Florida Lakes

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A Description of Lakes, Their Processes, and Means of Protection

written by

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Introduction

Florida is blessed with a large variety of aquatic resources. The warm subtropical marine waters and expansive white sand beaches are well known. However, the state's vast wetlands and over 7,700 freshwater lakes are recreational resources which are frequently overlooked by out-of-state visitors.

Most Floridians recognize the recreational opportunities that lakes provide because they live close to one. More than 99% of the population of the United States lives within 50 miles of a publicly owned lake. One-third of the national population lives within five miles of a lake. This percentage must be even higher for Florida residents because of the large number of lakes in the state.

Lakes which now provide residents and visitors recreational and aesthetic benefits face an uncertain future. Citizens have only recently become aware of the importance of lakes to the past, present, and future prosperity of the state. No doubt you or your friends have witnessed or discussed the decline of a good fishing lake, the virtual takeover of a lake by aquatic plants, the overdevelopment of a lake's shoreline, or the decreased clarity of a favorite swimming lake.

Unfortunately, many of Florida's lakes have already passed the point where it is technically or economically feasible to restore them to their natural water quality conditions. Overcrowding, shoreline clearing and development, watershed destruction, multiple use conflicts, and discharge of pollutants are but a few of the problems causing the decline of our lake resources. These problems, which have been building for years, come at a time of increased public awareness of the importance of lakes and also at a time of reduced government resources. Therefore, the degradation of our lakes cannot remain only a concern of government. Lakes can be saved, but the public must accept responsibility for and become part of the solution.

This booklet offers no miraculous cure-alls, for there are none. However, it offers a starting point for people who are interested and concerned about their lakes' future. This booklet will help you better understand lakes, the causes, effects, and solutions to water quality problems, help you recognize the warning signals of water quality problems, and inform you of how to help and who can help you.

Lake Characteristics

Central Florida solution basin lake area

Lake Formation

Lakes are formed by many different processes but generally can be divided into two categories: natural and man-made. Most lakes in Florida have a natural origin, and most of these natural lakes are solution lakes. Such lakes are usually circular at the surface, conically shaped in cross section, and generally form when percolating surface or ground water dissolves subsurface limestone. The subsurface cavity eventually collapses, leaving a surface depression which may fill with water from rivers, runoff, or underground sources. Sometimes these solution lakes are interconnected by underground channels and streams. The most extensive zone of closely spaced solution-basin lakes in North America can be found in central Florida. In fact, over 2,500 solution lakes are located in the four central Florida counties of Lake, Orange, Osceola, and Polk. Appendix C shows the distribution of lakes by county in Florida.

Another type of solution lake forms when a sinkhole develops in a natural valley. The part of the valley drained by the sinkhole erodes rapidly forming a branching elongate closed basin. If the sink becomes blocked and the water table rises, a valley lake results. Lake Jackson and Lake Miccosukee in Leon County are examples of this type of solution lake.

Other lakes found in Florida are relict sea bottom depressions formed during earlier geologic periods when large areas of the state were under water. These depressions were filled with freshwater from surface runoff when the land was elevated by tectonic movement or by receding sea level. Many of the shallow lakes of Florida which are not formed by solution are believed to have been formed in this way. Lake Okeechobee, one of the largest lakes in the United States, is an example of this type of lake.

The last important type of natural lake found in Florida is formed by stream processes. Meandering rivers often form broad bends that with time, erosion, and sedimentation cut a channel through the initial portion of the meander, leaving an oxbow lake separated from the main channel of the river. Lakes also are formed in low wide areas of river channels by changes in stream flow and sedimentation. An example is Lake George in the St. Johns River. Lakes may also form in flood plains of rivers by periodic overflows and sedimentation.

Man-made lakes are created by damming rivers and streams for hydroelectric power generation, navigation, recreation, and storage of water. Lake Seminole, Lake Rousseau and Rodman Reservoir are examples of such lakes. Other man-made lakes, prevalent in Florida are excavation lakes and borrow pits found along highways and mining operations.

Hydrologic cycle

Lake levels rise and fall in response to the dynamics of the water cycle. The cycle consists of three principal phases: precipitation, evaporation, and surface and groundwater runoff. Each phase involves transport,

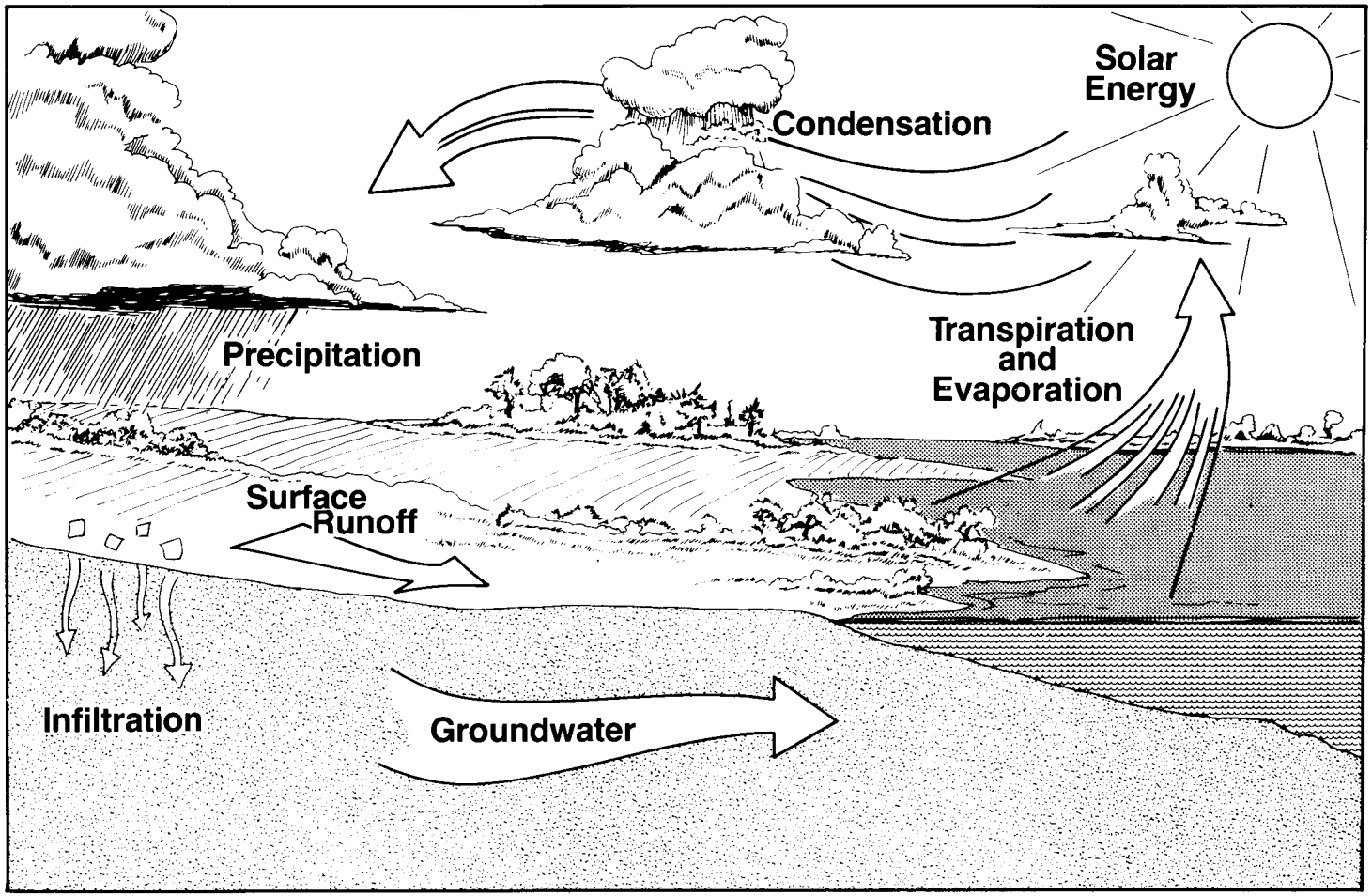
temporary storage, and a change in the state of water.

Florida receives an average of 53 inches of precipitation in the form of rain and dew annually. This precipitated water is intercepted by plants, runs off over the land surface to streams or lakes, or infiltrates into the ground. About 80 percent of the water that is not infiltrated into the ground is returned to the atmosphere through evaporation and transpiration, where it eventually becomes precipitation again. The portion that enters the ground becomes part of a groundwater flow system that travels within pore spaces of soils and rocks and in underground channels.

When the rate of rainfall exceeds the capacity of the soil to hold it, excess water flows over the surface as overland flow or runoff. The amount of runoff depends on the type of soil, climate, amount of rainfall, vegetation, land use, slope, and other factors. In Florida annual runoff averages about 14 inches. Lakes that are primarily fed by rivers and streams, called drainage lakes, depend on runoff for most of their water.

Watersheds and Lake Levels

The watershed (drainage basin) is defined by topography which governs the path runoff follows as it moves from higher to lower elevations. The watershed includes not only the streams and rivers that flow directly into the lake, but also wetlands and dry land areas from which the runoff flows. The slight topographic relief in many parts of Florida makes it difficult to accurately

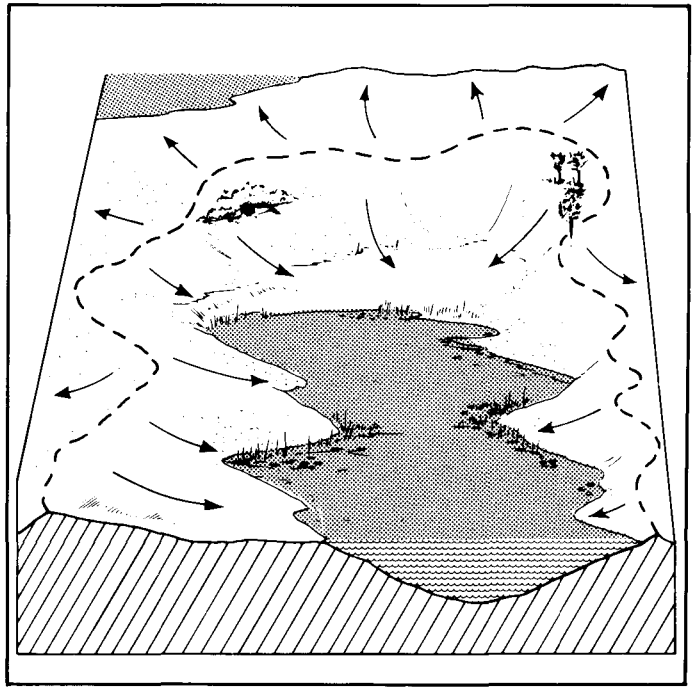


The hydrologic cycle

delineate many drainage basins. There are also many areas where water commonly drains underground and reappears as seepage or spring flow in basins other than the one where it entered.

Surface water inputs from the watershed are important in determining lake levels. Other important factors controlling lake levels are groundwater flow and the elevation of the water table. Most solution lakes are dependent upon the groundwater table for their surface elevations. Precipitation falling directly on a lake's surface can also significantly affect the water volume in lakes with large surface areas such as Lake Okeechobee.

Lakes can be differentiated by their sources of water. Seepage lakes, which are prevalent in Florida, are those into which groundwater enters or leaves the lake basin. Water levels in seepage lakes commonly fluctuate along with the regional water table. In contrast, drainage lakes depend upon streams, rivers, and runoff for their main source of water, and generally have a surface outlet as well. The time for replacement of the total volume of water in a lake, called residence time, is an important factor in determining the quantity of nutrients or pollution a lake can absorb without being seriously degraded. Drainage lakes generally are flushed more rapidly than seepage lakes due to faster and larger changes in surface flows, and thus they usually have shorter residence times than seepage lakes. Both the rate of entry and exit of water in a lake vary seasonally in practically all lake basins. This variation produces an annual variation in the lake level no matter what the sources of water.



