CHAPTER

14 Interactions in Ecosystems

KEY CONCEPTS

14.1 Habitat and Niche
Every organism has a habitat and a niche.

14.2 Community Interactions
Organisms interact as individuals and as populations.

14.3 Population Density and Distribution
Each population has a density, a dispersion, and a reproductive strategy.

14.4 Population Growth Patterns
Populations grow in predictable patterns.

14.5 Ecological Succession
Ecological succession is a process of change in the species that make up a community.

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Why are these zebras fighting?

For the zebra, life on the African savannah is about survival. Whether escaping the ambush of a pride of lions, walking vast distances to drink fresh water, or competing for the right to mate with females, only the best adapted zebras will survive and pass on their genes. The interactions among organisms, and between organisms and their environment, make ecosystems function.

Connecting CONCEPTS

Adaptation The zebra's stripes are not just for show. They are an adaptation that protect zebras against predators. As the herd moves, the stripes of all the zebras blend together, creating a kind of camouflage that makes it difficult for a predator to pick out just one.

14.1 Habitat and Niche

KEY CONCEPT Every organism has a habitat and a niche.

MAIN IDEAS

- A habitat differs from a niche.
- Resource availability gives structure to a community.

VOCABULARY

habitat, p. 428
ecological niche, p. 428
competitive exclusion, p. 429
ecological equivalent, p. 430

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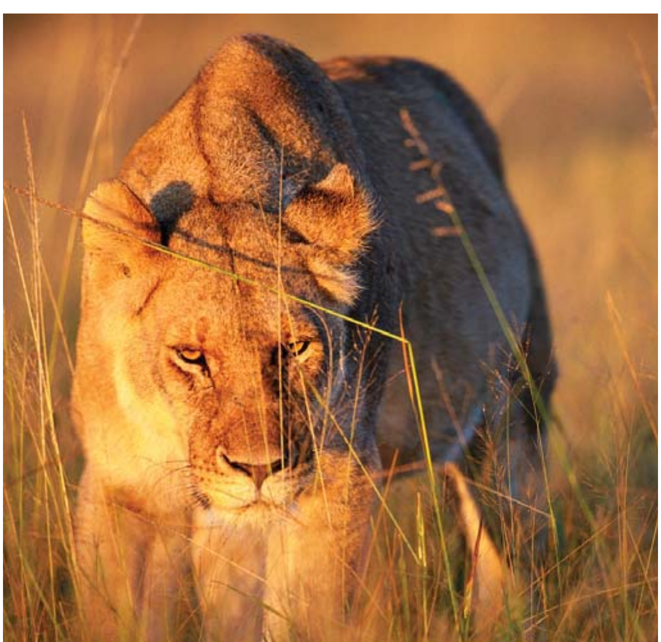
Connect The ways in which a zebra interacts with its environment and other organisms are only a small part of the ecology of the African plains. To understand what individuals, populations, and communities need to survive, ecologists study the interactions among species and between species and their environment. Why does a zebra fit so well into the African savannah?

MAIN IDEA

A habitat differs from a niche.

On the vast plains of Africa, tall grasses grow among trees and shrubs, and small pools of water surrounded by thirsty animals dot the landscape. This challenging environment is the home of the African lion, shown in **FIGURE 14.1**. Here, lions stalk through tall grass to hunt zebras and antelope, find places to rest in the shade of trees, and never stray far from valuable pools of water. These are just a few of the environmental features that make up the lion's habitat. A **habitat** can be described as all of the biotic and abiotic factors in the area where an organism lives. These factors include all aspects of the environment, including the grass, the trees, and the watering holes.

FIGURE 14.1 A lion must hunt and kill its prey in order to survive on the African savannah. Its role as a top predator is part of the lion's niche.



Each species interacts with its environment in a different way. Within an ecosystem, each species has an ecological niche. An **ecological niche** (nihch) is composed of all of the physical, chemical, and biological factors that a species needs to survive, stay healthy, and reproduce.

You can think of a habitat as *where* a species lives and a niche as *how* it lives within its habitat. A niche includes

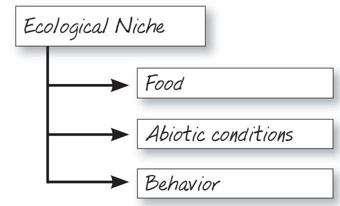
- **Food** The type of food a species eats, how a species competes with others for food, and where it fits in the food web are all part of its niche.
- **Abiotic conditions** A niche includes the range of conditions, such as air temperature and amount of water, that a species can tolerate.
- **Behavior** The time of day a species is active as well as where and when it reproduces are factors in the niche of a species.

Looking closely at all of these factors, we can see that while an antelope may use the tall grasses of the African plains as a food resource, a lion may use the same grasses as camouflage for hunting. A lion uses the antelope as a food resource and hunts primarily during low-light times like dawn or dusk. In order to avoid the intense heat of the savannah, lions often spend afternoons in the shade. These examples are only a few parts of the lion's ecological niche, but they help to give a picture of how a lion fits into the African savannah.

Connect **What are some of the abiotic and biotic factors of your habitat?**

TAKING NOTES

Define *ecological niche* by organizing your notes into a chart.



MAIN IDEA

Resource availability gives structure to a community.

As you learned in Chapter 10, the ability of an individual to survive and reproduce is the driving force behind natural selection. A species needs resources such as food, water, and shelter to be successful in its habitat. The organism that is best suited to obtain these resources is most likely to survive and reproduce. But what if two species are competing over limited resources?

Competitive Exclusion

We have already seen that many species can share similar habitats and that they may use some of the same resources, as shown in **FIGURE 14.2**. But when two species use the same resources in the same ways, one species will always be better adapted to the environment. The principle of **competitive exclusion** states that when two species are competing for the same resources, one species will be better suited to the niche, and the other species will be pushed into another niche or become extinct.

The North American gray squirrel was introduced to Great Britain in the late 1800s. The native European red squirrel was forced to compete with the newcomer for the same food resources, habitat, and space. In this case the gray squirrel was better adapted to the niche and pushed out its smaller competitor. Currently, the red squirrel population is declining due to competition with its larger, more aggressive cousin. But competitive exclusion can also result in other outcomes.

FIGURE 14.2 Even though bees and butterflies both use these flowers for food, they occupy different niches. Many species with similar niches can coexist.

- **Niche partitioning** The two squirrel species could have naturally divided different resources based on competitive advantages. If one type of squirrel ate nuts from the tops of trees while others ate nuts from the ground, the niche would have been divided.
- **Evolutionary response** The two species of squirrel could have experienced divergent evolution. Selection for larger teeth might have allowed one type of squirrel to become better at cracking large nuts, while selection for smaller teeth might have allowed the other to eat small seeds.

FIGURE 14.3 Ecological Equivalents

Animated BIOLOGY Explore survival in a niche at ClassZone.com.

Ecological equivalents are two species that occupy similar niches in geographically separate areas.

The mantella frog (left) and the poison dart frog (right) have evolved similar defense mechanisms. The bright coloration of each is a warning to predators. Each frog secretes a highly poisonous toxin through its skin that makes it an unpleasant meal for a predator.

Synthesize Explain how natural selection resulted in the evolution of two similar frog species in two similar niches.

Ecological Equivalents

The competitive exclusion principle involves species competing for resources in the same community. In different communities, ecological equivalents occur in very similar niches. In mathematics, numbers that are equal are called equivalents. Similarly, **ecological equivalents** are species that occupy similar niches but live in different geographical regions. Pictured in **FIGURE 14.3**, the mantella frog of Madagascar and the poison dart frog of South America have much the same niche in similar habitats. They both have brightly colored skin that secretes a highly poisonous toxin to ward off predators. Both prey on similar insects and live in a similar habitat, but because they live in different regions of the world, they never compete for the same resources.

Apply Are these frogs experiencing competitive exclusion? Explain.

Connecting **CONCEPTS**

Amphibians Amphibians were the first vertebrates to move out of the water and onto land. In **Chapter 25**, you will learn more about amphibians.

14.1 ASSESSMENT

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REVIEWING MAIN IDEAS

1. What are the three parts of an organism's **ecological niche**?
2. What does the principle of **competitive exclusion** say will happen when two species compete for the same resource?

CRITICAL THINKING

3. **Predict** If a group of mantella frogs were transported to the ecosystem of the poison dart frogs, what might happen to the two species' populations?
4. **Analyze** A bison and an elk live in the same **habitat** and feed on the same grasses. Does this mean that the competitive exclusion principle does not apply? Explain.

Connecting **CONCEPTS**

5. **Exotic Species** Considering the competitive exclusion principle, why may it be harmful to transport a species, such as a rabbit, to another habitat where it currently does not exist?

14.2 Community Interactions

KEY CONCEPT Organisms interact as individuals and as populations.

MAIN IDEAS

- Competition and predation are two important ways in which organisms interact.
- Symbiosis is a close relationship between species.

VOCABULARY

competition, p. 431
predation, p. 431
symbiosis, p. 432
mutualism, p. 432
commensalism, p. 432
parasitism, p. 432

Review
community

REVIEW AT CLASSZONE.COM

Connect Each day, two hot dog vendors sell virtually identical products to anyone who is hungry. They may be on different sides of the street, but they are still trying to sell hot dogs to the same hungry consumers. A vendor selling hot pretzels may also be trying to sell to the same customers, but with a slightly varied product. Just like these vendors, organisms constantly compete with one another.

MAIN IDEA

Competition and predation are two important ways in which organisms interact.

Two birds may fight over territories. A fish may prey on insects floating on the water. These are just two examples of the many interactions between species in an ecosystem.

