INTRODUCTION TO POLLUTION PREVENTION

Many satellites put in orbit by the United States and other countries have included geographic image surveys as part of their missions. Not only have those images clearly illustrated the beauty and diversity of the planet's surface, but also those images have shown that it is isolated and self-contained. Although enormous in scale, the Earth is not infinite nor are its resources. While the planet can support an abundance of life and even can absorb some level of pollution, its carrying capacity (the amount of life supportable through resource allocation and use) is fixed. Because of this, the combination of natural and human-made detrimental effects, including pollution, must be considered to ensure that the carrying capacity is not exceeded.

The effect of natural or human-made change on Earth is often difficult to determine and is speculative on a worldwide scale, although studies of individual ecosystems and smaller geographic areas prove less difficult to measure. Instances of pollution can be investigated to determine effects and risks posed. Environmental studies and analyses have received increasing attention in past decades. Only through education can we as citizens become informed enough to make accurate and responsible decisions about our environment. The focus of this chapter is environmental pollution, either occurring naturally or human-made. There are two fundamental reasons for our concern with environmental pollution: (1) human health, welfare, and resource needs and (2) concern about the rest of nature.

Human Health, Welfare, and Resource Needs

Our personal concern with environmental pollution mainly revolves around health problems from natural, as well as human-made, pollutants. Human health and well-being can be impacted by environmental pollution in two distinctly different ways: (1) on a personal level by detrimental health due to contamination or depletion of water, air, and other needed resources or (2) by reduced social and economic benefits or degradation in a geographic, ecosystem, or global context through slow deterioration of our habitat or decreasing availability of resources.

The cost of control and remediation measures for pollutants sometimes is reflected in health-care costs to treat afflictions caused by pollution. Reduced or eliminated mental well-being or recreational benefits often are overlooked and are underestimated because of the difficulty in quantifying costs. The cost of the inability to fish a stream segment because of aquatic pollution, to stay outdoors for extended periods because of elevated ozone levels, or to play in areas contaminated by pollution is difficult to determine economically. Maintaining a healthy and sustainable environment for these activities often runs contrary to human and economic needs for population, urban, agricultural, and manufacturing growth and development.

Concern for Nature

Concern for nature other than that readily identified as healthful or economically beneficial has been a part of human existence for centuries. For example, there are many things about the balance of nature that we don't know. The loss of some species may throw off that delicate balance in ways that we cannot foresee at the time. This is a major theme of the modern environmental movement. Although many concerns mainly address human enjoyment, nature has value simply in its existence. Consider, for example, the number of people who place value in the protection of endangered species and the national park system, even though they have never seen an Indiana Bat or visited Little River Canyon. This protection of nature does not come without a price to all of us. Some resources have to be left unclaimed, some land has to be left undeveloped, and funds must be spent on protection and preservation of the delicate balance of nature.

Cultural Change

One of the major factors in the creation of environmental pollution stems from the consumption of resources, production and manufacture of goods, and disposal of wastes. Demand from citizens for a ready supply of goods increases as the population increases. Technology offers more products to make our lives better and easier, and our purchasing power increases.

The controversy over the creation of pollution traditionally has focused on finger pointing and on placing economic matters above environmental concerns. Industry, government, and public groups have not always realized that environmental protection and economic growth do not have to be mutually exclusive. Government regulation, industry initiative, and public demand have caused great improvements to be made in the area of environmental protection. Better process design, control measures, and pollution prevention activities to reduce or eliminate pollutants at the source have reduced much pollution. Although great successes have been achieved, much more must be done in order to protect human health and the environment from pollutants.

A cultural change continues in the way many Alabamians work and play. Businesses, industry, agriculture, and other activities continue to make improvements in their operations. Collectively, they are trying to make a difference, as are public environmental groups and government agencies who keep watch over the environment and who encourage progress. These collective actions are important to success, but what can we do individually? We must all consider our activities, taking into consideration the environmental impact they may have. The idea of "throwing it away" is a myth. Wastes do not "disappear" when we "throw it away." All waste must be disposed of somewhere, and consumption of most materials creates at least one form of pollution from solid waste or from discharges in water or emissions into the air.

When purchasing materials and services, we must consider questions such as "What will happen to it after I use it? Can it be recycled? Can I purchase goods with less packaging? Is there a better alternative?" and finally, and most importantly, "Do I really need it?" Unfortunately, we often must act and make decisions without complete information. Educating ourselves, taking the time to get accurate information, and considering the consequences of our actions collectively and as individuals are important first steps in solving the problems created by environmental pollution.

From *World Book Encyclopedia*

Pumping Out Alabama

OBJECTIVES:

Students will be able to:

1. Discuss the importance of pumpout facilities and clean water.
2. Debate the need for facilities in the public and private sector.
3. Write a paragraph listing types of pumpout facilities and waters affected by flushed sewage.

Grades:
6-8

Subjects:
Science, Geography

Time Needed:
One class period

Materials:
Hydraulic regional basins of Alabama map showing all marinas and boat landings
map of boat pumpout facility locations (provided)

BACKGROUND:

Sewage discharged by recreational boaters is a substantial contributor to localized degradation of water quality in the United States. The discharge of untreated sewage by boaters is prohibited under federal law in all areas within the navigable waters of the United States. Many boaters have Type III marine sanitation devices (holding tanks) or portable toilets for sewage. However, there is currently an inadequate number of pumpout stations and dump stations for boaters to dispose of their sewage.

In response to growing fears of the "death" of our nation's treasured bodies of water, Congress enacted the Clean Water Act of 1972 (amended in 1987). This law addresses a wide spectrum of water pollution problems including marine sewage. It prohibits the discharge of untreated sewage from boats in navigable U.S. waters, including coastal waters, for a distance of three miles offshore. The law further provides for "no discharge" by boats operated in enclosed lakes and reservoirs or in rivers not capable of interstate navigation. States may apply to the EPA to have certain other waters declared "no discharge zones" if discharge of untreated sewage would be harmful. In short, boats with installed toilets must have an operable Coast Guard-approved MSD (marine sanitation device) designed either to hold sewage for pumpout ashore or for discharge in the ocean beyond the three-mile limit or to treat the sewage to federal standards prior to discharge.

The Clean Vessel Act of 1992 was signed into law to provide a five-year federal aid grant program to fund states for the construction, renovation, operation, and maintenance of pumpout stations and waste reception facilities to improve water quality.

The following coastal waters, including the territorial seas, estuaries, bays, and sounds (as well as U.S. lakes and rivers as defined below) are considered waters most likely to be affected by the discharge of sewage from vessels. These definitions are not ranked in priority order.

- Sheltered waters that are generally poorly flushed systems.
- Waters of national significance: Waters identified by the Environmental Protection Agency under the National Estuary Program, waters identified by the National Oceanic and Atmospheric Administration under the Estuarine Reserve program, and Marine Sanctuaries programs where appropriate.
- Waters of significant recreational value: A water body with unusual value as a resource for outdoor recreational activities: fishing, boating, canoeing, water skiing, swimming, scuba diving, or nature observation. The significance may be in the intensity of present usage, in an unusual quality of recreational experience, or in the potential for unusual future recreational use or experience.
- Shellfish harvest waters: Waters designated as shellfish producing and harvesting areas.
- Nursery areas of indigenous aquatic life: Significant aquatic plant beds, wetlands, or any area used by the early life stages of aquatic life during the period of rapid growth and development into the juvenile states.

- Waters designated by the EPA as "No Discharge Areas" under the Clean Water Act.
- Waters that do not meet state designated usage. Waters previously designated by the EPA under the Clean Water Act as "No Discharge Areas" are eligible for renovation, maintenance, and further construction funds under this program.

Significant doubt exists as to the effectiveness of the wastewater treatment via chlorination on pathogenic viruses. One public health specialist has commented that at least discharges from municipal treatment plants are fixed and can have a defined buffer zone around their discharges where shellfish are not harvested. Because boats are mobile, their operators can discharge wastes anywhere.

Every boat built since 1977 with an installed toilet must have an operable approved type MSD (marine sanitation device). Since 1980 all boats (including those built before 1977) with installed toilets must have an operable MSD. Nevertheless, boats often bypass these systems and discharge untreated sewage directly overboard.

VOCABULARY:

pumpout station, solid waste facility, marine sanitation device (MSD)

PROCEDURE:

1. Have the students look at a map of Alabama waterways. Have them predict and mark with a star the places they would find pumpout stations (on individual maps, a larger group map, or a projected overhead transparency).
2. The teacher should place circles on the existing pumpout facilities, triangles on proposed facilities, and squares on proposed private facilities.
3. Ask the students how close their predictions match actual facility sites.
4. What do the sites have in common? (along major waterways at marinas or boat landings.)
5. Ask the students if there are any areas in need of pumpout facilities. Have them support their answers.
6. Have the students debate whether private facilities should be included as possible locations for pumpout facilities funded by the Clean Water Act.
   - What types of waterways are affected by improper dumping?
   - Name some different types of pumpout stations. What advantages do each offer?

EVALUATION:

1. Have the students choose a river and follow it from where it starts in, or enters, Alabama to where it ends, counting the existing facilities as well as proposed public and private facilities. Have them write a paragraph about the importance of pumpout stations including the type of stations and waters most affected.

EXTENSION:

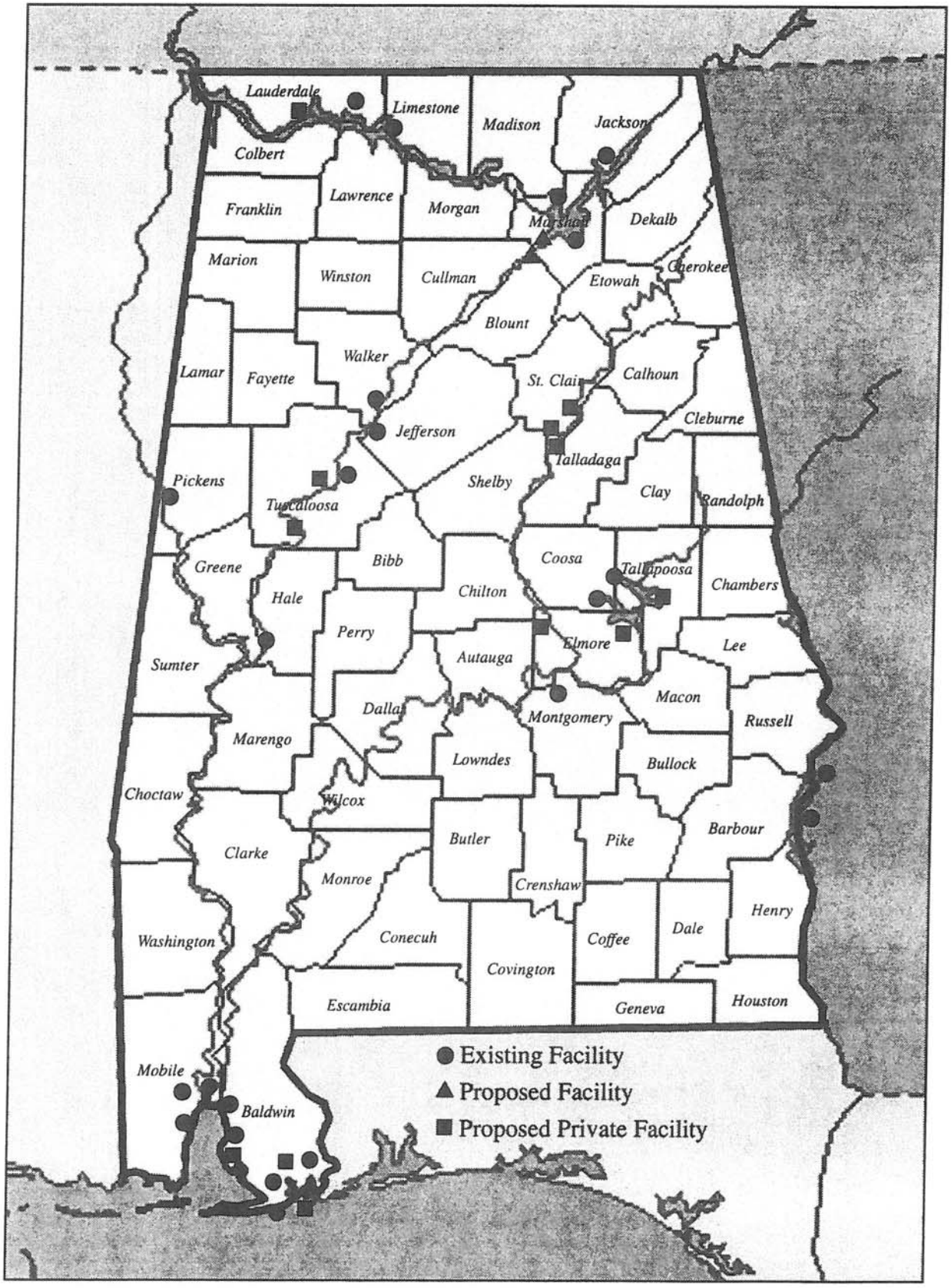
1. Invite a speaker from the Alabama Department of Environmental Management to speak to the class about the Clean Vessel Act and/or pumpout stations.