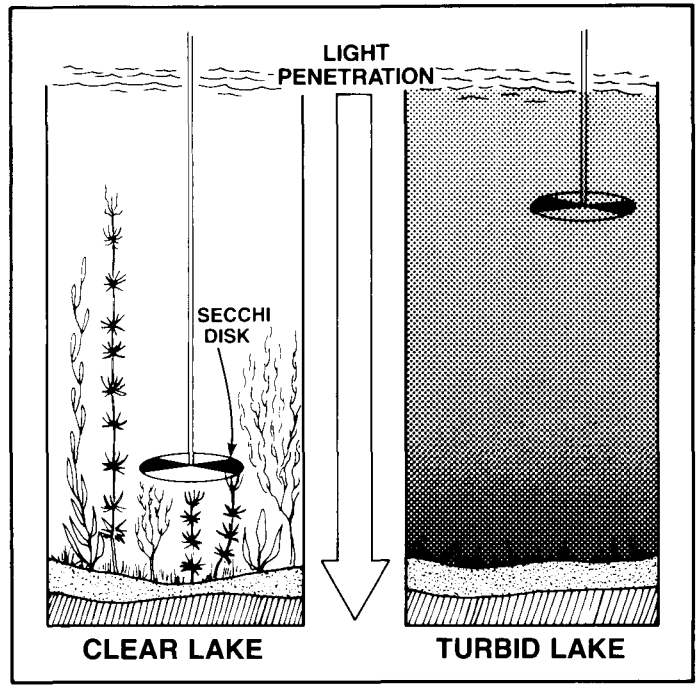
The watershed of a lake is determined by its surrounding topography.

Water and Important Parameters

In a lake, water is the medium in which plants and animals live, move, respire, and are nourished. Water's properties of transparency, heat retention, suspension, and dissolution are unique in nature and provide a tempered environment in which extreme fluctuations of climate are reduced.

The transparency of water, or its ability to transmit light, is dependent mainly upon color and turbidity. An increase in color or suspended particles will reduce the depth which sunlight can penetrate in a lake and thus reduce clarity. A simple piece of equipment called a

Light penetration in a lake



Secchi disc can be lowered into the water to measure clarity. Secchi depth values in Florida lakes range from approximately 0.2 to 9.5 meters (0.66 to 31.2 feet).

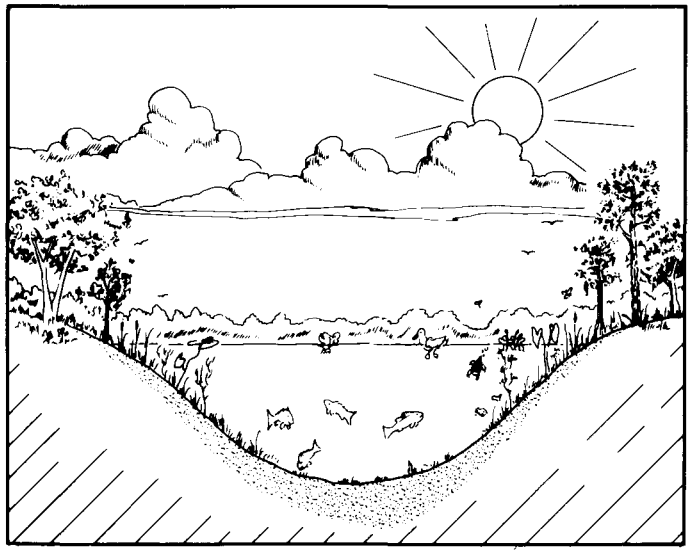
Temperature is one of the most important factors in an aquatic environment. Since the specific heat of water is great, a lake can absorb or give off large quantities of heat with only a small increase or decrease in temperature. Water temperature always lags far behind the larger changes in air temperature and only rarely experiences the extreme or rapid changes that occur on land. Thus, organisms living in water only need to adapt to gradual changes in temperature. Lakes also have a modifying influence on the climate of nearby land areas by acting as large heat radiators or sinks. Temperature also regulates the amount of dissolved gases (e.g., oxygen) water can retain. Warm water will hold less dissolved gases than cold water.

Other important non-biotic factors that regulate productivity of lakes are light penetration, dissolved oxygen content, and nutrient concentration. The depth of light penetration in lakes, called the photic zone, depends on the transparency. Plants can only grow in the photic zone, thus lakes which have a shallow photic zone have fewer areas where plants can grow. Dissolved oxygen (DO) is essential to most aquatic organisms. If dissolved oxygen levels fall too low, many species of sport fish are the first to die. The state of Florida requires that a minimum concentration of 5 parts per million be maintained in state waters used for recreation and propagation and management of fish and wildlife.

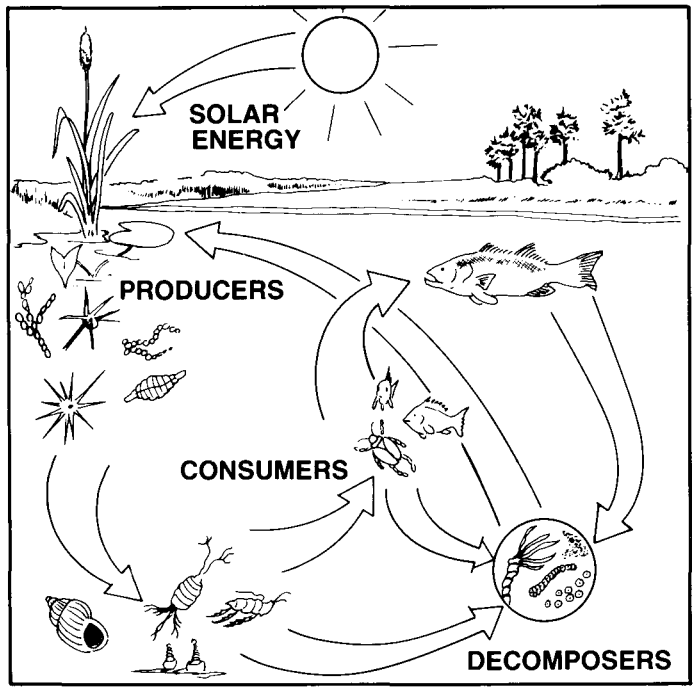
Water also contains a variety of dissolved substances of which nitrogen and phosphorus are considered the major nutrients for aquatic plant growth. Many other substances are needed but the availability of these nutrients is usually the most important factor controlling plant growth in lakes. Excessive concentrations of nitrogen and phosphorus can cause undesirable algal blooms or aquatic weed problems.

Lake Ecosystems

Lakes are more than standing bodies of water. Their physical and chemical characteristics make them ideal habitats for an immense variety of plants and animals. A lake ecosystem is composed of interacting plant and animal communities and the physical and chemical environments in which they live. All parts of the ecosys-



A typical Florida lake ecosystem.



The food web is a representation of the transfer of energy through a natural community. Each component feeds on and obtains energy from another component and is in turn eaten by and provides energy for still another component.

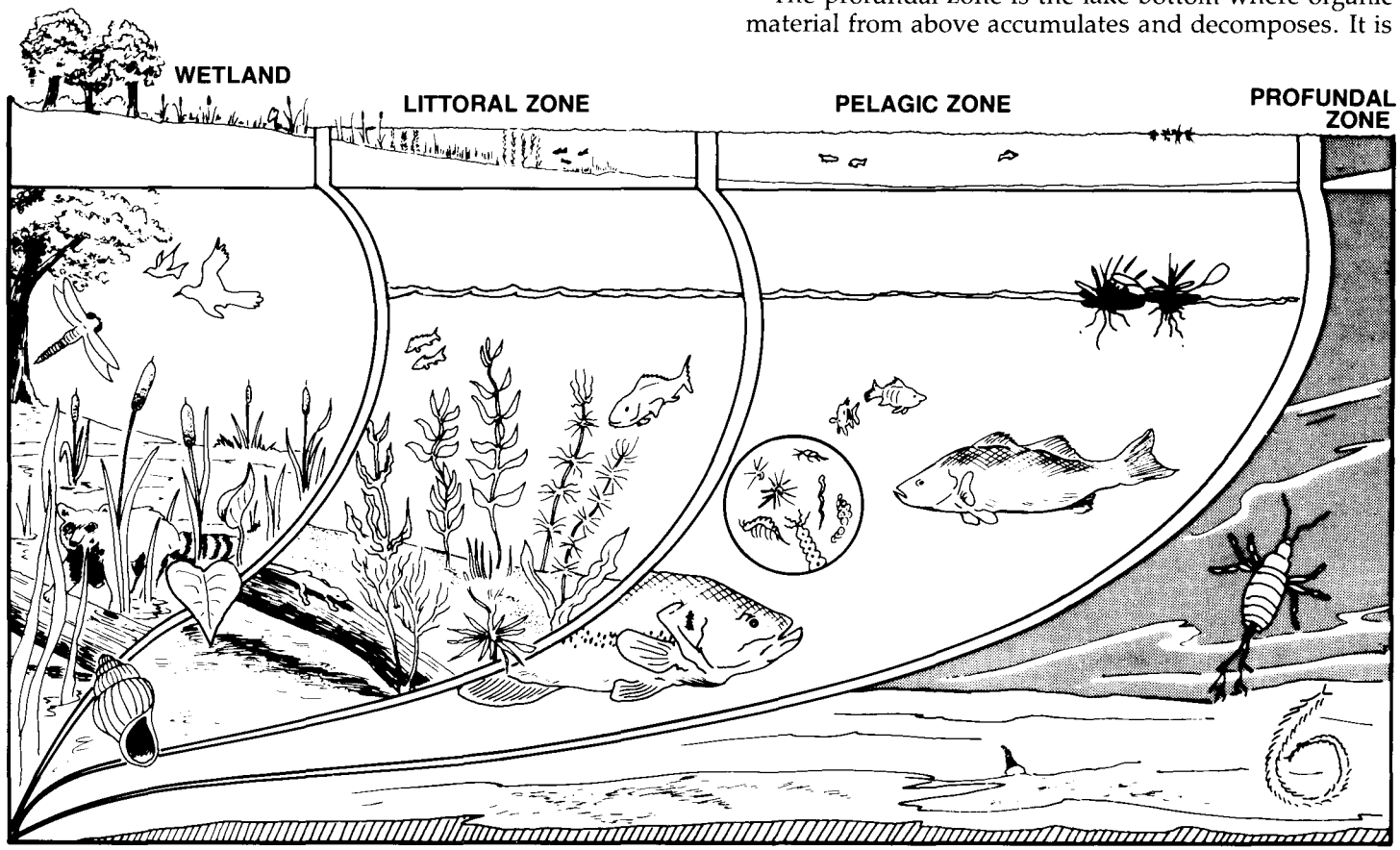
tem are linked together in an intricate scheme of interdependence. Therefore, if one part of the system is disturbed, other parts may also be affected.

In lakes, plants use the sunlight, nutrients, and gases to produce living tissue. The plants are eaten by animals which are in turn eaten by other animals. The predator of one species may be the prey of another species. Dead organisms are decomposed by bacteria which recycle nutrients back to the water and sediments. Some bottom dwelling organisms also help to break down organic matter into usable nutrients. This chain of producers, consumers, and decomposers constitutes the food web. Most food webs are complex and involve many different kinds of plants, animals, and bacteria. The abundance and variety of organisms making up a lake's food web is controlled by climate, runoff, watershed characteristics, and the structure and water quality of the lake.

Limnologists have defined certain zones in lakes with differing environments where different organisms live. The littoral zone is the shallow-water area around the shore where light usually penetrates to the bottom. Aquatic vegetation, such as emergent and submergent plants, which require a substrate grow in this area. The size of the littoral zone is directly related to the slope of the bottom and water clarity.

