MDC DISCOVER nature SCHOOLS

Conserving Missouri's AQUATIC ECOSYSTEMS

CONSERVATION DEPARTMENT MISSOURI

Serving nature and you®

Teacher Guide

MDC DISCOVER nature SCHOOLS

Conserving Missouri's AQUATIC ECOSYSTEMS

Teacher Guide

Acknowledgments

Production Team
Chief writer: Sam Faith
Curriculum development: Veronica Feilner
Editor: Bonnie Chasteen
Cover photo: Cliff White
Designer: Marci Porter

Contributors
Rhonda Anderson, Karen Armstrong, Jay Barber, Betsy Blake, Adam Brandsgaard, David Bruns, Elaine Callaway, Melanie Carden-Jessen, Linda Chorice, Marty Corcoran, Erica Cox, Stacey Davis, Veronica Feilner, Pat Holloway, Bridget Jackson, Kirk Keller, Regina Knauer, Liz Lyons, Carol Mahan, Lavada Mann, Jean Mayer, Kathi Moore, Kurt Otterstein, Betty Ream, Barb Sandhagen, Mary Scott, Nancy Snider, Dick Turner and Jack Woodhead

© Copyright 2006 by the Conservation Commission of the State of Missouri;
Revised 2007, 2008, 2009, 2010, 2013, 2014

Missouri Department of Conservation
P.O. Box 180
Jefferson City, MO 65102-0180
missouriconservation.org

Serving nature and you®

This publication was funded in part by the one-eighth of one percent Missouri Conservation Sales Tax. It also was funded in part by the Sport Fish Restoration Program, which uses federal excise taxes on fishing equipment and motorboat fuels to support aquatic education, fisheries research and management, fishing and boating accesses and habitat improvements.

Equal opportunity to participate in and benefit from programs of the Missouri Department of Conservation is available to all individuals without regard to their race, color, nationality, sex, age or disability. Questions should be directed to the Department of Conservation, P.O. Box 180, Jefferson City, MO 65102, (573) 751-4115 (voice) or 1-800-735-2966 (TTY), or to the U.S. Fish and Wildlife Service Division of Federal Assistance, 4401 N. Fairfax Drive, Mail Stop: MBSP-4020, Arlington, VA 22203.

Conserving Missouri's Aquatic Ecosystems

Table of Contents

Alignment to Missouri Standards 3

Missouri Science Concepts Addressed 3
Content Aligned to Science Grade-Level Expectations 4
Science Grade-Level Expectations Continuum 5
Connections to Missouri Grade-Level Expectations from Other Content Standards 13
Connections to Missouri Show-Me Performance Standards 13

Discover Nature Schools 15

How to Use *Conserving Missouri's Aquatic Ecosystems* 15

Using Science Notebooks 17
Cooperative Learning 20
Planning a Successful Field Trip 21
Safety Precautions and Concerns 22
Assessment Opportunities 23
Chapter Components 27
Unit Time Frame 27
Materials Funded by Grant 29

CMAE Materials Order Form 31

Pre- and Post-Test 33

Chapter 1: Water Is Life 39

Water's special properties make clean water essential to all life. Human activity affects our limited supply of clean, usable water.

Chapter 2: The Ultimate Recyclable 63

All water on Earth, including the water that flows from our taps and the water we flush down the drain, is part of a natural cycle.

Chapter 3: What's Your Watershed Address? 81

Everyone lives in a watershed. Everything that happens on the land in a watershed affects the water body into which it drains.

Chapter 4: Living in the Water 101

All aquatic species, including fish and other aquatic animals, are uniquely adapted to life in or around water.

Chapter 5: From Sun to Sunfish 121

Populations of organisms within a community compete with one another for limited resources, including food and habitat. This competition links them together in a complex interdependent web of relationships and limits the number and types of organisms an environment can support.

Chapter 6: Missouri's Aquatic Ecosystems 161

Ecosystems are complex interdependent webs of relationships between living and non-living things. Missouri has three kinds of aquatic ecosystems: streams, lakes and wetlands.

Chapter 7: Rivers and Streams 181

Missouri's rivers and streams are diverse and ever-changing ecosystems that move, store and transform water, sediment and organic matter. The healthiest streams are those with the least-altered natural processes.

Chapter 8: Lakes and Ponds 201

Lakes and ponds provide habitat for many plants, insects, fish, birds and other wildlife, and important recreational opportunities for many Missourians.

Chapter 9: Swamps and Marshes 217

Wetlands are the most productive ecosystems in the world, home to many specially adapted plant and wildlife species. Although most of Missouri's wetlands have been destroyed, wetlands provide many important ecological services.

Chapter 10: Fishing for Answers 239

Understanding Missouri's aquatic ecosystems helps us enjoy, appreciate and conserve our precious aquatic resources.

Field Study Day 262

Unit Summation 271

Enrichments 275

Using Missouri Department of Conservation Resources 275
Enrichments from Project WET, Project WILD Aquatic and the *Stream Team Middle School Acitvity Guide* . . . 276
Service Learning with Missouri Stream Teams 278
Project WET and Project WILD Aquatic 278
Reference Materials for Teacher Background 279
DVD Compilation for *Conserving Missouri's Aquatic Ecosystems* 282

Glossary 284

Bibliography 287

Alignment to Missouri Standards

Conserving Missouri's Aquatic Ecosystems is designed to be taught at any middle school grade level (6–8). Teachers can use *Conserving Missouri's Aquatic Ecosystems* to teach required content because all instructional activities have been correlated to the Missouri Department of Elementary and Secondary Education (DESE) science Grade-Level Expectations (GLEs). Please note, however, that the unit was developed based on the assumption that students have learned what is indicated in GLEs through 5th grade. The Teacher Guide contains plans for teaching each chapter in the Student Guide.

Missouri Science Concepts Addressed

EC.1.A.	All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem.
EC.1.B.	Living organisms have the capacity to produce populations of infinite size, but environments and resources are finite.
EC.1.D.	The diversity of species within an ecosystem is affected by changes in the environment, which can be caused by other organisms or outside processes.
EC.2.A.	As energy flows through the ecosystem, all organisms capture a portion of that energy and transform it to a form they can use.
EC.3.C.	Natural selection is the process of sorting individuals based on their ability to survive and reproduce within their ecosystem.
ES.1.B.	The hydrosphere is composed of water (a material with unique properties), gases and other materials.
ES.1.D.	Climate is a description of average weather conditions in a given area over time.
ES.2.E.	Changes in the form of water as it moves through Earth's systems are described as the water cycle.
ES.3.A.	Earth's materials are limited natural resources affected by human activity.
IN.1.A.	Scientific inquiry includes the ability of students to formulate a testable question and explanation, and to select appropriate investigative methods in order to obtain evidence relevant to the explanation.
IN.1.B.	Scientific inquiry relies upon gathering evidence from qualitative and quantitative observations.
IN.1.C.	Evidence is used to formulate explanations.
IN.1.E.	The nature of science relies upon communication of results and justification of explanations.
IS.1.C.	Technological solutions to problems often have drawbacks as well as benefits.
IS.3.B.	Social, political, economic, ethical and environmental factors strongly influence, and are influenced by, the direction of progress of science and technology.

Many GLEs are addressed in several chapters. For brevity's sake only the code is given here. In the chapter guides, when a GLE is first addressed the code and language of the GLE are given. When a GLE is addressed again in a subsequent chapter, the GLE is indicated by code only. Teachers must use their discretion to determine whether the referenced GLE has been mastered by their students.

Content Aligned to Science Grade-Level Expectations

Chapter	Grade-Level Expectations
1—Water Is Life	ES.3.A.6.a, ES.1.B.6.a, ES.3.A.6.b, IS.1.C.6.a, IN.1.A.6.b, IN.1.A.6.c, IN.1.B.6.a, IN.1.B.6.b, IN.1.B.6.c, IN.1.B.6.d, IN.1.B.6.e, IN.1.C.6.a, IN.1.C.6.b, IN.1.E.6.a
2—The Ultimate Recyclable	ES.2.E.7.a., ES.1.D.7.a., ES.3.A.6.b., ES.3.A.7.b., IS.1.C.6.a., IN.1.A.6.a., IN.1.B.6.a., IN.1.B.6.b.
3—What's Your Watershed Address?	ES.3.A.6.b., ES.3.A.6.c., IS.1.C.6.a., IN.1.B.6.a., IN.1.E.6.a.
4—Living in the Water	EC.3.C.6.a., EC.3.C.6.b., IN.1.A.6.a., IN.1.A.6.b., IN.1.A.6.c., IN.1.B.6.a., IN.1.B.6.b., IN.1.B.6.c., IN.1.B.6.d., IN.1.B.6.e., IN.1.C.6.a., IN.1.C.6.b., IN.1.E.6.a.
5—From Sun to Sunfish	EC.1.B.6.a., EC.1.B.6.b., EC.2.A.6.a., EC.2.A.6.b., EC.1.B.6.c., EC.1.D.6.a., IS.1.C.6.a.
6—Missouri's Aquatic Ecosystems	EC.1.A.6.a., EC.1.D.6.a., EC.1.D.6.b., EC.1.D.6.c., IS.1.C.6.a.
7—Rivers and Streams	EC.1.A.6.a., EC.1.B.6.a., EC.1.B.6.b., EC.1.B.6.c., EC.2.A.6.a., EC.2.A.6.b., EC.1.D.6.a., EC.1.D.6.b., EC.1.D.6.c., IS.1.C.6.a.
8—Lakes and Ponds	EC.1.A.6.a., EC.1.B.6.a., EC.1.B.6.b., EC.1.B.6.c., EC.2.A.6.a., EC.2.A.6.b., EC.1.D.6.a., EC.1.D.6.b., EC.1.D.6.c., IS.1.C.6.a.
9—Swamps and Marshes	EC.1.A.6.a., EC.1.B.6.a., EC.1.B.6.b., EC.1.B.6.c., EC.2.A.6.a., EC.2.A.6.b., EC.1.D.6.a., EC.1.D.6.b., EC.1.D.6.c., IS.1.C.6.a.
10—Fishing for Answers	EC.1.B.6.a., EC.1.B.6.b., EC.1.B.6.c., EC.1.D.6.a., EC.1.D.6.b., EC.1.D.6.c., EC.2.A.6.a., EC.2.A.6.b., EC.3.C.6.a. , EC.3.C.6.b. , IS.1.C.6.a., IS.3.B.6.a.
Field study day	IN.1.A.6.a, IN.1.A.6.b, IN.1.A.6.c, IN.1.A.6.e, IN.1.B.6.a, IN.1.B.6.b, IN.1.B.6.c, IN.1.B.6.d.
Unit wrap-up	IN.1.A.6.d, IN.1.B.6.e, IN.1.B.6.f, IN.1.C.6.a, IN.1.C.6.b, IN.1.E.6.a.

Science Grade-Level Expectations Continuum

In *Conserving Missouri's Aquatic Ecosystems*, students develop the science Grade-Level Expectations (GLE) listed in the "Targeted learning" column below. While supporting students in the development of these skills, teachers should consider students' prior learning and keep in mind their future learning. Although the following table lists each GLE in its entirety for the concept, the bold type denotes the specific parts of a GLE that are addressed in this unit.

Prior learning	Targeted learning	Future learning
EC.1.A.4.a. Identify the ways a specific organism may interact with other organisms or with the environment (e.g., pollination, shelter, seed dispersal, camouflage, migration, hibernation, defensive mechanism) b. Recognize that different environments (i.e., pond, forest, prairie) support the life of different types of plants and animals	**EC.1.A.6.a. Identify the biotic factors (populations of organisms) and abiotic factors (e.g., quantity of light and water, range of temperatures, soil composition) that make up an ecosystem**	EC.1.A.9–11.a. Explain the nature of interactions between organisms in different symbiotic relationships (i.e., mutualism, commensalism, parasitism) b. Explain how cooperative (e.g., symbiosis) and competitive (e.g., predator/prey) relationships help maintain balance within an ecosystem c. Explain why no two species can occupy the same niche in a community
Not assessed at this level	**EC.1.B.6.a. Identify populations within a community that are in competition with one another for resources** **b. Recognize the factors that affect the number and types of organisms an ecosystem can support (e.g., food availability, abiotic factors such as quantity of light and water, temperature and temperature range, soil composition, disease, competitions from other organisms, predation)** **c. Predict the possible effects of changes in the number and types of organisms in an ecosystem on the populations of other organisms within that ecosystem**	EC.1.B.9–11.a. Identify and explain the limiting factors that may affect the carrying capacity of a population within an ecosystem b. Predict how populations within an ecosystem change in number and/or structure in response to hypothesized changes in biotic and/or abiotic factors

Prior learning	Targeted learning	Future learning
EC.1.D.4.a. Identify examples in Missouri where human activity has had a beneficial or harmful effect on other organisms (e.g., feeding birds, littering vs. picking up trash, hunting/conservation of species, paving/restoring greenspace)	**EC.1.D.6.a. Describe beneficial and harmful activities of organisms, including humans (e.g., deforestation, overpopulation, water and air pollution, global warming, restoration of natural environments, river bank/coastal stabilization, recycling, channelization, reintroduction of species, depletion of resources), and explain how these activities affect organisms within an ecosystem** **b. Predict the impact (beneficial or harmful) of a natural environmental change (e.g., forest fire, flood,** volcanic eruption**, avalanche) on the organisms in an ecosystem** **c. Describe possible solutions to potentially harmful environmental changes within an ecosystem**	EC.1.D.9–11.a. Predict the impact (beneficial or harmful) a natural environmental event (e.g., forest fire, flood, volcanic eruption, avalanche) may have on the diversity of different species in an ecosystem b. Describe possible causes of extinction of a population
EC.2.A.4.a. Classify populations of organisms as producers, consumers, decomposers by the role they serve in the ecosystem b. Differentiate between the three types of consumers (herbivore, carnivore, omnivore) c. Categorize organisms as predator or prey in a given ecosystem	**EC.2.A.6.a. Diagram and describe the transfer of energy in an aquatic food web** and a land food web **with reference to producers, consumers, decomposers, scavengers, and predator/prey relationships** **b. Classify populations of unicellular and multicellular organisms as producers, consumers, and decomposers by the role they serve in the ecosystem**	EC.2.A.9-11a. Illustrate and describe the flow of energy within a food web b. Explain why there are generally more producers than consumers in an energy pyramid c. Predict how energy distribution and energy use will be altered due to changes in a food web
EC.3.C.4 a. Identify specialized structures and describe how they help plants survive in their environment (e.g., root, cactus needles, thorns, winged seed, waxy leaves) b. Identify specialized structures and senses and describe how they help animals survive in their environment (e.g., antennae, body covering, teeth, beaks, whiskers, appendages) c. Recognize internal cues (e.g., hunger) and external cues (e.g. changes in the environment) that cause organisms to behave in certain ways (e.g., hunting, migration, hibernation) d. Predict which plant or animal will be able to survive in a specific environment based on its special structures or behaviors	**EC.3.C.6.a. Relate examples of adaptations (specialized structures or behaviors) within a species to its ability to survive in a specific environment (e.g.,** hollow bones/flight, hollow hair/insulation, dense root structure/compact soil, seeds/food, protection for plant embryo vs. spores**, fins/movement in water)** **b. Predict how certain adaptations, such as behavior, body structure, or coloration, may offer a survival advantage to an organism in a particular environment**	EC.3.C.9-11.a. Describe how variation in characteristics provides populations an advantage for survival. b. Identify examples of adaptations that may have resulted from variations favored by natural selection (e.g., long-necked giraffes, long ears on jack rabbits) c. Explain how genetic homogeneity may cause a population to be more susceptible to extinction (e.g., succumbing to a disease for which there is no natural resistance) d. Explain how environmental factors (e.g., habitat loss, climate change, pollution, introduction of non-native species) can be agents of natural selection e. Given a scenario describing an environmental change, hypothesize why a given species was unable to survive

Prior learning	Targeted learning	Future learning
ES.1.B.5.a. Classify major bodies of surface water (e.g., rivers, lakes, oceans, glaciers) as fresh or salt water, flowing or stationary, large or small, solid or liquid, surface or groundwater b. Relate the type of water body to the process by which it was formed	**ES.1.B.6.a. Recognize the properties of water that make it an essential component of the Earth system (e.g., its ability to act as a solvent, its ability to remain as a liquid at most Earth temperatures)**	ES.1.B.9-11.a. Recognize the importance of water as a solvent in the environment as it relates to karst topography (cave formation), acid rain, and water pollution
Not assessed at this level	**ES.1.D.7.a. Differentiate between weather and climate** b. Identify factors that affect climate (e.g., latitude, altitude, prevailing wind currents, amount of solar radiation)	ES.1.D.9-11.a Provide evidence (e.g., melting glaciers, fossils, desertification) that supports theories of climate change due to natural phenomena and/or human interactions b. Explain how climate and weather patterns in a particular region are affected by factors, such as proximity to large bodies of water or ice/ocean currents, latitude, altitude, prevailing wind currents, and amount of solar radiation
ES.2.E.5.a. Describe and trace the path of water as it cycles through the hydrosphere, geosphere, and atmosphere (i.e., the water cycle: evaporation, condensation, precipitation, surface run-off/ groundwater flow) b. Identify the different forms water can take (e.g., snow, rain, sleet, fog, clouds, dew) as it moves through the water cycle	**ES.2.E.7.a. Explain and trace the possible paths of water through the hydrosphere, geosphere, and atmosphere (i.e., the water cycle: evaporation, condensation, precipitation, surface run-off/ groundwater flow)**	Not assessed at this level

Prior learning	Targeted learning	Future learning
ES.3.A.5.a. Explain how major bodies of water are important natural resources for human activity (e.g., food, recreation, habitat, irrigation, solvent, transportation) b. Describe how human needs and activities (e.g., irrigation, damming of rivers, waste treatment, sources of drinking water) have affected the quantity and quality of major bodies of fresh water c. Propose solutions to problems related to water quality and availability that result from human activity	**ES.3.A.6.a. Relate the comparative amounts of fresh water and salt water on the Earth to the availability of water as a resource for living organisms and human activity** **b. Describe the affect of human activities (e.g.,** landfills**, use of fertilizers and herbicides, farming, septic systems) on the quality of water** **c. Analyze the ways humans affect the erosion and deposition of soil and rock materials (e.g., clearing of land, planting vegetation, paving land, construction of new buildings, building or removal of dams)**	ES.3.A.9-11.a. Distinguish between renewable and nonrenewable energy resources b. Recognize the finite availability of fresh water for use by living organisms c. Identify human activities that adversely affect the composition of the atmosphere, hydrosphere, or geosphere d. Predict the effect of change on the other sphere when given a scenario describing how the composition of the atmosphere, hydrosphere, or geosphere is altered e. Recognize how the geomorphology of Missouri (i.e., different types of Missouri soil and rock materials such as limestone, granite, clay, loam; land formations such as karst (cave) formations, glaciated plains, river channels) affects the development of land use (e.g., agriculture, recreation, planning and zoning, waste management) f. Recognize the limited availability of major mineral deposits in the United States (e.g., lead, petroleum, coal, copper, zinc, iron, gravel, aluminum) and the factors that affect their availability g. Recognize the economic, political, social, and ethical constraints associated with obtaining and using natural resources (e.g., mining and use of different types of Missouri mineral resources such as lead mining, gravel dredging, strip mining, coal burning, production of fertilizers and explosives; use of fossil fuels versus renewable resources) (Assess Locally)

Prior learning	Targeted learning	Future learning
ES.3.A.4.a. Identify the ways humans affect the erosion and deposition of Earth's materials (e.g., clearing of land, planting vegetation, paving land, construction of new buildings) b. Propose ways to solve simple environmental problems (e.g., recycling, composting, ways to decrease soil erosion) that result from human activity ES.3.A.5.a. Explain how major bodies of water are important natural resources for human activity (e.g., food, recreation, habitat, irrigation, solvent, transportation) b. Describe how human needs and activities (e.g., irrigation, damming of rivers, waste treatment, sources of drinking water) have affected the quantity and quality of major bodies of fresh water c. Propose solutions to problems related to water quality and availability that result from human activity	ES.3.A.7.a. Distinguish between renewable (e.g., geothermal, hydroelectric) and nonrenewable (e.g., fossil fuel) energy sources **ES.3.A.7.b. Provide examples of how the availability of fresh water for humans and other living organisms is dependent upon the water cycle**	ES.3.A.9–11.a. Distinguish between renewable and nonrenewable energy resources b. Recognize the finite availability of fresh water for use by living organisms c. Identify human activities that adversely affect the composition of the atmosphere, hydrosphere, or geosphere d. Predict the effect of change on the other sphere when given a scenario describing how the composition of the atmosphere, hydrosphere or geosphere is altered e. Recognize how the geomorphology of Missouri (i.e., different types of Missouri soil and rock materials such as limestone, granite, clay, loam; land formations such as karst (cave) formations, glaciated plains, river channels) affects the development of land use (e.g., agriculture, recreation, planning and zoning, waste management) f. Recognize the limited availability of major mineral deposits in the United States (e.g., lead, petroleum, coal, copper, zinc, iron, gravel, aluminum) and the factors that affect their availability g. Recognize the economic, political, social, and ethical constraints associated with obtaining and using natural resources (e.g., mining and use of different types of Missouri mineral resources such as lead mining, gravel dredging, strip mining, coal burning, production of fertilizers and explosives; use of fossil fuels vs. renewable resources) (Assess Locally)

Prior learning	Targeted learning	Future learning
IN.1.A.5.a. Formulate testable questions and explanations (hypotheses) b. Recognize the characteristics of a fair and unbiased test c. Conduct a fair test to answer a question d. Make suggestions for reasonable improvements or extensions of a fair test	**IN.1.A.6.a. Formulate testable questions and hypotheses** **b. Recognize the importance of the independent variable, dependent variables, control of constants, and multiple trials to the design of a valid experiment** **c. Design and conduct a valid experiment** **d. Evaluate the design of an experiment and make suggestions for reasonable improvements or extensions of an experiment** **e. Recognize different kinds of questions suggest different kinds of scientific investigations (e.g., some involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve making observations in nature; some involve discovery of new objects and phenomena; some involve making models)**	IN.1.A.9–11.a. Formulate testable questions and hypotheses b. Analyzing an experiment, identify the components (i.e., independent variable, dependent variables, control of constants, multiple trials) and explain their importance to the design of a valid experiment c. Design and conduct a valid experiment d. Recognize it is not always possible, for practical or ethical reasons, to control some conditions (e.g., when sampling or testing humans, when observing animal behaviors in nature) e. Acknowledge some scientific explanations (e.g., explanations of astronomical or meteorological phenomena) cannot be tested using the standard experimental "scientific method" due to the limits of the laboratory environment, resources, and/or technologies f. Acknowledge there is no fixed procedure called "the scientific method," but that some investigations involve systematic observations, carefully collected and relevant evidence, logical reasoning, and some imagination in developing hypotheses and other explanations g. Evaluate the design of an experiment and make suggestions for reasonable improvements
IN.1.C.5.a. Use quantitative and qualitative data as support for reasonable explanations b. Use data as support for observed patterns and relationships, and to make predictions to be tested	**IN.1.C.6.a. Use quantitative and qualitative data as support for reasonable explanations (conclusions)** **b. Use data as support for observed patterns and relationships, and to make predictions to be tested** c. Recognize the possible effects of errors in observations, measurements, and calculations on the formulation of explanations (conclusions)	IN.1.C.9–11.a. Use quantitative and qualitative data as support for reasonable explanations (conclusions) b. Analyze experimental data to determine patterns, relationship, perspectives and credibility of explanations (e.g., predict/extrapolate data, explain the relationship between the independent and dependent variable) c. Identify the possible effects of errors in observations, measurements and calculations, on the validity and reliability of data and resultant explanations (conclusions)

Prior learning	Targeted learning	Future learning
IN.1.E.5.a. Communicate the procedures and results of investigations and explanations through: – oral presentations – drawings and maps – data tables – graphs (bar, single line, pictograph) – writings	**IN.1.E.6.a. Communicate the procedures and results of investigations and explanations through:** – **oral presentations** – **drawings and maps** – **data tables (allowing for the recording and analysis of data relevant to the experiment, such as independent and dependent variables, multiple trials, beginning and ending times or temperatures, derived quantities)** – **graphs (bar, single line,** pictograph**)** – **writings**	IN.1.E.9–11.a. Communicate the procedures and results of investigations and explanations through: – oral presentations – drawings and maps – data tables (allowing for the recording and analysis of data relevant to the experiment, such as independent and dependent variables, multiple trials, beginning and ending times or temperatures, derived quantities) – graphs (bar, single line, pictograph) – equations – writings b. Communicate and defend a scientific argument c. Explain the importance of the public presentation of scientific work and supporting evidence to the scientific community (e.g., work and evidence must be critiqued, reviewed and validated by peers; needed for subsequent investigations by peers; results can influence the decisions regarding future scientific work)
IS.1.C.6.a. Identify how the effects of inventions or technological advances (e.g., complex machinery, technologies used in space exploration, satellite imagery, weather observation and prediction, communication, transportation, robotics, tracking devices) may be helpful, harmful, or both (Assess Locally)	**IS.1.C.6–8.a. Describe how technological solutions to problems (e.g., storm water runoff,** fiber optics, windmills, efficient car design, electronic trains without conductors, sonar, robotics, Hubble telescope**) can have both benefits and drawbacks (e.g.,** design constraints**, unintended consequences, risks) (Assess Locally)**	Not assessed at this level

Prior learning	Targeted learning	Future learning
Not assessed at this level	**IS.3.B.6.a. Describe ways in which science and society influence one another (e.g., scientific knowledge and the procedures used by scientists influence the way many individuals in society think about themselves, others, and the environment; societal challenges often inspire questions for scientific research;** social priorities often influence research priorities through the availability of funding for research) b. Identify and evaluate the physical, social, economic, and/or environmental problems that may be overcome using science and technology (e.g., the need for alternative fuels, human travel in space, AIDS)	IS.3.B.9–11.a. Analyze the roles of science and society as they interact to determine the direction of scientific and technological progress (e.g., prioritization of and funding for new scientific research and technological development is determined on the basis of individual, political and social values and needs; understanding basic concepts and principles of science and technology influences debate about the economics, policies, politics, and ethics of various scientific and technological challenges) b. Identify and describe major scientific and technological challenges to society and their ramifications for public policy (e.g., global warming, limitations to fossil fuels, genetic engineering of plants, space and/or medical research) c. Analyze and evaluate the social, political, economic, ethical and environmental factors affecting progress toward meeting major scientific and technological challenges (e.g., limitations placed on stem-cell research or genetic engineering, introduction of alien species, deforestation, bioterrorism, nuclear energy, genetic counseling, computer technology)

Connections to Missouri GLEs from Other Content Standards

Connections to Missouri Grade-Level Expectations from other content standards
(Note: Learning of these Grade-Level Expectations is reflected within activities. Corresponding activities are listed at the end of each GLE. They are not assessed in the summative assessments.)

CA.W.2.E.6 In writing, use (All Activities)
- correct spelling of grade-level frequently used words
- classroom resources and dictionary to verify correct spelling

CA.W.3.C.6 Write expository and persuasive
- paragraphs (including cause/effect) with (Activity 4.5, Field Study Report)
  - a strong controlling idea
  - supporting and concluding sentences
  - appropriate logical sequence
  - relevant details, facts and/or examples from one or more sources
- multi-paragraph essays (Activity 4.5, Field Study Report)

Connections to Missouri Show-Me Performance Standards

(Note: Learning of these performance standards is reflected within activities. They are not assessed in summative assessments.)

Goal 1: Students in Missouri public schools will acquire the knowledge and skills to gather, analyze and apply information and ideas. Students will demonstrate within and integrate across all content areas the ability to:		
1.1.	Develop questions and ideas to initiate and refine research	Activities 1.8, 2.5, 2.6, 3.2, 3.3, 4.4, 4.5, 4.6, 5.4, 5.6, 5.8, 6.3, 6.7, 6.8, 7.2, 7.4, 8.2, 8.4, 9.2, 9.4, 10.3, 10.4, Field Study, Field Study Report
1.2.	Conduct research to answer questions and evaluate information and ideas	Activities 1.4, 1.5, 1.7, 2.3, 2.5, 3.2, 3.3, 4.4, 4.5, 4.6, 5.3, 5.4, 5.5, 5.6, 6.3, 6.4, 6.7, 7.3, 8.3, 9.3, 9.7, 10.4, 10.5, Field Study
1.3.	Design and conduct field and laboratory investigations to study nature and society	Activities 1.5, 1.7, 3.2, 3.3, 4.6, 6.7, 9.7, Field Study
1.4.	Use technological tools and other resources to locate, select and organize information	Activities 2.3, 2.5, 3.6, 4.4, 4.5, 5.4, 5.6, 6.3
1.5.	Comprehend and evaluate written, visual and oral presentations and works	Activities 1.2, 1.3, 1.6, 1.8, 2.2, 2.3, 2.4, 3.4, 3.5, 3.6, 4.2, 4.3, 4.4, 4.5, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 7.2, 7.3, 7.4, 7.5, 8.2, 8.3, 8.4, 8.5, 9.2, 9.3, 9.4, 9.5, 10.1, 10.3, 10.4, 10.5, Field Study Report
1.6.	Discover and evaluate patterns and relationships in information, ideas and structures	Activities 1.2, 1.3, 1.8, 2.2, 3.2, 3.4, 3.5, 3.6, 4.2, 4.3, 4.4, 4.5, 4.6, 5.2, 5.3, 5.4, 5.5, 5.6, 5.7, 5.8, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.8, 7.2, 7.3, 7.4, 7.6, 8.2, 8.3, 8.4, 8.6, 9.2, 9.3, 9.4, 9.6, 9.7, 9.8, 10.3, 10.4, Field Study, Field Study Report
1.8.	Organize data, information and ideas into useful forms (including charts, graphs, outlines) for analysis or presentation	Activities 1.5, 1.7, 1.8, 2.3, 2.6, 3.7, 4.4, 4.5, 4.6, 5.4, 5.6, 5.8, 6.3, 6.7, 6.8, 7.1, 8.1, 9.1, 9.7, 9.8, 10.3, Field Study, Field Study Report

Goal 2: Students in Missouri public schools will acquire the knowledge and skills to communicate effectively within and beyond the classroom. Students will demonstrate within and integrate across all content areas the ability to:		
2.1.	Plan and make written, oral and visual presentations for a variety of purposes and audiences	Activities 2.1, 4.2, 4.4, 4.5, 5.4, 5.6, Field Study Report
2.3.	Exchange information, questions and ideas while recognizing the perspectives of others	Activities 1.1, 1.2, 1.6, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 3.1, 3.2, 3.5, 3.6, 3.7, 4.1, 4.2, 4.3, 4.6, 5.1, 5.2, 5.3, 5.5, 5.7, 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 7.1, 7.3, 7.4, 8.1, 8.3, 8.4, 9.1, 9.3, 9.4, 9.7, 9.8, 10.1, 10.4, Field Study, Field Study Report
2.7.	Use technological tools to exchange information and ideas	Optional for multiple activities, Field Study Report
Goal 3: Students in Missouri public schools will acquire the knowledge and skills to recognize and solve problems. Students will demonstrate within and integrate across all content areas the ability to:		
3.1.	Identify problems and define their scope and elements	Activities 1.5, 1.8, 2.6, 3.3, 3.7, 4.5, 4.6, 5.2, 5.6, 5.7, 5.8, 6.2, 6.3, 6.5, 6.6, 6.8, 7.2, 7.4, 8.2, 8.4, 9.2, 9.4, 9.8, 10.3, Field Study, Field Study Report
3.2.	Develop and apply strategies based on ways others have prevented or solved problems	Activities 1.5, 1.8, 2.6, 3.7, 4.6, 5.8, 6.5, 6.8, 7.6, 8.6, 9.6, 9.8, 10.1, 10.2, 10.3, 10.4, Field Study, Field Study Report
3.3.	Develop and apply strategies based on one's own experience in preventing or solving problems	Activities 1.5, 1.8, 2.6, 3.7, 4.6, 5.8, 6.5, 6.8, 9.8, 10.2, Field Study, Field Study Report
3.4.	Evaluate the processes used in recognizing and solving problems	Activities 2.5, 3.3, 6.6, Field Study Report
3.6.	Examine problems and proposed solutions from multiple perspectives	Activities 1.5, 3.3, 5.2, 5.7, 6.2, 6.3, 6.5, 10.4, Field Study Report
3.8.	Assess costs, benefits and other consequences of proposed solutions	Activities 1.5, 3.3, 5.2, 5.7, 6.2, 6.3, 6.5, Field Study Report
Goal 4: Students in Missouri public schools will acquire the knowledge and skills to make decisions and act as responsible members of society. Students will demonstrate within and integrate across all content areas the ability to:		
4.1.	Explain reasoning and identify information used to support decisions	Activities 1.7, 2.2, 3.3, 4.5, 5.6, 6.2, 6.3, 6.5, 6.6, 10.1, Field Study Report
4.4.	Recognize and practice honesty and integrity in academic work and in the workplace	Entire unit
4.6.	Identify tasks that require a coordinated effort and work with others to complete those tasks	Activities 1.6, 1.7, 1.8, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 3.5, 3.7, 4.3, 4.6, 5.2, 5.3, 5.5, 5.7, 5.8, 6.2, 6.4, 6.5, 6.6, 6.7, 6.8, 7.3, 8.3, 9.3, 9.8, 10.4, Field Study, Field Study Report
4.7.	Identify and apply practices that preserve and enhance the safety and health of self and others	Activities 1.5, 1.7, 2.3, 2.5, 3.2, 3.3, 3.5, 3.7, 5.2, 5.7, 6.5, 10.1, 10.2, 10.3, 10.4, 10.5, Field Study
4.8.	Explore, prepare for and seek educational and job opportunities	Activities 1.6, 2.4, 3.5, 4.3, 5.3, 5.5, 6.4, 7.3, 8.3, 9.3, 10.4

Discover Nature Schools

Outdoors is the best place for students to learn how nature works. This premise shapes the Missouri Department of Conservation's statewide conservation education program, Discover Nature Schools. Teachers helped us develop this, so we're confident that it will meet their needs, both in the classroom and in the field. After a year of testing the curriculum and its field activities, one Missouri middle school teacher wrote, "MDC resources are great, a teacher's best friend."

Get your students excited about nature now, and they'll be conservationists for life. Key elements of the program include free instructional units that meet current testing needs, as well as grants for field trips and teaching materials. Our Discover Nature Schools program gives you the tools to inspire students ranging from preschool through grade 12. The program helps teachers deliver hands-on, place-based learning, helps school administrators meet funding and testing challenges, and helps students connect with nature close to home.

Instructional units include *Nature Revealed* (preschool), *Nature Unfolds* (grades K–2), *Nature Unleashed—The Untamed World of Missouri Ponds, Forests and Prairies* (grades 3–5), *Conserving Missouri's Aquatic Ecosystems* (grades 6–8) and *Nature Unbound—The Impact of Ecology on Missouri and the World* (grades 9–12). To launch a Discover Nature Schools program in your class, visit ***mdc.mo.gov/teacher/contacts*** to find your local education consultant. He or she can introduce you to the units, register you for training and help you get started.

How to Use *Conserving Missouri's Aquatic Ecosystems*

"Is my local stream polluted?"
"What is the condition of that marsh?"
"Is our neighborhood pond healthy?"

These are questions that many of us have asked in one form or another. When we wonder whether it is safe to eat the fish we caught in the river, drink the water from our taps or swim in our favorite lakes, we are really wondering about the ecological status of those waters. Our children and our students have the same questions. In fact, almost two-thirds of all Missourians worry "a great deal" about pollution of rivers, streams, lakes and drinking water. Good water quality is important to all Missourians. It also is essential to the health of the state's plants and animals. The Missouri Department of Conservation is committed to protecting clean and healthy waters, to educating Missourians about fish, forest and wildlife resources and to preserving Missouri's outdoor recreation heritage. This unit is intended to address and begin to fulfill these commitments.

Is it safe to swim in/drink from/eat fish from a particular body of water? *Conserving Missouri's Aquatic Ecosystems* helps students answer this question for themselves. To do so, students first must learn what the components of an ecosystem are, and what constitutes ecological "health." Students then must discover how those components may be measured or observed. They must figure out how to make, record and quantify their observations. Finally, students must evaluate those observations in the context of their original question. In this way they will develop a deeper understanding of aquatic ecosystems and of how natural processes and human actions affect them.

Each chapter of *Conserving Missouri's Aquatic Ecosystems* prepares students for a hands-on activity to make, record, quantify and evaluate observations about an aquatic ecosystem. Students must identify, describe and apply principles of aquatic ecology. On the field study day they use this knowledge to gather data. In the unit summation, students analyze their data, draw conclusions and create their own solutions to environmental problems. Students will develop an understanding of ecological concepts by direct contact with and observation of the natural world. Students will understand the processes by which scientists form and evaluate hypotheses about the natural world by doing those things themselves. Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning and critical thinking.

Chapter Structure and Instructional Strategy

The first activity in each chapter explores students' current understanding of the chapter's essentials. It gets students talking to one another and asking questions about the topics to be addressed. These simple advance organizers provide teachers with information about what students already know. At the same time, students link their prior knowledge to the new material.

Once students are engaged with the subject and prepared to learn, they explore the chapter's main ideas through hands-on demonstrations, watching short video segments or playing games that model concepts. Some of these activities include data gathering or self-directed research; others generate notebook entries or group discussions.

The middle activities in each chapter provide students with formal explanations of concepts. Readings in the Student Guide and cooperative learning activities centered on the chapter's **Questions to Consider** make up this phase of the process. The **Questions to Consider** provide teachers with a mid-chapter check for student understanding. Enrichment activities, including activities from Project WET and Project WILD Aquatic, guest speakers and demonstrations are suggested for firming up student understanding of key concepts.

More hands-on activities, self-directed research, short video segments and games that model concepts develop and deepen student understanding. Activity 4.4, for example, starts the students on a comparison matrix to which they add in several later activities. Other activities include water chemistry testing, line transect plant sampling on school grounds and a formal writing assignment.

The last activity in each chapter challenges students to apply what they have learned in the preceding activities to decide the best way to make and record observations in the field. Students then create data tables or other recording systems for use on the field study day. These data record pages become part of their science notebooks.

A formal summative assessment is provided at the end of each chapter, along with an answer key. These include multiple-choice questions and open-ended constructed-response questions.

Field Study and Unit Summation

Each chapter of *Conserving Missouri's Aquatic Ecosystems* anticipates a field study activity. Students learn and practice simple water chemistry tests in Chapter 1, observe and record weather conditions in Chapter 2 and learn to look for potential sources of pollution by observing land uses and site conditions in Chapter 3. Students not only learn to fish, but use the experience to collect data about fish. A wildlife walk provides an opportunity for direct visual and auditory observation of wildlife and teaches students to look for animal signs such as tracks and scat. Students practice simple line transect plant sampling in Chapter 6 and learn invertebrate sampling techniques in Chapters 7, 8 and 9. Classes that study wetland sites also examine soil for signs of saturation and anaerobic conditions. Depending on which chapters the class has completed, the equipment resources available, time constraints, number of adult assistants and other considerations, teachers will have many field day activity options from which to choose.

In the unit summation, students analyze their data, draw conclusions and propose their own solutions to environmental problems. Instructors will have to decide for themselves on a class-by-class basis how much and what kind of direction students need in analyzing their data. Students may write a formal report on their field study. Alternatively, the field study report could take the form of a science notebook entry. A class presentation and discussion of findings ensures that students understand the importance of communication and dialog in the scientific process.

Teaching about conservation helps students develop into young adults who are aware of the world around them and are able to make good choices. When our students understand what the components of an ecosystem are, what constitutes ecological health and how that health is maintained or impaired, they become able to envision solutions. For students to accept responsibility for the environment they must begin to imagine themselves as a part of the solution. They must feel ownership of the resources and the issues and feel empowered to do something about those issues. *Conserving Missouri's Aquatic Ecosystems* offers educators the opportunity to help students understand the issues and challenge them to create their own solutions.

For Further Information

Hungerford, H.R. "The Development of Responsible Environmental Citizenship: A Critical Challenge." Journal of Interpretation Research, Volume 1, Number 1.

Using Science Notebooks

A journal records observation and reflection while log books record data. A science notebook records both. *Conserving Missouri's Aquatic Ecosystems* is structured around keeping a science notebook.

Guiding Inquiry

Using science notebooks develops and strengthens students' thinking, and at the same time deepens their understanding of the science concepts they investigate. Science notebooks help build both science content and process skills. Writing in science notebooks is one of the most immediate points of integration with inquiry-based science. We want students to do science as scientists do; scientists write their observations, reflections and conclusions in their notebooks. They illustrate and label these illustrations, collect data, and make charts and graphs to organize the data before analyzing it. With appropriate guidance, students can do the same.

Each chapter of *Conserving Missouri's Aquatic Ecosystems* prepares students for a hands-on activity to be performed on the field study day. Depending on which chapters the class has completed, the equipment resources available, time constraints and other considerations, teachers will have many field study options from which to choose. The last activity in each chapter asks students to apply what they have learned in the preceding activities to decide the best way to make and record observations in the field. Students then create data tables or other recording systems for use on the field study day. These data record pages become part of their science notebooks.

After guiding students through a data-gathering method in the classroom, give students time to think about how they want to organize data they gather in the field. Ask students to share how they organized their information. Encourage students to make predictions based on prior knowledge and what they learned in the classroom. After the field study experience, students will need to refer to their notebooks to understand how they can better organize them and represent the information. Ask students to refer to their notebooks when discussing their findings. This will help them analyze and ultimately draw conclusions from their observations.

Encouraging Reflection and Heightening Awareness

Another reward of notebook keeping is its ability to heighten awareness of the natural world. Successfully identifying one wildflower, mushroom or tree opens up a whole new world of natural objects to explore and to get to know. After discovering one object, students may be surprised at how many times they encounter it in their daily lives.

Give students time for reflection and notebook writing after activities and investigations. Use this opportunity to make connections between what students have observed and their prior experiences. Ask students to explain what they have learned. Ask what questions they now want to ask. Encourage students to add to their notebooks what others have been saying. Also allow them to add their personal feelings and questions.

Improving Observation and Description Skills

Science notebooks provide opportunities for students to practice using their senses to make detailed observations. All of us are occasionally stumped by something we can't identify. Relying on memory alone to later identify a newly encountered object can be extremely frustrating. If it's a wildflower, recording written observations about the site on which it was found—habitat type, topography of the land, direction of the slope—combined with the date and notes about the size, color and shape will all aid in later identification. These kinds of detailed notes, combined with a field sketch of the flower, will help with identification.

Drawing an object forces the student to slow down, observe it carefully and see it as it really is. Drawing compels more accurate observation. This better enables students to identify things in nature. Science notebooks appeal to different learning styles and connect learning to the real world.

Integrating Science and Literacy

Science notebooks improve skills in thinking, drawing and writing. When students explain in writing what they have seen and why they think this occurs, they are forced to clarify their thoughts and organize their ideas in ways that others can understand. Using notebooks in guided or structured inquiry gives students opportunities to use language in the context of solving meaningful problems and, as a result, engage in genuine, purposeful communication.

Using Science Notebooks for Formative Assessment

Science notebooks are best used for formative assessment. They serve as tools for informing teachers of student progress. Teachers can collect and review notebooks throughout the unit. They can also observe and listen to class discussions generated from the notebooks. Look at what kind of organizers students are using, whether they are drawing, labeling, etc. In doing so, teachers can check developing misconceptions, find evidence of student learning and plan instruction based on what students know. Feedback should move students' understanding to a higher level and create opportunities for students to respond to that feedback. Teachers also can pose questions to help students clarify their thinking. Comments can be written on Post-it notes and placed on the notebook's pages.

Notebooks may be used for summative assessment or to check for student mastery, but it may be easier and better to do these using work generated from the notebook. Have students create informational writing and presentations to the class. As a vessel for the data and observations made on the field study day, the science notebook is the jumping-off point for unit wrap-up projects based on the notebook.

For Further Information

Britsch, Susan and Daniel P. Shepardson. " The Art of Reviewing Science Journals." Science and Children, Nov-Dec 2004. pgs 43–45.

Campbell, Brian, and Lori Fulton. Science Notebook, Writing about Inquiry. Portsmouth, NH: Heinemann. 2003.

Campbell, Brian, and Lori Fulton. "Student-Centered Notebooks" Science and Children, Nov-Dec 2004. pgs 26–29.

Calhoun, Jeri and Ellen Mintz. "Project Notebook." Science and Children, Nov-Dec 2004. pgs. 30–34.

Leslie, Clare Walker and Charles E. Roth. Nature Journaling, Vermont: Storey Books, 1998.

Worth, Karen, Robin Moriarty and Jeff Winokur, "Capitalizing on Literacy Connections," Science and Children, Feb 2004. pgs. 35–39.

Young, Jocelyn, Science Interactive Notebooks in the Classroom. Science Scope, v26 n4 pgs 44–47, Jan 2003.

Guidelines for Keeping a Science Notebook

Copy Page

1. Keeping a good record of your work in science is as important as anything else you do.

2. Use one 3-ring notebook for your science work. Put all your class notes, assignments, notes from reading and other material in this notebook. Use sectional dividers.

3. Date each page and handout. Write neatly and legibly so that you can read what you have written. Label all drawings and diagrams so that they mean something to you long after you have made them.

4. Get in the habit of writing complete sentences for all your notes. Only then will the notes mean something to you when you read them later. Make sure that your sentences express complete thoughts.

5. Begin each new topic on a new page. Leave spaces between topics so that new materials can be added if you want to.

6. In writing your notes try to put all ideas in your own words. If you copy materials from books put quotations marks in the proper place. This is the way all scientists work.

7. Developing the habit of keeping a good notebook is the same as developing any other habit. As you practice doing the job the right way, you will improve in your skill and it will be easier and less burdensome for you. Before long you will be doing your work automatically.

8. The notebook should be a complete record of everything you have done in connection with your science work. It should include the results of your work in class, your reading, experiments and projects performed, observations, and all drawings and diagrams that illustrate your work.

