13.1 Ecologists Study Relationships

VOCABULARY

ecology
community
ecosystem
biome

KEY CONCEPT **Ecology is the study of the relationships among organisms and their environment.**

MAIN IDEAS

- Ecologists study environments at different levels of organization.
- Ecological research methods include observation, experimentation, and modeling.

Connect to Your World

Water birds such as anhingas, along with a variety of other plants and animals, rely on the presence of wetlands for their survival. How might the loss of wetland areas affect these aquatic species? Learning about organisms and how they interact with one another, with other species, and with their environment is what the study of ecology is all about.

MAIN IDEA

Ecologists study environments at different levels of organization.

Over their life cycle, Pacific salmon are the main food source for more than 140 species of wildlife, including grizzly bears, as shown in **FIGURE 1.1.** If they are not eaten, their bodies return vital nutrients back into the river system, some of which are used by plants to grow. In addition to their role in the health of river systems, salmon are also important to the Pacific Northwest's economy. Today, many species of wild Pacific salmon are threatened with extinction due to competition from hatchery fish, blocked river paths, and loss of spawning grounds. As salmon populations decline, how are other species affected? What effect would the loss of salmon have on a local and a global scale? These are the types of questions ecologists are trying to answer.

FIGURE 1.1 Salmon are a primary food source for many species, including grizzly bears. If salmon disappeared, species dependent on them would also suffer.

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What Is Ecology?

Ecology is the study of the interactions among living things, and between living things and their surroundings. The word *ecology* comes from the Greek word *oikos,* which means "house." This word origin makes sense if you think of Earth as home and all organisms as members of Earth's household. Ernst Haeckel, a German biologist, coined the term *ecology* in 1866 to encourage biologists to consider the ways organisms interact. Until that time, most scientists studied a plant or an animal as though it existed in isolation—as if it did not affect its surroundings, and its surroundings did not affect it.

Levels of Organization

Ecologists study nature on different levels, from a local to a global scale. These levels, shown in **FIGURE 1.2,** reveal the complex relationships found in nature.

- **Organism** An organism is an individual living thing, such as an alligator.
- **Population** A population is a group of the same species that lives in one area, such as all the alligators that live in a swamp.
- **Community** A **community** is a group of different species that live together in one area, such as groups of alligators, turtles, birds, fish, and plants that live together in the Florida Everglades.
- **Ecosystem** An **ecosystem** includes all of the organisms as well as the climate, soil, water, rocks, and other nonliving things in a given area. Ecosystems can vary in size. An entire ecosystem may live within a decaying log, which in turn may be part of a larger wetland ecosystem.
- **Biome** A **biome** (BY-ohm) is a major regional or global community of organisms. Biomes are usually characterized by the climate conditions and plant communities that thrive there.

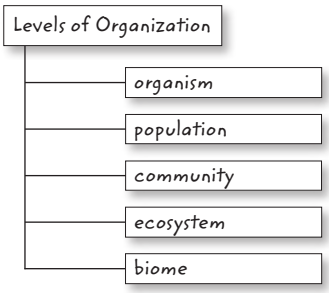
Ecologists study relationships within each level of organization and also between levels. For example, researchers may study the relationships within a population of alligators, as well as the relationships between alligators and turtles in a community.

Apply **What level of organization describes a flock of pigeons in a park?**

READING TOOLBOX

TAKING NOTES

Use a diagram to take notes on the levels of organization.



