POPULATIONS and COMMUNITIES

Ecology is the study of organisms and the nonliving world they inhabit. Central to ecology is the complex set of interactions between organisms, both *intraspecific* (between members of the same species) and *interspecific* (between members of different species). *Population ecologists* and demographers study population density, dispersion, and dynamics. They use population growth models to understand current and predict future population changes. Interspecific interactions are studied by *community ecologists.* These include predator-prey interactions, interspecific competition, and a variety of symbiotic relationships. *Ecological succession d*escribes the typical patterns of reestablishing populations observed within a community after a major environmental disturbance.

SECTION 1 - Ecological Levels of Organization

At the fundamental level, ecology should be approached from the perspectives of increasing levels of biological organization. Because at its most focused level of study, ecology investigates the interactions between individuals, population is the lowest organization level of significance.

Population

A group of organisms of the same species living together in the same geographic area constitutes a population. For example, all of the mockingbirds living on the island of Hood in the Galapagos are members of the same population. The mockingbirds on the neighboring island of San Cristobal, while closely related, are actually members of a different species, because the birds cannot and do not interbreed. *Intraspecific interactions* those between members of the same species, are of concern to population ecologists.

Community

A community is the next level of biological organization just after population.
A community includes all of the various species living together within a given habitat. Revisiting Hood from the previous scenario, the mockingbirds along with all of the other organisms whether fungi, plants, or other animals — that occupy the same regions of the island as the mockingbirds and that interact directly or indirectly would constitute a biological community.
Interspecific interactions, those between members of different species, are of concern to community ecologists.

An Ecosystem

All of the biological communities within a given geographic area make up an *ecosystem.* At this level of organization, nonliving factors (called abiotic) become relevant. These include elements like ambient temperature, precipitation levels, and soil quality. Many biotic factors are also significant, including the types of pathogens present, predator population levels, and the effects of human activity.

A Biome

A biome is a large, sweeping geographic area made up of many interconnected ecosystems. An individual biome is characterized by a typical climate and by biological communities with similar adaptations. Most terrestrial biomes (such as tropical rain forests and deserts) are well studied, but both freshwater and marine aquatic ecosystems are less understood due to the practical challenges of studying underwater life.

The Biosphere
The composite of all the biomes that exist on Earth to support life is called the *biosphere.* At its essence, the biosphere is the living portion of the planet.
For now, life as we recognize it exists only on Earth, but ongoing research seeks to discover any forms of life on other planets and in other galaxies.

**The notion of life on other planets has often been exaggerated and sensationalized. Much research is ongoing to discover whether Mars has — or more likely, ever did have — any form of life inhabiting its surface. If so, this organism would likely be similar to some of the earliest life forms that inhabit our own planet - extremophiles* like anaerobes.

SECTION 2 - Populations and Interspecific Interactions

The specific space in a natural environment that an individual organism occupies for survival and reproduction is called its *habitat.* The lifestyle of a particular species within its habitat is referred to as its niche. Members of different species must occupy different niches within a given community in order to allocate resources efficiently, resulting in interesting interspecific interactions (discussed later in this chapter).

Population Density
Population density is a measure of the number of individuals in a population relative to the geographic area those individuals inhabit. In other words, population density is a measure of how crowded individuals are within their habitat. If population density creeps too high, then limiting factors in the environment become increasingly important in affecting the welfare of individual organisms. For example, limiting factors for a population of bacteria living in a Petri dish in a lab include the size of the dish and the availability of essential nutrients supplied in the medium.

Population Dispersion
Population dispersion describes the pattern of distribution of individual organisms throughout their geographic range. Very few populations actually exhibit random distribution; most demonstrate uniform distribution or clumped distribution. Often, *uniform* distribution is associated with behaviors that influence such a pattern. For example, the nesting sites of certain birds are often distributed uniformly as a means of preserving social order in a crowded space. *Clumped distribution,* on the other hand, is often associated with individuals choosing or needing to live close to particular essential resources, or it is observed in individuals that live in natural groups or herds.

Population Dynamics
Factors such as life expectancy, birthrate, and death rate are significant to *demographers,* those who study population growth and describe how the basic makeup of the population changes over time. Numbers of individuals immigrating to or emigrating from the population are also relevant. Demographers assemble graphic displays like *survivorship curves* and *age structure diagrams* to demonstrate the likelihood that individuals will survive to a certain age and the distribution of individuals represented at different age ranges, respectively.

Population Growth

Two basic models describe the growth of populations: exponential and logistic. Exponential *growth* this relatively rare, as it results from a continuous, steady increase in the population size over time. On a graph, this appears as a J-shaped curve. *Logistic growth* is observed more often; this type of growth is eventually slowed and limited by the carrying capacity (K) of the population. This produces an S-shaped curve on a graph.

Carrying Capacity

The *carrying capacity* is determined by the limiting factors in the environment that most severely affect reproduction and/or survival. Some of these factors are described as density-dependent, indicating that their significance depends on the current population numbers. For example, the health effects of an infectious pathogen on a population depend on the number of host organisms that are interacting and the quality of such interactions. Other factors are described as density-independent, including abiotic factors like flash floods and heat waves.

