3–1 What Is Ecology?

“Floods hit Texas!” “Wildfires char three states!” “Drought withers Florida!” Such news often flashes across television screens, newspapers, and the Internet. We are fascinated and frightened by these natural events, but there are other stories, as well. Some tell of projects to restore wetlands in southern Florida and along the Mississippi River for the purpose of controlling floods and droughts. Others report on improvements in air and water quality as a result of changes in the gasoline that we put in our cars. Like all organisms, we interact with our environment. To understand these interactions better and to learn how to control them, we turn to the science called ecology.

Interactions and Interdependence

Ecology (ee-KAHL-uh-jee) is the scientific study of interactions among organisms and between organisms and their environment, or surroundings. The word ecology was coined in 1866 by the German biologist Ernst Haeckel. Haeckel based this term, or surroundings. The word oikos, meaning house, which is also the root of the word economy. Haeckel saw the living world as a household with an economy in which each organism plays a role.

Nature’s “houses” come in many sizes—from single cells to the entire planet. The largest of these houses is called the biosphere. The biosphere contains the combined portions of the planet in which all of life exists, including land, water, and air, or atmosphere. It extends from about 8 kilometers above Earth’s surface to as far as 11 kilometers below the surface of the ocean.

Interactions within the biosphere produce a web of interdependence between organisms and the environment in which they live. Whether it occurs on top of a glacier, in a forest like the one in Figure 3–1, or deep within an ocean trench, the interdependence of life on Earth contributes to an ever-changing, or dynamic, biosphere.

Figure 3–1 Organisms and their environment are interdependent. This giant land snail could not survive without plants and algae to eat, and the plants and algae could not grow unless bacteria and other organisms helped recycle nutrients in the water and soil. Classifying List the organisms that you see in the photograph. Then, list the nonliving parts of the environment with which the organisms interact.
Levels of Organization

To understand relationships within the biosphere, ecologists ask questions about events and organisms that range in complexity from a single individual to the entire biosphere. The many levels of organization that ecologists study are shown in Figure 3–2.

Some ecologists study interactions between a particular kind of organism and its surroundings. Such studies focus on the species level. A species is a group of organisms so similar to one another that they can breed and produce fertile offspring. Other ecologists study or populations of individuals that belong to the same species and live in the same area. Still other ecologists study communities, or assemblages of different populations that live together in a defined area.

Ecologists may study a particular ecosystem. An ecosystem is a collection of all the organisms that live in a particular place, together with their nonliving, or physical, environment. Larger systems called biomes are also studied by teams of ecologists. A biome is a group of ecosystems that have the same climate and similar dominant communities. The highest level of organization that ecologists study is the entire biosphere itself.

What is an ecosystem?

Levels of Organization

To understand relationships within the biosphere, ecologists ask questions about events and organisms that range in complexity from a single individual to the entire biosphere. The many levels of organization that ecologists study are shown in Figure 3–2.

Some ecologists study interactions between a particular kind of organism and its surroundings. Such studies focus on the species level. A species is a group of organisms so similar to one another that they can breed and produce fertile offspring. Other ecologists study populations, or groups of individuals that belong to the same species and live in the same area. Still other ecologists study communities, or assemblages of different populations that live together in a defined area.

Ecologists may study a particular ecosystem. An ecosystem is a collection of all the organisms that live in a particular place, together with their nonliving, or physical, environment. Larger systems called biomes are also studied by teams of ecologists. A biome is a group of ecosystems that have the same climate and similar dominant communities. The highest level of organization that ecologists study is the entire biosphere itself.

What is an ecosystem?
Ecological Methods

Ecologists use a wide range of tools and techniques to study the living world. Some, like the scientists in Figure 3–3, use binoculars and field guides to assess changes in plant and wildlife communities. Others use studies of DNA to identify bacteria in the mud of coastal marshes. Still others use radio tags to track migrating wildlife or use data gathered by satellites.

Regardless of the tools they use, scientists conduct modern ecological research using three basic approaches: observing, experimenting, and modeling. All of these approaches rely on the application of scientific methods to guide ecological inquiry.

Observing
Observing is often the first step in asking ecological questions. Some observations are simple: What species live here? How many individuals of each species are there? Other observations are more complex and may form the first step in designing experiments and models.

Experimenting
Experiments can be used to test hypotheses. An ecologist may set up an artificial environment in a laboratory to imitate and manipulate conditions that organisms would encounter in the natural world. Other experiments are conducted within natural ecosystems.

Modeling
Many ecological phenomena occur over long periods of time or on such large spatial scales that they are difficult to study. Ecologists make models to gain insight into complex phenomena such as the effects of global warming on ecosystems. Many ecological models consist of mathematical formulas based on data collected through observation and experimentation. The predictions made by ecological models are often tested by further observations and experiments.

