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Conserving Missouri's AQUATIC ECOSYSTEMS

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Student Guide

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Conserving Missouri's AQUATIC ECOSYSTEMS

Student Guide

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FIG. 1.2—Most of the water on Earth is too salty to drink or is frozen.

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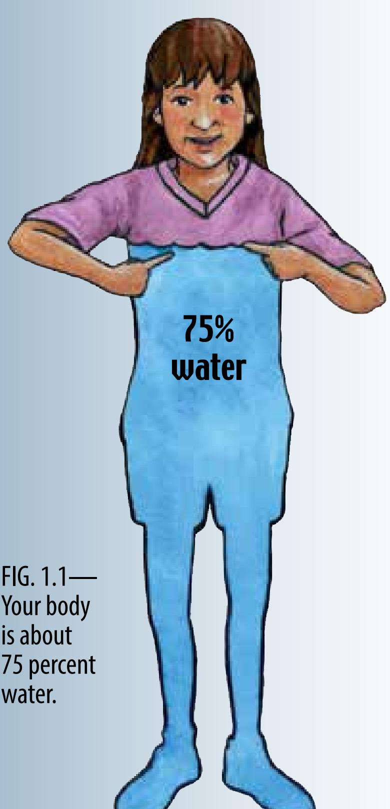

FIG. 1.1—Your body is about 75 percent water.

Did you know that every living thing—plants as well as animals—is made up mainly of water? Your body is about 75 percent water. (FIG. 1.1) All life forms (even humans) need clean water to keep them healthy. In fact, without clean drinking water you would die in one week. Our need for water links us to the past and to all living creatures. Since ancient times, societies have succeeded or failed according to their ability to get clean water. Today's modern cities still depend on water for everything from flushing toilets to making automobiles. Your community depends on water, too. Making the best use of water is critical to our survival. We can't live without it!

A water molecule is two hydrogen atoms and one oxygen atom joined together. That's why we call it H_2O. At this moment, the Earth has all the water it has ever had or will ever have. This is because water is a **natural resource**. It can't be made in a factory. Water and all things that live in or around water are called **aquatic resources**. The **hydrosphere** is all the water on Earth. Water covers about 71 percent of Earth's surface. That's about 358 quintillion (358,000,000,000,000,000,000) gallons of water! But 97 percent of the world's water is too salty for humans to drink.

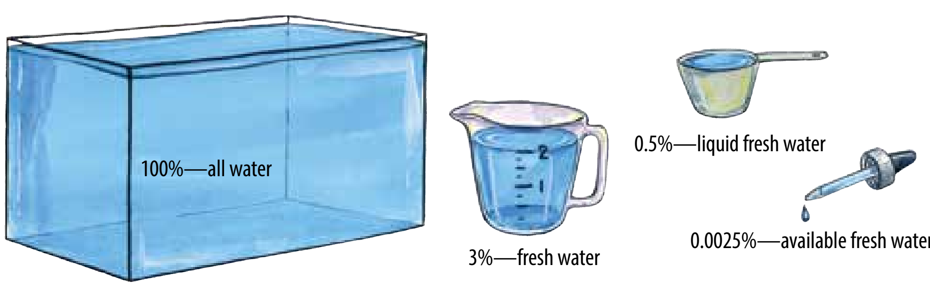

FIG. 1.3—Less than one half of one percent of Earth's water is available for use. Like all earth's materials, it is a limited natural resource affected by human activity.

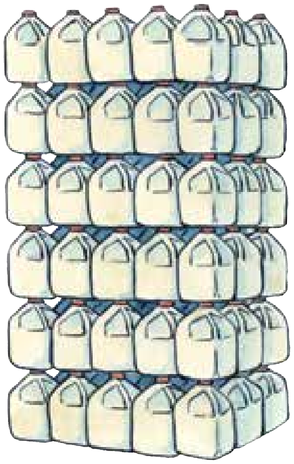

FIG. 1.4—On average, every American uses about 90 gallons of water a day.

How much is enough?

That leaves 3 percent to supply the whole world with fresh water. But 80 percent of fresh water is frozen in the polar ice caps. (FIG. 1.2) All but one-half of one percent of what's left is too polluted to use, trapped in soil or just too hard to get. (FIG. 1.3) That leaves only about two million gallons of water per person. Sounds like a lot, but if you used 150 gallons every day, you'd run out of water before your 40th birthday! Luckily, water is also one of the most recyclable substances on Earth. In fact, all the water on the planet has been recycled countless times—we drink the same water the dinosaurs drank! So when we use water, we don't destroy it or make it disappear. We move it or make it unusable—sometimes for a few minutes and sometimes for a few million years.

A person can live on a gallon of water a day for drinking, cooking and washing. But most people use far more than this. On average, every American uses about 90 gallons of water a day. (FIG. 1.4) Worldwide the need for water has tripled over the past 50 years. To have water to use, we have drained rivers dry, turned grand valleys into huge tubs and pumped so much water out of the ground that the Earth's surface has sunk beneath our feet. In the United States, we often take for granted the water that flows out of our faucets. We assume our water is safe. We don't think much about where it comes from, how much we use, or what happens to it when it swirls down the drain.

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FIG. 1.6—The Mississippi River is an important highway for moving goods through the nation.

Waste not, want not

The United States is water rich. We have 39,400,000 acres of lakes and **reservoirs**. The Great Lakes cover about 6,727,000 acres and contain about one-fifth of the world's fresh water supply. Water covers about 4 percent of the United States. This abundance has allowed the United States to grow surplus crops and build profitable industries. Everyone uses water, but it may surprise you to learn that homes and cities use only about one-tenth of the total water used. Agriculture is the biggest user of water. (FIG 1.5) For example, it takes about 24 gallons of water to grow one pound of potatoes. To produce one pound of beef takes 2,607 gallons of water! Growing a day's food for one adult takes about 1,700 gallons of water. The second biggest use of water is for industry. Producing electrical power takes more water than any other industrial use, but almost all of it is returned to or never removed from its source.

Missouri has 1,163,000 acres of fresh water, covering about 2 percent of the state. Part of this water is in 112,000 miles of streams. Another 276,708 acres are in public lakes and about half a million acres are in small private ponds. Our underground water resources also are vast. The state bubbles with a thousand springs, including some of the largest in the world. Our state also has one of the greatest varieties of freshwater fishes in the nation. Missouri

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FIG. 1.5—Agricultural irrigation is by far the biggest use of water in the United States.

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FIG. 1.7—Water is the only substance on Earth that exists naturally in all three states—solid, liquid and gas.

waterways provide homes for over 200 kinds of fish. Hundreds of thousands of geese, ducks and other migratory birds use Missouri's waters, too. Raccoon, beaver, muskrat, mink, river otters and other mammals depend on Missouri's aquatic resources. The two largest rivers in the United States—the Mississippi and the Missouri—flow through our state. These big rivers provide water for personal use, transportation and industry. They also give us opportunities to enjoy fishing and just being around water. (FIG. 1.6)

If our nation and state are so rich with aquatic resources, you may be asking why we need to study them and conserve them. The answer is that people harm rivers, streams, lakes, ponds, swamps and marshes by **pollution** and careless use. To protect our vital aquatic resources, we must use them wisely. **Conservation** means careful use. That is what this book is all about.

What's so special about water?

Water can take three forms: liquid, solid (ice) and vapor (steam). (FIG 1.7) Water can travel great distances, climb up tubes, keep animals and plants alive, break rocks and dissolve almost anything. Water's chemical structure gives it these amazing powers. Water molecules attract one another in a way that makes them form drops. Have you ever watched raindrops creep across a window? When the droplets get close to each other, they join to form one larger drop. Water's strong attraction to itself creates surface tension that allows insects such as the water strider to walk on it without breaking through. (FIG 1.8) Water molecules cling to other things, too. This clinginess allows water to climb up plant roots and enables blood to flow through tiny blood vessels.

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FIG. 1.8—Water striders take advantage of surface tension to walk on water.

Water has a high boiling point of 212º F and a low freezing point of 32º F). Water can absorb a lot of heat before it begins to get hot. A large body of water heats up very slowly, and it cools down just as slowly. This property allows living things to survive in a fairly constant environment. Water is unusual because its solid form (ice) is not as dense as its liquid form. This is why ice floats. Without this property, lakes would freeze solid, trapping and killing fish and other aquatic life.

Water is very good at dissolving many different things. For this reason, water in nature is never completely pure. It contains **dissolved oxygen** and other gases from the air and dissolved minerals from the Earth. These gases and minerals allow aquatic animals and plants to live and grow under water. Unfortunately, the gases, minerals and other things that water dissolves also can pollute it. **Water pollution** occurs when too many natural or man-made substances get in the water. These substances can harm or kill the plants and animals that live in or near the polluted water.

Pollution kills

Pure water is clear—transparent to light. This means that as long as it is relatively clear, plants can live under the water, using energy from sunlight to make food through photosynthesis. Cloudy water contains more suspended material, such as mud. Few plants grow in muddy water because the silt absorbs light. But not all clear water is clean.

Water may look clean but still be polluted. A body of water may have toxic (poisonous) chemicals in it. Most toxic pollution comes from man-made herbicides, pesticides and industrial compounds. Another kind of pollution we can't see is too much heat. Hot water holds less oxygen than cool water. All living things, including the plants and animals that live in water, need oxygen. Rainwater running off a hot asphalt parking lot after a summer storm can dump hot water into a stream, killing everything in it.

Organic pollution occurs when too much organic matter, such as manure or sewage, gets in the water. The decaying organic matter uses up a lot of oxygen. Organic pollution can also happen when **inorganic** pollutants such as nitrates and phosphates build up in the water. People use nitrates and phosphates as fertilizers because they help plants grow. High levels of these plant nutrients in the water feed the growth of plants and algae. Too much plant growth at the surface can block light from reaching deeper water. Then as the plants and algae die and **decompose**, they use up the supply of dissolved oxygen. The process of rapid plant growth followed by rotting and oxygen loss can result in the death of fish and other animals in the pond.

Quality water means quality life

The amounts and types of pollution in water affect its **water quality**, which is its fitness for a particular use. Untreated water might not be pure enough to drink, but it may be just fine for swimming or fishing. Many things affect water quality. Physical properties such as cloudiness and temperature make a big difference. Chemical characteristics also change water quality. Water-quality tests check the water's acidity and how much electricity it will conduct. By measuring water's ability to conduct electricity, you can tell how much salt and other substances are in the water. These tests also measure the amount of dissolved oxygen and detect the presence of chemicals such as fertilizers. The presence or absence of plants and animals in body of water indicates water quality, too. If you find a wide variety of healthy **aquatic organisms**, including plants, insects and fish, you can bet that the water quality is high.

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Water resource regulators keep water clean

The federal **Clean Water Act** was passed to protect our water resources. Water resource regulators enforce the Clean Water Act. They work for agencies such as the U.S. Environmental Protection Agency and the Missouri Department of Natural Resources. They enforce water laws and rules and penalize polluters. Environmental compliance officers monitor water pollution. They make sure industrial and domestic waste treatment systems are following the rules. They test water quality and collect water samples for chemical and biological analysis. These jobs require a college degree in science.

2 The Ultimate Recyclable

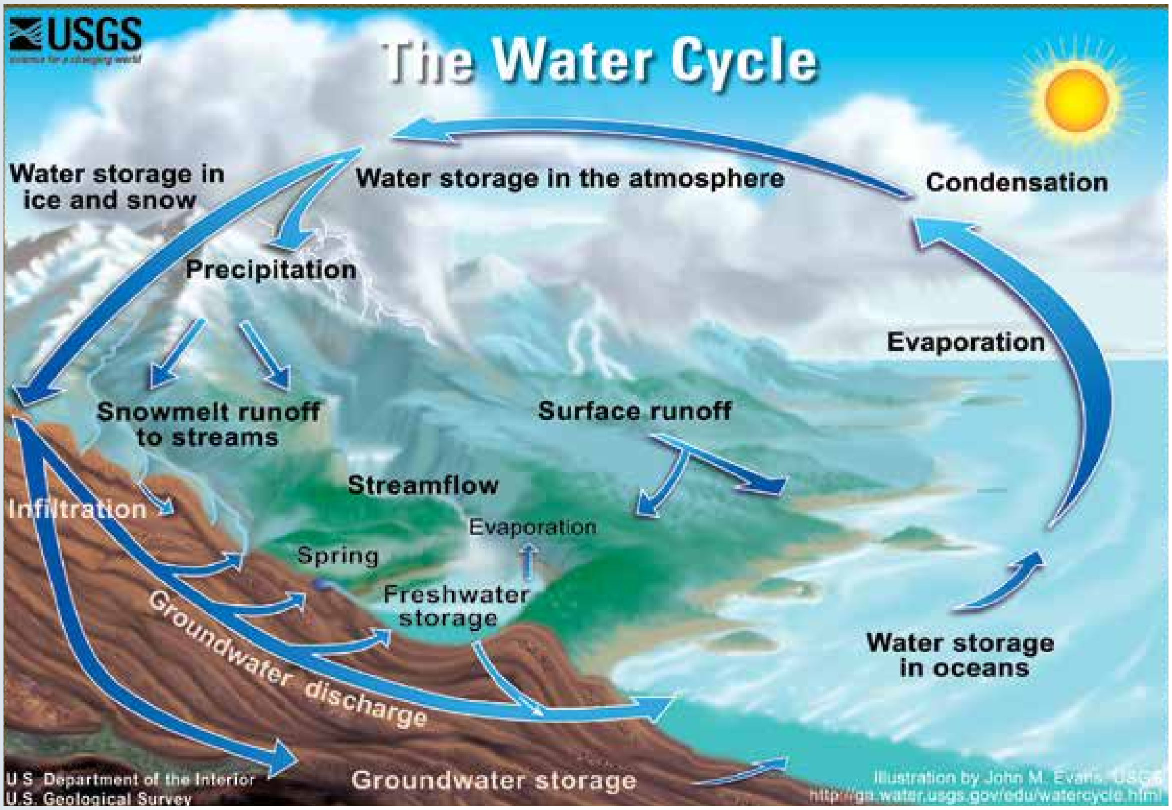

FIG. 2.1—Water is constantly recycled through the water cycle.

Questions to consider

1. What is the water cycle? Where does it start and where does it end? Where does water spend most of its time?
2. What is weather? What is climate? How do they affect the quality and quantity of our water?
3. What kind of climate does Missouri have?
4. What is surface water? What is groundwater?
5. Where does water go when it runs off a street?
6. Where does our water come from? How does it get to our faucets?
7. What happens to water after we've used it? Where does it go when it goes down the drain?

Pollution can make water unfit for people to drink. It also can make it harmful for plant and animals to live in it. Natural processes, however, can purify water over time. For three and a half billion years, the earth's water has been moving from streams to lakes to oceans, flowing underground, sitting high up on mountain glaciers, freezing and melting on the edges of the polar ice caps and forming clouds in the **atmosphere**. This never-ending round trip is called the **water cycle**, and it is the driving force behind weather and other natural processes. (FIG 2.1)

Solar-powered water pump

The water cycle works like a huge water pump powered by solar energy and gravity. It is a global system, and every molecule of water on Earth travels through it. Because it is a cycle, it has no beginning or end—we can start at any point. The sun warms water on the Earth's surface and changes it into invisible water vapor. This process is called **evaporation**. Every time water evaporates, it leaves behind whatever salts, pollutants or other impurities were dissolved in it and becomes pure again. Living things—the **biosphere**—also return water to the atmosphere. Every time we exhale, we release water vapor. Photosynthesis causes plants to release water vapor into the air in the process of **transpiration**. A one-acre cornfield (about the size of a football field) can give off as much as 4,000 gallons of water every day.

Rising air takes the water vapor up into the atmosphere where it cools. Cooling water vapor condenses as fog, mist or clouds. Raindrops and snowflakes condense around microscopic dust particles suspended in the atmosphere. Water can pick up other contaminants from the air, too, such as smog (forming **acid rain**) or mercury vapor from trash incinerators and coal-burning power plants. Water returns to Earth as precipitation, either liquid (rain) or solid (snow, sleet or hail). It also can condense on ground-level surfaces as dew or frost. About 85 percent of the world's precipitation falls into the oceans. The rest falls on land.

Talk about the weather

The amount of water that falls in a local area changes with each season. Weather also increases or decreases the amount of available water. Seasonal weather patterns move water around the world and from the atmosphere back to the Earth's surface. In fact, weather is the name we give to the movement of water through the water cycle. Average weather conditions over longer times are what we call climate. How much water a certain region will have in a given part of the water cycle depends on:

- the amount of rainfall
- the effect of temperature on evaporation
- the amount of water plants use during the growing season.

Even small changes in the global cycle can cause droughts or floods at the local level.

Missouri tends to have hot, humid summers and cold, damp winters. Some parts of Missouri receive abundant rain in late spring and may experience flooding. Other places may receive sparse rain in mid-summer and experience drought. Throughout Missouri, plants have plenty of time to grow each year. But every part of Missouri can expect to experience below-freezing temperatures each winter. We can't control the weather, but we do influence it. What we do or don't do to the atmosphere (keep the air clean or dirty), the biosphere (conserve or squander forests and prairies) and the geosphere (conserve soil or let it wash away) affects the quality of water and its movement through the water cycle (the hydrosphere).

Surface water runs off

On land, plants catch most rainfall before it reaches the Earth's surface. In a forest, for example, rain slowly drips off leaves and trickles down branches. Roots and the leaf-covered forest floor act like a sponge, soaking up water and slowly releasing it into waterways. About 66 percent of the 4,200,000,000 gallons of precipitation that fall on the continental United States each year returns to the atmosphere right away. Half of the rest runs off the surface of the land. This water is called **surface water**. It may collect in streams and flow to the ocean. Or people or other animals may slow or stop its flow to form ponds or lakes. When **precipitation** falls as snow, it can build up as snowpack, ice caps and glaciers. Ice caps and glaciers can store frozen water for thousands of years. Snowpacks in warmer places often thaw and melt when spring arrives. The melted water flows overland as snowmelt.

CLIFF WHITE

FIG. 2.2—Instead of soaking into the ground, stormwater runs rapidly over paved surfaces, taking pollution with it into our lakes, rivers and wetlands.

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FIG. 2.3—Storm drain stenciling reminds us to protect our waterways.

If rain is hitting the ground faster than it can soak in, it becomes **runoff**. The slope of the ground also affects runoff. On steep slopes, water moves quickly and very little of it soaks in the ground. Hard surfaces reduce the amount of water that soaks into the soil even further. Paved roads, rooftops and parking lots block water from soaking in, so all of it becomes runoff. (FIG 2.2) Heavy rains run off streets, sidewalks and other paved surfaces up to 10 times faster than on unpaved land. The faster water flows, the more power it has to wash away soil or to cause flash flooding. Stormwater that runs off paved roads, rooftops and parking lots flows into ditches and storm drains. This water then drains directly into streams, lakes and **wetlands** without any filtration or treatment. (FIG. 2.3) Any excess fertilizer, pesticides, mud, motor oil and antifreeze, trash, even lawn clippings and pet waste on the pavement wash into waterways during heavy rains. (FIG. 2.4)

METRO ATLANTA CLEAN WATER CAMPAIGN

FIG. 2.4

Let it soak in — groundwater

Plants, animals and people use some of the rain that falls on land. The rest of the rain—only about 3 percent—soaks into the ground. When water soaks into the ground it fills the empty spaces between soil particles. The water may remain as soil moisture, evaporate back into the atmosphere, be taken up into the roots of plants or trickle slowly through the soil. The solid part of the Earth is called the **geosphere**. Below the Earth's surface, layers of spongy soil, sand and rock act as filters to help clean the water. But if the water is badly polluted, the soil can't remove all of the pollutants. In some cases, water moving through the geosphere can even pick up pollutants already present in the soil. Eventually the water reaches a layer where all the spaces in the soil or rock are already filled up. This area is called the **saturated** zone, and the water it holds—over half of the fresh water on Earth—is called **groundwater**. (FIG 2.5) The boundary between the spongy layer and the saturated zone is known as the water table. The water table rises or falls as the amount of groundwater in the saturated zone increases or decreases.