Cooperative Learning

As the term suggests, cooperative learning involves students working in groups to help each other learn. Cooperative learning encourages development of problem solving skills and can be used with students of different levels of ability. Each group member is responsible for learning what is taught and for helping others learn. Students work through the assignment together so that all group members understand and complete the lesson successfully. Cooperative learning techniques honor individual strengths through remediation of student weaknesses and providing enrichment through interaction with others. Some commonly used cooperative learning techniques are summarized here.

Carousel Brainstorming—Have students work in small groups. For each group, display a poster board with a quote, question or concept related to the lesson. Provide each group a different color marker and assign each group to a poster. Give each group two or three minutes to write on the poster its ideas about the quote, question or concept. Answers might compare one thing to another, form an opinion, list characteristics or state an issue. Have groups then move to the next poster in the rotation. Have each group review the previous entries and quickly compose a response. Continue until all groups have contributed to all the posters. Conclude by reviewing the information for each poster.

Jigsaw—Have students work in small groups. Assign each student in the group some portion of the material to learn and then teach to the other students in the group. Have students working on the same portion of the material first work together to decide how to teach it to the others. After these "expert" groups have practiced, re-form the original groups and have students teach one another each portion of the material in turn.

Numbered Heads—Divide students into small groups. Give each student in every group a number (or numbers) that correspond to all the assigned questions. Call out a number and ask one of the questions. Ask each student assigned that number to give an answer.

Round Robin Brainstorming—Have students work in small groups. Assign a question or problem and give students time to think about answers. Designate one student in each group as recorder and tell students to take turns sharing their responses with the group. Each group then appoints another student as reporter to share the group's responses with the class.

Team-Pair-Solo—Have students work on problems or questions first in small groups, then in pairs, and finally on their own.

Think-Pair-Share—Assign a question or problem for the class. Allow time for individuals to think silently about it, then have students pair up and exchange thoughts. Have the pairs share their responses with the class.

Three-Minute Review—Stop any time during a lesson and give students working in small groups three minutes to review what has been said, ask clarifying questions or answer assigned questions.

Three-Step Interview—Have pairs of partners take turns interviewing one another about the assigned material. Each student then shares their partner's response with the class.

For Further Information

Hill, J. D. & Flynn, K. M. (2006). Classroom instruction that works with English language learners. Association for Supervision and Curriculum Development (ASCD), Alexandria, VA.

Marzano, R. J., Pickering, D. J., & Pollock, J. E. (2001) Classroom instruction that works: Research-based strategies for increasing student achievement. Association for Supervision and Curriculum Development (ASCD), Alexandria, VA.

Pollock, J. E. (2007). Improving student learning one teacher at a time. ASCD, Alexandria, VA.

Tovanni, C. (2004). Do I really have to teach reading? Content comprehension, grades 6–12. Stenhouse Publishers. Portland, Maine.

Wormeli, R. (2005). Summarization in any subject: 50 techniques to improve student learning. ASCD, Alexandria, VA.

Planning a Successful Field Trip

Setting a Date

Contact your Missouri Department of Conservation education consultant or outdoor skills specialist for assistance in planning and implementing your field trip. A field trip requires advanced planning to select and reserve a site that will fit your objectives. Determine a program date at least four months in advance. Having a Plan B in case of rain is always wise. Late spring and early fall provide the greatest variety of plant and animal life around aquatic areas. For a spring field trip, make arrangements in the fall. Contact your education consultant or outdoor skills specialist in the spring to arrange a fall field trip. These are good times for aquatic studies and for catching fish.

Selecting a Site

Choose a location with an aquatic feature, such as a stream, lake or wetland. Make sure there is some shade. This can be a stand of trees, a shelter or an awning. If restrooms are not available at the site, determine if some are close by. If none are nearby, you may need to arrange to have portable toilets available. Try to find a suitable place not too far from your school. This will reduce gas consumption and ensure adequate funds for the field trip. Moreover, students may feel more comfortable with and take more ownership of a location that is not too far from home.

If the site is a public site, check with the area manager to determine if a permit is needed and if any special rules apply to fishing or other activities at the site. Obtain permits if needed. If the site is on a private landowner's property, contact the owner, obtain permission and discuss any restrictions. Discuss with the manager/owner dates and times for the trip, the perimeter of the designated area, bathroom facilities, bus parking, etc.

Getting Help

Recruit adult volunteers to help on the trip. One volunteer for every 5–10 students is ideal. If you have more than 100 students, spread the trip over two days with half the students going each day. This may increase your adult-to-student ratio and make for a more rewarding and less stressful field trip. Having enough volunteers and knowledgeable help is essential. Parents, local fishing clubs, Rotary Clubs, etc., are potential sources of volunteers. Your Missouri Department of Conservation education consultant or outdoor skills specialist may be able to help with professional staff or trained volunteers. Contact other agencies such as the Department of Natural Resources, Natural Resources Conservation Service and Soil and Water Conservation District. Demand for these services is very high—staff availability depends on advanced planning. Keep in mind that those you have asked to assist may not be able to set aside another day in case of rain.

Finding a Location for a Fishing Event

Your Missouri Department of Conservation education consultant or outdoor skills specialist will need the following information:

- Who—the teacher's name, phone number, e-mail and other contact information
- When—the date of the event
- Where—if you have a specific body of water in mind for the event, or if not, how far the class can travel
- How long—length of time of the fishing event
- Ages of the students
- How many students will be fishing
- Whether the students will harvest fish or release them all

With this information, the education consultant or outdoor skills specialist will contact the regional fisheries supervisor and make arrangements for a successful and enjoyable fishing experience. In many cases, a fisheries biologist will be able to recommend nearby suitable waters. For situations where stocking is required, significant lead times are needed to work out stocking logistics. Rods, reels and other fishing tackle may be available if your school does not have equipment. Be sure to let your education consultant or outdoor skills specialist know if you need to borrow equipment.

Arranging Transportation

Contact the school district's transportation service to secure busses for your desired date. Ask for a cost estimate for the bus mileage and the driver. The transportation service may not be familiar with your field trip location or how to get there. Make sure you are and be prepared to provide a map.

Planning for Emergencies

Compile a list of all students participating in the trip and provide a copy to the school office. Let your principal know where the students are going and what they will be doing, and invite the school nurse to come along. On the day of the field study, post on the classroom door or other conspicuous location a sign indicating the destination of the class trip and departure and return times. Have a cell phone, two-way radio, etc. to contact the school should an emergency arise. Have a plan in case of sudden changes in weather, such as rainstorms. Do not seek shelter around water or under trees in lightening storms. In case of violent weather, the bus may be a vital refuge. Insist that the bus and driver remain in the immediate vicinity during the entire event. Should an emergency arise, finding the driver and waiting for him or her to return to the area could result in an unacceptable delay. Of course, a first-aid kit and life preserver or reach pole are musts for field trips around water.

Obtaining Permission

Send out a permission slip form (use copy page or create your own form) to get parents/guardians permission for the field trip. Permission slips should be sent home with the students at least a month in advance of the field trip with a reminder two weeks prior to the event. Permission slips must be returned before the field trip date. If some students are not given permission to participate in the field trip, make arrangement for the students to stay at school with a designated teacher or classroom. Make appropriate arrangements with the special education staff, school nurse, and/or parents for students with special needs.

Preparing Adult Volunteers

Be sure volunteers understand what is expected of them. The adult volunteers will need a list of students they will oversee and their responsibilities. Usually adult volunteers are tasked with keeping their students in designated areas, monitoring student behavior and assisting with fishing or other equipment, bait and fish. Be sure volunteers know what the students are supposed to be doing and what the volunteer should do to maintain order.

Safety Precautions and Concerns

Safety procedures are essential to successful hands-on science investigations, whether the activity takes place within the school laboratory or in the outdoors. Schools should have science lab safety guidelines such as those developed by the Council of State Science Supervisors. Visit *csss-science.org/safety.shtml* or *scienceaware.com/genlabsf.htm* for more information about school lab safety. Both teachers and their students should be familiar with and understand these guidelines before conducting hands-on science activities.

Using Chemicals and Equipment Safely

Teachers should familiarize themselves with chemicals and equipment that students will use to perform pH, dissolved oxygen and other chemical water quality tests. This includes a complete understanding of test procedure steps, material safety data and acceptable disposal methods for used chemicals. A thick polyethylene plastic container with closable lid, such as a rinsed-out bleach bottle can be used to collect used chemicals in field situations for eventual proper disposal back in the laboratory. When handling any type of chemical, teachers and students should wear protective eyewear. Long hair and loose clothing should be tied back. Always have a first-aid kit containing a buffered eye wash solution on hand.

All equipment including laboratory glassware, water sampling equipment and fishing gear should be inspected regularly. Equipment that is worn or broken should be repaired or discarded and replaced. Teachers also need to ensure that the students know how to use the equipment properly and appropriately. This is particularly true when casting with baited hooks.

Learning Outdoors Safely

Be alert to environmental hazards that may arise in outdoor situations. These include poisonous plants, biting and stinging insects and wild animals. Teach students to identify and avoid poison ivy. Remind students and parents to provide sunscreen and insect repellant as appropriate. Avoid conditions that could cause students to fall, such as steep terrain, slippery or unstable rocks, or animal burrows or holes. Minimize the risk of sun-, heat- and cold-related injuries by insisting that students come properly dressed for outdoor activity, including wearing closed-toed shoes. Do not tolerate running or horseplay with equipment or around water. Tell students to stay out of the water except as instructed and never to wade into water more than knee deep. A life preserver or reach pole is a must for field trips around water.

For the most part, using common sense will ensure that hands-on science investigations can be conducted safely and without incident. Common sense also dictates the need to be prepared for the unexpected by having an action plan, a first-aid procedure and ready method of contacting emergency help if necessary. Teach students that, by taking appropriate precautions and using common sense, the outdoors is a safe and wondrous place to learn.

Assessment Opportunities

The unit pre-test serves as a formative assessment and provides important baseline data for unit development. Re-deploying the pre-test as a unit post-test helps the Missouri Department of Conservation's education and curriculum development team by providing important before and after data.

Each chapter provides multiple assessment opportunities. The first activity in each chapter provides formative assessment data while keeping the focus on what is to come. Throughout the unit students design data sheets, develop experiments, create graphs, research and write. Teachers may use each chapter's **Questions to Consider** as discussions prompts, for cooperative learning activities, for formative assessment or for science notebook writings.

Formal summative assessments and answer keys are included in each chapter. These assessments allow students to practice answering the type of questions used on standardized tests such as *TerraNova* and the Missouri Assessment Program (MAP) test. They include multiple-choice questions and open-ended constructed-response questions. Open-ended constructed-response questions may have many correct answers. Answers in the keys are meant to provide guidance or examples of correct answers. They do not exhaust all possibilities.

Science notebooks are best used for formative assessment. They serve as tools for informing teachers of student progress. Teachers can collect and review notebooks throughout the unit. Notebooks may be used for summative assessment or to check for student mastery, but it may be easier and better to do these using work generated from the notebook. Science notebook assessment may be holistic or analytic, but no scoring rubric is provided in the Teacher Guide.

Field study activities may form the basis of performance assessments. However, no scoring guide is provided. While students are provided the opportunity to practice techniques before the field study day, it is not the intention of *Conserving Missouri's Aquatic Ecosystems* to develop student mastery of these techniques. Rather, introducing students to scientific techniques for studying the natural world is intended to deepen students' understanding of ecological concepts. Science understanding is developed through the use of science process skills, scientific knowledge, scientific investigation, reasoning, and critical thinking.

The unit summation provides other opportunities for assessment. Students may write a formal report on their field study. Alternatively, the field study report could take the form of a science notebook entry. A class presentation and discussion of findings ensures that students understand the importance of communication and dialog in the scientific process.

Permission Slip for Field Trip

Dear Parent/Guardian,

Students in _____ (teacher's name) class are studying Missouri's aquatic ecosystems. A field study day is planned for _____ (date of trip). We will leave from the school at _____ (leaving time) and will return by _____ (returning time).

Activities will include: soil and water quality testing, observation of weather conditions and land uses in the watershed, plant and invertebrate sampling, a wildlife walk and fishing. Procedures and safety rules have been reviewed and practiced at school for this event. Students will be divided into groups with an adult volunteer to ensure safety.

Students should dress for the weather, as we will be outside all day. See the checklist at the bottom of the page to see what students should bring. A school lunch will be provided for students who receive lunches from the cafeteria. Students may bring their own lunch if desired. Coolers will be provided for beverages if students want to bring them. Students will need to put their name on their beverage.

Please sign the permission slip below to indicate that your child does or does not have permission to participate in this field trip.

Permission granted or denied

My child _____ (print child's name) does or does not (circle one) have my permission

to participate in the field trip on _____ (date of trip).

_____ _____

Parent/guardian printed name Phone number

_____

Parent/guardian signature

Cut here

- - - -

Chapter Components

Estimated Time—Indicates approximate number of 50-minute class sessions for the chapter.

Vocabulary—Listed terms are the same as the bolded terms in the Student Guide. They are defined in the glossary of the Student Guide and in this guide.

Essential Concept for the Chapter—The main idea of the chapter.

Chapter Objectives—Lists student objectives addressed in the chapter.

Targeted Grade-Level Expectations—Lists GLEs targeted for learning in the chapter. Many GLEs are addressed in several chapters. The chapter in which a GLE is first addressed provides the code and language of the GLE. When a GLE is addressed again in a subsequent chapter, the GLE is indicated by code only. Teachers must use their discretion to determine whether the referenced GLE has been mastered by their students.

Technology Tools/Skills Used in the Chapter— Indicates connections made to technology such as the Internet, scientific or other special equipment in the chapter.

Reference Materials for Teacher Background—Lists recommended references for teacher background in the chapter.

Safety Precautions/Concerns—Indicates specific safety precautions, if any, applicable to the chapter.

Required Materials—Lists items supplies and equipment needed for completing the activities in the chapter, including copies of handouts, transparencies, materials for teacher demonstrations, and materials for student activities.

Activities—These sections contain several components: **Estimated time, required materials** and step-by-step **procedures** for each activity. **Transparency masters** and student **copy pages** are provided.

Assessments—Summative assessments and answer keys are provided for every chapter to be used at the teacher's discretion.

Enrichments—Optional activity ideas appropriate to the chapter, including Project WET and Project WILD Aquatic activities, additional video clips, guest speaker, demonstration, service learning and field trip suggestions.

Unit Time Frame

The Estimated Time section suggests how much time it may take to teach each chapter in 50-minute class sessions. Actual time will be affected by the following factors:

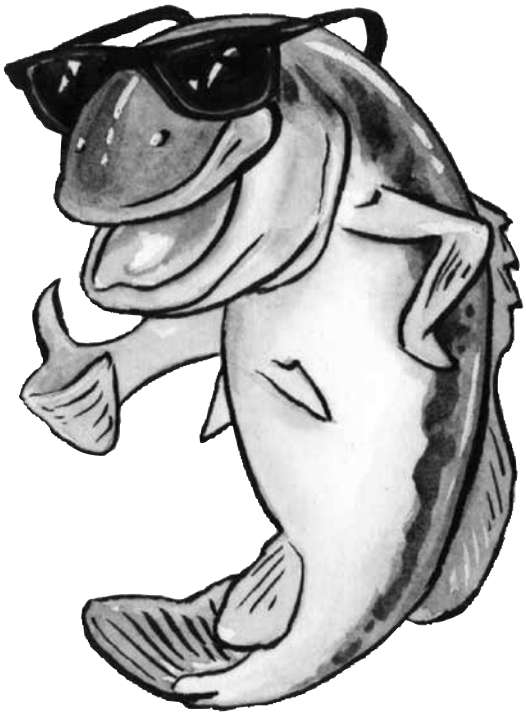
- daily schedule of the school (50-minute periods, block scheduling, etc.)
- need for review or re-teaching of previous learning based on extent of students' prior knowledge
- teacher's additional resources and knowledge
- time allotted for cooperative learning activities
- number of activities given as homework rather than in-class activities
- availability of resources for student use
- number and type of field study experiences
- number and type of enrichment activities used
- number of summative assessments used

Chapter Title	Estimated Time (50-minute class sessions)*
1—Water Is Life	4–5 sessions
2—The Ultimate Recyclable	3 sessions
3—What's Your Watershed Address?	3–4 sessions
4—Living In The Water	3 sessions
5—From Sun To Sunfish	5 sessions
6—Missouri's Aquatic Ecosystems	4 sessions
7—Rivers And Streams	3 sessions
8—Lakes And Ponds	3 sessions
9—Swamps And Marshes	3 sessions
10—Fishing For Answers	2–3 sessions
Field Study	1–2 full days
Unit Wrap-Up	2 sessions
All Chapters	35–38 sessions plus 1–2 full field study days

*Excluding time needed to administer summative assessments

Materials Funded by Grant

Please refer to the current *Conserving Missouri's Aquatic Ecosystems* Grant Agreement or Grant Guidelines for the list of these materials.



Conserving Missouri's Aquatic Ecosystems
Materials Order Form

Teacher Name: _____ **School:** _____

School Address: _____ **Phone #** _____

The items listed below are free publications that support the *CMAE* unit. Posters are sent in sets of two to allow access to information on both sides. Any of these publications or parts thereof may be reproduced for classroom use. Some items may be out of stock or under revision.

✓	Quantity	Inventory No.	Title
	1		*CMAE* DVD: Instructional Enrichment Video
	1		*Golden Guide to Pond Life* (160 pages)
	1	01-0250	*Crayfishes of Missouri* (152 pages)
	2	E00002	Missouri Pond Life (poster)
	2	E00003	Exploring Missouri Wetlands (poster)
	2	E00016	Missouri Stream Life (poster)
	2	E00115	Wetlands & Waterfowl (poster)
	2	E00509	Rivers and Streams: Missouri Currents (poster)
	1	FIS013	Zebra Mussels: Missouri's Most Unwanted (brochure)
	1	FIS034	Life Within the Water (brochure)
	1	FIS049	Volunteer Water Quality Monitoring (brochure)
	1	FIS056	Pond Handbook (68-page booklet)
	1	FIS110	Nuisance Aquatic Plants in Missouri Ponds and Lakes (brochure)
	1	FIS182	Form a Missouri Stream Team (brochure)
	1	FIS192	Understanding Streams (brochure)
	1	FIS193	Stream Team Inventory Guide (16-page brochure)
	1	STR250	Stream Insects & Crustaceans (2-sided sheet)
	1	SCI013	African Clawed Frogs (brochure)
	1	E00112	Teacher Request Form (free MDC publications for educators)

The following items are available in classroom sets.

✓	Classroom Qty	Inventory No.	Title
		E00430	Missouri Toads and Frogs (brochure)
		E00468	Missouri Turtles (brochure)
		E00606	Fishing Regulations Summary
		FIS011	Introduction to Crayfish (brochure)
		FIS020	Introduction to Missouri Fishes (39-page brochure)
		FIS152	Introduction to Fishing (brochure)
		FIS273	What's In Your Water? (watershed placemat)

7/2010

MAIL TO : Distribution Center
Missouri Department of Conservation
P.O. Box 180
Jefferson City, MO 65102-0180

Pre- and Post-test

Directions: Select the best answer for each of the following multiple-choice questions.

1. What proportion of the water on the earth is fresh water?
   a. 3 percent
   b. 25 percent
   c. 75 percent
   d. 97 percent

2. Water is a unique substance. It can be found in all three states on Earth—solid, liquid and gas. Which of the following are other properties of water?
   a. Exhibits surface tension
   b. Acts as a solvent
   c. Is transparent
   d. All of the above

3. How does water pollution affect aquatic life?
   a. Cloudy water blocks light and slows plant growth
   b. Too much fertilizer causes overgrowth of algae
   c. Toxic chemicals are poisonous to living things
   d. All of the above

4. What is conservation?
   a. Careful use
   b. Thinking very hard
   c. Taking anything we want
   d. Taking water for granted

5. How does water's temperature affect the amount of oxygen in it?
   a. Cold water floats
   b. Liquid water turns to gas
   c. Cold water holds more oxygen
   d. Oxygen is vital for life

6. How does the water cycle purify water?
   a. Water flows through underground aquifers
   b. Every time water evaporates it becomes pure again
   c. Water vapor condenses to form raindrops
   d. All of the above

7. What is climate?
   a. Hot, damp summers and cold, dry winters
   b. The movement of water from soil through plant roots and stems, and out the leaves into the atmosphere
   c. Average atmospheric conditions in an area over many years
   d. All of the above

8. Where does water go when it runs off a street?
   a. To wastewater treatment plants for processing before being returned to the environment
   b. To drinking water treatment plants, then through pipes to our taps
   c. To pick up air pollution, forming acid rain
   d. Through storm drains and ditches, then directly into streams, lakes and wetlands without being cleaned or processed

9. What is non-point pollution?
   a. A stream that empties into a particular body of water
   b. Water pollution that comes from a broad area or a number of sources
   c. The movement of solid material such as rock, soil or mud
   d. Contamination that can be traced to a single source

10. What is a watershed?
   a. A stream that empties into a particular body of water
   b. The area where precipitation first collects in tiny trickles too small to create a permanent channel
   c. A stream that flows all year long
   d. All the land that drains water into a particular body of water

11. What is sediment?
   a. Any bit of rock or soil that is suspended or carried in water
   b. Water pollution that comes from a broad area or a number of sources
   c. The movement of solid material such as rock, soil or mud
   d. None of the above

12. Which of the following statements about adaptations is true?
   a. Creatures can choose adaptations that will provide them with survival advantages.
   b. Species adaptations provide them with survival advantages in a particular environment.
   c. All aquatic species have the same adaptations.
   d. Both b and c

13. What is a species?
   a. A group of individuals sharing some common characteristics or qualities
   b. Animals with a backbone
   c. A particular kind of creature
   d. Both a and c

14. Complete this analogy: Individual is to population as
   a. Water is to surface tension.
   b. Fish is to gills.
   c. Niche is to habitat.
   d. Population is to community.

15. Which of the following statements about competition is true?
   a. Individuals within a population may compete with other individuals of the same species.
   b. Individuals within a population may compete with individuals of different species.
   c. A population within a community may compete with other populations within the community.
   d. All of the above

16. Carrying capacity is the result of the fact that:
   a. Different populations living in the same place interact with one another.
   b. Within a community every species has a particular niche.
   c. While living organisms have the capacity to produce populations of infinite size, environments and resources are limited.
   d. Most energy pyramids can continue for only four or five trophic levels and can support only a few top-level consumers.

17. Which of the following statements about invasive species is true?
   a. The invasive species may compete with native species for habitat or food.
   b. Invasive species are not subject to natural selection.
   c. Invasive species play an important role by keeping populations of prey species below their carrying capacity.
   d. None of the above

18. What is the biggest threat to aquatic communities?
    a. Predator/prey relationships
    b. Natural selection
    c. Human-caused habitat destruction
    d. All of the above

19. Why can most energy pyramids continue for only four or five trophic levels and support only a few top-level consumers?
    a. Most of the available food energy is lost moving up each trophic level.
    b. Animals lose energy doing tasks such as hunting and keeping their bodies warm.
    c. Only a little of the sun's energy passes from one trophic level to the next.
    d. All of the above

20. Why do scientists use sampling?
    a. To create new habitat
    b. Because each part of an ecosystem is connected to and depends on all the others
    c. Because ecosystems may change in response to natural or human-caused events
    d. To estimate things without having to count each organism

21. What is an endangered species?
    a. A type of plant or animal no longer in existence, having died out leaving no living representatives
    b. A type of plant or animal with a variety and number of different organisms and populations
    c. A type of plant or animal whose numbers are so small that it is at risk of extinction
    d. Both a and c

22. What does it mean for a species to be extinct?
    a. A type of plant or animal no longer in existence, having died out leaving no living representatives
    b. A type of plant or animal with a variety and number of different organisms and populations
    c. A type of plant or animal whose numbers are so small that it is at risk of extinction
    d. Both a and c

23. What is biodiversity?
    a. A complex web of relationships between living and non-living things
    b. The variety and number of different organisms and populations, and the way they live together
    c. The kinds of aquatic ecosystems found in Missouri
    d. None of the above

24. What kinds of aquatic ecosystems do we have in Missouri?
    a. Ozarks, Prairie, Lowland and Big River
    b. Rivers, lakes and wetlands
    c. Swamps, marshes and bogs
    d. Streams, oceans and ponds

25. Predict the impact of flooding on the organisms in a stream ecosystem.
    a. Some fish, plants or other aquatic life could be washed downstream.
    b. There would be no long-term damage.
    c. Fresh nutrients would be brought in.
    d. All of the above

26. Which of the following statements is true:
    a. In a straight stretch of river, the main force of the current is in the middle. The deepest water is also in the middle.
    b. When there is a sharp bend in the river, the strongest current and deepest water is at the outside edge of the bend.
    c. In flowing water, there is less current near the bottom.
    d. All of the above

27. Predict the impact of sediment and nutrients brought by storm water runoff on the organisms in a lake or pond ecosystem.
    a. Temperature changes would cause the layers to mix, bringing decaying organic matter from the bottom up to the surface
    b. There would be no long-term damage
    c. Pond succession would speed up
    d. All of the above

28. Predict the oxygen level in a pond.
    a. The amount of oxygen dissolved in the water stays pretty even over a 24-hour period.
    b. The water is too deep for plants to grow on the bottom, making it oxygen poor.
    c. Oxygen levels are high each day while the sun is shining and plants are photosynthesizing, but they can drop dramatically at night.
    d. None of the above

29. What three factors are required for a place to be considered a wetland?
    a. Saturated soil, diverse plant and animal community, standing water
    b. Saturated soil, diverse plant and animal community, plants specially adapted to live in saturated soil
    c. Saturated soil, wet for a major part of the growing season, plants specially adapted to live in saturated soil
    d. Standing water, wet for a major part of the growing season, plants specially adapted to live in saturated soil

30. What is detritus?
    a. A complex web of relationships between living and non-living things
    b. The variety and number of different organisms and populations, and the way they live together
    c. Dead plant and animal matter in the process of decay
    d. None of the above

31. Aquatic resource conservation is
    a. Best left to professionals
    b. Limited to certain times of the year
    c. Unnecessary because Missouri has plenty of water
    d. Everyone's responsibility

Apply your knowledge of these species' adaptations and their roles in the transfer of energy in Missouri aquatic food webs to predict the best bait or lure to use to catch:

32. Largemouth bass
    a. Live minnow
    b. Bare treble hook
    c. Plastic worm dipped in stinkbait
    d. Artificial fly that mimics a mayfly

33. Channel catfish
    a. Live minnow
    b. Bare treble hook
    c. Plastic worm dipped in stinkbait
    d. Artificial fly that mimics a mayfly

Apply your knowledge of these species' adaptations and habitat needs to predict where to find:

34. Largemouth bass
    a. Shallow marsh
    b. Below a riffle in weeds near a stream bank
    c. Muddy bottom of a pond
    d. Open water zone of a lake

35. Bluegill
    a. Shallow marsh
    b. Below a riffle in weeds near a stream bank
    c. Muddy bottom of a pond
    d. Open water zone of a lake

Pre- and Post-test Answer Key

1. **a**
2. **d**
3. **d**
4. **a**
5. **c**
6. **b**
7. **c**
8. **d**
9. **b**
10. **d**
11. **a**
12. **b**
13. **d**
14. **d**
15. **d**
16. **c**
17. **a**
18. **c**
19. **d**
20. **d**
21. **c**
22. **a**
23. **b**
24. **b**
25. **d**
26. **d**
27. **c**
28. **c**
29. **c**
30. **c**
31. **d**
32. **a**
33. **c**
34. **d**
35. **b**

1 Water Is Life

Water's special properties make clean water essential to all life. Human activity affects our limited supply of clean, usable water.

Estimated Time

Four or five 50-minute class sessions

Technology Tools/Skills Used in Chapter

Water quality test kits, meters or other equipment. Kits, meters or other equipment may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, etc.

Safety Precautions/Concerns

- Students and instructors must wear safety goggles for Activity 1.7.
- Use extra care when handling glass.

Vocabulary

Aquatic resource
Clean Water Act
Conservation
Decompose
Dissolved oxygen
Hydrosphere
Inorganic
Natural resource
Organic
Pollution
Reservoir
Water pollution
Water quality

Chapter Objectives

Students will be able to:

1. Relate how much fresh water is available for living organisms—including humans—to use. Compare/contrast this to the amount of salt water on Earth and to the total amount of all water on Earth. Explain why water is a natural resource that must be conserved.
2. Describe three special properties of water and justify why these are essential to life on Earth.
3. Using a specific example, explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences to aquatic resources in Missouri.
4. Decide whether water is polluted or clean and explain how water pollution affects aquatic life.
5. Explain how water's temperature affects the amount of oxygen dissolved in it.
6. Define water quality and give an example of how humans affect water quality.

Targeted Grade-Level Expectations

ES.3.A.6.a. Relate the comparative amounts of fresh water and salt water on the Earth to the availability of water as a resource for living organisms and human activity

ES.1.B.6.a. Recognize the properties of water that make it an essential component of the Earth system (e.g., its ability to act as a solvent, its ability to remain as a liquid at most Earth temperatures)

ES.3.A.6.b. Describe the affect of human activities (e.g., landfills, use of fertilizers and herbicides, farming, septic systems) on the quality of water

IS.1.C.6.a. Describe how technological solutions to problems (e.g., storm water runoff, fiber optics, windmills, efficient car design, electronic trains without conductors, sonar, robotics, Hubble telescope) **can have both benefits and drawbacks (e.g.,** design constraints, **unintended consequences, risks)**

IN.1.A.6.b. Recognize the importance of the independent variable, dependent variables, control of constants, and multiple trials to the design of a valid experiment

IN.1.A.6.c. Design and **conduct a valid experiment**

IN.1.B.6.a. Make qualitative observations using the five **senses**

IN.1.B.6.b. Determine the appropriate tools and techniques to collect data

IN.1.B.6.c. Use a variety of tools and equipment to gather data (e.g., microscopes, **thermometers,** computers, spring scales, balances, magnets, metric rulers, graduated cylinders, stopwatches**)**

IN.1.B.6.d. Measure length to the nearest millimeter, mass to the nearest gram, volume to the nearest milliliter, **temperature to the nearest degree Celsius,** force (weight) to the nearest Newton, time to the nearest second
IN.1.B.6.e. Compare amounts/measurements
IN.1.C.6.a. Use quantitative and qualitative data as support for reasonable explanations (conclusions)
IN.1.C.6.b. Use data as support for observed patterns and relationships, and to make predictions to be tested
IN.1.E.6.a. Communicate the procedures and results of investigations and explanations through:

- oral presentations
- drawings and maps
- data tables (allowing for the recording and analysis of data relevant to the experiment, such as independent and dependent variables, multiple trials, beginning and ending times or temperatures, derived quantities)
- graphs (bar, single line, pictograph)
- writings

Reference Material for Teacher Background

- Instructions for water quality test kits, meters or other equipment
- Missouri DNR Water Pollution Control Website page at *dnr.mo.gov/env/wpp/wp-index.html*
- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Start a Missouri Stream Team (FIS182)
- Now That I'm a Stream Team (FIS188)
- *Stream Team Middle School Activity Guide* by Mark Van Patten, *mostreamteam.org/activity_guide/contents.htm*
- Streets to Streams Guide (E00428)
- Streets to Streams Video (E00447)
- Volunteer Water Quality Monitoring (FIS049)

Required Materials

- 5-gallon bucket or aquarium filled with water
- 2-cup measure
- ½-cup measure
- 1-pound box of table salt
- Ice cubes
- Food coloring
- Paper towels for spills
- Three clear glass containers (beaker or drinking glass) filled with water
- Fresh celery stalk (Advanced preparation is required.)
- Knife
- Spoon or stirrer
- Bottle of warm seltzer
- Bottle of cold seltzer
- Container (paper cup) filled with water for each student or group
- Penny for each student or group
- Dropper for each student or group
- 2 Water Use Record sheets for each student
- Student Guide
- Safety goggles—one per student
- At least 2 water samples for each group pre-labeled A, B, etc. Sample sources may be tap water, rain water, pond water, etc. (Advanced preparation is required.)
- Water quality test kits, meters or other equipment. Kits, meters or other equipment may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, etc. (Advanced preparation is required.)
- Notebook paper
- Pens or pencils
- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player

Activity 1.1: Exploration of Students' Current Understanding of Water

This activity explores students' current understanding of the importance, availability and properties of water.

Estimated Time

5 minutes

Required Materials

None

Procedure

1. Use a cooperative learning activity to explore the following questions:
   - How do you use water?
   - How much water do you use each day?
   - How much water exists on Earth?
   - Would you drink water from [name a local pond]? Why or why not?
   - Would you drink water from the Mississippi River? Why or why not?

2. Explain to the class that this chapter will help them understand the value, importance and properties of water, as well as some ways to determine whether water is clean or not.

Activity 1.2: Teacher Demonstration of Water Distribution and Scarcity

This demonstration helps students visualize the comparative amount of fresh water and salt water on the Earth and the small portion available for human use.

Estimated Time

10 minutes

Required Materials

- 5-gallon bucket or aquarium filled with water
- 2-cup measure
- ½-cup measure
- Dropper
- One-pound box of table salt
- Ice cubes
- Food coloring
- Paper towels for spills

Procedure

1. Explain that the aquarium or bucket represents all the water on Earth.

2. Remove 2 cups of water. Explain that this is all the fresh water on Earth and the rest is salt water. Pour salt into the aquarium or bucket and place the salt container in front of it. Remove ½ cup of water from the 2 cups. Explain that the 1½ cups remaining is frozen in polar ice caps and glaciers. Pour out the 1½ cups of water and replace with ice cubes. The ½ cup represents all the unfrozen fresh water found on the Earth's surface, in the ground and in the air.

3. Fill the dropper from the ½ cup and place one drop in a student's hand.

4. Ask students what they think this amount represents. (The portion of all the water on Earth that is available for human use.) Explain that the rest of the half cup is too polluted, inaccessible or too costly to transport. Place a few drops of food coloring in the ½ cup of water.

5. Lead class discussion of ways people use water and how animals and plants use water.

6. Explain that every living cell contains water.

Activity 1.3: Teacher Demonstration of Properties of Water

This demonstration helps students understand the properties of water that make it an essential component of the Earth system.

Estimated Time

15 minutes

Required Materials

- Three clear glass containers (beaker or drinking glass) filled with water
- Fresh celery stalk
- Knife
- One-pound box of table salt
- Ice cubes
- Food coloring
- Spoon or stirrer
- Bottle of warm seltzer
- Bottle of cold seltzer
- Paper towels for spills

Prepare a day in advance

Add some food coloring to a container of water. Make a fresh cut across the bottom of a celery stalk and place the cut end in the container of colored water. Let it sit overnight.

Procedure

1. Tell the class that water can climb up tubes because it clings to things like the walls of the tubes. Explain that this clinginess allows water to climb up plant stems and enables blood to flow through our bodies. Show students that the colored water has traveled up the celery stalk and is visible in the veins of the plant.

2. Tell the class that, for most substances, the solid state is denser than the liquid state. Retrieve another container of water and ask the class what will happen when you place some ice cubes in liquid water. (The ice will float.) Place a few cubes of ice in the container of liquid water. Explain that the ice floats because it is less dense than the liquid, and that without this property, lakes would freeze solid in winter, killing fish and other aquatic life.

3. Retrieve the third container of water and the box of salt. Begin adding salt to the water and stirring. Ask students to say stop when they think no more salt will dissolve. (500 milliliters of water will dissolve 180 grams or about 17 teaspoons of salt in 2 cups of water at room temperature.) Lead class discussion about the importance of water's ability to dissolve things.

4. Retrieve the two bottles of seltzer. Ask the class what will happen when you open the warm one vs. the cold one. (The warm one will spew out more forcefully.) Open each bottle over a sink (or have paper towels handy). Explain that cold water can dissolve more gas, and that the spewing is due to dissolved gas escaping from the warmer water. Explain that aquatic animals depend on water's ability to hold dissolved oxygen.

Activity 1.4: Student Investigation of Surface Tension

This hands-on activity helps students understand the property of surface tension.

Estimated Time

10 minutes

Required Materials

- Container (paper cup) filled with water for each student or group
- Penny for each student or group
- Dropper for each student or group
- Paper towels for spills

Procedure

1. If necessary, divide students into groups. Otherwise each student may work independently.

2. Ask the class how many drops of water can fit on a penny. Note answers on the board for later reference.

3. Give each student or group a penny, a dropper and a container of water. Be sure to have paper towels on hand for spills.

4. Instruct students to place the penny on the desktop, and place water on the face of the penny a drop at a time.

5. Have them count the number of drops they can fit before water runs off.

6. Lead class discussion of what they observed. Be sure to introduce and explain the term **surface tension**. Refer to their hypotheses noted on the board and to their observed results.

7. Use a cooperative learning activity to lead class discussion of the properties of water. Ask students to give examples from nature and from their daily lives of how the properties of water may be observed and why they are important.

Activity 1.5: Student Investigation of Water Consumption

This activity helps students understand their own use of water, and helps students recognize independent *vs.* dependent variables and experimental constants.

Estimated Time

35 minutes of in-class time over three consecutive days (10-, 10- and 15-minute discussions)

Required Materials

- 1 Water Use Record sheet for each student
- 1 Bar Graph Template sheet for each student
- Pens or pencils

Procedure

Day one (10 minutes)

1. Distribute a Water Use Record sheet to each student.

2. Instruct students to use the sheet to record their water use for the next 24 hours and bring the completed page to class the next day.

Day two (10 minutes)

1. Lead class discussion of water use findings. Tabulate results on the board and calculate a class water use total. Ask students how they could reduce their daily water use. Ask students to agree upon one thing they will all change about their daily water use to conserve water (for example, take a shorter shower). Alternatively, students may be divided into groups, with each group choosing a different water use to change.

2. Using the Water Use Record sheet, instruct the students to record their water use for the next 24 hours (Day 2), changing the agreed-upon use, and bring the completed page to class the next day.

Day three (15 minutes)

1. Ask students to identify the constants and the dependent and independent variables in their water conservation experiment. (**Independent variables** are the water use habits they changed; a **dependent variable** is the amount of water they used; **constants** include the person using the water and recording water use, and the water use habits they did not change.)

2. Lead class discussion of water use findings. Tabulate results on the board and calculate a class water use total. If students worked in groups, compare water use and conservation results between groups. Lead class discussion about water conservation and challenge them to make their water use changes permanent.

3. Using their Personal Water Use information, instruct the students to create a bar graph on the template provided to show their results.
   Be sure that they know to provide the following:
   - An appropriate title
   - A label for each axis with appropriate units
   - An appropriate number scale and category labels
   - Correctly plotted data

4. Have students add the Water Use Record sheets to their science notebooks.

WATER USE RECORD

Objective

Record and present personal water usage data.

Directions

1. Using the charts below, make a tick mark in the appropriate box each time (or per minute, for showers) you use water.

2. Multiply the number of "Times" (or minutes, for showers) by the "Gallons per time" and place that number in the column "Total gallons per activity."

3. Add the "Total gallons per activity" column and enter the total in the last box.

4. Using your Personal Water Use information, create a bar graph on the template provided to show your results. Be sure to provide the following:
   - An appropriate title
   - A label for each axis with appropriate units
   - An appropriate number scale and category labels
   - Correctly plotted data

Name: _____ Date: _____

Personal Water Use—Day 1

Activity	Times	Gallons per time	Total gallons per activity
Flush a toilet		4	
Brush teeth with water running		3	
Take a shower (count minutes)		5 per minute	
Take a bath		20	
Eat one meal		2.5	
Total			

Personal Water Use—Day 2

Date: _____

Activity	Times	Gallons per time	Total gallons per activity
Flush a toilet		4	
Brush teeth with water running		3	
Take a shower (count minutes)		5 per minute	
Take a bath		20	
Eat one meal		2.5	
Total			

BAR GRAPH TEMPLATE

Name: _____

Date: _____

Activity 1.6: Student Reading and Research

This activity provides students with definitions and explanations about the importance of water, its distribution, scarcity, conservation and special properties. It introduces the concepts of water pollution and water quality, and describes how water can be tested for pollution.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 1: Water Is Life. Introduce vocabulary terms as needed.
2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.
   1. Why is water important? What is the hydrosphere?
      Water is essential to all life. The hydrosphere is all the water on Earth.
   2. What are natural resources? What are aquatic resources?
      Natural resources are anything found on Earth that can't be made by humans. Aquatic resources are water and all things that live in or around water.
   3. How do we use water? How much water is available for human use? What is conservation? Why is it important?
      Uses of water may include drinking, cooking, washing, growing crops, generating power, manufacturing, transportation, etc. The amount of water available for human use may be described as less than 0.003 percent, a tiny fraction of all water or about 2 million gallons per person. Conservation is careful use. Water (and other resources) are essential and in limited supply.
   4. What are the special properties of water? Why are they important?
      Answers may include:

Water Property	Importance
can take three forms: liquid, solid and vapor	• permits self-purifying (water) cycle
solid form (ice) is not as dense as liquid form	• ice floats and lakes do not freeze solid, trapping and killing fish and other aquatic life • can break rocks by freezing and thawing
dissolves many different things	• aquatic animals and plants can live and grow under water • animals and plants can draw nutrition from water
molecules attract one another, creating surface tension	• things can float on surface • forms drops
molecules cling to other things	• water can climb up plant roots and stems • blood can flow through tiny blood vessels
has a high boiling point and a low freezing point; can absorb a lot of heat before it begins to get hot	• provides living things a fairly constant environment
transparent to light	• plants can live under water

5. How can we tell if water is polluted or clean? How does water pollution affect aquatic life?
   We tell if water is polluted or clean by determining its quality using physical, chemical and biological tests. Some ways water pollution affects aquatic life include:
   - **Cloudy water blocks light and slows plant growth.**
   - **Too much fertilizer causes overgrowth of algae.**
   - **Toxic chemicals are poisonous to living things.**
6. How does water's temperature affect the amount of oxygen in it?
   Cold water holds more oxygen.
7. What is water quality? How do humans affect water quality?
   Water quality is water's fitness for a particular use.
   Humans affect water quality by polluting or conserving water. Answers may include specific examples.

Activity 1.7: Student Investigation of Water Quality

This hands-on activity introduces students to technology and methods for testing water for pollution and determining water quality. Students practice using water chemistry test kits and equipment in class. Students use water chemistry data to identify source of water samples.

Estimated Time

One 50-minute class followed by 25 minutes of discussion the next day.

Safety Precautions/Concerns

- Students and instructors must wear safety goggles for Activity 1.7.
- Use extra care when handling glass.

Required Materials

- Safety goggles—one per student
- At least two water samples for each group pre-labeled A, B, etc. Sample sources may be tap water, rain water, pond water, etc. (Advanced preparation is required.)
- Water quality test kits, meters or other equipment. Kits, meters or other equipment may include thermometer, pH kit, conductivity meter, dissolved oxygen kit, nitrate kit, etc. (Advanced preparation is required.)
- Water Chemistry Investigation sheet for each student. (Table may require modification depending on number of water samples and water quality test kits, meters or other equipment used.)

Procedure

Day one (50 minutes)

1. Prepare in advance by setting up the room. If there are enough water samples and water quality test kits or equipment, distribute a set for each group. Alternatively, provide water samples to each group and set up stations around the room where groups take turns using the test kit or equipment at each station to test their water samples. Or set up stations around the room with a water sample at each station where groups take turns using their test kits or equipment.

2. Distribute a Water Chemistry Investigation sheet to each student.

3. Divide students into groups. Tell students the sources of the water samples (e.g., tap water, rain water, pond water, etc.), and explain that they must figure out which is which by testing the samples.

4. Have students record observations about color and odor for each water sample.

5. Demonstrate the use of each kit, meter or other equipment according to the directions accompanying it, and guide students through their use. Have students test each sample and record their results.

- **pH** is a measure of acidity. Pure water has a pH of 7, which is considered neutral. In the United States, most rainwater is moderately acidic (5.5) due to contamination from acid-forming gasses in the air. These gasses include carbon dioxide, sulfur dioxide and nitrogen oxides. They come from the burning of fossil fuels. Water from Missouri's rivers and streams is usually slightly basic (7.8). This is because of Missouri's limestone/dolomite bedrock. Limestone neutralizes and buffers the acidity of rainwater. Acidity can cause toxic heavy metals to dissolve into the water.
- **Conductivity** measures how easily electricity flows through the water. Salts dissolved in water allow it to conduct more electricity. Other substances that may not be dissolved but are suspended in the water cause it to conduct electricity more easily. These may also cause the water to appear cloudy or dark. Some common causes of higher conductivity include wintertime road salt, animal (including human) waste and eroded soils that have washed into the water.
- **Dissolved oxygen** is important to support aquatic life. In general, higher dissolved oxygen is better. Air is 21 percent oxygen or 210,000 parts per million. Most of Missouri's water bodies are 0.0005-0.0015 percent oxygen or between 5 and 15 parts per million.
- **Nitrates** can come in many forms. Fertilizer and animal (including human) waste are common sources of nitrates in Missouri's waters. Nitrates may stimulate plant growth. When water is basic, nitrates may form toxic ammonia compounds.

6. Have students place the completed data sheets in their science notebooks.

7. Have students clean up and prepare kits, meters or equipment for use by the next group or class.

Day two (25 minutes)

1. Use a cooperative learning activity to lead class discussion of water chemistry. Ask students to consider what it means for one water sample to have a higher or lower pH, conductivity, dissolved oxygen level or nitrate content than another. Have students take notes in their science notebooks describing the meaning of each characteristic.

2. Lead class discussion of students' water chemistry findings and their hypotheses about the source of each of the water samples. Ask the students which sample they'd rather drink and why.

3. Reveal source of each of the water samples (e.g., A is tap water, B is rain water, C is pond water, etc.) and discuss. Be sure to address students' misconceptions about the meaning of each water chemistry characteristic.

WATER CHEMISTRY INVESTIGATION

Objective

Test physical and chemical characteristics of unknown water samples, record and present data and identify source of each sample.

Directions

1. Work with your partners following your teacher's instructions to conduct a valid experiment.
2. Record your group's observations about the color and odor of each water sample in the table below.
3. Following the directions for each meter, test kit or other equipment to test each water sample and record data in the table below.
4. When you have completed the activity, follow your teacher's instructions to clean up and prepare kits, meters and other equipment for use by the next group or class.
5. Discuss the results within your group and formulate a hypothesis identifying the source of each of the water samples. Record your hypothesis in the last (right-most) column of the table.