SECTION 3 - Communities and Interspecific Interactions

Interspecific interactions, those between members of different species (and thus different populations) within a community, are central to community ecology. These interactions are examples of emergent factors at the community level of biological organization, for they are not relevant at the population level when only one type of species is being studied.

Predator-Prey Interactions

One of the most significant types of interspecific interactions in a community is that of predator-prey (animals actively consuming other organisms). Adaptations that evolve among the prey population, for example, include physiological and behavioral mechanisms that make it more challenging for the predator to find and/or consume them. For instance, common prey adaptations include *camouflage* (blending into the environment), mimicry (appearing to be something else that is undesirable), and biotoxicity (producing toxic substances harmful to potential predators). Often, biotoxic animals also show warning coloration, using bright body color to discourage future predation. Given that the predator population is ultimately dependent on the prey population, the patterns of predator population growth and decline typically mirror yet lag those of the prey population. For example, as the gazelle population declines, the population of lions eventually declines too. This puts less pressure on the gazelle population, which slowly increases. This eventually supports a larger population of lions, which eventually influences a decrease in the gazelle population once again.

Interspecific Competition

Members of different species often compete for limited resources in an environment, as observed when two species of plants fight for sunlight in the thick canopy of the tropical rain forest. Sometimes shared resource use results in reduced populations of both species. Often, however, one species is much more efficient at obtaining and/or using the resources, resulting in the eventual elimination of the less-efficient species from the community. Other effects of interspecific competition include character displacement and resource partitioning. *Character displacement* results when natural selection has acted on populations within a competitive community in such a way as to produce traits that use resources differently. *Resource* partitioning describes how a species may avoid competition by using only a specific portion of a resource, leaving the remainder for other species to share.

Symbiotic Relationships
Understanding symbiotic relationships is very important to the study of community ecology. Symbiotic relationships are generally described as taking one of three forms. The most common is mutualism, a relationship between organisms that is beneficial to both participants (+/+); examples include lichens (fungi and unicellular photoautotrophs) and flowering plants and their pollinators. Other relationships, like that between a bedbug and its human host, exhibit parasitism, because they benefit one participant while harming the other (+/ —). Finally, some relationships demonstrate *commensalism.* They are beneficial to one participant while neither helping nor harming the other (+/0). Examples of commensalistic relationships are less common in nature and include barnacles residing in the flippers of whales and birds inhabiting the natural notches within a tree.

Species Richness and Species Evenness
Measures of the health and stability of a community include species richness and species evenness, *Species richness* is a measure of the number of different species present within a given community. From the global perspective, species richness increases with movement from either pole toward the equator. On a smaller scale, it is a useful measure in understanding the sensitivity of a community to a potential ecological disturbance. *Species evenness* is a *measure* of the relative abundance of each species within the community. It is, in essence, a measure of a community's biodiversity. It can provide a sense of the balance of ecological roles within an environment (such as producers and consumers).

Community Disturbances and Succession
When a biological community faces a major environmental disturbance, typical patterns of reestablishing populations are observed. If the disturbance is so severe that it results in completely new sediment on which new plant communities must then be established, then the succession is described as primary. *Primary succession* results after events such as a volcanic eruption that covers original sediment in lava or a glacial movement that removes all preexisting layers of productive soil. It proceeds very slowly and is characterized by the initial establishment *of pioneer species,* those that typically are the first to take up residence and establish a new community.
However, if the soil is left intact after a disturbance, then the succession is secondary. *Secondary, succession* is observed in nature much more frequently than primary succession; it is generally seen after a forest fire or flash flood.

**Many symbiotic relationships are often misclassified as commensalistic when they are, in fact, mutualistic. Upon close investigation, an organism usually gains some benefit, even if it is relatively small, by interacting with another.*

ASSESSMENT QUESTIONS

1. Which of the following levels of ecological organization is the least inclusive?
   a. Community
   b. Biome
   c. Biosphere
   d. Population
2. Which of the following are significant emergent factors at the ecosystem level of biological organization?
   a. Abiotic factors
   b. Biotic factors
   c. Population levels
   d. Predator-prey interactions
3. Use the theme of interdependence in nature to describe the concept of interspecific interactions.
4. Extremely territorial animals will most likely exhibit what form of dispersion pattern?
   a. Random
   b. Clumped
   c. Uniform
   d. Unknown from the information provided
5. Which of the following is most correctly associated with an S-shaped growth curve?
   a. Growth limited by the carrying capacity
   b. Bacterial growth
   c. Stable, steady growth
   d. Unregulated growth
6. Use the theme of interdependence in nature to describe the concept of density-dependent limiting factors.

7. In which of the following is the interspecific interaction mismatched with a result?
   a. Predator-prey — prey camouflage
   b. Interspecific competition — resource partitioning
   c. Interspecific competition — character displacement
   d. Commensalism — biotoxicity
8. Which of the following is associated with secondary succession?
   a. New soil in which to establish plants
   b. Very slow growth of populations
   c. Pioneer species
   d. Repopulation from dormant seeds
9. Use the theme of interdependence in nature to describe the concept of predator-prey population dynamics.