ORIGINAL DEVELOPMENT RESOURCEs:

Alabama Department of Environmental Management, P.O. Box 301463, Montgomery, AL 36130, www.adem.state.al.us

www.epa.gov/owow/nps/marinas

Boat Pumpout Facility Locations



Notes

Posters And People

OBJECTIVE:

Students will be able to:

Design a poster that will identify types of litter harmful to aquatic wildlife.

BACKGROUND:

"Only recently have we become aware of how severely we are plundering our planet. Some argue that pollution always existed, that we should be no more upset by the extinction of the bald eagle than that of the dinosaurs. This ignores the basic fact that we are no longer in a slow evolution process but in a violent explosive one. No comparison is possible. There are no precedents. We have to face the danger as a new kind of human peril that only human measures can remedy. The life cycle and the water cycle are inseparable; we must save our oceans and waterways if we are to save mankind." This is a direct quote written by Jacques Cousteau in a book in l968. Things have changed and not necessarily for the best. The litter problem on beaches and in rivers, lakes, streams, and ponds can be solved if people take litter home instead of throwing it in the water and on the shores. Public awareness and education can be persuasive elements in cleaning up aquatic environments.

VOCABULARY:

aquatic wildlife, litter, harmful, identify

Grades:

6-8

Subjects:

Science, Social Studies, Language Arts, Art

Time Needed:

One-two class periods

Materials:

cardboard pieces
poster board
construction paper
pictures of aquatic wildlife
pictures of litter
letters or stencils for lettering
drawing pencils
color markers
types of litter that could be harmful to aquatic wildlife (such as plastic rings, fishing line, plastic bags, etc.)

ADVANCE PREPARATION:

Gather materials needed such as fish net, fish line, balloons, plastic bags, poster board, construction paper, markers, and drawing instruments.

PROCEDURE:

Setting the Stage

1. Have a student come forward. Tell the class to pretend that this student is a wading bird. Hold up a piece of fishing line. Ask: "What would happen if this wading bird were to get caught in this fishing line?" Carefully wrap the fishing line around the student's feet and ask, "Could this wading bird walk like this?" Explain the dangers of fishing line to aquatic wildlife.
2. Have another student come forward. Tell the class to pretend that this student is a dolphin. Hold up a balloon or a plastic bag. Ask: "What would happen if this dolphin ingested this balloon or plastic bag?" Explain that the dolphin could not digest the plastic bag or the balloon; therefore, it would lay in the dolphin's stomach making it feel full and eventually starving it to death.
3. Have another student come forward. Have the class pretend this student is a pelican. Hold up a piece of fish net. Ask: "What would happen if this pelican got its wing caught in this net?" Put the net gently around the student's arm. Ask the student, "Could you fly like this?" Explain the dangers of fish net to aquatic wildlife.

Activity

1. Explain that students are to design a poster that will educate the public to the dangers of litter to aquatic wildlife.
2. Tell students they are to use the materials given to them but to be creative.
3. Tell students they should make a rough draft of their posters before beginning actual construction. Be sure they keep this rough draft to submit as a part of their grade.

Follow-Up

1. Have students share their posters with the class.
2. Have students place their posters around the school for viewing.

EXTENSION:

Have students conduct a poster contest.

ORIGINAL DEVELOPMENT RESOURCES:

Marine debris: Get a grip on it. (l990). Seattle, WA: Marine Advisory Service.

Trashing the oceans. (l988). Washington, DC: Center for Marine Conservation. Video available from: U.S. Coast Guard, Attn: Sea Partners Supplies, 2100 Second St., S.W., Washington, DC 20593, fax: (202) 267-

In the ocean with Jacques Cousteau. (l986). Danbury Press.

ADDITIONAL RESOURCES:

The Educators Guide to Marine Debris: Southeast and Gulf of Mexico.
http://florida4h.org/projects/marine/files/Marine_debris_guide.pdf

Jacques Cousteau Lesson Plans
http://www.lessoncorner.com/Science/Biology/Marine_Biology/Marine_Biologists/Jacques_Cousteau

Aquatic Litter Puzzles

OBJECTIVE:

Students will be able to:

Create a puzzle by gluing pictures of aquatic wildlife and the types of trash that could be harmful to them to 4 x 6 index cards that are cut into various shapes and sizes.

BACKGROUND:

Responsibility, stewardship, consideration, and caretaker—these are all words that are important for us to learn if we are to change what's happening on the shores and in the waters of our rivers, lakes, and streams. These beautiful habitats and their wildlife are being destroyed by the irresponsible and inconsiderate littering that we do while there. We must remember that we are only visitors and that the shorelines and waters of streams, rivers, and oceans are crucial habitats to wildlife as well as being vitally important to human health and recreation. Have you ever really noticed the litter as you walk along the shore or wade into the water of your favorite recreational area? Sometimes things happen so slowly we don't notice until it's too late. Let's wake up, put on litter-hunting glasses, and make a change now! Even alone, we can make a difference. But together WE CAN MAKE A CHANGE!

Grades:

6-8

Subjects:

Science, Social Studies, Language Arts

Time Needed:

Two-three class periods

Materials:

glue
scissors
4 x 6 cards
pictures of trash that could be dangerous to aquatic wildlife (Styrofoam, plastic)
video showing aquatic wildlife and their environment

VOCABULARY:

stewardship, caretaker, habitat, crucial

ADVANCE PREPARATION:

1. Gather pictures of litter that might be found near or in the water of a local river, lake, or bay.
2. Cut index cards into puzzle pieces (different sizes and shapes) and construct a small puzzle to use as a sample.
3. Obtain a video of aquatic wildlife in its habitat.

PROCEDURE:

Setting the Stage

1. Show a small portion of the video, just enough for the students to get a good visual idea.
2. Have students discuss what type of litter could harm the wildlife seen in the video.
3. Ask two students to go to the board. Have one student write the animal and the other student write the litter.

Activity

1. Divide students into teams or pairs.
2. Explain that the teams are to use the materials you've given them to create a puzzle about aquatic wildlife and the types of litter that can harm wildlife. Show them the sample you made. Instruct students to create their own puzzles.
3. Allow one class period of about 50 minutes to make the puzzles.
4. Laminate the puzzle pieces before students use with them.

Follow-Up

1. Have students put their puzzles together.
2. Have students change teams and put each other's puzzles together.

EXTENSIONS:

1. Have students draw their own pictures to put on the puzzle pieces.
2. Have students cut pictures from newspapers and magazines for the puzzle pieces.

ORIGINAL DEVELOPMENT RESOURCES:

Braus, J. *Marine habitants*. (l985). Man and the Gulf of Mexico Series, Jackson, MS: University Press of Mississippi.

Caduto, M. (l995). *Keeper of the earth.* Columbus, OH: Prentice Hall.

Ecology. (l993). Columbus, OH: Prentice Hall.

Project WET: water education for teachers.

ADDITIONAL RESOURCES:

Castro,P. & Huber,M. (2012). *Marine Biology* Edition 9

Ecology and the Environment. (2009). Prentice Hall

Fun Lovers, Enviro-Lovers - What's The Connection?

OBJECTIVES:

Students will be able to:

1. Describe the relationship between recreational activities and pollution using concept mapping.
2. List ways that pollution can be reduced during recreational activities.

BACKGROUND:

Humans spend a great deal of time and money having fun! Alabama offers a variety of activities from water sports to car racing. Recreational activities may have damaging effects on the environment if people are not aware of possible consequences. Relating consequences to fun will give students insight into the impact that "fun lovers" have on the environment.

VOCABULARY:

All Terrain Vehicles (ATVs), air pollution, water pollution, noise pollution, entangle, chemical pollution, habitat destruction, soil erosion, dissolved oxygen (DO)

Grades:
6–8

Subject:
Science

Time Needed:
50 minutes

Materials:
yarn (cut in varying lengths)
glue
index cards
construction paper
Alabama State Parks brochure

ADVANCE PREPARATION:

1. Gather the necessary materials for each group of two students.

PROCEDURE:

Setting the Stage

1. Discuss different recreational activities people do. On the board, list the materials that are needed to do some of the activities that were discussed. Relate the activity to the materials and any other factor that comes into play when the recreational activity takes place. For example, a day trip of water skiing requires food, gas, a pair of skis, suntan lotion, and many other materials. Discuss how these materials directly or indirectly affect the environment. Be sure to relate everything to the original topic.
2. After the discussion, go over the basics about concept mapping (refer to information included under "Resources" section). Some of the following may be ideas that students could use to begin their diagrams: recreational revenues, water activities, boating, car racing, hiking/camping, suntan oil in water, decrease in dissolved oxygen, entanglement of water fowl, fishing, swimming, plastic and paper waste, lead poisoning, noise, etc.

Activity

1. Show students the concept web about manatees and discuss the components and how they are linked.
2. Working in pairs, students should organize concepts to complete a web on their paper. Relationships for each group may be different; accept any reasonable relationships.
3. After the students have their sketches for the web, they then should write the concepts on index cards to be connected together with yarn.
4. Have students glue their diagrams to a larger piece of paper to share with the class.

EVALUATION:

1. Based on concept map consequences for recreational activities, would you recommend that litter or other environmental laws should be strengthened? Why?
2. List reasonable ways to eliminate some of the possible sources of pollution.
3. Which activity poses the most serious environmental threat? Explain.
4. Knowing that the environment suffers when used for recreation, compile a Do/Don't guide for several activities.
5. Recreational activities create litter and other problems that must be corrected. Do you think the economic revenues made from activities are worth it? Give a rationale for the answer.
6. What about environmental damage prevention through education? How can this be done more effectively?

EXTENSIONS:

1. Put concept maps on the bulletin board using pictures to illustrate activities.
2. Research careers related to recreational activities.
3. Locate Alabama State Parks and list each type of recreational activity that may be found there.

