The Massachusetts Lake and Pond Guide

Protection Through Education

dcr

Massachusetts Department of
Conservation and Recreation
Lakes and Ponds Program

Welcome to the MA Lake Book...

Massachusetts has over 3000 lakes and ponds that provide opportunities for recreation and valuable habitat for a wide diversity of plants and animals. By choosing to read this book you are taking the first step towards protecting your lake or pond. This book is a starting point for concerned citizens who wish to learn about lake ecology and ways they can protect the future of their lake or pond.

The first two chapters will help you understand the basic concepts of watersheds and the ecology of lakes and ponds, the importance of a watershed approach to lake and pond protection, and cycles within a lake system. The following chapters address the main causes of reduced water quality and detail ways that you, as a concerned citizen, can adopt a proactive role in preventing further degradation of our water bodies. The final two chapters provide guidance for people who wish to go one step further and begin or join a lake association, apply for grants or obtain additional educational publications. A glossary of aquatic terms is provided in the back of the book.

Act now and protect your lake's future!

Executive Office of Environmental Affairs
Department of Conservation and Recreation
Office of Water Resources
Lakes and Ponds Program

Written by Michelle Robinson 2004

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Cover photo by Michelle Robinson.

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Introduction

Michelle Robinson

In the mid 1800's, Henry David Thoreau, inspired by Walden Pond, wrote, "A lake is the landscape's most beautiful and expressive feature. It is earth's eye; looking into which the beholder measures the depth of his own nature." One hundred and fifty years later, residents and visitors continue to be inspired by the scenic lakes of Massachusetts. There are over 3,000 lakes and ponds in Massachusetts that provide drinking water, flood control, irrigation, electricity, aesthetic values, recreation and habitat for fish and wildlife. The lake environment creates a diverse habitat for wildlife and provides a home for hundreds of animals, including threatened species.

Today, the future of many of Massachusetts' lakes is at stake. Aquatic nuisance species, pollution, shoreline and watershed development and storm water issues threaten the health of our lakes. In many lakes the rate of succession has accelerated and is causing them to become "old" before their time. It is critical that citizens become involved and take an active role in improving the health of their lakes and protecting these valuable resources for future generations. This book was created to provide information and guidance for concerned citizens who wish to secure a safe future for their lakes.

Our Water Planet

Michelle Robinson

Michelle Robinson

The water of our planet is stored in many areas.

94% fills our oceans,
2% remains trapped in glaciers and snow caps,
4% lies under ground, and ***only 0.1%*** *of all the water on the Earth is fresh surface water.*

Michelle Robinson

It is crucial for citizens to work toward the protection of this precious and vulnerable resource.

Michelle Robinson

DCR - Wallum Lake

Chapter 1

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Understanding Watersheds

What is a Watershed?

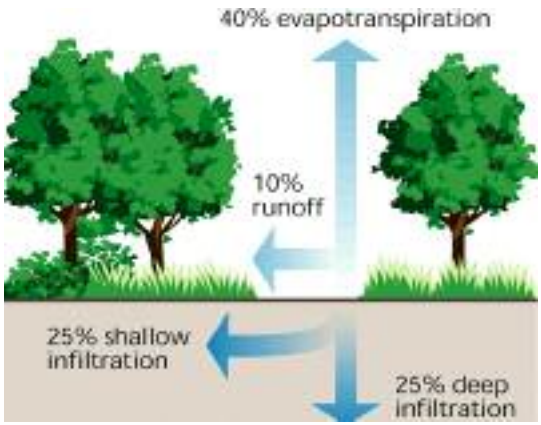
A watershed is an area of land in which all the water drains into a particular low-lying river or other surface water body. The boundaries of a watershed are determined by higher areas of land which separate it from adjacent watersheds. There are 27 watersheds in Massachusetts and within each of these are the smaller watersheds of each lake or pond. Within each lake's or pond's watershed, all the water in that area flows to the lowest point, the water body.

Since all the land in a watershed drains into a water body, every activity in that watershed ultimately has an impact. In undisturbed or natural areas, the majority of water is either absorbed by vegetation or infiltrates down through the soil and replenishes underlying groundwater. As the water passes through the layers of earth, many harmful toxins, nutrients and sediments are filtered out.

This cycle changes when an area is developed or altered. Impervious surfaces including pavement, buildings and other man-made constructions, prevent the infiltration of water into the ground. Instead, precipitation travels primarily across the impervious surfaces as runoff (see graphic below). Often, as storm water races over impervious surfaces it attains velocity, causing erosion and collecting pollutants. Storm water, loaded with sediments, toxins and nutrients, may flow untreated into nearby lakes and ponds.

Picture a drop of water falling near the summit of a mountain. As the droplet begins to travel down the mountainside it may pick up sediments and oil residue as it trickles over a road. The droplet continues to wind its way downward through a garden collecting pesticide residues, fertilizer and waste from a pet, and eventually enters a lake, stream or pond. This type of pollution is called non-point source pollution because the pollution did not enter the lake from a single identifiable location, such as a sewage pipe; instead, the pollution came from multiple locations.

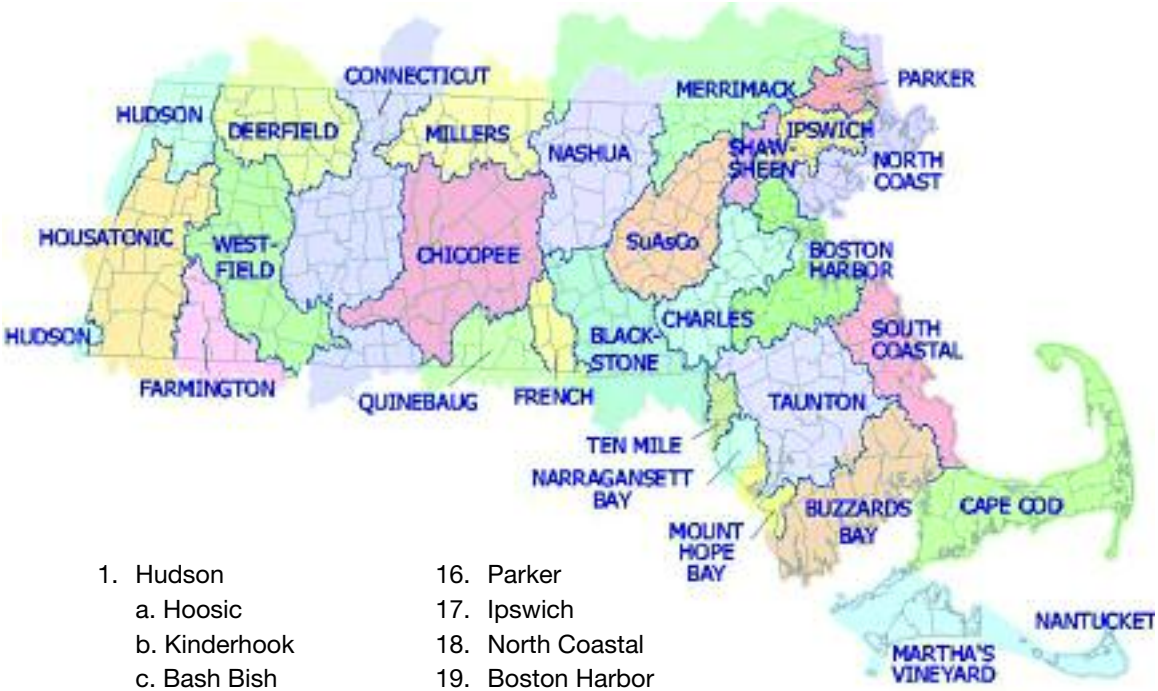
When trying to maintain a healthy lake it is important to monitor all the activities within the watershed and to prevent nutrients, such as phosphorus, sediments and other forms of pollution from draining into a lake. Storm water pollutants are covered in greater detail in Chapter 3 and treatments for storm water are discussed in Chapter 4.



Natural Ground Cover: 10% runoff

75-100% Impervious Surface: 55% runoff

Watersheds of Massachusetts



1. Hudson
   a. Hoosic
   b. Kinderhook
   c. Bash Bish
2. Housatonic
3. Deerfield
4. Westfield
5. Farmington
6. Connecticut
7. Millers
8. Chicopee
9. Quinebaug
10. French
11. Nashua
12. Blackstone
13. Merrimack
14. Concord
    a. Assabet
    b. Concord & Sudbury
15. Shawsheen
16. Parker
17. Ipswich
18. North Coastal
19. Boston Harbor
    a. Mystic
    b. Neponset
    c. Weymouth & Weir
20. Charles
21. South Costal
    a. North & South Rivers
    b. South Coastal Shore
22. Cape Cod
23. Islands
24. Buzzards Bay
25. Taunton
26. Narragansett Bay & Mt. Hope Bay Shore
27. Ten Mile

Massachusetts Watershed Approach

While many land and water resource managers have used the watershed as a resource management and planning unit for many years, the Commonwealth formally adopted a watershed approach in 1994. This EOEA initiative helped focus state and local resources on developing a better understanding of our natural resources and seeking improvements in protecting and restoring them in measurable ways. It also educated many community officials and citizens about the value of planning and managing resources on a watershed basis.

Then, in 2000, EOEA launched the Lakes and Ponds Watershed Action Strategy for the Commonwealth, a watershed approach focused on lakes and ponds management. Under this program, DCR lakes and ponds staff have worked with communities to identify immediate actions that could be taken to improve lake and pond protection efforts and to integrate these efforts with Massachusetts' watershed approach.

This effort also reaffirmed the existing Lakes and Ponds Policy of the Commonwealth, which states:

Massachusetts advocates a holistic approach to lake and pond management and planning, which integrates watershed management, in-lake management, pollution prevention and education. Lake management in Massachusetts will be designed with consideration of the quality of the lake's ecosystem, its designated uses and other desired uses, the ability of the ecosystem to sustain those uses, and the long term costs, benefits and impacts of available management options.

The Lakes and Ponds Watershed Action Strategy has involved individuals and groups across the state in lake and pond protection and restoration in order to promote local stewardship for these valuable Commonwealth resources. Efforts have included education at the local level to curb invasive species, development of an invasive species response team, and funding demonstration projects for innovative approaches to lake management.

Chapter 2

Michelle Robinson

Lake and Pond Basics

Lake and Pond Formation

Lakes are formed in a variety of ways, including: fluvial activity (river activity), tectonic land movements, volcanoes, glacial activity, animal activity and human activity.


Mark Abbot

Many of Massachusetts' lakes were formed 10,000 to 20,000 years ago at the end of the last ice age. The retreating glaciers carved deep holes and gouges in the surface of the earth, and some of remaining glacial moraines dammed the rivers and streams to create lakes.

Kettle ponds, commonly found in the southeastern part of the state, including Cape Cod, were created when ice chunks from glaciers were buried and later melted.


National Park Service

In the last few hundred years, human activity has resulted in the creation of new lakes and ponds. Dams have been constructed to provide irrigation for crops, reservoirs, roads and hydro power. Massachusetts alone has over 2,900 private and public dams.

The American Beaver (*Castor canadensis*) also creates dams across streams, forming temporary ponds. Intricate dams are constructed with mud and tree branches that the beavers cut with their sharp teeth. The lodges have two entrances beneath the water and a sleeping chamber just above the surface of the water.


© Bill Byrne

Lakes are constantly changing as sediments and organisms slowly fill in the basin and changes occur in the succession of plants and animals.


P. Gary White


© Bill Byrne

Hydrologic Cycle

Water enters lakes and ponds in a variety of ways, but precipitation is the largest factor determining most lake levels in Massachusetts. In Massachusetts, under natural conditions, approximately 50% of precipitation re-enters the atmosphere through evaporation and transpiration of plants, and 45% infiltrates back into the ground and replenishes the groundwater supply.

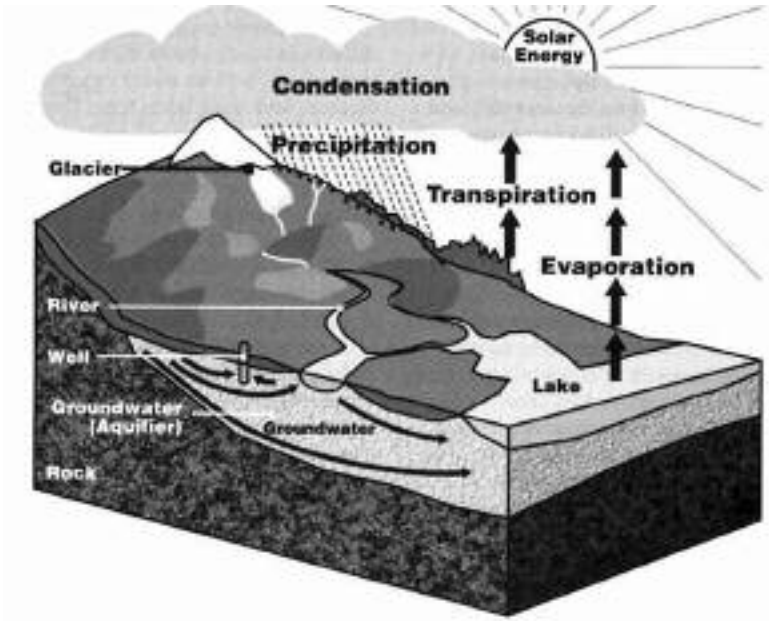
The remaining 5% of precipitation flows overland, as storm water runoff, through one of the 27 watersheds in Massachusetts to enter streams and lakes.

