Exploring Natural Resources

Kentucky 4-H Project
Contents

Whose environment is it, anyway? .................................................. 3
  Introduction .............................................................................. 4
  The First Law .......................................................................... 4
  More About the Food Chain ...................................................... 4
  The Human Role in the Food Chain ............................................ 5
  The Second Law ........................................................................ 6
  Problems With Waste Products ................................................ 7
  In Summary ............................................................................... 8
  The Third Law .......................................................................... 8
  Lunch Bag and Wrappers ........................................................ 9
  To Sum It Up! ......................................................................... 10

Soil—More Than Just Dirt .............................................................. 11
  Introduction .............................................................................. 12
  Soil Parts ................................................................................ 12
  Soil Types ............................................................................... 12
  Soil Formation ......................................................................... 13
  Soil Erosion ........................................................................... 13
  Horizons .................................................................................. 14
  Soil Life ................................................................................... 14
  Back to the Laws of Ecology! .................................................... 15

Air: The Breath of Life .................................................................. 16
  Introduction .............................................................................. 17
  What is Air? ............................................................................ 17
  Does Air Have Weight? ............................................................ 17
  Does Air Take Up Space? ........................................................ 18
  Why Does Hot Air Rise? .......................................................... 18
  What is Wind? ........................................................................ 19
  Taking Care of Our Air ............................................................. 20

“Water, Water, Everywhere...” ..................................................... 21
  Introduction .............................................................................. 22
  Water and Its Changing Nature ............................................... 22
  The Water Cycle ...................................................................... 22
  Water Life ................................................................................ 23
  Water Pollution ....................................................................... 24

Plants...the Foundation of Life ....................................................... 25
  Introduction .............................................................................. 26
  Plant Ecology .......................................................................... 26
  Ecosystem .............................................................................. 26
  Now... Another New Word: Biomes ......................................... 26
  The Forest Ecosystem ............................................................... 27
  Factors Affecting Succession .................................................... 28
  Plant Adaptations .................................................................... 29

Our Friends, the Animals ............................................................... 30
  Introduction .............................................................................. 31
  Wildlife Habitat ....................................................................... 32
  Wildlife Requirements ............................................................. 32
  Ecological Succession .............................................................. 33

Project Record Sheet .................................................................... 35
Whose environment is it, anyway?

Everything is connected to everything else.

Everything goes somewhere.

There is no such thing as a free lunch.
Introduction

Ecology is the scientific study of how living things interact with each other and with their surroundings (or environment). Living things and their environment together form an ecosystem. Wherever you are and whatever you are doing, you affect your surroundings and they affect you.

When people first became interested in ecology, a scientist named Barry Commoner suggested three laws of ecology, which were very short and easy to remember:
1. Everything is connected to everything else.
2. Everything goes somewhere.
3. There is no such thing as a free lunch.

In this project on natural resources you will learn about the different parts of the ecosystem: earth, air, water, plants and animals. But before you learn about the parts, you first need to look at the whole picture, so we need to explore these laws a bit more.

The First Law

Everything is connected to everything else. What does that mean? Does it mean all things are actually stuck together? Not exactly. It means that all things are interrelated. A good example of this is the food chain.

Look at the diagram below. This is called a food chain, because the energy that comes from food moves from one living thing to another. Any living thing or form of life is an organism. You can see by the arrows in these pictures that the grass and the animals are all connected in some way. They are all related, and each is an organism. Let's start at the top. Grass grows in soil. Animals, such as rabbits, eat the grass. These plant-eating animals are called herbivores. Animals which eat other animals are meat eaters and are called carnivores. Here the owl, which is a carnivore, eats the rabbit. (An animal that eats both plant and other animals is called an omnivore. Humans are omnivores.) When the owl or any organism dies, tiny microscopic plants and animals cause the body to decompose (rot or decay) and become organic material. Organic material is anything that comes from living organisms. Organic material helps make the soil more fertile because it contains many minerals and nutrients. The organic material in the soil helps the grass grow better, and the grass makes good food for herbivores. These herbivores may then become food for carnivores or omnivores.

Now you can see how food energy moves in a circle from one organism to another. When an animal or a plant dies, much of the energy, in the form of organic material, returns to the soil where the whole cycle begins again. This shows you how things are connected to each other or how everything is connected to everything else.

Activities:
1. Make a list of common herbivores, carnivores and omnivores. What type is your household pet? What does your pet eat that tells you this?
2. What are other examples of the first law? For example, brainstorm how a drought might affect the soil, water, air, plants and animals.
3. Make a 4-H display showing a food chain.

More About the Food Chain

Let's take a little closer look at the relationship between plants and animals. Green plants are called producers because they make their own food. They make it from sunlight, carbon dioxide from the air, water, and nutrients from the soil. This food-making process is called photosynthesis. In the process of making their food, green plants release oxygen and water. Oxygen is the part of the air that animals, including humans, breathe. Animals cannot produce their own food. They are consumers because they use the food energy made by green plants. They get this energy by eating green plants or by eating other animals that have eaten green plants.

Fungi and bacteria are decomposers. A decomposer causes dead plants and animals to rot or decay back into simpler organic matter. Fungi are small plants that are not green and do not make their food by photosynthesis. They get their food energy by decomposing organic matter. Bacteria are one-celled microorganisms (living things you can see only with a microscope). This breakdown of dead plants, animals and animal wastes by fungi and bacteria allows nutrients from the dead organisms to return to the soil.
What would happen in the food cycle if there were no decomposers? What does decomposition have to do with how things are connected to one another? How do you suppose it fits into the second law everything goes somewhere?

**Activities:**

1. Take a hike at a park or in a forest. Make a list of the different types of plants (producers, decomposers) and animals (herbivores, carnivores, omnivores). Find parts of the food chain in action (consumption, decomposition).

2. Look under a log or piece of wood that has been in the same place for some time. Describe/list the kinds of evidence you find that decomposers are at work.

**The Human Role in the Food Chain**

What does human role mean to you? A role is a part that we play. The difference in the role we play and the role plants and animals play is that we can make decisions. Animals eat what is available to them and what their instincts tell them they need. Plants and animals either die in their own habitat (habitat is a natural home), or they die where humans place them. Most people you know probably make choices about what they eat. Some people are not so fortunate. Where food is scarce, people eat whatever is available. But you probably make choices about what you eat.

As humans we also make choices about the decomposition of certain organic materials which need to be returned to the soil. One way we do this is in the way we dispose of our garbage. After a meal, the organic material left over can be returned to the soil to decompose just like the dead plants and animals. In this way, we can make a decision to help nutrients return to the soil for green plants to use. Many people make a compost heap of their vegetable garbage, leaves and grass cuttings to make rich organic material for their home gardens.

Sometimes we do not dispose of garbage in such a way that it can easily be returned to the soil to decompose. When garbage is tied inside plastic bags, it may not decompose as quickly as it would when placed unwrapped on a compost heap. Also the plastic does not decompose for a long time. Containers made of glass, plastic, and metal take a long time to decompose. Paper materials break down faster. Sometimes we can recycle the glass, plastic and metal containers. Then at least they can be used again, even if they don't decompose and go back into the organic matter cycle.
Activities:

1. Study the garbage from your house. How much does a day's garbage weigh? What different kinds of garbage are there (vegetables, fruits, meat bones, paper, etc.)? Where does your garbage go after you throw it away? What can you do to help the food chain work better?

2. Find out where the garbage in your community goes. What do you think is the best garbage disposal method for keeping the food chain working? Why? Give a 4-H speech or demonstration on what you find.

The Second Law

Everything goes somewhere. Sooner or later, all living things die and decompose... they go somewhere. In the example of the first law, you saw that things are related in cycles, so if things go somewhere, they also must come from somewhere.

As an example of the second law of ecology, we will first trace the path of the carbon dioxide cycle. Carbon dioxide is a gas in our atmosphere that you cannot see or smell. It is given in the symbol CO₂. One molecule of CO₂ is made up of one atom of carbon and two atoms of oxygen. Carbon dioxide is necessary for both plant and animal life. It is in the air, cycles (or moves) through plants and animals, and goes back into the air. Look at the following diagram and follow the path of carbon dioxide. Where do you fit into the cycle?

The important parts of the CO₂ cycle are respiration (breathing), combustion (burning), decomposition (decaying or rotting), and photosynthesis (food-making). The first three (respiration, combustion, and decomposition) use oxygen (O₂) and release CO₂.

