# Chapter 9: Ecology

## Lesson 9.1: The Principles of Ecology & Ecological Organization


How is your school organized? Your school is probably organized at several levels. Individual students and teachers are divided into classes. These classes are organized into an entire high school. Your high school and other nearby schools are organized into a school district. Just like schools are organized, ecosystems are also organized into several different levels, and an ecosystem can be studied at any one of the various levels of organization.

### Lesson Objectives

- Be able to define ecology.
- Describe the different ways that ecology is studied by scientists.
- Describe ecological levels of organization in the biosphere.
- Define ecosystem and other ecological concepts.
- Distinguish between abiotic and biotic factors.

### Lesson Objectives

- abiotic factor
- biomass
- biome
- biosphere
- biotic factor
- community
- competitive exclusion principle
- ecology
- ecosystem
- field studies
- habitat
- modeling
- niche
- population
- sampling
- species
- statistical analysis

### Introduction

Ecology is the study of how living things interact with each other and with their environment. It is a major branch of biology, but has areas of overlap with geography, geology, climatology, and other sciences. This lesson introduces fundamental concepts in ecology, beginning with methods of ecological study.

### Methods of Ecological Study

Ecology is more holistic, or all-encompassing, than some other fields of biology. Ecologists study both biotic and abiotic factors and how they interact. Therefore, ecologists often use methods and data from other areas of science, such as geology, geography, climatology, chemistry, and physics.

#### Field Studies

Ecologist use field studies because generally, they are interested in the natural world. Field studies involve the collection of data in real-world settings, rather than in controlled laboratory settings. The aim of field studies is to collect observations in wild populations without impacting the environment or its organisms in any way.

Ecologists commonly undertake field studies to determine the numbers of organisms of particular species in a given geographic area. For example, the data might help an ecologist decide whether a given species is in danger of extinction.

### Sampling

In field studies, it usually is not possible to investigate all the organisms in an area. Therefore, some type of sampling scheme is generally necessary. For example, assume an ecologist wants to find the number of insects of a particular species in a given area. There may be thousands of members of the species in the area. So, for practical reasons, the ecologist might count only a sample of the insects.

### Statistical Analysis

Like other scientists, ecologists may use two different types of statistical analysis to interpret the data they collect: descriptive statistics and inferential statistics. Descriptive statistics are used to describe data. For example, the ecologist studying insects might calculate the mean number of insects per test plot and find that it is 24. This descriptive statistic summarizes the counts from all the test plots in a single number.

Scientists often want to make inferences about a population based on data from a sample. For example, the ecologist counting insects might want to estimate the number of insects in the entire area based on data for the test plots sampled. Drawing inferences about a population from a sample requires the use of inferential statistics. Inferential statistics can be used to determine the chances that a sample truly represents the population from which it was drawn. It tells the investigator how much confidence can be placed in inferences about the population that are based on the sample.

### Modeling

Ecologists, like other scientists, often use models to help understand complex phenomena. Ecological systems are often modeled using computer simulations. Computer simulations can incorporate many different variables and their interactions. Computer simulations are also working models, so they can show what may happen in a system over time. Simulations can be used to refine models, test hypotheses, and make predictions. For example, simulations of global warming have been used to make predictions about future climates.

## Organisms and the Environment

Organisms are individual living things. Despite their tremendous diversity, all organisms have the same basic needs: energy and matter. These must be obtained from the environment. Therefore, organisms are not closed systems. They depend on and are influenced by their environment. The environment includes two types of factors: abiotic and biotic.

1. Abiotic factors are the nonliving aspects of the environment. They include factors such as sunlight, soil, temperature, and water.
2. Biotic factors are the living aspects of the environment. They consist of other organisms, including members of the same and different species.