Areas of underground rock that hold water in pores or crevices are called **aquifers**. To use the water in aquifers, people dig wells to bring it to the surface. Unfortunately, digging a well and pumping out groundwater can lower the water table and can cause lakes, streams and wetlands to dry up. Sometimes the Earth's surface can sink or even collapse when we pump out too much groundwater. In most places,

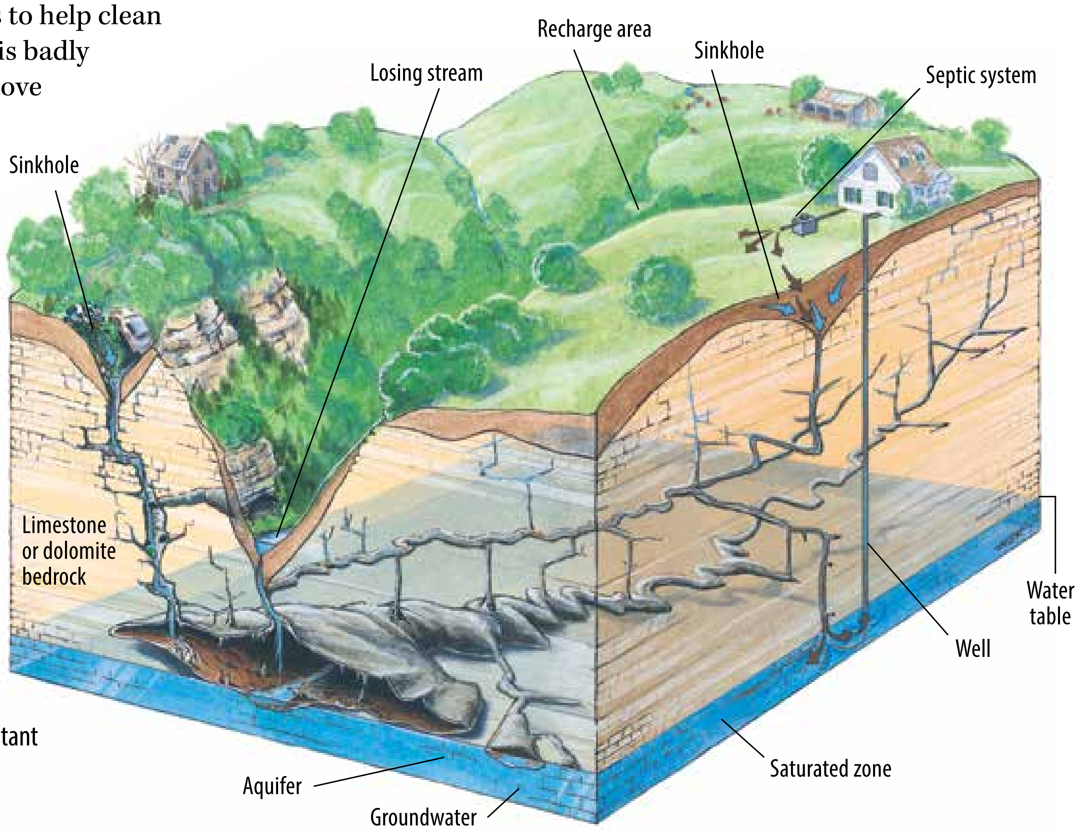


FIG. 2.5—Groundwater is an important source of drinking water that is not readily renewed by the water cycle.

groundwater moves so slowly that aquifers can take thousands of years to fill back up. In the Ozarks, however, the rate of flow is much faster and can be measured in miles per hour. Places where water soaks into aquifers are called **recharge** areas. Some streams lose water to the soil or rock around them. They are called losing streams. Streams that receive groundwater are called gaining streams because they gain water from the soil or rock around them. Where groundwater appears on the surface it forms springs.

Water coming and going

Missourians depend on both surface water and groundwater sources for drinking and other uses. In general, people in the northern half of the state (north of the Missouri River) as well as metropolitan Kansas City and St. Louis use surface water. In fact, the Missouri River itself is the source of tap water for over 2 million people—more than a third of the state's population—including metropolitan Kansas City and St. Louis. Most rural Missourians get their tap water from groundwater wells. Some well water is safe to drink right out of the ground. In other cases, it must be treated first. For community water supplies, water from wells or surface water intakes is piped to a drinking water treatment plant. There workers may filter the water or let it settle to remove suspended material. They also may add chemicals to the water to kill bacteria and other organisms. Pipes buried in the ground carry the water to homes and businesses.

A different set of underground pipes carry used water (sewage) to wastewater treatment plants. In rural areas sewage lagoons receive wastewater, letting it evaporate slowly. Underground septic systems store wastewater until it can soak into the ground. All of these methods include a step in which bacteria break down organic matter, helping to make the wastewater safer to return to the environment. Water from sewage treatment plants is piped back into surface waters such as rivers, lakes and wetlands after it is treated.

NOPPADOL PAOTHONG

After the flush

Wastewater treatment plant workers process wastewater so it is safe to return to the environment. They run equipment that removes or destroys chemicals, bacteria or other harmful pollutants in the water. They also control pumps and valves that move wastewater through the treatment processes. Wastewater treatment plant workers inspect sewage treatment systems and investigate sources of pollution to protect the public and environment. These jobs, like those of drinking water treatment workers, require special certification from the state.

Drinking water treatment plant workers make water safe to drink

Plant workers read and adjust meters and gauges to make sure the plant equipment is working right. Water from wells or surface water intakes is piped to the treatment plant, where workers may add chemicals to the water to treat it. They take samples of the water and analyze them in the lab. Water treatment plant workers must be licensed by their states. Workers must pass tests and prove work experience before they get a license to treat water for the public to drink.

NOPPADOL PAOTHONG

3 What's Your Watershed Address?

Questions to consider

1. What is a watershed? Which watershed do you live in?
2. How does the watershed affect the water body into which it drains? How do human activities affect the quality of water in a watershed?
3. What is point-source pollution? What is non-point pollution?
4. What is erosion? What causes it?
5. What is sediment? Where does it come from?
6. How does human activity affect erosion and sedimentation? What is the impact of erosion and sedimentation on aquatic resources?
7. What are Missouri's physiographic regions?

It's usually difficult to see a **watershed** unless you're standing on top of a ridge or looking down from an airplane. Then you can see all the hills and valleys that drain water into a stream, streams into rivers and rivers into lakes. (FIG 3.1) A watershed is all the land from which water drains into a specific body of water. Sections of connected hills and valleys form each watershed. Everyone lives in a watershed, and all land on Earth is part of some watershed. A watershed might be as small as your yard or millions of square miles. If you stand atop the ridge that divides two watersheds, you can pour a glass of water from one hand into one watershed and a glass of water from the other hand into a different watershed. Sooner or later, the water from the two different glasses will end up in two different streams.

Your watershed address

Missouri is a part of the largest watershed in the United States, the Mississippi River watershed. Although this watershed is 1.2 million square miles, it has many smaller watersheds and tributaries within it. These small (sub-) watersheds make up larger ones. For example, the Missouri River watershed is a sub-watershed of the Mississippi River watershed, just as the Missouri is a **tributary** (smaller branch) of the Mississippi. (FIG 3.2) And the Osage River watershed is a sub-watershed of the Missouri River watershed, just as the Osage River is a tributary of the Missouri River. Your **watershed address** is the watershed, sub-watershed, sub-sub-watershed, etc. in which you live. It tells which lake, stream or wetland collects the water that falls on your home. (FIG. 3.3)

At the top of the watershed is the land known as the **headwaters**. This is the high ground where precipitation first collects. From the headwaters it flows downhill in tiny trickles too small to create a permanent **channel**. When these trickles finally combine and

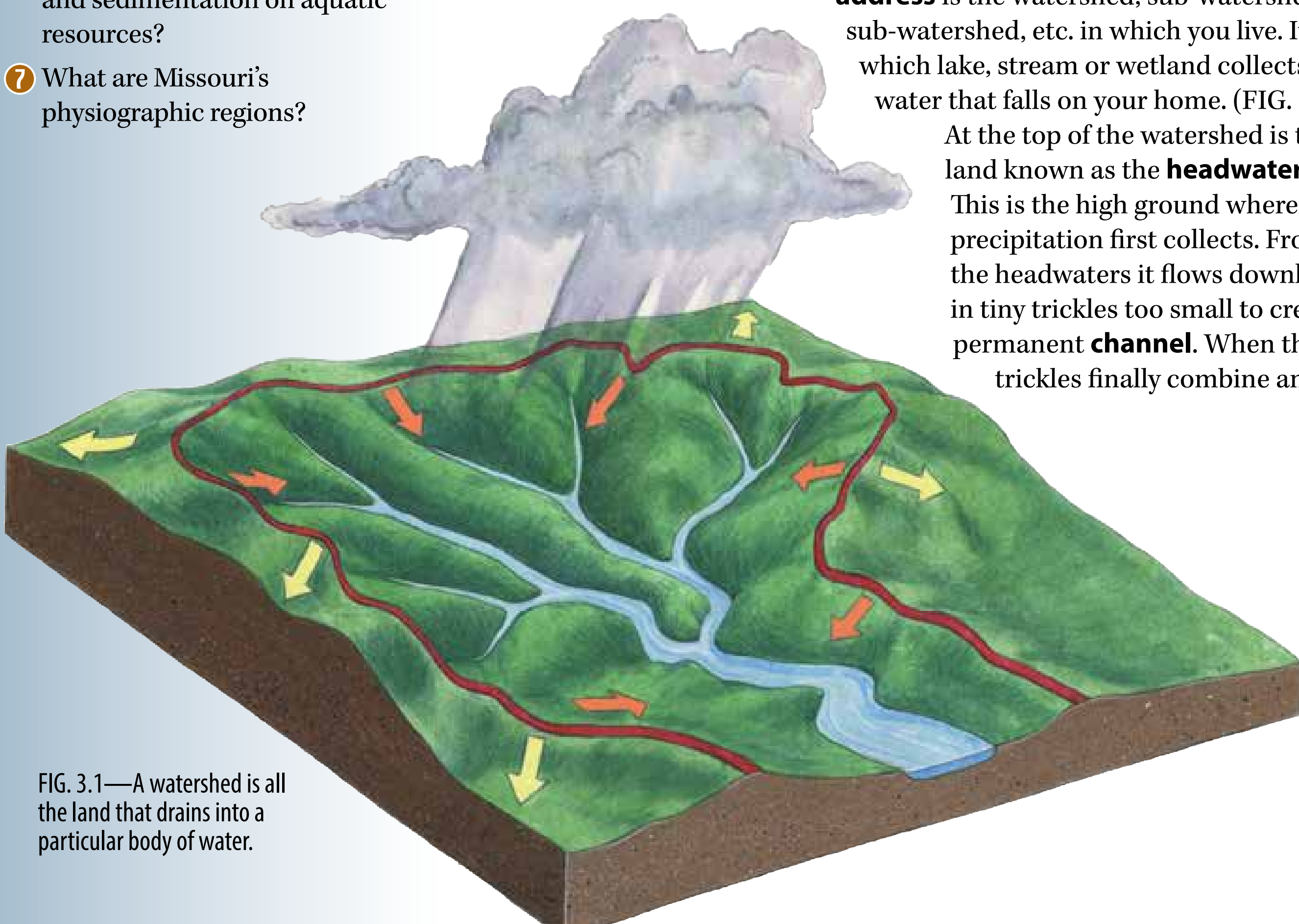


FIG. 3.1—A watershed is all the land that drains into a particular body of water.

begin carving a channel, they form a small stream. Small streams combine to form larger streams. The mouth of a stream is the place where it empties into a larger body of water. A permanent or **perennial stream** is one that has flowing water in it all year long. In the Ozarks, many streams only flow for part of the year, although water may be flowing just below ground, beneath the dry bed. Such streams are called **intermittent streams**, and they are marked on maps with blue dashes and dots.

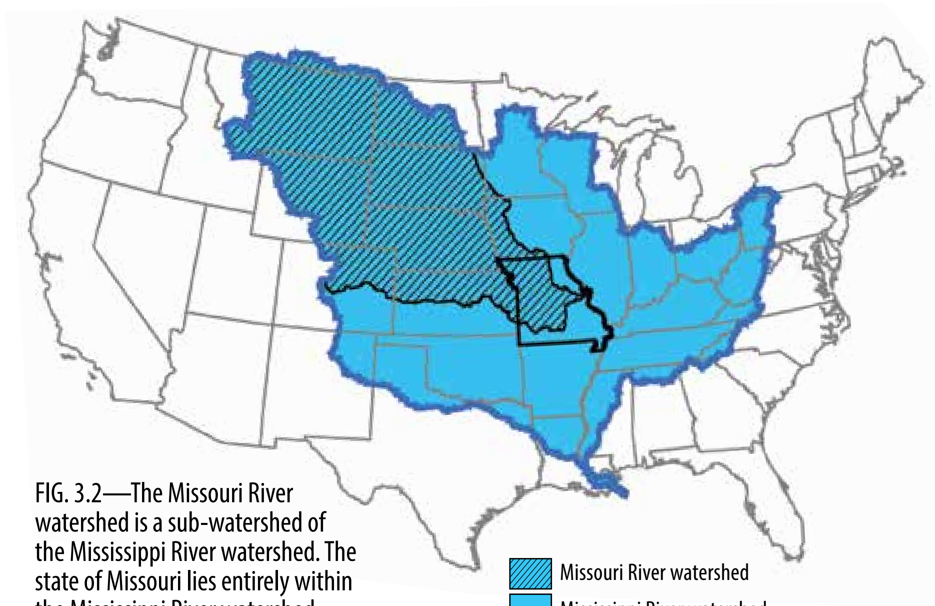


FIG. 3.2—The Missouri River watershed is a sub-watershed of the Mississippi River watershed. The state of Missouri lies entirely within the Mississippi River watershed.

What you do to the land, you do to the water

Everything that happens on the land in a watershed affects the water body into which it drains. A stream, pond or wetland can only be as healthy as its watershed. How we use the land affects the health of our aquatic resources. In a healthy watershed, water is filtered and stored. As water runs downhill, it picks up whatever is on the ground. When it flows through cities or across fields and pastures, water picks up dirt, pollutants and heat. These contaminants flow into a stream, wetland or lake, affecting the water you use to drink, swim or fish. When you flush your toilet, do the laundry, fertilize your lawn or dump used oil on the ground, you are affecting water quality in your watershed.

We describe sources of water pollution in two ways. One way is **point-source pollution**. Point-source pollution comes from a single source, such as a pipe. The other way, **non-point pollution**, comes from a combination of many sources rather than a single outlet. Examples of non-point pollution include runoff from fields and strip mines, fertilizers used on lawns and golf courses, fuel, oil and antifreeze from roads and animal waste and bacteria from feedlots. Finding and preventing water pollution in our state is vital to every Missourian's quality of life. What do you think is the biggest pollutant in Missouri's waters? Sewage? Industrial chemicals? Pesticides? Plant nutrients (fertilizers)? Trash? Believe it or not, the biggest pollutant of Missouri's waters is plain old dirt.

The proper name for dirt is soil, and when it gets into a water body, it becomes **sediment**. The biggest pollution problem in Missouri's waters is excess sediment. Sediment is any bit of rock or soil such as mud, clay, silt, sand, gravel—even boulders. Excess sediment blocks out light, killing aquatic plants or preventing their growth. Sediment covers up the nooks and crannies animals live in. It smothers aquatic animals by clogging their gills and by reducing the amount of oxygen in the water.

Raindrops can move mountains

Raindrops fall at a speed of about 30 feet per second, or 20 miles an hour (FIG 3.4). When a raindrop strikes bare soil it creates mud that is splashed as much as 2 feet high and 5 feet away. This is an example of **erosion**. Erosion is the movement of solid material such as soil, mud and rock. It is a natural process caused by the forces of wind, water, ice, gravity and living things. In fact, a certain amount of erosion and sediment is natural. However, too much of either can cause problems. Erosion can reduce soil fertility and water quality. Sediment that erodes from one place is carried away and settles out downstream. This can clog streams with gravel and fill reservoirs with sediment. Erosion

FIG. 3.4—Raindrops fall at a speed of about 30 feet per second, or 20 miles an hour and can splash mud as much as two feet high and five feet away.

can be a big problem in areas where too many trees are cut down or overgrazing or construction speeds up the natural process. Planting trees and building terraces are two ways to slow erosion. Plant leaves and stems slow moving water down, and plant roots hold soil and rock in place. Missouri farmers have switched to no-till planting and other conservation farming techniques to reduce the amount of soil and other sediment in Missouri streams. But excess erosion and sedimentation in Missouri's waters remains the biggest single problem facing our state's aquatic resources. (FIG. 3.5)

We can often see the close tie between land and water. Missouri has five **physiographic** regions. (FIG. 3.6) These five regions have different types of bedrock and soil, different elevations and plants and even slightly different kinds of weather. The different geologic forms and the different ways their land is used affect the overall water quality and quantity of their watersheds. The five regions are the Ozarks, Osage Plains, Southeastern Lowlands or the Bootheel, Dissected Till Plains and the St. Francois Mountains. Every stream, lake or wetland is a reflection of its watershed. Knowing our watershed and its relationship to surrounding watersheds can help us conserve our aquatic resources.

CLIFF WHITE

JIM RATHERT

FIG. 3.5—The biggest pollutant of Missouri's waters is soil and other sediment caused by accelerated erosion.

DAVID STONNER

Hydrologists study the hydrosphere

To collect water data, hydrologists make tests and measurements such as flow rate, dissolved oxygen, sediment load, acidity, saltiness, groundwater levels and pump tests. These data help hydrologists learn about surface watershed and groundwater aquifer characteristics and water quality. Hydrologists write reports and prepare water-level maps, geologic cross-sections, tables and graphs of study results and data analyses. These are published in government documents or scientific journals or as support for projects or large-scale investigations. Most hydrologists have at least a bachelor's degree; many have master's level education and certification as professional engineers.

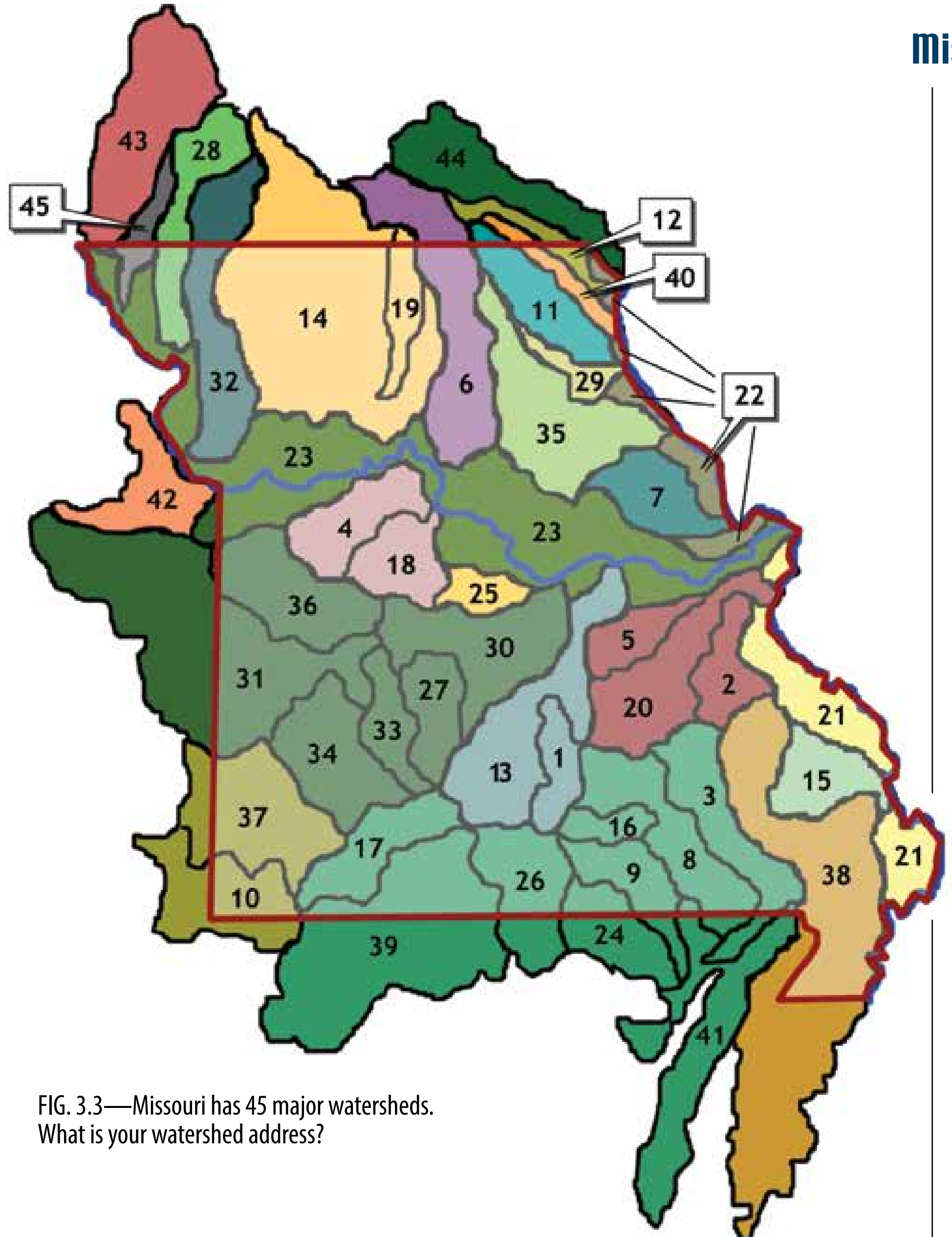
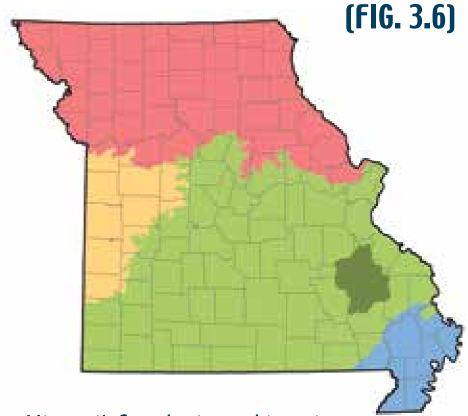


FIG. 3.3—Missouri has 45 major watersheds.
What is your watershed address?