Photosynthesis uses CO₂ and releases oxygen... that's the cycle. Green plants (producers) use carbon dioxide (CO₂) from the air during photosynthesis to make food called carbohydrates. Carbohydrates are many chains of carbon and hydrogen molecules put together in part from the carbon dioxide a plant takes in. Carbohydrates contain a lot of energy. Consumers (animals) cannot make their own food.

When a consumer eats a plant, it breaks apart the carbohydrates from the plant in the process of digestion so it can use the energy and minerals. Animals inhale oxygen and exhale carbon dioxide as they breathe. Here, carbon dioxide is returned to the atmosphere for plants to use. When plant and animal bodies die and decay or rot (decompose), carbon dioxide is also returned to the atmosphere. You can see that carbon dioxide is taken in and then released at different places in the food chain.

Along with the plants that grow on the surface of the earth, there are many valuable materials that come from under the earth’s surface. Coal, oil and natural gas are all valuable fuels to keep our homes at a comfortable temperature, to run our cars, trucks, and buses, and to keep industries running to make all the things we want to have in our lives. These fuels are called fossil fuels because they were made from plants that lived millions of years ago. These fuels are removed from underground by mining or drilling and are refined from their original crude state so that we can use them. When these fuels, or wood (which also comes from a plant), are burned (through combustion) to run our cars or to heat our homes, the carbon inside them (from the carbohydrates) is released into the atmosphere as carbon dioxide gas.

Earlier you saw that respiration, decomposition, and combustion all produce CO₂ that goes out into the atmosphere. All the plants, but especially the trees, consume or absorb CO₂. The oceans of the earth also absorb CO₂ from the air. Both forests and oceans release oxygen back into the atmosphere... this is the cycle we talked about before. It is important that the amounts of oxygen and carbon dioxide in the atmosphere remain in balance.

Anything that does not produce useful heat or energy from burning fuels is a waste product. When fuels are burned, certain waste products escape into the atmosphere. Some of the materials, like water vapor, are not very harmful. Others, like sulfur, nitrogen, and tiny solid particles cause air pollution. Too much of any of these gases can cause problems. Sulfur and nitrogen oxides are part of the problem of acid rain. Too much carbon dioxide may cause a problem called the greenhouse effect on our planet. When the light reflects back to the sun off the earth's surface, the heat that goes with the light is trapped in the atmosphere by a layer of carbon dioxide. Light waves from the sun pass through the atmosphere to the earth's surface.
Activities:

1. What is combustion? Look for different kinds of combustion around your home and community, and take photographs of them. Make a display with your photographs and label each clearly.

2. How can combustion be made clean? Where do the products of combustion go?

3. Find out how many different kinds of fossil fuels are used by people in your town or neighborhood. Which one is most expensive per unit of heat (Btu)? Why? Why do these fuels contain carbon?

4. Make a 4-H display of one of the fossil fuels—what materials it comes from, how we get it out of the earth, how it is refined for our use, how we use it and what its waste products are when it is burned.

Problems With Waste Products

In the carbon dioxide cycle, everything normally goes somewhere where it is useful. When there is too much carbon dioxide, it still goes into the air, but if it is not consumed by the forests or the oceans, then we have a problem. Whenever we have more waste products than useful products, we have a problem because it upsets the natural balance of things. We have been talking about gases in the carbon dioxide cycle, but we also have liquid and solid waste products that have to go somewhere. Often they can be used or recycled in a way that keeps the whole ecosystem in balance, but sometimes they are not taken care of properly or carefully.

For example, coal and wood fuels leave a solid residue called ashes after they burn. This residue has to go somewhere. Usually we throw the waste away; but where is away? If the ashes go to a sanitary landfill or dump, they will be covered with soil. Over time, the action of rainwater filtering through the soil and these solid wastes buried there will wash, or leach, chemicals out and will carry them deeper into the soil and into the groundwater underneath. This can be harmful, depending on the chemical action of the soil and water on the transported materials.

Living things are either plants or animals. All plants come either from seeds or from a part of another plant (root, stem, branch). Some plants, like trees, grow for many years while others, like corn, soybeans, and tobacco, grow for only one year. When a plant or animal dies, does it, too, go away? Dead plants and animals are a sense waste products, but they decompose mainly into water, carbon dioxide and organic nutrients which are beneficial to the ecosystem as a whole. When living things die, they usually cycle back through the ecosystem.

You are a living thing that will live for many years. You give off waste products all the time. Like the incinerator where solid wastes are burned, you give off gaseous waste products of carbon dioxide and water vapor. You excrete liquids through your perspiration and urine, and solids through feces. In our society, most of us have water-based plumbing systems in our homes where we flush these wastes away... without thinking. If you have a septic tank, the solids settle out in the bottom of the tank. The liquids usually move slowly out into a specially prepared part of the yard near the tank called a leaching field, where they gradually filter through the soil and become cleaner. If your house is connected to a sewer system, then your wastes either go to a sewage treatment plant or are released directly into a nearby stream or river. When there were only a few people who lived near a river, this wasn't a serious problem, since the moving water cleaned itself. However some rivers and streams today get more wastes than they can manage, and they become polluted.

Activities:

1. Visit the local dump, incinerator, or landfill. Find out where your solid waste or trash goes. Is there enough land for the wastes of your community? What could you do personally to reduce the amount of solid waste from your family?

2. Visit a nearby sewage treatment plant with your 4-H group. Does it have primary, secondary, or tertiary treatment? Ask the people there to explain the differences between such treatments and the various costs of each. Which treatment is economically best for your community? Which treatment would be most economical for a larger or a smaller community? Which treatment is best for the environment and for your own health?

3. Visit a recycling center. If there is no center in your area, find out if you could start one. Find out how much it costs to make 100 tons of new steel and how much it costs to remake the same amount from scrap metal. Find the same costs for new and recycled aluminum and new and recycled paper. Which of these resources is renewable, and which is not? What difference does it make if a resource if renewable or not?

Everything goes somewhere.
In Summary

Ecosystems in nature are self-regulating. They recycle water, minerals and gases among their different organisms. The CO₂ used by the plants to make food is eventually released by consumers and decomposers. The extra waste oxygen released by plants is essential for animal life, including humans. When people interrupt these natural systems and cycles, problems begin. For example, too many people in too small a space produce more waste products than nature can use, so the extra wastes pile up in the water, the soil, and the air we use.

Remember that everything must go somewhere and it is our responsibility to make sure that the places we use for throwing away our wastes can absorb or decompose them. This way our wastes can be recycled and used again somewhere else.

The Third Law

There is no such thing as a free lunch. You should have some understanding of the first two laws of ecology by now. Interesting laws, aren't they? They aren't laws that people make or enforce... they are natural laws. Nothing that people do can change them. There is one more law of ecology... it has to do with cost. What it really means is that you cannot change any part of the natural ecosystem without having a cost of some kind to another part of the system. Let's look at an actual lunch to illustrate the meaning of this law.

Suppose you bought a lunch to school today. It contained a tuna fish sandwich on whole wheat bread, an orange, chocolate chip cookies, and milk. Since you brought it from home in a paper bag, you probably didn't think about the cost in a very personal sense. You know the various ingredients... tuna, bread, orange, cookies, milk... were bought at the supermarket. But what about other, less obvious, costs?

Tuna

Tuna fish comes out of a can, right? Well, at some point. But first it comes from the fish itself. Tuna comes from the ocean where fishing boats catch the fish in large nets. Often, porpoises, which are highly intelligent sea mammals, and not fish, are caught in the same nets and drown because they can't get to the surface to breathe. Catching porpoises is illegal, but the fishermen say it would cost them too much in time and money to make their nets differently or to stop to let the porpoises swim out of the nets before they drown. This means that your tuna sandwich comes with the cost of killing animals other than the tuna fish.

Once the tuna are caught, they must be processed, canned and shipped to supermarkets. Each of these steps has energy costs, which are another type of cost, in addition to time (labor), money and environmental costs.

Bread

Producing the whole wheat bread for your sandwich has several costs that you usually don't think about. A farmer must prepare the ground, buy the seed, plant it and take care of the crop until it is ready to harvest. The harvested wheat is then shipped to a mill where it is ground into flour. The flour is sold and transported to a bakery where the bread is made. Most wheat is grown in the midwestern part of the United States, in the Great Plains area. Because little wheat is grown in Kentucky, the raw wheat or processed wheat flour must be transported here. Bread is probably baked nearby and transported to your local supermarket.

