Food and Agriculture Organization of the United Nations

CRADLE OF FORESTRY Interpretive Association IN AMERICA

NATURAL INQUIRER

THE WORLD'S FORESTS EDITION – NUMBER 20

USDA

FOREST SERVICE US DEPARTMENT OF AGRICULTURE

WELCOME TO THE THIRD EDITION OF THE WORLD'S FORESTS *NATURAL INQUIRER!*

2019

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This edition of *Natural Inquirer* presents the results of a worldwide effort to understand the world's forests, organized by the Food and Agriculture Organization of the United Nations (FAO). The *Global Forest Resources Assessment 2015 (FRA 2015)*, which contains information from 234 countries and territories around the world, was the source of information in this *Natural Inquirer*. This is the third edition of the World's Forests *Natural Inquirer*.

Visit:

http://www.naturalinquirer.org

http://www.fao.org/forest-resources-assessment

NATURAL INQUIRER

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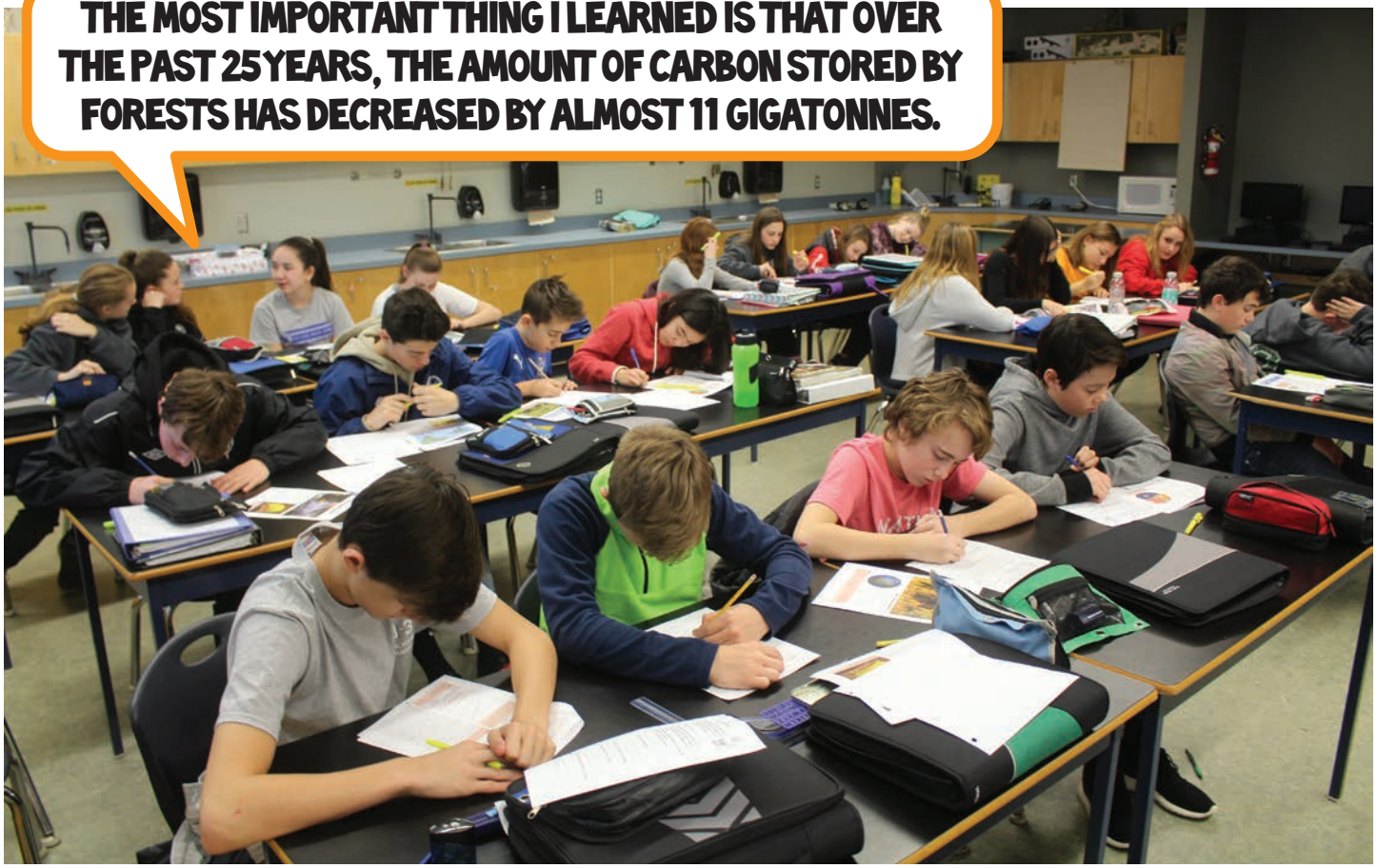
TABLE OF CONTENTS

EDUCATORS! GO FIRST TO THE NOTE TO EDUCATORS ON PAGE 5

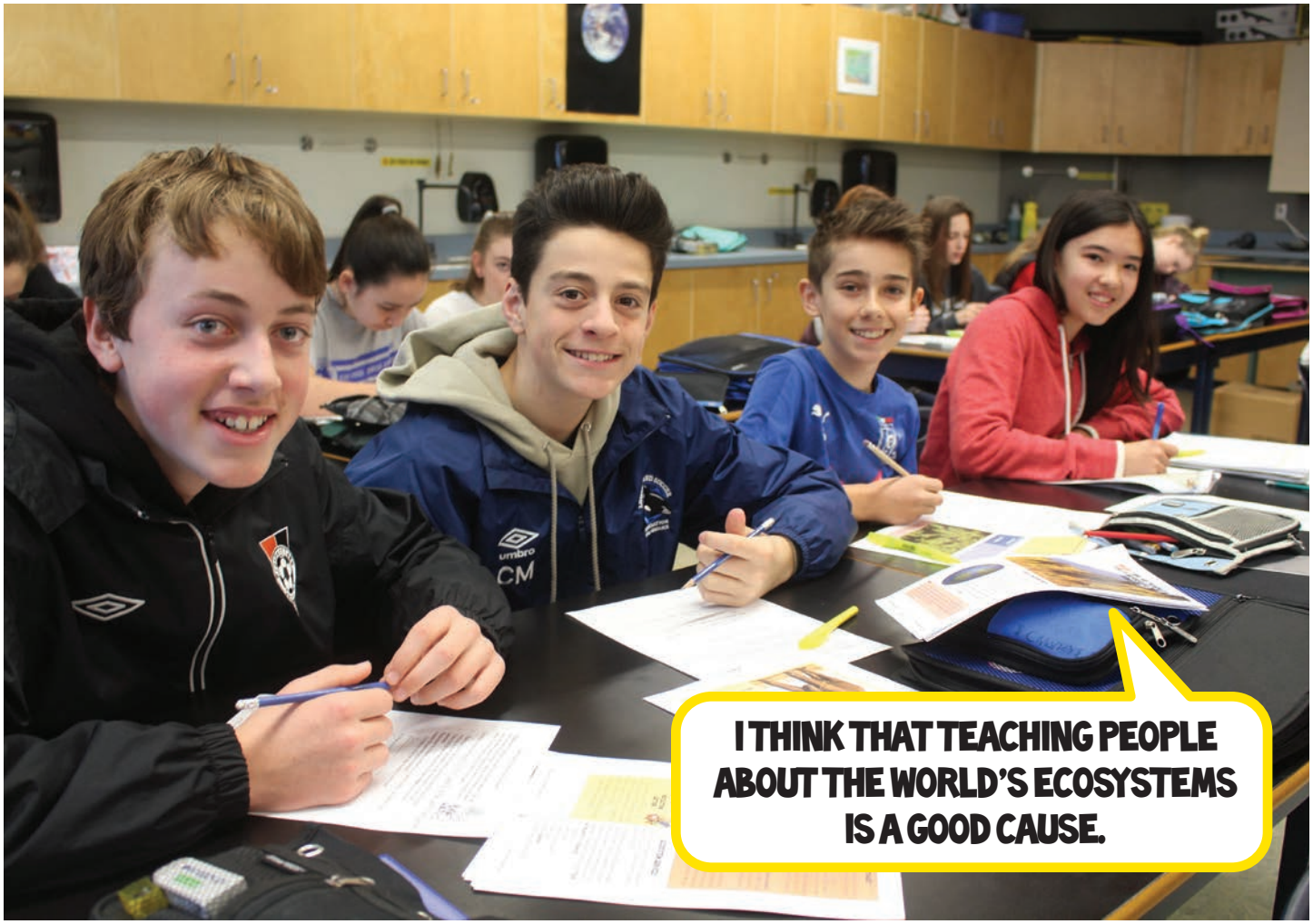
NATURAL INQUIRER EDITORIAL REVIEW BOARD AT WORK!

MR. OMAR AZIM'S 8TH GRADE CLASS, ROYAL OAK MIDDLE SCHOOL, BRITISH COLUMBIA, CANADA




I FULLY UNDERSTOOD THE ARTICLE. I THINK IT WAS WELL WRITTEN FOR OUR AGE. IF I COULD CHANGE ONE THING I WOULD ACTUALLY SAY THAT YOU COULD MAKE THE WRITING MORE SOPHISTICATED.


I WOULD TRY NOT TO REPEAT WORDS OVER AND OVER LIKE WE KNOW IT IS ABOUT FORESTS.


I THINK THAT TEACHING PEOPLE ABOUT THE WORLD'S ECOSYSTEMS IS A GOOD CAUSE.


THE MOST IMPORTANT THING I LEARNED IS HOW MUCH OF THE WORLD'S FORESTS ARE UNDER PROTECTION.
MAYBE FIND A WORD TO USE IN PLACE OF THE WORD "BENEFIT." I NOTICED IT WAS USED QUITE OFTEN.

WELCOME TO THE *NATURAL INQUIRER* WORLD'S FORESTS THIRD EDITION!

EDUCATORS!

READ THE NOTE TO EDUCATORS ON PAGE 9

Have you heard of the United Nations? The United Nations (UN) is an international organization that was established in 1945. Today, nearly every nation in the world belongs to the UN. In total, 193 countries are members of the UN. These nations are working together for peace, human rights, freedom, and social progress.

YOU DO THE MATH

How old is the UN today?

The Food and Agriculture Organization (FAO) is a part of the UN. FAO helps countries improve their agriculture, forestry, and fisheries practices. FAO also helps these countries provide good nutrition for all.

GLOSSARY

The Glossary on page 60 to 61 provides definitions for words in **bold**. If you do not understand a word that is in bold, be sure to use the glossary! If you do not understand any word that is not bolded, be sure to look it up in a dictionary.

Since 1948, FAO has been collecting information about the world's forests. It may seem unusual for an organization concerned with food and agriculture to be studying forests.

Trees, however, are important for human nutrition. Trees have many links to agriculture. They help protect soil and water needed for food crops. People use forests and plant trees for the many benefits trees and forests provide, including food, energy, wood products, medicines, and places for outdoor recreation and spiritual renewal (Figure 1 and Figure 2). Trees also help protect the environment.

FIGURE 1.
Cacao is a tropical tree that produces cacao seeds, or cocoa beans. People use cacao seeds to make cocoa, cocoa butter, and chocolate. Cacao trees are **native** to Central America and South America.
Photo courtesy of David Cappaert http://www.bugwood.org.

FIGURE 2.
Forests provide a place for people of all ages to observe and enjoy nature.
Photo courtesy of Babs McDonald.

YOU DO THE MATH

For how many years has FAO been collecting information about the world's forests?

The more knowledge FAO can collect and share about trees and forests, the more successfully it can help countries like yours grow and manage healthy forests. More information also helps your country take better advantage of forest benefits. These benefits improve the lives of all people. You will learn about the benefits provided by forests in Inquiry 2 on page 28.

Every 5 years, FAO publishes a report about the world's forests. The 2015 report was the source of information in this *Natural Inquirer*. The report contains information about forests in 234 countries and territories—these are the world's forests. No matter where these forests are located, they provide benefits for people and wildlife across our entire planet.

This *Natural Inquirer* presents much of the information by continent. The world has seven continents (Figure 3). These continents are Africa, Antarctica, Asia, Europe, North and Central America, Oceania, and South America. This journal contains information for every continent except Antarctica (Figure 4).

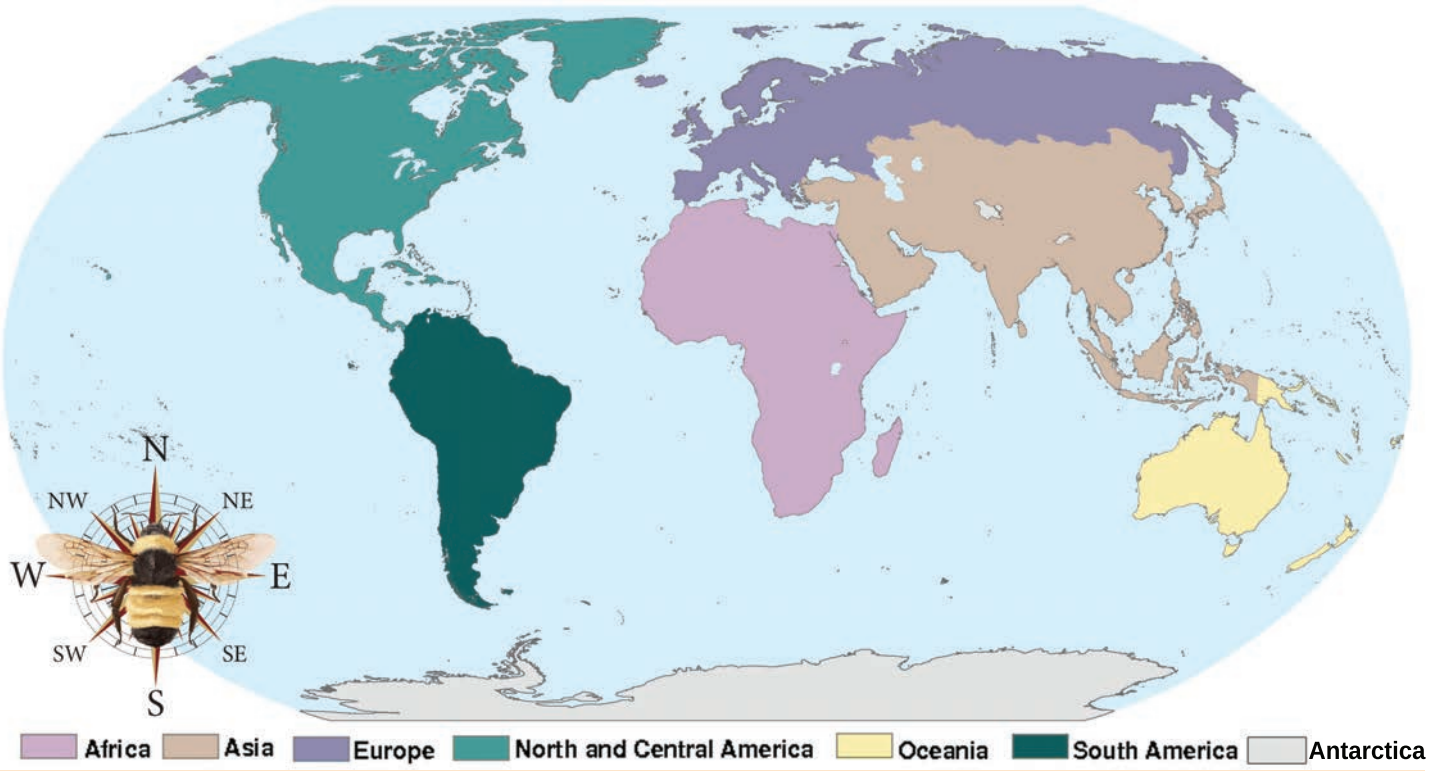


FIGURE 3.
Earth has seven continents and five oceans. This report presents much of the information by continent. Take a moment to identify the continent where you live.
Map courtesy of Food and Agriculture Organization of the United Nations.

FIGURE 4.
Antarctica is one of the world's seven continents. Locate Antarctica on the map in Figure 3. Why do you think the report on the world's forests does not include Antarctica?
Photo courtesy of Chuck Murphy, http://www.boywithcamera.com.

This journal contains three Inquiries. Each Inquiry represents a study done by FAO's team of scientists and country correspondents. Each Inquiry answers questions about the world's forests. After you complete all three Inquiries, you will know some new facts about the world's forests.

Each Inquiry builds on the previous Inquiry. It is best, therefore, to read the Inquiries in the order presented. As you read about FAO's work to collect data about the world's forests, think about the forests you have seen, visited, or read about.

If you want more information, you can see the entire report about the world's forests, *Global Forest Resources Assessment 2015*, second edition, at **http://www.fao.org/3/a-i4793e.pdf**.

THINKING ABOUT THE WORLD'S FORESTS

Forests are important to everyone. Worldwide, people benefit from forests, even if those forests do not exist in their own community. Forests provide materials such as wood for building or for energy. Forests provide food for people and for animals. Forests provide **habitat** for many different kinds of plants and animals, which helps maintain the **diversity** of life on Earth (Figure 5). Forests protect the quality of water and help keep the soil from **eroding**. Forests help keep the air clean and provide places for people to live and play. In many places, forests provide jobs, which help people and their families have better lives. Forests also hold carbon on Earth, which helps slow the rate of climate change. In this journal, you will learn how forests benefit people worldwide.

Forests contain different tree species depending where they are on Earth. Different types of forest exist mainly because they grow under different climates (Figure 6).

FIGURE 5.
Baboons in Botswana, a country in southern Africa. Photo courtesy of Chuck Murphy, **http://www.boywithcamera.com.**

This journal will help you understand the worldwide importance of forests and will inform you on how they are changing. Learning about forest **trends** will help you predict what may happen to our forests in the future.

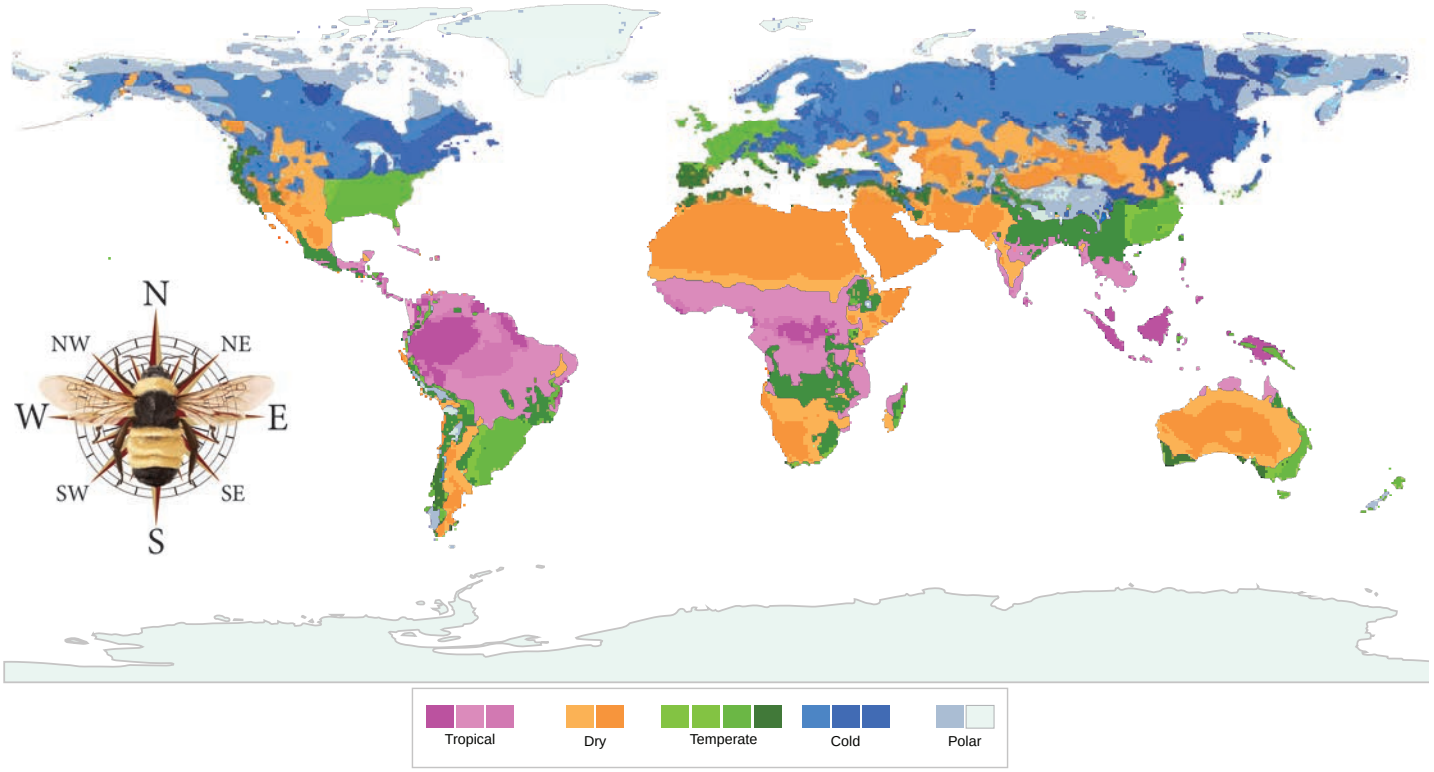
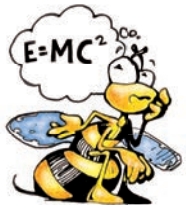


FIGURE 6.
Different climates characterize different places on Earth. An area's climate is identified by the average weather that occurs there over a long period.
Map by Carey Burda and Stephanie Pfeiffer, adapted from the Köppen Climate Classification System.



THINKING ABOUT SCIENCE

When scientists want to learn something, they must collect data. Although you might not realize it, you do the same thing when you want to learn something. When scientists collect data in the form of numbers, they can add, subtract, multiply, and divide the numbers. They can also calculate new numbers, such as **averages**. Numbers help scientists compare information collected from different places or times. However, if scientists collect numbers at different places or times, they must collect the numbers using the same **unit of measurement**. Otherwise, the calculations will be meaningless, like comparing apples and oranges.

Let's say, for example, that a scientist wants to calculate an average air temperature for one month across the entire Southern Hemisphere (Figure 7). Some measurements and records of air temperatures are in degrees Celsius and some are in degrees Fahrenheit. Would averaging those measurements allow the scientist to come up with a meaningful conclusion? Of course not! The scientist would have to change each number to the same unit of measurement. All air temperatures would have to be in Celsius or in Fahrenheit. Only then could the scientist calculate an average air temperature.

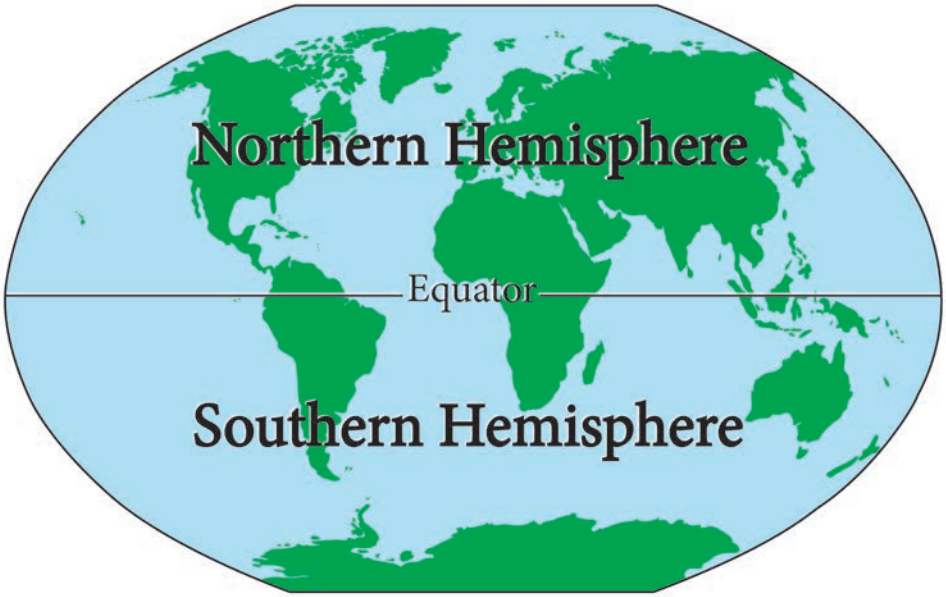


FIGURE 7.
The Southern Hemisphere is the area on Earth's surface that lies south of the **Equator**.
Illustration by Stephanie Pfeiffer.

