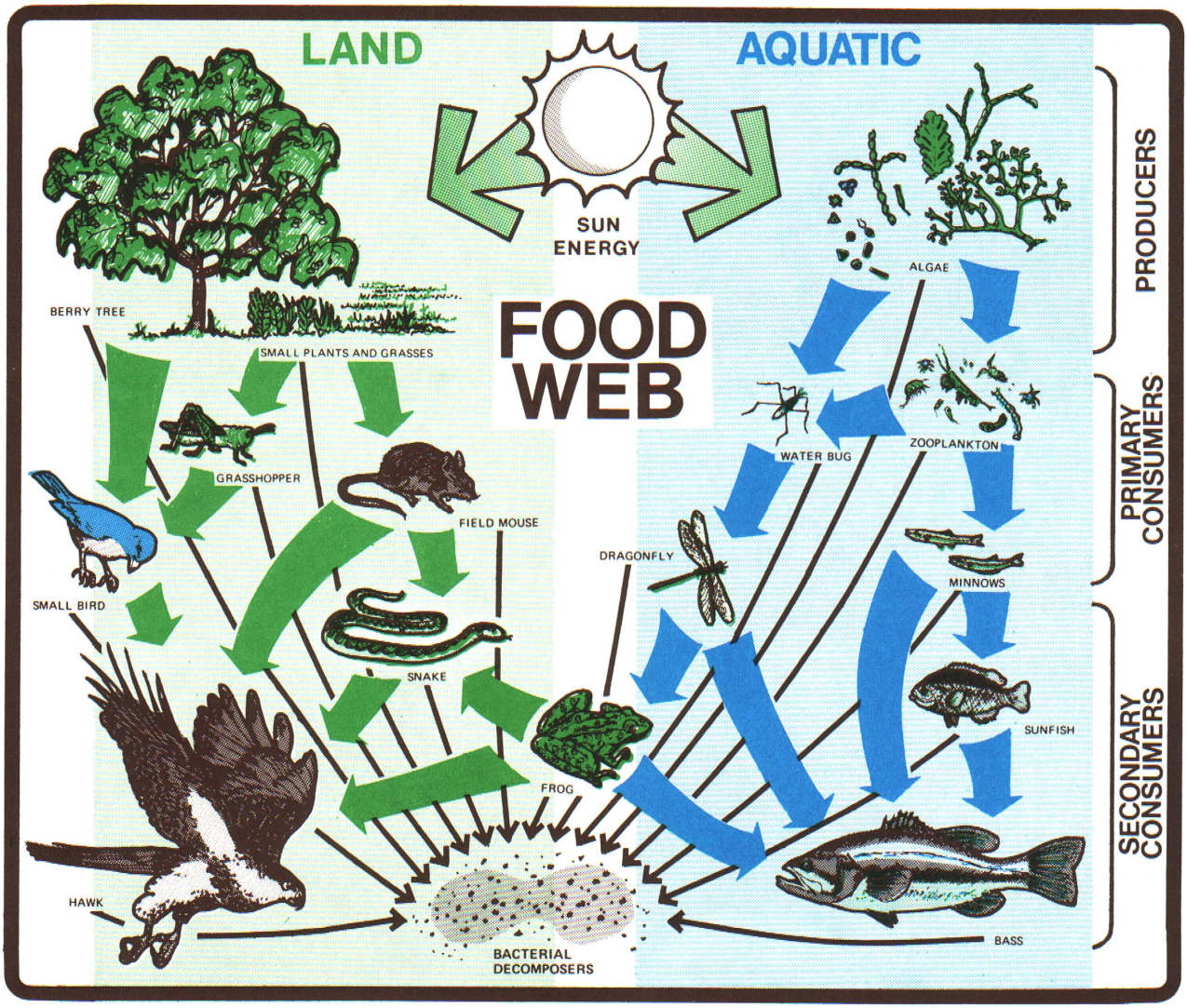
In order to stay alive algae and other green plants, like other living things, use some of the food they produce even before it can be passed on to animals. This process, called "respiration," results in carbon dioxide and water again, the original starting materials.

Plants use oxygen in respiration. During an algae bloom all the oxygen in the water may be used by algal respiration at night. Oxygen is also used by bacteria and fungi when organic matter decays. When the oxygen in a lake decreases sharply, or if it is used up entirely, the lake environment changes drastically. Many fish kills can be traced to oxygen deficiency, especially in the winter, when the lake may be covered with ice or snow. During the day when photosynthesis is occurring aquatic plants and algae are important sources of oxygen. It is only when the processes of decay exceed the rate of oxygen replenishment that the dissolved oxygen concentration decreases.



the food web
producers and consumers

Small microscopic animals, like Daphnia or Cyclops (sometimes used as fish food), cannot make their own food. They are consumers. They must eat algae or other plants as their food, or source of energy. This process, like our own digestive process, produces carbon dioxide, water, waste heat and other waste products. These small animals living in the water may be eaten by insect larvae or small fish. The small fish and insect larvae may be eaten in turn by bigger fish or bigger insect larvae. This is what is called the food web. In this web, energy coming from the sun flows from plants to animals. If more energy flows or if the flow is more rapid, more plants and animals will be present. Farmers strive for increased energy flow or increased productivity. Unfortunately, when productivity in a lake increases, problems may occur. The balance between producers and consumers may be upset. An overly productive lake becomes overgrown with algae and other aquatic plants.

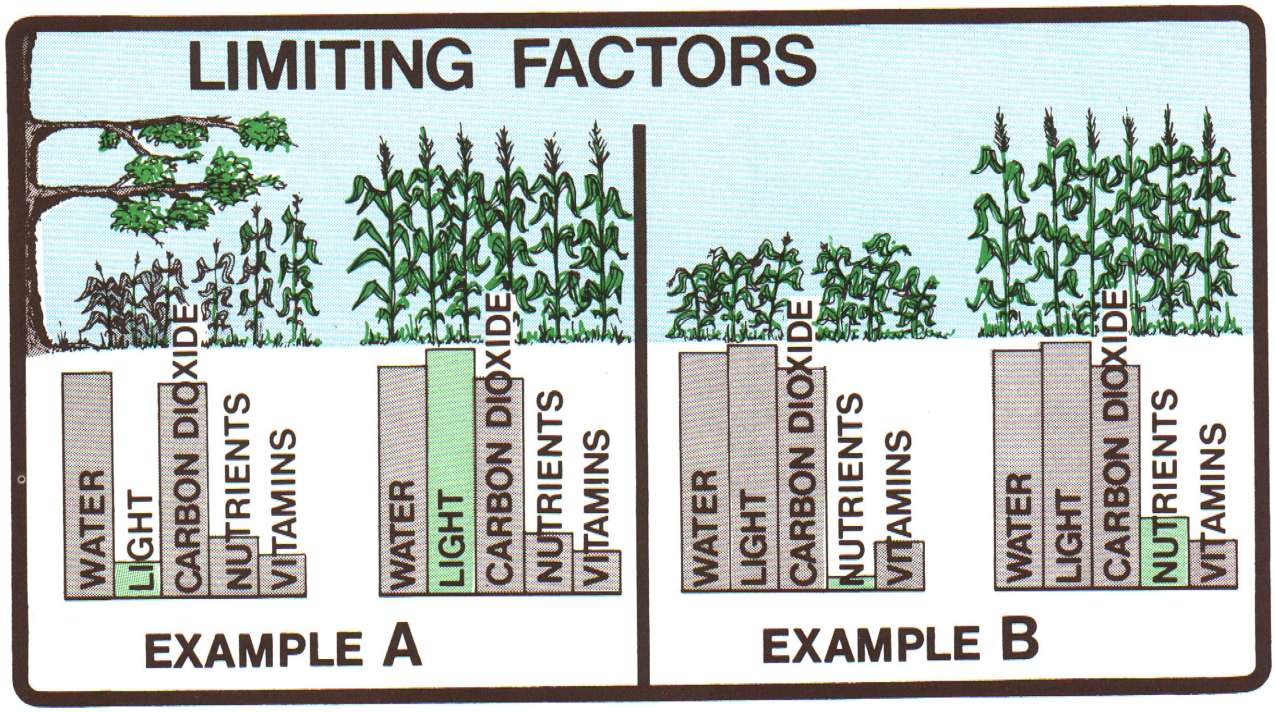


The arrows indicate the direction of energy transfer in the food web. Minnows and water bugs eat algae and plankton, and they in turn are eaten by fish.

a balanced community
stability and change

The producers (plants) and the consumers (animals) are usually in balance. If algae production increases, more animals that eat algae have a food supply and can survive. The existence of a balance does not imply that the actual numbers and types of organisms do not change, but that the ecosystem always tends toward stability and balance. An algae "bloom" is an example of a runaway population of algae that keeps on multiplying until there is a shortage of energy (the floating algae mats prohibit the penetration of light), a lack of materials needed for growth, or until the consumer population also expands to feed on the algae. Even though the number and kind of organisms in an ecosystem may fluctuate widely for a while and change considerably over a long period of time, there will usually be a dynamic or changing equilibrium unless the ecosystem has been severely disturbed by man, or destructive natural events.

Since light, carbon dioxide, and water are usually available anyway, the limits to the growth of algae and other plants are most often determined by nutrients and traces of other chemicals. Many homeowners and farmers add nutrients (phosphates, anhydrous ammonia and nitrates in the form of inorganic fertilizer) to stimulate plant growth and increase production. In comparison with light, carbon dioxide, and water, very small amounts of nutrients are needed. The nutrients in ten pounds of fertilizer could, under some circumstances, supply the needs of thousands of pounds of algae. Sometimes other factors may limit growth; these include: lack of a specific element such as iron, the acidity of the soil, or just the wrong combination of energy and materials. For example, people need only very small amounts of vitamins in fruit and vegetables, but even great quantities of meat and potatoes cannot be substituted for these vitamins.



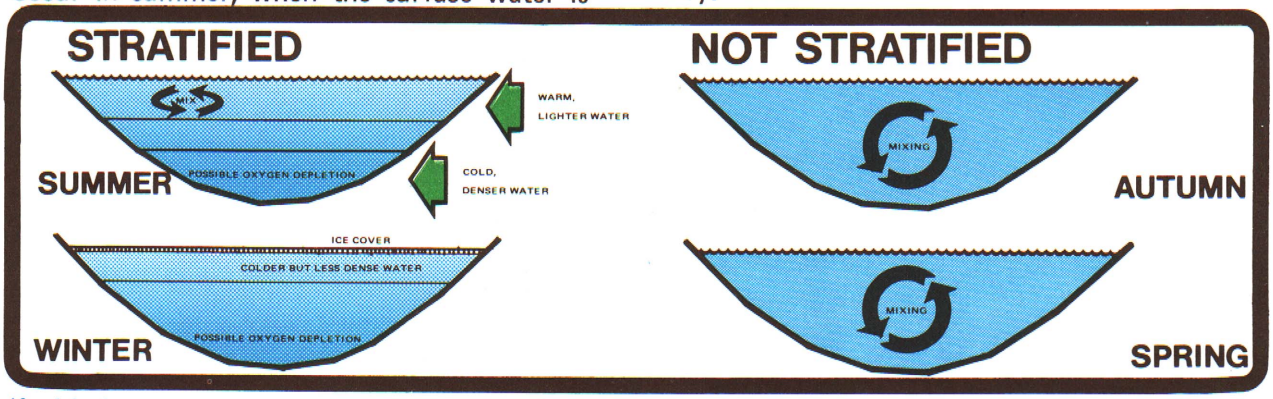
Light is the limiting factor. The corn on the left is in the shade of the tree. It grew very slowly. The corn on the right thrived in the sun. Both had enough water, carbon dioxide, and nutrients.

Nutrients are the limiting factors. The corn on the left grew in poor soil, lacking in nutrients. The corn on the right grew in rich, fertile soil. Both had enough water, sun, and carbon dioxide.

stratification

In many lakes, there are considerable seasonal variations in the amounts of dissolved oxygen and nutrients in various parts of the lake. These variations, which can cause sudden algae blooms, increased weed growths, or fish kills, are due in part to the physical properties of water itself: the relationship of the density of water to its temperature. As water warms, it becomes less dense—lighter—and rises to the surface of the lake. Thermal layers appear, inhibiting the circulation of water throughout the lake. This "stratification" may occur in summer, when the surface water is warmer than the bottom water, or in winter, when the surface water is colder and ice covers the lake. In spring and fall, when lake temperatures are uniform, mixing can occur throughout the lake, and the lake "turns over."

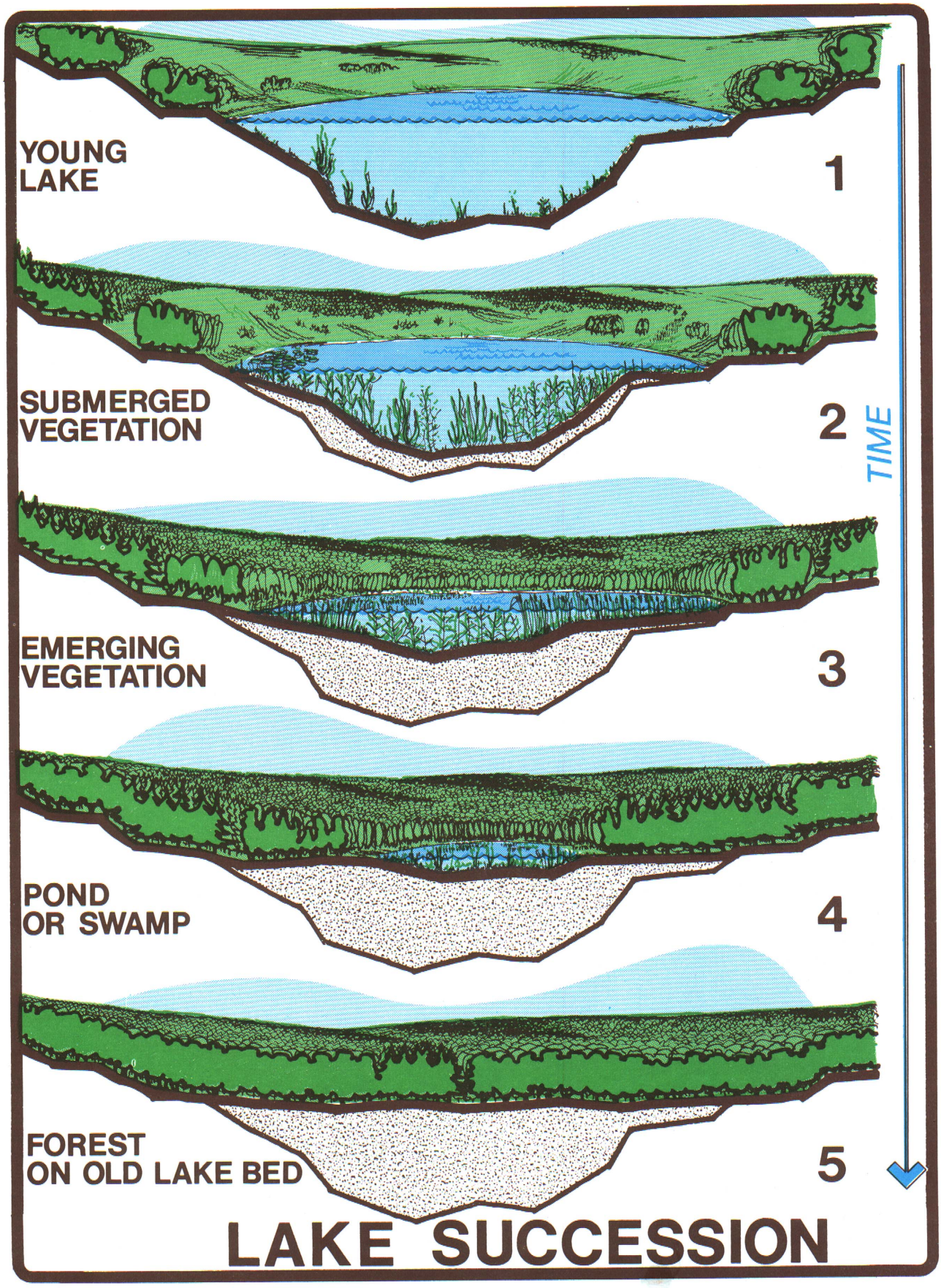
Not all lakes stratify and turn over. Some lakes turn over in both spring and fall, some only in the spring. In shallower warm lakes, where the water is generally well mixed by the wind, stratification may not occur at all. In other cases, only the deeper parts may stratify.