ORIGINAL DEVELOPMENT RESOURCES:

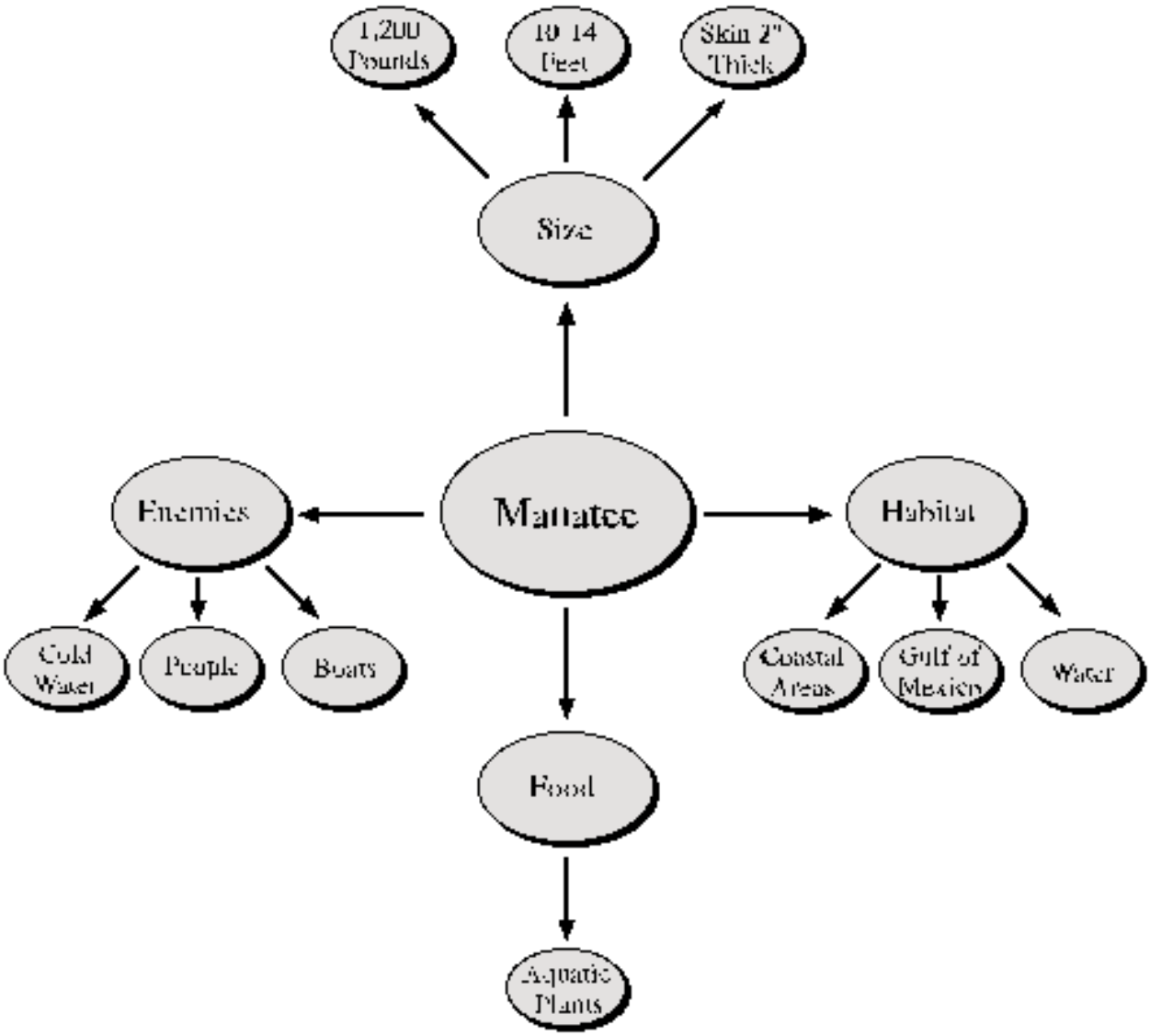
A concept map is similar to an outline or a flowchart and is a way of representing or organizing knowledge. Usually, a concept map is divided into nodes and links. Nodes (often circles) represent various concepts; and links (lines) represent the relationships between concepts. It becomes a visual graphic that represents how the individual thinks about a subject or topic.

Steps in making a concept map:

Write down major terms or concepts about a topic.
Identify the most general, intermediate, and specific concepts.
Begin drawing the concept map:
Concepts are circled
Place the most general concepts at the top
Place intermediate concepts below general concepts
Put specific concepts on bottom
Draw lines between related concepts
Label the lines with "linking words" to indicate how the concepts are related.

Alabama State Parks brochures and information pamphlets. available by calling 1-800-ALA-PARK or at http://www.alapark.com/brochures

Sample Concept Map



Notes

Effects Of Holding Tank Discharges

OBJECTIVES:

Students will be able to:

1. Record the results of the experiment.
2. Interpret data gathered from the experiment.
3. Discuss the impact of increased holding-tank disposal into water ecosystems.

BACKGROUND:

Although minimal sewage dumping into open waters may not pose health risks to water ecosystems or human life, concentrated and multiple dumping may have detrimental effects. Even though some pollutants, such as sewage, may disperse, the remnants of their unseen contaminants can affect the quality and purity of the water into which they are dumped. There are scientific tests that can test for coliform organisms. Fecal coliform including *Escherica coli* bacteria (bacteria which stains gram negative, is rod shaped, and is found in the human colon), are subclassifications of the total coliform count.

VOCABULARY:

sewage, ecosystem, pollutant, contaminant, *E. coli (Escherichia coli)*, bacteria, gram negative stain, colon, holding tank

Grades:

6-8

Subjects:

Science, Math

Time Needed:

One class period

Materials:

3-liter plastic tub
2 liters distilled water
blue litmus paper
one bottle concentrated lemon juice
clean detergent scoops
3-liter plastic drink caps
model glue

ADVANCE PREPARATION:

1. Prior to the experiment, have each student bring in one 3-liter bottle cap and one clean powdered detergent scoop.

PROCEDURE:

Setting the Stage

1. Discuss activities associated with fresh and salt water areas.
2. Discuss activities that substantially increase boaters in specific areas such as fishing rodeos, regattas, skiing competitions.
3. Discuss the discharging of holding tanks as related to health hazards or environmental harm.

Activity

1. Pour distilled water into the 3-liter plastic tub. The tub only needs enough water to insure that the detergent scoops will float. (The less water you use, the sooner the acid will become concentrated.) Explain to students that the water represents a large body of water used by boaters for many activities.
2. Teacher should apply modeling glue to top of bottle caps or inside of detergent scoops. Student presses two parts together, bonds in 30 seconds. The cap needs to be centered and slightly forward. Explain to the students that the cap represents the holding tank on the boat (detergent scoop).
3. Pour concentrated lemon juice into each student's holding tank (drink cap). Be careful to explain that holding tanks are not necessarily acidic. This test is to show mixing and concentration effects of boat sewage and treatment chemicals released into a water body.
4. Before anyone floats a boat, test the distilled water for acid content and have the students record litmus test result on their data tables.

5. Have the students come to the tub in groups of four. Have the group float its boats and then dump its holding tanks. Test the water for the acid content after each group.
6. After each litmus test, have the students record the results. Be sure that when the students set up their data tables, they include a column showing how many boats have dumped their holding tanks.
7. Continue the activity until the blue litmus paper indicates an acid content.

Follow-Up

1. Students should discuss their observations.
2. Students should discuss the correlation between actual holding tank disposal and their lemon juice holding tanks.
3. Students should answer the following questions:
   - Should holding tank disposal into open waters be allowed?
   - What alternatives could be developed or modified to combat this problem?
   - As the population increases and waterways become more crowded, what type of impact will this have on the environment?

EXTENSION:

1. Call local marinas and ask how many dumping or pump-out stations are available in respect to the number of boats moored at the marina. Discuss with the marina personnel whether there are periods of heavy boating activity when the dumping or pumpout stations are filled to capacity or cannot accommodate all the boats. When do such periods occur?
2. Invite a speaker from the Alabama Department of Environmental Management to speak to the class about the Clean Vessel Act and/or pumpout stations.

ORIGINAL DEVELOPMENT RESOURCES:

The Clean Vessel Act of 1992 (Pub. L. 102-587, subtitle F).

Alabama Department of Environmental Management, P.O. Box 301463, Montgomery, AL 36130, www.adem.state.al.us

www.epa.gov/owow/nps/marinas

Biodegradable Substances

OBJECTIVES:

Students will be able to:
1. Determine which substances are biodegradable.
2. Interpret data from an investigation.

BACKGROUND:

Waste can pollute the air, water, or land. Waste is found on the land on which we grow food and build our homes. You can taste, smell, see, or hear pollutants. Other pollutants cannot be detected by our senses. These usually can be detected by scientific instruments. Many pollutants can be broken down by living organisms. These pollutants are called biodegradable. Materials, such as glass, metal, plastic, and certain chemicals, can remain in the environment for hundreds of years; they are nonbiodegradable.

VOCABULARY:

biodegreadable, nonbiodegradable, organic, inorganic, pollution, pollutants, environment, organism

Grades:

6-8

Subjects:

Science, Language Arts

Time Needed:

One class period first day, 5 minutes every other day for a month

Materials:

2 small clay flowerpots per team
2 petri dish lids to fit clay pots
sand, gravel
regular soil
2 aluminum pie pans
plastic food wrap, rubber bands, organic waste material, plastic mild cartions and packing foam

ADVANCE PREPARATION:

1. On the day before the investigation, have students bring in *fallen* leaves, not fresh ones picked from a growing plant. Ask the school cafeteria for organic waste material (fruit or vegetable peelings). Collect plastic milk cartons and plastic foam packing materials that are used in shipping cartons.

PROCEDURE:

Setting the Stage

1. Discuss the difference between biodegradable and nonbiodegradable.
2. Discuss the terms “organic” and “inorganic” materials.

Activity

1. Divide the students into teams and have each team do the following:
   - Obtain two clay flowerpots. Put a layer of sand and then a layer of gravel in the two pots. Next fill the pots with regular soi to within 1.5 cm of the top.
   - In one of the clay pots, place a 2 cm square of newspaper, a leaf, a 2 cm square of fruit peel, and a 2 cm of vegetable peel on top of the soil.
   - In the other pot, place a 2 cm square of thick plastic, a 2cm square of plastic bag, a 2 cm square of aluminum foil, and a 2 cm square of plastic foam on the soil.
   - Cover the pots with the petri dishes or use plastic food wrap and rubber bands. Make sure the dish fits tightly over the top of each flowerpot.
   - Place each pot in an aluminum pie pan. Add a little water to the pan. The water will rise through the hole in each pot to keep the inside moist.
2. Observe the two pots every other day for a month. Record the observations on the chart as relates to which materials biodegraded and which did not.

EVALUATION:

1. Students should discuss their findings.
2. Students should answer the following questions:
   - Which substances were biodegradable? nonbiodegradable?
   - Did any substances decompose? To what degree?
   - Did you observe any organisms? If so, how did they cause a change?

EXTENSIONS:

1. Using plastic gloves, examine the classroom trash can. Have students discuss the biodegradable and nonbiodegradable materials and the way the class can reduce the amount of trash in the classroom.
2. Do research on biodegradability of substances in landfills, expecially ones which are capped to keep water from entering the landfill.

ORIGINAL DEVELOPMENT RESOURCES:

Focus on life science. (1989). Columbus, OH: Merrill.

Biogegradable Stubstances

Team #: _____

Pot 1				
Date	**Newspaper**	**Leaf**	**Fruit Peel**	**Vegetable Peel**

Pot 2				
Date	**Aluminum**	**Plastic Bag**	**Plastic Foam**	**Thick Plastic**

Notes

Breathing Air Pollution

OBJECTIVES:

Students will be able to:
1. Collect pollutants.
2. Compare samples of air pollutants.
3. Determine how air pollution can be controlled.

BACKGROUND:

Machines that people use, such as cars, trucks, and factory engines, produce smog that combines with the atmosphere. This type of air pollution is caused by impurities in the air. Also, materials, such as lint, soot, pollen, and dust, can be found in the air we breathe. Over the last 20 years, city, county, state, and federal agencies have begun to set standards to reduce air pollution. New cars must be equipped with catalytic converters, and factories have had to update their pollution control devices. The process of air pollution control will continue to be an ever-increasing factor in the years to come due to an ever-increasing world population growth.