This same scientist has found that some countries reported a daily air temperature using the highest temperature measured over a 24-hour period each day. Other countries used an average temperature calculated over a 24-hour period. Would averaging these measurements provide a meaningful conclusion? Again, the answer is no. For scientists to be able to combine numbers, the numbers must represent the same thing. Otherwise, their calculations are meaningless.

The scientists in this study wanted to learn about forests across our planet. To collect, analyze, and share this information, FAO worked with individuals from 155 countries, called **correspondents** (Figure 8).

FIGURE 8.
Correspondents from each country helped the Food and Agriculture Organization of the United Nations (FAO) collect information about their country's forests. The correspondents gave their country's data to FAO. They worked with FAO to make sure the numbers they provided represented the same thing. This allowed the scientists to combine the numbers from different countries.
Photo courtesy of Chiang Mai, Royal Forest Department of Thailand, and Food and Agriculture Organization of the United Nations.

INQUIRY 1: WHAT ARE THE WORLD'S FORESTS AND WHERE ARE THEY FOUND?

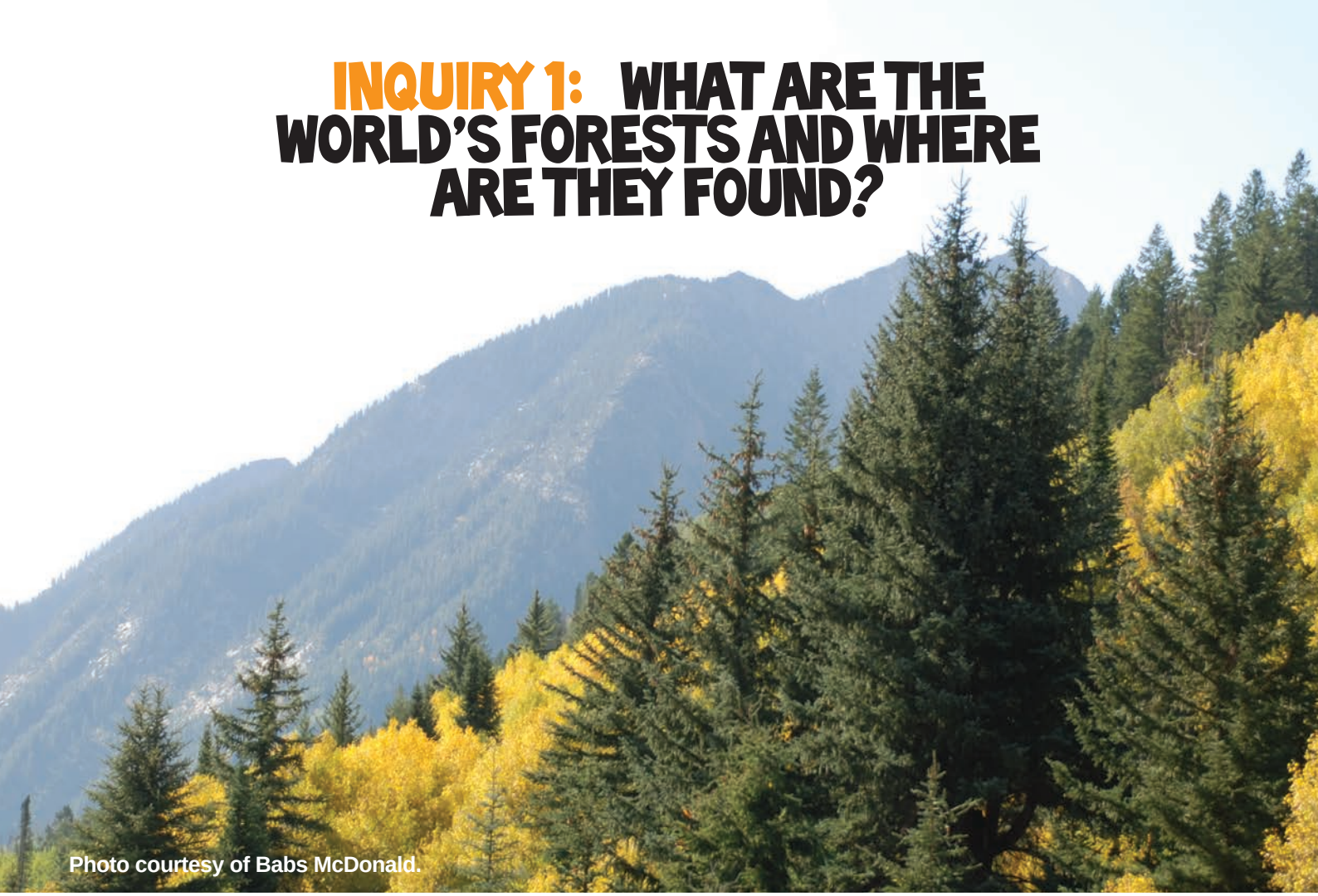
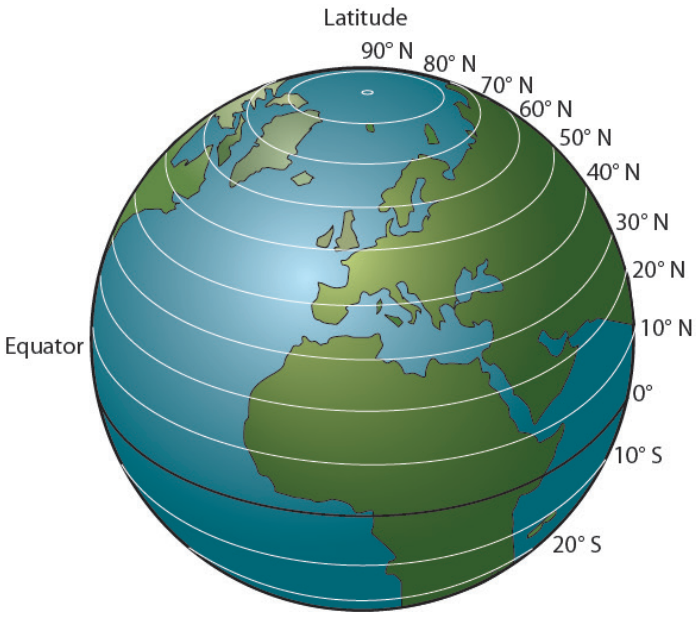


Photo courtesy of Babs McDonald.



EARTH'S CLIMATES AND FORESTS

Before we learn more about the world's forests, let's think about the place on which these forests grow. What do we call this place?

If you guessed Earth, you are correct! We know that Earth spins on its **axis** and revolves around the Sun. The area near the Equator is closest to the Sun. Earth is warmest near the Equator and coolest near the North Pole and the South Pole. The distance from the Equator, along with other factors, influence what kind of forests grow in particular areas on Earth (Figure 9).

FIGURE 9.
An imaginary circle around the middle of Earth at an equal distance from the North Pole and the South Pole, the Equator is given a label of 0 degrees. Imaginary lines, called lines of latitude, are placed around Earth's surface from the Equator toward the poles. Lines of latitude represent the distance from the Equator. The poles are labeled 90 degrees. Each latitude line is spaced equally apart, and each is labeled according to its position north and south of the Equator. Lines of latitude enable people to identify precise locations on Earth's surface, north and south of the Equator.
Illustration by Samantha Bond.

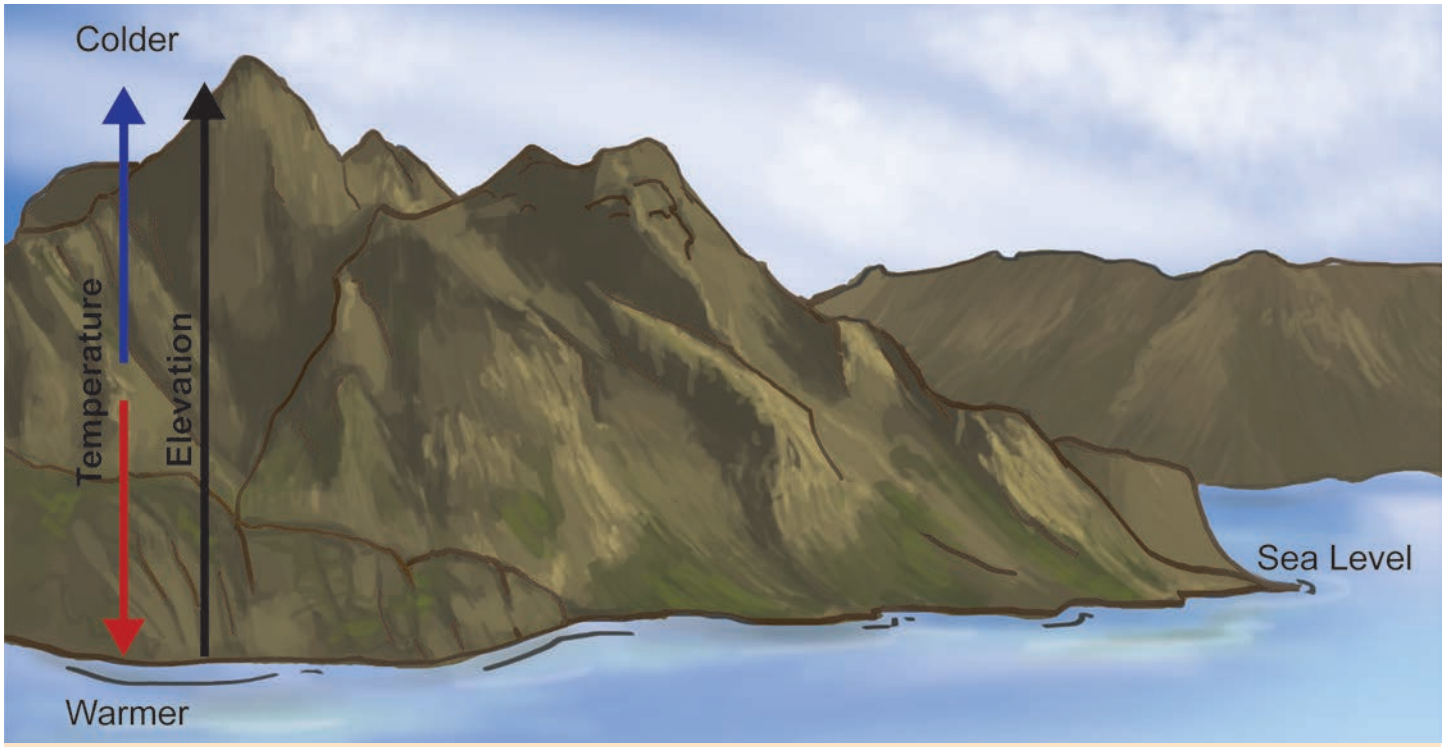


FIGURE 10.
The higher the land's elevation, the cooler its climate.
Illustration by Stephanie Pfeiffer.

At higher elevations, the climate is cooler (Figure 10). The top level of any ocean is called sea level. The height of the land above sea level is called its elevation.

Across Earth, different areas receive different amounts of precipitation. Plants need water to survive and have adapted over time to live with varying amounts of precipitation. Some plants, such as those in tropical rain forests, need a lot of water to survive. Other plants, like those in deserts, have adapted to **conserve** the water they receive. Therefore, they need much less water. Drier areas have fewer plants and trees. Some areas have no plants or trees at all.

The three things that we have just explored are latitude, elevation, and precipitation. These three things influence the type of forest that grows naturally in a particular area on Earth (Figure 11).

Different types of forests are found across the planet. In one area, a forest may be dry with little vegetation. In another, a forest may contain large trees that grow quickly because of high precipitation and fertile soil. Different types of forests exist because they grow under different climates. These different climates result in different ecological zones, or ecozones (Figure 12). Another reason different types of forests exist is that human activities have changed some of the forests. These activities include actions such as felling or planting trees.

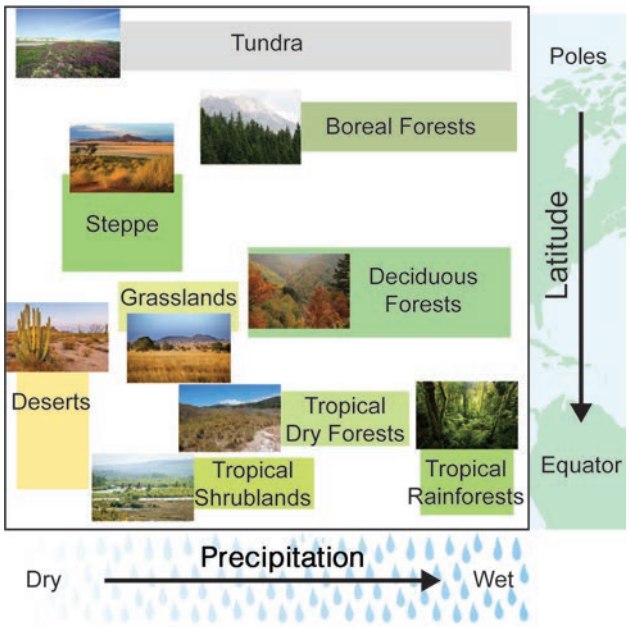


FIGURE 11.
Vegetation types, including tree species, vary with latitude, and precipitation.
Illustration by Stephanie Pfeiffer.

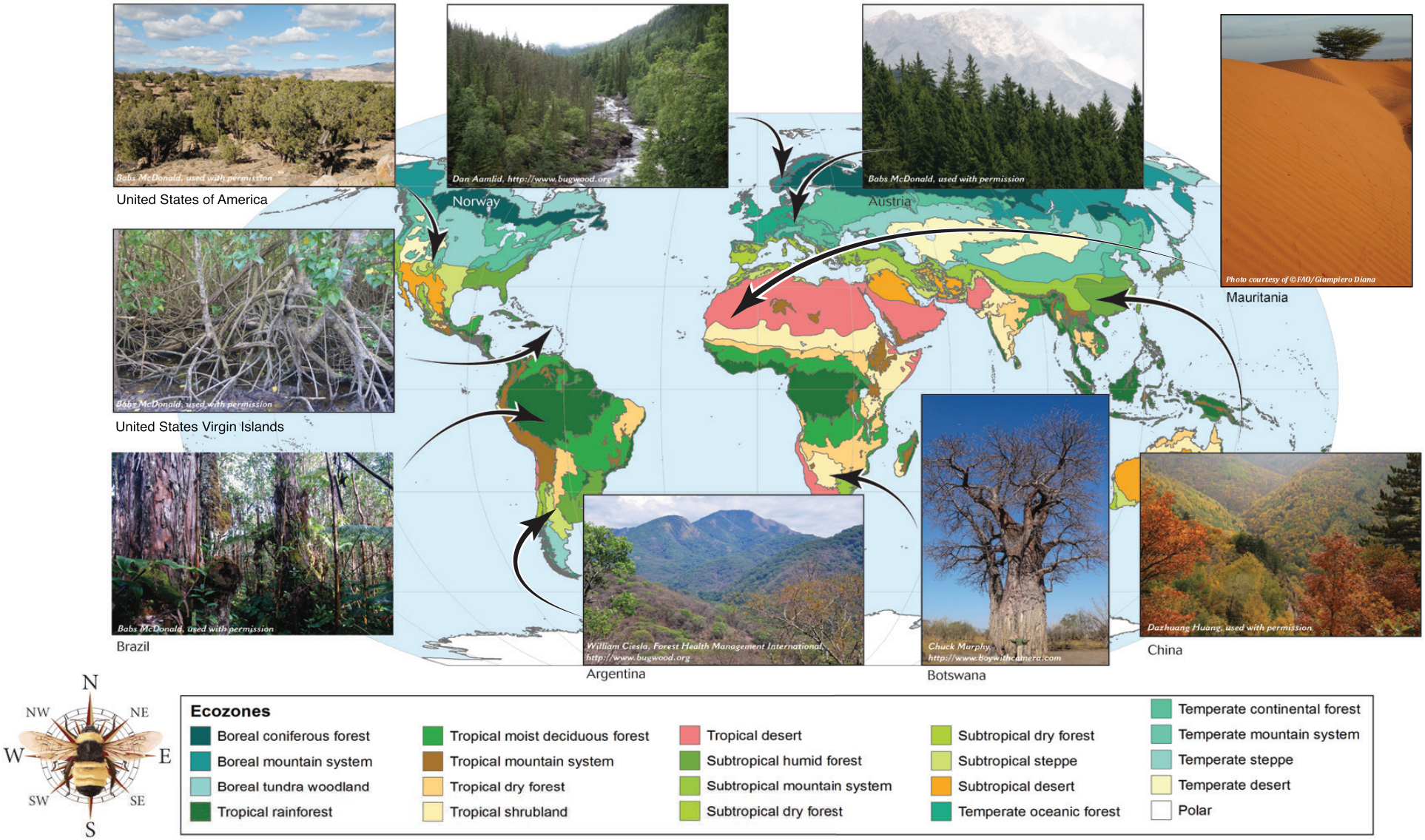


FIGURE 12.
An ecozone is a region with a similar type of land cover. Land cover is what covers Earth's surface, such as trees, desert, or even buildings. In this map, the ecozones describe what kind of vegetation, or plants, grow on Earth's surface. Notice that similar ecozones occur on different continents. Compare this map of the world's ecozones with the map of the world's climate regions on page 13. What do you observe? What are some of the similarities and differences in forests growing in different ecozones?
Map by Stephanie Pfeiffer, adapted from the Global Ecological Zones by Food and Agriculture Organization of the United Nations.

REFLECTION SECTION

Observe Figure 9 and 10. Do you think that a location at sea level and at the same latitude north and south of the Equator would have a similar average air temperature? Why or why not?

Observe the photographs in Figure 12. What is one advantage of having a diversity of forest types across the planet?

THE WORLD'S CHANGING FORESTS

Natural events can change Earth's forests. For example, forests may change as a result of hurricanes and typhoons. Earth's forests are also being changed by something else. It was this influence that FAO was most interested in understanding. What influence did the scientists want to understand?

If you guessed humans, you are correct! FAO wanted to understand how forests are changing as a result of human activity. To study the influence of humans on forests, the scientists classified the world's forests into two categories (Table 1).

TABLE 1. FAO has identified two major categories of forests worldwide: natural forests and planted forests.

NATURAL FORESTS	Natural forests maintain native tree species and support natural **ecological** processes (Figure 13 and Figure 14).
PLANTED FORESTS	Forests are planted for many reasons, such as for timber, fuelwood, or soil and water protection. Planted forests provide goods and services and reduce pressure on natural forests (Figure 15A and Figure 15B).

FIGURE 13.
Mongolian oak is a tree species native to Japan, southern Kuril Islands, Sakhalin, Manchuria, and central and northern China, Korean Peninsula, eastern Mongolia, and eastern Russia (Siberia). Mongolian oak trees are a part of natural forests in Asia.
Photo courtesy of Troy Kimoto, Canadian Food Inspection Agency, www.bugwood.org.

FIGURE 14.
This forest in the Democratic Republic of the Congo is composed of native trees that are regenerating naturally, without any human involvement. This is a natural forest.
Photo courtesy of ©Food and Agriculture Organization of the United Nations/Giulio Napolitano.

FIGURE 15A.
These Scots pine trees were planted in rows. This is a planted forest.
Photo courtesy of William M. Ciesla, Forest Health International, http://www.bugwood.org.

FIGURE 15B.
This forest was planted in Scotland to look and function like a natural forest. Sometimes it can be difficult to tell the difference between a natural and a planted forest.
Photo courtesy of Babs McDonald.

Combining the natural and planted forest categories, the world's forests cover a little less than 4 billion hectares (Figure 16 and Figure 17). This is about 31 percent of Earth's land surface. Of these forested hectares, 54 percent are in the following countries: Brazil, Canada, China, the Russian Federation, and the United States of America. Most of the world's forests are in natural forest area (Figure 18 and Figure 19).

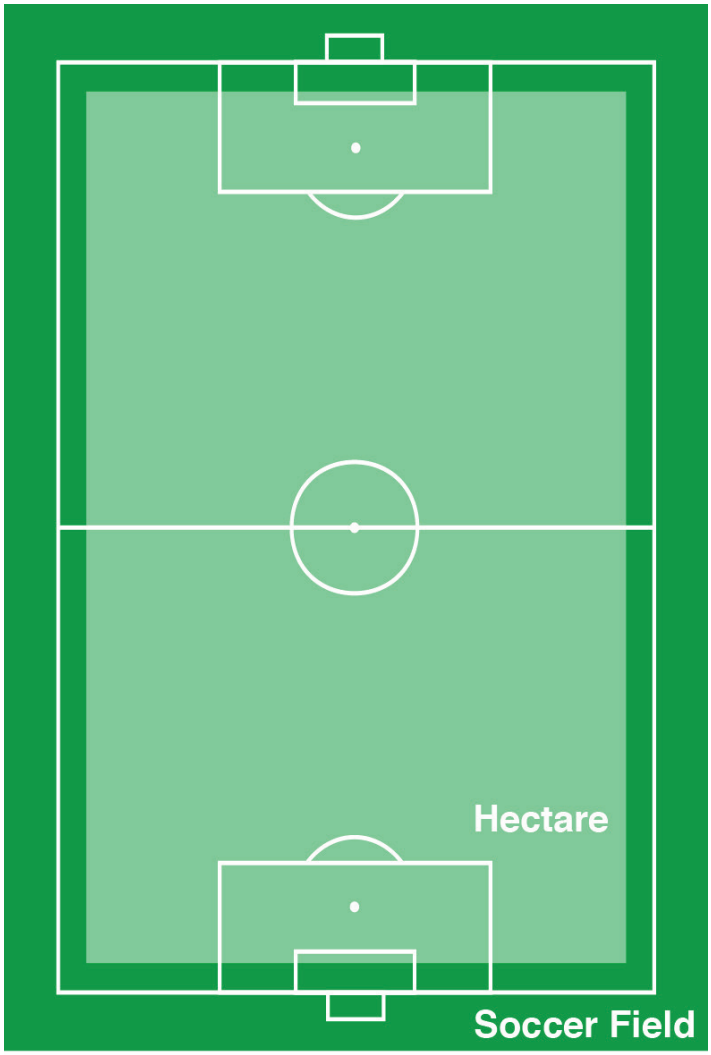
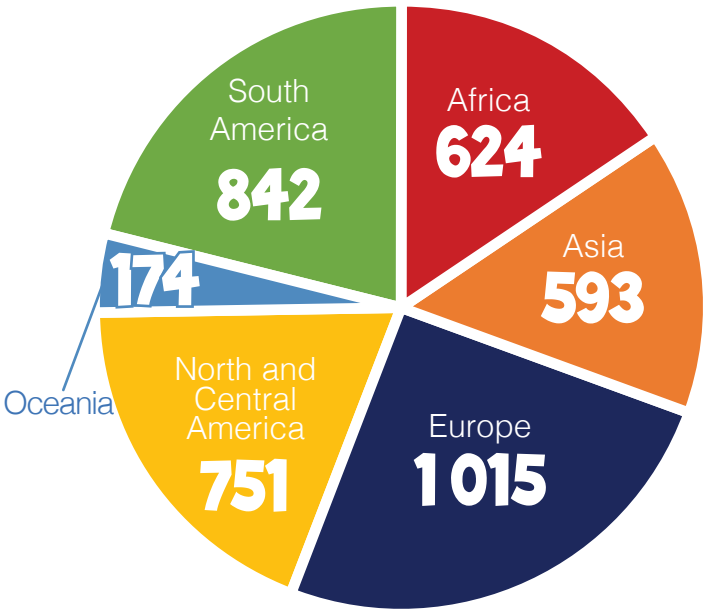
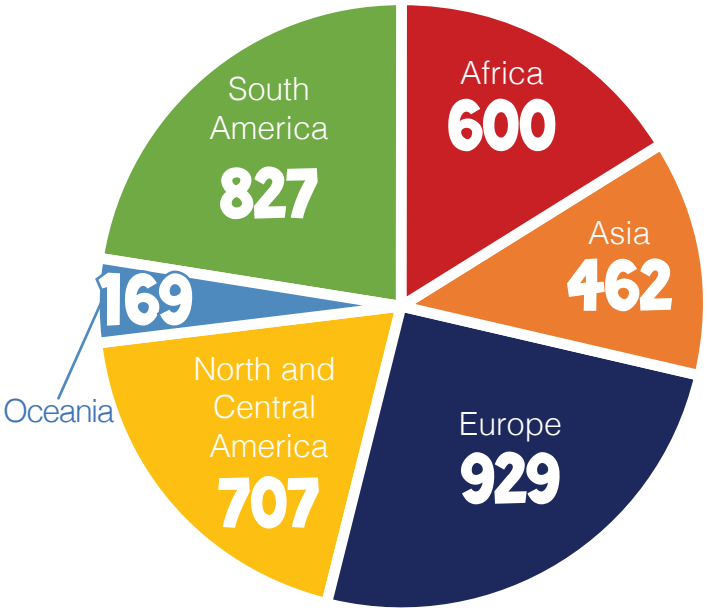


FIGURE 16.
A hectare is about the size of a football (soccer) field. One hectare is equal to 2.471 acres.
Illustration by Stephanie Pfeiffer.