Changes on the earth's surface, including paving and construction, alter the amount of rainfall that can filter down in the soil to refill the water table, thus affecting the hydrology of the area. These areas are called impervious surfaces because they do not allow water to percolate though to the soil beneath.

Although dams can help maintain water levels, fluctuations in lake levels are normal.

The underlying geology of a lake also determines the source of water to lakes. Seepage ponds are formed when the water table is at or near the surface of the earth, or the bed rock is pervious and ground water can seep upward into a lake basin. Other lakes, called drainage lakes, receive most of their water from streams. In some areas where the soils are very sandy, such as Cape Cod, water moves primarily as groundwater because most of the water that falls on the ground soaks in quickly.

About 96% of all the potable water on the planet is stored in ground water and over half of all Americans rely on ground water for their drinking supply. Ground water is primarily stored in aquifers and moves very slowly. Any toxins that enter the ground water move beneath the earth as a toxic plume and can discharge into a lake, stream or well.



Physical Characteristics

Like individual fingerprints, the 3000 lakes and ponds in Massachusetts are all different, but there are some common physical characteristics that influence the flora, fauna and chemistry in a water body:

Water

Water becomes increasingly dense and sinks as it cools but becomes buoyant as it approaches the freezing point, and floats to the surface to form ice. In addition to its remarkable density characteristics, water responds slowly to changes in ambient temperature, creating a stable environment for aquatic life. Water also readily absorbs many mineral components, making them available to aquatic organisms.

Bedrock

The properties of the underlying bedrock determine the amount of water that percolates down into the water table, or seeps upward into the lake. The composition of the surrounding bedrock greatly influences lake water chemistry. In areas where the bedrock contains limestone, the water bodies have a greater ability to buffer acid rain and experience less fluctuations in pH.

Surface Area

Surface area describes the interaction between the land and the water. One way to determine the surface area of a water body is to trace the outline of the water body on a map or arial photo using a tool called a planimeter. The planimeter converts the enclosed traced area into areal measurements. Lakes with an irregular shoreline tracing (less like a perfect circle) have a greater capacity for shoreline development.

Volume

The volume of a water body, or the amount of water that is contained in the basin, influences the water bodies ability to dilute pollutants, retain flood waters and buffer the impact of storm water runoff.

Hydrologic Residence

The hydrologic residence is the time required for all the water to be exchanged. This can be calculated by dividing the entire volume of the water body by either the inflow or the outflow. In small lakes with large inflows and outflows the hydrologic residence time is only a few days, but in large water bodies, such as 12,000 km (7200 mile) Lake Superior, it is over 184 years. Lake Tahoe, although only 156 km (93 miles), has a hydrologic resistance time of 700 years. This is due to the fact that Lake Tahoe lies within a deep volcanic crater and has a miniscule watershed (basically just the rim of the crater). There is very little water entering or exiting the water body and particles that reach this aquatic "sink" have no outlet. The hydrologic residence time is important when considering how long particles, such as pollutants or toxins, linger in a lake. Often, the longer the particles remain the water body, the greater their potential impact on the aquatic ecosystem.

Bathymetry

Bathymetry describes the topographic features of the lake's basin. Although fishermen are often primarily interested in the maximum depth (deep hole) during the summer, the mean or average depth is very important to limnologists. The mean depth is calculated by dividing the volume of the water body by the surface area. In lakes where the basin drops off very rapidly there is a narrow littoral zone, resulting in less aquatic vegetation and a reduced littoral community. (For more details see page 13)

Fetch

Fetch is the distance that wind blows over open water. The greater the fetch, the longer wind can travel, uninterrupted by land, over the water's surface and generate waves. Waves increase the mixing of the lake's waters and may result in higher rates of erosion along exposed shorelines.

Solar Radiation

Solar radiation affects a lake in many ways: warming water to create thermal stratification and seasonal circulation, creating the wind patterns that mix lake waters and providing energy for photosynthesis.

Thermal Stratification

During summer, deep lakes develop thermal layers due to temperature variations in the water. Stratification is a reflection of the variations in water density. The density of water changes with temperature; usually, cooler denser waters sink, warmer waters rise.

During the spring, lakes thaw and the surface water is warmed. Eventually this warmer water mixes with deeper waters and creates a spring turnover or circulation period. This stratification becomes more defined as summer progresses and the upper waters continue to be warmed by solar radiation. Eventually three distinct layers develop in ponds with adequate depth (see diagram).

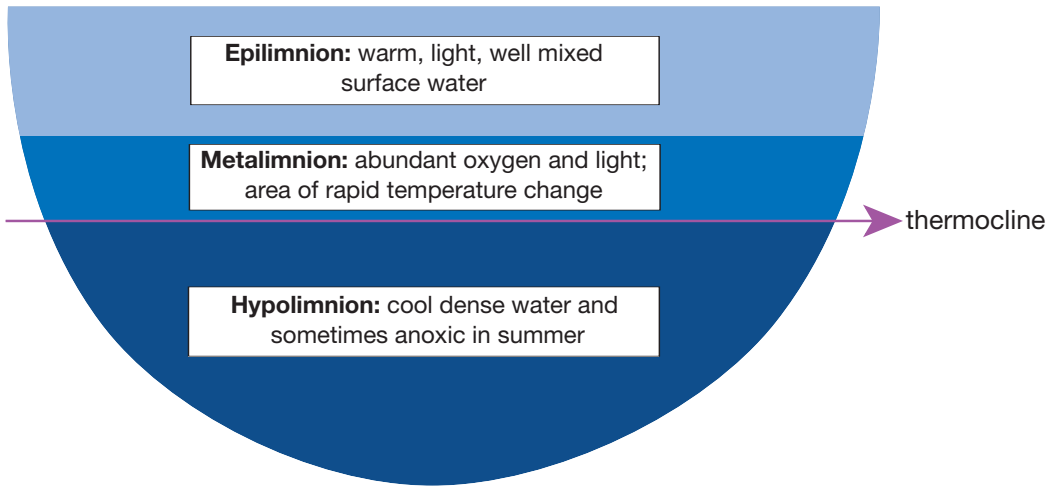
The top layer, or epilimnion, is the layer of greatest productivity due to warmer temperatures and abundant light.

The middle layer, called the metalimnion, has a rapid temperature change that helps to form a physical barrier, called the thermocline, between the top and bottom layers. Although the barrier is not visible, the difference in the water densities is strong enough to prevent mixing of water, chemicals and gases (including dissolved oxygen) between the upper and lower layer.

The waters in the deepest layer, the hypolimnion, are relatively cool, usually with lower dissolved oxygen and little light.

When you dive down into a thermally stratified lake or pond you may feel the changes in temperature as you pass through the three thermal layers. During the fall, the layers dissipate as the surface water cools and eventually the layers mix together.

Layers in a Stratified Lake



Light Zonation

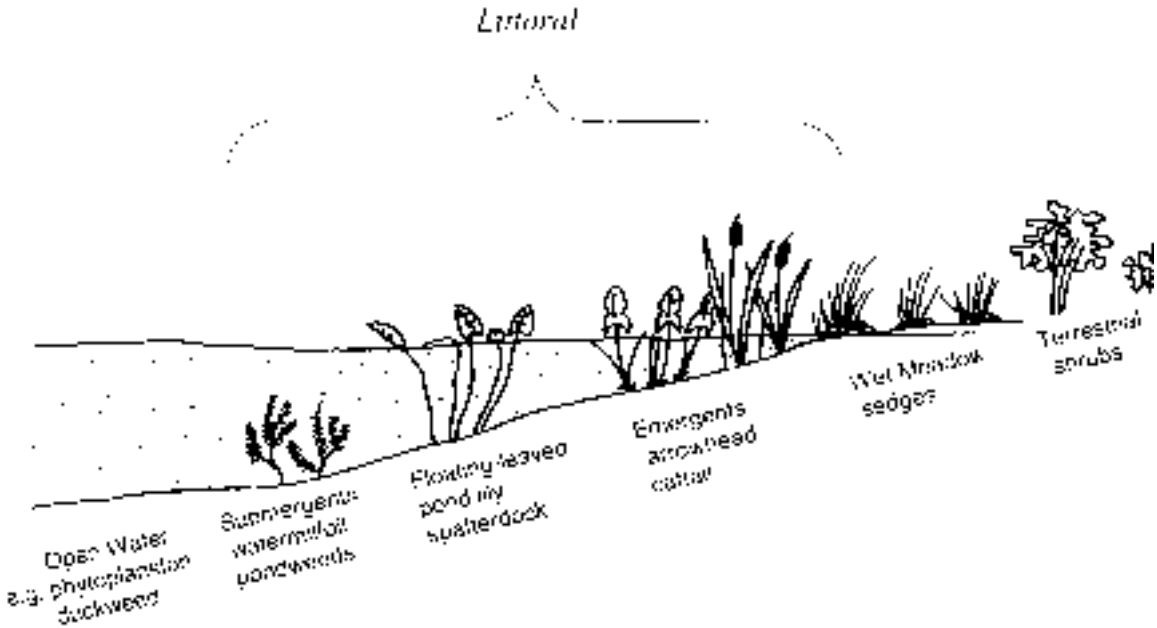
Light is critical for photosynthesis in plants. Photosynthesis is the process by which plants convert carbon dioxide and light to energy and release oxygen. Photosynthesis can only occur where there is sufficient light, so rooted plant growth is limited to the littoral zone of the lake (see diagram).

The littoral zone is the shallow area around the shore of the lake, where rooted plants (macrophytes) receive adequate sunlight for growth. In very shallow lakes the littoral zone can extend across the entire water body.

The well-lit photic layer of the lake includes surface waters down to the point where light dims to 1% of the light at the surface. The aphotic zone includes the deep darker waters where adequate sunlight does not reach and light levels are to low for photosynthesis to occur.

Bacterial activity and the presence of aquatic life in the aphotic zone consume oxygen but the lack of photosynthesis at this level results in no replenishing of oxygen.

Since the thermocline prevents oxygenated surface waters from mixing with deep waters, the aphotic zone of the lake is prone to becoming anoxic.



Other Zones in a Lake

Light or solar radiation warms the air which creates the earth's wind patterns. The wind affects the lake by mixing the waters and creating waves. The pelagic zone contains the open water in the middle of the lake and has no contact with either the shore or the lake's bottom.

Oxygen

Most aquatic animals require oxygen to live and the amount of dissolved oxygen in the water often determines where organisms can be found. In temperate lakes, during the summer months, very little oxygen is present in the hypolimnion, the deepest layer. No oxygen is produced at this depth because of the absence of plants, however oxygen is continuously being utilized.

When water has less than 0.5mg/l dissolved oxygen (DO) it is called anoxic and many fish can not survive this condition. Cold-water fish, such as trout, may be forced to move up into the warmer oxygenated waters, where they may become stressed and die due to the warmer temperature.

During the fall circulation period, when the temperature layers break down, oxygen is returned to the deeper layers. As winter arrives and an ice barrier forms over the surface, the oxygen supply in the lake begins to decline, but usually to a lesser degree.

Nutrients

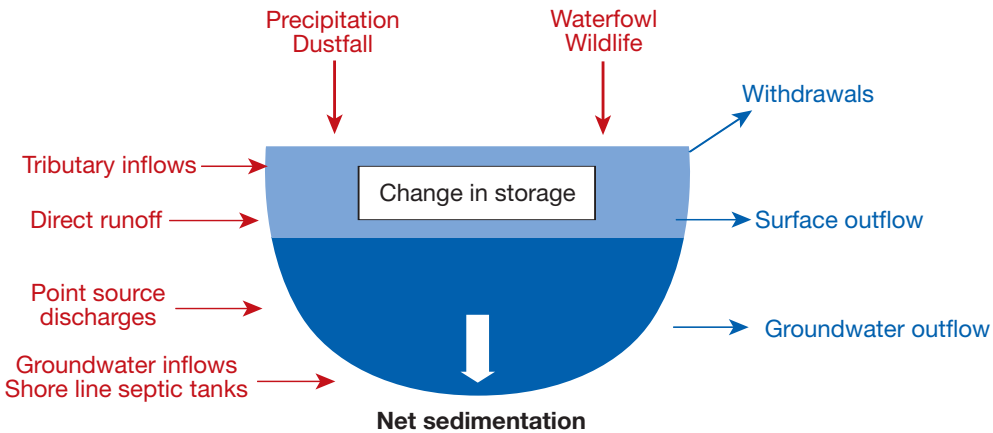
The two key nutrients that determine the algae and vegetative growth in a lake are nitrogen and phosphorus. Since phosphorus is relatively scarce in most inland freshwater systems, its availability determines the amount of plant growth.

Phosphorus

Phosphorus is generally not available in the environment because there is a relative lack of phosphorus containing materials. Phosphorus has no atmospheric gaseous phase and it is tightly bound by many organic sediments, making it generally unavailable for uptake by organisms.