VOCABULARY:

pollution, smog, pollutant, soot, impurities, toxic gas, acid rain

Grades:

6-8

Subjects:

Science, Math, Art

Time Needed:

Two days, 2 class periods

Materials:

glass slides (4 per team)
petroleum jelly
tongue depressors or small spatulas
masking tape
hand lens
microscope

ADVANCE PREPARATION:

1. Review the process of estimating (math).
2. Discuss the concept of air pollution by using pictures (see "Resources" section).

PROCEDURE:

Setting the Stage

1. Discuss air pollution as it relates to a city's population. Example: Mobile, AL, versus Atlanta, GA, or Los Angeles, CA, versus Dallas, TX. Relate these cities to your own city. Which has more air pollution? Why?
2. Set up the lab with all the materials necessary to carry out the investigation.

Activity

1. Select four places (some inside, some outside) where you will sample the air for pollutants.
2. Label the slides with the masking tape, putting the location and one of the team member's initials.
3. Use the tongue depressor to spread a *thin* coat of petroleum jelly on the slides (teacher should demonstrate).
4. Place the slides at the selected areas. Leave there for at least 24 hours.
5. Observe the slides with a hand lens and a microscope. Look for particles such as soot, pollen, lint, dust.
6. Construct a table like the following one and record the team's observations and data. Draw pictures of the various particles as they look under the microscope.
7. Estimate the number of particles on each slide and record the results.

TABLE

Location	Number of Particles	Drawing

EVALUATION:

1. Study the information in the table. Discuss your results with team members. All teams should discuss their results with the class.
2. Each student should individually answer the following questions:
   - How are the particles on the slides related to air pollution?
   - Did the different locations show different particles? If so, explain the reason. Were more particles collected at indoor or outdoor locations?
   - What effect might the following have on air pollution?
     smoking (indoor air pollution)
     transportation
     wind
   - How can air pollution be decreased?
   - What types of air pollution would this experiment not show?

EXTENSIONS:

1. Gather a clear plastic cup, rainwater, and purple grape juice. Collect 1/2 cup of rainwater. Add a teaspoon of grape juice. Observe any color change. Grape juice turns red in an acid and green in a base. Did the rain water turn red? If so, what might be the source of the acid?
2. Do research on the status of the development of the electric car and its relation to air pollution. Present the report orally to the class.
3. Discuss the air quality index. Keep a daily record of the air quality index.

ORIGINAL DEVELOPMENT RESOURCES:

Life Science. (1990). Glenville, IL: Scott Foresman.

Focus on Life Science. (1989). Columbus, OH: Merrill.

www.smogcity.com - interactive website

Who's Dumping Chemicals On My Catfish?

OBJECTIVES:

Students will be able to:

1. Write a well-organized play and perform it based on the "Captain Planet" environmental cartoon on TBS.
2. Compose music for the play.
3. Design a set for the play.
4. Create a script for the play.
5. Analyze their performance and production.

BACKGROUND:

"Captain Planet" is a popular cartoon on TBS. "Earth, Wind, Fire, Water, and Heart" are the powers of the rings that call Captain Planet to save our Earth when the planeteers find themselves overwhelmed with environmental pollution. The planeteers are led by Gyana, the spirit of Mother Earth. The planeteers fight evil polluters such as "Sludge." In a 1995 production of "Captain Planet," the planeteers take a trip down the Mississippi Delta in search of the causes of pollution in the river. They find that industries are dumping waste directly into the Mississippi River. Sickness and contamination control the areas along the river bed. The planeteers pretend to be Huck Finn on his raft going down the mighty Mississippi. Fishing, boating, swimming, skiing, shrimping, crabbing, or even crawdad catching are not permitted because of the pollution in the river. Of course "Captain Planet" is called from the power of the rings and saves the Mississippi. His last statement to all is, "The power is yours!"

Grades:

6-8

Subjects:

Science, Art, Music, Drama, Language Arts

Time Needed:

Three 50-minute classes during school plus rehearsals after school

Materials:

"CAPTAIN PLANET" videos
writing materials
video camera
blank videos
stage to perform
play props based on play script and music
costumes
five rings

VOCABULARY:

contaminant

ADVANCE PREPARATION:

1. If the students have not seen "Captain Planet," rent some tapes from the video store. Try to locate the video about Huck Finn/Planeteers "Who's Dumping Chemicals on My Catfish?"
2. It would be helpful to the writing of the play for students to read *Huck Finn and The Adventures of Tom Sawyer.*
3. Students also enjoy learning the "Captain Planet" song. What better way to learn how to present a message to others about protecting our water than by having fun doing it?

PROCEDURE:

Setting the Stage

1. Watch "Captain Planet" videos.
2. Divide into groups of three to five students. Give each group an assignment:
   Producers of the play, Art directors, Script writers, Editors, Camera persons, Set directors, Music directors (vocal and instrumental), Stage hands/props, Schedule directors/agents.

Activity

1. Begin to write the play script based on "Captain Planet" cartoons.
2. Edit and research environmental issues.
3. Once the theme of the script has been chosen and enough information has been collected, the music and stage preparations should begin.
4. Rehearse, rehearse, rehearse.

Follow-Up

1. A video should be made of the play.
2. Students in the class should critique the play after watching the video.
3. If the play is considered a success, plans for a live performance should be made.

EXTENSIONS:

1. Contact the local actors guild and share your play.
2. If the drama and music classes will participate, new themes can be produced and added.

ORIGINAL DEVELOPMENT RESOURCES:

Turner Broadcasting System (TBS) "CAPTAIN PLANET" cartoon. "Who's Dumping Chemicals on My Catfish?" (1995). www.captainplanetfdn.org

ADDITIONAL RESOURCES:

Captain Planet Foundation - http://www.captainplanetfoundation.org

Cleaner Clothes - Cleaner Environment?

OBJECTIVES:

Students will be able to:
1. Describe and analyze data.
2. Make decisions regarding phosphates in detergents.

Grades:
6-8

Subjects:
Ecology, Chemistry, Biology

Time Needed:
At least one 50-minute class period. Class time will be needed to introduce the background and set the stage. Most of the work will be done out of class as a project.

Materials:
examples of various detergents (dish and laundry)
survey form for consumers (student developed)
water analysis kits (if water survey is conducted)

BACKGROUND:

In recent years, some detergent companies have made advertising claims such as "Contains no phosphates" or "Low in phosphates." What are phosphates, and what is all the fuss about? If they are so bad, then why have they been used in detergents? If they are in detergents, then how can they lead to water pollution? Compounds containing phosphate ions usually are associated with the need for high-energy compounds such as detergents and fertilizers. Phosphates have been used to improve the cleaning ability of detergents as well as to enhance the sudsing ability. We have associated "lots of suds" with the ability to clean. Now the makers of detergents are trying to sell their products based on their low or no phosphate content.

What do excess phosphates do to the environment? When the water leaves your house, so do cleaning compounds, which then enter the ecosystem. Excessive use of phosphates can contribute to an environmental problem known as an "algal bloom." When this occurs, the algae undergo a population explosion until the body of water is covered. Sunlight cannot penetrate deeply into the water. The oxygen supply can be depleted, which could lead to the "death of the lake." This activity will allow students to research the source of these phosphates, survey consumer knowledge, and evaluate the impact of phosphates on water systems.

VOCABULARY:

phosphates, algal bloom

PROCEDURE:

Setting the Stage

1. Inform students how to collect data, how to devise a survey instrument, how to compile and interpret data into graphs and tables, and how to present their findings to the class and compare the results from each group.

Activity

1. After discussing the background, assign students to work in groups to compile data about detergents and phosphate amounts as well as the advertising claims of each product such as "free of phosphates."
2. Students need to collect data from both laundry detergents and dishwasher detergents. Predetermine the minimal number they must examine.
3. Students should then compile data in table and graph form. (A bar graph would work well.)
4. Have students design a survey form or questionnaire asking 25 people (different families) their choice of laundry and dishwasher detergent, the reason they chose the product, if they are aware of the effect of excessive use of phosphates, and whether they would change if their current choice were high in phosphates.

5. Students should then analyze their data and draw conclusions.
6. Have students compare the data from consumers to see if any relationships exist among choices and phosphate content.

EVALUATION:

1. Each group should turn in a report of its conclusions.

EXTENSIONS:

1. Students may want to analyze water from upstream or downstream of their town's waste water treatment plant(s).
2. Students may bring in samples of surface waters and add different detergents to each subsample to see if there are differences in algal growth among samples with different detergents.
3. Students then (optional) can analyze water from local water systems for phosphate content and algal growth. The data can be compared with choice of detergents and conclusions can be drawn.

ORIGINAL DEVELOPMENT RESOURCES:

www.phophatefacts.org

Cleaning An Oil Spill

OBJECTIVES:

Students will be able to:
1. Find out the best way to clean up an oil spill.
2. Analyze and interpret data obtained by doing an investigation.

BACKGROUND:

In the last 20 years, more and more oil spills have occurred in the world's oceans. Each occurrence has a major impact on the oceans' ecosystems. Clumps of oil that have hardened are found in all major bodies of water. Tankers and offshore oil wells produce oil spills that cause major problems for water animals. Many different types of fish and birds, such as loons, are killed when oil spills occur. Some animals are killed by the chemicals found in the oil; others are smothered by the oil. The process of cleaning up an oil spill is very costly and usually is not very effective. In some cases, bacteria are used to break down oil to help with cleaning up an oil spill. Other methods are being tested, and scientists are continuing research to combat this world-wide problem.

VOCABULARY:

pollution, ecosystem, biodegradable

ADVANCED PREPARATION:

1. Collect enough sets of the materials so that the class can be grouped into teams of 3 or 4 students.

Grades:

6-8

Subjects:

Science, Language Arts

Time Needed:

One class period

Materials:

3 petri dishes
graduated cylinder
water
motor oil
medicine dropper
plastic foam cups
baking soda
grass
paper towels
liquid detergent
flour
ice
cotton

PROCEDURE:

Setting the Stage

1. Discuss the ever-increasing problem of oil spills. Have students do research on the Alaskan oil spill. Have a debate on the major issues.

Activity

1. Divide the class into teams. Have each team complete the following:
   - Label the 3 petri dishes "A," "B," and "C."
   - Put 10 mL of water into each petri dish.
   - Add 10 drops of motor oil to each dish.
2. Attempt to remove the motor oil from each dish by doing the following:
   - Try to remove the oil in dish "A" by using the flour, cotton, and ice as follows:

   Flour - Sprinkle flour on surface of water. Use a paper towel to skim the surface of the water to collect the oil.

   Cotton - Skim the surface of the water with cotton to collect the oil.

   Ice - Hold ice with tongs and skim the surface of the water to collect the oil.
   - Try to remove the oil in dish "B" by using the plastic foam cups, baking soda, and grass as follows:

   Foam cups - Skim the surface of the water with the cups to collect the oil.

   Baking soda - Sprinkle the surface with baking soda. Use a paper towel and skim the surface of the water to collect the oil.

Grass - Sprinkle the surface with grass clippings. Use a paper towel and skim the surface of the water to collect the oil.

- Try to remove the oil in the last dish by using the medicine dropper, paper towels, and the detergent.

Medicine dropper - Place the tip of the dropper just on the surface of the water and suck up the oil.
Paper towels. Place the paper towel on the surface of the water and let sit for a minute. Remove the paper towel.
Detergent - Put two drops of a liquid detergent in the dish and wait one minute. Use a paper towel and skim the surface of the water to collect the oil.

EVALUATION:

1. Have each team discuss its findings. Then answer the following questions:
   - Which materials did the best job in removing the oil?
   - Which materials did the worst job in removing the oil?
   - What materials would you use if you were put in charge of removing an oil spill in the ocean?
   - What negative consequences could there be in the ocean from the materials used to clean up the oil spill?

EXTENSIONS:

1. Have students write a story from the point of view of an animal that has been caught in an oil spill.
2. Collect news articles about oil spills around the world. Rate each as to its effect on the environment.

