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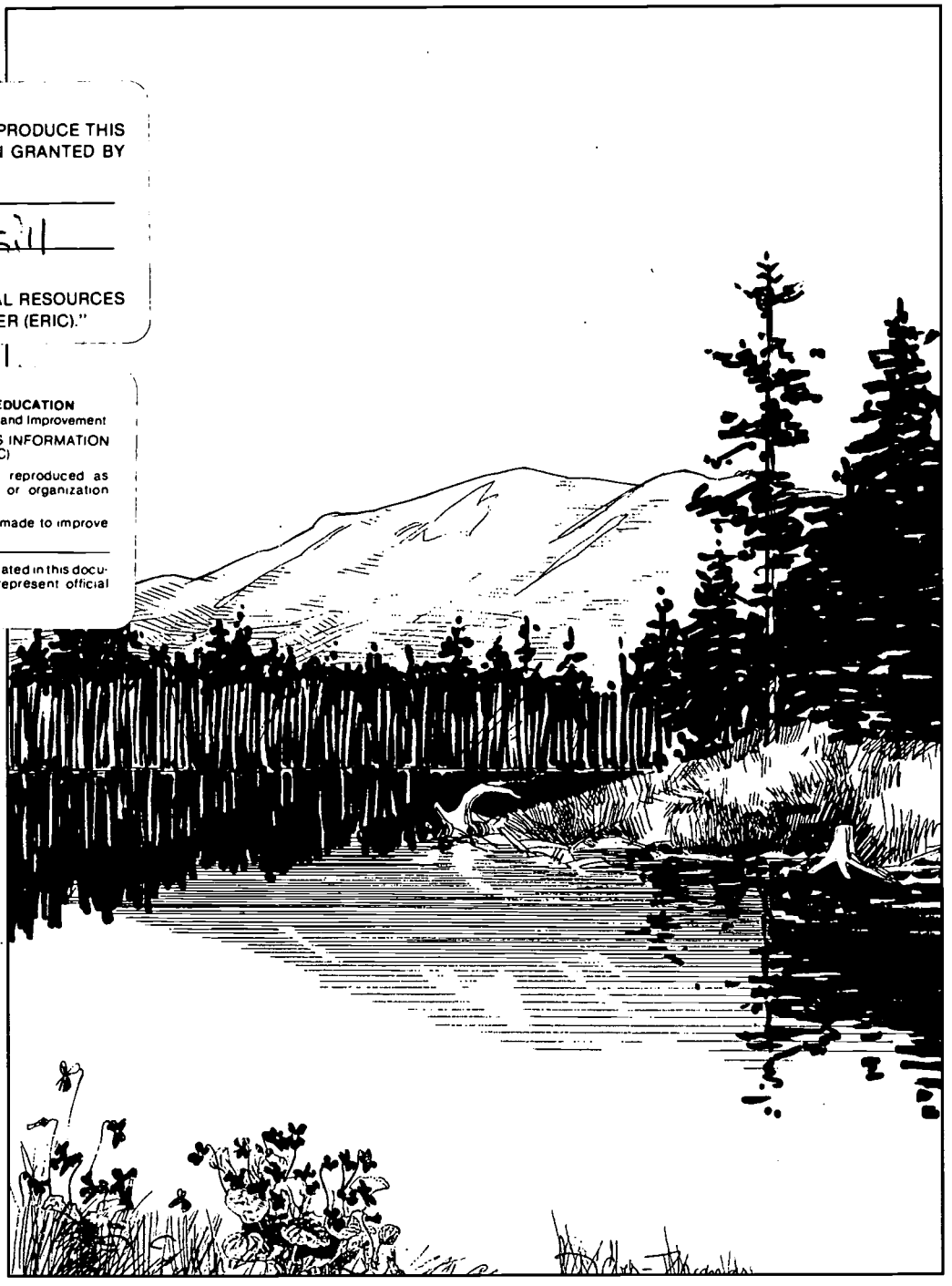
ABSTRACT

This leader's guide explains an outdoor environmental education program for youth, based on a child's natural learning progression: sensitivity and awareness, understanding and appreciation, and commitment and action. Chapter 1 discusses how to teach in the outdoors, including field trip planning and preparation, discipline tips, and suggestions for teaching methods. Chapter 2 sets the foundation by presenting brief explanations of the ecology of ecosystems, including background information on soil, air, water, producers, consumers, and decomposers. Chapter 3 explains five basic laws of ecology: everything is connected to everything else, everything has to go somewhere, everything is always changing, there is no such thing as a free lunch, and everything has limits. Five appendices present over 150 relevant publications; where to get equipment and materials; contact information for Maine's natural resource and environmental education organizations; a glossary; and 12 soil, air, and water activities. As additional support materials, activity cards describe 41 fun, hands-on activities that will help youth learn about the environment in outdoor settings. (TD)

CONNECTIONS TO OUR EARTH

Exploring Maine's Natural Resources



LEADER'S GUIDE

University of Maine
Cooperative Extension

BULLETIN #8002
4-H EARTH CONNECTIONS

The dramatic photographs of Earth taken from outer space reveal the connectedness of all that inhabits

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CONNECTIONS TO OUR EARTH

Exploring Maine's Natural Resources

LEADER'S GUIDE

4-H EARTH CONNECTIONS

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Resources throughout the country were examined to compile this guide. We believe that the resulting material is the most exciting and stimulating natural resources education material to date. We would like to express our sincere thanks to the following contributors:

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INTRODUCTION

CONNECTIONS TO OUR EARTH — WHAT IS IT?

Connections to Our Earth, consisting of a Leader's Guide and set of Activity Cards, is part of 4-H Earth Connections, University of Maine Cooperative Extension's environmental education program for youth. Using hands-on activities in outdoor settings, Connections to Our Earth will carry you, and young people you work with, into the heart of the natural world. You won't need plane tickets, fancy equipment or tour guides for the journey you're about to take. It's all at your doorstep! You need go no further than your backyard, school grounds or a local park. Nature surrounds you at every turn. From a drop of water to the Atlantic Ocean, from a tiny violet to the majestic white pine, from a grain of sand to the mighty Katahdin, all are ours to behold if we choose to see, listen, smell, taste and touch.

WHY SHOULD WE BE CONCERNED?

Throughout Maine, the United States and the world, people depend on Earth's natural resources for food, shelter, energy, employment, recreation, enjoyment and spiritual renewal. These resources are sunlight, air, water, soil, plants, animals and people. These are the components of all the ecosystems on Earth, from coastal waters to mountaintops, from tropical rain forests to deserts, and they are all interconnected. For centuries, American Indians have spoken eloquently on their natural connection to the Earth. One famous saying states, "He who harms his mother, harms himself." The challenge of Connections to Our Earth is to rediscover our links with the natural world, and encourage responsible action in caring for the environment.

YOU CAN TEACH IN THE OUTDOORS

Do you feel uncomfortable teaching in the outdoors? If you do, you are not alone. Parents and teachers often feel that they do not know enough about the natural world to teach about it. Even such experts as biologists, foresters and geologists sometimes have trouble teaching young children about the outdoors.

Introducing youngsters to the natural world isn't difficult. In fact, it can be lots of fun! Connections to Our Earth will show you how to help curious, inquisitive, wondering young minds discover the magic of nature.

WHAT WILL CONNECTIONS TO OUR EARTH DO FOR KIDS?

The mission of the 4-H Earth Connections program is to help young people:

- understand and examine their role in the interconnected web of life; and
- understand the need to conserve and protect the Earth's natural resources.

Connections to Our Earth is one step on the way toward that understanding. The Leader's Guide and Activity Cards offer opportunities for youth and adults to:

- make personal discoveries about the environment;
- develop life skills that emphasize decision making and problem solving; and
- discover recreational, vocational and avocational activities that bring lifelong pleasure.

WHAT IS THE CONNECTIONS TO OUR EARTH APPROACH?

The Connections to Our Earth approach is based on a child's natural learning process. This is a series of steps that begins with sensitivity and awareness, progresses to understanding and appreciation, and finally reaches commitment and action. Let's look at each of these stages and how they relate to this program.

Sensitivity and Awareness

Most kids enjoy activities that allow them to taste, smell and touch, as well as see and hear. You can capture their interest and imagination by giving them the opportunity to discover and touch creatures in a tidal pool, explore a bog and look for mysterious smells and sounds, or search the forest floor for the homes of wild things.

The idea is to develop a sense of wonder and awareness, rather than worrying about the names of all the plants and animals you find. As Rachel Carson said,

"I sincerely believe that for the child, and for the parent seeking to guide him, it is not half so important to know as to feel ... It is more important to pave the way for the child to want to know than to put him on a diet of facts he is not ready to assimilate."

Understanding and Appreciation

As understanding grows, the child becomes more enthusiastic and develops an appreciation for new ideas and concepts. Let's look at an example. Many of us are afraid of snakes. However, if you allow children to hold a harmless snake, such as a garter snake or ringneck snake, they will begin to discover new things about snakes. Was it slimy, as they might have expected? Could they feel the snake's muscles move? With this new knowledge, they may begin to appreciate snakes and fear them less.

Commitment and Action

When kids understand and appreciate the world around them, they develop positive values and attitudes toward nature. They begin to commit themselves to caring for the Earth.

Actions to conserve, protect and improve the Earth's natural resources can be many and varied, from protecting wetlands from development, to reducing waste and increasing recycling, to putting up bird nesting boxes. In addition to Connections to Our Earth, Maine 4-H offers other programs in natural resource conservation. Ask your county Extension educator for information about Tanglewood 4-H Camp, the Adopt-A-Road project, beach cleanups, composting and other programs.

WHAT DOES CONNECTIONS TO OUR EARTH PROVIDE FOR LEADERS?

Connections to Our Earth uses two types of support materials — a Leader's Guide and a set of Activity Cards.

The Leader's Guide

The Leader's Guide will provide you with some background information and ideas to help you teach youth about their connections to the Earth's ecosystems. There are three parts to the Guide:

Chapter 1 explains how to teach in the outdoors. Give it a try — it gets easier each time, and you will learn right along with the children.

Chapter 2 explains the ecology of ecosystems and the basic "laws" of ecology.

Appendices provide extra information to help you conduct successful activities and direct you to additional sources of information and materials.

Activity Cards

The Cards describe fun, hands-on activities that will help youth, and you, learn about the environment in outdoor settings. Each Card tells you everything you need to know to successfully conduct the activity. Paralleling the child's natural learning sequence, Activities 1 to 15 focus on sensory awareness, 16 to 38 on understanding and appreciation and 39 to 41 on commitment and action.

BEING A GOOD LEADER

You have the power to affect how children view nature. Your motivation, interest and enthusiasm will rub off on them. Don't worry if you don't know the names of animals, plants or trees. The kids will respect your honesty if you say you don't know, and they will have fun working with you to learn the answers.

The kids will notice how you respond to the outdoors and will see your attitude toward the environment. They will watch the respect with which you handle a toad, the gentleness with which you show them a flower and the calmness with which you hold snake.

Your actions speak louder than words. Think about the unspoken messages you send when you talk about a reverence for life and then take care not to squash a bug or break tree branches, or quietly pick up litter from along the trail as you conduct a nature hike.

WELCOME TO CONNECTIONS TO OUR EARTH

We welcome you to Connections to Our Earth and the wonderful world of nature.

Let the kid in you emerge. Roll up your sleeves and get your hands dirty. Be ready to explore the woods, wade into marshes and play hide-and-seek in the tall grass. Nurture your own feelings of wonder and awe.

Teaching kids in the outdoors is an adventure full of exploration and discovery. Your challenge is to provide youngsters with learning opportunities that reveal the magic of the natural world.

We have provided you with some tips, activities and teaching tools to start you on your way.

Good luck. Smile. And have fun!

Chapter 1
I CAN TEACH IN THE OUTDOORS

The teacher's job in the outdoor classroom is to set up an exciting learning environment. Being outside is only part of it. The leader has to teach in a way that makes the outdoors come alive for every member of the group. That may sound easy, but it requires that you, as a teacher and leader, be flexible and adaptable, whether it is to changing weather conditions, insects or responding to "teachable moments." Your enthusiasm is the all-important ingredient in involving young people in learning in the outdoors.

THE LEADER'S ROLE

You have the power to affect how children will view nature. How you respond to the outdoors and your attitude toward the environment will be noted by the children. We can hardly expect children to get excited about, appreciate or develop a commitment to the natural world if we appear bored or uninterested.

Let's take a look at three factors that can affect your success at leading an outdoor program.

You Don't Have to Know It All

The outdoors is a learning environment in which leader and student learn together. It's OK to say "I don't know the answer to that question. Does anyone have any ideas, or know where we can find the answer?" You're not expected to know everything, and it's good to admit if you don't. Children don't expect it, and they respect you for being honest when you don't have an answer. Remember that learning is a two-way street; you will learn as you help your students learn.

Develop a Sense of Wonder

The importance of a sense of wonder is best described by Rachel Carson: "If a child is to keep alive his inborn sense of wonder, he needs the companionship of at least one adult who can share it, rediscovering the joy, excitement and mystery of the world we live in."

Develop a style that kindles that "sense of wonder" in yourself and children. Look a little closer and get involved; outdoor magic can unfold before your very eyes. Good leaders get their feet wet and their hands dirty.

Speak with More Than Just Words

An adult's unspoken messages are sometimes as strong, if not stronger, than the spoken ones. Young people learn from what they see adults do. If you're not afraid to try new things, are willing and able to adapt to uncomfortable situations, or change your plans to adjust to the interests of the group, your openness will make a great impression on those you lead. Think about whether or not your actions match or clash with your words. If they match, you will be a very powerful and positive role model.

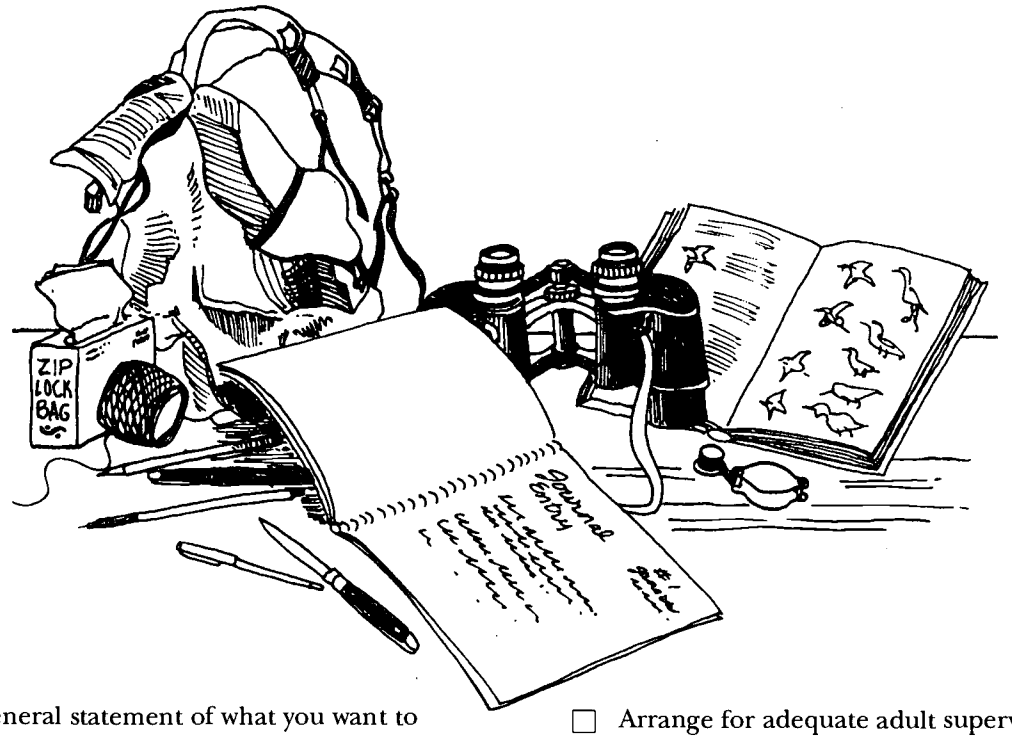
In conclusion, remember that you are not just a leader but a listener, learner and follower. Have a positive approach and a caring attitude; smile and enjoy yourself.

GETTING STARTED

A successful outdoor program requires that you prepare, whether this is your first group or your hundredth. The time you spend planning will help you make the most of the day, and allow you to concentrate on how the children are doing, rather than on what comes next.