When one nutrient is not as readily available as other nutrients, it is called the limiting nutrient, because its availability regulates plant growth. Although phosphorus is relatively rare, human sources such as fertilizer, sewage and eroded soil can overload lakes with available phosphorus (see diagram). Excess phosphorus introduced to a lake provides food for plants and algae and can increase the vegetation growth within a lake. Large concentrations of phosphorus may create algal blooms, which turn the waters murky, kill fish and diminish the lake's recreational and aesthetic appeal.

Phosphorus cycle in a waterbody



The decaying algae and plants eventually die and sink to the lake bottom where oxygen is utilized during the process of decomposition. As already low oxygen levels in the hypolimnion decline, the anoxic condition enables the phosphorus once trapped in the sediment to be released, increasing the availability of phosphorus to the lake system.

Nitrogen

Nitrogen is another element necessary for plant growth. Nitrogen is readily available to plants from several sources. First, the atmosphere consists of approximately 72% gaseous nitrogen (N_2) and blue green algae (cyanobacteria) can convert N_2 to a form that is useable by other plants. In addition, nitrogen moves rapidly through soils and is quickly converted from one form to another by nitrifying bacteria. Human sources of nitrogen include fertilizers, acid rain, human waste and changes in the surrounding vegetation due to fires, floods or clearing.

Other Nutrients

Other nutrients including iron and sulfur are essential cellular constituents that are needed in low concentrations. Sodium and potassium are required in small amounts and calcium plays a critical role in determining the hardness and pH of the lake's water. The composition of the soils and bedrock in the surrounding watershed determine the amount of calcium that enters the lake via storm water runoff. Aquifers rich in limestone can also supply water bodies with calcium.

Understanding pH

pH is an expression of the amount of hydrogen ions (H+) in the water. A pH 7 (ex. distilled water) has equal amounts of hydrogen (H+) and hydronium (OH-) ions. As the amount of hydrogen ions increases, the pH reading is lower and the water is considered more acidic. Conversely, when the quantity of hydrogen ions decreases, the pH reading is higher and the water is more alkaline (see illustration below). A change in 1 on the pH scale represents a tenfold difference in the amount of hydrogen ions in the water. For instance, a lake with a pH 6 is ten times more acidic that a lake with a neutral pH 7.

acidic 1 2 3 4 5 6 7 8 9 10 11 12 13 14 alkaline

When moisture, carbon dioxide and sulphur mix in the atmosphere, acid rain is formed. On average, acid rain has a pH of 5.6. If a water body's pH drops to this level, it is lethal to many aquatic organisms and can inhibit spawning in some fish species. In addition, as water becomes more acidic, the availability of several toxic chemicals, including mercury increases. Mercury does not necessarily kill fish, instead it bio-accumulates and remains stored in their tissue and over time becomes increasingly concentrated. Humans and animals that consume mercury-laden fish regularly face serious health risks. The increase of mercury in acidic lakes has been cited as one of the causes for the decline in osprey and eagles.

Lakes vary in their ability to buffer acid rain. Lakes with limestone (calcium carbonate) and calcium bicarbonate in their watershed or bedrock have a greater ability to neutralize acid rain as these compounds raise the hardness and pH of the water.

Living Components

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Michelle Robinson

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Phytoplankton

Phytoplankton are free floating microscopic algae that are an important part of the food chain. They produce oxygen as a byproduct of photosynthesis and are a source of food for other organisms. They can also affect the taste, color, clarity and odor of the water.

Zooplankton

The second group of organisms, the zooplankton (from the Greek word "wanderer"), are free floating or weakly swimming microscopic animals at the mercy of the wind and waves. Zooplankton are important because they are a bridge between the base of the food chain and the higher trophic levels. Zooplankton are the primary consumers and graze heavily on the phytoplankton. In turn, the zooplankton population is controlled by fish and other animal predation.

Plants

The rooted plants that thrive along the edges and in the littoral zone are called macrophytes. These plants are divided into three main groups: submerged, floating-leaved and emergent. Native aquatic plants are important in the ecological balance of lakes because they provide oxygen, food, habitat, shelter and contribute to the diversity of the aquatic environment. In addition, their roots help to stabilize the shore and slow the flow of sediments and pollutants.

Macroinvertebrates

The macroinvertebrates are another source of food and they process energy in the ecosystem. Many of these animals are found in the benthic zone (or bottom layer) of the lake and their tunneling activity helps to release nutrients from the sediments. This group includes immature dragonflies, mayflies, beetles, snails, leeches crayfish and bivalves.

Bacteria

Bacteria are single celled organisms that break down and decompose matter with in a lake's ecosystem.

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Fish

Fish are cold-blooded animals and comprise 40% of all the vertebrate species on earth. The great variety of fish enhances the biodiversity of the aquatic system and they play a major role in the food chain. Fish are often categorized based on their water temperature requirements. Cold-water species, such as trout and salmon, prefer more pristine water conditions with gravel bottoms cool temperatures and high dissolved oxygen. As the trophic state of lakes shift (see next section), warm water fish, including bass and carp, are supported. These species are more tolerant of decreased clarity lower levels of dissolved oxygen, and can withstand warmer temperatures.

Reptiles and Amphibians

Other wildlife found in and near lakes and ponds include many species of amphibians and reptiles. Amphibians, such as frogs and toads, are dependent on water for at least one stage of their life cycle. In the spring they reproduce and lay eggs in the water. The eggs hatch into a larval stage (tadpoles) which develop adaptations for living on land as they mature. Reptiles are independent of water for reproduction and lack a larval stage. However, many reptiles including turtles and snakes, make their homes in and around lakes and ponds. Turtles often lay eggs in sandy beaches.

Birds

Most birds have developed adaptations for flight, but species, such as ducks, geese, cormorants and herons have adjusted to a mainly aquatic life. Massachusetts has a variety of waterfowl that thrive in the aquatic environment.

Mammals

Many mammals including otter and beaver live in lakes and ponds. These mammals hunt for fish and fresh water bivalves, retreat to the water for safety and create homes out of branches and mud.

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Lake Enrichment and Eutrophication

Gene McSweeney

Michelle Robinson

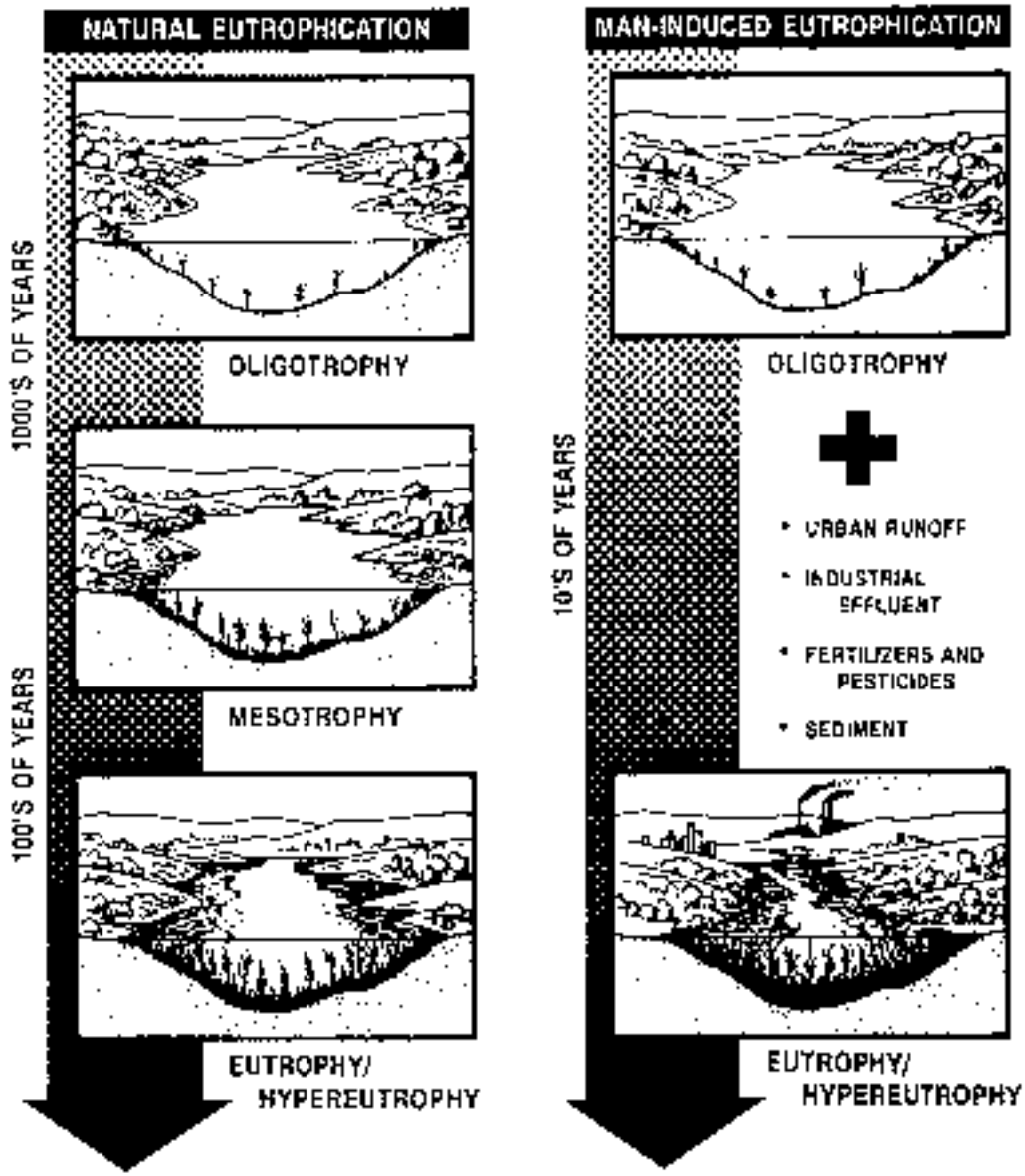
Natural Enrichment

"Lakes are destined to die" is a phrase commonly used by limnologists to describe the process of succession. Lakes are constantly changing as sediments and decomposing organisms slowly fill in the basin and changes occur in the succession of plant and animals. Lakes usually start out in an oligotrophic (nutrient poor) state and progress towards a eutrophic (nutrient rich) state. (see diagram next page) A classic example of an oligotrophic lake is Walden Pond in Massachusetts. These types of lakes tend to have clear water, deep barren basins and little aquatic plant growth.

As time progresses, silt from rivers and decaying organisms begin to fill in and enrich the lake. Plants start to take root, organisms that feed on algae and plants increase in number, and the lake becomes more biologically complex. Gradually, the succession of plant and animal communities shifts as the once clear lake moves toward an increasingly nutrient enriched, mesotrophic state. Most lakes in Massachusetts are considered to be mesotrophic or eutrophic. As nutrient levels continue to increase, the lake enters a hypereutrophic marsh like state. Lake depth, nutrient levels in the surrounding watershed, and erosion rates are all factors contributing to the successional process of a lake.

Cultural Eutrophication

A lake's successional process usually takes thousands of years, but human activity often accelerates the process. The process by which a lake receives unnaturally higher amounts of nutrients from human activity is called cultural eutrophication. Phosphorus from fertilizers, sediments from run-off, urban development, land clearing, recreation and septic waste all expedite the level of eutrophication. Chapter Three describes some of the issues that affect the level of eutrophication and how concerned citizens can adopt a proactive stance towards protecting their lakes.


NATURAL EUTROPHICATION
1000'S OF YEARS
OLIGOTROPHY
MESOTROPHY
100'S OF YEARS
EUTROPHY/
HYPEREUTROPHY
MAN-INDUCED EUTROPHICATION
10'S OF YEARS
OLIGOTROPHY
• URBAN RUNOFF
• INDUSTRIAL EFFLUENT
• FERTILIZERS AND PESTICIDES
• SEDIMENT
EUTROPHY/
HYPEREUTROPHY

Laws That Protect Your Lake

State Laws

This section summarizes some of the principal state laws that govern lake and shoreline activities in Massachusetts. The information is intended as a general guide only. If you plan to conduct any activities in or near the water you should contact your local conservation commission and Department of Environmental Protection (DEP) for information and permits.

Massachusetts Wetlands Protection Act

The Massachusetts Wetlands Protection Act (WPA), M.G.L. Chapter 131 Section 40, implemented by 310 CMR 10.00 regulates development activity near or affecting wetlands and floodplains in Massachusetts. The WPA exists to promote the following interests:

- protection of public and private water supply
- protection of groundwater supply
- flood control
- storm damage prevention
- prevention of pollution
- protection of land containing shellfish
- protection of fisheries
- protection of wildlife habitat

In general, the WPA reviews and regulates work that may alter a Wetland Resource Area.

These areas include a variety of lands that are affected in some way by water resources such as bordering vegetated wetlands, swamps, marshes, meadows and bogs, banks and dunes. To be protected under the WPA, these resource areas must be land under water or bordering a water body (lake, pond, river, stream, creek, estuary or the ocean). Activities proposed within one hundred (100) feet of a resource area are also subject to regulation as work within the Buffer Zone.