Since wheat is an important part of our diet, it is grown on a large scale by agribusinesses which often own thousands of acres of land. Chemical fertilizers and pesticides are used to increase the productivity of the land and to protect against insects and diseases. A single type of insect or disease can ruin an entire crop when large acreages are planted with only one kind of plant. Insects become resistant to chemicals when they are exposed to them all the time, so the farmer has to use more and more chemicals to kill the insects. The extra chemicals cost more money, but the larger amounts also kill insects and animals that the farmer doesn't necessarily want to kill. Some of the chemicals wash off the land into streams and rivers and kill creatures that live there, too. So your loaf of bread has costs to the environment as well as to the pocketbook.
Activity:

Plant different kinds of gardens (these can be in window boxes if you don't have land to use). Keep track of all your costs... planting soil, seeds or plants, chemicals, water. Include what you have to pay in time (labor) as well as in money. Make one garden all the same kind of plant (one flower type, one vegetable type). Make another, exactly the same size, of all different kinds of plants (all flowers, all vegetables). Do another kind of comparison: use recommended chemical fertilizers in one and organic compost in another (make sure the sizes of the areas and the kinds of things grown are the same in these two areas).

Compare costs in money and labor between these pairs of gardens. Compare how many and what size of flowers or vegetables you get from the two types of gardens you are comparing. Which do you prefer? Why?

Oranges

Because they grow on trees, oranges do not have the same kind of yearly cultivation that the wheat for your bread requires. However, they are sensitive tropical plants and must be protected from frost when the fruit is getting ripe. Growing citrus fruits is labor-intensive, which means lots of people are needed to do the work. This means lots of jobs, which is a good thing. Oranges may need chemicals to keep them free from insects. Chemicals, in large amounts, can cause the same problems that we saw with the wheat crop. Because oranges come so nicely packaged in their skins, there are only a few steps to get them from the trees to the supermarket. However, transportation costs are high because in our country oranges only grow in California and along the Gulf Coast. So energy must be used to transport them.

Milk

Milk is produced by cows, and dairy cows are raised in many places, including several parts of Kentucky. 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 getting it in a carton to drink. All of these steps... milking, cooling, mixing, pasteurizing, homogenizing, packing, shipping... use energy in some form and therefore have energy costs.

Cookies

The cookies in your lunch are made from flour, sugar, chocolate, butter, and a few other things. The flour has probably been refined and bleached. Refined and bleached flour requires more energy than is used to make the whole wheat flour for your bread. Chocolate comes from cocoa trees, which grow in South America. The cocoa is mixed with butter (which comes from dairy cows, like milk) and sugar (which comes from tropical areas like Central or South America). Products from foreign countries are taxed in order to come into this country, which then makes them more expensive to us. There is also the cost of the United States remaining on friendly terms with these countries so that we can continue to buy products from them.

The cookies go through many of the same stages as your bread, once all the ingredients are gathered together. All the ingredients are processed and brought to one place — the cookie factory — where they are mixed together, baked, packaged, and transported to big warehouses and then to supermarkets. You can see that a lot of gasoline gets used moving food products around this country! You probably hadn't thought about this hidden cost in your lunch.

Activities:

1. You see that your fairly ordinary lunch had costs that went from the oceans to foreign countries to faraway states. What could you bring for lunch that would be products of Kentucky or of one of our neighboring states? Milk is a local product, so you need only think of another grain for your bread, another filling for your sandwich, a different kind of fruit, and maybe a different kind of dessert other than cookies. Even though we are lucky to be able to get food products from all over the world, it is useful to know how well we could eat using only local products.

2. Make a display showing the journey, from beginning to end, of some local food product. Try to find out the money costs for each step.

Lunch Bag and Wrappers

Your lunch came in a paper bag, your milk in a waxed paper carton, and your cookies and sandwich in plastic bags. Paper is made from tree fiber, so that explains where both the bag and the milk carton come from. Wood goes through many steps before it becomes paper or cardboard. Plastic and wax on the carton are often made from petroleum... from coal tar or oil in particular. Wood resources are renewable (new crops can be grown to replace those that were used), but petroleum resources are gone once they have been used. Do you think it is important that a raw material is renewable? Why?

When you finish your lunch and throw things away, the different waste products will decay or decompose at different rates. Which will decay first? Last? Why?
Disposal of these waste products adds to the cost of your lunch. As you become more aware of all the costs involved in your lunch, think of ways you can make decisions and changes which will reduce these costs.

**Activities:**

1. Find out where the trash from your school, your home and your community goes. Who is responsible for taking care of it? Do you think the present system of trash disposal could be improved? How? What can you and your friends do to improve things? Give a speech on your results.

2. Keep track of how much the family car is used for one week. Were all the trips necessary? How many things could have been done by walking or bicycling? How many times could one trip have been made instead of two? Time is often saved in driving somewhere, but what are the other costs of driving? What kinds of waste products does a car give off, and what happens to those waste products?

**To Sum It Up!**

Everything you eat, wear, use at home, at school, at play, costs something. Some things cost a lot in money terms; others have costs less noticeable, but just as important. Damaging the environment is very expensive, and its cost may be felt for many years. Remember, from the examples of the first and second laws of ecology, that air and water systems are closed systems, or cycles. This means that even though air and water are constantly cycled, there are no new supplies . . . only the supplies we have now. The natural ecosystem has always been in balance. Only people have the ability to upset that balance and therefore must be very careful about new changes they cause in the ecosystem, so that the costs of those changes are not greater than the benefits to the system. We have learned that living systems are complex and delicate. Understanding some of the complexity helps us to make better decisions about using natural resources.

**Activity:**

Select an article of clothing you are wearing. What is it made of? Trace this piece of clothing back to the raw material from which it was made and find out how it came to be a piece of clothing. What will happen to it when it is worn out? What are some of the differences between things made of synthetics (polyester) and natural fibers (cotton)? Find out the different total costs of the same amount of a synthetic and a natural fabric. Why is there a difference? What are the obvious costs? What are some of the hidden costs?

There is no such thing as a free lunch.
SOIL—More Than Just Dirt

The overall quality of life in a country has a lot to do with the quality of its soils.
Introduction

Now that you have been introduced to the laws of ecology, you are ready to explore the different parts of the ecological system. A good place to start is with soil, since it is such a vital part of our environment.

To start with, plants grow in soil. Plants do more than just supply food for us and other animals. They also provide building materials and many other products that we use daily, such as pencils and the paper you are now reading. Where the quality of soil is poor, the plant life is also poor. This means that we cannot have many of the things that plants give us.

The overall quality of life in a country has a lot to do with the quality of its soils. Many times in history, great civilizations disappeared after people overused and abused their soils. The United States is the largest food-producing country in the history of the world. Many countries which have not taken care of their soils cannot grow the food needed to feed their people. The soils in our country are no different from the soils of other great civilizations; they too can be destroyed through neglect and misuse.

We all need to know what soil is made of, how it was formed, and what affects its quality. If we know these things we can all help to take care of, or manage, our soil so that it will be productive for us and for future generations.

Soil Types

There are many different types of soil just as there are many different types of people. Soils—like people—differ in several ways: (1) what they are formed from (parent material); (2) how they developed; (3) what has happened to them since they were formed; and (4) their age.

Soil is made of four different types of materials: organic matter, sand, silt and clay. You remember that organic matter is the material that comes from living organisms. Some soil organic matter, or humus, is made of leaves, stems, roots and animal wastes which have been decomposed.

Sand, silt and clay are soil particles of different sizes and are made of different types of chemicals. Sand is the only material that cannot hold water and nutrients in the spaces between particles. If you pour water in a glass of sand, all of the water quickly collects at the bottom. Sand and small rocks that are mixed in with other types of soil particles help water drain through the soil and help keep the soil from becoming too hard or compacted.

Silt and clay are the two most common materials in the solid part of the soil. Silt particles are very small but not nearly as small as clay particles. If you could put pure clay into a single layer it would be possible to put 4 million particles into the space shown (1 square inch).

Silt and clay particles are important for holding water and nutrients for plant use. A good soil should have 25% sand, 35% silt, 35% clay and 5% organic matter.

Activity:

Put about two measuring cups of soil in a shallow pan and dry it in a warm oven for a couple of hours. Fill a glass or cup with the soil until there is about a half-inch space between the top of the soil and the rim. Slowly pour a half glass of water onto the soil. Where did the water go? What does this tell you about the amount of water needed to rewet the soil in your yard once it has become very dry?