Goals and Objectives

Identifying goals and objectives helps us get from where we are to where we would like to be. We have to be clear about the purpose of the outdoor experience and what we want the children to gain from such an experience.



A goal is a general statement of what you want to accomplish. For example, "students will become caring stewards of our natural resources," or "participants will learn about the forest ecosystem."

Objectives, on the other hand, are more specific and can be measured. For example, "participants will be able to identify five tree species," and "participants will know the difference between evergreen and deciduous trees."

Writing down your goals and objectives may also help you to select appropriate activities from this, and other, sources.

Field Trip Preparation Checklist

After you have figured out what you want to do, there are still many things to consider before you walk out the door. Getting the entire group involved in some of the preparations will make your work load lighter, and help everyone feel more responsible for making the trip a success.

- ☐ Choose a location that offers many opportunities for exploring and experiencing.
- ☐ Get permission to use the site and find out if there are any rules or regulations about group size, use of the facilities, collecting plants and other items, and so on.
- ☐ Are toilet facilities available?
- ☐ Visit the site beforehand so that you are familiar with the area, and are better able to match the activities you will be doing to the site and your objectives.
- ☐ Schedule transportation to and from the site, if needed.
- ☐ Arrange for adequate adult supervision — at least one adult for every 10 children.
- ☐ Prepare, or have the children bring, snacks and lunches.
- ☐ Bring, or have the children bring, insect repellent and sunscreen.
- ☐ Have a pencil and paper for each participant.
- ☐ Bring along a backpack, bag, pouch, or even large pockets, for carrying "treasures," equipment and props. Be sure you have all the teaching materials you will need.
- ☐ Consider extra items that might be useful, such as field guides, magnifying glasses, bug boxes, small plastic containers, and so on. If it might be cold or wet, bring along extra mittens, hats or other items for those who forget.
- ☐ Be sure you have a firstaid kit, and know how to use it.
- ☐ Send home permission slips if necessary, and a list of what the children should bring with them on the day of the trip.

Setting Ground Rules

One other step that is essential to a successful trip is to set some ground rules. Ask the group members why the rules are important, or have them help determine what the rules will be. Why should they stay on trails? Take only pictures? Leave only footprints? State the rules in a positive way. Of course, rules should be based on common sense. For example, using a buddy system makes more sense walking through a thick forest than through a short grass meadow.

If your activity involves collecting items, such as

stones, plants or bugs, there are some special rules to follow:

1. Set well-defined boundaries for collecting.
2. Stress safety.
3. Be clear about what can and cannot be collected, and collect only what you need.
4. Living things should be collected only if they can be kept alive and later returned to where they were found.
5. Stress that the outdoors is home to many organisms and that we should treat it as if it were our own.

LET'S GO

Whether you are just going exploring, or are leading a structured, step-by-step activity with clear objectives, here are some tips and techniques to help you successfully guide your group.

Discipline

If you have planned and prepared yourself and your group in advance, it is unlikely you'll have major discipline problems. When setting ground rules, discuss the consequences of breaking the rules. If disruptive behavior means no more field trips, the children may keep each other in line! When a child does act up, channel his/her energy and interest by getting him/her involved. Have the child carry a pack, answer a question or lead the way along the trail.

Part of your job as leader is to be fully aware of the learning environment — the weather conditions, the energy of the children, other leaders and the dynamics of the activity. It is always better to prevent a distracting situation than try to correct it.

Equipment and Materials

Many of the activities do not require any equipment or props; others do. Some items can be made by you or by the children (see Activity A). You may also look into getting equipment donated by local business or organizations. If you are using equipment that is new to the kids, you may have to plan some time to teach them about its use. It is also a good idea to hand out items as they are needed, rather than at the beginning of an activity, to minimize the distraction from what you are saying!

Teach with Questions

Asking questions is one way to keep students involved. When someone asks a question, you do not need to be the one who always answers or explains what is happening. Instead, allow the children to interpret things themselves. Have them look for clues and put the pieces of the mystery together on their own.

Ask questions that force the group to think. Try "Why is a leaf green?" rather than "What color is this leaf?" Keep your questions brief and call on children at random. If you respond only to children who raise their hands, you run the risk of losing the interest of the others or not hearing from everyone in the group.

Also be aware of how you respond to the children's answers and ideas. If a response is laughed at, labeled wrong or ridiculed, that child, as well as others in the group, may not risk answering again. Remember, the purpose of asking questions is to keep kids involved in the activity.

Introducing New Words

Large words should be broken down into more easily understood parts. For example, photosynthesis, the process by which sunlight combines with water and carbon dioxide in green plants to form food, is derived from the following:

Photo = light (as in photograph)
Synthesis = putting together (as in music synthesizer)

Have the children repeat the words two or three times to help them remember the words and their meanings.

Introducing New Concepts

New concepts and information may be difficult for children to understand and remember without some background. There are several successful techniques to teach children new ideas.

Analogies

Analogies are a fun way to better understand a subject. In an analogy you compare something you don't know about to something you do. For example:

How is a fern like an antique? Both are very old. How is a fungus similar to a garbage collector? They both clean up the community. One cleans the city, the other cleans the forest. How is tree bark similar to our skin? Children may not know what bark does, but may know something about skin.

Stories

The use of stories can be an effective tool in introducing new information as well. Here is a story that explains the relationship between algae and fungus in lichens in a way that children will remember:

About 450 million years ago, when there was no life on land, Alan Algae just floated around in the sea all day. He was an excellent cook, but he had no home. Fanny Fungus, who also lived in the sea, was a carpenter and could build homes, but couldn't cook. One cloudy, cool day, a wave washed Fanny and Alan up on a rock. They were afraid because they had never been on land before. They didn't know each other very well, but they had to figure out how they could survive out of the water. Pretty soon Alan and Fanny decided to help each other out. Because Fanny was the carpenter, she built a home that sheltered both of them. Alan did his part by cooking for the two of them. The longer they stayed together, the more comfortable they became, and they took a "lichen" to each other.

Algae and fungus have what is called a "symbiotic" relationship. Each depends equally on the other for survival; the algae makes the food and the fungus provides the home.

Gimmicks

Another way to introduce new ideas is with gimmicks, which are often similar to analogies or short stories. Gimmicks are comparisons, usually to something already known, that serve to jog the learner's memory. For example, you can tell white pine from all the other pines because white pine is the only one with five needles to a bunch. Five needles, five letters in "white."

Quizzing

Quizzing children on what they have learned is fun and can easily be done following the activity. It's a way to measure an activity's effectiveness, review certain areas or clear up misunderstandings. Announcing the quiz to the group isn't always necessary, as it can create undesirable competition or anxiety. They may not even be aware that they are being quizzed! Questions should relate to the activities and cover the key points. Quizzing will reinforce your objectives.

Using Dramatics

Children have vivid imaginations and a natural sense of excitement that can be your ally. Use words, like secret, mystery or puzzle, that tap into their imaginations, or use personal dramatics. For example, if you know you are coming up to a spot where a bird has been killed and feathers are lying around, you can stop the group and exclaim: "A great crime has been committed! Can anyone find any clues and tell us what happened?"

Using Props

Special props can make a lesson come alive. Lighting a cashew with a match and watching it burn demonstrates the concept of stored energy. Using a sponge to soak up water illustrates how rainfall is absorbed into the soil or a wetland.

Developing props is a creative undertaking. Their value as teaching tools is worth the effort because they help introduce new information and make learning more fun.

Teachable Moments

One of the greatest qualities an outdoor leader can have is the ability to recognize a teachable moment and be flexible enough to make use of it. Teachable moments are those special times when a sudden discovery or observation takes hold of the children. If a deer crashes through the woods while you are working on a soil profile, it would be a waste of energy to try to keep their attention focused on the soil! Take the chance to ask questions about deer, and maybe discuss how the deer and its activities might affect the vegetation, and get back to how that might affect the soil.

Teachable moments often present the most valuable learning opportunities. Truly spectacular or interesting events are the most memorable. Take advantage of them, and try to tie the moment back into your lesson. Even if no connection can be made to the activity at hand, it is better to wait until the excitement lessens before returning to your original topic.

FINAL COMMENTS

Children have an inborn curiosity about the world around them. As an outdoor leader, it's your challenge to provide learning opportunities that open doors to the magic of the natural world. We have provided you with strategies, teaching tools and gimmicks to start you on your way. A good motto to remember is:

Discover First, Explain Second, Identify Last.

Chapter 2
ECOLOGICAL BACKGROUND — SETTING A FOUNDATION

What do building a house and teaching natural resources to children have in common? To be successful, both must be built on a steady, sturdy and reliable foundation. This chapter will provide you with that foundation. It's up to you, the outdoor leader, to build on from there!

"I went to the woods, because I wished to live deliberately, to front only the essential facts of life, and see if I could not learn what it had to teach, and not, when I came to die, discover that I had not lived." **— Henry David Thoreau**

THE ECOLOGY OF ECOSYSTEMS

Ecology is a word we hear often, on the radio and television, in newspapers and in magazines. The word comes from the Greek "oikos," meaning "house" or "place to live," and "ology," meaning "the study of." Ecology, then, is the study of living things, where they live, and how they interact, both with each other and with their environment. Ecologists look for interrelationships among plants, animals, people and the environment.

The basic unit of ecological study is the ecosystem. Ecosystems have two types of components — living and nonliving. The nonliving parts; the sun, air, water and soil; provide energy, nutrients and other basics of life to the living organisms.

The living organisms can also be grouped into categories, based on their function. Producers, or green plants, are the basic energy source for all other organisms. Consumers get their energy directly from plants (herbivores), from other animals (carnivores) or from both (omnivores). Decomposers, such as fungi and bacteria, are the clean-up crew, recycling dead plants and animals so that they can be used again by the plants.

Ecosystems are self-sustaining; they can run by themselves. They vary in size from a tiny pond to the Atlantic Ocean, or from a daisy to the great spruce and fir forests of northern Maine. Collectively, the earth's ecosystems are called the biosphere, that thin, fragile mantle of life that extends from a few feet below the soil surface to several miles above it. It is the only place in the universe known to support life. Ecologists usually study fairly small ecosystems, such as ponds, marshes, forests, fields and intertidal zones.

Let's take a look at each of the basic components of an ecosystem.

Soil

Soil and rocks cover the Earth's land surfaces. Soil is derived from small rocks, pebbles, mineral particles, and organic matter (decaying animal and plant parts). Living organisms, air and water are also found in soil. Soil has varying textures depending on the size of the particles that make it up. Mineral particles are classified as sand (large, coarse), silt (medium) and clay (fine, microscopic).

Water and nutrients are found in the spaces between the soil particles. If the spaces are large, as in sandy soils, water and nutrients flow so quickly through the soil that they are not readily available to plants, and the spaces are mostly full of air. If the spaces are very small, as in clay soils, water and nutrients quickly fill all the spaces, keeping air from entering. Adding sand, silt and small rocks to clay soils helps them drain better and keeps them from compacting as easily. Most soils are a combination of sand, silt and clay. This means that water, nutrients and air are all held within the soil and are available to plants.

Ideal Mineral Composition of Loam Soil
SAND – 40 percent
SILT – 40 percent
CLAY – 20 percent

Ideal Soil Composition for Plant Growth
MINERAL PARTICLES – 45 percent
AIR SPACES – 25 percent
WATER – 25 percent
ORGANIC MATTER – 5 percent

Soils are not the same throughout a given area.

Soils vary, even within the same yard or field. As you dig down into soil, you may see layers. These layers, called "horizons," are identified by letters. Most untilled or uncultivated soil has four distinct horizons.

The upper layer, called the O horizon, is made up of organic matter, including decayed leaves, grass and animals. The second layer, called the A horizon, is the most fertile growing area. It is often called topsoil. There is some organic matter in this area, as well as most of the creatures that live in the soil. In a cultivated field, the O horizon does not exist and the A horizon is the upper soil layer.

The next layer is the B horizon. It generally has more clay and very little organic matter and is less fertile. There may be some small rocks in this area. Rocks in a cultivated field might tell you that the A layer is gone and has been replaced by soil from the B horizon. Excessive cultivation can cause erosion, washing away the soil layers, and exposing more rocks.

The lowest soil layer is the C horizon. This is called the parent material. It is very rocky and has very low fertility. Below the C horizon is the bedrock, the layer of solid rock that lies beneath the soil.

The depth of each soil layer depends on the soil's age and the climatic conditions that formed the soil. Layers are sometimes different colors, though this is not always true. To better understand soils and their role in ecosystems, try the exercises in Appendix E.

Air

Because you can't see, taste or touch air, you don't pay much attention to it, even though it is all around you. Imagine the world without air. There would be no wind, no clouds, no rain, no sound, no fire, no plants, no animals, no you. The Earth would be very much like the moon.

Surrounding the Earth is a thin blanket of air called the atmosphere. The atmosphere is made up of several different gases, small solid particles, and tiny droplets of water and other liquids. These molecules of solids, liquids and gases exert a combined pressure on the Earth. Though you don't notice it, every square inch of your body is under the pressure of a column of air over 1,000 miles high! That one-inch-square column of air weighs 14.7 pounds at sea level and is called "atmospheric" or "barometric" pressure. At higher elevations, air weighs less because the column of air is shorter and the spaces between the particles are larger.

Air moves over the surface of the Earth. We feel that movement as wind. Why does air move? When air is warmed it becomes lighter and rises, just like a helium balloon rises because the gas inside it is lighter than the surrounding air. The space below the rising column of air is filled with cooler, heavier air. That movement of air is wind. Wind plays an important role in the Earth's weather and climate. Air warms and rises around the equator. When it reaches the upper levels of the atmosphere, it is forced to move toward the North and South Poles where it cools and moves back down toward the surface of the Earth. At the same time, cool air from the poles is moving along the surface of the Earth, filling in the space under the warm air that is rising at the equator. This pattern of air movement is also affected by the rotation of the Earth and other factors such as mountain ranges and deserts that affect air movement, warming and cooling.

To better understand air and its role in ecosystems, try the exercises in Appendix E.

Water

Water is the secondmost important substance in your life, second only to the air you breathe. Your body is about 80 percent water. You can live only minutes without air, and only a day or two without water. An average person drinks 23,000 ounces (182 gallons, or 1,500 pounds) of water every year. This is equal to about eight, eight-ounce glasses of water a day.

Water is made up of two atoms of hydrogen (H) and one atom of oxygen (O) — H_2O.

Water can be found in all three states of matter: solid (ice), liquid (water) and gas (water vapor or steam). Water must be at or below 32 degrees Fahrenheit (F) or 0 degrees Celsius (C) to be in the solid form. This temperature is called the freezing point, the point at which water (liquid) changes into ice (solid). When frozen, the volume of water increases, but the weight remains the same. This is why icebergs and ice cubes float. For most other substances, the solid form takes up less space than the liquid form. It is a special characteristic of water that it expands when it freezes.

Water has other unique characteristics. Pure water has no smell, taste or color. The liquid and gaseous forms can be compressed, or squeezed into a smaller space, but ice, the solid form, cannot. The surface of liquid water consists of tightly bonded water molecules. It is this "surface tension" that water striders and other insects make use of so that they can walk on water.

At 212 degrees F (100 degrees C), the molecules of liquid water are moving so fast that they escape into the air as gaseous water vapor. This temperature is the boiling point of water. Water can evaporate, or change from a liquid to a gas at any temperature, but it cannot remain a liquid after it has reached the boiling point. Water can also sublimate, change from a solid to a gas without first becoming a liquid (that's why the ice

cubes in your freezer shrink).Water vapor is invisible. If water vapor cools so that the molecules slow down a little, the vapor changes back into a liquid. This is called condensation. When water vapor condenses into very small water droplets, we see it as clouds, or our breath on a cold day, or a small cloud over a boiling tea kettle. There are approximately 50,000 tons of water in the atmosphere above a square mile of land on an average day. That's more than a half a gallon over every square foot!

To better understand water and its changing states, try the exercises in Appendix E.

These three elements, soil, air and water, are the primary nonliving components found in an ecosystem, the building blocks that set conditions for life. Energy to power the system originates from the sun, is captured by plants and moves along to other organisms. Let's take a look at the three primary living groups: producers, consumers and decomposers.