ORIGINAL DEVELOPMENT RESOURCES:

Life Science. (1989). Menlo Park, CA: Addison-Wesley.

Decomposers/Water Pollution

OBJECTIVES:

Students will be able to:

1. Explain that decomposers use oxygen to break down dead materials.
2. Record and interpret information found in a table.
3. Hypothesize an outcome.

BACKGROUND:

Fertilizers and detergents are wastes that are dissolved and carried into water sources such as streams, rivers, and lakes. This causes the algae to grow rapidly for a short time and then die. The algae then decomposes. This process, called decaying, uses up oxygen in the water. Eventually animals, mainly fish living in the water, die due to the lack of oxygen. A chemical, bromothymol-blue, can be used to detect the change in water as the oxygen decreases. This chemical, when added to water, will turn yellow as the oxygen level decreases.

VOCABULARY:

decomposers, pollution, eutrophication, decaying

ADVANCE PREPARATION:

1. Obtain bromothymol-blue solution (0.04 percent to 0.1 percent) from a biological supply house. Since at least 20 drops of the solution are used every time the investigation is completed, a 120 mL bottle should be adequate for 30 trials. This chemical is an acid-base indicator. In tap water (slightly basic), the indicator will be blue. Decomposers such as algae in the water release carbon dioxide during the decaying process. Carbonic acid is formed when carbon dioxide combines with water (explain reaction to students). The bromothymol-blue solution loses its blue color as the carbonic acid increases.

Grades:

6-8

Subjects:

Science, Language Arts

Time Needed:

First day 50 minutes; 5 minutes each day for next 5 days, 50 minutes last day to discuss findings

Materials:

4 corks
4 test tubes
mud from a puddle
test tube rack
glass marking pencil
dead grass
dead leaves
medicine dropper
bromothymol-blue solution (120 mL)

PROCEDURE:

Setting the Stage

1. Have a discussion about the role of decomposers in an aquatic ecosystem.

Activity

1. Divide the students into teams and have each team begin the activity.
2. Fill 4 test tubes 1/2 full of water. Add 4 drops of bromothymol to the water in each test tube. Put the 4 test tubes in the test tube rack.
3. To the first test tube, add a little dead grass that has been torn into little pieces. Add small pieces of leaves to the second test tube. Add a small amount of mud from an aquatic environment to the third test tube. Do not add anything to the fourth test tube. It will serve as the control.
4. Label the test tube indicating what substance was put inside. Label the fourth "Control." Ask students why a "Control" is necessary. Add water to the test tubes, leaving just enough room for a cork. Put a cork into each test tube.

5. Observe the test tubes every day for the next five days. Record any color change that occurs in the test tubes.

Observations

Contents of Test Tube	Day 1	Day 2	Day 3	Day 4	Day 5
Grass					
Leaves					
Mud					
Control					

EVALUATION:

1. Have a class discussion about the findings.
2. Have each group answer the following questions. Each team should present its results to the class.
   - In which test tube(s) was there a color change?
   - Did the control test tube have a change? Why? Why not?
   - Which test tube had the greatest change? Why?
   - What does color change and the amount of oxygen present tell you?
   - Were the results and your expected outcome the same? Why? Why not?
3. Have the class discuss the relationship of their experiment to the reduction of oxygen in an aquatic ecosystem. What would be the consequences to the oxygen levels of increased decaying materials in the water such as the grass, leaves, etc. used in experiment?

EXTENSIONS:

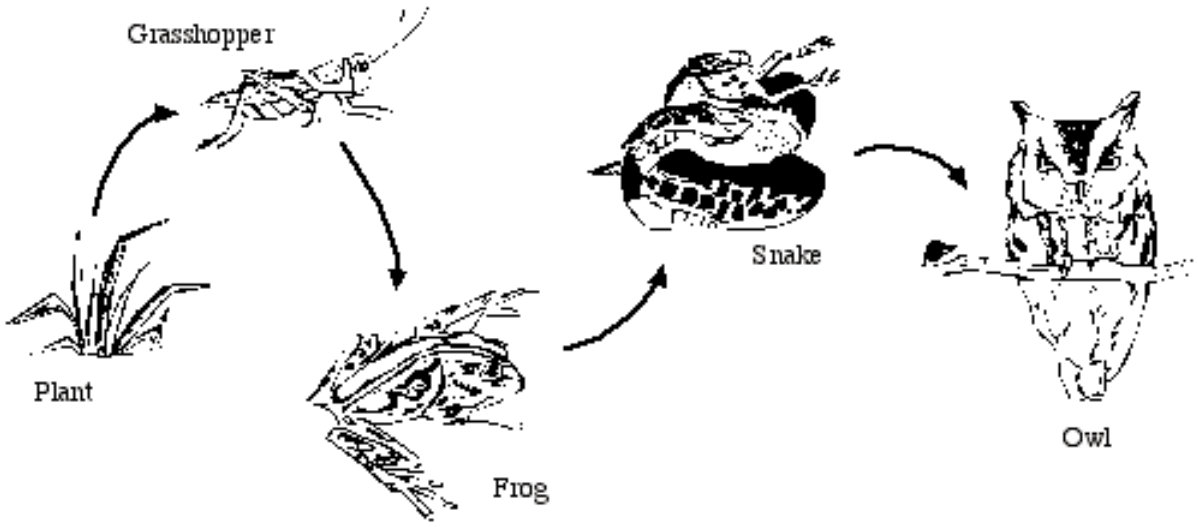
1. Using freshly cut grass, repeat the same experiment.
2. Find the meaning of the word eutrophication in a reference book. How is this word related to water ecosystems? What causes eutrophication?

ORIGINAL DEVELOPMENT RESOURCES:

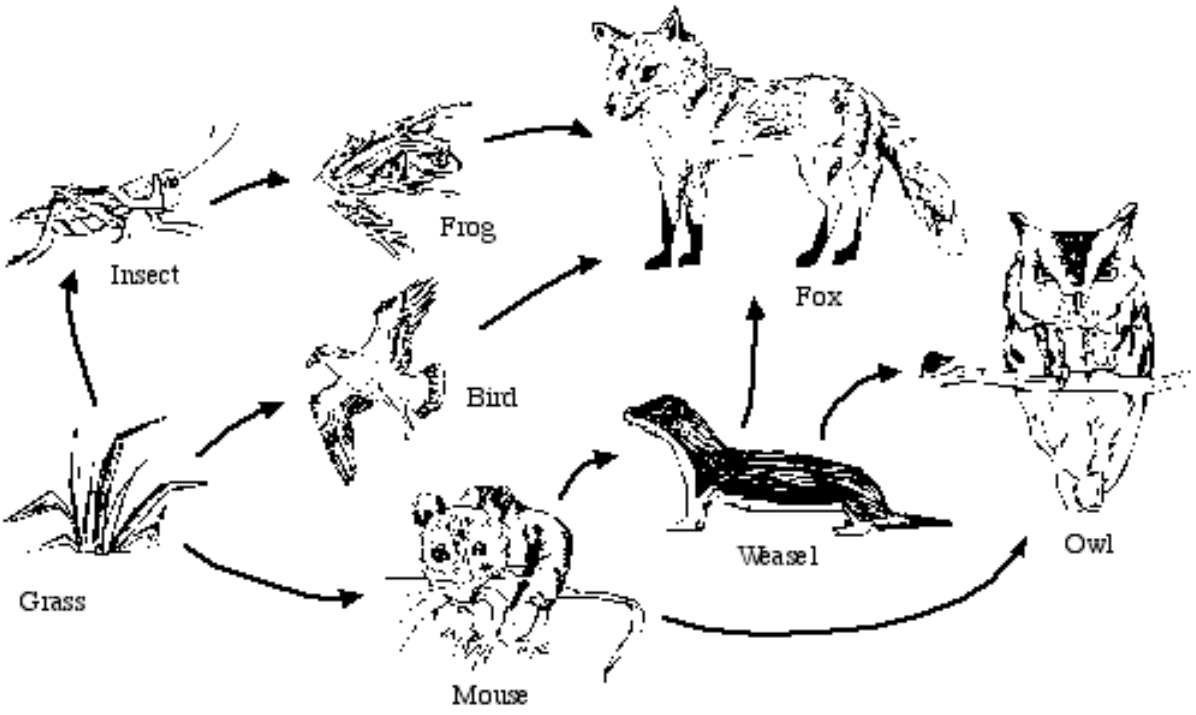
Focus on life science. (1981). Columbus OH: Merrill.

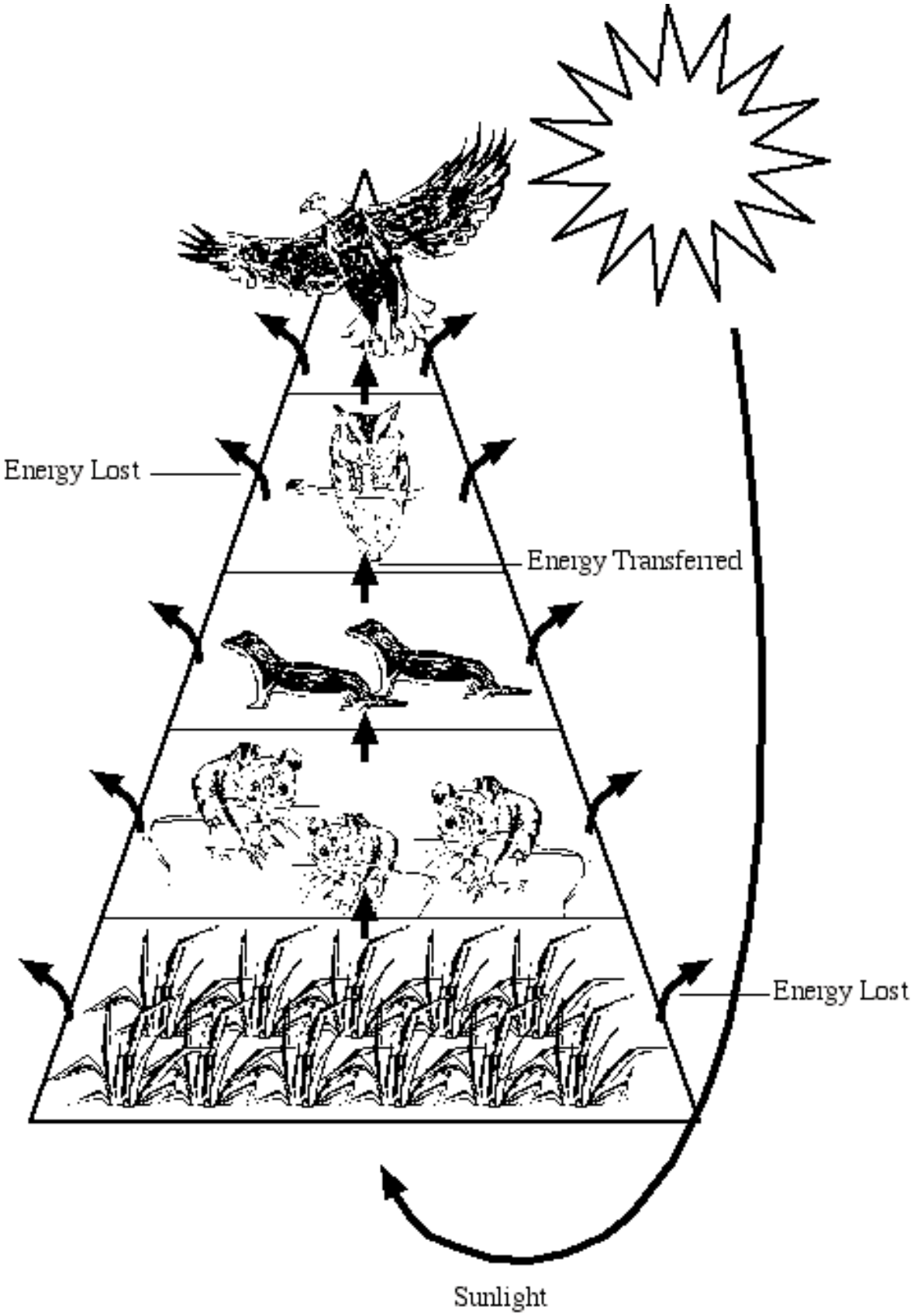
Experiences in life science. (1983). Irvine, CA: Laidlaw Brothers.