Group: _____ **(names)**

Date: _____

Physical and chemical characteristics of unknown water samples

Water sample	Temperature (°C)	Color	Odor	pH	Conductivity _____ (units)	Dissolved oxygen _____ (units)	Nitrates _____ (units)	Water sample source
A								
B								
C								
D								
E								

Activity 1.8: Student Investigation of Water Quality

Students apply what they have learned in the preceding activities to create science notebook pages to record water chemistry data and observations in preparation for their field study day.

Estimated Time

25 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player
- Notebook paper
- Pens or pencils

Procedure

1. Show and discuss video clip "Storm Drain Stenciling."

2. Instruct students to work in groups to decide the best way to record water chemistry data and observations as part of their field study day.

3. Have each group create a data table and have each student place a copy in his/her science notebook.

Chapter 1 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. What proportion of the water on the earth is fresh water?
   a. 3 percent
   b. 25 percent
   c. 75 percent
   d. 97 percent

2. What is water quality?
   a. Rainwater running off hot pavement can dump hot water into a stream, killing everything in it
   b. Water's fitness for a particular use
   c. Water used mainly for agriculture
   d. All of the above

3. Water is a unique substance. It can be found in all three states on Earth—solid, liquid and gas. Which of the following are other properties of water?
   a. Exhibits surface tension
   b. Acts as a solvent
   c. Is transparent
   d. All of the above

4. In the experiment in which you recorded your daily water use, what was a constant?
   a. The person using the water
   b. The amount water used
   c. The ways in which water was used
   d. The temperature of the water

5. How does water pollution affect aquatic life?
   a. Cloudy water blocks light and slows plant growth
   b. Too much fertilizer causes overgrowth of algae
   c. Toxic chemicals are poisonous to living things
   d. All of the above

6. How do humans affect water quality?
   a. By making Missouri's waters home to over 200 kinds of fish
   b. By creating surface tension
   c. By giving water a high boiling point and a low freezing point
   d. By polluting or conserving water

7. What is the hydrosphere?
   a. All the fresh water on Earth
   b. All the water on Earth
   c. Two hydrogen atoms and one oxygen atom bonded together
   d. None of the above

8. What are natural resources?
   a. Any recyclable substance
   b. Anything made in a factory
   c. Anything found in the hydrosphere
   d. Anything found on Earth that can't be made by humans

9. What is conservation?
   a. Careful use
   b. Thinking very hard
   c. Taking anything we want
   d. Taking water for granted

10. How does water's temperature affect the amount of oxygen in it?
    a. Cold water floats.
    b. Liquid water turns to gas.
    c. Cold water holds more oxygen.
    d. Oxygen is vital for life.

Chapter 1 Assessment

Directions

Write your own answer for each of the following questions.

1. How much fresh water is available for living organisms—including humans—to use? Compare this to the amount of salt water on Earth and to the total amount of all water on Earth. Explain why water is a natural resource that must be conserved.

2. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as farm irrigation, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Missouri.

3. On a separate sheet of paper, create a chart to describe three special properties of water and to justify why these are essential to life on Earth.

Chapter 1 Assessment Answer Key

Multiple-choice questions

1. What proportion of the water on the earth is fresh water?
   a. 3 percent

2. What is water quality?
   b. Water's fitness for a particular use

3. Water is a unique substance. It can be found on Earth in all three states—solid, liquid and gas. Which of the following are other properties of water?
   d. All of the above

4. In the experiment in which you recorded your daily water use, what was a constant?
   a. The person using the water

5. How does water pollution affect aquatic life?
   d. All of the above

6. How do humans affect water quality?
   d. By polluting or conserving water

7. What is the hydrosphere?
   b. All the water on Earth

8. What are natural resources?
   d. Anything found on Earth that can't be made by humans

9. What is conservation?
   a. Careful use

10. How does water's temperature affect the amount of oxygen in it?
    c. Cold water holds more oxygen

Write-in questions

1. How much fresh water is available for living organisms—including humans—to use? Compare this to the amount of salt water on Earth and to the total amount of all water on Earth. Explain why water is a natural resource that must be conserved.
   Answers should include:
   - **Less than 0.003 percent or a tiny fraction or about 2 million gallons per person**
   - **97 percent of all the Earth's water is salt water**
   - **Water is essential to all life**
   - **No new water can be made**

2. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as farm irrigation, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Missouri.
Answers may include:

Activity/technological solution	Potential benefit	Potential drawback
paved roads/parking lots	improve surface transportation	water running off surface carries heat and pollutants
farm irrigation	improves food production	uses/wastes too much water
use of fertilizers	increases plant growth	results in overgrowth of algae
sewer systems	carry away waste	contaminate water bodies
use of herbicides	kills weeds	toxic to other plants and animals

3. On a separate sheet of paper, create a chart to describe three special properties of water and to justify why these are essential to life on Earth.
Answers may include:

Property	Importance
can take three forms: liquid, solid and vapor	• permits self-purifying (water) cycle
solid form (ice) is not as dense as liquid form	• ice floats and lakes do not freeze solid, trapping and killing fish and other aquatic life • can break rocks by freezing and thawing
dissolves many different things	• aquatic animals and plants can live and grow under water • animals and plants can draw nutrition from water
molecules attract one another, creating surface tension	• things can float on surface • forms drops
molecules cling to other things	• water can climb up plant roots and stems • blood can flow through tiny blood vessels
has a high boiling point and a low freezing point; can absorb a lot of heat before it begins to get hot	• provides living things a fairly constant environment
transparent to light	• plants can live under water

Enrichments

Project WET:

- Adventures in Density
- Choices and Preferences, Water Index
- Common Water
- Drop in the Bucket
- Every Drop Counts
- H2Olympics
- Hangin' Together
- Is There Water on Zork?
- Water Meter
- What's the Solution?

Project WILD Aquatic:

- How Wet Is Our Planet?
- Something's Fishy Here!
- What's in the Water?

Video clips:

- Mississippi River Maintenance Man
- Missouri River Relief

Guest speakers:

- Department of Natural Resources water resource professional. If invited for Activities 1.7 or 1.8, the speaker may be able to assist with instruction as well as talk about careers and clean water issues.
- Stream Team volunteer water quality monitor. If invited for Activities 1.7 or 1.8, the speaker may be able to assist with instruction as well as talk about volunteer opportunities and clean water issues.

2 The Ultimate Recyclable

All water on Earth, including the water that flows from our taps and the water we flush down the drain, is part of a natural cycle.

Estimated Time

Three 50-minute class sessions

Technology Tools/Skills Used in Chapter

Retrieving reliable information from the Internet and other media.

Safety Precautions/Concerns

None

Vocabulary

Acid rain
Aquifer
Atmosphere
Biosphere
Condense
Evaporation
Geosphere
Groundwater
Precipitation
Recharge
Runoff
Saturated
Surface water
Transpiration
Wetland

Chapter Objectives

Students will be able to:

1. Diagram and describe the path of water through the hydrosphere, geosphere and atmosphere (the water cycle).
2. Define and differentiate between weather and climate
3. Using a specific example, explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences to aquatic resources in Missouri.
4. Explain, using Missouri-specific examples, how the availability of fresh water for humans and other living organisms is dependent upon the water cycle.

Targeted Grade-Level Expectations

ES.2.E.7.a. Explain and trace the possible paths of water through the hydrosphere, geosphere, and atmosphere (i.e., the water cycle: evaporation, condensation, precipitation, surface run-off/ groundwater flow)
ES.1.D.7.a. Differentiate between weather and climate
ES.3.A.6.b.
ES.3.A.7.b. Provide examples of how the availability of fresh water for humans and other living organisms is dependent upon the water cycle
IS.1.C.6.a.
IN.1.A.6.a. Formulate testable questions and hypotheses
IN.1.B.6.a.
IN.1.B.6.b. Communicate the procedures and results of investigations and explanations through:

- **oral presentations**
- **drawings** and maps
- **data tables (allowing for the recording** and analysis **of data relevant to the experiment,** such as independent and dependent variables, multiple trials, beginning and ending times or **temperatures, derived quantities)**
- graphs (bar, single line, pictograph)
- **writings**

Reference Material for Teacher Background

- EPA Missouri Drinking Water page at *epa.gov/safewater/dwinfo/mo.htm*
- *en.wikipedia.org/wiki/Sewage_treatment*
- *howstuffworks.com/sewer2.htm*
- Missouri DNR Public Drinking Water page at *dnr.mo.gov/env/wpp/dw-index.htm*
- Stream Team Middle School Activity Guide by Mark Van Patten at *mostreamteam.org/activity_guide/contents.htm*

- Streets to Streams Guide (E00428)
- Streets to Streams Video (E00447)
- USGS Water Science for Schools wastewater treatment page at *ga.water.usgs.gov/edu/wuww.html*
- What Happened to the Stream in My Backyard? (STR238)

Safety Precautions/Concerns

None

Required Materials

- Large strip of butcher paper
- Crayons, markers, colored pencils or chalk
- 3 large foil roasting pans
- Squeeze bottle or pump sprayer containing water
- Food coloring
- Soil (use topsoil or freshly dug yard/garden soil—commercial potting soil is too light)
- 1-inch square of sod (grass with soil attached—available at lawn and garden supply store)
- Paper towels for spills
- Student Guide
- Notebook paper
- Pens or pencils

Activity 2.1: Exploration of Students' Current Understanding of the Water Cycle

This activity explores students' current understanding of the water cycle.

Estimated Time

25 minutes

Required Materials

- Large strip of butcher paper
- Crayons, markers, colored pencils or chalk

Procedure

1. Post a large strip of butcher paper on a classroom wall and provide crayons, markers, colored pencils, or chalk. Alternatively, a strip of sidewalk may be used or students may work individually using smaller sheets of paper.

2. Ask students to work together to create a mural to explore the following questions:
   - Where does water come from?
   - Where does water go when it rains?
   - Does polluted water stay polluted forever or can dirty water get clean again?
   - What does water have to do with weather?
   - Where does water go when we flush it down the drain?

3. Explain to the class that this chapter will help them understand the water cycle, how we get clean water to drink and why weather matters.

Activity 2.2: Teacher Demonstration of Water Runoff and Infiltration

This demonstration helps students understand runoff and the benefits of allowing precipitation to soak in to soil and vegetation.

Estimated Time

25 minutes

Required Materials

- 3 large foil roasting pans
- Squeeze bottle or pump sprayer containing water
- Food coloring
- Soil (use topsoil or freshly dug yard/garden soil—commercial potting soil is too light)
- 1-inch square of sod (grass with soil attached—available at lawn and garden supply store)
- Paper towels for spills

Procedure

1. Prepare in advance by filling one foil pan with soil so that it comes half way up the side on one end and gently slopes to the bottom of the pan, stopping about 2 inches from the opposite end of the pan. Gently pack the soil. Place the sod in another pan. Trim the sod to fit if necessary, leaving about 2 inches open at one end of the pan. Gently press the sod down. To simulate a hill, raise the sod end of the pan. Leave the third pan empty and raise one end of the pan.

2. Tell the class that the pans represent three different hills: one with plants growing on it, one with bare ground and one with pavement. The hills slope to streams, lakes or wetlands, which are represented by the clear spaces at the bottom of the hills. Ask students to watch carefully as you simulate rain on the three hills.

3. Use the squeeze bottle or pump sprayer to spray or trickle water onto the sod, the bare soil and the paved surface. Try to release the water at the same rate each time. (You may wish to ask student volunteers to do this under your direction.)

4. Ask students what happened in each case. (The water takes longer to run out of the sod-covered hill than the bare-soil hill and faster down the pavement than the soil. Also, more soil will flow into the water from the bare-soil hill than from the sod-covered hill.) Ask students to explain the differences.

5. Ask students to describe some situations in which soil might be washed into aquatic resources. (Possible answers include house or road construction work, farming row crops, dirt from roads and parking lots, poorly grassed lawns, etc.)

6. Tell the class to imagine that a man has spilled used motor oil on the ground while changing the oil in his car. Ask the class what will happen if oil were spilled on each of the three hills. Place a few drops of food coloring on each hill. (Food coloring runs quickly off the bare surface but is absorbed by the soil and the sod.)

7. Ask the class to predict what will happen when it rains. Use the squeeze bottle or pump sprayer to spray or trickle water onto the sod, the bare soil and the paved surface. (Colored water runs quickly off the bare surface, less quickly off the soil, and slowly from the sod.)

8. Use a cooperative learning activity to have students discuss the results observed and their implications for local aquatic resources.

Activity 2.3: Student Investigation of Weather and Climate

This activity helps students understand the water cycle and differentiate between weather and climate.

Estimated Time

35 minutes of in-class discussion over two consecutive days (25- and 10-minute discussions)

Required Materials

- 1 Weather Terms and Measurements Table for each student
- 1 Weather Observations and Measurements sheet for each student
- Pens or pencils

Procedure

Day one (25 minutes)

1. Review the water cycle with the class as needed based on the results of Activity 2.1.

2. Use a cooperative learning activity to have students generate ideas for ways to find reliable weather information. Be sure they include newspapers, internet weather sites and television or radio stations. Have students discuss how weather affects their daily lives.

3. Distribute a Weather Terms and Measurements Table to each student.

4. Lead class discussion of the weather terms and measurements described in the table. Ask students to describe some ways weather affects the availability of fresh water in their area.

5. Distribute a Weather Observations and Measurements sheet to each student.

6. Instruct students to use the sheet to record the day's weather data and bring the completed page to class the next day.

Day two (10 minutes)

1. Lead class discussion of weather data findings.

2. Have students add the Weather Observations and Measurements sheets to their science notebooks.

Weather Terms and Measurements Table

Term	Description or definition	Instrument of measurement	Units of measurement	Abbreviation
Air temperature (High = highest temperature of the day; Low = lowest temperature of the day	Hotness or coldness of surrounding atmosphere	Thermometer	Celsius or Fahrenheit degrees	°C or °F
Wind speed	Velocity of air movement	Anemometer	Miles or kilometers per hour	mph, mi/hr or km/hr, kph
Wind direction	Compass bearing from which wind is moving	Vane or windsock	None	N, S, E, W, NE, SE, NW, SW
Atmospheric or barometric pressure	Weight of the atmosphere over a unit area of Earth's surface	Barometer	Inches of mercury or millibars	inHg or mb
Relative humidity	Amount of moisture in the air as a percentage of the maximum possible	Hygrometer	Percentage	%
Precipitation	Amount of rain, snow, sleet or hail that reaches the ground	Rain gauge	Inches, feet or millimeters	in., ft. or mm
Cloud cover	Fraction of sky obscured by clouds	Direct observation	Description	Clear, scattered clouds, partly cloudy, mostly cloudy, overcast

WEATHER OBSERVATIONS AND MEASUREMENTS

Copy Page

Objective

Obtain, record and present weather data.

Directions

1. Find a reliable source of daily information about the weather in your area.

2. Record today's weather data for your area. Be sure you report the source of each piece of data, the date and location for which it was reported.

Name: _____

Date: _____

Location: _____

Weather on _____ (date) for _____ (location)

Weather factor	Observation or measurement	Information source
High temperature		
Low temperature		
Wind speed		
Wind direction		
Atmospheric pressure		
Relative humidity		
Precipitation		
Cloud cover		

Activity 2.4: Student Reading and Research

This activity provides students with definitions and explanations about the path of water through the hydrosphere, geosphere and atmosphere (the water cycle) and helps students differentiate between weather and climate. It helps students understand where their tap water comes from and what happens to their wastewater.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 2: The Ultimate Recyclable. Introduce vocabulary terms as needed.

2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.
   1. What is the water cycle? Where does it start and where does it end? Where does water spend most of its time?
      The water cycle is the movement of water through the atmosphere, geosphere and biosphere. It starts anywhere water exists in any form; or, it has no beginning or end. Water spends most of its time in the oceans.
   2. What is weather? What is climate? How do they affect the quality and quantity of our water?
      Weather is the movement of water through the water cycle, or the observed atmospheric conditions in a given time and place. Climate is the average atmospheric conditions in an area over many years. Weather and climate affect the quality and quantity of our water in many ways, including:
      - **The water cycle is the natural process that purifies Earth's water.**
      - **How much water there will be in a certain region in a given part of the water cycle depends on the amount of rainfall, the effect of temperature on evaporation and the uptake of water by plants during the growing season.**
      - **Even small changes in the global cycle can cause droughts or floods at the local level.**

3. What kind of climate does Missouri have?
   Answers may include: 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.

4. What is surface water? What is groundwater?
   Surface water is water that flows over the land. Groundwater is water that soaks into the ground.

5. Where does water go when it runs off a street?
   Stormwater runoff goes through storm drains and ditches, then directly into streams, lakes and wetlands without being cleaned or processed.

6. Where does our water come from? How does it get to our faucets?
   Assess locally. Answers should include identifying the water source as either surface water or groundwater and whether or not the water is treated.

7. What happens to water after we've used it? Where does it go when it goes down the drain?
   Assess locally. Answers should include the treatment method used.

Activity 2.5: Student Investigation of Tap Water and Wastewater

This activity helps students understand where their tap water comes from and what happens to their wastewater.

Estimated Time

Varies—class time may be provided or research may be assigned as homework. Allow at least 25 minutes for in-class questions and discussion.

Required Materials

- Notebook paper
- Pens or pencils

Prepare in advance

Conduct your own investigation to determine where the school's tap water comes from, how the school's tap water is treated, where the school's wastewater goes and how the school's wastewater is treated.

Procedure

1. Use a cooperative learning activity to have students generate ideas about where they think their school and home tap water come from. Lead class discussion of various possibilities, including untreated groundwater (many individual domestic-use wells in rural areas), treated groundwater (many municipal wells) and treated surface water (many municipal water supplies). Have students work in groups to talk through the steps water must take to get from a source to the tap. Have students generate ideas about how they would go about finding out where their water comes from, both at school and at home. (Ask parents, look at water bill, call local water utility, etc.)

2. Have students generate ideas about where they think their school and home wastewater goes. Lead class discussion of various possibilities, including septic systems and sewage lagoons (many individual domestic systems in suburban and rural areas), small-scale "package" treatment systems (many domestic systems in suburbs) and large-scale treatment plants and wastewater wetlands (many municipal systems). Have students work in groups to talk through the steps wastewater must go through to get from toilets back into the environment. Have students generate ideas about how they would go about finding out where their wastewater goes, both at school and at home. (Ask parents, look at water bill, call local water utility, etc.)

3. Assign investigation of tap water source and wastewater treatment as homework or in-class research. Have students write science notebook entries describing the process and outcome of their research. When completed, lead class discussion of findings.

Activity 2.6: Student Investigation of Weather

Students apply what they have learned in the preceding activities to create science notebook pages to record weather conditions and observations in preparation for their field study day.

Estimated Time

25 minutes

Required Materials

- Notebook paper
- Pens or pencils

Procedure

1. Instruct students to work in groups to decide the best way to record weather conditions and observations as part of their field study day.

2. Have each group create a data table and have each student make a copy for his/her science notebook.

Chapter 2 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. How does the water cycle purify water?
   a. Water flows through underground aquifers
   b. Every time water evaporates it becomes pure again
   c. Water vapor condenses to form raindrops
   d. All of the above

2. Where does the water cycle start?
   a. Anywhere water exists in any form
   b. Water vapor condenses in clouds
   c. When precipitation falls to the ground
   d. In the oceans

3. What is weather?
   a. Hot, damp summers and cold, dry winters
   b. The movement of water from soil through plant roots and stems, and out the leaves into the atmosphere
   c. Average atmospheric conditions in an area over many years
   d. The movement of water through the water cycle

4. What is climate?
   a. Hot, damp summers and cold, dry winters
   b. The movement of water from soil through plant roots and stems, and out the leaves into the atmosphere
   c. Average atmospheric conditions in an area over many years
   d. All of the above

5. What is surface water?
   a. Water absorbed by plants and released slowly into waterways
   b. Water that soaks into the ground
   c. Water that flows over the land
   d. Water frozen in glaciers, snowpacks and polar ice caps

6. What is groundwater?
   a. Water absorbed by plants and released slowly into waterways
   b. Water that soaks into the ground
   c. Water that flows over the land
   d. Water frozen in glaciers, snowpacks and polar ice caps

7. Where does water go when it runs off a street?
   a. To wastewater treatment plants for processing before being returned to the environment
   b. To drinking water treatment plants, then through pipes to our taps
   c. To pick up air pollution, forming acid rain
   d. Through storm drains and ditches, then directly into streams, lakes and wetlands without being cleaned or processed

8. Where does water go when it goes down the drain?
   a. To a wastewater treatment plant, septic system or lagoon for processing before being returned to the environment
   b. To drinking water treatment plants, then through pipes to our taps
   c. To pick up air pollution, forming acid rain
   d. Through storm drains and ditches, then directly into streams, lakes and wetlands without being cleaned or processed

Chapter 2 Assessment

Copy Page

Directions

Write your own answer for each of the following questions.

1. Define weather and climate and differentiate between them. How are they related? Describe Missouri's climate.

2. Justify the following statement: The availability of fresh water for humans and other living organisms is dependent upon the water cycle.

3. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as groundwater wells, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Missouri.

4. Diagram and describe the path of water through the biosphere, geosphere and atmosphere (the water cycle). Show at least five processes that are part of the cycle. Be sure to label the parts of your diagram correctly. Use the back of this page.

Chapter 2 Assessment Answer Key

Multiple-choice questions

1. How does the water cycle purify water?
   b. Every time water evaporates it becomes pure again.

2. Where does the water cycle start?
   a. Anywhere water exists in any form

3. What is weather?
   d. The movement of water through the water cycle

4. What is climate?
   c. Average atmospheric conditions in an area over many years

5. What is surface water?
   c. Water that flows over the land

6. What is groundwater?
   b. Water that soaks into the ground

7. Where does water go when it runs off a street?
   d. Through storm drains and ditches, then directly into streams, lakes and wetlands without being cleaned or processed

8. Where does water go when it goes down the drain?
   a. To a wastewater treatment plant, septic system or lagoon for processing before being returned to the environment

Write-in questions

1. Define weather and climate and differentiate between them. How are they related? Describe Missouri's climate.
   Definitions:
   - **Weather is the movement of water through the water cycle, or the observed atmospheric conditions in a given time and place.**
   - **Climate is the average weather conditions over longer times.**

   Difference:
   - **Weather is the actual observed atmospheric condition at a given time and place.**
   - **Climate is the atmospheric conditions one would tend or expect to observe at a given time and place.**

   Relationship:
   - **Climate is determined and understood by observing and recording weather over many years. It includes seasonal variations in weather.**

   Missouri's climate: Answers may include:
   - **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.**

2. Justify the following statement: The availability of fresh water for humans and other living organisms is dependent upon the water cycle.
   Answers may include:
   How much water there will be in a certain region in a given part of the water cycle depends on the amount of rainfall, the effect of temperature on evaporation and the uptake of water by plants during the growing season. Even small changes in the global cycle can cause droughts or floods at the local level.

3. Assess how human activities affect the quality of water. Using a specific example, show how a technological solution (such as groundwater wells, paved roads and parking lots, sewer systems, use of fertilizers and herbicides, etc.) to a problem can have both benefits and drawbacks (such as risks or unintended consequences) to aquatic resources in Missouri.
   Answers may include:

Activity/technological solution	Potential benefit	Potential drawback
groundwater wells	provide water for various uses: drinking, cleaning, irrigation, etc.	can take thousands of years to recharge, pumping out water may cause ground subsidence (sinking or caving in)
paved roads/parking lots	improve surface transportation	water running off surface carries heat and pollutants
sewer systems	carry away waste	contaminate water bodies
use of fertilizers	increases plant growth	results in overgrowth of algae
use of herbicides	kills weeds	toxic to other plants and animals

4. Diagram and describe the path of water through the biosphere, geosphere and atmosphere (the water cycle). Show at least five processes that are part of the cycle. Be sure to label the parts of your diagram correctly. Use the back of this page.
   Refer to FIG. 2.1. Answers should include at least five of the following:
   - **evaporation**
   - **condensation**
   - **precipitation**
   - **interception (plants catch and slow precipitation)**
   - **infiltration or recharge (water soaking into the ground)**
   - **transpiration (plants releasing water through photosynthesis)**
   - **surface runoff or stream flow**
   - **groundwater flow or discharge**
   - **water storage in ocean, atmosphere, icepack, ground or fresh surface waters**

Enrichments

Project WET:

- Dust Bowls and Failed Levees
- Get the Ground Water Picture
- Incredible Journey
- Piece It Together
- Poetic Precipitation
- Poisoned Pump
- Sparkling Water
- Thirsty Plants
- Water Models
- Wet Vacation
- Where Are the Frogs?

Project WILD Aquatic:

- Alice in Waterland
- Water Wings
- What's in the Air?
- Where Does Water Run?

Video clips:

- Mississippi River Maintenance Man
- Missouri River Relief

Guest speakers:

- Local drinking water treatment plant worker. If invited for Activity 2.5, the speaker may take the place of the research assignment.
- Local wastewater treatment plant worker. If invited for Activity 2.5, the speaker may take the place of the research assignment.
- Local weather reporter. If invited for Activity 2.3 or 2.6, the speaker may be able to assist with instruction.

Demonstrations:

- Enviroscape model
- Stream Table

Service learning:

- Storm drain stenciling
- Litter pickup

Additional enrichments:

- School weather station
- Field trip: Wastewater treatment plant tour (drinking water treatment plants have been off limits to the public since the terrorist attacks of 9/11)

3 What's Your Watershed Address?

Everyone lives in a watershed. Everything that happens on the land in a watershed affects the water body into which it drains.

Estimated Time

Three or four 50-minute class sessions

Technology Tools/Skills Used in Chapter

Topographic map reading

Safety Precautions/Concerns

None

Vocabulary

Channel
Erosion
Headwaters
Intermittent stream
Non-point pollution
Perennial stream
Physiographic
Point-source pollution
Sediment
Tributary
Watershed
Watershed address

Chapter Objectives

Students will be able to:

1. Define watershed and identify the watershed in which they live or attend school.
2. Explain the relationship between the watershed and the water body into which it drains.
3. Define point-source and non-point pollution. Compare and contrast them and support the answer using a specific example of each that is relevant to aquatic resources in Missouri.
4. Define erosion and sedimentation and analyze how human activity affects erosion and sedimentation. Describe the impact of erosion and sedimentation on aquatic resources in Missouri.
5. Identify Missouri's physiographic regions and explain how land type affects Missouri's aquatic resources.
6. Define water quality and support using a specific example of how humans affect water quality in a Missouri watershed.
7. Explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences, and support the explanation using a specific example of aquatic resources in Missouri.

Targeted Grade-Level Expectations

ES.3.A.6.b.
ES.3.A.6.c. Analyze the ways humans affect the erosion and deposition of soil and rock materials (e.g., clearing of land, planting vegetation, paving land, construction of new buildings, building or removal of dams)
IS.1.C.6.a.
IN.1.B.6.a.
IN.1.E.6.a. Communicate the procedures and results of investigations and explanations through:

- oral presentations
- drawings and **maps**
- data tables (allowing for the recording and analysis of data relevant to the experiment, such as independent and dependent variables, multiple trials, beginning and ending times or temperatures, derived quantities)
- graphs (bar, single line, pictograph)
- **writings**

Reference Material for Teacher Background

- Bryant Creek Watershed Project at *watersheds.org*
- MDC Watersheds page at *mdc.mo.gov/fish/watershed/*

- Missouri DNR Water Pollution Control page at *dnr.mo.gov/env/wpp/wp-index.html*
- Stream Team Middle School Activity Guide by Mark Van Patten at *mostreamteam.org/activity_guide/contents.htm*
- Streets to Streams Guide (E00428)
- Streets to Streams Video (E00447)
- Teaching with topos—for information about obtaining, reading and using topographic maps go to *rockyweb.cr.usgs.gov/outreach/topoteach.html* and *interactive2.usgs.gov/learningweb/teachers/mapsshow.htm*
- Watershed Management Placemat (FIS273)
- Watershed Protection Practices (F00050)
- What Happened to the Stream in My Backyard? (STR238)

Safety Precautions/Concerns

None

Required Materials

- 1 square of aluminum foil for each student
- Squeeze bottle or pump sprayer containing water for each student or group
- Food coloring for each student or group
- Paper towels for spills
- Student Guide
- Notebook paper
- Pens or pencils
- Transparency of delineated watershed and notable features
- Transparency 3.1: Mississippi and Missouri Watersheds Map
- Transparency 3.2: Missouri's Watersheds Map
- Transparency 3.3: Missouri Counties Map
- Transparency 3.4: Missouri's Physiographic Regions Map
- Overhead projector (or other projection technology)
- Washable markers (enough for each student or group)
- USGS 7.5-minute quadrangle topographic map for each group (Obtain maps that include the area to which you will travel on your field study or your school. Laminate prior to use.)

Activity 3.1: Exploration of Students' Current Understanding of the Watershed Concept

This activity explores students' current understanding of the watershed concept.

Estimated Time

5 minutes

Required Materials

None

Procedure

1. Use a cooperative learning activity to explore the following questions:
   - Do you live in a watershed?
   - How does what happens on land in [name your area] affect the water in [name your local lake, stream or wetland]?
   - What makes water muddy? Is muddy water bad?

2. Explain to the class that this chapter will help them understand the relationship between what happens on the land and what happens in the water.

Activity 3.2: Student Investigation of Watershed Concept

This hands-on activity helps students visualize the concept of the watershed and helps them understand the relationship between a water body and its watershed.

Estimated Time

25 minutes

Be sure to have paper towels on hand!

Required Materials

- 1 square of aluminum foil for each student
- Squeeze bottle or pump sprayer containing water for each student or group
- Food coloring for each student or group
- Pens or pencils
- Paper towels for spills

Procedure

1. Tell students that they are going to make a watershed model. Explain that a watershed is all the land that drains water into a particular water body.

2. Distribute the squares of aluminum foil to each student or group. Instruct them to make a fist with one hand and place the foil over it using their other hand. Tell them to mold or smooth the foil around their fist, then to remove the foil and place it on the desk with the open side up like a cup. In some cases, it may be necessary to spread or flatten out the foil somewhat before proceeding.

3. Explain that the foil represents a watershed. The places where their knuckles were represent the low spots in the watershed. These will fill with water first, to become rivers, lakes and wetlands. Furrows where their fingers were represent valleys within the watershed. Explain that the edges of the foil are the highest points of the watershed. They represent ridgelines and mountaintops.

4. Direct the students to simulate rain in the watershed using the squeeze bottle or pump sprayer. Have students carefully observe the behavior of the water. Ask them to describe where the water went as it fell on their model watershed. (The water will run down from the high points through the valleys in streams until it reaches the low areas in the watershed, where it will collect.)

5. Invite the students to experiment by manipulating the contours of the foil and observing how the water changes paths when they spray on more water.

6. Suggest that students use a pencil to make one or two holes in the foil to simulate groundwater recharge in their model watersheds.

7. Ask students to place one or two drops of food coloring in locations around their watersheds, and simulate rain again. Explain that the food coloring represents pollution, and that the colored runoff represents non-point pollution—water pollution that comes from a broad area or a number of sources.

8. Lead class discussion of questions and observations. Be sure to emphasize that any pollutant on the land of a watershed will be carried by runoff into the waterbody of the watershed.

9. Have students clean up and dispose of used materials properly.

Activity 3.3: Student Investigation of Land Use and Pollution within a Watershed

This on-site activity helps students learn to make observations about watershed and land use conditions and develops understanding of non-point pollution.

Estimated Time

25 minutes

Required Materials

- Notebook paper
- Pens or pencils

Procedure

1. Take the class outside on the school grounds. (If that is not possible, the activity may be conducted from a suitable vantage point within the building.) Remind students that they are standing in a watershed and that everything around them is part of a watershed. Lead class discussion to help students understand that watersheds may include buildings, parking lots, athletic fields, lawns, homes, streets, farms, grasslands, forested areas, etc. Point out that when rain falls, water flows over all of the surfaces, picking up whatever contaminants may be present as it moves downhill. This is non-point pollution.

2. Have students explore the area to identify potential sources of pollution on the school grounds. Be sure to look for and point out signs of erosion. Ask students to identify land uses or features that may help reduce or contain pollution (for example, grassy swales or other planted areas between potential pollution sources and drainage areas). Ask students how non-point pollution gets in the watershed, and how people may prevent pollution or reduce its effects.

3. Have students record their thoughts and observations in their science notebooks.

Activity 3.4: Teacher Demonstration of Missouri Watersheds and Physiographic Regions

This demonstration helps students understand Missouri's watersheds, physiographic regions and the relationship between land types and aquatic resources. Students determine their watershed address.

Estimated Time

25 minutes

Required Materials

- Transparency 3.1: Mississippi and Missouri Watersheds Map
- Transparency 3.2: Missouri's Watersheds Map
- Transparency 3.3: Missouri Counties Map
- Transparency 3.4: Missouri's Physiographic Regions Map
- Overhead projector (or other projection technology)

Procedure

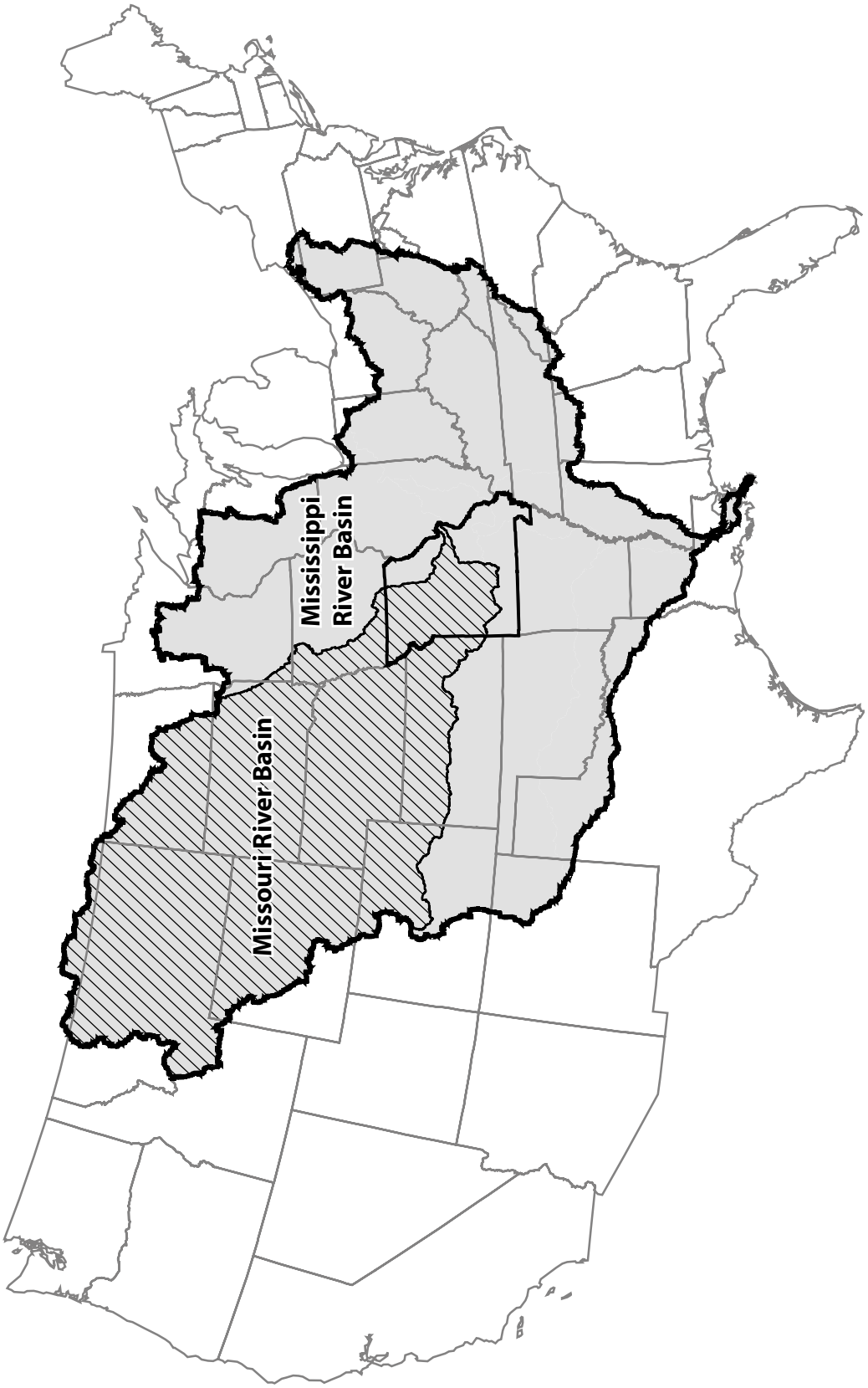
1. Display Transparency 3.1: Mississippi and Missouri Watersheds Map and discuss where Missouri fits into the United States and the Mississippi and Missouri watersheds. Point out that the state of Missouri lies entirely within the Mississippi watershed. Also point out that the Missouri watershed is part of the Mississippi watershed because the Missouri River flows into the Mississippi River. Explain that watershed boundaries frequently do not correspond to political boundaries. As an example, point out that a small part of the Missouri River watershed crosses the U.S. border into Canada.

2. Explain that, just as the Missouri watershed is a part of the Mississippi watershed, there are multiple smaller watersheds within every large watershed, and that Missouri has many watersheds within it. Put up Transparency 3.2: Missouri's Watersheds Map. Point out some of the significant watersheds in the state.

3. Place Transparency 3.3: Missouri Counties Map over the top of the watershed map. Carefully line up the state's borders. Draw the students' attention to your school's county. Ask students in which watershed the school is located. Lead class discussion to determine the school's watershed address. (For example, the watershed address of Summit Lakes Middle School in Lee's Summit is South Grand—Osage—Missouri—Mississippi.) Have students record the school's watershed address in their science notebooks. If any students live in other watersheds, help them determine their watershed address. Have students record in their science notebooks their home watershed address.

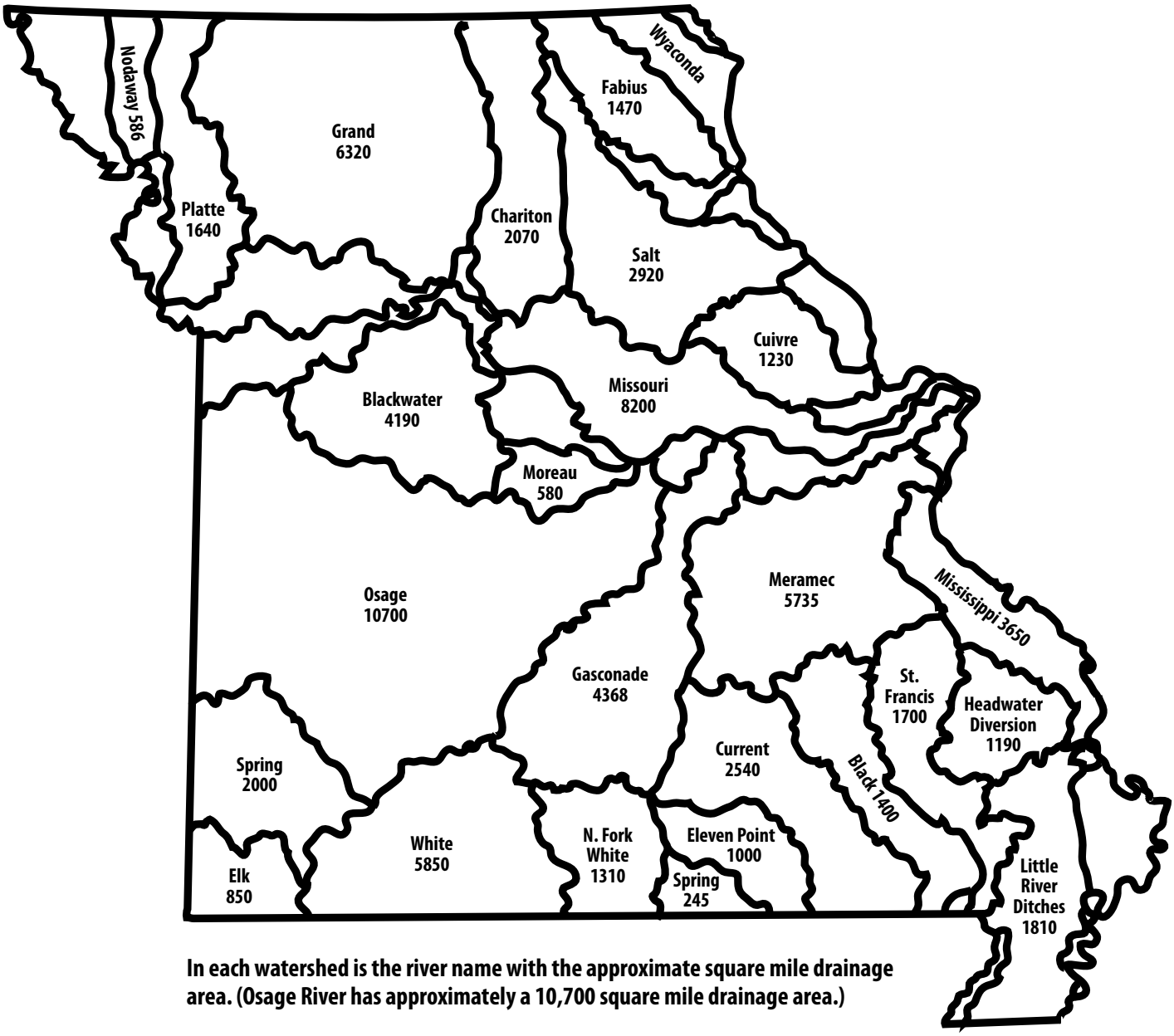
4. Using Transparency Master 3.4: Missouri's Physiographic Regions, briefly discuss the five major regions in Missouri. Be sure to identify and describe the physiographic region in which your school is located.

Transparency 3.1: Mississippi and Missouri Watersheds Map



Transparency 3.2: Missouri's Watersheds Map

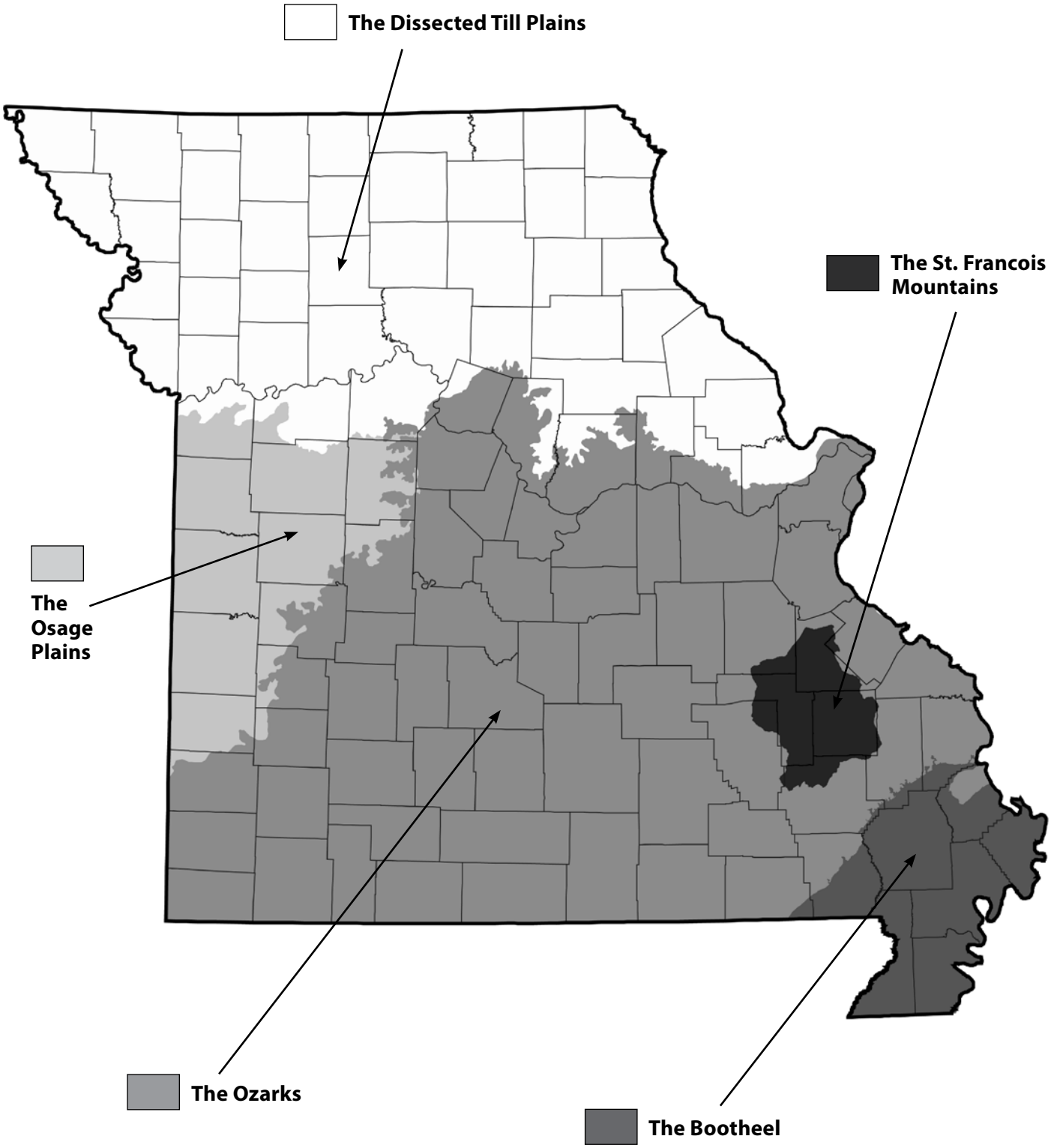
Map courtesy of Missouri Stream Team



In each watershed is the river name with the approximate square mile drainage area. (Osage River has approximately a 10,700 square mile drainage area.)