3–1 Section Assessment

1. **Key Concept** List the six different levels of organization that ecologists study, in order from smallest to largest.
2. **Key Concept** Describe the three basic methods of ecological research.
3. Identify two ways in which you interact every day with each of the three parts of the biosphere—land, water, and air.
4. **Critical Thinking** Applying Concepts Suppose you wanted to know if the water in a certain stream is safe to drink. Which ecological method(s) would you choose, and why?
5. **Critical Thinking** Applying Concepts Give an example of an ecological phenomenon that could be studied by modeling. Explain why modeling would be useful.

3 ASSESS

Evaluate Understanding

Using the diagrams they drew for the Inquiry Activity on page 62, have students write a paragraph describing how the organisms shown in the diagram depend on one another and on nonliving things in their environment.

Reteach

Call on one student to name an individual organism, a second student to identify the population to which the organism belongs, a third student to describe the community of which the population is a part, and a fourth student to describe the community’s ecosystem. Repeat this procedure until every student has had at least one turn.

The information in students’ tables may vary, because students may choose to include any of the populations common in the ecosystems in the area where they live. Each table should include columns for individuals, populations, communities, and ecosystems. Library resources or the Internet could provide students with specific examples of populations that live in the types of ecosystems in their area.

The Biosphere 65

Interactive Textbook

If your class subscribes to the iText, use it to review the Key Concepts in Section 3–1.

**Answer to . . .**

**Discoverer** A collection of all the organisms that live in a particular place, together with their nonliving, or physical, environment.
Chapter 3

After students have read this feature, you might want to discuss one or more of the following:

- From their previous learning, students may know how the destruction of forests affects the global carbon-oxygen cycle and water cycle. Have them share this information in a class discussion. Then, ask: Why is it important for ecologists to be aware of forest destruction? How do you think they would use this information?
- Discuss the role of phytoplankton in the carbon-oxygen cycle. (You may want to have students preview Energy From the Sun on page 68.)

Research and Decide

Have students write a report on what they found in their research on satellite use in ecological studies. Ask students to expand on the discussion in this feature about such use by ecologists and then propose ways governments might use the data collected. For example, a local government might study satellite images over time to find out about wetlands in order to make sure development doesn’t destroy important natural areas.

Students can research the use of satellites in ecology on the site developed by authors Ken Miller and Joe Levine.

FACTS AND FIGURES

Terra in space

Launched in 1999, the school-bus-sized Terra—the “flagship” spacecraft in NASA’s Earth Orbiting System—has been described as “a sort of Hubble Space Telescope aimed at Earth.” The amount of data that Terra collects each day—about 100,000 encyclopedia volumes’ worth—roughly equals the amount of data collected by the Hubble telescope in one year.

Terra circles 705 kilometers above Earth’s surface in a polar orbit that carries it past the equator at 10:30 AM each day, when cloud cover over Earth’s landmasses is minimal. The satellite’s five instruments monitor Earth’s radiation balance, sea surface temperatures, levels of greenhouse gases and changes in land cover use, ice sheet volume, and atmospheric chemistry. Data from Terra also may have practical applications, such as managing crops and coastal fisheries and assessing natural hazards such as volcanic activity, earthquakes, floods, and fires.

Modern research in global ecology would not be possible if all its tools were earthbound. Studies on a planetary scale require enormous data-gathering networks. Through a process called remote sensing, satellites extend the range of information that ecologists can collect within the biosphere.

Remote-sensing satellites are fitted with optical sensors that can scan several bands of the electromagnetic spectrum and convert those bands into electrical signals. The signals are run through a computer and converted into digital values, which are used to construct an image.

Remote sensing provides detailed images of essentially every square meter of Earth’s surface. How else could scientists view all the world’s lakes and oceans to see where concentrations of algae are the highest? Or view areas of destroyed forests in places like the Amazon Basin or northern Russia?

Global Change

The false-color image below was assembled from data gathered by NASA’s Sea-viewing Wide Field-of-view Sensor (SeaWiFS) Project. The project’s goal is to study factors that affect global change and to assess the oceans’ role in the global carbon cycle, as well as other chemical cycles. The different ocean colors indicate varying concentrations of microscopic algae. Blue represents the least amount of algae, and red represents the highest amount. On land, the dark green areas have the most vegetation, and gold land areas have the least.

Remote sensing provides detailed images of essentially every square meter of Earth’s surface. How else could scientists view all the world’s lakes and oceans to see where concentrations of algae are the highest? Or view areas of destroyed forests in places like the Amazon Basin or northern Russia?

Rain Forest Destruction

Satellite images that show the presence or absence of vegetation are useful in studying the effects of human activity on natural ecosystems. The two images above, taken 26 years apart, show the same tract of land in a Brazilian rain forest. Red areas show undisturbed forest, and whitish areas show places where trees have been cut and cleared. Note the “fishbone” pattern of vegetation clearing. This pattern occurs because cutting of forests typically begins along existing roads and rivers and then spreads out as new roads and paths are cut.

Data in images such as these, especially when taken over time, help ecologists estimate the rate at which rain forests are being cut down. These data are also valuable in discussing the effects of development with local governments.

Research and Decide

Use library or Internet resources to learn more about the use of satellites in ecological studies. Decide how ecologists and local governments might use the data in their discussion.