The WPA's definition of "alter" is broad enough to potentially trigger the regulation of all lake/pond restoration and maintenance projects. Most development impacts are considered an alteration, including changes in drainage, salinity, sedimentation, water flow, flood retention, water levels, water temperature or other characteristics of the receiving water. Applications (called Notices of Intent or NOI) for permits (called "orders of conditions" or OOC) under the WPA must be submitted to the local conservation commission for review. The NOI provides a complete description of the site and the proposed work.

Chapter 91

Chapter 91 of the Massachusetts General Laws is the chief vehicle for regulating development activities in and around great ponds, rivers and the ocean. Chapter 91 is based on the public trust doctrine, by which the Commonwealth holds these water bodies in trust for the benefit of the public. Section 9.2 defines Great Ponds as waterbodies that are over 10 acres in their natural state, as calculated based on the surface area of lands lying below the natural high water mark. This includes water bodies that have been artificially enhanced by dams or other methods. The title to such lands is held by the Commonwealth, in trust to the public, subject to any rights which the applicant demonstrates have been granted by the Commonwealth. Department of Environmental Protection shall assume that any pond presently larger then ten acres is a Great Pond unless the applicant presents topographic, historic or other information demonstrating that the original size of the pond was less than ten acres, prior to any alteration by damming or other human activity.

Phosphate Bill

Massachusetts has taken action and recently passed the Massachusetts Phosphate Bill (GML Chapter 111 Sec. 5R) The law prohibits the sale of any household cleaning products with a concentration of greater than 0.5% by weight.

Laws that Protect Your Lake, cont...

Massachusetts Clean Water Act

The Massachusetts Clean Water Act (CWA) governs the control of water pollution in the Commonwealth. The goal of the CWA is to maintain and restore water quality by (1) eliminating the discharge of pollutants into water bodies and, (2) when elimination is not feasible, by making and keeping discharges clean enough to protect fish, wildlife, and human recreation.

The CWA is administered by DEP, which is given broad regulatory and enforcement authority for protecting groundwater and surface waters from pollution discharges. The CWA defines "pollutant" as "any element or property of sewage, agricultural, industrial or commercial waste, runoff leachate, heated effluent or other matter, in whatever form…"

A federal permit and "Water Quality Certification", issued by the DEP, may be required for discharges from both point sources (effluent pipes, drainage, ditches, etc.) and non-point sources (diffuse sources: road runoff, agricultural runoff, landfills, etc.). You should assume that a discharge permit will be needed for any activity that may result in the discharge of storm water, sewage, or other waterbourne wastes.

For more information on permits for pollution discharges into surface waters and groundwater, contact your DEP regional office.

Stormwater Regulations

Massachusetts has made efforts to reduce the impact of storm water on our lakes and ponds. In 1992, the National Pollution Discharge Elimination System (NPDES) Phase I program was developed to regulate storm water in medium to large cities, and industries and in construction sites larger than 5 acres.

In 1997 the Storm Water Management Policy set standards for any construction activities that could have an impact on rivers, lakes, wetlands and coastal waters. The 1999 NPDES Phase II Storm Water Regulations Program was implemented to target smaller communities, small sewer systems (MS4's) and construction sites under five acres.

Boating and Fishing Regulations

Boating, fishing and other activities are regulated by the Environmental Police, who enforce boating and fishing laws. For guidelines on boating safety, boating laws and fishing regulations contact the Office of Law Enforcement Environmental Police.

Michelle Robinson

Chapter 3

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Lake Issues and Management

Storm Water Issues

One of the greatest threats to the quality of water in our lakes and ponds and the health of the aquatic environment is storm water pollution. When it rains or snows, the water rushes over highways, parking lots, streets and lawns and collects nutrients, oils, toxins, sediments and other pollutants. This untreated water flows into storm drains and frequently empties into our lakes or ponds. Storm water poses a greater threat to water quality in urban and agricultural areas than in undeveloped lands. In forested areas, the earth absorbs most of the storm water and the soil and vegetation filters out pollutants. In developed areas there is a larger percentage of impervious surfaces, including pavement, roofs, and asphalt, which prevent water from soaking into the ground. As a watershed becomes increasingly developed the percent of land that is covered by impervious surfaces increases and more storm water runs off into receiving water bodies.

Storm water is an example of nonpoint source pollution because the pollution comes from a very broad area rather than a single identifiable source such as a pipe. Nonpoint source pollution is harder to control because it results from many activities that occur in our watersheds, including development, fertilizing, and other human activities. In addition, rain absorbs pollutants from the atmosphere and deposits them on the ground or in water bodies.

EPA

Point Source Pollution vs. Non-point Source Pollution


Nancy Rose

Contaminants in Storm Water:

Storm water can carry a variety of contaminants that may degrade the receiving waterbody including: nutrients, sediments, bacteria, metals, toxic substances, trash, and warmer water with low dissolved oxygen.

Nutrients: Excess levels of phosphorus and nitrogen are introduced to water bodies from a variety of sources including; failing septic systems, sewer overflow, urban storm water runoff (carrying detergents, fertilizers, organic debris) and atmospheric deposition from industry and automobiles. Phosphorus is relatively rare in lakes and ponds and therefore, the level of available phosphorus frequently controls the amount of plant growth. When additional large amounts of phosphorus are introduced to a water body, algal blooms may result. The decomposition of algae utilizes the available oxygen, and fish often perish as the oxygen level drops. In addition, many toxins and pollutants are released from the sediments and become more water soluble under low oxygen (anoxic) conditions. Additionally excess nutrients accelerate the rate of eutrophication.

Sediments from a variety of sources are carried via stormwater runoff into water bodies. Although a lot of sediment can come from construction and agriculture, there are also many urban activities including winter road sanding, landscaping, loss of vegetation (which leads to erosion) and the development of new drainage pathways, which can be a source of sediments. Increasing the load of sediments into a lake or pond has many harmful effects. The sediments slowly fill in the lake basin, causing the lake to become increasingly shallow and less capable of retaining and storing floodwaters.

Sediments can trap solar radiation, which increases water temperature while simultaneously decreasing the water clarity. The breakdown of organic particles in the sediments can also deplete the available oxygen in a lake. This negatively impacts cold water fish that are dependent on cool, clear, oxygenated waters. Suspended sediment particles reduce light transmission, which may negatively impact the plant growth that bass and other fish require for shelter.

Bacteria and Pathogens: Many disease causing organisms can be carried via stormwater runoff into lakes and ponds when they are released from failing septic systems, agriculture waste, animal waste from pets or wildlife, and wastewater treatment plants. Although most bacteria are beneficial, some strains of bacteria can cause disease, alter the color, taste and odor of the water or force swim beach closures.

Metals pose a serious risk to our lakes and ponds, as they can be highly toxic to aquatic animals. Metals from industry and commercial waste materials, atmospheric deposition, mining and automobile emissions all contribute metals to water bodies. Some metals found in storm water include copper, zinc, lead, chromium, and cadmium. Metals can accumulate in animal's tissue and increase over time (bioaccumulation) leading to impaired reproduction, growth and development or even death. Humans who consume fish with an accumulated level of mercury or other toxic metals are also at great risk. Mercury is toxic to humans, causing hearing and vision loss, kidney failure and even death.

Oils and Grease from vehicles build up over time on the surface of the roads. During a rainstorm, water washes these toxins off the road and carries them to nearby storm drains where they are transported to nearby water bodies.

Pesticides, Organic Compounds, and Salts: Oil leaks, pesticides, road salts and other toxic compounds are often spilled or incorrectly disposed off, and then are carried via storm water runoff to lakes and ponds. These compounds can reduce oxygen levels in a lake and are often lethal to juvenile fish or sensitive organisms. Many of these chemicals contaminate groundwater and other drinking water supplies.

Litter: Plastics, organic litter, and toxic debris often degrade lakes and ponds when they are carried by storm water into the water body. Not only does the aesthetic appeal of the lake decline as trash accumulates, but animals can become entangled in the debris and the breakdown of certain products release toxins into the water column.

Warm Water/ Low Dissolved Oxygen: Stormwater is often heated as it flows over surfaces that have been warmed by the sun, and consequently may increase the water temperature of the receiving lakes and ponds. Warmer water holds less oxygen and can raise the lake's temperature to the point that cold water species, including trout and salmon, become stressed and die. In addition, elevated temperatures often accelerate the breakdown of toxic substances and the release of contaminants from the soil.

Invasive Species

What is an Invasive Species?


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Many plants that are found in Massachusetts were originally brought here from other places around the world and these plants are called non-native or exotic. Although many non-native species such as Purple Loosestrife (right photograph) are beautiful, they can be extremely destructive to the environment because they disrupt the delicate balance of the ecosystem. Some exotic species are harmless, but others can have a very detrimental impact on the environment by out-competing native species and taking over the water body. Once a species, native or non-native, dominates or disrupts the biological community it is considered invasive.

How did exotic species arrive here?

Exotic, or non-native species have been introduced to Massachusetts in a variety of ways including unintentional introduction in ship ballast water and accidental release through the aquarium or water garden trade. Others were deliberately imported and planted as colorful additions to gardens and ponds.

Why are they harmful?


© Bill Byrne

Since exotic species originated in other regions, most have not evolved natural predators in this region to keep their populations in control. In recent years, exotic invasive species have been spreading throughout Massachusetts' lakes at an alarming rate. Exotic invasive species out-compete other species for space, light and nutrients. Since these plants often do not provide ideal sources of food and shelter, as native plants die, many of the animals that were dependent on native plants must attempt to relocate or perish. In essence, exotic invasive species often create single species stands, thus reducing biodiversity (left photo).

Once established in a lake they are almost impossible to eradicate and managing them is very costly. Invasive species can impede recreational activities and, in cases when dense mats have formed, boat navigation is no longer possible (see top photograph). In addition, infestations of invasive species can lower property values, decrease aesthetic values, restrict movement of vertebrates, stunt fish growth, displace wildlife and in some cases damage docks, dive gear and boat motors.


Michelle Robinson

What is being done to control invasive species?

The best method for controlling exotic invasive plants is to prevent them from becoming established in a water body. The Department of Conservation and Recreation's Lakes and Ponds Program offers aquatic plant training to citizens through the Weed Watcher Program, in an effort to promote early detection and rapid response. Additionally, the Lakes and Ponds Program provides informative brochures, places signs at public access points, and posts boat ramp monitors at state boat ramps. Massachusetts is an active member of the Aquatic Nuisance Species (ANS) regional task force, which is a federally funded program working to develop tighter regulations on the sale and transportation of exotic plants and to promote education.

The Most *Un*-Wanted Aquatic Exotic Species

Fanwort
Cabomba caroliniana

Eurasian Milfoil
Myriophyllum spicatum

Variable Milfoil
Myriophyllum heterophyllum

Hydrilla
Hydrilla verticillata

South American Waterweed
Egeria densa

Curly-leaved Pondweed
Potamogeton crispus

Water Chestnut
Trapa natans

Common Reed
Phragmites australis

Purple Loosestrife
Lythrum salicaria

Potential Threats

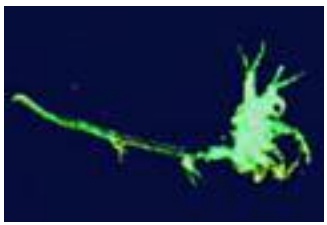
There are several exotic species including the Asian Clam, Zebra Mussel, Spiny-tailed Water Flea, Parrot Feather and Flowering Rush that have not yet invaded Massachusetts. The Zebra Mussel can be found in neighboring states and threatens to enter our state in the near future. It is important to learn to recognize these species and always remember to inspect your boat motor, trailer, bait buckets and gear to prevent their spread to Massachusetts' water bodies.

If you find any of these species, please report the sighting to:

Massachusetts Department of Conservation and Recreation
Michelle Robinson 617-626-1382
Jim Straub 617-626-1411

© Noel M. Burkhead USGS

Asian Clam



J. Lindgren

Spiny Water Flea

© Charles Ramcharan

Zebra Mussel

Vic Ramey UFL

Parrot Feather

Lad Johnson NOAA

You Can Make a Difference!

Boaters:

- Remove all plant fragments and animals from your boat motor, trailer, anchors, fishing gear and dive gear. Dispose of plant matter on dry land away from shore or in a trash can.
- Dispose of live well, bait and cooling water away from the shore after each use.
- If you are leaving a water body known to be infested, wash your boat with hot water and allow it to completely dry before entering another body of water.
- Never release a species into a body of water unless it came out of that body of water.

Everyone:

- Help spread the word and inform other boaters about exotic invasive species.
- Never dump aquariums or water garden contents in to a water body.
- Join the Massachusetts Weed Watchers program and help identify and eradicate new infestations in your lake before they become permanently established.
- Request a free "Stop the Spread of Invasive Species" sign for your boat ramp from the Department of Conservation and Recreation.
- Familiarize yourself with the exotic species by requesting a free color guide from the Department of Conservation and Recreation.

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Alison Fox

Algae

Algae are microscopic plants that grow naturally in lakes and ponds but are able to adapt to a wide range of conditions and are found in oceans, rivers, ponds, deserts and hot springs. Algae are photosynthetic yet lack vascular tissue such as roots and leaves and are considered to be evolutionarily less advanced than higher plants, such as macrophytes. Algae are the primary producers in the aquatic environment and provide food and energy for other animals. In addition, during photosynthesis, algae release oxygen into the water body.