The pelagic or open water zone is the area that extends from the surface to the depth where light intensity is reduced to about one percent of surface light. The pelagic and littoral zones are also referred to as the photic zone because below this depth sunlight is too weak for most plants to utilize. Generally, plants found in the pelagic zone are floating plants, such as duckweed and water-hyacinths, and microscopic plants called phytoplankton which form the base of lake food webs.

The profundal zone is the lake bottom where organic material from above accumulates and decomposes. It is



Lake habitats and environments

inhabited mostly by burrowing animals. Other animals such as fish, turtles, and swimming microscopic animals, called zooplankton, freely cross all of these zones for purposes of protection, feeding, and reproduction.

Many Florida lakes also have wetlands associated with them. A wetland can be a swamp, marsh, floodplain, or any area of land where water is the dominant factor determining the types of plant and animal communities living there. Wetlands generally represent the transition zone between the lake proper and the adjacent uplands. Wetlands are important habitats for terrestrial and aquatic communities and also may serve as filters for lakes by reducing pollutants, sediments, and nutrients from incoming watershed drainage.

Lake Processes

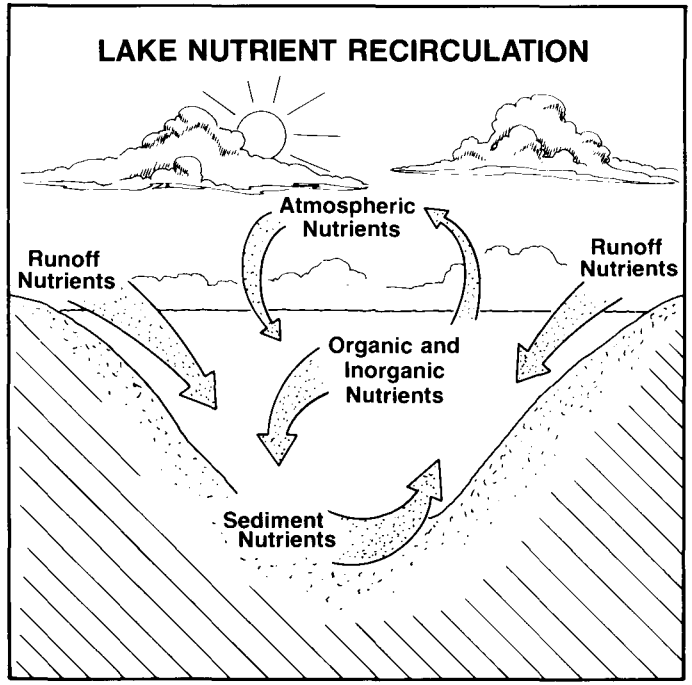
Interactions between organisms and their environment are critical to the vitality of a lake. Lakes are able to support life and remain healthy, productive bodies of water because of several biological processes.

Photosynthesis, carried out by plants which contain chlorophyll, is an important process in food webs. Using sunlight, plants convert water and carbon dioxide into oxygen and sugars. The sugars are then used by the plants to synthesize other organic compounds needed to sustain them. The productivity of a lake is generally related to the amount of chlorophyll present.

Decomposition of organic matter by bacteria is essential to lake ecosystems. Without decomposition, most material falling to the bottom would remain there and the lake would fill in. Decomposition speeds up the breakdown of matter and helps nutrients recycle back into the system for reuse.

Sedimentation is a process that greatly affects the ecosystem of lakes. Besides contributing to lake filling, sediments also introduce nutrients into lakes. Lakeshore vegetation and wetlands are able to trap incoming coarse sediment and hence slow sedimentation rates. Suspended particles also reduce the transparency of lake water, and can therefore decrease overall lake productivity.

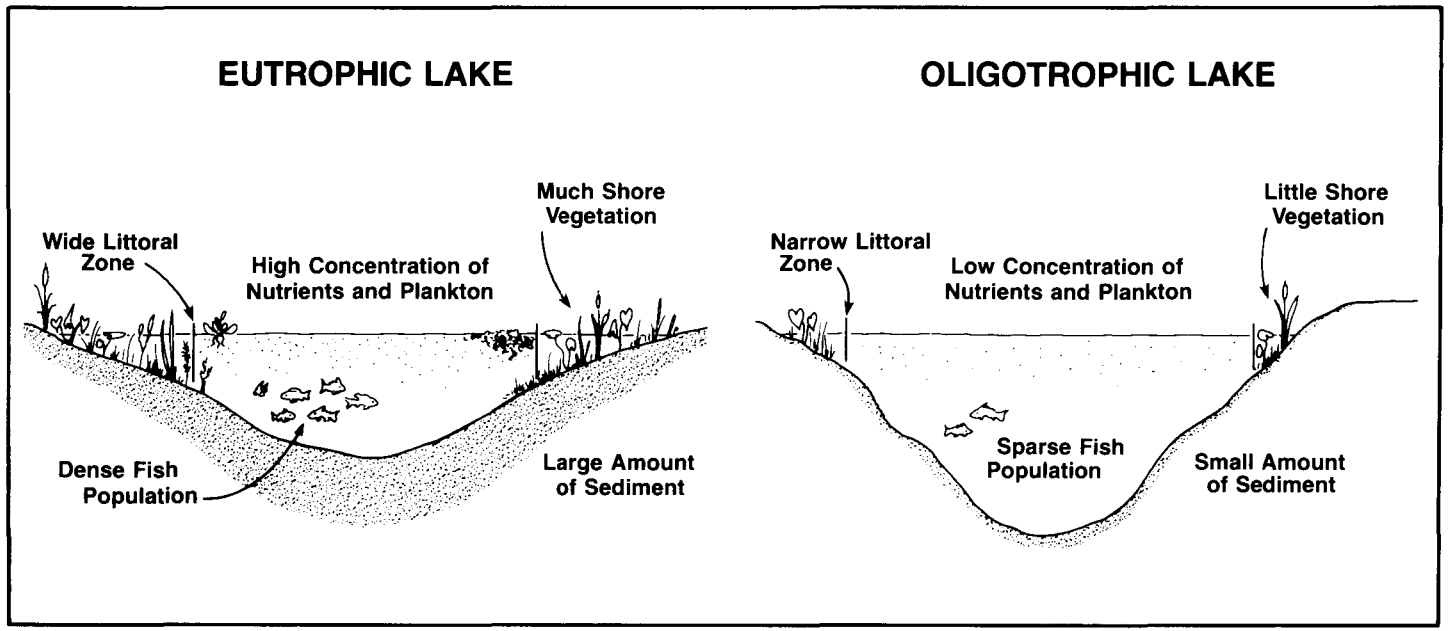
Nutrients introduced into lakes are subject to recycling. This involves changing the chemical form of nutrients already in the lake so that they may be utilized in the food web again. For example, plants take up inorganic nitrogen which animals cannot use and incorporate it in their tissues as organic nitrogen which animals



Nutrients enter and recycle within a lake.

can use. When animals die, nitrogen must be changed back to the inorganic form for plants or it will be lost to the system as a useful nutrient. This nutrient recycling is accomplished by biological (decomposition), chemical (oxidation), and physical (circulation) processes. Without recycling, many important nutrients such as phosphorus and nitrogen would become depleted and the productivity of many lakes would be drastically reduced.

Thermal stratification, an important process controlling productivity in northern lakes, is not as prevalent in Florida lakes. In Florida, lakes generally stratify in the summer or at irregular intervals. Stratification causes surface and bottom waters to be separated by a narrow band of water with rapidly changing temperature called the thermocline. This stratification reduces the circulation of nutrients and dissolved oxygen thereby reducing the productivity of the lake. Relatively mild temperatures and shallow depths reduce the importance of water stratification in Florida lakes.



A comparison of eutrophic and oligotrophic lakes.

Classification of Lakes

Classification schemes are a natural outgrowth of years of scientific study of lakes. As a scientific tool, classification can be a practical method useful in lake management. Scientists have developed lake classification schemes based on origin, shape, thermal range, depth, chemical content, dominant types of organisms, and trophic state. Trophic state is probably the most important factor to use when classifying lakes for lake management decisions.

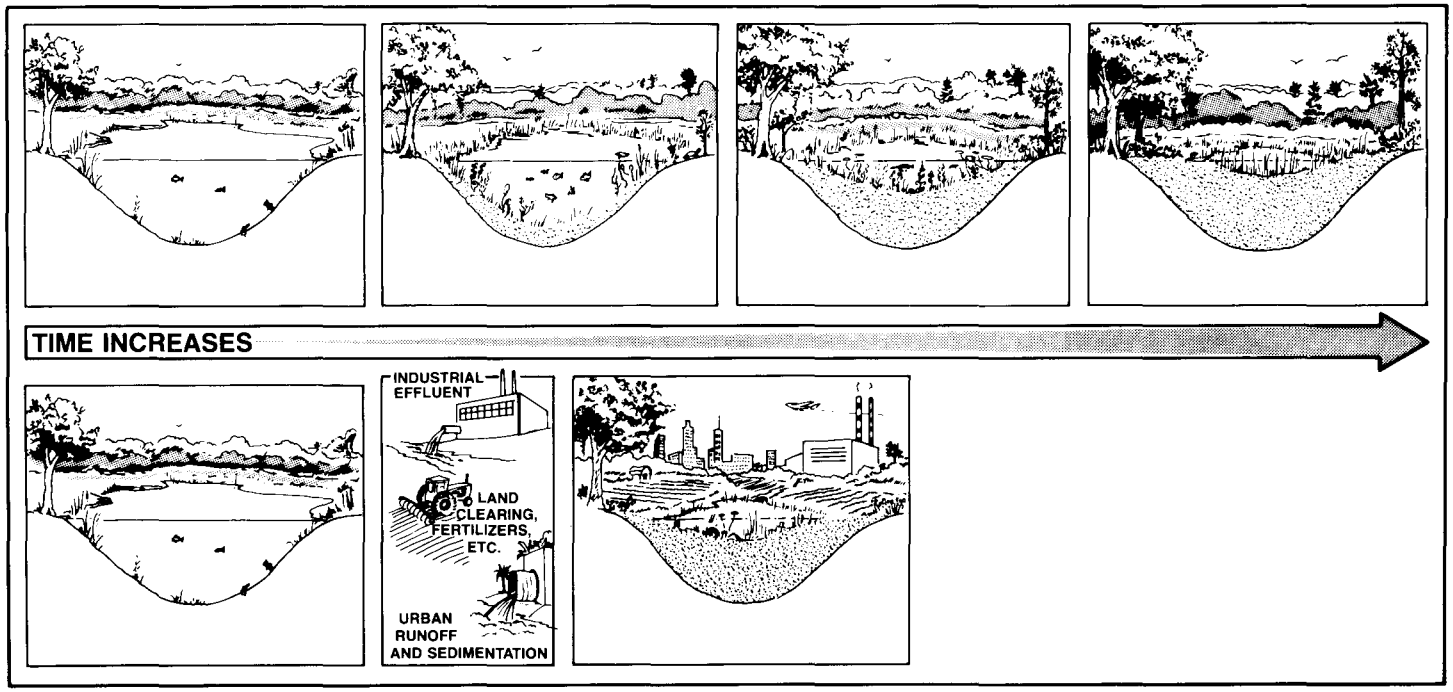
Trophic state can be loosely defined as the nutritional status of a lake and can give insight into the productivity and health of a lake. When a lake is formed, the natural process of aging begins. Generally, a geologically "young" lake is usually characterized by low nutrient concentration, low plant biomass, low productivity, very little sedimentation, high clarity, and good water quality. Such lakes are classified as oligotrophic lakes. As a lake continues to age a process known as eutrophication occurs. Newly formed lakes can also be naturally eutrophic due to geological and climatic conditions.

