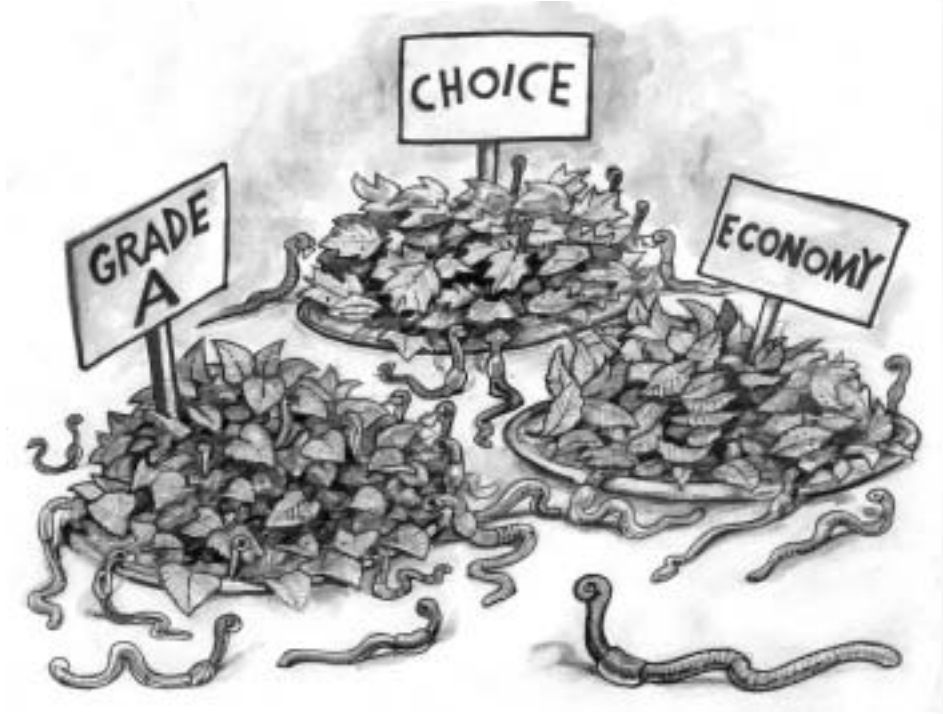
Leaf Me Alone!

The Movement of Nutrients Between Trees and the Soil



Meet Dr. Cuevas:

I like being a scientist because I get to discover new things about the natural environment.

Dr. Cuevas

Meet Dr. Lugo:

I like being a scientist because it brings me into contact with people who, like me, are fascinated by the *complexity* of nature and have an opportunity to try to figure it out. Then we can put the information to work for the benefit of people.

Dr. Lugo

Glossary:

complexity (käm **plek** suh te): The state of being complicated or having many related parts.

quality (**kwôl** ä te): Any of the features that make a thing what it is.

quantify (**kwän** tä fi): To count or measure; to give the quantity of.

nutrient (**noo** tre ent): Any of the substances found in food that are needed for the life and growth of plants and animals.

organism (**ôr** gä niz um): Any living thing.

decomposer (de käm **poz** ür): Organisms that digest parts of dead organisms and the wastes from living organisms.

analyze (**an** ä liz): To study or examine carefully.

species (**spe** sez): Groups of organisms that resemble one another in appearance, behavior, chemical processes, and genetic structure.

biomass (**bi** o mas): All the living things in a particular area.

external (ek **stür** nul): On the outside.

manager (**ma** ni jür): A skilled person who directs or manages something.

organic (ör **ga** nik):Related to or coming from living organisms.

Pronunciation Guide

a	as in ape	ô	as in for
ä	as in car	u	as in use
e	as in me	ü	as in fur
i	as in ice	oo	as in tool
o	as in go	*ng*	as in sing

Accented syllables are in **bold**.