Food Chain



Food Web




Energy Lost
Energy Transferred
Energy Lost
Sunlight

Dilution To The Solution of Pollution?

OBJECTIVES:

Students will be able to:

1. Explain the process of dilution.
2. Explain that toxic materials do not disappear when diluted in a large amount of water.
3. Describe the event demonstrated using these key words: pollution, dilution, and concentration.

BACKGROUND:

The environmental effects caused by the by-products of human activity, principally industrial and agricultural processes (noise; smoke; automobile emissions; chemical and radioactive materials in the air, seas, and rivers; pesticides; radiation; sewage) and household wastes, are called pollution. Pollutants may enter the food chain and may be passed on from one organism to another. They frequently are harmful and may cause additional damaging developments. Many industries dump their chemical wastes into nearby waterways. Soon this polluted water reaches the sea where it becomes highly diluted. It has been suggested that dilution on a large scale will destroy the highly toxic materials and the dangers that are associated with them.

Grades:

6-8

Subject:

Physical Science

Time Needed:

35 minutes

Materials:

beaker (jar)
water
food coloring
2 medicine droppers
white cloth or white paper towel
straw

VOCABULARY:

pollution, dilution, concentration

ADVANCE PREPARATION:

1. Gather enough materials for groups of four.
2. Fill liter bottles with enough water for the activity. Three liters should be enough.

PROCEDURE:

Setting the Stage

1. Discuss the effects of pollution. Ask them to describe ways in which pollution can be controlled or stopped.

Activity

1. Give students (in groups of four) a beaker (jar).
2. Have students pour water into the jar until it is half full.
3. Using a medicine dropper, drop one drop of food coloring into the water.
4. Using a straw, stir until all the food coloring has been evenly distributed throughout the water.
5. Make observations.
6. Using a clean dropper, put a drop of the diluted food coloring on a clean white handkerchief, square piece of white material, or white paper towel.
7. Put the square on a flat surface and leave overnight to allow the water to evaporate.
8. Once the cloth dries, make observations again.

EVALUATION:

1. The next day the students should observe the aspects of the activity closely for evidence of what happened to the colored material. Have them report their observations and answer the following:
   - What happened to the food coloring dropped in the water?
   - Did the color fade? Why?
   - What happened to the spot on the cloth?
   - Describe what happened to the "pollution."
   - Predict what would happen if the food coloring were a chemical.
   - Would the chemical (represented by the food coloring) have a harmful effect on fish?

EXTENSIONS:

1. Have the students investigate how industries dumping their chemical wastes in the sea is harmful.
2. Try the same experiment with different amounts of food coloring compared to the amount of water.

ORIGINAL DEVELOPMENT RESOURCES:

Allen, D. (1988). *Science demonstrations*. New York: Parker Publishing Company.

Morgan, S. (1995). *Ecology and environment*. New York: Oxford University Press.

Dry Land/Hot Land

OBJECTIVES:

Students will be able to:

1. Explain the importance of soil moisture to the growth of crops.
2. Show how an increase in temperature affects soil moisture.
3. Explain how an increase in yearly air temperature could affect plant growth.
4. Graph the differing rates of soil moisture loss induced in the experiment.

Grades:
6-8

Subjects:
Science, Math

Time Needed:
Two class periods

Materials:
two identical pans (2" deep, 13" x 9")
10 lb. bag of potting soil (well mixed)
adjustable lamp with 100-watt bulb
balance or scale
Celsius thermometer
student sheet (included)

BACKGROUND:

When carbon dioxide and other "greenhouse" gases are added to the atmosphere, a major result may be the gradual rise in the average temperature of the Earth. As the air temperature rises, more water evaporates from the ground surface; and the amount of water vapor in the atmosphere increases. When the amount of water vapor in the atmosphere increases, the amount of precipitation from the atmosphere also increases.

Higher evaporation rates and changing atmospheric circulation patterns could mean a 7 to 11 percent increase in precipitation in some areas of the world. However, the high evaporation rates resulting from warmer temperatures also could mean other parts of the world might suffer from decreased soil moisture and, consequently, decreased plant growth. Some computer models suggest that such drought conditions could be experienced by the rich agricultural areas of the North American mid-section if the average temperature of the Earth increases.

VOCABULARY:

carbon dioxide, greenhouse gases, evaporate

PROCEDURE:

Setting the Stage

1. Brainstorm with the students about what environmental conditions should be considered when deciding what kinds of crops to grow. *Note:* Students should mention the amount of moisture, the available pattern of moisture (spring and fall: rainy; summer: dry), the average high and low temperatures, and the temperature patterns.

Activity

1. Label the pans #1 and #2.
2. Fill the pans with equal amounts of potting soil. (You may want to weigh soil-filled pans to make sure they are the same.)
3. Add equal amounts of water (approximately 350 mL) to each pan, and mix to make sure all the soil is wet. Soil should be moist to the touch, but it should not be saturated with water to the point Of seeing water glistening on the surface. If you need more water, add the same amount to each pan.
4. Make the following initial readings for each pan, and have the students record the information on the data sheet.
   - *Soil temperature reading:* insert thermometer in middle of pan about 1" deep, wait 3 minutes, and read.
   - *Soil moisture reading*: weigh pan precisely.

5. Place the pans in two different places. Place Pan #1 at a location in the room where it will remain at room temperature and where there is no direct light.
6. Place a 100-watt light 8 to 12 inches directly above Pan #2. Maintain the soil temperature at 2 to 3 degrees Celsius above room temperature. Once you have determined how high to keep the light, do not move it around.(*Note:* The temperature readings should remain relatively constant after the first reading or two. However, students may note a slight increase in temperature in the warmer pan as it dries. They should not move the pan. Less moisture means less evaporative cooling, and the temperature rises. This demonstrates the interaction between temperature and moisture that must be considered in predicting the climate.)
7. Take soil temperature readings, and weigh pans as directed in step 4 every hour or so during the school day or until the soil is very dry to the touch. Remind the students to record the time at every reading. (You may need to record the information on the chalkboard or chart and allow them to transfer it to their data sheets later.)

EVALUATION:

1. Ask the students to construct a chart showing the time of each reading (number of hours from first reading), the weight of the soil, and the soil temperature at each time. (*Note:* Since weight is used as a measure of soil moisture, they should understand that decreasing weight means less moisture.)
2. Have the students draw graphs of soil weight versus time at both room temperature (Pan #1) and 2 to 3 degrees Celsius higher than room temperature (Pan #2). The graphs should be drawn on the same axis so students can compare easily.
3. Have the students write 1 to 3 paragraphs comparing the results in Pan #1 and Pan #2 using the graphs. What conclusions can be drawn about the broader climate and Earth's surface?

EXTENSIONS:

1. Try elevating the temperature of Pan #2 to 8 to10 degrees Celsius above room temperature and repeat the experiment. (*Note:* Two lamps can be used here. Moving one lamp much closer will then heat up only one part of the soil in the pan rather than all the soil in the pan.)
2. Discuss the effects on soil moisture and agriculture if precipitation decreases and temperatures rise in some areas and precipitation increases in other areas.
3. Have the students go to the library and look for models that predict areas that would be affected by loss of soil moisture.
4. Have the students identify on a map of their area where agriculture is a major industry and discuss what would be the consequences if the land in those agricultural areas were to become dryer and hotter.. You may wish to contact your local agricultural extension agency or check with a school system agriculture teacher.
5. Have students research the identity, sources, and effects of "greenhouse gases."

ORIGINAL DEVELOPMENT RESOURCES:

Brown, L. (1990). *State of the world.* Washington, DC: Worldwatch Institute.

Hayes, D. (1979). *Pollution: The neglected dimension*. Worldwatch Paper 27. Washington, DC: Worldwatch Institute.

Merken, M. (1989). *Physical science with modern application.* 4th ed. Philadelphia, Saunders.

Montgomery, C. R. (1989). *Environmental geology.* 2nd. Dubuque, IA: William C. Brown.

Student Data Sheet

Name: _____

Date: _____

Period: _____

Pan #1 Location:_____

Soil Temperature

Hour	1	2	3	4	5	6	7	8
Time								
Temp								

Soil Weight

Hour	1	2	3	4	5	6	7	8
Time								
Weight								

Pan #2 Location:_____

Soil Temperature

Hour	1	2	3	4	5	6	7	8
Time								
Temp								

Soil Weight

Hour	1	2	3	4	5	6	7	8
Time								
Weight								

Notes

How Small Is Small?

OBJECTIVES:

Students will be able to:
1. Define parts-per-million.
2. Describe how the greenhouse effect affects our climate.

BACKGROUND:

The Earth often is compared to a gigantic greenhouse. Energy in the form of sunlight passes through the planet's atmosphere. Some of the energy that strikes the land and water is reflected back into space. Most of the rest is absorbed by the land and water, converted to heat, and radiated back into the atmosphere. This radiated energy is mostly absorbed by carbon dioxide and other atmospheric gases, which act much like the glass in a greenhouse thereby warming the atmosphere.

Since the middle 1800s, scientists have wondered about the importance of CO_2 as a "greenhouse gas" in the regulation of the Earth's climate. According to the "greenhouse effect" theory, increasing levels of CO_2 in the atmosphere will trap more and more heat thus raising the planet's overall temperature and affecting regional climates, sea levels, distribution of arable land, animal and human habitats, and more.

The widespread burning of fossil fuels—coal, oil, and natural gas—releases greenhouse gases, including CO_2, into the atmosphere. Concern about the possible climatic effects of increasing atmospheric CO_2 levels was voiced in 1957 by Roger Revelle, then director of the Scripps Institute of Oceanography in LaJolla, California. He wrote, "Human beings are now carrying out a large-scaled geophysical experiment of a kind that could not have happened in the past nor could be reproduced in the future. Over a period of a few centuries, we are returning to the atmosphere and oceans the concentrated organic carbon stored in sedimentary rocks over hundreds of million of years." In the late 1950s, scientific information about the levels of CO_2 in the atmosphere was sketchy. So Revelle and others began an international effort to monitor CO_2 concentrations in the atmosphere from stations in Alaska, Antarctica, and Hawaii where measurements would not be affected as much by factories and other sources of greenhouse gases.

The Mauna Loa, Hawaii, station has been operating since November 1958. The record compiled there over more than 40 years reveals some interesting insights into the global carbon cycle. There is a sawtooth pattern of seasonal variations of CO_2 of about five parts per million (ppm) long-term increase of about 1.3 ppm per year.

This long-term increase in CO_2 levels raises new questions. What are the sources of this "new" CO_2? How much comes from burning fossil fuels? How much may be caused by the clearing and burning of forests? What are the "sinks," or storage places, for the "excess" CO_2; and how big are they? Is the increase in atmospheric CO_2 changing the global climate?

New tools such as computer simulation models and satellite images are used to estimate better the sources and

Grades:

6-8

Subjects:

Chemistry, Biology, Ecology, Microbiology

Time Needed:

One 50-minute class period

Materials:

for each group of students:
one eyedropper
a supply of water
a cylinder with 10-milliliter graduations
three 12-ounce clear plastic cups
masking tape
marking pen
one bottle of food coloring (dark colors work best)
a calculator
a box of crayons
pastels or colored chalk
student work sheet

sinks of the carbon cycle. CO_2 dissolves readily in sea water where it is absorbed by microscopic plants known collectively as phytoplankton. When phytoplankton organisms die, some are incorporated into the ocean bottom sediments, trapping their carbon for millions of years. Sensors borne on satellites can measure electromagnetic energy reflected from the Earth, providing images of the extent and vigor of plant growth. These satellite images are being used to map phytoplankton activity at the oceans' surfaces, including the Gulf of Mexico, and to estimate the role of the oceans as a sink for atmospheric carbon.