Producers

Producers, more commonly called plants, create their own food through a process called photosynthesis. "Photo" refers to the light energy of the sun, while "synthesis" refers to putting things together. In the simplest of terms, photosynthesis is making food with light. Plants "produce" themselves from the sun's energy. In reality, the process is much more complex.

In each plant, whether it is a giant redwood or microscopic plankton, there exist pigments called chlorophyll. These pigments give leaves their characteristic green color. But more importantly, the chlorophyll acts as a sun trap to collect light energy that hits its cells. This energy is what powers the process. It is while this light energy is trapped within the chlorophyll that water (H_2O) and carbon dioxide (CO_2) combine and produce glucose (food), with oxygen as a waste product. Why and exactly how all this occurs remains a biological mystery. One thing is certain, however, plants and algae with chlorophyll are the only living things that have this ability. All other life forms are in debt to plants for the miracle of photosynthesis that produces food and oxygen. Plants are crucial in supporting and maintaining all living things.

Consumers

Consumers are organisms that are unable to create their own food and must eat (consume) other organisms. All animals are included in this group and can be put into one of three categories:

1. Herbivores—eat primarily plants (mallard ducks, mice, deer, sparrows, aphids)
2. Carnivores—eat primarily meat (wolves, eagles, trout, spiders)
3. Omnivores—eat both plants and meat (bears, robins, skunks, humans, snapping turtle)

Decomposers

The most common decomposers are fungi, such as mushrooms and bracket fungus, and bacteria. They break down the complex substances that make up dead plants and animals into simple materials, such as carbon dioxide, water and minerals. These are released back into the environment where they are used again by plants. Thus, the nonliving parts of the ecosystem contribute to living forms that eventually die and return nutrients to the soil. These nutrients become new plant growth, continuing the cycle of life and death.

COMMUNITIES

Ecologists often speak of the living parts of the ecosystem as a biotic community. Community members are bound together through a series of self-sustaining interactions and interrelationships. For instance, different organisms are connected in food chains, and all of the food chains in a community make up an interwoven food web. Each organism lives in a specific habitat (home) that provides food, water, cover and space. What an organism does in a community, its functional role, is called its niche. For example, part of the niche of a squirrel is to collect and store nuts. The forgotten ones often grow into new trees. You can think of the habitat as the "address" of the organism, and its niche as its "profession."

In some communities, one or several species may be dominant. Dominant species are usually plants. The dominant plants are the ones that convert the most solar energy, moderate the climate and often provide most of the food and shelter available to other organisms. Communities are often named for their dominant species, for example, the spruce-fir forest of northern Maine.

SUMMARY

The biosphere is that thin layer on the surface of the Earth that supports life. All living things form unique interrelationships and interdependencies with other organisms and with their surrounding environment.

An ecosystem is composed of nonliving parts (sun, soil, air and water) and living parts (producers, consumers and decomposers).

Life and death maintain a flow of energy and a cycle of nutrients among nonliving and living parts of an ecosystem.

Communities are composed of the living members of an ecosystem. These members live in specific habitats and occupy a niche, playing particular roles in the community.

Chapter 3
COMMONER'S LAWS OF ECOLOGY

"We travel together, passengers on a little space ship, dependent on vulnerable supplies of air, water, and soil, all committed for our safety to its security and peace: preserved from annihilation only by the care, the work, and I will say the love, we give our fragile craft." — Adlai Stevenson

In the early 1970s, ecologist Barry Commoner wrote *The Closing Circle,* in which he discussed the rapid growth of industry and technology and their persistent effect on all forms of life. He suggested that we can reduce the negative effects by sensitizing, informing and educating ourselves about our connection to the natural world. Commoner summarized the basics of ecology into what he termed "laws of ecology." Others have also used this idea to develop simple statements that help us understand and remember our connections to nature. Here are five laws of ecology:

1. EVERYTHING IS CONNECTED TO EVERYTHING ELSE.
2. EVERYTHING HAS TO GO SOMEWHERE or THERE IS NO SUCH PLACE AS AWAY.
3. EVERYTHING IS ALWAYS CHANGING.
4. THERE IS NO SUCH THING AS A FREE LUNCH.
5. EVERYTHING HAS LIMITS.

These laws form the basis for studying and understanding the relationships and interdependencies found in communities and ecosystems. They further explain that humankind is, in fact, only one member of the biotic community and that people are shaped and nurtured by the characteristics of the land. These laws will not explain everything. Mysteries will remain. But they will give you a clearer understanding and appreciation of ecology, and your "niche" as a member of the living community.

LAW 1 - Everything Is Connected to Everything Else

"When we try to pick out anything by itself, we find it hitched to everything else in the universe." — John Muir

The basic message behind this law is that all things are connected to each other, sometimes in very obvious ways, and sometimes in very complex, indirect ways. To help illustrate this law, we will discuss food chains and webs, competition within communities, and the relationship between predators and their prey.

FOOD CHAINS AND FOOD WEBS

The essence of life begins with light from the sun. It continues with the transfer of this energy from sun to plant to animal. This series of links connecting organisms is called a "food chain."

Food chains are simple models that illustrate food relationships between different organisms. All food chains have a common beginning: the sun's solar energy. Producers receive this energy and convert it into food for primary consumers (herbivores) and secondary consumers (carnivores). Decomposers are the final link in the food chain.(See Figure 1).

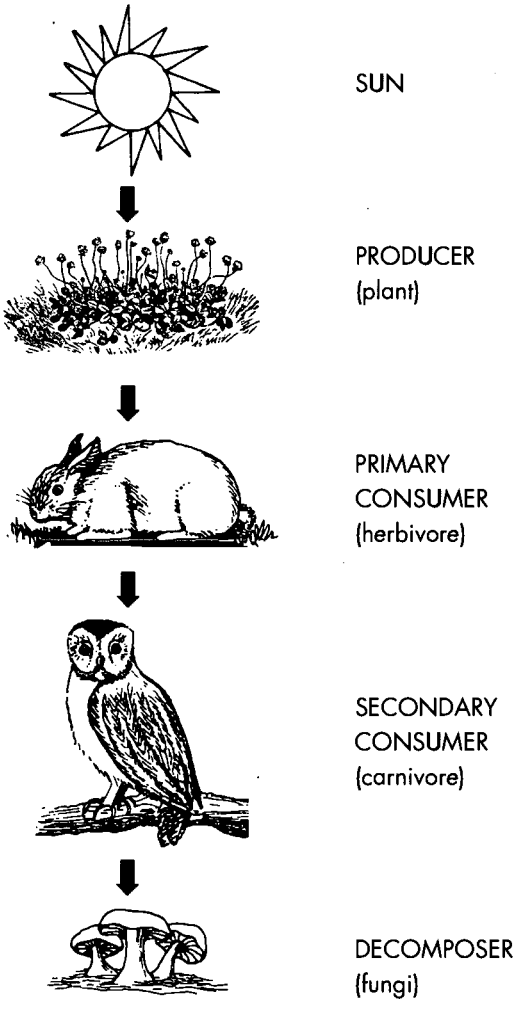


Figure 1. Movement of energy through a "food chain."

Each species, including *Homo sapiens*, is a link in many chains. The rabbit eats many different plants, and the owl consumes other animals besides rabbits. Both animals are links in hundreds of chains. These interlocking chains comprise a "food web" (see Figure 2). This tangle of chains seems confused and disorderly, yet in truth the web is highly structured and stable. When a strand of the web is altered or cut, many other strands are affected and must adjust. (Try Activity 36 — Web of Life.)

Long, long ago, food webs were fairly simple, but through eons of time organisms have changed and numbers increased, creating more complex food relationships. Similarly, over thousands of years, environmental changes have occurred. Because these changes were usually very gradual, organisms had time to adjust and adapt. Today, however, environmental changes are happening very rapidly. Habitats are being altered or destroyed over very short periods of time. Many organisms are finding it difficult to adjust to these changes.

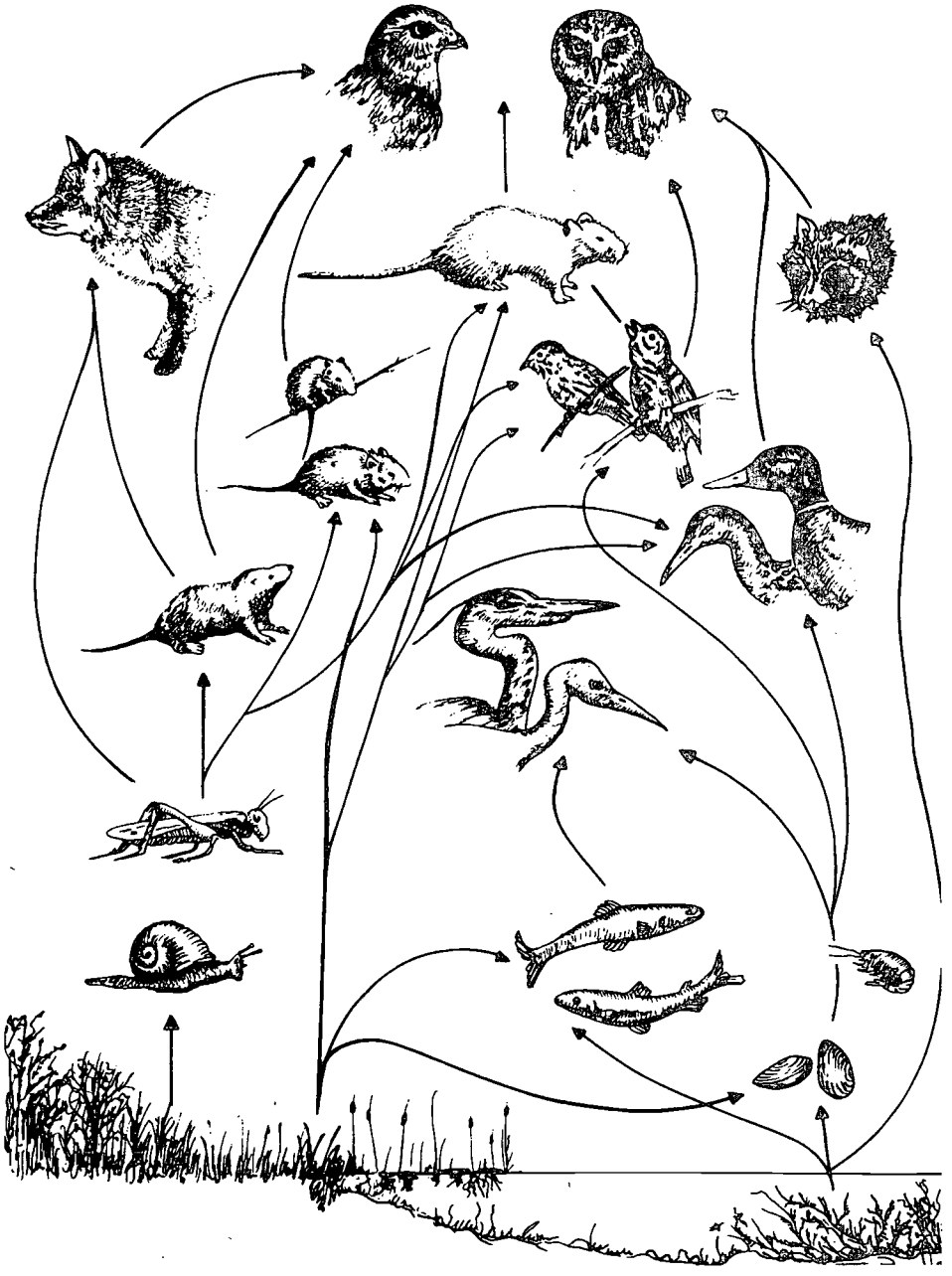


Figure 2. This is a freshwater marsh food web. It illustrates the variety of food chains created by marsh inhabitants' struggle for survival. Producers (submerged and emergent land plants pictured at the bottom of the drawing) are food for both primary consumers (insects, crustaceans and small fish) and omnivores (ducks, mice, rats, sparrows and raccoons). Secondary consumers include carnivores, such as fox and great blue herons. Top carnivores (marsh hawks and short-eared owls) feed on higher levels of the food chain.

For the first time in history, food chains are getting shorter, rather than longer.

Ecologists and other natural resource experts are beginning to recognize that maintaining these complex food relationships and interdependencies is crucial for a healthy, biotic community. Instead of managing land for the benefit of one species, land managers are starting to consider diversity and balance in their management plans.

COMPETITION

Competition occurs between members of the same species and between different species competing for the same resources, such as food, shelter, mates, nest or den sites, or water. Competition is not always bad and can benefit the species in the long run. Here are some examples.

For moose, competition becomes intensified in early fall during the breeding season or rut. Why? Because bull moose are competing for the same resource: cows.

Only the larger, more dominant bulls will mate. It is not only the strength and size of the bull that decides who will mate and who will not, but also the size of their antlers. Bulls often fight, but rarely sustain serious injuries. Larger and more dominant moose will prevent younger, less experienced bulls from mating. In this way, only the genes from the strongest moose are passed on to the next generation.

Competition also occurs among plants. White oak saplings must compete for limited sunlight, and only the strongest ones will be able to get ahead of the others to capture the sun's rays. Viewed as a whole, the white oak forest benefits because there are fewer plants competing for a limited amount of light, water and nutrients.

In competitions, there is often a winner and a loser. However, this is not always true. In New England, boreal softwood forests are inhabited by five species of warbler (a small bird). They all eat insects, and appear to occupy the same niche — something that is not supposed to happen. A detailed study of their feeding

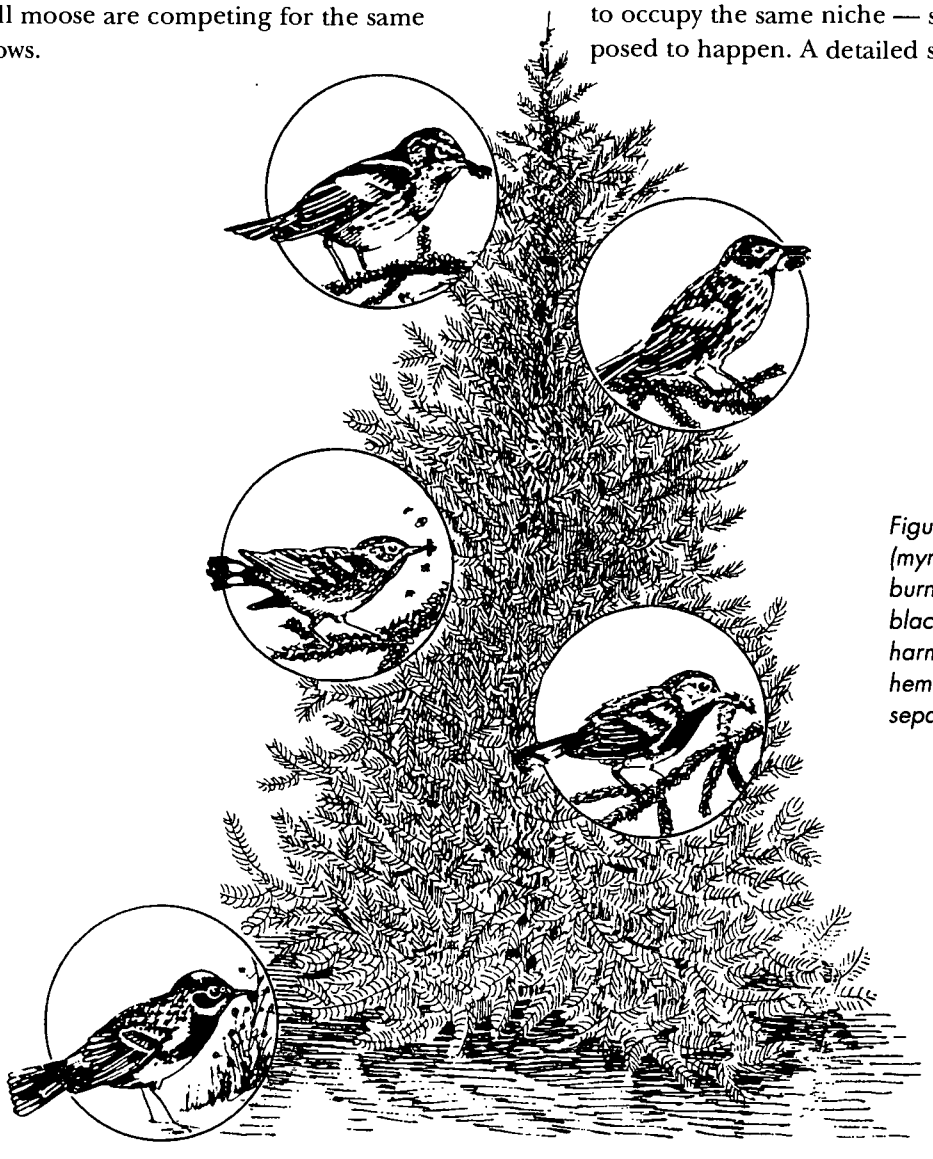


Figure 3. These five warblers (myrtle, Cape May, black-burnian, bay-breasted and black-throated green) coexist in harmony in the white pine/ hemlock forest by occupying separate niches.

habits showed that these five warblers (myrtle, Cape May, blackburnian, black-throated green and bay-breasted) are able to share the same habitat because they have adapted their feeding behavior so that each species feeds at a different level in the tree canopy (see Figure 3). These species also differ in the specific insects they eat, and they nest at different times. Their unusual success at adaptation can be attributed to an earlier period of competition. These five species were able to alter their feeding and nesting habits enough to coexist peacefully.