1—Big Piney River
2—Big River
3—Black River
4—Blackwater River
5—Bourbeuse River
6—Chariton River
7—Cuivre River
8—Current River
9—Eleven Point River
10—Elk River
11—Fabius River
12—Fox River
13—Gasconade River
14—Grand River
15—Headwater Diversion
16—Jacks Fork River
17—James River
18—Lamine River
19—Locust Creek
20—Meramec River
21—Mississippi River, Lower
22—Mississippi River,Upper
23—Missouri River
24—Spring River
25—Moreau River
26—North Fork White River
27—Niangua River
28—Nodaway River
29—North River
30—Osage River, East
31—Osage River, West
32—Platte River
33—Pomme de Terre River
34—Sac River
35—Salt River
36—South Grand River
37—Spring River
38—St. Francis River
39—White River
40—Wyaconda River
41—Cache River
42—Lower Kansas River
43—Nishnabotna River
44—Lower Des Moines River
45—Tarkio River

Missouri's physiographic regions (FIG. 3.6)



Missouri's five physiographic regions affect Missouri's waters and watersheds.

The Dissected Till Plains

The Dissected Till Plains region of northern Missouri is the product of the leading edge of the last ice-age glacier that once covered parts of North America. Deposits of soil and fine rock dust erode into silt, leaving the rivers of this region a very muddy color.

The St. Francois Mountains

The St. Francois Mountains region displays Missouri's oldest rocks. These igneous formations were once volcanic islands above the ancient shallow seas that covered Missouri.

The Osage Plains

The Osage Plains in west-central Missouri consist of rolling plains. The rivers in this region twist and turn through prairie grasslands that have deep, rich soils. As a result, these rivers carry more silt than Ozark streams.

The Ozarks

The Ozarks region lies on sedimentary rocks such as limestone and dolomite left millions of years ago by ancient seas. Today we see these rocks as ridges and bluffs. Geologic features such as caves, sinkholes, springs and losing streams are known as karst, formed by water's ability to dissolve away the limestone and dolomite bedrock into a sort of stone Swiss cheese.

The Bootheel

The Bootheel is the start of the Mississippi Delta. It is full of gravel and sand left by the Mississippi River. This region was once a vast swamp. Natural wetlands still exist in a few places and flooding still occurs, reminding residents that the natural path of the Mississippi once flowed over this land.

4 Living in the Water

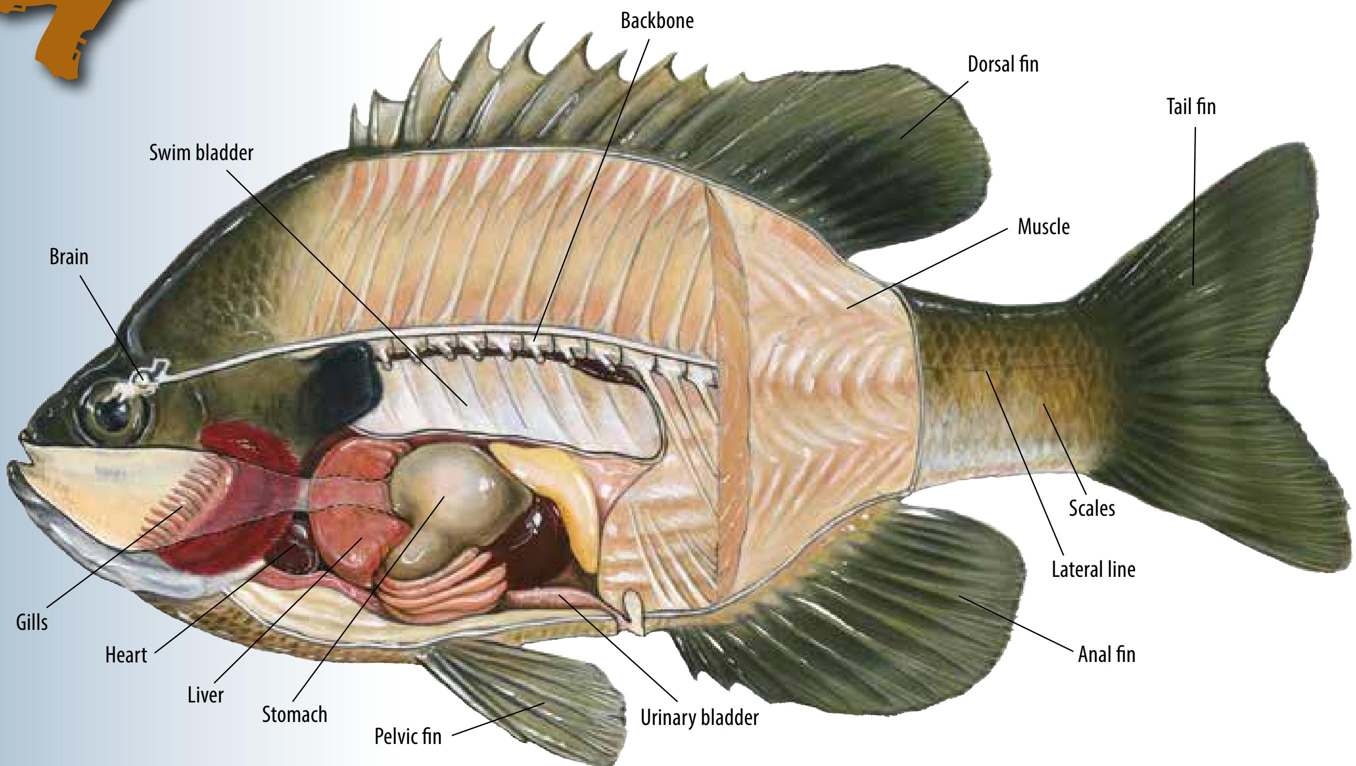


FIG. 4.1—Gills enable fish to take in oxygen and get rid of carbon dioxide by moving water over them.

Questions to consider

1. What is a species?
2. What is an adaptation?
3. How are fish adapted to aquatic environments?
4. How do fish swim? Why don't fish sink to the bottom or float on top of the water?
5. How do fish see, smell, hear, taste and feel?
6. What are some adaptations of different species of fish native to Missouri?
7. How do specific adaptations provide survival advantages to particular species?

You walk beside a pond. A red-winged blackbird flies overhead. A bluegill swims in the water. Humans, red-winged blackbirds and bluegill are distinct species. A species is a group of individuals sharing some common characteristics or qualities and whose offspring also share those characteristics or qualities. In other words, a species is a particular kind of creature. All species are specially suited for the lives they lead. Humans are perfect walkers, adapted to life on land. Red-winged blackbirds are perfect fliers, adapted to life in the air. Bluegills are perfect swimmers, adapted to living in water. An **adaptation** is a behavior or trait that increases a species' chance of survival in a specific environment. Every living thing must fit how it lives and where it lives. If it doesn't, it won't survive.

Fish guts

All fish are cold blooded. Their body temperature depends on the surrounding water temperature. This means they need less oxygen and energy to live than warm-blooded animals do. Fish have many of the same internal organs as we have. They have a heart to pump blood, intestines and stomach to digest food, a kidney, a liver, a gall bladder and a spleen.

All fish have **gills** to get oxygen from the water. Fish absorb dissolved oxygen from water passing over their gills. The gills contain capillaries (fine blood vessels) that absorb up to 85 percent of the oxygen available in the water and release carbon dioxide. Fish and amphibians are the only vertebrates (animals with a backbone) that are able to live in water without breathing air from the atmosphere. (FIG. 4.1)

How fish swim

Up to 80 percent of a fish's body is made of muscle. These bulging muscles are packed along its sides. That's where a fish gets most of its swimming power. When a largemouth bass wants to move forward, it begins a side-to-side wiggle that starts at its front and moves to its back. As this wiggle goes backward, the fish goes forward.

Fish also use their many **fins** to move about in the water. Coordinating all these fins comes naturally to them. The dorsal fin, located along the back of a fish, works like the keel of a boat. It helps keep the fish upright and stable. Some fish have split dorsal fins. Some species of fish, such as sunfish, have sharp spines in their fins to discourage other fish from eating them.

Most fish use their pairs of pectoral and pelvic fins, which are located along their sides, to steer or maneuver. These fins move independently, giving the fish the ability to move quickly in any direction. They can be used as brakes or rudders to help the fish stop, turn or go up or down or, in some cases, backward. Some fish rely on these or other fins rather than body movements to propel themselves forward part of the time. These fish usually aren't very fast. However, they are well adapted for moving in and out of tight places to catch food or to escape from other fish that want to eat them. Their ability to maneuver helps them survive.

Sink or swim

Swim bladders keep fish from sinking. The swim bladder works a little like a hot air balloon. The more air it contains, the higher a fish will suspend or float in the water. A fish can swim deeper or shallower, but the swim bladder takes a little time to adjust to the new depth.

Most fish are covered with **scales** that protect a fish as roof shingles protect a house. Fish don't grow more scales as they get older, the scales just get bigger. Scientists can determine a fish's age by counting the rings on a scale, similar to the way foresters can tell a tree's age by counting its growth rings. Fish are coated with slime, which helps reduce friction as they swim through the water. The slime also helps protect them from disease.

Almost every fish species is dark-colored across the back and light on the belly. This helps them blend in to the dark bottom when seen from above, and with the bright surface when seen from below. Many other color adaptations allow fish to blend in to their surroundings. For example, you must look very closely to see a sculpin sitting on a gravel **streambed** (the bottom of the stream) because of its ability to blend into its multicolored surroundings. (FIG. 4.2)


GAROLD W. SNEEGAS

FIG. 4.2—Protective coloration helps this sculpin avoid predators.

Fish sense

Fish have senses to see, hear, smell, taste and feel. The senses of some fish are better developed than those of others. Some fish use their sense of smell or taste to find food. Others feed primarily by sight. All fish are nearsighted, but the placement and shape of their eyes allows them to see almost all the way around their bodies. Fish can see colors, but those that feed at night or live on the bottom rely heavily on their excellent sense of smell. Fish have super hearing, especially for low-frequency sounds. A fish's ears are located beneath the skin on either side of the head. Fish also have a sensitive line along their sides, called a **lateral line**, which lets them sense water vibrations coming from each direction. Lateral lines are usually visible as faint lines like racing stripes. These run lengthwise along each side from the gill covers to the base of the tail. "Keep quiet or you'll scare away the fish" is good advice when you're on a fishing trip.

Fish have been on Earth for more than 400 million years. Today there are about 21,000 species worldwide and over 200 in Missouri. Each kind of fish has its own way of surviving. The diversity of fishes shows us how fish have adapted to live in a variety of environments. They thrive in the murky depths of the muddy Mississippi River, in the cypress swamps of southeast Missouri and in complete darkness in Missouri's many caves. Bluegill, catfish and bass live in most Missouri waters. Each of these is adapted to play a different role in the aquatic environment. Their adaptations of body shape, mouth size and coloring help them to survive. The different adaptations of these species show how fish are adapted to life in Missouri's waters.

Bluegill

Bluegill have thin bodies, short heads and small mouths. (FIG. 4.3) Their thin, disk-shaped body is ideal for short, quick turns. They need to be fast to catch food among plant stems. They have a small mouth because they eat small insects. Their protective coloring helps them hide from their enemies. Small bluegill are a favorite food of bass.

Channel catfish

Channel catfish have long, round bodies that are flattened on the bottom. (FIG. 4.4) They have skins without scales. They scavenge along the bottom of ponds or rivers for fish, frogs, crayfish and other foods—dead or alive. They are adapted to feed at night. They depend on barbels or "whiskers" with many taste buds and a good sense of smell to guide them to food even in dark, muddy waters. In fact, catfish have taste buds all over their bodies, including the tail. They can taste food even before taking it into their mouths. Their skin color camouflages them against pond and river bottoms. Channel catfish are adapted as bottom rovers. Small catfish are a favorite food of bass.

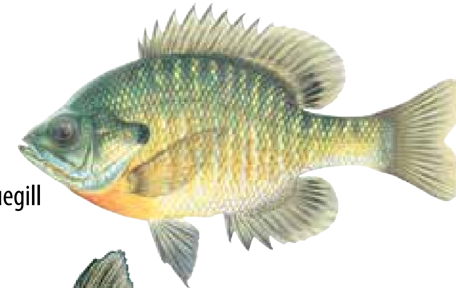


FIG. 4.3—Bluegill

FIG. 4.4—Channel catfish

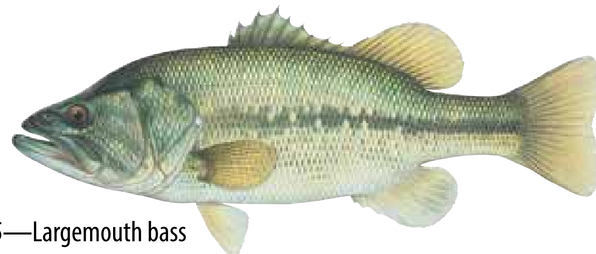


FIG. 4.5—Largemouth bass

Joseph R. Tomelleri illustrations

Largemouth bass

Largemouth bass live in clear waters that have many weeds. (FIG. 4.5) They are **predators**, meaning that they eat other animals, which are called **prey**. Their large mouths enable them easily to catch frogs, fish, crayfish and other animals. Their broad fins and strong, heavy bodies allow them to go in any direction (even backwards) as they seek food. Wide, sweeping tails give these predators quick powerful starts, enabling them to ambush their food. The colored blotches on their sides hide them well in weeds. Largemouth bass and many other popular Missouri game fish are roving predators, and they have similar adaptations.

Fish farming in Missouri

Fish farmers raise fish in artificial conditions for stocking, to use as bait or, in some cases, to eat. They must purchase their breeding fish from a commercial fisherman or another fish farmer, or keep their own captive breeding stock. Hatchery workers spawn fish by hand and grow them to a size large enough to use. Here, a hatchery worker squeezes sperm from a male trout into a bowl of eggs to fertilize them. Hatchery workers check fish health, spot fish diseases and control diseases with drugs. They keep hatchery records and write fish-production reports. The Missouri Department of Conservation operates two kinds of fish hatcheries. Warm-water hatcheries raise mostly native fish. Cold-water hatcheries raise trout, which are not native to Missouri, but which can survive in some spring-fed Ozark streams. Trout are very popular with fishermen. Channel catfish and trout also are raised for food in private fish farms in Missouri. Many hatchery workers have a bachelor's degree in fisheries management or biology.

JIM RATHERT

5 From Sun to Sunfish

Questions to consider

1. What are some of the basic survival needs of all living things?
2. What is a population? What is a community?
3. What is habitat? Why is it important? Why must organisms compete for resources? What is carrying capacity?
4. What is a niche? Why is it important? What are invasive species? Why are they a problem?
5. What is the source of energy for aquatic communities? How does energy circulate among organisms in an aquatic community?
6. What is a food chain? What is a food web? What is an energy pyramid? What is a trophic level?
7. How do predator and prey species keep one another in balance in aquatic communities? What is natural selection?

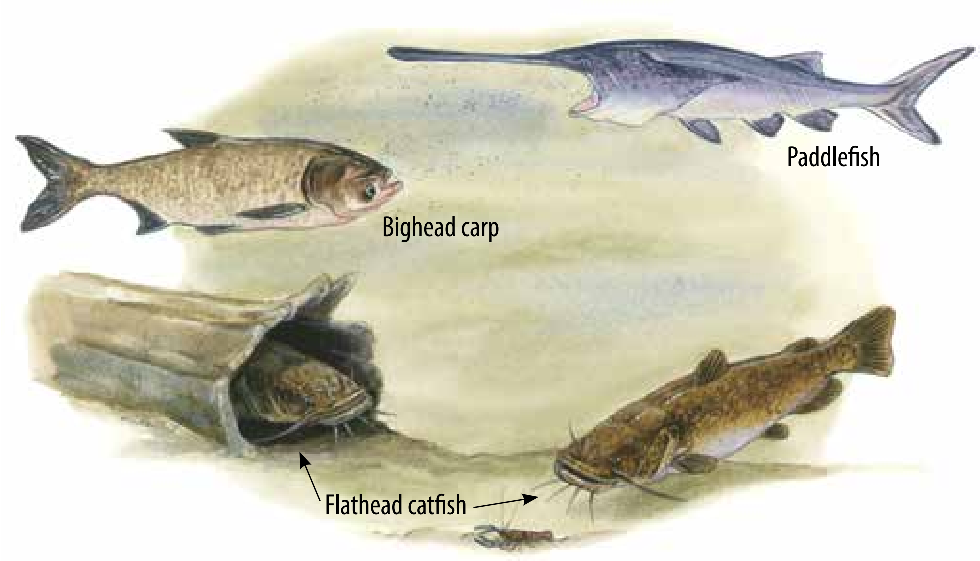


FIG. 5.1—Paddlefish and flathead catfish can both live in the same river because they don't compete for the same niche. Paddlefish eat microscopic **plankton** and spawn in gravel-bottomed tributaries, while flathead catfish hunt and eat small fish and crayfish. They spawn in logs or other sheltered areas on the river bottom. Bighead carp, a recently introduced invasive species, competes with the native paddlefish for plankton.

What do you need to survive? You need air to breathe, water to drink, food to eat and shelter to protect you from the elements. All living things have basic survival needs similar to yours. For organisms to survive, they must be able to meet all of their survival needs. In addition, while it does not influence the survival of individuals, reproduction must occur for a species to continue to exist.

A group of one kind of organism living in the same place at the same time is a **population** of that species. A group of the same kind of algae, a group of the same species of pond snail, or a group of bluegill are all examples of populations you might find living in a pond. Different populations living in the same place interact with one another. A group of populations living in the same place is called a **community**. The algae, snails and bluegill—along with all the other organisms living in or around the pond—interact with each other and make up a pond community.

The physical environment that a species needs to survive is its **habitat**. Habitat is more than a place. Habitat is the shelter a species uses to escape predators and the elements, as well as the space it needs for reproducing and for hunting, gathering or producing food. It includes all the conditions a species prefers. For example, trout need cold water with high dissolved oxygen content in order to survive. Trout can only live in Missouri near springs and even then their ability to reproduce without human intervention is limited. They were brought to Missouri for fishermen and are not well adapted to conditions here. In contrast, catfish are native to Missouri and are well adapted to Missouri's waters. They are able to tolerate the warm water and low oxygen conditions frequently found here. Many aquatic plants and animals have very specific needs.