Transparency 3.3: Missouri Counties Map

Transparency 3.4: Missouri's Physiographic Regions Map



Activity 3.5: Student Reading and Research

This activity provides students with definitions and explanations about the watershed concept and the relationship between the land of a watershed and the waterbody to which it drains.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 3: What's Your Watershed Address? Introduce vocabulary terms as needed.

2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.
   1. What is a watershed? Which watershed do you live in?
      A watershed is all the land that drains water into a particular body of water. Assess locally.
   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?
      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. 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 sediment, pollutants and heat. These contaminants flow into a stream, wetland or lake you use to drink, swim in or fish from.
   3. What is point-source pollution? What is non-point pollution?
      Point-source pollution is contamination that can be traced to a single source. Non-point pollution is water pollution that comes from a broad area or a number of sources.
   4. What is erosion? What causes it?
      Erosion is the movement of solid material such as rock, soil or mud. It is a natural process caused by the forces of wind, water, ice, gravity and/or living things.
   5. What is sediment? Where does it come from?
      Sediment is any bit of rock or soil that is suspended or carried in water. It comes from eroding rock, soil or mud.
   6. How does human activity affect erosion and sedimentation? What is the impact of erosion and sedimentation on aquatic resources?
      Erosion can be accelerated by cutting down too many trees, overgrazing or disturbing land for construction. Planting trees and building terraces are two ways to slow erosion. 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. 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. 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.
   7. What are Missouri's physiographic regions?
      Missouri's physiographic regions are the Bootheel, the Ozarks, the Osage Plains, the St. Francois Mountains and the Dissected Till Plains.

Activity 3.6: Student Investigation of Watershed Mapping

This hands-on activity helps students understand the watershed concept. Students use topographic maps to delineate watershed boundaries and to identify potential impacts on the watershed and waterbody.

Estimated Time

25 to 50 minutes

Required Materials

- 1 laminated topographic map for each group
- Washable markers (enough for each student or group)
- Paper towels for erasing marks on maps
- Transparency of delineated watershed and notable features

Prepare in advance

Familiarize yourself with the topographic map and symbols, and with the area you will be studying. Perform the activity yourself and determine the features of the watershed. Create a transparency by overlaying a transparency blank over the map and tracing the watershed features onto it or by photocopying the map with the watershed features delineated.

Procedure

1. Students should work in groups. Distribute laminated topographic maps, washable markers and paper towels to groups.

2. Briefly explain the activity to the students and explain how to interpret a topographic map. Be sure to describe how to identify bodies of water, including perennial and intermittent streams, contour lines, uphill and downhill directions and high points.

3. Instruct students to place an X on the furthest point downstream (lowest elevation) that they will evaluate. All waterways upstream from this point are tributaries to this waterway, and all land uphill from this point is the watershed. Have students trace the waterbody and its tributaries with a marker.

4. Have students find the highest points around the X. These are the circles or closed loops of contour lines surrounding the X. Ask students to mark these with a dot. Then have them connect the dots with a smooth line following the highest contours. The area enclosed by this loop is the watershed. Be sure each group has produced a correct watershed outline.

5. Have students identify points of interest within the watershed. Potential sources of pollution may include dumps or landfills, farms or animal-feeding operations, golf courses and other places that may use fertilizer, sewage treatment plants and other known point sources, highways and mall parking lots, mines and other areas of land disturbance such as construction sites. Also note features that may have positive impacts, such as forested or other less-developed areas.

6. Lead class discussion of the features of the watershed and the potential impacts to water quality that they can identify within the watershed.

Activity 3.7: Student Investigation of Watershed and Land Use Conditions

Students apply what they have learned in the preceding activities to create science notebook pages to record observations of watershed and land use conditions in preparation for their field study day.

Estimated Time

25 minutes

Required Materials

- Notebook paper
- Pens or pencils

Procedure

1. Instruct students to work in groups to decide the best way to record observations of watershed and land use conditions as part of their field study day.

2. Have each group create a data table and have each student make a copy for his/her science notebook.

Chapter 3 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. What is non-point pollution?
   a. A stream that empties into a particular body of water
   b. Water pollution that comes from a broad area or a number of sources
   c. The movement of solid material such as rock, soil or mud
   d. Contamination that can be traced to a single source

2. What is erosion?
   a. Any bit of rock or soil that is suspended or carried in water
   b. Water pollution that comes from a broad area or a number of sources
   c. The movement of solid material such as rock, soil or mud
   d. All of the above

3. What is a watershed?
   a. A stream that empties into a particular body of water
   b. The area where precipitation first collects in tiny trickles too small to create a permanent channel
   c. A stream that flows all year long
   d. All the land that drains water into a particular body of water

4. What is point-source pollution?
   a. A stream that empties into a particular body of water
   b. Water pollution that comes from a broad area or a number of sources
   c. The movement of solid material such as rock, soil or mud
   d. Contamination that can be traced to a single source

5. What is sediment?
   a. Any bit of rock or soil that is suspended or carried in water
   b. Water pollution that comes from a broad area or a number of sources
   c. The movement of solid material such as rock, soil or mud
   d. None of the above

Chapter 3 Assessment

Copy Page

Directions

Write your own answer for each of the following questions.

1. What is the watershed address of your school?

2. Identify and describe the physiographic region in which your school is located.

3. How does human activity affect erosion and sedimentation? Justify your answer using an example relevant to Missouri's aquatic resources.

4. Describe the relationship between a watershed and the waterbody into which it drains. Support your answer with an example relevant to Missouri's aquatic resources.

Chapter 3 Assessment Answer Key

Multiple-choice questions

1. What is non-point pollution?
   b. Water pollution that comes from a broad area or a number of sources

2. What is erosion?
   c. The movement of solid material such as rock, soil or mud

3. What is a watershed?
   d. All the land that drains water into a particular body of water

4. What is point-source pollution?
   d. Contamination that can be traced to a single source

5. What is sediment?
   a. Any bit of rock or soil that is suspended or carried in water

Write-in questions

1. What is the watershed address of your school?
   Assess locally. Refer to Activity 3.3.

2. Identify and describe the physiographic region in which your school is located.
   Assess locally. Refer to Activity 3.3.

3. How does human activity affect erosion and sedimentation? Justify your answer using an example relevant to Missouri's aquatic resources.
   Answers should include at least one impact, one effect of human activity and one example. Some possibilities include the following:
   Impacts:
   - **Sediment can clog streams with gravel and fill reservoirs with sediment.**
   - **Excess sediment blocks out light, killing aquatic plants or preventing their growth.**
   - **Sediment covers up the nooks and crannies animals live in.**
   - **Sediment smothers aquatic animals by clogging their gills and by reducing the amount of oxygen in the water.**

   Effects of human activity:
   - **Deforestation, overgrazing or construction speeds up the natural process of erosion.**
   - **Planting trees and building terraces are two ways to slow erosion.**
   - **Planting trees and other vegetation slows moving water down, and plant roots hold soil and rock in place.**

   Examples:
   - **Missouri farmers have switched to no-till planting, rotational grazing and other conservation farming techniques to reduce the amount of erosion and sedimentation in Missouri streams.**
   - **Missouri developers use silt fences, buffer zones and other conservation techniques to reduce the amount of erosion and sedimentation in Missouri streams.**
   - **Missouri Stream Teams plant trees along streams to protect them from erosion and to capture sediment.**

4. Describe the relationship between a watershed and the waterbody into which it drains. Support your answer with an example relevant to Missouri's aquatic resources.

   Answers may include:
   - **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.**
   - **As water runs downhill, it picks up whatever is on the ground.**

   Examples:
   - **When it flows through cities or across fields and pastures, water picks up sediment, pollutants and heat. These contaminants flow into a stream, wetland or lake, affecting the water you use to drink, swim in or fish from.**
   - **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.**

Enrichments

Project WET:

- Branching Out!
- Just Passing Through
- Rainy-Day Hike
- Sum of the Parts

Project WILD Aquatic:

- Watershed
- Where Does Water Run?

Video clips:

- Mississippi River Maintenance Man
- Missouri River Relief

Demonstrations:

- Enviroscape model
- Stream Table

Service learning:

- Storm drain stenciling
- Litter pickup

Guest speaker:

- Stream Team volunteer. If invited for activities, the speaker may be able to assist with instruction as well as talk about volunteer opportunities and watershed issues.

4 Living in the Water

All aquatic species, including fish and other aquatic animals, are uniquely adapted to life in or around water.

Estimated Time

Three 50-minute class sessions

Technology Tools/Skills Used in Chapter

Retrieving reliable information from the Internet and other media.

Safety Precautions/Concerns

None

Vocabulary

Adaptation
Fin
Gill
Lateral line
Predator
Prey
Scale
Streambed
Swim bladder

Chapter Objectives

Students will be able to:

1. Define species and give a Missouri-specific example of an aquatic species.
2. Define adaptation and identify specific adaptations of aquatic species native to Missouri.
3. Predict how certain adaptations may offer a survival advantage to a species in an aquatic environment.
4. Explain how fish swim.
5. Explain how fish see, smell, hear, taste and feel.
6. Compare and contrast fish species and other aquatic animal species native to Missouri.

Targeted Grade-Level Expectations

EC.3.C.6.a. Relate examples of adaptations (specialized structures or behaviors) within a species to its ability to survive in a specific environment (e.g., hollow bones/flight, hollow hair/insulation, dense root structure/compact soil, seeds/food, protection for plant embryo vs. spores**, fins/movement in water)**

EC.3.C.6.b. Predict how certain adaptations, such as behavior, body structure, or coloration, may offer a survival advantage to an organism in a particular environment

IN.1.A.6.a.

IN.1.A.6.b.

IN.1.A.6.c.

IN.1.B.6.a.

IN.1.B.6.b.

IN.1.B.6.c.

IN.1.B.6.d. Measure length to the nearest millimeter, mass to the nearest gram, volume to the nearest milliliter, temperature to the nearest degree Celsius, force (weight) to the nearest Newton, time to the nearest second

IN.1.B.6.e.

IN.1.C.6.a.

IN.1.C.6.b.

IN.1.E.6.a. Communicate the procedures and results of investigations and explanations through:

- oral presentations
- drawings and maps
- **data tables (allowing for the recording and analysis of data relevant to the experiment,** such as independent and dependent variables, multiple trials, beginning and ending times or temperatures, derived quantities)
- graphs (bar, single line, pictograph)
- writings

Reference Material for Teacher Background

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Introduction to Crayfish (FIS011)
- Introduction to Missouri Fishes (FIS020)
- Know Missouri's Catfish (FIS003)
- Life Within the Water (FIS034)
- Map: Smallmouth Bass (FIS019)
- Map: Trout Fishing In Missouri (FIS210)
- Missouri Marsh Birds (E00042)
- Missouri Toads and Frogs (E00430)
- Missouri Turtles (E00468)
- Poster: Missouri Fishes (E00013)
- Poster: Salamander (E00089)
- Poster: Toads & Frogs (E00012)
- Poster: Wetlands & Waterfowl (E00115)
- *Crayfishes of Missouri* (01-0250)
- *Fishes of Missouri* (01-0031)
- *Amphibians and Reptiles of Missouri* (01-0190)
- *Missouri Naiads* (01-0150)
- *Pond Life: Revised and Updated (A Golden Guide from St. Martin's Press)* by George K. Reid

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Poster: Toads & Frogs (E00012)
- Missouri Fishes poster (E00013)
- Missouri Marsh Birds (E00042)
- Poster: Salamander (E00089)
- Missouri Toads and Frogs (E00430)
- Missouri Turtles (E00468)
- Know Missouri's Catfish (FIS003)
- Introduction to Crayfish (FIS011)
- Introduction to Missouri Fishes (FIS020)
- Life Within the Water (FIS034)
- *Missouri Naiads* (01-0150)
- *Crayfishes of Missouri* (01-0250)
- *Fishes of Missouri* (01-0031)
- TV/DVD player
- 1 blank Missouri Fish and Their Characteristics comparison matrix for each student
- 1 copy of the Writing Scoring Guide for each student
- Notebook paper
- Pens or pencils
- Computer with internet connectivity (optional)

Activity 4.1: Exploration of Students' Current Understanding of Species Adaptations

This activity explores students' current understanding of species adaptations, particularly those of fish and other aquatic animals.

Estimated Time

10 minutes

Required Materials

None

Procedure

1. Use a cooperative learning activity to explore the following questions:
   - Why don't fish walk on land?
   - Why can't people breathe under water?
   - If you go swimming a lot, will you start to grow gills and fins? Why or why not?

2. Explain to the class that this chapter will help them understand how fish and other aquatic animals are specially suited for the lives they lead.

Activity 4.2: Video Introduction of Missouri Fishes

This activity helps students understand the concept of species and provides Missouri-specific examples of aquatic species.

Estimated Time

20 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Missouri Fishes poster (E00013)
- TV/DVD player

Procedure

1. Display the Missouri Fishes poster in the classroom. Invite students to share their "fish stories" with the class, that is, to briefly relate an experience they've had with a fish. Ask students to name the fish species and identify them on the poster if they are pictured.

2. Show the video clip: "Missouri Hatcheries."

Activity 4.3: Student Reading and Research

This activity provides students with definitions and explanations about adaptations of fish and other aquatic animals.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 4: Living in the Water. Introduce vocabulary terms as needed.

2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.

   1. What is a 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.
   2. What is an adaptation?
      An adaptation is a behavior or trait that increases a species' chance of survival in a specific environment.
   3. How are fish adapted to aquatic environments?
      Answers may include:
      - **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.**
      - **All fish have gills to get oxygen from the water.**
      - **Fish move about with the help of fins.**
      - **Swim bladders keep fish from sinking.**
      - **Most fish are covered with protective scales.**
      - **Fish are coated with slime, which helps reduce friction as they swim through the water.**
      - **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.**
      - **Fish have a sensitive line along their sides, called a lateral line, which lets them sense water vibrations coming from each direction.**
   4. How do fish swim? Why don't fish sink to the bottom or float on top of the water?
      When a fish 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. 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.

5. How do fish see, smell, hear, taste and feel?
   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. Some fish, like catfish, have taste buds all over their bodies, including the tail. They can taste food even before taking it into their mouths. 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.

6. What are some adaptations of different species of fish native to Missouri?
   Answers may include:
   - **Bluegill have thin bodies, short heads, small mouths and protective coloring.**
   - **Channel catfish have long, round bodies that are flattened on the bottom, skin without scales, barbels or "whiskers" with many taste buds and a good sense of smell, taste buds all over their bodies and dark-colored skin across the back and light on the belly.**
   - **Largemouth bass have large mouths, broad fins and strong, heavy bodies with wide, sweeping tails. They have colored blotches on their sides.**

7. How do specific adaptations provide survival advantages to particular species?
   Answers may include:
   - **Bluegill's thin, disk-shaped body is ideal for short, quick turns. They need to be fast to catch food among plant stems. Their small mouths are suited for eating small insects. Their protective coloring helps them hide from their enemies.**
   - **Channel catfish have barbels or "whiskers" with many taste buds and a good sense of smell to guide them to food even in dark, muddy waters. They have taste buds all over their bodies, including their tails, so they can taste food even before taking it into their mouths. Their skin color camouflages them against pond and river bottoms.**
   - **Largemouth bass have large mouths that 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.**

Activity 4.4: Student Investigation of Missouri Fishes

This activity helps students understand the concept of species and provides Missouri-specific examples of fish species. It helps students understand the concept of adaptation and identifies specific adaptations of fish species native to Missouri.

Estimated Time

Varies—class time may be provided or research may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Missouri Fishes poster (E00013)
- Know Missouri's Catfish (FIS003)
- Introduction to Missouri Fishes (FIS020)
- *Fishes of Missouri* (01-0031)
- TV/DVD player
- One blank Missouri Fish and Their Characteristics comparison matrix for each student
- Pens or pencils
- Computer with internet connectivity (optional)

Procedure

1. Distribute a blank Missouri Fish and Their Characteristics comparison matrix to each student.

2. Instruct students to choose three (or more) Missouri fish to investigate using video clip, online, in-class or library resources. Class time may be provided or research may be assigned as homework. Fish video clips include "Paddlefish," "Just Below The Surface (Grotto Sculpin)," "Lake Sturgeon" or "Big Bluegill."

3. Have students record their findings by completing rows of the comparison matrix. Have students add the matrix to their notebooks. This matrix will be used (added to) in later activities.

Missouri Fish and Their Characteristics

Species	Average adult		Body shape		Coloration	
	Weight in (units)	Length in (units)	Adaptation	Advantage	Adaptation	Advantage

Activity 4.5: Student Investigation of Missouri Aquatic Animals

This activity helps students understand the concept of species and provides Missouri-specific examples of non-fish aquatic animal species. It helps students understand the concept of adaptation and identifies specific adaptations of non-fish aquatic animal species native to Missouri.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Poster: Toads & Frogs (E00012)
- Missouri Marsh Birds (E00042)
- Poster: Salamander (E00089)
- Missouri Toads and Frogs (E00430)
- Missouri Turtles (E00468)
- Introduction to Crayfish (FIS011)
- Life Within the Water (FIS034)
- *Missouri Naiads* (01-0150)
- *Crayfishes of Missouri* (01-0250)
- TV/DVD player
- Notebook paper
- Pens or pencils
- One copy of the Writing Scoring Guide for each student
- Computer with internet connectivity (optional)

Procedure

1. Show the video clip: "Mussels." Lead class discussion of mussel adaptations.

2. Instruct students to choose at least two more non-fish aquatic animal species native to Missouri to investigate using video clip, online, in-class or library resources. Video clips include "Alligator Snapper Trapper," "Hellbender Mystery," "Taneycomo Turtles," "Cottonmouth!," "Canada Geese," "Eagle Days," "Otter Management" or "Salamanders." Class time may be provided or research may be assigned as homework.

3. Have students choose one of the animals they studied and report their findings in the form of an interview, biography or first-person narrative from the point of view of the animal. Provide a copy of the Writing Scoring Guide for each student.

Writing Scoring Guide

Be sure each paragraph:

- Contains an introductory sentence that clearly states your purpose
- Contains at least two supporting sentences that use relevant details
- Contains a concluding sentence
- Contains a controlling idea
- Progresses in a logical order
- Stays on topic
- Contains few errors in writing mechanics

Your score on this assignment will be based upon the following scoring guide:

4 Points

The paper:

- Has an effective beginning, middle and end.
- Uses paragraphing appropriately.
- Contains a strong controlling idea.
- Progresses in a logical order.
- Uses effective cohesive devices (such as transitions, repetition, pronouns, parallel structure) between and/or within paragraphs.
- Clearly addresses the topic and provides specific and relevant details/examples.
- Uses precise and vivid language.
- Contains sentences that are clear and varied in structure.
- Effectively uses writing techniques (such as imagery, humor, point of view, voice).
- Clearly shows an awareness of audience and purpose.
- Contains few errors in grammar/usage, punctuation, capitalization and/or spelling.

3 Points

The paper:

- Has a beginning, middle and end.
- Uses paragraphing.
- Contains a controlling idea.
- Generally progresses in a logical order.
- May use cohesive devices.
- Addresses the topic and uses relevant details/examples.
- Uses language that is usually precise.
- Contains sentences that are clear and show some variety in structure.
- Uses writing techniques.
- Shows an awareness of audience and purpose.
- May contain errors in grammar/usage, punctuation, capitalization and/or spelling that are not distracting to the reader.

2 Points

The paper:

- Has evidence of a beginning, middle and end.
- Shows evidence of paragraphing.
- Contains some sense of direction, but may lack focus.
- May not progress in a logical order.
- At times seems awkward and lacks cohesion.
- Addresses the topic, but may contain some details that are not relevant.
- May use imprecise language.
- Contains sentences that are generally clear, but lack variety in structure.
- May use writing techniques.
- Shows some awareness of audience and purpose.
- Contains errors in grammar/usage, punctuation, capitalization and/or spelling that may be distracting to the reader.

1 Point

The paper:

- May lack evidence of a beginning, middle and/or end.
- May lack evidence of paragraphing.
- Is difficult to follow and lacks focus.
- Does not progress in a logical order, and may digress to unrelated topics.
- Is awkward and lacks cohesion.
- May address the topic, but lacks details.
- Uses imprecise language.
- Contains sentences that are unclear and lack variety in structure.
- Does not use writing techniques.
- Shows little or no awareness of audience or purpose.
- Contains repeated errors in grammar/usage, punctuation, capitalization and/or spelling that are distracting to the reader.

Activity 4.6: Student Investigation of Fish Sampling

Students apply what they have learned in the preceding activities to create a data table to record fish sampling data and observations in preparation for their field study day.

Estimated Time

25 minutes

Required Materials

- Notebook paper
- Pens or pencils

Procedure

1. Instruct students to work in teams to decide the best way to record fish identification, sampling data and observations as part of their field study day.

2. Have each team create a data table and have each student make a copy for his/her notebook.

Chapter 4 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. Why don't fish sink to the bottom or float on top of the water?
   a. Water's surface tension
   b. Fish absorb dissolved oxygen from water passing over their gills.
   c. The more air a fish's swim bladder contains, the higher the fish will suspend or float in the water.
   d. All of the above

2. Which of the following statements about adaptations is true?
   a. Creatures can choose adaptations that will provide them with survival advantages.
   b. Species adaptations provide them with survival advantages in a particular environment.
   c. All aquatic species have the same adaptations.
   d. Both b and c

3. What is a species?
   a. A group of individuals sharing some common characteristics or qualities
   b. Animals with a backbone
   c. A particular kind of creature
   d. Both a and c

4. What is the function of a fish's lateral line organ?
   a. To taste food even before taking it into their mouths
   b. To help them hide from their enemies
   c. To reduce friction as fish swim through the water
   d. To sense water vibrations coming from each direction

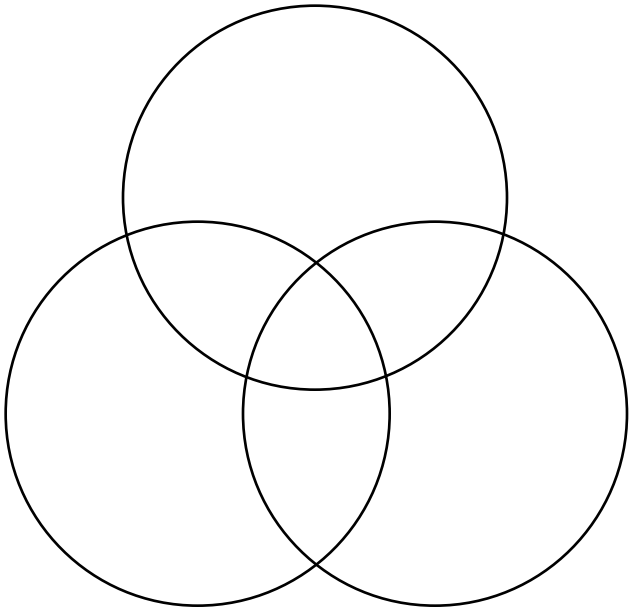
5. Why are fish coated with slime?
   a. To absorb up to 85 percent of the oxygen available in the water
   b. To help them blend in to the dark bottom when seen from above, and with the bright surface when seen from below
   c. To reduce friction as fish swim through the water and to protect them from disease
   d. None of the above

Chapter 4 Assessment

Directions

Write your own answer for each of the following questions.

1. Using the Venn Diagram below, sort some adaptations of the three species of fish you studied. Be sure to label each part of the diagram with the name of the fish species it represents. Assess the survival advantage of three of the adaptations in your diagram:
   - One which is shared by all three fish
   - One which is shared by two fish but not by the third fish
   - One which is displayed by only one of the three fish



2. Design a non-fish aquatic animal with adaptations that provide it with the following advantages:
   - It can avoid predators because it can see nearly all the way around itself.
   - It can walk on mud easily and is a powerful swimmer.
   - It can stay warm even in cold water.

You may use a drawing to depict your imaginary animal, but you should also use words to describe each adaptation. Use the back of this page.

Chapter 4 Assessment Answer Key

Multiple-choice questions

1. Why don't fish sink to the bottom or float on top of the water?
   c. The more air a fish's swim bladder contains, the higher the fish will suspend or float in the water.

2. Which of the following statements about adaptations is true?
   b. Species adaptations provide them with survival advantages in a particular environment.

3. What is a species?
   d. Both a and c

4. What is the function of a fish's lateral line organ?
   d. To sense water vibrations coming from each direction

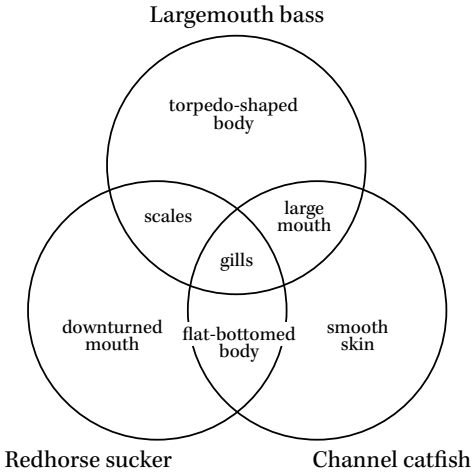
5. Why are fish coated with slime?
   c. To reduce friction as fish swim through the water and to protect them from disease

Write-in questions

1. Using the Venn Diagram below, sort some adaptations of the three species of fish you studied. Be sure to label each part of the diagram with the name of the fish species it represents. Assess the survival advantage of three of the adaptations in your diagram:
   - One that is shared by all three fish
   - One that is shared by two fish but not by the third fish
   - One that is displayed by only one of the three fish

   Many answers are possible, but all should resemble the following example:
   - **Shared by all three fish: Gills allow fish to extract oxygen from the water.**
   - **Shared by two fish but not by the third fish: Scales protect the fish from enemies.**
   - **Displayed by only one of the three fish: Downturned mouth allows fish to suck food up from the bottom.**

   Instructors may wish to refer to Introduction to Missouri Fishes (FIS020) and Fishes of Missouri (01-0031) for guidance in scoring.



2. Design a non-fish aquatic animal with adaptations that provide it with the following advantages:
   - It can avoid predators because it can see nearly all the way around itself.
   - It can walk on mud easily and is a powerful swimmer.
   - It can stay warm even in cold water.

You may use a drawing to depict your imaginary animal, but you should also use words to describe each adaptation. Answers may include:
- **Eyes on the sides of its head, on stalks or bulging out from the head allow it to avoid predators because it can see nearly all the way around itself.**
- **Webbed feet allow it to walk on mud easily and make it a powerful swimmer.**
- **Water-repellant fur or feathers insulate it and help it stay warm even in cold water.**

Enrichments

Project WET:

- Water Address

Project WILD Aquatic:

- Fashion a Fish
- Fishy Who's Who

Guest speakers:

- Fisheries biologist. If invited for Activities 4.2 or 4.4, the speaker may be able to assist with instruction as well as talk about fish adaptations and hatchery spawning.
- Hatchery worker. If invited for Activity 4.2 or 4.4, the speaker may be able to assist with instruction as well as talk about fish adaptations and hatchery spawning.

Additional enrichments:

- Students keep a classroom aquarium.
- Students perform actual or virtual fish dissection.
- Fish maze (dichotomous key)

5 From Sun to Sunfish

Populations of organisms within a community compete with one another for limited resources, including food and habitat. This competition links them together in a complex interdependent web of relationships and limits the number and types of organisms an environment can support.

Estimated Time

Five 50-minute class sessions

Technology Tools/Skills Used in Chapter

Retrieving reliable information from the Internet and other media.

Safety Precautions/Concerns

None

Vocabulary

Abiotic
Biotic
Carrying capacity
Community
Compete
Consumer
Decomposer
Energy pyramid
Food chain
Food web
Habitat
Invasive species
Natural selection
Niche
Plankton
Population
Producer
Trophic level

Chapter Objectives

Students will be able to:

1. Explain how populations of organisms within a community compete with one another for resources and provide a specific example from an aquatic community in Missouri.
2. Recognize factors that affect the number and types of organisms an environment can support and provide a specific example from an aquatic community in Missouri.
3. Describe a specific example from an aquatic community in Missouri of each of the following: producer, consumer and decomposer. Explain the role each serves in the community.
4. Diagram and describe the transfer of energy in an aquatic food web in Missouri, including producers, consumers, decomposers, scavengers and predator/prey relationships.
5. Predict the possible effects of changes in the number and types of organisms in an aquatic community on the populations of other organisms within that aquatic community. Illustrate with specific examples from aquatic communities in Missouri.
6. Explain how a technological solution to a problem can have both benefits and drawbacks such as risks or unintended consequences. Illustrate with specific examples from aquatic communities in Missouri.

Targeted Grade-Level Expectations

EC.1.B.6.a. Identify populations within a community that are in competition with one another for resources

EC.1.B.6.b. Recognize the factors that affect the number and types of organisms an ecosystem can support (e.g., food availability, abiotic factors such as quantity of light and water, temperature and temperature range, soil composition, disease, competitions from other organisms, predation)

EC.2.A.6.a. Diagram and describe the transfer of energy in an aquatic food web and a land food web **with reference to producers, consumers, decomposers, scavengers, and predator/prey relationships**

EC.2.A.6.b. Classify populations of unicellular and multicellular organisms as producers, consumers, and decomposers by the role they serve in the ecosystem

EC.1.B.6.c. Predict the possible effects of changes in the number and types of organisms in an ecosystem on the populations of other organisms within that ecosystem

EC.1.D.6.a. Describe beneficial and harmful activities of organisms, including humans (e.g., deforestation, overpopulation, **water and air pollution,** global warming, **restoration of natural environments,**

river bank/coastal **stabilization,** recycling, **channelization,** reintroduction of species, **depletion of resources), and explain how these activities affect organisms within an ecosystem**
IS.1.C.6.a.

Reference Material for Teacher Background

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Help Stop Aquatic Hitch Hikers (FIS002)
- Introduction to Crayfish (FIS011)
- Introduction to Fishing (FIS152)
- Introduction to Missouri Fishes (FIS020)
- Know Missouri's Catfish (FIS003)
- Life Within the Water (FIS034)
- Map: Smallmouth Bass (FIS019)
- Map: Trout Fishing In Missouri (FIS210)
- Missouri Marsh Birds (E00042)
- Missouri Toads and Frogs (E00430)
- Missouri Turtles (E00468)
- Missouri Wetlands & Their Management (SCI150)
- Nuisance Aquatic Plants in Missouri Ponds and Lakes (FIS110)
- Poster: Exploring Missouri Wetlands (E00003)
- Poster: Missouri Fishes (E00013)
- Poster: Missouri Pond Life (E00002)
- Poster: Missouri Stream Life (E00016)
- Poster: Rivers and Streams: Missouri Currents (E00509)
- Poster: Salamander (E00089)
- Poster: Toads & Frogs (E00012)
- Poster: Wetlands & Waterfowl (E00115)
- Zebra Mussels: Missouri's Most Unwanted (FIS013)
- *Crayfishes of Missouri* (01-0250)
- *Fishes of Missouri* (01-0031)
- *Amphibians and Reptiles of Missouri* (01-0190)
- *Missouri Naiads* (01-0150)
- *Pond Life: Revised and Updated (A Golden Guide from St. Martin's Press)* by George K. Reid

Required Materials

- Poker chips: two red, two white and two blue chips for each student (3 × 3 inch squares of construction paper may substitute if doing this activity indoors.)
- Sufficient space for students to stand arm's distance apart from one another
- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Missouri Fishes poster (E00013)
- Know Missouri's Catfish (FIS003)
- Introduction to Missouri Fishes (FIS020)
- *Fishes of Missouri* (01-0031)
- TV/DVD player
- Adhesive tape (e.g., Scotch or cellophane)
- One copy of Missouri Fish and Their Characteristics page 2 for each student
- One copy of Missouri Fish and Their Characteristics page 3 for each student
- *Aquatic Community Food Web Scramble* information card for each species (Advanced preparation is required.)
- *Aquatic Community Food Web Scramble* name tag for each species (Advanced preparation is required.)
- Three 6-foot-long strands of yarn or cord per student (Advanced preparation is required.)
- Notebook paper
- Pens or pencils
- Computer with internet connectivity (optional)

Activity 5.1: Exploration of Students' Current Understanding of the Interactions of Populations within Communities

This activity explores students' current understanding of the interactions of populations within communities.

Estimated Time

10 minutes

Required Materials

None

Procedure

1. Use a cooperative learning activity to explore the following questions:
   - What do you need to survive? Which needs are most urgent?
   - How do you get those needs met in your daily lives?
   - What would happen if one or more of the things you need were in much shorter supply?

2. Explain to the class that this chapter will help them understand how fish and other aquatic species interact to get the things they need to survive.

Activity 5.2: Student Simulation of Competition within a Community

Adapted from "Every Fish for Itself" by Melanie Carden-Jessen and Mary Scott, Missouri Department of Conservation

Students play a simulation game to help them understand the concept of competition for basic survival needs. The activity introduces the concept of habitat.

Estimated Time

40 minutes

Required Materials

- Poker chips: two red, two white and two blue chips for each student (3 × 3 inch squares of construction paper may substitute if doing this activity indoors.)
- Sufficient space for students to stand arm's distance apart from one another

Procedure

1. Tell students that they'll be playing a game called "Every Fish for Itself." The object of the game is to gather as many poker chips as possible. Explain that each student represents a fish and each poker chip represents something fish need to survive. Blue represents clean water, white represents oxygen and red represents food.

2. Have the students stand arm's distance apart from one another.

3. Tell the students that one foot must remain in place at all times. This represents the fact that fish have certain living conditions that they require and generally must remain in places with those living conditions. Students are not allowed to slide their foot across the ground and may not take a chip from another "fish" if they already have it in their "fin."

4. Students may gather only one chip at a time. They may start gathering only when told to start and must stop when told to stop.

5. Scatter the poker chips on the ground around the students so the chips are about 1-2 feet apart.

6. Tell students they will have 30 seconds to gather their survival needs. Tell the students to start. After 30 seconds, tell the students to stop. Have students sort and count their chips.

7. Explain that each fish must get at least two chips of each color in order to survive. Ask students the following questions:
    - How many of their survival needs did each fish get?
    - Do any fish lack a particular requirement?
    - What might happen to a real fish that lacked one of its requirements for survival?

8. Determine which fish survived the first round. Record the survival rate for "Initial Conditions" on the board.

9. Point out that not all fish have the same requirements. Some might survive water that is warmer or has less oxygen or is clouded with silt.

10. Gather the chips both from the ground and from the students.

11. Randomly designate one out of every four students as catfish. Repeats steps 5 and 6.

12. Explain that catfish can survive in water that is warmer or has less oxygen or is clouded with silt. Therefore catfish need to gather only one white chip and one blue chip to survive. (Refer students to Chapter 4.) Ask how many catfish survived this round and compare that to the survival rate among the other fish. Record the survival rates for "Catfish and Other Fish" on the board.

13. Gather the chips both from the ground and from the students. Have them stand together in groups of three to five with one foot touching the other students' feet. Repeats steps 3–6.

14. Explain that this represents a waterbody that is crowded or that lacks adequate living conditions. Tell students that the living conditions an organism requires are called its habitat.

15. Ask how many catfish and other fish survived. Record the survival rates for "Crowded/Poor Habitat" on the board. Compare the results of this round to those of the previous rounds. In most cases, students will notice that each fish gathered fewer of their survival needs. Ask if they can reach any conclusion about a pond that is overcrowded with fish or has poor habitat.

16. Gather the chips both from the ground and from the students and once again have them stand arm's distance apart from one another.

17. Explain that excess plant nutrients from cattle manure runoff have caused an increase in plant nutrients in the water. Ask students to predict what will happen. (Algae will grow out of control, use up the nutrients, die and decay. Their decay will use up much of the dissolved oxygen in the water. Refer students to Chapters 1–3.) Take out half of the white chips, representing oxygen and repeats steps 5 and 6. Record the survival rates for "Algae Overgrowth" on the board.

18. Gather the chips both from the ground and from the students.

19. Explain that careless construction in the watershed has caused rapid erosion. Ask students to predict the effect on fish survival. (Sediment entering the water will reduce fish survival. Refer students to Chapters 1–3.) Take out half of the blue clean water chips. Repeats steps 5 and 6. Record the survival rates for "Erosion and Sedimentation" on the board.

20. Gather the chips both from the ground and from the students.

21. Explain that a new predator species has appeared that eats the same food as native fish. Reduce the number of red food chips. Repeats steps 5 and 6. Record the survival rates for "Introduced Species" on the board. Gather the chips both from the ground and from the students.

22. Have students write a science notebook entry reviewing what they learned from the activity.

Activity 5.3: Student Reading and Research

This activity provides students with definitions and explanations about competition, habitat, niche and carrying capacity within aquatic communities.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read the first six paragraphs of Chapter 5: From Sun to Sunfish. Introduce vocabulary terms as needed.

2. Assign the first four **Questions to Consider** as homework or use them in a cooperative learning activity. (See Activity 5.5 for **Questions to Consider** 5-7.)

   1. What are some of the basic survival needs of all living things?
      Most living things require food, water, oxygen, space and shelter or protection from the elements and from enemies to survive and grow. Plants make their own food but need sunlight, carbon dioxide and minerals to do so. Most vertebrates need periodic sleep or rest. Some bacteria don't need oxygen.
   2. What is a population? What is a community?
      A group of one kind of organism living in the same place at the same time is a population of that species. Different populations living in the same place interact with one another. A group of populations living in the same place is called a community.
   3. What is habitat? Why is it important? Why must organisms compete for resources? What is carrying capacity?
      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. Many aquatic plants and animals have very specific needs. They either can't move or can't live in another habitat. When resources in an environment are in short supply, individuals and populations must compete for them. Carrying capacity is the maximum number of individuals in a particular population that an environment can support. The limits on biotic (living) and abiotic (non-living) resources determine the environment's carrying capacity.
   4. What is a niche? Why is it important? What are invasive species? Why are they a problem?
      A species' niche includes its way of getting food, the habitat it needs and the role it performs in the community. Within a community every species has a particular niche. 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. 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 it 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.

Activity 5.4: Video Introduction of Habitat, Niche, Competition and Non-native Species

This activity helps students understand the concepts of habitat, niche and competition by comparing and contrasting non-native fish species with native Missouri fish species.

Estimated Time

Varies—class time may be provided or research may be assigned as homework. Allow at least 30 minutes for video clips and in-class questions and discussion.

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Missouri Fishes poster (E00013)
- Know Missouri's Catfish (FIS003)
- Introduction to Missouri Fishes (FIS020)
- *Fishes of Missouri* (01-0031)
- TV/DVD player
- Pens or pencils
- Adhesive tape (e.g., Scotch or cellophane)
- Computer with internet connectivity (optional)
- One copy of Missouri Fish and Their Characteristics page 2 for each student

Procedure

1. Show the video clips: "Trout Eggs" and "Ozark Rainbows." Lead class discussion comparing and contrasting rainbow trout with some Missouri native fish species.

2. Have students add rainbow trout and its characteristics to the comparison matrix of fish species they started in Activity 4.4.

3. Distribute a blank Missouri Fish and Their Characteristics page 2 comparison matrix to each student. Have students tape it to the Missouri Fish and Their Characteristics comparison matrix in their notebooks, so as to create a fold-out extension.

4. Tell students to investigate the habitat requirements and origin of rainbow trout and their previous fish using video clip, online, in-class or library resources. Class time may be provided or research may be assigned as homework. Have students record their findings by completing columns of the comparison matrix. This matrix will be used (added to) again in later activities.

Missouri Fish and Their Characteristics, Page 2

Habitat requirements	Origin

Activity 5.5: Student Reading and Research

This activity provides students with definitions and explanations about food chains, food webs, energy pyramids, trophic levels and natural selection.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read the rest of Chapter 5: From Sun to Sunfish. Introduce vocabulary terms as needed.

2. Assign the rest of the **Questions to Consider** as homework or use them in a cooperative learning activity.

   5. What is the source of energy for aquatic communities? How does energy circulate among organisms in an aquatic community?
      Aquatic communities run on sunlight. Energy circulates among organisms through feeding relationships (they eat one another).
   6. What is a food chain? What is a food web? What is an energy pyramid? What is a trophic level?
      A food chain shows how energy moves from producers to primary consumers to secondary consumers and so on. Food webs show how different food chains are interconnected. 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.
   7. How do predator and prey species keep one another in balance in aquatic communities? What is natural selection?
      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. 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. 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.

Activity 5.6: Video Reinforcement of Habitat, Niche, Competition and Non-native Species

This activity helps students understand the concepts of habitat, niche and competition by comparing and contrasting non-native fish species with native Missouri fish species.

Estimated Time

Varies—class time may be provided or research may be assigned as homework. Allow at least 30 minutes for video clips and in-class questions and discussion.

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Poster: Missouri Fishes (E00013)
- Know Missouri's Catfish (FIS003)
- Introduction to Missouri Fishes (FIS020)
- *Fishes of Missouri* (01-0031)
- TV/DVD player
- Pens or pencils
- Adhesive tape (e.g., Scotch or cellophane)
- Computer with internet connectivity (optional)
- 1 copy of Missouri Fish and Their Characteristics page 3 for each student

Procedure

1. Show the video clip: "Jumping Carp." Lead class discussion comparing and contrasting silver/bighead carp (treat as a single species) with some Missouri native fish species.

2. Have students add silver/bighead carp and their characteristics to the comparison matrix of fish species they started in Activity 4.4. and continued in Activity 5.4.

3. Distribute a blank Missouri Fish and Their Characteristics page 3 comparison matrix to each student. Have students tape it to the Missouri Fish and Their Characteristics page 2 comparison matrix in their notebooks, so as to create another fold-out extension.

4. Tell students to investigate what silver/bighead carp eat, what eats them and what their trophic level (producer, primary consumer, secondary consumer, scavenger/decomposer) is. Have them do the same for their previous fish using video clip, online, in-class or library resources. Class time may be provided or research may be assigned as homework. Have students record their findings by completing columns of the comparison matrix.

Missouri Fish and Their Characteristics, Page 3

What it eats	What eats it	Trophic level

Activity 5.7: Student Simulation of Food Webs within an Aquatic Community

Adapted from Aquatic Community Food Web Scramble, by Jack Woodhead and Elaine Callaway, Missouri Department of Conservation

Students play a simulation game to help them understand the complexity of aquatic food webs.

Estimated Time

40 minutes

Required Materials

- *Aquatic Community Food Web Scramble* information card for each species (Advanced preparation is required.)
- *Aquatic Community Food Web Scramble* name tag for each species (Advanced preparation is required.)
- Three 6-foot-long strands of yarn or cord per student (Advanced preparation is required.)

Prepare in advance

- **Photocopy species card pages onto cardstock and laminate, then cut on the dotted lines to make playing cards.**
- **Photocopy species name tag pages onto cardstock and laminate, then cut on the dotted lines to make tags.**
- **Punch a hole in the upper corners or each tag. Tie the ends of a 3-foot strand of yarn or cord to each hole. Students may hang these around their necks during the game.**
- **Cut three 6-foot-long strands of yarn or cord per student. Tie or singe the ends of the cords to prevent unraveling. Brightly colored braided nylon string or Mason's chalk line, available at most hardware stores, work well.**

Procedure

1. This game is designed for groups of 15 to 30 students. If necessary, break students into smaller groups and conduct games simultaneously.

2. Explain to the class that they are going to play a game to illustrate the complexity of aquatic food webs. Tell them the objective of the game is to develop a self-sustaining community beginning with random populations of plant and animal species. After the community is established, various factors will be changed to illustrate the interdependency of the community. Each type of animal or plant listed represents a population of unknown size. The overhead lights represent the sun.

3. Spread the plant and animal nametags on a table.

4. Mix the cards and give each student one card at random, keeping the extra cards.

5. Have each student carefully read his/her entire card to himself/herself, and then pick up the corresponding nametag and three strings.

6. Check to be sure each student understands the information about the plant or animal he/she is playing. Explain terms and concepts as needed. Be sure each student recognizes his/her plant or animal.

7. Divide the students according to the information on the cards into the following groups:
   - Plants—producers
   - Animals that eat only plants—primary consumers or herbivores
   - Animals that eat both plants and animals—secondary consumers or omnivores
   - Animals that eat only other animals—secondary consumers or carnivores

8. Have the plants move to the center of the playing space. Primary consumers surround plants and give one end of a string (food line) to each type of plant they eat. Students may want to sit on the ground or floor.

9. Animals that eat both plants and animals (secondary consumers or omnivores), and animal eaters (secondary consumers or carnivores) surround plant eaters, giving a food line to each major food they eat. Check to be sure all students have an adequate food supply and calls the group's attention to any inadequacies. Any student with an inadequate food supply steps to the sidelines (dies) for the moment. The group of adequately fed students comprises the community.

10. Discuss the community that has been formed, noting presence or absence of major food sources or plant types, the proportion of plant eaters to animal eaters, etc. Have the class decide whether the community could survive.

11. Make selective substitutions from the extra cards, using students from the sidelines or the community as necessary to produce a well-established community that includes all students. Have students change name tags as well as cards when making substitutions. Have students raise the food lines over their heads and note the complexity and web-like appearance.

12. Explain that each change in the conditions in an area will cause corresponding changes among the community members.

13. When conditions change, those students who are eliminated must step to the sidelines, taking their food lines with them. They may then be assigned a new role to reestablish the community with the new conditions. Discuss each change as it occurs. The following changes have proved effective, but many others are possible.

14. Summer/winter: Most groups will assume summer conditions when beginning. Explain that changing to winter causes great differences due to migration, hibernation, plant dormancy, etc. Photosynthesis continues to occur in aquatic communities as long as sunlight can penetrate the ice layer, but it stops if ice is snow-covered, preventing sunlight from reaching plant-like plankton. Point out the temporary and cyclical nature of these natural changes. Ask students to provide examples of how species have adapted to temporary cyclical changes in conditions.

15. Drought conditions: Explain that low water conditions cause crowding and greater competition for food, less shoreline area, and increased access for terrestrial predators. Extreme drought conditions (i.e., drying up of pond) could eliminate some organisms. Some microscopic species can live in small puddles. Air breathers would travel to other areas or die. Ask students to speculate as to whether these changes would be temporary and cyclical or permanent. Point out the distinction between the death of an individual and the elimination of a population.