Activities:

1. Study the characteristics of the soil at your home. Put a little between your fingers and moisten it. Does it feel sandy or sticky like clay? Find out what type of soil you have from the Soil Conservation Service or from your county agent.

2. Fill a glass jar half full with ordinary soil; then fill it to the top with water. Screw the lid on tight and shake it up so that all of the soil is mixed up in the water. Allow the mixture to stand for a couple of days or until the water is once again fairly clear. Can you figure what part, or percent, of the soil is sand, organic matter, silt and clay? Compare soils from locations such as a stream bank, a field and a road cut. How are they different?
Soil Formation

Soils are being formed right now as you read these words. Soil formation is a very slow process. It will take at least 500 to 1000 years to form one inch of new soil. Soil is formed from parent material, organic matter or volcanic activity. It can also be moved from place to place by wind, water or glaciers.

Residual soils are formed from the weathering of parent material or bedrock. Rock is broken down into small pieces by freezing and thawing, as well as by acids in rain and the heat of the sun. These pieces are eventually broken down into soil particles as the weathering process continues.

Organic soils are formed in swampy regions mainly from decomposed grasses and mosses. These plants die and fall to the bottom of the swamp where they eventually form a layer of soil. As the layers build up, the swamp begins to fill in and dry up. These are called muck soils.

Volcanic soils are formed as the result of volcanic activity. These soils are more common in the western United States. They are fine and powdery and very fertile after some organic matter has been added.

Colluvial soils have been moved down hill by gravity. This is why the soil in mountain valleys may be very deep. Colluvial soils are sometimes rocky because heavy rocks also roll downhill.

Alluvial soils have been left or deposited by water. They are very common along streams and rivers. The soil closest to the stream will be sandier because sand is heavier than clay or silt and will be the first part to settle out of the water. Alluvial soils are generally deep and fertile, but farming next to streams and rivers is risky because of possible flooding.

Loessial soils are those which have been deposited by wind. They are less common. There are some loessial soils in the western part of Kentucky. They are part of a band which extends through the Mississippi River valley all the way to Louisiana.

Glacial soils have been moved from one location to another by large, slow-moving masses of ice. Glaciers pick up or push large amounts of soil as they move. They also pick up large rocks from the parent material or even the bedrock. As a result, the soils that glaciers leave behind are often very rocky.

Activity:

Take samples of different types of rock (about 2 or 3 inch diameter), and place them in the freezer for 1 hour. Then place each of these rocks in a separate pot of boiling water. Make sure that you stand back so that the boiling water does not splash on you.

What happens? Do the different types of rock react the same way?

Discuss your findings with your leader.
Horizons

Soils are not the same throughout any given area. There are differences in the soil in the same yard or field and differences as you go deeper into the soil. Some of the differences may be seen in the soil as layers. These layers are called horizons and are identified by letters. Most soils which have not been tilled or cultivated will have four distinct horizons.

The upper layer, called the O horizon is made of organic matter such as decayed leaves, grass and humus. 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 soil life. In a cultivated field the O horizon does not exist and the A horizon usually is the upper layer of soil.

The next layer is the B horizon. It has more clay, very little organic matter and is less fertile. There may be some small rocks in this area. Rocks in a field might tell you that the A layer is gone and the soil left (B horizon) is not as fertile. Each year the soil was cultivated, it was eroded away, making the plow go deeper and turning up and exposing more rocks. The rocks are not growing in the field; they are just being uncovered.

The lowest level of soil is the C horizon. This is the parent material, which is very rocky and has very low fertility. This layer is just above the bedrock. (Bedrock is the layer of solid rock that lies under all levels of soil.)

The depth of the layers of soil depends on the age of the soil and the conditions that formed the layers. Layers are sometimes different colors, though this is not always true.

Activities:

1. Go to an area where a road has been cut through a hillside. Look at the different layers of soil. What do you notice about the differences in the color and feel of the different layers? Is the soil deeper at the top of the hill or down in the valley? Why?

2. Dig a soil pit (at least 18" deep) in your backyard or in a vacant lot. How many horizons can you see? Would you expect the number of horizons in city soil to be different from the number in a more rural area? Why or why not?

Soil Life

While the sand, silt, clay and organic matter are not alive, there are many creatures that live in the soil. There are earthworms, nematodes (microscopic worms), insects, mites, snails, moles, bacteria, fungi and algae in the soil. The total weight of all of the different types of soil life can be as much as 6,000 pounds in the upper 12 inches of a fertile agricultural soil per acre. Some of these are beneficial to plants while others are harmful. They are all useful because they are all part of a very complex ecological system in the soil.

Many of the organisms living in the soil help to decompose organic matter. Others may harm plants by feeding on the roots. Some soil animals have little or no effect on the growth and development of plants.

Certain bacteria and fungi live in a symbiotic relationship with plants. A symbiotic relationship is one which is beneficial to both the plant and the bacteria or fungi. Some bacteria and fungi live in or on the surface of plant roots and are able to change soil minerals to nutrients for the plant to use. The plant gets more nutrients than its own root system would normally be able
to get. In return, the plant supplies the fungi or bacteria with foods that have been produced.

Bacteria and fungi are not able to make their own food like green plants. In a symbiotic relationship each is able to live and grow better than it would be able to by itself. The fungi are called mycorrhiza. The bacteria are called nitrogen-fixing bacteria because they are able to take nitrogen from the air in the soil and make it available to the plant.

**Activities:**

1. Take a large (gallon) can, remove both ends, and hammer it at least 6 inches into the soil. (It is easier to hammer a can into the ground if a board is placed across the top edge of the can and if the soil is moist.) Fill it up with water, observe and describe the types of animal life which come to the surface.

2. Make or purchase an ant farm (a colony of ants plus soil sealed between two plates of glass) and watch the activities of the ant colony. How do ants help the soil?

**Back to the Laws of Ecology!**

Do you remember the three laws of ecology? The first law was *Everything is connected to everything else.* How can a symbiotic relationship between a plant and a type of fungi help to put supper on the table for less money?

The second law is *Everything goes somewhere.* A rock falls off and rolls down a mountain side. How far can you trace what happens to that rock?

The third law is *There is no such thing as a free lunch.* There are many types of animals that make their homes in the soil. What might happen if we are careless with pesticides or the salt used in melting ice in the winter?

Can you think of other examples of things which relate to the three laws?

1. *Everything is connected to everything else.*

2. *Everything goes somewhere.*

3. *There is no such thing as a free lunch.*

Four animals having much to do with the digestion of the organic matter, especially of forest soils: left to right — Sowbug; mite (above); Spring-tail (below); millipede.

Parasitic nematodes (left), a ciliated protozoan (center), and a common rotifer (right).

The three most important plant microorganisms of the soil, from left to right, Fungal mycelium, various types of bacteria cells, and actinomycetes threads. The bacteria and actinomycetes are much more highly magnified than the fungi.
Imagine the world without air. There would be no wind, no clouds, no rain, no sound, no fire, no plants, no animals or other living things.

The earth would be very much like the moon is today.
Introduction

Since you can't see, taste, or touch air, you don't pay much attention to it, even though it is all around you. How long do you think you could live without air? In comparison, how long could you live without food or water? Let's find out more about air and its importance to us and to our environment.

Imagine the world without air. There would be no wind, no clouds, no rain, no sound, no fire, no plants, no animals or other living things. Doesn't sound very exciting, does it? The earth would be very much like the moon is today.

These particles and droplets are microscopic; that is, they can be seen only through a microscope, as these pictures show. Now let's take a look at some of the different solids, liquids and gases that we might be able to see without a microscope.

Activity:

Shine a flashlight into a dark, dusty room to see the particles suspended in the mixture of gases. Can you tell what some of the particles are? Do they seem to be moving? Why?

Does Air Have Weight?

Yes, air does have weight. Although you don't notice the weight of air on your shoulders, you are under the pressure of air every day of your life. Every square inch of your body and everything around you is under the pressure of a column of air over 1000 miles high! That column of air weighs 14.7 pounds for every square inch of surface at sea level. As you travel higher in elevation or altitude, the air weighs less because it is thinner.
Activity:

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 picture. Then remove one balloon, blow it up, and attach it again to the coat hanger. Which balloon is heavier? How does this show that air has weight? Give a demonstration of this to your 4-H club.

Does Air Take Up Space?