Competition

Competition occurs when two organisms fight for the same limited resources. There are two different types of competition: interspecific competition and intraspecific competition.

Even though they may have different niches, two species may still use similar resources. Interspecific competition occurs when two different species compete for a limited resource, such as space. In a lawn, for example, grass, dandelions, and many other plants all compete for nutrients and water.

Competition also occurs among members of the same species. This is known as intraspecific competition. Individuals of a particular species struggle against one another for limited resources. You can observe intraspecific competition during the spring breeding season of birds. A typical male will share a particular territory with males of different bird species but will not tolerate another male of its own species in the same area.

FIGURE 14.4 Snakes are predators that swallow their prey whole. The hollow fangs of this timber rattlesnake inject venom to paralyze and kill its prey.

Predation

Another way species interact with one another is through predation. **Predation** is the process by which one organism captures and feeds upon another organism. Many organisms, such as the snake in **FIGURE 14.4**, have become highly adapted to hunting and killing their prey.

The timber rattlesnake, for example, is a predator that preys on small animals such as mice, voles, rabbits, and squirrels. Lying silent, hidden among leaf litter on the forest floor, the rattlesnake has found a niche as an ambush predator. A swift bite from the snake's fangs injects its venom. The venom attacks the nervous system and eventually paralyzes the prey. The snake swallows the paralyzed animal whole.

Herbivores can also be considered predators. The deer that eats grass in fields and leaves from trees is preying on the plants.

Evaluate **How does natural selection shape predator–prey relationships?**

MAIN IDEA

Symbiosis is a close relationship between species.

VOCABULARY

The word *symbiosis* comes from the Greek word *sumbios*, which means "living together."

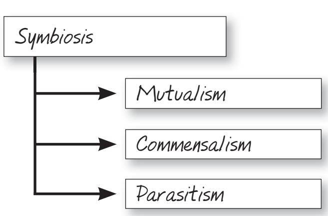
A honeybee buzzes away from a flower with its reward of nectar. Small pollen grains have become attached to the bee's back. When the bee arrives at the next flower, the pollen fertilizes the egg of the next plant. In this way, a relationship, or symbiosis, between the bee and the flower has evolved. **Symbiosis** is a close ecological relationship between two or more organisms of different species that live in direct contact with one another. There are three major types of symbiosis: mutualism, commensalism, and parasitism.

Mutualism

Mutualism is an interspecies interaction in which both organisms benefit from one another. The relationship between the lesser long-nosed bat and the saguaro cactus is another example of mutualism. During the spring, bats help pollinate the cacti through the indirect transfer of pollen as they fly from one cactus to another to feed on flower nectar. When the fruit ripens in the summer, bats become fruit eaters, as shown in **FIGURE 14.5.** The cactus benefits when bats spread its indigestible seeds across the desert.

TAKING NOTES

Mutualism, commensalism, and parasitism are distinct types of symbiosis. Add details with examples of your own.



Commensalism

Another type of symbiotic relationship is commensalism. **Commensalism** is a relationship between two organisms in which one receives an ecological benefit from another, while the other neither benefits nor is harmed. Right now you may be a part of a commensal relationship. Buried deep in the hair follicles of your eyelashes are microscopic mites that feed on the secretions and dead skin cells of your body. These harmless organisms are called demodicids, and they have found their highly specialized niche in your hair follicles.

Parasitism

Parasitism is a symbiotic relationship involving a species that directly harms its host. **Parasitism** is a relationship similar to predation in that one organism benefits while the other is harmed. But unlike a predator, which quickly kills and eats its prey, a parasite benefits by keeping its host alive for days or years. For example, the braconid wasp lays its eggs inside a caterpillar. When the larvae hatch, they eat the caterpillar from the inside out, consuming the nutrients they need to grow into adults.

FIGURE 14.5 Symbiotic Relationships

The interactions between species in an ecosystem can take many different forms. A symbiotic relationship involves interactions between organisms of different species that live in direct contact.

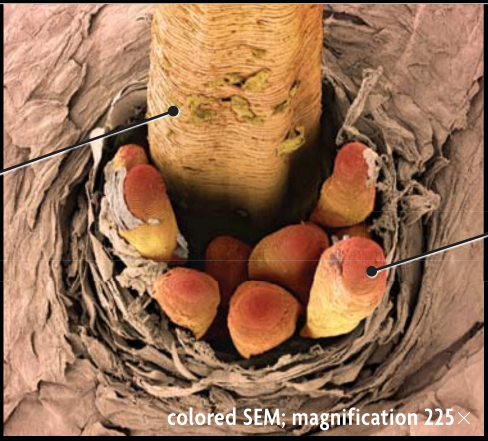
- − Organism is harmed
- 0 Organism is not affected
- + Organism benefits

Parasitism

− **Hornworm caterpillar** The host hornworm will eventually die as its organs are consumed by wasp larvae.

+ **Braconid wasp** Braconid larvae feed on their host and release themselves shortly before reaching the pupae stage of development.

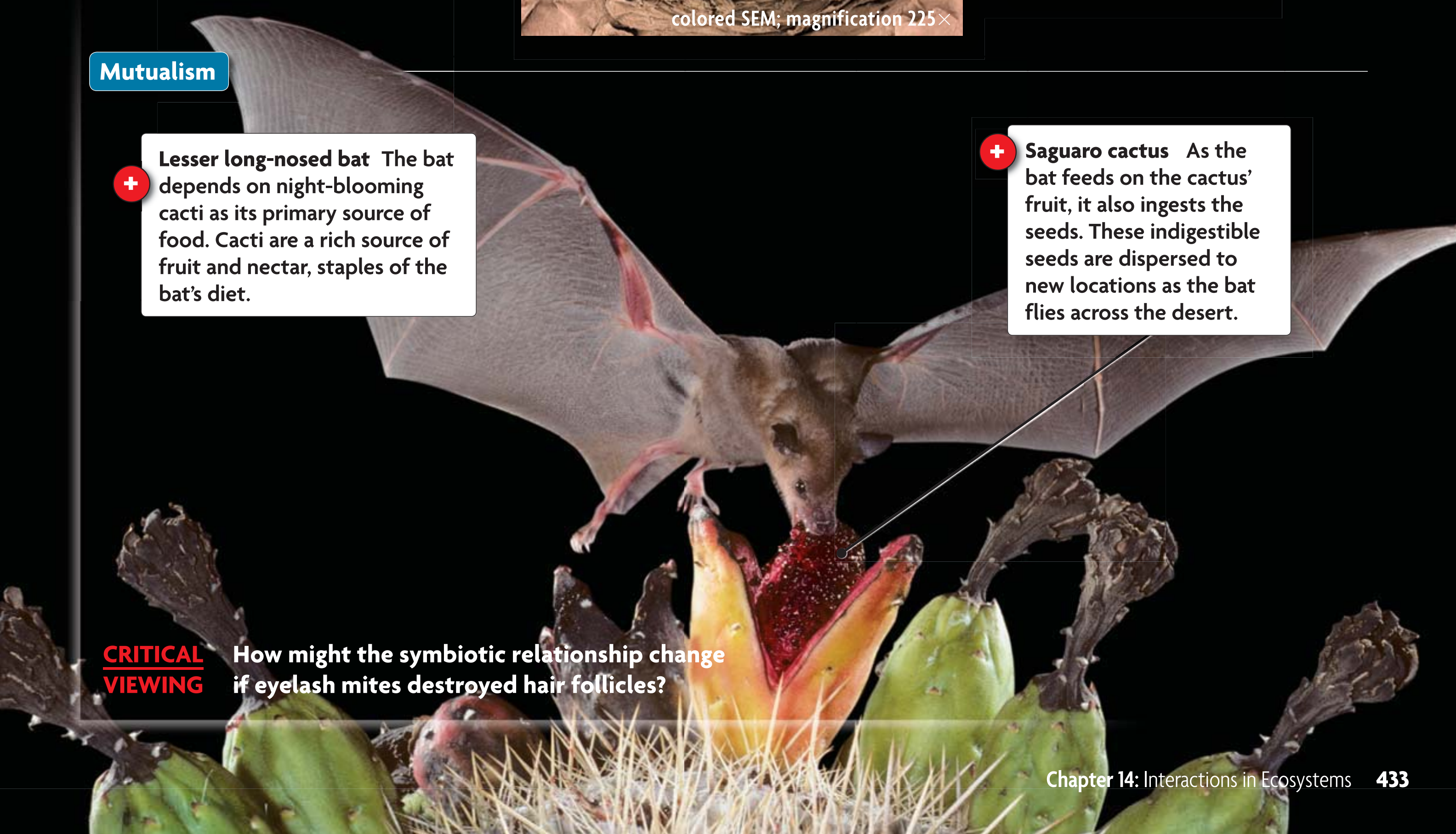
Commensalism


colored SEM; magnification 225×

0 **Human** Our eyelashes are home to tiny mites that feast on oil secretions and dead skin. Without harming us, up to 20 mites may be living in one eyelash follicle.

+ **Demodicids** Eyelash mites find all they need to survive in the tiny follicles of eyelashes. Magnified here 225 times, these creatures measure 0.4 mm in length and can be seen only with a microscope.

Mutualism



+ **Lesser long-nosed bat** The bat depends on night-blooming cacti as its primary source of food. Cacti are a rich source of fruit and nectar, staples of the bat's diet.