Eutrophication is the natural aging of a lake, characterized by increasing nutrient concentrations and

Many water quality problems are caused by overdevelopment in a lake's watershed.

sedimentation rates. Other characteristics include increased productivity, reduced clarity, and reduced water quality. The degree of eutrophication and the lake's intended use will determine whether or not this condition is harmful. Lakes which experience a high degree of eutrophication may experience fishkills, excessive aquatic weed and algal growth, loss of game fish, loss of recreational usage, and other water quality related problems. The final stage in lake aging will be the disappearance of the lake as it becomes a marsh or bog.

The length of time between formation and extinction of a lake depends on climate, watershed characteristics, shape, and many other factors. This natural process usually requires thousands of years to happen. However, man can accelerate the process considerably by drastically altering shoreline vegetation, wetlands, and watersheds, discharging sewage into lakes, and allowing uncontrolled use of water for agricultural and industrial purposes. This condition, known as cultural eutrophication, has created much concern about the effects of man's activities on lakes.



Cultural eutrophication can speed up the natural aging of lakes, shortening their life span considerably.

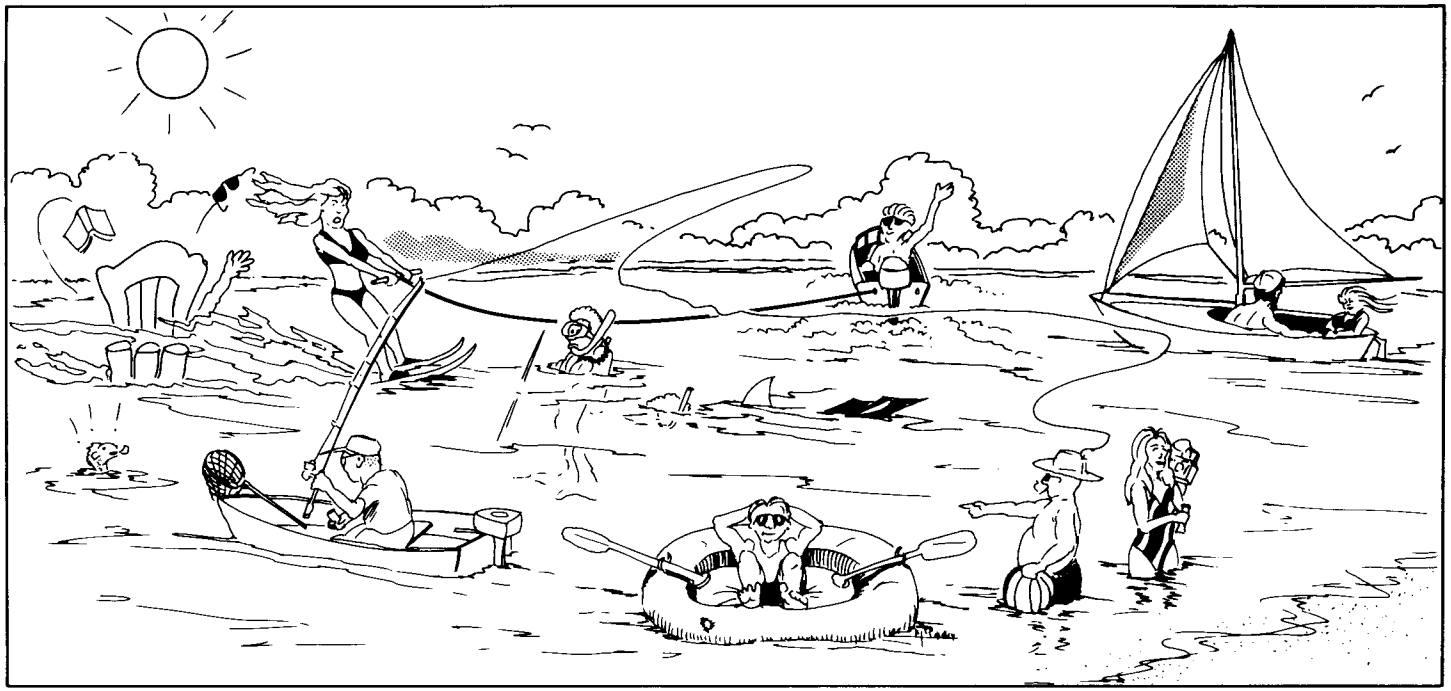
Challenges to Lake Survival

As Florida's population continues to increase rapidly, the various pressures exerted on lakes by man will also intensify. Ironically, those who have the most to gain by having clean, high quality lakes are also potential threats to lake water quality.

Public Conflicts

Recreational uses such as fishing, swimming, boating, skiing, and picnicking can cause conflicts among lake users. Boating and skiing can interfere with fishing and swimming and vice versa. Overuse of a lake's surface area can also damage lake water quality. Examples of problems associated with overuse include: littering; churning up sediments by motorboats in shallow areas; spilling fuel; and emptying boat toilets into the lake.

Conflicts can also occur over the use of lake water for municipal and industrial purposes. There can be a high demand for lake water from many sources. Water uses which affect lakes include: agricultural irrigation; industrial consumption; cooling for electrical generating plants; and municipal water supply. Many water uses exclude lakes from being used by other potential users. Lakes used for drinking water should not be allowed to be degraded or contaminated by industrial and sewage discharges. Likewise, recreational lakes may not be good municipal water supply lakes. The limited supply of water in a lake must be allocated wisely, not only based on user needs but also with regard to assuring the lake's survival as a unique water resource.



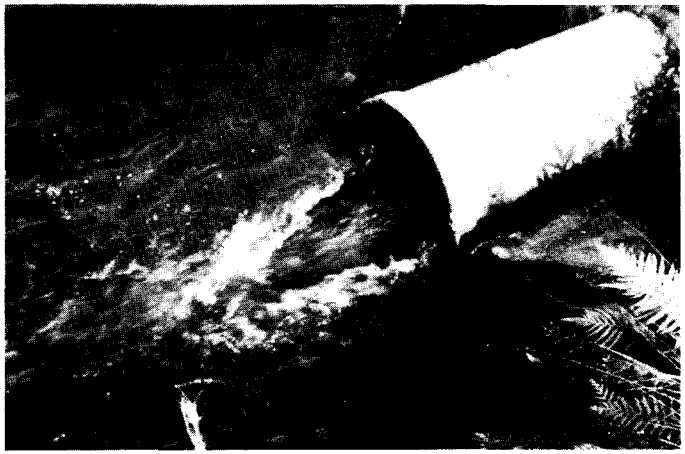
Overuse of a lake can cause many problems.

Conflicts can occur over development and land uses along lake shorelines. The shorelines and wetlands act as a buffer between water and land as they trap nutrients, filter pollutants, retard erosion, and provide habitats for plants and animals. Shoreline development directly affects lakes in two ways. First, wildlife habitats and buffering capacity are lost through destruction of the natural vegetation around lakes. Second, pollution from septic tanks, increased surface runoff, and nutrient additions from fertilized lawns can affect lake water quality. Sandy soils, characteristic of Florida, are especially noted for leaching of nutrients and bacteria from septic tank systems into lakes. Water quality problems caused by shoreline development usually do not appear until after large areas have been altered. By then much damage has already been done. Conflicts can arise between homeowners already in place and those who try to build in undeveloped areas.

Causes of Water Quality Problems

The causes of cultural eutrophication are varied but are directly related to man's activities. The resulting pollution can generally be divided into two categories: point and nonpoint sources.

Point sources are those that are discrete and easily definable, such as sewage or industrial discharges. Point sources are generally thought of as those that empty



Point source discharges are well defined.

Stormwater runoff from urban areas can seriously affect a lake's water quality.

wastes into waterways through discharge pipes. Point source discharges in Florida that impact lakes include private and municipal sewage plants, agricultural backpumping, electric power generation, citrus processing, industrial manufacturing, and wood product processing. These discharges may contain high levels of nutrients and organic matter, sediments, high temperature water, toxic metals, harmful chemicals, and disease-producing organisms. Ultimately many of these substances may end up in Florida lakes. Point source pollution can overwhelm the recycling and self-cleaning capacity of a lake and lead to its rapid decline.

In many lakes nonpoint sources are major causes of water quality degradation. Nonpoint sources are those that are dispersed or diffused and released at an unmanaged rate, such as stormwater runoff or acid rain. Nonpoint sources are subdivided into natural and man-made categories. Only man-made sources will be discussed since they are the major causes of lake water quality problems and also are generally the ones man can control.

Most nonpoint source pollution can be related to stormwater runoff. Urban areas have large impervious areas which greatly increase rates of direct surface runoff. Stormwater cannot soak into asphalt, concrete, and buildings and must flow over or around these areas, thus creating runoff. Urban runoff carries litter, toxic metals, organic materials, potentially harmful bacteria, oil and grease, and chemicals washed from streets, roofs, and parking lots. Fertilizers, pesticides, and sed-

iments are also washed from residential lawns and construction sites. In many cases the amount of pollutants from urban nonpoint sources can be significantly larger than the amount from domestic wastewater or other point sources. Thus, development in a lake's watershed can seriously affect water quality due to the increased runoff rates and pollutant loadings that are characteristic of urban areas.

Agricultural and silvicultural areas also contribute significantly to nonpoint source pollutant discharges. Forested areas that have been clear-cut can contribute significant amounts of nutrients and sediments. Pollutants of significance from these activities include: nitrogen and phosphorus from fertilizers; sediments; organic materials; animal wastes from feedlot operations; pesticides; potentially harmful bacteria; and salts from soils. These pollutants are washed into lakes by overland runoff and irrigation waters.

Nonpoint sources are varied and difficult to control.

Other nonpoint sources which can affect lake water quality in Florida include: mining operations; acid rain caused by air pollution; construction operations; recreational activities; and septic tank leachate. Septic tank leachate can have an important impact on the lake environment since septic tanks are the conventional waste treatment method in many lakeside communities. Florida ranks third nationally in the number of septic tanks in use with approximately 37 percent of all Florida households disposing of wastewater in this manner.

Effects of deteriorating water quality

Lakes are not permanent features of the landscape but undergo changes and eventually disappear. One of the primary causes of the aging and extinction of lakes is sedimentation. Sedimentation reduces depths, thereby increasing littoral areas where aquatic plants can grow and decreasing the amount of surface area available for recreation. Sedimentation also decreases the volume of water and makes the lake more susceptible to oxygen depletion and fish kills. Eventually, the lake fills in and becomes more like a marsh or swamp.

Cultural eutrophication is the most important cause of premature lake degradation. It is caused by the excessive addition of nutrients to a lake. When a lake becomes nutrient enriched, phytoplankton productivity proceeds at an accelerated rate. Nuisance algal blooms occur and shade beneficial plants, increase sedimenta-

Florida lakes can experience aquatic plant problems.

tion rates, create odor, taste and health problems, and deplete oxygen levels. Reduced oxygen levels can cause fish kills and elimination of game fish populations. Mosquito populations can also thrive in these conditions.

Nutrient enrichment also can cause excessive growth of larger aquatic plants. Florida lakes are particularly susceptible to such problems since most are generally shallow, warm water lakes and have large littoral zones in which aquatic plants can grow. Naturally high phosphorus concentrations (due to phosphate deposits), the long growing season, and the introduction of many exotic aquatic plants also contribute to the problem. Excessive growths of plants can clog lakes, decrease recreational opportunities, and deplete oxygen and increase sedimentation rates as they die and decay. Exotic species such as hydrilla, water-hyacinth, and watermilfoil represent particular problems because they grow faster than many beneficial native species and clog lakes until they are no longer of any recreational value.

