INQUIRY 2: WHAT BENEFITS DO THE WORLD'S FORESTS PROVIDE?

Photo courtesy of Babs McDonald.

FORESTS ARE MORE THAN TREES

When you hear the word "forest," what comes to mind? Many people think first of trees. These people are correct, but only partly correct. Trees, of course, are the foundation of a forest. An area without trees is not a forest at all. However, a forest is much more than trees. In addition to trees, forests include many other living and non-living parts. The living parts include other plants like shrubs, vines, grasses, flowers, mosses, and **algae**. Living parts also include animals like insects, **mammals**, birds, fish, reptiles, and **amphibians** (Figure 30, Figure 31, and Figure 32). Fungi and **bacteria**, which have characteristics of both plants and animals, are also in forests (Figure 33). Nonliving parts of forests include soil, water, rocks, and minerals.

FIGURE 30.
Leafcutter ants harvest green leaves to prepare and use in underground fungus farms.
Photo courtesy of Chuck Murphy, http://www.boywithcamera.com.

FIGURE 31.
Giraffes are mammals that live in Africa.
Photo courtesy of Chuck Murphy,
http://www.boywithcamera.com.

FIGURE 32.
Colorful birds, like these scarlet macaws, live in tropical forests.
Photo courtesy of Chuck Murphy,
http://www.boywithcamera.com.

FIGURE 33.
These red chanterelle mushrooms on the forest floor are the fruiting bodies of a fungus.
Photo courtesy of Chris Evans, University of Illinois,
http://www.bugwood.org.

All of the living parts of a forest **interact** with each other and with the nonliving parts. These living and nonliving parts create a complex community known as an ecosystem. Forest ecosystems help sustain the lives of everything on Earth.

Forests play a role in moving **nutrients** from nonliving things, such as the soil, to living organisms and back. Forests store and release gases such as carbon dioxide, nitrogen, and oxygen. Forests store **elements** such as carbon and **molecular compounds** such as water, and provide a way for these elements and compounds to move into, throughout, and out of the ecosystem (Figure 34).

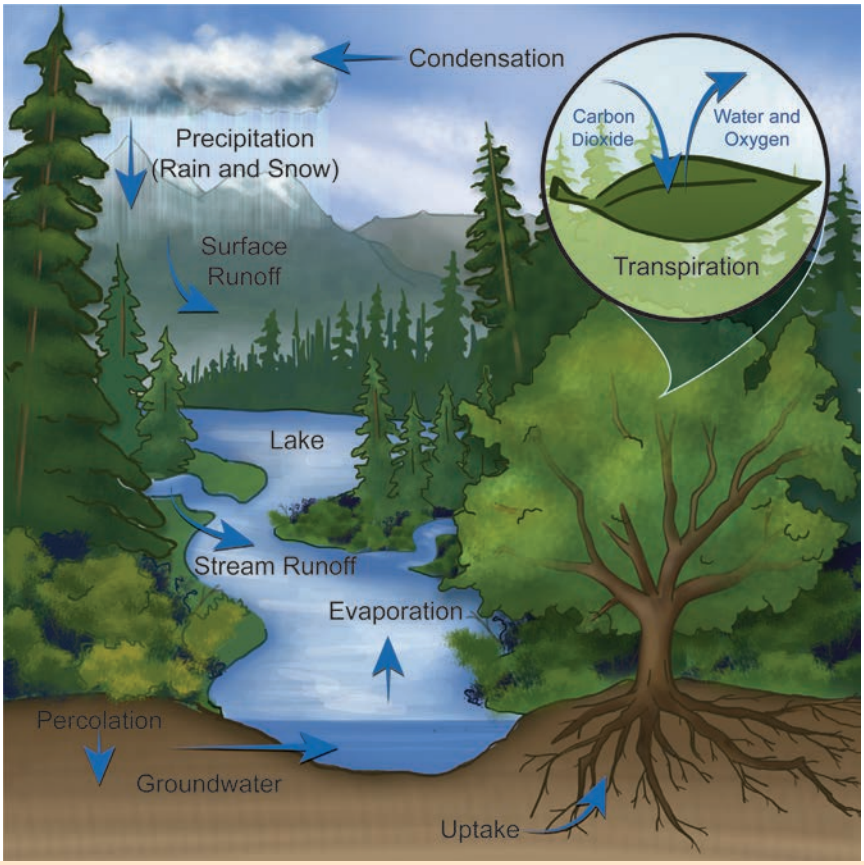


FIGURE 34.
The water cycle. Each individual tree contributes to the water cycle through transpiration.
Illustration by Stephanie Pfeiffer and Nickola Dudley.

THE WOOD WIDE WEB

Did you know that forest trees communicate with one another? In a forest, trees are connected to one another by a large network of underground fungi. This network has been called the "Wood Wide Web." Communication occurs through the fungi's hyphae, which are thin strands connected to the main body of the fungus and also to the tree's roots (Figure 35). Trees use these hyphae to pass nutrients to one another. A dying tree, for example, may send its remaining nutrients to other trees. But even more interesting, trees can pass information to one another. A tree, for example, may use the network of hyphae to warn other trees about an invading insect. A forest is more connected than it appears at first glance!

Information from *The hidden life of trees* (2016) by Peter Wohlleben and Tim Flannery, Vancouver/Berkeley: Greystone Books.

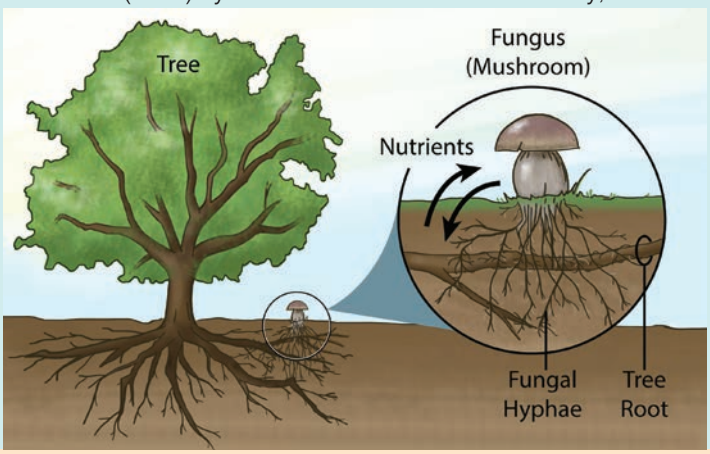


FIGURE 35.
Hyphae are fungi's thin strands. Hyphae assist in the transfer of nutrients and energy back and forth between a tree's roots and the fungi.
Illustration by Stephanie Pfeiffer.

FIGURE 36.
Genetic differences exist even within the same **genus**. For example, Hawaii's Nēnē goose (A) is thought to have evolved from the Canada goose (B), which probably arrived on Hawaii about 500,000 years ago. These species of geese are closely related so scientists put them both in the genus *Branta*. However, because of their differences, scientists consider them different species.
Photos courtesy of Forest and Kim Starr, Starr Environmental, Bugwood.org, and the U.S. Fish and Wildlife Service.

Forests contain a diversity of life. This diversity of life is called biodiversity. In most forests, you will find a wide diversity of plants and animals. These plants and animals live together and keep the ecosystem in balance over time.

A diversity of plants and animals, however, is just one kind of biodiversity. Biodiversity can be found within the same genus or species of a plant or animal (Figure 36). One tree of the same species may grow taller or one deer may run faster than another. These differences may give one plant or animal an advantage over another.

WHAT IS AN EXAMPLE OF DIVERSITY WITHIN A SPECIES?

The nuts and timber of the Persian walnut tree are highly valued. Scientists believe that the Persian walnut was first used in eastern and central Asia. For centuries, however, Persian walnuts were traded throughout Africa, Asia, and Europe. Today, Persian walnut trees are grown in over 60 countries on these continents.

Scientists studied the genetic diversity of Persian walnuts grown in 25 regions within 14 countries in Africa, Asia, and Europe. They found a lot of genetic diversity between walnuts growing in the 25 regions and the 14 countries. Over centuries, therefore, the cultivation of Persian walnuts has created biodiversity within Persian walnut trees. This is an example of biodiversity within a species.

REFLECTION SECTION

Are you surprised that trees can share nutrients with each other through underground hyphae? Name one other way that two different forest plant or animal species work together to maintain a healthy forest environment.

Is biodiversity present in the human species? How do you know?