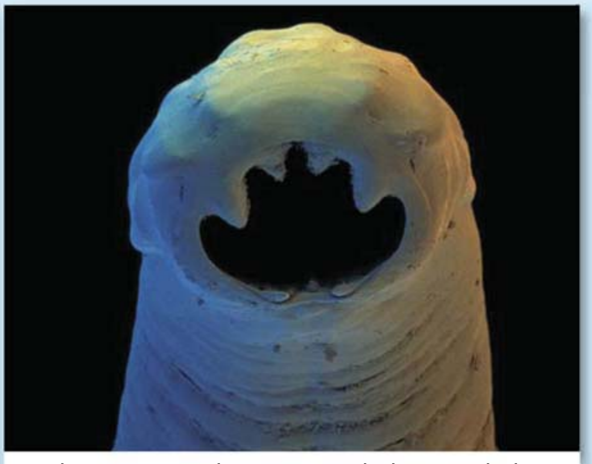
+ **Saguaro cactus** As the bat feeds on the cactus' fruit, it also ingests the seeds. These indigestible seeds are dispersed to new locations as the bat flies across the desert.

CRITICAL VIEWING **How might the symbiotic relationship change if eyelash mites destroyed hair follicles?**

FIGURE 14.6 Human Parasites: Inside and Out

Humans can get parasites in many ways. Leeches attach to the exposed skin of humans. By penetrating human skin, hookworms find their home in the digestive tract.

Many leeches feed on the blood of a host organism. Freshwater leeches such as this one can grow to lengths of 12 cm or more.



Hookworms are endoparasites with sharp teeth that attach to the intestinal wall of a host organism and absorb nutrients for food. (colored SEM; magnification 200×)

Hypothesize **Why is it important for ectoparasites to stay undetected by their hosts?**

Connecting CONCEPTS

Invertebrates Leeches and hookworms are classified as invertebrates. In **Chapter 23**, you will learn more about invertebrate diversity.

The needs of a parasite are met by a host—the victim of the parasite. There are two different ways that parasites can use their host. An ectoparasite makes its home on the exterior of an organism, attaching itself to the outside of the host and usually feeding on its fluids. Common ectoparasites include fleas, ticks, and leeches, such as the one seen in **FIGURE 14.6.** Many types of ectoparasites are also known to carry a wide variety of diseases that can affect their host. Parasites can also be found inside of living organisms. Endoparasites live in the tissues and organs of a host where, safely hidden, they feed on the nutrients ingested by their host. Large endoparasites, such as tapeworms and hookworms, and smaller protozoan endoparasites can kill their host if not treated.

Connect **What type of symbiosis is the relationship between a dog and its owner?**

14.2 ASSESSMENT

ONLINE QUIZ
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REVIEWING MAIN IDEAS

1. During the fall spawning of salmon, grizzly bears fight over space on the banks of a river. What type of **competition** is this?
2. Describe and give examples of the three types of **symbiosis.**

CRITICAL THINKING

3. **Compare and Contrast** How are **predation** and **parasitism** similar? How do they differ?
4. **Synthesize** After a lion has made a kill, birds will sometimes arrive to pick at the leftover carcass. Which are the predators: the birds, the lion, or both? Why?

Connecting CONCEPTS

5. **Animal Behavior** You have probably heard the saying "There is safety in numbers." Why might traveling in a large group be beneficial to prey species?

MATERIALS
- 21 × 27 cm^2 grid paper
- 400 uncooked rice grains
- toothpick

PROCESS SKILLS
- **Modeling**
- **Analyzing Data**

Modeling Predation

In this lab, you will model predation and the effects of changes in the environment on organisms. Blue herons are large birds that live in aquatic habitats and feed on fish, frogs, salamanders, lizards, small snakes, and dragonflies. You will model a lake filled with fish.

PROBLEM How do changes in environmental factors affect the predation habits of the blue heron?

PROCEDURE
1. Spread 200 rice grains over the grid. The grid represents the lake from which the heron feeds, and the rice grains represent fish.
2. A blue heron will catch an average of two fish per hour during daylight. To model the heron hunting for fish, close your eyes and lower the end of the toothpick slowly down onto the grid.
3. Remove the grains that are in the square touching the toothpick. Count the grains.
4. Rearrange the remaining grains on the grid, and repeat steps 2 and 3 five more times to model one day's worth of feeding for the heron. Count the total number of grains removed, and record this number in a data table like the one shown below.
5. Repeat steps 2–4 five more times to represent six total days of feeding by the heron.
6. Return all of the removed rice grains to the grid. Runoff containing large amounts of nitrates causes an algal bloom in the lake. When the algae die and decomposition occurs, the oxygen level in the lake becomes very low, causing fish to die. Remove 150 grains from the grid. Repeat steps 2–5. Make a second data table and record your data.
7. Return all of the removed grains to the grid. The fish in the lake spawn during the spring. To model this, add another 200 grains to the grid. Repeat steps 2–5. Make a third data table and record your data.

TABLE 1. NUMBER OF FISH CAUGHT PER DAY

Day	1	2	3	4	5	6
No. of Fish Caught						

ANALYZE AND CONCLUDE
1. **Graph Data** Construct a graph to represent your data.
2. **Analyze** How was the amount of food caught by a heron related to changes in biotic and abiotic factors?
3. **Infer** How might abundant amounts of food allow herons to reproduce more often?
4. **Predict** How would the populations of amphibians and small reptiles be affected if the fish population in the lake remained low for an extended period of time?

14.3 Population Density and Distribution

KEY CONCEPT Each population has a density, a dispersion, and a reproductive strategy.

MAIN IDEAS

- Population density is the number of individuals that live in a defined area.
- Geographic dispersion of a population shows how individuals in a population are spaced.
- Survivorship curves help to describe the reproductive strategy of a species.

VOCABULARY

population density, p. 436
population dispersion, p. 437
survivorship curve, p. 438

REVIEW AT CLASSZONE.COM

Connect If you have ever traveled from a rural area into a city, you may have noticed a change in population density. Cities have more dense populations, while rural areas have more widely dispersed populations. Scientists measure species populations in a similar way. What can we learn from population data?

MAIN IDEA

Population density is the number of individuals that live in a defined area.

The wandering albatross may fly over open ocean waters for days or weeks at a time without ever encountering another bird. In contrast to this solitary lifestyle, elephant seals may gather in groups of a thousand or more on California beaches. By collecting data about a population in a particular area, scientists can calculate the density of a population. **Population density** is a measurement of the number of individuals living in a defined space.

Calculating an accurate population density can tell scientists a great deal about a species. When scientists notice changes in population densities over time, they work to determine whether the changes are the result of environmental factors or are simply due to normal variation in the life history of a species. In this way a wildlife biologist can work to make changes that will help to keep the population healthy. One way to calculate population density is to create a ratio of the number of individuals that live in a particular area to the size of the area. This formula is simplified as follows:

$$\frac{\text{\# of individuals}}{\text{area (units}^2\text{)}} = \text{population density}$$

For example, if scientists sampling a population of deer counted 200 individuals in an area of 10 square kilometers, the density of this deer population would be 20 deer per square kilometer.

Connect What might a decrease in the density of a deer population over a specific time period tell scientists about the habitat in the area?

***Connecting* CONCEPTS**

Gene Flow Recall that in **Chapter 11** you learned about gene flow and geographic isolation. Population dispersion patterns influence the rate of gene flow among and between species.

FIGURE 14.7 Dispersion Patterns

Dispersion patterns help us understand species interactions by showing how populations group together.

CLUMPED DISPERSION

Many species of fish swim together in large groups called schools. By moving as a large mass, individuals have an advantage in avoiding predators.

UNIFORM DISPERSION

Nesting sites of the gannet show uniform distances for protection of eggs from other males. Territorial organisms generally display uniform dispersion.

RANDOM DISPERSION

The three-toed tree sloth, a solitary animal, spends most of its life in the canopy of tropical forests. The sloth has almost no competitors and has few natural predators.

MAIN IDEA

Geographic dispersion of a population shows how individuals in a population are spaced.

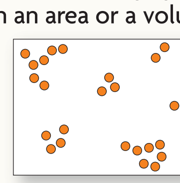
Other information can be gained from population density measurements. Patterns of geographical dispersion give us ideas of how individuals of the same species interact and how different species interact with one another. **Population dispersion** is the way in which individuals of a population are spread in an area or a volume. **FIGURE 14.7** shows the three types of population dispersion.

- **Clumped dispersion** Individuals may live close together in groups in order to facilitate mating, gain protection, or access food resources.
- **Uniform dispersion** Territoriality and intraspecies competition for limited resources lead to individuals living at specific distances from one another.
- **Random dispersion** Individuals are spread randomly within an area or a volume.

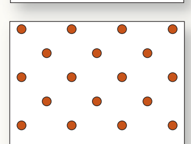
VISUAL VOCAB

Population dispersion is the way in which individuals of a population are spread in an area or a volume.

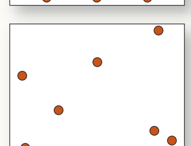
Clumped dispersion



Uniform dispersion



Random dispersion



Infer **What type of intraspecies interaction might cause uniform dispersion?**

QUICK LAB **INTERPRETING DATA**

Survivorship Curves

In this lab, you will make a type 1 survivorship curve using data from the obituary section of a newspaper.

MATERIALS
- obituary section of a newspaper
- graph paper

PROBLEM What is the trend in data for type 1 survivorship curves?

PROCEDURE
1. Obtain the obituary section of the newspaper.
2. Create a data table like the one at right that extends to include five-year age groups up to 91–95 years.
3. For 35 obituaries, place a tally next to the age group in which the individual died.
4. Subtract the number of individuals that died from the number of remaining survivors, and record the answer in the third column of your data table. Calculate the percent surviving in each age group by dividing the number of survivors by 35 and multiplying by 100. Repeat this step for all age groups.