Source: Food and Agriculture Organization of the United Nations

FIGURE 17.
The amount of forest area (in millions of hectares) by continent in 2015. When reading a table or chart that is labeled "in millions of hectares," add six zeros to the given number. For example, Africa includes 624 000 000 hectares of forest.
Illustration by Stephanie Pfeiffer.



Source: Food and Agriculture Organization of the United Nations

FIGURE 18.
The amount of natural forest area (in millions of hectares) by continent in 2015.
Illustration by Stephanie Pfeiffer.

HOW MUCH IS A MILLION?

If you counted from 1 to 1 million, you would have to count for 23 days without stopping!

https://youtu.be/MKkK87E46I4

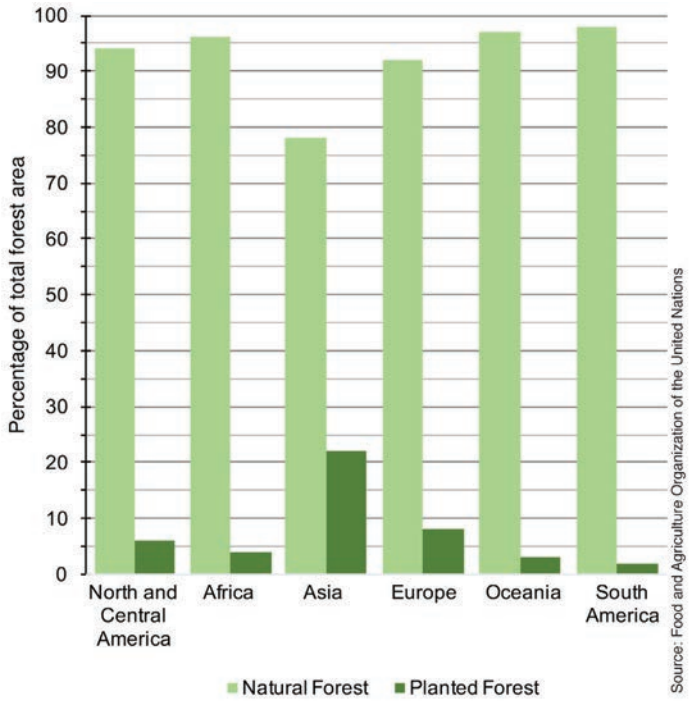


FIGURE 19.
The percentage of total forest area (TFA) in natural forest and planted forest by continent in 2015. For example, 97 percent of Africa's forested area is in natural forest.
Illustration by Stephanie Pfeiffer.

In the past 25 years worldwide, the amount of area that makes up the world's forests has slightly declined (Figure 20 and Figure 21). Even though the amount of forest has decreased, the rate of forest loss has been reduced by over 50 percent. Between the periods 1990-2000 and 2010-2015, the annual loss went from 7.3 million hectares per year to 3.3 million hectares per year.

In 1990, the world's forests covered 4128 million hectares. By 2015, 129 million hectares of forest land had been lost. This is a change from 31.6 percent of the world's land area in 1990 to 30.6 percent in 2015. This loss is equal to an area about the size of South Africa. Most forest area was lost in the tropical ecozone, and most of this loss was in South America and Africa (Figure 22).

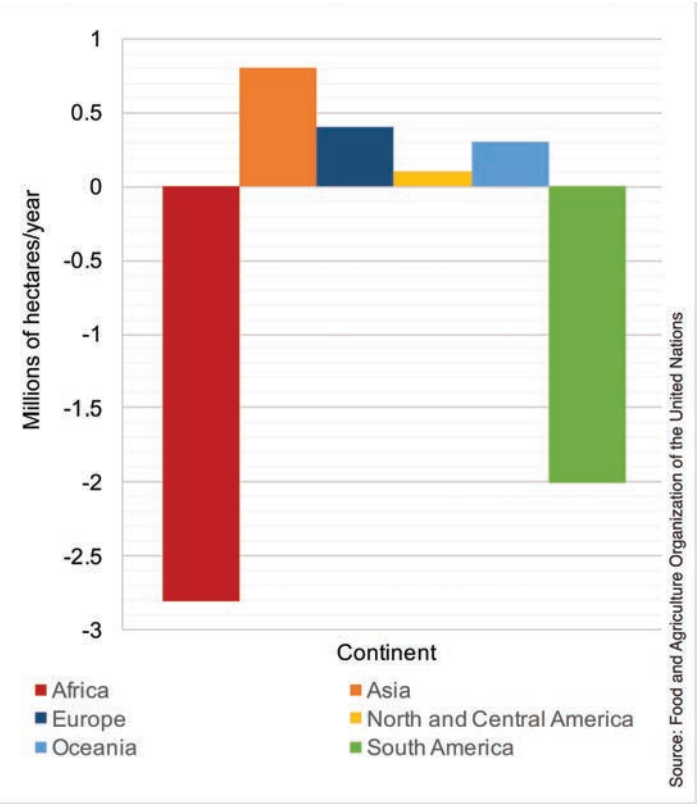


FIGURE 20.
Net annual forest change by continent between 2010 and 2015. This chart shows, for example, that Africa lost an average of 2.8 million hectares of forest area every year between 2010 and 2015.
Illustration by Stephanie Pfeiffer.

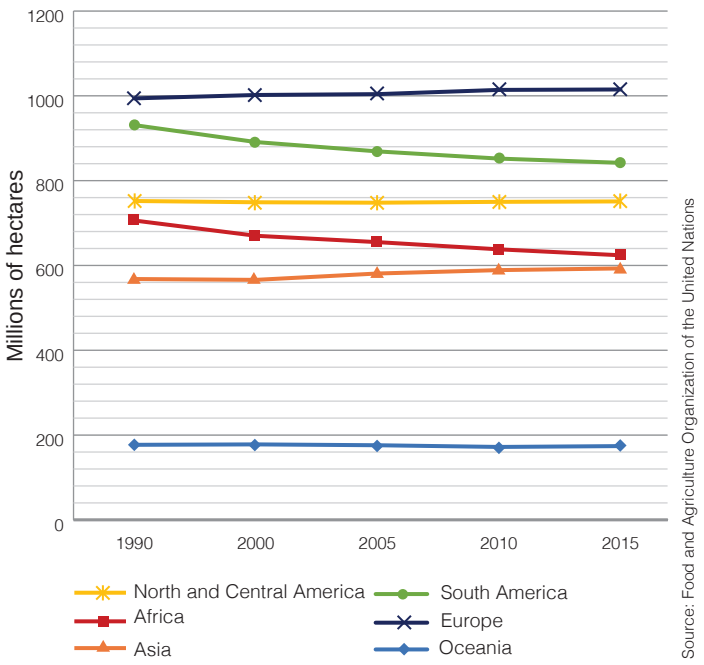


FIGURE 21.
Forest area by continent (in millions of hectares) between 1990 and 2015.
Illustration by Stephanie Pfeiffer.

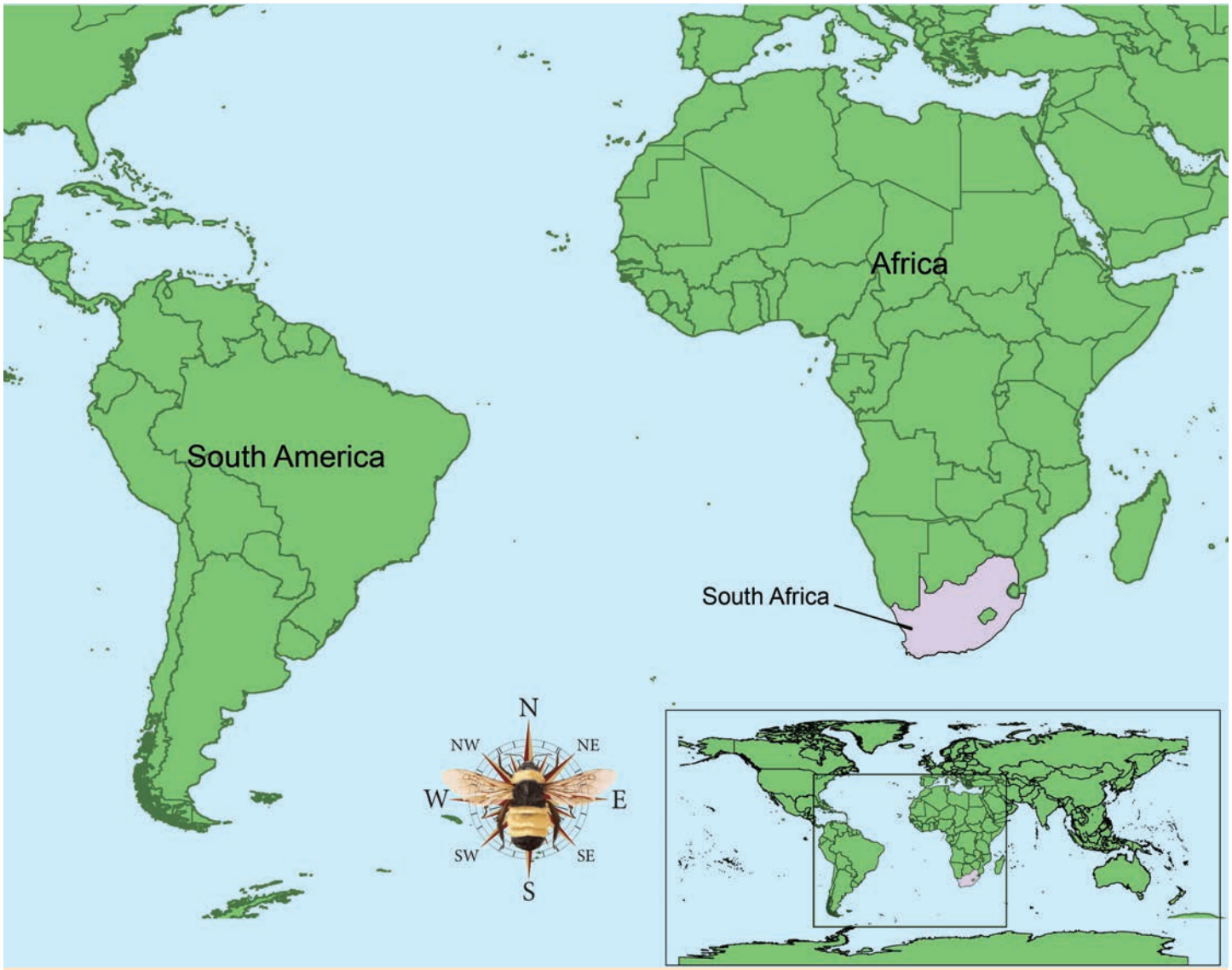


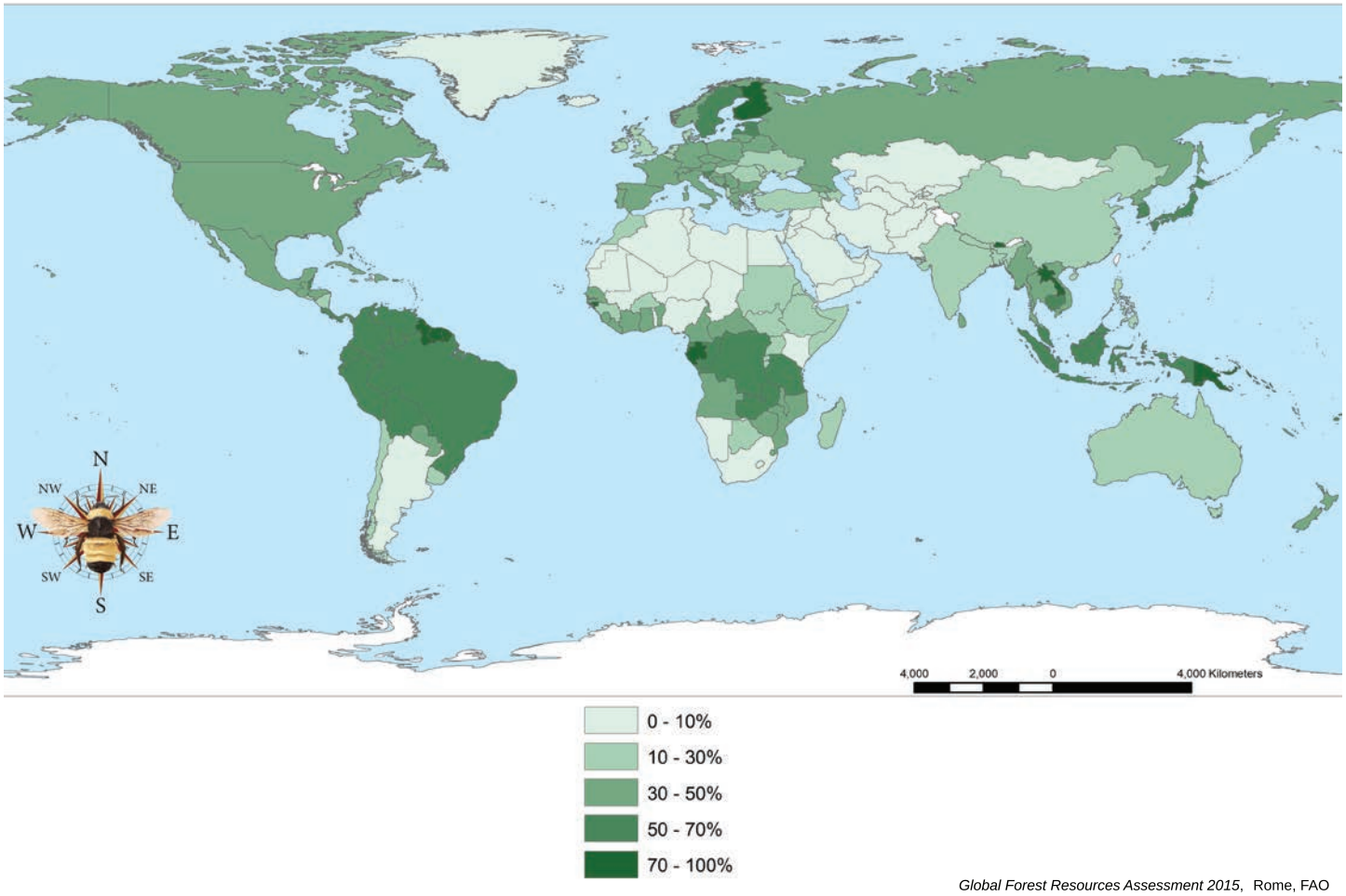
FIGURE 22.
The planet lost an area of forest about the size of South Africa over the past 25 years. Most of this loss occurred in South America and Africa. Africa is a continent, and South Africa is a country located on the African continent. Map by Carey Burda and Stephanie Pfeiffer.

HOW MUCH IS A BILLION?

If you counted from 1 to 1 billion, you would have to count for 95 years without stopping!

https://youtu.be/MKkK87E46I4

The percentage of forest area in each country varies (Figure 23). For countries that have a small percentage of their total area in forests, forest loss might be more noticeable.



Global Forest Resources Assessment 2015, Rome, FAO

FIGURE 23.
Forest area as a percentage of total land area in each country in 2015.
Map courtesy of Food and Agriculture Organization of the United Nations.

FIGURE 24.
Some forests are lost when trees are felled to plant food crops.
Photo courtesy of Alton Sparks, University of Georgia, http://www.bugwood.org.

Natural forests decrease when forests are lost to other land uses. For example, trees may be felled to plant food crops or to build roads and buildings (Figure 24). Constructing roads and buildings is not the only way that trees and forests are lost. Trees and forests can also be lost to insects and other threats, such as **invasive fungi**, forest fires, or hurricanes and typhoons.

Between 1990 and 2015, most of the world's natural forest area loss took place in the tropical ecozones (see Figure 12). In the **temperate** ecozones, natural forest area has been increasing since 1990. The boreal and subtropical ecozones have had little change in forest area over the same 25 years.

FAO is interested in how the amount of natural and planted forests on our planet has changed. Recall that natural forests are forests with native tree species and little evidence of human activities. FAO discovered that natural forests have been declining in area, and planted forests have increased in area (Figure 25 and Figure 26). Planted forest area increased 105 million hectares between 1990 and 2015, about 4.2 million hectares per year.

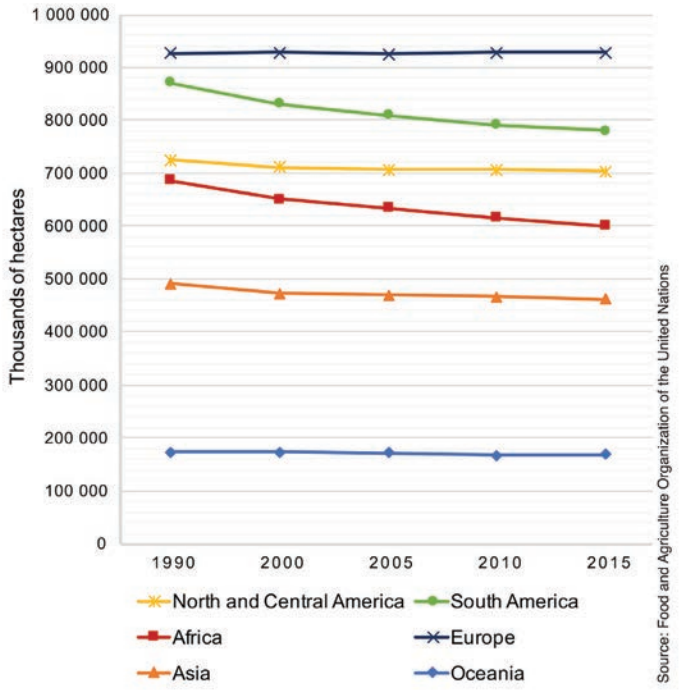


FIGURE 25.
The area of natural forests (in thousands of hectares) has declined slightly since 1990. The largest area of natural forest is found in Europe. About 85 percent of European natural forest is located in the Russian Federation.
Illustration by Stephanie Pfeiffer.

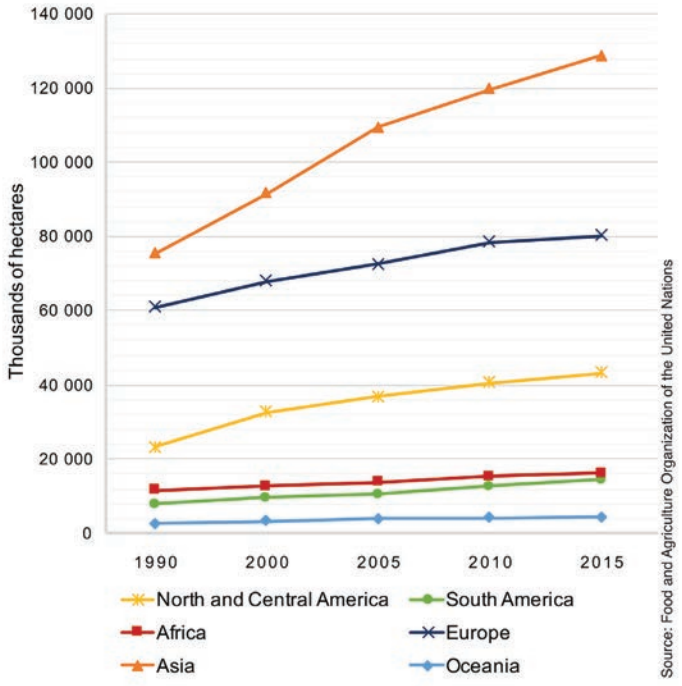


FIGURE 26.
The area of planted forest (in thousands of hectares) has increased on each continent between 1990 and 2015.
Illustration by Stephanie Pfeiffer.

Planted forests made up 7 percent of the world's forests in 2015. FAO scientists expect that planted forests will increase in area, particularly in the boreal ecozone (see Figure 12).

Another way scientists understand the amount of forest land in an area is to compare it with the number of people living in the area. This can be done within a community, a country, a continent, or across our planet. The calculated figure is called per capita, meaning the amount of something per person. Consider the 25 years between 1990 and 2015. During that time, the world's **population** increased by 2.1 billion people, and over 100 million hectares of forest land were lost. The amount of forest land per person, therefore, has decreased over the past 25 years (Figure 27).

Although the world's natural forest area has declined in area over the past 25 years, 93 percent of the world's forests are still natural. Regardless of whether a forest has grown naturally or has been planted, people worldwide gain important benefits from their forests.

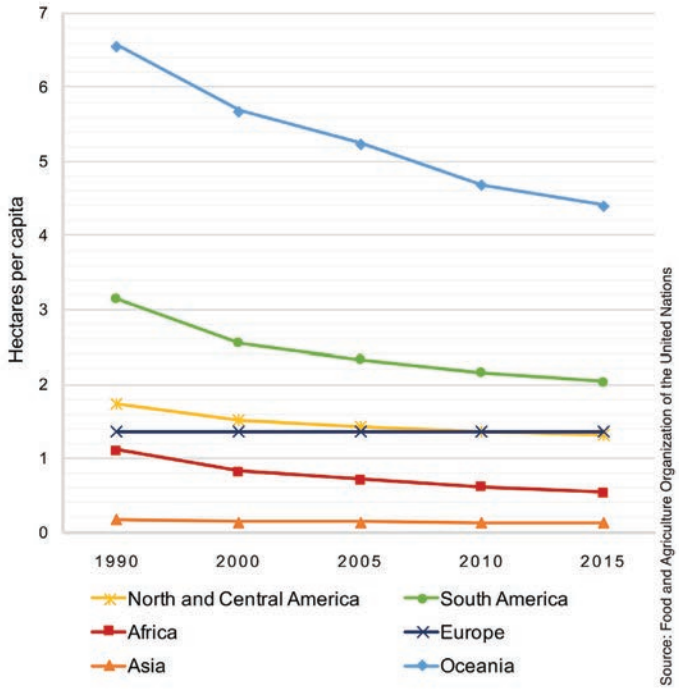


FIGURE 27.
Worldwide, the amount of forested hectares per capita has declined over the past 25 years.
Illustration by Stephanie Pfeiffer.