If a lake becomes stratified in the winter and summer, the oxygen-rich water near the surface cannot mix with the bottom water, which may then become oxygen deficient but rich in nutrients. In winter, when the lake surface freezes and the wind cannot mix the water, there may be so little oxygen in the lake that fish kills occur. In spring and fall the water temperatures equalize, all the water is circulated, and oxygen and nutrients are mixed throughout the lake. Nutrients normally trapped in the deeper water or the bottom mud by stratification are distributed throughout the lake. Immediately after these periods of mixing, algae blooms and dense weed growths are common.

succession

Although lakes are in a balance or equilibrium, two types of natural long-term changes are occurring: 1) The lake is gradually filling with eroding soil from upstream and surrounding land areas; and 2) The additional materials carried into the lake area may stimulate increased production. The lake not only fills with sediment but also with the remains of plants and animals. The number of dead plants and animals increases as the production of organisms increases. These forces cause lakes to become shallower. The area gradually tends to fill in completely. As this process, called succession, continues, the type of animals and plants present also changes drastically. Desirable game fish such as bass, pike, and pan fish may be replaced by rough species such as carp, suckers, and bullheads. Rough fish are better adapted to live in a lake which is relatively "old" on the time scale of succession. The lake or pond eventually becomes a bog or swamp. In turn the swamp tends to continue to fill in and, if conditions are right, a forest takes over. Depending on natural environmental conditions, the process of natural succession takes thousands of years.



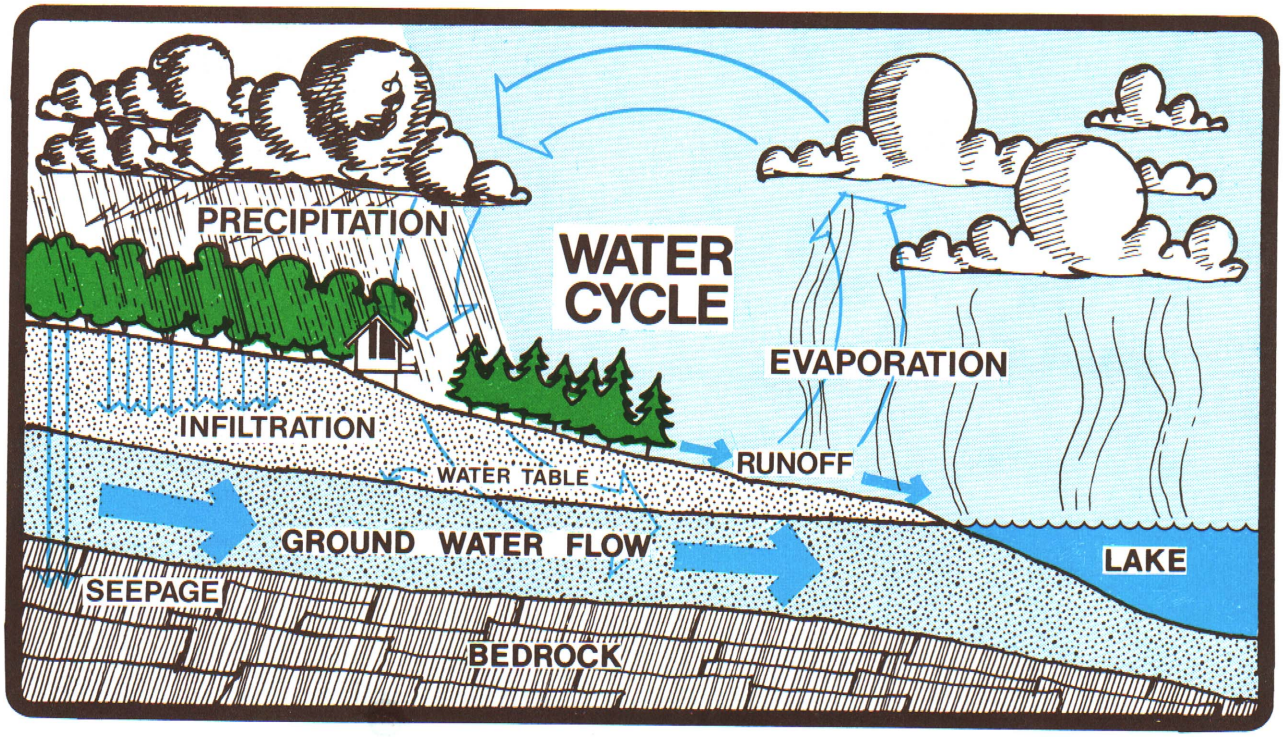
LAKE SUCCESSION

The young lake at the top of the page was formed by glaciers about 8,000 years ago. Over time the lake is enriched with nutrients and begins to fill up with sediment and decaying organic matter. In most cases it has taken thousands of years for glacial lakes to reach the final stages of succession naturally.

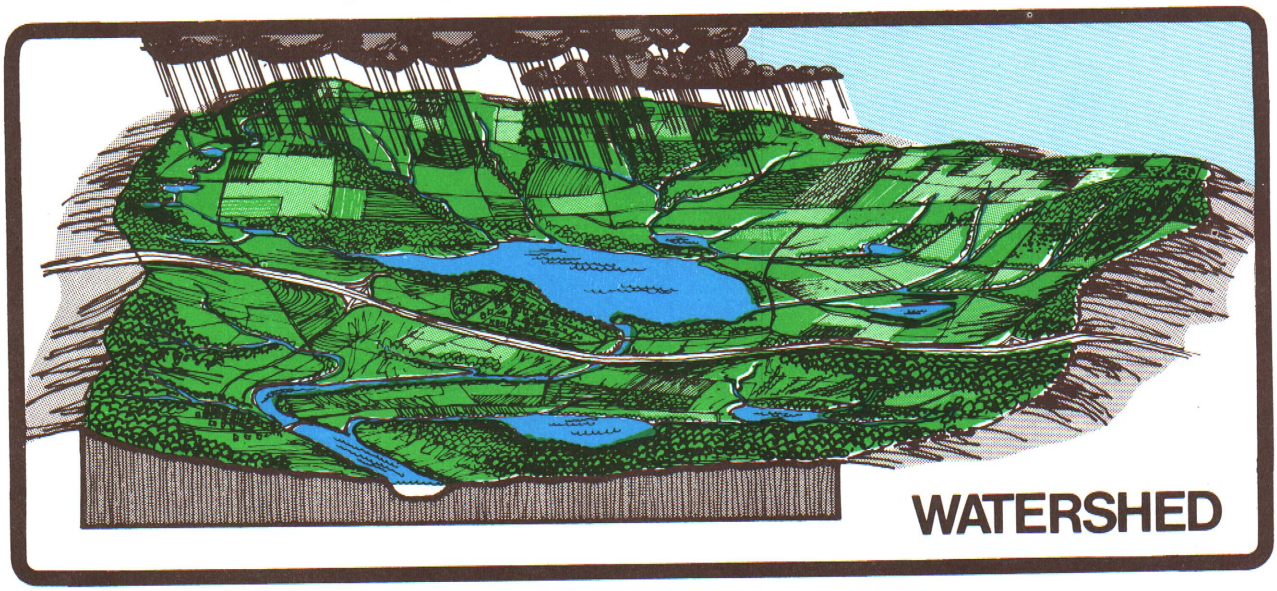
water

where it comes from and where it goes

Water, together with the living and nonliving things dissolved or suspended in it, is most important to the nature of a lake area. Most of the water falling as rain or snow in the watershed does not reach the lakes at all. It evaporates almost immediately back into the atmosphere before any flow is possible. The remainder of the rain and snow falling in the watershed (or drainage area) of the lake may eventually find its way into a lake in one of two common ways. Water may run over the surface of the land and into the small creeks or rivers that feed the lake. Most rain and snowmelt, however, soaks into the soil to become part of the groundwater which may also feed the lake through underwater seepage or springs. The water table is the upper elevation of the ground water. A lake is the surface expression of the level of the groundwater. When the water table or the groundwater level falls, the lake level will also fall. Even in major floods and droughts, lake levels fluctuate much less than river and stream levels. The major factors influencing lake levels are the amount of precipitation, and the balance between the inflow and the outflow of water. During periods of low rain or snowfall, less water enters the lake than flows or seeps out, causing a drop in the level. Lakes that have dams on the outlet or that are recharged with well water are usually managed so that a constant lake level is maintained regardless of the amount of rain or snow. Particularly in urban areas the water cycle can be severely altered by any change in land use that reduces the waterholding capability of the soil (for example removing vegetation) or that creates impermeable surfaces (rooftops, driveways, roads). Increased runoff and decreased groundwater infiltration and seepage may result.

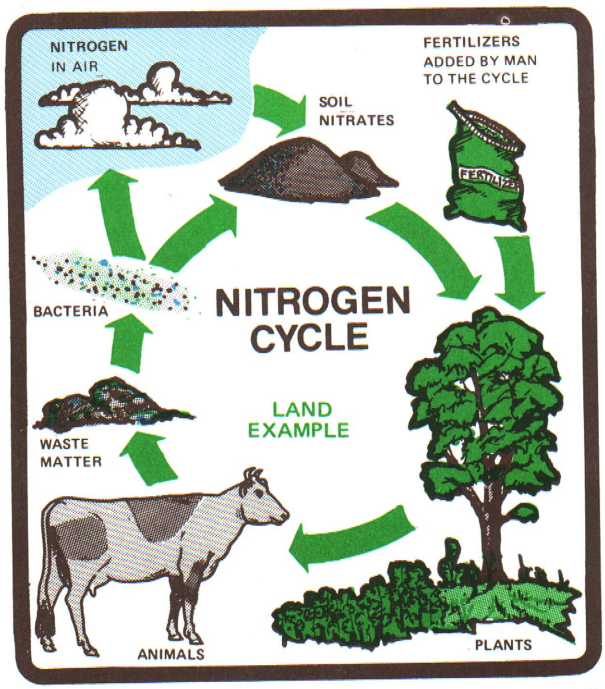


The nature of the watershed or drainage area determines the amount and purity of the water reaching the lake. The types of soil, rocks, vegetation, topography, and residential or industrial development in the watershed all have an effect on the quality and quantity of surface and sub-surface drainage.

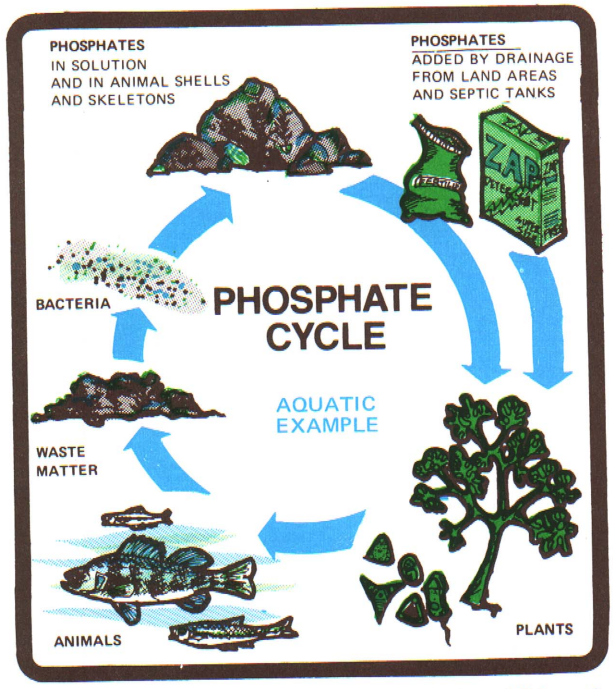


The lake is a trap for sediment, organic materials, and nutrients. Once in the lake much carbon, phosphate, and nitrogen is reused or recycled. The constant flow of water in a river may flush out pollution fairly rapidly.

In contrast, when a lake becomes polluted, it takes many years for it to "recover", or return to something near its original ecological balance, even if the sources of pollution are discovered and eliminated immediately.



The nitrogen cycle takes place in the lake ecosystem as well as on land. Animals eat plants which have absorbed nitrogen from the soil. The nitrogen is returned to the soil or escapes to the atmosphere when bacteria decompose animal excrement and the remains of dead plants and animals.



The phosphate cycle does not begin with the addition of fertilizers, detergents, and septic tank drainage—a certain amount of phosphate is naturally present in the environment and is constantly recycled. When bacteria decompose the bodies and excrement of animals and plants, phosphates are returned to the soil or water.

lake origins

natural lakes

Knowledge about the natural environment and how it evolved is useful in understanding the complexities of our current environmental condition, in which human settlements dominate the natural landscape. A study of the origins of inland lakes is also helpful since most of the geological processes that have led to lake formation are still continuing today. With few exceptions, these processes take a very long time to occur, and are barely perceptible during an individual's lifetime.

The following processes (singly or in combination) have formed the inland lakes of the world: movements of the earth's crust (tilting, folding, warping and faulting); volcanic action; glacial action; chemical solution; river and stream action; and wind and wave action.