On land, plants absorb and store CO_2 and give off oxygen. A large part of the carbon that is fixed in the leaves of plants as they grow is released into the atmosphere when the plants die and decay. In the dormant winter months, less CO_2 is taken in. This causes a seasonal oscillation of CO_2 levels in the atmosphere with maximum concentration in early spring and minimum levels in the fall. In the longer term, carbon is stored either as wood, as humus in soil, or in certain rocks such as limestone. Satellite sensors can be used to delineate better the world's forests and grasslands as both sources and sinks for CO_2.

All of this information is being integrated into computer models to help scientists model how the oceans, the biosphere, and the atmosphere interact in the global carbon cycle. The idea is to learn more about the effects of human activity on carbon levels and thus on our climate.

VOCABULARY:

greenhouse effect, parts-per-million, parts-per-billion, dilution, concentration, phytoplankton, arable

PROCEDURE:

Setting the Stage

1. Before beginning the activity, put a piece of masking tape on each cup and label "Sample 1," "Sample 2," and "Sample 3."

Activity

Sample 1

1. Have each group of students put 99 drops of water into the graduated cylinder. Record the volume of this amount of water. (They will need this measurement later to avoid having to measure another 99 drops.) They should pour the water From the 99 drops into the cup marked "Sample 1."
2. Students should add one drop of food coloring to Sample 1. Stir the water. Record the color using crayons, pastels, or chalk.
3. Students should answer questions 1 and 2 on the worksheet. They should use a calculator and should write the answers on the worksheet.

Sample 2

1. Have the students pour an amount of water equal to 99 drops into the graduated cylinder pour this into the cup marked "Sample 2."
2. Have students add one drop of Sample 1 to Sample 2, stir, and record the resulting color.
3. Answer questions 3 and 4 on the worksheet.

Sample 3

1. Have students pour an amount of water equal to 99 drops into the graduated cylinder and pour this into the cup marked "Sample 3."
2. Add one drop of Sample 2 to Sample 3, stir, and record the color of the solution.
3. Answer questions 5, 6, 7, and 8 on the worksheet.

FOR THE TEACHER: (Answers to questions)

Sample 1: Because you have added one drop of food coloring to 99 drops of water, the concentration is one part per hundred, which can also be expressed as 1/100 or 1 percent. A calculator should be used to visualize

the answer. Divide one by 100. The answer is 0.01. The color should be visible.

Question 7:
Students might answer that filtering the water through a substance like sand or through paper might "clean" it, but filtering will not remove a chemical solution. The teacher might use this question as an opportunity to discuss the removal of CO_2 from the atmosphere. Just as no simple process, such as filtering the water, will remove food coloring, no simple process will remove excess CO_2 from the atmosphere. Reducing the amount of CO_2 emitted by human activity is the only known way to prevent CO_2 in the atmosphere from increasing.

Sample 2: To 99 drops of new water, add a drop of the solution from Sample 1, which consists of 0.99 parts water and 0.01 part food coloring. Because you have not diluted the 0.01 drop of food coloring in a total of 100 drops of solution, divide 0.01 by 100 on the calculator. Your answer is 0.0001. This means you now have one part food coloring in ten thousand or 1/10,000. The food coloring may or may not be visible in the resulting selection.

Sample 3: Again you have 99 drops of new water and one drop from the solution in Sample 2. The one drop is 0.9999 parts water and 0.0001 parts food coloring. To calculate the concentration of food coloring in Sample 3, divide 0.0001 by 100 (the total number of drops in the solution). The answer is 0.000001 or one part food coloring in one million (1/1,000,000). The food coloring will not be visible at this concentration.

Question 8:
Making a parts-per-billion sample: Continue the procedures described above. Begin with 99 new drops of water. Use one drop of the parts-per-million solution. You will get 0.00000001 parts food coloring or one part food coloring in 100 million (1/100,000,000). For the final step, take nine new drops of water and add to them one drop of the previous solution. This yields 0.000000001 or one part per billion.

EVALUATION:

1. Students will be able to do the following:
   - Define parts-per-million.
   - Calculate parts-per-million.
   - Demonstrate successful completion of laboratory procedures.

EXTENSION:

1. Once the students are familiar with the procedure required to create a parts-per-million solution of a pollutant, have a variety of substances available for them to dilute and observe. Encourage the students to create experimental tests for determining if other substances are observable in the parts-per-million concentration. Some suggested substances to experiment with are detergent and acid (vinegar). You can ask:
   - Are the new substances observable in any way? (Do they form a film or foam or is there discoloration?)
   - Has there been a change in a pH test for the acid or base? (Use litmus paper to test the solutions.)

   Answers will vary.
   - Discussion note: Is a diluted substance "gone" just because it is no longer visible? How can these ideas be transferred from a liquid to a gas like CO_2?

ORIGINAL DEVELOPMENT SOURCES:

"Global Change," published by U.S. Department of the Interior, U.S. Geological Survey - Teachers' packet found at http://mac.usgs.gov.

Student Worksheet for Parts-per-Million

Name: _____
Date: _____
Period: _____

Questions

1. What is the concentration of food coloring in Sample 1? _____

2. Can you see the food coloring in Sample 1? _____

3. What happened to the color of the water in Sample 2? Describe and explain. _____

4. What is the concentration of food coloring in Sample 2? _____

5. What is the concentration of food coloring in Sample 3? _____

6. Can you see the food coloring in Sample 3? _____ Explain why or why not. _____

7. Suppose the food coloring was a harmful substance. How would you "clean" the water? _____

8. How could a parts-per-billion solution be made? _____

Rivers Of Life...Or Death

OBJECTIVES:

Students will be able to:

1. Identify point and non-point sources of pollution.
2. Create a map that demonstrates how a source of pollution that gets into states bordering the Mississippi can eventually reach many states.

BACKGROUND:

Streams and rivers are more than flowing waters that carry dissolved gases, minerals, and bits of sand and silt on a headlong course to the sea. Few people have the opportunity to follow a river through its entire course to the sea. If you did, however, you would quickly discover that whatever goes into the river upstream eventually finds its way downstream. Few streams flow directly into the sea. Instead, they rise from sources that lie hundreds of miles inland following a beautiful, intricate pattern of small streams flowing into larger ones, and then the larger streams unite to form rivers. As these rivers travel to the sea, many pollutants can be picked up and carried downstream. Take the Mississippi River, for instance. Whatever finds its way into this mighty river can eventually work its way to the Gulf of Mexico. Water pollution is a major problem today. There are as many sources as there are types of pollution—poisonous chemicals, untreated wastes, oil spills, and even litter from people and industry.

Grades:

6-8

Subject:

Science

Time Needed:

One 50- minute class period

Materials:

two large dish pans
two sheets of Plexiglas or acrylic large enough to fit over the pans
cooking oil
soy sauce or some dark liquid
litter collected on the street (bits of plastic, paper, and other litter)
spray water bottle
field notebook or journal
sanitary gloves
pencils

VOCABULARY:

point source pollution, non-point source pollution

ADVANCE PREPARATION:

1. Introduce the terms point source pollution and non-point source pollution.
2. Prepare a copy of a U.S. map for each student as well as a map showing how the Mississippi River flows through the states in the U.S.

PROCEDURE:

Setting the Stage

1. Discuss sources of river pollution by using slides, video, or pictures.
2. Give the students the following problem to solve: You own a lodge that offers public housing on the beautiful Mississippi River near a quaint little town in Wisconsin. This lodge is known all over for its sparkling, clear fishing waters. This has become a "booming" business for you. One day, however, you make an alarming discovery while walking out on your profitable fishing pier. You see a strange "brownish orange" goop floating in the water. You realize you must find its source as quickly as possible in order to save the pristine waters surrounding your lodge.

Activity

1. Divide the students into teams to investigate and trace the source or sources from which the pollution might have come. Compare and contrast the difficulties of tracing point and non-point sources of

pollution.
2. Have each team choose a spokesperson who will present the findings.

Follow-Up

Have each team present its findings.

EXTENSION:

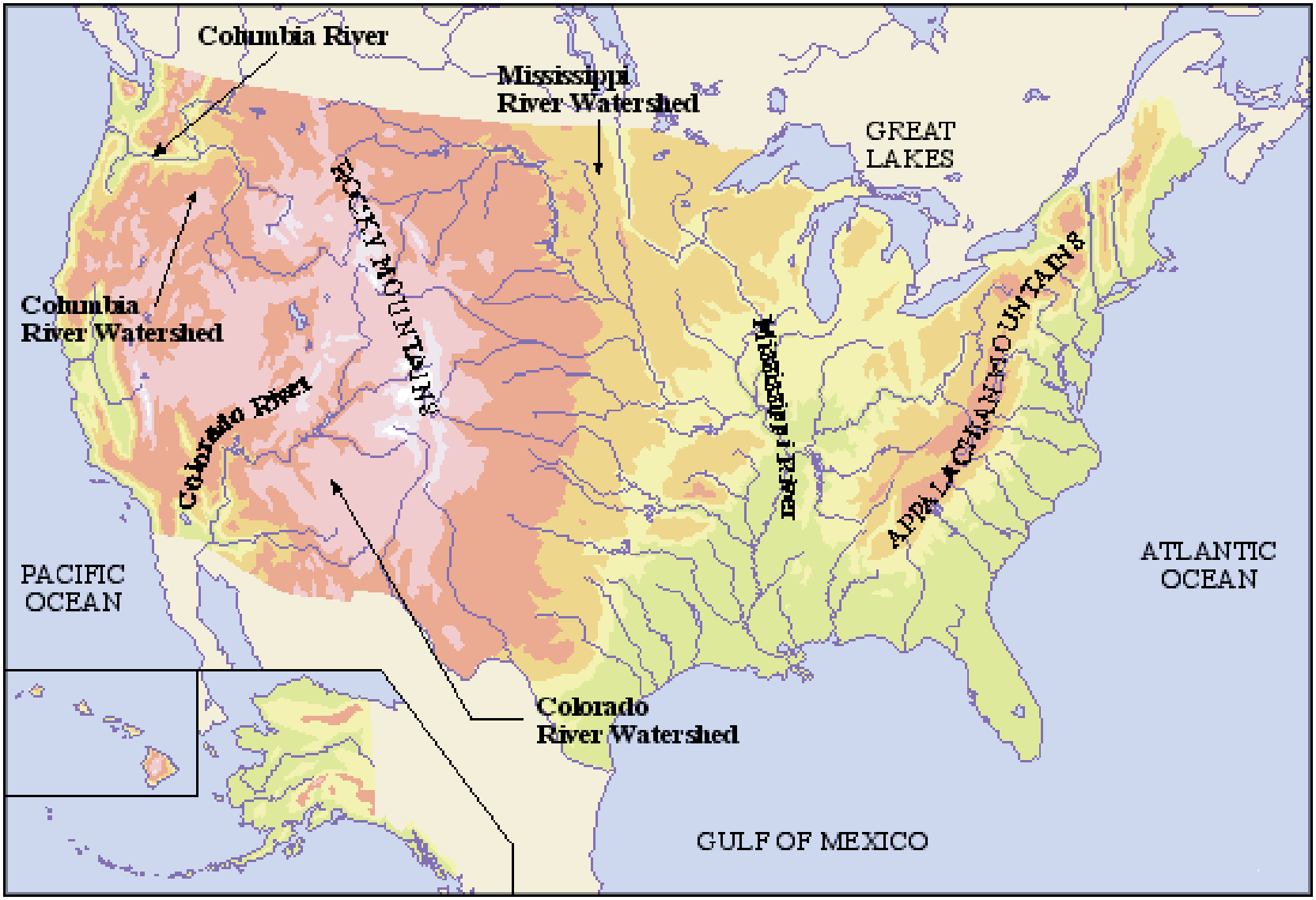
Have each team create a similar scenario using other states that border the Mississippi River, another large river like the Missouri, or a river in the area.