Another potentially serious problem that can affect water quality is the introduction of toxic and hazardous chemical compounds. Pesticides, heavy metals, PCB's (polychlorinated biphenyls), industrial wastes, and many other synthetic chemical contaminants are very persistent. Once introduced to lakes, these compounds may remain in the ecosystem for generations. These substances tend to become concentrated as they progress up the food chain. Thus, they can become toxic to animals and hazardous to man. Researchers are now studying short- and long-term effects of toxic chemicals on aquatic ecosystems.

Solutions to Water Quality Problems

The subjects of lake protection and restoration are emotional issues for citizens who live around threatened or degraded lakes. Lakeshore residents may wish to preserve or clean up their lake, but everyone has a different idea about what should be done. Even after the majority of lake users decide on a course of action, finding solutions to lake problems are never simple or straightforward. Our understanding of lakes is not advanced enough for us to have solutions to every water quality problem.

Preventive methods for protecting lakes are often less expensive and more effective than treating problems after they occur.

Prevention

Prevention is the best answer for maintaining clean lakes. Protecting our lakes by planning ahead and preventing problems is less expensive and more effective than using structural engineering solutions after problems develop. For example, it is estimated that 20–40% of the phosphorus released to U.S. waters is derived from detergents. In 1973, New York state imposed a ban on the use of phosphate detergents. Subsequent reports from three large sewage treatment plants indicated a 50–60% reduction in phosphorus discharges. Lakes which are phosphorus limited and receive sewage discharges could be helped considerably by relatively simple steps such as selective product banning or modification.

Other preventive methods include land use regulations, zoning laws, and better management practices for reducing runoff from agricultural, forestry, residential, mining, and construction activities. Voluntary measures such as maintaining beneficial shoreline vegetation, eliminating or reducing use of fertilizers, pesticides, and herbicides near lakes, and properly maintaining septic tank drain fields can significantly help. Through good site planning and the incorporation of management practices such as vegetative buffers, grassed waterways, sediment traps, and on-site retention, most nonpoint sources of pollution can be greatly reduced.

Discharges from point sources are usually easier to control because of their definable nature. Despite state and federal programs to control surface water discharges, industrial and municipal dischargers still affect many lakes. Better treatment or diversion of these wastes is necessary to prevent them from degrading lakes. Diversion has been used successfully in some cases by simply discharging wastes downstream of the affected lake. However, diversion does not eliminate the waste, it merely moves it somewhere else. Improved waste treatment, although expensive, is the most effective means of controlling point source pollution and ensuring clean lakes. Runoff (nonpoint source) from streets, parking lots, and other residential and commercial areas can be directed into percolation ponds rather than directly into a lake.

In-Lake Restoration Techniques

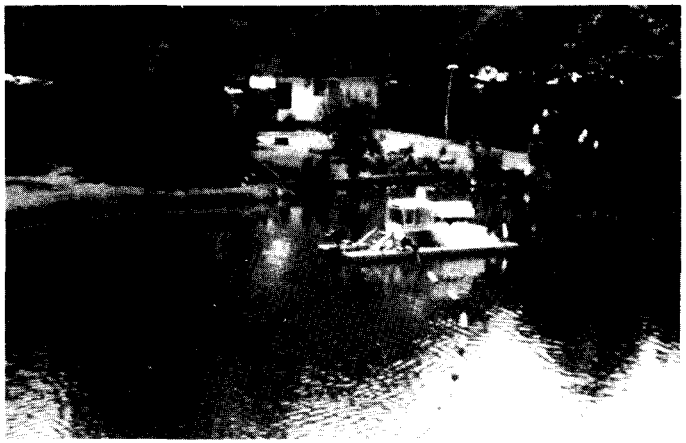
In many instances, controlling pollution sources will not improve lake water quality immediately. Years may

pass before lakes cleanse themselves of accumulated wastes. For this reason, a number of in-lake restoration techniques have been developed to accelerate recovery. However, the effectiveness of in-lake restoration techniques depends on control of pollution sources to the lake. Most in-lake restoration methods will be short-lived if the causes of the problems are not corrected. Sediment, nutrient, and toxic inputs must first be reduced or eliminated if a lake is expected to improve. Before steps to solve a lake's problems can be identified, extensive studies must often be done. Sources and types of pollutants must be identified and the lake's physical, chemical, and biological processes monitored. In short, lake management requires careful evaluation using the best scientific methods available.

The U.S. Environmental Protection Agency has conducted extensive research on the effectiveness of in-lake restoration techniques, and a brief description of the applicability of these restoration techniques is given below. The reader is urged to consult scientific papers listed in the References for more details on these techniques if needed.

Dredging

The most frequently prescribed treatment for lakes with excessive shallowness is dredging. This procedure also may be effective in long-term control of nuisance algae by removing nutrient-rich lake sediments and can be beneficial as a means of removing toxic sediments.



Dredging is a frequently used technique in lakes that are too shallow.

One of the first steps is the development of a plan to control sediment inflows to the lake. A dredging operation will be short-lived and futile if significant sources of sediment remain after dredging. The availability of a site for disposal of nutrient-rich or contaminated sediments can also be a serious obstacle to the sediment removal option.

Before sediment removal is contemplated as a long-term solution to algal blooms, the signficance of the sediments as an internal nutrient source must be determined. The nutrient release potential of the sediment must be analyzed. If the sediments account for only a small percentage of the problem, removing them would not produce the desired results. Good candidates for dredging include lakes for which deepening will immediately restore an impaired benefit, such as boating, and lakes for which sediments are significant nutrient sources. Deepening lakes also discourages the growth of some aquatic plants.

Problems caused by dredging can include nuisance algal blooms, resuspension of contaminants, and loss of habitat areas. The removal of aquatic plants can also promote algal growth since their shading effect and nutrient uptake are no longer present. Any dredging operation requires a permit from the Florida Department of Environmental Regulation.

Drawdown

Lake level drawdown has been used to control nuisance aquatic plants and to stimulate the growth of beneficial vegetation, to manage fish, to consolidate bottom sediments, to provide access to shoreline structures for maintenance, and to allow sediment removal using conventional equipment. Drawdown can be effective in nuisance aquatic plant control if the nuisance plants are susceptible to the stressful conditions of the drawdown. The physiology of nuisance plants must be known before attempting to control them by drawdown and exposure. If the nuisance plant survives while beneficial plants die, it will spread rapidly when the lake is refilled and become more of a problem than before the drawdown.

Fishing can be improved by the drawdown technique. Littoral vegetation has a chance to invade the lake bottom during drawdown, and upon refilling can provide cover and food for small fish and invertebrates, which in turn provide food for game fish. Drawdown can also

Lake level drawdown is sometimes used to control nuisance aquatic plants, to stimulate the growth of beneficial vegetation, and to improve fishing.

consolidate bottom sediment, thereby increasing potential spawning areas following refilling. Turbidity and internal nutrient cycling, which are partly caused by disturbance of bottom sediments, may be reduced during drawdown and the consolidated sediments may provide habitat for beneficial aquatic plants.

Negative aspects of drawdowns include: unsightliness; loss of use for a long period; nuisance algal blooms; fish kills; spread of nuisance plants; failure to refill; and loss of climate modifying aspect of lakes. These negative effects can be minimized by attempting control of only susceptible nuisance species and by carefully planning the drawdown.

Nutrient Inactivation

Nutrient inactivation and nutrient precipitation can only be successful in lakes from which significant inputs of nutrients have been eliminated. The techniques are used exclusively to control or lower phosphorus concentration in the water column, and therefore, are only effective for algal control and not rooted aquatic plants. Inactivation is an attempt at long-term control by stopping the release of phosphorus from lake sediments, while precipitation is the removal of phosphorus from the water column.

Precipitation of phosphorus is recommended in situations where sediments are not a significant source of phosphorus. Phosphorus inactivation is recommended in most other situations, since eutrophic lake sediments can be a major source of phosphorus for algal growth. Both techniques involve the addition of large amounts of aluminum sulfate to the lake. Negative aspects include low pH and high dissolved aluminum concentration if incorrect techniques are used.

Aquatic Plant Control

An effective method for controlling excessive aquatic vegetation is herbicide treatment. However, herbicides do not provide a long-term solution for nuisance plants or algal problems. There are no registered herbicides which provide lasting control of plants or algae. Many herbicides are also harmful to non-target species. Herbicide use also leads to the release of nutrients and to dissolved oxygen problems from the decomposing vegetation. Reliance on herbicides requires regular retreatment with the possible recurrence of the undesirable side effects. When used correctly, herbicides can be safe and effective. However, if misused, they can be dangerous to fish, wildlife, the applicator, and other water body users. An aquatic plant specialist should be consulted and permits must be obtained before treatment.

Mechanical harvesting is a technique involving the cutting and removal of aquatic plants, thus giving the lake user immediate benefits of improved swimming and boating. Harvesting usually does not constitute a long-term restoration technique since it does not affect external sediment or nutrient inputs or alter conditions for regrowth of the vegetation. In fact harvesting may also stimulate plant growth. Rarely does the amount of nutrients removed with the vegetation exceed the net nutrient inputs to the lake, therefore it is not usually effective as a method of nutrient control and is often prohibitively expensive. Although harvesting is not a long-term restoration method, it is a lake improvement technique that gives the users immediate access to the water without the problems associated with most herbicides. Harvesting does constitute habitat removal, and therefore can result in reduced numbers of animals in the harvested area.

Harvesting has several advantages over herbicide treatment. It is target specific and the site of harvesting

Herbicide spraying is only one technique useful in controlling nuisance aquatic plant problems.

is determined by the lake user. The nuisance vegetation is removed from the lake and with it a certain amount of nutrients. The plants do not remain in the lake to decompose, use oxygen, release nutrients, and build up sediments. Economic uses for harvested plants, such as methane production and animal food additives, are under development and if effective could reduce harvesting costs.

Biological control of aquatic plants and algae through the natural grazing of fish or insects is a relatively new experimental approach. However, the introduction of exotic species to combat nuisance vegetation is still in the experimental stage. Caution is being exercised since the introduction of exotic species can sometimes cause more problems than are solved. Local control of water hyacinths has had limited success using both fungi and insects. Alligator-weed also can be controlled by an insect. The grass carp has been successful in vegetation control in Europe and China and is being tested in the United States. However, more research is needed on the role of the grass carp and other herbivorous fish in cycling plant nutrients, interfering with game fish populations, and spreading fish diseases before widespread use is warranted.

Biomanipulation is an experimental technique which alters the food web of a lake to favor the naturally occurring animals which graze on algae. Grazing zooplankton are promoted by reducing fish populations that prey on them. Biomanipulation is a promising approach that could reduce algal blooms and improve water clarity. At present the use of biological controls on nuisance plants and algae is still largely in the experimental stage.

Prevention is the best method to stop invasion by problem aquatic plants. Only a few species usually become problems in lakes. The homeowner should learn to identify these plants, and if detected early, eradication may be possible if the appropriate authority is contacted.

Aeration and artificial circulation

In eutrophic lakes, the bottom sediments contain an excessive amount of organic matter. If the lake is stratified, bacterial decomposition consumes the dissolved oxygen in the bottom waters. The bottom waters then become unfit for fish and benthic animals. Nutrients, methane, and hydrogen sulfide can accumulate in the bottom waters creating taste and odor problems (in lakes used for drinking water).

Aeration introduces oxygen into the bottom waters and creates artificial circulation which mixes the entire water column. These techniques can reduce taste and odor problems, improve the benthic fishery, and prevent fish kills. Control of algal blooms or aquatic plants, oxidation of bottom sediments, and reduction of nutrient concentrations have not been sufficiently documented as benefits of aeration or artificial circulation. In Florida, aeration may not be a feasible restoration technique because most Florida lakes are shallow and have sufficient oxygen content. The Florida Department of Natural Resources is currently studying aeration and its effects on lakes.

What the Public Can Do

Water Rights

Citizens should know what legal rights are involved before steps are taken to protect lake water quality. The increasing demand for water and recreational facilities has resulted in a large number of laws being passed related to water conflicts. Laws affecting water rights vary greatly depending upon the legal classification of the water body.