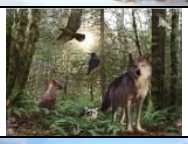
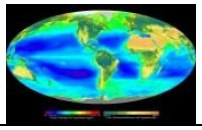
## Levels of Ecological Organization

Ecosystems can be studied at small levels or at large levels:

- An organism is an individual living thing.
- A population is a group of organisms belonging to the same species (a group of individuals that can breed to produce fertile young) that live in the same area and interact with one another.
- A community is all of the populations of different species that live in the same area and interact with one another. A community is composed of all of the biotic factors of an area.
- An ecosystem includes the living organisms (biotic) in an area and the non-living aspects (abiotic) of the environment.
- A biome is a group of ecosystems with the same climate and dominant biotic communities found in different location throughout the biosphere.
- The biosphere includes are the biotic organisms on Earth and the ecosystems they inhabit, including the oceans and the atmosphere.

These ecological levels of organization are summarized for you in Table 9.1 below:

**Table 9.1:** Levels of Ecological Organization

| **Level of Organization** | **Definition** | **Example** |
|---|---|---|
| Individual, Organism<br><br>Species | An individual living thing<br><br>a group of individuals that are genetically related and can breed to produce fertile young |  |
| Population | Organisms of the same species that live in the same area & interact with one another |  |
| Community | Populations of different species that live in same area & interact with one another |  |
| Ecosystem | All living organisms in an area functioning together w/all nonliving physical factors of the environment |  |
| Biome | Group of ecosystems that have same climate & dominant communities |  |
| Biosphere | All the organisms on Earth & areas where they live |  |

Ecologists study ecosystems at every level, from the individual organism to the whole ecosystem and biosphere. They can ask different types of questions at each level. Examples of these questions are given in **Table 9.2** below, using the zebra ( *Equus zebra* ) as an example.

**Table 9.2:** Ecological Sample Questions Based on Levels of Ecological Organization

| **Ecosystem Level** | **Question** |
|---|---|
| Individual | How do zebras keep water in their bodies? |
| Population | What causes the growth of zebra populations? |
| Community | How does a disturbance, like a fire or predator, affect the number of mammal species in African grasslands? |
| Ecosystem | How does fire affect the amount of food available in grassland ecosystems? |
| Biome | In what type of climates do we find large zebra populations? |
| Biosphere | How does carbon dioxide in the air affect global temperature? |

## Individual, Species, or Organisms

An individual is one organism and is also one type of organism (e.g., human, cat, moose, palm tree, gray whale, bacterium, or cow in our example). The type of organism is referred to as the species. There are many different definitions of the word species, but for now we'll leave it simply that it is a unique type of organism. As a grammatical aside, note that the word "species" always ends in an "s". Even if you are referring to just one type of organism, one species, it is a species; there is no such thing as a specie. That's just one of those grammatical facts of life.

Each species that has been studied and described by scientists has been given a two-part name, their binomial or scientific name, that uniquely identifies it (e.g., humans = *Homo sapiens*; domestic cats = *Felis catus*; moose = *Alces alces*; coconut palms = *Cocos nucifera*; gray whales = *Eschrichtius robustus*; cow tapeworms = *Taenia saginata*; and domestic cows = *Bos primigenius*). The power or value of the scientific name is that it makes clear what type of organism you are talking about. Since only one type of organism in the entire world has that unique name, it makes for much clearer communication and understanding than using common names. If you are talking about a gopher, for example, just using its common name like this, you might be referring to a type of mammal that lives underground, a type of snake, or even a type of tortoise, depending on what part of the country you are in.

## Population

It's a group of individuals that all belong to the same species. Populations are geographically based; they live in a particular area. But the size or scale of that area can be variable – we can talk about the human population in a city, a state, a country or a hemisphere. Or we can talk about the population of palm trees on just one island in the Indian Ocean, or on all of the islands that make up the Republic of Seychelles, or all of the islands in the Indian Ocean. The person studying or writing about the population gets to decide what scale to use, what is most appropriate for what they want to study or explain. That's one of the exciting things about science – there's a lot of freedom in defining the scope and scale of your project, but that means it is also important to explain clearly what scale you are using.

