MERIT BADGE SERIES

ENVIRONMENTAL SCIENCE

BOY SCOUTS OF AMERICA®

How to Use This Pamphlet

The secret to successfully earning a merit badge is for you to use both the pamphlet and the suggestions of your counselor.

Your counselor can be as important to you as a coach is to an athlete. Use all of the resources your counselor can make available to you. This may be the best chance you will have to learn about this particular subject. Make it count.

If you or your counselor feels that any information in this pamphlet is incorrect, please let us know. Please state your source of information.

Merit badge pamphlets are reprinted annually and requirements updated regularly. Your suggestions for improvement are welcome.

Send comments along with a brief statement about yourself to Youth Development, S209 • Boy Scouts of America • 1325 West Walnut Hill Lane • P.O. Box 152079 • Irving, TX 75015-2079.

Who Pays for This Pamphlet?

This merit badge pamphlet is one in a series of more than 100 covering all kinds of hobby and career subjects. It is made available for you to buy as a service of the national and local councils, Boy Scouts of America. The costs of the development, writing, and editing of the merit badge pamphlets are paid for by the Boy Scouts of America in order to bring you the best book at a reasonable price.

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Requirements

1. Make a timeline of the history of environmental science in America. Identify the contribution made by the Boy Scouts of America to environmental science. Include dates, names of people or organizations, and important events.

2. Define the following terms: population, community, ecosystem, biosphere, symbiosis, niche, habitat, conservation, threatened species, endangered species, extinction, pollution prevention, brownfield, ozone, watershed, airshed, nonpoint source, hybrid vehicle, fuel cell.

3. Do ONE activity from EACH of the following categories (using the activities in this pamphlet as the basis for planning and projects):

   A. Ecology

      (1) Conduct an experiment to find out how living things respond to changes in their environments. Discuss your observations with your counselor.

      (2) Conduct an experiment illustrating the greenhouse effect. Keep a journal of your data and observations. Discuss your conclusions with your counselor.

      (3) Discuss what is an ecosystem. Tell how it is maintained in nature and how it survives.

   B. Air Pollution

      (1) Perform an experiment to test for particulates that contribute to air pollution. Discuss your findings with your counselor.

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(2) Record the trips taken, mileage, and fuel consumption of a family car for seven days, and calculate how many miles per gallon the car gets. Determine whether any trips could have been combined ("chained") rather than taken out and back. Using the idea of trip chaining, determine how many miles and gallons of gas could have been saved in those seven days.

(3) Explain what is acid rain. In your explanation, tell how it affects plants and the environment and the steps society can take to help reduce its effects.

C. Water Pollution

(1) Conduct an experiment to show how living things react to thermal pollution. Discuss your observations with your counselor.

(2) Conduct an experiment to identify the methods that could be used to mediate (reduce) the effects of an oil spill on waterfowl. Discuss your results with your counselor.

(3) Describe the impact of a waterborne pollutant on an aquatic community. Write a 100-word report on how that pollutant affected aquatic life, what the effect was, and whether the effect is linked to biomagnification.

D. Land Pollution

(1) Conduct an experiment to illustrate soil erosion by water. Take photographs or make a drawing of the soil before and after your experiment, and make a poster showing your results. Present your poster to your counselor.

(2) Perform an experiment to determine the effect of an oil spill on land. Discuss your conclusions with your counselor.

(3) Photograph an area affected by erosion. Share your photographs with your counselor and discuss why the area has eroded and what might be done to help alleviate the erosion.

E. Endangered Species

(1) Do research on one endangered species found in your state. Find out what its natural habitat is, why it is endangered, what is being done to preserve it, and how many individual organisms are left in the wild. Prepare a 100-word report about the organism, including a drawing. Present your report to your patrol or troop.

(2) Do research on one species that was endangered or threatened but which has now recovered. Find out how the organism recovered, and what its new status is. Write a 100-word report on the species and discuss it with your counselor.

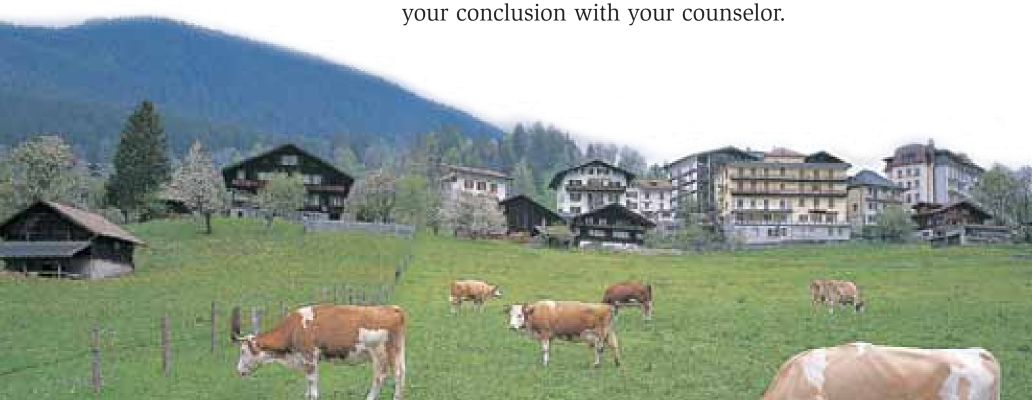
(3) With your parent's and counselor's approval, work with a natural resource professional to identify two projects that have been approved to improve the habitat for a threatened or endangered species in your area. Visit the site of one of these projects and report on what you saw.

F. Pollution Prevention, Resource Recovery, and Conservation

(1) Look around your home and determine 10 ways your family can help reduce pollution. Practice at least two of these methods for seven days and discuss with your counselor what you have learned.

(2) Determine 10 ways to conserve resources or use resources more efficiently in your home, at school, or at camp. Practice at least two of these methods for seven days and discuss with your counselor what you have learned.

(3) Perform an experiment on packaging materials to find out which ones are biodegradable. Discuss your conclusion with your counselor.



4. Choose two outdoor study areas that are very different from one another (e.g., hilltop vs. bottom of a hill; field vs. forest; swamp vs. dry land). For BOTH study areas, do ONE of the following:

   A. Mark off a plot of 4 square yards in each study area, and count the number of species found there. Estimate how much space is occupied by each plant species and the type and number of nonplant species you find. Write a report that adequately discusses the biodiversity and population density of these study areas. Discuss your report with your counselor.

   B. Make at least three visits to each of the two study areas (for a total of six visits), staying for at least 20 minutes each time, to observe the living and nonliving parts of the ecosystem. Space each visit far enough apart that there are readily apparent differences in the observations. Keep a journal that includes the differences you observe. Then, write a short report that adequately addresses your observations, including how the differences of the study areas might relate to the differences noted, and discuss this with your counselor.

5. Using the construction project provided or a plan you create on your own, identify the items that would need to be included in an environmental impact statement for the project planned.

6. Find out about three career opportunities in environmental science. Pick one and find out the education, training, and experience required for this profession. Discuss this with your counselor, and explain why this profession might interest you.

Contents

What Is Environmental Science?

Scientists ask questions about things they observe and then try to find out the answers. An environmental scientist asks questions about the environment and tries to learn the answers by observing and experimenting. While earning the Environmental Science merit badge, you will get a taste of what it is like to be an environmental scientist, as you make observations and carry out experiments to complete the activities and projects required for the badge.

The natural development of a living thing over time is its *natural history.* People who study natural history are *naturalists.*

From Nature Study to Ecology

People have always been curious about the natural world and have studied it in order to survive. Early humans learned which plants were good to eat and which ones made them sick. They learned the habits of animals that they hunted for food and how to avoid those animals that preyed upon humans.

Today, many people observe plants and animals in the wild as a hobby. Some go hiking to find rare wildflowers. Others keep binoculars and field guides near a window so they can identify the birds that visit backyard bird feeders. Because many people over the centuries have studied nature closely, much is known today about the natural history of plants and animals.

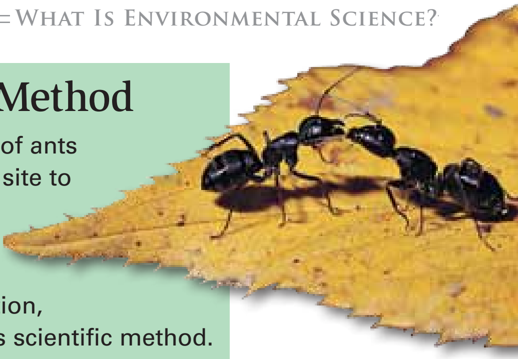
Plants and animals, however, do not live alone in the environment. A living thing's *environment* is made up of all of the living and nonliving materials around it, including plants, animals, air, soil, heat, light, food, water, and anything else that plays any role in its life. In addition, all plants and animals are connected to other living things.

The study of living things and their interactions with one another and with their environments is known as *ecology.* Scientists who study the interactions among organisms and their environments are *ecologists.*

They interact with one another and with the nonliving parts of their environment. Living things depend upon the materials found in their environment to survive. Anything that disturbs the environment may affect the living things found there.

Using This Pamphlet

An environmental scientist needs to know a great deal about living things, about their ways of life, and about the environment and its effect on life. For instance, an environmental scientist might study how the chemistry of soil affects ant behavior. Some other things that an environmental scientist might study include plants in a forest, makeup of rainwater, purity of air, and how many living things are found in a given environment. The activities in this pamphlet will introduce you to the wide range of subjects that environmental scientists study.



Steps in the Scientific Method

Imagine that you are watching a line of ants carrying pieces of food from a picnic site to an anthill. If you push the ants aside, they soon line up again. You want to know how the ants know where to line up. To try to answer that question, you follow a series of steps known as scientific method.

- First, you state the problem you want to solve—how ants know where to line up. Then you gather information about ants. Perhaps you do some research on ants in the library.
- Next, you form a hypothesis, that is, you formulate a statement or question that can be tested. Your hypothesis might be a statement such as: Ants know where to line up because they can see one another.
- You test your hypothesis by performing an experiment. In your experiment, you place food in one corner of a box and ants at the other end. When the ants have found the food and have formed a line to carry it, you disrupt the line, and then turn off the lights.
- Now you analyze your results. Did the ants line up again? If the ants lined up even in the dark, you might draw a conclusion that they do not need to see one another in order to line up, so your hypothesis is wrong. Your conclusion would be that ants must use some sense other than sight to line up. Sometimes, when the results of an experiment do not support a hypothesis, you can use what you learned to formulate a new hypothesis and carry out a new experiment to test the new hypothesis.

Not all hypotheses can be tested by doing an experiment in a laboratory. Some hypotheses are tested by observing events and collecting facts. You could test which kinds of birdseed a particular type of bird prefers just by observing what birds eat at several feeders.

The Roots of Environmental Science

American Indians used forests and other environmental resources for centuries before European settlers arrived on the continent. In the Pacific Northwest, tribes used forest materials to make cedar houses, boats, and clothing. In the Northeast and upper Midwest they built birch-bark canoes. Forests also were tremendous sources of food, both from plants and from wildlife.

At times, tribes overused certain forested areas. Sometimes they intentionally burned forests to clear land for cultivation or to make it easier to pursue game. If a forest became overused or too heavily damaged to support a tribe, the group would move on and the forest, left alone, would recover.

As more and more European settlers arrived in North America, their need for natural resources grew. They killed wildlife, cut trees, and contaminated the water near their settlements. When the pressure on natural resources in a settled area grew too great, people moved westward and began the cycle again. Settlers believed they could always move farther west to find more space and more resources.

Early on, however, some settlers realized that the abundant natural resources of this new land were not limitless. In 1626, Plymouth Colony passed a law to control the cutting and sale of timber on colony lands. People in Newport, Rhode Island, agreed in 1639 to restrict deer hunting to six months a year. In Pennsylvania in 1681, William Penn decreed that one acre must be left forested for every five acres of forest that were cleared.

By the 1830s, people such as artist George Catlin and naturalist Henry David Thoreau were writing about the need to preserve some of the unique environments of North America in national parks. People dedicated to environmental protection and wildlife conservation founded groups such as American Forests (1875), the Appalachian Mountain Club (1876), the New York Audubon Society (1886), the Boone and Crockett Club (1887), the Sierra Club (1892), the American Scenic and Historic Preservation Society (1895), and the Izaak Walton League of America (1922).

Government management of special areas can be traced back to the creation of the first national park—Yellowstone—set aside in 1872. Congress passed the Creative Act in 1891, designating much of the nation's publicly owned forests as protected forest reserves. The Forest Reserve Act of 1891 followed, changing the forest reserves to national forests and charging their managers with improving and protecting the nation's long-term supply of wood and water. The Bureau of Forestry became the Forest Service in 1905 when the forest reserves were transferred to the Department of Agriculture. In 1916, Congress established the National Park Service. The Park Service's mission is to preserve natural and cultural resources for the enjoyment, education, and inspiration of current and future generations.

In the decades that followed, forward-thinking agency personnel and a conservation movement made up of dedicated citizens established the idea of protecting some forests and other wilderness areas as reminders of the way they were before humans intervened and of balancing the use of public lands for recreation, timber, and biological resources. The Multiple-Use Sustained-Yield Act of 1960 officially established multiple-use management of the forests.

The Bureau of Land Management, the U.S. Army Corps of Engineers, the Fish and Wildlife Service, the Natural Resources Conservation Service, and other public agencies also strive to manage public lands that fall within their administrative boundaries. State and local agencies oversee smaller acreages of public lands. Private landowners with forested properties—from large forest-product companies to families with a few acres of trees around their homes—have a stake in the proper management of forest resources, too.

The Slaughter of the Bison

Huge herds of millions of bison, or American buffalo, were once a common sight on the Great Plains. By 1884, however, settlers had hunted so many of them that only 300 were left. The survival of the bison is largely credited to the efforts of Dr. William T. Hornaday, who led conservation efforts to protect the bison. Today, Scouts can earn the William T. Hornaday Award for distinguished service in conservation.

From Conservation to Environmentalism

During the late 1800s and early 1900s, people began to speak out about human activities that were causing serious environmental problems such as air and water pollution. American zoologist William T. Hornaday wrote about the need to protect wildlife in North America. In 1907, a scientific study by M. C. Marsh showed how fish were hurt by industrial wastes released into water sources. In 1962, Rachel Carson published *Silent Spring,* a book that discussed the dangers to the environment from using the pesticide DDT.

Carson and other people who wrote about the environmental effects of human activities helped make the public aware of environmental concerns. This public awareness led to the designation of April 22 as Earth Day. The first Earth Day in 1970 sparked an environmental movement in the United States. As a result, the U.S. Environmental Protection Agency (EPA), the Council on Environmental Quality, and many state and local environmental agencies were established. Today, many laws protect our air, water, land, and wildlife resources.

Activities designed to help you earn the Environmental Science merit badge can be found toward the back of this pamphlet.

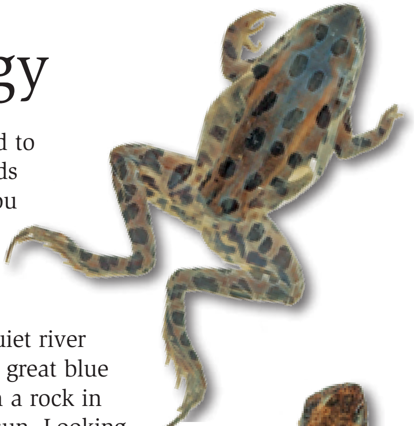
Boy Scouts and the Environment

In the early 1900s, as the conservation movement grew, two separate organizations for boys that focused on nature and the environment were founded. In 1902, the Woodcraft Indians was started in Connecticut by the naturalist Ernest Thompson Seton to preserve the wilderness knowledge of American Indians. As one of the foremost naturalists of his time, Seton spoke before the U.S. Congress in 1904 in support of legislation, which had been authored by William T. Hornaday, to protect migratory birds.

About the same time, Daniel Carter Beard, a former surveyor and engineer who became an author and illustrator, wrote a book titled *The American Boy's Handy Book*. In 1905, Beard founded a club called Sons of Daniel Boone to teach boys about nature, conservation, and outdoorsmanship.

On February 8, 1910, Seton and Beard merged their separate boys' clubs into the Boy Scouts of America. Publisher William D. Boyce founded this new organization. From its beginnings, the Boy Scouts of America had a strong foundation of woodcraft, nature study, and conservation. Many activities in Scouting come from activities of American Indians. Many of the principles that Scouts uphold come from the conservation ethics of Seton and Beard. The BSA has taught more than 45 million young environmentalists throughout its history. Currently, with more than 1.5 million active members, the BSA continues to train American youth in principles of conservation and environmental science.

Principles of Ecology



Although laws and agencies have been established to help protect and preserve nature, much more needs to be done. Before you can help protect nature, you must understand how it works.

Understanding Ecology

Imagine that you are standing on the bank of a quiet river in Florida. Along the banks of this river you see a great blue heron, an alligator, a rat snake, and a raccoon. On a rock in the river, a Florida red-bellied turtle basks in the sun. Looking down into the water, you see the long body of a fish called a gar gliding through slender leaves of eelgrass. Snails feed as they travel among the water plants. Here and there, whirligig beetles dot the water surface. Tiny duckweed plants float near the quiet banks. A bullfrog jumps from the river's edge and disappears into the water.