PREDATOR-PREY RELATIONSHIPS

A special form of competition that occurs between two different species is the predator-prey relationship. A predator is an animal that captures and kills its prey. Predators often eliminate the weakest or diseased members of the prey species, leaving stronger members behind to reproduce and pass their genes on to the next generation.

The populations of predators and prey often "cycle," with prey populations increasing when predator pressure is low and decreasing when predator pressure is high. Think about it this way — when prey populations are high, predator populations are able to increase because there is abundant food for pregnant females and their young. As the number of predators increases, they consume more prey than can be replaced, and the prey population starts to decrease. With less food available, the predators are not able to feed their young and their population declines. As the predator pressure then decreases, more prey survive and their populations increase, coming around full cycle to the beginning again. These predator-prey cycles are normal and healthy, and help maintain the strength of both species.

An often used example of the predator-prey cycle is the relationship between snowshoe hare and Canada lynx in the northern United States and Canada. Trapping records of pelts shipped to Europe since the early 1800s show that there are peaks, or highs, in the hare population every seven to nine years, followed by a "crash" and then a slow increase in the population leading to another peak. This pattern is the same for lynx, except that the peaks in the lynx population occur one year later than the peaks in the hare population. This suggests that the lynx are responding to the abundant food supply. More recently, it has been discovered that the food of the hare is involved in the cycle, too. As the hare populations increase, they eat more and more food, particularly small willow. The willow responds to this "predator pressure" by producing a toxin that makes the willow inedible to the hare. This reduction in winter food, along with increased disease and competition for burrow sites, contributes to the crash in the hare population.

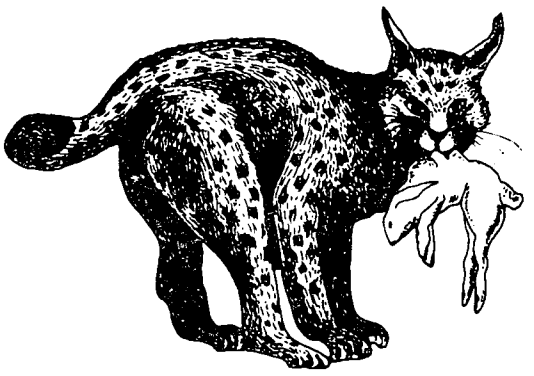


Figure 4. The predator-prey relationship between the Canada lynx and the snowshoe hare is a close one with both species dependant on one another for their survival. If the lynx disappears, the hare soon overpopulate the area, resulting in intensified competition, disease and death. If the hare disappears first, the lynx will soon perish due to starvation (70 percent of the lynx's annual diet is snowshoe hare).

LAW 2 - Everything Has to Go Somewhere or There Is No Such Place as Away

This is one law that has become increasingly clear as we attempt to find ways to deal with the waste that we produce each day. The garbage truck takes our trash "away," but where is that? Humans are not the only creatures who produce waste. Natural systems must deal with animals that have died and the leaves that fall each autumn, as well as waste products, such as feces. We are learning about recycling, but nature has been doing it for a long time.

LIFE-SUPPORT CYCLES

In any ecosystem, there is a limit to the amount of minerals, nutrients, air, water and soil that are available within the system, and the rate at which they can be imported from outside the system. These substances must be recycled to support the living members of the system. Any disturbance in these cycles can jeopardize the entire system.

Two of the most important cycles are the water cycle and the nutrient cycle. We will use them to take a closer look at the relationship between the living and nonliving members of ecosystems. A third, very important cycle, is the carbon dioxide and oxygen cycle. We won't be explaining it here, but it would make a good research project for you and your students!

Water Cycle

Seventy-five percent of the Earth's surface is covered by water. Of this, 97 percent can be found in our oceans, two percent in the ice of glaciers and a mere one percent in freshwater rivers, lakes, streams and underground reservoirs and in the atmosphere. This one percent is all we have ever had, or ever will have, for drinking, washing, cooking, industry and other uses. How do we keep from running out of fresh water? Because of the water cycle. Water is constantly changing form and moving, from clouds in the sky, to the land and oceans, and back to the sky, in a constant, self-renewing cycle.

Powered by heat from the sun, water evaporates from lakes, oceans and other surfaces into the air. Plants also release water into the air through transpiration, and animals release water into the air as they breathe. The gaseous water molecules are moved by wind. As the air moves upward, it cools and the water begins to condense, changing back into a liquid and forming clouds. When the clouds become over-saturated with water vapor, the water droplets are too heavy to remain in the sky and fall back to Earth as precipitation: fog, rain, snow, sleet or hail.

When precipitation reaches the ground, it may evaporate again, or it may be absorbed by plants or swallowed by animals; it may be stored in the ground, or it may run off the surface into creeks and streams, and eventually into lakes and oceans. The cycle then repeats itself as the water evaporates again (see Figure 5).

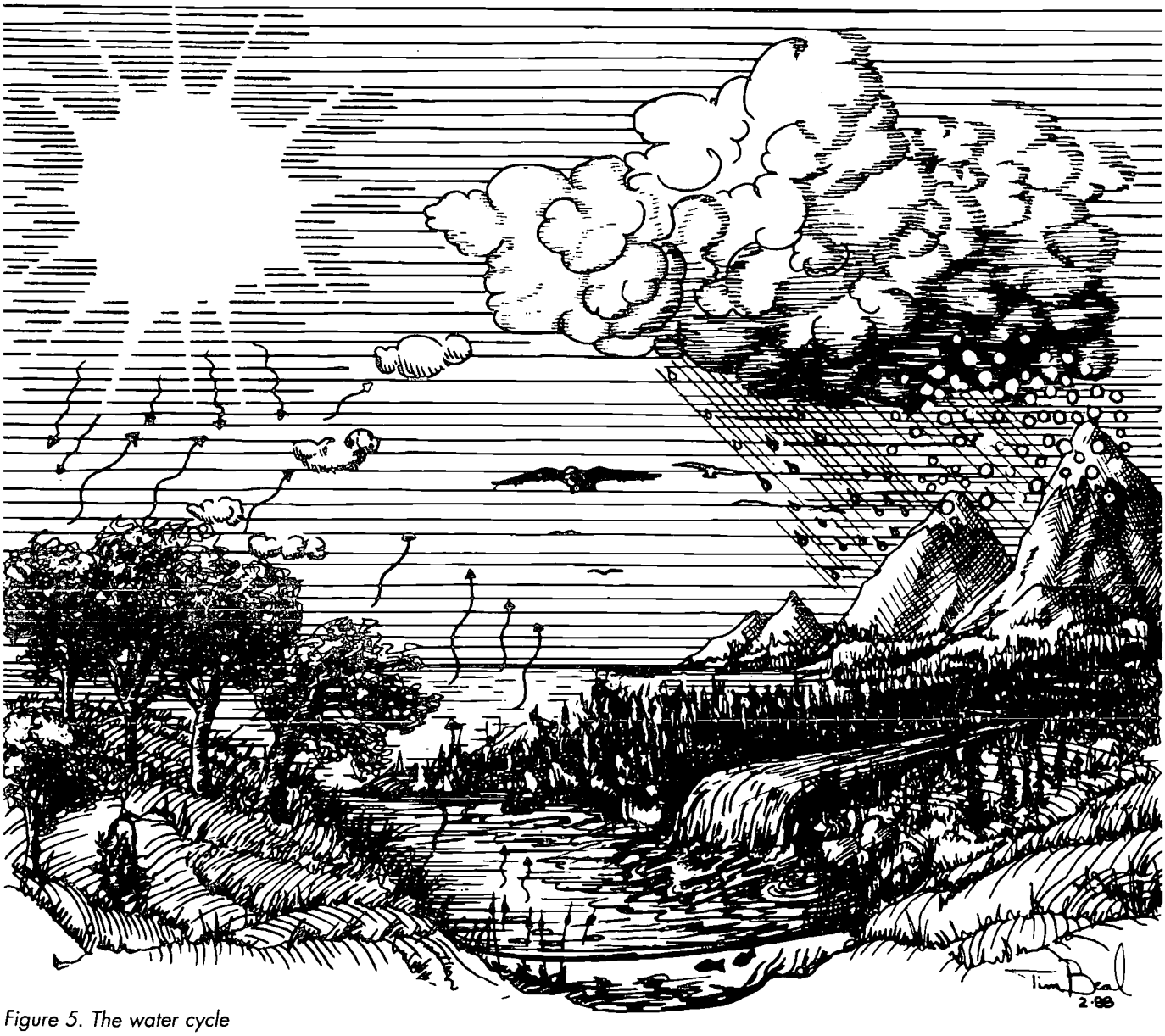


Figure 5. The water cycle

For millennia, the amount of water in the cycle has remained constant, and is never lost from the environment. The water molecules you drank today may have been drunk millions of years ago by a dinosaur, a prehistoric human or a whale!

Nutrient Cycle

Each plant and animal has specific nutritional requirements for proper growth. They acquire the appropriate amount of each nutrient from minerals and elements that are continuously cycling through soils, water, air and living tissues. The most important nutrients are phosphorus, nitrogen, potassium and calcium.

A key link in the cycling of nutrients is the decomposers: fungi and bacteria. Decomposers break down dead plant and animal material back into simple compounds. This organic matter helps make the soil more fertile because it contains many minerals and nutrients necessary for vigorous plant growth. These plants are in turn eaten by herbivores that in turn are eaten by carnivores or omnivores. Without decomposers, the necessary minerals and nutrients needed for life would be forever locked up in dead plants and animals.

ENERGY FLOW

Unlike water, nutrients and minerals, energy does not cycle in an ecosystem. Rather, energy enters an ecosystem and flows through it. An ecosystem is unable to create this energy and must rely on an outside source: sunlight. Every organism alive is dependent on the sun's energy for its survival.

Energy is defined as the ability to do work. The energy from sunlight is captured by producers (plants) and changed into a form that is usable by other organisms in the ecosystem. Plants use the sun's energy to convert nutrients, water and carbon dioxide into plant tissue and hence, grow. Oxygen is released as a waste product and is available to be used by animals.

The only energy forms available to a plant-eating animal (herbivore) are the nutrients found in the tissues of plants. Herbivores, such as sparrows and deer, are referred to as primary consumers. These primary consumers are in turn eaten by meat-eaters or carnivores, and are called secondary consumers. These animals vary from small carnivorous insects like dragonflies, to large fish like trout, to mammals like bobcats. Occasionally, a food chain will include a second level of carnivores (tertiary consumers), for example bald eagles and humans. During each of these transfers, some energy is lost to the environment as heat.

At each level in our food chain, the consumer is often restricted to a narrow selection of foods. For instance, if a great blue heron were to eat ants instead of fish, it would soon starve, because the heron would use more energy in pursuing ants than it would receive from eating them. Therefore, the further along the food chain a consumer is, the more efficient it must be at collecting food. For example, hawks, wolves and trout consume only those prey species that provide enough energy to make it worth the effort to hunt, capture and eat them.

Another way to look at an ecosystem's energy flow is with a food pyramid (see Figure 6). The first layer, the producers, provides a foundation for the pyramid. Their numbers are the greatest because they must support all the other layers. In general, the number of animals in each successive layer of the pyramid decreases. Thus, for every carnivore there are hundreds of prey, thousands of secondary prey, millions of insects and uncountable plants.

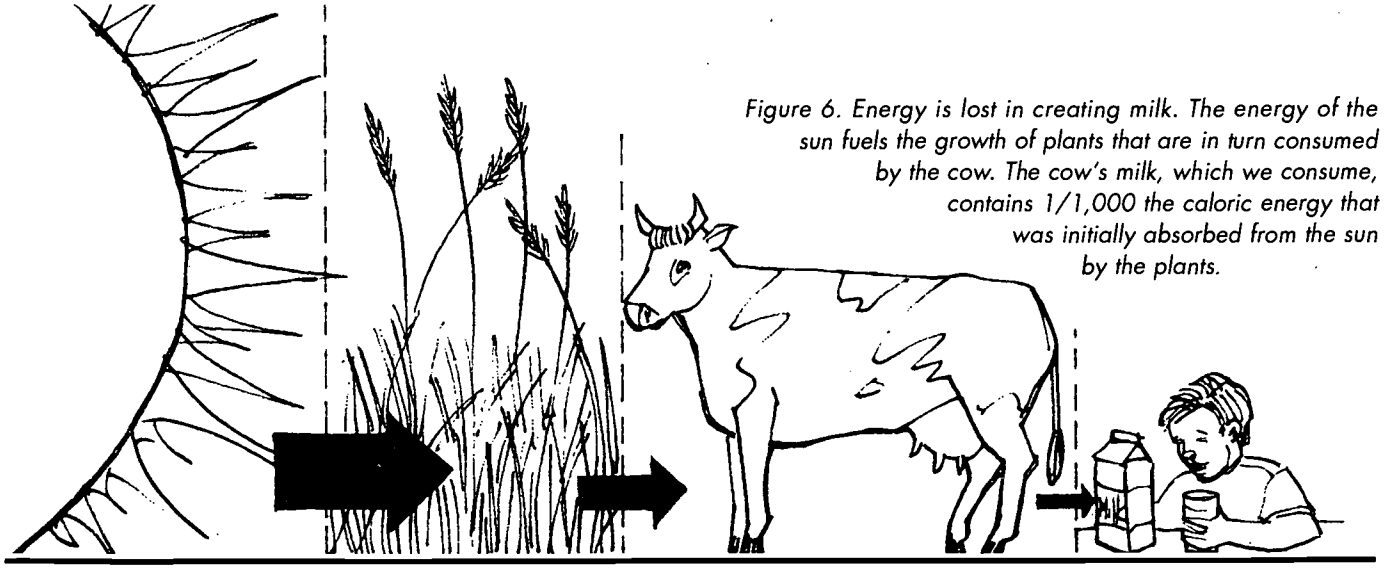


Figure 6. Energy is lost in creating milk. The energy of the sun fuels the growth of plants that are in turn consumed by the cow. The cow's milk, which we consume, contains 1/1,000 the caloric energy that was initially absorbed from the sun by the plants.

Just as life-support materials cycle through ecosystems, so do toxins, like pesticides, herbicides, heavy metals and naturally occurring radioactive substances. Regrettably, Commoner's Laws apply to unnatural, as well as natural, substances. Everything humans make and dispose of must go somewhere. Often these poisons go into the living tissues of plants and animals, including humans.

LAW 3 - Everything Is Always Changing

ECOLOGICAL SUCCESSION

The species of plants and animals that are found in a community do not remain the same forever. Rather, over long periods of time, they change, mainly because of the activities of the plants and animals themselves. This change is called ecological succession (see Figure 7). We can witness this change all around us as abandoned farmland changes to forest. This same process can be seen in an abandoned house lot in a city.

The first step in succession, called the pioneer stage, starts with lichens that grow on bare rock. Eventually enough soil is created to provide the nutrients needed to support the growth of grasses and herbs.