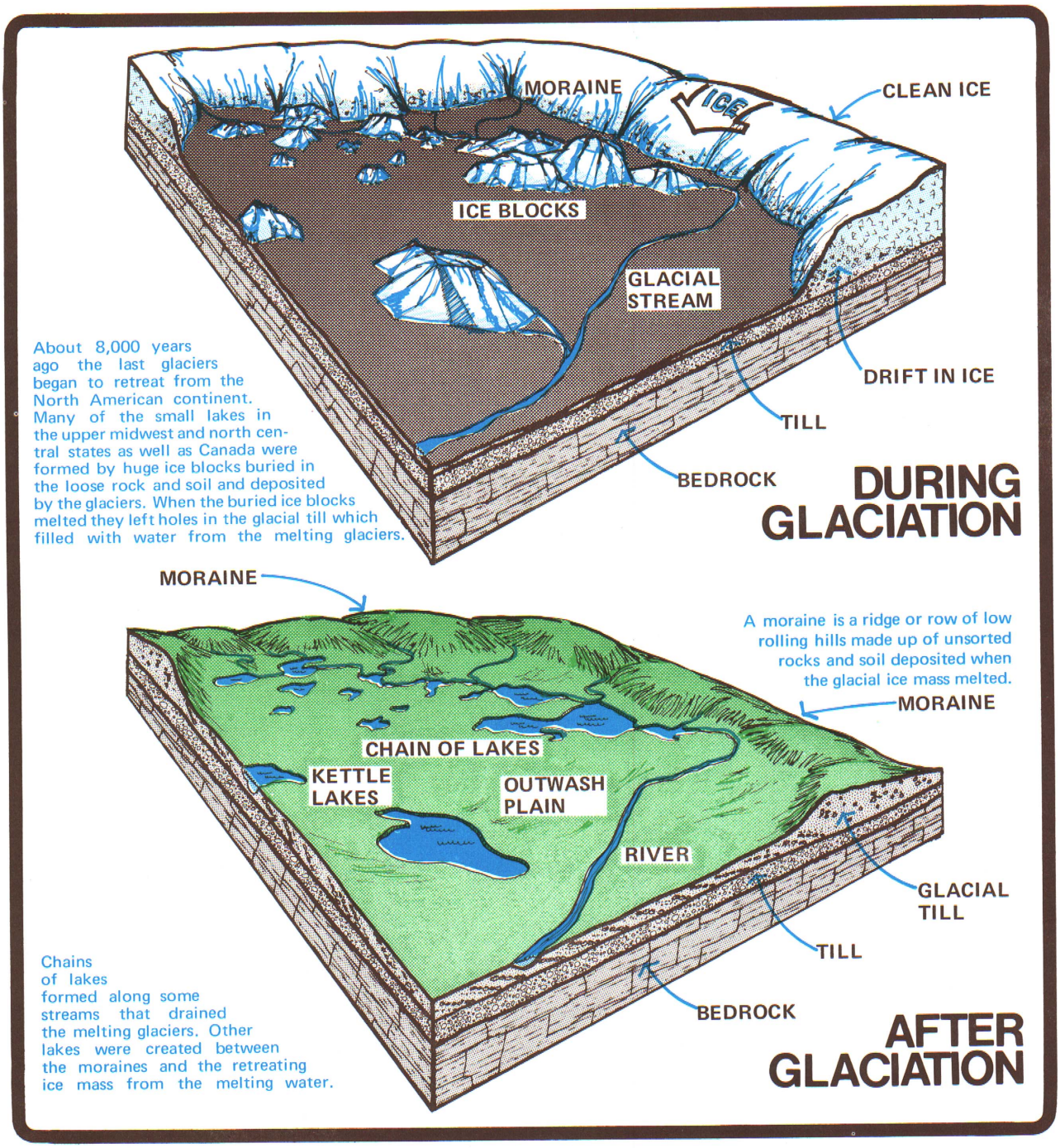
glacial lakes

The landscape we see today in most of the Great Lakes States and Provinces and in parts of New England is the result of the movement of massive continental glaciers and the effects of running water. The continental glaciers were large slow-moving masses of ice that formed when the temperature of the earth was lower. The last glacier receded from the Great Lakes area over 8,000 years ago. Smaller, valley glaciers are still common in colder mountainous regions of the world, including the Northern Rocky Mountains and Alaska.

When the glaciers slowly extended southward they picked up rocks, soil and debris as they advanced. As the northern hemisphere warmed and the huge continental glaciers began to melt, this mixture of sand, clay and rocks of all sizes (called "glacial till") was deposited on top of the underlying rock, or "bedrock" in layers up to hundreds of feet thick.

Most of the lakes in the northern United States and Canada are the result of the melting of glacial ice. Some, such as the Finger Lakes in upper New York State and the Great Lakes themselves, are the result of glacial "scouring": the glaciers wore away the bedrock and deepened valleys as they moved southward, forming deep depressions which eventually filled with water.

Other lakes were formed in depressions left by melting ice blocks. As the ice sheets slowly disintegrated into separate blocks, some of them were buried in the glacial till. When these blocks melted numerous depressions were formed. Lakes now exist in the depressions wherever the level of the water table is high enough.



other types of lakes

In some areas ox-bow lakes are distinctive valley-bottom features. Such lakes are formed when meandering streams cut a new and straighter channel, by-passing the old streambed. Other means by which lakes and their basins may be formed include: crustal movements such as block faulting or downwarping; volcanic activity; landslides; and enclosing of lagoons by barrier islands. Also, ground water conditions may cause the development of swamps and marshes even though open surface water is not present. This is common in glaciated areas and in coastal regions. Swamps and marshes are often located on deltas and adjacent to or back from artificial or natural levees.

man-made lakes

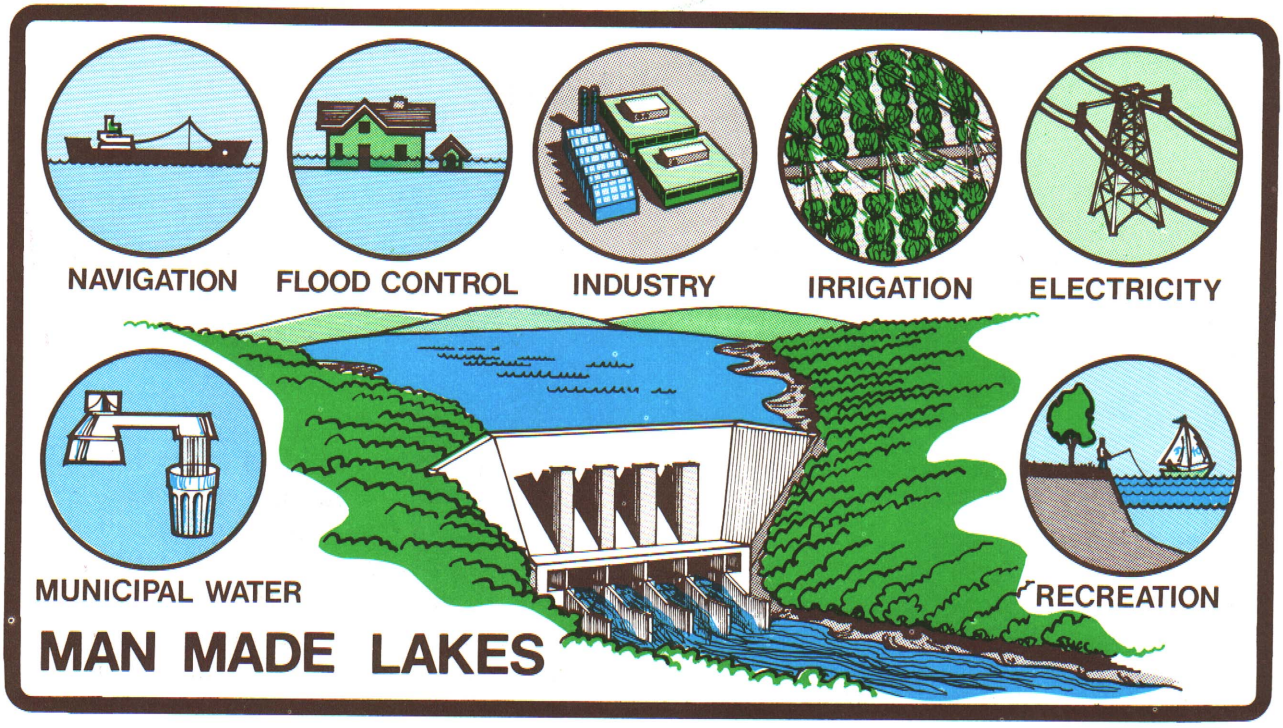
Most man-made lakes and reservoirs are formed by placing a dam on a river, or by excavating a depression which subsequently fills with water. These lakes are similar in most ways to natural lakes. In the United States there are 13 million acres of water surface created by man-made lakes. Construction and maintenance of large dams and reservoirs involve such large sums of money that they are usually built by the federal government, to meet specific, nationally beneficial public purposes. Some electric power companies build large reservoirs. State and local governments also construct reservoirs, primarily for water supply.

Man-made lakes are usually planned to meet specific water use objectives. The most common are power generation, navigation, water storage for industrial and municipal water supplies, irrigation, flood control, mosquito control, recreation, and fish and wildlife management.

The purposes for which man-made lakes and reservoirs are constructed vary from region to region, depending both on the regional needs and problems and on the availability of good dam sites. The most important uses of these artificial lakes are shown in the illustration.

Most man-made lakes and reservoirs are created by damming rivers and backing up water in the river valleys. The lakes which are formed are usually long and narrow, rather than circular. The shorelines tend to be very long and irregular, because they conform to the terrain of the river valley, which is often rugged.

Once formed, man-made lakes generally develop plant and animal communities similar to those in natural lakes. Some important differences are that artificial lakes are built over areas that were farmed or forested, or contained other types of natural communities. Site preparation before inundation helps to avoid problems after the area is flooded. An important management task is cutting and clearing the vegetation, especially trees, both to improve water quality and to



make recreational uses safer and more convenient. Also, the type of stratification that occurs is sometimes quite different because of strong river currents.

Seldom is there any significant ground water input, except in excavated lakes. There often is considerable water loss to the permeable rock formations under the lake. These water losses, together with losses from evaporation and transpiration (plants), can be great, particularly in arid regions such as the southwestern United States. Shallow, warmer reservoirs are more likely to suffer greater evaporation losses than cold, deep ones. The more water surface exposed, the worse the problem is.

Man-made lakes often fill up with silt much faster than natural lakes. If the river which is dammed up to create the lake has a great deal of eroded soil suspended in it, this heavier silt will settle out and drop to the bottom of the lake as soon as the speed and tumbling action of the river flow decreases in the lake.

In artificial lakes and reservoirs which are managed for power generation and flood control, the water level of the lake may change rapidly and may fluctuate over a wide range. When power is needed, more water is allowed to pass through the dam. If it is necessary to curtail downstream flooding, the water flow through the dam will be reduced and the water levels will rise. These extreme fluctuations in water level are not characteristic of natural lakes. Major changes can occur in the shoreline vegetation and habitat, and serious shoreline erosion often results. Large mud flats also appear when the lake level is lowered.

Despite the benefits of man-made lakes, their construction can have serious environmental consequences. Some specific problems are: the loss of the natural, free-running river and the associated animal and plant habitat; a total barrier or a major obstacle to fish migration; resettlement of people; increased possibility of earthquakes; increased water losses by evaporation; inundation or destruction of historic or pre-historic sites or other important places; and scouring and erosion problems in the stream below the dam.

Access to and the recreational use of man-made lakes is a problem in many areas. Special regulations and controls are necessary as well as careful preplanning and design of facilities. Land use problems around the major man-made lakes have not been as serious as with natural lakes, mainly because of public ownership of the shoreland as well as the land to be flooded. In many water supply reservoirs, recreation use of the water surface and sometimes any use of the whole watershed draining into these lakes is completely forbidden. Whether or not these reservoirs should be used for recreational purposes is a hotly debated question in many areas of the West.

A recent trend has been the practice of constructing small, shallow lakes and ponds as an integral part of industrial park and residential subdivision development, and in the construction of new communities. While built primarily for aesthetic reasons, these man-made lakes often are used to control (and sometimes improve the quality of) storm-water runoff.

farm ponds

Farm ponds are used for recreation, farm water supply, fish propagation, and aesthetic values. A complete discussion of this special type of man-made lake is beyond the scope of this booklet. Information on the use, construction and management of farm ponds may be obtained from the U.S. Department of Agriculture, Soil Conservation Service.

lake settlement

land use and development

In the short time that man has inhabited the North American continent, he has made tremendous changes in the land form, by adapting and using it to meet his needs and desires. We cultivate it to feed us, mine it for raw materials, and develop it into communities, both large and small. Yet our ability to bring about these changes is often far greater than our understanding of the environmental consequences of our actions.

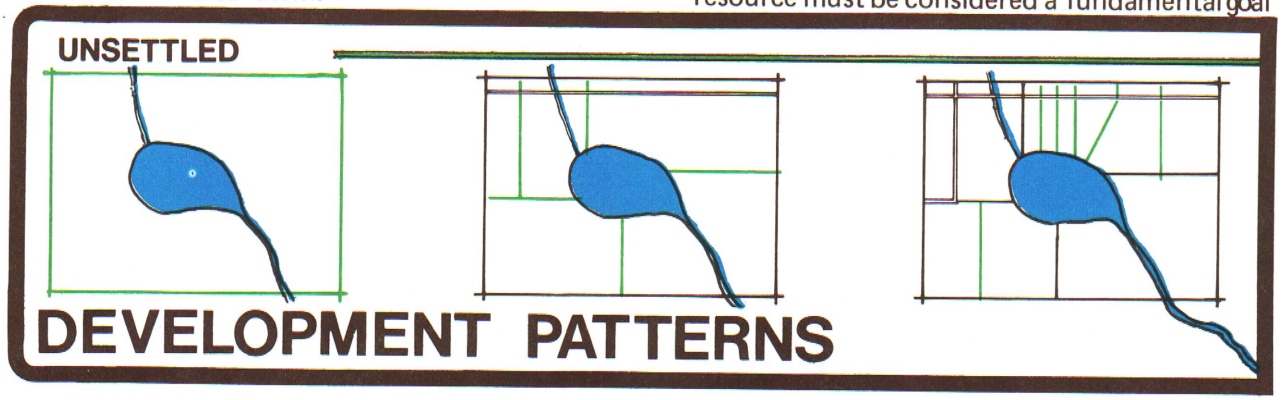
One way we make dramatic changes in our surroundings is by building places to live and work. While the shape and form of the land are still important considerations, population growth and economic pressures have become major factors influencing our land use decisions. As cities grow, they expand outward, and well-documented cycles of land use change appear: wilderness becomes farmland; farmland becomes suburbs and outlying industrial areas. All of these changes affect the natural ecosystem in some way.

The land surrounding inland lakes is also subjected to these pressures and patterns of land use change. People enjoy living near water, because of the recreational opportunities and the inherent beauty of lakes. Yet because of the way we live and our attitudes, we often destroy or damage the very lake characteristics which draw us to them.