Yes, air does take up space. The amount of space taken up by a certain amount of air is its volume. We can measure the volume of air in cubic inches, yards, pints, quarts or metric units. What examples can you find of air taking up space?

Activities:

1. Hold a small glass upside down inside a larger jar of water so that its mouth is facing downward. Why doesn't the water enter the glass?

2. Push an inflated balloon into a full bucket of water. Why does the water overflow? What does this show you about things going somewhere in the second law of ecology?

Why Does Hot Air Rise?

As air is heated, the gas molecules get excited, move faster and farther apart, and take up more space. We could say that molecules occupy a larger volume. Since there are fewer molecules in the same volume of warm air compared to cool air, the warm air weighs less and rises. In other words, at the same volume, warm air is lighter than cold air. Warm air can also hold more water droplets than cool air. In the summer when the air is warm, we often have a lot of moisture, or humidity, in the air.

Activities:

1. Attach two inflated balloons of the same size to the two corners of a straightened coat hanger and balance them so that the hanger is level. Now hold one of the balloons under hot water for a few minutes. What happens to that balloon? See if the two balloons still balance. Why should they still weigh the same? 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? This can be done along with the other coat hanger-balloon activity as part of a demonstration.

2. Place an empty balloon over the neck of an empty soft drink bottle. Place the bottle in a pan of hot water. What happens to the balloon? What is happening to the air inside the bottle?
What is Wind?

We have already learned that hot air rises. Rising hot air helps create wind by creating an empty space or vacuum. Cooler, heavier air then moves in immediately to fill that space. That moving air is wind. Wind plays an important role in weather and climate. Look at the illustration below and follow the flow of air as the city heats it and the ocean cools it in a cycle. Here is another example of how things are connected to each other.

Air also heats and cools the earth in a cycle. Air warms and rises around the equator. The turning of the earth forces the warm air to the colder North and South Poles, where the warm air cools, becomes heavier, and falls toward the surface of the earth. The cool air travels back along the surface of the earth toward the equator, warms there, and starts the cycle again.

The illustration below shows some ways air is useful to us.

Can you think of other ways air helps us?
Taking Care of Our Air

Sometimes we use the atmosphere as a place to dump waste products from industry, home, and school. We add things to the air that can affect its naturally helpful properties. Even pollutants that are added in small amounts can eventually add up to be a big problem. Since people, plants, and other animals breathe in air and use parts of it in order to live, clean air is important for the health of all life. Breathing polluted air can cause harmful particles to enter plants or animals in place of the needed gases. Harmful particles can then cause sickness or reduce the ability of living organisms to stay healthy. Look at the table below. It describes some pollutants and shows where they come from. Can you think of any more?

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Source</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>carbon dioxide</td>
<td>burning coal, oil, gas and other fuels</td>
<td>A normal component of our atmosphere, however in greater amounts is considered a pollutant. A worldwide increase could affect our climate.</td>
</tr>
<tr>
<td>sulfur oxides</td>
<td>burning of coal and oil</td>
<td>These sulfur chemicals are often emitted from the smokestack of coal-fired power plants. These chemicals can react in the atmosphere to cause &quot;acid rain.&quot;</td>
</tr>
<tr>
<td>nitrogen oxides</td>
<td>any burning process in air</td>
<td>Reddish brown gas with strong smell causes irritation, lung congestion and even death. Important in formation of smog and acid rain.</td>
</tr>
<tr>
<td>ozone</td>
<td>electric motors, lightning, sunlight, reaction with other pollutants</td>
<td>Normally present in air but higher concentrations have poisonous and unhealthy effects on humans and plants. Ozone however is very important in the upper atmosphere to filter out some of the sun's harmful rays.</td>
</tr>
<tr>
<td>particles and aerosols</td>
<td>numerous sources</td>
<td>Includes solids, liquids, aerosols, mists, dust, radioactive particles, salt, soil, meteor dust, pollen, spores, bacteria, etc.</td>
</tr>
</tbody>
</table>

Activities:

1. Acid rain is rain (or snow, sleet or fog) that contains pollutants. Collect rain samples during a rain shower—at the beginning, in the middle, and at the end. Measure the acidity of the water with paper that is sensitive to pH (check with a science teacher to find out where to get this). At what part of the rain is the water most acid (lowest pH number)? Why? What do you think causes acid rain? What does this experiment tell you about all three laws of ecology?

2. Place a glass slide, a Petri dish (see your science teacher), or even a piece of paper, covered with a very thin layer of petroleum jelly (like Vaseline®)* outside a window on a day when there is no wind. 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? Do the same experiment on a windy day. Do you get more particles on your sticky surface on a calm day or a windy day? Why?

3. Pay attention to the change in odor in the air after a thunderstorm when there has been lots of lightning. That clean smell is ozone in the atmosphere. Ozone is a special form of oxygen (it has an extra molecule and is written as O₃) and is beneficial in small amounts, such as from the storm. It is also produced when the sun heats pollutants such as those from car exhaust. In large quantities, ozone is harmful to plants. You can see then, the importance of controlling air pollution.

4. Visit a greenhouse with your 4-H club. Ask the manager how it works, especially how the temperature is controlled. Too much carbon dioxide (remember the CO₂ cycle!) in the atmosphere causes a greenhouse effect on the whole planet. From what you have learned in the greenhouse, what do you think this means? What happens when you can’t open the vents to let extra—or waste—heat out? What does this trip tell you about the three laws of ecology?

*Use of this brand name implies neither endorsement of this product nor discrimination against others.
Water is the second most important substance in your life, second only to the air you breathe.

You can live only minutes without air, and only a day or two without water.
Introduction

Water is the second most important substance in your life, second only to the air you breathe. Your body contains about 60 percent water. You can live only minutes without air, and only a day or two without water. An average person drinks three-fourths of a ton (1500 pounds) of water every year. This is equal to nearly eight (8 oz.) glasses (or 2 quarts) a day. This water comes from the water faucet, from the food you eat, and from other drinks. Water serves many purposes in addition to providing fluid for us to drink.

Activities:

1. List the activities that you personally do that require the use of water.
2. Keep a record of how much water you use a day for each of the activities on your list. Figure a total for each activity and add them all together for a grand total of your daily water use.

Water and Its Changing Nature

Did you know that water is a chemical? One water molecule is made of two atoms of hydrogen (H) and one atom of oxygen (O). Together these atoms make up water (H₂O). Water is naturally found as all three states of matter: solid (ice), liquid (water), and gas (water vapor, steam). It is the liquid form that we name water. Water must be at or below 32 degrees Fahrenheit (F) or 0 degrees Celsius (C) to be in the solid form. This temperature is the freezing point, the point at which water (liquid) changes into ice (solid). When frozen, the volume of water changes (takes up more space), 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 some other special 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. Water also has surface tension. Surface tension means that the top layer of water molecules are held together. The tension is strong enough to allow a water bug to walk across the surface.

At 212 degrees F (100 degrees C), the molecules of liquid water are moving so fast that they begin to escape very rapidly 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 once it has reached the boiling point. Water vapor is invisible. If water vapor cools so that the molecules slow down a little, the gaseous state changes back into a liquid. This is called condensation. After water vapor condenses into very small water droplets, we can see it as clouds, as our breath on a cold day, or as a small cloud over a 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 half a gallon over every square foot.

Activities:

1. Fill a narrow-mouth glass, such as a bud vase, half full with water. Can you see how the edge of the water surface goes up where it touches the side of the glass? Now begin filling the glass up to the top with an eye dropper. Continue filling it a drop at a time until it overflows. What did you notice about the level of the water at the center of the vase? At the edge of the rim? Just before it overflowed? This experiment shows you water's surface tension.
2. If the human body is 60% water, how many pounds of your body weight is water?
3. Have a contest to see who can hold an ice cube (either in your hand, or in a styrofoam cup) and keep it solid the longest. Make sure all the contestants are using the same equipment (hand or cup)! Why do the cubes melt at different rates?
4. Boil some water and pour it into a styrofoam cup. Put some room temperature tap water in another cup. Put both cups of water in the freezer and check them after an hour. Which freezes faster? Why?
5. Make a 4-H display or give a 4-H demonstration using the information from one of these activities about water.

The Water Cycle

Seventy-five percent of the earth's surface is covered by water: 97% of this is in the salty oceans and 2% is in the ice of glaciers or icebergs at the North and South Polar regions. This leaves only about 1% of the total for us to use from fresh water rivers, lakes, streams and underground reservoirs, or aquifers. If we can only use 1% of the earth's water resources, how do we keep from running out of fresh water?