16. Watershed development: Tell the class that the surrounding grassland or woodland is being converted to a housing development without proper soil conservation methods. Ask students to predict the results. (Sediment entering the water, possible fertilizer and pesticide pollution from lawns or increased runoff velocities and habitat destruction will alter the community and reduce survival. Refer students to Chapters 1–3.)

17. Cattle in watershed: Tell the class that the surrounding grassland or woodland is being converted to a livestock operation without proper fencing or waste management. Ask students to predict the results. (Increased pollution from cattle wastes may cause algae overgrowth and fish kills. Sediment entering the water from cattle trampling the banks and stirring up the mud bottom increases turbidity and reduces photosynthesis. There are few if any shoreline plants. All these will alter the community and reduce survival. Refer students to Chapters 1–3.)

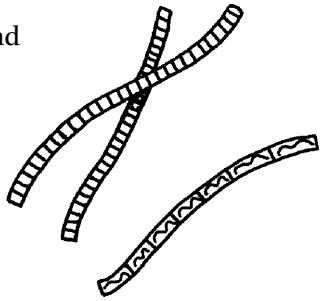
18. Herbicide use: Tell the class that herbicide is being used to control weeds in the watershed. Ask students to predict the results. (Depending on the type of herbicide, aquatic plants could be destroyed, which could completely destroy the food chain. Refer students to Chapters 1–3.) This is one way to end the game.

19. Have students write a science notebook entry reviewing what they learned from the activity.

Information cards

ALGAE

Producer: Many varieties found in ponds
Predators: Animals that eat aquatic plants
Habitat: Along shoreline and in open water; must have sunlight to produce food. Along with other plants, algae are the first link in the food chain.

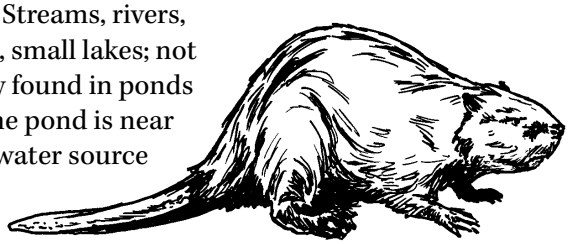


BACKSWIMMER

Foods: This fierce predator eats other insects, invertebrates and sometimes small fish.
Predators: Fish, frogs, birds
Habitat: Hanging from surface of the water; on or among the plants; occasionally free-swimming

BEAVER

Foods: Bark and twigs of shoreline trees. Summer foods include water lilies, pondweeds and cattails.
Predators: Coyotes, bobcat, otters, minks and—most importantly—humans
Habitat: Streams, rivers, marshes, small lakes; not normally found in ponds unless the pond is near a larger water source



BELTED KINGFISHER

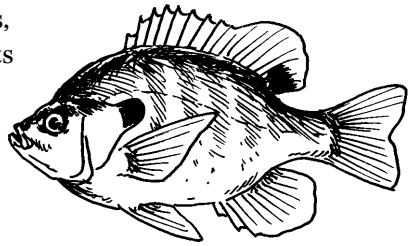
Foods: Mostly fish, some insects, frogs, lizards
Predators: Raccoons, snakes. Skunks prey on young and eggs.
Habitat: Nests in banks near pond; hovers over water or sits on overhanging branches

BLOODWORMS

Foods: Plankton, detritus
Predators: Large and small fish
Habitat: Bottom sediments of pond; not really a worm but the larva of a midge-fly

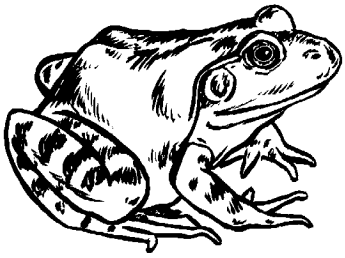
BLUEGILL

Foods: Mayflies and other insects, crustaceans, small fish, crayfish, snails; algae when animal foods are scarce
Predators: Bass and other fish, snapping turtles, herons, osprey; adults prized by humans
Habitat: Open water or along shoreline where food is abundant



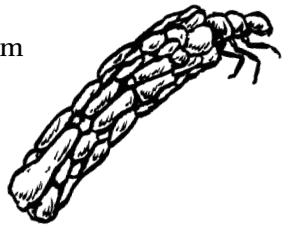
BULLFROG

Foods: Any small animal it can catch and swallow whole, including insects, crayfish, small snakes, minnows, other frogs
Predators: Any meat-eater that can catch and eat it, such as snakes, herons, fish, raccoons, humans
Habitat: Shores of lakes, ponds, streams



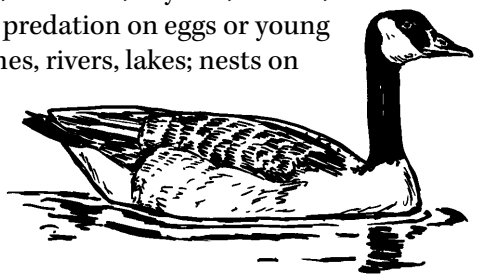
CADDISFLY LARVA

Foods: Small crustaceans, insects, worms, diatoms, algae Some species are entirely predacious.
Predators: Fish, diving beetles, giant water bugs
Habitat: Submerged stems of plants in shallow water; stream bottoms in riffles. They construct a tube-like shell from bits of plants or sand particles.



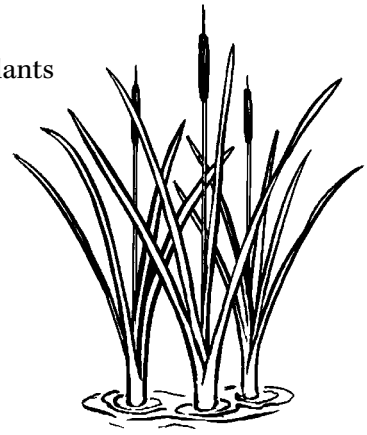
CANADA GOOSE

Foods: Wetland grasses, grains, sedges, roots of water plants
Predators: Fox, raccoons, coyotes, bobcat, humans; most predation on eggs or young
Habitat: Marshes, rivers, lakes; nests on ground; defends nest vigorously



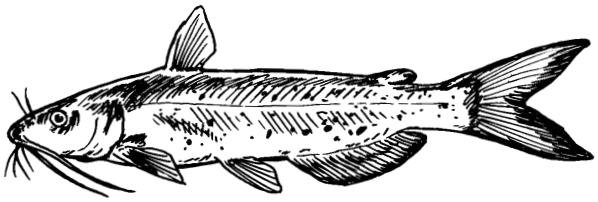
CATTAILS

Producer: Tall, erect plants with long leaves and usually a green or brown head
Predators: Aphids, caterpillars, moths, beetles, birds, small mammals
Habitat: Rooted along shoreline

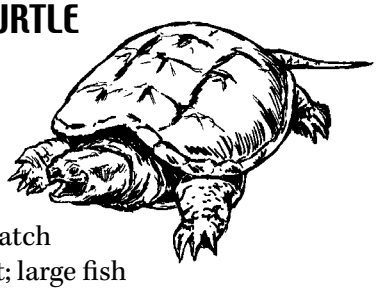


CHANNEL CATFISH

Foods: Fish, insects, crayfish, mollusks, plants
Predators: Young are eaten by other fish. Adults are prized by anglers.
Habitat: Open water or bottom of ponds where they have been stocked



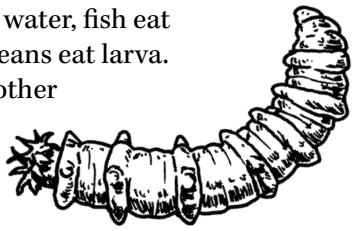
COMMON SNAPPING TURTLE



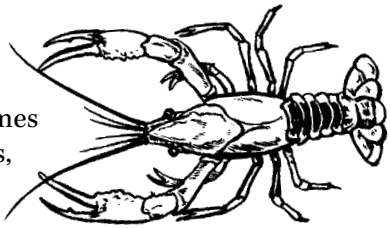
Foods: Insects, crayfish, fish, snails, earthworms, amphibians, snakes, small mammals, birds, aquatic plants
Predators: Few. Humans catch adult turtles for their meat; large fish eat young; snakes or raccoons or other mammals eat eggs; sometimes the turtles are hosts to leeches.
Habitat: Prefer ponds with muddy bottoms, submerged logs and snags and lots of plants

CRANEFLY

Foods: Larvae can be either predacious on worms or insects, or herbivorous, depending on species. Some adults feed on nectar, but many do not eat at all.
Predators: Birds. If near water, fish eat adults. Fish and crustaceans eat larva.
Habitat: Wet moss and other plants along shoreline



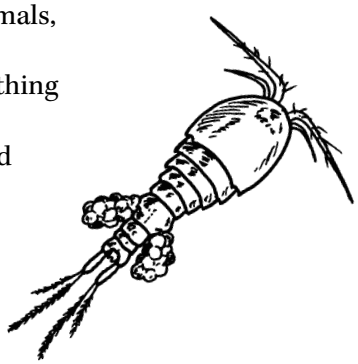
CRAYFISH



Foods: Both plants and animals. Sometimes crayfish are predators, and sometimes they act as scavengers.
Predators: Raccoons, otters, fish, wading birds, frogs, turtles. Some people consider crayfish a delicacy.
Habitat: Ponds and streams; sometimes in burrows or under logs or plants

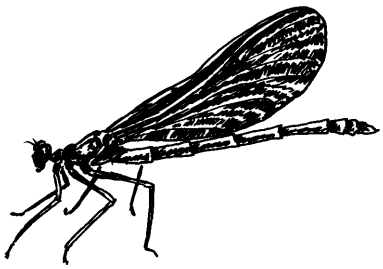
CYCLOPS

Foods: Microscopic animals, algae, detritus
Predators: Nearly everything that eats plankton
Habitat: Open water and shallow water of ponds



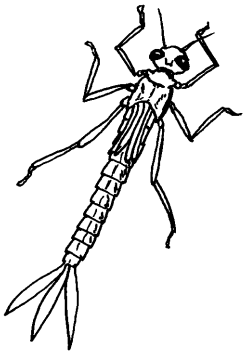
DAMSELFLY ADULT

Foods: Mosquitoes, flies, other insects
Predators: Fish, birds
Habitat: Plants that grow up and stick out from the water; open air over pond



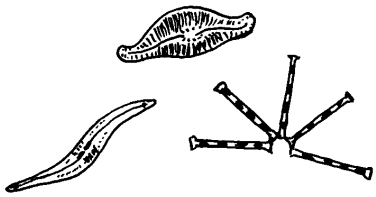
DAMSELFLY NYMPH

Foods: Insect larvae, worms, small crustaceans; occasionally small fish and tadpoles
Predators: Fish, larger insects, crustaceans
Habitat: Hides among algae and other plants along the shoreline



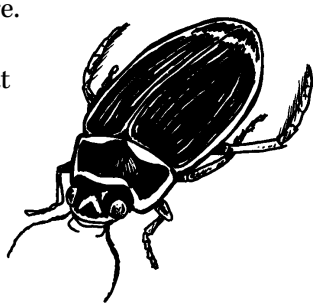
DIATOMS

Producer: Microscopic algae
Predators: Insects, fish, microscopic animals. Diatoms are a major part of the plant-like plankton, which is the basic food source for all consumers.
Habitat: Free-floating or suspended in open water



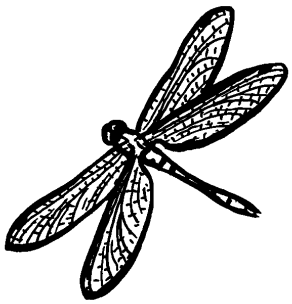
DIVING BEETLE

Foods: Caddisfly larva, or any small animal they can capture. Diving beetles are ferocious predators with large jaws that eat other insects.
Predators: Reptiles, amphibians, fish, wading birds, raccoons, skunks
Habitat: Usually in weedy shallows along shoreline.



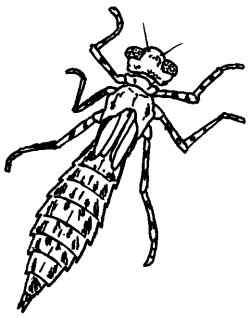
DRAGONFLY ADULT

Foods: Mosquitoes, flies, other insects
Predators: Birds, fish
Habitat: Plants that grow up and stick out from the water; open air over pond



DRAGONFLY NYMPH

Foods: Insect larvae, worms, small crustaceans; occasionally small fish and tadpoles
Predators: Fish, larger insects, crustaceans
Habitat: Hides among algae and other plants along the shoreline

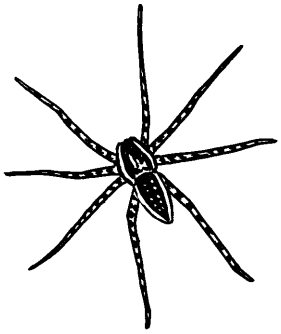


DUCKWEED

Producer: Small, single-leafed floating plant; rootlets dangle in water
Predators: Flatworms, insect larvae, ducks, geese
Habitat: Free-floating on pond surface

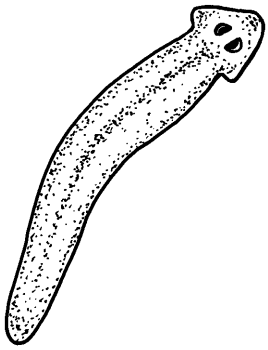
FISHING SPIDER

Foods: Mostly insects; occasionally small fish and tadpoles
Predators: Snakes, frogs, some birds
Habitat: Surface of pond in dense aquatic plants



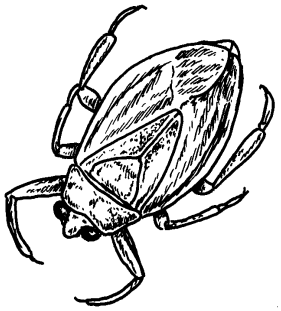
FLATWORM (Planaria)

Foods: Small animals; living or dead protozoans or nematodes
Predators: Worms, insects, crustaceans
Habitat: Under stones and submerged leaves in dark areas



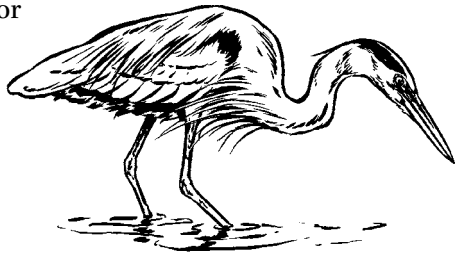
GIANT WATER BUG

Foods: Fiercely predacious, attacking insects, crustaceans and even tadpoles, frogs and fish several times their size
Predators: Fish, frogs, shorebirds
Habitat: Hanging from surface of the water; on or among the plants; occasionally free-swimming



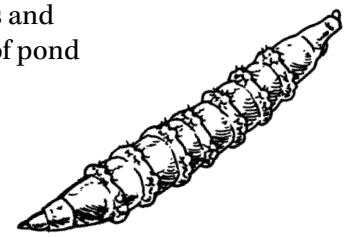
GREAT BLUE HERON

Foods: Mostly small fish, limited numbers of frogs, crayfish, insects and mice
Predators: Fox, coyotes, bobcat; too large for most predators
Habitat: Marsh, river, lakes; nest in colonies in tops of large, stream-side trees



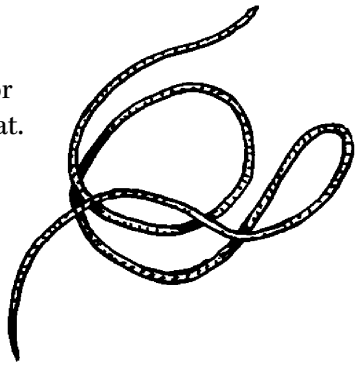
HORSEFLY LARVA

Foods: Worms, snails, other small insects in the water
Predators: Fish, birds
Habitat: Among plants and along bottom at edge of pond



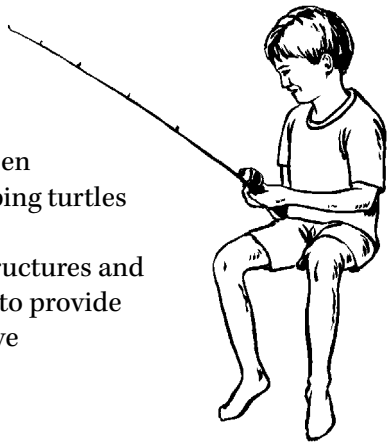
HORSEHAIR WORMS

Foods: Immature are parasites on various crustaceans, mollusks or insects. Adults do not eat.
Predators: Fish, giant water bugs
Habitat: Quiet water



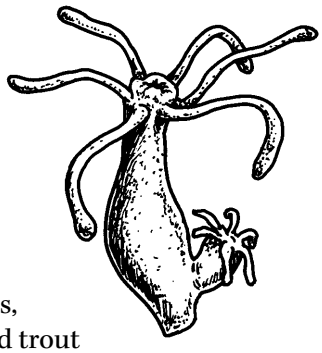
HUMANS

Foods: Bass, bluegill, channel catfish, bullfrog, green frog, crayfish, snapping turtles
Predators: None
Habitat: Designs structures and alters environment to provide suitable places to live

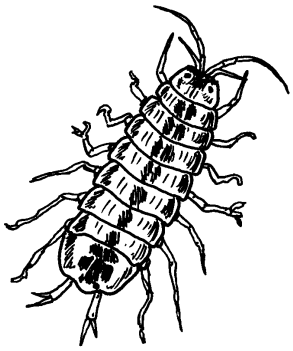


HYDRA

Foods: Tiny (microscopic) animals are trapped in its stinging tentacles. Also, small crustaceans, insects, small clams and fish, seed shrimp, water fleas
Predators: Carnivorous insects, water beetles, recently hatched trout
Habitat: Attached to twigs or other plants at the bottom of ponds

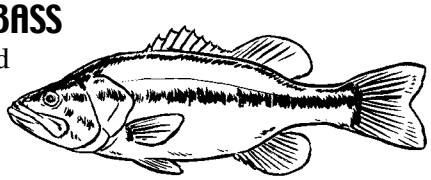


ISOPODS (Sowbugs)



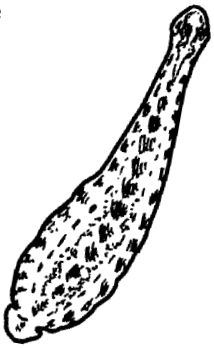
Foods: Detritus; decaying plants on the bottom
Predators: They have few predators and are seldom eaten by fish. Some are intermediate hosts for nematodes of fish, birds and amphibians.
Habitat: Bottom dwellers able to stand acidic water. Some species prefer clear, cold water; all hide beneath rock and other debris.

LARGEMOUTH BASS



Foods: Adults feed on fish, crayfish, frogs and large insects. Young feed on daphnia and other small crustaceans.
Predators: Snapping turtles, herons. Small fish are eaten by larger fish. Anglers prize large fish.
Habitat: Open water or along edge where food supply is abundant.

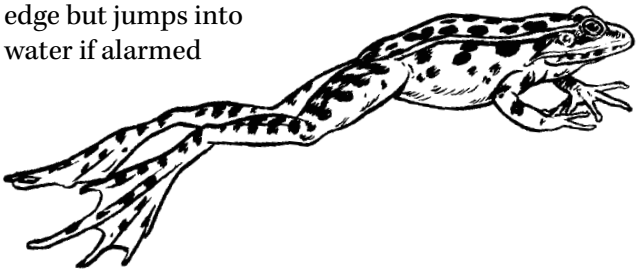
LEECH



Foods: Parasite that feeds on the blood of animals. Most attach to fish, turtles, frogs, snails, insect larvae and worms.
Predators: Fish
Habitat: Bottom dwellers

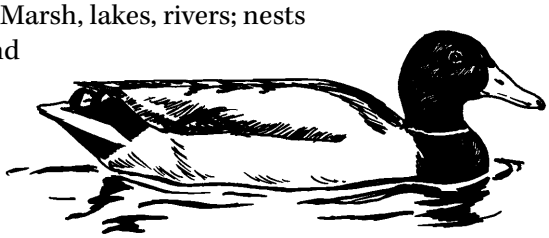
LEOPARD FROG

Foods: Insects, spiders, other invertebrates
Predators: Raccoons, snakes
Habitat: Sits near water's edge but jumps into water if alarmed



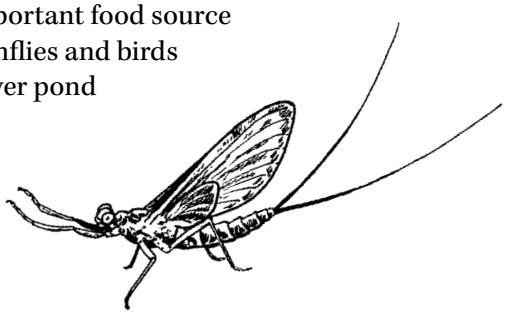
MALLARD DUCK

Foods: Smartweed, corn, acorns, seeds of many water plants, some aquatic invertebrates
Predators: Fox, coyotes, bobcat, mink, humans, raccoon, skunk
Habitat: Marsh, lakes, rivers; nests on ground



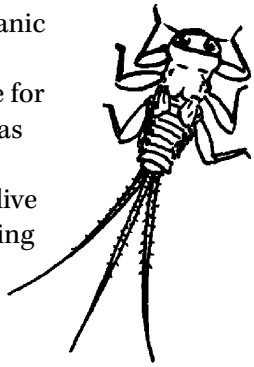
MAYFLY ADULT

Foods: Adults do not eat at all. They live long enough to reproduce, which may only be a few hours.
Predators: Important food source for fish, dragonflies and birds
Habitat: Air over pond



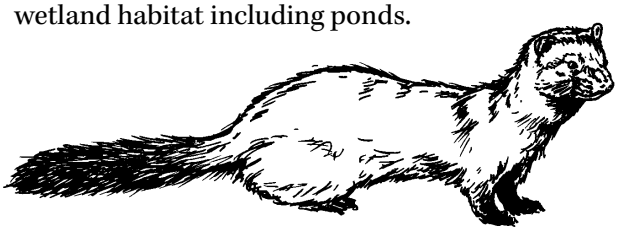
MAYFLY LARVA

Foods: Small plants, animals, organic debris, diatoms
Predators: Important food source for fish and other insect-eaters such as dragonfly larva and beetles
Habitat: Various species burrow, live on the bottom or are free-swimming among aquatic plants.



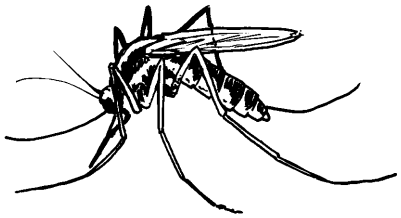
MINK

Foods: Rabbits, muskrats, other small mammals, birds, fish, crayfish, frogs, crustaceans, insects
Predators: Humans, dogs, foxes, owls, coyotes, bobcats
Habitat: These excellent swimmers live in or near wetland habitat including ponds.



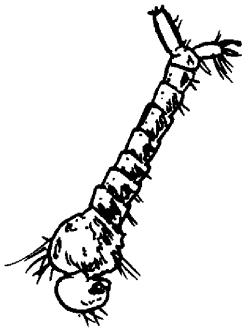
MOSQUITO ADULT

Foods: Females suck mammal blood; males feed on plant juices, if they eat at all.
Predators: Dragonflies, damselflies, other insects, birds, frogs, fish, bats
Habitat: Air over water and surrounding areas



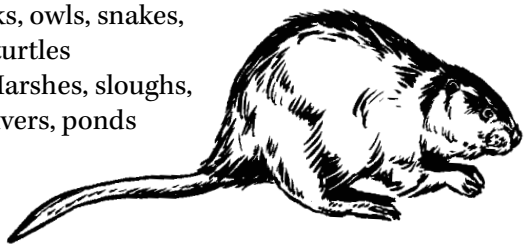
MOSQUITO LARVA

Foods: Tiny plants and animals suspended in the water
Predators: Fish, other insects
Habitat: Mostly on the water's surface, but dive and hide if threatened



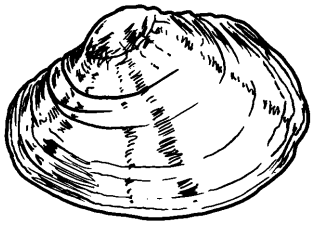
MUSKRAT

Food: Roots, bulbs and foliage of cattails, pondweeds, rushes and wild rice; will eat fish, frogs and insects if plants are not available
Predators: Minks, humans, large hawks, owls, snakes, snapping turtles
Habitat: Marshes, sloughs, streams, rivers, ponds and lakes



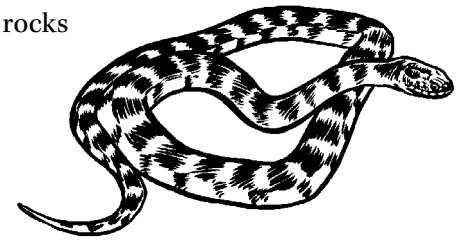
MUSSELS

Foods: Small bits of organic matter suspended in the water. Because they eat small bits of animal matter, they are considered scavengers
Predators: Fish, muskrats, mink, otters, raccoons; turtles that are able to open the shells or eat the smaller mussels
Habitat: On the bottom of ponds and streams



NORTHERN WATER SNAKE

Foods: Crayfish, frogs, tadpoles, small fish, worms, insects
Predators: Hawks, owls; large game fish eat young snakes
Habitat: Under rocks or debris near shore of ponds, lakes, streams and rivers

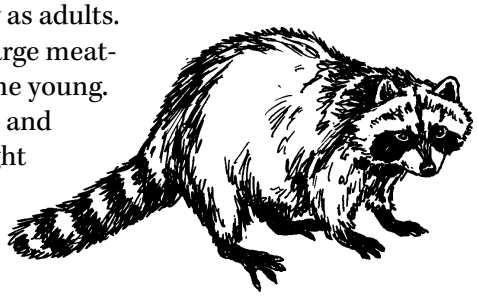


PONDWEEDS

Producers: Aquatic seed plants
Predators: Birds, muskrats, beaver, deer
Habitat: Rooted near shoreline

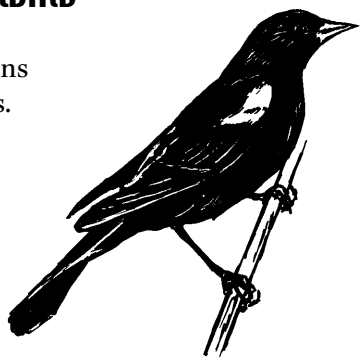
RACCOON

Foods: Wide variety of small animals, insects, fruits, seeds, garbage, crayfish, frogs, some fish
Predators: Few as adults. Humans and large meat-eaters take some young.
Habitat: Forest and forest edge; night time visitor to ponds and streams



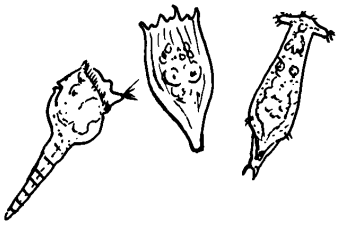
RED-WINGED BLACKBIRD

Foods: Insects, seeds
Predators: Few. Raccoons and snakes will eat eggs.
Habitat: Nest in cattails; migrate in winter



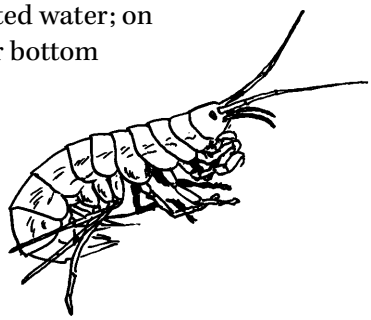
ROTIFERS

Foods: Microscopic plants and animals
Predators: Worms, crustaceans
Habitat: Near shoreline and around aquatic plants; some occur in open water



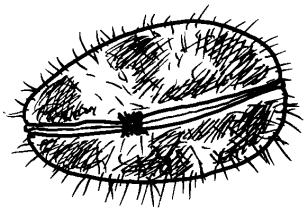
SCUDS

Foods: Scavengers on plant and animal debris
Predators: Birds, fish, insects, amphibians
Habitat: Clear, unpolluted water; on and among plants; near bottom of pond where they can avoid light



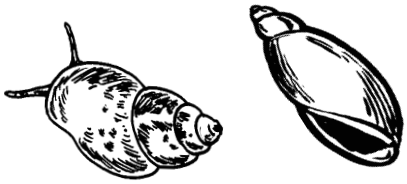
SEED SHRIMP (Ostracods)

Foods: Bacteria, mold, algae
Predators: Important food source of small fishes
Habitat: On and just above the bottom of ponds; they look like microscopic clams



SNAILS

Foods: Algae, other plants, dead plant and animal material
Predators: Many kinds of fish, turtles, some birds
Habitat: Pond bottom, or on plants and dead material in ponds



SPRINGTAIL

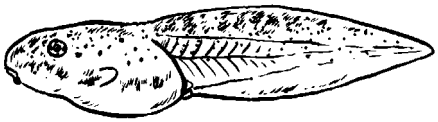
Foods: Decaying plant and animal material; occasionally some living plant material
Predators: Fish, spiders, frogs, other animals that eat insects
Habitat: Surface of the pond in quiet backwaters. They hibernate but are among first signs of animal life in the spring.

STONEFLY NYMPH

Foods: Dead plant material; detritus and fine organic particles and the algae, bacteria and fungi living on detritus. As they grow larger they become predators of other invertebrates.
Predators: Fish, other predaceous invertebrates, amphibians
Habitat: Only found in cool, well-oxygenated flowing waters (very sensitive to pollution); crawl about in rocks, gravel and debris on stream bottom

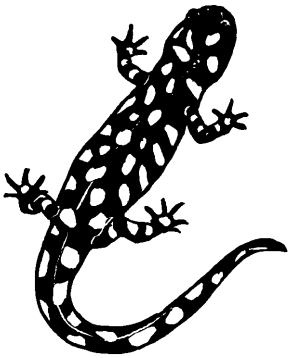
TADPOLES

Foods: Submerged oozes and scums containing small plants and animals; algae, diatoms, desmids, decaying plants
Predators: Fish, snakes, giant water bugs. Some predacious insects eat the small tadpoles.
Habitat: In shallow areas near the water's edge



TIGER SALAMANDER

Foods: Earthworms, insects, spiders, slugs, snails
Predators: Fishes, snakes, snapping turtles, some birds and mammals
Habitat: In burrows under logs and rocks near water; active only at night

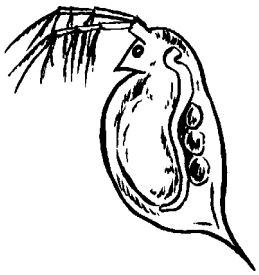


WATER BOATMAN

Foods: Algae and decaying plants; sometimes dive to feed on decaying animal material on the bottom; sometimes mosquito larvae
Predators: Fish
Habitat: Surface of pond, sometimes diving to find food; must cling to something to stay under water surface

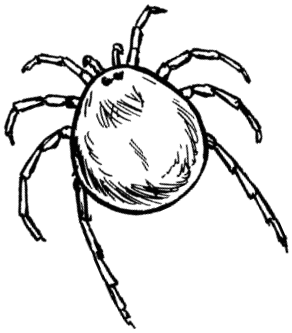
WATER FLEA (Daphnia)

Foods: Filter plankton from the water; algae; organic debris
Predators: Hydras, insects, fish, some rotifers
Habitat: Weedy margins of ponds, abundant in all types of water except fast streams and polluted water



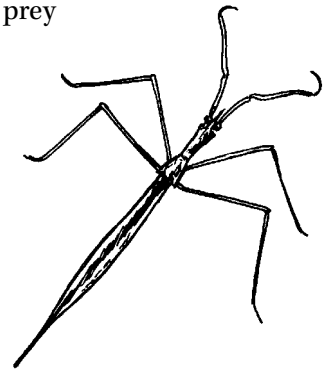
WATER MITES

Foods: Insects, worms. Some are parasitic.
Predators: Hydras, insect, fish
Habitat: Creep on bottom and on plants



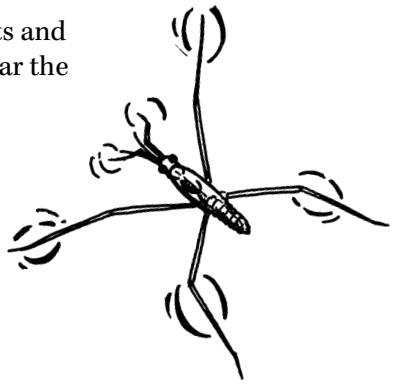
WATER SCORPION

Foods: Small insects; seize prey with powerful forelegs similar to preying mantis
Predators: Animals that eat insects
Habitat: Ponds and weedy sections of lakes and streams; hides just under the surface among plants; long breathing tube at rear



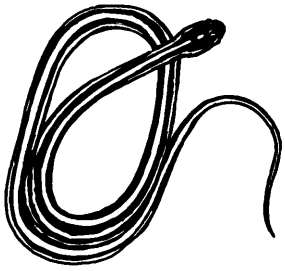
WATER STRIDER

Foods: Prey on insects and small crustaceans near the surface
Predators: Some fish and birds
Habitat: Surface of water; often seen "skating" over the surface in search of food



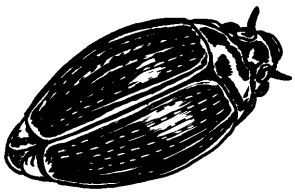
WESTERN RIBBON SNAKE

Foods: Worms, fish, tadpoles, frogs, toads, salamanders, mice, sometimes other small snakes
Predators: Hawks, owls, snapping turtles, herons. Some fish eat small snakes.
Habitat: Near water, ponds, swamps, marshes, sloughs, streams and rivers



WHIRLIGIG BEETLE

Foods: Whirl in circles collecting insects and organic debris at the surface
Predators: Fish, birds, frogs, snakes and other animals that eat insects
Habitat: On the surface, often among plants; eyes are divided and can see above and below water at same time



NAME TAGS

ALGAE

BACKSWIMMER

BEAVER

BELTED KINGFISHER

BLOODWORMS

BLUEGILL

BULLFROG

CADDISFLY LARVA

CANADA GOOSE

CATTAILS

CHANNEL CATFISH

COMMON SNAPPING TURTLE

CRANEFLY

CRAYFISH

CYCLOPS

DAMSELFLY ADULT

DAMSELFLY NYMPH

DIATOMS

DIVING BEETLE

DRAGONFLY ADULT

DRAGONFLY NYMPH

DUCKWEED

FISHING SPIDER

FLATWORM (Planaria)

GIANT WATER BUG

GREAT BLUE HERON

HORSEFLY LARVA

HORSEHAIR WORMS

HUMANS

HYDRA

ISOPODS (Sowbugs)

LARGEMOUTH BASS

LEECH

LEOPARD FROG

MALLARD DUCK

MAYFLY ADULT

MAYFLY LARVA

MINK

MOSQUITO ADULT

MOSQUITO LARVA

MUSKRAT

MUSSELS

NORTHERN WATER SNAKE

PONDWEEDS

RACCOON

RED-WINGED BLACKBIRD

ROTIFERS

SCUDS

SEED SHRIMP (Ostracods)

SNAILS

SPRINGTAIL

STONEFLY NYMPH

TADPOLES

TIGER SALAMANDER

WATER BOATMAN

WATER FLEA (Daphnia)

WATER MITES

WATER SCORPION

WATER STRIDER

WESTERN RIBBON SNAKE

WHIRLIGIG BEETLE

Activity 5.8: Student Investigation of Missouri Aquatic Animals

Students apply what they have learned in the preceding activities to create a data table to record observations about other aquatic animals in preparation for their field study day.

Estimated Time

35 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player
- Pens or pencils

Procedure

1. Show the video clip: "St. Francis Crayfish." Lead class discussion about niche, competition and natural selection.

2. Instruct students to work in teams to decide the best way to record observations about other aquatic animals as part of their field study day. Remind them to consider not only direct visual observation, but auditory observation and indirect signs of animal activity such as tracks, scat, nests, burrows, chewed stems and worn paths.

3. Have each team create a data table and have each student make a copy for his/her notebook.

Chapter 5 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. Complete this analogy: Individual is to population as
   a. Water is to surface tension.
   b. Fish is to gills.
   c. Niche is to habitat.
   d. Population is to community.

2. Which of the following statements about competition is true?
   a. Individuals within a population may compete with other individuals of the same species.
   b. Individuals within a population may compete with individuals of different species.
   c. A population within a community may compete with other populations within the community.
   d. All of the above

3. Complete this analogy: Habitat is to niche as
   a. Feeding habit is to niche.
   b. Producer is to consumer.
   c. Niche is to habitat.
   d. All of the above

4. Carrying capacity is the result of which of the following:
   a. Different populations living in the same place interact with one another.
   b. Within a community every species has a particular niche.
   c. While living organisms have the capacity to produce populations of infinite size, environments and resources are limited.
   d. Most energy pyramids can continue for only four or five trophic levels and can support only a few top-level consumers.

5. Complete this analogy: Habitat is to gravel-bottomed stream as _____ is to insect-eating predator.
   a. Algae
   b. Trophic level
   c. Niche
   d. None of the above

6. Which of the following statements about invasive species is true?
   a. The invasive species may compete with native species for habitat or food.
   b. Invasive species are not subject to natural selection.
   c. Invasive species play an important role by keeping populations of prey species below their carrying capacity.
   d. None of the above

7. Complete this analogy: Sunlight is to food web as
   a. Food source is to niche.
   b. Producer is to consumer.
   c. Niche is to habitat.
   d. None of the above

8. What is the biggest threat to aquatic communities?
   a. Predator/prey relationships
   b. Natural selection
   c. Human-caused habitat destruction
   d. All of the above

9. Complete this analogy: Competition is to _____ as _____ is to food webs.
   a. Competitor; decomposer
   b. Natural selection; sunlight
   c. Prey; consumer
   d. None of the above

10. Why can most energy pyramids continue for only four or five trophic levels and support only a few top-level consumers?
    a. Most of the available food energy is lost moving up each trophic level.
    b. Animals lose energy doing tasks such as hunting and keeping their bodies warm.
    c. Only a little of the sun's energy passes from one trophic level to the next.
    d. All of the above

Chapter 5 Assessment

Directions

Write your own answer for each of the following questions.

1. Create an imaginary aquatic community capable of existing in Missouri with populations of at least two examples of each of the following: producers, consumers and decomposers/scavengers. Specify producers by placing them in rectangles, consumers in circles and scavengers/decomposers in triangles. Draw (or diagram) and describe the transfer of energy within the community. Use the back of this page.

2. Create a graphic organizer to specify which populations of organisms within your community (above) compete with one another, and for what resources.

3. Predict the outcome in the community if one of the populations (you choose which) were completely removed from the community.

Chapter 5 Assessment Answer Key

Multiple-choice questions

1. Complete this analogy: Individual is to population as
   d. Population is to community.

2. Which of the following statements about competition is true?
   d. All of the above

3. Complete this analogy: Habitat is to niche as
   a. Feeding habit is to niche.

4. Carrying capacity is the result of the fact that:
   c. While living organisms have the capacity to produce populations of infinite size, environments and resources are limited.

5. Complete this analogy: Habitat is to gravel-bottomed stream as _____ is to insect-eating predator.
   c. Niche

6. Which of the following statements about invasive species is true?
   a. The invasive species may compete with native species for habitat or food.

7. Complete this analogy: Sunlight is to food web as
   d. None of the above

8. What is the biggest threat to aquatic communities?
   c. Human-caused habitat destruction

9. Complete this analogy: Competition is to _____ as _____ is to food webs.
   b. Natural selection; sunlight

10. Why can most energy pyramids continue for only four or five trophic levels and support only a few top-level consumers?
    d. All of the above

Write-in questions

1. Create an imaginary aquatic community capable of existing in Missouri with populations of at least two examples of each of the following: producers, consumers and decomposers/scavengers. Specify producers by placing them in rectangles, consumers in circles and scavengers/decomposers in triangles. Draw (or diagram) and describe the transfer of energy within the community. Use the back of this page.
   Many answers are possible.
   Instructors may wish to refer FIG. 5.3 in the Student Guide for an example.

2. Create a graphic organizer to specify which populations of organisms within your community (above) compete with one another, and for what resources.

   Many answers are possible, but may resemble the following example:

Population	Competitors	Resource competed for
Algae	Duckweed	Sunlight, water, nutrients
Duckweed	Algae	Sunlight, water, nutrients
Caddisfly larva	Crayfish Largemouth bass	Food Survival (to not be eaten)
Largemouth bass	Crayfish	Food (eats crayfish)
Crayfish	Caddisfly larva Largemouth bass	Food Survival (to not be eaten)
Bacteria	None	None

3. Predict the outcome in the community if one of the populations (you choose which) were completely removed from the community.

   Many answers are possible.

   Instructors may wish to refer to Chapter 5, paragraph 11, in the Student Guide for an example.

Enrichments

Project WET:

- Water Address

Project WILD Aquatic:

- Aquatic Times
- Designing a Habitat
- Migration Headache

Guest speakers:

- Fisheries biologist. If invited for Activities 5.4 or 5.6, the speaker may be able to assist with instruction as well as talk about fisheries management and aquatic communities.
- Hatchery worker. If invited for Activity 5.4, the speaker may be able to assist with instruction as well as talk about hatchery spawning and aquatic communities.

Additional enrichments:

- Students keep a classroom aquarium.
- Students perform actual or virtual fish dissection.
- Fish maze (dichotomous key)

6 Missouri's Aquatic Ecosystems

Ecosystems are complex interdependent webs of relationships between living and non-living things. Missouri has three kinds of aquatic ecosystems: streams, lakes and wetlands.

Estimated Time

Four 50-minute class sessions

Technology Tools/Skills Used in Chapter

Line transect sampling technique for collecting plant data.

Safety Precautions/Concerns

Identify and stay clear of poison ivy and other dangerous plants.

Vocabulary

Aquatic ecosystem
Biodiversity
Buffer
Current
Ecosystem
Lake
Marsh
Oxbow lake
Pond
River
Slough
Stream
Swamp
Wetland

Chapter Objectives

Students will be able to:

1. Define ecosystem and identify the factors that make up an ecosystem.
2. Explain how the parts of an ecosystem interact with one another.
3. Identify Missouri's aquatic regions and explain how the characteristics of the land affect the nature of the water.
4. Compare and contrast Missouri's aquatic ecosystems types.
5. Define biodiversity and assess its importance.
6. Predict the impact of a natural or human-caused environmental change on the organisms in an ecosystem.
7. Describe possible solutions to potentially harmful environmental changes within an ecosystem.

Targeted Grade-Level Expectations

EC.1.A.6.a. Identify the biotic factors (populations of organisms) and abiotic factors (e.g., quantity of light and water, range of temperatures, soil composition) that make up an ecosystem
EC.1.D.6.a.
EC.1.D.6.b. Predict the impact (beneficial or harmful) of a natural environmental change (e.g., forest fire, flood, volcanic eruption, **avalanche) on the organisms in an ecosystem**
EC.1.D.6.c. Describe possible solutions to potentially harmful environmental changes within an ecosystem
IS.1.C.6.a.

Reference Material for Teacher Background

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Help Stop Aquatic Hitch Hikers (FIS002)
- Introduction to Crayfish (FIS011)
- Introduction to Missouri Fishes (FIS020)
- Know Missouri's Catfish (FIS003)
- Life Within the Water (FIS034)
- Map: Smallmouth Bass (FIS019)
- Map: Trout Fishing In Missouri (FIS210)
- Missouri Marsh Birds (E00042)
- Missouri Toads and Frogs (E00430)
- Missouri Turtles (E00468)
- Missouri Wetlands & Their Management (SCI150)
- Nuisance Aquatic Plants in Missouri Ponds and Lakes (FIS110)
- Poster: Exploring Missouri Wetlands (E00003)
- Poster: Missouri Fishes (E00013)
- Poster: Missouri Pond Life (E00002)
- Poster: Missouri Stream Life (E00016)
- Poster: Rivers and Streams: Missouri Currents (E00509)

- Poster: Salamander (E00089)
- Poster: Toads & Frogs (E00012)
- Poster: Wetlands & Waterfowl (E00115)
- Zebra Mussels: Missouri's Most Unwanted (FIS013)
- *Crayfishes of Missouri* (01-0250)
- *Fishes of Missouri* (01-0031)
- *Amphibians and Reptiles of Missouri* (01-0190)
- *Missouri Naiads* (01-0150)
- *Pond Life: Revised and Updated (A Golden Guide from St. Martin's Press)* by George K. Reid
- *WOW! The Wonders of Wetlands*

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Missouri Pond Life poster (E00002)
- Exploring Missouri Wetlands poster (E00003)
- Rivers and Streams: Missouri Currents poster (E00509)
- *Fishes of Missouri* (01-0031)
- Introduction to Missouri Fishes (FIS020)
- TV/DVD player
- Notebook paper
- Pens or pencils
- Computer with internet connectivity (optional)
- 1 copy of Plant Sampling—Line Transect Survey Investigation for each student
- Set of transect lines—one for each group in class (Advanced preparation is required.)
- Mallet or hammer for driving wooden transect stakes (optional)
- Set of plant identification field guides—one for each group in class

Activity 6.1: Exploration of Students' Current Understanding of Missouri's Aquatic Ecosystems

This activity explores students' current understanding of Missouri's aquatic ecosystems.

Estimated Time

10 minutes

Required Materials

- Missouri Pond Life poster (E00002)
- Exploring Missouri Wetlands poster (E00003)
- Rivers and Streams: Missouri Currents poster (E00509)

Procedure

1. Display the three Missouri aquatic ecosystem posters in the classroom.

2. Use a cooperative learning activity to explore the following:
   - Which of the following are found in Missouri: rivers, lakes, swamps, oceans?
   - Which of these is nearest to our school?
   - How many have you visited?
   - Invite students to share briefly about their last visit to one of these ecosystems.

3. Explain to the class that this chapter will help them understand what an ecosystem is and what kinds of aquatic ecosystems are found in Missouri.

Activity 6.2: Video Exploration of Invasive Species in Missouri's Aquatic Ecosystems

This activity helps students understand the concept of invasive species and provides examples of how invasive species impact Missouri's aquatic ecosystems.

Estimated Time

15 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player

Procedure

1. Remind students of the "Jumping Carp" video clip and explain that the next two video clips show how other invasive species are affecting Missouri's aquatic ecosystems.