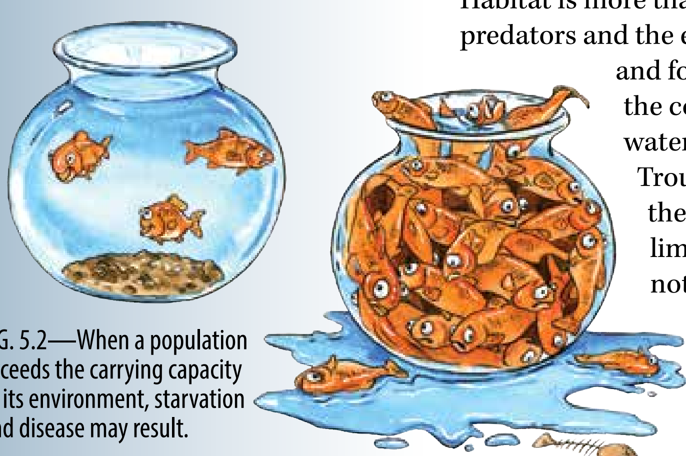


FIG. 5.2—When a population exceeds the carrying capacity of its environment, starvation and disease may result.

They either can't move or can't live in another habitat. Like other resources in an environment, individuals and populations may also **compete** for habitat.

Finding a niche

Within a community every species has a particular **niche**. A species' niche includes its way of getting food, the habitat it needs and the role it performs in the community. Missouri's diverse aquatic environments provide many different niches. For example, paddlefish and flathead catfish both make their homes in Missouri's larger rivers and reservoirs. Paddlefish, however, make their living by grazing on microscopic animals, while flathead catfish hunt and eat small fish and crayfish. These two big-river fish live in the same bodies of water, but they eat different things. They do not compete for the same food. Paddlefish and flathead catfish prefer different places for breeding, too. Flathead catfish seek out nesting sites under rocks and logs, while paddlefish swim upstream to spawn in shallow spots in gravel-bottomed streams. (FIG. 5.1) Different species may have similar or even overlapping habitats, but no two species can occupy exactly the same niche in the same community for long.

Competition and survival

Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite. When there is not enough of something to go around, individuals must compete for whatever resource is scarce. Populations within a community may compete against one another as well. Individual bluegills in a pond compete with one another for food. They also compete with green sunfish, since both species feed on the the same prey. When food is scarce, they are negatively impacted by the presence of the other because they will have less food.

The limits on **biotic** (living) and **abiotic** (non-living) resources determine the environment's **carrying capacity**. Carrying capacity is the maximum number of individuals in a particular population that an environment can support. When there are more resources than a particular population can use, the population is below its carrying capacity. When this happens, individuals continue to grow and reproduce. When there are more individuals in a population than the environment can support, the population is above carrying capacity. Populations don't stay above carrying capacity for long. Once a population exceeds its carrying capacity, individuals may starve, get sick or be forced to move to a place that can support them. Some examples of resource limits are the availability of food or habitat. If a population does not have enough food or habitat to sustain itself, it has exceeded its carrying capacity. (FIG. 5.2)

Go solar!

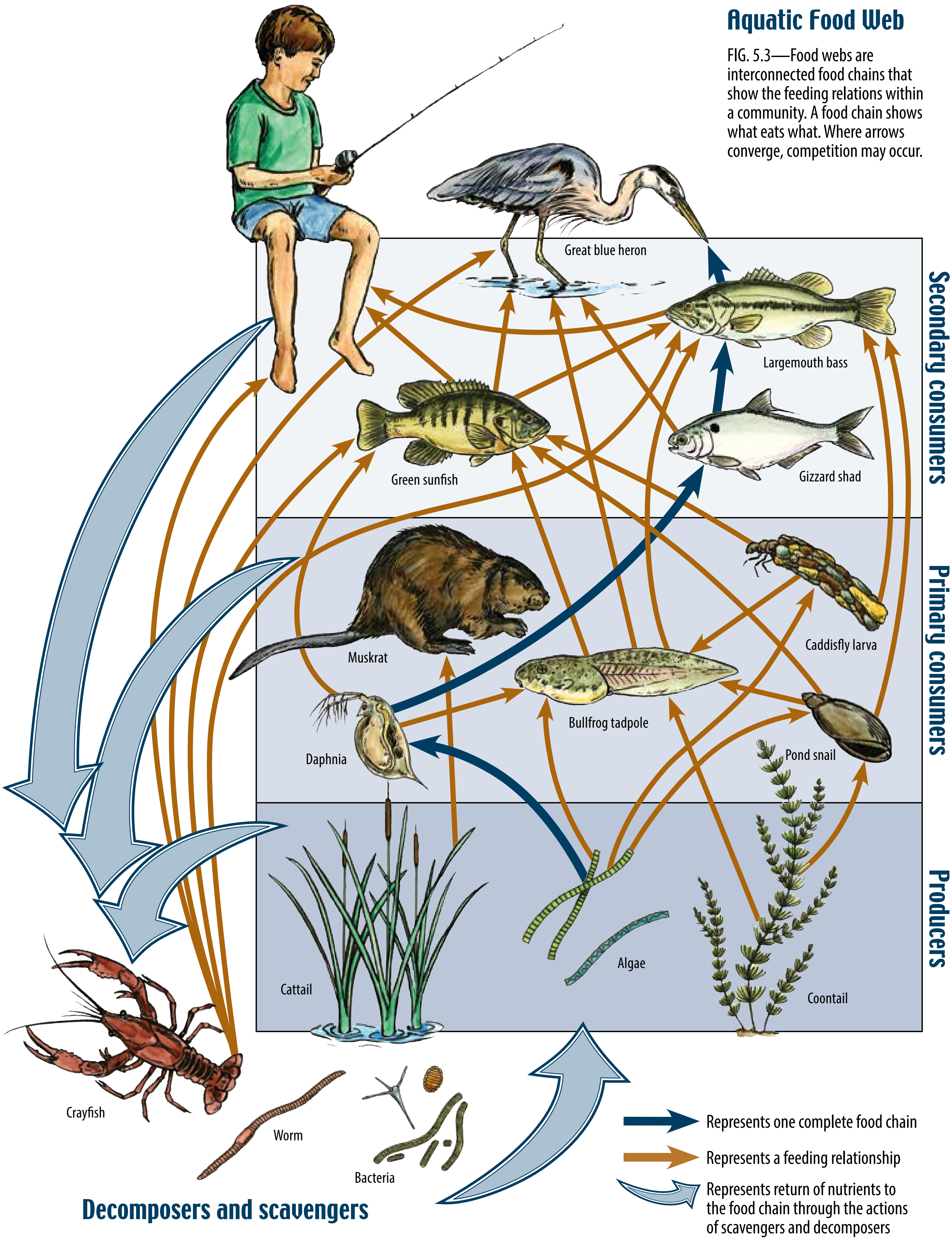
Aquatic communities run on sunlight. Plants capture the sun's energy and use the process of photosynthesis to turn sunlight, carbon dioxide, minerals and water into food and oxygen. Plants are called **producers** because they produce their own food. Unlike plants, animals cannot make their own food. To survive they must eat other living things. Animals that eat plants are called primary **consumers**, or herbivores. A pond snail is a primary consumer because it eats algae and other aquatic plants. Secondary consumers eat primary consumers. Sunfish are secondary consumers—they eat insects, crustaceans, and small fish. Secondary consumers can be carnivores or omnivores. Carnivores kill and eat other animals. Omnivores eat both plants and animals. Parasites such as leeches get their energy directly from feeding off of another living organism, but they usually don't kill the organism in the process. Scavengers such as crayfish eat the organic material of dead plants and animals. **Decomposers** such as bacteria and fungi also feed on non-living organic matter, in the process breaking it down into simple molecules that plants can use. Scavengers and decomposers play a vital role in recycling the energy and materials from the flesh of dead organisms directly back into the system for producers and other consumers to use.

A **food chain** shows how energy moves from producers to primary consumers to secondary consumers and so on. Food chains show what eats what. While they are easy to understand, food chains are simplified versions of what really happens in a community. Most animals have many sources of food, and each food source feeds many different kinds of animals. To illustrate this fact, **food webs** show how different food chains are interconnected. (FIG. 5.3) Taking out any link in a food web may upset the balance of the whole.

An **energy pyramid** is another way to look at feeding relationships. If you divide a pyramid into levels, you can see that the widest one is at the base and the narrowest one is at the top. The pyramid shape not only shows what eats what, but how much energy is available at each consumer level. Consumer levels are also known as **trophic levels**. Only a little of the sun's energy passes from one trophic level to the next. (FIG. 5.4) Animals lose energy doing tasks such as hunting and keeping their bodies warm. An energy pyramid illustrates this lost energy by showing each higher trophic level as a narrower block than the one below it. Most of the available food energy is lost moving up each trophic level. For example, it takes about 3,200 pounds of microscopic plants to produce 410 pounds of microscopic

Aquatic Food Web

FIG. 5.3—Food webs are interconnected food chains that show the feeding relations within a community. A food chain shows what eats what. Where arrows converge, competition may occur.



animals. Those 410 pounds of microscopic animals can feed 58 pounds of crayfish, snails, mussels, clams and aquatic insects. Those animals may in turn be eaten by up to 8 pounds of bluegill. Eating 8 pounds of bluegill will allow a largemouth bass to grow by 1 pound. An environment can support only a certain amount of life at each step of the energy pyramid. The higher up the energy pyramid an animal feeds, the fewer of this kind of animal the environment can support. Most energy pyramids can continue for only four or five trophic levels and can support only a few top-level consumers.

Consumers tend to specialize in the way they get their food. This feeding specialization is part of the animal's niche. Predation is a form of competition. Both predator and prey are competing against one another for survival; the predator is seeking food, and the prey is trying to keep from being eaten. To complicate matters, a species may be both a predator and prey at the same time. Predator/prey relationships develop naturally within a community. These relationships help to balance numbers within a group. Predators play an important role by keeping populations of prey species below their carrying capacity. At the same time, the amount of prey available in a predator's habitat can limit the number of predators that can live there.

For example, catching all the largemouth bass in a pond could lead to an overabundance of sunfish, since bass eat sunfish. With nothing to eat the sunfish and keep them below carrying capacity, they might in time become too numerous. Too many sunfish could eat all the snails and tadpoles in the pond. Without tadpoles to eat the algae, the algae could grow too much. An overgrowth of algae could use up all the available plant nutrients. The overgrown algae might then die all at once. Decomposers such as bacteria would feed on the dead algae. This process could use up all the dissolved oxygen in the water, which ultimately could result in the death of all the fish in the pond!

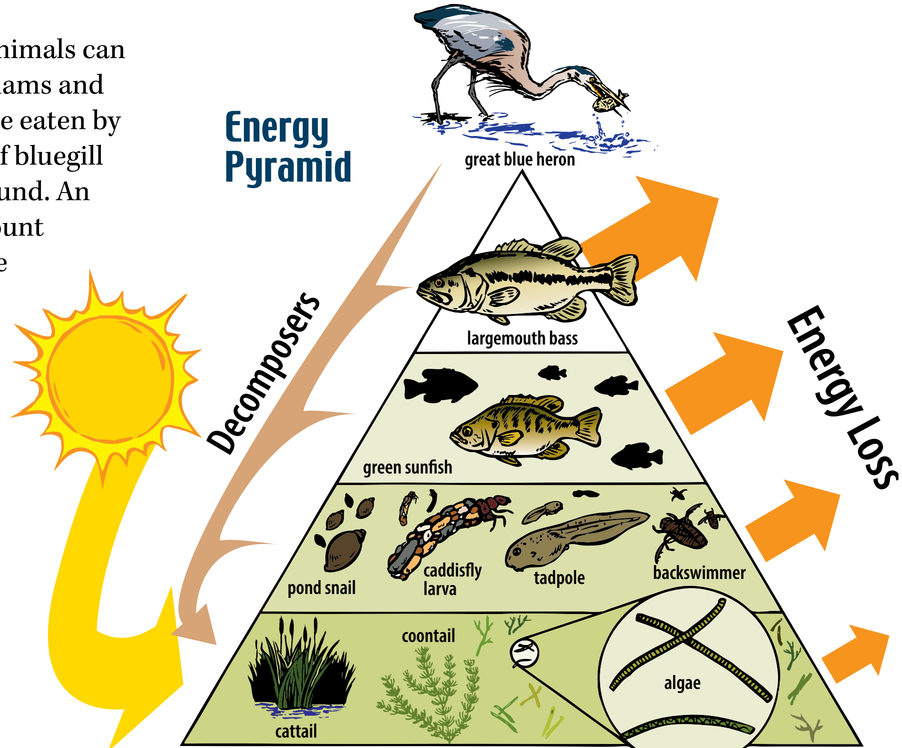


FIG. 5.4—As energy flows through the aquatic community, all organisms capture a portion of that energy and transform it to a form they can use. But this process is inefficient—only a little energy from each level of the energy pyramid is transferred upward. The rest is lost hunting for food, generating body heat or in other life processes.

Competition between members of a species is the driving force of **natural selection**. Natural selection is the process of sorting individuals based on their ability to survive and reproduce in their environment. Natural selection ensures that only the best-adapted species survive and reproduce. It happens as members of a species compete for resources, such as food, water, territory and sunlight. Some varieties of a species "win" because they are the ones best suited for survival in the environment. The tendency for the fittest, healthiest and most adaptable organisms to survive and reproduce helps the population to pass on useful traits and abilities to future generations. As a result, the species changes over time as it adapts to the environment in which it lives. All aquatic plants and animals, including fish, have adapted over millions of years to live in water.

Alien invasion!

Human-caused habitat destruction is the biggest threat to aquatic communities. Another serious threat is **invasive species**. A species is called invasive if it has been brought (usually by human action) to a place where it did not live naturally. If the invasive species can breed and sustain itself in the new habitat, then there is likely to be trouble. The invasive species may compete with native species for habitat or food. This competition could make it harder for the native species to survive. Over time, this invasion can unbalance the community. As a result, native species could become endangered.

6 Missouri's Aquatic Ecosystems

Questions to consider

1. What is an ecosystem? What are some of the parts of an ecosystem?
2. How do the parts of an ecosystem interact with one another?
3. What are Missouri's aquatic regions? How do the characteristics of the land affect the nature of the water?
4. What kinds of aquatic ecosystems do we have in Missouri? How are they alike or different from one another?
5. What is biodiversity? Why is it important?
6. How do humans impact aquatic ecosystems?
7. How can we help conserve aquatic ecosystems?

An **ecosystem** is a complex web of relationships between living and non-living things. The biotic parts of the ecosystem are the communities of plant and animal populations, including humans. The abiotic parts include sunlight, air, water, temperatures, soil and minerals. Each part of an ecosystem is connected to and depends on all the others. It takes all the parts interacting to make the system work. As Sierra Club founder John Muir said, "When one tugs at a single thing in nature, he finds it attached to the rest of the world." All populations living together within a community interact with one another and with their environment to survive and maintain a balanced ecosystem. Conversely, a healthy, balanced ecosystem provides for all the needs of the communities that live in it. Ecosystems organized around bodies of water are called **aquatic ecosystems**. The study of ecosystems is known as ecology.

The characteristics of the land in each of Missouri's five physiographic regions affect the nature of Missouri's waters and watersheds. Missouri has four different aquatic regions. The four regions are the Ozarks, Prairie, Lowland and Big River. Just as different watersheds create different water bodies, different aquatic regions support different kinds of life. (FIG. 6.1)

Three kinds of aquatic ecosystems

Missouri has three kinds of aquatic ecosystems: streams, lakes and wetlands. (FIG. 6.2) **Rivers** and **streams** contain flowing water. Rivers are just large streams. **Lakes** and **ponds** contain standing water. Lakes are larger than ponds. **Wetlands** are covered with shallow water at least part of the year. Missouri has two main kinds of wetlands—**marshes** and **swamps**. Marshes have cattails or other grass-like plants. Swamps have trees or woody shrubs. Other aquatic ecosystems not found in Missouri are oceans and estuaries, the places where rivers and oceans meet.

Streams

A stream is a body of water with a measurable **current**. The current flows between two stream banks and over an underwater streambed. Scientists use the word "stream" to describe all flowing natural waters. Streams are ever-changing systems that move, store and transform water. They also move, store and transform sediment and organic matter. Streams are constantly moving and changing. As someone has said, "You can't step into the same river twice."

Missouri has lots of different kinds of streams that vary from one corner of the state to the other. They have different sizes, shapes, lengths, flow rates, plants, animals, water quality and streambed composition. Regardless of their size, shape or location, however, all healthy Missouri streams share a common feature. They are diverse ecosystems. The plants and animals living in them exist in balance with the processes that recycle nutrients within an ecosystem. The healthiest streams are those that are closest to their natural state.

Lakes and ponds

Lakes and ponds are among Missouri's most well-known aquatic ecosystems. You may be surprised to learn, however, that Missouri actually has very few natural lakes or ponds. Those we have were formed from bends in rivers or streams that got cut off from the main channel. These are called **oxbow lakes**.

Missouri's aquatic regions (FIG. 6.1)

Missouri has four different aquatic regions: the Ozarks, Prairie, Lowland and Big River.

Big River

The Big Muddy gets its nickname from the high sediment load it picks up from its prairie watershed. The Missouri River once occupied a wide, braided channel with many islands, backwaters, sloughs, oxbow lakes and floodplain wetlands. In the 20th century, engineers straightened and restricted the Missouri into a single narrow channel with a swift current to make it easier for barges to navigate. While it still looks muddy to us today, it is in fact much clearer than it was in its natural condition. Like the Missouri, the Mississippi south of the meeting of the rivers has been straightened to enable barges to use it. Upstream from St. Louis, dams divide the Mississippi into a series of lake-like "pools." These pools flooded the shallow rapids that made navigation difficult. Big rivers harbor big fish. Blue catfish, flathead catfish, buffalo, drum, paddlefish and three species of sturgeon make the big rivers their home.

Prairie

The Osage Plains and the Dissected Till Plains of northern Missouri have similar aquatic communities. Prairie streams flow through broad, flat valleys that slope gradually through deep soil and other loose material. Originally these streams wound back and forth extensively, leaving oxbow lakes, sloughs and marshes. Most have now been straightened to accommodate intensive agriculture. The fish species in this region are less varied than in other regions, and aquatic plants are sparse.

Ozarks

Ozark streams run in narrow, steep-sided valleys bordered by sheer limestone/dolomite bluffs. The streams themselves are a series of short pools and well-defined riffles. Chert gravel and cobble and limestone/dolomite boulders and bedrock form the streambeds. Many springs feed these streams, while in other places streams lose water to the ground below. The abundance of springs keeps these streams cool year-round, allowing them to support smallmouth bass and even transplanted trout. Over a third of Missouri's fish species occur in the Ozarks, and more than a dozen species occur nowhere else in the world.

Lowland

Before Europeans and their descendants settled in Missouri, a cypress-tupelo swamp covered the southeastern lowlands. Floodwaters of the Mississippi River frequently swept as far west as the St. Francis River. In the early 1900s, developers cut the forests and dug 1,200 miles of drainage ditches. Today the lowlands support intensive agriculture. Draining the swamp greatly altered lowland aquatic animal communities, reducing species that favored still water and increasing those characteristic of flowing water.

(FIG. 6.3) Missouri also has natural sinkhole ponds, formed by collapsing cave systems. Most other lakes and ponds in Missouri are artificial. Large lakes are formed by damming rivers or streams. Small ponds are formed by trapping water in valleys or other low spots in a watershed. These range from small farm ponds of less than an acre to large reservoirs such as the Lake of the Ozarks.

A pond is a body of standing (not flowing) water. It is shallow enough that sunshine can reach the bottom, allowing rooted plants to grow completely across it. Its water temperature is fairly even throughout the pond and changes with air temperature. There is little wave action, and the bottom is usually covered with mud. Lakes are bigger than ponds. While lakes and ponds have much in common, a lake's larger size makes for some differences, including differences in oxygen levels, plant growth and temperature. Like ponds, lakes also benefit from plant **buffers** and other conservation methods to keep their waters clean and clear.

Swamps and marshes

Wetlands are the most productive ecosystems in the world. No other type of ecosystem has more value to countless species of wildlife. Wetlands provide many benefits to humans and the environment, and they offer endless hours of outdoor fun. Yet wetlands have a bad reputation. To some people, the word "wetland" means a stinky, bug-infested wasteland. Others think wetlands should be drained and put to "better" use. The truth is, healthy wetlands are very important to us.