Navigable lakes are generally treated as public lakes, owned by the state, and the public has the right to use these waters for almost any recreational purpose. However, these rights are subject to reasonable regulations to protect safety and public health and do not give the right to trespass on privately owned shorelands.

Another group of rights, riparian rights, relate to the laws governing private rights to use navigable surface waters. These rights accompany ownership of lands which border navigable waters, but only apply if ownership extends to the ordinary high water mark of the navigable lake. Riparian rights give the property owner the right to use the water in a reasonable manner. However, the property owner may not alter land under state waters by dredging, filling, aquatic plant control, or constructing a beach without state approval.

Private lakes are those that are not navigable, are entirely privately owned (have no public access), and do not discharge to other public water bodies. Contrary to navigable lakes, ownership of lake bottoms can occur in private lakes, and ownership of a small portion of lake bottom or shoreland entitles the landowner to full use of the total lake. Members of the public do not have the right to use the waters of a private lake.

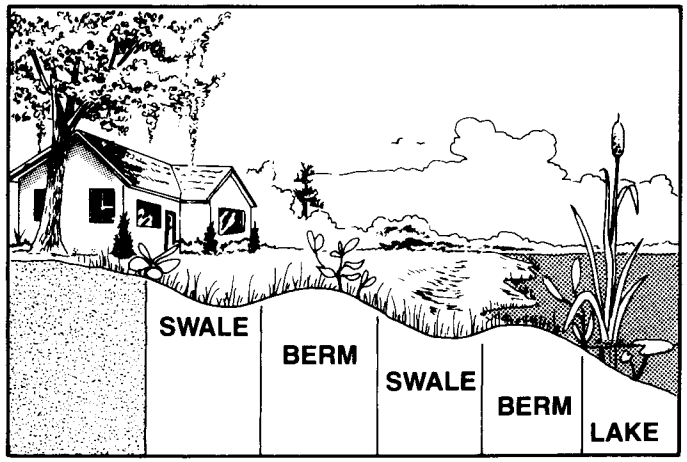
Many non-navigable lakes have public access (they are not entirely privately owned) or discharge into state waters. The public has the right to use these waters subject to the same reasonable regulations as navigable waters. Although individual shoreland owners have more privileges (riparian rights) than non-riparians, there are limits to these privileges. Within recent years many regulations designed to maintain good water quality have been extended to lakeshores. These regulations include shoreline vegetation clearing ordinances, zoning laws, sanitary codes, water quality standards, and specific discharge requirements. These regulations are designed to protect the health, safety, and general welfare of the public by insuring the continued health of lakes.

Natural shoreline vegetation should be left undisturbed (top) and not replaced by sandy beaches (bottom).

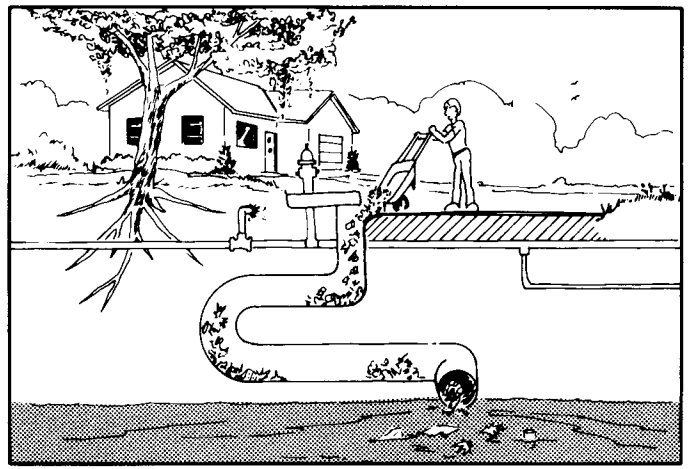
Individual Actions

The ultimate test of lake protection and restoration programs is whether or not lakes continue to be degraded. The following is a list of actions that individuals can take to reduce or eliminate unnecessary pollutants into lakes.

1. Beneficial shoreline vegetation should not be removed to construct a beach. Alternate access methods such as piers, swimming platforms, or narrow access zones should be substituted.
2. Terracing or swales and berms should be used to reduce erosion and stormwater runoff near lakes.
3. Plants native to the area should be used for landscaping. This usually reduces the need for fertilizers, pesticides, and special modifications to lakeshore property.
4. The use of fertilizers, herbicides, and pesticides should be restricted, especially near the water's edge.
5. Storm drains should not be used for the disposal of yard clippings, litter, and trash since this material will eventually reach the waterway.
6. If possible, lakeshore owners should connect to a sewage treatment plant. If septic tank systems must be used, they should be installed as far away from the water as possible. Also, soil conditions must be suitable for septic tanks, and installation must be done properly.



A swale and berm system slows down stormwater runoff and traps pollutants before they reach the lake.



Do not dispose of litter in storm drains because they eventually connect to water bodies.

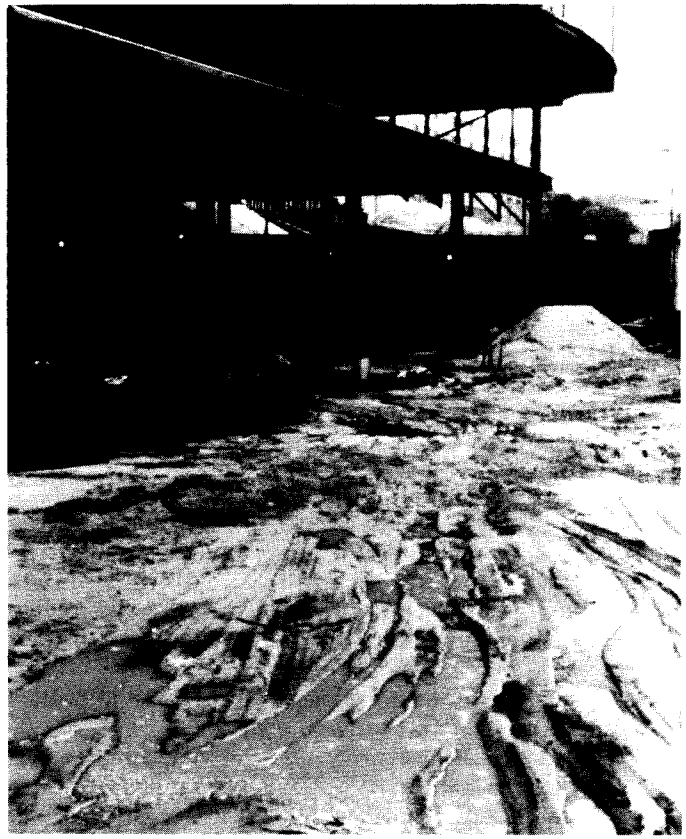
7. Detergents that contain phosphates or are non-biodegradable should not be used.
8. Boat engines should be properly maintained to avoid leaking gas and oil. Boaters should avoid shallow areas to keep from churning up and resuspending sediments. Boat trailers and motors should be inspected after use for aquatic plants to avoid introduction of exotic plants into non-infested areas.
9. Nutrients in the form of fertilizer are sometimes intentionally placed in a lake in order to increase fish production. This technique, which can be useful in small man-made ponds, often backfires in natural lakes causing severe aquatic plant and algae problems. Such activities should be conducted only under expert guidance.

Some water quality problems can be alleviated by individual actions. However, others are best handled by collective or community action. Local governments can adopt many regulations which have proven useful in protecting lakes and their watersheds. A few examples include:

1. Set back lines or buffer zones around lakes to protect natural habitats and prevent erosion.
2. Zoning laws that severely limit development in certain areas and allow different types of development such as recreational, residential, or commercial as long as lake protection standards are met.
3. Permit requirements for any building within a narrow

regulatory strip around the lake to insure that lake protection standards are met.

4. Minimum lot size regulations to control housing density and insure sufficient soil absorption area for septic tanks.
5. Septic tank regulations which insure proper location and maintenance.
6. Planning commissions with the power to modify or deny development plans which do not protect lake water quality standards.
7. Land use, construction, and stormwater runoff ordinances to prevent water quality problems in lakes.
8. Building codes limiting the amount of impervious surfaces on building sites.



Poor management techniques increase stormwater runoff and associated problems.

Such ordinances have been used around the country to protect the quality of lakes. A pooling of efforts with those of other concerned citizens can often permit more effective action than can individual efforts. Unfortunately, the effectiveness of voluntary activities is sometimes limited. If more technical help is needed, citizens must know where to go for assistance with their lake problems.

Where to Go for Help

A citizen can choose from several levels of government for help with water quality problems. The first step should be to obtain and organize the facts concerning the lake problem. Many lake property owners have formed lake associations to mobilize the community and influence changes in laws to protect their lakes. On the local level, planning commissions and city and county governments can act or seek help in solving local lake problems. State and federal governments are also involved in some facet of lake management programs. Appendix A lists federal, state, and local government agencies and their jurisdictional responsibilities for lakes. Appendix B lists agencies involved with lake management in Florida.

The Water Resources Restoration and Preservation Section of the Florida Department of Environmental Regulation is currently completing a lake classification and priority ranking study of Florida lakes. This project is designed to bring together water quality, aquatic plant, recreation, and public interest data from local, state, and federal sources. This information is being analyzed to provide a comprehensive lake management strategy for future restoration and preservation options.

Solving lake problems is not easy, but it is worth the effort. This booklet was designed to inform the interested reader about lakes, how they function, what the causes of lake degradation are, and some possible solutions to water quality problems. Hopefully, this booklet will contribute to solving at least some of the problems Florida's lakes face today.

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Appendix A

Federal, state, and local environmental control agencies and their respective regulatory responsibilities concerning lakes.

I. Federal Agencies

A. Army Corps of Engineers

Concerned with all activities which affect or modify navigable waters of the United States. Primarily concerned with construction of structures and dredge and fill permits in navigable waters. They are also involved in permitting the placement of dredge and fill material into navigable waters, including adjacent wetlands, and provide some funding for aquatic plant control in navigable and public waters.

B. Coast Guard

They have authority to respond in an emergency to hazardous waste releases and force responsible parties to clean up.

C. Department of Commerce—National Oceanic and Atmospheric Administration

The administrator of NOAA is currently directing a ten-year effort to develop and implement a program to deal with acid precipitation.

D. Environmental Protection Agency

This is the main federal agency responsible for "clean water." Duties performed by EPA which relate to lakes include: hazardous waste cleanup, public drinking water systems, all point source pollutant discharges into waters of the United States, and protection and restoration of lakes. EPA also reviews Corps of Engineers permit activities, sets minimum water quality standards, and sets guidelines for state environmental programs.

E. Department of Interior

The primary lake related functions performed by this agency involve proposed activities which impact threatened or endangered species, review of Corps' permits for effects on fish and wildlife, and management of all federal public lands. Under this department the U.S. Geological Service conducts research on lake levels and water use, and monitors lake water quality. The U.S. Fish and Wildlife Service manages and restores sport fish and wildlife populations and conducts research on effects of pollution on fishery resources.

F. Department of Agriculture

The Soil Conservation Service promotes the use of conservation practices to reduce soil losses including techniques to reduce runoff and thus improve water quality in waterways. The U.S. Forest Service promotes watershed management, wildlife habitat management, and reforestation programs. The Agricultural Stabilization and Conservation Service, through many of its programs, helps protect wetlands and helps solve water, woodland, and pollution problems on farms and ranches.

II. Florida Agencies

A. Department of Agriculture and Consumer Services

This department regulates the purchase and use of restricted pesticides and helps in soil and water conservation through activities of the Soil and Water Conservation Districts and the Division of Forestry.