All of the living things in and around the river are connected in some way. Bullfrogs eat whirligig beetles. Herons eat bullfrogs, rat snakes, gars, and hatchling red-bellied turtles. Raccoons eat bullfrogs, insects, worms, and snails. Snails and adult turtles eat aquatic (water) plants. In nature, living things interact in many ways.

Living Things in the Environment

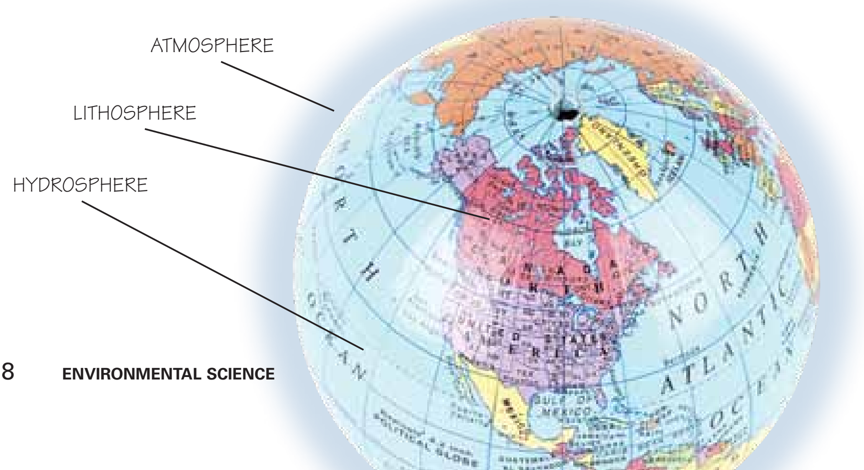
Snails, red-bellied turtles, and eelgrass are living things. All living things have the ability to reproduce, that is, to make more of the same kind of living thing. Living things also change during their lifetimes. They grow and develop and have a life span that eventually ends in death. Another important characteristic of living things is that they can usually adjust to their surroundings. They can respond to changes in their environments.

The organisms that live in and around a river in Florida include fish, amphibians, reptiles, birds, mammals, and plants.

Scientists call living things *organisms.* Think of all the millions of organisms that inhabit Earth. Organisms can be found in the deepest oceans and on the highest mountains. Some bacteria can even be found high in Earth's atmosphere. The part of Earth that contains and supports living things is known as the *biosphere.* The biosphere is all parts of Earth where life exists on land, in water, or in the air.

Within the biosphere are many different kinds of environments. Beaches, forests, glaciers, deserts, and rivers are environments. Every environment on Earth includes both the living things found there and the physical, or nonliving, environment

The regions that form Earth's biosphere include the atmosphere (air), hydrosphere (water), and lithosphere (land).



in which living things exist. Think about the living things in your own environment. No matter where you live, organisms surround you. You, the bacteria on your skin, your pet, the fleas on your pet, the spider in a corner, and the plants growing outside are organisms in your environment.

You have interactions with the bacteria, your pet, its fleas, the spider, and the plants, but these interactions are not the only ones in your environment. There also are nonliving things that influence the organisms in every environment.

Nonliving Things in the Environment

Let's go back to that Florida river you imagined before and think of nonliving things. You probably know that the water in the river is nonliving, but what about the wind? The sunlight? Rocks in the river? The soil that supports the plants growing at the river's edge? These are all nonliving things that interact with the living organisms in the river environment.

In your environment, the weather affects you and your pets. The soap you use when you shower affects the bacteria on your skin. Sunlight, temperature, rainfall, and minerals in the soil affect the plants outside. The important interactions between nonliving and living things determine which living things can share an environment with which nonliving things.

Let's look at four nonliving factors to find out how they affect the living things in an environment.

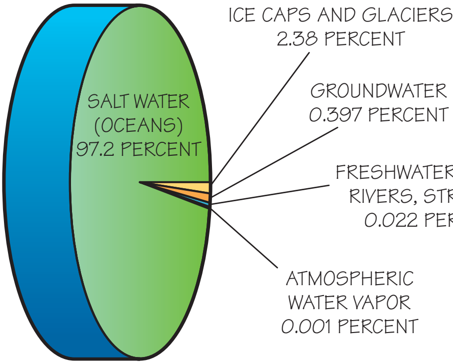
Water. Life on Earth would be impossible without water. The bodies of most organisms are 50 to 95 percent water. Water is necessary for many life processes, including respiration, photosynthesis, and digestion.

Water covers more than 70 percent of Earth's surface. But about 97 percent of the water on Earth is salt water contained in oceans. That means only about 3 percent is freshwater. Most of the freshwater is not available to living things, because it is frozen in the ice caps or glaciers. In fact, only a tiny fraction of Earth's water is freshwater that is available to organisms. This freshwater is in rivers, ponds, lakes, streams, underground water supplies (aquifers), or in water vapor.

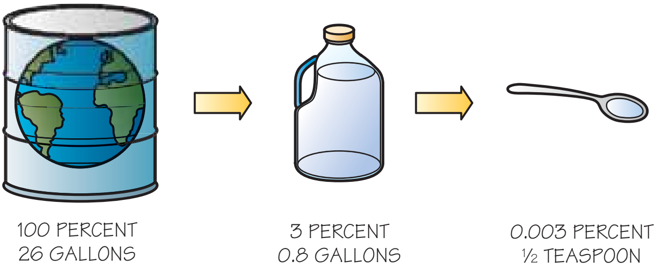
In photosynthesis, green plants, algae, and some other organisms capture the energy of sunlight and change it into a form of energy that they can use or store. Most of the energy that powers life in Earth's biosphere is made available through the process of photosynthesis.

Soil. Soil is formed by the physical and chemical breakdown of rocks and by the actions of living things. The breakdown of rock into soil releases minerals that organisms need for their life processes. These minerals return to the soil when organisms die and decay. Decayed material that once was living is called organic matter. The more organic matter in soil, the more fertile it is.

Soil determines the type of plant life that can grow in certain environments. Therefore, soil has an effect upon the other organisms that can live there, too. Among the factors that determine which organisms can live in a particular soil environment are the mineral and organic matter content, air content, and soil texture.



TOTAL WATER ON EARTH

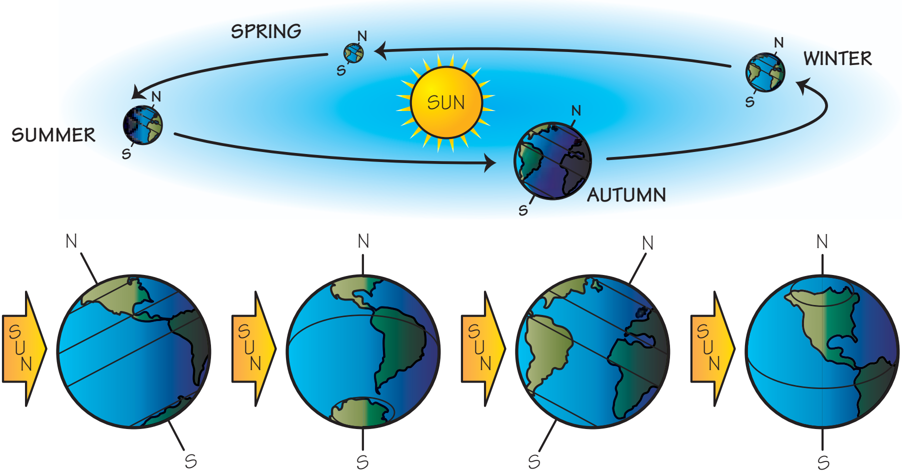


How much of Earth's freshwater is available for organisms? If you imagine that Earth has a total of 26 gallons of water, less than one gallon of that would be freshwater, and only half a teaspoon would be readily available to living things.

Sunlight. Nearly all living things depend upon the sun for energy, either directly or indirectly. Plants, algae, and some other organisms "trap" sunlight and capture its energy in the process of photosynthesis. Plants use this energy to power their life processes, or they store it. When a snail eats a plant, for example, the snail uses the stored energy in the plant to carry out life processes such as breathing and moving. When a raccoon eats the snail, the energy is passed along. Green plants, algae, and other photosynthetic organisms must live where there is sunlight. In aquatic environments, photosynthetic organisms can live only in the top layer of the water, where sunlight can reach the organisms.

Temperature. In general, the temperature of an environment depends on the amount of sunlight it gets. Air is heated more at the equator than at the poles. This is why tropical areas near the equator are hot, the polar regions are cold, and the regions in between have moderate temperatures. Temperatures also are affected by Earth's rotation, by winds and ocean currents created by that rotation, by the tilt of Earth on its axis (see the illustration), and by elevation. As you hike up a mountain, the air temperature drops. That is why it is possible to have a snowball fight on top of Mount Baldy at Philmont Scout Ranch in New Mexico in July!

Factors such as rainfall, sunlight, temperature, the nearness of large bodies of water (oceans), and elevation determine the climate (the general weather pattern) in an area.

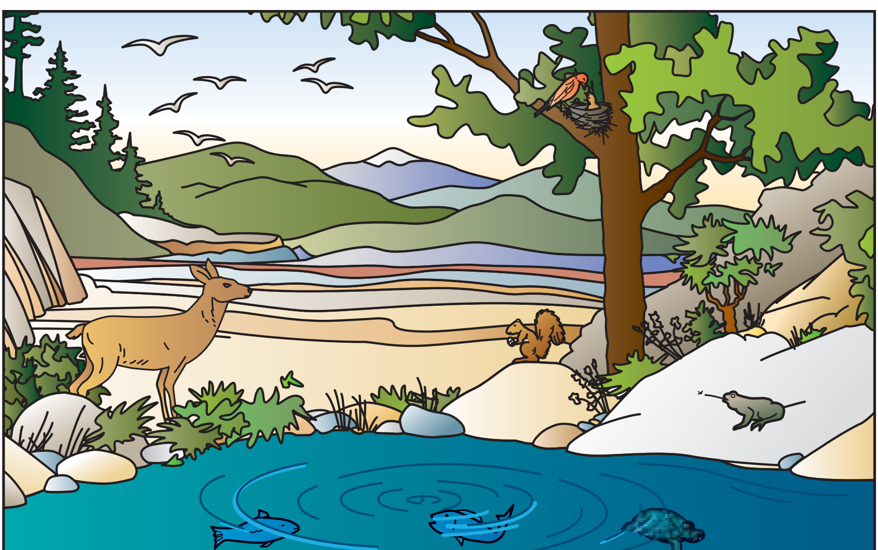


Earth's orbit

Interactions Among Living Things

Think again of the organisms living in a Florida river. There are several different species of turtles living there. A species is a group of organisms that has characteristics in common and can breed to produce offspring. For example, red-bellied turtles can mate with other red-bellied turtles to produce baby red-bellied turtles. In the river, there are at least three species of turtles—red-bellied turtles, cooters, and common snapping turtles. All the individual red-bellied turtles living in the river make up a population of red-bellied turtles. All the cooters make up a population of cooters, and all the snapping turtles make up a population of snapping turtles. You can see that the river environment contains many different populations of organisms.

Populations of organisms, of course, do not live alone in the environment. Most interact with other populations in a given area. The red-bellied turtles interact with the eelgrass (by eating it). The eelgrass provides hiding places for young fish and tadpoles. The great blue herons eat the bullfrogs. Populations are constantly changing in size, density, and age as they respond to changes in their environment. If the herons eat all of the adult bullfrogs in the river, for example, the population of bullfrogs will include only tadpoles and eggs.



A pond ecosystem

Groups of populations that interact with one another in a given area form a *community.* All the populations in a community depend upon one another for needs such as food and shelter. The populations of organisms that live together and interact with one another—such as herons, alligators, bullfrogs, insects, and turtles—form the Florida river's living community. The river, the soil along the bank, the rocks in the river, and the sun shining on the river are some of the nonliving factors in the environment.

The living community of the river, and the nonliving factors that affect it, form relationships that together make up an *ecosystem.* Ecosystems, such as a river, pond, forest, or desert, may be treated as separate parts of the environment.

The living community in a Florida river includes many populations that live together and interact with one another. The river, the soil along its bank, and the sun shining on the water are some nonliving factors in the environment.

Relationships Within Ecosystems

Within an ecosystem such as a Florida river, the actions of every species affect other species, populations, and communities. A rat snake feeds on small rodents, keeping the rodent population small enough that they do not eat all the plant seeds available. An alligator stirs up bottom mud, releasing worms and organic matter that other organisms use for food. Both rat snakes and alligators help maintain their ecosystems.

Niches and Habitats

A *niche* is the role of a species in its community. The niche of fungi such as mushrooms, for example, is not simply to get nutrients (food) from dead or dying trees but also to release those nutrients back into the environment in a form that other organisms can use.

Besides having a role within a community, organisms occupy space. For instance, you live in a house, an apartment, or some other type of shelter. In a river ecosystem, great blue herons roost high in trees along riverbanks. Common snapping turtles burrow into the mud at the bottom of a river. The place in which an organism lives is its *habitat.* An organism's habitat provides the organism with nourishment (food and water), shelter, protection from enemies, and the space needed for that organism to survive.

Within any habitat, the food, shelter, and other resources are divided into separate niches. For example, a Florida river is a habitat for both red-bellied turtles and bullfrogs. Adult turtles eat only water plants. Bullfrogs eat insects, snails, fish, and frogs. Because these two species eat different foods, they occupy different niches within the same habitat.

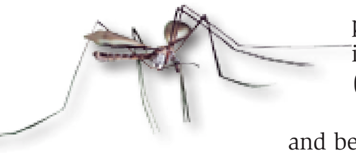
Feeding Relationships

Many of the relationships within a community are feeding relationships. That is because animals must eat to get the energy they need for life. Almost all the energy on Earth begins with the sun. Organisms such as green plants and algae trap the sun's energy during the process of photosynthesis. These organisms are called *producers.* All other organisms depend upon producers for energy.

Some organisms get the energy they need by eating plants and other producers. Mice and rats, for example, get their energy by eating plant seeds. Other living things get energy by eating organisms that eat plants. Rat snakes, for example, eat the mice and rats that eat plant seeds. Organisms such as mice, rats, and rat snakes are called *consumers.*

Organisms that break down dead plant and animal matter and absorb energy and nutrients from them are called *decomposers.* Bacteria, earthworms, and most fungi are decomposers. When they break down the bodies of dead organisms, they use some of the energy and nutrients for their own life processes but also return energy and nutrients to the soil as organic matter.

Producer, consumer, and *decomposer* are terms ecologists use for different niches within an ecosystem. These roles are important for an ecosystem to function. Ecologists further divide these niches into feeding relationships. You probably are already familiar with a feeding relationship known as the predator-prey relationship. Rat snakes, herons, alligators, and frogs all are



predators that eat prey. Other feeding relationships include parasite-host relationships, such as a mosquito (the parasite) feeding upon your blood (you are the host).

There are many other types of relationships within and between ecosystems. Sometimes, organisms of different species live together but do not feed upon each other. This is called *symbiosis,* which means "living together." Clown fish, for example, live among the stinging tentacles of sea anemones. These two animals have a symbiotic relationship. Scientists believe a clown fish develops immunity to the sting of a particular sea anemone. Yet predator fish are not immune, so the clown fish is protected from predators when it swims between the stinging tentacles of the sea anemone. The sea anemone benefits because the orange-striped clown fish, which is very noticeable and apparently safe swimming among the poisonous tentacles, lures in other species of fish. The sea anemone stings and eats the unsuspecting fish that come too close.

The sea anemone and clown fish have a symbiotic relationship—they are partners, helping each other survive.

Producer, Consumer, or Decomposer?

Which of these organisms are producers?
Which are consumers? Which are decomposers?

Cycling of Matter Through Ecosystems

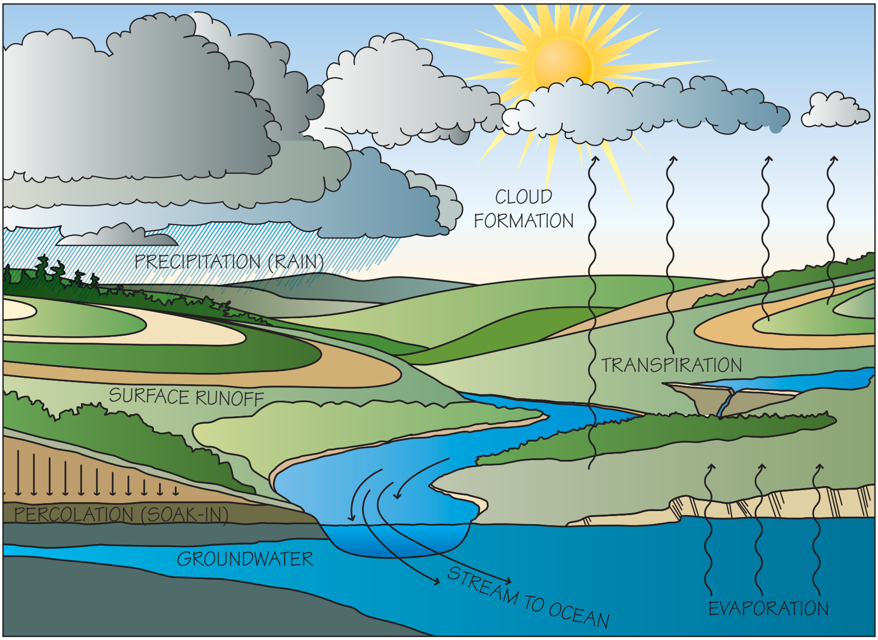
Every living and nonliving thing is made of matter. *Matter* is the physical material that moves through an ecosystem and is recycled in an ecosystem.