TABLE 1. SURVIVORSHIP DATA

Age (years)	Deaths	Survivors	% Surviving
0–5	I	35 – 1 = 34	97
6–10	I	34 – 1 = 33	94
11–15	0	33 – 0 = 33	94
16–20	IIII	33 – 4 = 29	83
21–25	I	29 – 1 = 28	80

ANALYZE AND CONCLUDE
1. **Graph Data** Draw a survivorship curve by plotting the age group on the *x*-axis, and the percent survivors on the *y*-axis.
2. **Analyze** Explain the trend in the data.

MAIN IDEA

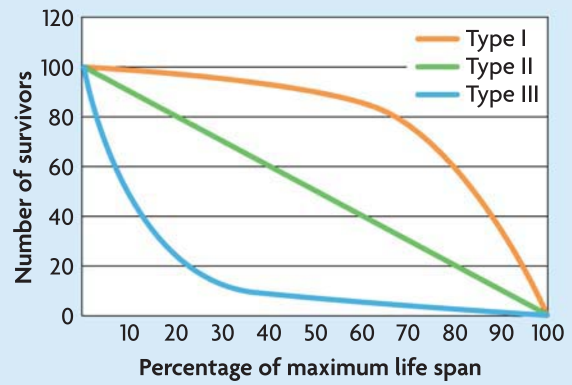
Survivorship curves help to describe the reproductive strategy of a species.

The California red-legged frog of the western United States is an amphibian that reproduces by laying 2000 to 5000 eggs in late winter and early spring. In one to two weeks, these eggs hatch, and over the next four to seven months, the tadpoles grow into frogs. If so many eggs are laid, why is this frog a threatened species in much of the western United States?

Many predators feed on the eggs of the red-legged frog, so of the thousands of eggs laid, only a small number of offspring will survive to adulthood. This type of reproductive strategy is to produce a lot of offspring. Species use many other reproductive strategies as well. Survivorship curves illustrate how offspring survival from birth to death fits in with the survival strategies of a particular species.

A **survivorship curve** is a generalized diagram showing the number of surviving members over time from a measured set of births. By measuring the number of offspring born in a year and following those offspring through until death, survivorship curves give information about the life history of a species. For example, we will begin with 100 coyotes born in year zero. After one year, 10 of those baby coyotes died from disease or predation. Of the original 100, 90 are left. During year two, 4 more coyotes die, leaving 86 of the original 100. In year three, 3 more die, leaving 83 of the original 100. The number of individuals surviving from year to year decreases, but a substantial portion of the group will live a full life and reproduce. In **FIGURE 14.8**, you can see the three basic patterns of animal survivorship curves.

FIGURE 14.8 SURVIVORSHIP CURVES



Type I The graph shows a type I survivorship curve in orange. Type I survivorship represents a life history that is common among large mammals, including humans. The curve shows a low level of infant mortality and a population that generally will survive until old age. A behavior that most organisms showing type I survivorship share is parental care for the young. Most infant organisms are unable to care for themselves. By protecting their young, parents are better able to ensure that their offspring stay alive until they can survive on their own.

Type II Organisms such as birds, small mammals, and some reptiles show a survivorship rate that is roughly equal at all ages of an organism's life. At all times, these species have equal chances of living and dying, whether from disease or as a result of predation. A type II survivorship curve is shown in green on the graph.

Type III Organisms with type III survivorship (shown in blue) have a very high birth rate and also a very high infant mortality rate. Species with type III survivorship are generally invertebrates, fish, amphibians, and plants. Many of their offspring will die from predation, but inevitably a few will survive to adulthood and be able to pass their genes on to the next generation. Though the California red-legged frogs are threatened largely because of habitat loss and pollution, the frogs are also targets of high levels of predation at an early age, making recovery for this species especially difficult.

Synthesize Is there any connection between survivorship curves and reproductive strategies? Explain.

NSTA SCILINKS scilinks.org

For more information about populations and communities, go to scilinks.org.

Keycode: MLB014

14.3 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. A shoreline mussel species has a **population density** of one organism per square meter. Will all mussels be found one meter apart? Explain.
2. Draw and label a diagram showing the three **population dispersion** patterns.
3. How do **survivorship curves** show three types of reproductive strategies?

CRITICAL THINKING

4. **Analyze** What might be the advantages of having a clumped dispersal pattern?
5. **Infer** An organism has ten offspring. Two of these offspring die each year over a five-year period. Is the organism more likely to be a bird or an insect? Explain.

Connecting CONCEPTS

6. **Abiotic Factors** On the African savannah, what types of abiotic factors may lead to high population density and clumped dispersion patterns?

14.4 Population Growth Patterns

KEY CONCEPT Populations grow in predictable patterns.

MAIN IDEAS

- Changes in a population's size are determined by immigration, births, emigration, and deaths.
- Population growth is based on available resources.
- Ecological factors limit population growth.

VOCABULARY

immigration, p. 440
emigration, p. 440
exponential growth, p. 441
logistic growth, p. 441
carrying capacity, p. 442
population crash, p. 442
limiting factor, p. 443
density-dependent limiting factor, p. 443
density-independent limiting factor, p. 444

REVIEW AT CLASSZONE.COM

Connect That banana you left in your backpack did not go unnoticed. After one week, you open your bag and dozens of tiny insects swarm out. The smell of rotting fruit follows close behind. Only a week ago, the population of fruit flies in your backpack was zero. Just before you opened it, the population had grown to several dozen. How did this population grow so quickly?

MAIN IDEA

Changes in a population's size are determined by immigration, births, emigration, and deaths.

The size of a population is usually changing. If resources such as food and water are abundant, or plentiful, a population may grow. On the other hand, if resources are in short supply, the population may decrease in size. Hopefully, the normal fruit fly population in your backpack is zero. But if an abundance of resources, such as an overripe banana, becomes available, the population will increase dramatically. However, when the resources are removed, the fruit fly population in your backpack will once again return to zero. Four factors affect the size of a population.

- **Immigration** When one or two fruit flies found the banana, they immigrated into your backpack. **Immigration** is the movement of individuals into a population from another population.
- **Births** Additional fruit flies were born in your backpack. Births increase the number of individuals in a population.
- **Emigration** After you opened your backpack, some fruit flies flew out and left to find other rotting fruit. **Emigration** is the movement of individuals out of a population and into another population.
- **Deaths** You might have squashed a couple of unlucky fruit flies as you were opening your backpack. The size of a population decreases when individuals die.

VOCABULARY

The word *immigrate* comes from the Latin word *immigrare*, meaning "to go into," and the word *emigrate* comes from the Latin word *emigrare*, meaning "to move."

Apply When a population is declining, what two factors are likely outpacing what other two factors?

MAIN IDEA

Population growth is based on available resources.

Population growth is a function of the environment. The rate of growth for a population is directly determined by the amount of resources available. A population may grow very rapidly, or it may take a bit of time to grow. There are two distinct types of population growth.

Exponential Growth

When resources are abundant, a population has the opportunity to grow rapidly. This type of growth, called **exponential growth,** occurs when a population size increases dramatically over a period of time. In **FIGURE 14.9**, you can see that exponential growth appears as a J-shaped curve.

Exponential growth may occur when a species moves to a previously uninhabited area. For example, in 1859 an Australian landowner returning home from England brought 24 European rabbits to the country for the purpose of sport hunting. The rabbits were introduced into an environment that had abundant space and food and no predators fast enough to catch them. The initial population of 24 rabbits grew exponentially and spread across the country. After many attempts to control the population, today there are between 200 million and 300 million rabbits in Australia.

FIGURE 14.9 EXPONENTIAL GROWTH

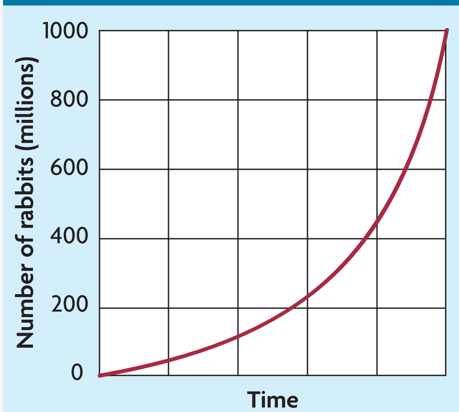
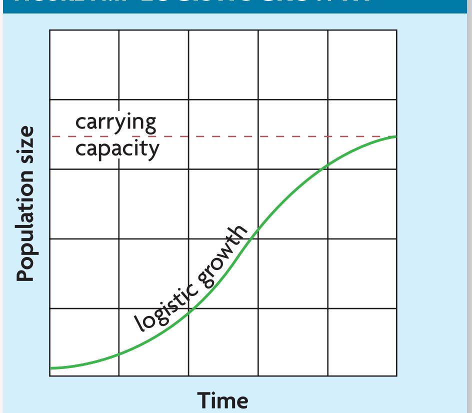


FIGURE 14.10 In Australia during the early 1900s, the introduced European rabbit population exhibited exponential growth.

Logistic Growth

Most populations face limited resources and thus show a logistic growth rate. During **logistic growth,** a population begins with a period of slow growth followed by a brief period of exponential growth before leveling off at a stable size. A graph of logistic growth takes the form of an S-shaped curve and can be seen in **FIGURE 14.11**, which models a population's change in size over time. During initial growth, resources are abundant, and the population is able to grow. Over time, resources begin to deplete, and growth starts to slow. As resources become limited, the population levels off at a size the environment can support.