Thinking About Science

Scientists use many ways to determine the *quality* of a thing. Most often, scientists use numbers to determine the amount of a particular quality a thing has. Sometimes, using numbers is not the best way to determine something's quality. For example, how could you determine how much better (a quality) your dinner tastes after you add salt to it? You would taste it and make a judgment. This judgment would be based on a comparison with how it tasted before you added salt. This is a way of determining quality without using numbers. You could *quantify* this quality of good taste by asking everyone in your neighborhood to taste your dinner before and after adding salt. Then, you could count the number of people who said it tasted better. Quality can be judged with or without numbers. Usually, scientists use numbers because numbers are less subject to individual choice or opinion, as when they measure height or weight. In this study, the scientists wanted to know the quality of leaves that fell from trees. Quality was determined by the amount of *nutrients* found in the fallen leaves. Do you think the scientists used numbers to determine quality in this case? Why or why not?

Thinking About the Environment

Food chains describe the flow of energy from one organism to another. A flow of energy occurs when one organism digests another. When this happens, some of the energy is lost to the environment. The food chain starts with green plants. Green plants are the only type of organism that can convert sunlight into food by photosynthesis (**fo** to **sin** thä sis). In forests, some of the green plants are consumed by animals such as insects and deer, but most of them are consumed by *decomposers* as dead plant material. Decomposers include bacteria, fungi (**fun** ji), and small animals such as earthworms. Decomposers move nutrients from the dead plant material to the soil. Once in the soil, plants can use the nutrients for new growth. The scientists in this study wanted to know whether some kinds of fallen leaves have more nutrients than other kinds of leaves. If so, those leaves would provide more nutrients to the soil, making more nutrients available to the plants.

Introduction

You probably know that trees depend on the soil in which they are rooted. But did you know that the soil depends on trees also? By

Thinking About Ecology

What is energy? Energy is the ability to do something. Energy always behaves in the same way. The behavior of energy is described by what we call the laws of energy. Energy can take many forms, and can be transferred from one form to another. When energy is transferred, its quantity decreases. That means that the amount of energy available to do something is less. The remainder of the energy becomes scattered or spread out, usually in the form of heat. This heat energy is usually lost to the environment. This means that whenever we use energy, we always end up with less useable energy than we started with. All living things need a continual source of high-quality energy to survive. As this energy is used, low-quality heat and other waste products are added to the surroundings. Everything on Earth follows the laws of energy, including us! These are laws that no one can break.

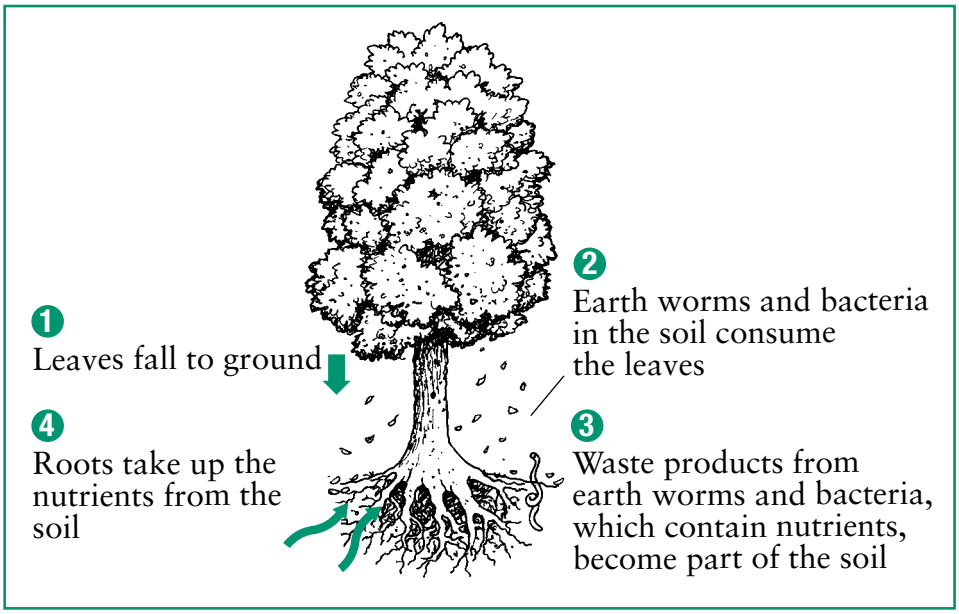


Figure 1. The tree nutrient cycle.

shedding their leaves, trees provide nutrients to the soil, which are made available to the trees once again (Figure 1). In this study, the scientists studied trees growing on Puerto Rico, an island in the Caribbean (Figure 2). The scientists wanted to know if different trees contribute different amounts of nutrients to the soil. By learning if some kinds of trees contribute more nutrients to the soil, the scientists could determine if those kinds of trees should be planted in areas where the soil needs more nutrients. This is especially important in the tropics, where the soil often has fewer nutrients than in other forested areas of the world.