The harmful effects of lakeshore communities on the lakes and their environs have become much more serious in recent years. Thirty or forty years ago people living along lakes placed fewer demands on the natural environment. Lake shore homes previously were used only for weekends and vacations. Residents were more inclined to "rough it" by doing without such modern conveniences as indoor plumbing. Also, many common conveniences such as automatic clothes washers and garbage disposals had not been invented.

As highway transportation improved and people had both more money and more time for leisure activities, lake shore homes became much more desirable, as both second homes and permanent residences. Lake community residents began placing heavier and heavier demands on the aquatic environment, both for domestic waste water disposal and water supply, and recreational activities.

Virtually everything that occurs in a lake community—from motorboating, to dishwashing, to lawn and garden care—affects in some way both the lake and the land around it. Land and water use problems cannot be separated from one another; lake problems such as pollution are largely land use problems. The preservation and protection of the natural resource must be considered a fundamental goal



of community land use planning.

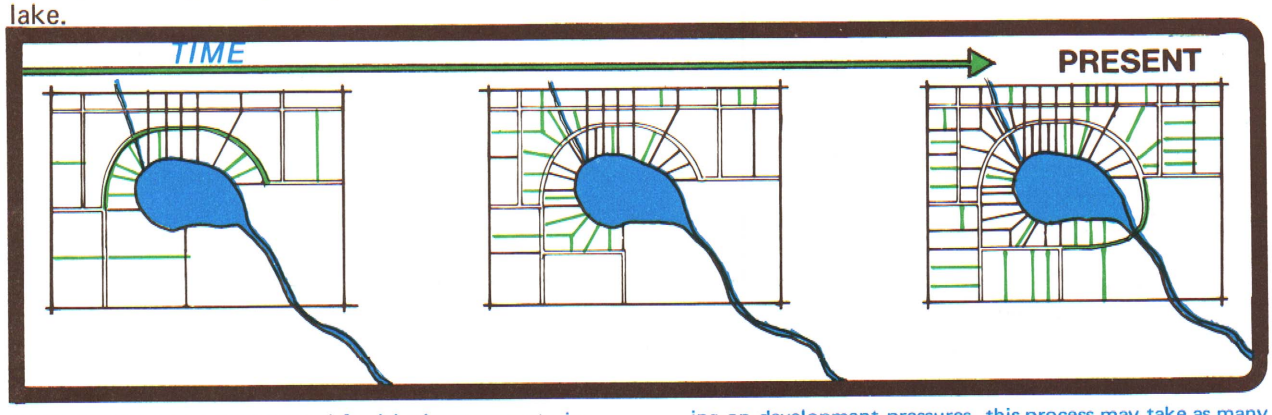
Whether the lake is already developed or not, it is vitally important that there be a general development plan for the lake community. This plan must have as its primary purpose the preservation of the natural setting and the lake itself. The first step in preparing such a plan is to determine what the lake community should be like. Among the issues which should be considered are whether there should be evenly sized and spaced residences or cluster development; commonly-owned shoreline; or buffer zones screening the homes from the lake.

Making this type of decision is not as easy as it might seem. Most people have not thought through the implications of lake residence. The desirability of a lake shore home is based in large part on its natural setting, unlike a home in town, whose value is based on other factors, such as convenience to schools and jobs, and the public services available only in urban communities. We cannot hope to set down a little piece of the city by a lake and at the same time preserve the natural environment that draws us to the lake in the first place.

At some point the level and type of lake shore development will come into direct conflict with the needs and requirements for lake preservation. Many people, after careful analysis, might find that the price of lake residence, measured in terms of lack of urban services and the high cost of preserving the natural lake from the impact of human habitation, is simply too high to justify their living at the lake.

Planning for any type of community requires a great deal of imagination, knowledge, foresight, and skill, especially if it is as closely tied to a natural resource as a lake community. Planning has become a highly developed profession, and planners are trained to translate general community desires and goals into workable, environmentally sound plans. But no matter how sensitively and carefully drawn, a plan will not work unless it is respected and followed, and the necessary laws, regulations, and ordinances are enacted and enforced to make sure that buildings are up to standard; that dredging, filling and erosion are controlled; that minimal public services such as sewers and roads are built and maintained; and that lot sizes, setbacks, side yards, and other land use and community development criteria specified in the plan are followed.

It is, of course, much less disruptive to plan a community sensitively and imaginatively from the start, than to try to change the land use patterns in an existing community. This is particularly true where there are basically unresolvable conflicts between man and nature, as with homes so close to lakes that they flood every year. But even where the most haphazard, uncontrolled development has resulted in serious lake community land use problems, planning can help improve the community over the long run, by setting goals and objectives, and establishing a program of controlled change, including gradual elimination of undesirable and incompatible land uses.



As population grows, the demand for lakeshore property increases. Many lakes are subdivided into small lots in piecemeal fashion without a comprehensive land-use plan. Depending on development pressures, this process may take as many as 100 or as few as 10 years. Some man-made lakes often are immediately subdivided for home sites.

lake problems

When people sense something wrong with a lake, what bothers them often is the result of a specific type of natural condition, or of human interference with the natural processes going on in the lake. In the pages that follow, many common types of lake problems are discussed. To understand these pages completely, it may be helpful to refer back to the "Environmental Concepts and Terms". Also, it should be remembered that this section on problems is intended to be descriptive; actions which can be taken to correct or prevent these problems are discussed on page 34.

water pollution

There is no precise, scientific definition of water pollution. Nor is there any one test that can be made of water to determine whether it is polluted. Generally, we say that water is polluted when the properties of water, physical, chemical, or biological, are changed in such a way that either the quality of the water is no longer acceptable for uses which people want to make of it, or the quality is changed in such a way that the natural ecological processes are disturbed. Anything which gets into a lake or river and either changes the natural processes occurring in the water or keeps us from using the water as we would like is a polluting substance.

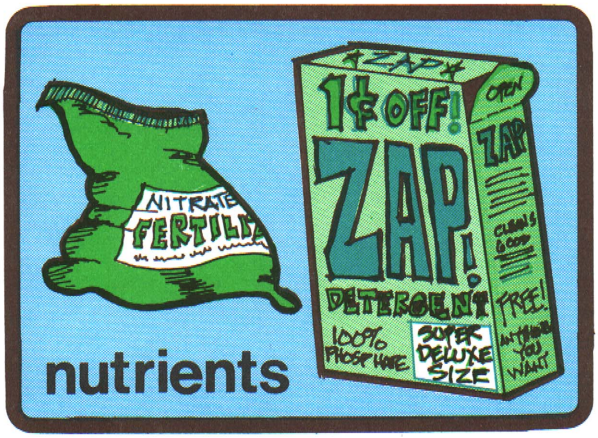
It is sometimes difficult for someone who is not a scientist to detect the presence of a polluting substance. In some cases, such as oil spills which float on top of the water or chemical dyes from a paper mill which change the color of the water, we can sense—see, taste, smell or feel—the actual polluting substances. In many other cases, though, we become aware not of the polluting substance itself, but of the results of the chemical or biological effects of the polluting substance on the animals or plants in the lake. An example of this is when excessive nutrients—phosphates, nitrates, or ammonia—get into the lake. These substances themselves are the polluting substances which have to be controlled or treated; yet the conditions which we sense as indicating that there is water pollution of this type are not these substances, but the result of their addition to the lake: the growth of excessive algae and aquatic weeds, which may be stimulated by the presence of the nutrients in the water.

In some cases, the undesirable conditions which people object to and call water pollution are natural processes which would occur even if there were no sewage, industrial waste, or other harmful man-caused substances entering the lake.

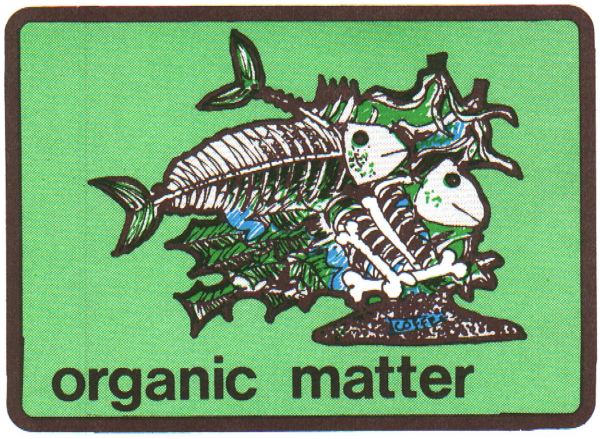
There are three general types of damage that can be caused by pollution: ecological damage (harmful changes to the aquatic life and to related terrestrial life, such as birds and mammals, as the result of substances introduced into the lake); economic damage (either the costs to clean up the water, or the uses of water which cannot be continued because the water is too polluted); and aesthetic damage (changes in the natural lake which make the lake less pleasing to look at, swim in, or use in some other ways, even though the effects on the natural environment or the pocketbooks of those concerned may not be measurable).

The following pages illustrate some of the more common types of pollution which are caused by people and their uses of land and water.

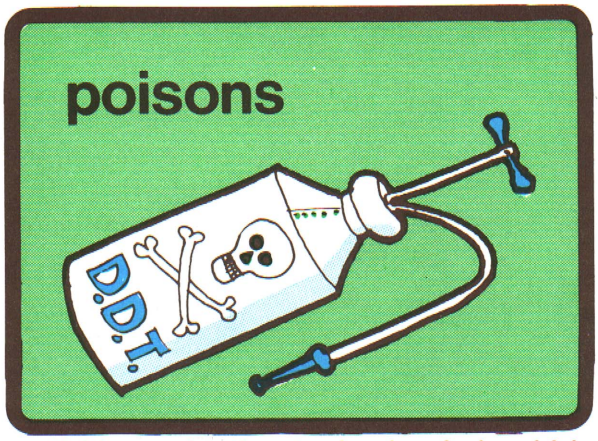
some types and effects:



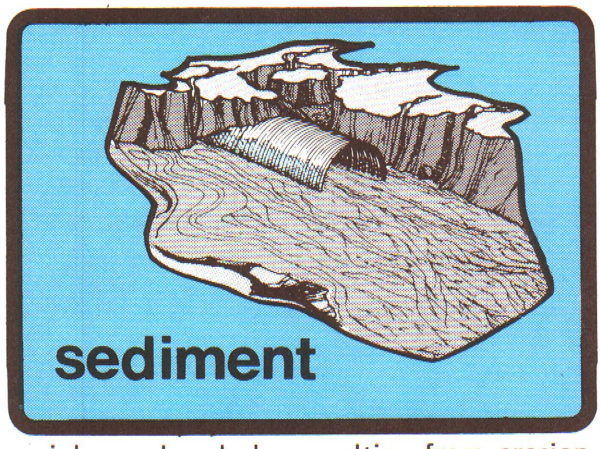
mainly phosphates, nitrates, and ammonia which may cause increased algae and weed production.



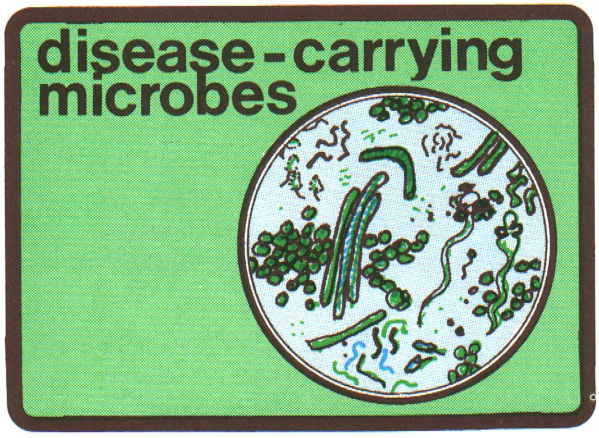
such as garbage, domestic sewage, some fertilizers, and animal wastes (manure).



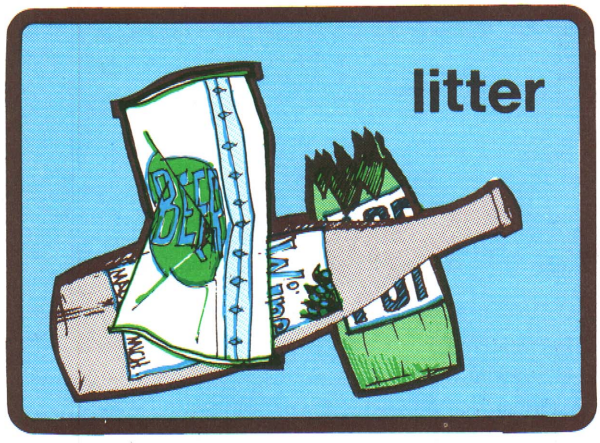
pesticides and other toxic chemicals which kill or adversely affect both man, in some cases, and the organisms present in the water—not only fish but also smaller organisms that fish eat.



mainly sand and clay resulting from erosion which fills lakes, clouds water, and hampers aquatic photosynthesis as well as the reproduction of desirable fish.



bacteria and viruses can cause dysentery, polio, typhoid, and other diseases.



cans, bottles, paper, and other rubbish.