Most of our country's wetlands have been destroyed over the last 70 years. Over half of them have been lost as a result of drainage and filling. Many of the wetlands that are left suffer from sedimentation, pollution and changes people have made. Of the 2.4 million acres of swamp that once stood in southeast

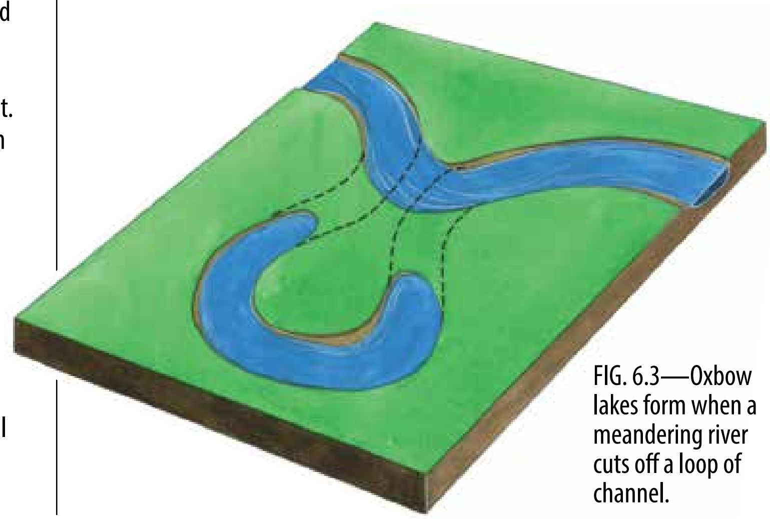


FIG. 6.3—Oxbow lakes form when a meandering river cuts off a loop of channel.

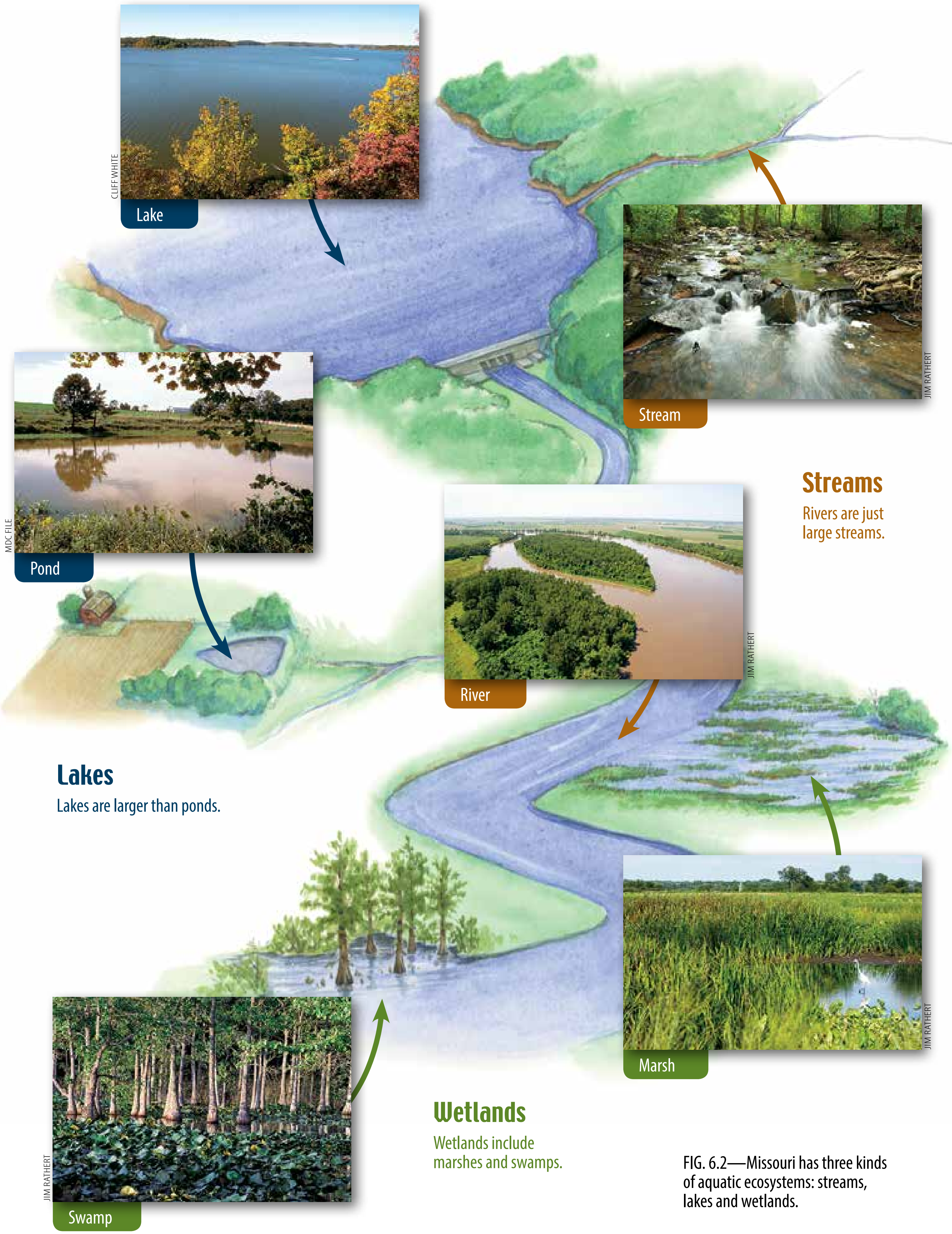


FIG. 6.2—Missouri has three kinds of aquatic ecosystems: streams, lakes and wetlands.

Managing aquatic ecosystems

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Fisheries biologists manage bodies of water for fishing. They conduct research studies including electrofishing surveys. They also work to improve aquatic habitat, fishing quality, fish community health and biodiversity, and write management proposals and reports. Fisheries biologists analyze fish scales to determine fish age and growth, conduct water-quality analyses, and survey fishermen to determine harvest and catch rates. They manage resources to maximize a water body's potential as a sustainable fishery. The Missouri Department of Conservation employs fisheries biologists throughout the state. These jobs usually require at least a bachelor's degree in fisheries management or a related field.

Missouri, less than 60,000 acres, or 2 percent, survive today. (FIG. 6.4) Statewide, 87 percent of Missouri's wetlands have been destroyed. Missouri once had 4.5 million acres of wetlands, mostly along major rivers. The **sloughs** and oxbow lakes along the Missouri and Mississippi rivers are gone. So are the wooded swamps of southeast Missouri. But today people are starting to understand and see the value of our wetland resources. Taking care of the wetlands that are left and putting some back are some of conservation's biggest challenges today.

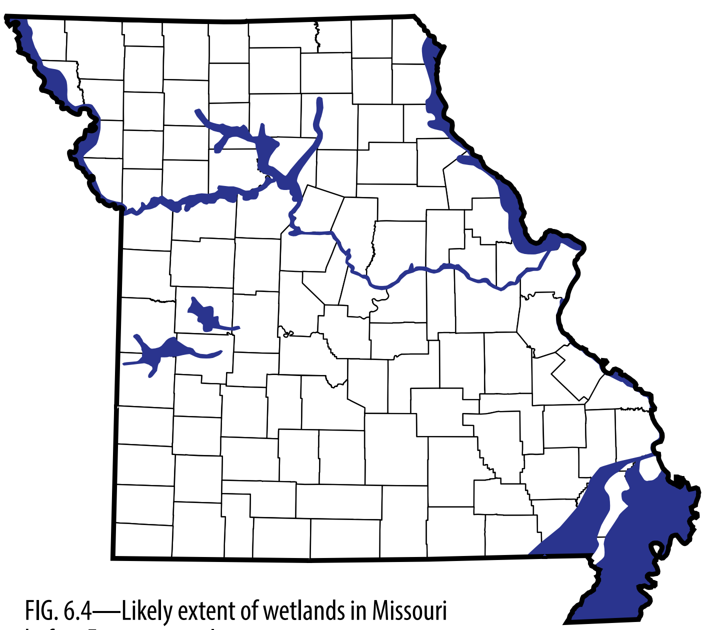

FIG. 6.4—Likely extent of wetlands in Missouri before European settlement.

Healthy ecosystems are said to be balanced, but balanced does not mean unchanging. Ecosystems are always changing. They may change in response to natural or human-caused events. For example, heavy rains can force a river to change course, leaving the old channel high and dry. A human activity such as straightening a stream speeds up erosion and cuts out curves that shelter fish and other aquatic life. Changes may destroy habitat for some species and create it for others.

Whether changes are good or bad depends on how they affect the ecosystem's **biodiversity**. This term refers to the variety and number of different organisms and populations, and the way they live together. The greater the biodiversity in an ecosystem, the healthier, more sustainable and better balanced it is. Some human activities that can reduce aquatic biodiversity are draining a swamp, damming a river or pumping out water. These activities destroy habitat, which is the main cause of species decline. Therefore, protecting and restoring a wide variety of habitat helps keep species from becoming endangered or extinct.

7 Rivers and Streams

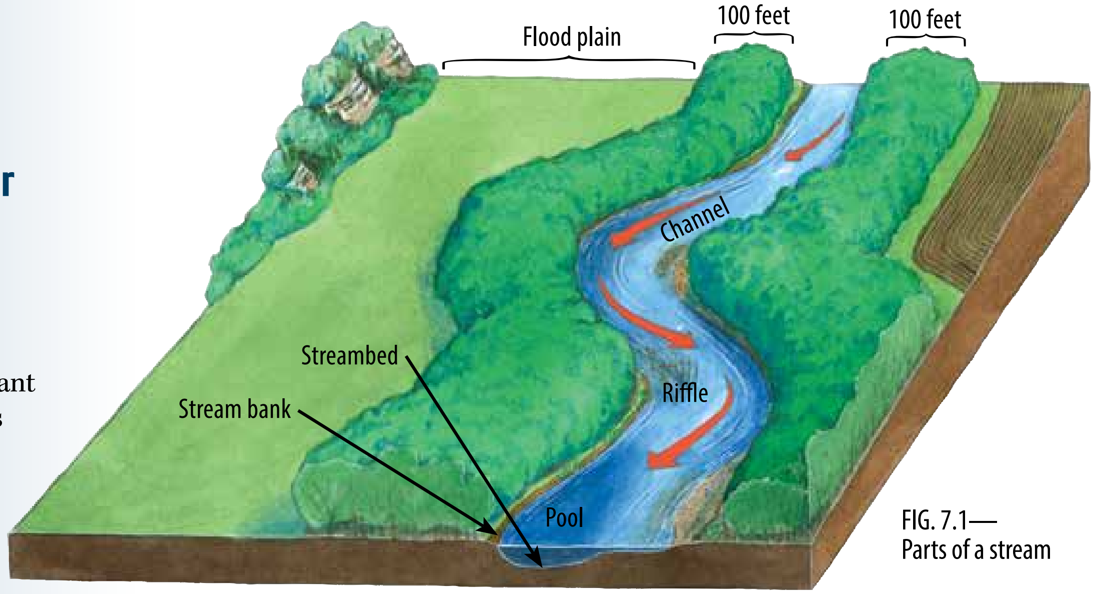

FIG. 7.1—
Parts of a stream

Questions to consider

1. What are the parts of a stream? How do they function together?
2. What is the riparian zone? Why is it important to have plenty of plants growing alongside a stream?
3. What is the floodplain? Are floods natural disasters?
4. What is stream order? How can it help us understand the aquatic community living in a particular place?
5. What can the presence or absence of aquatic invertebrates tell us about the health of a stream?
6. How are plants and animals adapted to living in flowing water?
7. How can rivers and streams be kept healthy?

Anatomy of a stream

When most people think of a stream, they're really thinking of the stream **channel**. (FIG. 7.1) The channel is the part of the stream where water collects to flow downstream. Stream channels always run downhill. In a straight stretch of river, the main force of the current is in the middle. The deepest water is also in the middle. The part near the shore is the shallowest. When there is a sharp bend in the river, however, the strongest current and deepest water is at the outside edge of the bend. In flowing water, there is less current near the bottom.

Deeper, slower-moving places in the stream channel are called **pools**. The shallow, faster-flowing places are called **riffles**. Healthy streams have riffle-pool-riffle sequences. These alternating slow and fast moving waters make great homes for aquatic life. Riffles mix oxygen into the water, which makes it better for the **invertebrates** living there. The invertebrates (mostly immature insects) provide a food source for fish.

But the channel is only one part of the stream. The **stream banks** are the shoulder-like sides of the stream channel—the part from the water's edge to the higher ground nearby. Stable stream banks have plenty of plants growing on them. The roots hold soil in place and minimize erosion. Stems and leaves slow the water and collect sediment. When a stream bank erodes, it can fill the stream's pools with sediment. Major erosion and sedimentation can smother aquatic life and destroy their habitat.

The **riparian zone** is the land next to the stream (starting at the top of the stream bank). A riparian zone with heavy plant cover 100 feet on either side of the stream may be the stream's best defense against pollution and other problems in the watershed. (FIG. 7.2) This zone buffers the stream from potential problems. Plants growing in the riparian zone keep the stream healthy in many ways. Trees


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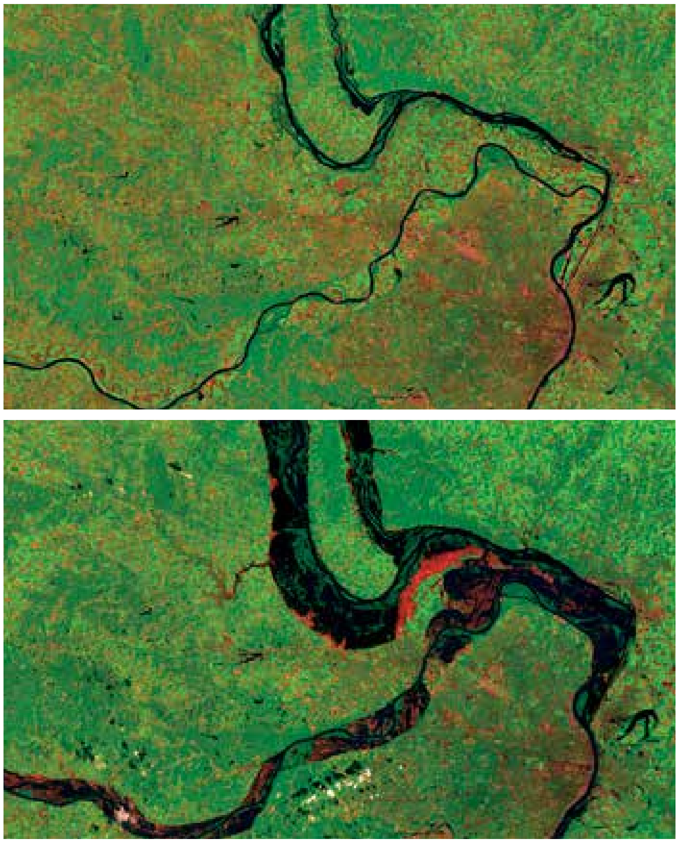
FIG. 7.2—A plant-filled riparian zone is essential to stream health.



DATA PROVIDED COURTESY THE LANDSAT PROJECT SCIENCE OFFICE AT NASA/GODDARD SPACE FLIGHT CENTER

FIG. 7.3—Satellite photos of the St. Louis region where the Missouri and Mississippi Rivers meet show a normal year (top) and during the flood of 1993 (bottom).

shade and cool the water, which increases the amount of dissolved oxygen the water can hold. Shaded stream segments may be as much as 10 degrees cooler than segments exposed to direct sunlight. Roots help hold the stream banks together. Leaves and branches falling into the water provide organic matter for aquatic food webs. Riparian plants offer habitat to birds, bats and other wildlife.

Further out from the stream channel is the **floodplain**. This is the flat land on both sides of the river or stream. During a flood, a stream's extra water spreads out to cover the floodplain. (FIG. 7.3) Flooding is a natural characteristic of all streams. By allowing excess water to spread out, floodplains reduce the floodwater's speed. As a result, less damage occurs in the stream and to regions downstream. In Missouri, floods large enough to overflow into the floodplain occur about every two to two-and-a half years. People tend to forget the function of floodplains and build roads, houses and levees in them, resulting in property loss during floods. (FIG. 7.4) While we tend to think of floods as natural disasters, they are really natural events and processes that have positive effects on stream ecosystems. The only disaster comes when humans put things in the water's way.

Changing to stay the same

All of these parts make up the stream system. Each part works together. The stream system moves water and sediment, temporarily stores excess floodwater and filters and traps sediment and pollutants. It also recharges and discharges groundwater, purifies instream flows and provides habitat for plants and animals. All streams have a natural tendency to follow a zig-zagging path. This is the stream's way of reducing the water's downhill speed. Fighting this tendency by channelizing or straightening the stream worsens erosion and sedimentation as the stream tries to return to a natural path. The stream is always changing to keep a healthy balance. For example, when sediment from the watershed enters a stream, the water in the channel carries it and releases an equal amount of sediment somewhere else. This ongoing balance is important. When extreme flooding damages a stream, all its parts work together to return it to a balanced but ever-changing state.

Precipitation first collects at the top of the watershed, in the headwaters. From there water flows downhill in tiny trickles too small to create a permanent channel. When these trickles finally combine and begin carving a channel, they form a **first-order stream**, a small stream with no tributaries coming into it. First-order streams combine to form larger second-order streams. These larger streams combine to form even bigger third-order streams and so on. At its mouth, the Current River is a seventh-order stream; the Mississippi is a 10th-order stream when it empties into the Gulf of Mexico; the Amazon River, the world's largest, is a 12th-order stream by the time it reaches the Atlantic Ocean.

Stream order and aquatic communities

Knowing the order of a stream and whether it has a perennial or intermittent flow can help you understand what aquatic life it can support. (FIG. 7.5) In the headwaters of a stream, the water is shallow and there

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FIG. 7.4—The floodplain is really part of the river, as nature sometimes reminds us. (Jefferson City, 1993)

are few aquatic plants. This lack of resources limits the number of animals that can live there. Since there is little aquatic plant growth at the headwaters, animals at the bottom of the food web depend on what falls or is washed into the stream. Insects, such as immature stoneflies, chew and tear these leaves and stems into tiny bits. They are called **shredders**. Small pieces that are not eaten by shredders are eaten by **collectors** (for example, immature mayflies) that gather food. **Grazers** (snails, for example) appear further downstream. As the grazers feed, they turn leaves and other big chunks of plant matter into smaller bits, which are eaten by collectors (such as mussels). Most fish that live in headwater streams are small predators such as darters or minnows. They feed on other smaller animals, such as insect larvae. Since they also eat grazers and collectors, they search for areas where there are lots of kinds of insects.

Mid-level streams (stream orders three through five) have both rooted and floating aquatic plants, and many more types of animals have a niche in which to live. Grazers such as snails and water pennies eat the growing plants. Collectors increase with the varied plant life. As the water and plants increase, shredders begin to decrease. A large variety of fish species, including many fish from headwater streams, live in the mid-level streams. **Anglers** (fishermen) like to pursue fish living in these streams.

When streams meet, the water mixes and flows downstream. Individual characteristics of the smaller streams and nutrients from each watershed combine into a big river. Few rooted plants grow because the water is too deep and very cloudy. Here, there are more collectors than shredders. One major group of collectors in big rivers is mussels. Big river fish species in the collector category include paddlefish, shad and suckers. These large collectors specialize in eating smaller animals. Big river predators range in size from tiny plankton to 80-pound blue catfish.

Stream food webs are easily upset. Excess plant nutrients, such as fertilizers or animal waste, can cause algae growth that can choke the stream. Algae can multiply rapidly to cover the surface of the water, forming a shade that prevents the sunlight from getting through. Underwater aquatic plants then cannot photosynthesize food, so they begin to decay. Decomposition of dead plants removes oxygen from the water, causing fish to die.

Indicators of good water quality

Besides testing the physical and chemical characteristics of the water, water quality experts also look for certain invertebrates that live in riffles on the stream bottom. Examples include the immature stages of stoneflies, caddisflies and mayflies. These insects are sensitive to pollution. The presence of such species generally indicates good quality water. When they are missing from a stream or when only pollution tolerant species such as black fly larvae and bloodworms are present, we know that something is wrong with the water. Biodiversity—a high number of species—as well as a high number of sensitive species living in a stream are good signs of a healthy stream. (FIG. 7.6)

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Soil and water conservationists

Soil and water conservationists work with farmers, ranchers and other land users to help them prevent erosion, improve water quality, manage nutrients and protect and preserve wildlife habitat. Agencies such as the Natural Resources Conservation Service, the Missouri Department of Conservation and local soil and water conservation districts hire people with degrees in soil science or related agricultural or natural resource fields.