B. Department of Community Affairs

This department is responsible for reviewing local comprehensive plans and has jurisdiction over "Developments of Regional Impact" (DRIs). DRIs concern developments which could have a substantial effect upon health, safety, or welfare of citizens of more than one country.

C. Department of Environmental Regulation

The DER is the lead state agency involved in water quality, dredge and fill, pollution control, and resource recovery programs. The department sets

water quality standards, pollution discharge loadings, and has permit jurisdiction over point and nonpoint source discharges, dredge and fill, drinking water systems, power plant siting, and many construction activities in waters of the state. The Water Resources Restoration and Preservation Section is responsible for lake restoration programs in Florida in conjunction with EPA. The department also interacts closely with other federal and state agencies on water related matters.

D. Florida Game and Fresh Water Fish Commission

The purpose of the Commission is to manage, protect, and conserve wild animal life and freshwater aquatic life. Most of its efforts related to lakes concern sport and commercial fishing, fishery and habitat management, lake drawdowns, fish stocking and herbivorous fish research.

E. Department of Health and Rehabilitative Services

HRS is responsible for septic tank system permitting through its county health departments and also mosquito control coordination.

F. Department of Natural Resources

The DNR is also highly involved in water related problems. Besides administering all state lands, including parks and aquatic preserves, DNR serves as the enforcement agency for the Florida Endangered and Threatened Species Act and the Oil Spill Prevention and Pollution Control Act. DNR is also responsible for coordinating aquatic plant research and control in the state. DNR issues permits for transport of aquatic plants, herbicide spraying, and other plant control methods in aquatic environments. DNR also has lake management extension services.

III. Other Agencies

A. Water Management Districts

The five multi-purpose water management districts are concerned with water use, lake levels, dredge and fill, water quality, and other water-related management programs. These districts can hold, control, and acquire land and water bodies which affect water storage in the state.

B. Regional Planning Councils

The eleven regional planning councils in the state act in an advisory capacity to local governments in matters concerning water resources, recreational areas, and DRIs.

C. Soil and Water Conservation Districts

These districts are supervised to a limited degree by the Department of Agriculture and Consumer Services and carry out preventive measures for flood prevention and soil erosion.

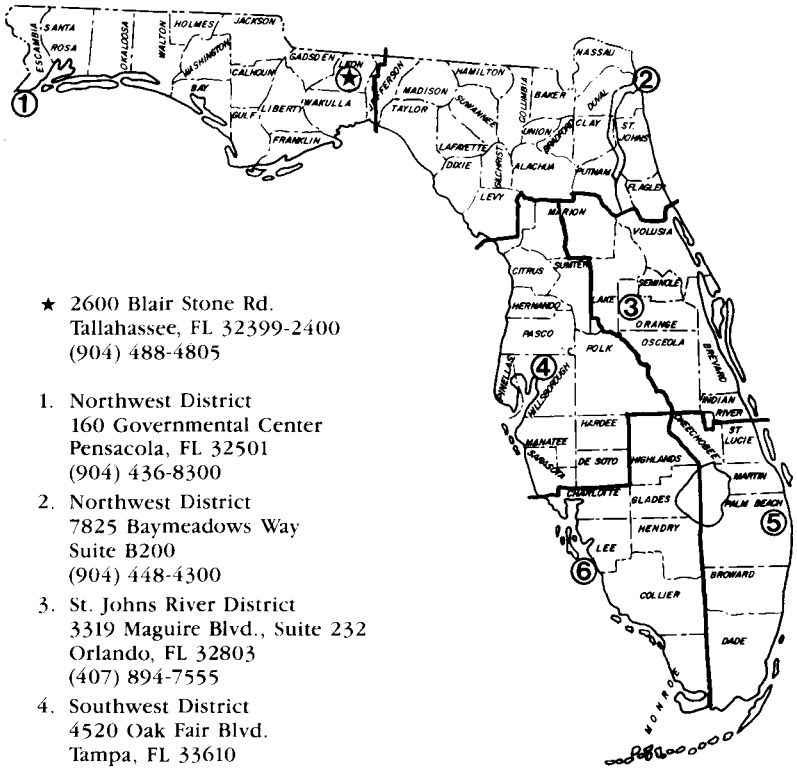
D. Miscellaneous

Many local counties and municipalities have environmental and planning agencies which can be involved in lake problems. Local governments can also pass pollution control laws, zoning and land use laws, and many other ordinances which can be effective in preventing water quality problems in lakes.

Many of these agencies perform functions which overlap on the state, federal, and local level. There are also many memoranda of understanding between agencies which allow sharing of overlapping functions. Local, state, and federal agencies interact extensively on programs due to mutual benefits and cost sharing agreements.

Appendix B

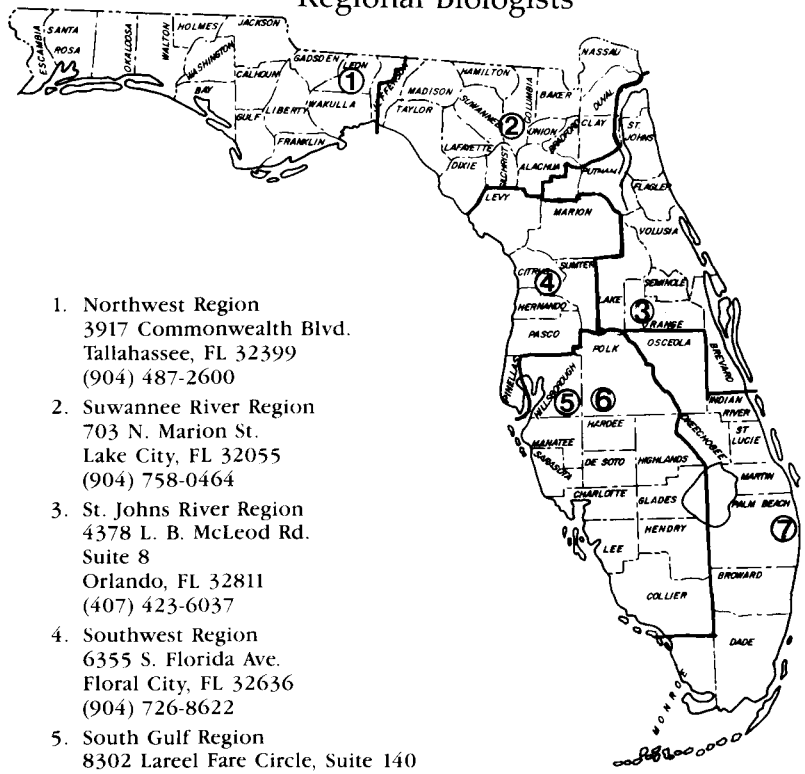
Department of Environmental Regulation



★ 2600 Blair Stone Rd.
Tallahassee, FL 32399-2400
(904) 488-4805

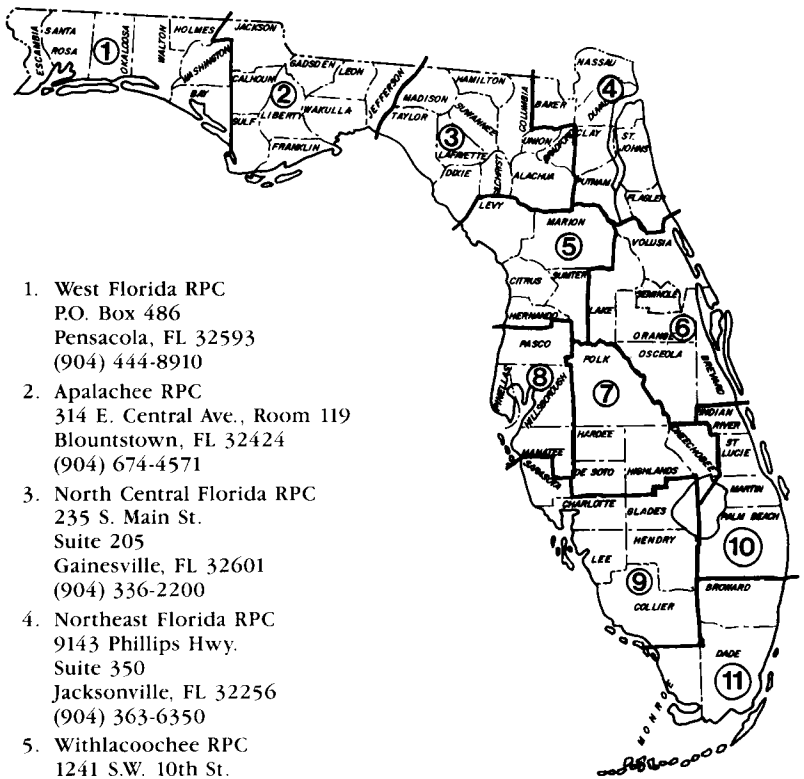
1. Northwest District
   160 Governmental Center
   Pensacola, FL 32501
   (904) 436-8300
2. Northwest District
   7825 Baymeadows Way
   Suite B200
   (904) 448-4300
3. St. Johns River District
   3319 Maguire Blvd., Suite 232
   Orlando, FL 32803
   (407) 894-7555
4. Southwest District
   4520 Oak Fair Blvd.
   Tampa, FL 33610
   (813) 623-5561
5. Southeast Florida District
   1900 S. Congress, Suite A
   W. Palm Beach, FL 33406
   (407) 433-2650
6. South Florida District
   2269 Bay St.
   Ft. Myers, FL 33901
   (813) 332-6975

Department of Natural Resources
Regional Biologists



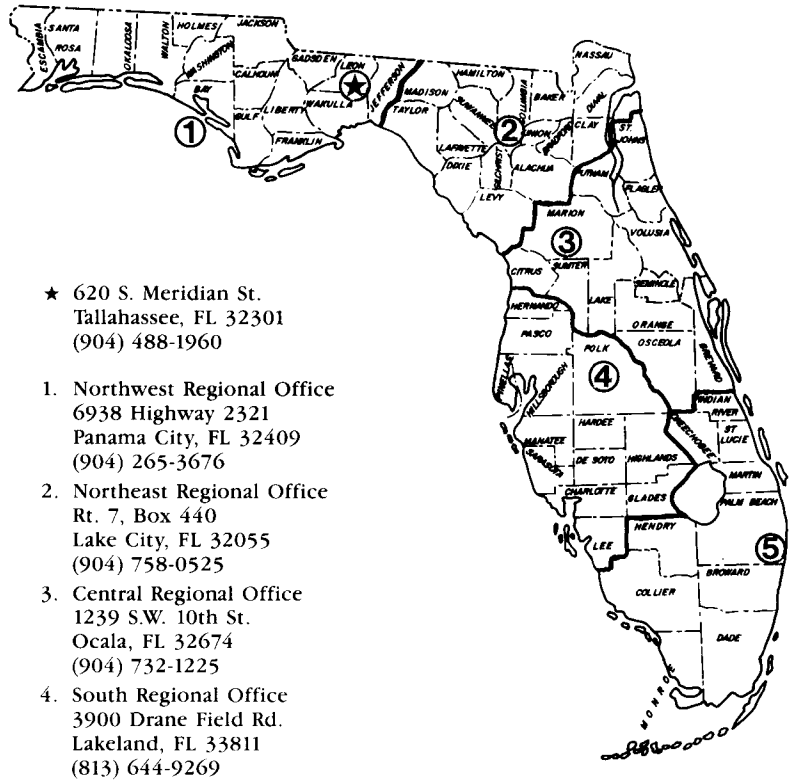
1. Northwest Region
   3917 Commonwealth Blvd.
   Tallahassee, FL 32399
   (904) 487-2600
2. Suwannee River Region
   703 N. Marion St.
   Lake City, FL 32055
   (904) 758-0464
3. St. Johns River Region
   4378 L. B. McLeod Rd.
   Suite 8
   Orlando, FL 32811
   (407) 423-6037
4. Southwest Region
   6355 S. Florida Ave.
   Floral City, FL 32636
   (904) 726-8622
5. South Gulf Region
   8302 Lareel Fare Circle, Suite 140
   Tampa, FL 33610
   (813) 626-5143
6. South Central Region
   1677 Highway 17 South
   Bartow, FL 33830
   (813) 533-3683
7. South Region
   300 Business Parkway, Suite B-100
   Royal Palm Beach, FL 33411
   (305) 793-5666