PRIMARY FORESTS

Primary forests are a type of natural forest. Primary forests contain native tree species. In primary forests, human activities are not noticeable and the forest's ecological processes are not widely disturbed. Primary forests help conserve the diversity of animal and plant species and protect natural ecosystems (Figure 37).

FIGURE 37.
This forest in China is an example of a primary forest.
Photo courtesy of Dazhuang Huang.

In 2015, 33 percent of the world's forests were primary forests. These forests covered 1.3 billion hectares, and half of these forests were in the tropical ecozone. Look at Figure 38 and Figure 39. Which continent had the highest amount of primary forest hectares in 2015? Which continent had the highest percentage of primary forest area as a percentage of its total forest area?

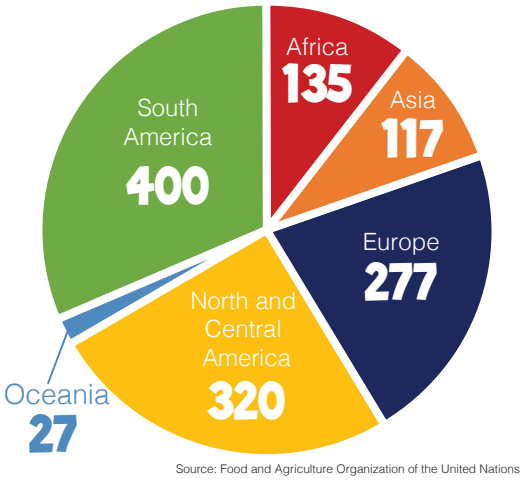


FIGURE 38.
Primary forest area by continent (in millions of hectares) in 2015.
Illustration by Stephanie Pfeiffer.

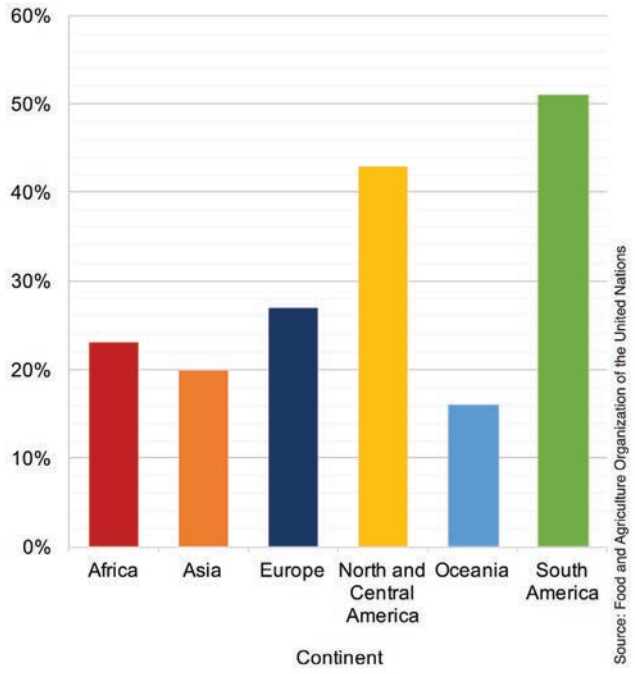


FIGURE 39.
Primary forest area as a percentage of total forest area (of countries that reported on primary forest) by continent in 2015.
Illustration by Stephanie Pfeiffer.

Between 1990 and 2015, the amount of primary forest has been changing on each of the world's continents. What patterns do you observe in Figure 40?

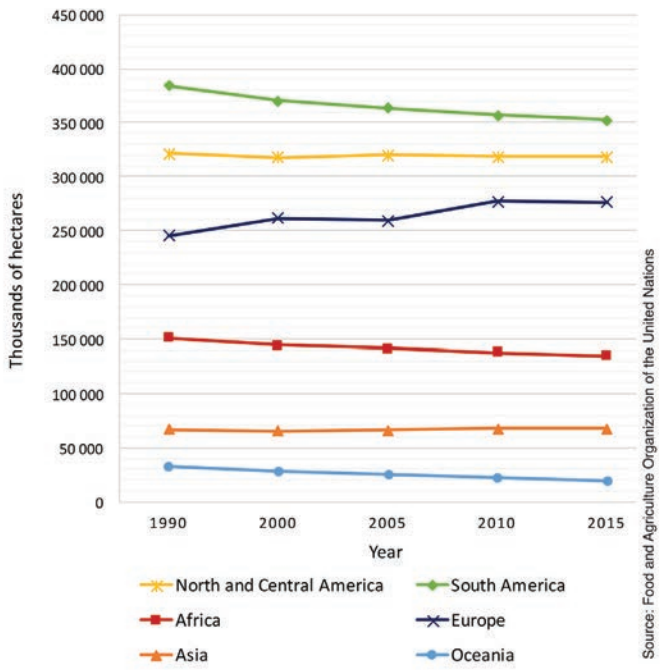


FIGURE 40.
Area of primary forest (in thousands of hectares) by continent between 1990 and 2015.
Note: this graph only includes data from countries that reported on primary forest for all Forest Resources Assessment reporting years.
Illustration by Stephanie Pfeiffer.

Some forests are managed to protect biodiversity. This type of forest management occurs in 13 percent of the world's forests (Figure 41 and Figure 42). These forests cover 524 million hectares. Worldwide, the amount of forest land set aside to protect biodiversity has slightly increased since 1990.

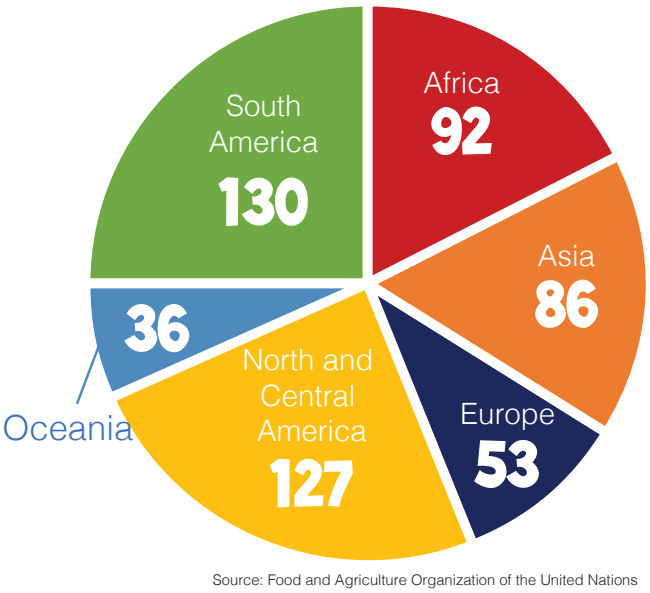


FIGURE 41.
The amount of forest area (in millions of hectares) set aside to protect biodiversity by continent in 2015.
Illustration by Stephanie Pfeiffer.

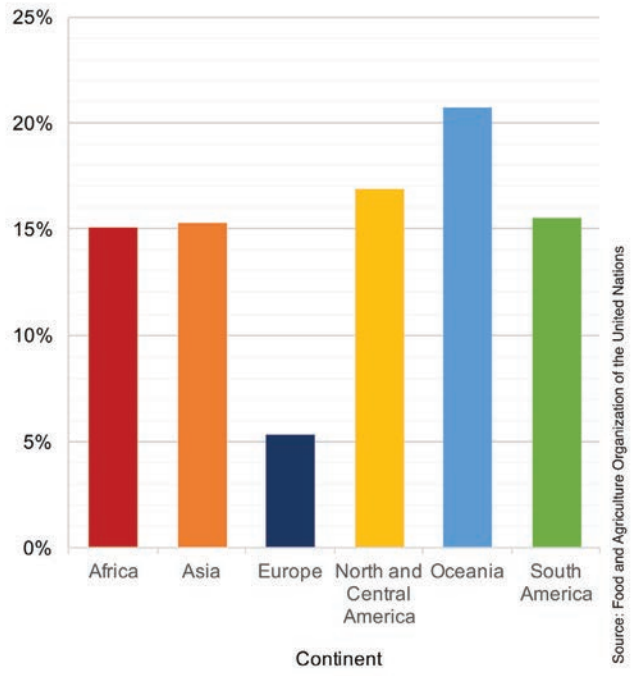


FIGURE 42.
The amount of forest set aside to protect biodiversity as a percentage of total forest area (of countries that reported on this variable) by continent in 2015.
Illustration by Stephanie Pfeiffer.

The United States of America and Brazil have set aside the largest areas of forested hectares to protect biodiversity. Venezuela and Mexico, however, have reported the largest percentage of their forested land area set aside and managed for biodiversity. Over half of Venezuela's forests are set aside to protect biodiversity.