Seeds from briars, shrubs, vines and trees are blown or carried by animals or water into the site, where they eventually are able to germinate. Trees and shrubs soon start to grow, outcompeting the grasses and herbs and a new forest begins. Changes in the plants continue until a climax community, the last stage in succession, is reached. These communities are in equilibrium with their environment and are considered mature. In Maine, forest types that are examples of climax communities are:

1. Spruce-Fir Forest
2. Pine-Hemlock Forest
3. Beech-Birch-Maple Forest

As one successional stage changes to another, the animal community also undergoes many changes. Rabbits, meadow mice and groundhogs find lush food in the grasses and herbs of early succession. As shrubs and trees replace the grasses and herbs, deer and grouse grow in numbers.

When the climax community, a mature forest, is reached, the white-footed mouse replaces the meadow mouse. Deer and grouse don't use the mature forest as much, but turkeys, owls and squirrels do. The owl needs the mature forest for nesting and hunting, while squirrels need the mature trees for nuts, and acorns and dens. As changes in the landscape take place, whether natural or unnatural, animal life also changes.

ADAPTATION AND NATURAL SELECTION

We have examined many ways that plants and animals interact with and depend on each other. We have looked at the movement of nutrients, food and energy through food webs. Competition between two species, as has previously been discussed, often results in the dominant species living in the best habitat, with the weaker species forced into less ideal habitat. Competition, whether between species or between individuals of the same species, results in the process of natural selection. The resulting changes in the species are called adaptations.

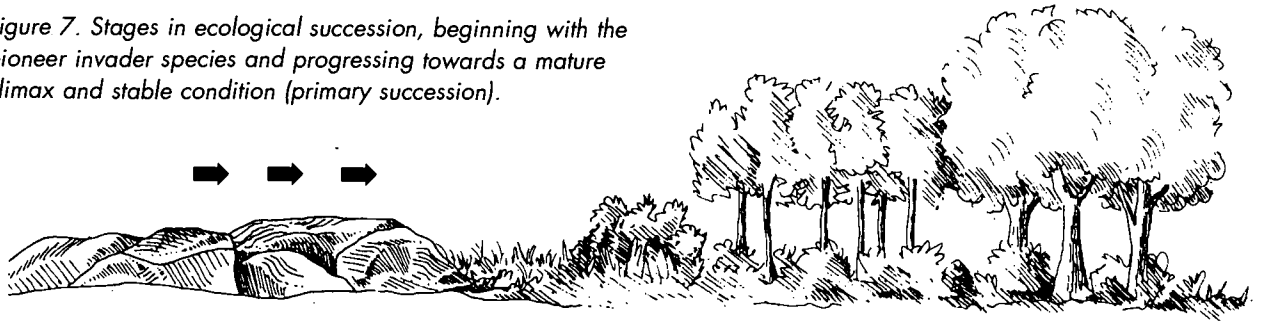
An adaptation can be 1) a physical or structural change, such as camouflage coloring, 2) a behavioral change, such as migration, or 3) a metabolic change, such as hibernation or estivation.

As individuals in the population experience success with an adaptation, they pass the trait on to their offspring. In time, adaptations become built-in tools that increase the chances of the organism's survival.

Physical or Structural Change

Consider the noiseless wings of the owl, the spots on a fawn, the claws of a badger, the compound eye of a fly, a woodpecker's beak, the large hind feet of a

Figure 7. Stages in ecological succession, beginning with the pioneer invader species and progressing towards a mature climax and stable condition (primary succession).



snowshoe hare or the placement of a frog's eyes. These are all examples of how organisms have adapted and evolved physical structures to fit a specific niche in an ecosystem.

Behavioral Change

Brown creepers and red-breasted nuthatches are similar, small, tree-climbing birds that feed on eggs, larvae and adult insects living on the bark of trees. The nuthatch moves down the tree eating food that it sees in that direction, while the creeper moves upward in search of food. They are eating the same kind of insects, but because of their feeding behavior, competition is decreased and both birds can coexist. This type of adaptation is a behavioral change.

Metabolic Change

Some animals are able to go into a state of dormancy to escape extreme temperatures, either hot or cold, in their environment, or scarce food supplies. Winter dormancy, called hibernation, and summer dormancy (estivation) are both examples of metabolic change.

LAW 4 - There Is No Such Thing as a Free Lunch

"We abuse land because we regard it as a commodity belonging to us. When we see land as a community to which we belong, we may begin to use it with love and respect."
— Aldo Leopold

The Earth, its ecosystems and its communities, have undergone millions of years of adaptation and change. Through eons of time these changes often increased the diversity of life and stability of the system. In the Earth's early history, only catastrophic changes, such as volcanic eruptions, earthquakes, floods and meteor showers, disrupted the balance between plants, animals, decomposers, water or air. Then, approximately two million years ago, human beings entered the interconnected web of life and took center stage.

What has been the effect? In modern times, we have seen substantial changes in medical care, worldwide communication, modes of travel, computer capabilities and other sophisticated technologies. Many of these have made our lives better and easier. But at what cost? These gains and advances have not come free, either in terms of dollars or in environmental stress.

To understand some of these costs, let's examine a lunch purchased at a local fast-food restaurant. We will trace the path of each item from origin to consumer, and track some of the costs along the way. The lunch

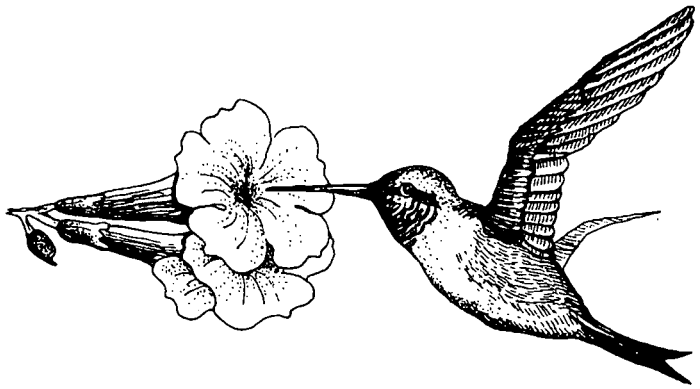


Figure 8. The hummingbird's long bill, probing tongue and ability to hover are adaptations that allow it to feed on nectar of the honeysuckle. The honeysuckle is adapted with a long tube that causes the hummingbird to brush against the pollen as it feeds. As the hummingbird moves from honeysuckle to honeysuckle, the pollen is transferred and hence pollination (fertilization) takes place.

includes a toasted sesame seed bun, a one-quarter pound hamburger, a milk shake and french fries.

Toasted Sesame Seed Bun: To begin, a farmer must prepare the ground (often adding chemical and organic fertilizers), buy the wheat seed, plant it and care for the crop until it is ready for harvest. To protect the crop from insects, weeds and disease, a farmer often sprays with chemical pesticides and herbicides. The harvested wheat is shipped to the grist mill where it is refined and bleached. (The process removes the wheat germ and bran, thus lowering the nutritional value of the flour.) The flour is sold to the bun factory where chemicals are added to the flour to enhance flavor and retard spoilage. The buns are baked and then shipped to the restaurant. What are some of the costs to ourselves, others and the environment? Here are a few:

- Insects and weeds become resistant to chemicals when they are constantly exposed to them.
- The farmer may attempt to control insects by using more chemicals.
- Overuse of these chemicals may result in the excess being washed into streams during storms or seeping into groundwater supplies, contaminating them.
- Extra chemicals cost more money and larger doses destroy birds, mammals and other insects that the farmer doesn't necessarily wish to kill.
- Overuse of fertilizers can also result in the excess running off into streams, lakes and ponds, causing subsequent algae blooms and

resulting in depleted oxygen levels for aquatic life.

- Farmers risk exposure to chemicals that may cause temporary illness or, in extreme cases, permanent disabilities.
- The energy costs are enormous. Consider the following:
  1. The cost of running farm machinery for sowing, planting and harvesting.
  2. Transportation costs for moving raw, processed and finished products around the country.
  3. Energy costs to run ovens, stoves and toasters to prepare the buns.

One-Quarter Pound Hamburger: Beef producers have found it economically advantageous to grow their beef in Central and South America and ship it back to the United States for use in fast-food restaurants. To raise beef, large tracts of tropical rain forests and local food crop areas are displaced. Costa Rica alone exports 42,000 tons of beef annually for fast foods. These countries have agreed to raise beef because it brings in money for the country's government. What are the costs? Here are a few:

- Eliminating the South and Central American rain forests affects migratory bird populations by destroying habitats and homes. Many of these birds help control blackflies, mosquitoes and other pests during the summer months in Maine.
- In a few years, the cleared land is overgrazed and abandoned. Often, vegetation does not return for years. New forests may not return for decades. Local people suffer, because land they need to grow food crops is being used to grow beef for fast foods.
- Consider the energy costs:
  1. Transportation costs from the tropical rain forests to the processing plant and to the fast-food restaurant in Maine.
  2. The operation of the fryers to cook the burgers.

Milk Shake: Milk is produced commercially throughout the country and in several parts of Maine. Dairy cattle are usually kept in pastures, where they graze on grass. As with all other food items, there are many steps between the cow producing milk and your milk shake. If too many cows are allowed to graze in the pasture, they may strip off the vegetation from the land. What are the costs for the milk in the milk shake? Here are a few:

- Damage to plant life because of overgrazing will result in erosion. If the land is steep, the erosion will be great.
- During rainstorms, loose soil in pastures may be transported to surrounding streams and be lost.
- The increase of soil in water bodies is called siltation. Siltation reduces oxygen levels and may interrupt the life cycles of aquatic life.
- Consider the energy costs:
  1. Milking of the cows, often done by electric machines.
  2. Heating, pasteurizing, cooling and homogenizing the milk into a finished product.
  3. Costs for packaging milk and transporting it to the restaurant.

French Fries: Because potatoes grow underground, they have different growth requirements than wheat. Potato blight is a fungus that can destroy the entire crop so the farmer may use several applications of fungicide to prevent blight. These chemicals, in large amounts, can cause problems similar to those discussed with the wheat crop. What are the costs? Here are a few:

- Excessive application of chemicals to curtail potato blight can result in the excess seeping into groundwater supplies and contaminating them.
- Oil to fry the potatoes is highly processed from the plant or animal to the final product. There are costs associated with the oil that we have not included here. There are also health considerations concerning saturated fats, cholesterol and heart disease.

Consider the energy costs:

1. Because potatoes are grown in Maine, the cost of transportation is low.
2. Energy to process the oil and operate the fryers.

Packaging: Our imaginary lunch came in several forms of packaging. The burger was in a paper wrapper, the milk shake in a waxed cup with a plastic lid and straw, and the french fries in a paper bag. Plastic and wax from the milk shake cup came from petroleum products, — oil and coal tar, that are nonrenewable. The process to convert the oil to a plastic lid and straw is a complex sequence of molecular changes that require additional energy inputs. In Maine, discarded plastics are becoming an increasing danger to marine wildlife, who die after eating or becoming trapped in the plastic.

Paper for the wrapper, bag and cup comes from trees. Trees go through many steps before they become paper for packaging food. Unlike petroleum

products, wood products are renewable (they can be replaced relatively quickly).

When we discard the waste from our lunch, we should consider where it goes. Some items can be recycled. Others are taken to an incinerator and burned to create electrical energy. Some items will be taken to a land fill and buried. How long will it take to decay? If you were to dig it up in a year, five years, 10 years, 50 years, which products would remain? Why?

It's clear from this example that everything we do on the Earth has costs, some less obvious that others. You can trace all modern conveniences and products back to their environmental origin and predict their future course. Some of our activities, such as trash disposal and groundwater contamination, have disrupted the natural ability of ecological systems to maintain themselves.

The costs of our changes and alterations to the environment need to be considered along with the benefits. We have learned that ecosystems are complex and maintain a delicate balance. Understanding how our choices affect the environment can help us make better decisions about our use of natural resources.

LAW 5 - Everything Has Limits

For many years, it was believed that there was no end to what we could take from the Earth. There were always more fish in the sea, more trees to be cut, more ore to be mined, more earth to be tilled and more places to dump our trash. We now realize that this is not true. Some resources, called renewable resources, can be replaced if conditions are suitable and there is enough time, energy and nutrients available. Renewable resources include trees, wildlife and agricultural crops. They will continue to be available only if they are replaced faster than we use them.

Many of the products we use on a daily basis, including energy, are made from non-renewable resources, especially oil, coal and minerals. Although there are very large amounts of these resources available worldwide, there is a limit to how much is there, and we will eventually use it all. Conservation and recycling can make these resources last for a much longer time.

There are other meanings to this law. One of those is the ability of the Earth to absorb waste products, particularly toxic wastes. Ocean dumping of wastes was, and in some cases continues to be, a common practice. It was believed that because the oceans were so vast that they would be able to dilute toxic materials to such an extent that we would never be able to detect them, and they would never cause any harm. We now know that that is not so, and have begun to restrict ocean dumping.

Similarly on land, some ecosystems, such as wetlands and certain types of soil, are known to be able to absorb large amounts of toxic materials and neutralize or absorb them. Again, we have learned that there are limits to what these systems can handle.

The very land itself, the soil, can be renewed through processes of erosion and decay. But if erosion occurs faster than new soils can be created, that resource will also be depleted. Once washed to the sea, soil is very difficult if not impossible to recover.

SUMMARY

LAW 1 - Everything Is Connected to Everything Else

"Food chains" describe how different plants and animals are linked to one another.

"Food webs" are interlocking "food chains" that form complex relationships and interdependencies among the members of the web.

Competition can be beneficial, as well as detrimental, to the survival of plant and animal species.

Increases and decreases in prey populations directly affect predator populations and vice-versa.

LAW 2 - Everything Has to Go Somewhere

The Earth can be thought of as a finite world, containing all the minerals, water, soil and air that we will ever have.

Nutrients, water and gases cycle within systems and are essential to all members of an ecosystem. Each individual plays a specific role in assuring the continuation of these cycles.

Energy does not cycle; it flows through an ecosystem, dissipating heat as it is moved along a food chain.

All chemicals, pollutants and hazardous materials that we create and use must also go somewhere. Some of these materials may be held in the bodies of organisms, including humans, accumulating and sometimes causing harm.

LAW 3 - Everything Is Always Changing

"Succession" refers to plant and animal communities undergoing change, with one stage being replaced by the next.

Over a period of time, bare ground will move through a succession of changes, from a pioneer community to a climax community.

Left undisturbed, ecosystems become more stable in later stages of succession.

Organisms adapt to survive and make better use of an ecosystem's resources.

LAW 4 - There Is No Such Thing as a Free Lunch

Everything we eat, wear and use during our lifetime has an environmental cost as well as a dollar cost.

Environmental costs can include contaminated water supplies, loss of wildlife habitat, soil erosion, air pollution, extinction of animal and plant species, depletion of the ozone layer, acid rain and waste disposal.

LAW 5 - Everything Has Limits

The resources available to us, both renewable and non-renewable, have limits. With non-renewable resources, once they are gone, they can never be replaced. Renewable resources will be available only if we conserve and replace them faster than we use them. We must learn to balance our use of natural resources with their availability and renewability.

APPENDIX A
Publications

Most of these publications are available at your local library, or through the Maine State Library in Augusta or the University of Maine Library System. Publications of the University of Maine Cooperative Extension are available through your local Cooperative Extension office, along with a complete listing of UMCE publications.

AIR AND CLIMATE

Bennett, D. B. 1986. *Science and Natural History: A Maine Studies Sourcebook.* Volumes 1-4. Down East Books, Camden, ME.

Cornell Cooperative Extension. Cornell University, Ithaca, NY.
Understanding Weather. 4-H Members #125M31.
Understanding Weather. 4-H Leaders #125L31.
Building a Weather Station. 4-H Members #125M32.
Building a Weather Station. 4-H Leaders #125L32.
Weather Maps and Weather. 4-H Members #125M33.
Weather Maps and Weather. 4-H Leaders #125L33.

Nature Scope. *Wild About Weather.* National Wildlife Federation, Washington, DC.

ECOLOGY AND ENVIRONMENTAL EDUCATION

Carson, R. 1965. *The Sense of Wonder.* Harper and Row Publishers, New York.

Heath, M. and A. Barker. 1994. *Pathways to a Sustainable Future: A Curriculum Guide for Maine Schools Exploring Waste Management Issues.* The Chewonki Foundation, Wiscasset, ME and the Maine Waste Management Agency, Augusta, ME.

Iowa State University Cooperative Extension Service. 1984. *Bugs, Birds, Beasts, and Us: Activities for Environmental Education.* 4-H Publication 808B, Ames, IA.