The Water Cycle

Energy from sunlight is constantly renewed or replenished in an ecosystem. Matter is not replenished. All of the physical material in your body and in the bodies of all organisms is the same matter that has been on Earth since life began. Let's see how these physical materials are recycled naturally in ecosystems.

Water circulates through the environment in a process known as the water cycle. Heat from the sun evaporates water from oceans, lakes, and streams that forms clouds of water vapor in the atmosphere. Eventually, the vapor condenses and falls as rain, snow, sleet or hail—called precipitation.

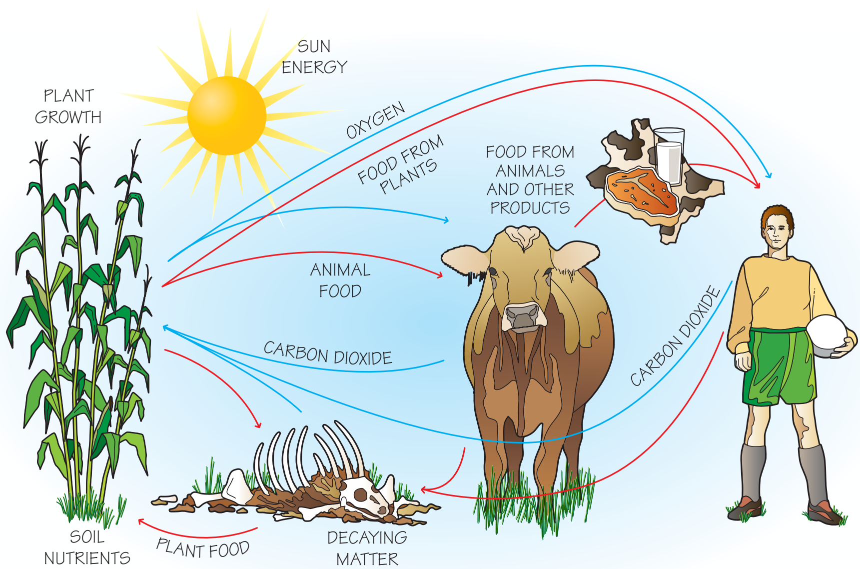
Of all the natural resources neccesary to the existence and comfort of all living things on Earth, water is the arguably the most important.



The water cycle

Some precipitation percolates into the soil where plant roots can absorb it. Some of the water seeps down through the soil and finds its way into aquifers (underground layers of porous rock that serve as natural storage areas for groundwater). Some rainwater finds its way into surface water such as streams and lakes. Surface water eventually evaporates, enters the atmosphere, condenses, and falls again as precipitation. Water is not used up; it is just reused over and over.

Living organisms also play a role in the water cycle. Plants absorb water from the soil through their roots and release water vapor into the air through a process called transpiration. Animals drink water directly from lakes and streams or get it from the foods they eat. Animals lose water through excretion. Both plants and animals also lose water to the atmosphere through respiration. When organisms die, their bodies release water to the environment as they decompose.



The oxygen-carbon cycle

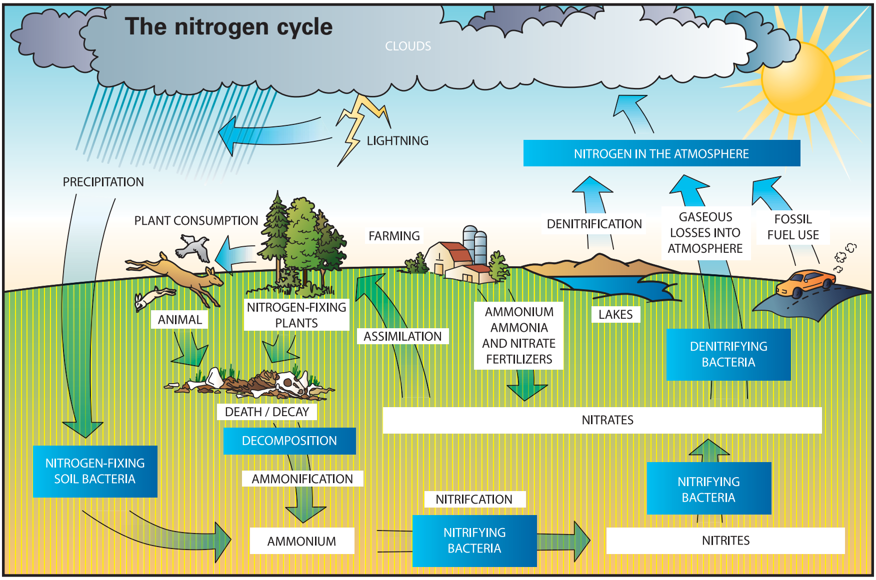
Carbon, like other matter, must be recycled through the biosphere for use by organisms.

The Oxygen-Carbon Cycle

All living things need carbon. Plants use carbon dioxide and water in the process of photosynthesis to make a type of sugar that living things use for energy. Consumers get carbon when they eat the producers and then use the carbon in their life processes. By breathing, animals release carbon dioxide into the atmosphere. Decomposers release carbon as they break down the bodies of dead organisms. The cycle begins anew as producers use the carbon from the air to make food.

Organisms do not always decay right away. They may fall into swampy or boggy areas with little oxygen. If decay happens without oxygen, eventually carbon may be bound into a fossil fuel—such as coal, oil, or natural gas. Scientists believe that tiny plants and animals that died thousands of years ago are what formed the fossil fuels we use today. The burning of fossil fuels returns carbon to the atmosphere in large amounts.

Some environments may have so little moisture or bacteria that they require an outside influence, such as a fire, to begin the decomposition process.



When organisms die and decompose, they release nitrogen into the atmosphere, soil, and water, and the cycle begins again.

The Nitrogen Cycle

Air is nearly 78 percent nitrogen. All living things need nitrogen, but most cannot use nitrogen in the air. Organisms need nitrogen in a form called nitrates, in which nitrogen is bonded to oxygen and another element. Nitrogen in the air is changed into nitrates by lightning and by certain soil bacteria or plants. Plants then take up the nitrates from the soil and pass them along to consumers.


OLD NORTH STATE
1954

Human Impact on the Biosphere

Think about the things you do every morning to get ready for school. You wake up as the sun filters through the window. You take a shower and put on your clothes.

Do you realize that you use natural resources every morning? The sun's energy is a natural resource. The water for your shower is also a natural resource, as is the soil that grew the cotton used to make your clothes.

What Are Natural Resources?

Natural resources are all of the living and nonliving factors in the biosphere, including nutrients, minerals, soil, water, organisms, and other resources made by natural processes on Earth. They are the materials that you and all living things use every day.

Some natural resources can be used over and over. Such resources are known as *renewable resources.* Natural processes replenish renewable resources. Renewable resources include fresh water, fresh air, soil fertility, forests, and elements such as carbon and nitrogen. Nonrenewable resources exist in limited amounts and are not replaced through natural processes. They include petroleum, coal, natural gas, copper, aluminum, and the products made from these resources.

Some resources are replaced so slowly by natural processes that they can be thought of as nonrenewable. Topsoil (the most fertile layer of soil) is an example of a resource that is renewable by natural processes, such as weathering, but topsoil formation takes so long that we think of topsoil as nonrenewable. It may take 500 to 1,000 years for one inch of topsoil to form.

Renewable or Nonrenewable?

Here are some items made from natural resources. Can you identify which of these are made from renewable resources and which are made from nonrenewable resources?

Problems With Resource Use

All organisms produce waste products. During photosynthesis, plants take in carbon dioxide and give off oxygen as a waste product. You breathe in oxygen and breathe out carbon dioxide as a waste product. When you eat a hardboiled egg or an orange, the eggshell and the orange peel are waste. Decomposers in the soil can break down eggshells and orange peels into the nutrients plants need. Orange peels, eggshells, oxygen, and carbon dioxide all are waste products, but they can be recycled in the biosphere by natural processes.

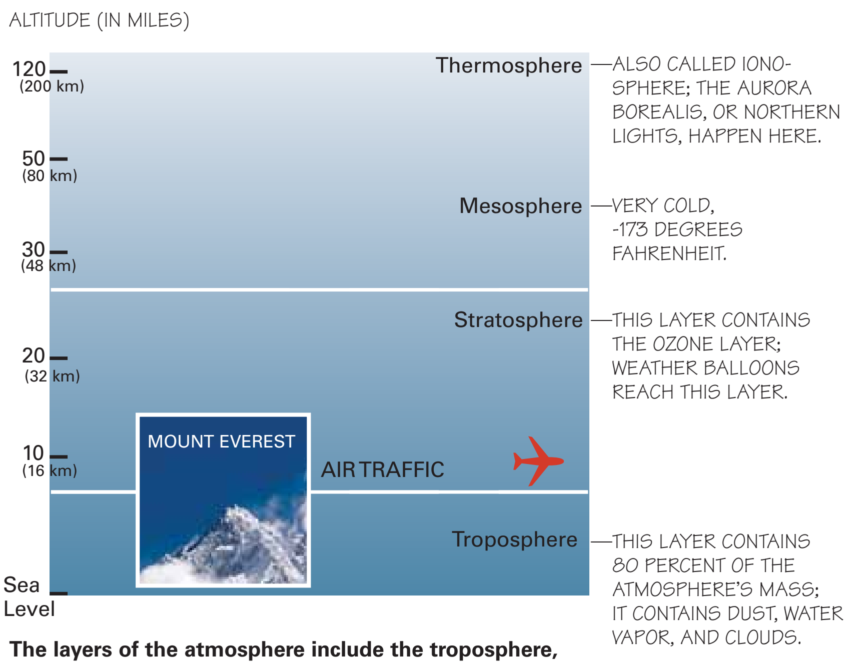
What happens when waste products are produced too quickly or in amounts too great to be recycled naturally? When waste products build up faster than they can be broken down, they become *pollutants.*

Air and Air Pollution

When you breathe, you exchange gases with the air. Animals, including humans, take in oxygen and breathe out carbon dioxide.

Air

The two most abundant gases in Earth's atmosphere are nitrogen and oxygen. Nitrogen makes up about 78 percent and oxygen another 21 percent. The remaining 1 percent consists of trace amounts of other gases, including carbon dioxide at 0.036 percent. Air also holds water vapor. Most of Earth's air is in the inner layer of the atmosphere, called the troposphere. Above the troposphere is the stratosphere.



The layers of the atmosphere include the troposphere, stratosphere, mesosphere, and thermosphere. Beyond the thermosphere is open space. The ozone layer is in the stratosphere.

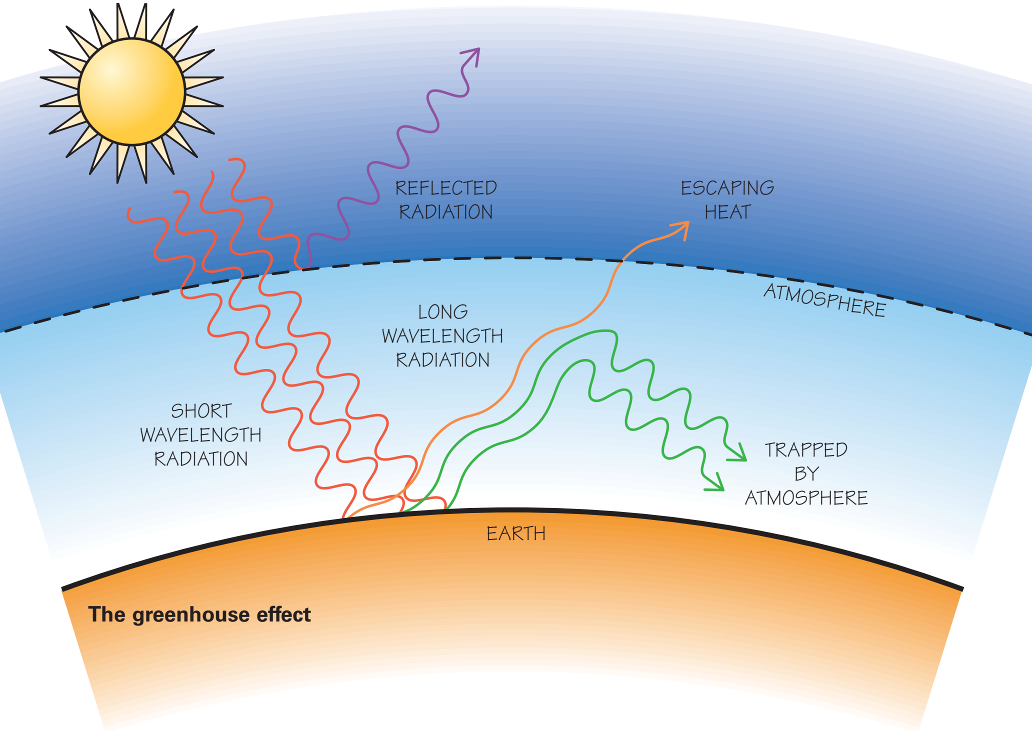
The ozone layer occurs between 6 and 25 miles above Earth.

The Ozone Layer

A gas called ozone forms in the stratosphere when oxygen interacts with lightning and ultraviolet radiation from the sun. Ozone is a form of oxygen that consists of three oxygen molecules bonded together; the oxygen we breathe consists of two molecules bonded together. Ozone is important because it prevents harmful ultraviolet radiation from reaching Earth's surface. Ultraviolet radiation harms humans and other animals by damaging the skin, eyes, and immune system. Excessive ultraviolet radiation also harms plants and aquatic organisms.

The Greenhouse Effect

Our climate is regulated by the greenhouse effect. Heat energy from the sun passes through Earth's atmosphere and heats Earth's surface. Some of this heat energy is radiated back up into the atmosphere, where greenhouse gases such as carbon dioxide in the troposphere absorb heat from the sun near Earth's surface. This heat is then reflected back to Earth. This natural phenomenon is known as the greenhouse effect, because the gases act like the panes of glass in a greenhouse, trapping the sun's warmth. Without the greenhouse effect, the whole world would be about the temperature of the North Pole.



The greenhouse effect

Air Pollutants

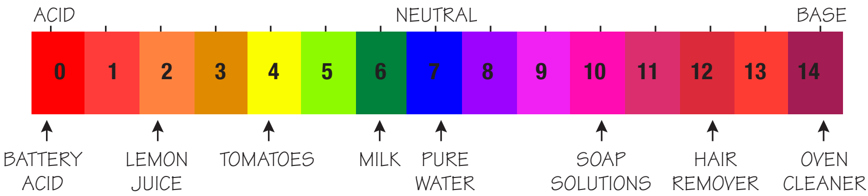
Some pollutants enter the atmosphere naturally. Volcanic eruptions, dust storms, and forest fires produce natural pollutants. For example, when Mount Pinatubo in the Philippines erupted, the ashes reduced the amount of sunlight that could pass through the atmosphere and slightly reduced Earth's average temperature for three years.

Human activities also cause air pollution. Most air pollution created by humans comes from burning fossil fuels for energy. For example, the smoke that comes from the exhaust pipe of a car or bus contains soot, ash, carbon monoxide, arsenic, sulfur, and nitrogen oxides as gases and particulates—tiny, solid particles of dust, ash, soot, or other visible pollutants in the air. Particulates interact with nitrogen oxides and other chemicals in the air to form a dangerous type of air pollution called smog (from "smoke" and "fog"). In cities with heavy traffic, the gases released by cars and trucks produce smog. Smog is especially dangerous for people with respiratory problems.

When studying sources of air pollution, such as the smoke from a factory, environmental scientists are concerned not only about the area immediately surrounding the factory, but also with a much larger area known as an airshed. An *airshed* is an area that, due to geography, weather patterns, and climate, shares the same air. Air pollutants travel. For example, a chemical you spray in your garden may be transported on air currents throughout the airshed around your house. In addition, how a pollutant is distributed through an airshed depends on the type of pollutant. For example, the way pollutants in car exhaust are distributed will be different from the way the pollutants from a forest fire are distributed. Scientists use computer models to try to determine how various pollutants affect airsheds.

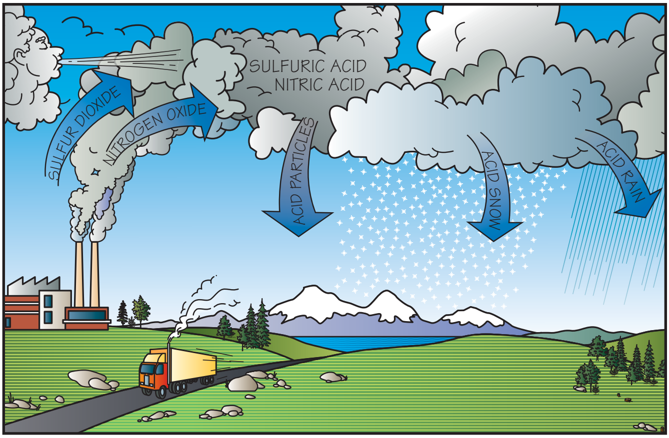
Acid Rain

Acidity is a property measured on a scale called the pH scale. The scale has a range of 0 to 14, with 7 being neutral. Pure water has a pH of 7. If a substance has a pH below 7, it is an acid. Rain is naturally slightly acidic, with a pH of about 5.6, because carbon dioxide in the atmosphere reacts with water vapor to become carbonic acid.