A continuing supply of water is made available to us in an amazing way. The water cycle is the movement of water from the clouds in the sky, to the land, to the oceans, and back to the sky.
Water from the oceans, lakes, and streams, and even from plants and animals, evaporates into the atmosphere. (Water from plants is called transpiration.) The water vapor is suspended in air and moved by winds. When the air is warm, it rises, as we learned before. Remember that warm air can hold a lot of water vapor (humidity). When the air cools, it can't hold as much water vapor, and the water vapor condenses back to a liquid form. When condensation occurs, the water vapor falls back to earth in the form of fog, rain, snow, sleet or hail. All of these are forms of precipitation. When precipitation reaches the ground, it either directly evaporates, or is absorbed into the ground to be stored or used by plants, or it runs off. The run-off flows down creeks and streams to larger bodies of water where the cycle is repeated with evaporation from water surfaces. See how things are connected and how they go somewhere? Water is never lost from the environment although it is constantly changing form. How do you think the way we use water relates to the third law of ecology?

**Activities:**

1. How can you make water disappear?

2. Boil some water in a kettle and place a large glass upside down over the cloud of steam. (Turn heat off once the water boils. Be very careful because steam can burn you badly.) What happens? Why? How is this like making rain? How does this example illustrate the laws of ecology? the water cycle?

3. Listen to weather forecasts daily. Keep a record of daily temperatures, the temperature when it rains, and how much it rains for a month. Are temperature and rainfall related? How?

4. Invite resource people or someone from the weather bureau to talk to your 4-H club about the local water supply. Is there some part of the water cycle that is unusual in your area?

**Water Life**

Bodies of water are the home or habitat for thousands of different types of animals and plants. Fish and seaweed are very important food sources for people. The same kind of food chain works in bodies of water, just as it does on land. There are the food producers—the plants; then there are creatures that eat only plants (sea
cows, for example) and creatures that eat other animals (sharks, for example). Because of the laws of ecology, water life is important for the well-being of all life on earth. When plants and animals that live in water are threatened by water pollution, the food chains both in the water and on land are also endangered.

Activities:

1. Visit a body of water (pond, lake, river, stream) close to your home. What kinds of animals and plants live in this body of water? Use a white container and a scoop net made from an old nylon stocking to drag through the water to see what you can find. After you look at the creatures you bring up, return them to the water. How does water life in Kentucky differ from that in the ocean? How is it the same?

2. What kinds of water-dwelling creatures do you use for food? Do they come from fresh water or ocean water? Keep a record of this over a week’s or a month’s time. Do a 4-H display of the food chain of one of your favorite seafoods. What does it eat? What eats it (besides you)? How far up the food chain are you—one step, two steps, three steps?

Water Pollution

Water pollution is caused by the addition of waste products of one kind or another to bodies of water. This reduces the quality of the water and makes it less desirable for the use of all living things.

Pollution Through Precipitation. Water that falls as precipitation (rain, snow, sleet) is nearly pure H₂O when it starts up in the upper atmosphere. On its way to the earth’s surface it picks up small amounts of dust and other particles from the air, plants, and roof tops. It may pick up lots of different things depending on what it touches. Some of the particles are hard to see because they become dissolved in the water (just as sugar or salt dissolve in water). Dissolved particles in water make a solution. You may be able to see other solid particles in water—these are easy to filter out. But it is very difficult to clean dissolved materials from water.

Sewage Pollution. Improper sewage disposal is a common cause of water pollution. Sewage is human and other animal waste. It pollutes by carrying harmful bacteria that may cause sickness or death.

Sewage flowing into rivers, creeks and streams may cause other problems, too. The solid waste particles can make the water turbid (cloudy or murky). When sunlight cannot reach the bottom of the stream, water plants can grow only near the top. Sometimes nutrients in the sewage cause too much growth of algae and other plants. These plants choke the streams so there is no living space for fish and other water-dwelling species. When the plants die, decomposing organisms use up most of the oxygen in the water to break down the plant material: remember the CO₂ cycle! If the decomposers use all the oxygen, there won’t be any left for the other animals. That’s a cost. Proper sewage treatment prevents these problems. Many towns and cities do not have good programs for treating sewage to make it safe before dumping it into a creek or river.

Chemical Pollution. One of the most dangerous causes of water pollution is chemical waste. This often comes from using too many chemical fertilizers and pesticides on crops. Often a heavy rain washes these chemicals off the land into our creeks, lakes and rivers. Many industries and factories release chemicals into our water supply because it is cheaper and easier than properly disposing of them. What are the hidden costs here?

Thermal Pollution. Another less noticeable type of water pollution is heat or thermal pollution. This can be caused by power plants or factories. Power plants need a lot of water to cool the generators that produce electricity. Even when these companies cool the heated water in special towers, the water they release into the nearby river or lake is warmer than it was when it came out of the water source. Most water-dwelling plants and animals are very sensitive to water temperature, so an increase in temperature is a shock to them and could either prevent them from reproducing or kill them.

Activities:

1. Where does your drinking water come from? How is it treated before you get it? What difference does it make to a community whether their sewage treatment plant release is upstream or downstream from the source of their drinking water? Why?

2. What kind of sewage treatment do you have at home (septic tank, city sewer, other)? What could you do to improve it or to encourage your community to improve it?

3. If your family purchases water from a public water supply, look at your bill and see the number of gallons used during the time period. Can you think of ways to use less water? Since there is a limited amount of clean fresh water on the earth, conservation can make more water available where it is usually scarce.
PLANTS...the Foundation of Life

Plants provide food, shelter, clothing, shade, beauty, new soil, even the oxygen in the air we breath.
Introduction

You have already learned the importance of plants to life on earth. Plants provide food, shelter, clothing, shade, beauty, new soil, even the oxygen in the air we breathe.

In this section, you will enlarge your understanding of plants. You will learn about the very complex system of plant life. And you will learn the importance of helping to protect this part of our environment.

You will probably see a lot of new words in this section. Some of the words you learned in the earlier sections of this manual. To understand our environment, you must see how all its parts fit together. These new words will help you understand this.

Plant Ecology

You have already learned about ecology—the study of relationships between organisms and their homes. So, what about plant ecology? It is the study of the relationship between plants and their home. What is another word for home? Environment. Well, what affects a plant’s environment? What about plant consumers (herbivores) and animal consumers (carnivores)? What about a plant’s terrestrial environment (the land on which the plant grows)? All of these make up the plant environment.

Biology of Populations

Ecosystem

Another new word—ecosystem. This is one that you need to learn also. But first you need to understand what a population is. A population is simply a group of similar organisms. There are populations of people, populations of mice and populations of ants, for example. People, mice and ants can all live in the same community. Such a community and its environment make up an ecosystem. An ecosystem has no size limits. Terrariums, aquariums, ponds, fields, swamps, streams or forests can be considered ecosystems because each contains special communities and environments.

Now . . . Another New Word: Biomes

Ecosystems grouped together in the same climate zones are called biomes. The different biomes will have different types of vegetation (plant life). The biomes of North America include the desert, tundra, prairie, eastern deciduous forest, western coniferous forest and northern boreal forest. For example, a pond ecosystem in Florida has different plant and animal life than a pond ecosystem in Michigan. What biome is Kentucky in?

You can see in the illustration above that populations of robins, white oaks and acorn weevils (insects that eat acorns) live in the oak community of the forest ecosystem. The pond and other nearby ecosystems are part of the Eastern Deciduous Biome, and along with all of the other biomes form the biosphere. (The soil, air and water where all life exists is called the biosphere.)

A forest ecosystem produces more living material than any other ecosystem. The amount of living material in an ecosystem is measured by its biomass. The biomass is the total weight of all living matter in a certain area.
Activities:

1. Find out as much as you can about the soils, plants and animals in the biome where you live.

2. List some of the ecosystems in your community.

3. Draw a diagram of an ecosystem, indicating its populations, communities, and the biome in which it belongs.

4. What are the major plant communities in your area? What changes have occurred since you were born? Since your parents were born?

The Forest Ecosystem

Plants in the forest ecosystem usually grow in three layers, or strata. The herb layer is closest to the ground (less than 3 feet in height) and consists of nonwoody plants like mosses, ferns, algae, herbs and wildflowers. The shrub layer is greater than 3 feet, but less than 20 feet in height and includes plants like rhododendron, mountain laurel and small trees such as dogwood and redbud. The tree layer is tallest (over 20 feet) and is made of trees like oaks, hickories, yellow poplar and other tall species. Some forests may have several tree layers. There are often exceptions to the layer rule because moss may sometimes grow on trunks and branches of trees above the shrub layer and hanging vines often extend well up into the tree layer.