Governments sometimes protect forests by giving them a special legal status. When a forest area is protected legally, it must be managed according to the law that established the area. Usually, these laws protect the area from human activities that might change the forest's natural character. Worldwide, 651 million hectares of forest are found within protected areas (Figure 43 and Figure 44).

Seventeen percent of the world's forests are legally protected from damaging human activities. Worldwide since 1990, the number of hectares in protected areas has increased by 200 million. Of these additional 200 million hectares, 143 million hectares are in the tropical ecozone (Figure 45).

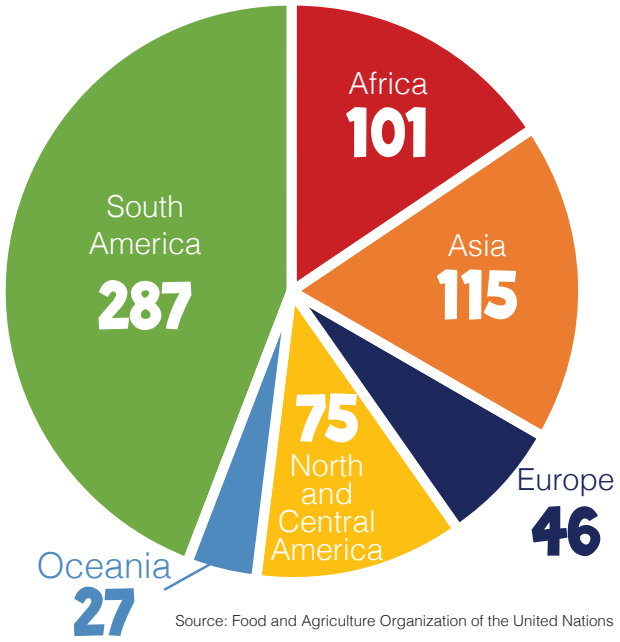


FIGURE 43.
Area of forest within protected areas (in millions of hectares) by continent in 2015.
Illustration by Stephanie Pfeiffer.

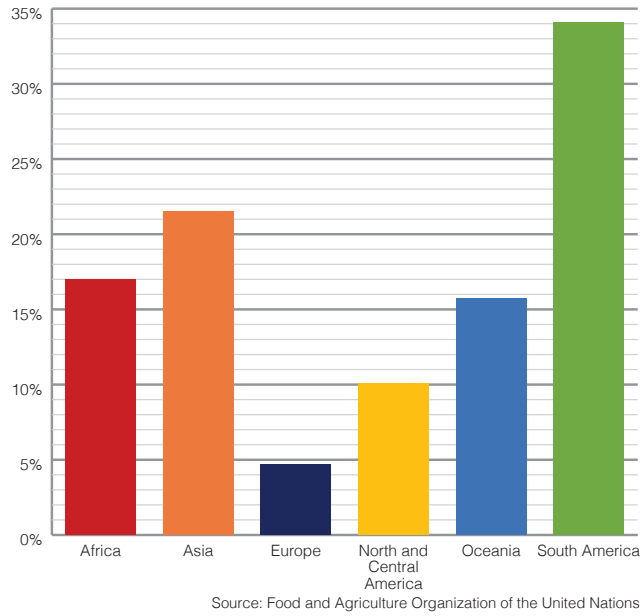


FIGURE 44.
Area of forest within protected areas as a percentage of total forest area (of countries that reported on this variable) by continent in 2015.
Illustration by Stephanie Pfeiffer.

FIGURE 45.
Tropical wildlife, such as this three-toed sloth, needs protected areas to maintain a healthy population size. According to the World Wildlife Fund, sloths are completely dependent upon healthy tropical rain forests. Without many trees in a healthy tropical rain forest, sloths lose their shelter and food sources.
Photo courtesy of Chuck Murphy, http://www.boywithcamera.com.

YOU DO THE MATH

What percentage of additional legally protected forest is located in the tropical ecozone?

Hint: Divide 143 by 200.

REFLECTION SECTION

Do you have a natural area nearby where people are not allowed to do some activities? If so, what is that area, and what activities are people not allowed to do? How do the rules help protect the natural land? If you do not have a natural area in which some activities are not allowed, can you think of a natural area that might benefit if some activities were not allowed? What is that area, and what kinds of activities should not be allowed? How would these rules benefit the land?

How do primary forests help conserve biodiversity?

DID YOU KNOW?

About 18 percent of your body is made up of carbon!

If you could take all of the water and other liquids out of a tree, about one-half of the tree's remaining weight would be carbon.

CARBON AND THE WORLD'S FORESTS

What is one element that your body shares with the rest of Earth's living things? If you guessed carbon, you are correct! Carbon is one of Earth's 118 elements. Carbon is needed for the growth, survival, and reproduction of living things. Carbon can form bonds with other elements to create compounds. One carbon compound you may have heard about is carbon dioxide. Carbon dioxide is a compound formed from carbon and oxygen atoms.

Carbon moves throughout Earth and Earth's atmosphere in a cycle. This movement is called the carbon cycle (Figure 46). When the carbon cycle is balanced, Earth's living systems are more likely to remain in healthy balance as well. One of the ways that the carbon cycle becomes unbalanced is when too much carbon goes into the atmosphere in the form of carbon dioxide. As the carbon cycle becomes unbalanced, Earth's climate responds by changing over time.

When Earth's carbon is cycled, a balanced percentage of Earth's carbon remains on Earth. This carbon is stored in living things such as trees, forests, animals, and the remains of living things, as well as nonliving things like soil, freshwater, and oceans. Forests and forest soils store a large amount of the world's carbon.

FAO has estimated the amount of carbon being stored in the world's forests as 296 gigatonnes (Gt). One Gt is equal to 1 billion tonnes. One tonne is equal to 1 000 kilograms, or 2,205 pounds. This estimate includes carbon stored in vegetation above and below the ground. The forests of South America and west and central Africa store about 120 tonnes of carbon per hectare (Figure 47 and Figure 48). Worldwide, in comparison, forests store an average of 73 tonnes of carbon per hectare.