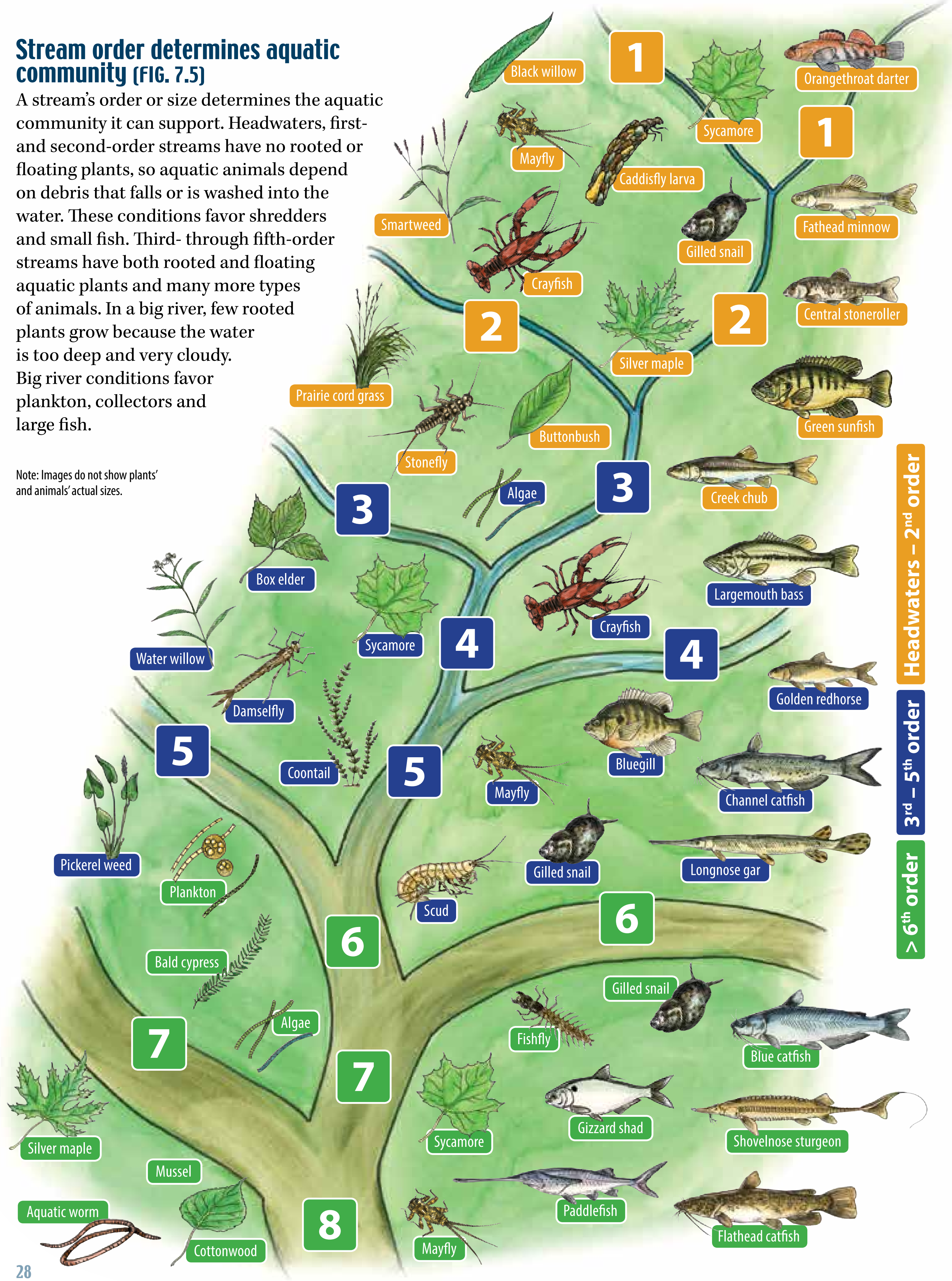
JIM RATHERT

FIG. 7.6—Some stream insects such as this stonefly nymph are more sensitive to pollution than others. Their presence or absence in a stream can help us determine the stream's health.

Stream order determines aquatic community (FIG. 7.5)

A stream's order or size determines the aquatic community it can support. Headwaters, first- and second-order streams have no rooted or floating plants, so aquatic animals depend on debris that falls or is washed into the water. These conditions favor shredders and small fish. Third- through fifth-order streams have both rooted and floating aquatic plants and many more types of animals. In a big river, few rooted plants grow because the water is too deep and very cloudy. Big river conditions favor plankton, collectors and large fish.

Note: Images do not show plants' and animals' actual sizes.



Stream plants and animals have developed special adaptations for life in river and stream habitats. (FIG. 7.7) Plants living in moving water have long, thin, flexible stems that offer little resistance to the current and strong root systems to hold them in place. Mussels burrow to avoid the current and snails use a broad, flat foot to stick to rocks. Water birds have long legs for wading and hunting or webbed feet for swimming and diving. River otters have an oily coat to keep them dry and warm. Fish such as bleeding shiners have streamlined bodies that allow them to remain stable in currents. Sculpins and many darter species are adapted as bottom clingers. They tend to have flattened heads and large pectoral fins that are angled to help them stay on the bottom in swift currents. With these advantages they can stay in the swift water of riffles and pick invertebrates from the rocks.

The diversity of plant species and clean sources of water make the streamside or riparian woodlands attractive to wildlife. Nuts, fruits, roots and grass are among the useful products found in this type of habitat. Trees, grasses and other plants provide shelter and cover for many species of wildlife. Various-sized trees serve as specific habitats. After trees have died, their decaying logs provide shelter for snakes, rodents and other ground-dwelling species. Some animal species use riparian woodlands through all stages of their lives.

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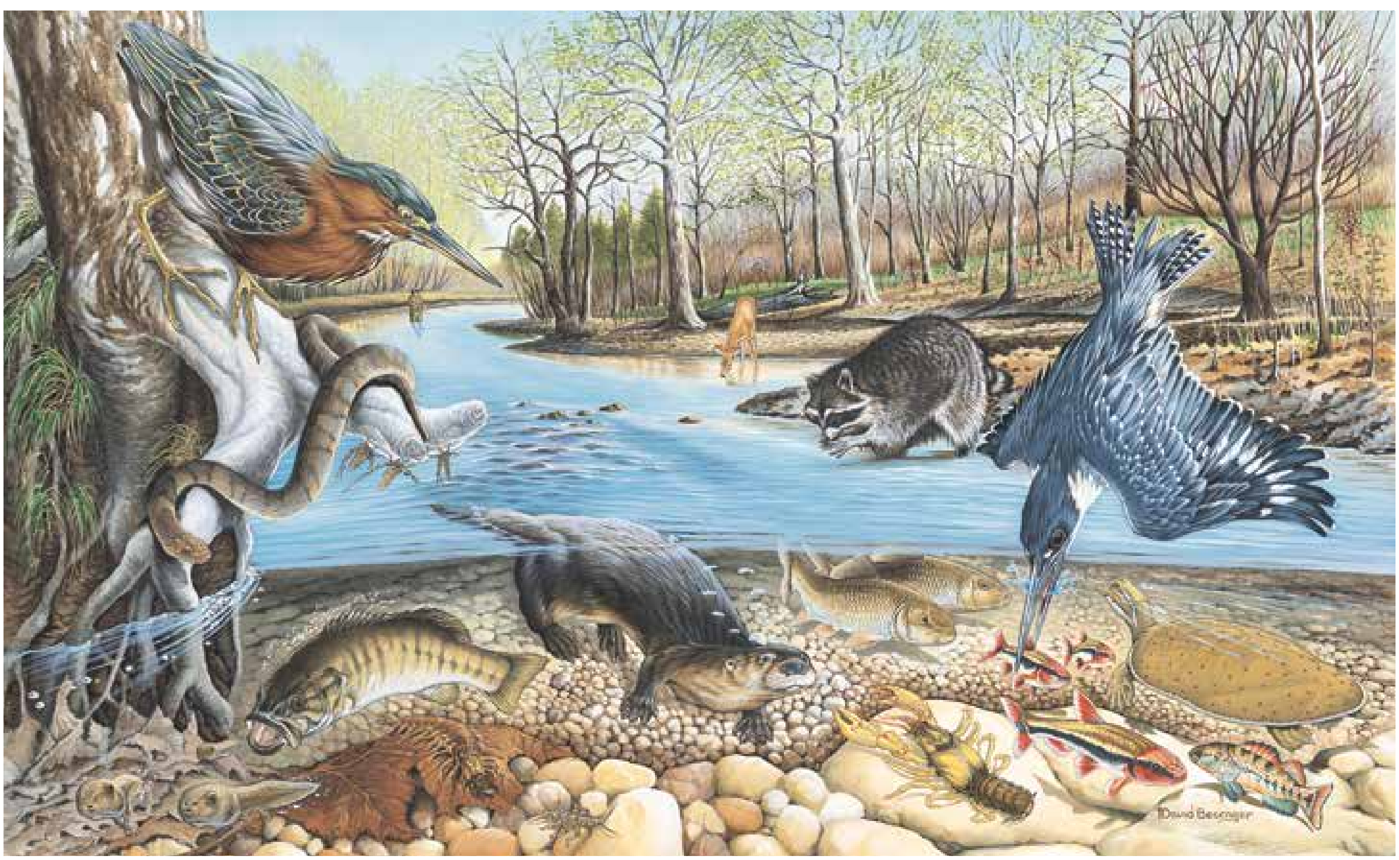
FIG. 7.8—Missouri: Where the rivers run

Enjoy Missouri streams

It's hard to imagine a better slogan for Missouri than "Where the rivers run." (FIG. 7.8) Streams zigzag across Missouri in ever-changing and fascinating but predictable patterns. They host a dazzling array of life. Canoe an Ozark stream or fish a big river and get in touch with just how precious these resources are. Then join a Missouri Stream Team and help clean up a stream in your community, learn to check water quality, learn more about watershed conservation, and take part in the many conservation activities offered.



DAVID BESENGER

FIG. 7.7—Healthy stream ecosystems support a dazzling array of living things.

8 Lakes and Ponds

FIG. 8.1—Missouri has few natural lakes and ponds—oxbow lakes formed by rivers and sinkhole ponds formed by collapsed caves. More common are farm ponds and reservoirs formed by damming rivers.

Questions to consider

1. How do oxygen levels in ponds change during each 24-hour period?
2. What kind of organism makes up the greatest amount of living material in a pond?
3. Besides providing food, what other roles do plants have in lake and pond ecosystems?
4. How are plants that live under water similar to plants that live on land? How are they different?
5. How do ponds change over time?
6. How are lakes similar to ponds? How are they different?
7. How can lakes and ponds be kept healthy?

Missouri has more than a quarter-million acres of public lakes and half-million acres of ponds. Both lakes and ponds are bodies of standing (not flowing) water, but lakes are larger. Most lakes and ponds in Missouri are artificial. These lakes are formed by damming rivers or streams. Small ponds are formed by trapping water in valleys or other low spots in a watershed. (FIG. 8.1) Some of Missouri's farm ponds were created to make up for water resources and aquatic habitat lost when wetlands were drained to create farmland and rivers were straightened to improve navigation.

A pond is shallow enough that sunshine can reach the bottom, allowing rooted plants to grow completely across it. Its water temperature is fairly even throughout and changes with air temperature. There is little wave action, and the bottom is usually covered with mud. As plants move in, they sink their roots into the pond bottom and hold the soil, making the water even clearer and allowing more plants to grow at greater depths. This is important to the life of a pond because the plants produce much more than food.

Ponds breathe

Out here in the air, oxygen levels are fairly constant, staying around 21 percent all the time. But in a pond the oxygen levels can vary wildly over the course of a day. This is because water takes up oxygen from the air more slowly than animals in the pond use it. Without plants, the animals would not have enough oxygen. Plants give off oxygen as a byproduct of photosynthesis. As the day goes on, plants release oxygen into the water, raising the overall level of dissolved oxygen in the pond. At night the plants stop photosynthesizing, but the pond's animals continue using oxygen. In this cycle the oxygen made each day is used at night. (FIG. 8.2)

Not all of the oxygen in a pond is made by the plants you can see. Some is made by plant-like plankton. These are tiny, free-floating plants. Most of them are species of algae. They release oxygen into the water and serve as food for tiny, free-floating animals (also called plankton) and larger animals that eat plankton. Underwater plants and plankton make up the food base for the entire pond ecosystem. Plankton makes up about 87 percent of the living stuff in a pond. (FIG. 8.3)

Animal-like plankton eat plant-like plankton and each other. Animal-like plankton can be larger, complex organisms, such as water fleas, or they can be as small as single-cell protozoa. (FIG. 8.4) Animal-like plankton is a major food source for many invertebrates, such as water scorpions and diving beetles, which eat almost nothing else. Plankton has a high protein content and there is a lot of it in lakes and ponds. Because of this, some fish have developed the ability to filter plankton from the water. Fish such as gizzard shad and paddlefish are **filter feeders**. They eat nothing but plankton. In the open water, plankton has no defense except luck against filter feeders. Other small animals are in a similar predicament. They also seek shelter among the plants and parts of plants growing underwater, which offer hiding places from predators.

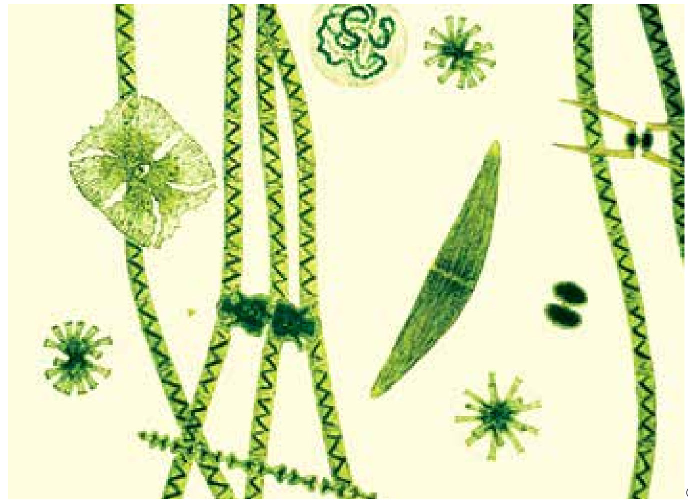


FIG. 8.3—Plant-like plankton are the food base of the pond ecosystem.

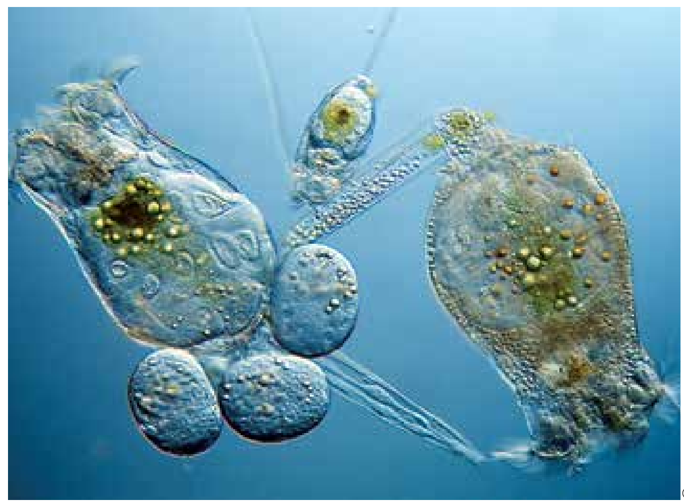


FIG. 8.4—Animal-like plankton are primary consumers of plant-like plankton, and are themselves food for secondary consumers such as filter feeders, newly hatched fish and many invertebrates.

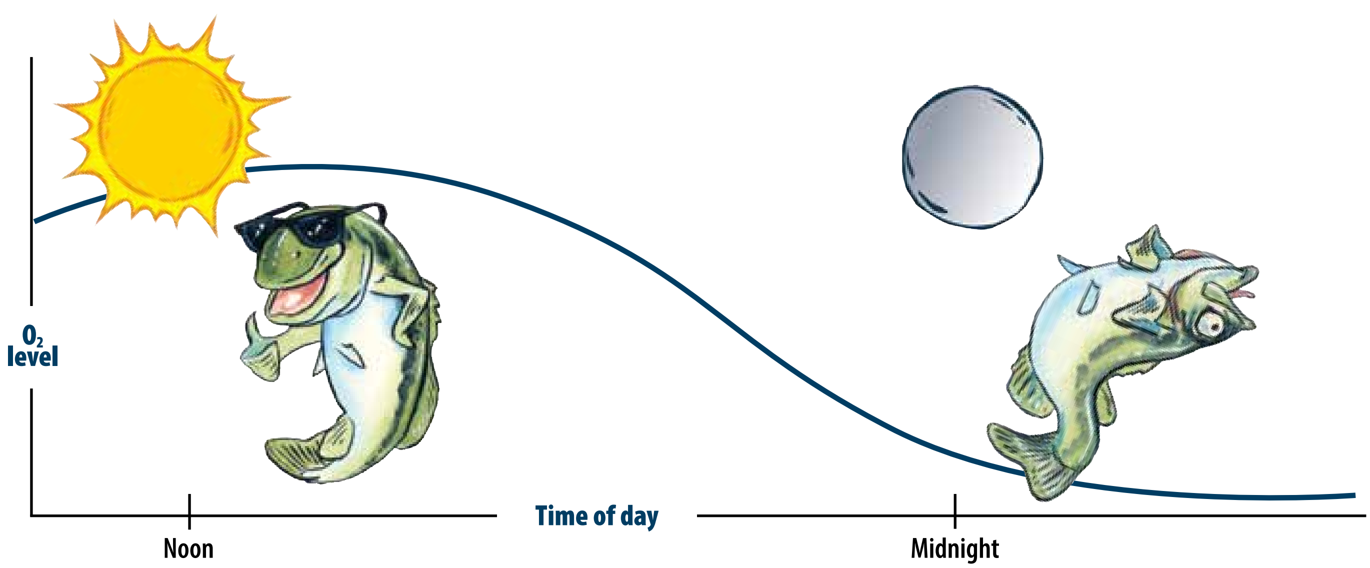


FIG. 8.2—Oxygen levels in a pond are high while the sun is shining and plants are photosynthesizing, but they can drop dramatically at night. If they drop too much, fish and other aquatic animals can die from lack of oxygen.

DAVID BESENGER

FIG. 8.5—Lakes and ponds are among Missouri's most well-known aquatic ecosystems.

A ring of life

Plants spread out in beds or clumps and attract a variety of animal life. But submerged plants can only grow as deep as the sunlight reaches into the water. Therefore, a lake or pond has most of its plant life in a ring around the shoreline, reaching out as far as it can survive. This ring holds the greatest variety of life to be found in the ecosystem. Mud around a pond often contains tracks of all kinds of animals. Look carefully—maybe a deer or raccoon has been there. (FIG. 8.5)

In North America around 5,000 species of insects spend some or all of their lives in the water. Many of these insects make plants their homes. The plant beds serve both as shelter from predators and as a food source for the insects. Insect-eating animals seek out the large number of insects in this area, too. They visit the plant beds to feed, forming a complex food web of predators and prey.