Michelle Robinson

Although algae are an important part of the lake ecosystem, a rapid growth of their population can create a condition called an algal bloom. Algal blooms can form scum or dense mats on the water's surface and may also affect water color, odor and taste. During an algal bloom the excess algae die, and the decomposition process consumes oxygen. This may result in an anoxic condition, which is harmful or fatal to some aquatic animals.

Diatoms and blue-green algae cause the most common algal blooms. Diatoms affect the water color, turning it bright green or brown, but rarely create an offensive odor or scum and may even occur unnoticed. On the other hand, blue-green algal blooms are rarely undetected. The wind can concentrate blue-green algae (cyanobacteria) into dense, unsightly surface mats, or surface scum, which may wash up on shore and produce a noxious odor as it decays.

Some species of blue-green algae, such as *Anabaena aphanizomenoides*, produce toxins that may be harmful to pets and small children if consumed in quantity. Although there are a variety of causes of algal blooms, the primary cause is the introduction of excess nutrients, such as phosphorus from fertilizers and detergents, into a water body. Unlike rooted macrophytes that draw their nutrients from the sediment, algae obtain essential nutrients directly from the water column. Storm water runoff, loaded with nutrients generated from a variety human activities, flows over the land or though a storm drain system into a water body. Excess nutrients entering the aquatic system allow algae populations to explode.

If your lake experiences algal blooms, it is important to complete a watershed assessment to evaluate land use, soil types, erosion, point sources (such as leaking septic systems) and other possible causes of nutrient loading. The lake's nutrient chemistry, fish population, dissolved oxygen and flow all should be examined as these various factors can also effect the algal population in your lake.

Although an introduction of excess nutrients to the waterbody is usually the culprit, it is not the sole cause of algal blooms. The size of the algal population is also controlled by microscopic herbivores, called zooplankton, which graze heavily on algae and keep the algal population under control. Zooplankton are in turn eaten by small fish, so an increase of small fish in the lake can result in an algal bloom

There are many management options for controlling algae, but there is no "quick fix" solution except to reduce the level of nutrients in the watershed.

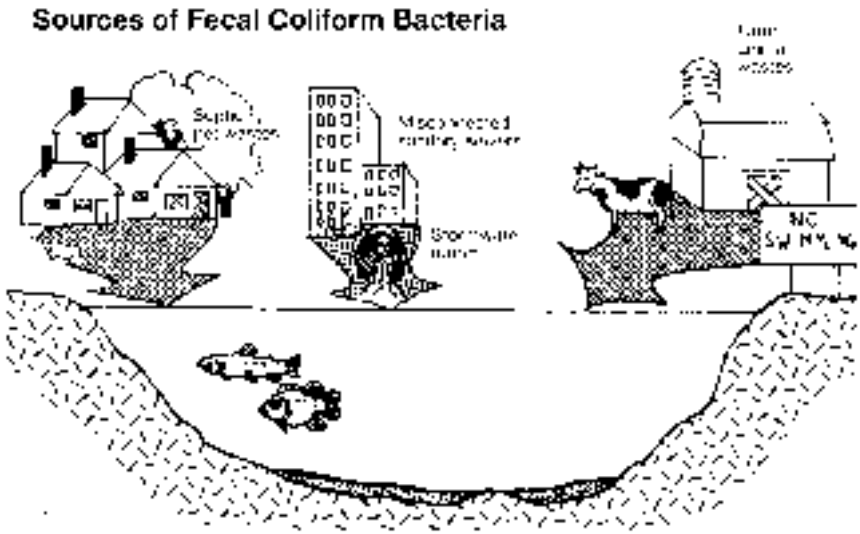
Bacteria

Bacteria are single-cell organisms that live in our environment. Although many are harmless, others are capable of causing serious health problems for humans. The majority of beach closings in Massachusetts are a result of high levels of the type microorganisms that are found in sewage. The state of Massachusetts routinely monitors public swimming areas during the summer, and weekly water tests are performed, to ensure that the water conforms to the standards set by the Department of Public Health. If the test fails, then the swim beach is closed until a second test can be completed and passes.

There are different types of bacteria that contribute to the total fecal coliform count; however, testing water samples for each and every type of disease-causing bacteria is very costly. Samples are only tested for the presence of *E. coli*, a generally harmless type of bacteria that lives in the intestines of all warm-blooded animals including humans, beaver, geese and dogs. Since *E. coli* occurs in high numbers in human sewage it is used as an indicator organism. Large amounts of *E. coli* indicate a **possible** source of contamination from sewage, thus indicating that other disease-causing bacteria could potentially be present in the water.

There are many possible sources of fecal coliform, including failing septic systems, waterfowl, farm animaland pet waste, polluted storm water runoff and wildlife (see illustration). Septic systems near water bodies can fail and release raw sewage into the lake or pond. Run off from agriculture can also contribute bacteria to the lake. Storm drains may be overloaded after heavy rainfall and overflow, discharging polluted storm water into nearby lakes and ponds.

It is very hard to predict the levels of fecal coliform in the water at any given time because levels fluctuate after rainstorms or periods of direct sunlight. However, if a lake continuously has high *E. coli* counts, other tests are available to examine the genetic material (RNA) of the bacteria to determine exactly which species of animal is responsible for adding the bacteria to the water. By knowing whether to focus on inspecting septic systems, improving storm drains, reducing waterfowl, or addressing agricultural runoff, lake managers are better able to control the bacteria loading to a lake.



Common Lake Issues

Murky Colored Water

During the summer, lake water may turn murky and have an unpleasant odor. The scum looks like blue-green paint and often drifts to the windward shore. This may be an algal bloom. Algae are microscopic plants that are natural components of lakes. Algal blooms are often the result of excess phosphorus (often from lawn fertilizers or other sources) entering a water body.

Yellow Green Dust

During the early summer months a yellow dusting may appear on your lake or pond. This dust is likely pollen from nearby pine trees. Over time the pollen will become water logged and sink to the lake bottom.

Dark Oily Cloud

The dark oily cloud may be insect cases left behind from a hatch of aquatic insects. The wind can concentrate the cases along the shore, and as they decompose, an oily sheen forms.

Vermont DEC

Dead Fish

An occasional dead fish is not cause for alarm. Sometimes anglers release an injured fish or the mid-summer stress due to warm water and disease may be the culprit. If you notice numerous dead fish, especially of more than one species, please contact the Department of Fisheries and Wildlife.

Foam (suds) on the shore

Foam on the shore is often natural and occurs when the surface tension of water is reduced and air mixes with the water, creating bubbles. This natural foam will have an earthy or fishy aroma. Many natural organic compounds are capable of reducing the surface tension of water.

Green Cotton-like Clouds

Green clouds floating in shallow water may be filamentous algae and their presence does not necessarily indicate a water quality problem. The clouds often occur after heavy runoff in the spring or a heat wave in the summer. However, if the algae are found only in specific areas, it may indicate a source of local pollution such as a failing septic system or a contaminated stream.

Red Itchy Rash on Swimmers

This rash may be Swimmer's Itch, which is caused by a larval stage of a parasitic fluke, *Schistome*. When a larva encounters a swimmer it will penetrate the swimmer's skin. The body's reaction to the presence of the larva results in red spots and swelling, similar to a mosquito bite. To avoid Swimmer's Itch towel off briskly after a swim, or try swimming in a different area of the lake.

Leeches

These are flat worm-like animals that attach to exposed skin and draw blood. Leeches are found in shallow protected waters and are most active on hot summer days and at night. Leeches are drawn to the disturbances in the water near docks and swim beaches. To avoid leeches, swim in deeper waters off docks and floats. Leeches are mostly found in organic sediments or debris, so try to avoid these areas if leeches are known to be in the pond.

Best Management Practices

What are Best Management Practices (BMP'S)?

There are many actions that will help reduce the harmful effects of polluted stormwater. BMP's, or best management practices, have been developed for town planners to enable them to make wise choices for the town's future. BMP's are either non-structural, (education, build-out assessments), or structural (installing new systems, creating wet ponds). A few have been listed below. For a complete list contact The Department of Environmental Protection or NALMS (pg 45).

Non-Structural Best Management Practices

• ***Zoning and Land Use Planning:*** By studying a town's current demographics, economics, existing natural resources, current land uses and forecasted growth, planners are able to create zoning plans and land use controls that will ensure protection of water resources and critical areas. These projects, called build out assessments, include simple steps such as determining minimum lot sizes, creating development plans with the least fragmentation, and determining best land use. These plans will help to insure a healthy future for the town and its fragile resources.

• ***Education*** is a critical component in any watershed management or town plan, and can be geared towards both municipalities and citizens alike. Training programs offered by the town or others help to introduce employers to stormwater management issues and new design technologies. Development of interactive community programs, including: storm drain stenciling, rain gardens, hazardous waste recycling days, responsible pet clean-up, water conservation education, holding lake-friendly home design workshops and promoting phosphorus-free fertilizer rebates help to encourage citizen involvement and increase public education.

• ***Routine Storm Drain Maintenance/ Mapping:*** Routine street sweeping and catch basin cleaning prevents an overflow of sediments and other contaminants into water bodies. It is also important to have current GIS mapping and ground-truthing of storm drain locations for each town.

• ***Source Reduction:*** There are many bylaws that towns can adopt to reduce the volume of stormwater contaminants, including; reducing road sanding and salting, banning fertilizers that are high in phosphorus, encouraging recycling of hazardous materials and reducing litter.

• ***Maintain Riparian Areas and Buffer Strips:*** Riparian areas and buffer strips are complex ecosystems established along drainage areas that function to slow/reduce storm water velocity, trap suspended sediments, filter out contaminants, absorb nutrients and reduce erosion.

• ***Site Planning:*** Unlike watershed planning, site planning is a small-scale approach. The soils, potential land uses, location in the watershed, topography and impacts of the proposed activities are all evaluated as part of the planning or subdivision process. There are several BMP's that can be followed when designing a home, and during construction, that can reduce the negative impacts of stormwater. These may include minimizing the driveway surface area and increasing areas of natural vegetation.

• ***Preventative Construction Techniques:*** Protecting exposed soils with tarps and hay bales, careful storage and removal of chemicals or other waste, installing washing areas, protecting storm drains and utilizing secure sanitary facilities will help to prevent stormwater contamination during construction.

Michelle Robinson

Structural Best Management Practices

Structural Best Management Practices include pre-treating the stormwater with a variety of new technologies, filtering, storing and moving stormwater, preventing erosion and upgrading existing systems.

• ***Pre-treatment of Stormwater:*** There are many new designs that towns can implement to improve the quality of stormwater before it reaches its destination. Some of these include using porous pavement, which allows a greater percentage of water to infiltrate into the soil, thus reducing the volume of runoff and recharging groundwater. Implementing new storm drain designs, including porous French Drains and Infiltration Basins, which allow water to slowly filter out into surrounding soils. Dry wells collect runoff primarily from rooftops and direct it into infiltration pipes where it can seep into the surrounding soils rather than rush into storm drains.

• ***Filtration of Stormwater:*** Sand filters, which allow stormwater to pass through layers of sand that filter out metals, bacteria, sediments and other contaminants, can be added to most storm drain systems to improve the quality of the stormwater.

• ***Transport of Stormwater:*** Vegetated swales can be constructed along roadsides to collect and filter street runoff.

• ***Settling of Stormwater:*** Wet ponds are capable of retaining storm water and later releasing it at a controlled rate, while constructed wetlands detain and treat stormwater before it is released. Both of these reduce the velocity of stormwater, allow it to be filtered first and then released slowly.

• ***Erosion Control:*** Vegetated buffers provide natural protection to sensitive areas by slowing approaching runoff and filtering contaminants. By slowing the velocity of runoff, erosion is decreased and infiltration increased.

• ***Installing New Technological Systems:*** Many companies have created systems to treat stormwater by filtering out grease, sediments and other contaminants. Some of the many available systems include: StormTreat, AquaShield, StormFilter, and Vortechs.

In-lake Management Techniques

General guidance on solving several common in-lake problems and some advantages and disadvantages of each are listed below. Because each lake or pond is unique, before implementing any method, an initial study should be performed to identify the cause of the problems noted. Most techniques require permits and need to be implemented by a professional. For detailed information on management techniques, refer to the Massachusetts Generic Environmental Impact Report (GEIR) and the accompanying Practical Guide to Lake and Pond Management in Massachusetts.

Method	Advantages	Disadvantages
Aluminate sulfate (alum treatment)	Lowers phosphorus levels. Blocks the release of phosphorus from sediments. Increases water clarity.	May result in an increase in plant growth due to improved water clarity.
Artificial Circulation	May prevent/disrupt stratification. Increases the levels of oxygen in the water and extends aerobic zone.	May increase turbidity. Will not affect plant/algae growth. May have negative impacts on cold water fish species.
Bio-manipulation (altering the fish community in the lake)	Usually increases the number of zooplankton that eat algae.	Hard to accomplish; may not be effective if other sources of nutrients are present.
Dilution (flush the lake)	Removes algae on the surface. Lowers the levels of nutrients.	Requires a large amount of water. Will not affect the inputs of phosphorus to the water body.
Dredging	Deepens the lake by removing the accumulated sediments and increasing the water volume. Improves clarity. Removes aquatic plant matter. Reduces littoral zone.	Temporarily disturbs the habitat and increases turbidity. Expensive. May release toxins from sediment.
Hypolimnetic Aeration	Adds oxygen to deep waters. Limits the release of phosphorus from sediments.	May cause destratification. Will not control macrophytes. May cause algal blooms.
Water Drawdown	A control technique for macrophytes. Allows for dock repair/maintenance.	Negative impact on fish and other organisms. Not ideal for some climates. May have negative impact on out flowing streams due to reduced water flow.