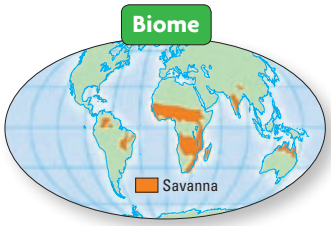
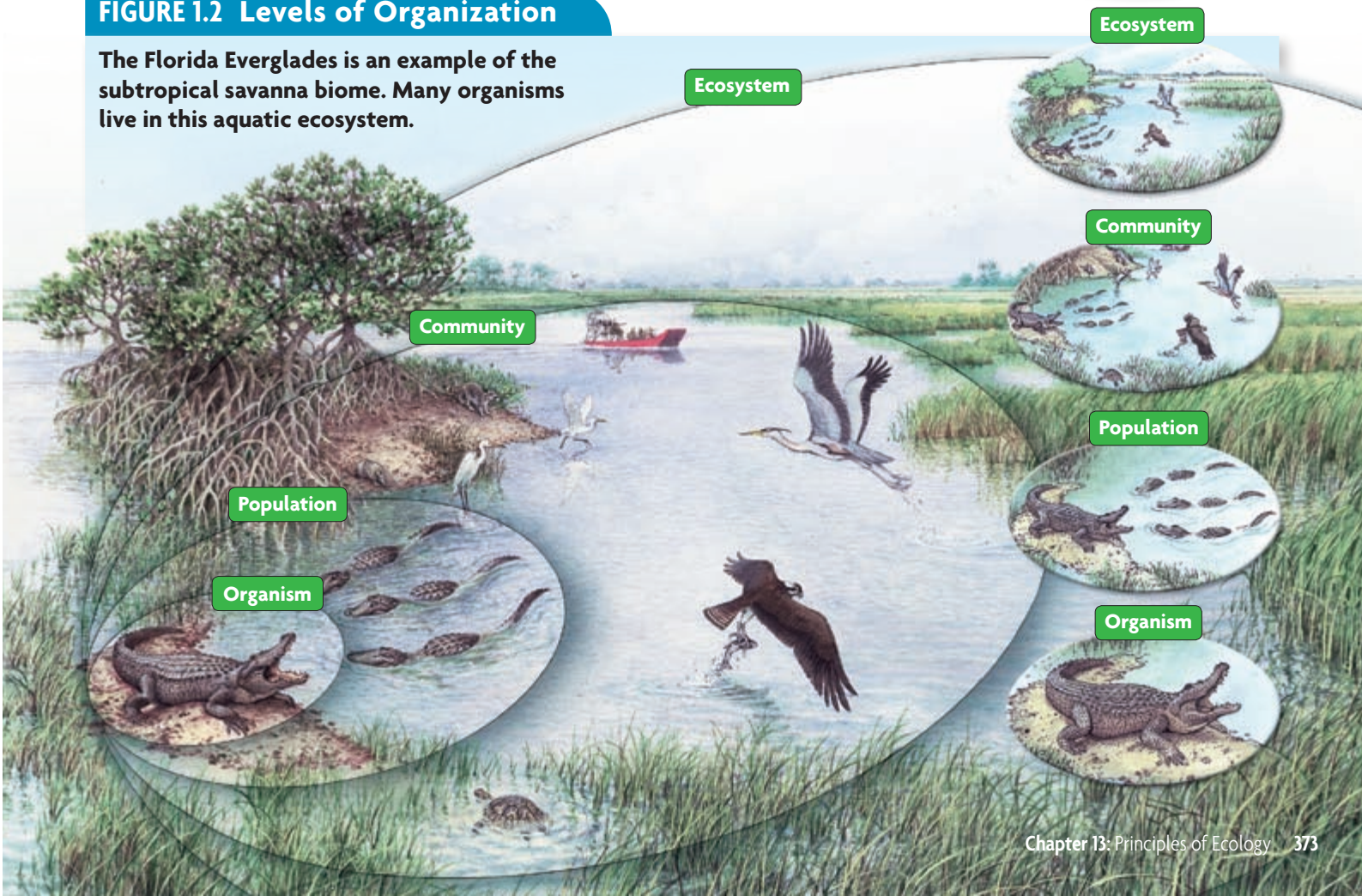


FIGURE 1.2 Levels of Organization

The Florida Everglades is an example of the subtropical savanna biome. Many organisms live in this aquatic ecosystem.