FIGURE 14.11 LOGISTIC GROWTH



Carrying Capacity

The environment determines how many individuals of the species can be supported based on natural cycles and species diversity. An environment, therefore, has a carrying capacity for each species living in it. The **carrying capacity** of an environment is the maximum number of individuals of a particular species that the environment can normally and consistently support.

In nature, a carrying capacity can change when the environment changes. Consider a population of grasshoppers that feed on meadow grasses. If a fire burns part of the meadow, the insects' food resources diminish, and the carrying capacity declines. But during years with plentiful rain, the meadow grasses flourish, and the carrying capacity rises.

The actual size of the population usually is higher or lower than the carrying capacity. Populations will rise and fall as a result of natural changes in the supply of resources. In this way, the environment naturally controls the size of a population.

Population Crash

When the carrying capacity for a population suddenly drops, the population experiences a crash. A **population crash** is a dramatic decline in the size of a population over a short period of time. There are many reasons why a population might experience a crash.

DATA ANALYSIS

READING COMBINATION GRAPHS

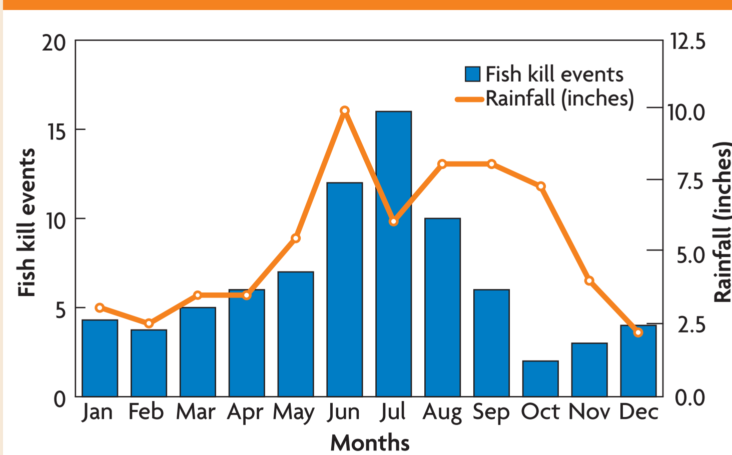
Combination graphs show two sets of data on the same graph. One set of data may be shown as a bar graph, while the other set may be shown as a line graph. The two data sets must share the same independent variable on the *x*-axis. Scientists can then interpret the data to determine if a relationship exists between the variables.

This combination graph displays data about fish kill events, during which many fish died at once, and average monthly rainfall in Florida from 1991–2001.

- The *y*-axis on the left side represents the total number of fish kill events.
- The *y*-axis on the right side represents average monthly rainfall during that time.
- The *x*-axis shows the month of data collection.

The graph shows that in January there were four fish kill events and an average of 2.7 inches of rain.

GRAPH 1. FLORIDA FISH KILLS 1991–2001



Source: The University of Florida Extension Information Circular 107. Used by permission.

1. **Analyze** An increase in fish kills and a decrease in rainfall occurs in what months?
2. **Analyze** Describe the trend in the fish kill events throughout the year. Describe the trend in rainfall data throughout the year.
3. **Hypothesize** What relationship might exist between fish kill events and rainfall?

For example, in 1944, 29 reindeer were introduced to St. Matthew Island off the coast of Alaska. At the time of the introduction, the entire island was covered with a rich mat of lichens. Plenty of good food allowed the reindeer herd to grow at an exponential rate. By the summer of 1963, the island population had grown to 6000 reindeer. However, over the winter, large amounts of snow fell on food resources that had already become greatly depleted by the large herd. By the spring of 1964, only 50 reindeer remained. The population crash on St. Matthew Island came as the result of two factors that limited resources: the harsh winter and the scarcity of food.

Predict What would have eventually happened to the reindeer herd if the winter had not made foraging so difficult? Explain.

MAIN IDEA

Ecological factors limit population growth.

Many factors can affect the carrying capacity of an environment for a population of organisms. The factor that has the greatest effect in keeping down the size of a population is called the **limiting factor.** There are two categories of limiting factors—density dependent and density independent.

Density-Dependent Limiting Factors

Density-dependent limiting factors are limiting factors that are affected by the number of individuals in a given area. Density-dependent limiting factors include many different types of species interactions.

Competition Members of populations compete with one another for resources such as food and shelter. As a population becomes denser, the resources are used up, limiting how large the population can grow.

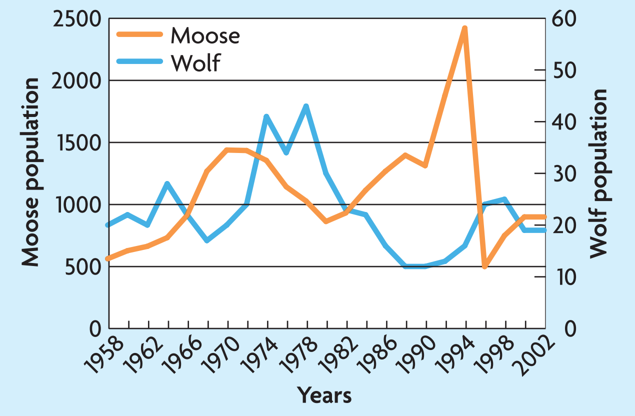
Predation The population of a predator can be limited by the available prey, and the population of prey can be limited by being caught for food. On Isle Royale in Michigan, changes in wolf and moose populations, shown in **FIGURE 14.13**, provide an example. As the moose population grows, so does the wolf population. But at a certain point, the wolves eat so many moose that there are not enough left to feed all the wolves. The result is a decrease in the wolf population. Over time, the two populations rise and fall in a pattern, shown in **FIGURE 14.13**.

Parasitism and disease Parasites and diseases can spread more quickly through dense populations. The more crowded an area becomes, the easier it is for parasites or diseases to spread. The parasites or diseases can then cause the size of the population to decrease.

Analyze How does the wolf population on Isle Royale affect the carrying capacity of the moose population?

FIGURE 14.12 Taking down prey as large as a moose requires that the members of a pack work together. As many as ten wolves may take hours or even days to wear down this moose.

FIGURE 14.13 DENSITY-DEPENDENT LIMITING FACTORS



Source: Isle Royale Research Data

Density-Independent Limiting Factors

Density-independent limiting factors are the aspects of the environment that limit a population's growth regardless of the density of the population.

Unusual weather Weather can affect the size of a population regardless of its density. For example, along the western coast of the United States, a lack of southerly winds can prevent nutrient-poor warm water from being replaced, as it normally is, with nutrient-rich cold water. The lack of nutrients in the water along the coast can prevent phytoplankton, which form the base of the marine ecosystem, from growing in their usual large numbers. In turn, zooplankton, tiny organisms that feed on phytoplankton, have smaller populations. The effects are felt all the way up the food chain, with smaller populations of fish and birds.

FIGURE 14.14 The storm surge accompanying a hurricane can cause dangerous flooding.

Natural disasters Volcanoes, tsunamis, tornados, and hurricanes, shown in **FIGURE 14.14**, can wipe out populations regardless of density. For example, the large wave of a tsunami can damage fragile coral reefs, knock down entire mangrove forests, and destroy sea turtle nesting beaches.

Human activities Destruction of a wetland habitat along the Platte River in Nebraska has threatened an important feeding ground for the sandhill crane. Urbanization in this area is depleting the resources these migratory birds need during their trek to nesting grounds in northern Canada and in Alaska. By clearing forests, filling wetlands, and polluting the air, land, and water, humans threaten habitats and the organisms that live in them. As we will discuss in Chapter 16, human influence as a limiting factor has had a profound effect on populations. For example, the introduction of nonnative species has caused population crashes in many parts of the world where biodiversity is an important part of the ecosystem's functioning.

Apply A population of algae in a pond is limited in size by the amount of sunlight that strikes the pond's surface. Is sunlight a density-dependent or density-independent limiting factor for the algae population?

14.4 ASSESSMENT

ONLINE QUIZ ClassZone.com

REVIEWING MAIN IDEAS

1. What four factors determine the growth rate of a population?
2. How does **carrying capacity** affect the size of a population?
3. What is the main difference between a **density-dependent limiting factor** and a **density-independent limiting factor**? Give examples of each.

CRITICAL THINKING

4. **Apply** What might cause **exponential growth** to occur only for a short period when a new species is introduced to a resource-filled environment?
5. **Synthesize** How might density-dependent limiting factors be affected by a flood or some other natural disaster?

Connecting CONCEPTS

6. **Symbiosis** Give an example of how a symbiotic relationship could cause a population crash.

14.5 Ecological Succession

KEY CONCEPT Ecological succession is a process of change in the species that make up a community.

MAIN IDEA

- Succession occurs following a disturbance in an ecosystem.

VOCABULARY

succession, p. 445
primary succession, p. 446
pioneer species, p. 446
secondary succession, p. 447

REVIEW AT CLASSZONE.COM

Connect It begins with a dirty sock. Then a discarded homework assignment. But this is only the start. If you have ever spent a Saturday afternoon cleaning your bedroom, you may have wondered how a perfectly clean room could manage to become such a cluttered mess. A clean room becoming cluttered is a gradual process much like the process that rebuilds damaged ecosystems.

MAIN IDEA

Succession occurs following a disturbance in an ecosystem.

After an ecosystem experiences a devastating catastrophe and begins to regrow, the space re-forms itself through a process known as succession. **Succession** is the sequence of biotic changes that regenerate a damaged community or create a community in a previously uninhabited area.

The Hawaiian Islands began to form more than 70 million years ago. Over time, volcanic eruptions like the one shown in **FIGURE 14.15** created these islands in the middle of the Pacific Ocean. Eventually, the bare volcanic rock began to break down into soil, which provided a place for plants to grow. As time passed, the process of succession created unique tropical ecosystems. Succession from bare rock to such highly diverse vegetation takes a great deal of time.