Aquatic Plant Management Techniques

Method	Advantages	Disadvantages
Manual Methods (hand pulling, cutting)	Inexpensive and non-toxic. Affects only the target plant species. Does not harm beneficial plants.	Not practical for very large areas. Need divers for deeper waters. Labor intensive. Stirs up sediment.
Benthic Barriers (bottom covers)	Restricts upward plant growth. Limits light to lake bottom. Good for small areas near docks or beaches without affecting the rest of the water body. Non-toxic.	Harmful to benthic community. Accumulated sediments must be removed. Need to inspect often. May be damaged by anchors. Must anchor barrier securely as gasesfrom decomposition may cause the barrier to float up.
Mechanical Cutting (clipping plants below the water surface)	Inexpensive. Immediate results. Targets one area of the water body. Fairly species specific. Non-toxic.	May produce plant fragments which can regrow. Roots may regrow. Must do several cuts each season. Not species specific.
Mechanical Harvesting	Removes plants from the area. Requires no herbicides.	Labor intensive and expensive. Does not target specific plants. Plant fragments may regrow. Can only cut up to 5' below surface.
Hydro-raking	Removes plants and roots.	Disturbs sediments which negatively impacts bottom dwellers, increases turbidity, and may release nutrients and toxins from sediments. Causes fragments which may regrow.
Biocontrols (weevils etc.)	Species specific and non-toxic. Potential for long-term control.	Will not remove all the plants. Expensive. Slow response.
Herbicides	Very effective and ideal for large areas. May be used to spot treat specific plants.	May harm beneficial plants. Decomposing plant matter may release nutrients and decrease oxygen levels in the water. Recreational activities may be temporarily restricted.
Drawdowns	Non-toxic and works on many plants.	May be an inconvenience for dock owners. Not species specific and may affect other organisms. Weather conditions may alter effectiveness/ feasibility. May affect out-flowing streams.

Chapter 4

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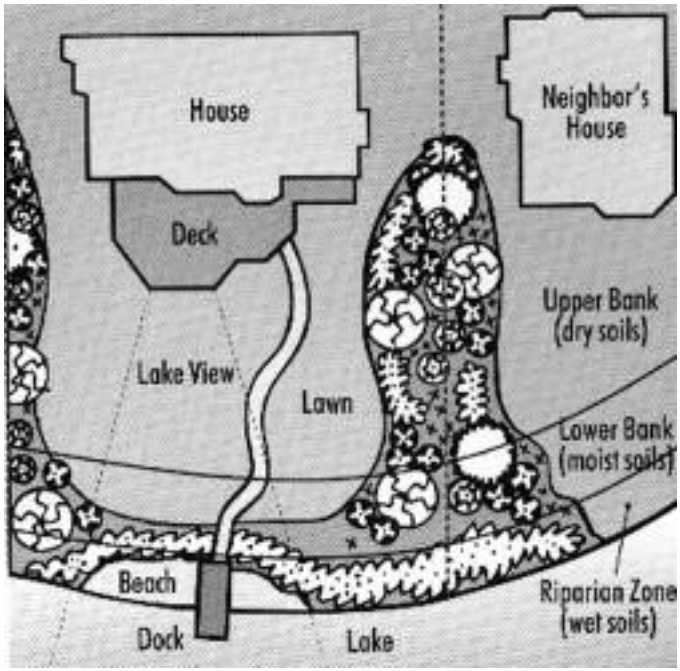
Actions *You* Can Take to Protect Your Lake

Ecological Landscaping



If you reside on lakefront property, use environmentally friendly landscaping techniques to prevent sedimentation and pollution.

- If possible, build homes where the land has the gentlest slope.
- Leave as much vegetation on slopes as possible to reduce the velocity of storm water runoff and to filter out sediments.
- Create the largest possible buffer along the shoreline (a minimum of 30' is recommended) by leaving existing vegetation and rocks and planting small shrubs. This buffer will reduce the effects of storm water runoff and erosion from waves and deter geese from the lawn, while still providing a view of the lake.
- Develop a winding dirt path to your shore or dock. The reduced slope of a winding dirt path generates less erosion and runoff than a steep paved path.
- Do not add sand to your beach area; introduced sand is a major source of sediments and phosphorus.
- If you plan to do construction in an area where the soil will be left unprotected, use hay bales and fabric fences to hold the soil in place, and mulch disturbed areas just prior to the final grading.
- Improve your driveway so that storm water is diverted through u-shaped gravel or vegetated ditches that are designed to filter sediments and nutrients.
- Work with your town to improve drainage from town roads and parking lots.
- Direct runoff towards wooded areas so sediments, toxins and nutrients can be filtered out.
- Work towards a goal of zero runoff from your property.

Select Native Plants

Native plants are ideal for landscaping lakeshore homes, and are often more disease resistant and hardier than their exotic counterparts, thus require less pesticide and fertilizer. Many native plants are a good source of food for wildlife and will enhance bird watching. Refer to the comprehensive Massachusetts Buffer Manual for directions on creating ideal buffers, and for information on landscaping with native plants contact the New England Wildflower Society (see page 47).

Exotic Species	Native Alternatives
Aquarium Plants	***Aquatic Plants***
Fanwort (*Cabomba caroliniana*)	Water Buttercup (*Ranunculus*)
Eurasian Milfoil (*Myriophyllum spicatum*)	Water Marigold (*Megalodonta*)
Variable Milfoil (*Myriophyllum heterophyllum*)	Coontail (*Ceratophyllum*)
S. American Waterweed (*Egeria densa*)	Common Waterweed (*Elodea*)
Hydrilla (*Hydrilla verticillata*)	
Water Garden Plants	***Wetland Plants***
Purple Loosestrife (*Lythrum salicaria*)	White Water Lily (*Nymphaea odorata*)
Curly-leaved Pondweed (*Potamogeton crispus*)	Pickerelweed (*Pontederia cordata*)
Parrot Feather (*Myriophyllum aquaticum*)	Swamp Loosestrife (*Decodon verticillatus*)
Water Hyacinth (*Eichhorina crassipes*)	Swampweed (*Polygonum*)
Frog's Bit (*Limnobium spongia*)	Cattail (*Typha*)
Yellow Floating Heart (*Nymphoides peltata*)	Arrowhead (*Sagittaria*)
Yellow Iris (*Iris pseudacorus*)	Blue Flag (*Iris virginica*)

Caution!

- Many species, native or non-native, can become invasive when they are released into a water body. Never dispose of aquarium or water garden plants or animals into a water body.
- Unwanted aquatic plants should be disposed of in the trash and unwanted aquarium water emptied down the toilet. Anglers should not release live bait fish or bait bucket water into a lake or pond.
- Use caution when selecting plants because suppliers often advertise species incorrectly or by alternate names. For example, Variable Milfoil is often sold as Foxtail and South American Waterweed is frequently displayed under the names *Anacharis* or *Elodea*. Bring a guide with you to the store for accurate identification. (A Guide to Selected Non-native Aquatic Species in Massachusetts is available free of charge through DCR. See Page 46)
- Thoroughly inspect each new addition to your aquarium or water garden. Exotic species such as Hydrilla frequently hitch rides on innocuous native plants.
- For information on where to return unwanted aquarium animals contact the Costal Zone Management Office. Some pet stores will allow you to return your pet. You can donate your pet to a public place (school, nature museum, nursing home etc.) or give your pet to a friend, family or neighbor. For CZM contact information see page 45.

Reduce Phosphorus

Reduce the level of phosphorus that is released into the watershed and/or lake. Massachusetts has taken action and recently passed the Massachusetts Phosphate Bill (GML Chapter 111 Sec. 5R). The law prohibits the sale of any household cleaning products with a concentration of greater than 0.5% by weight. However, there are additional actions you can take to reduce phosphorus:

- Perform a lawn test in the spring to determine if fertilizer is needed, before applying. For information visit: www.umass.edu/plsoils/soi
- Do not fertilize prior to or just after any precipitation because storm water runoff may carry the phosphorus to nearby water bodies, and like your lawn, it fuels plant growth.
- Select plants that require little fertilization and spot treat with liquid fertilizer only as needed.
- Use products that are organic, have no phosphates or have only slow release phosphorous. To determine the phosphorus content in the fertilizer, read the middle number in the formula on the package. For example: **16 4 8**. Four is the phosphorus content.

Maintain Your Septic Tank

- Conserve water and reduce the burden on your septic system by fixing leaking faucets.
- Choose commercial drain cleaners carefully as many may be harmful to the groundwater and to your leach field.
- Monitor the levels of sludge in the septic system and have the tank cleaned when it reaches half full. When septic systems are not pumped routinely, the leach field may become clogged.
- Bleach, drain cleaners, chemicals, and paints harm beneficial microorganisms in the septic system. Paper towels, cigarettes and garbage disposal debris should never be flushed as these products can overload the septic system.

Reduce Hazardous Materials

Consumer products such as paints, paint thinners, solvents, batteries, and household cleaning products are hazardous materials and need to be disposed of properly. Many of these products may be a health hazard once released into the environment, and may remain there for many years.

- Seek alternatives to hazardous cleaning products and reduce the use of heavy metals.
- Store hazardous materials in approved containers, in a safe location, and check for leaks.
- Never dispose of oil or gasoline on your driveway or street. Many gas stations recycle batteries and oil. Used motor oil is the major source of oil pollution in the aquatic system.
- Dispose of solvents and paint thinners responsibly because these products are toxic to the environment and are not biodegradable. Watch for a Hazardous Waste Disposal Day or encourage your town to hold one. Return materials to a Department of Environmental Protection facility (see page 46).
- Mercury is very toxic and exposure can cause hearing, memory or vision loss, paralysis, psychological effects, kidney problems and at high doses, death. Mercury can cause congenital malformations and pregnant women can pass mercury along to their child after eating contaminated fish. If you own a mercury thermometer, learn about disposal and trade-in options. (see contacts on back inside cover)

Reduce the Use of Pesticides

Although environmentally persistent pesticides of the past, such as DDT have been banned, there are still over 700 EPA registered pesticides available for use nationwide. Many are approved for use in Massachusetts, although only six active ingredients are approved for use in MA water bodies. If these, or any chemical, is improperly handled or used, there is the potential to damage non-target organisms.

To protect peoples' health and our environmental resources, the state requires the testing and registration of all pesticides and the licensing of all pesticide applicators. For lake and pond use, each application of a herbicide must be approved by a conservation commission.

There are a variety of pesticides on the market today including; rodenticides, fungicides, herbicides, insecticides and disinfectants, and although many of these products serve beneficial purposes, they can inadvertently end up in our environment. Most of these chemicals are associated with agriculture and industry.

According to the National Wildlife Federation, "research indicates that virtually all surface waters in the country contain detectable levels of one or more pesticides." In certain cases the impacts of a pesticide are very apparent, however, there are indirect impacts that may occur undetected.

For instance, some copper-based algaecides or fungicides can block the olfactory system in certain species of salmon, reducing their ability to avoid predation, migrate, and time their spawning, thus ultimately impacting the population. Pesticides often impact non-target organisms including beneficial insects (bees, spiders etc) that are invaluable pollinators or natural pest controllers.

Despite some negative impacts associated with some pesticides, there may be no feasible alternative to their use, particularly in the case of non-native species. To minimize harm to the environment follow the guidelines below.

If you must use pesticides

- Select and use the products for the specific purpose they are intended; use the minimum dose; and be sure to store or dispose of remaining product appropriately.
- Try to identify the pest and use only a product specifically designed for that species.
- Refrain from using pesticides prior to, during or shortly after a storm.
- Do not discard left over pesticides down drains or on the ground; empty containers are often still an environmental hazard. Visit your nearest DEP facility to return containers.
- Rake as little as possible because leaf litter will help to soak up excess chemicals

Alternatives to Pesticides

Reducing the use of household and yard chemicals can help prevent them from entering into our lakes and ponds.

- Marigolds help repel asparagus beetles.
- Pour beer or vinegar in a shallow pan to attract and trap snails and slugs.
- Bacterial spray can be used to kill gypsy moths during their larval stage.
- Cockroaches can be removed with a 1:1 powdered sugar and boric acid mix sprinkled along baseboards and in corners. Make sure that no water is available for the cockroaches to drink.
- Remove or replace rotting wood, as this is an attractant for carpenter ants and termites.
- Always keep counter tops very clean and store food carefully.
- Enhance your backyard so that wild birds and other insect eating animals take up residence.
- Do not leave standing pools of stagnant water as this creates a breeding ground for mosquitoes.