2. Show the video clips: "Purple Loosestrife" and "Zebra Mussels."

3. Use a cooperative learning activity to explore the following questions:
   - How have these three invasive species (bighead/silver carp, purple loosestrife and zebra mussels) entered Missouri's aquatic ecosystems?
   - How are these three invasive species (bighead/silver carp, purple loosestrife and zebra mussels) impacting Missouri's aquatic ecosystems?
   - What can humans do to reduce, eliminate or make up for the impact of these three invasive species on Missouri's aquatic ecosystems?

4. Have students record their thoughts and observations in their science notebooks.

Activity 6.3: Video Exploration of Endangered Species in Missouri's Aquatic Ecosystems

This activity helps students understand the concept of endangered species and provides examples of endangered species in Missouri's aquatic ecosystems.

Estimated Time

25 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player
- Introduction to Missouri Fishes (FIS020)
- *Fishes of Missouri* (01-0031)

Procedure

1. Use a cooperative learning activity to explore the following questions:
   - What does it mean for a species to be extinct?
   - How does a species become extinct?
   - Can you think of any species that are now extinct?
   - Can you think of any species that once lived in Missouri and no longer do?
   - What does it mean for a species to be endangered?
   - Can you think of any species that are now endangered?
   - What can humans do to prevent species from becoming endangered or extinct?

2. Have students record their thoughts and observations in their science notebooks.

3. Show the video clips: "Topeka Shiner" and "Niangua Darter."

4. Have students add Topeka shiner and Niangua darter to the comparison matrix of fish species they started in Activity 4.4 and continued in Activity 5.4 and 5.6. Have students investigate the Topeka shiner and Niangua darter. Class time may be provided or research may be assigned as homework. Have students record their findings by completing rows of the comparison matrix.

5. Use a cooperative learning activity to explore the following questions:
   - Why have these species become endangered?
   - What are humans doing to prevent these species from becoming extinct?
   - How would the loss of these species impact Missouri's aquatic ecosystems?

6. Have students record their thoughts and observations in their science notebooks.

Activity 6.4: Student Reading and Research

This activity provides students with definitions and explanations about Missouri's aquatic ecosystems.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 6: Missouri's Aquatic Ecosystems. Introduce vocabulary terms as needed.

2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.

   1. What is an ecosystem? What are some of the parts of an ecosystem?
      An ecosystem is a complex web of relationships between living and non-living things. The biotic (living) parts of the ecosystem are the communities of plant and animal populations, including humans. The abiotic (non-living) parts include sunlight, air, water, temperatures, soil and minerals.
   2. How do the parts of an ecosystem interact with one another?
      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. All populations living together within a community interact with one another and with their environment in order to survive and maintain a balanced ecosystem. Conversely, a healthy, balanced ecosystem provides for all the needs of the communities that live in it.
   3. What are Missouri's aquatic regions? How do the characteristics of the land affect the nature of the water?
      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.
   4. What kinds of aquatic ecosystems do we have in Missouri? How are they alike or different from one another?
      Missouri has three kinds of aquatic ecosystems: streams, lakes and wetlands. 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.
   5. What is biodiversity? Why is it important?
      Biodiversity refers to the variety and number of different organisms and populations in a community, and the way they live together. The greater the biodiversity in an ecosystem, the healthier, more sustainable and better balanced it is. Biodiversity is very important to the stability of an ecosystem. If many different species are present, then the loss of one or two will probably not have a great effect. But if species diversity is low, the loss of one or two could have a major impact.
   6. How do humans impact aquatic ecosystems?
      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. 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.
   7. How can we help conserve aquatic ecosystems?
      Protecting and restoring a wide variety of habitat helps keep species from becoming endangered or extinct.

Activity 6.5: Student Investigation of Conserving Aquatic Ecosystems

This activity helps students understand how humans can help conserve aquatic ecosystems.

Estimated Time

20 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player

Procedure

1. Use a cooperative learning activity to have students review and brainstorm some ways humans can help conserve aquatic ecosystems.

2. Show the video clip: "Stream Teams."

3. Have students write a science notebook entry exploring something they would like to do themselves to help conserve Missouri's aquatic ecosystems.

Activity 6.6: Video Exploration of Sampling

This activity helps students understand the concept of sampling. It provides examples of sampling methods used by scientists in Missouri aquatic ecosystems.

Estimated Time

25 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Use a cooperative learning activity to have students review ways of checking the health of an aquatic ecosystem (should include physical and chemical water testing, observation of watershed land uses and conditions, observations of populations and community interactions). Explain that they will now look at some ways scientists check the health of aquatic ecosystems by making observations of populations and community interactions.

2. Show the video clip: "Wranglers of the Deep." Ask students to take notes in their notebooks of the different sampling methods depicted (electrofishing, netting and creel sampling). After the video clip, review these with the class.

3. Show the video clip: "Crustacean Calculation." Lead class discussion of why scientists use sampling. Ask students to imagine that they have just been given the task of finding out how many dandelions or how many blades of grass are on the school grounds. Ask students how they would go about finding out. Explain that this problem is similar to the problems scientists face all the time. They might solve the problem by getting down on their hands and knees and counting every dandelion on the school grounds. This might take a very long time but if done carefully it would give a precise answer. It is often unrealistic for a scientist to count every organism in her/his research area. What scientists often do is to work with a sample, a small section or plot of their research area. From their sample the scientist can then estimate many things about their research area without having spent all the time to count each organism. Scientists do not base their calculations on just one sample. Instead they use data from many samples. Ask students why scientists do this. (To get the most accurate analysis of the data collected we will look at multiple samples.) Explain that the precise technique or sampling method used depends what you are sampling.

Activity 6.7: Student Investigation of Sampling

This hands-on activity helps students understand the concept of sampling and introduces students to the line transect sampling technique for collecting plant data in the field.

Estimated Time

One 50-minute class followed by
25 minutes of discussion the next day.

Safety Precautions/Concerns

- Identify and stay clear of poison ivy and other dangerous plants.

Required Materials

- Pens or pencils
- 1 copy of Plant Sampling—Line Transect Survey Investigation for each student
- Set of transect lines—one for each group in class (Advanced preparation is required.)
- Mallet or hammer for driving wooden transect stakes (optional)
- Set of plant identification field guides—one for each group in class

Procedure

Day one (50 minutes)

1. Prepare in advance by making a set of transect lines—one for each group in class. Tie heavy twine or nylon rope to a tent peg or small wooden stake. Measure out 10 meters of line and fasten the other end to another peg or stake at that point.

2. Set up transect lines by driving one peg or stake into the ground, stretching the line tight and driving the other into the ground. (Alternatively, class time may be used having students make and set their own transect lines.) If possible, choose transect line placements that show changes of plant species as along the line. For example, moving from a tree-covered area to an open field, from a mowed area to an unmowed area or down a slope.

3. Take the class outside. (If that is not possible, the activity may be adapted for indoor use by having students identify and count objects found in the classroom.)

4. Provide each student with a copy of Plant Sampling—Line Transect Survey Investigation.

5. Lead the class through the procedure.

6. Have students place the completed data sheets in their science notebooks.

Day two (25 minutes)

1. Invite students to share drawings, rubbings, samples or descriptions of plants they could not identify. Have the class identify as many as possible.

2. Have each group report their plant sampling findings.

3. Briefly summarize findings from the class's multiple samplings on the board.

4. Ask students what generalization or conclusions they would draw from their plant sampling findings. How diverse is the plant life on the school grounds?

PLANT SAMPLING — LINE TRANSECT INVESTIGATION

Copy Page

Objective

Determine the species composition of plant life on school grounds using line transect sampling.

Directions

1. Work with your partners following your teacher's instructions to conduct a valid sampling.

2. One student should act as recorder for your group's observations. Other students should work together to count and identify plants.

3. Use plant identification guides to help you identify and list each species that touches the line. If you cannot identify a species, describe or draw it as well as you can. With your teacher's permission, you may make a leaf rubbing or take a sample to identify later.

4. Make a tick mark under the "Individuals" column for each individual of a species that touches the line, but only count each individual once (this may be hard to determine for grasses and some other plants!).

5. Count live plants only—you want your data forms to reflect current conditions, not past.

6. Imagine that the line is a plane that extends into the sky. If the vertical plane would touch a plant above the ground, count it. Examine each vertical layer of plants separately: upper (e.g., trees), middle (e.g., shrubs), lower (ground-level, e.g., grasses).

7. Add up the tick marks in each row and enter the result in the right-hand column under "Total" for that row. Then add up the total number of species and enter that result at the bottom of the second column ("Total species"). Finally, add up all the numbers in the "Total" column and enter the result at the bottom of the column ("Total individuals").

PLANT SAMPLING—LINE TRANSECT INVESTIGATION

Copy Page

Group: _____ **(names)**

Date: _____

Location: _____

Plant Species Occurrence

Layer	Species name or description	Individuals	Total
Total species:		**Total individuals:**	

Activity 6.8: Student Investigation of Plant Sampling

Students apply what they have learned in the preceding activities to create a data table to record plant sampling data and observations in preparation for their field study day.

Estimated Time

25 minutes

Required Materials

- Notebook paper
- Pens or pencils

Procedure

1. Instruct students to work in teams to decide the best way to record plant identification, sampling data and observations as part of their field study day.

2. Have each team create a data table and have each student make a copy for his/her notebook.

Chapter 6 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. Why do scientists use sampling?
   a. To create new habitat
   b. Because each part of an ecosystem is connected to and depends on all the others
   c. Because ecosystems may change in response to natural or human-caused events
   d. To estimate things without having to count each organism

2. What is an endangered species?
   a. A type of plant or animal no longer in existence, having died out leaving no living representatives
   b. A type of plant or animal with a variety and number of different organisms and populations
   c. A type of plant or animal whose numbers are so small that it is at risk of extinction
   d. Both a and c

3. What does it mean for a species to be extinct?
   a. A type of plant or animal no longer in existence, having died out leaving no living representatives
   b. A type of plant or animal with a variety and number of different organisms and populations
   c. A type of plant or animal whose numbers are so small that it is at risk of extinction
   d. Both a and c

4. What is biodiversity?
   a. A complex web of relationships between living and non-living things
   b. The variety and number of different organisms and populations, and the way they live together
   c. The kinds of aquatic ecosystems found in Missouri
   d. None of the above

5. What kinds of aquatic ecosystems do we have in Missouri?
   a. Ozarks, Prairie, Lowland and Big River
   b. Rivers, lakes and wetlands
   c. Swamps, marshes and fens
   d. Streams, oceans and ponds

Chapter 6 Assessment

Copy Page

Directions Write your own answer for each of the following questions.

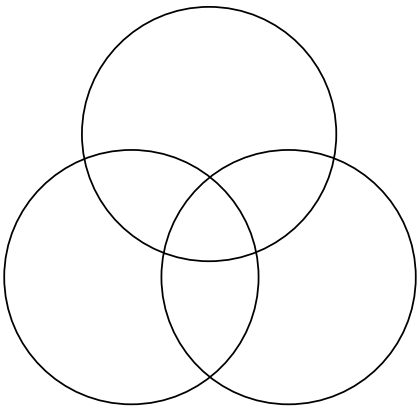
1. What are the biotic and abiotic factors that make up an ecosystem?

2. Describe a beneficial or harmful activity of humans, and explain how these activities affect organisms within an aquatic ecosystem in Missouri. Use one of the following activities as the basis for your example: water pollution, restoration of natural environments, introduction of an invasive species, picking up trash.

3. Predict the impact (beneficial or harmful) on the organisms in an aquatic ecosystem in Missouri of each of the following natural environmental changes: a forest fire in the watershed, a flood, an avalanche that deposits large amounts of rock and soil in the waterbody.

4. Suggest a possible solution to one of the potentially harmful environmental changes within an ecosystem that you used as an example in question 2 or 3.

5. Using the Venn Diagram to the right, compare and contrast Missouri's three types of aquatic ecosystems. Be sure to label each part of the diagram with the name of the ecosystem it represents.



Chapter 6 Assessment Answer Key

Multiple-choice questions

1. Why do scientists use sampling?
   d. To estimate things without having to count each organism

2. What is an endangered species?
   c. A type of plant or animal whose numbers are so small that it is at risk of extinction

3. What does it mean for a species to be extinct?
   a. A type of plant or animal no longer in existence, having died out leaving no living representatives

4. What is biodiversity?
   b. The variety and number of different organisms and populations, and the way they live together

5. What kinds of aquatic ecosystems do we have in Missouri?
   b. Rivers, lakes and wetlands

Write-in questions

1. What are the biotic and abiotic factors that make up an ecosystem?
   The biotic (living) parts of the ecosystem are the communities of plant and animal populations, including humans. The abiotic (non-living) parts include sunlight, air, water, temperatures, soil and minerals.

2. Describe a beneficial or harmful activity of humans, and explain how these activities affect organisms within an aquatic ecosystem in Missouri. Use one of the following activities as the basis for your example: water pollution, restoration of natural environments, introduction of an invasive species, picking up trash.
   Many answers are possible, but should resemble one of the following examples:

Human activity	Specific example of affect on organisms
Water pollution	Runoff polluted with insecticides could kill all the insect larvae living in a stream. This could cause the food web to collapse and most fish species to die.
Restoration of natural environments	Removing a river levee could allow natural oxbow lakes and wetlands to reform. This would restore habitat for fish species that need shallow, slow-moving water.
Introduction of an invasive species	Dumping a bait bucket full of crayfish that are not native to a stream could introduce a species that competes with the native crayfish. This could cause the native species to become endangered.
Picking up trash	Fish, birds and other wildlife die or get injured from swallowing or being tangled in plastic trash. Removing plastic bags, used fishing line and other plastics could reduce the number that die or get injured.

3. Predict the impact (beneficial or harmful) on the organisms in an aquatic ecosystem in Missouri of each of the following natural environmental changes: a forest fire in the watershed, a flood, an avalanche that deposits large amounts of rock and soil in the water body.
   Many answers are possible, but should resemble one of the following examples:

Natural environmental change	Specific example of affect on organisms
Forest fire in the watershed	Loss of plants in the watershed could result in increased erosion and sediment entering a water body. These changes may destroy habitat for some species and create it for others. When the plants grow back, the ecosystem will return to normal.
Flood	A flood could wash some fish, plants or other aquatic life away, but would not cause long-term damage. It could even have benefits, such as restoring wetland areas and bringing fresh nutrients. The greater the biodiversity in an ecosystem, the healthier, more sustainable and better balanced it is.
Avalanche that deposits large amounts of rock and soil in the water body	An avalanche could result in increased erosion and sediment entering a waterbody. It could cause a pond or wetland to fill in and become dry, or could cause a river to change course. These changes may destroy habitat for some species and create it for others.

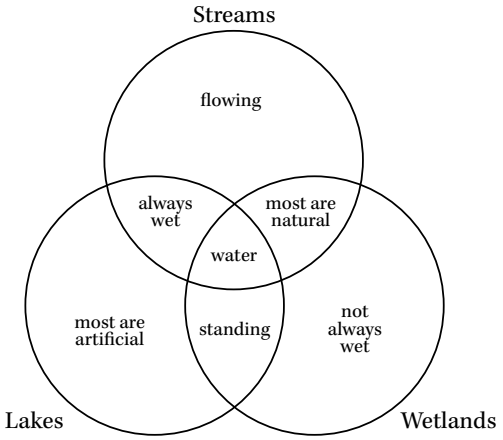
4. Suggest a possible solution to one of the potentially harmful environmental changes within an ecosystem that you used as an example in question 2 or 3.

   Many answers are possible, but should resemble one of the following examples:

Potentially harmful environmental change	Specific example of affect on organisms	Possible solution
Water pollution	Runoff polluted with insecticides could kill all the insect larvae living in a stream. This could cause the food web to collapse and most fish species to die.	Prevent water pollution through regulating insecticide use and by educating people about the potential for harm. Protect and restore habitat for the native species and consider hatchery spawning to support wild populations.
Introduction of an invasive species	Dumping a bait bucket full of crayfish that are not native to a stream could introduce a species that competes with the native crayfish. This could cause the native species to become endangered.	Prevent introduction of the invasive crayfish species by educating people about the potential for harm. Protect and restore habitat for native crayfish species and consider hatchery spawning to support wild populations.
Natural environmental changes	Generally do not have long-term harmful effects	Solutions to potentially negative temporary effects should emphasize protecting and restoring a wide variety of habitat, maintaining biodiversity and allowing nature to take its course.

5. Using the Venn Diagram to the right, compare and contrast Missouri's three types of aquatic ecosystems. Be sure to label each part of the diagram with the name of the ecosystem it represents.

   Many answers are possible, but all should resemble the following example:



Enrichments

Project WILD Aquatic:

- Aquatic Roots
- Edge of Home
- Watered-Down History

Guest speaker:

- Fisheries biologist. If invited for Activities 6.2, 6.3 or 6.6, the speaker may be able to assist with instruction as well as talk about fisheries management and aquatic ecosystems.

Additional enrichments:

- Students keep a classroom aquarium.

7 Rivers and Streams

Missouri's rivers and streams are diverse and ever-changing ecosystems that move, store and transform water, sediment and organic matter. The healthiest streams are those with the least-altered natural processes.

Estimated Time

Three 50-minute class sessions

Technology Tools/Skills Used in Chapter

- Invertebrate sampling technique for assessing water quality
- Invertebrate identification using a dichotomous key

Safety Precautions/Concerns

None

Vocabulary

Angler
Channel
Collector
First-order stream
Floodplain
Grazer
Invertebrate
Pool
Riffle
Riparian zone
Shredder
Stream bank

Chapter Objectives

Students will be able to:

1. Diagram the parts of a stream and explain how biotic and abiotic factors that make up the stream ecosystem function together.
2. Compare and contrast the adaptations of plants and animals living in flowing water to those of other aquatic and terrestrial species.
3. Predict the impact of flooding on the organisms in a stream ecosystem. Describe how technological solutions to problems, such as levees, dams and channelization, can have risks and unintended consequences. Describe possible solutions to potentially harmful environmental changes within a stream ecosystem.
4. Predict the changes in the number and types of organisms in a stream ecosystem based on stream order. Recognize the factors that affect the number and types of organisms a stream ecosystem can support.
5. Diagram and describe the transfer of energy in stream food web.
6. Assess the health of a stream based on the presence or absence of aquatic invertebrates.

Targeted Grade-Level Expectations

EC.1.A.6.a.
EC.1.B.6.a.
EC.1.B.6.b.
EC.1.B.6.c.
EC.2.A.6.a.
EC.2.A.6.b.
EC.1.D.6.a.
EC.1.D.6.b.
EC.1.D.6.c.
IS.1.C.6.a.

Reference Material for Teacher Background

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Start a Missouri Stream Team (FIS182)
- Introduction to Crayfish (FIS011)
- Introduction to Missouri Fishes (FIS020)
- Life Within the Water (FIS034)
- Map: Smallmouth Bass (FIS019)
- Map: Trout Fishing In Missouri (FIS210)
- Now That I'm a Stream Team… (FIS188)
- Poster: Missouri Fishes (E00013)
- Poster: Missouri Stream Life (E00016)
- Poster: Rivers and Streams: Missouri Currents (E00509)
- Stream Insects/Crustaceans ID (STR250)
- Stream Team Inventory Guide (FIS193)

- *Stream Team Middle School Activity Guide* by Mark Van Patten *mostreamteam.org/activity_guide/contents.htm*
- *Streets to Streams Guide* (E00428)
- Streets to Streams Video (E00447)
- Understanding Streams (FIS192)
- Volunteer Water Quality Monitoring (FIS049)
- What Happened to the Stream in My Backyard? (STR238)
- *Crayfishes of Missouri* (01-0250)
- *Fishes of Missouri* (01-0031)
- *Missouri Naiads* (01-0150)
- *Pond Life: Revised and Updated (A Golden Guide from St. Martin's Press)* by George K. Reid

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Rivers and Streams: Missouri Currents poster (E00509)
- TV/DVD player
- Notebook paper
- Pens or pencils
- 30 wooden stakes approximately 4 foot in length, or music stands, or masking tape
- *A-Mazing Macroinvertebrates* signs on paper or cardstock and laminated or placed in plastic sheet protectors
- Chalk, plastic non-adhesive survey tape or spray paint outside, or vinyl electrical tape, string or plastic non-adhesive survey tape indoors

Activity 7.1: Exploration of Students' Current Understanding of Missouri's River and Stream Ecosystems

This activity explores students' current understanding of Missouri's river and stream ecosystems.

Estimated Time

15 minutes

Required Materials

- Rivers and Streams: Missouri Currents poster (E00509)
- Notebook paper
- Pens or pencils

Procedure

1. Display the Rivers and Streams: Missouri Currents poster in the classroom.

2. Ask students to use their notebooks to free-write, brainstorm, mind-map or cluster for five minutes everything they know about rivers and streams. Lead class discussion by asking each student to contribute something to the board without repeating an item. Have students add to their notebooks any information on the board that they hadn't already included. Leave these items on the board for use in Activity 7.2.

3. Explain to the class that this chapter will help them understand what a stream ecosystem is and how it functions.

Activity 7.2: Video Exploration of Missouri's River and Stream Ecosystems

This activity helps students understand Missouri's river and stream ecosystems.

Estimated Time

35 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player
- Notebook paper
- Pens or pencils

Procedure

1. Show the video: "Streams: The Force of Life." Pause the video frequently and discuss facts, concepts and misunderstandings students wrote on the board in Activity 7.1 as they arise in the video.

2. Have students make notes in their science notebooks.

3. As time permits, show the video clips: "River of Many Uses" and "Mississippi River Monitoring."

Activity 7.3: Student Reading and Research

This activity provides students with definitions and explanations about Missouri's river and stream ecosystems.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 7: Rivers and Streams. Introduce vocabulary terms as needed.

2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.

   1. What are the parts of a stream? How do they function together?
      Channel—the part of the stream where water collects to flow downstream
      Pools—the deeper, slower-moving places in the stream channel
      Riffles—the shallow, faster-flowing places in the stream channel
      Stream banks—the shoulder-like sides of the stream channel
      Riparian zone—the land next to the stream (starting at the top of the stream bank)
      Floodplain—the flat land on both sides of the river or stream where extra water spreads out during a flood
      See also FIG. 7.1 and section titled "Anatomy of a stream" in student guide Chapter 7.

   2. What is the riparian zone? Why is it important to have plenty of plants growing alongside a stream?
      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. Plants growing in the riparian zone keep the stream healthy in many ways. Trees shade and cool the water, which increases the amount of dissolved oxygen the water can hold. 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.

   3. What is the floodplain? Are floods natural disasters?
      The floodplain 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. 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. 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.

   4. What is stream order? How can it help us understand the aquatic community living in a particular place?
      A first-order stream is 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. 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.

5. What can the presence or absence of aquatic invertebrates tell us about the health of a stream?
   Water quality experts 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.
6. How are plants and animals adapted to living in flowing water?
   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.
7. How can rivers and streams be kept healthy?
   The healthiest streams are those with the least-altered natural processes. 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. Avoid building roads, houses and levees in floodplains. Remember that everything that happens on the land in a watershed affects the waterbody into which it drains. Use land and water resources wisely and protect your watershed. 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.

Activity 7.4: Student Investigation of Stream Anatomy and River and Stream Food Webs

This activity helps students understand river and stream food webs.

Estimated Time

25 minutes

Required Materials

- Rivers and Streams: Missouri Currents poster (E00509)
- Notebook paper
- Pens or pencils
- Red, green and black yarn
- Scissors
- Pushpins or thumbtacks
- Set of Stream Anatomy Cards

Procedure

1. Display the Rivers and Streams: Missouri Currents poster in the classroom.

2. Have students take turns cutting lengths of yarn and using pushpins attach them to the poster to diagram the food web connections between the plants and animals depicted in the poster. Tell students to use red yarn to connect a predator to its prey. Have students use green yarn to connect primary consumers to producers. Use black yarn to connect scavengers and decomposers to their food. Also have students attach the Stream Anatomy Cards in the proper places.

3. Lead class discussion of river and stream food webs, with reference to the poster and to FIG. 7.4 in the Student Guide.

4. Ask students to predict the impact of flooding on the organisms in a stream ecosystem. (A flood could wash some fish, plants or other aquatic life away, but would not cause long-term damage. It could even have benefits, such as restoring wetland areas and bringing fresh nutrients.) Ask students to predict the impact of cutting down all the trees and removing the plants from the stream banks and riparian zone on the organisms in a stream ecosystem. (Without plants to hold the rocks and soil in place, the stream banks would erode, filling the stream's pools with sediment. Major erosion and sedimentation can smother aquatic life and destroy their habitat. Without plants growing in the riparian zone, the water would heat up in the sun, which would decrease the amount of dissolved oxygen the water can hold. No leaves and branches falling into the water would deprive the stream food web of organic matter. Lack of riparian plants would mean loss of habitat to birds, bats and other wildlife.

5. Have students write science notebook entries diagramming the parts of a stream and explaining how the biotic and abiotic factors that make up the stream ecosystem function together, including how a stream's order or size determines the aquatic community it can support.

Stream Anatomy Cards

Copy Page

Stream channel

The channel of the stream is where water concentrates to flow downstream. It includes the bed, the gravel bars and the stream banks. Stream channels always follow a downhill path.

Riffles

Shallow and fast-flowing water in the stream channel. Riffles mix oxygen into the water.

Flood plain

A relatively level area on both sides of the stream channel that carries excess water the channel cannot handle during a flood. Allowing excess water to spread out reduces the floodwater's speed, reducing damage downstream.

Riparian zone

The land bordering a stream channel that begins at the top of the stream banks. A riparian zone at least 100 feet wide and full of plants helps protect the stream ecosystem.

Pools

Deeper, slower-moving places in the stream channel.

Stream bank

The stream banks are the shoulder-like sides of the stream channel from the water's edge up to the adjacent higher ground. Stable stream banks have plants growing on them that help hold the soil in place and minimize erosion.

Activity 7.5: Video Instruction for Invertebrate Sampling

This activity helps students understand the techniques used for invertebrate sampling. It helps students understand the use of biodiversity and indicator species to assess water quality.

Estimated Time

25 minutes

Required Materials

- Volunteer Water Quality Monitoring Instructional Video
- TV/DVD player
- Notebook paper
- Pens or pencils

Procedure

1. Review with the class paragraph 12 of Chapter 7 in the Student Guide. Explain that the video will show them how to sample a stream for invertebrates. Finding a diverse group of invertebrates, including those that are sensitive to pollution, indicates that the stream has high water quality.

2. Show the video clip: "Stream Invertebrates Sampling." Ask students to follow along on the instruction sheet as the different sampling methods are depicted. Pause the video as needed to clarify, discuss and review.

3. If desired, distribute copies of the Invertebrate Sampling Instructions and data pages (see Field Study Day section) for students to follow along with the video.

Activity 7.6: Student Investigation of Invertebrate Identification

Adapted from "A-Mazing Macroinvertebrates" by Rhonda Anderson, Missouri Department of Conservation

This activity helps students learn to identify invertebrates in preparation for their field study day. It helps students understand how to use dichotomous keys.

Estimated Time

25 minutes

Required Materials

- 30 wooden stakes approximately 4 foot in length, or music stands, or masking tape
- *A-Mazing Macroinvertebrates* signs (printed from a PDF on DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*) on paper or cardstock and laminated or placed in plastic sheet protectors
- Chalk, plastic non-adhesive survey tape or spray paint outside, or vinyl electrical tape, string or plastic non-adhesive survey tape indoors

Procedure

1. This activity is a maze that uses a large open space such as a grassy field or a gymnasium. This activity lends itself better to outdoor situations, but it can be done inside when ample space is available.

2. Using a permanent marker, write the letter corresponding to the layout on the back of each sign. Write a corresponding letter on each invertebrate picture to allow the student to know if he or she has correctly identified the invertebrate.

3. For an outdoor set up, use 30 wooden stakes approximately 4 foot in length. Attach the signs with staples or velcro and drive stakes into the ground. For an indoor set-up, use music stands or tape the signs directly on the floor.

4. Make lines connecting the stations at right angles. Use chalk, plastic non-adhesive survey tape or spray paint outside or vinyl electrical tape, string or non-adhesive survey tape inside. Always ask permission to use spray paint before applying to grass of a public lawn. If using string or tape, be sure to place it close to the ground at each station to avoid tripping.

5. This key was designed for use with specific invertebrates. Pictures of the 15 invertebrates are included to ensure that the students are able to properly key them out. Each invertebrate should be labeled with letters corresponding to the sign. This way the students will be able to know immediately if they are correct. (Caution, some students will just look for the matching letter!) You will also be able to match the invertebrate to the answer key and know if the students are correct.

6. Walk through the maze with a couple of different invertebrates to ensure that the maze is set up correctly.

7. Emphasize to students the importance of proper handling of the pictures to minimize wear. Review with the class the important points of invertebrate anatomy before starting. These include: head, thorax, abdomen, gills, wing pads, prolegs, segmented legs and lateral filaments.

8. Allow students to select an invertebrate and review its anatomy. Explain any vocabulary words that may be unfamiliar to the students. The key to success is in looking at the correct body part for each clue.

9. Go over the first clue with the students and explain how to follow the maze. Tell them to read both options before making any decisions.

10. Each student should walk through the maze with the picture of the invertebrate in hand, making choices and eventually reaching a dead end–the name of their invertebrate.

11. Sometimes students will need correction on a selection. Encourage them to return to the start of the maze until their invertebrate is correctly identified.

12. Encourage students to select another invertebrate and repeat the process as time permits.

13. Students can be paired up to go through the maze. Students having problems can be reassigned a partner who has been successful at identifying several invertebrates.

Chapter 7 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. Predict the impact of flooding on the organisms in a stream ecosystem.
   a. Some fish, plants or other aquatic life could be washed downstream.
   b. There would be no long-term damage.
   c. Fresh nutrients would be brought in.
   d. All of the above

2. Predict the types of organisms in a fourth-order stream.
   a. Few rooted plants grow because the water is too deep and very cloudy; there are more collectors than shredders, for example: black willow, smartweed, buttonbush, silver maple, cottonwood, sycamore, mayfly, gilled snail, stonefly, crayfish, green sunfish, creek chub and fathead minnow.
   b. Both rooted and floating aquatic plants and many types of animals have a niche in which to live, for example: algae, water willow, coontail, silver maple, sycamore, mayfly, gilled snail, crayfish, damselfly, scud, channel catfish, bluegill, largemouth bass and longnose gar.
   c. There is little aquatic plant growth; animals depend on what falls or is washed into the stream.
   d. None of the above.

3. Sculpins and many darter species are adapted as bottom clingers. They:
   a. Have streamlined bodies that allow them to remain stable in currents
   b. Have flattened heads and large pectoral fins that are angled to help them stay on the bottom in swift currents
   c. Have upturned eyes and mouths to slurp down mosquito larvae
   d. None of the above

4. Which of the following statements is true:
   a. In a straight stretch of river, the main force of the current is in the middle. The deepest water is also in the middle.
   b. When there is a sharp bend in the river, the strongest current and deepest water is at the outside edge of the bend.
   c. In flowing water, there is less current near the bottom.
   d. All of the above

5. Plants living in moving water have:
   a. Long, thin, flexible stems that offer little resistance to the current and strong root systems to hold them in place
   b. Are tiny, free-floating species of algae and are the food base of the ecosystem
   c. Are tall because they have greater support, enabling them to rise above other plants to reach the sun
   d. None of the above

Chapter 7 Assessment

Copy Page

Directions

Write your own answer for each of the following questions.

1. Describe how technological solutions to problems can have risks and unintended consequences. Justify your answer by using one of the following as an example:
   - Building a levee in the floodplain
   - Damming a stream
   - Channelizing (straightening) a river

2. Suggest a possible solution to potentially harmful environmental changes within a stream ecosystem caused by the technical solution you chose in the previous question.

3. Diagram the parts of a stream and explain how biotic and abiotic factors that make up the stream ecosystem function together. Use the back of this page.

Chapter 7 Assessment Answer Key

Multiple-choice questions

1. Predict the impact of flooding on the organisms in a stream ecosystem.
   d. All of the above

2. Predict the types of organisms in a fourth-order stream.
   b. Both rooted and floating aquatic plants and many types of animals have a niche in which to live, for example: algae, water willow, coontail, silver maple, sycamore, mayfly, gilled snail, crayfish, damselfly, scud, channel catfish, bluegill, largemouth bass and longnose gar.

3. Sculpins and many darter species are adapted as bottom clingers. They:
   b. Have flattened heads and large pectoral fins that are angled to help them stay on the bottom in swift currents

4. Which of the following statements is true:
   d. All of the above

5. Plants living in moving water have:
   a. Long, thin, flexible stems that offer little resistance to the current and strong root systems to hold them in place

Write-in questions

1. Describe how technological solutions to problems can have risks and unintended consequences. Justify your answer by using one of the following as an example:
   - Building a levee in the floodplain
   - Damming a stream
   - Channelizing (straightening) a river

   Many answers are possible, but should resemble one of the following examples:

Technological solution	Potential risk or unintended consequence
Building a levee in the floodplain	Building levees prevents the natural functioning of the floodplain to allowing excess water to spread out, slow down and release sediment and nutrient. This causes floodwaters to rise even higher, move faster and do more damage. It also prevents the natural replenishment of floodplain soil and wetland ecosystems. Some fish depend on flooding to trigger spawning, which takes place in the shallow water of the flooded floodplain. Levees prevent these fish from spawning, which could result in their extinction.
Damming a stream	Damming a river turns the stream ecosystem into a lake ecosystem. Species adapted to live in flowing water may not be able to survive in the still water of the lake. Also, as dams slow and stop the flow of water, the sediment the water carried drops out and builds up as the stream becomes a lake, further destroying stream habitat. Below the dam, the rushing water scours out the stream bed, destroying more habitat and causing severe erosion downstream. Dams also prevent fish from moving up or down stream, potentially isolating them from other populations or from spawning grounds upstream.
Channelizing (straightening) a river	Channelizing or straightening a stream increases the water's downhill speed. This worsens erosion and sedimentation as the stream tries to return to a natural path. In the process, habitat is destroyed and water quality is reduced.

2. Suggest a possible solution to potentially harmful environmental changes within a stream ecosystem caused by the technical solution you chose in the previous question.
Many answers are possible, but should resemble one of the following examples:

Technological solution	Potential risk or unintended consequence	Possible solution
Building a levee in the floodplain	Building levees prevents . . . in their extinction.	Remove or do not build levees. Instead, allow floodplains to perform their natural function. Do not build in the floodplain. Instead, use the land for low-impact agriculture and recreation.
Damming a stream	Damming a river . . . spawning grounds up-stream.	Remove or do not build dams. If this is not possible, create new habitat elsewhere to make up for habitat lost to the dam. Spawn fish artificially. Create fish passages around the dam (fish ladders). Build something (partial barriers, check dams, grade control structures) to slow the water down when it comes out of the dam, to reduce damage downstream.
Channelizing (straightening) a river	Channelizing or straighten-ing . . . quality is reduced.	Do not straighten streams. When channelization has already been done, try to dig a zig-zagging channel for the stream to return to, or just let the stream find a new path on its own. Protect the soil from erosion as much as possible by keeping plenty of plants, especially trees or prairie plants, growing in the area.

3. Diagram the parts of a stream and explain how biotic and abiotic factors that make up the stream ecosystem function together. Use the back of this page.
Refer to FIG. 7.1 and FIG. 7.5 in the Student Guide to assess potential responses.

Enrichments

Project WET:

- After Math
- Macroinvertebrate Mayhem

Project WILD Aquatic:

- Blue Ribbon Niche
- Riparian Retreat
- To Dam or Not to Dam
- Water Canaries

Demonstration:

- Stream Table

Service learning:

- Storm drain stenciling
- Litter pickup

Guest speaker:

- Soil and water conservationist
- Stream Team volunteer water quality monitor. If invited for activities, the speaker may be able to assist with instruction as well as talk about volunteer opportunities and stream issues.

Video clips:

- Our Corner of the World
- Ozark Mountain Paddlers

Lakes and Ponds

Lakes and ponds provide habitat for many plants, insects, fish, birds and other wildlife, and important recreational opportunities for many Missourians.

Estimated Time

Three 50-minute class sessions

Technology Tools/Skills Used in Chapter

- Invertebrate sampling technique for assessing water quality
- Invertebrate identification using a dichotomous key

Safety Precautions/Concerns

None

Vocabulary

Filter feeder
Pond succession

Chapter Objectives

Students will be able to:

1. Diagram the parts of a lake and explain how biotic and abiotic factors that make up the lake ecosystem function together, including how depth zones determine where populations of species live in the lake.
2. Compare and contrast the adaptations of plants and animals living in lakes and ponds to those of other aquatic and terrestrial species.
3. Diagram and describe the transfer of energy in a pond food web.
4. Predict the impact of storm water runoff on the organisms in a pond ecosystem. Describe how technological solutions to problems, such as dams, intensive agriculture and urban development, can have risks and unintended consequences. Describe possible solutions to potentially harmful environmental changes within a pond ecosystem.
5. Assess the health of a pond based on the presence or absence of aquatic invertebrates.

Targeted Grade-Level Expectations

EC.1.A.6.a.
EC.1.B.6.a.
EC.1.B.6.b.
EC.1.B.6.c.
EC.2.A.6.a.
EC.2.A.6.b.
EC.1.D.6.a.
EC.1.D.6.b.
EC.1.D.6.c.
IS.1.C.6.a.

Reference Material for Teacher Background

- African Clawed Frogs (SCI013)
- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Introduction to Crayfish (FIS011)
- Introduction to Missouri Fishes (FIS020)
- Know Missouri's Catfish (FIS003)
- Life Within the Water (FIS034)
- Missouri Toads and Frogs (E00430)
- Missouri Turtles (E00468)
- Nuisance Aquatic Plants in Missouri Ponds and Lakes (FIS110)
- Poster: Missouri Fishes (E00013)
- Poster: Missouri Pond Life (E00002)
- Poster: Toads & Frogs (E00012)
- Stream Insects/Crustaceans ID (STR250)
- *Crayfishes of Missouri* (01-0250)
- *Fishes of Missouri* (01-0031)

- *Amphibians and Reptiles of Missouri* (01-0190)
- *Pond Life: Revised and Updated (A Golden Guide from St. Martin's Press)* by George K. Reid

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Missouri Pond Life poster (E00002)
- TV/DVD player
- Notebook paper
- Pens or pencils
- 30 wooden stakes approximately 4 foot in length, or music stands, or masking tape
- *A-Mazing Macroinvertebrates* signs on paper or cardstock and laminated or placed in plastic sheet protectors
- Chalk, plastic non-adhesive survey tape or spray paint for outside activity; vinyl electrical tape, string or plastic non-adhesive survey tape for indoor activity

Activity 8.1: Exploration of Students' Current Understanding of Missouri's Lake and Pond Ecosystems

This activity explores students' current understanding of Missouri's lake and pond ecosystems.

Estimated Time

15 minutes

Required Materials

- Missouri Pond Life poster (E00002)
- Notebook paper
- Pens or pencils

Procedure

1. Display the Missouri Pond Life poster in the classroom.

2. Ask students to use their notebooks to free-write, brainstorm, mind-map or cluster for five minutes everything they know about lakes and ponds. Lead class discussion by asking each student to contribute something to the board without repeating an item. Have students add to their notebooks any information on the board that they hadn't already included. Leave these items on the board for use in Activity 8.2.

3. Explain to the class that this chapter will help them understand what a lake ecosystem is and how it functions.

Activity 8.2: Video Exploration of Missouri's Lake and Pond Ecosystems

This activity helps students understand Missouri's lake and pond ecosystems.

Estimated Time

35 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player
- Notebook paper
- Pens or pencils

Procedure

1. Show the video clips: "CAP Lakes" and "Farm Pond Stocking." Pause the video frequently and discuss facts, concepts and misunderstandings students wrote on the board in Activity 8.1 as they arise in the video.

2. Have students make notes in their science notebooks.

Activity 8.3: Student Reading and Research

This activity provides students with definitions and explanations about Missouri's lake and pond ecosystems.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 8: Lakes and Ponds. Introduce vocabulary terms as needed.

2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.
   1. How do oxygen levels in ponds change during each 24-hour period?
      Oxygen levels in a pond are high while the sun is shining and plants are photosynthesizing, but they can drop dramatically at night, killing fish and other aquatic animals.
   2. What kind of organism makes up the greatest amount of living material in a pond?
      Plankton makes up about 87 percent of the living stuff in a pond.
   3. Besides providing food, what other roles do plants have in lake and pond ecosystems?
      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. Plants give off oxygen as a byproduct of photosynthesis. Small animals seek shelter among the plants and parts of plants growing underwater, which offer hiding places from predators. Plant beds serve both as shelter from predators and as a food source for insects.
   4. How are plants that live under water similar to plants that live on land? How are they different?
      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.
   5. How do ponds change over time?
      As ponds age, they fill with sediment and organic material. They become smaller, shallower ponds. In time the pond will become a wetland, then as it fills even more, a meadow. This natural process is called pond succession.
   6. How are lakes similar to ponds? How are they different?
      Lakes are bigger than ponds. While lakes and ponds have much in common, a lake's larger size makes for some differences. In a lake, the amount of oxygen dissolved in the water stays pretty even over a 24-hour period. Wind on a lake can whip up high waves mixing oxygen into the water. The ecology of the lake's shoreline zone is like a pond's ecology. 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. This is a natural process that mixes nutrients, minerals and oxygen throughout the lake.

7. How can lakes and ponds be kept healthy?
   Because every waterbody 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. A plant buffer will greatly improve the pond's health and extend its life. The same is true for lakes.

Activity 8.4: Student Investigation of Pond Anatomy and Lake and Pond Food Webs

This activity helps students understand lake and pond food webs.

Estimated Time

25 minutes

Required Materials

- Missouri Pond Life poster (E00002)
- Notebook paper
- Pens or pencils
- Red, green and black yarn
- Scissors
- Pushpins or thumbtacks

Procedure

1. Display the Missouri Pond Life poster in the classroom.

2. Have students take turns cutting lengths of yarn and using pushpins, attach them to the poster to diagram the food web connections between the plants and animals depicted in the poster. Tell students to use red yarn to connect a predator to its prey. Have students use green yarn to connect primary consumers to producers. Use black yarn to connect scavengers and decomposers to their food.

3. Lead class discussion of lake and pond food webs, with reference to the poster and to FIG. 8.8 in the Student Guide.

4. Ask students to predict the impact of storm water runoff on the organisms in a pond ecosystem. (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. 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 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 chokes fish. This can speed up pond succession.)

5. Have students write science notebook entries diagramming the parts of a lake and explaining how the biotic and abiotic factors that make up the lake ecosystem function together, including how the depth zones of a lake determine where populations of species live in the lake.

Activity 8.5: Video Instruction for Invertebrate Sampling

This activity helps students understand the techniques used for invertebrate sampling. It helps students understand the use of biodiversity and indicator species to assess water quality.

Estimated Time

25 minutes

Required Materials

- Volunteer Water Quality Monitoring Instructional Video
- TV/DVD player
- Notebook paper
- Pens or pencils

Procedure

1. Explain that, besides testing the physical and chemical characteristics of the water, water quality experts also look for certain invertebrates that live among the plants and in the bottom at the edge of the lake or pond. Examples include the immature stages of dragonflies, damselflies and mayflies. These insects are sensitive to pollution. The presence of such species generally indicates good quality water. When they are missing from a lake or pond 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 lake or pond are good signs of its health. Explain that the video will show them how to sample a lake or pond for invertebrates. Finding a diverse group of invertebrates, including those that are sensitive to pollution, indicates that the lake or pond has high water quality.

2. Show the video clip: "Pond Invertebrate Sampling." Ask students to follow along on the instruction sheet as the different sampling methods are depicted. Pause the video as needed to clarify, discuss and review.

3. If desired, distribute copies of the Invertebrate Sampling Instructions and data pages (see Field Study Day section) for students to follow along with the video.

Activity 8.6: Student Investigation of Invertebrate Identification

Adapted from "A-Mazing Macroinvertebrates" by Rhonda Anderson, Missouri Department of Conservation

This activity helps students learn to identify invertebrates in preparation for their field study day. It helps students understand how to use dichotomous keys.

Estimated Time

25 minutes

Required Materials

- 30 wooden stakes approximately 4 foot in length, or music stands, or masking tape
- *A-Mazing Macroinvertebrates* signs (printed from a PDF on DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*) on paper or cardstock and laminated or placed in plastic sheet protectors
- Chalk, plastic non-adhesive survey tape or spray paint outside, or vinyl electrical tape, string or plastic non-adhesive survey tape indoors

Procedure

1. This activity is a maze that uses a large open space such as a grassy field or a gymnasium. This activity lends itself better to outdoor situations, but it can be done inside when ample space is available.

2. Using a permanent marker, write the letter corresponding to the layout on the back of each sign. Write a corresponding letter on each invertebrate picture to allow the student to know if he or she has correctly identified the invertebrate.

3. For an outdoor setup, use 30 wooden stakes approximately 4 foot in length. Attach the signs with staples or velcro and drive stakes into the ground. For an indoor setup, use music stands or tape the signs directly on the floor.

4. Make lines connecting the stations at right angles. Use chalk, plastic non-adhesive survey tape or spray paint outside or vinyl electrical tape, string or non-adhesive survey tape inside. Always ask permission to use spray paint before applying to grass of a public lawn. If using string or tape, be sure to place it close to the ground at each station to avoid tripping.

5. This key was designed for use with specific invertebrates. Pictures of the 15 invertebrates are included to ensure that the students are able to properly key them out. Each invertebrate should be labeled with letters corresponding to the sign. This way the students will be able to know immediately if they are correct. (Caution, some students will just look for the matching letter!) You will also be able to match the invertebrate to the answer key and know if the students are correct.

6. Walk through the maze with a couple of different invertebrates to ensure that the maze is set up correctly.

7. Emphasize to students the importance of proper handling of the pictures to minimize wear. Review with the class the important points of invertebrate anatomy before starting. These include: head, thorax, abdomen, gills, wing pads, prolegs, segmented legs and lateral filaments.

8. Allow students to select an invertebrate and review its anatomy. Explain any vocabulary words that may be unfamiliar to the students. The key to success is in looking at the correct body part for each clue.