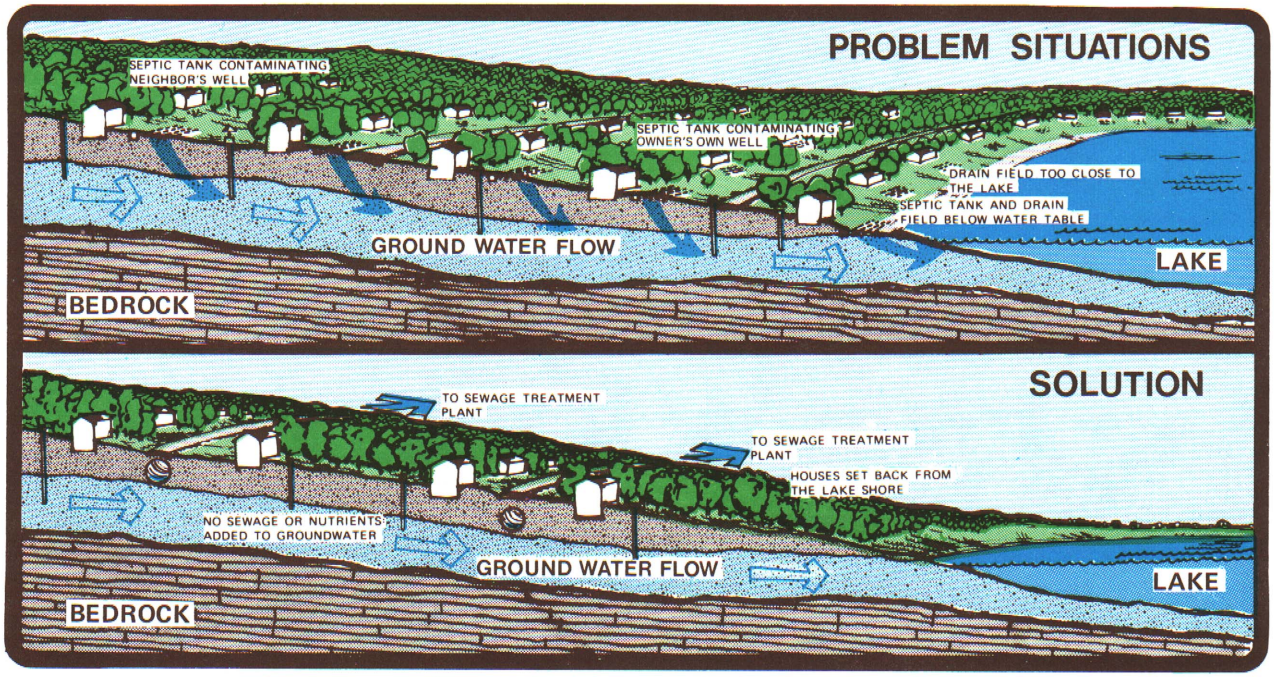
local sources of pollution

While pollution of a lake may be caused in part by harmful substances coming from other communities or areas, many of the sources of water pollution are found in the lake community itself.

septic tank / drain field operation

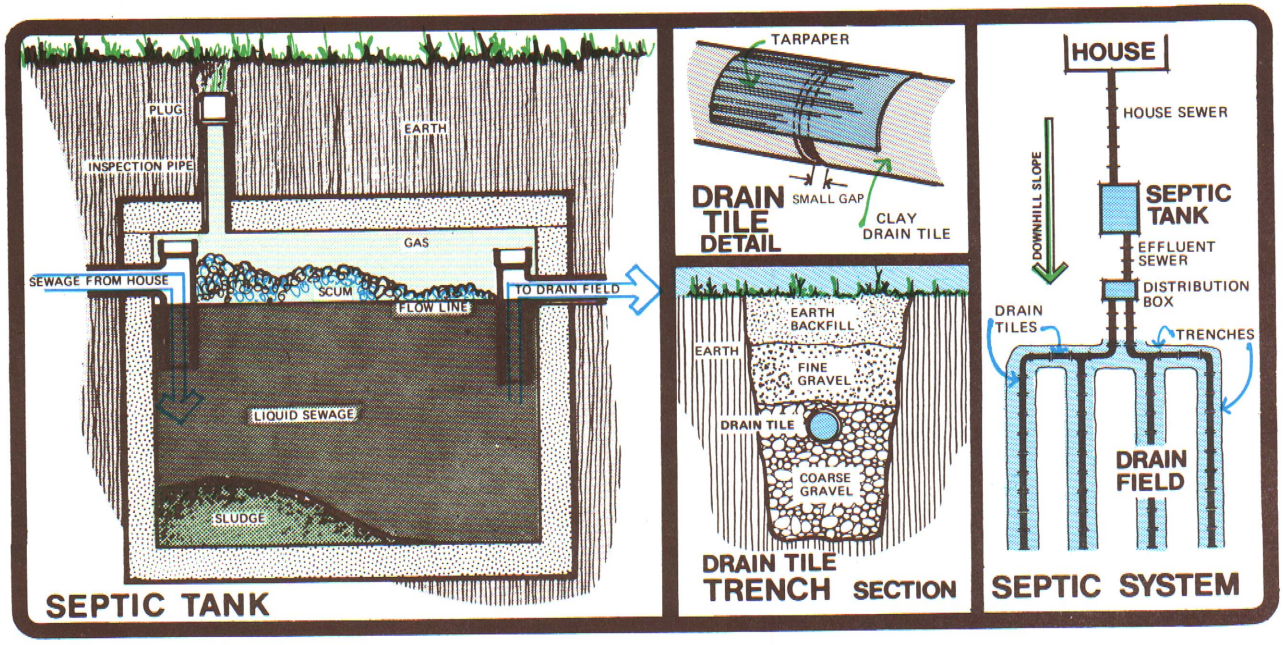
Faulty septic tank/drain field operation is common because:

- drain fields may be too close to the water table or to surface drains—the effluent or outflow is not filtered through soil to remove nutrients which stimulate algae production or to remove organic material which uses up oxygen dissolved in the water.
- organic soils (muck) are common on the shores of many lakes. These soils often are saturated with water so that little or no purification of effluent takes place.
- clay soils are not effective filters of septic tank/drain field effluents because they absorb water very slowly, if at all, resulting in surface flows.
- sand absorbs outflows quickly but unfortunately may not filter out all impurities.
- bedrock at or near the land surface does not absorb drain field effluent, resulting in surface flows.



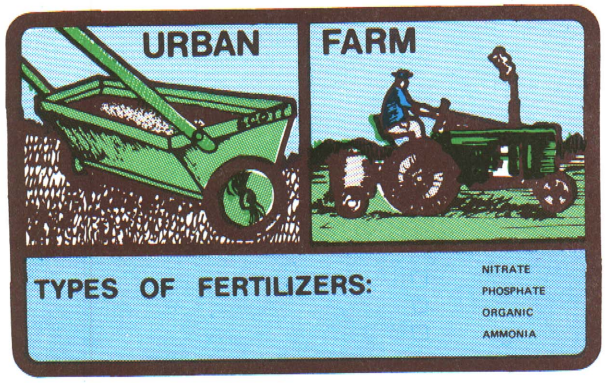
Generally soils that are a mixture of sand and clay work best if not overloaded. Although soil and water table factors are very important to the efficient operation of the septic tank/drain field system, the ideal soil-water table situation can become saturated, ineffective filters if too many septic tank-drain field systems are located in the same area. Also drain fields of homes built back from the water on sloping ground may contaminate the water table of homes down the slope from them.

Waste water from the house is flushed to the septic tank where most solids settle out. Bacterial action in the tank breaks down some materials before the liquid flows out to the drain field where it seeps into the soil.



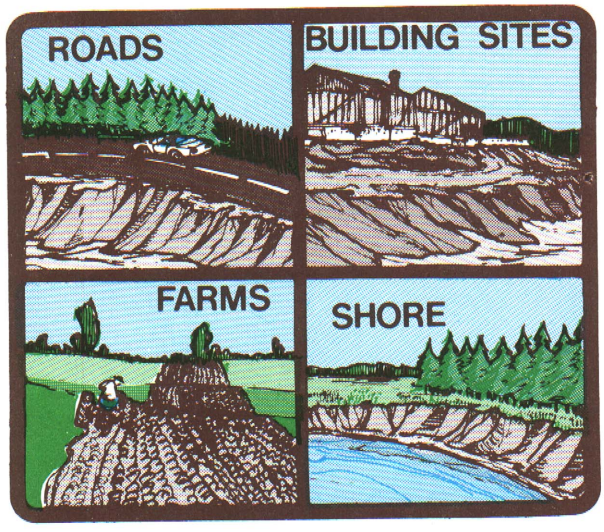
fertilizers and pesticides

The way individual property owners manage their lawns and gardens also can contribute to the supply of nutrients in the lake. Lawn and garden fertilizers applied to slopes facing the lake or to slopes draining into the lake can stimulate algae production in the lake as well as the growth of a lawn. Persistent pesticides (lindane, DDT, etc.) washed into the lake kill some beneficial organisms outright, inhibit reproduction of animals, and are accumulated in the fatty tissues of animals, including man.



erosion

Development around a lake can contribute in many ways to the load of sediment being introduced into the lake. Erosion at the construction sites of new homes, road erosion and shore erosion are major sources of this kind of pollution. Hillsides or shore slopes are the most likely spots. Normally vegetation will prevent erosion. But where banks are steep, construction of artificial drainage channels or bank stabilization with railroad ties or steel sea walls may be necessary. A band of natural vegetation left near the shore not only can help curtail sediment reaching the lake but may more effectively prevent nutrients and pesticides from reaching the lake.

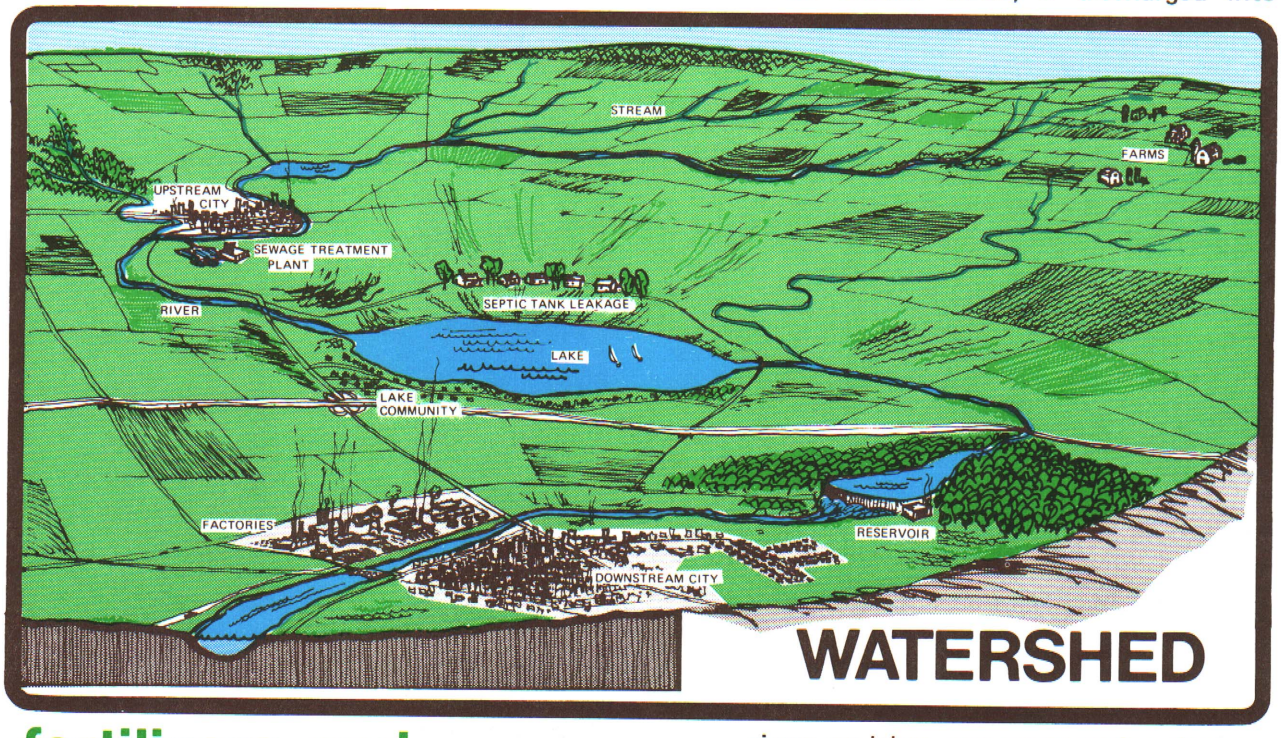


watershed influences:

The water quality in lakes may be affected by more than just the pollution from lakeshore sources or lake users. Most lakes are fed by rivers or streams, which may carry harmful or undesirable substances from the upstream areas which are drained by these tributaries. The sources of water pollution from upstream areas may include:

inadequately treated sewage

from improperly installed or maintained septic tank/drain field systems near upstream lakes or streams, or from municipal sewage treatment plants;



fertilizers and pesticides

washed into the lake or tributary streams (either in solution, or adhering to soil particles) from agricultural and urban areas as well as from sewage treatment plants which do not remove enough nutrients;

sediment

in the form of soil erosion from construction sites in urban areas, from roads, or from farms;

industrial effluent

either from intentional use of the water to carry off waste products from the manufacturing process, or from careless handling of the products which the plant manufactures. Metal processors and chemical manufacturers may discharge metallic substances which are toxic. Food processors and paper mills, on the other hand, may discharge substances which place heavy demands on the dissolved oxygen in the water. Water is also used to absorb waste heat from electric generating plants or other industrial processes. This heated water, if discharged into rivers or lakes, can cause major changes in the lake ecosystem.

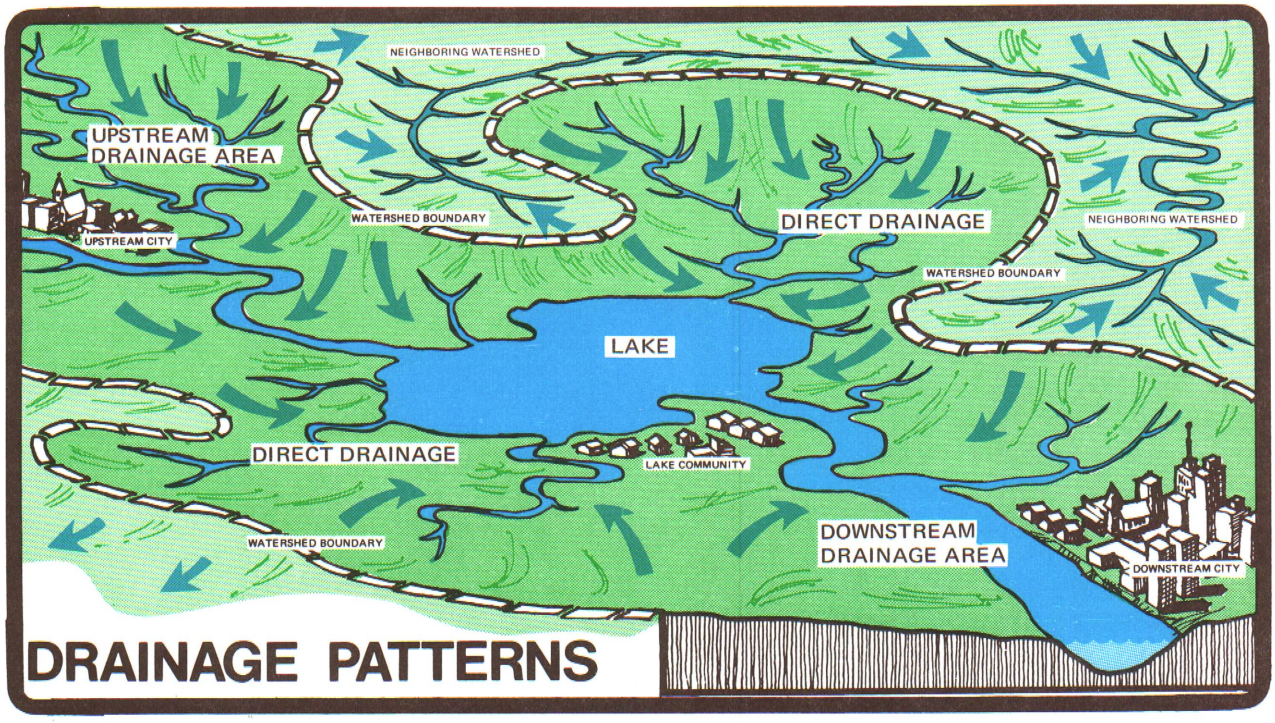
urban runoff

is a particularly serious problem because the surface runoff which enters rivers and lakes through storm sewers and drains contains virtually every substance which can be "washed" from the land: lawn and garden fertilizers, pesticides, sediment from soil erosion, animal wastes from pets, and oil and rubber fragments which wash off streets and parking lots.

upstream effects

All lakes and rivers are surrounded by land areas which drain into them, either directly or indirectly. The path which surface water runoff or polluting waste discharges takes in reaching the lake is dependent largely on topography: where the drainage divides are. Anything which happens within the drainage area or "watershed" of the lake and its tributary streams and rivers influences the water quality in the lake.