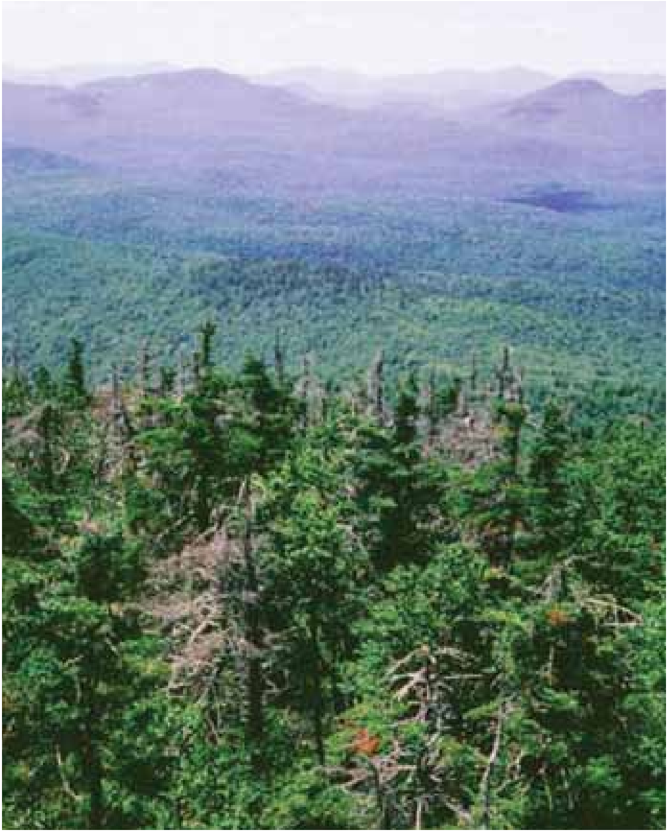


The pH of some common substances is shown on this scale.

Sulfur dioxide and nitrogen oxides are the primary causes of acid rain. When vehicles and power plants that burn fossil fuels emit sulfur dioxide and nitrogen oxides into the air, these gases interact with water vapor to form sulfuric and nitric acids.



Acid rain can deplete the soil of the nutrients that plants need to grow. When acid rain falls, it filters down through the soil and dissolves soil nutrients and other materials, moving them down to layers out of reach of plant roots.



These acids then mix with rain and fall to Earth's surface as acid rain. According to the U.S. Geological Survey, acid rain is rain (or any other type of precipitation) with a pH lower than 5.

Plants may die from acid rain or be weakened so that they are more easily harmed by other kinds of stresses in the environment, such as cold temperatures, insect damage, or droughts. Acid rain damages aquatic ecosystems by changing the pH of the water. Many aquatic organisms may die when acid rain falls into lakes and ponds.

Acid rain is a worldwide problem because the gases that make it may be produced in one state or country and be blown to another state or country by winds. Acid rain that falls in southeastern Canada and the northeastern United States, for instance, may begin with pollutants emitted by coal-burning power plants as far south as Tennessee.

Global Warming

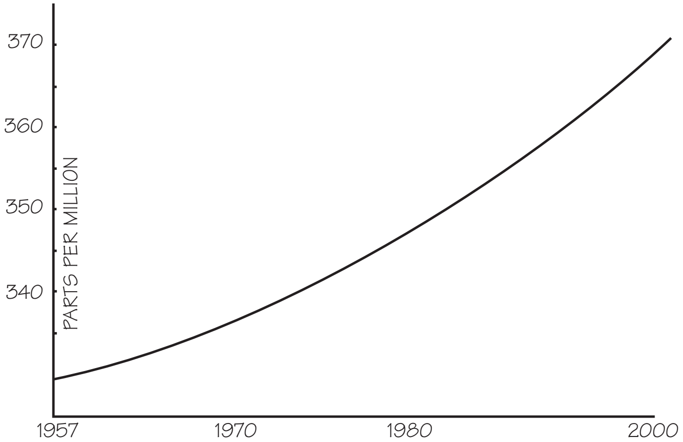
Earth's temperature is affected by various factors. We add heat to the air and water through thermal pollution. Increased particulates in the air reduce the amount of heat from the sun that can reach us, and increased greenhouse gases trap more heat on Earth. Since the mid-20th century, many scientists say, human activities have released more and more greenhouse gases—particularly carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons—into the atmosphere.

- *Carbon dioxide* is released during forest fires and in large amounts by the burning of fossil fuels, especially coal.

- *Methane* occurs naturally as a component of natural gas. It also is produced as bacteria decompose organic waste in the absence of oxygen. This gas traps more than 20 times as much heat as does carbon dioxide. Landfills, which contain large amounts of organic waste, are a major source of methane. Livestock such as cattle also produce methane during their digestive processes. The breakdown of animal manure from cattle, hogs, and poultry is another source of methane.
- *Nitrous oxide* is a pollutant that forms during forest fires, when coal is burned and when nitrogen fertilizers break down in soil. Nitrous oxide traps about 230 times as much heat as does carbon dioxide.
- *Chlorofluorocarbons (CFCs)* were once used as propellants in spray cans and as coolants in refrigerators and air conditioners. CFCs trap thousands of times more heat than does carbon dioxide. Most uses of CFCs are now banned. However, since it takes 10 to 20 years for CFCs to reach the stratosphere and, once there, they may persist for decades, CFCs will continue to affect the environment for some time.

CFCs and the Ozone Layer

Many scientists agree that CFCs also destroy ozone in the stratosphere, thus thinning the ozone layer and allowing additional harmful ultraviolet radiation to reach Earth. Increased amounts of ultraviolet radiation can damage or kill plant and animal cells. All organisms on Earth are at risk from the thinning of the ozone layer.



The amounts of carbon dioxide in the atmosphere have shown a general upward trend from the 1960s to the present.

All of these greenhouse gases have increased in the atmosphere as a result of human activities. Some scientists think greenhouse gases cause global warming, others believe that increased particulate emissions are cooling Earth, and still others believe that thermal pollution will have the biggest effect on global climate. Scientists who study global climate trends have records that show Earth's average temperature has risen 0.7 degree Fahrenheit to 1.3 degrees Fahrenheit in the last 100 years. Even though many scientists agree that global warming may be happening, they disagree about the damage that this warming might do.

Solutions to Air Pollution

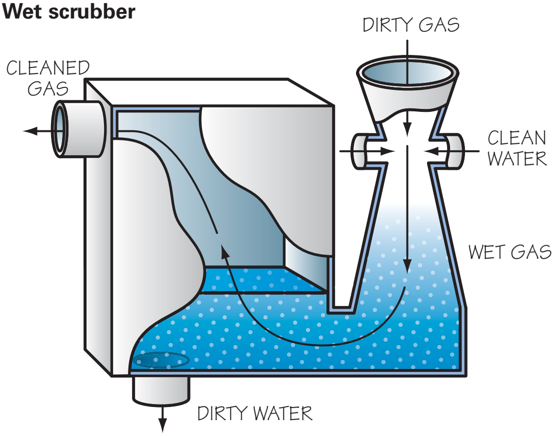
The Clean Air Act of 1970 created federal air pollution regulations that each state must enforce. Since this enactment, the United States has significantly lowered the levels of six major air pollutants including sulfur dioxides, nitrogen oxides, and particulates.

There are several ways that the nitrogen oxides, sulfur dioxides, and particulates that power plants and industries release into the air have been lowered. Some plants burn coal that has a lower sulfur content. Others remove the sulfur from coal or convert coal to a liquid or gas before it is burned. A third way to reduce greenhouse gas emissions is to use alternative sources of power, such as wind, water, or solar energy.

An added benefit of using alternative energy sources is that they can produce electricity without producing thermal pollution. When electricity is produced at either a fossil fuel– or nuclear-powered power plant, more than two-thirds of the energy in the source material is released as heat and not converted into electricity. This is a major source of thermal pollution in the world today. In addition, much study has gone into designing equipment such as filters, separators, and scrubbers that can be used inside smokestacks and exhaust systems to remove particulates.

Because cars and trucks produce high levels of nitrogen oxides, laws restrict the amount of air pollutants that vehicles may emit. A device known as a catalytic converter converts harmful pollutants created from the burning of gasoline into safer substances. States with smog problems require that cars undergo annual inspections to test emissions and fuel efficiency. Today, 99 percent of cars in the United States burn only unleaded gasoline, which has significantly reduced the amount of toxic lead in the air in the United States.

Wet scrubber



A wet scrubber removes hazardous particulates and sulfur dioxide gas from power plant emissions.

A growing number of people are buying hybrid vehicles. *Hybrid vehicles* use two different sources to produce energy. Currently, most hybrid vehicles use a small gasoline-powered engine and an electric motor with a special battery. Hybrid cars get significantly better mileage than most conventional gasoline-only vehicles, so they help conserve fuel resources. In addition, they emit only a fraction of the smog-producing pollutants that conventional vehicles emit.

Some auto manufacturers are developing zero-emission vehicles—vehicles that do not produce any air pollution. Vehicles powered by a *fuel cell* operate on electricity produced through a chemical reaction. The most common type of fuel cell relies on a chemical reaction between hydrogen and oxygen. The only by-products of the reaction are heat and water.

An easy way to reduce air pollution from vehicles is to not use them as much. You can practice *pollution prevention* by walking, biking, or carpooling.

Trip Chaining

Remember when you trip chain, you can help save the air in addition to time. Chances are, you and your family members already combine errands, which helps cut down on traffic congestion and saves gasoline. If you can, try cycling or using public transportation whenever possible.

How much mileage would you save by going from A → B → C → D → E → F → A rather than from A → B → A → C → A → D → A → E → A → F → A?

Wind energy, the fastest growing energy source, can reduce the need for power plants that burn fossil fuels.

Reducing the amount of fossil fuels we burn can have wide-ranging positive effects on the environment including cleaner air and water. It may also help reduce acid rain and slow global warming. Scientists suggest that using less fossil fuel, changing to renewable and alternative energy sources, protecting forests and replanting harvested trees, and slowing human population growth will all benefit the environment in the long run.

Water and Water Pollution

Pollution may enter a body of water directly or indirectly as runoff from a point anywhere in a body of water's watershed. A *watershed* is the region draining into a river, river system, or other body of water. Small watersheds make up larger ones. For example, the Mississippi River drains a watershed of about 1,243,000 square miles. Precipitation that falls at any point within a body of water's watershed will eventually drain into that body of water. Many kinds of pollutants can diminish water quality, including toxic metals, industrial waste, agricultural chemicals, household products, petroleum products, and heat.

Fertilizers

Chemicals used to fertilize lawns and crops may be carried by rainwater into lakes, streams, and other bodies of water. Pollutants such as fertilizers and pesticides that enter our water system from runoff are called *nonpoint source pollution* because the sources of the pollution cannot be traced to a single identifiable point. The phosphates in fertilizers are plant nutrients that crops need, but if they get into ponds and lakes, they cause overgrowths, or "blooms," of algae. The algae can cover the water surface, blocking life-supporting sunlight and killing some forms of pond life. When the algae die and decay, the decay process takes oxygen from the water, which in turn may kill fish and other organisms.

Pesticides

Chemicals that farmers, homeowners, and others use to control pests, such as insects, are called pesticides. Some pesticides kill only particular species, but others are toxic to many living things. Many of these toxic chemicals end up in the air, surface water, and groundwater. Pesticides in rainwater runoff kill millions of fish each year. Traces of pesticides can be found in nearly all of the freshwater fish in the United States.

DDT in the Food Chain

A pesticide called DDT was widely used in the 1950s and 1960s to kill mosquitoes and insects that harmed crops. But DDT also killed many beneficial insects and washed into bodies of water, where it was absorbed by tiny water organisms. Small invertebrates that fed on the contaminated organisms were affected next. Fish ate the contaminated invertebrates, and the fish were in turn eaten by birds. In this way, the DDT moved its way up the food chain. At each level, the pesticide became more concentrated as a result of a phenomenon known as *biomagnification.* DDT killed many insects, invertebrates, fish, and songbirds. The buildup of the pesticide in the bodies of larger birds, such as brown pelicans, bald eagles, and peregrine falcons, caused their eggs to develop thin, fragile shells. These thin-shelled eggs tended to break in the nest before the young were hatched, causing a rapid and drastic decline in the populations of these species. DDT's effect on birds received wide public attention when Rachel Carson published her book *Silent Spring* (1962), which helped rally public support for the ban of most uses of DDT.

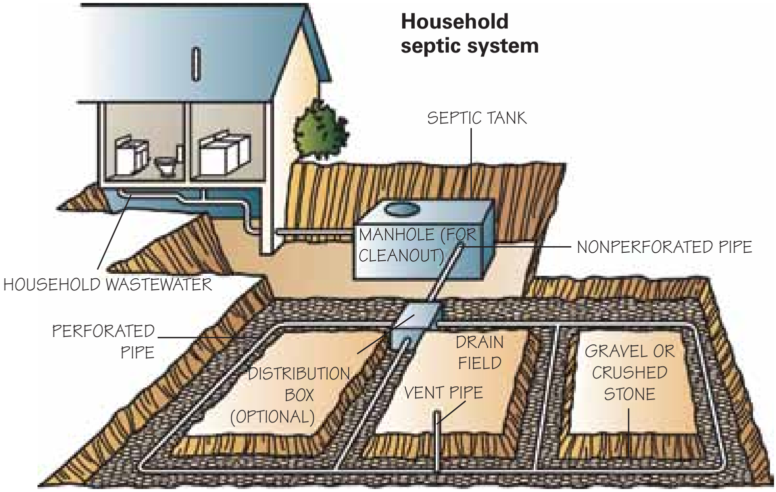
Hazardous household products include pesticides, paints, solvents, drain cleaners, oil, gasoline, and car batteries.

Toxic Metals and Industrial Pollutants

Mercury, lead, and other toxic metals that are mined or used in industry have contaminated bodies of water. These toxic metals as well as PCBs (synthetic chlorine compounds once used in paints, adhesives, lubricants, and electrical equipment) are also examples of waterborne pollutants that become more concentrated as they move up the food chain. Many states have issued health warnings because of the toxic metal content of native fish.

Household Products

Some chemicals used in household products also cause water pollution. When you clean the bathtub, for instance, the cleaning solution goes down the drain. What happens to the water then? If you live in a city or suburban area, that wastewater is piped to a water-treatment plant, where it is filtered and treated so that the pollutants can be removed and the water reused. In rural areas, wastewater may be piped into a septic tank. Eventually, water leaves the septic tank and filters down into the soil and back into the groundwater. When this wastewater contains more toxic chemicals than the soil can absorb, the chemicals also enter the groundwater.



Household sewage may be disposed of through a septic tank and leach field. Water and wastes spread over the leach field, where the soil filters out some chemicals and decomposers break down organic matter.

Petroleum Products

Petroleum (oil), gasoline, kerosene, and other petroleum products are a major source of water pollution. You probably have heard about oil spills at sea. Oil can devastate ocean ecosystems. It kills some organisms immediately. Others die more slowly as oil coats their feathers, fur, or skin. Some oil sinks to the ocean floor, where it kills bottom-living creatures. Even with expensive cleanup efforts, it takes three to 10 years for marine life to recover from the effects of an oil spill.

An oil spill or the emissions from a factory are considered *point source pollution* because the source of the pollution can be identified.

Thermal Pollution

Thermal water pollution occurs when water is taken from a river to cool a power plant. If the heated water is released back into the river, it raises the river's temperature. Thermal pollution of the water harms many aquatic organisms. It may hurt them directly or lower the amount of dissolved oxygen in water and make organisms more prone to the effects of damaging chemicals and attacks by parasites or disease.

Solutions to Water Pollution

Suppose you are out playing basketball. You get thirsty and run inside to get a glass of water from the kitchen tap. Where does that tap water come from? In the United States, most communities get their water supply from rivers and lakes or from underground aquifers. Before the water gets to you, it must undergo a treatment process to make sure it meets the standards for safe, clean drinking water that are set by the Environmental Protection Agency (EPA). Because water is so important to all life, we must protect water resources and prevent and clean up water pollution whenever possible.

When waterfowl fall victim to oil spills, immediate action is often the only thing that will save them. Specially trained and licensed wildlife rescue crews "shampoo" individual birds to remove the oil from their feathers. They also give the birds food, medical care, and a warm place to stay until it is safe to release them back into the wild. Such rescue efforts, however, can be very labor-intensive and costly.