FIGURE 28.
Urban forests include individual trees planted along streets, such as this urban forest in China (A). Urban forests can also be found in urban parks. Individual trees or groups of trees provide beauty and shade, as well as other benefits to urban residents. This is Central Park in New York City (B).
Photos courtesy of Dazhuang Huang and Babs McDonald.

URBAN FORESTS

FAO has classified the world's forests into two categories: natural forests and planted forests. If you live in an urban area, however, you might have a third kind of forest nearby. The trees in this forest may have **germinated** and grown without human assistance, or the trees may have been planted. Usually, the trees in this kind of forest are surrounded by grass and other **landscaped** areas or even roads and buildings. According to FAO, these forests may include individual trees or groups of trees. This kind of forest is called an urban forest, and it is often found as a part of urban parks (Figure 28).

Urban forests provide many of the same benefits as natural forests. Some urban forests, for example, are found along rivers and provide a place for rivers to flood during high rainfall. Urban forests and parks provide beautiful places for people to walk, play, picnic, and rest. Urban forests also provide homes for wildlife, reduce **erosion** into urban waterways, and help keep urban areas cooler in hot weather.

DID YOU KNOW?

In 1950, less than 30 percent of the world's population lived in urban areas. In 2008, this percentage reached 50 percent; and in 2014, 54 percent of the world's population lived in urban areas. Sixty-six percent, or two-thirds of the world's population, are predicted to live in urban areas by 2050.

Information from the Population Reference Bureau, 2008 World Population Data Sheet, and the United Nations.

REFLECTION SECTION

Has an area of forest been felled in or near your community? If so, what was this forest replaced with?

Describe in your own words the difference between a natural forest and a planted forest.

FACTIVITY
LEAF RUBBINGS

TIME NEEDED

30–40 minutes

MATERIALS

(for each student or group of students)

- A hard surface, such as a table or desk
- A plain white piece of paper
- Crayons, colored pencils, or regular pencil
- A leaf (can be from a tree or off the ground)
- Tape (optional)

METHODS

1. Go outside and find a leaf (or more than one leaf). Observe the leaf's size, texture, and features. Do you know what kind of leaf it is? Notice that the two sides of a leaf are different. On one side, the veins are much more noticeable.
2. Place the leaf on the hard surface. The side with the more noticeable veins should be facing up.
3. Place the white sheet of paper over the leaf. You can tape the leaf on the hard surface to keep it from moving.
4. Using the side of the crayon or pencil, rub over the leaf. As you rub, you will see the leaf's features appear on the white paper. You can use different colors and different amounts of pressure to create your leaf picture.
5. If you know or can identify what kind of leaf you have drawn, write its name on the paper and post your leaf picture on the wall. Compare and contrast different leaf sizes, shapes, and vein patterns.

ALTERNATE FACTIVITY
MEASURING PRECIPITATION

TIME NEEDED

One month. Initial setup should take one or two class periods, then a few minutes each day to monitor and record information.

MATERIALS

(for each student or group of students)

- Five rain gauges or the materials to make rain gauges
- Paper for a logbook or science notebook

Rain gauge materials

- Five 2-liter plastic bottles
- Tool to cut off the tops of plastic bottles
- Duct tape
- Ruler
- Permanent marker
- Stones/pebbles
- Water

The question you will answer in this FACTivity is: How much precipitation falls over a month's time at my school or where I live?

Continued next page >

METHODS

1. Find five rain gauges. If you do not have rain gauges, you can make them using by following steps 2-6.
2. Get a 2-liter plastic bottle and have an adult cut off the top of the bottle. Keep the top. Place duct tape around the area that was cut so that any sharp edges are covered.
3. Place pebbles or stones in the bottom of the bottle. These stones will help keep the bottle upright if it is windy outside.
4. On the bottom part of the bottle, use a ruler to make a scale of horizontal lines. Start marking the lines from 2 inches (5.08 centimeters) above the bottom to 2 inches (5.08 centimeters) from the top. The lines should be separated by ½ inch (1.27 centimeters).
5. Fill the bottom with water to the first line on your scale.
6. Next, place the cut-off top upside down into the bottle. The upside-down top creates a funnel. Your rain gauge is ready (Figure 29).
7. Number your rain gauges from 1 to 5. Take two rain gauges and place them in flat areas away from buildings or trees. Take the other three rain gauges and place them in flat areas underneath trees and near buildings.
8. Create a logbook so that you can keep track of the precipitation over an entire month. Make a separate page for each rain gauge, and write the number of the gauge as well as a brief description of the area in which the rain gauge is located. Be sure to write a date on each entry.
9. Each day, check the rain gauges to see whether water has evaporated from them. If water has evaporated, then fill the gauge with water again to the first line. After it has rained and you have taken your measurement, empty the rain gauge and fill again to the first line. Make a note in your logbook every time you have to fill up the water to the first line.
10. After a month, examine the data you have collected. Create a graph for each rain gauge and the amount of precipitation.

As a class, discuss what you learned when you examined the data. Here are some questions to get you started.

- Were there really wet times and really dry times? Did you see the same things with each of the rain gauges?
- How did different rain gauges compare?
- Did all the gauges get the same amount of precipitation? If not, why do you think the amounts may have been different?
- Did you have to fill some rain gauges with water more often than others? If so, why do you think that is?

FIGURE 29.
How to make your own rain gauge.
Illustration by Stephanie Pfeiffer.

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).

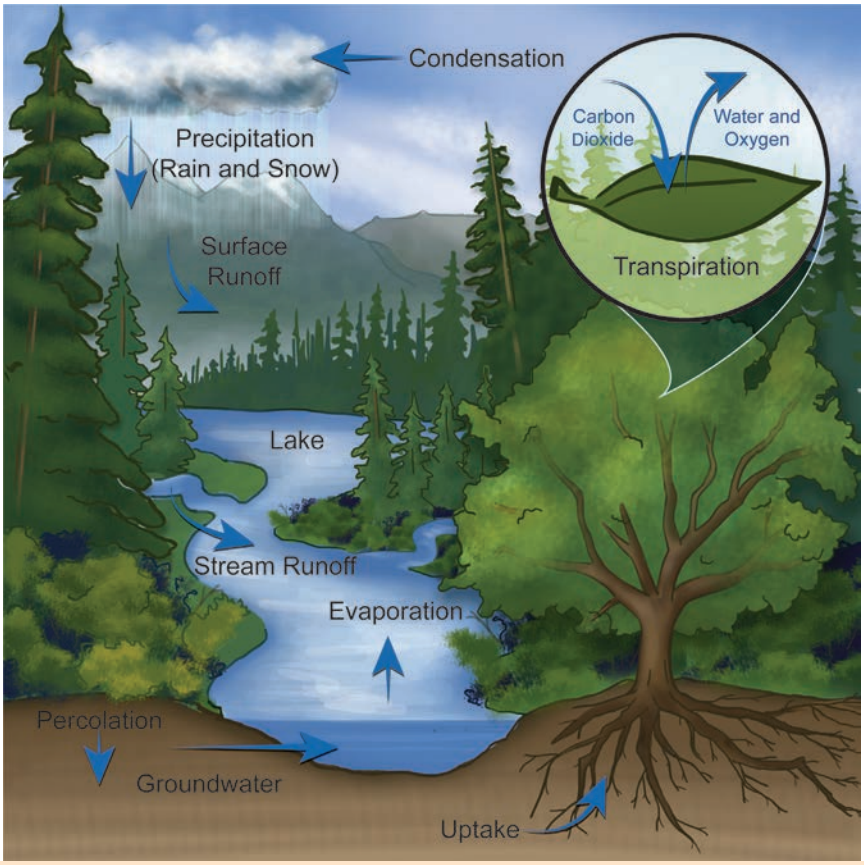


FIGURE 34.
The water cycle. Each individual tree contributes to the water cycle through transpiration.
Illustration by Stephanie Pfeiffer and Nickola Dudley.

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.

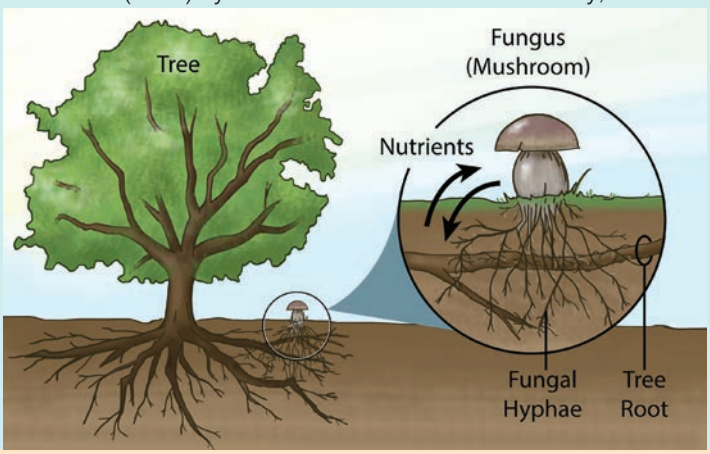


FIGURE 35.
Hyphae are fungi's thin strands. Hyphae assist in the transfer of nutrients and energy back and forth between a tree's roots and the fungi.
Illustration by Stephanie Pfeiffer.

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?

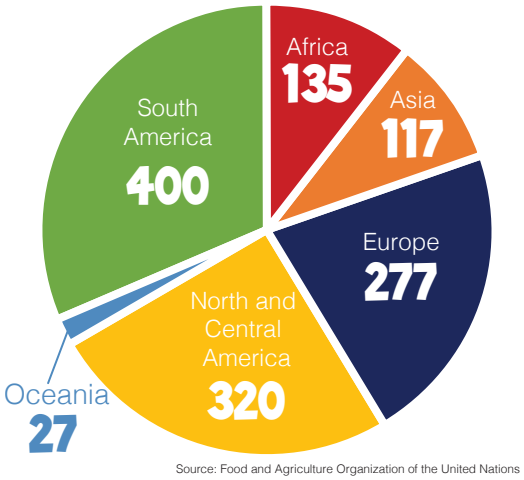


FIGURE 38.
Primary forest area by continent (in millions of hectares) in 2015.
Illustration by Stephanie Pfeiffer.

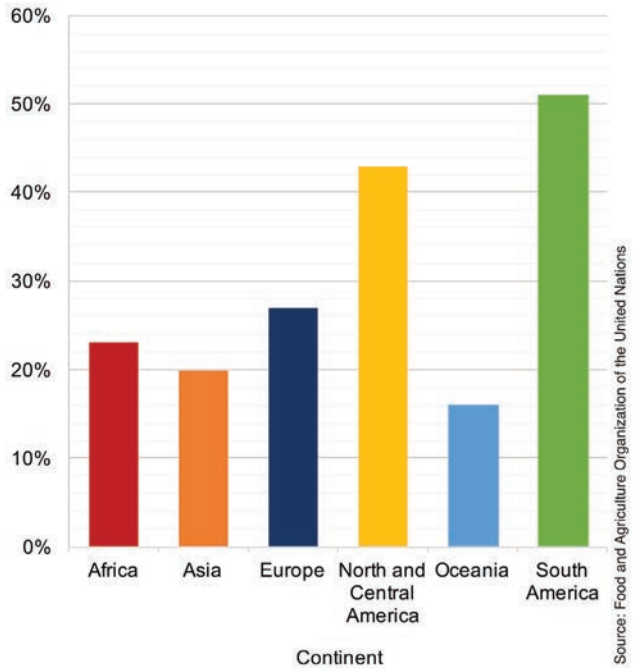


FIGURE 39.
Primary forest area as a percentage of total forest area (of countries that reported on primary forest) by continent in 2015.
Illustration by Stephanie Pfeiffer.

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?

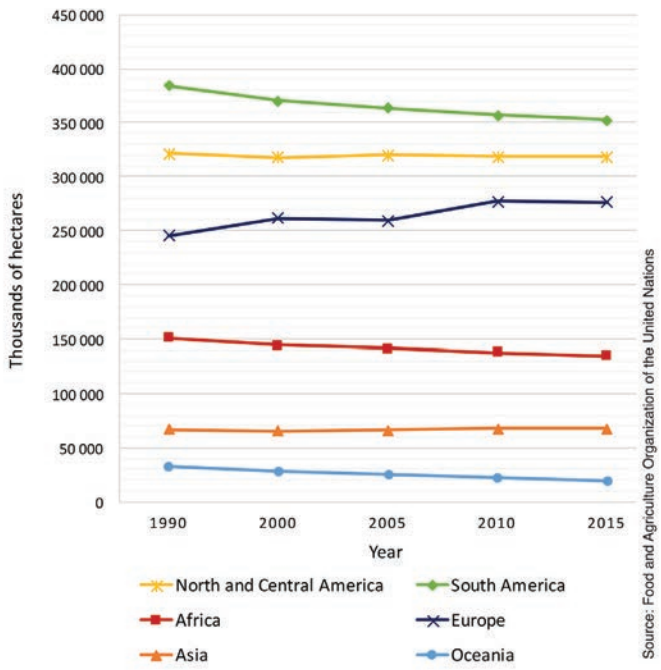


FIGURE 40.
Area of primary forest (in thousands of hectares) by continent between 1990 and 2015.
Note: this graph only includes data from countries that reported on primary forest for all Forest Resources Assessment reporting years.
Illustration by Stephanie Pfeiffer.

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.

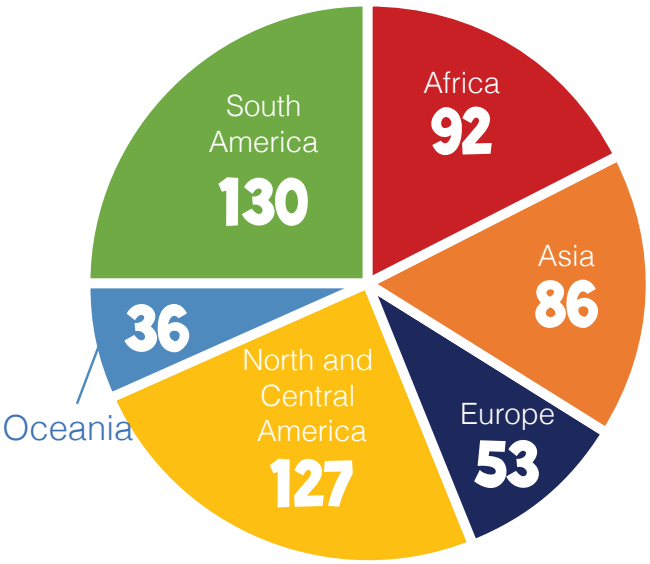


FIGURE 41.
The amount of forest area (in millions of hectares) set aside to protect biodiversity by continent in 2015.
Illustration by Stephanie Pfeiffer.

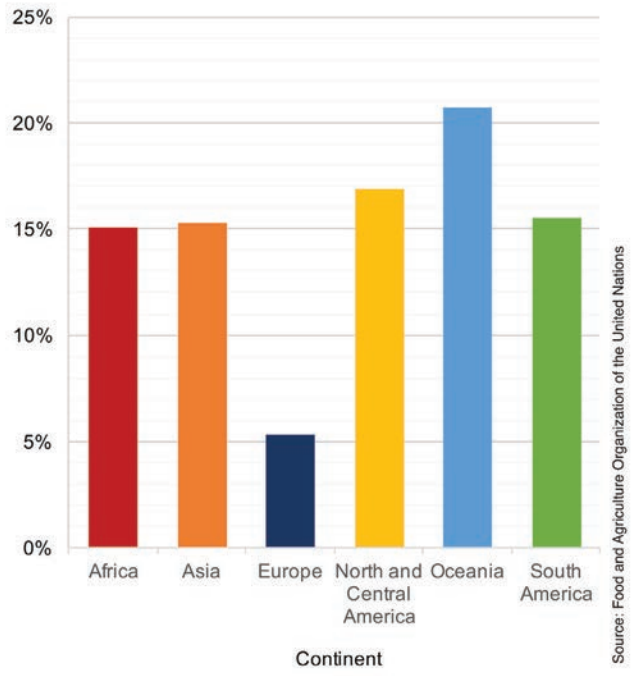


FIGURE 42.
The amount of forest set aside to protect biodiversity as a percentage of total forest area (of countries that reported on this variable) by continent in 2015.
Illustration by Stephanie Pfeiffer.

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).

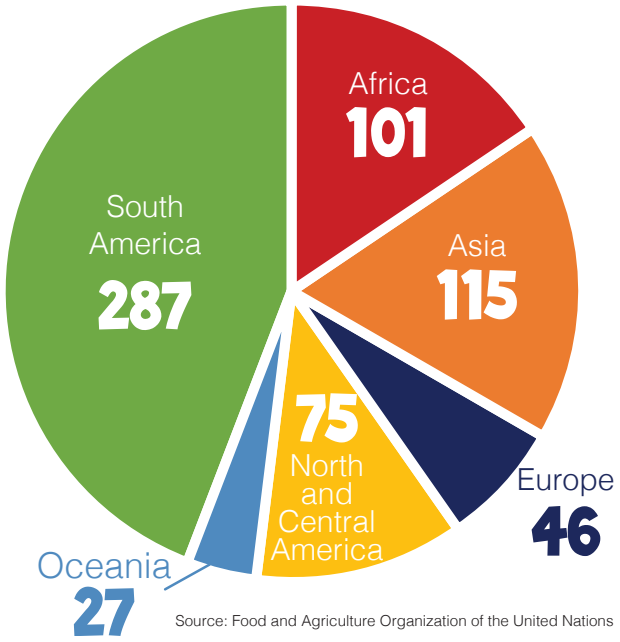


FIGURE 43.
Area of forest within protected areas (in millions of hectares) by continent in 2015.
Illustration by Stephanie Pfeiffer.

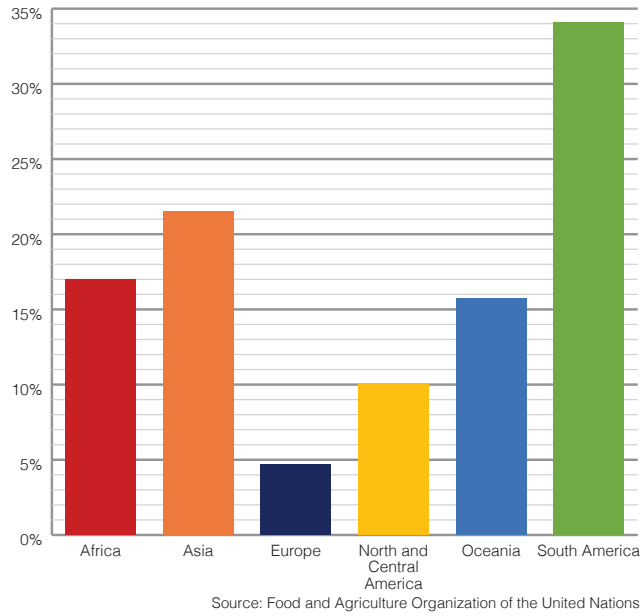


FIGURE 44.
Area of forest within protected areas as a percentage of total forest area (of countries that reported on this variable) by continent in 2015.
Illustration by Stephanie Pfeiffer.

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.

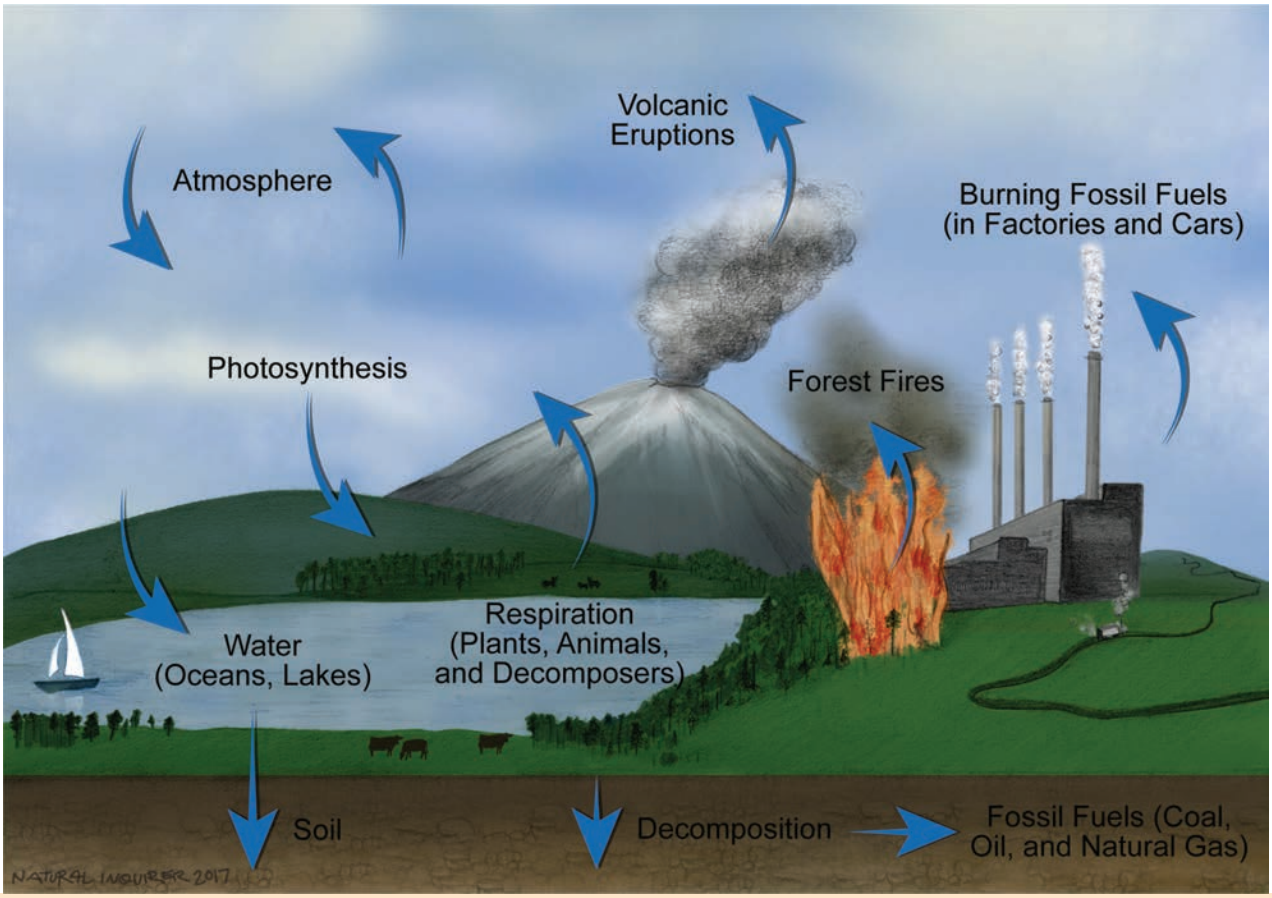
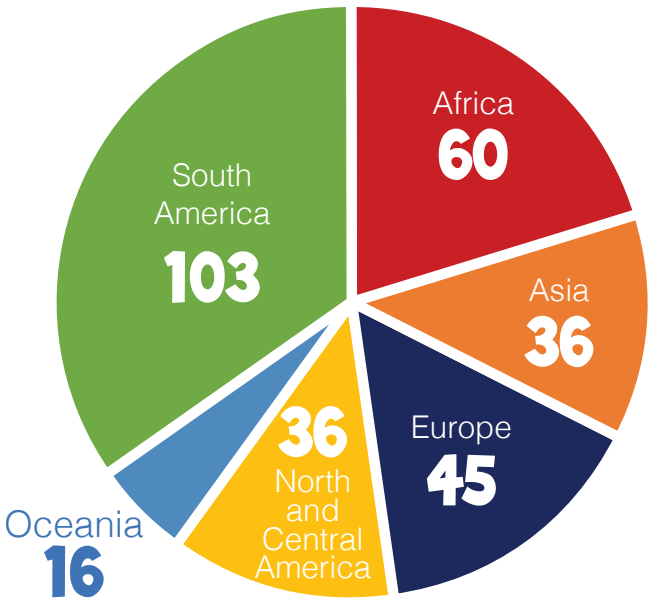
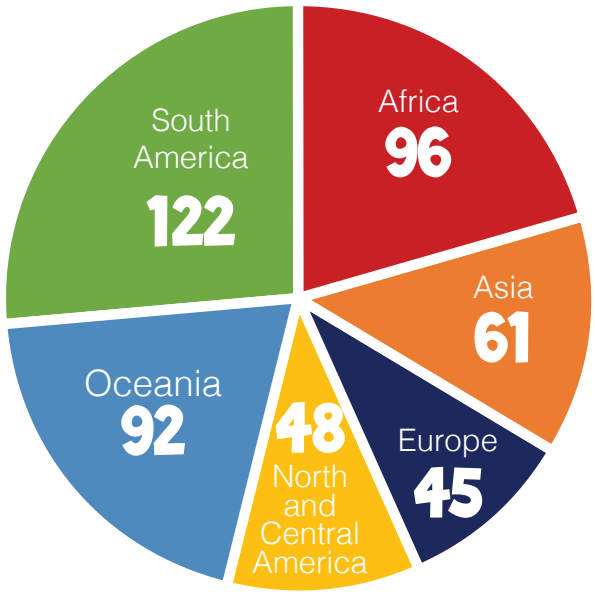


FIGURE 46.
The carbon cycle describes the movement of carbon throughout Earth and Earth's atmosphere.
Illustration by Stephanie Pfeiffer.