Not all undesirable substances carried off the land by runoff or discharged directly into upstream rivers or lakes will necessarily cause a water quality problem in a lake downstream. Because of natural processes at work in streams, the polluting potential of the substance may dissipate before it reaches the lake. Potentially harmful bacteria, for example, may die off long before the tributary water flows into the lake. Many polluting substances, though, remain harmful to the lake ecosystem regardless of how far they must flow before reaching the lake.



downstream effects

Areas downstream from the lake of course receive the combined effects of pollution from the lake area and from land and lake areas further upstream. In other words, residents of lake communities have to act to curb pollution not only in their own lake, but also should pass water downstream as clean or cleaner than when it entered their community. Few communities can boast of this.

low water and flooding

Unless artificially controlled, most lake levels vary from season to season, from year to year and over longer climatic cycles. High lake levels may result in flood damage to homes, piers, roads and other structures. The proper and safe operation of wells, septic tanks, drain fields, and storm sewers or drains may be affected. A habitat for "nuisance" insects may develop. High lake levels also may lead to adverse water quality changes, accelerated shoreline erosion, and difficulties with the use of beaches, piers and boat launch facilities.

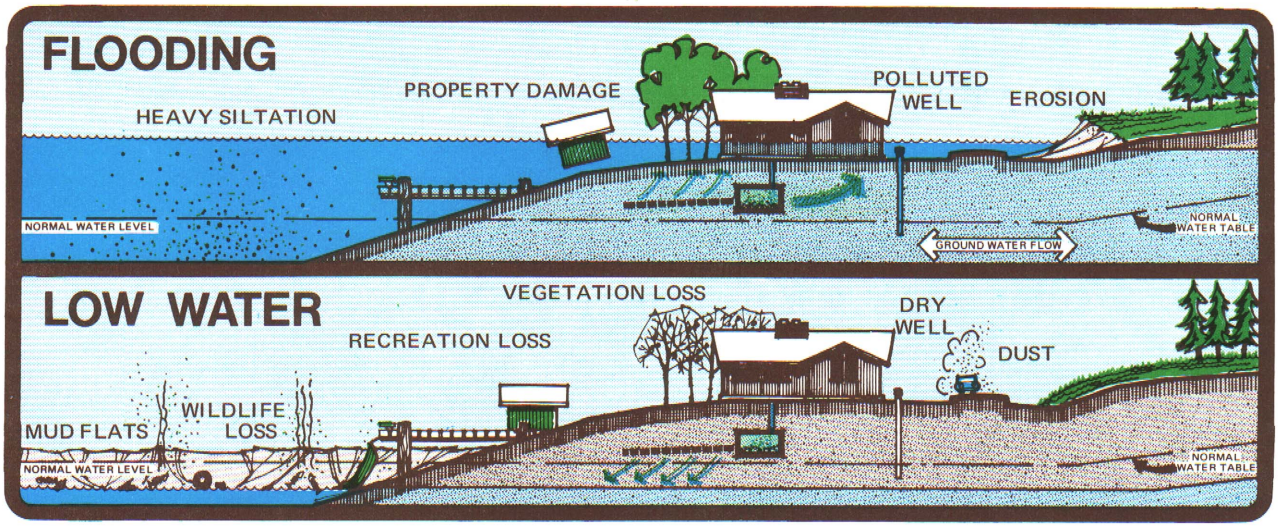
Low lake levels may interfere with customary recreational uses and result in unsightly mud flats. Shore structures such as piers and boathouses are often left useless. Water quality changes, and alterations of fish and wildlife habitat may also result.

On many natural inland lakes, dams have been built to permit stabilization of the lake level. These dams generally perform their intended function, but sometimes there are unplanned, often serious side-effects. If the dam significantly raises the lake level, the water table in the surrounding area may be raised, affecting the safe operation of both wells and septic tank/drain field installations. The operation of the dam may also alter downstream water flow.

Inadequate maintenance and improper operation of dams are often key lake level control problems. Dams on some lakes have been forgotten until critical problems—structural damage and public health dangers—occur. If the dam gates are open far enough to lower the lake level rapidly, or if the dam breaks, downstream areas may suffer flood damage from the suddenly increased flows.

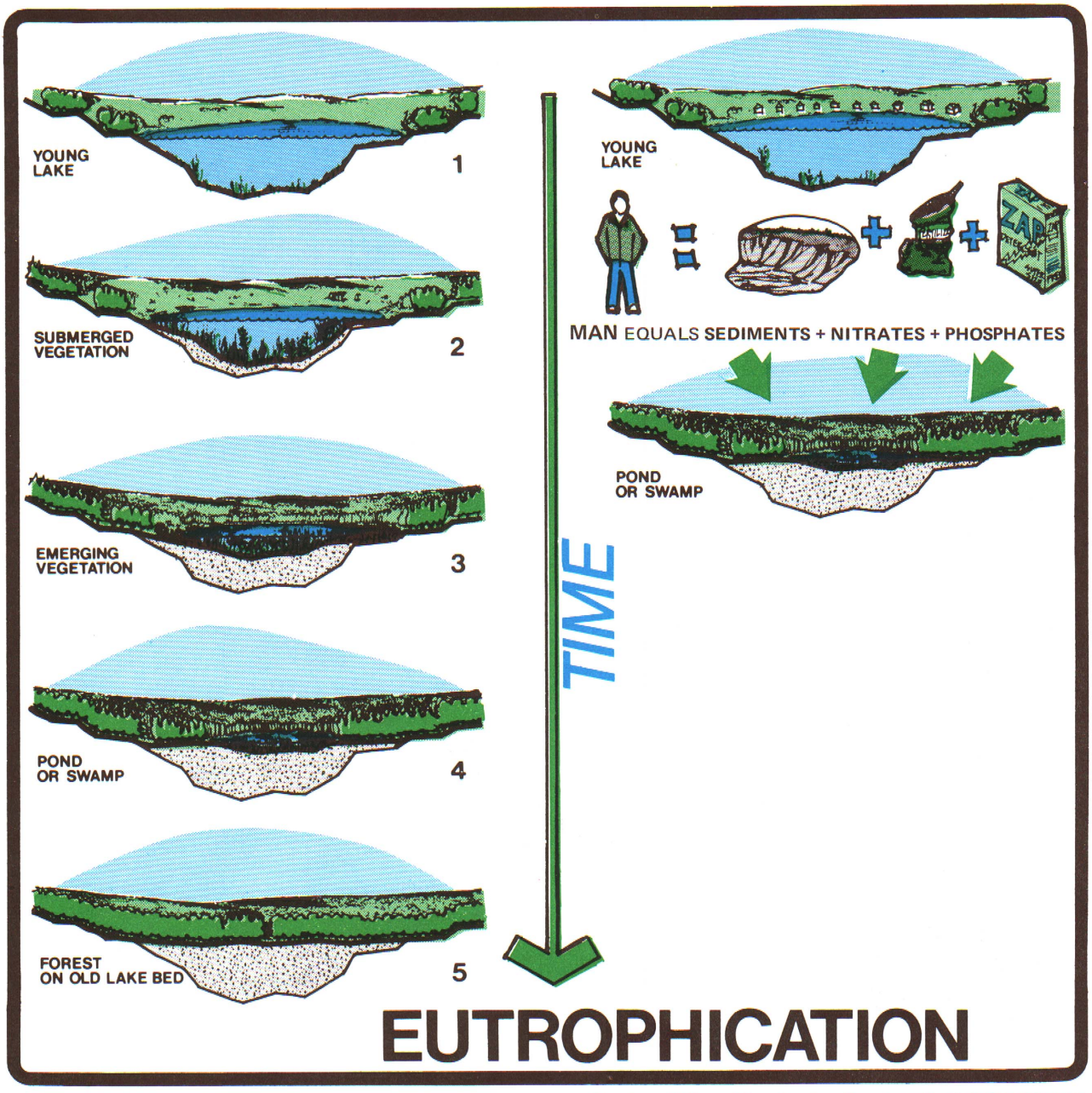
Dams should be considered mainly as a means of stabilizing the lake level, rather than a method of flood control. If a lake level is stabilized, an operating plan for all expected water flow conditions should be developed that is suitable not only to lake property owners but also to communities and property owners downstream. The operation of the dam should be coordinated with the operation of other dams upstream and downstream. Lake levels often are dropped in the fall to protect shorelines and piers and the dam itself from ice damage, and to avert spring flooding downstream.

In the operation of lake level control devices, careful consideration should be given to the effects on fish, birds, and shore plants. In some areas mosquito control is possible without harming either wildlife or recreational values. This is important in malaria and encephalitis control in some areas of the country.



algae and aquatic weeds

Excessive growth of algae and other aquatic plants is a problem frequently mentioned by inland lake residents. The growth of aquatic plants occurs naturally in a lake. A very slow increase in plant production over a long period of time is a natural change. This increase is called eutrophication and is a type of natural succession already described. Pollution of the lakes has, however, speeded up the process. Much of the excessive plant growth in lakes is due to increased levels of nutrients—phosphates and nitrates—and other factors that stimulate plant growth. Waves and currents also affect the area where algae and aquatic weeds are generally found. With prevailing winds from the Southwest the residents of the north and east shores of lakes are more likely to have algae accumulate in the water and on the beach in front of their property.



Man's activities often shorten the amount of time necessary for a lake to change to a swamp. The changes in the lake shown on the left are natural changes. The sketches above show how man may speed up the change from lake to swamp.

wildlife

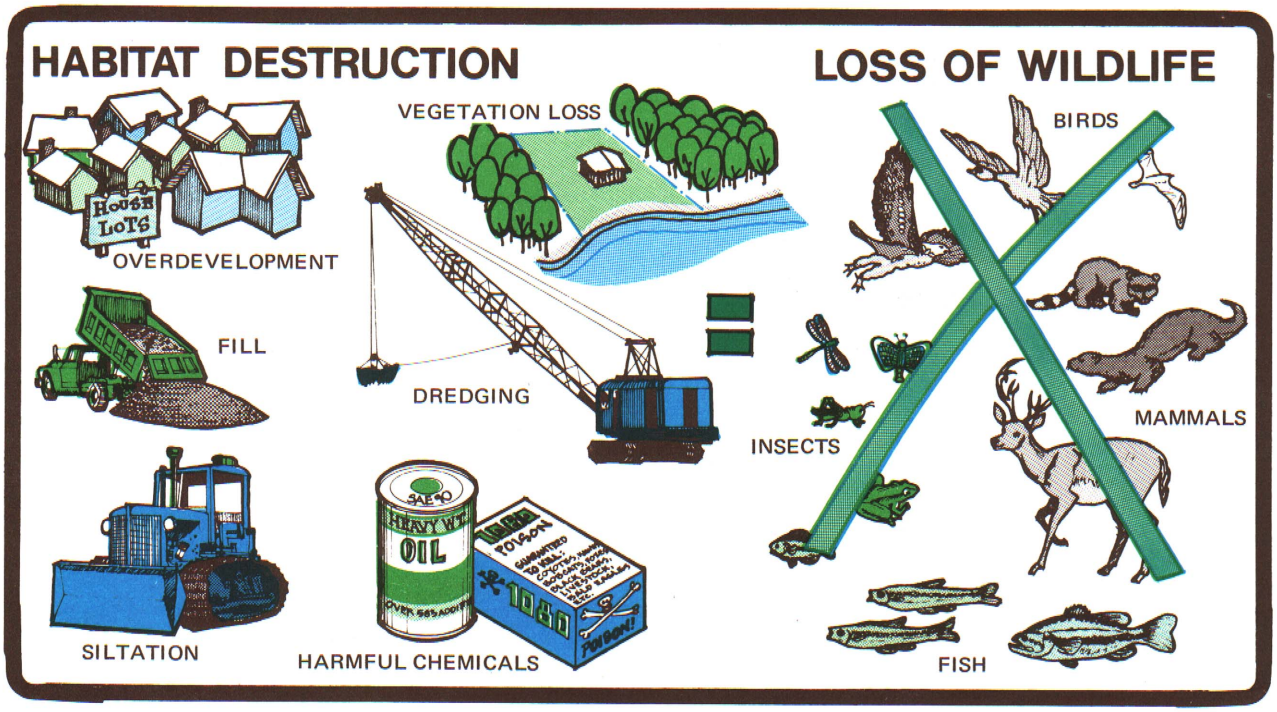
All forms of life, plant and animal, are adapted to live in certain "habitats"—surroundings—which must contain all of their requirements. Unlike man, most living things cannot change their habitat to suit their needs, nor can they adapt readily to severe changes in their environment. When man changes a habitat, such as by filling in a swamp, the effects of that change on wildlife populations can be severe.

wildlife values

Each person attaches different values or special meanings to the living plant and animal communities. There is *commercial value,* as a source of food or fiber. Also, one can *"consume"* wildlife for other than the necessities of life, such as sport fishing, hunting, and picking wild berries and flowers. Wildlife also has a *"spectator"* value: many individuals find wildlife interesting just to view and photograph in their natural surroundings. A final value derived from wildlife is the satisfaction gained by just *knowing they exist.*

Some people do not value certain types of wildlife so highly, because they may *interfere* with their activities. There may be *competition* with man for food in the family garden. Some forms of wildlife, such as mosquitoes, may be *public health hazards.* Others, like sand flies and poison ivy, are simply *bothersome.*

Once man begins altering wildlife habitat and consuming wildlife, a new dimension of the question of values comes into play; is maintaining a healthy, well balanced wildlife community more important than developing a lakeshore for people to use? This question is seldom raised; when it is, the answer often is "no." Managing wildlife for both their survival and our enjoyment and convenience, then, becomes a difficult problem of balancing the needs of the wildlife against the desires of man.



fish

Managing the fishery resource must take into account all the factors which affect the fish habitat—water quality, the effects of sport fishing, and the size and balance of the total fish population: how many fish eat plants and how many eat insects and other fish. Another important aspect of fishery management is preserving the quality of the sport fishing experience by providing well designed access sites and by carefully accommodating other lake uses which may conflict with sport fishing.

Serious damage to fish habitat may occur as a result of weed removal, accumulation of pesticides, erosion, dredging, and filling. Sediment can choke out vegetation needed by some fish for food, destroy spawning grounds, reduce the depth of light penetration, and fill in nesting areas and places of refuge for smaller fish.

Among the most common fishery management methods are water quality control, stocking of desirable species, habitat protection and improvement, and rough fish control programs.

birds

Birds are also found in specific habitats. There are certain kinds of birds found in each area of the inland lake ecosystem. The feeding of ducks, geese, and other birds tie them to and make them dependent upon the vegetation, insects, fish, and other animals in and near the lake. In many places man has altered or destroyed bird habitat by filling in or draining nesting areas and removing the food supply.