Figure 2. The Caribbean

Reflection Section

- What is one of the problems the scientists were trying to solve?

- Do you think that it would be good to plant trees that contribute more nutrients to the soil? Why or why not?

Methods

Trees contribute nutrients to the soil in many ways. One of the primary ways they do this is by shedding their leaves. When leaves fall to the ground, bacteria, fungi, and animals such as earthworms digest the leaves, moving the nutrients from the leaves to the soil. The scientists decided to collect falling leaves and to *analyze* the leaves for nutrient content. They selected trees that had been planted 23 to 26 years earlier in the Luquillo (lu **ke** o) Experimental Forest in Puerto Rico (Figure 3). Puerto Rico is an island in the Caribbean (See Figure 2 and locate Puerto Rico on the map).

The scientists chose to study 10 types of trees that are usually planted to produce wood products such as lumber, baseball bats, and paper. The scientists randomly (**ran** dum le) selected six trees to study from each species. This means that the selection of trees was purely by chance, like a drawing in

a lottery. For each type of tree studied, the scientists hung a wire basket from the selected trees (Figure 4). The baskets caught some of the falling leaves. Every 2 weeks, the leaves were collected, weighed, and a chemical analysis was done to determine the amount of nutrients in the fallen leaves. The scientists collected the leaves 29 times over a period of 58 weeks. How many total baskets of leaves did the scientists analyze? (Multiply 10 tree species X 6 baskets X 29 collections.) Each time, the scientists weighed the leaves to determine the quantity of *biomass*. They analyzed the leaves for the following nutrients: Nitrogen (N), phosphorous (P), potassium (K), calcium (Ca), and magnesium (Mg). The amount of these nutrients measured in the leaves helped the scientists to determine their quality.

Figure 3. Luquillo Experimental Forest.

Reflection Section

- After leaves fall to the ground, decomposers, such as bacteria and fungi, and animals such as earthworms, help to move the nutrients from the leaves to the soil. Do you think that the soil receives the same amount of energy as was in the leaves? Why or why not? (Hint: Think about the laws of energy.)

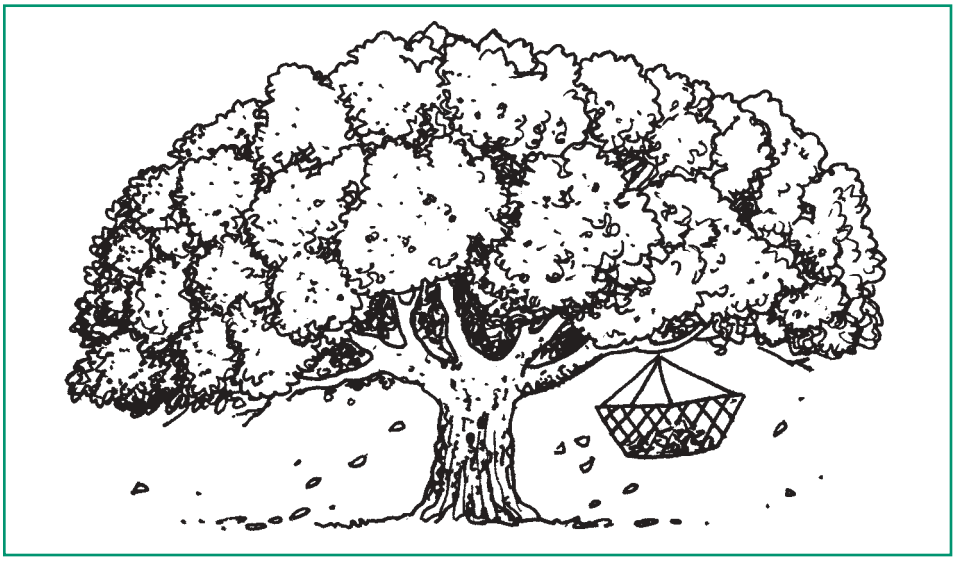


Figure 4. Wire mesh baskets were used to catch falling leaves.