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).

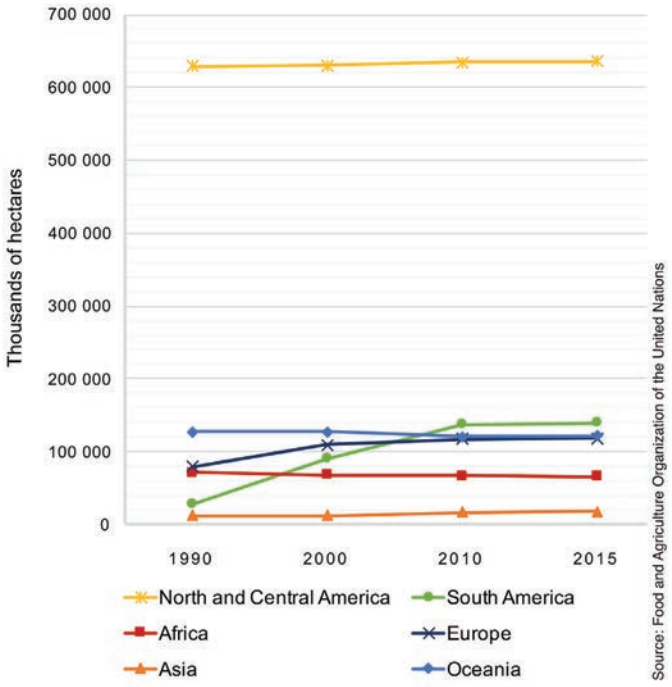


FIGURE 53.
The amount of forest (in thousands of hectares) managed for ecosystem services, including cultural and spiritual values, by continent from 1990 to 2015.
Note: this graph only includes data from countries that reported on this variable for all Forest Resources Assessment reporting years.
Illustration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

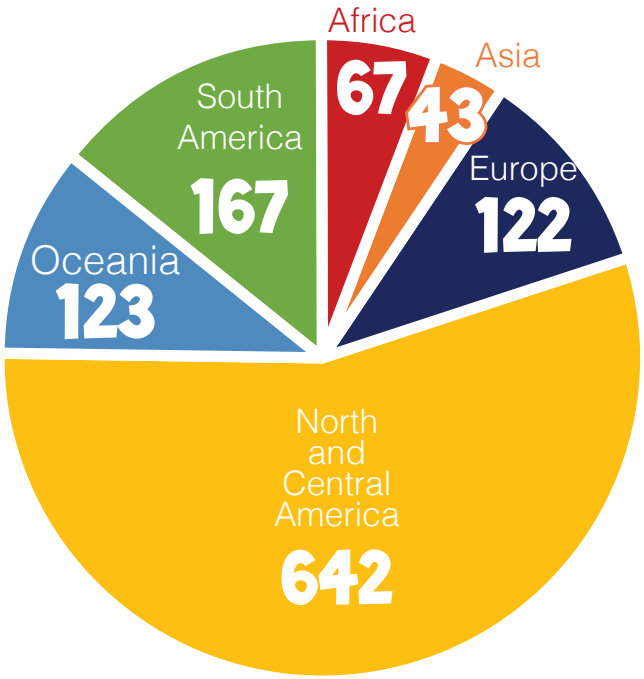


FIGURE 54.
Provision of ecosystem services and cultural and spiritual values (in millions of hectares) by continent in 2015.
Illustration by Stephanie Pfeiffer.

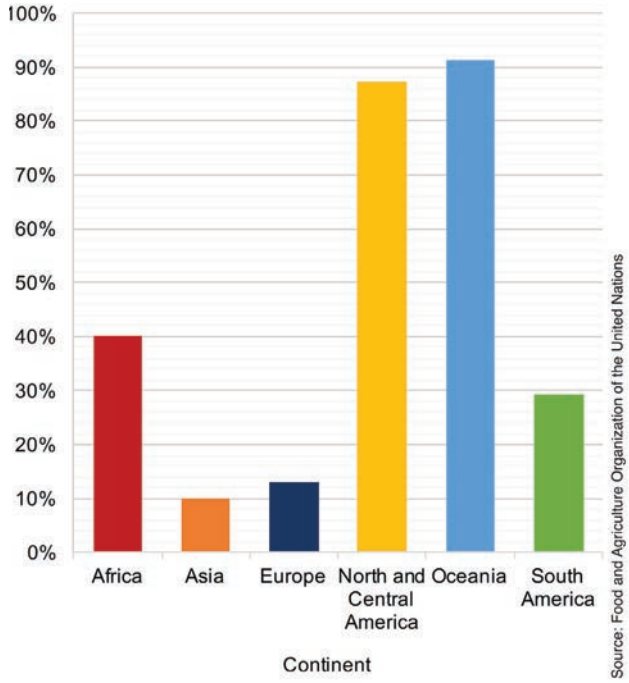


FIGURE 55.
Provision of ecosystem services and cultural and spiritual values by continent as a percentage of total forest area (of countries that reported on this variable) in 2015.
Illustration by Stephanie Pfeiffer.

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.

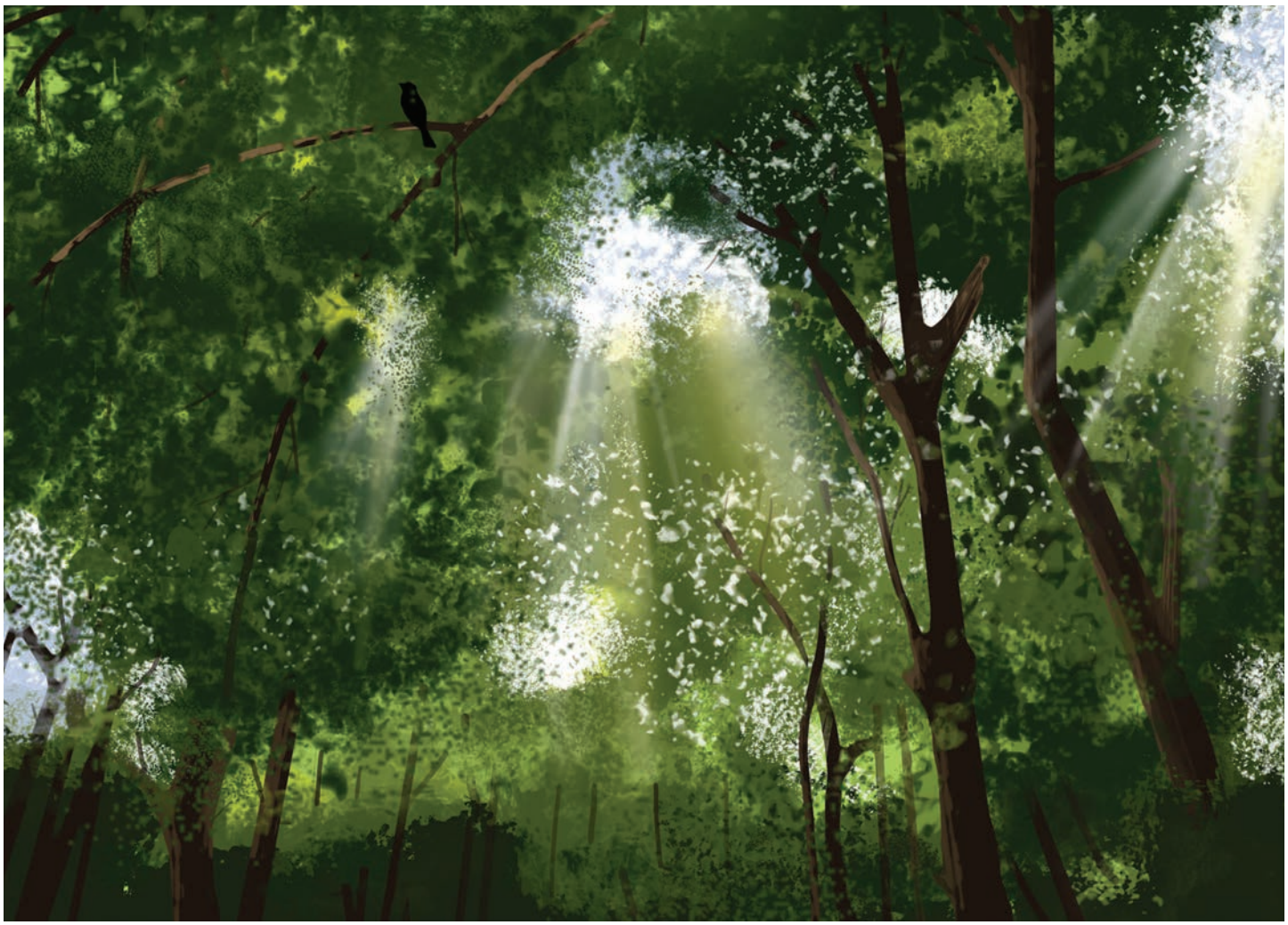


FIGURE 57.
The forest canopy is the top layer where most of the trees' leaves are found. The canopy helps protect the soil from erosion by reducing the impact of heavy rains.
Illustration by Stephanie Pfeiffer.

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

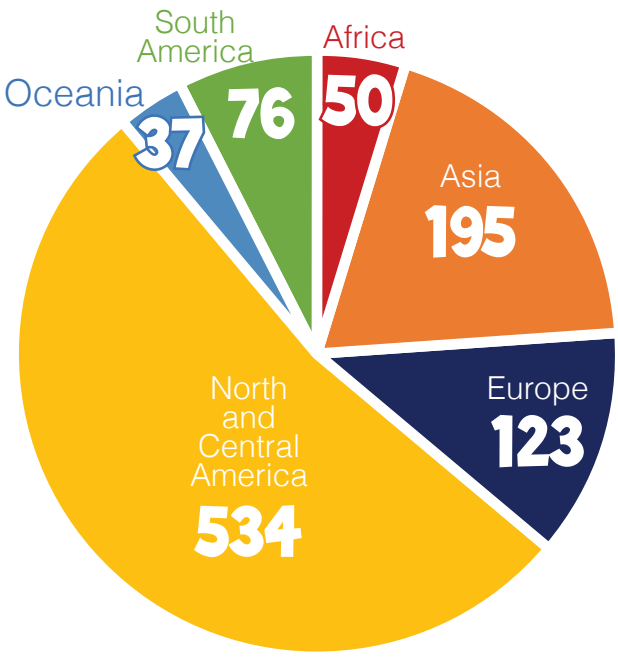
Clean water is another of Earth's most important **natural resources**. All of our planet's organisms need water. Some small amounts of water may come to Earth from outside of our atmosphere, such as from meteors. Practically speaking, however, water found on Earth is our water supply today and into 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.

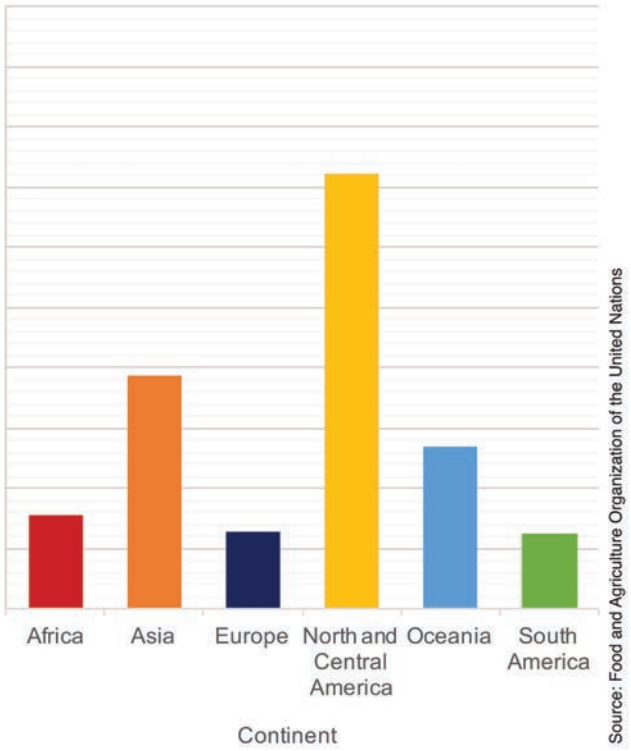


FIGURE 61.
Protection of soil and water and provision of ecosystem services as a percentage of total forest area (of countries that reported on this variable) by continent in 2015.
Illustration by Stephanie Pfeiffer.

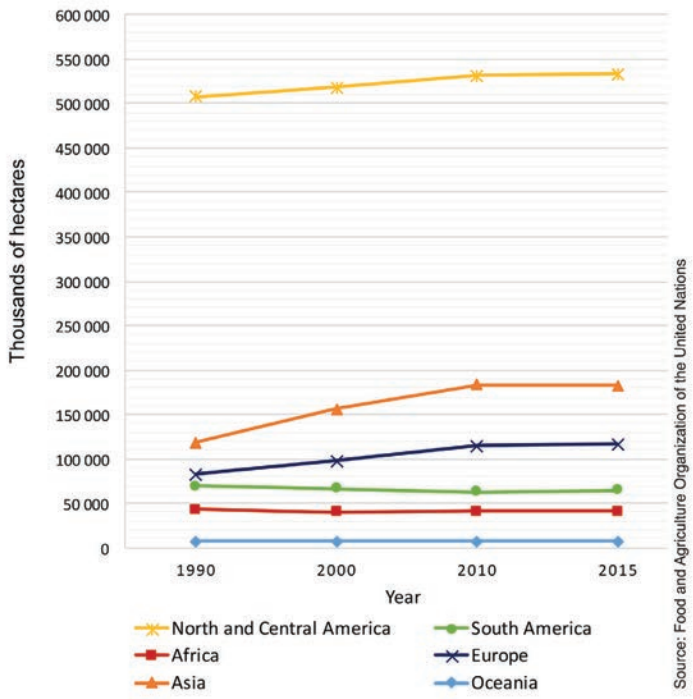
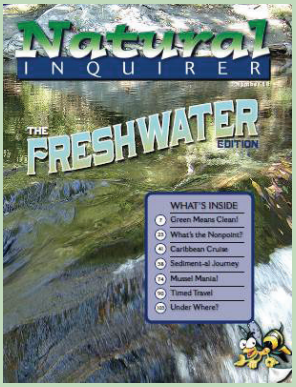


FIGURE 62.
The amount of forest managed for soil and water protection (in thousands of hectares) between 1990 and 2015, by continent.
Note: this graph only includes data from countries that reported on this variable for all Forest Resources Assessment reporting years.
Illustration by Stephanie Pfeiffer.



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.

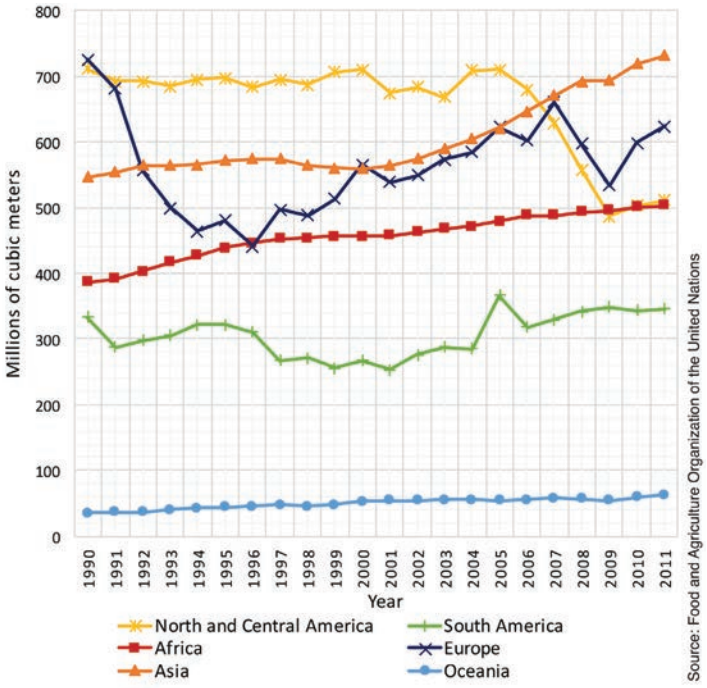


FIGURE 67.
Yearly wood removals by continent from 1990 to 2011 in millions of cubic meters.
Illustration by Stephanie Pfeiffer.

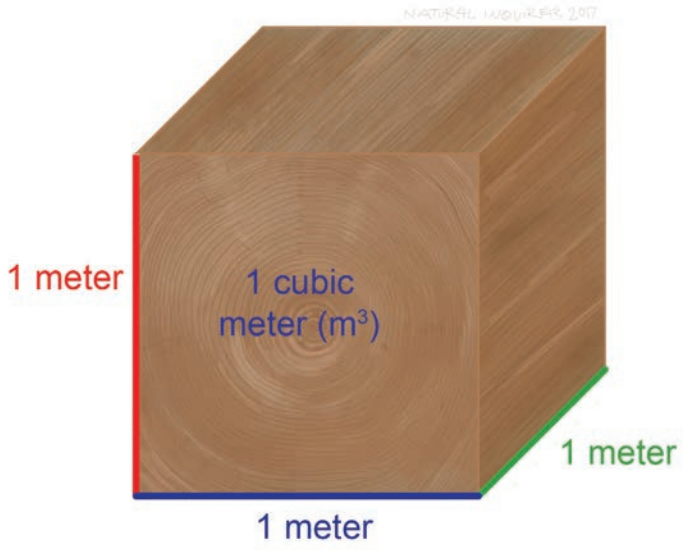


FIGURE 68.
A cubic meter of wood is the amount contained in a cube of wood that is 1 meter long on each side.
Illustration by Stephanie Pfeiffer.

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.

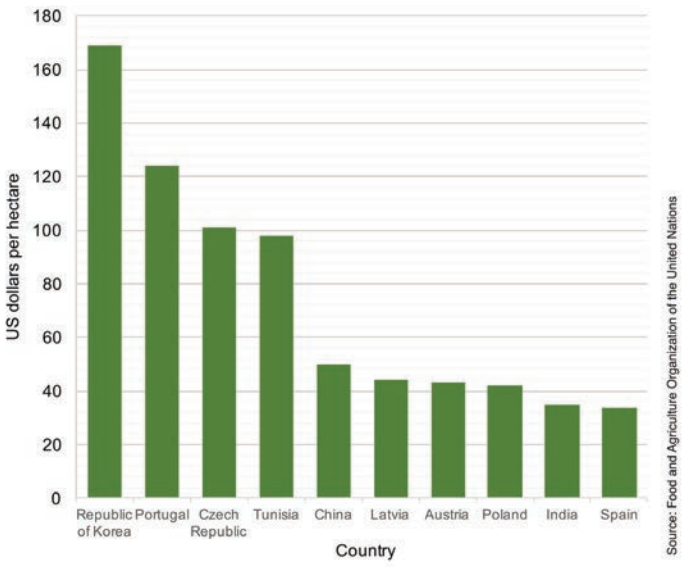


FIGURE 71.
The top 10 countries by reported value of non-wood forest product removals (in United States dollars per hectare) in 2010.
Illustration by Stephanie Pfeiffer.

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).

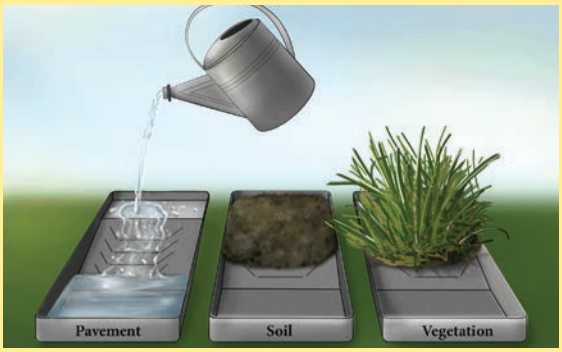


FIGURE 73.
How to set up the paint roller pans.
Illustration by Stephanie Pfeiffer.

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).

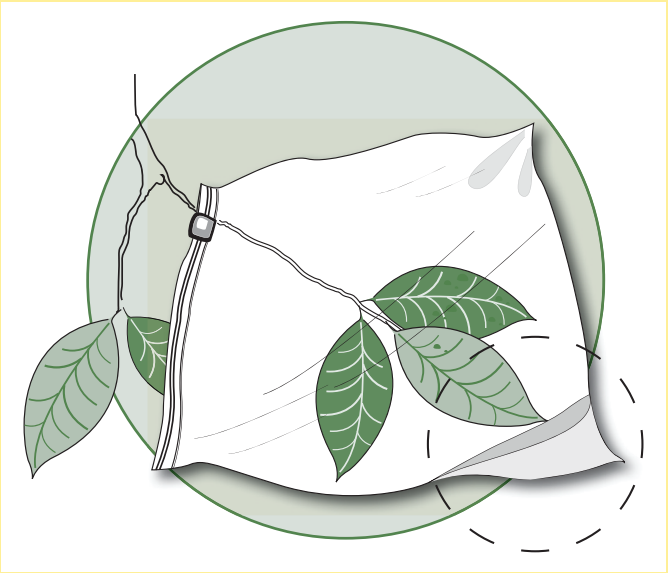


FIGURE 75.
Make sure that none of the water is spilled from the plastic bag.
Illustration by Nickola Dudley.

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.