Conserve Water

- Bring your vehicle to a car wash rather than cleaning it in the driveway. Carwashes usually use up to 60% less water and most recycle their water. The average driveway car wash uses over 16 gallons of water and the detergents can end up in storm drains and ultimately in a lake or pond.
- Select native plants and grasses when landscaping. Most native species are hardier and require less water. Grasses that are labeled insect resistant and have a high percent of fescues are usually fairly drought resistant.
- Mulch heavily to keep plants cool and lock moisture in.
- Only water the lawn when it is necessary. (If you walk across the lawn and you leave lingering footprints then it is time to water.) Most traditional lawns require 1 inch of water per week, so if adequate rain has fallen, no hand watering is necessary.
- Keep blades sharp and cut grass high (2.5 inches) as this will keep the roots shaded.
- Water slowly to prevent runoff, and at night, to prevent loss of water through evaporation.
- Collect rainfall in rain barrels for use in watering the garden. Adding a few drops of baby oil to the barrel will prevent mosquitoes from breeding.
- Cover swimming pools to prevent water loss through evaporation and recycle water from kids wading pools.

Sky Juice Rainbarrel System

Washington Department of Ecology

- Reduce the amount of water you use. Small changes in daily habits including shortening showers, only running full loads of dishes or laundry and flushing less frequently, can greatly reduce daily consumption of water.
- Install low flow showerheads and low flush toilets. As a temporary fix, sink weighted water-filled plastic bottles, into the tank of the toilet. The water displaced by the bottles will be conserved with each flush.
- Keep cold water in a bottle in the fridge to prevent water lost while you are waiting for the tap water to run cold. Conversely, keep water pipes insulated to prevent water lost while you are waiting for the water to run hot (saves energy also).
- Check all faucets and pipes annually for leaks.
- When selecting new household appliances select the brand that uses the least water per pounds of wash (and the least energy).

Start a Lake Group

If you live on or near a lake, starting a lake group is a good first step towards protecting your lake's future and resolving problems that maybe threatening your lake's health. Although one person working alone can make a difference, a group of people with similar concerns and interests have a much larger voice and can have a greater impact. Members of a lake association meet to discuss lake issues and determine courses of action to protect their lake. You and your neighbors can:

- Attend town meetings to be a voice for your lake,
- Apply for grants to protect or improve your lake,
- Monitor your lake or pond for invasive species and check water quality,
- Work with the towns to address watershed issues including increased cleaning of storm drains, implementing new storm water control techniques,
- Work with planning boards to reduce the impact of increasing development,
- Attend workshops to gain more knowledge about lake ecology, hydrology etc., and
- Hold training workshops to educate the community about lake and watershed issues

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The Congress of Lakes and Ponds (COLAP) is an organization that provides guidance to lake and pond associations. They can assist you in developing an association and provide opportunities for training, networking and support. Visit the COLAP website: www.colap.com

Other Guidance Material:

• ***Starting a Lake Association*** To request a brochure (free) contact UW-Extension, Lakes Management Program, College of Natural Resources, Un.of Wisconsin, Stevens Point WI 54481 or call 715-346-2116

• ***Citizen Monitoring*** To order send $5.00 to NALMS P.O. Box 5443 Madison, WI 53705 or call 608-233-2836 www.nalms.org

• ***Handling Conflicts on Your Lake*** Write Ecovision Associates 76 E. Sherwood Road, Williamstown, MI 48895-9435 or call 517-347-2652

• ***Your Lake and You*** NALMS PO Box 5443 Madison, WI 53705 5443 email:nalms@nalms.org or visit the web at www.nalms.org

• ***Lake Line*** NALMS PO Box 5443 Madison, WI 53705 5443 email:nalms@nalms.org or visit the web at www.nalms.org

• ***Managing Lakes & Reservoirs*** NALMS PO Box 5443 Madison, WI 53705 5443 email:nalms@nalms.org or visit the web at www.nalms.org

Funds for Your Lake

A number of sources for funding are available to help you identify lake problems and obtain assistance in fixing them.

Department of Environmental Protection Grants

319 Nonpoint Source Grant Program

This grant program focuses on projects that implement measures that address the prevention, control and abatement of non-point source pollution; target the major source(s) of nonpoint source pollution within a watershed/subwatershed; have a 40 percent non-federal match of the total project cost; contain an appropriate method for evaluating the project results; address activities that are identified in the Massachusetts NPS Management Program Plan.

- RFR: typically issued by the DEP each February.
- Who Can Apply?: Any interested Massachusetts public or private organization.
- Contact: Department of Environmental Protection, 627 Main St. Worcester, MA 01608 www.mass.gov/dep/dephome.htm

Source Water Protection Technical Assistance/Land Management Grant Program

This grant provides funds to third party technical assistance organizations that assist public water suppliers in protecting local and regional ground and surface drinking water supplies.

- RFR: issued each program year.
- Who Can Apply?: Organizations that have experience providing technical assistance related to drinking water protection.
- Information available at: www.state.ma.us/dep/brp/dws/dwspubs.htm or www.comm-pass.com

Department of Fish and Game

Riverways Small Grants Program

Projects that advance river and/or stream and/or riparian land protection and/or restoration are available.

- Who Can Apply?: Municipalities and nonprofit organizations such as land trusts and watershed associations are eligible.
- Contact: www.state.ma.us/dfwele/river/rivsmallgrnts.htm

Massachusetts Water Watch Program

The Massachusetts Water Watch Partnership (MassWWP) provides training and other technical assistance to citizen organizations who conduct water quality monitoring programs on the lakes, rivers, and estuaries of Massachusetts.

For information visit: http://www.umass.edu/tei/mwwp/

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Chapter 5

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Resources

Lake Contacts

Executive Office of Environmental Affairs (EOEA)
251 Causeway Street – 9th Floor, Boston, MA 02114 Phone: 1-617-626-1000
www.state.ma.us/envir
- ***Coastal Zone Management (CZM)***
  www.mass.gov/czm
  Phone 617-626-1200

Massachusetts Department of Conservation and Recreation (DCR)
251 Causeway Street, Suite 600 Boston, MA 02114 Phone: 1-617-626-1250
www.mass.gov/dcr
- ***Lakes and Ponds Program***
  www.mass.gov/lakesandponds
  Phone 1-617-626-1382

Massachusetts Department of Environmental Protection (DEP)
1 Winter Street, Boston, MA 02108
Phone: 617-292-5500
www.state.ma.us/dep

Massachusetts Division of Fish and Game
251 Causeway Street Suite 400, Boston, MA 02114 Phone:1-617-626-1500
www.ma.gov/dfwele/dpt_toc.htm
- ***Division of Fisheries and Wildlife***
  1 Rabbit Hill Rd., Westboro, MA 01581
  Phone: 1-508-792-7270
  www.mass.gov/dfwele/dfwldfw_toc.htm
- ***Natural Heritage & Endangered Species***
  Program www.state.ma.us/dfwele/dfw/nhesp
  Phone: 508-792-7270 x200
- ***MassWildlife***
  www.state.ma.us/dfwele/dfw/dfw_toc.htm
  Phone: 617-626-1590

U.S. Environmental Protection Agency (EPA)
EPA New England Region 1
1 Congress Street Suite 1100 Boston, MA 02114-2023 Phone:1-888-372-7341
1-800-424-8802 (emergency number)
www.epa.gov/OW/index.html

North American Lake Management Society (NALMS)
P.O. Box 5443 Madison, WI 53705-5443
Phone:1-608-233-2836
www.nalms.org

Massachusetts Congress of Lakes and Ponds (COLAP)
135 Washington Street, Holliston, MA 01746
Phone:1-800-845-2769
www.colap.com

Lakes and Ponds Association of Western Massachusetts (LAPA-WEST)
C/O Hampton Ponds State Park 1048 North Road, Westfield MA 01085
LAPAWEST@aol.com

Massachusetts Water Watch Partnership
Blaisdell House- University of Massachusetts
Box 30820 Amherst, MA 01003-0820
Phone:1-413-545-5531
www.umass.edu/tei/mwwp/

State Publications

Brochures

Lawns & Landscapes in Your Watershed (DEP)
TMDL's: Another Step to Cleaner Waters (DEP)
Don't Trash the Grass (DEP)
Invasive Plants (DCR)
Shoreline Surveys: Action Tool (DEP)
Clean Rivers Begin at Home: A Guide to Understanding Nonpoint Pollution (DEP)
Protect Your Pet and Preserve the Environment: Don't Release Exotic Species! (CZM)

Manuals and Guides

- Guide to Selected Invasive Non-native Aquatic Species in Massachusetts (DCR)
- Guide to Aquatic Plants in Massachusetts (DCR)
- Final Generic Environmental Impact Report (GEIR) on Eutrophication and Aquatic Plant Management in Massachusetts (DCR)
- The Practical Guide to Lake Management in Massachusetts (A Companion to the Final Generic Environmental Impact Report on Eutrophication and Aquatic Plant Management in Massachusetts)(DCR)
- Nonpoint Source Management Manual: A Guidance Document for Municipal Officials (DEP)
- Massachusetts Erosion and Sediment Control Guidelines for Urban and Suburban Areas: A Guide for Planers, Designers, and Municipal Officials (DEP)
- Volume I: Stormwater Policy Handbook (DEP)
- Volume II: Stormwater Technical Handbook (DEP)
- A Guide to Lakes and Ponds in Massachusetts Forests and Parks
- Surveying a Lake Watershed and Preparing an Action Plan (DEP)
- Give Your Lake the Blues! (DEP)
- Shoreline Buffer Guide (BCRP + DEP)
- More than Just a Yard (EOEA)
- A Field Guide to the Animals of Vernal Pools (DFW)
- Critters of Massachusetts (DFW)
- Guide to the Dragonflies and Damselflies of Massachusetts (DFW)

Other

- Boat Ramp Sign "Stop the Spread of Nuisance Species" (DCR)
- Invasive Species Poster (DCR)
- Waterline (a quarterly guide to watersheds, wetlands waterways, drinking water) (DEP)
- Online Lake and Pond Maps (DFW) www.state.ma.us/dfwele/dfw/dfw_pond.htm
- Abstracts of the Fish and Wildlife Laws (DFW)
- Boat Massachusetts Your Guide to Boating Laws and Responsibilities (Environmental Police)

Additional copies of DEP Materials can be obtained by calling a Regional DEP Service Center:
Northeast (978) 661- 7677
Southeast (508) 946-2714
Central (508) 792-7683
Western (413) 755-2124
www.state.ma.us/dep

Additional copies of DCR publications/materials can be obtained from:
Department of Conservation and Recreation
www.mass.gov/lakesandponds

Additional copies of DFW publications can be obtained from:
Division of Fisheries and Wildlife
1-508-792-7270

Additional copies of Environmental Police publications, or for information on fishing and boating regulations call 1-800-632-8075 or visit www.mass.gov/dfwele/dle

Useful Lake Links

U.S Environmental Protection Agency

www.epa.gov
Envirofacts
www.epa.gov/enviro/index.html
Surf Your Watershed
www.epa.gov/surf
Nonpoint Source
Homepagewww.epa.gov/OWOW/NPS
TMDL Home pagewww.epa.gov/OWOW/TMDL

U.S. Department of Agriculture

Agricultural Research Service
www.ars.usda.gov
Natural Resources Conservation
Servicewww.nrcs.usda.gov

Other Sites

Environmental Information Resources
www.gwu.edu/~greenu/index2.html
National Wildlife Federation
www.nwf.org
U.S. Geological Services
www.usgs.gov
Global Rivers Environmental Education
Network www.earthforce.org/green
Washington State Lake Book
www.ecy.wa.gov/programs/wq/plants/lakes/walpa.html
Water on the Web (educational site)
wow.nrri.umn.edu/wow/under/primer/index.html
Glossary of useful words
www.nalms.org/glossary/glossary.htm

Invasive Species Sites

Center for Invasive & Aquatic Plants
aquat1.ifas.ufl.edu/welcome.html
Invasive Plant Atlas of New England
invasives.eeb.uconn.edu/ipane/
North East Aquatic Nuisance Species panel
www.northeastans.org/
USGS Non-indigenous Aquatic Species
nas.er.usgs.gov/
MA AIS Management Plan
www.state.ma.us/czm/invasivemanagementplan.htm
New England Wildflower Society
www.newfs.org
National Aquatic Nuisance Species Panel
www.protectyourwaters.net Invasive Species
www.invasivespecies.gov/profiles/main.shtml
National Sea Grant Website
www.sgnis.org

For More Information

on Benthic Organisms
www.epa.gov/bioindicators/html/dragonflies.html
on Endangered Species
www.state.ma.us/dfwele/dfw/nhesp
on Hazardous Waste Alternatives
www.metrokc.gov/hazwaste/house/cleaners.html
on Hazardous Material Facts
environment.about.com/library/weekly/blchem1.htm
on Pesticides
www.pesticides.org

Glossary

Algae: Algae are small, non-vascular (lacking roots and leaves) plants that grow in the water.

Anoxic water: Waters that contain less than 0.5 ml/l of dissolved oxygen. Most aquatic animals cannot survive with so little available oxygen.

Blue-green Algae: Although not actually true algae, they are often indicators of high phosphorus concentrations in the water. Blue-green algae have been reclassified as cyanobacteria.