The larger plants in the shrub layer and tree layer are the main food producers and soil stabilizers, but all plants are important. All rooted plants create new soil, improve water quality by preventing erosion and increase soil-water absorption so less water runs off.

Activities:

1. Visit a woodlot and identify some of the plants in the herb, shrub and tree layers.

2. Use a long piece of string to mark out a 1-yard square area in the woodlot. Count all of the different types of plants in this area. Beware of poison ivy! If you do not know the name of a type of plant, draw a picture of it and try to find out its name.

3. Choose a tree in your yard, along your street, or in a nearby park and make it your special tree for a year. Keep a journal, showing what date the tree leaves out, when it changes color, when it loses its leaves and other major changes you observe on regular visits (for example, once a week). Make a bark rubbing with paper and crayon. Collect leaves, twigs, fruits and seeds during the year. Learn its common name(s) and its scientific name. What kind of soil does it grow in (loose and sandy, dense and clay-like)? Does it grow near a lake or stream or up on a hilltop or ridge? What animals or birds live in it or get food from it? Take pictures of it during the four seasons. Is it damaged by insects or diseases? Make a display or a booklet including all the things you have learned about your tree over the year. Write up a story about your tree.

Succession

Succession is another principle you need to know in order to have a real understanding of plant ecology.

When plant ecosystems are left alone, or undisturbed, they develop and change in a predictable pattern. Change in nature has always taken place and always will. This process of ecosystems changing over time is called succession. We can speed up or slow down the rate of succession depending on how we manage an ecosystem, but we cannot stop change.

There are two types of succession, primary and secondary. Primary succession growth begins on a bare place where no organisms lived before, such as a sand dune or volcano. Secondary succession growth begins after an established community has been removed or partly destroyed. An abandoned corn field where forest trees are beginning to grow back is an example of secondary succession.

Lichens are sometimes the first step in primary succession. Lichens are combinations of algae and fungi that live together in a symbiotic (mutually beneficial) relationship. They can grow on bare rock and gradually help break it down into soil particles. Mosses can then grow on the small amount of soil and help make more soil.
Eventually, grasses may start to grow, then shrubs will begin to appear. The plants that grow in these early stages are called pioneer species because they are the first types of plants to grow in an area. After the very long time needed to build up soil, trees may start to grow on the site. You can imagine that it may take hundreds of years for young tree seedlings to become a mature forest. The final, most stable stage is called the climax stage. In Kentucky, the climax stage is almost always an oak-hickory forest. Even a climax forest will change naturally as the environment and the biosphere change. Fire is the most common thing which can cause a climax forest to go back to pioneer species.

Secondary succession goes from grasses to shrubs, pines and finally to a more stable forest of pines, oaks and hickories. Secondary succession is the stage that the land goes to after a fire. Soil is already present, so growth occurs more rapidly than in primary succession. The amount of time between stages can still be affected by many natural things such as soil conditions and how far away the seed source is for the next stage. In Kentucky, an old field surrounded by locust or red cedar will have these trees as its secondary succession stage rather than shrubs and pines. It may take 150-200 years or more for secondary succession to reach its climax stage. As you can see, natural succession is a very slow process.

Activities:

1. Visit an old field that is no longer being farmed and identify some of the plants that have invaded since it has been abandoned. Compare this field with one which was abandoned long ago. From what you have learned, can you predict what will happen to the more newly abandoned field?

2. Draw a picture or make a model of what you think will happen as a pond begins to fill in and dry up. This is also a type of succession. What types of plants will be the first to invade? Show what you think each stage will look like.

3. Describe some of the stages of succession that you can see in the plant communities of your area. Your own-back yard is a good place to start looking. What will happen to each of these stages? What do people do to change nature’s ways?

Factors Affecting Succession

Think of the kinds of things that will interrupt or set back the process of succession. Animals, insects, fire, drought, a logging operation, farming, construction, strip mining and pollution are a few. You can probably think of more.

Did you have animals and birds on your list? They can affect the rate of succession by bringing seeds from other areas. Seeds from a more mature area (like acorns from an oak forest) will help speed up the rate of succession. This is what has happened when you see a very large, old tree in a forest which is surrounded by younger trees of the same species. However, more grass seeds than tree seeds will slow up the process because it is hard for tree seeds to germinate in a thick layer of grass. This is why we do not see tree seeds coming up in a lawn but do see them in flower beds.

Depending on the stage of development, plant-consuming animals and insects can speed up or slow down succession. They may destroy a mature forest so that succession has to start all over again, or they may eat the pioneer plants so that there is more room for the climax species to grow. Animals and insects exist naturally outdoors, but people can unbalance nature’s ways. For example, pesticides, if not used properly, will kill not only the pest that we are seeking to control but also many beneficial animals and insects.

Moving life from one environment to another can also unbalance nature. The gypsy moth is a good example of how this can be a problem. This species, brought to this country for a silk experiment, escaped and is defoliating (eating the leaves off) trees in our northeastern forests. It is now moving south and west.

Fire has always played an important part in our environment. Fire destroys vegetation, setting back succession and changing the type of plants. Some plants, like aspen and yellow-poplar, naturally appear after a fire. A hot, out-of-control forest fire is very dangerous and will cause a lot of damage. However, foresters have learned to use fire in a safe controlled way. They will often set fires on purpose to control unwanted types of plants. This will set back succession to a more productive stage. These are

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Old-field Succession

<table>
<thead>
<tr>
<th>Age in Years</th>
<th>1</th>
<th>2</th>
<th>3-20</th>
<th>25-100</th>
<th>150+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Community Type</td>
<td>Bare Field</td>
<td>Grassland</td>
<td>Grass-Shrub</td>
<td>Pine Forest</td>
<td>Oak-Hickory Forest Climax</td>
</tr>
</tbody>
</table>
relatively cool fires and are set only when the weather conditions are exactly right. The fires are small and controlled so that they can be put out easily when they have done the job. Foresters use fire to reduce the number of hardwoods in a pine forest, to make meadow-like openings for wildlife, and to control diseases. They also use fire to help some plants get started (some types of seed have to have fire to sprout) and to recycle nutrients in grass communities. Setting small, cool fires every few years keeps branches and leaves from building up. This helps to reduce the chance of a large, dangerous fire that could destroy the whole forest.

Fires should be set only by professionals who know how to do it safely. Real problems occur when people set fires on purpose (arson) or through carelessness. These are the main causes of forest fires in Kentucky.

Activities:

1. List any major disturbances in the land in your community. Can you tell when they occurred by the plant growth? Which have healed faster?

2. List some plant communities that are regulated or controlled by people. How and why are they controlled? Do you think that trying to control a plant community is a good idea? Why or why not?

Plant Adaptations

Plants must be able to survive changes in the environment or they will die. Usually the types of plants that make up a community will be different after a major change in the environment. These new types of plants have special characteristics which help them survive. Some species of plants grow only in full sun while others grow only in the shade. The shade tolerant plants will grow under a forest canopy while the shade intolerant plants will not survive without more sunshine.

As a forest ecosystem develops into the different layers (strata), plants compete for the available light. The shade intolerant species have to grow quickly and remain in the upper layers or they will die. The shade tolerant species are usually slower growing, generally shorter and will be overtopped by the others. They will have to make do with the light that filters through the canopy or die. Each layer from the tree layer to the herb layer is adapted to the decreasing level of sunlight. Trees which are shade intolerant are usually found in young forests. They do not live long and when they die, the shade tolerant plants, which have been living underneath, replace them in the mature forest.

Light is very important, but it is not the only factor affecting whether or not a plant survives. The thick bark of some mature tree species, such as bur oak and longleaf pine, lets them survive fires without serious injury. Yellow-poplar is often killed by fire because it has thin bark. Certain plants, like aspen, produce large numbers of seed with hard seed coats. These seeds lie dormant (inactive) in the soil until a fire cracks the seed coat; then they soon germinate.

Plants in desert regions often have very deep, fleshy root systems to reach and store water. Some cacti and other types of succulents also develop water-storing leaves with a waxy coating to help reduce the loss of water.

Some plants produce chemicals that prevent other plants from growing around them. For instance, walnut trees give off a chemical called juglone that reduces competition from other plants for water and nutrients.