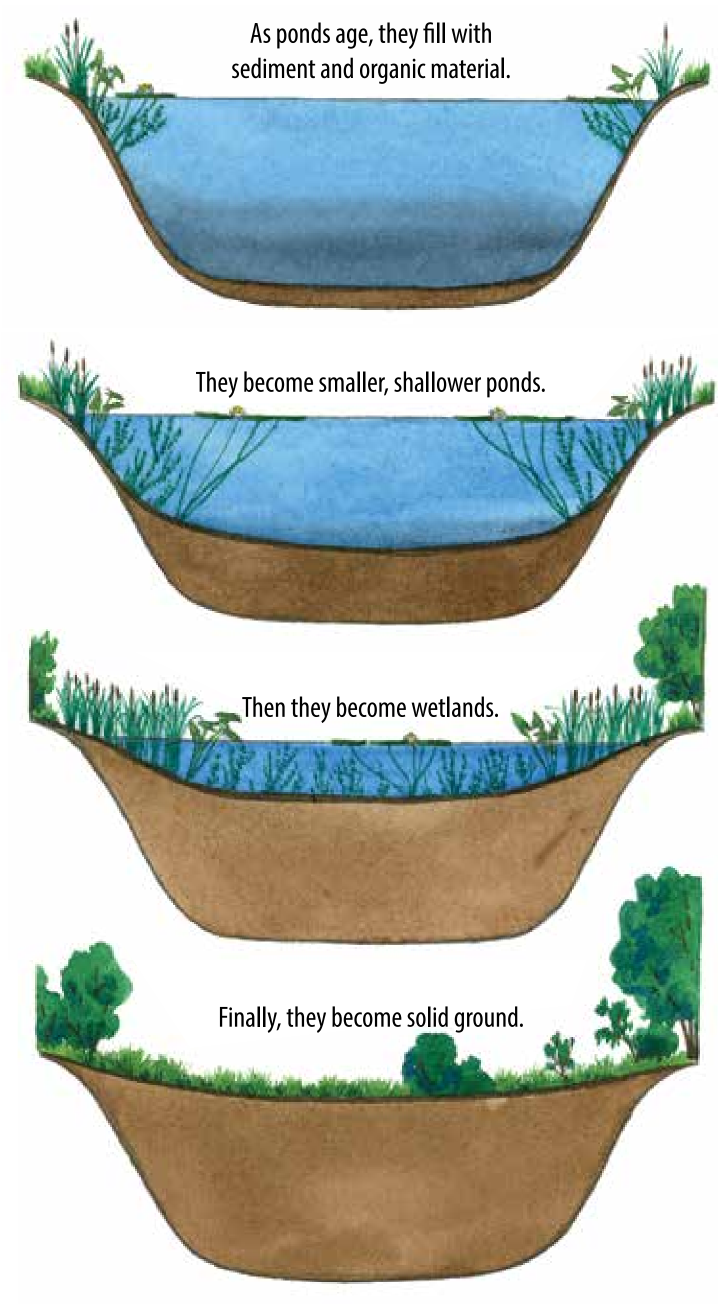
Some plants live entirely underwater, while others have some of their parts sticking out of the water. Plants that live underwater are like plants that live above water. They need water, carbon dioxide, sunlight and nutrients such as phosphorous and nitrogen. But water plants have special adaptations that help them thrive in their underwater environment. Waxy or slimy coatings protect them from drying out when water levels drop. Porous stems or leaves let them absorb minerals right from the water.

Ponds don't last forever

As water runs downhill through the pond's watershed, it picks up small bits of soil and anything else that can be moved. This erosion brings sediment to the pond, replacing water with soil and creating more shallow areas. Decaying plants and animals fall to the pond bottom, adding to and enriching the sediment. Plants thrive in the rich sediment and take up more space. In time the pond will become a wetland, then as it fills even more, a meadow. This natural process is called **pond succession**. (FIG. 8.6)

The surface water that fills a pond also can bring trouble in the form of pollution. Excess soil and plant nutrients can overload the pond and unbalance its growth cycle. A common result of this imbalance is too

Pond succession (FIG. 8.6)



much algae growth. Algae overgrowth makes the water cloudy and shades out rooted plants. When the excess algae dies, it creates a lot of decomposing material that uses up oxygen and causing the fish to die from lack of oxygen. This can speed up pond succession. (FIG. 8.7)

Because every water body is a reflection of its watershed, good watershed management is important to keeping a pond healthy. Stopping excess erosion and runoff loaded with fertilizers, pesticides or other pollutants is key. Keeping a 100-foot-wide buffer of thick plant growth around the pond helps filter out pollutants and eroded earth before they reach the pond.

FIG. 8.7—Bubbling mats of free-floating or hair-like algae and dead fish indicate that excess nutrients have caused overgrowth of algae, resulting in oxygen depletion in this pond.

A plant buffer will greatly improve the pond's health and extend its life. The same is true for lakes.

Lakes are bigger than ponds

While lakes and ponds have much in common, a lake's larger size makes for some differences. These include oxygen levels, plant growth and temperature. In a lake, the amount of oxygen dissolved in the water stays pretty even over a 24-hour period. While a strong wind can ruffle up a pond's surface, on a lake, it can whip up high waves. This mixes oxygen into the water.

In at least some places, the water in a lake is too deep for plants to grow on the bottom. Only in the area around the shore is the water shallow enough for sunlight to reach plants growing on the bottom. The ecology of the shoreline zone is like pond ecology. (FIG. 8.8)

A lake also has an open-water zone away from shore, as far down as sunlight reaches. Most large fish spend most of their time in this zone, swimming into the shoreline zone now and then to feed or spawn. In the deep-water zone, below the open-water zone, not enough light reaches the bottom for plants to grow. This makes the deep-water zone oxygen poor, and not much lives there. Dead organic matter sinks to the lake bottom, where bacteria and other decomposers break it down.

The temperature in a lake is fairly even from day to day in a given season. However, in summer, lake water is much warmer on top in the shoreline zone and the open-water zone than in the deep-water zone. In the fall, temperature changes cause the layers to mix, bringing decaying organic matter from the bottom up to the surface. We may not like the smell, but this is a natural process that mixes nutrients, minerals and oxygen throughout the lake.

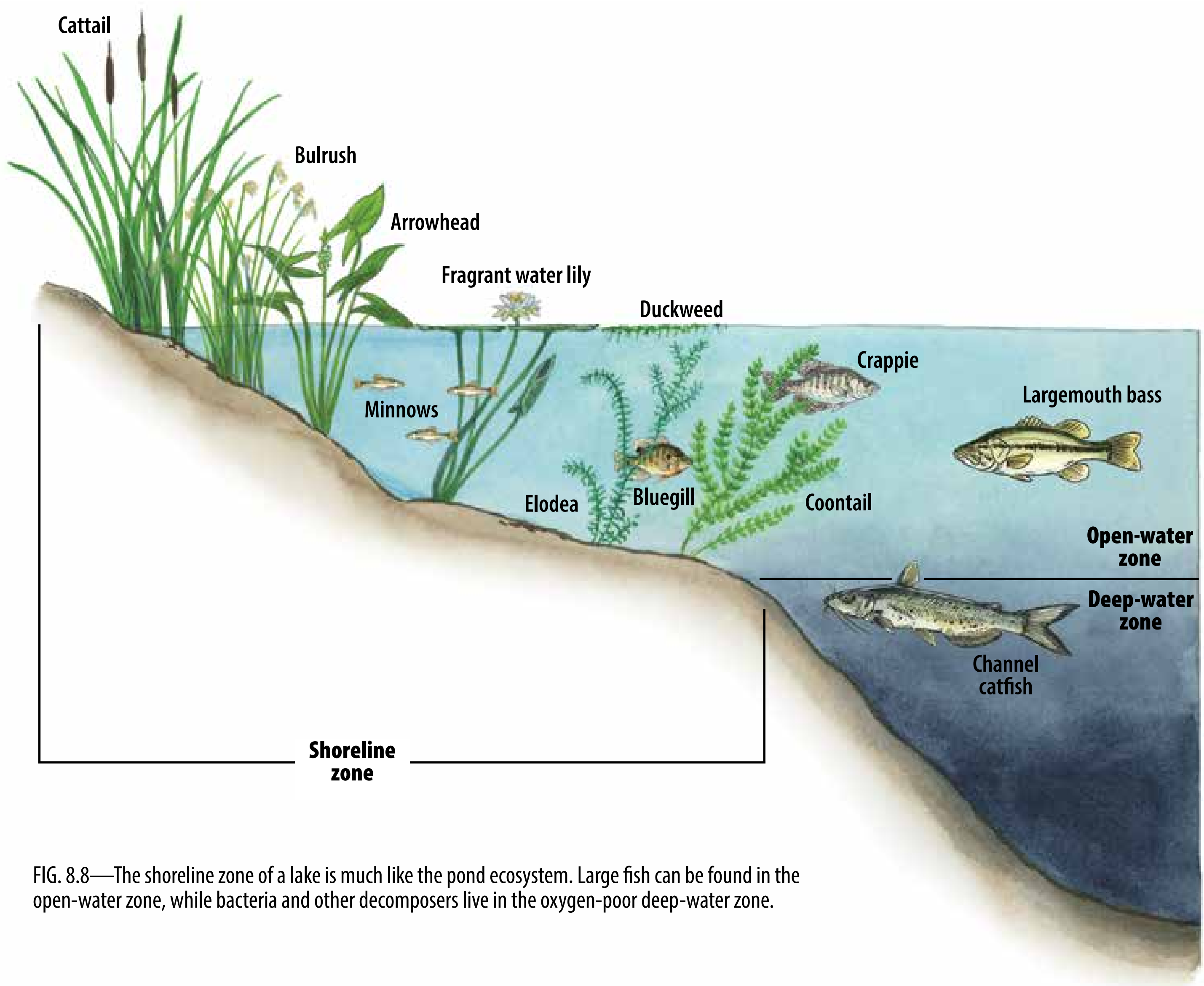


FIG. 8.8—The shoreline zone of a lake is much like the pond ecosystem. Large fish can be found in the open-water zone, while bacteria and other decomposers live in the oxygen-poor deep-water zone.

Lake and pond management

Lake managers provide the good watershed management needed to maintain a healthy lake or pond. Like fisheries biologists, they often manage resources to make the most of the lake as a place to fish. Many have degrees in fisheries management. Besides working for agencies such as the Missouri Department of Conservation, lake managers sometimes go into business for themselves, working as independent advisors and managing a number of lakes for several customers.

CLIFF WHITE

9 Swamps and Marshes

Questions to consider

1. What is a wetland? What three factors must be present for a place to be considered a wetland?
2. What are the main types of wetlands found in Missouri? What are the differences and similarities between them?
3. What is different about wetland soil? How does it get that way? How can we recognize it?
4. What are some examples of the special adaptations found in wetland plants?
5. How are wetlands important to Missouri's fish, birds, and other wildlife?
6. How do wetlands improve water quality?
7. How do wetlands provide natural flood control?

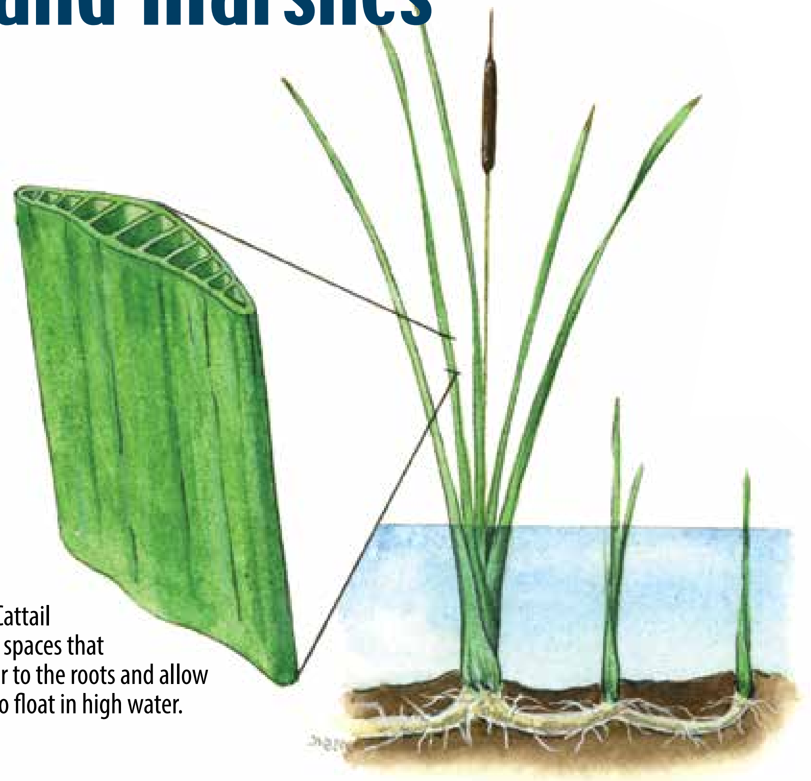


FIG. 9.1—Cattail leaves have spaces that transport air to the roots and allow the leaves to float in high water.

Wetlands are wet land

Wetlands are places where the land and water meet. In a wetland, the soil is saturated or covered with water at least part of the year. Staying wet gives the soil unique properties. In those places, the wet land becomes a home to a wide range of plants and animals that live in the soil and on its surface. Wetland plants are specially adapted to live in saturated soil. Missouri has two main types of wetlands: marshes, where reeds and other grasslike plants grow, and swamps, in which woody species (trees and shrubs) thrive. But the key ingredient in a wetland is water.

All wetlands are wet for a major part of the growing season (spring and summer). Some wetlands may have standing water. Others may only appear slightly muddy, or may even seem dry at the ground's surface. But dig a hole and it will fill with water very quickly. The soil holds water like a sponge.

When soil is saturated the space between the bits of dirt is filled with water. This leaves little or no room for air, giving the soil a grayish color and a gooey texture. In the water, tiny creatures break down dead plant and animal matter called **detritus**. Because the detritus layer settles beneath the water and is not exposed to air, special kinds of decomposers are needed. **Anaerobic** bacteria, which do not need oxygen to live, are the stars of the wetland ecosystem. As they break down the detritus, they produce sulfur-containing compounds. The sulfur compounds smell like rotten eggs. But the smell tells us the wetland is healthy. The rich detritus nourishes a complex food web.

How to breathe under water

Wetland plants are adapted to take advantage of every ray of sunlight. They have special ways to expose their leaves to the sun and avoid being shaded by other leaves. They also have roots that can pull in water and still get air, too. Plants that grow in shallow water have roots that grow in the mud and hold onto silt. Most of these plants are tall because they have greater support, enabling them to rise above other plants to reach the sun. Cattails, buttonbush, rushes, sedges and arrowheads do this very well. Other plants such as water lilies grow in deeper water but are still anchored. Plants such as duckweed grow in open water to avoid the shade of taller plants, but they float by using air spaces in their leaves. (FIG. 9.1) Their short roots hang free in the nutrient-rich water. Another challenge of wetland plants is how to get enough air for their cells. Only specially adapted plants that like to have their roots wet can grow in saturated soils. Since there is not much air in the soil, only specially adapted plants can live in a wetland. The cypress tree's roots (called knees) extend up and out of the water. Sedges and rushes have air spaces inside their leaves to take oxygen and carbon dioxide to the roots. Nearly half of Missouri's plant species grow in wetlands.

Like wetland plants, animals that live in wetlands are special too. Wetlands are home to many invertebrates, amphibians, reptiles, fish, birds and mammals. In fact, you can find more animals and plants in an acre of wetland than in any other kind of ecosystem. (FIG. 9.2) They are adapted to find and catch food in wet places. The whirligig beetle's eyes focus both above and below water level to help it find prey at the water's surface. The heron's feet help it to walk on mud. Herons can snatch fish from under water with their long, slender necks and scissorlike beaks. Wetlands are the main habitat for furbearing animals, like beaver, otter and muskrat. The dense, oily fur, sharp teeth and webbed feet of beavers and muskrats help them stay dry, cut through tough stems and swim quickly. The frog's long legs and the turtle's shell help them escape predators. Ducks have spoonlike, flattened bills that make it easy for them to strain plants from shallow water. Such diverse and specialized plants and animals make wetlands interesting places to study. (FIG. 9.3)

MARK RAITHEL

FIG. 9.2—Wetland ecosystems are the most productive in the world.

CLIFF WHITE

FIG. 9.3—Specialized plants and animals make wetlands interesting places to study.

With their upturned eyes and mouths, mosquitofish can slurp down mosquito larvae. Some fish, such as northern pike, walleye and yellow perch, need shallow, marshy places for spawning. In fact all freshwater fish are partially dependent on wetlands. Young fish can find protection from larger fish and other predators by staying in the plant-filled shallow water of wetlands. Nutrients are available in the detritus in forms that small fish can use.

Gas, food, lodging

More than a quarter of our nesting and migratory birds depend on wetlands for part of their life cycle. Missouri's wetlands serve the vital function of providing migrating waterfowl a place to rest and replenish energy reserves lost in flight. Predatory birds such as osprey, bald eagles, kites, hawks, and owls also feed and nest in wetlands.

Ducks, geese, swans and shorebirds rely on wetland habitats. In fact, many of Missouri's wetlands are managed specifically with ducks in mind. Protecting and restoring wetlands in Missouri will allow more migrating ducks, like these mallards, to spend time in the state. (FIG. 9.4) Ducks Unlimited and other citizen conservation groups, together with state and federal agencies, have helped restore millions of acres of wetland.

Wetlands improve water quality

Until the 1990s, people rarely thought that wetlands were good for anything more than wildlife habitat. Today, however, we know that wetlands have many other helpful functions. Wetlands filter out pollutants. They recharge aquifers. They reduce flood damage, control the quantity and quality of water flow and even produce useful money-making crops. Wetlands are also fun for people. Millions of birdwatchers, hunters, fishermen and outdoor lovers of all types enjoy wetland beauty.

Wetland plants absorb pollutants, store them, break them down and in some cases even use them as nutrients. For example, excess plant nutrients from fertilizers reduce water quality in many streams and lakes. But because wetland plants can store these nutrients, they use them as fuel for growth. Bacteria found in wetlands can even break these chemicals down into harmless gases and release them into the atmosphere. Livestock feedlots and some cities are using wetlands' amazing ability to improve water quality to treat their wastewater.

Wetland ecologists help protect wetland ecosystems

Most wetland ecologists focus on recreating wetlands and taking care of the those that are left. They work for agencies such as the U.S. Environmental Protection Agency, Missouri Department of Conservation, Army Corps of Engineers and U.S. Fish and Wildlife Service. Others work for private companies or groups such as Ducks Unlimited. Finding wetland borders and enforcing laws that protect wetland ecosystems requires field work. Wetland ecologists have to check water quality, identify water-loving plants and understand the water, geology and soil of the area. These jobs require at least a bachelor's degree in biology, environmental science or a related field.

JIM RATHERT

JIM RATHERT

FIG. 9.4—Missouri wetlands allow ducks to restore fat reserves.

Wetlands also improve water quality by cleansing runoff that comes from higher in the watershed. Because of their flatness and lush plant growth, wetlands slow the flow of water coming into them. In the slow water, suspended soil particles settle out. The water then trickles into nearby streams and seeps into groundwater. Wetland plants also filter particles from water, keeping sediment out of streams and rivers.

Soaking it up

Another function of wetlands is their role in flood control. Wetlands act as giant sponges. Their organic matter and specialized plants take in up to 18 times their weight in water. During periods of heavy rains or runoff, wetlands first hold water then release it slowly back into the watershed. By holding water and letting it go slowly, wetlands reduce the total amount of water going into lower watersheds. This reduces flood risk and peak flood volume downstream. Because wetlands hold soils and slow water flows, they are great at stopping erosion. Unfortunately, humans have disrupted this natural flood control mechanism by building levees along rivers, digging drainage ditches through wetlands, and channelizing streams. The ironic and unfortunate consequence of these actions is to increase damage from floods. We might like to think it's a natural disaster, but really it is a problem people have created through their own actions.

We have just begun to know and value the special role of wetland ecosystems in controlling pollution, improving water quality, reducing flooding and erosion and refilling groundwater supplies. Because of the great number and variety of life forms they support, wetlands provide many hours of outdoor fun, plus educational and scientific research opportunities. One of the best ways to protect the wetlands we have left is to understand how their many benefits serve us all.

The future of wetlands

In 1972, Congress passed the Clean Water Act, which gave strong protection to wetlands. After the floods of 1993 and 1995, areas such as Columbia Bottom near St. Louis and Big Muddy near Boonville were turned back into wetlands to provide flood control and wildlife habitat. Cities such as Columbia even use wetlands to treat wastewater. Farmers across the state use wetlands to filter polluted water from feedlots. These examples show that people are learning to value and use the many good things that wetlands do. But we have a long way to go toward bringing back these special places to Missouri. The future of Missouri's wetlands depends on citizens who value and enjoy them.

CLIFF WHITE

10 Fishing for Answers

Questions to consider

1. How can knowledge of aquatic communities and food webs be used to improve fishing success?
2. How can knowledge of fish adaptations be used to improve fishing success?
3. How can knowledge of aquatic ecosystem types be used to improve fishing success?
4. How can knowledge of weather be used to improve fishing success?
5. Why are rules about fishing limits and seasons important?
6. What is an ethical angler? What are some rules of angling ethics?
7. How can people help conserve Missouri's aquatic ecosystems?

FIG. 10.2—Anglers make it possible for the Missouri Department of Conservation to better manage all the state's fish populations. The Sport Fish Restoration Act places tax on items such as boat motors, fishing tackle and boat fuel. In 1978, Missourians voted for a one-eighth-of-one-percent sales tax dedicated to funding statewide conservation efforts. Along with federal Sport Fish Restoration funds, this Conservation Sales Tax pays for kids fishing programs, Stream Team volunteer water quality monitoring workshops, fish hatcheries and fisheries management.