Algal Bloom: An algal bloom is the burst of algae growth that can result in scum on the water surface, odor, color or taste changes and decreased oxygen in the water.

Aphotic Zone: Zone where there is insufficient light for photosynthesis, so plants cannot survive.

Benthic Communities: The diverse group of animals (including snails, leeches, and some stages of insects) that live in the lake bottom and have a major role in the decomposition of organic material.

Best Management Practices: BMP's are practices that minimize the impact from non-point source pollution including logging, storm water runoff, construction and agriculture.

Buffer: Trees, shrubs, grass and other plants that lie between a body of water and an area of development. The vegetation helps to absorb nutrients, slow storm water runoff and reduce sedimentation.

Circulation: The seasonal mixing of layers of water in lakes or ponds of adequate depth. Often referred to as spring turnover or fall turnover.

Dissolved Oxygen: (DO) Refers to the amount of free oxygen dissolved in the water. Low levels of DO can be harmful to fish and other animals.

Ecosystem: This is a spatial unit including the relationship between living things, and their abiotic environment including one another. An ecosystem can be a drop of water or the whole earth.

Erosion: The gradual removal of rock or soil particles through the actions of weather (wind, water, and ice) or human activities.

Erosion controls: Methods developed to reduce erosion during human activities. Hay bales, silt fencing, and mulching buffers are all physical barriers that help prevent erosion.

Eutrophication: The enrichment, above the natural level of a waterbody. This is the accelerated rate at which a lake ages due to human influences, which increase nutrient loading and sedimentation.

Exotic Species: An exotic species is a species that has been introduced to a region. Since the species did not originate in the area, it often does not have natural control agents (ex. disease) and may spread rapidly and disrupt the ecosystem.

Groundwater: Water that travels or is stored beneath the surface of the earth, yet occasionally discharges into lakes, streams or the ocean.

Habitat: An area where animals can find suitable shelter, food and are able to reproduce and live.

Impervious Surface: A surface, such as pavement or rooftops that limit or prevent water from entering and being filtered by the soil. These surfaces disrupt normal groundwater recharge, increase the amount and velocity of runoff, heat the runoff and alter natural hydrological flows.

Invasive Species: A species, native or non-native, that is able to spread rapidly and alter or dominate an ecosystem.

Lake: There is no real definition of a lake. Generally speaking, lakes are mixed primarily by wind action, tend to be deeper, have unlit bottom waters, rooted aquatic plant growth only in the lake's margins, and in New England, they usually become thermally stratified in the summer.

Lake Ecology: The study of the relationship between living things and the lake environment.

Limiting Nutrient: A nutrient (ex. phosphorus) that is relatively rare in the natural environment, yet is essential for plants to grow. Therefore, its availability determines the amount of plant growth.

Glossary

Limnologist: A person who studies fresh water ecology. Limnologists work on lake management, restoration, pollution control and other issues.

Littoral Zone: The area extending from the shore to the maximum depth of plant growth.

Macrophytes: Vegetation with vascular tissue; considered evolutionarily "higher" than algae.

Native Species: These are species that originated in a region and were not introduced to the region from another area. They are part of the original flora or fauna of the area.

Nonpoint Source Pollution: Pollution that enters a waterbody from a variety of sources, including storm water, wildlife influences and recreational activities. Nonpoint source pollution does not come from a specific identifiable source, such a pipe or drain.

Nutrients: Nutrients are substances, including nitrogen (N), phosphorus (P) and carbon (C) that are required for the survival of plants and animals.

Oligotrophic: A term that describes a lake that is not very productive, low in algae and nutrients, usually has clear waters and, if stratified, has adequate oxygen in the lower layer.

Pelagic Zone: describes "open waters" that do not have contact with the shore or lake bottom.

pH: pH describes the acidity of water on an exponential scale of 1-14. A range of 0-7 is acidic, 7-14 is alkaline. A pH of exactly 7.0 is neutral. Derived from a French word meaning "strength of the hydrogen."

Phosphorus: This is a nutrient that is required by all living organisms. Phosphorus is found naturally in the environment and also in fertilizers and sewage.

Photic Zone: The sunlit upper waters that extend from the surface to the point where light dims to 1% of that at the surface.

Photosynthesis: The process by which plants and some other organisms convert carbon dioxide to sugars and oxygen, using the sun's energy and chlorophyll.

Point Source: Pollution that can be traced to a specific source such as a pipe.

Respiration: The process that utilizes oxygen to convert food molecules, such as glucose, into energy, water and carbon dioxide.

Runoff: Runoff is the water from rain or melting snow that runs downward over the earth's surface. Storm water runoff is often considered a key source of nonpoint source pollution.

Secchi Disk: The Secchi disk is a simple tool used to measure water transparency. An 8" black and white disk is lowered into the water to the point where it is just visible and the depth is then recorded.

Sediment: Particles of minerals and organic soil that are carried from one place to another by wind, glaciers and flowing water.

Shoreline Erosion: The loss of soils along a shoreline into the lake. This is often accelerated by the removal of vegetation near the shore that once held soils in place.

Succession: the natural process of a lake from nutrient poor to increasingly productive and nutrient rich. Under natural conditions, this process can take thousands of years to occur.

Temperate (lake): Lakes that are located in a climate where the summers are warm and the winters relatively cool. This zone extends between the Tropic of Cancer to the Arctic Circle.

Thermocline: The zone of rapid temperature change that develops in the summer in lakes of adequate depth. The thermacline is a barrier that prevents the upper layer (epilimnion) and the lower layer (hypolimnion) from mixing.

Transparency: Describes the clarity of water. When many soils or organic particles are clouding the water, turbidity is increased and transparency decreases.

Turbidity: Describes that clarity of water. The presence of suspended matter in the water reduces transparency.

References

Text References

Davis, J., Storer, B., Zisette, R. 1995 The Washington Lake Book

Washington State Department of Ecology

EPA 1996 Guide to Environmental Issues

EPA 1985 Protecting Our Groundwater

Horne, A. J., Goldman, C.R., 1994 Limnology 2nd Ed. Mcgraw-Hill, Inc, USA

Niering, W. A. 1998 National Audubon Society Nature Guides: Wetlands Chanticleer Press, Inc., New York.

EPA Office of Wetlands, Oceans and Watersheds, Tools for watershed Protection

DEP. 2001 Surveying a Lake Watershed and Preparing an Action Plan

Department of Fisheries and Wildlife

Wisconsin Department of Natural Resources

MA DEP Drought Management Task Force

Graphic/ Illustration References:

Page 7 "Watershed Illustration" Executive Office of Environmental Affairs

Page 5 "Runoff Graph" Federal Interagency Stream Corridor Restoration Handbook

Page 6 "What Is Your Watershed?" map from Executive Office of Environmental Affairs

Page 10 "Hydraulic Cycle" from Washington State Lake Book
Washington State Department of Ecology

Page 12 "Lake Layers" illustration redrawn from Tools for Watershed Protection The Office of Wetlands, Oceans and Watersheds, U.S. Environmental Protection Agency

Page 13 "Littoral Zone of a Lake" Diagram "Managing Lakes and Reservoirs" by NALMS 2002

Page 14 "Phosphorus Budget" diagram redrawn from Tools for Watershed Protection The Office of Wetlands, Oceans and Watersheds, U.S. Environmental Protection Agency

Page 19 "Eutrophication" diagram "Managing Lakes and Reservoirs" by NALMS 2002

Pages 26 & 27 Florida Aquatic Species web site aquat1.ifas.ufl.edu/welcome.html
(line drawings of Curly-leaved Pondweed, Common Reed, Hydrilla and Water Chestnut)

Maine Department of Environmental Protection (line drawing of Variable Milfoil)

King County web site dnr.metrokc.gov/wlr/waterres/smlakes/weed.htm
(line drawings of Fanwort, Eurasian Milfoil and Purple Loosestrife)

Page 30 "Sources of Fecal Coliform" courtesy of Washington State Department of Ecology

Page 37 "Shoreline Design" The Washington State Lake Book
Washington State Department of Ecology

Fun Lake Facts

- There are approximately five million lakes in the world.
- In terms of volume, Lake Baikal, located in Siberia, Russia, is the largest freshwater lake in the world. Lake Baikal's volume is 23,600 km^3 (14,160 mi^3) compared to Lake Superior's volume of 12,100 km^3 (7260 mi^3). 20% of the Earth's freshwater, the same amount as the all five Great Lakes combined, is stored in Lake Baikal. At 5346 feet deep (1620 m), it is also the deepest lake in the world.
- In terms of surface area, the largest freshwater lake is the world is Lake Superior, with a surface area of 31,700 mi^2 (82,103 km^2).
- The world's largest saltwater lake in surface area is the Caspian Sea. The Caspian Sea is 143,200 mi^2 (370,886 km^2).
- Lying 1,300 feet beneath sea level, the Dead Sea in Jordan and Israel is the lowest lake on earth. The Dead Sea is also the saltiest waterbody on earth, having about ten times the salinity of the ocean
- Lake Titicaca in Peru is the highest navigable lake in the world. It is located 12,500 feet above sea level.
- The saltiest lake in the world, the Dead Sea in Israel, has salinity is so high that only a few species of specialized algae can survive.
- The deepest lake in the United States is the 1932 foot deep Crater Lake in Oregon. Scientists consider Crater Lake an oligotrophic lake, due to its lack of nutrients and crystal clear cool water.
- Walden Pond is the deepest pond in Massachusetts. In 1846 Henry David Thoreau measured it at its maximum depth of 102 feet. The depth of 102 feet was confirmed in a 1995 report prepared for the Department of Conservation and Recreation.
- Quabbin Reservoir (24,704 acres) and Wachusett Reservoir (4,160 acres) are the largest manmade lakes in Massachusetts.
- Assawompsett Pond (2,656 acres) in Lakeville and Middleborough, is the largest natural waterbody.
- Lake Chargoggagoggmanchauggauggagoggchaubunagungamaugg (otherwise thankfully known as Lake Webster), is the longest lake name in Massachusetts. It means “you fish on your side, I’ll fish on my side and nobody will fish in the middle.”
- A freshwater jellyfish, the exotic Appalachian Jellyfish (*Crespedocusta sowerbii*), can occasionally be found in Massachusetts.
- Large-mouth Bass is actually not native to Massachusetts. Due to a high demand for this fish as a prized game fish, it was introduced to Essex County in 1879.
- The largest freshwater fish caught in Massachusetts was a 44 lb 2 oz carp, caught in 1993 in the Connecticut River. The record holder for second place is a 35 lb Pike, caught in 1988 in South Pond, Brookfield.
- The highest waterfalls in Massachusetts are the 80 feet high twin Bish Bash Falls, located in the southwest corner of the Berkshires.
- The lakes and ponds of Massachusetts have a native carnivorous aquatic plant, Bladderwort. In addition to photosynthesis, Bladderwort has a competitive edge over other native species.

Key Contacts

1. Grant Information (page 42)

Contact the Department of Conservation and Recreation - Lakes and Ponds Program
617-626-1353 or visit www.mass.gov/lakesandponds

2. Water Quality and Use Issues

Contact the MA Department of Environmental Protection
617-292-5500 or visit www.state.ma.us/dep/dephome.htm

3. Dam Questions

Contact Department of Conservation and Recreation Office of Dam Safety
617-626-1410 or for emergencies call 1-800-831-0596
www.state.ma.us/dcr

4. Permitting and Notice of Intents

Contact your local town Conservation Commission or Wetlands Chief
www.maccweb.org

5. Herbicide Questions

Contact the Department of Environmental Protection
617-292-5500 or visit www.mass.gov/dep/dephome.htm or
Contact the Department of Agricultural Resources
617-626-1700 or visit www.mass.gov/lakesandponds

6. Lake and Pond Restoration

Contact the Department of Conservation and Recreation Lakes and Ponds Program
617-626-1395 or visit www.mass.gov/lakesandponds

7. Public Access and Great Ponds

Contact the Department of Fish and Game Public Access Board
617-727-1843 or visit www.mass.gov/dfwele/pab/pab_toc.htm

8. Fishing

Contact the Department of Fish and Game
617-626-1590 www.state.mass.gov/dfwele/dfw.dfw_toc.htm

9. Invasive Species

Contact the Department of Conservation and Recreation Lakes and Ponds Program
617-626-1382 or visit www.mass.gov/lakesandponds

10. Hazardous Materials Recycling

Contact the Department of Environmental Protection
617-292-5574 or visit www.state.mass.gov/dep/contact.htm

11. Volunteer Monitoring and Forming a Lake Association)

-Water Quality: Mass WaterWatch Partnership 413-545-5531
www.umass.edu/tei/mwwp/
-Invasive Species Monitoring: DCR Weed Watcher Program 617-626-1382
www.mass.gov/lakesandponds
-Forming a Lake Group: Congress of Lakes and Ponds (COLAP) 1-800-845-2769
www.macolap.org

12. Fishing and Boating Laws

Environmental Police 800-632-8075 www.mass.gov/dfwele/dle

Mitt Romney, *Governor, Commonwealth of Massachusetts*
Ellen Roy Herzfelder, *Secretary, EOEA*
Stephen R. Pritchard, *Acting Commissioner, DCR*

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