Methods of Oil-Spill Cleanup

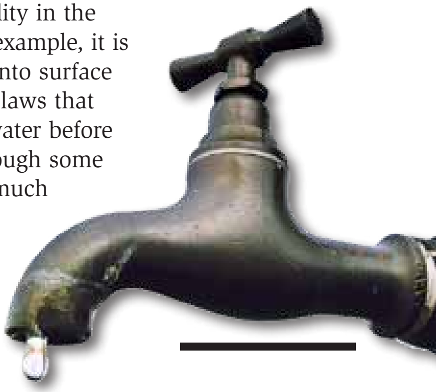
Here are some of the ways oil spills can be cleaned up.

- Bioremediation uses fertilizers to increase the population of oil-eating microbes. This process is very harmful to humans and animals in the first 24 hours after application. If animals cannot be restricted from the cleanup area, bioremediation should not be used.
- Booms are floating barriers used to contain and absorb oil spills. Their high-maintenance requirements can sometimes outweigh their effectiveness.
- Burning reduces large amounts of oil to a tarry residue. It requires favorable weather conditions and must be done within 72 hours after the spill occurs. Unfortunately, burning produces smoke that is poisonous to humans and animals.
- Chemical dispersants help scatter oil into larger volumes of water and help prevent oil from reaching shorelines. Dispersants must be mixed with oil, which requires good wave action.
- Hot-water washing works best on heavily oiled beaches, but hot water "cooks" all plant and animal life in its path, leaving beaches sterile.
- Skimmers collect oil from the water's surface. Under the right conditions, skimmers serve as one of the most environmentally sound forms of oil collection. However, like booms, skimmers are difficult to maintain.
- Oil-absorbing products and chemicals soak up oil. When they are removed from the area, the oil is removed with them. These products are often used to clean up oil on land but have also proved effective for oil spills in water.

Reducing Water Pollution

There are many ways to reduce water pollution. Farmers can keep fertilizer out of runoff by using only small amounts at a time or by switching to farming practices that require less fertilizer. They can cut their use of pesticides or switch to biological controls. For example, they might use natural predators, such as ladybugs, to eat insect pests.

There have been improvements in water quality in the United States thanks to the Clean Water Act. For example, it is against the law to discharge any toxic pollutants into surface waters. In addition, most states have now passed laws that require power plants and other factories to cool water before releasing it back into rivers and streams. Even though some sources of water pollution have been addressed, much more can be done.



Protecting Water Resources

One way to protect water resources is through conservation. We can conserve water by cutting the amount we use daily. Some scientists estimate that about 60 percent of the water people use is wasted through leaks, evaporation, and other losses that could be prevented. For example, the average leaky faucet can waste as much as 2,000 gallons of water a year—that's enough water to fill 40 bathtubs!

Currently, 40 percent of the world's people live with serious water shortages.

Industries and farms also waste water. Water used in crop irrigation is often not used efficiently. For example, irrigating crops in the heat of the day is wasteful because a significant amount of water evaporates before plant roots can take it up.

To save water, everyone needs to use less in his or her daily life. Installing low-flow showerheads and toilets and fixing leaky pipes and faucets are few ways you can conserve water. Farmers are switching to drip-irrigation systems, in which tubes deliver water directly to plant roots. Gardeners who live in arid climates might consider growing native plants that are adapted to dry conditions.

Land Degradation and Pollution

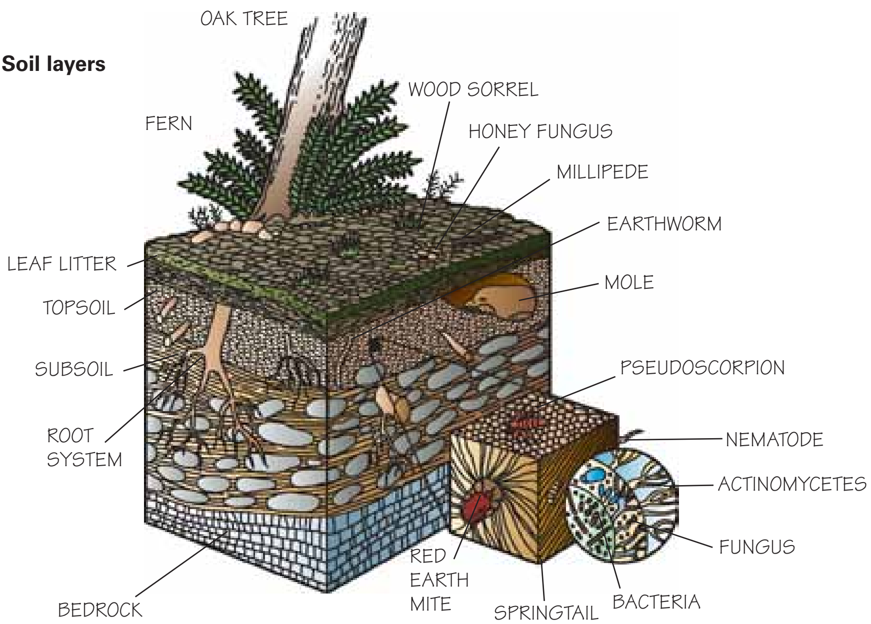
If you look closely at a shovelful of soil, you will notice that there is a lot more to it than you might have thought. Soil contains eroded rock, organic matter, water, air, minerals, nutrients, and organisms such as earthworms and other kinds of decomposers.

Soil

Soil has layers. The top layer, or litter layer, consists of leaves, twigs, fungi, animal wastes, and partially decomposed organic materials. The litter layer is thin and usually dark brown or black.

The next layer—the most fertile—is called topsoil. The depth and fertility of topsoil are factors that determine what kinds of plants can grow in a particular environment. Topsoil contains most of the roots of plants and most of the soil's organic matter and is the storehouse for water that plants need to grow. Decomposers, such as mushrooms and other fungi, in topsoil make nutrients available to plants.

Soil layers



In most soils, the layers include the litter layer, topsoil, subsoil, and bedrock.

Underneath the litter layer and topsoil is the subsoil. This layer consists of broken-down rock materials including sand, silt, clay, and gravel. This layer does not contain any nutrients or organisms that can support plant growth. Below the subsoil is bedrock, the unweathered rock that was broken down to make the soil.

Soil Erosion

Soil erosion is a natural process. Wind wears down mountains. Sediments, carried in rivers, build up deltas. Wind, water, and ice all contribute to natural soil erosion. However, the litter and topsoil layers of soil help prevent erosion because they contain plant roots and air spaces that absorb water. When plowing digs up roots or logging removes trees from the soil, topsoil becomes exposed to the natural forces of erosion. When topsoil is lost, the soil beneath it is often less fertile and unable to absorb water. Farming, logging, mining, construction, overgrazing by livestock, and burning forests all destroy the soil plant cover and speed up erosion. Today, soil is eroding faster than it forms on about one-third of Earth's croplands.

Signs of erosion and land degradation include the following:

- Mud and silt on sidewalks and driveways after a rain
- Exposed tree roots where the soil has been washed away
- Roadside ditches filled with sediment
- Muddy water in a stream or river
- Caved-in stream banks

Land Pollution

Paper and plastic bags, aluminum cans, glass bottles, orange peels, eggshells, old tires, old homework assignments, and worn-out clothing are just some of the trash, or *solid waste,* that people throw away every day. Garbage trucks across the United States collect 132 million tons of solid waste every year.

Most solid wastes are dumped in sanitary landfills and then covered with a layer of soil. Wastes such as grass clippings and spoiled food are *biodegradable,* that is, they were once living organisms, so natural processes can break them down. Wastes such as plastics or glass bottles are *nonbiodegradable*—natural processes cannot break them down. Nonbiodegradable wastes may last for hundreds or thousands of years. Sometimes, even biodegradable wastes in landfills do not decay because the oxygen that most decomposers need to begin the decay process does not reach the buried trash.

Each year, American office workers discard about 4 million tons of paper. That's enough to build a 12-foot wall from New York City to Los Angeles.

Currently in the United States, about 55 percent of solid waste goes into landfills; about 30 percent is recycled; and about 15 percent is incinerated, or burned.

Hazardous Wastes

You might think the garbage that households and businesses throw out makes up the largest percentage of solid waste, but more than 98 percent of solid waste actually comes from industries such as mining, agriculture, and oil and natural gas production. The solid waste produced by mining and many industries can pollute the air, water, and soil. Some solid wastes are hazardous because they contain toxic compounds or release toxic fumes.

Sometimes, hazardous wastes are buried in metal containers. Improperly contained, toxic substances can corrode through the metal and seep into the soil, eventually contaminating groundwater. Much of the groundwater in the United States has been contaminated with agricultural or industrial chemicals, or with oil and other petroleum products that have seeped into the soil and then into the groundwater. These wastes may be toxic to both animals and plants.

Hazardous wastes are any solid wastes that contain toxic compounds, are unstable, catch fire easily, or corrode metals.

With funding from the federal Superfund program, the Environmental Protection Agency is investigating and cleaning up more than 85,000 hazardous waste sites across the country.

An abandoned piece of commercial or industrial land that is contaminated (or is suspected of being contaminated) by a hazardous substance is known as a *brownfield.* Abandoned factories and gas stations are examples of brownfield sites. A real or perceived health danger makes it more complicated to redevelop the site for new uses. A new law, however, allows communities and developers to reclaim brownfields by working with the EPA to clean up the sites. The EPA determines how much cleanup needs to be done to make the site safe for its new use. Cleaned-up brownfields have been redeveloped for offices and stores. Some have even been turned into parks with bike paths and playgrounds.

If you take used motor oil to an oil recycling center, it can be cleaned and reused, which saves energy. Recycled oil can be used to generate electricity for homes and businesses.

Solutions to Land Degradation and Pollution

Loss of topsoil is one of the most serious land degradation problems today. Most of the topsoil that erodes in the United States comes from land used to raise crops or graze cattle. According to the Natural Resources Conservation Service of the U.S. Department of Agriculture, more than 5 billion tons of soil erode from pasture, rangeland, and cropland in the United States every year. Nearly five times as much soil erodes from cultivated cropland as from uncultivated land.

Soil Conservation

Farmers around the world have learned to use a variety of methods to conserve soil and prevent soil erosion on their fields. In the past, bare, newly plowed soil was often left exposed to winds and rain for months at a time. More recent farming practices, however, recommend that farmers leave a plant cover on the soil at all times. In no-till farming, special machines poke holes through the layer of organic matter left over from the previous crop and plant new seeds into the unplowed soil. Other kinds of sustainable farming practices reduce the need for fertilizers and pesticides and also improve the soil's ability to hold water.

Terracing *(left)* and contour strip-cropping are soil conservation practices that farmers use to help prevent soil erosion on fields.

Farmers in very hilly or mountainous areas conserve soil with terracing. Terracing creates level fields along the slope of a hill, preventing soil erosion and holding water for the crops. On more gently sloping lands, farmers conserve soil by contour farming. They plant crops in rows that go across the sloped land rather than up and down. In strip-cropping, farmers plant different crops in strips that alternate. Sometimes they plant crops that are grown as feed for livestock between rows of trees.

Stream banks can be protected against erosion by using plants, rocks, or structural measures. In woodlands, planting, thinning, pruning, and proper harvest techniques can help protect the soil and climate, maintain beauty, improve conditions for wildlife, and maintain cover for erosion control.

Using compost to help control erosion is a new technology being implemented in the United States.

Reduce, Reuse, Recycle

The three R's—reduce, reuse, and recycle—can be applied to decrease the amount of solid waste that human activities generate.

REDUCE

To *reduce* the amount of solid waste you throw out, simply do not bring home those materials in the first place. Buy loose fruits and vegetables rather than produce packaged in a plastic-wrapped foam tray. Choose items that do not use excess packaging materials.

To reduce the amount of organic matter that you throw away, put kitchen scraps and grass clippings into a compost pile. Over time, the material will decompose and become a nutrient-rich, organic fertilizer.

We all can change our habits to produce less waste just by being mindful of the things we buy. Industries, businesses, and government agencies have all begun to change the way they buy supplies and dispose of wastes. Reducing waste saves money and helps the environment.

REUSE

Every time you turn a piece of paper over to write on the back instead of using a new piece, you are *reusing* a resource. If you bring food home in plastic bags, you can reuse the bags to carry your gym clothes. If you use a paper cup to get a drink, you can reuse it to plant seeds for your garden. Plastic and glass bottles and containers that held food can be washed and reused over and over.

Industries and businesses also reuse materials. Some stores sell drinking water in reusable plastic jugs. Many hotels and motels offer guests the option to not have their sheets and towels washed every day, which saves water and energy.

RECYCLE

Paper, plastics, glass, and aluminum can be *recycled*—collected and used to make new products. Newspapers can be recycled into new newspaper. Glass can be crushed, melted, and molded into other glass items. Aluminum can be melted and formed into new cans. Plastics can be broken up, melted, and reformed into new plastic products. These recycling processes conserve our resources and reduce waste in landfills.

About 65 percent of all the aluminum beverage cans sold in the United States are recycled. It takes the same amount of energy to make one can from aluminum ore as it does to make 20 cans from recycled aluminum.

The Problem With Plastics

Most plastics are made from petroleum and are nonbiodegradable. Plastic items make up about 20 percent of all municipal solid waste. Plastics are more difficult to recycle because there are so many different types, and they must be separated according to type. Currently, it is cheaper to make new plastics from petroleum than to recycle most plastics. In addition, recycling often uses more energy than making new plastics. Therefore reusing plastic containers or, better yet, purchasing fewer plastic items reduces the amount of plastics in landfills more efficiently than recycling them.

Because paper products are made from trees, you help reduce the number of trees that need to be cut when you recycle paper. In the United States, about 40 percent of all used paper is recovered and recycled. Mexico, Thailand, Denmark, South Korea, and Taiwan all recycle at least 70 percent of their waste paper.

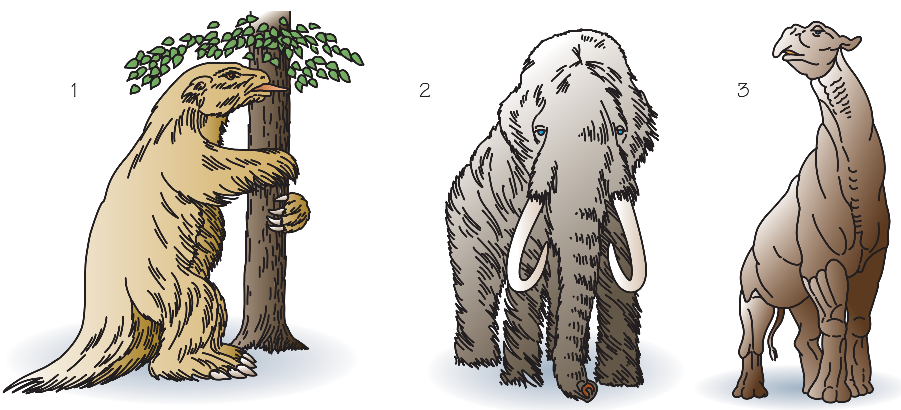
Hazardous Wastes

Because of the dangers hazardous wastes pose to the environment and the difficulties associated with their disposal, reducing the production of hazardous wastes is the most desirable goal. Various local, state, and federal laws regulate the disposal of hazardous wastes.

Some hazardous wastes can be treated to remove the toxic materials with biological controls such as bioremediation. When bioremediation processes are used, organisms such as plants and bacteria destroy hazardous wastes or make them harmless. Bioremediation is sometimes used to help clean up oil spills and to clean up streams and groundwater contaminated with hazardous waste.

Endangered and Threatened Species

During Earth's history, many species have become *extinct,* that is, all the individuals of a given species have died, and the species has disappeared from Earth. Scientists estimate that 99 percent of all species that have ever lived on Earth are now extinct. Some species, such as the giant ground sloth, died out gradually as the environment changed and the species was unable to adapt to the new conditions. Others, such as the Carolina parakeet, have become extinct because of human activities.

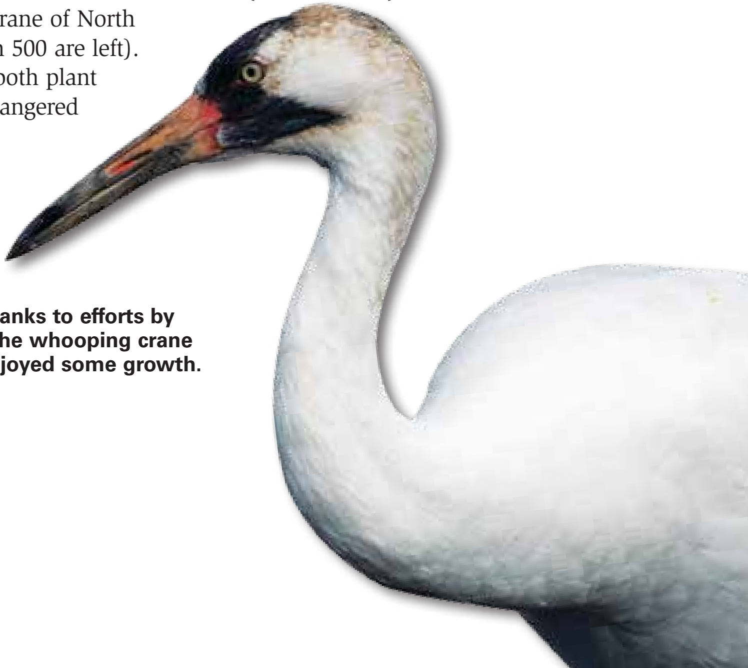


Three species that have become extinct are (1) the giant ground sloth, (2) the hairy mammoth, and (3) Indricotherium, the largest land mammal that ever lived.