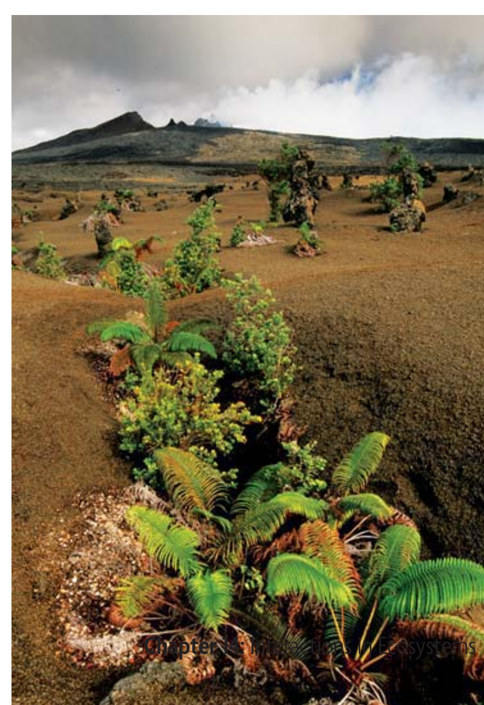
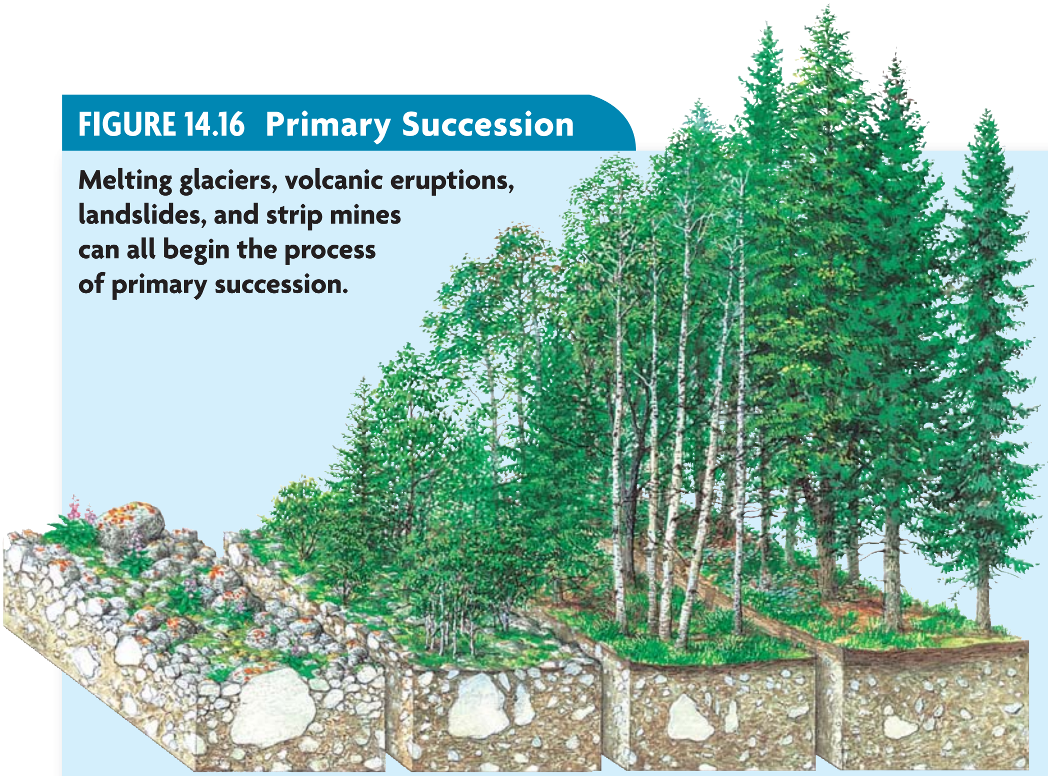


FIGURE 14.15 The path of a lava flow, like this one on the island of Hawaii (left), leaves behind nothing but solid rock. Over time, primary succession will turn this harsh landscape into a fertile ecosystem (right).

FIGURE 14.16 Primary Succession

Melting glaciers, volcanic eruptions, landslides, and strip mines can all begin the process of primary succession.



0–15 years Moss, lichens, grasses

15–80 years Shrubs, cottonwoods, alder thicket

80–115 years Transition to forest, alder, spruce

115–200 years Hemlock-spruce forest

Glacier Bay National Park in Alaska has given scientists an opportunity to witness primary succession as the glacier recedes.

Apply **What function might the mosses and lichens serve in primary succession?**

Connecting CONCEPTS

Symbiosis A lichen is actually two completely different species. Fungus and algae form a symbiotic relationship in which the fungi collects water, while the algae uses chlorophyll to conduct photosynthesis and synthesize food for the lichen community.

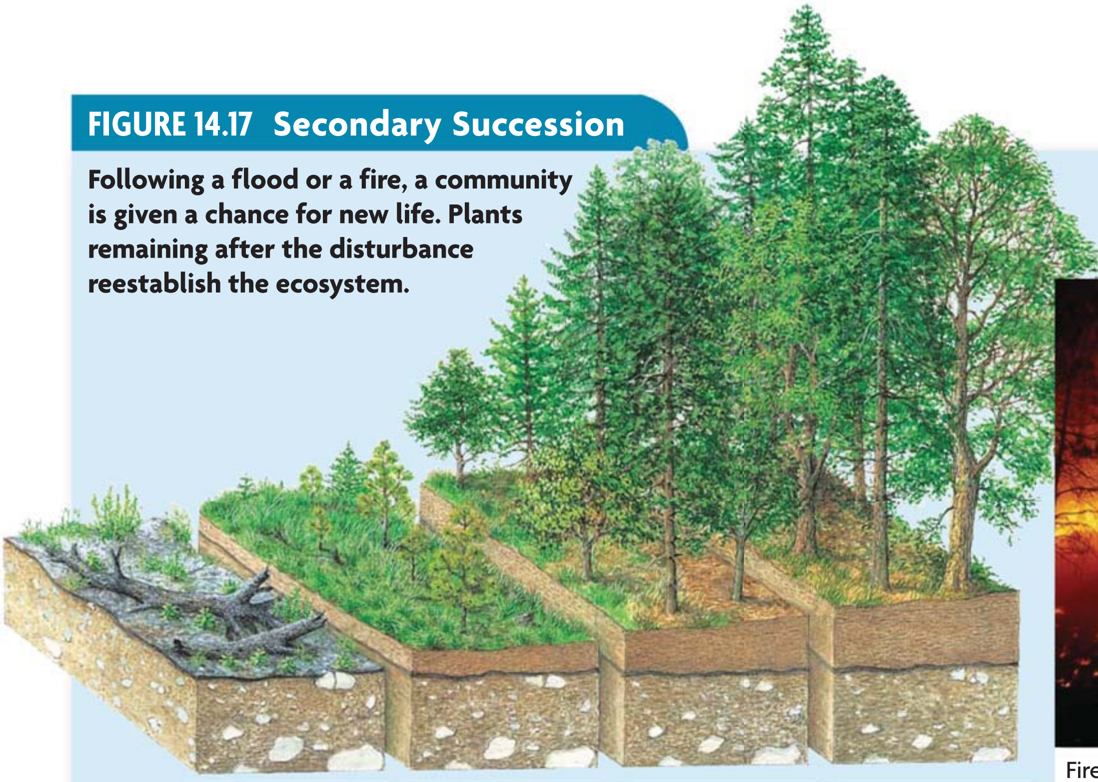
Primary Succession

One of the best ways to understand succession is to watch it progress. **Primary succession** is the establishment and development of an ecosystem in an area that was previously uninhabited. The first organisms that live in a previously uninhabited area are called **pioneer species.** Typical examples of pioneer species are lichens and some mosses, which can break down solid rock into smaller pieces. The process of primary succession, which is illustrated in **FIGURE 14.16,** follows this basic pattern:

- Bare rock is exposed by a retreating glacier or is created when lava cools. Wind, rain, and ice begin to break down the surface of the rock, forming cracks and breaking the rock into smaller pieces.
- Lichen and moss spores are blown in by wind. As they grow, they break up the rock further. When they die, their remains mix with the rock pieces to form a thin layer of soil.
- Over time, seeds are blown into the area or are dropped by birds. Small flowers and hardy shrubs grow from these seeds. These new plants provide a habitat for small animals, break up the rock with their roots, and add material to the soil when they die.
- As the soil continues to grow thicker, small trees take root, and different animals move into the area. These trees provide shade.
- Different tree species take root in the shade and eventually replace the original trees, which need direct sunlight to thrive.

FIGURE 14.17 Secondary Succession

Following a flood or a fire, a community is given a chance for new life. Plants remaining after the disturbance reestablish the ecosystem.



0–2 years Horseweed, crabgrass, asters

2–18 years Grass, shrubs, pine seedlings

18–70 years Pine forest and young hardwood seedlings

70–100 years Oak-hickory forest

Fire is important in helping forests return nutrients to the soil. Secondary succession uses these nutrients to grow.

Analyze **Why does secondary succession take less time than primary succession?**

Secondary Succession

Succession does not always begin from bare rock. More often, a disturbance, such as a fire or hurricane, halts the progress of succession or destroys an established community. **Secondary succession,** which is illustrated in **FIGURE 14.17**, is the reestablishment of a damaged ecosystem in an area where the soil was left intact. Plants and other organisms that remain start the process of regrowth. There is no end to secondary succession. Small disturbances, such as a tree falling, start the process again and again. The dynamic processes of succession are always changing the face of an ecosystem.