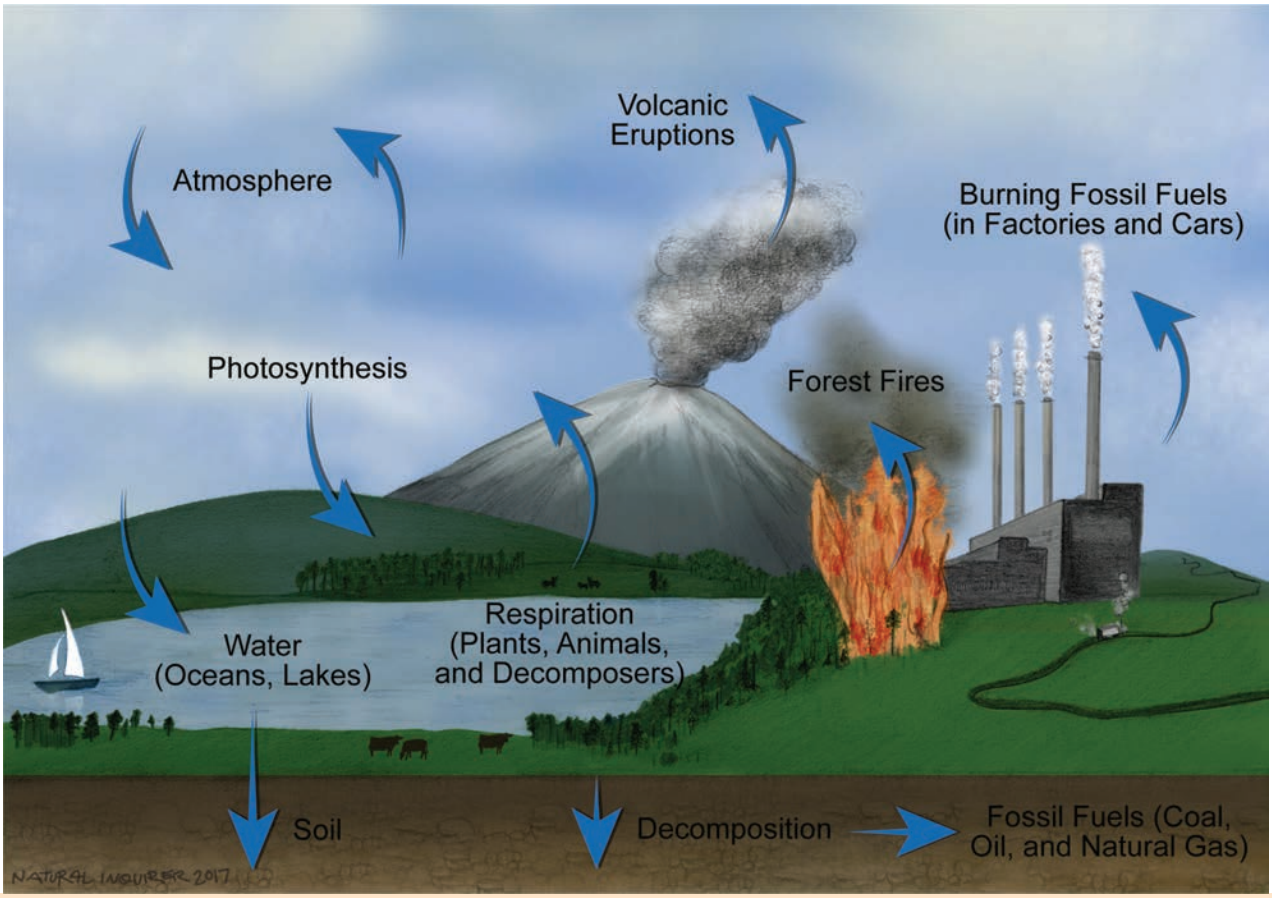
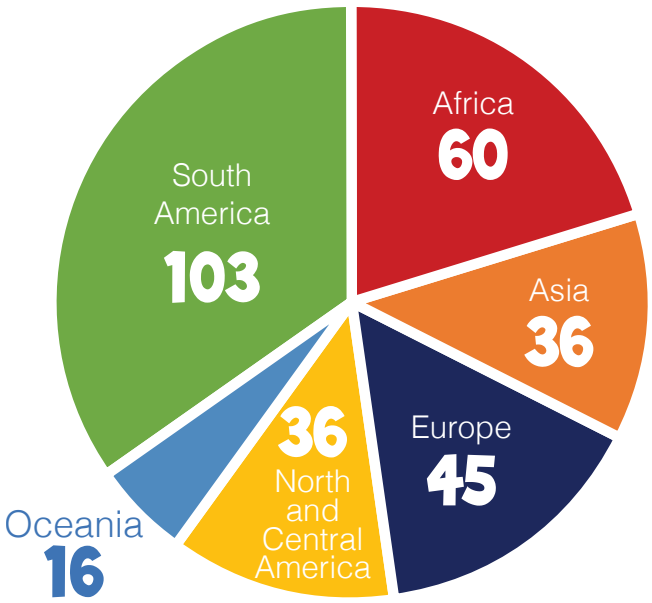
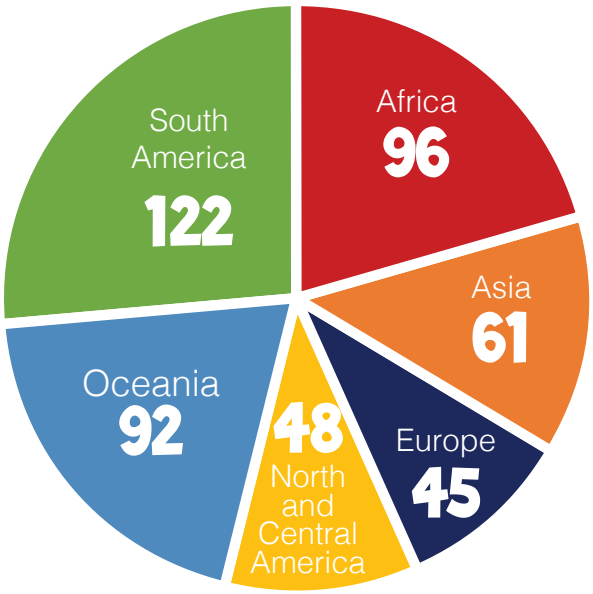


FIGURE 46.
The carbon cycle describes the movement of carbon throughout Earth and Earth's atmosphere.
Illustration by Stephanie Pfeiffer.



Source: Food and Agriculture Organization of the United Nations

FIGURE 47.
Total forest carbon storage in living biomass in gigatonnes (Gt) by continent in 2015.
Illustration by Stephanie Pfeiffer.



Source: Food and Agriculture Organization of the United Nations

FIGURE 48.
Forest carbon storage in living biomass in tonnes per hectare by continent in 2015.
Illustration by Stephanie Pfeiffer.

YOU DO THE MATH

Elephants vary in size and weight. Let's say, however, that the average elephant weighs 4 tonnes (Figure 49). How many elephants would it take to equal 1 Gt?

To calculate this, divide 1 000 000 000 by 4. How many elephants would it take to equal the weight of carbon in all of the world's forests?

FIGURE 49.
This elephant lives in Botswana, southern Africa.
Photo courtesy of Chuck Murphy, http://www.boywithcamera.com.

Over the past 25 years, the amount of carbon stored by forests has decreased by almost 11 Gt. This decrease is mostly due to felling trees and replacing forests with crops and human settlements. Sometimes, forests are not completely destroyed. However, when forests are **degraded** but not destroyed, they still store less carbon than healthy forests.

HOW DOES THE UNITED NATIONS ENCOURAGE CARBON STORAGE?

Forests store carbon in the wood of trees, in other plants, and in forest soils. Carbon is released from forests in the form of carbon dioxide. In forests, some carbon dioxide is released through plant and animal **respiration** and from decaying organisms.

When forests are felled and the felled trees are burned, the carbon that was in the trees is released to the atmosphere. After trees are felled, more carbon is released from the soil as well.

Some countries, sometimes called developing countries, are changing from traditional lifestyles to more modern lifestyles. During these changes, developing countries may find it necessary to fell forests for agricultural land or to build roads and settlements. To address deforestation, the United Nations has started a new program.

The United Nations **Collaborative** Program on Reducing Emissions from **Deforestation** and Forest Degradation in Developing Countries (REDD+) was started in 2008. Two of the Program's goals are to reduce forest carbon **emissions** and improve carbon storage in forests. Another Program goal is to support **sustainable** development in developing countries.

REDD+ is a process established under the United Nations that encourages developing countries to increase the carbon stored in their forests, either by reducing deforestation or by increasing their forest area. Financial aid is available from various sources to reward developing countries that can demonstrate they have reduced deforestation or increased their forest area. This financial aid encourages countries to increase forest carbon storage and supports sustainable development.

REFLECTION SECTION

In an earlier section of this journal, you learned that forests provide benefits to humans. Would you say that holding carbon on Earth is a benefit to humans? Why or why not?

What happens to the carbon that is found in wood furniture and buildings?

ECOSYSTEM SERVICES

Have you ever heard the term "ecosystem services"? Can you imagine what ecosystem services might be?

Ecosystem services are provided by healthy forests and other healthy ecosystems. Ecosystem services are valued by people, even if people do not always think about where these services come from. Examples of ecosystem services include (Figures 50 to 52):

- Clean air
- Clean water
- Beautiful landscapes
- Healthy soil
- Wildlife **habitat**
- Places for outdoor recreation

FIGURE 50.
Tropical forests provide habitat for animals, such as this vermiculated owl. Wildlife habitat is an ecosystem service.
Photo courtesy of Chuck Murphy, http://www.boywithcamera.com.

FIGURE 51.
Forests provide clean water that is used for drinking, cooking, bathing, and other uses. The provision of clean water is an ecosystem service.
Photo courtesy of Babs McDonald.

Ecosystem services are important because they provide goods and services that are vital to human health and quality of life. Ecosystem services are called "public goods" because they are available to everyone, such as clean air. Carbon storage, which you read about in the previous section, is an ecosystem service. Soil and water protection are two important ecosystem services that you will learn about in the next section.

FIGURE 52.
Forests provide areas for flowers to bloom and pollination to occur. These bluebell wildflowers cover a forest floor in Scotland. Pollination is an ecosystem service.
Photo courtesy of Babs McDonald.

FAO is interested in learning whether people living in different **cultures** value their forests for ecosystem services. FAO is interested in how nearby forests support local culture and how forests are used for spiritual renewal. Since 1990, more of the world's forests are being managed for ecosystem services, and cultural and spiritual values (Figure 53 to Figure 55).

