

Chapter 5

Biodiversity, Species Interactions, and Population Control

Summary

1. Two major factors affect the number of species in a community: the latitude in terrestrial communities and salinity/nutrients in aquatic systems.
2. Species play different roles in a community. Native species sustain the ecosystem in which they are a part. Some nonnative species will crowd out native species. Indicator species alert us to harmful changes in the community. Keystone species play ecological roles in the specific community: they may assist in pollination help regulate populations. Foundation species affect the community's habitat to benefit other species.
3. Species interact with each other in these different ways: interspecific competition, predation, parasitism, mutualism, and commensalism.
4. As environmental conditions change, one species may be replaced by other groups of species. This gradual change in the composition of species in a given area is called ecological succession.
5. A community has three aspects of sustaining itself: its persistence, the ability to resist being altered, its constant population, and its resilience in repairing damage. High biodiversity may give a community some edge in surviving, but we do not know this for certain.

Key Questions and Concepts

5-1 How do species interact?

CORE CASE STUDY. Sea otters are a keystone species found on the west coast of the United States that are endangered. For many years they have been in recovery. Why should we be concerned about their status? Sea otters are charismatic, they generate tourist revenue, and they are very valuable in terms of controlling biological populations.

- A. Five basic species interactions are competition, predation, parasitism, mutualism, and commensalism.
- B. Competition between species for food, sunlight, water, soil, space, nest sites, etc. is interspecific competition.
 1. With intense competition for limited resources, one species must migrate, shift its feeding habits/behavior, or face extinction.
 2. As humans take more and more space, other species are compromised.
- C. In competitive situations, some species evolve adaptations that reduce/avoid competition for resources.
 1. Over a long time, species evolve more specialized traits that allow them to use shared resources at different times, in different ways, or in different places; this is termed resource partitioning.
 2. Predator-prey relationships define one species (the predator) feeding/preying on another.
 3. Predators have a variety of ways to capture prey. Herbivores feed on immobile plant species; carnivores use pursuit of prey or ambush to capture prey. Some predators use camouflage, and others use chemical warfare (venom) to capture prey or deter predators.
 4. Prey species escape predators in a number of different ways such as swift movement, protective shells, camouflage, or use of chemicals to repel or poison.

SCIENCE FOCUS: Giant kelp forests are very productive and biologically diverse ecosystems. Sea urchins are a major threat to kelp, but sea otters keep their populations in check. Polluted water and the warming of the world's oceans also threaten kelp forests. If kelp forests decline significantly, many other species could be affected.

5. Coevolution is when predator and prey can exert intense natural selection pressures on one another.

- D. Parasitism, mutualism, and commensalism.
 1. Parasites live on or in another species. The host of this arrangement is obviously harmed by it, but the parasite can contribute to biodiversity by controlling the size of specific species populations.
 2. Mutualism is a relationship that benefits both species; these benefits can be in dispersing pollen and seeds for reproduction, in receiving food, or in receiving protection.
 - a. Mutualism is not cooperation; each species exploits the other.
- E. Some species interactions help one species but does nothing for the other; this is commensalism. Examples of this are the bromeliads and orchids (epiphytes).

2. What limits the growth of populations?

- A. Populations change in size, density, and age distribution; most members of populations live together in clumps or groups.
 1. Three general patterns of population distribution occur in a habitat: clumping, uniform distribution, and random dispersion. Most species live in clumps or groups.
 - a. Availability of resources varies from place to place.
 - b. Living in groups offers better protection from predators.
 - c. Some predator species live in packs to have a better chance of getting a meal.
 - d. Temporary groups may form for mating and caring for young.
 2. Uniform pattern distribution may occur where a resource such as water is scarce.
- B. Four variables influence/govern population size: birth, death, immigration, and emigration.
 1. Increase in population occurs by birth and immigration.
 2. Decrease in population occurs by death and emigration.
 3. Age structure of a population is usually described as a pre-reproductive stage, the reproductive stage, and the post-reproductive stage. A population with a large reproductive stage is likely to increase while a population with a large post-reproductive stage is likely to decrease.
 4. Each population has a range of tolerance to variations in the environment.
 5. The limiting factor principle states that too much or too little of a physical or chemical factor can limit population growth even if all other factors are optimal.

SCIENCE FOCUS: Many human activities have had detrimental effects of sea otter populations. Their low reproductive rate has limited their ability to increase in numbers.