9. Go over the first clue with the students and explain how to follow the maze. Tell them to read both options before making any decisions.

10. Each student should walk through the maze with the picture of the invertebrate in hand, making choices and eventually reaching a dead end—the name of their invertebrate.

11. Sometimes students will need correction on a selection. Encourage them to return to the start of the maze until their invertebrate is correctly identified.

12. Encourage students to select another invertebrate and repeat the process as time permits.

13. Students can be paired up to go through the maze. Students having problems can be reassigned a partner who has been successful at identifying several invertebrates.

Chapter 8 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. Predict the impact of sediment and nutrients brought by storm water runoff on the organisms in a lake or pond ecosystem.
   a. Temperature changes would cause the layers to mix, bringing decaying organic matter from the bottom up to the surface.
   b. There would be no long-term damage.
   c. Pond succession would speed up.
   d. All of the above

2. Predict the oxygen level in a pond.
   a. The amount of oxygen dissolved in the water stays pretty even over a 24-hour period.
   b. The water is too deep for plants to grow on the bottom, making it oxygen poor.
   c. Oxygen levels are high each day while the sun is shining and plants are photosynthesizing, but they can drop dramatically at night.
   d. None of the above

3. Which of the following is important to slowing pond succession and keeping a pond healthy:
   a. Keeping a 100-foot-wide buffer of thick plant growth around the pond
   b. Stopping excess erosion
   c. Stopping runoff loaded with fertilizers, pesticides or other pollutants
   d. All of the above

4. A lake has most of its life:
   a. In a ring around the shoreline, reaching out as far as it can survive
   b. In open-water zone away from shore, as far down as sunlight reaches
   c. In the deep-water zone
   d. Both a and c

5. Plants living in lakes and ponds:
   a. Have long, thin, flexible stems that offer little resistance to the current and strong root systems to hold them in place
   b. Include tiny, free-floating species of algae and are the food base of the ecosystem
   c. Have waxy or slimy coatings protect them from drying out when water levels drop, and porous stems or leaves let them absorb minerals right from the water
   d. Both b and c

Chapter 8 Assessment

Copy Page

Directions

Write your own answer for each of the following questions.

1. Describe how technological solutions to problems can have risks and unintended consequences. Justify your answer by using one of the following as an example:
   - Damming a stream to create a lake or pond
   - Urban development in the watershed of a lake or pond
   - Intensive agriculture (such as cattle or row crops) in the watershed of a lake or pond

2. Suggest a possible solution to potentially harmful environmental changes within a stream ecosystem caused by the technical solution you chose in the previous question.

3. On a separate sheet of paper, diagram the parts of a lake and explain how biotic and abiotic factors that make up the lake ecosystem function together.

Chapter 8 Assessment Answer Key

Multiple-choice questions

1. Predict the impact of sediment and nutrients brought by storm water runoff on the organisms in a lake or pond ecosystem.
   c. Pond succession would speed up.

2. Predict the oxygen level in a pond.
   c. Oxygen levels are high each day while the sun is shining and plants are photosynthesizing, but they can drop dramatically at night.

3. Which of the following is important to slowing pond succession and keeping a pond healthy:
   d. All of the above

4. A lake has most of its life:
   a. In a ring around the shoreline, reaching out as far as it can survive

5. Plants living in lakes and ponds:
   d. Both b and c

Write-in questions

1. Describe how technological solutions to problems can have risks and unintended consequences. Justify your answer by using one of the following as an example:
   - Damming a stream to create a lake or pond
   - Urban development in the watershed of a lake or pond
   - Intensive agriculture (such as cattle or row crops) in the watershed of a lake or pond

   Many answers are possible, but should resemble one of the following examples:

Technological solution	Potential risk or unintended consequence
Damming a stream to create a lake or pond	Damming a river turns the stream ecosystem into a lake ecosystem. Species adapted to live in flowing water may not be able to survive in the still water of the lake or pond. Also, as dams slow and stop the flow of water, the sediment the water carried drops out and builds up as the stream becomes lake or pond, further destroying stream habitat. Eventually the lake or pond will fill with sediment, becoming solid ground. Below the dam, the rushing water scours out the stream bed, destroying more habitat and causing severe erosion downstream. Dams also prevent fish from moving up or down stream, potentially isolating them from other populations or from spawning grounds upstream.
Urban development in the watershed of a lake or pond	Urban development can speed up erosion, and surface water from the watershed can bring sediment to the pond, replacing water with soil and creating more shallow areas. Excess soil and plant nutrients can overload the pond and unbalance its growth cycle. This can speed up pond succession. Water from sewage treatment plants may be piped back into lakes or ponds after treatment. Stormwater that runs off paved roads, rooftops and parking lots flows into ditches and storm drains. This water then may drain directly a lake or pond without any filtration or treatment. Excess fertilizer, pesticides, mud, motor oil and antifreeze, trash, even lawn clippings and pet waste wash off pavement into waterways during heavy rains, creating significant hazards for swimmers and for people using the lake or pond for drinking water. Rainwater running off a hot asphalt parking lot after a summer storm can dump hot water into a pond, killing everything in it.

Intensive agriculture (such as cattle or row crops) in the watershed of a lake or pond	Plowing and overgrazing can speed up erosion, and surface water from the watershed can bring sediment to the pond, replacing water with soil and creating more shallow areas. Excess soil and plant nutrients can overload the pond and unbalance its growth cycle. This can speed up pond succession. 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. Animal waste and bacteria from feedlots can create significant hazards for swimmers and for people using the lake or pond for drinking water. Organic pollution also can happen when inorganic pollutants such as nitrates and phosphates build up in the water. Farmers 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 lake or pond.

2. Suggest a possible solution to potentially harmful environmental changes within a stream ecosystem caused by the technical solution you chose in the previous question.
   Many answers are possible, but should resemble one of the following examples:

Technological solution	Potential risk or unintended consequence	Possible solution
Damming a stream to create a lake or pond	Damming a river . . . spawning grounds upstream.	Remove or do not build dams. If this is not possible, create new habitat elsewhere to make up for habitat lost to the dam. Dredging may be necessary to slow down succession in the lake or pond. Spawn fish artificially. Create fish passages around the dam (fish ladders). Build something (partial barriers, check dams, grade control structures) to slow the water down when it comes out of the dam, to reduce damage downstream.
Urban development in the watershed of a lake or pond	Urban development can . . . killing everything in it.	Because every waterbody 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. A plant buffer will greatly improve the pond's health and extend its life. The same is true for lakes.
Intensive agriculture (such as cattle or row crops) in the watershed of a lake or pond	Plowing and overgrazing . . . lake or pond.	Because every waterbody 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. A plant buffer will greatly improve the pond's health and extend its life. The same is true for lakes. Missouri farmers have switched to no-till planting and other conservation farming techniques to reduce the amount of soil and other sediment in Missouri lakes and ponds.

3. On a separate sheet of paper, diagram the parts of a lake and explain how biotic and abiotic factors that make up the lake ecosystem function together.
   Refer to FIG. 8.8 in the Student Guide to assess potential responses.

Enrichments

Project WET:

- Macroinvertebrate Mayhem

Project WILD Aquatic:

- Glass Menagerie
- Micro Odyssey
- Pond Succession

Service learning:

- Storm drain stenciling
- Litter pickup

Guest speaker:

- Lake and pond manager

Video clips:

- Crappie Radio Tagged

9 Swamps and Marshes

Wetlands are the most productive ecosystems in the world, home to many specially adapted plant and wildlife species. Although most of Missouri's wetlands have been destroyed, wetlands provide many important ecological services.

Estimated Time

Three 50-minute class sessions

Technology Tools/Skills Used in Chapter

- Soil saturation testing
- Invertebrate sampling technique for assessing water quality
- Invertebrate identification using a dichotomous key

Safety Precautions/Concerns

None

Vocabulary

Anaerobic
Detritus

Chapter Objectives

Students will be able to:

1. Compare and contrast swamps and marshes.
2. Explain how biotic and abiotic factors that make up wetland ecosystems function together.
3. Compare and contrast the adaptations of plants and animals living in wetlands to those of other aquatic and terrestrial species.
4. Diagram and describe the transfer of energy in marsh food web.
5. Predict the impact of channelization/drainage on the organisms in a wetland ecosystem. Describe how technological solutions to problems, such as drainage and agricultural development, can have risks and unintended consequences. Describe possible solutions to potentially harmful environmental changes within a wetland ecosystem.
6. Assess the health of a wetland based on the presence or absence of aquatic invertebrates.

Targeted Grade-Level Expectations

EC.1.A.6.a.
EC.1.B.6.a.
EC.1.B.6.b.
EC.1.B.6.c.
EC.2.A.6.a.
EC.2.A.6.b.
EC.1.D.6.a.
EC.1.D.6.b.
EC.1.D.6.c.
IS.1.C.6.a.

Reference Material for Teacher Background

- African Clawed Frogs (SCI013)
- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Introduction to Crayfish (FIS011)
- Introduction to Missouri Fishes (FIS020)
- Know Missouri's Catfish (FIS003)
- Life Within the Water (FIS034)
- Missouri Marsh Birds (E00042)
- Missouri Toads and Frogs (E00430)
- Missouri Turtles (E00468)
- Missouri Wetlands & Their Management (SCI150)
- Nuisance Aquatic Plants in Missouri Ponds and Lakes (FIS110)
- Poster: Exploring Missouri Wetlands (E00003)
- Poster: Missouri Fishes (E00013)
- Poster: Salamander (E00089)
- Poster: Toads & Frogs (E00012)

- Poster: Wetlands & Waterfowl (E00115)
- Stream Insects/Crustaceans ID (STR250)
- *Crayfishes of Missouri* (01-0250)
- *Fishes of Missouri* (01-0031)
- *Amphibians and Reptiles of Missouri* (01-0190)
- *Pond Life: Revised and Updated (A Golden Guide from St. Martin's Press)* by George K. Reid
- *WOW! The Wonders of Wetlands*

Required Materials

- 30 wooden stakes approximately 4 foot in length, or music stands, or masking tape
- Chalk, plastic non-adhesive survey tape or spray paint outside, or vinyl electrical tape, string or plastic non-adhesive survey tape indoors
- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Garden spades or shovels
- Notebook paper
- 1 copy of Soil Sampling—Percolation and Characteristics for each student
- Pens or pencils
- Poster: Exploring Missouri Wetlands (E00003)
- Pushpins or thumbtacks
- Red, green and black yarn
- Rulers
- Scissors
- *A-Mazing Macroinvertebrates* signs on paper or cardstock and laminated or placed in plastic sheet protectors
- Stopwatches, watches or clocks
- Student Guide
- TV/DVD player

Activity 9.1: Exploration of Students' Current Understanding of Missouri's Swamp and Marsh Ecosystems

This activity explores students' current understanding of Missouri's swamp and marsh ecosystems.

Estimated Time

15 minutes

Required Materials

- Poster: Exploring Missouri Wetlands (E00003)
- Notebook paper
- Pens or pencils

Procedure

1. Display the Exploring Missouri Wetlands poster in the classroom.

2. Ask students to use their notebooks to free-write, brainstorm, mind-map or cluster for five minutes everything they know about swamps and marshes. Lead class discussion by asking each student to contribute something to the board without repeating an item. Have students add to their notebooks any information on the board that they hadn't already included. Leave these items on the board for use in Activity 9.2.

3. Explain to the class that this chapter will help them understand what a wetland ecosystem is and how it functions.

Activity 9.2: Video Exploration of Missouri's Swamp and Marsh Ecosystems

This activity helps students understand Missouri's swamp and marsh ecosystems.

Estimated Time

35 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player
- Notebook paper
- Pens or pencils

Procedure

1. Show the video: "Southeast Missouri." Pause the video frequently and discuss facts, concepts and misunderstandings students wrote on the board in Activity 9.1 as they arise in the video.

2. Have students make notes in their science notebooks.

3. As time permits, show one or more of the video clips: "Winter Hike (Dresser Island Wetland)," "A Day on a Marsh" and "Grand Pass Conservation Area."

Activity 9.3: Student Reading and Research

This activity provides students with definitions and explanations about Missouri's wetland ecosystems.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 9: Swamps and Marshes. Introduce vocabulary terms as needed.
2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.
   1. What is a wetland? What three factors must be present for a place to be considered a wetland?
      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 plants that are specially adapted to live in saturated soil.
   2. What are the main types of wetlands found in Missouri? What are the differences and similarities between them?
      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. 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.
   3. What is different about wetland soil? How does it get that way? How can we recognize it?
      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.
   4. What are some examples of the special adaptations found in wetland plants?
      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. Their short roots hang free in the nutrient-rich water. Another challenge of wetland plants is how to get enough air for their cells. 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.
   5. How are wetlands important to Missouri's fish, birds, and other wildlife?
      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. 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. Wetlands are the main habitat for furbearing animals, like beaver, otter and muskrat. 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.

6. How do wetlands improve water quality?
   Wetlands filter out pollutants. 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. 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. Wetland plants also filter particles from water, keeping sediment out of streams and rivers.

7. How do wetlands provide natural 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.

Activity 9.4: Student Investigation of Wetland Food Webs

This activity helps students understand wetland food webs.

Estimated Time

25 minutes

Required Materials

- Poster: Exploring Missouri Wetlands (E00003)
- Notebook paper
- Pens or pencils
- Red, green and black yarn
- Scissors
- Pushpins or thumbtacks

Procedure

1. Display the Exploring Missouri Wetlands poster in the classroom.

2. Have students take turns cutting lengths of yarn and using pushpins, attach them to the poster to diagram the food web connections between the plants and animals depicted in the poster. Tell students to use red yarn to connect a predator to its prey. Have students use green yarn to connect primary consumers to producers. Use black yarn to connect scavengers and decomposers to their food.

3. Lead class discussion of wetland food webs emphasizing the importance of scavengers, detritus and anaerobic decomposers.

4. Ask students to predict the impact of channelization/drainage on the organisms in a wetland ecosystem. (Drainage removes water—the most vital component of a wetland—from the ecosystem. If drainage is successful, the entire ecosystem and the organisms within it could be permanently lost.)

5. Have students write science notebook entries explaining how the biotic and abiotic factors that make up the wetland ecosystem function together, including the importance of the role scavengers, detritus and anaerobic decomposers play in wetland ecosystems.

Activity 9.5: Video Instruction for Invertebrate Sampling

This activity helps students understand the techniques used for invertebrate sampling. It helps students understand the use of biodiversity and indicator species to assess water quality.

Estimated Time

25 minutes

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- TV/DVD player
- Notebook paper
- Pens or pencils

Procedure

1. Explain that, besides testing the physical and chemical characteristics of the water, water quality experts also look for certain invertebrates that live among the plants and in the bottom of the swamp or marsh. Examples include the immature stages of dragonflies, damselflies and mayflies. These insects are sensitive to pollution. The presence of such species generally indicates good quality water. When they are missing from a swamp or marsh 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 swamp or marsh are good signs of its health. Explain that the video will show them how to sample a swamp or marsh for invertebrates. Finding a diverse group of invertebrates, including those that are sensitive to pollution, indicates that the swamp or marsh has high water quality.

2. Show the video clips: "Wetland Invertebrate Sampling." Ask students to follow along on the instruction sheet as the different sampling methods are depicted. Pause the video as needed to clarify, discuss and review.

3. If desired, distribute copies of the Invertebrate Sampling Instructions and data pages (see Field Study Day section) for students to follow along with the video.

Activity 9.6: Student Investigation of Invertebrate Identification

Adapted from "A-Mazing Macroinvertebrates" by Rhonda Anderson, Missouri Department of Conservation

This activity helps students learn to identify invertebrates in preparation for their field study day. It helps students understand how to use dichotomous keys.

Estimated Time

25 minutes

Required Materials

- 30 wooden stakes approximately 4 foot in length, or music stands, or masking tape
- *A-Mazing Macroinvertebrates* signs (printed from a PDF on DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*) on paper or cardstock and laminated or placed in plastic sheet protectors
- Chalk, plastic non-adhesive survey tape or spray paint outside, or vinyl electrical tape, string or plastic non-adhesive survey tape indoors

Procedure

1. This activity is a maze that uses a large open space such as a grassy field or a gymnasium. This activity lends itself better to outdoor situations, but it can be done inside when ample space is available.

2. Using a permanent marker, write the letter corresponding to the layout on the back of each sign. Write a corresponding letter on each invertebrate picture to allow the student to know if he or she has correctly identified the invertebrate.

3. For an outdoor set up, use 30 wooden stakes approximately 4 foot in length. Attach the signs with staples or velcro and drive stakes into the ground. For an indoor set-up, use music stands or tape the signs directly on the floor.

4. Make lines connecting the stations at right angles. Use chalk, plastic non-adhesive survey tape or spray paint outside or vinyl electrical tape, string or non-adhesive survey tape inside. Always ask permission to use spray paint before applying to grass of a public lawn. If using string or tape, be sure to place it close to the ground at each station to avoid tripping.

5. This key was designed for use with specific invertebrates. Pictures of the 15 invertebrates are included to ensure that the students are able to properly key them out. Each invertebrate should be labeled with letters corresponding to the sign. This way the students will be able to know immediately if they are correct. (Caution, some students will just look for the matching letter!) You will also be able to match the invertebrate to the answer key and know if the students are correct.

6. Walk through the maze with a couple of different invertebrates to insure that the maze is set up correctly.

7. Emphasize to students the importance of proper handling of the pictures to minimize wear. Review with the class the important points of invertebrate anatomy before starting. These include: head, thorax, abdomen, gills, wing pads, prolegs, segmented legs, and lateral filaments.

8. Allow students to select an invertebrate and review its anatomy. Explain any vocabulary words that may be unfamiliar to the students. The key to success is in looking at the correct body part for each clue.

9. Go over the first clue with the students and explain how to follow the maze. Tell them to read both options before making any decisions.

10. Each student should walk through the maze with the picture of the invertebrate in hand, making choices and eventually reaching a dead end—the name of their invertebrate.

11. Sometimes students will need correction on a selection. Encourage them to return to the start of the maze until their invertebrate is correctly identified.

12. Encourage students to select another invertebrate and repeat the process as time permits.

13. Students can be paired up to go through the maze. Students having problems can be reassigned a partner who has been successful at identifying several invertebrates.

Activity 9.7: Student Investigation of Soil Characteristics

This hands-on activity helps students understand soil characteristics.

Estimated Time

40 minutes

Required Materials

- Notebook paper
- Pens or pencils
- Rulers
- Garden spades or shovels
- Stopwatches, watches or clocks
- One copy of Soil Sampling—Percolation and Characteristics for each student

Procedure

1. Take the class outside. If possible, have students work in small groups in varying locations in order to compare results from different sites.

2. Provide each student with a copy of Soil Sampling—Percolation and Characteristics.

3. Lead the class through the procedure.

4. Have students compare their results and place the completed data sheets in their science notebooks.

SOIL SAMPLING — PERCOLATION AND CHARACTERISTICS

Copy Page

Objective

Determine the soil percolation rate and observe the color, texture and odor of the soil.

Directions

1. If there is standing water at the site, use a ruler to measure the depth of the standing water. Measure in inches from the soil surface to the top of the water and record the result. If there is standing water, do not dig a test hole.

2. If there is no standing water at the site, dig a hole 12 inches square and 12 inches deep using a spade or shovel.

3. Measure the rise in water level during an approximate 30-minute period.

4. Calculate percolation rate in inches per minute and record it below.

5. While waiting, examine some of the soil from the hole. 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. These gray, blue, even black wetland soils also may have irregularly shaped reddish-brown or orange-yellow mottles. Record your observations under color and texture.

6. 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, break down the detritus. They produce sulfur-containing compounds, which smell like rotten eggs. Remove a small piece of soil from the hole. Crush this piece between thumb and forefingers and smell it to determine if hydrogen sulfide is present. Record your observations.

7. Fill in your soil hole when done!

SOIL SAMPLING — PERCOLATION AND CHARACTERISTICS

Copy Page

Group: _____ **(names)**

Date: _____

Location: _____

Water level change after 30 minutes: _____ inches.
Percolation rate = water level change after 30 minutes ÷ 30 = _____ inches per minute.

Soil Characteristics

Site	Depth of standing water (inches)	Percolation rate (inches per minute)	Color	Texture	Odor

Activity 9.8: Student Investigation of Wetland Soil

Students apply what they have learned in the preceding activities to create a data table to record soil sampling data and observations in preparation for their field study day.

Estimated Time

10 minutes

Required Materials

- Notebook paper
- Pens or pencils

Procedure

1. Instruct students to work in teams to decide the best way to record soil sampling data and observations as part of their field study day.

2. Have each team create a data table and have each student make a copy for his/her notebook.

Chapter 9 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. Which of these statements is true about Missouri wetlands?
   a. Reeds and other grasslike plants grow in marshes, while woody species (trees and shrubs) thrive in swamps.
   b. Reeds and other grasslike plants grow in swamps, while woody species (trees and shrubs) thrive in marshes.
   c. Swamps and marshes have standing water all year round.
   d. None of the above

2. Plants living in wetlands have:
   a. Long, thin, flexible stems and strong root systems to hold them in place
   b. Are tiny, free-floating species of algae and are the food base of the ecosystem
   c. Roots that can pull in water and still get air
   d. None of the above

3. Predict the impact of flooding on the organisms in a wetland ecosystem.
   a. Some fish, plants or other aquatic life could be washed downstream.
   b. There would be no long-term damage.
   c. Fresh nutrients would be brought in.
   d. All of the above

4. What three factors are required for a place to be considered a wetland?
   a. Saturated soil, diverse plant and animal community, standing water
   b. Saturated soil, diverse plant and animal community, plants specially adapted to live in saturated soil
   c. Saturated soil, wet for a major part of the growing season, plants specially adapted to live in saturated soil
   d. Standing water, wet for a major part of the growing season, plants specially adapted to live in saturated soil

5. What is detritus?
   a. A complex web of relationships between living and non-living things
   b. The variety and number of different organisms and populations, and the way they live together
   c. Dead plant and animal matter in the process of decay
   d. None of the above

Chapter 9 Assessment

Copy Page

Directions

Write your own answer for each of the following questions.

1. What is detritus? What are anaerobic decomposers? Explain how the biotic and abiotic factors that make up the wetland ecosystem, including detritus anaerobic decomposers, function together.

2. Technological solutions to problems can have risks and unintended consequences. Justify this statement by using the channelization/drainage of a Missouri wetland as an example.

3. Suggest a possible solution to potentially harmful environmental changes within a wetland ecosystem caused by the channelization/drainage of a Missouri wetland.

Chapter 9 Assessment Answer Key

Multiple-choice questions

1. Which of these statements is true about Missouri wetlands?
   a. Reeds and other grasslike plants grow in marshes, while woody species (trees and shrubs) thrive in swamps.

2. Plants living in wetlands have:
   c. Roots that can pull in water and still get air

3. Predict the impact of flooding on the organisms in a wetland ecosystem.
   d. All of the above

4. What three factors are required for a place to be considered a wetland?
   c. Saturated soil, wet for a major part of the growing season, plants specially adapted to live in saturated soil

5. What is detritus?
   c. Dead plant and animal matter in the process of decay

Write-in questions

1. What is detritus? What are anaerobic decomposers? Explain how the biotic and abiotic factors that make up the wetland ecosystem, including detritus anaerobic decomposers, function together.
   Detritus is dead plant and animal matter in the process of decay. Anaerobic decomposers are bacteria that do not need oxygen to live. Because the detritus layer settles beneath the water and is not exposed to air, anaerobic decomposers are needed. Anaerobic bacteria are the stars of the wetland ecosystem. As they break down the detritus, they produce sulfur-containing compounds. Nutrients are available in the detritus in forms that small fish can use. The rich detritus nourishes a complex food web.

2. Technological solutions to problems can have risks and unintended consequences. Justify this statement by using the channelization/drainage of a Missouri wetland as an example.
   Answers may include:
   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. Most wetlands were drained to make the land farmable. In other cases, wetlands have been lost due to channelization to improve river navigation. Statewide, 87 percent of Missouri's wetlands have been destroyed. Many of the wetlands that are left suffer from sedimentation, pollution and changes people have made. 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. Of the 2.4 million acres of swamp that once stood in southeast Missouri, less than 60,000 acres, or 2 percent, survive today. Southeast Missouri was once the part of the state with the most diverse and the most abundant wildlife. Today it has the least wildlife, and the least diverse wildlife. The water table continues to fall, leaving some areas of former swamp so dry they resemble desert and require irrigation for farming. While the swamps yielded valuable timber and have become profitable farms, the land continues to suffer.

3. Suggest a possible solution to potentially harmful environmental changes within a wetland ecosystem caused by the channelization/drainage of a Missouri wetland.

   Answers may include:

   Taking care of the wetlands that are left and putting some back are some of conservation's biggest challenges. 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. But we have a long way to go toward bringing back these special places to Missouri. 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 Missouri's wetlands depends on citizens who value and enjoy them. To learn more about conserving Missouri's wetlands, 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 a wetland. Begin thinking of it as YOUR 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. Follow the rules of ethical conduct in the use of aquatic resources and teach others to do so, too. Volunteer to become a Master Naturalist or Water Quality Monitor. And if you're up to the challenge, choose a career in conservation and make wetland conservation your life's work. Above all, enjoy your aquatic resources and use them wisely!

Enrichments

Project WET:

- Capture, Store, Release
- Life in the Fast Lane
- Wetland Soils in Living Color
- Macroinvertebrate Mayhem

Project WILD Aquatic:

- Dragonfly Pond
- Wetland Metaphors

Service learning:

- Storm drain stenciling
- Litter pickup

Guest speaker:

- Wetland ecologist

Electronic media:

- Duck wing maze DVD (Also requires duck wing collection borrowed from Missouri Department of Conservation staff.)
- Are You Still There? (Chicken Turtle) video clip

10 Fishing for Answers

Understanding Missouri's aquatic ecosystems helps us enjoy, appreciate and conserve our precious aquatic resources.

Estimated Time

Two or three 50-minute class sessions

Technology Tools/Skills Used in Chapter

Fishing skills

Safety Precautions/Concerns

Use extra care when handling rods and reels.

Vocabulary

Angler
Ethics
Sport fisherman

Chapter Objectives

Students will be able to:

1. Apply knowledge of species adaptations in the conservation of Missouri's aquatic resources.
2. Apply knowledge of factors that affect the number and types of organisms an environment can support and how populations of organisms within a community compete with one another for resources in the conservation of Missouri's aquatic resources.
3. Apply knowledge of the roles producers, consumers and decomposers in the transfer of energy in an aquatic food web in Missouri.
4. Apply knowledge of how changes in the number or type of organisms in an aquatic community in Missouri might affect populations of other organisms within that community in the conservation of Missouri's aquatic resources.
5. Demonstrate ethical judgment with regard to the conservation of Missouri's aquatic resources.

Targeted Grade-Level Expectations

EC.1.B.6.a.
EC.1.B.6.b.
EC.1.B.6.c.
EC.1.D.6.a.
EC.1.D.6.b.
EC.1.D.6.c.
EC.2.A.6.a.
EC.2.A.6.b.
EC.3.C.6.a.
EC.3.C.6.b.
IS.1.C.6.a.

Reference Material for Teacher Background

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Fishing Regulations Summary (E00606)
- Introduction to Fishing (FIS152)
- Introduction to Missouri Fishes (FIS020)
- Kids Fishing Book (E00092)
- Know Missouri's Catfish (FIS003)
- Map: Smallmouth Bass (FIS019)
- Map: Trout Fishing In Missouri (FIS210)
- Poster: Missouri Fishes (E00013)
- Stream Insects/Crustaceans ID (STR250)
- Zebra Mussels: Missouri's Most Unwanted (FIS013)
- *Fishes of Missouri* (01-0031)

Required Materials

- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Fishing Regulations Summary (E00606)
- Hula-hoops, Backyard Bass or other suitable casting targets (optional)
- Missouri Fishes poster (E00013)
- Notebook paper
- 1 copy of Casting Instructions for each student
- 1 copy of Fishing Instructions for each student
- 1 copy of Summary of Missouri Fishing Regulations booklet for each student
- 1 copy of the Scavenger Hunt for Missouri Fishing Regulations for each student
- Pens or pencils
- Poster: Missouri Fishes (E00013)
- Prizes or rewards (optional)
- Rod-and-reel combinations set up with casting plugs (Advanced preparation is required.)
- Student Guide
- TV/DVD player

Activity 10.1: Exploration of Students' Current Understanding of Fishing, Aquatic Recreation and Conservation

This activity explores students' current understanding of fishing, aquatic recreation and conservation.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Poster: Missouri Fishes (E00013)
- 1 copy of Casting Instructions for each student

Procedure

1. Display the Missouri Fishes poster in the classroom. Use a cooperative learning activity to explore the following questions:
    - Have you ever been fishing? If so, tell about the experience. If not, would you like to go?
    - How do people find and catch fish?
    - What are the rules for fishing?
    - What else do people do to enjoy Missouri's aquatic resources? Have you ever done any of those things? If so, tell about the experience. If not, would you like to?
    - What can I do to help conserve Missouri's aquatic ecosystems? Have you ever done any of those things? If so, tell about the experience. If not, would you like to?

2. Explain to the class that this chapter will help them understand how to find and catch fish, follow the rules for fishing and enjoy and conserve Missouri's aquatic ecosystems.

3. Distribute one copy of Casting Instructions for each student.

4. Have students read Casting Instructions—class time may be provided or reading may be assigned as homework in advance of class. Have students keep the instructions in their notebooks for use in Activity 10.2 and the field study day.

CASTING INSTRUCTIONS

1. Casting is a mechanical activity. The fishing rod extends your arm and allows you to "throw" your lure or bait a long distance with little effort. Casting is a matter of timing, not strength. You don't need to "beef up" to become a good caster. In these directions, left-handers should substitute left for right.

2. Look behind you to make sure that there are no trees or bushes around the area to interfere with your cast and to make sure that no one is standing behind you to get caught by the hook when you are casting.

3. Lightly grip the fishing rod in your right hand. Start with your shoulders square to your target, right elbow near the front of your rib cage, forearm and rod pointing in the direction of the cast. Let out 5 to 10 inches of line from the tip of your rod to the practice plug, bait or lure which, because the rod is motionless, hangs straight down. Look at your target.

4. Push the button of the reel with your thumb and hold it in.

5. Lift your right forearm straight up, keeping the elbow in place or allowing it to rise just a little. The rod will follow backwards. Continue until your hand moves to about the level of your ear.

6. Sweep your forearm forward, again keeping the elbow pretty much in place. When your arm is about halfway back to its original position, let loose the line, by releasing the button. The plug, bait or lure will be propelled forward, pulling line off the reel until it lands.

7. Picture a clock face. Think of your elbow as the hub of the clock and your forearm as the hour hand. Start the cast at 10 o'clock. Bring your forearm slowly but steadily back to 2 o'clock. Sweep the forearm forward back to 10 o'clock, releasing the line somewhere near 11 o'clock.

8. If your lure shoots up in the air and doesn't go very far, you probably released the line too early. If the lure smacks into the ground in front of you, you released the line too late.

9. Remember that the cast has no sudden or jerky motions. Practice until it becomes smooth and nearly effortless.

10. Accuracy is often more important than distance. Many fish remain near protective cover and will strike only those lures that come into their immediate vicinity. Improve your accuracy by casting to definite targets, even while on the water. Make sure you focus on your target while casting.

Activity 10.2: Student Exploration of Casting Technique

This hands-on activity helps students understand casting technique.

Estimated Time

50 minutes

Required Materials

- Rod-and-reel combinations set up with casting plugs (Advanced preparation is required.)
- Hula-hoops, Backyard Bass or other suitable casting targets (optional)

Procedure

1. Take the class outside to a suitable open area such as a ball field, empty parking lot or open lawn. Alternatively, this activity may be done indoors in a suitably large space with a high ceiling, such as a gymnasium.

2. Set out casting targets, if available.

3. Guide the class through the casting process. Have students refer to the copy of Casting Instructions in their notebooks.

4. Allow students to practice as time allows; they may need to take turns.

5. Give lots of positive reinforcement and guidance as needed.

Activity 10.3: Video Introduction to Fishing Techniques

This activity helps students understand ethical and effective fishing techniques.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- 1 copy of Fishing Instructions for each student
- DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*
- Missouri Fishes poster (E00013)
- TV/DVD player

Procedure

1. Distribute one copy of Fishing Instructions for each student.

2. Have students read Fishing Instructions—class time may be provided or reading may be assigned as homework in advance of class. Have students keep the instructions in their notebooks for use on the field study day.

3. Show the video clip: "Bass Catch and Release."

4. As time permits, show one or more of the video clips: "Catch and Release Tips" and "Fish Tips."

5. Display the Missouri Fishes poster in the classroom.

6. Have students identify species on the poster and describe proper handling techniques for each.

7. Instruct students to add columns for bait, tackle and location caught to fish sampling data table they created in Activity 4.6 for use as part of their field study day.

FISHING INSTRUCTIONS

1. Handle rod carefully at all times.

2. Carry rod with both hands and hold rod tip up. Secure hook in rod guide.

3. Lay rod down to bait hook.

4. Before casting, look behind you and to the side to see that no one is near.

5. Cast your line into the water. When the line has stopped, turn the handle of the reel once or twice to make your line tight.

6. Now wait for a fish to bite.

7. If you are using a bobber and your bobber jiggles, plunges downward or skates across the water, you have a bite. If you are holding your fishing pole, you may feel a tap, a tug or a pull, or the line may go slack.

8. When you suspect a bite, set the hook with a powerful upward snap of the rod.

9. Keep the rod up high, so your arms and the bend of the fishing pole absorb some of the power of the fighting fish.

10. Allow the fish to run, taking line from the reel. Recover line by lifting the rod handle and then lowering the rod tip as you reel in, pumping the fish closer.

11. Repeat this process until the fish is close enough to reach.

12. You can draw fish up the bank with your fishing rod until it is close enough to grab by hand, or by backing slowly away from the water.

13. Don't let fish flop on the ground. They could injure themselves. Don't put fingers in their gills or eyes. Be careful not to hook yourself when you grab the fish.

14. The fins of sunfishes and bass become rigid when the fish is threatened. Slide your hand down over the fins of small fish and hold them firmly. Grasp larger fish over the back of the head, above the gills. Bass, crappie and small catfish can be safely held by putting your thumb into their mouth and pinching their lower lip. For catfish, protect yourself by holding the fish from the underside, with your fingers firmly beneath the pectoral spines. Remember, the barbels are harmless.

15. Immobilize fish by holding them upside down. Remove the hook by hand or with needlenose pliers. If the fish is hooked deeply in the gills or stomach where the hook cannot easily be removed, clip the line as close to the hook as possible. The hook will fall out after a time, with minimal damage to the fish.

16. Measure the fish from the tip of the snout to the end of the tail, with the fish laid flat and the tail lobes pressed together. Weigh and identify the fish quickly and record bait, tackle and location caught data in the data table you made in Activity 4.6.

17. Release fish as soon as possible. The longer the fish remains out of the water, the less its chances of surviving. Stressed fish can often be revived by holding them upright in the water and moving them slowly back and forth until they can swim away under their own power. Fish have a good chance of surviving after being caught many times, if they are handled carefully.

18. If the line becomes snagged, ask for adult help. Carefully pull or cut the snagged line. Jerking the line is dangerous and may result in a hook flying through the air.

Activity 10.4: Student Reading and Research

This activity provides students with definitions and explanations about fishing, aquatic recreation and conservation. It introduces guidelines for ethical conduct in the use of aquatic resources.

Estimated Time

Varies—class time may be provided or reading may be assigned as homework. Allow at least 20 minutes for in-class questions and discussion.

Required Materials

- Student Guide
- Notebook paper (optional)
- Pens or pencils (optional)

Procedure

1. Have students read Chapter 10: Fishing for Answers. Introduce vocabulary terms as needed.

2. Assign the **Questions to Consider** as homework or use them in a cooperative learning activity.

   1. How can knowledge of aquatic communities and food webs be used to improve fishing success?
      Answers may include:
      Use bait that looks or smells like a fish's natural food. Cast your line where you think fish are feeding. Fish may scour the bottom, hunt near the surface or swim anywhere between. Their need for cover attracts them to structures such as rocks, logs and plants. 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?"

   2. How can knowledge of fish adaptations be used to improve fishing success?
      Answers may include:
      Bluegill have a small mouth because they eat small insects. Channel catfish 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. They can taste food even before taking it into their mouths. Largemouth bass are predators. Their large mouths enable them easily to catch frogs, fish, crayfish and other animals. The need for comfortable temperatures and oxygen levels keep fish moving. All fish are nearsighted, but the placement and shape of their eyes allows them to see almost all the way around their bodies. Fish have super hearing, especially for low-frequency sounds. Lateral lines let them sense water vibrations coming from each direction. "Keep quiet or you'll scare away the fish" is good advice when you're on a fishing trip.

   3. How can knowledge of aquatic ecosystem types be used to improve fishing success?
      Answers may include:
      The edge of a lake's shoreline zone usually produces the most fish. In rivers, fish often feed where the flow changes direction or slows down. In flowing water, there is less current near the bottom. Because of this, most stream fish rest with their bellies almost touching the bottom. 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. 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.

   4. How can knowledge of weather be used to improve fishing success?
      Answers may include:
      Weather affects fish, but not always in predictable ways. Fish seem to prefer eating during the low-light conditions of morning and evening rather than in the bright sun of midday. Cloud cover mimics these low-light periods and may help get fish to bite. 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. 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.

5. Why are rules about fishing limits and seasons important?
   Answers may include:
   These rules help Missourians share limited resources and keep our ecosystems healthy. Fishing season rules protect species by limiting the time of year 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. Rules about fishing limits and seasons can help us to make sure our aquatic ecosystems and other resources stay diverse, balanced and healthy far into the future.

6. What is an ethical angler? What are some rules of angling ethics?
   Refer the section titled "Do the right thing" in the Student Guide

7. How can people help conserve Missouri's aquatic ecosystems?
   Answers may include:
   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). 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!

Activity 10.5: Student Investigation of Missouri Fishing Regulations

This activity helps students understand Missouri fishing regulations.

Estimated Time

25 minutes

Required Materials

- 1 copy of Summary of Missouri Fishing Regulations booklet for each student
- 1 copy of the Scavenger Hunt for Missouri Fishing Regulations for each student
- Pens or pencils
- Prizes or rewards (optional)

Procedure

1. Ask the class why we have fishing regulations. (To help conserve and improve fish populations; to protect fish; to make sure there are enough fish to be shared by everyone.) Tell students that fishing is a fun sport, but that it is very important to know and follow fishing rules and regulations.

2. Distribute one copy of Summary of Missouri Fishing Regulations booklet and one copy of the Scavenger Hunt for Missouri Fishing Regulations to each student.

3. Discuss how the fishing regulations summary booklet is organized. Work through a few of the questions with the class to ensure that students understand how to find information in the book.

4. Tell the class that they are to use the Summary of Missouri Fishing Regulations booklet to find answers to questions on fishing regulations. (Optional) Explain to the class that the student or group with the highest points may receive a prize or reward.

5. Note: If your field trip is to a public impoundment, a river or stream, have students look up the special regulations for that area.

6. Score and discuss the answers in class.

7. (Optional) Award prizes to the winners.

SCAVENGER HUNT FOR MISSOURI FISHING REGULATIONS

Copy Page

Objective

Find answers to questions on fishing regulations using the Summary of Missouri Fishing Regulations booklet.

Directions

Look under each heading in the Summary of Missouri Fishing Regulations booklet to find the answers to the questions or complete the statements listed below.

Permits General Information

1. At what age must you have a fishing permit? _____
2. Do you need a fishing permit to fish in a pond or lake completely located on your own property? _____
3. Does a Missouri resident who is permanently disabled and confined to a wheelchair need to purchase a fishing permit to be legal to fish? _____

Missouri Fishing Permits

1. How much does a resident fishing permit cost? _____
2. Does a resident fishing permit allow Missouri residents to catch frogs by fishing methods? _____
3. Who can buy a lifetime fishing permit? _____

Sport Fishing General Rules

1. Can a Missouri resident legally use explosives, poison, chemical or electrical equipment to kill fish? _____
2. Hooks on a trotline must be at least _____ feet apart.
3. Trotlines must be checked at least every _____ hours.

Jug Line Regulations

1. _____ jug lines must be personally attended at all times.

Game Fish

1. What is the length limit of a largemouth black bass caught from an Ozark stream? _____
2. When is the open season on a flathead catfish? _____
3. Is a walleye considered a game fish? _____
4. Name five Missouri game fish.
    1. _____
    2. _____
    3. _____
    4. _____
    5. _____

Nongame Fish

Name five Missouri nongame fish.

1. _____
2. _____
3. _____
4. _____
5. _____

Trout Fishing Areas

Name four Missouri trout parks.

1. _____
2. _____
3. _____
4. _____

Do You Know the Fishes of Missouri?

Identify the following Missouri fish by the description given:

1. Long, pointed side fin, very small mouth, distinct ear flap without border or orange spot. _____
2. Upper jaw does not extend beyond back of the eye, two fins on back connected, very small cheek scales, side plain with a series of separate vertical bars. _____
3. The mouth is at tip of snout on bottom, slender-bodied, tail is forked, prominent cross bars on body _____
4. All endangered fish species must be returned unharmed immediately to the water. Name two of these species.
   1. _____
   2. _____

How to Measure a Fish (total length)

1. The total length of a catfish is measured from the _____ to the _____ with the mouth closed and the tail lobes pressed together.

Special Area Regulations

1. Do statewide regulations apply to large reservoirs, rivers and streams? _____
2. Most public fishing areas have methods, seasons, limits or other fishing regulations that are different from the statewide rules. How do you find out what the fishing regulations are for these areas? _____
3. What is the lake-wide length requirement for crappie in the Lake of the Ozarks? _____
4. What is the regulation for catching spotted bass in Blue Spring Creek? _____

Catch on to Catch-and-Release Fishing

Although practicing catch-and-release fishing is not always a regulation, the regulations booklet provides guidelines anglers can follow that will increase a fish's chances of survival. Name two of them.

1. _____
2. _____

SCAVENGER HUNT FOR MISSOURI FISHING REGULATIONS

Answer Key

Permits General Information

1. At what age must you have a fishing permit? **16–64 years of age**
2. Do you need a fishing permit to fish in a pond or lake completely located on your own property? **No**
3. Does a Missouri resident who is permanently disabled and confined to a wheelchair need to purchase a fishing permit to be legal to fish? **No**

Missouri Fishing Permits

1. How much does a resident fishing permit cost? **$12**
2. Does a resident fishing permit allow Missouri residents to catch frogs by fishing methods? **Yes**
3. Who can buy a lifetime fishing permit? **Any Missouri resident**

Sport Fishing General Rules

1. Can a Missouri resident legally use explosives, poison, chemical or electrical equipment to kill fish? **No**
2. Hooks on a trotline must be at least **2** feet apart.
3. Trotlines must be checked at least every **24** hours.

Jug Line Regulations

1. **Unanchored** jug lines must be personally attended at all times.

Game Fish

1. What is the length limit of a largemouth black bass caught from an Ozark stream? **12-inch minimum**
2. When is the open season on a flathead catfish? **All year**
3. Is a walleye considered a game fish? **Yes**
4. Name five Missouri game fish.
   Any five of the following: black bass (largemouth, smallmouth, spotted/Kentucky) catfish (channel, blue, flathead), crappie (black, white), muskellunge, northern pike, paddlefish, pickerel (chain, grass), rock bass, warmouth, shovelnose sturgeon, trout (rainbow, brown), walleye, sauger, white, yellow and striped bass

Nongame Fish

Name five Missouri nongame fish.
Any five of the following: bluegill, sunfish, carp, carpsuckers, suckers, buffalo, drum, gar, and those not listed as game fish or endangered

Trout Fishing Areas

Name four Missouri trout parks.
Maramec Spring Park, Bennett Spring State Park, Montauk State Park and Roaring River State Park

Do You Know the Fishes of Missouri?

Identify the following Missouri fish by the description given:

1. Long, pointed side fin, very small mouth, distinct ear flap without border or orange spot. **Bluegill**
2. Upper jaw does not extend beyond back of the eye, two fins on back connected, very small cheek scales, side plain with a series of separate vertical bars. **Smallmouth bass**
3. The mouth is at tip of snout on bottom, slender-bodied, tail is forked, prominent cross bars on body **Northern hog sucker**
4. All endangered fish species must be returned unharmed immediately to the water. Name two of these species.
   Lake sturgeon and pallid sturgeon

How to Measure a Fish (total length)

1. The total length of a catfish is measured from the **tip of the snout** to the **end of the tail** with the mouth closed and the tail lobes pressed together.

Special Area Regulations

1. Do statewide regulations apply to large reservoirs, rivers and streams? **Yes, unless otherwise indicated in special regulations**
2. Most public fishing areas have methods, seasons, limits or other fishing regulations that are different from the statewide rules. How do you find out what the fishing regulations are for these areas? **They are posted at the areas and included in area brochures.**
3. What is the lake-wide length requirement for crappie in the Lake of the Ozarks? **15-inch minimum**
4. What is the regulation for catching spotted bass in Blue Spring Creek? **No minimum length limit**

Catch on to Catch-and-Release Fishing

Although practicing catch-and-release fishing is not always a regulation, the regulations booklet provides guidelines anglers can follow that will increase a fish's chances of survival. Name two of them.

Any two of the following:

- **Do not take fish out of water if possible.**
- **File barbs off hooks.**
- **Never pull a hook from the fish's throat or stomach; cut the line instead.**
- **Avoid excessive handling of the fish.**
- **Do not squeeze or drop the fish.**
- **Don't put your fingers in the fish's gills or eye sockets.**

Chapter 10 Assessment

Directions

Select the best answer for each of the following multiple-choice questions.

1. How do weather conditions affect fishing success?
   a. Hot weather makes fish hungry.
   b. Not always in easily predictable ways
   c. Snow and ice guarantee fishing success.
   d. Both a and b

2. Fish in flowing water tend to face:
   a. Upstream
   b. Downstream
   c. Perpendicular to the current
   d. No particular direction

3. The best time to fish is:
   a. Mid-day
   b. Morning and evening
   c. When there is no wind blowing
   d. From 2 to 4 p.m.