MAIN IDEA

Ecological research methods include observation, experimentation, and modeling.

FIGURE 1.3 Much of the data gathered by ecologists results from long hours of observation in the field. This ecologist is using radio telemetry to track gray wolves.

Scientists rely on a variety of methods and tools to conduct research. Tools can range from a simple tape measure used to find an organism's size to a sophisticated computer system used to create a model of an entire ecosystem.

Observation

Observation is the act of carefully watching something over time. Such observations may occur over short or long periods of time. Long-term studies are a key part of a scientist's toolkit because most environmental changes happen over a long period of time. For example, studies of prairie-dog populations are helping scientists to determine which locations are most appropriate for the reintroduction of the black-footed ferret. The black-footed ferret is an endangered species that relies on the prairie dog as its main food source.

One way that scientists monitor and observe populations is by conducting surveys. Visual surveys may be direct or indirect.

- Direct surveys are used for species that are easy to follow. In these surveys, scientists watch animals either with the naked eye or with tools such as binoculars or scopes.
- Indirect surveys are used for species that are difficult to track. In these surveys, scientists search for other signs of its presence, such as feces or a recent kill.

Radio telemetry is another method used by scientists to monitor populations. Scientists fit an animal with a radio collar that emits a signal and then use the signal to track the animal's movement, as shown in **FIGURE 1.3.** This practice is especially useful when studying a species that has a broad range, such as the gray wolf.

In addition to observing the activities of a species, scientists often determine its population size. Rather than count every individual organism in a large study area, scientists can sample the population instead. Mark-recapture is a method used by scientists to estimate the population size of mobile organisms. For example, to monitor prairie-dog populations, scientists capture and mark prairie dogs with ear tags and then release them back into the wild. When scientists later repeat the survey, the captured prairie dogs will include both marked and unmarked animals. Scientists calculate the ratio of marked to unmarked animals and use this value to estimate the total population size.

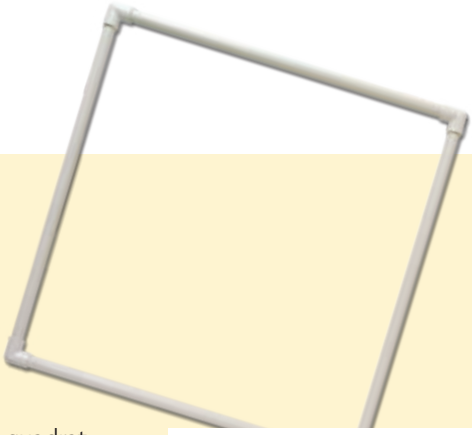
To monitor plant populations, scientists use a method called quadrat sampling. In this method, quadrats, or rectangular frames, are randomly placed on the study site. To determine plant population numbers, scientists identify and count the number of plants within each randomly selected plot. The total number of counted plants is then plugged into a mathematical formula to determine the plant population of the entire study site.

Apply How might a scientist use observation to study a population of mountain goats? Explain your answer.

QUICK LAB SAMPLING

Quadrat Sampling

Ecologists often use quadrats—square or rectangular grids—to collect data about population numbers in an ecosystem. In this lab, you will use a quadrat to collect data on three "species."



PROBLEM What is the population size of each species?

MATERIALS

- quadrat
- meter stick
- calculator
- objects to count

PROCEDURE

1. Obtain a quadrat frame. Measure, calculate, and record the area of the quadrat.
2. Stand at the edge of the area you will sample and randomly throw your quadrat.
3. Move your quadrat so that it does not overlap with any other quadrat. Each different object represents a different species. Count how many individuals of each species are in your quadrat and record your data in a data table. Repeat this procedure three times.
4. Combine your data with that of your classmates. Find the average number of each species for all of the samples. Obtain the area of the sampling plot from your teacher. Calculate how many quadrats would fit in the area of the sampling plot. Multiply this by the average number of each species found in one quadrat to estimate the population of each species.