Regional Planning Councils



1. West Florida RPC
   P.O. Box 486
   Pensacola, FL 32593
   (904) 444-8910
2. Apalachee RPC
   314 E. Central Ave., Room 119
   Blountstown, FL 32424
   (904) 674-4571
3. North Central Florida RPC
   235 S. Main St.
   Suite 205
   Gainesville, FL 32601
   (904) 336-2200
4. Northeast Florida RPC
   9143 Phillips Hwy.
   Suite 350
   Jacksonville, FL 32256
   (904) 363-6350
5. Withlacoochee RPC
   1241 S.W. 10th St.
   Ocala, FL 32674-2798
   (904) 732-1315
6. East Central Florida RPC
   1011 Wymore Rd., Suite 105
   Winter Park, FL 32789
   (407) 623-1075
7. Central Florida RPC
   P.O. Drawer 2089
   Bartow, FL 33830
   (813) 534-7130
8. Tampa Bay RPC
   9455 Koger Blvd., Suite 219
   St. Petersburg, FL 33702
   (813) 577-5151
9. Southwest Florida RPC
   P.O. Box 3455
   North Ft. Myers, FL 33918
   (813) 995-4282
10. Treasure Coast RPC
    P.O. Box 1529
    Palm City, FL 34990
    (407) 221-4060
11. South Florida RPC
    3440 Hollywood Blvd., Suite 140
    Hollywood, FL 33021
    (305) 961-2999 (Broward)
    (305) 620-4266 (Dade)

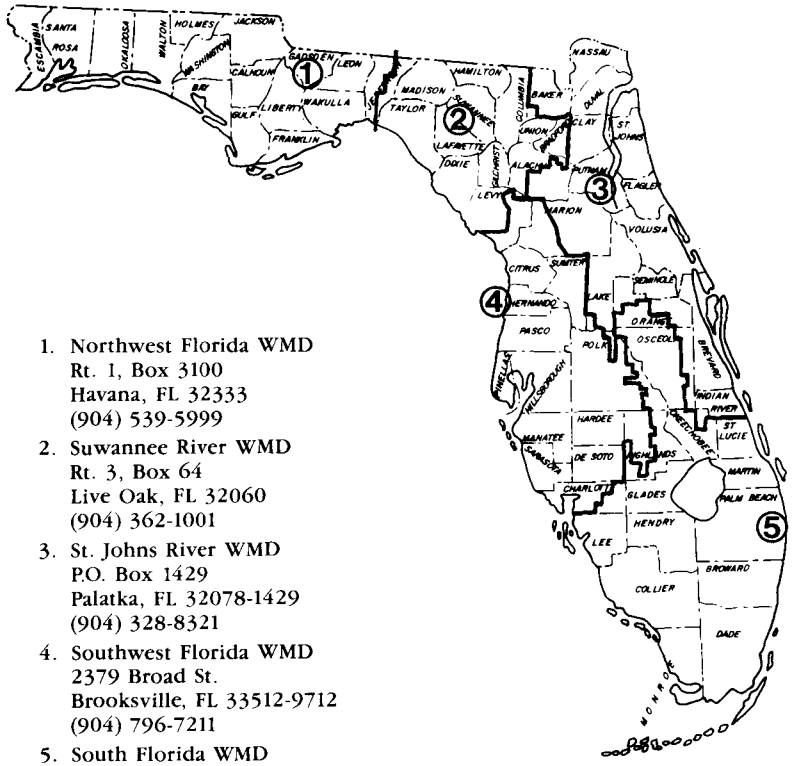
Florida Game & Fresh Water Fish Commission



★ 620 S. Meridian St.
Tallahassee, FL 32301
(904) 488-1960

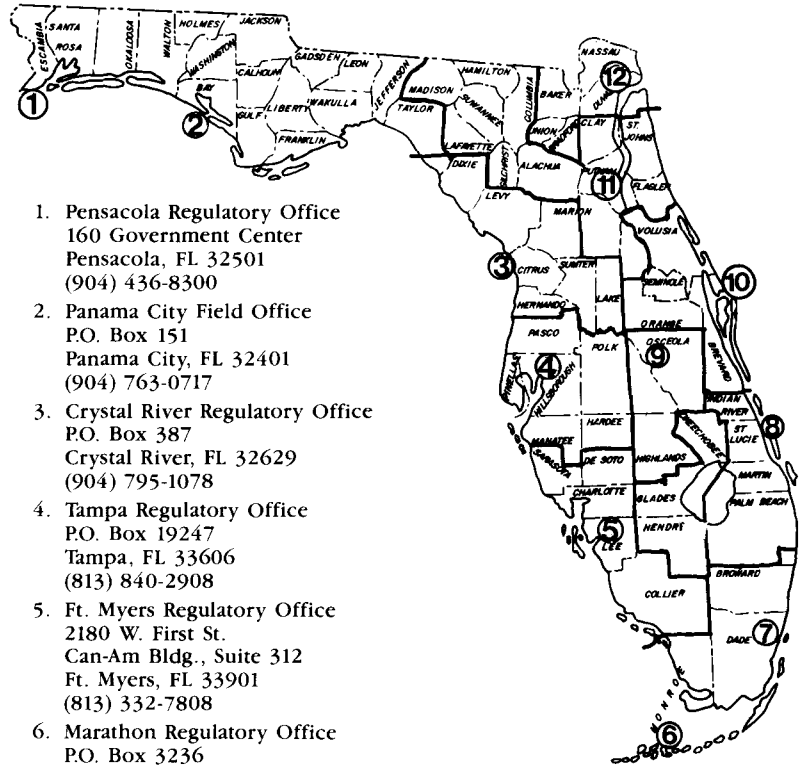
1. Northwest Regional Office
   6938 Highway 2321
   Panama City, FL 32409
   (904) 265-3676
2. Northeast Regional Office
   Rt. 7, Box 440
   Lake City, FL 32055
   (904) 758-0525
3. Central Regional Office
   1239 S.W. 10th St.
   Ocala, FL 32674
   (904) 732-1225
4. South Regional Office
   3900 Drane Field Rd.
   Lakeland, FL 33811
   (813) 644-9269
5. Everglades Regional Office
   551 N. Military Trail
   W. Palm Beach, FL 33415
   (407) 640-6100

Water Management Districts



1. Northwest Florida WMD
   Rt. 1, Box 3100
   Havana, FL 32333
   (904) 539-5999
2. Suwannee River WMD
   Rt. 3, Box 64
   Live Oak, FL 32060
   (904) 362-1001
3. St. Johns River WMD
   P.O. Box 1429
   Palatka, FL 32078-1429
   (904) 328-8321
4. Southwest Florida WMD
   2379 Broad St.
   Brooksville, FL 33512-9712
   (904) 796-7211
5. South Florida WMD
   P.O. Box 24680
   W. Palm Beach, FL 33402-4680
   (305) 686-8800

U.S. Army Corps of Engineers



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   160 Government Center
   Pensacola, FL 32501
   (904) 436-8300
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   P.O. Box 151
   Panama City, FL 32401
   (904) 763-0717
3. Crystal River Regulatory Office
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   Crystal River, FL 32629
   (904) 795-1078
4. Tampa Regulatory Office
   P.O. Box 19247
   Tampa, FL 33606
   (813) 840-2908
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   Can-Am Bldg., Suite 312
   Ft. Myers, FL 33901
   (813) 332-7808
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   Marathon Shores, FL 33052
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7. Maimi Regulatory Office
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   (305) 591-1302
8. Stuart Regulatory Office
   10 Central Parkway, Suite 213
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   (407) 286-0509
9. Merritt Island Regulatory Office
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   Courtney Square Bldg., Suite 216
   Merritt Island, FL 32952
   (407) 453-7655
10. Palatka Regulatory Office
    P.O. Box 1317
    Palatka, FL 32077
    (904) 325-2028
11. Field Operations Branch
    Regulatory Division
    P.O. Box 4970
    Jacksonville, FL 32232
    (904) 791-2502

Appendix C

Number and Area of Lakes by Counties in Florida (Modified from Heath and Conover, 1981)

County	Number of Lakes	Area of Lakes (acres)
Alachua	169	59,126
Baker	2	1,817
Bay	49	7,274
Bradford	14	4,657
Brevard	89	16,213
Broward	77	721,398*
Calhoun	36	1,009
Charlotte	146	2,844
Citrus	37	21,003
Clay	59	15,401
Collier	46	2,038
Columbia	52	1,671
Dade	81	2,434
DeSoto	41	816
Dixie	76	1,605
Duval	23	470
Escambia	26	473
Flagler	16	2,669
Franklin	29	703
Gadsden	34	8,360
Gilchrist	11	627
Glades	13	507
Gulf	9	10,862
Hamilton	27	659
Hardee	3	180
Hendry	66	1,014
Hernando	130	5,695
Highlands	95	48,601
Hillsborough	238	8,760
Holmes	62	1,880
Indian River	24	7,231
Jackson	324	51,162
Jefferson	55	8,138
Lafayette	65	1,561
Lake	572	94,311
Lee	88	2,040
Leon	111	14,242
Levy	101	7,444
Liberty	30	346
Madison	113	14,510
Manatee	19	296
Marion	284	25,732
Martin	12	323
Nassau	2	118
Okaloosa	58	884
Okeechobee	70	2,138
Orange	711	78,295
Osceola	877	147,583
Palm Beach	15	579,097**
Pasco	300	11,774
Pinellas	38	4,263
Polk	550	93,194
Putnam	264	47,219
St. Johns	6	136
St. Lucie	31	1,366
Santa Rosa	52	640
Sarasota	15	1,586
Seminole	185	18,717
Sumter	253	17,059
Suwannee	34	1,051
Taylor	96	2,669
Union	3	1,916
Volusia	240	79,795
Wakulla	44	1,472
Walton	90	3,097
Washington	295	17,393
TOTAL	7,783	2,289,564

* Includes Conservation Areas 2, 3A, and 3B.
** Includes Conservation Area 1 and Lake Okeechobee.

Appendix D

Glossary

Chlorophyll—Green pigment found in algae and higher plants which enables them to utilize energy from the sun.
Decomposition—The breakdown of organic materials into simpler forms by the action of microorganisms (mostly bacteria).
Leachate—The liquid which has passed through a porous material into the soil.
Limnologist—A person who studies freshwater systems.
Macrophytes—Large aquatic plants.
pH—A measure of the hydrogen ion content of a substance on a scale of O to 14. Distilled water is neutral (pH = 7.0) and the lower the pH, the more acidic a solution is.
Phytoplankton—Microscopic free-floating plants found in aquatic systems.
Nutrient—A chemical element or compound that sustains life and promotes growth of organisms.
Sedimentation—The process by which mineral and organic matter is deposited.
Silviculture—A branch of forestry dealing with the development and care of forests.
Sinkhole—A depression in the surface of the ground caused by the collapse of the roof over a limestone cavern.
Specific Heat—The amount of heat necessary to raise the temperature of one gram of any material one degree centigrade.
Tectonic Movement—Movement of the land upward or downward caused by pressures on the earth's crust.
Transpiration—The process by which water vapor escapes from a living plant and enters the atmosphere.
Topographic Relief—The difference in elevation between the highest and lowest features of an area.
Watershed—Land area that is drained by a stream, river, or lake system.
Zooplankton—The passively floating or weakly swimming microscopic animals in aquatic systems.

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