Lingelbach, J. 1986. *Hands-On Nature.* Vermont Institute of Natural Science, Woodstock, VT.

Michigan State University Cooperative Extension Service. East Lansing, MI.
Just Outside the Door - Activity Guide.
Just Outside the Door - Leader's Guide.

National 4-H Council. 1994. *Educating Young People about Energy for Environmental Stewardship.* Environmental Stewardship Program, Chevy Chase, MD.

Nature Scope. *Pollution: Problems & Solutions.* National Wildlife Federation. Washington, DC.

Odom, E. P. 1971. *Fundamentals of Ecology.* Saunders Press, Philadelphia, PA.

Pike, G. and D. Selby. 1988. *Global Teacher, Global Learner.* Hodder & Stoughton, Toronto, Canada.

Ross, B. L. 1989. *Waste Away: Information and Activities for Investigating Trash Problems and Solutions.* Vermont Institute of Natural Science, Woodstock, VT.

Storer, J. H. 1968. *Man in the Web of Life.* Signet Books, New York, NY.

University of Kentucky Cooperative Extension Service. 1985. Exploring Natural Resources. 4-H Publication 1145, Lexington, KY.

Smith, R. L. 1974. *Ecology and Field Biology.* Harper and Row Publishers, New York, NY.

Van Matre, S. 1970. *Acclimatization.* Towering Pines, Eagle River, WI.

Van Matre, S. 1974. *Acclimatizing - A Personal and Reflective Approach to Natural Relationships.* American Camping Association, Martinsville, IN.

Van Matre, S. and B. Weiler. 1983. *The Earth Speaks.* The Institute for Earth Education, Greenville, WV.

FISH AND FRESHWATER

Colorado State University Cooperative Extension. *4-H Wildlife Habitat Evaluation Handbook.* Boulder, CO.

Hunter, M. L., Jr., J. Albright, and J. Arbuckle. 1992. *The Amphibians and Reptiles of Maine.* Bulletin 838, Maine Agricultural Experiment Station, University of Maine, Orono, ME. (Also available from the Maine Department of Inland Fisheries and Wildlife, Augusta, ME.)

National Audubon Society. *Audubon Adventures Newsletter.* New York, NY.

Nature Scope. Wading Into Wetlands. National Wildlife Federation, Washington, DC.

Reid, B. K. *Golden Guide to Pond Life.* Golden Press, NY.

University of Maine Cooperative Extension. *Hook, Line and Sinker.* #7034. Orono, ME.

Western Regional Environmental Education Council. 1992. *Project WILD* and *Project WILD - Aquatic Activity Guides.* Boulder, CO. (For information about Project WILD in Maine, contact the Maine Department of Inland Fisheries and Wildlife at 207-287-3303.)

FORESTRY, FOREST LIFE AND WOOD SCIENCE

American Forest Foundation. 1993. *Project Learning Tree: Environmental Education Activity Guide.* Washington, DC. (For information about PLT in Maine, contact the Maine Forest Service at 1-800-367-0223.)

Bennett, D. B. 1986. *Science and Natural History: A Maine Studies Sourcebook.* Volumes 1-4. Down East Books, Camden, ME.

Cornell Cooperative Extension. *Wildlife and Timber from Private Lands: A Landowner's Guide to Planning.* #147IB193. Cornell University, Ithaca, NY.

Maine Forest Service. *Forest Trees of Maine.* Department of Conservation, Augusta, ME.

Nature Scope. National Wildlife Federation, Washington, DC.
Trees Are Terrific!
Rain Forests: Tropical Treasures.

University of Maine Cooperative Extension. Orono, ME.
Conifers of Maine. #7015.
Forest Nutrient Cycle. #7029.
Yankee Woodlot: Basic Mapping. #7007.
How to Tap Maple Trees and Make Maple Syrup. #7036.
Measuring Trees. #7110
Raindrops Keep Falling: How Woodlands Affect Our Water Supply. #7070.
Why Leaves Change Color. #7078.

University of Wisconsin Cooperative Extension Service. *Naturespace 4-H Natural Science Publications 335, 336, 338, 340, 341.* Madison, WI.

USDA Forest Service. 1964. *Classroom Demonstration of Wood Properties.* Publication PA900. U.S. Printing Office, Washington, DC.

USDA Forest Service. *A Guide to Common Insects & Diseases of Forest Trees in Northeastern United States.* Publication NA-FR-4, Northeast Forest Experiment Station, Broomall, PA.

USDA Forest Service. *Investigating Your Environment: Teaching Materials for Environmental Education.* Publication F5349, U.S. Government Printing Office, Washington, DC.

USDA Forest Service. *Why Trees Grow Where They Do in New Hampshire Forests.* Publication NE-INF-37-79, Northeast Forest Experiment Station, Broomall, PA.

GEOLOGY AND MINERALS

Bennett, D. B. 1986. *Science and Natural History: A Maine Studies Sourcebook.* Volumes 1-4. Down East Books, Camden, ME.

Nature Scope. *Geology - The Active Earth.* National Wildlife Federation, Washington, DC.

University of Maine Cooperative Extension. *Collecting Rocks, Minerals and Fossils.* #8013. Orono, Me.

INSECTS

Michigan Cooperative Extension Service. East Lansing, MI.
Entomology Series - Unit I.
Entomology Series - Unit II.
Entomology Series - Unit III.
Entomology Leader's Guide.

National Audubon Society. *Audubon Adventures Newsletter.* New York, NY.

Nature Scope. National Wildlife Federation, Washington, DC.
Incredible Insects.
Insects Discovery Pac.

Western Regional Environmental Education Council. 1992. *Project WILD* and *Project WILD Aquatic Activity Guides.* Project WILD, Boulder, CO. (For information about Project WILD in Maine, contact the Maine Department of Inland Fisheries and Wildlife at 207-287-3303.)

LEADERSHIP AND YOUTH DEVELOPMENT

Michigan State University Cooperative Extension Service. *SPACES.* East Lansing, MI.

University of Illinois Cooperative Extension Service. Urbana, IL.
Leadership Skills You Never Outgrow - Book I - IV.
Leadership Skills You Never Outgrow - Helper's Guide.
Leadership Skills You Never Outgrow - Leader's Guide.

University of Maine Cooperative Extension. Orono, ME.
About You and Me. #8046.
Connecting to a Community. #4187.
I'm Positive: Growing Up with Self Esteem. #4099.
Teens: Being Happy and Building Self Esteem. #8049.
The Growing Child. #4164.
Understanding Children Through Play. #4096.
What Are Children Like? #4097.
Winning Ways to Talk With Young Children. #4077.

MARINE SCIENCE AND AQUACULTURE

Bennett, D. B. 1986. *Science and Natural History: A Maine Studies Sourcebook.* Volumes 1-4. Down East Books, Camden, ME.

Coulombe, D. H. 1984. *The Seaside Naturalist.* Prentice Hall Press, Englewood Cliffs, NJ.

Nature Scope. *Diving into Oceans.* National Wildlife Federation, Washington, DC.

Sharpe, G. W. *Acadia National Park and Nearby Coast of Maine.* Golden Press, New York, NY.

University of Maine Cooperative Extension. *Connections to the Sea.* #8015. Orono, ME.
University of Massachusetts. *Sealife in a Marine Aquarium.* 4-H Publication 108. Amherst, MA.
University of New Hampshire Marine Program. 1981. *Through the Looking glass: Teacher's Guide.* Office of Cooperative Ocean Programs, Portsmouth, NH.
Zim, H. S. *Seashores.* Golden Press. New York, NY.

MISCELLANEOUS

Cornell Cooperative Extension. *Leader's Guide to Community Action.* #159S115. Cornell University, Ithaca, NY.
Headstrom, R. 1976. *Adventures With a Hand Lens.* J.P. Lippincott Company, New York, NY.
Leopold, A. 1969. *A Sand County Almanac.* Oxford University Press, London.
Muir, J. 1916-1924. *The Writings of John Muir.* Houghton-Mifflin Co., Boston, MA.
Nature Scope. *Discovering Deserts.* National Wildlife Federation, Washington, DC.
Simon, S. B. 1975. *Beginning Values Clarification: A Guidebook for the Use of Values Clarification in the Classroom.* Pennant Press, San Diego, CA.
Simon, S. B., H. W. Howe, and H. Kirschenbaum. 1972. *Values Clarification - A Handbook of Practical Strategies for Teachers and Students.* Hart Publishing Company, New York, NY.
Thoreau, H. D. 1906. *The Writings of Henry David Thoreau.* Houghton-Mifflin Co., Boston, MA.

NIGHTTIME RESOURCES

Bennett, D. B. 1986. *Science and Natural History: A Maine Studies Sourcebook.* Volumes 1-4. Down East Books, Camden, ME.
Brown, V. 1972. *Knowing the Outdoors in the Dark.* Stackpole Books, New York, NY.
Jobb, J. 1977. *The Night Sky Book.* Little Brown Books, San Francisco, CA.
Milne, L. J. and M. J. 1956. *The World of Night.* Harper and Row Publishers, New York, NY.
Nature Scope. *Astronomy Adventures.* National Wildlife Federation, Washington, DC.
Olcott, W. T. 1954. *Field Book of the Skies.* Houghton-Mifflin Company, Boston, MA.
Prince, J. H. 1968. *Animals in the Night.* Tri-Oceans, San Francisco, CA.
Reed, W. M. 1951. *Patterns in the Sky: The Story of Constellations.* Morrow Publishers, New York, NY.
Rey, H. A. 1958. *The Stars: A New Way to See Them.* Houghton-Mifflin Company, Boston, MA.
Roots, C. 1974. *Animals of the Dark.* Praeger Publishers, Inc., New York, NY.

OUTDOOR EDUCATION AND OUTDOOR RECREATION

Anonymous. 1976. *The New Games Book.* Dolphin Books/Doubleday & Co., Inc., Garden City, NY.
Anonymous. 1976. *More New Games Book.* Dolphin Books/Doubleday & Co., Inc., Garden City, NY.
Ashbaugh, B. L. *Planning a Nature Center.* National Audubon Society, New York, NY.
Cornell, J. 1979. *Sharing Nature with Children.* Ananda Publications, Nevada City, CA.
Knapp, C. F. G. 1981. *Humanizing Environmental Education: A Guide for Leading Nature and Human Nature Activities.* American Camping Association, Martinsville, IN.
Michigan State University Cooperative Extension Service. East Lansing, MI.
Cross-Country Skiing, 4-H Publication 1174.
Michigan 4-H Challenge.
Oregon State University Cooperative Extension Service. Corvallis, OR.
Advanced Camping Skills, Project Unit I.
Conducting Hikes and Field Trips, Project Unit II.
Pennsylvania State University Cooperative Extension Service. *4-H Orienteering.* University Park, PA.
University of California. 1975. *Outdoor Biological Instructional Strategies.* Lawrence Hall of Science, Berkley, CA.
University of Wisconsin Cooperative Extension Service. 1982. *I Can Teach in the Outdoors.* Madison, WI.
USDA Forest Service. 1974. *Developing the Self-Guiding Trail in the National Forests.* Misc. Publication 968, U.S. Government Printing Office, Washington, D.C.

PHOTOGRAPHY AND VISUAL ARTS

Nature Scope. *Wild and Crafty.* National Wildlife Federation. Washington, DC.
University of Illinois Cooperative Extension Service. *4-H Visual Arts - Leader's Guide.* Urbana, IL.
University of Maine Cooperative Extension. Orono, ME.
Adventures With Adjustable Cameras.
Adventures With Your Camera.
Exploring Photography.
4-H Photography - Unit I - Leader's Guide.

SOIL AND WATER CONSERVATION

Bennett, D. B. 1986. *Science and Natural History: A Maine Studies Sourcebook.* Volumes 1-4. Down East Books, Camden, ME.
Buller, D. *Pond Guide.* Outdoor Biology Instructional Strategies, Delta Education, Nassau, NH.
Iowa State University Cooperative Extension Service. *4-H Ding Darling Project.* Ames, IA.

Maine Geological Survey. Curriculum Resources for Earth Science Teachers (CREST). State House Station 22, Augusta, ME. 207-287-2801 (Variety of curricular materials including activities, posters, brochures, and so on.)

Morgern, A. H. *Field Book of Ponds and Streams.* Houghton-Mifflin Company, Boston, MA.

Soil Conservation Service. *Conserving Soil.* Washington, D.C.

WILDLIFE

Anthony, E. *Field Book of North American Mammals.* Houghton-Mifflin Company, Boston, MA.

Burt, W. H. and R. P. Grossenheider. 1976. *A Field Guide to the Mammals.* Houghton-Mifflin Company, Boston, MA.

Colorado State University Cooperative Extension. *4-H Wildlife Habitat Evaluation Handbook.* Boulder, CO.

Cornell Cooperative Extension. Cornell University, Ithaca, NY.
Managing Small Woodlands for Wildlife. #147IB157.
Wildlife Notebook. #147IB210.
Understanding Predation and Northeast Birds of Prey. #147IB175.
Wildlife Habitat Enhancement. #147L516.
Birds in Your Backyard. #147L517
Wildlife Discovery. #147L519.
Wildlife in Today's Landscapes. #147L520.

Harrison, H. H. 1975. *A Field Guide to Bird's Nests.* Houghton-Mifflin Company, Boston, MA.

Hausman, F. *Field Book of Eastern Birds.* Houghton-Mifflin Company, Boston, MA.

Henderson, C. L. 1987. *Landscaping for Wildlife.* Minnesota Department of Natural Resources, St. Paul, MN.

Henderson, C. L. 1992. *Woodworking for Wildlife.* Minnesota Department of Natural Resources, St. Paul, MN.

Hunter, M. L., Jr., J. Albright, and J. Arbuckle. 1992. *The Amphibians and Reptiles of Maine.* Bulletin 838, Maine Agricultural Experiment Station, University of Maine, Orono, ME. (Also available from the Maine Department of Inland Fisheries and Wildlife, Augusta, ME.)

Maine Department of Inland Fisheries and Wildlife. *On Water, On Wings, In the Woods: A Guide for Maine Wildlife Watchers.* MDIFW, Augusta, ME.

McElroy, T.P., Jr. *The Habitat Guide to Birding.* Houghton-Mifflin Company, Boston, MA.

National Audubon Society. *Audubon Adventures Newsletter.* New York, NY.

Nature Scope. National Wildlife Federation, Washington, DC.
Amazing Mammals - Part I.
Amazing Mammals - Part II.
Birds, Birds, Birds!
Endangered Species: Wild and Rare
Let's Hear it for Herps!
Wading Into Wetlands.

Peterson, R. T. 1980. *A Field Guide to the Birds.* Houghton-Mifflin Company Boston, MA.

Peterson, R. T. *A Field Guide to Bird Songs.* Houghton-Mifflin Company, Boston, MA. (bird songs recorded on cassette tape or CD)

University of Maine Cooperative Extension. 1988. *A Forester's Guide to Managing Wildlife Habitats in Maine.* #7000. Orono, ME.

Western Regional Environmental Education Council. 1992. *Project WILD* and *Project WILD - Aquatic Activity Guides.* Boulder, CO. (For information about Project WILD in Maine, contact the Maine Department of Inland Fisheries and Wildlife at 207-287-3303.)

APPENDIX B
Equipment and Materials

WHERE TO GET NATURE EQUIPMENT AND SUPPLIES: write for catalogs of supplies that can be used in your programs. No official endorsement of any of the suppliers is intended or implied.

COMPUTER SOFTWARE

CBS Software
Greenwich, CT 06836

Computer Skill Builders
Department EE
PO Box 42050
Tucson, AZ 85733

Earthware Computer Service
PO Box 30039
Eugene, OR 97403

Educational Computing
Oakton, VA 22124

Krell Software
1320 Stony Brook Rd.
Stony Brook, NY 11790

Learning Arts
Department EE
PO Box 179
Wichita, KS 67201

Micro Center
PO Box 444005
Eden Prairie, MN 55344

Micro Ed
P.O. Box 444005
Eden Prairie, MN 55344

GARDENING AIDS

Cornell Cooperative Extension Service
Gardening Program
11 Park Pl., Suite 1016
New York, NY 10007
Various publications

Kings
24 Yost Ave.
Sp. City, PA 19475
Biological pest control

Necessary Trading Company
367 Main St.
New Castle, VA 24127
Chemical-free gardener's guide

New England Insect Traps
PO Box 938
Amherst, MA 01004
Natural pesticides, biological pest control

Ortho-Chevron Chemical Company
Public Affairs Department
PO Box 3744
San Francisco, CA 94119
"A Child's Garden," "Trees for a More Livable Environment," "Learning on the Light Side."