Activities:

1. List plants that you can think of that are adapted to cold, heat, flood, drought and other changes that take place in the environment. List plants which are not adapted to each of these changes.

2. Discuss the following questions with your 4-H group. Or think about the answers yourself.

Do you remember the three laws of nature? The first law was, Everything is connected to everything else. How can a forest fire in Eastern Kentucky affect the quality of the drinking water in Lexington?

The second law is, Everything goes somewhere. A tree in the forest dies of old age. What happens to all of the nutrients that it has taken up in the past 100 years?

The third law is, There is no such thing as a free lunch. Billions of dollars are spent in managing plant communities each year. What are the short-term problems of letting a strip mine site start off with primary succession (lichen)? What are the long-term problems?
Every living thing contains energy.
**Introduction**

Almost everyone is interested in animals. They are fascinating to watch and to study. Many people devote their lives to the study of animals.

Have you ever thought about how animals fit into the environment? There are probably some animals you don't want in your environment... like a snake! In this section, you are going to learn how animals fit into the environment. You will learn about the **animal ecosystem**.

Ecosystems are groups of things that are dependent on each other. Air, soil, and water, producers (plants), consumers (herbivores and carnivores), and decomposers are all part of an ecosystem.

Every living thing contains energy. The energy first comes from the sun. Producers use the sun's energy, along with air, water and nutrients, to make the food that allows them to live and grow. In looking at the food chain, you can see how energy moves through the ecosystem: herbivores (animals) eat producers (plants), carnivores (animals) eat herbivores (animals) and decomposers (bacteria and fungi) eventually return nutrients back to the soil for producers (plants). The order of the food web is that there must be more plants than herbivores and more herbivores than carnivores.

Below is a diagram of a food web. Study it for awhile. Are there more green plants than rabbits? Are there more rabbits than bobcats or eagles?
Activity:

Choose a woodlot, park or other wooded area near your home. If possible, get other 4-H'ers to visit the spot with you. Observe and make a list of all the different plants and animals you can identify. Draw a line from each species of plant that is important food for each species of animal (example: grass and rabbits). Draw a line from animals that are important food for other animals (example: rabbits and foxes). Which animals are important to the plant’s existence (examples: pollination and seed movement)? Draw a picture to tie this all together. Remember the first law—everything is connected to everything else.

You may want to use this information for your 4-H project story. You may also use it in a 4-H demonstration or speech.

Wildlife Habitat

Remember the term habitat? Habitat is the place in the environment in which a plant or animal lives. All of the plants and animals living together in a habitat form a community. Many species of plants and animals can share a habitat, but each uses different parts of that habitat. For example, squirrels and deer are both herbivores which live in a woodland habitat. Squirrels spend much of their time in the trees feeding on nuts and buds, while deer spend their time on the ground eating juicy young plants, twigs, and some nuts. Each of the species—the squirrels, the deer, the mice, etc.—lives in its own part of the total habitat.

That special part for each species is called its ecological niche (pronounced niche). Some habitats contain more niches than others, allowing more room for different species to live together. A habitat is more diverse if more species live there. A mature oak-hickory forest with its three strata layers contains a wide variety of food and places for shelter. Squirrels, deer, mice, owls, and honeybees can live there because there is a wide variety of plant species in a mature forest. There would not be as many different species living in a rocky cliff or desert because only plants and animals with special adaptations to the wind or drought can live there.

Look at the diagram below that divides a woodland habitat into niches for different species of birds. You can see that different birds prefer different strata of the forest. What reasons do you think there might be that cause the different birds to choose a special layer?

Wildlife Requirements

All animals need three things to live: food, shelter, and water. Animals cannot survive unless they have all three.

Food. Different wildlife species eat different types of food. Some are quite particular and, like river otters, feed mainly on fish. Others, like raccoons and opossums, eat any type of plant or animal that is available for them. If a river otter can’t find fish to eat, or if water pollution poisons the fish, the otters will leave the area. River otters are becoming rarer today for this reason.

Shelter. Cover (or shelter) is a place in the habitat that the animal can use for protection. Animals must be protected from weather, predators and other harmful things. Some species are not selective about where they will find cover. For example, opossums will use hollow trees, underground burrows, leaf piles, or whatever else is available. On the other hand, red-cockaded woodpeckers...
make holes only in old, large living pine trees for nesting and resting cover. However, most pine trees are cut down before they grow to the size needed for red-cockaded woodpeckers, so the woodpeckers then are eliminated from areas where they used to live when these pine trees are cut. The red-cockaded woodpeckers are on the endangered species list because of this problem.

Numbers of other bird, animal, fish, reptile, insect, and plant species are endangered because of similar circumstances. Unless we help by observing the basic laws of ecology and helping these species to survive, we'll have more and more of these added to the list of species that are now extinct. Remember the third law of ecology. There is a cost involved when we destroy or change any habitat necessary for certain species.

Professional wildlife management done through fish and wildlife departments at state levels, the Department of Interior at the federal level, and other organizations and agencies at international levels are doing all possible to help protect all species of wildlife. We too must do our part. Together, we can be of significant help.

Water. Finally, water is essential to all life. Some wildlife, such as muskrats, need water for drinking, cover and food, while others, such as field mice, get most of their water from their food. Usually, there are more different animal species in an area where water is easily available.

### Activities:

1. **Play Animal Detective**
   Pick five species of animals that interest you. Then find one of the animals and follow it around as best possible for an hour or so. Make a list of the places it visits, the types of plants it uses, and for what purposes it uses the plants. Identify the important habitat characteristics for your chosen species.

2. **Arrange for a Conservation officer to talk with you and your group or club about fish and wildlife programs, laws and enforcement. A visit to a wildlife management area is always fun and educational. It makes a great family trip.**

### Ecological Succession

You learned in the section about plants that ecosystems are always changing through the process of succession. If we could live long enough and revisit the same spot every year for a 100-year period, we would see many changes. An abandoned old field is first covered by grasses and weeds such as goldenrod and asters. Then trees

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**Habitats for Different Animals in Forest Succession**

- **Wood Thrush**
- **Cardinal**
- **Grasshopper**
- **Sparrow**

<table>
<thead>
<tr>
<th>Community</th>
<th>Bare Field</th>
<th>Grassland</th>
<th>Grass-Shrub</th>
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</thead>
</table>
such as pines, poplars and other fast-growing pioneer species begin to dominate. Finally, in 100 years or more, a mature oak-hickory forest may occupy the site that used to be a field.

Animal communities change along with plant communities because animals depend on plants for food and cover. For example: grasshoppers and rabbits live in grassy fields, but you rarely see them in a forest where grass does not get enough sunshine to thrive. Sparrows prefer small shrubs and trees. Wood thrushes and woodpeckers live in mature forests because they eat the insects under the tree bark. You can see this animal succession in the diagram on page 33.

Activity:

This activity is designed to help you see: 1) how everything in an ecological system is in some way connected to everything else; 2) the importance of each part to the others; 3) the effect that changing one part has on all others.

With your fellow 4-H’ers, visit the following: 1) a grassy field, 2) an area that has some plant growth but is not yet a wooded area, 3) a wooded area.

Make a list of all of the plants and animals that you can identify at each location. Which species of plants are important for which species of animal? How does this change with succession? Discuss your study and your answers with your 4-H group, your family, and friends. You can help them to learn a lot also.
Record Sheet

EXPLORING NATURAL RESOURCES

Kentucky 4-H Project

Name ___________________________ Birthday __________ Date __________

Address
(Street and Number) _______________________ (City) __________ (Zip) __________

County ___________________________ Name of Club or School _______________________

Number of Years in 4-H __________

1. Write about the new things you learned in this project.

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

2. List the activities related to this project in which you participated, such as group meetings, tours, visits to woodlands, pond, refuge, exhibits, experiments, demonstrations or other things you've done.

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

3. If you helped others with this project and activities, tell about what you did with them.

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________

4. List any awards or recognition you have received in this project.

_________________________________________________________________________
_________________________________________________________________________
_________________________________________________________________________
5. Write your 4-H Natural Resources project story telling about what you did and learned including how the project helped you, who helped you with the project, and why we all need to learn more about our natural resources.

(When you have completed your project work and this record, you should turn it in to your 4-H leader or 4-H agent and enter it in the records judging program.)

Approved: Parent

Project Leader

County Extension Agent

Your signature

Your address

Street, Route, Box

City, Town, and Zip Code