Species are made up of populations. How many populations? It all depends. It depends on how widespread the species is and how small or large the geographic area is. Some species have very limited ranges or distributions, being restricted, for example, to a single island or the top of a single mountain in the whole world. The single population on the island or mountaintop makes up the entire species. From a conservation perspective, such populations are extremely vulnerable – if anything happens to that one population, the entire species will be lost; the species will go extinct. But many species are more widespread. There are populations of moose, for example, in Yellowstone National Park, Maine, Minnesota, Alberta, Manitoba and other U.S. states and Canadian provinces. If you want to know how many moose there are on Earth, you have to know the sizes of all the different populations in all the different locations.

## Community

Communities are made up of all the populations of different species in a given area. Why the vague term "in a given area?" Because once again the scale is flexible, determined by the person studying or writing about the community. We might be talking about the community of all the organisms living in the very top or canopy of a single rainforest tree or of all the trees in the forest.

What's most important about the community concept is that it involves multiple populations of all the different species in the given area and how these species interact with each other. Each of the populations is made up of individuals of a particular species, and the individuals interact with each other – with members of their own species (e.g., fighting, grooming, mating, pollinating each other) and with individuals of other species (e.g., hunting them for food, using them as a place to build a nest, growing on them). Community ecologists study the populations in a given area and their interactions. There's another article in this tutorial about different types of ecological interactions.

## Ecosystem

An ecosystem is a unit of nature and the focus of study in ecology. It consists of all the biotic and abiotic factors in an area and their interactions. Ecosystems can vary in size. A lake could be considered an ecosystem. So could a dead log on a forest floor. Both the lake and log contain a variety of species that interact with each other and with abiotic factors.

What's the difference between communities and ecosystems? When you're talking about ecosystems, you're not only looking at all the different populations and species in the given area, but you're also looking at the physical environment, the non-living or abiotic conditions, and not just what they are, but how they impact the organisms, and in some cases how the organisms impact the physical environment. For example, temperature and rainfall patterns influence where different terrestrial species of plants and animals live; some can survive dry desert conditions, others need the high rainfall found in rainforests. But the forests themselves also influence temperature and rainfall patterns. Have you ever noticed on a hot summer day how much cooler and moist it is in the shade of a forest than out in the open?

### Niche

One of the most important concepts associated with the ecosystem is the niche. A niche refers to the role of a species in its ecosystem. It includes all the ways that the species interacts with the biotic and abiotic factors of the environment. Two important aspects of a species' niche are the food it eats and how the food is obtained. Look at **Figure 9.1**. It shows pictures of birds that occupy different niches. Each species eats a different type of food and obtains the food in a different way.