ANALYZE AND CONCLUDE

1. **Analyze** Compare your population estimate for each species to the actual number that your teacher provides. Is the estimate accurate? Why or why not?
2. **Evaluate** How can you ensure that your estimate of population size will be as accurate as possible?

Experimentation

Scientists may perform experiments in the lab or in the field. There are benefits and drawbacks to each type of experiment. While a lab experiment gives the researcher more control, the artificial setting does not reflect the complex interactions that occur in nature. A field experiment, on the other hand, gives a more accurate picture of how organisms interact in a natural setting. However, in a field study, it is more difficult to determine cause and effect due to the large number of factors at work in nature.

A lab experiment is conducted in a controlled, indoor environment. This isolation helps scientists to focus each experiment on a very specific part of an ecosystem, such as a single organism. For example, to find out how climate change affects the growth rates of plants, scientists can grow plants in a lab and adjust temperature settings. Working in a lab allows scientists to control variables in a way that would not be possible in the field.

A field experiment is performed where the organisms live. Like lab experiments, field experiments also have controls and manipulated variables. For example, to determine how browsing by deer affects plant and small-animal communities, scientists might fence off large study plots to keep out the deer. By monitoring the fenced and unfenced plots over a period of time, scientists can determine whether deer significantly change the areas in which they browse for food.

Contrast **What is the difference between a lab experiment and a field experiment?**

CONNECT TO

SCIENTIFIC METHOD

As you learned in **Biology in the 21st Century**, all fields of science, including ecology, use the scientific method to investigate and answer scientific questions. Applied ecology uses the principles of ecology along with the scientific method to solve environmental problems.

FIGURE 1.4 Ecologists use data transmitted by GPS receivers worn by elephants to develop computer models of the animals' movements.

Modeling

Sometimes the questions scientists wish to ask cannot be easily answered through observation or experimentation. Instead, scientists use computer and mathematical models to describe and model nature. Scientists can manipulate different model variables to learn about organisms or whole ecosystems in ways that would not be possible in a natural setting.

Although they are used to test hypothetical situations, models are created with the use of real data. For example, in Kenya, scientists are using satellite technology to track the movement of elephants, as shown in **FIGURE 1.4.** These data, in turn, can be used to create a model to study how changes to the ecosystem might affect elephant movement patterns. Before putting the model to use, scientists can test it by inserting actual data values. Such testing allows scientists to make sure that the values predicted by the model are similar to actual observations in the field.

In the United States, scientists developed a computer software program to create a virtual model of the Greater Yellowstone ecosystem. A variety of data were used to create this model, including

- the movements of elk, bison, bear, and wolf populations
- the location of different vegetation, such as meadows and forests
- the amount of snow
- the activities of geysers and other geothermal landforms

The combination of these data together with computer-generated maps creates a virtual ecosystem that scientists can use to model how one variable affects another. This type of modeling program sometimes plays a role in the development of wildlife conservation plans. Computer programs modeled population dynamics with and without the presence of the gray wolf. These programs were used to study how the reintroduction of gray wolves into Yellowstone might affect other species within the park and the surrounding area. By understanding how different organisms and factors within an ecosystem interact, wildlife managers are able to make well-informed decisions.

Contrast **How does modeling differ from experimentation?**

13.1 Formative Assessment

REVIEWING MAIN IDEAS

1. What are the five different levels of organization studied by ecologists?
2. Describe the three general methods used by ecologists to study organisms.

CRITICAL THINKING

3. **Apply** What ecological research methods would you use to study bird migration? Explain your choices.
4. **Apply** How might an ecologist use modeling to study fire in a forest **ecosystem**? What might be some key variables used to create the model?

CONNECT TO EVOLUTION

5. Ernst Haeckel was greatly influenced by the writings of Charles Darwin. How do the principles of **ecology** relate to understanding how adaptations occur?