4. Aquatic resource conservation is:
   a. Best left to professionals
   b. Limited to certain times of the year
   c. Unnecessary because Missouri has plenty of water
   d. Everyone's responsibility

Apply your knowledge of these species' adaptations and their roles in the transfer of energy in Missouri aquatic food webs to predict the best bait or lure to use to catch:

5. Largemouth bass
   a. Live minnow
   b. Bare treble hook
   c. Plastic worm dipped in stinkbait
   d. Artificial fly that mimics a mayfly

6. Bluegill
   a. Live minnow
   b. Bare treble hook
   c. Plastic worm dipped in stinkbait
   d. Artificial fly that mimics a mayfly

7. Channel catfish
   a. Live minnow
   b. Bare treble hook
   c. Plastic worm dipped in stinkbait
   d. Artificial fly that mimics a mayfly

Apply your knowledge of these species' adaptations and habitat needs to predict where to find:

8. Largemouth bass
   a. Shallow marsh
   b. Below a riffle in weeds near a stream bank
   c. Muddy bottom of a pond
   d. Open water zone of a lake

9. Bluegill
   a. Shallow marsh
   b. Below a riffle in weeds near a stream bank
   c. Muddy bottom of a pond
   d. Open water zone of a lake

10. Channel catfish
    a. Shallow marsh
    b. Below a riffle in weeds near a stream bank
    c. Muddy bottom of a pond
    d. Open water zone of a lake

Chapter 10 Assessment

Copy Page

Directions

Write your own answer for each of the following questions.

1. More effective fishing methods represent a technological solution to the problem of finding food. Predict how this could have both benefits and drawbacks such as risks or unintended consequences to aquatic ecosystems.

2. Justify the following statement: Fishing regulations, limits and seasons are among the best solutions to potentially harmful environmental changes within aquatic ecosystems in Missouri.

3. Apply your knowledge to recommend another solution to potentially harmful environmental changes within aquatic ecosystems in Missouri.

Chapter 10 Assessment Answer Key

Multiple-choice questions

1. How do weather conditions affect fishing success?
   b. Not always in easily predictable ways

2. Fish in flowing water tend to face
   a. Upstream

3. The best time to fish is
   b. Morning and evening

4. Aquatic resource conservation is
   d. Everyone's responsibility

Apply your knowledge of these species' adaptations and their roles in the transfer of energy in Missouri aquatic food webs to predict the best bait or lure to use to catch:

5. Largemouth bass
   a. Live minnow

6. Bluegill
   d. Artificial fly that mimics a mayfly

7. Channel catfish
   c. Plastic worm dipped in stinkbait

Apply your knowledge of these species' adaptations and habitat needs to predict where to find:

8. Largemouth bass
   d. Open water zone of a lake

9. Bluegill
   b. Below a riffle in weeds near a stream bank

10. Channel catfish
    c. Muddy bottom of a pond

Write-in questions

1. More effective fishing methods represent a technological solution to the problem of finding food. Predict how this could have both benefits and drawbacks such as risks or unintended consequences to aquatic ecosystems.
   Answers may include:
   Potential benefits:
   More effective fishing methods could lead to easier to obtain, cheaper and more abundant food. This could provide better nutrition and greater health for humans. This could result in wealth accumulation and population growth. Less time and energy spent pursuing food could allow time and energy to be spent developing technology, art and culture.
   Potential drawbacks:
   More effective fishing methods could lead to over-exploitation of the resource, or over-fishing—taking out more fish than natural processes can replenish. Over-fishing could result in a decline in fish populations and destabilization of the ecosystem. Fish and other species in the aquatic community could decline or become extinct. Humans could exceed their carrying capacity in the region and also begin to decline.

2. Justify the following statement: Fishing regulations, limits and seasons are among the best solutions to potentially harmful environmental changes within aquatic ecosystems in Missouri.
   Answers may include:
   Fishing regulations, limits and seasons help Missourians share limited resources and keep our ecosystems healthy. Rules protect species by limiting the time of year 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. The regulations, limits and seasons they prescribe can help us to make sure our aquatic ecosystems and other resources stay diverse, balanced and healthy far into the future. The greater the biodiversity in an ecosystem, the healthier, more sustainable and better balanced it is, and the more resilient it is to potentially harmful environmental changes.

3. Apply your knowledge to recommend another solution to potentially harmful environmental changes within aquatic ecosystems in Missouri.
   Answers may include:
   - **Always bring a trash bag when visiting aquatic resources, and take a moment to leave the spot in better shape than you found it.**
   - **Avoid spilling and never dump any pollutants, such as gasoline or oil, into the aquatic environment.**
   - **Be careful not to harm fish when doing catch-and-release fishing.**
   - **Carefully handle and release alive all fish that are unwanted or not allowed, as well as other animals that may be caught accidentally.**
   - **Choose a career in conservation and make aquatic resources your life's work.**
   - **Follow rules of ethical conduct in the use of aquatic resources and teach others to do so, too.**
   - **Get involved with nature—go outside and visit local aquatic resources.**
   - **Join a Missouri Stream Team and help clean up a stream.**
   - **Keep buffer zones of plant growth around water bodies.**
   - **Keep no more fish than needed for eating, and never waste fish.**
   - **Learn and obey angling and boating rules, and treat other anglers, boaters and property owners with courtesy and respect.**
   - **Learn more about watershed conservation.**
   - **Learn to check water quality.**
   - **Practice good watershed management by stopping excess erosion and runoff loaded with fertilizers, pesticides or other pollutants.**
   - **Put all trash, including used lines, leaders and hooks, in proper containers and help to keep fishing sites litter-free.**
   - **Replenish fish populations by hatchery spawning and stocking.**
   - **Respect property rights, and never go onto on private lands or waters without permission.**
   - **Support enforcement of water laws and rules that penalize polluters.**
   - **Take action to prevent the spread of invasive plants and animals, and never dump live bait into the water.**
   - **Take part in conservation activities.**
   - **Value and respect the aquatic environment and all living things in it.**
   - **Visit a Conservation Department office or a conservation nature center.**
   - **Volunteer to become a Master Naturalist.**
   - **Work to pass legislation protecting aquatic ecosystems in Missouri.**
   - **Work with Ducks Unlimited and other citizen conservation groups to protect and restore wetlands.**
   - **Work with farmers, ranchers and other land users to help them prevent erosion, improve water quality, manage nutrients and protect and preserve wildlife habitat.**

Enrichments

Project WILD Aquatic:

- Living Research: Aquatic Heroes and Heroines
- Net Gain, Net Activity

Guest speaker:

- Missouri Department of Conservation outdoor skills specialist. If invited for activities, the speaker may be able to assist with instruction.
- Missouri Department of Conservation agent. If invited for activities, the speaker may be able to assist with instruction.

Video clips:

- Mississippi River Maintenance Man
- Missouri River Relief

Field Study Day

Each chapter of *Conserving Missouri's Aquatic Ecosystems* prepares students for a hands-on activity to be performed on the field study day. The last activities in chapters 1–6 ask students to decide the best way to make and record their observations. They are then tasked with creating a data table or other recording system for use on the field study day. These data record pages then become part of their science journals. In chapters 7–9, students are prepared to sample invertebrates. A data record page for invertebrate sampling is provided as a copy page. Chapter 10 requires no new data record, but students may wish to modify or add to the data table they created in chapter 4. Depending on which chapters the class has completed, the equipment resources available, time constraints, number of adult assistants and other considerations, teachers will have many field day activity options from which to choose.

Field Study Activities Specified in *Conserving Missouri's Aquatic Ecosystems*

***Conserving Missouri's Aquatic Ecosystems* Chapter**	**Field Study Activity**
1—Water Is Life	Water chemistry
2—The Ultimate Recyclable	Weather conditions
3—What's Your Watershed Address?	Land uses and site conditions
4—Living In The Water 10—Fishing For Answers	Fish sampling (fishing)
5—From Sun To Sunfish	Wildlife walk (direct observation and looking for sign)
6—Missouri's Aquatic Ecosystems	Plant sampling
7—Rivers And Streams 8—Lakes And Ponds 9—Swamps And Marshes	Invertebrate sampling
9—Swamps And Marshes	Soil testing (wetland sites only)

Possible combinations:
Water chemistry + Weather conditions
Land uses and site conditions + Wildlife walk
Plant sampling + Soil testing

Keep group sizes down for easier management. Have at least one adult at each station, or per every 10 students. One adult for every 5–10 students is ideal. If you have a large number of students, break each station into sub-stations and rotate or conduct simultaneous subgroups. For example, Water chemistry + Weather conditions could consist of the following five substations:

- weather and temperature
- pH and conductivity
- turbidity, color and odor
- dissolved oxygen
- nitrates

Allow at least 30 minutes per station with time for rotation. Three stations in the morning and three after lunch works well. Most students are used to having 30 minutes or less for lunch. A lunch break of no more than 45 minutes will keep the program moving and keep students focused. Make an activity rotation schedule and have enough copies for all adult volunteers.

Sample Rotation Schedule

Station	Field Study Activity	Time slot						
		8:30–9:15	9:20–10:05	10:10–10:55	11:00–11:45	11:50–12:35	12:40–1:25	1:30–2:15
1	Water chemistry + Weather	Red team	Orange team	Yellow team	Green team	Lunch	Blue team	Purple team
2	Land uses and site conditions	Orange team	Yellow team	Green team	Blue team	Lunch	Purple team	Red team
3	Wildlife walk	Yellow team	Green team	Blue team	Purple team	Lunch	Red team	Orange team
4	Plant sampling + Soil testing	Green team	Blue team	Purple team	Red team	Lunch	Orange team	Yellow team
5	Fish sampling	Blue team	Purple team	Red team	Orange team	Lunch	Yellow team	Green team
6	Invertebrate sampling	Purple team	Red team	Orange team	Yellow team	Lunch	Green team	Blue team

Review sections on Planning a Successful Field Trip and Safety Precautions and Concerns.

The morning of the field trip or one day prior, check the field site. If you are having the students bring their lunch, have the school cafeteria make up some sack lunches for those that forget. Remember that all food, drink and sanitation items are pack in/pack out unless other arrangements are made.

If you have not already done so, compile a list of all students participating in the trip and provide a copy to the school office. Post on the classroom door or other conspicuous location a sign indicating the destination of the class trip and departure and return times. Have a way (cell phone, two-way radio, etc.) to contact the school should an emergency arise.

In case of sudden changes in weather, such as rainstorms, do not seek shelter around water or under trees in lightening storms. In violent weather, the bus may be a vital refuge. Insist that the bus and driver remain in the immediate vicinity during the entire event. Should an emergency arise, finding the driver and waiting for him or her to return to the area could result in an unacceptable delay. Of course, a first-aid kit and life preserver or reach pole are musts for field trips around water.

Checklist for teachers—day of event

- Cell phone
- First-aid kit
- Life preserver or reach pole
- Fishing tackle
- Aquatic studies equipment
- Copies of instructions for each activity for each station, group or student
- Copies of activity rotation schedule for all adult volunteers
- Cooler with water and ice
- Paper cups (no styrofoam!)
- Trash bags
- Hand sanitizer
- Toilet paper
- Soap and water
- Paper towels
- Blankets, towels, or tarps for students to sit on at lunch
- Class trip participants, departure and return times left at classroom and school office
- Remind students to bring their journals and pens or pencils!

Field Study Procedure

1. Load students. As students walk on the bus, take a head count. Have adult volunteers ride on the buses or in separate vehicles, whichever way your school requires or allows. Pass out name tags.

2. Upon arrival at the site, unload buses. Have adult volunteers get their groups of students together.

3. Review the fishing rules for the site and field trip manners. Remind students of safety precautions:
   - Stay on the path or in the designated area for each activity.
   - Stay out of the water except as instructed.
   - Never wade into water deeper than your knees.
   - No pushing or shoving.
   - No running or "horseplay" with equipment or around water.
   - Never stand behind any student while fishing.
   - Bring litter back to the classroom or place in appropriate receptacles.

4. Have each group of students help with equipment and supplies for activities.

5. Have each adult volunteer lead their group to their designated activity area.

6. Conduct the activities and rotate students as scheduled.

7. When preparing to leave, have adult volunteers collect equipment from their students.

8. Before leaving the site, have students pick up their trash.

9. When boarding the bus, take a roll call to make sure all students are on board.

10. Congratulate students on a successful field study day and recognize your assistants!

Managing Student Behavior While Learning Outdoors

Students are accustomed to learning in an indoor environment. They know the rules and expectations, have established routines for focusing attention and are bounded by the limited space available. Outdoors, these well established rules, routines and expectations are quickly "forgotten." Additionally, outside there are more distractions and the fresh air increases energy levels. Your task when teaching outdoors is to work with students' increased enthusiasm and energy while maintaining focus so that learning occurs and student safety is maintained. Here are some ways to maximize control in the outdoor environment.

Set ground rules about outdoor behavior before leaving the classroom. Make a list of the behaviors which you believe to be essential such as staying on the path, bringing litter back to the classroom, not pushing or shoving, etc. Reinforce this behavior when students are gathered outside, before beginning any activities. Preplan ways to handle disruptive behavior such as having students sit out from an activity or otherwise restricting their freedom.

Set physical boundaries beyond which students cannot wander. Use clear landmarks such as a specific patch of trees or a path as your boundary markers. Don't partner up students who wind each other up. Designate a "home base"—usually your debriefing area. If students are scattering to do an activity, set a clear signal which indicates that the activity is over and students should return to home base.

Gather students in a circle, preferably seated, when debriefing an activity, so that you have everybody's attention and everyone can participate. Be aware of the volume of your voice when you are talking outside. Debrief away from competing noises. Ask for eye contact. Avoid speaking to a group with your back to the sun or an interesting distraction. Set the tone for the type of learning which you want to happen by speaking softly if you want to focus attention or being energetic if the work to be done is active.

Be aware of weather conditions and physical fitness levels of students. Many students will whine about being cold, hot or about the long distance that they have to walk. You need to read when these complaints are serious and need to be heeded or when the student just requires some positive but firm encouragement. If you are walking for a distance, make sure that one adult leads the group and one adult brings up the rear, encouraging the slower walkers and making sure that no stragglers get left behind. Be vigilant. Be aware of students' whereabouts and watch for behavior that may be disruptive or destructive to the host site or natural environment.

Use the buddy system. Students should be paired with a buddy in their group all day. Students should notify their teacher or other adult when they are going to the restroom, and they should take their buddy with them. Have all students, parents and teachers wear nametags with group number, or class and grade on the nametags. Color-coding each group's tag may be helpful.

Adapted from ecomentors.ca

ROCKY BOTTOM INVERTEBRATE SAMPLING

Required materials:

(One set for each group of students to be working simultaneously)

- Kick seine (a fine 3 × 3 foot net with 1/16 inch mesh and supporting poles on each side)
- Small hand rake
- Invertebrate Identification Card
- Invertebrate Sampling—Water Quality Investigation Data Sheet
- Small magnifier boxes/magnifying glasses
- Tweezers or forceps
- White ice cube trays for sorting organisms
- Squirt or spray bottle or watering can
- Clipboards
- Pens or pencils

Procedure

1. Select a riffle typical of the stream, that is, a shallow fast-moving area with a depth of 3–12 inches and cobble-sized stones (2–10 inches) or larger.

2. Place the kick seine or screen at the downstream edge of the riffle. Be sure that the bottom of the seine or screen fits tightly against the stream bed so that no insects escape under the net. You may want to use rocks to secure the net against the stream bottom. Also, don't allow any water to flow over the top of the net.

3. Sample the stream bed for a distance of 3 feet upstream of the kick seine. Firmly and thoroughly rub your hands over all rock surfaces (top, sides and bottom) to dislodge any attached insects. Carefully place any large rocks outside of your 3 foot sampling area after you have rubbed off any invertebrates. Stir up the bed with hand rake until the entire 3 foot square area has been worked over. All detached insects will be carried into the net. Then for at least 60 seconds, kick the stream bed with a sideways shuffling motion towards the net. Disturb the first few inches of sediment to dislodge burrowing organisms.

4. Remove the seine with a forward-scooping motion. Firmly grab the bottom of the net so that your sample does not spill out of the net. The idea is to remove the net without allowing any insects to be washed under, washed from the net surface or fall off the net.

5. Place the net on a flat, well-lit area. Using tweezers or fingers, pick all the insects from the net and place them in your ice cube trays (half full of water). Any creature that moves, even if it looks like a worm, is part of the sample. Look closely, since most insects are only a fraction of an inch long.

6. Critters will stop moving as the net dries. Occasionally wetting the net using the squirt or spray bottle or watering can will cause the insects to move, making them easier to spot. Watering the net is especially important on hot, dry days.

7. You may also want to sort your insects into look-a-like groups as you pick them. This will make your identification quicker when you are ready to record results on your survey form. For example, put all organisms with legs in one ice cube tray section and all organisms with no legs in another section, etc.

MUDDY BOTTOM INVERTEBRATE SAMPLING

Required materials: *(One set for each group of students to be working simultaneously)*

- D-Frame aquatic dip net with mesh of 1/32 inch and a 4-foot pole
- Clean/new toilet brush
- Plastic shallow white pan
- Small magnifier boxes/magnifying glasses
- Tweezers or forceps
- White ice cube trays for sorting organisms
- Invertebrate Identification Card
- Invertebrate Sampling—Water Quality Investigation Data Sheet
- Clipboards
- Pens or pencils

Procedure

1. The four main habitats of muddy bottom water bodies are: steep banks, vegetated margins, silty bottom with organic matter, woody debris with organic matter and sand/rock/gravel. Look for these habitats.

   Steep banks/vegetated margins

   This habitat is the area along the bank and the edge of the water body consisting of overhanging bank vegetation, plants living along the shoreline, and submerged root mats. Vegetated margins may be home to a diverse assemblage of dragonflies, damselflies and other organisms. Move the dipnet in a bottom-to-surface motion, jabbing at the bank to loosen organisms.

   Silty bottom with organic matter

   Silty substrates with organic matter can be found where the water is slow moving and where there is overhanging vegetation or other sources of organic matter. These silty substrates harbor burrowing organisms such as dragonflies or burrowing mayflies. Samples are collected by moving the net forward with a jabbing motion to dislodge the first few inches of organic layer.

   Woody debris with organic matter

   Woody debris consists of dead or living trees, roots, limbs, sticks, cypress knees and other submerged organic matter. It is a very important habitat. The wood helps trap organic particles that serve as a food source for the organisms and provides shelter from predators, such as fish. To collect woody debris, hold the net under the section of wood you wish to sample, such as a submerged log. Use the toilet brush to scrub the surface of the log. It also is good to dislodge some of the bark as organisms may be hiding underneath. You also can collect sticks, leaf litter, and rub roots attached to submerged logs. Be sure to thoroughly examine any small sticks you collect with your net before discarding them. There may be caddisflies, stoneflies, riffle beetles, and midges attached to the bark.

   Sand/rock/gravel

   Large rocks provide the most productive habitat. The bottom can be sampled by moving the net forward with a jabbing motion to dislodge the first few inches of gravel, sand or rocks. You may want to gently wash the gravel in your screen bottom bucket and then discard the gravel. If you have large rocks (greater than two inches diameter) you should also kick the bottom to dislodge any burrowing organisms.

2. Each time you sample you should sweep the mesh bottom of the D-Frame net back and forth through the water (not allowing water to run over the top of the net) to rinse fine silt from the net. This will avoid a large amount of sediment and silt from collecting in the pan and clouding your sample.

3. After collecting your samples, dump the net into a shallow white pan filled with a few inches of water. You should dump your debris into your pan of water after every three scoops to avoid clogging the net. Dumping your net periodically also will prevent you from having to sort a great deal of debris all at once. Collect organisms from your pan and place like organisms in ice cube trays for identification.

4. You also may want to sort your insects into look-a-like groups as you pick them. This will make your identification quicker when you are ready to record results on your survey form. You can use plastic ice cube trays to do this. For example, put all organisms with legs in one section and all organisms with no legs in another section, etc.

IDENTIFYING INVERTEBRATES

Once you have collected the organisms, sort and identify them using the Invertebrate Identification Card. Not all organisms you may find are listed on the card. For instance, invertebrates such as whirligig beetles, water striders, and predaceous diving beetles are not included on the survey sheet. They are surface breathers and do not provide any indication of water quality.

Specimens can be put into magnifier boxes to ease identification. Use characteristics such as body shape, number of legs, tails and antennae, size, color, swimming movement and gill locations to identify organisms. When using the Invertebrate Identification Card, remember to read the descriptions for each organism. Also remember that the lines on the card indicate the sizes of the organisms. However, if you catch a young invertebrate that has just hatched and has not yet reached full size, it may be smaller than indicated on the card.

To identify the organisms, use body shape, size and other characteristics (number of legs and tails), because the same family can vary in size and color. **Ask yourself the following questions to identify an organism:**

- How large is the organism?
- Is the body long and slender, round, or curved?
- Does the organism have any tails? How many?
- Does the organism have any antennae?
- Does the organism have legs? How many? Where?
- Is the body smooth and all one section or is it segmented (two or more distinct sections)?
- Does the organism have any gills (fluffy or plate-like appendages)?
- Where are the gills located? Sides, back, underside, under its legs?
- Does it have pinching jaws like a beetle larvae?
- Are any legs or antennae missing because they were broken off in the net?
- What color is the organism?
- Does the organism swim underwater or remain on the surface?

After identifying your organisms, record your results on the Invertebrate Sampling—Water Quality Investigation data sheet. Return specimens to the water after you have finished. Tabulate your results to determine the water quality using the instructions on the survey sheet. Count the number of types of invertebrates (not the number of individuals) in each column and multiply by the index value at the bottom of the column. The rating is based on the diversity and sensitivity of the organisms, not the number of individual organisms found. Add the subtotal for each column to arrive at your final water quality rating.

INVERTEBRATE SAMPLING — WATER QUALITY INVESTIGATION

Group: _____ **(names)**

Date: _____

Location: _____

Invertebrate Occurrence

Sensitive	**Somewhat Sensitive**	**Tolerant**
___ caddisfly larvae ___ hellgrammite ___ mayfly nymphs ___ gilled snails (right) ___ riffle beetle adult ___ stonefly nymphs ___ water penny larvae	___ beetle larvae ___ clams/mussels ___ crane fly larvae ___ crayfish ___ damselfly nymphs ___ dragonfly nymphs ___ scuds ___ sowbugs ___ fishfly larvae ___ alderfly larvae ___ watersnipe fly	___ aquatic worms ___ blackfly larvae ___ leeches ___ midge larvae ___ pouch snails (left) ___ other snails (flat)
Count the number of types (not number of individuals) ___ × 3 = ___ index value	Count the number of types (not number of individuals) ___ × 2 = ___ index value	Count the number of types (not number of individuals) ___ × 1 = ___ index value
Now add together the three index values from each column for your total index value. **Total index value** = ___		

Compare this total index value to the following ranges of numbers to determine the water quality of your stream. Good water quality is indicated by a variety of different kinds of organisms and the sensitivity of the organisms, not the number of individual organisms found.

Water Quality Rating

_____ Excellent (>22) _____ Good (17–22) _____ Fair (11–16) _____ Poor (<11)

Unit Summation

The structured inquiry of the field study activities guides students to formulate testable questions and to select appropriate investigative methods in order to obtain evidence relevant to those questions. Students develop an understanding of ecological concepts by direct contact with and observation of the natural world. And they understand the processes by which scientists form and evaluate hypotheses about the natural world by doing those things themselves. In the unit summation, students analyze their data, draw conclusions and propose their own solutions to environmental problems.

Instructors will have to decide for themselves on a class-by-class basis how much and what kind of direction students need in analyzing their data. With one exception—invertebrate sampling—no method for data analysis or interpretation is provided in the unit. To the greatest extent possible, challenge students to decide for themselves what reasonable conclusions they can draw from their observations.

Guide students back to the initial question: Is it safe to swim in/drink from/eat fish from their particular body of water? Use the Field Study Report copy page that follows and the Writing Scoring Guide from Chapter 4, or create your own instructions.

Science relies upon communication of results and justification of explanations. To complete the unit, consider using a jigsaw or carousel procedure for having the class report their findings, conclusions and solutions. That is, task each working group with reporting on a different part of the field study, and assemble a whole-class proposal to conserve the aquatic ecosystem they studied. Don't miss the opportunity to challenge students to create a personal action plan to implement their solutions!

FIELD STUDY REPORT

Objective

Report, analyze and draw conclusions from observations and data collected in the field study of an aquatic ecosystem.

Directions

Work with your partners to write a report on your field study of an aquatic ecosystem. Each person should write and turn in his or her own work. Use the following format:

1. In the first paragraph, briefly summarize what you did on your field study day to help you understand your aquatic ecosystem. End the paragraph by stating, in your own words, what you wanted to discover about your aquatic ecosystem.

2. In your second paragraph, briefly summarize the observations you made and the data you obtained. Refer to your data tables, notebook entries and other records.

3. Third, state what reasonable conclusions you can draw from your observations. What more do you need to know about the aquatic ecosystem you studied and how could you obtain that information?

4. In the fourth paragraph, self-evaluate your data gathering and recording techniques. Were there observations that you didn't know how to record or information you were unable to capture? Were there instances in which you expected to find data but did not? Did you need to reorganize your data after you had collected it? What would you do differently "next time"? What would you keep the same? Can you identify potential sources of error? How might an error in your data affect your conclusions?

5. Begin the next paragraph by restating as a question what you wanted to discover about your aquatic ecosystem. Then answer the question and justify your answer with your own data (refer to paragraphs 2 and 3).

6. Finally, propose solutions to any environmental problems you found or which your aquatic ecosystem might face. What could you personally do to help conserve the aquatic ecosystem you studied?

Enrichments

Using Missouri Department of Conservation Resources

Your Missouri Department of Conservation education consultant or outdoor skills specialist can assist you in arranging field trips, guest speakers and demonstrations. They also have enrichment resources you may borrow, including materials and prepared activities. To find the contacts in your area, check the directory included with this publication, call 573/751-4115, visit our website at mdc.mo.gov/teacher/contacts/ or write to Outreach and Education Field Unit Chief, Missouri Department of Conservation, P.O. Box 180, Jefferson City, MO 65102-0180.

Classroom Visits and Demonstrations

Conservation education consultants or outdoor skills specialists may be able to arrange for guest speakers to provide demonstrations. Class visitors may include naturalists, fisheries biologists, conservation agents, Master Naturalists or Stream Team Volunteers. Demand for these educational services is very high—please allow a minimum of six weeks prior to the date you would like the program.

Discovery Trunks

Check with your conservation education consultant or outdoor skills specialist about other materials that may be available in your area. These materials may include Discovery Trunks filled with activities and reference materials about Missouri plant and animal life and other manipulatives you may borrow and use in the classroom.

Enviroscape Demonstrations

The Enviroscape is a three-dimensional model of a watershed that demonstrates how stream health and water quality are the products of land use practices within a watershed. One may be available for loan, or a class visit may be arranged. Some regions also have groundwater models. Ask your conservation education consultant or outdoor skills specialist about what is available in your area.

Stream Trailer Demonstrations

The Stream Trailer is a large model of a flowing stream mounted on a trailer. The model consists of a metal box filled with a plastic material that simulates sediment. A battery-powered pump circulates water through it to portray a range of fluvial processes, including erosion and sedimentation. The model is very effective in demonstrating complex concepts and illustrating conservation techniques that can stabilize and restore streams. This self-contained unit is well-suited for outdoor presentations but can be brought indoors in larger spaces such as gymnasiums.

Educator Workshops

If you have a strong professional interest in conservation or want to enrich your teaching, consider signing up for a Missouri Department of Conservation educator workshop. Many workshops are provided in cooperation with colleges or universities throughout the state and offer undergraduate or graduate credit hours. Workshops that are not for credit are free or require a small registration fee.

Check mdc.mo.gov/teacher/workshops/ for dates, locations and contact information to register. Workshops and events listed on this site are updated periodically, so check back to see what new ones have been added. The Missouri Department of Conservation also offers many public events, programs and workshops that are great educational opportunities for teachers and students. If you don't find a workshop that fits your needs, contact your conservation education consultant and outdoor skills specialist to find out what they may be able to provide.

Enrichments from Project WET, Project WILD Aquatic and the *Stream Team Middle School Activity Guide*

***Conserving Missouri's Aquatic Ecosystems* Chapter**	**Project WILD Aquatic Activities**	**Project WET Activities**	***Stream Team Middle School Activity Guide* Activities**
1—Water Is Life	• How Wet Is Our Planet? • Something's Fishy Here! • What's in the Water?	• Adventures in Density • Choices and Preferences, Water Index • Common Water • Drop in the Bucket • Every Drop Counts • H2Olympics • Hangin' Together • Is There Water on Zork? • Water Meter • What's the Solution?	• Governor's Solution • Points of View
2—The Ultimate Recyclable	• Alice in Waterland • Water Wings • What's in the Air? • Where Does Water Run?	• Dust Bowls and Failed Levees • Get the Ground Water Picture • Incredible Journey • Piece It Together • Poetic Precipitation • Poisoned Pump • Sparkling Water • Thirsty Plants • Water Models • Wet Vacation • Where Are the Frogs?	• Catch that Rainfall!
3—What's Your Watershed Address?	• Watershed • Where Does Water Run?	• Branching Out! • Just Passing Through • Rainy-Day Hike • Sum of the Parts	• Land Use and Watershed Pollution • Missouri River Basins and Watersheds • Riparian Corridor—What Is It?
4—Living In The Water	• Fashion a Fish • Fishy Who's Who	• Water Address	
5—From Sun To Sunfish	• Aquatic Times • Designing a Habitat • Migration Headache	• Water Address	• Aquatic Stream Habitats • Stream Substrate Habitat
6—Missouri's Aquatic Ecosystems	• Aquatic Roots • Edge of Home • Watered-Down History		

***Conserving Missouri's Aquatic Ecosystems* Chapter**	**Project WILD Aquatic Activities**	**Project WET Activities**	***Stream Team Middle School Activity Guide* Activities**
7—Rivers and Streams	• Blue Ribbon Niche • Riparian Retreat • To Dam or Not to Dam • Water Canaries	• After Math • Macroinvertebrate Mayhem	• Aquatic Stream Habitats • Captured Critters • Floodplain Functions • Inventory/Field Study • Riparian Corridor—What Is It? • Short Float • Stream Discharge • Stream Substrate Habitat • Water, Sediment, Energy, and Vegetation
8—Lakes and Ponds	• Glass Menagerie • Micro Odyssey • Pond Succession	• Macroinvertebrate Mayhem	
9—Swamps and Marshes	• Dragonfly Pond • Wetland Metaphors	• Capture, Store, Release • Life in the Fast Lane • Macroinvertebrate Mayhem • Wetland Soils in Living Color	• Wetland Madness • Wetland Migration
10—Fishing For Answers	• Living Research: Aquatic • Heroes and Heroines • Net Gain, Net Activity		• Governor's Solution • Personal Commitment to Stewardship • Points of View • Sensory Development • Voices From the Wilderness

Service Learning with Missouri Stream Teams

Forming a school Stream Team is a great way to teach students about stream ecology. The Stream Team program provides an opportunity for all interests to get involved in river conservation. The program is sponsored by the Missouri Department of Conservation, the Missouri Department of Natural Resources and the Conservation Federation of Missouri. These three groups provide different strengths, resources and areas of expertise to volunteers. Stream Team membership is free to any interested citizen, family or organization. With 3,000 teams on board, an estimated 60,000 members are working to improve our streams. Missouri leads the nation in volunteer stream organizations. The Stream Team program encourages members to speak on behalf of Missouri's stream resources.

Stream Team projects are chosen according to each team's interests and local needs. Teams may adopt any stream or river of their choice, but adoption is not mandatory. From the largest rivers in the state to the smallest backyard tributaries, groups have adopted nearly 15,000 miles of flowing water. Stream Team coordinators can also help set up partnerships with other teams in your area. Stream Teams began monitoring the water quality of adopted streams in 1993. The Stream Team Volunteer Water Quality Monitoring program provides training, equipment and information to better understand our stream systems and the problems and opportunities they face. Stream Team can help you plan hands-on service learning projects such as litter control, streambank stabilization, streamside tree planting, water quality monitoring, and storm drain stenciling or match you with an agency or organization with an ongoing project. The Stream Team Academy offers continuing education on natural resources. Workshops have been held on understanding streams, fish identification, crayfish, herpetology, mussels, hellbenders, tree planting and groundwater.

If you'd like to start a Stream Team or get involved in similar efforts in your area, contact a Stream Team coordinator at 800/781-1989 or go to *mostreamteam.org*. The *Stream Team Middle School Activity Guide* by Mark Van Patten is available at *mostreamteam.org*.

Project WET & Project WILD Aquatic

Project WILD Aquatic (Wildlife In Learning Design) and Project WET (Water Education for Teachers) are two of the most widely used conservation and environmental education programs among educators of students in grades K–12. Project WILD Aquatic emphasizes aquatic wildlife and aquatic ecosystems. Project WET promotes awareness, appreciation, knowledge and stewardship of water resources. The activities found in Project WILD Aquatic and Project WET stimulate students' critical and creative thinking, develop students' ability to make informed decisions on environmental issues, and instill in students the commitment to take responsible action on behalf of the environment. The instructional materials are designed to support state and national academic standards appropriate for grades K–12. The activities can easily be adapted to meet the learning requirements for academic disciplines ranging from science and environmental education to social studies, math and language arts. Educators may choose one or more project activities with which to teach a concept or skill. The activities may be integrated into existing courses of study, or an entire set of activities may serve effectively as the basis for a specific course. Each activity contains all the information needed to conduct that activity including objectives, method, background information, a list of materials needed, procedures, evaluation suggestions, recommended grade levels, subject areas, duration, group size, setting and key terms. A glossary is provided, as well as a cross-reference by topics and skills.

Project WET and Project WILD Aquatic Training

To obtain these instructional materials, educators participate in a professional development workshop that is fun-filled and interactive, providing hands-on experiences in conducting activities and integrating them into the class curriculum. In Missouri, Project WILD is sponsored by the Missouri Department of Conservation and Project WET is sponsored by the Missouri Department of Natural Resources. Both agencies coordinate and conduct training. For additional information about the Projects to obtain training, contact your Missouri Department of Conservation education consultant or visit the links listed below:

- *mdc.mo.gov*
- *dnr.mo.gov*
- *projectwild.org*
- *projectwet.org*

Reference Materials for Teacher Background

The Missouri Department of Conservation publishes a number of free instructional resources for educators. These items include posters, activity books and much more. Most of the recommended reference materials are available free of charge from the Missouri Department of Conservation. Many publications are also available online. To get a copy of our Materials Request Form or specific publications, call your Conservation education consultant or outdoor skills specialist, visit our website at mdc.mo.gov/teacher/materials, e-mail your request to pubstaff@mdc.mo.gov or write to Publications, Missouri Department of Conservation, P.O. Box 180, Jefferson City, MO 65102-0180.

Publications available free of charge from the Missouri Department of Conservation

Publication Title	Inventory Number	Web Address
African Clawed Frogs	SCI013	Not on the Web
DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*		Some videos are available on the Web. See pages 282 and 283.
Fishing Regulations Summary	E00606	mdc.mo.gov/2115
Start a Missouri Stream Team	FIS182	mdc.mo.gov/58
Help Stop Aquatic Hitch Hikers	FIS002	Not on the Web
Introduction to Crayfish	FIS011	mdc.mo.gov/7913
Introduction to Fishing	FIS152	mdc.mo.gov/3267
Introduction to Missouri Fishes	FIS020	mdc.mo.gov/fish/fishid/
Kids Fishing Book	E00092	Not on the Web
Know Missouri's Catfish	FIS003	mdc.mo.gov/15569
Life Within the Water	FIS034	Not on the Web
Map: Smallmouth Bass	FIS019	Not on the Web
Map: Trout Fishing In Missouri	FIS210	mdc.mo.gov/13260
Missouri Marsh Birds	E00042	mdc.mo.gov/node/9017
Missouri Toads and Frogs	E00430	mdc.mo.gov/8262
Missouri Turtles	E00468	mdc.mo.gov/8273
Missouri Wetlands & Their Management	SCI150	mdc.mo.gov/7797
Now That I'm a Stream Team...	FIS188	mdc.mo.gov/57
Nuisance Aquatic Plants in Missouri Ponds and Lakes	FIS110	mdc.mo.gov/8418

Publication Title	Inventory Number	Web Address
Poster: Exploring Missouri Wetlands	E00003	Not on the Web
Poster: Missouri Fishes	E00013	Not on the Web
Poster: Missouri Pond Life	E00002	Not on the Web
Poster: Missouri Stream Life	E00016	Not on the Web
Poster: Rivers and Streams: Missouri Currents	E00509	Not on the Web
Poster: Salamander	E00089	Not on the Web
Poster: Toads & Frogs	E00012	Not on the Web
Poster: Wetlands & Waterfowl	E00115	Not on the Web
Stream Insects/Crustaceans ID	STR250	Not on the Web
Stream Team Inventory Guide	FIS193	Not on the Web
Stream Team Middle School Activity Guide		mdc.mo.gov/15571
Streets to Streams Guide	E00428	Not on the Web
Streets to Streams Video	E00447	Not on the Web
Understanding Streams	FIS192	mdc.mo.gov/7262
Volunteer Water Quality Monitoring	FIS049	Not on the Web
Watershed Management Placemat	FIS273	Not on the Web
Watershed Protection Practices	F00050	mdc.mo.gov/441
What Happened to the Stream in My Backyard?	STR238	mdc.mo.gov/8969
Zebra Mussels: Missouri's Most Unwanted	FIS013	mdc.mo.gov/8260

Publications for sale by the Missouri Department of Conservation

For-sale publications are available at Missouri Department of Conservation's nature centers or at **mdcnatureshop.com**. Schools and teachers may be eligible for a 30 percent education discount on Missouri Department of Conservation products. For more information, call toll-free (877) 521–8632.

Pond Life: Revised and Updated (A Golden Guide from St. Martin's Press) by George K. Reid is widely available (ISBN-10: 0307240177, ISBN-13: 978-0307240170) from book retailers.

WOW! The Wonders of Wetlands (Environmental Concern Inc. and The Watercourse, 2003) can be ordered from Project WET at *store.projectwet.org/*.

DVD Compilation for *Conserving Missouri's Aquatic Ecosystems*

Video Package/Menu

Chapter	Activity	Title	Time
1	1.8	Storm Drain Stenciling	6:11
4	4.2	Missouri Hatcheries	3:30
4	4.4 option	Big Bluegill	5:39
4	4.4 option	Paddlefish	
4	4.4 option	Lake Sturgeon	
4	4.4 option	Just Below The Surface (Grotto Sculpin)	9:37
4	4.5	Missouri Mussels	6:58
4	4.5 option	Alligator Snapper Trapper	4:38
4	4.5 option	Cottonmouth!	6:47
4	4.5 option	So Close To Home (St. Louis Eagle Days)	5:58
4	4.5 option	Hellbender Mystery	6:54
4	4.5 option	The Trouble with Success (Otter Management)	5:02
4	4.5 option	Secretive Salamanders	4:20
4	4.5 option	Taneycomo Turtles	5:05
5	5.4	Trout Eggs	
5	5.4	Ozark Rainbows	
5	5.6	Leaping Exotics (Carp)	6:04
5	5.8	St. Francis Crayfish	5:00
6	6.2	Zebra Mussel	5:36
6	6.2	Purple Loosestrife	5:02
6	6.3	Topeka Shiner	5:12
6	6.3	Niangua Darter	4:45
6	6.5	Stream Teams	6:44
6	6.6	Wranglers of the Deep	5:07
6	6.6	Crustacean Calculation	4:30
7	7.2	Streams: The Force of Life	19:00
7	7.2 option	River of Many Uses (Missouri River Flow Animation)	7:51
7	7.2 option	Mississippi River Monitoring	7:29

Chapter	Activity	Title	Time
7	7.5	Stream Invertebrate Sampling	
8	8.2	CAP Lakes	3:40
8	8.2	Farm Pond Stocking	4:06
8	8.5	Pond Invertebrate Sampling	
9	9.2	A Southeast Story	8:08
9	9.2 option	A Winter Walk (Dresser Island Wetland)	6:14
9	9.2 option	A Day on a Marsh	
9	9.2 option	Grand Pass Conservation Area	
9	9.5	Wetland Invertebrate Sampling	
10	10.3	Bass Catch & Release	4:20
10	10.3 option	Catch & Release Tips (Art of Catch & Release)	5:16
10	10.3 option	Fishing Tips	1:42

Enrichment	Time
Mississippi River Maintenance Man	5:57
Missouri River Relief	6:51
Crappie Radio Tagged	4:28
Are You Still There? (Chicken Turtle)	7:37
Our Corner of the World	10:46
Ozark Mountain Paddlers	4:45

Other Files	
CMAE Student Guide pdfs	
CMAE Teacher Guide pdfs	
Dichotomous Key Mazes	
Chapter	**Title**
4	Fish
7 8 9	Macroinvertebrates
9	Duck wings

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 caddisfly 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, molluscs 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 animal 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

Bibliography

Missouri Department of Conservation Publications

Fishes of Missouri by William Pflieger
Fishing for Answers by Jeanne Pyland and Bob Fluchel
How Fish Swim by Phil Pitts
Introduction to Fishing by Tom Cwynar
Introduction to Missouri Fishes
Missouri Pond Handbook by Ken Perry
Missouri Wetlands and Their Management by Jay Bowmaster and Steve Young
Rivers and Streams Habitat Pack
Stream Team Inventory Guide
Stream Team Middle School Activity Guide by Mark Van Patten
Streets to Streams: Youth Investigations into Water Quality
Understanding Streams by Bill Turner
Wetland Habitat Pack

Articles

Capitalizing on Literacy Connections by K. Worth, R. Moriarty and J. Winokur
Science Interactive Notebooks in the Classroom by J. Young
The Development of Responsible Environmental Citizenship: A Critical Challenge by H.R. Hungerford.
The River Continuum Concept by R.L.Vannote, G. W. Minshall, K. W. Cummins, J.R. Sedell and C. E. Gushing

Books

Ecology: Concepts and Applications by Manuel C. Molles
Environment by Peter H. Raven, Linda R. Berg, and George B. Johnson
Environmental Science: Living Within the System of Nature, 3rd ed. by Charles E. Kupchella and Margaret C. Hyland
Limnological Aspects Of Recreational Lakes by K.M. Mackenthun, W.M. Ingram and R. Porges
Pond Life: Revised and Updated (A Golden Guide from St. Martin's Press) by George K. Reid
Sport Fishing and Aquatic Resources Handbook by Bob Schmidt
Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods by Thomas B. Murdoch and Martha Cheo with Kate O'Laughlin
WOW! The Wonders of Wetlands: An Educator's Guide by George B. Robinson, Alan S. Kesselheim and Sandra Chisholm-Robinson

Projects, Programs and Web sites

Bryant Creek Watershed Project, watersheds.org
Council of State Science Supervisors, csss-science.org/safety.shtml
ecoMentors, ecomentors.ca
Missouri Department of Elementary and Secondary Education, dese.mo.gov/
Missouri Stream Team, mostreamteam.org
Project WET: Curriculum and Activity Guide by The Watercourse and the Council for Environmental Education
Project WILD Aquatic K-12 Curriculum and Activity Guide by Project Wild and the Council for Environmental Education
ScienceAware, scienceaware.com/genlabsf.htm
U.S. Environmental Protection Agency, epa.gov/safewater/kids/teachers_4-8.html
U.S. Geological Survey Water Science for Schools, ga.water.usgs.gov/edu/

REGIONAL OFFICES

Northwest
701 James McCarthy Drive
St. Joseph, MO 64507
816–271–3100

Northeast
3500 S. Baltimore
Kirksville, MO 63501
660–785–2420

Kansas City
12405 SE Ranson Road
Lee's Summit, MO 64082
816–622–0900

Central
3500 East Gans Road
Columbia, MO 65201
573–815–7900

Southwest
2630 N. Mayfair
Springfield, MO 65803
417–895–6880

Ozark
551 Joe Jones Blvd.
West Plains, MO 65775
417–256–7161

St. Louis
2360 Highway D
St. Charles, MO 63304
636–441–4554

Southeast
2302 County Park Drive
Cape Girardeau, MO 63701
573–290–5730

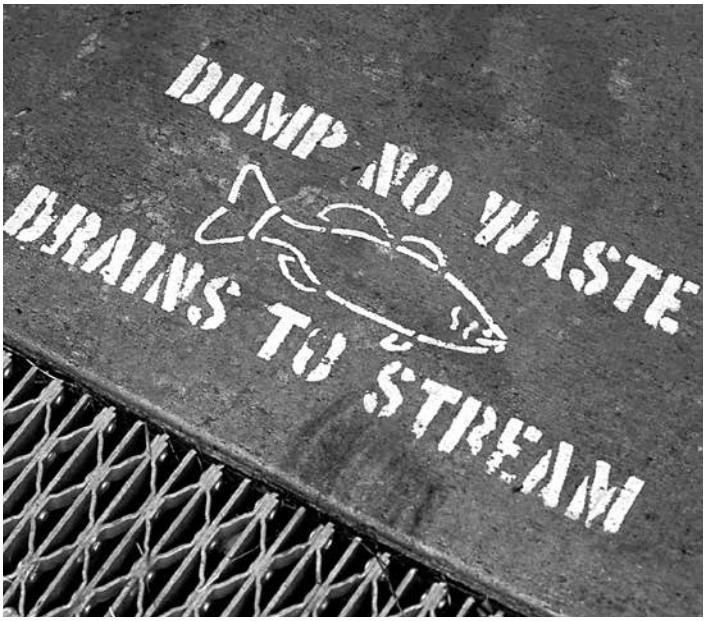
Missouri Department of Conservation

Mailing address:
P.O. Box 180
Jefferson City, MO 65102-0180

Street location:
2901 W. Truman Blvd.
Jefferson City, MO 65109

Telephone:
573–751–4115

Web address:
missouriconservation.org



MDC FILE

Start a Stream Team at your school!

mdc.mo.gov/programs/strteam/

E00138 6/2014