The Last Passenger Pigeon

In 1810, an ornithologist (a scientist who studies birds) named Alexander Wilson saw a flock of passenger pigeons one mile wide and 240 miles long. He estimated that the flock was composed of more than 2 billion birds. Over the next 100 years, settlers destroyed much of the pigeons' forest habitat when they cut down trees to make farms and home sites. Hunters killed millions of the birds for food. The last passenger pigeon in existence died in 1914 in a zoo in Cincinnati, Ohio.

A species that has so few individuals left that it is in danger of extinction is called an *endangered species.* Some endangered species include the giant panda of China (only 1,600 left in the wild), the black rhinoceros of Africa (3,100 remain), and the whooping crane of North America (fewer than 500 are left). About 500 species, both plant and animal, are endangered in the United States.



In recent years, thanks to efforts by wildlife workers, the whooping crane population has enjoyed some growth.

Threatened species are species that are losing members at such a rate that they will become endangered if nothing is done to change the situation. African elephants are an example of a threatened species. Even though there may still be 500,000 elephants in the wild, this number is down from the 3 to 5 million of the 1930s. If people continue to illegally hunt African elephants for their ivory tusks, the elephants may become endangered.

Many species of manatee are endangered or threatened.

Causes of Extinction

Many scientists believe that the fossil record indicates that many species have arisen, dominated land or sea, and then become extinct. They believe that several times during Earth's history, there have been mass extinctions in which some catastrophe wiped out most of the then-existing species. During one such episode, scientists say, the dinosaurs died. Scientists believe that an outside event, such as the impact of a huge asteroid, caused most mass extinctions by changing Earth's climate.

On Earth today, however, extinctions are happening at an alarming rate as a result of human activities. Scientists estimate 50 to 200 species become extinct daily. Humans are severely damaging some of our critical ecosystems, such as tropical rain forests and coral reefs. Unfortunately, these two ecosystems have the greatest biodiversity of any ecosystems on Earth.

Threats to Biodiversity

The World Wildlife Fund has identified five key threats that contribute to decreases in biodiversity and increases in threatened and endangered species.

Habitat loss. The clearing of forests, prairies, and other wild lands for home building, farming, and other construction forces animal species that once lived in these places to move deeper into the remaining natural areas. With limited habitat remaining, significant population declines occur that threaten species' survival.

Introduced species. Introduced species are plant or animal species that are not native to a particular area. Introduced species compete with native species for nutrients, water, and space and may crowd out the native species. For example, during the 1930s farmers in the southeastern United States planted kudzu, a vine native to Asia, to control erosion. The kudzu vines choked out native plants and were so difficult to control they soon covered telephone poles and abandoned buildings.

Pollution. Pollution can damage an ecosystem and harm organisms. For example, an oil spill near a coastal area may wipe out entire populations of plants and animals in the affected area.

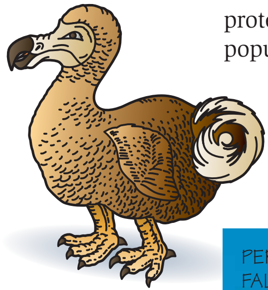
Population growth. Each year more than 90 million people are born, placing increasing strain on the natural resources that all life on Earth rely upon.

Overconsumption. Overconsumption refers to using up natural resources faster than they can be replenished. For example, if we use forest products such as paper faster than the forests can regrow, forest habitat that is critical for the survival of many species of plants and animals is lost.

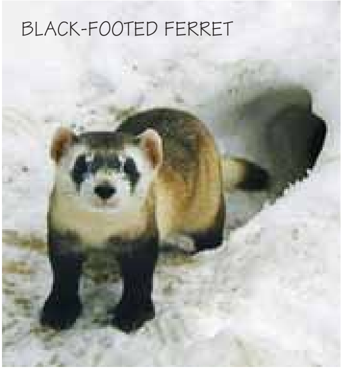
Extinction Solutions

Laws are now in place to preserve and manage endangered species' natural habitat. Recovery programs also have been developed to capture some of the individuals, help them reproduce in captivity, and then put them back into a suitable habitat. This approach is often used when there are only a few individuals of an endangered species remaining. Such programs have saved animals such as the American alligator and the California condor.

In addition, legally protected wilderness areas that preserve entire ecosystems have been set aside. National, state, and international parks and wildlife refuges have been established to protect wildlife. In the United States, the National Wildlife Refuge system includes more than 500 protected ecosystems. Most of these refuges are wetlands that are managed to protect migratory waterfowl, but every other organism in these ecosystems benefits from protection as well. Even so, protected wildlife sanctuaries make up only 6 percent of the land area worldwide. Regulated wildlife management programs protect species where hunting is allowed. They make sure populations of wild animals are not overhunted.



The dodo was a flightless bird that lived only on the island of Mauritius, near Madagascar. It was abundant there when sailors first arrived in the 1400s. The dodo was hunted for its meat and became extinct in 1680, less than 200 years after sailors first saw it.



Endangered species in the United States that are being bred in captivity and released to the wild include the peregrine falcon and black-footed ferret.

The Convention on International Trade in Endangered Species (CITES) is an agreement that went into effect in 1975. CITES bans commercial international trade of endangered species and regulates trade of other species that might become endangered. Some 28,000 species of plants and 5,000 species of animals are protected by CITES. More than 160 countries uphold this agreement.

Assessing Environmental Impacts

Now that you have seen how human activities affect the biosphere, you can begin to understand how hard it is to predict all the environmental effects of any construction project. What might seem like a simple project—building a new house, for example—may have many environmental impacts beyond simply disturbing the soil on-site. What happens to the moles and shrews that live in the soil? What happens to the red fox and the great horned owl that prey upon the moles and shrews? How will soil erosion from the site be controlled? Will the topsoil be saved and put back after construction?

Environmental Impact Statements

When a federal agency proposes new regulations or actions that may affect the environment, it is required by law to prepare an environmental assessment (EA) or an environmental impact statement (EIS). Federal, state, and local agencies and the general public may review the proposed activity before it begins. An EIS, which may be as long as 1,000 pages, must discuss five environmental concerns:

- The environmental impact of the proposed action
- Any harmful environmental effects that cannot be avoided
- Alternatives to the proposed action
- Short-term use of the environment versus maintaining and enhancing the environment's long-term productivity
- Any permanent commitment of resources

Taking Action

Now that you have completed most of the requirements for the Environmental Science merit badge, think about what you have learned. How are organisms and their environments connected in your community? What are some sources of air and water pollution in your community? What are some ways you can prevent pollution and conserve resources at home and at school?

Think Globally, Act Locally

As a Boy Scout, you are expected to leave your campsite cleaner than you found it. Wouldn't it be great if everyone on Earth felt the same way about protecting the environment?

Sometimes it may seem that environmental problems are too big for any one person to solve. But if each person starts doing things that will help the environment, it can make a huge difference. The more people become involved in preventing pollution and conserving resources, the better it will be for the environment.

Ten Ways to Reduce Pollution

- Walk, bike, or arrange to carpool with friends to cut down on air pollution.
- Pack your lunch in reusable containers instead of using foil or plastic wrap. Carry your lunch in a reusable nylon bag or lunch box instead of using a new paper bag each day.
- Use rechargeable batteries. Recycling programs for disposable alkaline are not widely available, so batteries end up as solid waste in landfills.
- Use environmentally friendly cleaning solutions such as baking soda and vinegar instead of chemical cleaning products.
- Recycle used clothing and household items by having a garage sale or taking them to resale shops.
- Volunteer to pick up trash in a park, at a beach, or along a river.
- Encourage your family to buy locally grown fruits and vegetables. Since locally grown food does not have to travel great distances, fewer greenhouse gases and other pollutants are emitted as the produce is transported from field to market.
- If you live in a house with a yard, suggest that your family not use chemical fertilizers on the lawn. Pull weeds by hand instead of using chemical weed killers.
- Use a rake instead of a leaf blower. Gas-powered leaf blowers produce as much air pollution as some cars.
- Keep organic matter out of landfills by making compost. Place leaves, grass clippings, raw kitchen scraps, and other plant material in a pile or a bin. Keep the pile moist and mix it regularly. Over a period of about six months, the material will break down and can be used in the garden as a replacement for chemical fertilizers.

Ten Ways to Conserve Resources

- Turn off lights, fans, radios, and televisions when leaving a room—even if you are going to be gone only a few minutes.
- Shut off the faucet when you are brushing your teeth or washing your face.
- Reduce, reuse, and recycle paper products, glass, aluminum, steel, and plastic items.
- Save water and energy by running the dishwasher and the washing machine only when they are full.
- If you wash dishes by hand, rinse them in a sink or dishpan of water rather than under running water.
- Ask your family's permission to lower the thermostat. If each American household were to lower its average heating temperature by 6 degrees over a 24-hour period each day, the equivalent of 500,000 barrels of oil would be saved.
- Suggest that your family eat fewer meals that include meat. The production and processing of grains requires far less water and land than does meat.
- If you notice leaky faucets or pipes, ask if you can help fix them.
- Ask your parents about installing water-saving showerheads in your home if you don't already have them.
- Have your family consider replacing incandescent lightbulbs with compact fluorescent lightbulbs. CFLs use 75 percent less energy and last 10 to 13 times longer than standard bulbs.

One very important thing you can do that will have long-range benefits for the environment is plant trees. Planting trees helps conserve forest resources and provide habitat for wildlife. Planting trees also helps counter air pollution. Like all plants, trees take in carbon dioxide for photosynthesis. More trees means less carbon dioxide enters the atmosphere. Contact a local conservation group and find out if your troop could help with tree plantings in a natural area that is being restored. Or ask permission to plant trees at your school or at a local park. You might even organize a class or school fund-raiser to protect tropical rain forests in Central and South America. Doing positive things like these makes you an environmental activist.

Even though laws restrict pollution, there are not enough law enforcement officers to watch every potential polluter. That is why private citizens, like you, must help protect the environment. After all, it is the air you breathe, the water you drink, and the land you inhabit.

The Outdoor Code

As an American, I will do my best to—
Be clean in my outdoor manners.
Be careful with fire.
Be considerate in the outdoors.
Be conservation-minded.

Environmental Activism

Suppose you organized your troop to clean up a local creek or plant 100 trees? You can make a difference.

How much of an impact would you make? Every time one person starts an environmental project, talks about it, advertises it, and then completes it, other people notice. They figure that if you can do it, so can they. This is how an environmental movement begins.

Careers in Environmental Science

Thinking about a career in environmental science? Environmental science is the study of how humans and all living things interact with one another and with the nonliving environment, so just about every scientific field involves environmental science.

To have a career in science, you must go to college and earn at least an associate's degree for a technical position, a bachelor's degree for a professional position, and a master's degree or doctorate degree for a research or teaching position. To work in environmental science, you may want to explore a career in the natural sciences, physical sciences, or engineering.

Occupations You Might Choose

Companies and agencies working in the fields of environmental science or conservation hire employees for a great variety of occupations. Government agencies from the U.S. Army Corps of Engineers to the Environmental Protection Agency hire scientists and managers to write and review environmental impact statements. Scientists and engineers work in government and industry laboratories to develop wind, solar, geothermal, and other alternative fuels to reduce our need for fossil fuels. Environmental lawyers help companies follow environmental laws. Environmental engineers design projects that are environmentally sound.

Manufacturers hire chemists, engineers, physicists, mathematicians, planners, and managers to develop more efficient manufacturing technologies, new environmentally safe products, and technologies to reduce, reuse, and recycle waste products. Other companies employ people to properly transport and dispose of municipal, agricultural, and industrial wastes.

The USDA Forest Service maintains the world's largest natural science research organization.

Scientists working in ecology, toxicology, physiology, meteorology, geology, and many other sciences develop products that are more environmentally friendly. They also research the environmental impacts of human activities.

Farmers, agronomists, entomologists, geneticists, water-resource managers, soil scientists, foresters, wildlife managers, and range managers help conserve wildlife, soil, and water resources through improved farming techniques and management of wildlife resources. They also help reduce the environmental hazards of pesticides by developing and testing pest-control techniques.

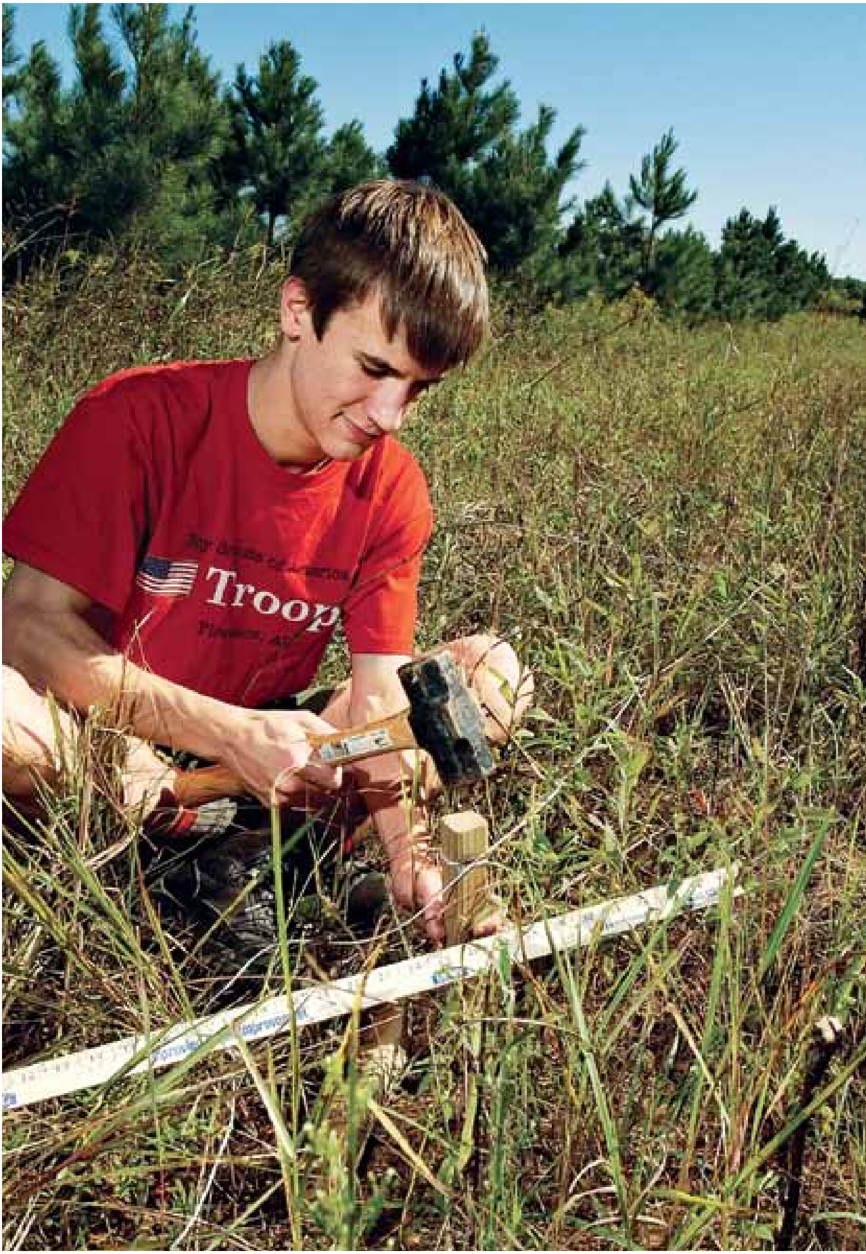
Oceanographers, fishery biologists, and fishery managers work on developing ways to maintain fish stocks and avoid overfishing and water pollution. Wildlife managers, zoologists, game managers, and naturalists work to preserve wildlife populations, breed endangered species, protect natural habitats, and reintroduce recovering species into the wild.

Landscape architects, land-use planners, and developers work to balance the needs of ever-growing urban and suburban populations with the need for wilderness and natural recreational areas. Teachers, writers, illustrators, television reporters, journalists, and many others who promote environmental education also are environmentalists.

Being an Environmentalist

Even if you do not choose a career as an environmental scientist, you can and should be a conservationist and environmentalist in your own life and in any career you pursue. You can bring an environmental awareness to the choices you make every day as a citizen, an employee, and a consumer. You can choose the environmentally friendly option when shopping, using resources, and disposing of wastes.

No matter what vocation you choose, remember to leave "your campsite"—our planet Earth—cleaner than it was when you arrived.


Troop

Activities in Environmental Science

These activities will help you fulfill requirements for earning the Environmental Science merit badge.

How Does the Environment Affect Living Things?

You have learned that the nonliving parts of the environment have important effects on living things. In this experiment you will learn how light affects earthworms.

PROCEDURE

Step 1—Cut the shoe box lid in half. Put half of the lid on the shoe box so that it shades one side of the box.

Step 2—Place a lamp next to the middle of the shoebox, close enough that it shines on the uncovered part of the box.

Step 3—Place 10 earthworms on the centerline of the bottom of the box so that the worms are half in the dark and half in the light.