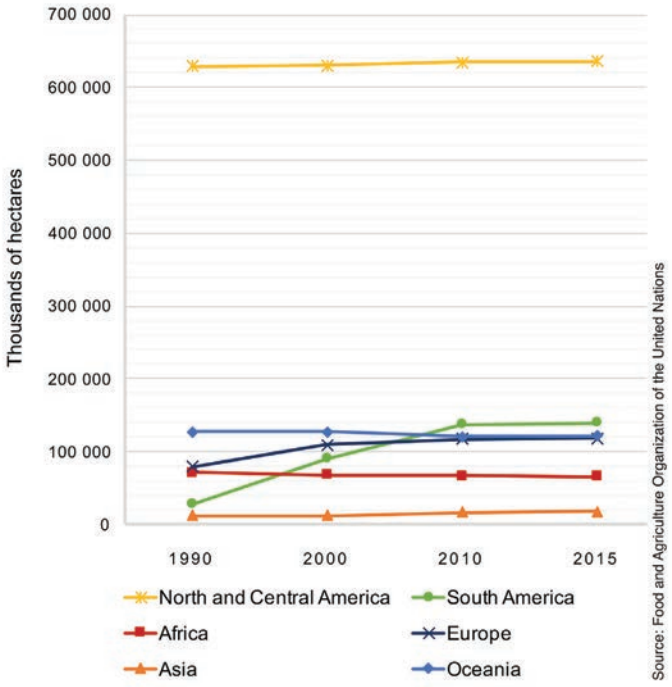


FIGURE 53.
The amount of forest (in thousands of hectares) managed for ecosystem services, including cultural and spiritual values, by continent from 1990 to 2015.
Note: this graph only includes data from countries that reported on this variable for all Forest Resources Assessment reporting years.
Illustration by Stephanie Pfeiffer.

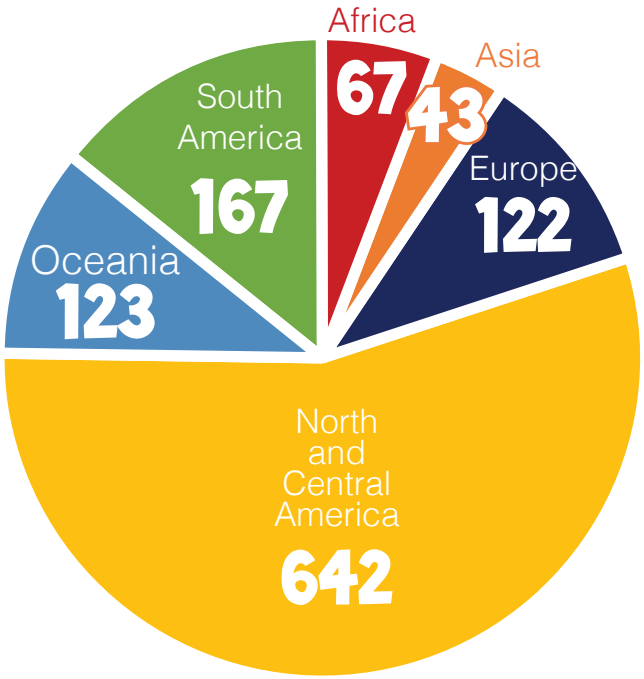


FIGURE 54.
Provision of ecosystem services and cultural and spiritual values (in millions of hectares) by continent in 2015.
Illustration by Stephanie Pfeiffer.

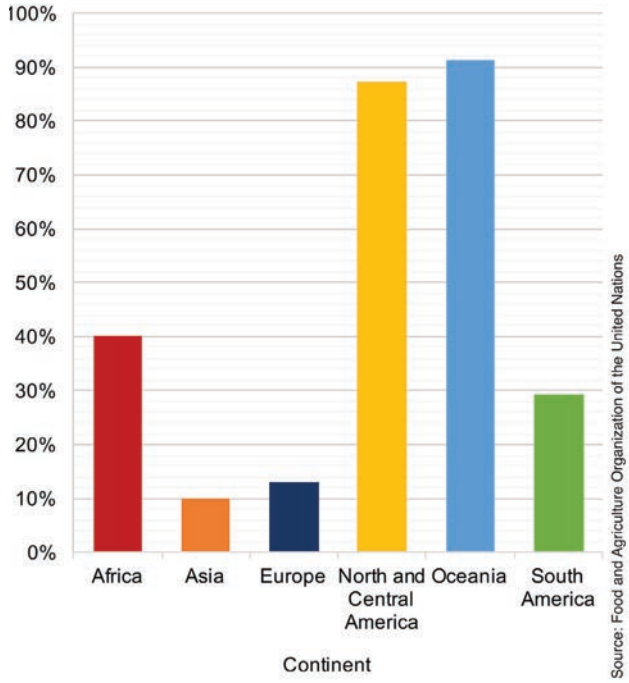


FIGURE 55.
Provision of ecosystem services and cultural and spiritual values by continent as a percentage of total forest area (of countries that reported on this variable) in 2015.
Illustration by Stephanie Pfeiffer.

HOW IS WATER QUALITY IMPORTANT IN YOUR COMMUNITY?

Forests must be protected if their ecosystem services and their cultural benefits are to remain available to people. Local residents play an important role in forest protection and management. Scientists working in Madagascar discovered that local residents were most interested in the health of forested watersheds and the forest's ability to protect water quality (Figure 56).

FIGURE 56.
A watershed is an area of land where all of the water that is underground within the area, and all of the water that drains off the land's surface, goes to the same place.
Illustration by Stephanie Pfeiffer.

NATURAL INQUIRER CONNECTIONS

For more information about ecosystem services, read the *Natural Inquirer* Ecosystem Services edition at **http://www.naturalinquirer.org/Ecosystem-Services-i-26.html**.

REFLECTION SECTION

Describe three ecosystem services provided by a nearby natural area.

Do you live in a watershed? Explain why or why not.

SOIL AND WATER PROTECTION

Soil and water protection are two ecosystem services. These two particular ecosystem services are vital to human health. Where would we be without healthy soil? Can you imagine a world where the soil could not support crops, trees, and other plant life? Life as we know it depends on healthy soil.

A forest floor is covered with a layer of decaying leaves, sticks, and trees, or litter. As litter decays over time, it creates a layer of soil that is protected from heavy rainfall by the forest **canopy** (Figure 57). Without forest cover, the rich top level of soil is easily worn away by rain and wind (Figure 58). Tree roots and the roots of other plants also help hold the soil in place. Forested areas reduce the impact of heavy rains because trees slow down the flow of rainwater. When rainfall is slowed, less soil erosion occurs. When rainfall falls on **forest litter**, the litter slows the **runoff** and reduces soil erosion into streams. In a healthy forest, rainfall seeps through the leaf litter to the soil beneath. Forest soils filter out **sediment** and **pollutants** that might be in water before the water flows into streams and rivers.