- The scientists collected leaves over the course of a little over 1 year. Why do you think that they wanted to collect leaves during different times of the year?

Results

The scientists found that the 10 species studied differed in both the number of fallen leaves and the quality of the nutrients. They also found that there was a relationship between the number of fallen leaves and the quality of the nutrients. For example, if the nutrient content of individual leaves was low, there usually was a high quantity of biomass, or a lot of fallen leaves. If the nutrient quality of the leaves was high, not as many leaves fell. That meant that the amount of overall nutrients available to the decomposers in the soil was about the same for most tree species (Figure 5).

The scientists also found that before the trees shed their leaves, some of the trees took nutrients back from their leaves before shedding them. Those trees kept much of their nutrients rather than contributing them to the soil through fallen leaves. The scientists concluded that there were three groups of trees. The first group of trees kept their nutrients within the tree itself. The second group cycled most of their nutrients *externally*, meaning that the nutrients were shed with the leaves and cycled into the soil for later use by the tree and

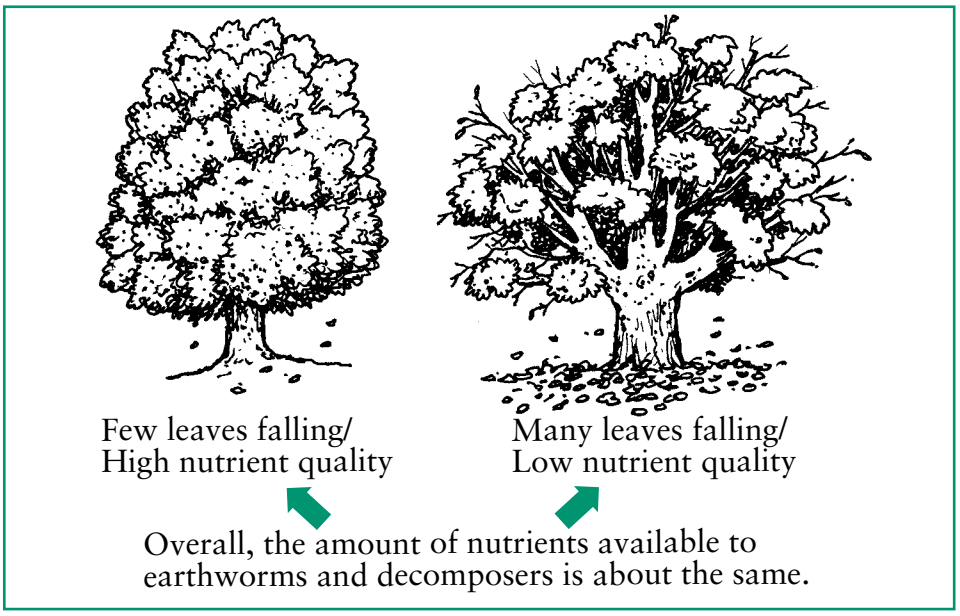


Figure 5. Overall, the amount of nutrients from falling leaves was equal.

other plants. The third group used both kinds of nutrient cycling.

Reflection Section

- Think about all of the animals and plants in the forest. What do you think might be the advantages of external nutrient cycling for other plants and animals? What might be some advantages for the trees when they take the nutrients back from their leaves before shedding them?

- In what ways is energy scattered or spread around during external nutrient cycling?

Implications

Not all trees cycle their nutrients in exactly the same way. If forest *managers* want to enrich soil with a lot of *organic* matter, they should plant trees that shed a lot of leaves. If they want to put a lot of nutrients into the soil quickly, they should plant trees that shed leaves with a high nutrient quality. By knowing the nutrient quality of fallen leaves, forest managers can help nature cycle nutrients from trees to the soil and back to the trees again.