Step 4—Observe the worms for five minutes. Note their behavior in your notebook.

Step 5—When your experiment is over, take the worms outside and return them to the soil.

OBSERVATIONS

1. What did the worms do at the beginning of the experiment?
2. How much time did the worms spend in the lighted part of the box? In the shaded part of the box?
3. What nonliving environmental factor does the lamp represent?

CONCLUSIONS

An organism's response to light is called *phototropism.* An organism that responds to light by moving toward it is said to be positively phototropic. An organism that moves away from light is negatively phototropic. Which type of response did your worms show? Why would earthworms react this way to light?

An Ecosystem Study

Every ecosystem involves complicated interactions between the environment and the organisms that live there. You have learned about some of these interactions. In this project you will use this knowledge to study an ecosystem.

Locate a beach, pond, lake, forest, meadow, undeveloped land, or other natural area outdoors. Choose two outdoor study areas that are different from one another. For example, a forest and a grassy meadow, or a sandy beach and scrub woodland, or a desert and a wetland.

Canada goose

Once you have selected your study areas, visit the sites and write your general observations in your notebook. Record the types of ecosystems, the weather, soil types, dominant species, and the season.

After making general observations about your study areas, select ONE of the following two projects to complete requirement 4. Before you begin your ecosystem study, get permission from the landowner. Tell your parent or counselor the location of your study area and when you are going to visit it. Consider going with a buddy.

Study Plots Activity

PROCEDURE

Step 1—In your chosen study areas, identify the ecosystem types.

Step 2—Begin at one of the two ecosystems you have selected. Using a yardstick, stakes, hammer, and a piece of string, mark out a shape, such as a square, that contains 4 square yards inside its boundaries. This is study plot 1.

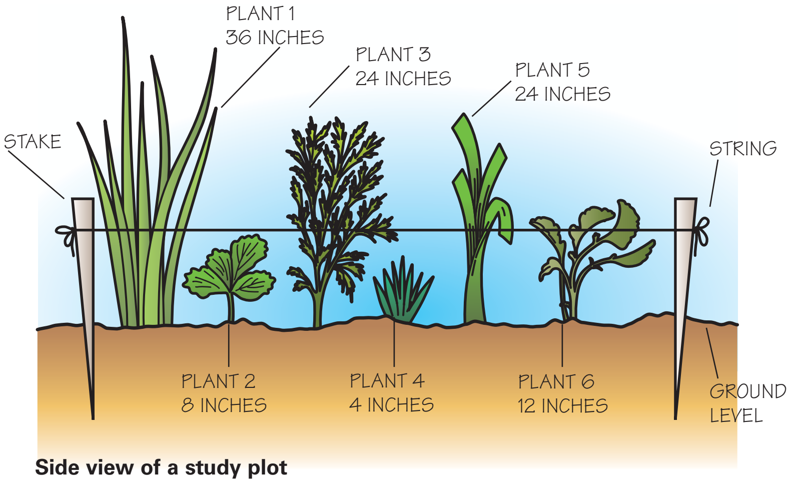
Step 3—Sit beside plot 1. Begin your study by writing in your notebook information about all the nonliving factors around you. Note the date, time of day, temperature, and whether it is sunny or cloudy, windy or calm, rainy or dry. If any of these factors change as you observe the plot, make note of the change. Note also whether the plot is flat or on a slope.

Step 4—Next, look at the living things in the plot. If you can see any nonplant species (fungi, insects, birds, etc.), note their common names or draw pictures in your notebook for later identification. Identify all the different plants you see. Use a field guide to identify each species by name, or make a drawing of each in your notebook. Use a magnifying glass, if needed, to see the features of each plant and nonplant species.

Step 5—Estimate how much space each plant species occupies in the plot. For example, in a grassy meadow, one species of grass might occupy about 90 percent (nine-tenths) of the space in the plot. Record this estimate next to the name of each species in your notebook.

Step 6—Using a yardstick, measure the height range of identified plant species and add the data to your notes. Use these measurements to draw a side view of your study plot. Try to draw the plants to scale. (See the illustration shown here.)

Step 7—Go to the second ecosystem. Repeat steps 1 through 6 for plot 2.



Side view of a study plot

OBSERVATIONS

1. How many nonplant species did you identify in each study plot? How many plant species?
2. What was the difference between the number of nonplant and plant species in the study plots?
3. Which plot was more biodiverse?
4. What, if any, species did you find in both plots?

Nature Study Activity

In this activity, you will make three visits to each of the two study areas, staying for at least 20 minutes each time to observe the living and nonliving parts of the ecosystem. Your results will vary depending upon when you choose to observe the area. Your visits must be spread out enough that your observations show differences between your visits.

PROCEDURE

Step 1—Decide on your schedule for visiting each of the study areas. Make sure your parent or counselor agrees with your plan.

Step 2—On your first visit, arrive quietly, making as little noise as possible. Find a good place to observe wildlife. Make yourself comfortable and have your notebook and pen or pencil handy. Note the date, time of day, temperature, and other information such as whether it is windy, calm, sunny, cloudy, rainy, or dry. Note whether your study area is flat or on a slope. Draw a small map of the area in your notebook, showing how it looks from where you are sitting.

Step 3—Once you are settled and have noted the environmental conditions, begin your observation period. Identify any plants you see (by using field guides or by drawing them in your notebook for later identification). Note the stage of life cycle for each plant species—that is, look for buds, leaves, flowers, seeds, and so on. Record these data in your notebook.

Step 4—Each time you see another species, write down its common name and describe its appearance or behavior. If you do not know its common name, make a drawing of it and note its size and color so that you can identify it later. If you have a camera (one that takes photographs quietly!), you may take photographs.

Step 5—Note and describe any sounds you hear. If you have a battery-operated recorder, turn it on and let it run for the 20-minute observation period. When an animal makes a sound, note the time in your notebook so that you can identify the taped sound later.

Step 6—If you have binoculars, try to identify nonplant species that are far away. For tiny organisms such as insects and worms, use a magnifying glass. Do not pick up or disturb any organisms. Your role is to observe, not to interact with living things.

Step 7—After your observation period of at least 20 minutes is over, mark your spot with a natural trail marker such as crossed sticks or a stone cairn. Collect your materials and leave quietly. Complete your notes by writing any other observations that you were not able to note during the study period.

Step 8—Visit the area and repeat your observations two more times, according to the schedule you set up in step 1. Be sure to observe from exactly the same spot each time.

OBSERVATIONS

1. During your study periods, which changes did you observe in the plant species that you identified?
2. At which times did you see more nonplant species (e.g., birds, insects, fungi) during your observation period?
3. How did the time of day or season affect your observations?
4. How did environmental conditions affect your observations?

CONCLUSIONS

Write a report, based on your observations. Include your general observations about the ecology of your study areas. Also include your findings and conclusions from your detailed study.

The Greenhouse Effect

This activity demonstrates how the atmosphere traps the sun's energy to warm Earth's surface.

PROCEDURE

Step 1—Using scissors, cut the tops off of two 2-liter soda bottles. Make your cut about 4 inches from the top. Label one bottle "A" and the other bottle "B."

Step 2—Pour 2 cups of garden soil or potting soil into each bottle.

Step 3—Place a thermometer inside each bottle. Make sure the thermometers are placed at the same distance above the soil in each bottle.

Step 4—Cover the top of bottle B with clear plastic wrap and secure it with a rubber band or tape.

Step 5—Place a lamp on a table, removing the lampshade to expose the lightbulb. Position each bottle exactly 1 inch from the exposed bulb. Be sure to turn the bottles so that the thermometers face away from the lightbulb. (You may need to shade the thermometers from direct light to get accurate readings of air temperatures.)

Step 6—With the light off, record the temperature in each bottle in your notebook.

Step 7—Turn on the lamp.

Step 8—Using a watch, wait three minutes, and then record the temperatures again. Record the temperatures in each bottle every three minutes for 15 minutes.

OBSERVATIONS

1. Did the temperature in each bottle change during your experiment?
2. Explain what the lightbulb and the plastic wrap represent in this model of the greenhouse effect.

CONCLUSIONS

Compare your experimental setup to real conditions on Earth. Using your data, explain why the greenhouse effect makes it possible for life to exist on Earth.

Air Pollution

In this experiment, you will observe some of the particulates that pollute air.

PROCEDURE

Step 1—Spread a thin film of petroleum jelly on two paper plates or two white 3-by-5-inch index cards. These will serve as your air pollution collectors.

Step 2—Place one collector in an urban environment, such as near a busy street. Place the other collector in a nonurban environment, such as in a field or a forested area.

Step 3—Protect each collector from precipitation by placing a cover above it or placing it underneath an overhanging roof or tree limb.

Step 4—Leave both collectors in place for one week.

Step 5—Retrieve the collectors. Using a magnifying glass, look at the surface of each collector to identify any particulates.

Step 6—Place a sheet of clear plastic, marked off in a grid of 1-inch squares, over one collector. Using the magnifying glass, count the number of particulates in four of the squares. Find the average number of particulates in a square and record this number.

Step 7—Repeat step 6 for the other collector.

OBSERVATIONS

1. What was the average number of particulates on the collector left in an urban environment? In the nonurban environment?
2. What do the particulates on the two collectors suggest about the level of air pollution in each environment?

CONCLUSIONS

Using your data, report what you learned about how particulates contribute to air pollution in urban and rural environments.

Acid Rain

In this experiment you will test the effect of acid rain on land plants.

PROCEDURE

Step 1—Label five potted plants of the same size and species with the numbers 1 through 5.

Step 2—Measure the height of each plant with a ruler, and record the heights in your notebook. Count the number of leaves on each plant and record this also.

Step 3—Use a magnifying glass to examine each plant. Draw each plant and color in any areas that show damage.

Step 4—Put on safety goggles and an apron to protect your eyes and clothing. Measure some distilled water and vinegar into five labeled bottles, using the proportions shown in the table.

Bottle number	Vinegar	Water	pH
5	1 cup	none	2
4	4 teaspoons	1 cup	3
3	3 teaspoons	1 cup	4
2	2 teaspoons	1 cup	5
1	none	1 cup	7

Step 5—Place all five plants in a sunny location. Water each one with the same amount of tap water. Do not overwater the plants.

Step 6—Spray plant 1 with bottle 1, plant 2 with bottle 2, plant 3 with bottle 3, plant 4 with bottle 4, and plant 5 with bottle 5. Make sure you spray the soil in each pot, because plants absorb water through their roots. Use the same number of sprays on each plant each time.

Step 7—Wait one day and examine each plant with a magnifying glass. Measure the height of each plant and count the number of leaves. Record these data.

Step 8—Repeat steps 6 and 7 every day for five days.

OBSERVATIONS

1. During the experiment, what kinds of changes did you see in the leaves of each plant?
2. Normal rainwater has a pH of about 5.6. How did the pH of the plants in the experiment compare to that of normal rain?
3. Explain why you drew a picture of the damaged areas on the plants' leaves before you began your experiment.

CONCLUSIONS

Use your data and observations to explain how acid rain affects land plants.

Cleaning Up Oil Spills

When an oil spill occurs in an aquatic environment, the first step in the cleanup process is trying to control the oil and keep it from spreading to coastal areas where it would affect many wildlife species. Waterfowl are especially vulnerable to oil spills. The oil coats the birds' feathers, causing their feathers to clump together and lose the ability to keep the birds insulated from the cold. Oil-soaked birds often freeze to death. Others die after consuming the toxins from the oil as they attempt to rid their feathers of the oil. At least a half million waterbirds die each year as a result of oil spills. In this experiment you can examine several methods that are used to clean up oil spills at sea and speculate upon which methods might work best to reduce the effects of the spill on waterfowl.

PROCEDURE

Step 1—Label four aluminum pie pans "A," "B," "C," and "D."

Step 2—Using a measuring cup, pour 1 cup of tap water into each pie plate.

Step 3—Measure 4 tablespoons of vegetable oil. Add 1 tablespoon of vegetable oil to the water in each pie plate.

Step 4—In pan A, use a plastic spoon to stir the oil into the water. Then, using a straw, try to blow the oil into one part of the pan. Be careful not to touch the water with the straw.

Step 5—In pan B, stir the oil and use a piece of string to try to collect the oil and contain it in one area.

Step 6—Stir the oil in pan C. Using a paper towel, try to absorb the oil. Then use strips of newspaper, cotton balls, and fabric scraps to try to absorb the oil. Record and compare how well each material worked.

Step 7—Stir the oil in pan D, then add 1 teaspoon of liquid dishwashing detergent to the water in the pan.

OBSERVATIONS

1. What happened to the oil and the water when you used a straw to blow the oil away? What conditions at sea might this represent that would make cleaning an oil spill more difficult?
2. How well did the string work to contain the oil in pan B?
3. Which of the materials used in pan C worked best to absorb the oil?
4. What happened when you added liquid dishwashing detergent to pan D? Can you explain why?

CONCLUSIONS

Scientists have developed many methods to clean up oil spills. In this experiment, you explored several. Explain which treatment worked best to clean up your oil spill. Would this type of treatment be practical in an actual spill at sea? Consider how cleanup methods might affect waterfowl and other organisms. Is a treatment better or worse for them than the effects of the spill itself? Compare the methods you used with the methods explained in the box about methods of oil-spill cleanup in the section "Human Impact on the Biosphere."

Thermal Pollution of Water

Recall that thermal pollution occurs when a source of heat raises air or water temperature above normal. The normal temperature ranges for our lakes and rivers are: above 68 degrees for warm water where most bass like to live; between 68 and 55 degrees for moderate water where salmon like to live; and below 55 degrees for cold water where most trout like to live. In this experiment you will discover if algae are sensitive to thermal pollution.

PROCEDURE

Step 1—Set up two 10-gallon aquarium tanks or other clear large containers. Place one of them in a location where it will not get above 60 degrees. Fill them both with tap water. Be very careful if you attempt to move a tank after you have filled it with water.

Step 2—Place a thermometer in each tank and add a heat source (aquarium heater, external lightbulb, or direct sunlight) to one of the tanks. This tank should be raised to a temperature over 70 degrees.

Step 3—Feed each of the tanks with enough fish food or liquid plant fertilizer to feed several fish or plants in the tanks. Record the date, time, and temperature of each tank in your notebook.

Step 4—Repeat step three several times each day for the next seven days. In addition to the above information also record any presence of algae growing on the sides of the tank in your notebook. Describe the algae and make a sketch or take pictures to show the growth of the algae.

Step 5—At the end of the experiment, be sure to clean the containers and remove the algae buildup.

OBSERVATIONS

1. Why did you feed the water in both tanks at the beginning and throughout the experiment? Why not just feed the heated tank?
2. What was the difference in temperature of the two tanks? What activities would increase the temperature of a river or lake near you by this much?
3. Did you notice any change (color, appearance, pattern, etc.) in the algae during the experiment? What do you think might have caused this?

CONCLUSIONS

Using your data, explain how thermal pollution may affect aquatic organisms. Recall what you learned about how fertilizers can promote algae blooms. Why is increased growth of algae bad for an aquatic environment? How would thermal pollution affect fish, water plants, or other organisms that cannot escape from the source of the heat? Can you speculate about the effects of thermal pollution in the air?

Soil Erosion

In this experiment you can find out how soil erosion happens and learn about one way to prevent soil erosion.

PROCEDURE

Step 1—Get permission before you dig up any soil for this experiment.

Step 2—Place cut-up strips of newspaper into a bucket and fill the bucket with water. Stir occasionally. Leave the newspaper in the water until it falls apart and becomes a mushy mix of paper and water. This may take a few days.

Step 3—Build three long, narrow boxes out of wood, shoe boxes, or plastic or metal pipe. If you use cardboard, line the boxes with plastic bags or foil and cover any seams with adhesive or duct tape to prevent leaking.

Step 4—At one end of each box, cut a large V-shaped notch about half as deep as the end wall of the box. Label the boxes "1," "2," and "3."

Step 5—Fill boxes 1 and 2 with garden soil so that the surface of the soil is about half an inch below the top edges of the boxes.

Step 6—Fill box 3 with soil that has grass growing on it. Make the soil surface about half an inch below the top edge of the box.

Step 7—Drain off the water from the newspaper mix. Take a handful of the mush, squeeze out more water, and spread this on top of the soil in box 2. Continue to do this until the surface of the soil in box 2 is covered with the newspaper mixture. Let it sit overnight.

Step 8—The following day, line up the three boxes in a row. Place a brick, large rock, or book under the uncut end of each box. Place a collecting pan, jar, or cup under the lower end of each box below the cutout V. Photograph or make a drawing of each box.

Step 9—Fill the watering can with a measured amount of tap water. Standing at the higher end of box 1, sprinkle the water on the soil surface until the can is empty. Wait about three minutes until the water stops running from the V notch, and then observe the water that collects in the pan, jar, or cup. Measure the amount of water and note its color. Record the data in your notebook.

Step 10—Repeat step 9 for boxes 2 and 3, using the same amount of water each time. Photograph or make a drawing of each box to show the changes.