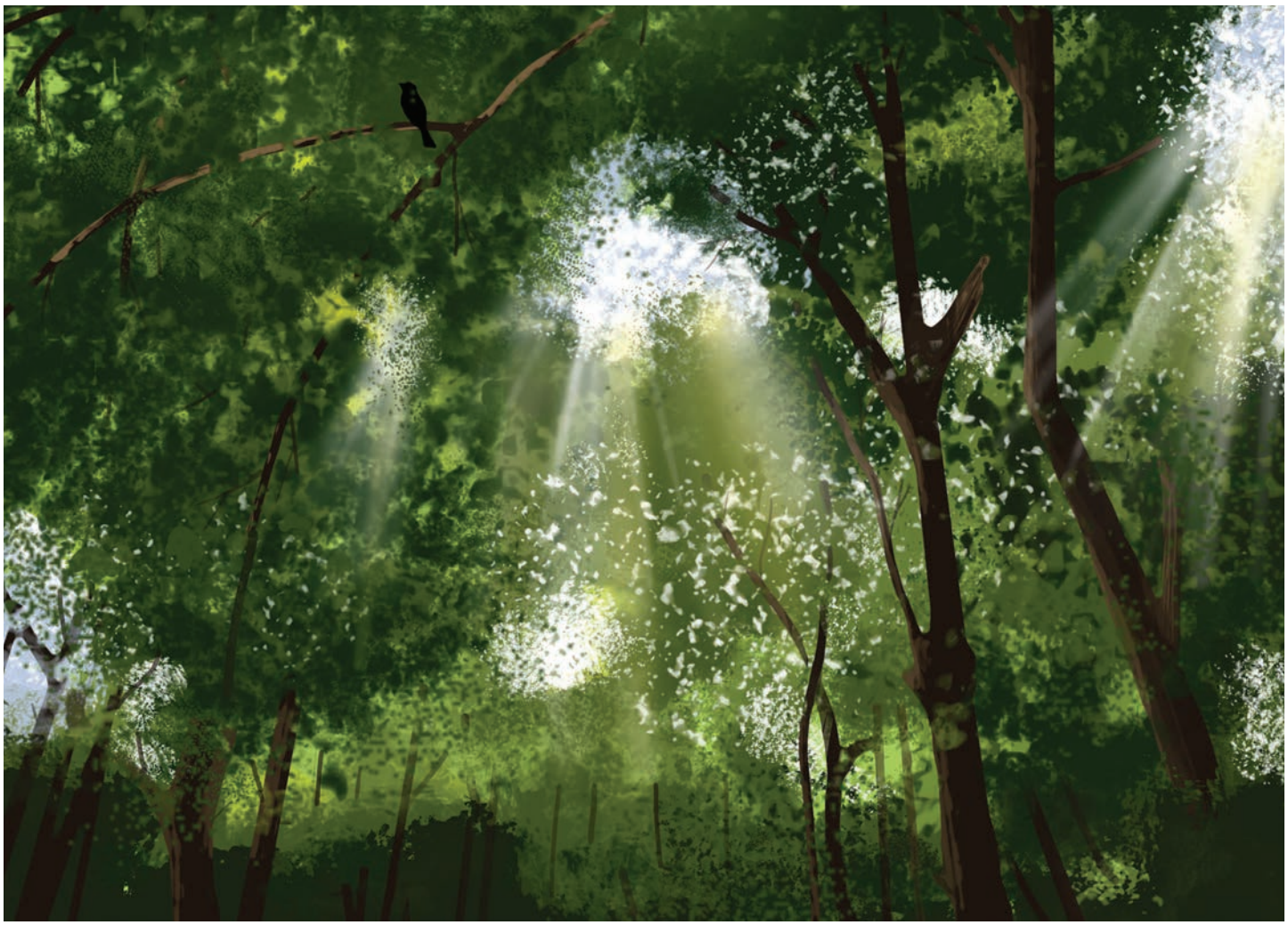


FIGURE 57.
The forest canopy is the top layer where most of the trees' leaves are found. The canopy helps protect the soil from erosion by reducing the impact of heavy rains.
Illustration by Stephanie Pfeiffer.

FIGURE 58.
Trees are planted in Egypt to reduce soil erosion.
Photo courtesy of Food and Agriculture Organization of the United Nations/Rosetta Messori.

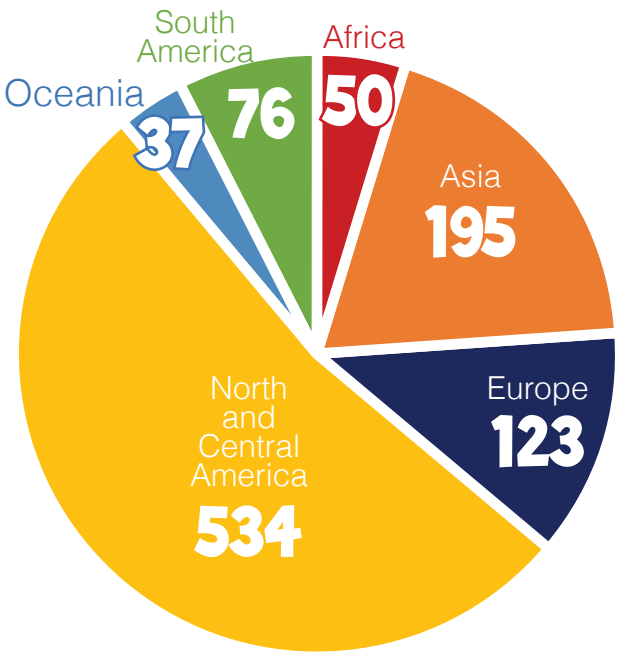
Clean water is another of Earth's most important **natural resources**. All of our planet's organisms need water. Some small amounts of water may come to Earth from outside of our atmosphere, such as from meteors. Practically speaking, however, water found on Earth is our water supply today and into the future. The water you drink today was on Earth even before the dinosaurs lived!

Water moves from Earth's atmosphere, to its surface and underground, and then back to the atmosphere in a continuous cycle. See Figure 34 on page 30 for an illustration of the water cycle.

Just over 70 percent of Earth's surface is covered by water. Of this surface area, 97.5 percent is saltwater. Saltwater is found in oceans, bays, and other coastal areas. Take a look at a globe or a map of Earth. You will see for yourself just how much saltwater is found on our planet. The remaining 2.5 percent of Earth's water is freshwater. Humans must have clean freshwater to live (Figure 59).

Worldwide, about one-third of forests are managed for soil and water protection (Figure 60 and Figure 61). In the last 25 years, about 117 million more hectares of forest area have been designated for soil and water protection (Figure 62).

FIGURE 59.
River water is used for cleaning in Sierra Leone.
Photo courtesy of Sebastian List/NOOR for Food and Agriculture Organization of the United Nations.



Source: Food and Agriculture Organization of the United Nations

FIGURE 60.
Protection of soil and water and provision of ecosystem services (in millions of hectares) by continent in 2015.
Illustration by Stephanie Pfeiffer.

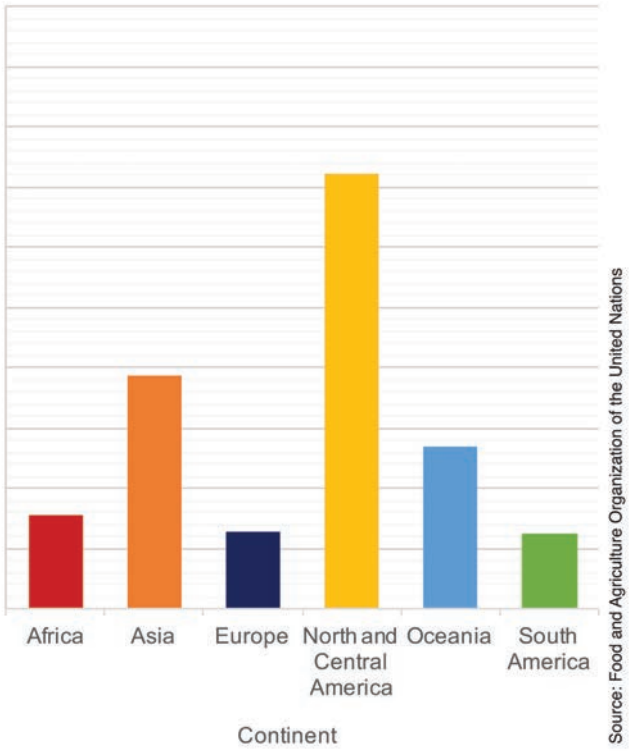


FIGURE 61.
Protection of soil and water and provision of ecosystem services as a percentage of total forest area (of countries that reported on this variable) by continent in 2015.
Illustration by Stephanie Pfeiffer.

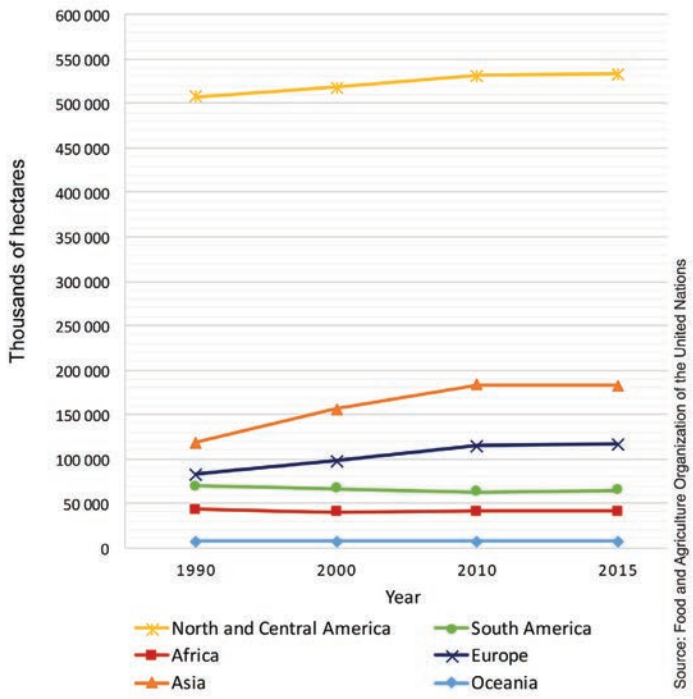
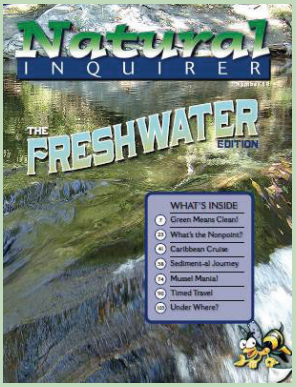


FIGURE 62.
The amount of forest managed for soil and water protection (in thousands of hectares) between 1990 and 2015, by continent.
Note: this graph only includes data from countries that reported on this variable for all Forest Resources Assessment reporting years.
Illustration by Stephanie Pfeiffer.



