# 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 pollution 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 biologic populations.

B. Five basic species interactions are competition, predation, parasitism, mutualism, and commensalism.

C. 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.

D. 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. Example include: insect-eating warblers in Maine forests that eat insects in specific parts of a spruce tree, owls, which hunt at night, and hawks, whcih hunt during the day.

2. Predator-prey relationships define one species (the predator) feeding/preying on another. Individual prey is harmed, but predation can help the population by eliminating the sick, weak, and old.

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, sea urchin, and sea otter populations have evolved to be dependent on each other.

E. 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. Mutually beneficial interactions also exist in ecological environments.

3. 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.

4. Mutualism is not cooperation; each species exploits the other. Examples include:

a. Birds and African buffalo, elephants, and rhinoceroses.

b. Clownfish and anemones.

c. Fungi and plant root associations called mycorrhizae.

F. Some species interaction helps one species but does nothing for the other; this is commensalism. Examples of this are the bromeliads and orchids (epiphytes).

* 1. **How can natural selection reduce competition between species?**

1. Resource partitioning occurs when species competing for similar scarce resources evolve specialized

traits that allow them to use resources at different times, in different ways, or in different places.

* 1. **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.

**SCIENCE FOCUS**: Factors that have affected the southern sea otter’s ability to increase in numbers.

C. No population can grow indefinitely due to limited resources such as light, water, and nutrients and because of competitors or predators.

1. The biotic potential is the population’s capacity for growth.

2. The intrinsic rate of increase (r) is the rate of population growth with unlimited resources.

3. Rapidly growing populations have four characteristics:

a. Individuals in the population reproduce early in life.

b. Individuals have short periods between generations.

c. Individuals have long reproductive lives.

d. Individuals reproduce multiple offspring each time they reproduce.

D. Environmental resistance consists of factors that limit population growth.

1. Carrying capacity (K) is determined by biotic potential and environmental resistance. This is the number of a species’ individuals that can be sustained indefinitely in a specific space.

2. As a population reaches its carrying capacity, its growth rate will decrease because resources become scarcer.

E. A population can grow rapidly with ample resources.

1. With few resource limitations, a population will have exponential growth. This is a fixed rate of growth that will be a J-shaped growth curve as the base size of population increases. This represents its intrinsic rate of increase (r) or biotic potential.

2. This exponential growth is converted to logistic growth when the population gets larger and faces environmental resistance. In logistic growth, the growth rate levels off as population size reaches or nears carrying capacity.

3. The sigmoid (s-shaped) population growth curve shows that the population size is stable, at or near its carrying capacity.

F. When population size exceeds its carrying capacity, organisms die unless they move or switch to new resources.

1. Exponential growth leads to logistic growth and may lead to the population overshooting the environment’s carrying capacity.

a. Overshooting an environment’s resources often is a result of a reproductive time lag.

b. 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.

2. If the carrying capacity of an area is exceeded, changes in the area itself can reduce future carrying capacity. Reducing grass cover by over-grazing allowed sagebrush to move in and reduce the number of cattle that the land could support.

3. Technological, social, and cultural changes have extended the earth’s carrying capacity for human beings, for the time being.

G. The density of a population may or may not affect how rapidly it can grow.

1. Density-independent population controls affect a population’s size regardless of its density. These are abiotic factors in the community.

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.

H. Population sizes may stay about the same, suddenly increase and then decrease, vary in regular cycles, or change erratically.

1. Four general types of population fluctuations in nature are: stable, irruptive, cyclic, and irregular.

2. A stable population fluctuates slightly above and below carrying capacity and is characteristic of many species living under fairly constant environmental conditions.

3. 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.

4. Cyclic fluctuations occur over a regular time period, generally a multiple-year cycle.

5. Irregular behavior is poorly understood. Some scientists attribute irregular behavior to chaos in the system, others disagree.

I. Interaction between predators and their prey change in cycles, appear to be caused by species interactions, but other factors may be involved.

1. Hypothesis of top-down control of prey by predators may not be the only explanation for cyclic boom-and-bust seen in these populations. May also be related to food supply of prey.

2. Bottom-up control hypothesis is that plants consumed too rapidly by prey for replacement to keep up. Have crash of plant predators, and that leads to crash of higher predators of the herbivores.

3. Not mutually exclusive hypotheses, more probably have interaction between predation and food supplies.

**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.

**5-4 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.

a. Pioneer species attach themselves to patches of bare rock to begin the process. Lichens and moss begin the building of soil particles.

b. Early successional plants include tiny annuals that reseed, followed by small perennial grasses, herbs, and ferns and grow close to the ground

c. Mid-successional plants include low shrubs and trees that require more soil and lots of sunlight. This process takes hundreds of years.

d. Late successional plant species are generally tree species that create shade and can tolerate shade to become a complex forest community.

e. Primary succession can also take place in newly created small ponds that over a long period of time will be transformed to a marsh and finally to dry land.

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. Changes in vegetation during secondary succession also change the numbers and types of animals and decomposers also.

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. Three factors have been identified that affect how and at what rate succession occurs:

1. Facilitation—An area is made suitable for a second species by the actions of the first.

2. Inhibition—Early species delay establishment of later species.

3. Tolerance—Later species are unaffected by plants at earlier stages of succession.

C. Changes in environmental conditions that disrupt a community can set back succession.

1. Disturbances such as fire, drought, mining, plowing, climate change, etc. can set back succession to an earlier stage.

2. Large catastrophic disturbances can devastate a community, but in the long run such disturbances create unfilled niches and may encourage greater biodiversity.

3. The intermediate disturbance hypothesis contends that infrequent, moderate disturbances are large enough to create openings for colonizing species, but mild enough for the survival of some mature species in undisturbed areas. There is some evidence to support this hypothesis, but not enough to state that this applies to all types of communities.

**SCIENCE FOCUS**: Factors that effect ecological succession.

D. Scientists can’t predict the course of a given succession in a community toward a stable climax community in balance with its environment.

1. The equilibrium model of succession was thought of as the balance of nature.

2. Ecologists now view a community as a continuous change with instability rather than equilibrium.

3. Succession reflects a struggle for each species to obtain food, light, nutrients, and space to gain an advantage by occupying much of its fundamental niche as possible.

4. The term biotic change better describes the changes occurring than does the term succession, and mature community fits better than climax community when describing a relatively stable community with a mosaic of vegetation patches.

### Key Terms

**commensalism** (p. 101)

**ecological succession** (p. 115)

**inertia** (p. 119)

**interspecific competition** (p. 101)

**mutualism** (p. 101)

**nonnative species** (p. 145)

**parasitism** (p. 101)

**persistence** (p. 119)

**predation** (p. 101)

**primary succession** (p. 115)

**resilience** (p. 119)

**resource partitioning** (p. 107)

**secondary succession** (p. 115)