OBSERVATIONS

1. Describe the differences in the path the water took in each of the three boxes.
2. How much water ended up in each collecting pan after three minutes? What was the color of the water in each collecting pan?
3. How did the color and the amount of water differ in each collecting pan after three minutes?
4. How much soil ended up in each collecting pan?
5. The newspaper mixture used in box 2 resembles a mixture sprayed on bare soil at construction sites to prevent erosion. Based on your experiment, why do you think this is a good idea?

CONCLUSIONS

Using your experimental data and photographs (or drawings), show your results on a poster. Present your poster to your counselor.

Biodegradable Packing Materials

Items purchased online or from mail-order catalogs are shipped in boxes and protected with packing materials that range from plastic bubble wrap to popcorn. Packing materials sometimes end up as litter along roadsides or take up space in landfills. In this experiment, you will find out which packing materials are biodegradable.

PROCEDURE

Step 1—Label four resealable plastic bags “1,” “2,” “3,” and “4.”

Step 2—Pour a cup of sand into each plastic bag. Then add a cup of garden soil to each bag. Carefully mix the sand and soil by squeezing the mixture in each bag.

Step 3—In bag 1, place six small strips of newspaper.

Step 4—In bag 2, place six foam packing peanuts.

Step 5—In bag 3, place six pieces of unbuttered, unsalted popped popcorn.

Step 6—In bag 4, place a small piece of plastic bubble wrap.

Step 7—Fill each bag almost to the top with garden soil. (Leave enough space to allow the bag to be closed.)

Step 8—Pour half a cup of tap water into each plastic bag.

Step 9—Close each bag. Place all four bags near a sunny window.

Step 10—After two days, open the plastic bags, stir the soil, add half a cup of tap water, and reclose the bags.

Step 11—Wait three more days, then empty each bag onto a sheet of newspaper and look for the packing materials in each. Use a magnifying glass to examine each material.

OBSERVATIONS

1. Which packing materials showed signs of decomposition?
2. Which do you think were biodegradable? Which were nonbiodegradable?
3. Explain the differences between the materials that are biodegradable and the ones that are nonbiodegradable.

CONCLUSIONS

Based on the results of this experiment, make a statement about which kinds of packing materials are biodegradable and would create less solid waste. What other kinds of biodegradable packing materials would protect fragile items during transport?

Oil Pollution on Land

What happens to the oil that leaks out of engines onto asphalt parking lots? When it rains, that oil is washed onto the soil, where it seeps down toward plant roots. Do this experiment to find out how oil pollution on land affects plants.

PROCEDURE

Step 1—Set out a pitcher of tap water for 24 hours. Obtain four small potted plants, such as pansies or another fast-growing annual flower. Label the pots "A," "B," "C," and "D."

Step 2—On day 1, place the four plants in a sunny window. Water each plant with the same amount of tap water from your pitcher.

Step 3—Use a ruler to measure each plant. In your notebook, record their heights, number of leaves, and any other important characteristics you observe.

Step 4—Pour 1 teaspoon of motor oil on the soil of plant B, making sure not to get any oil on the leaves. Pour 2 teaspoons of oil on the soil of plant C. Pour 3 teaspoons of oil on the soil of plant D. Do not put any oil on the soil of plant A.

Step 5—On day 2, water each plant with half a cup of water from the pitcher. Do not overwater the plants.

Step 6—Examine each plant daily for the next three days. Write your observations in your notebook. On day 3, again measure the height of each plant and record the number of leaves. Also record in your notebook any color changes.

Step 7—At the end of your experiment, dispose of the soil contaminated with oil. Contact your local EPA offices or hazardous waste agency to find out where to take the soil for proper disposal.

OBSERVATIONS

1. Why was it necessary not to put any oil on the soil of plant A?
2. Why water the plants after pouring oil on the soil? What environmental conditions did this action imitate?
3. What kinds of effects did you see in the plants that were treated with oil?

CONCLUSIONS

Oil is one of many toxic substances that can be absorbed by soil. Explain why it is important to keep cars maintained so they do not leak oil, and to collect used oil from gas stations and garages for recycling.

Endangered Species

Endangered species can be found in every state and in most countries around the world. Find out about endangered species by doing this activity.

PROCEDURE

Step 1—To research the endangered and threatened species in your state, contact your state's departments of fish and game, wildlife, or parks and recreation, or your environmental protection agency. The U.S. Fish and Wildlife Department reports the endangered and threatened species by state. For more information, see the resources section at the end of this pamphlet.

Step 2—List the endangered or threatened species in your state. Choose one species to study.

Step 3—Go to the library or access the Internet (with your parent's permission) to find information about your chosen species. Use at least four different reference sources. Research hint: Ask your librarian if the library offers access to magazine-article databases such as ProQuest or EBSCOhost.

Step 4—Find out what the natural habitat of the species is, why it is endangered or threatened, and how many individual organisms of the species are estimated to still live in the wild. If the species is now protected by state or federal law, explain how this protection has helped the species survive and what else needs to be done to protect the species.

Step 5—Prepare a 100-word report on your endangered species. Make a drawing of your species to include in your report.

Step 6—Present your report to your patrol or troop.

How Does an Endangered Species Recover?

Sometimes a commitment of time, money, and other resources can bring a species back from the edge of extinction. In this activity, you will research one such species and learn its recovery story.

Bald eagle

PROCEDURE

Step 1—Using resources you have found at the library, at home, or on the Internet (with your parent's permission), make a list of endangered species that have recovered. You could write to the World Wildlife Fund and other organizations that focus on plant or wildlife conservation. See the resources section at the end of this pamphlet for more information.

Step 2—Choose one species that has recovered from near-extinction and research how it recovered. Find out what is the status of the species today.

Step 3—Write a 100-word report on the species.

Step 4—Discuss your report with your counselor.

Environmental Impact Assessment

In this activity, you will identify the items that would need to be included in an environmental impact statement for a hypothetical (imaginary) construction project.

PROCEDURE

Step 1—In your notebook, describe a construction project that might be proposed for your community by your local or state government. Suggested projects include building a new highway or bridge in a rural area; building a new school or library on farmland; building a bicycle path or nature trail in a wooded area; or paving over a vacant lot for parking cars. Include a description of the size and nature of the project and how the community will benefit from it.

Step 2—Choose a suitable site for your project and visit it. (The project is imaginary, but the site must be a real place.) Record the following data for the project site:

a. What types of plant and animal life are at the site?

b. What type of ecosystem (forest, grassland, desert, etc.) is it?

c. Has it been disturbed before?

d. Is it a habitat for an endangered or threatened species?

e. Does it slope? Would the soil be in danger of erosion during construction?

f. Are there streams or wetlands such as swamps at the site?

g. Is there reason to believe important fossils or artifacts are at the site?

h. Are there activities on lands next to the site?

Step 3—Describe how the proposed project fits into existing plans for the area. For example, is the site the last empty lot in a housing subdivision? If you are planning a highway, would it cut through a state or local park? Will a bike path allow area residents to bicycle to school or work rather than drive cars?

Step 4—Suggest ways the proposed project will likely affect the environment. Answer the following questions:

a. Will the project cause soil erosion?

b. Will it disturb forests, grasslands, deserts, or other ecosystems?

c. Will it disturb any habitats of endangered or threatened species?

Step 5—Identify any effects of the project that probably will be harmful but cannot be avoided. A bridge over a river to connect two existing roads, for example, probably cannot be built elsewhere, so the project's negative effects may have to be accepted.

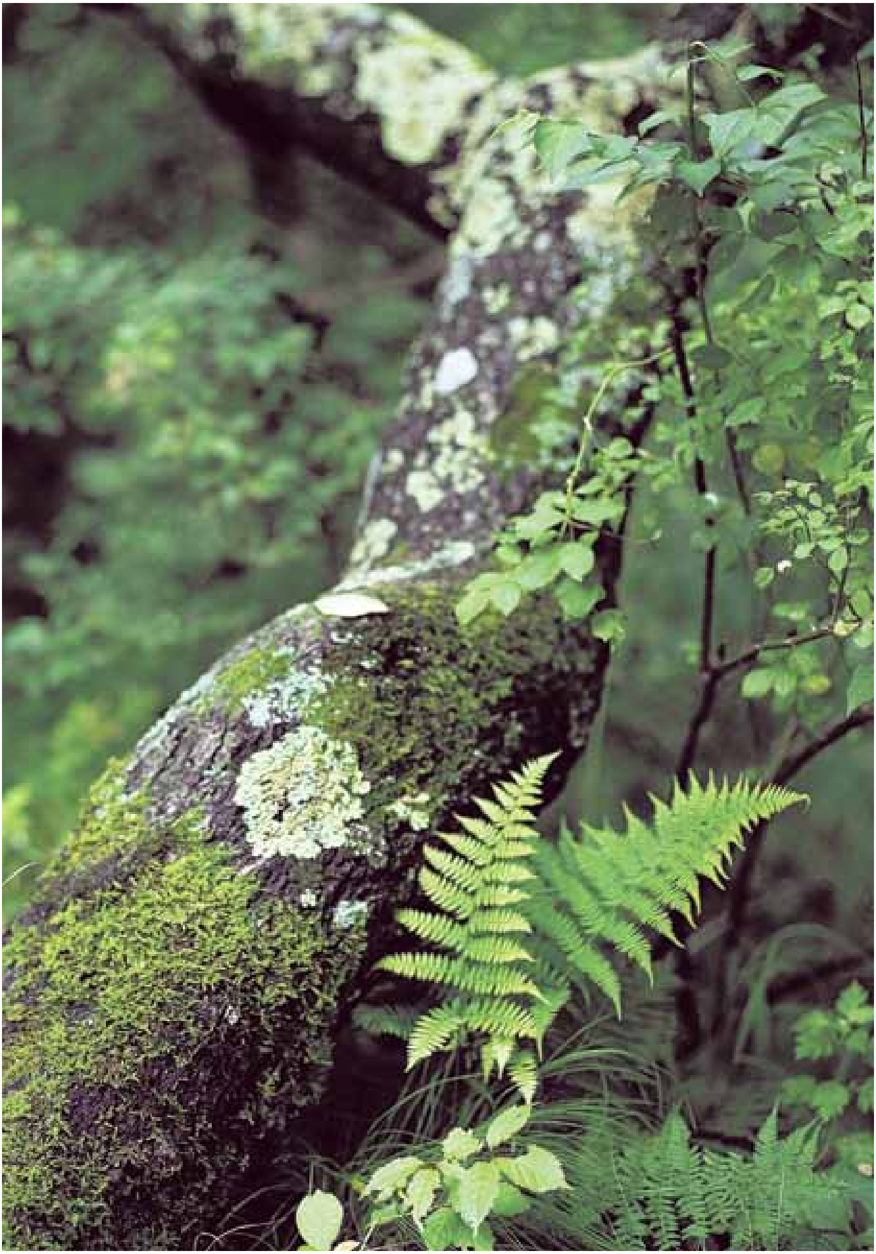
Step 6—Suggest alternatives to the proposed project that would protect the environment, yet still meet the needs of people. Alternatives may include different project designs at the same site or the same project built at a different site.

Step 7—Discuss the trade-offs between the short- and long-term environmental losses and the short- and long-term benefits of the proposed project.

Step 8—Determine how the proposed project would permanently prevent other uses of the site. If a vacant lot is paved, for example, then that land could not be used for a community garden.

CONCLUSIONS

Based on your review of the proposed project, tell your coun-selor what information would need to be included in an environmental impact statement and whether you think the project should go ahead as designed or be stopped. If you recommend stopping the project, tell why and suggest any alternative designs or projects that you would support.



Environmental Science Resources

Scouting Literature

Conservation Handbook; Fieldbook; Animal Science, Chemistry, Citizenship in the Community, Citizenship in the Nation, Citizenship in the World, Energy, Engineering, Fish and Wildlife Management, Fishing, Forestry, Gardening, Landscape Architecture, Mammal Study, Nature, Oceanography, Plant Science, Pulp and Paper, Soil and Water Conservation, and *Weather* merit badge pamphlets

For more information about Scouting-related resources, visit the BSA's online retail catalog (with your parent's permission) at *http://www.scoutstuff.org.*

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Organizations and Web Sites

Earth 911
1375 N. Scottsdale Road, Suite 360
Scottsdale, AZ 85257
Telephone: 480-889-2650
Web site: *http://www.earth911.com*

Environmental Protection Agency
Ariel Rios Building
1200 Pennsylvania Ave., NW
Washington, DC 20460
Telephone: 202-272-0167
Web site: *http://www.epa.gov*

Keep America Beautiful
1010 Washington Blvd.
Stamford, CT 06901
Telephone: 203-323-8987
Web site: *http://www.kab.org*

Natural Resources Conservation Service
Attn: Conservation Communications Staff
P.O. Box 2890
Washington, DC 20013
Telephone: 202-720-3210
Web site: *http://www.nrcs.usda.gov*

Society of American Foresters
5400 Grosvenor Lane
Bethesda, MD 20814-2198
Telephone: 301-897-8720
Web site: *http://www.safnet.org*

U.S. Fish and Wildlife Service
Main Interior
1849 C St., NW
Washington, DC 20242-0001
Toll-free telephone: 800-344-9453
Web site: *http://www.fws.gov*
Endangered Species Web site: *http://fws.gov/endangered/*

USDA Forest Service
1400 Independence Ave., SW
Washington, DC 20250-0003
Telephone: 202-205-8333
Web site: *http://www.fs.fed.us*

Advocacy Organizations and Web Sites

Save Our Environment
Web site:
http://www.saveourenvironment.org

Sierra Club
National Headquarters
85 Second St., Second Floor
San Francisco, CA 94105
Telephone: 415-977-5500
Web site: *http://www.sierraclub.org*

World Wildlife Fund
1250 24th St., NW
Washington, DC 20037
Telephone: 202-293-4800
Web site: *http://www.worldwildlife.org*

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MERIT BADGE LIBRARY

Though intended as an aid to Boy Scouts, Varsity Scouts, and qualified Venturers in meeting merit badge requirements, these pamphlets are of general interest and are made available by many schools and public libraries. The latest revision date of each pamphlet might not correspond with the copyright date shown below, because this list is corrected only once a year, in January. Any number of merit badge pamphlets may be revised throughout the year; others are simply reprinted until a revision becomes necessary.

If a Scout has already started working on a merit badge when a new edition for that pamphlet is introduced, *he may continue to use the same merit badge pamphlet to earn the badge and fulfill the requirements therein.* In other words, the Scout need not start all over again with the new pamphlet and possibly revised requirements.

Merit Badge Pamphlet	Year
American Business	2002
American Cultures	2005
American Heritage	2005
American Labor	2006
Animal Science	2006
Archaeology	2006
Archery	2004
Architecture	2008
Art	2006
Astronomy	2004
Athletics	2006
Automotive Maintenance	2008
Aviation	2006
Backpacking	2007
Basketry	2003
Bird Study	2005
Bugling (*see* Music)	
Camping	2005
Canoeing	2004
Chemistry	2004
Cinematography	2008
Citizenship in the Community	2005
Citizenship in the Nation	2005
Citizenship in the World	2005
Climbing	2006
Coin Collecting	2008
Collections	2008
Communication	2009
Composite Materials	2006
Computers	2009
Cooking	2007
Crime Prevention	2005
Cycling	2003
Dentistry	2006
Disabilities Awareness	2005
Dog Care	2003
Drafting	2008
Electricity	2004
Electronics	2004
Emergency Preparedness	2008
Energy	2005
Engineering	2008
Entrepreneurship	2006
Environmental Science	2006
Family Life	2005
Farm Mechanics	2008
Fingerprinting	2003
Fire Safety	2004
First Aid	2007
Fish and Wildlife Management	2004
Fishing	2009
Fly-Fishing	2009
Forestry	2005
Gardening	2002
Genealogy	2005
Geology	2005
Golf	2002
Graphic Arts	2006
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Home Repairs	2009
Horsemanship	2003
Indian Lore	2008
Insect Study	2008
Journalism	2006
Landscape Architecture	2008
Law	2003
Leatherwork	2002
Lifesaving	2008
Mammal Study	2003
Medicine	2009
Metalwork	2007
Model Design and Building	2003
Motorboating	2008
Music and Bugling	2003
Nature	2003
Nuclear Science	2004
Oceanography	2009
Orienteering	2003
Painting	2008
Personal Fitness	2006
Personal Management	2003
Pets	2003
Photography	2005
Pioneering	2006
Plant Science	2005
Plumbing	2004
Pottery	2008
Public Health	2005
Public Speaking	2002
Pulp and Paper	2006
Radio	2008
Railroading	2003
Reading	2003
Reptile and Amphibian Study	2005
Rifle Shooting	2001
Rowing	2006
Safety	2006
Salesmanship	2003
Scholarship	2004
Scuba Diving	2009
Sculpture	2007
Shotgun Shooting	2005
Skating	2005
Small-Boat Sailing	2004
Snow Sports	2007
Soil and Water Conservation	2004
Space Exploration	2004
Sports	2006
Stamp Collecting	2007
Surveying	2004
Swimming	2008
Textile	2003
Theater	2005
Traffic Safety	2006
Truck Transportation	2005
Veterinary Medicine	2005
Water Sports	2007
Weather	2006
Whitewater	2005
Wilderness Survival	2007
Wood Carving	2006
Woodwork	2003

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