NATURAL INQUIRER CONNECTIONS

For more information about freshwater, read the *Natural Inquirer* Freshwater edition at http://www.naturalinquirer.org/Freshwater-Natural-Inquirer-i-61.html.

REFLECTION SECTION

What is the source of the freshwater you use?

Explain in your own words how forests build new soil.

Explain how forests protect soil and water.

FIGURE 63.
A woman cooking a meal with woodfuel in the Philippines. Woodfuel may include whole or chopped-up tree trunks and branches, charcoal, wood chips, wood pellets, and sawdust.
Photo courtesy of Food and Agriculture Organization of the United Nations/Noel Celis.

WOOD AND NON-WOOD FOREST BENEFITS

Forests provide a wide variety of benefits. You have just learned about the ecosystem services provided by healthy forests. You may already know about the wood products that forests provide. FAO has noted that "wood is a part of almost everyone's life." The list of wood products used by people includes woodfuel (wood used for cooking fires or for heating), construction material, furniture, paper, pencils, baseball bats, and fence posts (Figures 63, 64, and 65). Look around you and see if you can identify products made from wood.

FIGURE 64.
A chair being made from wood in a U.S. chair factory.
Photo courtesy of Cassy Young.

FIGURE 65.
Wood chips may be used for fuel or as ground cover.
Photo courtesy of Babs McDonald.

Roundwood is used for non-fuel purposes. Roundwood is felled in its natural state, with or without bark (Figure 66). After being **harvested**, roundwood is either left in its round state or is cut into sheets, squares, or other forms. Roundwood may also be crushed into small pieces called pulp, which is then used to make paper products.

Close to 1.2 billion hectares of forest land are managed for wood production worldwide, and the amount of wood removals is increasing (Figure 67). In 2011, about 3 billion cubic meters of wood were removed from forests worldwide (Figure 68).

FIGURE 66.
Roundwood is used to make many wood products for everyday use. Why do you think this type of wood is called roundwood?
Photo courtesy of Babs McDonald.

DID YOU KNOW?

Three billion cubic meters is equal to 30 football (soccer) fields 10 kilometers or about 6 miles high.

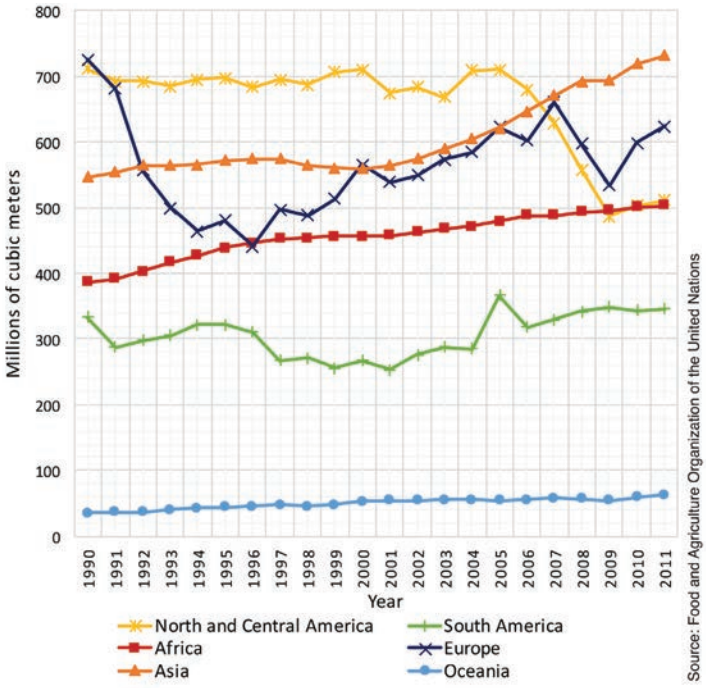


FIGURE 67.
Yearly wood removals by continent from 1990 to 2011 in millions of cubic meters.
Illustration by Stephanie Pfeiffer.

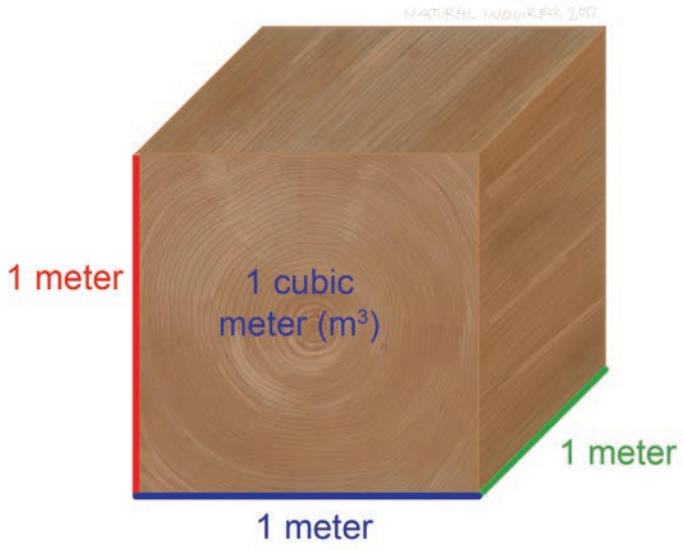


FIGURE 68.
A cubic meter of wood is the amount contained in a cube of wood that is 1 meter long on each side.
Illustration by Stephanie Pfeiffer.

Worldwide, woodfuel is used for about half of total wood removals from forests. Most woodfuel worldwide is removed from forests in countries with lower income levels. In these low-income countries, about 93 percent of wood removals are for woodfuel.

Forests also provide non-wood products that people buy and use. Examples of non-wood products include food and food additives, such as **edible** nuts, mushrooms, fruits, herbs, spices, **aromatic** plants, and game animals (Figure 69).

Other non-wood products include fibers used in construction, furniture, clothing, or utensils. Non-wood products also include resins, gums, and plant and animal products used for **medicinal**, cosmetic, or cultural purposes. Non-wood removals provide a **livelihood** for many people and provide income for industries that use these products (Figure 70). The Republic of Korea, Portugal, the Czech Republic, and Tunisia all reported a high value for their non-wood forest products in 2010 (Figure 71).

DID YOU KNOW?

How can wood products affect human health?

Scientists have recently discovered that oils and **compounds** in the wood of some cedar trees may repel or be **toxic** to mosquitoes, ticks, and fleas. These oils and compounds are a non-wood product that might become important to human health worldwide.

Information from the USDA Forest Service.

FIGURE 69.
Wild mangos are a non-wood forest product.
Photo courtesy of Whitney Cranshaw, Colorado State University, http://www.bugwood.org.

FIGURE 70.
A man sorts pine nuts to sell at a local market in Mongolia.
Photo courtesy of Food and Agriculture Organization of the United Nations/Sean Gallagher.

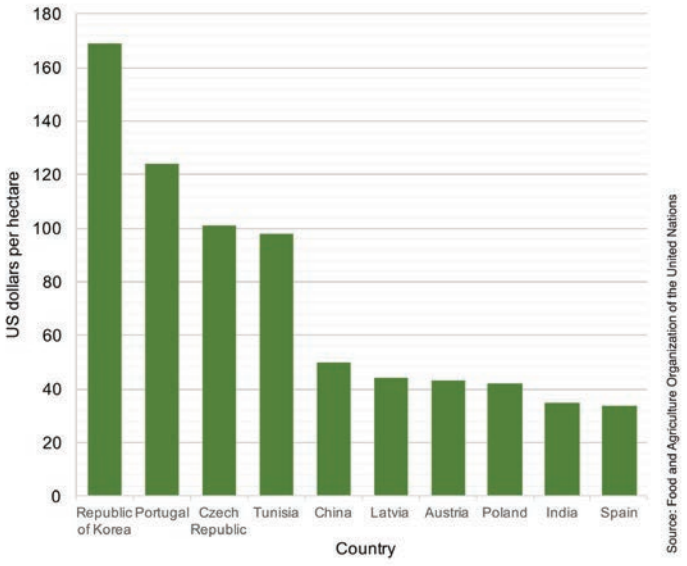


FIGURE 71.
The top 10 countries by reported value of non-wood forest product removals (in United States dollars per hectare) in 2010.
Illustration by Stephanie Pfeiffer.