Persistent insecticides like DDT and substances such as mercury are also very harmful to birds as well as to fish. These substances, which retain their toxicity for a long time, are transferred through the food web to the meat-eating organisms at the top, such as fish, birds, and other large animals where it concentrates in flesh. The effects of this concentration may only weaken the individual and its offspring, or it may eventually kill off the entire species.

The guiding principle in bird management is to maintain an adequate habitat for all species. The important thing is to make certain that the birds have the kind and amount of food, shelter, and breeding grounds they need. Hunting also must be regulated to assure adequate reproduction, and to maintain bird populations which can be supported by the habitat available.

insects

Different species of insects also are adapted to live in specific habitats. There is a vast number of species and types. Most of them do not compete with man, threaten his health or well-being, or bother to annoy him. They are, however, an important part of the food web, providing a major source of food for many birds, fish, and other insects.

The most common form of management is wholesale poisoning. The principal justification has been to control diseases such as malaria, typhoid fever, and encephalitis, and to protect food crops.

Insect "pests" on most inland lakes are generally neither health hazards nor competitors with man for food or fiber. They are usually the "nuisance" insects: flies, gnats, and mosquitoes. The broad spectrum poisons normally used to control them destroy all insects, beneficial and otherwise. Also some of the most troublesome insects are beginning to develop resistance to the more common poisons. An excessive insect population may indicate that the normal biological control found in a balanced ecosystem has broken down.

other plants and animals

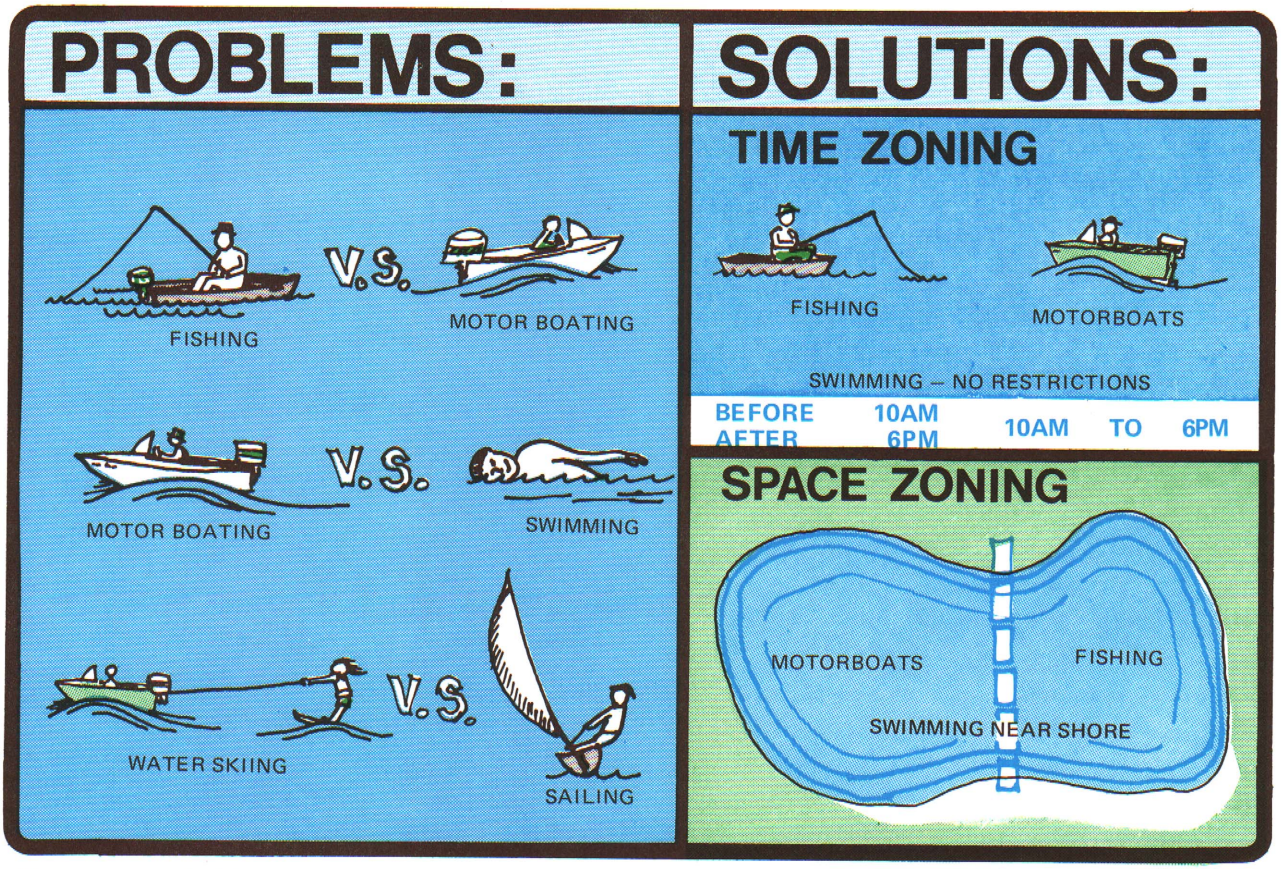
There are other plants and animals which are part of the natural inland lake community: snails, clams, worms, beaver, otter, raccoon, frogs, turtles, snakes, shore plants, wild rice, and many more.

surface use conflicts

Lake residents often are familiar with numerous conflicts of use and overcrowding which occur on the lake surface and shore. Some wish to fish quietly, while others prefer more active forms of recreation such as water skiing. Many residents and fishermen express concern about the excessive speed, direction of travel, and time of operation of boats, and about air and water pollution resulting from normal boat operation and fuel spills. On small lakes especially, both forms of recreation cannot occur in the same general area at the same time. Controlled use, defining either the area or the time of use, may offer a partial solution.

In some areas there is also a conflict between public and private uses of the lake surface and shore. Both are increasing at a rapid rate. As boat ownership continues to increase, conflicts of interest may get worse before they get better.

Proposals for new public access sites are a cause of concern for many lake property owners. Increasing demand for public recreation may make the development of new sites inevitable, but local residents must have a say in the planning of public facilities. The design of parking and boat launching facilities and requirements for sanitation, law enforcement, and landscaping and maintenance of public access sites will determine the quality and quantity of public use of the lake environment.



If everyone uses the lake when and where he pleases, no one can enjoy it fully. Conflicts of use can be resolved through time and area zoning of the lake surface.

environmental quality

Many of our environmental goals for both land and water have not as yet been achieved because of our greater desire for the conveniences and pleasures offered by modern technology. In the long run, however, our personal happiness and well-being depend on the maintenance of a livable environment. Our ecological blunders are beginning to haunt us. Our fathers and grandfathers cut the natural forests to build our homes and planted crops to feed us. Lakes changed when this occurred. Our very survival, as well as a desirable, livable environment, is now at stake, because of ever-increasing population pressures.

The planned development of lake communities is now necessary not only to minimize conflicts of interest but to maintain the environment as a suitable place to live. Housing density, land use, roads and other aspects of urban development need to be controlled. Up to a point, it is possible for lake communities to develop without destroying the natural resource. However, no area can sustain continued population growth without degrading the environment.

Most lake area residents appear to be willing to tackle these problems and see possibilities for the future. Individuals and groups within the community may have different methods and priorities—but they share common concerns and a willingness to act.

action

citizen involvement

The natural ecosystem and human settlement are inter-connected. Whether the balance between them is maintained or destroyed will determine the fate of the lake: as a stable natural resource, or as a nuisance that might better be filled in. The major point is that individuals, groups, and the community at large can act to protect and preserve the lake community.

People get things done through group action. Everyone can participate at least in some small way. Each lake resident should give some time to community affairs by keeping informed and attending meetings. However, not everybody has or takes the time. In the local community and at the state and federal levels as well, the balancing of interests, bargaining and compromising is never ending. Development takes place through the exercise of economic and political power.

The ideal is to bring the greatest good to the greatest number of people and to pass on to future generations a better environment in which to live. This goal is achieved only by the combined efforts of people and the give-and-take between interest groups. The real world falls far short of the ideal. What actually occurs may be the result of an individual or a small group working hard to get what it wants, without regard for the needs of the community. A new road, some new cottages, a public access site, or dredging and filling of the lake may benefit these special interests while at the same time causing new problems for others.

It is important that the entire lake community take part in all these decisions. The broader and the more informed the participation in decision making, the less likely is the possibility that decisions will serve only small private self-interests, to the possible disadvantage of the whole community.

It is not necessary that everyone have the expertise to analyze independently and completely every type of problem. In most communities there are "citizen specialists": individuals who have developed an interest in and detailed understanding of some aspect of community affairs and problems. These specialists can be important sources of information and leadership to the entire community. **One way an individual citizen can influence and help determine the future of the community is to specialize in a few lake problems and take the responsibility of informing others about them.** If many members of the community follow this course of action, it will be our best guarantee of successful lake community management, protecting and preserving the full value of the lake area.

Most of our behavior is not directly controlled and regulated by government. This would be an impossible task, and undemocratic as well. In order to live together as families, communities, or even as nations, we have learned to share certain values and accept certain standards of conduct voluntarily.

Governmental units have the power and responsibility to tax, in order to pay for necessary goods and services. Some forms of taxation are fairer and more appropriate for some purposes than others. Also, some community improvement projects may be paid for by voluntary contributions. Experience has shown, though, that taxation is by far the best way to finance major community-wide services.

how to get government to act

Become familiar with the people and procedures involved in government of the lake community. Read the local newspapers and follow the activities of local organizations and governmental bodies.

Identify the decision makers in the local community and in the governmental units involved. It is always a small fraction of the people in the community or of the appointed and elected officials. People with "power" are most often representatives of organized groups.

Be able to explain the nature and extent of the particular problem. Read up on the subject; talk or write to experts in the field at nearby universities or colleges or in state agencies.

Be able to explain what it is you want the governmental unit to do and make sure it has the power to do it. Obtain legal advice if necessary.

Inform the entire community of the plan of action and check to see if they generally agree. Use the newspaper and newsletters. Be prepared to make written and oral public statements to explain what you want to do, and why.

Identify sources of support throughout the community, such as the Jaycees, the Chamber of Commerce, fraternal, religious, and other civic associations, conservation organizations, township or county planning commissions and governing boards.

Identify people or groups in your area that may have another point of view. Some groups may simply be unaware of your positions and only need information before they will support you. Others may present active opposition.

Present a united front among the organizations or groups which support you. Talk with group leaders and have a strategy for public hearings, petition drives, and other activities.

Communicate your concerns in an organized and forceful manner to the responsible governmental officials. Meet with, call and write both elected and appointed officials and support them in their efforts to solve lake problems.

Participate personally in both community and local government affairs. Attend board and commission meetings even when nothing is on the agenda that specifically relates to lake problems. Vote in all local elections and support people responsive to lake management problems.

Indicate willingness to pay for the needed services to solve lake problems. Help officials who initiate programs bring them to a successful conclusion by urging your neighbors and friends to follow up their concern with dollars for projects and with votes for public officials who will cooperate.

what to do:

Listed below are some suggestions for action to solve both general and specific lake problems. Before you urge action on any of them, though, make sure you understand what the problem really is. Nothing can be more discouraging to a community or harmful to a lake ecosystem than spending money to "correct" a "problem", only to discover afterwards either that the wrong thing was done, or that the solution caused other, more serious problems.

LAND USE PLANNING AND CONTROL

Determine what the residents of the community want; assess the current situation and compare it to the stated desires of the people; prepare a general plan with professional assistance and in cooperation with the governmental units involved; develop and enforce zoning and subdivision control ordinances to control land use; check to see if your state or local governmental unit has shoreline, green belt and flood plain zoning; do not allow overcrowding but at the same time do not encourage sprawl; encourage planned unit development and cluster development; make a wide range of housing opportunities available both in cost and in type.

PUBLIC WORKS

Support public works undertaken by governmental units for the improvement of the community including public water supply; refuse collection, disposal and recycling; sewer construction and establishment of a sewage treatment system that will not hurt either the lake or downstream areas; road maintenance and construction; drainage improvements; erosion control; and the construction and maintenance of community parks, beaches and other facilities.

TAXATION

Insist on professional, competent property assessment for tax purposes. Make sure that there is some equity between tax burden and the services received.

LEGAL ACTION

Do not forget that we have three branches of government: the executive, the legislative and the judicial. Use the courts to accomplish lake management goals. Identify and use public interest law firms as well as tax free foundations that support the use of legal mechanisms for environmental improvement.

RESEARCH

Support research in environmental and community affairs to help solve acute and perplexing lake problems. Research expenditures are appropriate and necessary at every level of government. Sponsor research on unique local problems.

EDUCATION AND INFORMATION

People knowledgeable of land and water use problems and their own relation to them are more likely to take preventive action and support governmental programs needed to protect and improve the environment. Support the development or extension of the schools in your community. Make sure that environmental education, especially about lakes, is included in the school curriculum. Also, support informational programs such as newsletters, public meetings and slide talks by private organizations and citizen groups. Encourage governmental agencies to undertake specialized informational services as well as regulatory and administrative activities.

LAKE POLLUTION

Test septic tank/drain field systems to see if they are operating properly. If they are found to be inadequate, build a sewer system and an effective waste treatment plant. Check the operation of existing sewage treatment plants. Curtail erosion of stream banks, construction sites, roads, drains, ditches and the lake shore itself. Stop fertilizing lakeside lawns; use pesticides—including herbicides—sparingly if at all. Buy boat motors that do not pollute. Help identify local sources of industrial and agricultural pollution; urge the responsible local, county, state and federal agencies to control pollution; support appropriations for water pollution enforcement and management programs that will help solve the problems. Sue polluters if necessary.

PEST CONTROL

Take extreme care in programs to eliminate insect pests and other organisms such as leeches and snails (swimmer's itch). Avoid the use of broad spectrum and persistent pesticides that might create more serious problems by upsetting the natural balance.

NUISANCE WEED AND ALGAE GROWTH

Undertake an environmental monitoring and analysis program; curtail the flow of nutrients which may cause the nuisance growth, including septic tank effluent, inadequately treated municipal wastes, agricultural and feedlot runoff; curtail or stop the use of lawn fertilizers around the lake; enact a soil erosion control ordinance; preserve the natural vegetation on the shore of the lake to serve as a nutrient filter; cut and harvest nuisance aquatic weeds.

PUBLIC HEALTH

Check the operation of septic tanks to eliminate the possibility of disease spreading from this source; make sure that your water supply is safe to drink; check the quality of water coming into the lake as well as swimming areas for poisons and disease-causing organisms.

LAKE LEVELS

Prevent building in areas subject to flooding. Where extreme natural fluctuations occur, permit building only on high ground if lake level control would harm wildlife habitat. Undertake a continuing program of lake level monitoring aimed at identifying all water sources and predicting lake level changes in advance. If lake level stabilization is necessary and desirable, use a professionally engineered control device with adequate capacity and controllability. Insist on proper controls of upstream development which might otherwise change the inflow of water.