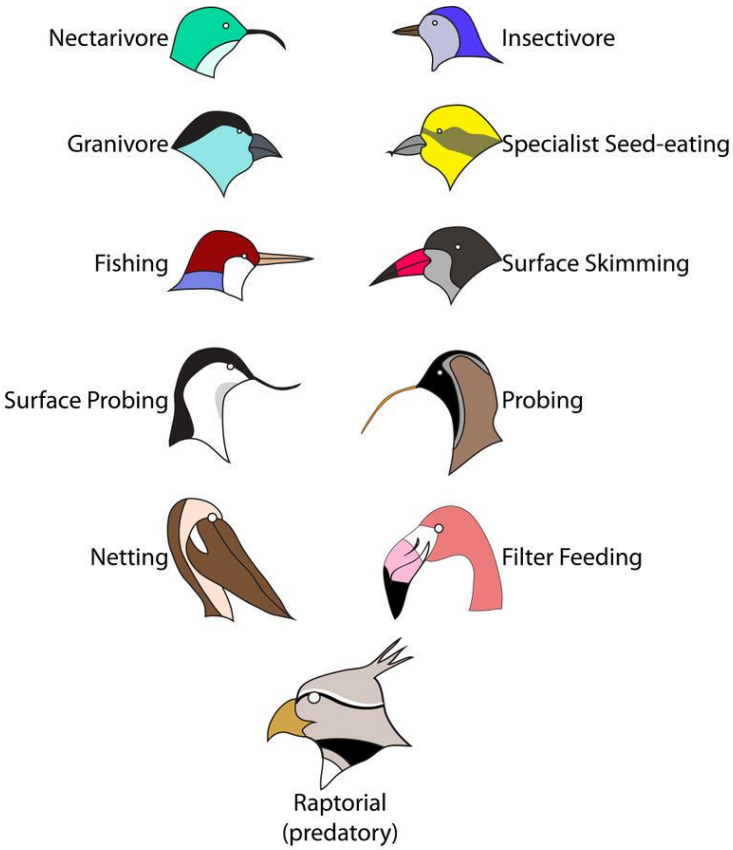



**Figure 9.1**: Bird Niches. Each of these species of birds has a beak that suits it for its niche. For example, the long slender beak of the nectarivore allows it to sip liquid nectar from flowers. The short sturdy beak of the granivore allows it to crush hard, tough grains.

### Habitat

Another aspect of a species' niche is its habitat. The habitat is the physical environment in which a species lives and to which it is adapted. A habitat's features are determined mainly by abiotic factors such as temperature and rainfall. These factors also influence the traits of the organisms that live there.

### Competitive Exclusion Principle

A given habitat may contain many different species, but each species must have a different niche. Two different species cannot occupy the same niche in the same place for very long. This is known as the competitive exclusion principle. If two species were to occupy the same niche, what do you think would happen? They would compete with one another for the same food and other resources in the environment. Eventually, one species would be likely to outcompete and replace the other.

## Biome

A biome, in simple terms, is a set of ecosystems sharing similar characteristics with their abiotic factors adapted to their environments located in different areas of the biosphere (see **Figure 9.2** below). This particular level of organization will be explored more deeply in the next lesson of this chapter.

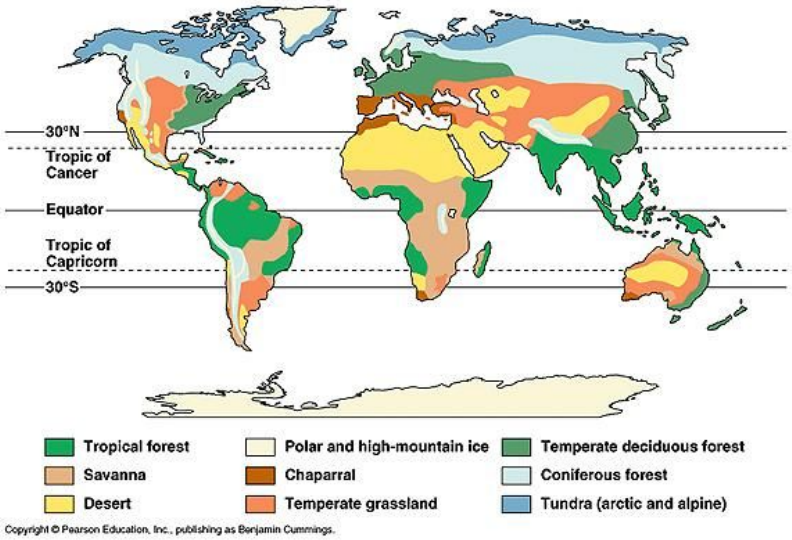



**Figure 9.2** The same type of biomes can be found in very different geographic locations. For example, tropical forest can be found in South America and Asia.

## Biosphere

When we consider all the different biomes, each blending into the other, with all humans living in many different geographic areas, we form a huge community of humans, animals, and plants, in their defined habitats. A biosphere is the sum of all the ecosystems established on Earth.

## Lesson Summary

- Ecology is the study of how living organisms interact with each other and with their environment.
- Abiotic factors are the parts of the environment that have never been alive, while biotic factors are the parts of the environment that are alive, or were alive and then died.
- Ecology is the study of how living things interact with each other and with their environment.
- The environment includes abiotic (nonliving) and biotic (living) factors.
- An ecosystem consists of all the biotic and abiotic factors in an area and their interactions.
- A niche refers to the role of a species in its ecosystem.
- A habitat is the physical environment in which a species lives and to which it is adapted.
- Two different species cannot occupy the same niche in the same place for very long.
- Levels of organization in ecology include the population, community, ecosystem, biome, and biosphere.
- An ecosystem is all the living things in an area interacting with all of the abiotic parts of the environment.

### References/ Multimedia Resources