Connect **Where might succession occur in the ocean?**

14.5 ASSESSMENT

ONLINE QUIZ
ClassZone.com

REVIEWING ▶ MAIN IDEAS

1. How is **primary succession** different from **secondary succession**?
2. Why are **pioneer species** so important for primary succession?

CRITICAL THINKING

3. **Infer** Does the process of primary succession take longer in tropical or arctic areas? Explain.
4. **Predict** During **succession,** what might become the limiting factor for sun-loving mosses as taller plants begin to grow?

Connecting CONCEPTS

5. **Niche** At what point during primary succession does an ecosystem provide the fewest habitats for organisms? Explain your reasoning.

Use these inquiry-based labs and online activities to deepen your understanding of ecosystems.

INVESTIGATION

Limiting Nutrients for Algae

All organisms require sufficient nutrients to grow. In many ecosystems, two important limiting nutrients, nitrogen and phosphorus, may limit plant growth.

SKILL **Interpreting Data**

PROBLEM Are nitrogen and phosphorus limiting nutrients for algae growth?

MATERIALS

- 3 baby food jars with lids
- glass marking pencil
- 200 mL pond water
- 3 eyedroppers
- 50 mL algae culture
- 5 drops 10% trisodium phosphate solution
- 5 drops 10% ammonium sulfate or urea solution
- 50-mL graduated cylinder

PROCEDURE

1. Mark the three jars *control*, *A*, and *B*, and add pond water until each is two-thirds full.
2. Add 40 to 50 mL of algae culture to each jar.
3. Add 4 or 5 drops of the trisodium phosphate solution to jar A. This is a source of phosphorous. Swirl to mix.
4. Add 4 or 5 drops of the ammonium sulfate or urea solution to jar B. This is a source of nitrogen. Swirl to mix.
5. Cap the jars and place them in a sunny window.
6. Design a data table to record your observations.
7. Predict how algae levels will change in each jar after seven days.
8. Observe every day for seven days. Record your observations.

ANALYZE AND CONCLUDE

1. **Observe** After seven days, how did the appearances of the three jars differ? How did their smells differ?
2. **Evaluate** Use your data to determine whether your results support your prediction.
3. **Conclude** Explain how you know whether phosphorus or nitrogen was a limiting nutrient.
4. **Experimental Design** In what way did your experiment fall short in revealing limiting nutrients for algae?
5. **Application** Based on what you learned in this experiment, which nutrients would you add to a vegetable garden?

EXTEND YOUR INVESTIGATION

Excess nutrients in waterways can cause an environmental problem called eutrophication. Sources of excess nutrients include sewage treatment runoff, agriculture runoff, industrial waste, storm water runoff, and atmospheric fallout. Do research on eutrophication and the effects of excess amounts of nitrogen and phosphorus on algae growth.

INVESTIGATION

Making a Local Field Guide

Field guides contain descriptions and pictures of plant, insect, and animal species. In this activity, you will observe specimens near your home or school to create your own local field guide.

SKILL Observing

PROBLEM What plant and animal species can you identify in your region?

MATERIALS

- several field guides appropriate to the plants and animals in your area
- hand lens
- blank notebook
- pencil
- colored pencils
- camera (optional)

PROCEDURE

1. Find an area near your home or school with as many different species as possible, such as an open field or a pond. Choose a category of species from your teacher's list, and find as many different species in that category as you can.
2. Draw pictures in your notebook or take photographs of each species.
3. Use field guides to identify each species. Write down both the common and scientific names, and note any interesting species information.
4. Make a field-guide page for each species you identified in your local ecosystem. Include the drawing or photograph of each species, along with its common and scientific names, when and where you collected it, and interesting information about it.
5. Compile your field guide in a binder or folder. Give your guide a title and a table of contents.

ANALYZE AND CONCLUDE

1. **Analyze** How diverse is the ecosystem you studied? Compare the species richness you observed with what your classmates discovered.
2. **Conclude** Summarize what you learned about the ecosystem you surveyed. How did creating your own field guide affect your understanding of the ecosystem?

Online BIOLOGY
CLASSZONE.COM

ANIMATED BIOLOGY

What Limits Population Growth?
Apply a limiting factor within a sample environment and see how the populations of organisms react.

WEBQUEST

In this WebQuest, you will examine how Hurricane Hugo affected endangered Puerto Rican parrots. Explore how healthy parrot populations weathered hurricanes in the past, then determine if the current population recovered from the hurricane.

DATA ANALYSIS ONLINE

By 1900, most bison in Yellowstone Park had been wiped out. Between 1902 and 1968, scientists gathered data on the reemerging bison population. Make a graph of the data to analyze how the population grew and when the population reached its carrying capacity.

CHAPTER 14 **Interactive Review** @ CLASSZONE.COM

KEY CONCEPTS | Vocabulary Games | Concept Maps | Animated Biology | Online Quiz

14.1 Habitat and Niche

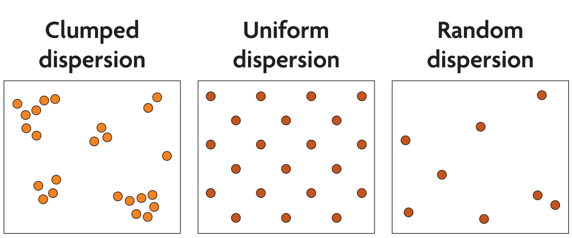
Every organism has a habitat and a niche. Each organism in an ecosystem has an ecological niche, which includes the type of food it consumes, its behavior, and its habitat—the place where it lives. Competitive exclusion prevents two species from sharing the same niche. In different geographical regions, ecological equivalents may have similar ecological niches.

14.2 Community Interactions

Organisms interact as individuals and as populations. Interactions between species include competition and predation. Interactions shape ecosystem dynamics. Parasitism, commensalism, and mutualism are symbiotic relationships involving two species living in direct contact with one another.

14.3 Population Density and Distribution

Each population has a density, a dispersion, and a reproductive strategy. The distribution of a population can be measured by population density. Species can have clumped, uniform, or random dispersion patterns. Survivorship curves describe the reproductive strategies of different species.



14.4 Population Growth Patterns

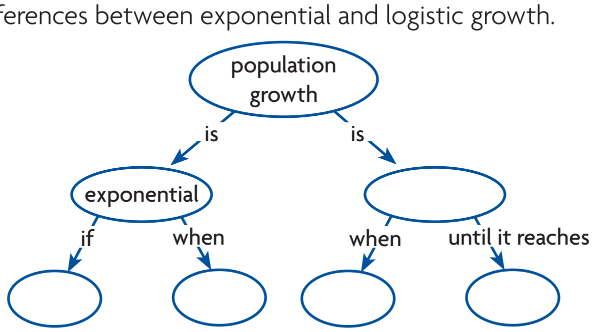
Populations grow in predictable patterns. Population growth accommodates changes in population size due to births and deaths as well as immigration and emigration. Populations experiencing exponential growth increase dramatically over time. When resources become a limiting factor, a population will grow logistically until it reaches the environmental carrying capacity, or the maximum population size the environment can support. Density-dependent limiting factors affect dense populations, but density-independent limiting factors affect populations regardless of density.

14.5 Ecological Succession

Ecological succession is a process of change in the species that make up a community. *Succession* refers to the progression of plants and animals that repopulate a region after an ecological disturbance. Primary succession begins in a previously uninhabited area, such as bare rock exposed by the receding of a glacier or created by a volcanic eruption. Secondary succession occurs in a previously inhabited area that is damaged by an ecological disturbance, such as a fire or a flood.

Synthesize Your Notes

Concept Map Use a concept map to display the differences between exponential and logistic growth.



Main Idea Chart Use the main idea chart to explain and give examples of density-independent and density-dependent limiting factors.

Density Independent	Density Dependent

CHAPTER 14

Interactive Review @ CLASSZONE.COM

KEY CONCEPTS | Vocabulary Games | Concept Maps | Animated Biology | Online Quiz

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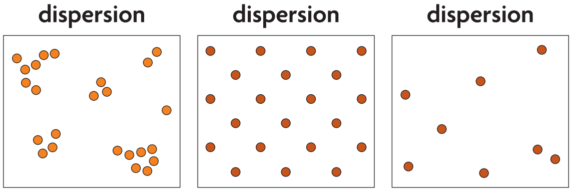
Clumped dispersion | Uniform dispersion | Random dispersion



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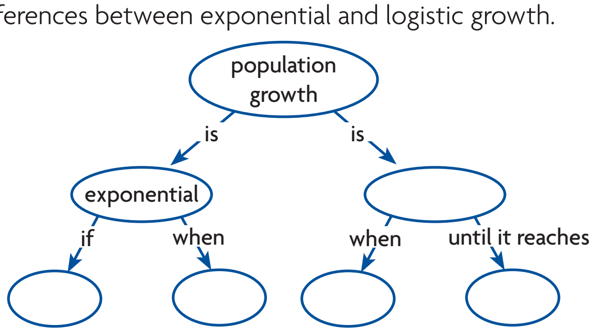
Concept Map Use a concept map to display the differences between exponential and logistic growth.



Main Idea Chart Use the main idea chart to explain and give examples of density-independent and density-dependent limiting factors.