INQUIRY 3: HEALTHY FORESTS NOW AND INTO THE FUTURE

Photo courtesy of Xiping Wang

PLANNING FOR HEALTHY FORESTS

Did you know that people manage or work with forest resources to achieve goals and gain benefits? For example, people might have a goal of maintaining clean water for drinking and cooking. Clean water is a benefit of healthy forests. To gain and maintain this benefit, for example, people purposely leave forest areas undisturbed when they are close to streams and rivers. People may also plant vegetation next to streams and rivers to protect water resources (Figure 76).

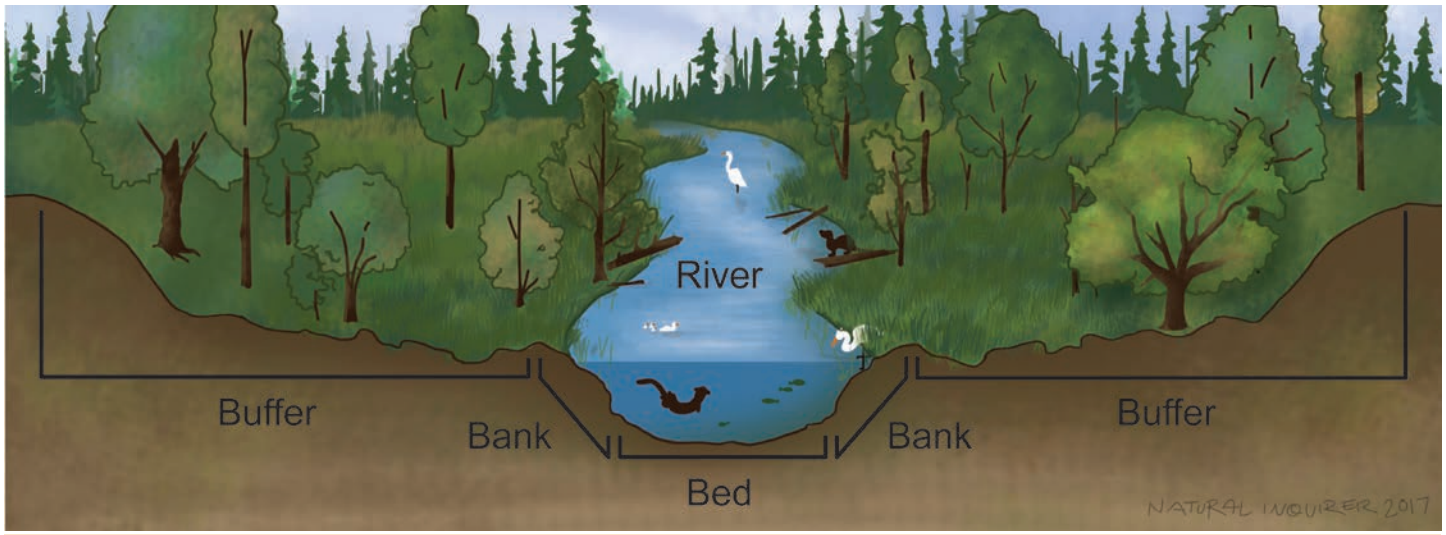


FIGURE 76.
Areas next to streams and rivers may be purposely left undisturbed or planted with trees and shrubs. Trees and other vegetation protect the stream or river from soil erosion, sediment, and pollutants. These managed areas are called stream buffers.
Illustration by Stephanie Pfeiffer.

FIGURE 77.
An example of managing forests sustainably is cleaning brush and leaves away from an area so that trees and food crops can be grown close together in that area, as this woman is doing in the United Republic of Tanzania. Photo courtesy of Food and Agriculture Organization of the United Nations/Simon Maina.

FIGURE 78.
Sustainable forest management enables people in Kyrgyzstan to provide for their children, and in the future, for their children to provide for their own children. Photo courtesy of Food and Agriculture Organization of the United Nations/Vyacheslav Oseledko.

Forests are managed to achieve many different benefits. (You learned about these benefits in Inquiry 2.) Sustainable forest management is a method people use to gain and maintain desired benefits from their forests (Figure 77).

Let's examine the word "sustainable." The Merriam-Webster dictionary defines sustainable in this way:

1. Capable of being sustained.
2. Of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged.

The second definition is the one that best describes sustainable forest management. Sustainable forest management includes the actions that forest managers take to produce benefits from healthy forests. No matter what benefits people want to gain from their forests, sustainable forest management is important. When forests are managed sustainably, people gain the benefits they want now and into the future.

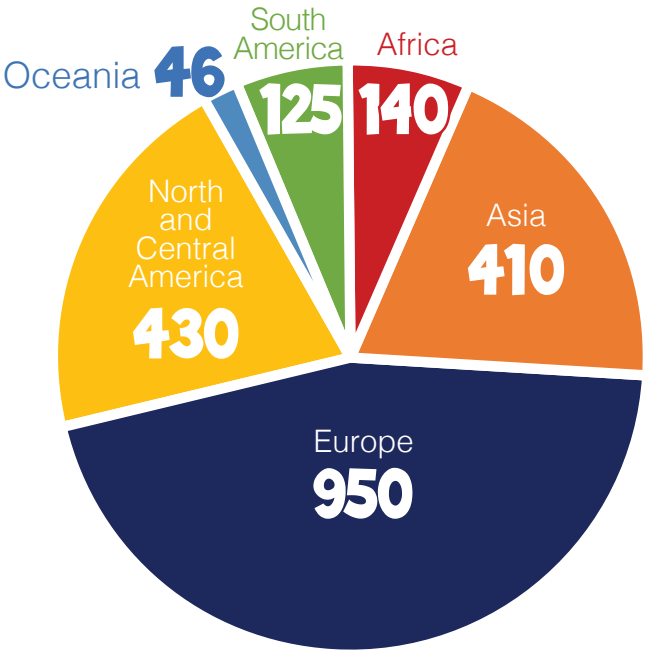
Sustainable forest management helps people balance the social, environmental, and **economic** benefits that forests provide. Sustainable forest management also recognizes the importance of providing benefits to present and future generations (Figure 78).

FAO has defined an important way to understand sustainable forest management. This understanding has to do with the amount of land worldwide that is being managed as forests. FAO asked: How much of the world's forest area is managed so that it remains healthy into the future?

FAO was interested in finding out how much of the world's forests people manage to provide benefits. They found that in 2010, 2.1 billion hectares of forest area have a management plan to provide either forest products or

environmental protection. The amount of land permanently managed as forests was slightly larger, making 2.2 billion hectares, and 1 billion of these hectares were in the tropical ecozones. The most successful forest management is done with the aid of a forest management plan. A forest management plan is a written document that identifies what actions will be taken and when they will be taken. These actions are meant to gain particular benefits from the forest.

Forest management plans are important because when forests are managed for specific benefits identified in a plan, the chance of people gaining those benefits is increased (Figure 79, Figure 80, and Figure 81). A forest management plan includes a specific statement of the benefits an individual or an organization would like to gain from the forest land. The plan also includes specific actions to be taken to gain those benefits and when those actions will be taken.



Source: Food and Agriculture Organization of the United Nations

FIGURE 80.
Amount of forest area under a management plan (in millions of hectares) in 2010 by continent.
Illustration by Stephanie Pfeiffer.

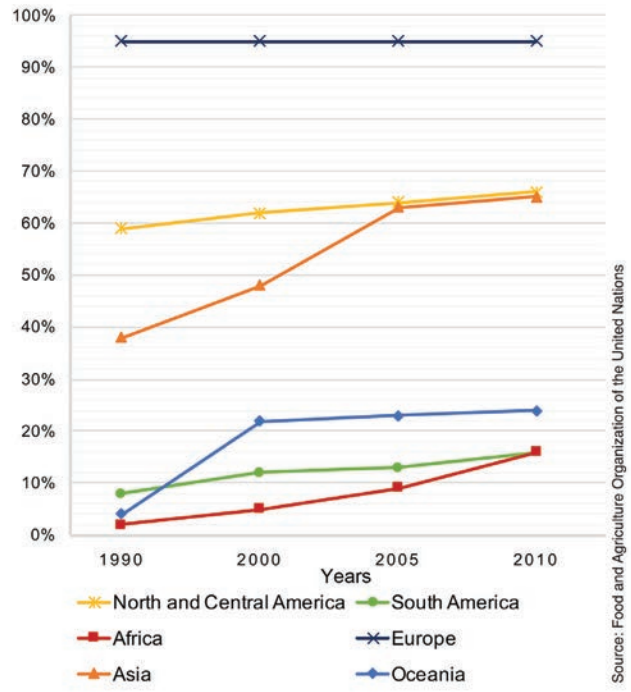


FIGURE 79.
Percentage of forest land managed under a forest management plan between 1990 and 2010 by continent.
Illustration by Stephanie Pfeiffer.

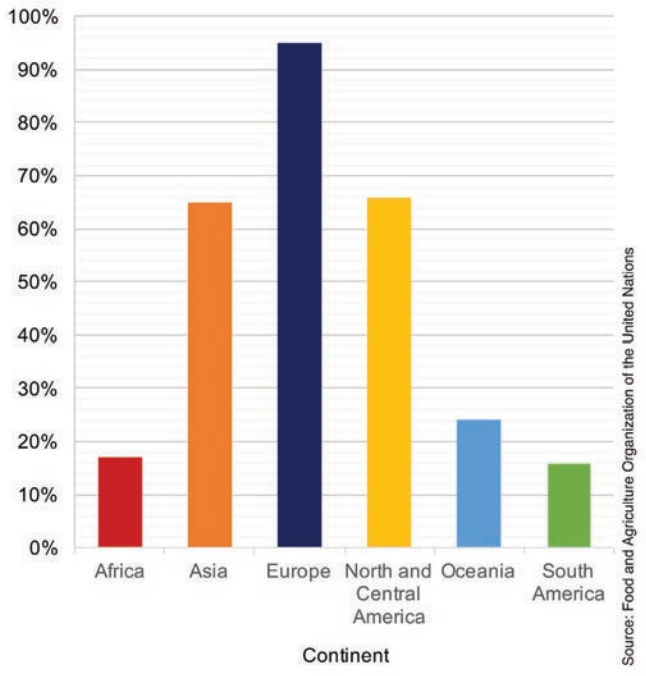


FIGURE 81.
Amount of forest area under a management plan as a percentage of total forest area (of countries that reported on this variable) in 2010 by continent.
Illustration by Stephanie Pfeiffer.

REFLECTION SECTION

Describe in your own words what "sustainable" means.

Do you think having a forest management plan is a good idea? Why or why not?

PUTTING FOREST MANAGEMENT TO THE TEST!

FAO was also interested in learning more about forest management **certification**. Forest management certification occurs when an independent organization reviews and **confirms** that a forest is being managed according to a written plan.

When a forest is certified as being managed according to a written management plan, people can feel more comfortable that the best management practices are being used. People can also feel more confident that the forest benefits identified in the plan will be received.

People use forest certification programs to **monitor** areas under a forest management plan to make sure they meet certain conditions. People also use certification programs to evaluate whether the written sustainable forest management plan is being followed.

When a plan describes a condition to be met, the condition is meant to protect the forest and the people for whom the forests are being managed. For example, certified sustainable forest management plans should protect the rights of **indigenous** people who live near or in the forest. These plans must also protect the rights of people who work in the forest or in forest-related jobs. The forest managers must restore forested ecosystems, if needed, and protect the forested ecosystems that they are managing. Biodiversity must be maintained in a certified forest. Forest certification provides a way to ensure that human rights and environmental health are being protected.

FAO collected information on two of the most widely used forest management certification programs. These programs are operated by the Forest Stewardship Council (FSC) and the Program for the **Endorsement** of Forest Certification (PEFC) (Figures 82 and 83; Table 2).

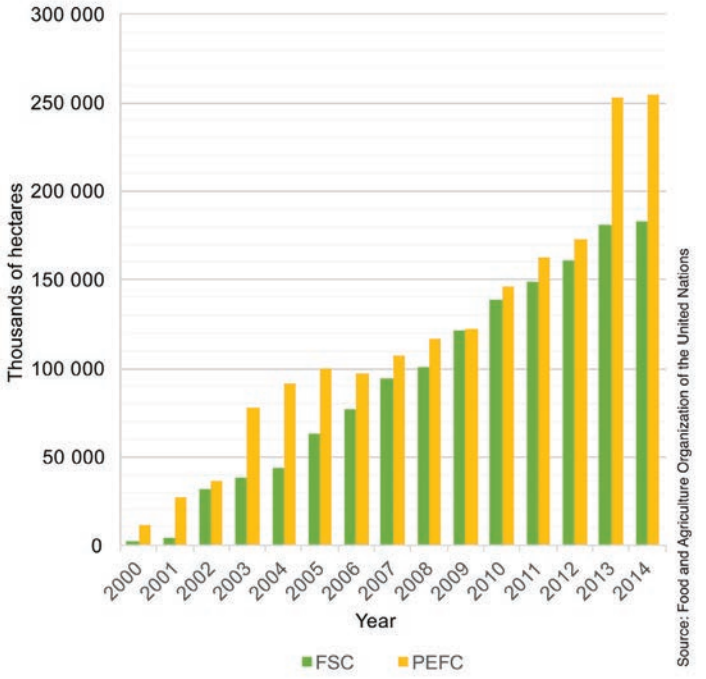


FIGURE 82.
Amount of the world's forest area (in thousands of hectares) certified under a certification program by type of certification program and total amount between 2000 and 2014. FSC = Forest Stewardship Council; PEFC = Program for the Endorsement of Forest Certification. Illustration by Stephanie Pfeiffer.

TABLE 2. Forest area under an international certification program (in millions of hectares) by continent in 2014.

CONTINENT	AFRICA	ASIA	EUROPE	NORTH AND CENTRAL AMERICA	OCEANIA	SOUTH AMERICA
Forest area certified under an international scheme (million ha)	6.4	14	167	222	13	15

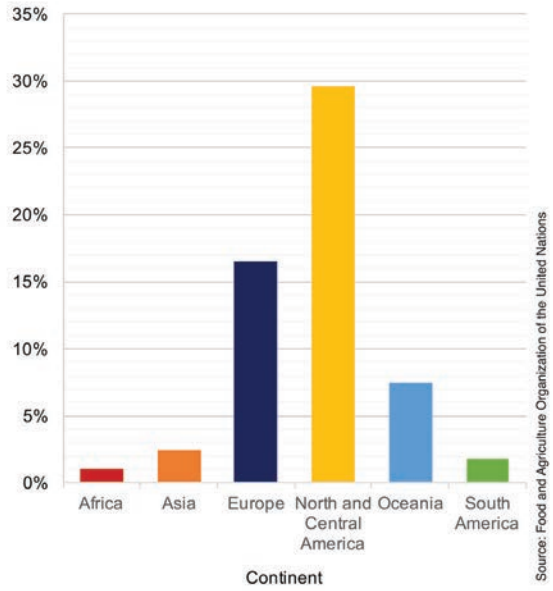


FIGURE 83.
Forest area under an international certification program as a percentage of total forest area by continent in 2014.
Illustration by Stephanie Pfeiffer.

The number of forested hectares worldwide under forest certification programs increased from 14 million hectares in 2000 to 438 million hectares in 2014. The temperate and boreal ecozones had the greatest number of hectares under forest certification programs (see Figure 12 on page 17).

If you didn't take tests or submit schoolwork for your teacher's review, would you know whether you have improved in school? You might have a feeling one way or another, but you wouldn't know for sure. Forest managers are in the same situation! Without doing an **assessment**, or monitoring, of their practices, forest managers and others may not know how well they are doing.

Worldwide, the condition of 83 percent of the world's forests is monitored by forest managers and scientists in 116 countries. These countries periodically produce national reports about their forests. Eighty-six countries, covering 77 percent of the world's forest area, include information describing how well their country is progressing toward sustainable forest management.

HOW CAN FOREST MONITORING BE MADE EASIER?

More forest land area is being periodically monitored worldwide for forest management practices and benefits. The USDA Forest Service's Forest Inventory and Analysis (FIA) Program has created a way to assist countries with forest monitoring. The FIA Program has developed a 15-step process to help tropical countries better understand and monitor their forest management. The FIA Program has worked with Honduras, Peru, Guyana, and the Democratic Republic of the Congo (Figure 84).

FIGURE 84.
The countries using the FIA 15-step program to monitor their country's forest management include Honduras, Peru, Guyana, and the Democratic Republic of the Congo.
Map by Carey Burda and Stephanie Pfeiffer.

REFLECTION SECTION

Everyone benefits when forest managers use a forest management plan to guide them. Name a time when having a plan provided a benefit to you. What was your plan, and how did you benefit from having a plan?

Observe Figure 82. Do you think the number of forested hectares under forest certification will increase or decrease in the future? Why?

Observe Figure 84. What is similar about the 4 countries that used FIA's 15-step program for forest monitoring?

FACTIVITY

PLANNING YOUR OWN FOREST

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- Blank paper
- Writing utensil
- Crayons, colored pencils, or colored markers
- Planning Your Own Forest Graphic Organizer

In this FACTivity, you will create a forest management plan for a 1-hectare (or 1-acre) forest. You will make this plan by using the Planning Your Own Forest Graphic Organizer on page 58. Since this forest is a creation of your imagination, it can contain any kind of trees, other plants, and animals that you want.

METHODS

1. Take a blank piece of paper. You will draw a picture of your forest on this paper.
2. Draw two native tree species that grow in your forest. Remember, you can make up any kind of tree, or you can draw trees that you are familiar with from your area or from your research.
3. Draw two native mammal species that live in your forest. You can make up these mammals or you can draw mammals that you are familiar with from your area or from your research.
4. Draw two native bird species that live in your forest. You can make up these birds or you can draw birds with which you are familiar.
5. Make a list of other features that are found in your forest. For example, you might find a stream or river in your forest. You might find waterfalls. You might find a lake in your forest. What other features are found in your forest? Once you have a list, draw these features in your picture.
6. On a separate piece of paper, make a list of the benefits your forest provides. If you need a reminder, review Inquiry 2: Benefits of Healthy Forests.
7. Once you have completed your forest picture, give your forest a name and write it on the paper.

Unfortunately, a cyclone, typhoon, hurricane, or tornado has recently passed across your forest, destroying the trees. Fortunately, the wildlife escaped unharmed. They have left your forest, however, because their habitat was destroyed. It is your job to make a plan to restore your forest. You will use the Planning Your Own Forest Graphic Organizer that follows to make a plan to restore your forest to a healthy condition.

8. Using the Planning Your Own Forest Graphic Organizer, list your goals for restoring your forest. What benefits do you want the forest to provide? How are these benefits similar or different to the benefits your original forest provided? How long will it take to restore the forest?
9. Using a blank piece of paper, draw the shape of your forest. Draw features like streams, ponds, lakes, and trails you want within the forest.
10. Use the Planning Your Own Forest Graphic Organizer to detail how you will meet your goals for the forest. When will you complete each part of the plan? For example, will planting trees come before or after making trails? How many trees will you plant? Which species of trees? Where exactly will those trees be planted?
11. If you want to use your forest for recreation, show on your map where you will put a trail. Identify when you will put the trail in place and how long you think it will take to complete the trail. Be sure to name the trail.
12. If you need to create a special habitat to attract your wildlife or bird species back to your forest, describe what you will do, where you will do it, and when it will be done.

PLANNING YOUR OWN FOREST GRAPHIC ORGANIZER

Forest Management Plan for _____Forest.

What are your goals for your forest? Your goals should include whether you want to have the forest managed for recreation, timber production, wildlife habitat, or other benefits.

My goals for _____ Forest are:

_____

_____

_____

_____

_____

How long will it take to achieve these goals?

I would like to achieve these goals in _____.

What will you do to achieve your goals?

_____

_____

_____

_____

_____

_____

_____

_____

When you have finished your plan, look again at your original picture of your forest. How did your restoration activities improve your forest?

_____

_____

_____

_____

_____

_____

_____

WORLD'S FORESTS THIRD EDITION SUMMARY

FAO's report, as well as this journal based on FAO's report, summarizes the state of the world's forests in 2015. Much of the report's information also looks at trends in the world's forests over 25 years (Figure 85). Based on Figure 85, what can you conclude about the future of your continent's forests specifically, and the world's forests overall?

FIGURE 85.
Direction of change (D = Downward, U = Upward) (1990 to posted year) (~ = Less than ½ percent change) by continent.

CONTINENT	AFRICA	ASIA	EUROPE	NORTH AND CENTRAL AMERICA	OCEANIA	SOUTH AMERICA
Forest area (million ha) 2015	D	U	U	~	D	D
Natural forest (million ha) 2015	D	D	~	D	D	D
Planted forest (million ha) 2015	U	U	U	U	U	U
Carbon (Gt) 2015	D	D	U	U	~	D
Carbon (Gt per ha) 2015	U	D	U	U	U	U
Total wood removals (million cubic meters) 2011	U	U	D	D	U	U
Protection of soil and water (million ha) 2015	D	U	U	U	U	D
Ecosystem services, cultural, and spiritual values 2015 (million ha)	D	U	U	~	D	U
Conservation of biodiversity 2015 (million ha)	U	U	U	U	U	U
Primary forest (million ha) 2015	D	~	U	~	D	D
Forest area within protected areas 2015 (million ha)	U	U	U	U	U	U
Forest area certified under an international program 2014 (million ha)	U	U	U	U	U	U

ha = hectares; Gt = gigatonnes.

GLOSSARY

Algae Simple plants that have no true root, stem, or leaf and that usually grow in water or on damp surfaces.

Amphibian Any organism that has gills and lives in water during the larval (juvenile) stage and has lungs and breathes air during the adult stage. Examples include frogs, toads, and salamanders.

Aromatic Having a strong smell.

Assessment The action or an instance of making a judgment about something. The act of assessing something.

Average (1) The usual kind or amount; (2) The number determined by dividing the sum of two or more quantities by the number of quantities added.

Axis A straight line about which a body or geometric figure rotates.

Bacteria Living things that only have one cell and can only be seen using a microscope.

Canopy (1) Anything that covers like a roof; (2) On a tree, the area of leaves that cover the ground.

Certification The act of confirming something as being true or as represented or as meeting a standard.

Collaborative Characteristically working jointly with others or together.

Compound Chemical substance formed from two or more elements.

Confirm (1) To assure that something is true; (2) To give approval to.

Conserve To avoid wasteful or destructive use of something.

Correspondent (1) One who has regular commercial relations with another; (2) Regarding the World's Forest editions, a correspondent is a representative from each country who gathered and sent information to FAO.

Culture The set of shared attitudes, values, goals, and practices that characterizes an institution, organization, or community.

Deforestation (1) The action or process of clearing of forest; (2) Deforestation happens when a forest is destroyed and the area previously occupied by the trees is used for other purposes.

Degrade The act of impairing or bringing to a lower level of quality.

Diversity (1) The condition of having or being composed of differing elements; (2) Variety.

Ecological Having to do with ecology, the study of the relationship of living things with each other and their environment.

Economic Of, relating to, or based on the production, distribution, and consumption of goods and services.

Edible (1) Fit to be eaten; (2) Safe to be eaten.

Element (1) Any of the parts or qualities of a thing, especially a necessary one; (2) One of a class of substances that cannot be separated into simpler substances by chemical means.

Emission Something discharged or sent out.

Endorsement The act of approving openly.

Equator An imaginary circle around the middle of Earth at an equal distance from the North Pole and the South Pole.

Erode To wear away by water or wind.

Erosion The process or state of wearing or washing away.

Forest litter Dead plant material, such as leaves, bark, needles, and twigs, that have fallen to the ground.

Fungi Plant-like organisms that contains no chlorophyll and reproduce by spores, including mold, mushrooms, and mildew.

Genetic (1) Having to do with genes; (2) The hereditary material of living things.