Rincon-Vita
PO Box 96
Oakview, CA 93022
Biological pest control

GENERAL SCIENTIFIC SUPPLIES

Carolina Biological Supply
2700 York Rd.
Burlington, NC 27215

Cenco
11222 Melrose Ave.
Franklyn Park
Chicago, IL 60131

Connecticut Valley Biological Supply
Valley Road
Southampton, MA 01073
Source for live specimens, books providing information and culture methods

Edmund Scientific
101 East Gloucester Pike
Barrington, NJ 08007

Fisher Scientific Company
1-800-621-4769

Frey Scientific Company
905 Hickory Ln.
Mansfield, OH 44905

Kuhl Company
Flemington, NJ 08822
Makers of Educational Chick Incubator (Hovabator)

Lab-Aids, Inc.
130 Wilbur Pl.
Bohemia, NY 11716
Supplies, kits

NASCO
Fort Atkinson, WI 53538
Biotips

National Teaching Aids
120 Fulton Ave.
Garden City Park, NY 11040
Makers of microviewers

Sargent-Welch
35 Stern Ave.
Springfield, NJ 07081
Microscopes, information cards

School Masters
745 State Circle
Ann Arbor, MI 48104

Science Source, The
Rte 1
Waldoboro, ME 04572

Turtox/Cambosco
MacMillan Science Company
8200 South Hoyne Ave.
Chicago, IL 60620
Science Leaflets

Wards
PO Box 1712
Rochester, NY 14603
Booklet, "How to Assemble an Animal Kingdom Survey Collection," other aids

Warner Scientific
1-800-523-0267

NATURE SUPPLIERS

Biological Resource Development Company
1750 Wooten Rd.
Beaumont, TX 77707
Styrofoam display boxes

Butterfly Company
51-17 Rockaway Beach Blvd.
Far Rockaway, NY 11691

Creative Dimensions
Box 1393
Bellingham, WA 98225
Owl pellets

Havahart Trap
PO Box 551
Ossining, NY 10562
Live Traps

Insect Lore Products
PO Box 1535
Shafter, CA 93263

Learning Spectrum
1390 Westridge
Portola Valley, CA 94025
Inexpensive student microscopes, other materials

Museum Products
3175 Gold Star Highway
Mystic, CT 06355
Catalog

REPRINTS, GRAPHICS, POSTERS

Argus Communications
One DLM Park
Allen, TX 75002

Forest Service
U.S. Department of Agriculture
PO Box 2417
Washington, D.C. 20013
"What We Get from Trees" poster, and other materials

Information Division
Agriculture Resource Service
U.S. Department of Agriculture
Washington, D.C. 20256
Science study aids

John Wiessinger
Lakeshore Curriculum Materials
2694 E. Dominguez St.
PO Box 6291
Carson, CA 90749

North American Bluebird Society
Box 6295
Silver Springs, MD 20906

St. Regis Paper Company
150 East 47th St.
New York, NY 10017
"Life in the Forest," "The Forest Community," others

SVE
2750 North Wayne Ave.
Chicago, IL 60614
Posters

Pennsylvania Game Commission
PO Box 1567
Harrisburg, PA 17120
Display material

Roy G. Scarfo, Inc.
PO Box 217
Thorndale, PA 19372

SUGGESTIONS, TEACHING TIPS

Ampersand Press
691 26th St.
Oakland, CA 94612
Makers of "Predator/Prey" and other ecology games

Brooklyn Botanical Garden
1000 Washington Ave.
Brooklyn, NY 11225
Catalog, booklets on plant dyes

Crows Nest Bookstore
Laboratory of Ornithology
Cornell University
159 Sapsucker Woods Rd.
Ithaca, NY 14850
Games, puzzles, books, Audible Audubon

Education Section
Office of Public Information and Education
Ohio Department of Natural Resources
Fountain Square
Columbus, OH 43224
Imagination Books

ERIC/SMEAC
1200 Chambers Rd., 3rd Floor
Columbus, OH 43212
Clearinghouse for environmental education

Girl Scouts of the USA
830 Third Ave.
New York, NY 10022
Book, "Exploring Wildlife Communities with Children"

Gull Lake Environmental Ed Project
Kellogg Bird Sanctuary
Michigan State University
12685 East C Ave.
Augusta, MI 49012
Good teaching aids

Lawrence Hall of Science
Astronomy Education Program
University of California
Berkeley, CA 94720
Producers of "Stargazer's Gazette" and "Sky Challenger" materials

National 4-H Council
150 North Wacker Dr.
Suite 1950
Chicago, IL 60606
"What's a Tree to Me?"

Nature Impressions
1007 Leneye Pl.
El Cerrito, CA 94530
Rubber stamp makers

P.A. Schiller Associates
PO Box 307
Chicago, Il 60690
Activities, mini-field games

Robatom Publications
Route 1, Box 148
Prudenville, MI 48651
Spirit masters

Safari Ltd.
PO Box 630685
Ovus, FL
Animal rummy games

Soil Conservation Society of America
N.E. Ankeny Pl.
Ankeny, IA 50021
Materials in comic book format

APPENDIX C
Maine's Natural Resource and Environmental Education Organizations

ACADIA NATIONAL PARK
PO Box 177
Bar Harbor, ME 04409
207-288-3338
Provides recreational use and preserves lands within the boundaries of Acadia National Park.

APPALACHIAN MOUNTAIN CLUB
Maine Chapter
12 Pleasant Street
South Portland, ME 04103
207-244-3747
Recreation and conservation organization that promotes outdoor safety and environmental protection.

ATLANTIC SEA RUN SALMON COMMISSION (ASRSC)
650 State Street
Bangor, ME 04401-5654
207-941-4449
Undertakes activities for managing, conserving and restoring Atlantic salmon in state waters.

BAXTER STATE PARK (BSP)
64 Balsam Drive
Millinocket, ME 04462
207-723-9616
Protects the lands of the park and keeps them "forever wild"; provides for recreational use consistent with the "forever wild" concept; and establishes areas that will be used for "scientific forestry management."

BUREAU OF PARKS AND RECREATION (BPR)
Department of Conservation
State House Station 22
Augusta, ME 04333
207-287-3821
Develops, manages and maintains state parks, historic sites, Allagash Waterway, Squaw Mountain, Bigelow preserve, Penobscot corridor, snowmobile trails and boat launching sites. Prepares statewide comprehensive outdoor recreation plan and other studies. Provides technical assistance and financial assistance to municipal recreation departments.

BUREAU OF PUBLIC LANDS (BPL)
Department of Conservation
State House Station 22
Augusta, Maine 04333
207-287-3061
Manages and administers public reserved and submerged lands; administrator of Maine Coastal Island Registry.

CHEWONKI FOUNDATION
RR 2, Box 1200
Wiscasset, ME 04578
207-882-7323
Offers courses and experiences to all ages in natural history and wilderness expeditions: summer camp; school environmental education programs; college semesters; and family programs.

CRITICAL AREAS PROGRAM (CAP)
State Planning Office
State House Station 38
Augusta, ME 04333
207-287-3261
Publications: Reports and brochures. Conducts statewide inventories to identify and document significant natural areas worthy of conservation. Maintains the Register of Critical Areas.

DEPARTMENT OF CONSERVATION
State House Station 22
Augusta, ME 04333
207-287-2211
Preserves, protects and enhances land and water resources; encourages wise use of scenic, mineral and forest resources; and provides for effective management of public lands.

DEPARTMENT OF ENVIRONMENTAL PROTECTION (DEP)
State House Station 17
Augusta, ME 04333
207-287-7688
Administers state and federal programs to regulate and improve the quality of the state's air, land and water.

DEPARTMENT OF INLAND FISHERIES AND WILDLIFE (MDIFW)

State House Station 41
Augusta, ME 04333
207-287-2871

Protects and encourages the wise use of the inland fisheries and wildlife resources of the state.

DEPARTMENT OF MARINE RESOURCES (DMR)

State House Station 21
Augusta, ME 04333
207-624-6650

Serves to conserve and develop marine and estuarine resources by conducting and sponsoring scientific research and developing the Maine commercial fishing industry.

DUCKS UNLIMITED, INC (DU)

Maine State Committee
71 Carroll Street
Portland, ME 04102-3522
207-775-7276

Raises funds for preserving, restoring, developing, maintaining and managing waterfowl habitat along Atlantic flyway and throughout North America.

GARDEN CLUB FEDERATION OF MAINE

119 Burnham Road
Gorham, ME 04038
207-839-3878

Educates and encourages good gardening practices and supports good conservation in all aspects.

GREENPEACE NEW ENGLAND

709 Center Street
Jamaica Plain, MA 02130
617-983-0300

Promotes protection of Gulf of Maine from offshore oil drilling; fights offshore oil drilling, toxic chemical pollution; promotes disarmament, wildlife protection through direct civil disobedience.

MAINE APPALACHIAN TRAIL CLUB (MATC)

PO Box 283
Augusta, ME 04330-0283
207-246-4663

A public service organization for the management and maintenance of the Appalachian Trail in Maine from Grafton Notch (Rte 26) to Katahdin summit.

MAINE AUDUBON SOCIETY (MAS)

Gilsland Farm
PO Box 6009
Falmouth, ME 04105-6009
207-781-2330

Programs cover natural history, environmental education, energy programs and environmental advocacy in legislature, agencies and courts. See regional list for descriptions of the Society's three chapters: Down East, Penobscot and Schoodic.

MAINE COAST HERITAGE TRUST (MCHT)

167 Park Row
Brunswick, ME 04011
207-729-7366

A land conservation organization protecting the islands and coastline of Maine. Provides advisory services on land protection to landowners, community groups and other conservation organizations, including local land trusts.

MAINE CONSERVATION SCHOOL

Conservation Education Foundation of Maine
Department of Education
State House Station 23
Augusta, ME 04333
207-287-5909 (winter)
PO Box 188
Bryant Pond, ME 04219
207-665-2068 (summer)

Seeks to foster, through educational programs at Bryant Pond, an understanding of Maine's natural environment; provides unique educational experiences for school groups, teachers and environmentally concerned organizations.

MAINE ENVIRONMENTAL EDUCATION ASSOCIATION, INC. (MEEA)

PO Box 9
Wiscasset, ME 04578

Promotes environmental education in Maine's schools and communities. Through its newsletter and workshops series, provides a forum through which environmental educators can share information and ideas.

MAINE FOREST SERVICE (MFS)

Department of Conservation
State House Station 22
Augusta, ME 04333
800-367-0223

Responsible for protection of the forest resource from forest fires, and destructive insects and diseases; provides technical and informational assistance to forest landowners on forest management; assists forest landowners and processors in marketing and utilization of wood products; assists communities in urban forestry; conducts an information and education program for citizens on the economic and social value of the forest.

MAINE GEOLOGICAL SURVEY (MGS)

Department of Conservation
State House Station 22
Augusta, ME 04333
207-287-2801

Maps, interprets and publishes geologic information; provides advisory assistance to the minerals industry and interpretive information for planning and regulatory agencies; provides a variety of curricular materials including activities, posters, charts, field trip guide book, sets of minerals and rocks for loan, brochures, and pamphlets.

MAINE ORGANIC FARMERS AND GARDENERS ASSOCIATION (MOFGA)

PO Box 2176
Augusta, ME 04338
207-622-3118
Promotes good soil management, good nutrition, energy efficiency, proper livestock care and a strong agricultural economy.

MID-COAST CHAPTER, NATIONAL AUDUBON SOCIETY

PO Box 862
Rockland, ME 04841
207-354-6074
Dedicated to understanding and preserving the natural environment through education, field trips, workshops and conferences; manages Guy Van Duyn Wildlife Refuge, chapter covers Wiscasset-Belfast-Augusta area.

NATIONAL AUDUBON SOCIETY (NAS)

Maine State Office
PO Box 524
Dover-Foxcroft, ME 04426
207-564-7946
National organization dedicated to understanding and protection of the natural environment; maintains wildlife sanctuaries throughout Maine; sponsors coastal summer ecology camps. Several local chapter located in Maine.

NATURAL RESOURCES CONSERVATION SERVICE (NRCS)

5 Godfrey Drive
Orono, ME 04473
207-866-7241
Offers assistance to farmers and other land users in the conservation and development of the state's soil and water resources.

NATURAL RESOURCES COUNCIL OF MAINE (NRCM)

271 State Street
Augusta, ME 04330
207-622-3101
Maine's principal environmental advocacy organization; does legal defense for the environment, lobbies state and federal governments, serves as watchdog of state environmental agencies and provides information and assistance to affiliates and citizens. State affiliate of National Wildlife Federation.

NEW ENGLAND WILD FLOWER SOCIETY, INC. (NEWFS)

Maine Chapter
PO Box 5508
Augusta, ME 04332
207-621-0038
Nonprofit organization established to promote the conservation of temperate North American flora.

OFFICE OF ENERGY RESOURCES (DER)

State House Station 53
Augusta, ME 04333
207-287-3811
Coordinates state energy on policies and programs regarding renewable energy resources; operates Energy Extension Service providing technical assistance and information to the public; provides information on utility company conservation programs and energy libraries.

SIERRA CLUB

Maine Chapter
PO Box 8553
Portland, ME 04104
207-761-5615
Provides outings at all levels to members and non-members. Supports, through publicity, public meetings and letter writing, environmental protection measures for Maine.

SMALL WOODLAND OWNERS ASSOCIATION OF MAINE, INC. (SWOAM)

PO Box 926
Augusta, ME 04332-0926
207-626-0005
Statewide, nonprofit organization affiliated with the National Woodlands Owners Association. Pursues better understanding, skills and directions in small woodland ownership and management under integrated use objectives.

SOIL AND WATER CONSERVATION COMMISSION (SWCC)

Department of Agriculture
State House Station 28
Augusta, ME 04333
207-287-2666

SPORTSMAN'S ALLIANCE OF MAINE (SAM)

PO Box 2783
Augusta, ME 04338-2783
207-622-5503
Statewide, nonprofit organization dedicated to hunting, fishing, trapping, protection of wildlife habitat and conservation.

TANGLEWOOD 4-H CAMP AND LEARNING CENTER

PO Box 102
Lincolnville, ME 04849
207-789-5868 (spring, summer, fall)
800-244-2104 (all year)
Provides learning opportunities for youth and adults so they may become knowledgeable and caring inhabitants of the earth.

THE NATURE CONSERVANCY (TNC)

Maine Chapter, Fort Andross
14 Maine St., Suite 401
Brunswick, ME 04011-2026
207-729-5181
Works to identify and protect special natural areas, especially those containing rare species. Manages over 70 nature preserves throughout state.

THE WILDLIFE SOCIETY, MAINE CHAPTER (TWS)

20 Dillingham St., Apt. 1
Bangor, ME 04401-6858
207-827-5938
A nonprofit scientific and educational organization of professionals and students dedicated to the wise management and conservation of wildlife resources.

THE WILDLIFE SOCIETY, UNIVERSITY OF MAINE STUDENT CHAPTER

5755 Nutting Hall
Orono, ME 04469-5755
207-581-2907
A nonprofit scientific and educational organization of professionals and students dedicated to the wise management and conservation of wildlife resources. The Student Chapter's Environmental Awareness Committee offers programs on Maine wildlife to schools and other youth organizations.

TROUT UNLIMITED (TU)

Maine Council
PO Box 53
Hallowell, ME 04347
207-724-3476
Preserves, protects and enhances cold water fishery resources.

U.S. GEOLOGICAL SURVEY (USGS)

Water Resources Division
26 Ganneston Dr.
Augusta, ME 04330
207-622-8201
Collects, disseminates and evaluates information on water availability, quantity and quality to guide the management of water resources.

WATER RESOURCES PROGRAM, UNIVERSITY OF MAINE

5715 Coburn Hall
Orono, ME 04469-5715
207-581-1490
Sponsors research and dissemination of information on water and other natural resources in Maine; one of 54 similar units located at U.S. land-grant colleges.