PUBLIC ACCESS

Assemble the facts of the situation where there is an existing access site or where one is proposed; make provision for public access in a general community development plan that does not infringe on private rights.

BOATING CONTROL

Support the development, enactment and adequate enforcement of boating control regulations; on very small lakes and in some critical portions of larger lakes it may be advisable to forbid the use of high speed boating or all motor boats. Boat crowding and control problems often are related to the high intensity of shoreline development, particularly marinas.

FISH AND WILDLIFE PROTECTION

Limit or forbid filling of shore areas for homes, beaches, boathouses or piers to preserve swamps, bogs and shorelines for wildlife habitat; support the enactment and the strict enforcement of soil erosion and dredging controls; support laws that protect fish and other wildlife from depletion or extinction; protect vegetative cover including weed beds.

PRESERVATION OF NATURAL BEAUTY AND OPEN SPACE

Undertake a long range program of neighborhood and community park and open space acquisition; purchase outright and obtain easements to protect the shoreline; promote adequate zoning controls.

LAKE RENEWAL AND RESTORATION

Seek out applications of technology to improve already deteriorated lakes. Give attention to the basic causes of lake deterioration as well as to the unfortunate results. Consider advanced waste treatment, new methods of erosion control, and efficient aquatic weed cutting and harvesting techniques and other environmentally sound solutions.

WATERSHED MANAGEMENT AND REGIONAL PLANNING

Recognize that not all lake problems can be solved by local action alone, since many problems have their origin outside the community. Cooperate with the local soil conservation district, join an existing or form a new watershed association to help solve watershed problems including flooding, erosion, and water supply. Support special planning and development districts, if needed to solve special area-wide problems.

glossary

biological community

All of the living things in a given area or environment.

cluster development

Housing developments, including subdivisions, in which the dwelling units are grouped in order to provide larger blocks of undivided open space (commons) near homes. Impacts of the houses on the natural environment are lessened.

consumers

Animals which cannot produce their own food through photosynthesis.

cycling

The flow of energy and materials from one living thing to another and from one environment to another.

decay

The process whereby microscopic bacteria and fungi break down or simplify complex organic substances; decay makes the cycling of organic substances possible.

ecology

The study of the interrelationships of living things to one another and to the environment.

ecosystem

Energy-driven complex of living things and the environment.

effluent

The sewage or industrial waste which is released into natural waters by sewage treatment plants, industry, or septic tanks.

energy

The ability to perform work or potential for power and activity; energy may be captured or held in living matter—food is stored energy.

environment

All of the surrounding things, conditions, and influences which affect an organism or a community.

erosion

The wearing down or washing away of the soil and land surface by water, wind or ice.

eutrophication

The biological, chemical, and physical changes associated with the aging of lakes; nutrient enrichment. This natural process may be accelerated by improper or excessive human use of the lake and shore.

flood plain

Land adjacent to lakes, streams, and rivers which is covered as water levels rise and overflow the normal water channels. Special regulations governing development are needed to control land uses in flood plains.

food web

The sun's energy is captured by green plants (producers) and is transferred to other living things within the ecosystem when the plants are eaten by animals. These animals (consumers) are in turn eaten by larger animals. A series of plants and animals related to one another as food sources constitutes a food web.

ground water

Underground water in a zone of soil saturated with water.

habitat

The place where a plant or animal lives, which has all of the conditions necessary to support its life and reproduction.

hydrologic cycle

The circular flow or cycling of water from the atmosphere to the earth (precipitation) and back to the atmosphere (evaporation and transpiration from plants). While it is on the

surface of the earth, water is involved in many processes including runoff, infiltration into the soil, and storage in lakes, streams and groundwater.

limiting factor

Any influence or material which tends to slow down growth and productivity in an ecosystem; either too much or too little of these critical factors may limit production.

nutrients

Elements or chemicals which are essential to life including carbon, oxygen, nitrogen, phosphorous and many others.

organic matter

Plant and animal residues or substances made by living organisms.

persistent pesticide

A chemical agent used to control pests, which breaks down extremely slowly, remaining toxic to desirable species of wildlife as well as pests, under natural conditions. Some of these include DDT, chlordane, lindane, and dieldrin.

broad spectrum pesticide

Kills beneficial insects, fish, birds, and mammals as well as pests. Almost all pesticides are broad spectrum.

photosynthesis

A process whereby green plants (those with chlorophyll) use energy from the sun to convert water and carbon dioxide into carbohydrates, fats, and proteins.

platting

Before land can be subdivided and sold in small parcels or lots, a plan for the subdivision called a plat must be submitted to the local government and the state for approval.

pollution

Any alteration in the character or quality of the environment which renders it unfit or less suited for certain uses.

producers

Green plants that manufacture their own food through photosynthesis.

productivity

The amount or mass of living things which is supported by an environment over a specified period of time.

respiration

A chemical process that takes place in living cells whereby food (fats, carbohydrates, and proteins) is "burned" to release energy and waste products, mainly carbon dioxide and water. Living things use energy produced through respiration to drive vital life processes.

sediment

Solid material both mineral and organic, suspended or moved from its site of origin by water and deposited elsewhere.

succession

Progressive change in the types of plants and animals in a given area due to changes in climate, continued erosion and deposition, accumulation of organic matter and other factors.

watershed

A drainage area or basin, all land and water areas which drain or flow toward a central collector such as a stream, river or lake at a lower elevation.

water table

The upper surface of ground water, the point below the surface of the earth where the soil is saturated with water.

zoning

Township, city, village, county, or state laws regulating land uses and development; used to implement and enforce plans to protect public health and welfare and to attain the "best use" of available land. Can be used to protect shoreland areas from overdevelopment, and for wildlife habitat preservation.

references

Ecology. ($1.95, paperback) by Eugene P. Odum; published by Holt, Rinehart, and Winston. A good introduction to basic ecological concepts.

Science and Survival. ($1.35, paperback) by Barry Commoner; published by Viking Compass. Discussion of pressing environmental issues by a prominent scientist.

Man in the Web of Life. ($.95, paperback) by John Storer; published by New American Library. A readable account of natural communities and man's actions in and dependence on them.

Defending the Environment: A Strategy for Citizen Action. ($6.95, hardcover) by Joseph L. Sax; published by Alfred Knopf. A discussion of the legal techniques for environmental protection. Available to members of Consumers Union, P.O. Box 1000, Mt. Vernon, New York 10550 for $2.00 (paperback).

The Great Chain of Life. ($1.95, paperback) by Joseph Wood Krutch; published by Pyramid. The interdependent relations among all forms of life are explained in this book.

A Sand County Almanac. ($.95, paperback) by Aldo Leopold; published by Sierra Club/Ballantine. A classic. The philosophical foundation of conservation in the last 25 years. "Land ethic" coined and described.

The Environmental Handbook. ($.95, paperback) edited by Garrett De Bell; published by Ballantine Books. Critical environmental problems are briefly reviewed, as are techniques, "eco-tactics," for groups dealing with such problems. One chapter devoted to individual and group actions for reducing environmental destruction.

The Last Landscape. ($1.95, paperback) by William H.Whyte; published by Anchor. A well written account of the need for open space and the techniques for acquiring it.

Pesticides and the Living Landscape. ($1.95, paperback) by Robert C. Rudd; published by the University of Wisconsin Press. A comprehensive, well organized discussion of the nature and effects of pesticide usage.

Design with Nature. ($5.95, paperback) by Ian L. McHarg; published by Doubleday/Natural History Press. A remarkable book which integrates ecological and design principles into a practical, environmentally responsible technique for guiding development.

Streams, Lakes, Ponds. ($2.25, paperback) by Robert L. Coker; published by Harper Torch Books. Easily understood and thorough explanation of chemical, physical and biological characteristics of streams, lakes and ponds.

Cleaning our Environment: The Chemical Basis for Action. ($2.75, paperback) published by the American Chemical Society. Priority recommendations by a professional society on actions required in the areas of air, water, solid wastes and pesticides.

"The Biosphere". ($1.00, paperback) September 1970 issue of *Scientific American.* The major worldwide energy and mineral cycles are reviewed along with the alterations and impacts created by man's activities.

Leadership In A Small Town. ($7.50, hardcover) by Aaron Wildavsky; published by Bedminster Press, 1964. Power and politics in Oberlin, Ohio. Chapter 23 is especially useful for citizens interested in public affairs.

Studying Your Community. ($2.95, paperback) by Roland Warren; published by Free Press. Guidelines and questions to be asked by individuals or groups studying their community's structure and services.

U.S. Government Printing Office publications may be obtained by writing congressmen or by writing to the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402.

A Primer on Water Quality. ($.30, booklet) by Swenson and Baldwin, U.S. Geological Survey.

A Primer on Ground Water. ($.25, booklet) by Baldwin and McGuiness, U.S. Geological Survey.

A Primer on Water. ($.35, booklet) by Leopold and Langbein, U.S. Geological Survey.

A Primer on Waste Water Treatment. ($.55, booklet) by the Federal Water Quality Administration.

All four "primers" present information of interest to lake residents. Like other federal publications they are very reasonably priced.

For a detailed, comprehensive study of aquatic biology:

Eutrophication: Causes, Consequences, Correctives. ($12.50, hardcover); published by the National Academy of Sciences. Results of an international symposium on eutrophication of lakes, streams and estuaries.

A Treatise on Limnology. (Volume 1–$25.00, Volume 2–$39.00, hardcover) by G.E. Hutchinson, Volume 1, Geography, Physics and Chemistry and Volume 2, Biology and Limnoplankton. John Wiley & Sons.

The Biology of Polluted Waters. ($6.00, hard cover) by H.V.N. Hynes; published by Liverpool University Press.

AGENCIES AND ORGANIZATIONS

Many aspects of inland lake management and lake community development are the responsibility of governmental agencies, local, state, and federal. Each level has its own interests and concerns, but all can be valuable sources of information and assistance and should be contacted.

LOCAL GOVERNMENT

Because the organization of county and municipal government varies throughout the state, not all counties and municipalities will have the same agencies and officials. You should become familiar with the responsibilities and capabilities of those in your community. County agencies which can help are: the Planning Commission; Sheriff's Department; Departments of Public Works and of Public Health; Drain Commission; and Parks and Recreation Commission. Municipal and Township government officials and agencies can also be very important. These include the city or village councils; the township boards; and planning commissions. Other key officials are the zoning administrator, building inspector, attorney, and assessor.

Special purpose agencies and regional or watershed organizations can provide lake management services. These include public recreation authorities, sanitary districts, watershed councils, councils of governments, regional planning commissions, soil conservation districts, and special drainage districts.

STATE GOVERNMENT

Michigan Department of Agriculture, (Inter-County Drain Commission, Soil Conservation Committee); *Lewis Cass Building, Lansing, Michigan 48913.*

Michigan Department of Commerce, (Office of Community Planning); *525 W. Ottawa, Lansing, Michigan 48926.*

Michigan Department of Natural Resources, (Divisions: Fish, Parks, Hydrological Survey, Law Enforcement, Water Quality Control, Water Development Services, Planning Services, Waterways); *Stevens T. Mason Building, Lansing, Michigan 48926.*

Michigan Department of Public Health, (Engineering Division, Waste Water and Water Supply Sections); *3500 N. Logan, Lansing, Michigan 48914.*

Michigan Department of State Highways; *State Highways Building, Lansing, Michigan 48926.*

Michigan Water Resources Commission; *Stevens T. Mason Building, Lansing, Michigan 48926.*

FEDERAL GOVERNMENT

Council on Environmental Quality; *722 Jackson Place N.W., Washington, D.C. 20006.*

Environmental Protection Agency, (Water & Air Pollution Standards & Enforcement); *1 N. Wacker Drive, Chicago, Illinois 60606.*

U.S. DEPARTMENT OF AGRICULTURE:

Cooperative Extension Service; *Michigan State University, 107 Agriculture Hall, East Lansing, Michigan 48823.*

Forest Service; *203 Conservation Building, East Lansing, Michigan 48823.*

Soil Conservation Service, (State Conservationist); *1405 S. Harrison Road, East Lansing, Michigan 48823.*

U.S. DEPARTMENT OF COMMERCE:

National Oceanographic and Atmospheric Administration, (State Climatologist); *1405 S. Harrison Road, East Lansing, Michigan 48823.*

U.S. DEPARTMENT OF THE INTERIOR:

Geological Survey, (Water Resources Division); *700 Capitol Savings and Loan Building, Lansing, Michigan 48926.*

Bureau of Outdoor Recreation, (Lake Central Regional Office); *3853 Research Park Drive, Ann Arbor, Michigan 48104.*

Bureau of Sport Fisheries and Wildlife; *801 Capitol Savings and Loan Building, Lansing, Michigan 48926.*

Office of Water Resources Research; *Office of the Secretary, Department of the Interior; Washington, D.C. 20240.*

U.S. DEPARTMENT OF DEFENSE:

U.S. Army Corps of Engineers, (Detroit District); *150 Michigan Avenue, Detroit, Michigan 48226.*

U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, (Flood Insurance, Planning Assistance, Open Space Grants); *500 First National Bank Building, 600 Woodward Avenue, Detroit, Michigan 48226.*

CONSERVATION ORGANIZATIONS

Sierra Club, Mackinac Chapter; *409 Seymour Street, Lansing, Michigan 48833.*

Trout Unlimited, Michigan Council; *2737 Davenport Street, Saginaw, Michigan 48601.*

Michigan United Conservation Clubs (National Wildlife Federation Affiliate); *2101 Wood, P.O. Box 2235, Lansing, Michigan 48911.*

Michigan Lake and Stream Associations, Inc.; *9610 East Shore Drive, Kalamazoo, Michigan 49002.*

The Izaak Walton League; *Suite 806, 1800 N. Kent, Arlington, Virginia 22209.*

Sport Fishing Institute; *719 13th Street N.W., Washington, D.C. 20005.*

Michigan Soil Conservation District, Inc.; *Harmon Williams, Secretary, AuGres, Michigan 48703.*

League of Women Voters of Michigan; *224 Olds Plaza, Lansing, Michigan 48933.*

Zero Population Growth; *c/o Ecology Center, 417 Detroit Street, Ann Arbor, Michigan 48104.*

SOCIETIES OFFERING PROFESSIONAL SERVICE AND REFERRALS:

Michigan Society of Professional Engineers; *533 S. Washington, Lansing, Michigan 48933.*

American Society of Consulting Planners; *1819 H Street N.W., Washington, D.C. 20006.*

Michigan Society of Architects; *28 W. Adams, Detroit, Michigan 48226.*

American Institute of Planners; *917 15th Street N.W., Washington, D.C. 20005.*

State Bar of Michigan; *306 Townsend, Lansing, Michigan 48914.*