Reflection Section

- In the fall, many people rake the fallen leaves from their yards. What happens to the nutrient cycle when people remove the fallen leaves? How do some people make up for the loss of nutrients available for plant growth? (Hint: What do people usually do in the spring to encourage tree and plant growth?)

- When people build a compost bin, they are providing a special area for leaves and other organic wastes to decompose (Figure 6). What kind of organisms are causing the organic matter to decompose in a compost bin? How is a compost bin like a forest floor? How is it different?

Figure 6. Many people use a compost bin to recycle and reuse their leftover, non-meat foods, fall leaves, and grass clippings. They then use the compost for their gardens and trees.

FACTivity

In this FACTivity, you will explore the bacteria living in the soil near your home or school. The question you will be answering is: What kind of bacteria live in different kinds of soil? It will take 3 to 4 weeks to complete this FACTivity, so be patient. Bacteria need time to grow! You will need:

- 4 clear plastic 2-liter soda bottles with labels removed
- Enough clear, sturdy plastic wrap to cover the bottles
- four rubber bands
- marker
- masking tape
- 2-gallon bucket
- a 1-cup measuring cup
- tablespoon
- paint stirrer or other stirring utensil
- 4 small buckets of soil or mud, each collected from one of four different sources (like a pond, garden, stream, forest, yard, etc.).
- 4 small buckets of water, one from each place you collected the soil (use distilled water for soil collected from a dry place).
- 4 sheets of newspaper
- 1 cup of powdered chalk (crush several pieces of chalk or you can buy some powdered chalk at a hardware store)

Wash your hands before starting. If you have a cut on your hand, wear latex gloves when working with soil. Divide into four groups. Each group will prepare one of the experiments. Be sure to match the bucket of soil with the bucket of water from the same source. Label each bucket with the source of soil or mud and water using the masking tape and marker.

For each experiment:

Cut off the top end of your plastic bottle. The top end will be used as a funnel, and the bottom will hold your experiment. Shred the sheet of newspaper into thin strips and set it aside. In the 2-gallon bucket, add 5 or 6 cups of soil or mud. Pick out all of the sticks, leaves, and pebbles. While stirring, slowly add water (from the same source) until the mixture becomes like a thick cream. Add the shredded newspaper and 1 tablespoon of powdered chalk. Mix gently, and make sure the mixture is wet enough to flow through the funnel. Label your plastic bottle with the source of the soil. Then, using the funnel, pour about 1 centimeter or 1/2 inch of the mixture into the plastic bottle. With one hand over the top of the plastic bottle, gently tap the mixture on a hard surface to allow the mixture to settle evenly. Continue this process until you have filled the bottle to within about 4 centimeters or 2 inches from the top. Cover the top with plastic wrap and seal with the rubber band. Place your bottle in a well-lit place, but not in direct sunlight. Keep it out of heat and at room temperature.

For 3 or 4 weeks, observe the bottles daily. Look for color changes in the mixtures. Record your observations, using the chart below as an example. You may draw, label, and color a picture of each of the jars at the end of each week.

You should begin to see different colors in the bottles. What are the colors and where are they located in the bottle? What do you think causes the different colors?

- Red and orange are purple photosynthetic (**fo** to sin **theh** tik) bacteria
- Green at the surface are cyanobacteria (**si** an o bak **ter** e uh) and algae
- Olive green in the middle or lower area are green sulphur bacteria
- Black patches are iron sulfide, a chemical formed by certain bacteria

To learn more about these different kinds of bacteria, visit www.ucmp.berkeley.edu/bacteria/bacteriasy.html

This FACTivity was adapted from an activity titled "Biosphere in a Bottle" developed by the National Association of Biology Teachers. For more fun activities related to bacteria, visit http://www.microbe.org.

From: Cuevas, E. & Lugo, A. E. (1998). Dynamics of organic matter and nutrient return from litterfall in stands of ten tropical tree plantation species. *Forest Ecology and Management*, 112: 263-279.

To learn more about nutrient cycling, visit http://www.swifty.com/apase/charlotte/soil7.html