ZERO POPULATION GROWTH (ZPG)

Maine Chapter
9 Delano Park
Cape Elizabeth, ME 04107
207-799-3555
Educates and lobbies on population issues facing the United States and the world.

APPENDIX D
Glossary

Abiotic — The nonliving components of the environment, including sun, air, water and soil; not involving or produced by living organisms.

Adaptation — The process of making changes in the structure, behavior or metabolism of an organism that adjusts it to the environment.

Biotic — The living components of the environment, including producers, consumers and decomposers; involving or produced by living organisms.

Camouflage — A behavior, coloration or shape that is designed to deceive or hide.

Carnivore — Any animal that eats primarily meat.

Carrying Capacity — The number of animals that a given area can support for a specific period of time, usually the most critical season of the year

Chlorophyll — A group of pigments that produce the green hue of plants; essential to photosynthesis.

Climax, Climax Community — The relatively stable association of plants and animals that represents the final stage of ecological succession under existing conditions of soil and climate; regenerates and replaces itself without marked and further change.

Community — An association of plants and animals, inhabiting a common environment, and interacting with each other; bound together by a food web and other interrelations.

Conifer, Coniferous — A plant that bears its seeds in cones. Usually refers to needleleaf trees, although some needleleaf plants, such as yew, do not bear cones.

Conservation — The use of natural resources in such a way as to ensure their continuing availability; see Preservation.

Consumer — An organism that obtains its food by eating other organisms.

Crepuscular — Animals active at dawn and dusk.

Deciduous — A plant that periodically loses all its leaves, usually in autumn. Most North American broadleaf trees are deciduous. A few conifers, such as larch and cypress, also are deciduous.

Decomposer — A plant or animal that feeds on dead material and causes its mechanical or chemical breakdown; convert dead organic matter into inorganic materials.

Diurnal — Animals active during the day.

Ecology — The scientific study of living things' relationships to one another and to their environment. A scientist who studies these relationships is called an ecologist.

Ecosystem — An area of any size that includes living and nonliving things and their environment. All are linked together by energy flow and nutrient cycling.

Energy — The capacity for doing work.

Environment — The sum of all external conditions affecting the life, development and survival of an organism.

Eutrophication — The enrichment of soils and water because of fertilization, sewage, effluent or other waters that carry a high plant-nutrient component, especially nitrogen, and phosphorus. Eutrophication can be accelerated by many human activities.

Evaporation — The process of converting a liquid into a gas or vapor.

Evolution — The theory that all species of plants and animals developed from earlier forms by hereditary transmission of slight variations to successive generations.

Food Chain — A series of plants and animals linked by their food relationships. A green plant, a leaf-eating insect and an insect-eating bird would form a simple food chain. Any one species is usually included in many food chains.

Food Web — The sum of interacting food chains in an ecological community.

Groundwater — The supply of fresh water under the Earth's surface that forms a natural reservoir.

Habitat — The natural environment of an animal or plant that includes food, water, shelter and space, in the proper arrangement.

Herbivore — An animal that eats plants.

Home Range — The area in which an animal travels during its normal activities; see Territory.

Interaction — The relationship of one organism to another. Some interactions are positive, some are negative, some are neutral.

Interdependence — Interrelationships of organisms with one another and with their environment; mutual dependence on one another for survival.

Life Cycle — The continuous sequence of changes undergone by an organism from one primary form to the development of the same form again.

Microhabitat — A "small habitat" within a larger one in which environmental conditions differ from those in the surrounding area. A hole in a tree trunk and a decomposing animal carcass are examples of microhabitats within a forest habitat.

Natural Selection — The natural process of survival of the fittest by which the organisms best adapted to their environment survive and those less well adapted are eliminated.

Niche — The role of an organism in the environment, its activities and relationships to the other living and nonliving parts in the environment; the "job" an organism does, in contrast to the "place" it lives.

Nocturnal — Animals active at night.

Nutrient — A substance that provides nourishment, such as vitamins and minerals.

Omnivore — An organism that eats both plants and animals.

Organism — A living thing; a form of life composed of mutually dependent parts that maintain various vital processes.

Photosynthesis — The process by which green plants convert carbon dioxide and water into simple sugar. Chlorophyll and sunlight are essential to the series of complex chemical reactions involved.

Pioneer Species or Pioneer Community — Any species or community that develops in barren areas, disturbed areas or newly created soils.

Pollution — Harmful substances deposited in the air, water or land, leading to a state of dirtiness, impurity or unhealthiness; the presence of matter or energy whose nature, location or quantity produces undesired environmental effects.

Population — The number of individuals of a particular species in a defined area.

Precipitation — A deposit of water in some form, such as rain, sleet, hail, snow, fog or mist, onto the Earth.

Predator — An animal that kills and eats other animals.

Preservation — Protection that emphasizes nonconsumptive values and uses; see Conservation.

Prey — Animals that are killed and eaten by other animals.

Producer — An organism that produces its own organic compounds from simple substances such as carbon dioxide, inorganic nitrogen and water.

Scavenger — An organism that habitually feeds on refuse or dead animals.

Species — A biological classification that follows the genus or subgenus; individuals of the same species are potentially capable of interbreeding.

Succession — The gradual replacement of one kind of community by another kind; the progressive changes in vegetation and in animal life that culminates in the climax community.

Territory — An area defended by an animal against others of the same species; territories are used for breeding, feeding or both; see Home Range.

Transpiration — The passage of water vapor from a living plant into the air, through specialized leaf cells.

Understory — The layer of plants growing under another higher layer of plants, such as grass, herbs and brush growing under forest trees.

APPENDIX E
Soil, Air and Water Exercises

SOIL EXERCISES

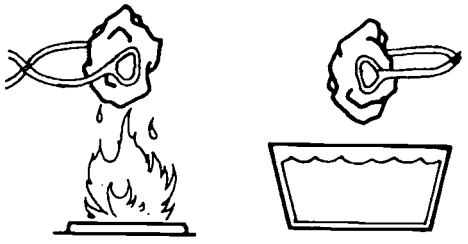
1. HOW SOIL IS FORMED

You can demonstrate some of the physical forces of nature that break up rocks to form soils.

A. Heat and Cold

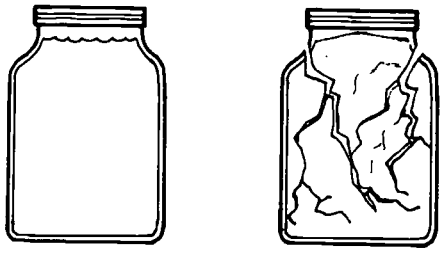
(Ask your leader to help.)

a. Using tongs, hold a piece of limestone over a flame or stove, being very careful not to burn yourself!
b. Drop the hot rock into a pan of cold water. Record what happens. Explain how the heat of summer and cold winter can break rocks into smaller pieces.



B. Freezing and Thawing

a. Fill a small jar completely with water. Screw the lid on tightly.
b. Wrap a towel around the jar. Place in a paper or plastic bag.
c. Place the bag in a freezer and leave it long enough to completely freeze the water in the jar.
d. Careful remove the towel and jar from the bag. Record the effect of freezing on the glass. What happened? Why? How does that relate to soil formation?



C. Wind and Water

a. Rub two soft stones or rocks together.
b. Record what happens. How does this demonstrate the effects of wind and water?

D. Water

Sodium chloride is a mineral compound that makes up table salt.

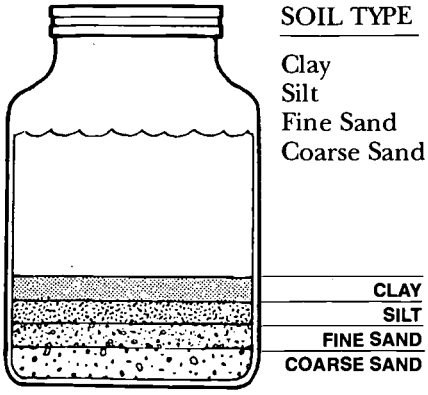
a. Put one tablespoon of table salt in a glass of water and stir.
b. Record what happens. How does this relate to soil formation?

All of these factors — heat, cold, freezing, thawing, wind and water — are vital to the development of new soil. The term "weathering" is used to include the effects of all of these factors. In your own words, explain the term "weathering" and how it relates to soil formation.

2. SEPARATING SAND, SILT AND CLAY

Sand, silt and clay are the primary components of soil. To see them, try this exercise.

a. Get a quart of soil from the garden, flower bed or field. Empty onto newspaper, and let it dry.
b. Crush any lumps.
c. Remove trash, rocks and roots.
d. Fill a quart jar 1/4 full with dry soil.
e. Add water until the jar is 3/4 full.
f. Add a tablespoon of non-foamy detergent.
g. Close the lid tightly and shake hard for about three minutes. Keep shaking until all the particles are separated from each other.
h. Set the jar on a table and watch very closely for 10-15 minutes. Write down what you see happening. Do not disturb the jar for two days.
j. Place an index card along side the jar. Mark off the depth of each layer that you can see in the jar. These layers are the clay, silt, fine sand and coarse sand. Label your card for each layer as illustrated.



k. Shake the jar again to mix up the layer. Set the jar down and hold your card beside it. Note how long it takes for each layer to reform. You may have to leave the jar for a while before you can see the upper layers form. Explain this difference in time.

l. Discuss why is each layer of soil necessary for growing plants. You may have to do some reading to find the answers!

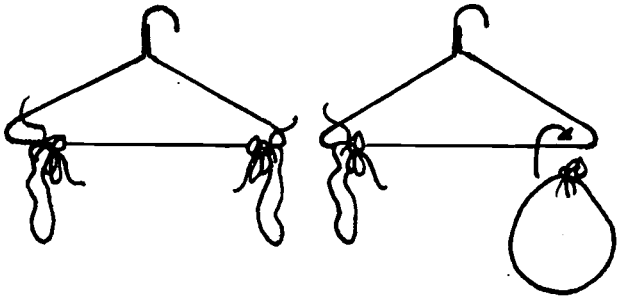
AIR EXERCISES

1. AIR HAS WEIGHT.

a. Take two empty balloons of equal size and weight and attach them with two equal lengths of string to two corners of a wire coat hanger. Balance it as shown in the diagram.

b. Remove one balloon, blow it up, and attach it again to the coat hanger.

c. Record happens. How does this show that air has weight?



2. AIR HAS VOLUME.

a. Attach two inflated balloons of the same size to the two ends of a straightened coat hanger and balance them so that the hanger is level.

b. Hold one of the balloons under hot water for a few minutes.

c. Record what happens to the balloon.

d. Record what happens to the hanger. Does it still balance in the same place?

e. Now release some of the air from the larger, heated, balloon until it is the same size as the other one. Do they balance now? Why or why not?

3. AIR CONTAINS SOLID PARTICLES.

a. Coat a glass slide, a petri dish (see your science teacher), or a piece of white paper with a very thin layer of petroleum jelly.

b. Place it outside, on a window sill or table, on a day when there is no wind.

c. After an hour or two, bring it inside and examine it. What has collected on the sticky surface? Is it dirty or dark? Can you guess where these particles have come from?

d. Repeat the same experiment on a windy day.

e. Do you get more particles on your sticky surface on a calm day or a windy day? Why?

WATER EXERCISES

1. WATER MOLECULES BOND TOGETHER.

a. Fill a narrow-mouth glass, such as a bud vase, half full with water.

b. Observe the edge of the water surface where it touches the side of the glass. Record your observations.

c. Fill the glass almost to the top. Using an eye dropper, continue adding water one drop at a time until it overflows. Record your observations. What did you notice about the level of the water at the center of the vase just before it overflowed? What about at the edge of the rim just before it overflowed? This experiment shows you strength of the bonds between water molecules that result in water's surface tension.

2. HOW MUCH WATER IS IN YOU?

a. Use a scale to determine your body weight.

b. The human body is about 80 percent water. How many pounds of your body weight is water?

3. MELTING RATES OF ICE

a. Make some ice cubes that each have the same amount of water in them.

b. Give each person an ice cube to hold. You can use your hand or a cup, but everyone has to use the same thing.

c. Record how long it takes for each person's ice cube to melt. Why do the cubes melt at different rates?

4. HOW FAST DOES WATER FREEZE?

a. Boil some water and pour it into a heat-proof cup. Steam is very hot, so be careful not to burn yourself!
b. Put the same amount of room-temperature tap water in another cup.
c. Put the same amount of cold tap water in another cup.
d. Place all of the cups in the freezer. Check them after an hour. Which freezes faster? Why?

5. MAKE IT RAIN!

a. Boil some water in a kettle.
b. Turn the heat off. Wearing oven mitts, and being very careful not to get burned by the hot steam, hold a large glass or bowl upside down over the rising steam. What happens? Why? How is this like rain forming and falling?
c. Discuss how this illustrates the laws of ecology and the water cycle.

6. TEMPERATURE AND RAINFALL

a. Keep a daily record of the weather. Include the high and low temperature, the amount of rain (or snow) and the temperature when it was raining (or snowing).
b. What was the total amount of rain (or snow) each month?
c. Can you find any relationship between temperature and rainfall (or snowfall)? What is that relationship? Why?

7. ACID PRECIPITATION

Rain, snow, sleet or fog that contains certain pollutants is called acid precipitation.

a. Collect samples of rain at the beginning, in the middle and at the end of a storm.
b. Measure the acidity of the water using paper that is sensitive to pH. Your science teacher or Extension educator can help you find out where to get this.
c. Record your observations. During what part of the rain storm is the water most acidic (lowest pH number)? Why?
d. What do you think causes acid precipitation? Do some research into the sources of pollutants that cause acid precipitation, and the effects of acid precipitation on plants and animals.

University of Maine Cooperative Extension

Androscoggin and Sagadahoc Counties Extension Office
133 Western Ave.
Auburn, ME 04210-4927
1-800-287-1458 (in Maine)
(207) 786-0376

Aroostook County Extension Offices
Houlton Rd.
PO Box 727
Presque Isle, ME 04769-0727
1-800-287-1462 (in Maine)
(207) 764-3361

13 Hall St.
Fort Kent, ME 04743-1126
1-800-287-1421 (in Maine)
(207) 834-3905

Central Building
PO Box 8
Houlton, ME 04730-0008
1-800-287-1469 (in Maine)
(207) 532-6548

Cumberland County Extension Office
PO Box 9300
Portland, ME 04104-9300
1-800-287-1471 (in Maine)
(207) 780-4205

Franklin County Extension Office
78 Main St.
PO Box 670
Farmington, ME 04938-0670
1-800-287-1478 (in Maine)
(207) 778-4650

Hancock County Extension Office
RR5, Boggy Brook Road
Ellsworth, ME 04605
1-800-287-1479 (in Maine)
(207) 667-8212

Kennebec County Extension Office
125 State St.
Augusta, ME 04330-5692
1-800-287-1481 (in Maine)
(207) 622-7546

Knox and Lincoln Counties Extension Office
375 Main St.
Rockland, ME 04841-3304
1-800-244-2104 (in Maine)
(207) 594-2104

Oxford County Extension Office
9 Olson Rd.
South Paris, ME 04281-6402
1-800-287-1482 (in Maine)
(207) 743-6329

Penobscot County Extension Office
307 Maine Ave.
Bangor, ME 04401-4913
1-800-287-1485 (in Maine)
(207) 942-7396

Piscataquis County Extension Office
Court House Complex
Dover-Foxcroft, ME 04426-1396
1-800-287-1491 (in Maine)
(207) 564-3301

Somerset County Extension Office
Norridgewock Ave.
PO Box 98
Skowhegan, ME 04976-0098
1-800-287-1495 (in Maine)
(207) 474-9622

Waldo County Extension Office
RR2, Box 641
Belfast, ME 04915-9627
1-800-287-1426 (in Maine)
(207) 342-5971

Washington County Extension Office
11 Water St.
Machias, ME 04654-1017
1-800-287-1542 (in Maine)
(207) 255-3345

York County Extension Office
RFD 2, Box 1678
Sanford, ME 04073
1-800-287-1535 (in Maine)
(207) 324-2814

UMCE State 4-H Office
5717 Corbett Hall
Orono, ME 04469-5717
1-800-287-0274 (in Maine)
(207) 581-3877
TDD 1-800-287-8957

National 4-H Council
7100 Connecticut Ave.
Chevy Chase, MD 20815
(301) 961-2800

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