- C. Rapidly growing populations typically reproduce early in life, have many offspring, and reproduce many times with short intervals between reproductive events.
- D. There are always limits to population growth in nature.
- E. Environmental resistance is all factors that limit the growth of a population, and largely determine an area's carrying capacity.
- F. Exponential growth starts slow then accelerates, yielding a J-curve.

CASE STUDY. White tailed deer populations were in decline 100 years ago, due to habitat loss and hunting. Subsequent protection and decline in their natural predators led to a drastic increase in their numbers to the extent that they have become a nuisance and even a danger on the urban edge. Efforts to control their populations are very complicated, and in many cases expensive.
- G. Exponential growth leads to logistic growth and may lead to the population overshooting the environment's carrying capacity.
 1. Overshooting an environment's resources often is a result of a reproductive time lag.
 2. The reproductive time lag can produce a dieback/crash of organisms unless the organisms can find new resources or move to an area with more resources.
- H. Carrying capacities can fluctuate seasonally or from year to year.
- I. Species use different reproductive patterns.
 1. Some have many offspring and give them little protection.
 2. Some have few offspring that are cared for by their parents.
- J. Population density is the number of individuals per unit area.
 1. Density-independent population controls affect a population's size regardless of its density.
 2. Density-dependent population controls have a greater affect on the population as its density increases. Infectious disease is an example of density-dependent population control.
- K. Four general types of population fluctuations in nature are: stable, irruptive, cyclic, and irregular.
 1. A stable population fluctuates slightly above and below carrying capacity and is characteristic of many species living under fairly constant environmental conditions.
 2. Some species have a fairly stable population size that may occasionally irrupt to a high peak and then crash to below carrying capacity. This is characteristic of short-lived, rapidly reproducing species.

3. Cyclic fluctuations occur over a regular time period, generally a multiple-year cycle.
- A. Humans are not exempt from population crashes. Examples include the Irish potato famine, the bubonic plague, and the current AIDS epidemic.

5-3 How do communities and ecosystems respond to changing environmental conditions?

- A. With new environmental conditions, community structures can change; one group of species is replaced by another.
1. Ecological succession is the gradual change in species composition of a given area.
 2. Primary ecological succession is the gradual establishment of biotic communities on lifeless ground; in the soil there is no terrestrial community; in an aquatic community, there is no bottom sediment. This process generally takes a very long time.
 3. Secondary ecological succession defines a series of communities with different species developing in places with soil or bottom sediment. The soil or sediment remains after the natural community of organisms has been disturbed, removed, or destroyed.
 - a. Forest fires or deforestation, for example, can convert a particular stage of succession to an earlier stage.
- B. The classic view of ecological succession is that it is an orderly sequence, each stage leading to the next, more stable stage until a climax community is reached. Such a community would represent the balance of nature, one dominated by a few long-lived plant species that is in balance with its environment.
- C. Changes in environmental conditions that disrupt a community can set back succession.
1. Scientists can't predict the course of a given succession in a community toward a stable climax community in balance with its environment.
- SCIENCE FOCUS:** Three factors that affect ecological succession. Facilitation is when a species makes an area more suitable for other species. Inhibition occurs when early successional species hinder the establishment of other species. Tolerance is when later plants are unaffected by plants that came in during earlier stages.
- D. Living systems are sustained through change.
1. Stability, the capacity of an ecosystem to withstand external stress and disturbance, is maintained by constant change in response to changing environmental conditions.
 - a. Inertia or persistence is the ability of a system to survive moderate disturbances.
 - b. Resilience is the ability to be restored through secondary succession.

Teaching Tips

Large Lecture Courses:

Compare and contrast r-selected and K-selected species on the board. Take an example of an r-selected species most of the group will be familiar with. Review some points about its natural history. Next, engage the class in determining how, if they were the researchers, they might determine the carrying capacity of that species. How can K be determined in a humane way? How do we know what K is for humans? What are the inevitable consequences of finding out?

Smaller Lecture Courses:

Most species compete with one another for certain resources. This is a generalization in the biological world. Does it apply to humans? If so, in what way? You might work with the group as a whole, or break them into groups, each focusing on some aspect of human survival, such as agriculture or epidemiology. Are we really free from competition, or are we constantly competing?

Key Terms

age structure
carrying capacity
coevolution
commensalism
ecological succession
environmental resistance
inertia
interspecific competition

limiting factor
limiting factor principle
mutualism
parasitism
persistence
population
population crash
population density

predation
predator-prey relationship
primary ecological succession
range of tolerance
resilience
resource partitioning
**secondary ecological
succession**