Density Independent	Density Dependent

Chapter Assessment

Chapter Vocabulary

14.1 habitat, p. 428
ecological niche, p. 428
competitive exclusion, p. 429
ecological equivalent, p. 430

14.2 competition, p. 431
predation, p. 431
symbiosis, p. 432
mutualism, p. 432
commensalism, p. 432
parasitism, p. 432

14.3 population density, p. 436
population dispersion, p. 437
survivorship curve, p. 438

14.4 immigration, p. 440
emigration, p. 440
exponential growth, p. 441
logistic growth, p. 441
carrying capacity, p. 442
population crash, p. 442
limiting factor, p. 443
density-dependent limiting factor, p. 443
density-independent limiting factor, p. 444

14.5 succession, p. 445
primary succession, p. 446
pioneer species, p. 446
secondary succession, p. 447

Reviewing Vocabulary

Category Clues

For each clue in the category group, list the appropriate vocabulary words from the chapter.

Category: Types of Symbiosis

1. two-way benefit
2. host is harmed
3. no effect on host

Category: Types of Dispersion

4. a herd
5. no pattern
6. territories

Category: Population Growth

7. quick growth
8. sudden decrease in size
9. number environment can sustain

Word Origins

10. *Niche* is an English word with a French origin. In general, it means "a special place." How does this meaning relate to the ecological definition of the word?
11. *Habitat* comes from a Latin word meaning "it inhabits." Connect this meaning with the definition in Section 14.1.

Reviewing MAIN IDEAS

12. A deer is a large herbivore that usually lives in a forest. What is the deer's habitat, and what is its niche?
13. How does competitive exclusion differ from ecological equivalents?
14. A brown bear is an omnivore. Explain how a brown bear and a squirrel can be in interspecific competition and have a predatory–prey relationship.
15. The remora fish has an adaptation that allows it to attach to a shark, and it feeds on scraps of food left over from the shark's meal. What type of symbiotic relationship is this? Explain.
16. If you were to add two goldfish into a fish tank that already contains three goldfish, explain what happens to the population density of the fish tank.
17. Explain how the three types of survivorship curves align with different reproductive strategies.
18. If a large number of individuals immigrated into a population of bison, what two things could happen to return the population to its original size?
19. Why does a population that experiences exponential growth have a high chance of having a population crash?
20. How might the carrying capacity of an environment for a particular species change in response to an unusually long and harsh winter? Why?
21. Describe and give examples of two limiting factors that affect a dense population.
22. Why is succession considered an ongoing process?

Critical Thinking

23. Apply A bee gathers nectar from a flower by using a strawlike appendage called a proboscis. While on the flower, grains of pollen attach to the bee's back. When the bee travels to another flower, the pollen fertilizes the new plant. What type of symbiosis is this?

24. Predict A population of prairie dogs is experiencing high immigration and birthrates, but resources are beginning to deplete. What could eventually happen to this population? Give two possibilities.

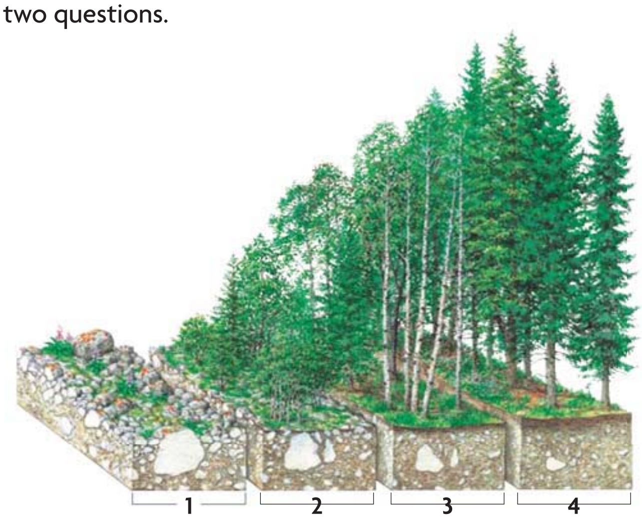
25. Synthesize A species of beetle is in a period of exponential growth, but a competing species has started sharing the same space. Is the competing species an example of a density-dependent or a density-independent limiting factor? Explain.

26. Evaluate Imagine that scientists introduced a disease into the rabbit population of Australia, and the rabbit population crashed. Was the crash caused by a density-dependent or density-independent limiting factor? Justify your answer.

27. Apply Each year, thousands of California market squid swim up from the ocean depths and lay millions of eggs along California shorelines. The squid then die, leaving their offspring to fend for themselves. Draw and label a graph that illustrates a likely survivorship curve of the California market squid.

Analyzing a Diagram

Use the diagram below to answer the next two questions.



28. Apply What part of the diagram depicts pioneer species? Explain your answer.

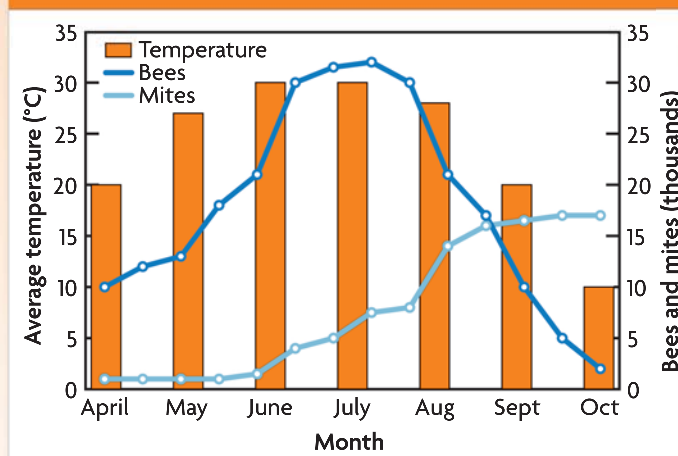
29. Infer What could happen in the ecosystem shown that could make it revert to an earlier stage of succession?

Analyzing Data

Use the graph to answer the next three questions.

The combination graph below shows changes in the sizes of bee and mite populations in one area of the Midwest. The mites live as parasites on the bees.

INSECT POPULATION SIZE AND TEMPERATURE



30. Interpret A decrease in the number of bees occurs during which months?

31. Analyze Describe the trends in the bee and mite populations from April through October.

32. Hypothesize What might explain the relationship between the bee and mite population numbers?

Connecting CONCEPTS

33. Write Ad Copy Imagine that you are an advertising agent trying to encourage a new species to move into an environment. Design an advertisement using the concepts from the chapter. Keep in mind that a population will not want to move to a new area without abundant resources. Choose a target species and make sure that your advertisement answers the following questions: What resources and environmental factors would make this species want to move? What abiotic and biotic factors does it need? Include several vocabulary terms from the chapter.

34. Apply The two zebras on page 427 are competing for the right to mate with females. Are they engaging in intraspecific or interspecific competition? Explain your answer.

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Test Practice
For more test practice, go to ClassZone.com.

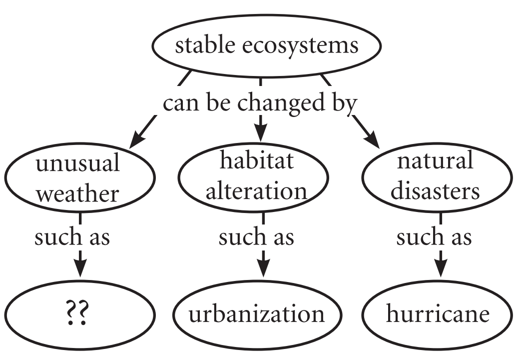
1. Archaeologists find that the disappearance of a large mammal occurred shortly after the arrival of hominids in a certain region. What most likely occurred between these two species?

A dispersion
B predation
C commensalism
D parasitism

2. Officials attempt to control the spread of an exotic wildflower species by introducing its natural predator, a beetle. Unexpectedly, the beetle population grows exponentially and begins to eat local crops. What best accounts for this unexpected population explosion?

A Adaptive radiation allowed the beetle population to evolve faster.
B The beetle population has few predators in the new habitat.
C The wildflower and the local crops are genetically similar kinds of plants.
D The beetle has different nutritional requirements in the new habitat.

3.



Which of these best completes this concept map?

A acid rain
B pollution
C an earthquake
D extended drought

THINK THROUGH THE QUESTION

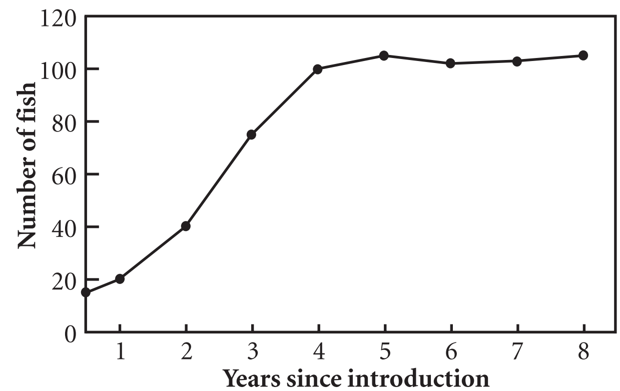
Keep in mind that unusual weather is a natural part of ecosystem function.

4. A population of rodents becomes stranded on a remote island. Eventually, the population reaches the island's carrying capacity. At this point, the birth and death rates are

A relatively equal.
B crashing.
C density independent.
D density dependent.

5.

Fish Population in Birch Park Pond



A fish species is introduced to a park pond. Which statement best describes the population growth of these fish shown in the graph?

A The population stopped growing because the fish stopped reproducing.
B The population stopped growing because this species of fish lives less than one year.
C The population grew until disease caused the population to level off.
D The population grew until it reached the pond's carrying capacity.

6. In many parts of the United States, native plants that once grew on the forest floor have been replaced by garlic mustard, an invasive species that thrives in cool forest understories. This situation is an example of

A parasitism between species.
B primary succession between species.
C predation between species.
D competition between species.