Genus A class, kind, or group marked by common characteristics or by one common characteristic, specifically a category of biological classification ranking between the family and the species.

Germinate To start growing, sprouting, or developing.

Habitat The place or environment where a plant or animal naturally or normally lives and grows.

Harvest To gather, collect, or take a crop.

Indigenous Produced, growing, living, or occurring naturally in a particular region or environment.

Interact To act upon one another.

Invasive Tending to spread or infringe upon.

Landscape The visual land, such as trees, water, and sky.

Livelihood A means of obtaining the necessities of life.

Mammal Any warm-blooded animal with a backbone and glands to produce milk for feeding the young.

Medicinal Tending or used to cure disease or relieve pain.

Molecular compound Chemical combination of two or more atoms that are usually non-metal, such as water (H_2O).

Monitor To watch, observe, listen to, or check (something) for a special purpose over a period of time.

Native Living or growing naturally in a particular region.

Natural resource A supply of something in nature that takes care of a human need, such as oil, forests, or water.

Nutrient Any of the substances found in food that are needed for the life and growth of plants and animals.

Pollutant (1) A substance that makes land, water, air, etc., dirty and not safe or suitable to use; (2) Something that causes pollution.

Population The whole number of individuals of the same type occupying an area.

Respiration The process by which a living thing takes in oxygen from the air and gives off carbon dioxide and other waste products.

Runoff Quantity of water discharged in surface streams, above groundwater level.

Sediment Material deposited by wind, water, or glacier.

Sustainable Of, relating to, or being a method of using a resource so that the resource is not depleted or permanently damaged.

Temperate Having a moderate climate, which does not have extremes in temperature; found in or associated with a moderate climate.

Toxic Containing or being a poisonous material, which may be capable of causing death or serious illness.

Trend A behavior pattern occurring and developing over a period of time.

Unit of measurement A standardized quantity of a physical property, such as inches, meters, kilograms, etc.

WORLD'S FORESTS IMAGE CHALLENGE!

These images appear somewhere in this edition of *Natural Inquirer* World's Forests. As a class or individually, have students explain the significance of each image as it relates to the world's forests. Hold a class discussion about these images. What story do these images tell about the world's forests?

Optionally, have students write a sentence explaining each image.

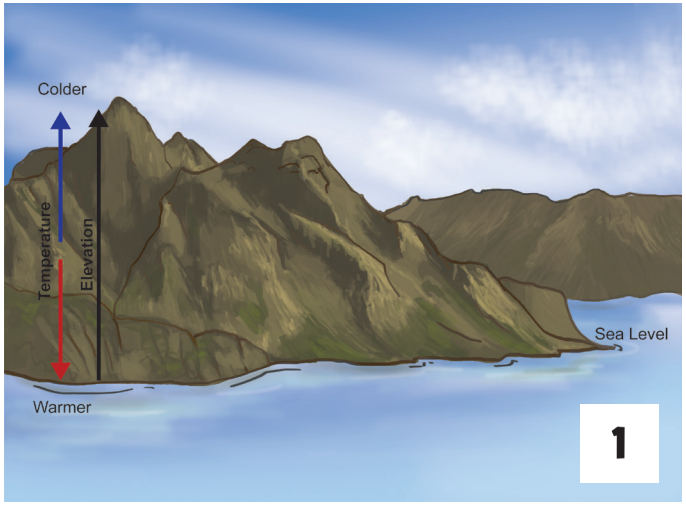


Illustration by Stephanie Pfeiffer.

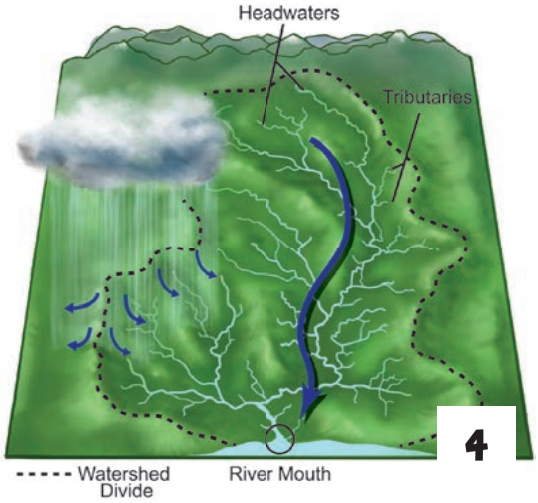


Illustration by Stephanie Pfeiffer.

Photo courtesy of Alton Sparks, University of Georgia, http://www.bugwood.org

Photo courtesy of Babs McDonald.

Photo courtesy of Chuck Murphy, http://boywithcamera.com.

Photo courtesy of Food and Agriculture Organization of the United Nations/Sean Gallagher.

NOTE TO EDUCATORS

The lesson plans provided below are intended to provide a framework for presenting the information contained in this *Natural Inquirer*. You may choose to develop your own lesson plans or to focus on only one or two Inquiries. The Inquiries are best presented in order, however, as subsequent Inquiries build on previous ones.

Be sure to examine the Educational Concepts Addressed by the Inquiries on page 92.

NATURAL INQUIRER WORLD'S FORESTS THIRD EDITION LESSON PLANS

INTRODUCTION TO THE LESSON PLANS

These lesson plans give you a blueprint for taking your students through the World's Forests Third Edition *Natural Inquirer*. The introductory material includes "Welcome to the *Natural Inquirer* World's Forests Third Edition," "Thinking About the World's Forests," and "Thinking About Science." Using these sections to introduce your students to the remainder of the journal will give a foundation for better understanding what follows.

The main body of the journal includes three Inquiries. These Inquiries provide information on forests worldwide, the benefits provided by forests, and how forests are being managed to keep them sustainable into the future.

In these three Inquiries, students will examine charts and graphs that provide information about forests by continent. As students examine these charts and graphs, they will use graphic organizers. These graphic organizers will help students analyze their continent's forest status and trends. The graphic organizers will also enable students to compare their continent's forests with forests on other continents.

Take a moment now to review the graphic organizer beginning on page 58. You may, as you and your students read the journal, provide countrywide or local examples, or have students research countrywide or local forests.

Note the Glossary on page 60-61. Have students use the glossary when they encounter a word in **bold** that is unfamiliar. If students encounter unbolded words that they do not know, help them understand the word's meaning or direct them to use a dictionary.

To access forest data by country, go to **http://www.fao.org/3/a-i4808e.pdf**.

WELCOME TO THE *NATURAL INQUIRER* WORLD'S FORESTS THIRD EDITION!

TIME NEEDED

30 minutes

MATERIALS

(for each student or group of students)

- World's Forests Third Edition

METHODS

Have students read this section individually or as a class. After they have read the section, have students do the math regarding the United Nations' current age and how long the Food and Agriculture Organization (FAO) has been collecting information about the world's forests.

Have students observe Figures 1 and 2. Ask students what they can learn about forests from observing these two photographs. Hold a discussion as appropriate.

Have students examine Figures 3 and 4. Have students identify their continent, and then answer the question posed in Figure 4's caption. Have students continue reading to complete this section.

THINKING ABOUT THE WORLD'S FORESTS

Have students read this section individually or as a class. Briefly discuss the benefits provided by forests and that forests vary in appearance depending on the climate zone in which they grow. Using Figure 6, have students identify their climate zone. Have students identify differences between the types of forest.

Ensure that students understand what is meant by the term "trends."

THINKING ABOUT SCIENCE

Have students read this section individually or as a class. The important message of this section is that all scientists, including the FAO scientists featured in this journal, must use data with the same unit of measurement if they are to meaningfully make sense of their data. Ensure that students understand units of measurement and why the unit of measurement must be the same for meaningful analysis. This section also describes how FAO collected forest-related data from all over the world. Note that scientists usually work in teams, and have students examine Figure 8. Ask students for any observations they have about the FAO team shown in Figure 8.

Emphasize to students that the information they will learn about the world's forests was collected by the large team of correspondents (in Figure 8) from countries all over the world.

INQUIRY 1: WHAT ARE THE WORLD'S FORESTS AND WHERE ARE THEY FOUND?

EARTH'S CLIMATES AND FORESTS

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Graphic Organizer for Inquiry 1: Earth's Climates and Forests
- Writing utensils

METHODS

In the first pages, students will learn about Earth's axis and its revolution around the Sun. They will learn about the Equator and lines of latitude. They will learn about sea level. Before leaving this section, make sure that students understand these terms and how the location on Earth affects an area's climate. Remind students that climate is the average weather in a location. Some climates are cool and other climates are warm. What kind of climate is found where your students live? Have students read about rainfall. Have students do research to discover the average yearly rainfall in their area. Students should read through Figure 11.

Observe the ecozones map and the photographs around it (Figure 12). Have students compare the ecozones figure with the climate figure (Figure 6 on page 13). Have students discuss why they think the maps compare as they do. Have students identify the climate zone and ecozone in which they live. Ask students to examine the forest photographs around the map. What do they notice about these forests?

Discuss the Reflection Section questions as a class or in small groups:

Observe Figures 9 and 10. Do you think that a location at sea level and at the same latitude north and south of the Equator would have a similar average air temperature? Why or why not? *Students will have individual answers to this question. You can test their conclusions by comparing the average air temperatures of seaside communities in Montevideo, Uruguay (24 °C), and Cape Town, South Africa (23 °C); and Jacksonville, Florida, United States of America (13 °C), and Hangzhou, China (15.6 °C). You may identify other seaside communities at similar latitudes to compare.*

Observe the photographs in Figure 12. What is one advantage of having a diversity of forest types across the planet? *Students will have individual answers to this question, and they may need your help. They should conclude, however, that a diversity of forest types worldwide is a good thing because a diversity of forests supports a diversity of animal and plant species and provides a wide range of products and services to people.*

Using information discussed during this section, have students complete the Graphic Organizer for Inquiry 1: Earth's Climates and Forests (on page 77).

INQUIRY 1: WHAT ARE THE WORLD'S FORESTS AND WHERE ARE THEY FOUND?

THE WORLD'S CHANGING FORESTS

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil
- Graphic Organizer for Inquiry 1: The World's Changing Forests

METHODS

Read through Table 1 on page 18. Ensure that students understand the difference between natural and planted forests. Use the photographs in Figures 14, 15A, and 15B to emphasize the difference.

Continue reading the text and have students examine Figure 16. Check students' understanding of the size of a hectare. Now read and examine Figure 17. Check students' ability to read tables and charts.

Throughout these lesson plans, students will be identifying their own continent's forest information on charts and graphs, and using that information to compare their continent's forests with other forests on other continents using graphic organizers. Where indicated in these lesson plans, students will follow a similar process to build this set of information.

For example, in Figure 17, students living in Africa will do the following:

Rank each continent from most to least amount of forest area according to data from 2015. The continent with the most will go at the top, and the continent with the least will go at the bottom. Then, write the name of the continents in order from most to least in the graphic organizer in the space provided for each figure.

Africa 624 = 4

Asia 593 = 5

Europe 1015 = 1

North and Central America 751 = 3

Oceania 174 = 6

South America 842 = 2

Then, students should circle their continent's name.

	Fig. 17 – Forest Area (millions ha)
Continent in Rank Order From Most to Least	Europe
	South America
	North & Central America
	Africa
	Asia
	Oceania

Students should do this exercise for Figures 17 to 20.

Have students read page 23 and examine Figure 23. Ask students what they notice about the percentage of forest area worldwide.

Now, have students examine Figure 22. What is similar about Africa and South America? (*Hint: Where on Earth are they located? Both are in the Southern Hemisphere at similar latitudes.*)

Students should read the paragraph on page 23 about decreases in forest area and observe Figure 24. Ask students to describe times when they observed forests being felled to construct buildings or roads, or for other uses such as agriculture.

Students will now read about trends in the amount of natural forests and planted forests.

For Figures 25 and 26, have students rank order the continents from most to least in hectares of both natural and planted forest in 2015 in the graphic organizer. Have students circle their continent's name in both columns. Note that for negative numbers, the highest negative number indicates the least value.

Now, have students read the paragraph that follows Figure 26 on page 24.

Ask students to summarize the trends in natural and planted forest land, based on the text and the information in Figures 25 and 26. Using 100 small stones, coins, or some other item, illustrate how much 7 percent is compared with 93 percent. Students should understand that even though planted forests are increasing in area, they are still a small percentage of total forest land worldwide.

Next, have students read about the amount of forested land per capita (page 24). Check to make sure that students understand what per capita means. Then, ask students to observe Figure 27. What is the general trend shown by this figure? Have students rank order the values for 2015 and write the continent names in the graphic organizer, from most to least amount of forested hectares per capita. Then have your students circle their continent's name.

Read the paragraph that follows Figure 27.

Have students read about urban forests on page 25 and observe the photographs of urban forests. If you have an urban forest nearby, hold a class discussion about the benefits the forest provides to your community. Using the Graphic Organizer for Inquiry 1: The World's Changing Forests (page 78), have students draw their idea of an urban forest and identify the benefits provided by the urban forest.

Have students read the sidebar about the world's urban population (page 25). Ask students to identify whether they live in an urban or a rural area. What are the characteristics of each?

Ensure that students have completed each column of the Graphic Organizer for Inquiry 1: The World's Changing Forests. Students should now summarize what they have learned about their continent's forests by comparing and contrasting the rank ordering they have completed so far. Students can write important ideas in the designated space.

Discuss the Reflection Section on page 25 as a class or in small groups:

Has an area of forest been felled in or near your community? If so, with what was this forest replaced? *Students will have individual answers to this question. One response, which has not yet been introduced in this journal, is that following harvest new trees may be planted. Other responses may include buildings, roads, parking lots, pastureland, and food crops.*

Describe in your own words the difference between a natural forest and a planted forest. *Students should realize that planted forests are created by planting, usually one species of tree, in straight rows, similar to food crops. Natural forests have a variety of native tree species and other vegetation, and the trees are different ages. The ecological processes of a natural forest are left to function normally.*

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

FORESTS ARE MORE THAN TREES

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil
- Graphic Organizer for Inquiry 2: Forests Are More Than Trees

METHODS

Individually or as a group, have students read the first paragraph and observe Figures 30 to 33. Have students think about the photographs, then have them identify a tree, mammal, bird, and insect found in the forests on their own continent. Have students write the name of this tree and these animals, as well as their continent, in the Graphic Organizer for Inquiry 2: Forests are More than Trees (page 81).

Ask students to read page 29-30. Have them examine Figure 34, which shows the water cycle and how trees transpire water.

Optional: Read the box on page 30 describing communication between trees by way of underground hyphae. Hold a class discussion about the advantages of using hyphae to transfer nutrients and information between trees.

If students need help, remind them that hyphae are found underground. Have students observe Figure 35 and discuss how hyphae can help move nutrients and chemical signals between underground fungi and tree roots.

Read the text on page 31. Hold a class discussion about biodiversity. Examine Figure 36. Ask students if they think these two species of geese are related. Describe how a goose may become different from its ancestors after years of living in a new ecosystem. Geese, or any species, may adapt over time as they live in their new environment. Over time, small adaptations might be advantageous in the new environment. The individuals of that species with the advantageous adaptations will pass these traits on to successive generations.

Optional: Have students read the sidebar and compare and contrast what is shown in Figure 36 with how Persian walnuts have developed genetic diversity across 14 countries. Hawaiian geese adapted on their own. Persian walnuts were cultivated by people, and this cultivation, along with the new environments, enabled Persian walnut trees to diversify genetically.

Discuss the Reflection Section questions on page 31 as a class or in small groups:

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. *Students will have individual answers to this question and may need hints. One example is that bird species carry tree or other plant seeds to a new area and drop them. In this way, birds help trees grow in new areas. These young trees, in turn, provide habitat for the birds. Another way that forest species interact is when ants live in a tree and by living there protect the tree from being eaten by another animal. Pollination is a good example of how plants and animals provide benefit to each other. Students may have many examples to share.*

Is biodiversity present in the human species? How do you know? *Students will have individual answers to these questions. Human biodiversity is evident in the variety of skin color, eye color, height, hair texture and color, facial features, and many other individual human characteristics.*

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

PRIMARY FORESTS

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil
- Graphic Organizer for Inquiry 2: Primary Forests

METHODS

Have students read the first paragraph on page 32. Ensure that they understand the concept of a primary forest. Note that a primary forest is distinct from a planted forest. Primary forests are self-generating and natural ecological processes are not disturbed. Have students answer the questions posed in the text.

Have students examine Figures 38 and 39. For each of the figures, have students rank order the values from most to least. Then, as they did with earlier figures, have students write the continent names in order from most to least in the Graphic Organizer for Inquiry 2: Primary Forests (page 82). Then have the students circle their continent's name.

Have students examine Figure 40. Ask them to identify the pattern they see in this figure.

Have students read the paragraph about biodiversity on page 33 and examine Figures 41 and 42. As students have done for previous figures, have them rank order the values from most to least in each figure and write the continent names in order in the Graphic Organizer for Inquiry 2: Primary Forests. Have students circle the name of their continent.

Have students read the next paragraph. Ask students to describe the difference between the number of forested hectares and the percentage of forested hectares in a country.

The next two paragraphs introduce the concept of protected areas. Have students read these paragraphs and examine Figures 43 and 44. If any students have had experience with protected areas, ask them to share their experiences with the class. If no students have had experience with protected areas, explore why this might be so.

Using Figures 43 and 44, have students rank order the values by continent, then write the

continent names in order from most to least in the Graphic Organizer for Inquiry 2: Primary Forests. Have students circle the name of their continent on each figure.

Have students do the You Do the Math sidebar on page 36. Discuss the implications of the tropical ecozone having such a large percentage of legally protected forest. This percentage is important because the tropical ecozone is also losing the largest amount of forested hectares worldwide (see Figure 21).

Discuss the Reflection Section questions on page 34 as a class or in small groups:

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? *Students will have individual answers to these questions.*

How do primary forests help conserve biodiversity? *Students will have individual answers to this question. Students should realize that by restricting damaging human activities from occurring in primary forests, managers are protecting the primary forest and allowing a variety of trees, other vegetation, and wildlife to maintain a balanced and healthy ecosystem.*

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

CARBON AND THE WORLD'S FORESTS

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil
- Graphic Organizer for Inquiry 2: Carbon and the World's Forests

METHODS

Have students read the first paragraph and the Did You Know? sidebar on page 34. Ask which students were aware that their body contains carbon. Ask students if the baboons in Figure 5 on page 12 contain carbon. (The answer is "yes." All living things contain carbon.)

The two paragraphs and the figures on page 35 provide information about carbon. Have students read the paragraphs and examine Figure 46. In particular, students should understand the difference between the natural carbon cycle and the influence of humans on the carbon cycle. Students should understand the role that Earth and its living beings play in holding carbon on Earth and maintaining a better balance to the carbon cycle.

Have students read the next two paragraphs about carbon storage and examine Figures 47 and 48. Again, have students rank order the values by continent, then write the continent names in order from most to least in the Graphic Organizer for Inquiry 2: Carbon and the World's Forests (page 84). Have them circle the name of their continent on each figure.

Optional: Have students do the You Do the Math sidebar on page 34. Discuss the amount of carbon held by the world's forests.

Have students read the next paragraph. Discuss the possible implications of a decrease in carbon storage in the world's forests.

Optional: Have students read the sidebar describing the United Nations REDD and REDD+ programs on page 37. Discuss putting a value on forests because they hold carbon on Earth. Do your students think this is a good idea? Why or why not?

Discuss the Reflection Section questions on page 37 as a class or in small groups:

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? *Students will have individual answers to this question. They should realize that by holding carbon on Earth, trees help keep the carbon cycle in better balance. Climate change occurs as the carbon cycle remains unbalanced. A better balanced carbon cycle reduces the rate of climate change and provides benefits to everyone.*

What happens to the carbon that is found in wood furniture and buildings? *Students will have individual answers to this question, and may need your help thinking the question through. Because the wood is not destroyed when it is made into furniture or a home, the carbon that is in the wood stays in the wood.*

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

ECOSYSTEM SERVICES

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil
- Graphic Organizer for Inquiry 2: Ecosystem Services

METHODS

Have students read the first three paragraphs about ecosystem services and examine Figures 50 to 52 (page 38). Hold a class discussion about ecosystem services. Check student comprehension to ensure that they understand the concept of ecosystem services.

Now have students read the next paragraph on page 39 that introduces cultural and spiritual values as ecosystem services. Examine Figure 53. Ask students to identify any cultural or spiritual ecosystem services of which they are aware. Ask students to identify the trend shown in the figure. Examine Figures 54 and 55. Again, have students rank order the values from most to least by continent, then write the continent names in order from most to least in the Graphic Organizer for Inquiry 2: Ecosystem Services (page 85). Have students circle the name of their continent on each figure.

Have students read the sidebar on page 40 about water quality. Hold a discussion about watersheds. Have students discuss the importance of water quality in their community. When students understand what a watershed is (Figure 56 on page 40), have them identify their closest waterway. This could be a stream or a river.

Optional: Order free copies or download copies of the *Natural Inquirer*'s Ecosystem Services edition for more information and activities about ecosystem services. **http://www.naturalinquirer.org**.

Discuss the Reflection Section questions on page 40 as a class or in small groups:

Describe three ecosystem services provided by a nearby natural area. *Students will have individual answers to this question. Some potential answers include ecosystem services such as water protection, wildlife habitat, biodiversity, recreation, and places to feel renewed. The type of ecosystem services mentioned will depend on the area under consideration.*

Do you live in a watershed? Explain why or why not. *Students will have individual answers to this question. Every place on Earth is a part of a watershed, even if no streams or rivers are nearby. When any rain falls or runs underground, it flows in a direction that makes it a part of a watershed. Do additional research if needed so that students become more familiar with their own watershed.*

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

SOIL AND WATER PROTECTION

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil
- Graphic Organizer for Inquiry 2: Soil and Water Protection

METHODS

Have students read the first two paragraphs and examine Figures 57 and 58 (page 41 to 42). Discuss these photographs with your students. Ask your students if they have seen soil erosion. Ask them to discuss how trees and other vegetation protect the soil from eroding.

Have students read the text on page 42 describing clean water and forests. Ask students to examine Figure 59. What does this photograph demonstrate about freshwater?

Ask students to explain why clean water is important to them. Have students write a sentence summarizing the importance of clean freshwater in the Graphic Organizer for Inquiry 2: Soil and Water Protection (page 86).

Now, have students read and examine Figures 60 and 61 on pages 42 and 43. As before, have students rank order the values by continent, then write the continent names in order from most to least in the Graphic Organizer for Inquiry 2: Soil and Water Protection. Have students circle the name of their continent on each figure.

Have students examine Figure 62 and describe the patterns shown by the figure. Discuss the implications of these patterns for the future.

Optional: Order or download the *Natural Inquirer* Freshwater edition for more information and activities about freshwater. **http://www.naturalinquirer.org**.

Discuss the Reflection Section questions on page 43 as a class or in small groups:

What is the source of the freshwater you use? *Students will have individual answers to this question, and may need help answering the question. Sources of freshwater include streams, rivers, lakes, reservoirs, wells, and springs.*

Explain in your own words how forests build new soil. *Students will have individual answers to this question. They should, however, realize that when leaves or needles fall to the ground in*

a forest, they begin to decay and build a layer of rich soil. When trees fall to the ground and are left in the forest, they begin to decay, and this decay also contributes to building soil.