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FIG. 10.1—Use what you have learned about aquatic ecosystems to catch fish.

Now that you've learned about Missouri's aquatic ecosystems, one of the most fun ways to use your knowledge is fishing. (FIG. 10.1) If you fish, you've always got a reason to be outdoors. Hike or take a canoe or boat to a fishing spot. Try camping near a lake, cook what you catch and have a picnic. Fishing gets you involved with nature. When you go fishing, you are called a **sport fisherman** or **angler**. To be a good angler, you need patience, fishing skills and knowledge of aquatic life. (FIG. 10.2)

Here fishy, fishy

You can use what you have learned about fish, habitats, food webs, niches, trophic levels and aquatic ecosystems to help improve your fishing success. Fish may scour the bottom, hunt near the surface or swim anywhere between. Spawning brings fish together in one place. Their need for cover attracts them to structures such as rocks, logs and plants. Their need for comfortable temperatures and oxygen levels keeps them moving. Individual and species needs and preferences present a complicated challenge.

To catch a fish, you need to think about its food preference. Use bait that looks or smells like a fish's natural food. (FIG. 10.3) Fish tend to gather where there is plenty of food. Schools of minnows or other prey fish will attract larger fish to feed on them. Fish watch for hatching insects and migrating frogs. Signs of small fish activity can lead you to fishing hotspots. Minnows darting above the surface are often trying to escape from larger fish. Many small fish in the shallows could mean that larger fish are not far behind. Look for the signs of feeding fish. Rings spreading across the surface of a pond could mean that bluegill are feeding on insects. A splash in the shallows could be a largemouth bass eating a bluegill. Cast your line where you think fish are feeding.

Finding fish

Fish use cover to escape predators and to help them ambush prey. Ask yourself, “If I were a fish, where could I hide from enemies and find food?” Some fish spend most of their lives near cover; others move out of cover to feed. Cover can be anything that will hide or protect the fish. Weeds, docks, brush, rocks and logs all provide cover. Shade can be cover because it makes the fish less visible to other fish, predatory birds and humans. Look under overhanging trees, cliffs or swimming platforms. Once you start looking, you’ll see all kinds of cover. Weeds grow near the bank, fallen trees lean over the water, boat docks rim lakes, flooded timber reaches above the water’s surface and loose rock often rings shorelines. A lot of cover cannot be seen. Underwater rocks and sunken logs, as well as fish shelters of sticks, brush or old Christmas trees that anglers have placed to attract fish rest on many lake and river bottoms. Cast close to these fish hide-outs.

Drop-offs, points, ridges and sandbars shape the beds of lakes and rivers. These features often attract more fish than do flat or gently sloping bottoms. You can find good places to fish from clues on land or in the water. Land points often extend into a lake; a path between flooded trees might be an old river channel; a break in a wave pattern reveals an underwater island and the weed edge tells where the water has become too deep to allow sunlight to penetrate to the bottom. (FIG. 10.4)

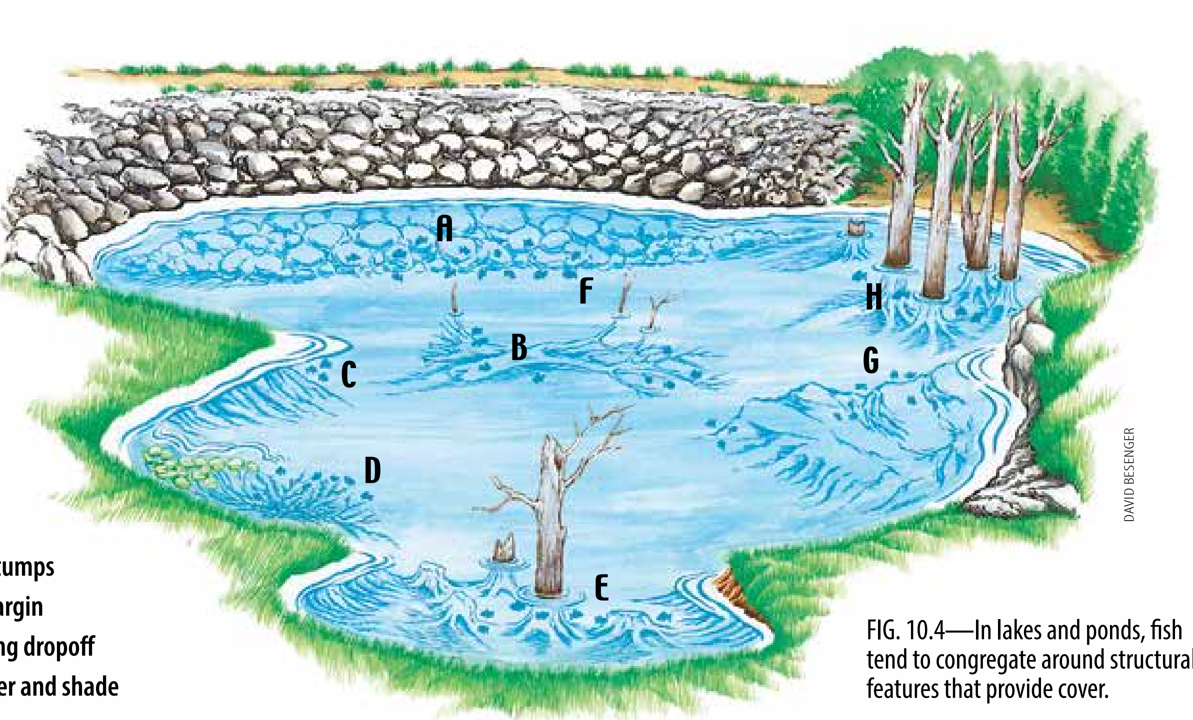
Hungry fish seem to favor places where one kind of habitat changes to another—in other words, border areas. The edge of a lake’s shoreline zone, for example, usually produces the most fish. In rivers, fish often feed where the flow changes direction or slows down. You can see these from the surface. Also, look for the break between muddy and clear water. Places where mud bottom meets gravel bottom attract active fish.

In flowing water, there is less current near the

NOPPADOL PAOTHONG

CLIFF WHITE

FIG. 10.3—Serious anglers watch the water to see what aquatic insects have just hatched. Then they choose a fishing lure, such as the one on the bottom, that looks like the mayfly in the top photo. This is called “matching the hatch.”



DAVID BESENGER

- **A** Rocks
- **B** Sunken cover
- **C** Points
- **D** Weeds
- **E** Submerged stumps
- **F** Lake basin margin
- **G** Stair step along dropoff
- **H** Flooded timber and shade

FIG. 10.4—In lakes and ponds, fish tend to congregate around structural features that provide cover.

bottom. Because of this, most stream fish rest with their bellies almost touching the bottom. They like to take advantage of low spots that have less current than the nearby water. They do this to save their energy and to avoid being pushed downstream. Most fish in a river face the flow of water and wait for food to come to them. Fish in current rarely move far for food. (FIG. 10.5)

Gone fishin'

Fishing can be good at any time. However, fish seem to prefer eating during the low light conditions of morning and evening rather than in the bright sun of midday. Fish stay in shallower water in low light and choppy conditions but move to deeper water when the sun is bright and winds are calm. Cloud cover mimics these low-light periods and may help get fish to bite. Catfish, bass, crappie and many other species of fish will bite day or night. In some clear lakes, fishing is better at night than during the day. Big fish seem to be less picky about food and easier to catch when it is dark. Fishing at night is hard, even for experienced anglers. If you are just starting out, try fishing during the evening and see if you can continue after dark.

Weather affects fish, but not always in predictable ways. Fish are often near the surface in spring and early summer. Hotter weather sends fish deeper to find cooler temperatures such as in the open-water zone of a lake. Most fish stay out of the deep-water zone of the lake because there is little oxygen there. Warm fronts improve fishing, and the longer the front stays the better. Cold fronts often reduce fish movements. A light to moderate wind is better than no wind. Fish will move into shallower water to feed in windy conditions. Fishing is usually better where the wind blows into the shore than along protected shorelines. Fishing is good before and during a gentle rain but poor during and after a thunderstorm. If this all seems like too much to learn, just remember that any time you can safely fish is a good time to go fishing.

Do the right thing

An **ethical** angler:

- Follows rules of ethical conduct in the use of aquatic resources and teaches others to do so, too.
- Values and respects the aquatic environment and all living things in it.
- Avoids spilling and never dumps any pollutants, such as gasoline or oil, into the aquatic environment.
- Puts all trash, including used lines, leaders and hooks, in proper containers and helps to keep fishing sites litter-free.
- Takes action to prevent the spread of invasive plants and animals, and never dumps live bait into the water.
- Learns and obeys angling and boating rules, and treats other anglers, boaters and property owners with courtesy and respect.
- Respects property rights, and never goes onto on private lands or waters without permission.
- Keeps no more fish than needed for eating, and never wastes fish.
- Carefully handles and releases alive all fish that are unwanted or not allowed, as well as other animals that may be caught accidentally.
- Is careful not to harm to fish when doing catch-and-release fishing.

Limits and seasons

In Missouri, the Department of Conservation makes and enforces rules for the wise use of fish, forests and wildlife. These rules help Missourians share limited resources and keep our ecosystems healthy. Hunting and fishing season rules protect species by limiting the time of year

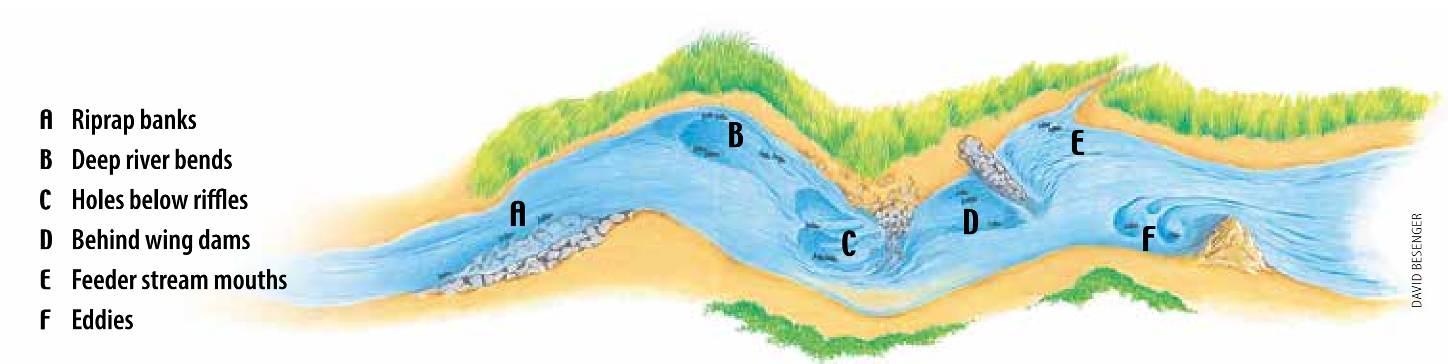


FIG. 10.5—In rivers and streams, fish stay in low current to save energy, but feed near swifter flows that may bring them food.

during which they may be taken. Length limits give fish a chance to grow and spawn before people are allowed to catch and keep them. Number limits assure that no one takes too many. Missouri's rules are based on scientific data and research provided by fisheries biologists. Taxes and the sale of hunting and fishing permits pay for this work. Up until your 16th birthday you can fish in Missouri without a permit. But before you go fishing, get to know the rules and follow them. This is one way you can help conserve Missouri's aquatic ecosystems for years to come. Conservation can help us to make sure our aquatic ecosystems and other resources stay diverse, balanced and healthy far into the future.

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FIG. 10.6—Start or join a Stream Team and adopt a body of water.

To learn more about conserving Missouri's aquatic resources, visit the Missouri Department of Conservation's Web site. You can also visit your local Conservation Department office or a conservation nature center. Better yet, go outside and visit your favorite local aquatic resource. Begin thinking of it as YOUR lake, pond, river, stream, swamp or marsh. Always bring a trash bag when you visit, and take a moment to leave the spot in better shape than you found it. Start or join a Stream Team and adopt a water body (you're not limited to streams). (FIG. 10.6) Learn more about checking water quality by taking a Stream Team Volunteer Water Quality Monitoring class. Volunteer to become a Master Naturalist. And if you're up to the challenge, choose a career in conservation and make aquatic resources your life's work. Above all, enjoy your aquatic resources and use them wisely!

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Fishing guides and float outfitters

Fishing guides provide boats, tackle and fishing experience to people who want help learning and enjoying the sport. Most guides work part time and have another job, mainly in the off season. In Missouri, canoeing is a popular sport. Outfitters rent canoes and other equipment to people who want to experience a river first hand.

Glossary

Abiotic—nonliving; not derived from living organisms; inorganic

Acid rain—rain or other precipitation containing a high amount of acidity

Adaptation—a behavior or trait that increases a species chance of survival in a specific environment; the process of adapting

Anaerobic—occurring or living in the absence of oxygen

Angler—fisherman, especially one fishing for pleasure using a hook and line

Aquatic ecosystem—an ecosystem organized around a body of water

Aquatic organism—any living thing that is part of an aquatic ecosystem

Aquatic resource—water and all things that live in or around water

Aquifer—an underground layer of sand, gravel, or rock that hold water in pores or crevices

Atmosphere—the gaseous envelope surrounding the earth; the air

Biodiversity—the number and variety of living things in an environment

Biosphere—the part of the world in which life can exist; living organisms and their environment

Biotic—of or having to do with life or living organisms; organic

Buffer—to serve as a protective barrier to reduce or absorb the impact of other influences; something that buffers

Carrying capacity—an ecosystem's resource limit; the maximum number of individuals in a population that the ecosystem can support

Channel—the part of the stream where water collects to flow downstream, including the streambed, gravel bars and stream banks

Clean Water Act—primary federal law in the United States governing water pollution, first passed by Congress in 1972

Collector—an aquatic invertebrate that feeds on fine material; examples include caddis fly larvae and mayfly nymphs

Community—a group of plants and animals living and interacting with one another in a particular place

Compete—the act of actively seeking after and using an environmental resource (such as food) in limited supply by two or more plants or animals or kinds of plants or animals

Condense—to change a gas or vapor to liquid

Conservation—the wise use of natural resources such that their use is sustainable long term; includes protection, preservation, management, restoration and harvest of natural resources; prevents exploitation, pollution, destruction, neglect and waste of natural resources

Consumer—an organism that feeds on other organisms in a food chain

Current—the part of a body of water continuously moving in a certain direction

Decompose—to decay or rot; to break down or separate into smaller or simpler components

Decomposer—an organism such as a bacterium or fungus that feeds on and breaks down dead plant or animal matter, making essential components available to plants and other organisms in the ecosystem

Detritus—loose material that results from natural breakdown; material in the early stages of decay

Dissolved oxygen—oxygen gas absorbed by and mixed into water

Ecosystem—a community of organisms together with their physical environment and the relationships between them

Energy pyramid—a graphical representation designed to show the relationship between energy and trophic levels of a given ecosystem

Erosion—the gradual wearing away of land surface materials, especially rocks, sediments, and soils, by the action of water, wind, or ice; usually includes the movement of such materials from their original location

Ethical—following the rules of good conduct governing behavior of an individual or group

Evaporation—to change from a liquid state into vapor

Filter feeder—an aquatic animal, such as a mussel or some species of fish, that feeds by filtering tiny organisms or fine particles of organic matter from water that passes through it

Fin—a wing- or paddle-like part of a fish used for propelling, steering, or balancing in the water

First-order stream—a small stream with no tributaries coming into it

Floodplain—the flat land on both sides of a stream, into which the stream's extra water spreads during a flood

Food chain—a series of plants and animals linked by their feeding relationships and showing the transfer of food energy from one organism to another

Food web—many interconnected food chains within an ecological community

Geosphere—the solid part of the earth consisting of the crust and outer mantle

Gill—a respiratory organ that enables aquatic animals to take oxygen from water and to excrete carbon dioxide

Grazer—an aquatic invertebrate such as a snail or water penny that eats aquatic plants, especially algae growing on surfaces

Groundwater—water that flows or collects beneath the earth's surface in saturated soil or aquifers

Habitat—the natural environment in which an organism normally lives, including the surroundings and other physical conditions needed to sustain it

Headwaters—the high ground where precipitation first collects and flows downhill in tiny trickles too small to create a permanent channel

Hydrosphere—all of the Earth's water, including surface water, groundwater and water vapor

Inorganic—composed of matter that does not come from plants or animals either dead or alive; abiotic

Intermittent stream—a stream that flows, dries up and flows again at different times of the year

Invasive species—a species that has been introduced by human action to a location where it did not previously occur naturally, has become capable of establishing a breeding population in the new location without further intervention by humans and has spread widely throughout the new location

Invertebrate—any animal without a spinal column; for example, insects, worms, mollusks and crustaceans

Lake—a large body of standing water

Lateral line—an organ running lengthwise down the sides of fish, used for detecting vibrations and pressure changes

Marsh—a wetland dominated by reeds and other grass-like plants

Natural selection—the natural process in which those organisms best adapted to the conditions under which they live survive and poorly adapted forms are eliminated

Natural resource—something that is found in nature that is useful to humans

Niche—the function, position or role of a species within an ecosystem

Non-point pollution—water pollution that comes from a combination of many sources rather than a single outlet

Organic—composed of matter that comes from plants or animals either dead or alive; biotic

Oxbow lake—crescent-shaped lake formed when a bend of a stream is cut off from the main channel

Perennial stream—a stream that flows for most or all of the year

Physiographic—pertaining to physical geography; relating to the surface features of terrain

Plankton—microscopic free-floating plant- or animal-like organisms

Point-source pollution—water pollution that comes from a single source or outlet

Pollution—the contamination of air, water, or soil by substances that are harmful to living organisms, especially environmental contamination with man-made waste; also the harmful substances themselves

Pond—a body of standing water small enough that sunlight can reach the bottom across the entire diameter

Pond succession—the natural process by which sediment and organic material gradually replace the water volume of a pond ultimately resulting in the area becoming dry land

Pool—an area of deeper, slower-moving water in a stream

Population—a group of individuals of the same species occupying a specific area

Precipitation—a form of water such as rain, snow or sleet that condenses from the atmosphere and falls to Earth's surface

Predator—an animal that lives by capturing and eating other animals

Prey—an animals that is eaten by a predator

Producer—an organism that is able to produce its own food from non-living materials, and which serves as a food source for other organisms in a food chain; green plants

Recharge—water that soaks into and refills an aquifer

Reservoir—an artificial lake used to store water

Riffle—an area of shallow, faster-flowing water in a stream

Riparian zone—land next to the stream, starting at the top of the bank, with heavy plant cover on either side

River—a large stream

Runoff—precipitation not absorbed by soil

Saturated—soaked with moisture; having no pores or spaces not filled with water

Scale—any of the small, stiff, flat plates that form the outer body covering of most fish

Sediment—silt, sand, rocks and other matter carried and deposited by moving water

Shredder—an aquatic invertebrate such as a stonefly nymph that feeds by cutting and tearing organic matter

Slough—a backwater or secondary channel of a stream

Sport fisherman—an angler who catches fish for personal use or recreation, rather than to make a living

Stream—a body of flowing water

Stream bank—the shoulder-like sides of the stream channel from the water's edge to the higher ground nearby

Streambed—the bottom of the stream channel

Surface water—precipitation that runs off the land surface

Swamp—a wetland in which trees or woody shrubs predominate

Swim bladder—an air-filled sac near the spinal column in many fishes that helps maintain buoyancy

Transpiration—the passage of water through a plant to the atmosphere

Tributary—a stream that flows into a larger stream or other body of water

Trophic level—a group of organisms that occupy the same position in a food chain; each step of an energy pyramid

Water cycle—the natural process of evaporation and condensation, driven by solar energy and gravity, that distributes the earth's water as it evaporates from bodies of water, condenses, precipitates and returns to those bodies of water

Water pollution—an excess of natural or man-made substances in a body of water; especially, the contamination of water by substances that are harmful to living things

Water quality—the fitness of a water source for a given use, such as drinking, fishing or swimming

Watershed—all the land from which water drains into a specific body of water

Watershed address—the watershed, sub-watershed, and sub-sub-watershed that includes a particular location

Wetland—a low-lying area where the soil is saturated with water

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MDC FILE

Start a Stream Team at your school!

www.mdc.mo.gov/programs/strteam/

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