ORIGNAL DEVELOPMENT RESOURCES:

Earth science. (l991). Columbus, OH: Prentice Hall Publishing Company.

The United States Today

Rivers of Life/Death



Street Runoff

OBJECTIVE:

Students will be able to:
1. List forms of non-point source pollution.

Grades:
6-8

Subject:
Science

Time Needed:
One 50- minute class period

Materials:
two large dish pans
two sheets of Plexiglas or acrylic large enough to fit over the pans
cooking oil
soy sauce or some dark liquid
litter collected on the street (bits of plastic, paper, and other litter)
spray water bottle
field notebook or journal
sanitary gloves
pencils

BACKGROUND:

Pollution originates not just from one source but from many different sources. Point source pollution is also defined very broadly in the Clean Water Act because it has been through 25 years of litigation. It means any discernible, confined and discrete conveyance, such as a pipe, ditch, channel, tunnel, conduit, discrete fissure, or container. It also includes concentrated animal feeding operations, which are places where animals are confined and fed. Non-point source pollution is responsible for more than half the nation's water pollution. There are several sources of non-point source pollution. The Environmental Protection Agency states that NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water. These pollutants include: excess fertilizers, herbicides, and insecticides from agricultural lands and residential areas; oil, grease, and toxic chemicals from urban runoff; sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks; and bacteria and nutrients from livestock, pet wastes, and faulty septic systems. Golf courses use two and a half times more chemicals per acre than are used on farmland. Landfills, leaky septic systems, and improperly disposed household hazardous wastes contribute pollution and chemicals into waterways each day. When too much water enters the system, such as during a rainstorm, the water may be diverted around a treatment plant and may be discharged raw into the nearest waterway. A relatively small amount of rain may overload a combined sewer system. Over-development of areas will generate large quantities of phosphorus and nitrogen, which cause nitrification, leading to algal blooms and fish kills.

VOCABULARY:

biodegradable, litter, pollution, runoff, sewage, solid waste, household hazardous waste, treatment plant, non-point source pollution, point source pollution

PROCEDURE:

Setting the Stage
1. Define, or have the students define, terms such as pollution, runoff water, sewage, solid waste, household hazardous waste, biodegradable, and treatment plant.
2. The students or the teacher should collect roadside trash from around town. Students should work in teams and wear sanitary gloves.

Activity
1. Have students keep a record in a journal of the types of pollution they can identify but cannot collect in the areas of collection.

2. Students should use their own categories for dividing the litter. One category must include biodegradable items, and one category must include solid waste materials. Other types of pollutants that were not able to be collected should be listed in a column called "Other."
3. Students should fill both pans with water, covering them with sheets of Plexiglas or acrylic and leaving about half an inch open.
4. They should then put oil, soy sauce, and litter on top of one of the pieces of plexiglass. Students should spray the top of the plexiglass with water to simulate rain. Keep spraying until most of the runoff and litter have fallen into the basin.
5. Students should spray the top of the clean plexiglass for an equal amount of time.
6. Students should remove the pieces of plexiglass from the pans and observe the differences. Compare the pan with dirty water to the pan with clean water.

Follow-Up

1. Brainstorm with students how litter and chemicals in runoff can be reduced.
   Discuss these questions:
   - Why are treatment plants necessary?
   - What happens to litter left on the street if it is not picked up?
   - What happens to pollutants such as chemicals in the water that cannot be picked up or that will not biodegrade?
   - Would stricter littering laws help this problem in any way? What parts of the problem would it NOT have an effect on?

EXTENSIONS:

1. Collect garbage from a selected area of a known size to display on a bulletin board at school.
2. Design a monument to "litter" made out of the litter found on the school grounds.
3. Paint trash cans bright colors with catchy slogans to inspire people to use them.
4. Adopt a stream crossing or road-side mile.

ORIGINAL DEVELOPMENT RESOURCES:

"PALS," a newsletter by People Against A Littered State, Fall 1992.

www.epa.gov/owow/nps

ADDITIONAL RESOURCES:

http://www.alpals.org

http://water.epa.gov

Thermal Pollution And Aquatic Ecosystems

OBJECTIVE:

Students will be able to:

Discuss the immediate and long-range effects of thermal pollution with an awareness of the interrelationship that exists between people and nature.

Grades:
6-8

Subject:
Science

Time Needed:
One class period for teacher demonstration; aquarium on-going

Materials:
aquarium
sand
fish
plants
heavy paper cup

BACKGROUND:

Much of the water we drink today has been around since the beginning of time. Whether it has been part of a rainstorm, a fish, or a plant, water is ancient. Agriculture and industry account for most of the water usage in the United States. An entire ecosystem may suffer the effects of water pollution. In the past few years, there have been several spills of toxic chemicals directly into rivers or streams, killing every living thing for miles downstream from the spills. In fish, toxic chemicals can cause cancers and scale or fin rot; and these chemicals can accumulate in their tissues, making many fish too dangerous for humans to eat. When excessive amounts of heat are added to a body of water, thermal pollution can result. Thermal pollution occurs when power plants and other industries located along lakes or rivers use the water in their cooling systems. (Thermal pollution can cause massive fish kills when the discharged water is too hot for the fish to tolerate.) Cool water from rivers or lakes is circulated around engines to absorb waste heat. The hot water from this is returned to the lake or river, creating an unnaturally warm or even hot area. Because hot water does not hold as much oxygen as cool water, aquatic organisms are deprived of oxygen and may suffocate. A constant influx of hot water into an aquatic ecosystem may totally disrupt it if the organisms are not able to adapt to the higher temperatures. This is the reason citizens often oppose the construction of the power plants on lakes and rivers or insist on cooling systems that reduce the temperatures of the water before it is returned to the waterways.

VOCABULARY:

pollution, thermal pollution, ecosystem, aquatic ecosystem, heat

ADVANCE PREPARATION:

1. Design and construct an aquatic ecosystem.
2. Have the ecosystem in the class for about a week. (This is for student observation.)
3. Purchase inexpensive life for the ecosystem. (fish, plants)
4. Discuss the importance of the water temperature and how life adapts.
5. Make arrangements to have access to hot water.

PROCEDURE:

Setting the Stage

1. Enlist the aid of student volunteers to perform the experiment.
2. Place an aquarium tank or other container that provides a large surface area for contact with the atmosphere in an area that provides sunlight and allows for clear viewing by students.
3. On the bottom of the tank, place washed sand to prepare a base land.
4. Fill the tank with clear water. (Do not disturb the sand.)
5. Allow the temperature of the aquarium to adjust to that of the room.

6. Place a small number of freshwater fish, selected for transfer to the aquarium, in a plastic bag containing water from the original habitat.
7. Float the bag and its contents on the surface of the water in the aquarium.
8. After a couple of hours when the temperature of the water in the plastic bag is the same as that of the aquarium water, release the fish into the water in the aquarium.

Activity

1. Show the students the cold water and the hot water.
2. Ask questions as to what would happen if this water were added to the ecosystem.
3. Remind students that for a week the temperature has been constant.
4. Tell students that a power plant has been constructed, and the new sight is next to the aquatic ecosystem.
5. Put holes around the bottom of the heavy paper cup.
6. Place the cup with the holes in the aquarium. Pour hot water into the cup in the aquarium. Make observations.
7. Repeat Step Six one time only. Taking care not to injure the lifeforms in the aquarium, choose the placement of the cup of hot water carefully.

Follow-Up

1. Have the students write about the lab activity, utilizing the steps of the scientific method (problem, information, hypothesis, experiment, data, and conclusion).
2. Investigate and report on what Congress and the Environmental Protection Agency are doing about thermal pollution.

EXTENSIONS:

1. Have a debate on what Congress and the EPA are doing about water pollution. Ask questions: Do you feel that it is enough? Do environmental groups? Are you willing to pay higher prices for goods in order to have a better system? Are your friends and relatives? Conduct a survey to find out.
2. Attend a public hearing about water pollution problems. Write a letter to your local official and express your opinion on the topic. Share the letters and replies with the class.

ORIGINAL DEVELOPMENT RESOURCES:

Arms, K. (1996). *Environmental science*. Orlando, FL: Holt, Rinehart, and Winston.

Allen, D. *Hands-on science.* The Center for Applied Research in Education, West Nyack, NY.

Vegetation Survey

OBJECTIVE:

Students will be able to:

Apply information from various sources (literature, documents, topographical and aerial maps, pictures) to enhance their knowledge of biodiversity and conservation.

Grades:

6-8

Subjects:

Science, Literature, Ecology

Time Needed:

Two 50-minute class periods, and a trip to the area under investigation (optional)

Materials:

two aerial photographs
clear sheet of plastic large enough to cover the photographs
thin black markers to draw zones on plastic overlay
identification cards (cut out swatches from one of the photographs that represent each vegetation type written on the back of each swatch)
field guides for plant identification

BACKGROUND:

Humans are making increasing demands on natural ecosystems. One recent study has concluded that our species is consuming or diverting over 40 percent of the net photosynthetic productivity of our planet. Many habitats are being converted to simpler systems that provide more harvestable goods for people. As a result, genetic diversity, species, and entire ecosystems are disappearing. Some scientists suggest that as many as 25 percent of the world's species could be lost in the next several decades.

Jeffrey A. McNeely's *The Sinking Ark* is usually characterized in terms of pollution, habitat loss, poaching, introduced species, and illegal trade in wildlife products, but these are symptoms rather than causes. At a more fundamental level, many of the same factors that have caused pollution to become such a problem also have been responsible for the loss in biodiversity. The effects of pollutants on biodiversity have been considered an external, unintended side effect of industrial activity that brought measurable benefits to people; development of activities that have decreased biodiversity have proven profitable only because the real costs have been unknown, hidden, or ignored.

Some scientists feel that the root of the problem is over-population. The real costs have been ignored rather than hidden by those mainly responsible for production, though many of the costs have been concealed from consumers. This problem is a product of greed and selfishness.

"Keeping the ark afloat" will require this approach: Investigation (learning how natural systems function), Information (ensuring that the facts are available to make informed decisions), Incentives (using economic tools to help conserve biodiversity), Integration (promoting a cross-sectional approach to conserving biodiversity), and International Support (building productive collaboration for conserving biodiversity).

In order to comprehend these concepts, one must be familiar with biodiversity in the local area. Photographs and "earth truthing" (physically examining) are possible in a local area and are meaningful. An understanding of local demands on biodiversity will help in the understanding of global demands.

VOCABULARY:

biodiversity, conservation, pollution, species loss, habitat loss, introduced species, poaching

PROCEDURE:

1. Cut out swaths of an aerial photograph for a site with which you are familiar.
2. Label the vegetation type on the back of each swath to be used as reference data.

3. Spread the aerial photograph on a table and secure.
4. Have students place a plastic sheet over the photo and begin tracing different vegetation zones. Using the cut-out swatch as a reference, students should label these zones on the plastic.
5. Go to the site and "ground truth" (walk the area) to make sure it is the same vegetation. An alternative to this would be for the teacher to make photographs to verify the class map.
6. Identify any changes made since the photographs were taken.

EVALUATION:

Observe students to record the completion of the activity.

EXTENSIONS:

1. Use the map to locate industrial and residential areas. Have students form hypotheses about the growth of population and industry.
2. Identify wildlife and describe the impact on the vegetation.
3. Write a proposal to a legislator telling of your findings and your wishes for this area.

ORIGINAL DEVELOPMENT RESOURCES:

McNeely, J. A. (1992). *The sinking ark: pollution and the worldwide loss of diversity*. Chapman and Hall.

Geological Survey Of Alabama, Tuscaloosa, AL