HOW DO DIFFERENT CULTURES USE NON-WOOD FOREST PRODUCTS?

Hawaiians collect non-wood forest products for traditional and modern cultural uses. For example, they gather forest flowers, vines, and ferns to create garlands or leis for hula dances, parades, and other celebrations (Figure 72).

FIGURE 72.
These Hawaiian temple tree flowers are made into leis, or flower necklaces.
Photo courtesy of Forest and Kim Starr, Starr Environmental, http://www.bugwood.org.

REFLECTION SECTION

What is one advantage of using wood as a material?

How is wood used in your community?

Name two non-wood forest products that you have used in the past 6 months. Were these non-wood products gathered from a nearby forest?

FACTIVITY
PROTECTING WATER QUALITY

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- Three paint roller pans
- Shovel
- ¾ cup liquid kitchen oil, such as canola oil
- 2 gallons (7.5 liters) of water in plastic jugs
- One garden sprinkler can
- Blue or red food coloring

The questions you will answer in this FACTivity are: Which land cover best protects water quality and why?

METHODS

1. Identify an area of thick grass near the edge of a grassy area. Ask an adult if the area you have chosen is a good location. Using the shovel, dig up an area of grass half the size of the paint roller pan, including ½ to 1 inch (1.27 to 2.54 centimeters) of the soil underneath. Brush off the loose soil and place the grass into one of the pans. The roots of the grass should be holding the soil together. Make sure that the area of grass that you remove is away from the main grassy area.
2. Identify an area of bare soil. Bare soil is dirt with little or no vegetation. Dig up a shovelful of bare soil and place it into the second paint roller pan, to about 1 inch (2.54 centimeters) deep. If it is not possible to find the grass or bare soil in your schoolyard, your teacher will bring them to class. Leave the third pan empty. Line up the three pans so that you can easily compare them (Figure 73).

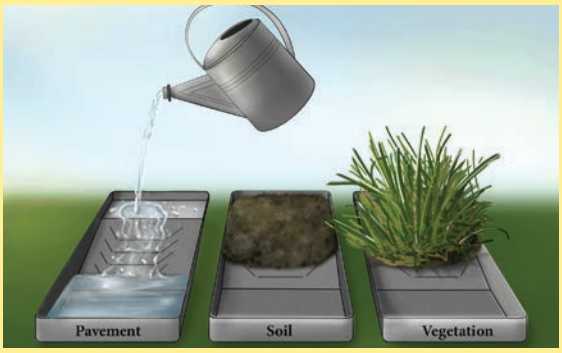


FIGURE 73.
How to set up the paint roller pans.
Illustration by Stephanie Pfeiffer.

3. During your experiment, use the graphic organizer on page 49 to answer the following questions. What do think each of the paint roller pans represents? (Hint: Think about different land covers. Land cover is what covers the land, such as trees, grass, water, concrete, parking lots, and buildings.) What do the water and oil represent? (The answers are given after the graphic organizer.) What do you predict will happen when oil is added and water is poured across each of the pans? Write your prediction in the form of a complete sentence in the graphic organizer.
4. Pour ¼ cup (0.059 liters) of oil over the contents of each pan. Wait 5 minutes.
5. Add food coloring to the water. Mix the water and food coloring together until it makes a bright color. Add the water to the garden sprinkler can. Using the sprinkler can, pour an equal amount of water over each of the three paint roller pans. As the water drains into the bottom of each pan, observe the drained water in each of the pans. What differences do you see between the water in each pan? What has happened to the water in each case? What do you think is the reason for the water's appearance in each of the pans?

In this FACTivity, each paint roller pan represents a different type of land cover that may exist in a watershed. The grass represents a watershed with vegetation, such as grass or forests. The soil represents a watershed with agricultural land. The bare aluminum represents an urban watershed with pavement, such as roads and parking lots. The oil represents pollution from cars, industry, and agriculture. The water represents rain.

Now answer the questions posed at the beginning of this FACTivity: Which land cover best protects water quality and why? Share your answers with your class.

PROTECTING WATER QUALITY GRAPHIC ORGANIZER

Note: Write using complete sentences, proper grammar, and appropriate punctuation.

The grass represents:	
The soil represents:	
The bare aluminum represents:	
Write your predictions about how the water will look after oil is added, and the water drains into each pan.	Bare aluminum: Grass: Soil:
Describe your observations of the water in each pan.	Bare aluminum: Grass: Soil:
Explain why you think the water looks like it does in each pan.	Bare aluminum: Grass: Soil:
How does this experiment relate to the information you learned in this *Natural Inquirer*?	
Based on what you learned, what are your conclusions about forests and water quality?	

ALTERNATE FACTIVITY

TREES AND THE WATER CYCLE

(Adapted from the USDA Natural Resources Conservation Service and Project Learning Tree.)

TIME NEEDED

- 15 minutes in the first day
- 50 minutes the second day

MATERIALS

(for each student or group of students)

- 1 pint (about ½ liter) closable plastic bag (must be able to close tightly)
- Permanent marker or small piece of paper, tape, and a pencil or pen
- Graduated cylinder (1 to 5 milliliters) or other measuring device
- Piece of blank or lined paper and a pencil

In this FACTivity, you will answer the question: How much water is transpired by a tree during daylight hours? Transpiration happens when the water that entered a tree's roots travels up the tree's trunk, through its branches, to its leaves, and out of the leaves through small pores.

METHODS

Day 1

Your teacher will divide the class into pairs of students and will give each pair a plastic bag that can be tightly closed. Write your names on the plastic bag (or use paper and tape to identify the bag as yours). Go outside and select a tree that has leaves or needles that can be easily reached from the ground. You can select the same tree as another pair of students, but you must be able to use a separate branch and leaves.

The bag must be placed on a tree branch the following morning (Day 2) as early as possible in the day. When you place the plastic bag on a branch, seal the bag as tightly as possible around two or three of the leaves (Figure 74).

FIGURE 74.
Place the plastic bag with two to three leaves in it on a tree branch.
Illustration by Nickola Dudley.

Day 2

If possible, allow the plastic bag to stay on the branch for at least 2 hours. Regardless, be sure to note the amount of time each bag is on the tree and, if possible, keep as close to an hourly schedule as possible.

Before removing the bag from the tree, estimate the percentage of the tree's total area of the leaves contained in the plastic bag. To do this, estimate the total number of leaves on the tree. Count the number of leaves on your branch (including the leaves inside of the bag). Then, estimate the number of branches on the tree and multiply the two numbers. Record the estimated total number of leaves. This is difficult and will just be an estimate. Do the best job you can to estimate the number of leaves on the tree.

Count the number of leaves in the bag and divide the estimated total number of leaves by this number. Record the result. Before removing the bag, gently shake it to dislodge water from the leaves' surfaces. Carefully remove the plastic bag from the branch and leaves, keeping the water in the bag after removing it from the tree. Gently wave the bag to move the water into one corner (Figure 75).

FIGURE 75.
Make sure that none of the water is spilled from the plastic bag.
Illustration by Nickola Dudley.

In the classroom, measure the amount of water in each bag by pouring the contents into the graduated cylinder. Calculate how much water was transpired by the tree in 1 hour. For example, if the bag was on the tree for 2 hours, divide the amount of water in half. Then multiply that amount by 10, assuming that there are 10 hours of sunlight during which the tree transpires. Finally calculate how much water the whole tree would transpire during 10 hours of daylight.

For example, say there are 3 leaves in the bag and an estimated 27,000 leaves on the tree. Divide 27,000 by 3 to get 9,000. If the three leaves transpired 1 milliliter in 1 hour, they would transpire 10 milliliters in 10 hours. To estimate how many milliliters the entire tree would transpire in 10 hours, multiply 9,000 X 10 = 90 000 milliliters. Multiply 0.001 X 90 000 milliliters to get an estimated 90 liters transpired by the tree in 1 day. To convert this to gallons, multiply 90 X 0.264 = 23.76 gallons.

Compare your findings with other students' findings. Larger trees should be found to transpire much more water than smaller trees. Are you surprised at how much water is transpired by a tree during daylight hours?

Look at the water cycle illustration (Figure 34 on page 29). How do individual trees contribute to the water cycle?

You can try this experiment overnight to see how much water a tree transpires when sunlight is not available.