Explain how forests protect soil and water. *Students will have individual answers to this question. They should, however, mention that forest canopies slow down rainfall, causing less soil to be washed away. They may also note that forest floor litter allows rainfall to seep into the ground, protecting the soil from washing away. Roots also help hold soil in place. Students should also realize that by protecting soil, forests also protect water resources by reducing silt and sediment in waterways. When water seeps through the ground, it is filtered by the rocks and other materials underground, reducing the amount of pollutants and sediment entering waterways.*

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

WOOD AND NON-WOOD FOREST BENEFITS

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil

METHODS

Have students read the first two paragraphs on pages 44 to 45 and examine Figures 63 to 66. As they read the paragraphs and captions, stop and hold a short discussion to answer the questions posed. For example, what wood products do students observe around them? Why do they think roundwood is called roundwood?

Have students read the next paragraph and examine Figure 67. Have students look at the line position for each continent in 2011. Have a class discussion about where the students' continent stands in relation to others on this topic.

Ask students to examine Figure 68 to learn how cubic meters of wood are measured. You can also have them read Figure 67 describing how many cubic metres of wood are removed from the world's forests. Then have students read the paragraph on page 46 about woodfuel removals. Discuss any experience students have with using wood for fuel.

Have students read the next two paragraphs and examine the photographs of non-wood forest products (Figures 69 and 70). Hold a class discussion about non-wood forest products. Have students describe experiences they have had using non-wood forest products.

Examine Figure 71 and discuss the concept of non-wood forest products as an economic resource for some countries.

Optional: Read the sidebar about Hawaiian leis on page 47. Ask students how leis might be an economic resource for Hawaiians.

Discuss the Reflection Section questions as a class or in small groups:

What is one advantage of using wood as a material? *Students will have individual answers to this question. Advantages that students may identify are that wood is renewable, it holds carbon on Earth, and it may be readily available to many communities.*

How is wood used in your community? *Students will have individual answers to this question. Brainstorm with your students to identify the many ways that wood is used.*

Name two non-wood products that you have used in the past six months. Were these non-wood products gathered from a nearby forest? *Students will have individual answers to these questions. You can also have students identify how these non-wood forest products were used. For example, were they used as food, decoration, or for clothing?*

INQUIRY 3: HEALTHY FORESTS NOW AND INTO THE FUTURE

PLANNING FOR HEALTHY FORESTS

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil
- Graphic Organizer for Inquiry 3: Planning For Healthy Forests

METHODS

Have students read the first two paragraphs on pages 52 and 53 and examine Figures 76 and 77. Ensure that they understand that people take action to manage forests so that desired benefits are realized. Have students name some of the forest benefits they learned about in Inquiry 2.

Have students read about the definition of "sustainable" and sustainable forest management. Have students examine Figure 78 and ask them to explain how the photograph demonstrates sustainable forest management.

Have students read the text on page 53. As they read the last paragraph, emphasize that people take actions, called sustainable forest management. These actions are taken so that forests provide desired benefits such as forest products and environmental protection today and into the future.

Have students discuss forest management plans. Ensure that they understand that a forest management plan is a written document that describes what forest managers will do to gain forest benefits. Have students discuss whether and why having a forest management plan is a good idea.

Have students examine Figure 79. Ask them to describe the pattern shown in the graph.

Have students examine Figures 80 and 81. As students did with previous figures, have them rank order the values by continent, then write the continent names in order from most to least in the Graphic Organizer for Inquiry 3: Planning For Healthy Forests (page 87). Have students circle the name of their continent for each figure on the graphic organizer.

Optional: Have students read the text on page 54 that defines a forest management plan. Remind them that a forest management plan identifies actions to be taken.

Discuss the Reflection Section questions as a class or in small groups:

Describe in your own words what "sustainable" means. *Students will have individual answers to this question. Sustainable means that something is used in such a way so the benefits it provides continue into the future.*

Do you think having a forest management plan is a good idea? Why or why not? *Students will have individual answers to these questions. They*

should, however, conclude that having a forest management plan is a good idea because through such a plan, specific benefits are identified and then actions are taken to achieve those benefits.

INQUIRY 3: HEALTHY FORESTS NOW AND INTO THE FUTURE

PUTTING FOREST MANAGEMENT TO THE TEST!

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil
- Graphic Organizer for Inquiry 3: Putting Forest Management to the Test

METHODS

Have students read the first two paragraphs on page 55. Ensure that they understand what is meant by forest certification.

Have students read the third paragraph that introduces monitoring. Ensure that they understand that monitoring is done to certify that forests are being managed according to a sustainable management plan.

Have students read the next two paragraphs. Ensure that they understand that forest monitoring and certification are meant to protect the rights of people and to protect the forest environment. Discuss, if appropriate, any indigenous peoples who live or work in a nearby forest or a forest on the students' continent.

Have students examine Figure 82. Ask students what pattern is shown by this graph. Ask students whether, and why, they think this pattern is positive or negative.

Have students examine Table 2 and Figure 83. As they did with previous figures, have students rank order the values by continent, then write the continent names in order from most to least in the Graphic Organizer for Inquiry 3: Putting Forest Management to the Test (page 88). Have them circle the name of their continent for each figure in the graphic organizer.

Have students read the first paragraph on page 56 about the number of forested hectares worldwide under forest certification programs. They may want to review the map of the world's ecozones (see Figure 12).

Have students read the second paragraph on page 56 and discuss the role of tests and schoolwork as a way to monitor their own school progress. Compare and contrast student schoolwork and tests with forest monitoring and certification.

Have students read the third paragraph on page 56. Hold a class discussion about the journal they are reading. Discuss whether the journal might be considered an international report about how the world's forests are progressing toward sustainable forest management. Discuss why or why not this journal would be considered such a report. Discuss whether the FAO report, on which this journal is based, is such a report.

At this point, you can tell students that they will be doing their own analysis to determine how well their own continent is progressing toward sustainable forest management.

Optional: Students may read the sidebar on page 56 about the Forest Service's Forest Inventory and Analysis Program.

Discuss the Reflection Section questions as a class or in small groups:

Everyone benefits when foresters use a forest management plan to guide them. Name a time

when having a plan provided a benefit to you. What was your plan, and how did you benefit from having a plan? *Students will have individual answers to this question. They could have used a plan to study for a test or to accomplish some other goal that was important to them.*

Observe Figure 82. Do you think the number of forested hectares under forest certification will increase or decrease in the future? Why? *Students will have individual answers to these questions. They should notice the trend in the chart showing an increase in the number of hectares under forest management certification over time.*

Observe Figure 84. What is similar about the four countries that used FIA's 15-step program for forest monitoring? All of these countries are in the tropical ecozone.

WORLD'S FORESTS THIRD EDITION SUMMARY

TIME NEEDED

One class period

MATERIALS

(for each student or group of students)

- World's Forests Third Edition
- Blank paper
- Writing utensil
- Graphic Organizer: Summary

METHODS

Have students read the summary on page 59. Their next step will be to review their graphic organizers, as well as the Graphic Organizer: Summary (pages 89 to 91). In small groups, have students review all of the information they have gathered about their continent in comparison with other continents. This information, along with the trend information in the Graphic Organizer: Summary, should give them enough information to evaluate their continent's progress toward sustainable forest management.

Have student groups present their results to the class and give reasons for the conclusions they have drawn.

GRAPHIC ORGANIZER FOR INQUIRY 1

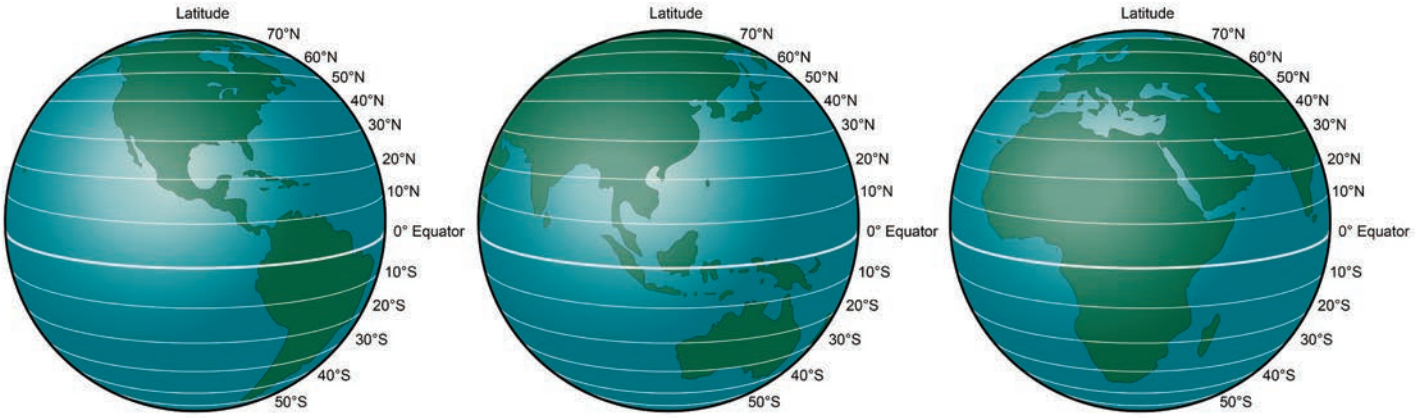
WHAT ARE THE WORLD'S FORESTS AND WHERE ARE THEY FOUND?

EARTH'S CLIMATE AND FORESTS

Write your location. Include your local community name, your country name, and your continent name:

Local community	Country	Continent

Identify your location's latitude using this image. If you have access to a media center or the Internet, identify your latitude to the closest whole degree. Note whether the latitude is north or south of the Equator. Identify a place on Earth at the same latitude but on the opposite side of the Equator.



Illustrations by Stephanie Pfeiffer.

My latitude is _____° _____ (North or South)

Using available resources, identify your location's elevation. Using Figure 9 as a guide, have students estimate their location above sea level and label the figure with that information. Using available resources, identify your location's average yearly rainfall amount and write it here:

_____

Using Figure 11, identify what kind of forests your location should have. Write the vegetation type here:

_____

Identify two similarities and two differences in the forests represented in Figure 12.

_____

_____

_____

_____

_____

_____

GRAPHIC ORGANIZER FOR INQUIRY 1

WHAT ARE THE WORLD'S FORESTS AND WHERE ARE THEY FOUND?

THE WORLD'S CHANGING FORESTS

Rank order your continent by writing the continents in order from most to least forest area. Circle your continent's name in each column.

	Fig. 17 – Forest Area (millions ha)	Fig. 19 – Natural Forest (% TFA)	Fig. 19 – Planted Forest (% TFA)	Fig. 20 – Net Annual Forest Change (millions ha)
Continents in Rank Order from Most to Least				

ha = hectare; TFA = total forest area.

	Fig. 25 – Natural Forest Change (thousand ha)	Fig. 26 – Planted Forest Change (thousand ha)	Fig. 27 – Per Capita Change (ha)
Continents in Rank Order from Most to Least			

ha = hectare; TFA = total forest area.

Draw a picture of an urban forest.

Write a paragraph on what you have learned about the world's changing forests.

GRAPHIC ORGANIZER FOR INQUIRY 2

WHAT BENEFITS DO THE WORLD'S FORESTS PROVIDE?

FORESTS ARE MORE THAN TREES

I live on the _____continent.

Some plants and animals that live on this continent include:

Tree: _____

Mammal: _____

Bird: _____

Insect: _____

GRAPHIC ORGANIZER FOR INQUIRY 2

WHAT BENEFITS DO THE WORLD'S FORESTS PROVIDE?

PRIMARY FORESTS

Rank order your continent by writing the continents' names in order from most to least. Circle your continent's name in each column.

	Fig. 38 – Primary Forest (millions ha)	Fig. 39 – Primary Forest (% TFA)	Fig. 41 – Biodiversity (millions ha)	Fig. 42 – Biodiversity (% TFA)
Continents in Rank Order from Most to Least				

ha = hectare; TFA = total forest area.

	Fig. 43 – Protected Areas (millions ha)	Fig. 44 – Protected Areas (% TFA)
Continents in Rank Order from Most to Least		

ha = hectare; TFA = total forest area.

GRAPHIC ORGANIZER FOR INQUIRY 2

WHAT BENEFITS DO THE WORLD'S FORESTS PROVIDE?

CARBON AND THE WORLD'S FORESTS

Rank order your continent by writing the continents' names in order from most to least. Circle your continent's name in each column.

	Fig. 47 – Carbon Storage (Gt)	Fig. 48 – Carbon Storage (average Gt per ha)
Continents in Rank Order from Most to Least		

Gt = gigatonne; ha = hectare; TFA = total forest area.

GRAPHIC ORGANIZER FOR INQUIRY 2

WHAT BENEFITS DO THE WORLD'S FORESTS PROVIDE?

ECOSYSTEM SERVICES

Rank order your continent by writing the continents' names in order from most to least. Circle your continent's name in each column.

	Fig. 54 – Ecosystem Services Cultural and Spiritual (millions ha)	**Fig. 55 – Ecosystem Services Cultural and Spiritual (% TFA)**
Continents in Rank Order from Most to Least		

ha = hectare; TFA = total forest area.

GRAPHIC ORGANIZER FOR INQUIRY 2

WHAT BENEFITS DO THE WORLD'S FORESTS PROVIDE?

SOIL AND WATER PROTECTION

Clean freshwater is important because

_____

_____

Rank order your continent by writing the continents' names in order from most to least. Circle your continent's name in each column.

	Fig. 60 – Soil and Water Protection (millions ha)	**Fig. 61 – Soil and Water Protection (% TFA)**
Continents in Rank Order from Most to Least		

ha = hectare; TFA = total forest area.

GRAPHIC ORGANIZER FOR INQUIRY 3

HEALTHY FORESTS NOW AND INTO THE FUTURE

PLANNING FOR HEALTHY FORESTS

Rank order your continent by writing the continents' names in order from most to least. Circle your continent's name in each column.

	Fig. 80 – Forests Under a Management Plan (millions ha)	**Fig. 81 – Forests Under a Management Plan (% TFA)**
Continents in Rank Order from Most to Least		

ha = hectare; TFA = total forest area.

GRAPHIC ORGANIZER FOR INQUIRY 3

HEALTHY FORESTS NOW AND INTO THE FUTURE

PUTTING FOREST MANAGEMENT TO THE TEST!

Rank order your continent by writing the continents' names in order from most to least. Circle your continent's name in each column.

	Table 2 – Forests Under Certification Program (millions ha)	Fig. 83 – Forests Under Certification Program (% TFA)
Continents in Rank Order from Most to Least		

ha = hectare; TFA = total forest area.

GRAPHIC ORGANIZER

SUMMARY

Ranking of the _____ continent as it compares with other continents worldwide.

Check the correct ranking in each column for each figure or table that corresponds to the ranking you identified for your continent on the previous pages of this graphic organizer. For example, if your continent was ranked #2 in Figure 17, Forest Area (in millions of hectares), check the column labeled "2" in the row marked "Fig. 17, Forest Area (millions ha)."

Ranking	**1**	**2**	**3**	**4**	**5**	**6**
Fig. 17 – Forest Area (millions ha)						
Fig. 19 – Natural Forest (% TFA)						
Fig. 19 – Planted Forest (% TFA)						
Fig. 20 – Net Annual Forest Change (millions ha)						
Fig. 25 – Natural Forest Change (thousands ha)						
Fig. 26 – Planted Forest Change (thousands ha)						
Fig. 27 – Per Capita Change (ha)						
Fig. 38 – Primary Forest (millions ha)						
Fig. 39 – Primary Forest (% TFA)						
Fig. 41 – Biodiversity (millions ha)						
Fig. 42 – Biodiversity (% TFA)						
Fig. 43 – Protected Areas (millions ha)						
Fig. 44 – Protected Areas (% TFA)						
Fig. 47 – Carbon Storage (Gt)						
Fig. 48 – Carbon Storage (average Gt per ha)						
Fig. 54 – Ecosystem Services, Cultural and Spiritual (millions ha)						
Fig. 55 – Ecosystem Services, Cultural and Spiritual (% TFA)						
Fig. 60 – Soil and Water Protection (millions ha)						
Fig. 61 – Soil and Water Protection (% TFA)						
Fig. 80 – Forests Under a Management Plan (millions ha)						
Fig. 81 – Forests Under a Management Plan (% TFA)						
Table 2 – Forests Under Certification Program (millions ha)						
Fig. 83 – Forests Under Certification Program (% TFA)						

Gt = gigatonne; ha = hectare; TFA = total forest area.

With this summary ranking of your continent on these variables, you can more easily assess the progress your continent is making toward sustainable forest management.

Note that not all continents have the same amount of land area or forest area. A better comparison, therefore, may be to look closely at the percentages rather than the total number of hectares. For example, look at the ranking for Figures 41 and 42 in the graphic organizer above. The ranking for Figure 42 may be the better measure of how well your continent is doing compared with other continents. Why might using percentages be a better measure than using the total number of hectares?

REFLECTION SECTION

In which areas do you believe your continent is doing well in progressing toward sustainable forest management?

In which areas do you believe your continent needs to focus to improve its progress toward sustainable forest management?

Compared with continents worldwide, how well is your continent doing to conserve biodiversity in your forests?

Compared with continents worldwide, how well is your continent doing to conserve ecosystem services and spiritual and cultural values in your forests?

Compared with continents worldwide, how well is your continent doing to manage your forests under a forest management plan?

Compared with continents worldwide, how well is your continent doing to certify the sustainability of the continent's forest management?

What else have you learned about your continent's forests in comparison with the world's other continents?

Overall, how do you think we are doing worldwide to manage our forests sustainably?

EDUCATIONAL CONCEPTS ADDRESSED BY THE INQUIRIES

Note: These educational concepts have been adapted from the North American Association for Environmental Education's Excellence in Environmental Education: Guidelines for Learning, and focus on learning by students aged 11–15.

INQUIRY SKILLS

QUESTIONING SKILLS

Learners are able to identify, develop, or explain Inquiry questions based on personal experience, discussion, or reading.

Learners are able to summarize environmental problems or situations based on personal experience, discussion, or reading.

DATA COLLECTION SKILLS

Learners are able to understand and/or use measurement tools or metrics.

Learners are able to choose and synthesize materials from second-hand sources, such as books, journals, newspapers, and the Internet.

DATA ORGANIZATION SKILLS

Learners are able to read and explain data summarized in tables, charts, graphs, or maps.

Learners are able to draw conclusions and develop explanations based on data or information.

Learners are able to distinguish between description and explanation.

Learners are able to propose explanations and evaluate the strengths and weaknesses of these explanations.

Learners are able to compare and contrast data representing different geographical locations.

KNOWLEDGE OF EARTH SYSTEMS AND PROCESSES

EARTH AS A PHYSICAL SYSTEM

Learners understand and are able to describe the following physical Earth processes:

- Global carbon cycling
- Carbon cycling in trees
- Climate change
- Latitude and its relation to tree species
- Elevation and its relation to tree species

ENVIRONMENT AND SOCIETY

HUMAN/ENVIRONMENT INTERACTIONS

Learners understand and can explain how human-caused changes to forests have consequences: immediately and in the future and locally, regionally, and globally.

NATURAL RESOURCES FORESTS

Learners understand that natural resources (forests) are unevenly distributed across the planet.

Learners understand and can describe the multiple benefits offered by forests.

Learners understand that forests can change because of natural and human activity.

Learners understand that a variety of forests exist on Earth, and this variety may be created naturally or may be caused by people.

TECHNOLOGY

Learners understand the increasing human ability to shape and control the environment as a function of the development and use of technology.

ENVIRONMENTAL ISSUES

Learners understand that environmental issues occur at all scales and that people in other places in the world experience environmental issues similar to the ones they are concerned about locally.

SKILLS FOR UNDERSTANDING AND ADDRESSING ENVIRONMENTAL ISSUES

UNDERSTANDING AND ADDRESSING ENVIRONMENTAL ISSUES

Learners are able to apply their knowledge of ecological and human processes and systems to identify the consequences of specific environmental issues.

Learners understand the nature of trade-offs and are able to analyze the risks and benefits of human environmental actions.

Learners are able to predict the consequences of inaction or failure to resolve an environmental issue.

Learners are able to identify and evaluate solutions and courses of action to address environmental issues.

DECISION-MAKING AND CITIZENSHIP SKILLS

Learners are able to identify, justify, and clarify their views on environmental issues.

WHAT DOES FAO DO?

FAO's Member Nations have given the Organization the task of helping them create a world where no one goes hungry.

So what does FAO do to help build a world without hunger? Its work is divided into four main activities:

INFORMATION

First and foremost, the world needs reliable information about how many people are hungry, who they are, and where they live. To help bring an end to hunger, countries need to have up-to-date and trustworthy information about all sorts of things: food production, prices, trade, land use, nutrition levels, food aid, and population. FAO is the world's leading source for this sort of information and has been so for more than 50 years. Find out more about how FAO provides the world with information by visiting **http://www.fao.org/kids/en/information.html**.

ADVICE

Having mountains of information is essential. But you also need to know how to make sense of all these data to put them to practical use. When governments request assistance, FAO's experts offer advice on how to establish policies on agriculture, forestry, fisheries, and rural development that can truly benefit the hungry.

A MEETING PLACE

Individual countries working on their own cannot bring an end to world hunger. This is a global problem that requires international cooperation on many issues, including agriculture, fisheries, forestry, trade, and the environment. FAO provides the common ground where rich and poor countries can come together to reach international agreements that can help the world's hungry.

FIELDWORK

FAO also helps countries bring technical knowledge and expertise directly to farmers and others. The Organization coordinates thousands of field projects throughout the world. It mobilizes and manages millions of dollars provided by industrialized countries, development banks, and other sources, to make sure these projects are effective.

A great many of these projects are carried out in response to humanitarian emergencies arising from natural disasters or armed conflict.

WHAT IS THE U.S. DEPARTMENT OF AGRICULTURE (USDA), FOREST SERVICE?

The USDA Forest Service is an organization of people who manage, teach about, and study the forests and ranges in the United States of America and worldwide. The Forest Service publishes *Natural Inquirers* on a variety of topics, such as climate change, bioenergy, invasive species, and tropical forests.

The Forest Service worked with FAO to create the *Natural Inquirer* World's Forests edition so that students worldwide can learn about the forests that sustain life on Earth. For more information and to order *Natural Inquirer*, visit http://naturalinquirer.org.

WHAT IS THE CRADLE OF FORESTRY IN AMERICA INTERPRETIVE ASSOCIATION?

The Cradle of Forestry in America Interpretive Association (CFAIA) is a non-profit organization based in Pisgah Forest, North Carolina. The CFAIA strives to help people better understand ecology through recreation and education opportunities. Their projects include the following:

- Campground and recreation area management
- Educational programs and services, including *Natural Inquirer*, *Investi-gator*, *Natural Inquirer* Reader Series, *NSI: Nature Science Investigator*, scientist cards, and *Leaf Prints* (formerly *Nature-Oriented Parenting*)
- Sales of forest-related gifts and educational materials
- Workshops, newsletters, and publications
- Partnership with the Forest Service to provide programming at the Cradle of Forestry Historic Site

http://www.cfaia.org

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NOTES

NOTES

EDITORIAL REVIEW BOARD

The *Natural Inquirer* Editorial Review Board is made up of students between the ages of 11 and 15. The Editorial Review Board reads an early copy of the *Natural Inquirer* and makes suggestions for improvement. The review board for this edition is Mr. Omar Azim's 8th grade class, Royal Oak Middle School, Victoria, British Columbia, Canada.

INTERNET RESOURCES

United Nations: http://www.un.org
Food and Agriculture Organization: http://fao.org
***Natural Inquirer*: http://www.naturalinquirer.org**
International Year of Forests: http://www.un.org/en/events/iyof2011/
Forest Service for Kids: http://www.fs.fed.us/kids/
***Global Forest Resources Assessment 2015*: http://www.fao.org/3/a-i4793e.pdf**
Member States (countries) of the United Nations: http://www.un.org/en/members/index.shtml

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